PERFECT HARMONY SERIES
ADJUSTABLE SPEED
AC MOTOR DRIVE
(200 hp through 2000 hp)
USER'S MANUAL

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ROBICON

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This user's manual applies to all third generation (reduced cabinet size) air-cooled ROBICON Perfect Harmony adjustable-speed AC motor drives that are rated from 200 HP through 2000 HP. For information on liquid-cooled Perfect Harmony Drives, refer to manual number 902463. For information on original air-cooled Perfect Hamrony drives, refer to manual number 902330. Perfect Harmony units discussed in this manual use *high voltage cells* which accept 690 VAC.

This manual corresponds to Perfect Harmony software version 1.13.

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Perfect Harmony Series User's Manual (200-2000 hp 3rd Generation)
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ABOUT THIS MANUAL

Organization

This manual is organized with the intention of providing maximum benefit to a variety of users. The order in which the chapters are presented allows the manual to be used as a *learning* tool, that is, the "student" is presented with basic concepts that are followed by more advanced concepts. The product is introduced, important components are identified, the theory of operation is explained, the user interface and operational configuration parameters are outlined. Finally, after a discussion of components and configuration capabilities, the installation and setup procedure is explained, followed by a troubleshooting section. Additional advanced topics chapters follow the troubleshooting section. These chapters include system programming, PLC interface information, compiler and reverse compiler operations, and uploading and downloading capabilities. The chapters and the questions they answer are outlined below.

Chapter 1: Introduction	What is a Perfect Harmony VFD?
Chapter 2: Electrical Components	What are the major parts?
Chapter 3: Theory	How does it work?
Chapter 4: The Keypad and Display Interface	How will I "talk" to it?
Chapter 5: Parameters Overview	What might I "say"?
Chapter 6: Installation and Setup	How do I install and use it?
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Chapter 8: System Programming	Are there any advanced features or tools?
Chapter 9: Transfer System PLC Interface	
Chapter 10: Compiler and Reverse Compiler	
Chapter 11: Uploading and Downloading	

Many steps have been taken to promote the use of this manual as a *reference* tool as well as a *learning* tool. After the user reads the chapters in order from basic to more advanced, he may use the reference tools to find specific information. Reference tools include the following:

- a thorough table of contents for locating particular sections or subsections
- a list of all figures and their associated captions as they appear in the manual
- a list of all tables and their associated titles as they appear in the manual
- "In This Section" page references at the beginning of each chapter
- 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.

These tools are especially useful in locating information of particular interest to specific individuals. For example, an electrician may be interested in the installation and setup section. A programmer may only be interested in the system programming and parameter overview sections. An operator may only be interested in the keypad and display interface.

Your approach to using this manual depends on your target audience category. If you are reading this manual from a complete learning perspective, then follow the chapters in the order that they are presented. This method is recommended if you have little or no drive experience, are unfamiliar with ROBICON products, or would like to refresh your knowledge on the subject.

If you are using this manual for reference, use the reference tools (listed above) to quickly and easily locate the information pertinent to your needs. This method is recommended if you seek specific details or are interested in only a particular phase of product use (e.g., installation, programming, troubleshooting, etc.). Use this method only if you have previous experience with drives or experience using ROBICON products.

If you have any comments or suggestions to improve the organization or increase the usability of this manual, please complete the Readers' Comments Form located at the end of this manual and return it to ROBICON.

Conventions

The following conventions are used throughout this manual.

- An "In This Section" box begins each chapter and outlines some of the key issues that are addressed in the chapter. This feature is an abbreviated table of contents for the chapter. Page numbers are included to facilitate the look-up process.

- Attention icons may appear in the outer margins and are used to alert readers of important safety and operational 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.

- Electrical hazard icons may appear in the outer margins to alert readers of important safety and operational precautions such as potential electrical hazards. Important text is enclosed in a border for high visibility.

- Note icons appear in the outer margins to alert readers of information that may have extra special significance.
- Parameters are shown in lowercase, 8 pt Arial font (e.g., flux pause).
- Chapter numbers are highlighted in the outer margins to facilitate referencing (see left).

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- Software flags and variables are shown in lowercase italic fonts (e.g., *sw_estop_f*).
- Test points are shown in uppercase, boldface, 8 pt Arial fonts (e.g., **TB1A**).
- Test points followed by an asterisk (e.g., Eb*) represent reference quantities.
- Menus names are shown with initial capitals and are usually followed by the menu number in brackets, e.g., Main Menu [5].
- The symbol " ∇ ∇ ∇ " is used to mark the end of each section

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CHAPTER 1: INTRODUCTION

In This Section:

1.1. Goals and Objectives

This manual presents the steps and tools necessary to safely operate a 200-2000 hp air-cooled Perfect Harmony AC motor drive. You will learn to identify the key components of the drive, how to use the integrated keypad and display to operate the drive, how to identify the elements in the menu structure (parameters, menus, pick lists and functions), how to navigate through menus, how to set parameter values, how to initiate functions, how to select pick list variables, how to recognize and diagnose fault conditions, and how to properly maintain the drive for optimal performance. A list of objectives follow.

1. Given the appropriate handling, placement and safety guidelines as a reference, properly install the Perfect Harmony drive.
2. Identify major internal and external hardware components.
3. Given the technical references found in this manual and the cell specification for a particular drive, determine the associated input and output current ratings, the typical thermal losses (BTUs/hr), and the required CFM for proper system cooling.
4. Using the integrated keypad/LCD and navigation techniques, locate menus, submenus, parameters, pick lists and functions.
5. Make appropriate changes to parameter and pick list values.
6. Using the integrated keypad and LCD, perform basic drive functions such as manual start, manual stop, automatic mode, and fault reset.
7. Given a fault message or error indication, troubleshoot the drive, define appropriate corrective actions to remedy the problem, clear the fault message, and restore proper operation to the drive.
8. Given (1) a properly installed Perfect Harmony system, (2) system control drawings, (3) operational theory background, (4) desired configuration specifications, and (5) a startup check list, configure the drive's control parameters appropriately for the application and prepare the drive for normal operation.
9. Given the appropriate software and hardware tools, successfully perform uploads and downloads of a system program.
10. Given an operating Perfect Harmony drive, upload the system program and reverse compile it into source code.
11. Given a valid system program source file, make operational changes to the logic, compile, and download the new file to a Perfect Harmony drive.
12. Given (1) a compatible communications network connection, (2) the appropriate hardware, and (3) an understanding of the third party's communications protocol and specifications, connect and configure the Perfect Harmony drive for operation as a slave device on the third-party communications network.
13. Given a specific drive issue and reference material, locate supporting information to resolve the issue.

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1.2. Target Audience

This manual is intended for use by plant maintenance personnel, operators and average users. Some information is also provided for system integration technicians, programmers and advanced users.

After reading this manual, you will be aware of the steps and tools necessary to startup, operate and troubleshoot a Perfect Harmony AC motor drive. You will also learn how the drive functions and some of the advanced operational tools and techniques used in conjunction with the drive.

1.3. Introduction to the Perfect Harmony

Perfect Harmony is a series of pulse-width modulated, variable frequency AC motor drives designed and manufactured by ROBICON. The Perfect Harmony drive system addresses the following power quality issues:

- providing clean power input
- providing a high power factor
- providing nearly perfect sinusoidal output.

Figure 1-1 illustrates a typical Perfect Harmony drive system.

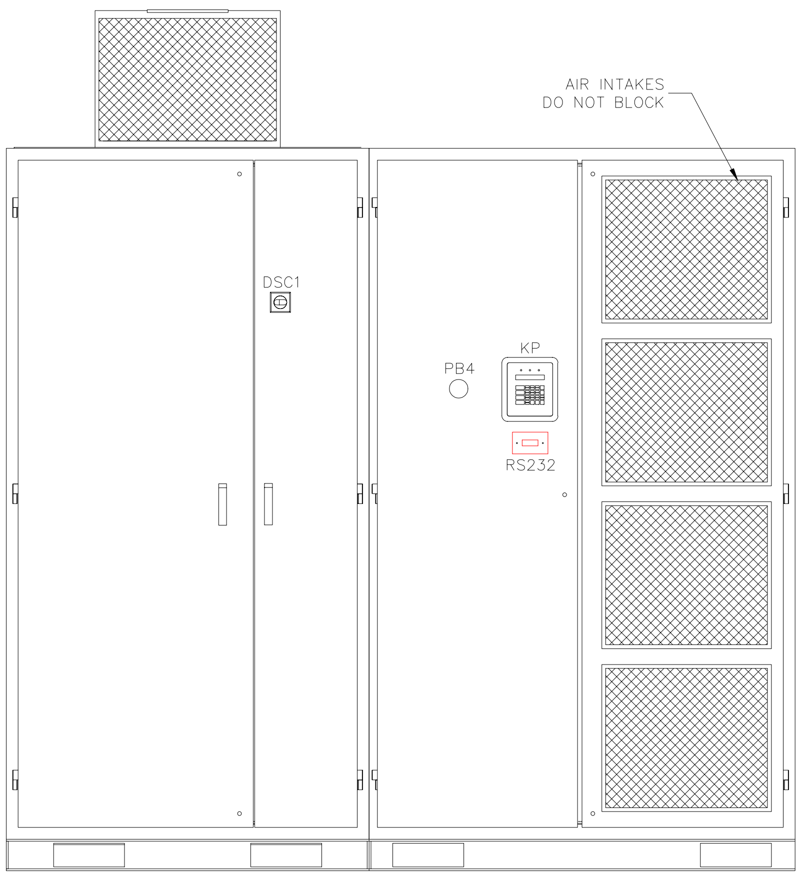

Figure 1-1. Typical Perfect Harmony VFD

1.3.1. 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 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 1-2 illustrates input wave forms for typical 6-pulse, 12-pulse and Perfect Harmony series drives.

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.

> 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.

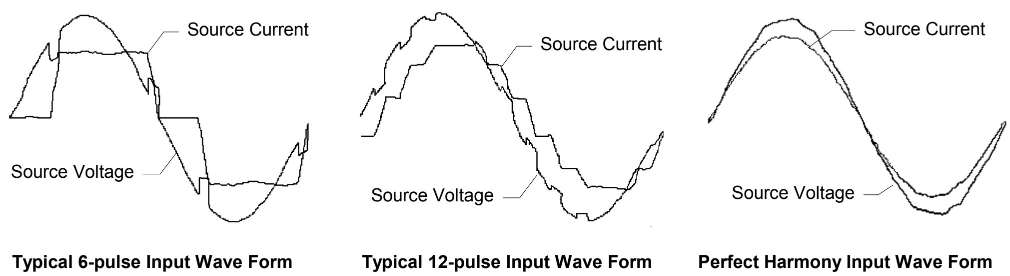

Figure 1-2. Harmonic Distortion Wave Form Comparisons

1.3.2. High Power Factor, Nearly Perfect Sinusoidal Input Currents

Power factor is a measure of the fraction of current which 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%). VFD’s 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 since a high and stable power factor is maintained throughout the entire speed range using standard induction motors. Figure 1-3 compares graphs of power factor versus percent speed for the Perfect Harmony series and a typical phase-controlled SCR drive.

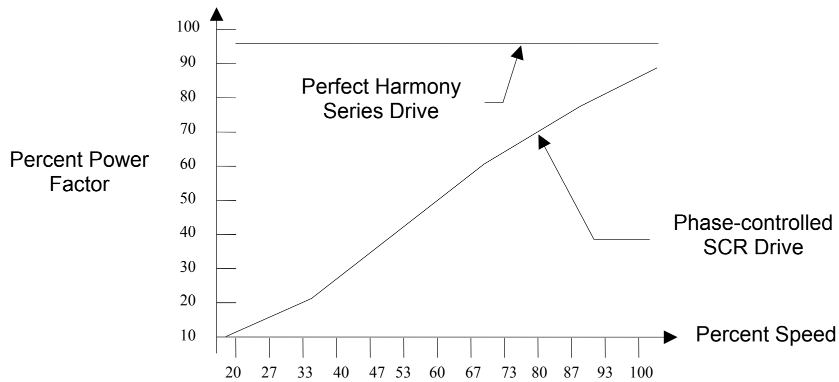

Figure 1-3. Power Factor vs. Percent Speed Comparison

1.3.3. 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 stress on mechanical 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 1-4.

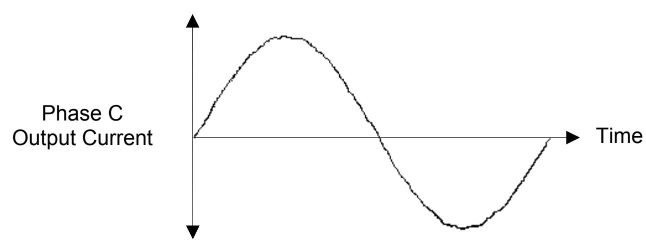

Figure 1-4. Nearly Sinusoidal Wave Form of Perfect Harmony Output Current

1.4. Features

Additional features of the Perfect Harmony drive include the following:

- Reliability
- Modular construction
- Surge arrestors
- Fiber optic control circuitry
- Soft start protection
- Multi-motor operation
- High efficiency
- Dual performance operation modes
- Trip-free operation
- Undervoltage ride-through
- Spinning load restart
- Cell back-up
- On-line diagnostics
- Power cell check
- Reports
- Serial port
- Keypad
- Digital display module
- Advanced diagnostics
- English messages
- On-line operation while tuning
- Micro PLC capabilities
- Industry standard communication.

1.5. Cell Specifications

ROBICON's Perfect Harmony AC drive system is offered in 3 basic cell sizes (current ratings), grouped to provide output operating voltages of 3300 VAC (3 cells in series), 4160 VAC (4 cells in series), and 6600 VAC (6 cells in series). Table 1-1, Table 1-2, and Table 1-3 (starting on page 1-6) provide the basic specifications associated with all cell combinations.

> 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.

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 galvanically isolated from the main control. Refer to Figure 1-5.

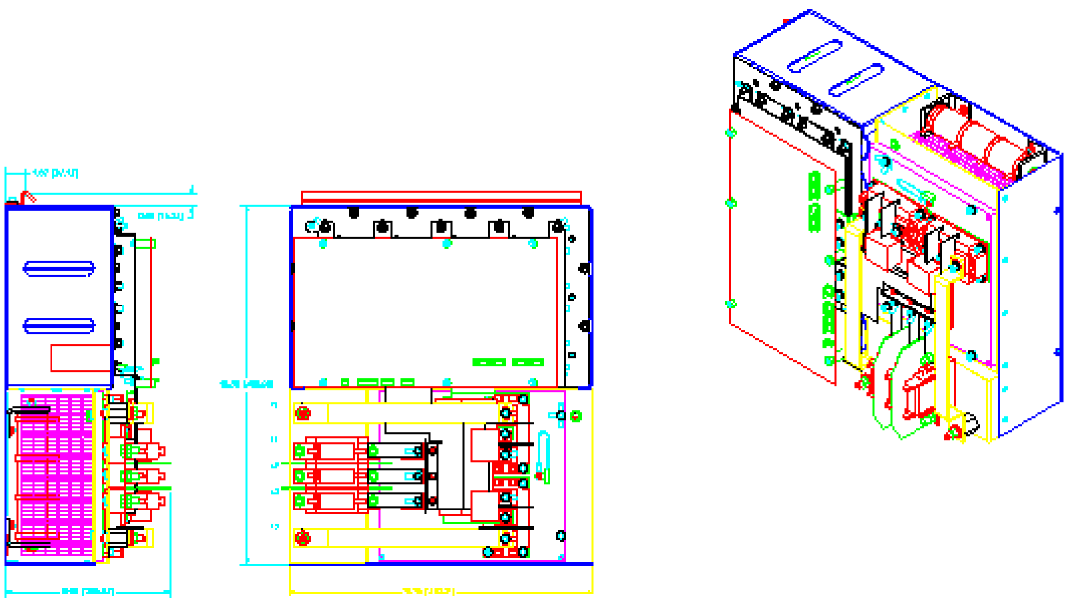

Figure 1-5. Typical Perfect Harmony Cell

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. This power supply is fully operational at 250 VAC.

The Control Section contains PC boards which provide central control of the 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.

Table 1-1 through Table 1-3 give length and weight information for many common configurations of sectional Harmony drives, based on 60 Hz input power at the voltages listed. If applications require inputs at 50 Hz or horsepowers above 2000 hp, sizes and weights may increase.

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The CFM and BTU information given in the following tables represents worst case conditions. Actual values may vary based on load, blower size, cell size and transformer size.

Table 1-1. 3,300 VAC Cell Specifications (9 Cells Total, 3 Cells per Phase in Series)

Hp [3]	In [4] Amps	Out [5] Amps	Losses [6] (BTU/Hr)	Req CFM	Length [7] (in)	Weight [8] (lbs)	Cell Size [9]
200	33	70	20,000	4,400	100	4,800	70A
300	49	70	30,000	4,400	100	4,800	70A
400	64	70	40,000	4,400	100	5,600	70A
500	80	100	50,000	4,400	100	6,200	100A
600	96	100	60,000	4,400	100	6,200	100A
700	112	140	70,000	4,400	100	7,500	140A
800	128	140	80,000	4,400	100	7,500	140A

Table 1-2. 4,160 VAC Cell Specifications (12 Cells Total, 4 Cells per Phase in Series)

Hp [3]	In [4] Amps	Out [5] Amps	Losses [6] (BTU/Hr)	Req CFM	Length [7] (in)	Weight [8] (lbs)	Cell Size [9]
300	38	70	30,000	4,400	100	5,100	70A
400	51	70	40,000	4,400	100	5,100	70A
500	63	70	50,000	4,400	100	5,800	70A
600	75	100	60,000	4,400	100	6,600	100A
700	89	100	70,000	4,400	100	6,600	100A
800	101	140	80,000	4,400	100	7,700	140A
900	114	140	90,000	4,400	100	7,700	140A
1000	126	140	100,000	4,400	100	7,700	140A

Table 1-3. 6,600 VAC Cell Specifications (18 Cells Total, 6 Cells per Phase in Series)

Hp [3]	In [4] Amps	Out [5] Amps	Losses [6] (BTU/Hr)	Req CFM	Length [7] (in)	Weight [8] (lbs)	Cell Size [9]
600	48	70	60,000	8,800	137	7,700	70A
700	56	70	70,000	8,800	137	9,000	70A
800	64	70	80,000	8,800	137	9,000	70A
900	72	100	90,000	8,800	137	9,000	100A
1000	80	100	100,000	8,800	137	10,400	100A
1250	100	100	125,000	8,800	137	10,400	100A
1500	120	140	150,000	8,800	137	12,300	140A
1750	140	140	175,000	8,800	137	12,300	140A

[3] Motor nameplate hp may not exceed the drive rated hp.
[4] Drive rated input current is the transformer rated current.
[5] Drive rated output current is the maximum cell current.
[6] BTU/hr losses are based on a loss of 3 kW per 100 hp.
[7] Represents lineup minimum length, subject to change.
[8] Represents estimated minimum weight of lineup, subject to change.
[9] The cell sizes for each hp rating are based on motors with at least 95% efficiency and at least 85% power factor.

1.6. Safety Issues

Perfect Harmony drives are designed with considerable thought to personal safety. However, as in any electrical or electronic equipment, there are numerous exposed connections that present **potentially lethal voltages**. In addition to the high voltages that are present in the cabinet, the heat sinks and many other internal components are thermally hot to the touch. The warnings shown below should be followed when working in or near the Perfect Harmony system.

Attention!
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 megohm 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 megohm 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 ROBICON, always use static-safe packing. This limits any further component damage due to ESD.

Attention!

- **Never** disconnect blower control power while medium voltage is energized. This could cause system overheating and/or cell damage.
- **Never** store flammable material in, on or near the drive enclosure. This includes equipment drawings and manuals.
- When transporting the Perfect Harmony drive system, the truck bed must be even and flat. Before unloading, be sure that the concrete pad is level for storage as well as permanent positioning.
- When lifting with cranes, be sure the crane, cables, and hooks have proper tonnage rating. Be careful not to drop the cabinet or lower it too quickly. This could damage the unit.

Caution - 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 until verifying that it is neither thermally hot nor electrically alive.
- **Never** assume that by switching off the input disconnect, that all of the voltage is removed from inside the cabinet. 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.
- **Never** connect any grounded (i.e., non-isolated) meters or oscilloscopes to the Perfect Harmony system.
- **Never** connect or disconnect any meters, wiring or printed circuit boards while the drive is energized.
- **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.
- **Always** check the class of insulation on meter lead wires before using a meter.
- **Never** run the drive with cabinet doors open. Also, **never** leave the Transformer Cabinet doors open - it reduces cooling to the drive.
- **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."

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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CHAPTER 2: ELECTRICAL COMPONENTS

In This Section:

2.1. Introduction

The basic electrical diagrams for all Perfect Harmony systems are similar. One critical component of all Perfect Harmony drives is the *output cell*. Depending on the operating voltages, either 3, 4, 5 (in future releases) or 6 output cells are operated in series to develop the required output operating voltage (refer to Figure 2-1 and Figure 2-2). Table 2-1 provides cell specification details for the Perfect Harmony system.

Table 2-1. Cell Specification Details

Number of Output Cells Per Phase	Line-to-line Voltages (VAC)	Total Number of Cells in Drive (Without Spares)	Hp Range	Available Cell Sizes
3	3,300	9	200-800	70A, 100A, 140A
4	4,160	12	300-1000	70A, 100A, 140A
6	6,600	18	600-1750	70A, 100A, 140A

2.2. The Cell Control System

All Perfect Harmony cells are controlled in exactly the same manner. The Cell Control/Gate Driver Boards reside within the output cell (refer to Figure 2-4 and illustrations in Chapter 1) and accept all communication from the Master Link Boards 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.

2.3. The Master Control System

The Master Control located within the Control Cabinet consists of three basic component groups. The Power Interface Board contains a “piggy back” Microprocessor Control Board which monitors and controls the overall operation of the system. Control power for both Power Interface Board and Microprocessor Board is supplied from a switch mode power supply on the Power Interface Board. Refer to Figure 2-3 and illustrations in Chapter 1.

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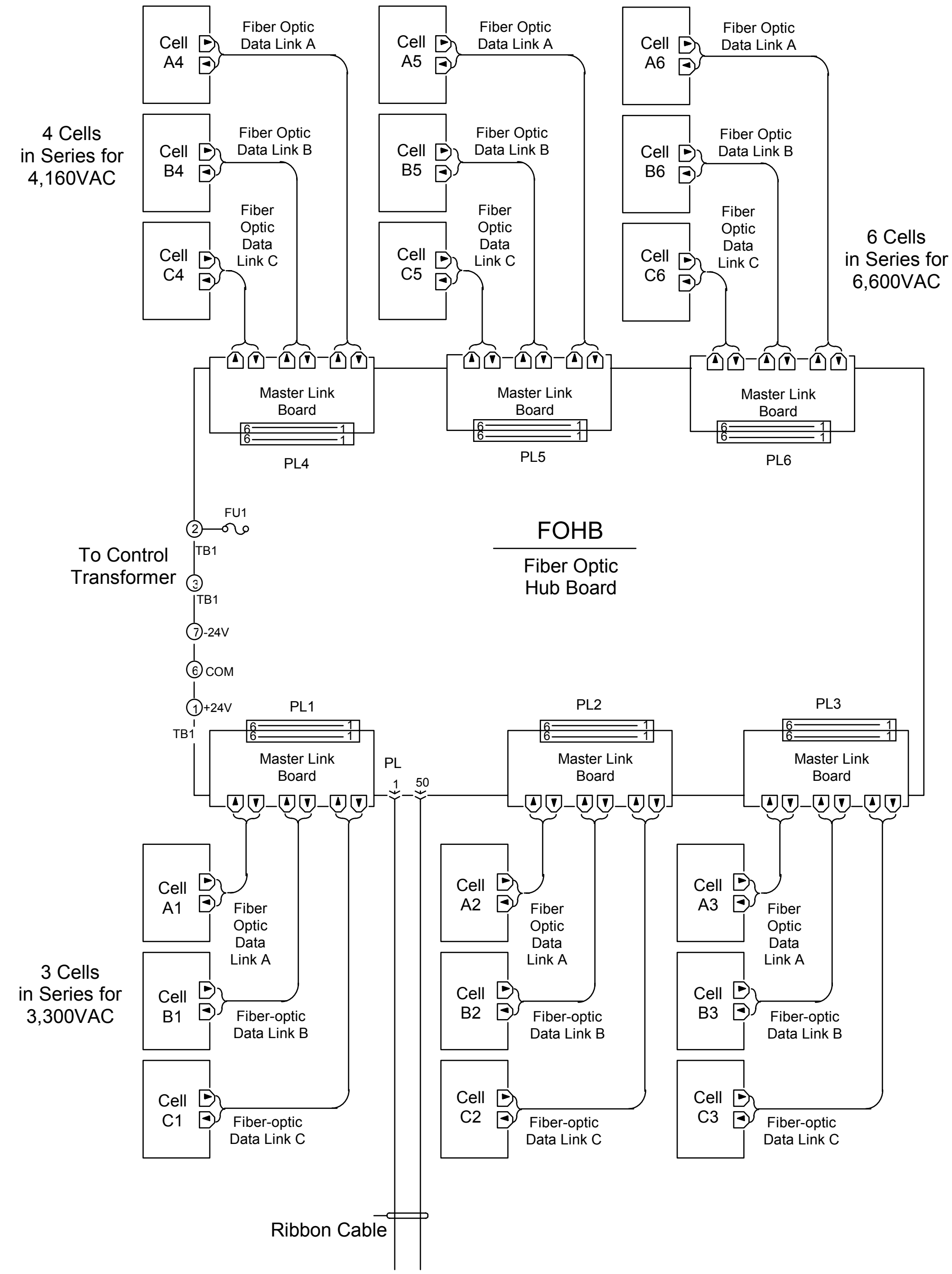


Figure 2-1. Typical Connection Diagram for an 18 Cell 6.6 KV System

The System Module is a daughter board that is located on the Microprocessor Board. It may be disconnected from the Microprocessor Board if it ever needs to be replaced. The System Module 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, both the system module (EEPROM) and **IC39** (EPROM) should be moved to the new board (see Figure 2-3).

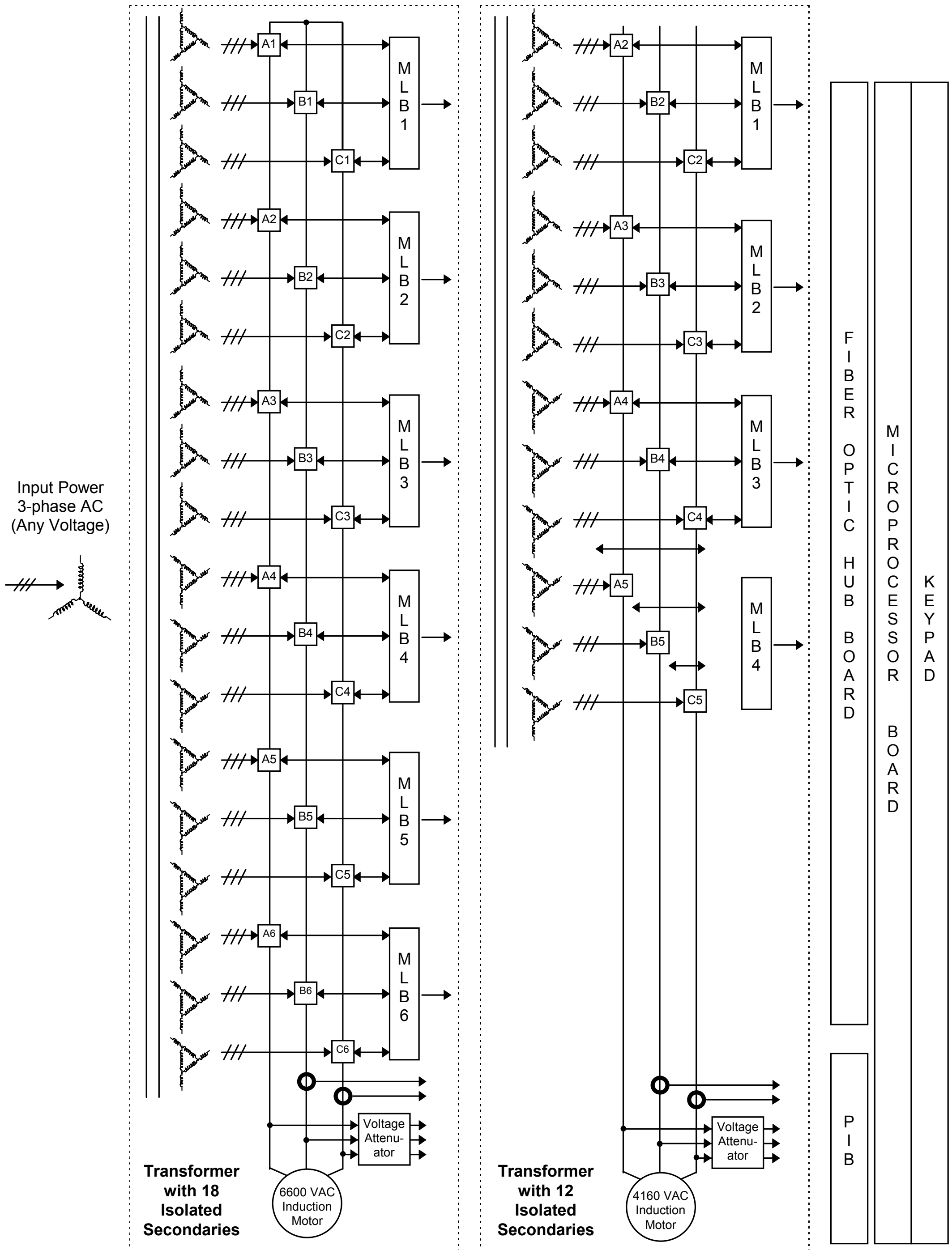


Figure 2-2. Typical Perfect Harmony Power Circuit (18 and 12 Secondary Configurations Shown)

The communication between the Microprocessor/Power Interface Board group and the individual Cell Control/Gate Driver Boards is accomplished by the Fiber Optic Hub Board (FOHB). This board may contain from 3 to 6 plug-in Master Link Boards depending on the output operating voltage of the drive (refer to Figure 2-2 on page 2-3 and illustrations in Chapter 1). These boards contain the fiber-optic transmitter/receiver system used for communication between the cells and the system. A separate switch mode power supply in the FOHB supplies all necessary power to the FOHB and Master Link Boards.

For each motor voltage (3,300 VAC through 6,600 VAC), the number of cells per output phase are shown in Table 2-1 on page 2-1. This corresponds to the same number of Master Link Boards that are used by the system. For 3,300 VAC rated systems, 3 Master Link Boards are used. For 4,160 VAC rated systems, 4 Master Link Boards are used. For 6,600 VAC rated systems, 6 Master Link Boards are used. An extra slot is also available on the Hub Board for an optional redundant cell operating feature. Refer to Figure 2-1 (on page 2-2) and Figure 2-2 (on page 2-3).

> Although each PC slot (**PL1** through **PL6**) on the FOHB is dedicated to particular cell inputs (see Figure 2-1), the Master Link Boards themselves are identical.

2.4. The Power Circuit

The basic power schematic for a three cell (3,300 VAC) system is shown in Figure 2-2. 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 Power Interface Board by an attenuator system consisting of a voltage divider and voltage clamps.

Output motor current is sensed by 2 low burdened 2000:5 ratio CTs placed on output phases B and C. Polarity and burden resistor values must always be maintained.

Each three-phase 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 leads is dramatically reduced and, the quality of the motor currents is dramatically increased.

> **DANGER!** Although each cell by itself develops no more than 690 VAC , the voltage to ground can increase to the L-N output rating at full speed.

Since each cell is fed from T1 with varying degrees of phase shift (see Figure 2-2), the input VFD current distortion is dramatically reduced. Input power factor is always maintained greater than 0.95 lagging. See Chapter 3 for more information on the theory of operation.

Each Perfect Harmony VFD cell within a specific system is identical. Figure 2-4 depicts the basic schematic for a typical power cell (also refer to illustrations in Chapter 1). 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/Gate Driver Board. All communication and control for each cell is performed by the Cell Control/Gate Driver Board.

Each cell contains a thermal sense unit (**TAS2B**) which senses the heat sink temperature and will allow automatic thermal rollback if a problem develops in the VFD cooling system.

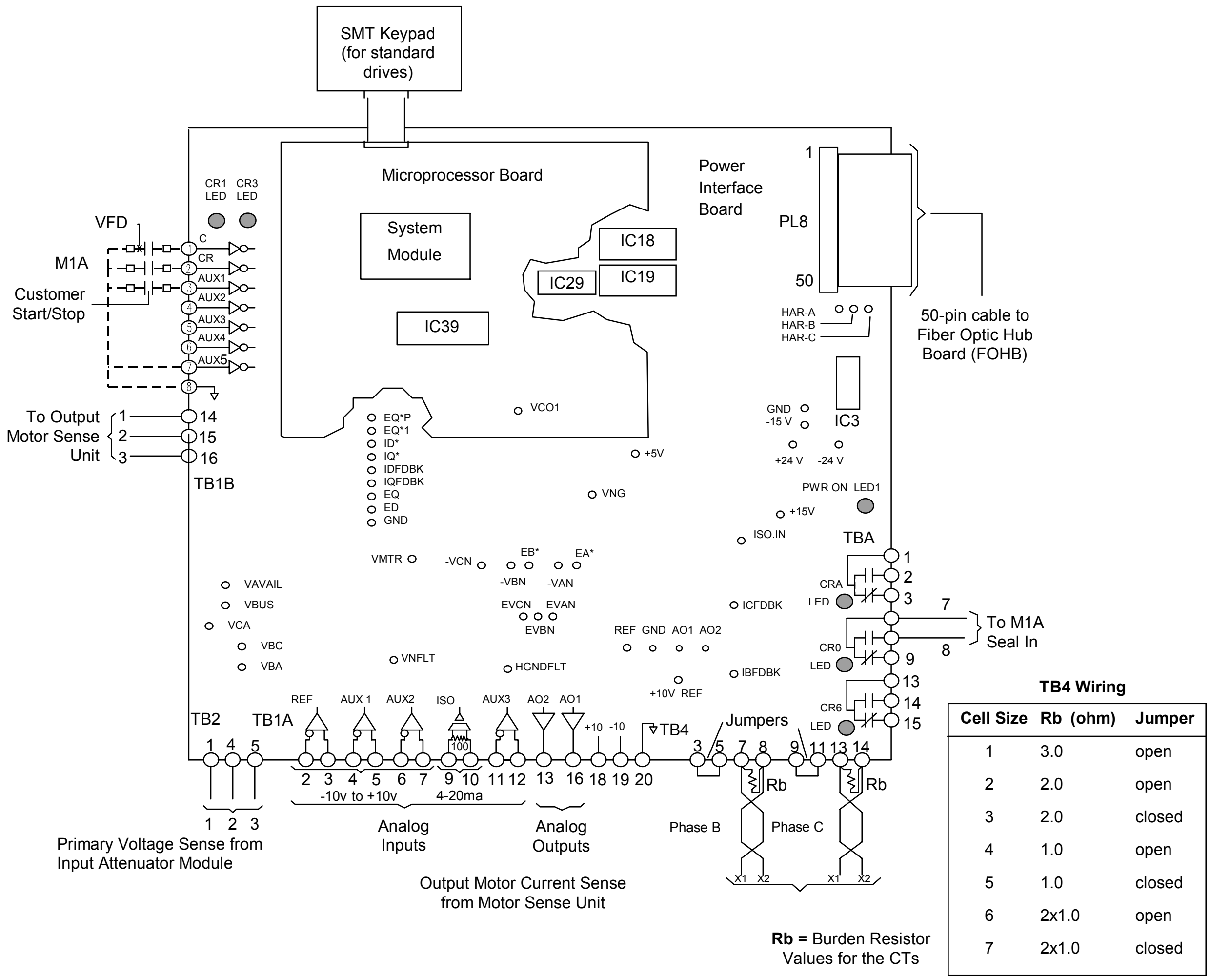
A typical operating interface for the Perfect Harmony series VFD is shown in Figure 2-3. Usually two modes of operation exist. A local mode is available for "Manual" operation. In this mode, on/off and speed setpoint control is available through the keypad controls.

In auto mode, on/off control is usually accomplished through an external contact connected to the AUX 1 input on the Power Interface Board (PIB). Speed setpoint is usually programmed to use the 4-20 mA analog input on the Power Interface Board (PIB). In both cases, a contact connected to the **CR3** input must be closed in order to enable the VFD.

The **CR1** input is usually configured to accept seal in contacts from external bypass equipment.

> **NOTE!!** All the analog and digital input and output interfaces shown on the PEM and PIB boards of Figure 2-3 can be configured using the system program environment described in Chapter 8 (with the exception of the **CR3** input).

A typical system program which might be written for the system depicted in Figure 2-3 is shown in Chapter 8.



TB4 Wiring

Cell Size	Rb (ohm)	Jumper
1	3.0	open
2	2.0	open
3	2.0	closed
4	1.0	open
5	1.0	closed
6	2x1.0	open
7	2x1.0	closed

Figure 2-3. Typical System Control Schematic

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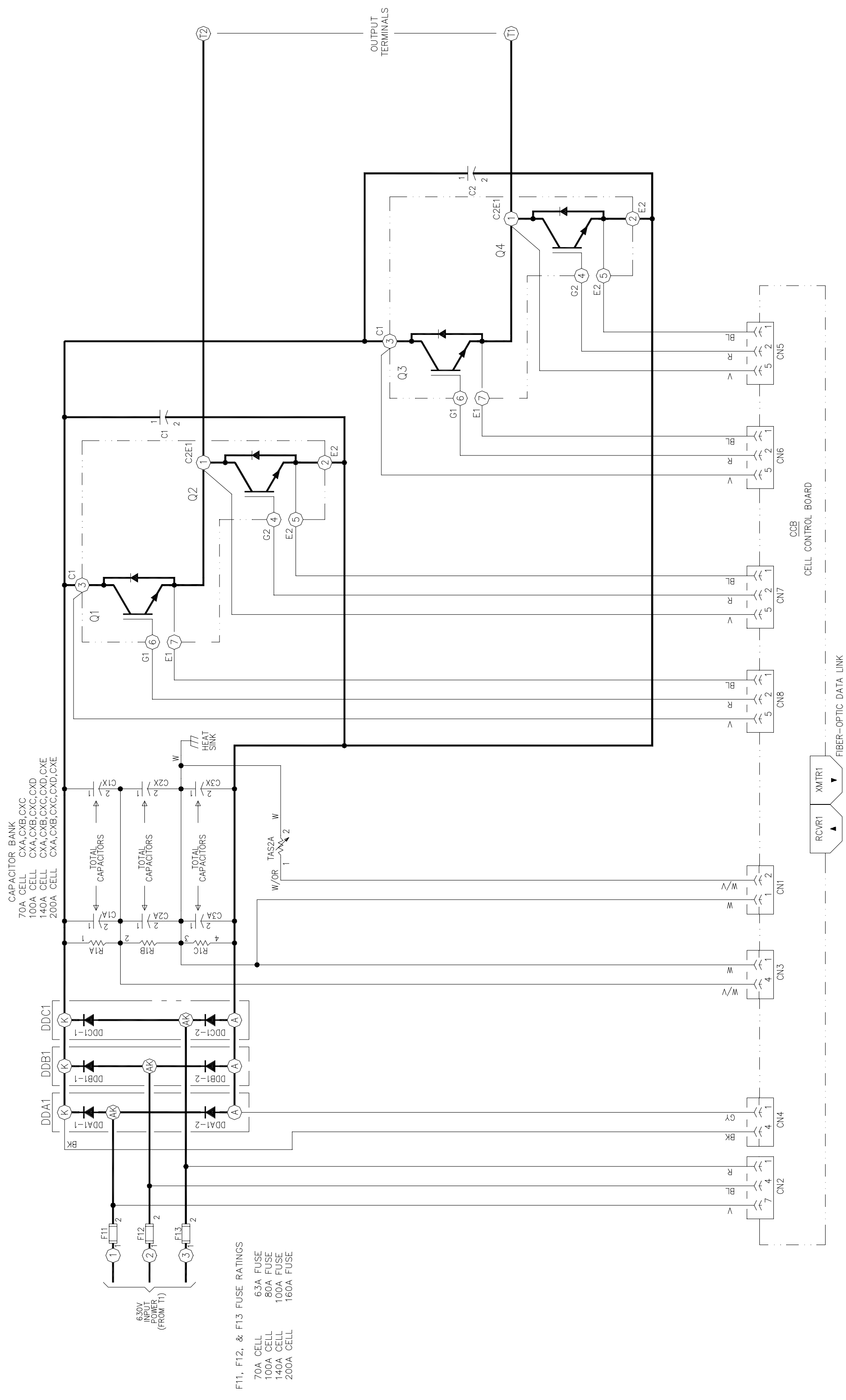

Figure 2-4. Typical Power Cell Schematic

2.5. Specifications

Table 2-2 lists common electrical (and mechanical) specifications for all standard Perfect Harmony systems. Note that Perfect Harmony specifications may be changed without notice.

Table 2-2. Common Specifications for Standard Perfect Harmony Systems

Item	Description
Hp range	200-800 hp (3,300 VAC) 300-1,000 hp (4,160 VAC) 600-1,750 hp (6,600 VAC)
Input voltage tolerance	+10%, -5% from nominal 3-phase at rated output
Input power factor	0.95 at all speeds
Output frequency drift	±0.5%
Speed range	0.5-120 Hz (motor dependent)
Overload capability	Not to exceed cell maximum current rating (70 A, 100 A, or 140 A)
Acceleration/deceleration time range	0.5-3,200 sec (load dependent)
Output torque	0-60 Hz variable, 5-60 Hz constant (motor limited)
Enclosure	NEMA 1 ventilated
Ambient temperature	0-40° C
Humidity	95% non-condensing
Altitude	3,300 feet above mean sea level or less
Dust contamination	<100 micron @ 6.5 mg/cu. ft.
Gas contamination	<4 PPB reactive chlorides and sulfides

Caution! Indoor equipment is not weatherproof and must be protected. If it is necessary to temporarily store it in an outdoor area, heaters should be placed in the equipment and operated to prevent moisture accumulation. A protective cover such as plastic or a tarp should be placed over the drive to reduce any problems due to the outside elements. This is especially important if the storage is for more than a few days.

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CHAPTER 3: THEORY

In This Section:

3.1. Introduction

The Perfect Harmony series of drives from ROBICON is intended for use with standard medium-voltage three-phase AC induction motors. This type of motor is widely used due to its robust and simple construction, its tolerance for bad environments, and its low cost. However, when operated from the utility supply at a fixed frequency (60 or 50 Hz), the induction motor runs at a single fixed speed. The Perfect Harmony series of drives allows variable speed operation, without sacrificing any of the other desirable properties of the induction motor.

The Perfect Harmony series of drives provides 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 Perfect Harmony series does not force the user to accept unpleasant by-products of this conversion process. Specifically:

- Perfect Harmony 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.
- Perfect Harmony drives present a high power factor to the utility, typically 95% or better throughout the speed range. No power factor correction is required.
- Perfect Harmony 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.
- Perfect Harmony drives do not produce torque pulsations which can excite mechanical resonances.
- Perfect Harmony drives cause no noticeable increase in acoustic noise from the motor, versus operation directly from the utility.
- Perfect Harmony drives cause no appreciable additional stress to the motor insulation, versus operation directly from the utility.
- Perfect Harmony drives allow unrestricted use of rated motor torque throughout the speed range, subject only to the thermal limitations of the motor.
- Perfect Harmony drives are virtually silent in operation if liquid-cooled. If air-cooled, the blower noise is typically less than 75 DBA, so that normal conversation is possible next to drives running at full power.
- Perfect Harmony 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.

3.2. Theory - The Power Circuit

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

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

Figure 3-1 shows the power circuit topology for a 3,300 volt Perfect Harmony series drive. 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 9 secondaries are each rated for 630 VAC at one ninth of the total power. The power cells and their secondaries are insulated from each other and from ground for the full output voltage of the drive.

For a 4,160 volt drive, Figure 3-1 would be extended to have 4 power cells in series in each phase, with 12 secondaries on the integral isolation transformer. For a 6,600 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 630 VAC 3-phase, 50/60 Hz and delivering that power to a single-phase load at any voltage up to 630 VAC and at any frequency up to 120 Hz.

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 5 KV 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 Figure 3-3. In this example, a 3-phase diode rectifier, fed by the 630 VAC secondary, charges a DC capacitor bank to about 900 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 +900 volts from T1 to T2. If Q2 and Q3 are on, the output will be -900 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 Figure 3-3 can produce 7 distinct line-to-neutral voltage levels (±2700, ±1800, ±900, or 0 volts). With 5 cells per phase, 11 distinct voltage levels are available. The ability to generate many different voltage levels allows the Perfect Harmony to produce a very accurate approximation of a sinusoidal output wave form.

Figure 3-2 shows how these wave forms are generated for the case of 3 cells per phase. First, a reference signal is created for each phase. These signals are scaled-down replicas of the ideal wave form to be approximated. In Figure 3-2, **RA** is the reference signal for phase A. This reference signal is then compared with 3 triangular carrier signals, oscillating at 600 Hz. Figure 3-2 shows conditions when the output frequency is 60 Hz, 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 carrier frequency). Carrier phase shift is computed based on the following equation.

Carrier Phase Shift = (180 degrees) / (# of cells per phase)

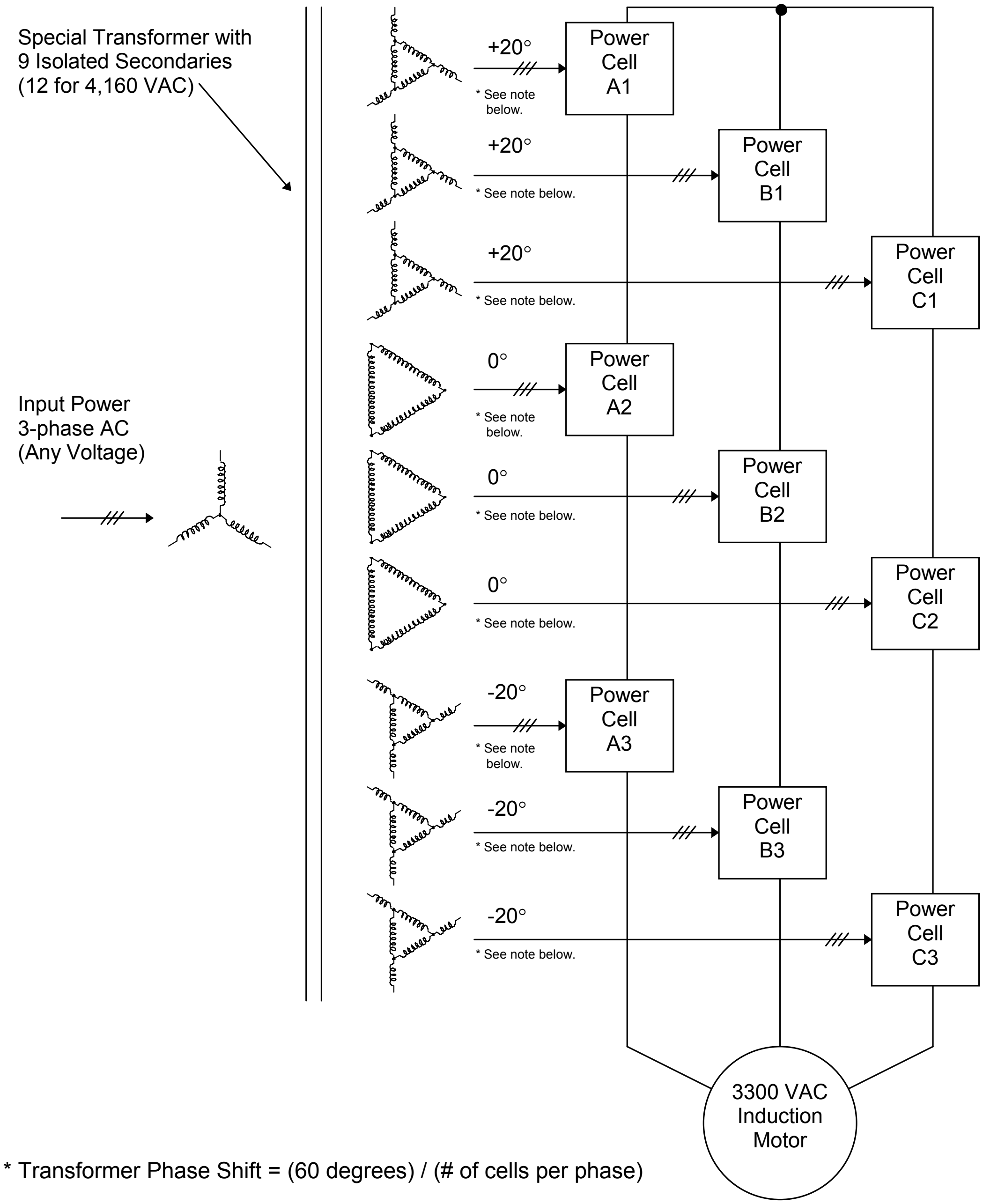

Figure 3-1. Topology of Perfect Harmony VFD (3 Cells, 3,300 VAC)

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 in Figure 3-3). 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 3-3).

The difference between **L1** and **R1** gives the output wave form of cell **A1**, shown in Figure 3-2 for Phase A as **A1**.

In a similar manner, the reference signal is compared with the second carrier (shifted 60 degrees) and its inverse to generate control signals **L2** and **R2** for the transistors in cell **A2**. The output wave form of cell **A2** is shown as **A2**.

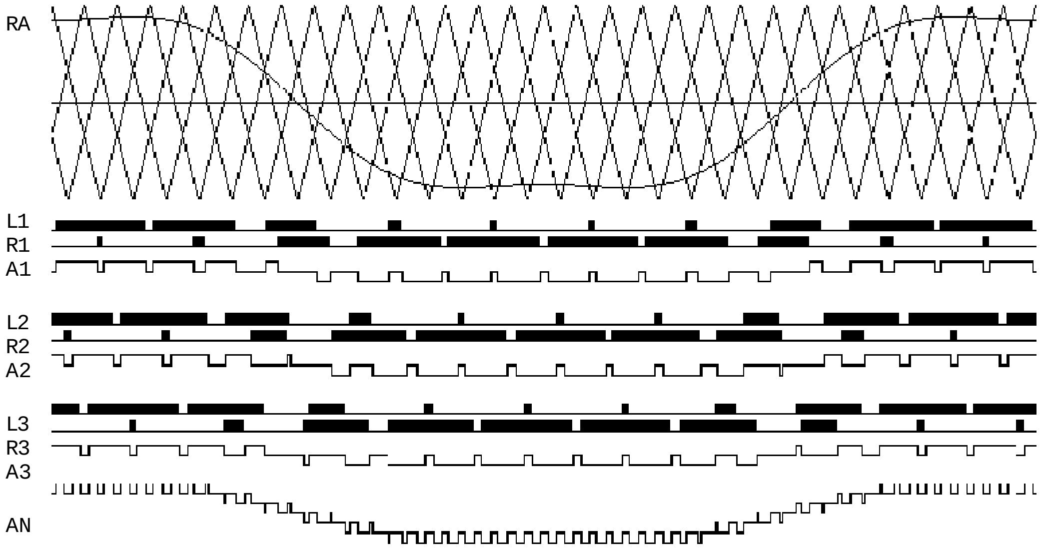

Figure 3-2. Wave Forms for Phase A

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 wave form of cell **A3** is shown as **A3**.

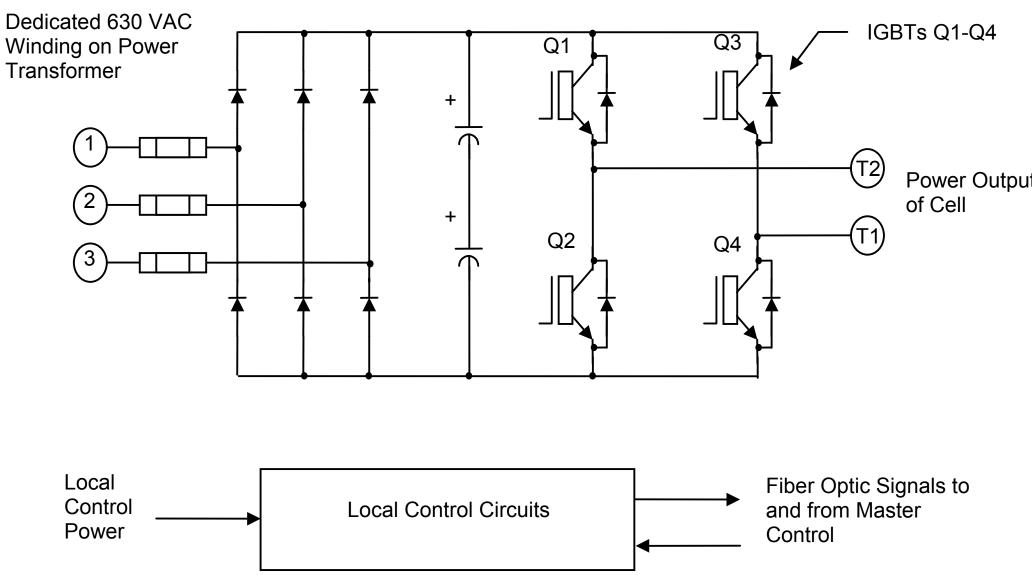

Figure 3-3. Schematic of a Typical Power Cell

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 3-2 as **AN**. There are seven distinct voltage levels. Note that this voltage is defined between terminal A and the floating neutral inside the drive, not the motor neutral.

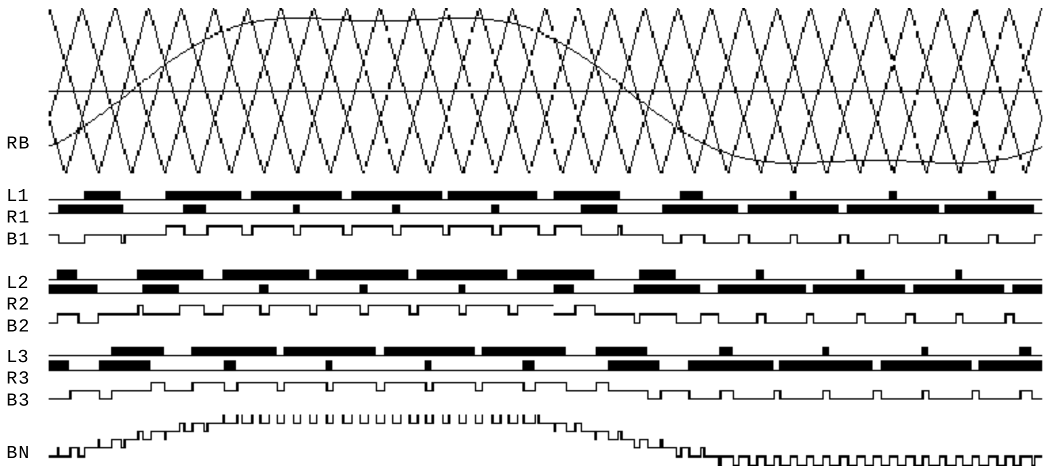

Figure 3-4. Wave Forms for Phase B

Figure 3-4 shows the same signals for Phase B. The 3 carriers are identical to Figure 3-2. The reference **RB** is also identical to Figure 3-2, 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 3-4 as **BN**.

Figure 3-5 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 3-5 as **AB**.

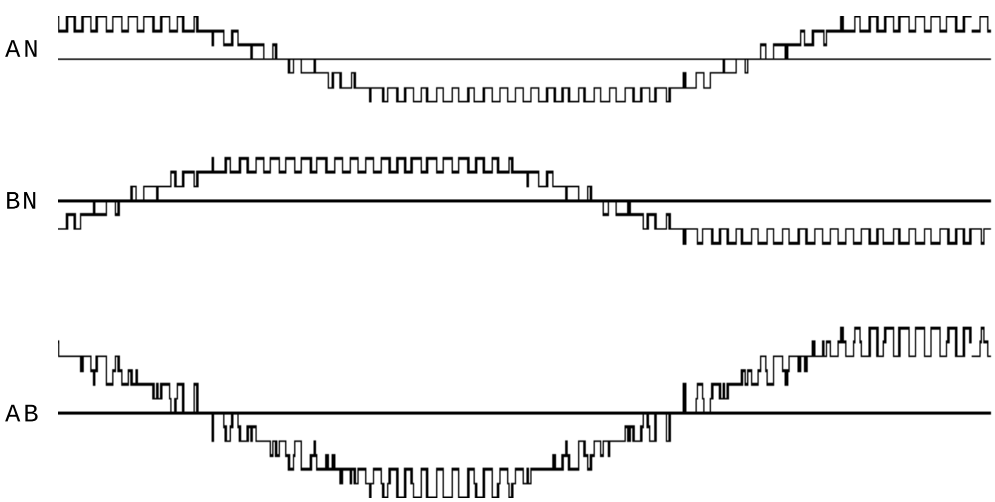

Figure 3-5. Wave Forms for Line-to-line Voltage

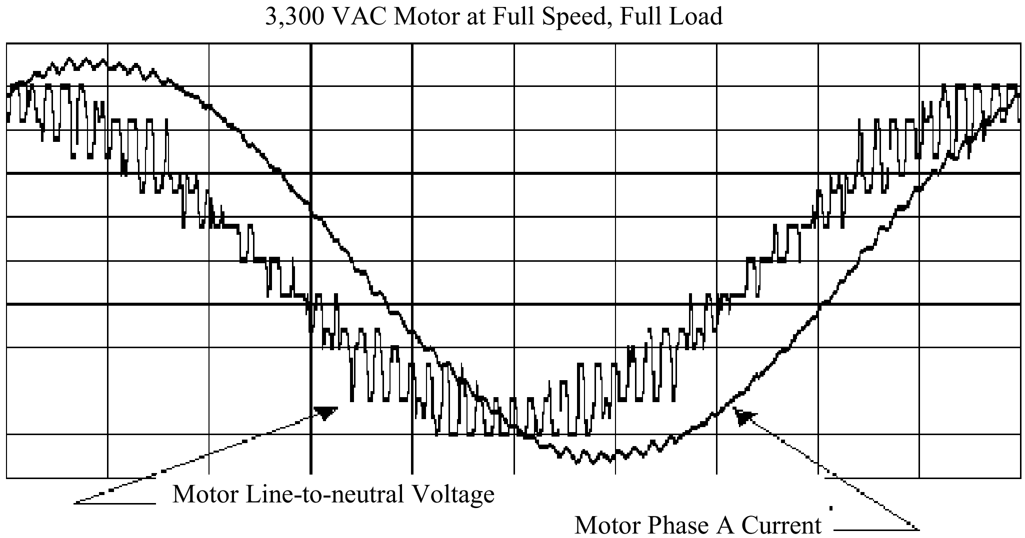

Figure 3-6. Perfect Harmony Output Wave Forms, 3,300 Volt Drive at Full Load

Figure 3-6 shows motor voltage and current wave forms for a 3,300 VAC Perfect Harmony drive. 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 wave forms for other types of static drives will appreciate how accurately they approximate true sine waves. A quantitative measure of the wave form quality is its Total Harmonic Distortion, or THD. The THD of the motor currents with a Perfect Harmony series drive is always less than 5 percent.

Figure 3-7 shows the input voltage and current wave forms for the same drive as in Figure 3-6, under the same conditions. The perfect sine wave in Figure 3-7 is the voltage into the special input transformer, measured between phase A and the neutral of the wye-connected primary. The other wave form is the current into phase A of the same winding.

The currents drawn from the power source by the Perfect Harmony 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 Perfect Harmony series drive is also always less than 5 percent.

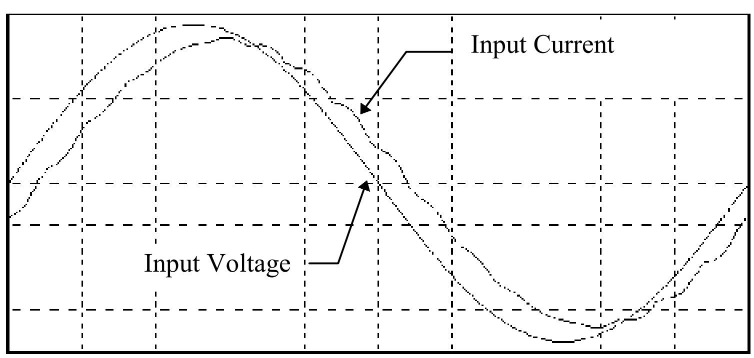

Figure 3-7. Input Wave Forms for a 3,300 Volt Drive at Full Load

Note in Figure 3-7 that the input current lags behind the input voltage by less than 15 degrees at full load. Perfect Harmony drives always maintain a high power factor, typically better than 95 percent throughout the speed and load range.

The wave forms shown in Figure 3-3 through Figure 3-7 represent the worst cases for a Perfect Harmony series drive when there are only 3 cells per phase. When the number of cells increases, as in 4,160 volt drives and higher, the wave forms become considerably better. Figure 3-8 shows the motor voltage and current for a 6,600 volt Perfect Harmony drive at full power, while Figure 3-9 shows the input voltage and current for the same drive and load.

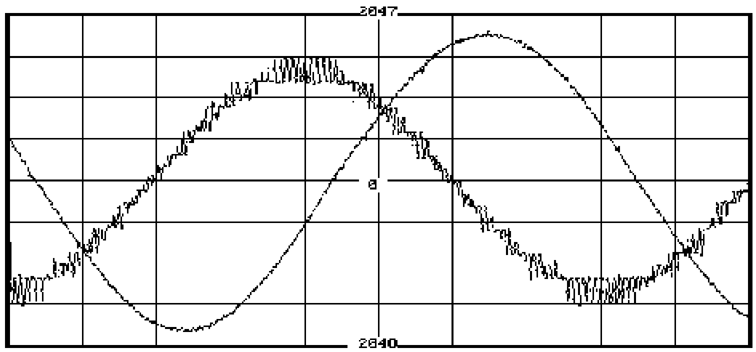

Figure 3-8. Motor A-B Voltage and Current in Phase C at Full Load for a 6,600 Volt Perfect Harmony Drive

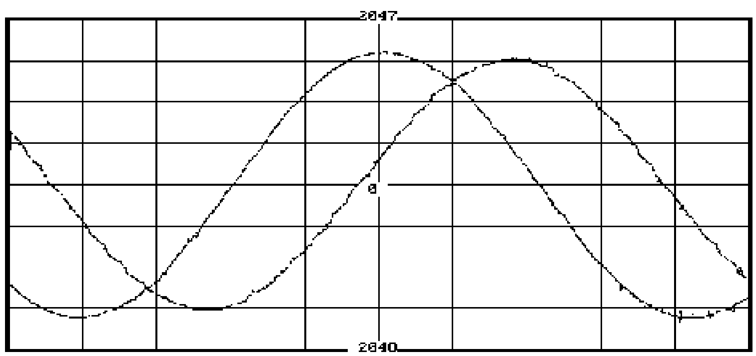

Figure 3-9. Input A-B Voltage and Current in Phase C at Full Load for a 6,600 Volt Perfect Harmony Drive

The block diagram in Figure 3-10 shows how the Perfect Harmony control circuits are organized. The power cells receive commands and return status information via duplex fiber optic cables, using serial communication at a speed of 5 MBaud. The local communication circuits in each power cell are slaves, and only transmit in response to an incoming message. These messages originate on one of the Master Link Boards, which can initiate a transmission. Each Master Link Board has 3 communication channels and controls 3 power cells, one in each output phase. The 3 power cells connected to one Master Link Board have all the same stage number. Master link #1 controls power cells **A1**, **B1** and **C1**, while master link #2 controls power cells **A2**, **B2** and **C2**, and so forth.

The Master Link Boards all plug into a single motherboard called the Fiber Optic Hub Board. The Hub Board has slots for as many as 6 Master Link Boards, which will accommodate a 6,600 VAC drive. Drives with fewer than 18 power cells will have one or more vacant slots on the Hub Board. Refer to Figure 3-10.

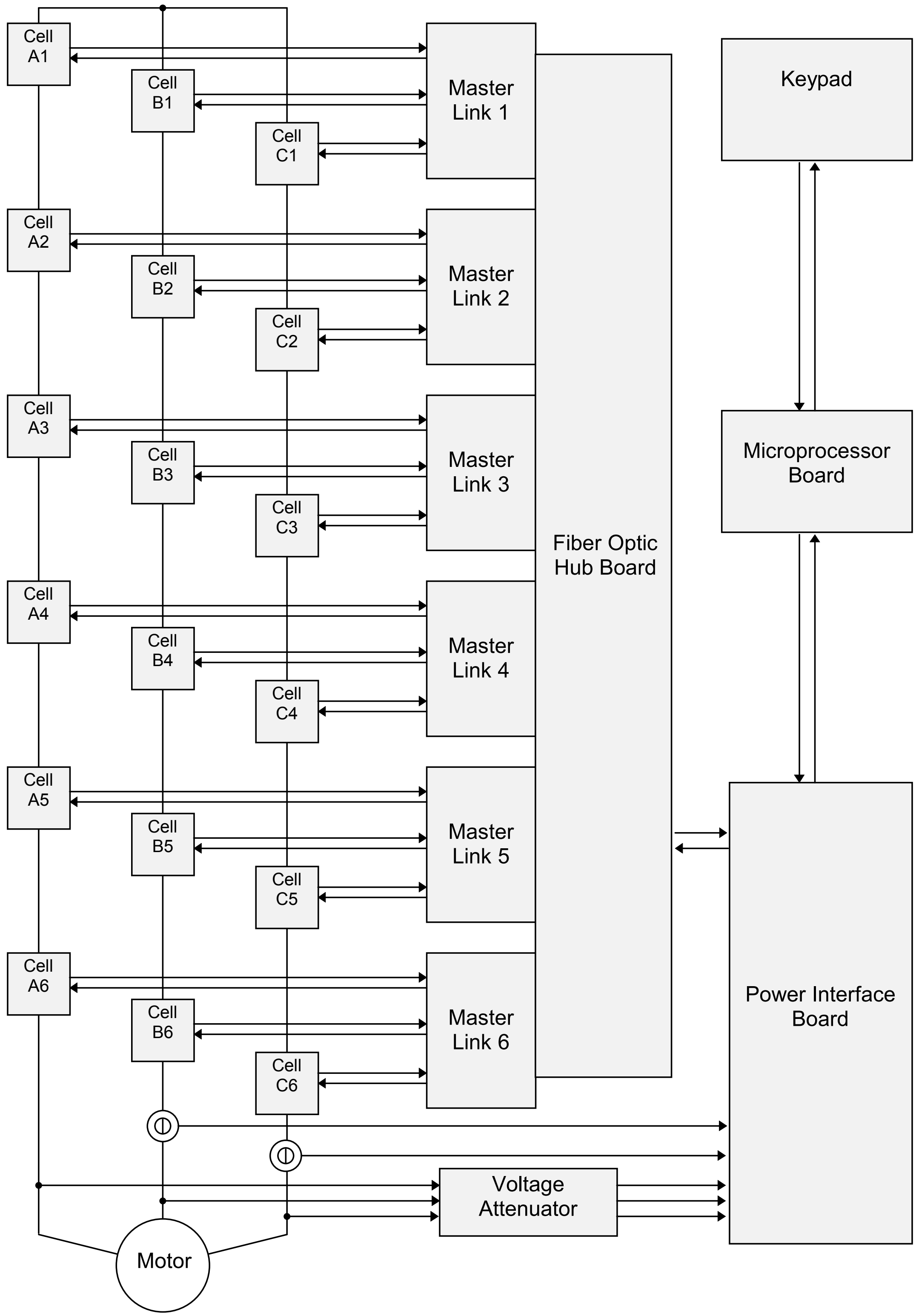

Figure 3-10. Block Diagram of Perfect Harmony Control Structure for 6,600 V Drive

The Hub Board provides +5 volt DC power to the Master Link Boards, and also a set of timing signals derived from a crystal oscillator. These timing signals cause all of the Master Link Boards to transmit simultaneously, once every 10.4 microseconds. The transmitted message contains 11 bits (2 start bits, 8 data bits, and 1 stop bit), and is delivered in less than 4 microseconds. The power cells then send back a similar message in response, which arrives within an additional 4 microseconds. During the remaining 2.4 microseconds, the Master Link Boards check that every transmission is complete, and has the correct parity. If an error is detected a link fault is generated.

For a 6,600 volt drive with 6 power cells per phase, there are 6 pairs of carrier waves displaced by multiples of 30 degrees. For a 3,300 volt drive with 3 power cells per phase, there are 3 pairs of carrier waves displaced by multiples of 60 degrees. The carrier waves are compared with reference signals to generate PWM control signals for the power cells.

The Hub Board also contains several digital registers, which store data determining the drive configuration. Such data include (1) the phase displacement needed for the carrier waves, (2) the power cells that have been bypassed, and (3) which power cells are being replaced by spares.

The Hub Board contains a multiplexing scheme that allows the microprocessor to interrogate each power cell in sequence, for diagnostics.

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CHAPTER 4: THE KEYPAD AND DISPLAY INTERFACE

In This Section:

4.1. 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.

Two keypad versions are available on Perfect Harmony drives - a standard surface mount technology (SMT) keypad and the expanded function keypad for engineered applications. The standard (SMT) keypad has built-in buttons for fault reset, auto mode, manual start, and manual stop functions. Three diagnostic LEDs (power on, fault status and run) are built in to the standard keypad. The expanded function has only the standard menu buttons. Diagnostic LEDs and control switches are optional for engineered jobs and are specified by the customer.

Normally, the keypad and display interface is mounted permanently to the drive. However, the keypad/display module need not be mounted for normal operation. It can be plugged in as an external module for set-up and diagnostic purposes only. This can be used to provide extra parameter security.

> This chapter focuses primarily on the standard SMT keypad used for Perfect Harmony drives. Most illustrations in this chapter depict this standard interface. The expanded function keypad (used for engineered applications) is discussed later in this chapter.

The Perfect Harmony system provides a fully-programmable, multi-level security system that assures menu access and modification capabilities by only authorized personnel.

4.2. The Standard Keypad

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 4-1.

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 9 common system menus, a help display function and a [Cancel] button. 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.

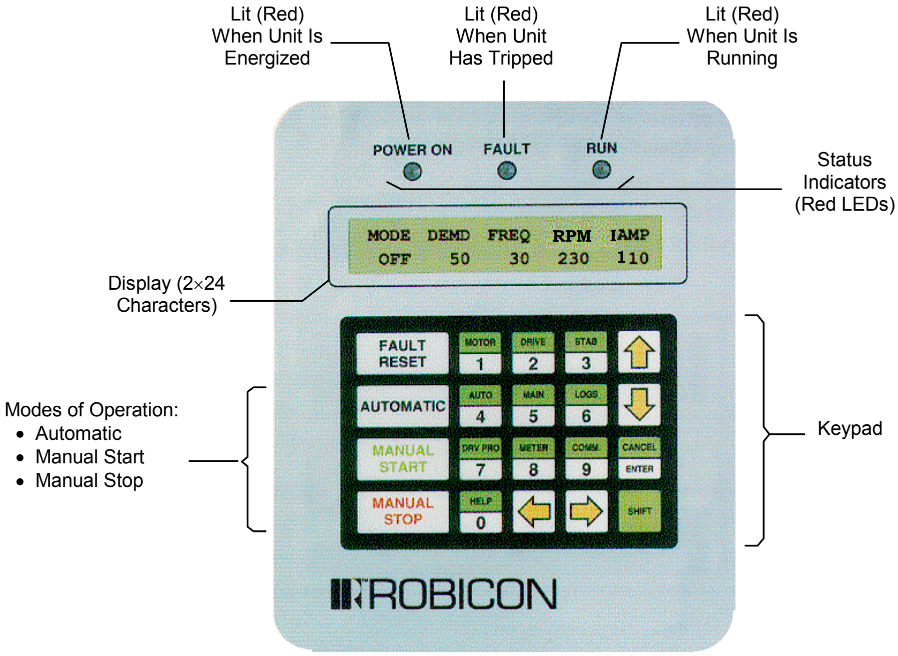

Figure 4-1. The Keypad and Display Interface of the Perfect Harmony Series

> The standard drive start-up message is replaced with "ROBICON **Vector PWM**" for Perfect Harmony drives containing the vector control option.

