STARTUP AND ADVANCED TOPICS MANUAL FOR AIR COOLED PERFECT HARMONY SERIES

ADJUSTABLE SPEED AC MOTOR DRIVES WITH NEXT GENERATION CONTROL

Manual Number: 902232*
Version 3.0
July 2004

SIEMENS

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This manual applies to all air-cooled Perfect Harmony adjustable-speed AC motor drives including GEN III (GEN3) (200 hp through 10,000 hp) having the following cell sizes:

00A through 5C (460 V cells)

70, 100, 140, 200, and 260 (630 V cells)
0I, 1I, 2I, 3I, and 4I (690 V cells).

This manual applies to NXG software up to and including version 2.5.

For the support representative nearest you, please call Siemens Electrical Drives(Shanghai)Ltd. main office at (86-21-58485775).

Perfect Harmony, GEN II (GEN2) and GEN III (GEN3) are product lines of AC motor drives from Siemens .

PLC is a trademark of Allen-Bradley Company, Inc.

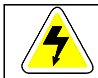
Version History:

Version 1.0 April 2001	Version 1.6
Version 1.1 May 2001	Version 1.7 June 2002
Version 1.2 May 2001	Version 1.8 December 2002
Version 1.3 December 2001	Version 1.9 October 2003
Version 1.4 February 2002	Version 2.0 March 2004
Version 1.5 March 2002	Version 3.0 July 2004

Table of Contents

Safety Precautions and Warnings

Perfect Harmony drives are designed with considerable thought to personal safety. However, as with any piece of high power equipment, there are numerous internal connections that present potentially lethal voltages. In addition, some internal components are thermally hot to the touch. Follow the warnings below when working in or near the Perfect Harmony system.



Danger - Electrical Hazards!

Always follow the proper lock-out/tag-out procedures before beginning any maintenance or troubleshooting work on the drive.

Never touch anything within the Perfect Harmony cabinets (other than the control cabinet) until verifying that it is neither thermally hot nor electrically alive.

Always follow standard safety precautions and local codes during installation of external wiring. Protective separation must be kept between extra low voltage(ELV) wiring and any other wiring as specified in the safety standard.

Never assume that switching off the input disconnect will remove all voltage from internal components. Voltage is still present on the terminals of the input disconnect. Also, there may be voltages present that are applied from other external sources.

Always work with one hand, wear insulated or rubber safety shoes, and wear safety glasses. Also, always work with another person present.

Use only instrumentation (e.g., meters, oscilloscopes, etc.) intended for high voltage measurements (that is, isolation is provided inside the instrument, not provided by isolating the chassis ground of the instrument). Never defeat the instrument's grounding.

Never remove safety shields (marked with a **HIGH VOLTAGE** sign) or attempt to measure points beneath the shields.

Always use extreme caution when handling or measuring components that are inside the enclosure. Be careful to prevent meter leads from shorting together or from touching other terminals.

Hazardous voltages may still exist within the Perfect Harmony cabinets even when the disconnect switch is open (off) and the supply power is shut off.

Never run the drive with cabinet doors open. The only exception is the control cabinet which contains extra low voltages (ELV).

Only qualified individuals should install, operate, troubleshoot, and maintain this drive. A qualified individual is "one familiar with the construction and operation of the equipment and the hazards involved."

Warning!

- **Never** disconnect control power while medium voltage is energized. This could cause severe system overheating and/or cell damage.
- **Never** store flammable material in, on or near the drive enclosure. This includes equipment drawings and manuals.
- **Always** ensure the use of an even and flat truck bed to transport the Perfect Harmony drive system. Before unloading, be sure that the concrete pad is level for storage and permanent positioning.
- **Always** confirm proper tonnage ratings of cranes, cables, and hooks when lifting the drive system. Dropping the cabinet or lowering it too quickly could damage the unit.
- **Never** use fork trucks to lift cabinets that are not equipped with lifting tubes. Be sure that the fork truck tines fit the lifting tubes properly and are the appropriate length.
- **Always** comply with local codes and requirements if disposal of failed components is necessary (for example, CPU battery, capacitors, etc.).
- **During** operation, the nominal weighted sound pressure level may exceed 70 dB at a distance of 1 meter from the drive.

ESD Sensitive Equipment!

- Always be aware of electrostatic discharge (ESD) when working near or touching components inside the Perfect Harmony cabinet. The printed circuit boards contain components that are sensitive to static electricity. Handling and servicing of components that are sensitive to ESD should be done only by qualified personnel and only after reading and understanding proper ESD techniques. The following ESD guidelines should be followed. Following these rules can greatly reduce the possibility of ESD damage to PC board components.
- Make certain that anyone handling the Perfect Harmony printed circuit boards is wearing a properly grounded static strap. The wrist strap should be connected to ground through a 1 megaohm resistor. Grounding kits are available commercially through most electronic wholesalers.
- Static charge buildup can be removed from a conductive object by touching the object to a properly grounded piece of metal.
- Always transport static sensitive equipment in antistatic bags.
- When handling a PC board, always hold the card by its edges.
- Do not slide printed circuit boards across any surface (e.g., a table or work bench). If possible, perform PCB maintenance at a workstation that has a conductive covering which is grounded through a 1 megaohm resistor. If a conductive tabletop cover is unavailable, a clean steel or aluminum tabletop is an excellent substitute.
- Avoid plastic, Styrofoam™, vinyl and other non-conductive materials. They are excellent static generators and do not give up their charge easily.
- Always use a soldering iron that has a grounded tip. Also, use either a metallic vacuum-style plunger or copper braid when desoldering.
- When returning components to SIEMENS, always use static-safe packing. This limits any further component damage due to ESD.

Additional safety precautions and warnings appear throughout this manual. These important messages should be followed to reduce the risk of personal injury or equipment damage.

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About This Manual

Reference Tools

Many steps have been taken to promote the use of this manual as a *reference* tool. Reference tools include the following:

- a thorough table of contents for locating particular sections or subsections
- chapter number thumb nails in the outer margins for easy location of chapters
- special text styles are applied to easily differentiate between chapters, sections, subsections, regular text, parameter names, software flags and variables, and test points.
- a comprehensive index with special locator references for illustrations and tables.

Conventions Used in this Manual

The following conventions are used throughout this manual:

- This manual is for use with the Perfect Harmony product line.
- The terms “Perfect Harmony,” “VFD,” “variable frequency drive,” and “drive” are used interchangeably throughout this manual.

Note: Hand icons in the left margin alert readers of important operational or application information tha may have special significance. The associated text is enclosed in a border for high visibility.

Attention! Attention icons in the left margin alert readers of important safety and operationaol precautions. These notes warn readers of potential problems that could cause equipment damage or personal injury. The associated text is enclosed in a border for high visibility.

Caution - Electrical Hazard! Electrical hazard icons in the outer margins alert readers of important safety and operational precautions. These notes warn readers of dangerous voltages, potential safety hazards or shock risks that could be life threatening. The associated text is enclosed in a border for high visibility.

ESD Warning! These icons in the left margin alert readers of static sensitive devices. Proper electdrostatic discharge precautions should be taken before proceeding or handling the equipment.

- Chapter numbers are highlighted in the outer margins to facilitate referencing (see margin).
- Test points and terminal block designations are shown in uppercase, boldface, Arial fonts (e.g., **TB1A**).
- The symbol “ ∇∇∇ ” is used to mark the end of each chapter.

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CHAPTER

1 Introduction

1.1 Introduction to the Perfect Harmony

Perfect Harmony is a series of pulse-width modulated, variable frequency AC motor drives designed and manufactured by Siemens. The Perfect Harmony drive system addresses the following power quality issues: providing clean power input, providing a high power factor, and providing nearly perfect sinusoidal output.

1.1.1 Clean Power Input

The Perfect Harmony drive series meets the most stringent IEEE 519 1992 requirements for voltage and current harmonic distortion, even if the source capacity is no larger than the drive rating. This series of drives protects other on-line equipment (such as computers, telephones, and lighting ballasts) from harmonic disturbances. Perfect Harmony also prevents "cross talk" with other variable speed drives. Clean power input eliminates the need for time-consuming harmonic/resonance analyses and costly harmonic filters**.** Figure 1-1 illustrates input wave forms for typical 6-pulse, 12-pulse and Perfect Harmony series drives.

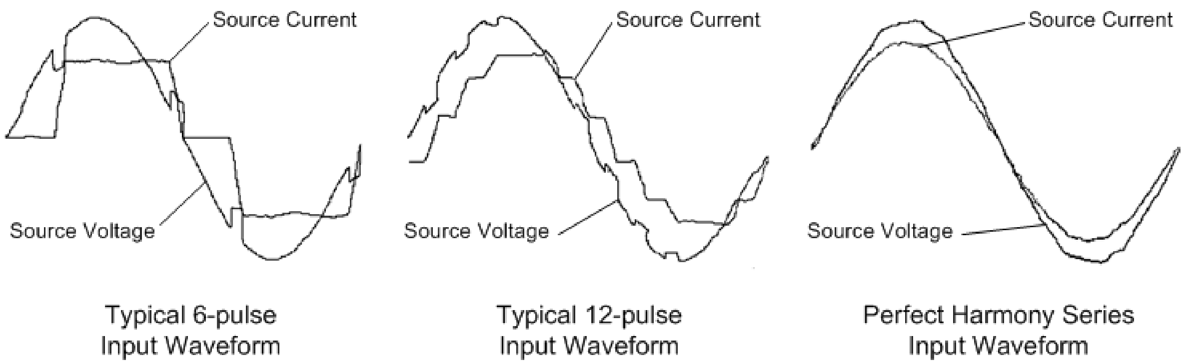

Figure 1-1. Harmonic Distortion Wave Form Comparisons (6-pulse, 12-pulse and Perfect Harmony)

Total harmonic distortion of the source current is 25% for the 6-pulse, 8.8% for the 12-pulse, and 0.8% for the Perfect Harmony series drive. The corresponding voltage distortions with a typical source impedance are 10%, 5.9% and 1.2%, respectively.

Note: The above comparisons were done using a typical 1,000 hp current source drive (6-pulse and 12-pulse modes) and a Perfect Harmony series drive operating from a 1100 kVA, 5.75% impedance source.

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1.1.2 High Power Factor and Nearly Perfect Sinusoidal Input Currents

Power factor is a measure of the fraction of current that produces real power to the load. Typically, power factor is given as a percentage. A high power factor VFD (e.g., 95%) makes much better use of its input line current demand in producing real power to the motor than a VFD operating at a low power factor (e.g., 30%). VFDs having low operating power factor often generate square-wave shaped line currents. This can lead to harmonics and other associated resonance problems.

The Perfect Harmony series draws nearly perfect sinusoidal input currents having a power factor that exceeds 95% throughout the entire speed range without the use of external power factor correction capacitors. This eliminates utility penalties for power factor and demand charges, and improves voltage regulation. In addition, feeders, breakers and transformers are not overloaded with reactive power. Low speed applications specifically benefit from the Perfect Harmony series because a high and stable power factor is maintained throughout the entire speed range using standard induction motors. Figure 1-2 compares graphs of power factor versus percent speed for the Perfect Harmony series and a typical phase-controlled SCR drive.

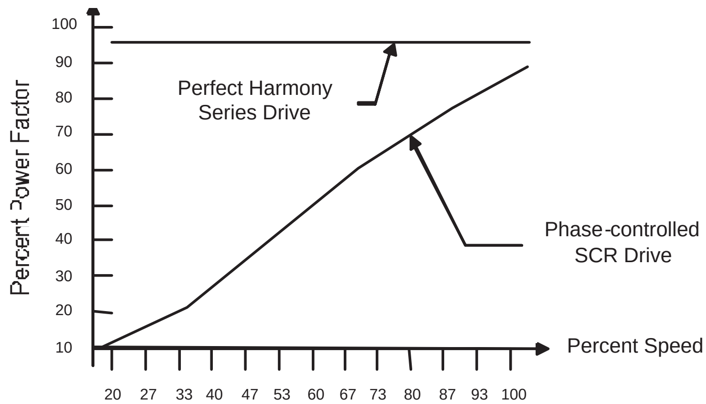

Figure 1-2. Comparison of Perfect Harmony and a Typical Phase-controlled SCR Drive

1.1.3 Nearly Perfect Sinusoidal Output Voltages

The design of the Perfect Harmony series of variable frequency drives inherently provides a sinusoidal output without the use of external output filters. This means that the drive provides a low distortion output voltage wave form that generates no appreciable audible motor noise. In addition, there is no need to derate motors (the drive can be applied to new or existing 1.0 service factor motors). In fact, Perfect Harmony drives eliminate harmful VFD-induced harmonics which cause motor heating. Similarly, VFD-induced torque pulsations are eliminated (even at low speeds), thereby reducing the mechanical stress on equipment. Common mode voltage stress and dV/dt stress are also minimized. A typical graph of the output current from a Perfect Harmony drive is illustrated in Figure 1-3.

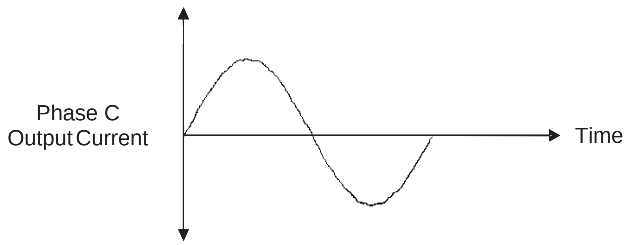

Figure 1-3. Nearly Sinusoidal Wave Form of the Output Current from a Perfect Harmony Drive

1.2 Hardware Overview

The cabinet configurations of Perfect Harmony drives vary based on the horsepower of the drive, the number and type of cells, and other factors. However, cabinet configurations can generally be divided into two broad categories:

- GEN II (multiple cabinet) style (shown in Figure 1-4).
- GEN III style (shown in Figure 1-5).

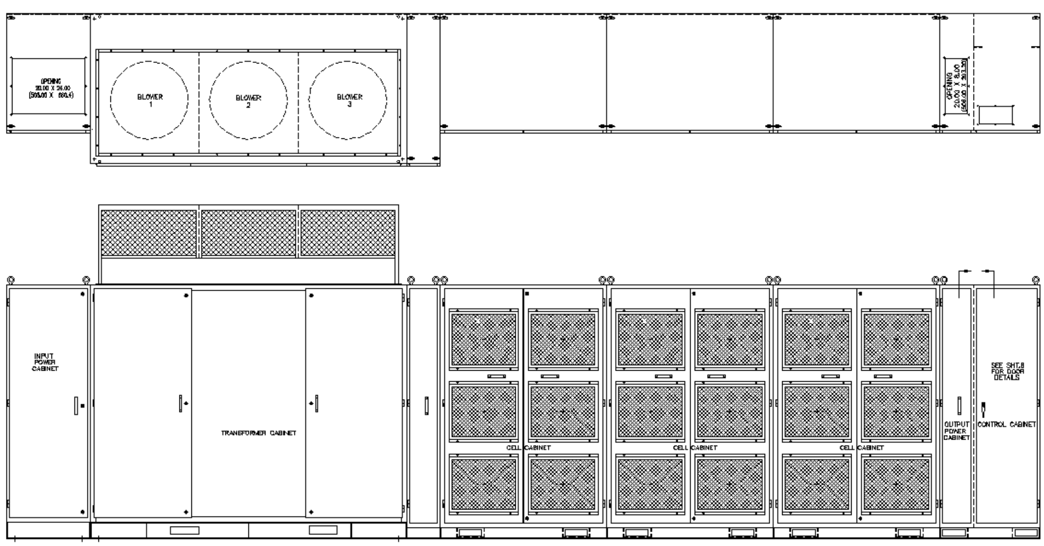

Figure 1-4. Typical GEN II Perfect Harmony VFD Lineup

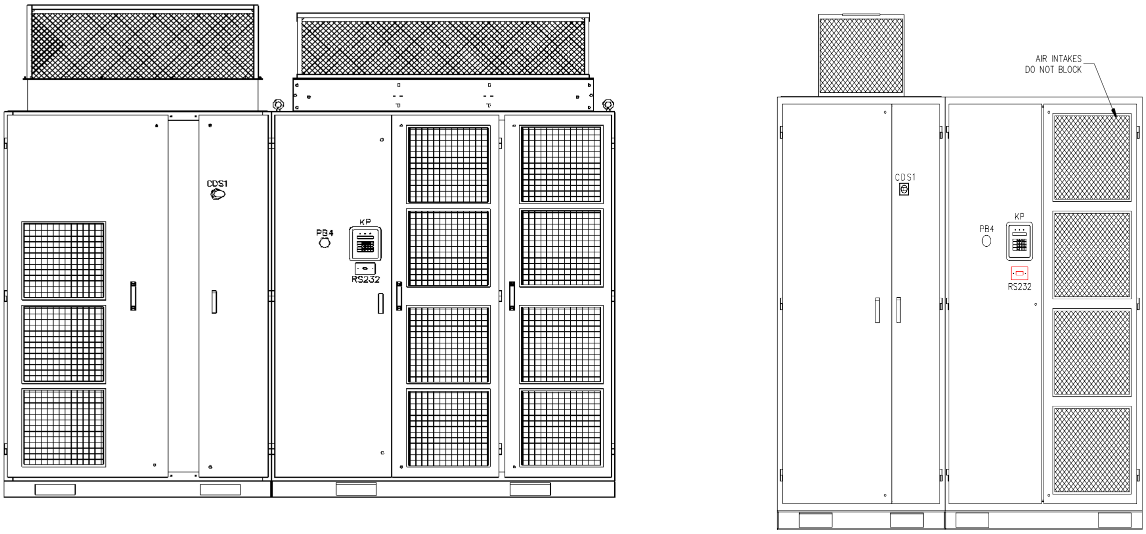

Figure 1-5. Typical 4,160V (Left) and 6,600V (Right) GEN III Perfect Harmony VFDs

These two styles are discussed in Chapter 2: Hardware Components.

1.3 Features Overview

Additional features of the Perfect Harmony drive include the following:

- redundant cooling blowers
- high efficiency
- reliability
- modular construction
- surge arrestors
- fiber optic control circuitry
- soft start protection
- multi-motor operation
- trip-free operation
- multi-operational modes
- undervoltage ride-through
- spinning load restart
- transparent cell bypass
- PC tool interface
- power cell check
- serial port
- micro PLC capabilities
- keypad and English message display
- on-line diagnostics
- digital display module
- advanced diagnostics
- on-line operation while tuning
- industry standard communications
- dual frequency braking
- auto tuning
- input monitoring

1.4 Specifications

Table 1-11-1 lists common electrical and mechanical specifications for all standard Perfect Harmony systems. Note that Perfect Harmony specifications may be changed without notice.

Table 1-1. Common Specifications for Standard Perfect Harmony Systems

Item	Description
hp range	**GEN II:** Up to 4,000hp at 7,200V **GEN III:** Up to 3,000 hp at 6,300V
Input line voltages	2.4 kV, 3.0 kV, 3.3 kV, 3.4kV, 4.16 kV, 4.8 kV, 6.0 kV, 6.6 kV, 6.9 kV, 7.2 kV, 8.4 kV, 10.0 kV, 11.0 kV, 12.0 kV, 12.5 kV, 13.2 kV, 13.8 kV and 22kV.
Input voltage tolerance	+10%, -5% from nominal 3-phase at rated output (drive will alarm at +10%)
Input power factor	0.95 above 10% load
Output line voltages	2.4 kV, 3.0kV, 3.3 kV, 3.4kV, 4.16 kV, 4.8 kV, 6.0 kV, 6.6 kV, 6.9 kV, and 7.2 kV.
Output frequency drift	±0.5%
Speed range	0.5-330 Hz (motor dependent)
Overload capability	A function of the installed type of cell.
Accel/decel time range	0.5-3,200 sec (load dependent)
Output torque	15-139 Hz rated torque; 3-14 Hz and 140-330 Hz derated torque
Enclosure	NEMA 1 ventilated, IP31
Ambient temperature	0-40°C
Humidity	95% non-condensing
Altitude	Up to 3,300 feet. Above 3,300 feet require derating.
Dust contamination	<100 micron @ 6.5 mg/cu. ft.
Gas contamination	<4 PPB reactive halides and sulfides

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CHAPTER

2 Hardware Components

2.1 GEN II Style Hardware Configuration

Figure 2-1 depicts a typical GEN II style line-up in which each VFD normally consists of six cabinets. These cabinets are:

- the power input cabinet
- the transformer/blower cabinet
- the cell cabinet(s)
- the output power cabinet
- the control cabinet

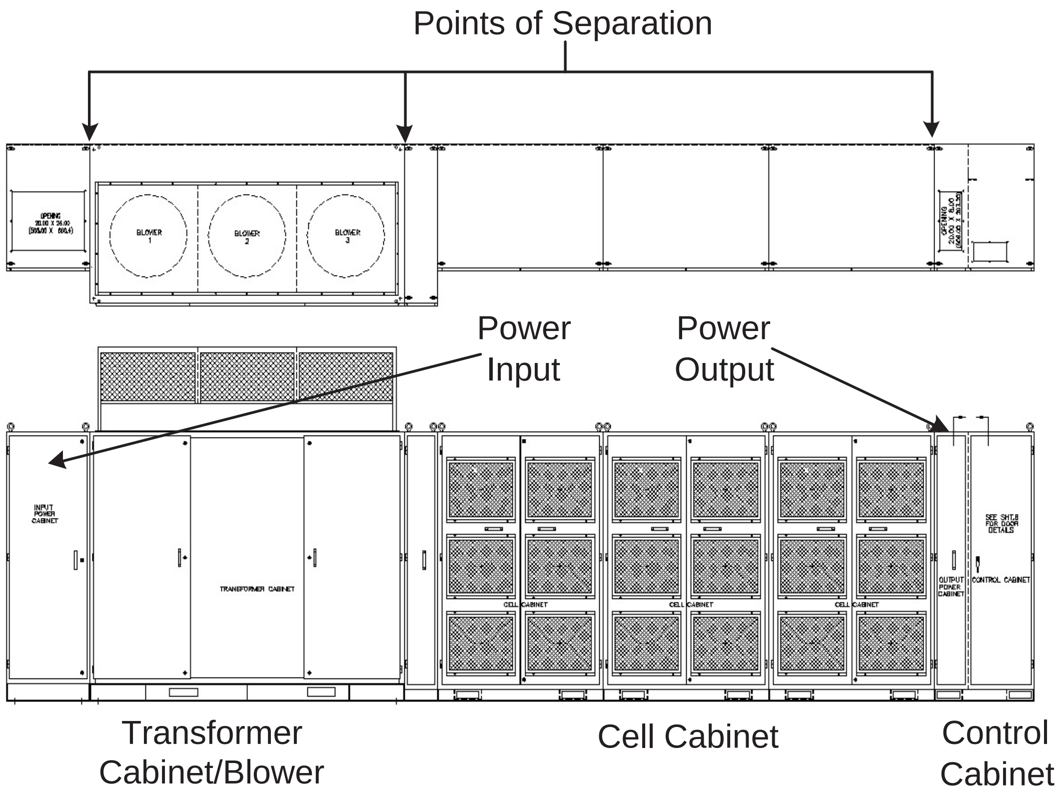

Figure 2-1. Typical GEN II Perfect Harmony VFD Lineup (Top and Front Views)

These cabinets are described in the sections that follow.

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2.1.1 Power Input Cabinet

The power-input cabinet houses the input power cable terminals for the drive. A cutaway side view of this cabinet is shown in Figure 2-2.

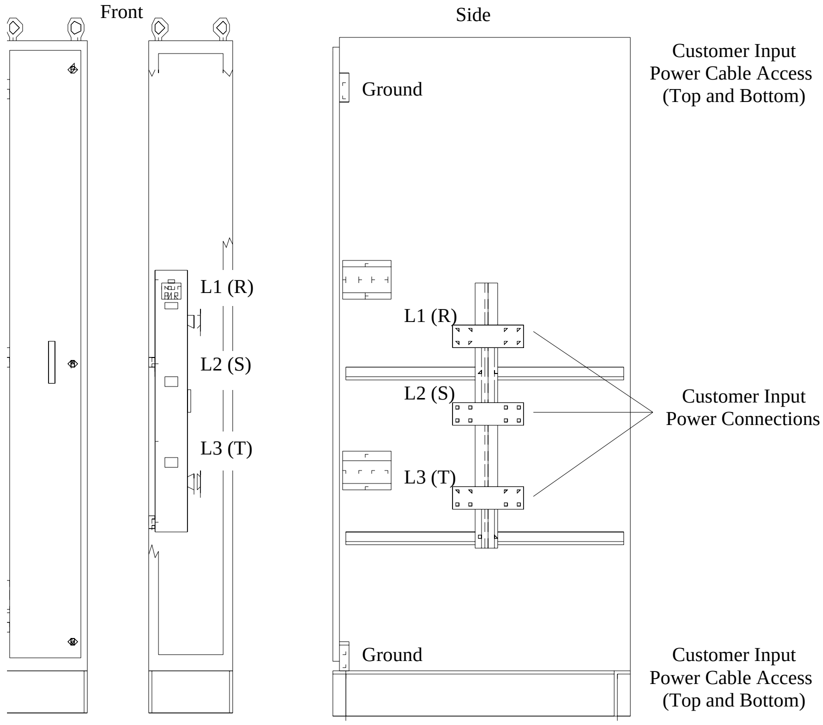

Figure 2-2. Typical Power Input Cabinet (Front, Door Removed, and Side Views)

2.1.2 Blower Section

The blower section contains the cooling blower and associated motor. This section resides above the Transformer Cabinet as shown in Figure 2-3. Ambient air in the room enters the cell cabinet(s) through the air intake vents. This air passes over the cells to cool them, then passes across the transformer (in the transformer cabinet) and is finally drawn into the blower section where it is exhausted through the top of the cabinet.

Attention! During operation, the nominal weighted sound pressure level may exceed 70 dB at a distance of 1 meter from the drive.

2.1.3 Transformer Cabinet

The transformer cabinet houses the input phase shifting transformer and surge suppression which supplies 3-phase voltages to the output cells (refer to Figure 2-3). The transformer secondary contains connection points for the various cells' input cables (see Figures 2-3 and 2-4). Surge suppression is also supplied in this cabinet.

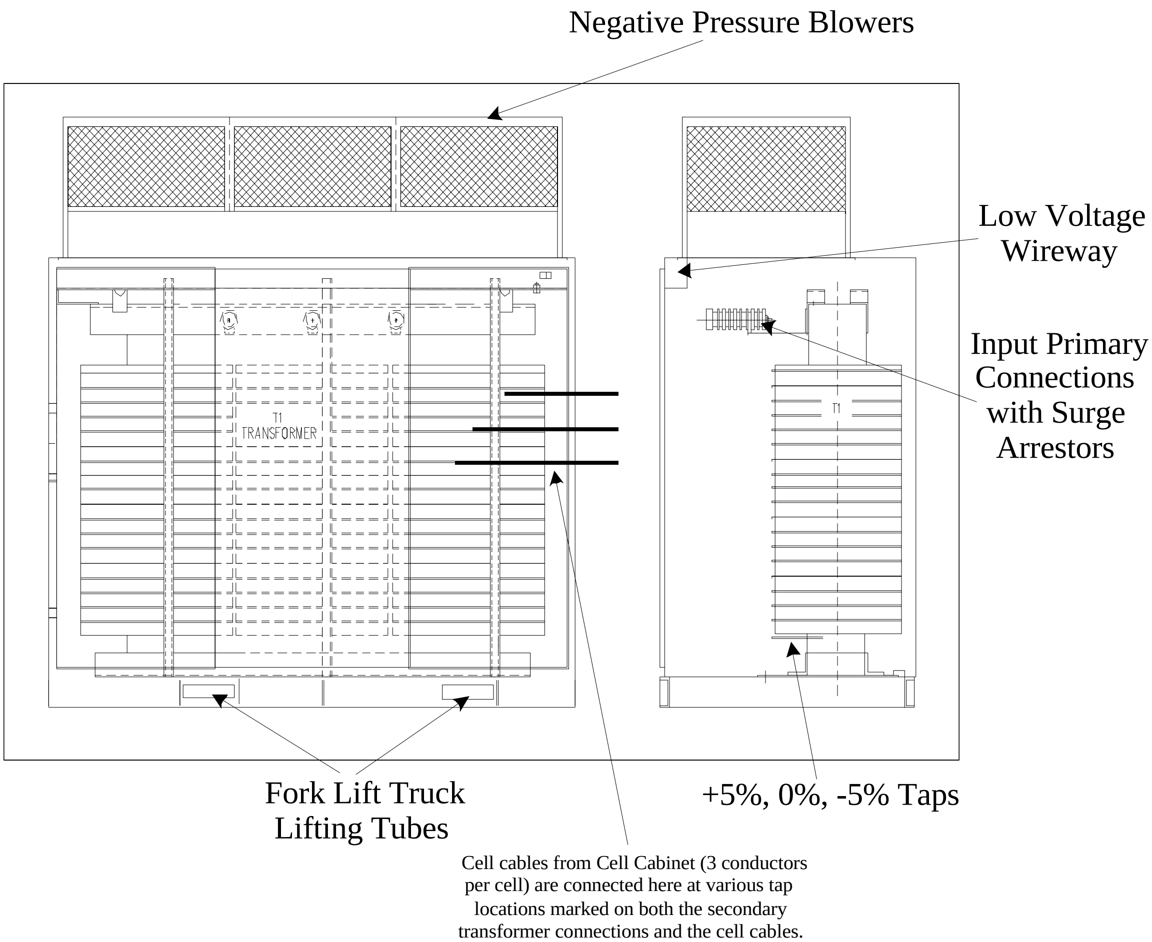

Figure 2-3. Typical Blower Cabinet /Transformer Cabinet (Front and Side)

2.1.4 Cell Cabinet(s)

The cell cabinet (shown in Figure 2-4) houses between 3 and 6 cells per output phase (possibly including a redundant cell option). The voltage of each output phase is the series sum of the horizontal cell voltages. Each cell can be disconnected and removed from the cabinet by disconnecting the 3-phase input power, the two output connections, the fiber optic cable and a retaining bolt. All cells are electrically and mechanically identical, so they may be interchanged. Each cell contains its own control boards which communicate with the system through an isolated link using fiber optic cables.

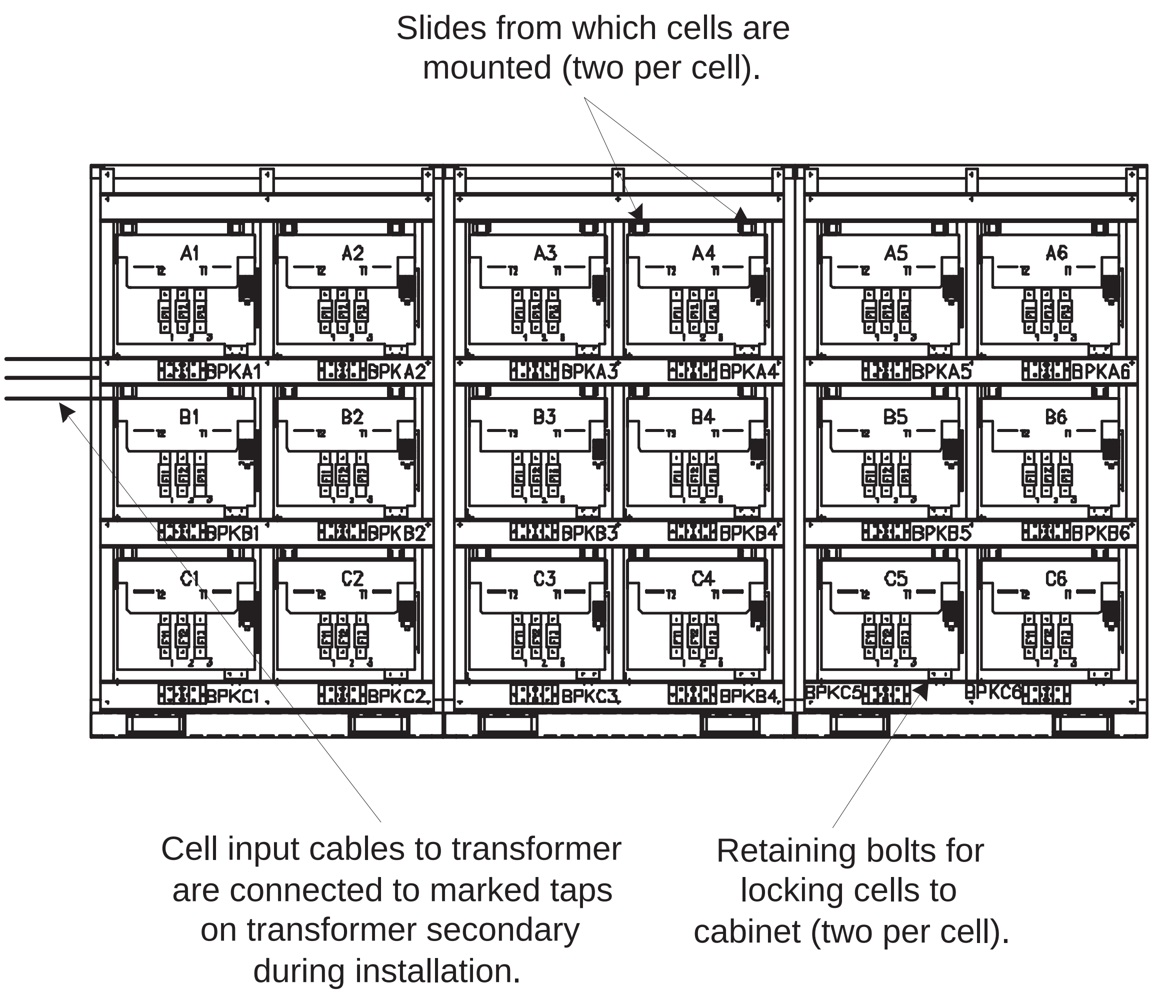

Figure 2-4. Typical Cell Cabinet (Front Views without Doors)

2.1.5 GEN II Cell Specifications

Siemens's Gen II Perfect Harmony AC drive system is offered in 3 basic 460 VAC and 3 basic 690VAC cell sizes (current ratings), grouped to provide output operating voltages of 2,400 VAC (three 460VAC cells in series), 3,300 VAC (four 460VAC cells in series), 4,160 VAC (five 460VAC cells in series), or 4,800 VAC (six 460VAC in series). Tables 2-1, 2-2, and 2-3 shown below provide the basic specifications associated with all 460VAC cell combinations.

The Perfect Harmony Gen II system is also available with three additional (690 VAC) cell sizes for higher voltage applications. These high voltage cells are grouped to provide operating voltages of 6,000 VAC (5 cells in a series–15 total) and 7,200 VAC (6 cells in a series–18 cells total). Refer to Tables 2-5 and 2-6 for 6,000 VAC and 7,200 VAC cell specifications.

Note: Output current ratings are a function of the selected cell size. Input current ratings are a function of the transformer size associated with each horsepower rating. Note that all specifications are subject to change without notice.

The individual output cells are located in the Cell Cabinet. All cells are electrically and mechanically identical, so that they may be interchanged. Each cell contains its own control boards which communicate with the system through a fiber optic link. This link is the only connection between the cells and the master control located in the Control Cabinet, thus each cell is fully isolated from the main control.

A switch mode power supply located on the Cell Control Board (refer to Figure 2-5) allows the control power to be derived from the individual 3-phase rectified secondary connections of the transformer. This power supply is fully operational between 380VDC and 800VDC (460VAC cells) and 530VDC and 1200VDC (690VAC cells).

The Control Cabinet contains PC boards which provide central control of the Harmony drive system. The Control Cabinet is physically and electrically isolated from all medium voltage for safety.

Control for each of the output cells is provided via a fiber optic communications link between the Master Control System and the Cell Control Board located within each output cell.

The tables below give length and weight information for many common configurations of the Perfect Harmony drives, based on 60 Hz input power at the voltages listed. These tables also include input and output currents, heat losses (in BTUs/hour), minimum ventilation requirements (in cubic feet per minute [CFM] and liters per second [lps]), and cell size information. Footnote information for all tables appears at the end of Table 2-5.

Note: If applications require a supply input frequency of 50 Hz or voltages above 5 kV, sizes and weights may increase.

Table 2-1. 2,400 VAC Cell Specifications: 9 Cells Total, 3 (460 VAC) Cells in Series

Hp[1]	Amps In[2]	Amps Out[3]	Losses[4]	Ventilation[5]	Length[6]	Weight[7]	Size[8]
1250	272	330	125,000	10,000 (4720)	210	11,400	4B
1750	381	440	180,000	10,000 (4720)	234	14,300	5C
2250	490	500	230,000	10,000 (4720)	234	17,200	5B

Table 2-2. 3,300 VAC Cell Specifications: 12 Cells Total, 4 (460 VAC) Cells in Series

Hp[1]	Amps In[2]	Amps Out[3]	Losses[4]	Ventilation[5]	Length[6]	Weight[7]	Size[8]
2000	317	330	200,000	10,000 (4720)	234	17,000	4B
2500	396	440	250,000	10,000 (4720)	270	18,000	5C
3000	476	500	300,000	10,000 (4720)	270	19,000	5B

Table 2-3. 4,160 VAC Cell Specifications: 15 Cells Total, 5 (460 VAC) Cells in Series

Hp[1]	Amps In[2]	Amps Out[3]	Losses[4]	Ventilation[5]	Length[6]	Weight[7]	Size[8]
2500	314	330	250,000	10,000 (4720)	270	19,200	4B
3000	377	440	300,000	10,000 (4720)	324	21,900	5C
3500	440	500	360,000	13,200 (6230)	324	24,500	5B

Table 2-4. 4,800 VAC Cell Specifications: 18 Cells Total, 6 (460 VAC) Cells in Series

Hp[1]	Amps In[2]	Amps Out[3]	Losses[4]	Ventilation[5]	Length[6]	Weight[7]	Size[8]
2500	272	330	250,000	10,000 (4720)	294	18,600	4B
3500	381	440	350,000	13,200 (6230)	348	24,500	5C
4000	436	500	400,000	13,200 (6230)	348	26,000	5B

Table 2-5. 6,000 VAC Cell Specifications: 15 Cells Total, 5 (690 VAC) Cells in Series

Hp[1]	Amps In[2]	Amps Out[3]	Losses[4]	Ventilation[5]	Length[6]	Weight[7]	Size[8]
2250	196	220	230,000	10,000 (4720)	258	22,000	3I
3000	261	300	300,000	10,000 (4720)	324	24,500	4I (300H)
4000	348	360	400,000	13,200 (6230)	324	28,500	360H

Table 2-6. 7,200 VAC Cell Specifications: 18 Cells Total, 6 (690 VAC) Cells in Series

Hp[1]	Amps In[2]	Amps Out[3]	Losses[4]	Ventilation[5]	Length[6]	Weight[7]	Size[8]
2500	198	220	230,000	10,000 (4720)	294	23,100	3I
3500	277	300	360,000	13,200 (6230)	348	28,500	4I (300H)
4000	317	360	400,000	13,200 (6230)	348	30,000	360H

[1] Motor nameplate hp may not exceed the drive rated hp.

[2] Drive rated input current (in Amps) is the transformer rated current.

[3] Drive rated output current (in Amps) is the maximum cell current.

[4] Losses are given in BTU/hr and are based on a loss of 3 kW per 100 hp.

[5] Minimum ventilation requirements are given in CFM (lps in parentheses)

[6] Represents lineup minimum length in inches (centimeters in parentheses), subject to change.

[7] Represents estimated minimum weight of lineup in pounds (kg in parentheses), subject to change.

[8] Cell sizes for each hp are based on motors with ≥ 95% efficiency and ≥ 85% power factor.

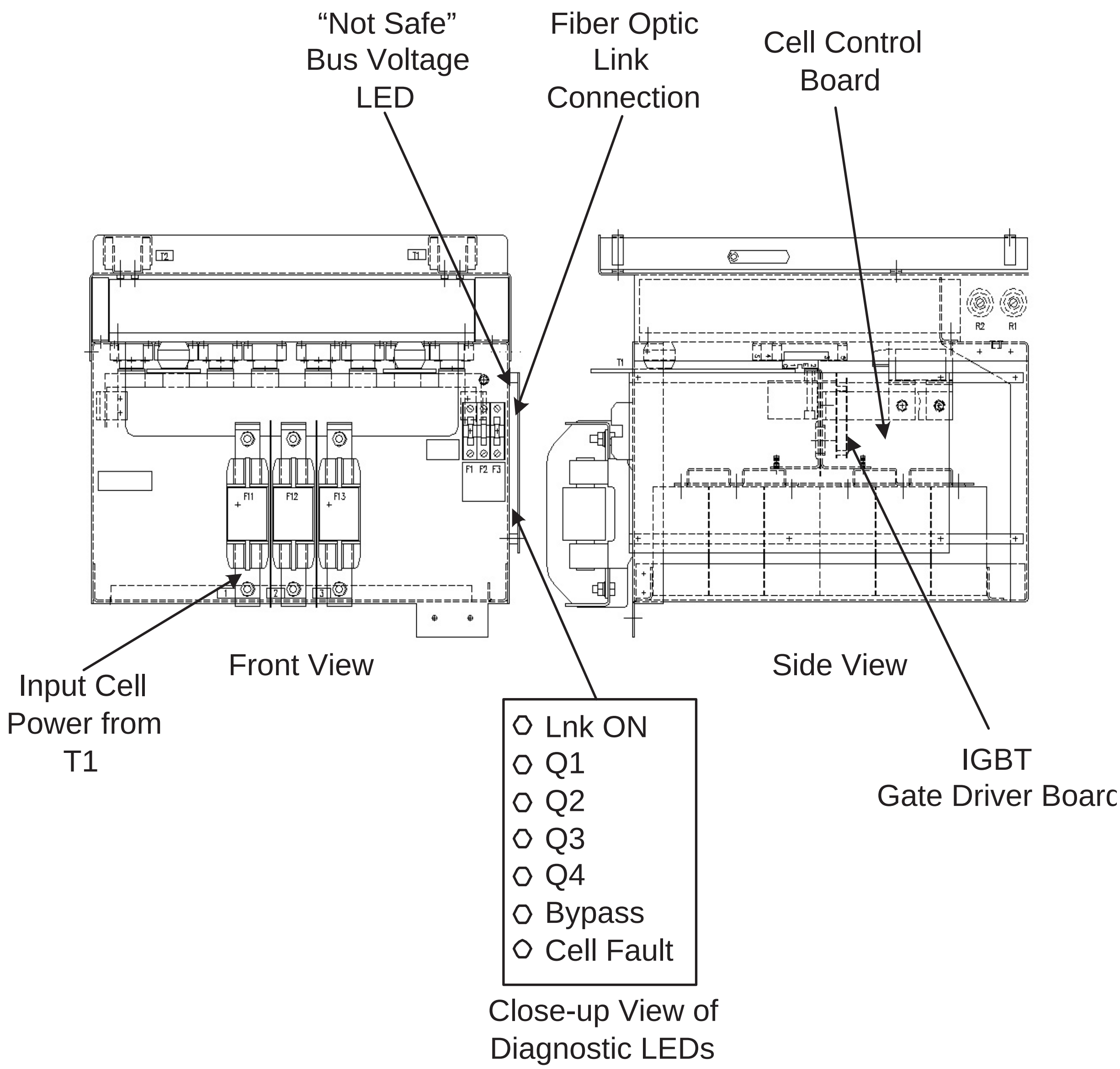

Figure 2-5. Typical Multiple-Cabinet Harmony Cell (Front, Side and Bottom Views)

Note: The Bus Voltage LED referenced in Figure 2-5 remains illuminated down to at least 50 VDC.

2.1.6 Output Power Cabinet/Control Cabinet

The output power cabinet contains the VFD output connections to the motor. The output power cabinet (and attached control cabinet) is illustrated in Figure 2-6. The control cabinet contains the control boards, optional input/output modules, and customer control connections.

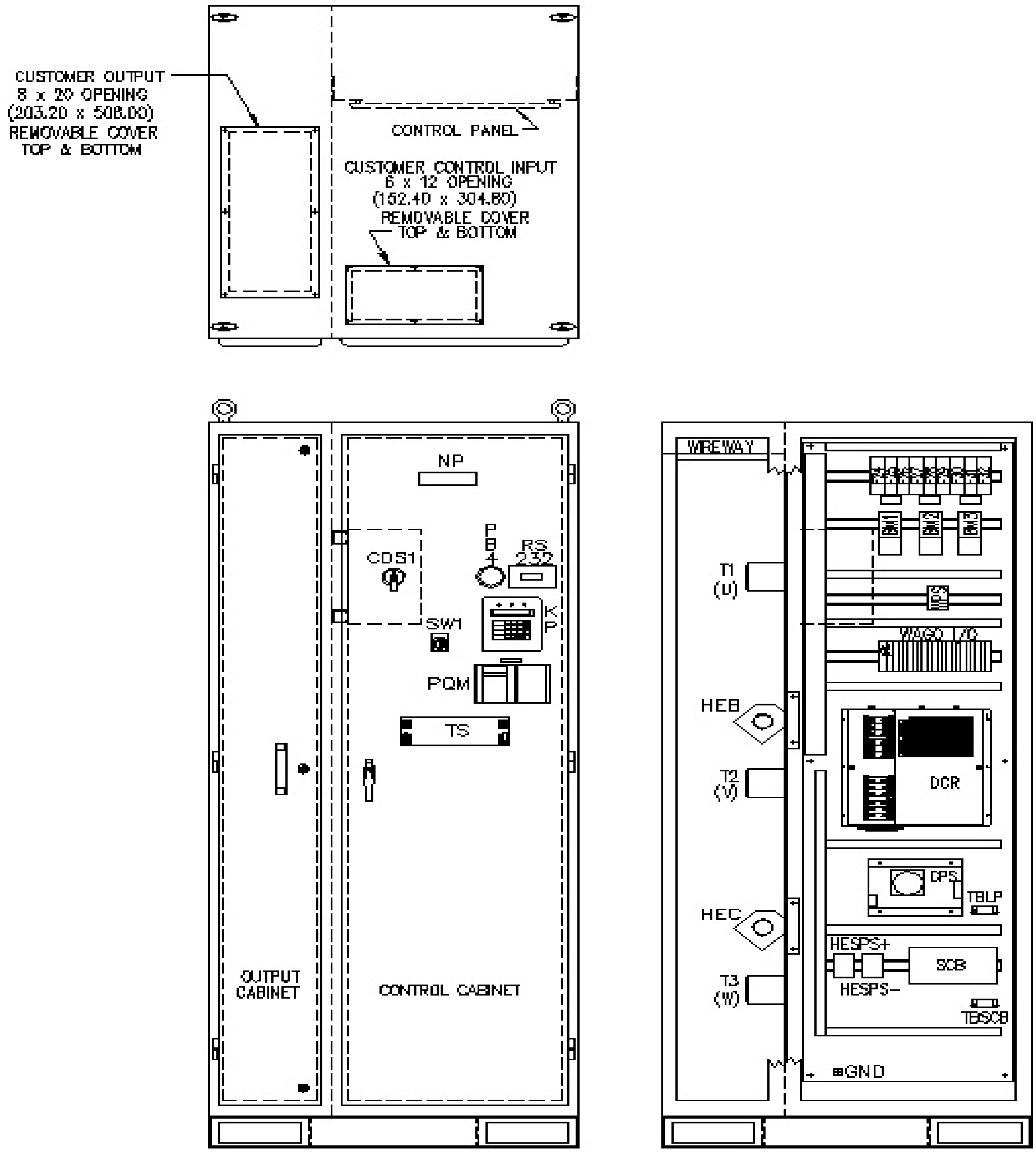

Figure 2-6. Typical Output Power and Control Cabinets (Top, Front, and Side Views)

2.2 GEN III Style Hardware Configuration

Figure 2-7 depicts a typical GEN III style configuration in which each VFD normally consists of a single cabinet with multiple sections. These sections, described below, are:

- the transformer section
- the customer I/O section
- the control section
- the cell section

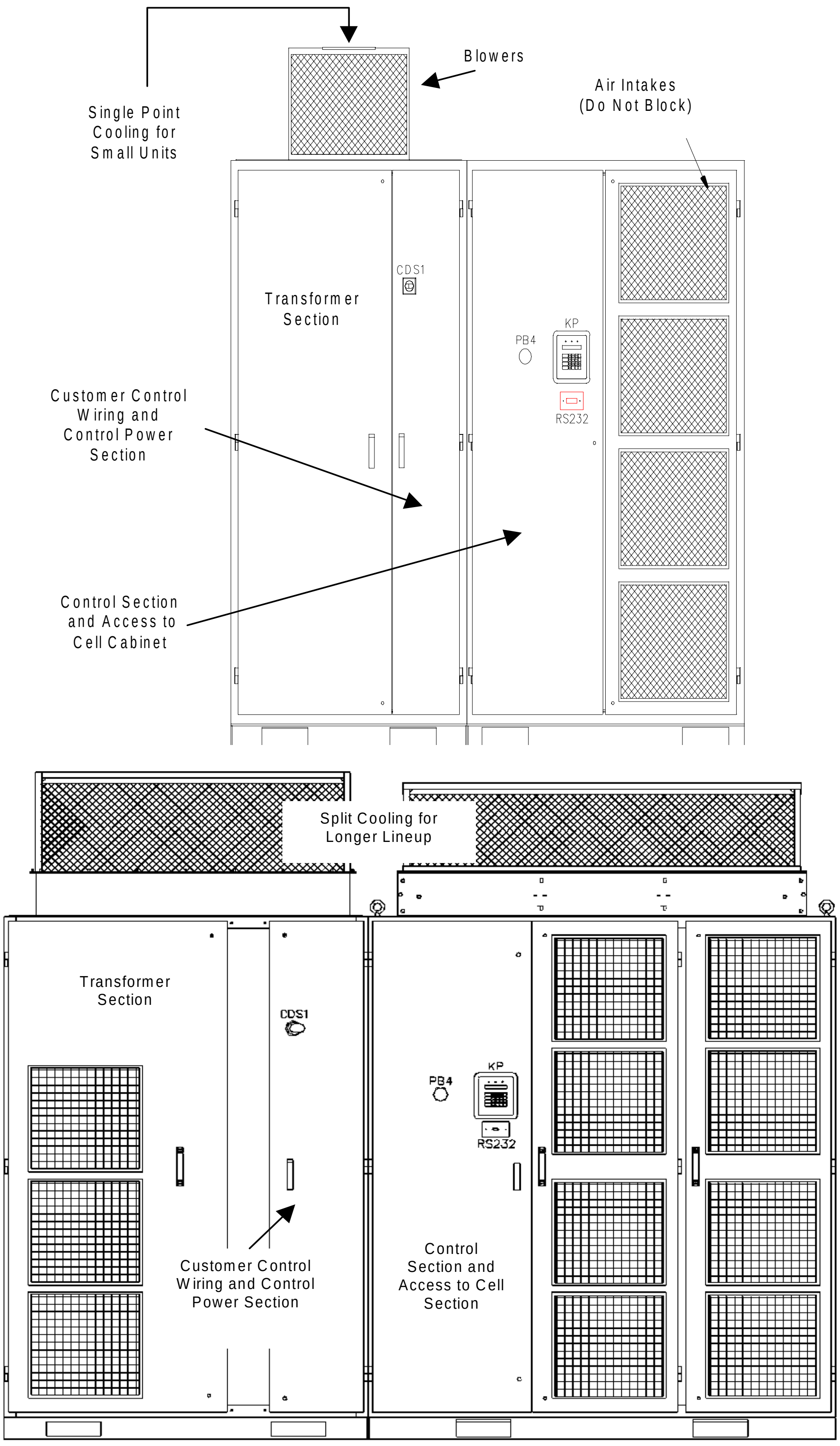

Figure 2-7. Typical GEN III-style VFDs

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2.2.1 Transformer Section

The transformer section of the GEN III-style Perfect Harmony drive contains the input power transformer. Input power wires enter the drive through this section and output wires to the motor exit the drive through this section. The input and output power wiring can enter and exit the drive from either the top or bottom of this section. In addition to the main multi-secondary phase-shifting power transformer, the transformer section contains either one or more blowers (at the top of the cabinet) used to cool the drive. Refer to Figure 2-8. Major components of the transformer section are illustrated in Figure 2-9 and described in Table 2-7.

Note: Input and output wiring enters the cabinet from the top or bottom of the transformer section.

Figure 2-8. Power Section (Typical) of a GEN III-style Perfect Harmony Drive

Table 2-7. Field Connections and Major Components in the Transformer Section

Item	Description
L1, L2, L3	Input power terminals
T1, T2, T3	Output power terminals
T1	Multi-secondary, phase-shifting power transformer
T5	Control power transformer
F24-F35	Control fuses
F21, F22	Blower fuses
F4, F5	Fuses
BM1-BM5	Blower motor starters
CDS1	Control power disconnect switch
RA1-RA4, RB1-RB4, RC1-RC4	Input and output voltage feedback resistors
CT4, CT5	Output current transformers
TB-120-CUS	Customer wiring terminal strip
METERING	Metering terminal strip
TB-ELV	Low voltage terminal strip (4-20 mA signals, etc.)

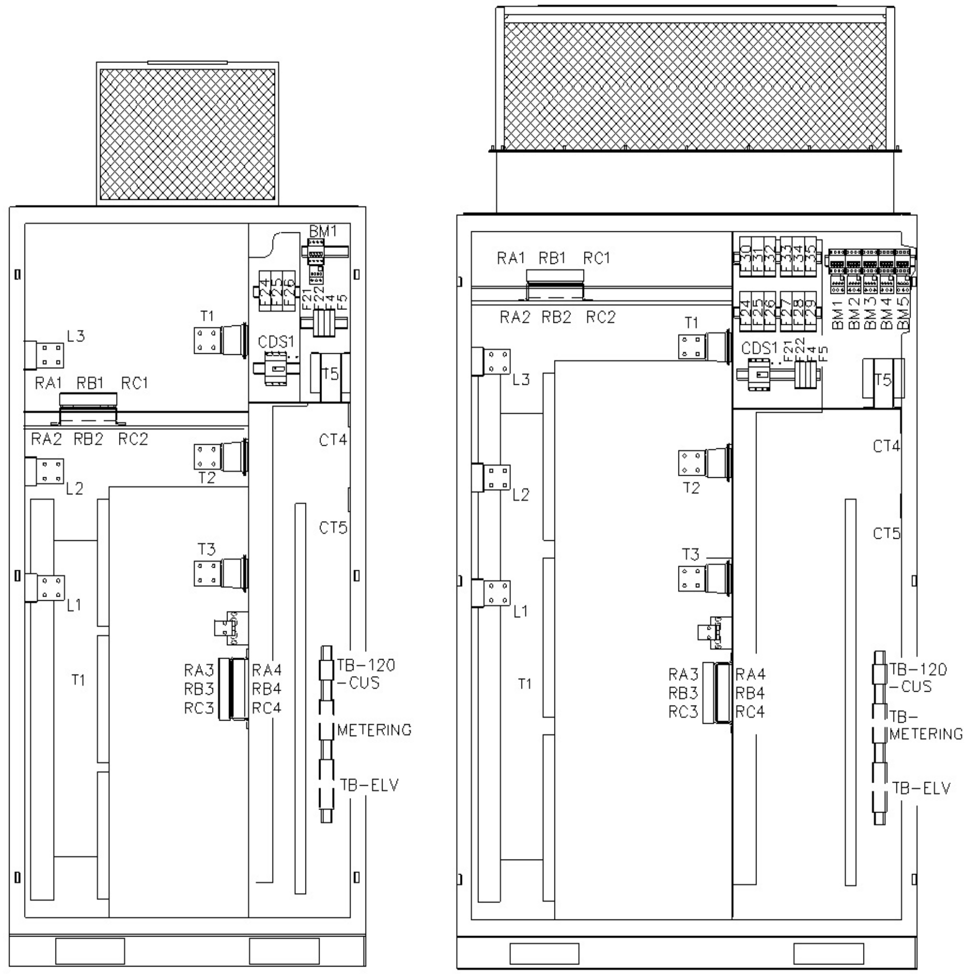

Figure 2-9. Field Connections and Major Components in the GEN III Transformer Section

2.2.2 Customer I/O Section

The customer I/O section of the GEN III-style Perfect Harmony drive contains terminal blocks for customer control wiring connections, control power connections, and the blower control panel. Optional motor monitors and power quality meters (PQMs) are mounted in this section if they are ordered with the drive. Refer to Figure 2-10.

Note: Refer to the “as built” system drawings that are shipped with the drive for information on specific customer I/C connections.

Figure 2-10. Customer I/O Section (Typical) of a GEN III-style Perfect Harmony Drive

2.2.3 Cell and Control Sections (GEN III Cell Specifications)

The control section is a hinged section that swings out to provide access to the cell section. The control section contains master control components. The cell contains power cells and up to three blowers mounted on top of the cabinet.

Siemens's GEN III AC drive system is offered in 5 basic cell sizes (current ratings), grouped to provide output operating voltages of 3300 VAC (3 cells in series), 4160 VAC (4 cells in series), 4800 VAC (5 cells in series), and 6600 VAC (6 cells in series). Table 2-8 provides the basic specifications associated with all cell combinations for GEN III Perfect Harmony drives.

> **Note:** Output current ratings are a function of the selected cell size. Input current ratings are a function of the transformer size associated with each hp rating. All specifications are subject to change without notice.

Table 2-8. Cell Specification Details

Output Cells Per Phase	Line-to-line Voltages (VAC)	Cells in Drive (Without Spares)	hp Range	Available Cell Sizes
3	3,300	9	up to 1500	70A, 100A, 140A, 200A, 260A
4	4,160	12	up to 2000	70A, 100A, 140A, 200A, 260A
6	6,600	18	up to 3000	70A, 100A, 140A, 200A, 260A

The individual output cells are located in the Cell Section. All cells are electrically and mechanically identical, so that they may be interchanged. Each cell contains its own control boards, which communicate with the system through a fiber optic link. This link is the only connection between the cells and the master control located in the Control Section, thus each cell is isolated from the main control. Refer to Figure 2-11.

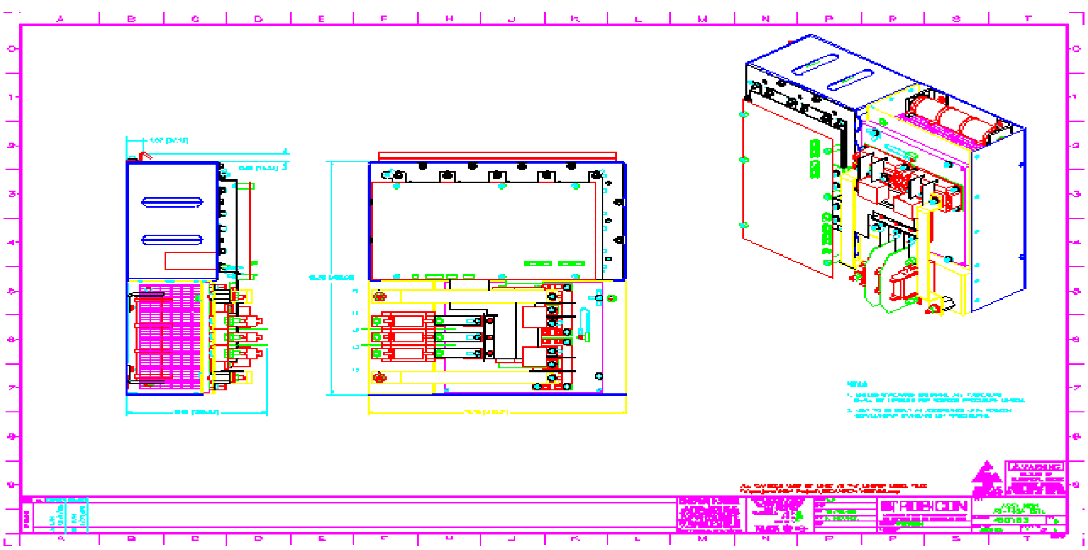

Figure 2-11. Typical GEN III Cell

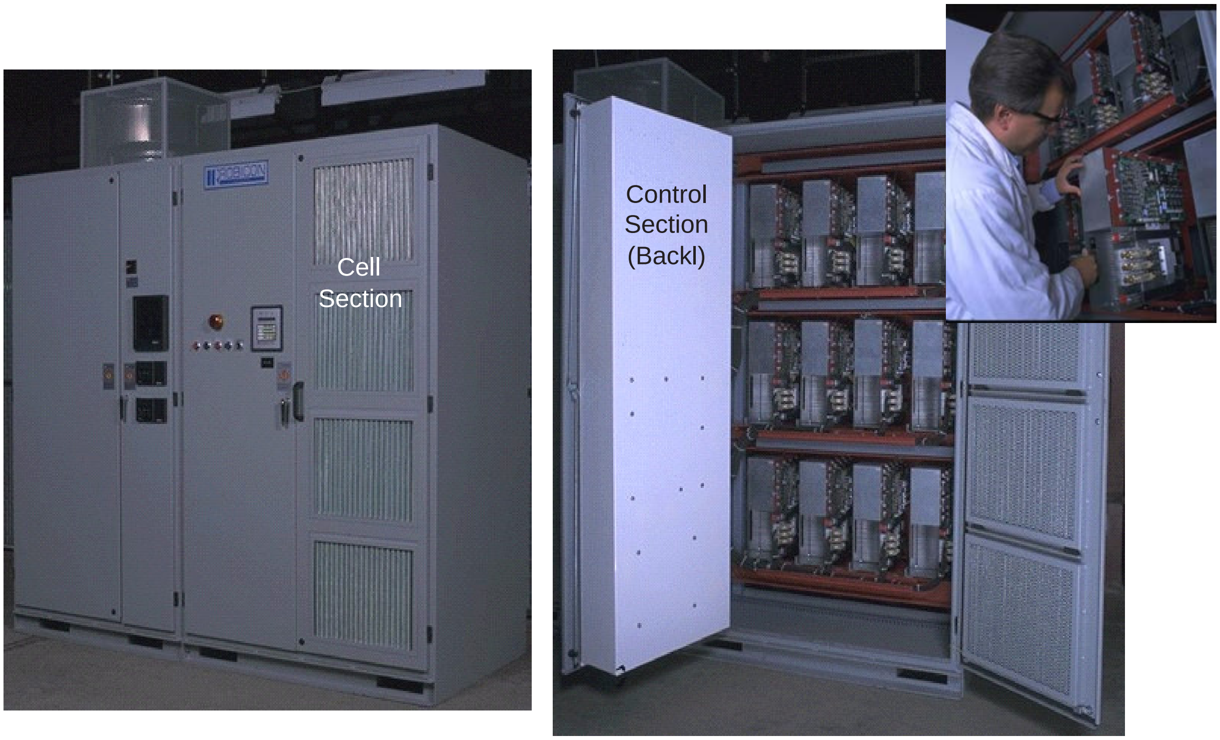

Figure 2-12. Cell Section (Typical) of a GEN III-style Perfect Harmony Drive

A switch mode power supply located on the Cell Control/Gate Driver Board allows the control power to be derived from the individual 3-phase secondary connections of the transformer.

The Control Section contains PC boards which provide central control of the Perfect Harmony drive system. The Control Section is physically and electrically isolated from all medium voltage for safety.

Control for each of the output cells is provided via a fiber optic communications link between the Master Control System and the Cell Control/Gate Driver Board located within each output cell.

The following tables give length and weight information for many common configurations of sectional Perfect Harmony drives, based on 60 Hz input power at the voltages listed. If applications require inputs at 50 Hz or horsepowers not listed, sizes and weights will increase.

> **Note:** The ventilation information (in CFM) and losses information (in BTUs) given in the following tables represent worst case conditions. Actual values may vary based on load, blower size, cell size and transformer size.

Table 2-9. 3,300 VAC Cell Specifications: 9 Cells Total, 3 (630 VAC) Cells in Series

Hp[1]	Amps In[2]	Amps Out[3]	Losses[4]	Ventilation[5]	Length[6]	Weight[7]	Size[8]
200	33	70	20,000	4,400	100	4,800	70
300	49	70	30,000	4,400	100	4,800	70
400	64	70	40,000	4,400	100	5,600	70
500	80	100	50,000	4,400	100	6,200	100
600	96	100	60,000	4,400	100	6,200	100
700	112	140	70,000	4,400	100	7,500	140
800	128	140	80,000	4,400	100	7,500	140
900	145	200	90,000	8,800	123	7,500	200
1000	162	200	100,000	8,800	123	8,000	200
1250	202	260	125,000	8,800	137	8,500	260
1500	242	260	150,000	8,800	137	9,000	260

Table 2-10. 4,160 VAC Cell Specifications: 12 Cells Total, 4 (630 VAC) Cells in Series

Hp[1]	Amps In[2]	Amps Out[3]	Losses[4]	Ventilation[5]	Length[6]	Weight[7]	Size[8]
300	38	70	30,000	4,400	100	5,100	70
400	51	70	40,000	4,400	100	5,100	70
500	63	70	50,000	4,400	100	5,800	70
600	75	100	60,000	4,400	100	6,600	100
700	89	100	70,000	4,400	100	6,600	100
800	101	140	80,000	4,400	100	7,700	140
900	114	140	90,000	4,400	100	7,700	140
1000	126	140	100,000	4,400	100	7,700	140
1250	160	200	125,000	8,800	137	9,500	200
1500	192	200	150,000	8,800	137	9,500	200
1750	224	260	175,000	8,800	137	10,000	260
2000	256	260	200,000	8,800	137	11,000	260

Table 2-11. 6,600 VAC Cell Specifications: 18 Cells Total, 6 (630 VAC) Cells in Series

Hp[1]	Amps In[2]	Amps Out[3]	Losses[4]	Ventilation[5]	Length[6]	Weight[7]	Size[8]
600	48	70	60,000	8,800	137	7,700	70
700	56	70	70,000	8,800	137	9,000	70
800	64	70	80,000	8,800	137	9,000	70
900	72	100	90,000	8,800	137	9,000	100
1000	80	100	100,000	8,800	137	10,400	100
1250	100	100	125,000	8,800	137	10,400	100
1500	120	140	150,000	8,800	137	12,300	140

Hp[1]	Amps In[2]	Amps Out[3]	Losses[4]	Ventilation[5]	Length[6]	Weight[7]	Size[8]
1750	140	140	175,000	8,800	137	12,300	140
1750	141	200	175,000	13,200	172	12,500	200
2000	162	200	200,000	13,200	192	13,000	200
2250	182	200	225,000	13,200	192	13,000	200
2500	202	260	250,000	13,200	192	13,500	260
2750	222	260	275,000	13,200	192	14,000	260
3000	242	260	300,000	13,200	192	14,000	260

[1] Motor nameplate hp may not exceed the drive rated hp.
[2] Drive rated input current (in Amps) is the transformer rated current.
[3] Drive rated output current (in Amps) is the maximum cell current.
[4] Losses are given in BTU/hr and are based on a loss of 3 kW per 100 hp.
[5] Minimum ventilation requirements are given in CFM (lps in parentheses)
[6] Represents lineup minimum length in inches (centimeters in parentheses), subject to change.
[7] Represents estimated minimum weight of lineup in pounds (kg in parentheses), subject to change.
[8] Cell sizes for each hp are based on motors with ≥ 95% efficiency and ≥ 85% power factor.

The basic electrical diagrams for all Perfect Harmony systems are similar. Depending on the operating voltages, different numbers of output cells are operated in series to develop the required output operating voltage (refer to the previous tables).

2.2.4 Cell Bypass Option

As an option, each cell in the system can be equipped with a bypass contactor. This contactor will be automatically energized by the VFD master control if the associated cell malfunctions. Once the contactor is energized, the damaged cell is no longer electrically part of the system, which allows the VFD to resume operation.

Anytime a cell malfunctions and is bypassed, the control automatically compensates (shifts the neutral point) so that the motor voltage stays balanced. To compensate for the loss in voltage, systems with up to 5 cells per phase can be equipped (as an option) with an extra cell per phase. The 3 spare cells would then compensate for the loss in voltage. If spare cells are not installed, then the VFD will operate at a slightly lower voltage, but will still provide full rated current.

The cell bypass system includes a bypass contactor per cell, a contactor control board (installed inside the cell cabinet) and a fiber optic link between the master control system and the contactor control board.

2.3 The Cell Control System

All Perfect Harmony cells are controlled in the same manner. The Cell Control/Gate Driver Boards reside within the output cell and accept all communication from the Digital Modulator in the Control Cabinet via fiber-optic links.

Control power for all cell boards is supplied from a switch mode power supply resident on the Cell Control/Gate Driver Board.

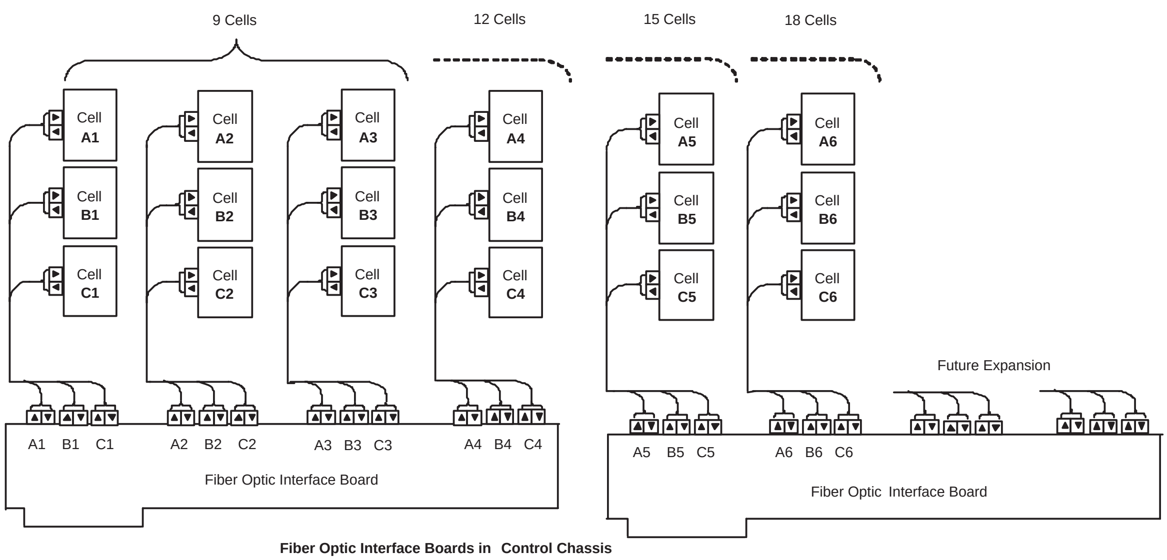

Figure 2-13. Typical Connection Diagram for an 18 Cell 6.6 KV System

2.4 The Master Control System

The Master Control located within the Control Cabinet consists of a chassis and several control boards refer to Figure 2-14. The chassis is supplied power by a stand alone power supply. The heart of the control is the Microprocessor board. This board is the master of the backplane bus and controls the operation of each board in the system.

Contained on the Microprocessor Board is Flash Disk, which may be removed from the Microprocessor Board if, for any reason, the microprocessor board would need to be replaced. The Flash Disk contains all the specific parameter information and system program for the VFD and therefore, allows the Microprocessor Board to be replaced without the need to re-program the VFD.

Note: If the Microprocessor Board is replaced, the Flash Disk should be moved to the new board. See Figure 2-15**.**

The System Interface board collects the drive input and output feedback signals and sends them to the Analog to Digital board. The Analog to Digital board executes the conversion at specified intervals and sends digital representations of the feedback signals to the Microprocessor board. The Microprocessor board then computes the next set of values to be sent to the Digital Modulator and sends them. The Digital Modulator then determines the switching commands for each cell and compiles a message with this command for each cell. These messages are then sent through the Fiber Optic Interface boards. Refer to Figure 2-14.

Note that the number of Fiber Optic Interface Boards and the number of fiber optic channels varies depending on the number of cells in the drive.

Also shown in Figure 2-14 is a communications board. This board provides a direct interface to a Modbus network and allows network adapter boards for several other industrial networks to be connected to the drive control. A typical schematic of the master control is shown in Figure 2-16**.**

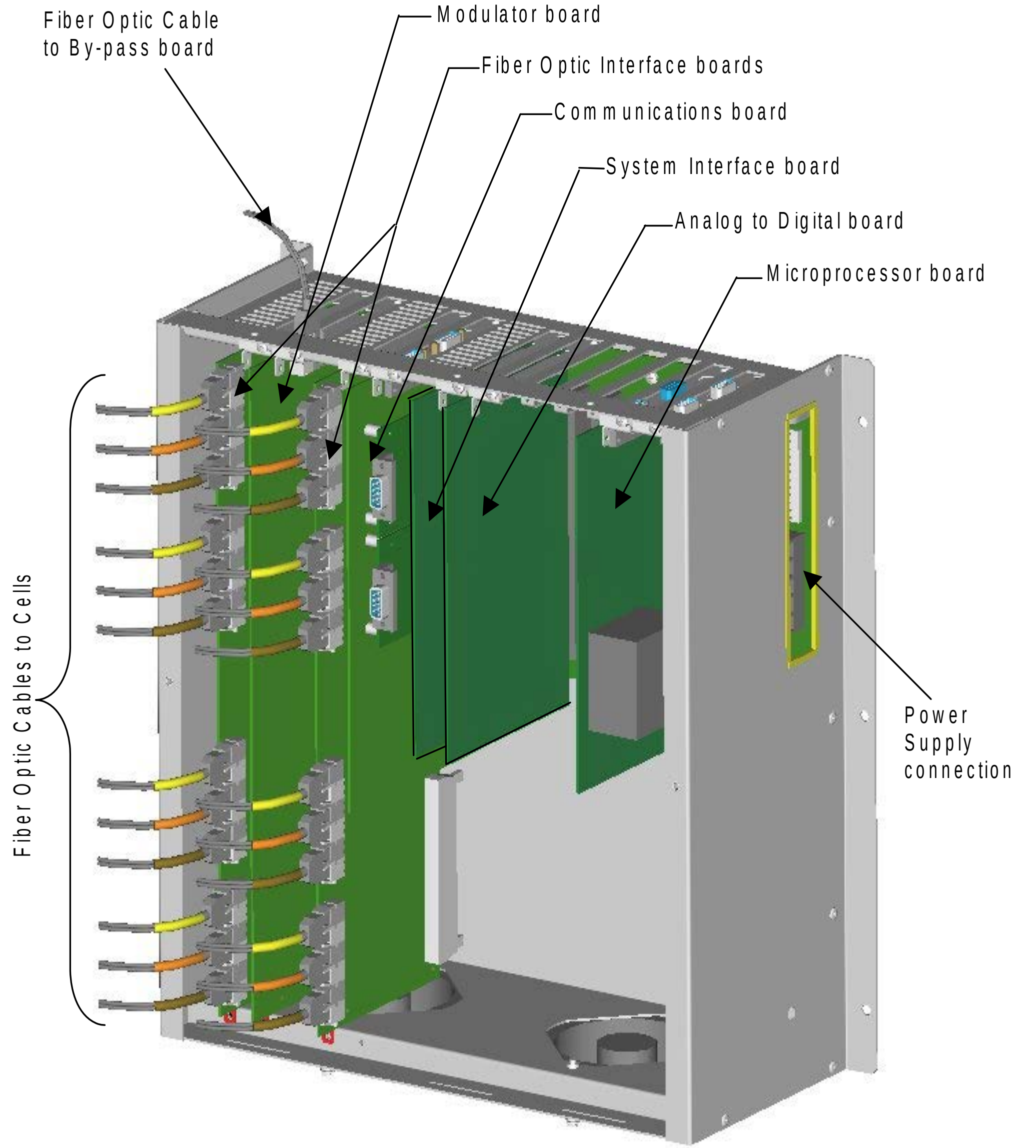

Figure 2-14. Master Control System

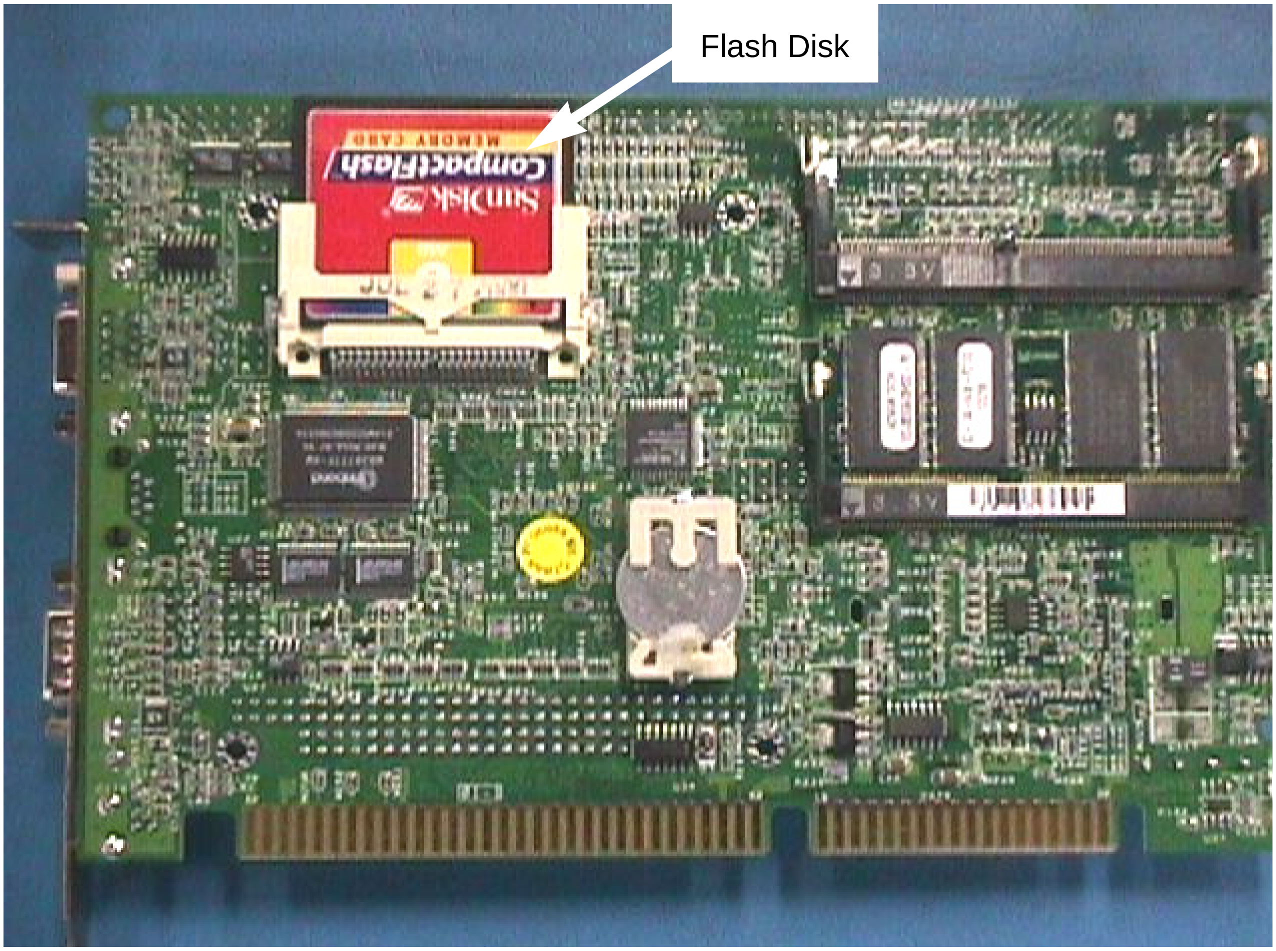

Figure 2-15. Location of Flash Disk on Microprocessor Board

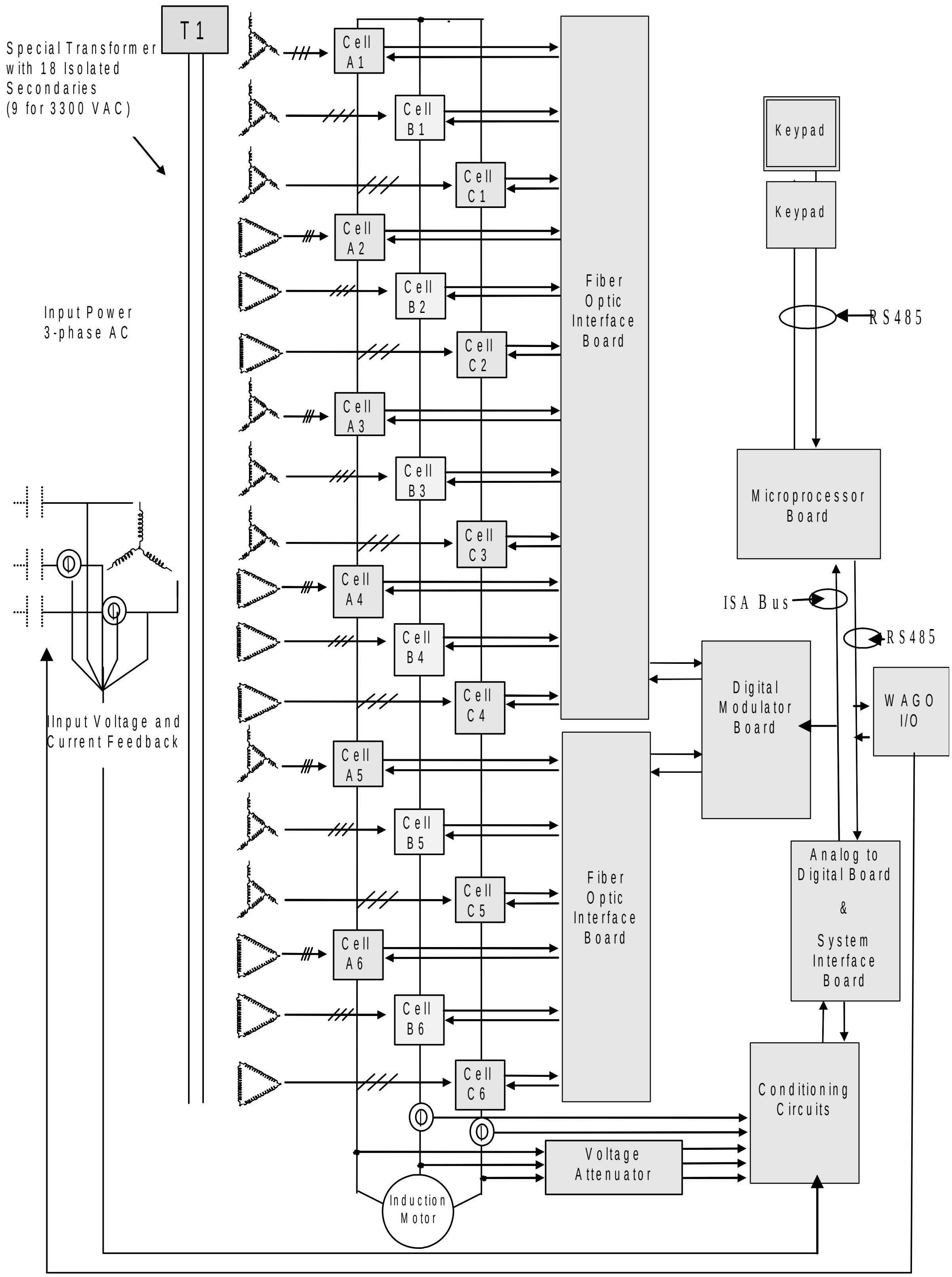

Figure 2-16. Typical Perfect Harmony Power Circuit

2.5 The Power Circuit

The basic power schematic for an 18 cell (4160 VAC) system is shown in Figure 2-16. Besides the direct operating information received from each cell by the Fiber Optic System, input voltage, output voltage, and current are also directly monitored. Input and output voltage information is supplied to the control boards by an attenuator system consisting of a voltage divider and voltage clamps.

Two Hall Effect sensors placed on output phases B and C sense output motor current. Two CTs placed on input phase B and C sense drive input current. Polarity and burden resistor values must always be maintained.

Each secondary of the power transformer T1 serves one cell only. Each cell receives modulation information through the Fiber Optic System in a way that develops the required output voltage and frequency demanded by the load. Unlike standard PWM systems, the voltage applied to the motor leads is developed in many small steps instead of through a few large steps. This provides two distinct advantages: the voltage stress on the motor insulation is dramatically reduced, and the quality of the motor currents is dramatically increased.

DANGER—Electrical Hazard! Even though each cell by itself develops no more than 690 VAC, the voltage to ground can increase to the rated drive output.

Since each cell is fed from transformer **T1** with varying degrees of phase shift (see Figure 2-16), the input VFD current distortion is dramatically reduced. Input power factor is always maintained greater than 0.94 lagging.

Each Perfect Harmony VFD cell within a specific system is identical (refer to Figure 2-17). Larger and smaller versions of power cells differ in the size or quantity of input diodes, filter capacitors and IGBTs.

At a minimum, each cell contains a Cell Control Board and an IGBT Gate Driver Board. The Cell Control Board performs all communication and control for each cell.

2

2.5.1 Monitoring of Input Power Quality

Input currents and voltages to the drive input T1 transformer are also measured and processed continuously by the control system. Information such as efficiency, power factor, and harmonics are available to the user through the tool suite, communication network, and some on the keypad. The input monitoring also protects against T1 transformer secondary side faults that cannot be seen by typical primary protection relaying. Thus it is very important that the drive input medium switchgear, if not supplied, is interlocked to the control system so that input medium voltage can be interrupted upon the rare event of such a fault.

A Form C 250VAC/300VDC rated contact output is supplied standard for liquid cooled drives only, to trip the drive input medium voltage circuit breaker or contactor. This contact is designated "TRIP INPUT MEDIUM VOLTAGE" and changes state whenever the drive input power and power factor are outside hardcoded normal operating conditions. This contact must be integrated with input switchgear to deactivate drive input medium voltage in the rare event of a T1 transformer secondary circuit fault.

DANGER! This contact must be integrated with input switch-gear to deactivate the drive input medium voltage upon the rare event of a secondary circuit fault.

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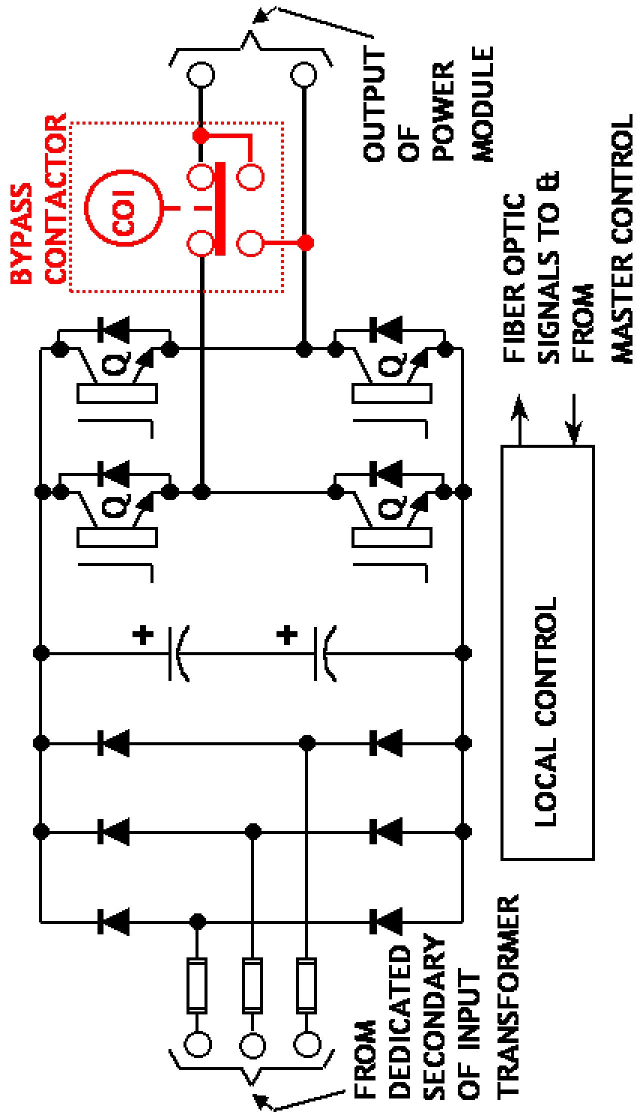

Figure 2-17. Typical Power Cell Schematic

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CHAPTER

3 The Keypad and Display Interface

3.1 Introduction

The menu system is the software program that allows operators to navigate through hierarchical structures (menus), which contain related menu items. Menu items include parameters, pick lists, functions and submenus ("nested" menus). These menu items allow the operator to configure a drive to his particular needs.

It is important to understand the mechanism through which the menu system operates. This mechanism is the front panel keypad and display interface. The display interface is a 24-by-2 character back-lit LCD. The keypad provides numerical keys for entering data and arrow keys for scrolling through the menu structure of the Perfect Harmony drive.

The keypad has built-in keys for fault reset, auto mode, manual start, and manual stop functions. Three diagnostic LEDs (power on, fault status, alarm status, and run) are built in to the standard keypad.

Normally, the keypad and display interface is mounted permanently to the drive. However, the keypad/display module need not be mounted for normal operation. With power removed, the keypad/display can be plugged in as an external module for set-up and diagnostic purposes only. Thus, one may use it to provide extra parameter security.

The Perfect Harmony system provides a fully programmable, multi-level security system that assures menu access and modification capabilities by only authorized personnel. A key lockout parameter, which can be set by a physical lockout key or by software in the SOP, can prevent any changes to the set parameters.

3.2 The Keypad

Warning! Do not remove or attach the keypad while the drive is powered.

The Perfect Harmony series contains a user-friendly keypad and display interface. This keypad/display interface is located on the front of the Perfect Harmony Drive Control Cabinet. The Keypad and Display Interface is illustrated in Figure 3-1.

The Keypad and Display Interface is used to access the control parameters and functions of the Perfect Harmony drive. Parameters are organized into logical groups using a menu structure. To view or edit parameters, the operator must maneuver through the menu structure to the desired parameters. This is accomplished using special key sequences. A summary of these key sequences is given later in this chapter.

The [SHIFT] key (which is used in conjunction with the 10 numeric keys and the [ENTER] key) is provided to access nine common system menus, a help display function and a [CANCEL] key. The keypad is used to navigate through the menu system, activate control functions, reset the system after faults have occurred, edit parameter values, enter security access codes, and place the system in either automatic, manual or stop (auto/hand/off) mode.

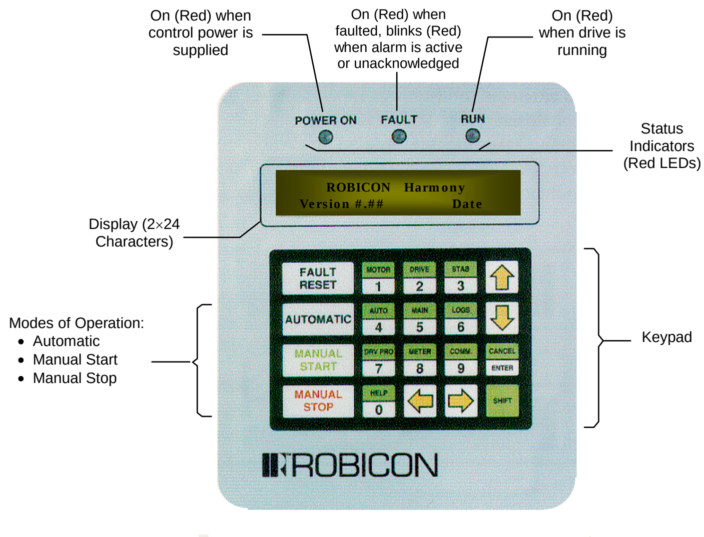

Figure 3-1. The Keypad and Display Interface of the Perfect Harmony Series

> **Note:** Parameter values are stored in a Flash Disk - a non-volatile memory area. When a parameter value is changed, the new value is saved internally. Even after a power failure, the value remains intact and can be recalled.

The Perfect Harmony keypad contains 20 keys. Each of these keys has at least one function associated with it. Some keys are used for 2 or more functions. The following sections give descriptions and uses for each of the keys on the keypad, as well as the diagnostic LEDs and the built-in display.

3.2.1 Fault Reset Key and LED Indicator

The FAULT RESET key is located in the top left corner of the keypad and has two built-in functions. Function one is to clear fault conditions that may occur in the Perfect Harmony system. Function two is to acknowledge alarm conditions that may occur in the Perfect Harmony system. Faults refer to fatal errors that have been detected by both the hardware and software and prevent the drive from running. Alarms refer to nonfatal errors that have been detected by both the hardware and software and, as such, do not prevent the drive from running. However, alarm conditions that are ignored may ultimately lead to a fatal fault. The current alarm/fault status of the drive is displayed by the Fault indicator LED located above the keypad and display (refer to Figure 3-1).

The Fault LED can be flashing, on continuously, or off.

A flashing LED means that an alarm is either active or unacknowledged. An LED that is on continuously means that a fault condition exists. Table 3-1 details all of the LED conditions.

Table 3-1. Fault LED Conditions

Fault LED Condition	Display	Fault Condition	Alarm Condition	Alarm Acknowledged or Fault Reset?
Flashing	Toggles between alarm name and normal display.	N/A	Active	No
Flashing*	Toggles between alarm name and normal display.	N/A	Cleared	No
Flashing	None	N/A	Active	Yes
Flashing	Toggling between alarm name, normal display, next alarm, normal display, etc.	N/A	Multiple Active Alarms	No
On Continuously	Fault name	Active	N/A	No
On Continuously	Fault name with in display**	Multiple Faults	N/A	No

*After an alarm condition is resolved, the Fault LED will continue to flash until you acknowledge the alarm by pressing the [FAULT RESET] key.

**Use the down and up arrow keys to cycle through the active fault list.

Note: If an alarm condition occurs before or during a fault condition, the LED and display will not indicate the presence of an alarm until the fault condition is cleared and reset. The alarm conditions are recorded in the Alarm/Fault Log.

When a fault condition occurs, the fault indicator glows red continuously. To reset the system:

1. Determine the cause of the fault (see the display or check the Alarm/Fault Log).
2. Correct conditions that may have caused the fault, if appropriate.
3. Reset the system by pressing the [FAULT RESET] key on the keypad.

When there are no fault conditions and an alarm condition occurs, the fault indicator flashes red. To acknowledge the alarm conditions:

1. Determine the cause of the alarm (see the display or check the Alarm/Fault Log).
2. Correct conditions that may have caused the alarm, if appropriate.
3. Acknowledge the alarm by pressing the [FAULT RESET] key on the keypad. Acknowledging an alarm will cause all alarms to be no longer displayed on the keypad display. However, if any alarm condition still exists, the Fault LED will flash red
4. If there are both faults and alarms, press the [FAULT RESET] key twice to first reset the fault and then acknowledge the alarms.

3.2.2 Automatic Key

The [AUTOMATIC] key is a programmable key located below the [FAULT RESET] key on the keypad and can be used via the SOP, to put the Perfect Harmony drive into automatic mode. In automatic mode, the standard speed setting for the drive is obtained from the 4-20 mA input and through speed profile parameters located in the Speed Profile Menu (4000).

> **Note:** Automatic mode can be customized to suit particular application needs by modifying the appropriate I/O parameters from the keypad and display interface. Modification of the standard system program of the Perfect Harmony is also a viable option, although it requires an understanding of the system program format, the compilation process and downloading techniques.

3.2.3 Manual Stop Key

The [MANUAL STOP] key is a programmable key which can be used, via the SOP, to place the Perfect Harmony into stop mode. Stop mode shuts down the drive in a controlled manner, regardless of its current state (manual, remote or automatic).

> **Note:** Modification of the standard system program of the Perfect Harmony requires an understanding of the system program format, the compilation process and downloading techniques.

3.2.4 Manual Start Key

The [MANUAL START] key is a programmable key located below the [AUTOMATIC] key on the left side of the keypad. [ANUAL START] can be used via the SOP, to put the Perfect Harmony system into manual control mode.

There are two varieties of control mode: local and remote. These varieties are distinguished by the sources of the velocity demand. The sources of velocity demand as well as operation of the drive via the various customer interfaces, are completely configurable through the SOP (or system program). Details of programming the SOP are covered in Chapter 8. An example, which will be referred to in the remainder of the chapter, is illustrated in Figure 3-2.

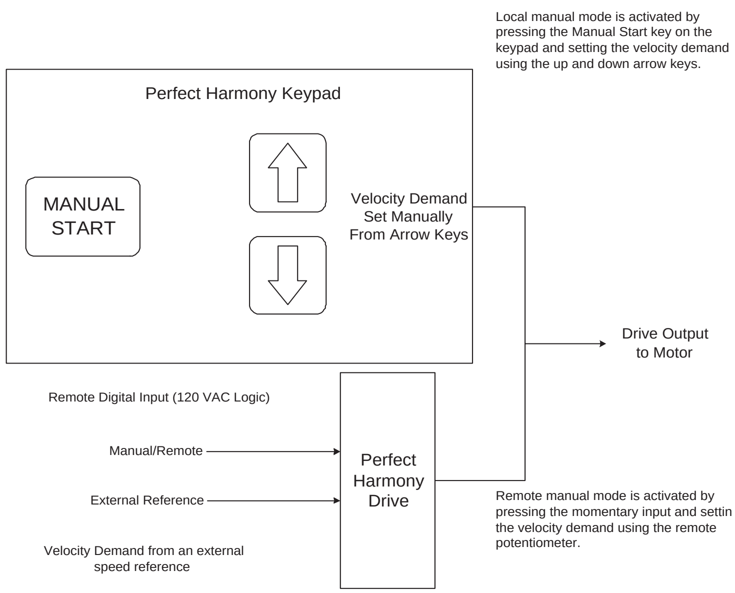

Figure 3-2. Example of two Programmed Control Modes

3.2.5 The 0-9 Key

Numeric keys are centrally located on the keypad of the Perfect Harmony system. These 10 keys (labeled 0 through 9) provide the following functions:

- Entry of security access codes.
- *Speed menu* (direct access to 10 basic menus according to assigned menu names [in green text above each numeric key]).

- Direct access to all menus, submenus, and parameters and pick lists (with proper security) based on ID number.
- Ability to change the values of parameters.

One function of the numeric keys of the Perfect Harmony keypad is to enter a 4-digit security access code. The security code consists of any combination of digits 0 through 9 and hexadecimal digits “A” through “F”.

Note: *Hexadecimal* (or hex) is a method of representing numbers using base 16 (digits 0-9, A, B, C, D, E and F) rather than the more common base 10 (digits 0-9). Hex digits “A” through “F” can be entered from the keypad by pressing the [SHIFT] key followed by the numbers [1] through [6], respectively. The keystrokes required to enter hex values “A” through “F” are listed in Table 3-2. Decimal equivalents are also listed.

Another function of the numeric keys is the *speed menu* feature. Speed menu allows the operator to access 10 common menus within the system using the pre-programmed numeric keys. Each of the numeric keys has an associated menu name printed in green (on top of each numeric key). To access one of these 10 menus, the operator uses the [SHIFT] key followed by the appropriate numeric key (e.g., [SHIFT]+[1] to access the Motor menu, [SHIFT]+[2] to access the Drive menu, etc.). Refer to Figure 3-3.

Table 3-2. Hexadecimal Digit Assignments on the Perfect Harmony Keypad

Key Combination	Hex Value	Decimal Equivalent
SHIFT + MOTOR 1	A	10
SHIFT + DRIVE 2	B	11
SHIFT + STAB 3	C	12
SHIFT + AUTO 4	D	13
SHIFT + MAIN 5	E	14
SHIFT + LOGS 6	F	15

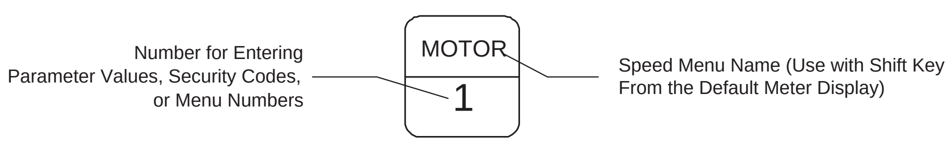

Figure 3-3. Anatomy of a Numeric Keypad Key

In addition to the speed menu feature, a second menu access feature is available for all remaining menus in the Perfect Harmony system. The speed menu feature is available only from the main meter display on the LCD. The hexadecimal entry feature is available only during security code entry. Therefore, the results of [SHIFT]+[1] through [SHIFT]+[6] key combinations depends on the context in which they are used. This second access feature cannot only be used on menus, but can also be used to go directly to a particular parameter, or pick list. While this second method requires more keystrokes to access target menus, parameters or pick lists, the operator can gain access to *all* security approved items rather than just the 10 most common menus. Accessing items in this manner requires that the operator know the item ID number. This item number will be a four-digit number. This number is listed on the display each time the item is displayed and is also listed in the menu reference charts later in this chapter. To access an item using its ID number, press the [SHIFT] key followed by the right arrow key [⇨]. The display prompts the operator for the desired ID number. Using the numeric keys on the keypad, the operator enters the desired ID number then presses the [ENTER] key. If the number was a valid ID number, and the current security level permits access to that item, then the desired item will be displayed. Refer to Figure 3-4.

Note: Any menu, parameter, or pick list can be accessed by ID. To do this press [SHIFT]+ [⇨]. The display will read “Enter Param ID:”. Simply enter the ID number of the item you want to go to and hit [ENTER].

