TRYSTAR

PCS-RS40

OWNERS MANUAL

PCS-RS40
40KW ENERGY STORAGE POWER CONVERSION SYSTEM

Rack Scale™ Series



15765 Acorn Trail / Faribault, MN 55021 / 507.333.3990

TRYSTAR.com

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About Trystar

Trystar LLC. is a proven innovator of power, control, and instrumentation solutions for the most demanding industrial applications. Trystar products include variable motor drives, grid tie inverters, frequency converters, standalone inverters, DC/DC converters, and DSP based control boards for power control applications.

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IMPORTANT SAFETY INSTRUCTIONS

IMPORTANT SAFETY INSTRUCTIONS

SAVE THESE INSTRUCTIONS

This manual contains important instructions for the PCS-RS40 power conversion system (PCS), that shall be followed during installation and maintenance of the PCS. The PCS-RS40 is designed and tested according to international safety requirements, but as with all electrical and electronic equipment, certain precautions must be observed when installing and/or operating the PCS. To reduce the risk of personal injury and to ensure the safe installation and operation of the PCS-RS40, you must carefully read and follow all instructions, cautions and warnings in this installation guide.

Warnings in this Document

The following safety notices are provided for your safety and as a means of preventing damage to the product or components in the application. Specific Dangers, Warnings, and Cautions are listed at the beginning of the relevant sections and are repeated or supplemented at critical points throughout these sections. Please read the information carefully since it is provided for your personal safety and will also help prolong the service life of your PCS and the equipment you connect to it.

DANGER

This symbol indicates high voltage. It calls your attention to items or operations that could be dangerous to you and other persons operating this equipment. Read the message and follow the instructions carefully.

WARNING

Indicates a potentially hazardous situation which, if not avoided, can result in serious injury or death.

CAUTION

Indicates a potentially hazardous situation which, if not avoided, can result in minor to moderate injury, or serious damage to the product. The situation described in the CAUTION may, if not avoided, lead to serious results. Important safety measures are described in CAUTION (as well as WARNING).

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INTRODUCTION

This document is intended to provide detailed specifications and instructions on how to properly install and operate an Trystar 40kW Energy Storage Power Conversion System (PCS). To provide for safe installation and operation of the equipment, please read the safety guidelines at the beginning of this manual and follow the procedures outlined before connecting power to the PCS.

Referenced Documents

Author	Document
Modbus.org	Modbus Over Serial Line v1.02
Modbus.org	Modbus Application Protocol Specification v1.1b
MESA Alliance	MESA-PCS Specification Draft 2014
SunSpec Alliance	SunSpec Technology Overview 12040 v1.4
SunSpec Alliance	SunSpec Information Models 12041 v1.8
SunSpec Alliance	SunSpec Inverter Models 12020 v1.5
SunSpec Alliance	SunSpec_Information_Model_Reference.xls

General Information

Throughout this document, acronyms may be employed for brevity and readability. These are summarized in Table 1.

Table 1 - Document Acronyms

Acronym	Full Text Equivalent
AC	Alternating Current
AFE	Active Front End
AWG	American Wire Gauge
CEC	California Energy Commission
DC	Direct Current
ESD	Electrostatic Discharge
GUI	Graphical User Interface
HV	High Voltage
HVRT	High Voltage Ride Through
HFRT	High Frequency Ride Through
I/O	Input/Output
LVRT	Low Voltage Ride Through
LFRT	Low Frequency Ride Through
NOP	No Operation
OOT	Out of Tolerance

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PCC	Point of Common Coupling
PCS	Power Conversion System
RH	Relative Humidity
RMS	Root Mean Square
RTC	Real Time Clock
RTU	Remote Terminal Unit
STS	Static Transfer Switch
THD	Total Harmonic Distortion

General Safety

DANGER

Power inverters are typically connected to hazardous voltages. When servicing an inverter, there may be exposed terminals at or above line potential, as well as residual charge in place for some time after the removal of the input source. Extreme care should be taken to protect against shock.

1. Before startup, observe the warnings and safety instructions provided throughout this manual. All power terminals should be considered at utility AC or high DC potential unless verified to be otherwise. These voltages are extremely dangerous and may cause death or severe injury if contacted.
2. All power terminals should be considered live with the application of input voltage regardless of operating mode of the load.
3. Do not make any connections when the PCS is connected to its power source.
4. Never work on the PCS, power cables, or load when input power is applied.

WARNING

1. Do not make any insulation or voltage withstand tests on the PCS.
2. Before servicing the unit, always ensure by measuring with a multimeter that
   a. There is no voltage between the AC terminals (A, B, & C) and chassis ground.
   b. There is no voltage between the DC terminals (+ & -), nor between either DC terminal and chassis ground.

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⚠ CAUTION ⚠

1. The PCS operates on several electrical reference points, whether these be earth ground, communication ground, signal ground, etc. Proper system design regarding equipotential bonding must be employed so that all simultaneously accessible conductive parts are electrically connected to prevent hazardous voltages appearing between them. This is accomplished by a proper factory grounding.
2. Ensure sufficient cooling for safe operation of the PCS.
3. The PCS is not field repairable. Never attempt to repair a malfunctioning unit; contact Trystar for a replacement.
4. Each PCS is sealed with a warranty void sticker across the top cover which will tear if the cover is removed. A torn warranty void sticker shall be interpreted as unauthorized access to the internal contents of the PCS, in violation of warranty terms, thereby terminating any remaining warranty otherwise in effect.

⚠ CAUTION ⚠

Write (W) parameters must not be changed cyclically.

The majority of registers that can be modified using Modbus Write commands (W) are non-volatile and intended for long term storage of device configuration. Cyclical changing of these parameters will lead to failure of the non-volatile memory device.

Registers used for the immediate control and limitation are an exception and may be changed cyclically with no damage to the electronics. These registers are denoted with a cyclical (C) access designator.

Orderable Part Numbers

The PCS-RS40 is currently available with two airflow options, either front to back, or back to front. The options are identified using the orderable part number shown below.



Figure 1 - Part Number Guide

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The PCS-RS40 ships with mounting brackets used to attach the unit to the front of the rack (see Installation). These brackets are available in two versions – one compatible with US Customary mounting hardware (10-32) and one for metric mounting hardware (M6). When placing your order, please specify which brackets (US Customary or metric) should be included. Additional mounting bracket options are also available, contact Trystar for more details.

SPECIFICATIONS

Reliability

Operational Life	20 Years at 25°C, 33% full load duty cycle
Service Interval	No field service required.

Electrical Specifications

DC Input	
DC Input Voltage Range	330 to 820 V, Derated below 550 V, see DC Input Voltage Based Power Derating, on page 14
DC Input Current	75 A maximum (operating)
Maximum Overload DC Input Current	The DC input does not include fuse protection. It is recommended that the customer provide a means to limit the current to 100 Amps
DC Input Impedance	750k Ohm minimum across DC inputs
Max Input Short Circuit Current	107 A
Max Backfeed Current	n/a, no backfeed current from AC to DC terminals
AC Interface (Utility-interactive and Stand-alone)	
Power Rating	±40 kW, ±40 kVAR, ±40 kVA @ 480 VAC
Power Factor	0 to 1 leading or lagging
Number of Phases	3-wire / 4-wire, Configurable
Nominal Grid Frequency	50 Hz / 60 Hz, Configurable
Operating Voltage	208 to 480 V RMS , Configurable
Rated AC Output Current	50 A RMS
Max AC Output Over Current Protection	88 A RMS
Max AC Fault Current	208 A
Max AC Fault Current Duration	2.24 msec
Phase Voltage Imbalance	<10%
Max AC Connect Voltage	585 V RMS (line to line): The PCS will disconnect from the AC interface at voltages greater than this value.
Max Operating Frequency	90 Hz
Min Operating Frequency	30 Hz
AC Interface (Utility-interactive)	
PQ Power Accuracy	±3% of full scale
PQ Command Resolution	1% rated

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PQ Command Slew Rate	400 kVA/s max (configurable)
Output Current Distortion	< 5% TDD per IEEE 519 operating conditions < 3% Max at rated power
Active Ride Through V MAX	535 V RMS (line-to-line), 576 V RMS (isolated 3-wire operation): Regions in the High Voltage Ride Through Momentary Cessation curve that exceed this voltage will be forced to this value.
AC Interface (Stand-alone)	
Max Operating Voltage	576 V RMS
Voltage Regulation[1]	< 10% of Voltage Rating, 0-100% load - per UL1741 45.2.1
Frequency Regulation[1]	< 1 Hz of Frequency Rating - per UL1741 45.2.1
Max Black Start Voltage[2]	10 V RMS
Output Voltage Distortion	< 1% Max THD operating at 100% resistive load
Max Current Imbalance	25 A RMS
General	
CEC Efficiency	96.7% (PCS-RS40-B) 96.2% (PCS-RS40-F)
Peak Efficiency	97.5% (PCS-RS40-B) 97.2% (PCS-RS40-F)
Standby Power	29W, Power draw from DC input when in Standby state
Inrush Current	< 1A, internal soft start provided
Power On Response Time	• 3.5 sec: time from Bias Enable input asserted to when PCS transitions to DISABLED state • 6 sec: time to transition from DISABLED to STANDBY state from receipt of "Start" serial command, (worst case, cold start with maximum DC input voltage) • 2 ms: time to transition from STANDBY to ONLINE state from receipt of "Exit Standby" serial command
Discrete Outputs	
Voltage (max)	32 VDC
Current (max)	5 mA
Discrete Inputs	
Voltage (min) – ESTOP, DIN	5 VDC
Voltage (min) – BIAS ON/OFF	19 VDC
Voltage (max)	32 VDC
Current (max)	10 mA
RS-485 ("+" or "-" signal to RS485_GND)	
Voltage (min)	-7 VDC
Voltage (max)	12 VDC

[1]Regulated voltage and frequency are affected by Grid Forming droop control and virtual impedance settings. For true stand-alone operation, these can be disabled (see Single Unit Standalone Operation, on page 43).