> Parameter values are stored in EEPROM - 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 standard 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.

4.2.1. Fault Reset Button

The [Fault Reset] button is located in the top left corner of the keypad and is used to clear fault conditions that may occur in the Perfect Harmony system. Faults refer to errors that have been detected by both the hardware and software. The current fault status of the drive is displayed by the Fault indicator located above the keypad and display (refer to Figure 4-1).

When a fault condition occurs, the fault indicator glows red. To reset the system (that is, acknowledge fault conditions), the operator must:

- Determine the cause of the fault (see the display or check the fault logger table)
- Correct conditions that may have caused the fault, if appropriate
- Reset the system by pressing the [Fault Reset] button on the keypad.

4.2.2. Automatic Button

The [Automatic] button is located below the [Fault Reset] button on the keypad and is used 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 (26).

> Using the default system configuration, the Perfect Harmony will not enter automatic mode if the jog digital input switch is pressed. 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.

4.2.3. Manual Stop Button

The [Manual Stop] button is used 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). During manual remote mode, the operator may press a user-supplied, digital input switch that is programmed as a manual stop input. This input (which is only valid during manual remote mode) is assigned to input **DI7** by default, but can be changed either through the front keypad or through modification of the system program.

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

4.2.4. Manual Start Button

The [Manual Start] button is located below the [Automatic] button on the left side of the keypad. [Manual Start] is used to put the Perfect Harmony system into manual control mode.

There are two varieties of manual mode: local and remote. These varieties are distinguished by the sources of the velocity demand. In local manual mode, the desired velocity is selected *manually* using the up and down arrow buttons ([⇧] and [⇩]) on the system keypad. In remote manual mode, the desired velocity is selected *manually* using a user-supplied potentiometer connected to the system. Remote manual mode is activated by pressing the momentary digital input assigned to manual start mode. A simplified flow diagram of manual mode is illustrated in Figure 4-2.

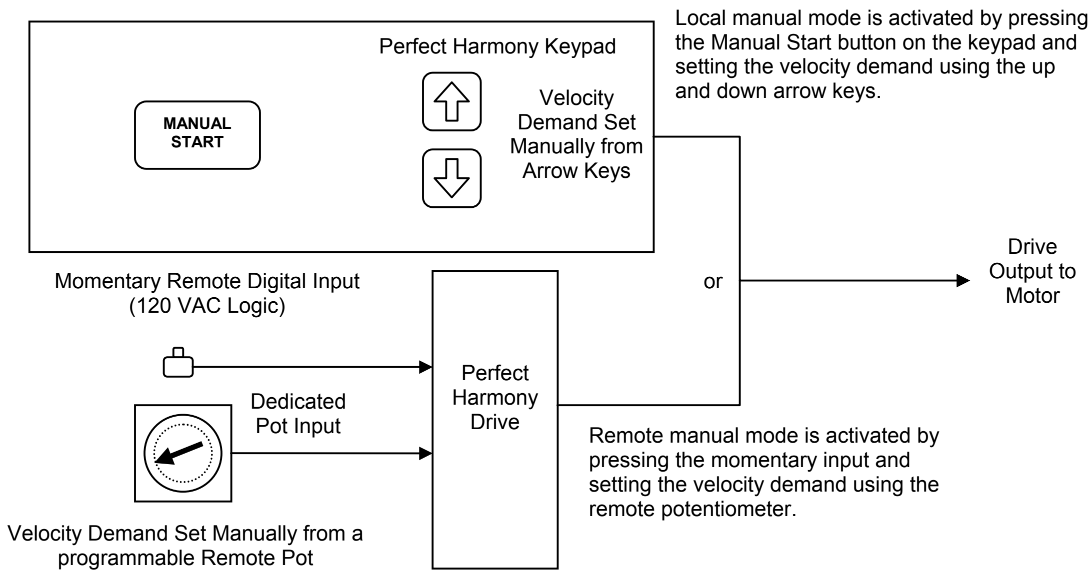

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Figure 4-2. Comparison of the Two Manual Control Modes

4.2.5. The 0-9 Buttons

Numeric buttons are centrally located on the keypad of the Perfect Harmony system. These 10 buttons (labeled 0 through 9) provide the following functions that are listed and explained below:

- entry of security access codes
- *quick menu* access
- direct access to all menus and submenus (with proper security) based on menu numbers
- ability to change the values of parameters.

One function of the numeric buttons 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”.

> *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] button followed by the numbers [1] through [6], respectively. Hexadecimal digits may also be required to make changes to parameters that use hexadecimal format. The keystrokes required to enter hex values “A” through “F” are listed in Table 4-1. Decimal equivalents are also listed.

Another function of the numeric buttons is the *quick menu* feature. Quick menu allows the operator to access 10 common menus within the system using the pre-programmed numeric keys. Each of the numeric buttons has an associated menu name printed in green (on top of each numeric button). To access one of these 10 menus, the operator uses the [Shift] button followed by the appropriate numeric button (e.g., [Shift]+[1] to access the Motor menu, [Shift]+[2] to access the Drive menu, etc.). Refer to Figure 4-3.

Table 4-1. 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

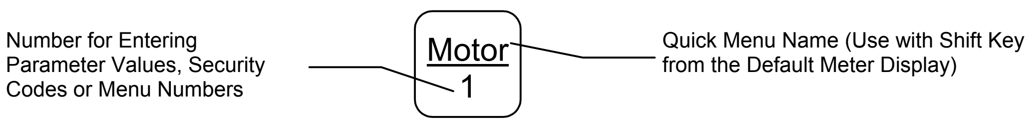

Figure 4-3. Anatomy of a Numeric Keypad Button

> The quick menu feature is available only from the main meter display on the LCD. The hexadecimal entry feature is available only during security code entry and parameter value modification. Therefore, the results of [Shift]+[1] through [Shift]+[6] key combinations depends on the context in which they are used.

In addition to the quick menu feature, a second menu access feature is available for all remaining menus in the Perfect Harmony system. While this second method requires more keystrokes to access target menus, the operator can gain access to *all* security approved menus rather than just the 10 most common menus. Accessing menus in this manner requires that the operator know the menu number associated with the target menu. This menu number can be a one, two or three digit number. To access a menu using its menu number, press the [Shift] key followed by the right arrow key [⇨]. The display prompts the operator for the desired menu number. Using the numeric buttons on the keypad, the operator enters the desired menu number then presses the [Enter] button. If the number was a valid menu number and the current security level permits access to that menu, then the desired menu will be displayed. Refer to Figure 4-4.

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.

Finally, the numeric buttons 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. The active digit can be changed by pressing a numeric key. 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.

> 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.

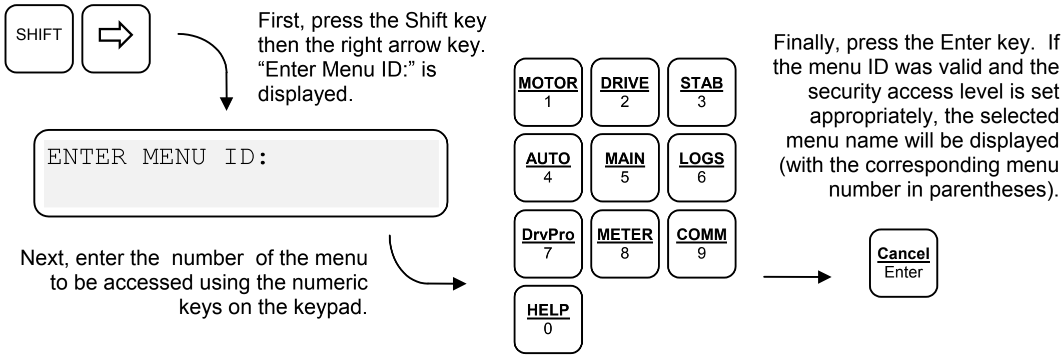

Figure 4-4. Accessing Menus Using Menu Numbers

> 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 a "-" 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 sign is implied in the parameter name itself.

4.2.6. The Enter/Cancel Button

The [Enter] button 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 to the previous menu
- Rejecting any modifications to a parameter value in edit mode.

4.2.7. Shift Function Buttons

The [Shift] button is located in the bottom right corner of the keypad on the Perfect Harmony system. This button is used to access a second set of functions using existing buttons on the keypad. Keypad buttons that can be used with the [Shift] key have two labels (one on top and one on the bottom of the button). The standard (un-shifted) function of the button is listed on the bottom half of the button and has a white background. The shifted function of the button is shown on the top of the button and has a green background (matching the green background of the [Shift] button 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 buttons 1 through 6 changes from quick menus to hexadecimal numbers "A" through "F" respectively. Refer to Table 4-1 on page 4-5 for more information.

> It is not necessary to simultaneously press the [Shift] button and the desired function key. The operator must press the [Shift] key first 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 4-5.

Figure 4-5. Location of Shift Mode Indicator on the Perfect Harmony Display

Common functions of the [Shift] key include:

- Entering “quick menus” ([Shift] plus appropriate “quick 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 based on menu 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).

A summary of [Shift] button key sequences is listed in Table 4-2.

4.2.8. Arrow Buttons

There are four yellow arrow buttons on the Perfect Harmony keypad. The up and down arrow buttons ([⇧] 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 Section 4.2.4: Manual Start Button on page 4-3). 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 4-6.

4

> 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.

Table 4-2. Summary of Common Shift Button Key Sequences

Key Combination	Description
[SHIFT] [Motor / 1]	Quick menu to the Motor menu (from the default meter display) Enters hexadecimal "A" (from value edit and security prompts)
[SHIFT] [Drive / 2]	Quick menu to the Drive menu (from the default meter display) Enters hexadecimal "B" (from value edit and security prompts)
[SHIFT] [Stab / 3]	Quick menu to the Stability menu (from the default meter display) Enters hexadecimal "C" (from value edit and security prompts)
[SHIFT] [Auto / 4]	Quick menu to the Auto menu (from the default meter display) Enters hexadecimal "D" (from value edit and security prompts)
[SHIFT] [Main / 5]	Quick menu to the Main menu (from the default meter display) Enters hexadecimal "E" (from value edit and security prompts)
[SHIFT] [Logs / 6]	Quick menu to the Logs menu (from the default meter display) Enters hexadecimal "F" (from value edit and security prompts)
[SHIFT] [DrPro / 7]	Quick menu to the Drive Protect menu (from the default meter display)
[SHIFT] [Meter / 8]	Quick menu to the Meter menu (from the default meter display)
[SHIFT] [Comm / 9]	Quick menu to the Communications menu (from the default meter display)
[SHIFT] [HELP / 0]	Quick menu to a context sensitive Help menu (from anywhere except the default meter display)
[SHIFT] [cancel / enter]	Cancels/aborts the current action/keystroke or returns to the previous menu
[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] [⇩]	Jumps to the bottom of the menu or submenu.

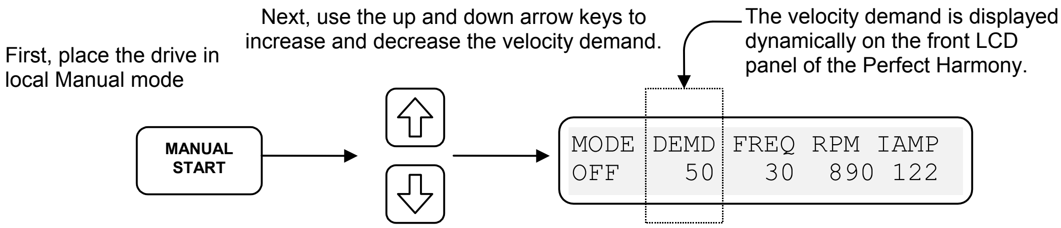

Figure 4-6. Using the Up and Down Arrow Keys to Control Velocity Demand

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 located to 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 pressing a reset button (**PB1** or **PB2**), 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 4-7.

Figure 4-7. Security Level Cleared Message on the Perfect Harmony Display

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 access feature. The operator can gain access to *all* security approved menus. Accessing menus in this manner requires that the operator know the menu number associated with the target menu. This menu number can be a one, two or three digit number. To access a menu using its menu number, press the [Shift] key followed by the right arrow key [⇨]. The display prompts the operator for the desired menu number. Using the numeric buttons on the keypad, the operator enters the desired menu number then presses the [Enter] button. If the number was a valid menu number and the current security level permits access to that menu, then the desired menu will be displayed. Refer to Figure 4-4 on page 4-6. Some common arrow key sequences are listed in Table 4-3.

Table 4-3. 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 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 currently selected menu or submenu.
[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] [⇩]	Going to the bottom of the menu or submenu.

4.2.9. Diagnostic Indicators

The standard keypad and display interface also contains 3 diagnostic indicators that are located above the display: Power On, Fault and Run. The Power On indicator is lit when power is supplied to the system. The Run indicator lights to show 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 Reset] key must be pressed to clear any existing fault conditions and restore the system to normal operation. Refer to Figure 4-1 for the location of the 3 diagnostic indicators.

4.2.10. The Display

The following illustrations depict the 2-line, 24-character display in various modes of access as the operator attempts to locate and change the “spd fwd lim” (speed forward limit) parameter.

Figure 4-8 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 Variable Menu (37).

The Mode display will show 1 of 8 possible VFD conditions depending on the operating control and conditions of the VFD. These modes are summarized in Table 4-4.

[SHIFT] [cancel/enter] →

```
Mode Demd Freq RPM  Itot
Hand 70   70   1260 40
```

Figure 4-8. Status Display After [Shift] [Enter] (Cancel) Key Sequence

The Demd display (refer to Figure 4-8) shows the “commanded speed reference” in percent. Figure 4-9 depicts the display following a [Shift]+[2] (Drive) key combination. The nine standard menus listed in Table 4-2 can then be selected using the up/down arrow keys ([⇧] and [⇩]).

Figure 4-10 depicts the display prior to the selection of the Speed Setup Menu (15). If the [Enter] or right arrow key ([⇨]) is pressed at this display, the Speed Setup Menu (15) will be entered. Figure 4-11 depicts the display following down arrow keystrokes to the Speed Setup Menu (15). The down arrow key ([⇩]) was pressed three times to obtain this display. Figure 4-12 depicts the display once the “spd fwd lim” (speed forward limit) parameter in the Speed Setup Menu (15) is entered. 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 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 4-13 depicts the display if +300 is attempted to be entered for the “spd fwd lim” parameter. Since the range of the variable is 0-200%, an error message will be displayed.

Figure 4-9. Status Display After [Shift]+[2] Key Sequence

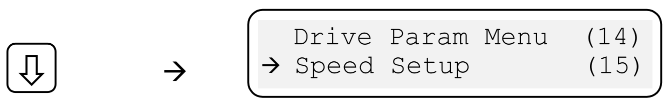

Figure 4-10. Status Display After [⇩] Key Sequence

Figure 4-11. Status Display After [Enter] Key and Multiple ⇩ Key Sequences

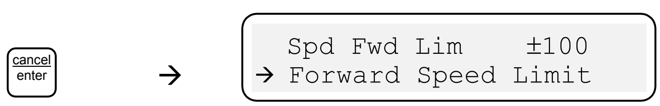

Figure 4-12. Status Display After [Enter] Key to Change a Parameter

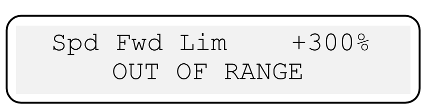

Figure 4-13. Status Display Upon Entering a Value Beyond the Range of the System

> The status display has a dynamic decimal point feature. This feature adds more precision to percentage display items that have values less than 10%. In these cases, the Perfect Harmony adds a decimal point in the display. For example, ten percent would be displayed as 10, while a slightly smaller percentage would be displayed as 9.9.

Table 4-4. Summary of Operation Mode Displays

Display	Meaning	Description
Slim	Speed Limit	The inner torque loop integrator is clamped in limit (*std_trq_lim_f*). Check the settings of "spd fwd lim" or "spd rev lim". The drive cannot produce the requested torque. If left unchecked, the speed loop integrator will wind-up until the torque command is clamped at the dynamic torque limit (*pos_limit*).
Frst	Fault Reset	The drive fault reset flag (*drv_flt_rst_f*) is enabled and the drive is inhibited.
CR3	CR3 Relay	**CR3** relay is not picked. The drive is inhibited (*cr3_picked* is not TRUE).
Tlim	Torque Limit	The output of the speed regulator (the torque command) is a torque limit. This is the dynamic limit clamped at the motor or regen limit and possibly smaller based on other drive restraints (see Output Current Limit in Section 7 for troubleshooting tips).
Ovld	Overload	An overload fault is imminent due to the output current exceeding the "I overload" parameter in the Overload Menu (34).
Byps	Bypass	VFD is operating at reduced output voltage capability due to operation of the optional bypass system following a cell fault.
Rgen	Regeneration	VFD is decreasing output speed due to a change in the speed command.
Inh	Inhibit	VFD is unable to enter the Run State D due to software emergency stop switch *sw_estop_f*, the drive fault flag *drv_flt_f* or an open **CR3** input *cr3_f*. See system program example in Section 8.0. (See the Troubleshooting section for descriptions of *sw_estop_f* and *drv_fit_f*).
Rlbk	Rollback	VFD is attempting to limit output speed due to torque output limitations.
Off	Off	Indicates that the VFD is in Idle State A.
Auto	Automatic	Normal Operating Mode if the *auto_f* switch in the system program is set to "true". Usually indicates operation resides from remote (customer contacts) control.
Hand	Hand	Normal Operating Mode if the *auto_f* switch in system program is set to "false". Usually indicates that operation is controlled from the front cabinet.

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CHAPTER 5: PARAMETER OVERVIEW

In This Section:

5.1. Menu Descriptions

The following sections contain a condensed description of all parameter items available in the Perfect Harmony menu structure. Table 5-1 lists main menus and submenus of the system. Figure 5-1 depicts the menu and submenu structure. Each menu and submenu is associated with a number (shown in parentheses). The key sequences [Shift]+[⇨] ([Shift] followed by the right arrow key) and [⇧] and [⇩] (up and down arrow keys) can be used to directly access each menu item. The use of these key sequences and menu navigation techniques are described in detail in Chapter 4: The Keypad and Display Interface.

> Table 5-1 lists menu and submenu names. Use the associated page numbers to quickly locate the corresponding section that explains all associated menu items. The "Zone" column refers to system drawing 479333 (sheets 1-8, located in Appendix B). The format [*p*,*xy*] gives the page number (*p*) and the zone on that page (*xy*) where related information can be found. For example, [2,5F] references zone 5F on page 2 of drawing 479333.

> **NOTE!** Menus and menu items highlighted by a ^{V} superscript denote menus available only in Vector Control Mode. These items are displayed only if the *std_cntrl_f* flag is set to "false". Menus and menu items highlighted by an ^{S} superscript denote menus available only for Standard Performance Mode. These items are displayed only if the *std_cntrl_f* flag is set to "true". Menus and menu items that are available in both vector control mode and standard mode are highlighted with a ^{B} superscript. Menus and menu items that relate exclusively to the transfer operation are shown with a ^{T} superscript.

> *Vector control* is a closed-loop control algorithm that determines the exact position of the motor's rotor based on encoder (or tachometer) feedback and makes appropriate output adjustments to maintain very accurate speed regulation in applications that require tight control. *Standard control* is an open-loop (i.e., no feedback) control algorithm that determines the appropriate speed command and sends it to the motor. It is assumed that the motor will interpret the speed command properly (based on its nameplate data) and reach the desired speed. Typically, standard control is used in applications that do not require the very accurate speed regulation and tight control of vector control mode.

Table 5-1. Perfect Harmony Menu and Submenu Summary

Menus	Submenus	Page	Zone References on Drawing # 479333
Motor Menu [1]	Motor Parameter [11]	5-4	[4,2H] [4,2J] [4,1R] [4,5S] [5,0T] [7,6F]
	Encoder^{V} [12]	5-5	[5,0S]
	Motor Flux^{V} [13]	5-7	[4,2J] [4,4K] [4,6J] [4,4M] [4,4P] [4,5P]
Drive Menu [2]	Drive Parameter [14]	5-8	[4,1R] [4,5S] [5,2K]
	Speed Setup [15]	5-10	[1,3B] [1,7B] [1,2A] [2,2C] [2,2E] [2,5B] [3,1T] [3,5J] [3,6J] [4,0N]
	Torque Reference [16]	5-12	[2,5F] [2,6E] [2,4J] [2,5J] [2,5M] [2,6N] [2,5S] [3,5C] [3,6D]
	Ramp Setup [17]	5-13	[1,2P] [1,3R] [1,4N] [1,5N]
	Pot Setup [18]	5-14	[1,3C] [1,8A] [1,8B] [1,4F] [2,6F] [2,7F] [2,6N] [2,6S]
	Timebase Setup [19]	5-15	n/a
	Hour Meter Setup [50]	5-15	n/a
	Hardware Scale [20]	5-16	[3,0B] [3,1B] [3,7S] [3,8S] [4,8P] [5,4P] [5,5R]
	Cell [21]	5-16	[3,5N] [5,0P] [5,2N] [5,2H]
	Transfer [200]	5-17	[7,6C] [7,8E] [7,7M] [7,9M] [7,8K]
Stability Menu [3]	Current Loop Setup^{V} [22]	5-18	[5,3J] [5,5J] [5,6J]
	Vector Control Tune [23]	5-19	[2,1N] [2,3N] [4,5M] [4,6M] [4,7M]
	Std Control Setup^{S} [24]	5-20	[1,3R] [2,1N] [2,3N] [3,4A] [3,6J] [3,5M] [3,6M] [3,7M] [3,7P] [3,7N] [3,4C]
	Control Loop Test [25]	5-24	[1,0A] [2,4D]
Auto Menu [4]	Speed Profile [26]	5-26	[1,2H]
	Speed Setpoint [27]	5-28	[1,5H]
	Critical Speed [28]	5-28	[1,2K]
	Comparator Setup [29]	5-29	n/a
	Comp. Setup [121-136]	5-30	n/a
	PID Select [48]	5-31	[1,7A] [1,7C]
Main Menu [5]	Security Edit [0]	5-34	n/a
Log Control Menu [6]	Memory Functions [30]	5-35	n/a
	Diagnostic Log [31]	5-35	n/a
	Historic Log [32]	5-37	n/a
	Fault Log [33]	5-37	n/a
Drive Protect Menu [7]	Overload [34]	5-38	[5,7N]
	Limit^{V} [35]	5-40	[4,2C] [4,2D] [4,3C] [4,3D]
Meter Menu [8]	Analog I/O Setup [36]	5-42	[1,6A] [1,7E] [2,8C] [2,7H]
	Analog Out [111-118]	5-43	n/a
	Analog In [181-188]	5-44	n/a
	Display Variable [37]	5-45	n/a
	Trim Analog Meters [38]	5-47	n/a
	Local Analog Meters [39]	5-47	n/a
	Analog Meter [51-58]	5-47	n/a
	Local Digital Meters [40]	5-48	n/a
	Digital Meter [61-67]	5-48	n/a
Commu-nications Menu [9]	RS232 Functions [41]	5-49	n/a
	Remote I/O [42]	5-50	n/a
	XCL Send Setup [43]	5-50	n/a
	XCL Global Send [145]	5-51	n/a
	XCL Send Regs [147-148]	5-52	n/a
	XCL Receive Setup [44]	5-55	n/a
	XCL Velocity Ref [141]	5-55	[1,1A] [1,4A] [2,6B]
	XCL Velocity Ctrl [142]	5-56	[1,6N] [1,6S] [1,8N] [1,8S] [2,1B] [2,1F]
	XCL Torque Ctrl [143]	5-56	[2,7E] [3,7T] [4,1A] [4,1E]
	XCL Comm Flags [144]	5-57	n/a
	Serial Input Scalers [146]	5-58	[1,4B] [2,1C] [2,1E] [2,7C] [2,8F] [2,7S] [4,1C] [4,1D]

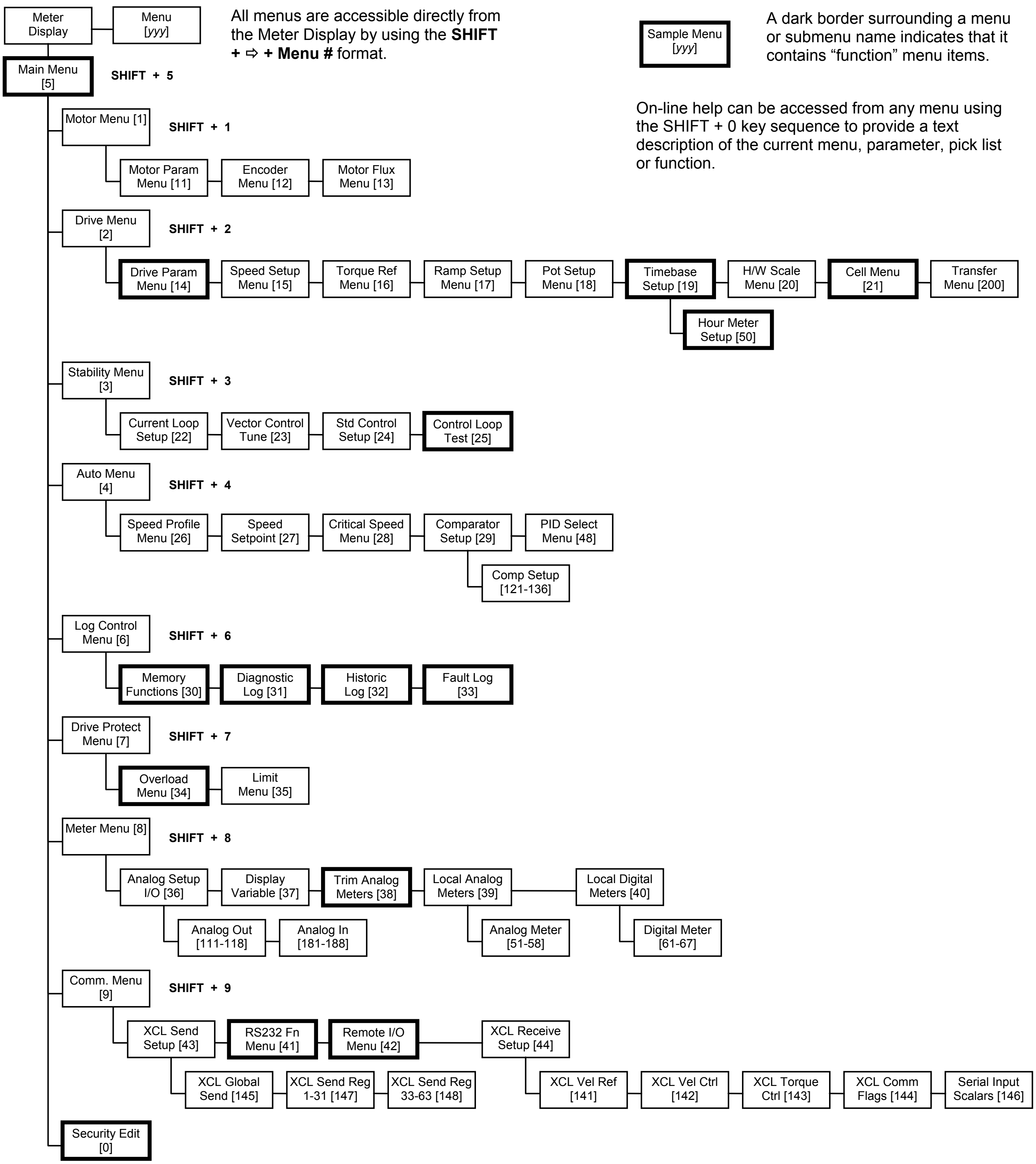

Figure 5-1. General Menu Structure Showing Submenus

5

5.2. Motor Menu [1] Options

The Motor Menu [1] consists of the following menu options:

- Motor Parameter Submenu [11]
- Encoder Submenu [12] [V]
- Motor Flux Submenu [13] [V].

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

5.2.1. Motor Parameter Submenu [11] [B]

The Motor Parameter Submenu [11] contains menu items available in both standard and vector control modes. These menu items are listed and explained in Table 5-2.

Table 5-2. Motor Parameter Submenu [11] [B]

<table>
<tr><th>Parameter</th><th>Range (Min)</th><th>Range (Max)</th><th>Typical Values</th><th>Description</th></tr>
<tr><td>Motor Frequency (Hz) [B]</td><td>15</td><td>120</td><td>60</td><td>Specifies the design frequency (in Hz) of the motor being driven. Usually found on the name plate of the motor.</td></tr>
<tr><td>Number of Poles [B]</td><td>2</td><td>36</td><td>4</td><td>Specifies the number of poles in the motor being driven. If this information is not listed, typical catalog data may be substituted. This information can also be determined using the equation:

# of Poles = 120 × F / S, where

F = frequency
S = motor synchronous speed.

If “S” is not known, the full load speed can be used, but the resulting value for number of poles must be rounded to the nearest whole number of poles.
Refer to the tables below for typical values for 50 and 60 Hz motors. (Note: “RPM” refers to the synchronous speed. The actual speed of the motor will include slip [i.e., the actual speed will be lower]).

<table>
<tr><th colspan="2">60 Hz</th><th colspan="2">50 Hz</th></tr>
<tr><th>RPM</th><th>Poles</th><th>RPM</th><th>Poles</th></tr>
<tr><td>3600</td><td>2</td><td>3000</td><td>2</td></tr>
<tr><td>1800</td><td>4</td><td>1500</td><td>4</td></tr>
<tr><td>1200</td><td>6</td><td>1000</td><td>6</td></tr>
<tr><td>900</td><td>8</td><td>750</td><td>8</td></tr>
</table></td></tr>
<tr><td>Motor Efficiency [B]</td><td>0.60</td><td>0.99</td><td>0.93</td><td>Specifies the efficiency rating of the motor being driven. This parameter determines how much of the current is torque current and how much is magnetizing current. It also ensures a proper kW reading and scales the torque</td></tr>
</table>

Parameter	Range (Min)	Range (Max)	Typical Values	Description
				current.
Full Load Speed [B]	1	7200	**1780**	Specifies the speed (rpm) that the motor attains (with rated load connected) while delivering the rated output at the rated speed. This value may also be referred to as the *slip speed* and is found on the name plate of the motor.
Motor Voltage (V_{rms}) [B]	380	9000	**4160**	Specifies the voltage (V_{rms}) at which the motor is rated. This value is found on the name plate of the motor.
Full Load Current (A_{rms}) [B]	12	1500	**100**	Specifies the motor current (A_{rms}) of the motor operated at its full load torque. Use the F.L.A. (full load amperage) value found on the name plate of the motor.
Motor kW [B]	10	10000	**373**	This parameter must be set to the motor's rated kW ($0.746 \times hp_{rated}$).

In Table 5-2, typical values are based on a 4-pole, 4,160 VAC, 500 hp machine.

5.2.2. Encoder Submenu [12] [V]

The Encoder Submenu [12] contains menu items that are available only in vector control mode. These menu items are listed and explained in Table 5-3.

Note that the Encoder Submenu [12] is a vector control menu which is visible from the Motor Menu [1] only if the *std_cntrl_f* flag in the system program is set to "false".

Table 5-3. Encoder Submenu [12] [V] (Vector Control Mode Only)

Parameter	Range (Min)	Range (Max)	Typical Value	Description
Encoder 1 PPR Resolution [V]	1	4000	**720**	Configures the resolution of the *feedback* encoder input on **TB3** (terminal numbers 5-8) of the power interface board. The value is given in pulses per revolution (PPR) of the encoder. Refer to Figure 5-2.
Encoder 2 PPR Resolution [V]	1	4000	**720**	Note: This parameter is typically used only in specialized encoder applications. Configures the resolution of the *reference* encoder input on **TB3** (terminal numbers 9-12) of the power interface board. The value is given in pulses per revolution (PPR) of the encoder. Refer to Figure 5-2.

Vector control requires closed-loop feedback signals. These inputs come from a *tachometer* or *encoder* that is directly sensing the shaft speed of the motor being driven. The Perfect Harmony requires four square wave signals (channel A, channel B, channel $\overline{A}$, channel $\overline{B}$) from the tachometer/encoder.

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The channel A and channel B signals are directly proportional to the motor shaft speed. The signals are 90° out of phase with each other and are 180° out of phase with their respective complements. This is illustrated in Figure 5-3.

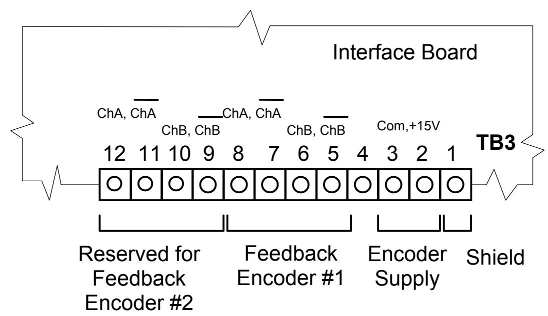

Figure 5-2. Encoder Connections on TB3 of the Harmony Interface Board

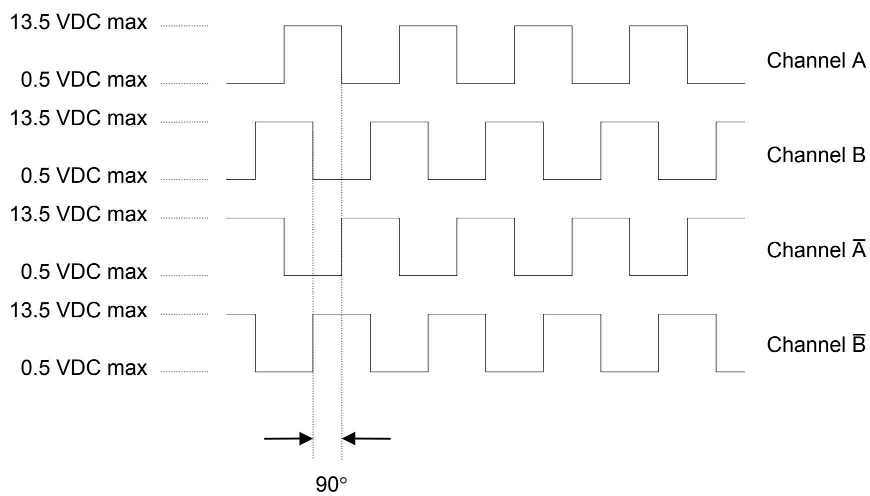

Figure 5-3. Wave Forms of Encoder/Tachometer Feedback Signals

The maximum signal level at the input to the drive is 0.5 VDC_{max} for the low signal and 13.5 VDC_{max} for the high signal. ROBICON recommends a minimum pulse rate of 1024 pulses per revolution to ensure good speed regulation. Note that the Perfect Harmony requires all four feedback signals to function properly.

ROBICON recommends Avtron model M485 or M585 pulse generators for use with vector control (closed loop) configurations of Perfect Harmony drives.

5.2.3. Motor Flux Submenu [13] ^{V}

The Motor Flux Submenu [13] contains menu items that are available only in vector control mode. These menu items are listed and explained in Table 5-4.

Note that the Motor Flux Submenu [13] is a vector control menu which is visible from the Motor Menu [1] only if the *std_cntrl_f* flag in the system program is set to "false".

See Table 5-17: Standard Control Setup Submenu [24] on page 5-20 for Standard Performance Information.

Table 5-4. Motor Flux Submenu [13] ^{V} (Vector Control Mode Only)

Parameter	Range (Min)	Range (Max)	Typical Value	Description
Motor Volts Trim ^{V}	0.050	2.000	**1.000**	Scales the slip speed which is computed from the Full Load Speed parameter and the torque command.
Volts/Hz Gain ^{V}	0.00	10.00	**1.00**	Scales the flux reference sent to the flux regulator.
Magnetizing Current ^{V}	0.1	1500.0	**25.0 A**	Provides for the initial magnetizing current level (in Amps) when under base speed or when the Extended Enable parameter is used to disable extended speed compensation.
Extended Enable ^{V}	0	1	**0**	Enables and disables the extended speed compensation feature. 0 = disable extended speed compensation 1 = enable extended speed compensation. This parameter enables the "shaping function".
Flux Pause Level ^{V}	0	100	**10%**	Sets the height of the pulse used during state B in flux pause mode. See Flux Pause (below).
Flux Pause ^{V}	0.01	8.00	**1.00 sec**	Sets a pulse duration (the pulse width) used during the flux pause state (state B) during startup in vector control mode. During state B, a pulse is sent out. This pulse is at a level defined by ID* and for a duration of Flux Pause seconds. This forces the magnetizing current to build flux on the motor before torque can be produced.

For newer features that require the use of a system program flag, a new version of the DRCTRY.PWM must be used (v1.12 dated 092397).

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5.3. Drive Menu [2] Options

The Drive Menu [2] consists of the following menu options:

- Drive Parameter Submenu [14]
- Speed Setup Submenu [15]
- Torque Reference Submenu [16]
- Ramp Setup Submenu [17]
- Pot Setup Submenu [18]
- Timebase Setup Submenu [19]
- Hardware Scale Submenu [20]
- Cell Submenu [21]
- Transfer Submenu [200].

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

5.3.1. Drive Parameter Submenu [14] *B*

The Drive Parameter Submenu [14] contains menu items available in both standard and vector control modes. These menu items are listed and explained in Table 5-5.

Table 5-5. Drive Parameter Submenu [14] *B*

Parameter	Range (Min)	Range (Max)	Typical Value	Description
Drive Scale Current *B*	12	1500	**100**	Displays the rated VFD drive current (in Amps). This parameter is configured at the factory and represents a scaling factor for the current feedback. Consult the factory before changing the value of this parameter.
Drive Rated Out *B*	200	23000	**4160**	Displays the rated VFD drive output voltage (in volts). This parameter is configured at the factory. Consult the factory before changing the value of this parameter.
Drive Input Voltage *B*	200	23000	**4160**	Displays the rated VFD input voltage (in volts). This parameter is configured at the factory. Consult the factory before changing the value of this parameter.
Auto Reset Enable *B*	0	1	**0**	Enables [1] or disables [0] the auto reset function. 0 = disable the auto reset function 1 = enable the auto reset function. When enabled (=1), the VFD will attempt up to four automatic resets (after a fault has occurred) with the specified time delay between resets (see Auto Reset Time parameter).
Auto Reset Time *B*	1.00	120.00	**1.00**	Specifies a delay time (in seconds) that occurs before the drive tries to automatically reset after a fault has occurred. This cycle can only occur a maximum of four [4] times before the drive is shut down.

Parameter	Range (Min)	Range (Max)	Typical Value	Description
Spinning Load Select [S]	0	1	**0**	Enables or disables the spinning load feature if it is not controlled by the system program. 0 = disables the spinning load feature 1 = enables the spinning load feature. For high inertial pump applications, this parameter is usually set to 0. For fan applications, this parameter should typically be set to 1.
Vector Control Select [B]	0	1	**0**	Enables [1] or disables [0] vector control mode. 0 = disables vector control mode (std. ctrl.) 1 = enables vector control mode.
Ramp Stop Select [B]	0	1	**1**	Defines how the drive behaves when the drive looses the run request flag, i.e., a stop condition occurs (e.g., from the SOP, stop button, keypad, etc.): 0 = disables ramp stop mode (motor coasts down under its own power) 1 = enables ramp stop mode (motor is decelerated [controlled stop] using the appropriate deceleration rate parameter). Note: This parameter has no effect on a fault stop or an emergency stop.
Hall Effect Select [B]	0	1	**0**	Selects the type of current feedback transducer used on the motor's output terminals. This parameter is configured at the factory. Consult the factory before changing the value of this parameter. 0 = Hall effect transducer 1 = CTs. CTs detect the AC component of the output current and rely on an alternating wave. In addition to the AC component, Hall effect transducers detect the DC component of the current. They use the electric field that is generated by the current passing through the conductor. Hall effect transducers are typically used in precision tuning applications.
Reduced Voltage Operation [B]	0	1	**0**	Enables [1] or disables [0] reduced voltage operation mode. This mode provides redundant cell operation of the drive. 0 = disables reduced voltage operation mode 1 = enables reduced voltage operation mode. Operation of the reduced voltage feature of the Perfect Harmony is summarized below. • The spare slot on the hub board is no longer used.

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Parameter	Range (Min)	Range (Max)	Typical Value	Description
				• The redundant cell group link board will instead be located in the left most slot next to the highest cell group (for instance, **PL5** for 4160 V, **PL4** for 3300 V). • All cells function in normal operation. A new transformer design allows for increased input pulse performance if the redundant cell option is ordered (for instance, 24-pulse for 2.4 kV, 30-pulse for 3.3 kV, and 36-pulse for 4.1 kV). • The redundant cell option is not available for 4.8 kV. • If a cell in any group (including the redundant cell) fails, the unit will continue to run (after system reset) at the nominal output voltage. • If another cell failure occurs after the first cell fault, the system will respond in the usual bypass performance mode (proportional is lost in output voltage, but full output capability remains).
Display Version Number ^{B}	*function*		***n/a***	Function used to display the current version of the drive software. This number is printed on each report and log. This number is a read-only value that cannot be changed manually.
Customer Order ^{B}	0	999999	**0**	Six digits that represent the original customer order number. This number is displayed in all reports and logs. This number is a read-only value that cannot be changed manually.
Customer Drive ^{B}	0	20	**1**	Number used to distinguish different drives at a common site. This value is displayed in all reports and logs.

5.3.2. Speed Setup Submenu [15]

The Speed Setup Submenu [15] contains menu items available in both standard and vector control modes. These menu items are listed and explained in Table 5-6.

Table 5-6. Speed Setup Submenu [15]

Parameter	Range (Min)	Rang e (Max)	Typical Value	Description
Ratio Control ^{B}	-125.000	+125.000	**1.000**	Controls the gain of analog references connected to terminal block **TB1A** (terminal numbers 2 through 7 and 9 through 12) on the power interface board or the XCL speed references (pointers 05-08) as selected by the system program. This parameter is configured at the factory. Consult the factory before

Parameter	Range (Min)	Range (Max)	Typical Value	Description
				changing the value of this parameter. See [1,3D].
Speed Forward Limit [B]	0%	200%	**100%**	Directly limits the maximum forward speed as a percentage of the Motor Frequency parameter. See [2,2D].
Speed Reverse Limit [B]	-200%	0%	**-100%**	Directly limits the maximum reverse speed as a percentage of the Motor Frequency parameter. See [2,2D].
Zero Speed [B]	0%	100%	**1%**	Percentage of the Full Load Speed at which the VFD will go from run mode to idle mode when a normal stop is commanded. Note that the Ramp Stop Select parameter in the Drive Parameter Submenu [14] must be set to 1 (i.e., ramp stop mode is enabled).
Analog Speed Scaler [B]	0%	250%	**100%**	Controls the gain of the analog references connected to **TB1A** (terminal numbers 2-12) on the power interface board when these inputs are selected before the critical speed and speed profile process blocks. The system program controls which inputs are used. See [1,7C].
Auxiliary Speed Scaler [B]	0%	250%	**100%**	Controls the gain of the analog references connected to **TB1A** (terminal numbers 2-12) on the power interface board when these inputs are selected directly to the PI speed regulator reference. The system program controls which inputs are used. See [2,5C].
Speed Forward Limit 2 [B]	0%	200%	**100%**	Multiple parameter set #2. Set switch *vl_sw1* to the value "true" in the system program to use this limit. See [2,2B].
Speed Reverse Limit 2 [B]	-200%	0%	**-100%**	Multiple parameter set #2. Set switch *vl_sw7* to the value "true" in the system program to use this limit. See [2,2B].
Speed Forward Limit 3 [B]	0%	200%	**100%**	Multiple parameter set #3. Set switch *vl_sw8* to the value "true" in the system program to use this limit. See [2,2B].
Speed Reverse Limit 3 [B]	-200%	0%	**-100%**	Multiple parameter set #3. Set switch *vl_sw9* to the value "true" in the system program to use this limit. See [2,2B].
Encoder Filter Adjust [V]	0	6	**0**	Adjusts the time constant of the filter base on ($2^n * \tau$), where τ = 2.78 ms and n is the input. If n = 0, the filter is disabled.

5.3.3. Torque Reference Submenu [16] [B]

The Torque Reference Submenu [16] contains menu items available in both standard and vector control modes. These menu items are listed and explained in Table 5-7.

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Table 5-7. Torque Reference Submenu [16] *B*

Parameter	Range (Min)	Range (Max)	Typical Value	Description
Analog Torque Scaler *B*	0%	250%	**100%**	Controls the gain of the analog references connected to **TB1A** (terminal numbers 2-12) on the power interface board when these inputs are selected before the torque ramp process block. The system program controls which inputs are used. See [2,6E].
Auxiliary Torque Scaler *B*	0%	250%	**100%**	Controls the gain of the analog references connected to **TB1A** (terminal numbers 2-12) on the power interface board when these inputs are selected directly to the PI torque regulator reference. The system program controls which inputs are used. See [2,6S].
Torque Setpoint *B*	0%	250%	**50%**	This parameter can be used to set a torque reference directly to the input of the torque regulator. The system program must be configured to use this input. See [2,6E].
Holding Torque *B*	-250%	250%	**0%**	Used to set an auxiliary holding torque reference which can be summed to velocity loop error. This parameter can be set from the keypad. [2,6R].
Analog Holding Torque Scaler *B*	0%	250%	**0%**	Used to control the holding torque in the Conditional Run state of the VFD. This parameter adjusts the gain of hold torque signals supplied to **TB1A** (terminal numbers 2-12). The system program controls which inputs are used and when they are used. See [2,6M].
Torque Ramp Increase *B*	0.00	999.99	**1.00 sec**	Controls the increasing rate of change of the torque reference signals as supplied from the torque test mode and analog torque reference sections. See [2,4J].
Torque Ramp Decrease *B*	0.00	999.99	**1.00 sec**	Controls the decreasing rate of change of the torque reference signals as supplied from the torque test mode and analog torque reference sections. See [2,4J].

5.3.4. Ramp Setup Submenu [17] *B*

The Ramp Setup Submenu [17] contains menu items available in both standard and vector control modes. These menu items are listed and explained in Table 5-8.

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Table 5-8. Ramp Setup Submenu [17] [B]

Parameter	Range (Min)	Range (Max)	Typical Value	Description
Forward Acceleration [B]	0.0	3200.0	**5.0**	Used with the Zero Speed and Full Load Speed settings to determine the Forward Acceleration rate (in seconds). $+\text{Accel} = \dfrac{\text{FL Speed - Zero Speed}}{\text{Forward Acceleration}}$
Forward Deceleration [B]	0.0	3200.0	**5.0**	Used with the Zero Speed and Full Load Speed settings to determine the Forward Deceleration rate (in seconds). $+\text{Decel} = \dfrac{\text{Zero Speed - FL Speed}}{\text{Forward Deceleration}}$
Reverse Acceleration [B]	0.0	3200.0	**5.0**	Used with the Zero Speed and Full Load Speed settings to determine the Reverse Acceleration rate (in seconds). $-\text{Accel} = \dfrac{\text{FL Speed - Zero Speed}}{\text{Reverse Acceleration}}$
Reverse Deceleration [B]	0.0	3200.0	**5.0**	Used with the Zero Speed and Full Load Speed settings to determine the Reverse Deceleration rate (in seconds). $-\text{Decel} = \dfrac{\text{Zero Speed - FL Speed}}{\text{Reverse Deceleration}}$
Jerk Rate [B]	0.00	78.12	**0.10**	Determines the rate of change of the acceleration or deceleration (in seconds). $\text{Jerk} = \pm \dfrac{\text{Accel or Decel}}{\text{Jerk Rate}}$
2 Stage Ramp Enable [V]	0	1	**0**	Divides forward and reverse speed ramp rates by 4 between demand speeds of ±9 Hz. 0 = disable two-stage ramp mode 1 = enable two-stage ramp mode. For deceleration ramping, set Ramp Stop Select parameter in the Drive Parameter Submenu [14] = 1 (i.e., ramp stop mode enabled). This does not affect acceleration ramping.
Forward Acceleration 2 [B]	0.0	3200.0	**5.0**	Multiple parameter sets of forward/reverse, accel/decel parameters (given in seconds) that are enabled/disabled using software switches in the system program.
Forward Deceleration 2 [B]	0.0	3200.0	**5.0**	Parameter set # 2 is active when switch *acc_sw4* is set to the value "true" in the system program.
Reverse Acceleration 2 [B]	0.0	3200.0	**5.0**	When *acc_sw1* is set to the value "true" in the system program (default), then parameter set #1 (shown above) is active.

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Parameter	Range (Min)	Range (Max)	Typical Value	Description
Reverse Deceleration 2 [B]	0.0	3200.0	**5.0**	See descriptions above.
Forward Acceleration 3 [B]	0	32000	**50**	Multiple parameter sets of forward/ reverse, acceleration/ deceleration parameters (given in seconds) that are enabled/disabled using software switches in the system program.
Forward Deceleration 3 [B]	0	32000	**50**	Active when *acc_sw5* = "true" in system program.
Reverse Acceleration 3 [B]	0	32000	**50**	When *acc_sw1* = "true" in the system program (default), then parameter set #1 (shown above) is active.
Reverse Deceleration 3 [B]	0	32000	**50**	

5.3.5. Potentiometer Setup Submenu [18] [B]

The Potentiometer Setup Submenu [18] contains menu items available in both standard and vector control modes. These menu items are listed and explained in Table 5-9.

Table 5-9. Potentiometer Setup Submenu [18] [B]

Parameter	Range (Min)	Range (Max)	Typical Value	Description
Set Maximum Positive [B]	0%	200%	**100%**	Sets full-scale control of the keypad potentiometer as a percentage of the Full Load Speed. Speed = %Wiper (SMP + SMN) where SMP is Set Max Positive and SMN is Set Max Negative. If Set Max Positive = Set Max Negative = 150%, then: mid pot = 0 speed full CW = 150% full CCW = -150%.
Set Maximum Negative [B]	-200%	0%	**-100%**	See [1,4H].
4-20 mA Maximum [B]	1.0%	150.0%	**100.0%**	Sets full scale control of 4-20 mA input on **TB1A** (terminal numbers 2-12) as percentage of Full Load Speed. See [1,8B].
4-20 mA Dropout (mA) [B]	0.0	10.0	**4.0**	Sets the zero input threshold. This value is subtracted from the signal before scaling. One half of this value is the

Parameter	Range (Min)	Range (Max)	Typical Value	Description
				setting for the signal loss flag *signal_loss_f*. See [1,8C].

5.3.6. Timebase Setup Submenu [19] B

The Timebase Setup Submenu [19] contains menu items available in both standard and vector control modes. These menu items are listed and explained in Table 5-10.

Table 5-10. Timebase Setup Submenu [19] B

Parameter	Range (Min)	Range (Max)	Typical Value	Description
Conditional Stop Timer B	0.0	999.9	**0.8 sec**	Specifies (in seconds) the “time to true” of the *c_s_timeout_f* flag (in Cond Stop State F) when the Stop state (as defined by the system program) is entered. Refer to the state diagram on sheet 6 of drawing 479333 in Appendix B.
Conditional Run Timer B	0.0	999.9	**0.8 sec**	Specifies (in seconds) the “time to true” of the *c_r_timeout_f* (in Cond Run State C) flag when the run state (as defined by the system program) is entered. Refer to the state diagram on sheet 6 of drawing 479333 in Appendix B.
Cycle Timer B	0	10,000	**0 hrs**	This parameter allows the user to set the desired time period (in hours) for the redundant pumps to be cycled into service. The Perfect Harmony keeps track of time lapses even when not in the Run mode, but does not cycle anything until the drive is in the Run mode.
Hour Meter Setup [50] B	n/a	n/a	***n/a***	Setup submenu for the kWh meter. Refer to Table 5-11 on page 5-15.
Set the Clock Time B	*function*		***n/a***	Function used to set the VFD’s real time clock.

5.3.7. Hour Meter Setup Submenu [50] B

The Hour Meter Setup Submenu [50] contains menu items available in both standard and vector control modes. These menu items are listed and explained in Table 5-11.

Table 5-11. Hour Meter Setup [50] B

Function Name	Description
Display Hour Meter B	Used to display the amount of time that the drive has been operational since it was commissioned.
kW Hours Consumed B	Displays the total kW hours that have been accumulated since the

Function Name	Description
	drive was commissioned.

5.3.8. Hardware Scale Submenu [20] *B*

The Hardware Scale Submenu [20] contains menu items available in both standard and vector control modes. These menu items are listed and explained in Table 5-12.

Table 5-12. Hardware Scale Submenu [20]B

Parameter	Range (Min)	Range (Max)	Typical Value	Description
Motor Voltage Feedback *B*	1	3000	**1000 v/v**	Scales the motor voltage feedback to the PI voltage (flux) regulator. See [3,8R].
Line Voltage Feedback *B*	1	9000	**1000 v/v**	Scales the available voltage feedback used for the dynamic torque limits used in standard performance mode. See [3,2B].
Ib Offset Adjust *B*	00	FF	**7F**	Offset value (specified in hex format) which is used to eliminate the DC components to the DQ transformation chip **IC41** on the power interface board. This value is factory set. See [5,5P]. Since this value is factory set, it should not be changed unless the CTs/Hall effects of the power interface board are changed.
Ic Offset Adjust *B*	00	FF	**7F**	Offset value (specified in hex format) which is used to eliminate the DC components to the DQ transformation chip **IC41** on the power interface board. This value is factory set. See [5,5P]. Since this value is factory set, it should not be changed unless the CTs/Hall effects of the power interface board are changed.
Standard Motor Voltage Trim *S*	0.000	10.000	**8.000**	Value (specified in volts) used to scale the final output voltage reference to the IDQ transformation chip from the flux regulator. See [3,6R].

5.3.9. Cell Submenu [21] *B*

The Cell Submenu [21] contains menu items available in both standard and vector control modes. These menu items are listed and explained in Table 5-13.

Table 5-13. Cell Submenu [21] *B*

Parameter	Range (Min)	Range (Max)	Typical Value	Description
Installed Stages *B*	3	7	**5**	Specifies the number of stages in the drive. Set to 4 for 4160 VAC drives. See [5,2H] and [5,1P].
Minimum Stage Count *B*	1	6	**3**	This parameter specifies the minimum number of operable stages that can be run. See [5,1P].

Parameter	Range (Min)	Range (Max)	Typical Value	Description
Auto Bypass Enable [B]	0	1	**0**	Enables/disables the auto bypass feature. Setting to 1 enables the bypass feature (if supplied) upon a cell failure. 0 = disables auto bypass feature 1 = enables auto bypass feature.
Print Cell Status [B]	*function*		***n/a***	Function that sends a detailed cell fault log to the RS232 port to a printer or terminal emulator. The current status of each cell is listed, including bypass and fault information. For prior fault status, see Display Cell Fault(s) and Print Cell Fault(s) functions.
Display Cell Fault(s) [B]	*function*		***n/a***	Function that reports a detailed cell fault log to the LCD display of the drive, most recent fault first, including fault time and date.
Print Cell Fault(s) [B]	*function*		***n/a***	This function prints the cell fault log to the RS232 output buffer.
RS232 Diagnostic Bypass [B]	0	1	**1**	Enables/disables the diagnostic information sent out the RS232 port while in cell diagnostic mode (during cell fault detection or reset). 0 = disables feature 1 = enables feature. This parameter should be disabled (set to 0) under normal conditions to expedite the reset process. This feature is not yet available on the Perfect Harmony (200-2000 hp units).

5.3.10. Transfer Submenu [200] [T]

The Transfer Submenu [200] contains menu items available only in the synchronous transfer mode of operation. These menu items are listed and explained in Table 5-14. Note that transfer mode is only available when the drive is configured for standard (not vector control) operation.

Table 5-14. Transfer Submenu [200] [T]

Parameter	Range (Min)	Range (Max)	Typical Value	Description
Phase I Gain [T]	0	15	**2**	Integral gain for the phase lock loop.
Phase P Shift [T]	1	12	**4**	Proportional gain setting for the phase lock loop, where $P = (2^n)^{-1}$.
Phase Offset [T]	0.0	180.0	**0.0 deg**	Offset adjustment to allow the setting of a leading angle to prevent regeneration on transfer.
Hardware Offset [T]	-180.0	180.0	**0.0 deg**	Used to correct for the offsets caused by hardware tolerances and inherent phase

Parameter	Range (Min)	Range (Max)	Typical Value	Description
				shifts between the feedbacks.
Phase Error Threshold ^{T}	0.0	5.0	**1.5 deg**	Sets the threshold of phase error allowed before advancing in transfer. Acts as a transfer enable.
Line Synchronization Source ^{T}	0	2	**0**	Determines the source of the line sync detection circuitry: 0 = local (from PIB) 1 = remote (overcurrent board used with transfer). Normally, remote mode [1] is used when transfer is available. Setting zero [0] disables the function for non-transfer applications.

5.4. Stability Menu [3] Options

The Stability Menu [3] consists of the following menu options:

- Current Loop Setup Submenu [22] ^{V}
- Vector Control Tune Submenu [23]
- Standard Control Setup Submenu [24] ^{S}
- Control Loop Test Submenu [25].

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

5.4.1. Current Loop Setup Submenu [22] ^{V}

The Current Loop Setup Submenu [22] contains menu items available in vector control mode. These menu items are listed and explained in Table 5-15.

> Note that the Current Loop Setup Submenu [22] is a vector control menu which is visible from the Stability Menu [3] only if the *std_cntrl_f* flag in the system program is set to “false”.

Table 5-15. Current Loop Setup Submenu [22] ^{V} (Vector Control Mode Only)

Parameter	Range (Min)	Range (Max)	Typical Value	Description
I Quad Integral Gain ^{V}	0.000	0.996	**0.000**	These parameters adjust the individual D and Q axis PI gains for the hardware current regulators resident on the power interface board. See [5,5H].
I Quad Proportional Gain ^{V}	0.000	0.996	**0.000**	The direct gains control the flux producing current response. See [5,5H].
I Direct Integral Gain ^{V}	0.000	0.996	**0.000**	The quad gains (integral and proportional) control the torque producing current response of the induction machine. See [5,5H].
I Direct Prop.	0.000	0.996	**0.000**	

Gain ^{V}				

See Table 5-17: Standard Control Setup Submenu [24] on page 5-20 for standard performance information.

5.4.2. Vector Control Tune Submenu [23] ^{V}

The Vector Control Tune Submenu [23] contains menu items available in vector control mode. These menu items are listed and explained in Table 5-16.

Table 5-16. Vector Control Tune Submenu [23] ^{V}

Parameter	Range (Min)	Range (Max)	Typical Value	Description
Velocity Proportional Gain ^{V}	0.000	127.996	**5.000**	Adjusts the proportional error compensation of the PI speed regulator when the VFD is operating in vector control mode. See [2,2N].
Velocity Integral Gain ^{V}	0.000	255.996	**5.000**	Adjusts the integral error compensation of the PI speed regulator when the VFD is operating in vector control mode. See [2,4M].
Imag Proportional Gain ^{V}	0.000	127.996	**0.062**	Proportional gain used in a PI flux regulator which adjusts output voltage when output load condition is less than 30%. See [4,6M].
Imag Integral Gain ^{V}	0.000	127.996	**0.933**	Integral gain used in a PI flux regulator which adjusts output I_{mag} reference or voltage when output load conditions are less than 30%. See [4,6M].
Slip Proportional Gain ^{V}	0.000	127.996	**0.062**	Proportional gain used in a PI regulator which adjusts motor slip ω_s when load condition is greater than 30%. See [4,7M].
Slip Integral Gain ^{V}	0.000	127.996	**0.933**	Integral gain used in a PI flux regulator which adjusts motor slip ω_s when output load condition is greater than 30%. See [4,7M].
Velocity Proportional Gain 2 ^{V}	0.000	127.996	**5.000**	Multiple parameter sets which allow different velocity gains depending on flags set in the system program:
Velocity Int. Gain 2 ^{V}	0.000	255.996	**5.000**	*vel_gain_set_1 = true* (default allows above gain set to be active).
Velocity Proportional Gain 3 ^{V}	0.000	127.996	**5.000**	*vel_gain_set_2 = true* allows set 2 to be active, etc.
Velocity Int. Gain 3 ^{V}	0.000	255.996	**5.000**	Also see the system program example in Chapter 8: System Programming.

See Table 5-17: Standard Control Setup Submenu [24] on page 5-20 for standard performance information.

A state control diagram of the Perfect Harmony is available on sheet 6 of drawing 479333 in Appendix B: System Control Diagrams.

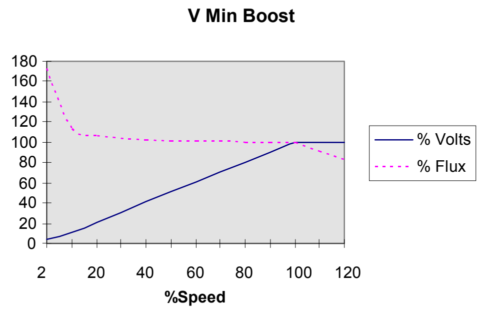
5.4.3. Standard Control Setup Submenu [24] ^{S}

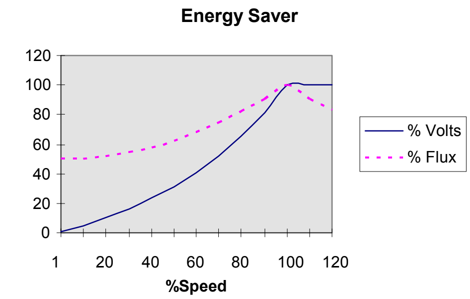
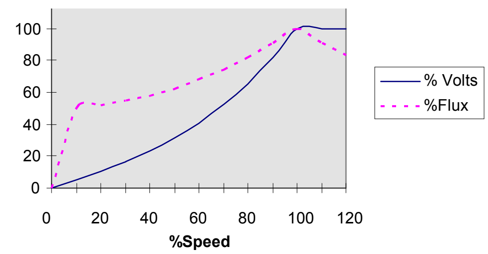
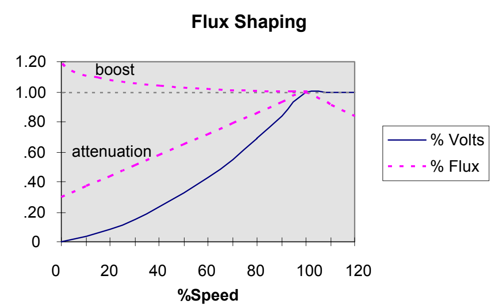
The Standard Control Setup Submenu [24] contains menu items available in standard control mode. These menu items are listed and explained in Table 5-17.

Note that the Standard Control Setup Submenu [24] is a standard menu that is visible from the Stability Menu [3] only if the *std_cntrl_f* flag in the system program is set to "true".

Table 5-17. Standard Control Setup Submenu [24] ^{S} (Standard Performance Mode Only)

Parameter	Range (Min)	Range (Max)	Typical Value	Description
Standard Volts/Hz ^{S}	-127.996	127.996	**1.000**	Adjusts the motor voltage level for proper flux under base speed. See [3,6L].
Volt Proportional Gain ^{S}	-127.996	127.996	**0.312**	These parameters adjust proportional and integral compensation of the voltage regulator which controls the proper terminal voltage as a function of speed.
Volt Integral Gain ^{S}	-127.996	127.996	**0.312**	See [3,7N].
Velocity Proportional Gain ^{S}	0.000	127.996	**5.000**	Adjusts the velocity regulator's proportional and integral gains which control the reference to the torque regulator as required to control the commanded speed.
Velocity Integ. Gain ^{S}	0.000	255.996	**5.000**	See [2,2M].
Torque Proportional Gain ^{S}	0.000	127.96	**0.011**	Adjusts the inner loop torque regulator's proportional and integral gains which control the proper motor frequency (including slip) as required to satisfy the commanded torque.
Torque Integ. Gain ^{S}	0.000	255.996	**0.300**	See [3,5H].
Voltage Min Boost	0.0	6.0	**0.0%**	This parameter is used to adjust the V/Hz curve into a more non-linear curve, thereby providing more starting torque. It offsets the starting point of the linear V/Hz curve, creating a non-linear flux response for starting torque.

Parameter	Range (Min)	Range (Max)	Typical Value	Description
				 **Figure 5-4. Voltage Min Boost**
Slow Ramp Time^{S}	0.00	9.99	**3.00 sec**	Upon achieving the initial Run State B, a 240 second velocity ramp is initialized to allow the AC machine (e.g., the motor) to achieve rated flux. This ramp is disabled when either the mmf speed attains 0.5 Hz or the interval set by Slow Ramp Time is achieved. See [2,3P] and sheet 6.
Motor Torque Limit^{S}	0%	300%	**100%**	Provides absolute motoring limits to the torque command as a percentage of Full Load Current. See [3,6D]. If a 1.15 service factor motor is used, you can run it up to (1.15) × Amps (e.g., 115%).
Regeneration Torque Limit^{S}	0.2%	10.0%	**3.0%**	Provides absolute regenerative limits to the torque command as a percentage of Full Load Current. See [3,6D].
Energy Saver^{S}	0%	100%	**0%**	When Energy Saver is set to 0%, the output voltage is linear with respect to speed. When set to > 0%, the output voltage will approach the rated value as a function of load torque. For pump or fan loads, Energy Saver = 100% will cause the output voltage to attain the rated value exponentially with speed and the required torque. See [3,8L]. Refer to Figure 5-5 and Figure 5-6.

Parameter	Range (Min)	Range (Max)	Typical Value	Description
Energy Saver[S] (Continued)	0%	100%	**0%**	 **Figure 5-5. Energy Saver**  **Figure 5-6. Energy Saver at 50%**
Flux Shape	0.01	1.10	**1.00**	This parameter allows you to add flux boost or flux attenuation for starting purposes in standard control mode.  **Figure 5-7. Flux Shaping Curve (at 0.30)**
Spinning Load Threshold[S]	0.0%	50.0%	**4.3%**	Sets the percentage of total current that the drive must go down to in order to switch from scanning the frequency to holding frequency while ramping to full flux during spinning load pick-up. Enabled by Spinning Load Select in Drive Parameter Menu [14].
Spin Flux Scale	1.00	15.00	**6.25%**	Represents the scale that can be used to change the amount of magnetizing current in the motor. For most standard motors, the default of 6.25% (1/16) is used. This value may be adjusted when (1) custom motors are used, or (2) IOC trips occur.

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Parameter	Range (Min)	Range (Max)	Typical Value	Description
Flux Ramp S	0.1 sec	15.0 sec	**7.0 sec**	Sets the rate of change for the flux ramp during the initial and final flux reference changes during spinning load pick-up. The slope is based on the time to go from zero to rated flux reference. Enabled by Spinning Load Select in Drive Parameter Menu [14].
Frequency Scan Rate S	1.5	9.0	**5.0 sec**	Sets the rate of change (slope) of the frequency scan for spinning load detection. Five seconds is normal, while higher values may be required on low-slip machines.
Frequency Drop Level % S	0.0	12.0	**5.0%**	Used when the drive attempts to catch a spinning load, this parameter specifies a cutoff frequency (as a percentage of the base frequency) where the drive will assume zero speed and simply start to ramp up the drive speed. Typically this parameter is used in high inertia, low slip applications. Increasing this parameter will produce smoother starts. A value that is too high may cause an IOC trip, while a value that is too low could cause an unstable condition with current oscillation.
Velocity Proportional Gain 2 S	0.000	127.996	**5.000**	Multiple parameter set 2 for Vel P Gain and Vel I Gain parameters. See sheet 2, zone (3N). Enabled from system program by setting *vel_gain_set_2* flag to "true".
Velocity Int. Gain 2 S	0.000	255.996	**5.000**	See also Chapter 8: System Programming and Appendix B: System Control Diagrams.
Velocity Proportional Gain 3 S	0.000	127.996	**5.000**	Multiple parameter set 3 for Vel P Gain and Vel I Gain parameters. See [2,3N]. Enabled from system program by setting *vel_gain_set_3* flag to "true".
Velocity Int. Gain 3 S	0.000	255.996	**5.000**	See also Chapter 8: System Programming and Appendix B: System Control Diagrams.
Torque Proportional Gain 2 S	0.000	127.996	**0.011**	Multiple parameter set 3 for Torque P Gain and Torque I Gain parameters. See sheet 3, zone (5H). Enabled from system program by setting *trq_gain_set_2* flag to "true".
Torque Integ. Gain 2 S	0.000	255.996	**0.300**	See also Chapter 8: System Programming and Appendix B: System Control Diagrams.
Torque Proportional Gain 3 S	0.000	127.996	**0.011**	Multiple parameter set 3 for Torque P Gain and torque I gain parameters. See [3,5H]. Enabled from system program by setting *trq_gain_set_3* flag to "true".
Torque Integ. Gain 3 S	0.000	255.996	**0.300**	See also Chapter 8: System Programming and Appendix B: System Control Diagrams.

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Parameter	Range (Min)	Range (Max)	Typical Value	Description
Motor Torque Limit 2 ^{S}	0%	300%	**100%**	Multiple parameter set 2 for Motor Torque Limit parameters. See [3,5C]. Enabled from system program by setting *ai_swi7* flag to "true". See also Chapter 8: System Programming and Appendix B: System Control Diagrams.
Regeneration Torque Limit 2 ^{S}	0.2%	10.0%	**3.0%**	
Motor Torque Limit 3 ^{S}	0%	300%	**100%**	Multiple parameter set 3 for Motor Torque Limit parameters. See [3,5C]. Enabled from system program by setting *ai_swi9* flag to "true". See also Chapter 8: System Programming and Appendix B: System Control Diagrams.
Regeneration Torque Limit 3 ^{S}	0.2%	10.0%	**3.0%**	

> See Table 5-16: Vector Control Tune Submenu [23] on page 5-19 for high performance vector control information.

5.4.4. Control Loop Test Submenu [25] ^{B}

The Vector Control Tune Submenu [23] contains menu items available in both standard and vector control modes. These menu items are listed and explained in Table 5-18.

Table 5-18. Control Loop Test Submenu [25] ^{B}

Parameter	Range (Min)	Range (Max)	Typical Value	Description
Speed Test Positive ^{B}	-200%	200%	**30%**	Sets the positive speed reference of square wave test as a percentage of Full Load Speed. Speed Fwd Limit and Speed Rev Limit override these setpoints.
Speed Test Negative ^{B}	-200%	200%	**-30%**	Sets the negative speed reference of square wave test as a percentage of Full Load Speed. Speed Fwd Limit and Speed Rev Limit override these setpoints.
Speed Test Time ^{B}	0.0	500.0	**0.0**	Sets time period (in seconds) of the test envelope defined by Speed Test Pos and Speed Test Neg parameters.
Begin Speed Loop Test ^{B}	*function*		***n/a***	Function used to start the speed loop test. VFD must be in State A (idle) (see state diagram in Appendix B). See [1,2C].
Stop Speed Loop Test ^{B}	*function*		***n/a***	Function used to stop the speed loop test. VFD must be in State A (idle) (see state diagram in Appendix B). See [1,2C].