The menu, parameter and pick list ID can be found in the menu tables later in this chapter or is listed on the display in () when the item is displayed.

If the operator requests access to a menu number that is assigned a higher security level than the current security level, the drive will prompt the operator for the appropriate security level code.

3

Finally, the numeric keys on the keypad can also be used to change the value of system parameters. Once a parameter is selected for modification, the leftmost digit of the parameter value is underlined and is called the *active* digit. Pressing a numeric key can change the active digit. This method automatically advances the underline to the next digit to the right. The operator continues pressing numeric keys until the desired value is displayed. The [ENTER] key is used to accept the new value.

Note: When editing parameter values, be sure to pad significant digit fields with zeroes where appropriate. For example, to change the value of a 4-digit parameter from 1234 to 975, the operator must enter 0975.

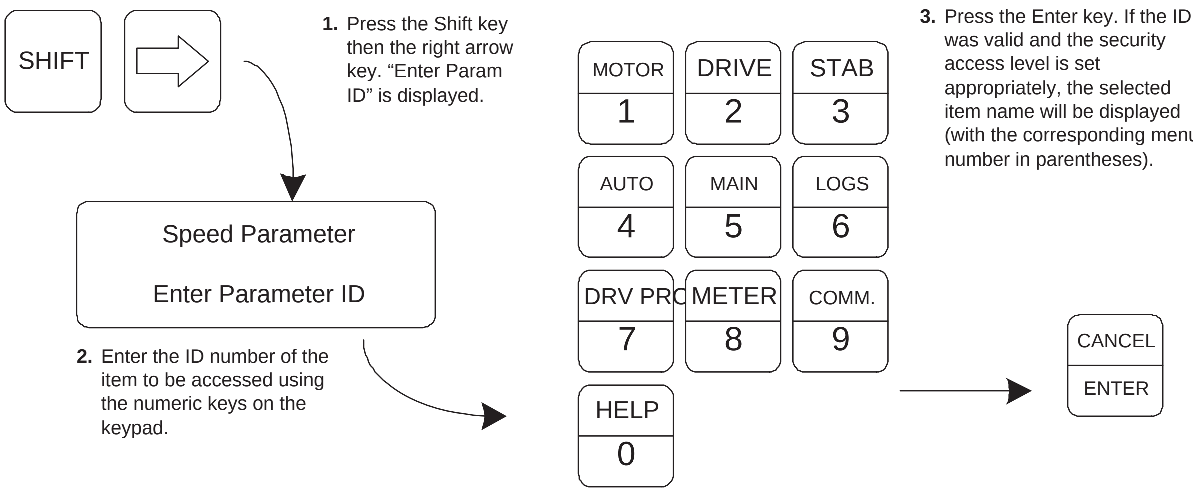

Figure 3-4. Accessing Items Using ID Numbers

Note: In the case of signed parameters (parameter values that can be either positive or negative), the first active digit is actually the sign of the value. The sign is changed by using the up and down arrow keys when the leftmost (sign) position of the value is underlined (i.e., it is the active “digit”). Either a “+” or “-” will be displayed during the editing process. After the new value is accepted (using the [ENTER] key), positive values are displayed without the “+” sign. Negative values always show the “-” sign unless the negative signs is implied in the parameter name itself.

3.2.6 The Enter/Cancel Key

The [ENTER] key is located below the up and down arrow keys on the right side of the keypad. This key is similar to the Return or Enter key on a standard PC keyboard. It is used to choose/accept a selection or confirm an operation. For example, after locating and displaying a parameter within the Perfect Harmony menu structure, the operator may use the [ENTER] key to edit the parameter’s value. Common functions of the [ENTER] key include:

- Selecting a submenu.
- Enter edit mode for a selected parameter value.
- Accept a new parameter value after editing.

By using the [SHIFT] key, the [ENTER] key can be used as a cancel function. The [CANCEL] function is used to abort the current operation or return to the previous menu display. Common functions of the [CANCEL] key include:

- Returning out of the menu system.
- Rejecting any modifications to a parameter value in edit mode.

3.2.7 Shift Function Keys

The [SHIFT] key is located in the bottom right corner of the keypad on the Perfect Harmony system. This key is used to access a second set of functions using existing keys on the keypad. Keypad keys that can be used with the [SHIFT] key have two labels (one on top and one on the bottom of the key). The standard (un-shifted) function of the key is listed on the bottom half of the key and has a white background. The shifted function of the key is shown on the top of the key and has a green background (matching the green background of the [SHIFT] key to identify that they are used together).

When the Perfect Harmony prompts the operator for a numerical value (e.g., during entry of the security access code, parameter modification, etc.), the [SHIFT] function of numerical keys 1 through 6 changes from quick menus to hexadecimal numbers “A” through “F” respectively. Refer to Table 3-2 for more information.

Note: It is not necessary to simultaneously press the [SHIFT] key and the desired function key. The operator must press the [SHIFT] key first, release it, and then press the desired function key. When the [SHIFT] key is pressed, the word “SHIFT” appears in the lower right corner of the interface display (indicating that the Perfect Harmony is waiting for the second key to be pressed). After a key is pressed, the word SHIFT is removed from the LCD. Refer to Figure 3-5.

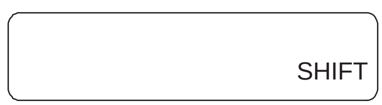

Figure 3-5. Location of Shift Mode Indicator on the Perfect Harmony Display

Common functions of the [SHIFT] key include:

- Entering “speed menus” ([SHIFT] plus appropriate “speed menu” key from main meter display).
- Using the [CANCEL] function ([SHIFT] + [ENTER] sequence).
- Entering hex values “A” through “F” ([SHIFT] + [1] through [SHIFT] + [6] when editing values or entering security code).
- Accessing menus, parameters or pick lists based on ID numbers ([SHIFT] + [⇨]).
- Returning to the top of the current menu/submenu ([SHIFT] + [⇧]).
- Going to the bottom of the menu or submenu ([SHIFT] + [⇩]).
- Resetting the current security level to 0 ([SHIFT] + [⇦] + [SHIFT] + [⇦] + [SHIFT] + [⇦] from the main meter display).
- Setting a parameter value back to its factory default ([SHIFT] + [⇦]).

A summary of [SHIFT] key sequences is listed in Table 3-3.

3.2.8 Arrow Keys

There are four yellow arrow keys on the Perfect Harmony keypad. The up and down arrow keys ([⇧] and [⇩]) are located in the upper right corner of the keypad. The left and right arrow keys ([⇦] and [⇨]) are located on the lower row of the keypad. Common uses of the arrow keys include:

- Navigating through the menu structure
- Scrolling through lists of parameters
- Incrementing/decrementing parameter values (when in edit mode)
- Manually advancing to the next digit (when in edit mode)
- Increasing (up arrow [⇧]) and decreasing (down arrow [⇩]) the desired velocity demand of the drive (when in local manual mode)
- Clearing security level (press [SHIFT] + [⇦] 3 times from the default meter display)
- Entering menu access mode ([SHIFT] + [⇨]).

The left and right arrow keys ([⇦] and [⇨]) can be used to navigate through the menu structure of the Perfect Harmony system. In general, the right arrow [⇨] is used to penetrate deeper into the menu structure and the left arrow [⇦] is used to back out of the menu structure. For example, from the main display, the operator can press the right arrow key [⇨] to access the Main menu.

The up and down arrow keys ([⇧] and [⇩]) can be used to scroll through lists of items. For example, after using the right arrow key [⇨] to reach the Main menu, the operator may select the down arrow key [⇩] to scroll through the list of options within the Main menu. These options may be parameters, pick lists, or submenus. Refer to the next section for information about the structure of the menu system.

The up and down arrows ([⇧] and [⇩]) can be used to increment or decrement the desired velocity demand when the system is in local manual mode (refer to 3.2.4). As the up and down arrow keys are pressed, the changes in desired velocity demand can be viewed from the main display on the LCD. Refer to Figure 3-6.

☝ **Note:** The velocity demand field (DEMD) on the front panel display is assigned by default. This display assignment (and the other three) can be changed from the menu system.

3

Table 3-3. Summary of Common [SHIFT] Key Sequences

Key Combination	Description
SHIFT + MOTOR 1	Speed menu to the Motor menu (from the default meter display) Enters hexadecimal "A" (from value edit and security prompts)
SHIFT + DRIVE 2	Speed menu to the Drive menu (from the default meter display) Enters hexadecimal "B" (from value edit and security prompts)
SHIFT + STAB 3	Speed menu to the Stability menu (from the default meter display) Enters hexadecimal "C" (from value edit and security prompts)
SHIFT + AUTO 4	Speed menu to the Auto menu (from the default meter display) Enters hexadecimal "D" (from value edit and security prompts)
SHIFT + MAIN 5	Speed menu to the Main menu (from the default meter display) Enters hexadecimal "E" (from value edit and security prompts)
SHIFT + LOGS 6	Speed menu to the Logs menu (from the default meter display) Enters hexadecimal "F" (from value edit and security prompts)
SHIFT + DRV PR(7	Speed menu to the Drive Protect menu (from the default meter display)
SHIFT + METER 8	Speed menu to the Meter menu (from the default meter display)
SHIFT + COMM. 9	Speed menu to the Communications menu (from the default meter display)

Key Combination	Description
SHIFT HELP/0	Speed menu to a context sensitive Help menu (from anywhere except the default meter display)
SHIFT CANCEL/ENTER	Cancels/aborts the current action/keystroke or exits menu system
SHIFT ⇨	Enters “numerical menu access mode”. The operator is then prompted to enter the 1, 2 or 3 digit number for the associated menu.
SHIFT ⇧	Returns to the top of the current menu or submenu.
SHIFT ⇦ SHIFT ⇦ SHIFT ⇦	Restores the security level back to 0. The [SHIFT] + [⇦] key sequence must be entered three times in succession from the default meter display to restore the security level back to 0.
SHIFT ⇩	Going to the bottom of the menu or submenu.
SHIFT ⇦	When editing a value that has been changed from its factory default, this key sequence will return the value to its factory default.

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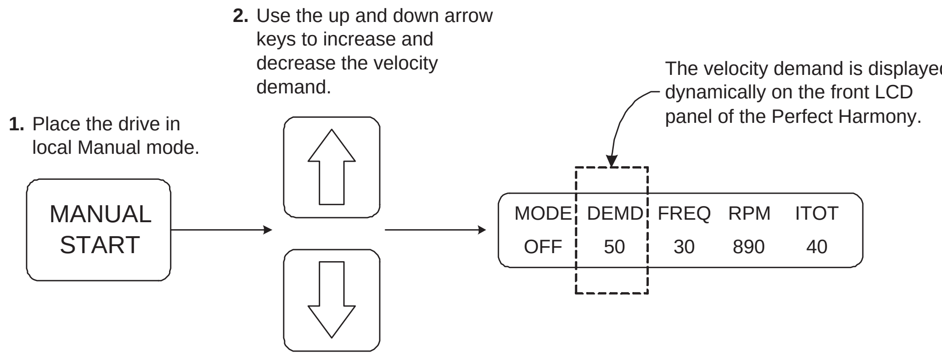

Figure 3-6. Using the Up and Down Arrow Keys to Control Velocity Demand

Another feature of the arrow keys is that they can be used to edit the values of parameters. To edit a parameter value, the operator must first navigate through the menu structure (using the arrow keys) and locate the parameter to be changed. With the parameter displayed on the LCD, the operator must press the [ENTER] key. This places the selected parameter into edit mode. Once in edit mode, an underscore is displayed beneath the first (i.e., the most significant) position of the parameter value. Changing the value of that position can be accomplished by pressing the desired numeric key or by using the up and down arrow keys ([⇧] and [⇩]) to scroll (and wrap around) through the numbers 0 through 9 for that position. When the up and down arrow keys are used, the operator must press the right and left arrow keys ([⇦] and [⇨]) to move to the next (or previous) position in the number to be edited (unlike using the number keys which automatically shift the underscore to the next digit in the number). The operator must press the [ENTER] key to accept the new value or press the [SHIFT] + [ENTER] (i.e., [CANCEL]) to abort the change.

A feature unique to the left arrow key (with the [SHIFT] key) is its ability to cancel the current security mode and return to level 0. An operator can increase the security access level (by entering the appropriate security codes), but cannot lower the security access level using the standard “Change Security Code” option of the Main menu. If an experienced user enters level 7 (or any other security level) then wishes to return to level 0 when he is finished (for security reasons), he may reset the drive by toggling power to the drive or using the [SHIFT] + [⇦] sequence three times from the main display (i.e., [SHIFT] + [⇦] + [SHIFT] + [⇦] + [SHIFT] + [⇦]). The latter method is a convenient way to reset the security level to 0 without interrupting the operation of the drive. When the security level is reset, the display shows a “Security Level Cleared” message. Refer to Figure 3-7.

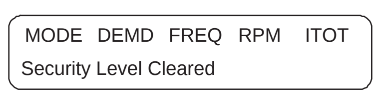

Figure 3-7. Security Level Cleared Message on the Perfect Harmony Display

Note:

* Security will return automatically to level 0 after 15 minutes of inactivity.

** The [SHIFT] + [⇦] + [SHIFT] + [⇦] + [SHIFT] + [⇦] key sequence is valid only when performed from the default meter display.

The right arrow key [⇨] is also used in conjunction with the [SHIFT] key to provide a menu, parameter, or pick list access feature. The operator can gain access to *all* security approved menus parameters, or pick lists. Accessing items in this manner requires that the operator know the ID number associated with the target item. This ID number can be a one, two, three or four digit number. To access an item using its ID number, press the [SHIFT] key followed by the right arrow key [⇨]. The display prompts the operator for the desired ID number. Using the numeric keys on the keypad, the operator enters the desired ID number then presses the [ENTER] key. If the number was a valid ID number and the current security level permits access to that item, then the desired item will be displayed. Refer to Figure 3-4. Some common arrow key sequences are listed in Table 3-4.

Table 3-4. Summary of Common Arrow Key Sequences

Key Combination	Description
⇦ or ⇨	Used individually to navigate through the menu structure. Also used to change the active digit of a parameter value (when in edit mode).
⇧ or ⇩	Used individually to scroll through lists of menu options, lists and parameters. Used to change velocity demand (from default meter display). Increments/decrements parameter values (when in edit mode).
SHIFT ⇨	Enters “numerical item access mode”. The operator is then prompted to enter the 1 or 4 digit ID number for the associated item.
SHIFT ⇧	Jumps to the top menu item of the currently selected menu or submenu. Hitting an additional up arrow will take you out of the current menu or submenu to the previous menu.
SHIFT ⇦ SHIFT ⇦ SHIFT ⇦	Restores the security level back to 0. The [SHIFT]+[⇦] (left arrow) key sequence must be entered three times in succession from the default meter display to restore the security level back to 0.
SHIFT ⇩	Jumps to the bottom menu item of the currently selected menu or submenu.
SHIFT ⇦	When editing a value that has been changed from its factory default, this key sequence will return the value to its factory default.

3.2.9 Diagnostic Indicators

The standard keypad and display interface also contains 3 diagnostic LED indicators that are located above the display: Power On, Fault and Run. The Power On indicator is lit when control power is supplied to the system. The Run indicator is illuminated when the drive is running. The Fault indicator is lit when one or more system errors have occurred (e.g., boot-up test failure, overvoltage fault, etc.). The Fault indicator blinks when one or more alarms are active or unacknowledged. The [FAULT RESET] key must be pressed to clear any existing fault conditions and restore the system to normal operation. Refer to Figure 3-1 for the location of the 3 diagnostic indicators.

3.2.10 The Display

After power up or reset, the Siemens identification and software version number is displayed for 2-3 seconds. Afterwards, the meter display is shown on the LCD by default. The meter display is the starting point of the menuing system. This display remains on the LCD until keys are pressed.

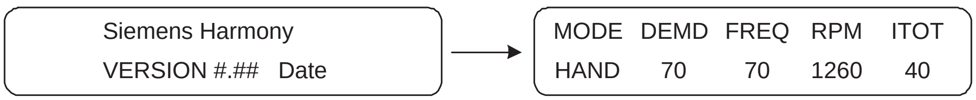

Figure 3-8. The Identification/Version Screen and Meter Displays

The meter display screen contains five fields that are monitored and updated dynamically. These fields are the MODE (the operational mode), DEMD (the velocity demand), RPM (calculated revolutions per minute), VLTS (motor voltage) and ITOT (total output current) fields. The value (or state) of each field is shown dynamically on the second line of the display. Refer to Figure 3-9. The MODE field is fixed. The last 4 fields on the display contain parameter values that can be defined by the operator.

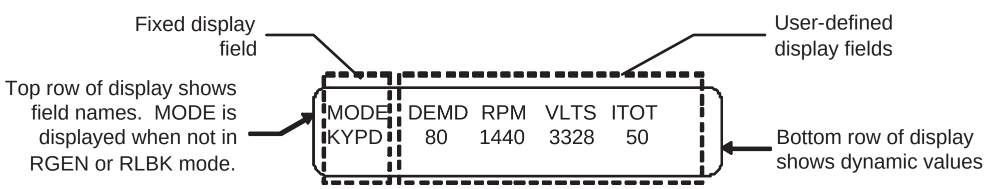

Figure 3-9. Dynamic Programmable Meter Display

The MODE field displays the current operational mode of the Harmony system. This field can have any one of the displays summarized in Table 3-5 depending on the current operational mode or the current state of the drive.

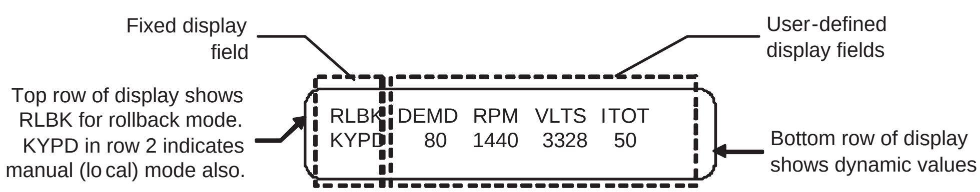

Figure 3-10. Dynamic Programmable Meter Display in Rollback Mode

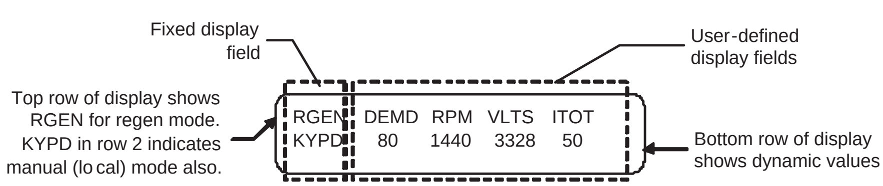

Figure 3-11. Dynamic Programmable Meter Display in Regeneration Mode

The following illustrations depict the 2-line, 24-character display in various modes of access as the operator attempts to locate and change the Ratio Control and Motor Frequency parameters.

Figure 3-12 depicts the display immediately following power up or system reset. Note that the first three variable displays (from the right) can be selected from a pick list using the Display Parameters (8000).

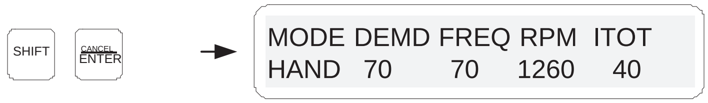

Figure 3-12. Status Display After [SHIFT] [ENTER] ([CANCEL]) Key Sequence

The DEMD display (refer to Figure 3-12) shows the "commanded speed reference" in percent. Figure 3-13 depicts the display following a [SHIFT]+[2] ([DRIVE]) key combination. From this point the nine standard menus listed in Table 3-7 can then be selected using the up/down arrow keys ([⇧] and [⇩]). Figure 3-14 depicts the display after the down arrow key ([⇩]) is pressed twice and prior to the selection of the Speed Setup Menu (2060). If the [ENTER] or right arrow key ([⇨]) is pressed at this display, the Speed Setup Menu (2060) will be entered . Figure 3-16 depicts the display following a down arrow keystroke to the Ratio Control Parameter (2070). The down arrow key ([⇩]) was pressed once to obtain this display. Figure 3-17 depicts the display once the Ratio control parameter in the Speed Setup Menu (2060) is entered for edit. Note the word edit appears in the display when a parameter is in the edit mode. The left/right arrow keys ([⇦] and [⇨]) can be used to position the cursor under the desired digit (or sign) to be changed. The digit can be set by either using the number keys, or it may be incremented/decremented using the up/down arrow keys ([⇧] and [⇩]). The sign can be changed using the up/down arrow keys. The parameter is selected into memory once the [ENTER] or right arrow key ([⇨]) is pressed. Figure 3-18 depicts the display when a number in range is entered.

> **Note:** An asterisk (*) is used to denote when a parameter is changed from its current default value. This allows the user to quickly see which parameters have been changed. To return a parameter to its factory default value, press [SHIFT] + [⇦] while in edit mode.

Figure 3-13. Status Display After [SHIFT]+[2] Key Sequence

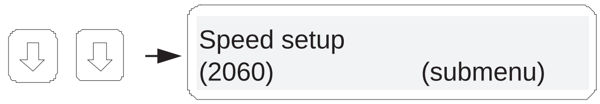

Figure 3-14. Status Display After [⇩] [⇩] Key Sequence

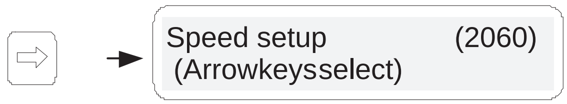

Figure 3-15. Status Display After [⇨]

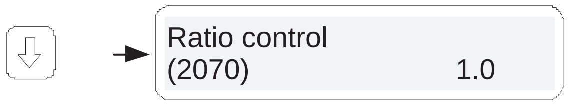

Figure 3-16. Status Display After [⇩] Key Sequences

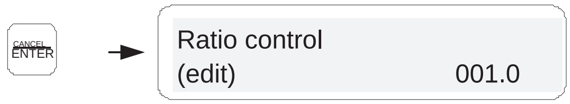

Figure 3-17. Status Display After [ENTER] Key to Change a Parameter

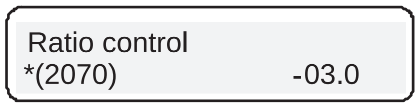

Figure 3-18. Status Display Upon Entering a Value In the Range of the System

In the following example, a [SHIFT] [⇨] to get to the Parameter ID display. The parameter ID for Motor Frequency (1020) is entered. See Figure 3-19. The [ENTER] key is then pressed once to show the Motor Frequency display and then [ENTER] is pressed again to edit its value. Figure 3-21 depicts the display if 010 is attempted to be entered for the Motor Frequency. Since the range of the variable is 15 to 330, an error message will be displayed for approximately 4 seconds, then the initial value, before the edit will be displayed.

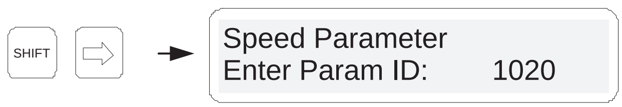

Figure 3-19. Status Display After [SHIFT] [⇨] and the Parameter ID 1020 is entered

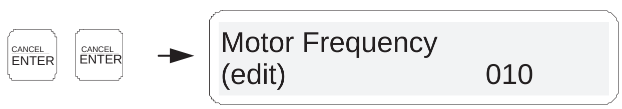

Figure 3-20. Status Display After [ENTER] [ENTER]

Figure 3-21. Status Display Upon Entering a Value Beyond the Range of the System

Table 3-5. Summary of Operation Mode Displays: Line 1 of Mode Display

Code	Meaning	Description
FRST	Fault reset	Displayed after the [FAULT RESET] button is pressed. *Note*: **This may not be visible** because of the speed of response to a Fault Reset.
TLIM	Menu setting rollback	Drive is being limited by a menu setting. Refer to torque limits settings in 3-9.
SPHS	Single phasing rollback	A Single phasing condition of the input line is limiting drive torque.
UVLT	Under voltage rollback	A Under Voltage condition of the input line is limiting the drive torque.
T OL	Thermal overload rollback	The drive has limited the amount of torque produced to prevent thermal overload of the input transformer.
F WK	Field weakening rollback	This condition exists when the motor flux is low and the application requires high torque. This prevents “motor pull-out”, an unstable operating condition of the motor.
C OL	Cell overload rollback	A Cell current overload model has calculated a thermal overload condition of the drive cells and the drive has limited the amount of torque produced.
RGEN	Regeneration	During normal deceleration, this message will be displayed because the drive is preventing the motor from regenerating power back into the drive.
BRKG	Dual Frequency Braking	Appears while drive is decelerating with dual frequency braking enabled.
RLBK	Roll back	Appears during acceleration if drive has reached its torque limit setting.
BYPS	Cell Bypassed	Indicates that one or more cells is in bypass.
OLTM	Open Loop Test Mode	Appears if drive control algorithm is set to Open Loop Test Mode.
NET1	Network 1 limit	Torque limited by network 1 setting.
NET2	Network 2 limit	Torque limited by network 2 setting.
ALIM	Analog Torque Limit	Torque limited by analog input.
MODE	Normal mode display	This is the typical display message during normal operation.

3

Table 3-6. Summary of Operation Mode Displays: Line 2 of Mode Display

Code	Meaning	Description
NOMV	No medium voltage	No input line voltage detected.
INH	CR3 inhibit	The CR3 or “Drive inhibit” input is asserted.
OFF	Idle state	The drive is ready to run but is in an idle state.
MAGN	Magnetizing motor state	The drive is magnetizing the motor.
SPIN	Spinning load state	The drive is trying to detect the speed of the motor in order to synchronize the drive frequency.
UXFR	Up transfer state	The drive is in the “Up Transfer State” preparing to transfer the motor to the input line.
DXFR	Down transfer state	The drive is in the “Down Transfer State” preparing to transfer the motor from the input line to the drive.
KYPD	Keypad speed demand	The drive speed demand source is the keypad.
TEST	Speed/Torque test	The drive is in a Speed or Torque test mode.
LOS	Loss of Signal	The drive 4-20mA analog input signal has dropped below a predefined setting. See Tables 3-35, 3-36, 3-38, and 3-39.
AUTO	Automatic mode	The SOP flag AutoDisplayMode_O is set true usually to indicate drive is receiving its speed demand from a source other than the keypad or network. Typically used with a analog input speed source.
NET1	Network 1	Indicates drive is being controlled from Network 1.
NET2	Network 2	Indicates drive is being controlled from Network 2.
DECL	Decelerating (no braking)	The drive is decelerating normally.
BRAK	Dynamic Braking	Indicates that dynamic braking is enabled.
COAS	Coasting to stop	The drive is not controlling th.e motor and it is coasting to a stop due only to friction.
TUNE	Auto Tuning	The drive is in a “Auto Tuning” mode used to determine motor characteristics.
HAND	Hand mode	Appears if the drive is running under normal conditions.

3.3 Menu Descriptions

The following sections contain a condensed description of all parameter items available in the Perfect Harmony menu structure. Table 3-7 depicts main menus and submenus of the system. Each menu and submenu is associated with an ID shown in the ID column. The key sequence [SHIFT]+[⇨] ([SHIFT] plus the right arrow key) and up/down arrow keys ([⇧] and [⇩]) as described above can be used to directly access each menu item.

Note: To prevent the unauthorized changes to the parameters, you can set a software flag, *KeySwitchLockOut_O*, to true. You will be able to display all parameters as usual. See Chapter 8 for information about setting software flags.

Note:

A help feature for all parameter settings is available by pressing the [SHIFT] + [0] ([HELP]) key sequence on the keypad. This feature provides a text description of the desired selection, plus the parameters minimum and maximum value if applicable. If more that 2 lines of help text are available, the operator may use the up and down arrow keys ([⇧] and [⇩]) to scroll through the entire help message.

Parameters are always hidden in the menu display when there is insufficient security clearance to edit the parameter.

Menu items may be hidden if they do not apply to the current drive configuration. Example if Spinning load mode (ID 2430) is set to “Off” IDS 2440 through 2480 (spinning load parameters) are not displayed.

Table 3-7 lists menus with associated “Off” submenu names only. Parameters and functions found in these menus are described in the sections that follow. Use the associated table and page number from Table 3-7 to quickly locate the section of the chapter that explains all of the associated items.

Note that menu items change with new releases of software. Hence the menu system described here may be slightly different than the menu system on your drive. Your drive has help functions for every parameter and these can be used if the function is not described here.

3

Table 3-7. Perfect Harmony Menu and Submenu Summary

Menu	ID	Submenu Names	ID	Table	Page	Description
Motor Menu	1	Motor Parameter	1000	Table 3-8		Used to enter motor-specific data.
		Limits	1120	Table 3-9		
		Autotune	1250	Table 3-11		
		Encoder	1280	Table 3-12		
Drive Menu	2	Drive Parameter	2000	Table 3-13		Used to configure the VFD for various load conditions and drive applications.
		Speed Setup	2060	Table 3-14		
		Speed Ramp Setup	2260	Table 3-15		
		Critical Frequency	2340	Table 3-16		
		Spinning Load	2420	Table 3-17		
		Conditional Time Setup	2490	Table 3-18		
		Cells	2520	Table 3-19		
		Sync Transfer	2700	Table 3-20		
		External I/O	2800	Table 3-21		
		Output Connection	2900	Table 3-22		
Stability Menu	3	Input Processing	3000	Table 3-24		Used to adjust the VFD's various control loop gains, including current and speed regulator gains.
		Output Processing	3050	Table 3-25		
		Control Loop Test	3460	Table 3-31		
Auto Menu	4	Speed Profile	4000	Table 3-33		Used to configure various speed setpoint, profile, and critical speed avoidance and comparator parameters.
		Analog Inputs	4090	Table 3-34		
		Analog Outputs	4660	Table 3-40		
		Speed Setpoints	4240	Table 3-42		
		Incremental Speed Setup	4970	Table 3-43		
		PID Select	4350	Table 3-44		PID Select Menu contains PID setup parameters.
		Comparator Setup	4800	Table 3-45		Used to configure the analog comparators controlled through the SOP.

Menu	ID	Submenu Names	ID	Table	Page	Description
Main Menu	5	Motor	1	see Motor Menu, above		
		Drive	2	see Drive Menu, above		
		Stability	3	Table 3-23		
		Auto	4	see Auto Menu, above		
		Logs	6	see Logs Menu, below		
		Drive Protect	7	Table 3-56		
		Meter	8	Table 3-59		
		Communications	9	Table 3-64		
		Security Edit Functions	5000	Table 3-49		Configures security features.
Logs Menu	6	Event Log	6180	Table 3-52		Used to configure and inspect the event, alarm/fault, and historic logs of the VFD.
		Alarm/Fault Log	6210	Table 3-53		
		Historic Log	6250	Table 3-54		
Drive Protect Menu	7	Input Protection	7000	Table 3-57		Adjusts setpoint limits for critical VFD variables.
Meter Menu	8	Display Parameters	8000	Table 3-60		Set up Variables for display to LCD.
		Hour Meter Setup	8010	Table 3-62		
		Input Harmonics	8140	Table 3-63		
		Fault display override	8200	Table 3-59		
Communications Menu	9	Serial Port Setup	9010	Table 3-65		Used for configuring the various Communications features of the VFD.
		Network Control	9943	Please refer to Communications manual (number 902399)		
		Network 1 Configure	9900			
		Network 2 Configure	9914			
		Display Network Monitor	9950	Table 3-64		
		Serial echo back test	9180	Please refer to Communications manual (number 902399)		
		Sop & serial functions	9110	Table 3-66		
		TCP/IP Setup	9300	Table 3-67		

3.3.1 Motor Menu (1) Options

The Motor Menu (**1**) consists of the following menu options:

- Motor Parameter Menu (**1000**)

- Limit Protection Menu (**1120**)
- Autotune Menu (**1250**)
- Encoder Menu (**1280**)

The contents of these menus are explained in tables that follow.

Table 3-8. Motor Parameter Menu (1000)

Parameter	ID	Units	Default	Min	Max	Description
Motor frequency	1020	Hz	60	15	330	Enter the rated or base frequency of the motor from the nameplate.
Full load speed	1030	RPM	1780	1	19800	Enter the full load speed of the motor from the nameplate. Full load speed is base or rated speed minus slip.
Motor voltage	1040	V	4160	380	13800	Enter the rated voltage for the motor from the nameplate.
Full load current	1050	A	125.0	12.0	1500.0	Enter the rated nameplate full load current of the motor.
No load current	1060	%	25.0	0.0	100.0	Enter the no load current of the motor, if it is provided, or use the Autotune function.
Motor kW rating	1010	kW	746.0	120.0	20000.0	Enter the motor kW (0.746 * Hp) from the nameplate.
Leakage inductance	1070	%	16.0	0.0	30.0	Enter the leakage inductance of the motor if it is provided, or use the Autotune function.
Stator resistance	1080	%	0.10	0.00	25.00	Enter the stator resistance of the motor, if it is provided. To convert from ohms to % use the formula: [%Rs = 100 * √3 * Rs(*in ohms*) * Motor Current/Motor Voltage], or use the Autotune function.
Inertia	1090	Kgm^2	30.0	0.0	100000.0	Enter the rotor inertia of the motor if known ($1Kgm^2 = 23.24 lbft^2$), or use the Autotune function.

Table 3-9. Limits Menu (1120)

Parameter	ID	Units	Default	Min	Max	Description
Overload select	1130		Constant			Selects the overload trip algorithm: Constant (fixed current-based TOL). Straight Inverse Time (motor temperature-based TOL). Inverse Time with speed derating (motor temperature-based TOL). Note: Selecting "constant" here and setting the next tow parameters (1139 & 1140) to max, effectively disables this function.
Overload pending	1139	%	100.0	10.0	210.0	Sets the overload level at which a warning is issued (constant mode).
Overload	1140	%	120.0	20.0	210.0	Sets the overload trip level at which the timeout counter is started (constant mode).
Overload timeout	1150	sec	60.0	0.01	300.0	Sets the time for the overload trip (constant mode).
Speed Derate Curve	1151	Submenu				This menu sets allowable motor load as a function of speed. See Table 3-10.
Motor trip volts	1160	V	4800	5	20,000	Sets the motor over-voltage trip point.
Maximum Load Inertia	1159	Kgm^2	0.0	0.0	500000.0	Sets the maximum load inertia that the motor can line start without exceeding maximum temperature.
Overspeed	1170	%	120.0	0.0	250.0	Sets the motor overspeed trip level as a percentage of rated speed.
Underload enable	1180		Disable			Enables or disables underload protection.
I underload	1182	%	10.0	1.0	90.0	Sets the current underload level based on the rated motor current.
Underload timeout	1186	sec	10.0	0.01	900.0	Sets the time for underload trip.
Motor torque limit 1	1190	%	100.0	0.0	300.0	Sets the motoring torque limit as a function of the rated motor current.
Regen torque limit 1	1200	%	-0.25	-300.0	0.0	Sets the regenerative torque limit as a function of rated motor current at full speed. The limit is allowed to increase inversely with speed.
Motor torque limit 2	1210	%	100.0	0.0	300.0	Sets the motoring torque limit as a function of the available motor current.

Parameter	ID	Units	Default	Min	Max	Description
Regen torque limit 2	1220	%	-0.25	-300.0	0.0	Sets the regenerative torque limit as a function of rated motor current at full speed. The limit is allowed to increase inversely with speed.
Motor torque limit 3	1230	%	100.0	0.0	300.0	Sets the motoring torque limit as a function of the available motor current.
Regen torque limit 3	1240	%	-0.25	-300.0	0.0	Sets the regenerative torque limit as a function of rated motor current at full speed. The limit is allowed to increase inversely with speed.
Phase Imbalance Limit	1244	%	40.0	0.0	100.0	Sets the current threshold level for the output phase current imbalance alarm.
Ground Fault Limit	1245	%	5.0	0.0	100.0	Sets the threshold of voltage for the output ground fault alarm.
Ground Fault Time Const	1246	sec	0.017	0.001	2.000	Sets the filter time constant for averaging the ground voltage and delaying the response of the ground fault detection.
H/W Ground Fault Enable	1247		Disabled			Enables and disables hardware ground fault detection.

3

Table 3-10. Speed Derate Curve Menu (1151)

Parameter	ID	Units	Default	Min	Max	Description
0 Percent Break Point	1152	%	0.0	0.0	200.0	Sets the maximum motor load at 0% speed.
10 Percent Break Point	1153	%	31.6	0.0	200.0	Sets the maximum motor load at 10% speed.
17 Percent Break Point	1154	%	41.2	0.0	200.0	Sets the maximum motor load at 17% speed.
25 Percent Break Point	1155	%	50.0	0.0	200.0	Sets the maximum motor load at 25% speed.
50 Percent Break Point	1156	%	70.7	0.0	200.0	Sets the maximum motor load at 50% speed.
100 Percent Break Point	1157	%	100.0	0.0	200.0	Sets the maximum motor load at 100% speed.

Table 3-11. Autotune Menu (1250)

Parameter	ID	Type	Description
Autotune stage 1	1260	Function	This function determines the stator resistance and leakage inductance of the motor. The motor does not rotate during this stage. If this function is not used the menu-entered values are used. If the function is used, the parameters will be updated with the calculated values.
Autotune stage 2	1270	Function	This function determines the no-load current & rotor inertia of the motor. The motor rotates during this stage. If this function is not used the menu entered values are used. **Note:** This should be used in only very special circumstances requiring high response rates, and should only be used under engineering guidance.

Auto Tuning provides motor information that optimizes the Output Processing Control. Both stages of Auto Tuning are optional. The user can enter the motor information if available (see Table 3-11). The process is performed in two stages.

Table 3-12. Encoder Menu (1280) (Closed Loop Vector Control Only)

Parameter	ID	Units	Default	Min	Max	Description
Encoder 1 PPR	1290		720	1	10000	Rated number of pulses per revolution delivered by the encoder. (Name plate value).
Encoder filter gain	1300		0.0	0.0	0.999	Sets the gain of the filter for encoder feedback. This parameter can have a value between 0.0 (no filtering) and 0.999 (maximum filtering).
Encoder loss threshold	1310	%	0.0	0.0	75.0	Sets the level for the error between encoder output and calculated motor speed to determine encoder loss.
Encoder loss response	1320		Open Loop			Sets the drive response to a loss of encoder event. Stop (on Fault) Open Loop (control)

3.3.2 Drive Menu (2) Options

The Drive Menu (**2**) consists of the following submenus:

- (**2000**) Drive Parameter Menu
- (**2060**) Speed Setup Menu
- (**2260**) Speed Ramp Setup Menu
- (**2340**) Critical Frequency Menu
- (**2420**) Spinning Load Menu
- (**2490**) Conditional Timer Menu
- (**2520**) Cell Menu
- (**2700**) Sync Transfer Menu
- (**2800**) External I/O Menu
- (**2900**) Output Connection Menu

Contents of these menus are explained in the tables that follow.

Table 3-13. Drive Parameter Menu (2000)

Parameter	ID	Units	Default	Min	Max	Description
Rated input voltage	2010	V	4160	200	125000	Rated RMS input voltage of the drive. Set according to the input transformer primary voltage rating. **Note:** The input attenuator kit should always correspond to the rated primary voltage of the transformer.
Rated input current	2020	A	100.0	12.0	3000.0	Rated RMS input current of the drive. Set according to input transformer nameplate kVA rating as noted below.*
Rated output voltage	2030	V	4160	200	23000	Rated drive output voltage RMS. Set according to the rating of the output attenuator kit. **Note:** This value is typically equal to or higher than the motor voltage rating.
Rated output current	2040	A	100.0	12.0	1500.0	Rated drive output current RMS. Set equal to the cell (output) current rating. **Note:** The output Hall Effects and burden resistors should be sized for the cell current rating.
Control loop type See Note below.	2050		OLVC			Control loop algorithm type selection. Volts per Hertz (V/Hz) for parallel motors. Open Loop Vector Control (OLVC) for single induction motors. Closed Loop Vector Control (CLVC) for single induction motors with speed sensor(s). Open Loop Test Mode (OLTM) for checking cell modulation and testing Hall-effect transducer. Synchronous Motor Control (SMC) without speed sensor. Closed Loop Synchronous Motor Control (CSMC) with speed sensor.

Note: Changing the control loop algorithm type to open loop test mode (OLTM) or Volts/Hz (V/Hz) diasables fast bypass and turns off spinning load by changing those parameters (2600 and 2430 respectively).

*The calculation is derived as follows:

Rated Input Current = [(kVA rating) x (802)] ÷ [(√3) x (Rated nominal primary voltage) x (0.96) x (0.94)

= [(kVA rating) ÷ (Rated nominal primary voltage)] x 513.11

Note: The parameters discussed in are based on hardware used within the drive and on the design limits of drive components. These settings should not be changed in the field to match the conditions on the site unless hardware modifications have been made and approval from applications engineering has been obtained.

Table 3-14. Speed Setup Menu (2060)

Parameter	ID	Units	Default	Min	Max	Description
Ratio control	2070		100.0	-250.0	250.0	Used to adjust the scaling of the speed reference value.
Speed fwd max limit 1	2080	%	100.0	0.0	200.0	The forward max speed reference limit 1.
Speed fwd min limit 1	2090	%	0.0	0.0	200.0	The forward min speed reference limit 1.
Speed fwd max limit 2	2100	%	100.0	0.0	200.0	The forward max speed reference limit 2.
Speed fwd min limit 2	2110	%	0.0	0.0	200.0	The forward min speed reference limit 2.
Speed fwd max limit 3	2120	%	100.0	0.0	200.0	The forward max speed reference limit 3.
Speed fwd min limit 3	2130	%	0.0	0.0	200.0	The forward min speed reference limit 3.
Speed rev max limit 1	2140	%	-100.0	-200.0	0.0	The reverse max speed reference limit 1.
Speed rev min limit 1	2150	%	0.0	-200.0	0.0	The reverse min speed reference limit 1.
Speed rev max limit 2	2160	%	-100.0	-200.0	0.0	The reverse max speed reference limit 2.
Speed rev min limit 2	2170	%	0.0	-200.0	0.0	The reverse min speed reference limit 2.
Speed rev max limit 3	2180	%	-100.0	-200.0	0.0	The reverse max speed reference limit 3.
Speed rev min limit 3	2190	%	0.0	-200.0	0.0	The reverse min speed reference limit 3.
Zero speed	2200	%	0.0	0.0	100.0	The zero speed threshold value. This is used for the threshold of the “Minimum Speed Trip” (or alarm).

Table 3-15. Speed Ramp Setup Menu (2260)

Parameter	ID	Units	Default	Min	Max	Description
Accel time 1	2270	sec	5.0	0.0	3200.0	Acceleration time 1 in seconds.
Decel time 1	2280	sec	5.0	0.0	3200.0	Deceleration time 1 in seconds.
Accel time 2	2290	sec	5.0	0.0	3200.0	Acceleration time 2 in seconds.
Decel time 2	2300	sec	5.0	0.0	3200.0	Deceleration time 2 in seconds.
Accel time 3	2310	sec	5.0	0.0	3200.0	Acceleration time 3 in seconds.
Decel time 3	2320	sec	5.0	0.0	3200.0	Deceleration time 3 in seconds.
Jerk rate	2330		0.1	0.0	3200.0	Jerk rate in time to reach an acceleration rate that will achieve rated velocity in 1 sec.

Table 3-16. Critical Frequency Menu (2340)

Parameter	ID	Units	Default	Min	Max	Description
Skip center freq 1	2350	Hz	15.0	0.0	360.0	Enter the center of the first critical frequency band to be avoided.
Skip center freq 2	2360	Hz	30.0	0.0	360.0	Enter the center of the second critical frequency band to be avoided.
Skip center freq 3	2370	Hz	45.0	0.0	360.0	Enter the center of the third critical frequency band to be avoided.
Skip bandwidth 1	2380	Hz	0.0	0.0	6.0	Enter the bandwidth of the first critical frequency band to be avoided.
Skip bandwidth 2	2390	Hz	0.0	0.0	6.0	Enter the bandwidth of the second critical frequency band to be avoided.
Skip bandwidth 3	2400	Hz	0.0	0.0	6.0	Enter the bandwidth of the third critical frequency band to be avoided.

The critical frequency feature (sometimes called resonance avoidance) is accomplished using skip frequencies and skip bands as defined in Table 3-16. This is illustrated in Figure 3-22.

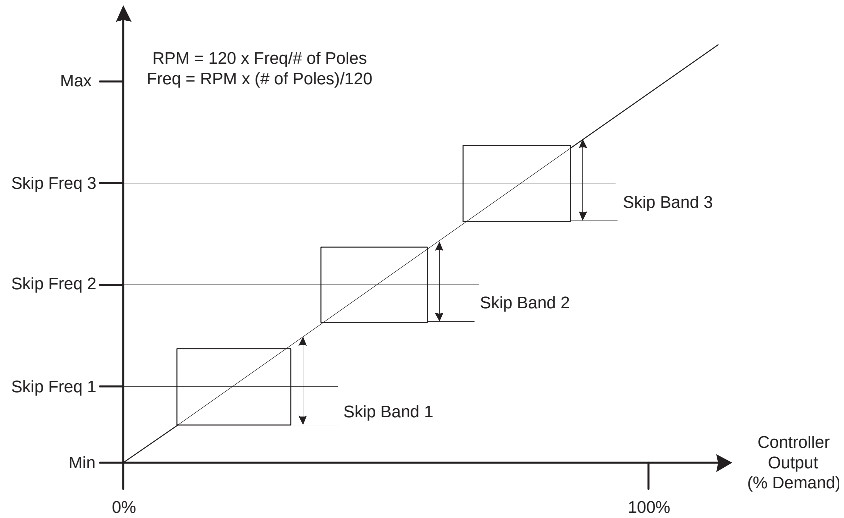

Figure 3-22. Critical Speed (Resonance Avoidance) Parameters

Table 3-17. Spinning Load Menu (2420)

Parameter	ID	Units	Default	Min	Max	Description
Spinning load mode See Note below	2430		Off			Enable/Disable Spinning Load and set the direction of frequency scans: • Off • Forward • Reverse • Both (scans first in the forward direction, then in the reverse direction) See Chapter 5, Section 5.3 for information.
Scan end threshold	2440	%	20.0	1.0	50.0	Point where scan ends if motor flux is above this level, as a percentage of motor rated flux.
Current Level Setpoint	2450	%	15.0	1.0	50.0	Sets the drive current level (I_d), as a percentage of motor rated current, used during scanning.
Current ramp	2460	sec	0.01	0.00	5.00	Time to ramp drive current (I_d)to Current Level Setpoint.
Max current	2470	%	50.0	1.0	50.0	Sets the current trip level, as a percentage of motor rated current, for scanning. Use the default value of 50%.
Frequency scan rate	2480	sec	3.00	0.00	5.00	Sets the time taken to scan from rated speed to zero. The default value of 3.00 sec should be satisfactory for most cases.

Note: The spinning load mode is changed to “off” when either Volts/Hertz (V/Hz) or open loop test mode (OLTM) is selected for control, and must be manually selected before running other control modes if the feature is desired. Spinning load is required for sync transfer.

Table 3-18. Conditional Timer Setup Menu (2490)

Parameter	ID	Units	Default	Min	Max	Description
Cond stop timer	2500	sec	0.8	0.0	999.9	Dwell time after stop is invoked. User function defined. (Not currently implemented)
Cond run timer	2510	sec	0.8	0.0	999.9	Dwell time after start is invoked. User function defined. (Not currently implemented)

Table 3-19. Cell Menu (2520)

Parameter	ID	Units	Default	Min	Max	Description
Installed cells/phase	2530		4	1	8	Installed cells per phase in the drive.
Min cells/phase count (n/3)	2540		4	1	8	Minimum cells per phase count. Due to neutral point shifting, 3 times this number, allowing one active cell per phase, is the minimum allowable cells (n) permitted to run in a system, allowing for the shift in the neutral point.
Cell voltage	2550	Vrms	630			Sets the value of the cell rated voltage: 460V 630V 690V
Thermistor warn level	2560	%	20.0	5.0	70.0	Sets the level at which a temperature alarm is generated.
Contactor settling time	2570	msec	250.0	0.0	1000.0	Time taken by bypass contactors to change state. Use 100ms for small contactors and 250ms for larger ones. Note: the default is not adequate for larger contactors.
Max back EMF decay time	2580	sec	7.0	0.0	10.0	Sets the maximum time that the control waits for the motor voltage to decay while attempting a fast bypass. Once cell fault(s) occurs, the drive may not be able to support actual motor voltage. If the motor voltage does not decay below the max drive voltage capability (with the faulted cell(s)) within the time set by this parameter, the drive issues a fault.
Bypass Type	2590		Mech			Designates the type of bypass in the drive: Mechanical None

3

Parameter	ID	Units	Default	Min	Max	Description
Fast bypass See the Note below	2600		Disable			This parameter enables or disables fast cell bypass. Disabling fast bypass with mechanical contactors will still provide manual bypass after a manual reset.
Display Cell Status	2610	Function				Displays cell status: A = active, B = bypassed, F = faulted. Format is all A phase followed by all B phase followed by all C phase.
Display Bypass Status	2620	Function				Displays bypass status: Same format as for cell status. A = available, B = active, U = unavailable.
Reset Bypassed Cells	2640	Function				Allows bypassed cells to be reset when the drive is in an **idle** state. Use the reset function only after verifying that the problems with the faulted cell(s) have been resolved.
Neutral Connection	2630		T2			Sets the pole inversion type based on the cell neutral connection point. Select the terminal, T1 or T2, which forms the neutral connection. This selection depends on the terminal of cells A1, B1, and C1 that is used to form the drive start-point neutral.

Note: Fast Bypass is changed to “disabled” when Volts/Hertz (V/Hz) or open loop test mode (OLTM) is selected (parameter 2050), and must be manually reset before running other modes.

Table 3-20. Sync Transfer Menu (2700)

Parameter	ID	Units	Default	Min	Max	Description
Phase I gain	2710		2.0	0.0	15.0	Phase integrator gain.
Phase P gain	2720		4.0	1.0	12.0	Phase proportional gain.
Phase offset	2730	deg	2.0	-90.0	90.0	Specifies the phase angle setpoint used during Up Transfer. This is set positive, expressed in degrees leading to prevent power flow back into drive.
Phase error threshold	2740	deg	1.5	0.0	5.0	Specifies the phase synchronization error window during Up Transfer. This parameter adjusts the amount of error allowed during phase-locking and is expressed in degrees.
Frequency Offset	2750	%	0.5	-10.0	10.0	Frequency offset used during Down Transfer.
Up Transfer Timeout	2760	sec	0.0	0.0	600.0	If the time taken for Up Transfer exceeds this value then an Up Transfer Timeout Fault is generated. This setting should be greater than the acceleration time setting (2270, 2290, or 2310). Setting zero disables the timeout fault.
Down Transfer Timeout	2770	Sec	0.0	0.0	600.0	If the time taken for Down Transfer exceeds this value then a Down Transfer Timeout Fault is generated. This is unaffected by the acceleration rate and zero disables the timeout fault.

Table 3-21. External I/O Menu (2800)

Parameter	ID	Units	Default	Min	Max	Description
Analog Inputs	2810		0	0	24	Sets the quantity of analog inputs in the attached external I/O.
Analog Outputs	2820		0	0	16	Sets the quantity of analog outputs in the attached external I/O.
Digital Inputs	2830		0	0	96	Sets the quantity of digital inputs in the attached external I/O.
Digital Outputs	2840		0	0	64	Sets the quantity of digital outputs in the attached external I/O.
Wago timeout	2850	sec	0	0	600	Sets the Wago watchdog timeout period. Setting to zero disables this function.

3

Table 3-22. Output Connection Menu (2900)

Parameter	ID	Units	Default	Min	Max	Description
Filter CT Secondary Turns	2910		0	0	250	Secondary side turns (assuming primary turns = 5) of the CTs used to measure filter capacitor currents.
Filter Inductance	2920	%	0.0	0.0	20.0	Sets the output filter inductor (impedance) value as a ratio of the base output impedance of the drive (typically 5%).
Filter Capacitance	2930	%	0.0	0.0	20.0	Sets the output filter capacitor (admittance) value as a ratio of the base output admittance of the drive (typically 10%). Admittance is the inverse of impedance.
Cable Resistance	2940	%	0.0	0.0	50.0	Output cable resistance value as a ratio of the base output impedance of the drive.
Filter damping gain	2950		0.50	-5.00	5.00	Controls the gain for damping oscillations due to output filter. Use a positive constant (typically 0.5) with short cable lengths (< 30,000 feet) and a negative constant (typically -0.5) for long cable lengths.

3.3.3 Stability Menu (3) Options

The Stability Menu (**3**) consists of the following menu options:

Input Processing Menu (**3000**)

Output Processing Menu (**3050**)

Control Loop Test Menu (**3460**)

The Stability Menu also contains some parameters. These menus and parameters are explained in tables that follow.

Table 3-23. Stability Menu (3) (Parameters)

Parameter	ID	Units	Default	Min	Max	Description
Input Processing Menu	3000	Submenu				Contains all of the sub menus related to drive line side processing. See Table 3-24.
Output Processing Menu	3050	Submenu				Contains all of the sub menus related to drive motor side processing. See Table 3-25.
Control Loop Test Menu	3460	Submenu				Contains all of the sub menus related to speed and torque loop testing. See Table 3-32.
Slip constant	3545		0.0	0.0	20.0	Gain for slip compensation. This value is calculated by the control software and cannot be changed.
Dead time comp	3550	msec	16.0	0.0	50.0	Sets the dead time (or firing delay time) of the IGBTs for software compensation.
Feed forward constant	3560		0.0	0.0	1.0	Sets the gain for voltage feed forward. This is used to improve the torque current regulator response.
Carrier frequency	3580	Hz	600.0	100.0	1500.0	IGBT switching frequency. The control adjusts the entered value according to available resolution from the modulator registers (e.g., if you enter 600, the actual frequency may be 601.0).

Table 3-24. Input Processing Menu (3000)

Parameter	ID	Units	Default	Min	Max	Description
PLL prop gain	3010		70.0	0.0	200.0	Proportional gain of input phase locked loop (PLL).
PLL integral gain	3020		3840.0	0.0	12000.0	Integral gain of input PLL.
Input current scaler	3030		1.0	0.0	2.0	Sets the scaling for input current feedback. Normally should be set to 1.0.
CT Turns	3035		200	50	3000	Secondary side turns for input current CT (with primary turns equal to 5).
Input voltage scaler	3040		1.0	0.0	2.0	Sets the scaling for input line voltage feedback. Normally should be set to 1.0.
Input Attenuator Sum	3045	kOhm	3000	100	10000	Sets scaling for input nominal value. This is the sum of the two input resistors per phase.

Note: Many of the parameters in the Output Processing section are automatically set up during autotuning. They are presented here so the user can do additional fine-tuning of the drive. Additional fine-tuning is not generally required, but may be needed in special circumstances.

Table 3-25. Output Processing Menu (3050)

Parameter	ID	Units	Default	Min	Max	Description
Low freq comp	3060	Submenu				Menu contains parameters that effect motor flux calculation. See Table 3-26.
Flux control	3100	Submenu				This menu contains the flux control parameters. See Table 3-27.
Speed loop	3200	Submenu				This menu contains the speed loop parameters. See Table 3-28.
Current loop	3250	Submenu				This menu contains the current loop parameters. See Table 3-29.
Stator resis est	3300	Submenu				This menu contains the stator resistance estimator parameters. See Table 3-30.
Braking	3350	Submenu				This menu contains the dual frequency braking parameters. See Table 3-31.
PLL prop gain	3420		188.0	1.0	500.0	Proportional gain of output phase-locked loop. This value is updated by the control and cannot be changed.
PLL integral gain	3430		2760.0	0.0	12000.0	Integral gain of output phase-locked loop. This value is updated only by the control and cannot be changed.
Output current scaler	3440		1.0	0.0	2.0	Scaling for output current feedbacks. Normally should be set to 1.0.
Output voltage scaler	3450		1.0	0.0	2.0	Scaling for output voltage feedbacks. Normally should be set to 1.0.
Output attenuator sum	3455	kOhms	3000	100	10000	Scaling for the output nominal value.

3

Table 3-26. Low Frequency Compensation Menu (3060)

Parameter	ID	Units	Default	Min	Max	Description
Low Freq Wo	3070	Rad	12.566	0.0	100.0	Pole of hardware RC integrator. This is the setting for the -00 board. For the 02 board the value should be 37.859.
Low freq com gain	3080		1.0	0.5	5.0	Low Frequency compensation gain for scaling estimated flux.
S/W compensator pole	3090		2.0	0.5	12.6	Pole of software integrator used for flux estimation.

Table 3-27. Flux Control Menu (3100)

Parameter	ID	Units	Default	Min	Max	Description
Flux reg prop gain	3110		1.72	0.0	10.0	Flux PI regulator proportional gain term
Flux reg integral gain	3120		1.0	0.0	1200.0	Flux PI regulator integral gain term
Flux Filter Time Const	3130	sec	0.0667	0.0	10.0	Time constant of the low pass filter used on the flux error.
Flux demand	3150	per unit	1.0	0.0	10.0	Sets the flux demand (or desired Volts-per-Hertz ratio) in per unit.
Flux ramp rate	3160	sec	0.5	0.0	5.0	Sets the ramp time to go from zero to rated flux. This time establishes the time to magnetize the motor.
Energy saver min flux	3170		100.0	10.0	125.0	This parameter sets the lowest value of flux (as a percentage of Rated Motor Flux) that the drive will apply to an unloaded motor. Energy Saver is enabled if a value that is less than the Flux Demand is entered. The control establishes the amount of flux (or motor voltage) that minimizes the losses in the motor.
Ids DC	3190	%	10.0	1.0	25.0	DC current level used when stator resistance estimator is enabled.

Table 3-28. Speed Loop Menu (3200)

Parameter	ID	Units	Default	Min	Max	Description
Speed reg prop gain	3210		0.02	0.0	1.0	Speed PI regulator proportional gain term. Automatically calculated after Auto Tuning stage 2.
Speed reg integral gain	3220		0.046	0.0	1200.0	Speed PI regulator integral gain term. Automatically calculated after Auto Tuning stage 2.
Speed reg Kf gain	3230		0.6	0.1	1.0	Allows a smooth variation of the speed regulator from a simple PI (Kf =1.0) to a double speed loop (Kf=0.5).
Speed filter time const	3240		0.0488	0.0	10.0	Time constant of the low pass filter used on the speed error. Automatically calculated after Auto Tuning stage 2.
Droop	3245		0.0	0.0	10.0	Droop in percent of rated speed at full load current.

Table 3-29. Current Loop Menu (3250)

Parameter	ID	Units	Default	Min	Max	Description
Current reg prop gain	3260		0.5	0.0	5.0	Current PI regulator proportional gain term.*
Current reg integ gain	3270		25.0	0.0	6000.0	Current PI regulator integral gain term.*
Prop gain during brake	3280		0.16	0.0	5.0	Current PI regulator proportional during dual frequency braking.*
Integ gain during brake	3290		9.6	0.0	6000.0	Current PI regulator integral gain term during dual frequency braking.*

* All values in this table are automatically updated after AutoTuning stage 1.

Table 3-30. Stator Resistance Estimator Menu (3300)

Parameter	ID	Units	Default	Min	Max	Description
Stator resistance est	3310		Off			This parameter enables or disables the stator resistance estimator function. Off On
Stator resis filter gain	3320		0.0	0.0	1.0	Stator resistance estimator filter gain.
Stator resis integ gain	3330		0.002	0.0	1.0	Stator resistance estimator integral gain.

Table 3-31. Braking Menu (3350)

Parameter	ID	Units	Default	Min	Max	Description
Enable braking	3360		Off			Enable or disable dual frequency braking (DFB). User must be aware of torque pulsations and motor heating produced with this method.
Pulsation frequency	3370	Hz	275.0	100.0	5000.0	Torque pulsation frequency when dual-frequency braking is enabled. Adjust for a different torque pulsation frequency. The control always recalculates the desired value due to limited resolution. Can be adjusted to avoid mechanical resonance frequencies.
Brake power loss	3390	%	0.25	0.0	50.0	Amount of high frequency losses at the onset of braking. Affects the limit of the V_q component of output braking voltage.
VD Loss	3400	p.u.	0.25	0.0	0.5	Max amplitude of the loss inducing voltage. Use this to adjust the braking torque. Sets the maximum loss limiting (V_d) voltage amplitude.
Braking constant	3410		1.05	0.0	10.0	Ratio of motor (induced) losses to power absorbed from load. **This parameter should always be set to a value greater than 1.0**. Setting this parameter higher increases V_q and V_d voltage amplitude of losses in the motor and increases braking. Caution must be exercised to prevent a motor thermal trip.

Note: The need for braking capacity is addressed through a feature known as dual frequency braking. This feature essentially creates a braking function by means of injecting a counter-rotating flux vector at well beyond the slip of the machine. This generates additional losses in the motor. The injection frequency is adjustable via a menu setting to allow critical frequencies (i.e. mechanical resonances) to be avoided.

Table 3-32. Control Loop Test Menu (3460)

Parameter	ID	Units	Default	Min	Max	Description
Test type	3470		Speed			This pick list selects the type of loop test desired (speed or torque). Speed Torque
Test positive	3480	%	30.0	-200.0	200.0	Positive going limit of the test waveform.
Test negative	3490	%	-30.0	-200.0	200.0	Negative going limit of the test waveform.
Test time	3500	sec	30.1	0.0	500.0	Sets the time for the drive to spend in either the positive or negative test setting.
Begin test	3510	Function				This Function starts the speed or torque loop test.
Stop test	3520	Function				This function stops the speed or torque loop test.

3.3.4 Auto Menu (4) Options

The Auto Menu (**4**) consists of the following menu options:

- Speed Profile Menu (**4000**)
- Analog Input Menu (**4090**)
- Analog Outputs Menu (**4660**)
- Speed Setpoint Menu (**4240**)
- PID Select Menu (**4350**)
- Comparator Setup Menu (**4800**)

These menus are explained in the tables that follow.

Table 3-33. Speed Profile Menu (4000)

Parameter	ID	Units	Default	Min	Max	Description
Entry point	4010	%	0.0	0.0	200.0	Sets the % of speed cmd at which the drive begins following the speed cmd.
Exit point	4020	%	150.0	0.0	200.0	Sets the % of speed cmd at which the drive stops following the speed cmd.
Entry speed	4030	%	0.0	0.0	200.0	Sets the speed that the drive accelerates to when given a start command when the speed profile function is enabled.
Exit speed	4040	%	150.0	0.0	200.0	Sets the speed that the drive reaches at the exit point.
Auto off	4050	%	0.0	0.0	100.0	Sets the level of cmd at which the drive turns off.
Delay off	4060	sec	0.5	0.5	100.0	Sets a time delay between the time the cmd reaches the Auto Off point and the time the drive shuts off.
Auto on	4070	%	0.0	0.0	100.0	Sets the level of cmd at which the drive turns on.
Delay on	4080	sec	0.5	0.5	100.0	Sets a time delay between the time the cmd reaches the Auto On point and the time the drive starts.

Figure 3-23 illustrates the advantages of using speed profiling control. This method of control provides an increased “usable control range” for the motor. Ultimately, the speed of the motor can be adjusted in much finer increments when speed profiling is used.

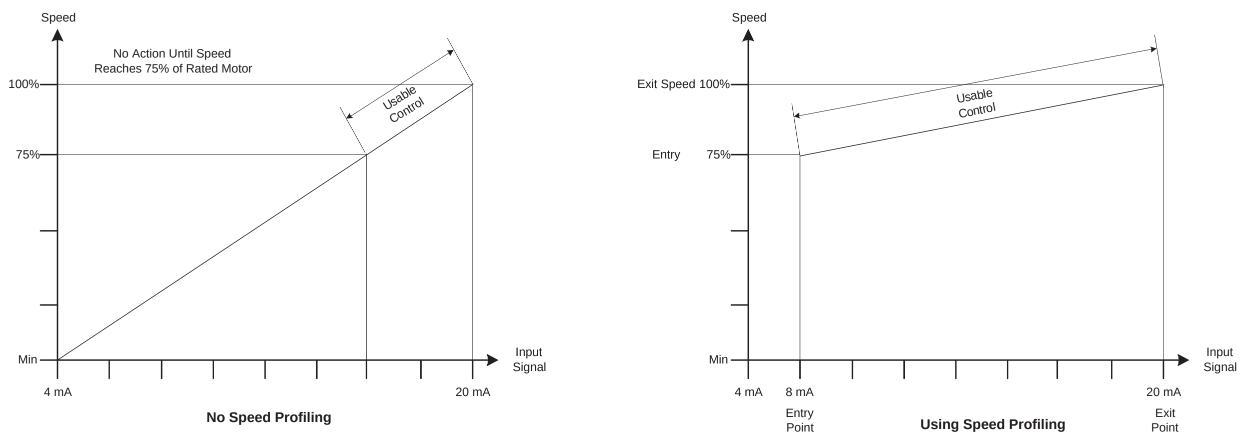

Figure 3-23. Advantages of Using Speed Profiling Control

Table 3-34. Analog Input Menu (4090)

Parameter	ID	Type	Description
Analog input #1	4100	Submenu	Menu for Analog input #1. See Table 3-35.
Analog input #2	4170	Submenu	Menu for Analog input #2. See Table 3-36.
Auxiliary input #1	4500	Submenu	Menu for Auxiliary input #1. See Table 3-38.
Auxiliary input #2	4580	Submenu	Menu for Auxiliary input #2. See Table 3-39.

Note: When an external PID controller is used as the speed reference, Analog Input 1 is used for PID command, and Analog Input 2 is used for PID feedback. See Tables 3-35 and 3-36 for scaling information.

Table 3-35. Analog Input #1 Menu (4100)

Parameter	ID	Units	Default	Min	Max	Description
Source	4105		Off			This parameter sets the input source for analog input #1. Can be any one of 24 External Analog Inputs. Off Ext 1-24
Type	4110		4 – 20mA			This parameter sets the operational mode for analog input 1. 0 - 20mA 4 - 20mA 0 - 10V
Min input	4120	%	0.0	0.0	200.0	Minimum Analog input
Max input	4130	%	100.0	0.0	200.0	Maximum Analog input
Loss point threshold	4140	%	15.0	0.0	100.0	Threshold where loss of signal action is activated. Entered as percentage of upper range for any type. (does not differentiate).
Loss of signal action	4150		Preset			Select loss of signal action. Preset Maintain Stop
Loss of signal setpoint	4160	%	20.0	0.0	200.0	Loss of signal preset speed.

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Table 3-36. Analog Input #2 Menu (4170)

Parameter	ID	Units	Default	Min	Max	Description
Source	4175		Off			This parameter sets the input source for analog input #2. Off Ext 1-3
Type	4180		4 – 20mA			This parameter sets the operational mode for analog input 2. 0 – 20mA 4 – 20mA 0 – 10V
Min input	4190	%	0.0	0.0	200.0	Minimum Analog input
Max input	4200	%	100.0	0.0	200.0	Maximum Analog input
Loss point threshold	4210	%	15.0	0.0	100.0	Threshold where loss of signal action is activated. Entered as percent of upper range for any type. (does not differentiate).
Loss of signal action	4220		Preset			Select loss of signal action. Preset Maintain Stop
Loss of signal setpoint	4230	%	20.0	0.0	200.0	Loss of signal preset speed.

☝ **Note:** When an external PID controller is used as the speed reference, Analog Input 1 is used for PID command, and Analog Input 2 is used for PID feedback. See Tables 3-35 and 3-36 for scaling information.

Table 3-37. Analog Input #3 Menu (4232)

Parameter	ID	Units	Default	Min	Max	Description
Source	4233		Off			This parameter sets the input source for analog input #1. Off Ext 1-24
Type	4234		4 – 20mA			This parameter sets the operational mode for analog input 1. 0 – 20mA 4 – 20mA 0 – 10V
Min input	4235	%	0.0	0.0	200.0	Minimum Analog input
Max input	4236	%	100.0	0.0	200.0	Maximum Analog input
Loss point threshold	4237	%	15.0	0.0	100.0	Threshold where loss of signal action is activated. Entered as percentage of upper range for any type (does not differentiate).
Loss of signal action	4238		Preset			Select loss of signal action. Preset Maintain Stop
Loss of signal setpoint	4239	%	20.0	0.0	200.0	Loss of signal preset speed.

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Table 3-38. Auxiliary Input #1 Menu (4500)

Parameter	ID	Units	Default	Min	Max	Description
Source	4510		Off			Auxiliary input source Off Ext 1-3
Type	4520		4 – 20mA			This parameter sets the operational mode for auxiliary input 1. 0 - 20mA 4 - 20mA 0 - 10V
Min input	4530	%	0.0	0.0	200.0	Minimum auxiliary input.
Max input	4540	%	100.0	0.0	200.0	Maximum auxiliary input.
Loss point threshold	4550	%	15.0	0.0	100.0	Threshold where loss of signal action is activated. Entered as percentage of upper range for any type (does not differentiate)
Loss of signal action	4560		Preset			Select loss of signal action. Preset Maintain Stop
Loss of signal setpoint	4570	%	20.0	0.0	200.0	Loss of signal preset speed.

Table 3-39. Auxiliary Input #2 Menu (4580)

Parameter	ID	Units	Default	Min	Max	Description
Source	4590		Off			Auxiliary input source Off Ext 1-3
Type	4600		4 – 20mA			This parameter sets the operational mode for analog input 1.
Min input	4610	%	0.0	0.0	200.0	Minimum auxiliary input.
Max input	4620	%	100.0	0.0	200.0	Maximum auxiliary input.
Loss point threshold	4630	%	15.0	0.0	100.0	Threshold where loss of signal action is activated. Entered as percentage of upper range for any type. (does not differentiate).
Loss of signal action	4640		Preset			Select loss of signal action. Preset Maintain Stop
Loss of signal setpoint	4650	%	20.0	0.0	200.0	Loss of signal preset speed.

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Table 3-40. Analog Outputs Menu (4660)

Parameter	ID	Units	Default	Min	Max	Description
Analog Output #*n**	4660+4(*n*-1)+1	Submenu				ID of submenu for Analog Output #*n* (*n*=1-16).
Analog variable	4660+4(*n*-1)+2		Total Current			This variable sets the input source for analog output #*n*. See Table 3-41.
Output module type	4660+4(*n*-1)+3		Unip			Sets the output type for the module. Unip (Unipolar) Bip (Bipolar)
Full range	4660+4(*n*-1)+4	%	0.0	0.0	300.0	Scales the output range of the variable selected.

* Each analog output parameter, 1 to 16, contains a submenu consisting of Analog variable, Output module type, and Full range. The formulas presented in the ID column will give you the direct ID number for the corresponding Analog output. For example, for Analog output 4, the Analog output ID will be 4660+4(4-1)+1, or 4673. The Analog variable ID for Analog output 4 will be 4660+4(4-1)+2, or 4674, etc.

3

Table 3-41. Pick list for Analog Variable parameters (all units are %)

Motor Voltage	Total Current	Average Power	Analog Input #1
Motor Speed	Speed Demand	Speed Reference	Analog Input #2
Raw Flux Demand	Flux Reference	Current (RMS)	Analog Input #3
Zero Sequence Av	Neg Sequence D	Neg Sequence Q	Analog Input #4
Input Frequency	Input Power Avg	Input Pwr Factor	Analog Input #5
Ah Harmonic	Bh Harmonic	Total Harmonics	Analog Input #6
Xfmr Therm Level	1 Cycle Protect	Single Phase Cur	Analog Input #7
Under Volt Limit	Out Neutral Volts	Synch Motor Field	Analog Input #8
Motor Torque	Encoder Speed	Input KVAR	Drive Losses
Excess React I	Droop		

Table 3-42. Speed Setpoint Menu (4240)

Parameter	ID	Units	Default	Min	Max	Description
Speed setpoint 1	4250	rpm	0	-18000	18000	Programmable speed setpoint that can be selected through an external contact and the system program.
Speed setpoint 2	4260	rpm	0	-18000	18000	Programmable speed setpoint that can be selected through an external contact and the system program.
Speed setpoint 3	4270	rpm	0	-18000	18000	Programmable speed setpoint that can be selected through an external contact and the system program.
Speed setpoint 4	4280	rpm	0	-18000	18000	Programmable speed setpoint that can be selected through an external contact and the system program.
Speed setpoint 5	4290	rpm	0	-18000	18000	Programmable speed setpoint that can be selected through an external contact and the system program.
Speed setpoint 6	4300	rpm	0	-18000	18000	Programmable speed setpoint that can be selected through an external contact and the system program.
Speed setpoint 7	4310	rpm	0	-18000	18000	Programmable speed setpoint that can be selected through an external contact and the system program.
Speed setpoint 8	4320	rpm	0	-18000	18000	Programmable speed setpoint that can be selected through an external contact and the system program.
Jog speed	4330	rpm	0	-18000	18000	This parameter sets the drive jog speed.
Safety setpoint	4340	rpm	0	-18000	18000	Safety Override preset speed.

Table 3-43. Incremental Speed Setup Menu (4970)

Parameter	ID	Units	Default	Min	Max	Description
Speed increment 1	4971	%	1.0	0.0	200.0	When selected through the SOP it will increase the speed demand by the program amount.
Speed decrement 1	4972	%	1.0	0.0	200.0	When selected through the SOP it will decrease the speed demand by the program amount.
Speed increment 2	4973	%	5.0	0.0	200.0	When selected through the SOP it will increase the speed demand by the program amount.
Speed decrement 2	4974	%	5.0	0.0	200.0	When selected through the SOP it will decrease the speed demand by the program amount.
Speed increment 3	4975	%	10.0	0.0	200.0	When selected through the SOP it will increase the speed demand by the program amount.
Speed decrement 3	4976	%	10.0	0.0	200.0	When selected through the SOP it will decrease the speed demand by the program amount.

3

Table 3-44. PID Select Menu (4350)

Parameter	ID	Units	Default	Min	Max	Description
Prop gain	4360		0.39	0.0	98.996	Sets the PID loop Proportional (P) gain.
Integral gain	4370		0.39	0.0	98.996	Sets the PID loop Integral (I) gain.
Diff gain	4380		0.0	0.0	98.996	Sets the PID loop Derivative (D) gain.
Min clamp	4390	%	0.0	-200.0	200.0	Sets the minimum value for the PID loop integrator.
Max clamp	4400	%	100.0	-200.0	200.0	Sets the maximum value for the PID loop integrator.
Setpoint	4410	%	0.0	-200.0	200.0	Sets a value to be used as the reference setpoint for the external PID loop. The value is set as a percent of full scale.

Note: When an external PID controller is used as the speed reference, Analog Input 1 is used for PID command, and Analog Input 2 is used for PID feedback. See Tables 3-35 and 3-36 for scaling information.

Attention! The user is responsible for providing correct inputs for PDI command and feedback.

Table 3-45. Comparator Setup Menu (4800)

Submenu	Description
Comparator *n* Setup	Submenus that contain 32 sets of comparators for custom use in the system program. Each comparator set (Compare 1 through Compare 32) consists of three parameters that are located in the comparator setup menus. Comparators are system program flags (Comparator1_I through Comparator32_I) which can be used anywhere within the system program environment to control software switches. Refer to Table 3-46.

Table 3-46. Compare 1-32 Setup Menu Parameter Descriptions

Menu Item	Default Value	Description
Comp *n* A in variable select (list) (*n*=1-32)	Manual value	"Comp *n* A" and "Comp *n* B" inputs can be selected from the list in Table 3-47.
Comp *n* B in variable select (list) (*n*=1-32)	Manual value	The comparator flag *compar_**n**_f* (where ***n**=1-16)* in the system program is set true if "Comp *n* A in" > "Comp *n* B in".
Comp *n* manual value	0.0%	Min: -1,000% Max: 1,000%
Compare *n* type (list) (n=1-32)	'Mag' if *n*=1; 'Off' if *n*>1	"Compare *n*" can be set to the following: • signed (e.g., 10 > -50) • magnitude (e.g., -50 > 10) • disabled (no compare is done)

Table 3-47. Variable Pick List for Comparator Setup Submenus

Manual Value		
Analog Input 1	Analog Input 13	Motor speed
Analog Input 2	Analog Input 14	Motor current
Analog Input 3	Analog Input 15	Enter Manual Value
Analog Input 4	Analog Input 16	Manual ID
Analog Input 5	Analog Input 17	Max Avail Out Vlt
Analog Input 6	Analog Input 18	Magnetizing Current Ref (Ids Ref)
Analog Input 7	Analog Input 19	Magnetizing Current (Ids)
Analog Input 8	Analog Input 20	Torque Current Ref (Iqs Ref)
Analog Input 9	Analog Input 21	Torque Current (Iqs)
Analog Input 10	Analog Input 22	Input frequency
Analog Input 11	Analog Input 23	Manual ID Number
Analog Input 12	Analog Input 24	

3.3.5 Main Menu (5) Options

The Main Menu (**5**) consists of the following menu options:

- Motor Menu (**1**)
- Drive Menu (**2**)
- Stability Menu (**3**)
- Auto Menu (**4**)

- Log Control Menu (**6**)
- Drive Protect Menu (**7**)
- Meter Menu (**8**)
- Communications Menu (**9**)
- Security Edit Functions Menu (**5000**)
- Parameter Default/File Functions
- Language and Security Functions

The contents of submenus 1-4 have already been explained earlier in this chapter. The contents of submenus 6-9 are explained later in this chapter. All of these submenus can be accessed directly using the keypad or from the Main Menu (**5**). Refer to the appropriate sections elsewhere in this chapter for descriptions of menu options within these submenus.

Main Menu (**5**) functions and submenus are explained in the tables that follow.

Table 3-48. Main Menu (5) Options

Parameter (ID)	ID	Type	Description
Motor Menu	1	submenu	Provides access to the Motor Menu. See page 3-22.
Drive Menu	2	submenu	Provides access to the Drive Menu. See page 3-26.
Stability Menu	3	submenu	Provides access to the Stability Menu. See page 3-35.
Auto Menu	4	submenu	Provides access to the Auto Menu. See page 3-25.
Log Control	6	submenu	Provides access to the Log Control Menu. See page 3-54.
Drive Protect Menu	7	submenu	Provides access to the Drive Protect Menu. See page 3-57.
Meter Menu	8	submenu	Provides access to the Meter Menu. See page 3-59.
Communications Menu	9	submenu	Provides access to the Communications Menu. See page 3-63.
Security Edit Functions Menu	5000	submenu	This menu contains functions that are used to edit a menu item's security codes. See Table 3-49.
Set Defaults to Current	5045	function	Used to set all default parameters to the current parameter settings.
Reset to Defaults	5050	function	Used to reset all parameters to their factory defaults.
Select Language	5080	pick list	Sets language for keypad. English (default) French German Spanish
Change Security Codes	5090	function	Used to change the security codes for the various security levels used by the drive. Default codes are shown in Table 3-51.
Enter Security Code	5500	function	Used to enter the security code to set the clearance level for access.

An electronic security code is provided to limit unauthorized access to various parameters within the drive equipment. The default factory settings for parameter security codes is as follows:

Table 3-49. Security Edit Functions Menu (5000)

Parameter	ID	Type	Description
Change security level	5010	Function	This function is used to change a menu item's security level. When active, an "x" will appear as the first character on the second line of the display. Please scroll past Main(5) into another menu. The current security level will appear as the last character on the second line of the display. Press [ENTER] to edit the security level for the ID that is shown. Choose among levels 0, 5, 7, or 8. See Table 3-50.
Drive running inhibit	5020	Function	This function is used to change a menu item's run inhibit. When active an "x" will appear as the first character on the second line of the display. The current run inhibit state will appear as the last character on the second line of the display. See Table 3-50.

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Table 3-50. Security Edit Menu Function Descriptions (5010, 5020)

ID	Name	Description
5010	Change Security Level Level = 0,5,7,8	"Change security level" prohibits access to menu or menu items until "enter security level" is set to that level or higher. Sets the level of security on that particular menu item.
5020	Drive Running Inhibit 1 = enable 0 = disable	Prohibits certain parameters from being changed when drive is in the Run State (D). Drive running lockout will not allow the parameter to be changed while the drive is running. "0" indicates that a parameter may be changed while the drive is running. "1" indicates that a parameter may not be changed while the drive is running.

CAUTION!-Do not change the Drive Running Inhibit (5020) setting of any parameter unless you are completely certain that the change is safe. Changes may result in massive environmental and property destruction, injuries, and/or loss of life.

When you select either of these functions, the display returns to the top of the Main Menu (5), allowing you to navigate the menu system as you normally would. When the menu item to be changed is displayed, press the ENTER key to edit the security level, An asterisk character (*) appears on the left of the display to indicate that the menu or submenu is in the security edit mode, and not in normal mode.

Press the CANCEL key to exit the security edit mode.

Table 3-51. Default Security Access Levels and Access Codes

Access Level	Default Access Code	Level of Security
0	None	Minimum Access
5	5555	Startup Access for Service and/or Startup
7	7777	Advanced Access for Troubleshooting
8	Proprietary	Factory Use Only

Note that menu options above security level 5 are more technical in nature and are typically used by Siemens personnel during commissioning or servicing.

The Security Edit Menu (5000) can be accessed to change the factory default security settings. When the Harmony is configured for security level 7 access, the Security Edit Menu (5000) is visible from the Main Menu (5). Functions within this menu are used to set the security levels for menu items, to "hide" menu items, and to prevent changes to specific parameters. The Security Edit Functions Menu (5000) contains security functions described in Table 3-51.

3.3.6 Log Control Menu (6) Options

The Log Control Menu (**6**) consists of the following menu options:

- Event Log Menu (**6180**)
- Alarm/Fault Log Menu (**6210**)
- Historic Log Menu (**6250**)

The contents of these menus are explained in the tables that follow.

Table 3-52. Event Log Menu (6180)

The event log is stored in a file on the CompactFLASH. The maximum file size is 65Kbytes. The file is overwritten once the maximum size is reached.

Parameter	ID	Units	Default	Min	Max	Description
Upload event log	6190	Function				Upload the event log via the RS232 serial port.
Clear event log	6200	Function				Used to clear the event log.

Table 3-53. Alarm/Fault Log Menu (6210)

Parameter	ID	Units	Default	Min	Max	Description
Alarm/Fault log display	6220	Function				Used to display the fault log.
Alarm/Fault log upload	6230	Function				Upload the fault log via the RS232 serial port.
Alarm/Fault log clear	6240	Function				Used to clear the fault log.

Table 3-54. Historic Log Menu (6250)

The historic log is stored in non-volatile battery backed up RAM. Seventy-eight "snapshots" are recorded at the slow cycle update rate, 58 before a fault occurs and 20 after. If the "Store in event log" is "On", several historical logs can be stored. The maximum number is limited by the event log size (512Kbytes).

Parameter	ID	Default	Description
Store in event log Historic log variable 1	6255 6260	On Spd Ref	When selected, the Historical log is stored in the event log Select the 1st variable for the historic log. See Table 3-55 for pick list variables.
Historic log variable 2	6270	Trq I Cmd	Select the 2nd variable for the historic log. See Table 3-55 for pick list variables.
Historic log variable 3	6280	Mtr Flux	Select the 3rd variable for the historic log. See Table 3-55 for pick list variables.
Historic log variable 4	6290	Pwr Out	Select the 4th variable for the historic log. See Table 3-55 for pick list variables.
Historic log variable 5	6300	I Total Out	Select the 5th variable for the historic log. See Table 3-55 for pick list variables.
Historic log variable 6	6310	Mag I Fdbk	Select the 6th variable for the historic log. See Table 3-55 for pick list variables.
Historic log variable 7	6320	Mtr Flux	Select the 7th variable for the historic log. See Table 3-55 for pick list variables.
Historic log upload	6330		Upload Historic log to serial port.

3

Table 3-55. Pick List Variables for Historic Log (all units are %)

Abbreviation	Description
Mtr Spd	Motor speed
Spd Ref	Speed reference
Spd Dmd	Raw Speed Demand
Trq I Cmd	Torque Current Command
Trq I Fdbk	Torque Current Feedback
Mag I Cmd	Magnetizing Current Command
Mag I Fdbk	Magnetizing Current Feedback
I Total Out	Total Motor Current
Mtr Volt	Motor Voltage
Mtr Flux	Motor Flux
V Avail	Line Voltage Available
V Avail RMS	Line Voltage RMS
Pwr Out	Output Power
V Neutral	Output Neutral Volts
I Total In	Total Input Current
Pwr In	Input Power
Freq In	Input Frequency
KVAR In	Input reactive power PU
Xcess I Rct	Excessive input reactive current (above limit) PU
Freq Out	Output Frequency PU
Drv Loss	Internal drive power losses in PU input power
Droop	Speed Droop PU

Note: See Appendix D for Historical Log Fault word decoder.

3.3.7 Protect Menu (7) Options

The Drive Protect Menu (**7**) consists of the following menu options:

- Input Protect Menu (**7000**)
- Single Phasing Menu (**7010**)

These menus are explained in tables that follow.

Table 3-56. Drive Protect Menu (7) Parameters

Parameter	ID	Units	Default	Min	Max	Description
Input Protection	7000	Submenu				Input protection parameters. See Table 3-57.
Drive IOC Setpoint	7110	%	150.0	50.0	200.0	Drive instantaneous overcurrent setpoint (as a percentage of drive output rating).
Cell Overload Level	7112	%	100.0	100.0	150.0	Cell current overload (as a percentage of drive output rating) allowed for 1 minute out of every 10 minutes.
Auto Reset Enable	7120		No			Enables the reset of the Drive after a fault.
Auto Reset Time	7130	sec	1	0	120	Adjusts the time between the fault and its automatic reset.
Auto Reset Attempts	7140		4	1	10	The number of attempts a drive will be reset before a permanent shutdown.
Auto Reset Memory Time	7150	sec	10	1	1000	The amount of time between faults that will clear the attempts counter.
Fault Reset	7160	function				Issues a Drive fault reset when selected.

3

Table 3-57. Input Protect Menu (7000)

Parameter	ID	Units	Default	Min	Max	Description
Single phasing	7010	Submenu				Single phasing protection parameters. See Table 3-58.
Undervoltage prop gain	7060		0.0	0.0	10.0	Under voltage PI regulator proportional gain term.
Undervoltage integ gain	7070		0.001	0.0	1.0	Undervoltage PI regulator integral gain term.
1 Cyc Protect integ gain	7080		0.0025	0.0	1.0	Gain of integral regulator for detecting excessive input reactive current. Output of this regulator is used to fault the drive in case high reactive currents flow in the input (other than the instant when MV is applied to the drive). Adjust the gain to change the response to high reactive currents.
1 Cycle Protect Limit	7081	%	50.0	0.0	100.0	Integrator output level at which drive issues a 1 Cycle Protect Fault.
Xformer tap setting	7050	%	0			Choose from the {-5,0,+5%} settings to match transformer tap setting.
Xformer thermal gain	7090		0.0133	0.0	1.0	Gain of integral regulator to limit input current to 105% of its rated value.
Xformer protection const	7100		0.5	0.0	10.0	Gain to adjust model of input transformer. Use the default value of 0.5.
Phase Imbalance Limit	7105	%	40.0	0.0	100.0	Input current level (as a percent of Rated Input Current) above which Input Phase Imbalance Alarm is issued.
Ground Fault Limit	7106	%	40.0	0.0	100.0	Level above which drive issues an Input Ground Fault Alarm.
Ground Fault Time Const	7107	sec	0.2	0.001	2.0	Time constant of filter used for averaging input neutral voltage.

Table 3-58. Single Phasing Menu (7010)

Parameter	ID	Units	Default	Min	Max	Description
SPD prop gain	7020		0.0	0.0	10.0	Single phase detector PI regulator proportional gain term.
SPD integral gain	7030		0.001	0.0	1.0	Single phase detector PI regulator integral gain term.
SPD threshold	7040	%	50.0	0.0	100.0	Regulator output level below which an alarm is generated

3.3.8 Meter Menu (8) Options

The Meter Menu (**8**) consists of the following menu options:

- Display Parameters Menu (**8000**)
- Hour Meter Setup Menu (**8010**)
- General Drive Parameters Menu (Set Time, Software Version, Language, Output Units)
- Input Harmonics Menu (**8140**)

These menus are explained in tables that follow.

Table 3-59. Meter (8) General Drive Parameters

Parameter	ID	Units	Default	Min	Max	Description
Display Parameters	8000	Submenu				This menu contains display parameters. See Table 3-60.
Hour Meter Setup	8010	Submenu				This menu contains hour meter setup. See Table 3-62.
Input Harmonics	8140	Submenu				This menu contains input harmonics. See Table 3-63.
Fault Display Override	8200		Off			Enables or disables the display of Fault/Alarm messages on the keypad.
Set the clock time	8080	Function				Used to change the time and date of the real-time clock chip.
Display version number	8090	Function				Displays the installed version of firmware.
Customer order	8100		0	0	9999999	Customer order number (7 decimals)
Customer drive	8110		1	0	20	Customer drive number.

Table 3-60. Display Parameters Menu (8000)

Parameter	ID	Default	Description
Status variable 1	8001	DEMD	Select variable 1 to be displayed on the LCD display. Pick List – See Table 3-61.
Status variable 2	8002	%SPD	Select variable 2 to be displayed on the LCD display. Pick List - See Table 3-61.
Status variable 3	8003	VLTS	Select variable 3 to be displayed on the LCD display. Pick List - See Table 3-61.
Status variable 4	8004	RPM	Select variable 4 to be displayed on the LCD display. Pick List - See Table 3-61.

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This menu contains the pick lists to select the variables to be displayed on the front panel default display.

Note: Table 3-61 contains name, abbreviation, display and variable columns of standard pick list variables (used in the Historic Log Menu, the Display Variable Menu, etc.). The name column contains the name of the display variable. This is what is displayed as the user scrolls through the list of available display variables. The abbreviation column contains an abbreviation that is displayed after a variable is selected from the list. The display column contains an even more abbreviated form of the variable name. This final abbreviation (between 2 and 5 characters in length) is what the Perfect Harmony displays on the front panel of the drive. The variable column shows the associated system program variable for reference.

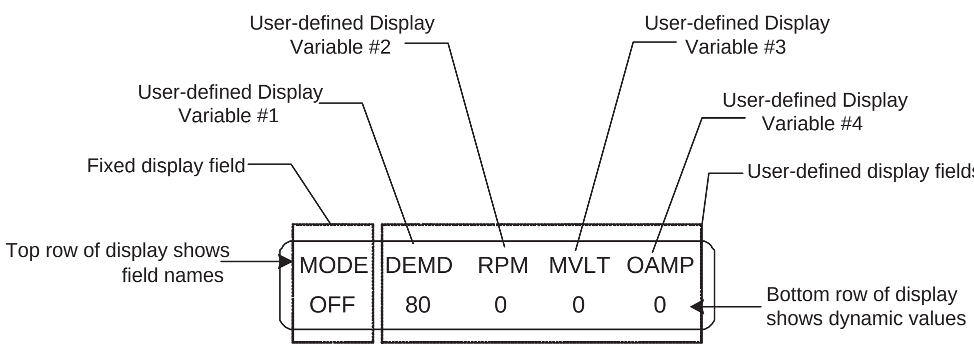

Figure 3-24. Dynamic Programmable Meter Display

Table 3-61. Pick List Variables for the Front Display

Abbreviation	Description & Units	Abbreviation	Description & Units
IMRF	Magnetizing current ref (A)	VAIN	Phase A input voltage (V)
ITRF	Torque current ref (A)	VBIN	Phase B input voltage (V)
FLDS	Flux DS (%)	VCIN	Phase C input voltage (V)
FLQS	Flux QS (%)	VZSQ	Zero sequence voltage (V)
VDRF	Vds reference (%)	VNSD	Negative sequence D voltage (V)
VQRF	Vqs reference (%)	VNSQ	Negative sequence Q voltage (V)
SLIP	Slip frequency (%)	VDIN	Input D voltage (V)
%SPD	Motor speed (%)	VQIN	Input Q voltage (V)
FREQ	Motor speed (Hz)	VAVI	Input voltage (V)
RPM	Motor speed (RPM)	FRIN	Input frequency (Hz)
VLTS	Motor voltage (V)	KWIN	Input power average (kW)
IMAG	Magnetizing current filtered (A)	PFIN	Input power factor (%)
ITRQ	Torque current filtered (A)	HRCA	Ah harmonic coefficient (%)
ITOT	Motor current (A)	HRCB	Bh harmonic coefficient (%)
%TRQ	Torque out (%)	HARM	Total A, B harmonics (%)
KWO	Output power (kW)	XTHL	Transformer thermal level (%)
RESS	Stator resistance	1CRI	One cycle reactive current level (%)
DEMD	Speed demand (%)	SPHI	Single phasing current level (%)
SREF	Speed reference (%)	UNVL	Under Voltage level (%)
FDMD	Raw flux demand (%)	EFF	Efficiency (%)
FXRF	Flux reference (%)	THD	Total Harmonic Distortion (%)
IDIN	Id input current (A)	VNGV	Output Neutral Voltage (V)
IQIN	Iq input current (A)	%VNG	Output Neutral Voltage (%)
IAIN	Phase A input current (A)	SMFC	Synch Motor Field Current (A)
IBIN	Phase B input current (A)	%ESP	Encoder Speed (%)
ICIN	Phase C input current (A)	ERPM	Encoder Speed (RPM)
IAVI	Total input current (A)	KVAR	Input KVAR in PU power
	Phase A filter current (A)	LOSS	Drive losses in PU input power
IBF	Phase B filter current (A)	IXEX	Input Excessive Reactive current (Amps)
ICF	Phase C filter current (A)	UXFR	Up transfer state machine value
MVAO	Measure phase A volts (V)	DXFR	Down transfer state machine value
MVBO	Measured phase B volts (V)	%DRP	Percent Droop (in speed)
MVCO	Measured phase c volts (V)		
MVNG	Measured output neutral voltage (V)		
% MAV	Max avail output volts (%)		

Table 3-62. Hour Meter Setup (8010)

Parameter	ID	Units	Default	Min	Max	Description
Display hour meter	8020	Function				Used to display the amount of time that the drive has been operational since it was commissioned.
Preset hour meter	8030	Function				Used to preset the hour meter to the accumulated time that the drive has been operational since it was commissioned (in the event that a micro board has been replaced on an existing drive).
Reset hour meter	8040	Function				Used to reset the hour meter when the drive is commissioned.
Display Output kWH meter	8050	Function				Displays the total output kW hours that have been accumulated since the drive was commissioned.
Preset output kWH meter	8060	Function				Presets the output kW hour counter to a previous value (when the microboard is replaced).
Reset output kWH meter	8070	Function				Resets the output kW hour counter to zero.
Display input kWH meter	8072	Function				Displays the total input kW hours that have been accumulated since the drive was commissioned.
Preset input kWH meter	8074	Function				Presets the input kW hour counter to a previous value (when the microboard is replaced).
Reset input kWH meter	8076	Function				Resets the input kW hour counter to zero.

Table 3-63. Input Harmonics Menu (8140)

Parameter	ID	Units	Default	Min	Max	Description
Selection for HA	8150		IA			Selection for harmonic Analysis • IA • IB • IC • VA • VB • VC
Harmonics order	8160		1.0	0.0	30.0	Harmonic Order
Harmonics integral gain	8170		0.001	0.0	1.0	Harmonics regulator integral gain term

3.3.9 Communications Menu (9) Options

The Communications Menu (**9**) consists of the following menu options:

- Serial Port Setup Menu (**9010**)
- Network Control (**9943**)
- Network 1 Configure (**9900**)
- Network 2 Configure (**9914**)
- Serial Functions (**9110**)
- TCP/IP Setup (**9300**)

These menu items are explained in tables that follow.

Table 3-64. Communications Menu (9) Parameters

Parameter	ID	Units	Default	Min	Max	Description
Serial port setup	9010	Submenu				This menu contains all serial port setup parameters. See Table 3-65.
Network Control	9943	Submenu				Please refer to Communications manual (number 902399).
Network 1 Configure	9900	Submenu				
Network 2 Configure	9914	Submenu				
Display Network Monitor	9950	Function				
Serial echo back test	9180	Function				
Sop & serial Functions	9110	Submenu				This menu contains functions that utilize the local serial port. See Table 3-66.
TCP/IP Setup	9300	Submenu				This menu contains functions which set the parameters for TCP/IP. See Table 3-67.

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Table 3-65. Serial Port Setup Menu (9010)

Parameter	ID	Units	Default	Min	Max	Description
Serial port use	9020		Local			Designates the usage of the on board serial port. • Remote • Modem • Local
Modem password	9025					Four character password can consist of 1-9, A-F (Hex).
Flow Control	9030		Xon/ Xoff			Designates the type of flow control used by the serial port. • None • Xon/Xoff
Baud rate	9040		19200			Designates the baud rate of the on board serial port: • 9600 • 19200 • 38400 • 57600 • 115200

Table 3-66. Serial Functions Menu (9110)

Parameter	ID	Units	Default	Min	Max	Description
System program download	9120	Function				Used to transfer the system program to a remote system.
System program upload	9130	Function				Used to transfer the system program from a remote system.
Display sys prog name	9140	Function				Displays the current system program name.
Display drectry version	9147	Function				Displays current directory file version.
Select system program	9145		none			Displays the list of system program files.
Multiple config files	9185		Off			Enables multiple configuration files.
Parameter data upload	9150	Function				Used to transfer the current configuration file to a remote system.
Parameter data download	9160	Function				Used to transfer the current configuration file from a remote system.
Parameter dump	9170	Function				Used to get a print out of the current configuration data.
Menu based timer setup	9111	Submenu				Menu contains the menu-based SOP timers 1-16.
Menu timers 1-8	9112 - 9119	Sec	0	0	86400	
Menu timers 9-16	9121 - 9128	Sec	0	0	86400	

Parameter upload functions are used to transmit data from the drive to a printer or computer. Parameter download functions are used to transmit data to the drive. A terminal emulator such as Smart Term's "ST220.EXE" or Procomm's "PCPLUS" is required to upload, download, and echo files. Windows "Terminal" protocol settings for the RS232 port are 9600 baud, no parity, and one stop bit.

Note that all parameters are printed on the parameter dump.

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Table 3-67. TCP/IP Setup Menu (9300)

Parameter	ID	Units	Default	Min	Max	Description
IP address	9310		172.16.106.16	0.0.0.0	255.255.255.255	Used to enter the system IP address in dotted decimal.
Subnet mask	9320		255.255.0.0	0.0.0.0	255.255.255.255	Used to enter the system subnet mask in dotted decimal.
Gateway address	9330		172.16.1.1	0.0.0.0	255.255.255.255	Used to enter the system gateway address in dotted decimal.

3

Menu Setup for Multiple Configuration Files (Slaves)

The NXG drive is designed to operate with multiple motors that may or may not be of the same size. This is accomplished by using multiple parameter configuration files. There is one master configuration file that is always named current cfg. The slave files are stored in a sub directory of CfgFiles named SubCfgs and can have any legal name conforming to the “eight dot three” file naming convention. (xxxx xxxx.yyy)

NOTE: All slave configuration files have the ‘.sfg’ extension. This is not changeable through the menus, therefore only eight characters can be chosen.

The configuration files can be created at runtime in the drive’s memory and then stored to a flash disk. The slave files are created via the keypad menus by setting the slave parameters as desired and writing them to a flash disk. (More on this in the application section, in Chapter 5).

There are up to eight SOP flags that can be set to point to a configuration file. The menus are used to map each SOP flag to a corresponding configuration file. Once mapped, the SOP flags are used to activate the SOP for a particular motor.

Menu item descriptions

Multiple config files	This pick list enables the switching of the slave configuration files. If set to OFF, no other multiple configuration file menus will be displayed. Once enabled, if any one of SOP flags is set to true, the corresponding configuration file will become active.
Show active config file	Function to display the current active configuration file. If correct configuration file is not displayed, the SOP file should be checked for accuracy. Check the ‘Setup SOP configuration flags menu to be sure the correct file is mapped to the SOP flag.
Set active config file	This pick list sets the displayed file to be the active configuration file. This function overrides what is set in the SOP program. Any change in the SOP program is checked against the file set in this function. Once a change in the SOP is detected, that file will then be the active file. The keypad menu setting is now ignored. This insures no unintentional toggling of the configuration files. To switch back to the keypad file set it by this menu. If no change in the SOP program occurs, the keypad set configuration file will remain in memory.
Setup SOP config flags	Submenu for SOP flag configuration.

Create new config file	This function allows you to save slave parameters to a file name you specify. The name is entered using the drive keypad. To get to the alphanumeric characters, you must use the left or right arrow keys to position the cursor. Then using the up or down arrow keys, scroll to the desired letter or number.
Set SOPConfigFileX_O (X = 1 to 8)	This function allows you to map the name of the flag in the SOP file, SOPConfigFileX_O, where X = 1 to 8, to a name of a slave configuration file. Then, when the SOP program is running, and this flag is set to 'true', the configuration file will be switched into memory. This is a method of switching among multiple motors using one drive. The file names are selected from a pick list. New files can be created using the method described previously.

☝ **NOTE**: You do not need to add the file extension. The file extension is **always** 'sfg'. Press the 'enter' key to save the parameter(s) as they exist in memory to a new configuration file name. This file will be stored to the flash disk in the 'SubCfgs' subdirectory. This function does **NOT** make this configuration file the active configuration file. It uses the current data in memory to create a new slave configuration file. Any parameter that is saved to a slave configuration file is easily identifiable by the small '**s**' adjacent to the parameter ID number if it has not changed from the default setting, or a '**$**' if it has been changed from its default setting, i.e. (s9586) or ($9586).