[2]The island voltage must be below this value for the PCS to perform a black start.

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Environmental Specifications (Indoor use)

Operating Temperature Range	"F" Option, Air Flow front to back: -5 to 60 °C "B" Option, Air Flow back to front: -5 to 50 °C *Customer derating required to meet warranty and life specifications (see Temperature Based Power Derating on page 12 for details)*
Storage Temperature Range	-20 to 60 °C
Operating Humidity Range	30 - 90% RH (no condensation)
Storage Humidity Range	10 - 95% RH (no condensation)
Operating Altitude	1,000 m No Derating, >1,000 m Derated
Pollution Degree	2 (IEC 1010-1)
Ingress Protection Rating	IPC20
Acoustic Noise	75 dBA Max in all directions, horizontal distance of 3ft

Mechanical Specifications

Cooling	Forced air cooled by internal fans.
Weight	97 lb
Dimensions	19" rack, 2.5U, see Accuracies on page 10.
Vibration	MIL-810E, method 514.4 test condition I-3.3.1
Shock	Less than 20G, half sine, 11mS, unpacked
Seismic	1G seismic zone (IEEE 693 High Seismic) with seismic spectra of 0.5G

Accuracies

The following accuracies apply to both 480 V RMS and 208 V RMS operation:

Parameter	Maximum Error
AC Voltage	±2% of 480 V RMS , or ±9.6 V RMS
DC Voltage	±2% of 820 V, or ±16.4 V
AC Current	±3% of 50 A RMS , or ±1.5 A RMS
DC Current	±3% of 75 A, or ±2.25 A
Power	±3% of 40 kW/kVAR, or ±1.2 kW/kVAR
Power Factor	±5%
Frequency	±0.1 Hz
Time	±0.1 sec

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Mechanical Dimensions

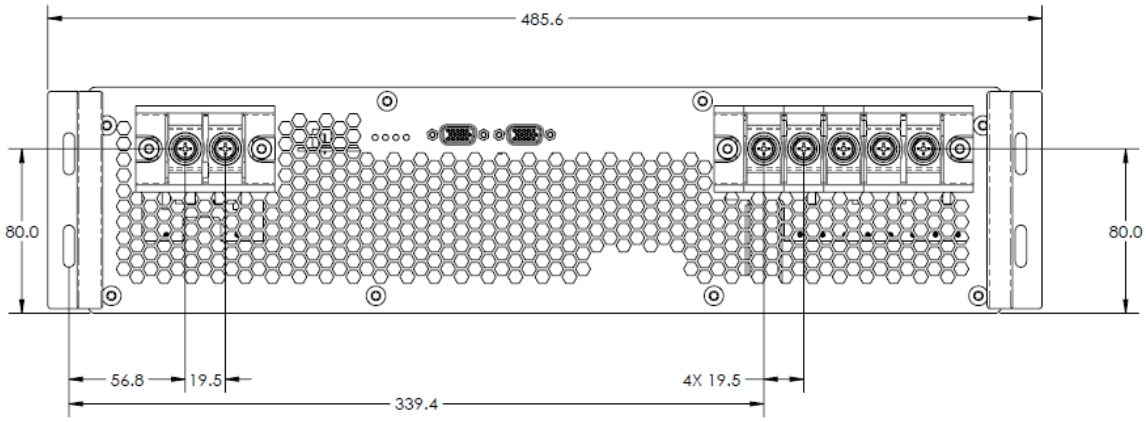

Figure 2 - Mechanical Outline, Front View

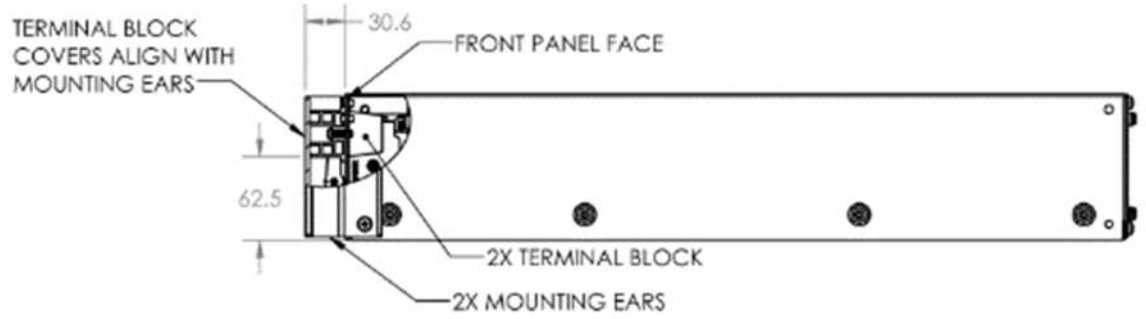

Figure 3 - Mechanical Outline - Side View

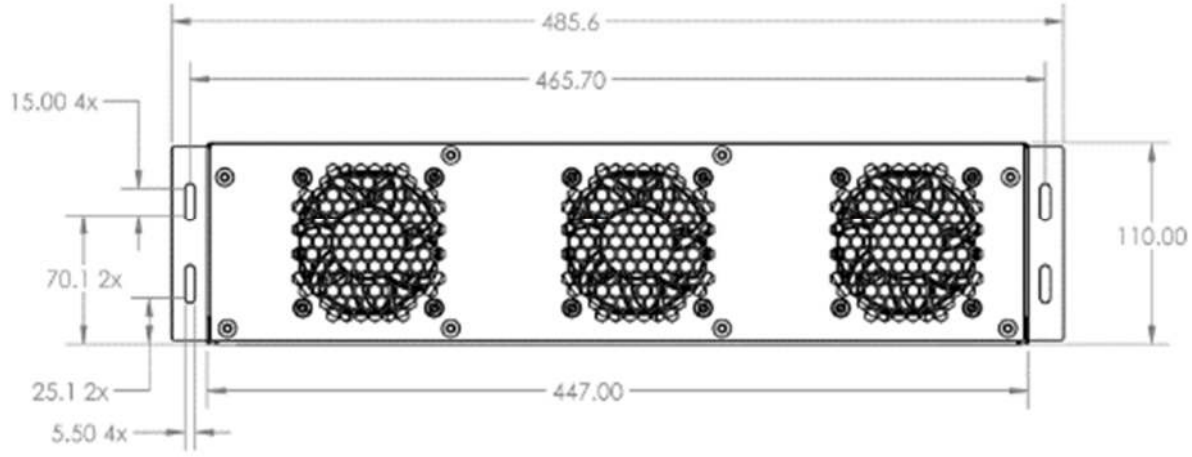

Figure 4 - Mechanical Outline - Rear View

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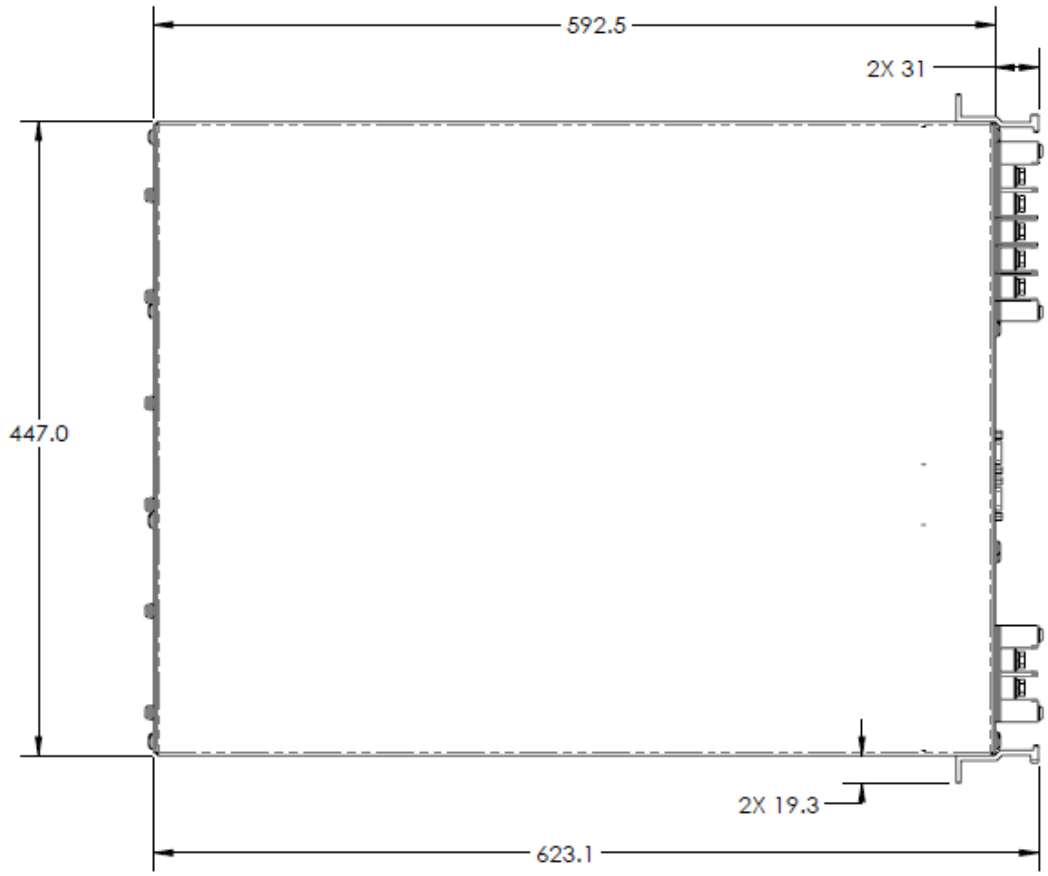