Parameter	Range (Min)	Range (Max)	Typical Value	Description
Torque Test Positive[B]	-200%	200%	**23%**	Positive torque reference of square wave test (for vector control) or triangular wave test (for standard control) as a percentage of Full Load Current. Mot Torque Limit and Regen Torque Limit override these setpoints.
Torque Test Negative[B]	-200%	200%	**-23%**	Negative torque reference of square wave test (for vector control) or triangular wave test (for standard control) as a percentage of Full Load Current. Mot Torque Limit and Regen Torque Limit override these setpoints.
Torque Test Time[B]	0.00	91.00	**0.67**	Sets time period (in seconds) of the test envelope defined by the Torque Test Positive and Torque Test Neg parameters.
Begin Torque Loop Test[B]	*function*		***n/a***	These functions start and stop torque loop test. VFD must be in State (A) (see state diagram in Appendix B). Parameters are replicated in Diagnostic Log Submenu [31].
Stop Torque Loop Test[B]	*function*		***n/a***	See [2,5E].
Start Diagnostic Log[B]	*function*		***n/a***	This function is used to start the diagnostic log. The diagnostic log can also be selected and enabled through the system program by setting the following flags: *diag_log_select* = true *log_done* = true. Also see Chapter 8: System Programming.
Select Diagnostic Log[B]	*function*		***n/a***	Function used to select the Diagnostic Log as the current log feature. See Diagnostic Log Submenu [31] for a description.
Diagnostic Log Upload[B]	*function*		***n/a***	Function used to upload diagnostic log information through the RS-232 port on the door or on the microprocessor board.

> A state control diagram of the Perfect Harmony is available on sheet 6 of drawing 479333 in Appendix B: System Control Diagrams.

5.5. Auto Menu [4] Options

The Auto Menu [4] consists of the following menu options:

- Speed Profile Submenu [26]
- Speed Setpoint Submenu [27]
- Critical Speed Submenu [28]
- Comparator Setup Submenu [29]
- PID Select Submenu [48].

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

5.5.1. Speed Profile Submenu [26] *B*

The Speed Profile Submenu [26] contains menu items available in both standard and vector control modes. These menu items are listed and explained in Table 5-19. Speed profiling is illustrated in Figure 5-9 and Figure 5-10.

Table 5-19. Speed Profile Submenu [26] *B*

Parameter	Range (Min)	Range (Max)	Typical Value	Description
Entry Point *B*	0.0	150.0	**0.0%**	Determines percentage of full input reference signal at which VFD will operate at the minimum Entry Speed as percentage of the Full Load Speed. See [1,2K].
Exit Point *B*	0.0	150.0	**150.0%**	Determines percentage of full input reference signal at which VFD will operate at the maximum Exit Speed as percentage of the Full Load Speed. See [1,2K].
Entry Speed *B*	0.0	150.0	**0.0%**	Determines the percentage of the full input reference signal at which the VFD will operate at the minimum Entry Speed as percentage of the Full Load Speed. See [1,2K].
Exit Speed *B*	0.0	150.0	**150.0%**	Determines percentage of full input reference signal at which VFD will operate at the maximum Exit Speed as percentage of Full Load Speed. See [1,2K].
Auto Off *B*	0.0	100.0	**0.0%**	Sets the threshold of velocity reference below which the drive is disabled (off). This setting must be ≤ Auto On to operate normally. This parameter is specified as a percentage.
Delay Off *B*	0.5	100.0	**0.5**	Delay Off sets delay time to VFD off when the Auto Off percentage of Full Load Speed is satisfied. This parameter is specified in seconds. See [1,2K].
Auto On *B*	0.0	100.0	**0.0%**	Sets the threshold of velocity reference at which the drive is disabled (in run). This setting must be ≥ Auto Off to operate normally. This parameter is specified as a percentage.
Delay On *B*	0.5	100.0	**0.5**	Delay On sets delay time to VFD on when the Auto On percentage of Full Load Speed is satisfied. This parameter is specified in seconds. See [1,2K].

Figure 5-8 shows a control diagram of speed profiling and the related parameters from the Speed Profile Submenu (26).

Figure 5-9 and Figure 5-10 illustrate the disadvantages and advantages of using speed profiling control. This method of control provides an increased “usable control range” for the motor (refer to Figure 5-10). Ultimately, the speed of the motor can be adjusted in much finer increments when speed profiling is used.

Speed profiling control uses the velocity demand signal as input, and generates a modified velocity demand output based on the four parameter entries: Entry Point, Exit Point, Entry Speed, and Exit Speed. If the velocity demand input is less than or equal to the Entry Point the output of the speed profile will be the value specified in Entry Speed. If the input is greater than or equal to the Exit Point, the output will be the value specified in Exit Speed. Inputs that are between these two points generate outputs based on the slope of the line generated between the Entry Speed and Exit

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Speed parameters. The speed profile function can be enabled and disabled through the system program.

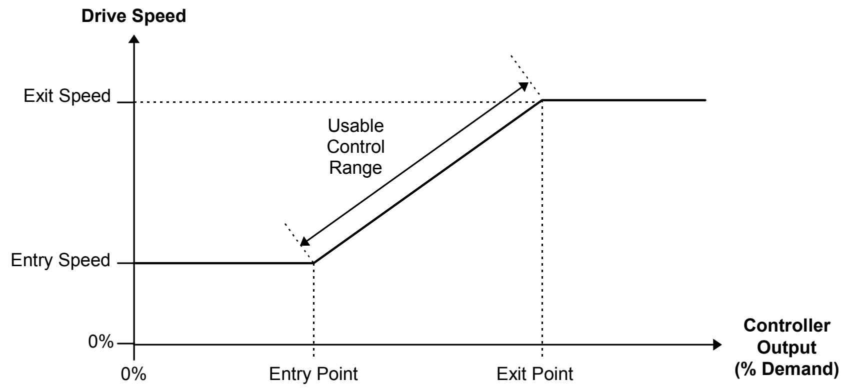

Figure 5-8. Speed Profile Diagram

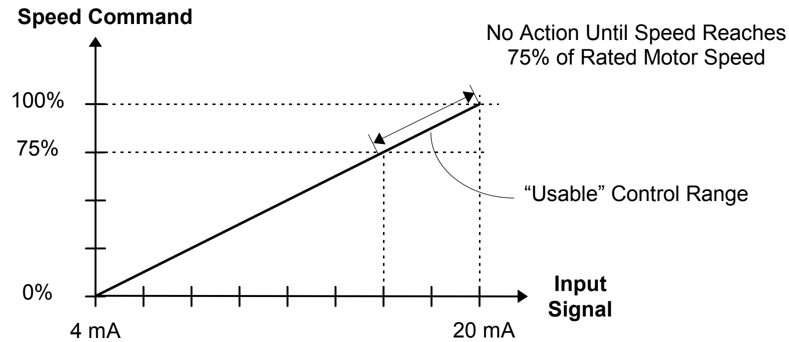

Figure 5-9. Negative Effects of Not Using Speed Profiling Control

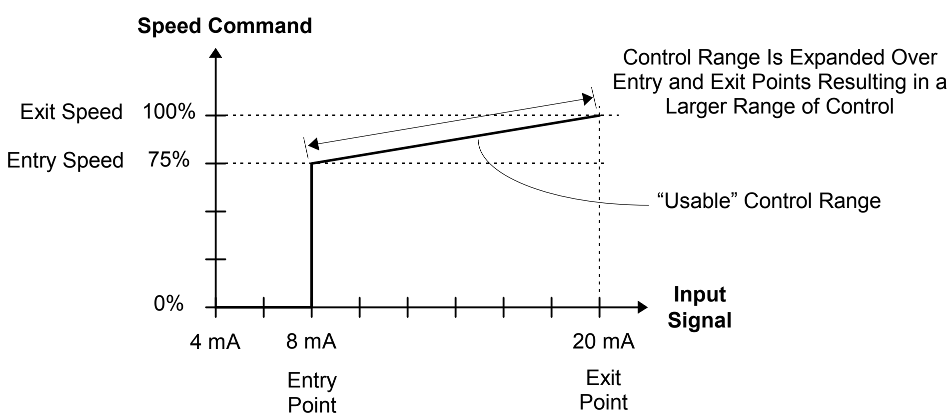

Figure 5-10. Advantages of Using Speed Profiling Control

5.5.2. Speed Setpoint Submenu [27] *B*

The Speed Setpoint Submenu [27] contains menu items available in both standard and vector control modes. These menu items are listed and explained in Table 5-20.

Table 5-20. Speed Setpoint Submenu [27] [B]

Parameter	Range (Min)	Range (Max)	Default Value	Description
Speed Setpoint *n* [B] (*n*=1-7)	-9999	9999	0 rpm	Programmable speed setpoints 1 through 7 (given in rpm) set by system program switches *vd_sw7* through *vd_sw13*, respectively. For example, *vd_sw13* = *true* in the system program enables Speed Setpoint 7. See [1,5J], Appendix D and Chapter 8.

5.5.3. Critical Speed Submenu [28] [B]

The Critical Speed Submenu [28] contains menu items available in both standard and vector control modes. These menu items are listed and explained in Table 5-21. The critical speed feature is illustrated in Figure 5-11.

Table 5-21. Critical Speed Submenu [28] [B]

Parameter	Range (Min)	Range (Max)	Typical Values	Description
Skip Frequency 1 [B]	0.0	120	**15.0 Hz**	Skip frequencies 1-3 set the center frequency (in Hz) of the speed reference signals for critical speed avoidance. Typical values are 15.0 Hz, 30.0 Hz, and 45.0 Hz, respectively. Refer to Figure 5-11 and [1,2L].
Skip Frequency 2 [B]	0.0	120	**30.0 Hz**	The critical speed feature is activated by setting *csa_sw* equal to “true” in the system program.
Skip Frequency 3 [B]	0.0	120	**45.0 Hz**	If this feature is enable, SF1 < SF2 < SF3 must be met, otherwise unpredictable behavior may result.
Skip Band 1 [B]	0.0	6.0	**0.0 Hz**	Skip bands 1-3 set the respective bandwidths of the speed reference signals for critical speed avoidance. The skip band represents a positive and negative band around the skip frequency (a total of 2 times the actual specified skip band). Typical values are 0.0 Hz for each skip band. Refer to Figure 5-11 and [1,2L].
Skip Band 2 [B]	0.0	6.0	**0.0 Hz**	The critical speed feature is activated by setting *csa_sw* equal to “true” in the system program.
Skip Band 3 [B]	0.0	6.0	**0.0 Hz**	

The critical speed feature is accomplished using skip frequencies and skip bands as defined in Table 5-21. This is illustrated in Figure 5-11.

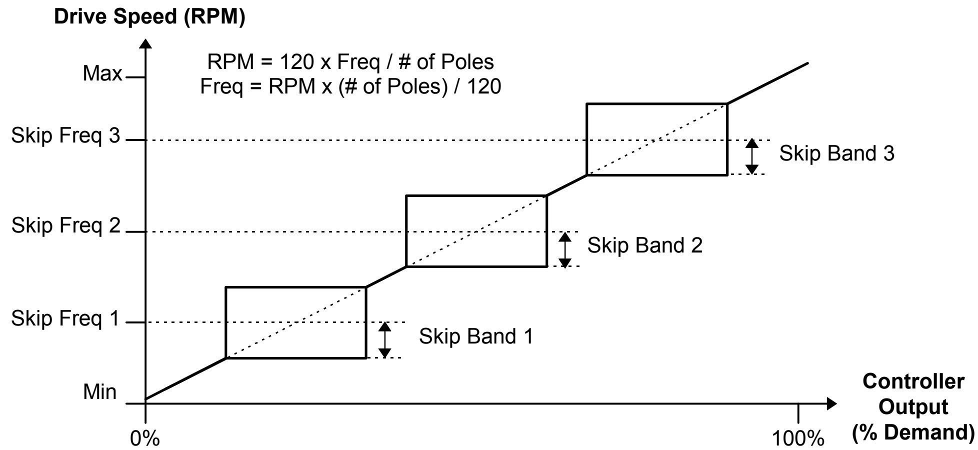

Figure 5-11. Critical Speed (Resonance Avoidance) Parameters

Critical speed avoidance (or *resonance avoidance*) is used as required to permit the drive from operating in frequency ranges that may cause resonant frequencies in mechanical systems. The user defines up to 3 speed regions that correspond to these resonant frequencies. In addition, there are 3 parameters that define a band width for each resonant frequency.

When a critical speed avoidance band is active (i.e., a non-zero skip band and valid [non-zero] corresponding skip frequency have been entered), the user is notified (via an SOP flag being set) that the system is attempting to "step" out of an exclusion area. The user can then change ramp rates based on this flag such that the actual time within the skip band can be minimized.

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5.5.4. Comparator Setup Submenu [29] [B]

The Comparator Setup Submenu [29] contains menu items available in both standard and vector control modes. These menu items are listed and explained in Table 5-22.

Table 5-22. Comparator Setup Submenu [29] [B]

Submenu	Description
Compare *n* Setup (*N*) [B] (*n* = 1-16 and *N* = 121-136)	Submenus that contain 16 sets of comparators for custom use in the system program. Each comparator set (Compare 1 through Compare 16) consists of three parameters that are located in setup menus 121 through 136. Comparators are system program flags (*compar_**1**_f* through *compar_**16**_f*) which can be used anywhere within the system program environment to control software switches. Refer to Table 5-23 that follows and the example system program later in this document.

Table 5-23. Compare 1-16 Setup Submenu Parameter Descriptions

Menu Item	Typical Value	Description
Comp *n* A in variable select (list) (*n*=1-16)	**empty**	Comp *n* A in and Comp *n* B in can be selected from the list in Table 5-24.
Comp *n* B in variable select (list) (*n*=1-16)	**empty**	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.
Compare *n* type (list) (n=1-16)	**off**	Compare *n* can be set to the following: signed (e.g., 10 > -50) magnitude (e.g., -50 > 10) disabled (no compare is done).

☝ The Enter Address Manually function can be used to select a variable not listed in the table. Hexadecimal addresses can be found using the locator file HAR*b_bb*.LOC (the *b_bb* corresponds to the software version installed in the drive). For example, version 1.15 software has the locator file HAR1_15.LOC.

☝ The Enter Fixed Value and Enter Fixed Percentage functions are used for selecting constant values for comparison.

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Table 5-24. Variable Pick List for Compare Setup Submenus [121-136] and AO Variables

Raw Speed Input Signal	Torque Command	Analog Aux3 Input
Speed Regulator Command	Torque Current Feedback	Ground Fault Offset Level
Speed Command Abs Val	Torque Regulator Feedback	Analog Module Input 1
Speed Feedback Abs Val	Available Line Voltage	Analog Module Input 2
Speed Regulator feedback	Peak Line Voltage	Analog Module Input 3
Encoder Speed Feedback	Total Current Feedback	Analog Module Input 4
Frequency Demand	Slip Speed	Analog Module Input 5
Motor Voltage Command	MMF Output Speed	Analog Module Input 6
Motor Voltage Feedback	VCO Analog Value	Analog Module Input 7
Quadrature Current Command	VCO Delta Count	Analog Module Input 8
Quadrature Current Output	Phase Lock Loop Error	Enter Address Manually
Quadrature Current Feedback	Output Power in kW	Enter Fixed Value
Direct Current Command	Analog Reference Input	Enter Fixed Percentage
Direct Current Output	Analog Aux1 Input	
Direct Current Feedback	Analog Aux2 Input	

5.5.5. PID Select Submenu [48] *B*

The PID Select Submenu [48] contains menu items available in both standard and vector control modes. These menu items are listed and explained in Table 5-25.

Table 5-25. PID Select Submenu [48] ^{B}

Parameter	Range (Min)	Range (Max)	Typical Value	Description
PID scaler 1 ^{B}	-127.996	127.996	**0.390**	Selects the scaling for the PID process variables 1 and 2 in the PID controller.
PID scaler 2 ^{B}	-127.996	127.996	**-0.390**	See Appendix B, sheet 1, zone (7B).
PID Proportional Gain ^{B}	0	98.996	**0.390**	Sets the PID loop Proportional (P), Derivative (D) and Integral (I) gains.
PID Integral Gain ^{B}	0	98.996	**0.390**	See Appendix B, sheet 1, zone (7B).
PID Derivative Gain ^{B}	0	98.996	**0.000**	
PID Minimum Clamp ^{B}	-200%	200%	**0%**	Sets the minimum and maximum values for the PID loop integrators.
PID Maximum Clamp ^{B}	-200%	200%	**100%**	See Appendix B, sheet 1, zone (7B).
PID Setpoint ^{B}	-200%	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 the full scale.

5.6. 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]
- Enter Security Code Function
- Change Security Code Function
- Security Edit Menu [0].

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 sections that follow.

5.6.1. Motor Menu [1]

Components of the Motor Menu [1] are listed and described in Section 5.2: Motor Menu [1] Options on page 5-4.

5.6.2. Drive Menu [2]

Components of the Drive Menu [2] are listed and described in Section 5.3: Drive Menu **[2] Options** on page 5-8.

5.6.3. Stability Menu [3]

Components of the Stability Menu [3] are listed and described in Section 5.4: Stability Menu [3] Options on page 5-18.

5.6.4. Auto Menu [4]

Components of the Auto Menu [4] are listed and described in Section 5.5: Auto Menu [4] **Options** on page 5-25.

5.6.5. Log Control Menu [6]

Components of the Log Control Menu [6] are listed and described in Section 5.7: Log Control Menu [6] Options on page 5-34.

5.6.6. Drive Protect Menu [7]

Components of the Log Control Menu [7] are listed and described in Section 5.7: Log Control Menu [6] Options on page 5-34.

5.6.7. Meter Menu [8]

Components of the Meter Menu [8] are listed and described in Section 5.9: Meter Menu [8] Options on page 5-42.

5.6.8. Communications Menu [9]

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Components of the Communications Menu [9] are listed and described in Section 5.10: Communications Menu [9] Options on page 5-48.

5.6.9. The Security System Overview

The Perfect Harmony has a security system which has several useful features. These include the display of parameters, limiting access for changes, blocking the display of menu entries, preventing the printout of submenu or menu items during a parameter dump, and preventing the changing of parameters while the drive is running. The code settings are printed on the right side of each item on a parameter dump. They are under the heading "lev hmpd". Entries beneath the "lev" heading list the security level for each item. In order to change the parameter, the security level must be set to this level or higher. Entries in the "hmpd" column are the security bits which are set [1] or not set [0] for each item. The meanings of each bit are listed below.

h Hide the menu item until the security level is set to its level or higher.
m Submenu print lockout (does not print the menu on a parameter dump).
p Print lockout (does not print the item on a parameter dump)
d Drive running lockout (will not allow parameter changes while drive is running).

There are seven levels of security for the customer's use. When the drive is initially powered up, or the microprocessor is reset, the security level defaults to "0", which is "no security".

Use of the security system involves three menu items from the Main Menu [5]:

- Enter Security Code function
- Change Security Code function
- Security Edit Menu [0].

These are discussed in the sections that follow.

5.6.10. Enter Security Code Function

The Enter Security Code function allows the operator to change the current security level for menu access to critical drive parameters. The drive is shipped with default codes that are detailed in Table 5-26.

Table 5-26. Default Security Access Codes

Security Level Number	Degree of Access	Default Access Code
0	minimum access	*none*
1	:	1111
2	:	2222
3	:	3333
4	:	4444
5	:	5555
6	:	6666
7	maximum access	7777

To change the current security level, scroll down through the Main Menu to the Enter Security Code function. Selecting this item will prompt the user with Enter Security Code, at which time the code for the desired security level is entered. The security code is a 4-digit number consisting of the alphanumeric set “0” through “9” and “A” through “F”.

Once the new code is entered, any menu item which has a security level less than or equal to the new level will become accessible (i.e., visible to the user). All menu items having a security level greater than the current level will not be visible to the user.

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5.6.11. Change Security Code Function

The codes listed in Table 5-26 can be changed using the Change Security Code function found in the Main Menu [5]. This function is only available if the current security level is already at level 2 or higher. Security codes can only be changed for a particular security level (or lower) after the VFD is configured for that security level. For example, if an operator enters security access level 5 (using the Enter Security Code function), he will only be able to change security codes for security levels 5 and lower. This is detailed in Table 5-27.

Table 5-27. Security Levels and Modification Capabilities

At This Security Level…	You Can Modify Security Codes for These Levels	At This Security Level…	You Can Modify Security Codes for These Levels
0	*not available*	4	4, 3, 2, 1, 0
1	*not available*	5	5, 4, 3, 2, 1, 0
2	2, 1, 0	6	6, 5, 4, 3, 2, 1, 0
3	3, 2, 1, 0	7	7, 6, 5, 4, 3, 2, 1, 0

5.6.12. Security Edit Menu [0]

When the security level is set to level 7, the Security Edit [0] Menu can be displayed. This menu is used to set the security level for individual menu items, to "hide" menu items, to customize the parameter printout, and to prevent changes to specified parameters while the drive is running.

Upon entering any of the following functions, an "Enter Menu #" prompt will appear on the display. If the menu number is known, it can be entered at this point. If the menu number is not known, press [Enter] and the display will default to the top of the Main Menu, allowing the user to scroll to the menu item to be changed.

> An asterisk character (*) appears on the left of the display to indicate that the menu or submenu is in the security edit feature mode, and not the normal mode.

When the operator reaches the menu item to be changed, he must press [Enter] followed by either a "0" (the [0] key) to disable or a "1" (the [1] key) to enable the selected edit feature. To leave the "change security level" function, press [Cancel]. Available edit features are outlined in Table 5-28. To clear security access, press the [Shift] and [⇦] (left arrow) key sequence three times.

Table 5-28. Security Edit [0] Functions

Function	Description
Change Security Level	Change security level prohibits access to menu or menu items until enter security level is set to that level or higher.
Hide Till Clearance Set	Allows submenus or items in menus from being displayed until a security level equal to or greater than that item's level is entered.
Submenu Print Inhibit	Allows the parameter dump to be customized for the particular application. If certain menus of the drive are not used, then they can be set so they are not printed in a parameter dump.
Block From Printout	Performs the same function as submenu print inhibit except on individual menu items.
Drive Running Inhibit	Prohibits certain parameters from being changed when drive is in the Run State (D).

> A state control diagram of the Perfect Harmony is available on sheet 6 of drawing 479333 in Appendix B.

5.7. Log Control Menu [6] Options

The Log Control Menu [6] consists of the following menu options:

- Memory Functions Submenu [30]
- Diagnostic Log Submenu [31]
- Historic Log Submenu [32]
- Fault Log Submenu [33].

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

5.7.1. Memory Functions Submenu [30] *B*

The Memory Functions Submenu [30] contains menu items available in both standard and vector control modes. These menu items are listed and explained in Table 5-29.

Table 5-29. Memory Functions Submenu [30] [B]

Function	Description
Read Memory Byte [B]	Reads contents of RAM address *bbbbb* (hex) and returns data byte *xx* (hex).
Read Memory Word [B]	Reads contents of RAM address *bbbbb* (hex) and returns data word *xxxx* (hex).
Write Memory Byte [B]	Writes (sends) the data byte *xx* (hex) to the RAM address *bbbbb* (hex).
Write Memory Word [B]	Writes (sends) the data word *xxxx* (hex) to the RAM address *bbbbb* (hex).
Copy from RAM to EEPROM [B]	Copies current contents of RAM to EEPROM for permanent storage. Changes to RAM are lost during reset.
Copy from EEPROM to RAM [B]	Copies current contents of EEPROM to RAM.

For address locations of flags used in system program see Appendix D. For address locations of process variables, see version of file HAR*b_bb*.LOC, where *b_bb* is the version number of the software installed in the drive.

When reading or writing data to/from RAM addresses, a "4" prefix must be used, i.e., 4*bbbb* (where *bbbb* is a valid RAM address in hexadecimal format). Similarly, when reading or writing data to/from EEPROM addresses, a "5" prefix must be used, i.e., 5*bbbb* (where *bbbb* is a valid RAM address in hexadecimal format). A '6' prefix is used for I/O addresses. (Note that hexadecimal digits include 0-9 and A-F.)

5.7.2. Diagnostic Log Submenu [31] [B]

The Diagnostic Log Submenu [31] contains menu items available in both standard and vector control modes. These menu items are listed and explained in Table 5-30.

Table 5-30. Diagnostic Log Submenu [31] [B]

Parameter	Range (Min)	Range (Max)	Typical Value	Description
Log variable*n* (*n* = 1-4)	*list* (see Table 5-31)		***(empty)***	Specifies each of 4 log variables (Log var1-4) which are selected from the list in Table 5-31. The values of these variables are captured in the diagnostic log.
Diagnostic Log Time	0.0 sec	310 sec	**3.6 sec**	Specifies the time interval (in seconds) over which 1280 samples of each variable (specified by Log var1 through Log var4, above) are captured. Minimum sample period is 2.78 msec (at 60 Hz) so it would take 3.56 sec (0.00278 × 1280) to produce the highest resolution available. This parameter defaults to 3.6 seconds.

Parameter	Range (Min)	Range (Max)	Typical Value	Description
Select Diagnostic Log	*function*		***n/a***	This function is initiated by pressing the [Enter] key on the keypad before using the diagnostic log.
Start Diagnostic Log	*function*		***n/a***	Starts recording log variables.
Diagnostic Log Upload	*function*		***n/a***	Uploads diagnostic log (in 2's complement hex format) in a 4 x 1,280 word block. Var1<sp>Var2<sp>Var3<sp> Var4<CR> This information is translated into ASCII format when it is displayed.

Table 5-31. Pick List Variables for Diagnostic Log, Analog Meters and Digital Meters

Raw Speed Input Signal [B]	Direct Current Command [V]	VCO Delta Count [B]
Speed Reg Command [B]	Direct Current Output [V]	Phase Lock Loop Error [T]
Speed Command Abs Val [B]	Direct Current Feedback [V]	Output Power in kW [B]
Speed Feedback Abs Val [B]	Torque Command [B]	Analog Reference Input [B]
Speed Regulator Feedback [B]	Torque Current Feedback	Analog Aux1 Input [B]
Encoder Speed Feedback [V]	Torque Regulator Feedback	Analog Aux2 Input [B]
Frequency Demand [B]	Available Line Voltage [B]	Analog Aux3 Input [B]
Motor Voltage Command [B]	Peak Line Voltage [B]	Gnd Fault Offset Level [B]
Motor Voltage Feedback [B]	Total Current Feedback [B]	Analog Module Input 1 [B]
Quadrature Current Command [V]	Slip Speed [V]	:
Quadrature Current Output [V]	MMF Output Speed [B]	Analog Module Input 8 [B]
Quadrature Current Feedback [V]	VCO Analog Value [B]	Enter Address Manually [B]

Also see Appendix B for the Perfect Harmony control diagram.

> The Enter Address Manually function can be used to select a variable not listed in the previous table. Hexadecimal addresses can be found using the locator file HAR*b_bb*.LOC (the *b_bb* corresponds to the software version installed in the drive). For example, version 1.15 software has the locator file HAR1_15.LOC.

5.7.3. Historic Log Submenu [32] [B]

The Historic Log Submenu [32] contains menu items available in both standard and vector control modes. These menu items are listed and explained in Table 5-32.

Table 5-32. Historic Log Submenu [32] [B]

Parameter	Range (Min)	Range (Max)	Typical Value	Description
Select Historic Log [B]	*function*		***n/a***	This function is initiated by pressing the [Enter] key on the keypad before using the historic log.
Historic Variable 1 [B]	*list* (*see* Table 5-40 on page 5-46)		**M % spd**	Historic log variables can be selected from Table 5-40 on page 5-46. The 7 selected variables are logged 144 times before and 100 times after the occurrence of a fault. Each record is recorded at 2.78 msec intervals. The format of the record is:
Historic Variable 2 [B]			**Mtr Freq**	Rec No <Variables 1-7> Drive State <sp> Flt1 <sp> Flt2 <cr>
Historic Variable 3 [B]			**Trq cmd**	"Rec (record) No" designates sample number, - before fault, + after fault. Drive state designates state of drive at the time of the sample.
Historic Variable 4 [B]			**Trq I Fb**	Flt1 and Flt2 form a 32-bit bitmap which can be decoded through .DAT file to inspect VFD fault status for each sample.
Historic Variable 5 [B]			**Mtr V fb**	
Historic Variable 6 [B]			**I sum fb**	
Historic Variable 7 [B]			**V Avail**	
Historic Log Upload [B]	*function*		***n/a***	Uploads the historic log in ASCII formatted text through the RS-232 port.

> A state control diagram of the Perfect Harmony is available on sheet 6 of drawing 479333 in Appendix B.

5.7.4. Fault Log Submenu [33] [B]

The Fault Log Submenu [33] contains menu items available in both standard and vector control modes. These menu items are listed and explained in Table 5-33.

Table 5-33. Fault Log Submenu [33] [B]

Function Names	Description
Fault Log Display [B]	Lists the 64 most recent fault conditions along with the date and time of the occurrence.
Fault Log Upload [B]	Uploads the fault log in ASCII formatted text through the RS-232 port.

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5.8. Drive Protect Menu [7] Options

The Drive Protect Menu [7] consists of the following menu options:

- Overload Submenu [34]
- Limit Submenu [35] ^{V}.

These menus are explained in the sections that follow.

5.8.1. Overload Submenu [34]

The Overload Submenu [34] contains menu items available exclusively in vector control mode and available in both standard and vector control modes. These menu items are listed and explained in Table 5-34.

Table 5-34. Overload Submenu [34]

Parameter	Range (Min)	Range (Max)	Typical Values	Description
Overload Select ^{B}	0	2	**1**	Defines the drive's reaction to overload conditions: 0 = Constant 1 = Inverse 1 2 = Inverse 2. **Constant** - Causes an overload fault condition when input current exceeds I Overload (as a percentage of Full Load Current) for time period I Time-out. **Inverse 1** - Causes overload conditions to mimic a "classical" time inverse TOL motor relay (speed independent) when I Overload setting is exceeded. **Inverse 2** - Same as Inverse 1 except it linearly de-rates the I Overload setting when actual speed falls below 50% of the Full Load Speed setting to protect totally enclosed fan cooled (TEFC) blowerless motors.
I Overload ^{B}	20%	210%	**150%**	For "Inverse 1 and 2", I Time-out can be used to shorten (<1 sec) or extend (>1 sec) standard class 20 TOL trip times.
I Time-out ^{B}	0.01 s	300.00 s	**60.00 s**	For "Constant", I Time-out sets trip time.
Motor Trip Volts ^{B}	5 v	9999 v	**4800 v**	Sets the absolute trip point for an output overvoltage fault.
Overspeed ^{B}	0%	250%	**120%**	Sets the threshold at which an overspeed fault will occur. The value is entered as a percent of the full load speed.

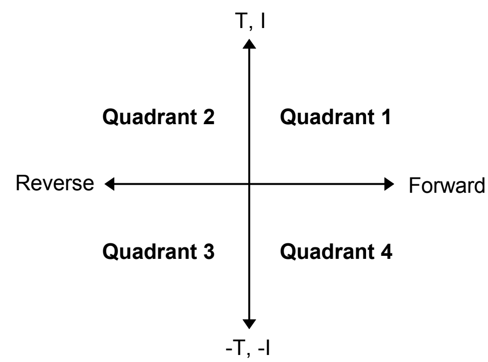
Parameter	Range (Min)	Range (Max)	Typical Values	Description
Encoder Loss Threshold [V]	0%	75%	**0%**	Sets the threshold of error between the encoder feedback and the motor frequency at which the drive will trip with a loss of encoder fault. 0% = disable encoder loss trip 1-75% = error threshold for trip.
Drive IOC Setpoint [B]	50%	200%	**165%**	Sets the threshold (as percent of Full Load Current) at which an output overcurrent fault will occur.
I Overload 2 [B]	20%	210%	**150%**	Multiple parameter set 2 for I Overload settings (see above). These parameters are used when *tol_set_2* = true (in the system program).
I Time-out 2 [B]	0.01 s	300.00 s	**60.00 s**	
I Overload 3 [B]	20%	210%	**150%**	Multiple parameter set 3 for I Overload settings (see above). These parameters are used when *tol_set_3* = true (in the system program).
I Time-out 3 [B]	0.01s	300.00 s	**60.00 s**	
Enter for Fault Reset [B]	*function*			Sets the flag *drv_flt_rst_f* in the system software to "true". This flag could be used to reset drive faults if the system program is configured to do so.
Clear Fault Message [B]	*function*			Clears the fault message from the display without having to reset the fault.

Note that the Limit Submenu [35] is a vector control menu which is visible from the Drive Protect Menu [7] only if the *std_cntrl_f* flag in the system program is set to "false".

5.8.2. Limit Submenu [35] ^{V}

The Limit Submenu [35] contains menu items available only in vector control mode. These menu items are listed and explained in Table 5-35.

Table 5-35. Limit Submenu [35] ^{V} (Vector Control Mode Only)

Parameter	Range (Min)	Range (Max)	Typical Values	Description
Motor Torque Limit ^{V}	0.0%	300%	**100%**	Torque limit (positive in the forward direction, negative in the reverse direction) invoked on the reference of the torque regulator in vector control mode to limit maximum torque during accel and decel conditions. Values are entered as a percentage of the full load current. This parameter operates in quadrants 1 and 3 as shown in Figure 5-12. Also refer to the motor torque limit parameter in the Standard Control Setup Submenu [24].  **Figure 5-12. Quadrants of Motor Operation** For more information, refer to Appendix B, sheet 4, zone (6D).
Regen Torque Limit ^{V}	0.0	30.0	**2.0%**	Represents the same polarity shift in the reverse direction of the torque regulator in vector control mode to limit maximum torque during accel and decel conditions. Values are entered as a percentage of the full load current. This parameter operates in quadrants 2 and 4 as shown in Figure 5-12. Also refer to the regen torque limit parameter in the Standard Control Setup Submenu [24].
Motor Analog Limit ^{V}	0.0%	300%	**100%**	Scales inputs from power interface board inputs if selected for use as forward torque limit and reverse torque limit.
Regen Analog Limit ^{V}	0.0	30.0	**2.0%**	For more information, refer to Appendix B, sheet 4, zone (6D).

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Parameter	Range (Min)	Range (Max)	Typical Values	Description
Motor Torque Limit 2 [V]	0.0%	300%	**100%**	Multiple parameter set number two. Used for controlling forward torque limit and reverse torque limit. Selected for limits by setting flags *ai_swi7* = true and *al_swi8* = true in the system program.
Regen Torque Limit 2 [V]	0.0	30.0	**2.0%**	
Motor Torque Limit 3 [V]	0.0%	300%	**100%**	Multiple parameter set number three. Used for controlling forward torque limit and reverse torque limit. Selected for limits by setting flags *ai_swi9* = true and *al_swi20* = true in the system program.
Regen Torque Limit 3 [V]	0.0	30.0	**2.0%**	

See Table 5-17: Standard Control Setup Submenu [24] on page 5-20 for standard performance information.

5.9. Meter Menu [8] Options

The Meter Menu [8] consists of the following menu options:

- Analog Setup I/O Submenu [36]
- Display Variable Submenu [37]
- Trim Analog Meters Submenu [38]
- Local Analog Meters Submenu [39]
- Local Digital Meters Submenu [40].

These submenus are explained in sections that follow.

5.9.1. Analog I/O Setup Submenu [36] [B]

The Analog I/O Setup Submenu [36] contains menu items available in both standard and vector control modes. These menu items are listed and explained in Table 5-36.

Table 5-36. Analog I/O Setup Submenu [36] [B]

Parameter	Range (Min)	Range (Max)	Typical Values	Description
Analog Variable 1 [B]	*list*		**empty**	Analog variables can be selected from the list in Table 5-31 on page 5-36. These outputs are on test points TP1 and TP2 on the microprocessor board.
Analog Variable 2 [B]	*list*		**empty**	
Analog TP 1 [B]	-20.000 v	20.000 v	**10.000 v**	Scales Analog Var1 and Analog Var2. 10.000v = 100%.
Analog TP 2 [B]	-20.000 v	20.000 v	**10.000 v**	
Analog In Scaler [B]	0%	250%	**100%**	Scaler for pick list items “ref in” and “aux 1,2 and 3” (see Table 5-40 on page 5-46) such that the full range (10V) represents this percentage of internal units (PU). This is used for comparators and other pick lists only. A separate scaler is used for scaling to the speed or torque command.
Analog Out *n* (*N*) [B] (*n*=1-8, *N*=111-118)	*submenu*		***n/a***	Provides access to the individual analog output module submenus. Refer to Table 5-24 (page 5-30) for pick list names and variable descriptions for Analog Output submenus. See Table 5-37 for switch settings. Note that there is only one analog output reference per AO Module.

Parameter	Range (Min)	Range (Max)	Typical Values	Description
Analog In *n* (*N*) [B] (*n*=1-8, *N*=181-188)	*submenu*		***n/a***	Provides access to the individual analog input configuration submenus. Inputs from the Analog Input Modules are available as velocity, aux velocity, PID and torque references. Refer to Appendix B. See Table 5-38 for switch settings. Note that there is only one analog input reference per AI Module.
Velocity Reference [B]	*list*		**empty**	These parameters are used to define input variables for the corresponding references. Any one of the eight analog inputs (Analog Module Input 1 through Analog Module Input 8) or "empty" can be assigned to each of these parameters. Refer to Appendix B for more information.
PID Reference [B]	*list*		**empty**	
Auxiliary Velocity Reference [B]	*list*		**empty**	
Torque Reference [B]	*list*		**empty**	

5.9.2. Analog Output 1 Submenu [111] through Analog Output 8 Submenu [118] [B]

The Analog Output 1 Submenu [111] through Analog Output 8 Submenu [118] contain menu items available in both standard and vector control modes. These menu items are listed and explained in Table 5-37.

Table 5-37. Analog Output 1 Submenu [111] through Analog Output 8 Submenu [118] [B]

Parameter	Range (Min)	Range (Max)	Typical Values	Description
Analog Variable *x* [B] (*x*=1-8)	*list*		**empty**	Select for each module *x*, a variable from any listed in Table 5-24 (page 5-30).
Full Range [B]	0.0%	300.0%	**0.0%**	Scales the output range of the variable selected.
Module Address [B]	0	15	**0**	Selects the address number set on the binary address switch found on the output module. Note: The module addresses must be unique from other installed analog input or analog output modules.

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Parameter	Range (Min)	Range (Max)	Typical Values	Description
Variable *x* type [B] (*x* =1-8)	*list*		**empty**	Selects an output type for each module *x* (display text is shown in boldface): **Disabled** – Analog output disabled (off). **Bipolar** – Selects all module outputs so that "0" value of selected variable is: 2.5 v for 0-5 v output 0 v for -10 v to +10 v output 10 mA for 4-20 mA output. **Unipolar** – Selects all module outputs so that "0" value of selected variable is: 0 v for 0-5 v output -10 v for -10 v to +10 v output 0 mA for 4-20 mA output. **4-20 mA** – Selects all module outputs so that "0" value of selected variable is: +1 v for 0-5 v output -8 v for -10 v to +10 v output 4 mA for 0 to 20 mA output.

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5.9.3. Analog Input 1 Submenu [181] through Analog Input 8 Submenu [188] [B]

The Analog Input 1 Submenu [181] through Analog Input 8 Submenu [188] contain menu items available in both standard and vector control modes. These menu items are listed and explained in Table 5-38.

Table 5-38. Analog Input 1 [181] through Analog Input 8 [188] [B]

Parameter	Range (Min)	Range (Max)	Typical Values	Description
Full Range [B]	0.0%	300.0%	**0.0%**	Scales the input range of the variable selected.
Module Address [B]	0	15	**0**	Selects the address number set on the binary address switch located on the input module. Note: Module addresses must be unique from other installed analog input or output modules.
Variable *x* Type [B] (*x* = 1-8)	*list*		**empty**	Selects an input type for each module *x* (display text is shown in boldface): **Disabled** – Analog input disabled (off). **Bipolar** – Selects all module inputs so that "0" value of selected variable is: 2.5 v for 0-5 v input 0 v for -10 v to +10 v input 10 mA for 4-20 mA input. **Unipolar** – Selects all module inputs so that "0" value of selected variable is: 0 v for 0-5 v input -10 v for -10 v to +10 v input 0 mA for 4-20 mA input.

Parameter	Range (Min)	Range (Max)	Typical Values	Description
				4-20 mA – Selects all module inputs so that “0” value of selected variable is: +1 v for 0-5 v input -8 v for -10 v to +10 v input 4 mA for 0 to 20 mA input.

5.9.4. Display Variable Submenu [37] [B]

The Display Variable Submenu [37] contains menu items available in both standard and vector control modes. These menu items are listed and explained in Table 5-39.

Table 5-39. Display Variable Submenu [37] [B]

Parameter	Type	Typical Values	Description
Display Variable 0 [B]	*list*	Speed Input	The LCD display variables can be selected from Table 5-40.
Display Variable 1 [B]	*list*	Motor Freq	
Display Variable 2 [B]	*list*	Motor RPM	
Display Variable 3 [B]	*list*	Torque I Fb	

Table 5-40 contains name, abbreviation, display and variable columns of standard pick list variables (used in the Historic Log Submenu [32], the Display Variable Submenu [37], 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.

Table 5-40. Pick List Variables for the Historic Log and the Front Display

Selection Text	Abbreviation	Display	Variable
Motor Operating Frequency [B]	Mtr Freq	Freq	*mmf_spd*
Motor Speed in RPM [B]	Mtr rpm	RPM	*vel_fb*
Motor Speed in Percent [B]	M % spd	%Spd	*vel_fb*
Speed Regulator Command [B]	Spd Reg Cmd	RPM	*vel_cmd*
Raw Speed Input Signal [B]	Spd Input	Demd	*raw_vel_dmd1*
Encoder Speed Feedback [V]	Encoder fb	Erpm	*vel_xdr_fb*
Torque Command	Trq cmd	%Trq	*trq3_cmd*
Torque Current Feedback	Trq I Fb	Itrq	*trq_i_fb*
Magnetizing Current Fb [B]	Mag I Fb	Imag	*mag_i_fb*
Total Current Feedback [B]	I sum fb	Itot	*sum_i_fb*
Motor Voltage Feedback [B]	Mtr V fb	Vlts	*av_fb*
Input Line Frequency [B]	Line Freq	LFrq	*line_freq*
Output Phase wrt Line [T]	Output Phase	PhFb	*phase_fb*
Available Line Voltage [B]	V Avail	LVlt	*v_avail*
Peak Line Voltage [B]	V Avail Pk	Pk-V	*vin_pk_fb*
Output Power in kW [B]	kW output	KW	*power*
Ground Fault Offset Level [B]	Gnd Flt Lev	VNGa	*ground_fault_level*
Flux Position [B]	Flux Pos	FPos	*vco_cnt*
Flux Delta Position [B]	Delta Pos	DPos	*del_cnt_vco*
Reference Analog Input [B]	Ref Input	Ref %	*ref_in_analog*
Aux1 Analog Input [B]	Aux1 Input	Aux1	*aux_in1_analog*
Aux2 Analog Input [B]	Aux2 Input	Aux2	*aux_in2_analog*
Aux3 Analog Input [B]	Aux3 Input	Aux3	*aux_in3_analog*
Ramp Input [B]	Ramp Input	RmpI	*raw_vel_dmd2*
Ramp Output [B]	Ramp Output	RmpO	*vel_ref*
Analog Module Input 1 [B]	Alg In 1	Alg1	*analog_in_modules[0].value*
Analog Module Input 2 [B]	Alg In 2	Alg2	*analog_in_modules[1].value*
Analog Module Input 3 [B]	Alg In 3	Alg3	*analog_in_modules[2].value*
Analog Module Input 4 [B]	Alg In 4	Alg4	*analog_in_modules[3].value*
Analog Module Input 5 [B]	Alg In 5	Alg5	*analog_in_modules[4].value*
Analog Module Input 6 [B]	Alg In 6	Alg6	*analog_in_modules[5].value*
Analog Module Input 7 [B]	Alg In 7	Alg7	*analog_in_modules[6].value*
Analog Module Input 8 [B]	Alg In 8	Alg8	*analog_in_modules[7].value*
Enter Address Manually [B]	n/a	(1234)	(hex address)

5.9.5. Trim Analog Meters Submenu [38] [B]

The Trim Analog Meters Submenu [38] contains menu items available in both standard and vector control modes. These menu items are listed and explained in Table 5-41.

Table 5-41. Trim Analog Meters Submenu [38] [B]

Function Names	Description
Trim Local Analog Meter *n* (*n* = 1-8) [B]	This function trims the analog meter selected in Local Analog Meter Submenu [39]. The up [⇧] and down [⇩] arrow keys on the keypad can be used to trim the meter to a desired level.

5.9.6. Local Analog Meter Submenu [39] [B]

The Local Analog Meter Submenu [39] contains menu items available in both standard and vector control modes. These menu items are listed and explained in Table 5-42. Each of these submenus contains an identical list of parameters which are described in the next section. Refer to Table 5-43.

Table 5-42. Local Analog Meter Submenu [39] [B]

Submenu	Description
Analog Meter *n* (*N*) (*n*=1-8, *N*=51-58) [B]	Provides access to submenus Analog Meter 1 [51] through Analog Meter 8 [58]. The contents of these menus are identical and are explained in the following table.

5.9.7. Analog Meter *n* Submenus [51-58] [B]

The Analog Meter *n* Submenus [51-58] contains menu items available in both standard and vector control modes. These menu items are listed and explained in Table 5-43.

Table 5-43. Analog Meter *n* Submenu [51-58] [B]

Parameter	Range (Min)	Range (Max)	Typical Values	Description
Meter *n* Variable (*n*=1-8) [B]	*list*		**empty**	Each analog meter variable can be selected from the list in Table 5-31 on page 5-36.
Full Scale [B]	000000	400000	**000000**	Scale each selected analog meter variable as required (32,000 = 100%).
Zero Position [B]	0	1	**1**	Choose the location of the zero position on the meter: 0 = Left 1 = Center.

5.9.8. Local Digital Meter Submenu [40] [B]

The Local Digital Meter Submenu [40] contains menu items available in both standard and vector control modes. These menu items are listed and explained in Table 5-44. Each of these submenus contains an identical list of parameters which are described in the next section. Refer to Table 5-45.

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Table 5-44. Local Digital Meter Submenu [40] [B]

Submenu	Description
Digital Meter *n* (*N*) [B] (*n*=1-7, *N*=61-67)	Provides access to submenus Digital Meter 1 [61] through Digital Meter 7 [67]. The contents of these menus are identical and are explained in the following table.

5.9.9. Digital Meter *n* Submenus [61-67] [B]

The Digital Meter *n* Submenus [61-67] contains menu items available in both standard and vector control modes. These menu items are listed and explained in Table 5-45.

Table 5-45. Digital Meter *n* Submenu [61-67] [B]

Parameter	Range (Min)	Range (Max)	Typical Values	Description
Meter *n* Variable (*n*=1-7) [B]	*list*		**empty**	Each digital meter variable can be selected from the list in Table 5-31 on page 5-36.
Rated Value [B]	000000	400000	**000000**	Scale each selected digital meter variable as required (400,000 = 100%).
Decimal Places [B]	0	4	**0**	Specifies the number of decimal places to be used (i.e., the number of significant digits to the right of decimal point).

5.10. Communications Menu [9] Options

The Communications Menu [9] consists of the following submenu options:

- RS232 Functions Submenu [41]
- Remote I/O Submenu [42]
- XCL Send Setup Submenu [43]
- XCL Receive Setup Submenu [44]
- RS232 Input list
- RS232 Output list.

These menu items are explained in sections that follow.

5.10.1. RS232 Functions Submenu [41] [B]

The RS232 Functions Submenus [41] contains menu items available in both standard and vector control modes. These menu items are listed and explained in Table 5-46.

> RS232 upload functions transmit data from the drive to a printer or computer. RS232 download functions transmit data to the drive. A terminal emulator (e.g., Smart Term's ST220.EXE or Procomm's PCPLUS) is required to upload, download, and echo files. Protocol settings for the RS232 port are 9600 baud, no parity, and one stop bit.

> The on-board RS232 parameter needs to be set to "0" when using the integrated keypad. This precludes the use of the serial port on the microprocessor board by replacing that function with the integrated serial port of the keypad. These serial ports are mutually exclusive and are not intended to work together. *When changing the* On-board RS232 *parameter, the microprocessor board must be reset in order for the change to take effect.*

The functions listed in Table 5-47 are used to test if the microprocessor is receiving inputs and transmitting outputs as indicated by the User Module's LEDs. The drive must be off when reading or writing to the user modules.

Table 5-46. RS232 Functions Submenu [41] B

Parameter	Type	Description
System Program Download B	function	Downloads the drive's system program to the EEPROM on the system module via the RS232 port. The program must be compiled with CMP.EXE.
System Program Upload B	function	Uploads the drive's system program to a printer or computer in hex format via the RS232 port. The program can be reverse compiled with REVCMP.EXE.
Display System Program Name B	function	Displays the system program version, revision date and time.
Download Entire EEPROM B	function	Downloads to the EEPROM located on the system module (via the RS232 port), a hex data file which contains the drive system program and parameter settings.
Upload Entire EEPROM B	function	Uploads from the EEPROM located on the system module (via the RS232 port), a hex data file which contains the drive's system program and parameter settings.
Parameter Data Download B	function	Downloads to the EEPROM located on the system module (via the RS232 port), a hex data file which contains the drive's parameter settings.
Parameter Data Upload B	function	Uploads from the EEPROM located on the system module (via the RS232 port), a hex data file which contains the drive's parameter settings.
RS232 Echo-back Test B	function	Tests the drive's RS232 communication interface. Receives external data from a computer and echoes it back. Data may be an ASCII text or hex file. No processing of data is performed.
Parameter Log Upload B	function	Uploads the parameter settings of the drive in formatted ASCII text to a computer or printer via the RS232 port.
Onboard RS232 B	0 or 1	0 = Enables RS232 port on the keypad (use with integrated/engineered keypad). 1 = Enables RS232 port on microprocessor board (use with SMT keypad) (default).

5.10.2. Remote I/O Submenu [42] B

The Remote I/O Submenu [42] contains menu items available in both standard and vector control modes. These menu items are listed and explained in Table 5-47.

Using either of the functions described in Table 5-47 stops the operation of the system program.

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Table 5-47. Remote I/O Submenu [42] Functions *B*

Function	Description
Read User Module (0-15) *B*	Reads the state of the inputs of a digital input module. Enter the address set on the module switch. The state of the 6 inputs is displayed. For example, “111000” indicates inputs “a” through “f” from *right to left*. Inputs “a”, “b”, and “c” are false (0), and inputs “d”, “e”, and “f” are true (1).
Write User Module (0-15) *B*	Writes to a digital output module. Enter the address set on the module switch and the desired state of the 4 relay outputs. Press [Enter] to write to the module. For example, “1110” sets relays “a” through “d” from *right to left*. Relay “a” is off (0); relays “b”, “c”, and “d” are on (1).

For drives equipped with an eXternal Communications Link (XCL), and Communications Adapter Board (CAB), the data item for each of the drive’s output registers is selected. The network protocol determines whether data items are broadcast as global data onto the network bus, or as register based data transfers. Up to 16 32-bit global data items can be broadcast by the drive. Up to 32 drive output data registers are available. Programmable controller networks which support global data transfers are Modbus-Plus and Reliance’s RE-Net. Controller networks which require register-to-register (point-to-point) data transfers include Allen Bradley’s Data Highway, and Reliance’s R-Net.

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5.10.3. XCL Send Setup Submenu [43] *B*

The XCL Send Setup Submenu [43] contains menu items available in both standard and vector control modes. These menu items are listed and explained in Table 5-48.

Table 5-48. XCL Send Setup Submenu [43] *B*

Parameter	Range (Min)	Range (Max)	Typical Values	Description
XCL Global Send Submenu [145] *B*	submenu		*n/a*	Submenu that contains parameters XCL send01 through XCL send 16 which specify 32-bit global data items.
XCL Send Register 1-31 [147] *B*	submenu		*n/a*	Submenu that contains parameters which specify variables whose values (register data, i.e., 1, 3, 5, 7, ..., 29, 31) are to be sent from the drive in applications where the network protocol dictates the use of register based data transfers. A value of “empty” means that no information is to be sent. Refer to Table 5-50 on page 5-52.
XCL Send Register 33-63 [148] *B*	submenu		*n/a*	Submenu that is a continuation of submenu 147.

Parameter	Range (Min)	Range (Max)	Typical Values	Description
XCL Node Address [B]	0	128	**10**	This parameter specifies a network or node address for networks that have software configurable node addresses. The value corresponds to the node address of the Perfect Harmony drive. This parameter defaults to a value of 10.
CAB Configuration [B]	0000	FFFF	**0000**	This parameter is used to configure the CAB board for special network handling. This parameter specifies a CAB configuration word that is used for global data and/or special functions. Refer to respective CAB manual for more information.

5.10.4. XCL Global Send Submenu [145] [B]

The XCL Global Send Submenu [145] contains menu items available in both standard and vector control modes. These menu items are listed and explained in Table 5-49.

Table 5-49. XCL Global Send Submenu [145] [B]

List Items	Typical Values	Description
XCL Send *nn* where *nn* = 01-16 [B]	**empty**	These parameters (XCL send01 through XCL send 16) specify the 32-bit global data items (variables) whose values are to be globally broadcast from the drive over the network via the CAB. Each XCL Send*nn* parameter can be selected from a pick list as a drive variable (see Table 5-52 on page 5-53), a serial flag, or a drive memory address. Serial flags are defined in the drive system program as "SERIAL_F*xx*", where *xx* is the bit number 00-16. A memory address is entered as a 4-digit hexadecimal number that is obtained from the drive's locator file. This directs a 16-bit word, data type hex. A value of "empty" means that no information is to be sent. "Erase entry" will define XCL send*nn* as empty. "Heartbeat" is incremented every 2.7 ms to indicate that the drive microprocessor board is "healthy".

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5.10.5. XCL Send Reg 1-31 Submenu [147] [B]

The XCL Send Reg 1-31 Submenu [147] contains menu items available in both standard and vector control modes. These menu items are listed and explained in Table 5-50.

Table 5-50. XCL Send Reg 1-31 Submenu [147] [B]

List Items	Typical Values	Description
XCL Register 001 [B]	**Raw Speed Input %**	Parameters which specify variables whose values (register data, i.e., 1, 3, 5, 7, ..., 29, 31) are to be sent from the drive in applications where the network protocol dictates the use of register based data transfers. A value of “empty” means that no information is to be sent. Table 5-52 on page 5-53 gives a complete list of the available variables from which to choose.
XCL Register 003 [B]	**Ramp Output %**	
XCL Register 005 [B]	**Frequency Demand %**	
XCL Register 007 [B]	**Total Curr Fb %**	
XCL Register 009 [B]	**Mtr voltage feedback %**	
XCL Register 011 [B]	**kW output in %**	
XCL Register 013 [B]	**Serial 1 Bit Flags**	
XCL Register 015 [B]	**Heartbeat**	
XCL Register 017 through XCL Register 031 [B]	**<empty>**	

5.10.6. XCL Send Reg 33-63 Submenu [148] [B]

The XCL Send Reg 33-63 Submenu [148] contains menu items available in both standard and vector control modes. These menu items are listed and explained in Table 5-51.

Table 5-51. XCL Send Reg 33-63 Submenu [148] [B]

List Items	Typical Values	Description
XCL Register 033 through XCL Register 063 [B]	**<empty>**	Parameters which specify variables whose values (register data, i.e., 33, 35, 37, 39, ..., 61, 63) are to be sent from the drive in applications where the network protocol dictates the use of register based data transfers. A value of “empty”

		means that no information is to be sent. Table 5-52 on page 5-53 gives a complete list of the available variables from which to choose.

Table 5-52. XCL Send Setup Pick List

Selection Text	Display Text	Variable
Speed Regulator Command RPM [B]	Spd Cmd RPM	*vel_cmd*
Speed Command % [B]	Spd Cmd %	*vel_cmd*
Speed Feedback RPM [B]	Spd fb RPM	*vel_fb*
Speed Feedback % [B]	Spd fb %	*vel_fb*
Frequency Demand [B]	Freq Dmd	*mmf_spd*
Frequency Demand % [B]	Freq Dmd %	*mmf_spd*
Raw Speed Input % [B]	Spd Input %	*raw_vel_dmd1*
Ramp Output % [B]	Ramp Out %	*vel_ref*
Encoder Feedback RPM [V]	Encoder Fb	*vel_xdr_fb*
Encoder Feedback % [V]	Encoder Fb %	*vel_xdr_fb*
Torque Command AMPS	Trq Cmd AMP	*trq3_cmd*
Torque Command %	Trq cmd %	*trq3_cmd*
Motor Voltage Feedback [B]	Mtr V fb	*av_fb*
Motor Voltage Feedback % [B]	Mtr V fb %	*av_fb*
Available Line Voltage [B]	V Avail	*v_avail_ser*
Line Frequency [B]	Line Freq	*line_freq*
Torque Current Feedback [B]	Trq I Fb	*trq_i_fb*
Torque Current Feedback % [B]	Trq I Fb %	*trq_i_fb*
Magnetizing Current Feedback [B]	Mag I Fb	*mag_i_fb*
Magnetizing Current Feedback % [B]	Mag I Fb %	*mag_i_fb*
Total Current Feedback [B]	Tot I Fb	*sum_i_fb*
Total Current Feedback % [B]	Tot I Fb %	*sum_i_fb*
Serial 1 Bit Flags [B]	Serial flg1	*serial_f1*
Serial 2 Bit Flags [B]	Serial flg2	*serial_f2*
Serial 3 Bit Flags [B]	Serial flg3	*serial_f3*
Serial 4 Bit Flags [B]	Serial flg4	*serial_f4*
Fault Word 1 [B]	Flt wrd1	*flt_word1*
Fault Word 2 [B]	Flt wrd2	*flt_word2*
Drive State [B]	Drv State	*drv_state*
Heartbeat [B]	Heartbt	*lcl_watchdog*
Analog Reference Input [B]	Ref input %	*ref_in_analog*

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Selection Text	Display Text	Variable
Analog Aux1 Input [B]	Aux1 input %	*aux_in1_analog*
Analog Aux2 Input [B]	Aux2 input %	*aux_in2_analog*
Analog Aux3 Input [B]	Aux3 input %	*aux_in3_analog*
Ground Fault Offset Level [B]	Gnd Flt Lev	*ground_fault_level*
Output Power in KW [B]	KW output	*power*
Output Power in % [B]	KW output %	*power*
Elapsed Hour Counter	Elapsed Hrs	*hour_meter[2]*
Analog Module Input 1 [B]	Alg In 1	*analog_in_modules[0].value*
Analog Module Input 2 [B]	Alg In 2	*analog_in_modules[1].value*
Analog Module Input 3 [B]	Alg In 3	*analog_in_modules[2].value*
Analog Module Input 4 [B]	Alg In 4	*analog_in_modules[3].value*
Analog Module Input 5 [B]	Alg In 5	*analog_in_modules[4].value*
Analog Module Input 6 [B]	Alg In 6	*analog_in_modules[5].value*
Analog Module Input 7 [B]	Alg In 7	*analog_in_modules[6].value*
Analog Module Input 8 [B]	Alg In 8	*analog_in_modules[7].value*
Enter Address Manually [B]	(1234)	(hex address)
Erase Entry [B]	(empty)	(clears entry)

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Table 5-53. XCL Data Types for "Address Entered Manually" Option

Selection Text	Display Text (Not Displayed)	Selection Text	Display Text (Not Displayed)
Velocity type	0	Percent (%) Q13	10
Current type	1	Percent (%) Q14	11
Ratio type	3	Raw 16 Bit type	13
Acceleration type	4	Voltage type	14
System Flag type	9		

For drives equipped with an eXternal Communications Link (XCL) and Communications Adapter Board (CAB), the data item for each of the drive's input registers is selected within the submenus which follow. The network protocol determines whether data items are broadcast as global data onto the network bus, or as register-based data transfers.

For global data, the XCL pointers and communication flags define the network node and item as "*AA*:*XXX*", where "*AA*" is the network node, and "*XXX*" is the item, as determined by user protocol.

For networks with register-to-register data transfer, enter "99" for the network node, and "*XXX*" as the desired 16-bit register.

5.10.7. XCL Receive Setup Submenu [44] *B*

The XCL Receive Setup Submenu [44] contains menu items available in both standard and vector control modes. These menu items are listed and explained in Table 5-54.

Table 5-54. XCL Receive Setup Submenu [44] *B*

Submenu Items	Description
XCL Velocity Reference [141] *B*	Submenu containing XCL pointers 01-12.
XCL Velocity Control [142] *B*	Submenu containing XCL pointers 13-36.
XCL Torque Control [143] *B*	Submenu containing XCL pointers 37-52.
XCL Communications Flags [144] *B*	Submenu containing communications flags F01-F16.
Serial Input Scalers [146] *B*	Submenu containing serial input scalers.

5.10.8. XCL Velocity Reference Submenu [141] *B*

The XCL Velocity Reference Submenu [141] contains menu items available in both standard and vector control modes. These menu items are listed and explained in Table 5-55.

Table 5-55. XCL Velocity Reference Submenu [141] *B*

Parameter	Range (Min)	Range (Max)	Typical Values	Description
XCLPTR_*bb* (*bb* = 01-04 and 06-12) *B*	00:000	99:127	**00:000**	*Xclptr_01* through *xclptr_04* direct a ratio control reference to the drive. *Xclptr_05* through *xclptr_08* direct a velocity command to the drive. *Xclptr_09* through *xclptr_12* direct an auxiliary velocity input to the drive. The drive's system program will have a corresponding software switch *xcl_swxx* (where *xx*=1-12) set true to read an input. Values for these parameters take the form *AA*:*XXX*, where: *AA* The network node number (0-64, and 99) *XXX* The item number (000 and 065-127).
XCLPTR_*05* *B*	00:000	99:127	**99:065**	Same as above for *xclptr_05* (which has a different default value). The default item number (i.e., 065) corresponds to the raw velocity demand from the network.

5.10.9. XCL Velocity Control Submenu [142] *B*

The XCL Velocity Control Submenu [142] contains menu items available in both standard and vector control modes. These menu items are listed and explained in Table 5-56.

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Table 5-56. XCL Velocity Control Submenu [142] B

Parameter	Range (Min)	Range (Max)	Typical Values	Description
XCLPTR_*bb* (*bb* = 13-36) B	00:000	99:127	**00:000**	*Xclptr_13* through *20* direct forward and reverse velocity limits to the drive. *Xclptr_21* through *36* direct forward and reverse acceleration and deceleration rates to the drive. The drive's system program will have a corresponding software switch *scl_swxx* (where *xx*=13-36) set true to read an input. Values for these parameters take the form *AA*:*XXX*, where: *AA* The network node number (0-64, and 99) *XXX* The item number (000 and 065-127).

5.10.10. XCL Torque Control Submenu [143] B

The XCL Torque Control Submenu [143] contains menu items available in both standard and vector control modes. These menu items are listed and explained in Table 5-57.

Table 5-57. XCL Torque Control Submenu [143] B

Parameter	Range (Min)	Range (Max)	Typical Values	Description
XCLPTR_*bb* (*bb* = 37-52) B	00:000	99:127	00:000	*Xclptr_37* through *40* direct a torque command to the drive in torque follower applications. *Xclptr_41* through *44* direct a torque auxiliary command to be added to the internal torque command. *Xclptr_45* through *52* direct positive and regenerative torque limits to the drive. The drive's system program will have a corresponding software switch *scl_swxx* (where *xx*=37-52) set true to read an input. Values for these parameters take the form *AA*:*XXX*, where: *AA* The network node number (0-64, and 99) *XXX* The item number (000 and 065-127).

5.10.11. XCL Communication Flags Submenu [144] B

The XCL Communications Flags Submenu [144] contains menu items available in both standard and vector control modes. These menu items are listed and explained in Table 5-58.

Table 5-58. XCL Communication Flags Submenu [144] B

Parameter	Range (Min)	Range (Max)	Typical Values	Description
COMM_F01 B	00:000	99:127	**99:067**	Up to 16 communications flags may be received by the drive. Each flag consists of 16 bits. The individual bits are used as the drive's system program inputs. Syntax is comm_f*bb_xx*, where "*bb*" is the communication flag number, and "*xx*" is the bit. This permits up to 256 general purpose control functions from the network. Values for these parameters take the form *AA*:*XXX*, where: *AA* The network node number (0-64, and 99) *XXX* The item number (000 and 065-127). The default item number (i.e., 067) corresponds to serial bit data from the network.
COMM_F02 B	00:000	99:127	**99:069**	Same as above for *comm_f02* (which has a different default value). The default item number (i.e., 069) corresponds to serial bit data from the network.
COMM_F*bb* (*bb*=03-16) B	00:000	99:127	**00:000**	Same as above for *comm_f03* through *comm_f16* (which have different default values).

5.10.12. Serial Input Scalers Submenu [146] B

The Serial Input Scalers Submenu [146] contains menu items available in both standard and vector control modes. These menu items are listed and explained in Table 5-59.

Table 5-59. Serial Input Scalers Submenu [146] [B]

Parameter	Range (Min)	Range (Max)	Default Value	Description
Velocity Reference Serial [B]	-125.000	125.000	**1.000**	Scalers for XCL serial inputs: Velocity reference
Velocity Auxiliary Reference Serial [B]	-125.000	125.000	**1.000**	Velocity auxiliary reference
Velocity Reference Positive Limit Serial [B]	-125.000	125.000	**1.000**	Velocity reference positive limit
Velocity Reference Negative Limit Serial [B]	-125.000	125.000	**1.000**	Velocity reference negative limit
Torque Command Serial [B]	-125.000	125.000	**1.000**	Torque command
Auxiliary Torque Serial [B]	-125.000	125.000	**1.000**	Auxiliary torque command
Torque Positive Limit Serial [B]	-125.000	125.000	**1.000**	Torque positive limit
Torque Negative Limit Serial [B]	-125.000	125.000	**1.000**	Torque negative limit

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5.10.13. RS232 Input and RS232 Output List Items [B]

The RS232 Input [B] menu item is a list item that redirects an input from the drive's RS232 port to either the local keypad/display or to an external communication network (XCL). Log files listed under Log Control Menu [6] may be redirected. Options are as follows:

- Local keypad/display (LCL kbd)
- XCL network (XCL net).

The RS232 Output [B] menu item redirects an output from the drive's RS232 port to either the local keypad/display or to an external communication network (XCL). Log files listed under Log Control Menu [6] may be redirected. Options are as follows:

- Local keypad/display (LCL kbd)
- XCL network (XCL net).

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CHAPTER 6: INSTALLATION AND SET-UP

In This Section:

6.1. Introduction

Important! Before installing the Perfect Harmony drive, be sure to read and understand the Installation Practices section that follows.

When installing Perfect Harmony drives, it is essential to understand the proper techniques associated with the following procedures.

- Receiving
- Storage Considerations
- Off-loading
- Weight estimates
- Handling
- Location
- Anchoring
- Re-connecting wiring.

Each of these procedures is discussed in the sections and subsections that follow.

6.2. Installation Practices

6.2.1. Receiving

The proper receiving procedure consists of the following steps:

- Verify that the proper items have been shipped
- Inspect all shipments for damage that may have occurred during shipping
- File a claim with the shipping carrier if any damage is present.

NOTE: Depending on cell size, wood shipping blocks may be mounted between the cell support structure and the cells. These should be removed during installation.

6.2.2. Storage Considerations

Attention! Indoor equipment is not weatherproof and must be protected.

If it is necessary to temporarily store the drive in an outdoor area, heaters should be placed in the equipment and operated to prevent moisture accumulation. Air conditioning should be used in the equipment to maintain the temperature below 40° C. A protective cover such as plastic or a tarp should be placed over the drive to reduce any problems due to the outside elements. This is especially important if the storage is for more than a few days.

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6.2.3. Off-loading

Due to the size and weight of Perfect Harmony components, it is important to carefully plan all handling operations. Off-loading from the truck is often the most critical operation because of the limited access. Advance planning and coordination between the manufacturer, the carrier, the installation contractor, and the owner are vital.

6.2.4. Weight Estimates

Because the Perfect Harmony drive system is a customizable system, exact weights of systems will vary based on the ratings of the drive and included options. However, approximate dimensions and weight estimates for Perfect Harmony drives are given in tables in Chapter 1.

6.2.5. Handling

Perfect Harmony enclosures are provided with heavy duty base structures that contain transverse tubes to accept fork-lift tines. There are three possible methods of handling these Perfect Harmony cabinets:

- Overhead Crane Lifting
- Fork Lift Truck Lifting
- Lifting Cables.

These methods are summarized below.

Danger! Do not reposition lifting eye bolts from the manufacturer's positions.

Caution! The Transformer Section has female threads in the four top corners for lifting eye bolts (not provided). These are used in the factory to handle the <u>empty</u> cabinet only. They are <u>**not**</u> capable of lifting the assembled transformer.

The Perfect Harmony drive contains many cable entry and exist locations. Refer to the system drawings supplied with the drive for complete details.

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- **<u>Overhead Crane Lifting</u>** - The best method if an overhead crane is available is to pass fabric slings through the base tubes, and lift as shown in Figure 6-1. Key points are the length and strength of the slings. The slings must be long enough that the crane hook is at least 4 feet above the enclosure top to prevent buckling of the drive cabinets. If this distance cannot be maintained, spreader bars of appropriate strength must be used. The strength of the slings must be adequate for the weight given on the drawings (or estimated in Chapter 1).

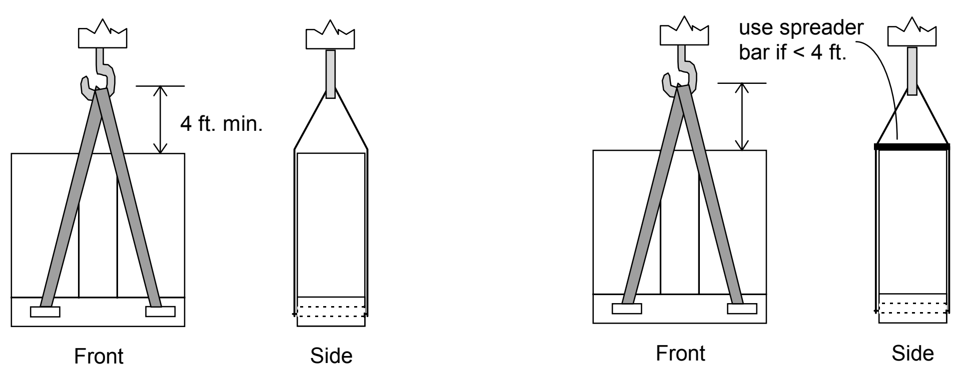


Figure 6-1. Proper Handling Using the Sling Lifting Technique

- **Fork Lift Truck** - A second handling method is to use a suitable fork lift truck. The truck must be rated for the weight to be lifted. The tines of the truck must be at least 40″ long, and no greater than 10″ wide or 2.5″ thick. Transformer cabinets will accept tines that are up to 2.75″ thick. The tine spacing must be adjustable from 30″ to 50″.

Attention! Be careful that the fork lift does not damage the front surface of the enclosure. It is a good idea to place a wooden stop block in the corner of the tines as shown in Figure 6-2. The center of gravity of the Perfect Harmony enclosure is approximately midway between the front and back surfaces.