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Table 3-68. Slave Parameter

Parameter	ID	Units	Default	Min	Max	Description
Multiple config files	9185		OFF			Enable multiple config file operation.
Show active config file	9195					Display current active config file.
Set active config file	9196		Defaults.sfg			Set the displayed file to be the active config file.
Setup SOP config flags	9186		Sub menu			Sub-menu for SOP flag configuration.
Create new config file	9197					Create new config file using numeric keypad.
Set SOPConfigFile1_O	9187		Defaults.sfg			Set name of config file #1 that corresponds to the SOP flag #1.
Set SOPConfigFile2_O	9188		Defaults.sfg			Set name of config file #2 that corresponds to the SOP flag #2.
Set SOPConfigFile3_O	9189		Defaults.sfg			Set name of config file #3 that corresponds to the SOP flag #3.
Set SOPConfigFile4_O	9190		Defaults.sfg			Set name of config file #4 that corresponds to the SOP flag #4.
Set SOPConfigFile5_O	9191		Defaults.sfg			Set name of config file #5 that corresponds to the SOP flag #5.
Set SOPConfigFile6_O	9192		Defaults.sfg			Set name of config file #6 that corresponds to the SOP flag #6.
Set SOPConfigFile7_O	9193		Defaults.sfg			Set name of config file #7 that corresponds to the SOP flag #7.
Set SOPConfigFile8_O	9194		Defaults.sfg			Set name of config file #8 that corresponds to the SOP flag #8.

Table 3-69. Parameter Menu - Slave

Parameter	ID	Parameter	ID
Motor Menu			
Motor kW rating	1010	50 Percent Break Point	1156
Motor frequency	1020	100 Percent Break Point	1157
Full load speed	1030	Maximum Load Inertia	1159
Motor voltage	1040	Motor trip volts	1160
Full load current	1050	Overspeed	1170
No load current	1060	Underload enable	1180
Leakage inductance	1070	I underload	1182
Stator resistance	1080	Underload timeout	1186
Inertia	1090	Motor torque limit 1	1190
Overload select	1130	Regen torque limit 1	1200
Overload pending	1139	Motor torque limit 2	1210
Overload	1140	Regen torque limit 2	1220
Overload timeout	1150	Motor torque limit 3	1230
0 Percent Break Point	1152	Regen torque limit 3	1240
10 Percent Break Point	1153	Phase Imbalance Limit	1244
17 Percent Break Point	1154	Ground Fault Limit	1245
25 Percent Break Point	1155	Ground Fault Time Const	1246
Drive Menu			
Control loop type	2050	Skip center freq 3	2370
Ratio control	2070	Skip bandwidth 1	2380
Speed fwd max limit 1	2080	Skip bandwidth 2	2390
Speed fwd min limit 1	2090	Skip bandwidth 3	2400
Speed fwd max limit 2	2100	Freq avoid accel time	2410
Speed fwd min limit 2	2110	Spinning load mode	2430
Speed fwd max limit 3	2120	Scan end threshold	2440
Speed fwd min limit 3	2130	Current Level Setpoint	2450
Speed rev max limit 1	2410	Current ramp	2460
Speed rev min limit 1	2150	Max current	2470
Speed rev max limit 2	2160	Frequency scan rate	2480
Speed rev min limit 2	2170	Cond. stop timer	2500
Speed rev max limit 3	2180	Cond. run timer	2510
Speed rev min limit 3	2190	Min cells/phase count (n/3)	2540
Accel time 1	2270	Fast bypass	2600
Decel time 1	2280	Phase I gain	2710
Accel time 2	2290	Phase P gain	2720
Decel time 2	2300	Phase offset	2730
Accel time 3	2310	Phase error threshold	2740

Parameter	ID	Parameter	ID
Decel time 3	2320	Frequency Offset	2750
Jerk rate	2330	Up Transfer Timeout	2760
Skip center freq 1	2350	Down Transfer Timeout	2770
Skip center freq 2	2360	Cable Resistance	2940
Stability Menu			
Flux reg prop gain	3110	Integ gain during brake	3290
Flux reg integral gain	3120	Enable braking	3360
Flux Filter Time Const	3130	Pulsation frequency	3370
Flux demand	3150	Brake power loss	3390
Flux ramp rate	3160	VD Loss Max	3400
Energy saver min flux	3170	Braking constant	3410
Speed reg prop gain	3210	Test Type	3470
Speed reg integral gain	3220	Test positive	3480
Speed reg Kf gain	3230	Test negative	3490
Speed filter time const	3240	Test time	3500
Current reg prop gain	3260	Slip constant	3545
Current reg integ gain	3270	Feed forward constant	3560
Prop gain during brake	3280		
Auto Menu			
Entry point	4010	Delay on	4080
Exit point	4020	Prop gain	4360
Entry speed	4030	Integral gain	4370
Exit speed	4040	Diff gain	4380
Auto off	4050	Min clamp	4390
Delay off	4060	Max clamp	4400
Auto on	4070	Setpoint	4410
Logs Menu			
Historic log variable 1	6260	Historic log variable 5	6300
Historic log variable 2	6270	Historic log variable 6	6310
Historic log variable 3	6280	Historic log variable 7	6320
Historic log variable 4	6290		
Drive Protection Menu			
Auto reset Enable	7120	Auto Reset Attempts	7140
Auto Reset Time	7130	Auto Reset Memory Time	7150
Display Configuration Data Menu			
Status variable 1	8001		8005
Status variable 2	8002		8006
Status variable 3	8003		8007
Status variable 4	8004		

Parameter	ID	Parameter	ID
Meters Menu			
Customer Order	8100	Harmonics order	8160
Customer Drive	8110	Harmonics integral gain	8170
Selection for HA	8150	Fault Display Override	8200

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CHAPTER

4 Startup Procedure

4.1 Introduction

This chapter outlines the necessary steps that are required to successfully startup a Perfect Harmony drive from a pre-power visual inspection to a complete medium voltage motor test. These checks are discussed individually within the separate sections of this procedure. Following any introductory text and precautions, each section contains a series of individual steps. Tables may be included in some sections. Some tables are used to record parameter settings, test point data, and any errors or deviations from expectations.

DANGER—Electrical Hazard! The steps outlined in the following procedure could cause serious injury or death if the drive has not been properly installed and checked. Before proceeding, be sure to remove power from the drive and follow proper lock out and tag out procedures.

DANGER—Electrical Hazard! Hazardous voltages may still exist within the Perfect Harmony cabinets even when the medium voltage disconnect switch is open (off) and the control power switch is shut off (for example, internally stored energy found in cells).

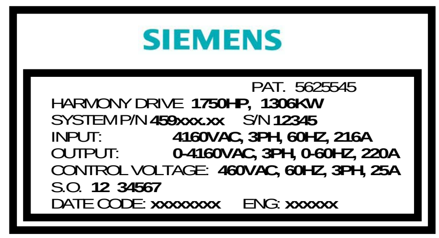
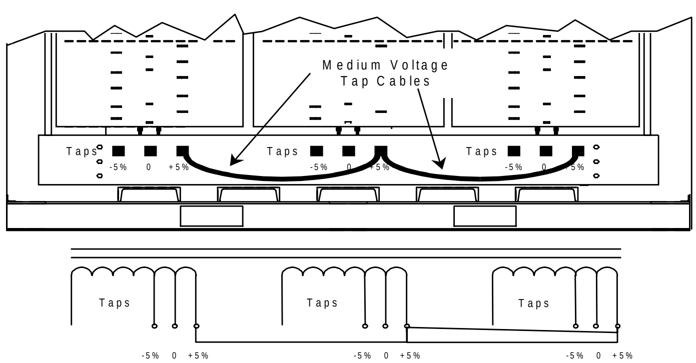
Warning! Never disconnect control power while medium voltage is energized. This will disable the cooling system and potentially cause severe overheating of the system and possibly cause damage to the cells.

Note: Proper drive setup will require the use of a DC voltmeter, an AC voltmeter and a dual-trace oscilloscope for testing purposes. In addition, a 3-phase, 460 volt source is required. (690 volt for high voltage cells. With 55 A fuses, a fixed, three-phase voltage source can also be used with a voltage of 270 V for 460 V cells or 390 V for 690 V cells.

4.2 Pre-power Visual Inspection

Before power is applied to the drive, pre-power visual inspections must be conducted. Verify the system specifications as detailed below.

Table 4-1. Pre-power Visual Inspection

Step	Description
1	Verify the source voltage to the drive matches the drive specification. The drive's intended input voltage is specified on the foil label located inside the control panel door. See Figure 4-1. (Note: This foil label may be located in the customer connection cabinet.)
2	The drive's maximum output voltage as stated on the foil label should match the motor's voltage rating as stated on the motor nameplate. See Figure 4-1. If they do not match, contact the factory.
3	The control voltage (low voltage) must match the drive's control voltage ratings as stated on the foil label. See Figure 4-1.
4	The motor nameplate power rating must match the drive's power rating. Refer to Figure 4-1.  **Figure 4-1. Sample System Nameplate**
5	Verify that the two tap cables for the medium voltage input are securely connected to the three transformer taps. These connections should be made to the +5% taps on each of the three coils of the transformer. The other taps are used only when the power requirements of the system (or the voltage source) are not sufficient for system operation. In low line voltage situations, moving to the "0" taps will increase voltage by 5%. Refer to Figure 4-2. The input voltage must be high enough for transfer jobs, to ensure that the available output voltage can match the input line voltage. Also ensure that parameter 2050 (xformer tap setting) is set to match the actual setting.  **Figure 4-2. Transformer Cabinet Detail Showing Typical Tap Connections**
6	Verify that all wiring between the transformer and cell cabinet shipping splits has been properly and securely re-connected.
7	Inspect all connections and wiring ensuring that they are connected appropriately and securely. Verify all torque markings are properly aligned on all electrical connections including power connections. Tighten any incorrect connections in accordance with the torque specifications listed in the Installation Manual.

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Step	Description
8	Ensure that all electrical connections are tight and that all torque markings are intact. Verify that no sheet metal damage nor excessive coating damage has occurred. If found, verify the integrity of the components, cables or other materials behind or below the damage.
9	Check all cabling for splitting and/or cracking. Verify that no conductors are exposed due to chafing or other shipping abuse.
10	If applicable, ensure that all stress cones are adequately connected to ground and installed properly on the cables.
11	Verify the presence of markings or labels on all terminal strips, mounted components, cells, and other sub-assemblies. Notify the factory of any discrepancies.
12	Verify the presence and proper installation of all protective covers.
13	Verify the installation of the fan hood. Verify that the fan rotates freely while mounted.
14	Ensure that control and main power are installed and connected properly and in accordance with local regulations.
15	Verify all customer connections for tightness and accuracy.
16	Standard safety precautions and local codes must be followed during installation of external wiring. Protective separation must be kept between extra low voltage (ELV) wiring and any other wiring as specified in the CE safety standard.
17	To maintain EMC compliance, be sure to use shielded cables as described on the drawings shipped with the Perfect Harmony system.
18	Control wiring for GEN II and GEN III Perfect Harmony Drives must be routed down the wireway where the EMI filter is located. (typically the left side), then to the disconnect switch. These wires must be kept away from the output (filtered side) of the EMI Filter. Use of metallic electrical conduit is required to maintain EMC Compliance.
19	Verify that all system grounds are connected between shipping splits. Verify that the system ground is connected to a suitable site ground in accordance with local regulations. Ensure that the entire system is earth grounded at one of its grounding points. Grounding points are located inside the cabinet and are labeled with the protective earth symbol ⏚.

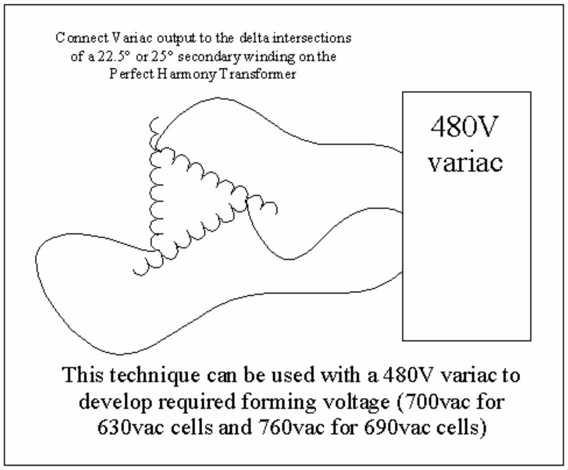
Note: If any of the previous checks yield inconsistent or unusual results, cancel the startup procedure and notify the factory.

4

4.3 Power Circuit, Modulation and Bypass Contactor Test

This test can be performed with a single 55A, 3-phase, 480VAC variac (see Figure 4-3 for the variac connection diagram) and an optional PC/Laptop with Siemens's Tool Suite. Full voltage can be supplied to all cells

Table 4-2. Power Circuit, Modulation, and Bypass Contactor Test

Step	Description
1	To connect the PC/Laptop to the Pentium control processor, use an Ethernet cable with a RJ-45 standard jack along with a crossover cable.
2	Disconnect the series connection between **T1** and **T2** of all adjacent cells. Disconnect the motor leads or open the motor contactor. Connect a 3-phase variac (see Figure 4-3) to the input of cell B1, in addition to the existing cables from the transformer.  **Figure 4-3. 480 VAC Variac Connection Technique**
3	Connect an AC voltmeter to the input of any cell. Turn on the control power to the Control Cabinet and verify that the control properly initializes.
4	Make sure the Drive Parameters (2000) match the rated values for the Drive. Set the Control Loop Type (2050) to Open Loop Test Mode.
5	Verify that the Input Voltage (3030) and Input Current (3040) Scalers (Stability -> Input Processing) are set to the default values of 1.0.
6	Select the correct Transformer Tap Setting using Drive Protect -> Input Protect -> Xformer Tap Setting (7050).
7	Turn on the variac and slowly increase the variac's output voltage to about 75VAC. Measure all cell input voltages to make sure they are all receiving approximately the same voltage. The "Not Safe" neon light should be lit on each Cell Control Board. If all cell voltages are OK, continue increasing the variac to 230VAC and make sure all of the switch-mode power supplies are working (the Lnk ON and cell fault LEDs on the cell control boards should be ON). Continue increasing the voltage to 460VAC (see TN00137 for high voltage cells). Push the Fault Reset Button on the Keypad. All power cell faults should be reset and the normal keypad display should appear. The previous steps verify that the main power transformer is OK and the Attenuator Module in the Transformer Cabinet is properly connected.

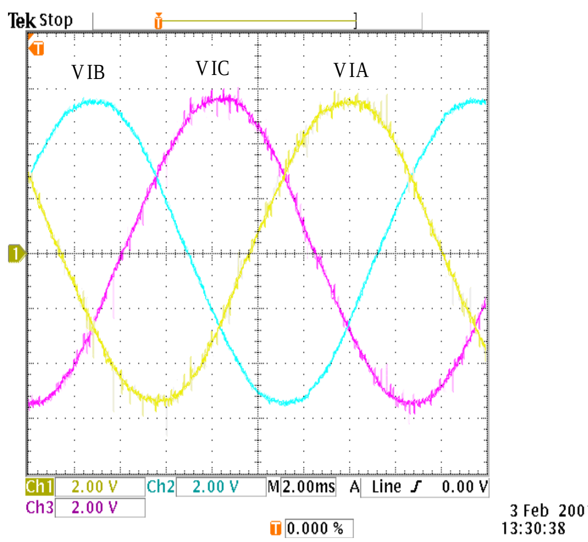
4

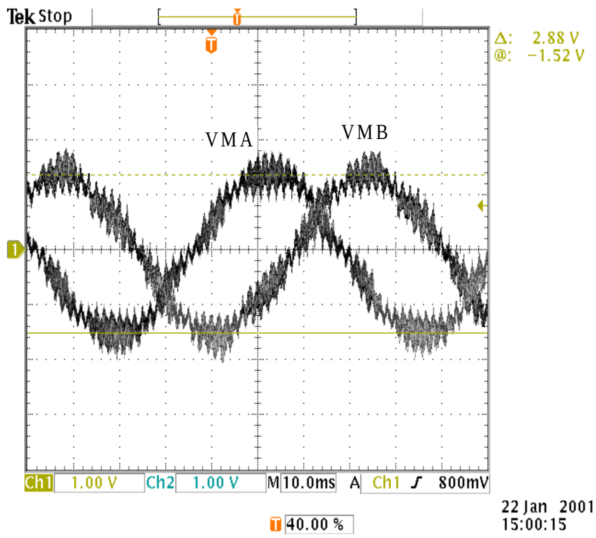
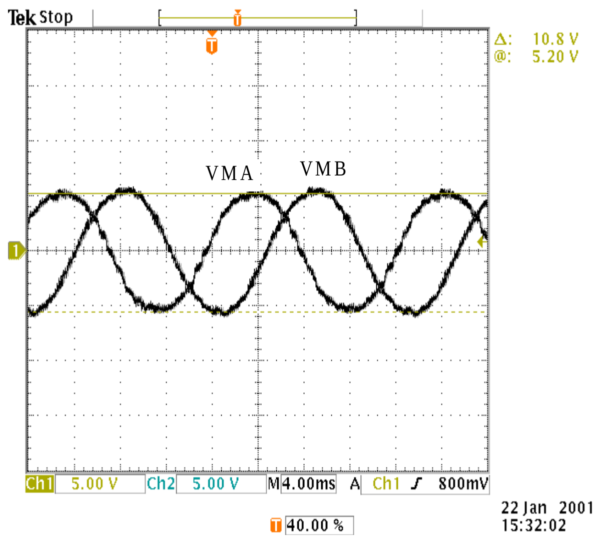
Step	Description
8	Check the modulation at the outputs of all cells by placing the VFD in the run mode. Verify that the 4 LED's (Q1 – Q4) on each Cell Control Board should illuminate.
9	Perform this test only if the Drive is equipped with Mechanical Bypass Contactors. Stop the drive by giving a STOP command. Once the drive is in the OFF or IDLE state, change the Control Mode (2050) to Open Loop Vector Control ENABLE Fast (cell) Bypass (2600). Access this parameter through Drive -> Cells -> Fast Bypass. Also make sure that in the Cells submenu, the Min. Cells/Phase Count (2540) is set to be one less than the installed rank of cells. On the keypad, select Bypass Status (2620). The display should show all "A" (available) characters. The order displayed is A-phase (1 through *n*), B-phase (1 through *n*), and C-phase (1 through *n*), where n represents the number of cells per phase. Pull a fiber-optic link for an A-phase cell (e.g., A1) out of the fiber-optic interface board. Check Bypass Status (2620). It will now display a "B" (bypassed) character in the location for the cell that the fiber was removed from. Repeat steps A and B for a cell from each of the other two phases (e.g., B1 and C1). Re-connect all fiber-optic links to their corresponding cells and reset their bypass status using Reset Bypassed Cells (2640). Repeat steps A through C until all bypass contactors have been verified. Make sure all fiber-optic links are connected back in the correct order before moving to the next step.
10	Shut down the AC supply to the control and the variac. Disconnect the variac.

4.4 Drive Test in Open Loop Test Mode without Motor

The following steps verify operation of the drive (**without** a motor) in Open Loop Test Mode.

Table 4-3. Drive Test in Open Loop Test Mode without Motor

Step	Description
1	Reconnect the series connections between T1 and T2 of all adjacent cells, plus the neutral connection between cells A1, B1 and C1.
2	Secure all doors to the Cell and Transformer Cabinets.
3	Enable the blower motor and remove any interlock jumpers.
4	Re-energize the AC control power. Energize the medium voltage feeder.
5	Change the Control Loop Type (2050) back to Open Loop Test Mode.
6	DISABLE Spinning Load using Drive (2) -> Spinning Load (2420) -> Spinning Load Mode (2430).
7	Make sure that Fast bypass (2600) is DISABLED. Access this parameter through Drive -> Cells -> Fast Bypass.
8	Configure the Keypad to display input voltage (VDIN), input frequency (FRIN) and motor voltage (VLTS).
9	Set the Motor Rated Voltage (1040) parameter (access it through Motor -> Motor Parameters) to be equal to the Drive Rated Output Voltage and the Motor Frequency (1020) equal to 60Hz.
10	Verify that the Keypad displays the correct value of input voltage and frequency. At rated primary voltage, the AC input voltage feedback on test points VIA, VIB and VIC should be 10.80Vpp or 3.82Vrms. See Figure 4-4. These test points are on the system interface card. Perform the following corrective step if the input (or line) voltage is too high or too low.  **Figure 4-4. AC input voltages at test-points VIA, VIB and VIC on system interface card** If the input voltage to the drive is too high, then this needs to be corrected. Harmony Drives are shipped with the transformer tap set to + 5% which reduces the voltage by that percentage on the secondary side of the transformer. If the voltage is low (5% less than rated) then change the tap on the transformer to the neutral (“O”) or the –5 % tap. If the input frequency is displayed as a negative number then one pair of input phases has to be switched.

Step	Description
11	Enter a speed demand of 25% and give the RUN command. The AC output voltage on test-points VMA, VMB and VMC should be 2.70Vpp +/-0.27V (measure the average peak-to-peak voltage) or 0.96Vrms +/-0.20V. See Figure 4-5 for signals on test-points VMA and VMB at 25% speed (15Hz).  **Figure 4-5. AC output voltages at test-points VMA and VMB at 15Hz in Open Loop Test Mode**
12	Increase the speed demand to 50%. The output feedback signals should increase in proportion. Note that in Open Loop Test Mode the flux regulator is not perfect and hence the output voltage will read higher or lower than the calculated value corresponding to 50% of rated voltage. Adjust the Flux Demand parameter (3150) such that the motor voltage (on the Keypad or Tool) is approximately equal to 50% of rated voltage. Further increase the speed demand to 100%. The AC output voltage on test-points VMA, VMB and VMC should be 10.80Vpp +/-0.27Vor 3.82Vrms +/-0.20V. The Motor Voltage on the Keypad should read the rated value of output voltage +/-5%. See Figure 4-6 for the AC output voltage waveforms VMA and VMB at 60Hz.  **Figure 4-6. AC output voltages at test-points VMA and VMB at 60Hz in Open Loop Test Mode**

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4.5 Drive Test in Open Loop Test Mode with Motor Connected

The following steps verify operation of the drive (**with** a motor connected at its output) in Open Loop Test Mode. This test is required only when the operation of the output Hall Effect Transducers requires to be verified . During this test the motor should be unloaded. If this test is not required then proceed to the next test.

Table 4-4. Drive Test in Open Loop Test Mode with Motor Connected

Step	Description
1	Disconnect control voltage and medium voltage sources. Reconnect motor leads or enable motor contactor.
2	Energize the control circuit breaker. Energize input voltage.
3	Set the Motor Rated Voltage (1040) and Frequency (1020) parameters (access it through Motor -> Motor Parameters) to be equal to the motor nameplate values.
4	Make sure that Spinning Load Mode (2430) and Fast Bypass (2600) are DISABLED.
5	Increase the Speed Ramp parameters in order to slow down drive acceleration and deceleration. Speed ramp setup (2260) Accel time 1 (2270) 60.0 sec or greater Decel time 1 (2280) 60.0 sec or greater
6	Reduce the Flux Demand parameter to 0.5. Stability (3) Output Processing (3050) Flux Control (3100) Flux demand (3150) 0.5
7	Energize the medium voltage feed to the VFD. Push the Fault Reset Button on the Keypad to reset faults and push the Button a second time to acknowledge any alarms. If the Mode on the Keypad display reads RLBK, then change the Control Loop Type (2050) to Open Loop Vector Control and exit out of the menu entry. This should force the RLBK on the Keypad to change back to Mode. Then change the Control Loop Type (2050) back to Open Loop Test Mode.
8	Configure the Keypad to display motor magnetizing current, motor torque current and motor voltage.
9	Spin the motor at 1% speed and observe proper rotation.

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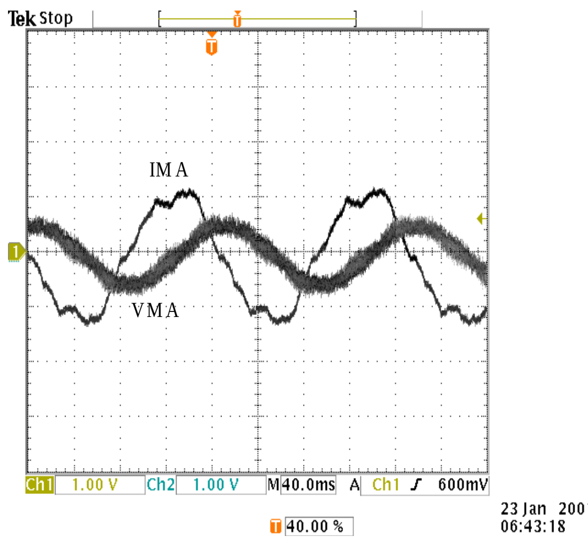
Step	Description
10	Operate the drive with a Speed Demand of 10%. Observe the AC output voltage feedback and motor current for phase A on test-points VMA and IMA using an oscilloscope. • Since the motor is unloaded the current waveform should lead the voltage waveform by almost 90° (see Figure 4-7). The Hall Effect Current Transducers introduce a negative sign since they are configured to measure the incoming current. Check test-points VMB, IMB and VMC, IMC for similar waveforms. • The Keypad display should read a positive average value for Ids (magnetizing current) and a small value for Iqs (the torque current). Note that the Keypad displays of Ids and Iqs will not show constant values. This is because in the Open loop Test Mode, the drive does not have good control of the currents. The average value of Ids should be equal to half the no-load current of the motor while the average value of Iqs should be nearly zero.  **Figure 4-7. Open Loop Test Mode operation at 10% speed with an unloaded motor. AC motor voltage and motor current at test-points VMA and IMA are shown.**

4.6 Drive Test in Open Loop Vector Control Mode with Motor Connected

At this point the VFD is ready for actual (*induction*) motor operation. The following steps verify operation of the drive and the load induction motor in Open Loop Vector Control Mode. If the drive is connected to a synchronous motor then use the steps in the following section.

Table 4-5. Drive Test in Open Loop Vector Control Mode with Motor Connected

Step	Description
1	Reconnect motor leads or enable motor contactor, if required.
2	Energize the control circuit breaker.
3	Change the drive Control Loop Type (2050) to Open Loop Vector Control.
4	DISABLE Spinning Load Drive (2) Spinning Load (2420) Spinning Load Mode (2430) Disabled [Enable]
5	Setup the Speed Ramp parameters according to the following recommendation: The acceleration and deceleration rate for a fan should be set to around 60 seconds and for a pump around 30 seconds. Speed ramp setup (2260) Accel time 1 (2270) 30.0 sec Decel time 1 (2280) 60.0 sec
6	Verify that Fast (cell) bypass is disabled at this time if you have that option Fast bypass (2600) Disabled
7	Setup the following motor parameters according to the nameplate values. Motor parameter (1000) Motor frequency (1020) Hz Full load speed (1030) rpm Motor voltage (1040) V Full load current (1050) A Motor kW Rating (1010) kW
8	Use default values for the other motor parameters as shown below. For this test set the Stator Resistance to 0.1%. The entry within square braces refers to the no-load field current setting for Synchronous Motor Control. Leakage inductance (1070) 16.0 % Stator resistance (1080) 0.1 % No load current (1060) 25.0 % [No load Field Current = 15.0%] Inertia (1090) 30.0 Kgm^2

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Step	Description		
9	Setup the Motor Overload and Torque Limits as shown below. Set the Motor Trip Volts to be equal to 120% of the Motor Rated Voltage or to the value required by the customer. Set the Overspeed parameter to be 120% or to the value required by the customer.		
	Limits	(1120)	
	Overload select	(1130)	Constant
	I overload Pending	(1139)	100.0 %
	I overload	(1140)	110.0 %
	Overload timeout	(1150)	60.0 sec
	Motor Trip Volts	(1160)	4800 V or value required by customer
	Overspeed	(1170)	120 % or value required by customer
	Motor torque limit 1	(1190)	100.0 %
	Regen torque limit 1	(1200)	-0.3 %

Step	Description			
10	Verify that the control loop gains are at their default values as shown below. Entries within square braces refer to settings for Synchronous Motor Control.			
	Stability	(3)		
	Output Processing	(3050)		
	Flux Control	(3100)		
	Flux reg prop gain	(3110)	1.72	[0.50]
	Flux reg integral gain	(3120)	1.00	[0.50]
	Flux filter time const	*(3130)*	*0.0667 sec*	*[0.022 sec]*
	Flux demand	(3150)	1.0	
	Flux ramp rate	(3160)	0.5 sec	
	Energy saver min flux	(3170)	100 %	
	Speed Loop	(3200)		
	Speed reg prop gain	(3210)	0.02	
	Speed reg integral gain	(3220)	0.046	
	Speed reg Kf gain	(3230)	0.60	
	Speed filter time const	(3240)	0.0488 sec	
	Current Loop	(3250)		
	Current reg prop gain	(3260)	0.50	
	Current reg integral gain	(3270)	25.0	
	Braking	(3350)		
	Enable braking	(3360)	Disable	
	Pulsation frequency	(3370)	275.0 Hz	
	Output Processing	(3050)		
	Output current scaler	(3440)	1.0	
	Output voltage scaler	(3450)	1.0	
	Stability	(3)		
	Dead time comp	(3550)	12.0 usec	
	Feed forward constant	(3560)	0.0	
	Carrier frequency	(3570)	600.0 Hz	
	Note:			
	Auto-Tuning modifies the italicized menu items in the above list.			

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Step	Description
11	For **synchronous motors** make sure that the WAGO Analog Output module providing the command for the Field Supply is correctly selected. Select the appropriate Analog Module # within the Analog Outputs sub-menu (4660). For this analog module select: • Synch Motor Field as the Analog Variable • Unipolar as the Module Type • 100% for the Full Range
12	Verify the System Operational Program and Customer Interface.
13	Energize the medium voltage feed to the VFD. Push the Fault Reset Button on the Keypad to reset faults and push the Button a second time to acknowledge any alarms. Spin the motor at 1% speed and observe proper rotation, if this was not verified in the previous test.
14	Configure the Keypad to display motor magnetizing current, motor torque current, and motor voltage
15	Operate the drive with a Speed Demand of 10%. Observe the AC output voltage feedback and motor current for phase A on test-points VMA and IMA using an oscilloscope. • If the motor is unloaded, then the current waveform should lead the voltage waveform by almost 90° (see Figure 4-8 [top frame]). The Hall Effect Current Transducers introduce a negative sign since they are configured to measure the incoming current. The Keypad display should read a positive value of Ids (magnetizing current) equal to the no-load current of the motor and Iqs (the torque current) should read a small value (typically 1-3% of rated current). • If the motor is loaded then the current waveform will lead the motor voltage by an angle smaller than 90° (see Figure 4-8 [bottom frame]). Ids would still read a positive value that is larger than the no-load current while Iqs would read a value larger than zero. The sign of Iqs directly depends on the direction of rotation. • The motor voltage should be 10% of the motor rated voltage.
16	Increase the Speed Demand while monitoring the motor voltage. The motor voltage should read according to the following table. See Figure 4-9 for waveforms at 100% speed (60Hz). Table 4-6 shows the drive voltage scaling for signals on test-points VMA, VMB and VMC as a function of speed. Table 4-7 lists the scaling for the currents and voltage feedback signals available on the Signal Conditioning Board at the rated operating point of the drive.

Table 4-6. Scaling of drive output voltage as a function of speed

Speed Command (%)	Motor Speed (Hz)	Motor Voltage Feedback (V, pp)	Motor Voltage Feedback (V, rms)
10	6	1.08	0.38
25	15	2.70	0.96
50	30	5.40	1.91
75	45	8.10	2.87
100	60	10.80	3.82

Table 4-7. Scaling of drive input and output voltages and currents on Signal Conditioning Board.

Variable	Rated value (rms) at drive terminals	Feedback value under rated conditions (Vpeak)	Feedback value under rated conditions (Vrms)
Input Current	Primary Current Rating of Input CT	5.0	3.54
Input Voltage	(Rated Input Voltage L-L) / 1.732	5.4	3.82
Output Current	Output Current Rating (≡ Cell Rating)	5.0	3.54
Output Voltage	(Rated Output Voltage L-L) / 1.732	5.4	3.82
Examples -	Output Current Scaling: Cell current rating ≡ 3.54 Vrms Output Voltage Scaling: [(Rated output voltage L-L) / 1.732] * 1.414 ≡ 5.4 Vpeak		

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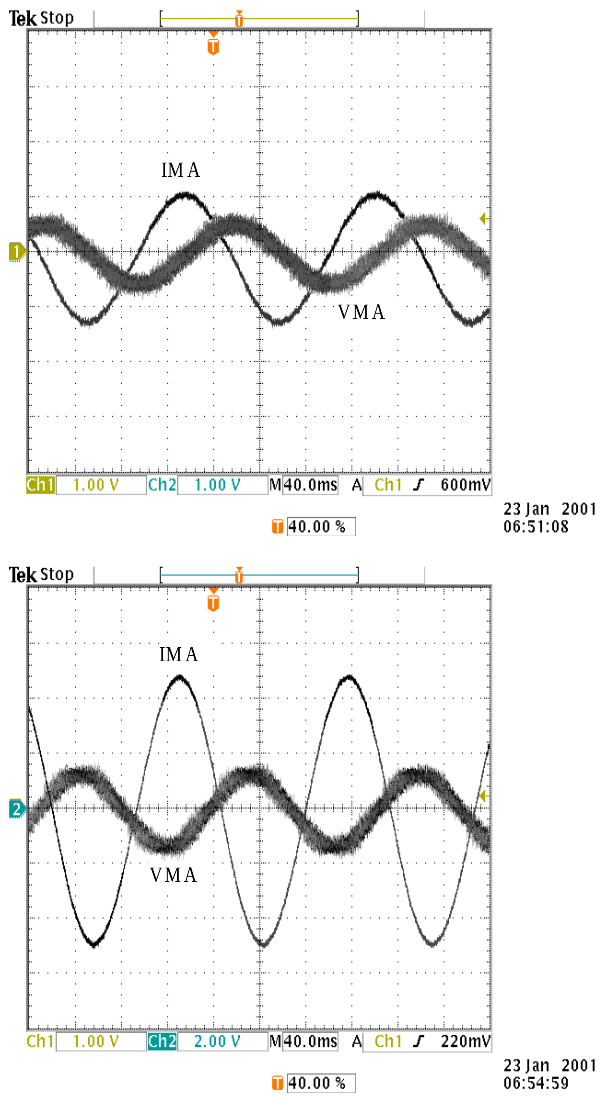

Figure 4-8. AC motor voltage and motor current at test-points VMA and IMA at 10% speed in Open Loop Vector Control
(a) Unloaded Operation and (b) Full Load Operation

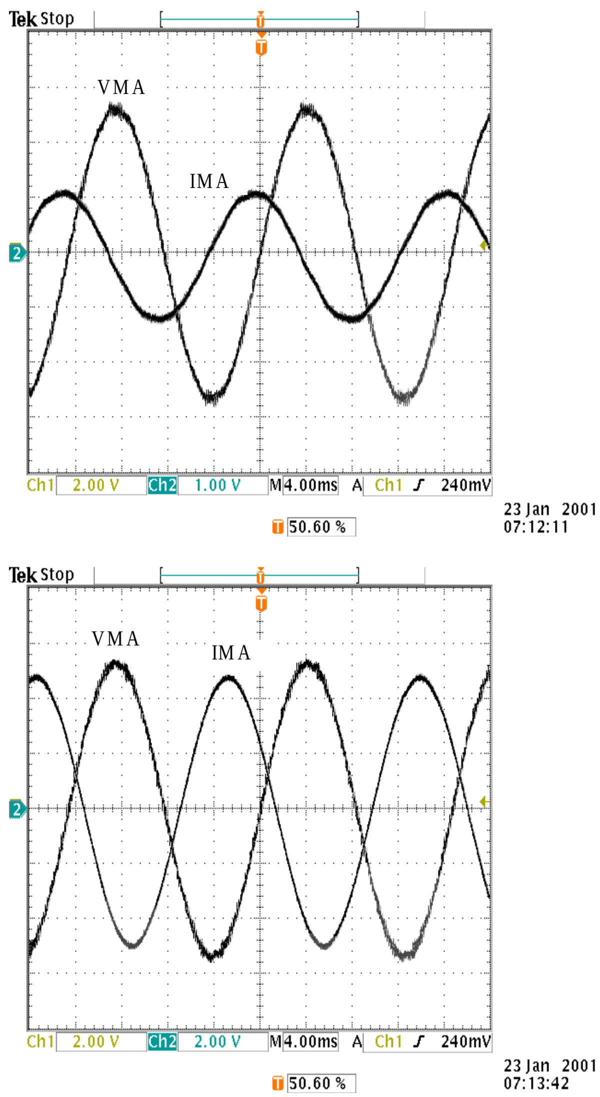

Figure 4-9. AC motor voltage and motor current at test-points VMA and IMA at 100% speed in Open Loop Vector Control
(a) Unloaded Operation and (b) Full Load Operation

4.7 Drive Test in Synchronous Motor Control Mode

This section tests the operation of the VFD with a synchronous motor. A 3PCI regulator is typically used for the exciter supply. The following items are required for tuning the 3PCI regulator:

4-20mA current output box.

If the drive is not equipped with meters for displaying output voltage and output current, then DVMs are needed for observing the voltage and current (in one of the phases) at the output of the 3PCI regulator.

Values of (a) rated output current of 3PCI, (b) maximum field current for the synchronous motor field, and (c) rated synch motor field current.

Drawing #479150 (3PCI control schematics) and the drawing (shipped with drive) that shows connections to the 3PCI regulator will be helpful during setup.

Warning! Field current should not be applied for more than a few minutes at a time to prevent damage to the field current windings.

DANGER! During the following tests, high voltages may be present on the stator side of the motor.

4.7.1 Tuning the 3PCI (SCR Regulator)

Perform the following set-up changes and tests to tune the 3PCI. The following should be performed with a stationery motor. For these tests MV is not required on the drive. Make sure that the input voltage sequence to the 3PCI is correct.

Table 4-8. Tuning the 3PCI (SCR Regulator)

Step	Description
1	**Jumper and Potentiometer Settings.** Ensure that the jumper and potentiometer setting are set as follows: **Jumper:** **J1** Should be OPEN, i.e. not connected to any other terminal (for NO ramp) **J2** Position A (for Standard Integrator) **J3, J4** Position B (for Current Regulation) **J5** Position B (for Current Regulation) **Potentiometer:** Set all pots as stated below, and then adjust them as described in Step 3 . These are 10-20 turn pots except for P3 (single turn pot): **P100** Full CCW **P1** This is the bias pot and is required to be adjusted with zero command so that the SCRs are barely (but not) phased-on **P2** This adjusts the gain for current feedback scaling. Set to full CW. **P3** This adjusts the max current limit for the 3PCI. Viper of P3 (at Pt. C, block D8, sheet 2, drawing #479150) should be connected to Pt. C1. This should be first set to Full CW. **P4** Full CCW
2	Point A (block J8, sheet 2 of drawing #479150) should not be connected to either Pt. A1 or Pt. A2.

Step	Description
3	Make sure that the output contactor of the 3PCI is closed. Apply 480V power to the field supply and make the following adjustments as required: (1) Adjustment of the bias pot – P1. a. Check the type of WAGO module that is used to provide the field exciter current command. It should be an Analog Output module with either a 0-20 mA or a 4-20mA output. b. If the module is a 4-20mA type, then connect a 4-20mA box between terminals 7 and 1 on TB1 (refer to block A8, sheet 1 of drawing #479150). Set the output for 4mA. c. If the module has a 0-20mA output, then do not connect any device to the reference inputs on TB1. d. Adjust pot P1 until the SCRs just begin to be gated-on, i.e. the output voltage meter will begin to show output volts. (2) Adjustment of the gain adjust pot – P2. a. Connect the 4-20mA current output box to terminals 7 and TB1, if not already done. Increase the command slowly towards 20mA while monitoring the current as the output of the field exciter. At 20mA, the output of the 3PCI should be equal to its rated output (which 60A in this case). Adjust P3 to make sure that the rated current is observed with a 20mA command. b. If the winding resistance is such that the rated current cannot be achieved (because the 3PCI regulator runs out of voltage capability), then adjust 20mA to be equal to the max expected field current (50A in this case) which should be smaller than the PCI current rating. If such an adjustment is made, then skip the adjustment for P3 and leave pot P3 in the Full CW position. (3) Adjustment of max current limit pot – P3. c. With the command adjusted for 20mA, adjust P3 until the output current of the 3PCI is reduced to the max field current required for the application (which is 50A in this case).

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4.7.2 Testing 3PCI Connection to the VFB

The following tests verify the WAGO connection of the VFD to the 3PCI Regulator.

Table 4-9. Testing 3PCI Connection to the VFD

Step	Description
1	Change the variable selection for the Analog Output (that is being used for 3PCI control) from *Synch Motor Field I* to *Speed Demand*. This will allow for control of the 3PCI current from the drive Keypad.
2	Make sure that the output contactor of the 3PCI is closed. With zero Speed Demand, the 3PCI should put out zero voltage.
3	Increase the Speed Demand 10%. Verify that the 3PCI output is 10% of the (3PCI) Full-Scale setting.
4	Further increase the Speed Demand to 50%. Verify that the 3PCI output is 50% of the (3PCI) Full-Scale setting.

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4.7.3 Drive Test with Synchronous Motor

The following procedure verifies operation of drive with a synchronous motor in Synchronous Motor Control Mode.

Table 4-10. Drive test with Synchronous Motor

Step	Description
1	Connect the synchronous motor to the drive. Enter motor parameters and use default gains except for the following parameters: (1) Enter Synch Motor Field no-load current as the No-load Current setting (1060). This parameter should be calculated (in %) on the basis of the actual no-load field current and the maximum capability of the 3PCI regulator. Example: Drive with a synchronous motor that requires 24A of no-load field current and a 3PCI that is tuned such that 75A is the maximum output (at 20mA command input), then the No-Load Current Parameter should be set to: No-Load Current setting = 100% *24/75A = 32.0% (2) Enable Spinning Load (2420). (3) Change the drive control loop type (2050) to Synchronous Motor Control. (4) Use default control loop gains except for the flux loop gains that should be changed as follows: Flux reg prop gain (3110) 0.50 Flux reg integral gain (3120) 0.50 Flux filter time coast (3130) 0.022 sec (5) The SOP should have been modified to include the logic for controlling the 3PCI output contactor. The contactor should be ON as soon as the Start command to the drive is given and should be turned OFF immediately when the drive trips on a Fault or when the drive goes to Coast State (while stopping).
2	Energize medium voltage to the drive. Run the drive with a speed demand of 10%.
3	Verify that after Start command is given, the 3PCI (field supply) first starts by applying current and building motor flux. During this time Ids and Iqs should be zero.
4	After a time period equal to the Flux Ramp Rate parameter (3160), the drive starts by increasing the Speed Reference to the Speed Demand.
5	With Synchronous Motors, the drive current is always in phase with the voltage, i.e., Ids ≈ 0 under steady-state conditions. At no-load, there is very little current supplied from the drive (on the Keypad, motor current display, ITOT ≈0).
6	Run the drive to 10% speed. Verify that the no-load and full load (if possible) current waveforms along with the drive voltage waveforms as shown in Figure 4-10.
7	Run the drive to 100% speed. Verity that the no-load and full-load (if possible) current waveforms along with the drive voltage waveforms are as shown in Figure 4-10**.** Note that the drive output currents at 100% speeds are distorted. This is due to the shape of the poles in the synchronous motor. At low speeds the current regulator bandwidth is sufficient to correct for the distortion introduced by the motor poles as shown in the second figure of Figure 4-10. However, at high speeds, the current regulator gains are insufficient to maintain sinusoidal output currents when the distortion is due to motor pole construction.

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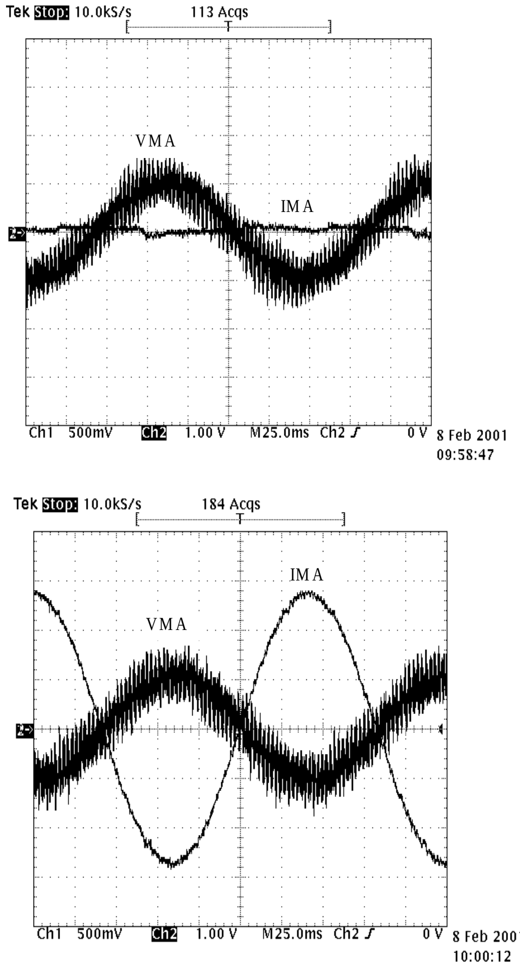

Figure 4-10. AC motor voltage and motor current at test-points VMA and IMA at 10% speed with Synchronous Motor Control
(a) Unloaded and (b) 75% torque operation

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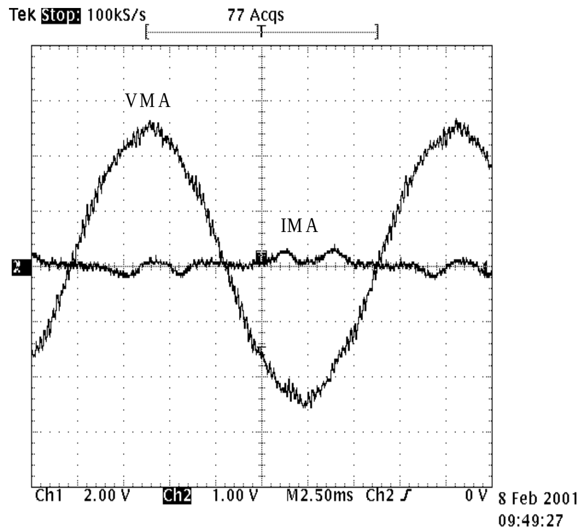

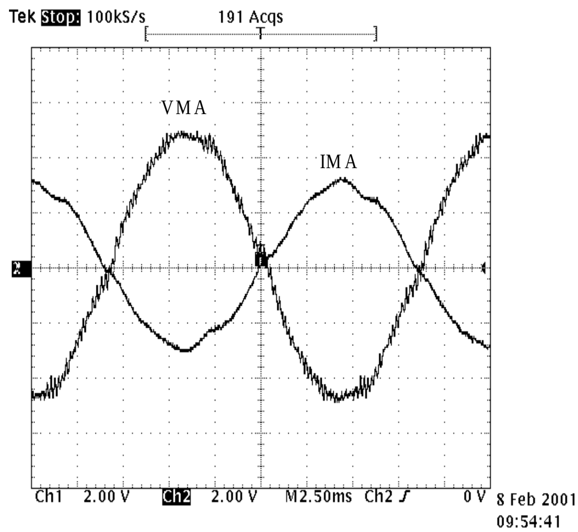

Figure 4-11. AC motor voltage and motor current at test-points VMA and IMA at 100% speed with Synchronous Motor Control (a) Unloaded and (b) 75% torque operation

4.8 Drive Tuning

Use the following sections to complete the startup of the drive. The first section describes Auto-Tuning and its use in determining motor and control parameters. The second section describes the setup of the Spinning Load Menu. This feature is used by the drive control to detect motor speed by scanning the output frequency over the operating range of the application. The last section lists the other menus that may need adjustment for completing the drive setup.

4.8.1 Auto-Tuning

The basic motor parameters can be divided into two categories - nameplate data and equivalent circuit data. Nameplate data, as the name suggests, is readily available (such as Motor Rated Voltage, Full Load Current, etc.). However, equivalent circuit data (such as Stator Resistance, No-load Current, etc.) is available only from the motor manufacturer.

Notes: (1) Auto Tuning is **optional**, but is recommended for applications in which high performance, as stated above, is required. (2) The correct equivalent circuit data is *required only when* good control performance, such as high starting torque or very low speed operation, is desired.

When operating an induction motor, the drive control has the capability to perform Auto-Tuning. This feature allows the drive to estimate parameters of the motor equivalent circuit. There are two stages of auto-tuning; each stage being selected individually. Apart from measuring the motor equivalent circuit parameters during auto-tuning, the control uses the measured motor parameters to adjust the control loops for best possible control bandwidth (the bandwidth for each control loop is fixed internally in software) and hence provides good performance in demanding applications.

Such a feature provides drive tuning without the need for an extensive adjustment procedure. Although, the auto-tuning feature can be used with all induction motors, there are some limitations. Both stages of auto-tuning can be performed with induction motors (OLVC or CLVC). However, o*nly Stage 1 should be performed with Synchronous Motors (SMC or CSMC) or when Output Filters are connected.*

Note: In most general-purpose applications (such as pumps and fans) default data for the motor equivalent circuit is sufficient and auto-tuning is not necessary.

- **Autotune Stage 1 (1260)**
  Stage 1 determines the Stator Resistance and Leakage Inductance. This stage of auto tuning does not require the motor to be de-coupled from the load. The motor does not rotate during this Stage. The data obtained from stage 1 are used to tune the inner regulators that control motor current. The current loop gains are automatically calculated and saved by the control.

DANGER—LETHAL VOLTAGES!! Lethal voltages will appear on the drive outputs during **both** stages (1 and 2) of Auto Tuning.

- **Autotune Stage 2 (1270**)

  Stage 2 determines the no-load motor current and the motor inertia. The motor rotates at 30% of rated speed during this stage. Generally, this stage of auto tuning requires the motor to be de-coupled from the load. Make sure that it is ok (to spin the motor) with the customer before this test is enabled. Data obtained in stage 2 are used to optimize the operation of the outer loops that control motor speed and motor flux. The speed and flux loop gains are automatically calculated and saved by the control.

DANGER!! The motor will spin during stage 2 of Auto Tuning.

Note: Quadratic loads, such as pumps and fans, do not require the motor to be de-coupled. The control is designed to minimize the errors introduced by such loads.

4.8.2 Spinning Load

Spinning Load should be enabled if one or more of the following operating modes/features are selected:

- Fast Bypass
- Auto-Restart (controlled through the auto reset parameters (7120-7150) and the SOP)
- Synchronous Motor Control (SMC and CSMC)
- Closed Loop Vector Control (CLVC)

Note: Spinning Load does not provide instantaneous restart with V/Hz control.

Note: With synchronous motors, spinning load is always instantaneous, i.e. the drive will never go into a scan mode.

Perform the following steps to tune the scan mode of Spinning Load. Use the Tool Suite to monitor Motor Flux (FluxDS), Motor Speed and Speed Reference.

Table 4-11. Tuning the Scan Mode of Spinning Load

Step	Description
1	Enable Spinning Load and make sure the following parameters are set to the values shown.
2	Spinning Load (2420) Spinning Load Mode (2430) Forward or Reverse, whichever is appropriate Scan end threshold (%) (2440) 20 % Current level set point (%) (2450) 25 % [or equal to the No-load current setting] Current ramp (s) (2460) 0.01 s Max current (%) (2470) 50 % Scan time (s) (2480) 3.0 s
3	Operate the drive with a demand of 30%.
4	Trip the drive by using ESTOP.
5	Wait for the motor flux to decay below 4%. This can take more than a few seconds for large horsepower or high efficiency motors.
6	Reset ESTOP (and hit Fault Reset if required) and give a RUN command.
7	On the Tool Suite monitor the speed reference and motor speed at the moment the drive 'catches' the motor. If the speed reference is higher than the motor speed, then the drive has 'caught' the motor too soon. In this case, increase the Scan End Threshold parameter (2440). If the speed reference is lower than the motor speed, then the drive has 'missed' the motor. In this case, reduce the Scan End Threshold parameter (2440).
8	Repeat steps 3 through 7 until the speed reference and motor speed (at the moment the drive 'catches' the motor) are within a few percent of each other.

4.8.3 Application Menus

Setup the following Menus according to user/application requirements:

- Motor Limits (1120) including Phase Imbalance (1244) and Ground Fault (1245)
- Speed Profile Menu (4000)
- Bypass Type (2590) and Fast Bypass (2600)
- Critical Frequency Menu (2340)
- Drive Protection Menu (7)
- Display Parameters Menu (8000)

4.9 Synchronous Transfer Procedure (if applicable)

This section of the startup procedure involves optional synchronous transfer checks. The Perfect Harmony may be configured for optional synchronous transfer operation in which the drive can be used to control multiple motors (for example) one motor at a time. If such a configuration is not defined for the application, then this section may be skipped. For additional information on signals, flags, transfer steps and sample application refer to **Section 9.2** describing Synchronous Transfer Operation in **Chapter 9**.

The following steps should be used to set up the drive control for Synchronous Transfer:

Table 4-12. Drive Control Setup for Synchronous Transfer

Step	Description
1	Configure Synchronous Transfer Menu parameters as shown below. Synchronous Transfer (2700) Phase I gain (2710) 2 Phase P shift (2720) 4 Phase offset (2730) 2 deg Phase error threshold (2740) 1.5 deg Frequency Offset (2750) 0.5 % Up Transfer Timeout (2760) 0 sec Down Transfer Timeout (2770) 0 sec
2	ENABLE Spinning Load by setting Spinning Load Mode (2430) to Forward.
3	Set the Speed Fwd Max Limit1 (2080) to at least 105%.

Go through the following checklist to complete the set up for Synchronous Transfer:

Table 4-13. Synchronous Transfer Check List

Step	Description
1	Configure the drive control as described above.
2	Ensure that PLC related hardware is properly connected (for information, see the respective PLC communications network manuals supplied by the vendor) to the WAGO I/O modules.
3	Verify wiring of all VFD control and line control electrical contactors.
4	Ensure that the system operating program for the “up transfer” and “down transfer” process logic is implemented as described in the Application and Operations chapter.
5	The state machines for up and down transfers reside in the Perfect Harmony’s control program. These interface with the control system integrator’s PLC network via the VFD system operating program to handle handshaking between each motor control center (MCC) and the VFD. All controls for the VFD and line reactors are controlled from the system integrator’s PLC. Verify that these controls are operational.
6	Verify all communications flags.

4.10 Output Filter Setup (if applicable)

An output filter is typically used to prevent the output cable dynamics from interfering with the drive output. The Output Connection submenu (2900) should be used when an output filter is connected at the drive output (refer to Table).

The Filter CT secondary turns parameter (2910) represents the secondary side turns on the filter CT assuming primary turns are 5. The percent filter inductance (2920) and capacitance (2930) can be calculated from the inductor value (in Henries) and capacitor value (in Farads), respectively, using the following formula. Typical values for the filter inductance and capacitance are 5.0% and 10.0%, respectively. The cable resistance (in ohms) can be estimated from the total cable length and the cable resistance per foot. For this parameter entry (2940), an estimate is sufficient. Use the last formula to convert from ohms to percent of drive output impedance.

Drive_base_impedance [in ohms] = Drive_output_rated_voltage / (1.732 * Drive_output_rated_current)

%Filter_inductance = 100.0 * 377.0 * Filter_inductance [in Henries] / Drive_base_impedance [in ohms]

%Filter_capacitance = 100.0 * 377.0 * Filter_capacitance [in Farads] * Drive_base_impedance [in ohms]

% Cable_resistance = 100.0 * Cable_resistance [in ohms] / Drive_base_impedance [in ohms]

> **Note:** Entries in the Output Connection submenu are related to the drive and not to the motor. Hence changes in motor parameters do not affect the parameters in this submenu.

Table 4-14Table 4-14. Output Connection Menu (2900)

Parameter	ID	Units	Default	Min	Max	Description
Filter CT secondary turn	2910		0	0	250	Secondary side turns (assuming primary turns = 5) of the CTs used to measure filter capacitor currents.
Filter inductance	2920	%	0	0	16	Sets the output filter inductor value (impedance) as a ratio of the base output impedance of the drive (typically 5%).
Filter capacitance	2930	%	0	0	96	Sets the output capacitor value (admittance) as a ratio of the base output admittance of the drive (typically 10%).
Cable resistance	2940	%	0	0	64	Sets the output calble resistance value as a ratio of the base output impedance of the drive.
Filter damping gain	2950	p.u.	0	-5.0	5.0	Adjusts the active damping gain.

A new parameter called Filter Damping Gain (2950) in the Output Connection submenu is available in versions 2.20 and higher. This allows an adjustment of the damping gain that is used by the control to damp the output frequencies amplified by the filter. For long cables (length > ~ 30000 feet) the damping gain is required to be a negative number, normally between –1.0 and 0.0. For shorter cable lengths, the gain should be in the range of 0.0 and +1.0.

For versions 2.02 and 2.11, there is no direct parameter that can be adjusted to control damping. An indirect way of adjusting the internal damping gain is to change the Motor Leakage Inductance parameter. The internal damping gain is directly proportional to the square root of the motor leakage inductance.

For active damping, the sample rate should be above the 4.0 – 4.5 kHz range. Depending on the number of ranks in the drive, use the following table to adjust the carrier frequency (3580).

Table 4-15. Recommended value of carrier frequency as a function of cell stages in the drive

Number of Ranks	Carrier Frequency (Hz)
3	800
4	600
5	600
6	500

4.10.1 Adjusting Current Regulator Gains with Output Filters

When output filters are used, the current loop gains (3260 and 3270) should be below 0.30 (for proportional gain) and 30.00 (for integral gain), respectively.

If the drive repeatedly trips on IOC when the start command is given, then the wiring of the filter CTs must be checked for correct connections using the procedure described in the following subsection. After the connections are verified, both visually and by operating in OLTM, then the next step is to reduce current loop gains. Reduction of the current loop gains (in steps on 0.05 and 5.00, respectively) must be performed until IOC-free operation is obtained. The Filter damping gain should then be adjusted to reduce the high frequency oscillations in the drive output current waveforms. A good value of Filter damping gain will allow an increase in current loop gains towards 0.30 and 30.00.

4.10.2 Verification of Filter CT Wiring

Three CTs are used for measuring the filter capacitor currents, one CT for each phase. The CTs are placed on the star-point (or Y-point) of the capacitors so that the CTs are not subject to high common-mode voltages. For each CT, two wires, one from each secondary, go back to the control section. This results in a total of six wires going from the CTs to the control section. Perform a visual inspection of the filter cabinet (with Medium Voltage off) to verify CT placement and connections.

The capacitor current feedback signals are available on test-points IFA, IFB, and IFC, located on the System Interface Board. In order to check the CT connections, the drive should be operated without the motor in Open Loop Test Mode. Run the drive to at least 50% speed and observe the drive output voltage, VMA and filter capacitor current, and IFA on a scope. The filter capacitor current should lead the drive voltage as shown in Figure 4-12, where the waveforms were measured at 100% speed.

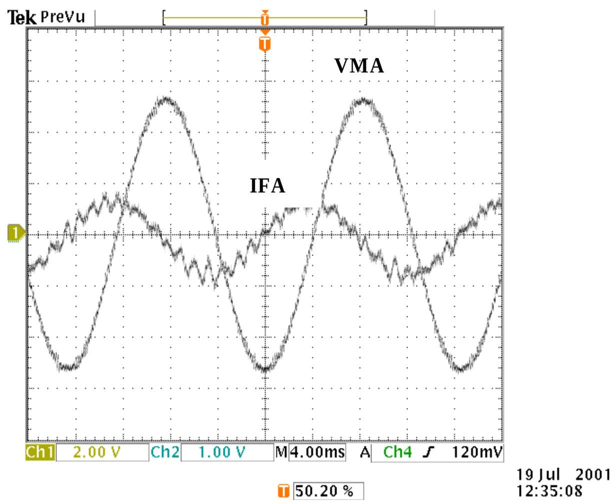

Figure 4-12. Drive output voltage and filter capacitor current on test-points VMA and IFA, respectively, to determine if filter CT wiring is correct

4.10.3 Determining Stator Resistance in Long Cable Application

If cable resistance data is not available then an alternate way of determining cable and motor resistance (total resistance in series with the drive) is to use Auto-Tuning Stage 1. Use this feature **only** when the motor current rating is **at least 50%** of the drive current rating. If cable resistance (2940) has already been entered as a value less than the actual resistance value, then the drive will subtract the entered cable resistance value from the estimated (total) stator resistance and save the difference as the motor stator resistance (1080). If cable resistance is entered as 0.0, then the drive will assign the total (measured) resistance as the stator resistance parameter.

Note: Stator resistance is with respect to motor base impedance, while cable resistance is with respect to drive output base impedance. The drive does the conversion only after Auto-Tuning Stage 1.

Note: After Auto-Tuning Stage 1, the current loop gains have to be manually adjusted such that they are below 0.30 and 30.0, respectively.

4.11 Encoder Setup (if applicable)

An encoder is used in applications that require very tight speed control, especially at low speeds. Use the following steps to set the drive that is equipped with an encoder.

Step	Description
1	Set the drive Control Loop Type (2050) to CLVC (for Closed Loop Vector Control). Choose CSMC (Closed Loop Synchronous Motor Control) if the motor is of synchronous type.
2	Enable Spinning Load by choosing the appropriate direction in menu 2430.
3	Enter the parameters in the Encoder Menu (1280) as shown. Encoder PPR — 1290 — Enter PPR value from encoder Encoder filter gain — 1300 — 0.75 Encoder loss threshold — 1310 — 5.0% Encoder loss response — 1320 — Open loop

4.11.1 Verification of encoder operation

Use the following steps to determine if the encoder is operating correctly.

Step	Description
1	Run the drive in Open Loop Vector Control.
2	Compare the (estimated) motor speed with the encoder speed (measured) value for different speed demands. They should track each other very closely. If tracking is greater than the rated slip of the motor, then check the Encoder PPR parameter to see if it is correct. To change the polarity of the encoder feedback, switch the pair A, A′ with B, B′.

4.12 Verification of Input Monitoring

This section provides steps to verify the monitoring capabilities of the drive. The following steps should be performed after drive operation in one of the (motor) control modes has been verified.

Step	Description
1	Run the drive to a speed at which output power is greater than 20 – 25% of rated drive power.
2	Check if the calculated values of input and output power are reasonably close, in other words, the drive efficiency should read 95% or higher. If this is not the case, then an adjustment of voltage and/or current scalers (input or output) may be required.

Determination of the voltage/current scaling requires independent means of measuring these quantities. In some drives, PQMs are already installed. PQM readings can be compared with the calculated values from the drive control to determine the actual scaler setting (default setting is 1.0). If a PQM is not available, then a PT/CT can be used to make the independent measurement.

Table 4-6 provides values of voltage/current signals on the test points at rated conditions. For each signal, note the drive display reading, the reading from the independent measurement and the value measured at the test point. Compare these three readings to determine the cause of the error. A (drive) scaler adjustment should be made until the measurements are within 1% of each other.

Note: Increasing the scaler value (for voltage or current) increases the value of the measured quantity in the control.

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CHAPTER

5 Application and Operation Issues

5.1 Introduction

This chapter provides an overview of some of the more complex application and operation issues surrounding the Perfect Harmony VFD.

5.2 Synchronous Transfer Operation

5.2.1 Introduction

The term “up transfer” is used to transfer a motor running from a variable frequency drive (VFD) to the line and then decouple the motor from the drive. “Down transfer” is used to match the drive with a motor running off the line and decouple the motor from the line and transfer the motor to the VFD.

5.2.2 Transfer Setup and Faults

Before attempting synchronous transfer, the command generator options selected during pre-synchronous transfer should be examined. It is important to disable command generator functions that may cause the transfer to fail. Verify that the speed profile, polarity change function, and speed limits do not modify the input frequency when a synch transfer is requested. The input frequency is treated much the same way as any other raw speed demand into the drive. Refer to the Command Generator diagram (459713).

During synchronous transfer there are three alarm/fault conditions that can occur:

- Up Transfer timeout (alarm): Meaning that the transfer has taken longer than allocated in the “Up transfer timeout” menu (ID = 2760).
- Down Transfer timeout (alarm): Meaning that the transfer has taken longer than allocated in the “Up transfer timeout” menu (ID = 2770).
- Phase Sequence (alarm or fault): Indicating that the Drive input phase sequence or direction is different than the Drive output.

The timeout alarms may indicate that other conditions maybe causing the transfer to fail. An example would be that there might not be enough active cells left in the drive to support the line voltage during down transfer. In this case, the drive sets the SOP flag *InsufficientOutputVolts_I* high.

5.2.3 Up Transfer

Up transfers are accomplished by taking the motor up to speed on the VFD to match the frequency of the line. This is accomplished by using the drive input line frequency as a velocity reference. This is accomplished by the drive software when the up transfer request is received. Once the frequency is matched the phase also needs to be matched with a predetermined leading phase to ensure the power flow is out of the VFD while the line contactor is closed. This step is done by using the line frequency and phase information from the input PLL and the output phase information from the output PLL to determine a vernier adjustment to the frequency that is added to the velocity command. When the synchronization is complete, the drive contactor is opened and the drive coast-stopped to end the transition. The sequence of control logic is as follows:

Note: All discrete steps imply a time delay for the drive to recognize each step independently. All handshaking must allow a minimum of 250 ms between signals sent.

1. Start the VFD as a normal running drive with proper speed command. The drive must be in the "RUN" state in order to initiate transfer.
2. Initiate the transfer with the transfer request system flag (*UpTransferRequest_O*) when a transfer is desired. Also a menu timer can be enabled for transfer time-out (a transfer failed alarm). If no transfer failure exists, the drive enters "UP_TRANSFER" state and transfer state "TRANSFER_INIT" (A). **If the drive output voltage capability, due to cell bypass or high input line voltage, is less than the line voltage (see Section on Neutral Point Shift during Cell Bypass in this chapter), the control will prevent the Drive from entering the "UP_TRANSFER" state, and set the *InsufficientOutputVolts_I* flag high.**
3. From this point the transfer is controlled through the transfer state machine from within the "UP_TRANSFER" Drive State. With the entry into this state the velocity regulator demand generator is forced to accept the reference from the line frequency measurement.

   The Up Transfer State machine consists of the following five states:

State	Value*
A – TRANSFER_INIT	0
B – WAITING_FOR_FREQUENCY_LOCK	1
C – WAITING_FOR_PHASE_LOCK	2
D – WAITING_FOR_CONTACTOR_CLOSURE	4
E – TRANSFER_COMPLETE	6

*Value is the value of the state machine variable for plotting purposes.

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4. In Transfer State "TRANSFER_INIT"(A), the new velocity reference represents input line frequency as described above with no vernier for phase offset correction. The drive will stay in this state until the frequency error is reduced to less than 0.5 Hz. At this point the Transfer State is advanced to "WAITING_FOR_FREQUENCY_ LOCK"(B).

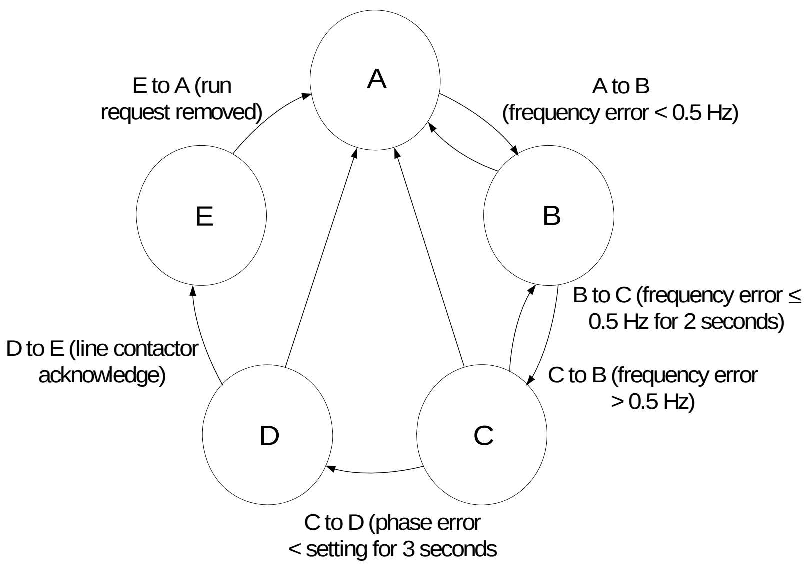

Figure 5-1. Synchronous Transfer State Diagram for "Up Transfer"

5. In transfer state "WAITING_FOR_FREQUENCY_LOCK"(B) the drive maintains frequency lock for 2 seconds before advancing to the next Transfer State "WAITING_FOR_PHASE_ LOCK"(C).

6. In transfer state “WAITING_FOR_PHASE_LOCK”(C) the drive uses the phase lock loop phase error in a P+I loop to calculate a phase correction velocity reference vernier adjustment that is added to the line frequency reference as the input demand to the velocity regulator. This correction is continued until the phase error is less than a user entered value for a period of 3 seconds. An optional offset to the error, programmable through a menu entry in degrees of phase shift, may be added as well. When the minimized phase error has been maintained for the proper time, the state machine sets a system program flag “*UpTransferPermit_I*” to enable the line contactor and advance to the next transfer state, waiting for contactor closure (D). This flag must be used to enable the line contactor. If frequency lock is lost during this state, the state machine drops back to state B until frequency lock is again restored.
7. In transfer state “WAITING_FOR_CONTACTOR_CLOSURE”(D) the drive maintains the phase lock loop and waits for the acknowledgment of the line contactor pickup. When the contactor closed is sensed via the system program flag “*LineContactorAcknowledge_O*”, the drive sets the “*UpTransferComplete_I*” and advances to the final Transfer State “TRANSFER_COMPLETE”.
8. In transfer state “TRANSFER_COMPLETE”(E) the drive is waiting until the Drive Run request is removed. The flag must be used to drop out the VFD contactor while maintaining the line contactor.
9. Once the drive enters the drive state “UP_TRANSFER”, the only way out is through the normal completion of the transfer, or if a transfer time-out failure, or if a drive fault or E-stop occurs. A transfer timeout failure (alarm) occurs if the system is unsuccessful at completing a transfer before the end of the timeout period. If a timeout occurs before reaching the “TRANSFER_COMPLETE” (E) State the drive returns to drive state “RUN” state and presets the Transfer State back to “TRANSFER_INIT”(A). The drive issues a Transfer Failure Warning and waits for a reset before attempting a new Up Transfer. If the drive makes it to the “TRANSFER_COMPLETE” (E) State the drive will not issue a timeout.

A Drive Fault causes the drive to go into “Coast Stop” and then the drive “IDLE” state. A Fault Reset is required to re-enable the drive to run (ready-to-run equals true). A drive restart is required as in Step # 1 to begin a new Up Transfer Sequence. The drive responds to a CR3 or drive-inhibit in the same way as a Fault. If this occurs in any state other than the Transfer Complete State (E), the drive drops back to the Drive Run State.

5.2.4 Down Transfer

"Down transfer" is used to transfer a motor from the line to the Drive. With NXG control, the drive monitors the output voltage before locking-in to the motor frequency via the spinning load algorithm. For the drive to perform such a sync, the VFD contactor is required to be closed at the beginning of the Down Transfer sequence. The drive is capable of locking-in within a few milliseconds. The drive then raises the output torque current before indicating that it is ready to accept the motor (and open the line contactor). The sequence for down transfer is as follows:

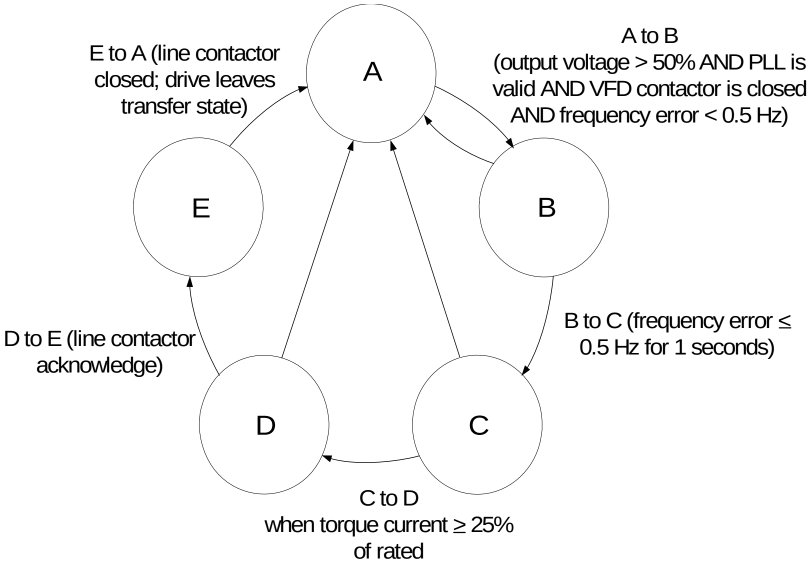

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Figure 5-2. Synchronous Transfer State Diagram for "Down Transfer"

1. NXG Control requires Spinning Load to be enabled, and that the Drive is in the "IDLE" state prior to down transfer. To start, assume that the motor is running from the line, the line contactor is closed and a contactor acknowledge is provided to the drive.
2. The down transfer request system program flag (*DownTransferRequest_O*) is set.
3. A "run request" is issued to the drive. If the drive is capable of supporting the voltage on the motor, the drive issues a permit (*DownTransferPermit_I*) which is used to close the VFD Output Contactor, then goes into the Down Transfer State machine. The Drive will begin to sense the voltage from the drive output. **If the drive output voltage capability, due to cell bypass is less than the line voltage (see Section on Neutral Point Shift during Cell Bypass in this chapter), the control will prevent the Drive from entering the "DOWN_TRANSFER" state, and set the *InsufficientOutputVolts_I* flag high.**

   The Down Transfer State machine consists of the following five states (refer to Figure 5-2):

State	Value*
A – TRANSFER_INIT	0
B – WAITING_FOR_FREQUENCY_LOCK	1
C – WAITING_FOR_TORQUE_TO_BUILD	3
D – WAITING_FOR_CONTACTOR_OPENING	5
E – TRANSFER_COMPLETE	6

*Value is the value of the state machine variable for plotting purposes.

4. After entering "DOWN_TRANSFER" state the drive is initially in the transfer state A-(TRANSFER_INIT), and will transition to transfer state B-(WAITING_FOR_ FREQUENCY_LOCK) after the output PLL stabilizes with the motor flux. The drive transistors are enabled in the transition from state A to state B. Transition from B to C requires that the drive output frequency and the line frequency be within ½ hertz for 1 second while the drive is connected to the line.
5. Now that the drive has matched the line frequency, it will begin to raise the amount of torque producing current to the motor in preparation for the transfer of motor control from the line to the drive. Transition from C to D occurs when the torque producing current is greater than or equal to 25% of the maximum permissible current (Iqs max). The drive issues a signal (sets it True) to unlatch the line contactor (*LineContactorUnlatch_I*).
6. Once the PLC opens the line contactor it should clear the line contactor acknowledge flag (*LineContactorAcknowledge_O set to False*), then the state machine transitions to the E-(TRANSFER_COMPLETE) state. It is vital that this signal is sent only after ensuring that the contactor is open.
7. The drive issues a down transfer complete signal (*DownTransferComplete_I*) after which the down transfer request (*DownTransferRequest_O*) can be removed.
8. The drive then ramps to the speed setpoint set by the customer, and the Down Transfer State machine is reinitialized to state "A".
9. If a Transfer Time-out occurs when the drive is within the "DOWN_TRANSFER" state, then the drive goes back to the state A-(TRANSFER_INIT). The drive issues a Transfer Failure Warning and waits for a reset before attempting a new Down Transfer.

To Stop the Drive while it is connected to the line, issue a Stop Request by reviewing the Run Request. This will disable the Drive output immediately. Then remove the VFD Contactor Acknowledge, open the VFD Contactor, and remove the Down Transfer Request.

A Drive Fault causes the drive to go into "Coast Stop" and then to the "IDLE" state. A Fault Reset is required to allow the drive to run again. To reset the Fault, open the VFD Contactor, remove the VFD Contactor Acknowledge, and remove the Down Transfer Request. Follow the sequence listed from Step # 1 for a new Down Transfer sequence. The drive responds to a CR3 or drive-inhibit in the same way as a Fault, except that a fault reset is not required, but the drive-inhibit must be cleared in order to run again.

5.2.5 Synchronous Transfer with Multiple Motors and a PLC

Perfect Harmony drives can be used to control multiple motors using synchronous transfer methodology. Such applications are used to sequentially control a series of motors one motor at a time. Consider the following example. A reservoir is being filled with liquid at an unknown, variable rate. Up to three pumps are used to remove the liquid to keep the reservoir level at a certain setpoint (this is the external process). As the external system error (i.e., the positive or negative deviation from the setpoint) continues for an external process (e.g., the feedback value rises above a setpoint value), the first motor (a pump, for example) is controlled by the drive to attempt to correct the error and bring the reservoir level back to its setpoint level. If the error from the external process continues (i.e., the reservoir level remains above its setpoint value), the first pump may be unable to reach or maintain the level setpoint - even at greater than 100% speed. If this occurs, the first pump is smoothly transferred to line voltage (at 100% speed), and the drive begins to control a second pump motor. If the error of the external process remains, the second pump can then be operated in addition to the first pump (at 100%) using straight line voltage, while a third motor is brought on line and controlled by the drive. This transfer of drive control from one motor to the next can occur with a single Perfect Harmony drive and any number of motors.

Figure 5-3 shows a reservoir being emptied by pumps 1, 2 and 3 (which use induction motors M1, M2 and M3, respectively). As the tank fills past the setpoint level (monitored by an external feedback signal), the drive controls motor M1 (via motor control center MCC1) to maintain the level. As the tank level continues to increase, the motor on pump 1 will eventually reach 100% speed. If the tank level continues to increase, the Perfect Harmony initiates an "up transfer". This process involves electronically switching control of motor M1 to line control (rather than VFD control). This process is done smoothly using a serial communications network (MODBUS protocol, for example) and a pair of electronically controlled contactors (**L1** for line control and **V1** for VFD control). With motor M1 running at 100% (line voltage), motor M2 (on pump 2) is switched from an idle state into VFD control using PLC commands and contactor **V2**. This process continues with additional motors until the external process feedback indicates that the tank level is at its setpoint. This entire process works in the reverse order (called a “down transfer“) when a negative error occurs (i.e., the feedback signal shows that the measured value is below the setpoint value). An “up transfer” process is illustrated graphically in Figure 5-4 . A “down transfer” process is illustrated graphically in Figure 5-5 . These graphs show motor output percentages as functions of time with either continued demand (positive error) for “up” transfers or no demand (negative error) for “down” transfers.

Note that the graphs in Figures 5-4 and 5-5 show very “clean” proportional ramps. These ramps are for illustration purposes only and do not include any integral or derivative control action. A continued demand throughout time period t_4 is assumed in Figure 5-4 and no demand is assumed throughout time period t_9 in Figure 5-5. An overview of the control states of the motors used in the example of Figure 5-4 is given in Table 5-1. A similar overview for Figure 5-5 is given in Table 5-3.

> **Note:** The state machines for up and down transfers reside in the Perfect Harmony’s state control program. These interface with the control system integrator’s PLC network via the VFD system operating program to handle handshaking between each motor control center (MCC) and the VFD. All controls for the VFD and line contactors are controlled from the system integrator’s PLC.

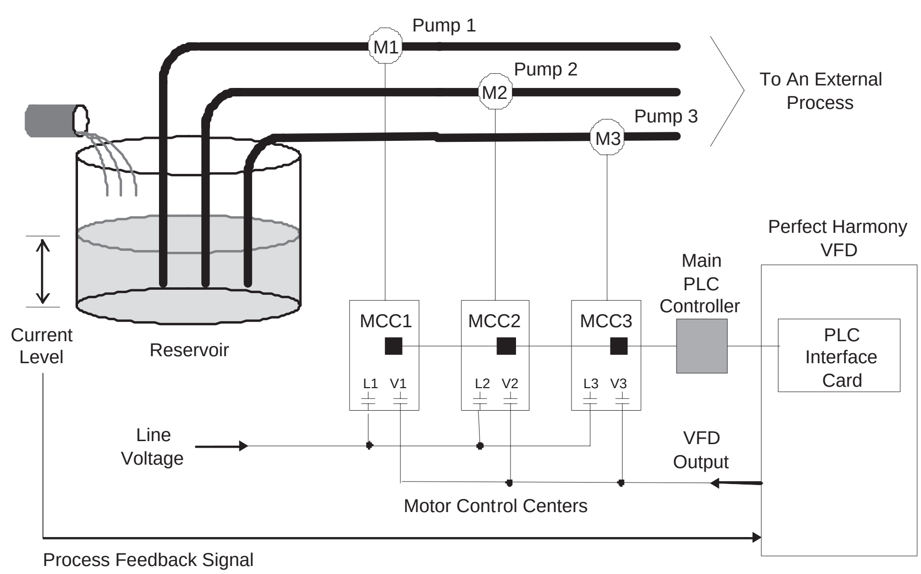

Figure 5-3 Overview of a Sample Transfer Application

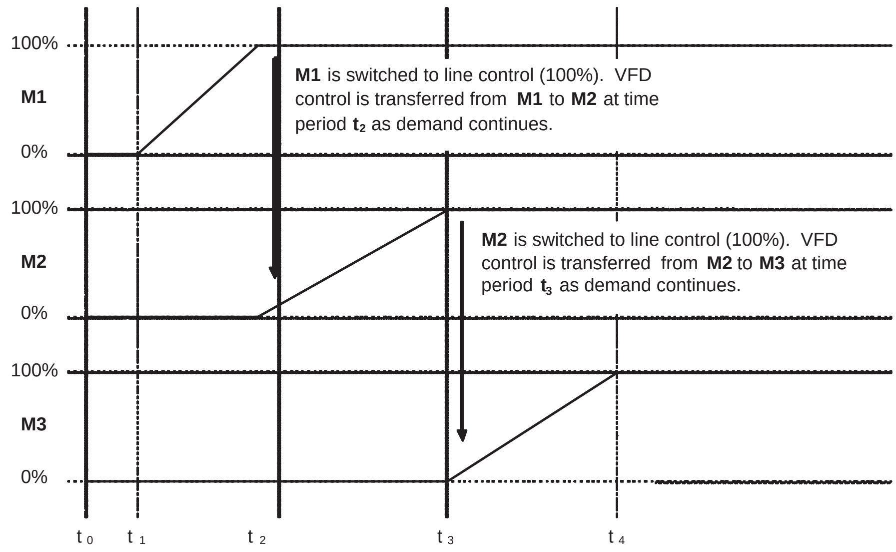

Figure 5-4. Graphical Representation of a Sample "Up Transfer" with Continued Demand

Table 5-1. Control States of Motors in a Sample "Up Transfer"

Time	M1	M2	M3
t_0	VFD Off (0%)	Off (0%)	Off (0%)
t_1	VFD (0-100%)	Off (0%)	Off (0%)
t_2	Line (100%)	VFD (0-100%)	Off (0%)
t_3	Line (100%)	Line (100%)	VFD (0-100%)
t_4	Line (100%)	Line (100%)	VFD (100%)

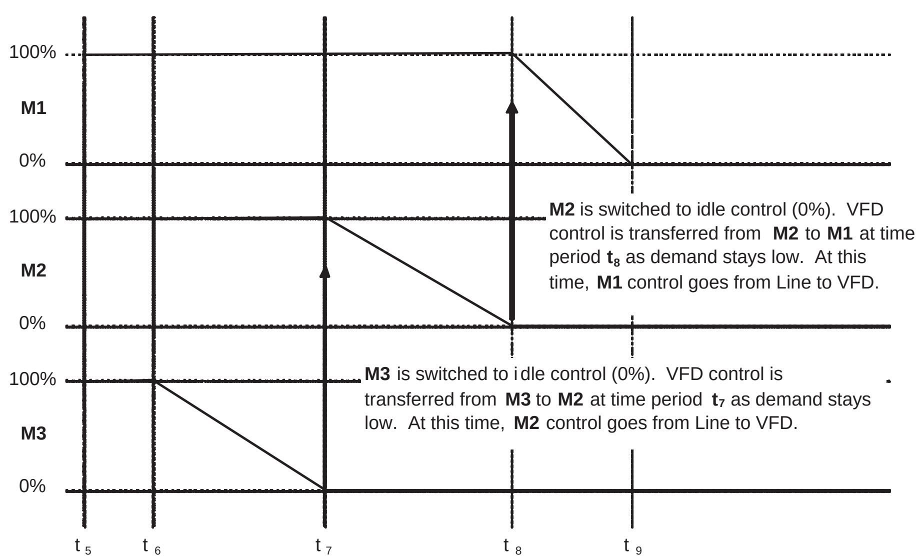

Figure 5-5. Graphical Representation of a Sample "Down Transfer" with No Demand

Table 5-2. Control States of Motors in a Sample "Down Transfer"

Time	M1	M2	M3
t_5	Line (100%)	Line (100%)	VFD (100%)
t_6	Line (100%)	Line (100%)	VFD (100-0%)
t_7	Line (100%)	VFD (100-0%)	Off (0%)
t_8	VFD (100-0%)	Off (0%)	Off (0%)
t_9	VFD Off (0%)	Off (0%)	Off (0%)

5.2.6 The PLC Interface

All VFD control is accomplished over a RS485 serial communications network using a supported communications protocol (e.g., Modicon Corporation's MODBUS communications protocol). For example, a Modicon-compatible PLC interface is located at each motor control center. These PLCs are networked to a main MODBUS controller (e.g., a PC) and the communications board on the Perfect Harmony drive. Refer to Figure 5-6.

Note: PLC interface refers to Modicon's MODBUS Serial interface only. This is for purposes of example only. Any supported communication network will do and the interface can also be done with no PLC, or by direct logic control.

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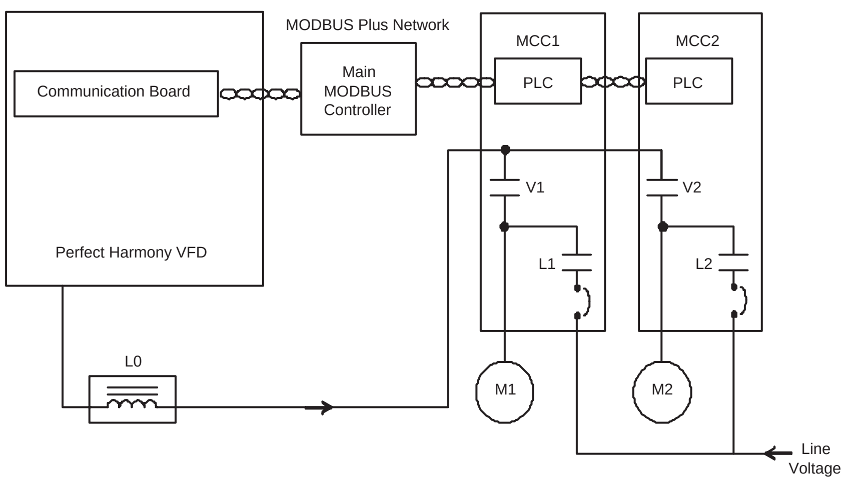

Figure 5-6. Communications Outline Drawing using a Modbus Network Configuration

5.2.7 "Up" Transfer (from VFD to Line Control)

Note: All discrete steps imply a time delay for the drive to recognize each step independently. All handshaking must allow a minimum of 250 ms between signals sent.

This section provides the necessary steps to be followed for Up Transfer. The state transitions that occur during these sequences are graphically shown in Figure 5-7.

Note: If the drive is not already running, the PLC should begin by closing the VFD Output Contactor.

1. The PLC issues an "up transfer request" [*UpTransferRequest_O*].
2. If the drive is not already running, the PLC issues a "run request" [*RunRequest_O*].
3. The PLC provides the VFD with the output contactor acknowledge [*VFDContactorAcknowledge_O*].
4. The VFD ramps to line frequency and phase-locks to the line for 3 seconds. (The VFD substitutes the input line frequency as the raw speed demand).
5. The VFD issues an "*Up Transfer Permit* " command [*UpTransferPermit_I*] to the PLC.
6. The line contactor (e.g., **L1**) is closed by the PLC.
7. The PLC signals the VFD that the line contactor (e.g., **L1**) is closed.
8. The VFD receives the "line contactor closed acknowledge" signal [*LineContactorAcknowledge_O*] and signals the PLC "up transfer complete" [*UpTransferComplete_I*].
9. The PLC stops the VFD through the serial interface by removing the "run request" [*RunRequest_O*].
10. The PLC removes the "up transfer request" [*UpTransferRequest_O*].
11. The VFD contactor (e.g., **V1**) is opened by the PLC.
12. The PLC removes the "VFD contactor closed" [*VFDContactorAcknowledge_O*] signal to the VFD.
13. PLC removes [*linecontactoracknowledge*] for VFD while maintaining the line contactor closed.
14. New motor parameters are loaded through the serial interface for use in the next operation (or the VFD stays idle). This step is possible in version 2.3 or higher of NXG software.

Note: All hand shaking signals between the VFD and the PLC must be done sequentially as described. No two signals can be sent a the same time as timing is critical for proper operation.

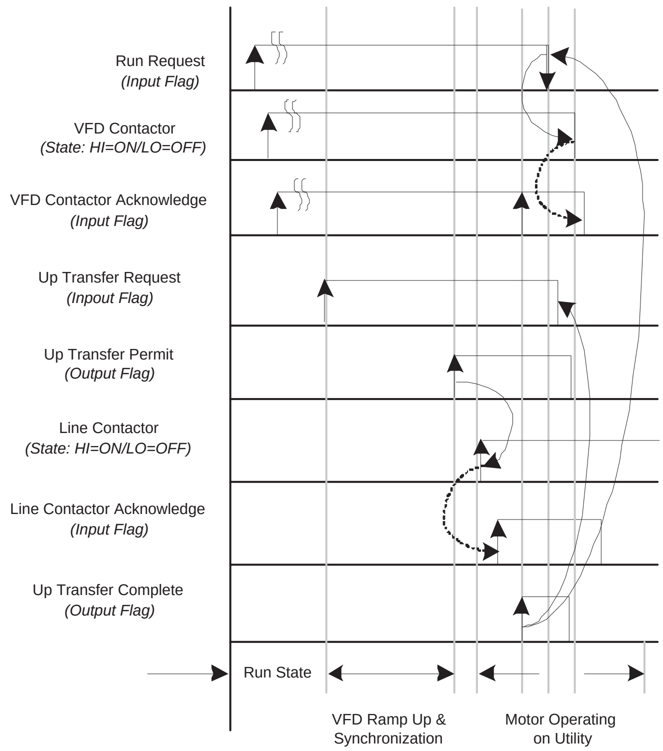

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Figure 5-7. State changes during Up Transfer Sequence

The ↑↓ arrows indicate transitions that are used by the customer interface (for e.g., a PLC) to control the process.

5.2.8 "Down" Transfer (from Line to VFD Control)

Note: All discrete steps imply a time delay for the drive to recognize each step independently. All handshaking must allow a minimum of 250 ms between signals sent.

1. The Down Transfer process (refer to Figure 5-8) consists of the following steps. The line contactor is assumed to be closed at the beginning of this procedure.
2. The PLC switches to the correct motor parameters in the VFD through the system program if required. (This step is possible in version 2.3 or higher of NXG software.)
3. The PLC provides the VFD with the acknowledge from the line contactor [*LineContactorAcknowledge_O*].
4. The PLC issues a "down transfer request" [*DownTransferRequest_O*].
5. The PLC issues a "run request" [*RunRequest_O*] to the drive.
6. The VFD issues a "transfer permit" command [*DownTransferPermit_I*] to the PLC if the drive can provide sufficient voltage to match the line. The VFD then enters the Down Transfer drive state.
7. The PLC closes the VFD contactor. When the VFD contactor is closed, the PLC sends a signal to the VFD indicating the VFD contactor (e.g., **V1**) is closed [*VFDContactorAcknowledge_O*]. VFD then waits five seconds for stabilization of the PLL.
8. The VFD locks-in to the line frequency and builds torque current to 25%; it then issues the "line contactor unlatch" signal [*LineContactorUnlatch_I*] to the PLC.
9. The PLC verifies that the VFD has not faulted.
10. The line contactor (e.g., **L1**) is opened by the PLC. When the line contactor is opened, the signal [*LineContactorAcknowledge_O*] is cleared.
11. The VFD signals the PLC "down transfer complete" [*DownTransferComplete_I*].
12. The PLC removes the "down transfer request" [*DownTransferRequest_O*], but maintains the "run request."
13. The VFD clears the [*DownTransfer Permit_I*] and the Line [*ContactorUnlatch_I*] flags, exits the Down Transfer Drive state, and enters the Drive Run state.
14. The VFD follows the process setpoint from the PLC.

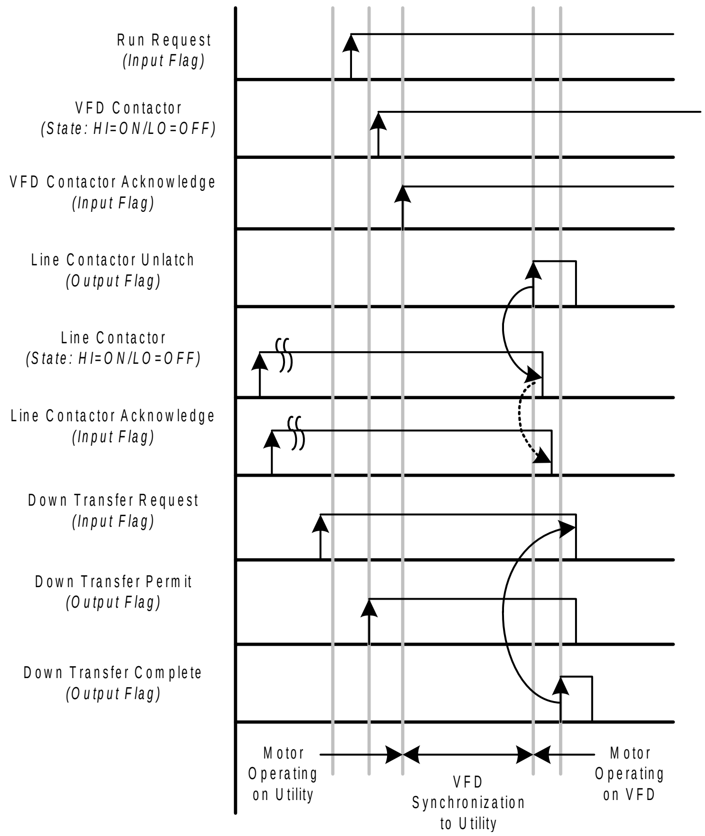

Figure 5-8. State changes during Down Transfer Sequence

The ↑↓ arrows indicate transitions that are used by the customer interface (for e.g., a PLC) to control the process.

Note: Run Request must be maintained after the transfer is complete.

5.2.9 Required Signals

Table 5-3 lists descriptions of signals that are required for synchronous transfer operation.

Table 5-3. Required Signals and Descriptions

Signal	Description
UpTransferRequest_O	Input signal from PLC used to request transfer from VFD to Line.
DownTransferRequest_O	Input signal from PLC used to request transfer from Line to VFD.
VFDContactorAcknowledge_O	Input from PLC to indicate the VFD output contactor status.
LineContactorAcknowledge_O	Input from PLC to indicate the Line contactor status.
UpTransferPermit_I	Permit from drive to close the Line contactor during an Up Transfer.
UpTransferComplete_I	Signal from drive indicating successful synchronization of the drive to the line. After receiving this, the PLC can remove the run request and up transfer request.
LineContactorUnlatch_I	Signal from drive to open the Line contactor during Down Transfer. This is not a latched signal. It disappears on Transfer complete.
DownTransferPermit_I	Indicates the VFD is capable of supporting line voltage, and is used by the PLC to command the closing of the VFD contactor. The drive will then enter the Down Transfer State machine (TRANSFER_INIT state). This is not a latched signal. It disappears on Transfer complete.
DownTransferComplete_I	Signal from drive indicating a successful Down Transfer. After receiving this the PLC can remove the down transfer request.

5.2.10 Additional Parameter Description

The Sync Transfer Menu (2700) is used exclusively for synchronous transfer applications. The menu items and descriptions for this menu are listed in Table 5-4. This information is also available in Chapter 3 of this manual.

Table 5-4. Sync Transfer Menu (2700)

Parameter	ID	Units	Default	Min	Max	Description
Phase I gain	2710		2.0	0.0	15.0	Phase integrator gain
Phase P gain	2720		4.0	1.0	12.0	Phase proportional gain
Phase offset	2730	Degrees	2.0	-90.0	90.0	Specifies the phase angle setpoint used during Up Transfer. This is set positive, expressed in degrees leading to prevent power flow back into drive.
Phase error threshold	2740	Degrees	1.5	0.0	5.0	Specifies the phase synchronization error window during Up transfer. This parameter adjusts the amount of error allowed during phase-locking and is expressed in degrees.
Frequency Offset	2750	%	0.5	-10.0	10.0	Frequency offset used during Down transfer to establish torque current by driving the speed regulator into limit.

Note: In software versions up to and including 2.4, parameter 2740 was actually in radians, not degrees. In these versions, the desired degrees should be multiplied by $\pi/180$ and then entered.

5.3 Spinning Load Operation

The Spinning Load feature allows the drive to determine the speed of a motor that is already rotating. The drive is thus able to apply output voltages at the same frequency as the rotating motor and minimize any chance of a speed transient. The Spinning Load feature in NXG Control is divided into two stages. During the first stage Spinning Load operates automatically when enabled, and requires no user adjustments. The drive control monitors motor flux and is able to provide an instantaneous restart. This stage is valid as long as there is detectable flux in the motor. Typically the drive is capable of restarting instantaneously if the time duration between drive disable and re-start is within 3 to 4 motor time constants.

The second stage consists of a scan feature during which a fixed level of current (set by the Current Level Set Point parameter) of varying frequency is applied to the motor. The control monitors the measured motor flux, and when the motor flux exceeds a flux threshold (set by the Scan End Threshold parameter) the control assumes that the applied frequency is equal to the rotating speed of the motor. This stage requires parameters to be tuned in order for the Scan to function properly.

Spinning Load should be enabled if any of the following operating modes or features is selected:

- Fast Bypass
- Auto-Restart
- Synchronous Motor Control (SMC and CSMC)
- Close Loop Vector Control (CLVC)

> **Note:** Spinning Load does not provide instantaneous restart with V/Hz control.
> With synchronous motors, spinning load is always instantaneous, i.e., the drive will never go into a scan mode.

Table 5-5 describes the Spinning Load menu.

Table 5-5. Spinning Load Menu (2420)

Parameter	ID	Units	Default	Min	Max	Description
Spinning load mode	2430		Off			Enable/Disable Spinning Load and set the direction of frequency scans: • Off • Forward • Reverse • Both (scans first in the forward direction, then in the reverse direction)
Scan end threshold	2440	%	20.0	1.0	50.0	Point where scan ends if motor flux is above this level, as a percentage of motor rated flux. Set at 50% and 100% speed to match the motor for proper operation.
Current Level Setpoint	2450	%	15.0	1.0	50.0	Sets the drive current level (I_d), as a percentage of motor rated current, used during scanning. Set at 50% and 100% speed to match the motor for proper operation.
Current ramp	2460	sec	0.01	0.00	5.00	Time to ramp drive current (I_d) to Current Level Setpoint.
Max current	2470	%	50.0	1.0	50.0	Sets the current trip level, as a percentage of motor rated current, for scanning. Use the default value of 50%.
Frequency scan rate	2480	sec	3.00	0.00	5.00	Sets the time taken to scan from rated speed to zero. The default value of 3.00 sec should be satisfactory for most cases.

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5.4 User I/O

5.4.1 Introduction

The I/O modules (Digital In/Out, Analog In/Out) allow user customization of the system for the application requirements. The Next Gen control uses the Wago© I/O system. This system consists of DIN rail mounted modules that can be easily expanded by simply inserting modules to the existing modules (see photo below). The Configuration of the I/O is handled through the External I/O Menu (2800) see Section 5.4.4.

Note: Like modules must be grouped together. Refer to the wage literature for specifics on limitations and power equipment.