Figure 5 - Mechanical Outline - Top View

Temperature Based Power Derating

The PCS can be ordered with two different fan orientations: one for front-to-back airflow and one for back-to-front. The recommended configuration is the front-to-back airflow option as this provides better cooling for the PCS's internal components. The back-to-front model is available for end systems that are constrained to airflow in this direction, however this comes at the expense of reduced operating temperature range.

The figures below show the continuous and peak operating temperature regions for the different PCS fan configurations. The green shaded regions represent the continuous safe operating zone. PCS operation should be limited to this region to meet rated life and not affect the warranty period.

The yellow shaded region represents the intermittent safe operating zone. The PCS may be operated in this region for brief durations. The warranty period is not affected if the total time spent operating in this region is kept below 120 hours. Each additional hour of operation in this zone that exceeds 120 hours will reduce the warranty coverage length by one month.

The red shaded region represents the over-temperature zone. The PCS does not prohibit operation in this zone, but the unit may trip off to protect itself based on its internal over temperature limits (internal air

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temperature of 70°C or power device heatsink temperature of 100°C). The end application must be configured to avoid operation in this zone. Continuous operation in this zone will void the warranty.

⚠ CAUTION ⚠

Operating the PCS for longer than 120 hours in the yellow regions shown below will shorten the product warranty as described above. Continuously operating the PCS in the red regions shown below will void the product warranty.

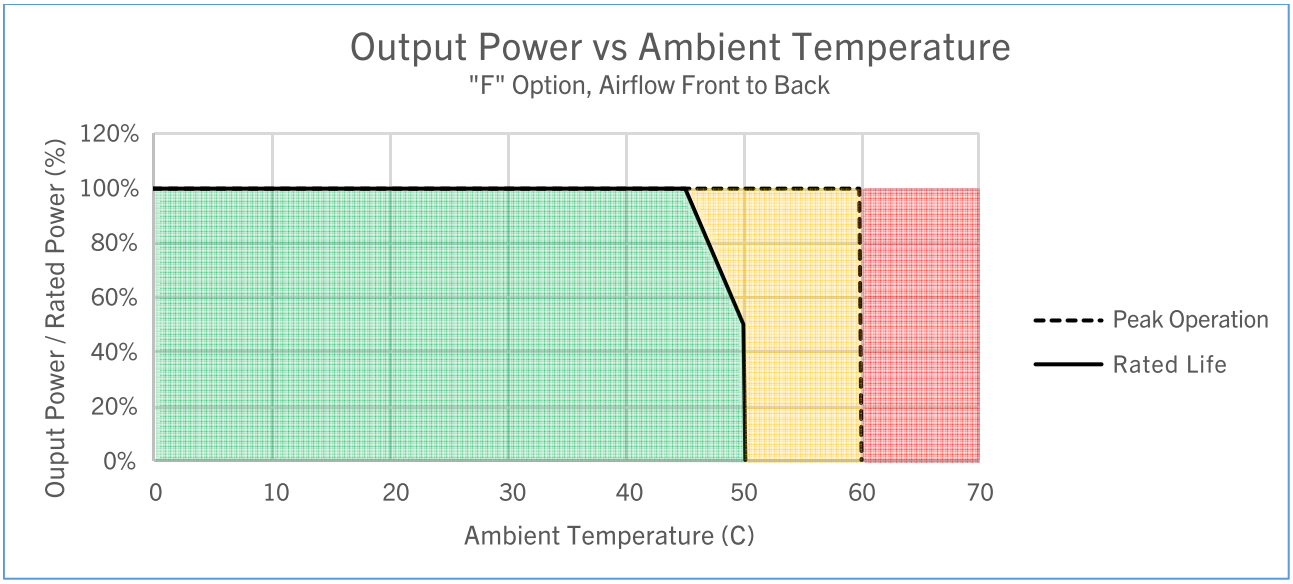

Figure 6 - Temperature Derating Curve – "F" Option

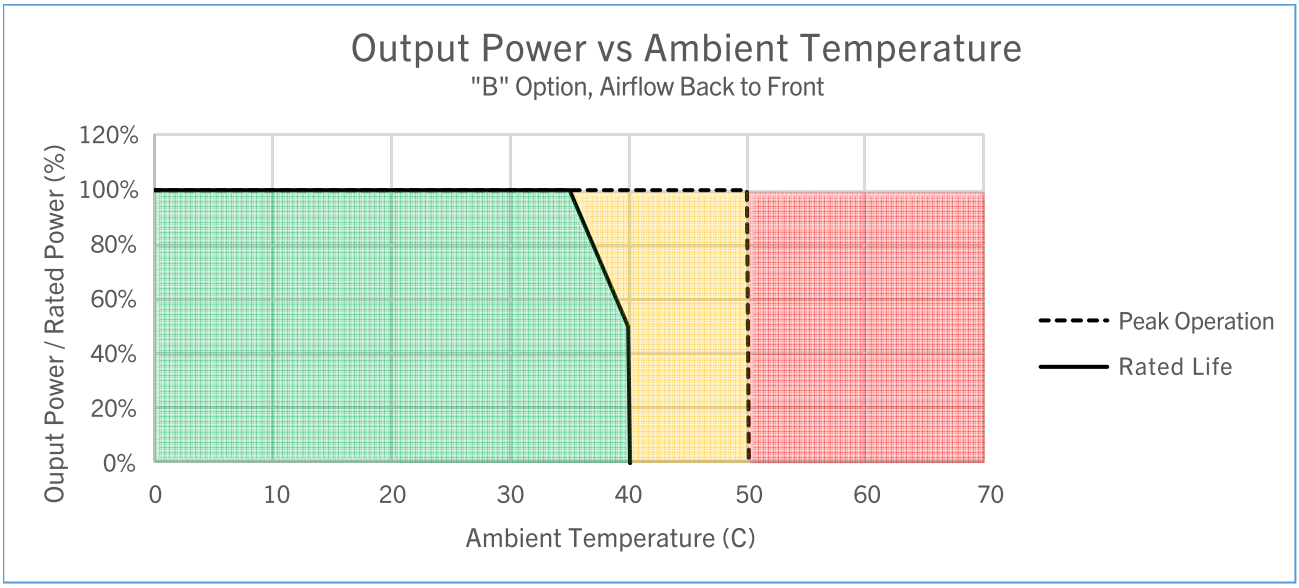

Figure 7 - Temperature Derating Curve – "B" Option

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The PCS monitors the air temperature inside the enclosure using a sensor located immediately behind the front panel. Accumulated operating time across various temperature ranges is recorded as described in the Datalogging section of this document. For “F” option units with front-to-back airflow, the measured air temperature is the inlet air and will match the external ambient temperature.

For “B” option units with back-to-front airflow, the internal air temperature is the outlet air, which will be greater than the external ambient temperature based on operating power levels. In general, the temperature rise through the unit is less than 10°C up to 50% power and less than 20°C when operating between 50% and rated power. For the purpose of determining external ambient temperature using the data log measurements, a 10°C rise is assumed for 50% power or less, and a 20°C rise is assumed for greater than 50% power.

DC Input Voltage Based Power Derating

The chart below illustrates the power derating at low DC input voltages based on the maximum DC current rating. Note that the user may lower the ***Maximum DC Charge/Discharge Current*** limits ***(REG 41238/41239)*** from the maximum rated value, in which case the power derating will occur at higher DC input voltages.

When operating in Grid Tie mode, the PCS will automatically limit the AC power based on the derating curve and will assert the ***DC Power Limit*** warning flag if the user’s power command is limited to a lower value.

When operating in Grid Forming mode, the PCS does not enforce the DC power derating curve. In this mode, it is the user’s responsibility to keep the load power below the available power for a given DC input voltage and DC current limit value. Failure to do so may result in DC over current faults. If the DC input voltage and programmed current limit values are such that the PCS will be unable to provide the specified rated power, the ***DC Power Limit*** warning flag will be set to indicate that full power is not available.