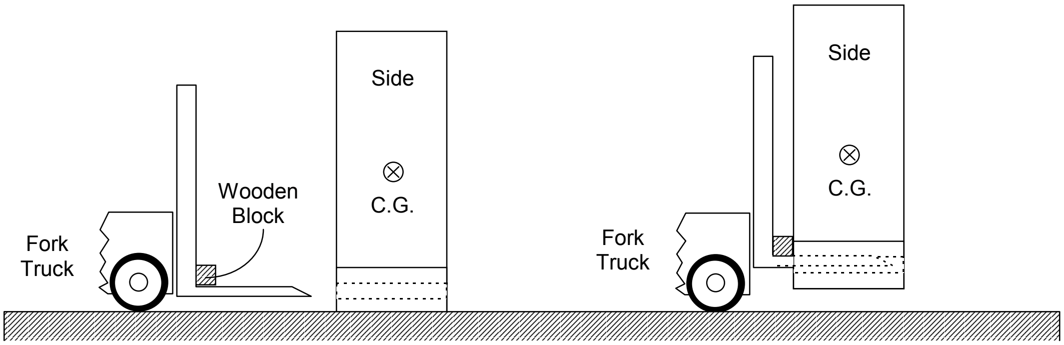
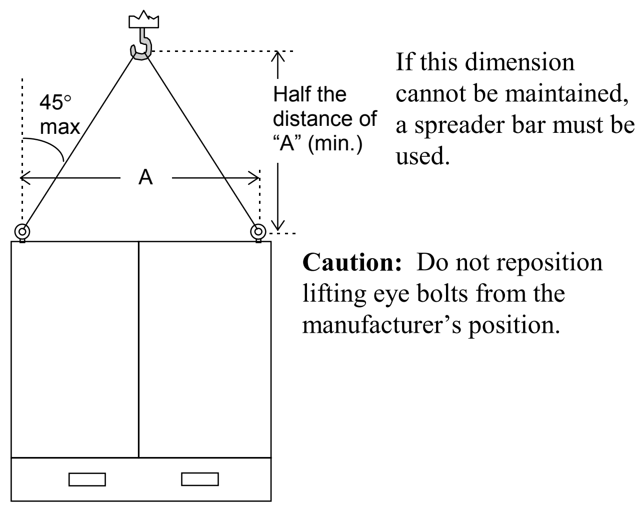


Figure 6-2. Proper Handling Using a Fork Lift Truck

- **Lifting Cables** - If lifting cables are used, they should be placed as shown in Figure 6-3.



Caution: Do not reposition lifting eye bolts from the manufacturer's position.

Figure 6-3. Proper Handling Using Lifting Cables

6.2.6. Location

When choosing the location for the Harmony drive be sure the area is clean, flat, dry, and the front of the drive is easily accessible with the drive doors open.

Attention! If the mounting surface is not flat, the metal cabinets of the drive may buckle, causing the cabinet doors to be misaligned and/or not open and close properly.

All cooling air for both the Cell and Transformer Cabinets is drawn through the front doors of the Cell Cabinets, into the Transformer Cabinet by centrifugal blowers located at the top of the

Transformer Cabinet. Output air is ejected at the roof of the Transformer Cabinet. The final placement of the drive should permit appropriate air circulation.

Caution! Indoor equipment is not weatherproof and must be protected. If it is necessary to temporarily store it in an outdoor area, heaters should be placed in the equipment and operated to prevent moisture accumulation. A protective cover such as plastic or a tarp should be placed over the drive to reduce any problems due to the outside elements. This is especially important if the storage is for more than a few days.

Refer to tables in Chapter 1 for rated losses and CFM requirements of drives.

NOTE!! Centrifugal blower performance is strongly effected by output plenum pressure and air resistance.

NOTE!! Verify the proper AC input phasing to the main power switch on the control door. Improper phasing will cause the blower motor(s) to run in reverse.

6.2.7. Anchoring Cabinets to Floors and Walls

Holes for anchor bolts are located on the base mounting channel for each cabinet section (see Figure 6-4).

It is recommended that when anchoring the unit to the floor, the installer should use cemented J-bars on all corners. Holes in the base of the drive cabinets are 0.81″ in diameter and easily accept 0.5″ threaded J-bars. If the drive is mounted against a wall, top angles may be used to secure the drive to the back wall in lieu of the rear J-bar connections to the floor. Refer to Figure 6-4 for an overview. Exact dimensions are given in the system drawings supplied with the drive.

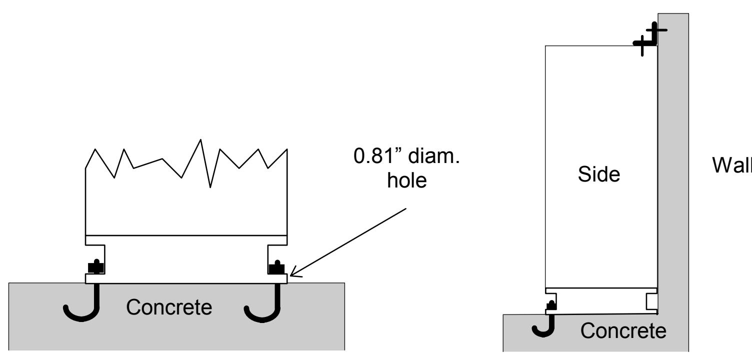


Figure 6-4. Proper Anchoring Techniques for Perfect Harmony Cabinets

6.2.8. Wiring

For information on supply and control wiring, refer to the drawings supplied with your ROBICON drive.

Harmony drives are wired to have correct blower rotation for R-S-T phase sequencing. Wire all phases according to standard codes, that is, wire the phases from left to right (T1-T2-T3 or R-S-T) for proper operation. Check blower rotation at start-up.

Located at the bottom of the transformer is a set of ±5% voltage taps for compensating the primary voltage source. The VFD is shipped with the +5% taps connected. This means that the VFD secondary cell voltages are at the nominal 630 VAC (for example) for an input voltage of 5% above primary nominal rating. Do not change taps unless operating experience requires it.

> **NOTE:** Depending on cell size, wood shipping blocks may be mounted between the cell support structure and the cells. These should be removed during installation.

In some cases, the individual power cells may be shipped separately. After installing the cells, verify that the input power wire and fiber optic cables are connected properly.

Customer-supplied AC power for both control and blowers enters an access plate in the top or bottom of the transformer cabinet section. Customer-supplied medium voltage power enters an access plate in the top or bottom of the transformer section.

> **Warning!** For cooling considerations, always maintain the appropriate blower power when medium voltage is applied to the VFD.

> **Danger!** Ensure that the entire system is earth grounded at one of its grounding points.

Torque specifications for the Perfect Harmony drive are listed in Table 6-1.

Table 6-1. Torque Specifications for the Perfect Harmony

Standard Torque Chart	
Fastener Size English (Metric)	**Tightening Torque**
2-56 (M2)	3.0 in-lb
4-40 (M3)	6.0 in-lb
6-32 (M3.5)	12.0 in-lb
8-32 (M4)	22.0 in-lb
10-32 (M5)	36.0 in-lb
1/4-20 (M6)	70.0 in-lb
1/4-20 (M6) elec	100.0 in-lb
1/4-28	70.0 in-lb
5/16-18	155.0 in-lb
(M8)	80.0 in-lb
3/8-16, 3/8-24	275.0 in-lb
(M10)	180.0 in-lb
1/2-13 (M12)	672.0 in-lb
5/8-11	112.0 ft-lb
3/4-10	198.0 ft-lb
1	500.0 ft-lb

Deviations to Standard Torque Specifications	
Perfect Harmony Connectors	**Tightening Torque**
All Green Connectors	6.0 in-lb
Receptacle GRND	36.0 in-lb
Panel GRND	22.0 in-lb
F4, F5, F21, F22	22.0 in-lb
F23, F24, F25	36.0 in-lb
3MI	9.0 in-lb
TB2, TBAMA, B, C, Metal Cover	12.0 in-lb
T6, Relays, Receptacle Wiring	12.0 in-lb
Transformer GND (**T5**)	70.0 in-lb
PB and Light Switches (Door)	9.0 in-lb
RTM	4.0 in-lb
Keypad	6.0 in-lb
Breaker (Wiring) Lugs	36.0 in-lb
CTB and CTC Terminals	12.0 in-lb

6.2.9. Power-up Check List

The following is a minimum check list which should be followed **before** applying power to the VFD.

- ☐ Verify integrity of all cabinet seals between cabinet air plenums (especially between transformer and cell cabinet sections).

- ☐ Verify that all low voltage control wiring is properly connected and located in appropriate conduit or cable ways separate from high voltage cable.
- ☐ Verify proper operation of the cooling system. Input air flow through the doors and filters of the Cell cabinet should be strong enough to cause a small piece of notebook paper to stick to the filters when the blowers are running.
- ☐ Verify that air flow *enters* (not *exits*) the cabinet in front of the filter.
- ☐ Verify that the cabinet is earth grounded.

6.3. Set-up

The following procedure assumes that significant changes or disassembly have occurred between final factory test and commissioning. If this is the case, the following procedure can be used to re-qualify the Perfect Harmony for full power operation. If system integrity after installation is not felt to be an issue, then this section may be skipped.

> Proper drive setup will require the use of a DC voltmeter, an AC voltmeter and a dual-trace oscilloscope for testing purposes. A variable voltage source may also be needed.

6.3.1. Initial Set-up Procedure for Re-qualification of Perfect Harmony VFD

Before proceeding, refer to the check list in the previous section.

- ☐ Lock out the incoming medium voltage feeder that feeds the Transformer Cabinet. (Follow the standard lock out tag procedures to verify the unit is safe.) Also make sure the Perfect Harmony's output contactor (if any) is locked open.
- ☐ Extend all cells and visually inspect all internal mechanical and electrical connections.
- ☐ Visually inspect all cabinets and verify there is no damage due to shipping.

Power and Control connection verification:

- ☐ Verify the mechanical integrity of all the electrical connections, especially output connections between cells and cell input connections from the transformer.
- ☐ Verify all connections between cabinets, especially connections for current feedback, motor voltage feedback, and line voltage feedback.
- ☐ Check transformer secondary connections to the cells. Ohm check input cell connections to secondary of the transformer.

Customer interconnection verification:

- ☐ Ensure that all the customer connections at **TB2** are properly terminated.

> If an unloaded motor is used for these tests, set the appropriate parameters in Motor Menu (11) for nameplate values. If an unloaded motor is not available, verify that the motor voltage parameter is set to the rated output voltage of the drive.

- ☐ Turn on the control power (e.g., 630 VAC). Verify that the microprocessor initializes and the blower rotation is correct. If blower rotation is incorrect, change the incoming phasing at the control cabinet circuit breaker.
- ☐ In the Drive Menu (14), drive current should be set to the cell rating used in the system:

Table 6-2. Drive Current Settings for Various Cell Sizes

Size	Size 70A	Size 100A	Size 140A
Current	70 A	100 A	140 A

- ☐ In the Ramp Menu (17), set the fwd accel and fwd decel parameters to no less than 10 seconds. Set the jerk rate parameter to 0.1 second.
- ☐ In the Cell Menu (21), set the installed stages parameter to the number of series cells in the system, i.e., 3-7.
- ☐ Set the following parameters in the Standard Control Setup Menu (24):

Table 6-3. Parameter Settings for Standard Control Setup Menu (24)

Parameter	Setting	Parameter	Setting
Volt P Gain	0.000	Vel I Gain	4.000
Volt I Gain	0.000	Trq P Gain	1.000
Vel P Gain	5.000	Trq I Gain	0.000

- ☐ Jumper the test point **HGNDFLT** to **GND** on the Power Interface Board.

6.3.2. Modulator and Power Circuit Test for Low Voltage Cells Only

This test is intended for systems that use low voltage cells and can be performed with a single 30 amp, 3-phase, 630 VAC variable voltage source. Full voltage can be supplied to all cells. The auxiliary AC control power to the Control Cabinet can be used for this purpose if it is 630 VAC.

- ☐ Disconnect the series connections between **T1** and **T2** of all adjacent cells. Disconnect the motor leads or open the motor contactor. Connect a 3-phase variable voltage source to the input of cell B1, with the existing cables from the transformer. Refer to the Solid-state Variable Voltage Source Option appendix.

Danger - Electrical Hazard! During this test, the Perfect Harmony transformer will be excited from one of the secondary windings. This will cause rated voltage to appear on the primary terminals. The input disconnect should be open and/or input fuses pulled and/or input wiring disconnected to prevent medium voltage from backfeeding the input power system.

Danger - Electrical Hazard! If the neutral connections between cells A1, B1, and C1 are also disconnected, all cell structures (except B1) can be earth grounded for added safety. Be sure to remove these earth grounds before medium voltage is switched on!

Danger - Electrical Hazard! The current demand on the variable voltage source should be monitored during the following tests. Do not exceed the source's current rating. The variable voltage source should be fused.

- ☐ Connect an AC voltmeter to the input of any cell. Turn on the control power at the Control Cabinet and verify that the Microprocessor Board properly initializes.
- ☐ Turn on the variable voltage source and slowly increase its output voltage to about 75 VAC. Measure all cell input voltages to make sure they are all receiving approximately the same voltage. The "Not Safe" LED should be lit on each Cell Control Board.
- ☐ If all cell voltages are OK, continue increasing the variable voltage source to 230 VAC 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 630 VAC. Push the VFD Fault Reset Button on the door of the VFD. All power cell faults should be reset and the normal keypad display should appear.

At 630 VAC, check the following test points on the PIB with a scope:

- ☐ At rated primary voltage, DC voltage on **VAVAIL** test point on Power Interface Board should be approximately 4.0 VDC with <0.5 vpp ripple at 360 Hz (see Figure 6-5).

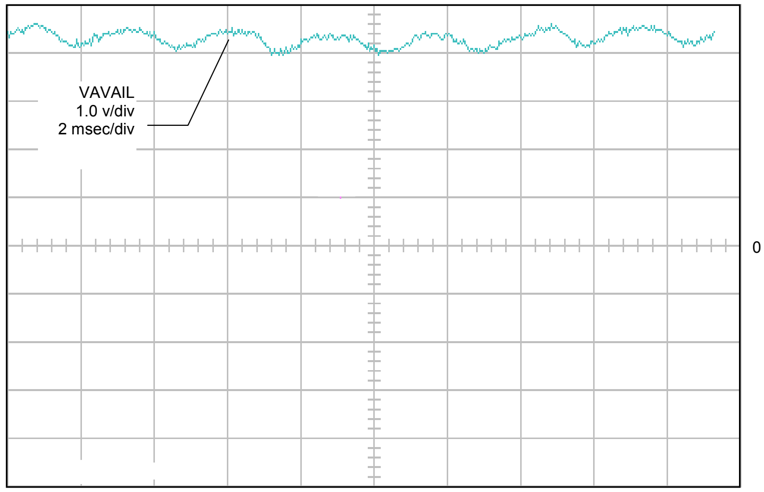


Figure 6-5. VAVAIL TP at Rated Primary Voltage (Unloaded)

- ☐ AC voltage on test points **VBA**, **VBC**, **VCA** should be 8 volts pp @ 60 Hz.

The previous steps verify that the main power transformer is OK and the Attenuator Module in the Transformer Cabinet is properly connected.

Trim offsets on test points **IcFDBK** and **IbFDBK**.

- ☐ Using a DC millivolt meter on the above test points, use the parameters Ic Offset Adjust and Ib Offset Adjust in Menu (20) to trim offsets to less than ±1.0 mVDC. Verify that VFD is in off mode (state A). If the drive is configured with Hall effect CTs, skip this test.

Check modulation at the outputs of all cells by placing the VFD in the run mode (state D).

- ☐ Verify that the 4 LEDs (Q1-Q4) on each Cell Control Board should illuminate.
- ☐ Measure and verify the AC voltage across T1 and T2 at full speed.

Shut down the AC supply to the control and variable voltage source and then disconnect it.

Remove the jumper between **HGNDFLT** to **GND** on the Power Interface Board.

6.3.3. Modulator and Power Circuit Test for High Voltage Cells Only

ROBICON recommends using a variable 0-690 VAC source for testing high voltage cell systems.

- ☐ Disconnect the series connections between T1 and T2 of all adjacent cells. Disconnect the motor leads or open the motor contactor. Connect a 3-phase variable voltage source to the input of cell B1, in addition to the existing cables from the transformer.

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Caution - Electrical Hazard! During this test the Perfect Harmony transformer will be excited from one of the secondary windings. This will cause rated voltage to appear on the primary terminals. The input disconnect should be open and/or input fuses pulled and/or input wiring disconnected to prevent medium voltage from backfeeding the input power system.

Warning! If the neutral connections between cells A1, B1, and C1 are also disconnected, all cell structures (except B1) can be earth grounded for added safety. Be sure to remove these earth grounds before medium voltage is switched on!

Caution - Electrical Hazard! The current demand on the voltage source should be monitored during the following tests. Do not exceed the device's current rating. It should be fused.

- ☐ Connect an AC voltmeter to the input of any cell. Turn on the control power at the Control Cabinet and verify that the Microprocessor Board properly initializes.
- ☐ Turn on the variable source and slowly increase its output voltage to about 75 VAC. Measure all cell input voltages to make sure they are all receiving approximately the same voltage. The "Not Safe" LED should be lit on each Cell Control Board.
- ☐ If all cell voltages are OK, continue increasing the variable voltage source to 340 VAC 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 630 VAC. Push the VFD Fault Reset Button on the door of the VFD. All power cell faults should be reset and the normal keypad display should appear.

At 630 VAC, check the following test points on the PIB with a scope:

- ☐ At rated primary voltage, DC voltage on **VAVAIL** test point on Power Interface Board should be approximately 4.0 VDC with <0.5 vpp ripple at 360 Hz (see Figure 6-5).
- ☐ AC voltage on test points **VBA**, **VBC**, **VCA** should be 8 volts pp @ 60 Hz.

The previous steps verify that the main power transformer is OK and the Attenuator Module in the Transformer Cabinet is properly connected.

Trim offsets on test points **IcFDBK** and **IbFDBK**.

- ☐ Using a DC millivolt meter on the above test points, use the parameters Ic Offset Adjust and Ib Offset Adjust in Menu (20) to trim offsets to less than ±1.0 mVDC. Verify that VFD is in off mode (state A).

Check modulation at the outputs of all cells by placing the VFD in the run mode (state D).

- ☐ Verify that the 4 LEDs (Q1-Q4) on each Cell Control Board should illuminate.
- ☐ Measure the AC voltage across T1 and T2 at full speed.

Shut down the AC supply to the control and voltage source, then disconnect the source.

Remove the jumper between **HGNDFLT** to **GND** on the Power Interface Board. Note that you may need this jumper to run the drive with the motor disconnected.

6.3.4. Hardware Voltage Regulator Test

- ☐ Reconnect the series connections between T1 and T2 of all adjacent cells, plus the neutral connections between cells A1, B1 and C1.

- ☐ Secure all doors to the Cell and Transformer Cabinets.
- ☐ Enable the blower motor and remove any interlock jumpers.

Energize the medium voltage feeder. Re-energize the AC control power and check the follow test point voltages in the run mode (state D).

- ☐ Increase speed potentiometer until 4.25 VDC is on test point **ID***, then check the following test points with a scope (see Figure 6-6).

> An asterisk (*) following a variable name means that the variable is a reference variable (e.g., **EB*** is the B-phase reference voltage).

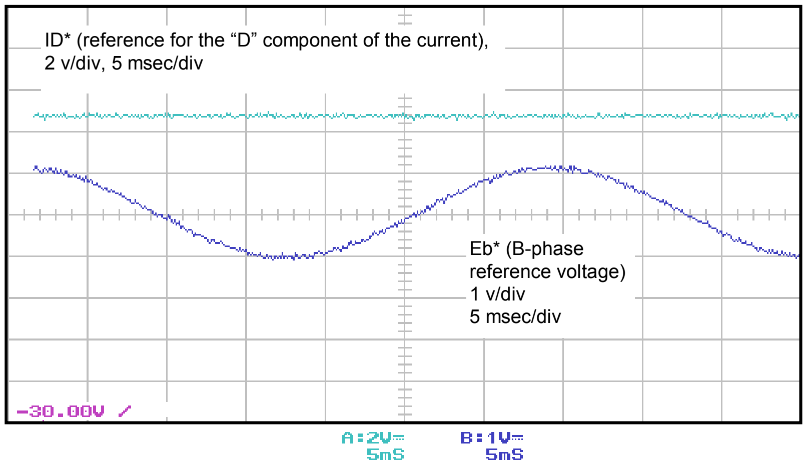

Figure 6-6. ID* and EB* at 30 Hz (Unloaded)

- ☐ AC voltage on test points **Ea***, **Eb*** and **Ec*** should be about 1.1 vpeak (see Figure 6-6 above).
- ☐ AC voltage on test points **HAR-A**, **HAR-B** and **HAR-C** should be 3.3 vpeak with slight dip at center (see Figure 6-7).

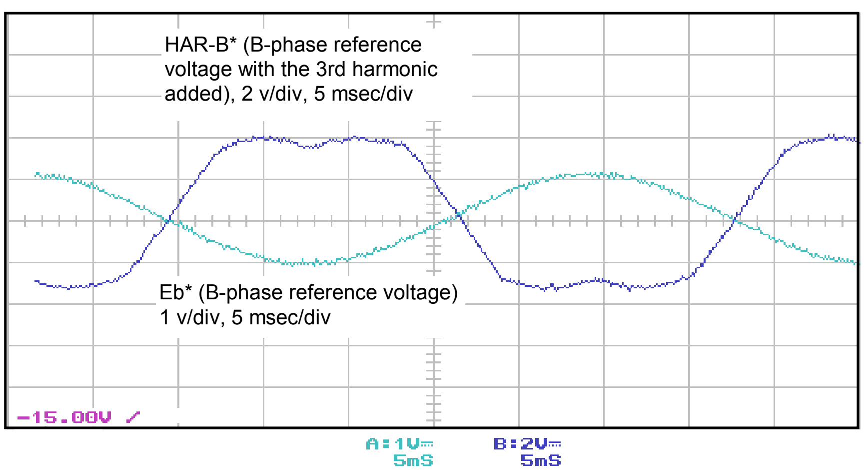

Figure 6-7. Eb* and HAR-B at 30 Hz (Unloaded)

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Figure 6-8 may be used to indicate imbalances in either the modulator or power circuit. AC voltages on test points **Eb*** and **-VBN** should be 180 degrees out of phase to each other. The signal on test point **Eb*** should be slightly less than 50% of the signal on test point **-VBN**. Check test points **Ea***, **-VAN**, **Ec*** and **-VCN** in the same manner.

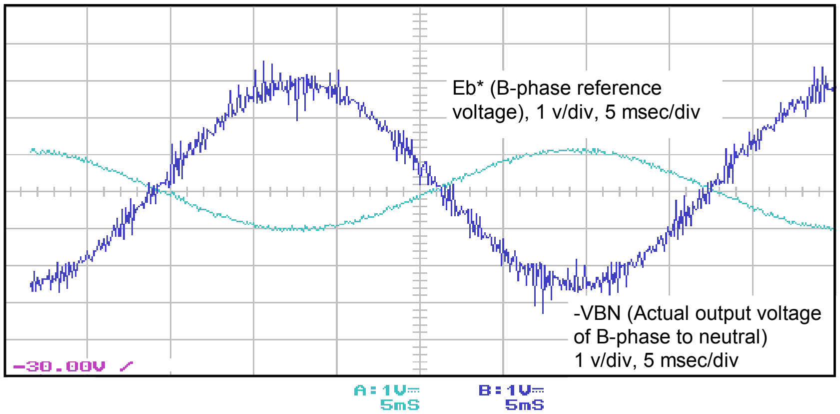

Figure 6-8. Eb* and -VBN at 30 Hz (Unloaded)

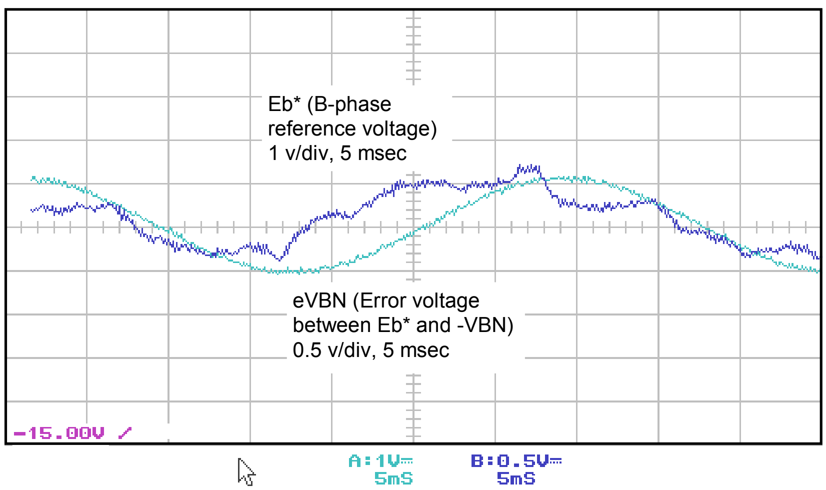

Figure 6-9. Eb* and eVBN at 30 Hz (Unloaded)

- ☐ If imbalances are suspected, the modulator can be ruled out by verifying that voltages on test-points **VA***, **VB*** and **VC*** (as compared to the triangle wave forms ±CAR1-5) appear as depicted in Figure 6-10.

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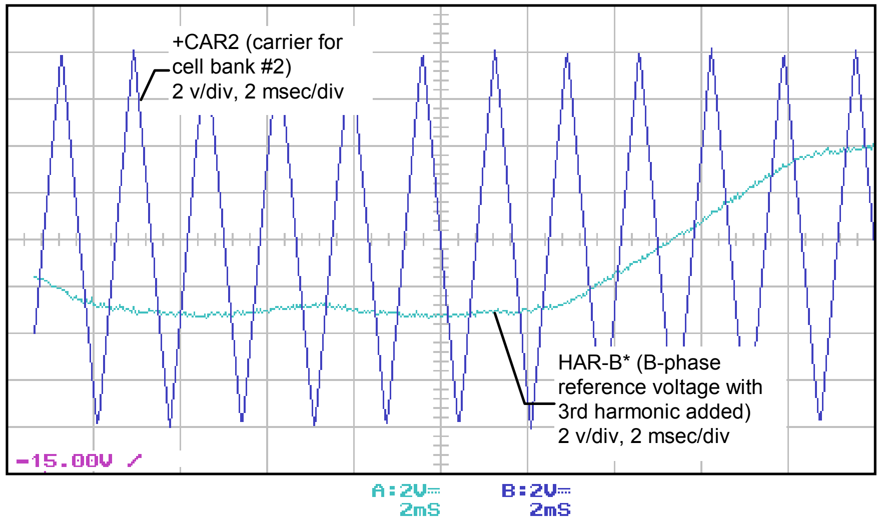

Figure 6-10. HAR-B* and +CAR2 at 30 Hz (Unloaded)

6.3.5. Scaling Adjustments

> **NOTE!!** All scaling adjustments are set from the factory. There should be no need to change these parameters unless changes are made to system hardware.

To scale for proper voltage feedback, choose the Motor Terminal Voltage from the Display Variable Menu (37) for one of the keypad displays.

- ☐ In the Hardware Scalar Menu (20), to adjust mot V fb so that the display matches the rated motor voltage when the system is operated at 60 Hz. Set speed pot for a measured actual motor voltage. Measure VMTR feedback signal on the PIB. Set mot V fb vv = Actual Motor Voltage/VMTR. Display should read the actual motor voltage. This scales the drives internal voltage feedback to the resistor divide ratio.

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To scale for rated flux, adjust the keypad pot so the output frequency is exactly 60 Hz. In the Standard Control Setup Menu (24), std volts/Hz should be set to 1.000. Verify that the Volt P Gain and Volt I Gain in this menu are set to 0.000.

- ☐ In the Hardware Scalar Menu (20), adjust the std mot V trim for the rated output voltage on the motor. The nominal value is 8.00 V. If external output PTs are available, then verify proper voltage at each operating point using the table below.

Table 6-4. Proper Output Line Voltage Settings

Speed Dmd (%)	Freq (Hz) (60 Hz std.)	Output Line Voltages for Selected Motor Ratings		
		3300 VAC	4160 VAC	6600 VAC
0	0	0	0	0
25	15	825	1040	1650
50	30	1650	2080	3300
75	45	2475	3120	4950
100	60	3300	4160	6600

If PTs are not available, connect an AC voltmeter between tests points **-VAN** and **-VBN**. Verify proper voltage at each operating point below.

Table 6-5. Proper Test Point Voltages

Speed Dmd (%)	Freq (Hz) (60 Hz std.)	-Van to -Vbn for Selected Motor Ratings		
		3300 VAC	4160 VAC	6600 VAC
0	0	0	0	0
25	15	1.7	1.7	1.7
50	30	3.5	3.5	3.5
75	45	5.2	5.2	5.2
100	60	6.9	6.9	6.9

To scale for proper line voltage, choose the "available line voltage" from the Display Variable Menu (37) for one of the keypad displays.

- ☐ The Hardware Scalar Menu (20) is used to adjust the line voltage display. The Line V fb vv = Actual Line Voltage/V_{AVAIL}. The display should read the actual line voltage. This scales the drive's internal voltage feedback to the resistor divide ratio. This is a factory set adjustment.

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6.3.6. Closed Loop Operation

At this point, the VFD is ready for the actual motor operation.

- ☐ Reconnect motor leads or enable motor contactor.

Energize the 630 VAC control circuit breaker. The following parameter settings should be initially used to verify proper operation of the VFD under loaded conditions.

- ☐ Set the parameters from the Standard Control Setup Menu (24) as listed in Table 6-6.

Table 6-6. Standard Control Setup Menu (24) Parameter Settings for Closed Loop Operation

Parameter	Setting	Parameter	Setting
Volt P gain	0.5000	Vel I gain	4.000
Volt I gain	0.5000	Trq P gain	0.025
Vel P gain	5.000	Trq I gain	0.300

- ☐ In the Ramp Setup Menu (17) set the ramp rates appropriately for the application.
- ☐ Energize the medium voltage feed to the VFD. Push the fault reset button on the keypad. Jog the motor and observe proper rotation.

To test for proper current feedback polarity, check the voltage feedback signal on **-VBN** against the motor line current signal on **IbFDBK**.

- ☐ The **IbFDBK** signal must lag **-VBN** by 90 degrees for proper polarity (see Figure 6-11). Also, check test points **-VCN** and **IcFDBK** in same manner.

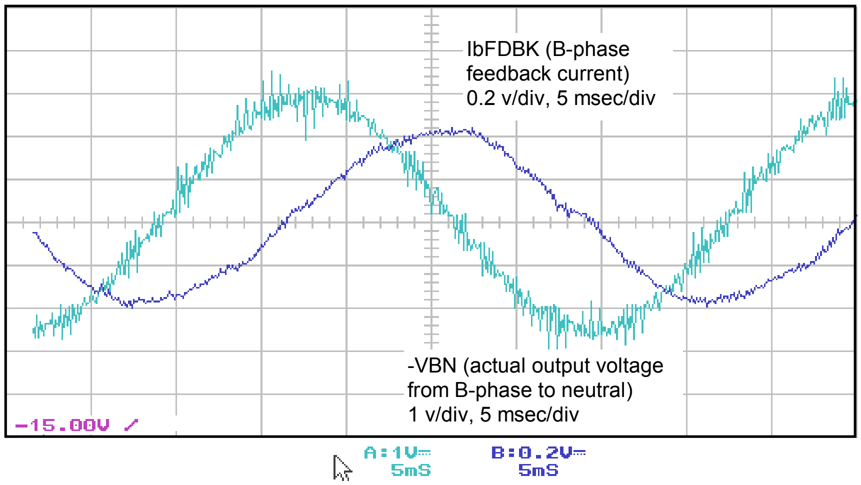

Figure 6-11. -VBN and IBFDBK at 30 Hz (Unloaded)

Check the DC signals on test points **IDFDBK** and **IQFDBK**. These test points represent the magnetizing (**IQFDBK**) and torque producing (**IDFDBK**) currents.

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- ☐ Under unloaded conditions, **IDFDBK** should stay at least 0.1 VDC while **IQFDBK** should stay at approximately 0.5 VDC when **ID*** is varied between 1 and 2.5 VDC (see Figure 6-12).

6.3.7. Full Load Operation

Operate the drive over the speed range of the motor. Once the VFD is successfully loaded, re-check the following test points.

- ☐ The **IbFDBK** signal should significantly increase in magnitude over the unloaded condition shown in Figure 6-11, but lag **-VBN** by only about 30 degrees (see Figure 6-12). Also re-check test points **-VCN** and **IcFDBK**.

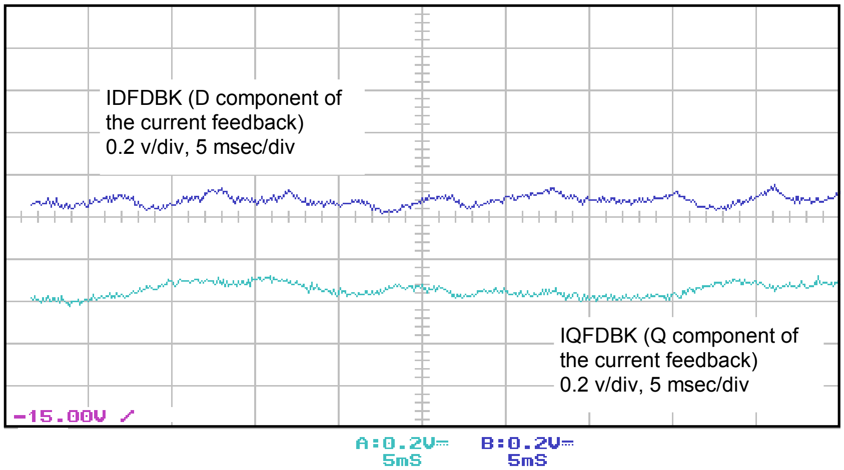

Figure 6-12. IQFDBK and IDFDBK at 30 Hz (Unloaded)

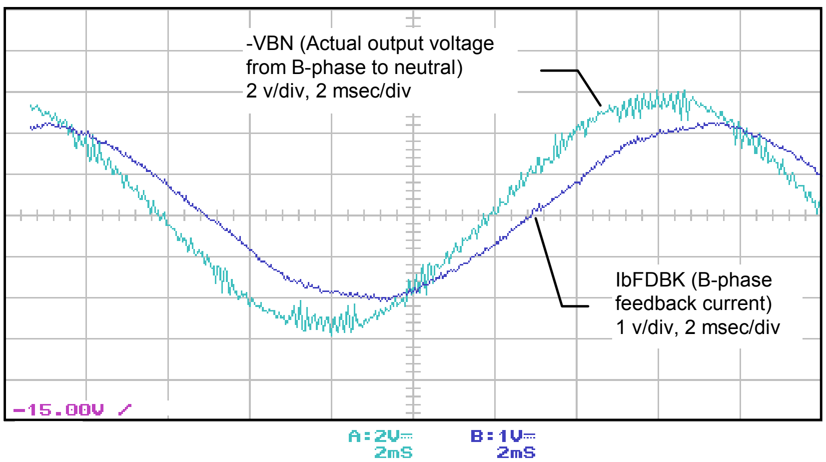

Figure 6-13. -VBN and IbFDBK at 60 Hz (Fully Loaded)

☐ The **IDFDBK** signal should increase to about 2 volts DC under a fully loaded condition. **IQFDBK** should increase only slightly (see Figure 6-14).

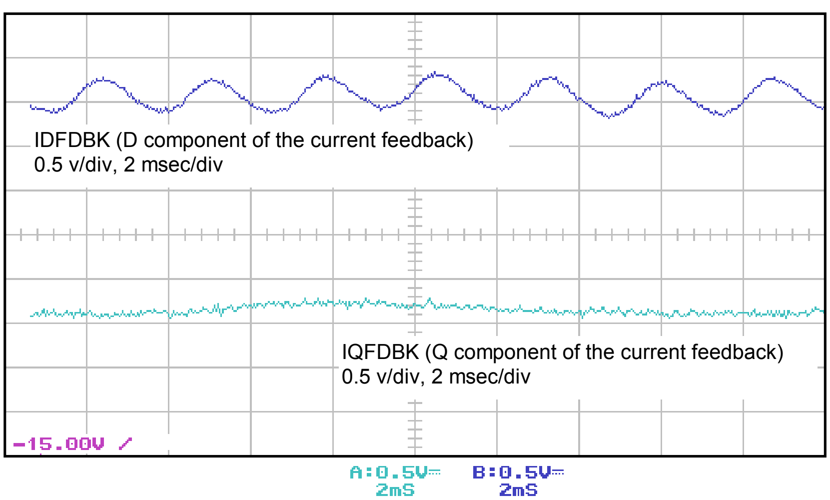

Figure 6-14. IQFDBK and IDFDBK at 60 Hz (Fully Loaded)

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- ☐ Recheck the signals on test points **Eb*** and **eVBN**. Under normal operating conditions, these voltages should appear as shown in Figure 6-15.

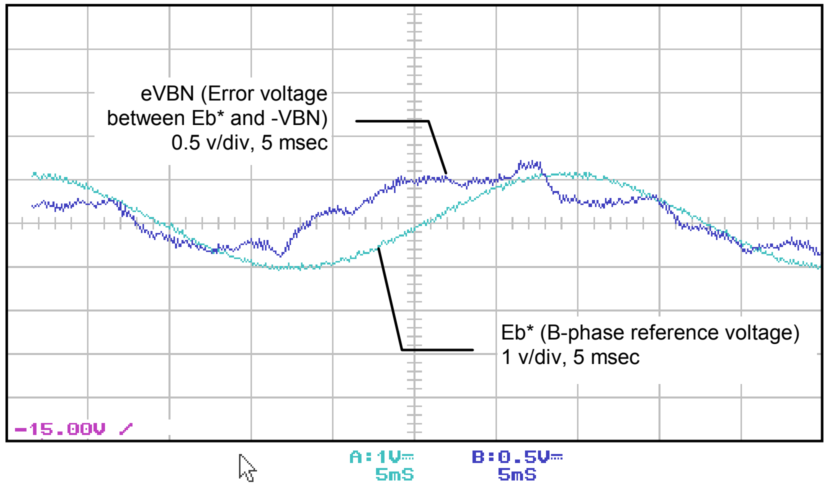

Figure 6-15. Eb* and eVBN at 30 Hz (Unloaded or Fully Loaded)

- ☐ Verify the proper motor loading and torque limit as well as proper overload settings in the menus listed in Table 6-7.

Table 6-7. Proper Motor Loading Verification

Menu 15	Menu 17	Menu 24	Menu 34
Speed Fwd Limit	Fwd Accel	Motor Torque Limit	I Overload
Speed Rev Limit (0)	Fwd Decel	Regen Torque Limit	Motor Trip Volts
	Rev Accel		Drive IOC Setpoint
	Rev Decel		

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CHAPTER 7: TROUBLESHOOTING AND MAINTENANCE

In This Section:

7.1. Introduction

The Perfect Harmony variable speed drive is designed, built and tested for long, trouble-free service. Periodic maintenance is required to keep the drive working reliably and to minimize the chance of down time.

Caution - Lethal Voltages! Always switch off the main input power to the equipment before attempting inspection or maintenance procedure.

Warning! WARNING!! Only qualified service personnel should maintain Perfect Harmony equipment and systems.

7.2. Six Month Inspection

- ☐ Since the cooling system of the Perfect Harmony VFD draws air through the cell heat sinks, dirt will tend to collect at the inputs of the cell heat sinks. If significant collection is noted, these cells should be removed and cleaned (see Chapter 1).
- ☐ Thoroughly clean the inside and outside of all enclosures using a vacuum cleaner fitted with a plastic nozzle. Keeping the equipment free from dirt and dust allows proper heat dissipation.
- ☐ Inspect the belts and blower motor in the Blower/Transformer Cabinet. Blowers are located above the transformer.
- ☐ If the Cell Cabinets are fitted with air filters, these filters can be cleaned and replaced.

Warning! Filter orientation must be noted so that air flow is from outside to inside of the cabinet.

- ☐ Use touch-up paint as required on any rusty or exposed parts.
- ☐ Inspect all electrical connections in the Cell and Transformer Cabinets for tightness (especially during the first 6 months from start-up) and re-tighten if necessary.

- ☐ Verify proper operation of cooling system by placing a single sheet of standard ply notebook paper over the cabinet air intakes. The paper should stick to the cabinet.

It is strongly recommended that the power connections be re-tightened after the first few days of operation and checked monthly for tightness during the first few months of operation, then every 6 months thereafter. Other important connections are:

- ☐ All input power and output series connections within the Cell Cabinet (see illustrations in Chapter 1).
- ☐ All secondary and primary transformer connections within the Transformer Cabinet (see illustrations in Chapter 1).

When tightening connections, be sure to follow the proper torque specifications. This information is available in Chapter 6: Installation and Setup.

7.3. Replacement of Parts

Replacement of component parts may be the best method of troubleshooting when spare parts are available. Use troubleshooting guidelines found later 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.

Spare parts are available through the ROBICON Customer Service Center by calling (724) 339-9501.

7.4. Interpreting Keypad Display Fault Messages

Faults as displayed on the keypad can be grouped into two categories:

- Drive Faults
- Cell Faults.

Drive Faults are system faults sensed by the Master Control circuitry in the Control Cabinet.

Cell Faults are faults sensed by the control logic located on the Cell Control/Gate Driver Board in each output power cell. Each power cell has its own sense circuitry.

Faults are ranked according to their level of severity as follows:

- Level A (Major Fault)
- Level B (Fault)
- Level C (Warning).

Drives respond differently to different fault classes. These responses are summarized in Table 7-1.

Table 7-1. Drive Responses to Fault Classes

Fault Class	Drive Response
Level A(Major Fault)	All IGBT gate drives are inhibited, motor coasts to stop, the fault is logged in the Fault Log Menu (33) or Cell Fault Log Menu (21) and displayed on the front panel.
Level B(Fault)	Motor either ramp stops or coast stops depending on the switch setting in Menu 14 or the content of the System Program (see Chapter 8: System Programming). The fault is displayed on front panel and logged into the fault log.
Level C (Warning)	Drive does not necessarily revert to the idle state via a coast or ramp stop unless specifically required to do so by the system program.

Depending on the fault condition, faults are reset in one of two possible ways:

- Manual Reset
- Automatic Reset.

The fault reset push-button on the front panel or the Enter for Fault Reset function in Menu 34 can be used to *manually reset* the fault. The drive must be returned to the run condition by manual start or by forcing the *run_req_f* equal to "true" (see system program example in Section 8).

The fault can be reset *automatically* up to 4 times if enabled by the Auto Reset Enable function in Menu 14. If reset is successful, then drive will return to the run state automatically only if the *run_req_f* flag is maintained at the value "true" (see system program example in Section 8).

7.5. Drive Faults

All drive faults are sensed by circuits located on the Power Interface Board (PIB) and the Fiber Optic Hub Board (FOHB). Table 7-2 can be used as a quick troubleshooting guide to locate the cause of the fault condition.

Table 7-2. Drive Faults

Fault Display (Fault Class*)	Potential Causes and Possible Corrective Actions
Over Voltage Fault (A)	**Cause:** Signal from **VMTR** test point on Power Interface Board exceeds threshold set by "Motor Trip Volts" in Menu 34. This fault is usually caused by an improperly set-up or tuned drive. **Actions:** Verify that the motor and drive nameplate settings match the corresponding parameters in Motor Menu (11) and Drive Parameter Menu (14). Verify that the signals on the **VMTR** and **VPKAC** test points on the Power Interface Board match proper voltage levels indicated in Appendix B, sheet 5. If an incorrect voltage is noted, check the voltage divider in the Motor Sense Unit (see sheet 5, zone 2R of 479333) or replace the Power Interface Board.

Fault Display (Fault Class*)	Potential Causes and Possible Corrective Actions
±15 VDC Supply (A)	**Cause:** Zero (0) volt level from A8 pin 3 or 2 on Power Interface Board into fault GAL IC28 pin 4 due to low voltage on **+5**, **+15**, and **-15** test points. Usually this is the result of a defective Power Interface Board. **Action:** If DC voltages on **+5**, **+15**, and **-15** test points on the Power Interface Board are OK, replace the Power Interface Board.
Overload Fault (A)	**Cause:** Incorrect signals from **IDFDBK** and **IQFDBK** test points on Power Interface Board. This fault is usually caused by an improperly set-up or tuned drive - specifically the result of an incorrect "I overload" setting in Menu 34. **Actions:** Verify that the motor and drive nameplate settings match parameters in Motor Menu (11) and Drive Parameter Menu (14). Verify that the signals on test points **IcFDBK** and **IbFDBK** on the Power Interface Board match the percentage of full scale signals indicated on sheet 5. If these signals are incorrect, then replace the Power Interface Board.
Ground Fault (C)	**Cause:** >1 v peak AC signal on test point **VNFLT** on the Power Interface Board resulting in 5v logic signal on **HGNDFLT** test point. This fault is usually caused by an output ground fault condition. **Action:** Verify proper symmetry of voltages on test points **-VCN**, **-VBN**, and **-VAN**. With the VFD operating, all voltages should appear as specified in Chapter 6. If ground faults are not a problem, check the divider resistors in the Motor Sense Unit or replace the Power Interface Board. Check if the motor is disconnected from VFD (output contactor open in drive run state).
Drive IOC (A)	**Cause:** Signal from **A16** pin 14 on Power Interface Board exceeds level set by the drive IOC setpoint parameter in Menu 34. **Actions:** Verify that the motor and drive nameplate settings match parameters in Motor Menu (11) and Drive Parameter Menu (14). Verify that the signals on test points **IcFDBK** and **IbFDBK** on the Power Interface Board match the percentage of full scale signals indicated on sheet 5. If these signals do not match, then replace the Power Interface Board.

Fault Display (Fault Class*)	Potential Causes and Possible Corrective Actions
Transformer Overtemp (C)	**Cause:** Logic high signal on **TB1B-11** on PIB resulting from open thermal switch. **Actions:** Check cooling system for proper temperatures and flows. Inspect all transformer cooling paths for leaks or collapsed hoses. Be sure all transformer manifolds are fully open. If the source of the problem is not found, then replace the Power Interface Board, then the Microprocessor Board.
Hub Loss of Enable (A)	**Cause:** Logic low signal on **IC29** pin 18 on Fiber Optic Hub Board usually resulting from unlatched cell fault. Signal is monitored by pin 11 of **IC19** on Power Interface Board. This fault is usually caused by an improperly set-up or tuned drive. If this fault is verified to be latched low on pin 18 of **IC29** on the FOHB, but no cell fault is displayed using the display cell fault parameter in Menu (21), then the problem is an unlatched fault sent by one of the power cells. Since this fault is not latched in the cell control, the cell sending the fault signal cannot be identified by the diagnostic system. Future revisions of the Master Link Board will include an LED on the board to indicate which cell sent a fault signal. This condition is usually the result of a defective Cell Control/Gate Driver Board. **Actions:** On existing versions, the problem cell can be located by using the following procedure. Disconnect motor leads. Configure the system for one less cell by completely removing the rightmost Master Link Board from the Hub Board and reducing the installed stages parameter in Menu 21 to one less cell. Reset the system (or re-energize 630 VAC control). If the problem goes away, then the problem cell is one of the cells connected to the disconnected link board. If the problem persists, then swap each of the remaining link boards with the disconnected board and repeat the procedure. Once the cell has been traced to one of the three possible cells connected to the Master Link Board, then the individual cell can be located by swapping individual fiber optic connections from the disconnected board to one of the active boards. **WARNING!!** Always swap within a phase group (**A2** with either **A1**, **A3**, **A4** or **B2** with either **B1**, **B3**, **B4**). For instance, **NEVER** **A2** with **B3** or **C3**.

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Fault Display (Fault Class*)	Potential Causes and Possible Corrective Actions
Medium Voltage Supply Fault (A)	**Cause:** Logic high signal on pin 10 of **IC19** on Power Interface Board usually resulting from disconnected **PL8** connection between PIB and FOHB or Loss of +24, +15, +5 on the FOHB. **Action:** If the source of the problem is not found, then do the following. Ensure that the **PL8** connection between the Power Interface Board (PIB) and the Fiber Optic Hub Board (FOHB) is secure. Verify **+24**, **+15**, and **+5 V** signals on the FOHB. Replace Power Interface Board, then the Microprocessor Board.
CAB Hardware Fault (A)	**Cause:** Network or software fault associated with XCL interface card plugged into **P6** on the Microprocessor Board. **Action:** If the source of the problem is not found, then replace the CAB Board and/or the Microprocessor Board.
XCL Comm Status Fault (A)	**Cause:** Drive not on active PLC network. **Actions:** If the source of the problem is not found, then replace the CAB Board and/or the Microprocessor Board. Refer to the XCL Send Setup Menu.
Power Cell Fault (A)	**Cause:** Logic low signal on pin 12 of **IC18** on FOHB caused by latched fault condition detected in one or more power cells. **Action:** Refer to the section on Cell Faults (on page 7-7).
Overspeed Fault (A)	**Cause:** The *mmf_spd_abs* flag in control software exceeds "Overspeed setting" in Menu 34. This fault is usually caused by an improperly set-up or tuned drive. **Actions:** Verify that the motor and drive nameplate settings match parameters in the Motor Menu (11) and Drive Parameter Meter (14).
User Fault #1-16 (B)	**Cause:** The *user_fault1* through *user_fault16* flags set by the value "true" by system program. See system program example in Section 8. **Actions:** Refer to the section on User Faults (on page 7-10).
24 VDC Supply Fault (A)	**Cause:** Logic low signal on pin 8 of **IC3** on the Power Interface Board usually caused by a short on the 24 VDC supply. Usually caused by defective Power Interface Board or User Modules. **Actions:** If the source of the problem is not found, then replace Microprocessor Board.

* Fault Class designations (in parentheses) are explained in Table 7-1 on page 7-3.

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7.6. Cell Faults

Cell faults are logged by the Microprocessor Board following a power cell fault indication. These faults are available for inspection through the display cell fault parameter in the Cell Menu (21). See the appropriate tables in Chapter 5.

All cell faults are generated by circuitry located on the Cell Control/Gate Driver Board of each power cell and are received by the Microprocessor Board through circuitry on the Master Link Boards which plug into the Fiber Optic Hub Board FOHB. Table 7-3 can be used as a troubleshooting guide to locate the cause of the fault condition. All cell faults are initiated by the Cell Control/Gate Driver Board located in each power cell.

> The Perfect Harmony has a reduced voltage operation mode. This feature allows reduced voltage operation under normal conditions, but bypasses the entire stage (with no reduction in output voltage) on the occurrence of a cell fault. If a second cell fault occurs, the voltage is then reduced. No spare cells are used in this mode of operation. ***Care must be exercised in setting the output voltage in this mode to prevent cell voltages that are higher than recommended for the cell!***

Table 7-3. Cell Faults

Fault Display (Fault Class*)	**Causes**	**Sec. Ref.**
AC Fuse(s) Blown (A)	A Cell Control/Gate Driver Board has detected that the DC voltage in its cell is abnormally low (i.e., the signal on test point **VDC** is <3.5 VDC) while the incoming AC voltage is acceptable (i.e., the signal on test point **VAVAIL** is >5 VDC). This usually indicates a loss of one or more power fuses (**F11**, **F12**, and **F13**) at the cell input. Refer to Figure 1-12.	7.6.1
Cell Overtemp (A)	Each cell sends a PWM signal (on **A11** pin 7) related to heat sink temperature to the FOHB. The **TEMP** test point on the FOHB is an indication of the highest-temperature cell. If this signal falls below 2.0 VDC, an excessive heat sink temperature is indicated. If this fault occurs, check the condition of the blowers. Also check for restrictions in air flow or leaks in the air duct system.	7.6.2
Control Power Fault (A)	One or more of the local power supplies (+24, +15, +5, -5 VDC) on a Cell Control/Gate Driver Board has been detected out of specification (i.e., a logic high signal on pin 13 of **A5**). If this occurs, the Cell Control/Gate Driver Board should be repaired or replaced.	7.6.1
Device OOS (Out of Saturation) (A)	Each Cell Control/Gate Driver Board includes circuits which verify that each IGBT has fully turned on. This fault may indicate a shorted IGBT, an open IGBT, or a failure in the detection circuitry. The cell's power components and Cell Control/Gate Driver Board should be checked.	7.6.1
Overvoltage (A)	The bus voltage in a cell has been detected over 1,076 VDC. This is usually caused by a regeneration limit that is too high, or improper tuning of the drive.	7.6.3

Fault Display (Fault Class*)	**Causes**	**Sec. Ref.**
Cap Shr Fault (A)	The voltage on an individual capacitor in a cell has been detected over 411 VDC. This usually indicates a broken bleeder resistor/wire or a failed DC link capacitor (**C1** and/or **C2**).	7.6.1
Cell Comm. Fault (A)	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 between the Cell Control/Gate Driver Board and its Master Link Board.	7.6.4
Output Fuse Blown (A)	The **S2** trigger fuse is open on a cell. This is usually caused by failure of bypass fuse **F10** (bypass option only). This type of fault could also be caused by loose connections in the cell harness.	7.6.1
Q1-Q4 OOS (A)	Individual annunciation of **Q1**, **Q2**, **Q3**, and **Q4** Out of Saturation Fault. See also Device OOS fault above.	7.6.1
Link Fault (A)	An error in the optical communication channel was detected by the Master Link Board. This is usually a parity error caused by noise, but can also be a time-out error caused by a faulty communications channel.	7.6.4
VDC Undervoltage (A)	The DC bus voltage detected in a cell is abnormally low (signal on test point **TP29** on the Cell Control/Gate Driver Board is <1.83 VDC). If this symptom is reported by more than one cell, it is usually caused by a low primary voltage on the main transformer **T1**.	7.6.1
Device Failure (A)	Refer to Table 7-4 for information.	*n/a*

* *Fault Class designations (in parentheses) are explained in Table 7-1 on page 7-3.*

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.

Table 7-4. Diagnostic Cell FaultsTable

Fault Displayed	Rank	Causes	Reference
Blocking Failure	A1	Voltages across power transistors Q1-Q4 are low while the transistors are **not** gated. Usually caused by a defective Cell Control/Gate Driver Board.	7.6.1
Switching Failure	A1	Voltages across power transistors Q1-Q4 are high while the transistors **are** gated. Usually caused by defective Cell Control/Gate Driver Board.	7.6.1

7.6.1. 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
- Cap Shr Faults
- Output Fuse Blown Faults
- Q1-Q4 OOS Faults
- VDC Undervoltage Faults
- Blocking Failure Faults
- Switching Failure Faults.

Cell fault indications of this variety usually indicate circuit failures within the cell power or control circuitry. If this is the case, and no bypass or redundant cell option was ordered, the Perfect Harmony can still be configured to run, but at a reduced output voltage rating using the following procedure:

- Locate faulted cell and remove all fuses (F11, F12, and F13) in that cell and both vertically adjacent cells in the remaining phases, i.e., A4 and B4, if C4 failed.
- Short output of disconnected cells by placing a 5 KV high voltage bypass cable between the **T1** and **T2** connections. This connection must be of a suitable current rating for the cell rating of the Perfect Harmony drive.
- Remove the Master Link Board which connects the fiber optic cables of the bypassed cells from the Fiber Optic Hub Board.
- Left justify the remaining Master Link Boards so that all boards fill the left most slots of the FOHB.
- In the Cell Menu (21), reduce the installed stages parameter by 1 (new number of operating cells in series).
- Set appropriate motor voltage in Menu 11.

7.6.2. Troubleshooting Cell Overtemperature Faults

Check for adequate cooling air by placing a standard ply 8.5″×11″ sheet of notebook paper against the input louver of the cell cabinet.

- If the paper fails to stick, then air is probably inadequate. Check for excessive output pressure in the plenum or reverse the phase power on the blower motor.
- Check for a loose or broken belt on the blower.

7.6.3. Troubleshooting Overvoltage Faults

This fault is usually caused by an improperly set-up or tuned drive.

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- Verify that the motor and drive nameplate settings match parameters in the Motor Menu (11) and Drive Parameter Menu (14).
- Reduce regen torque limit parameter in Menu 24.
- Reduce torque P gain and torque I gain parameters in Menu 24.
- If failure is occurring in bypass mode, increase energy saver parameter in Menu 24 to at least 50%.
- If the measured signals seem to be correct, change the Power Interface Board.

7.6.4. Troubleshooting Cell Communication and Link Faults

Faults of this variety can be the result of circuit failures on either the Master Link Board or Cell Control/Gate Driver Board.

- If the fault indication persists after replacing the Master Link Board, see Section 7.3.1 above.

7.7. User Faults

User faults originate due to conditions defined by the system program. User faults are displayed on the keypad in the form of user defined fault #n, where n equals 1 to 16. The faults can also be displayed through user defined text strings. Most user defined faults are written to respond to various signals from the user module interface such as the Analog Input Module (through the use of comparators) as well as the Digital Input Module.

A copy of the system program is required to specifically define the origin of the fault. In the example program in Section 8, the *user_fault1* flag is used to display the event of a blower fault. Note that the *user_text_1* 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".

7.8. Output Limitations with No Apparent Fault Message

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 below.

The mode display can sometimes be used to troubleshoot the cause of the output limitation.

7.8.1. Output Voltage Limit

If the mode display shows Byps (bypass), then the Perfect Harmony VFD has placed one or more series cells in the bypass mode due to a cell fault. Inspect the Display Cell Fault menu item in Menu (21) for the cells bypassed and the reason for bypass.

If the mode display shows Hand or Auto (normal modes), check the energy saver parameter in Menu (24). Any setting above 0% will limit the rated output voltage until full load current is attained.

Check all motor and drive nameplate ratings against parameters set in the Motor Parameter Menu (11) and Drive Parameter Menu (14).

7.8.2. Output Current Limit

If the mode display shows Tlim (Torque Limit), then the Perfect Harmony VFD has reduced the motor torque limit due to a loss of input phase (or cell phase) or has received a cell overtemperature warning flag from one of the output cells (see *mv_ot_warning_f* flag in Appendix H).

- Normal acceleration rates with high inertial loads (fans) or high acceleration rates with low inertial loads (pumps) will normally cause the Tlim display to occur.
- Low setting of "torque I gain" (< 0.3) in Menu 24 (Standard Performance Mode), will also cause this mode to display during accelerations.

If no Tlim (Torque Limit) is displayed, check all motor and drive nameplate ratings against the parameter set in Motor Parameter Menu (11) and Drive Parameter Menu (14).

7.8.3. Output Speed Limit

If the mode display shows Rlbk (Rollback), then the Perfect Harmony VFD is attempting to reduce the output speed due to a torque limit condition. Check the motor torque limit parameter in Menu (24), or check all motor and drive nameplate ratings against parameters set in Motor Parameter Menu (11) and Drive Parameter Menu (14).

7.9. Diagnosing Inhibit Mode

The Inh operating mode (see Section 3.0) can be caused by a combination of conditions involving the *sw_estop_f* and *drv_flt_f* (the emergency stop and drive fault software flags). Addresses for these flags can be found in the HARMONY.LOC and DRCTRY.PWM files, respectively.

If the *sw_estop_f* is set "true", but the *drv_flt_f* is "false", then the *estop_f* has been set by equations in system program. Inspect the system program to find the reason.

If the *sw_estop_f* and *drv_flt_f* are set "true", then one or more of the following conditions may have occurred:

- ☐ EEPROM checksum failure
  System program checksum
  Incompatible DRCTRY.PWM file (version is too old or too new for installed software).
- ☐ Incorrect CAB software version
- ☐ 15 volt encoder supply fault (Power Interface Board)
- ☐ Cell overtemperature (see Table 7-3) (Harmony only)
- ☐ Hardware drive fault
  Analog power supply fault (±15 volts on Power Interface Board)
  Drive IOC (Instantaneous Overcurrent)
- ☐ Medium voltage loss of enable (see Table 7-2)
- ☐ Medium voltage power supply fault (see Table 7-2)
- ☐ ±15 VDC supply (see Table 7-2)
- ☐ Cell power fault (see Table 7-3)
- ☐ Illegal cell count
- ☐ Fault in motor voltage feedback (voltage > 20% when drive disabled)
- ☐ Cell hardware fault (indeterminate)
- ☐ Software generated faults (see Table 7-2)
  Overspeed
  User module 24 V power supply
  Overload (current and time) motor overvoltage
- ☐ Analog Data Acquisition System (DAS) failed to initialize
- ☐ XCL communication faults when triggered through system program.

If the *drv_flt_f* is set "true", but the *sw_estop_f* is set "false", then any one or more of the following conditions may have occurred:

- ☐ RAM checksum failure
- ☐ *drv_flt_f* set by an equation in the system program

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- ☐ DCL communication faults when enabled through system program
- ☐ User faults (see Section 7.1.2).

If neither the *sw_estop_f* or *drv_flt_f* flags are set "true", then one or more of the following conditions may have occurred:

- ☐ Ground fault - sets the system program flag *ground_flt_f* in system program (see Table 7-2)
- ☐ Transformer overtemperature - sets the system program flag *therm_ot_f* (see Table 7-2).

☝ Spare parts are available through the ROBICON Customer Service Center by calling (724) 339-9501.

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CHAPTER 8: SYSTEM PROGRAMMING

In This Section:

8.1. Introduction

The need for a flexible system architecture lead to the development of a programmable system configuration and operation interface for the ROBICON ID series of drives. This is generally referred to as the System Program™. Originally developed for the ID2010 DC drive, the system program has been adopted by the ID-CSI, Perfect Harmony, and GT series drives as well as the Harmony DC power systems products. All start/stop logic and feature selections, as well as Boolean logic functions can be implemented giving the ROBICON drives a significant marketing and technological advantage due to virtually unlimited flexibility.

The purpose of the manual is to illuminate the first time user to the features and functionality of the ROBICON System Program without bogging him down with the technical aspects of this feature. The scope of this paper will be limited to the Harmony drive but applies equally well to the other ROBICON products mentioned above.

To get the most out of the system program, it is necessary to understand the resources. This document assumes knowledge of the drive and its capability as well as a good understanding of the system in which the drive will operate. Other references include individual controller protocol manuals for external networks.

8.2. System Program Overview

System configuration and operational logic is depicted in the control diagram (ROBICON drawing 479333) which displays (in a diagram format) the various input options, parameter sets, and modes of operation of the drive, and shows the state machine diagram for normal operation and transition logic for advanced features such as synchronous transfer. 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 an external compiler, the source ASCII text sum-of-products (SOP) file, 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 in the following fashion:

1. First the inputs are scanned from external I/O or memory locations and mapped to internal register spaces (input scan).
2. Next the logic structures are evaluated and the results assigned to the internal registers (logic scan).
3. Finally, the outputs are updated by mapping the internal registers to the output memory or I/O (output scan).

8.2.1. 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 taking into account what features 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.

The actual scan is broken down into the following steps of evaluation:

1. Comparator scan - evaluate the enabled comparators (if any)
2. Input scan - read and map all inputs or memory flags to internal registers
3. Logic scan - evaluate the logic of the program within the registers
4. Output scan - map all results from internal registers to system memory flags or outputs
5. Do a synchronization context swap (all flags updated simultaneously)
6. Map any special outputs on PIB
7. Run drive state machine
8. Initialize XCL communications if necessary
9. Handle any XCL parameter reads or writes
10. Update elapsed timer counter
11. Update blower cycle timer
12. Read and scale all active analog user module inputs
13. Scale and write all active analog user module outputs
14. Perform auto reset if enabled and drive is faulted.

8.2.2. SOP Format

The SOP file, as mentioned above is written with a text editor or a word processor set for pure ASCII text (*.txt) with no control or formatting codes with the exception of horizontal tabs (ASCII code 09h) and carriage returns (0Dh). Other reserved special characters and spaces (20h) can be used. The file consists of the following format:

Table 8-1. 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 Harmony this would be "#Harmony;" without the quotation marks).
Header	A comment field containing the following information: Title - ROBICON Perfect Harmony drive Program part number Customer name Sales order number ROBICON 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 that is used exclusively for informational purposes and is ignored by the compiler.
Operators	Comment field containing operators and symbols

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Item	Description
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.

8.2.3. Sum-of-Products (SOP) Notation

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" (abbreviated with the "+" character) and "NOT" (abbreviated with a line above the operand, e.g., $\overline{A}$). The commutative, associative, and distributive rules are shown as follows. Basic Boolean functions are reviewed in Table 8-4.

Table 8-2. Boolean Laws

Commutative	Associative	Distributive
$A + B = B + A$	$A + (B + C) = (A + B) + C$	$A (B + C) = AB + AC$

Table 8-3. General Rules of Boolean Math

General Rules	General Rules	General Rules[1]
$A \cdot 0 = 0$	$A + 0 = A$	$A + AB = A$
$A \cdot 1 = A$	$A + 1 = 1$	$A (A + B) = A$
$A \cdot A = A$	$A + A = A$	$(A + B) (A + C) = A + BC$
$A \cdot \overline{A} = 0$	$A + \overline{A} = 1$	$A + \overline{A}B = A + B$
$\overline{\overline{A}} = A$		

1 - The syntax "AB" implies (A•B).

Table 8-4. Basic Boolean Functions (AND, OR and NOT)

		A·B	A+B	$\overline{A}$
A=0	**B=0**	0	0	1
A=0	**B=1**	0	1	1
A=1	**B=0**	0	1	0
A=1	**B=1**	1	1	0

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.

$$O = AB + B\overline{C}D + CD\overline{F};$$

8.2.4. 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 8-1.

Conversely, if the ladder logic shown in Figure 8-2 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.

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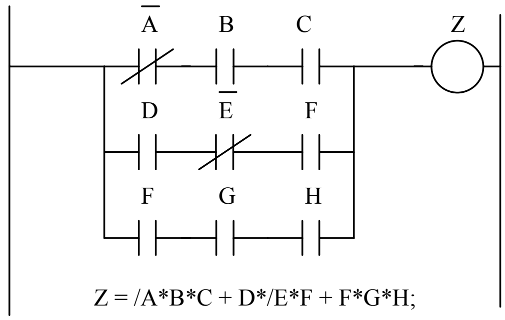

Figure 8-1. Ladder Logic Representation of a Boolean Expression - Example 1

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.
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.

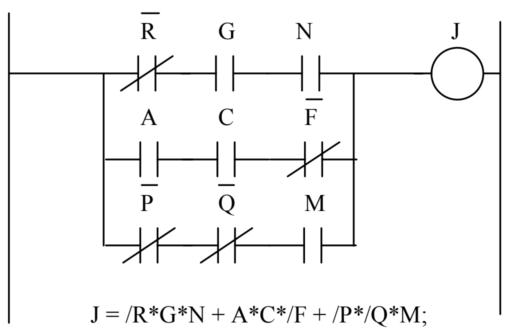

Figure 8-2. Ladder Logic Representation of a Boolean Expression - Example 2

The resultant statement written for the ladder logic in Figure 8-2 is shown below.

```
J =  /R*G*N
     + A*C*/F
     + /P*/Q*M;
```

> For all program statements that span multiple lines, only the last line has the semi-colon end-of-line character (";").

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8.2.5. 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 levels or thresholds to allow conditions to change. This is the purpose of the comparator functions. Any signal that is fed into the drive through an analog input either on the PIB or from a user module can be mapped to create a system flag to use in any logic statement.

These comparators exist in Comparator *n* Setup Submenus [121-136] under the Comparator Setup Submenu [29] in the Auto Menu [4]. There are sixteen (16) 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 (*compar_1_f* through *compar_16_f*) that are controlled by the comparator functions. In essence, the logical state of the comparator flags (TRUE or FALSE) is determined by the equation: *compar_xx_f* = (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 or reset.

8.2.6. 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 of a comparator. However, the analog input needs to be setup properly before it has any meaning to the system program comparator functions.

The analog inputs on the PIB are updated every 2.78 msec but are not filtered. 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 on the module itself so that the micro board does not have to interface to an analog signal or spend time converting it to a digital number. The resolution of the analog to digital converter is 8 bits and the resolution at the connection depends on the type of input used (the physical terminals direct the signals to the converters through various analog circuits). The resolution for each of the 256 discrete steps is then, 78 mV for the bipolar (±10V), 19.5 mV for the unipolar (0-5 V), and 78 mA for the 4-20 mA connections.

In the case of the 4 analog input signals on the PIB (Ref input, Aux1 input, Aux2 input, and Aux3 input), this means adjusting the scaling of the analog signal. There is one common scaler for these four inputs ("Alg In Scaler" in the Analog I/O Setup - Menu 36) which is strictly for the value that appears to the comparators, analog test points, display, and XCL outputs. These inputs use another (separate) scaler for use in the controls (e.g., "Vel Ref" or "PID Ref" also in Menu 36).

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If using the Analog User Modules, one of 8 analog inputs can be selected, Analog Module Input 1-8. This determines a memory location and retrieves the contents for use by the comparators if selected. But since they are linked to user modules, this gets a little trickier. Each analog input must be mapped to a specific user module address (0 to 15) through the setup menu for that specific analog input, and the type of input (how it is used in the system, i.e., unipolar 0-5 volts, ±10V Bipolar, or 4-20 mA current loop or off if not used) and scaling (for percent of rated at full scale) must be set as well for any used inputs. These settings are found in sub-menus 181 to 188 (one for each analog input 1 through 8) which reside under the Analog I/O Setup menu (36). The eight analog inputs can be mapped to any address of analog user module which is determined by the dip switch settings on the module. There cannot be two analog I/O modules with the same address, just as two digital I/O modules cannot have the same address. However, the addresses for the analog and digital user modules do not overlap, they are physically separated with hardware. Therefore, an analog user module can have the same address as a digital module with no conflict on the bus. This is probably not a good idea, however, as it leads to confusion.

8.2.7. Analog Outputs

Although not directly related to the system program but for completeness, this section describes the analog outputs. There are only two usable (re-configurable) analog outputs on the PIB. These are the programmable test points. The variable to output is selected as before, from the pick list associated with the parameter "Alg var1" and "Alg var2" in menu 36. The scaling is done for each by its associated scaling parameter "Analog TP 1 *xx.xxx* V" and "Analog TP 2 *xx.xxx* V" respectively. These are scaled by adjusting the voltage level to represent rated (100%) output (assuming the value is scaled to internal units of 8192=100%). These outputs are updated at 2.77 msec, but **TP1** has a 12-bit resolution while **TP2** has 8 bits of resolution (both with one bit used for signed operation).

> These analog outputs are not to be used for metering. They may only be used for troubleshooting the system.

The analog output user modules are setup much the same way as the input modules with address ("Module Address"), type (how it is used in the system i.e. unipolar 0 to 5 volts, ±10V Bipolar, or 4 to 20 ma current loop or off if not used), and scaling ("Full Range %") parameters. The additional parameter is a selection for the variable ("Analog var*x*") to be output (like with the test points). These parameters are grouped as sub-menus "Analog Output 1" to "Analog Output 8" under menu 36 ("Analog I/O Setup") and are listed as menus 111 to 118 respectively. These user modules are also updated at the rate of the system program scan rate.

A feature often overlooked is the ability to re-map the analog inputs to the programmable outputs. This is done by selecting an analog input from the pick list for the analog outputs. Then both the analog output and analog input need to be setup as described in their appropriate sections above. This provides a means to use the analog signal as a comparator input, log it to the historic log, display it, or pass it to the XCL communications interface (which we will cover later) while making the wiring more straight forward and flexible. This also provides an unexpected bonus of having an ability to force the output by selecting a constant as the output variable for purposes of testing.

This feature is not without drawbacks, however. There may be a small, indeterminate time delay between the reading of the input and the update of the output although it will be much smaller than the scan time of the system program (the inputs are read just prior to the update of the outputs during the scan cycle but may be interrupted by the control software), and it requires the use of an additional user module. If this cannot be tolerated, then the same basic functionality can be implemented by daisy-chaining from the input module to wherever else the analog signal is needed. This is less flexible but provides almost the same functionality as mapping an input to the output.

8.3. External Communications Links

8.3.1. XCL Interface - Overview

The system program begins to come into its own with the ability to interface through the XCL interface. This requires the use of a daughter board, the Communications Adapter Board (or CAB), attached to the micro board providing a standard 8 bit, ISA slot to attach PC based serial communication boards. The firmware on the CAB acts as a translator, converting data flow from the network card (plugged into the CAB) into a format that the drive uses to communicate. Most industry standard protocols are supported, including, but not limited to ModBus and ModBus+, RENET, Data Highway+, Genius I/O, modem, and Profibus. The following discussion will be limited to the common drive protocol. For discussions on protocol specific implementations, refer to the individual manuals for these protocols.