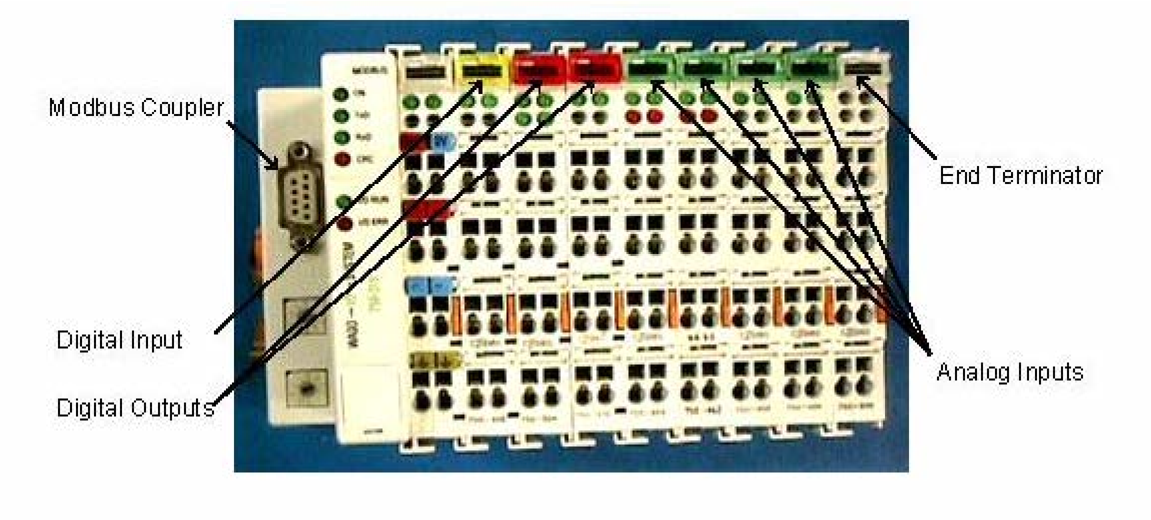

Figure 5-9. Wago I/O System Photo

Table 5-6. Wago I/O Module Color Codes

Module Function	Color
Digital Outputs	Red
Digital Input	Yellow
Analog Input	Green
Analog Output	Blue
Special Modules	Colorless

5.4.2 Wago Modbus Coupler Settings

This section covers the settings of the MODBUS coupler used for communications between the NXG control and the Wago I/O system. Normally this coupler is configured at the factory and there is no need to make changes.

Figure 5-10 shows the bottom of the WAGO Fieldbus coupler case. To access the DIP switches you have to remove the cover. To do so, you must pry with just a little pressure on the bottom of the sides of the unit where there are little “bump” on either side. You can the start applying pressure from the top where the DB9 connector is, pushing down.

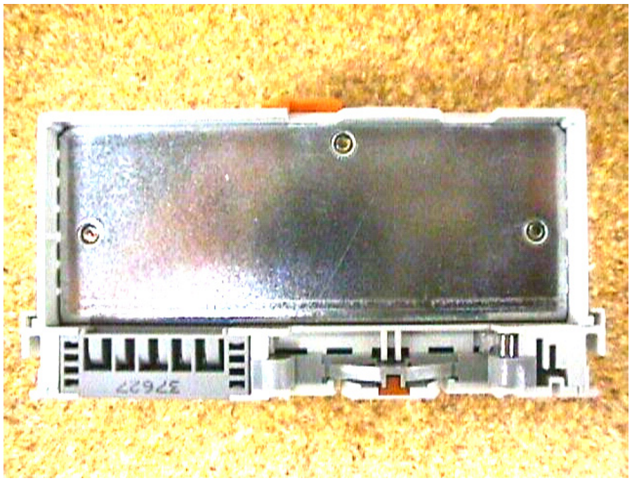

Figure 5-10. Wago MODBUS Coupler Bottom

Figure 5-11 shows how the cover should lift off of the WAGO Fieldbus Coupler to give access to the DIPswitches.

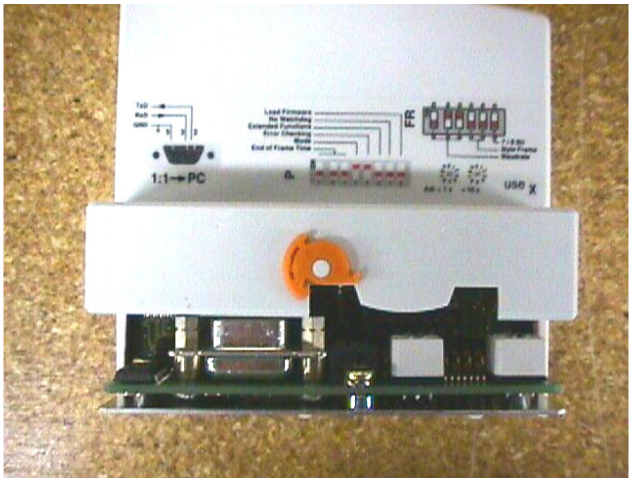

Figure 5-11. Wago MODBUS Coupler with Cover lifted

Figure 5-12 shows the actual DIP switches in the WAGO Fieldbus Coupler. The first three switches of the top DIP switches, labeled FR on the cover plate, are to set the baudrate. Switch 1 is off, switch 2 is on, and switch 3 is off. The correct settings are shown here and is different than the picture displayed on the outside cover that is removed to access the DIP switches.

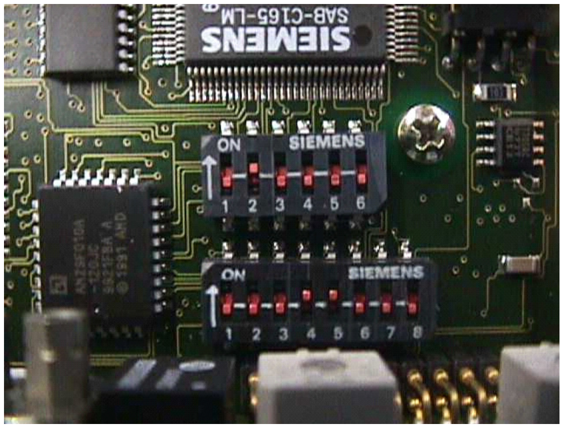

Figure 5-12. Wago MODBUS Coupler DIP switch settings

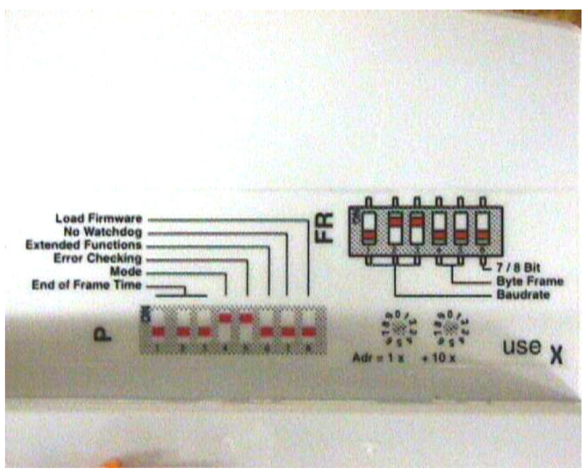

Figure 5-13. Wago MODBUS Coupler DIP switch settings label

5.4.3 External I/O Menu (2800)

The External I/O is configured from the External I/O Menu (2800). The user must define the total number of I/O's per the Table below for each type of I/O (Analog I/O and Digital I/O). If the I/O count is incorrect the Drive will indicate a "Wago Configuration Fault". Once the correct number of I/O is entered, the fault can be cleared by a Fault Reset.

Table 5-7. External I/O Menu (2800)

Parameter	ID	Units	Default	Min	Max	Description
Analog Inputs	2810		0	0	24	Sets the quantity of analog inputs in the attached external I/O.
Analog Outputs	2820		0	0	16	Sets the quantity of analog outputs in the attached external I/O.
Digital Inputs	2830		0	0	96	Sets the quantity of digital inputs in the attached external I/O.
Digital Outputs	2840		0	0	64	Sets the quantity of digital outputs in the attached external I/O.

5.4.4 Digital I/O

The Digital I/O data is only available and useable within the System Program. The System Program has predefined variable names for External Digital Inputs and Outputs. You may write a system program and making use of these I/O for whatever functionality or logic is required. The I/O is assigned system program variable names based on the location or order that the module is inserted into the Wago I/O system. For example, if a single Digital input module and a single Digital Output module are inserted into the Wago system the system program would define them as follows:

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Digital Input Module #1: (assuming the module is a 4 input module)

`ExternalDigitalInput01a_I through ExternalDigitalInput01d_I`

Digital Output Module #1: (assuming the module is a 2-output module)

`ExternalDigitalOutput01a_I through ExternalDigitalOutput01b_I`

If there are additional modules added they would be defined as follows:

Digital Input Module #2: (assuming the module is a 4 input module)

`ExternalDigitalInput01e_I through ExternalDigitalInput01h_I`

Digital Output Module #2: (assuming the module is a 2-output module)

`ExternalDigitalOutput01c_I through ExternalDigitalOutput01d_I`

5.4.5 Analog Output Menu (4660)

The analog outputs are set up via the pick list parameters in the Analog Output menus (4661 through 4721). First a pick list is presented to allow selection of the variable to be output to the Analog Output module. To complete the setup the type of output, bipolar, unipolar and the percent of the value to provide full scale analog output to determine the scaling for the variable.

Note: A set of standards has been established for the use of certain I/O. Please refer to these standards as a beginning point of establishing wiring and system program creation. See Chapter 8 on System Programming for details.

Table 5-8. Analog Output #1 (4661)

Parameter	ID	Units	Default	Min	Max	Description
Analog variable	4662					This variable sets the input source for analog output #1.
Output module type	4663					Sets the output type for the module (Unipolar or Bipolar).
Full range	4664	%	0	0	300	Scales the output range of the variable selected.

5.4.6 Analog Input Menu (4090)

The analog inputs are set up to receive the converted data from the user modules selected as either 0 - 20mA, 4 - 20mA, 0 - 10V. The user defines the minimum and maximum values for scaling as well as the Loss of Signal (LOS) threshold and action. All Analog inputs are available to be used by the Comparators for additional control functionality (refer to the Comparator Setup Menu (4800) in Chapter 3).

Table 5-9. Analog Input #1 Menu (4100)

Parameter	ID	Units	Default	Min	Max	Description
Source	4105					This parameter sets the input source for analog input #1. Can be any one of 24 External Analog Inputs.
Type	4110		0 - 20ma			This parameter sets the operational mode for analog input 1. 0 - 20mA 4 - 20mA 0 - 10V
Min input	4120		0	0	200	Minimum Analog input
Max input	4130		100	0	200	Maximum Analog input
Loss point threshold	4140		15	1	100	Threshold where loss of signal action is activated.
Loss of signal action	4150		Preset			Select loss of signal action. Preset Maintain Stop
Loss of signal setpoint	4160		20	0	200	Loss of signal preset speed.

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5.5 Signal Frame of Reference for Motor Control

The control signals used for controlling the motor must be assigned a polarity for use over four quadrants of control to maintain consistency of the algorithms. This section clarifies what they are and what their polarities mean in the various quadrants.

5.5.1 Frame of Reference

The four-quadrant frame of reference is defined as the four quadrants of operation of a motor. They are divided left to right by the direction of rotation and from top to bottom by the polarity of the torque in the machine. Energy flow from the drive into the machine is called motoring and out of the machine and into the drive is called regeneration or braking. The diagram is shown in Figure 5-14.

Figure 5-14 shows the relationship between the polarities of the signals. For example, starting at rest (in the ordinances of the two axes), if a positive torque is applied to the motor, the acceleration is positive and the resultant speed increases in the forward direction. This is governed by the following equations:

$$\alpha = \frac{T}{J} \qquad \omega = \int \alpha dt$$

where:

α =	acceleration	T =	torque
J =	inertia (an unsigned magnitude)	ω =	rotational speed.

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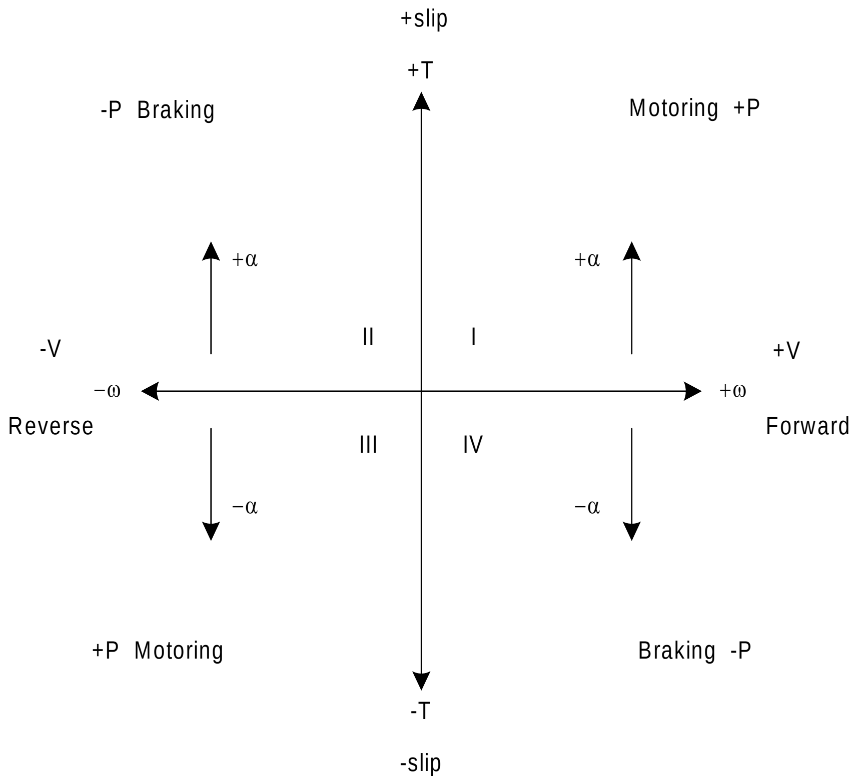

Figure 5-14. Four Quadrant Operation of a Motor

This then carries over into quadrant IV showing that a negative torque produces negative acceleration (deceleration) stopping the motor. If however, the same torque is applied continuously, the speed of the motor will decrease to zero and begin to accelerate in the opposite direction producing a negative rotational speed (ω) in what is now quadrant III. Now if a positive torque is applied, the motor enters quadrant II and begins to decelerate. Since the rotational speed is negative and begins to diminish and approaches a positive value, the acceleration must be positive to conform to the above equations. Again, if the torque is held constant, the motor will slow to zero and then accelerate in the forward direction passing back into quadrant I.

The injection frequency must always be opposing the direction of rotation and is only used in the case of braking or negative energy flow. Therefore it is zero in the motoring quadrants (I and III) and is the inverse polarity of the electrical frequency in the braking quadrants (II and IV).

5.5.2 Signal Polarities

Table 5-10. Signal Polarities

Signals	Quadrant 1	Quadrant 2	Quadrant 3	Quadrant 4
Rotation speed (ω_r)	+	-	-	+
Electrical frequency (ω_s)	+	-	-	+
Slip (ω_{slip})	+	+	-	-
Torque	+	+	-	-
Current (I_q)	+	+	-	-
Voltage (v_{qs})	+	+	-	-
Acceleration	+	+	-	-
Injection Frequency (ω_{inj})	0	+	0	-
Power (flow)	+	-	+	-
Mag Current (I_d)	+	+	+	+
Voltage (v_{ds})	+	+	+	+

Note: For the electrical frequency **(ω_s)** in the braking quadrants (II and IV) where the slip opposes the rotational speed, when the speed magnitude approaches the slip magnitude, the electrical polarity is uncertain (when the slip magnitude is greater than the rotor speed, the sign will match that of the slip rather than the sign of the rotor speed). This is due to the relationship .

5.6 Mechanical Bypass

When the Perfect Harmony was first introduced, its most salient attributes were improved power quality at the utility interface, and at the motor interface. A third attribute is now becoming recognized, which offers extremely high reliability by utilizing the inherent redundancy of these drives. Mechanical Cell Bypass is the feature that allows this third attribute to be realized.

The Mechanical Cell Bypass option is implemented by adding a contactor to the output of each cell as shown in Figure 5-15. Now when the control detects that a cell has failed, a command can be sent to close the appropriate contactor. This simultaneously disconnects the cell output from the circuit and connects the two adjacent cells together, effectively taking the failed cell out of the circuit. The drive can then be restarted and operation can continue at reduced capacity.

It does not matter which of the components has failed within the cell, as long as the failure can be detected. In fact, even a failure in the fiber optic link that communicates to the cell can be detected and bypassed. Therefore, this approach protects against the failure of any component in the power circuits or in the communications circuits, rather than protecting the drive against power semiconductor failure only.

The amount of reduction in capacity that can be tolerated will depend on the application, but in most cases a reduction in capacity is preferable to a complete shutdown. Neutral Point Shift is a feature that was developed to minimize the reduction in capacity after a bypass. Neutral Point Shift is discussed in Section 5.8. Another related feature is Fast Bypass. This feature is designed to quickly bypass a cell and get the drive running again in less than ½ second. Fast Bypass is discussed in Section 5.7.

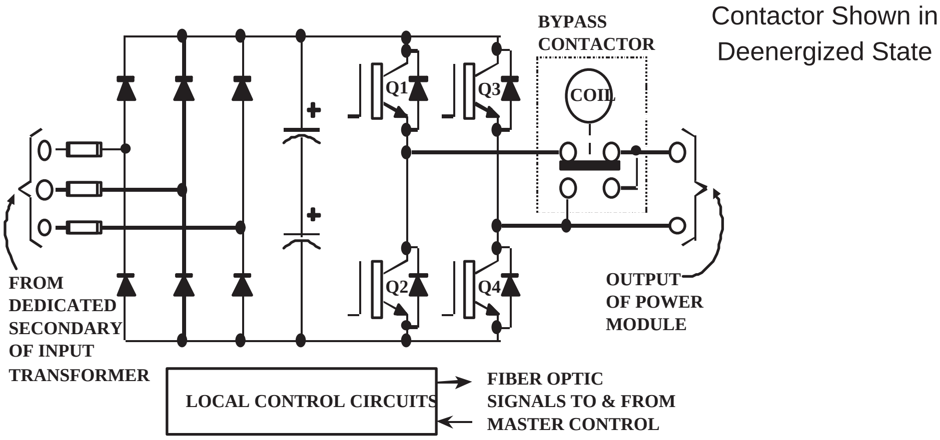

Figure 5-15. Typical Cell with Bypass Contactor

5.7 Fast Bypass

Up time is an important factor in many processes. A Medium Voltage drive is often a critical part of the process and even small interruptions in output torque of a Medium Voltage drive can cause the process to stop. This can result in lost material and production time.

Fortunately, in general, a process can ride through an interruption of ½ second or less. The NXG control has a feature that is designed to limit the interruption of torque to the process to less than ½ second if a cell failure is detected. This feature is called Fast Bypass. The conditions as to when the drive can meet this ½ second maximum interruption are described below.

All cell failures are detected in hardware. This hardware is designed to quickly shut down the drive so that additional damage will not occur. Once this happens the control is notified. The control can then quickly determine which cell failed and the bypass process can be started.

When the drive trips and stops delivering torque to the motor, the motor acts like a generator and produces a voltage on the drive output terminals. This voltage decays over time, but can be near the drive rated output voltage for a few seconds. If a cell is bypassed the remaining cells may not be able to support this voltage and damage can occur.

To prevent this damage a check is done in the control to verify if the motor output voltage can be supported before a cell is bypassed and the drive is restarted. If this check passes when it is first done the cell can be bypassed and torque can be delivered to the drive in under ½ second from the time the fault occurred. If the motor voltage is too high, an additional delay may be needed to allow the voltage to decay.

To guarantee that the drive will bypass a cell fault in under ½ second the drive needs to be running at an output voltage that can be supported by one less than the existing number of cells per phase. One way is for the drive to be sized so that it has more than the minimum number of cells required to provide the voltage needed. Another way is to limit the maximum speed. These issues will have been studied and resolved before the drive is installed.

Note: In a drive with an additional cell per phase, bypass in under ½ second will happen only on the first cell failure per phase. If a second cell in a phase fails the control needs to wait for the motor voltage to decay, hence the bypass time may exceed ½ second.

Note: In Fast Bypass the drive will start to deliver torque to the motor in ½ second after a fault occurs. It may take longer for the drive to get back up to the set-point speed.

5.8 Neutral Point Shift During Bypass

Since the cells in each phase of a Perfect Harmony Drive are in series, bypassing a failed cell has no effect on the current capability of the drive, but the voltage capability will be reduced. Usually the required motor voltage is roughly proportional to speed, so that the maximum speed at which the drive can fulfill the application requirements will also be reduced. Therefore it is important to maximize the motor voltage available after one or more cells have failed.

Figures 5-16 through 5-20 illustrate the voltage available from a Harmony drive, where the cells, represented by circles, are shown as simple voltage sources. Figure 5-20 shows a 15-cell drive in which no cells are bypassed. With 100% of the cells in use, 100% of the original voltage is available. The voltage commands to the three phase groups of cells will have phase A displaced from phase B by 120°, and from phase C by 120°.

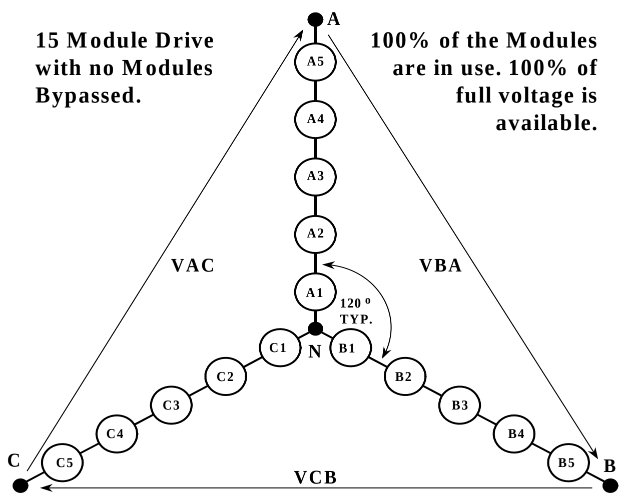

Figure 5-16. A Simplified diagram of a 15 Cell Drive

When cells are bypassed in one of the drive phases, the output voltage will tend to become unbalanced, as illustrated in Figure 5-17. One possible remedy is to bypass an equal number of cells in all three phases, even though some may not have failed. Figure 5-18 illustrates this approach. Obviously, this method prevents unbalance but sacrifices possible voltage capability. In Figure 5-18, 87% of the cells are functional, but only 60% are in use, and only 60% voltage is available.

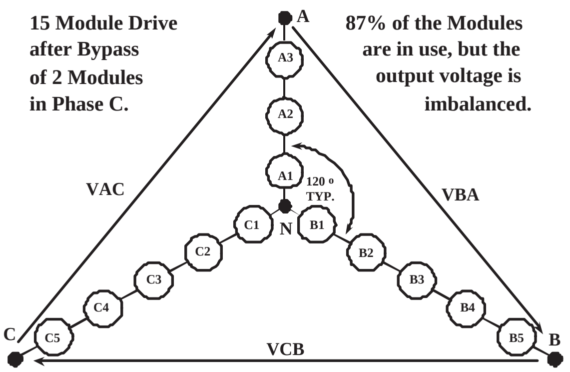

Figure 5-17. Drive output with 2 Cells Bypassed

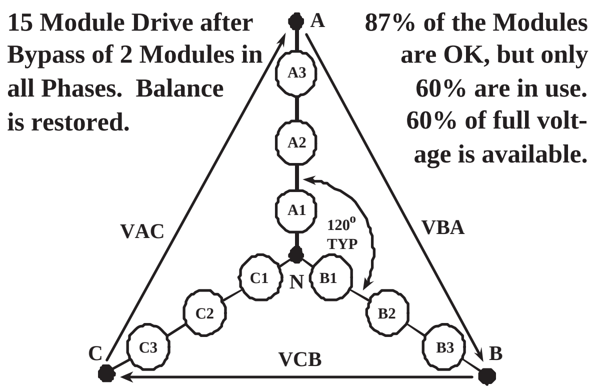

Figure 5-18. Drive output re-balanced by Bypassing Functional Cells.

A better approach is illustrated in Figure 5-19. This method takes advantage of the fact that the star-point of the cells is floating, and is not connected to the neutral of the motor. Therefore the star-point can be shifted away from the motor neutral, and the phase angles of the cell voltages can be adjusted, so that a balanced set of motor voltages is obtained even though the cell group voltages are not balanced.

Siemens calls this approach *Neutral-Shift,* and has a US Patent (5,986,909) that covers it. This approach is equivalent to introducing a zero-sequence component into the voltage command vectors for the cells. In Figure 5-19 the full remaining 87% of functional cells are in use, and 80% of the original voltage is available. The phase angles of the cell voltages have been adjusted so that phase A is displaced from phase B and from phase C by 132.5°, instead of the normal 120°.

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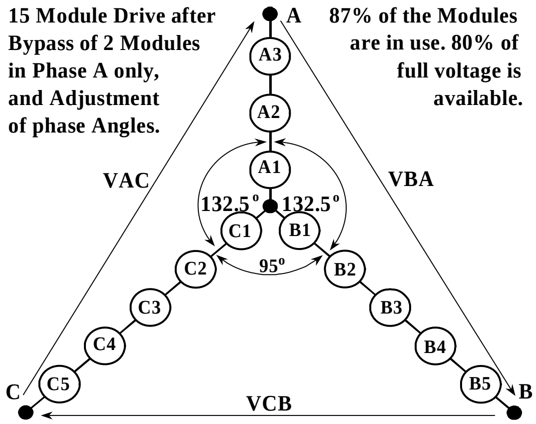

Figure 5-19. Drive output re-balanced by Adjusting Phase Angles (Neutral-Shift)

The same neutral-shift approach can be applied to more extreme situations, as is illustrated byFigures 5-20 and 5-21. Figure 5-20 shows a drive which originally had five cells per phase, or a total of 15 cells. All five cells remain in phase A, but one cell has failed in phase B and two cells have failed in phase C. Without neutral-shift, all phases would need to be reduced to match the cell count of phase C in order to maintain balanced motor voltages. One functional cell would be bypassed in phase B, and two functional cells would be bypassed in phase A. Only 60% of the original cells would remain in use, and only 60% of the original voltage would be available.

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However, with the neutral-shift approach shown in Figure 5-20, only the failed cells are bypassed. The phase angles of the cell voltages have been adjusted so that phase A is displaced from phase B by 96.9° and from phase C by 113.1°, instead of the normal 120°. The star point of the cells no longer coincides with the neutral of the motor voltages, but the motor voltage is still balanced. The neutral-shift keeps 80% of the original cells in use, and 70% of the original voltage is available.

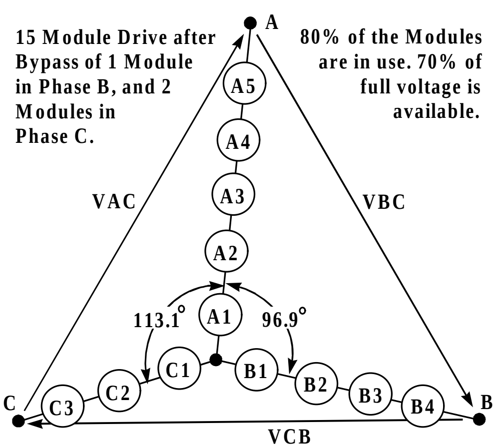

Figure 5-20. Drive output after loss of 3 Cells

As another example, Figure 5-21 shows the same 15-cell drive. All five cells remain in phase A, but two cells have failed in phase B and three cells have failed in phase C. Without neutral-shift, one functional cell would be bypassed in phase B, and three functional cells would be bypassed in phase A. Only 40% of the original cells would remain in use, and only 40% of the original voltage would be available. However, in Figure 5-21, only the failed cells are bypassed. The phase angles of the cell voltages have been adjusted so that phase A is displaced from phase B by 61.1° and from phase C by 61.6°. The star point of the cells is far removed from the neutral of the motor voltages, but the motor voltage is still balanced. The neutral-shift keeps 67% of the original cells in use, and 50% of the original voltage is available.

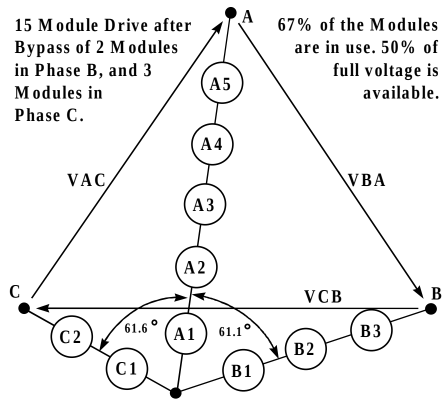

Figure 5-21. Drive output after loss of 5 Cells

Figure 5-22 compares the available voltage after one failure with and without using neutral-shift. In many cases, the extra voltage available with neutral-shift will determine whether or not a cell failure can be tolerated. The voltage capability of a drive after cell bypass can be calculated by using the following procedure.

If **X** is the largest number of cells in bypass in **two of the phases**, then the maximum voltage at the drive output will be:

Vout_bypass = Vout * (2*N - X) / (2*N)

where: Vout is maximum output voltage that the drive can deliver (Vout = 1.78*N*Vcell)
N is the number of ranks (or the total number of cells = 3*N)
Vcell is the cell voltage rating.

Example: Consider a drive with 18 cells, each rated for 690V. The maximum output voltage that this drive can deliver is (with N = 6 and Vcell = 690):

Vout = 1.78 * 6 * 690 = 7.37 kV

If after cell bypass, the drive has 6 cells operational in phase A, 5 cells in phase B, and 4 cells in phase C, then the maximum voltage that the drive can produce with neutral shift from the above formula is (with **X** = 1 + 2 = 3, because 2 cells in phase C and 1 cell in phase B are bypassed):

Vout_bypass = 7370 * (2 * 6 - 3) / (2 * 6) = 5.53 kV

The ratio (Vout_bypass / Vout) is available as the Max. Available Drive Voltage (%MAV) for display on the Keypad and for use in the Comparator and Analog Output Menus.

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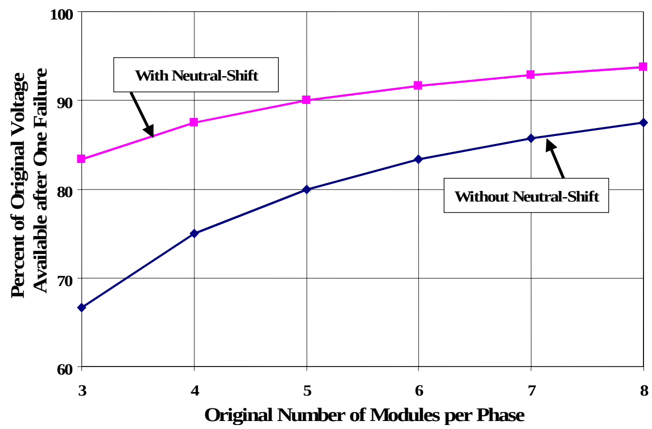

Figure 5-22. Available Voltage after First Failure

The drive control uses the information of faulted cells to automatically calculate the phase angles of cell voltages to maintain balanced motor voltages. During neutral-shift, each phase of the drive operates with a different power factor. Under lightly loaded conditions it is possible that one or more phases is absorbing real power while the other phase(s) are delivering power to the motor. In order to prevent the cell dc-voltage (corresponding to cells that are absorbing real power) from increasing (and subsequently causing a drive trip condition) the control automatically enables the "Energy Saver" function. Under light loads the energy saver function reduces motor flux sufficiently so that the motor operates with 70% power factor. At this operating point the magnetizing and torque components of motor current are equal and all cells deliver real power to the motor. As motor load is increased, the motor flux level is automatically increased to maintain 70% power factor until rated flux (or maximum possible flux) is achieved. This function ensures that the cells are delivering real power under all operating conditions.

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Note: In Cell Bypass the drive will invoke Energy Saver under light loads to prevent certain cells from charging-up.

5.9 Power Monitoring

Many Harmony Drives that Siemens builds have requirements for optional Power Quality Meters (PQM). Adding PQMs can be an expensive option. NXG control builds this functionality into the drive.

NXG control does processing on the input waveforms to aid in control of the drive. Because of this the drive can determine and display information about the drive input. Likewise, since the control is continuously sampling the drive output, the drive output information can also be displayed. Tables 5-11 and 5-12 list the parameters that can currently be displayed. See Meter Menu (8) for details on displaying this information.

Table 5-11. Input

Input Display Parameters
Phase A Input Current
Phase B Input Current
Phase C Input Current
Phase A Input Voltage
Phase B Input Voltage
Phase C Input Voltage
Input Frequency
Average Input Power (kilowatts)
Input Power Factor
Average Input Current THD
Efficiency
Input KWHrs
Input Reactive Power (kVAr)

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Table 5-12. Output

Output Display Parameters
Motor Current
Motor Voltage
Magnetizing Current
Torque Current
Motor Speed
Output Torque
Motor Flux
Motor Slip
Output Power
Output KWHrs

5.10 Dual Frequency Braking

5.10.1 Introduction to Dual Frequency Braking

There are many applications for VFDs that need occasional negative torque for braking. Unfortunately, at present the most popular static converters used for VFDs are not capable of returning energy to the utility. Such applications therefore require additional circuits to regenerate the braking energy into the AC mains, or to dissipate the braking energy in a resistor. Both of these solutions add cost to the VFD, and are especially undesirable for large modular medium-voltage VFDs.

Additional power devices can be avoided by using the existing circuits to inject DC current into the motor windings. This method dissipates the braking energy in the motor, and adds little cost to the VFD. However, DC injection braking is not very effective unless the available current is several times rated, especially for large motors. Another drawback is that estimation of motor speed is very difficult during DC injection braking.

Dual Frequency Braking is another method in which braking energy can be dissipated in the motor. Dual Frequency Braking provides much higher torque per ampere than DC injection braking, and permits continuous estimation of motor speed. Like DC injection braking, this approach is implemented in software and requires no additional hardware that can reduce the reliability of the drive.

Siemens has a patent on Dual Frequency Braking (US 6,417,644).

5.10.2 Operation

Dual Frequency Braking causes extra losses to be induced in the motor, by applying a second set of three-phase voltage vectors to the motor; in addition to the normal set of voltage vectors used for speed control. These extra losses are used to absorb the kinetic energy released during braking.

There are two side effects of Dual Frequency Braking (DFB) that are protected against as follows.

1. Torque pulsations: The motor can be subjected to as much as 1 per-unit torque pulsation at the pulsation frequency with DFB. However, the customer can select the torque pulsation frequency via the menu entry for Pulsation Frequency to avoid any mechanical resonance frequencies.

2. Motor heating: The losses generated during DFB cause motor heating and limit the number of deceleration ramps (from full speed to zero) that can be performed repetitively. Motor heating due to the additional losses is designed to be no worse than a line start. The software motor thermal model in NXG monitors motor heating due to these losses and can provide an alarm and/or a trip to indicate excessive heating. (Refer to the Motor Thermal Overload Protection section in this chapter for information on the thermal model.)
   The number of repetitive deceleration ramps (from full speed to zero) is limited to 2-per-hour (based on MG-1, Part 20, which assumes that the motor has cooled down to its rated temperature before the second ramp down). This recommendation applies when the load inertia and load torque are those for which the motor is designed. With lower values of load inertia and/or smaller speed reductions, DFB can be used more frequently.

The second set of voltage vectors creates a counter-rotating flux vector that produces high slip in the machine and generates these additional losses in the motor. The pulsation frequency is adjustable via a menu setting to allow critical frequencies (i.e. mechanical resonances) to be avoided. The injection frequency is always in opposite rotation to the applied motor electrical frequency (speed and direction of the machine).

> **Note:** Zero Sequence Voltage is the DC offset voltage.

Figure 5-23 is a block diagram showing how the two voltage vectors (normal VA1 and loss-inducing VA2) are added together to produce the braking function. Figure 5-24 is a scope picture of the two voltage vectors added together. The higher frequency voltage waveform VA2 is riding on the lower frequency waveform VA1.

> **Note:** The pulsation frequency is an input from the menu system (Parameter ID 3370) that is selectable by the end user. It provides the reference to produce the desired additional braking for the system and is adjustable in order to avoid resonance in the system.

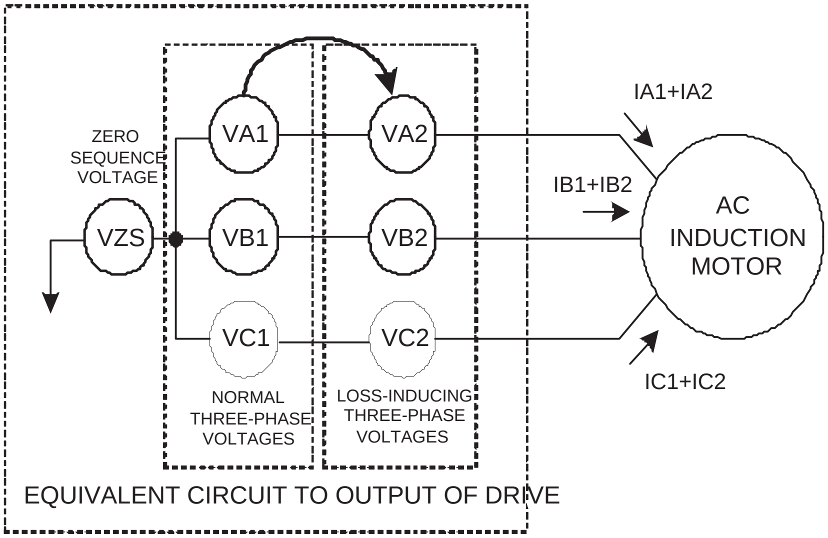

Figure 5-23. Dual Frequency Voltages Being Added Together with the Normal Three-Phase Voltages.

Note: Zero Sequence Voltage is the DC offset voltage.

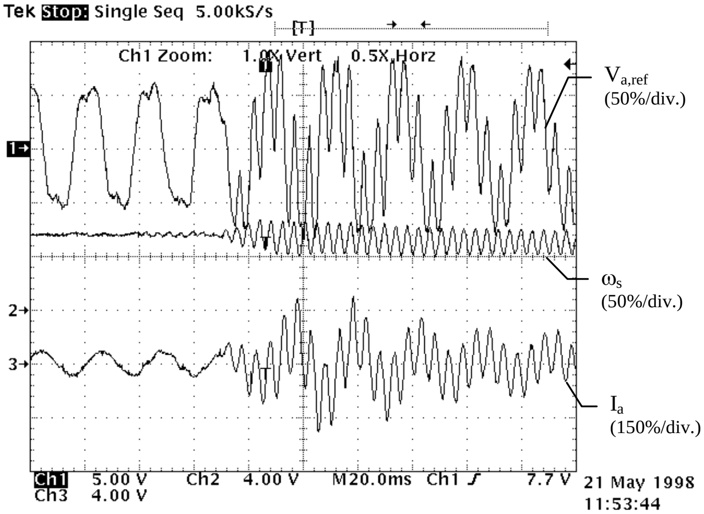

Figure 5-24. Scope picture showing Dual Frequency Braking waveform

In this method the first vector set controls the torque and flux in the motor, and is nearly synchronous. The second vector set induces losses in the motor, to absorb the braking power returned by the first vector set. The amplitudes of the two vector sets are coordinated to best utilize the current and voltage limitations of the converter. The frequency of the loss-inducing vector set is chosen with the goal of maximizing losses per ampere. This automatically minimizes the torque pulsations by minimizing the loss-inducing current.

The dominant losses in a motor are conduction losses, proportional to I^2R. Maximum losses per ampere require a large value of R. The nominal resistance of the motor windings is fixed by the design. Fortunately, the effective resistance depends on the frequency. The rotor windings are deliberately designed to exhibit a strong “deep-bar” effect, so that their resistance (above a low threshold) increases roughly proportional to frequency.

In principle the frequency of the loss-inducing vector set should be as high as possible, for maximum effective resistance. Since this high loss-inducing frequency produces negative slip, it will have negative sequence. The maximum applied frequency is limited by the control bandwidth of the converter, and also by the available voltage. However, because the loss-inducing vector set is negative sequence, the rotor frequency will be higher than the stator frequency due to the rotational speed.

5.10.3 Setting parameters for Dual-Frequency Braking

Table 5-13 provides a description of parameters in the Braking Menu (ID 3350). The Pulsation Frequency should be chosen such that it avoids the (mechanical) resonant frequencies of the system (motor, shaft and load). A study of the mechanical system is required to determine these resonant frequencies. The Brake Power Loss parameter sets the initial value of motor losses; the default value is satisfactory for most cases. The maximum voltage that is applied at the second (loss inducing) frequency is set by VD loss. This parameter cannot be set to a value higher than 0.5p.u. Adjustment of this parameter will have a direct effect on the achievable braking torque. Braking Constant sets the ratio of the power losses created in the motor to the power absorbed by the drive during braking. Using the default value gives sufficient margin and prevents the cell dc-bus voltages from increasing to trip levels.

Table 5-13. Description of parameters for Dual-Frequency Braking (DFB)

Parameter Name	Units	ID #	Description
Enable		3360	Enable or disable dual frequency braking (DFB). User must be aware of torque pulsations and motor heating produced with this method.
Pulsation Frequency	Hz	3370	Torque pulsation frequency when dual-frequency braking is enabled. Adjust for a different torque pulsation frequency. The control always recalculates the desired value due to limited resolution. Can be adjusted to avoid mechanical resonance frequencies.
Brake Power Loss	%	3390	Amount of high frequency losses at the onset of braking. Affects the limit of the V_q component of output braking voltage.
VD loss	p.u.	3400	Max amplitude of the loss inducing voltage. Use this to adjust the braking torque. Sets the maximum loss limiting (V_d) voltage amplitude.
Braking Constant	p.u.	3410	Ratio of motor (induced) losses to power absorbed from load. **This parameter should always be set to a value greater than 1.0**. Setting this parameter higher increases V_q and V_d voltage amplitude of losses in the motor and increases braking. Caution must be exercised to prevent a motor thermal trip.

5.10.4 Limitations

The drive output current plus the braking current must not exceed the current capability of the cells in the drive. Hence the braking torque is limited in the drive and is greatest at slow speed and smallest at high speed. Figure 5-25 shows the typical braking torque that can be expected with Dual Frequency Braking.

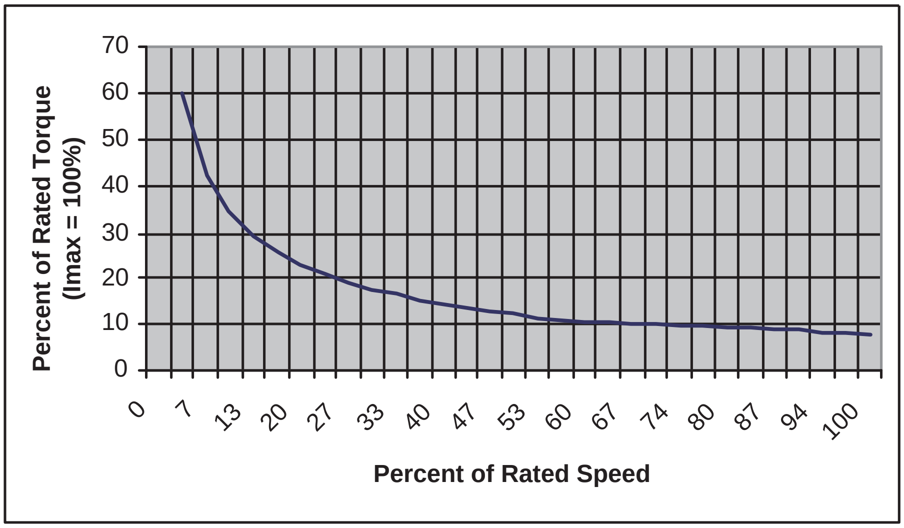

Figure 5-25. Best case braking torque with Dual Frequency Braking for a typical motor

With high efficiency motors and inverter duty motors, the braking torque that can be achieved with DFB is lower than the values shown in Figure 5-25. Contact IPD with the following motor-related data to determine the braking torque capability with a higher efficiency motor:

Rated HP	Rated Voltage
Rated Frequency	Full-load Speed
Half-load Efficiency	Full-load Efficiency
Half-load Power Factor	Full-load Power Factor
Locked-rotor Torque	Locked-rotor Current
Pull-out Torque	Critical Frequencies of the Mechanical System

Information on critical frequencies will allow a selection for the torque pulsation frequency.

5.11 Energy Saver

Energy saver control allows the reduction of motor losses (and improves overall efficiency) when the demanded motor load is low. To activate the energy saver control, adjust the Energy Saver Min Flux Demand (parameter ID 3170) in the Flux Control Menu (3100) to a value that is less than the Flux Demand (ID 3150, which is typically set to 1.0). Depending on the motor load, the control will reduce motor flux to a level between the Energy Saver Min Flux Demand and Flux Demand. As motor load increases, the control will increase motor flux until the value set by Flux Demand is achieved. Note that the response of the drive to sudden load changes is reduced with lower flux demand.

Energy saver is automatically invoked when an unbalanced set of cells is present after fast bypass. Under light loads, it is possible for one or more phases to be absorbing power from the motor. To prevent the cell DC bus from charging up to a trip level, the control reduces motor flux to improve power factor, which allows all three phases to provide power to the motor, and prevents the cells from charging up.

5.12 Motor Thermal Overload Protection

Table 5-14. Parameters for Motor Thermal Overload protection.

Parameter	ID	Description	Default
Overload select	1130	Selects the overload trip algorithm. • Constant (fixed current-based TOL) • Straight inverse time (motor temperature based TOL) • Inv time w/ speed derating (motor temperature based TOL)	Constant
Overload pending	1139	Sets the thermal overload level at which a warning is issued (constant mode).	100.0
Overload	1140	Sets the motor thermal overload trip level at which the timeout counter is started (constant mode).	120.0
Overload timeout	1150	Sets the time for the overload trip (constant mode).	60.0
Speed Derate Curve	1151	This menu sets allowable motor load as a function of speed.	Sub-menus
Maximum Load Inertia	1159	Sets the maximum load inertia that the motor can line start without exceeding maximum temperature.	0.0

NXG Harmony control provides Motor Thermal Overload (TOL) protection to prevent the motor from being subjected to excessive temperatures. TOL protection of the motor can be set up using the menus shown in Table 5-14. The “overload select” parameter allows one of three options to be selected for motor protection. The first model, which is called “constant,” is based on the current flowing into the motor. A Motor Thermal Overload Alarm 1 is issued as a warning to the user (of an impending overload fault) when the motor current exceeds the “overload pending” parameter. When the drive current exceeds the “overload” setting, Motor Thermal Overload Alarm 2 is issued and a thermal trip timer is started. If this condition is present for a period greater than the time set in the “overload timeout” parameter, the drive will trip and annunciate the event as Motor Thermal Overload Fault. **It should be noted that both the Alarms – 1 and 2 – have to be enabled through the SOP for the drive to display those conditions.**

The second and third thermal models, which are called “straight inverse time” and “inverse time with thresholds,” use a software motor thermal model to determine motor temperature. See Figure 5-26. For these options, the “overload pending” and “overload” settings represent the motor temperature limits (in percent of rated motor temperature) at which the overload warning and trip are generated. A brief description of the thermal model follows.

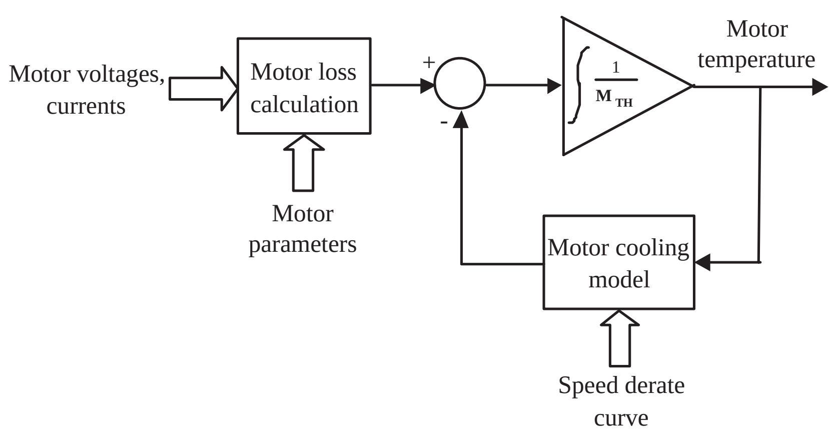

Figure 5-26. Block diagram of motor thermal model

The motor model estimates motor temperature based on the net heat generated in the motor and its thermal mass. A block diagram of the implementation is shown in Figure 5-26. The heat generated in the motor is estimated from the stator voltages, currents and motor parameters, while an estimate of the heat transferred from the motor (due to motor cooling) is made from the allowable motor current (more on this in the following paragraph). The motor loss calculation also includes the losses generated with Dual-Frequency Braking. The thermal mass (shown as M_{TH}) of the motor (or its heat capacity) is determined from the maximum load inertia listed in Table 20-1 of NEMA Standard MG-1 1993 Part 20.42. The user has the option of entering a known value of max load inertia as well (which can be obtained from the manufacturer).

If “straight inverse time” protection is chosen, then it is assumed that the motor has an allowable current level of 100% (for example, when the motor is equipped with a constant-speed cooling fan). With “inverse time with speed-derating,” the allowable current level is determined from the speed-derating curve entered through the keypad. This curve requires the user to enter allowable motor load for various speed breakpoints. The default-derating curve provides breakpoints for a quadratic cooling curve (and is shown in Figure 5-27). The motor manufacturer normally provides data for this curve. The control software uses the allowable current level to determine the cooling capability of the motor.

If the user’s preference is to enter a fixed value of an allowable current level other than 100% (as with the “straight inverse time” option), the speed-derating curve can be modified to have the same desired level for all the breakpoints.

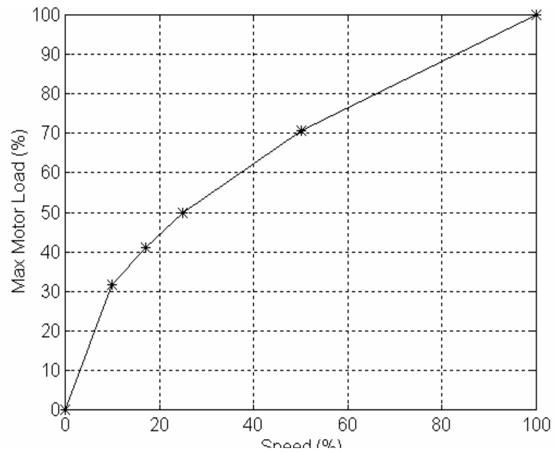

Figure 5-27. Default speed-derating curve showing maximum motor load as a function of speed

The plot in Figure 5-28 shows results from an experimental evaluation of the software thermal model with the “straight inverse time” option (100% “overload” setting) for various levels of drive current. A 4kV, 300hp motor was used for this test. The experimental data shows the time taken for the estimated motor temperature to go from rated temperature to 120% of rated. This curve is quite conservative as compared to a Class 10 TOL that trips at 280sec with 150% current and at 630sec with 125% current.

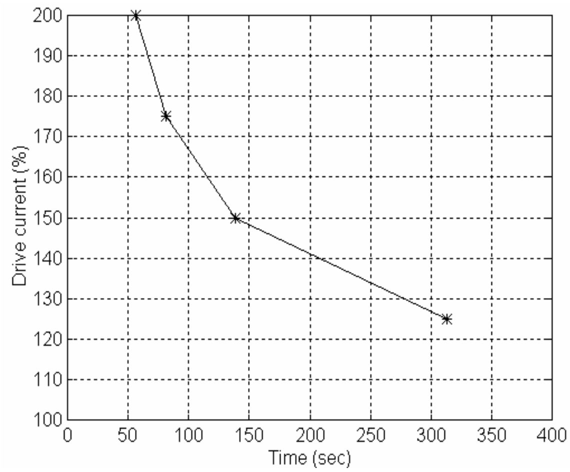

Figure 5-28. Drive current (in percent of motor rated current) versus time taken for motor temperature to rise from rated temperature to 120% of rated. The data was measured with the "straight inverse time" option.

5.13 Process Availability - The Perfect Harmony Advantage

Process availability is the primary prerequisite for applying a Medium Voltage VFD system in a process critical application. By combining the capabilities of Perfect Harmony's unique distributed power architecture, with the power of the NXG control, and the patented advanced power cell bypass feature, it is possible to deliver unparalleled opportunities for improved process availability. It is also essential that the process operator receive complete and accurate information on VFD status, to allow for process adjustments that can preclude process trips and disruptions in process capability.

5

5.13.1 What is ProToPS?

ProToPS is an acronym that stands for "Process Tolerant Protection Strategy". ProToPS is a standard implementation of the VFD SOP (System Operating Program). The ProToPS goal is simply to put the process operator in control of the process. ProToPS is a system program implemented from a customer process perspective.

ProToPS provides the operator with indication of a change in state in the VFD. These annunciation's identify changes that can impact the ability of the VFD to meet process demands, or to provide advance indication of a pending VFD trip. ProToPS allows the process operator to make process corrections to maintain the VFD in use in service, or adjust the process to address a pending VFD trip.

With ProToPS the process operator not only knows the general status of the VFDs, but also understands the VFD condition that has caused the general alarm to exist.

5.13.2 How Does ProToPS Work?

In the ProToPS SOP all of the automatic roll-back flags are turned off, and both cell bypass and auto-restart are implemented as standard. The need to roll-back is still necessary, but the process operator is now responsible to implement a roll-back as part of a process correction, as opposed to having the VFD roll-back either dictating, or in worse case upsetting, the process.

ProToPS takes the standard fault indications available in the VFD and categorizes them into four basic major categories as follows:

1. **Alarm**

   An alarm is an indication that a VFD parameter limit has been reached, or that a VFD system condition is present. An alarm provides the operator with awareness of the condition, but demands no immediate action. Examples of alarms include: over-voltage, under-voltage, and ground fault.

2. **Process Alarm**

   A process alarm is an indication that a VFD parameter limit has been exceeded and that the process either should be limited, or that the VFD capacity to meet the process demand is limited. Examples of process alarms include thermal limits above the rated limit and the condition of a cell having been bypassed.

3. **Trip Alarm**

   A trip alarm provides a clear indication that a VFD high parameter limit has been reached. A trip alarm is a indication that a VFD trip is pending. The operator receives a message that that unless the alarm can be cleared by a process change the VFD will trip.

4. **Trip**

   Certain VFD faults cannot be provided with advance warning. This limited number of faults will result in a VFD trip. A trip message is also annunciated when a trip alarm time limit has been exceeded. The number of mandated trips is considerably reduced with the implementation of GEN III cell bypass.

   With ProToPS the (VFD Run) signal is maintained as "true" and the (VFD Trip) signal is maintained as "false" for all alarm states.

5.13.3 ProToPS Implementation

With ProToPS the five main protection indication categories are provided as separate digital output signals. The concept is to provide the operator, or the process program, with a clear message to indicate a status change in the VFD. These five digital outputs are delivered from the Wago I/O system. The location of the five outputs is maintained as a standard set of TB2 terminations.

The specific information on the VFD parameter change is indicated (along with the general category information) as a serial address across a serial communications interface. Any serial communications protocol supported by the VFD product can be supported in the ProToPS implementation.

If other specific digital output information is required for a specific customer project that information must be mapped to a new digital output point on an additional digital output module. **The five basic category outputs must be present as digital outputs, at the standard designated TB2 terminal point locations, to validate the ProToPS implementation.**

5.13.4 The ProToPS Advantage

With advanced contactor cell bypass there are virtually no cell faults or cell communication faults that are non-bypassable. With NXG control the need for the designation "Transient Alarm" has disappeared as all bypassable faults become process transparent.

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With ProToPS and the NXG control, combined with the unique benefits of the Perfect Harmony cell based distributed power technology, process availability can be considerably enhanced and, the process operator can truly control the process.

5.14 PID Controller

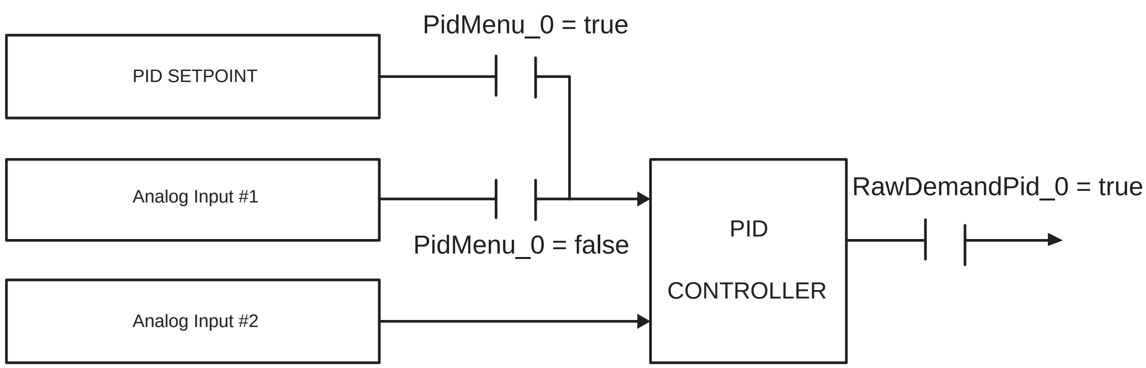

Figure 5-29. PID Controller

The NXG Control has a built-in PID controller available for use as a process control input of the NXG Command Generator. The PID is depicted in the figure below and also in the Command Generator Diagram drawing number 459713 located in Appendix C. The PID output is selected as the Speed Demand for the system by setting the System Program flag “RawDemandPid_0” to true. The PID command feedback source is fixed from Analog Input #2. This Analog input can be any of the available Analog inputs within the system, but must be designated as Analog input #2 in the setup menu (refer to section “Analog Input #2 Menu (4170)” in Chapter 3). The PID command has two possible sources: Analog input #1 or the PID set point menu item (ID 4410). The source for the PID command is controlled by the state of the system program flag “PidMenu_0”. Setting this flag to true selects the PID set point menu as the source. Setting this flag to false selects Analog Input #1. Analog input #1 source is configured from the “Analog input #1 menu (4100)” in Chapter 3. Refer to “PID Select Menu (4350)” Chapter 3 for details regarding the PID parameters.

5.15 Speed Droop

Droop is the decrease in the speed of a motor with a constant voltage and frequency, when the motor is under load. The difference between the synchronous (unloaded) speed of the motor and the full load speed is known as slip. Normally, slip compensation increases the output frequency of the VFD as the motor speed attempts to decrease. This compensation maintains a constant motor speed by minimizing droop.

However, in some applications, droop is needed. For example, in a multiple motor application, such as two motors mechanically connected to a common load, there are inherent differences between the motors. In case of a torque current increase, these differences may allow one motor to attempt to run faster, causing that motor to bear a greater portion of the load.

By adding droop to the more heavily loaded motor, its speed reference will proportionally decrease (based on load), shifting some of the load to the less loaded motor. The less loaded motor speed reference is not affected as much (because the current is lower) and so will start to pick up more of the load. As the loaded motor’s speed reference is decreased, it begins to shed load until an equilibrium is reached, and each motor is bearing its share of the load.

Figure 5-30 illustrates the Siemens method of speed droop control.

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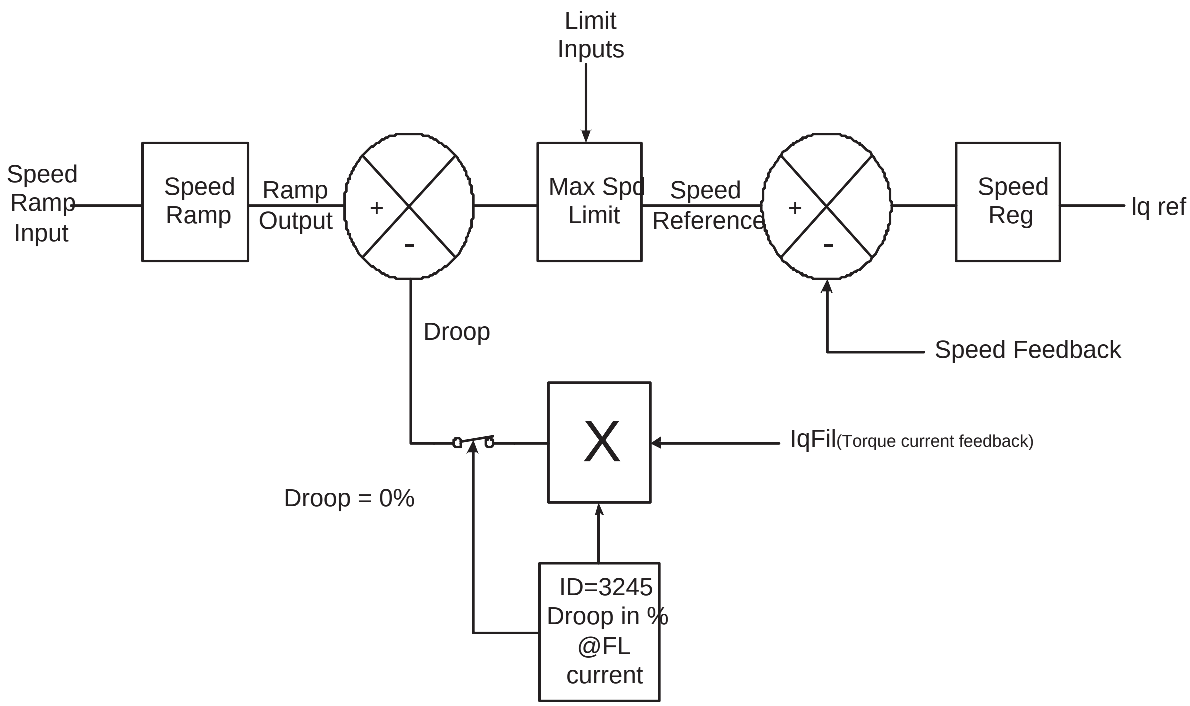

Figure 5-30. Method of Droop Control

The droop is entered in % of rated speed at full load current. The droop increases linearly with an increase in the torque current.

See Section 3.3.3 of Chapter 3 for instructions to set the droop.

5.16 Verification of Excessive Drive Losses Protection

NXG control utilizes input power and output power calculations to determine whether an internal fault has occurred. Drive Power Loss is estimated as the difference between input power and output power. This quantity is continuously checked with a pre-defined threshold that is inverse time-based, i.e., if the threshold is exceeded by a large margin, then the trip occurs in a short time after the event, and vice-versa.

Because the Drive Losses calculation (See Section 6.8 of Chapter 6) depends on input and output power calculations, it is important to make sure that the Drive Input and Output Rated Values (voltage and current – IDs 2010, 2020, 2030, and 2040), Drive Input Scalers (IDs 3030, 3040), Input CT turns ratio (ID 3045), Output Scalers (IDs 3440 and 3450), and Low Freq Wo (ID 3070) are correctly set.

A typical Harmony Drive has a full load efficiency of 96.0 to 96.5%. It is at full load that the drive has maximum losses and hence this is the operating point that may get closest to the threshold setting. If, during startup, the drive trips on an Excessive Drive Losses Fault, then the following steps may be followed to determine if it was a nuisance trip:

1. 1.Verify that the parameters listed above are correctly entered. Use VFD drawings along with visual inspection (if possible) to make the verifications. A common error is made in entering the Output Current Rating. This menu entry should always be set equal to the Cell Current Rating. A tech note on setting these parameters, “Drive Rated Parameters in NXG Control Topics,” is available on the Siemens website.
2. 2.Make sure that the Low Freq Wo parameter (ID 3070) matches the version of System Interface Board, since this parameter affects the phase-shift introduced in the measured voltage signals (and hence affects the output power calculation). This parameter should be set to 12.566 rad/s for the 461F53.00 version or to 37.859 rad/s for the 461F53.02 version.

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3. 3.Run the drive to a speed-point at which measurable values of input and output, voltage and current are present. Use the table in the Startup Procedure chapter of the Harmony Manual to verify if the feedback signals on the System Interface Board (i.e., on the test-points VMA, …, IMA, …, VIA, …, IIB, IIC) correspond to the values displayed by the drive. A Tech Note describing Drive Voltage Feedback scaling and verification is available on the Siemns website.
4. 4.Manually verify that the Drive Losses (= Input Power – Output Power, both of which can be read off from the keypad, ToolSuite, or the Debug Screen) are less than the threshold setting (for this type of drive and NXG software version) as listed in the block diagram and calculated in the equation of Section 6.8.4.
5. 5.Increase speed (and load) to make sure that the Drive Losses are within the range of 2.5% to 4.5% of Rated Input Power (which is also defined in equation 1).

Note: Transformers rated above 5000 hp and those designed prior to summer of 2002 may have higher than normal losses. Drives with such units may have more than 3.5% losses at full load. Use of version 2.50 of NXG software will help if drive losses at full load are 5.0% or lower. If the losses are higher than 5.0%, then discuss the issue with Application Engineering or Product Development.

5.17 Transformer Protection Constant for One Cycle Protection

The menu parameter Xformer Protection Constant (ID 7100) can be set according to the expected input power factor at full load. On a typical Harmony Transformer, the full load power is no worse than 0.96. Hence, the default value of 0.50 for the Xformer Protection Constant is adequate. Table 5-15 shows that the default value is good for power factors as low as 0.90, but may be marginal. See Chapter 6 for details of the one cycle protection implementation.

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Table 5-15. Transformer Protection Constant for Various Full Load Power Factors

Full load PF	K_{tr}
0.88	0.54
0.89	0.51
0.90	0.47
0.91	0.43
0.92	0.40
0.93	0.36
0.94	0.32
0.95	0.29
0.96	0.24

5.18 Effect of Slip Compensation on Motor Speed with NXG Control

With Slip Compensation, the electrical frequency is always greater than the desired shaft speed (mechanical frequency) for all non-zero loads. Therefore at 100% speed demand, the NXG OLVC will maintain the shaft speed at the rated synchronous speed of the motor – not full load speed.

Example:

A 6-pole motor rataed for 60 Hz has a synchronous speed of 1200 rpm. The Full Load speed (entered from the nameplate to ID 1030) is 1192 rpm.

Sending a speed demand of 100% will produce a mechanical (shaft) speed of 1200 rpm with slip compensation. This will result in a higher output (electrical) frequency to the motor, to provide the necessary torque to achieve the desired speed. The slip frequency is directly proportional to the required torque, up to the rated torque current. The display will show (depending on what is selected):

- Motor speed, in rpm, of 1200 rpm
- Motor speed, in percent, of 100%
- Motor Frequency, in Hz, of 60.4 Hz at rated torque (101% if motor frequency is displayed in percent)

Theory:

Sending the drive a speed demand of 100% means that Synchronous or Rated Speed is desired. This is calculated by equation 1 below.

Synchronous Speed, Ns, is defined by the formula:

1. $N_S = 120 * f_{RATED} / \#$ of poles

Slip is defined as a percentage (at rated torque) of the difference between synchronous and full-load speed (N_{FL}) divided by the synchronous speed:

2. Slip (%) = $100 * (N_S - N_{FL}) / N_S$

With slip compensation, the slip frequency is subtracted from the output frequency (f_{OUT}) to ensure that the mechanical speed matches the desired speed. In simple terms, this is done by taking the per unit (PU) Torque (T_{PU}) times the slip and subtracting it from the speed feedback (in frequency), effectively adding it to the speed reference:

3. $S_{MOT} = f_{OUT} - (\text{Slip} * T_{PU})$
4. $S_{ERR} = S_{DMD} - S_{MOT}$

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In equation 4, S_{ERR} represents the error signal processed by the speed regulator. The implication for this is that for a speed command of 100%, based on the synchronous speed, the applied electrical frequency will be higher than rated frequency due to the increase created by the slip compensation (equation 3 and 4). This will result in the motor running at true requested mechanical speed with the electrical frequency adjusted to provide the torque necessary to produce that speed.

Limiting Frequency by Disabling Slip Compensation:

If The motor is to be limited to a specific frequency, then the slip compensation can be disabled. In the same example, the Full Load speed parameter (1030) must be set to 1200 rpm. This effectively disables the slip compensation by reducing equation 2 to produce a slip of zero. Then equation 3 and 4 reduce to:

1. Slip = (1200 – 1200) / 1200 = 0
2. $S_{MOT} = f_{OUT} - 0 = f_{OUT}$

The end result will be that the drive will regulate to the output frequency rather than the motor shaft speed (mechanical speed). No compensation for slip is done.

Conclusion:

With Slip compensation

- Output shaft speed will equal the percentage of synchronous speed requested
- The frequency will vary depending on load but the speed will be fixed
- Motor Speed in rpm should be monitored

Without Slip Compensation (parameter 1030 set to the synchronous speed)

- The Output Frequency will equal the speed demand percentage of rated frequency
- The mechanical (shaft) speed will vary with load but the frequency will be fixed
- Motor Frequency in Hz should be monitored

Note: The internal units for speed and frequency are in radians/sec. When plotting any related internal variables with the Siemens Tool Suite, the selected values are normalized to rated speed, so a scaling factor of 1.0 can be used.

5.19 Calculating Voltage Attenuator Resistors

5.19.1 Resistor Calculation

Input and output voltages are attenuated to provide a low voltage signal for measurement. Typically, two resistors are used (on both the input and output sides) to support medium voltages. Use the calculations explained below if the resistor values are not available in the Harmony NXG Cookbooks. Note that even if the discrete value of available resistors is not the same as the exact calculated value, no scaling is required; the NXG software automatically scales the voltages as needed.

Note: The input attenuator resistors must be selected to match the input transformer nameplate rating. The output attenuator resistors must be selected to match the motor nameplate rating.

Figure 5-31 shows the attenuator circuit that is used to convert medium voltages to low voltage measurement signals. R_f represents the effective feedback resistance used in the System Interface Board (R_f = 4765 Ω in current versions, i.e., 461F53-00 and 461F53-02).

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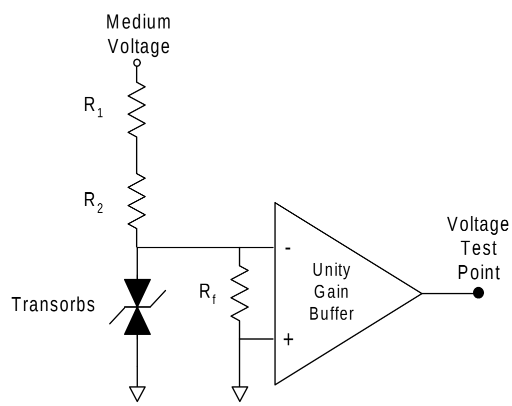

Figure 5-31. Attenuator Circuit

Calculate the resistor values as follows:

$$\mathbf{R_1 + R_2 = (722.3 * V_{mv}) - 4765}$$

Where:

- V_{mv} is the nominal line-to-line input voltage in RMS
- 4765 is the value of R_f
- 722.3 is a combined constant equal to (4765/5.3864) * (√2 / √3)
- 5.3864 is the nominal voltage at the test point for 1 PU

- √2 is used to convert from L-L to L-N voltage
- √3 is used to convert from RMS to peak voltage

For example, for a V_{mv} of 4160 V, $R_1 + R_2 = 3.0$ MΩ. The Harmony NXG Cookbook yields values of $R_1 = 2.0$ MΩ and $R_2 = 1.0$ MΩ. In typical applications, R_2 is fixed at 1.0 MΩ and R_1 is selected based on the rated medium voltage level. Both resistors are 10 W, 1% medium voltage resistors.

For rated voltages below 1.0 kV, fix the value of R_2 at 120 kΩ.

Warning: Never place a third resistor inside the control cabinet in series with the medium voltage resistors to achieve the calculated values. Doing so will violate the protection of the transorbs in the attenuator circuit and introduce dangerous voltages into the control cabinet.

5.19.2 Software Supported Voltages

The following input and output voltages are supported by the NXG software and will be automatically scaled for measurement:

2400, 3000, 3300, 3400, 4160, 4800, 6000, 6600, 7200, 8400, 10000, 11000, 12000, 12500, 13200, 13800, and 22000.

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CHAPTER

6 Theory

6.1 Introduction

The Harmony series of drives from Siemens is intended for use with standard medium-voltage three-phase AC induction and synchronous motors. The induction motor is widely used due to its robust and simple construction, its tolerance for bad environments, and its low cost. On the other hand, a synchronous motor is used in applications where very high efficiency or high torque is required. When either of these types of motors is connected to a utility supply at a fixed frequency (60 or 50 Hz), operation at a single fixed speed is obtained. The Harmony series drives allow variable speed operation, without sacrificing any of the desirable properties of the induction motor.

The Harmony series drives provide variable speed operation by converting utility power at fixed frequency and fixed voltage to variable frequency, variable voltage power. This conversion is done electronically, without moving parts. Unlike older drive types, the Harmony series does not force the user to accept unpleasant by-products of this conversion process. Specifically:

- The Perfect Harmony series drives do not inject significant harmonic distortion into the plant's distribution system. No power filters are required. No interference to sensitive equipment or resonance problems with power factor capacitors will occur.
- The Perfect Harmony series drives present a high power factor to the utility, typically 95% or better throughout the speed range. No power factor correction is required.
- The Perfect Harmony series drives do not require any derating of the motor due to output harmonics. No additional motor heating is produced versus operation directly from the utility.
- The Perfect Harmony series drives when set up properly, do not produce torque pulsations, which can excite mechanical resonance.
- The Perfect Harmony series drives cause no noticeable increase in acoustic noise from the motor, versus operation directly from the utility.
- The Perfect Harmony series drives cause no appreciable additional stress to the motor insulation, versus operation directly from the utility.
- The Perfect Harmony series drives allow unrestricted use of rated motor torque throughout the speed range, subject only to the thermal limitations of the motor.
- The Perfect Harmony series drives are virtually silent in operation if liquid-cooled, so that normal conversation is possible next to drives running at full power.
- The Perfect Harmony series drives are completely modular in construction, so that if necessary, a defective module can be replaced in minutes. Sophisticated microprocessor-based diagnostics pinpoint the location of any defects.

6.2 The Power Circuitry

> **Note:** The examples used in this section refer to drives having low-voltage cells. High-Voltage cell systems will have different values.

The Harmony series drives achieve this uncompromised performance by employing well-proven technology in a new configuration. Medium voltage levels are obtained by adding together the outputs of multiple low-voltage power cells. The low-voltage power cells are simplified variations of standard PWM motor drives for low-voltage service, which have been built in high volume for many years.

Figure shows a typical power circuit topology for a 2400 or 3300 volt Perfect Harmony series drive, using 690 VAC cells. Each motor phase is driven by 3 power cells connected in series. The groups of power cells are wye connected with a floating neutral. Each cell is powered by an isolated secondary winding of an integral isolation transformer. The nine secondaries are each rated for 690 VAC at one ninth of the total power. The power cells and their secondaries are insulated from each other and from ground for 7.2 kV class service.

For a 4160 or 4800 volt drive, Figure would be extended to have 4 power cells in series in each phase, with 12 secondaries on the integral isolation transformer. For a 6000 volt drive, there would be 5 power cells in series in each phase, with 15 secondaries on the integral transformer. For a 6600 to 7200 volt drive, there would be 6 power cells in series in each phase, with 18 secondaries on the integral transformer.

Each cell is a static power converter. It is capable of receiving input power at 690 VAC 3-phase, 50/60 Hz and delivering that power to a single-phase load at any voltage up to 690 VAC and at any frequency up to 330 Hz. Note: for output frequencies greater than 180 hertz the VFD power cell current output will be de-rated. Consult the factory for information applicable to the specific application requirements

With three 690 VAC power cells in series per phase, a Perfect Harmony series drive can produce as much as 2080 VAC line-to-neutral, or a maximum V-available of 3600 volts. With four 690 VAC power cells in series per phase, a Perfect Harmony series drive can produce as much as 2780 VAC line-to-neutral, or a maximum V-available of 4800 volts. With five 690 VAC power cells in series per phase, a Perfect Harmony series drive can produce as much as 3470 VAC line-to-neutral, or a maximum V-available of 6000 volts. With six 690 VAC power cells in series per phase, a Perfect Harmony series drive can produce as much as 4160 VAC line-to-neutral, or a maximum V-available of 7200 volts.

It should be noted that it is possible to connect as many as eight power cells in series using the Harmony control, but without some capability. V-available determines the maximum voltage that can be delivered from the VFD output. The actual voltage delivered is fully adjustable. As the Harmony VFD topology is based on multi-level output capabilities the result is true adjusted voltage. The advantages of utilizing the V-available capability of the VFD become apparent when the patented advanced cell bypass option is applied.

Other cell voltages are available, which will change the number of cells needed for a given output voltage. However, the basic principle is unchanged.

The power cells all receive commands from one central controller. These commands are passed to the cells over fiber optic cables in order to maintain the 7kV class isolation.

The transformer secondaries that supply the power cells in each output phase are wound to obtain a small difference in phase angle between them. This cancels most of the harmonic currents drawn by the individual power cells, so that the primary currents are nearly sinusoidal. The power factor is always high - typically 95% at full load.

The schematic of a typical power cell is shown . In this example, a 3-phase diode rectifier, fed by the 690 VAC secondary, charges a DC capacitor bank to about 860 VDC. The DC voltage feeds a single-phase H-bridge of IGBTs.

At any instant of time, each cell has only three possible output voltages. If **Q1** and **Q4** are on, the output will be +DC bus volts from **T1** to **T2**. If **Q2** and **Q3** are on, the output will be –DC bus volts. Finally, if either **Q1** and **Q3** or **Q2** and **Q4** are on, the output will be 0 volts.

With 3 power cells per phase, the circuit of can produce 7 distinct line-to-neutral voltage levels (±2570, ±1720, ±860, or 0 volts). With 5 cells per phase, 11 distinct voltage levels are available. With 6 cells per phase, 13 distinct voltage levels are available. The ability to generate many different voltage levels allows the Harmony series drives to produce a very accurate approximation to a sinusoidal output waveformm.

Figure hows how these waveforms are generated for the case of 3 cells per phase. First, a reference signal is created for each phase. These signals are digital replicas of the ideal waveform to be approximated. In , **RA** illustrates the reference signal for phase A. This reference signal is then compared with 3 triangular carrier signals. shows conditions when the output frequency is 60 Hz and the carrier frequency is 600Hz, so that there are exactly 10 carrier cycles per reference cycle. The 3 carriers are identical except for successive phase shifts of 60 degrees (based on the number of cells per phase). Phase shift between carriers in each phase is computed based on the following equation:

$$\text{Carrier Phase Shift (same phase)} = \frac{180 \text{ degrees}}{\# \text{ of cells/phas}}$$

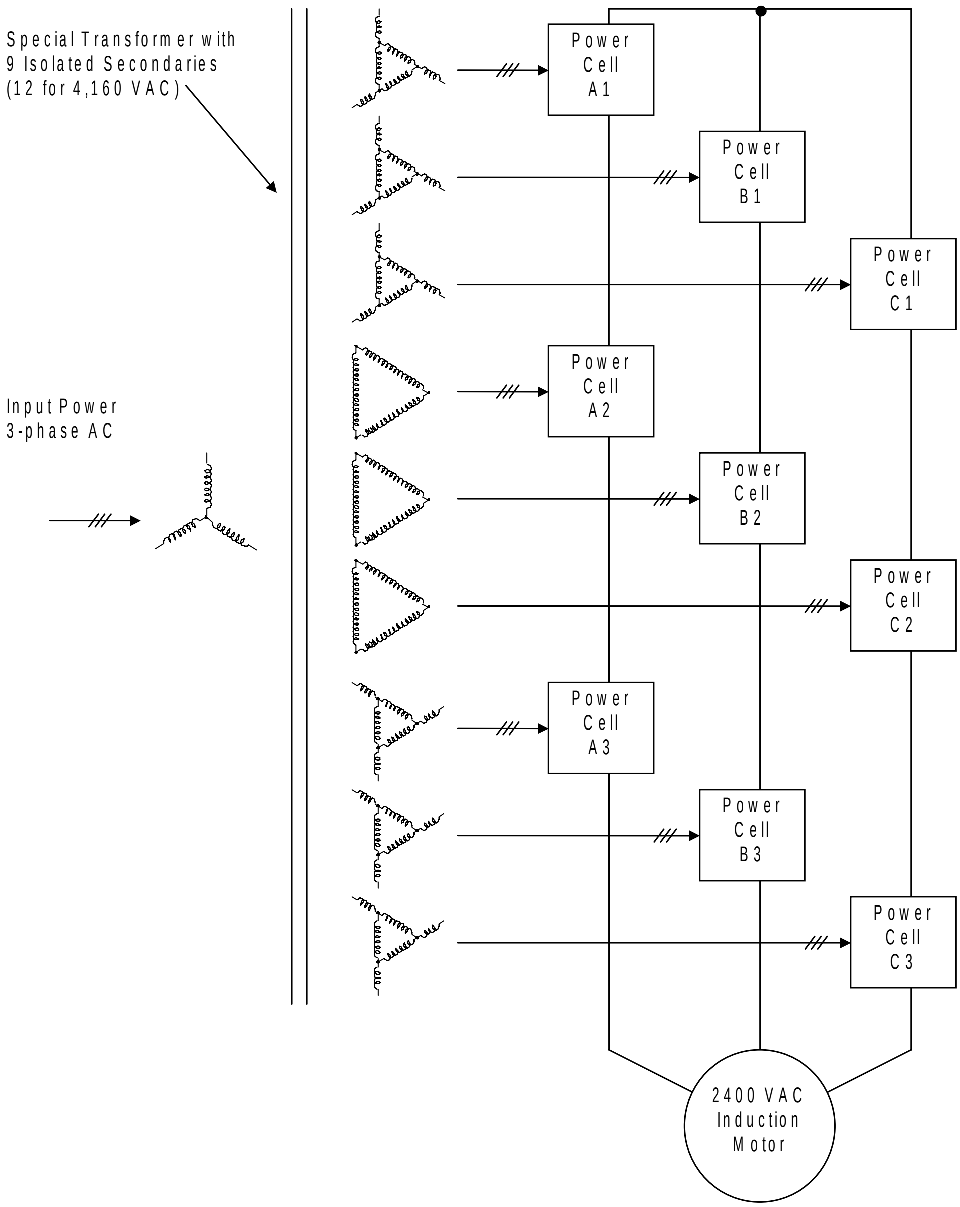

Figure 6-1. Topology of Perfect Harmony VFD (3 Cells, 2400 or 3300 VAC)

Whenever the reference is greater than the first (unshifted) carrier, the signal **L1** is high; otherwise **L1** is low. **L1** is used to control the pair of transistors **Q1** and **Q2** in cell **A1** (see the left pair of transistors inFigure). Whenever the reference is greater than the inverse of the first carrier, the signal **R1** is low; otherwise **R1** is high. **R1** is used to control the pair of transistors **Q3** and **Q4** in cell **A1** (see the right pair of transistors in Figure).

The difference between **L1** and **R1** gives the output waveform of cell **A1**, shown in Figure for Phase A as **A1**.

In a similar manner, the reference signal is compared with the second carrier (shifted 120 degrees) and its inverse to generate control signals **L2** and **R2** for the transistors in cell **A2.** The output waveform of cell **A2** is shown as **A2**.

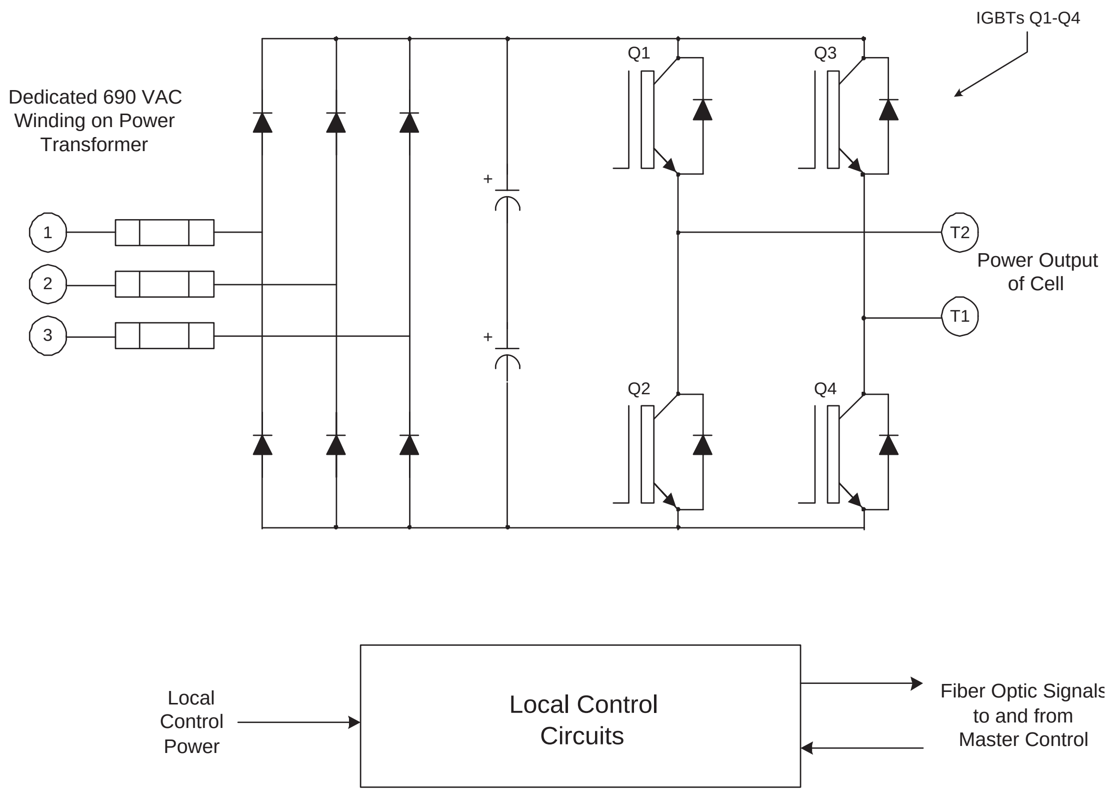

Figure 6-2. Schematic of a Typical Power Cell

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Finally, the reference signal is compared with the third carrier (shifted 240 degrees) and its inverse to generate control signals L3 and R3 for the transistors in cell A3. The output waveform of cell A3 is shown as A3.

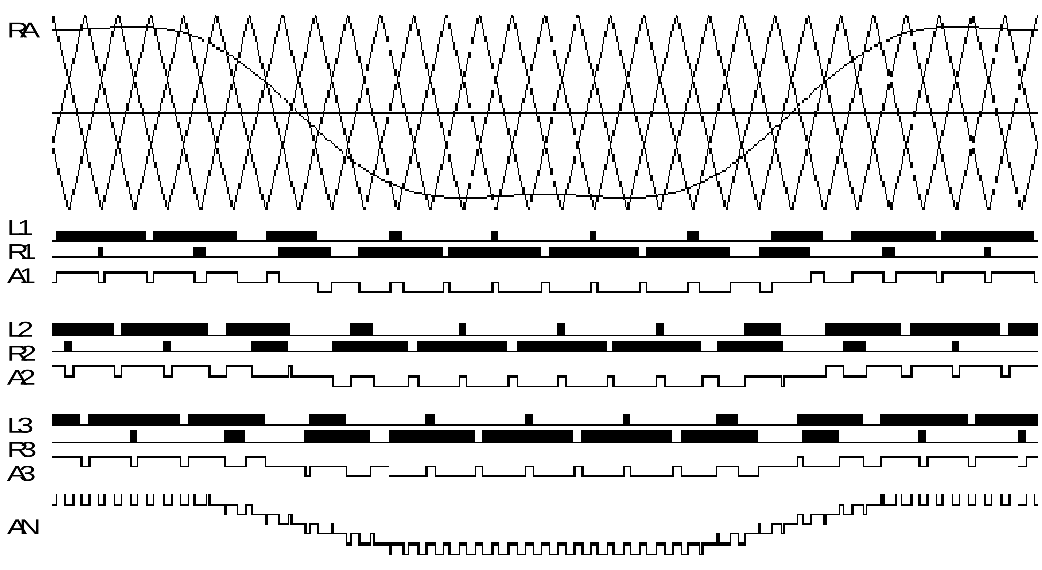

Figure 6-3. Waveforms for Phase A

The sum of the output voltages from cells **A1**, **A2** and **A3** produces the A-to-neutral output voltage of the drive, shown in Figure 6-3 as **AN**. There are 7 distinct voltage levels. Note that this voltage is defined between terminal **A** and the floating neutral inside the drive, not the motor neutral.

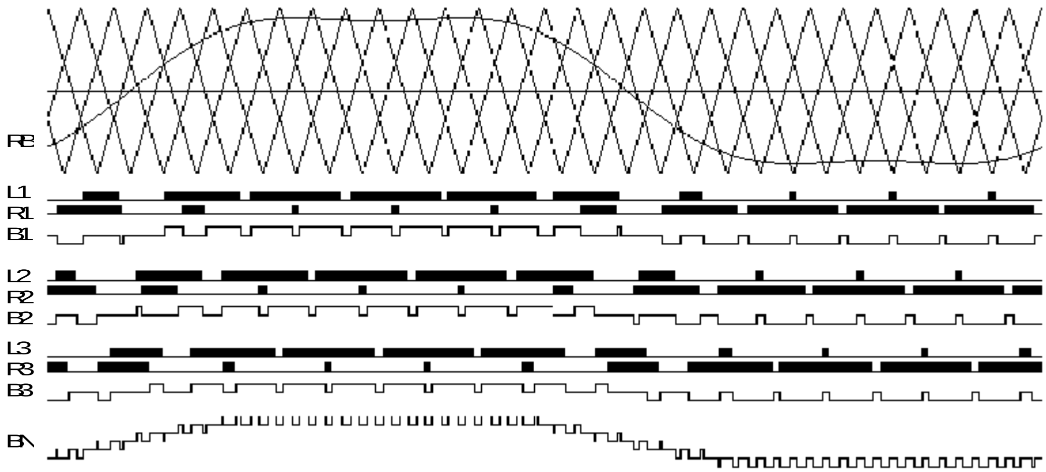

Figure 6-4. Waveforms for Phase B

Figure 6-4 shows the same signals for Phase B. The 3 carriers are identical to Figure 6-3, except each is shifted by 20 degrees from its Phase A equivalent (see note below). The reference **RB** is also identical to Figure 6-3 , except that it is delayed by 120 degrees (at the reference frequency).

The sum of the output voltages from cells **B1**, **B2** and **B3** produces the B-to-neutral output voltage of the drive, shown in Figure 6-4 as **BN**.

Figure repeats the two line-to-neutral voltages **AN** and **BN**. The numerical difference between **AN** and **BN** forms the line-to-line voltage impressed on the motor, and is shown in Figure 6-3 as **AB**.

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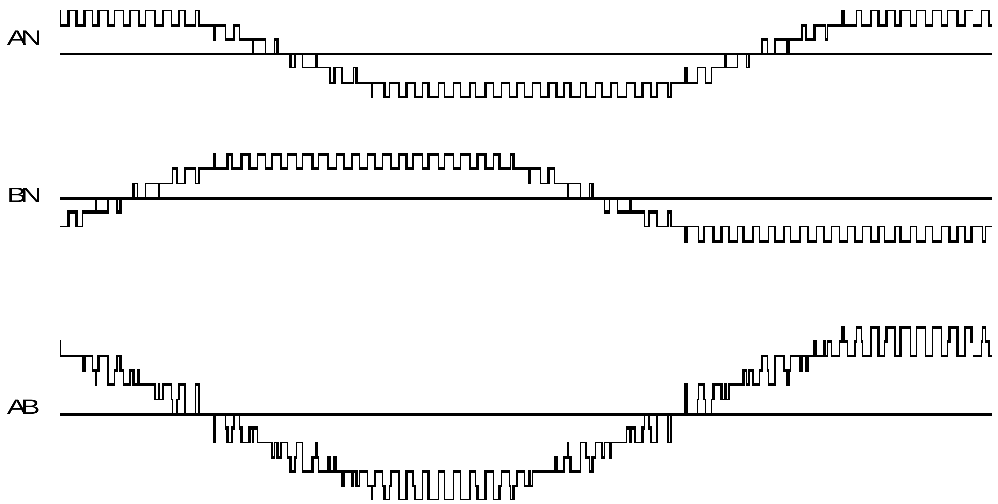

Figure 6-5. Waveforms for Line-to-line Voltage

> **Note:** The phase shift of the carrier signals between phases is determined by the number of cells in the system. The equation being Phase shift = 180 degrees / total number of cells. In this case (3 ranks or 9 cells) the carrier signal phase shift phase to phase is (180 / 9) = 20 degrees. This shift of the carriers between phases reduces the number of devices that are switching at one time. The above is true if no cells are in bypass. If one or more cells are in bypass the carrier signals are offset by 180 degrees / total remaining cells.

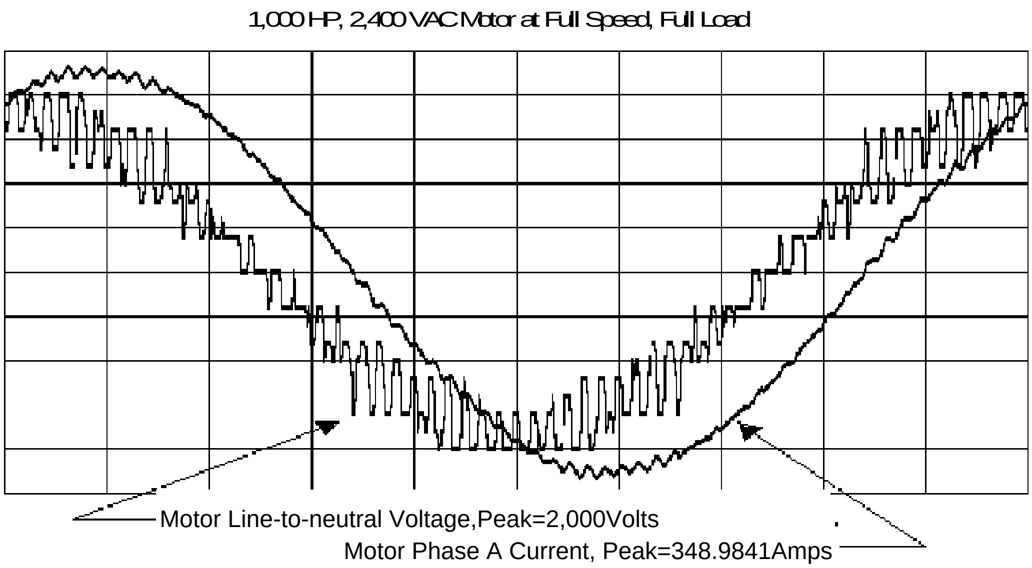

Figure 6-6. Harmony Output Waveforms, 2400 Volt Drive at Full Load

Figure shows motor voltage and current waveforms for a 2400 VAC Harmony drive rated at 1000 hp. The voltage shown is between phase A and the motor neutral (not the same as the drive neutral). The motor current is in phase A during full-load operation. Anyone familiar with such waveforms for other types of static drives will appreciate how accurately they approximate true sine waves. A quantitative measure of the waveform quality is its Total Harmonic Distortion, or THD. The THD of the motor currents with a Harmony series drive is always less than 5 percent.

Figure shows the input voltage and current waveforms for the same drive as in Figure , under the same conditions. The perfect sine wave in Figure is the voltage into the special input transformer, measured between phase A and the neutral of the wye-connected primary. The other waveform is the current into phase A of the same winding.

The currents drawn from the power source by Harmony series drives are also good approximations to true sine waves, due to the harmonic cancellation obtained with the phase-shifted secondary windings of the transformer. The THD of the input currents with a Harmony series drive is also always less than 5 percent.

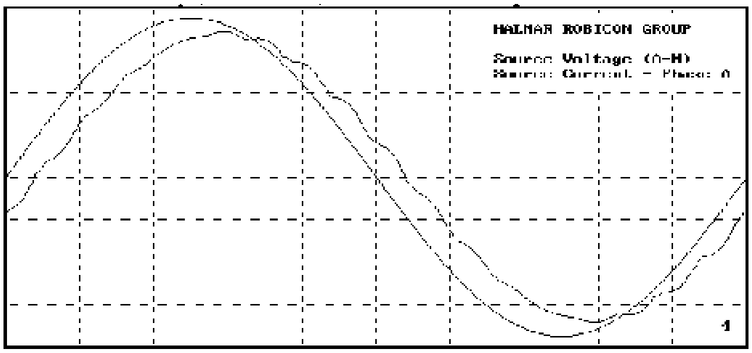

Figure 6-7. Harmony Input Waveforms for a 2400 Volt Drive at Full Load

Note in Figure that the input current lags behind the input voltage by less than 15 degrees at full load. This represents a power factor better than 96 percent. Harmony series drives always maintain a high power factor, typically better than 95 percent throughout the speed and load range.

> The waveforms shown in through represent the worst case for a Harmony series drive when there are only 3 cells per phase. When the number of cells increases, as in 12 or 15 cell drives, the waveforms become considerably better.

Figure shows the motor voltage and current for a 15 cell Harmony drive at full power, while shows the input voltage and current for the same drive and load.

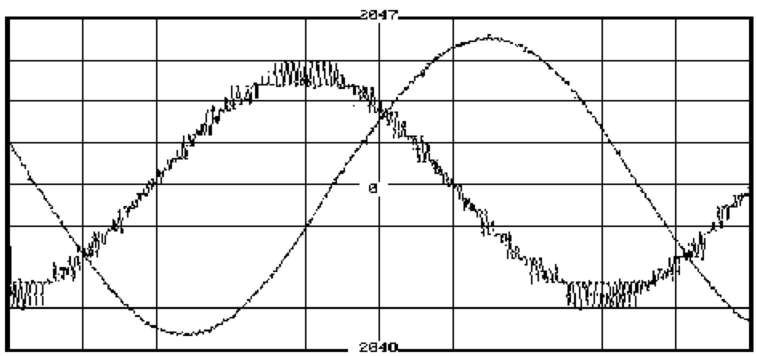

Figure 6-8. Motor A-B Voltage and Current in Phase C at Full Load for a 4160 Volt Harmony Drive

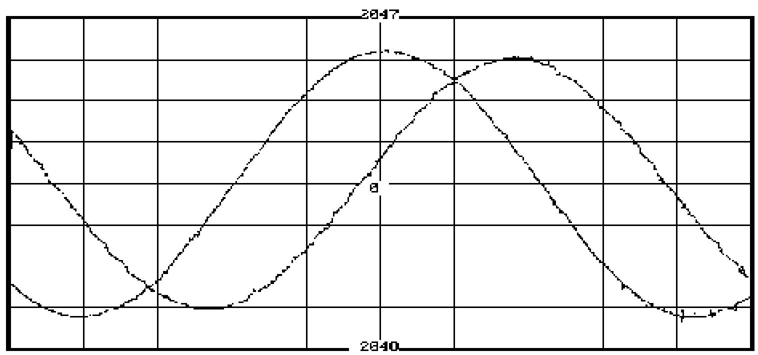

Figure 6-9. Input A-B Voltage and Current in Phase C at Full Load for a 4160 Volt Harmony Drive

6.3 The Control System

The block diagram in Figure shows the implementation of the Harmony Control System. The Control System consists of Signal Interface and Conditioning Boards, an A/D Converter Board, a Pentium Processor Board, a Digital Modulator Board, and one or two Fiber Optic Interface Boards.

The Signal Interface Board processes the feedback signals collected from the drive. The circuits on this board scale and filter the feedback signals before passing them along to the A/D Converter Board over a 50pin cable. This board also contains connections for an analog input signal and a relay contact. The contact is typically used for ESTOP.

The function of the A/D Converter Board is to sample the input and output currents and voltages, and convert them to digital signals for the Pentium processor. The sample rate varies from 3kHz to 6KHz and is a function of the carrier frequency (which is also the IGBT switching frequency) and the number of 'available' cells in the system. The Digital Modulator Board generates the signal for the A/D converters to start sampling. Once the A/D converters finish sampling, they provide an interrupt to the processor to begin its calculation cycle.

The Pentium processor performs all the functions for motor control and generates three-phase voltage commands for the digital modulator. In addition, it monitors the input voltages and currents to provide metering functions (such as power factor, input power and harmonic calculation), input protection (from over-current, excessive reactive current, under-voltage and single-phasing), and input voltage magnitude, frequency and phase angle for Synchronous Transfer.

The Digital Modulator is comprised of four modulator EPLDs (Erasable Programmable Logic Devices), one master and three slaves, each running the same code. Each EPLD provides communications for six Harmony cells. The master EPLD contains registers that are used for communication with the Processor. For each phase voltage command, the processor writes to the EPLDs, two values, the first for the present time instant and the second for a time instant that is half-a-sampling period away. A voltage increment, or step corresponding to these values, and the direct number of steps between values, is also written to the EPLDs. These phase commands are written to the EPLDs once every sampling period.

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The master EPLD creates a set of timing signals that causes the control software to sample the feedback signals and run the control, monitoring algorithms. These timing signals cause all of the EPLDs to transmit information to the cells simultaneously, once every 9 to 11 microseconds. This time (is determined by the processor and) is based on the drive configuration and is fixed for a particular configuration. In between every transmission period, each EPLD performs interpolation, phase-shifted carrier generation, pulse-width modulation (PWM), and cell communication. The resulting PWM commands for each cell along with the mode of operation is assembled as an 8-bit packet (at a rate of 5 Megabaud) that is transmitted to the cells through the Fiber Optic Interface. In response to the transmitted data, the modulators receive a similar 8-bit packet from each of the cells. The return message from the cells contains status bits that are decoded by the EPLDs and conveyed to the processor. In case of a fault other EPLDs are also affected. The portion of firmware code that is associated with sending and receiving messages from the cells is called the FOLA (for Fiber Optic Link Adapter).

In addition to the tasks listed above, the master EPLD communicates with the bypass controller and monitors hardware faults such as IOC, ESTOP and power supply faults. The Bypass Controller is implemented in a separate EPLD that is configured to control the cell bypass (mechanical) contactors. This device resides along with the modulator EPLDs on the Modulator Board. After detection of a cell fault the processor communicates with the Bypass Controller to bypass the faulted cells. In addition to bypassing cells, the Bypass Controller constantly checks the status of the contactors to verify if they are in their requested states.