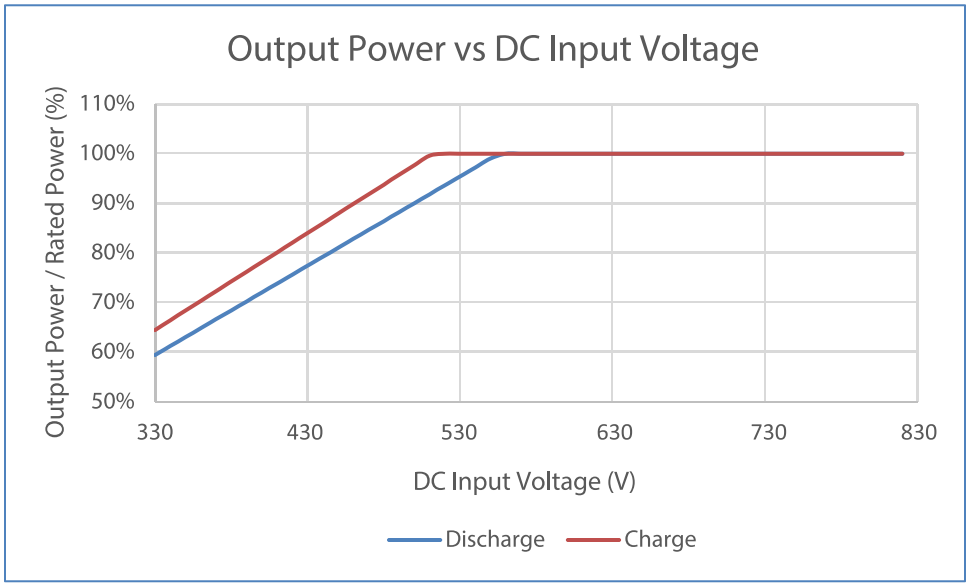

Figure 8 - DC Input Voltage Derating Curve

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AC Voltage Based Power Derating

The chart below illustrates the power derating at low AC line voltages based on the maximum AC current rating. When operating in Grid Tie mode, the PCS will automatically limit the AC power based on the derating curve and will assert the ***AC Current Limit*** warning flag whenever the commanded power is being limited to a lower value as a result of this current limit.

When operating in Grid Forming mode, the PCS does not enforce the AC power derating curve. In this mode, it is the user's responsibility to keep the load power below the available power for the desired range of acceptable AC line voltages. Failure to do so may result in AC over current faults.

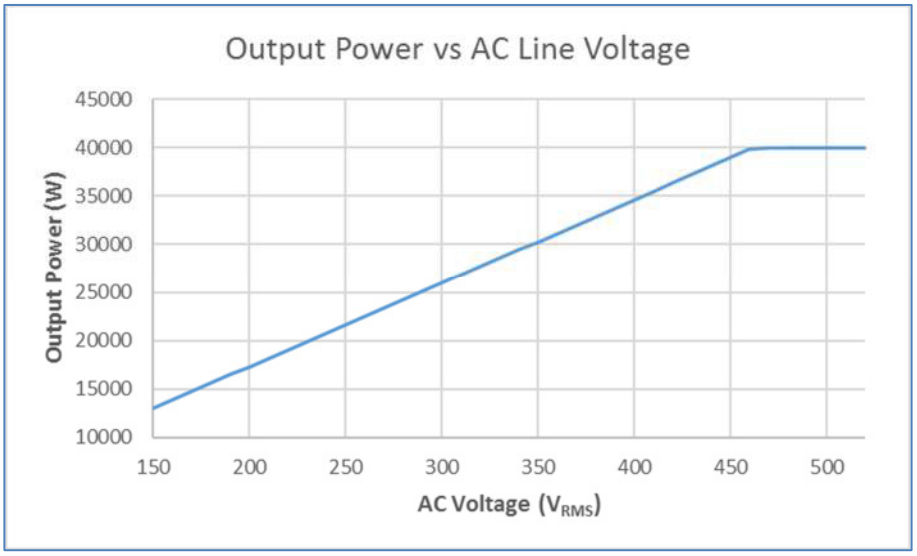

Figure 9 - AC Line Voltage Derating

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Elevation Based Power Derating

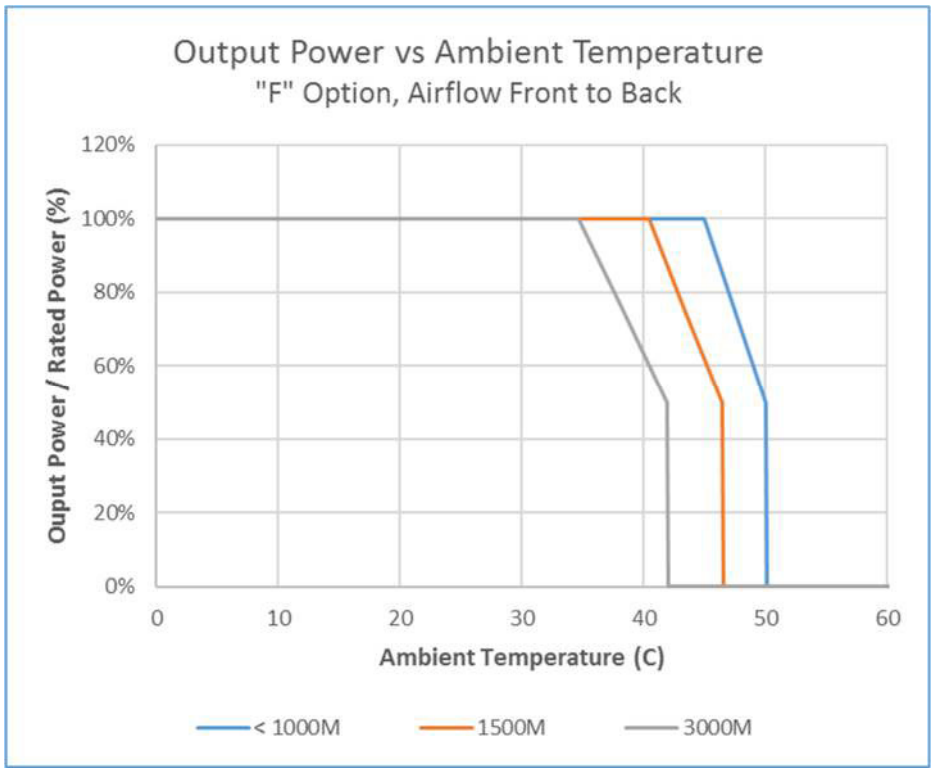

Figure 10 - Elevation Derating Curves – "F" option

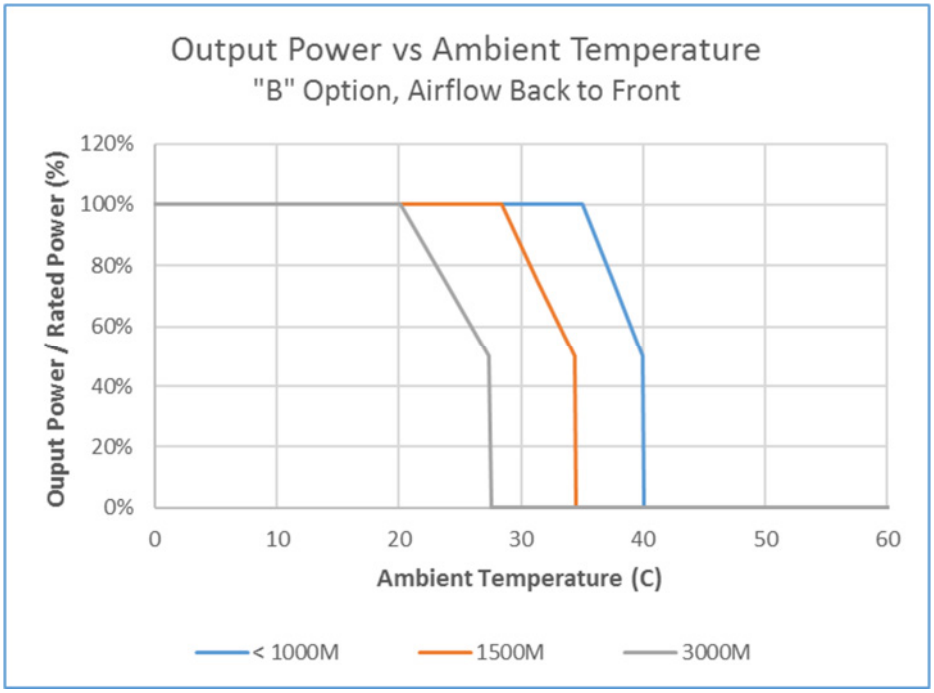

Figure 11 - Elevation Derating Curves – "B" option

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Maintenance

The PCS has been designed to require no maintenance over its operating life.