The Harmony drive XCL communications interface provides several distinct user features and capabilities. These include control/status command passing (discrete signals), transfer of variables as either raw or scaled values, changing parameters in the drive, upload/download functions for uploading report information (fault logs, historic logs, parameter logs, etc.) and system archiving (system programs, parameter, etc.), and remote keyboard operation (requires customer programming). The drive accomplishes this by utilizing both global (where supported) and register addressing and communications. For specific operation of these functions and their implementation, see the individual manuals for each supported protocol. A memory map of the dual port memory on the CAB is attached as Appendix A.

The way in which the drive is able to talk to the various protocols is through the CAB interface. The dual port memory on the CAB is used by both the drive micro board and the CAB processor. The CAB is responsible for initializing and communicating with both the add-in PC based communications board, which handles all network level issues, and the drive. It translates information from the communications board into drive based information by scaling and formatting, and places it into the dual port memory to be retrieved by the drive. Likewise, it takes drive information from the dual port, and sends it to the communications board to be output to the network. The status of both the network and the integrity of the CAB is sent to the drive for use as status information or to generate a drive fault where the communications link is essential to drive operation rather than just to provide drive status to the network. The ability to generate the fault is user programmable through the system program.

8.3.2. XCL Network Support

Two distinct types of networks exist and this determines the type of data transfers that occur. One is a token ring type of network in which all nodes have equal access to all other nodes in what is known as a token passing protocol (also known as Peer to Peer). Each node can write out data when it gets its turn (when it has the token) and any node can read whatever is being written by any active node at any time. The other type of protocol is a master/slave network. Only one Master resides on the network and it alone is responsible for retrieving and passing the data. The Master reads the data from one node and writes it to another node. ROBICON drives can never be masters on this type of network.

In each type of network, each node is known by its node address. Each node must have a distinct node address on the network (no two can share the same address or a conflict occurs). This is accomplished (in the ROBICON drive) by setting the switches on the communications board which have them, or by setting the XCL node address in menu 43 “XCL Send Setup”.

Global data is for Peer to Peer communications (one node can talk directly to another) in a token rotation network protocol. Each node gets a token (kind of like a pass key) which enables it to transfer information on the network. It places the information stored in its own local node memory area up on the network and when done, passes the token to the next node on the network. Each other node will copy what is transferred into its own remote node area. The drive, acting as a node on the network, assigns all other active nodes to a remote node area or block of memory in the dual port. The node address assignment is copied to what is called a node descriptor table. It is this table that acts as a map key to determine what block of memory is associated to each active node. Up to 16 nodes can be supported on a network on which a ROBICON drive is a node. All this is transparent to the user.

Register data is for communication protocols that use a master/slave arrangement to transfer data. On the network, the one Master transfers data to and from each of the Slave nodes. ROBICON drives are always slaves on these networks. In order to transfer data from one node to another, the Master must first read from one node and transfer the data by writing to another node. To store the register data, each drive has a block of the dual port set aside for registers. These are broken into registers 1 to 63, which in the drive, are reserved for send or transmit registers. Only the odd numbered registers are used since the data sent is 32 bits wide and span the register selected plus the next register (even numbered). Likewise, the input or receive registers are numbered 65 to 127 with only the odd numbered registers being valid. This is again caused by the size of the data format on the network. All registers are implemented as memory location in the dual port RAM of the CAB. Each drive has its own set of registers that do not overlap with another node.

8.3.3. XCL Data Transfer

All data flowing between the network nodes consists of 32 bit double words. These are transferred as two 16 bit words of data scaled to network units, along with the data type. The data can be divided into transmitted or "send" data and received data (accepted by setting up pointers in the menu system). These are setup in the XCL Send Setup Menu [43] and the XCL Recv Setup Menu [44]. These must be set up properly in order for the drive to correctly use the data.

First we will look at the send data. Currently, only a total of 32 double words are able to be transmitted from the drive which can consist of 16 global and 16 register values or variables (where global transfers are supported), or no globals and up to 32 register variables. All variables selected for transfer (XCL send setup) are put into two 16 variable table lists. If globals are used at all, they are placed in the first table and then any register variables are loaded into the second table. If only register variables are used, they are placed into the first table until it is full and then placed into the second table. The point of the table is to provide a simple means to transmit the information to the CAB dual port memory, making it available to the CAB to place on the network card for broadcast (global information) or when selected by the network (register read). What is stored in the table is the source address (internal to the drive) of the variable, followed by the destination address (in the CAB dual port memory), and then the data type (so that the CAB knows how to scale the variable for the network. All this is done when selecting variables from the pick list. The scale factors for the various data types are pre-loaded when the CAB is initialized. For a more detailed description of the memory allocation of the CAB dual port memory, see one of the CAB manuals for the specific communications network of interest. Also refer to Appendix A for a brief overview of the memory allocation.

A similar process occurs when the receive variables (XCLPTR_01 - XCLPTR_52) and Communications flags (COMM_F01 to COMM_F16) are setup. These are broken into sub-menus by functional groupings. The variable to be used is mapped via the node address and data item number (for global data). This sets up a node descriptor table which the drive uses to retrieve the information from the dual port. Also, the number of variables set up by the receive variable menu items (Menus 141 to 143) and the sixteen system program XCL Communications flags (Menu 144) must match the items setup for each node to transmit, or else a data exception flag (xcl_data_fail) is set. When selected, the drive keeps track of all data items expected from each of the nodes, and when a packet of information comes in, the number of data items received, must match the total expected. In addition, the integrity of the network itself is determined by the CAB and this information along with the integrity of the CAB itself is checked through two other status flags (*xcl_status_fail* and *cab_hw_fail*, respectively). These three status flags will not cause a drive fault or be logged as a fault. To do this it is necessary to use the "log" versions of the flags (*xcl_data_fail_log*, *xcl_status_fail_log*, and *cab_hw_fail_log*) by setting them (conditionally usually) equal to their associated status flags.

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8.3.4. XCL System Flags

The XCL interface to the drive is broken down into two areas, the system program flags and the menu system setup for redirecting information (mapping) to and from the drive. The menu system creates links to the dual port memory on the CAB so that information can easily be transferred. The system program uses bit-mapped flags to transfer control/status information to and from the CAB.

The system program flags are broken into the user flags, the configuration flags, and the status flags. The user flags are bit-mapped and consist of the "serial" flags used for transmission of data, and the "Comm" or communication flags which are used for receiving information. These are essentially the same, only the direction is different. For instance, the communications flags are used individually as inputs (to the right side of the equals) in the logic statements whereas the serial flags are addressed individually but as output (left side of the equals) flags only. As mentioned before, these flags are bit-mapped which means that each of the sixteen bits is considered a separate and distinct flag. This allows data compression and is necessary for the limited number of words allowed in a transfer.

Each drive can broadcast up to four 16 bit serial flags allowing a total of 64 discrete bits of information or status to be output. These are selected from the send pick list as Serial Flg1 to Serial Flg4 with each representing 16 serial flags each in the system program (i.e., serial flag 1 breaks down into 16 individual flags usable in the system program as *serial_f0* to *serial_f15*; serial flag 2 breaks down into *serial_f2_0* to *serial_f2_15*; serial flag3 and serial flag 4 follow in a similar fashion with the *f2* being replaced by *f3* and *f4*, respectively). Once the system program is implemented using the flags, they must be setup to broadcast on the network by selecting them to send as one of the global variables or as a send register.

To use the serial flag information from another node, the Comm Flag(s) must be programmed to receive from that node (global) or from an input register. Once one or more of the Comm flags are mapped from the menu, they are accessed by using their associated bit flags as an input in the system program. Remember that each Com flag represents 16 individual system program flags. For example, communications flag 1 (*comm_f01*) would break down into *comm_f01_0* through *comm_f01_15*. Other Comm flags would follow in a similar fashion (with the "*fxx*" representing the communications flag used).

8.3.5. XCL Status Flag Setup Example

For purpose of illustration, assume that two drives communicate in a token ring network in which drive 1 had the node address 10 and drive 2 had the node address 5. Also assume that they are the only two nodes on the network. Assume that the condition of the zero speed flag on drive 1 is to affect drive 2, then the following setup would be required.

In the system program on drive 1, the following statement might be used:

```
serial_f2_5 = zero_spd_f; This puts bit 5 of Serial Flg2 in use.
```

The global data item 1 (XCL send01 in menu 145 "XCL Global Send") would be setup by selecting "Serial Flg2" from the pick list. This maps the variable (the one bit flag being used and 15 others currently not being used) to be broadcast on the network when drive 1 gets the token.

Now to set up drive 2 to use the status the following condition might be used in the system program to turn on a light controlled by Digital Output User Module 0 contact 'a' when both drives are at zero speed.

```
umdo00_a = zero_spd_f * comm_f01_5;
```

Note that the local zero speed flag for drive 2 would simply be the zero speed flag, while the zero speed flag from drive 1 has been mapped to serial flag 2 and sent as data item 1. We will receive it into Comm flag 1 and it will appear as bit 5 on that Comm flag (same as the bit 5 on the serial flag). In order to complete the setup, however, we need to setup Comm flag 1 (*comm_f01*) in menu 144 "XCL Com Flags". We select that item and program the node address for drive 1 (10) and the item as the first item (of 16). The entry field appears as "10:001". Only node addresses up to 64 are accepted.

If registers were used instead of global data items, the setup would change slightly and the communications would not be directly between the drives. Furthermore, another node would have to be added to act as the Master on the network (remember, a ROBICON drive can never be a Master in a Master/Slave type of network). The changes required are to the menu setups and not to the system program statements which remain unchanged. The required configuration changes would be as follows:

On drive 1 the send selection would change to one of the registers. Let's choose register 5 XCLreg005 on XCL Send Reg 1-31 Menu [147] to send the data. We would select that menu item and then from the pick list, pick serial flg2 just as before. The only change here then, is the way we send the data.

To receive the data, we choose communications flag 1 again, but instead of entering the node for drive 1 we must pick a register. We can't select register 5 since this is a send register. We must pick one of the receive registers (65 to 127). Let's arbitrarily choose register 77. In the entry field for COMM_F01, we enter for the node address the number "99". This tells the drive that we want a register, not a node address. Next we enter the register number in the item number field. Our completed entry now looks like "99:077".

Now everything from the drive standpoint is setup. Here it becomes critical to understand that the Master must be programmed to read register 5 on drive 1 and write to register 77 on drive 2, or the status information never gets transmitted. Unlike token passing protocols, where a third node was unnecessary, a master/slave protocol absolutely requires the additional node and the programming that goes along with the data transfers from node to node. Each drive has its own set of registers that map into the master's set. The capabilities of these registers and the possibility of overlap, etc. are better handled in the specific manuals that cover the particular protocol.

8.3.6. XCL Configuration Setup Example

System configuration with XCL parameters allows things like speed commands or torque limits to come through the XCL interface. Viewing the system control diagram (479333), the various configuration flags correspond to the menu structures. The following table shows the relationship.

Table 8-5. XCL Flag Relationships

Menu #	Title	Location	Sys Flags	XCL Flags	Function
141	XCL Vel Ref	1 / B1	*rc_sw2*	*xcl_sw1-4*	ratio control
		1 / B4	*vd_sw21*	*xcl_sw5-8*	velocity reference
		2 / B6	*as_sw2*	*xcl_sw9-12*	aux velocity ref
142	XCL Vel Ctrl	2 / B1	*vl_sw2*	*xcl_sw13-16*	pos speed limit
		2 / F1	*vl_sw6*	*xcl_sw17-20*	neg speed limit
		1 / P6	*acc_sw2*	*xcl_sw21-24*	forward accel
		1 / R6	*acc_sw2*	*xcl_sw25-28*	forward decel
		1 / P8	*acc_sw2*	*xcl_sw29-32*	reverse accel
		1 / R8	*acc_sw2*	*xcl_sw33-36*	reverse decel
143	XCL Trq Ctrl	2 / E8	*ai_sw8*	*xcl_sw37-40*	torque command
		2 / T7	*aa_sw6*	*xcl_sw41-44*	aux torque cmd
		4 / B1	*al_sw2*	*xcl_sw45-48*	positive torque lim
		4 / E1	*al_sw7*	*xcl_sw49-52*	negative torque lim

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Note that for every XCL switch (*xcl_sw1* to *xcl_sw52*) that is used, a corresponding XCL Pointer (*xclptr_01* to *xclptr_52*) must be set up. Also it is important to note that the system flags must be set in conjunction with the XCL flags. Generally, if these inputs will be switched dynamically, the XCL switch can be set TRUE and only the system flag need be dynamically set. Perhaps the best way to explain is by way of an example.

For this illustration we will assume the case of a single drive connected through a network to a logic controller. We will also assume that the network is a token ring and that the controller is monitoring drive data: speed, total current, and power. The controller is supplying the run request and the speed command (as data items 1 and 2 respectively). This example will only address the drive setup, assuming that the logic controller is programmed to place and accept the data. The data will be transferred by means of global data and the node addresses are 7 for the controller and 23 for the drive. There will be both a local and remote operation with the local controls and speed signal coming from a panel connected through the user modules (both analog and digital). Data sent out of the drive will be on data items 1, 2, and 3 for speed, current, and power.

The drive system program would have the following statements assigned in the appropriate locations of run and configuration.

```
;-------------------------------------------------------------------------------
;       SYSTEM DESCRIPTION SECTION
;       Drive is node 23      Controller is node 7 using global data passing.
;       Remote operation is selected by input ‘a’ on digital input user module 1.
;       Remote mode uses bit 1 on node 7 data item 1 and speed command from
;       node 7 data item 2.  Local mode uses analog input 1 from analog user
;       module 5 set to bipolar operation and scaled for 5 Volts equal to 100%
speed.
;       Controller will monitor speed and current feedback and drive power set
;       up as global data items 1, 2, and 3.
;
;       xclptr_05             (xcl pointer 5) used for remote speed ref
;                             uses data item 2 from node 7 (07:002)
;       vd_sw21               selects XCL speed reference
;       vd_sw23               selects local speed reference
;                             5 volts equals 100% on module 5
;       COMM_F01              com flag 1 bit 1 used for run command
;                             uses data item 1 from node 7 (07:001)
;       umdi01_a              digital input for remote (/local) operation
;       umdi01_b              digital input for local run
;       umdi01_c              digital input for local stop (NC)
;-------------------------------------------------------------------------------
;  CONFIGURATION SECTION
xcl_sw5  = true;                                switch for the XCL channel for speed
reference
vd_sw21  = umdi01_a;          use XCL speed ref if in remote
vd_sw23  = /vd_sw21;          user module speed ref if not remote fall back
;-------------------------------------------------------------------------------
;  RUN/STOP SECTION
;              run if run pushed *  local + remote * remote run - sealed with stop
;              note that local stop stops both
run_req_f  = umdi01_b * /umdi01_a + umdi01_a * comm_f01_1
          + run_req_f * umdi01_c;                          local, remote, then
seal-in on bottom
;-------------------------------------------------------------------------------
;  DRIVE FAULTS
xcl_status_fail_log = xcl_status_fail * umdi01_a;
cab_hw_fail_log = cab_hw_fail * umdi01_a;
xcl_data_fail_log = xcl_data_fail * umdi01_a;
;-------------------------------------------------------------------------------
```

Figure 8-3. Sample XCL Configuration Components of a System Program Printout

Note from the example that the system is thoroughly described so that it can be setup easily from the write-up on the system program. Also note that each section is logically set apart and commented throughout. This is important to having a readable document. Comments are not included in the compiled file and have no impact on code size. A well organized and documented system program is easy to understand and troubleshoot. Note also that the fall-back local mode is selected by the loss of the remote mode (vd_sw23 = /vd_sw21;) making sure at least one input is selected. An indicator lamp of some sort should probably be used to indicate remote mode selected, and another to indicate drive running. This is just good system design. Also note how the communications channel status flags are used to create a drive fault only if the remote mode is selected (*umdi01_a* is true). This allows operation locally in case the remote network is down.

Now to complete the setup, the following entries need to be made in the menu system for the XCL parameters in remote control. All of these XCL parameters appear under the general menu “Communications Menu [9]”.

Table 8-6. XCL Parameter Adjustments Necessary in the XCL Receive Setup Menu (44)

Submenu	Parameter	Parameter Value
XCL Vel Ref (141)	xclptr_05	07:002
XCL Com Flags (144)	commf01	07:001
Ser Input Scalers (146)	vel ref ser	1.000

Table 8-7. XCL Parameter Adjustments Necessary in the XCL Send Setup Menu (43)

Submenu	Parameter	Pick List Option	Description
XCL Global Send (145)	XCL send01	Spd fb RPM	speed feedback rpm
	XCL send02	Tot I Fb	total current feedback
	XCL send03	KW output	output power in kw

For local control, the following parameters need to be set. These are primarily used to steer and scale the analog input. In the analog setup menu "Analog I/O Setup (36)" which is under the "Meter Menu (8)", we go to the setup menu for analog input 1 "Analog Input 1 (181)".

Table 8-8. XCL Parameter Adjustments Necessary in the Analog I/O Setup Menu (36)

Submenu	Parameter	Value	Notes
Analog Input 1 (181)	Full Range	200.0 %	5 V to equal 100% (span=10V)
	Module Address	05	Sets Analog 1 to input module 5
	Var1 type	Bipolar	-10V to +10V

Remember the constraint said that the input had to be bipolar and scaled such that 5 V equals rated or 100% speed. Had we determined that unipolar operation was acceptable, we would have set the Full Range to 100% and the Type to Unipolar "Unipolar (0 to 5V)" in the pick list, to accomplish the same scaling but with 4 times the resolution. Bipolar operation uses the 8 bits of resolution to span 20 V (±10V) as opposed to unipolar where the entire 8 bits is used to represent a span of 0 to 5 V. The range of input is solely determined by the physical connection to the user module.

Now we are able to read and scale the analog input from the user module and it is available for use in the system as Analog Input 1, but is still not assigned as a velocity reference. To do this we must go back to the menu "Analog I/O Setup (36)" and select the parameter for the velocity reference and select Analog Input 1 as the source. Thus it would appear as this:

```
              Vel Ref → Alg In 1            " Analog Module Input 1"  from the
pick list
```

Now the analog input is used as the velocity reference when *vd_sw23* is set true in the system program. Since analog user modules can have any valid, unused address and can be used in three ways with different ranges, and since the analog user modules can also be used as inputs in 3 other configurations and in comparators, the display and in the historic log, this is the only practical way to set it up. Flexibility brings with it a degree of complexity, but if the whole process is thought out and planned, and the configuration is understood, it becomes pretty straightforward.

This example was moderately difficult but shows the power of the system program in configuring a very flexible drive.

8.4. System Implementation

The system designer, using the control diagram (479333), maps out the inputs and operational modes needed for a specific installation. In the header section of the SOP file, the input and output flags used can be documented in comment fields consisting of lines of text prefixed with the comment delimiter, a semicolon. The example above shows this technique, which facilitates the implementation of the design.

The Control Diagram, as mentioned above several times, plays a vital role in understanding the complexity of the drive. Each page and sub-section is grouped logically to aid in understanding the system. Starting on page one and going through pages 3 (standard control) or 4 (vector control) the flow is from velocity reference input through special reference modifiers (speed profile and critical speed avoidance) and into the ramp. Page two takes the ramp output, adds in any auxiliary reference, goes through the velocity limits and into the speed loop. This is provided that the drive is in velocity mode. If the drive is configured as a torque follower drive (where a torque command comes from some other source than the speed loop), then the speed loop is disabled (this is controlled by *ai_sw1*). On the right side of the page are several other sources of torque input.

From this page, we go to either page 3 which is used for standard control, or page 4 which is used for vector control. Both pages have the torque command passing through the torque limits and then to the torque and magnetizing or voltage loops and frequency generators. Page 5 shows an overview of the hardware associated with the software represented by pages 1 through 4 with the interface from the software (analog outputs and inputs) in the center of the page.

The following page depicts the logic of the drive controlled by the other system flags. This is shown as a drive state machine on page 6. The left side of the page is the graphical depiction of the states. The circles are distinct states that the drive must be in at any time. The arrows show the transitions between the states. Where there are no arrows, there is no transition, in other words, if there is no connection between two circles, it is impossible for the drive to transition between those two states (e.g., the drive cannot go directly from running in state D to idle in state A without going through state L along some path. The right side of the page is broken into two parts again with the top giving a description of the condition of the drive in each state. This portion describes what's in the circles. The bottom portion describes the conditions that must be met in order to transition from one circle or state to another. In essence, it describes the arrows. To comprehend the operation of the drive, and to control it in a pre-described manner, it is only necessary to follow the desired flow of the drive through the various states, and then program the flags to perform in the manner that the transitions require.

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Pages 7 and 8 are directly related to the synchronous transfer function of the drive. Page 7 describes the functionality of the associated control algorithms and shows how the inputs and settings affect the performance of the function. Page 8 describes the state machines for the up and down transfers. Each state machine is related to the drive as a single state in the drive's state machine. This is shown by the vertical line separating the drive states and transitions on the left, from the states and transitions of the individual transfer state's state machine. For example, the up transfer drive state is represented on the left as a single state U. Inside U is the entire transfer state machine with the notation of each state designated as the capital letter U suffixed by the small letters of each state in the state machine. It is important to understand this notation in order to understand the state descriptions and transition logic on the right. Looking to the right, we notice four sections, two apiece for each function. Again using the up transfer for the example, we look at the state descriptions for each of the individual transfer states, remembering that this whole description makes up the single description for drive state U, the up transfer state. In the transition descriptor section under this, it becomes necessary to describe both the transition between the individual transfer states, but also the transitions between the other drive states and the transfer state. Here the notation reflects the portion of the state diagram being examined on the left side of the page. Any description that uses only upper case letters is for the drive state transitions. The descriptions that use the upper case letter with a lower case subscript, are all transitions between the transfer states only, all within the drive state U. Note that these are conveniently divided from left to right to match the graphical depiction on the left side of the page. Here, all the timing and handshaking required to perform the transfer, resides.

That is an overview of the drawing details. To examine the functions more carefully, we need to look at each section individually, noting the naming conventions of the configuration switches. These are identical to those found in the directory file (DRCTRY.PWM) so that the names can be used directly from the drawing.

In the directory file itself, each flag (relating to the switches shown) has an individual description. Switches with similar names comprise a single selection during configuration. Only one switch can be set true at a time. Also, with only one known exception, the priority of the switch starts at the lowest number and recedes as the number gets higher (the exception is in the ramp rate selection switches). Also during the evaluation of the switches, the selection process halts when a switch is found true. Therefore if both *vd_sw17* and *vd_sw23* were both set true, *vd_sw17* would be the one used. This is a dangerous practice as there is no guarantee of the end selection results. Also, if a feature is not used, not setting any of the related flags results in a default condition that essentially renders the functional output to a zero value where this makes the most sense for a default off condition.

Looking then at functional groupings of switches, the configuration pages become greatly simplified. They can then be summarized by the following table. Not all switches are shown, but this covers the majority of the configuration flags. A functional summary of system swicthes is provided in Table 8-9.

Table 8-9. Functional Summary of System Switches

Function	Control Switches	Drawing Page/Location
Vel Ref source selection	*vel_tst_sw* (*vd_sw1*) *vd_sw2* to *vd_sw28*	1 / left side
PID loop input selection	*pid_sw1* to *pid_sw6*	1 / left side (needs *vd_sw19* enabled)
Speed Profile enable	*sp_sw*	1 / J3
Critical Speed enable	*csa_sw*	1 / L3
Reference Inversion (Negation)	*pc_sw1*	1 / M3
Ramp Rate selection	*acc_sw1* to *acc_sw5*	1 / right side
Velocity Limit	*vl_sw1* to *vl_sw9*	2 / upper left requires 2 selected
Aux Vel Ref selection	*as_sw1* to *as_sw8*	2/ lower left side
Trq Ref select	*ai_sw1* to *ai_sw8*	2/ left of center *ai_sw1* enable speed loop operation
Vel Loop Gain Set	*vel_gain_sel* 1 to 3	2 / upper right defaults to gain set 1
Holding Trq select	*hold_f* and *hi_sw1* to 6	2 / N6 needs hold_f to enable
Aux Trq Ref	*aa_sw1* to *aa_sw6*	2 / right side uses NOT *hold_f* to enable
Trq Limit enable (vector)	*al_sw1* to *al_sw20*	4 / upper left
Trq Limit enable	*al_sw4*, *al_sw17*,	3 / B4 no other switches should be

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Function	Control Switches	Drawing Page/Location
(standard)	*al_sw19*	set
Trq Loop Gain set	*trq_gain_set1* to 3	3 / center on J
Disable Dynamic Limits	*dis_dyn_lim*	3 / E6 (standard), 4 / D6 (vector)
Disable Rollback	*disable_rollback*	1 / R2
XCL sources	(see table)	(see table)

8.5. User Faults

This is a description of the user faults referenced above. User faults are definable drive or system faults that are used to either inhibit or trip the drive. By default, the user faults produce a drive fault or inhibit to the drive (they set the *drv_flt_f* true, but not the *sw_estop_f*). The system *estop_f* flag must be set in order for the drive to shut down due to the defined condition.

User faults, by definition, can be either fatal or non-fatal, but they are still drive faults. They automatically set the *drv_flt_f*, the internal system flag that causes the faults to be logged to the fault log, and also provides a run inhibit to the drive. (They do not set the internal *sw_estop_f* flag which is used to trip or shut down the drive and display the fault message.) This inhibit is only in effect for restarting the drive from idle and does not cause the drive to stop. So by definition, all user faults are non-fatal by default. To make them a fatal fault, the system *estop_f* must be set.

For fatal faults the *sw_estop_f* is set. This is an internal flag not directly accessible to the system program. When this flag is set, either by a software trip (e.g., overspeed or cell fault) or by setting the system *estop_f*, the drive goes immediately into a coast stop and then into the idle state, inhibited from running (by the state of the *drv_flt_f*).

In either case, a fault can only be reset by a drive fault reset. The *fault_display* system flag was added to display non-fatal faults while the drive was still running (a run inhibit pending) or to indicate that an inhibit is in effect (drive in idle state). This should be used in conjunction with timers to toggle between the fault message and the normal display. For additional information on internal faults and drive response see the description of system faults in the next section.

8.5.1. Triggering User Faults

User faults are enabled by conditions that are defined in a statement assigned to the bit-field output flags *user_fault1* to *user_fault16*. Once set true, these faults must be latched by adding a seal-in statement to the logic statement.

```
user_fault1 = <fault condition> + user_fault1;
```

Where <fault condition> is a logical statement using system flags, comparator flags, or digital inputs. These can consist of any number of conditions following the constraints of any sum-of-products notation.

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8.5.2. User Fault Messages

As mentioned above, the default condition of the user fault is to simply create a run inhibit, or non-fatal fault. In order to create a fatal fault or trip, that will also shut the drive down and display a message, the system *estop_f* must set true with the user fault. This is done by ORing the user fault flag into the *estop_f* statement.

For non-fatal faults, the display of the message becomes more involved. However, it is possible to use them to enunciate warnings, e.g. the loss of redundant blowers or pumps. This is the purpose of the "*fault_display_f*". Since the drive can remain running, it is important to allow the display to be read to monitor the system status. For this purpose timers must be used in the statement to toggle the fault message and normal display. For external enunciation via lamps or through the serial communications, it is only necessary to use the user fault flag to set the output.

Text can be defined in the system program by using the labels *user_text_1* through *user_text_16* followed by the message to be displayed in quotation marks. If user text is not applied, the default message "User defined fault #1" through "User defined fault #16" will be displayed instead.

A user fault example is shown below.

```
;-------------------------------------------------------------------------------
;   USER FAULT MESSAGES
user_text_1 = " Non-Fatal Fault"
user_text_2 = " Fatal Fault" ;

;-------------------------------------------------------------------------------
; AUTOMATIC RESET OF A NON-FATAL FAULT
;       Five second delay for reset.  Drive must be stopped.
;       Fault must be non-fatal with no fatal faults
;
timer03(5) = user_fault1;
drv_flt_rst_f =  <normal reset>  + /fatal_fault_f * timer03 * /trq_cntr_en_f;


;   For display of non-fatal faults
;              - this arrangement allows different on and off display times
;              - fault_display must be conditional for non-fatal faults only
;-------------------------------------------------------------------------------
user_fault1    = loc_sw_tb5_2 + user_fault1; user fault to test auto reset
user_fault2    = loc_sw_tb5_5 + user_fault2; user fault to test auto reset
estop_f    = user_fault2;                 fatal fault - trips the drive
timer01(2) = user_fault1 * /temp03_f;
timer02(1) = temp03_f;
temp03_f   = timer01 + temp03_f * /timer02;
fault_display  = user_fault1 * /fatal_fault_f * /temp03_f;
```

Figure 8-4. Sample User Fault Component of a System Program Printout

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8.6. System Faults and Drive Response

8.6.1. Drive Action of Internal Flags

Table 8-10 lists selected internal flags and describes related drive actions for each.

Table 8-10. Internal Flags and Related Drive Actions

Internal Flag	Drive Actions
drv_flt_f	This flag must be set to log a fault into the fault log. If not explicitly set as described below, the system program must set it when the condition exists. This flag will not cause the fault to be displayed and will not shut the drive down. It provides only a run inhibit once the drive is back in the idle state. It will not cause a drive state change. If this flag is used in the system program, it MUST be sealed in, i.e., *drv_flt_f* = [condition] + *drv_flt_f* * /*drv_flt_rst_f* ;.
sw_estop_f	This flag causes the drive to come to a coast stop (regardless of stop flag settings) and will inhibit the drive until reset. This flag also causes the fault to be displayed. If this flag is not explicitly set as described below, it must be set by the system program when the desired result (coast stopping the drive) is needed. It can only be set by the system program by setting *estop_f* in the system program. To delay the coast stop so that a controlled ramp stop may be used (while still displaying the fault), *zero_spd_f* may be ANDed with the fault condition to set *estop_f*. This is an internal flag that can only be set externally through the *estop_f*. Once set, *drv_flt_rst_f* must be used to reset it. The *estop_rst_f* flag has no effect.
cr3_picked	This flag is updated on every scan of the system program and mirrors the CR3 digital input (this occurs on the state machine update portion of the system program scan). This flag must be true in order to start the drive from the idle state. If the flag should go low in any drive state, the drive will go directly to the coast stop state regardless of any stop flag condition or setting. It works exactly like the *sw_estop_f* with the exception that it does not latch. Therefore, no drive fault reset (using *drv_flt_rst_f*) needs to occur to restart the drive. No system program access is available to this internal flag (*cr3_f*, available as an input in the system program, causes another read of the digital input hardware during the input scan portion of the system program).
fatal_fault_f	This flag is defined as the condition *drv_flt_f* = true AND *sw_estop_f* = true. This flag is used as input only to differentiate between non-fatal faults (faults that set only the *drv_flt_f* and do not trip the drive) and fatal faults which trip the drive (also set the *sw_estop_f*). A true estop will not set this flag.

8.6.2. Special Notes

Ramp stop, quick stop, and coast stop flags have no effect during a drive trip. The drive will always stop in coast stop on either a trip or an inactive CR3 input. Also, these flags take no action to actually stop the drive, but determine *how* the drive will stop during a “normal” stop (removing the run request).

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8.6.3. Drive Conditions and Associated Internal Flags

Table 8-11 lists drive conditions and the flags that they control. Groupings are used to signify automatically controlled flags that cannot be changed through the system program. For example, the user faults set the drive fault flag automatically and do not need to be included in the *drv_flt_f* statement in the system program.

Table 8-11. Drive Conditions and Internal Flags

Condition	Set TRUE by/when…
sw_estop_f (only)	estop_f = [condition];[1]
sw_estop_f and *drv_flt_f*[2]	Hardware Generated Faults • EEPROM checksum failure • RAM checksum failure (flags set in version 1.13 and newer) • System program faults (system program checksum, Incompatible DRCTRY file (version of DRCTRY.PWM is either too old or too new - check version history for allowable range), System program for wrong drive (wrong drive type), No system program) • 15 Volt Encoder supply fault (interface board) • Medium Voltage OT trip (cell thermister to 10 V signal < 2 volts) (also sets the cell power fault flag) • Hardware drive faults (analog power supply fault [±15 volts on interface board], drive IOC, medium voltage loss of enable, medium voltage power supply fault, ±15 volt supplies on micro board, cell power fault [must check cell fault log for fault determination], illegal cell count, fault in motor voltage feedback [voltage > 20% when drive disabled], unlatched fault GAL trip, user module 24 v power supply [through hardware interrupt], cell hardware fault [indeterminate]). Software Generated Faults • Overspeed • Overload (current and time) • Motor overvoltage • Loss of encoder (vector control) • Analog data acquisition system (DAS) failed to initialize • XCL communication faults (3) when triggered through system program (setting the "*_log*" flags equal to the status flags) • CAB hardware failure • Programmable IC fault (caused by the chip being re-initialized externally, usually by noise).
drv_flt_f (only)	User Faults
Neither *sw_estop_f* or *drv_flt_f*	Ground Fault - This sets the system program flag *ground_flt_f* and fault word 2 bit 2 (system flag *flt_word2_2*). This also logs the ground fault into the fault logger in the drive fault flag (*drv_flt_f*) is true (regardless of what sets it). In order to create the fault, *ground_flt_f* must appear in both the *estop_f* and *drv_flt_f* statement lines. The flag *disable_ground_flt*, disables setting the fault word and *ground_flt_f* and prevents the fault

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	log message from appearing.

1 - System program control.
2 - The *fatal_fault_f* flag is also set true.

8.6.4. System Flag Seal-in

Some system program flags need to be sealed in when used in a logic statement. This is due to the dual use of the flags in both internal algorithms and in the system program. Since the output condition of the flag is controlled by a logic statement, if an internal condition sets the flag and the statement is not sealed, the next scan of the system program will clear it again causing a possible race condition or indeterminate state to exist. An example of this would be the drive fault flag. Many internal conditions cause the flag to be set. If the statement

```
drv_flt_f = <fault condition>;
```

is used, the flag will be cleared anytime the fault condition declared here is not true.

This should be written as

```
drv_flt_f = <fault condition> + drv_flt_f * /drv_flt_rst_f;
```

All user faults must be sealed in also but can be done more simply by the following expression:

```
user_fault1 = <fault condition> + user_fault1;
```

The seal-in is broken when the drive enters the fault reset sequence.

8.6.5. Drive Mode

Different "Mode" messages (the 4 character field on the left of the display) indicate a condition that prevents the drive from running if no fault message is displayed or the fault display has been cleared. This simplifies trying to troubleshoot the drive. They are shown below.

Table 8-12. Modes That Prevent the Drive from Running

Mode	Condition
Inh	drv_flt_f is set true and the drive is not running (trq_cntr_en_f is false) this is a non-fatal fault
CR3	the CR3 input is not closed (active)
FRst	the fault reset (drv_flt_rst_f) is true
SOP?	one of the 4 system program faults is active - check the fault log.
Trip	sw_estop_f and drv_flt_f are both true - this is a fatal fault and the fatal_fault_f will also be set.
Estp	sw_estop_f is true and drv_flt_f is false - this is a latched E-STOP and not a drive fault. The drive reset still needs to be used to clear.

> Note: For the fatal fault condition (when both *drv_flt_f* AND *sw_estop_f* are set) - The display will show the fault message. If the fault message is cleared via the menu selection Clear Fault Message in the "Overload Menu (34)" (from security level 7), then the mode on the display will read "Trip".

8.7. Sample System Program

This section illustrates a sample system program that might be written to control a typical Perfect Harmony drive configuration. A system program for the Perfect Harmony VFD can be written and installed using the following software tools:

- An ASCII text editor such as Microsoft Notepad™ (Windows)
- The ROBICON compiler program COMPILER.EXE
- The directory file DRCTRY.PWM (updated as required to match the software revision)
- A terminal emulator such as Hyperterminal™ (Windows).

This example program is written for a dual pump system in which redundant pumps are installed with a program to cycle the pumps. It also includes a section developed to address Transfer System interface functionality.

Refer to Appendix A for a description of system flags.

8.7.1. Comments Section

The first section of the system program usually consists of comments which explain the use of the various inputs and outputs used by the system program. Note that all comments must be preceded by a semicolon character (;). All equations must be followed by a semicolon even if a comment string is not used. Refer to the sample program section in Figure 8-5.

> **NOTE:** The program segments displayed in this chapter are examples only, and may not reflect the content of customized drives.

```
#HARMONY;
;---------------------------------------------------------------------------------
;System Program For Medium Voltage PWM Drive (Standard Performance)
;CUSTOMER:     ACME PUMP
;CO:           12345678
;P/N:          459280.00
;DATE:         January 1999
;FILE:         TEST_v1.SOP
;ENGINEER:
;---------------------------------------------------------------------------------
;REVISIONS
;              (Use this space to document SOP changes.)
;---------------------------------------------------------------------------------
; SYMBOL DEFINITION
;                             = equals       * logical and  + logical or
;                             / logical not  ; comment line
;---------------------------------------------------------------------------------
; INTERFACE BOARD TERMINAL REFERENCE
;   pib_aux1_f is the pump 1 contactor auxiliary contact
;              normally open...closes when the contactor is picked up
;   pib_aux2 f is the pump 2 contactor auxiliary contact
;              normally open...closes when the contactor is picked up
;---------------------------------------------------------------------------------
; USER MODULE REFERENCES
;              umdo00_a = DOM0_a = Condensation Heaters Enable
;              umdo00_b = DOM0_b = Drive Ready
;              umdo00_c = DOM0_c = Run request acknowledged
;              umdo00_d = DOM0_d = De-ionizer solenoid valve (n/o)

;              umdo01_a = DOM1_a = Pump 1 contactor
;              umdo01_b = DOM1_b = Pump 2 contactor
;              umdo01_c = DOM1_c = Do up transfer flag
;              umdo01_d = DOM1_d = Do down transfer flag
```

Figure 8-5. Comments Section of a Sample System Program Printout

```
;       umdi02_a  = DIM2_a = main flow switch
;       umdi02_b  = DIM2_b = pump 1 pressure switch
;       umdi02_c  = DIM2_c = pump 2 pressure switch
;       umdi02_d  = DIM2_d = transformer manifold overtemp (ts1 in water cab)
;       umdi02_e  = DIM2_e = cell manifold overtemperature (ts2)
;       umdi02_f  = DIM2_f = reservoir level low alarm
;       umdi03_a  = DIM3_a = reservoir level low trip
;       umdi03_b  = DIM3_b = jog pump 1
;       umdi03_c  = DIM3_c = jog pump 2
;       umdi03_d  = DIM3_d = transformer inlet overtemp (tsA in xformer cab)
;       umdi03_e  = DIM3_e = momentary auto start from PLC
;       umdi03_f  = DIM3_f = VFD fault reset push button
;       umdi04_a  = Up Request from PLC
;       umdi04_b  = Down Request from PLC
;       umdi04_c  = Transfer interlock
;       umdi04_d  = Transfer Fault Reset
;       umdi04_e  = VFD Contactor Ack.  Input
;       umdi04_f  = Line Contactor Ack.  Input
;       umdi05_a  = Spare
;       umdi05_b  = Spare
;       umdi05_c  = Spare
;       umdi05_d  = Spare
;       umdi05_e  = Spare
;       umdi05_f  = Spare
;       umdo06_a  = Heat exchanger fan control
;       umdo06_b  = Down transfer complete flag
;       umdo06_c  = Map phase error threshold compar_10_f
;       umdo06_d  = DC Eliminator enable
;---------------------------------------------------------------------------------
; KEYPAD REFERENCES
;
; kbd_run_led  - When true, " RUN"  led is lit on the keypad
; kbd_flt_led  - When true, " FAULT"  led is lit on the keypad
; kbd_flt_reset               - True while the " FAULT RESET"  key is pressed
; kbd_man_start               - True while the " MANUAL START"  key is pressed
; kbd_auto     - True while the " AUTOMATIC"  key is pressed
; kbd_man_stop - True while the " MANUAL STOP"  key is pressed
;
; compar_1_f = fixed percent of cond > .05 uS, 5%
; compar_2_f = fixed percent of cond > 1 uS, 10%
; compar_3_f = fixed percent of cond > 3 uS, 30%
; compar_4_f = fixed percent of cond > 4 uS, 40%
; compar_5_f = fixed percent of temp > 0 deg C, 50%
; compar_6_f = fixed percent of temp > 5 deg C, 55%
; compar_7_f = fixed percent of temp > 55 deg C, 77.5%
; compar_8_f = ground fault level
; compar_9_f = Speed feedback
; compar_10_f= Sync error check
; compar_11_f= Speed check for DC eliminator control
; timer00    = Transfer Fault Timer
; timer01    = dbounce for cond > 1uS
; timer02    = dbounce for cond > 3uS
; timer03    = dbounce for cond > 4uS
; timer04    = dbounce for temp > 0 deg C
; timer05    = dbounce for temp > 5 deg C
; timer06    = dbounce for temp > 55 deg C
; timer07    = Pump 1 delay soft timer #1 switch
; timer08    = Pump 2 delay soft timer #2 switch
; timer09    = reservoir level dropping alarm
; timer10    = time for pump 1 to reach operating pressure
; timer11    = time for pump 2 to reach operating pressure
; timer12    = xfer do contactor fault
; timer13    = timer for correct flow to be reached
; timer15    = spare
```

Figure 8-5. Comments Section of a Sample System Program Printout (Continued)

```
; temp01_f     = start request (remote)
; temp02_f     = Up transfer abort
; temp03_f     = soft switching day timer
; temp04_f     = soft switching /day timer
; temp05_f     = start request (local)
; temp10_f     = start pump 1
; temp11_f     = VFD CONTROL (AUTOMATIC MODE)
; temp12_f     = start pump 2
; temp13_f     = SETPOINT (AUTOMATIC)
; temp14_f     = flag for coolant flow level
```

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```
; temp15_f     = pump changeover logic
; temp16_f     = 1 second time base
; temp17_f     = XCL fault
; temp18_f     = pump flow
; temp19_f     = NOT USED
; temp20_f     = used for conductivity logic
; temp30_f     = Bypass contactor close pilot
; temp31_f     = VFD contactor close pilot
; temp32_f     = Map cr1_f
;
; comm_f01_0 = Up transfer request flag
; comm_f01_1 = Down transfer request flag
; comm_f01_2 = Transfer fault reset
; comm_f01_3 = Line contactor closed on motor being transferred to line
; comm_f01_4 = VFD contactor closed
; comm_f01_5 = Bypass pilot
; comm_f01_6 = VFD pilot
; comm_f01_7 = Spare
; comm_f01_8 = Up Transfer in progress
; comm_f01_9 = Spare
; comm_f01_10  = Spare
; comm_f01_11  = Spare
; comm_f01_12  = Spare
; comm_f01_13  = Up transfer Abort
; comm_f01_14  = VFD ESD Stop Command
; comm_f01_15  = VFD Run Requested
;
; serial_f0    = Okay to do up transfer
; serial_f1    = Okay to do down transfer
; serial_f2    = Up transfer sequence complete
; serial_f3    = Down transfer sequence complete
; serial_f4    = Up transfer failure
; serial_f5    = down transfer failure
; serial_f6    = Run request flag
; serial_f7    = Torque control enable flag
; serial_f8    = User Fault 8 Down Transfer Fault
; serial_f9    = User Fault 7 Ground Fault
; serial_f10   = User Fault 6 Pump Cycle failure
; serial_f11   = User Fault 5 Reservoir low level
; serial_f12   = User Fault 4 Water in manifolds over temperature
; serial_f13   = User Fault 3 Temperature below freezing
; serial_f14   = User Fault 2 Extra high conductivity
; serial_f15   = User Fault 1 Low Main Flow
;
; serial_f2_0  = Coolant Pump failure
; serial_f2_1  = High conductivity alarm
; serial_f2_2  = High H20 temperature alarm
; serial_f2_3  = Reservoir Low level
;---------------------------------------------------------------------------------
```

Figure 8-5. Comments Section of a Sample System Program Printout (Continued)

8.7.2. Flag Initialization Section

The next section of the system program is usually written to provide initialization of flags which configure the control system for various operating modes. A short description of these flags is available in Appendix A. Note also that many of these flags are referenced with respect to the system control drawing (479333) shown in Appendix B. Refer to Figure 8-6.

```
;---------------------------------------------------------------------------------
;INITIALIZED FLAGS
;
std_cntrl_f      = TRUE;  Set Harmony standard torque control algorithm
vel_dl_cntrl_f   = TRUE;  enable velocity double loop control
ai_sw1           = TRUE;  Torque command from speed regulator output
as_sw1           = TRUE;  auxiliary speed reference set to zero
aa_sw1           = TRUE;  auxiliary torque reference set to zero
vl_sw3           = TRUE;  forward speed limit from keypad setpoint
vl_sw5           = TRUE;  reverse speed limit from keypad setpoint
al_sw4           = TRUE;  positive torque limit from keypad setpoint
al_sw8           = TRUE;  negative torque limit from keypad setpoint
disable_ground_flt        = TRUE;           Disable ground fault logging
plc_a_select_f   = TRUE;  Enable PLC A Modbus Plus
;---------------------------------------------------------------------------------
;              Initialize 1 second clock.  Timer 14 will be used as a one second
timer
```

8

```
;               elsewhere in the program (with counter05 for xcl fault control, and
with
;               counter06 for sync delay control before transfer do signals).

timer14(1)      = /temp16_f;
```

Figure 8-6. Flag Initialization Section of a Sample System Program Printout

> The *fault_display* flag has been added to the DRCTRY.PWM file for use in Perfect Harmony system programs. This flag allows the Perfect Harmony to display non-fatal faults (i.e., ones that set the drive fault flag, but do not stop the drive like user-defined faults). This flag should be used in conjunction with timers to toggle the fault and normal display.

8.7.3. User Fault Text Message Setup

Text messages associated with user faults appear in this section.

```
;----------------------------------------------------------------------------------
;USER FAULT TEST MESSAGE SETUP
;
user_text_1 = “ Low Main Flow” ;                              ;low main flow
user_text_2 = “ High Conductivity” ;                          ;extra           high
conductivity fault
user_text_3 = “ Water Temp Below Freeze” ;    ;temperature below freezing
user_text_4 = “ Water Manifold OverTemp” ;    ;water manifolds over temperature
user_text_5 = “ Reservoir Level Low” ;                        ;reservoir level low
user_text_6 = “ Pump Cycle Failure” ;                         ;pump cycle failure
user_text_7 = “ Comparator Ground Fault” ;    ;comparator ground fault
user_text_8 = “ Down Transfer Fault” ;                        ;down transfer fault
user_text_9 = “ Contactor Sequence Fault” ;   ;contactor sequence fault
;----------------------------------------------------------------------------------
```

Figure 8-7. User Fault Text Message Section of a Sample System Program Printout

8

8.7.4. XCL Fault Control Logic Sections

Figure 8-8 illustrates typical logic used to control an external communications fault condition.

```
;XCL FAULT CONTROL LOGIC
temp17_f    = xcl_status_fail + Cab_hw_fail + xcl_data_fail;
counter05(2)   = temp17_f * timer14;
cntr_reset05= drv_flt_rst_f;
;
cab_hw_fail_log   = counter05 * cab_hw_fail;
xcl_data_fail_log  = counter05 * xcl_data_fail;
```

Figure 8-8. XCL Fault Control Logic Section

8.7.5. Transfer System Interface

The following section of the program implements the up and down transfer process. Refer to drawing 479333 for a description of the corresponding state machine diagrams.

```
;DC ELIMINATOR CONTROL
;  Enable the DC eliminator when operation is above 15% speed and not doing a down
transfer.
;
umdo06_d   = compar_11_f * /dnxfer_req_f * /dnxfer_complete_f;
;
;      In sync delay VFD must be below sync error threshold set on compar_10_f.
Set compar_10_f
;      A Manual Address (phase_error from locator file), B Fixed percent set to
2%.  C Magnitude
;      compar.  This will only let the do transfer through after the phase error
is less than 2% for 3
;      seconds.  This insures the PLL has settled out.
;
counter06(5)   = timer14 * /compar_10_f * phase_lock_enabled;
cntr_reset06   = counter06 *  upxfer_complete_f  + counter06 *  dnxfer_complete_f
           + compar_10_f + xfer_flt_rst_f + upxfer_flt_f + dnxfer_flt_f;
umdo06_c   = compar_10_f;                                  Map     phase     error
detection
;--------------------------------------------------------------------------------
;UP AND DOWN TRANSFER REQUEST FROM MBP OR INPUT MODULE
;   Up and down request can come either from the MBP via comm_f01 or user module
;   input via umdi04 if drive is not in cell bypass.
;
upxfer_req_f   = comm_f01_0 * /bypass_f + umdi04_a * /bypass_f
           + upxfer_req_f * trq_cntr_en_f * /upxfer_flt_f * /user_fault9;
dnxfer_req_f   =   comm_f01_1   *   /do_dn_xfer_f   *   /bypass_f     +   umdi04_b   *
/do_dn_xfer_f * /bypass_f
           + dnxfer_req_f * /dnxfer_complete_f * /dnxfer_flt_f * /user_fault9;
;--------------------------------------------------------------------------------
;SERIAL SEND FLAGS OVER NETWORK
serial_f0      = do_up_xfer_f * counter06 * umdi04_c;
serial_f1      = do_dn_xfer_f * counter06 * umdi04_c;
serial_f2      = upxfer_complete_f;
serial_f3      = dnxfer_complete_f;
serial_f4      = upxfer_flt_f;
serial_f5      = dnxfer_flt_f;
serial_f6      = run_req_f;
serial_f7      = trq_cntr_en_f;
serial_f8      = user_fault8;                ;Down Transfer Fault
serial_f9      = user_fault7;                ;Ground Fault
serial_f10     = user_fault6;                ;Pump Cycle failure
serial_f11     = user_fault5;                ;Reservoir low level
serial_f12     = user_fault4;                ;Water in Manifold OT
serial_f13     = user_fault3;                ;Temperature below freezing
serial_f14     = user_fault2;                ;Extra high conductivity
serial_f15     = user_fault1;                ;Low Main Flow
```

Figure 8-9. Transfer System Logic of a Sample System Program Printout

```
;-------------------------------------------------------------------------------
;USER MODULE SENT FLAGS
;
umdo01_c       = do_up_xfer_f * counter06 * umdi04_c;   do up transfer flag
umdo01_d       = do_dn_xfer_f * counter06 * umdi04_c;   do down transfer flag
;-------------------------------------------------------------------------------
;TRANSFER FAULT LOGIC
;
;              Timer 15 monitors the up and down requests for transfer.  If this
timer times
;              out either the up or down time out flags will be set.  These time
out flags then
;              set  the  transfer  up  or  down  fault.   Setting  this  aborts  the
transfer in progress
;              the  drive  will  drop  back  into  state  d.   In  order  to  attempt
transfer again the
;              xfer_flt_rst_f must be toggled.
;
timer00(90)    = upxfer_req_f * /upxfer_complete_f
                              + dnxfer_req_f * /dnxfer_complete_f;
upxfer_timeout_f              = timer00 * upxfer_req_f
                              + upxfer_timeout_f * /xfer_flt_rst_f;
dnxfer_timeout_f              = timer00 * dnxfer_req_f
                              + dnxfer_timeout_f * /xfer_flt_rst_f;
;-------------------------------------------------------------------------------
;CONTACTOR SEQUENCE FAULT
;
timer12(2)  = do_up_xfer_f * counter06 * /line_con_ack_f
                              + do_dn_xfer_f * counter06 * /vfd_con_ack_f;
user_fault9                   = timer12 + user_fault9 * /xfer_flt_rst_f;
temp02_f                      = /comm_f01_0 * /upxfer_complete_f * upxfer_req_f +
temp02_f * /xfer_flt_rst_f;
upxfer_flt_f                  =  upxfer_timeout_f  +  temp02_f  +  upxfer_flt_f  *
/xfer_flt_rst_f;
dnxfer_flt_f                  = dnxfer_timeout_f;
user_fault8                   = dnxfer_timeout_f;
xfer_flt_rst_f                = umdi04_d + comm_f01_2 + drv_flt_rst_f;
;-------------------------------------------------------------------------------
;VELOCITY GAIN SET AND RAMP SELECT FOR XFER CONTROL
;
;              Use velocity gain set 2 when PLL speed control is enabled.
;              Set vel_gain_set_2 P term for 40 and I term for 40.
;
counter11(2)   = phase_lock_enabled * /compar_10_f * timer14;
;
vel_gain_set_2 = dnxfer_req_f;
vel_gain_set_3 = counter11 * upxfer_req_f;
;
cntr_reset11      =  upxfer_complete_f  +  dnxfer_complete_f  +  upxfer_flt_f  +
dnxfer_flt_f;
;
vel_gain_set_1 = /vel_gain_set_2 * /vel_gain_set_3;
;
;              Set accel in ramp set 2 for 2 seconds.  This will only be active
when VFD is
;              running open circuit without a motor.
;
acc_sw4        = dnxfer_req_f;
acc_sw1        = /dnxfer_req_f;
;-------------------------------------------------------------------------------
```

Figure 8-9. Transfer System Logic of a Sample System Program Printout (Continued)

8

```
;------------------------------------------------------------------------------
;CONTACTOR LOGIC FOR FACTORY TEST ONLY
;This code is only used for Factory test at ROBICON in Pittsburgh.
;
;VFD CONTACTOR ACK CONTROL
;
vfd_con_ack_f  = comm_f01_4 + umdi04_e;
temp31_f       = comm_f01_13; Map PLC Serial Stop
temp32_f       = flt_word2_5;
;------------------------------------------------------------------------------
;LINE CONTACTOR ACK CONTROL
;
line_con_ack_f               = comm_f01_3 + umdi04_f;
temp30_f                     = comm_f01_15; Map PLC serial Start
```

Figure 8-9. Transfer System Logic of a Sample System Program Printout (Continued)

System program flags are available for monitoring system functions for the transfer phase lock loop (*phase_lock_enabled*), the drive direction sensing (*forward_f*) which determines the quadrant of operation (forward or reverse), and "*drive_ready*" which indicates the drive is in the idle state (drive state "A") and is not faulted or inhibited. These flags are for monitoring only, i.e., they can only be used as an input to a system program logic statement (to the right of the equals sign). Using this on the output side can have adverse effects. This warning also includes the following:

- *rollback_f* (ramp rollback in effect)
- all fault word bit flags (*flt_word1_0* to *flt_word2_15*)
- *ground_flt_f* (ground fault detected)
- *overload_pending* (TOL overload pending)
- *single_phase_f* (input line single phasing)
- *vavail_ok_f* (V available Ok flag from cells)
- *signal_loss_f* (loss of 4-20 mA signal)
- *cell_fault_f* (indicates a cell fault)

any others marked **input only** in the DRCTRY.PWM file.

8.7.6. Speed Reference Section

This section of the program defines the speed reference sources, enables the speed profile function in auto mode, and sets the auto mode on display. Refer to Figure 8-10.

```
;------------------------------------------------------------------------------
;SPEED REFERENCE
;
vd_sw24 = temp11_f;    Speed command source from isolated 4-20 mA input
vd_sw28 = /vd_sw24;    Speed command source from keypad up/down arrows
;sp_sw  = vd_sw24;     Speed profile enabled in auto
auto_f = vd_sw24;      AUTO mode on keypad display

;------------------------------------------------------------------------------
```

Figure 8-10. Speed Reference Section of a Sample System Program Printout

8.7.7. Local Start/Stop Logic Section

This section implements the standard push button latched start/stop logic. Refer to Figure 8-11.

```
;------------------------------------------------------------------------------
;LOCAL START/STOP
;
counter00(1)   = kbd_man_start * /kbd_man_stop * /drv_flt_f * /temp11_f;
cntr_reset00   = kbd_man_stop + drv_flt_f + /cr3_f + upxfer_complete_f;
temp05_f       = counter00;
;------------------------------------------------------------------------------
;VFD CONTROL (AUTO) and (Remote) Redundant controls

counter02(1)   = comm_f01_15 + cr1_f;        ;Auto Control from Serial Network
cntr_reset02   = comm_f01_13 + kbd_man_stop + drv_flt_f + /cr1_f + /cr3_f;

temp11_f   = counter02        ;Set temp11_f for Auto VFD Control
umdo06_b   = /kbd_man_stop * /upxfer_complete_f
;                             ;Export stop button to drop out CR1 control relay
```

Figure 8-11. Local Start/Stop Logic Sections

8.7.8. Pump Logic Section

The next section of the program implements the pump control logic. Note how the many available system program flags allow the flexible use of the hardware to overcome abnormal operating conditions, and hence, maximize the overall system reliability. The use of temporary flags can simplify the control equations, and facilitate the reusability of code.

> While the use of temporary flags may simplify equations and facilitate code reusability (especially if the statement replaced by the temporary flag is complex), overuse of temporary flags (especially as used in the following example to replace the timer flags) may tend to make the "code" more confusing and add to the system processing overhead. The following example is provided for illustration purposes only.

```
;------------------------------------------------------------------------------
;PUMP PRESSURE TEST
;
timer10(3) = /umdi02_b * temp10_f;    Check Pressure for Pump 1
counter07(1)                          = timer10;
;
timer11(3) = /umdi02_c * temp12_f;    Check Pressure for Pump 2
counter08(1)                          = timer11;

counter09(5)                          = timer10 + timer11;  Pump  cycle  stop  This
stops pump cycle after 3 faults

serial_f2_0                           = timer10 + timer11;  Pump  1  or  2  serial
pressure fault

cntr_reset07   = timer11 * /counter09 + umdi03_f;
cntr_reset08   = timer10 * /counter09 + umdi03_f;
cntr_reset09   = umdi03_f;

;------------------------------------------------------------------------------
```


Figure 8-12. Pump Logic Section of a Sample System Program Printout

```
;-------------------------------------------------------------------------------
;Pump 1 OPERATION
;
;              Line 1 Primary start
;              Line 2 Back up start if primary has pressure fault

timer07(3) =  days_timer_f * /counter07 + /days_timer_f * counter08 * /counter07;
temp10_f = timer07;
;
umdo01_a = temp10_f + umdi03_b;
;
;-------------------------------------------------------------------------------
;PUMP 2 OPERATION
;
;              Line 1 Primary start
;              Line 2 Back up start if primary has pressure fault

timer08(3)     =  /days_timer_f * /counter08
          + days_timer_f * counter07 * /counter08;
;
temp12_f  = timer08;
;
umdo01_b  = temp12_f + umdi03_c;
;-------------------------------------------------------------------------------
;HEAT EXCHANGER CONTROL
;
umdo06_a = temp10_f + temp12_f;    Heat exchanger control flags
;-------------------------------------------------------------------------------
;PUMP FLOW
;
timer13(10) = /umdi02_a * pib_aux1_f + /umdi02_a * pib_aux2_f;

temp18_f = timer13;

;-------------------------------------------------------------------------------
;CONDUCTIVITY SIGNAL, USE AUX2 INPUT
;
;              Set up comparators for the conductivity functions.   Conductivity
feedback
;              (in micro-siemens [μS]) comes in on tb1A-6,7 which is aux input #2,
2-10vdc.
;
;              4mA = .1uS, 20 mA = 10uS
;
;              compar_1_f = fixed percent of cond > .5 uS, 23.2%
;              compar_2_f = fixed percent of cond > 1 uS, 27.3%
;              compar_3_f = fixed percent of cond > 3 uS, 43.4%
;              compar_4_f = fixed percent of cond > 4 uS, 51.5%
;
temp20_f  = compar_2_f + temp20_f * compar_1_f;
timer01(2)     = temp20_f;
temp21_f  = timer01;
umdo00_d  = /temp21_f;        If cond > 1 uS, leave solenoid valve open.
;                                            until cond < .5 uS.
timer02(30)    = compar_3_f;
temp22_f  = timer02;
;
serial_f2_1    = temp22_f;                   Serial  flag  for  High  conductivity
alarm
;
timer03(30)    = compar_4_f;                 If  cond  >  4  uS  then  trip  drive  on
user flt 2
temp23_f  = timer03 + temp23_f * /drv_flt_rst_f;
;-------------------------------------------------------------------------------
```

Figure 8-12. Pump Logic Section of a Sample System Program Printout (Continued)

```
;-------------------------------------------------------------------------------
;COOLANT TEMPERATURE, USE AUX1 INPUT
;
;              Set   up   comparators   for   the   coolant   temperature   monitor.
Temperature feedback
;              comes in on tb1A-4,5 which is aux input #1, 2-10vdc.
;
;              4mA = -100 deg C, 20 mA = 100 deg C
;
;              compar_5_f = fixed percent of temp = 0 deg C, 60%
;              compar_6_f = fixed percent of temp > 5 deg C, 62%
;              compar_7_f = fixed percent of temp > 55 deg C, 82.5%
```

8

```
;
timer04(30)    = /compar_5_f;                If temp < 0 deg C, then trip.
temp24_f  = timer04 + temp24_f * /drv_flt_rst_f;
;
timer05(30)    = /compar_6_f;
temp25_f  = timer05;
timer06(3)     = compar_7_f;
temp26_f  = timer06;
;
serial_f2_2    = temp26_f;                   Send  high  water  temp  warning  via
serial network
;
;------------------------------------------------------------------------------
;RESERVOIR LEVEL LOGIC
;
timer09(10) = umdi03_a;
temp28_f = timer09 + temp28_f * /drv_flt_rst_f;
;
serial_f2_3 = umdi02_f;   Send low level alarm via serial network
;------------------------------------------------------------------------------
```

Figure 8-12. Pump Logic Section of a Sample System Program Printout (Continued)

8.7.9. Run Request and Drive Fault Logic Sections

In this section of the system program, the run request and drive fault conditions are specified. The state of the run_req_f and drv_flt_f flags play an important role in determining the run state of the Perfect Harmony VFD. Reference drawing number 479333, sheet 6 for more information about these flags. Refer to Figure 8-13.

```
;------------------------------------------------------------------------------
;RUN REQUEST
;
run_req_f      = temp11_f * /drv_flt_f * cr3_f
         + temp05_f * /drv_flt_f * cr3_f
         + dnxfer_req_f * /dnxfer_flt_f  * /drv_flt_f * /dnxfer_complete_f * cr3_f
         + upxfer_req_f * /upxfer_flt_f * /drv_flt_f * /upxfer_complete_f * cr3_f;
;
;       Note that the use of temp flags to replace the counter flags in the logic
above (temp05_f is
;       set equal to counter00 and temp11_f is set equal to counter02) might be
confusing to a
;       less-than-expert  programmer.   The  key  benefit,  however,  is  that  this
section can be located
;       either before or after the definition of the counters.  In most cases, the
added complexity
;       is not warranted, but it is included here for illustration purposes.
;
;------------------------------------------------------------------------------
```

Figure 8-13. Run Request and Drive Fault Logic Sections in a Sample System Program

8

```
;-------------------------------------------------------------------------------
;DRIVE FAULT LOGIC
;
drv_flt_f =  loc_pcl_flt
          + drv_flt_f * /drv_flt_rst_f;
;
estop_f   = drv_flt_f * /drv_flt_rst_f
          + user_fault1 + user_fault2
          + user_fault3 + user_fault4
          + user_fault5 + user_fault6
          + user_fault7 + user_fault8
          + user_fault9;
;
drv_flt_rst_f                = umdi03_f + comm_f01_2;      fault  reset  from  the
VFD Fault Reset PB
;
estop_rst_f    = umdi03_f + comm_f01_2;      estop reset from the VFD Fault Reset
PB
;
user_fault1    = temp18_f
          + user_fault1 * /drv_flt_rst_f;    If main flow < 100 GPM then trip on
user fault 1.
;
user_fault2    = temp23_f;                                If conductivity > 4 uS
then trip on user fault 2.
user_fault3    = temp24_f;                                If  temp  <  0  deg  C,
then trip drive on user fault 3.
user_fault4    = /umdi02_d + /umdi02_e
          + /umdi03_d
          + user_fault4 * /drv_flt_rst_f;    Trip   on   xfmr   manifold   OT,   cell
manifold OT,
;                                            or xfmr inlet OT.
;
user_fault5    = temp28_f;                   Trip if reservoir drops  2"
user_fault6    = counter09;                  Trip if pump cycle fails.
;
temp29_f       = dnxfer_req_f + upxfer_req_f;
user_fault7    = compar_8_f * /temp29_f
          + user_fault7 * /drv_flt_rst_f;    Trip  if  ground  fault  level  is  too
high.
;
umdo00_b       = /drv_flt_f * cr3_f;
umdo00_c       = trq_cntr_en_f;
;-------------------------------------------------------------------------------
```

Figure 8-13. Run Request and Drive Fault Logic Sections (Continued)

8

8.7.10. Miscellaneous Logic Section

This final section of the system program contains miscellaneous information. Refer to Figure 8-14.