The Fiber Optic Interface transfers data between the modulator EPLDs and the cells over fiber optic channels. Each Fiber Optic Interface Board can communicate with up to 12 cells. Up to two Fiber Optic Interface Boards can be put in the system. Each cell receives its firing commands and status signals from the Interface Board through a dual fiber optic channel.

Every transmission is checked for completeness and parity. If an error is detected a link fault is generated. The 8-bit packet sent to the power cells provides operational mode and switching information. The local communication circuits in each power cell operate as slaves to the EPLDs on the Modulator Board. The local control circuits on each power cell convert the information received to IGBT firing pulses.

The return packet echos the operational mode and cell status. One bit is the output of a PWM signal that monitors cell temperature. Should a failure occur on an individual cell, the worst case shut down of all power cells requires 2 transmission cycles or 22 µsec. maximum.

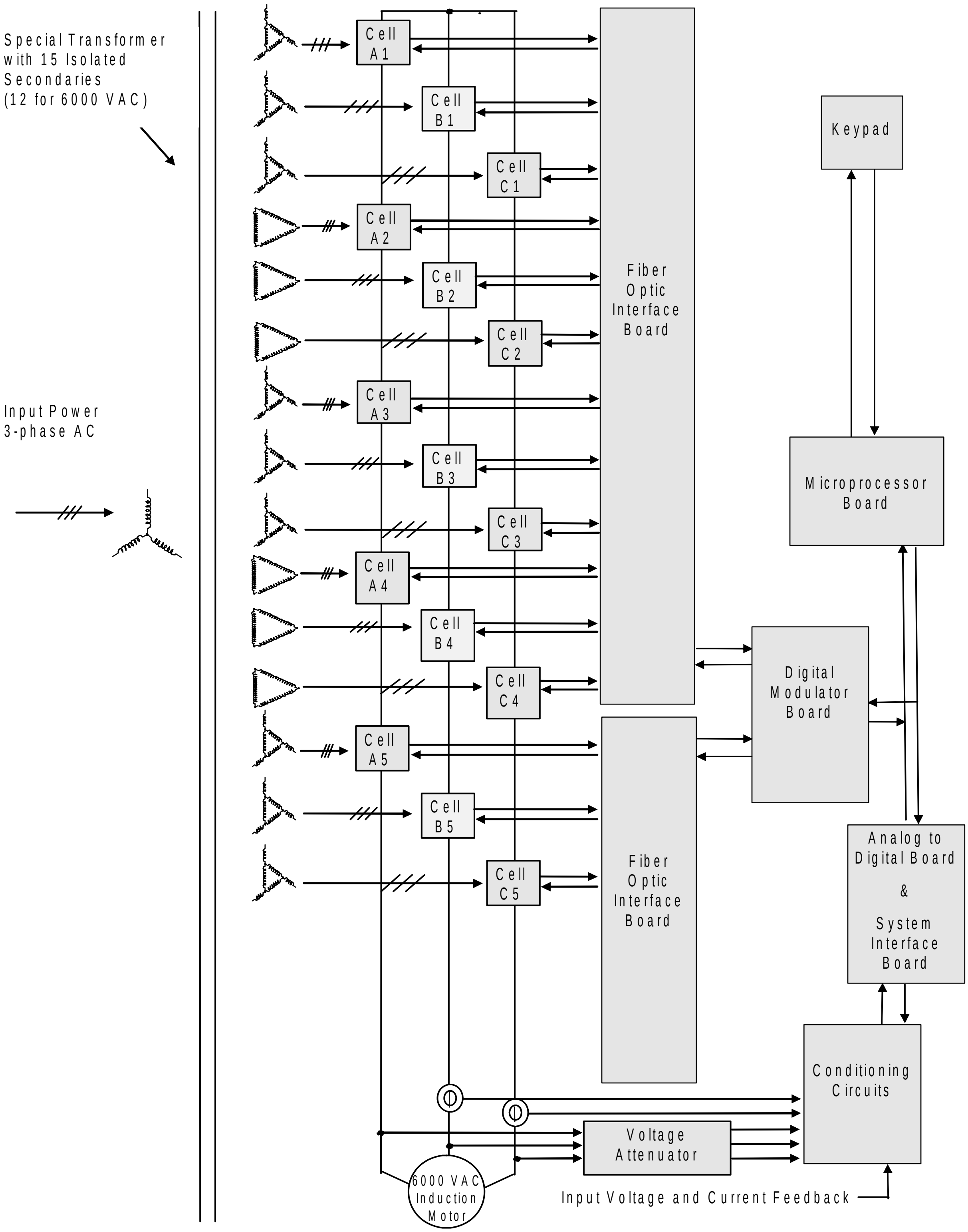

Figure 6-10. Block Diagram of Harmony Control Structure for 6000 V Drive

6.4 The Control Modes

Harmony drives use vector control to control induction and synchronous motors. Vector control provides a framework that is simple to implement, but performs nearly as well as a DC motor. Figure shows a simplified representation of the vector control algorithm implemented in Harmony drives. The basic components of vector control are:

1. **Motor model**: determines motor flux and speed.
2. **Current regulators**: these regulators are referred to as the inner loops.
3. **Flux and speed regulators**: these regulators are referred to as the outer loops.
4. **Feed-forward (FF) compensation**: improves the transient response of torque loop and flux loop.

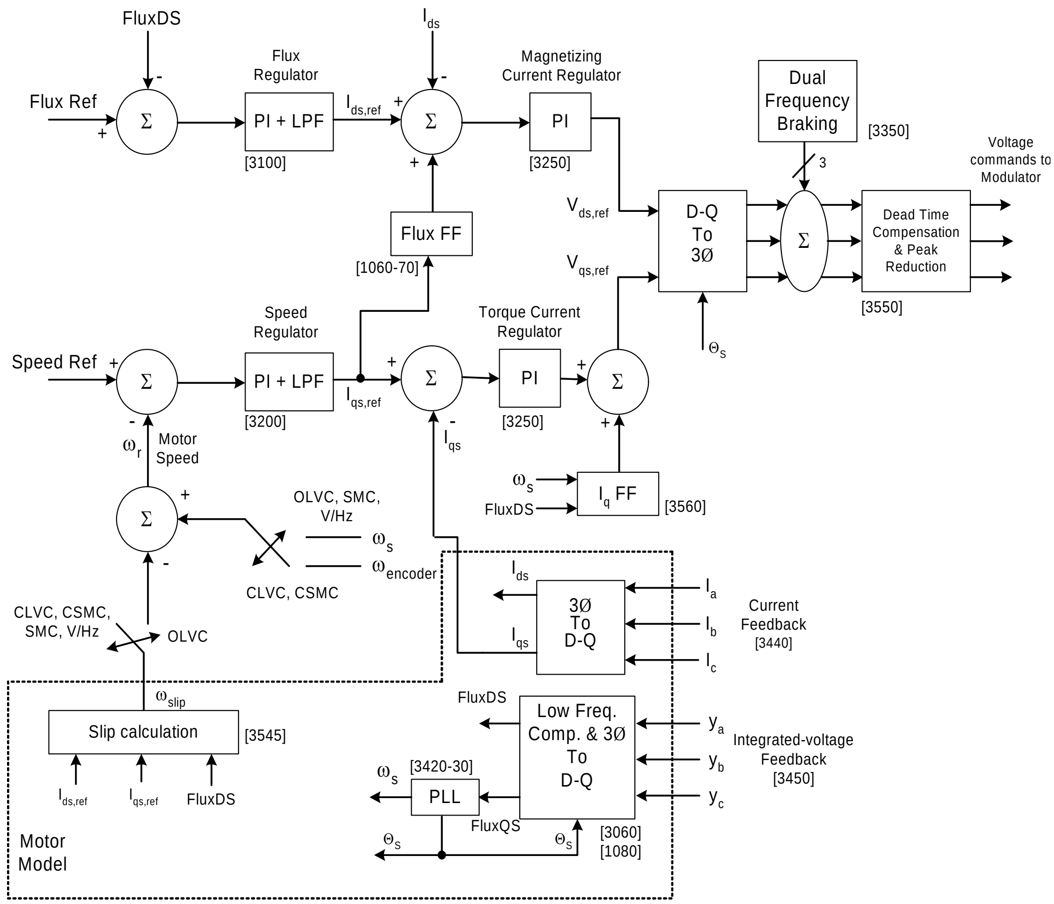

Figure 6-11. Block diagram of vector control algorithms for induction and synchronous motor control

(Numbers within square brackets indicate the parameter IDs that affect the corresponding functions)

The motor model uses measured motor voltage and estimated stator resistance voltage drop to determine stator flux amplitude, motor speed and flux angle. This allows stator resistance compensation to be automatic. A simplification of motor equations is obtained by transforming the 3-phase AC quantities (which are referred to being in a stationary reference frame) to DC quantities (that are in a synchronously rotating or DQ reference frame). A phase-locked loop (PLL) within the motor model tracks the (stator) frequency and angle of the flux vector.

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Motor flux amplitude is controlled by the flux regulator; its output forms the command for the magnetizing (or flux producing) component. Motor speed is determined from stator frequency, and is controlled by the speed regulator. Its output is the command for the torque (producing) current regulator.

The flux angle is used to decompose the measured motor currents into magnetizing and torque producing components. It is this decomposition that allows independent control of flux and torque, similar to DC motor control. These current components are regulated to their commanded values by the current regulators. Outputs of the current regulators are combined to produce three-phase voltage commands that get modified with signals from various other control routines before being passed on to the modulator. These control routines include: (1) dead-time compensation (to compensate for dead-time in the switching of the upper and lower IGBTS of each pole in a power cell), (2) peak reduction for third-harmonic injection (to maximize drive output voltage, and for drive neutral-shift [during transparent cell-bypass]), and (3) voltage commands to produce losses for dual-frequency braking. Transient response of the flux and torque regulators is improved with the use of feed-forward compensation (FF) as shown in Figure 6-11. The following table describes the symbols used to represent various quantities in the control diagram.

Table 6-1. List of Symbols Used in Figure 6-11

Symbol	Description
FluxDS	D-component of motor flux; also equal to the motor flux, since Q-component is zero. Motor Flux is defined as: Motor_Voltage / Stator_Frequency (rad/s). Flux (which has units of Volt-seconds) is also proportional(but not equal) to Volts-per-Hertz ratio.
r	For an induction motor: Motor_Speed = Stator_Frequency / Pole_Pairs – Slip_Speed This is the rotor (mechanical) frequency, which is equivalent to the motor speed. For a synchronous motor: Motor _Speed = Stator_Frequency / Pole_Pairs
I_{ds}	Magnetizing component of motor current.
I_{qs}	Torque component of motor current.
$V_{ds,ref}$	Output of magnetizing current regulator used in the D-Q transformation to produce 3-phase voltages.
$V_{qs,ref}$	Output of torque current regulator used in the inverse D-Q transformation to produce 3-phase voltages.
s	Stator frequency or output frequency of the drive. This is motorspeed ($_r$) + Slip.
s	Flux angle. This is the instantaneous position of the rotating Slip vector.
I_a I_b, I_c	Motor phase currents.

Motor torque (in Newton-meters) and shaft power can be calculated as,

Torque (Nm)= 3* Pole_Pairs * Flux (Vs)* Iqs (A)

$\approx$ 3* Pole_Pairs * Motor_Voltage (V) * Iqs (A) / (2π * Frequency (Hz)),

Shaft Power (W) = Torque (Nm) * Speed (rad/s) = Torque (Nm) * Speed (rpm) / 9.55

6.4.1 Open Loop Vector Control (OLVC)

This control mode should be used for most applications with single induction motors. In this method the control estimates motor slip as a function of load torque and provides a performance that matches a vector controlled drive (with speed sensor/transducer) above a certain minimum speed. With the correct motor parameters the control can provide good performance even at 1% of rated speed.

Speed feedback is synthesized from the stator frequency and the estimated motor slip, as shown in Figure 6-11. With this control method, slip compensation is automatic.

In this control mode, (if Spinning Load is selected) the drive begins by scanning the frequency range to detect the speed of the rotating motor (please refer to Chapter 5 for a description of Spinning Load Operation). Once the drive has completed the scan or if the feature is disabled, the drive goes into Magnetizing State. During this state the drive ramps the motor flux to its commanded value at the specified Flux Ramp Rate (parameter ID 3160). Only when the flux feedback is within 90% of the commanded flux, the drive changes to the Run State. Once in Run State, the drive increases the speed to the desired value. All motor and drive parameters as described in Chapter 3 are required for this mode of operation. Default values for the control loop gains (in the Stability Menu) are sufficient for most applications.

6.4.2 Open Loop Test Mode (OLTM)

In this control method the motor current feedback signals are ignored. This control mode should be used during drive set-up, when the modulation on the cells is to be verified or when testing the drive without a load. It can also be used when the motor is first connected to the drive to make sure that the Hall Effect Transducers are working correctly and are providing the correct feedback signals. This method should *not* be used to adjust scale factors for input and output, voltages and currents.

In this mode, the drive goes through the Magnetizing State to the Run State without looking at the motor flux. Only motor nameplate values and some drive related parameters as described in Chapter 3 are required for this mode. Special attention should be given to the following parameters:

1. Spinning Load and Fast Bypass should be disabled.
2. Acceleration and deceleration times (in the Speed Ramp Menu) should be increased.
3. Flux Demand should be reduced.

6.4.3 Synchronous Motor Control (SMC)

For synchronous motor control (SMC), the drive is equipped with a field exciter that usually consists of a SCR based current regulator; a 3PCI controller is typically used for the exciter. The field exciter operates to maintain a field current level that is commanded by the flux regulator. An example application for a brushless synchronous motor is shown in Figure 6-12. For brushless motors, the diagram assumes that the exciter stator is wound for 3 phase AC in the range of 350 to 400 volts. If that is not the case, a transformer will be necessary between the auxiliary power and the 3PCI. The circuit wheel needs only a rectifier. For the brushless case without bypass, the motor does not require any protection other than that included in the drive. Next Gen Control will trip the drive on a loss of field fault, if the motor draws excessive reactive current, which will occur when the exciter fails full on or off. Please refer to Chapter 7 for further discussion of this fault.

The overall control strategy is similar to Open Loop Vector Control, except for the flux regulator implementation as shown in Figure 6-11. For synchronous motors, the flux regulator provides two current commands, one for the field exciter current, and another for the magnetizing component of stator current.

With synchronous motor control, scanning the motor frequency to determine motor speed is completely avoided. The control uses information from the rotor induced speed voltages on the stator to determine rotor speed before applying torque to the motor. When starting the motor, the drive begins (in the Magnetizing State) by giving a field current command, which is equal to the no-load field current setting, to the exciter. This lasts for a time equal to the flux ramp time that is entered through the keypad (parameter ID 3160).

After this period of time, the drive goes into the run state. In most cases, the regulator in the field exciter is slow, and the drive applies magnetizing current (through the stator windings) to assist the exciter in establishing rated flux on the motor. At the same time, the speed regulator commands a torque-producing current to accelerate the motor to the demanded speed. Once the field exciter establishes the required field current to maintain flux in the motor, the magnetizing component of stator current reduces to zero. From this point onward, the drive provides torque-producing current (for acceleration or deceleration) that is in-phase with the drive output voltage. In other words, under steady state conditions, unity power factor condition is automatically maintained at the drive output.

The field current command is provided to the field exciter with the use of an analog output module from WAGO. Other differences between SMC and OLVC are summarized below.

- The motor no-load current parameter represents the Field no-load current value in SMC.
- With SMC the flux loop gains are slightly lower than with OLVC.
- Spinning Load should always be enabled with SMC.
- The drive magnetizing current regulator uses only the proportional gain for the flux exciter.
- Only Stage 1 Auto-Tuning can be used with synchronous motors.

Attention! Never use Stage 2 Auto-tuning with synchronous motors.

- When you are performing Stage 1 Auto-Tuning, you must short the field winding to get a proper setup of the stator resistance.

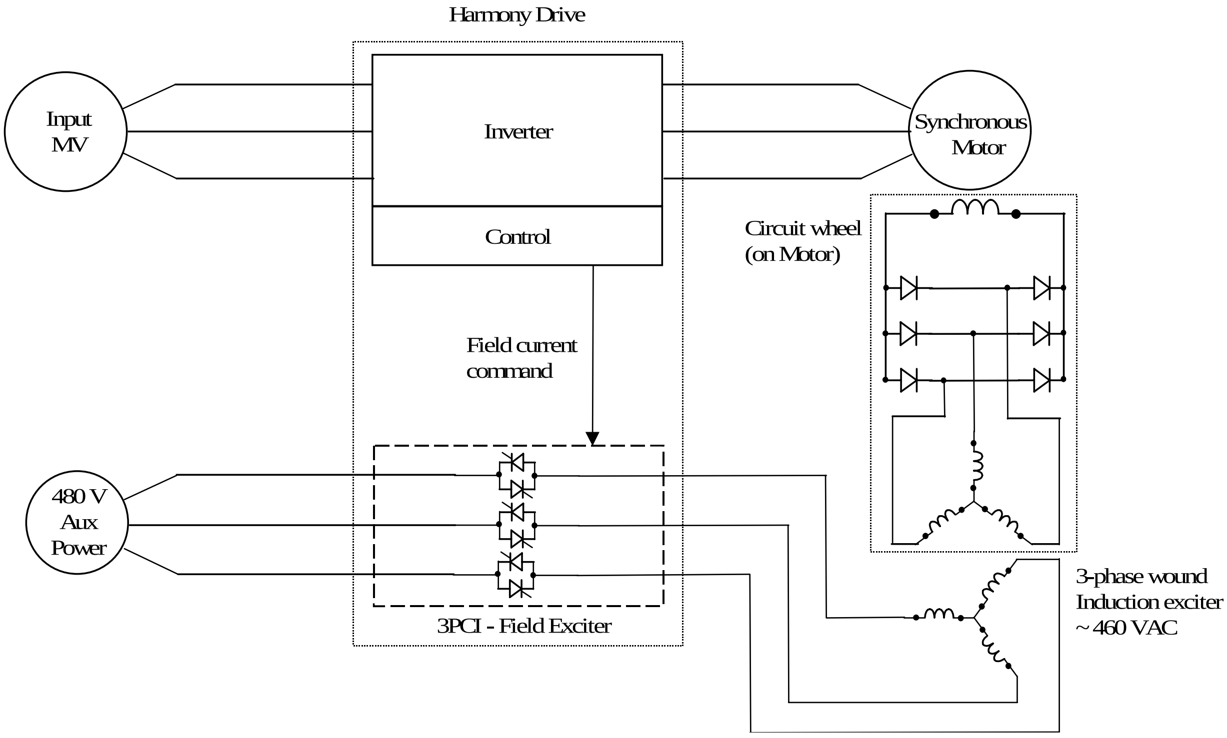

Figure 6-12. Harmony drive arrangement for brushless synchronous motor (with no bypass)

6.4.4 Volts/Hertz Control (V/Hz)

This control mode should be used when the drive is connected to multiple motors in parallel. The control algorithm is similar to that of Open Loop Vector Control (OLVC), but it does not use some of the motor parameters in its control algorithm that OLVC does.

Note: Many of the features available with OLVC, such as fast bypass, spinning load, and slip compensation, are not available with this method, as the individual feedback and control of each motor is not possible.

6.4.5 Closed Loop Control (CLVC or CSMC)

In some applications, when stable, low speed (below 1 Hz) operation under high torque conditions is required, an encoder may be used to provide speed feedback. The drive uses an 'off-the-shelf' carrier board to interface with industry standard encoders.

The control diagram of Figure 6-11 remains the same except for the slip calculation block which is disabled, so that encoder speed feedback is directly used as an input to the speed regulator.

When an encoder is used with the drive, the control loop type is required to be set to CLVC (for closed loop vector control with an induction motor) or to CSMC (for closed loop vector control with a synchronous motor). The encoder menu (ID 1280) contains parameters required for encoder operation. The table below describes the menu entries and provides typical values. Spinning load should be enabled when this control mode is enabled.

Table 6-2. Description of parameters in Encoder Menu (1280) and recommended values

Parameter name	ID	Description	Value
Encoder PPR	1290	Pulse-per-revolution of the encoder.	From encoder nameplate
Encoder filter gain	1300	Sets the gain of the filter for encoder feedback. This parameter can have a value between 0.0 (no filtering) and 0.999 (maximum filtering).	0.75
Encoder loss threshold	1310	When the difference between the encoder feedback and the estimated speed is greater than this level, an encoder loss alarm/ fault is generated.	5.0%
Encoder loss response	1320	This sets the response of the drive when encoder loss occurs. In the event of an encoder loss, selection of 'Stop (fault)' will cause the drive to trip, while 'Open loop' will cause the control to switch to Open Loop Vector Control.	Open loop

6.5 Input Side Monitoring and Protection

The NXG Control monitors input side voltages and currents, as well as those on the output side. This allows the control to monitor and respond to events on the input side of the drive. RMS values of the input currents and voltages are available, along with input power, kVA, energy and power factor. Figure shows a simplified view of the functions implemented for input side monitoring. Other quantities such as drive efficiency, average input current THD, and individual harmonic component (in input voltages/currents) are also calculated. All variables have an accuracy of ± 1%, except for efficiency (< ± 2%) and input current THD (± 1% above ~ 60% of rated power). A list of symbols used in Figure and a description of the parameters they represent are given in Table 6-3. Note that the definition of I_d and I_q components of the input current is different from the output side quantities.

Input side monitoring allows the drive to protect the secondary side of the transformer from abnormal conditions. Two faults, excessive drive losses and one cycle protection, are generated under such conditions. Please refer to Chapter 7 for further discussion of these two faults. Input side control also provides torque current limiting for line under-voltage, single-phasing and transformer overload conditions. These are described below. Please note that these three rollback sources can be disabled using the SOP.

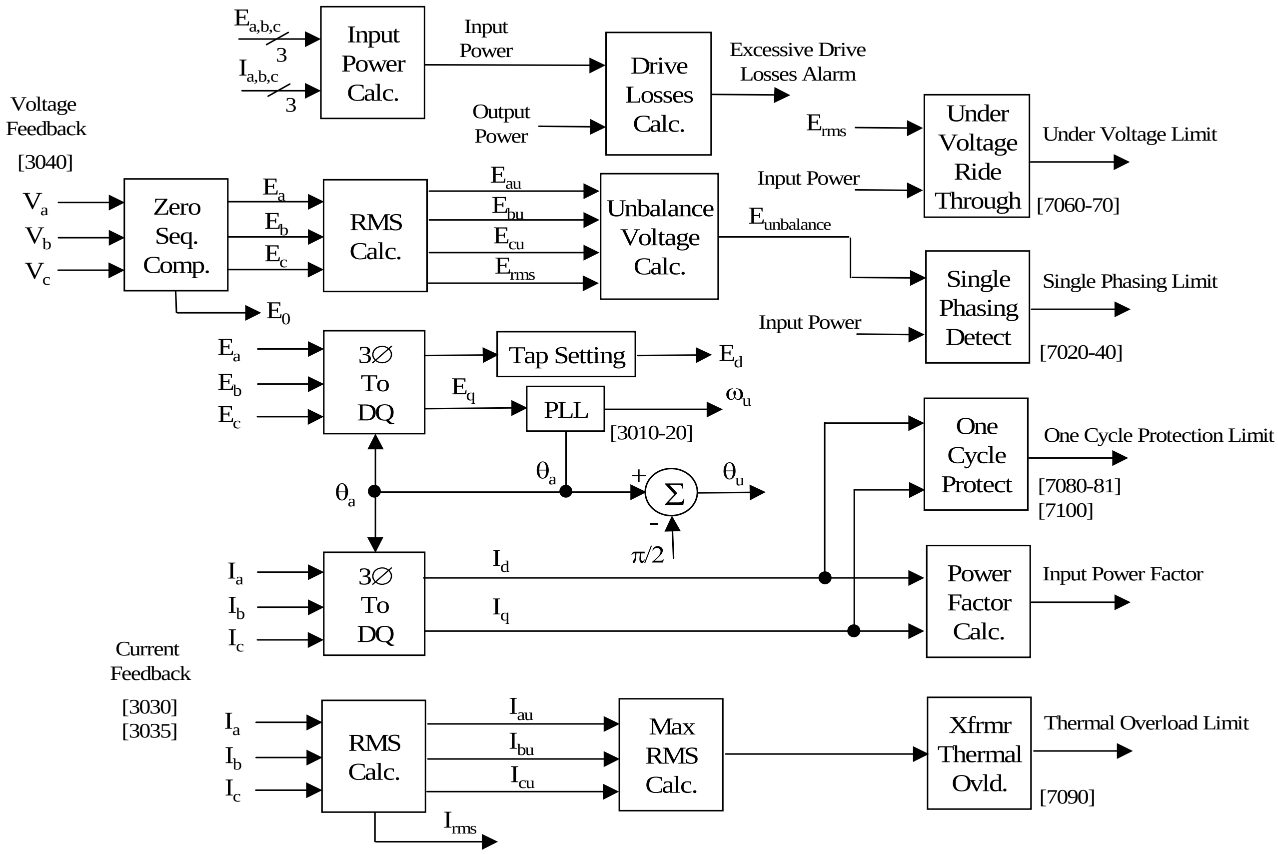

Figure 6-13. Block diagram of input-side monitoring. (Numbers within square brackets indicate the parameter IDs that affect the corresponding functions.)

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Table 6-3. List of Symbols Used in Figure 6-13

Name	Description
E_{rms}	Average rms voltage (of all 3 phases).
E_d	Amplitude of voltage taking the transformer tap setting into account. This represents the actual voltage being provided to the cells. If the tap setting is +5%, Ed will be 5% smaller than Erms, and vice versa.
$E_{a,b,c}$	Zeor sequence (DC offset) corrected input phase voltages.
u	Input frequency.
u	Angle of input-side flux.
I_{rms}	Average rms current (in all 3 phases).
I_d	Real component of input current.
I_q	Reactive component of input current.
$I_{a,b,c}$	Single-phase components of input current.

6.6 Drive Output Torque Limiting

The drive uses measured voltages and currents to implement rollback conditions. Under one or more of these conditions, the drive will continue to operate, but at a lower output torque (or current) level. An output torque limit will force the motor (and the drive) to go into speed rollback, during which speed is reduced until the torque demanded by the load falls below the torque limit. Rollbacks which are triggered by various conditions are described below.

6.6.1 Input Under-Voltage Rollback

When the input line voltage drops below 90% of its rated value, the drive limits the amount of power (and hence the torque) that can be delivered to the load. The maximum allowable drive power as a function of line voltage is shown in Figure 6-14. At 66% input voltage, the maximum drive power is limited to 50%, and is quickly reduced to a slightly negative value (Regen Limit) at 65%. This limit forces the drive to absorb power from the motor and maintain the (cell) DC-bus voltages in case the input voltage recovers during MV ride-through. The limit is implemented as an inverse function of speed in order to maintain constant power flow to the (cell) DC-bus.

A regulator is implemented to match the maximum drive power (P_{MAX}) to the actual power flowing into the drive. The output of this regulator sets the output torque limit. Keypad parameters 7060 and 7070 (in the Drive Protect Menu, under Input Protection) represent the proportional and integral gains of this regulator. Typical values of the proportional and integral gains are 0.0 and 0.001. An under voltage rollback condition is annunciated by the drive as UVLT on the keypad and in the Tool Suite.

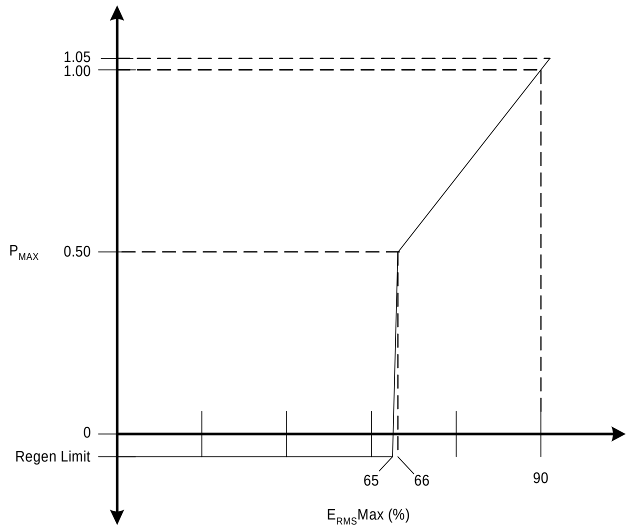

Figure 6-14. Drive power (P_{max}) as a function of input voltage magnitude (E_d)

6.6.2 Input Single-Phase Rollback

With Next Gen Control, input voltage unbalance ($E_{unbalance}$) is used for rolling back the drive output torque. Figure shows the reduction in drive power as a function of the unbalance voltage. When the unbalance is less than 10% the drive operates without any output limitation. There is a linear reduction as the unbalance voltage increases from 10% to 30%, at which point the input has a single-phase condition. When the input line voltage unbalance increases above 30%, the drive limits the amount of output power that can be delivered to the load to 40% of rated.

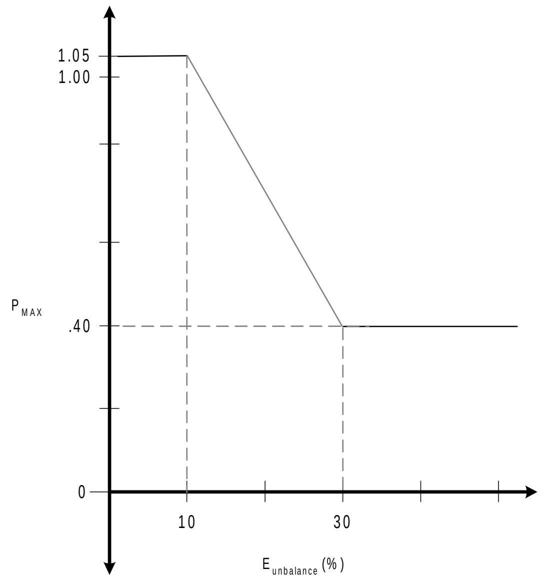

Figure 6-15. Drive power (P_{max}) as a function of input unbalance voltage ($E_{unbalance}$)

A regulator is implemented to match the maximum drive power (P_{MAX}) with the actual power flowing from the drive. The output of this regulator sets the output torque limit. Keypad parameters 7020 and 7030 (in the Drive Protect Menu, under Input Protection, Single Phasing) represent the proportional and integral gains of this regulator. Typical values of the proportional and integral gains are 0.0 and 0.001. A single-phasing alarm is generated when the output level of this regulator goes below the level set by the SPD threshold parameter (ID 7040). The drive's keypad displays SPHS instead of MODE, and the Tool Suite displays SPHS when a rollback occurs because of this condition. This regulator detects input single phase condition in this manner.

6.6.3 Transformer Thermal Rollback

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The input currents to the drive are monitored continuously. The largest among the three input phase currents is limited to be at or below 105% of the nominal rating of the transformer. Drive output torque is reduced when this current level is exceeded.

An integral regulator is implemented to limit the maximum input current to 105%. The output of this regulator sets the output torque limit. The Xformer thermal gain parameter (ID 7090, in the Drive Protect Menu, under Input Protection) represents the integral gain of this regulator. A typical value of the integral gain is 0.0133. During transformer thermal rollback, the drive displays T OL on the keypad and in the ToolSuite.

6.6.4 Menu Torque Limit

When the output torque current exceeds the max torque limit setting (parameter ID 1190, 1210 or 1230), the drive will limit output current. When this happens, the drive displays TLIM on the keypad and in the Tool Suite.

6.6.5 Regeneration

An inverse speed function based on the Regen torque limit setting (parameter ID 1200, 1220 or 1240) is used during drive deceleration. This forces the drive to absorb a constant amount of power from the load. When this happens, the drive displays RGEN on the keypad and in the Tool Suite.

6.6.6 Field-Weakening Limit

The field-weakening limit is a torque limit that is based on the motor flux and motor leakage inductance. This limit prevents the motor slip from exceeding pullout torque slip. Thus, it prevents unstable operation of the motor. This limit normally occurs when motor flux is reduced significantly during energy saver operation or when operating beyond the base speed of the motor. Under such conditions, a large step (increase) in load will force the output to be limited, resulting in a loss of speed rather than motor pullout. When this happens, the drive displays F WK on the keypad and in the Tool Suite.

6.6.7 Cell Current Overload

The cell (current) overload setting is given by the keypad parameter ID 7112 in the Drive Protect Menu (7). A cell can operate at this overload value for 1 minute out of every 10 minutes. When the current is between the cell rating and the overload rating, then the time spent at that level is inversely proportional to the overload current. An example of the time versus current overload capability with a cell that has 120% overload capacity is shown in Table 6-4.

Table 6-4. Example of overload current capability versus time of a cell with 120% overload

Drive current (%)	Allowed operating time (out of every 10 minutes)
120	1 minute
110	2 minutes
105	4 minutes
100	Continuous

If the motor current rating is smaller than the drive rating, then the rollback is annunciated on the keypad and in the Tool Suite as TLIM for Torque Limit. However, when the drive current rating is smaller than the motor rating, C OL (for Cell Overload) is displayed.

Note: The power cells used in Harmony drives do not have a fixed overload capability. Please consult the factory to determine the level of overload capability for a particular type of cell.

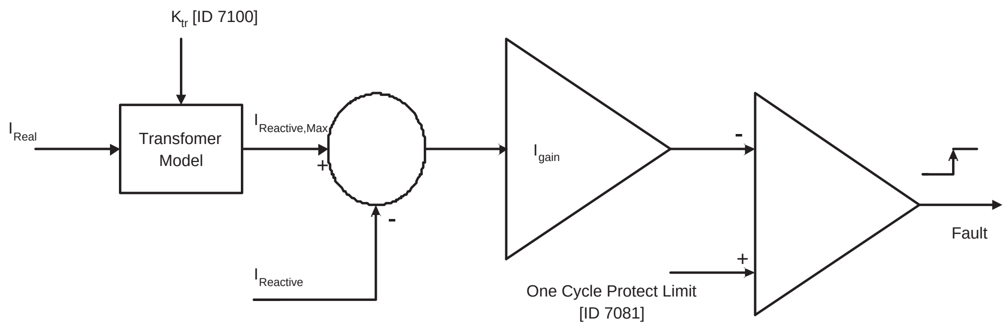
6.7 One Cycle Protection

6.7.1 Summary

NXG Control utilizes input reactive current to determine whether a “hard” fault on the secondary side of the transformer has occurred. For example, a short-circuit in one of the secondary windings will result in poor power factor on the high-voltage side of the transformer. A model of the transformer based on the power factor at rated load is implemented in the control processor. The drive input reactive current is continuously checked with the predicted value from the model. An alarm/trip is generated if the actual reactive current exceeds the prediction by more than 10%. This check is avoided during the first 0.25 seconds after medium voltage power-up to avoid the inrush current from causing nuisance trips.

6.7.2 Implementation

Figure shows the implementation of One Cycle Protection.



I_{gain} = 1 Cyc Protect Integ gain [ID 7080]

K_{tr} = Xformer protection constant [ID 7100]

Figure 6-16. Implementation of One Cycle Protection

6.7.3 Transformer Model

The Transformer Model block in Figure 6-16 provides the maximum value of the input reactive current for a given value of transformer constant, Ktr as given below:

$$I_{Reactive,Max} = 1.10 * (0.05 + K_{tr} * I_{Real}^2)$$

Figure 6-17 shows a plot of the Max Reactive Current versus Real Current with a transformer constant of 0.5.

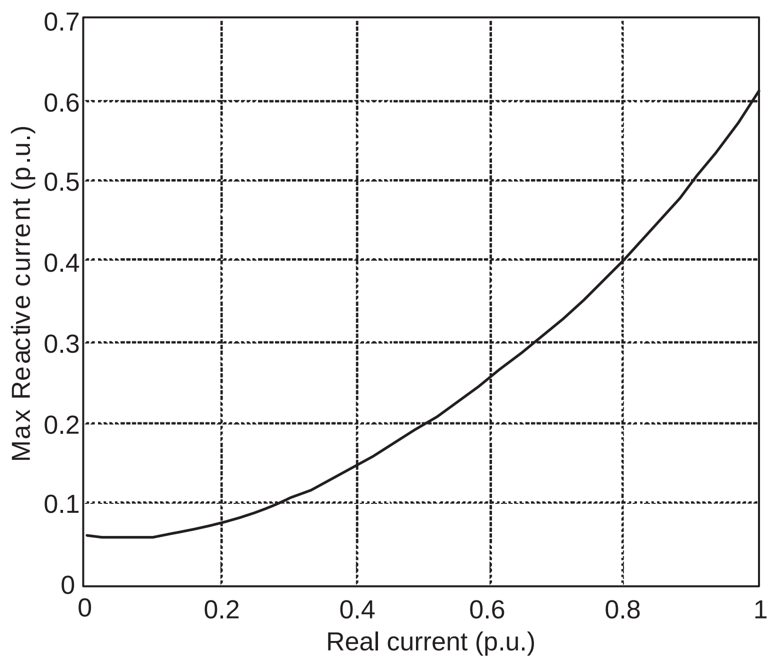


Figure 6-17. Plot of Max Reactive Current Versus Real Current with a Transformer Constant of 0.5

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6.7.4 Integral Timer

The integral timer gain can be calculated based on the desired response time (T_{trip}) as shown below:

$$I_{gain} = T_{trip} / (Error * Slow\_loop\_sample\_rate)$$

Where:

- Error is the maximum error (in per unit) that can be tolerated between $I_{Reactive,Max}$ and actual reactive current $I_{reactive}$
- Slow_loop_sample_rate is the sample frequency of the slow loop (450 – 600 Hz).

Note: Below the sampling rate of 4500, the slow loop is 1/5 of the sampling frequency (F_{samp}). At 4500 or above, the slow loop is 1/10 of F_{samp}.

6.8 Excessive Drive Losses

6.8.1 Summary

NXG control utilizes input power and output power calculations to determine whether an internal fault has occurred. Drive Power Loss is estimated as the difference between input power and output power. This quantity is continuously checked with a pre-defined threshold that is inverse time-based, i.e., if the threshold is exceeded by a large margin, then the trip occurs in a short time after the event, and vice-versa.

6.8.2 Implementation

Figure 6-18 shows the implementation of the Drive Loss fault circuit.

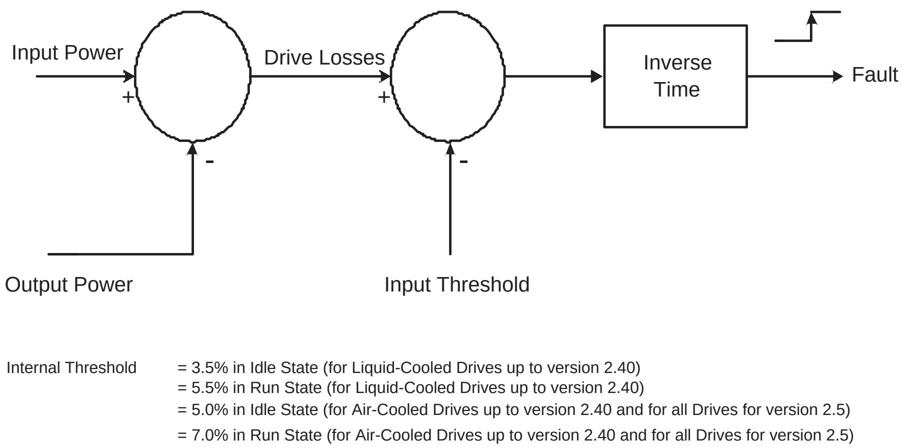

Figure 6-18. Implementation of the Drive Loss Fault Circuit

6.8.3 Inverse Time Curve

Figure shows the inverse time-to-trip curves as a function of Drive Losses. Each plot shows two curves – one for Idle State and the other for Run State (slightly longer time to trip). For software versions 2.22 and lower, a fixed trip time of one second was used instead of the curves shown below.

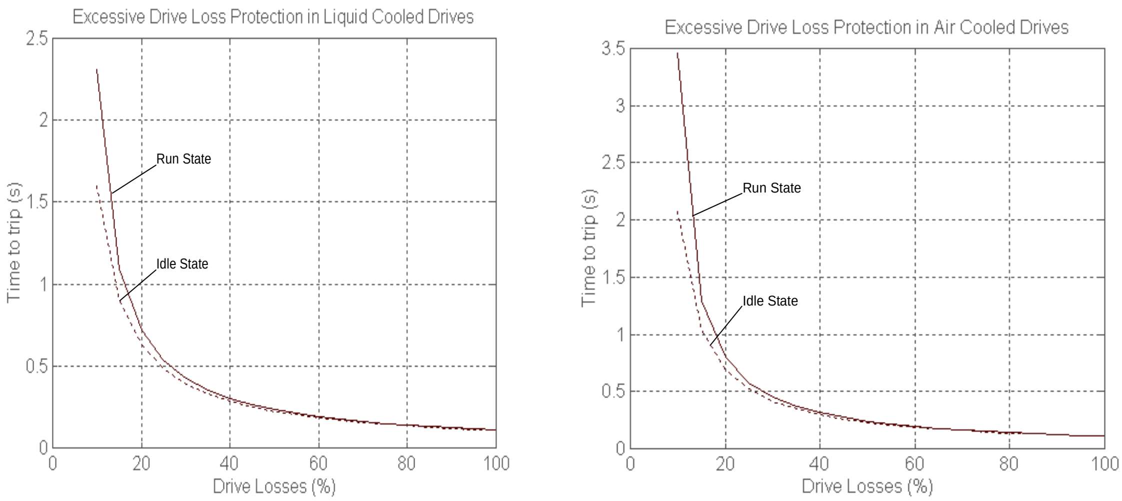

Figure 6-19. Inverse Time-To-Trip Curves
Left – Idle State, Right – Run State

6.8.4 Internal Threshold

The internal threshold is a function of the rated drive input power. For example, in Run State, the internal threshold is given as:

Internal Threshold (Watts)= 0.07 * rated Drive Input Poser

= 0.07 * √3 * Rated Input Voltage * Rated Input Current

Where:

- Rated Input Voltage and Rated Input Current are menu entries 2010 and 2020, respectively.

Note: For software versions 2.30 and 2.40, Air-Cooled and Liquid-Cooled Drives had different internal threshold settings (as listed in the block diagram). For versions 2.50 and higher, only one common set of threshold settings are used; these correspond to the settings for Air-Cooled Drives as shown Figure 6-18.

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CHAPTER

7 Troubleshooting and Maintenance

7.1 Introduction

We have designed, built and tested the Perfect Harmony variable speed drive for long, trouble-free service. However, periodic maintenance is required to keep the drive working reliably, to minimize system down time, and to maintain safety.

DANGER-Electrical Hazard! Always switch off the main input power to the equipment before attempting inspection or maintenance procedure.

Warning: Only qualified service personnel should maintain Perfect Harmony equipment and systems.

- This chapter is contains information that can be categorized as:
- Fault and Error troubleshooting (beginning)
- Supporting (technical) information (middle)
- Maintenance information (end).

The sections at the beginning of this chapter explain faults, how they are annunciated, fault messages, fault logging, and troubleshooting techniques. The sections in the middle of this chapter provide supporting information such as technical data, test point locations, and internal operations. Finally, the sections at the end of this chapter provide maintenance information such as inspections, replacement parts, etc. Review the section titles shown in the "In This Section" table above, then proceed to the appropriate section to troubleshoot or maintain your drive as appropriate.

Note: Refer to **Chapter 2: Hardware Components** for locations and details of major hardware components of the Perfect Harmony system.

7.2 Faults and Alarms

If a fault or alarm condition exists, it will be annunciated on the keypad. The Master Control software and hardware sense faults and alarms and store them within the fault logger and the event logger. Faults are either detected via direct hardware sensing or by software algorithm.

Cell faults are sensed by the cell control system logic located on the Cell Control Board (see Figure 7-2) in each output power cell. Each power cell has its own sense circuitry (Refer to **Chapter 6: Theory**). The Master Control software interprets the cell faults and displays them and logs them based on the faulted cell and the specific fault within the cell.

Generally, all faults will immediately remove power from the motor and inhibit the drive from running. Some faults that are user defined can control the drive response via the system program. Alarms are annunciated and logged but usually do not inhibit the drive from operation.

Refer to Table 7-1 for a determination of the drive response for the various fault and alarm conditions.

Table 7-1. Fault/Alarm Type and Drive Responses

Type	Drive Responses
Fault	• All IGBT gate drivers are inhibited. • Motor coasts to stop. • The fault is logged. Refer to the Fault Log Menu (6210). • The fault is displayed on the front panel. • The Keypad Fault LED is ON.Refer to Section 3.2.1 for information about the LED. • Most faults are logged to the event log.
User Faults	• The motor either ramp stops or coast stops depending on the content of the System Program. • The fault is logged. Refer to the Fault Log Menu (6210). • The fault is displayed on the front panel. • The Keypad Fault LED is ON. Refer to Section 3.2.1 for information about the LED. • User defined faults are logged to the event log.
Alarm	• Drive does not necessarily revert to the idle state via a coast or ramp stop unless specifically required to by the system program. • The alarm is logged. Refer to the Fault Log Menu (6210). • The alarm is displayed on the front panel. • The Keypad Fault LED flashes. Refer to Section 3.2.1 for information about the LED.

The [FAULT RESET] key on the Keypad can be used to *manually reset* a fault. The drive must be returned to the run condition by manual start or by forcing the *RunRequest_I* equal to “true” (refer to **Chapter 8: System Programming**).

Certain faults can be reset *automatically* if enabled by the auto fault reset enable (7120). Refer to Table 7-2 for a list of auto re-settable faults. These are fixed and not adjustable. If reset is successful, then drive will return to the run state automatically only if the *RunRequest_I* is maintained at the value “true” (refer to **Chapter 8: System Programming**). The [FAULT RESET] key of the Keypad can acknowledge alarms.

Table 7-2. Auto Re-settable faults

Back EMF Timeout	Over speed fault
Encoder Loss	Under load fault
Failed to magnetize	Loss of Signal 1-24
IOC	Loss of Signal Internal
Keypad communication	Loss of Drive Enable
Line over voltage	Loss of Field Format (SM)
Medium voltage low	
Menu initialization	
Motor over voltage	
Output ground fault	
Network 1 communication fault	
Network 2 communication fault	

7.3 Drive Faults and Alarms

The master control senses all drive faults and alarms, either from direct hardware or via software algorithms. Use Table 7-3 to quickly locate major causes of fault conditions. The table also lists the type of drive response, if it is a fault (**F**), alarm (**A**), or both (**F/A**), and whether it can be enabled or disabled using the SOP program (**SOP**), or if it is permanently enabled (**Fixed** in software).

Table 7-3. Drive Faults

Fault Display	Type	Enable	Potential Causes and Corrective Actions
Input Line Disturbance			
Input Phase Loss	A	Fixed	**Cause** Loss of input phase. **Action** **1.** Check the input fuses and connection to verify that the input phases are connected properly. **2.** Using an Oscilloscope verify the presence of all 3 input voltages on test points **VIA/TP1, VIB/TP2, VIC/TP3** of the System Interface board.
Input Ground	A	Fixed	**Cause** Estimated input ground voltage is greater than limit set by the Ground Fault Limit (in the Drive Protection Menu). **Action** **1.** Using an Oscilloscope, verify the symmetry (L-L and L-N) of the 3 input voltages on test points (**VIA/TP1, VIB/TP2, VIC/TP3**) of the System Interface board. **2.** Use a voltmeter to check for common mode DC to neutral.
Line Over Voltage 1	A	SOP	**Cause** The drive-input RMS voltage is greater than 110% of the drive rated input voltage. **Action** Using a voltmeter verify the input voltages on test points (**VIA/TP1, VIB/TP2, VIC/TP3**) of the System Interface board are ~3.8 VRMS. This is the expected value for rated input voltage. Values greater than ~4.2 VRMS will trigger over voltage conditions. **Note:** This alarm can be caused by a transient condition, and may not be present when making the measurements.
Line over voltage 2	A	SOP	**Cause** The drive-input RMS voltage is greater than 115% of the drive rated input voltage. **Action** Refer to Line over voltage 1 section above. Values >4.37 VRMS will trigger this alarm.

7

Fault Display	Type	Enable	Potential Causes and Corrective Actions
Line over voltage fault	F	SOP	**Cause** The drive-input RMS voltage is greater than 120% of the drive rated input voltage. **Action** Refer to Line over voltage 1 section above. Values >4.56 VRMS will trigger an alarm or trip, depending on the SOP.
Medium voltage low 1	A	SOP	**Cause** The drive-input RMS voltage is less than 90% of the drive rated input voltage. **Action** Using a voltmeter, verify the input voltages on test points (**VIA/TP1, VIB/TP2, VIC/TP3**) of the System Interface board are ~3.8V RMS. This is the expected value for rated input voltage. Values less than ~3.4v RMS (90% of rated) will trigger Medium voltage low conditions. Note: This alarm can be caused by a transient condition, and may not be present when making the measurements.
Medium voltage low 2	A	Fixed	**Cause** The drive-input RMS voltage is less than 70% of the drive rated input voltage. **Action** Refer to Medium voltage low 1 section above. The threshold is 2.66 V.
Medium voltage low Flt	F	Fixed	**Cause** The drive-input RMS voltage is less than 55% of the drive rated input voltage. The fault will not occur, even after the threshold condition is met, until the first cell fault occurs. This fault is then logged and associated cell faults ignored. **Action** Refer to Medium voltage low 1 section above. The threshold is 2.09 V.

Fault Display	Type	Enable	Potential Causes and Corrective Actions
Input One Cycle (or excessive input reactive current)	F/A	Fixed	**Cause** (1) Possible fault on the secondary side of the transformer, or (2) inrush current is too high and creating a nuisance fault. **Action** (1) Remove medium voltage and visually inspect all the cells and their connections to the transformer secondary; contact Siemens for field support. (2) Reduce the 1 Cyc Protect integ gain (7080) and the 1 Cycle Protect Limit (7081) to avoid nuisance trips.
Input Phase Imbal	SOP	Fixed	**Cause** Drive input (line) current imbalance is greater than the setting in the Phase Imbalance Limit parameter (in Drive Protection Menu). **Action** **1.** Verify proper symmetry of the input voltages and currents on test points **VIA/TP1, VIB/TP2, VIC/TP3, IIB/TP12** and **IIC/TP13.** **2.** Check the values of the input attenuators.
Motor/Output Related			
Over Speed Alarm	A	SOP	**Cause** The motor speed is greater than 95% of the Overspeed parameter setting (1170) in the Limits Menu (1120). An improperly set-up or mistuned drive usually causes this fault. **Action** Verify that the motor and drive nameplate settings match the corresponding parameters in Motor Parameter Menu (1000) and Drive Parameter Menu (2000).
Over Speed Fault	F	Fixed	**Cause** The motor speed exceeds the Overspeed setting (1170) parameter in the Limits Menu (1120). An improperly set-up or mistuned drive usually causes this fault. Action Verify that the motor and drive nameplate settings match the corresponding parameters in Motor Parameter Menu (1000) and Drive Parameter Menu (2000).

Fault Display	Type	Enable	Potential Causes and Corrective Actions
Output Ground Fault	A	Fixed	**Cause** This fault is caused (due to an output ground fault condition) when the estimated ground voltage exceeds the Ground Fault Limit parameter (1245) in the Motor Limits Menu. **Action** **1.** Verify proper symmetry of voltages on test points **VMA/TP5, VMB/TP6,** and **VMC/TP7.** If voltages are not a problem, check the divider resistors in the Motor Sense Unit or replace the System Interface Board. **2.** Disconnect the motor from the VFD. Use a Meger to verify motor and cable insulation.
Encoder loss	Menu	Menu	**Cause** The software has detected an encoder signal loss due to a faulty encoder or faulty encoder interface. **Action** **1.** Verify that the information in the Encoder menu (1280) is correct for the encoder being used. **2.** Run the drive in Open Loop Vector Control mode (select OLVC in the Control loop type, ID 2050) of the Drive parameter menu (2000). **3.** Go to Meter Menu (8); select Display Parameters Menu (8000) and set one of the display parameters (8001-8004) to ERPM or %ESP and observe if ERPM follows motor speed.
Mtr Therm Over Load 1	A	SOP	**Cause** Motor temperature (or motor current, depending on choice of overload method) above Overload pending setting. **Action** **1.** Verify if the Overload pending parameter (1139) is set correctly. **2.** Check load conditions and, if applicable, verify that the speed derate curve (submenu 1151) matches the load conditions.

7

Fault Display	Type	Enable	Potential Causes and Corrective Actions
Mtr Therm Over Load 2	A	SOP	**Cause** Motor temperature (or motor current, depending on choice of overload method) above Overload setting. **Action** Check if the Overload parameter (1140) is set correctly. Refer to Mtr Therm Over Load 1 section above.
Mtr Therm Over Ld Fault	F	Fixed	**Cause** Motor temperature (or motor current, depending on choice of overload method) has exceeded the Overload setting for the time specified by the Overload timeout parameter. **Action** Check if the Overload timeout parameter (1150) is set correctly. Refer to Mtr Therm Over Load 1 section above.
Motor Over Volt Alarm	A	SOP	**Cause** If motor voltage exceeds 90% of the Motor over voltage limit in the Motor limit menu. **Action** Check menu settings for correct motor rating, and limit setting.
Motor Over Volt Fault	F	SOP	**Cause** The measured motor voltage exceeds the threshold set by the Motor trip volts (1160) parameter in the Limits Menu (1120). An improperly set-up or tuned drive usually causes this fault. This could include the secondary tap setting. A high line condition can also cause this. **Actions** **1.** Verify that the motor and drive nameplate settings match the corresponding parameters in Motor Parameter Menu (1000) and Drive Parameter Menu (2000). **2.** Verify that the signals on the **VMA/TP5, VMB/TP6,** and **VMC/TP7** test points on the System Interface Board are operating properly with in +/-6V. If an incorrect voltage is noted, check the voltage divider in the Motor Sense Unit or replace the System Interface Board. **3.** Also check the tap settings on the transformer. The tap setting may have to be changed to accommodate a high input line.

7

Fault Display	Type	Enable	Potential Causes and Corrective Actions
IOC	F	Fixed	**Cause** Drive instantaneous over-current (IOC) faults usually result when the signal from test point IOC on the System Interface Board exceeds the level set by the Drive IOC setpoint (7110) parameter in the Input Protect Menu (7000). **Actions** **1.** Verify that the motor current rating (1050) is below the Drive IOC setpoint (7110) in the Drive Protect Menu (7). **2.** Check if the output current scaler (3440) is set to a number that is close to 1.0. **3.** Verify that the signals on test points IMB and IMC on the System Interface Board match the percentage of full-scale signals. **4.** Perform the tests listed in Section 6.4.2 to verify the operation of hall effect transducers.
Under Load Alarm	A	SOP	**Cause** The torque producing current of the drive has dropped below a preset value set by the user. **Actions** This alarm usually indicates a loss of load condition. If this not the case verify the settings in I underload menu (1182) within the Limits menu (1120).
Under Load Fault	F	Menu	**Cause** This fault usually indicates a loss of load condition when the torque producing current of the drive has dropped below a preset value set by the user for the specified amount of time. **Actions** If this is not an unexpected condition then verify the setting of the I underload (1182) and the Under Load Timeout (1186) parameters within the Limits Menu (1120).

7

Fault Display	Type	Enable	Potential Causes and Corrective Actions
Output Phase Imbal	A	Fixed	**Cause** The software has detected an imbalance in the motor currents. **Action** Verify proper symmetry of the motor currents on test points **VMA/TP5, VMB/TP6, VMC/TP7, IMA/TP21, IMB/TP22,** and **IMC/TP23**. If the currents are unsymmetrical, verify if the burden resistors for the Hall Effect Transducers are connected correctly on the Signal Conditioning board.
Output Phase Open	A	SOP	**Cause** The software has detected an open phase condition at the drive output to the motor. Generally, if this occurs, the problem is with the feedback. A true open output phase will result in an IOC trip. **Action** **1.** Verify all connections to the motor are secure. **2.** Verify the presence of motor voltages and currents on test points **VMA/TP5, VMB/TP6, VMC/TP7, IMA/TP21, IMB/TP22,** and **IMC/TP23** during drive operation.
In Torque Limit	A	SOP	**Cause** This alarm is issued when the drive is in speed rollback (due to a torque limit condition) for more than one minute. **Action** **1.** Check load conditions. **2.** Check proper settings for drive and motor ratings.
In Torq Limit Rollback	F/A	SOP	**Cause** This fault or alarm (depending on the SOP program) is issued when the drive is in speed rollback (due to a torque limit condition) for more than 30 minutes. **Action** **1.** Check load conditions. **2.** Check proper settings for drive and motor ratings.

Fault Display	Type	Enable	Potential Causes and Corrective Actions
Minimum Speed Trip	F/A	SOP	**Cause** Motor speed is below the Zero speed setting (2200). This is either due to a motor stall condition (if speed demand is higher than the Zero speed setting) or a low speed demand condition (where speed demand is lower than the Zero speed setting). **Action** Increase motor torque limit (ID 1190, 1210 or 1230) if it is a stall condition or adjust the Zero speed setting to avoid the desired low speed operating region.
Loss of Field Current	F/A	SOP	**Cause** This occurs only with synchronous motor control due to field exciter failure or loss of power to the exciter. **Action** Check if the power supply to the exciter is energized To determine if the field exciter is operating correctly, reduce Flux demand (3150) to 0.40, increase Accel time 1 (2260) to a larger value and run the motor with 5% speed demand. If the drive magnetizing current reference (Idsref) does not go to zero, then the field exciter is not working (or is not adjusted) properly.

7

Fault Display	Type	Enable	Potential Causes and Corrective Actions
Failed to magnetize	F/A	SOP	**Cause** This occurs only with induction motors due to high magnetizing current (or poor power factor). The trip occurs when I_{ds} (or magnetizing current) is greater than 80% of rated current for a duration greater than 5 times the flux Ramp Rate parameter setting. With induction motors, this trip should normally occur only when starting, either due to incorrect stator resistance (ID 1080) and cable resistance (ID 2940) settings (settings that are higher than actual value are not good) or due to the incorrect setup of of the Spinning Load. Once the motor is magnetized and running, such an event is unlikely to occur. **Action** **1.** Increase the flux ramp time to give more time for magnetizing current to settle down at startup. **2.** Verify if the motor stator resistance parameter (1060) is not set too high for the application; reduce it if continuous operation at very low speed is not desired. Check that Spinning Load is set correctly. **3.** Review procedure for adjusting the Spinning Load routine if necessary.
Back EMF Timeout	F	Fixed	The software timed out waiting for the Motor Back EMF Voltage to decay to a safe level for bypass or turn-on (drive enable). The safe voltage is the amount of voltage that the drive can support. The back EMF is the motor voltage when the drive is not active. If an induction machine has a long time constant, or if a synchronous machine has not disabled its field, and in either case the machine is spinning, the timeout threshold will cause a fault. This is also possible for parallel drives on the motor.

Fault Display	Type	Enable	Potential Causes and Corrective Actions
System Related			
Excessive Drive Losses	SOP	Fixed	**Cause** Estimated drive losses are too high, due to (1) internal problem in the cells, or (2) scaling error in voltage and current measurement on input and output side. **Action** **1.** Remove medium voltage and visually inspect all the cells and their connections to the transformer secondary. Contact Siemens for support. **2.** With the drive operating above a 25% power rating, verify if estimated drive efficiency is above 95%. If this is not the case, then voltage and current scaling needs to be checked.
Carrier Frq Set Too Low	A	Fixed	**Cause** The software detected a menu entry for Carrier Frequency Menu (3580) was below the lowest possible setting based on the system information. **Action** **1.** Change the value entered in Carrier Frequency Menu (3580). **2.** Check the value of the Installed Cells/phase Menu (2530). **3.** Consult factory.
System Program	F	Fixed	**Cause** The software detected an error in the system program file. **Actions** **1.** Reload system program. **2.** Consult factory.
Menu Initialization	F	Fixed	**Cause** The software detected an error in one of the files stored on the CPU board Compact FLASH disk. **Action** Consult factory.
Config File Write Alarm	A	Fixed	**Cause** Occurs if system not able to write a master or slave config file. **Action** Consult factory.

Fault Display	Type	Enable	Potential Causes and Corrective Actions
Config File Read Error	F	Fixed	**Cause** Occurs if system not able to read data from a master of slave config file. **Action** Consult factory.
CPU Temperature Alarm	A	Fixed	**Cause** CPU Temperature is > 70 C. **Action** **1.** Check air flow and chassis fans. **2.** Check CPU heatsink.
CPU Temperature Fault	F	Fixed	**Cause** CPU Temperature is > 85 C. **Action** **1.** Check air flow and chassis fans. **2.** Check CPU heatsink.
A/D Hardware Alarm	A	Fixed	**Cause** A/D board indicated a hardware error. **Action** Replace A/D board.
A/D Hardware Fault	F	Fixed	**Cause** A/D board hardware error persists for more than 10 samples. **Action** Replace A/D board.
Modulator related			
Modulator Configuration	F	Fixed	**Cause** The software detected a problem when attempting to initialize the Modulator. **Action** Replace Modulator board.
Modulator Board Fault	F	Fixed	**Cause** The software detected a Modulator board fault. **Action** Replace Modulator board.

7

Fault Display	Type	Enable	Potential Causes and Corrective Actions
Cell Fault/Modulator	F	Fixed	**Cause** Modulator has an undefined fault from a cell. Cell shows fault but the fault is undetectable. **Action** Check cell, modulator board.
Bad Cell Data	F	Fixed	**Cause** Cell data packet mode bits incorrect. **Action** Check cell control board and modulator board.
Cell Config. Fault	F	Fixed	**Cause** Modulator Cell configuration does not agree with Menu setting of Installed cells. **Action** **1.** Ensure correct number of cells are entered into menu setting. **2.** Check modulator board. **3.** Check that all fibers are connected.
Modulator Watchdog Flt	F	Fixed	**Cause** Modulator detected that the CPU stopped communicating with it. **Action** **1.** Reset drive control power. **2.** Check that all boards are seated properly. **3.** Check for proper grounding practices.
Loss of Drive Enable	F	SOP	**Cause** Modulator detected loss of drive enable. **Action** **1.** Reset drive control power. **2.** Check for proper grounding practices.
Modulator Battery Low	A	Fixed	**Cause** The software detected a weak battery on the Modulator board. This battery is used to power the memory for the fault and historical logger. **Actions** **1.** Replace battery on Modulator board. **2.** Replace Modulator board. **3.** Consult factory.

Fault Display	Type	Enable	Potential Causes and Corrective Actions
Low Voltage Power Supply Related			
Hall Effect Pwr Supply	F	Fixed	**Cause** One or both of the supplies that power the Hall Effects on the drive output has failed. **Actions** **1.** Verify +/-15V on the Hall Effect Power supplies. **2.** Verify +/-15V on the System Interface Board Connector P4 pins 31 and 32. If +/-15V is not present, check wiring from Hall Effect Power Supplies to the System Interface Board. If these signals are incorrect, replace the System Interface Board.
Power Supply	F	Fixed	**Cause** The chassis power supply has indicated a loss of power. This can either be due to loss of AC or a failed power supply. **Action** Verify control power outputs.
System I/O Related			
Loss of Signal (1-24)	A	Menu/ SOP	**Cause** The software detected a Loss of Signal on one of the 0-20mA inputs (1 through 24). This is usually a result of an open circuit or defective driver on the current loop. **Actions** **1.** Check connection to the Wago 0-2 0mA input corresponding to the Loss of signal message and associated wiring. **2.** Replace affected Wago module. Consult factory.

7

Fault Display	Type	Enable	Potential Causes and Corrective Actions
Wago Communication Alarm	A	Fixed	**Cause** The software was unable to establish or maintain communication with the Wago I/O system. The fault is triggered when the lack of communication exceeds timeout. **Actions** **1.** Verify that the cable between the CPU board and Wago Communication alarm module is connected properly. **2.** Replace Wago Communication Alarm module. **3.** Replace the CPU board. Consult factory.
Wago Communication Fault	F	SOP	**Cause** The software was unable to establish or maintain communication with the Wago I/O system. The alarm is triggered when the lack of communication exceeds timeout. **Actions** **1.** Verify that the cable between the CPU board and Wago Communication alarm module is connected properly. **2.** Replace Wago Communication Alarm module. **3.** Replace the CPU board. **4.** Consult factory.
Wago configuration	F	Fixed	**Cause** Number of Wago modules does not equal number set in menu. **Action** **1.** Ensure correct number of Wago modules are set in the menu. **2.** Check Wago modules and placement on the DIN rail.
External Serial Communications Related			
Tool communication	SOP	SOP	**Cause** Tool is not communicating to drive **Action** Check PC connecting cable, CPU BIOS settings, and correct TCP/IP address agrees in Tool and Drive.

7

Fault Display	Type	Enable	Potential Causes and Corrective Actions
Keypad Communication	SOP	SOP	**Cause** Drive is not communicating to keypad. **Action** **1.** Check keypad cable, connections. **2.** Check for CPU crash.
Network 1 Communication	SOP	SOP	**Cause** The drive is not communicating with the active external network. **Actions** **1.** Verify all network connections are secure. **2.** Verify that the UCS board #1 and Communications board are properly seated. **3.** If the source of the problem is not found, then replace the UCS board #1 and then the Communications board.
Network 2 Communication	SOP	SOP	**Cause** The drive is not communicating with the active external network 2 **Actions** **1.** Verify all network connections are secure. **2.** Verify that the UCS board #2 and Communications board are properly seated. **3.** If the source of the problem is not found, then replace the UCS board #2 and then the Communications board.
Synch Transfer Related			
Up Transfer Failed	A	SOP	**Cause** Time-out has occurred from request to up synch transfer complete. **Action** **1.** Check input line for voltage and distortion. **2.** Check status of InsufficientOutputVolts_O flag or the output voltage versus safe voltage to see if transfer is prohibited. **3.** Increase menu setting, or set to zero to disable time out.

7

Fault Display	Type	Enable	Potential Causes and Corrective Actions
Down Transfer Failed	A	SOP	**Cause** Time-out has occurred from request to down synch transfer. **Action** **1.** Check feedback voltage waveform. **2.** Check status of InsufficientOutputVolts_O flag or the output voltage versus safe voltage to see if transfer is prohibited. **3.** Increase menu setting, or set to zero to disable time out.
Phase Sequence	F/A	SOP	**Cause** Sign of input frequency and operating frequency are opposite. This will prohibit a transfer but is not fatal for normal operation. This fault needs to be enabled via the system program flags for transfer operations.. **Action** Swap one pair of motor leads and change sign of speed command if needed.
User Defined Faults			
User Defined Fault (64)	F/A	SOP	**Cause** The *UserFault_1* through *UserFault_64* flags in the system program have been set to the value “true”. Refer to **Chapter 8: System Programming**. These can be set up as either faults or alarms, and the message can be defined via the SOP. **Action** Refer to the section on User Faults (Section 7.5).
Cooling Related			
One Blower Not Avail	A	SOP	**Cause** Drive initiated alarm set when the OneBlowerLost_O SOP flag is set true and the alarm is enabled by setting OneBlowerLost_EN_O true. On an air cooled drive, when one of either of the cell blowers or transformer blowers is not functioning, this is triggered via the SOP. This is part of the Standard SOP for air cooled drives. **Action** **1.** Check physical input connected to SOP flag. **2.** Check for faulty blowers or obstruction.

7

Fault Display	Type	Enable	Potential Causes and Corrective Actions
All Blowers Not Avail	F/A	SOP	**Cause** Drive initiated alarm or fault when AllBlowerLost_O SOP flag is set true and the alarm/fault is enabled by setting the AllBlowerLostEn_O flag true. This defaults to a fault with no way to change to a warning with this release. If an alarm is desired, then the flag AllBlowersLostWn_O must also be set true. This is triggered by the SOP when 2 of 3 cell banks or both transformer banks of blowers is not functioning. This is primarily used as a trip alarm preceding an over temperature trip, used on air cooled drives as part of the Standard SOP. **Action** **1.** Check physical input connected to SOP flag. **2.** Check for faulty blowers or obstruction.
Clogged Filters	F/A	SOP	**Cause** Drive initiated fault/alarm when the CloggedFilters_O SOP flag is set true and the CloggedFiltersEn_O flag is set true to enable it. The default is a fault. If you desire an alarm, then the flag CloggedFiltersWn_O must be set true. This is used when an air filter becomes clogged to warn of reduced air flow. This is not part of the Standard SOP. **Action** **1.** Check physical input connected to SOP flag. **2.** Change filter or check for obstruction.
One Pump Not Available	A	SOP	**Cause** Drive initiated alarm when the OnePumpFailure_O SOP flag is set true and the OnePumpFailureEn_O flag is true to enable it. The default is an alarm and it cannot be changed. This is used in the Standard SOP for liquid cooled drives as an alarm. **Action** **1.** Check physical input connected to SOP flag. **2.** Check for faulty pumps tripped CBs, or obstruction.

7

Fault Display	Type	Enable	Potential Causes and Corrective Actions
Both Pumps Not Available	F/A	SOP	**Cause** Drive initiated fault/alarm when the AllPumpsFailure_O SOP flag is set true and the AllPumpsFailureEn_O flag is true to enable it. The default is a fault, but it can be changed to an alarm by setting the AllPumpsFailureWn_O flag true. This is used in the Standard SOP for liquid cooled drives as a trip alarm. **Action** **1.** Check physical input connected to SOP flag. **2.** Check for faulty pumps tripped CBs, or obstruction.
Coolant Cond > 3 uS	A	SOP	**Cause** Drive initiated alarm when the CoolantConductivityAlarm_O SOP flag is set true and the CoolantConductivityAlarmEn_O flag is true to enable it. The default is an alarm and it cannot be changed. This is used in the Standard SOP for liquid cooled drives as an alarm. **Action** **1.** Check physical input connected to SOP flag. **2.** Check conductivity level. **3.** Check ionizer.
Coolant Cond > 5 uS	F/A	SOP	**Cause** Drive initiated fault/alarm when the CoolantConductivityAlarm_O SOP flag is set true and the CoolantConductivityAlarmEn_O flag is true to enable it. The default is a fault, but it can be changed to an alarm by setting the CoolantConductivityAlarmWn_O flag true. This is used in the Standard SOP for liquid cooled drives as a trip alarm. **Action** **1.** Check physical input connected to SOP flag. **2.** Check conductivity level. **3.** Check ionizer.

7

Fault Display	Type	Enable	Potential Causes and Corrective Actions
Coolant Inlet Temp > 60° C	F/A	SOP	**Cause** Drive initiated alarm when the InletWaterTempHigh_O SOP flag is set true and the InletWaterTempHighEn_O flag is true to enable it. The default is an alarm but it can be changed to a fault by setting the InletWaterTempHighWn_O flag to False (true is an alarm). This is used in the Standard SOP for liquid cooled drives as an alarm. **Action** **1.** Check physical input connected to SOP flag. **2.** Check coolant temperature. **3.** Check for flow.
Coolant Inlet Temp < 22° C	F/A	SOP	**Cause** Drive initiated alarm when the InletWaterTempLow_O SOP flag is set true and the InletWaterTempLowEn_O flag is true to enable it. The default is an alarm but it can be changed to a fault by setting the InletWaterTempLowWn_O flag to False (true is an alarm). This is used in the Standard SOP for liquid cooled drives as an alarm. **Action** **1.** Check physical input connected to SOP flag. **2.** Check coolant temperature. **3.** Check for flow.
Cell Water Temp High	F/A	SOP	**Cause** Drive initiated alarm when the CellWaterTempHigh_O SOP flag is set true and the CellWaterTempHighEn_O flag is true to enable it. The default is an alarm but it can be changed to a fault by setting the CellWaterTempHighWn_O flag to False (true is an alarm). This is used in the Standard SOP for liquid cooled drives as an alarm. **Action** **1.** Check physical input connected to SOP flag. **2.** Check coolant temperature. **3.** Check for flow.

Fault Display	Type	Enable	Potential Causes and Corrective Actions
Coolant Tank Level < 30 inches	A	SOP	**Cause** Drive initiated alarm when the LowWaterLevelAlarm_O SOP flag is set true and the LowWaterLevelAlarmEn_O flag is true to enable it. The default is an alarm and it cannot be changed. This is used in the Standard SOP for liquid cooled drives as an alarm. **Action** **1.** Check physical input connected to SOP flag. **2.** Check sensor. **3.** Check and fill tank.
Coolant Tank Level < 20 inches	F/A	SOP	**Cause** Drive initiated fault/alarm when the LowWaterLevelFault_O SOP flag is set true and the LowWaterLevelFaultEn_O flag is true to enable it. The default is a fault, but it can be changed to an alarm by setting the LowWaterLevelFaultWn_O flag true. This is used in the Standard SOP for liquid cooled drives as a trip alarm. **Action** **1.** Check physical input connected to SOP flag. **2.** Check sensor. **3.** Check and fill tank.
Low Coolant Flow < 60%	A	SOP	**Cause** Drive initiated alarm when the LowWaterFlowAlarm_O SOP flag is set true and the LowWaterFlowAlarmEn_O flag is true to enable it. The default is an alarm and it cannot be changed. This is used in the Standard SOP for liquid cooled drives as an alarm. **Action** **1.** Check physical input connected to SOP flag. **2.** Check sensor.

7

Fault Display	Type	Enable	Potential Causes and Corrective Actions
Low Coolant Flow < 20%	F/A	SOP	**Cause** Drive initiated fault/alarm when the LowWaterFlowFault_O SOP flag is set true and the LowWaterFlowFaultEn_O flag is true to enable it. The default is a fault, but it can be changed to an alarm by setting the LowWaterFlowFaultWn_O flag true. This is used in the Standard SOP for liquid cooled drives as a trip alarm. **Action** **1.** Check physical input connected to SOP flag. **2.** Check sensor.
Loss One HEX Fan	A	SOP	**Cause** Drive initiated alarm when the LossOneHexFan_O SOP flag is set true and the LossOneHexFanEn_O flag is true to enable it. The default is an alarm and it cannot be changed. This is used in the Standard SOP for liquid cooled drives as an alarm. **Action** Check physical input connected to SOP flag. Check sensor. Check for faulty fan. Check for obstruction.
Loss All HEX Fans	F/A	SOP	**Cause** Drive initiated alarm/fault when the LossAllHexFan_O SOP flag is set true and the LossAllHexFanEn_O flag is true to enable it. The default is an alarm but it can be changed to a fault by setting the LossAllHexFanWn_O flag to False (true is an alarm). This is used in the Standard SOP for liquid cooled drives as an alarm. **Action** **1.** Check physical input connected to SOP flag. **2.** Check sensor. **3.** Check for faulty fan. **4.** Check for obstruction.

7

Fault Display	Type	Enable	Potential Causes and Corrective Actions
All HEX Fans On	A	SOP	**Cause** Drive initiated alarm when the AllHexFansOn_O SOP flag is set true and the AllHexFansOnEn_O flag is true to enable it. The default is an alarm and it cannot be changed. This is used in the Standard SOP for liquid cooled drives as an alarm. **Action** **1.** Check physical input connected to SOP flag. **2.** Check sensor. **3.** Check for faulty fan. **4.** Check for obstruction.
Input Transformer Temperature Related			
Xformer OT Alarm	A	SOP	**Cause** Drive initiated alarm when the XformerOverTempAlarm1_O SOP flag is set true and the XformerOverTempAlarm1En_O flag is true to enable it. The default is an alarm and it cannot be changed. This is used in the Standard SOP for liquid cooled drives as an alarm. **Action** **1.** Check physical input connected to SOP flag. **2.** Check sensors. **3.** Check blowers if air cooled – flow and water temperature if liquid cooled.
Xformer OT Trip Alarm	A	SOP	**Cause** Drive initiated alarm when the XformerOverTempAlarm2_O SOP flag is set true and the XformerOverTempAlarm2En_O flag is true to enable it. The default is an alarm and it cannot be changed. This is used in the Standard SOP for liquid cooled drives as an alarm. **Action** **1.** Check physical input connected to SOP flag. **2.** Check sensors. **3.** Check blowers if air cooled – flow and water temperature if liquid cooled.

7

Fault Display	Type	Enable	Potential Causes and Corrective Actions
Xformer OT Fault	F/A	SOP	**Cause** Drive initiated fault/alarm when the XformerOverTempFault_O SOP flag is set true and the XformerOverTempFaultEn_O flag is true to enable it. The default is a fault, but it can be changed to an alarm by setting the XformerOverTempFaultWn_O flag true. This is used in the Standard SOP for liquid cooled drives as a trip alarm. **Action** **1.** Check physical input connected to SOP flag. **2.** Check sensors. **3.** Check blowers if air cooled – flow and water temperature if liquid cooled.
Xfrm Cool OT Trip Alarm	A	SOP	**Cause** Drive initiated alarm/fault when the XformerWaterTempHigh_O SOP flag is set true and the XformerWaterTempHighEn_O flag is true to enable it. The default is an alarm and it cannot be changed. This is used in the Standard SOP for liquid cooled drive as an alarm. **Action** **1.** Check physical input connected to SOP flag. **2.** Check flow and water temperature.
Input Reactor Temperature Related			
Reactor OT Alarm	A	SOP	**Cause** Drive initiated alarm when the ReactorTemperature1_O SOP flag is set true and the ReactorTemperature1En_O flag is true to enable it. The default is an alarm and it cannot be changed. This is used in the Standard SOP for liquid cooled drives as an alarm. **Action** **1.** Check output current waveform for sinusoidal shape. **2.** Check sensor. **3.** Check physical input connected to SOP flag.

7

Fault Display	Type	Enable	Potential Causes and Corrective Actions
Reactor OT Trip Alarm	A	SOP	**Cause** Drive initiated alarm when the ReactorTemperature2_O SOP flag is set true and the ReactorTemperature2En_O flag is true to enable it. The default is an alarm and it cannot be changed. This is used in the Standard SOP for liquid cooled drives as an alarm. **Action** **1.** Check output current waveform for sinusoidal shape. **2.** Check sensor. **3.** Check physical input connected to SOP flag.
Reactor OT Fault	F/A	SOP	**Cause** Drive initiated fault/alarm when the ReactorTemperatureFault_O SOP flag is set true and the ReactorTemperatureFaultEn_O flag is true to enable it. The default is a fault, but it can be changed to an alarm by setting the ReactorTemperatureFaultWn_O flag true. This is used in the Standard SOP for liquid cooled drives as a trip alarm. **Action** Verify the Fiber Optic connection bw
Cell Bypass Related			
Cell Bypass Com Fail	F	Fixed	**Cause** The Master Control system is not communicating with the MV Bypass board.. **Action** **1.** Verify the Fiber Optic connection between the Modulator board and MV Bypass board is intact. **2.** Replace Modulator board **3.** Replace MV Bypass board

Fault Display	Type	Enable	Potential Causes and Corrective Actions
Cell Bypass Acknowledge	F	Fixed	**Cause** The Master Control issued a command to bypass a cell, but the MV bypass board did not return an acknowledgement. **Action** **1.** Verify that the bypass contactor is working properly. **2.** Check wiring between MV bypass board an contactor. **3.** Replace MV bypass board or Contactor.
Cell Bypass Link	F	Fixed	**Cause** The Master Control system is not communicating with the MV Bypass board—i.e., the MV Bypass board is either not receiving commands, or is getting parity errors in the messages from the modulator boards. **Action** Refer to "Cell Bypass COM Fail" above.
Cell Bypass COM Alarm	A	Fixed	**Cause** The Master Control system is not communicating with the MV Bypass board, but the bypass system is not in use. **Action** Refer to "Cell Bypass COM Fail" above.
Cell Bypass Link Alarm	A	Fixed	**Cause** The Modulator board is not communicating with the MV Bypass board, but the bypass system is not in use. **Action** Refer to "Cell Bypass COM Fail" above.
Cell Bypass Fault	F	Fixed	**Cause** The cell failed to go into bypass when commanded to do so. **Action**
xx Bypass Verify Failed xx=cell that is faulted	F	Fixed	**Cause** Bypass contactor closure verify failed **Action** Check bypass system, contactor MV Bypass board, and Modulator board.

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Fault Display	Type	Enable	Potential Causes and Corrective Actions
xx Bypass Ack Failed xx=cell that is faulted	F	Fixed	**Cause** Bypass contactor closure acknowledge failed **Action** Check bypass system, contactor MV Bypass board, and Modulator board.
xx Bypass Avail Warning *xx=cell that is faulted*	A	Fixed	**Cause** Cell level bypass available alarm. Only if bypass is not used **Action** Check bypass system, fiber optic cable, MV Bypass board, and supply.
Cell Related			
Cell Count Mismatch	F	Fixed	**Cause** The software detected a difference in the number of cells detected versus the Installed Cells/phase Menu (2530). **Action** **1.** Verify that the Installed Cells/phase Menu (2530) matches the actual number of cells in the system. **2.** Verify all fiber optic cable connections are correct. **3.** Replace Modulator board. Replace Fiber Optic board(s).
Cell DC Bus Low	A	Fixed	**Cause** Cell DC bus below alarm level. This is set by the cell control board and comes back from the cell as /Vavail_ok flag. **Action** **1.** Check for single phase input, low input line conditions, blown input fuses. **2.** Check for a cell control board failure.

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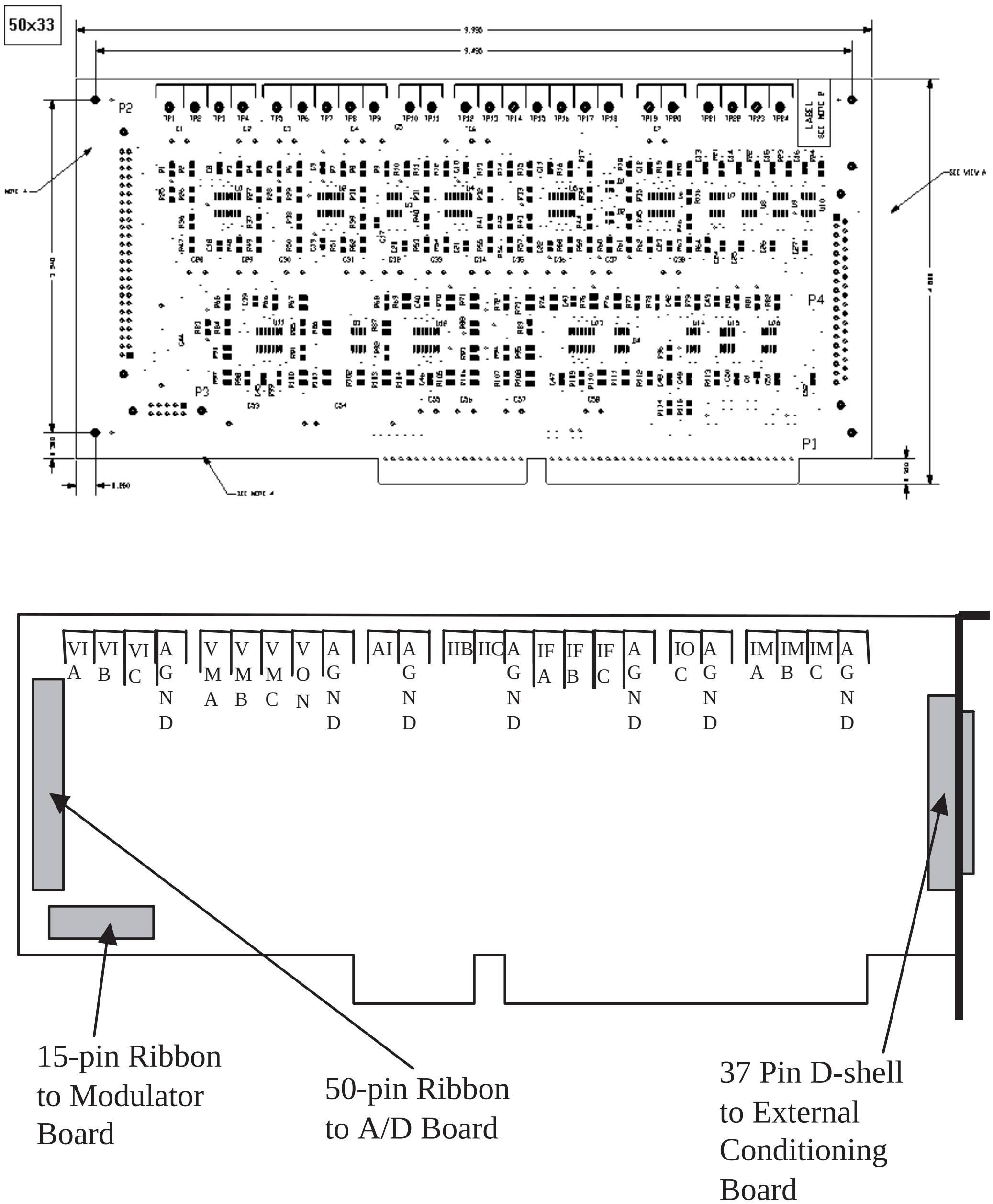

Figure 7-1. Connections and Test Points on the System Interface Board

7.4 Cell Faults/Alarms

Cell faults/alarms are logged by the Microprocessor Board following a power cell fault indication. These faults are available for inspection through the keypad display or can be uploaded to a PC via the serial port. All active cell faults/Alarms are displayed on the keypad display. Use the arrow keys to scroll up and down through the faults. The Alarm/Fault log upload function (Parameter ID 6230) in the Alarm/Fault Log Menu (6210) can be used to upload the log to a PC for analysis and for sending to the appropriate Siemens or plant personnel.

All cell faults are generated by circuitry located on the Cell Control Board (CCB) of each power cell and are received by the Microprocessor Board through circuitry on the Digital Modulator Board. Table 7-4 can be used as a quick troubleshooting guide to locate the cause of the fault condition. This table lists faults that may occur in multiple-cabinet and GEN III styles of Perfect Harmony drives unless otherwise noted. All cell faults are initiated by the Cell Control Board or CCB (see Figure 7-2) located in each power cell.

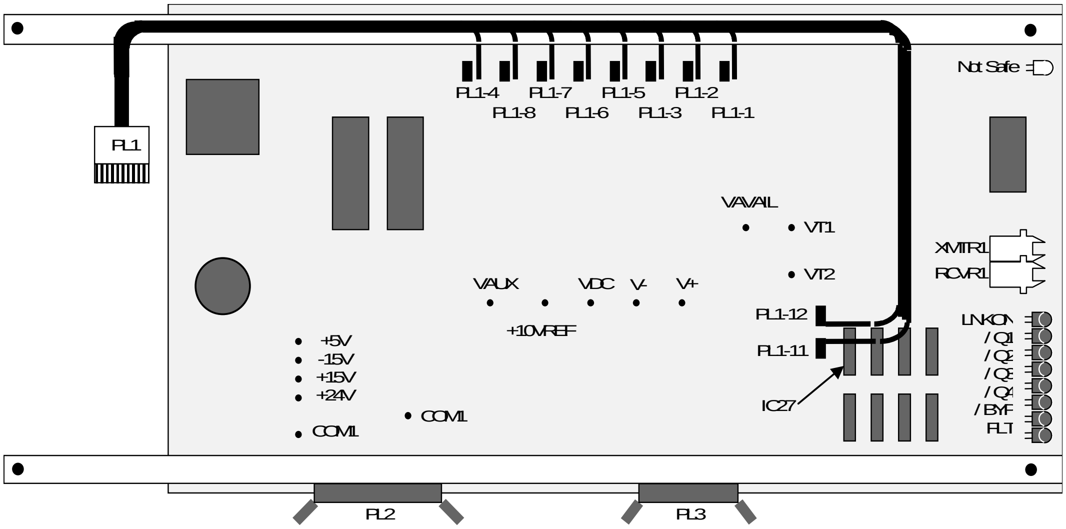

Figure 7-2. Connectors and Diagnostic Components of a Model 430 Cell Control Board

Note:
- Model 430 Cell Control Boards are only used in the multiple-cabinet versions of Perfect Harmony drives (not GEN III). Cell Control Boards for GEN III drives use a model N15 board which is different from the board depicted in 7-2.
- If a spare Cell Control Board is ordered for a drive that contains a model 430 board, a model N15 board will be shipped with an adapter harness for proper connection.

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Table 7-4. Cell Faults

Fault Display	Type	Enable	Potential Causes and Possible Corrective Actions
Power Fuse Blown	F	Fixed	**Cause** One or more of the input power fuses to a cell are open. **Action** Determine the reason for the fuse failure then repair (if required) and replace the fuse.
xx Over Temp Warning xx=cell that has alarm	A	SOP	**Cause** Cell temperature is above the programmable fault limit. Each cell sends a PWM signal to the Modulator Board. This signal represents the heat sink temperature. The temperature has exceeded the fixed fault level (80% duty cycle). **Action** Check condition of the cooling system. Check motor load conditions.
Over Temperature xx=cell that is faulted	F	Fixed	**Cause** Each cell sends a PWM signal to the Modulator Board. This signal represents the heat sink temperature. The temperature has exceeded the fixed fault level (80% duty cycle). **Action** **1.** Check the condition of the cooling system. **2.** Refer to Section 7.4.1.
xx Control Power	F	Fixed	**Cause** One or more of the local power supplies (+24, +15, +5, or -5 VDC) on a Cell Control Board (see Figure 7-2) has been detected to be out of specification. **Action** If this occurs, repair or replace the Cell Control Board.
xx IGBT OOS n (n=1,2,3,4)	F	Fixed	**Cause** Each Gate Driver Board includes circuits which verify that each IGBT has fully turned on. This fault may indicate a bad gate driver, an open IGBT, or a failure in the detection circuitry (i.e., logic low signals on opto-couplers **IC12**, **IC22**, **IC32**, and **IC42** pin 7 on Gate Drive Board usually as a result of a **Q1**, **Q2**, **Q3**, or **Q4** collector-to-emitter short in the cell's power bridge). **Action** Check the cell's power components and Gate Driver Board.

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xx Cap Share	F	Fixed	**Cause** A capacitor share fault usually indicates that the voltage shared by the two or three DC link capacitors is not being shared equally (i.e., the voltage on an individual capacitor in a cell has been detected over 425 VDC). This can be caused by a broken bleeder resistor (or wire) or a failed DC link capacitor (**C1** and/or **C2**). **Action** Refer to Section 7.4.1.
xx Link xx=cell that is faulted	F	Fixed	**Cause** Cell communication link failure—the cell failed to respond to a modulator command packet. **Action** **1.** Check fiber optic cable. **2.** Cell may need to be serviced. **3.** Change out fiber optic or modulator board. **4.** Change cell control board.
xx Communication	F	Fixed	**Cause** An error in the optical communications was detected by a cell (i.e., a logic low signal is detected on pin 13 of **IC37**). This is usually a parity error caused by noise, but can also be a time-out error caused by a faulty communications channel on the Cell Control Board (see Figure 7-2). **Action** Refer to Section 7.4.4.
xx Control Fuse Blown xx=cell that is faulted	F	Fixed	**Cause** Cell control power fuse blown. This is rarely seen since the cell control board has a dual source of power. **Action** Check cell fuses, replace if necessary.
xx DC Bus Low Warning xx=cell that has alarm	A	Fixed	**Cause** Cell DC bus below alarm level **Action** Check for single phase input, low input line conditions, blown input fuses.

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Cell DC Bus Low	A	Fixed	**Cause** Cell DC bus below alarm level. This is set by the cell control board and comes back from the cell as /Vavail_ok flag. **Action** Check for single phase input, low input line conditions, blown input fuses. Check for a cell control board failure.
xx DC Bus Over Volt	F	Fixed	**Cause** The bus voltage in a cell has been detected over 800 VDC (for 460VAC cells) or 1200VDC (for 690VAC cells) (i.e., the signal on the **VDC** test point is >8.0 VDC). This is usually caused by a regeneration limit that is too high, or improper tuning of the drive. **Action** Refer to Section 7.4.3.
xx DC Bus Under Volt	F	Fixed	**Cause** The DC bus voltage detected in a cell is abnormally low (the signal on test point VDC on the Cell Control Board is <3.5 VDC). Refer to 7-2. If this symptom is reported by more than one cell, it is usually caused by a low primary voltage on the main transformer **T1**. **Action** **1.** Check input line voltage. **2.** Check for faults on other cells.

Note: Fault class designations in the previous table are shown in parentheses and are explained in Figure 7-2.

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The following cell faults will occur only during the cell diagnostic mode (immediately following initialization or reset). All IGBTs in each cell are sequentially gated and checked for proper operation (blocking/not blocking). See Table 7-5.

Table 7-5. Diagnostic Cell Faults

Fault Display	Type	Enable	Potential Causes and Possible Corrective Actions
xx Blocking Q*n* (*n* = 1,2,3,4)	F	Fixed	**Cause** During cell diagnostic mode, the Perfect Harmony checks the voltage across each IGBT under "gate off" conditions. A blocking failure is reported if insufficient voltage is detected, i.e., voltages on test points **VT1** and **VT2** on the Cell Control Board (see Figure 7-2) are < ±0.5 VDC when power transistors **Q1-Q4** are gated. This may indicate a damaged IGBT, or a malfunctioning gate driver board or cell control board. **Action** Refer to Section 7.4.1.
xx Switching Q*n* (*n* = 1,2,3,4)	F	Fixed	**Cause** During cell diagnostic mode, the Perfect Harmony turns each IGBT on one-by-one, and verifies the collapse of voltage across the devices. A switching failure is reported if a device is supporting voltage while it is gated on (i.e., voltages on test points **VT1** and **VT2** on the Cell Control Board are > ±0.5 VDC when power transistors **Q1-Q4** are gated). Usually, this fault is caused by a malfunctioning gate driver board, IGBT, or cell control board. **Action** Refer to Section 7.4.1.
xx Blocking Timeout xx=cell that is faulted	F	Fixed	**Cause** Blocking Test timeout. A cell failed the blocking test. **Action** Check cell, or back EMF too high
xx Switching Timeout xx=cell that is faulted	F	Fixed	**Cause** Switching Test timeout. A device failed the switching test after successfully passing blocking. **Action** Check cell, or back EMF too high to run the test.

Note: Fault class designations in the previous table are shown in parentheses and are explained in Figure 7-2.

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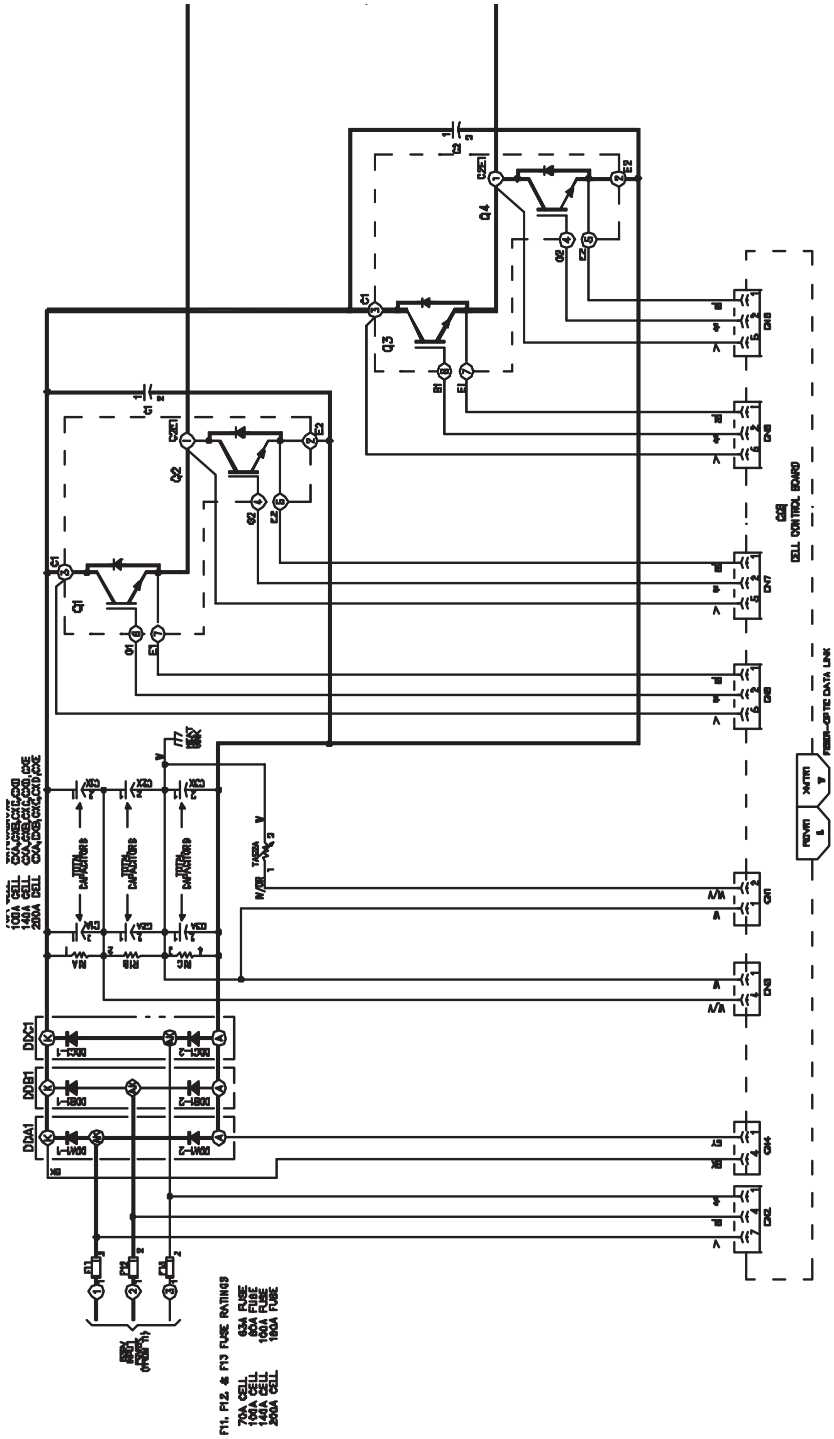

Figure 7-3. Typical Power Cell with Optional Mechanical Bypass

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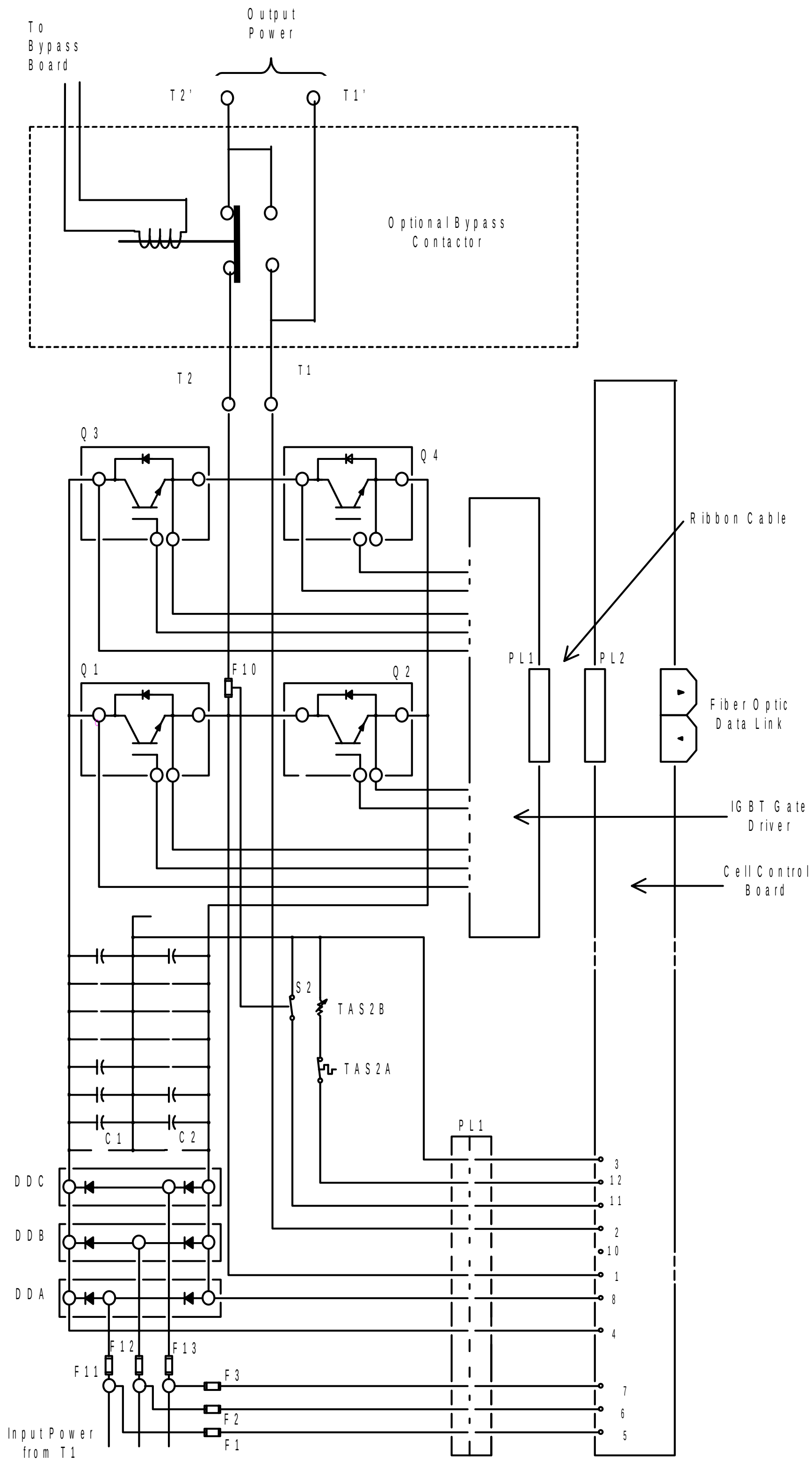

Figure 7-4. Typical Power Cell Schematic (GEN III Design)

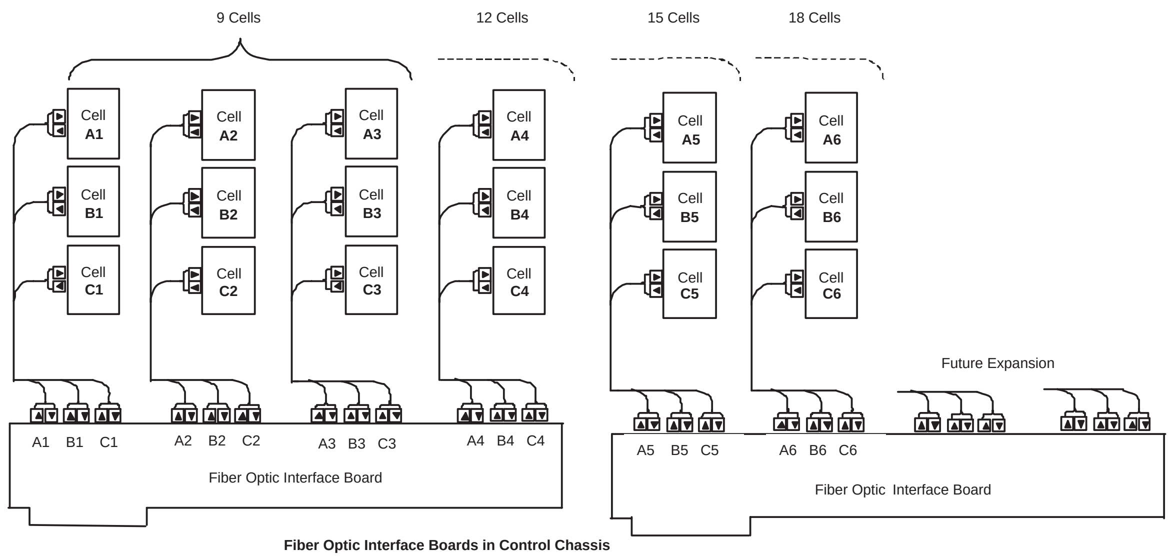

Figure 7-5. Typical Fiber Optic Interface Boards Connection Diagram

7.4.1 Troubleshooting General Cell and Power Circuitry Faults

The types of faults addressed in this section include the following:

- AC fuse(s) blown faults
- control power faults
- device out of saturation (OOS) faults
- capacitor sharing faults
- bypass failed faults
- VDC undervoltage faults
- blocking failure faults
- switching failure faults.