Regulatory Specifications

Listings (See Appendix A)

1.	UL1741	Inverters, Converters, Controllers and Interconnection System Equipment for Use with Distributed Energy Resources
2.	UL1741-SA	CA Rule 21 including SA17, SA18, IEEE2030.5 CSIP, Phase 3 Functions 1&8
3.	CSA C22.2#017	Safety Requirements for Electrical Equipment for Measurement, Control, and Laboratory Use.
4.	IEEE 1547	Standard for Interconnecting Distributed Resources with Electric Power Systems
5.	CE	Low Voltage Directive per IEC 62477-1
6.	CE	EMC Directive per EN61000-6-4 (emissions), EN61000-6-2 (immunity)
7.	SunSpec Cert # 032-001	Certified for SunSpec Information Models 1, 17, 103, 120, 121, 122, 123, 126, 129, 130, 135, 136, 139, 140, 143, 144
8.	California Energy Comm.	CEC Listed Grid Support Inverter, Rule 21 CSIP Phase 2 and Phase 3 Function 1 and 8 Functionality

Compliance

This product is designed to comply with the following standards:

1.	IEEE 519	Recommended Practices and Requirements for Harmonic Control in Electrical Power Systems
2.	IPC9592	Performance Parameters for Power Conversion Devices (for components derating and general design guidelines)

Unpacking and Inspection

Qty 1

PCS-RS40

Qty 2

Mounting Ears

Qty 4

Screws for Mounting Ears

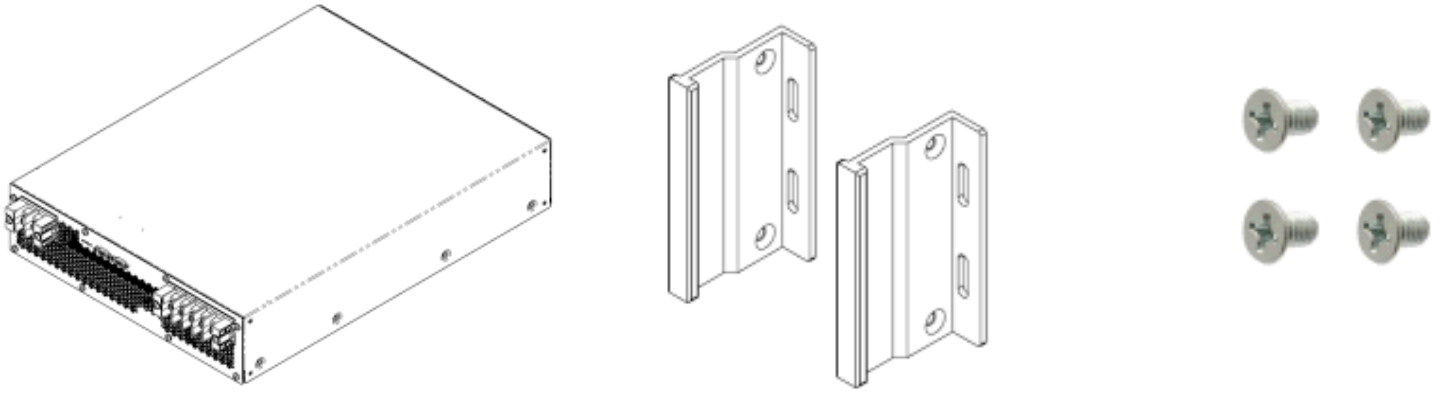

Figure 12 - Shipping Contents

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Notice: Retain the packaging material!

Proper packaging, including internal cushioning and palletization, is required to maintain warranty coverage on any unit returning to Trystar.

⚠ CAUTION ⚠

Mechanical lift is strongly recommended. Product weight exceeds limits for individual lift. Team lift is mandatory for any manual movement of the unit before or after unpackaging.

1. Using the provided packing list, verify that the model received corresponds to that ordered and inspect the packaging for any signs of shipping damage. Immediately seek assistance from the freight carrier for any visible signs that the packaging or product has been damaged. If it is necessary to send the PCS-RS40 back, use the original packaging.
2. The PCS is a sensitive electronic device. While it has been designed to mitigate risks of ESD damage under normal circumstances, care should be taken not to handle electrical interfaces unnecessarily.
3. Use the enclosed nylon handling straps to hoist the unit out of the shipping container. These straps should be retained and used for all necessary hoisting until the unit has been installed into its system mounting location.
4. Use the four provided Phillips head screws to attach the two mounting ears. Do not exceed 1.8 Nm (16 in-lb) when installing the screws. Note that the mounting ears can be installed at the front panel, where the terminal blocks are located, or at the rear panel, where the fans are situated. The unused mounting holes can be ignored, as they do not impact mechanical integrity of the enclosure.
5. User supplied bolts which penetrate the enclosure beyond 7mm will void the product warranty. Trystar strongly recommends using the supplied hardware to install rack support brackets and mounting ears.

⚠ CAUTION ⚠

Do not carry or lift the PCS-RS40 by the mounting ears. The mounting ears are intended as pull handles to slide the unit into or out of a rack. Attempting to lift or carry the unit with these handles may result in injury to the handler and damage to the unit.

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INSTALLATION

Mechanical

1. Using the lifting straps in conjunction with team lift or mechanical lift best practices, raise the unit to the level at which it is to be installed into the rack.
2. Gently slide the unit onto the rack shelf/rails until the mounting ears contact the rack frame and the ear slots align with the holes in the frame.

⚠ CAUTION ⚠

The PCS-RS40 is not intended to be supported by the mounting ears. The unit must be installed on rails or a shelf to support its weight.

3. Using rack hardware (not provided), secure each mounting ear in two places to 3.4 Nm (30 in-lb), or to the torque value recommended by the rack provider, if specified.
4. Ensure that adequate spacing is provided from both the rear and front panels of the unit such that ventilation airflow is not obstructed. Trystar requires 40 mm (1.6”) minimum clearance front and back, with greater than 50 mm (2.0”) recommended.

Electrical

⚠ WARNING ⚠

All electrical installations must be done in accordance with the local and National Electrical Code®ANSI/NFPA 70 or the Canadian Electrical Code®CSA C22.1. This document does not and is not intended to replace any local, state, provincial, federal or national laws, regulation or codes applicable to the installation and use of the PCS, including without limitation applicable electrical safety codes. All installations must conform with the laws, regulations, codes and standards applicable in the jurisdiction of installation. Trystar assumes no responsibility for the compliance or noncompliance with such laws or codes in connection with the installation of the PCS.

⚠ CAUTION ⚠

Do Not Remove Panels or Cover. No user serviceable parts inside.

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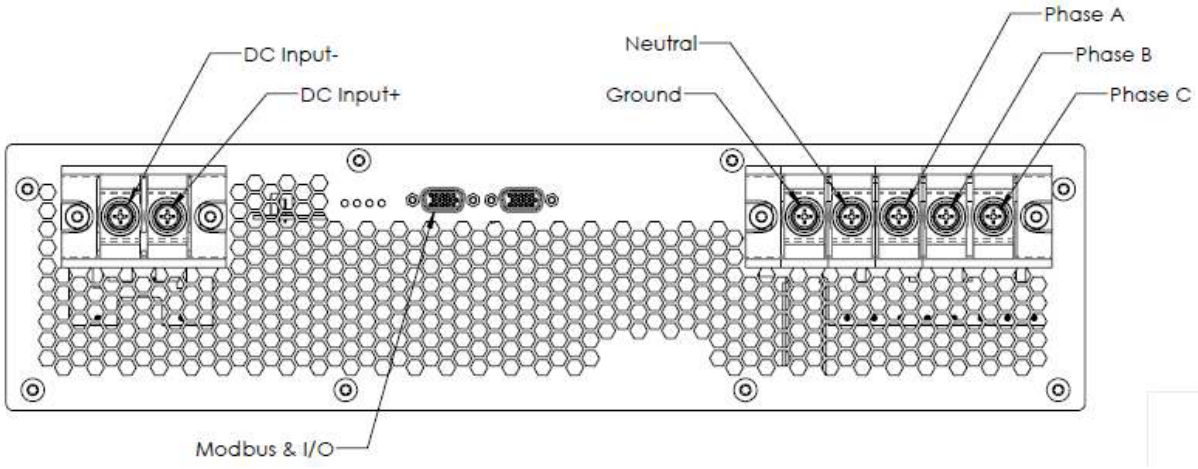

Figure 13 - Interface Identification and Location

DC Connection

DANGER

High voltage may cause severe personal injury or death.
Avoid contact with electrical terminals.
De-Energize all sources before servicing.

CAUTION

The PCS-RS40 does not include overcurrent protection on the DC input. The customer is required to provide adequate overcurrent protection external to the PCS.

CAUTION

The DC inputs are intended to float and must not be referenced to earth ground. Referencing either DC terminal to ground will void the warranty and may cause permanent damage to the PCS-RS40.

Notice: Ambient Temperature
The higher the ambient temperature the higher the power losses. Use cables having larger cross-sections in installations with high ambient temperatures.

1. For all DC cable connections, use a minimum 4 AWG copper wire that is designed for +90 °C (+194 °F).
2. Connections can be made using wire and compression lugs. See Table 2 for a list of compatible compression lugs.