```
;-------------------------------------------------------------------------------
;MORE DIGITAL OUTPUTS AND LED INDICATORS
;
;              INTERFACE BOARD RELAY CONTROL
;              Cr0 is energized when motor is running.
;              Cr6 is energized when no VFD faults exist.
;              Cra is energized when no VFD alarms exist.
;
cr0_f    = trq_cntr_en_f;
cr6_f    = /drv_flt_f;
cra_f    = /temp22_f * /temp26_f * /umdi02_f * /timer10 * /timer11;
;
counter04(300) = /trq_cntr_en_f * timer14;
cntr_reset04 = trq_cntr_en_f;
;
umdo00_a = counter04;
;
kbd_flt_led   = drv_flt_f;
;
counter10(1)  = vel_gain_set_2 * timer14;
counter12(2)  = vel_gain_set_3 * timer14;
;
kbd_run_led   = run_req_f * /counter10 * /counter12;
 ;
cntr_reset10  = /timer14;
cntr_reset12  = counter12;
;
;Reset temp flag
temp16_f = timer14;
;-------------------------------------------------------------------------------
;END PROGRAM
```

Figure 8-14. Miscellaneous Logic Section of a Sample System Program Printout

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8

CHAPTER 9: TRANSFER SYSTEM PLC INTERFACE

In This Section:

9.1. Introduction

Perfect Harmony drives can be used to control multiple motors. Such applications are used to proportionally 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 can be 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 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. 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. Refer to Figure 9-1.

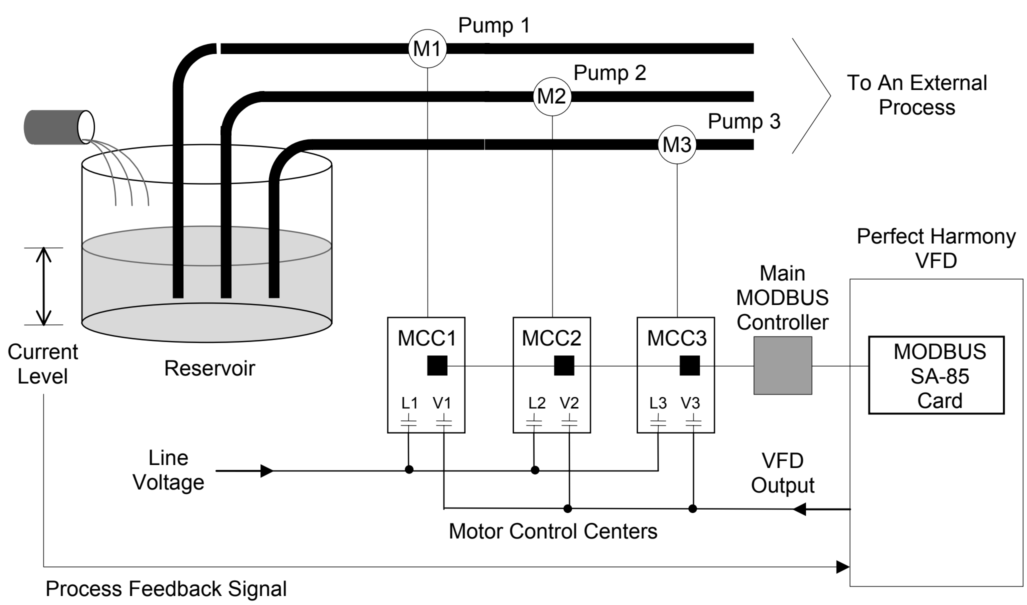

Figure 9-1. Overview of a Sample Transfer Application

Figure 9-1 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 Plus protocol) 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 9-2. A “down transfer” process is illustrated graphically in Figure 9-3. 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.

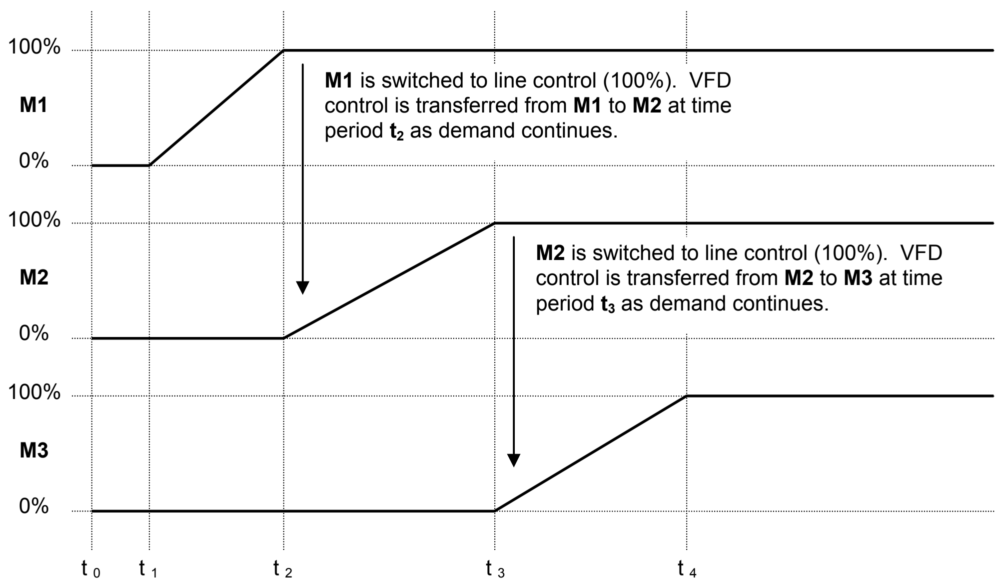

Figure 9-2. Graphical Representation of a Sample “Up Transfer” with Continued Demand

Note that the graphs in Figure 9-2 and Figure 9-3 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 $\mathbf{t_4}$ is assumed in Figure 9-2 and no demand is assumed throughout time period $\mathbf{t_9}$ in Figure 9-3. An overview of the control states of the motors used in example Figure 9-2 is given in Table 9-1. A similar overview for Figure 9-3 is given in Table 9-2.

☝

> 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.

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Table 9-1. Control States of Motors in a Sample "Up Transfer"

Time	M1	M2	M3
t_0	VFD (0-100%)	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%)

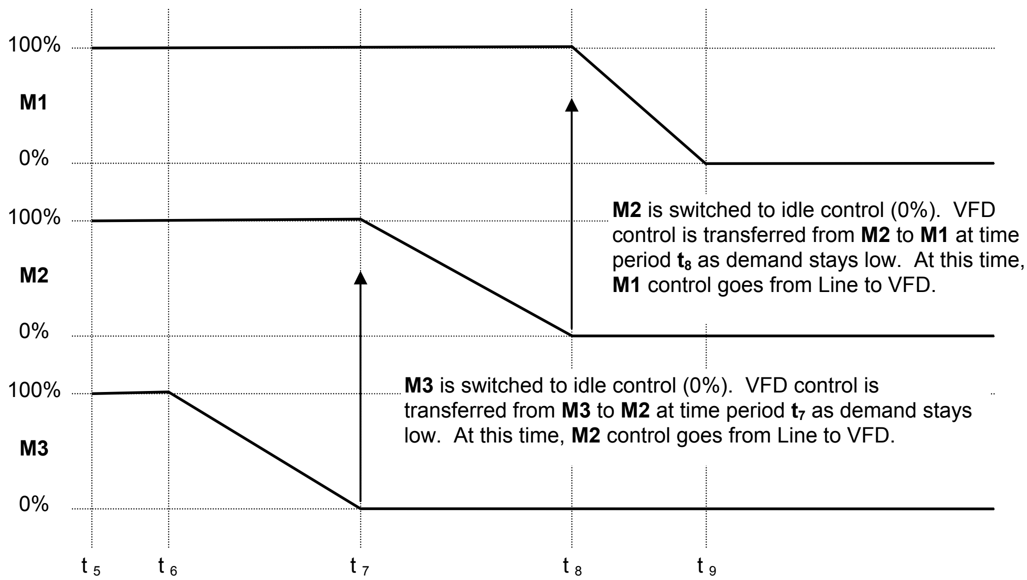

Figure 9-3. Graphical Representation of a Sample "Down Transfer" with No Demand

Table 9-2. 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 (100-0%)	Off (0%)	Off (0%)

9.2. 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 Plus 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 a Modicon SA-85 communications board on the Perfect Harmony drive. Refer to Figure 9-4.

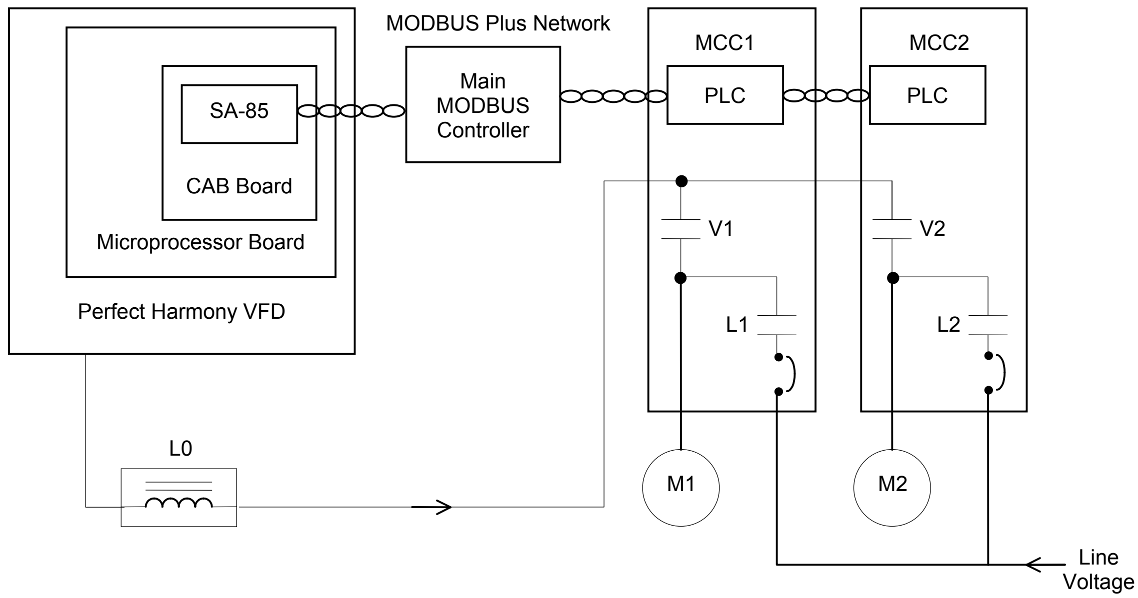

Figure 9-4. Communications Outline Drawing using a Modbus Plus Network Configuration

PLC interface refers to Modicon's MODBUS Plus Serial interface only.

9.3. The "Up" Transfer (from VFD to Line Control)

The "up" transfer process (refer to Figure 9-2) consists of the following steps.

1. The Modbus PLC issues a request for an "up transfer" by setting *upxfer_req_f* to true.
2. The VFD ramps to 60 Hz.
3. The Modbus PLC enables the Perfect Harmony VFD to synchronize its output to the line frequency.
4. The Perfect Harmony drive issues a *do_up_xfer_f* command to the Modbus PLC.
5. The PLC closes the line contactor (e.g., **L1**).
6. The PLC sends a signal to the VFD indicating the line contactor (e.g., **L1**) is closed.
7. The VFD receives the line contactor signal and sends an *upxfer_complete_f* message to the Modus PLC.
8. The PLC disables the *upxfer_req_f* input.
9. The PLC disables the VFD by removing the *run_req_f* input signal.
10. The PLC clears the "line contactor closed" signal to the VFD.
11. New motor parameters are loaded through the Modicon PLC interface for the next operation (or stays idle).

9.4. The "Down" Transfer (from Line to VFD Control)

The "down" transfer process consists of the following steps.

1. The Modicon PLC loads the correct motor parameters into the drive system.
2. The Modicon PLC issues *dnxfer_req_f*.
3. The Perfect Harmony VFD ramps to 60 Hz open circuit.
4. The Modbus PLC enables the Perfect Harmony VFD to synchronize its output to the line frequency.
5. The Perfect Harmony drive issues a *do_dn_xfer_f* command to the PLC.
6. The VFD contactor (e.g., **V1**) is closed by the PLC.
7. The PLC sends a signal to the VFD indicating the VFD contactor (e.g., **V1**) is closed.

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8. The PLC checks the status of the VFD fault signal.
9. The line contactor (e.g., L1) is opened.
10. The PLC removes the *dnxfer_req_f* flag.
11. The VFD sends the *dnxfer_complete_f* message to the PLC.
12. The VFD follows the process setpoint from the PLC.

9.5. Required Signals

Table 9-3 lists descriptions of signals that are required for synchronous transfer operation. Table 9-4 lists required program flags with their respective functions.

Table 9-3. Required Signals and Descriptions

Signal	Description
upxfer_req_f	Input signal from PLC used to request transfer from VFD to Line.
dnxfer_req_f	Input signal from PLC used to request transfer from Line to VFD.
vfd_con_ack_f	Input from PLC to indicate that the VFD output contactor is closed.
line_contactor_ack_f	This contact closes during the up transfer sequence to indicate the line contactor for the motor being driven from the VFD has closed. This signal needs to be masked for multiple motor applications.
do_up_xfer_f	This will indicate that the VFD is running in sync with the line sync signal and is ready to transfer the motor to the line.
do_dn_xfer_f	This will indicate that the VFD is running in sync with the line sync signal and is ready to transfer the motor to the VFD.

Table 9-4. Program Flags and Descriptions

Flag	Reference Address	Function
upxfer_req_f	2042 0 1	Begins a closed up transfer
dnxfer_req_f	2044 0 1	Begins a closed down transfer
xfer_flt_rst_f	2250 0 1	Transfer fault reset
upxfer_flt_f	2252 0 1	Up transfer fault flag
upxfer_timeout_f	2254 0 1	Up transfer time-out flag
do_up_xfer_f	2256 0 1	Up transfer output flag
dnxfer_flt_f	2258 0 1	Down transfer fault flag
do_dn_xfer_f	225A 0 1	Down transfer output flag
dnxfer_timeout_f	225C 0 1	Down transfer time-out flag
upxfer_complete_f	2270 0 1	Up transfer complete flag
dnxfer_complete_f	2272 0 1	Down transfer complete flag
line_con_ack_f	225E 0 1	Line contactor closed flag
vfd_con_ack_f	226E 0 1	VFD contactor closed flag

9.6. Additional Parameter Descriptions

Transfer Menu (200) is used exclusively for synchronous transfer applications. The menu items and descriptions for this menu are listed in Table 9-5. This information is also available in Chapter 3 of this manual.

Table 9-5. Transfer Menu (200)

Parameter	Range (Min, Max)	Default Value	Description	Sec. Level	HMPD Codes
Phase I gain	0, 15	1	Specifies the integral gain of the phase lock loop. The speed at which the drive will integrate the phase error is determined by the following calculation: Phase I Gain * 1/T where T is the sampling rate (e.g., 2.7 ms).	7	1000
Phase P shift	1, 12	8	Specifies the proportional gain of the phase lock loop. The proportional term is determined using the following equation: $(0.5)^{\text{Phase P Shift}}$ (0.5 raised to the "Phase P Shift" power).	7	1000
Phase offset	0.0, 180.0	0.0 deg	Specifies the phase angle setpoint expressed in degrees leading.	7	1000
Hardware offset	-180.0, 180.0	0.0 deg	Correction factor for aligning synchronization (+ is leading, - is lagging).	7	1000
Phase error threshold	0.0, 5.0	0.0 deg	Specifies the phase synchronization error. This parameter adjusts the amount of error allowed and is expressed in degrees.	0	0001
Line sync source	0, 2	0	This parameter specifies the hardware line synchronization interrupt: 0 - Off 1 - Local 2 - Remote 3 - Microprocessor Board.	7	1001

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CHAPTER 10: COMPILER AND REVERSE COMPILER

In This Section:

10.1. Compiler

10.1.1. Overview

Many of the ROBICON ID Series of digital drives implement the ability to execute customized programmable logic functions that are either factory or field programmed. These functions are repetitively executed in the drive and can implement functions such as drive start/stop logic, control logic, digital logic inputs/outputs, lamp annunciators, interlocks, drive/machinery coordination and more.

The logic functionality to be implemented is described off-line in an ASCII text file using simple Boolean statements and operators. This ASCII system program source file is then compiled into a binary form to generate a hex image file of the system program. This 'hex' file is then serially 'downloaded' into the drive during an inactive state in and stored in nonvolatile memory in a binary form.

During system operation, the system run time software executes these binary statements in a repetitive sequence to cause the intended logic statements to perform their functionality.

The binary system program can be serially 'uploaded' to a external computer for archival or reverse compilation purposes. Such a reverse compilation can yield information about the system program statements that are executed internal to the drive.

The purpose of the system program compiler is to off-line transform the human readable logic statements into a binary form that the drive can then implement in real time. The compiler is an off-line program that executes on an IBM compatible computer. The compiler reads in the source input file, 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 the Intel Hex File format. An overview of file formats used in this process is given in Table 10-1.

Table 10-1. File Formats Used in System Program Compiling and Reverse Compiling

Process	File Format Information
Upload (drive to PC)	.HEX file
Reverse compile	.HEX file changes to .DIS file
Compile	.SOP file changes to .HEX file
Download (PC to drive)	must be .HEX file

10.1.2. Input Source File

The logic statements to be executed in the drive are entered into a file using any standard ASCII text editor. The file can contain both logic statements and explanatory comments to aid in documenting the content and intent of the logic statements. The order of the statements in the source file is the order that the statements will be executed by the system run time software. (Except for logic assignments where the source state is a simple TRUE or FALSE. In this case the assignment is made only once at runtime software initiation). It is also important to note that the execution flow of the run time software is to (1) scan the input flags and record their present state(s), (2) execute the logic equations based on the recorded input states and then (3) output the results of the logic statement(s).

> Note: Always save a copy of the original SOP before making any changes. The file name extension must be .SOP to be compiled. The compiler (cmp.exe) will change the file extension from .SOP to .HEX. It can then be downloaded to the drive.

10.1.3. Symbol Directory File

The symbols that are permitted for use in a source file are defined to the compiler using a Symbol Directory File. This directory file is unique to the end target system and is opened by the System Program Compiler for use in 12

validating the syntax and generating the binary hex form of the system program. If an attempt to use a symbol that is not defined by the directory file, an error will result. See the section on the System Program Directory File for more details.

10.1.4. Output Hex File

The results from the compiler that contains the encoded logic functions is stored in an output hex file. This file has an Intel hex record format, and when interpreted as an Intel Hex file by the drive during the download process, results in a binary image of the logic functions that are stored and later executed by the drive. Each line of the hex file contains its own checksum, and in addition, the compiler generates an overall file checksum. All of these checksums are validated during system program downloading to ensure correctness prior to using the statements inside the drive.

10.1.5. Compiler Invocation

The compiler is a MS-DOS application that is invoked with or without command line fields and options. If the compiler is invoked without command line fields, the compiler will prompt for required fields (but will default non required fields).

The syntax for the command line is:

CMP <inputfile> <dirfile> </t:nn> </h> </s>

where:	<inputfile>	is the input source system program file.	(required)
	<dirfile>	is the name of the directory file	(optional)
	</t:nn>	defines a system type to the compiler	(optional)
	</h>	requests help text	(optional)
	</s>	requests file size info to be printed	(optional)

The input filename follows standard DOS filename format. If no extension is given, .SOP will be used as a default. If a <dirfile> is not specified, the file "DRCTRY.DAT" in the current directory will be assumed. If it is not found, an error message will be given.

> Note: A copy of the program DRCTRY.PWM (drctry.dat) must be within the same directory as the compiler and reverse compiler.

10.1.6. 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 end system. There are two methods that can be used to inform the compiler what the end target is.

The first method (and least preferred) is to define the system type on the invocation command line using the /t:n switch. In this case n is defined as:

1	HARMONY
2	ID_454GT
3	ID_CSI
4	HARMONY_DC (torch supply for example)
5	ID_2010 DC Drive

The second method is to include as the FIRST line in the system program SOP file a line such as:

#SYSTEM_TYPE;

The statement must be on the first line, with the '#' in column 1 and end with a semicolon. A comment can follow the semicolon.

Where SYSTEM_TYPE is one of HARMONY, ID_454GT, ID_CSI, HARMONY_DC or ID_2010. Using this definition provides a lasting identification to the compiler of what end target is expected.

Based on the system type, a unique directory file will be searched for. 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 file searched for is as follows:

HARMONY	DRCTRY.PWM
ID_454GT	DRCTRY.IGB
ID_CSI	DRCTRY.CSI
HARMONY_DC	DRCTRY.HDC
ID-2010	DRCTRY.DC

10.1.7. Statement Format

The format for an system program source statement is as follows:

output_symbol = <u_operator>input_symbol <[b_operator input_symbol] ...>;

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 optional space(s) and then the required assignment operator '='. A source statement can contain only a single assignment operator.

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. There is no syntactical limit on the number of input symbols that may be combined, but there is a practical limit imposed by the compiler. The input symbols and binary operators are evaluated left to right by the run time software, with '*' having a higher precedence over '+' in binary operators. Unary operators have a higher precedence over binary operators. The statement is terminated with a semicolon (which is required).

Symbol names are case sensitive. The symbols symbol_1, Symbol_1 and SYMBOL_1 are all unique.

10.1.8. Operators

There are two forms of operators, unary and binary. Unary operators take the form:

/	NEGATE

For example, the expression '/zero_spd_f' would equate to NOT zero_spd_f. If the input variable 'zero_spd_f' were FALSE, then '/zero_spd_f' would equate to TRUE.

Binary operators take the form:

+	OR
*	AND

The unary '/' (NEGATE) will form the inverse logic equivalent of the symbol immediately following it for incorporation into the statement evaluation. The '/' must be followed by an input symbol.

The operators implement the following truth tables:

A	B	A + B
FALSE	FALSE	FALSE
FALSE	TRUE	TRUE
TRUE	FALSE	TRUE
TRUE	TRUE	TRUE

A	B	A * B
FALSE	FALSE	FALSE
FALSE	TRUE	FALSE
TRUE	FALSE	FALSE
TRUE	TRUE	TRUE

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 muse be formed with left to right precedence and must be expanded to simple form. Examples follow.

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 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

10.1.9. Comments

Comments can appear at any point in an source line, but not in the middle of a statement. All text following a semicolon on a line are treated as comments, but the first semicolon encountered in a statement is treated as the statement terminator.

10.1.10. Input Flags

Input flags are symbols that are encountered on the right hand side of a source statement that express the state of an input to the system. They may reflect the state of some digital input or switch (*loc_sw_tb5_1*, etc.), the state of a system process (*trq_cntr_en_f*, *phase_loss_f*, *zero_spd_f*, etc.), timer state (*timer_01*), internal variable (*temp01_f*), comparator flag (*compare_01_f*), or a simple literal (TRUE, FALSE). These input flags are combined using the unary and binary operators to form the desired logic expressions.

10.1.11. Output Flags

The output flags (the symbol placed on the left hand side of the assignment '=' operator) direct the result of the input expression towards a output purpose. Output flags represent items such as digital outputs (*loc_lamp_tb4_2*, *relay_1*, *kbd_run_led*, etc.), system control switches (*vl_sw1*, *qstop_f*, *drv_flt_f*, etc.), counter/timer enables (timer01(20.0), counter01(10), etc.) and serial flags (*serial_f01_1*).

10.1.12. Constants

The system constants TRUE and FALSE are predefined and can be used as input terms to an expression. Note that any expression that equates to 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.

10.1.13. Control Outputs

Each ID Series of 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, drive emergency stop 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). In addition, there is an implied precedence to the switches contained within a group of similar names. The switch with the highest numerical content will have priority over the other switches which may be set. For example, if *vd_sw2*, *vd_sw4* and *vd_sw10* were all set, the switch *vd_sw10* would have precedence over the other switches. Thus it is not required to have only one switch in a group set to get the desired effect, one must only ensure that the desired switch has the highest precedence.

10.1.14. Digital Inputs

The digital input flags generally represent 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. For example, the digital inputs from a keypad are scanned from the keypad by the keypad microprocessor, then that information is passed to the main drive microprocessor during the next keypad message (up to 16 or 20 ms later), then that information is scanned by the system program run time software.

10.1.15. Digital Outputs

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 (except for constant expressions which are only set during system program initiation).

10.1.16. Serial Flags

Serial flags are a 16 bit field that can be sent from the drive to an external device. There are two serial flags, one that is used for PLC (or XCL) type external communication (*serial_f*) and another (*serial_fd*) that is used for drive-to-drive communications in products that support DCL. Each bit in these words have an associated system program symbol that is used (generally on the output side) to set or clear the corresponding bit in the resulting 16 bit output word.

10.1.17. Communication Flags

There are two sets of 16, 16 bit words (*COMM_Fxx* and *COMM_FDxx*) that are used to input digital bit information from PLC networks and drive-to-drive communication links into the system program. Each 16 bit word has a system program symbol assigned to it. These symbols, representing a single bit in the communication flag, can be used on the input side of a logic statement to input digital information from an external PLC or device. For example *COMM_02_5* represents bit 5 from the external flag *COMM_02*. The source PLC and register for *COMM_02* is defined from the keypad under the XCL Receive Items menu.

10.1.18. Temporary Flags

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, setting a temporary flag to the intermediate results and then using the flag instead of the longer expression.

For example:

```
mc_pickup_f = umdi01_a + umdi01_b + run_req_f;
loc_lamp_tb4_5 = umdi01_a + umdi01_b + run_req_f;
loc_lamp_tb4_6 =  umdi01_a + umdi01_b + run_req_f;
```

could be replaced with:

```
temp01_f =  umdi01_a + umdi01_b + run_req_f;
mc_pickup_f = temp01_f;
loc_lamp_tb4_5 = temp01_f;
loc_lamp_tb4_6 = temp01_f;
```

10.1.19. Comparators

There exists the capability to compare 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 (*compar_1_f ... compar_16_f*) are available for use in the system program as input symbols.

10.1.20. Timers

The ability to implement a time-out function is 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 may be set in multiples of time tic intervals dependent on the particular system (60 per second on ID-CSI and Harmony drives, or 200 per second in ID-454GT drives). The units specified in the logic statement is seconds (with a decimal fraction rounded to the nearest tick). Time intervals are up to 32768 time tics long (9.1 minutes for ID-CSI and Harmony or 2.7 minutes for ID-454*GT*).

> Note that on the ID_2010 and ID_CSI drives the timers are based on the line frequency, if the line frequency is not exact, the timer's timing will be correspondingly incorrect.

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.

10.1.21. Counters

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;
cntr_reset_01 = 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 counter01 (and *output_a*) will be set TRUE. After 13 transitions, *counter01* will remain TRUE until it is cleared by *cnter_reset01*. The maximum count value must be less than 32768. The count value must be an integer.

10.1.22. User Fault Text

There exists the capability for the system program to define the text that is displayed as a result if User Faults in the system. The compiler and runtime system have this added capability. The definition line(s) have the form:

```
user_text_1 = “ My Fault text” ;
user_text_2 = “ My second fault” ;
user_text_15 = “ I have no faults” ;
```

The statement begins with the output symbol identifying the fault message number. Following that is the assignment operator and then followed by a text string delimited with double quotation marks. The text string can be up to 24 characters and will be truncated if longer. This text information is compiled and placed into the hex file from which the run-time software will use it if a user fault occurs. In the event that a user fault occurs that does not have text assigned for it, the default messages “User Fault xx” will be used.

10.1.23. Error Messages

In the event that an error occurs during system program compilation, error message(s) will result that will indicate the problem and lead the user towards problem resolution. Error messages are listed in Table 10-2.

Table 10-2. Error Messages

Error Message	Description
ERROR!! file %s cannot be opened	DOS error (file corrupted or not found). %s is the directory file.
WARNING...DRCTRY.DAT overflows internal storage	Too many flags (>1000) are in the directory file.
ERROR!! a filename must be entered	No source filename was given either on the command line or prompt.
ERROR!! file << %s >> cannot be opened” (prompted)	DOS error (file corrupted or not found). %s is the source file.
ERROR!! file %s cannot be opened (command line)	DOS error (file corrupted or not found). %s is the source file.
ERROR!! opcode >>%s<< not supported	Either not in directory or not a legal opcode (+ * ;).
ERROR!! input >>%s<< is not an input type	The 4th field of flag token in directory must be (1, 2, 3, 4, 5, 6, 8, 9).

Error Message	Description
ERROR!! input >>%s<< not in directory	Cannot find flag name (%s) in the directory file.
ERROR!! expecting = got >>%s<<	Was expecting an equal sign '=' after an output flag name or compiler could be out of sync with source.
ERROR!! output >>%s<< is not an output type	The 4th field of flag token in directory must be (1, 2, 3, 4, 5, 6, 8).
ERROR!! output name >>%s<< not in directory	Cannot find flag name (%s) in the directory file.
ERROR! no timer/counter defined	Timers and counters must be defined as outputs before they can be used as an input.
ERROR!! input scan table is full	Only a maximum of 800 input flags can be used (although each can be used more than once).
ERROR!! Reset used without a defined counter	Counters must be defined as outputs before their associated reset flags can be defined.
ERROR!! output scan table is full	Only a maximum of 800 output flags can be used. (An output can only be defined once.)
ERROR!! logic table is full	A maximum of 5,000 entries can exist in the logic table - this roughly evaluates to the total number of flags that are used counting a flag for each use in an expression.
ERROR!! expecting (got >>%s<<	Enclosing parentheses not used or number format not proper for a counter or timer.
ERROR!! expecting) got >>%s<<	Enclosing parentheses not used or number format not proper for a counter or timer.
ERROR!! data overflows EEPROM	The entire system file will occupy more space than is available on the EEPROM (4K [4096] bytes on the IDCSI and existing ID2010 drives. This is limited to about 2.5K bytes on the new ID2010's with PLC communications capability).

10.1.24. Limitations and Other Cautions

- 800 individual inputs
- 800 individual outputs
- 5000 logic table entries
- 4K (2.5K) file size
- counters and timers defined as outputs before using as inputs
- counters must be defined before defining resets
- flag names up to 20 characters only 16 significant
- timer numbers must have a preceding ‘0’ if less than 1
- timer values only valid for 60 Hz line frequency (based on 360) on ID-CSI
- directory file must be in current DOS directory with source unless the full path name is given on the command line
- If an output is listed more than once with a different equation the compiler will generate an error. It will obligingly generate the logic for both equations, but only the last statement will have a lasting effect.
- The output from one statement is immediately available as an input to any following statements! Therefore *evaluation order may be critical*! This is true even though the control code must wait until the entire system program is evaluated before seeing changes.

Attention! The evaluation order of expressions in the system program is critical.

10.2. System Program Directory File

10.2.1. Overview

The system program directory file defines, for the compilation and reverse compilation functions, valid symbolic names for the inputs and outputs that can be used in the system program. In addition, the specific type code, bit address and system address for the symbol is defined. If a symbol is not defined in the directory file, it cannot be used in as system program. In addition, the numeric information contained in the directory file must match that expected by the embedded run time software in the system. This defines that the content of the directory file cannot be changed by the user because it closely associated with the run time software.

The directory file can be used as a reference to look up the possible variables that can be used in the system program however since it defines the list of possibilities.

The format of the directory file is as follows:

<variable name> <system_address> <bit_address> <type_code>

Each line (except those that are comment lines containing an exclamation point character as the first non white space character) begins with the name of the symbol to be defined. Each symbol must be unique and are case sensitive. Following the symbol name are 4 hex digits that define the system address for that variable. This address is used by the run time software to reference the actual information. Next is a bit number for bit oriented variables. It is zero for non bit oriented variables. The last field defines the type of the variable. The bit types defined are somewhat dependent on the target system, for exact details, please see the responsible software engineer for that product.

10.3. Run Time Software

10.3.1. Overview

A brief description of how the drive implements the system program software is given here to aid in understanding so that system programs can be written with this understanding. This section is not intended to answer all questions about how the drive functions.

10.3.2. System Program Storage

The drive stores the system program in non volatile EEPROM internal to the drive. This provides a semi-permanent storage for the program statements, but permits modification of the system program as required. There is a maximum size that the system program can attain. This is AFF hex bytes for the ID2010 and Harmony and FFF hex bytes for ID-454 GT and IC-CSI.

10.3.3. Software Initiation/Restarts

At system startup, or after a new system program is downloaded, the system program is copied from EEPROM into RAM (where it executed). The system program can be separated into two parts: those statements that are data dependent and those that are not. Statements such as output = TRUE; are not dependent on system data and need to be executed only once during system program initiation. The system program speeds normal execution by executing such invariant statements only once during startup, and then bypassing them in later execution loops.

10.3.4. Input Phase

The execution loop begins with the input phase. This is the phase where all of the input variables are filled with current data about the system. For example, if the variable *loc_sw_tb4_5* is referenced, then the actual state of *loc_sw_tb4_5* is obtained from the hardware and placed into that variable during this phase. After all of the input variables are filled with the current states, the statement evaluation phase is entered.

10.3.5. Evaluation Phase

During this phase, the logic embedded in the system program statements is executed in the order entered in the source program. After the state of each output variable is determined, the next statement is executed.

All true/false statements are sorted to the top of the logic table and are executed only once after a system program reset. In the ID-CSI these statements are not re-executed after a system program download. In that case the system must be reset after a new system program download.

10.3.6. Output Phase

After all of the statements are executed and the output variables have been determined, the outputs are transferred from temporary storage to the actual hardware (and software) in the system. At this point the effect of the statements will occur. After the output phase, the execution loop returns to the input phase for another iteration.

10.3.7. Displaying System Program Name

The name and source file date 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.

10.4. Reverse Compiler

10.4.1. Overview

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, the directory file that was used to compile the system program file is needed during the reverse compile process to convert from the binary address information back into symbolic readable form.

> **Note**: The system program will upload (to a PC or notebook computer) as a hex file. It must be reverse compiled to be viewed. The file name extension must be .HEX to be reverse compiled. The reverse compiler (revcmp.exe) will change the file extension from .HEX to .DIS. The resulting text filecan be viewed using any standard ASCII text editor.

10.4.2. Invocation

The reverse compiler command line has the following format:

revcmp <hexfile> </d:direcfile> </o:outfile> </h> </s>

where:

hexfile	name of the system program hex file , required except if /h
/d:directfile	dirfile = name of the directory file, optional
/o:outfile	outfile = name for the output file, optional
/h	causes help text to be displayed, use by itself
/s	causes a symbol table listing to be added, optional
/r	puts each product group into ladder logic “rung” mode.

The name of the input hexfile is required. An extension of '.HEX' will be assumed if one is not given. The switch /d:dirfile can be used to specify the name of the directory file to be used for symbol lookup. If a dirfile name is not given, the system will search the current directory for the file name 'DIRCTRY.DAT'. The switch /o:outfile can be used to enter the desired name for the output source file if desired. If an outfile name is not given, a file with the same name as the hexfile, but with the extension '.REV' will be created.

The command switch '/h' will cause a help text message to be given. This is useful in situations where the command line format needs to be displayed.

The command switch /s causes a symbol table dump to be added to the reverse compiled program. This can be useful in determining all of the symbols referenced in the program and for debugging purposes. Note, however, that the symbols must be deleted from the file prior to recompilation.

The '/r' switch causes each product group in a statement to occupy its own line. This format is similar to a ladder logic format in that each rung in the ladder would be on its own line. Because comments are not reverse compiled, this provides some formatting that can aid in understanding the original intent of the program.

10.4.3. Output File Format

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.

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CHAPTER 11: UPLOADING AND DOWNLOADING

In This Section:

11.1. Downloading Hex Files

11.1.1. Overview

Once 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.

11.1.2. Serial Communications

From the IBM PC compatible side, a serial communications program such as Microsoft Windows Terminal, ST220, QMODEM, or PROCOMM-PLUS can be used for this purpose. The ID-CSI and Harmony drives use a 9600 baud, 8 bit, no parity, 1 stop bit protocol for the communications. The ID-454GT is similar except the baud rate can be set between 300 and 38,400 baud using the keypad.

11.1.3. Initiating Download Process

In all cases, from the drive keypad, enter the communications menu, select the RS-232 submenu, and choose the System Program Download function. Once this function has been invoked, the keypad will indicate that the drive is ready (and waiting) for the download to begin. From the PC side, using the Data Upload function of the communications package, enter the name of the hex file to upload (using an ASCII or text format) and start the upload process.

Once the drive starts to receive data, the drive will indicate it is receiving 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.

11.1.4. Abnormal Termination

Note that at the end of each hex line, a checksum test is performed for data validation. If a checksum error occurs, the drive will terminate the download reception from its side and discard any data that was downloaded, reverting back to the original system program. In addition, after all of the data is received, an overall checksum test is performed, and if an error occurs, all the downloaded data is discarded.

11.1.5. Completing the Download

In the event that all of the checksum tests are performed correctly, the downloaded data is transferred from temporary RAM into non-volatile EEPROM storage, the system program is re-initialized with the new information, and the system program is restarted, executing the new statements.

11.1.6. User Termination

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.

11.2. Uploading Hex Files

11.2.1. Overview

In a manner similar to downloading a system program, the drives current system program (in hex form) can be uploaded from the drive to a receiving computer. This can permit archival of a functioning system program, or by using the system program's reverse compiler, the text statements in a system program can be re-created so that the program can be examined or modified as needed.

11.2.2. Initiating the Upload

Using a communications package similar to that described in the download section, invoke the serial communications download function, or as an alternate, the data logging function of the screen display can be used to capture the uploaded data. In all cases, invoke the capture process prior to starting the data upload function in the drive.

From the drive keypad, enter the communications menu, RS-232 submenu, System Program Upload function. 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 RS-232 menu. At this point, the data capture process in the PC is stopped and the resulting file saved.

11.2.3. User Termination

As with the download, the upload process can be terminated from the drive side by entering a SHIFT-CANCEL key sequence.

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APPENDIX A: GLOSSARY OF TERMS

A

This appendix contains definitions of terms and abbreviations used throughout this manual.

AND - AND is a logical Boolean function whose output is true if all of the inputs are true. In SOP notation, AND is represented as "•" (e.g., C=A•B), although sometimes it may be omitted between operands with the AND operation being implied (e.g., C=AB).

ASCII - ASCII is an acronym for American Standard Code for Information Interchange, an set of 8-bit computer codes used for the representation of text.

automatic bypass operation - Automatic bypass operation is the same as bypass operation, but it occurs automatically if a drive fault occurs and a pre-defined time has elapsed after the fault.

automatic mode - Automatic mode is a control scheme in which the operator selects an input to be used as the desired velocity input. Speed profiling is used in automatic mode to allow the operator to scale the output based on a programmable input range.

bit - Bit is an acronym for BInary digiT. Typically, bits are used to indicate either a true (1) or false (0) state within the drive's programming.

Boolean algebra - A form of mathematical rules developed by the mathematician George Boole used in the design of digital and logic systems.

bypass option - Bypass is an option that can be selected to customize a drive to provide optional line operation of the motor.

converter - The converter is the component of the drive that changes AC voltage to DC voltage.

critical speed avoidance - Critical speed avoidance is a feature that allows the operator to program up to 3 mechanical system frequencies that the drive will "skip over" during its operation.

DC link - The DC link is a large inductor between the converter and inverter section of the drive. The DC link, along with the converter, establish the current source for the inverter.

De Morgan's Theorem - The duality principal of Boolean algebra. Refer to the system program section for more information.

DRCTRY - Directory file which contains system tokens and internal addresses.

drive - The term "drive" refers to the controlled source for both power and control of a motor (i.e., the Perfect Harmony system).

ESD - ESD is an acronym for electrostatic discharge. ESD is an undesirable electrical side effect that occurs when static charges build up on a surface and are discharged to another. When printed circuit boards are involved, impaired operation and component damage are possible side effects due to the static sensitive nature of the PC board components. These side effects may manifest themselves as intermittent problems or total component failures. It is important to recognize that these effects are cumulative and may not be obvious.

faults - Faults are error conditions that have occurred in the Perfect Harmony system. The severity of faults vary. Likewise, the *treatment* or corrective action for faults may vary from changing a parameter value to replacing a hardware component such as a fuse.

GAL - GAL is an acronym for Generic Array Logic - a device similar to a PAL (programmable array logic) that is electrically erasable and programmable like an EEPROM.

harmonics - Harmonics are undesirable AC currents or voltages at integer multiples of the fundamental frequency. The fundamental frequency is the lowest frequency in the wave form (generally the repetition frequency). Harmonics are present in any non-sinusoidal wave form and they cannot transfer power on average.

Harmonics arise from non-linear loads in which current is not strictly proportional to voltage. Linear loads like resistors, capacitors and inductors do not produce harmonics. However, non-linear devices such as diodes and SCRs do generate harmonic currents. Harmonics are also found in uninterruptable power supplies (UPSs), rectifiers, transformers, ballasts, welders, arc furnaces and personal computers.

hmpd - The term "hmpd" refers to a set of four security fields associated with each parameter of the system. These fields allow the operator to individually customize specific security features for each menu option (submenu, parameter, pick list and function). These fields are shown in parameter dumps and have the following meanings. Setting H=1 hides the menu option from view until the appropriate access level has been activated. Setting M=1 blocks submenus from printing when a parameter dump is performed. Setting P=1 locks out the menu option during parameter dump printouts. Setting D=1 hides the menu option only when the drive is running.

I/O - I/O is an acronym for input/output. I/O refers to any and all inputs and outputs connected to a computer system. Both inputs and outputs can be classified as analog (e.g., input power, drive output, meter outputs, etc.) or digital (e.g., contact closures or switch inputs, relay outputs, etc.).

induction motor - An induction motor is an AC motor that produces torque by the reaction between a varying magnetic field (generated in the stator) and the current induced in the coils of the rotor.

Intel hex - Intel hex refers to a file format in which records consist of ASCII format hexadecimal (base 16) numbers with load address information and error checking embedded.

inverter - The inverter is a portion of the drive that changes DC voltage into AC voltage. The term "inverter" is sometimes used mistakenly to refer to the entire drive (the converter, DC link and inverter sections).

jerk rate - Jerk rate is the time it takes for the drive to go from one acceleration rate to another. The jerk rate is a programmable parameter used to limit the rate of change of the acceleration. Jerk rate has no effect if acceleration is constant. Jerk rate helps to prevent small overshoots and provides the "S-curve" (time/speed plot) characteristic as the speed setpoint is reached.

jog mode - Jog mode is an operational mode that uses a pre-programmed jog speed when a digital input (programmed as the jog mode input) is closed.

jumpers - Jumper blocks are groups of pins that can control functions of the system based on the state of the jumpers. Jumpers (small, removable connectors) are either installed (on) or not installed (off) to provide a hardware switch.

ladder logic - (Also Ladder Diagram) A graphical representation of logic in which two vertical lines representing power flow from the source on the left and the sink on the right with logic branches running between and resembling rungs of a ladder. Each branch consists of various labeled contacts placed in series and connected to a single relay coil (or function block) on the right.

LCD - liquid crystal display. On the Perfect Harmony, a 2-line by 24-character back-lit display interface located on the front panel of the system.

loss of signal feature - The loss of signal feature is a control scheme (in automatic mode) that gives the operator the ability to select one of 3 possible actions in the event that an external sensor is configured to specify the speed demand and the signal from that sensor is lost. Under this condition, the operator may program the drive (through the system program) to (1) revert to a fixed, pre-programmed speed, (2) maintain the current speed, or (3) perform a controlled (ramped) stop of the drive. By default, current speed is maintained.

microprocessor - A microprocessor is a central processing unit (CPU) that exists on a single silicon chip. The microprocessor board is the printed circuit board on which the microprocessor is mounted.

NEMA 1 and **NEMA 12** - NEMA 1 is an enclosure rating in which no openings allow penetration of a 0.25-inch diameter rod. NEMA 1 enclosures are intended for indoor use only. NEMA 12 is a more stringent NEMA rating in which the cabinet is said to be "dust tight" (although it is still not advisable to use NEMA 12 in conductive dust atmospheres).

Normally closed (NC) - Normally closed refers to the contact of a relay that is closed when the coil is de-energized.

Normally open (NO) - Normally open refers to the contact of a relay that is open when the coil is de-energized.

OR - OR is a logical Boolean function whose output is true if any of the inputs is true. In SOP notation, OR is represented as "+".

PID - PID is an acronym for proportional + integral + derivative, a control scheme used to control modulating equipment in such a way that the control output is based on (1) a proportional amount of the error between the desired setpoint and the actual feedback value, (2) the summation of this error over time, and (3) the change in error over time. Output contributions from each of these three components are combined to create a single output response. The amount of contribution from each component is programmable through gain parameters. By optimizing these gain parameters, the operator can "tune" the PID control loop for maximum efficiency, minimal overshoot, quick response time and minimal cycling.

qualified user - A qualified user is an individual who is familiar with the construction and operation of the equipment and the hazards involved.

RS232C - RS232C is a serial communications standard of the Electronics Industries Association (EIA). The RS232C interface is a DB25 serial port located on the front of the drive or on DB9 of the microprocessor board. This interface is used to connect the drive to a printer, dumb terminal or PC to allow parameter listing, system program downloading (after off-line editing), and uploading of historical and diagnostic log files.

setpoint - Setpoint is the desired or optimal speed of the VFD to maintain process levels. (Speed command).

slip - Slip is the difference between the stator frequency of the motor and the rotor frequency of the motor, normalized to the stator frequency as shown in the following equation.

$$\text{Slip} = \frac{\omega_S - \omega_R}{\omega_S}$$

Slip is the force that produces torque in an induction motor. Slip can also be defined as the shaft power of the motor divided by the stator input power.

standard control - Standard control is one of two available application modes of the Perfect Harmony drive. Standard control mode means that the control algorithm of the drive consists of an *open loop* speed control component with *closed* loop voltage and current control. In standard control applications, the drive compensates for the load by using the current and voltage loops. Encoders and magnetic pickups are not needed in standard control applications. Typical standard control applications include centrifugal loads such as fans and pumps. Compare with *vector control*.

system program - The functions of the programmable inputs and outputs are determined by the default *system program*. These functions can be changed by modifying the appropriate setup menus from the front keypad and display. I/O assignments can also be changed by editing the system program (an ASCII text file with the extension .SOP), compiling it using the compiler program (CMP.EXE), and then downloading it to the controller through its serial port.

torque - The force that produces (or attempts to produce) rotation as in the case of a motor.

vector control - Vector control is one of two available application modes of the Perfect Harmony drive. Vector control mode means that the control algorithm of the drive consists of a *closed loop* speed control component and a *closed loop* torque control component. Since vector control applications require (a) precisely controlled starting torques (±0.1%), (b) precisely controlled speeds (±0.1%), and/or (c) fast response, such applications use either an encoder or a magnetic pickup for direct speed control feedback. Typical vector control applications include centrifuges, extruders and test stands. Compare with *standard control*.

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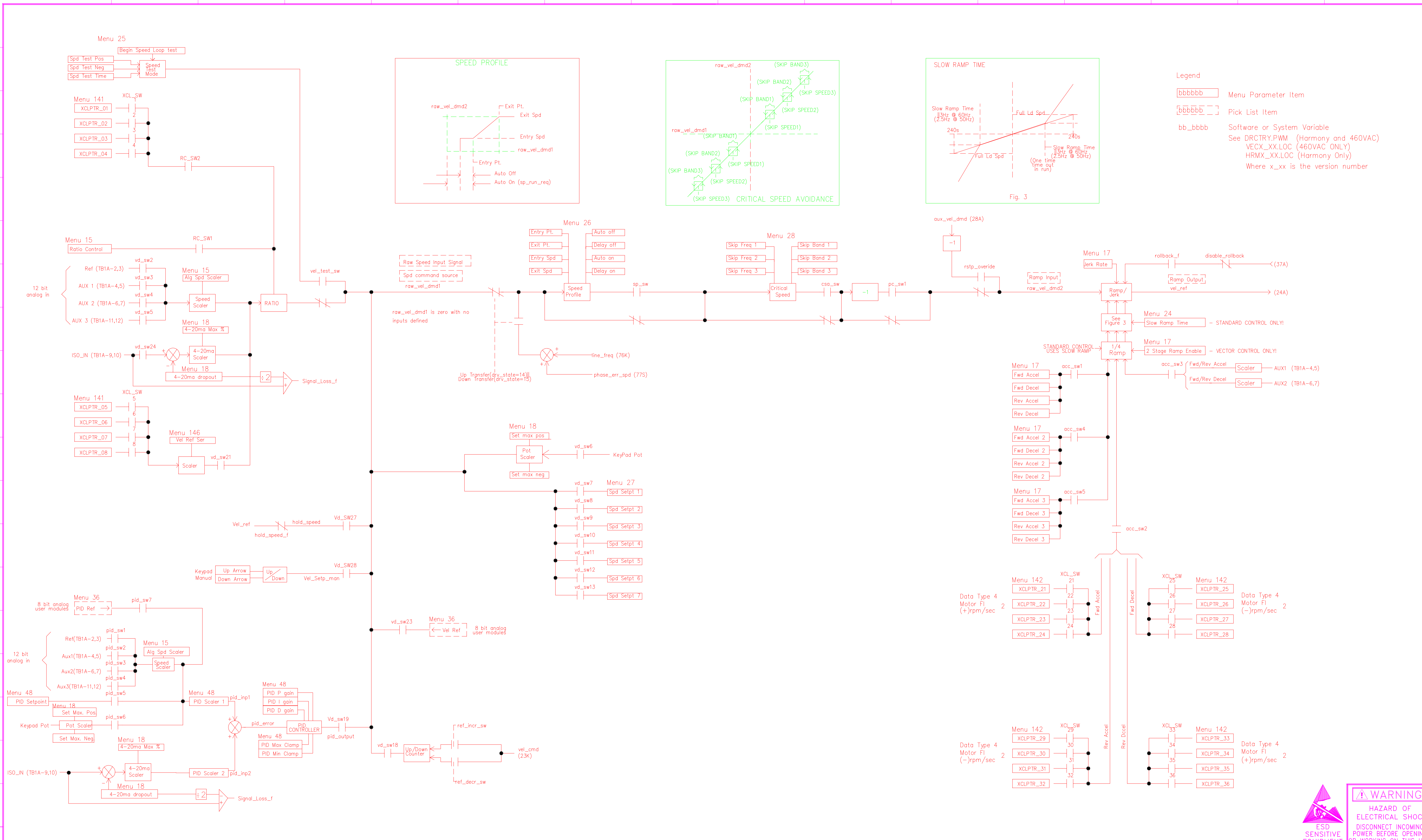
APPENDIX B: SYSTEM CONTROL DIAGRAMS

This appendix contains the system control diagrams for the Perfect Harmony drive. The pages that follow are sheets 1 through 8 of ROBICON drawing number 479333.



REVISIONS

B	C	D	E	F	G	H	I	J	K
Revised Cnt Diagram MFA 1/10/95	Revised Cnt Diagram MSW 6-8-95	Revised Cnt Diagram JTP 01/29/96	02813 Revised Cnt Diagram ELB 4/3/97	03414 ADDED UP/DOWN TRANSFER ELB 6/30/97	04068 Revised Cnt Diagram JDR 2/13/98	05270 Revised Cnt Diagram ELB 12/8/98	06105 REVISED TEXT SHEET 1 AP/DLS 09/01/99	06459 REVISED HOLD_SPEED_F TO N.C. SHEET 1 MA/DLS 12/08/99	

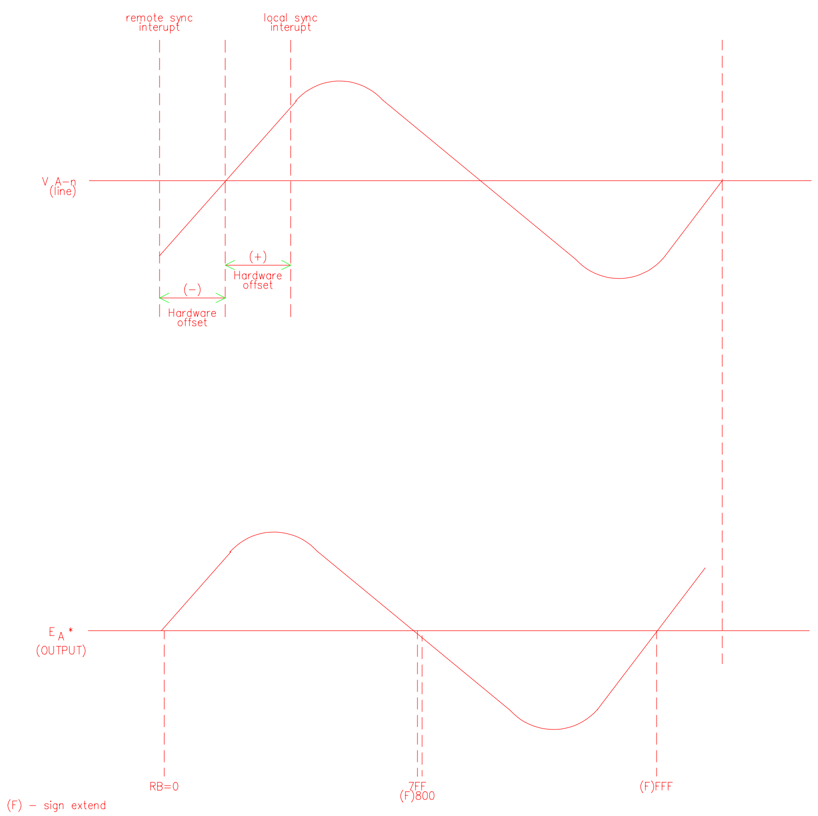
UNLESS OTHERWISE SPECIFIED: ALL DIMENSIONS IN INCHES INTERPRET DRAWING PER ASME Y14.5M-1994
TOLERANCES: .XX ± .03 .XXX ± .015 ANGLES ± 1°
THIRD ANGLE PROJECTION

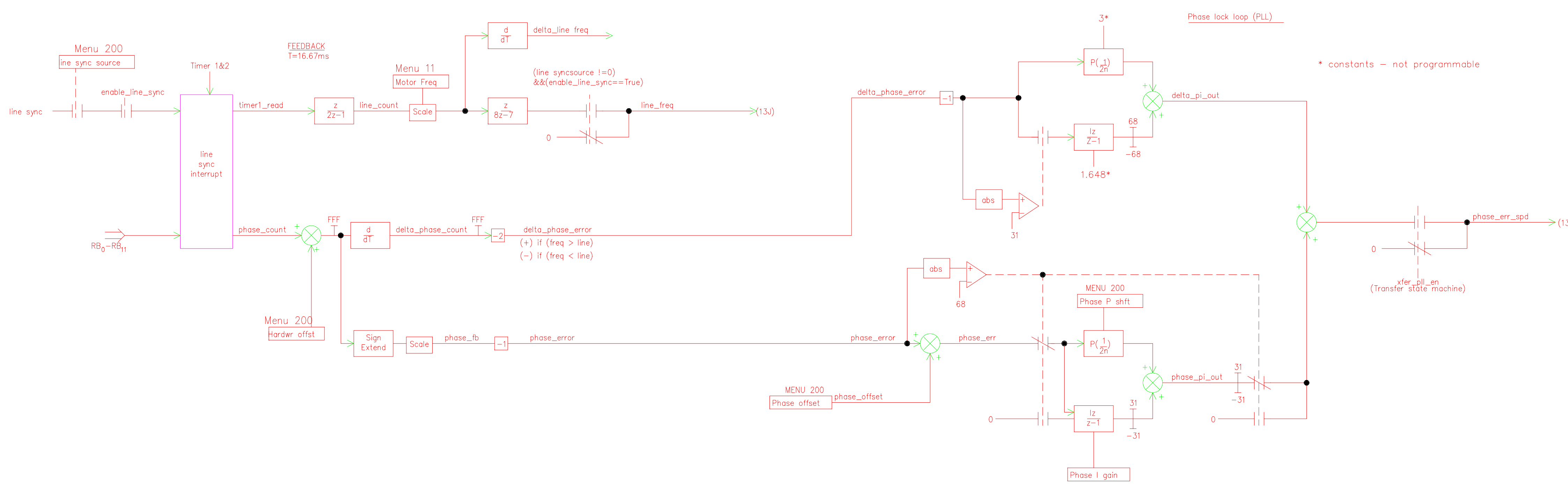
SCALE NTS
LAYER N/A
DATE 11/28/94
DFTR MFA
ENGR MFA

ROBICON
A SUBSIDIARY OF HIGH VOLTAGE ENGINEERING CORP
500 Hunt Valley Drive, New Kensington, PA 15068

CUSTOMER ROBICON
CUST ORDER NUMBER STD

TITLE CONTROL DIAGRAM VECTOR CONTROL/HARMONY
DWG NO 479333 REV K
CAD FILE 479333K1
SHEET NO 1 OF 8





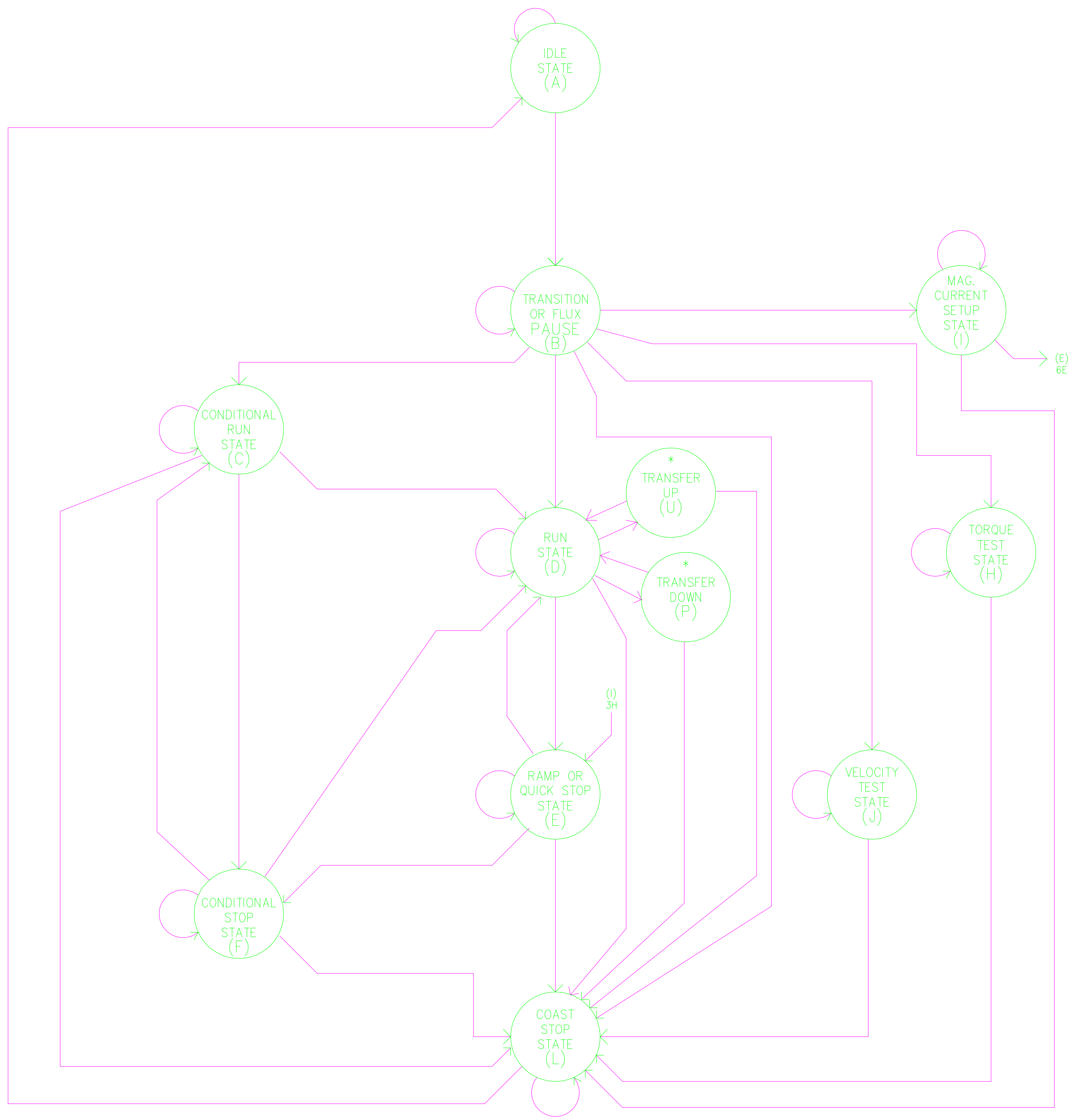
DFTG CODE NO.	
REVISIONS	

WARNING
HAZARD OF ELECTRICAL SHOCK
DISCONNECT INCOMING POWER BEFORE OPENING OR WORKING ON THIS UNIT.

SCALE	NTS
TOL.	N/A
LAYER	N/A
DATE	07/01/97
DFTR	ELB
ENGR	MFA

ROBICON
A SUBSIDIARY OF HIGH VOLTAGE ENGINEERING CORP. 500 Hunt Valley Dr., New Kensington, PA 15068

TITLE	CONTROL DIAGRAM VECTOR CONTROL/HARMONY
DWG.NO	479333
REVISION	K
CUSTOMER	ROBICON
WORK ORDER	STD.
CAD FILE	479333K7
SHEET NO.	7



* – SEE NEXT SHEET FOR TRANSFER STATE MACHINES

THE PERFECT HARMONY CONTROLS OPERATE AS A STATE MACHINE, i.e. THE DRIVE IS EITHER IN ONE OF THE DEFINED STATES SHOWN, OR IN THE TRANSITION BETWEEN STATES.
THE STATES OF THE IDPWM VECTOR CONTROL ARE AS FOLLOWS:

State A: Idle State

The drive is idle.
All feedbacks are enabled.
All selected inputs are read.
The hardware current loops are disabled (Vector).
The hardware voltage loop is disabled (Standard control and Harmony).
The control is looking for a valid run request.

State B: Transition or Flux Pause State

The drive is in transition between idle and other states.
The current loops are enabled if in vector control else the hardware voltage loop is enabled.
The torque loop is enabled.
It will remain in this state for one pass through the state machine before continuing to the next state. In vector control the duration of this state is controlled by the time setting of the "Flux Pause" parameter.

State C: Conditional Run State

The drive is waiting for the timeout from conditional run.
The torque loop is enabled and the velocity loop is disabled.
The torque command comes strictly from the holding current switches which are disabled with no transfer (no preset) when going to the run state.

State D: Run State

The drive is fully operational with the torque loop enabled and the velocity loop enabled only if ai_sw1 is active.
All holding current switches are inactive.

State E: Ramp and Quick Stop State

Drive is enabled and waiting for zero speed.
This state is available for velocity mode only (ai_sw1 = true).
Quick stop uses an override to zero the speed loop command while the ramp stop zeroes the input to the ramp.

State F: Conditional Stop State

The drive is at zero speed waiting for conditional stop timeout.
The velocity loop is disabled and the torque loop enabled.
The torque reference comes from the holding current switches only (no transition from the existing torque command prior to entering this state).

State H: Torque Loop Test State

The torque loop is enabled and velocity loop disabled.
The torque reference comes from the torque loop setpoints and toggles between the two setpoints at the time period entered (Vector).
For the Standard control the torque command ramps from zero to the first setpoint and then between the setpoints with the ramp rate calculated from the time setting.

State I: Magnetizing Current Setup State

The velocity and torque loops are both enabled and the drive is in velocity mode.
The velocity command is generated by the background program to setup the extended speed flux profile.
This mode is entered automatically by first enabling extended speed and then changing the magnetizing current parameter value. Therefore extreme caution should be used to ensure safety to personnel and equipment.

State J: Velocity Loop Test State

The velocity and torque loops are both enabled and the drive is in velocity mode.
The velocity reference comes from the speed test setpoints and toggles between the two setting at the rate entered in the speed test time parameter. The reference becomes an input to the velocity ramp.

State L: Coast Stop State

This is the transition state between coast stop and idle states.
It disables the hardware (START = False) and delays a minimum of 28 msecs before disabling the velocity and torque loops and going to the idle state. This assures software control until the hardware is completely shut down.

State Transition Logic

```
A -> B
------
run_request || vel_tst_mode_f || trq_tst_mode_f || vel_tst_sw || trq_tst_sw
|| i_mag_tst_mode_f && !sw_estop_f && !drv_flt_f && cr3_picked
  (add these two statements for Harmony Only)
&& !one_sec_tmr && (av_fb < M_V_5_PERCENT)
&& cells_initialized
  (add this statement for 460 and Harmony)
&& !drv_flt_rst_f

B -> C
------
!sw_estop_f && cr3_picked
&& run_request && cndtnl_r_s_f && !leave_c_r_f
&& [std_cntrl_f ||(flux_pause_tmr>=flux_pause_thrshld)]

B -> D
------
!sw_estop_f && cr3_picked
&& run_request && (!cndtnl_r_s_f || leave_c_r_f)

B -> H
------
!sw_estop_f && cr3_picked &&(trq_tst_mode_f || trq_tst_sw)

B -> I
------
!sw_estop_f && cr3_picked && i_mag_tst_mode_f

B -> J
------
!sw_estop_f && cr3_picked &&(vel_tst_mode_f || vel_tst_sw)

B -> L
------
sw_estop_f || !cr3_picked
|| ![run_request || vel_tst_mode_f || trq_tst_mode_f
|| vel_tst_sw || trq_tst_sw || i_mag_tst_mode_f]

&& - AND
|| - OR
 ! - NOT

C -> D
------
!sw_estop_f && cr3_picked && run_request && leave_c_r_f

C -> F
------
!sw_estop_f && cr3_picked
&& !run_request && (cndtnl_r_s_f && !leave_c_r_f)

C -> L
------
sw_estop_f || !cr3_picked
|| [!run_request && !(cndtnl_r_s_f && !leave_c_r_f)]

D -> E
------
!sw_estop_f && cr3_picked
&& [(!run_request && ai_sw1 && rstop_f) ||
(!run_request && ai_sw1 && qstop_f)]

D -> L
------
sw_estop_f || !cr3_picked
|| (!run_request && !ai_sw1)
|| (!run_request && ai_sw1 && !rstop_f && !qstop_f && cstop_f)
|| (!run_request && ai_sw1 && !rstop_f && !qstop_f)

E -> D
------
!sw_estop_f && cr3_picked && run_request

E -> F
------
!sw_estop_f && cr3_picked
&& [!run_request && zero_spd_f && (cndtnl_r_s_f && !leave_c_s_f)]

E -> L
------
sw_estop_f || !cr3_picked
|| [!run_request && zero_spd_f && !(cndtnl_r_s_f && !leave_c_s_f)]

F -> C
------
!sw_estop_f && cr3_picked
&& [run_request && (cndtnl_r_s_f && !leave_c_r_f)]

F -> D
------
!sw_estop_f && cr3_picked
&& [run_request && !(cndtnl_r_s_f && !leave_c_r_f)]

F -> L
------
sw_estop_f || !cr3_picked
|| (!run_request && leave_c_s_f)

H -> L
------
sw_estop_f || !cr3_picked
|| [!trq_tst_mode_f && !trq_tst_sw]

I -> E
------
!sw_estop_f && cr3_picked
&& !i_mag_tst_mode_f

I -> L
------
sw_estop_f || !cr3_picked

J -> L
------
sw_estop_f || !cr3_picked
|| [!vel_tst_mode_f && !vel_tst_sw]