7

AC Fuse(s) Blown Faults

These faults are caused by the blowing of the power fuses on the front end of the cell. Check the fuses and replace any that are blown—more than one could be out. Replace defective or damaged parts.

Control Power Faults

This fault is caused when one or more of the control fuses that supply power to the CCB (Cell Control Board) are blown. This is rarely seen because the CCB is supplied by two circuits: the control power supply bridge and the DC link. If Control Power Fault is observed, the AC fuses might also be blown. Replace the defective or damaged parts.

Capacitor Sharing Faults

The Cell Capacitor bank is made up of from two to three series capacitor banks. Circuitry on the CCB measures the voltage on each section and if the voltages are off by any amount, the fault is set. This indicates that under load the capacitors are not sharing load evenly and could be the result of faulty capacitors or loose connections. Fix or replace damaged or defective components.

Q1-Q4 OOS (Out Of Saturation) Faults

Out of Saturation faults occur when the transitor junction is depleted of charge carriers resulting in a higher junction resistance. This in turn created a larger voltage drop and more losses in the transistor which can lead to premature failure. The cause of the OOS can be a defective gate driver board or a high di/dt transition on the device. The gate board is designed with circuitry to detect the larger voltage drop when the device should be on, shutting down the device in a fault condition. The fault can also be caused by a defective CCB or noise on the CCB. The exact cause needs to be determined before pulling a power cell out of service.

Bypass Failed Faults

This fault results from the failure of a cell to go into bypass when faulted. The cause can be from a defective modulator board, bad link between the modulator and the MV bypass board, a defective MV bypass board or supply, or a defective bypass contactor. Find and replace the faulty components.

VDC Undervoltage Faults

The undervoltage fault occurs when the voltage drops below the threshold of the detection circuitry on the CCB. This can be the result of a low MV level coupled with a high current drainage by the load, or simply as an excessive load that may give a momentary dip in current. It can also occur if one of the AC power fuses fails under load. Check the cell fuses and check the historic log for line dips. Correect the problem before continuing operation. A faulty CCB couldgive a false indication as well. Replace defective or faulty parts.

Blocking Failure Faults

Blocking failures occur when IGBTs short due to perforation of their junction caused by excessive current (high current density). This may be a result of out of saturation conditions and fequent trips. The device will need to be replaced when the cell is removed for service. A defective gate driver may be the root cause. A faulty CCB or bad data from the CCB could give a faulty indication of this fault. Replace damaged or defective parts.

Switching Failure Faults

Switching failures occur when a device opens or fails to turn on. It could also be caused by a defective gate drive or a damaged device. Also, a defective CCB or modulator board could give a faulty indication. Replace defective parts.

7.4.2 Troubleshooting Cell Over Temperature Faults

Water Cooled

Cell Over Temperature faults are typically caused by problems in the cooling system. Use the following steps to troubleshoot this type of fault:

1. Check the cooling system for proper flows and temperatures.
2. Inspect cell cooling paths for kinked hoses or major leaks.
3. Be sure all Cell Cabinet manifold valves are fully open.

Water Cooled

1. Check that the blowers are working properly.
2. Check ambient temperature. Verify that all cabinet doors are shut to ensure proper air flow.
3. Check for faulty RTD on cell or bad cell control board.

7.4.3 Troubleshooting Overvoltage Faults

This fault is usually caused by an improperly set-up or tuned drive. Use the following steps to troubleshoot this type of fault.

1. Verify that the motor and drive nameplate settings match parameters in the Motor Parameter Menu (1000) and Drive Parameter Menu (2000).
2. Reduce the regen torque limit parameters (1200, 1220, 1240) in the Limits Menu (1120).

3. Reduce Flux Regulator Proportional Gain (3110) and Flux Regulator Integral Gain (3120) parameters in the Flux Control Menu (3100).
4. If the failure is occurring in bypass mode, increase the Energy Saver Minimum Flux (3170) parameter in the Flux Control Menu (3100) to at least 50%.
5. If the measured signals (from the previous section) seem to be correct, change the Modulator board.

7.4.4 Troubleshooting Cell Communications and Link Faults

Faults of this variety can be the result of circuit failures on either the Digital Modulator Board or Cell Control Board (see Figure 7-2).

1. Check fiber optic links—replace if defective.
2. Check or replace cell control board.
3. Reseat fiber optic board and modulator board. Replace if necessary.
4. If the fault indication persists after replacing the Digital Modulator Board, call the factory.

7.4.5 Status Indicator Summaries for MV Mechanical Bypass Boards

The MV Mechanical Bypass Board includes 3 LEDs that provide complete status of the MV board. These LEDs are summarized in the following table.

Table 7-6. LED Status Indicators for MV Mechanical Bypass Boards

LED Function	Color	Description
CommOK	green	Indicates active communication link established with Modulator board.
Fault	red	Indicates that a bypass fault is active.
PwrOK	green	This LED is hardware controlled and indicates that the 5/15VDC supplies are in tolerance.

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7.5 User Faults and Alarms

> **Attention!** User faults and alarms are closely tied to the system program configuration and will be designated here generically as faults although they can be programmed as alarms only. Refer to **Chapter 8: System Programming** for more information.

MUser faults occur due to conditions defined in the system program. User faults are displayed on the keypad in the form of user defined fault #*n*, where *n* equals 1 to 64. The faults can also be displayed using user-defined text strings. Most user-defined faults are written to respond to various signals from the Wago I/O such as the analog input modules (through the use of comparators) as well as the digital input modules.

A copy of the system program is required to specifically define the origin of the fault. In the example program found in the **Chapter 8: System Programming**, the *UserFault_1* flag is used to display the event of a blower fault. Note that the *UserText1* string pointer is used to display the specific fault message. If this string pointer is not used, then the fault displayed would be “user defined fault #1.”

7.6 Unexpected Output Conditions

In some cases, the Perfect Harmony VFD will revert to operating conditions which limit the amount of output current, output speed, or output voltage, but with no apparent fault condition displayed. The most usual causes of these conditions are described in the subsections that follow.

The keypad mode displays can sometimes be used to troubleshoot the cause of the output limitation. The modes are displayed in two lines at the left of the keypad display:

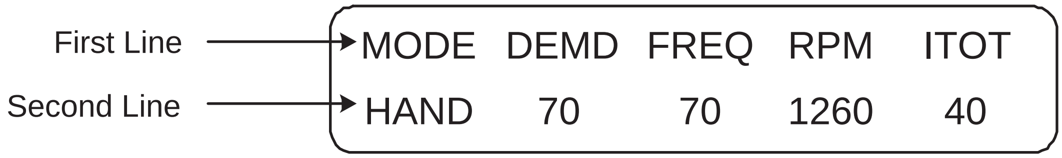

Figure 7-6. Keypad Mode Display

Tables 7-7 and 7-7 list the mode displays for the first and second lines, respectively. The first column of the tables lists the abbreviated message that is shown on the display of the drive. The second column lists descriptions of the operating modes. Further descriptions of possible limit situations and troubleshooting tips are listed in the subsections that follow.

Table 7-7. Summary of Operation Mode Displays, Line 1

Display	Description
FRST	Fault reset is active.
TLIM	Menu torque limit is active.
SPHS	A single phase on the MV input has occurred, drive limited.
UVLT	The drive is experiencing an input under-voltage torque limit.
T OL	The thermal overload is active, limiting drive torque.
F WK	Motor is operating in a field-weakened condition. Torque is limited but current is not.
C OL	A cell overload limit has been reached.
NET1	A torque limit from Network1 is active.
NET2	A torque limit from Network2 is active.
ALIM	A torque limit from analog input is active.
RLBK	A torque limit is active and the speed demand input from the ramp has been rolled back.
RGEN	A motor is in regen mode—power dissipated in motor losses.
F WK	The motor is operating in a field—power dissipated in motor losses.
BRKG	The motor is in dual frequency braking mode.
BYPS	At least one cell is in bypass.
OLTM	Open loop test mode control algorithm used.
MODE	Default for display line 1 if no other conditions exist.

Table 7-8. Summary of Operation Mode Displays, Line 2

Display	Description
NOMV	Medium voltage is off or there is no feedback.
INH	The drive is in an inhibit mode (CR3 signal is missing).
OFF	The drive is in the idle state—ready to run.
MAGN	The motor is being magnetized—no torque output.
SPIN	The drive is performing a spinning load catch of the motor (startup with motor turning).
UXFR	The drive is performing a synchronous transfer of the motor to the line.
DXFR	The drive is performing a synchronous transfer of the motor from the line.
KYPD	The drive is in the run state with speed command from the keypad.
TEST	The drive is in the speed test mode.
LOS	The drive is running with the primary speed reference signal lost.
NET1	The drive is running with the speed signal from Network1.
NET2	The drive is running with the speed signal from Network2.
AUTO	The SOP “AutoDisplayMode_0” flag is set to true—speed reference is usually from an analog signal selected by the SOP.
HAND	Default running mode—speed reference is selected by the SOP and “AutoDisplayMode_0” is set to false.
BRAK	The drive is in the stop state with dual frequency braking active.
DECL	The drive is in the ramp stop state—speed is ramping down..
COAS	The drive is in the coast stop state—drive output is forced off.
TUNE	The drive is in the auto tune state—auto tuning is active.

If the mode display shows RLBK (rollback mode), then the Perfect Harmony VFD is attempting to reduce the output speed due to a torque limit condition. Use the following steps to troubleshoot this type of fault:

1. Check the motor torque limit (1190, 1210, 1230) parameters in the Limits Menu (1120).
2. Check all motor and drive nameplate ratings against parameters set in the Motor Parameter Menu (1000) and the Drive Parameter Menu (2000).

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Note: Spare parts are available through our Customer Service Center by calling (724) 339-9501.

7.7 Drive Input Protection

This section describes the routines used to detect abnormal conditions due to an internal drive failure and thus provide protection to the drive. The faults generated by the routines may be used with suitable interlocking, via a relay output and/or serial communication, to disconnect medium voltage from the drive input.

7.7.1 One Cycle Protection (or Excessive Input Reactive Current Detection)

NXG Control utilizes input reactive current to determine whether a ‘hard’ fault on the secondary side of the transformer has occurred. For example, a short-circuit in one of the secondary windings will result in poor power factor on the high-voltage side of the transformer. A model of the transformer based on the power factor at rated load (typically 0.95) is implemented in the control processor. The drive input reactive current is continuously checked with the predicted value from the model. An alarm/trip is generated if the actual reactive current exceeds the prediction by more than 10%. This check is avoided during the first 0.25 seconds after medium voltage power-up to avoid the inrush current from causing nuisance trips. See Section 6.7 for the theory and implementation of one cycle protection.

7.7.2 Excessive Drive Losses

The Excessive Drive Loss protection guards against low-level fault currents. Drive losses are calculated as the difference between the measured input and output powers, and compared against reference losses. The reference losses are fixed at 5.0% during “Idle” State and at 7.0% during “Run” State. When the calculated losses exceed the reference losses, a drive trip is issued and this condition is annunciated as an “Excessive Drive Loss Alarm”. In addition to this response, a digital output is set low in the System Operating Program (SOP), which in the default drive configuration is used to open the input disconnect device. The fixed reference limit is low enough to detect a fault in one set of transformer windings, and at the same time is large enough to avoid nuisance trips. When the drive is not supplying power to the motor, the losses in the system are primarily due to the transformer; the fixed limit is then lowered to increase the sensitivity of the protection routine.

In earlier software versions up to version 2.22, the protection was such that when the calculated losses exceeded the reference losses for more than one second, a trip was generated. For software versions 2.30 and higher, an inverse power loss function is implemented for Excessive Drive Loss protection. The plot in Figure 7-7 shows the time to trip as a function of calculated losses for Liquid and Air Cooled Drives. The plot contains two curves, one of which is used when the Drive is in “Idle” State (i.e. medium voltage is applied, but the motor is not being operated) while the second curve (slightly longer time to trip) is used during the “Run” State.

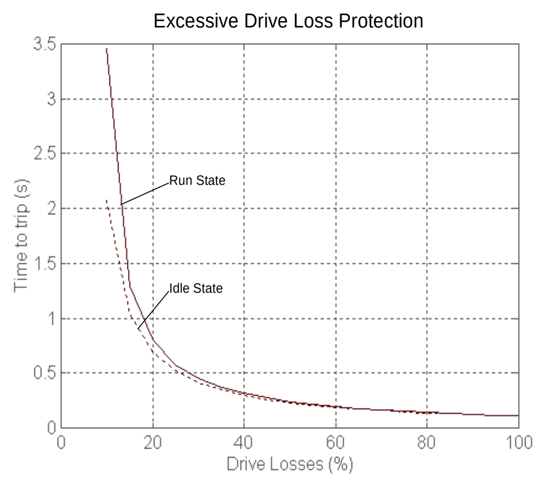

Figure 7-7. Excessive Drive Loss Protection

See Section 6.8 for the theory and implementation of excessive drive loss protection.

7.7.3 Transformer Over-Temperature and Loss of Cooling

The temperatures of all the secondary windings are monitored using two (series-connected) sets of (normally closed) thermal switches. The first set opens when the temperature exceeds 150°F (or 65°C) while and the second set opens above 180°F (or 82°C). Two outputs, one output corresponding to each set, are read through the WAGO by the control logic. A Xfrmr Temperature Alarm 1 is issued when one or more 150°F switches open, and a Xfrmr Temperature Alarm 2 is issued when one or more 180°F switches open. When both these conditions exist for 30 seconds, a Xfrmr Over Temp Fault is generated that causes the drive to trip.

A vortex flow sensor monitors liquid coolant flow through the Liquid Cooled Drive. This sensor is connected to a display unit on the door of the Coolant Section, which displays flow rate, among other parameters, and outputs a 4-20 mA signal to the WAGO. A software comparator, interacting with the control logic, monitors this 4-20 mA signal. As a standard default, the alarm "Loss of Coolant Flow" is issued whenever the detected flow rate is below 40 percent of rated for 7 seconds.

The SOP program can be used to trip the input Medium Voltage Breaker when the conditions of Xfrmr Temperature Alarm 1, Xfrmr Temperature Alarm 2, and Loss of Coolant Flow exist simultaneously.

7.8 Flash Disk Corruption

While copying files to the flash disk from Windows 2000, an incomplete write function can corrupt the flash disk contents without any visible warnings.

To avoid this corruption:

1. When the copy function is complete, right-click on the drive letter representing the flash disk.
2. Select the Eject option from the pop-up menu.

This forces Windows 2000 to flush the write cache and complete the write to the flash disk.

If you are going to disconnect the flash disk, wait a few seconds after selecting the Eject command before you disconnect the flash disk.

7.9 Portable Harmony Cell Tester

Siemens can supply the necessary equipment to perform on-site cell testing at a customer’s site. This test is essentially a duplication of the cell test done at the factory prior to installation into the Cell Cabinet. Since each cell operates independently within the Perfect Harmony system, it is possible to fully test the performance of each cell and thus verify the proper performance of the cell system without having to actually apply rated voltage to the motor.

The following equipment is required for on-site cell testing:

- Portable Harmony Cell Tester (PCT) (P/N 469939.00)
- IBM compatible computer (286 or greater with Centronics port and EGA capability)
- 480 VAC, 30 A variable auto transformer variable voltage source (STACO type 6020-3 or equivalent)
- Load reactor (refer to Table 7-9).
- DVM capable of measuring 500 VAC (Beckman 3030A or equal).
- Clamp on ammeter (Beckman CT-232 or equal).

Table 7-9. Load Reactor Information

Cell Size	Reactor P/N	Reactor Configuration	
NBH 70	161661.13	1 Unit with Series windings L=8mH	
NBH100	161661.13	1 Unit with Series windings L=8mH	
NBH 140	161661.13	1 Unit with Series windings L=8mH	
NBH 200	161661.13	1 Unit with single windings L=4mH	
NBH 260	161661.13*	1 Unit with parallel windings L=2mH	
3I	161661.13*	1 Unit with single winding L=4mH	
360H	161661.13*	1 Unit with parallel windings L=2mH	
4I (300H)	161661.13*	1 Unit with parallel windings L =2mH	
4B	161661.13*	1 Unit with parallel windings L=2mH	
5C	161661.13*	1 Unit with parallel windings L=2mH	
5B	161661.13*	2 Units in parallel with series windings L= 1mH	

* Requires small cooling fans that are not included.

The portable cell tester (PCT) comes equipped with cables and software required to interface the PCT with the cell's optical communications port and the PC. The individual tests are menu driven with *go* and *no go* features.

The load reactors will allow each cell to attain full rated current with a minimal input service requirement to the variable voltage source.

The clamp-on ammeters and voltmeters will allow evaluation of the proper output voltages and cell currents during the test.

To test an installed cell:

1. If possible, switch off the source of the medium voltage power at the switchgear. Make sure the drive's medium voltage input switch is open, and lock it out. Rack out any output contactors in the system and lock them out. Take any other necessary steps to release the interlock key that allows access to the cell cabinet. Keep the transformer cabinet and power input cabinet closed and locked. Be sure the cooling system pump is operational.
2. Isolate the cell to be tested by removing the series links from the output at **T1** and **T2**.
3. Unplug the fiber optic cable from this cell at the Fiber Optic Interface Board and plug it into the PCT. Connect the PCT to the parallel printer port of the computer. Turn on the power to the portable cell tester.
4. Disconnect the 3-phase input from the cell and connect the 3-phase output of the variable voltage source to the input of the cell. Connect the input of the variable voltage source to the load side of the 460 VAC control breaker (**CB1**).
5. Execute the 1CELL.EXE program on the computer. From the Main Menu (5) choose #1. The preliminary test will go through a step-by-step go/no go procedure. This will verify that the communications are working and the transistors are blocking (not shorted).

Attention! At this point of the test, the functionality of the IGBTs has been determined. When prompted to use a resistor, the operator should cancel the program by following the instructions on the screen.

6. Turn off the variable voltage source. Connect the load reactor to output connections **T1** and **T2** of the cell. If the cell is operated externally from the cabinet, a separate water supply is required.
7. From the Main Menu [5] choose #2 Burn-in Test Menu. Make sure that the pot on the tester is turned fully in the counter-clockwise direction. From the Burn-in Test Menu start the burn-in. The bottom of the screen will indicate that the cell is running. LED’s Q1-Q4 on the cell should be illuminated. This verifies that all four transistors are firing. Connect an ammeter to **T1** or **T2**. Turn the pot on the tester clockwise and note that the output current increases. Continue until output current reaches the rated current of the cell. Run the cell for 1 hour. Turn the pot fully in the counter-clockwise direction. Stop the burn-in test and exit to the Main Menu.
8. If faults occur while the cell is running, the PC will display all faults detected.
9. Install the cell in the Cell Cabinet and reconnect all power cables, hoses and fiber optic cables.

7.10 Removing Power Cells

Lethal Voltages—DANGER!! Verify that the input power is fully locked in the off position and that the bus LED on each cell is off.

To remove a single power cell from a drive that is filled with coolant:

1. 1.Disconnect input and control power to the drive. Allow the cell capacitor bank to bleed down. This usually takes 5 to 10 minutes after removal of input power.
2. 2.Close valves **BV4A** and **BV4B AND 16A** to isolate the cell cooling liquid from the rest of the system. Disconnect the fiber optic cable from the cell.
3. 3.Using two temporary clamps (Siemens P/N 088145.00), clamp off the two hoses to the cell to minimize spillage when the hose quick disconnect fittings are uncoupled.
4. 4.Disconnect the two cooling liquid lines from the cell using the quick disconnects. The fittings are disconnected by pushing the hose side of the fitting inward and pulling the ring around the cell side fitting from the hose side. When the ring is moved, the hose side of the fitting can be pulled out.
5. 5.Protect the two open hose connectors and the two open cell connectors to prevent entry of dirt or debris. Dummy connectors or a plastic sheet and tape can be used. See Figure 7-8
6. 6.Disconnect the three phase input connections by removing the links at the bottom of the cell power fuses **F11**, **F12** and **F13** (shown in Figure 7-10). Disconnect the output link to each adjacent cell.
7. 7.Position the cell lift device (e.g., a fork lift truck or Siemens P/N163469.01) in front of the cell with the lifting rails aligned both horizontally and vertically with the cell mounting frame rails. Lock the cell lift device in position on the floor.
8. 8.Remove the cell retaining angle brackets at the front bottom of the cell (seeFigure 7-10). Roll the cell onto the lift device rails and lock it in place prior to moving the lifting device. Refer to 7-9.

Figure 7-8. Protecting an Open Cell Connector Using Plastic and a Wire Tie

Figure 7-9. Installation/Removal of a Cell Using a Fork-style Lifting Device

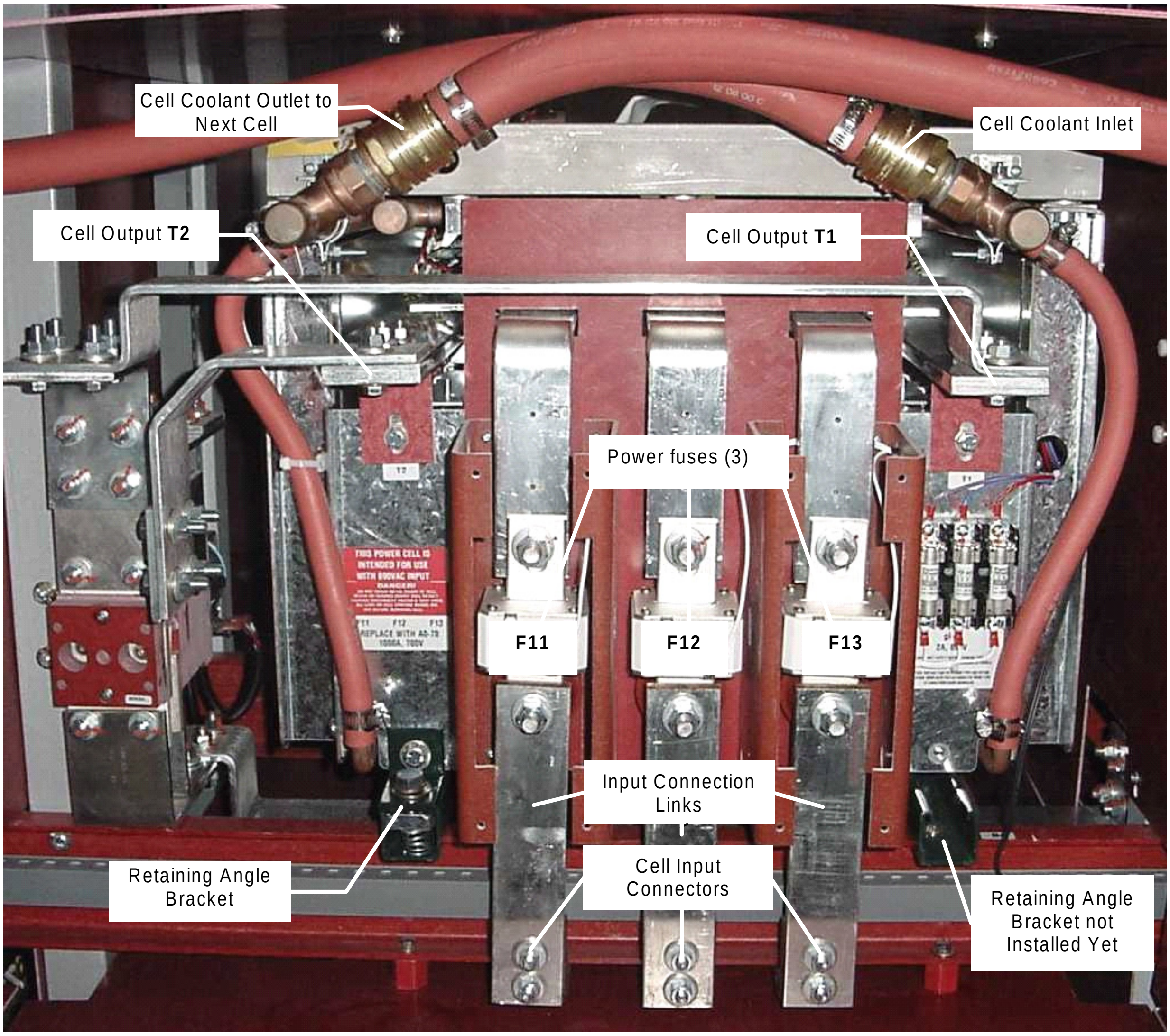

Figure 7-10. Front View of a Cell in Cabinet

> **Attention!** When placing power cells into service which have been stored for more than two (2) years without application of rated input voltage, it is advisable to use the following procedure to reform the cell's electrolytic capacitor bank: follow the procedure in Section 7.8, then apply rated voltage from the variable 690VAC voltage source for at least one hour prior to installation of the cell into the cell cabinet.

7

7.11 Six Month Inspection

1. Check operation of fans in the top rear portion of the Cell Cabinet. Clean or replace them if necessary.

1. Inspect cooling system for leaks. Repair or replace components as necessary.

2. Use touch-up paint as required on any rusty or exposed parts.

3. Test coolant for presence of required glycol concentration. Refer to Table 9-4 in Section 9.12 of this manual. **Note:** a minimum of 5% concentration by weight is recommended to control bacteria.

7.12 Replacement of Parts

Replacement of component parts may be the best method of troubleshooting when spare parts are available. Use troubleshooting guidelines found elsewhere in this chapter when attempting to locate a failed sub-assembly. When any sub-assembly is to be replaced, always check that the part number of the new unit matches that of the old unit (including the dash number).

- Failures traced to individual PC boards within the Control Cabinet are best serviced by replacement of the entire board.
- Failures traced to individual power cells are best serviced by replacement of the entire cell.

Note: For spare parts lists for customized drives, refer to the custom documentation package shipped with the drive or call Siemens Customer Service Department at (724) 339-9501. When calling for spare parts information, please have your sales order number.

Attention! The disposal of any failed components (for example, CPU battery, capacitors, etc.) must be done in accordance with local codes and requirements.

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CHAPTER

8 System Programming

8.1 Introduction

Siemens ’s ID Series of digital drives contain customized programmable logic functions that define many features and capabilities of the drives. These logic functions are combined into a *system program* (SOP) that can be edited either at the factory or in the field. Examples of logic functions include start/stop control logic, input and output control logic (e.g., annunciators, interlocks, etc.), drive-to-machinery coordination and more). The system program is stored on the drive’s flash disk. Upon power-up it is executed continuously by the drive’s run-time software in a repetitive fashion causing the intended logic statements to perform their functionality.

To fully understand the system program operation it is necessary to look at how data is structured, how the compiler puts the data together, how the drive’s software performs its evaluation, and timing related issues. To begin, an understanding of system program terminology is required.

8.2 System Program Terminology

To understand system programs, it is helpful to understand the process by which these programs are created, edited, translated, and transferred to the drive. These processes use certain terms which are summarized in Table 8-1.

8

Table 8-1. System Program Terminology

Name	Function
PC	All of the software programs (the ASCII text editor, compiler program, reverse compiler program, communications software package, etc.) are found on the PC. The PC is also used to send/receive the compiled system program (the hex file) to/from the drive (via the communications cable).
Source File	The source file is an ASCII text file containing simple Boolean statements and operators. This is the “human” version of the system program. The source file is edited on a PC using any standard ASCII text editor. This file is used as the input to the compiler program and is unreadable by the drive. The source file uses the .SOP file extension.
Hex File	The hex file is a compiled version of the source file (in an Intel hex format). This is the “machine” version of the system program. The hex file is a result (or output) of the compile process. This file is the compiled version of the system program source file that is used by the drive. It is sent from the PC to the drive over the communications cable using communications software located in the PC and software functions chosen from the drive menus. The hex file is unreadable by the user. It must be reverse compiled in order to be viewed by the user.
ASCII Text Editor	The ASCII text editor is a software program used on the PC to edit the source file of the system program.
Compiler Program	The compiler program is an off-line (i.e., separate from the drive) software program that resides and runs on an IBM-compatible PC. It is used to translate the ASCII text source file (.SOP) into the hex version system program file (.HEX). This program reads the input source file (.SOP), validates the statements for proper syntax and symbolic content, generates primitive logic functions that implement the higher level logic statements, and stores this information into an output file using Intel hex file format. The resulting .HEX file can be downloaded to the drive. With Version 2.4 drive software, the source file is appended to the hex file for retrieval by the reverse compiler.
Reverse Compiler Program	The reverse compiler program does the opposite of the compiler program. It uses the compiled hex file (with a .HEX extension) as the input and produces an ASCII text output file (with a .DIS [for disassembly] extension) that can be read by the user via any standard text editor software. This program is useful if the original source file is lost, damaged or unavailable. Note that any comments in the original source file will not be reverse compiled since they are ignored by the compiler program when the hex file is created. (See Section 8.12 on combined source and Hex files). With Version 2.4 drive software, if the source file is appended to the hex file, a reverse compile will retrieve the source complete with comments.
Communications Software	The communications software is used to send the compiled version of the system program from the PC to the drive. The communications software must be configured for proper communications to occur (i.e., baud rate, number of data bits, number of stop bits, and parity settings). Siemens recommends using the Siemens SOP Utilities program (requires Windows 95™ or later); however an appropriate third-party serial communications program is acceptable, as long as it was designed for the platform on which it is run. (It is not recommended to run DOS-based programs from Windows 95™ or later.)
Communications Cable	This is a serial communications cable over which data (e.g., the system program) is transmitted between the drive and the PC. The exact specifications of this cable vary based on the drive being used and the type of connector available on the serial communications port of the PC.

Name	Function
Drive	The drive is an Siemens ID-Series motor drive. It contains a system program that is stored in a non-volatile portion of memory on the drive and is executed continuously by the drive in a repetitive fashion causing intended logic statements to perform their functionality. Within its menu structure, the drive contains software functions used to enable uploading and downloading between the drive and the PC. The settings of communications parameters in the drive must match the settings in the communications software on the PC for proper communications during system program transfers.

Note: Intel hex format is an ASCII representation of binary data. The hex file mentioned in the previous table uses various record types to set the download location and for error detection.

8.3 SOP Development Process

The Siemens SOP Development Process is detailed in document EPI-001. You can locate this document by going to http://powernet, then selecting Processes>ISO9000 Manual>EPI-Engineering Process>EPI-001SOP Development.

The general process consists of:

- Obtaining customer requirements
- Creating a textual description of the process logic
- Converting the textual description to a logic diagram
- Writing the SOP from the logic diagram
- Testing the SOP

The textual description is created in the SOP text templates (available at: \\Ntrob09\FORMS\Templates\SOP). The templates are a series of spreadsheets that textually define the TB2 designation, the WAGO assignment, the sequence of operation, etc. Templates are available for both air-cooled and water-cooled systems.

The standard logic diagrams and accompanying SOP function blocks are defined in Engineering Reports (available at: \\Ntrob14\ctl-plt_read\Software_Release\Standard_SOP_Templates). The Engineering Report provides a standard means to produce customer SOPs. The function blocks can be used as presented, or can serve as a template for customer requests not specifically addressed by the blocks.

The SOP input source file is composed in an ASCII text editor and compiled by an Siemens compiler. SOP testing is performed at the Siemens facility. The remainder of this chapter details the process of creating and compiling the SOP.

8.4 Overview of the Compile Process

To be practical, the “logic” that is represented by the system program must be understood by both man and machine. For the system program to be an effective mechanism through which human operators define (and even change) the logic functions of the drive (in the field, especially), the representation of the logic functions in the system program must be easily understood by the operator. However, the defined logic functions ultimately must be interpreted by the drive itself. In ID Series drives, a compiler is used to convert user-friendly logic statements (in English text) into a downloadable, ASCII representative format of binary data which is run (interpreted) by the drive, increasing its flexibility of configuration and system integration. The logic statements can be written directly from a ladder logic representation of the system logic. It is recommended that the logic be worked out in this form before committing it to text logic statements.

The compile process is accomplished *off-line* on a PC. The term *off-line* means that the process is separate from the drive and does not require a physical or electrical connection to the PC. The chief advantage of off-line editing is that the source code of the system program can be changed anywhere (not just near the drive) using any standard ASCII text editor on any IBM compatible PC. With the system program compiler software installed on the PC, the source code can even be remotely compiled into its machine-friendly hex format. Then, all that remains is to serially connect the PC and the drive and download the hex file to the non-volatile RAM portion of the drive. The run-time software of the drive then executes the system program logic statements sequentially and repetitively, causing the drive to function as intended. After downloading to the drive volatile RAM, the program is stored permanently in the flash disk.

The compiler reads the source input file, validates the statements for proper syntax and symbolic content, generates primitive logic functions and stores this information into an output file using the Intel hex file format. Refer to Figure 8-1.

Note:

- After off-line creation and compilation, the system program (in hex file format) can be downloaded to the ID Series drive. The downloading process requires a PC, a communications cable (appropriate for the PC and the drive) and either (1) appropriately configured communications software in the PC, or (2) the upload/download component of the Siemens SOP Utilities software (requires Windows 95™ or later).
- In this context, the term "operator" refers to the individual in charge of customizing the system program, and not necessarily *any* user of the drive.

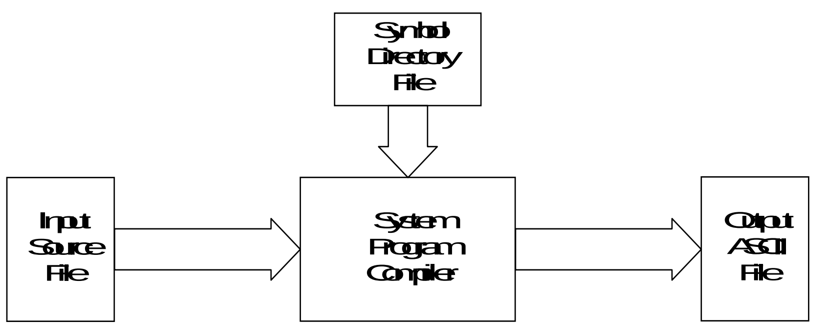

Figure 8-1. Block Diagram of the Compile Process

Note:

- It is a good programming practice to save an electronic copy of the original SOP file before making any changes. This gives you the opportunity to refer back to the original SOP if the need ever arises.
- A copy of the symbol directory file (e.g., DRCTRY.NGN) must exist within the same directory as the compiler and reverse compiler, or on a pre-determined path on the PC.

8.5 Software Tools

Siemens offers a Windows™-based program that contains an integrated compiler, reverse compiler and upload/ download utility. The program is compatible with Windows 95™ and later. For additional information, contact the Siemens 's Customer Service Center at (724) 339-9501.

8.6 Input Source File

The input source file is the ASCII text version of the system program that is edited by the user. Editing can be performed using any standard ASCII text editor on an IBM (or compatible) PC. The file can contain both logic statements and explanatory comments to aid in documenting the content and intent of the logic statements. With the exception of simple true and false logic assignments, the order of the statements in the source file is the order that the statements will be executed by the drive's run time software. True and false statements are placed first in the hex file and are executed only once.

Note: In the case of logic assignments where the source state is a simple "true" or "false", the assignment is made only once at runtime software initiation.

The execution flow of the run time software is as follows:

1. Comparator evaluations are performed and the resulting system flags are updated.
2. Input flags are scanned and their present state(s) are recorded .
3. Logic equations are executed based on the recorded input states.
4. The results of the logic statement(s) are output.

A sample input source file is illustrated at the end of this section. Although this sample source file may appear to be very complex, it contains only two basic types of statements:

- source lines
- comment lines.

Comment lines are distinguished by a semi-colon (;) followed by descriptive text for the rest of the line. All lines that begin with text instead of a semi-colon are program source lines. Program source lines may continue to other lines and are finally terminated with a semi-colon. This makes the logic more readable.

Comment lines provide additional information to the reader. This information includes the program name, the date it was written, the author's name, an edit history, etc. Comments can also be placed strategically throughout the code to separate source lines into logical groups and to improve readability. In addition, comment lines can be used to explain the functionality of complex program statements. It is good programming practice to use comments to thoroughly document source code, especially if more than one person may be editing or reviewing it. Note, however, that comments should add useful information to the source code (e.g., make the code more readable, describe the purpose of a particular logic statement, define the goal of the program segment, etc.) and not just restate the obvious.

Note:
- All source code comment lines are ignored by the system program compiler. Only the program statements (with any optional comment suffixes omitted) are compiled into the binary (hex formatted) system program that is downloaded to the drive. For this reason, the process of reverse compiling the system program yields source code without comments. For more information on the process of reverse compilation, refer to Section 8.12.
- Comment text can be included in source lines if it appears after the program statement (i.e., after the statement terminator [;]). Never embed a comment within a program statement. For examples, Refer to the sample input source file that follows.

Source lines contain logic statements that define inputs, outputs, control logic and operations of the drive. Logic statements contain statements, flags and operators that must follow precise spelling and syntax rules in order for them to be interpreted correctly by the compiler. An example of one such syntax rule is the fact that all program statements within a system program are terminated with a semi-colon character. Program statements may, however, continue on multiple lines to aid in readability. Syntax rules for all source code components are discussed later in this chapter.

Note:
- Single source lines of code must not exceed 132 characters in length, **and must be terminated with a semi-colon**.
- The name and source file date/time stamp of the system program can be recalled and displayed in the keypad display using the Display System Program Name function. This can be useful in determining the exact system program that is being executed in the drive.

8.6.1 System Type Identification

Because the compiler and reverse compiler support a number of different end products, the compiler needs to know what the target system is so that it can generate the proper code for that target system.

To identify the system type, include the system type identifier command as the first line in the system program SOP file. The syntax of this command is shown below.

#*system_type*;(begins with "#" in column 1, ends with ";")

The statement must be on the first line of the file, the "#" character must appear in column 1, and the program line must end with a semicolon. For Perfect Harmony drives, the proper format of this command is shown below.

#NEXTGEN;

8

Note: A comment can follow the semicolon with the system type identification command.

The compiler also recognizes other system types. These are listed in 8-2. 8-2 shows the interface for the pull-down product type selector.

Table 8-2. Product Types Recognized by the System Program Compiler

Target Product Type	Identification Command
Perfect Harmony	#HARMONY;
454 *GT*	#ID_454GT;
ID-CSI	#ID_CSI;
DC Harmony	#HARMONY_DC;
ID-2010	#ID_2010;
NXG Control	#NEXTGEN
Silcovert H	#SILCOVERT_H

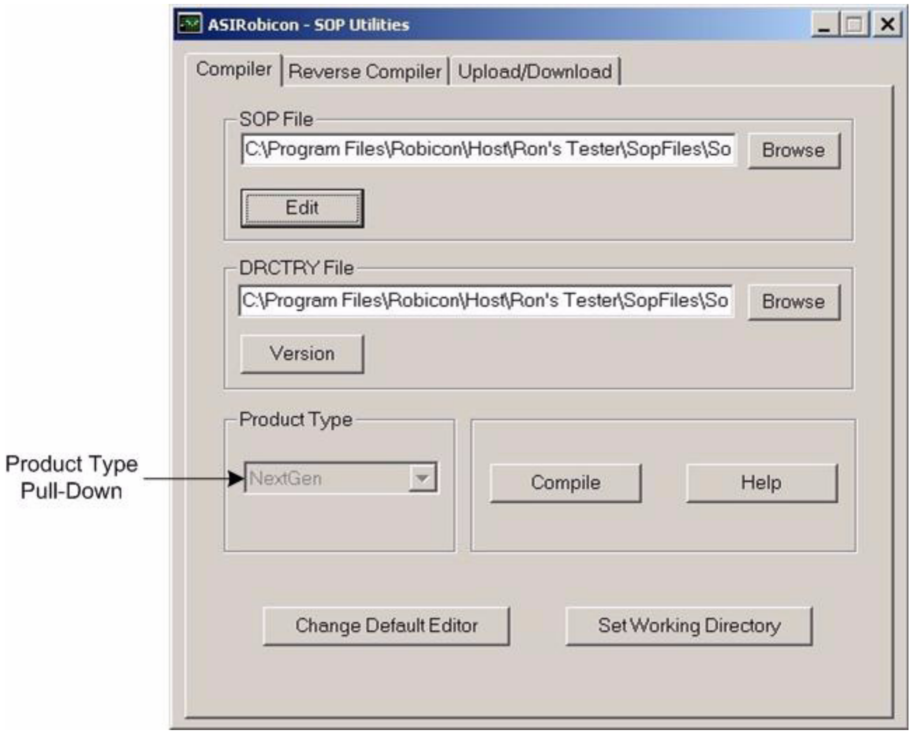

Figure 8-2. Windows-based Compiler Showing Product Type Pull-Down

Note: If you use the Siemens SOP Utilities program to compile an SOP file that does not include the *#system_type*; identifier, then the Product Type selector pull-down (see Figure 8-2) will become enabled and the user must select the appropriate product type.

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Based on the system type, the compiler will search for a unique directory file. Because each system type uses its own directory file, it is convenient for the compiler (and reverse compiler) to *automatically* use the correct file. The directory file that the compiler uses is based on the target system type. These are summarized in Table 8-3.

Table 8-3. Directory Filename Associations

Target System Type	Directory File Name
Perfect Harmony	DRCTRY.PWM
454 *GT*	DRCTRY.IGB
ID-CSI	DRCTRY.CSI
DC Harmony (e.g., torch supply)	DRCTRY.HDC
ID-2010	DRCTRY.DC
NXG Control	DRCTRY.NXG
Silcovert H	DRCTRY.SIH

8.6.2 Operators and Precedence

There are two forms of operators that can be used in a source line of the system program. These forms are *unary operators* (requiring only a single operand) and *binary operators*.

There is a single unary operator–the negate operator. This operator takes the form of a slash character ("/") which precedes a single input symbol. This operator forms the inverse logic equivalent of the symbol immediately following it for incorporation into the statement evaluation. It has higher precedence than the binary operators, which means it is evaluated before the evaluation of any binary operations.

> **Note:** The "/" symbol must be followed by an input symbol.

For example, the expression

/Zero_O

equates to

NOT Zero_O.

If the input variable "Zero_O" were FALSE, then "/Zero_O" would equate to TRUE.

There are two binary operators–AND and OR. These operators take the form of an asterisk ("*") and a plus sign ("+"), respectively. These operators correspond to the Boolean AND and OR functions. Unlike the unary NOT operator (which requires only a single variable), each of these operators requires two variables which surround the operator.

The binary operators "+" and "*" serve to form the simple Boolean combination of the combined expression preceding the operator and the symbol (possibly negated) immediately following the operator. Parentheses are not allowed to force expression evaluation. The expression must be formed with left to right precedence and must be expanded to simple form.

8

Refer to the Boolean truth tables in Table 8-4 for functional descriptions of the operators.Table 8-5 shows the precedence of operations. shows syntax examples.

Table 8-4. Boolean Truth Table for the NOT, AND and OR Functions

NOT Function	
A	**/A**
False	True
True	False

AND Function		
A	**B**	**A*B**
False	False	False
False	True	False
True	False	False
True	True	True

OR Function		
A	**B**	**A+B**
False	False	False
False	True	True
True	False	True
True	True	True

Table 8-5. Precedence of Operations

Type of Operation	Symbol	Meaning	Precedence
Unary Operation	/	Not	High (performed first)
Binary Operation	*	And	:
Binary Operation	+	Or	Low (performed last)

8

Table 8-6. Syntax Examples

Example	Description
C = A + B;	Correct, C equals A OR B
C = A * B + D;	Correct, C equals (A AND B) OR D
C = A + B * D;	Correct, C equals A OR (B AND D)
C = A * B + A * D;	Correct, C equals (A AND B) OR (A AND D)
C = A * (B + D);	Incorrect, parentheses not allowed.
C = A + /B;	Correct, C equals A OR (NOT B)
/C = A * B;	Incorrect, negation not permitted on output side

8.6.3 Statement (SOP) Format

The format for a system program source statement is as follows:

output_symbol = {*unary_operator*} input_symbol { [*binary_operator* {unary_operator} input_symbol] ... };

where:

output_symbolrepresents an output symbol defined in the symbol directory file

=the assignment operator (only one per source statement)

input_symbolrepresents an input symbol defined in the symbol directory file

unary_operatorBoolean NOT operator (/ character)

binary_operatorBoolean operators OR and AND (+ and *, respectively)

{ }represents optional syntax

[ ]represents required syntax

...the previous operation may be repeated

;statement terminator

The statement can span multiple lines and can contain spaces as needed for readability. The output_symbol is a required field and can be any symbol that would be valid as an output variable. The output_symbol is followed by one or more optional spaces and then the required assignment operator “=”. A source statement can contain only a single assignment operator.

Note: Program statements may span multiple lines by breaking the line at a convenient operator. The single line length of 132 characters should not be exceeded.

The input side of the equation must equate to a simple Boolean form (either true or false) after evaluation. It is formed from either a simple input symbol (possibly negated with a NOT unary operator) or a combination of input symbols operated on with binary operators.

8

Input symbols and binary operators are evaluated left to right by the run time software. The precedence of operations is summarized in the next section.

Note:
Each statement must be terminated with a semicolon.
Symbol names are case insensitive to the compiler. The symbols symbol_1, Symbol_1 and SYMBOL_1 are all treated identically.

The term “sum-of-products” comes from the application of Boolean algebraic rules to produce a set of terms or conditions that are grouped in a fashion that represents parallel paths (ORing) of required conditions that all must be met (ANDing). This would be equivalent to branches of connected contacts on a relay logic ladder that connect to a common relay coil. In fact the notation can be used as a shortcut to describe the ladder logic.

First let us examine the rules of Boolean algebra. The set of rules that apply in this logical math are broken into 3 sets of laws: commutative, associative, and distributive. The operators are “AND” (abbreviated with the “•” character [or “*” character from a keyboard]), “OR” (abbreviated with the “+” character) and “NOT” (abbreviated with a line above the operand, e.g., $\overline{A}$ [or a preceding “/” character from a keyboard]). The commutative, associative, and distributive rules are shown as follows.

Table 8-7. Boolean Laws

Commutative[1]	Associative[1]	Distributive[1]
A + B = B + A	A + (B + C) = (A + B) + C	A (B + C) = AB + AC
AB = BA	A (BC) = (AB) C	

1 - The syntax “AB” implies (A•B).

Table 8-8. General Rules of Boolean Math

General Rules	General Rules	General Rules[1]
A • 0 = 0	A + 0 = A	A + AB = A
A • 1 = A	A + 1 = 1	A (A + B) = A
A • A = A	A + A = A	(A + B) (A + C) = A + BC
$A \cdot \overline{A} = 0$	$A + \overline{A} = 1$	$A + \overline{AB} = A + B$
=A = A		

1 - The syntax “AB” implies (A•B).

Add to this DeMorgan’s Theorem which states “the complement of the intersection (AND) of any number of sets equals the union (OR) of their complements” which, simply stated, means that if you invert a grouping of elements, you invert the individual elements and also change the logical relationship between them. So you can change from an OR to an AND function, for example

$$(\overline{A+B}) = (\overline{A} \cdot \overline{B})$$

or from an AND to an OR function, for example

$$(\overline{A \cdot B}) = (\overline{A} + \overline{B}).$$

By using these rules, any logical statement can be reduced to the sum (+) of products (•) or the ORing of ANDed terms as illustrated in the following example.

$$O = AB + B\overline{C}D + CD\overline{F};$$

The SOP file, as mentioned above is written with a text editor or a word processor set for pure ASCII text (having a .TXT file extension) with no control or formatting codes with the exception of horizontal tabs (ASCII code 09h) and carriage returns (0Dh). Only printable characters and spaces (20h) can be used. The file consists of the following format:

8

Table 8-9. SOP Text File Format

Item	Description
Drive type specifier	This must reside on the first line of the file prefixed with the pound sign (#) and followed with the name of the drive (in the case of Perfect Harmony this would be #Harmony;).
Header	A comment field containing the following information: Title - Siemens Perfect Harmony drive Program part number Customer name Sales order number and Siemens drive part number Drive description Original SOP date File name Engineer name (Originator) Revision history (date and change description). Note: A comment is any text within the file, preceded by a semi-colon, which is used exclusively for informational purposes and is ignored by the compiler.
Operators	Comment field containing operators and symbols
I/O specifier	Comment field describing the system input and output flags as they relate to the external system. This would include any user faults and notes on menu settings, such as Comparator setups and XCL settings, as they apply to the system program (more on this later). These can (and should) be grouped logically to allow easy access to information and to make the SOP more understandable.
User fault messages	Assigns the text to be displayed when this particular user fault is activated.
Main logic section	All the equations and assignments for the configuration, annunciation, and operation of the drive. These should be logically arranged with careful consideration given to the order of evaluation of the equations.

8.6.4 Input Flags

Input flags are identified by variable_I. Input flags are symbols that are encountered on the right hand side of a source statement (to the right of the equals sign) that express the state of an input to the system. They may reflect the state of a digital input (e.g., ExternalDigitalInput*01a_O*, *ExternalDigitalInput01b_O*) or switch (e.g., *KeypadManualStart_O*), the state of a system process (e.g., *Cells_I*, *OverloadFault_I*, *OutputPhaseOpen_I*), internal variable, Comparator flag (e.g., *Comparator_1*), or a simple literal (TRUE, FALSE). These input flags are combined using the unary and binary operators to form logic expressions.

8

Digital input flags generally represent the state of a discrete digital input signal into the system. These may be a 24-volt logic input, a key switch or push-button in the system or some form of a binary input. The inputs are scanned at the beginning of each execution cycle, but may reflect older information in some cases.

System constants TRUE and FALSE are predefined and can be used as input terms to an expression.

> **Note:**
>
> - Note that any expression that uses a TRUE or FALSE constant by the compiler will be placed in a section of run time system program statements that are executed only once during system program initialization. The one time execution of invariant expressions improves the execution speed of the remaining conditional expressions.
> - Constant expressions are not updated at the completion of each system program execution loop. They are only set during system program initiation

There exists the capability to compare at the value of certain system variables against preset thresholds in real time and then use the results of the comparisons (TRUE or FALSE) in the system program to control actions on the drive. The variable(s) to be compared and the thresholds are entered into the system using the keypad. The output of the comparisons (*Comparator1_I ... Comparator16_I*) are available for use in the system program as input symbols.

8.6.5 Output Flags

The output flags all have "_O", tagged onto the end of the variable name (variable_O). The output flags (the symbol placed on the left-hand side of the assignment "=" operator) direct the result of the input expression towards an output purpose. Output flags represent items such as digital outputs and system control switches.

Table 8-10. Types of Output Flags

Types	Examples
digital outputs	ExternalDigitalOuptput01a_O, ExternalDigitalOutput01b_O, …
system control switches	AutoDisplayMode_O, *RampStop_O*, , RunRequest_O

Digital output flags generally represent some form of discrete digital output bit(s) from the system. These may be a relay coil driving contacts (NO or NC), direct digital outputs or lamp controls. The digital output signals are updated at the completion of each system program execution loop.

The Perfect Harmony series of drives (as well as all other ID series drives) has a set of pre-defined symbols that describe control outputs or "switches" that can be controlled by the system program. These switches can control functions such as the source of the speed reference, a selection for the system acceleration rate and a multitude of others. In most cases, to cause the system to perform in the intended manner, the proper control switches must be set (and others cleared) by the system program. The default state for all control switches is FALSE. Unless the system program sets the switch to TRUE, it will be inactive (FALSE).

> **Note:** No variable_I, Input variable can appear on the left side of the "=" sign. Both variable_I and variable_O can appear on the right side of the "=" sign.

> **Note:** Only one switch should be set at any one time from any functional grouping of switches (e.g., command generator input grouping).

8

There is a set of Boolean temporary flags available to hold temporary or common expressions in the system program. By using these temporary flags to hold common expressions, system program execution times can be improved. The system program compiler does not perform any optimization, it generates code closely matching the equations as written. If there are expressions that are repeatedly evaluated, set a temporary flag to the intermediate results and then use the flag instead of the longer expression.

For example:

```
ExternalDigitalOutput01a_O = ExternalDigitalInput01_a +
ExternalDigitalInput01_b + RunRequest_O;

SetPoint1_O = ExternalDigitalInput01_a + ExternalDigitalInput01_b +
RunRequest_O;

SetPoint2_O = ExternalDigitalInput01_a + ExternalDigitalInput01_b +
RunRequest_O ;
```

could be replaced with:

```
TempFlag01 = ExternalDigitalInput01_a + ExternalDigitalInput01_b +
RunRequest_O;

ExternalDigitalOutput01a_O = TempFlag01;

SetPoint1_O = TempFlag01;

SetPoint2_O = TempFlag01;
```

A time-out function may be implemented with system program timers. These timers are enabled using logic statements and the output (based on the timer expiring) is available as an input to logic statements. The time period is set in seconds with the resolution. The unit specified in the logic statement is seconds (with a decimal fraction rounded to the nearest internal resolution). Time intervals are up to 16,383.5 seconds for the Next Gen version of Perfect Harmony.

The statement

```
Timer01(20.0) = symbol_a;
```

enables timer 1 if *symbol_a* is true. The statement

```
output_1 = Timer01;
```

sets the symbol *output_1* true if the timer has expired (timed out). In the example above, if *symbol_a* is false, *output_1* will be false. If *symbol_a* is set true, then 20 seconds later, *output_1* will be set true (assuming *symbol_a* remains true).

Once the enabling logic goes FALSE, the entire time-out period must pass before the timer will time-out. Should it go FALSE before the time-out period, the timer count is reset to zero and the timer must go the entire period before timing out.

Counters in a system program can be used to count the number of FALSE to TRUE transitions of the counter input. A corresponding counter reset input is used to reset the counter value to zero. For example:

```
Counter01(13) = input_a;

CounterReset01 = input_b;

output_a = Counter01;
```

If *input_b* is set TRUE, Counter01 is set and held to zero. If *input_b* is FALSE, after 13 FALSE to TRUE transitions of *input_a*, the symbol C*ounter01* (and *output_a*) will be set TRUE. After 13 transitions, *Counter01* will remain

TRUE until C*ounter01* is cleared by CounterR*eset01*. The maximum count value is 32767. The count value must be an integer.

8.6.6 Redefining Flag Names

To make flag names more intuitive, you can redefine flag names so that your names may be substituted for the generic flag names thereafter. The definitions are made near the start of the program to ensure that they are defined when needed. The format for the definitions is:

$NewFlagName=nameInDirectoryFile

where **NewFlagName** is your new definition, and **nameInDirectoryFile** is the flag name found in the drty.ngn file.

For example, a typical SOP program might define flags as follows:

```
Counter01(30) = /ExternalDigitalInput01f_I*/
ExternalDigitalInpout01e_I*Timer00;

CounterReset01 = ExternalDigitalInpout01e_I;
```

If you include the following at the start of the program:

```
$FireAlarmCircuitTimer = Counter01;

$FireAlarm_I = ExternalDigitalInput01f_I;

$FireAlarmPumpHasOverheated = ExternalDigitalInput01e_I;

$FireAlarmWarningTimer = Timer00;

$ResestFireAlarmCircuitTimer01 = CounterReset01;
```

then the lines in the program become:

```
FireAlarmCircuitTimer(30) = /FireAlarm_I*/
FireAlarmPumpHasOverheated_I*FireAlarmWarningTimer;

ResetFireAlarmCircuitTimer01 = FireAlarmPumpHasOverheated_I;
```

8.6.7 SOP Interpretation

System configuration and operational logic is depicted in the command generator diagram (Siemens drawing 459713) which displays (in a diagram format) the various input options, parameter sets, and modes of operation of the drive. All logic flags controlling the configuration and control flags used in the state transitions are shown along with many internal variable names.

The system program consists of the hex program output file (created with an external compiler, the source ASCII text sum-of-products [SOP] file, and the DRCTRY.xxx directory file [used for mapping flag names to internal variable addresses]) and the system interpreter in the drive itself.

The SOP file is written by application engineering (and can be modified by field service personnel), compiled to a tokenized, Intel hex formatted file, and then downloaded via an RS-232-C serial channel to the drive. The drive initializes the file and then begins to interpret the token codes and data structures. This is detailed in the next section.

8.6.8 SOP Timing

The scan time for running the compiled program is dependent on the length and complexity of the program and the available time left over from the control software. The control software timing includes any features that are running (based on the configuration information flags in the system program itself). The typical scan time is between 20 and 50 msec, but can become longer for a synchronous transfer program.

8.6.9 Ladder Logic Translation

It was mentioned above that the sum-of-products notation can represent ladder logic. In actuality, it is very easy to directly translate between the two. For example, consider the equation or statement

$Z = \overline{A}BC + D\overline{E}F + FGH;$

Translated into the notation of the limited ASCII characters available in a common text editor, the statement would read as follows (note that the components are separated at "ORs" and stacked for clarity).

```
Z =/A*B*C

+ D*/E*F

+ F*G*H;
```

This statement can be pictorially represented by breaking each statement down in the following manner.

1. First, the output variable (in this case Z) is represented by a coil to the right of the ladder.
2. Second, each product term (the variables separated by the asterisk) is represented by a single line of contacts connecting to the coil.
3. All the product terms that are summed (separated by the plus sign) are represented by parallel paths to the same coil.
4. All non-inverted contacts are represented by normally open (NO) contacts while the inverted terms are represented by normally closed (NC) contacts.

The resulting ladder logic is illustrated in Figure 8-3.

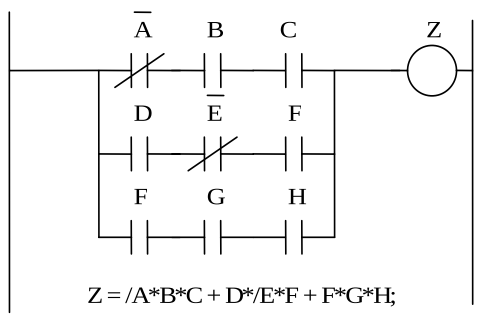

Figure 8-3. Ladder Logic Representation of a Boolean Expression - Example 1

Conversely, if the ladder logic shown in Figure 8-4 was desired, it could be converted into a sum-of-products statement. The procedure would be the inverse of the previous and is enumerated below.

1. First place the label of the output relay coil to the left, with an equals sign following.
2. Next, start in each path from left to the connection to the coil on the right, writing the label for each contact with the asterisk representing the AND or product operator in between.
3. In front of each NC contact, place a forward slash representing the inversion or NOT operator (shown in the equations as a bar over the variable name).
4. Repeat this for each parallel path using the OR (sum) operator (+) in between each grouping of product terms.
5. Finally the statement is terminated by a semicolon to represent the end of the statement.

8

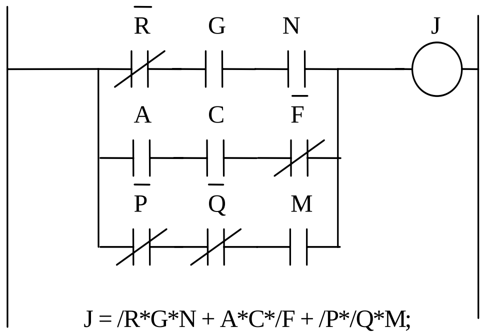

Figure 8-4. Ladder Logic Representation of a Boolean Expression - Example 2

The resultant statement written for the ladder logic in 8-4 is shown below.

```
J = /R*G*N
+ A*C*/F
+ /P*/Q*M;
```

> **Note:** For all program statements that span multiple lines, only the last line has the semi-colon end-of-line character (;).

8.6.10 Comparators

Sometimes a simple digital input is not enough to adequately control a system function or establish a warning or protection scheme. Analog signals from various transducers may need to be monitored and compared to set thresholds to allow conditions to change. This is the purpose of the comparator functions. Any signal fed into the drive through an analog input externally or internally can be mapped to a system flag to use in any logic statement.

These comparators exist in Comparator *n* Setup Submenus (4810-4965) under the Comparator Setup Submenu (4800) in the Auto Menu (4). There are 32 comparators with individual setup menus. Each comparator has an ‘A’ and a ‘B’ input and a control setting. These are set up by selecting from a pick list - a scrollable listing that allows the selection of predetermined variables, or entry of variable addresses (only in RAM) or a fixed percentage of rated value or a fixed number entered in hexadecimal (the base 16 numbering system as opposed to decimal which is base 10).

The comparators have a system program flag associated with each (*Comparator01_I* through *Comparator32_I*) that are controlled by the comparator functions. In essence, the logical state of the comparator flags (TRUE or FALSE) is determined by the equation: *Comparatorxx_I* = (A > B), which means that if input A is greater than input B, the flag is set true, and if A is less than or equal to B the flag is set false.

The rest of the setup is accomplished by setting the control variable. This also is a pick list but consists of the selections: signed, magnitude, and off or disabled. When the comparator is switched off, no further processing is done and the system flag retains its last value indefinitely. The flags (as are all system flags) are initialized to false on power-up, system program re-initialization, or hard reset.

8.6.11 Analog Inputs

Sometimes you may want to use an external analog signal as an input to a comparator. This can be accomplished by selecting an analog input source in the pick list. However, the analog input needs to be setup properly before it has any meaning to the system program comparator functions.

When the system program scans the comparators, the last analog sample is used. The analog inputs have a 12 bit resolution, which means that 12 bits are used to determine the sign and magnitude of the signal. Therefore the voltage resolution for each step is approximately 5 mV.

When the analog user modules are enabled (when their type is set to something other than off or disabled) they are only read at the system program scan rate. They are, however, converted constantly inside the external module itself so that the drive processor does not have to interface to an analog signal or spend time converting it to a digital number.

To use the external or internal analog input modules as a reference to the drive they need to be set up using the Analog inputs menu (4090). The sequential number used in Analog input #1 source (4105), or Analog input #2 source (4175) menu of the external analog inputs is determined by left to right orientation arrangement of the modules as they are placed on the DIN rail. The leftmost analog input module is the first input. It contains two ports so analog inputs one and two are within this module. Reading left to right the second module contains the next two analog inputs. This module also contains two ports so they are numbered three and four and so on. The remaining menus are filled in as required.

8.7 Compiler Invocation

Note: The Windows-based utilities program is compatible with Windows 95™ and later versions.

To invoke the Windows™-based SOP utilities program, double-click on the COMPILER.EXE icon. This causes the Siemens SOP Utilities pop-up to be displayed. Alternatively, you can launch the SOP Utilities with the Tool Suite application interface shown in Figure 8-6.

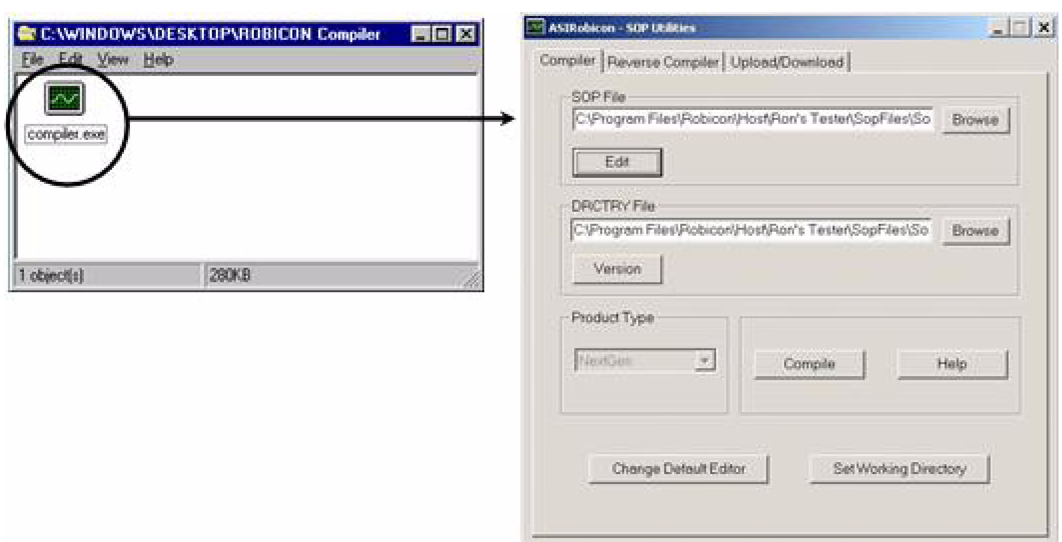

Figure 8-5. Siemens SOP Utilities Icon and Pop-up Box

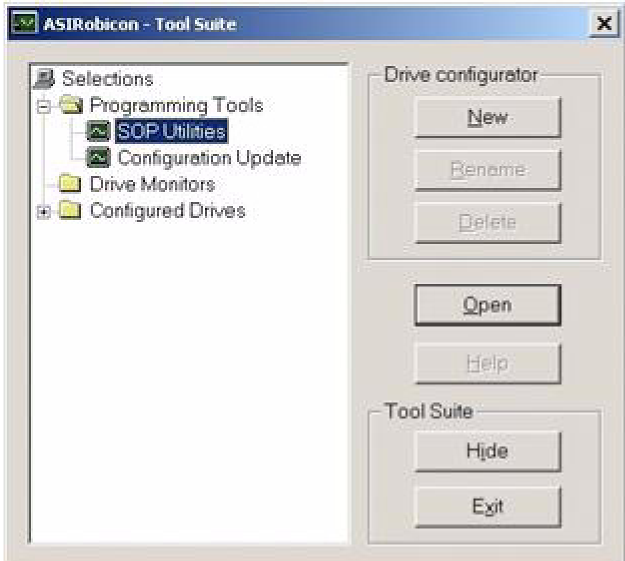

Figure 8-6. Tool Suite Application Interface

8.8 Compiler Operation

As discussed earlier in this chapter, three files are accessed during the compilation process: the source (or SOP) file, the DRCTRY.NGN (directory) file, and the output hex file. When the compiler is invoked, it first opens the SOP file to determine if it contains a *system_id* definition line as the first line in the file. This line defines the target system type to the compiler. If the necessary files are not found in the default directory, you may search elsewhere using the standard Browse button.

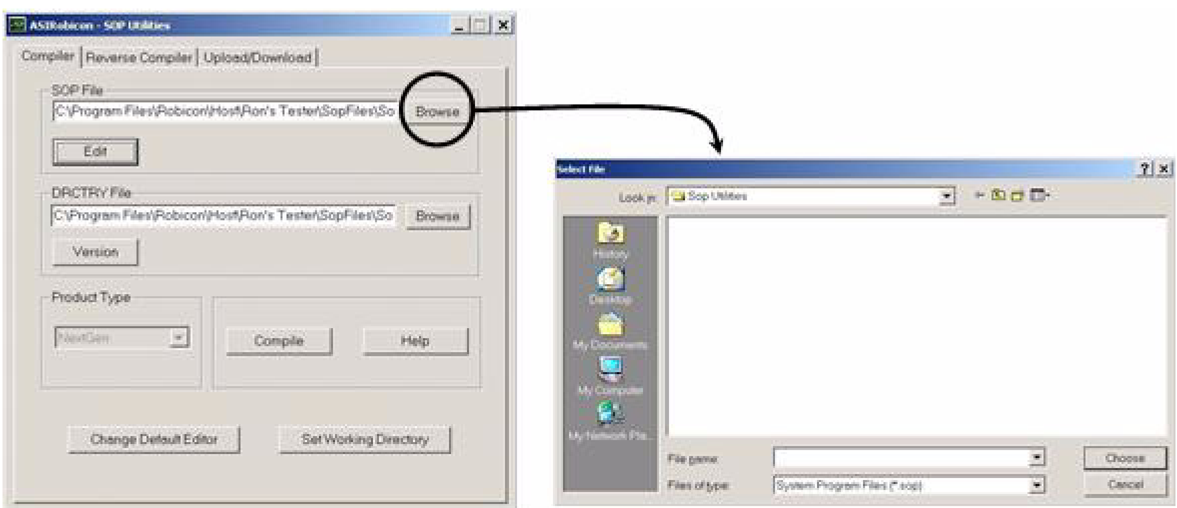

Figure 8-7. Selecting the .SOP File Using the Browse Button

The system type information is used to search for a proper directory file to use during compilation. The type information is placed into the hex file so that the system program cannot be used in the wrong type of system (e.g., loading a Harmony system program into a 454 *GT* drive).

8

> **Note:** If you use the Siemens SOP Utilities program to compile an SOP file that does not include the *#system_type*; identifier, then the Product Type drop-down list (see 8-7) is enabled, and you must select the appropriate product type. This selection will then be compiled into the resulting hex file.

The compiler searches for the directory file in the current directory first. If it is not found there, the compiler looks in "C:\program files\Siemens \soputilities" for the files. If the directory file is not found, the compiler provides a browse function for finding an appropriate file. In all cases, the full search path of the "found" file is displayed so the operator can verify that the intended file was used.

> **Note:** The DRCTRY.NGN file must adhere to certain syntax and format rules. Refer to Appendix D.

8.9 Output Hex File

Any inconsistencies that occur during the compilation process are flagged and error messages are displayed in a pop-up window. These error messages indicate the problem and lead the user towards problem resolution. Error messages are listed in Table 8-11.

After successful processing, the third and final file is created. This is the hex file and it is named the same as the source file with the extension changed to ".HEX". The entire compiled system program is summed up in a modulo 256 result that is inverted (2s complement) and placed in the header of the compiled system program. This is the system program checksum. The output is formatted in Intel 8086/8088 record format with a starting load offset of 0000. Each record consists of 16 bytes of data. Zeroes are appended to the final record for padding.

When interpreted as an Intel hex file by the drive during the download process, a binary image of the logic functions results. These logic functions are stored and later executed by the drive. Each line of the hex file contains its own checksum. In addition, the compiler generates an overall system program checksum. All of these checksums are validated during system program downloading and restart to ensure correctness prior to storing the statements inside the drive.

When downloaded into the drive, the system program is structured into sections. The first section is called the *header* and contains system program location pointers as well as the version number and the system program checksum.

The other sections concern the functionality of the system program and are not covered here.

8.10 Downloading a System Program (Hex File)

When the text for a system program has been created, and the text file has been compiled into a hex file using the system program compiler, the resulting hex file must be downloaded into the drive to become functional. Software embedded in the drive can be invoked to accept the properly formatted hex file into the drive using the RS-232 serial port as the transfer medium. The program can be downloaded in one of two methods:

1. Using the Upload/Download component of the Siemens SOP Utilities software. This method can be used by PCs that have at least Windows 95™ or later installed.
2. Using a terminal emulation program on the PC set up in ASCII file mode. This method can be used by PCs that do not run Windows or have a Windows version before Windows 95 (using a DOS™ window). A native Windows terminal emulator can also be used.

8.10.1 Siemens SOP Upload/Download Utility Method

The .HEX file must be downloaded using the Upload/Download component of the Siemens SOP Utilities program.

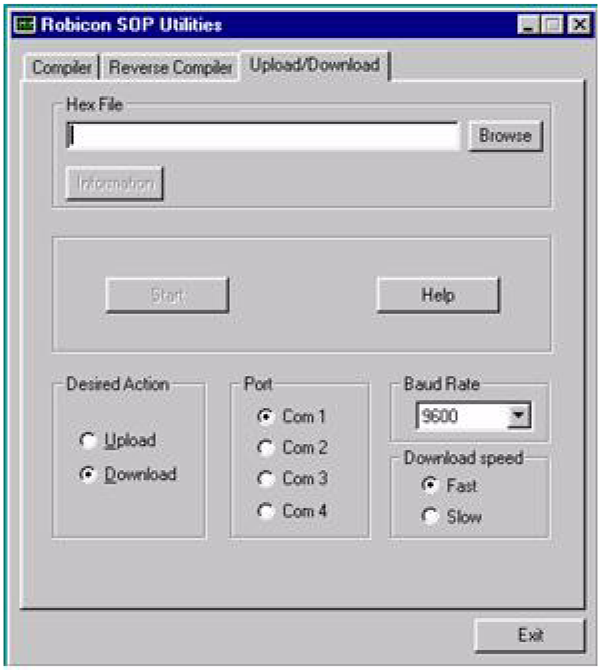

Figure 8-8. Upload/Download SOP Utility Screen

1. Invoke the Siemens SOP Utilities program.
2. Select the Upload/Download tab.
3. Enter the HEX file to be downloaded.
4. Select the Download radio button.
5. Set the baud rate from the drop down box to 9600 baud.
6. Connect the appropriate serial port of the host PC to the DB9 port of the drive using an appropriate serial cable (9-pin with appropriate connectors).
7. Select the “System Program Download” function menu (9120) of the drive. The drive will display download status information on the front panel (e.g., “Downloading from RS232”). The drive will indicate when it starts to receive data.

At the end of each hex line received, the drive will cause a bar in the last column of the keypad display to rotate to indicate that data is being received. Each data record that follows is then checked against its own checksum and loaded at the appropriate address in RAM. Errors in a data record result in a displayed error message and termination of the download process.

Note: The drive’s software checks the downloaded system program file for the proper version number. If the user tries to download a system program that was compiled with the wrong DRCTRY.NGN file (for example, an obsolete DRCTRY.DAT file), an error message will be displayed and the downloaded system program will not be transferred to FLASH. Further, the system will not run a motor if, on power-up, the software detects a system program checksum error or an out of range system program version stored in the FLASH. In order to use an older system program in a drive with newer software, the system program must be recompiled with the newer DRCTRY.NGN file before it is downloaded.

8.10.2 Terminal Emulation Method

The .HEX file must be downloaded with a terminal emulation program on the PC set up in ASCII file mode.

1. Set the baud rate (the same as drive's baud rate parameter), parity (none), data bits (8) and stop bits (1) of the communications software on the host PC, notebook or laptop computer.
2. Connect the appropriate serial port of the host PC to the DB9 port of the drive using an appropriate serial cable (9-pin with appropriate connectors).
3. "Enable" the communications software (i.e., prepare the software to either send information to the drive or receive information from the drive). This basically puts the PC and communications software into a ready state. Typical communications software packages include Microsoft Windows Terminal and Procomm-Plus (only Windows 95™-compatible if running this operating system).
4. Use the "System Program Upload" or "System Program Download" function from the Serial Functions Menu (9110) of the drive to perform the desired function. The drive will display download status information on the front panel (e.g., "Downloading from RS232").

The drive will indicate when it starts to receive data. At the end of each hex line received, the drive will cause a bar in the last column of the keypad display to rotate to indicate that data is being received. Each data record that follows is then checked against its own checksum and loaded at the appropriate address in RAM. Errors in a data record result in a displayed error message and termination of the download process.

Note: The drive's software checks the downloaded system program file for the proper version number. If the user tries to download a system program which was compiled with the wrong DRCTRY.NGN file (for example, an obsolete DRCTRY.DAT file), an error message will be displayed and the downloaded system program will not be transferred to FLASH. Further, the system will not run a motor if, on power-up, the software detects a system program checksum error or an out of range (wrong) system program version stored in the FLASH.

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8.10.3 Termination

Termination occurs when a valid “End Record” is received. If any error in transmission occurs, or if the user manually “CANCELs” the transmission, the original system program will be copied back down from FLASH. If the new program is accepted and reaches normal termination, it is then transferred from temporary RAM into non-volatile FLASH storage, overwriting the original. The system program is then re-initialized with the new information, and the system program is restarted, executing the new statements.

Note:

During the system program download process, if it is desired to cancel the download process, a [SHIFT]+[CANCEL] key sequence can be entered from the drive’s keypad to terminate the download process and restore the system to its original state.

Since the system program execution must be stopped while downloading a new system program, the drive cannot be running during the download process.

Table 8-11. Compiler Error Messages

Error Message	Description
DRCTRY Error ERROR in line *nnnn* - << *flag name* >> is longer than 43 characters. The error occurred in the Directory file.	While loading, the system program flag found that the directory file is too long. The offending flag and its line number in the directory file are listed. The directory file is probably corrupted. Get the latest version and try again.
DRCTRY Error ERROR in line *nnnn* - << *flag name* >> can't find system address.	While loading the directory file, the compiler can't determine the system address. The flag name and error line number points to the source of the error. The directory is probably corrupted. Get the latest and try again.
DRCTRY Error ERROR in line *nnnn*!! << *flag name* >> can't find bit address.	While loading the directory file, the bit address cannot be determined. The file is probably corrupted. The flag name and line number should show where the corruption occurs. Replace the directory file and try again.
DRCTRY Error ERROR in line *nnnn*!! << *flag name* >> can't find type code.	While loading the directory file, the flag type cannot be determined. The file is probably corrupted. The flag name and line number should show where the corruption occurs. Replace the directory file and try again.
SOP Error ERROR!! User Text *text flag* defined multiple times.	The user text assignment flag displayed has been used multiple times in the system program. Find the occurrences and correct them, then recompile.
SOP Error ERROR!! Expecting '\' found >> CR or LF <<	The compiler was expecting an end quotation mark and found an end of line instead. The error location will show in another popup window at the end. Edit the source program and try again.
SOP Error ERROR!! User Text *flag ID* is longer than 24 characters.	User Text must not exceed 24 characters – the limit on the keypad display. Edit the source file and try again.
SOP Error ERROR!! Expecting '\' found >> *character* <<.	The compiler was expecting an end quotation mark but found another character instead. Locate the error by the line number shown in an error popup window, edit the file, and try again.
SOP Error ERROR!! Expecting '=' found >> *flag name* <<.	The compiler is looking for the assignment operator and found another flag. This is usually caused by improper use of the statement terminator, the semi-colon, or the comment indicator – also a semi-colon.
SOP Error ERROR!! opcode >> *token name* << not supported.	The compiler has parsed the source code and found a 'token' it interprets as an opcode, but is not an acceptable operator ('=', '+', '*', '/', or ';'). This can be caused by an improper logic statement. Check the file and try again.
SOP Error ERROR! Timer enable *flag name* cannot be set false.	The timer flag shown was set to false. This will never do anything and is therefore displayed as an error.

Error Message	Description
SOP Error ERROR! Counter reset *flag name* cannot be set true or false.	Setting the counter reset flag that is named prevents proper operation of the counter. The name of the reset flag is displayed to help find the error.
SOP Error ERROR! Counter enable *flag name* cannot be set true or false.	Counters count transitions from low to high. Setting the counter to true or false renders the counter useless and is thus displayed as an error. The offending flag name is displayed.
SOP Error ERROR!! input >> *flag name* << is not an input type.	The flag named is not defined as an input only flag and cannot be used as an input (on the right side of the equals sign).
SOP Error ERROR!! Expecting ';' found >> *flag name* <<.	This error is usually displayed when the preceding logic statement is not properly terminated by a semi-colon.
SOP Error ERROR!! input >> *flag name* << not in directory.	The input flag named is not found in the directory file. Check the spelling and try again.
SOP Error ERROR!! Expecting '=' found >> *flag name* <<.	The compiler is expecting the assignment operator as it is parsing what it thinks is a new logic statement. Check the syntax in the preceding statement, edit the file, and try again.
SOP Error ERROR!! attempt to redefine output >> *flag name* <<.	An output flag has a logic statement assigned to it (it is used on the left side of the assignment operator) more than once. Find and change the offending line and recompile.
SOP Error ERROR!! output >> *flag name* << is not an output type.	The flag named is not defined as an output only flag and cannot be used as an output (on the left side of the equals sign).
SOP Error ERROR!! output name >> *flag name* << not in directory.	The output flag on the left of the equals sign is not found. Check the spelling of the flag name shown and try again.
SOP Error ERROR!! Too Many Timers and Counters (Max 128 combined).	There is a fixed number of timers and counters that can be used in any system program. The limit is 128 for the total of both timers and counters. Try to reduce the number of either timers or counters and compiler again.
SOP Error ERROR!! Drty name << *flag name* >> used in alias not found in drty file	The flag named as an alias is not found in the directory file. This is an advanced feature of the new compiler being released with the version 2.5 drive software, but will work with version 2.4 software. Define statements can be used for more user friendly names of functions and substituted for fixed names.
SOP Error ERROR!! << *flag name* >> is longer than 43 characters.	System program flag names are limited to 43 characters, and are truncated to that number. A flag longer than this is probably caused by a typo. Find and fix the error and recompile.

Error Message	Description
SOP Error ERROR! A timer or counter (*flag name*) must be defined as an output before being used as an input!	Timers and Counters are unique system flags. They require storage space for intermediate values for time or count, and additional space for storing their preset, enable logic state, reset, and output status flag. Therefore, the Timer or Counter must logically be assigned (on the left of the equals sign) before the status flag (the timer or counter name without the value) can be used as an input flag (to the left of the equals sign).
SOP Error ERROR!! input scan table is full	The storage space for the number of inputs is limited to the assignment of unique inputs. The limit for NXG is 800 entries. A flag is assigned only once even if used multiple times (as an input).
SOP Error ERROR!! Counter reset (<flag name>) used without a defined counter. A counter must be defined as an output first!	A reset flag is a unique flag used for resetting counters, but due to the storage situation as described above, a reset flag cannot appear in a system program before the counter is defined as an output (to the left of the equals sign). If the logic for the reset must appear before the definition, the use of a temporary flag to define the logic state, can appear before the Counter, with the reset flag assigned to the temporary flag. Rewrite the logic and recompile.
SOP Error ERROR!! output scan table is full	The output scan table can contain a maximum of 800 unique entries. Timers and counters are created in the output scan table even if they are used as an input. These are the entries that map an I/O table location to the real world source (memory location, hardware output, etc.). And only one is required for each flag used. Bit flags take up 8 spaces even if only one is used.
SOP Error ERROR!! input scan table is full	The input scan table can contain a maximum of 800 unique entries. These are the entries that map an input flag from the real world source to the I/O table. Only one entry is required for each flag used. Bit flags take up 8 spaces even if only one is used.
SOP Error ERROR!! logic table is full.	The logic table can contain a maximum of 5000 total entries. The entries are created by logic statements as strings of inputs and outputs in sequential order separated by their operators. Each input, output, and operator used counts as an entry.
SOP Error ERROR!! The maximum time for a single timer is 16383.5 secs! (4.55 hours)	The amount of time assigned to a timer exceeded the max value allowed. This value applies for NXG software only.
SOP Error ERROR!! The maximum count for a counter is 32767!	The number of low to high transitions required to activate the output of a counter has been exceeded. Reduce the number in the parentheses and recompile.
SOP Error ERROR!! expecting) got >> *name* <<	For timers and counters, when they are defined, must have the flag name followed by a value enclosed in parentheses. The trailing parenthesis is missing.

Error Message	Description
SOP Error ERROR!! expecting (got >> *name* <<	For timers and counters, when they are defined, must have the flag name followed by a value enclosed in parentheses. The compiler expected a left parenthesis as the next character.
SOP Error ERROR!! System Program size (*nnnn* bytes) is greater than allowed (8192 bytes)	The total storage size of the system program, listed in bytes, exceeds the max allowed space. This is the actual bytes used and not the size of the Intel Hex file, which is an ASCII representation of the data within a header, load information, and checksum error checking.
SOP Error WARNING...Unable to load complete directory! Too many flags in directory (*nnnn*)	The size of the directory file has exceeded the allocated memory for storing that file. Check the version of the compiler to ensure you are using the latest. Also check the directory file to ensure it isn't corrupted.
SOP Error WARNING!! *flag name* has been redefined as an output on statement:*nnnn* line:*nnnn*.	An output flag has a logic statement assigned to it (it is used on the left side of the assignment operator) more than once. Find and change the offending line and recompile. The second usage of the flag is located by the statement or line number.
SOP Error WARNING!! Timer/counter >>*flag name*<< logic is redefined in line *nnnn*.	This is the same as redefining output flags, but is specific to timers or counters. The line number shows the attempted redefinition.
No output file created. There is a warning message in the file. It needs to be commented out or removed before recompiling. Edit <source file name> and try again. The error occurred in logic statement: *nnn*, line: *nnnn*.	This is a special error that only occurs after a reverse compiled file is recompiled. The reverse compilation process inserted a warning message. This message needs to be reviewed before proceeding. Based on the message, it may be simply a matter of deleting the warning, or it could require rewriting portions of the system program.
This file was created by the reverse compiler from a corrupt HEX file or utilizing the wrong DRCTRY file. No output file created. Edit *source file name* and try again. The error occurred in logic statement: *nnnn*, line: *nnnn*.	If a corrupted hex file is reverse compiled, or if the wrong directory file was used in that process, there is usually "UNDEFINED" flags in the source file. If this is the case the program will have to be rewritten. It is ALWAYS advisable to use source files instead of reverse compiled files so that changes can be documented, and the logic is described via the comments in the original file. The location of the compiler error is shown as both the statement and line number.

8.11 Uploading a System Program (Hex File)

In a manner similar to downloading a system program, the drive's current system program can be uploaded from the drive to a receiving computer (binary format in the drive, hex format from the drive or compiler). This can permit archival of a functioning system program. Also, the text statements in a system program can be re-created (by using the system program's reverse compiler) so that the program can be examined or modified as needed.

Using a similar method as described in the download section, invoke the serial communications upload function on the drive. If using the DOS-based upload utility, invoke the data capture process of the communications software prior to starting the data upload function in the drive. If using the Windows-based SOP Utilities program, press the "Start" button prior to starting the data upload function in the drive.

From the drive keypad, enter the "System Program Upload" function menu (9130). Once this function has been invoked, the keypad will indicate that the drive is uploading data. Most serial communications packages will display the ASCII hex data while it is being uploaded so that the upload process can be monitored. Once complete, the drive will indicate that it has finished and will return to the System program upload menu (9130). At this point, the data capture process in the PC is stopped and the resulting file is saved.

Note: As with the download, the upload process can be terminated from the drive side by entering a [SHIFT]+[CANCEL] key sequence.

8.12 Reverse Compiler

Because the system program embedded in the drive is in a non-readable form, a program to reverse compile the hex records of a system program back into readable statements was created. A reverse compiled program can be examined for logic functions and even edited, recompiled, and re-downloaded into the drive to alter the system program functionality as needed. Since the embedded hex file does not contain any symbolic information, a directory file within range is needed during the reverse compile process to convert from the binary address information back into symbolic readable form. (See Section 8.13 on combined source and Hex files)

The Siemens SOP Utilities program contains an integrated Reverse Compiler program. This component is similar to the compile component. A HEX file and DRCTRY file must be specified. If they do not exist in the default directory, you must use the "Browse" buttons to locate the necessary files. When the appropriate files are specified, press the "Rev Compile" button to perform the reverse compilation. See Figure 8-9. Reverse Compiler errors are listed in Table 8-12.

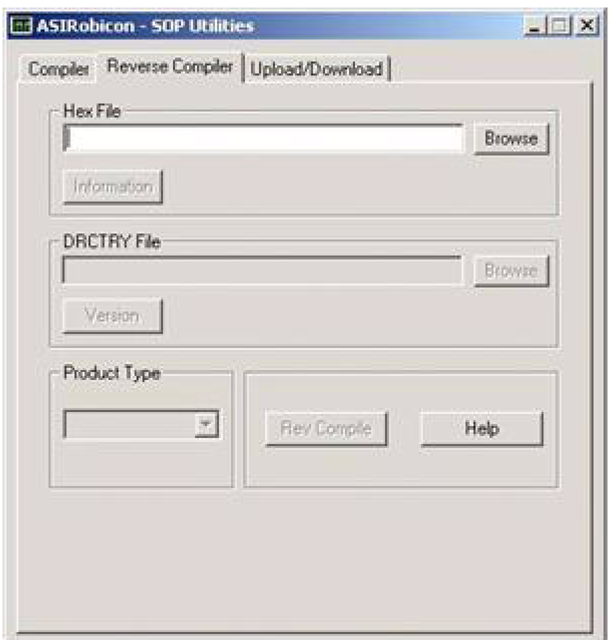

Figure 8-9. Reverse Compiler Options Window

8

Table 8-12. Reverse Compiler Error Messages

Error Message	Description
Hex File Error Too many input table entries (> 800)	Then number of distinct inputs in the scan table exceeds the maximum allowable 800 entries. The hex file is possibly corrupted or is of the wrong drive type.
Hex File Error Too many output table entries (> 800)	Then number of distinct outputs in the scan table exceeds the maximum allowable 800 entries. The hex file is possibly corrupted or is of the wrong drive type.
Hex File Error Too many logic table entries (> 5000)	Then number of entries in the logic table exceeds the maximum allowable 5000 entries. The hex file is possibly corrupted or is of the wrong drive type.
Hex File Error Too many counter/timer entries (> 128)	The hex file contains too many timers and counters (total sum of both) which cannot exceed 128 for NXG. The hex file is possibly corrupted or is of the wrong drive type.
DRCTRY Error ERROR in line *nnnn* - << *flag name* >> is longer than 43 characters. The error occurred in *directory file name*.	The flag name shown is longer than the max allowable 43 characters. Check the indicated flag indicated and check for a corrupted hex file.
!!!!!!!!!!!!!!!!!!!! Warning !!!!!!!!!!!!!!!!!!!!!! This file is corrupted (bad system program checksum). Carefully check all logic equations for invalid or undefined flags, erroneous timer or counter values, wrong use of flags, erroneous logic, etc. Edit these lines (and comment these warning lines), compile and use at your own risk. !!!	This error message is added to the top of a reverse compiled program when the stored system program checksum does not compare with the calculated one. The file must be check for integrity, any errors corrected, and this comment removed before re-compiling. Since the checksum is invalid, the file may or may not work properly.
DRCTRY Version Error The version of *directory file name* used is DIFFERENT from the original DRCTRY. Probable errors will occur, check the output files. (You must comment out the warning lines out in the '.DIS' file before recompiling).	This message will display if the version the system program is reverse compiled with is different than the version used to create the original hex file. A warning will be added to the file along with the statistics of the compiler version and directory version, along with other information on the file.

8

Error Message	Description
!!!!!!!!!!!!!!!!!!!!!!! Warning !!!!!!!!!!!!!!!!!!!!!!!!! The version of *directory file name* used is DIFFERENT from the original DRCTRY Probable errors will occur, check the output files (You must comment these lines out before recompiling) !! ; Siemens Group ; ID Series System Program Reverse Compiler *version Number* ; REVCMP Directory File Name : *directory file name* ; REVCMP used *directory file name* ver : *n.nn* ; Hex File Name : *hex file name* ; System Program Name : *system program name* ; System Program Date/Time : *time/date* ; System Type : *drive type* ; Hex file used DRCTRY version : *n.nn*	This header is added to the top of the reverse compiler output file When the directory version error above displays. The comments must be removed before the file can be recompiled successfully.
The file was reverse compiled successfully. Original DRCTRY file version: *n.nn*. Current DRCTRY file version: *n.nn*. Number of counters and timers: *nnn*. Number of in items: *nnn*. Number of out items: *nnn*. Number of logic items: *nnnn*. Checksum: 0x*NNNN*.	Header continuation.
Hex File Error The hex file is corrupted. *nn* UNDEFINED label(s) found. Output file created anyway. Check file for error(s).	The hex file used as the input to the reverse compiler was corrupted in some manner, creating UNDEFINED labels – labels that could not be found in the directory file. It may simply be that the directory file used to reverse compile did not contain the flags found. This error occurs anytime there is one or more "UNDEFINED" labels found.
Source Corrupt This file is a dual source/hex file, but the source is corrupt. Do you want to try to reverse compile using the older method?	This message occurs only with embedded source file information in the hex file. If the source file exists, the reverse compiler simply extracts the source text directly. If the end of file is not found within the source text, it is assumed corrupted and prompts the user to do an actual reverse compiler of the compiled code. All comments are lost.

Error Message	Description
No Errors The SOP source has been successfully extracted from the hex file	This message displays if the source text exists within the hex file and is successfully extracted.

The output file will contain a source statement for each original statement in the system program. The statements will be ordered with the invariant statements first, followed by the dependent statements. All of the statements in a section will be in the same order as the original file, with the exception of any true/false type statements which are moved to the front of the file.

Note:
Comments from the original source file are not included in a compiled hex file and therefore cannot be reverse compiled. (See Section 8.12 on combined source and Hex files)
A copy of the symbol directory file (e.g., DRCTRY.NGN) must exist within the working directory of the compiler and reverse compiler, or in the directory of the invoked executable program.

8.13 Combined Source / Hex File

Beginning with NXG software version 2.4 the system is capable of accepting a combined source/hex file format. The file extension of these files is “.hex”, the same as the older style compiled sop files. However, when reverse compiling, this new file format undergoes a pseudo reverse compiling process rather than the traditional reverse compiling process. In this pseudo reverse compiling process all the original source comments and formatting is extracted from the “.hex” file and is presented to the user as the reverse compiled output. This combined file type must be created or reverse compiled with SOP Utilities version 5.0 or later. In all other respects this type of compiled sop is the same as the older file version.

For example:

Original Sop File

```
#NEXTGEN;
;--------------------------------------------------------------------------
;               Siemens  NEXT GEN HARMONY AC MOTOR DRIVE
;               SYSTEM OPERATING PROGRAM (TEST VERSION)

;        Program Number: NoWago.sop
;              Customer:Siemens
;    Siemens  Sales Order: xxxx
;  Siemens  Part Numbers: xxxx
;           Description: none
;              Engineer: JAB
;
;  Original Version Date: 10/31/00
;---------------------------------------------------------------------------
;SYMBOL DEFINITION
;---------------------------------------------------------------------------
;
;     = equals      * logical AND      + logical OR     / logical NOT
;     ; comment line
;
;---------------------------------------------------------------------------
;INITIALIZED FLAGS
;---------------------------------------------------------------------------
```

8

```
;
; Keypad Speed reference
RawDemandKeypad_O                    = TRUE;

; Speed profile
SpeedProfile_O                       = FALSE;

RunRequest_O = TempFlag01_O * TempFlag02_O ;
RampStop_O = TempFlag02_O;
;
; Fault Reset
;
DriveFaultReset_O = KeypadFaultReset_I + ToolFaultReset_I;

;=============================================================================
;=============================== END OF FILE ================================
;=============================================================================
```

8

Old Style .hex file data

```
:020000020000FC
:1000000046005F00800065008A000104AC009B464A
:100010004E4F5741474F2E534F50000000000000F5
:1000200000000000000000002044656320313920FA
:1000300030393A34333A3130203230303200000037
:10004000A20006009E00240203000125020400011 4
:10005000410007000F450008000F000000000000ED
:100060000008010009030004040006020001040066
:100070000605000107000208000606000100000056
:100080001300000001 2E0001000140000200015495
:1000900000050001490006000100000000000000 0A
:0C00A0009E0000000000000000009E0018
:00000001FF
```

Old Style reverse compiled output

```
#NEXTGEN;


; Siemens  Group
; ID Series System Program Reverse Compiler Windows Ver. 5.0.0   12/3/02
;
;    REVCMP Directory File Name : C:\PROGRAM FILES\Siemens \FLASH FILES\DRCTRY.NGN
;    REVCMP used DRCTRY.NGN ver : 0401
;                Hex File Name : nowago.hex
;     System Program Name      : NOWAGO.SOP
;     System Program Date/Time : Dec 19 09:43:10 2002
;                 System Type : NEXTGEN
;  Hex file used DRCTRY version : 0401



RawDemandKeypad_O    = TRUE;
SpeedProfile_O       = FALSE;
RunRequest_O         = TempFlag01_O * TempFlag02_O;
RampStop_O           = TempFlag02_O;
DriveFaultReset_O    = KeypadFaultReset_I + ToolFaultReset_I;
```

8

New Style .hex file

```
:020000020000FC
:1000000046005F00800065008A000104AC009B464A
:100010004E4F5741474F2E534F50000000000000F5
:10002000000000000000000020446563203139 20FA
:1000300030393A34333A3130203230303200000037
:10004000A20006009E002402030001250204000114
:10005000410007000F450008000F000000000000ED
:10006000000080100090300040400060200010400 66
:10007000060500010700020800060600010000 0056
:1000800013000000012E0001000140000200015495
:1000900000005000149000600010000000000000000A
:0C00A0009E0000000000000000009E0018
:00000001FF
<1><216>Start-of-source
<2><129>#NEXTGEN;
<3><161>;--------------------------------------------------------------------------
<4><23>;                 Siemens  NEXT GEN HARMONY AC MOTOR DRIVE
<5><130>;                 SYSTEM OPERATING PROGRAM (TEST VERSION)
<6><74>
<7><235>;        Program Number: NoWago.sop
<8><157>;              Customer: Siemens
<9><255>;   Siemens  Sales Order: xxxx
<10><94>;   Siemens  Part Numbers: xxxx
<11><115>;           Description: none
<12><121>;              Engineer: JAB
<13><69>;
<14><59>;  Original Version Date: 10/31/00
<15><206>;--------------------------------------------------------------------------
<16><36>;SYMBOL DEFINITION
<17><206>;--------------------------------------------------------------------------
<18><69>;
<19><71>;     = equals       * logical AND      + logical OR     / logical NOT
<20><251>;     ; comment line
<21><69>;
<22><14>;--------------------------------------------------------------------------
<23><8>;INITIALIZED FLAGS
<24><206>;--------------------------------------------------------------------------
<25><101>;
<26><163>; Keypad Speed reference
<27><65>RawDemandKeypad_O                    = TRUE;
<28><10>
<29><103>; Speed profile
<30><157>SpeedProfile_O                        = FALSE;
<31><10>
<32><87>RunRequest_O = TempFlag01_O * TempFlag02_O ;
<33><198>RampStop_O = TempFlag02_O;
<34><69>;
<35><132>; Fault Reset
<36><69>;
<37><30>DriveFaultReset_O = KeypadFaultReset_I + ToolFaultReset_I;
<38><10>
<39><219>;=================================================================================
<40><206>;================================ END OF FILE ================================
<41><219>;=================================================================================
<42><10>
<43><240>End-of-file
```

8

New Style reverse Compiled Output

```
#NEXTGEN;
;---------------------------------------------------------------------------
;               Siemens  NEXT GEN HARMONY AC MOTOR DRIVE
;               SYSTEM OPERATING PROGRAM (TEST VERSION)

;        Program Number: NoWago.sop
;              Customer: Siemens
;    Siemens  Sales Order: xxxx
;  Siemens  Part Numbers: xxxx
;           Description: none
;              Engineer: JAB
;
;  Original Version Date: 10/31/00
;---------------------------------------------------------------------------
;SYMBOL DEFINITION
;---------------------------------------------------------------------------
;
;     = equals       * logical AND      + logical OR     / logical NOT
;     ; comment line
;
;---------------------------------------------------------------------------
;INITIALIZED FLAGS
;---------------------------------------------------------------------------
;
; Keypad Speed reference
RawDemandKeypad_O                    = TRUE;

; Speed profile
SpeedProfile_O                       = FALSE;

RunRequest_O = TempFlag01_O * TempFlag02_O ;
RampStop_O = TempFlag02_O;
;
; Fault Reset
;
DriveFaultReset_O = KeypadFaultReset_I + ToolFaultReset_I;

;================================================================================
;=============================== END OF FILE =================================
;================================================================================
```

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APPENDIX

A Performance Capabilities

A.1 General Features

Feature	V/Hz Control	Open Loop Vector Control	Closed Loop Vector Control
Cell Bypass	Manual[1]	Fast	Fast
Output filter compatibility	Yes	Yes	Yes
Spinning Load	No	Yes	Yes

1. Manual Bypass is obtained when Fast Bypass is disabled but Mechanical Bypass is still selected. When a cell fault occurs, the drive will trip on the cell fault, but the user can reset the fault (manually), which triggers a cell bypass and can then proceed to restart the drive.