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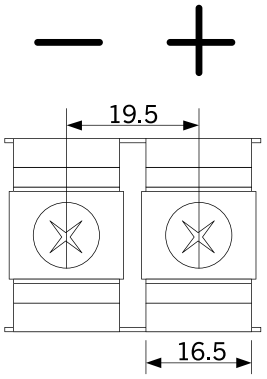
Table 2 - Compatible Compression Lugs (DC)

Wire Size	Manufacturer	P/N
000	Panduit	LCAN3/0-14-X
00	Panduit	LCAN2/0-14-X
0	Panduit	LCAN1/0-14-X
1	Panduit	LCAN1-14-E
2	Panduit	LCAN2-14-Q
3,4	Panduit	LCAN4-14-L

3. Turn off the DC source and secure against turning on again.
4. Remove the plastic cover of DC terminal block which is supplied with the product.
5. Connect the negative and positive cables to the DC terminal block as shown in Figure 14.
6. Connections should be tightened to a specified torque of 2.8 Nm (25 in-lb) +/- 5%.
7. After the DC connections are tightened, the manufacturer-supplied cover of the DC terminal block must be re-installed.



Screw Size: M6 x 14L
All dimensions in mm

Figure 14 - DC Terminal Block Connections

AC Connection

DANGER

High voltage may cause severe personal injury or death.
Avoid contact with electrical terminals.
De-Energize all sources before servicing.

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⚠ CAUTION ⚠

The PCS-RS40 does not include overcurrent protection on the AC input. The customer is required to provide adequate external branch level protection. The following AC branch circuit current ratings are recommended:

One unit 70A
Two units 150A
Three units 200A

Notice: Ambient Temperature
The higher the ambient temperature the higher the power losses. Use cables having larger cross-sections in installations with high ambient temperatures.

1. For all AC cable connections, use a minimum 4 AWG copper wire that is designed for +90 °C (+194 °F).
2. Connections can be made using wire and compression lugs. See Table 3 for a list of compatible compression lugs.

Table 3 - Compatible Compression Lugs (AC)

Wire Size	Manufacturer	P/N
000	Panduit	LCAN3/0-14-X
00	Panduit	LCAN2/0-14-X
0	Panduit	LCAN1/0-14-X
1	Panduit	LCAN1-14-E
2	Panduit	LCAN2-14-Q
3,4	Panduit	LCAN4-14-L

3. Turn off the AC source and secure against turning on again.
4. Remove the plastic cover of AC terminal block which is supplied with the product.
5. Connect the ground cable as well as the three utility phase cables to the AC terminal block as shown in Figure 15.
6. The neutral connection (N) is provided for 4-wire grid-forming or standalone operation – this terminal should be left unconnected for grid-tie only applications. When used, ***REG 41240 – AC Connection Type*** must be set to '1' to indicate 4-wire operation.
7. Connections should be tightened to a specified torque of 2.8 Nm (25 in-lb) +/- 5%.
8. After the AC connections are tightened, the manufacturer-supplied cover of the AC terminal block must be re-installed.

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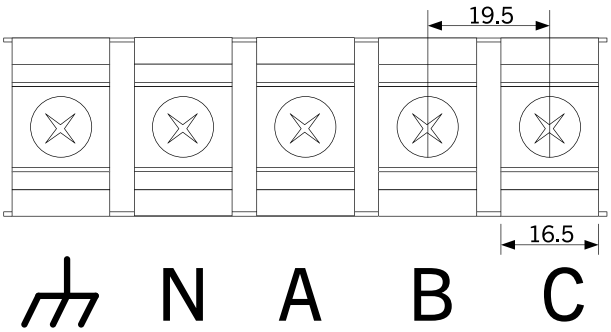

Screw Size: M6 x 14L
All dimensions in mm

Figure 15 - AC Terminal Block Connections

Low Voltage I/O

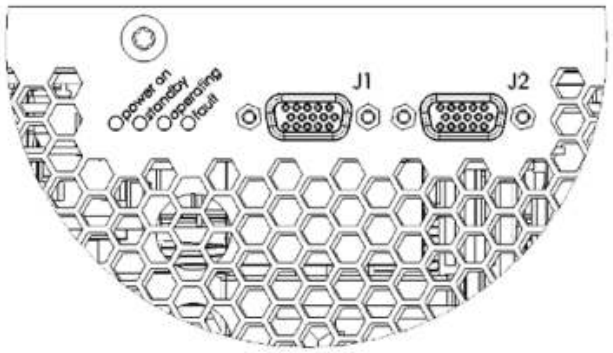

Figure 16 - Low Voltage I/O Connections

All isolated, low voltage I/O signals are provided on a standard High Density, D-Sub, 15-pin, female connector (J1). A second connector (J2) with an identical pin-out is provided to allow for daisy-chaining paralleled units, as well as terminating the Modbus data link. An example of a mating connector part number is given below:

Manufacturer: Amphenol

Manufacturer p/n: 10090769-P154ALF

1. Install the primary interface cable to either connector J1 or J2. Tighten the mounting screws to no more than 0.6Nm (5 in-lb).
2. If the unit is to be daisy-chained with other units in parallel, secure a second I/O cable to the unused connector, J1 or J2. Tighten the mounting screws to no more than 0.6Nm (5 in-lb).
3. When using a single unit or if the unit is the last in a string of daisy-chained units, attach a terminating jumper dongle to the unused connector, J1 or J2. Tighten the mounting screws to no more than 0.6Nm (5 in-lb). The dongle should jumper pins 4 to 5 and pins 14 to 15 to provide termination for the Modbus communications link.

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Configuration

The PCS-RS40 is shipped from the factory configured for a nominal line voltage of 480 VAC and a frequency of 60 Hz. If the PCS-RS40 is intended to be used with line voltages other than 480 VAC, 60Hz, the user must configure ***REG 40168 – Voltage at the PCC*** and ***REG 40185 – Nominal Frequency*** for the proper conditions.

Likewise, there are many user configurable parameters that determine the operating behavior of the PCS. It is the responsibility of the user to review this manual and the register set to ensure the PCS is configured appropriately for their application.

Interface

Visual Indicators

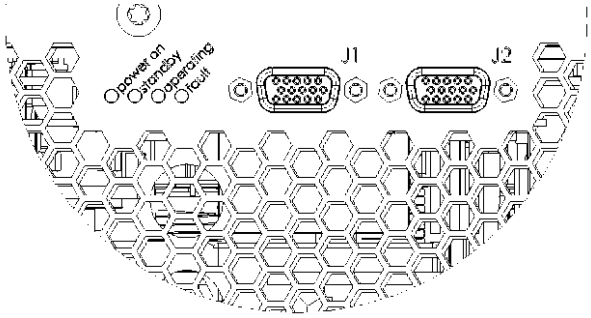

Figure 17 - Visual Indicators

The PCS includes 4 LED's on the front panel to indicate operating status. Table 4 defines the meaning of each LED for normal operation while Table 5 defines their meaning when the bootloader is running.

Table 4 - LED Functions - Normal Operation

Color	Label	Location	Meaning
Green	POWER ON	Front Panel	On Solid: Bias Supply is Operating
Yellow	STANDBY	Front Panel	On Solid: System is in Standby State
Yellow	OPERATING	Front Panel	On Solid: System is processing power
Red	FAULT	Front Panel	On Solid: System is Faulted

Table 5 - LED Functions - Bootloader Operation

Color	Label	Location	Meaning
Green	POWER ON	Front Panel	Blinking: Bootloader is running
Yellow	STANDBY	Front Panel	On Solid: PCS is connected to the Host
Yellow	OPERATING	Front Panel	Rapid Blink: Data exchange with Host in progress
Red	FAULT	Front Panel	On Solid: Bootloader error, e.g. CRC error

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Low Voltage I/O

All isolated, low voltage I/O signals are provided on two standard High Density, D-Sub, 15-pin, female connectors. The pinout for the two connectors is provided in the following table.

Table 6 - I/O D-Sub 15 Pinout

Pin #	Name	Meaning
1	ESTOP_C	Opto-Isolated Emergency Stop - Cathode Input
2	ESTOP_A	Opto-Isolated Emergency Stop - Anode Input
3	DOUT1_C	Opto-Isolated Output #1 – Collector
4	TERM "+"	RS-485 Termination Resistor ("+" connection)
5	RS485 "+"	RS-485 "+" Signal
6	DIN_A	Opto-Isolated Island Control Input – Anode Input
7	BIAS_EN_A	Opto-Isolated Bias Enable – Anode Input
8	DOUT2_C	Opto-Isolated Output #2 – Collector
9	DOUT1_E	Opto-Isolated Output #1 – Emitter
10	RS485_GND	Isolated Ground for RS-485 interface
11	DIN_C	Opto-Isolated Island Control Input – Cathode Input
12	BIAS_EN_C	Opto-Isolated Bias Enable – Cathode Input
13	DOUT2_E	Opto-Isolated Output #2 – Emitter
14	TERM "-"	RS-485 Termination Resistor ("-" connection)
15	RS485 "-"	RS-485 "-" Signal

Modbus RS-485

The RS-485 interface requires three signals, "+" and "-" data signals and Ground. RS-485 is a multi-drop data bus; i.e., multiple devices can all tie directly onto the same physical signals. For proper signal integrity, the data bus must be terminated at both ends. To allow for easy wiring of paralleled units, two connectors are provided. In addition, an internal terminating resistor is provided.

Figure 18 illustrates how to correctly wire the RS-485 data bus when paralleling multiple devices. Please note the following:

- ***All three wires, "+" and "-" signal wires as well as a ground reference, should be connected***
- ***The last device on the bus must have its terminating resistor connected by providing a jumper wire between pins 4-5 and 14-15.***

⚠ CAUTION ⚠

The RS-485 data bus must be terminated for reliable communications. Do NOT terminate every device on the bus, as this will degrade the signals and overload the transceivers. Only the devices physically located at the end of the wires should have termination.