L -> A
------
stop_dwell_tmr >= stop_dwell_thrshld
```

DFTG. CODE NO.

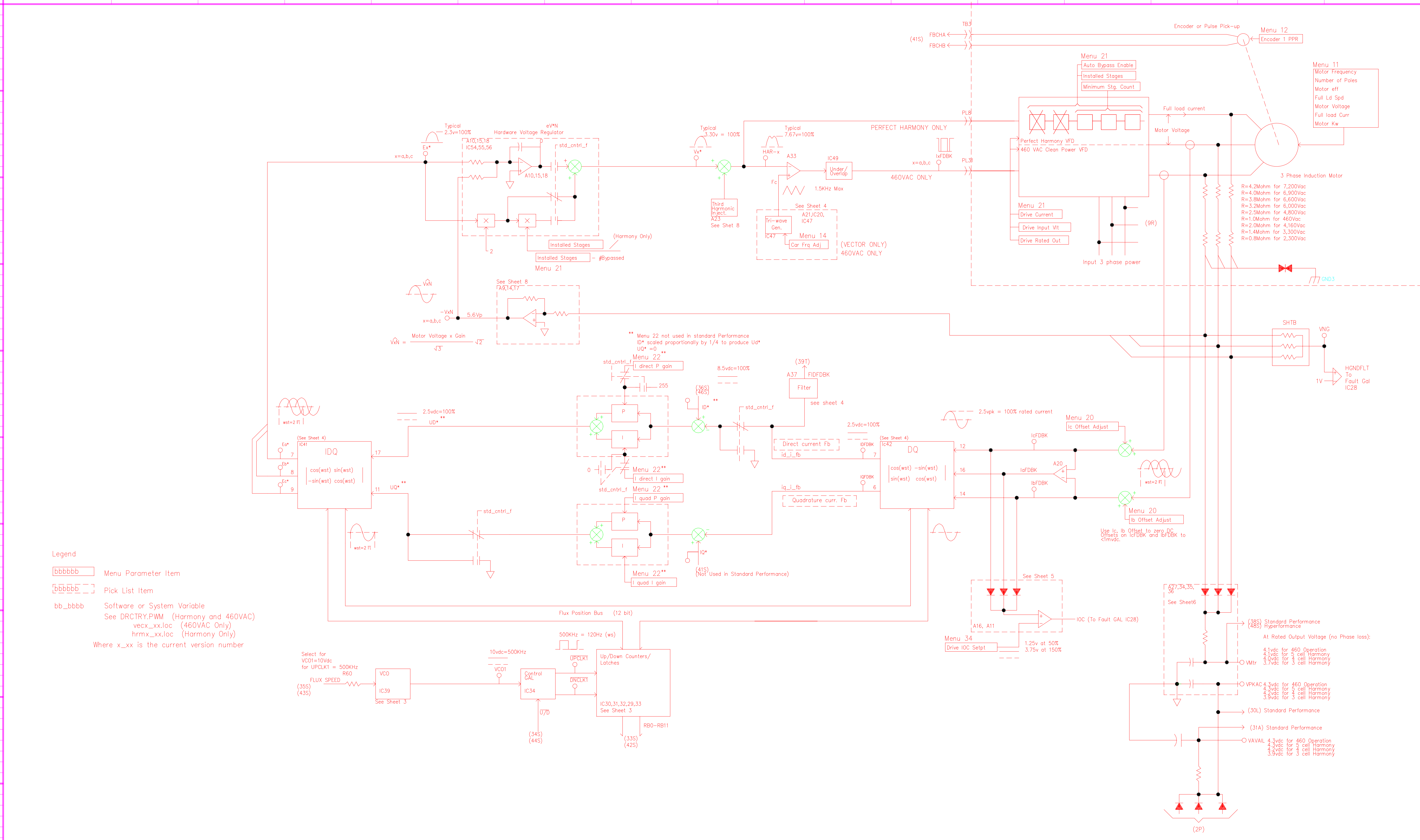
REVISIONS

⚠ WARNING
HAZARD OF ELECTRICAL SHOCK
DISCONNECT INCOMING POWER BEFORE OPENING OR WORKING ON THIS UNIT.

SCALE	NTS
TOL:	N/A
LAYER	N/A
DATE	11/25/94
DFTR	MFA
ENGR	MFA

ROBICON
A SUBSIDIARY OF HIGH VOLTAGE ENGINEERING CORP.
500 Hunt Valley Dr., New Kensington, PA 15068

CUSTOMER	ROBICON
WORK ORDER	STD.
TITLE	STATE FLOW DIAGRAM VECTOR CONTROL/HARMONY
DWG.NO	479333
REVISION	K
CAD FILE	479333K6
SHEET NO.	6



DFTG CODE NO.

REVISIONS

⚠ WARNING
HAZARD OF ELECTRICAL SHOCK
DISCONNECT INCOMING POWER BEFORE OPENING OR WORKING ON THIS UNIT.

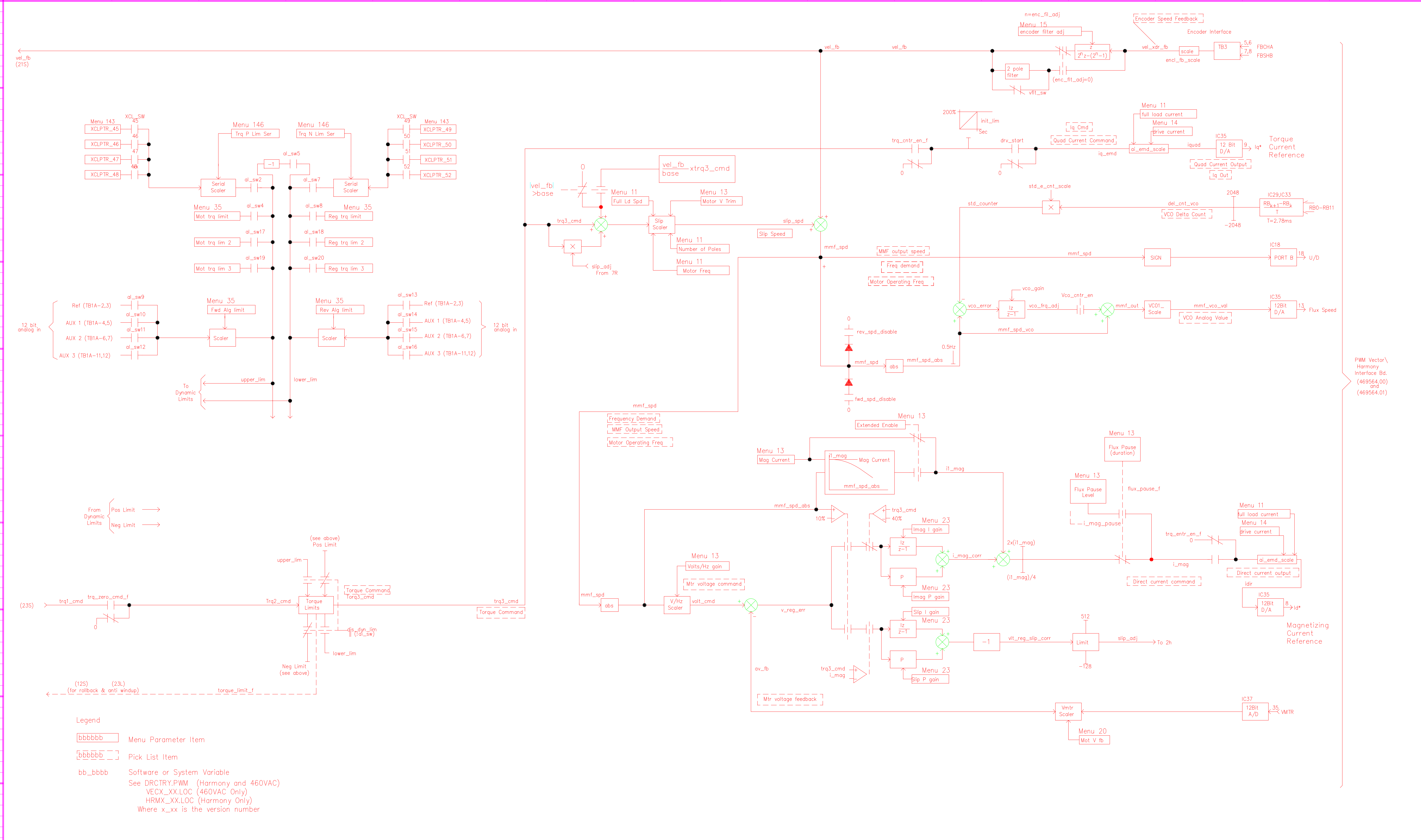
SCALE	NTS
TOL	N/A
LAYER	N/A
DATE	11/29/94
DFTR	MFA
ENGR	MFA

ROBICON
A SUBSIDIARY OF HIGH VOLTAGE ENGINEERING CORP.
500 Hunt Valley Dr., New Kensington, PA 15068

CUSTOMER ROBICON
WORK ORDER STD.

TITLE
CONTROL DIAGRAM
VECTOR CONTROL/HARMONY

DWG NO 479333
REVISION K
CAD FILE 479333K5
SHEET NO. 5



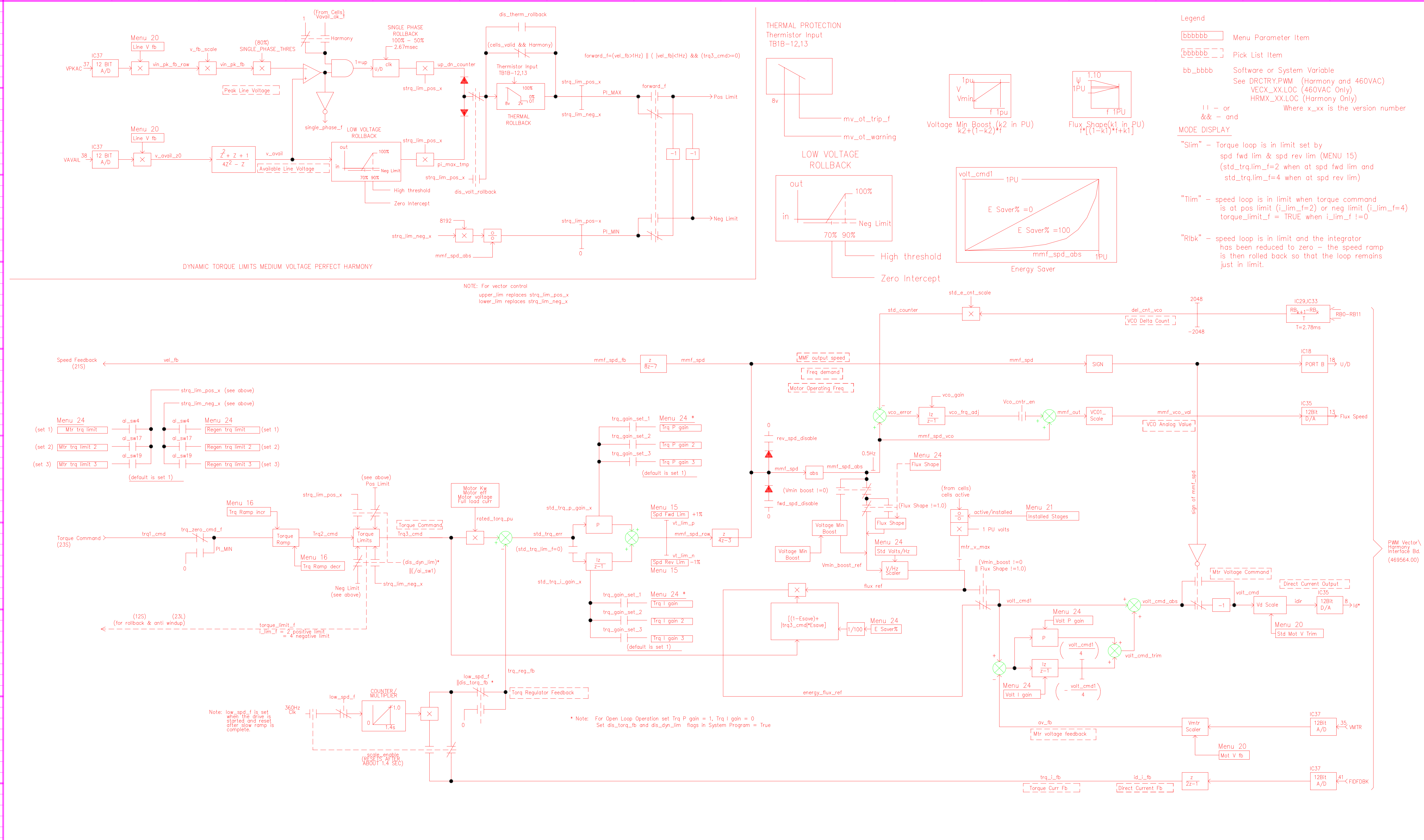
WARNING
HAZARD OF ELECTRICAL SHOCK
DISCONNECT INCOMING POWER BEFORE OPENING OR WORKING ON THIS UNIT.

SCALE	NTS
TOL	N/A
LAYER	N/A
DATE	11/29/97
DFTR	MFA
ENGR	MFA

ROBICON
A SUBSIDIARY OF HIGH VOLTAGE ENGINEERING CORP.
500 Hunt Valley Dr., New Kensington, PA 15068

CUSTOMER: ROBICON
WORK ORDER: STD.

TITLE: CONTROL DIAGRAM VECTOR CONTROL/HARMONY
DWG.NO: 479333
REVISION: K
CAD FILE: 479333K4
SHEET NO.: 4

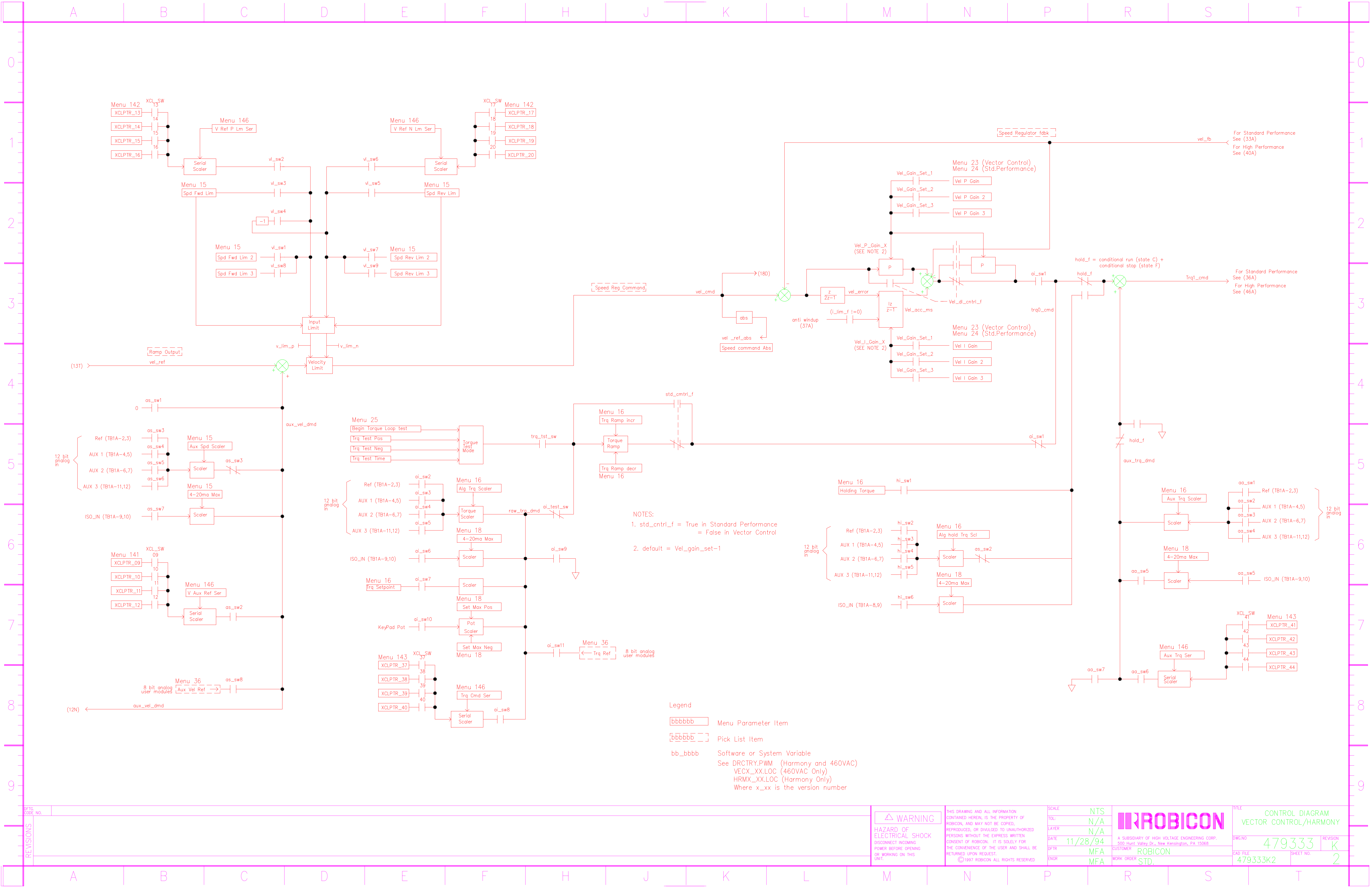


TITLE	CONTROL DIAGRAM VECTOR CONTROL/HARMONY
DWG.NO	479333
REVISION	K
CAD FILE	479333K3
SHEET NO.	3
SCALE	NTS
TOL	N/A
LAYER	N/A
DATE	11/29/94
DFTR	MFA
ENGR	MFA
CUSTOMER	ROBICON
WORK ORDER	STD.

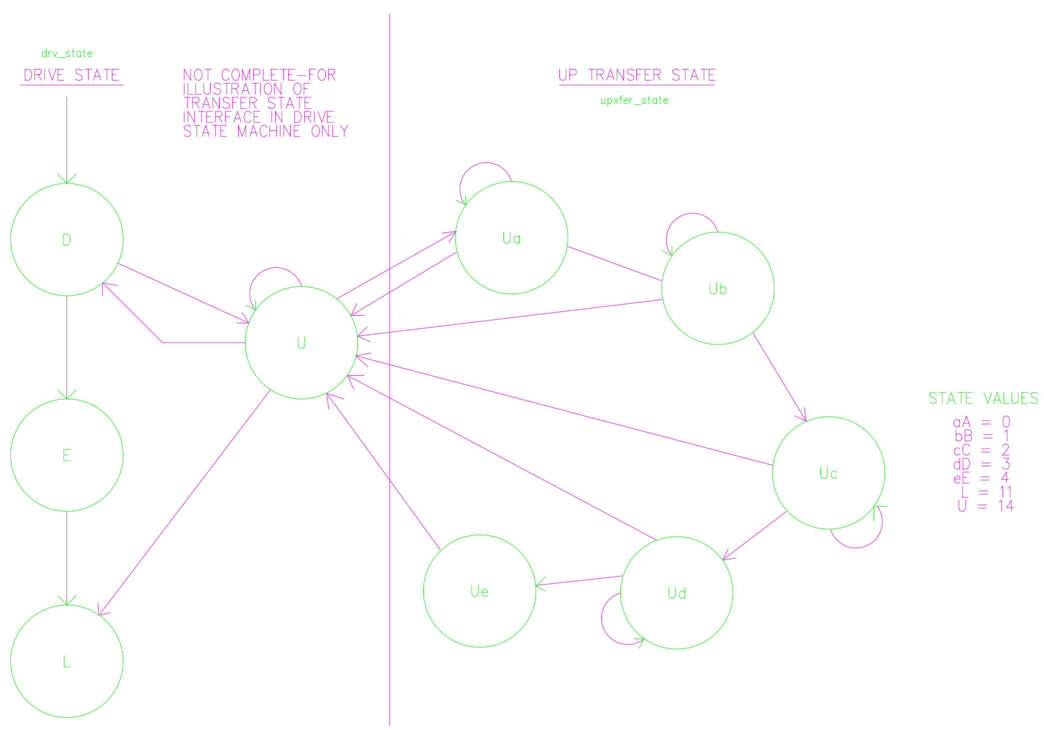
ROBICON
A SUBSIDIARY OF HIGH VOLTAGE ENGINEERING CORP.
500 Hunt Valley Dr., New Kensington, PA 15068

⚠ WARNING
HAZARD OF ELECTRICAL SHOCK
DISCONNECT INCOMING POWER BEFORE OPENING OR WORKING ON THIS UNIT.

REVISIONS


Menu 142
XCL_SW
XCLPTR_13
XCLPTR_14
XCLPTR_15
XCLPTR_16
Menu 146
V Ref P Lm Ser
Serial Scaler
Menu 146
V Ref N Lm Ser
Menu 142
XCLPTR_17
XCLPTR_18
XCLPTR_19
XCLPTR_20
Menu 15
Spd Fwd Lim
Spd Rev Lim
Spd Fwd Lim 2
Spd Fwd Lim 3
Spd Rev Lim 2
Spd Rev Lim 3
Input Limit
Velocity Limit
Ramp Output
vel_ref
(13T)
aux_vel_dmd
Ref (TB1A-2,3)
AUX 1 (TB1A-4,5)
AUX 2 (TB1A-6,7)
AUX 3 (TB1A-11,12)
12 bit analog in
Aux Spd Scaler
4-20ma Max
ISO_IN (TB1A-9,10)
Menu 141
XCLPTR_09
XCLPTR_10
XCLPTR_11
XCLPTR_12
V Aux Ref Ser
8 bit analog user modules
Menu 36
Aux Vel Ref
(12N)
Speed Reg Command
vel_cmd
(180)
abs
vel_ref_abs
Speed command Abs
Speed Regulator fdbk
vel_fb
For Standard Performance See (33A)
For High Performance See (40A)
Menu 23 (Vector Control)
Menu 24 (Std.Performance)
Vel_Gain_Set_1
Vel_Gain_Set_2
Vel_Gain_Set_3
Vel P Gain
Vel P Gain 2
Vel P Gain 3
Vel_P_Gain_X (SEE NOTE 2)
vel_error
anti windup (37A)
(i_lim_f !=0)
Vel_acc_ms
Vel_di_cntrl_f
Vel_I_Gain_X (SEE NOTE 2)
Vel I Gain
Vel I Gain 2
Vel I Gain 3
trq0_cmd
hold_f = conditional run (state C) + conditional stop (state F)
Trq1_cmd
For Standard Performance See (36A)
For High Performance See (46A)
Menu 25
Begin Torque Loop test
Trq Test Pos
Trq Test Neg
Trq Test Time
Torque Test Mode
trq_tst_sw
std_cntrl_f
Menu 16
Trq Ramp incr
Torque Ramp
Trq Ramp decr
Alg Trq Scaler
Torque Scaler
raw_trq_dmd
Menu 18
4-20ma Max
Scaler
Trq Setpoint
Set Max Pos
Pot Scaler
KeyPad Pot
Set Max Neg
Trq Ref
Menu 143
XCLPTR_37
XCLPTR_38
XCLPTR_39
XCLPTR_40
Trq Cmd Ser
NOTES:
1. std_cntrl_f = True in Standard Performance
= False in Vector Control
2. default = Vel_gain_set-1
Holding Torque
Alg hold Trq Scl
ISO_IN (TB1A-8,9)
aux_trq_dmd
Aux Trq Scaler
Aux Trq Ser
XCLPTR_41
XCLPTR_42
XCLPTR_43
XCLPTR_44
Legend
bbbbbb Menu Parameter Item
bbbbbb Pick List Item
bb_bbbb Software or System Variable
See DRCTRY.PWM (Harmony and 460VAC)
VECX_XX.LOC (460VAC Only)
HRMX_XX.LOC (Harmony Only)
Where x_xx is the version number
WARNING
HAZARD OF ELECTRICAL SHOCK
DISCONNECT INCOMING POWER BEFORE OPENING OR WORKING ON THIS UNIT.
THIS DRAWING AND ALL INFORMATION CONTAINED HEREIN, IS THE PROPERTY OF ROBICON, AND MAY NOT BE COPIED, REPRODUCED, OR DIVULGED TO UNAUTHORIZED PERSONS WITHOUT THE EXPRESS WRITTEN CONSENT OF ROBICON. IT IS SOLELY FOR THE CONVENIENCE OF THE USER AND SHALL BE RETURNED UPON REQUEST.
©1997 ROBICON ALL RIGHTS RESERVED
SCALE NTS
TOL. N/A
LAYER N/A
DATE 11/28/94
DFTR MFA
ENGR MFA
ROBICON
A SUBSIDIARY OF HIGH VOLTAGE ENGINEERING CORP.
500 Hunt Valley Dr., New Kensington, PA 15068
CUSTOMER ROBICON
WORK ORDER STD.
TITLE CONTROL DIAGRAM VECTOR CONTROL/HARMONY
DWG.NO 479333
REVISION K
CAD FILE 479333K2
SHEET NO. 2
REVISIONS

UP TRANSFER STATE MACHINE TRANSITIONS



UP TRANSFER STATE MACHINE
DRIVE STATE "U"

STATE DESCRIPTIONS:

State Ua: Initial State

Point of entry into up transfer state machine
Any means that removes the drive from drive state "U"
initializes the up transfer state machine to state "a"
The drive is waiting until it is running at line frequency.
this is determined by the calculated error being less than 0.73%.
The frequency lock timer is initialized to zero.

State Ub:

The drive is waiting for frequency lock, determined by the velocity loop error "vel_err_z" (which is half of actual error) remaing below 0.18% for one second. Transfer phase lock loop is enabled ("phase_lock_enabled" ==True) on exit.

State Uc:

The drive is waiting for phase lock. This is determined by the phase error remaining below phase error threshold "Phase err thrsh" for three seconds. Once this occurs the "do_up_xfer_f" is set true. This should be used to enable the line contactor.

State Ud:

The drive is waiting for the line contactor to close.
this is detected by the state of the "line_con_ack_f" system flag which should be tied to the aux contact on the line contactor and debounced.
When the line contactor is closed, the "do_up_xfer_f" is set false on exit.

State Ue:

The vfd hardware and all software loops are disabled and the transfer complete flag "upxfer_complete_f" is set true.
The drive will stay in this state until an e-stop or fault occurs or there is a loss of CR3 or run request at which time the drive will reinitialize the up transfer state (to Ua) and the drive will enter the coast stop state (drive state "L")

The loss of run request or up transfer timeout in any state other than Ue will result in the drive returning to the run state (drive state "D")

State Transition Logic

D -> U
```
upxfer_req_f && ! dnxfer_req_f
&& ! upxfer_flt_f && ! line_con_ack_f
```

U -> L
```
sw_estop_f || !cr3_picked                              tripped
|| !run_request && (upxfer_state>state_d)              stopped when synch'd
```

U -> D
```
!run_request && (upxfer_state <= state_d)              stopped before completion
|| upxfer_timeout_f && (upxfer_state != state_e)       transfer timed out before complete
||(line_freq==0)                                       no line freq to sync with
|| !upxfer_req_f && (upxfer_state != state_e)          transfer cancelled before completion
```

Ua -> Ub
```
                            (0.73%)
abs(line_freq-vel_fb) <= 60                            wait for vel error to be small
```

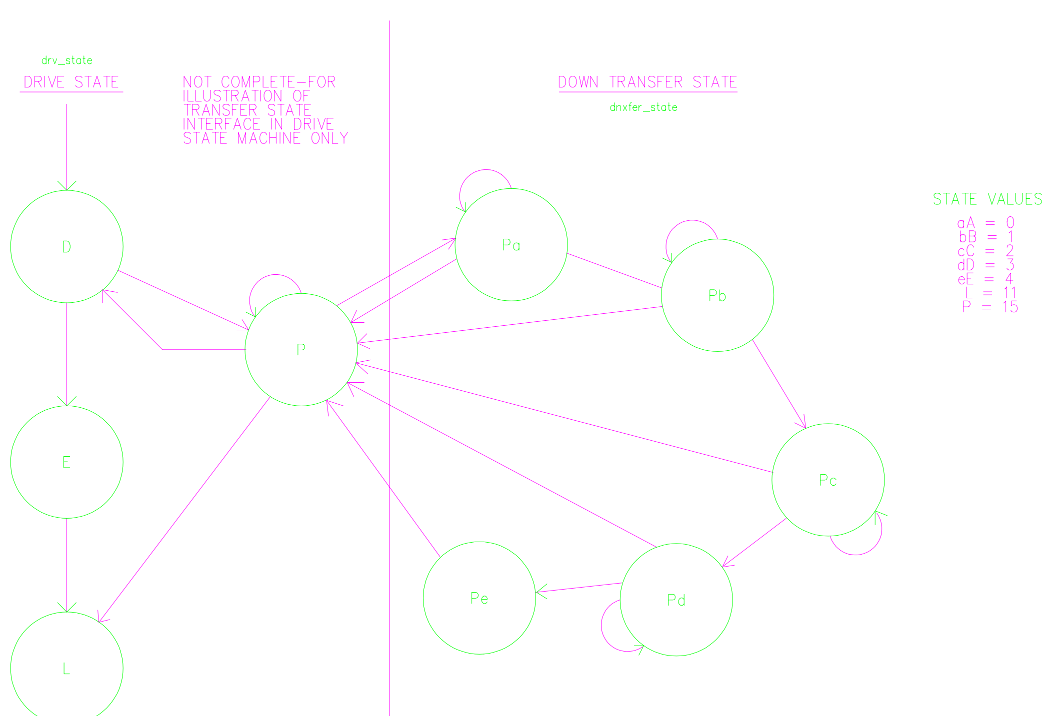
Ub -> Uc
```
(abs(vel_err_z) <= 15) && freq_ok_cnt >= 360)          small vel error, frequency
       (0.37%)        (0.18%)                          matched for one second
```

Uc -> Ud
```
(abs(phase_err) <= phase_err_thrsh) && (synch_cnt >= 1080)     phase error is below minimum
                                                               threshold for three seconds
```

Ud -> Ue
```
line_con_ack_f                                         line contactor is in
```

&& - AND
|| - OR
! - NOT

DOWN TRANSFER STATE MACHINE TRANSITIONS



DOWN TRANSFER STATE MACHINE
DRIVE STATE "P"

STATE DESCRIPTIONS:

State Pa: Initial State

Point of entry into down transfer state machine
Any means that removes the drive from drive state "P"
initializes the down transfer state machine to state "a"
The drive is waiting until the output frequency reaches line frequency.
This is determined by the calculated error being less than 0.24%.
The frequency lock timer is initialized to zero.

State Pb:

The drive is waiting for frequency lock, determined by the velocity loop error "vel_err_z" (which is half of actual error) remaing below 0.18% for one second. Transfer phase lock loop is enabled ("phase_lock_enabled" ==True) on exit.

State Pc:

The drive is waiting for phase lock. This is determined by the phase error remaining below phase error threshold "Phase err thrsh" for three seconds. Once this occurs the "do_dn_xfer_f" is set true. This should be used to enable the VFD contactor.

State Pd:

The drive is waiting for the VFD contactor to close.
this is detected by the state of the "vfd_con_ack_f" system flag being set true by a debounced VFD contactor auxiliary contact.
This should be used to drop the line contactor.

State Pe:

The down transfer is complete with the exception of the removal of the line contactor. The "dnxfer_complete_f" is set true and the "do_dn_xfer_f" is set false. When the line contactor is removed, these system flags should be used to drop the "dnxfer_req_f" to put the drive back into the run state (drive state "D")

With the exception of the sw_estop_f and loss of CR3,which result in a drive "trip" placing the drive in the coast stop state,all other exits from the down transfer state machine place the drive back into the run state with only a successful transfer not setting the down transfer fault flag (dnxfer_flt_f). A successful transfer does not check for the line contactor to be open and must be addressed outside the state machine.

State Transition Logic

D -> P
```
dnxfer_req_f && ! upxfer_req_f
&& ! dnxfer_req_f && ! vfd_con_ack_f
```

P -> L
```
sw_estop_f || !cr3_picked                              tripped
```

P -> D
```
!run_request && (dnxfer_state<state_d)                 stopped before synch
|| dnxfer_timeout_f && (dnxfer_state != state_e)       timed out before complete
||(line_freq==0)                                       no line sync signal
  || !dnxfer_req_f                                     transfer cancelled
                                                       (fault if transfer not complete)
```

Pa -> Pb
```
                            (0.24%)
abs(line_freq-vel_fb) <= 20                            wait for velocity error to be small
```

Pb -> Pc
```
(abs(vel_err_z) <= 15) && (freq_ok_cnt >= 360)         small vel error, frequency
                       (0.18%)                         matched for one second
```

Pc -> Pd
```
(abs(phase_err) <= phase_err_thrsh) && (synch_cnt >= 1080)     phase error is below minimum
                                                               threshold for three seconds
```

Pd -> Pe
```
  vfd_con_ack_f                                        VFD contactor is in
```

&& - AND
|| - OR
! - NOT

DFTG CODE NO.
REVISIONS

⚠ WARNING
HAZARD OF ELECTRICAL SHOCK
DISCONNECT INCOMING POWER BEFORE OPENING OR WORKING ON THIS UNIT.

SCALE	NTS
TOL:	N/A
LAYER	N/A
DATE	11/25/94
DFTR	ELB
ENGR	MFA

ROBICON
A SUBSIDIARY OF HIGH VOLTAGE ENGINEERING CORP.
500 Hunt Valley Dr., New Kensington, PA 15068

CUSTOMER	ROBICON
WORK ORDER	STD.
TITLE	STATE FLOW DIAGRAM VECTOR CONTROL/HARMONY
DWG.NO	479333
REVISION	K
CAD FILE	479333K8
SHEET NO.	8

APPENDIX C: WARRANTY POLICY AND PRODUCT LIABILITY

This appendix details the warranty policy of ROBICON products as well as product liability information. ROBICON's standard warranty policy is listed below. Note that the warranty policy for a particular job agreement may be different from the standard policy. When in doubt about warranty information, consult the factory.C

C.1. Guarantee and Product Liability

ROBICON's "standard" warranty policy is listed as follows. When in doubt about warranty and/or product liability issues, consult the factory.

All products are warranted for a period of 18 months from the date of original receipt, not to exceed 1 year from the date of start-up, against defects in materials or workmanship. Guarantee repairs are to be performed FOB (free on board) ROBICON factory to qualify for no charges. ROBICON's liability and customer's exclusive remedy under this warranty are expressly limited to repair, replacement, or repayment of the purchase price. Whether there shall be repair, replacement, or repayment is to be exclusively ROBICON's decision. ROBICON is not liable for incidental and consequential damages.

This warranty shall not apply to major devices or equipment such as transformers and motors not manufactured by the seller or to equipment or parts which shall have been repaired or altered by others than the seller so as, in its judgment, to affect adversely the same, or which shall be subject to negligence, accident, or damage by circumstances beyond the seller's control. For equipment and parts not manufactured by the seller, the warranty obligations of the seller shall in all respects conform and be limited to the warranty extended to the seller by the supplier.

C.2. In-house Repair Services

For **all** repair service at ROBICON, you will need a Repair Service Order (SO) number. Call **(724) 339-9307** and request a Repair Service Order (SO) number. Please reference this number when making any inquiries. Use the shipping address below for returns:

ROBICON
500 Hunt Valley Drive
New Kensington PA 15068
Attention: Repair Department/SO # ( )

Prepay the shipment and include the following information if you are not using a ROBICON Return Repair Tag: the Repair Service Order (SO) number, part number, a description of the problem, contact phone number, a technical contact phone number (if different) and any additional comments. Put the Repair Service Order (SO) number on the label.

Warranty Repairs: In addition to securing Repair Service Order (SO) number, please supply the **System CO number** (found on the system, usually on the tag inside the cabinet door), whenever possible.

Non-Warranty Repairs: Secure a Repair Service Order (SO) number from ROBICON. The price for exchange or repair is available at this time. Please include your hard copy purchase order (PO) for this amount with the item when it is returned, or fax your PO directly to the Repair/Spares Department at (724) 339-3240. Expedited services are available upon request.

For additional information, you can E-mail your questions or comments to the Repair/Spares Department at jcieslew@robicon.com.

> Before sending a printed circuit board to ROBICON for repair, please make a list of parameter values first, then be sure to follow proper ESD precautions when handling boards.

C

C.3. Field Service Repairs

If guarantee repairs are performed in the field, a per-diem charge will be made for the serviceman or engineer's travel, living expenses and all time short of the repair time required.

Determination of warranty vs. non-warranty issues will be determined by ROBICON. Call ROBICON at (724) 339-9501 for information on pricing for on-site evaluations.

C.4. Terms and Conditions

C.4.1. Warranty

- Repairs will be at ROBICON's expense. Acts of God and use outside of design specification are excluded. Determination will be made by ROBICON.
- Standard warranties are two (2) years for Heating and Regulating equipment, except 1 kHz power supplies and turbos, one (1) year from startup OR 18 months from shipment for all others. **Exceptions: Units with valid extended warranty or preventive maintenance agreements.**
- Decisions to repair or replace with **NEW** or voided warranties will be determined by ROBICON.
- Call tags will be issued as necessary.
- A repair will be warranted for the remainder of the original equipment warranty.
- A minimum evaluation fee will be billed for each unit that is evaluated and which proves to be non-defective. *This fee will be credited to the order if a new unit is purchased.* ***No*** *evaluation fee will be assessed for units that are repaired.*
- A 25% restocking fee will be assessed for any units that are returned to ROBICON stock for credit to you.

☝ Decision of reparability will be determined by ROBICON.

- The warranty on repairs is 30 days from date of repair.
- Shipping will be prepaid and billed.
- Repair system testing at your site may be required.
- If, after best effort, a unit is found to be "beyond economical repair" (BER), it will be returned immediately after you are contacted. You may request the unit be scrapped at ROBICON. With your approval, a fully tested, refurbished unit maybe purchased (based on availability) in place of a repair. A 90-day warranty will apply to the refurbished unit.

C.4.2. Expedited Service

- The feasibility of expedited service will be determined by ROBICON after examining the unit. *Expedited service* ***cannot*** *be promised for all units.*

  Expedited Service may be available at the following levels: one (1) day, (2) day, (3) day or one (1) business week.

- A refurbished unit may be substituted for the returned unit pending availability and your approval.

Prices and Conditions Are Subject to Change Without Notice.

∇ ∇ ∇

APPENDIX D: PARAMETER SUMMARY

```
  Harmony PWM Parameter Dump (Ver 1.13   9-30-98)  1/07/99   15:35:33
           description          change              range       xcl# lev hmpd


           Main menu     (5)

      Motor Menu          (1)                     (submenu)            0   0000
      Drive Menu          (2)                     (submenu)            0   0000
      Stability Menu      (3)                     (submenu)            0   0000
      Auto Menu           (4)                     (submenu)            0   0000
      Log Control         (6)                     (submenu)            0   0000
      Drive Protect Menu  (7)                     (submenu)            0   0000
      Meter Menu          (8)                     (submenu)            0   0000
      Communications Menu (9)                     (submenu)            0   0000
      Enter Security Code                         (function)           0   0000
      Change Security Codes                       (function)           2   1000
      Security Edit       (0)                     (submenu)            7   1000

           Motor Menu    (1)

      Motor Param Menu   (11)                     (submenu)            0   0000
      Encoder Menu       (12)                     (submenu)            0   0000
      Motor Flux Menu    (13)                     (submenu)            0   0000

           Drive Menu    (2)

      Drive Param Menu   (14)                     (submenu)            0   0000
      Speed Setup        (15)                     (submenu)            0   0000
      Torq Ref Menu      (16)                     (submenu)            0   0000
      Ramp Setup Menu    (17)                     (submenu)            0   0000
      Pot Setup Menu     (18)                     (submenu)            0   0000
      Timebase Setup     (19)                     (submenu)            0   0000
      Hardware Scale Menu(20)                     (submenu)            0   0000
      Cell Menu          (21)                     (submenu)            0   0000
      Transfer Menu     (200)                     (submenu)            7   1000

          Stability Menu (3)

      Current Loop Setup (22)                     (submenu)            0   0000
      Vector Control Tune(23)                     (submenu)            0   0000
      Std Control Setup  (24)                     (submenu)            0   0000
      Control Loop Test  (25)                     (submenu)            0   0000

           Auto Menu     (4)

      Speed Profile Menu (26)                     (submenu)            0   0000
      Speed Setpoint Menu(27)                     (submenu)            0   0000
      Critical Speed Menu(28)                     (submenu)            0   0000
      Comparator Setup   (29)                     (submenu)            7   1000
      PID Select Menu    (48)                     (submenu)            0   0000

           Log Control   (6)

      Memory Functions   (30)                     (submenu)            0   0000
      Diagnostic Log Menu(31)                     (submenu)            0   0000
      Historic Log Menu  (32)                     (submenu)            0   0000
      Fault Log Menu     (33)                     (submenu)            0   0000

        Drive Protect Menu(7)

      Overload Menu      (34)                     (submenu)            0   0000
      Limit Menu         (35)                     (submenu)            0   0000

           Meter Menu    (8)

      Analog I/O Setup   (36)                     (submenu)            0   0000
      Display Var. Menu  (37)                     (submenu)            0   0000
      Trim Analog Meters (38)                     (submenu)            0   0000
      Loc. Alg. Meters   (39)                     (submenu)            0   0000
      Loc. Dig. Meters   (40)                     (submenu)            0   0000
```

D

```
  Harmony PWM Parameter Dump (Ver 1.13   9-30-98)  1/07/99   15:35:33
           description          change             range      xcl# lev hmpd

      Communications Menu(9)

     RS232 Functions    (41)                     (submenu)           0   0000
     Remote I/O Menu    (42)                     (submenu)           0   0000
     XCL Send Setup     (43)                     (submenu)           7   1000
     XCL Recv Setup     (44)                     (submenu)           7   1000
     RS232 input-  (empty)                         (list)            0   0000
     RS232 out   -  (empty)                        (list)            0   0000

         Motor Param Menu(11)

     Motor Freq        60 Hz   _______        15         120   1101   0   0000
     Number of poles        8   _______         2          36   1102   0   0000
     Motor eff           0.93   _______      0.60        0.99   1103   0   0000
     Full Ld Spd     896 rpm   _______         1        7200   1104   0   0000
     Motor voltage    4160 V   _______       380        9000   1105   0   0000
     Full load curr    366 A   _______        12        1500   1106   0   0000
     Motor KW        2250 KW   _______        10       10000   1107   0   0000

           Encoder Menu  (12)

     Encoder1 PPR       1200   _______         1        4000   1201   0   0000
     Encoder2 PPR        720   _______         1        4000   1202   0   0000

         Motor Flux Menu  (13)

     Motor V Trim      0.820   _______     0.050       2.000   1301   0   0000
     Volts/Hz gain      1.00   _______      0.00       10.00   1302   0   0000
     Mag Current      24.0 A   _______       0.1      1500.0   1303   0   0000
     Extended Enable       0   _______         0           1   1304   0   0000
     Flux Pause Level   10 %   _______         0         100          0   0000
     Flux pause     1.00 sec   _______      0.01        8.00          0   0000

         Drive Param Menu(14)

     Drive Scale Curr  400 A   _______        12        1500   1401   7   1000
     Drive Rated Out  4160 V   _______       200       23000   1402   0   0000
     Drive Input Vlt 13800 V   _______       200       23000   1403   0   0000
     Auto reset enable     1   _______         0           1   1404   0   0000
     Aut rst time   5.00 sec   _______      1.00      120.00   1405   0   0000
     Spinning Load Select  1   _______         0           1   1407   0   0000
     Vector Control Select 0   _______         0           1   1408   7   1001
     Ramp Stop Select      1   _______         0           1   1409   0   0000
     Hall Effect Select    1   _______         0           1          7   1001
     Reduced Voltage Oper. 0   _______         0           1   1411   7   0000
     Display Version Number                       (function)         0   0000
     Customer Order   161995   _______         0      999999          0   0000
     Customer Drive        1   _______         0          20          0   0000

           Speed Setup   (15)

     Ratio Control     1.000   _______  -125.000     125.000   1501   0   0000
     Spd Fwd Lim        85 %   _______         0         200   1502   0   0000
     Spd Rev Lim         0 %   _______      -200           0   1503   0   0000
     Zero Speed          1 %   _______         0         100   1504   0   0000
     Alg Spd Scaler    100 %   _______         0         250   1505   0   0000
     Aux Spd Scaler    100 %   _______         0         250   1506   0   0000
     Spd Fwd Lim 2     100 %   _______         0         200   1507   7   1000
     Spd Rev Lim 2    -100 %   _______      -200           0   1508   7   1000
     Spd Fwd Lim 3     100 %   _______         0         200   1509   7   1000
     Spd Rev Lim 3    -100 %   _______      -200           0   1510   7   1000
     Encoder filter adj    3   _______         0           6   1511   7   1000

          Torq Ref Menu  (16)

     Alg Trq Scaler    100 %   _______         0         250   1601   0   0000
     Aux Trq Scaler    100 %   _______         0         250   1602   0   0000
     Trq Setpoint       50 %   _______         0         250   1603   0   0000
     Holding Torque      0 %   _______      -250         250   1604   7   1000
     Alg hold Trq Scl    0 %   _______         0         250   1605   7   1000
     Trq Ramp incr  1.00 sec   _______      0.00      999.99   1606   0   0000
     Trq Ramp decr  1.00 sec   _______      0.00      999.99   1607   0   0000
```

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  Harmony PWM Parameter Dump (Ver 1.13   9-30-98)  1/07/99   15:35:33
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         Ramp Setup Menu (17)

      Fwd Accel     500.0 sec  _______       0.0      3200.0  1701  0  0000
      Fwd Decel     500.0 sec  _______       0.0      3200.0  1702  0  0000
      Rev Accel       5.0 sec  _______       0.0      3200.0  1703  0  0000
      Rev Decel       5.0 sec  _______       0.0      3200.0  1704  0  0000
      Jerk Rate      0.10 sec  _______      0.00       78.12  1705  0  0000
      2 Stage Ramp Enable   0  _______         0           1  1706  0  0000
      Fwd Accel 2     5.0 sec  _______       0.0      3200.0  1707  7  1000
      Fwd Decel 2     5.0 sec  _______       0.0      3200.0  1708  7  1000
      Rev Accel 2     5.0 sec  _______       0.0      3200.0  1709  7  1000
      Rev Decel 2     5.0 sec  _______       0.0      3200.0  1710  7  1000
      Fwd Accel 3      50 sec  _______         0       32000  1711  7  1000
      Fwd Decel 3      50 sec  _______         0       32000  1712  7  1000
      Rev Accel 3      50 sec  _______         0       32000  1713  7  1000
      Rev Decel 3      50 sec  _______         0       32000  1714  7  1000

          Pot Setup Menu (18)

      Set max pos      100 %   _______         0         200  1801  0  0000
      Set max neg        0 %   _______      -200           0  1802  0  0000
      4-20ma Max     105.0 %   _______       1.0       150.0  1803  0  0000
      4-20ma Dropout   3.9 ma  _______       0.0        10.0  1804  0  0000

          Timebase Setup (19)

      Cond Stop Tmr    0.8 sec _______       0.0       999.9  1901  0  0000
      Cond Run Tmr     0.8 sec _______       0.0       999.9  1902  0  0000
      Cycle Timer       96 Hrs _______         0       10000  1903  0  0000
      Hour Meter Setup   (50)                     (submenu)         0  0000
      Set the Clock time                          (function)        0  0000

      Hardware Scale Menu(20)

      Mot V fb       1022 v/v  _______         1        3000  2001  0  0000
      Line V fb      3430 v/v  _______         1        9000  2002  0  0000
      Ib Offset Adjust    5A   _______        00          FF  2003  0  0000
      Ic Offset Adjust    6C   _______        00          FF  2004  0  0000
      Std Mot V Trim  8.900 V  _______     0.000      10.000  2006  0  0000

            Cell Menu   (21)

      Installed Stages      5  _______         3           7  2101  0  0000
      Minimum Stage Count   4  _______         1           6  2102  0  0000
      Auto Bypass Enable    1  _______         0           1  2103  0  0000
      Print Cell Status                           (function)        0  0000
      Display Cell Fault(s)                       (function)        0  0000
      Print Cell Fault(s)                         (function)        0  0000
      RS232 Diag Bypass     0  _______         0           1        7  1000

       Current Loop Setup(22)

      I quad I gain     0.648  _______     0.000       0.996  2201  0  0000
      I quad P gain     0.550  _______     0.000       0.996  2202  0  0000
      I direct I gain   0.648  _______     0.000       0.996  2203  0  0000
      I direct P gain   0.894  _______     0.000       0.996  2204  0  0000

      Vector Control Tune(23)

      Vel P gain       15.000  _______     0.000     127.996  2301  0  0000
      Vel I gain       15.000  _______     0.000     255.996  2302  0  0000
      Imag P gain       0.066  _______     0.000     127.996  2303  0  0000
      Imag I gain       0.101  _______     0.000     127.996  2304  0  0000
      Slip P gain       0.062  _______     0.000     127.996  2305  0  0000
      Slip I gain       0.750  _______     0.000     127.996  2306  0  0000
      Vel P gain 2      5.000  _______     0.000     127.996  2307  7  1000
      Vel I gain 2      5.000  _______     0.000     255.996  2308  7  1000
      Vel P gain 3      5.000  _______     0.000     127.996  2309  7  1000
      Vel I gain 3      5.000  _______     0.000     255.996  2310  7  1000
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Std Control Setup(24)

description		change	range		xcl#	lev	hmpd
Std Volts/Hz	1.000	_______	-127.996	127.996	2401	0	0000
Volt P gain	0.500	_______	-127.996	127.996	2402	0	0000
Volt I gain	0.500	_______	-127.996	127.996	2403	0	0000
Vel P gain	5.000	_______	0.000	127.996	2404	0	0000
Vel I gain	5.000	_______	0.000	255.996	2405	0	0000
Trq P gain	0.011	_______	0.000	127.996	2406	0	0000
Trq I gain	0.800	_______	0.000	255.996	2407	0	0000
Voltage Min Boost	0.0 %	_______	0.0	6.0	2408	7	1000
Slow Ramp Time	3.00 sec	_______	0.00	9.99	2409	0	0000
Mot trq limit	85 %	_______	0	300	2410	0	0000
Regen trq limit	2.0 %	_______	0.2	10.0	2411	0	0000
Energy Saver	0 %	_______	0	100	2412	0	0000
Flux Shape	1.00	_______	0.01	1.10	2413	7	1000
Spin Load Thresh	4.3 %	_______	0.0	50.0	2414	0	0000
Spin Flux Scale	6.25 %	_______	1.00	15.00	2415	0	0000
Flux Ramp	7.0 sec	_______	0.1	15.0	2416	0	0000
Freq Scan Rate	5.0 sec	_______	1.5	9.0	2417	0	0000
Freq Drop Level	5.0 %	_______	0.0	12.0	2418	0	0000
Vel P gain 2	40.000	_______	0.000	127.996	2419	7	1000
Vel I gain 2	40.000	_______	0.000	255.996	2420	7	1000
Vel P gain 3	50.000	_______	0.000	127.996	2421	7	1000
Vel I gain 3	50.000	_______	0.000	255.996	2422	7	1000
Trq P gain 2	0.011	_______	0.000	127.996	2423	7	1000
Trq I gain 2	0.300	_______	0.000	255.996	2424	7	1000
Trq P gain 3	0.011	_______	0.000	127.996	2425	7	1000
Trq I gain 3	0.300	_______	0.000	255.996	2426	7	1000
Mot trq limit 2	100 %	_______	0	300	2427	7	1000
Regen trq limit 2	3.0 %	_______	0.2	10.0	2428	7	1000
Mot trq limit 3	100 %	_______	0	300	2429	7	1000
Regen trq limit 3	3.0 %	_______	0.2	10.0	2430	7	1000

Control Loop Test(25)

description		change	range		xcl#	lev	hmpd
Spd Test Pos	35 %	_______	-200	200		0	0000
Spd Test Neg	25 %	_______	-200	200		0	0000
Spd Test Time	10.1 sec	_______	0.0	500.0		0	0000
Begin Speed Loop test			(function)			0	0000
Stop Speed Loop test			(function)			0	0000
Trq Test Pos	50 %	_______	-200	200		0	0000
Trq Test Neg	0 %	_______	-200	200		0	0000
Trq Test Time	0.75 sec	_______	0.00	91.00		0	0000
Begin Torque Loop test			(function)			0	0000
Stop Torque Loop test			(function)			0	0000
Start Diagnostic Log			(function)			0	0000
Select Diagnostic Log			(function)			0	0000
Diagnostic Log Upload			(function)			0	0000

Speed Profile Menu(26)

description		change	range		xcl#	lev	hmpd
Entry Pt.	0.0 %	_______	0.0	150.0	2601	0	0000
Exit Pt.	150.0 %	_______	0.0	150.0	2602	0	0000
Entry Spd	0.0 %	_______	0.0	150.0	2603	0	0000
Exit Spd	150.0 %	_______	0.0	150.0	2604	0	0000
Auto off	0.0 %	_______	0.0	100.0	2605	0	0000
Delay off	0.5 sec	_______	0.5	100.0	2606	0	0000
Auto on	0.0 %	_______	0.0	100.0	2607	0	0000
Delay on	0.5 sec	_______	0.5	100.0	2608	0	0000

Speed Setpoint Menu(27)

description		change	range		xcl#	lev	hmpd
Spd Setpt 1	0 rpm	_______	-9999	9999	2701	0	0000
Spd Setpt 2	0 rpm	_______	-9999	9999	2702	0	0000
Spd Setpt 3	0 rpm	_______	-9999	9999	2703	0	0000
Spd Setpt 4	0 rpm	_______	-9999	9999	2704	0	0000
Spd Setpt 5	0 rpm	_______	-9999	9999	2705	0	0000
Spd Setpt 6	0 rpm	_______	-9999	9999	2706	0	0000
Spd Setpt 7	0 rpm	_______	-9999	9999	2707	0	0000

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      Critical Speed Menu(28)

      Skip Freq 1     15.0 Hz  _______        0.0        120.0  2801   0  0000
      Skip Freq 2     30.0 Hz  _______        0.0        120.0  2802   0  0000
      Skip Freq 3     45.0 Hz  _______        0.0        120.0  2803   0  0000
      Skip band 1      0.0 Hz  _______        0.0          6.0  2804   0  0000
      Skip band 2      0.0 Hz  _______        0.0          6.0  2805   0  0000
      Skip band 3      0.0 Hz  _______        0.0          6.0  2806   0  0000

         Comparator Setup(29)

      Compare 1 Setup   (121)                    (submenu)            7  1000
      Compare 2 Setup   (122)                    (submenu)            7  1000
      Compare 3 Setup   (123)                    (submenu)            7  1000
      Compare 4 Setup   (124)                    (submenu)            7  1000
      Compare 5 Setup   (125)                    (submenu)            7  1000
      Compare 6 Setup   (126)                    (submenu)            7  1000
      Compare 7 Setup   (127)                    (submenu)            7  1000
      Compare 8 Setup   (128)                    (submenu)            7  1000
      Compare 9 Setup   (129)                    (submenu)            7  1000
      Compare 10 Setup  (130)                    (submenu)            7  1000
      Compare 11 Setup  (131)                    (submenu)            7  1000
      Compare 12 Setup  (132)                    (submenu)            7  1000
      Compare 13 Setup  (133)                    (submenu)            7  1000
      Compare 14 Setup  (134)                    (submenu)            7  1000
      Compare 15 Setup  (135)                    (submenu)            7  1000
      Compare 16 Setup  (136)                    (submenu)            7  1000

         PID Select Menu (48)

      PID scaler 1     0.390   _______  -127.996     127.996  4801   0  0000
      PID scaler 2    -0.390   _______  -127.996     127.996  4802   0  0000
      PID P Gain       0.390   _______     0.000      98.996  4803   0  0000
      PID I Gain       0.390   _______     0.000      98.996  4804   0  0000
      PID D Gain       0.000   _______     0.000      98.996  4805   0  0000
      PID Min Clamp       0 %  _______      -200         200  4806   0  0000
      PID Max Clamp     100 %  _______      -200         200  4807   0  0000
      PID Setpoint        0 %  _______      -200         200  4808   7  1000

         Memory Functions(30)

      Read Memory Byte                           (function)           0  0000
      Read Memory Word                           (function)           0  0000
      Write Memory Byte                          (function)           0  0000
      Write Memory Word                          (function)           0  0000
      Copy from RAM to EEPROM                    (function)           0  0000
      Copy from EEPROM to RAM                    (function)           0  0000

      Diagnostic Log Menu(31)

      Log var1   - (empty)                         (list)             0  0000
      Log var2   - (empty)                         (list)             0  0000
      Log var3   - (empty)                         (list)             0  0000
      Log var4   - (empty)                         (list)             0  0000
      Diag Log Time   3.6 sec  _______        0.0        310.0        0  0000
      Select Diagnostic Log                      (function)           0  0000
      Start Diagnostic Log                       (function)           0  0000
      Diagnostic Log Upload                      (function)           0  0000

        Historic Log Menu(32)

      Select Historic Log                        (function)           0  0000
      Hist var1  -M % spd                          (list)             0  0000
      Hist var2  -Mtr Freq                         (list)             0  0000
      Hist var3  -Trq cmd                          (list)             0  0000
      Hist var4  -Trq I Fb                         (list)             0  0000
      Hist var5  -Mtr V fb                         (list)             0  0000
      Hist var6  -I sum fb                         (list)             0  0000
      Hist var7  -V Avail                          (list)             0  0000
      Historic Log Upload                        (function)           0  0000
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          Fault Log Menu (33)

      Fault Log Display                              (function)            0   0000
      Fault Log Upload                               (function)            0   0000

          Overload Menu  (34)

      Overld Select         1    _______         0           2   3401   0   0000
      I overload          150 %  _______        20         210   3402   0   0000
      I timeout       60.00 sec  _______      0.01      300.00   3403   0   0000
      Motor Trip volts   4800 V  _______         5        9999   3404   0   0000
      OverSpeed           150 %  _______         0         250   3405   0   0000
      Encoder Loss Thsh     0 %  _______         0          75   3406   0   0000
      Drive IOC Setpt     165 %  _______        50         200   3407   7   1000
      I overload 2        150 %  _______        20         210   3408   7   1000
      I timeout 2     60.00 sec  _______      0.01      300.00   3409   7   1000
      I overload 3        150 %  _______        20         210   3410   7   1000
      I timeout 3     60.00 sec  _______      0.01      300.00   3411   7   1000
      Enter for Fault Reset                          (function)            0   0000
      Clear Fault Message                            (function)            7   1000

            Limit Menu   (35)

      Mot trq limit       150 %  _______         0         300   3501   0   0000
      Reg trq limit       3.0 %  _______       0.0        30.0   3502   0   0000
      Mot Alg limit       100 %  _______         0         300   3503   0   0000
      Regen Alg limit     2.0 %  _______       0.0        30.0   3504   0   0000
      Mot trq limit 2     100 %  _______         0         300   3505   7   1000
      Reg trq limit 2     2.0 %  _______       0.0        30.0   3506   7   1000
      Mot trq limit 3     100 %  _______         0         300   3507   7   1000
      Reg trq limit 3     2.0 %  _______       0.0        30.0   3508   7   1000

         Analog I/O Setup(36)

      Alg var1   -Speed fb                             (list)              0   0000
      Alg var2   -Trq Reg Fb                           (list)              0   0000
      Analog TP 1    10.000 V  _______   -20.000      20.000               0   0000
      Analog TP 2    10.000 V  _______   -20.000      20.000               0   0000
      Alg In Scaler       100 %  _______         0         250             0   0000
      Analog Output 1   (111)                        (submenu)             7   1000
      Analog Output 2   (112)                        (submenu)             7   1000
      Analog Output 3   (113)                        (submenu)             7   1000
      Analog Output 4   (114)                        (submenu)             7   1000
      Analog Output 5   (115)                        (submenu)             7   1000
      Analog Output 6   (116)                        (submenu)             7   1000
      Analog Output 7   (117)                        (submenu)             7   1000
      Analog Output 8   (118)                        (submenu)             7   1000
      Analog Input 1    (181)                        (submenu)             7   1000
      Analog Input 2    (182)                        (submenu)             7   1000
      Analog Input 3    (183)                        (submenu)             7   1000
      Analog Input 4    (184)                        (submenu)             7   1000
      Analog Input 5    (185)                        (submenu)             7   1000
      Analog Input 6    (186)                        (submenu)             7   1000
      Analog Input 7    (187)                        (submenu)             7   1000
      Analog Input 8    (188)                        (submenu)             7   1000
      Vel Ref    - (empty)                             (list)              7   1000
      PID Ref    - (empty)                             (list)              7   1000
      Aux Vel Ref- (empty)                             (list)              7   1000
      Trq Ref    - (empty)                             (list)              7   1000

        Display Var. Menu(37)

      Disp var0  -Spd Input                            (list)              0   0000
      Disp var1  -Trq cmd                              (list)              0   0000
      Disp var2  -Mtr rpm                              (list)              0   0000
      Disp var3  -Trq I Fb                             (list)              0   0000
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           description          change             range      xcl# lev hmpd

         Trim Analog Meters(38)

      Trim local meter 1                         (function)          0   0000
      Trim local meter 2                         (function)          0   0000
      Trim local meter 3                         (function)          0   0000
      Trim local meter 4                         (function)          0   0000
      Trim local meter 5                         (function)          0   0000
      Trim local meter 6                         (function)          0   0000
      Trim local meter 7                         (function)          0   0000
      Trim local meter 8                         (function)          0   0000

         Loc. Alg. Meters(39)

      Analog Meter 1     (51)                    (submenu)           0   0000
      Analog Meter 2     (52)                    (submenu)           0   0000
      Analog Meter 3     (53)                    (submenu)           0   0000
      Analog Meter 4     (54)                    (submenu)           0   0000
      Analog Meter 5     (55)                    (submenu)           0   0000
      Analog Meter 6     (56)                    (submenu)           0   0000
      Analog Meter 7     (57)                    (submenu)           0   0000
      Analog Meter 8     (58)                    (submenu)           0   0000

         Loc. Dig. Meters(40)

      Digital Meter 1    (61)                    (submenu)           0   0000
      Digital Meter 2    (62)                    (submenu)           0   0000
      Digital Meter 3    (63)                    (submenu)           0   0000
      Digital Meter 4    (64)                    (submenu)           0   0000
      Digital Meter 5    (65)                    (submenu)           0   0000
      Digital Meter 6    (66)                    (submenu)           0   0000
      Digital Meter 7    (67)                    (submenu)           0   0000

         RS232 Functions (41)

      System Program Download                    (function)          0   0000
      System Program Upload                      (function)          0   0000
      Display Sys Prog Name                      (function)          0   0000
      Download entire EEPROM                     (function)          0   0000
      Upload entire EEPROM                       (function)          0   0000
      Parameter Data Download                    (function)          0   0000
      Parameter Data Upload                      (function)          0   0000
      RS232 Echo-back test                       (function)          0   0000
      Parameter Log Upload                       (function)          0   0000
      Onboard RS232        1   ______         0           1          7   1000

         Remote I/O Menu (42)

      Read user module                           (function)          0   0000
      Write user module                          (function)          0   0000

          XCL Send Setup (43)

      XCL Global Send   (145)                    (submenu)           7   1001
      XCL Send Reg 1-31 (147)                    (submenu)           7   1000
      XCL Send Reg 33-63(148)                    (submenu)           7   1000
      XCL Node Address      9  ______         0         128          7   1001
      CAB Configuration  0000  ______      0000        FFFF          0   0001
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           description          change              range      xcl# lev hmpd

         XCL Global Send(145)

      XCL send01 - (empty)                           (list)            0  0000
      XCL send02 - (empty)                           (list)            0  0000
      XCL send03 - (empty)                           (list)            0  0000
      XCL send04 - (empty)                           (list)            0  0000
      XCL send05 - (empty)                           (list)            0  0000
      XCL send06 - (empty)                           (list)            0  0000
      XCL send07 - (empty)                           (list)            0  0000
      XCL send08 - (empty)                           (list)            0  0000
      XCL send09 - (empty)                           (list)            0  0000
      XCL send10 - (empty)                           (list)            0  0000
      XCL send11 - (empty)                           (list)            0  0000
      XCL send12 - (empty)                           (list)            0  0000
      XCL send13 - (empty)                           (list)            0  0000
      XCL send14 - (empty)                           (list)            0  0000
      XCL send15 - (empty)                           (list)            0  0000
      XCL send16 - (empty)                           (list)            0  0000

       XCL Send Reg 1-31(147)

      XCLreg001  -Spd fb %                           (list)            0  0000
      XCLreg003  -Spd Cmd %                          (list)            0  0000
      XCLreg005  -Trq I Fb %                         (list)            0  0000
      XCLreg007  -Tot I Fb %                         (list)            0  0000
      XCLreg009  -KW output %                        (list)            0  0000
      XCLreg011  -Serial flg1                        (list)            0  0000
      XCLreg013  -Flt wrd2                           (list)            0  0000
      XCLreg015  -Flt wrd1                           (list)            0  0000
      XCLreg017  -Flt wrd1                           (list)            0  0000
      XCLreg019  -Flt wrd2                           (list)            0  0000
      XCLreg021  - (empty)                           (list)            0  0000
      XCLreg023  - (empty)                           (list)            0  0000
      XCLreg025  - (empty)                           (list)            0  0000
      XCLreg027  - (empty)                           (list)            0  0000
      XCLreg029  - (empty)                           (list)            0  0000
      XCLreg031  - (empty)                           (list)            0  0000

      XCL Send Reg 33-63(148)

      XCLreg033  - (empty)                           (list)            0  0000
      XCLreg035  - (empty)                           (list)            0  0000
      XCLreg037  - (empty)                           (list)            0  0000
      XCLreg039  - (empty)                           (list)            0  0000
      XCLreg041  - (empty)                           (list)            0  0000
      XCLreg043  - (empty)                           (list)            0  0000
      XCLreg045  - (empty)                           (list)            0  0000
      XCLreg047  - (empty)                           (list)            0  0000
      XCLreg049  - (empty)                           (list)            0  0000
      XCLreg051  - (empty)                           (list)            0  0000
      XCLreg053  - (empty)                           (list)            0  0000
      XCLreg055  - (empty)                           (list)            0  0000
      XCLreg057  - (empty)                           (list)            0  0000
      XCLreg059  - (empty)                           (list)            0  0000
      XCLreg061  - (empty)                           (list)            0  0000
      XCLreg063  - (empty)                           (list)            0  0000

          XCL Recv Setup (44)

      XCL Vel Ref      (141)                      (submenu)          7  1000
      XCL Vel Ctrl     (142)                      (submenu)          7  1000
      XCL Trq Ctrl     (143)                      (submenu)          7  1000
      XCL Com Flags    (144)                      (submenu)          7  1000
      Ser Input Scalers (146)                     (submenu)          7  1001
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  Harmony PWM Parameter Dump (Ver 1.13   9-30-98)  1/07/99   15:35:33
           description          change              range       xcl#  lev hmpd

            XCL Vel Ref  (141)

      XCLPTR_01       00:000   _______       000         099        0   0001
      XCLPTR_02       00:000   _______       000         099        0   0001
      XCLPTR_03       00:000   _______       000         099        0   0001
      XCLPTR_04       00:000   _______       000         099        0   0001
      XCLPTR_05       99:065   _______       000         099        0   0001
      XCLPTR_06       00:000   _______       000         099        0   0001
      XCLPTR_07       00:000   _______       000         099        0   0001
      XCLPTR_08       00:000   _______       000         099        0   0001
      XCLPTR_09       00:000   _______       000         099        0   0001
      XCLPTR_10       00:000   _______       000         099        0   0001
      XCLPTR_11       00:000   _______       000         099        0   0001
      XCLPTR_12       00:000   _______       000         099        0   0001

            XCL Vel Ctrl (142)

      XCLPTR_13       00:000   _______       000         099        0   0001
      XCLPTR_14       00:000   _______       000         099        0   0001
      XCLPTR_15       00:000   _______       000         099        0   0001
      XCLPTR_16       00:000   _______       000         099        0   0001
      XCLPTR_17       00:000   _______       000         099        0   0001
      XCLPTR_18       00:000   _______       000         099        0   0001
      XCLPTR_19       00:000   _______       000         099        0   0001
      XCLPTR_20       00:000   _______       000         099        0   0001
      XCLPTR_21       00:000   _______       000         099        0   0001
      XCLPTR_22       00:000   _______       000         099        0   0001
      XCLPTR_23       00:000   _______       000         099        0   0001
      XCLPTR_24       00:000   _______       000         099        0   0001
      XCLPTR_25       00:000   _______       000         099        0   0001
      XCLPTR_26       00:000   _______       000         099        0   0001
      XCLPTR_27       00:000   _______       000         099        0   0001
      XCLPTR_28       00:000   _______       000         099        0   0001
      XCLPTR_29       00:000   _______       000         099        0   0001
      XCLPTR_30       00:000   _______       000         099        0   0001
      XCLPTR_31       00:000   _______       000         099        0   0001
      XCLPTR_32       00:000   _______       000         099        0   0001
      XCLPTR_33       00:000   _______       000         099        0   0001
      XCLPTR_34       00:000   _______       000         099        0   0001
      XCLPTR_35       00:000   _______       000         099        0   0001
      XCLPTR_36       00:000   _______       000         099        0   0001

            XCL Trq Ctrl (143)

      XCLPTR_37       00:000   _______       000         099        0   0001
      XCLPTR_38       00:000   _______       000         099        0   0001
      XCLPTR_39       00:000   _______       000         099        0   0001
      XCLPTR_40       00:000   _______       000         099        0   0001
      XCLPTR_41       00:000   _______       000         099        0   0001
      XCLPTR_42       00:000   _______       000         099        0   0001
      XCLPTR_43       00:000   _______       000         099        0   0001
      XCLPTR_44       00:000   _______       000         099        0   0001
      XCLPTR_45       00:000   _______       000         099        0   0001
      XCLPTR_46       00:000   _______       000         099        0   0001
      XCLPTR_47       00:000   _______       000         099        0   0001
      XCLPTR_48       00:000   _______       000         099        0   0001
      XCLPTR_49       00:000   _______       000         099        0   0001
      XCLPTR_50       00:000   _______       000         099        0   0001
      XCLPTR_51       00:000   _______       000         099        0   0001
      XCLPTR_52       00:000   _______       000         099        0   0001
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  Harmony PWM Parameter Dump (Ver 1.13   9-30-98)  1/07/99   15:35:33
          description          change               range        xcl# lev hmpd

          XCL Com Flags (144)

      COMM_F01        99:067   _______       000          099         0   0001
      COMM_F02        99:069   _______       000          099         0   0001
      COMM_F03        00:000   _______       000          099         0   0001
      COMM_F04        00:000   _______       000          099         0   0001
      COMM_F05        00:000   _______       000          099         0   0001
      COMM_F06        00:000   _______       000          099         0   0001
      COMM_F07        00:000   _______       000          099         0   0001
      COMM_F08        00:000   _______       000          099         0   0001
      COMM_F09        00:000   _______       000          099         0   0001
      COMM_F10        00:000   _______       000          099         0   0001
      COMM_F11        00:000   _______       000          099         0   0001
      COMM_F12        00:000   _______       000          099         0   0001
      COMM_F13        00:000   _______       000          099         0   0001
      COMM_F14        00:000   _______       000          099         0   0001
      COMM_F15        00:000   _______       000          099         0   0001
      COMM_F16        00:000   _______       000          099         0   0001

       Ser Input Scalers(146)

      Vel Ref Ser       1.000  _______  -125.000      125.000  4601  7  1000
      V Aux Ref Ser     1.000  _______  -125.000      125.000  4602  7  1000
      V Ref P Lm Ser    1.000  _______  -125.000      125.000  4603  7  1000
      V Ref N Lm Ser    1.000  _______  -125.000      125.000  4604  7  1000
      Trq Cmd Ser       1.000  _______  -125.000      125.000  4605  7  1000
      Aux Trq Ser       1.000  _______  -125.000      125.000  4606  7  1000
      Trq P Lim Ser     1.000  _______  -125.000      125.000  4607  7  1000
      Trq N Lim Ser     1.000  _______  -125.000      125.000  4608  7  1000

         Hour Meter Setup(50)

      Display Hour Meter                          (function)          0   0000
      KW Hours Consumed                           (function)          0   0000

          Analog Meter 1 (51)

      Meter 1 var- (empty)                          (list)            0   0000
      Full Scale      000000   _______    000000      400000          0   0000
      Zero Position        1   _______         0           1          0   0000

          Analog Meter 2 (52)

      Meter 2 var- (empty)                          (list)            0   0000
      Full Scale      000000   _______    000000      400000          0   0000
      Zero Position        1   _______         0           1          0   0000

          Analog Meter 3 (53)

      Meter 3 var- (empty)                          (list)            0   0000
      Full Scale      000000   _______    000000      400000          0   0000
      Zero Position        1   _______         0           1          0   0000

          Analog Meter 4 (54)

      Meter 4 var- (empty)                          (list)            0   0000
      Full Scale      000000   _______    000000      400000          0   0000
      Zero Position        1   _______         0           1          0   0000

          Analog Meter 5 (55)

      Meter 5 var- (empty)                          (list)            0   0000
      Full Scale      000000   _______    000000      400000          0   0000
      Zero Position        1   _______         0           1          0   0000

          Analog Meter 6 (56)

      Meter 6 var- (empty)                          (list)            0   0000
      Full Scale      000000   _______    000000      400000          0   0000
      Zero Position        1   _______         0           1          0   0000
```

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  Harmony PWM Parameter Dump (Ver 1.13   9-30-98)  1/07/99  15:35:33
           description          change              range       xcl# lev hmpd

          Analog Meter 7 (57)

      Meter 7 var- (empty)                           (list)            0  0000
      Full Scale      000000   _______    000000      400000          0  0000
      Zero Position        1   _______         0           1          0  0000

          Analog Meter 8 (58)

      Meter 8 var- (empty)                           (list)            0  0000
      Full Scale      000000   _______    000000      400000          0  0000
      Zero Position        1   _______         0           1          0  0000

         Digital Meter 1 (61)

      Meter 1 var- (empty)                           (list)            0  0000
      Rated Value     000000   _______    000000      400000          0  0000
      Decimal Places       0   _______         0           4          0  0000

         Digital Meter 2 (62)

      Meter 2 var- (empty)                           (list)            0  0000
      Rated Value     000000   _______    000000      400000          0  0000
      Decimal Places       0   _______         0           4          0  0000

         Digital Meter 3 (63)

      Meter 3 var- (empty)                           (list)            0  0000
      Rated Value     000000   _______    000000      400000          0  0000
      Decimal Places       0   _______         0           4          0  0000

         Digital Meter 4 (64)

      Meter 4 var- (empty)                           (list)            0  0000
      Rated Value     000000   _______    000000      400000          0  0000
      Decimal Places       0   _______         0           4          0  0000

         Digital Meter 5 (65)

      Meter 5 var- (empty)                           (list)            0  0000
      Rated Value     000000   _______    000000      400000          0  0000
      Decimal Places       0   _______         0           4          0  0000

         Digital Meter 6 (66)

      Meter 6 var- (empty)                           (list)            0  0000
      Rated Value     000000   _______    000000      400000          0  0000
      Decimal Places       0   _______         0           4          0  0000

         Digital Meter 7 (67)

      Meter 7 var- (empty)                           (list)            0  0000
      Rated Value     000000   _______    000000      400000          0  0000
      Decimal Places       0   _______         0           4          0  0000

         Analog Output 1(111)

      Analog var1- (empty)                           (list)            7  1000
      Full Range        0.0 %  _______       0.0       300.0          7  1000
      Module Address       0   _______         0          15          7  1000
      Var1 type  - (empty)                           (list)            7  1000

         Analog Output 2(112)

      Analog var2- (empty)                           (list)            7  1000
      Full Range        0.0 %  _______       0.0       300.0          7  1000
      Module Address       0   _______         0          15          7  1000
      Var2 type  - (empty)                           (list)            7  1000

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  Harmony PWM Parameter Dump (Ver 1.13  9-30-98)  1/07/99  15:35:33
           description          change             range      xcl# lev hmpd

         Analog Output 3(113)

      Analog var3- (empty)                          (list)            7  1000
      Full Range        0.0 %  _______      0.0      300.0        7  1000
      Module Address        0  _______        0         15        7  1000
      Var3 type  - (empty)                          (list)            7  1000

         Analog Output 4(114)

      Analog var4- (empty)                          (list)            7  1000
      Full Range        0.0 %  _______      0.0      300.0        7  1000
      Module Address        0  _______        0         15        7  1000
      Var4 type  - (empty)                          (list)            7  1000

         Analog Output 5(115)

      Analog var5- (empty)                          (list)            7  1000
      Full Range        0.0 %  _______      0.0      300.0        7  1000
      Module Address        0  _______        0         15        7  1000
      Var5 type  - (empty)                          (list)            7  1000

         Analog Output 6(116)

      Analog var6- (empty)                          (list)            7  1000
      Full Range        0.0 %  _______      0.0      300.0        7  1000
      Module Address        0  _______        0         15        7  1000
      Var6 type  - (empty)                          (list)            7  1000

         Analog Output 7(117)

      Analog var7- (empty)                          (list)            7  1000
      Full Range        0.0 %  _______      0.0      300.0        7  1000
      Module Address        0  _______        0         15        7  1000
      Var7 type  - (empty)                          (list)            7  1000

         Analog Output 8(118)

      Analog var8- (empty)                          (list)            7  1000
      Full Range        0.0 %  _______      0.0      300.0        7  1000
      Module Address        0  _______        0         15        7  1000
      Var8 type  - (empty)                          (list)            7  1000

         Compare 1 Setup(121)

      Comp 1 A in-V Avail                           (list)            0  0000
      Comp 1 B in- + 80.0 %                         (list)            0  0000
      Compare 1  -Magnitude                         (list)            0  0000

         Compare 2 Setup(122)

      Comp 2 A in-Spd fb Abs                        (list)            0  0000
      Comp 2 B in- + 80.0 %                         (list)            0  0000
      Compare 2  -Magnitude                         (list)            0  0000

         Compare 3 Setup(123)

      Comp 3 A in- (empty)                          (list)            0  0000
      Comp 3 B in- (empty)                          (list)            0  0000
      Compare 3  - (empty)                          (list)            0  0000

         Compare 4 Setup(124)

      Comp 4 A in- (empty)                          (list)            0  0000
      Comp 4 B in- (empty)                          (list)            0  0000
      Compare 4  - (empty)                          (list)            0  0000

         Compare 5 Setup(125)

      Comp 5 A in- (empty)                          (list)            0  0000
      Comp 5 B in- (empty)                          (list)            0  0000
      Compare 5  - (empty)                          (list)            0  0000
```

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  Harmony PWM Parameter Dump (Ver 1.13  9-30-98)  1/07/99  15:35:33
           description          change              range      xcl# lev hmpd

         Compare 6 Setup(126)

      Comp 6 A in- (empty)                          (list)             0  0000
      Comp 6 B in- (empty)                          (list)             0  0000
      Compare 6  - (empty)                          (list)             0  0000

         Compare 7 Setup(127)

      Comp 7 A in- (empty)                          (list)             0  0000
      Comp 7 B in- (empty)                          (list)             0  0000
      Compare 7  - (empty)                          (list)             0  0000

         Compare 8 Setup(128)

      Comp 8 A in- (empty)                          (list)             0  0000
      Comp 8 B in- (empty)                          (list)             0  0000
      Compare 8  - (empty)                          (list)             0  0000

         Compare 9 Setup(129)

      Comp 9 A in- (empty)                          (list)             0  0000
      Comp 9 B in- (empty)                          (list)             0  0000
      Compare 9  - (empty)                          (list)             0  0000

        Compare 10 Setup(130)

      Comp 10 A i- (empty)                          (list)             0  0000
      Comp 10 B i- (empty)                          (list)             0  0000
      Compare 10 - (empty)                          (list)             0  0000

        Compare 11 Setup(131)

      Comp 11 A i- (empty)                          (list)             0  0000
      Comp 11 B i- (empty)                          (list)             0  0000
      Compare 11 - (empty)                          (list)             0  0000

        Compare 12 Setup(132)

      Comp 12 A i- (empty)                          (list)             0  0000
      Comp 12 B i- (empty)                          (list)             0  0000
      Compare 12 - (empty)                          (list)             0  0000

        Compare 13 Setup(133)

      Comp 13 A i- (empty)                          (list)             0  0000
      Comp 13 B i- (empty)                          (list)             0  0000
      Compare 13 - (empty)                          (list)             0  0000

        Compare 14 Setup(134)

      Comp 14 A i- (empty)                          (list)             0  0000
      Comp 14 B i- (empty)                          (list)             0  0000
      Compare 14 - (empty)                          (list)             0  0000

        Compare 15 Setup(135)

      Comp 15 A i- (empty)                          (list)             0  0000
      Comp 15 B i- (empty)                          (list)             0  0000
      Compare 15 - (empty)                          (list)             0  0000

        Compare 16 Setup(136)

      Comp 16 A i- (empty)                          (list)             0  0000
      Comp 16 B i- (empty)                          (list)             0  0000
      Compare 16 - (empty)                          (list)             0  0000

          Analog Input 1(181)

      Full Range        0.0 %  _______        0.0       300.0        7  1000
      Module Address      0  _______          0          15        7  1000
      Var1 type  - (empty)                          (list)             7  1000
```

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  Harmony PWM Parameter Dump (Ver 1.13   9-30-98)  1/07/99   15:35:33
            description          change              range      xcl# lev hmpd

           Analog Input 2(182)

      Full Range         0.0 %   _______       0.0        300.0        7  1000
      Module Address        0    _______         0           15        7  1000
      Var2 type  - (empty)                          (list)               7  1000

           Analog Input 3(183)

      Full Range         0.0 %   _______       0.0        300.0        7  1000
      Module Address        0    _______         0           15        7  1000
      Var3 type  - (empty)                          (list)               7  1000

           Analog Input 4(184)

      Full Range         0.0 %   _______       0.0        300.0        7  1000
      Module Address        0    _______         0           15        7  1000
      Var4 type  - (empty)                          (list)               7  1000

           Analog Input 5(185)

      Full Range         0.0 %   _______       0.0        300.0        7  1000
      Module Address        0    _______         0           15        7  1000
      Var5 type  - (empty)                          (list)               7  1000

           Analog Input 6(186)

      Full Range         0.0 %   _______       0.0        300.0        7  1000
      Module Address        0    _______         0           15        7  1000
      Var6 type  - (empty)                          (list)               7  1000

           Analog Input 7(187)

      Full Range         0.0 %   _______       0.0        300.0        7  1000
      Module Address        0    _______         0           15        7  1000
      Var7 type  - (empty)                          (list)               7  1000

           Analog Input 8(188)

      Full Range         0.0 %   _______       0.0        300.0        7  1000
      Module Address        0    _______         0           15        7  1000
      Var8 type  - (empty)                          (list)               7  1000

           Transfer Menu (200)

      Phase I gain       2       _______         0           15        7  1000
      Phase P shft       4       _______         1           12        7  1000
      Phase offset   22.0 deg    _______       0.0        180.0        7  1000
      Hardwr offst -147.0 deg    _______    -180.0        180.0        7  1000
      Phase err thrsh 1.5 deg    _______       0.0          5.0        0  0000
      Line sync source      1    _______         0            2        7  1001