A.2 Speed and Torque Control

Feature	V/Hz Control	Open Loop Vector Control	Closed Loop Vector Control
Speed Range for 100% holding torque and 150% starting torque	40:1	100:1	200:1
Torque Regulation (% of rated)	N/A	±2%	±2%
Torque Linearity (% of rated)	N/A	±5%	< ±5%
Torque Response[1]	N/A	> 750 rad/s	> 750 rad/s
Speed Regulation (% of rated)	Motor Slip	±0.5%[2]	±0.1%[3]
Speed Response[4]	20 rad/s	20 rad/s	> 20 rad/s[5]
Torque Pulsation (% of rated)	< 1.0%	< 1.0%	< 1.0%

1. Torque response values are valid for a drive without an output filter. Tuning may be required to achieve these values.
2. ~0.3% speed error is typical. Worst-case speed error is equal to ~30% of rated motor slip.
3. 0.1% can be achieved with a 1024 PPR encoder. Speed accuracy depends on the encoder PPR.
4. Speed response numbers apply as long as torque limit is not reached.
5. Testing is required to determine exact value.

Applications that require lower than 1% speed operation under high load torque should use the CLVC option. In such cases, it is preferable to select a motor that has **high full-load slip** (> 1.0%) and **high breakdown torque**.

A.3 Starting Torque

Starting torque capability in both OLVC and CLVC modes, with NXG control versions 2.2 and higher, is such that 85-90% torque can be achieved with 100% current as long as stated motor slip is greater than 1% of rated speed.

The following should be considered for high starting torque applications:

- The motor should be sized such that its breakdown torque is 50% (of rated) higher than the starting torque requirement for the application. For example, if an application requires 150% starting torque, then the motor should have 200% (i.e., 150% + 50%) breakdown torque.
- The motor full slip should be higher than 1.0%.
- The drive should be sized such that its current rating is 20% higher than the ideal motor current required for producing the desired starting torque.
- Low speed inverter derating should also be taken into account if the drive is going to be operating at low frequencies for extended periods of time.

V/Hz control has a special mode of operation (that can be set up via the menus) where 95-100% starting torque can be achieved with 100% current. This is useful in high starting torque application with (or without) long cable and/or high efficiency/low-slip motors. However, low speed control is not possible in this mode, i.e., speed control is possible only above a minimum speed that is typically five times the rated motor slip. If this mode is applied to parallel motors, then current sharing between motors (due to motor mismatch) must be considered while sizing the drive for a high starting torque application. Note that only Manual Bypass is available with V/Hz control.

A

A.4 Output Voltage and Current Characteristics

A.4.1 Output Voltage

Distortion at rated voltage	2% of drive rated output voltage (for the first 20 harmonics)
Unbalance	1% of drive rated output voltage
dV/dt[1]	<1000 V/us for water-cooled cells <4000 V/us for air-cooled cells
Harmonic Voltage Factor (HVF)[2]	<0.02 (see tables below for HVF values as a function of ranks and cell voltages)

1. Although output dV/dt values are high with air-cooled drives, the control ensures that only one cell switches at a particular instant. The magnitude of voltage steps applied to the motor are thus smaller than the rated voltage (and equal to the dc-bus voltage of a single cell), which limits the stress on the insulation of the first few turns (of the motor winding).

2. MG-1, Part 30, suggests that no motor derating is required when the inverter voltage waveform has a HVF value that is less than 0.03. HVF is defined as:

$$HVF = \sqrt{\sum_{n \geq 5}^{\infty} \frac{V_n^2}{n}}$$

where V_n is the harmonic amplitude in per-unit, and n is the harmonic order (equal ratio of harmonic frequency to fundamental frequency). All Harmony drive configurations (with more than nine cells) meet this requirement. Therefore, heating due to switching harmonics is negligible and no motor derating is needed.

Table A-1. Table Harmonic Voltage Factor as a function of ranks with 690 V cells

Number of Cells	Drive Output Voltage (kV)	HVF
9	2.40	0.019
9	3.30	0.017
12	4.16	0.009
12	4.80	0.010
15	5.50	0.007
18	6.90	0.005

Table A-2. Table Harmonic Voltage as a function of ranks with 630 V cells

Number of Cells	Drive Output Voltage (kV)	HVF
9	2.40	0.014
9	3.30	0.014
12	4.16	0.010
15	5.50	0.007
18	6.60	0.005

A.4.2 Output Current

DC component	1% of drive rated output current
Distortion (or THD)[1]	3% of drive rated output current when the motor rating is equal to drive rating and the *typical motor leakage reactance* of 16%.[2]

1. The output current distortion limit of 3% is valid for all ranks of cells (3 to 6). As the number of ranks increases, the current distortion decreases to below 2% for 6 ranks of cells with a typical motor.
2. Most motors have a leakage reactance that is greater than 16%. Output current distortion is inversely proportional to motor leakage reactance; i.e., as motor leakage reactance decreases, output current distortion increases.

A.5 Drive Output Transformer Considerations

A drive output transformer needs to be sized carefully. The following procedure provides a method to determine if transformer over-sizing is required based on the starting torque requirement for the application. In addition, and air gap should be provided such that the transformer can handle up to 1% of DC current from the drive.

At startup, the drive typically goes through a magnetization state during which motor flux is established. The time spend during this state is adjustable between 0.25 and 5.0 seconds, with the default setting at 0.5 seconds. During this state, the output voltage is increased from zero to the normal value (equal to IR drop in the motor and cable) required to establish motor flux. If an output transformer is connected to the drive, then the drive voltage during this state is equivalent to a low frequency AC voltage (with frequency = 1/(4*FluxRampTime)) applied to the primary winding.

When an output transformer is used, take care to rate the transformer for the additional flux that is required to be supported during high starting torque conditions. This additional flux can be estimated as:

Additional Transformer Flux = Istart * (Rmotor + Rxfmrsec + Rcable)/Starting Frequency

= Oversize Factor (when all variables are in per-unit)

where:

- Istart is the starting current into the motor
- Rmotor, Rxfmrsec, Rcable are the motor stator resistance, transformer secondary resistance, and cable resistance, respectively
- Starting Frequency is the drive output frequency at which substantial torque is required.

If all values are in per-unit, then this formula provides the *extra volt-second* capability (in per-unit) required for the transformer core. The above expression shows that even nominal starting with a long cable or high stator resistance will require an oversized transformer.

Hence, if the original transformer is rated only for the rated volts-per-hertz (or flux) of the motor, then the transformer for a long cable or high starting torque application must have a core size that is (1 + Oversize Factor) times larger than the original value.

A.6 Voltage Capability

A.6.1 With All Cells Operating

The maximum output voltage of the drive in terms of the number of ranks and the secondary-side cell voltage is given as:

Vout = 1.78 * N * Vcell_rating * Tap_Setting * Input_Voltage / Rated_Input_Voltage

Where:

- N = number of ranks in the drive (or the total number of cell = 3 * N)
- Vcell_rating = 460, 630, or 690 V (depending on its design)
- Input_Voltage = actual input line voltage
- Rated_Input_Voltage = rated drive input voltage
- Tap_Setting = 1.00 (for 0% tap), 0.95 (for +5% tap), or 1.05 (for -5% tap)

> **Note:**
> - The above formula is valid for all air-cooled drives and only those water-cooled drives with the newer transformer design (i.e., those units produced after summer of 2002). The older versions of water-cooled transformers above 5000 hp had higher than normal leakage impedance, which lowered the effective drive voltage capability.
> - Drive voltage capability must be calculated based on worst-case line voltage (minimum value).

A.6.2 After Cell Bypass

If X is the largest number of cells in bypass in two of the phases, then the maximum voltage at the drive output will be:

Vout_bypass = Vout * (2N – X) / 2N

Where:

Vout is the maximum output voltage with all cells operating and can be calculated as shown above.

A.6.3 During Synchronous Transfer with Cell Bypass

When deciding on the feasibility of Up/Down Transfer with cell-bypass, first calculate the maximum output voltage of the drive with all cells in operation (Vout) as given above.

If X is the largest number of cells in bypass in two of the phases, then calculate the drive output after bypass (Vout_bypass) as given above. Assuming that Vin is the input voltage to which the drive has to synchronize, NXG software will allow Up or Down Transfer only if Vout_bypass > Vin.

A.6.4 Example of Calculating Drive Output Voltage Capability

Consider a drive with 18 cells, each rated for 690 Volts. The maximum output voltage that this drive can deliver on the +5% tap with rated line voltage is (with N = 6 and Vcell = 690):

Vout = 1.78 * 6 * 690 * 0.95 * 1.0 = 7.00 kV.

If, after cell bypass, the drive has 6 cells operational in phase A, 5 cells in phase B, and 4 cells in phase C, then the maximum voltage that the drive can produce with neutral shift from the above formula is (with X = 1 + 2 = 3, because 2 cells in phase C and 1 cell in phase B are bypassed):

Vout_bypass = 7000 * (2 * 6 – 3)/(2 * 6) = 5.25 kV

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Suggested Spare Parts List

B

SPARE PARTS LIST

Item	P/N	Description	Qty.
1	10501420	FUSE,6A,600V,ATQR6	1
2	10501422	FUSE,2A,600V,ATQR2	1
3	10501425	FUSE,10A,600V,ATQR10	1
4	10506501	FUSE,3A,600V,ATQR3	2
5	10506502	FUSE,2.25A,600V,AJT2-1/4	3
6	10506503	FUSE,0.5A,600V,ATQR1/2	3

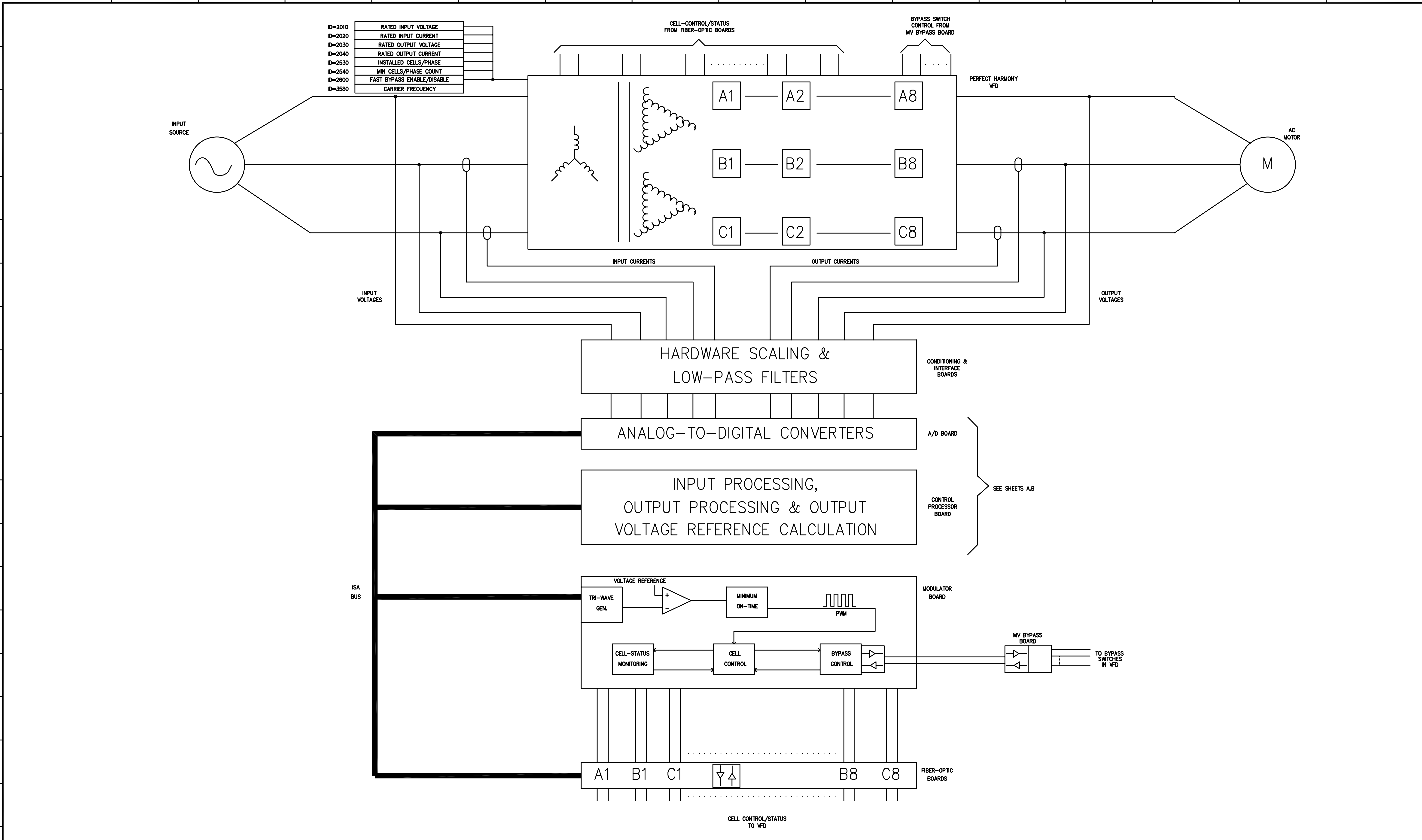
APPENDIX

C System Control Drawings

This appendix contains the system control diagrams for a Perfect Harmony drive with Next Gen Control.

- Harmony Control Diagram drawing number 459712
- Command Generator Diagram drawing number 459713
- Input/Output Process Diagram drawing number 459717

C



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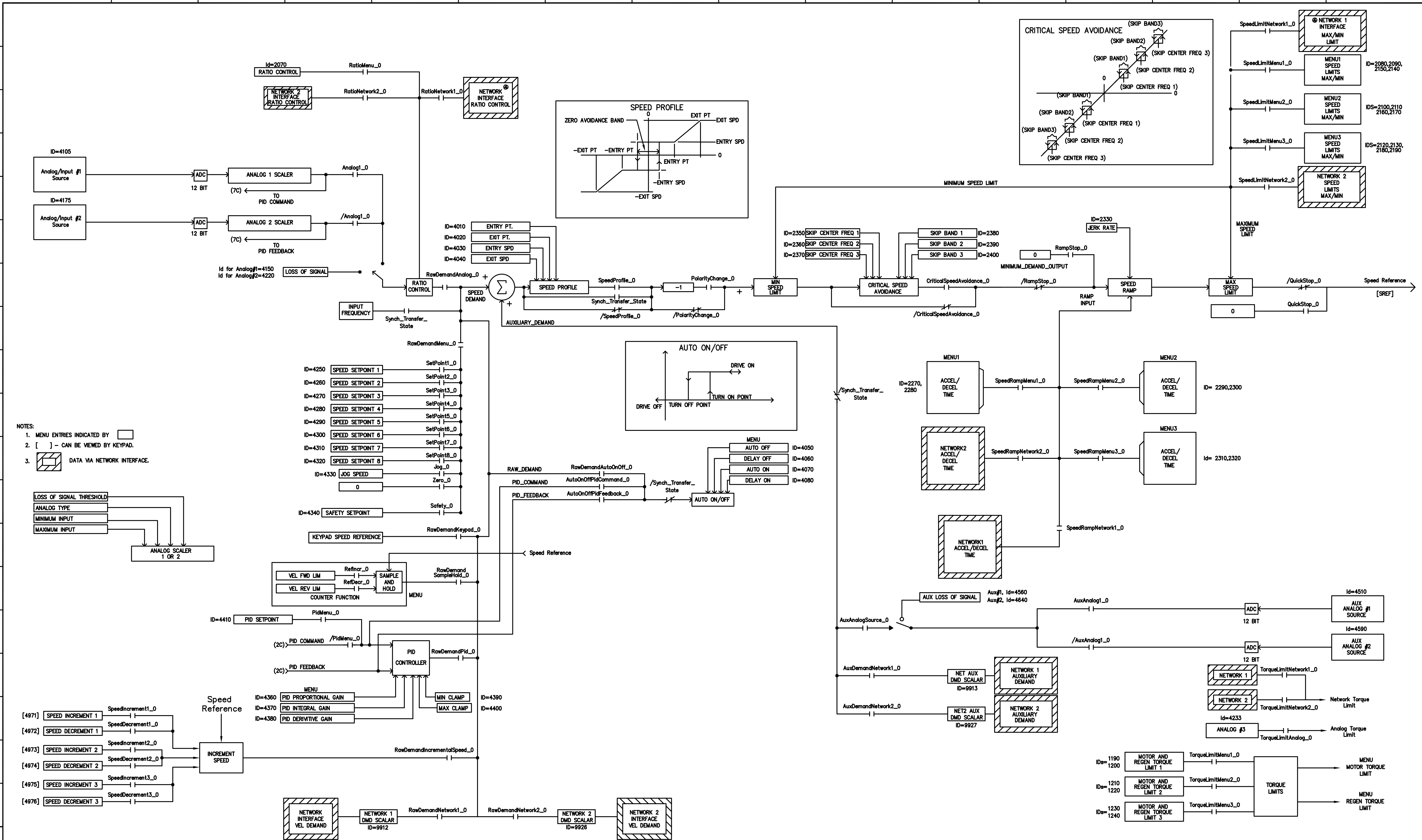
DFTG CODE NO.
REVISIONS



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REVISIONS	A GENERAL UPDATES APR/REM 07/12/01	B NXG CONTROL UPDATES APR/JB 11/05/01	C GENERAL UPDATES APR/JB 02/08/02	D GENERAL UPDATES APR/JB 02/28/02	E GENERAL UPDATES APR/JB 07/27/02	F GENERAL UPDATES JEP/MA 2/6/03

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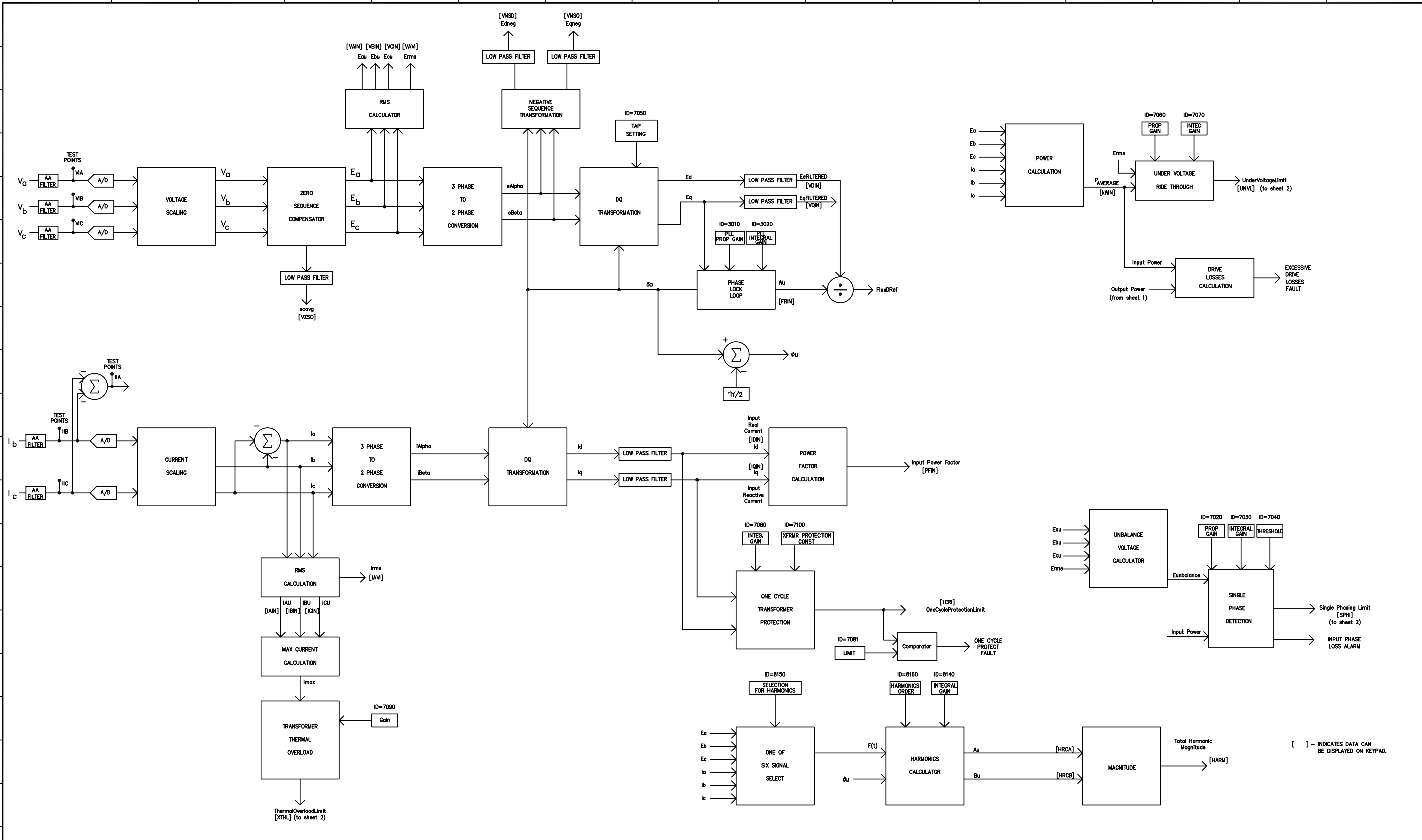
TITLE COMMAND GENERATOR DIAGRAM
DWG NO 459713
REV F
CAD FILE 459713E1
SHEET NO 1 OF 1



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B	GENERAL UPDATES APR/JB 07/27/02	08745	

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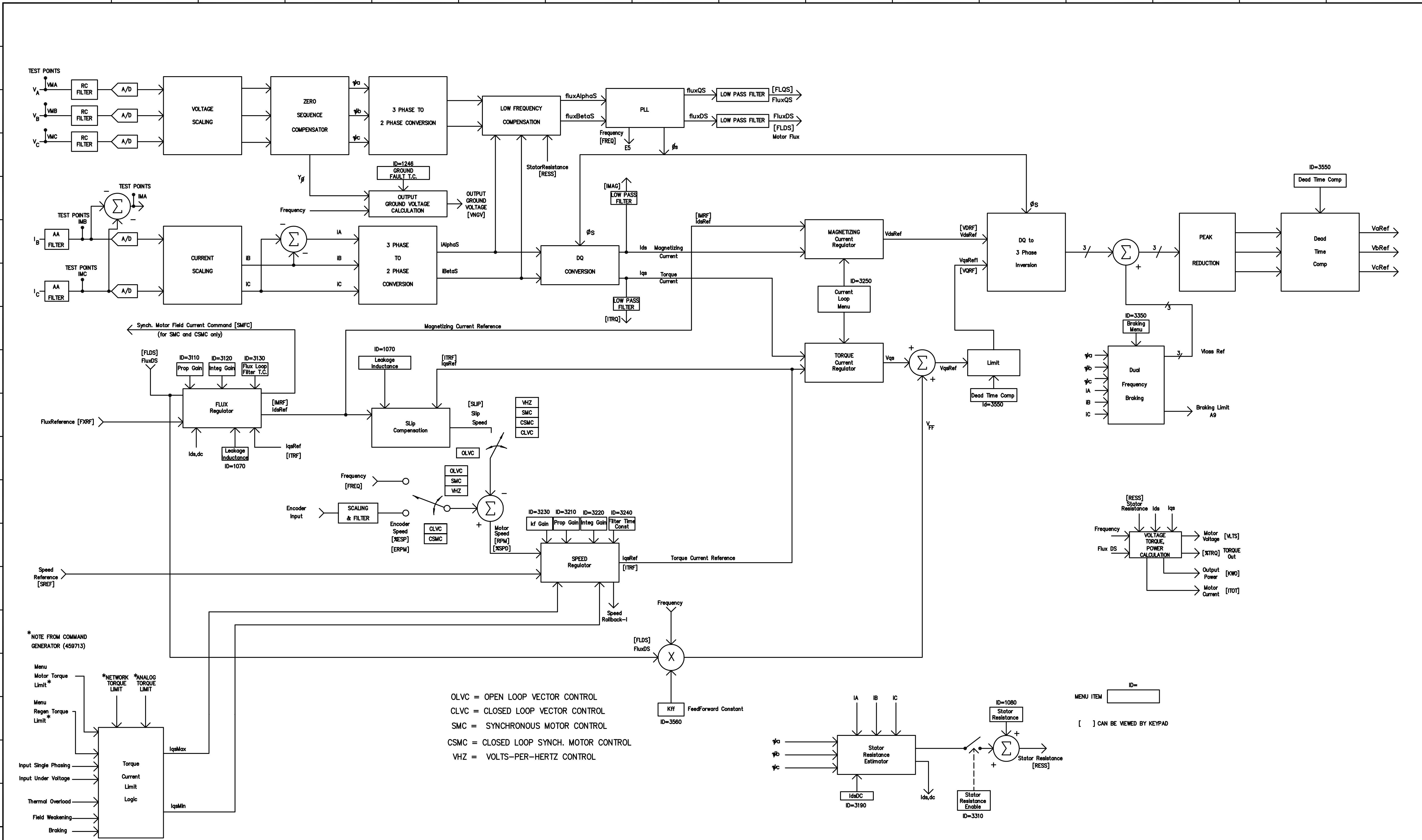
TITLE INPUT PROCESS DIAGRAM
DWG NO 459717
REV B
CAD FILE 459717B1
SHEET NO 1 OF 2



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TOLERANCES: .XX ±.03 .XXX ±.015 ANGLES ±1°
THIRD ANGLE PROJECTION

SCALE 1:1
LAYER
DATE 05/15/01
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CUST ORDER NUMBER STD

TITLE OUTPUT PROCESS DIAGRAM
DWG NO 459717
REV B
CAD FILE 459717B2
SHEET NO 2 OF 2

D Flags and Switches

D.1 Introduction

System program flags and switches are described in this appendix. The bulk of this appendix consists of a sample copy of the latest DRCTRY.NGN file. This file contains memory locations of software flags and switches that are referenced by the system program (.SOP file).

IMPORTANT!! This sample may not be compatible with your installed software. The information that this appendix refers to may change because of software updates and new releases. Refer to the file DRCTRY. NGN (located on the diskette that is shipped with the Perfect Harmony system) for the most recent information.

D.2 Sample DRCTRY. NGN File

The following information is a sample DRCTRY. NGN file for a Perfect Harmony drive and not a complete representation of the SOP File.

Note: Please refer to the Operations and Maintenance Manual for the complete SOP

D

```
!*START_SYPHDR ***************************************************************
!
!      $Workfile: Drctry.ngn $
!
!      $Revision: 108 $
!      $Date: 11/04/03 12:03p $
!      $Author: Ron Gaillot $
!
!      Description:  NXG Standard System Program variable definition file
!
!*END_SYPHDR*******************************************************************/
!
!       Data type definitions
!
!         1= byte flag - bi-directional
!         2= bit flag - bi-directional (general purpose)
!         3= bit flag - bi-directional (user module - old - for backward compatibility)
!         4= bit flag - bi-directional (hardware generally)
!         5= Timer flag - special handling
!         6= Counter flag - special handling
!         7= counter reset flag - output only
!         8= Bit flag - special handling (16 bit flags in interpolator - not in compiler)
!         9= bit flag - input only (generally hardware)
!        10= bit flag - input only (intended for XCL input flags - never used)
!        11= bit flag - input only (system I/O board or Wago)
!        12= bit flag - output only (system I/O board or Wago)
!        13= bit flag - input only (generally hardware)
!        14= bit flag - output only (generally hardware)
!        15= byte flag - input only
!        16= byte flag - output only
!       250= special for text handling
!       254= True case handling
!       253= False case handling
!
VERSION                              0412 0 0       Version tag
TRUE                                 0000 0 254
FALSE                                0000 0 253     Version 4.12 of the directory file
true                                 0000 0 254     for the NXG software.
false                                0000 0 253     9/22/2003
```

```
+                                   0000 0 102
*                                   0000 0 104
;                                   0000 0 106
! struct CommandGeneratorSwitchesType CmdGenSwTyp
! first variable is place holder in drive software
Analog1_O                         0001 0 1       Selects analog input #1 if true, else analog input #2 if false
(id=4105,4175)
RatioMenu_O                         0003 0 1       Selects the ratio data from the menu source (id=2070) when
set true
RatioNetwork1_O                   0004 0 1       Selects the ratio data from the network #1 source when set true
RatioNetwork2_O                   0005 0 1       Selects the ratio data from the network #2 source when set true

RawDemandMenu_O                     0007 0 1       Selects the speed demand data from one of the menu sources
when set true
SetPoint1_O                         0008 0 1       Selects setpoint #1 (id=4250) as the speed demand
SetPoint2_O                         0009 0 1       Selects setpoint #2 (id=4260) as the speed demand
SetPoint3_O                         000A 0 1       Selects setpoint #3 (id=4270) as the speed demand
SetPoint4_O                         000B 0 1       Selects setpoint #4 (id=4280) as the speed demand
SetPoint5_O                         000C 0 1       Selects setpoint #5 (id=4290) as the speed demand
SetPoint6_O                         000D 0 1       Selects setpoint #6 (id=4300) as the speed demand
SetPoint7_O                         000E 0 1       Selects setpoint #7 (id=4310) as the speed demand
SetPoint8_O                         000F 0 1       Selects setpoint #8 (id=4320) as the speed demand

RawDemandNetwork1_O                 0010 0 1       Selects network #1 as the raw speed demand
RawDemandNetwork2_O                 0011 0 1       Selects network #2 as the raw speed demand
RawDemandAnalog_O                  0012 0 1       Selects an analog input (#1 or #2) (id=4105,4175) as the raw
speed demand
RawDemandKeypad_O                   0013 0 1       Selects keypad as the raw speed demand
RawDemandPid_O                      0014 0 1       Selects pid output as the raw speed demand

AutoTune_I                          0015 0 15      Flag is set true while drive is in the auto tune mode
SpeedRampMenu1_O                   0016 0 1       Selects the use of the accel/decel (id=2270,2280) rates from
menu 1
SpeedRampMenu2_O                   0017 0 1       Selects the use of the accel/decel (id=2290,2300) rates from
menu 2
SpeedRampMenu3_O                   0018 0 1       Selects the use of the accel/decel (id=2310,2320) rates from
menu 3
SpeedRampNetwork1_O                 0019 0 1       Selects the use of the accel/decel rates from network 1
SpeedRampNetwork2_O                 001A 0 1       Selects the use of the accel/decel rates from network 2

SpeedLimitMenu1_O                  001B 0 1       Selects the use of the speed limits (id=2080,2090,2140,2150)
from menu 1
SpeedLimitMenu2_O                  001C 0 1       Selects the use of the speed limits (id=2100,2110,2160,2170)
from menu 2
SpeedLimitMenu3_O                  001D 0 1       Selects the use of the speed limits (id=2120,2130,2180,2190)
from menu 3

PidMenu_O                           001E 0 1       Selects the PID setpoint menu (ID=4410) as the PID command
AutoOnOffRunRequest_O               0020 0 1       Selects the auto on/off module to generate a run request

AuxAnalogSource_O                   0021 0 1       Selects the analog inputs #1 or #2 for the auxiliary demand
AuxAnalog1_O                        0022 0 1       Selects the analog input #1 (true) or #2 (false) as the
auxiliary demand
AuxDemandNetwork1_O                 0023 0 1       Selects network #1 as the source for the auxiliary demand
AuxDemandNetwork2_O                 0024 0 1       Selects network #2 as the source for the auxiliary demand
Spare3                              0025 0 1

Jog_O                               0026 0 1       Selects the jog speed (id=4330) as the speed demand
Zero_O                              0027 0 1       Selects the zero speed as the speed demand
KeySwitchLockOut_O                  0028 0 1Overrides all security to prevent parameter edit if true
Safety_O                          0029 0 1       Selects the safety setpoint speed (id=4340) as the speed demand
RefIncr_O                           002A 0 1       Increments the speed demand by the select accel/decel rate
when set true
RefDecr_O                           002B 0 1       Decrements the speed demand by the select accel/decel rate
when set true
RawDemandSampleHold_O               002C 0 1       Selects the sample and hold output as the speed demand
SpeedProfile_O                      002E 0 1       Enable the use of speed profile function if true
PolarityChange_O                    0030 0 1       Enable the polarity change feature if true
Spare5                              0031 0 1
RawDemandAutoOnOff_O               0032 0 1       Selects the raw speed demand as the input to the auto on/off
module
AutoOnOffPidFeedback_O            0033 0 1       Selects the pid feedback as the input to the auto on/off module
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AutoOnOffPidCommand_O             0034 0 1       Selects the pid command as the input to the auto on/off module
SpeedLimitNetwork1_O               0035 0 1       Selects the network #1 speed limits when true
SpeedLimitNetwork2_O               0036 0 1       Selects the network #2 speed limits when true
CriticalSpeedAvoidance_O           0038 0 1       Selects the use of the criical speed avoidance module when
true
UnacknowledgedAlarms_I            0039 0 1        Indicates that there are unacknowledged alarms present

DisableThermalRollback_O           003C 0 1       Disables the controls use the thermal rollback
DisableVoltageRollback_O           003D 0 1       Disables the controls use of voltage rollback
TorqueLimit_I                      003E 0 15      Set TRUE when drive is in rollback and enabled
RollBack_I                         003F 0 15      Indicates drive is in rollback when set true
RunRequest_O                       0040 0 1       Enables drive to run when set true
KeypadFaultReset_I                 0041 0 15      Keypad fault reset button status
KeypadManualStart_I                0042 0 15      Keypad manual start button status
KeypadManualStop_I                 0043 0 15      Keypad manual stop button status
KeypadAuto_I                       0044 0 15      Keypad auto button status
ToolFaultReset_I                   0045 0 15      Tool fault reset button status
ToolManualStart_I                  0046 0 15      Tool manual start button status
ToolManualStop_I                   0047 0 15      Tool manual stop button status
ToolAuto_I                         0048 0 15      Tool auto button status
DriveFaultReset_O                  0049 0 1       Issues a drive fault reset when set true
CellDiagnosticActive_I             004A 0 15      Indicates cell diagnostics is in progress
AutoDisplayMode_O                 004D 0 1       Keypad and Tool will indicate "AUTO" if set true while drive
!                                                 is running and raw demand is not from the keypad or networks
ActiveAlarms_I                     004E 0 15      Indicates that there are active alarms present
FatalFault_I                       0050 0 15      Indicates a fatal drive fault has occurred (any fault)
Cr3_I                              0052 0 15      Indicates state of CR3 input true is OK
QuickStop_O                        0053 0 1       Inserts a zero speed reference command when set true
RampStop_O                         0054 0 1       Inserts a zero speed demand into speed ramp when set true
CellBypassInProgress_I             0055 0 15      Indicates a cell bypass operation is in progress when true
ReadyToRun_I                       0056 0 15      Indicates the drive is ready for a run request when true
DriveRunning_I                     0057 0 15      Indicates drive is running when true
DisableSinglePhaseRollback_O       0058 0 1       Disables the speed rollback during single phasing
DownTransferRequest_O              0059 0 1       Issues a down transfer request to the drive when true
DownTransferPermit_I               005A 0 15      Command to close the VFD contactor for synch transfer
VFDContactorAcknowledge_O          005B 0 1       Set true when the VFD contactor is closed for synch transfer
DownTransferComplete_I             005C 0 15      Indicates when true that the drive has completed the down
transfer
UpTransferRequest_O                005D 0 1       Issues a up transfer request to the drive when true
UpTransferPermit_I                 005E 0 15      Indicates the drive is ready to up transfer
LineContactorAcknowledge_O        005F 0 1       Set true when the line contactor is closed for synch transfer
UpTransferComplete_I               0060 0 15      Indicates when true that the drive has completed the up
transfer
TorqueLimitMenu1_O                 0061 0 1       Selects the use of torque limits from menu (id=1190) and
(id=1200)
TorqueLimitMenu2_O                 0062 0 1       Selects the use of torque limits from menu (id=1210) and
(id=1220)
TorqueLimitMenu3_O                 0063 0 1       Selects the use of torque limits from menu (id=1230) and
(id=1240)
BrakingEnable_O                    0064 0 1       Enable the use of dual frequency braking during decel

! Dedicated Network flags, original names maintained for backwards compatability
!        -- new names in 'dedicated' section of this file
!    -- Indicates the status of Network #1 fixed register bits (0-15)
Network1FixedRegBit0_I             0065 0 2       Run Forward command
Network1FixedRegBit1_I             0065 1 2       Run Reverse command
Network1FixedRegBit2_I             0065 2 2       Fault Reset
Network1FixedRegBit3_I             0065 3 2       Stop command
Network1FixedRegBit4_I             0065 4 2
Network1FixedRegBit5_I             0065 5 2       Start/Stop toggle
Network1FixedRegBit6_I             0065 6 2       Network 1 for speed demand
Network1FixedRegBit7_I             0065 7 2
Network1FixedRegBit8_I             0066 0 2
Network1FixedRegBit9_I             0066 1 2
Network1FixedRegBit10_I            0066 2 2
Network1FixedRegBit11_I            0066 3 2
Network1FixedRegBit12_I            0066 4 2
Network1FixedRegBit13_I            0066 5 2
Network1FixedRegBit14_I            0066 6 2
Network1FixedRegBit15_I            0066 7 2

Network2FixedRegBit0_I            0067 0 2       Indicates the status of Network #2 fixed register bits (0-15)
```

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Network2FixedRegBit1_I              0067 1 2
Network2FixedRegBit2_I              0067 2 2
Network2FixedRegBit3_I              0067 3 2
Network2FixedRegBit4_I              0067 4 2
Network2FixedRegBit5_I              0067 5 2
Network2FixedRegBit6_I              0067 6 2
Network2FixedRegBit7_I              0067 7 2
Network2FixedRegBit8_I              0068 0 2
Network2FixedRegBit9_I              0068 1 2
Network2FixedRegBit10_I             0068 2 2
Network2FixedRegBit11_I             0068 3 2
Network2FixedRegBit12_I             0068 4 2
Network2FixedRegBit13_I             0068 5 2
Network2FixedRegBit14_I             0068 6 2
Network2FixedRegBit15_I             0068 7 2

! Network Run Enable

Network1RunEnable_O                        0069 0 1       Set true to run from network #1
Network2RunEnable_O                        006A 0 1       Set true to run from network #2

! Network health variables

Network1CommOk_I                           006B 0 15      Indicates whether network #1 is active
Network2CommOk_I                           006C 0 15      Indicates whether network #2 is active

ACellIsBypassed_I                   006D 0 15      Indicates that at least one cell is in bypass
CounterFlag_24Hours_I             006E 0 15      Flag that toggles every 24 hours
ResetCntFlag_24Hours_O            006F 0 1       Reset for 24 hour counter flag

! Speed increment variables
SpeedIncrement1_O              0070 0 2       Invokes speed increment 1
SpeedDecrement1_O              0070 1 2       Invokes speed decrement 1
SpeedIncrement2_O              0070 2 2       Invokes speed increment 2
SpeedDecrement2_O              0070 3 2       Invokes speed decrement 2
SpeedIncrement3_O              0070 4 2       Invokes speed increment 3
SpeedDecrement3_O              0070 5 2       Invokes speed decrement 3

RawDemandIncrementalSpeed_O    0071 0 1       Enables use of incremental speed function
DisableWagoCommunicationFault_O     0072 0 1       Set true to disable Wago Comm Fault
TorqueLimitNetwork1_O             0073 0 1       Set true to enable torque limit commands from network 1

TorqueLimitNetwork2_O               0074 0 1       Set true to enable torque limit commands from network 2
TorqueLimitAnalog_O                 0075 0 1       Set true to enable torque limit from Analog Input #3

CounterFlag_1Second_I               0076 0 15      Flag that toggles every Second
ResetCntFlag_1Second_O              0077 0 1       Reset for 1 Second counter flag
CounterFlag_1Minute_I               0078 0 15      Flag that toggles every Minute
ResetCntFlag_1Minute_O              0079 0 1       Reset for 1 Minute counter flag
CounterFlag_1Hour_I                 007A 0 15      Flag that toggles every Hour
ResetCntFlag_1Hour_O                007B 0 1       Reset for 1 Hour counter flag

SpeedAtSetPoint_I                   007C 0 1       Set when motor speed matches demand

SopConfigFile1_O                    007D 0 12      Makes the config file #1 active as set by menus
SopConfigFile2_O                    007D 1 12      Makes the config file #2 active as set by menus
SopConfigFile3_O                    007D 2 12      Makes the config file #3 active as set by menus
SopConfigFile4_O                    007D 3 12      Makes the config file #4 active as set by menus
SopConfigFile5_O                    007D 4 12      Makes the config file #5 active as set by menus
SopConfigFile6_O                    007D 5 12      Makes the config file #6 active as set by menus
SopConfigFile7_O                    007D 6 12      Makes the config file #7 active as set by menus
SopConfigFile8_O                    007D 7 12      Makes the config file #8 active as set by menus

LineContactorUnlatch_I              007E 0 15      Command to open the line contactor for down transfers
InsufficientOutputVolts_I           007F 0 15      Indicates drive cannot support voltage to perform sync
transfer

MenuTimer1Enable_O                  0080 0 1       Enables and starts Menu based timers 1-16
MenuTimer2Enable_O                  0081 0 1
MenuTimer3Enable_O                  0082 0 1
MenuTimer4Enable_O                  0083 0 1
MenuTimer5Enable_O                  0084 0 1
```

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MenuTimer6Enable_O                  0085 0 1
MenuTimer7Enable_O                  0086 0 1
MenuTimer8Enable_O                  0087 0 1
MenuTimer9Enable_O                  0088 0 1
MenuTimer10Enable_O                 0089 0 1
MenuTimer11Enable_O                 008A 0 1
MenuTimer12Enable_O                 008B 0 1
MenuTimer13Enable_O                 008C 0 1
MenuTimer14Enable_O                 008D 0 1
MenuTimer15Enable_O                 008E 0 1
MenuTimer16Enable_O                 008F 0 1

MenuTimer1Output_I                  0090 0 15       Outputs of Menu based timers 1-16
MenuTimer2Output_I                  0091 0 15
MenuTimer3Output_I                  0092 0 15
MenuTimer4Output_I                  0093 0 15
MenuTimer5Output_I                  0094 0 15
MenuTimer6Output_I                  0095 0 15
MenuTimer7Output_I                  0096 0 15
MenuTimer8Output_I                  0097 0 15
MenuTimer9Output_I                  0098 0 15
MenuTimer10Output_I                 0099 0 15
MenuTimer11Output_I                 009A 0 15
MenuTimer12Output_I                 009B 0 15
MenuTimer13Output_I                 009C 0 15
MenuTimer14Output_I                 009D 0 15
MenuTimer15Output_I                 009E 0 15
MenuTimer16Output_I                 009F 0 15


!space for more variables
!unused []                                          Empty space reserved, 00A0-01FF
!                                                   Digital inputs start at 0x200h
!
!struct digInCh DigIn1[12]                          External digital inputs 96 are possible in directory file
!                                   0200            Assigments depend on the module type and location
!                                   020B

! Dedicated Discrete Input for 'standard drive configuration
!        -- orig names used for backward compatibility
ExternalDigitalInput01a_I           0200 0 11       RemoteStart
ExternalDigitalInput01b_I           0200 1 11       RemoteStop
ExternalDigitalInput01c_I           0200 2 11       Remote Fault Reset
ExternalDigitalInput01d_I           0200 3 11       Local Select
ExternalDigitalInput01e_I           0200 4 11       Local Mode
ExternalDigitalInput01f_I           0200 5 11       Remote Mode
ExternalDigitalInput01g_I           0200 6 11       XFMR OT Trip [90 deg / LC][190 deg / AC]
ExternalDigitalInput01h_I           0200 7 11       XFMR OT Alarm [80 deg / LC][170 deg / AC]

ExternalDigitalInput02a_I           0201 0 11       Coolant Tank Low Level
ExternalDigitalInput02b_I           0201 1 11       Coolant Tank Low Low Level
ExternalDigitalInput02c_I           0201 2 11       Loss of Pump 1
ExternalDigitalInput02d_I           0201 3 11       Loss of Pump 2
ExternalDigitalInput02e_I           0201 4 11       CB3 Aux Sw Pump 1
ExternalDigitalInput02f_I           0201 5 11       CB4 Aux Sw Pump 2
ExternalDigitalInput02g_I           0201 6 11       Cell Cab Col 2 Amb > 50
ExternalDigitalInput02h_I           0201 7 11       Cell Cab Col 2 Amb > 60

ExternalDigitalInput03a_I           0202 0 11       Cell Cab Col 4 amb > 50
ExternalDigitalInput03b_I           0202 1 11       Cell Cab Col 4 amb > 60
ExternalDigitalInput03c_I           0202 2 11       Xfmr Cab Left Side amb > 60
ExternalDigitalInput03d_I           0202 3 11       Xfmr Cab Left Side amb > 70
ExternalDigitalInput03e_I           0202 4 11       Xfmr Cab Right Side amb > 60
ExternalDigitalInput03f_I           0202 5 11       Xfmr Cab Right Side amb > 70
ExternalDigitalInput03g_I           0202 6 11       Sw 2 Pump 1 Hand position
ExternalDigitalInput03h_I           0202 7 11       Sw 2 Pump 1 Off position

ExternalDigitalInput04a_I           0203 0 11       Sw 2 Pump 1 Auto position
ExternalDigitalInput04b_I           0203 1 11       MV IP Latch Relay Feedback
ExternalDigitalInput04c_I           0203 2 11       Sw 3 Pump 2 Hand position
ExternalDigitalInput04d_I           0203 3 11       Sw 3 Pump 2 Off position
ExternalDigitalInput04e_I           0203 4 11       Sw 3 Pump 2 Auto position
```

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ExternalDigitalInput04f_I          0203 5 11      MV IP Key Reset PB
ExternalDigitalInput04g_I          0203 6 11      DownXferRequest
ExternalDigitalInput04h_I          0203 7 11      VfdContactorAck

ExternalDigitalInput05a_I          0204 0 11      Up Transfer Request
ExternalDigitalInput05b_I          0204 1 11      Line Contactor Ack
ExternalDigitalInput05c_I          0204 2 11      EDi05-c, TB2-35/36 (spare)
ExternalDigitalInput05d_I          0204 3 11      Multilin Fault input
ExternalDigitalInput05e_I          0204 4 11      SM AC Excitor CB5 Aux contactor (Reactor Temp > 165 C)
ExternalDigitalInput05f_I          0204 5 11      SM AC Exciter Heatsink Thermal Switch (Reactor Temp > 190 C)
ExternalDigitalInput05g_I          0204 6 11      Drive Internal Heat Exchanger Fan 120VAC Power
ExternalDigitalInput05h_I          0204 7 11      (spare), No terminals
ExternalDigitalInput06a_I          0205 0 11
ExternalDigitalInput06b_I          0205 1 11
ExternalDigitalInput06c_I          0205 2 11
ExternalDigitalInput06d_I          0205 3 11
ExternalDigitalInput06e_I          0205 4 11
ExternalDigitalInput06f_I          0205 5 11
ExternalDigitalInput06g_I          0205 6 11
ExternalDigitalInput06h_I          0205 7 11

ExternalDigitalInput07a_I          0206 0 11
ExternalDigitalInput07b_I          0206 1 11
ExternalDigitalInput07c_I          0206 2 11
ExternalDigitalInput07d_I          0206 3 11
ExternalDigitalInput07e_I          0206 4 11
ExternalDigitalInput07f_I          0206 5 11
ExternalDigitalInput07g_I          0206 6 11
ExternalDigitalInput07h_I          0206 7 11

ExternalDigitalInput08a_I          0207 0 11
ExternalDigitalInput08b_I          0207 1 11
ExternalDigitalInput08c_I          0207 2 11
ExternalDigitalInput08d_I          0207 3 11
ExternalDigitalInput08e_I          0207 4 11
ExternalDigitalInput08f_I          0207 5 11
ExternalDigitalInput08g_I          0207 6 11
ExternalDigitalInput08h_I          0207 7 11

ExternalDigitalInput09a_I          0208 0 11
ExternalDigitalInput09b_I          0208 1 11
ExternalDigitalInput09c_I          0208 2 11

ExternalDigitalInput09d_I          0208 3 11
ExternalDigitalInput09e_I          0208 4 11
ExternalDigitalInput09f_I          0208 5 11
ExternalDigitalInput09g_I          0208 6 11
ExternalDigitalInput09h_I          0208 7 11

ExternalDigitalInput10a_I          0209 0 11
ExternalDigitalInput10b_I          0209 1 11
ExternalDigitalInput10c_I          0209 2 11
ExternalDigitalInput10d_I          0209 3 11
ExternalDigitalInput10e_I          0209 4 11
ExternalDigitalInput10f_I          0209 5 11
ExternalDigitalInput10g_I          0209 6 11
ExternalDigitalInput10h_I          0209 7 11

ExternalDigitalInput11a_I          020A 0 11
ExternalDigitalInput11b_I          020A 1 11
ExternalDigitalInput11c_I          020A 2 11
ExternalDigitalInput11d_I          020A 3 11
ExternalDigitalInput11e_I          020A 4 11
ExternalDigitalInput11f_I          020A 5 11
ExternalDigitalInput11g_I          020A 6 11
ExternalDigitalInput11h_I          020A 7 11

ExternalDigitalInput12a_I          020B 0 11
ExternalDigitalInput12b_I          020B 1 11
ExternalDigitalInput12c_I          020B 2 11
ExternalDigitalInput12d_I          020B 3 11
ExternalDigitalInput12e_I          020B 4 11
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ExternalDigitalInput12f_I          020B 5 11
ExternalDigitalInput12g_I          020B 6 11
ExternalDigitalInput12h_I          020B 7 11

! ********************* DIGITAL OUTPUTS *****************************

! Dedicated Discrete Output for 'standard drive configuration
!       -- orig names with comments on assigned or dedicated outputs
!      External digital outputs 64 are possible in directory file
!      Assigments depend on the module type and location
ExternalDigitalOutput01a_O         020C 0 12Speed Demand in Local at VFD
ExternalDigitalOutput01b_O         020C 1 12       Drive Ready to Run
ExternalDigitalOutput01c_O         020C 2 12       Drive Running
ExternalDigitalOutput01d_O         020C 3 12       Drive Alarm
ExternalDigitalOutput01e_O         020C 4 12       Process Alarm
ExternalDigitalOutput01f_O         020C 5 12       Drive Trip Alarm
ExternalDigitalOutput01g_O         020C 6 12       Drive Tripped
ExternalDigitalOutput01h_O         020C 7 12       MV Input Breaker Enable

ExternalDigitalOutput02a_O         020D 0 12Loss of 4-20ma Speed Command
ExternalDigitalOutput02b_O         020D 1 12       (Spare)
ExternalDigitalOutput02c_O         020D 2 12       (Spare)
ExternalDigitalOutput02d_O         020D 3 12       (Spare)
ExternalDigitalOutput02e_O         020D 4 12       Sync Transfer Down Transfer Permit
ExternalDigitalOutput02f_O         020D 5 12       Sync Transfer Down Transfer Complete
ExternalDigitalOutput02g_O         020D 6 12       Sync Transfer Up Transfer Permit
ExternalDigitalOutput02h_O         020D 7 12       Sync Transfer Up Transfer Complete

ExternalDigitalOutput03a_O         020E 0 12       Pump 1 Motor Starter
ExternalDigitalOutput03b_O         020E 1 12       Pump 2 Motor Starter
ExternalDigitalOutput03c_O         020E 2 12       MV Input Protection Trip and Latch
ExternalDigitalOutput03d_O         020E 3 12       MV Input Protection Relay Reset
ExternalDigitalOutput03e_O         020E 4 12       SM Exciter Enable
ExternalDigitalOutput03f_O         020E 5 12       Not Assigned
ExternalDigitalOutput03g_O         020E 6 12       Not Assigned
ExternalDigitalOutput03h_O         020E 7 12       Not Assigned


ExternalDigitalOutput04a_O         020F 0 12       Not Assigned
ExternalDigitalOutput04b_O         020F 1 12       Not Assigned
ExternalDigitalOutput04c_O         020F 2 12       Not Assigned
ExternalDigitalOutput04d_O         020F 3 12       Not Assigned
ExternalDigitalOutput04e_O         020F 4 12       Not Assigned
ExternalDigitalOutput04f_O         020F 5 12       Not Assigned
ExternalDigitalOutput04g_O         020F 6 12       Not Assigned
ExternalDigitalOutput04h_O         020F 7 12       Not Assigned

ExternalDigitalOutput05a_O         0210 0 12       Not Assigned
ExternalDigitalOutput05b_O         0210 1 12       Not Assigned
ExternalDigitalOutput05c_O         0210 2 12       Not Assigned
ExternalDigitalOutput05d_O         0210 3 12       Not Assigned
ExternalDigitalOutput05e_O         0210 4 12       Not Assigned
ExternalDigitalOutput05f_O         0210 5 12       Not Assigned
ExternalDigitalOutput05g_O         0210 6 12       Not Assigned

ExternalDigitalOutput05h_O         0210 7 12       Not Assigned

ExternalDigitalOutput06a_O         0211 0 12       Not Assigned
ExternalDigitalOutput06b_O         0211 1 12       Not Assigned
ExternalDigitalOutput06c_O         0211 2 12       Not Assigned
ExternalDigitalOutput06d_O         0211 3 12       Not Assigned
ExternalDigitalOutput06e_O         0211 4 12       Not Assigned
ExternalDigitalOutput06f_O         0211 5 12       Not Assigned
ExternalDigitalOutput06g_O         0211 6 12       Not Assigned
ExternalDigitalOutput06h_O         0211 7 12       Not Assigned

ExternalDigitalOutput07a_O         0212 0 12       Not Assigned
ExternalDigitalOutput07b_O         0212 1 12       Not Assigned
ExternalDigitalOutput07c_O         0212 2 12       Not Assigned
ExternalDigitalOutput07d_O         0212 3 12       Not Assigned
ExternalDigitalOutput07e_O         0212 4 12       Not Assigned
ExternalDigitalOutput07f_O         0212 5 12       Not Assigned
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ExternalDigitalOutput07g_O         0212 6 12       Not Assigned
ExternalDigitalOutput07h_O         0212 7 12       Not Assigned

ExternalDigitalOutput08a_O         0213 0 12       Not Assigned
ExternalDigitalOutput08b_O         0213 1 12       Not Assigned
ExternalDigitalOutput08c_O         0213 2 12       Not Assigned
ExternalDigitalOutput08d_O         0213 3 12       Not Assigned
ExternalDigitalOutput08e_O         0213 4 12       Not Assigned
ExternalDigitalOutput08f_O         0213 5 12       Not Assigned
ExternalDigitalOutput08g_O         0213 6 12       Not Assigned
ExternalDigitalOutput08h_O         0213 7 12       Not Assigned

! ********************* COMPARATORS *****************************
Comparator1_I                      0214 0 15       Comparator flags 16 total
Comparator2_I                      0215 0 15
Comparator3_I                      0216 0 15
Comparator4_I                      0217 0 15
Comparator5_I                      0218 0 15
Comparator6_I                      0219 0 15
Comparator7_I                      021A 0 15
Comparator8_I                      021B 0 15
Comparator9_I                      021C 0 15
Comparator10_I                     021D 0 15
Comparator11_I                     021E 0 15
Comparator12_I                     021F 0 15
Comparator13_I                     0220 0 15
Comparator14_I                     0221 0 15
Comparator15_I                     0222 0 15
Comparator16_I                     0223 0 15

TempFlag01_O                       0224 0 1        Temporary flags 60 total
TempFlag02_O                       0225 0 1
TempFlag03_O                       0226 0 1
TempFlag04_O                       0227 0 1
TempFlag05_O                       0228 0 1
TempFlag06_O                       0229 0 1
TempFlag07_O                       022A 0 1
TempFlag08_O                       022B 0 1
TempFlag09_O                       022C 0 1
TempFlag10_O                       022D 0 1
TempFlag11_O                       022E 0 1
TempFlag12_O                       022F 0 1
TempFlag13_O                       0230 0 1
TempFlag14_O                       0231 0 1
TempFlag15_O                       0232 0 1
TempFlag16_O                       0233 0 1
TempFlag17_O                       0234 0 1
TempFlag18_O                       0235 0 1
TempFlag19_O                       0236 0 1
TempFlag20_O                       0237 0 1
TempFlag21_O                       0238 0 1
TempFlag22_O                       0239 0 1
TempFlag23_O                       023A 0 1
TempFlag24_O                       023B 0 1
TempFlag25_O                       023C 0 1
TempFlag26_O                       023D 0 1        Pump 1 in Hand mode (25)
TempFlag27_O                       023E 0 1        Pump 2 in Hand mode (26)
TempFlag28_O                       023F 0 1        Next Cell to bypass (28)
TempFlag29_O                       0240 0 1        Slow Conductivity Change Detector (29)
TempFlag30_O                       0241 0 1        Fast Conductivity Change Detector (30)
TempFlag31_O                       0242 0 1        Any OT alarm conditions (31)
TempFlag32_O                       0243 0 1        Allows an IOC reset for X counts and is re-enabled after a
window (32)
TempFlag33_O                       0244 0 1        Used for cooling system drop-out timer initialization (33)
TempFlag34_O                      0245 0 1        Critical Cooling System failure - immediate removal of power
(34)
TempFlag35_O                       0246 0 1        One of the pumps has power (35)
TempFlag36_O                       0247 0 1        Resets the One Hour Timer (toggle) (36)
TempFlag37_O                     0248 0 1       Indication that an Ambient Temperature warning Switch is active
(37)
TempFlag38_O                      0249 0 1       Indication that an Ambient Temperature fault Switch is active
(38)
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TempFlag39_O                    024A 0 1      Indication that an Ambient Temperature warning Switch is active
(39)
TempFlag40_O                     024B 0 1       Indication that an Ambient Temperature fault Switch is active
(40)
TempFlag41_O                     024C 0 1       Slow leak detection (1 hour between low and low - low levels)
(41)
TempFlag42_O                      024D 0 1        Sync Transfer Mode Active - either Up or Down Transfer is
active (42)
TempFlag43_O                      024E 0 1        Up Transfer Reset Flag (43)
TempFlag44_O                      024F 0 1        Down Transfer Reset Flag (44)

TempFlag45_O                      0250 0 1        Analog Speed Mode (45)
TempFlag46_O                      0251 0 1        Network # 1 Run Request (46)

TempFlag47_O                      0252 0 1        Network # 1 Speed Control (47)
TempFlag48_O                      0253 0 1        Pump #1 is Available (48)
TempFlag49_O                      0254 0 1        Pump #1 Run Command  (49)
TempFlag50_O                      0255 0 1        Pump #2 is Available (50)
TempFlag51_O                      0256 0 1        Pump #2 Run Command (51)
TempFlag52_O                      0257 0 1        Cooling System OT Hysteresis (52)
TempFlag53_O                      0258 0 1        Cooling System OT (53)
TempFlag54_O                      0259 0 1        Cooling System Malfunction (54)
TempFlag55_O                      025A 0 1        Forward reference of latching pulse memory to enable drive
fault reset (55)
TempFlag56_O                      025B 0 1        Input Contactor Trip Command (56)
TempFlag57_O                     025C 0 1        Falling edge detection for key reset switch push button (57)
TempFlag58_O                      025D 0 1        Cooling days Cycle Flag for pumps & redundant fans (58)
TempFlag59_O                      025E 0 1        Resets the One Minute Timer (toggle) (59)
TempFlag60_O                      025F 0 1        Resets the One Second Timer (toggle) (60)

!********** fault1Word1a
OverSpeedAlarm_I                  0260 0 9        Over speed alarm indicator, set true when speed is greater
than 90% of trip point (id=1170)
OverSpeedFault_I                  0260 1 9        Over speed fault indicator, set true when speed is greater
than trip point (id=1170)
UnderLoadAlarm_I                  0260 2 9        Under load alarm indicator, set true when less than the
underload trip point (id=1182)
UnderLoadFault_I                  0260 3 9        Under load fault indicator, set true when less than the
underload trip point (id=1182,1186)
MotorThermalOverload1_I           0260 4 9        Indicates motor thermal over load alarm point 1
MotorThermalOverload2_I           0260 5 9        Indicates motor thermal over load alarm point 2
MotorThermalOverloadFault_I       0260 6 9        Indicates motor thermal over load fault
OutputPhaseImbalance_I           0260 7 9       Indicates ouput phase imbalance is greater than menu setting

!********** fault1Word1b
OutputGroundFault_I               0261 1 9        Indicates a ground fault at the drive output
IOC_I                             0261 2 9        Indicates an IOC trip
MenuInit_I                        0261 3 9        Indicates that the menu system failed to initialize
Cells_I                           0261 4 9        Indicates a cell fault
InTorqueLimit_I                   0261 5 9        Indicates the drive in torque limit for more than 1 minute
InTorqueLimitRollback_I          0261 6 9       Indicates the drive in torque limit for more than 20 minutes
InputPhaseLoss_I                  0261 7 9        Indicates the drive has lost an input phase

!********** fault1Word2a
PhaseSequence_I                 0262 0 9      Indicates that the phase sequence of the drive input and output
are different
CpuTempAlarm_I                    0262 1 9        Indicates that the Cpu temperature is above the alarm level
CpuTempFault_I                   0262 2 9       Indicates that the Cpu temperature is above the fault level
(must be anable in SOP CPUTempFaultEn_0)
CellOverTemperatureAlarm_I       0262 3 9      Indicates that a cell temperature has reached the alarm level
CellOverTemperatureFault_I       0262 4 9       Indicates that a cell temperature has reached the trip level
ModulatorInitializationFault_I    0262 5 9       Indicates that the modulator failed to initialize properly
CellCountMissMatch_I             0262 6 9      Indicates that the cell count detected is different than the
menu (id=2530)
PowerSupplyFault_I                0262 7 9        Indicates that the control power supply has fialed

!********** fault1Word2b
WagoCommunication_I              0263 0 9       Indicates the drive has lost communication with the Wago I/O
system
WagoConfiguration_I               0263 1 9       Indicates the drive has I/O configuration is different than
the Wago I/O system
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CellBypassComFailure_I          0263 2 9      Indicates a problem with the communication link from the
modulator to the MV bypass board
CellBypassAckFailure_I          0263 3 9      Indicates a problem with the bypass relay or the MV bypass
board
CellBypassLinkFail_I            0263 4 9      Indicates a problem with the communication link from the MV
bypass board
WeakBattery_I                   0263 5 9      Indicates a weak battery on the modulator board
SystemProgram_I                 0263 6 9      Indicates a bad system program or that none exist
MediumVoltageLowAlarm1_I        0263 7 9      Indicates that the medium voltage is < 90% of the rated input
voltage

!********** fault1Word3a
MediumVoltageLowAlarm2_I        0264 0 9      Indicates that the medium voltage is < 70% of the rated input
voltage
MediumVoltageLowFault_I         0264 1 9      Indicates that the medium voltage is < 55% of the rated input
voltage
CellAlarm_I                     0264 2 9      Indication that one or more cells has an alarm condition
LineOverVoltage1_I              0264 3 9      Indicates that the line voltage is greater than 110% of rated
voltage
LineOverVoltage2_I              0264 4 9      Indicates that the line voltage is greater than 115% of rated
voltage
LineOverVoltageFault_I          0264 5 9      Indicates that the line voltage is greater than 120% of rated
voltage
InputPhaseImbalance_I           0264 6 9      Indicates that there is a phase current imbalance at the drive
input
InputOneCycle_I                 0264 7 9      Indicates a one cycle transformer fault (secondary short)

!********** fault1Word3b
InputGroundFault_I              0265 0 9      Indicates a ground fault on the drive input line
EncoderLoss_I                   0265 1 9      Indicates that the encoder in closed loop vector control is
not working properly
KeypadCommunication_I           0265 2 9      Indicates a communication loss betwee the control and the
keypad
Network1Communication_I         0265 3 9      Indicates a communication loss betwee the control and network
#1
Network2Communication_I         0265 4 9      Indicates a communication loss betwee the control and network
#2
MotorOverVoltageAlarm_I         0265 5 9      Indicates that the motor voltage is within 90% of the trip
point (id=1040)
MotorOverVoltageFault_I         0265 6 9      Indicates that the motor voltage is greater than the trip
point (id=1040)
CellBypassComWarning_I          0265 7 9      Indicated that the MV board is not communicating with the
modulator (Bypass not active)

!********** fault1Word4a
CellBypassLinkWarning_I         0266 0 9      Indicates a communication problem from the MV bypass board
(Bypass not active)
CellBypassFault_I               0266 1 9      Indicates that the cell bypass operation failed
CellConfigurationFault_I        0266 2 9      Indicates that there is a mismatch in the number of cells
detected versus the menu entry for # of cells
EffectiveSwitchFreqAlarm_I      0266 3 9      Indicates that the switching frequency is outside of the
desired range
BackEmfTimeout_I                0266 4 9      Indicates that the drive time out waiting for the back emf of
the motor to decay to a safe level
HallEffectPowerSupplyFault_I    0266 5 9      Indicates that one of the hall effect sensor power suppies
has failed
UnknownModulatorFault_I         0266 6 9      Indicates an internal modulator fault

!********** fault1Word4B
ModulatorWatchdogTimeout_I      0267 0 9      Indicates that the CPU has not updated the modulator within
3 sample periods
CellDcBusLowWarning_I           0267 1 9      Indicates that a cell issued a low DC bus warning
ToolCommunication_I             0267 2 9      Indicates that the control is not communicating to the PC tool
software
FailedToMagnetizeFault_I        0267 3 9      Indicates that the drive failed to magnetize the motor within
a flux ramp rate (id=3160)
LossOfFieldFault_I              0267 4 9      Indicates that the field control of a synch motor has failed
LowMotorSpeedFault_I            0267 5 9      Indicates that motor speed is below zero speed parameter
(id=2200) for 15 seconds
ExcessiveDriveLosses_I    0267 6 9      Indicates that the losses within the drive are outside of the
acceptable range
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WagoCommunicationAlarm_I           0267 7 9       Indicates that the control temporarily lost communications
with the wago i/o system

!********** fault2Word1A
OneBlowerLost_I                    0268 0 9       Indicates that a single blower is not functioning
AllBlowersLost_I                   0268 1 9       Indicates that all of the blowers are not functioning
CloggedFilters_I                   0268 2 9       Indicates that a filter is clogged (blocked)
ReactorTemperature1_I              0268 3 9       Indicates that reactor temperature #1 flag is set
ReactorTemperature2_I              0268 4 9       Indicates that reactor temperature #2 flag is set
ReactorTemperatureFault_I          0268 5 9       Indicates that reactor temperature fault flag is set
XformerOverTempAlarm1_I            0268 6 9       Indicates that transformer over temperature #1 flag is set
XformerOverTempAlarm2_I            0268 7 9       Indicates that transformer over temperature #2 flag is set

!********** fault2Word1B
XformerOverTempFault_I            0269 0 9       Indicates that transformer over temperature fault flag is set
OnePumpFailure_I                   0269 1 9       Indicates that a single pump is not functioning
AllPumpsFailure_I                  0269 2 9       Indicates that all of the pumps are not functioning
CoolantConductivityAlarm_I         0269 3 9       Indicates that the coolant conductivity at an alarm level
CoolantConductivityFault_I         0269 4 9       Indicates that the coolant conductivity at an fault level
InletWaterTempHigh_I              0269 5 9       Indicates that the inlet water temperature is at a high level
InletWaterTempLow_I                0269 6 9       Indicates that the inlet water temperature is at a low level
CellWaterTempHigh_I                0269 7 9       Indicates that the cell water temperature is at a high level

!********** fault2Word2A
XformerWaterTempHigh_I             026A 0 9       Indicates that the transformer water temperature is at the
high level
LowWaterLevelAlarm_I               026A 1 9       Indicates a low water level alarm

LowWaterLevelFault_I               026A 2 9       Indicates a low water level fault
LowWaterFlowAlarm_I                026A 3 9       Indicates a low water flow alarm
LowWaterFlowFault_I                026A 4 9       Indicates a low water flow fault
LossOneHexFan_I                    026A 5 9       Indicates that one hex fan is not functioning
LossAllHexFan_I                    026A 6 9       Indicates that all hex fan are not functioning
AllHexFansOn_I                     026A 7 9       Indicates that all hex fan are on

!********** fault2Word2B
LossOfDriveEnable_I                026B 0 9       Indicates that the drive enable was lost
UpTransferFault_I                  026B 1 9       Indicates that a up transfer fault occurred
DownTransferFault_I                026B 2 9       Indicates that a down transfer fault occurred
AdcHardwareErrorAlarm_I            026B 3 9       Indicates that a ADC hardware alarm occurred
AdcHardwareErrorFault_I            026B 4 9       Indicates that a ADC hardware fault occurred
ConfigFileWriteAlarm_I             026B 5 9       Indicates config file write alarm occured
ConfigFileReadFault_I              026B 6 9       Indicates config file read fault occured
WagoInternalErrorFault_I           026B 7 9       Indicates an internal Wago Error Fault condition

!********** fault2Word3A
WagoCouplerErrorFault_I            026C 0 9       Indicates an Wago Coupler Error Fault condition
WagoErrorAfterModuleFault_I        026C 1 9       Indicates an Wago Error After Module X Fault condition
WagoErrorAtModuleFault_I           026C 2 9       Indicates an Wago Error At Module X Fault condition
WagoInternalErrorAlarm_I           026C 3 9       Indicates an internal Wago Error Alarm condition
WagoCouplerErrorAlarm_I            026C 4 9       Indicates an Wago Coupler Error Alarm condition
WagoErrorAfterModuleAlarm_I        026C 5 9       Indicates an Wago Error After Module X Alarm condition
WagoErrorAtModuleAlarm_I           026C 6 9       Indicates an Wago Error At Module X Alarm condition

!********** fault2Word3B
LossOfSignal1_I                    026D 0 9       Indicates loss of signal from analog input 1 - 24
LossOfSignal2_I                    026D 1 9
LossOfSignal3_I                    026D 2 9
LossOfSignal4_I                    026D 3 9
LossOfSignal5_I                    026D 4 9
LossOfSignal6_I                    026D 5 9
LossOfSignal7_I                    026D 6 9
LossOfSignal8_I                    026D 7 9

!********** fault2Word4A
LossOfSignal9_I                    026E 0 9
LossOfSignal10_I                   026E 1 9
LossOfSignal11_I                   026E 2 9
LossOfSignal12_I                   026E 3 9
LossOfSignal13_I                   026E 4 9
LossOfSignal14_I                   026E 5 9
LossOfSignal15_I                   026E 6 9
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LossOfSignal16_I                  026E 7 9

!********** fault2Word3B
LossOfSignal17_I                  026F 0 9
LossOfSignal18_I                  026F 1 9
LossOfSignal19_I                  026F 2 9
LossOfSignal20_I                  026F 3 9
LossOfSignal21_I                  026F 4 9
LossOfSignal22_I                  026F 5 9
LossOfSignal23_I                  026F 6 9
LossOfSignal24_I                  026F 7 9

!********** fault3Word1A
UserFault1_I                      0270 0 9       Indicates the status of user fault 1 through 64
UserFault2_I                      0270 1 9
UserFault3_I                      0270 2 9
UserFault4_I                      0270 3 9
UserFault5_I                      0270 4 9
UserFault6_I                      0270 5 9
UserFault7_I                      0270 6 9
UserFault8_I                      0270 7 9

UserFault9_I                      0271 0 9
UserFault10_I                     0271 1 9
UserFault11_I                     0271 2 9
UserFault12_I                     0271 3 9
UserFault13_I                     0271 4 9
UserFault14_I                     0271 5 9
UserFault15_I                     0271 6 9
UserFault16_I                     0271 7 9

UserFault17_I                     0272 0 9
UserFault18_I                     0272 1 9
UserFault19_I                     0272 2 9
UserFault20_I                     0272 3 9
UserFault21_I                     0272 4 9
UserFault22_I                     0272 5 9
UserFault23_I                     0272 6 9
UserFault24_I                     0272 7 9

UserFault25_I                     0273 0 9
UserFault26_I                     0273 1 9
UserFault27_I                     0273 2 9
UserFault28_I                     0273 3 9       Asco Switch on Alternate (28)
UserFault29_I                     0273 4 9       UPS is on inverter (29)
UserFault30_I                     0273 5 9       UPS Alarm (30)
UserFault31_I                     0273 6 9       Sync Motor Exciter OT fault (31)
UserFault32_I                     0273 7 9       Sync Motor Loss of Exciter (32)

UserFault33_I                     0274 0 9       Sync Motor Exciter Fault (33)
UserFault34_I                     0274 1 9       Pump One Loss of power alarm (34)
UserFault35_I                     0274 2 9       Pump One TOL alarm (35)
UserFault36_I                     0274 3 9       Pump Two Loss of power alarm (36)
UserFault37_I                     0274 4 9       Pump One TOL alarm (37)
UserFault38_I                     0274 5 9       Estop Alarm for logging (38)
UserFault39_I                     0274 6 9       Multilin Fault of Drive (39)
UserFault40_I                     0274 7 9       Avail Volts below rated alarm (40)

UserFault41_I                     0275 0 9       Cell Cabinet Column 2 Ambient alarm (50 Deg) (41)
UserFault42_I                     0275 1 9       Cell Cabinet Column 2 Ambient fault (60 Deg) (42)
UserFault43_I                     0275 2 9       Cell Cabinet Column 4 Ambient alarm (50 Deg) (43)
UserFault44_I                     0275 3 9       Cell Cabinet Column 4 Ambient fault (60 Deg) (44)
UserFault45_I                     0275 4 9       Transformer Left side Ambient alarm (60 Deg) (45)
UserFault46_I                     0275 5 9       Transformer Left side Ambient fault (70 Deg) (46)
UserFault47_I                     0275 6 9       Transformer Right side Ambient alarm (60 Deg) (47)
UserFault48_I                     0275 7 9       Transformer Right side Ambient fault (70 Deg) (48)

UserFault49_I                     0276 0 9       Hex Fans Power Failed (49)
UserFault50_I                     0276 1 9       Transformer OT Alarm (> 65 deg) (50)
UserFault51_I                     0276 2 9       Coolant Outlet OT Fault (> 70 deg) (51)
UserFault52_I                     0276 3 9       Low, Low Coolant Level (> 20") (52)
UserFault53_I                     0276 4 9       High Conductivity Fault (> 5uS) (53)
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UserFault54_I                   0276 5 9        Coolant Inlet Temp above 52 deg C (54)
UserFault55_I                   0276 6 9        Pump #1 Failed (55)
UserFault56_I                   0276 7 9        Pump #2 Failed (56)

UserFault57_I                   0277 0 9        Both Cooling Pumps Failed (57)
UserFault58_I                   0277 1 9        Cooling Ot Mv Trip (58)
UserFault59_I                   0277 2 9        Cooling Ot Vfd Trip (59)
UserFault60_I                   0277 3 9        Cooling Ot Trip Alarm (60)
UserFault61_I                   0277 4 9        Coolant Outlet Temperature Alarm (65 Deg C) (61)
UserFault62_I                   0277 5 9        Cooling Sys Vfd Trip (62)
UserFault63_I                   0277 6 9        Cooling Sys Mv Trip (63)
UserFault64_I                   0277 7 9        MV Input Protection Latched Fault (64)

!**************************************** Fault/Alarm enables ************************************

OverSpeedAlarmEn_O              0278 0 2        Enables the overspeed alarm
UnderLoadAlarmEn_O              0278 2 2        Enables the underload alarm
MotorThermalOverload1En_O       0278 4 2        Enables the motor overload alarm #1
MotorThermalOverload2En_O       0278 5 2        Enables the motor overload alarm #2

InTorqueLimitEn_O               0279 5 2        Enables the in torque limit alarm
InTorqueLimitRollbackEn_O       0279 6 2        Enables the in torque limit rollback alarm or fault

PhaseSequenceEn_O               027A 0 2        Enables the phase sequence alarm or fault
CpuTempFaultEn_O                027A 2 2        Enables the Cpu temperature fault

MediumVoltageLowAlarm1En_O      027B 7 2        Enables the medium voltage low alarm #1

LineOverVoltage1En_O            027C 3 2        Enables the line over voltage alarm #1
LineOverVoltage2En_O            027C 4 2        Enables the line over voltage alarm #2

KeypadCommunicationEn_O         027D 2 2        Enables the keypad communications loss alarm or fault
Network1CommunicationEn_O       027D 3 2        Enables the network #1 communications loss alarm or fault
Network2CommunicationEn_O       027D 4 2        Enables the network #2 communications loss alarm or fault
MotorOverVoltageAlarmEn_O       027D 5 2        Enables the motor over voltage alarm

ToolCommunicationEn_O           027F 2 2        Enables the tool communications loss alarm or fault
unused1Fault4A3En_O             027F 3 2
LowMotorSpeedFaultEn_O          027F 5 9        Enables the Low Motor Speed Fault or Alarm
unused1Fault4A6En_O             027F 6 2
unused1Fault4A7En_O             027F 7 2

OneBlowerLostEn_O               0280 0 2        Enables the one blower loss alarm
AllBlowerLostEn_O               0280 1 2        Enables the all of the blowers loss fault
CloggedFiltersEn_O              0280 2 2        Enables the filter is clogged (blocked) alarm or fault
ReactorTemperature1En_O         0280 3 2        Enables the reactor temperature #1 alarm
ReactorTemperature2En_O         0280 4 2        Enables the reactor temperature #2 alarm
ReactorTemperatureFaultEn_O     0280 5 2        Enables the reactor temperature fault
XformerOverTempAlarm1En_O       0280 6 2        Enables the transformer over temperature #1 alarm
XformerOverTempAlarm2En_O       0280 7 2        Enables the transformer over temperature #2 alarm

XformerOverTempFaultEn_O        0281 0 2        Enables the transformer over temperature fault
OnePumpFailureEn_O              0281 1 2        Enables the one pump failure alarm
AllPumpsFailureEn_O             0281 2 2        Enables the all pumps failure fault
CoolantConductivityAlarmEn_O    0281 3 2        Enables the coolant conductivity alarm
CoolantConductivityFaultEn_O    0281 4 2        Enables the coolant conductivity fault
InletWaterTempHighEn_O          0281 5 2        Enables the inlet water temperature high alarm or fault
InletWaterTempLowEn_O           0281 6 2        Enables the inlet water temperature low alarm or fault
CellWaterTempHighEn_O           0281 7 2        Enables the cell water temperature high alarm or fault

XformerWaterTempHighEn_O        0282 0 2        Enables the transformer water temperature high alarm or fault
LowWaterLevelAlarmEn_O          0282 1 2        Enables low water level alarm
LowWaterLevelFaultEn_O          0282 2 2        Enables low water level fault
LowWaterFlowAlarmEn_O           0282 3 2        Enables low water flow alarm
LowWaterFlowFaultEn_O           0282 4 2        Enables low water flow fault
LossOneHexFanEn_O               0282 5 2        Enables the one hex fan alarm
LossAllHexFanEn_O               0282 6 2        Enables the all hex fan alarm or fault
AllHexFansOnEn_O                0282 7 2        Enables the all hex fan alarm

LossOfDriveEnableEn_O           0283 0 2        Enables the loss of drive enable fault
UpTransferFaultEn_O             0283 1 2        Enables the up transfer fault
DownTransferFaultEn_O           0283 2 2        Enables the down transfer fault
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unused2Fault2B3En_O              0283 3 2
unused2Fault2B4En_O              0283 4 2
unused2Fault2B5En_O              0283 5 2
unused2Fault2B6En_O              0283 6 2
unused2Fault2B7En_O              0283 7 2

unused2Fault3A0En_O              0284 0 2
unused2Fault3A1En_O              0284 1 2
unused2Fault3A2En_O              0284 2 2
unused2Fault3A3En_O              0284 3 2
unused2Fault3A4En_O              0284 4 2
unused2Fault3A5En_O              0284 5 2
unused2Fault3A6En_O              0284 6 2

LossOfSignal1En_O               0285 0 2       Enables loss of signal alarm or fault for analog inputs 1 - 24
LossOfSignal2En_O                0285 1 2
LossOfSignal3En_O                0285 2 2
LossOfSignal4En_O                0285 3 2
LossOfSignal5En_O                0285 4 2
LossOfSignal6En_O                0285 5 2
LossOfSignal7En_O                0285 6 2
LossOfSignal8En_O                0285 7 2

LossOfSignal9En_O                0286 0 2
LossOfSignal10En_O               0286 1 2
LossOfSignal11En_O               0286 2 2
LossOfSignal12En_O               0286 3 2
LossOfSignal13En_O               0286 4 2
LossOfSignal14En_O               0286 5 2
LossOfSignal15En_O               0286 6 2
LossOfSignal16En_O               0286 7 2

LossOfSignal17En_O               0287 0 2
LossOfSignal18En_O               0287 1 2
LossOfSignal19En_O               0287 2 2
LossOfSignal20En_O               0287 3 2
LossOfSignal21En_O               0287 4 2
LossOfSignal22En_O               0287 5 2
LossOfSignal23En_O               0287 6 2
LossOfSignal24En_O               0287 7 2

InTorqueLimitRollbackWn_O        0289 6 2        Sets in torque limit rollback as an alarm
PhaseSequenceWn_O                028A 0 2        Sets phase sequence as an alarm

LineOverVoltageFaultWn_O         028C 5 2        Sets the line over voltage Trip as an alarm
InputPhaseImbalanceWn_O          028C 6 2        Sets input phase imbalance as an alarm
InputOneCycleWn_O                028C 7 2        Sets input one cycle detection to an alarm

KeypadCommunicationWn_O          028D 2 2        Sets keypad communication loss as an alarm
Network1CommunicationWn_O        028D 3 2        Sets network #1 communication loss as an alarm
Network2CommunicationWn_O        028D 4 2        Sets network #2 communication loss as an alarm

ToolCommunicationWn_O            028F 2 2        Sets tool communication loss as an alarm
FailedToMagnetizeFaultWn_O       028F 3 2        Sets failed to magnetize as an alarm
LossOfFieldFaultWn_O             028F 4 2        Sets loss of field as an alarm
LowMotorSpeedFaultWn_O           028F 5 2        Sets the Low Motor Speed Fault as an Alarm
ExcessiveDriveLossesWn_O    028F 6 2        Sets excessive drive losses as an alarm
unused1Fault4A7Wn_O              028F 7 2

AllBlowersLostWn_O               0290 1 2        Sets the all of the blowers loss as an alarm
CloggedFilters_Wn_O             0290 2 2        Sets clogged filters as an alarm
ReactorTemperatureFaultWn_O      0290 5 2        Sets the reactor temperature fault as an alarm

XformerOverTempFaultWn_O         0291 0 2        Sets Transformer over temperature as an alarm
AllPumpsFailureWn_O              0291 2 2        Sets all pump failure as an alarm
CoolantConductivityFaultWn_O     0291 4 2        Sets coolant conductivity fault to an alarm
InletWaterTempHighWn_O           0291 5 2        Sets inlet water temperature high as an alarm
InletWaterTempLowWn_O            0291 6 2        Sets inlet water temperature low as an alarm
CellWaterTempHighWn_O            0291 7 2        Sets cell water temperature high as an alarm

LowWaterLevelFaultWn_O           0292 2 2        Sets low water level fault as an alarm
LowWaterFlowFaultWn_O            0292 4 2        Sets low water flow fault as an alarm
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LossAllHexFanWn_O                    0292 6 2        Sets loss all hex fans as an alarm

unused2Fault2B1Wn_O                  0293 1 2
unused2Fault2B2Wn_O                  0293 2 2
unused2Fault2B3Wn_O                  0293 3 2
unused2Fault2B4Wn_O                  0293 4 2
unused2Fault2B5Wn_O                  0293 5 2
unused2Fault2B6Wn_O                  0293 6 2
unused2Fault2B7Wn_O                  0293 7 2

unused2Fault3A0Wn_O                  0294 0 2
unused2Fault3A1Wn_O                  0294 1 2
unused2Fault3A2Wn_O                  0294 2 2
unused2Fault3A3Wn_O                  0294 3 2
unused2Fault3A4Wn_O                  0294 4 2
unused2Fault3A5Wn_O                  0294 5 2
unused2Fault3A6Wn_O                  0294 6 2

! Sets loss of signal of analog input 1 - 24 as an alarm
LossOfSignal1Wn_O                    0295 0 2
LossOfSignal2Wn_O                    0295 1 2
LossOfSignal3Wn_O                    0295 2 2
LossOfSignal4Wn_O                    0295 3 2
LossOfSignal5Wn_O                    0295 4 2
LossOfSignal6Wn_O                    0295 5 2
LossOfSignal7Wn_O                    0295 6 2
LossOfSignal8Wn_O                    0295 7 2

LossOfSignal9Wn_O                    0296 0 2
LossOfSignal10Wn_O                   0296 1 2
LossOfSignal11Wn_O                   0296 2 2
LossOfSignal12Wn_O                   0296 3 2
LossOfSignal13Wn_O                   0296 4 2
LossOfSignal14Wn_O                   0296 5 2
LossOfSignal15Wn_O                   0296 6 2
LossOfSignal16Wn_O                   0296 7 2

LossOfSignal17Wn_O                   0297 0 2
LossOfSignal18Wn_O                   0297 1 2
LossOfSignal19Wn_O                   0297 2 2
LossOfSignal20Wn_O                   0297 3 2
LossOfSignal21Wn_O                   0297 4 2
LossOfSignal22Wn_O                   0297 5 2
LossOfSignal23Wn_O                   0297 6 2
LossOfSignal24Wn_O                   0297 7 2

! Sets loss of user fault 1 - 64 as an alarm
UserFault1Wn_O                       0298 0 2
UserFault2Wn_O                       0298 1 2
UserFault3Wn_O                       0298 2 2
UserFault4Wn_O                       0298 3 2
UserFault5Wn_O                       0298 4 2
UserFault6Wn_O                       0298 5 2
UserFault7Wn_O                       0298 6 2
UserFault8Wn_O                       0298 7 2

UserFault9Wn_O                       0299 0 2
UserFault10Wn_O                      0299 1 2
UserFault11Wn_O                      0299 2 2
UserFault12Wn_O                      0299 3 2
UserFault13Wn_O                      0299 4 2
UserFault14Wn_O                      0299 5 2
UserFault15Wn_O                      0299 6 2
UserFault16Wn_O                      0299 7 2

UserFault17Wn_O                      029A 0 2
UserFault18Wn_O                      029A 1 2
UserFault19Wn_O                      029A 2 2
UserFault20Wn_O                      029A 3 2
UserFault21Wn_O                      029A 4 2
UserFault22Wn_O                      029A 5 2
UserFault23Wn_O                      029A 6 2
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UserFault24Wn_O	029A 7 2	
UserFault25Wn_O	029B 0 2	
UserFault26Wn_O	029B 1 2	
UserFault27Wn_O	029B 2 2	
UserFault28Wn_O	029B 3 2	Asco Switch on Alternate (28)
UserFault29Wn_O	029B 4 2	UPS is on inverter (29)
UserFault30Wn_O	029B 5 2	UPS Alarm (30)
UserFault31Wn_O	029B 6 2	Sync Motor Exciter OT fault (31)
UserFault32Wn_O	029B 7 2	Sync Motor Loss of Exciter (32)
UserFault33Wn_O	029C 0 2	Sync Motor Exciter Fault (33)
UserFault34Wn_O	029C 1 2	Pump One Loss of power alarm (34)
UserFault35Wn_O	029C 2 2	Pump One TOL alarm (35)
UserFault36Wn_O	029C 3 2	Pump Two Loss of power alarm (36)
UserFault37Wn_O	029C 4 2	Pump One TOL alarm (37)
UserFault38Wn_O	029C 5 2	Estop Alarm for logging (38)
UserFault39Wn_O	029C 6 2	Multilin Fault of Drive (39)
UserFault40Wn_O	029C 7 2	Avail Volts below rated alarm (40)
UserFault41Wn_O	029D 0 2	Cell Cabinet Column 2 Ambient alarm (50 Deg) (41)
UserFault42Wn_O	029D 1 2	Cell Cabinet Column 2 Ambient fault (60 Deg) (42)
UserFault43Wn_O	029D 2 2	Cell Cabinet Column 4 Ambient alarm (50 Deg) (43)
UserFault44Wn_O	029D 3 2	Cell Cabinet Column 4 Ambient fault (60 Deg) (44)
UserFault45Wn_O	029D 4 2	Transformer Left side Ambient alarm (60 Deg) (45)
UserFault46Wn_O	029D 5 2	Transformer Left side Ambient fault (70 Deg) (46)
UserFault47Wn_O	029D 6 2	Transformer Right side Ambient alarm (60 Deg) (47)
UserFault48Wn_O	029D 7 2	Transformer Right side Ambient fault (70 Deg) (48)
UserFault49Wn_O	029E 0 2	Hex Fans Power Failed (49)
UserFault50Wn_O	029E 1 2	Transformer OT Alarm (> 65 deg) (50)
UserFault51Wn_O	029E 2 2	Coolant Outlet OT Fault (> 70 deg) (51)
UserFault52Wn_O	029E 3 2	Low, Low Coolant Level (> 20") (52)
UserFault53Wn_O	029E 4 2	High Conductivity Trip (> 5uS) (53)
UserFault54Wn_O	029E 5 2	Coolant Inlet Temp above 55 deg C (54)
UserFault55Wn_O	029E 6 2	Pump #1 Failed (55)
UserFault56Wn_O	029E 7 2	Pump #2 Failed (56)
UserFault57Wn_O	029F 0 2	Both Cooling Pumps Failed (57)
UserFault58Wn_O	029F 1 2	Cooling Ot Trip Alarm (set true) (58)
UserFault59Wn_O	029F 2 2	Cooling Ot Vfd Trip (set false - default) (59)
UserFault60Wn_O	029F 3 2	Cooling Ot Mv Trip (set false - default) (60)
UserFault61Wn_O	029F 4 2	Coolant Outlet Temperature Alarm (65 Deg C) (61)
UserFault62Wn_O	029F 5 2	Cooling Sys Vfd Trip (set false - default) (62)
UserFault63Wn_O	029F 6 2	Cooling Sys Mv Trip (set false - default) (63)
UserFault64Wn_O	029F 7 2	MV Input Protection Latched Fault (set false - default) (64)
OneBlowerLost_O	02A0 0 2	Set to trigger a single blower loss condition
AllBlowerLost_O	02A0 1 2	Set to trigger all of the blowers loss condition
CloggedFilters_O	02A0 2 2	Set to trigger a filter is clogged (blocked) condition
ReactorTemperature1_O	02A0 3 2	Set to trigger reactor temperature #1 condition
ReactorTemperature2_O	02A0 4 2	Set to trigger reactor temperature #2 condition
ReactorTemperatureFault_O	02A0 5 2	Set to trigger reactor temperature fault condition
XformerOverTempAlarm1_O	02A0 6 2	Set to trigger transformer over temperature #1 condition
XformerOverTempAlarm2_O	02A0 7 2	Set to trigger transformer over temperature #2 condition
XformerOverTempFault_O	02A1 0 2	Set to trigger transformer over temperature fault condition
OnePumpFailure_O	02A1 1 2	Set to trigger a single pump failure condition
AllPumpsFailure_O	02A1 2 2	Set to trigger all of the pumps failure condition
CoolantConductivityAlarm_O	02A1 3 2	Set to trigger the coolant conductivity alarm condition
CoolantConductivityFault_O	02A1 4 2	Set to trigger the coolant conductivity fault condition
InletWaterTempHigh_O	02A1 5 2	Set to trigger the inlet water temperature high condition
InletWaterTempLow_O	02A1 6 2	Set to trigger the inlet water temperature low condition
CellWaterTempHigh_O	02A1 7 2	Set to trigger the cell water temperature high condition
XformerWaterTempHigh_O	02A2 0 2	Set to trigger the transformer water temperature high condition
LowWaterLevelAlarm_O	02A2 1 2	Set to trigger a low water level alarm condition
LowWaterLevelFault_O	02A2 2 2	Set to trigger a low water level fault condition
LowWaterFlowAlarm_O	02A2 3 2	Set to trigger a low water flow alarm condition
LowWaterFlowFault_O	02A2 4 2	Set to trigger a low water flow fault condition

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LossOneHexFan_O	02A2 5 2	Set to trigger that one hex fan loss condition
LossAllHexFan_O	02A2 6 2	Set to trigger that all hex fan loss condition
AllHexFansOn_O	02A2 7 2	Set to trigger that all hex fan are on condition
unused2Fault2B0_O	02A3 0 2	
unused2Fault2B1_O	02A3 1 2	
unused2Fault2B2_O	02A3 2 2	
unused2Fault2B3_O	02A3 3 2	
unused2Fault2B4_O	02A3 4 2	
unused2Fault2B5_O	02A3 5 2	
unused2Fault2B6_O	02A3 6 2	
unused2Fault2B7_O	02A3 7 2	
unused2Fault3A0_O	02A4 0 2	
unused2Fault3A1_O	02A4 1 2	
unused2Fault3A2_O	02A4 2 2	
unused2Fault3A3_O	02A4 3 2	
unused2Fault3A4_O	02A4 4 2	
unused2Fault3A5_O	02A4 5 2	
unused2Fault3A6_O	02A4 6 2	
UserFault1_O	02A8 0 2	User fault flags 1-64, set true to generate a fault
UserFault2_O	02A8 1 2	
UserFault3_O	02A8 2 2	
UserFault4_O	02A8 3 2	
UserFault5_O	02A8 4 2	
UserFault6_O	02A8 5 2	
UserFault7_O	02A8 6 2	
UserFault8_O	02A8 7 2	
UserFault9_O	02A9 0 2	
UserFault10_O	02A9 1 2	
UserFault11_O	02A9 2 2	
UserFault12_O	02A9 3 2	
UserFault13_O	02A9 4 2	
UserFault14_O	02A9 5 2	
UserFault15_O	02A9 6 2	
UserFault16_O	02A9 7 2	
UserFault17_O	02AA 0 2	
UserFault18_O	02AA 1 2	
UserFault19_O	02AA 2 2	
UserFault20_O	02AA 3 2	
UserFault21_O	02AA 4 2	
UserFault22_O	02AA 5 2	
UserFault23_O	02AA 6 2	
UserFault24_O	02AA 7 2	
UserFault25_O	02AB 0 2	
UserFault26_O	02AB 1 2	
UserFault27_O	02AB 2 2	
UserFault28_O	02AB 3 2	Asco Switch on Alternate (28)
UserFault29_O	02AB 4 2	UPS is on inverter (29)
UserFault30_O	02AB 5 2	UPS Alarm (30)
UserFault31_O	02AB 6 2	Sync Motor Exciter OT fault (31)
UserFault32_O	02AB 7 2	Sync Motor Loss of Exciter (32)
UserFault33_O	02AC 0 2	Sync Motor Exciter Fault (33)
UserFault34_O	02AC 1 2	Pump One Loss of power alarm (34)
UserFault35_O	02AC 2 2	Pump One TOL alarm (35)
UserFault36_O	02AC 3 2	Pump Two Loss of power alarm (36)
UserFault37_O	02AC 4 2	Pump One TOL alarm (37)
UserFault38_O	02AC 5 2	Estop Alarm for logging (38)
UserFault39_O	02AC 6 2	Multilin Fault of Drive (39)
UserFault40_O	02AC 7 2	Avail Volts below rated alarm (40)
UserFault41_O	02AD 0 2	Cell Cabinet Column 2 Ambient alarm (50 Deg) (41)
UserFault42_O	02AD 1 2	Cell Cabinet Column 2 Ambient fault (60 Deg) (42)
UserFault43_O	02AD 2 2	Cell Cabinet Column 4 Ambient alarm (50 Deg) (43)
UserFault44_O	02AD 3 2	Cell Cabinet Column 4 Ambient fault (60 Deg) (44)
UserFault45_O	02AD 4 2	Transformer Left side Ambient alarm (60 Deg) (45)
UserFault46_O	02AD 5 2	Transformer Left side Ambient fault (70 Deg) (46)

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UserFault47_O                   02AD 6 2       Transformer Right side Ambient alarm (60 Deg) (47)
UserFault48_O                   02AD 7 2       Transformer Right side Ambient fault (70 Deg) (48)

UserFault49_O                   02AE 0 2       Hex Fans Power Failed (49)
UserFault50_O                   02AE 1 2       Transformer OT Alarm (> 65 deg) (50)
UserFault51_O                   02AE 2 2       Coolant Outlet OT Fault (> 70 deg) (51)
UserFault52_O                   02AE 3 2       Low, Low Coolant Level (> 20") (52)
UserFault53_O                   02AE 4 2       High Conductivity Fault (> 5uS) (53)
UserFault54_O                   02AE 5 2       Coolant Inlet Temp above 55 deg C (54)
UserFault55_O                   02AE 6 2       Pump #1 Failed (55)
UserFault56_O                   02AE 7 2       Pump #2 Failed (56)

UserFault57_O                   02AF 0 2       Both Cooling Pumps Failed (57)
UserFault58_O                   02AF 1 2       Cooling Ot Trip Alarm (58)
UserFault59_O                   02AF 2 2       Cooling Ot Vfd Trip (59)
UserFault60_O                   02AF 3 2       Cooling Ot Mv Trip (60)
UserFault61_O                   02AF 4 2       Coolant Outlet Temperature Alarm (65 Deg C) (61)
UserFault62_O                   02AF 5 2       Cooling Sys Vfd Trip (62)
UserFault63_O                   02AF 6 2       Cooling Sys Mv Trip (63)
UserFault64_O                   02AF 7 2       MV Input Protection latched fault (64)

!********* end 64 bit fault words *******

SerialFlag0_O                   02B0 0 2       Serial flags that can be used to indicate condition too
networks 0-63
SerialFlag1_O                   02B0 1 2
SerialFlag2_O                   02B0 2 2
SerialFlag3_O                   02B0 3 2
SerialFlag4_O                   02B0 4 2
SerialFlag5_O                   02B0 5 2
SerialFlag6_O                   02B0 6 2
SerialFlag7_O                   02B0 7 2
SerialFlag8_O                   02B1 0 2
SerialFlag9_O                   02B1 1 2
SerialFlag10_O                  02B1 2 2
SerialFlag11_O                  02B1 3 2
SerialFlag12_O                  02B1 4 2
SerialFlag13_O                  02B1 5 2
SerialFlag14_O                  02B1 6 2
SerialFlag15_O                  02B1 7 2

SerialFlag16_O                  02B2 0 2
SerialFlag17_O                  02B2 1 2
SerialFlag18_O                  02B2 2 2
SerialFlag19_O                  02B2 3 2
SerialFlag20_O                  02B2 4 2
SerialFlag21_O                  02B2 5 2
SerialFlag22_O                  02B2 6 2
SerialFlag23_O                  02B2 7 2
SerialFlag24_O                  02B3 0 2
SerialFlag25_O                  02B3 1 2
SerialFlag26_O                  02B3 2 2
SerialFlag27_O                  02B3 3 2
SerialFlag28_O                  02B3 4 2
SerialFlag29_O                  02B3 5 2
SerialFlag30_O                  02B3 6 2
SerialFlag31_O                  02B3 7 2

SerialFlag32_O                  02B4 0 2
SerialFlag33_O                  02B4 1 2
SerialFlag34_O                  02B4 2 2
SerialFlag35_O                  02B4 3 2
SerialFlag36_O                  02B4 4 2
SerialFlag37_O                  02B4 5 2
SerialFlag38_O                  02B4 6 2
SerialFlag39_O                  02B4 7 2
SerialFlag40_O                  02B5 0 2
SerialFlag41_O                  02B5 1 2
SerialFlag42_O                  02B5 2 2
SerialFlag43_O                  02B5 3 2
SerialFlag44_O                  02B5 4 2
SerialFlag45_O                  02B5 5 2
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SerialFlag46_O              02B5 6 2
SerialFlag47_O              02B5 7 2

SerialFlag48_O              02B6 0 2
SerialFlag49_O              02B6 1 2
SerialFlag50_O              02B6 2 2
SerialFlag51_O              02B6 3 2
SerialFlag52_O              02B6 4 2
SerialFlag53_O              02B6 5 2
SerialFlag54_O              02B6 6 2
SerialFlag55_O              02B6 7 2
SerialFlag56_O              02B7 0 2
SerialFlag57_O              02B7 1 2
SerialFlag58_O              02B7 2 2
SerialFlag59_O              02B7 3 2
SerialFlag60_O              02B7 4 2
SerialFlag61_O              02B7 5 2
SerialFlag62_O              02B7 6 2
SerialFlag63_O              02B7 7 2

!********** Network1 Input Flags
Network1Flag0_I             02B8 0 9       Network 1 input flags 0-63 from an external network
Network1Flag1_I             02B8 1 9
Network1Flag2_I             02B8 2 9
Network1Flag3_I             02B8 3 9
Network1Flag4_I             02B8 4 9
Network1Flag5_I             02B8 5 9
Network1Flag6_I             02B8 6 9
Network1Flag7_I             02B8 7 9

Network1Flag8_I             02B9 0 9
Network1Flag9_I             02B9 1 9
Network1Flag10_I            02B9 2 9
Network1Flag11_I            02B9 3 9
Network1Flag12_I            02B9 4 9
Network1Flag13_I            02B9 5 9
Network1Flag14_I            02B9 6 9
Network1Flag15_I            02B9 7 9

Network1Flag16_I            02BA 0 9
Network1Flag17_I            02BA 1 9
Network1Flag18_I            02BA 2 9
Network1Flag19_I            02BA 3 9
Network1Flag20_I            02BA 4 9
Network1Flag21_I            02BA 5 9
Network1Flag22_I            02BA 6 9
Network1Flag23_I            02BA 7 9

Network1Flag24_I            02BB 0 9
Network1Flag25_I            02BB 1 9
Network1Flag26_I            02BB 2 9
Network1Flag27_I            02BB 3 9
Network1Flag28_I            02BB 4 9
Network1Flag29_I            02BB 5 9
Network1Flag30_I            02BB 6 9
Network1Flag31_I            02BB 7 9

Network1Flag32_I            02BC 0 9
Network1Flag33_I            02BC 1 9
Network1Flag34_I            02BC 2 9
Network1Flag35_I            02BC 3 9
Network1Flag36_I            02BC 4 9
Network1Flag37_I            02BC 5 9
Network1Flag38_I            02BC 6 9
Network1Flag39_I            02BC 7 9

Network1Flag40_I            02BD 0 9
Network1Flag41_I            02BD 1 9
Network1Flag42_I            02BD 2 9
Network1Flag43_I            02BD 3 9
Network1Flag44_I            02BD 4 9
Network1Flag45_I            02BD 5 9
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Network1Flag46_I                    02BD 6 9
Network1Flag47_I                    02BD 7 9

Network1Flag48_I                    02BE 0 9
Network1Flag49_I                    02BE 1 9
Network1Flag50_I                    02BE 2 9
Network1Flag51_I                    02BE 3 9
Network1Flag52_I                    02BE 4 9
Network1Flag53_I                    02BE 5 9
Network1Flag54_I                    02BE 6 9
Network1Flag55_I                    02BE 7 9

Network1Flag56_I                    02BF 0 9
Network1Flag57_I                    02BF 1 9
Network1Flag58_I                    02BF 2 9
Network1Flag59_I                    02BF 3 9        VFD Contactor Closed Acknowledge (59)
Network1Flag60_I                    02BF 4 9        Line Contactor Closed Acknowledge (60)
Network1Flag61_I                    02BF 5 9        Up Transfer Request (61)
Network1Flag62_I                    02BF 6 9        Down Transfer Request (62)
Network1Flag63_I                    02BF 7 9        Transfer Fault Reset (63)

!********** Network2 Input Flags
Network2Flag0_I                     02C0 0 9        Network 2 input flags 0-63 from an external network
Network2Flag1_I                     02C0 1 9
Network2Flag2_I                     02C0 2 9
Network2Flag3_I                     02C0 3 9
Network2Flag4_I                     02C0 4 9
Network2Flag5_I                     02C0 5 9
Network2Flag6_I                     02C0 6 9
Network2Flag7_I                     02C0 7 9

Network2Flag8_I                     02C1 0 9
Network2Flag9_I                     02C1 1 9
Network2Flag10_I                    02C1 2 9
Network2Flag11_I                    02C1 3 9
Network2Flag12_I                    02C1 4 9
Network2Flag13_I                    02C1 5 9
Network2Flag14_I                    02C1 6 9
Network2Flag15_I                    02C1 7 9

Network2Flag16_I                    02C2 0 9
Network2Flag17_I                    02C2 1 9
Network2Flag18_I                    02C2 2 9
Network2Flag19_I                    02C2 3 9
Network2Flag20_I                    02C2 4 9
Network2Flag21_I                    02C2 5 9
Network2Flag22_I                    02C2 6 9
Network2Flag23_I                    02C2 7 9

Network2Flag24_I                    02C3 0 9
Network2Flag25_I                    02C3 1 9
Network2Flag26_I                    02C3 2 9
Network2Flag27_I                    02C3 3 9
Network2Flag28_I                    02C3 4 9
Network2Flag29_I                    02C3 5 9
Network2Flag30_I                    02C3 6 9
Network2Flag31_I                    02C3 7 9

Network2Flag32_I                    02C4 0 9
Network2Flag33_I                    02C4 1 9
Network2Flag34_I                    02C4 2 9
Network2Flag35_I                    02C4 3 9
Network2Flag36_I                    02C4 4 9
Network2Flag37_I                    02C4 5 9
Network2Flag38_I                    02C4 6 9
Network2Flag39_I                    02C4 7 9

Network2Flag40_I                    02C5 0 9
Network2Flag41_I                    02C5 1 9
Network2Flag42_I                    02C5 2 9
Network2Flag43_I                    02C5 3 9
Network2Flag44_I                    02C5 4 9
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Network2Flag45_I                    02C5 5 9
Network2Flag46_I                    02C5 6 9
Network2Flag47_I                    02C5 7 9

Network2Flag48_I                    02C6 0 9
Network2Flag49_I                    02C6 1 9
Network2Flag50_I                    02C6 2 9
Network2Flag51_I                    02C6 3 9
Network2Flag52_I                    02C6 4 9
Network2Flag53_I                    02C6 5 9
Network2Flag54_I                    02C6 6 9
Network2Flag55_I                    02C6 7 9

Network2Flag56_I                    02C7 0 9
Network2Flag57_I                    02C7 1 9
Network2Flag58_I                    02C7 2 9
Network2Flag59_I                    02C7 3 9
Network2Flag60_I                    02C7 4 9
Network2Flag61_I                    02C7 5 9
Network2Flag62_I                    02C7 6 9
Network2Flag63_I                    02C7 7 9

!********** Network1 Output Flags
Network1Flag0_O                     02C8 0 12        Network 1 output flags 0-63 to an external network
Network1Flag1_O                     02C8 1 12
Network1Flag2_O                     02C8 2 12
Network1Flag3_O                     02C8 3 12
Network1Flag4_O                     02C8 4 12
Network1Flag5_O                     02C8 5 12
Network1Flag6_O                     02C8 6 12
Network1Flag7_O                     02C8 7 12

Network1Flag8_O                     02C9 0 12
Network1Flag9_O                     02C9 1 12
Network1Flag10_O                    02C9 2 12
Network1Flag11_O                    02C9 3 12
Network1Flag12_O                    02C9 4 12
Network1Flag13_O                    02C9 5 12
Network1Flag14_O                    02C9 6 12
Network1Flag15_O                    02C9 7 12

Network1Flag16_O                    02CA 0 12
Network1Flag17_O                    02CA 1 12
Network1Flag18_O                    02CA 2 12
Network1Flag19_O                    02CA 3 12
Network1Flag20_O                    02CA 4 12
Network1Flag21_O                    02CA 5 12
Network1Flag22_O                    02CA 6 12
Network1Flag23_O                    02CA 7 12

Network1Flag24_O                    02CB 0 12
Network1Flag25_O                    02CB 1 12
Network1Flag26_O                    02CB 2 12

Network1Flag27_O                    02CB 3 12
Network1Flag28_O                    02CB 4 12
Network1Flag29_O                    02CB 5 12
Network1Flag30_O                    02CB 6 12
Network1Flag31_O                    02CB 7 12

Network1Flag32_O                    02CC 0 12
Network1Flag33_O                    02CC 1 12
Network1Flag34_O                    02CC 2 12
Network1Flag35_O                    02CC 3 12
Network1Flag36_O                    02CC 4 12
Network1Flag37_O                    02CC 5 12
Network1Flag38_O                    02CC 6 12
Network1Flag39_O                    02CC 7 12

Network1Flag40_O                    02CD 0 12
Network1Flag41_O                    02CD 1 12
Network1Flag42_O                    02CD 2 12
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Network1Flag43_O                02CD 3 12
Network1Flag44_O                02CD 4 12
Network1Flag45_O                02CD 5 12
Network1Flag46_O                02CD 6 12
Network1Flag47_O                02CD 7 12

Network1Flag48_O                02CE 0 12
Network1Flag49_O                02CE 1 12
Network1Flag50_O                02CE 2 12
Network1Flag51_O                02CE 3 12
Network1Flag52_O                02CE 4 12
Network1Flag53_O                02CE 5 12
Network1Flag54_O                02CE 6 12
Network1Flag55_O                02CE 7 12

Network1Flag56_O                02CF 0 12
Network1Flag57_O                02CF 1 12
Network1Flag58_O                02CF 2 12      Drive producing torque - Ok to drop line contactor (58)
Network1Flag59_O                02CF 3 12      Initiate Up Transfer (59)
Network1Flag60_O                02CF 4 12      Up Transfer Complete (60)
Network1Flag61_O                02CF 5 12      Initiate Down Transfer (61)
Network1Flag62_O                02CF 6 12      Down Transfer Complete (62)
Network1Flag63_O                02CF 7 12      Command to remove MV Input power (63)

!********** Network2 Output Flags
Network2Flag0_O                 02D0 0 12       Network 2 output flags 0-63 to an external network
Network2Flag1_O                 02D0 1 12
Network2Flag2_O                 02D0 2 12
Network2Flag3_O                 02D0 3 12
Network2Flag4_O                 02D0 4 12
Network2Flag5_O                 02D0 5 12
Network2Flag6_O                 02D0 6 12
Network2Flag7_O                 02D0 7 12

Network2Flag8_O                 02D1 0 12
Network2Flag9_O                 02D1 1 12
Network2Flag10_O                02D1 2 12
Network2Flag11_O                02D1 3 12
Network2Flag12_O                02D1 4 12
Network2Flag13_O                02D1 5 12
Network2Flag14_O                02D1 6 12
Network2Flag15_O                02D1 7 12

Network2Flag16_O                02D2 0 12
Network2Flag17_O                02D2 1 12
Network2Flag18_O                02D2 2 12
Network2Flag19_O                02D2 3 12
Network2Flag20_O                02D2 4 12
Network2Flag21_O                02D2 5 12
Network2Flag22_O                02D2 6 12
Network2Flag23_O                02D2 7 12

Network2Flag24_O                02D3 0 12
Network2Flag25_O                02D3 1 12
Network2Flag26_O                02D3 2 12
Network2Flag27_O                02D3 3 12
Network2Flag28_O                02D3 4 12
Network2Flag29_O                02D3 5 12
Network2Flag30_O                02D3 6 12
Network2Flag31_O                02D3 7 12

Network2Flag32_O                02D4 0 12
Network2Flag33_O                02D4 1 12
Network2Flag34_O                02D4 2 12
Network2Flag35_O                02D4 3 12
Network2Flag36_O                02D4 4 12
Network2Flag37_O                02D4 5 12
Network2Flag38_O                02D4 6 12
Network2Flag39_O                02D4 7 12

Network2Flag40_O                02D5 0 12
Network2Flag41_O                02D5 1 12
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Network2Flag42_O               02D5 2 12
Network2Flag43_O               02D5 3 12
Network2Flag44_O               02D5 4 12
Network2Flag45_O               02D5 5 12
Network2Flag46_O               02D5 6 12
Network2Flag47_O               02D5 7 12

Network2Flag48_O               02D6 0 12
Network2Flag49_O               02D6 1 12
Network2Flag50_O               02D6 2 12
Network2Flag51_O               02D6 3 12
Network2Flag52_O               02D6 4 12
Network2Flag53_O               02D6 5 12
Network2Flag54_O               02D6 6 12
Network2Flag55_O               02D6 7 12

Network2Flag56_O               02D7 0 12
Network2Flag57_O               02D7 1 12
Network2Flag58_O               02D7 2 12
Network2Flag59_O               02D7 3 12
Network2Flag60_O               02D7 4 12
Network2Flag61_O               02D7 5 12
Network2Flag62_O               02D7 6 12
Network2Flag63_O               02D7 7 12

StaticFlag01_O                 02D8 0 1        Static Flags stored in battery backed RAM (16 total)
StaticFlag02_O                 02D9 0 1
StaticFlag03_O                 02DA 0 1
StaticFlag04_O                 02DB 0 1
StaticFlag05_O                 02DC 0 1
StaticFlag06_O                 02DD 0 1
StaticFlag07_O                 02DE 0 1
StaticFlag08_O                 02DF 0 1
StaticFlag09_O                 02E0 0 1
StaticFlag10_O                 02E1 0 1
StaticFlag11_O                 02E2 0 1
StaticFlag12_O                 02E3 0 1
StaticFlag13_O                 02E4 0 1
StaticFlag14_O                 02E5 0 1
StaticFlag15_O                 02E6 0 1
StaticFlag16_O                 02E7 0 1

MediumVoltageAvailable_I       02E8 0 15       Indicates medium voltage is available
AutoFaultResetInProgress_I     02E9 0 15       Indicates an Auto Fault Reset is in progress

LossOfSignalFlag1_I            02EA 0 15       Loss of signal indicator flags 28
LossOfSignalFlag2_I            02EB 0 15
LossOfSignalFlag3_I            02EC 0 15
LossOfSignalFlag4_I            02ED 0 15
LossOfSignalFlag5_I            02EE 0 15
LossOfSignalFlag6_I            02EF 0 15
LossOfSignalFlag7_I            02F0 0 15
LossOfSignalFlag8_I            02F1 0 15
LossOfSignalFlag9_I            02F2 0 15
LossOfSignalFlag10_I           02F3 0 15
LossOfSignalFlag11_I           02F4 0 15
LossOfSignalFlag12_I           02F5 0 15
LossOfSignalFlag13_I           02F6 0 15
LossOfSignalFlag14_I           02F7 0 15
LossOfSignalFlag15_I           02F8 0 15
LossOfSignalFlag16_I           02F9 0 15
LossOfSignalFlag17_I           02FA 0 15
LossOfSignalFlag18_I           02FB 0 15
LossOfSignalFlag19_I           02FC 0 15
LossOfSignalFlag20_I           02FD 0 15
LossOfSignalFlag21_I           02FE 0 15
LossOfSignalFlag22_I           02FF 0 15
LossOfSignalFlag23_I           0300 0 15
LossOfSignalFlag24_I           0301 0 15


Comparator17_I                 0302 0 15      Comparators 17 - 32
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Comparator18_I                0303 0 15
Comparator19_I                0304 0 15
Comparator20_I                0305 0 15
Comparator21_I                0306 0 15
Comparator22_I                0307 0 15
Comparator23_I                0308 0 15
Comparator24_I                0309 0 15
Comparator25_I                030A 0 15
Comparator26_I                030B 0 15
Comparator27_I                030C 0 15
Comparator28_I                030D 0 15
Comparator29_I                030E 0 15
Comparator30_I                030F 0 15
Comparator31_I                0310 0 15
Comparator32_I                0311 0 15

ConfigFileXferComplete_I      0312 0 15       Transfer of config file completed.