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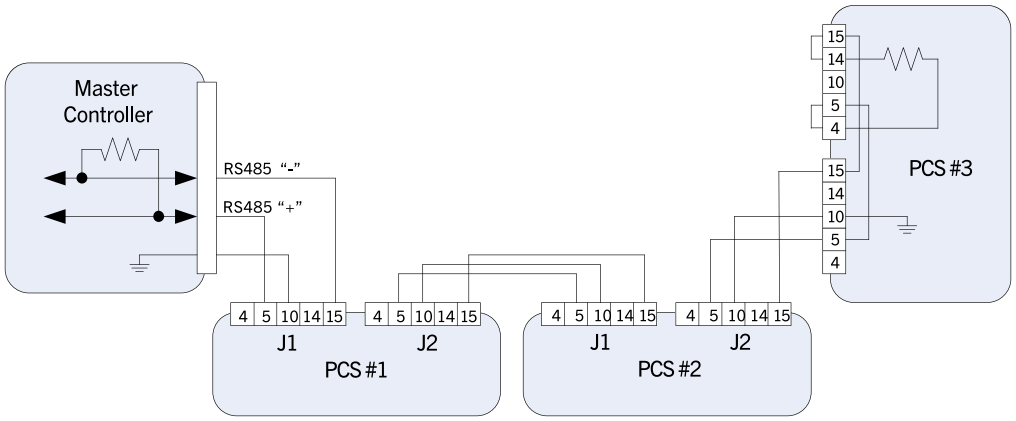

Figure 18 - Modbus Serial Interface Wiring

Inputs

The PCS provides three, opto-isolated, discrete inputs. The Emergency Stop and DIN inputs are designed such that they can be directly driven with voltages from 5 up to 32VDC as illustrated in Figure 19. Note that the Bias Enable input has a slightly different interface and requires a 24VDC input to work.

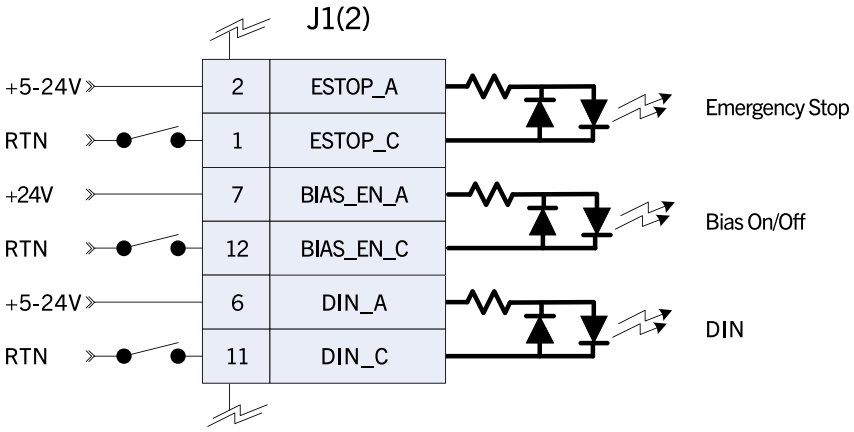

Figure 19 - Discrete Input Interface

Emergency Stop

The Emergency Stop (ESTOP) input provides a hardware only enable path. For the PCS to process power, i.e., DC/DC and inverter contactors closed, this input must remain asserted. The signal provides a direct hardware enable path to both the input and output contactors. The PCS will report an ESTOP fault whenever this input isn't asserted,

Bias On/Off

The Bias On/Off input is used to enable the PCS's bias supply. As long as this opto-isolated input is asserted by applying 24 VDC, the bias supply remains operating. When the input is deasserted, the bias supply will hold up for approximately 2.5 sec to allow the microprocessor to finish its housekeeping tasks, after which the bias supply is powered off.

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CAUTION

The PCS's internal bias supply is generated from the high voltage DC battery input. The user should ensure that the battery voltage remains present while the Bias On/Off input is asserted, as well as for the brief shutdown period after this pin is deasserted. Disconnecting the battery input while Bias On/Off is asserted will cause the internal bias supply to turn off immediately, bypassing any power-down housekeeping tasks, and possibly resulting in the loss of accumulated datalogging information!

Island Control Input

The PCS provides a digital input that may be configured for use as an Island Control pin, allowing an external controller to switch between Grid Tie and Grid Forming modes. See ***REG 42813 – Island Control Input Pin Configuration*** for details on programmable options for this pin. If not used, this pin may be left unconnected.

Outputs

There are two, opto-isolated, discrete status outputs as illustrated in Figure 20. Each of the outputs can be configured to represent a combination of selectable fault, warning, and operational events. The output polarity can be configured using ***REG 41287 – Alarm Output Pin Polarity.***

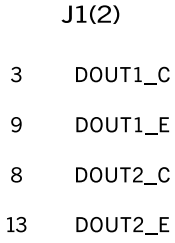

Figure 20 - Discrete Output Interface

Each output has four mask registers associated with it, one corresponding to the Fault status register, another to the Warning Status Register, a third for operating state, and a fourth for other miscellaneous events. The table below lists the mask registers along with the corresponding status register.

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Table 7 - Alarm Output Mask Registers

Alarm Output Mask Register		Status Register
41279	Alarm Output 1 – PCS Fault Mask	40129
41281	Alarm Output 1 – PCS Warning Mask	40131
41288	Alarm Output 1 – PCS State Mask	n/a
41292	Alarm Output 1 – Misc. Function Mask	n/a
41283	Alarm Output 2 – PCS Fault Mask	40129
41285	Alarm Output 2 – PCS Warning Mask	40131
41290	Alarm Output 2 – PCS State Mask	n/a
41293	Alarm Output 2 – Misc. Function Mask	n/a

Setting a bit to “1” in the mask register, will enable the corresponding fault, warning, state, or function to drive that output. Setting multiple mask bits to “1” logically OR’s those faults, warnings, states, and functions together.

For example, setting Register 41279 and 41281 to 0xFFFFFFFF, enables any PCS fault or warning to drive Alarm Output 1. Similarly, setting Register 41283 and 41285 to 0xFFFFFFFF, enables any PCS fault or warning to drive Alarm Output 2.Operation

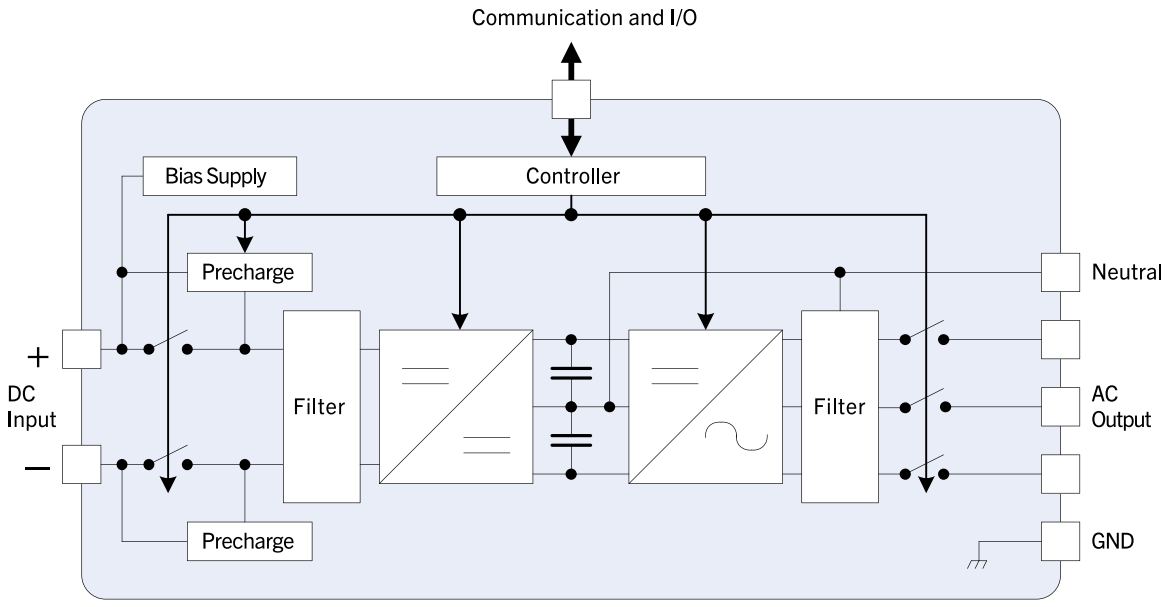

Figure 21 - System Block Diagram

Bias Power

The PCS incorporates an internal bias supply that derives the necessary working voltages from the high voltage DC input. The bias supply is controlled with the “Bias On/Off” discrete input. When this input is asserted, the bias supply is enabled and drawing power from the DC input.

When the input is deasserted, the bias supply is disabled. Note that it may take up to 2.5 sec to turn off after the signal is deasserted to allow orderly shutdown of the PCS controller.