                          End of Harmony PWM Parameter Dump
```

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APPENDIX E: SOLID-STATE VARIABLE VOLTAGE SOURCE OPTION

In This Section:

E.1. Introduction

This appendix contains information on the Solid State Variable Voltage Source from ROBICON. Two versions are available: a 480 VAC, 25 A version (P/N 430278.00) and a 480 VAC, 50 A version (P/N 430278.01). This product is an option when a Perfect Harmony is purchased.

The ROBICON solid-state variable voltage source is a light-weight way of supplying a variable voltage source for back-feeding Perfect Harmony drives. It can also be used for supplying power to an individual cell being tested.

> Use of this supply for back-feeding systems is reserved for ROBICON qualified service personnel.

E.2. Protective Circuits

The ROBICON solid-state source contains built-in current limiting circuitry and input power fuses for protection. The variable voltage source contains solid-state *current limit control* that limits the source's output to the maximum rated output current. In addition, *input power fuses* are supplied to protect the supply from internal short circuits.

> **Lethal voltages** are present when this equipment is in normal use. Users who have not been specifically trained to operate in this type of environment should contact qualified personnel.

> Before connecting the solid-state variable voltage source to a drive (or other device), be sure that all power to the drive (or device) is turned off at the source. Be sure to follow proper lock-out/tag-out instructions.

E.3. Operation

Use the connection diagram shown in Figure E-1 when connecting the ROBICON solid-state variable voltage source to a cell for testing. Follow the steps outlined below.

- After the unit is connected, check that the voltage adjust potentiometer is fully rotated to the counter-clockwise (CCW) position, and the On/Off switch is in the "off" position. Refer to Figure E-2.

> **WARNING!** An SCR does not completely isolate the load when switched to the "off" position. Before voltage is supplied to the variable voltage source, be sure the load is ready for voltage.

- Set the On/Off switch to the "on" position.
- Adjust the voltage as needed by the cell test procedure.

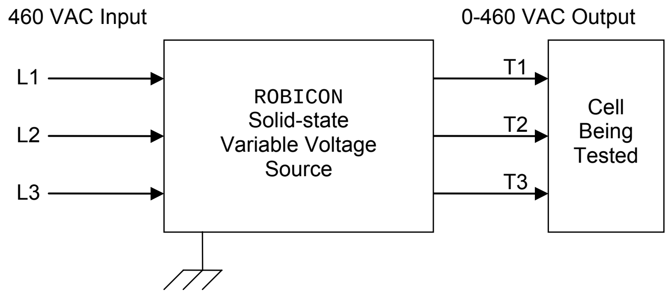

Figure E-1. Cell Test Connection Diagram

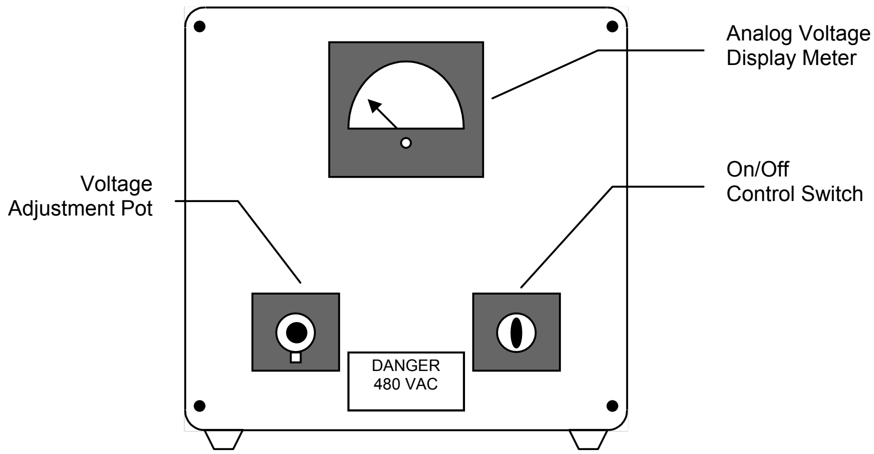

Figure E-2. Variable Voltage Source Controls

E.4. Troubleshooting

Table E-1 lists some common troubleshooting issues.

Table E-1. Common Troubleshooting Issues

Problem	Possible Cause	Possible Solution
No output voltage...	Is the unit switched "on"?	Switch unit to "on" position.
	Pot not properly adjusted?	Adjust voltage adjustment potentiometer clock-wise (CW).
	Input voltage is incorrect?	Correct the input source according to the specifications in Table E-2.
	Blown power fuse(s)?	Replace blown power fuse(s). Also, do a power bridge test to check for shorted SCRs.
	Defective control circuit?	Replace control cards.
Full output voltage...	Load is not connected?	If the variable voltage source has input voltage with no load connected, full voltage will appear on the output. This is due to the inherent leakage from the SCRs.
	Defective control circuit?	Replace control cards.

E

E.4.1. SCR Power Bridge Test

The ROBICON solid-state variable voltage source uses three sets of back-to-back SCRs as illustrated in Figure E-3. A VOM (volt/Ohm meter) can be used to test the resistance across the SCR switch. A zero Ohm reading (0 Ω) indicates a defective SCR. To test, connect one lead to **L1** and the other to **T1**. Repeat the test for **L2** to **T2** and **L3** to **T3**. Replace any SCRs that are shorted. The VOM test meter should be set to the Ohm scale (R×1).

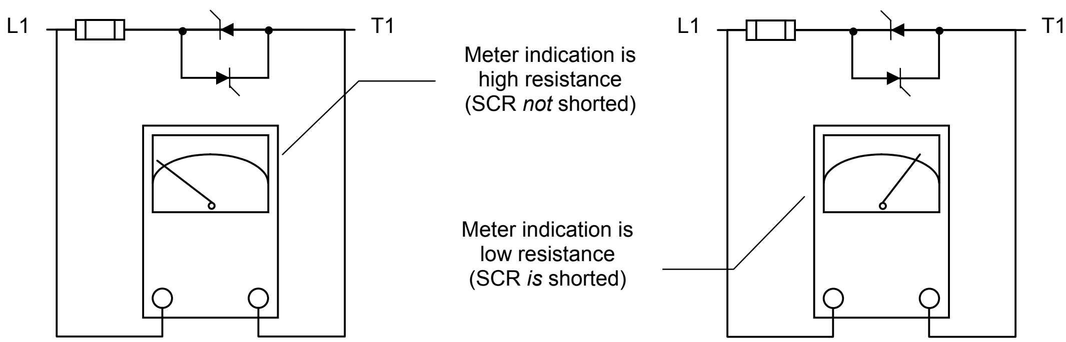

Figure E-3. Sample Power Bridge Test Results

E.4.2. Power Fuse Replacement

Follow the instructions listed below for proper power fuse replacement.

1. Disconnect the input voltage to the variable voltage source.
2. Fuse access is provided via the back panel of the variable voltage source. Refer to Figure E-4.

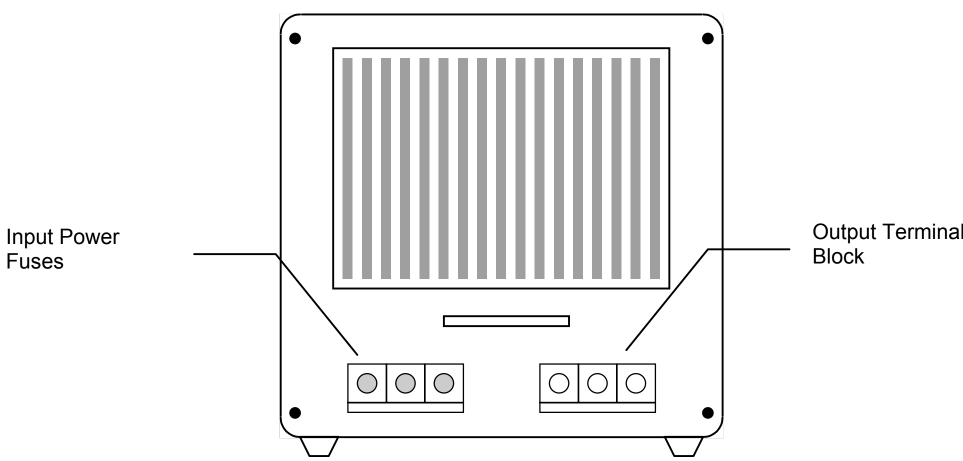

Figure E-4. Solid-state Variable Voltage Source (Rear View)

E.5. Warranty

ROBICON warrants each solid-state variable voltage source for 90 days from the date of shipment. ROBICON will repair or replace (without charging for parts or labor) any part of the variable voltage source if it is deemed defective in material or workmanship within reasonable judgment by ROBICON. This warranty will not cover damage due to misuse or misapplication. All products intended for service must be sent to the ROBICON factory.

E

E.6. Specifications

Specifications for the ROBICON solid-state variable voltage source are outlined in Table E-2.

Table E-2. Solid State Variable Voltage Source Specifications

Item	Description (P/N 430278.00)	Description (P/N 430278.01)
Input Voltage	460 VAC +10% to -5%, 3-phase, 60 Hz	460 VAC +10% to -5%, 3-phase, 60 Hz
Input Current	25 Amps AC (max)	50 Amps AC (max)
Output Voltage	0-460 VAC phase angle output	0-460 VAC phase angle output
Output Current	25 Amps AC (max)	50 Amps AC (max)
Ambient Temperature	0-40° C	0-40° C
Humidity	95% non-condensing	95% non-condensing
Altitude	Maximum 3,300 ft (MSL)	Maximum 3,300 ft (MSL)

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E

APPENDIX F: SUGGESTED SPARE PARTS LIST

This appendix contains a sample spare parts list for Perfect Harmony drives (200-2000 hp). The quantity and part number "dash numbers" in Table F-1 are typical for 800 hp Perfect Harmony drives (part number 459384.SPK). Perfect Harmony drives may have different quantities and "dash numbers" based on the horsepower of the drive. Some drives may have spare parts lists that differ slightly from the list in Table F-1.

The lists are arranged in sections based on drive voltages. Within each section, the lists are arranged based on horsepower and part number. A base part number is given for each table. The part number for each associated spare parts kit is the base part number with the .SPK extension.

> The spare parts list in this appendix is for an 800 hp Perfect Harmony drive only. Parts lists for customized drives and other standard drives may vary. Call the ROBICON Customer Service Department at (724) 339-9501 for more information. Spare parts lists are subject to change without notice.

Table F-1. Spare Parts List for 800 hp Perfect Harmony Drive (459384.SPK)

Cabinet	Qty	Description	P/N
VFD Cell Cabinet	1	VFD Power Cell	460Y83.140
	1	Cell Control/Gate Board	4600A3.02
	3	Fuse, 100A, 690V (F11-F13)	088181
	3	Dual Rectifier Module	089706
	2	IGBT Module	088794
Control and Output Cabinet	1	Interface Board (IB)	469564.04T
	1	Micro Processor Board (MB)	469718.00T
	1	System Module Board (SMB)	362877.01T
	1	Fiber Optic Hub Board (FOHB)	460B80.00T
	1	Master Link Board (MLB)	460K78.01T
	1	Keypad (KPD)	460A68.10
	1	Bezel Keypad	487173.00
	1	Analog Output Module	369174.00T
	2	Fuse 3A, 600V	089533
	1	Fuse 6A, 600V	089207
	1	Fuse 5A, 600V	089206
	3	Fuse 4.5A, 600V	089637

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APPENDIX G: COMMONLY USED ABBREVIATIONS

This appendix contains a list of abbreviations commonly used in this manual.

Table G-1. Commonly Used Abbreviations

Abbreviation	Meaning
″	inches
Σ	summation
τ	torque
A	amperes
A/D	analog-to-digital (converter)
AC	alternating current
accel	acceleration
ADC	analog-to-digital converter
ai or AI	analog input
alg	analog
ao or AO	analog output
AOFF	automatic off condition
AOUT	analog output
AREF	analog reference
ASCII	American Standard Code for Information Interchange
AUTO	automatic
bit	binary digit
BTU	British thermal units
CAB	Communications Adapter Board
cap	capacitor
ccw	counter clockwise
cmd	command
com	common
comp	comparator
conn	connector
CTS	clear to send
curr	current
cw	clockwise
D	derivative (PID), depth

Abbreviation	Meaning
D/A	digital-to-analog (converter)
DAC	digital-to-analog converter
DC	direct current
DCL	drive communications link
decel or DECL	deceleration
di or DI	digital input
dmd	demand
do or DO	digital output
e	error
EEPROM	electrically erasable programmable read-only memory
EPROM	erasable programmable read-only memory
EMF	electromotive force
ESD	electrostatic discharge
ESTOP	emergency stop
fb, fdbk	feedback
ffwd	feed forward
FLC	full load current
FOHB	Fiber Optic Hub Board
freq	frequency
fwd	forward
GAL	generic array logic
gnd	ground
H	height
hex	hexadecimal
hist	historic
hp	horsepower
hr	hour
Hz	Hertz

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Abbreviation	Meaning
I	current, integral (PID)
I/O	input(s) and/or output(s)
ID	identification
IDMD	current demand
IGBT	insulated gate bipolar transistor
in	inches
info	information
INH	inhibit
K	1,000 (e.g., Kohm)
KYPD	keypad
LAN	local area network
lbs	pounds (weight)
LCD	liquid crystal display
ld	load
LED	light-emitting diode
lim	limit
LOS	loss of signal
mA	milliamperes
max	maximum
MCC	motor control center
min	minimum, minute
msec	millisecond(s)
msl	mean sea level
mvlt	motor voltage
NEMA	National Electrical Manufacturer's Association
NC	normally closed
NO	normally open
no.	number
NMI	non-maskable interrupt
NVRAM	non-volatile random access memory
oamp	output current
OOS	out of saturation
overld	overload

Abbreviation	Meaning
P	proportional (PID)
pb	push button
PC	personal computer
PIB	Power Interface Board
PID	proportional integral derivative
PLC	programmable logic controller
pot	potentiometer
PPR	pulses per revolution
psi	pounds per square inch
pt	point
PWM	pulse width modulation
RAM	random access memory
rc	ration control
ref	reference
rem or REM	remote mode or remark
rev	reverse, revolution(s)
RFI	radio frequency interference
RGEN	regeneration
RLBK	rollback
RPM	revolutions per minute
RTS	request to send
RTU	remote terminal unit
RX	receive
s	second(s)
SAFE	safety speed
sec	second(s)
SOP	sum of products
SPIN	spinning load
spd	speed
stab	stability
std	standard
sw	switch
TB	terminal block
TOL	thermal overload

Abbreviation	Meaning
TP	test point
trq	torque
TX	transmit
UPS	uninterruptable power supply
V	voltage, volts
V/Hz	volts per Hertz (ratio)
VAC	volts AC
var	variable
VDC	volts DC
vel	velocity
VFD	variable frequency drive
vl	velocity limit
vlts	voltage(s)
W	width, watts
XCL	external communications link

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HAPPENDIX H: DRCTRY.PWM FILE DESCRIPTIONS

In This Section:

H.1. Introduction

This appendix contains a complete list of variable names found in the DRCTRY.PWM file. Each of the variable names also has a description of its function. The variable names may be used within the logic of the system program of the Perfect Harmony drive. Sample logic statements (as they might appear in a system program source file) are included with many of the variables and flags.

Attention! Only qualified individuals should consider making changes to the system program of the Perfect Harmony drive.

The variable names are divided into logical groups and then arranged alphabetically within each group. The logical groups are as follows:

- keypad input and output variables
- user digital input module variables
- user digital output module variables
- power interface board variables
- temporary flags
- comparators
- counters and counter reset flags
- timers
- programmable controller communications flags
- drive configuration variables
- drive indicator variables
- drive control variables
- user defined text strings
- user fault flags
- drive fault words.

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H.2. Keypad Variables

There are two groups of keypad variables:

- Surface mount keypad inputs and outputs
- Expanded function keypad inputs and outputs.

Surface mount keypad inputs and outputs are listed and described in Table H-1. *Expanded function keypad inputs and outputs* are listed and described in Table H-2.

Table H-1. Surface Mount Keypad Input and Output Variables

Variable	Description	Expanded Function Keypad Cross-ref.
kbd_auto	This flag is tied to the input switch for the keypad's [Automatic] button. Usually it is defined in the SOP to set the automatic flag.	*loc_sw_tb5_2*
kbd_flt_led	This variable acts as a switch which controls the state of the "Fault" LED on the integrated keypad and display. Setting this variable to "true" causes the "Fault" LED to turn on. Setting this variable to "false" causes the "Fault" LED to turn off.	*loc_lamp_tb4_2*
kbd_flt_reset	This variable is tied to the input switch for the keypad's [Fault Reset] button. Usually it is defined in the SOP to reset a drive fault. The input is a momentary input (state = "true" as long as the Fault Reset button is pressed).	*loc_sw_tb5_1*
kbd_man_start	This flag is tied to the input switch for the keypad's [Manual Start] button. Usually it is defined in the SOP to switch the drive to manual mode and start the drive.	*loc_sw_tb5_3*
kbd_man_stop	This flag is tied to the input switch for the keypad's [Manual Stop] button. Usually it is defined in the SOP to switch the drive to manual mode and stop the drive.	*loc_sw_tb5_5*
kbd_run_led	This variable acts as a switch which controls the state of the "Run" LED on the integrated keypad and display. Setting this variable to "true" causes the "Run" LED to turn on. Setting this variable to "false" causes the "Run" LED to turn off.	*loc_lamp_tb4_1*

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Table H-2. Expanded Function Keypad Input and Output Variables

Variable	Description
loc_lamp_tb4_x	Variable *loc_lamp_tb4_x* is actually an array of variables that corresponds to the desired state of the lamp outputs. The "*x*" in the variable name corresponds to the associated terminal number (1-3, 5-10, 12-17, 19-24, and 26- 28). The lamp will light when the flag is set to "true" from the system program. loc_lamp_tb4_1 = true; Turn on lamp 1 (TB4, terminal 1) loc_lamp_tb4_5 = false; Turn off lamp 5 (TB4, terminal 5) Lamps are wired from the output terminal (listed above) to +24 V (terminal 4, 11, 18, or 25 on **TB4**).
loc_sw_tb5_x	Variable *loc_sw_tb5_x* is actually an array of variables that corresponds to the current hardware state of **TB5** inputs. The "*x*" in the variable name corresponds to the associated terminal number (1-3, 5-10, 12-17, 19-24, and 26-28). Inputs read "true" when the associated input terminal (listed above) is activated by connecting it to ground (terminal 4, 11, 18, or 25 on **TB5**). Note the use of the unary "negate" or "not" operator "/" in the second example, and how it affects the logic. loc_lamp_tb4_7 = loc_sw_tb5_8; ;Turn on lamp 7 if switch 8 ;is closed (made). loc_lamp_tb4_5 = /loc_sw_tb5_6; ;Turn on lamp 5 if switch 6 'is open (not made).

H.3. User-defined Digital Input and Digital Output Module Variables

This section contains variable names and descriptions associated with digital input modules and digital output modules defined by the user. *Digital input module variables* are listed and described in Table H-3. *Digital output module variables* are listed and described in Table H-4.

Table H-3. User-defined Digital Input Module (DIM) Variables

Variable	Description
umdixx_y	The user-defined DIM variables are used to read the current state of the digital inputs. The "*xx*" in the variable name represents the user module number (00 to 15). Each module must have a unique address which is set by DIP switches on the module. Note: These flags are *input only* flags, therefore they can only be used on the right side of a system program statement (i.e., to the right of the equal sign). The "*y*" in the variable name represents the individual input for the particular module (a, b, c, d, e, and f). For example, the variable *umdi12_c* corresponds to the third (or "c") input of the user input module addressed as number 12. Input modules provide 6 inputs each. Each input has a neon light to verify it is on. A user-defined DIM variable reads "true" (or is "activated") when 120 VAC is provided across the corresponding input. Run_req_f = umdi00_f; ;The drive enters the run state when energized ;and enters the "stopping" state when de-energized.

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Table H-4. User-defined Digital Output Module Variables

Variable	Description
umdoxx_y	The user-defined digital output module (DOM) variables are used to set the current state of the digital outputs. The "*xx*" in the variable name represents the user module number (00 to 15). Each module must have a unique address which is set by DIP switches on the module. Note: These flags are *output only* flags, therefore they can never be used on the right side of a system program statement (i.e., to the right of the equal sign). The "*y*" in the variable name represents the individual output for the particular module (a, b, c, and d). For example, the variable *umdo05_b* corresponds to the second (or "b") input of the user output module addressed as number 5. Each output module provides four form C relay outputs. Each relay output has an associated LED on the board to show the status of the relay. Setting a DOM variable to "true" causes the associated relay output to turn on. Setting a variable to "false" causes the associated relay variable to turn off. umdo03_d = true; ;Energize relay 3 (d) on DOM #3

H.4. Power Interface Board Variables

This section lists and describes variables associated with the Power Interface Board of the Perfect Harmony drive. Variables are listed and described in Table H-5.

Table H-5. Power Interface Board

Name	Description
cr0_f	Setting this flag true in an SOP will turn on the CR0 relay on the board. Two form C relay contacts are provided on the PIB. (Usually used for drive running condition.)
cr1_f	Input usually used for drive start/stop. (**TB1B-1**)
cr3_f	Input that must be true to run the drive. This input can also be used in system program control. (**TB1B-2**)
cr6_f	Setting this flag true in an SOP will turn on the **CR6** relay on the board. Two form C relay contacts are provided on the PIB. Usually used for drive healthy indication (i.e., cr6=/drv_flt_f;).
cra_f	This is a general purpose flag that controls the state of the CRA relay on the PIB. It is usually used to pick up an output contactor.
mc_pickup_f	Setting this true in an SOP will force terminal **TB1B-20** low. The common use for this is to control a relay connected between this terminal and +24 V. Note: The chip used to control the external relay is an open collector chip, you must have some external device connected to +24 V to verify the terminal is working. This is the same as *cra_f*.

Name	Description
pib_aux1_f	Input for system program use (**TB1B-3**). The input is pulled to +24 V on the card. To make the input true, connect it to ground. Note: This flag is an *input only* flag, therefore it can only be used on the right side of a system program statement (i.e., to the right of the equal sign).
pib_aux2_f	Input for system program use (**TB1B-4**). The input is pulled to +24 V on the card. To make the input true, connect it to ground. Note: This flag is an *input only* flag, therefore it can only be used on the right side of a system program statement (i.e., to the right of the equal sign).
pib_aux3_f	Input for system program use (**TB1B-5**). The input is pulled to +24 V on the card. To make the input true, connect it to ground. Note: This flag is an *input only* flag, therefore it can only be used on the right side of a system program statement (i.e., to the right of the equal sign).
pib_aux4_f	Input for system program use (**TB1B-6**). The input is pulled to +24 V on the card. To make the input true, connect it to ground. Note: This flag is an *input only* flag, therefore it can only be used on the right side of a system program statement (i.e., to the right of the equal sign).
pib_aux5_f	Input for system program use (**TB1B-7**). The input is pulled to +24 V on the card. To make the input true, connect it to ground. Note: This flag is an *input only* flag, therefore it can only be used on the right side of a system program statement (i.e., to the right of the equal sign).
pib_aux6_f	Input for system program use (**TB1B-11**). The input is pulled to +24 V on the card. To make the input true, connect it to ground. Note: This flag is an *input only* flag, therefore it can only be used on the right side of a system program statement (i.e., to the right of the equal sign).

H.5. Temporary Flags

The DRCTRY.PWM file contains 60 temporary flags that can be used in the system program. These flags are named *temp1_f* through *temp60_f*. A description and example is given in Table H-6.

Table H-6. Temporary Flags

Name	Description
tempxx_f	Sixty (60) temporary flags are provided for general use in the system program for the temporary storage of intermediate logic state during evaluation. The "*xx*" in the flag name represents the flag number from 01 to 60 (i.e., *temp01_f* through *temp60_f*). `temp01_f = cr1_f + cr3_f;` ;Set temp flag 1 to true when either ;CR1 or CR3 flag is true. `loc_lamp_tb4_1 = temp01_f;` ;Turn on local lamp when temp flag is true

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H.6. Comparator Flags

The DRCTRY.PWM file contains 16 comparator flags that can be used in the system program. These flags are named *compar_01_f* through *compar_16_f*. A description and example is given in Table H-7.

Table H-7. Comparator Flags

Name	Description
compar_xx_f	Sixteen comparator flags are provided for general use in the system program. The "*xx*" in the flag name represents the comparator flag number from 1 to 16 (i.e., *compar_1_f* through *compar_16_f*). Note: These flags are *input only* flags, therefore they can only be used on the right side of a system program statement (i.e., to the right of the equal sign). The comparator flag is set to "true" when the value of the input specified in the A input parameter is greater than the value of the input specified in the B input parameter of the associated comparator. These parameters are found in the Comparator Submenus [121-136]. Each input parameter (A and B for each of the 16 comparators) uses a pick list from which the operator may select a particular system input. The result of the "Is A>B?" comparison is stored in the respective *compar_xx_f* flag. You must configure the comparator from the appropriate comparator menu using the keypad. From the comparator setup menu, the user defines the A input and the B input are as well as which type of comparison is used (signed, magnitude, or disable comparator). A fixed value may also be selected as an input, rather than using an existing variable. It can either be entered as a hexadecimal number or as a percentage (of the rated value). `loc_lamp_tb4_1 = compar_1_f;     Turn on light when speed demand > 10%.` Using the keypad, access comparator number 1 (Comparator 1 Setup Menu [121]). Set the A input parameter for "speed demand" (from the pick list). Using the "Enter Fixed Percent" option in the pick list, set the B input parameter for "+0010.0%". Next, set the type of comparison to "magnitude". In the previous example, the system program would turn on the light (*loc_lamp_tb4_1*) when the speed demand was > 10%.

H.7. Counters and Counter Reset Variables

The DRCTRY.PWM file contains 16 counters that can be used in the system program. These counters are named *counter00* through *counter15*. To reset the values of these counters to zero, a series of counter reset variables (*cntr_reset_00* through *cntr_reset_15*) are included. Counters and counter reset variables are described in Table H-8 and Table H-9, respectively.

Table H-8. Counter Variables

Name	Description
counterxx	Counters are variables that reflect a "true" state after a specified number of "false-to-true" transitions occur. They retain their true state until reset through their corresponding counter reset variable activation. There are 16 counters provided for general use. The "*xx*" portion of the variable name indicates the number of the counter, from 00 to 15 (i.e., *counter00* through *counter15*). For each counter, the *count* is defined before the flag is set true. The syntax for the counter definition is: counter*xx*(*nn*) = *m* where "*xx*" is the counter number (00 through 15), "*nn*" is target value, and

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Name	Description
	"*m*" is the input variable name. The current count value of each counter, which is maintained internally, is incremented when the respective counter is set from "false" to "true". The actual Boolean value of the counter will remain "false" until the current count reached the target value (specified by the *nn* argument). Once a counter is set "true", it must be set to "false" and then to "true" again to increment the current count value to the next count. An example follow. `counter00(01) = kbd_man_start;` ;Define counter 0. Set target count at 1. ;Count "Manual Start" keypad presses. `Run_req_f = counter00;` ;Initiate Manual Start mode based on ;the state of counter 0. `cntr_reset00 = kbd_man_stop;` ;Reset counter after Manual Stop button ;on keypad is pressed. In the first line of the example, the number in the parentheses defines the number of counts before the counter flag is set "true". By closing and opening the appropriate switch (i.e., pressing the manual start button on the keypad, in this example), the flag for this counter will be set to "true" after the closing of the switch. The second line of the example causes the drive to enter manual run mode when the counter becomes "true" (after the press of the manual start button). The third line of the example above provides a method to reset the counter. Closing the switch *kbd_man_stop* (i.e., pressing the manual stop button on the keypad) causes the current count value of *counter00* to be reset to zero. Note: Counter variables can be used to latch a momentary event (such a key press in the previous example) or be used to count events. An example would be to use a 60-second timer combined with one counter to count elapsed minutes and then cascade it to other counters to produce hours or even days.

Table H-9. Counter Reset Variables

Name	Description
cntr_resetxx	Counter resets are variables that are used to reset the current count value of a particular counter to zero. There are 16 counter reset variables provided for use with each of the respective counter variables. The "*xx*" portion of the variable name indicates the number of the counter reset variable, from 00 to 15 (i.e., *cntr_reset00* through *cntr_reset15*). When a counter reset variable is set to "true", the current internal count of the associated counter is reset to zero. In the example for the *counterxx* variable (in the previous table), the internal count of the *cntr_reset00* variable is reset to zero when the manual stop button on the keypad is pressed.

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H.8. Timers

The DRCTRY.PWM file contains 32 timers that can be used in the system program. They are named *timer00* through *timer31*. Timers are described in Table H-10.

Table H-10. Timers

Name	Description
timerxx	Timers are variables that reflect a Boolean "true" state after an associated user-defined input remains in a "true" state for a user-specified number of seconds up to a maximum of 90 seconds. There are 32 timers provided for general use. The "*xx*" portion of the timer name indicates the number of the timer, from 00 to 31 (i.e., *timer00* through *timer31*). For each timer, a duration and an input variable are defined initially. The syntax for the timer definition is: timer*xx*(*nn*) = *m* where "*xx*" is the timer number (00 through 31), "*nn*" is the duration time in seconds (which is counted down), and "*m*" is the input variable name or logic statement. Refer to the example below. timer00(10) = cr1_f; ;Define timer 0 start as 10 seconds. ;Define timer input as cr1_f. loc_lamp_tb4_1 = timer00; ;Turn on light after timer 0 remains true ;for 10 seconds. In the first line of the example, the number in the parentheses (10 in this example) defines the duration time (or starting point) in seconds and the input variable as *cr1_f*. The SOP program will monitor the total amount of time that the input variable (*cr1_f*) is in a "true" state. If the input variable remains in a "true" state for a total of 10 seconds, the timer will be set to "true". If the associated input changes to a "false" state before the specified duration time expires, then the timer remains "false" and the accumulated time is reset to zero. Also the output and accumulated times are set to zero should the input statement ever evaluate to "false" . The second line of the example is used to turn on the light (*loc_lamp_tb4_1* in this example) after the timer has been set to "true" and turn off the light when the timer is set to "false". Note: Although decimal fractions are acceptable as time duration values, and the time is based on a real time interrupt rate of 360 Hz, the actual resolution is dependent on the system program cycle time.

H.9. Programmable Controller Communications Flags

Using optional hardware and customized software, Perfect Harmony drives may reside on networks of programmable controllers. The DRCTRY.PWM file of the Perfect Harmony contains a series of flags that may be used in the system program for drives configured with such options. These flags are listed and described in Table H-11.

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Table H-11. Programmable Controller Communications Flags

<table>
<tr><th>Name</th><th>Description</th></tr>
<tr><td>cab_hw_fail</td><td>This flag is set true from the drive when the Microprocessor Board detects a heartbeat failure between the CAB and the Microprocessor board, or when the CAB has re-booted.</td></tr>
<tr><td>cab_hw_fail_log</td><td>Setting this input flag true will enable the drive to display the message “CAB Hardware Fault” on the keypad. Note: This flag is usually set equal to the cab_hw_fail flag (cab_hw_fail_log = cab_hw_fail).</td></tr>
<tr><td>cab_pres</td><td>This flag is set true from the drive when the Microprocessor Board detects a CAB is installed.</td></tr>
<tr><td>comm_f01_0 to comm_f01_15</td><td rowspan="15">These flags are general purpose flags that are sent from a programmable controller. The flags can be used in an SOP to control a variety of things from the programmable controller.

Note: There are 256 flags available (16 words of 16 bits each). They essentially map and pack discrete inputs from a programmable controller which are then received by the drive as 16-bit word.

The drive can then unpack the individual inputs from the words and use each separate one independently within the SOP program.

The format for the naming convention is comm_fxx_y(y), where xx is the individually received serial word set up by drive node and item number in the XCL Comm Flags Menu [144]. This parameter must be set up via menu selection before any individual flags may be used.

The y(y) notation denotes the bit pattern from least significant (0) to most significant (15).</td></tr>
<tr><td>comm_f02_0 to comm_f02_15</td></tr>
<tr><td>comm_f03_0 to comm_f03_15</td></tr>
<tr><td>comm_f04_0 to comm_f04_15</td></tr>
<tr><td>comm_f05_0 to comm_f05_15</td></tr>
<tr><td>comm_f06_0 to comm_f06_15</td></tr>
<tr><td>comm_f07_0 to comm_f07_15</td></tr>
<tr><td>comm_f08_0 to comm_f08_15</td></tr>
<tr><td>comm_f09_0 to comm_f09_15</td></tr>
<tr><td>comm_f10_0 to comm_f10_15</td></tr>
<tr><td>comm_f11_0 to comm_f11_15</td></tr>
<tr><td>comm_f12_0 to comm_f12_15</td></tr>
<tr><td>comm_f13_0 to comm_f13_15</td></tr>
<tr><td>comm_f14_0 to comm_f14_15</td></tr>
<tr><td>comm_f15_0 to</td></tr>
</table>

Name	Description
comm_f15_15	
comm_f16_0 to *comm_f16_15*	
plc_2_stop_bits	Setting this flag true, typically, selects the CAB communication protocol to use two stop bits. This flag is CAB network specific (i.e., it is not used or defined on every protocol). Refer to appropriate CAB manual to verify specific flag usage.
plc_a_active_f	This flag is typically set true when network board 'A' on a CAB dual network is the active board for receiving data for drive control. This flag is CAB network specific, refer to appropriate CAB manual to verify specific flag usage.
plc_a_fault_f	This flag is typically set true when network board 'A' on a CAB dual network is faulted. This flag is CAB network specific, refer to appropriate CAB manual to verify specific flag usage.
plc_a_net_down_f	This flag is typically set true when network board 'A' determines the network connected is not active. This flag is CAB network specific, refer to appropriate CAB manual to verify specific flag usage.
plc_a_select_f	Setting this flag true, typically, selects network board 'A' as the active board for network received data to be used by the drive. This flag is CAB network specific, refer to appropriate CAB manual to verify specific flag usage.
plc_b_active_f	This flag is typically set true when network board 'B' on a CAB dual network is the active board for receiving data for drive control. This flag is CAB network specific, refer to appropriate CAB manual to verify specific flag usage.
plc_b_fault_f	This flag is typically set true when network board 'B' on a CAB dual network is faulted. This flag is CAB network specific. Refer to appropriate CAB manual to verify specific flag usage.
plc_b_net_down_f	This flag is typically set true when network board 'B' determines the network connected is not active. This flag is CAB network specific. Refer to appropriate CAB manual to verify specific flag usage.
plc_b_select_f	Setting this flag true, typically, selects network board 'B' as the active board for network received data to be used by the drive. This flag is CAB network specific. Refer to appropriate CAB manual to verify specific flag usage. Note: Both boards in a dual network cannot be active at the same time.

Name	Description
plc_baud_1 *plc_baud_2* *plc_baud_3* *plc_baud_4* *plc_baud_5* *plc_baud_6* *plc_baud_7* *plc_baud_8*	Setting one of these flags true, typically, selects a network specific baud rate. These flags are CAB network specific. Refer to appropriate CAB manual to verify specific flag usage.
plc_baud_1200	Setting this flag true, typically, selects a CAB baud rate of 1200 to be used as the network baud rate. This flag is CAB network protocol specific, refer to appropriate CAB manual to verify specific flag usage.
plc_baud_2400	Setting this flag true, typically, selects a CAB baud rate of 2400 to be used as the network baud rate. This flag is CAB network specific, refer to appropriate CAB manual to verify specific flag usage.
plc_baud_4800	Setting this flag true, typically, selects a CAB baud rate of 4800 to be used as the network baud rate. This flag is CAB network specific, refer to appropriate CAB manual to verify specific flag usage.
plc_baud_9600	Setting this flag true, typically, selects a CAB baud rate of 9600 to be used as the network baud rate. This flag is CAB network specific, refer to appropriate CAB manual to verify specific flag usage.
plc_baud_19200	Setting this flag true, typically, selects a CAB baud rate of 19200 to be used as the network baud rate. This flag is CAB network specific, refer to appropriate CAB manual to verify specific flag usage.
plc_baud_38400	Setting this flag true, typically, selects a CAB baud rate of 38400 to be used as the network baud rate. This flag is CAB network specific, refer to appropriate CAB manual to verify specific flag usage.
plc_baud_115200	Setting this flag true, typically, selects a CAB baud rate of 115200 to be used as the network baud rate. This flag is CAB network specific, refer to appropriate CAB manual to verify specific flag usage.
plc_baud_spare	Setting this flag true, typically, selects a predefined CAB baud rate as the network baud rate. This flag is CAB network specific, refer to appropriate CAB manual to verify specific flag usage.

Name	Description
plc_data_format_f	ROBICON CAB networks typically use 2-16 bit words per register. The 2-16 bit words can be used in one of two different data formats. Note: Networks may support the 'Original' data format only, the 'New' data format or both. Refer to the CAB network manual for an explanation of the data format used by the specific network and specific flag usage. Networks that support **both** data formats default to the 'Original' data format. Setting the *plc_data_format_f* true, enables the 'New' data format.
plc_even_parity_f	Setting this flag true, typically, selects the CAB communication protocol to use even parity. This flag is CAB network specific, refer to appropriate CAB manual to verify specific flag usage.
plc_odd_parity_f	Setting this flag true, typically, selects the CAB communication protocol to use odd parity. This flag is CAB network specific, refer to appropriate CAB manual to verify specific flag usage.
plc_protocol_3 *plc_protocol_4* *plc_protocol_5* *plc_protocol_6* *plc_protocol_7*	These flags have no predefined use. These flags are CAB network specific, refer to appropriate CAB manual to verify specific flag usage.
plc_same_adrs_f	This flag is typically set true when network board 'A' and network board 'B' in dual network CAB's have the same address. This flag is CAB network specific, refer to appropriate CAB manual to verify specific flag usage.
plc_spare_f	This flag has no predefined use. This flag is CAB network specific, refer to appropriate CAB manual to verify specific flag usage.
plc_unique_adrs_f	Setting this flag true, typically, selects the dual CAB networks to use unique addresses. The address for network 'A' is set via the drive keypad and network 'B's address is set to network 'A's address plus one. If this flag is not set true, then the address for both network 'A' and network 'B' are set to the same address, but the boards must be connected to two different networks. Note: The MB+ network uses dip switches on the card to set the network address. If the flag is set true the CAB will verify the dip switch addresses are unique. (only network 'A' will go live if the two addresses are the same and the flag is set) This flag is CAB network specific, refer to appropriate CAB manual to verify specific flag usage.

Name	Description
serial_f0 : *serial_f15*	These flags are general purpose flags that are set true or false from the SOP for programmable controller communication. The flags are sent to the programmable controller which defines the use of each flag. Note: All 16 flags are packed and sent to the programmable controller as the 16-bit word “serial 1 bit flags” regardless of how many are used in the SOP. It must be selected from a pick list from any of the XCL send parameters in XCL Send Setup Menu [43].
serial_f2_0 : *serial_f2_15*	These 16 flags are general purpose flags that are set true or false from the SOP for programmable controller communication. The flags are sent to the programmable controller which defines the use of each flag as “serial 2-bit flags”. Note: All 16 flags are sent to the programmable controller regardless of how many are used in the SOP.
serial_f3_0 : *serial_f3_15*	These 16 flags are general purpose flags that are set true or false from the SOP for programmable controller communication. The flags are sent to the programmable controller which defines the use of each flag as “serial 3-bit flags”. Note: All 16 flags are sent to the programmable controller regardless of how many are used in the SOP.
serial_f4_0 : *serial_f4_15*	These 16 flags are general purpose flags that are set true or false from the SOP for programmable controller communication. The flags are sent to the programmable controller which defines the use of each flag as “serial 4-bit flags”. Note: All 16 flags are sent to the programmable controller regardless of how many are used in the SOP.
xcl_data_fail	This flag is typically set true when CAB detects a dropout (or shortage) of global data from a node when global inputs are expected. This flag is CAB network specific, refer to appropriate CAB manual to verify specific flag usage.
xcl_data_fail_log	Setting this input flag true will trip the drive and display the message on the keypad. Note: This flag is usually set equal to the *xcl_data_fail* flag (*xcl_data_fail_log* = *xcl_data_fail*).
xcl_override_f	Setting this flag true, typically, cancels keyboard re-direction to the XCL. This flag is CAB network specific, refer to appropriate CAB manual to verify specific flag usage.
xcl_status_fail	This flag is set true from the drive when it detects an error or network dropout on the programmable controller communications line. Some networks can not determine if a network dropout has occurred. Refer to appropriate CAB manual to verify specific flag usage.
xcl_status_fail_log	Setting this input flag true will trip the drive and display the following message on the keypad: “XCL node *xx* data loss”, where *xx* is the node from which data was expected. Note: This flag is usually set equal to the *cab_hw_fail* flag (*xcl_status_fail_log* = *xcl_status_fail*).

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Name	Description
xcl_sw1 : *xcl_sw4*	Setting one of these four flags true with the switch *rc_sw2* closed allows the fixed ratio multiplier to come from one of the programmable controller pointers (*xclptr_1* through *xclptr_4*, respectively).
xcl_sw5 : *xcl_sw8*	Setting one of these four flags true with the switch *vd_sw21* closed allows the velocity command to come from one of the programmable controller pointers (*xclptr_05 - xclptr_08*, respectively).
xcl_sw9 : *xcl_sw12*	Setting one of these four flags true allows an auxiliary velocity demand, (*xclptr_9 - xclptr_12*, respectively) which is not ramped, to be added to the velocity reference.
xcl_sw13 : *xcl_sw16*	Setting one of these four flags true with the switch *vl_sw2* closed allows the forward velocity limit to come from one of the programmable controller pointers (*xclptr_13 - xclptr_16*, respectively).
xcl_sw17 : *xcl_sw20*	Setting one of these four flags true with the switch *vl_sw6* closed allows the reverse velocity limit to come from one of the programmable controller pointers (*xclptr_17 - xclptr_20*, respectively).
xcl_sw21 : *xcl_sw24*	Setting one of these four flags true with the switch *acc_sw2* closed allows the forward acceleration limit to come from one of the programmable controller pointers (*xclptr_21 - xclptr_24*, respectively).
xcl_sw25 : *xcl_sw28*	Setting one of these four flags true with the switch *acc_sw2* closed allows the forward deceleration limit to come from one of the programmable controller pointers (*xclptr_25 - xclptr_28*, respectively).
xcl_sw29 : *xcl_sw32*	Setting one of these four flags true with the switch *acc_sw2* closed allows the reverse acceleration limit to come from one of the programmable controller pointers (*xclptr_29 - xclptr_32*, respectively).
xcl_sw33 : *xcl_sw36*	Setting one of these four flags true with the switch *acc_sw2* closed allows the reverse deceleration limit to come from one of the programmable controller pointers (*xclptr_33 - xclptr_36*, respectively).
xcl_sw37 : *xcl_sw40*	Setting one of these four flags true with the switch *ai_sw8* closed allows a torque demand to come from one of the programmable controller pointers (*xclptr_37 - xclptr_40*, respectively).
xcl_sw41 : *xcl_sw44*	Setting one of these four flags true with the switch *aa_sw6* closed allows an auxiliary torque demand, which is not ramped, to come from one of the programmable controller pointers (*xclptr_41 - xclptr_44*, respectively).
xcl_sw45 : *xcl_sw48*	Setting one of these four flags true with the switch *al_sw2* closed allows the positive torque limit to come from one of the programmable controller pointers (*xclptr_45 - xclptr_48*, respectively).

Name	Description
xcl_sw49 : *xcl_sw52*	Setting one of these four flags true with the switch *al_sw7* closed allows the negative torque limit to come from one of the programmable controller pointers (*xclptr_49* - *xclptr_52*, respectively).

H.10. Drive Configuration Variables

Drive configuration variables for the Perfect Harmony drive are listed and described in Table H-12. All flags with the same letter designation and different number are grouped logically into one input section from which only one will be selected and active.

Table H-12. Drive Configuration Variables

Group	Name	Description
Aux Torque Reference Configuration Switches	*aa_sw1*	Setting this input flag true enables a torque command from the REF input (that is added and not ramped) to be added to the output of the torque ramp. The combined signal is the input to the torque limit circuit.
	aa_sw2	Setting this input flag true enables a torque command from the AUX 1 input (that is added and not ramped) to be added to the output of the torque ramp. The combined signal is the input to the torque limit circuit.
	aa_sw3	Setting this input flag true enables a torque command from the AUX 2 input (that is added and not ramped) to be added to the output of the torque ramp. The combined signal is the input to the torque limit circuit.
	aa_sw4	Setting this input flag true enables a torque command from the AUX 3 input (that is added and not ramped) to be added to the output of the torque ramp. The combined signal is the input to the torque limit circuit.
	aa_sw5	Setting this input flag true enables a torque command to come from an analog input module (not ramped). That is added to the output of the torque ramp and the combined signal is the input to the torque limit circuit.
	aa_sw6	Setting this input flag true enables the torque command to come from the XCL communications link. Note: When this switch is set true, one of the corresponding XCL communication switches must also be set true. See *xcl_sw41* through *xcl_sw44* for details. *xcl_sw41* *xcl_sw42* *xcl_sw43* *xcl_sw44*.

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Group	Name	Description
Ramp Acceleration Configuration Switches	*acc_sw1*	Setting this input flag true enables the forward acceleration, forward deceleration, reverse acceleration and reverse deceleration rates to be defined from the keypad. (Menu set #1)
	acc_sw2	Setting this input flag true enables the forward acceleration, forward deceleration, reverse acceleration and reverse deceleration rates to come from the programmable controller input flags (XCL communication). See *xcl_sw21* through *xcl_sw36* for details.
	acc_sw3	Setting this input flag true enables the forward acceleration, forward deceleration, reverse acceleration and reverse deceleration rates to come from the AUX1 / AUX2 inputs.
	acc_sw4	Setting this input flag true enables the forward acceleration, forward deceleration, reverse acceleration and reverse deceleration rates to be defined from the keypad. (Menu set #2)
	acc_sw5	Setting this input flag true enables the forward acceleration, forward deceleration, reverse acceleration and reverse deceleration rates to be defined from the keypad. (Menu set #3)
Torque Ref Configuration Switches	*ai_sw1*	Setting this input flag true enables the torque command to come from the velocity loop.
	ai_sw2	Setting this input flag true enables the torque command to come from the REF input on the PIB.
	ai_sw3	Setting this input flag true enables the torque command to come from the AUX 1 input on the PIB.
	ai_sw4	Setting this input flag true enables the torque command to come from the AUX 2 input on the PIB.
	ai_sw5	Setting this input flag true enables the torque command to come from the AUX 3 input on the PIB.
	ai_sw6	Setting this input flag true enables he torque command to come from an the 4-20 ma. input on the PIB.
	ai_sw7	Setting this input flag true enables the torque command to be set from the keypad “torque setpoint”.
	ai_sw8	Setting this input flag true enables the torque command to be set from a programmable controller. (XCL communications)
	ai_sw9	Setting this input flag true enables the torque command to come from a thumb wheel switch. Note: The thumb wheel switch is not currently an available option.
	ai_sw10	Setting this input flag true enables the torque command to come from the pot of the keypad.

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Group	Name	Description
Torque Ref Configuration Switches (Continued)	*ai_sw11*	Setting this input flag true enables the torque command to come an analog input module.
Torque Limit Configuration Switches	*al_sw2*	Setting this input flag true sets the positive torque limit to come from a programmable controller. (XCL communications)
	al_sw4	Setting this input flag true enables the positive torque limit to come from the keypad. (Menu set #1)
	al_sw5	Setting this input flag true sets the negative torque limit equal to the negated value of the positive torque limit.
	al_sw7	Setting this input flag true sets the negative torque limit to come from a programmable controller. (XCL communications)
	al_sw8	Setting this input flag true enables the negative torque limit to come from the keypad. (MENU set #1)
	al_sw9	Setting this input flag true enables the positive torque to come from the REF input on the PIB.
	al_sw10	Setting this input flag true enables the positive torque limit to come from the AUX 1 input on the PIB.
	al_sw11	Setting this input flag true enables the positive torque limit to come from the AUX 2 input on the PIB.
	al_sw12	Setting this input flag true enables the positive torque limit to come from the AUX 3 input on the PIB.
	al_sw13	Setting this input flag true enables the negative torque limit to come from the REF input on the PIB.
	al_sw14	Setting this input flag true enables the negative torque limit to come from the AUX 1 input on the PIB.
	al_sw15	Setting this input flag true enables the negative torque limit to come from the AUX 2 input on the PIB.
	al_sw16	Setting this input flag true enables the negative torque limit to come from the AUX 3 input on the PIB.
	al_sw17	Setting this input flag true enables the positive torque limit to come from the keypad. (Menu set #2)
	al_sw18	Setting this input flag true enables the negative torque limit to come from the keypad. (Menu set #2)
	al_sw19	Setting this input flag true enables the positive torque limit to come from the keypad. (Menu set #3)
	al_sw20	Setting this input flag true enables the negative torque limit to come from the keypad. (Menu set #3)

Group	Name	Description
Aux Velocity Reference Configuration Switches	*as_sw1*	Setting this input flag true enables a speed command of zero magnitude to be added to the output of the speed ramp. The output of the combined signals is the input to the speed limit circuit.
	as_sw2	Setting this input flag true enables a speed command from a programmable controller (XCL communications) to be added to the output of the speed ramp. The output of the combined signals is the input to the speed limit circuit.
	as_sw3	Setting this input flag true enables a speed command from the REF input that is not rate limited to be added to the output of the speed ramp. The output of the combined signals is the input to the speed limit circuit.
	as_sw4	Setting this input flag true enables a speed command from the AUX1 input that is not rate limited to be added to the output of the speed ramp. The output of the combined signals is the input to the speed limit circuit.
	as_sw5	Setting this input flag true enables a speed command from the AUX2 input that is not rate limited to be added to the output of the speed ramp. The output of the combined signals is the input to the speed limit circuit.
	as_sw6	Setting this input flag true enables a speed command from the AUX3 input that is not rate limited to be added to the output of the speed ramp. The output of the combined signals is the input to the speed limit circuit.
	as_sw7	Setting this input flag true enables a speed command from the 4-20 ma input that is not rate limited to be added to the output of the speed ramp. The output of the combined signals is the input to the speed limit circuit.
	as_sw8	Setting this input flag true enables a speed command from an analog input module that is not rate limited to be added to the output of the speed ramp. The output of the combined signals is the input to the speed limit circuit.
Miscellaneous Configuration Switches	*auto_f*	Setting this input flag true enables the LCD display on the keypad to display “AUTO” in place of “MAN” during running conditions.
	auto_save	Setting this flag true automatically backs up a parameter to EEPROM when parameters are changed from serial communications via the XCL interface (the default condition).
	csa_sw	Setting this input flag true will enable the critical speed avoidance which must be configured using the Critical Speed Avoidance Menu [28] from the keypad.
	cstop_f	Setting this input flag true selects the type of stop to coast stop. (Disable gating immediately.) This is the default stop type if no other type of stop has been defined in the SOP.

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Group	Name	Description
Miscellaneous Configuration Switches (Continued)	*days_timer_f*	The flag is used for toggling redundant cooling systems on a time period established by programming the cycle timer parameter in the Timebase Setup Menu [19].
	diag_log_select	Setting this input flag to true selects the type of log as "diagnostic". Setting this flag to false selects the type of log as "historic".
	dis_dyn_lim	Setting this input flag true disables the dynamic torque limits.
	dis_therm_rollback	Setting this input flag true disables rollback occurring due to drive cell temperature. The temperature warning flag and temperature trip are not affected.
	dis_torq_fb	This flag is used by factory personnel to allow the drive to be run completely in open loop mode for testing and diagnostics.
	dis_volt_rollback	Setting this input flag true disables rollback from occurring due to low drive input voltage, low cell input voltage, or input single phase detection.
	Disable_ground_flt	Setting this flag disables ground fault detection. It is used to momentarily disable the fault under controlled conditions.
	disable_hsot_flt	This flag has no function in the latest software release.
	disable_rollback	Setting this input flag true disables the ramp rollback feature that occurs when the drive is in hard current limit.
	enable_line_sync	This flag must be set true to perform synchronous transfers with the line. It enables the line sync feedback.
	fwd_spd_disable	Setting this input flag true disables the ability of the drive to be used in the forward direction by preventing the output frequency from going positive. Parameters should also be set up to prevent the drive from running in the forward direction.
Holding Trq. Ref. Config. Switches	*hi_sw1*	Setting this input flag true enables a holding torque command to be used from the keypad menu system.
	hi_sw2	Setting this input flag true enables a holding torque command to be used from the PIB REF input.
	hi_sw3	Setting this input flag true enables a holding torque command to be used from the PIB AUX2 input.
	hi_sw4 *hi_sw5*	Setting this input flag true enables a holding torque command to be used from the PIB AUX2 input. Setting this input flag true enables a holding torque command to be used from the PIB AUX3 ma input.

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Group	Name	Description
	hi_sw6	Setting this input flag true enables a holding torque command to be used from the PIB 4-20 ma input.
Miscellaneous Configuration Switches	*hold_speed_f*	Setting this input flag true prevents the speed command (*vel_ref*) from being stored in the variable *hold_speed*. This value will remain until the flag is set false.
	key_switch_f	Setting this parameter true disables users from changing parameters from the keypad. Any attempt to change parameters from the keypad will result in the message "Keypad change lockout. Unlock to proceed." being displayed to the LCD display.
	line_con_ack_f	This flag is used for transfer. It is a hardware handshake to inform the drive that the line contactor has closed. This input should be set true from the line contactor closing. This switch should be used in up transfers to open the VFD contactor.
	pc_sw1	Setting this input flag true enables the drive polarity flag which changes the drive direction. (Inverts velocity demand.)
PID Loop Input Reference Selection Switches	*pid_sw1*	Setting this input flag true allows the PID loop's setpoint to come from the PIB reference (REF) input.
	pid_sw2	Setting this input flag true allows the PID loop's setpoint to come from the PIB auxiliary 1 (AUX1) input.
	pid_sw3	Setting this input flag true allows the PID loop's setpoint to come from the PIB auxiliary 2 (AUX2) input.
	pid_sw4	Setting this input flag true allows the PID loop's setpoint to come from the PIB auxiliary 3 (AUX3) input.
	pid_sw5	Setting this input flag true allows the PID loop's setpoint to come from the PID setpoint parameter in the keypad menu system.
	pid_sw6	Setting this input flag true allows the PID loop's setpoint to come from the keypad pot.
	pid_sw7	Setting this input flag true allows the PID loop's setpoint to come from an analog input module.
Miscellaneous Configuration Switches	*qstop_f*	Setting this input flag true selects the type of drive stop to "quick" (torque limit stop).
Ratio Control Configuration Switches	*rc_sw1* *rc_sw2*	Setting this input flag true enables the fixed ratio multiplier for speed input to come from the keypad variable named "ratio control" in the menu system. Setting this input flag true enables the fixed ratio multiplier for speed input to come from a programmable controller. (XCL communications)

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Group	Name	Description
Ratio Control Configuration Switches (Continued)	*rc_sw3*	Setting this input flag true enables the fixed ratio multiplier for speed input to come from a thumb wheel switch. Note: The thumb wheel switch is not currently an available option.
Miscellaneous Configuration Switches	*ref_decr_sw*	Setting this parameter true while using monitor and hold (*vd_sw18*) decreases the drive speed down to the minimum allowable speed. Setting this parameter false will cause the drive to retain the last speed until *ref_incr_sw* or *ref_decr_sw* are set true. The rate of change is 1% of rated at 360 Hz update rate, or approximately 360%/second.
	ref_incr_sw	Setting this parameter true while using monitor and hold (*vd_sw18*) increases the drive speed up to the maximum allowable speed. Setting this parameter false will cause the drive to retain the last speed until *ref_incr_sw* or *ref_decr_sw* are set true.
	rev_spd_disable	Setting this input flag true disables the ability of the drive to be used in the reverse direction. Note: This parameter prevents the hardware from being used in the reverse direction. Parameters should also be set up to prevent the drive from running in the reverse direction.
	rstop_f	Setting this input flag true selects ramp stops. The drive is stopped at the deceleration rate defined from the SOP.
	sp_sw	Setting this input flag true will enable the speed profile function. Note: The speed profile function must be set up using the Speed Profile Menu from the keypad.
	spin_load_en_f	Setting this input flag enables the drive to "catch a spinning load" when the drive is started.
	std_cntrl_f	Setting this flag true changes selects open loop operation.
Thermal Overload Configuration Switches	*tol_set_1*	Selects thermal overload protection based on parameter set 1 (the drive's default).
	tol_set_2	Selects parameter set 2 for thermal overload protection setup.
	tol_set_3	Selects parameter set 3 for thermal overload protection setup.
Torque Loop Gain Configuration Switches	*trq_gain_set_1*	Selects torque loop gains from the parameter set 1 of torque gains (the drive's default).

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Group	Name	Description
Torque Loop Gain Configuration Switches	*trq_gain_set_2*	Selects parameter set 2 for torque loop gain setup.
(Continued)	*trq_gain_set_3*	Selects parameter set 3 for torque loop gain setup.
Miscellaneous Configuration Switches	*vc_sw1*	Setting this flag true enables the speed feedback (not used).
	vco_loop_disable	Setting this flag true disables the VCO loop and zeroes the integrator. This is for internal use only.
Velocity Reference Configuration Switches	*vd_sw0*	Not Used (same as test mode).
	vd_sw1	Not Used (zeroes input).
	vd_sw2	Setting this input flag true enables the speed command to come from the REF input on the PIB.
	vd_sw3	Setting this input flag true enables the speed command to come from the AUX1 input on the PIB.
	vd_sw4	Setting this input flag true enables the speed command to come from the AUX2 input on the PIB.
	vd_sw5	Setting this input flag true enables the speed command to come from the AUX3 input on the PIB.
	vd_sw6	Setting this input flag true enables the speed command to come from the pot on keypad.
	vd_sw7	Setting this input flag true enables the speed command to come from software setpoint #1. (Set from a menu via keypad.)
	vd_sw8	Setting this input flag true enables the speed command to come from software setpoint #2. (Set from a menu via keypad.)
	vd_sw9	Setting this input flag true enables the speed command to come from software setpoint #3 (Set from a menu via keypad.)
	vd_sw10	Setting this input flag true enables the speed command to come from software setpoint #4. (Set from a menu via keypad.)
	vd_sw11	Setting this input flag true enables the speed command to come from software setpoint #5. (Set from a menu via keypad.)
	vd_sw12	Setting this input flag true enables the speed command to come from software setpoint #6. (Set from a menu via keypad.)

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Group	Name	Description
Velocity Reference Configuration Switches	*vd_sw13*	Setting this input flag true enables the speed command to come from software setpoint #7. (Set from a menu via keypad.)
(Continued)	*vd_sw14*	Not Used
	vd_sw15	Not Used
	vd_sw16	Not Used
	vd_sw17	Not used
	vd_sw18	Setting this input flag true enables the speed command to come from the monitor and hold software function. The monitor and hold speed command is controlled by setting the switches *ref_incr_sw* true to increase the speed command, and setting the switch *ref_decr_sw* true to decrease the speed command. Note: When the speed command is being controlled from the monitor and hold function, the speed command is ramped.
	vd_sw19	Setting this input flag true enables the speed command to come from the output of the PID controller. Note: The PID controller must be set up from the PID Select Menu from the keypad.
	vd_sw20	Not Used
	vd_sw21	Setting this input flag true enables the speed command to come from a programmable controller. (XCL - communication)
	vd_sw22	Reference encoder 2 input (not used).
	vd_sw23	Setting this input flag true enables the speed command to come from an analog input user module.
	vd_sw24	Setting this input flag true enables the speed command to come from the 4-20 mA input terminals on the PIB.
	vd_sw25 *vd_sw26*	The switches *vd_sw25* - *vd_sw26* are not used in current software they are reserved for future use. Setting these flags true or false will have no effect on the drive operation.
	vd_sw27	Setting this input flag true allows the speed command to come from the *hold_speed* variable.
	vd_sw28	Setting this input flag true allows the speed command to come from the up and down arrow keys on the keypad.
	vd_sw29 *vd_sw30* *vd_sw31*	The switches *vd_sw29* - *vd_sw31* are not used in current software. They are reserved for future use. Setting these flags true or false will have zero the velocity reference.

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Group	Name	Description
Miscellaneous Configuration Switches	*vel_dl_cntrl_f*	Setting this flag true enables the drive software double loop velocity speed regulator.
Velocity Gain Configuration Switches	*vel_gain_set_1*	Selects the first set of velocity loop gain parameters. This is the drive's default.
	vel_gain_set_2	Selects the second set of velocity loop gain parameters.
	vel_gain_set_3	Selects the third set of velocity loop gain parameters.
Miscellaneous Configuration Switches	*vfd_con_ack_f*	This flag is used for transfer. It is a hardware handshake to inform the drive that the VFD contactor has closed. This input should be set true from the VFD contactor closing. This flag should be used in down transfer applications to open the line contactor.
	vflt_sw	Setting this input flag true enables a two-pole filter for the encoder feedback.
Velocity Limit Configuration Switches	*vl_sw1*	Setting this input flag true enables the forward velocity limit to come from the speed forward limit 2 parameter in the keypad menu system.
	vl_sw2	Setting this input flag true enables the forward velocity limit to come from a programmable controller (XCL communications). See *xcl_sw13* through *xcl_sw16*.
	vl_sw3	Setting this input flag true enables the forward velocity limit to come from the speed forward limit parameter in the keypad menu system.
	vl_sw4	Setting this input flag true sets the reverse velocity limit equal to the negated positive velocity limit.
	vl_sw5	Setting this input flag true enables the reverse velocity limit to come from the speed reverse limit parameter in the keypad menu system.
	vl_sw6	Setting this input flag true enables the reverse velocity limit to come from a programmable controller. See *xcl_sw17* through *xcl_sw20*.
	vl_sw7	Setting this input flag true enables the reverse velocity limit to come from the speed reverse limit 2 parameter in the keypad menu system.
	vl_sw8	Setting this input flag true enables the positive velocity limit to come from the speed forward limit 3 parameter in the keypad menu system.
	vl_sw9	Setting this input flag true enables the reverse velocity limit to come from the speed reverse limit 3 parameter in the keypad menu system.

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H.11. Drive Indicator Variables

Indicator variables for the Perfect Harmony drive are listed and described in Table H-13.

Table H-13. Drive Indicator Variables

Name	Description
auto_rst_in_prog_f	This flag is set true from the drive when there is an auto fault reset in progress.
Bypass_f	This flag is set true from the drive when one or more cells are in bypass.
c_r_timeout_f	This flag is set true from the drive when the drive has completed state "c" (conditional run) as set by the time entered from the keypad for the conditional run timer parameter.
c_s_timeout_f	This flag is set true from the drive when the drive has completed state "f" (conditional stop) as set by the time entered from the keypad for the conditional stop timer parameter .
cell_fault_f	This flag is set true from the drive when one or more cells are faulted.
dnxfer_complete_f	This flag is set true from the drive when a down transfer is complete.
dnxfer_flt_f	This flag is set true from the drive when a down transfer fails.
dnxfer_timeout_f	This flag is set true from the SOP when the drive transfer time-out occurs as set by a timer variable.
do_dn_xfer_f	This flag is set true from the drive during down transfer when the line and the VFD are in sync. This flag should be used to close the VFD contactor.
do_up_xfer_f	This flag is set true from the drive during an up transfer when the VFD is in sync with the line. This flag should be used to close the VFD contactor.
drive_ready	This flag is set true from the drive when the drive is not running AND is in a non-faulted condition.
drv_flt_f	This flag is set true from the drive when there is a drive fault and can be set by the system program to inhibit the drive.
fatal_fault_f	This flag is set true when both the *drv_flt_f* and (internal) *sw_estop_f* are true, indicating that a fatal (trip) fault has occurred.
fault_display	This is used in conjunction with the *drv_flt_f*, *fatal_fault_f*, and a timer to allow the display of non-fatal fault messages.
forward_f	This flag is set true from the drive when the drive is running is a forward direction.
ground_flt_f	This flag is set when the drive detects a ground fault condition. Action must be taken by the SOP to create a fault.
loc_pcl_flt	This flag is set true from the drive when the drive cannot communicate to the local keypad. Note: This flag is latched and must be reset by the user. Also note that keypad resets will not work.
mot_ov_fault	This flag is set true from the drive when the drive creates a motor over voltage fault.
mv_ot_trip_f	This flag is set true by the drive when the cell temperature creates a fatal fault.

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Name	Description
mv_ot_warning_f	This flag is set true when an overtemperature condition exists that will eventually result in an overtemperature fault.
over_spd_f	This flag is set true from the drive when the speed of the drive exceeds the overspeed parameter set from the keypad.
overld_fault	This flag is set true from the drive as a result of a current overload fault (TOL).
overload_pending	This flag is set when a current overload condition exists that will eventually result in a TOL fault.
phase_lock_enabled	This flag is set by the drive during transfer indicating that frequency lock has completed and the phase lock loop (PLL) has been enabled.
rollback_f	This flag is set true by the drive when, in hard current limit, the ramp is rolled back.
signal_loss_f	This flag is set true from the drive when the 4-20 mA signal is below half of the value specified in the 4-20 mA dropout parameter in menu 29.
single_phase_f	This flag is set true by the drive when a single phase condition is detected.
therm_ot_f	Not used
torque_limit_f	This flag is set true by the drive when it is in torque (current) limit.
trq_cntr_en_f	This flag is set true from the drive when the torque control circuit from the drive is active, i.e., when the drive is not in the idle state.
um_24v_flt	This flag is set true from the drive when the user modules connected to the Microprocessor Board from a ribbon cable pull to much current on the 24 volt rail.
upxfer_complete_f	This flag is set true by the drive to indicate that a successful up transfer has been accomplished. This is used to reset the up transfer request in the SOP.
upxfer_flt_f	This flag is set true from the drive when there is an up transfer fault.
upxfer_timeout_f	This flag is set true by the SOP when a successful up transfer has not completed in the time allotted by a timer variable.
vavail_ok_f	This flag indicates that all cell input voltages are within limits and no low line exists to the cells.
zero_spd_f	This flag is set true from the drive when the speed is below the zero speed threshold parameter setting.

H.12. Drive Control Variables

Control variables for the Perfect Harmony drive are listed in Table H-14.

Table H-14. Drive Control Variables

Name	Description
cndtnl_r_s_f	Setting this input flag true selects the drive to the conditional run stop state. Refer to Perfect Harmony run state drawing for additional usage.

Name	Description
dnxfer_req_f	This flag is set true by the SOP to request that the drive perform a down transfer sequence. All handshaking for state sequencing is handled by the SOP. Refer to the down transfer state machine on page 8 of drawing 479333.
drv_flt_rst_f	Setting this input flag true resets drive faults, providing they can be cleared. This flag also resets an emergency stop (e-stop).
estop_f	Setting this input flag true will case the drive to immediately stop gating, regardless of the type of stop defined in the system program. To set this flag false, (enable the drive to run), you must toggle the drive fault reset flag (*drv_flt_rst_f*) to true.
estop_rst_f	Not used.
leave_c_r_f	The drive sets this flag true to allow the drive to exit the conditional run state. (State “c” on 7-segment display on the Microprocessor Board.)
leave_c_s_f	The drive sets this flag true to allow the drive to exit the conditional stop state. (State “f” on 7-segment display on the Microprocessor Board.)
log_done	Setting the flag false will cause the drive to start logging data for the diagnostic logger. The logger will continually run and reset as long as this flag is forced false. When released, the diagnostic logger immediately stops with as much data as has been collected.
run_req_f	Setting this input flag true will enable the drive to run provided that no drive inhibits exist. Note: The **CR3** input to the PIB must be set true to run the drive.
spin_load_start_f	This flag can be set true by the SOP to force the drive to start with spinning load active even when no fault has shut down the drive. Spinning load must be enabled.
trq_tst_mode_f	The drive sets this flag true and enables the torque test mode from the menu. The parameters for the torque test mode are set from the keypad. The flag *std_ctrl_f* (standard control) must be set false for torque test mode.
trq_tst_sw	This flag can be set true from the SOP to put the drive in the torque test mode. The torque test mode can be set from the keypad from a menu or by setting the flag *trq_tst_sw* true.
upxfer_req_f	This flag is set true by the SOP to request that the drive perform an up transfer sequence. All handshaking for state sequencing is handled by the SOP. Refer to the down transfer state machine on page 8 of drawing 479333.
vel_tst_mode_f	The drive sets this input flag true from the menu to enable the velocity test mode. The parameters for the test are set using the keypad.
vel_tst_sw	This flag can be set true from the SOP to put the drive in the velocity test mode. The velocity test mode can be set from the keypad from a menu or by setting the flag *vel_tst_sw* true.
xfer_flt_rst_f	Setting this input flag true resets the up and down transfer faults.

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H.13. User Defined Text String Variables

User defined text string variables are listed and described in Table H-15.

Table H-15. User Defined Text String Variables

Name	Description
user_text_x (1-16)	These special variables are used to assign text strings to the various user faults, overriding the default messages. The text must be enclosed in parentheses and limited to 23 characters.

H.14. User Fault Flags

User defined fault flags are listed and described in Table H-16.

Table H-16. User Fault Flags

Name	Description
user_faultx (1-16)	When set true by conditions defined in an SOP, these variables produce a non-fatal drive fault and log the fault message. To actuate a drive trip (fatal fault) the *estop_f* must also be set true (the drive fault flag *drv_flt_f* is set automatically).

H.15. Drive Fault Words

Drive fault words are listed and described in Table H-17.

Table H-17. Drive Fault Words

Name	Description
flt_word1_0	This flag is set true from the microprocessor when the drive detects a cell overtemperature fault.
flt_word1_1	Reserved for future use.
flt_word1_2	Reserved for future use.
flt_word1_3	Not used by Perfect Harmony.
flt_word1_4	Reserved for future use.
flt_word1_5	This flag is set true from the microprocessor when the drive detects a Motor Over Voltage fault.
flt_word1_6	Reserved for future use.
flt_word1_7	Reserved for future use.
flt_word1_8	Reserved for future use.
flt_word1_9	Not used by Perfect Harmony.
flt_word1_10	Reserved for future use.
flt_word1_11	Reserved for future use.
flt_word1_12	Reserved for future use.

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Name	Description
flt_word1_13	Reserved for future use.
flt_word1_14	This flag is set true from the microprocessor when the drive detects a Timer Interrupt Overrun fault.
flt_word1_15	This flag is set true from the microprocessor when the drive detects a Micro Board ±15 Volt Supply fault.
flt_word2_0	This flag is set true from the microprocessor when the drive detects a 15 Volt Digital Supply fault.
flt_word2_1	This flag is set true from the microprocessor when the drive detects an Analog Power Supply fault.
flt_word2_2	This flag is set true from the microprocessor when the drive detects a Ground fault.
flt_word2_3	Not used by Perfect Harmony.
flt_word2_4	Not used by Perfect Harmony.
flt_word2_5	This flag is set true from the microprocessor when the drive detects a Drive IOC fault.
flt_word2_6	Not used by Perfect Harmony.
flt_word2_7	This flag is set true from the microprocessor when the drive detects a Medium Voltage Loss of Enable fault.
flt_word2_8	This flag is set true from the microprocessor when the drive detects a Medium Voltage Supply fault.
flt_word2_9	This flag is set true from the microprocessor when the drive detects a XCL Communication Status fault.
flt_word2_10	This flag is set true from the microprocessor when the drive detects a CAB Hardware fault.
flt_word2_11	This flag is set true from the microprocessor when the drive detects a XCL Node x Data Loss fault.
flt_word2_12	This flag is set true from the microprocessor when the drive detects a Power Cell fault.
flt_word2_13	This flag is set true from the microprocessor when the drive detects an Overspeed fault.
flt_word2_14	This flag is set true from the microprocessor when the drive detects a 24 Volt Supply fault.
flt_word2_15	This flag is set true from the microprocessor when the drive detects an Overload fault.

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Note that locator page numbers appear in regular type faces for standard index references [e.g., 7-10]. For index references that correspond to items found in tables, the locator page numbers are shown in an italic type face [e.g., *6-24*]. For index references that correspond to items found in figures and illustrations, the locator page numbers are shown in a boldface type face [e.g., **3-3**]. Illustrations that appear in tables have locator page numbers that are both boldface and italic [e.g., ***6-16***].

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