!Spare0313                                0313 0 1         Skipped 0313 to align data on word boundary

InternalDigitalInput1_I       0314 0 11Internal Digital Inputs on System I/O board (20)
InternalDigitalInput2_I       0314 1 11
InternalDigitalInput3_I       0314 2 11
InternalDigitalInput4_I       0314 3 11
InternalDigitalInput5_I       0314 4 11
InternalDigitalInput6_I       0314 5 11
InternalDigitalInput7_I       0314 6 11
InternalDigitalInput8_I       0314 7 11
InternalDigitalInput9_I       0315 0 11
InternalDigitalInput10_I      0315 1 11
InternalDigitalInput11_I      0315 2 11
InternalDigitalInput12_I      0315 3 11
InternalDigitalInput13_I      0315 4 11
InternalDigitalInput14_I      0315 5 11
InternalDigitalInput15_I      0315 6 11
InternalDigitalInput16_I      0315 7 11
InternalDigitalInput17_I      0318 0 11
InternalDigitalInput18_I      0318 1 11
InternalDigitalInput19_I      0318 2 11
InternalDigitalInput20_I      0318 3 11


InternalDigitalOutput1_O      0316 0 12Internal Digital Outputs on System I/O board (16)
InternalDigitalOutput2_O      0316 1 12
InternalDigitalOutput3_O      0316 2 12
InternalDigitalOutput4_O      0316 3 12
InternalDigitalOutput5_O      0316 4 12
InternalDigitalOutput6_O      0316 5 12
InternalDigitalOutput7_O      0316 6 12
InternalDigitalOutput8_O      0316 7 12
InternalDigitalOutput9_O      0317 0 12
InternalDigitalOutput10_O     0317 1 12
InternalDigitalOutput11_O     0317 2 12
InternalDigitalOutput12_O     0317 3 12
InternalDigitalOutput13_O     0317 4 12
InternalDigitalOutput14_O     0317 5 12
InternalDigitalOutput15_O     0317 6 12
InternalDigitalOutput16_O     0317 7 12

!********** Fault4 Word1a
InternalLossOfSignal1_I       031A 0 9        System I/O board loss of analog input 1
InternalLossOfSignal2_I       031A 1 9System I/O board loss of analog input 2
InternalLossOfSignal3_I       031A 2 9System I/O board loss of analog input 3

!********** Fault4 Enable
InternalLossOfSignal1En_O    0322 0 2       Enables system I/O board loss of signal alarm/fault for analog
inputs 1
InternalLossOfSignal2En_O    0322 1 2       Enables system I/O board loss of signal alarm/fault for analog
inputs 1
InternalLossOfSignal3En_O    0322 2 2       Enables system I/O board loss of signal alarm/fault for analog
inputs 1
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!********** Fault4 Alarms
InternalLossOfSignal1Wn_O          032A 0 2Sets system I/O board loss of signal analog input 1 as an alarm
InternalLossOfSignal2Wn_O          032A 1 2Sets system I/O board loss of signal analog input 1 as an alarm
InternalLossOfSignal3Wn_O          032A 2 2Sets system I/O board loss of signal analog input 1 as an alarm

!********** Fault4 Outputs
unused4Fault1A0_O                  0332 0 2
unused4Fault1A1_O                  0332 1 2
unused4Fault1A2_O                  0332 2 2

!   User Text
UserText1                         D000 0  250      User text messages strings 1-64 (maximum string length is 24)
UserText2                          D000 1  250
UserText3                          D000 2  250
UserText4                          D000 3  250
UserText5                          D000 4  250
UserText6                          D000 5  250
UserText7                          D000 6  250
UserText8                          D000 7  250
UserText9                          D000 8  250
UserText10                         D000 9  250
UserText11                         D000 10 250
UserText12                         D000 11 250
UserText13                         D000 12 250
UserText14                         D000 13 250
UserText15                         D000 14 250
UserText16                         D000 15 250

UserText17                         D002 0  250
UserText18                         D002 1  250
UserText19                         D002 2  250
UserText20                         D002 3  250
UserText21                         D002 4  250
UserText22                         D002 5  250
UserText23                         D002 6  250
UserText24                         D002 7  250
UserText25                         D002 8  250
UserText26                         D002 9  250
UserText27                         D002 10 250
UserText28                         D002 11 250     Asco Switch on Alternate (28)
UserText29                         D002 12 250     UPS is on inverter (29)
UserText30                         D002 13 250     UPS Alarm (30)
UserText31                         D002 14 250     Sync Motor Exciter OT fault (31)
UserText32                         D002 15 250     Sync Motor Loss of Exciter (32)

UserText33                         D004 0  250     Sync Motor Exciter Fault (33)
UserText34                         D004 1  250     Pump One Loss of power alarm (34)
UserText35                         D004 2  250     Pump One TOL alarm (35)
UserText36                         D004 3  250     Pump Two Loss of power alarm (36)
UserText37                         D004 4  250     Pump One TOL alarm (37)
UserText38                         D004 5  250     Estop Alarm for logging (38)
UserText39                         D004 6  250     Multilin Fault of Drive (39)
UserText40                         D004 7  250     Avail Volts below rated alarm (40)
UserText41                         D004 8  250     Cell Cabinet Column 2 Ambient alarm (50 Deg) (41)
UserText42                         D004 9  250     Cell Cabinet Column 2 Ambient fault (60 Deg) (42)
UserText43                         D004 10 250     Cell Cabinet Column 4 Ambient alarm (50 Deg) (43)
UserText44                         D004 11 250     Cell Cabinet Column 4 Ambient fault (60 Deg) (44)
UserText45                         D004 12 250     Transformer Left side Ambient alarm (60 Deg) (45)
UserText46                         D004 13 250     Transformer Left side Ambient fault (70 Deg) (46)
UserText47                         D004 14 250     Transformer Right side Ambient alarm (60 Deg) (47)
UserText48                         D004 15 250     Transformer Right side Ambient fault (70 Deg) (48)

UserText49                         D006 0  250     Hex Fans Power Failed (49)
UserText50                         D006 1  250     Transformer OT Alarm (> 65 deg) (50)
UserText51                         D006 2  250     Coolant Outlet OT Fault (> 70 deg) (51)
UserText52                         D006 3  250     Low, Low Coolant Level (> 20") (52)
UserText53                         D006 4  250     High Conductivity Fault (> 5uS) (53)
UserText54                         D006 5  250     Coolant Flow is below 20% (54)
UserText55                         D006 6  250     Pump #1 Failed (55)
UserText56                         D006 7  250     Pump #2 Failed (56)
UserText57                         D006 8  250     Both Cooling Pumps Failed (57)
UserText58                         D006 9  250     Cooling Ot Trip Alarm (58)
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UserText59                    D006 10 250    Cooling Ot Vfd Trip (59)
UserText60                    D006 11 250    Cooling Ot Mv Trip (60)
UserText61                    D006 12 250    Coolant Outlet Temperature Alarm (65 Deg C) (61)
UserText62                    D006 13 250    Cooling Sys Vfd Trip (62)
UserText63                    D006 14 250    Cooling Sys Mv Trip (63)
UserText64                    D006 15 250    Input Protection Fault (64)


Timer00                       E000 0 5       Timers 0-31
Timer01                       E001 0 5
Timer02                       E002 0 5
Timer03                       E003 0 5
Timer04                       E004 0 5
Timer05                       E005 0 5
Timer06                       E006 0 5
Timer07                       E007 0 5
Timer08                       E008 0 5
Timer09                       E009 0 5
Timer10                       E00A 0 5
Timer11                       E00B 0 5
Timer12                       E00C 0 5
Timer13                       E00D 0 5
Timer14                       E00E 0 5
Timer15                       E00F 0 5
Timer16                       E010 0 5
Timer17                       E011 0 5
Timer18                       E012 0 5
Timer19                       E013 0 5
Timer20                       E014 0 5       Debounces the pump one hand position (20)
Timer21                       E015 0 5       Debounces the pump one off position (21)
Timer22                       E016 0 5       Debounces the pump two hand position (22)
Timer23                       E017 0 5       Debounces the pump two off position (23)
Timer24                       E018 0 5       Debounces the comparitor setting for Analog Outlet Temp (65
deg C)(24)
Timer25                       E019 0 5       Inlet temperature comparitor debounce (55 deg C) (25)
Timer26                       E01A 0 5       Pump 1 Flow Mask Timer (26)
Timer27                       E01B 0 5       Pump 2 Flow Mask Timer (27)
Timer28                       E01C 0 5       Coolant Low Level Debounce (28)
Timer29                       E01D 0 5       Coolant Low Low Level Debounce (29)
Timer30                       E01E 0 5       1 minute conductivity change rate timer (30)
Timer31                       E01F 0 5       Resets the IOC auto reset permissive after this window (31)

Timer32                       E020 0 5       Delay on drop-out of Pump 1 run command (32)
Timer33                       E021 0 5       Delay on drop-out of Pump 2 run command (33)
Timer34                       E022 0 5       Debounce for Pump 1 Loss of Power (34)
Timer35                       E023 0 5       Debounce for Pump 1 TOL (35)
Timer36                       E024 0 5       Debounce for Pump 2 Loss of Power (36)
Timer37                       E025 0 5       Debounce for Pump 1 TOL (37)
Timer38                       E026 0 5       Time Delay before OT VFD trip (38)
Timer39                       E027 0 5       Time Delay before OT MV trip (39)
Timer40                       E028 0 5       One Hour timer for extended time base (40)
Timer41                       E029 0 5       Timer for drive in torque limit (41)
Timer42                       E02A 0 5       Debounces the Cell Cabinet Ambient Over Temperature Alarm
Switches (42)
Timer43                       E02B 0 5       Debounces the Cell Cabinet Ambient Over Temperature Fault
Switches (43)
Timer44                       E02C 0 5       Debounces the Xfmr Cabinet Ambient Over Temperature Alarm
Switches (44)
Timer45                       E02D 0 5       Debounces the Xfmr Cabinet Ambient Over Temperature Trip
Switches (45)
Timer46                       E02E 0 5       Debounces the comparitor input for low temperature (22 deg) (46)
Timer47                       E02F 0 5       Debounces the comparitor setting for Conductivity Alarm level
(47)
Timer48                       E030 0 5       Debounces the comparitor for Drive available volts above rated
(48)
Timer49                       E031 0 5       Debounces the comparitor setting for Conductivity Fault level
(5 uS)(49)
Timer50                       E032 0 5       Debounces the comparitor setting for Analog Inlet Temp (50)
Timer51                       E033 0 5       Debounces the comparitor setting for Analog Coolant Flow
(60%)(51)
Timer52                       E034 0 5       Debounces the comparitor setting for Analog Outlet Temp (82
deg)(52)
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Timer53                             E035 0 5       Slow Leak timer (1 Hour) (53)
Timer54                             E036 0 5       Low Water Flow Alarm Delay Timer (54)
Timer55                             E037 0 5       Input Protection Delay timer (2 minutes) (55)
Timer56                             E038 0 5       Debounces the comparitor setting for Analog Coolant Flow
(20%)(56)
Timer57                             E039 0 5       Input Protection LFR Reset pulse duration timer (57)
Timer58                             E03A 0 5       Input Protection Power On Debounce delay (58)
Timer59                             E03B 0 5       Input Protection LFR Latch pulse duration timer (59)
Timer60                             E03C 0 5       Pump One Flow Timeout Timer (60)
Timer61                             E03D 0 5       Pump Two Flow Timeout Timer (61)
Timer62                             E03E 0 5   Intended for use as a 1 minute timer (toggles) (62)
Timer63                             E03F 0 5   Intended for use as 1 second timer (toggles) (63)

!        Counters 0-63
!        -------------
Counter00                           F000 0 6
Counter01                           F001 0 6
Counter02                           F002 0 6
Counter03                           F003 0 6
Counter04                           F004 0 6
Counter05                           F005 0 6
Counter06                           F006 0 6
Counter07                           F007 0 6
Counter08                           F008 0 6
Counter09                           F009 0 6
Counter10                           F00A 0 6
Counter11                           F00B 0 6
Counter12                           F00C 0 6
Counter13                           F00D 0 6
Counter14                           F00E 0 6
Counter15                           F00F 0 6
Counter16                           F010 0 6
Counter17                           F011 0 6
Counter18                           F012 0 6
Counter19                           F013 0 6
Counter20                           F014 0 6
Counter21                           F015 0 6
Counter22                           F016 0 6
Counter23                           F017 0 6
Counter24                           F018 0 6
Counter25                           F019 0 6
Counter26                           F01A 0 6
Counter27                           F01B 0 6
Counter28                           F01C 0 6
Counter29                           F01D 0 6
Counter30                           F01E 0 6
Counter31                           F01F 0 6

Counter32                           F020 0 6
Counter33                           F021 0 6
Counter34                           F022 0 6
Counter35                           F023 0 6
Counter36                           F024 0 6
Counter37                           F025 0 6
Counter38                           F026 0 6
Counter39                           F027 0 6
Counter40                           F028 0 6
Counter41                           F029 0 6       First Cell Cabinet Blower cycle period (41)
Counter42                           F02A 0 6       Second Cell Cabinet Blower cycle period (42)
Counter43                           F02B 0 6       Third Cell Cabinet Blower cycle period (43)
Counter44                           F02C 0 6       Sync Motor Excitor power fault Counter (44)
Counter45                           F02D 0 6       Sync Motor Excitor field loss fault counter (45)
Counter46                           F02E 0 6       Synch Motor Exciter Enable (46)
Counter47                           F02F 0 6       Run Request (47)
Counter48                           F030 0 6       Latches input for increment or decrement (48)
Counter49                           F031 0 6       Local Speed Command Select (49)
Counter50                           F032 0 6       Cooling System OT MV Trip Latch (50)
Counter51                           F033 0 6       Permits one IOC reset within a window (51)
Counter52                           F034 0 6       Cooling System OT VFD Trip Latch (52)
Counter53                           F035 0 6       Pump #1 Failure latch (53)
Counter54                           F036 0 6       Pump #2 Failure latch (54)
Counter55                           F037 0 6       IP LFR Reset pulse End (55)
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Counter56                    F038 0 6      IP LFR Latch pulse enable (56)
Counter57                    F039 0 6      IP LFR latch pulse End (57)
Counter58                    F03A 0 6      Input Protection latching pulse memory (58)
Counter59                    F03B 0 6      Key Reset Push Button Release detector (59)
Counter60                    F03C 0 6      MV Input Protection Key Reset Push Button Latch (60)
Counter61                    F03D 0 6      cooling system days cycle counter (61)
Counter62                    F03E 0 6      24 Hour half cycle counter (62)
Counter63                  F03F 0 6     used to create a square wave for cycling the cooling system (63)

!       Counter resets 0-63
!       -------------------
CounterReset00               F000 0 7
CounterReset01               F001 0 7
CounterReset02               F002 0 7
CounterReset03               F003 0 7
CounterReset04               F004 0 7
CounterReset05               F005 0 7
CounterReset06               F006 0 7
CounterReset07               F007 0 7
CounterReset08               F008 0 7
CounterReset09               F009 0 7
CounterReset10               F00A 0 7
CounterReset11               F00B 0 7
CounterReset12               F00C 0 7
CounterReset13               F00D 0 7
CounterReset14               F00E 0 7
CounterReset15               F00F 0 7
CounterReset16               F010 0 7
CounterReset17               F011 0 7
CounterReset18               F012 0 7
CounterReset19               F013 0 7
CounterReset20               F014 0 7
CounterReset21               F015 0 7
CounterReset22               F016 0 7
CounterReset23               F017 0 7
CounterReset24               F018 0 7
CounterReset25               F019 0 7
CounterReset26               F01A 0 7
CounterReset27               F01B 0 7
CounterReset28               F01C 0 7
CounterReset29               F01D 0 7
CounterReset30               F01E 0 7
CounterReset31               F01F 0 7

CounterReset32               F020 0 7
CounterReset33               F021 0 7
CounterReset34               F022 0 7
CounterReset35               F023 0 7
CounterReset36               F024 0 7
CounterReset37               F025 0 7
CounterReset38               F026 0 7
CounterReset39               F027 0 7
CounterReset40               F028 0 7
CounterReset41               F029 0 7      First Cell Cabinet Blower cycle period (41)
CounterReset42               F02A 0 7      Second Cell Cabinet Blower cycle period (42)
CounterReset43               F02B 0 7      Third Cell Cabinet Blower cycle period (43)
CounterReset44               F02C 0 7      Sync Motor Excitor power fault reset (44)
CounterReset45               F02D 0 7      Sync Motor Excitor field loss reset (45)
CounterReset46               F02E 0 7      Synch Motor Exciter Enable reset (46)
CounterReset47               F02F 0 7      Run Request Reset (47)
CounterReset48               F030 0 7      Increment Decrement input latch Reset (48)
CounterReset49               F031 0 7      Local Speed Command Select Reset (49)
CounterReset50               F032 0 7      Cooling System OT MV Trip latch Reset (50)
CounterReset51               F033 0 7      Resets the IOC reset permissive counter (51)
CounterReset52               F034 0 7      Cooling System OT VFD Trip latch Reset (52)
CounterReset53               F035 0 7      Pump #1 Failure latch reset (53)
CounterReset54               F036 0 7      Pump #2 Failure latch reset (54)
CounterReset55               F037 0 7      IP LFR Reset pulse End (55)
CounterReset56               F038 0 7      IP LFR Latch pulse enable reset (56)
CounterReset57               F039 0 7      IP LFR latch pulse End reset (57)
CounterReset58               F03A 0 7      Input Protection latching pulse memory reset (58)
CounterReset59               F03B 0 7      Key Reset Push Button Release detector Reset (59)
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CounterReset60                    F03C 0 7       MV Input Protection KeyReset Push Button Latch Reset (60)
CounterReset61                    F03D 0 7       Pump day cycle counter reset (61)
CounterReset62                    F03E 0 7       Pump half cycle counter reset (62)
CounterReset63                    F03F 0 7       Resets the cooling cycle counter (63)

! ====================================================
! OBSOLETED FLAGS - to maintain backwards compatibility
! ====================================================
AnalogDemand_O                    0002 0 1
DisableGroundFault_O              0006 0 1
PidAnalog1_O                      001F 0 1
SpeedTest_O                       002D 0 1
SpeedProfileOutput_O              002F 0 1
RampStopOveride_O                 0037 0 1
QuickStopOverride_O               003A 0 1
AuxDemandBeforeRamp_O            003B 0 1       Adds the auxiliary demand to the speed demand before the speed
ramp when true
EvenOddDays_I                     004B 0 15
EmergencyStop_O                   004C 0 1
LocalPLCFault_O                   004F 0 1
TorqueControlEnable_O             0051 0 1

OutputPhaseOpen_I                 0261 0 9
ExcessivePhaseError_I             0262 1 9
InputSinglePhase_I               0266 7 9        Indicates that single phase condition exists on the input or
line side of the drive
ExcessiveDriveLossesAlarm_I       0267 6 9
LossOfSignalInternal_I            026C 7 9
OutputPhaseOpenEn_O               0279 0 2
ExcessivePhaseErrorEn_O           027A 1 2
LossOfSignalInternalEn_O          0284 7 2
InTorqueLimitWn_O                 0289 5 2
ExcessivePhaseErrorWn_O           028A 1 2
LossOfSignalInternalWn_O          0294 7 2
LossOfSignalInternal_O            02A4 7 2

XfmrCoolant82DegTS_I              0200 6 11      EDi01-g, Temperatures changed - replace with OT fault
XfmrCoolant65DegTS_I              0200 7 11      EDi01-h, Temperatures changed - replace with OT alarm
UpTransferReset                   024E 0 1       Up Transfer Reset Flag (temp flag 43 alias)
Net1XferEnable_O                  02CF 2 12      Drive in Synch - Ok to transfer (Network1Flag58_O alias)
Net1UpXferStartCmd_O              02CF 3 12      Initiate Up Transfer (59)
Net1DnXferEnableVfd_O             02CF 5 12      Initiate Down Transfer (close VFD contactor) (61)
Net1XferEnable_O                  02CF 2 12      Drive in Synch - Ok to transfer (58)

DownTransferPermit_O              020D 4 12      EDo02-e, TB2-41/42
DownTransferComplete_O            020D 5 12      EDo02-f, TB2-43/44
UpTransferPermit_O                020D 6 12      EDo02-g, TB2-49/50
UpTransferComplete_O              020D 7 12      EDo02-h, TB2-51/52

RemoteStart_I                     0200 0 11      EDi01-a, TB2-3/4
RemoteStop_I                      0200 1 11      EDi01-b, TB2-5/6
RemoteFaultReset_I                0200 2 11      EDi01-c, TB2-7/8
LocalSelect_I                     0200 3 11      EDi01-d, No terminals - SEL SW (Option 25224112)
HandSelect_I                      0200 3 11      EDi01-d, No terminals - SEL SW (Option 25224114)
LocalModeSw1_I                    0200 4 11      EDi01-e, No terminals - SW1 (Option 25224113)
RemoteModeSw1_I                   0200 5 11      EDi01-f, No terminals - SW1 (Option 25224113)
HandModeSw1_I                     0200 4 11      EDi01-e, No terminals - SW1 (Option 25224115)
AutoModeSw1_I                     0200 5 11      EDi01-f, No terminals - SW1 (Option 25224115)
XfmrOtFaultTS_I                   0200 6 11      EDi01-g
XfmrOtAlarmTS_I                   0200 7 11      EDi01-h
CoolantLowLevel_I                 0201 0 11      EDi02-a, TB1-10/11
CoolantLowLowLevel_I              0201 1 11      EDi02-b, TB1-12/13
Pump1Tol_I                        0201 2 11      EDi02-c, TB1-15/16
Pump2Tol_I                        0201 3 11      EDi02-d, TB1-17/18
Pump1PwrSense_I                   0201 4 11      EDi02-e, TB1-20/21
Pump2PwrSense_I                   0201 5 11      EDi02-f, TB1-22/23
CellCabCol2Amb50Deg_I             0201 6 11      EDi02-g, TB1-25/26
CellCabCol2Amb60Deg_I             0201 7 11      EDi02-h, TB1-27/28
CellCabCol4Amb50Deg_I             0202 0 11      EDi03-a, TB1-29/30
CellCabCol4Amb60Deg_I             0202 1 11      EDi03-b, TB1-31/32
XfmrLeftSideAmb70Deg_I            0202 2 11      EDi03-c, TB1-33/34
XfmrLeftSideAmb75Deg_I            0202 3 11      EDi03-d, TB1-35/36
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XfmrRightSideAmb70Deg_I            0202 4 11       EDi03-e, TB1-37/38
XfmrRightSideAmb75Deg_I            0202 5 11       EDi03-f, TB1-39/40
Pump1Sw2Hand_I                     0202 6 11       EDi03-g, No terminals
Pump1Sw2Off_I                      0202 7 11       EDi03-h, No terminals
Pump1Sw2Auto_I                     0203 0 11       EDi04-a, No terminals
MvIpLatchFeedback_I                0203 1 11       EDi04-b, No terminals
Pump2Sw3Hand_I                     0203 2 11       EDi04-c, No terminals
Pump2Sw3Off_I                      0203 3 11       EDi04-d, No terminals
Pump2Sw3Auto_I                     0203 4 11       EDi04-e, No terminals
MvIpKeyResetPb_I                   0203 5 11       EDi04-f, No terminals
DownXferRequest_I                  0203 6 11       EDi04-g, TB2-37/38
VfdContactorAck_I                  0203 7 11       EDi04-h, TB2-39/40
UpXferRequest_I                    0204 0 11       EDi05-a, TB2-45/46
LineContactorAck_I                 0204 1 11       EDi05-b, TB2-47/48
MultilinInput_I                    0204 3 11       EDi05-d, No terminals
SmExciterPowerOn_I                 0204 4 11       EDi05-e, CB5 AC Exciter Cabinet
SmExciterHeatsinkTS_I              0204 5 11       EDi05-f, AC Exciter Cabinet OT switch 93 C deg
ReactorOtAlarm_I                   0204 4 11       EDi05-e, Reactor Temp > 165 C
ReactorOtFault_I                   0204 5 11       EDi05-f, Reactor Temp > 190 C
HexFanPwrOk_I                      0204 6 11       EDi05-g, No terminals

LocalSpeedDemand_O                 020C 0 12       EDo01-a, TB2-11/12
DriveReady_O                       020C 1 12EDo01-b, TB2-13/14
DriveRunning_O                     020C 2 12EDo01-c, TB2-15/16
DriveAlarm_O                       020C 3 12EDo01-d, TB2-17/18
ProcessAlarm_O                     020C 4 12EDo01-e, TB2-19/20
DriveTripAlarm_O                   020C 5 12EDo01-f, TB2-21/22
DriveTripped_O                     020C 6 12EDo01-g, TB2-23/24
MvInputEnable_O                    020C 7 12EDo01-h, TB2-25 LFR-3 (LFR-5 to TB2-26 NC contact)
SpeedDemandSignalLoss_O            020D 0 12       EDo02-a, TB2-27/28  Loss of 4-20ma Speed Command
LnContactUnlatch_O                 020D 3 12       EDo02-d, TB2-33/34  (Spare)
DownXferPermit_O                   020D 4 12       EDo02-e, TB2-41/42
DownXferComplete_O                 020D 5 12       EDo02-f, TB2-43/44
UpXferPermit_O                     020D 6 12       EDo02-g, TB2-49/50
UpXferComplete_O                   020D 7 12       EDo02-h, TB2-51/52
Pump1MotorStarter_O                020E 0 12       EDo03-a, MS1-A
Pump2MotorStarter_O                020E 1 12       EDo03-b, MS2-A
MvLfrTripLatch_O                   020E 2 12       EDo03-c, LFR-1
MvLfrReset_O                       020E 3 12       EDo03-d, LFR-2
SmExciterEnable_O                  020E 4 12       EDo03-e, SM Exciter

! ==========================================================
! Dedicated flags renamed for 'standard' drive configuration
!  original names maintained for backwards compatibility
! ==========================================================
Network1RunForward           0065 0 2        Network1FixedRegBit0_I for Run Forward command
Network1RunReverse                 0065 1 2        Network1FixedRegBit1_I for Run Reverse command
Network1FaultReset                 0065 2 2        Network1FixedRegBit2_I for Fault Reset
Network1Stop                       0065 3 2        Network1FixedRegBit3_I for Stop command
!Network1FixedRegBit4_I             0065 4 2        Not assigned
Network1StartStopControl           0065 5 2        Network1FixedRegBit5_I for Start/Stop toggle
Network1SpeedDemand                0065 6 2        Network1FixedRegBit6_I Selects Network 1 for speed demand
!Network1FixedRegBit7_I             0065 7 2        Not assigned

! Dedicated Discrete Inputs for 'standard drive configuration
! -----------------------------------------------------------
! Dedicated Name                   Address         Wago #   Termination
! --------------                   -------         ------   -----------
RemoteStart_DI                     0200 0 11       EDi01-a, TB2-3/4
RemoteStop_DI                      0200 1 11       EDi01-b, TB2-5/6
RemoteFaultReset_DI                0200 2 11       EDi01-c, TB2-7/8
LocalSelect_DI                     0200 3 11       EDi01-d, No terminals - SEL SW (Option 25224112)
HandSelect_DI                      0200 3 11       EDi01-d, No terminals - SEL SW (Option 25224114)
LocalModeSw1_DI                    0200 4 11       EDi01-e, No terminals - SW1 (Option 25224113)
RemoteModeSw1_DI                   0200 5 11       EDi01-f, No terminals - SW1 (Option 25224113)
HandModeSw1_DI                     0200 4 11       EDi01-e, No terminals - SW1 (Option 25224115)
AutoModeSw1_DI                     0200 5 11       EDi01-f, No terminals - SW1 (Option 25224115)
XfmrOtFaultTS_DI                   0200 6 11       EDi01-g
XfmrOtAlarmTS_DI                   0200 7 11       EDi01-h

! Liquid Cooled
! ------------- (Duplicates commented out)
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CoolantLowLevel_DI               0201 0 11       EDi02-a, TB1-10/11
CoolantLowLowLevel_DI            0201 1 11       EDi02-b, TB1-12/13
Pump1Tol_DI                      0201 2 11       EDi02-c, TB1-15/16
Pump2Tol_DI                      0201 3 11       EDi02-d, TB1-17/18
Pump1PwrSense_DI                 0201 4 11       EDi02-e, TB1-20/21
Pump2PwrSense_DI                 0201 5 11       EDi02-f, TB1-22/23
CellCabCol2Amb50Deg_DI           0201 6 11       EDi02-g, TB1-25/26
CellCabCol2Amb60Deg_DI           0201 7 11       EDi02-h, TB1-27/28

CellCabCol4Amb50Deg_DI           0202 0 11       EDi03-a, TB1-29/30
CellCabCol4Amb60Deg_DI           0202 1 11       EDi03-b, TB1-31/32
XfmrLeftSideAmb70Deg_DI          0202 2 11       EDi03-c, TB1-33/34
XfmrLeftSideAmb75Deg_DI          0202 3 11       EDi03-d, TB1-35/36
XfmrRightSideAmb70Deg_DI         0202 4 11       EDi03-e, TB1-37/38
XfmrRightSideAmb75Deg_DI         0202 5 11       EDi03-f, TB1-39/40
Pump1Sw2Hand_DI                  0202 6 11       EDi03-g, No terminals
Pump1Sw2Off_DI                   0202 7 11       EDi03-h, No terminals

Pump1Sw2Auto_DI                  0203 0 11       EDi04-a, No terminals
MvIpLatchFeedback_DI             0203 1 11       EDi04-b, No terminals
Pump2Sw3Hand_DI                  0203 2 11       EDi04-c, No terminals
Pump2Sw3Off_DI                   0203 3 11       EDi04-d, No terminals
Pump2Sw3Auto_DI                  0203 4 11       EDi04-e, No terminals
MvIpKeyResetPb_DI                0203 5 11       EDi04-f, No terminals
DownXferRequest_DI               0203 6 11       EDi04-g, TB2-37/38
VfdContactorAck_DI               0203 7 11       EDi04-h, TB2-39/40

UpXferRequest_DI                 0204 0 11       EDi05-a, TB2-45/46
LineContactorAck_DI              0204 1 11       EDi05-b, TB2-47/48
!ExternalDigitalInput05c_I       0204 2 11       EDi05-c, TB2-35/36 (spare) Do not unComment
MultilinInput_DI                 0204 3 11       EDi05-d, No terminals
SmExciterPowerOn_DI              0204 4 11       EDi05-e, CB5 AC Exciter Cabinet
SmExciterHeatsinkTS_DI           0204 5 11       EDi05-f, AC Exciter Cabinet OT switch 93 C deg
ReactorOtAlarm_DI                0204 4 11       EDi05-e, Reactor Temp > 165 C
ReactorOtFault_DI                0204 5 11       EDi05-f, Reactor Temp > 190 C
HexFanPwrOk_DI                   0204 6 11       EDi05-g, No terminals
!ExternalDigitalInput05h_I        0204 7 11       EDi05-h, No terminals      Do not unComment


! Air Cooled only
! ----------  (Duplicates commented out)
BlowerMotorTol1_DI               0201 0 11       EDi02-a, Blower 1 on feedback
BlowerMotorTol2_DI               0201 1 11       EDi02-b, Blower 2 on feedback
BlowerMotorTol3_DI               0201 2 11       EDi02-c, Blower 3 on feedback
BlowerMotorTol4_DI               0201 3 11       EDi02-d, Blower 4 on feedback
BlowerMotorTol5_DI               0201 4 11       EDi02-e, Blower 5 on feedback
AcMultilinInput_DI               0201 5 11       EDi02-f, Motor Protection Relay Trip
LowVoltagePwrAvail_DI            0201 6 11       EDi02-g, Low Voltage Power is available permissive (CB-LV)
AcDownXferRequest_DI             0201 7 11       EDi02-h, Down Sync Transfer Request

AcVfdContactorAck_DI             0202 0 11       EDi03-a, VFD contactor acknowledge feedback
AcUpXferRequest_DI               0202 1 11       EDi03-b, Up Sync Transfer Request
AcLineContactorAck_DI            0202 2 11       EDi03-c, Line contactor acknowledge feedback
BlowerMotorTol6_DI               0202 3 11       EDi03-d, Blower 6 on feedback
BlowerMotorTol7_DI               0202 4 11       EDi03-e, Blower 7 on feedback
BlowerMotorTol8_DI               0202 5 11       EDi03-f, Blower 8 on feedback
BlowerMotorTol9_DI               0202 6 11       EDi03-g, Blower 9 on feedback
BlowerMotorTol10_DI              0202 7 11       EDi03-h, Blower 10 on feedback

AcMvIpKeyResetPb_DI              0203 0 11       EDi04-a, MV Input Protection Key Reset Pushbutton
MvIpLatchFeedback_DI             0203 1 11       EDi04-b, MV Input Protection latching relay feedback
AcUPSOnInverter_DI               0203 2 11       EDi04-c, UPS on Inverter
AcUPSAlarm_DI                    0203 3 11       EDi04-d, UPS ALarm
AcSmExciterPowerOn_DI            0203 4 11       EDi04-e, AC Exciter CB5 Aux Contact
AcSmExciterHeatsinkTS_DI         0203 5 11       EDi04-f, AC Exciter Heatsink OT switch
AcReactorOtAlarm_DI              0203 4 11       EDi04-e, Reactor Temperature > 165 C
AcReactorOtFault_DI              0203 5 11       EDi04-f, Reactor Temperature > 190 C
TransferSwitch_DI                0203 6 11       EDi04-g, ASCO transfer switch on NORMAL Source
FrontPanelRun_DI                 0203 7 11       EDi04-h, Front panel control PB2 - Run

FrontPanelStop_DI                0204 0 11       EDi05-a, Front panel control PB3 - Stop
FrontPanelFltReset_DI            0204 1 11       EDi05-b, Front panel control PB1 - Fault Reset
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! Dedicated Discrete Outputs for 'standard drive configuration
! -------------------------------------------------------------
! Dedicated Name                    Address         Wago #   Termination
! --------------                    -------         ------   -----------
LocalSpeedDemand_DO                 020C 0 12       EDo01-a, TB2-11/12
DriveReady_DO                       020C 1 12EDo01-b, TB2-13/14
DriveRunning_DO                     020C 2 12EDo01-c, TB2-15/16
DriveAlarm_DO                       020C 3 12EDo01-d, TB2-17/18
ProcessAlarm_DO                     020C 4 12EDo01-e, TB2-19/20
DriveTripAlarm_DO                   020C 5 12EDo01-f, TB2-21/22
DriveTripped_DO                     020C 6 12EDo01-g, TB2-23/24

MvInputEnable_DO                    020C 7 12EDo01-h, TB2-25 LFR-3 (LFR-5 to TB2-26 NC contact)

! Liquid Cooled
! -------------
SpeedDemandSignalLoss_DO            020D 0 12       EDo02-a, TB2-27/28  Loss of 4-20ma Speed Command
!ExternalDigitalOutput02b_O          020D 1 12       EDo02-b, TB2-29/30  (Spare)
!ExternalDigitalOutput02c_O          020D 2 12       EDo02-c, TB2-31/32  (Spare)
LnContactUnlatch_DO                 020D 3 12       EDo02-d, TB2-33/34  (Spare)
DownXferPermit_DO                   020D 4 12       EDo02-e, TB2-41/42
DownXferComplete_DO                 020D 5 12       EDo02-f, TB2-43/44
UpXferPermit_DO                     020D 6 12       EDo02-g, TB2-49/50
UpXferComplete_DO                   020D 7 12       EDo02-h, TB2-51/52

Pump1MotorStarter_DO                020E 0 12       EDo03-a, MS1-A
Pump2MotorStarter_DO                020E 1 12       EDo03-b, MS2-A
MvLfrTripLatch_DO                   020E 2 12       EDo03-c, LFR-1
MvLfrReset_DO                       020E 3 12       EDo03-d, LFR-2
SmExciterEnable_DO                  020E 4 12       EDo03-e, SM Exciter
!ExternalDigitalOutput03f_O          020E 5 12      EDo03-f, (Spare)
!ExternalDigitalOutput03g_O          020E 6 12       Not Assigned
!ExternalDigitalOutput03h_O          020E 7 12       Not Assigned

! Air Cooled
! ---------- (Duplicates commented out)
!SpeedDemandSignalLoss_DO         020D 0 12      EDo02-a, Loss of 4-20ma Speed Command
BlowerMotorControl1_DO          020D 1 12      EDo02-b, Blower 1 command
BlowerMotorControl2_DO          020D 2 12      EDo02-c, Blower 2 command
BlowerMotorControl3_DO          020D 3 12      EDo02-d, Blower 3 command
BlowerMotorControl4_DO          020D 4 12      EDo02-e, Blower 4 command
BlowerMotorControl5_DO          020D 5 12      EDo02-f, Blower 5 command
AcDownXferPermit_DO             020D 6 12      EDo02-g, TB2-41/42 Down Transfer Permit
AcDownXferComplete_DO           020D 7 12      EDo02-h, TB2-43/44 Down Transfer Complete

BlowerMotorControl6_DO          020E 0 12      EDo03-a, Blower 6 command
BlowerMotorControl7_DO          020E 1 12      EDo03-b, Blower 7 command
!MvLfrTripLatch_DO                020E 2 12      EDo03-c, Input MV Contactor Trip and Latch
!MvLfrReset_DO                    020E 3 12      EDo03-d, Input MV Contactor un-latch (Reset)
!SmExciterEnable_DO               020E 4 12      EDo03-e, SM Exciter
AcUpXferPermit_DO               020E 5 12      EDo03-f, TB2-49/50 Up Transfer Permit
AcUpXferComplete_DO             020E 6 12      EDo03-g, TB2-51/52 Up Transfer Complete
AcUPSOnInverterAck_DO           020E 7 12      EDo03-h, UPS On Inverter

AcUPSAlarmAck_DO               020F 0 12       EDo04-a - UPS Alarm
BlowerMotorControl8_DO         020F 1 12       EDo04-b - Blower 8 command
BlowerMotorControl9_DO         020F 2 12       EDo04-c - Blower 9 command
BlowerMotorControl10_DO        020F 3 12       EDo04-d - Blower 10 command


! Timers
! ------
Pump1HandDebounce                   E014 0 5        Debounces the pump one hand position (20)
Pump1OffDebounce                    E015 0 5        Debounces the pump one off position (21)
Pump2HandDebounce                   E016 0 5        Debounces the pump two hand position (22)
Pump2OffDebounce                    E017 0 5        Debounces the pump two off position (23)
OutletTempAlarmDebounce             E018 0 5       Debounces the comparitor setting for Analog Outlet Temp (65
deg C)(24)
InletTempAlarmDebounce              E019 0 5        Inlet temperature comparitor debounce (55 deg C) (25)
Pump1FlowMaskTimer                  E01A 0 5        Pump 1 Flow Mask Timer (26)
Pump2FlowMaskTimer                  E01B 0 5        Pump 2 Flow Mask Timer (27)
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CoolantLowLevelDebounce             E01C 0 5       Coolant Low Level Debounce (28)
CoolantLowLowLevelDebounce          E01D 0 5       Coolant Low Low Level Debounce (29)
CondChangeTimer                    E01E 0 5       1 minute conductivity change rate timer (30)
IocResetPermitTimer                 E01F 0 5       Resets the IOC auto reset permissive after this window (31)

Pump1DelayOnDropOut                 E020 0 5       Delay on drop-out of Pump 1 run command (32)
Pump2DelayOnDropOut                 E021 0 5       Delay on drop-out of Pump 2 run command (33)
Pump1PwrLossDebounce                E022 0 5       Debounce for Pump 1 Loss of Power (34)
Pump1TolDebounce                    E023 0 5       Debounce for Pump 1 TOL (35)
Pump2PwrLossDebounce                E024 0 5       Debounce for Pump 2 Loss of Power (36)
Pump2TolDebounce                    E025 0 5       Debounce for Pump 1 TOL (37)
CoolSysOTVfdTripTimer               E026 0 5       Time Delay before OT VFD trip (38)
CoolSysOTMvTripTimer                E027 0 5       Time Delay before OT MV trip (39)
OneHourTimer                        E028 0 5       One Hour timer for extended time base (40)
InTorqLimitTimer                    E029 0 5       Timer for drive in torque limit (41)
CellCabAmbTempAlarmDebounce         E02A 0 5       Debounces the Cell Cabinet Ambient Over Temperature Alarm
Switches (42)
CellCabAmbTempFaultDebounce         E02B 0 5       Debounces the Cell Cabinet Ambient Over Temperature Fault
Switches (43)
XfmrCabAmbTempAlarmDebounce         E02C 0 5       Debounces the Xfmr Cabinet Ambient Over Temperature Alarm
Switches (44)
XfmrCabAmbTempFaultDebounce         E02D 0 5       Debounces the Xfmr Cabinet Ambient Over Temperature Trip
Switches (45)
InletLowTempDebounce                E02E 0 5       Debounces the comparitor input for low temperature (22 deg)
(46)
ConductivityAlarmDebounce          E02F 0 5       Debounces the comparitor setting for Conductivity Alarm level
(47)
AvailVoltsDebounce                 E030 0 5       Debounces the comparitor for Drive available volts above rated
(48)
ConductivityFaultDebounce          E031 0 5       Debounces the comparitor setting for Conductivity Fault level
(5 uS)(49)
InletTempFaultDebounce              E032 0 5       Debounces the comparitor setting for Analog Inlet Temp (50)
LowFlowAlarmDebounce                E033 0 5       Debounces the comparitor setting for Analog Coolant Flow
(60%)(51)
OutletTempFaultDebounce             E034 0 5       Debounces the comparitor setting for Analog Outlet Temp (82
deg)(52)
SlowLeakTimer                       E035 0 5       Slow Leak timer (1 Hour) (53)
LowWaterFlowAlarmTimer              E036 0 5       Low Water Flow Alarm Delay Timer (54)
IpTripDelayTimer                    E037 0 5       Input Protection Delay timer (2 minutes) (55)
LowFlowFaultDebounce                E038 0 5       Debounces the comparitor setting for Analog Coolant Flow
(20%)(56)
IpLfrResetPulseTimer                E039 0 5       Input Protection LFR Reset pulse duration timer (57)
IpPowerOnDelayTimer                 E03A 0 5       Input Protection Power On Debounce delay (58)
IpLfrLatchPulseTimer                E03B 0 5       Input Protection LFR Latch pulse duration timer (59)
Pump1FlowTimer                      E03C 0 5       Pump One Flow Timeout Timer (60)
Pump2FlowTimer                      E03D 0 5       Pump Two Flow Timeout Timer (61)
OneMinuteTimer                      E03E 0 5   Intended for use as a 1 minute timer (toggles) (62)
OneSecondTimer                      E03F 0 5   Intended for use as 1 second timer (toggles) (63)

! Dedicated Counters
! ------------------
FirstPeriodCounter                  F029 0 6       First Cell Cabinet Blower cycle period (41)
SecondPeriodCounter                 F02A 0 6       Second Cell Cabinet Blower cycle period (42)
ThirdPeriodCounter                  F02B 0 6       Third Cell Cabinet Blower cycle period (43)

SmPowerFailCount                    F02C 0 6       Sync Motor Excitor power fault Counter (44)
SmExciterLossCount                  F02D 0 6       Sync Motor Excitor field loss fault counter (45)
SmExciterEnableLatch                F02E 0 6       Synch Motor Exciter Enable (46)
RunRequestLatch                     F02F 0 6       Run Request (47)
IncrementDecrementLatch             F030 0 6       Latches input for increment or decrement (48)
LocalSpdCommandLatch                F031 0 6       Local Speed Command Select (49)
CoolSysOTMvTripLatch                F032 0 6       Cooling System OT MV Trip Latch (50)
IocResetCounter                     F033 0 6       Permits one IOC reset within a window (51)
CoolSysOTVfdTripLatch               F034 0 6       Cooling System OT VFD Trip Latch (52)
Pump1FailedLatch                    F035 0 6       Pump #1 Failure latch (53)
Pump2FailedLatch                    F036 0 6       Pump #2 Failure latch (54)
IpLfrResetPulseEnd                  F037 0 6       IP LFR Reset pulse End (55)
IpLfrLatchPulseEnable               F038 0 6       IP LFR Latch pulse enable (56)
IpLfrLatchPulseEnd                  F039 0 6       IP LFR latch pulse End (57)
IpLatchPulseMemory                  F03A 0 6       Input Protection latching pulse memory (58)
IpKeyResetPBReleaseDetect           F03B 0 6       Key Reset Push Button Release detector (59)
IpKeyResetPBLatch                   F03C 0 6       MV Input Protection Key Reset Push Button Latch (60)
```

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DayCounter                    F03D 0 6      cooling system days cycle counter (61)
24HourCounter                 F03E 0 6      24 Hour half cycle counter (62)
CyclePeriodCounter            F03F 0 6      used to create a square wave for cycling the cooling system
(63)

! Dedicated Counter Resets
! ------------------------
FirstPeriodCounterReset       F029 0 7      First Cell Cabinet Blower cycle period (41)
SecondPeriodCounterReset      F02A 0 7      Second Cell Cabinet Blower cycle period (42)
ThirdPeriodCounterReset       F02B 0 7      Third Cell Cabinet Blower cycle period (43)

SmPowerFailCountReset         F02C 0 7      Sync Motor Excitor power fault Counter (44)
SmExciterLossCountReset       F02D 0 7      Sync Motor Excitor field loss fault counter (45)
SmExciterEnableLatchReset     F02E 0 7      Synch Motor Exciter Enable reset (46)
RunRequestLatchReset          F02F 0 7      Run Request Reset (47)
IncrementDecrementLatchReset  F030 0 7      Increment Decrement input latch Reset (48)
LocalSpdCommandLatchReset     F031 0 7      Local Speed Command Select Reset (49)
CoolSysOTMvTripLatchReset     F032 0 7      Cooling System OT MV Trip latch Reset (50)
IocResetCounterReset          F033 0 7      Resets the IOC reset permissive counter (51)
CoolSysOTVfdTripLatchReset    F034 0 7      Cooling System OT VFD Trip latch Reset (52)
Pump1FailedLatchReset         F035 0 7      Pump #1 Failure latch reset (53)
Pump2FailedLatchReset         F036 0 7      Pump #2 Failure latch reset (54)
IpLfrResetPulseEndReset       F037 0 7      IP LFR Reset pulse End (55)
IpLfrLatchPulseEnableReset    F038 0 7      IP LFR Latch pulse enable reset (56)
IpLfrLatchPulseEndReset       F039 0 7      IP LFR latch pulse End reset (57)
IpLatchPulseMemoryReset       F03A 0 7      Input Protection latching pulse memory reset (58)
IpKeyResetPBReleaseDetectReset F03B 0 7     Key Reset Push Button Release detector Reset (59)
IpKeyResetPBLatchReset        F03C 0 7      MV Input Protection KeyReset Push Button Latch Reset (60)
DayCounterReset               F03D 0 7      Pump day cycle counter reset (61)
24HourReset                   F03E 0 7      Pump half cycle counter reset (62)
CyclePeriodReset              F03F 0 7      Resets the cooling cycle counter (63)

! Dedicated Temp Flags
! --------------------
Pump1InHandMode               023D 0 1      Pump 1 in Hand mode (26)
Pump2InHandMode               023E 0 1      Pump 2 in Hand mode (27)
NextCellToBypass              023F 0 1      Next Cell to bypass (28)
SlowCondChangeDetect          0240 0 1      Slow Conductivity Change Detector (29)
FastCondChangeDetect          0241 0 1      Fast Conductivity Change Detector (30)
CoolantLevelFault             0242 0 1      Coolant Level Fault Condition (< 20 inches) (31)
IocResetPermit                0243 0 1      Allows an IOC reset for X counts and is re-enabled after a
window (32)
CoolingInitComplete           0244 0 1      Used for cooling system drop-out timer initialization (33)
CriticalAlarmCondition        0245 0 1      Critical Cooling System Alarm Condition (34)
PumpPwrOk                     0246 0 1      One of the pumps has power (35)
OneHourReset                  0247 0 1      Resets the One Hour Timer (toggle) (36)
CellCabinetAmbOTAlarm         0248 0 1      Indication that an Ambient Temperature warning Switch is
active (37)
CellCabinetAmbOTFault        0249 0 1      Indication that an Ambient Temperature fault Switch is active
(38)
XfmrCabinetAmbOTAlarm         024A 0 1      Indication that an Ambient Temperature warning Switch is
active (39)
XfmrCabinetAmbOTFault        024B 0 1      Indication that an Ambient Temperature fault Switch is active
(40)
SlowLeakDetector             024C 0 1      Slow leak detection (1 hour between low and low - low levels)
(41)
SyncTransferActive            024D 0 1      Sync Transfer Mode Active - either Up or Down Transfer is
active (42)
;;;UpTransferReset                024E 0 1      Up Transfer Reset Flag (43)
DownTransferReset             024F 0 1      Down Transfer Reset Flag (44)
AnalogSpeedMode               0250 0 1      Analog Speed Mode (45)
Network1RunRequest            0251 0 1      Network # 1 Run Request (46)
Network1Speedcontrol          0252 0 1      Network # 1 Speed Control (47)
Pump1Available                0253 0 1      Pump #1 is Available (48)
Pump1RunCommand               0254 0 1      Pump #1 Run Command  (49)
Pump2Available                0255 0 1      Pump #2 is Available (50)
Pump2RunCommand               0256 0 1      Pump #2 Run Command (51)
CoolSysOTHysteresis           0257 0 1      Cooling System OT Hysteresis (52)
CoolingSysOT                  0258 0 1      Cooling System OT (53)
CoolingSysFail                0259 0 1      Cooling System Malfunction (54)
LfrDriveResetEnable           025A 0 1      Forward reference of latching pulse memory to enable drive
fault reset (55)
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MvContactorTripCommand           025B 0 1       Input Contactor Trip Command (56)
LfrKeyResetPBEnable              025C 0 1       Falling edge detection for key reset switch push button (57)
CoolingCycleFlag                 025D 0 1       Cooling days Cycle Flag for pumps & redundant fans (58)
OneMinuteReset                   025E 0 1       Resets the One Minute Timer (toggle) (59)
OneSecondReset                   025F 0 1       Resets the One Second Timer (toggle) (60)

! Air Cooled Temp Flags
! ----------
AllXfrmBlowersTol                0248 0 1       All Transformer blowers failed (37)
BlowerGroup1Tol                  0249 0 1       1st group of blowers failed (38)
BlowerGroup2Tol                  024A 0 1       2nd group of blowers failed (39)
BlowerGroup3Tol                  024B 0 1       3rd group of blowers failed (40)

AnyBlowerTol                     0253 0 1       any blower TOL's tripped (48)
CellBlowerGrp1                   0254 0 1       control for 1st set of cell blowers (49)
CellBlowerGrp2                   0255 0 1       control for 2nd set of cell blowers (50)
CellBlowerGrp3                   0256 0 1       control for 3rd set of cell blowers (51)



! Dedicated User Fault Inputs
! ---------------------------
TransferSwitchActive_I           0273 3 9       Asco Switch on Alternate (28)
UpsOnInverter_I                  0273 4 9       UPS is on inverter (29)
UpsAlarm_I                       0273 5 9       UPS alarm (30)
SmExciterOtAlarm_I               0273 6 9       Sync Motor Exciter OT fault (31)
SmExciterLoss_I                  0273 7 9       Sync Motor Loss of Exciter (32)

SmExciterPowerFault_I            0274 0 9       Sync Motor Exciter Fault (33)
Pump1LossOfPwr_I                 0274 1 9       Pump One Loss of power alarm (34)
Pump1Tol_I                       0274 2 9       Pump One TOL alarm (35)
Pump2LossOfPwr_I                 0274 3 9       Pump Two Loss of power alarm (36)
Pump2Tol_I                       0274 4 9       Pump One TOL alarm (37)
EstopAlarm_I                     0274 5 9       Estop Alarm for logging (38)
MultilinFault_I                  0274 6 9       Multilin Fault of Drive (39)
AvailVoltsAlarm_I                0274 7 9       Avail Volts below rated alarm (40)

CabCol2AmbAlarm_I                0275 0 9       Cell Cabinet Column 2 Ambient alarm (50 Deg) (41)
CabCol2AmbFault_I                0275 1 9       Cell Cabinet Column 2 Ambient fault (60 Deg) (42)
CabCol4AmbAlarm_I                0275 2 9       Cell Cabinet Column 4 Ambient alarm (50 Deg) (43)
CabCol4AmbFault_I                0275 3 9       Cell Cabinet Column 4 Ambient fault (60 Deg) (44)
XfmrLeftAmbAlarm_I               0275 4 9       Transformer Left side Ambient alarm (60 Deg) (45)
XfmrLeftAmbFault_I               0275 5 9       Transformer Left side Ambient fault (70 Deg) (46)
XfmrRightAmbAlarm_I              0275 6 9       Transformer Right side Ambient alarm (60 Deg) (47)
XfmrRightAmbFault_I              0275 7 9       Transformer Right side Ambient fault (70 Deg) (48)

HexFansPowerFailed_I             0276 0 9       Hex Fans Power Failed (49)
TransformerOtAlarm_I             0276 1 9       Transformer OT Alarm (> 65 deg) (50)
CoolantOutletOtFault_I           0276 2 9       Coolant Outlet OT Fault (> 70 deg) (51)
LowLowCoolantFault_I             0276 3 9       Low, Low Coolant Level (> 20") (52)
HighConductivityFault_I          0276 4 9       High Conductivity Fault (> 5uS) (53)
CoolantInletOtAlarm_I            0276 5 9       Coolant Inlet Temp above 55 deg C (54)
Pump1Failed_I                    0276 6 9       Pump #1 Failed (55)
Pump2Failed_I                    0276 7 9       Pump #2 Failed (56)

BothPumpsFailed_I                0277 0 9       Both Cooling Pumps Failed (57)
CoolingOtTripAlarm_I             0277 1 9       Cooling Ot Mv Trip (58)
CoolingOtVfdTrip_I               0277 2 9       Cooling Ot Vfd Trip (59)
CoolingOtMvTrip_I                0277 3 9       Cooling Ot Trip Alarm (60)
CoolantOutletOtAlarm_I           0277 4 9       Coolant Outlet Temperature Alarm (65 Deg C) (61)
CoolingSysVfdTrip_I              0277 5 9       Cooling Sys Vfd Trip (62)
CoolingSysMvTrip_I               0277 6 9       Cooling Sys Mv Trip (63)
MvIpLatchedFault_I               0277 7 9       MV Input Protection Latched Fault (64)

! Dedicated User Fault Warning Enables
! ------------------------------------
TransferSwitchActiveWn_O         029B 3 2       Asco Switch on Alternate (28)
UpsOnInverterWn_O                029B 4 2       UPS is on inverter (29)
UpsAlarmWn_O                     029B 5 2       UPS alarm (30)
SmExciterOtAlarmWn_O             029B 6 2       Sync Motor Exciter OT fault (31)
SmExciterLossWn_O                029B 7 2       Sync Motor Loss of Exciter (32)
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SmExciterPowerFaultWn_O          029C 0 2       Sync Motor Exciter Fault (33)
Pump1LossOfPwrWn_O               029C 1 2       Pump One Loss of power alarm (34)
Pump1TolWn_O                     029C 2 2       Pump One TOL alarm (35)
Pump2LossOfPwrWn_O               029C 3 2       Pump Two Loss of power alarm (36)
Pump2TolWn_O                     029C 4 2       Pump One TOL alarm (37)
EstopAlarmWn_O                   029C 5 2       Estop Alarm for logging (38)
MultilinFaultWn_O                029C 6 2       Multilin Fault of Drive (39)
AvailVoltsAlarmWn_O              029C 7 2       Avail Volts below rated alarm (40)

CabCol2AmbAlarmWn_O              029D 0 2       Cell Cabinet Column 2 Ambient alarm (50 Deg) (41)
CabCol2AmbFaultWn_O              029D 1 2       Cell Cabinet Column 2 Ambient fault (60 Deg) (42)
CabCol4AmbAlarmWn_O              029D 2 2       Cell Cabinet Column 4 Ambient alarm (50 Deg) (43)
CabCol4AmbFaultWn_O              029D 3 2       Cell Cabinet Column 4 Ambient fault (60 Deg) (44)
XfmrLeftAmbAlarmWn_O             029D 4 2       Transformer Left side Ambient alarm (70 Deg) (45)
XfmrLeftAmbFaultWn_O             029D 5 2       Transformer Left side Ambient fault (75 Deg) (46)
XfmrRightAmbAlarmWn_O            029D 6 2       Transformer Right side Ambient alarm (70 Deg) (47)
XfmrRightAmbFaultWn_O            029D 7 2       Transformer Right side Ambient fault (75 Deg) (48)

HexFansPowerFailedWn_O           029E 0 2       Hex Fans Power Failed (49)
TransformerOtAlarmWn_O           029E 1 2       Transformer OT Alarm (> 65 deg) (50)
CoolantOutletOtFaultWn_O         029E 2 2       Coolant Outlet OT Fault (> 70 deg) (51)
LowLowCoolantFaultWn_O           029E 3 2       Low, Low Coolant Level (> 20") (52)
HighConductivityFaultWn_O        029E 4 2       High Conductivity Trip (> 5uS) (53)
CoolantInletOtAlarmWn_O          029E 5 2       Coolant Inlet Temp above 55 deg C (54)
Pump1FailedWn_O                  029E 6 2       Pump #1 Failed (55)
Pump2FailedWn_O                  029E 7 2       Pump #2 Failed (56)

BothPumpsFailedWn_O              029F 0 2       Both Cooling Pumps Failed (57)
CoolingOtTripAlarmWn_O           029F 1 2       Cooling Ot Trip Alarm (set true) (58)
CoolingOtVfdTripWn_O             029F 2 2       Cooling Ot Vfd Trip (set false - default) (59)
CoolingOtMvTripWn_O              029F 3 2       Cooling Ot Mv Trip (set false - default) (60)
CoolantOutletOtAlarmWn_O         029F 4 2       Coolant Outlet Temperature Alarm (65 Deg C) (61)
CoolingSysVfdTripWn_O            029F 5 2       Cooling Sys Vfd Trip (set false - default) (62)
CoolingSysMvTripWn_O             029F 6 2       Cooling Sys Mv Trip (set false - default) (63)
MvIpLatchedFaultWn_O             029F 7 2       MV Input Protection Latched Fault (set false - default) (64)

! Dedicated User Fault Outputs
! ----------------------------
TransferSwitchActive_O           02AB 3 2       Asco Switch on Alternate (28)
UpsOnInverter_O                  02AB 4 2       UPS is on inverter (29)
UpsAlarm_O                       02AB 5 2       UPS alarm (30)
SmExciterOtAlarm_O               02AB 6 2       Sync Motor Exciter OT fault (31)
SmExciterLoss_O                  02AB 7 2       Sync Motor Loss of Exciter (32)

SmExciterPowerFault_O            02AC 0 2       Sync Motor Exciter Fault (33)
Pump1LossOfPwr_O                 02AC 1 2       Pump One Loss of power alarm (34)
Pump1Tol_O                       02AC 2 2       Pump One TOL alarm (35)
Pump2LossOfPwr_O                 02AC 3 2       Pump Two Loss of power alarm (36)
Pump2Tol_O                       02AC 4 2       Pump One TOL alarm (37)
EstopAlarm_O                     02AC 5 2       Estop Alarm for logging (38)
MultilinFault_O                  02AC 6 2       Multilin Fault of Drive (39)
AvailVoltsAlarm_O                02AC 7 2       Avail Volts below rated alarm (40)

CabCol2AmbAlarm_O                02AD 0 2       Cell Cabinet Column 2 Ambient alarm (50 Deg) (41)
CabCol2AmbFault_O                02AD 1 2       Cell Cabinet Column 2 Ambient fault (60 Deg) (42)
CabCol4AmbAlarm_O                02AD 2 2       Cell Cabinet Column 4 Ambient alarm (50 Deg) (43)
CabCol4AmbFault_O                02AD 3 2       Cell Cabinet Column 4 Ambient fault (60 Deg) (44)
XfmrLeftAmbAlarm_O               02AD 4 2       Transformer Left side Ambient alarm (60 Deg) (45)
XfmrLeftAmbFault_O               02AD 5 2       Transformer Left side Ambient fault (70 Deg) (46)
XfmrRightAmbAlarm_O              02AD 6 2       Transformer Right side Ambient alarm (60 Deg) (47)
XfmrRightAmbFault_O              02AD 7 2       Transformer Right side Ambient fault (70 Deg) (48)

HexFansPowerFailed_O             02AE 0 2       Hex Fans Power Failed (49)
TransformerOtAlarm_O             02AE 1 2       Transformer OT Alarm (> 65 deg) (50)
CoolantOutletOtFault_O           02AE 2 2       Coolant Outlet OT Fault (> 70 deg) (51)
LowLowCoolantFault_O             02AE 3 2       Low, Low Coolant Level (> 20") (52)
HighConductivityFault_O          02AE 4 2       High Conductivity Fault (> 5uS) (53)
CoolantInletOtAlarm_O            02AE 5 2       Coolant Inlet Temp above 55 deg C (54)
Pump1Failed_O                    02AE 6 2       Pump #1 Failed (55)
Pump2Failed_O                    02AE 7 2       Pump #2 Failed (56)

BothPumpsFailed_O                02AF 0 2       Both Cooling Pumps Failed (57)
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CoolingOtTripAlarm_O            02AF 1 2        Cooling Ot Trip Alarm (58)
CoolingOtVfdTrip_O              02AF 2 2        Cooling Ot Vfd Trip (59)
CoolingOtMvTrip_O               02AF 3 2        Cooling Ot Mv Trip (60)
CoolantOutletOtAlarm_O          02AF 4 2        Coolant Outlet Temperature Alarm (65 Deg C) (61)
CoolingSysVfdTrip_O             02AF 5 2        Cooling Sys Vfd Trip (62)
CoolingSysMvTrip_O              02AF 6 2        Cooling Sys Mv Trip (63)
MvIpLatchedFault_O              02AF 7 2        MV Input Protection latched fault (64)

! Dedicated User Fault Text
! ------------------------
TransferSwitchActiveText        D002 11 250     Asco Switch on Alternate (28)
UpsOnInverterText               D002 12 250     UPS is on inverter (29)
UpsAlarmText                    D002 13 250     UPS alarm (30)
SmExciterOtAlarmText            D002 14 250     Sync Motor Exciter OT fault (31)
SmExciterLossText               D002 15 250     Sync Motor Loss of Exciter (32)

SmExciterPowerFaultText         D004 0  250     Sync Motor Exciter Fault (33)
Pump1LossOfPwrText              D004 1  250     Pump One Loss of power alarm (34)
Pump1TolText                    D004 2  250     Pump One TOL alarm (35)
Pump2LossOfPwrText              D004 3  250     Pump Two Loss of power alarm (36)
Pump2TolText                    D004 4  250     Pump One TOL alarm (37)
EstopAlarmText                  D004 5  250     Estop Alarm for logging (38)
MultilinFaultText               D004 6  250     Multilin Fault of Drive (39)
AvailVoltsAlarmText             D004 7  250     Avail Volts below rated alarm (40)
CabCol2AmbAlarmText             D004 8  250     Cell Cabinet Column 2 Ambient alarm (50 Deg) (41)
CabCol2AmbFaultText             D004 9  250     Cell Cabinet Column 2 Ambient fault (60 Deg) (42)
CabCol4AmbAlarmText             D004 10 250     Cell Cabinet Column 4 Ambient alarm (50 Deg) (43)
CabCol4AmbFaultText             D004 11 250     Cell Cabinet Column 4 Ambient fault (60 Deg) (44)
XfmrLeftAmbAlarmText            D004 12 250     Transformer Left side Ambient alarm (60 Deg) (45)
XfmrLeftAmbFaultText            D004 13 250     Transformer Left side Ambient fault (70 Deg) (46)
XfmrRightAmbAlarmText           D004 14 250     Transformer Right side Ambient alarm (60 Deg) (47)
XfmrRightAmbFaultText           D004 15 250     Transformer Right side Ambient fault (70 Deg) (48)

HexFansPowerFailedText          D006 0  250     Hex Fans Power Failed (49)
TransformerOtAlarmText          D006 1  250     Transformer OT Alarm (> 65 deg) (50)
CoolantOutletOtFaultText        D006 2  250     Coolant Outlet OT Fault (> 70 deg) (51)
LowLowCoolantFaultText          D006 3  250     Low, Low Coolant Level (> 20") (52)
HighConductivityFaultText       D006 4  250     High Conductivity Fault (> 5uS) (53)
CoolantInletOtAlarmText         D006 5  250     Coolant Inlet Temp above 55 deg C (54)
Pump1FailedText                 D006 6  250     Pump #1 Failed (55)
Pump2FailedText                 D006 7  250     Pump #2 Failed (56)
BothPumpsFailedText             D006 8  250     Both Cooling Pumps Failed (57)
CoolingOtTripAlarmText          D006 9  250     Cooling Ot Trip Alarm (58)
CoolingOtVfdTripText            D006 10 250     Cooling Ot Vfd Trip (59)
CoolingOtMvTripText             D006 11 250     Cooling Ot Mv Trip (60)
CoolantOutletOtAlarmText        D006 12 250     Coolant Outlet Temperature Alarm (65 Deg C) (61)
CoolingSysVfdTripText           D006 13 250     Cooling Sys Vfd Trip (62)
CoolingSysMvTripText            D006 14 250     Cooling Sys Mv Trip (63)
MvIpLatchedFaultText            D006 15 250     Input Protection Fault (64)


! Dedicated Network 1 Input Flags
! -------------------------------
Net1VfdContactorAck_I           02BF 3 9        VFD Contactor Closed Acknowledge (59)
Net1LineContactorAck_I          02BF 4 9        Line Contactor Closed Acknowledge (60)
Net1UpXferReq_I                 02BF 5 9        Up Transfer Request (61)
Net1DnXferReq_I                 02BF 6 9        Down Transfer Request (62)
Net1XferFaultReset_I            02BF 7 9        Transfer Fault Reset (63)

Net1XferLnContactUnlatch_O      02CF 2 12       Drive producing torque - Ok to drop line contactor (58)
Net1UpXferPermit_O              02CF 3 12       Initiate Up Transfer (59)
Net1UpXferComplete_O            02CF 4 12       Up Transfer Complete (60)
Net1DnXferPermit_O              02CF 5 12       Initiate Down Transfer (61)
Net1DnXferComplete_O            02CF 6 12       Down Transfer Complete (62)
Net1MvTripCommand_O             02CF 7 12       Command to remove MV Input power (63)

CellFault_I                     0261 4 9        Indicates a cell fault
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APPENDIX

E Historical Logger

E.1 Historical Logger

The NXG Control has a Historical log for continuously logging a series of records consisting of 10 entries. The entries consist of the drive state, seven user programmable variables, and two fault data words. This information is sampled every speed loop update cycle, and is stored in a circular buffer. When a fault condition occurs, 57 pre-fault samples and 20 post-fault samples are recorded along with the current sample (for a total of 78 samples) in nonvolatile memory along with the time/date stamp. This information stays in nonvolatile memory until the next fault occurs, at which time the old information is overwritten. To preserve multiple records of Historical logs, the user can enable (default is enabled) saving the historical logs into the Event log file. This data is preserved on the CompactFLASH. The user-defined variables are to be selected from a predefined list defined in Chapter #3. The fault information is stored in the two fault data words. The following serves as a reference for the individual meaning of each fault bit.

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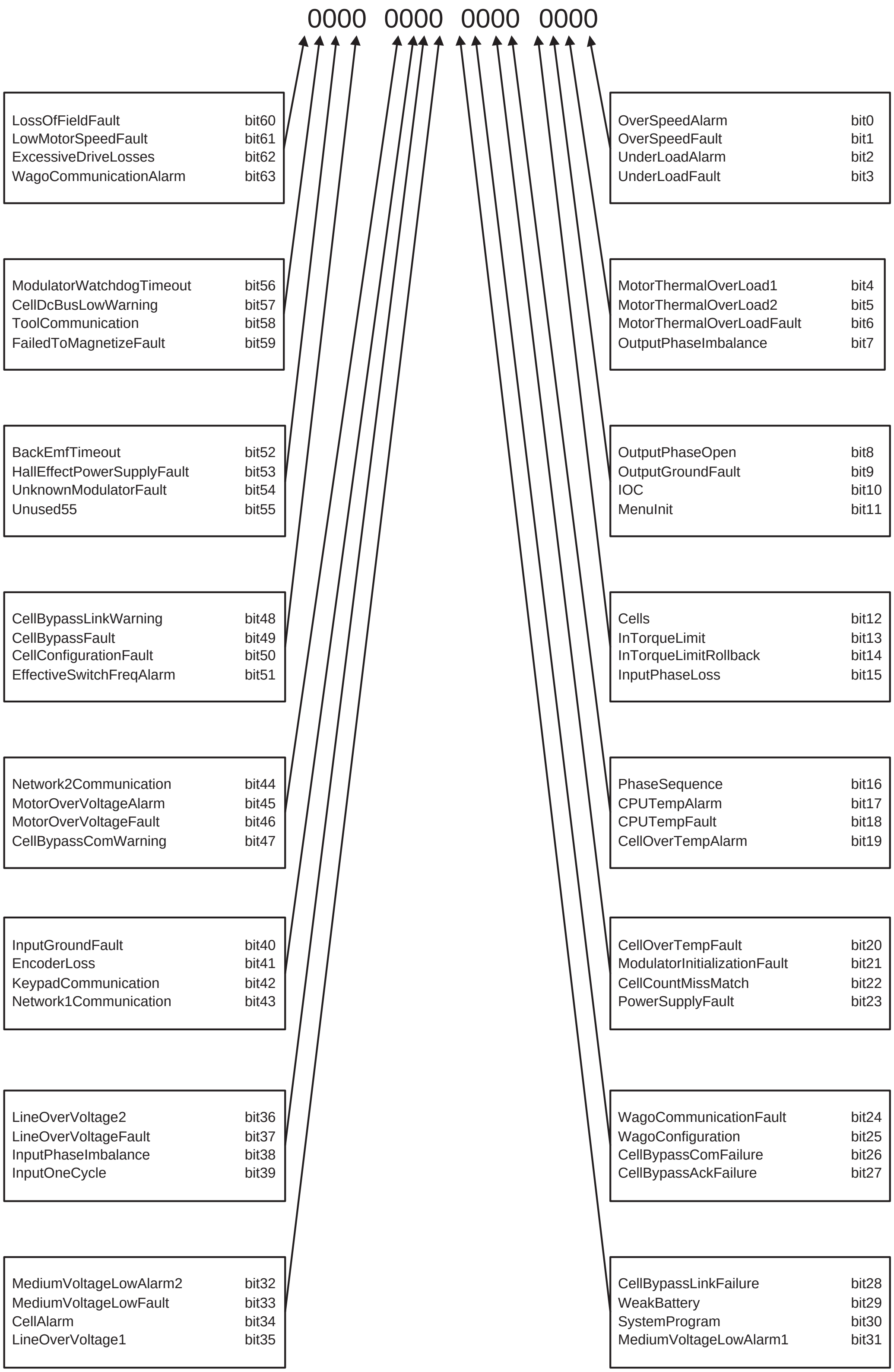
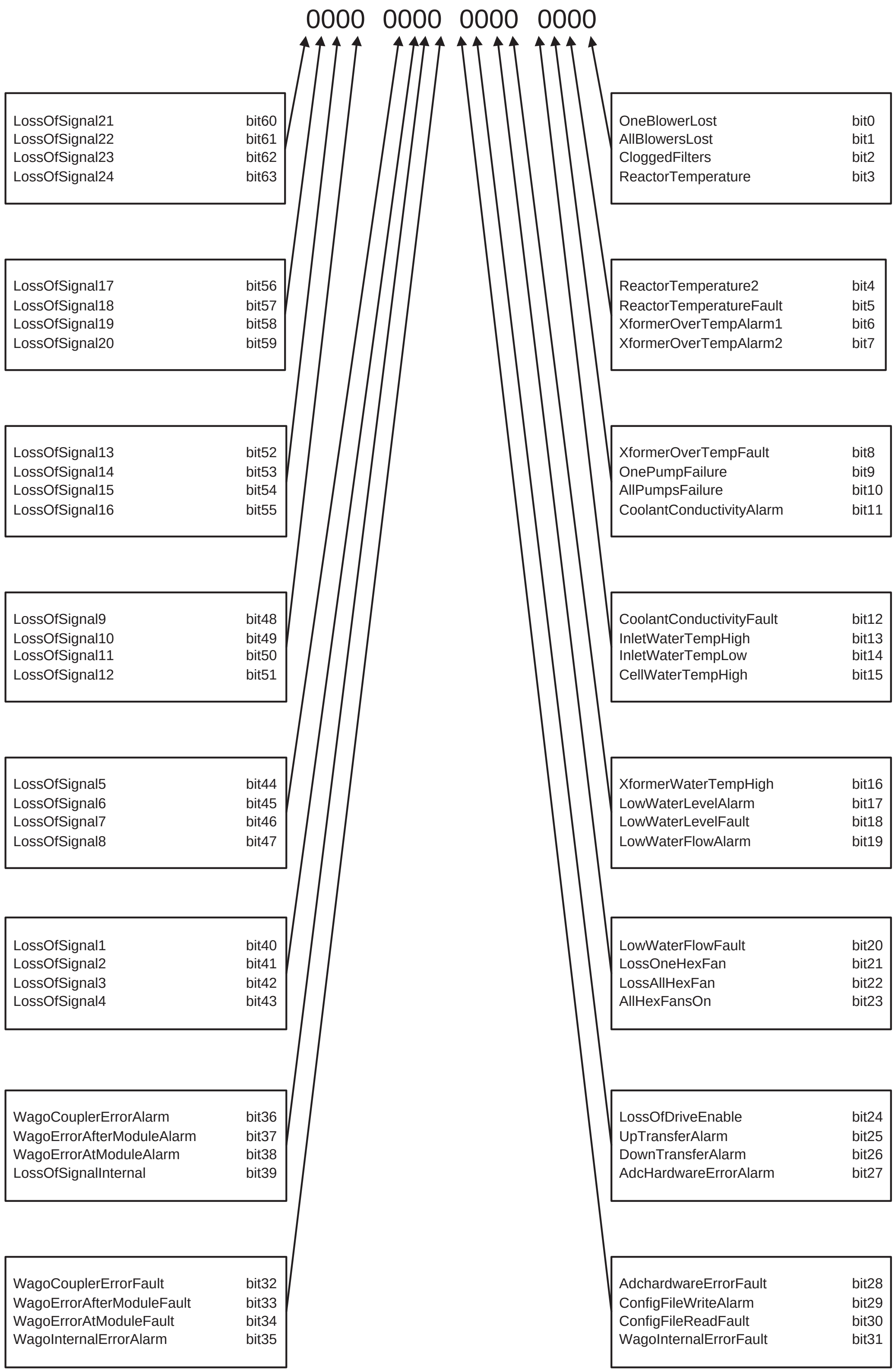
Fault Word 1

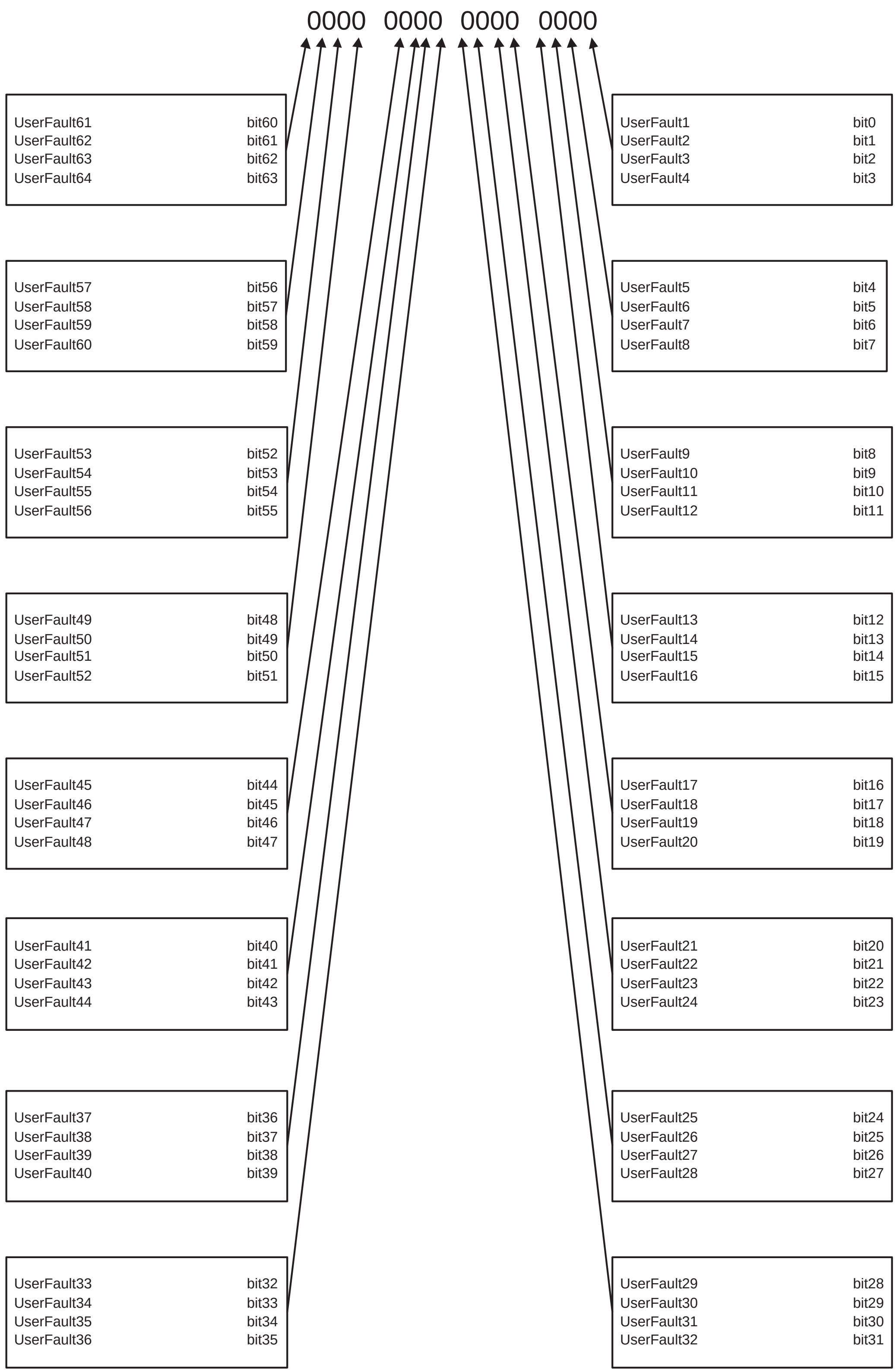

0000 0000 0000 0000
OverSpeedAlarm bit0
OverSpeedFault bit1
UnderLoadAlarm bit2
UnderLoadFault bit3
MotorThermalOverLoad1 bit4
MotorThermalOverLoad2 bit5
MotorThermalOverLoadFault bit6
OutputPhaseImbalance bit7
OutputPhaseOpen bit8
OutputGroundFault bit9
IOC bit10
MenuInit bit11
Cells bit12
InTorqueLimit bit13
InTorqueLimitRollback bit14
InputPhaseLoss bit15
PhaseSequence bit16
CPUTempAlarm bit17
CPUTempFault bit18
CellOverTempAlarm bit19
CellOverTempFault bit20
ModulatorInitializationFault bit21
CellCountMissMatch bit22
PowerSupplyFault bit23
WagoCommunicationFault bit24
WagoConfiguration bit25
CellBypassComFailure bit26
CellBypassAckFailure bit27
CellBypassLinkFailure bit28
WeakBattery bit29
SystemProgram bit30
MediumVoltageLowAlarm1 bit31
MediumVoltageLowAlarm2 bit32
MediumVoltageLowFault bit33
CellAlarm bit34
LineOverVoltage1 bit35
LineOverVoltage2 bit36
LineOverVoltageFault bit37
InputPhaseImbalance bit38
InputOneCycle bit39
InputGroundFault bit40
EncoderLoss bit41
KeypadCommunication bit42
Network1Communication bit43
Network2Communication bit44
MotorOverVoltageAlarm bit45
MotorOverVoltageFault bit46
CellBypassComWarning bit47
CellBypassLinkWarning bit48
CellBypassFault bit49
CellConfigurationFault bit50
EffectiveSwitchFreqAlarm bit51
BackEmfTimeout bit52
HallEffectPowerSupplyFault bit53
UnknownModulatorFault bit54
Unused55 bit55
ModulatorWatchdogTimeout bit56
CellDcBusLowWarning bit57
ToolCommunication bit58
FailedToMagnetizeFault bit59
LossOfFieldFault bit60
LowMotorSpeedFault bit61
ExcessiveDriveLosses bit62
WagoCommunicationAlarm bit63

Fault Word 2

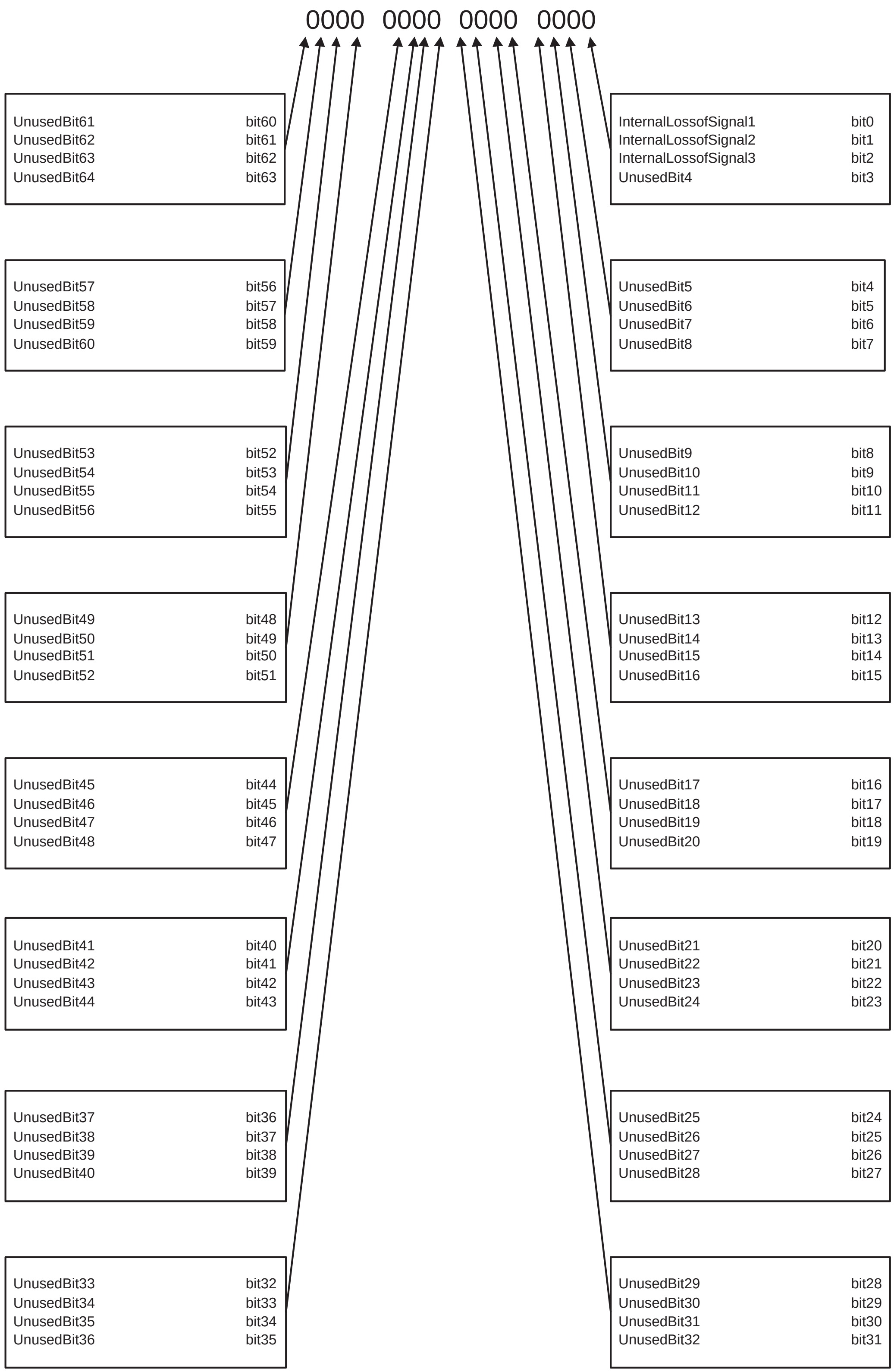


E

Fault Word 3


0000 0000 0000 0000
UserFault61 bit60
UserFault62 bit61
UserFault63 bit62
UserFault64 bit63
UserFault57 bit56
UserFault58 bit57
UserFault59 bit58
UserFault60 bit59
UserFault53 bit52
UserFault54 bit53
UserFault55 bit54
UserFault56 bit55
UserFault49 bit48
UserFault50 bit49
UserFault51 bit50
UserFault52 bit51
UserFault45 bit44
UserFault46 bit45
UserFault47 bit46
UserFault48 bit47
UserFault41 bit40
UserFault42 bit41
UserFault43 bit42
UserFault44 bit43
UserFault37 bit36
UserFault38 bit37
UserFault39 bit38
UserFault40 bit39
UserFault33 bit32
UserFault34 bit33
UserFault35 bit34
UserFault36 bit35
UserFault1 bit0
UserFault2 bit1
UserFault3 bit2
UserFault4 bit3
UserFault5 bit4
UserFault6 bit5
UserFault7 bit6
UserFault8 bit7
UserFault9 bit8
UserFault10 bit9
UserFault11 bit10
UserFault12 bit11
UserFault13 bit12
UserFault14 bit13
UserFault15 bit14
UserFault16 bit15
UserFault17 bit16
UserFault18 bit17
UserFault19 bit18
UserFault20 bit19
UserFault21 bit20
UserFault22 bit21
UserFault23 bit22
UserFault24 bit23
UserFault25 bit24
UserFault26 bit25
UserFault27 bit26
UserFault28 bit27
UserFault29 bit28
UserFault30 bit29
UserFault31 bit30
UserFault32 bit31

Fault Word 4



E

Index

D

E

Q

R

T

U

V

W

Z