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Grid Tie Operating Mode

When configured to operate in Grid Tie mode (see ***REG 4116***7 and **REG 41144),** the PCS provides bi-directional, real and reactive (P/Q) power control to the grid. Assuming the grid is present and within specification, the PCS will connect and accept P and Q commands from the user. Multiple PCSs may be operated in parallel, providing a modular solution for higher power applications.

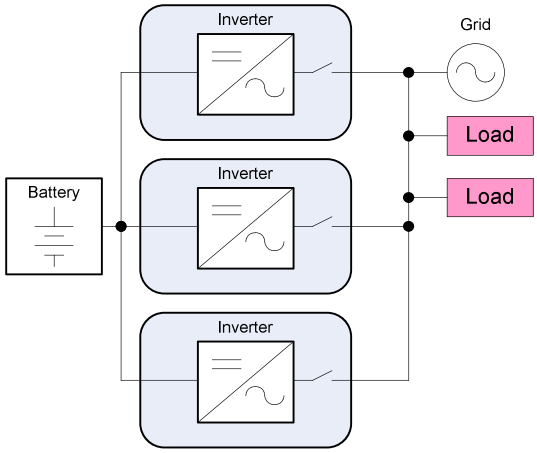

Figure 22 - Grid Tie Mode System Block Diagram

Initiating Grid Tie Operation

When the PCS is first powered up, its internal DC and AC contactors are both open. Prior to operating the PCS, it must be commanded to close these contactors by first writing a "1" to ***REG 40247*** – ***Connection Control*** followed by writing a "1" to ***REG 41123*** – ***Set Operation.*** At this point, if a valid grid voltage and frequency are detected, the PCS will go through an internal precharge process to safely bring all internal voltages up to their required levels and then the contactors will be closed. Once connected to the grid, the PCS can be turned on by writing a "4" to ***REG 41123*** – ***Set Operation.*** When this command is received, the PCS will first wait the random period specified in ***REG 41335*** – ***Initial Turn-On Window.*** Once this time has expired, the PCS will turn on and ramp to the last commanded real and reactive (P/Q) power setpoints at the rate specified in ***REG 41336*** – ***Initial Turn-On Ramp Time.*** The initial turn-on wait period can be bypassed by setting the turn-on window to zero. Once the output power has finished ramping to the commanded setpoints, any subsequent changes in P/Q power commands will cause the PCS to ramp to these values at a rate specified in ***REG 40177*** – ***Ramp Rate for change in Power Setpoint.***

A single PCS may be turned on by issuing the above commands to that specific unit's unique Modbus device address (specified in ***REG 40069***). Alternatively, multiple PCS's may be turned on at the same time by issuing the above commands to the dedicated Modbus broadcast device address of zero. This assumes that all parallel PCS's are attached to the same physical RS-485 bus.

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Real Power Control

The real power is controlled by writing the desired power, as a percentage of the maximum output power, ***REG 40167, to REG 40248 – Power Setpoint,*** followed by writing a "1" to ***REG 40252 – Power Setpoint – Enable/Disable*** to enable or "latch" the new setpoint value. Register 40248 defaults to zero each time the PCS is powered on. Once written to, the register retains the last command until bias power is removed.

Reactive Power and Power Factor Control

The reactive power may be controlled either directly, through ***REG 40259 – Reactive Power Setpoint,*** or via ***REG 40253 – Power Factor Setpoint.*** When directly setting the reactive power, the user writes the desired command, as a percentage of the maximum reactive power, ***REG 40173-40176,*** to ***REG 40259 – Reactive Power Setpoint,*** followed by writing a "1" to ***REG 40265 – Reactive Power Setpoint – Enable/Disable*** to enable or "latch" the setpoint.

Rather than directly commanding the reactive power, it's possible to operate the PCS with power factor control. In this mode, the power factor is set by writing to ***REG 40253 – Power Factor Setpoint,*** followed by writing a "1" to ***REG 40257 – Power Factor Setpoint – Enable/Disable*** to enable or "latch" the setpoint. In power factor mode, the PCS will maintain the requested power factor by calculating the required reactive power based on the real power setpoint. If the calculated reactive power is greater than the maximum, ***REG 40173-40176,*** it will be limited to the max and the "AC Power Limit" warning bit is set in ***REG 40131 – PCS Warning Status.***

Note that it is only possible to enable one reactive power control scheme at a time. In other words, if the Reactive power setpoint is enabled, i.e.,, register 40265 = 1, power factor control may not be enabled, i.e.,, writes to register 40257 are ignored, until the reactive power setpoint is disabled by setting register 40265 = 0. Similarly, the reactive power setpoint may only be enabled if the power factor setpoint is disabled, register 40257 = 0.

Volt/VAR Control

To support grid voltage stabilization during over-voltage and under-voltage conditions, the PCS may be optionally configured to automatically generate reactive power commands based on the average of the three grid voltages measured at the PCS terminals. This behavior is implemented using a configurable array of Volt-VAR points that when combined, define a series of linear, piece-wise curves that create the desired Volt-VAR curve. Each curve can contain between 1 to 12 points, and up to three independent curves can be configured. These curves are defined using the registers found in SunSpec Model 126.

Figure 23 illustrates a basic Volt-VAR curve that consists of four points. At the endpoints, to the left of the lowest point and to the right of the highest point, the VAR level remains constant (i.e.,, flat lines). The voltage points are defined as a percentage of the nominal grid voltage configured in ***REG 40168 – Voltage at the PCC.*** The corresponding reactive power points are defined as a percentage of the PCS's maximum reactive power setpoint configured in ***REG 40173 – 40176.***

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CAUTION

The voltage of each consecutive point in the curve must be higher than the previous point. Failure to meet this requirement will result in the curve being disabled and an **Invalid User Configuration** fault will be asserted. The offending curve is reported in ***REG 41131 – User Configuration Error Status (LSW).***

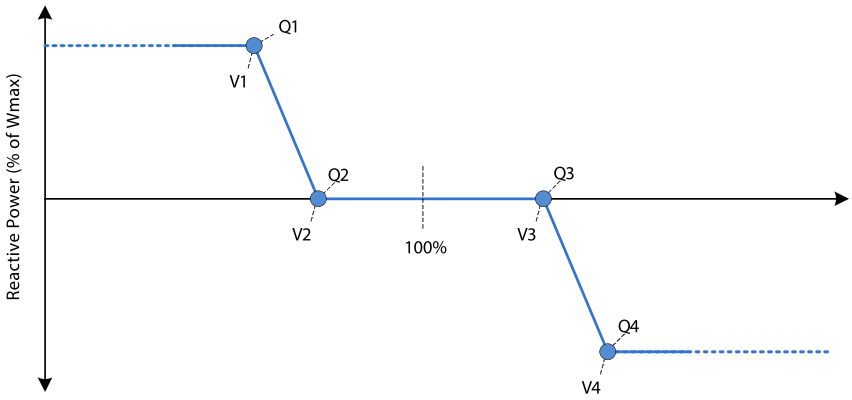

Figure 23 - Volt/VAR Configuration

When the Volt-VAR function is enabled, direct user control of reactive power is not possible and the setpoints from ***REG 40259 – Reactive Power Setpoint or REG 40253 – Power Factor Setpoint*** are not used. Instead, the reactive power setpoint will follow the specified Volt-VAR curve. When the Volt-VAR function is resulting in a non-zero reactive power command, the "Volt-VAR Active" warning bit will be asserted in ***REG 40131 – PCS Warnings.*** The maximum rate at which the reactive power is allowed to change is defined by the slew rate configured in ***REG 40177 – Ramp Rate for change in Power Setpoint.***

Volt/Watt Control

In addition to Volt/VAR control, the PCS may also be configured to limit the allowable real power commanded by the user during over-voltage and under-voltage conditions, using the average of the measured three phase voltages. This behavior is implemented using a configurable array of Volt-Watt points that are used to specify voltage-based P MAX and P MIN curves. These curves can contain between 2 to 10 points, and up to three independent P MAX and P MIN curves can be configured. Each curve must contain a minimum of two points. The P MAX curves are defined using the registers found in SunSpec Model 132. The P MIN curves are defined using the registers found in Trystar Extension Model 64306.

Figure 24 illustrates a basic Volt-Watt P MAX curve (shown in blue) and P MIN curve (shown in red), each consisting of two points. At the endpoints, to the left of the lowest point and to the right of the highest

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point, the Watt level remains constant (i.e.,, flat lines). The voltage points are defined as a percentage of the nominal grid voltage configured in ***REG 40168 – Voltage at the PCC.*** The corresponding power limits are defined as a percentage of the PCS's maximum output power setpoint (W MAX) configured in ***REG 40167.*** When the Volt-Watt curves are enabled, the user's real power command will be clamped below the value specified by the P MAX curve and above the values specified by the P MIN curve.

In general, the P MAX curve is intended to reduce the power being delivered to the grid during over-voltage conditions, while the P MIN curve is meant to increase the power during undervoltage conditions. The power limit is not required to stop at 0% as shown in the figure below and may continue beyond the X-axis. For example, a P MAX point P2 that is configured with a negative value would extend the curve below the X-axis, indicating that for high over-voltage conditions the PCS will be forced to absorb power from the grid. Similarly, a P MIN point P1 that is configured with a positive value would extend the curve above the X-axis, indicating that for extreme under-voltage conditions the PCS will be forced to push power to the grid.

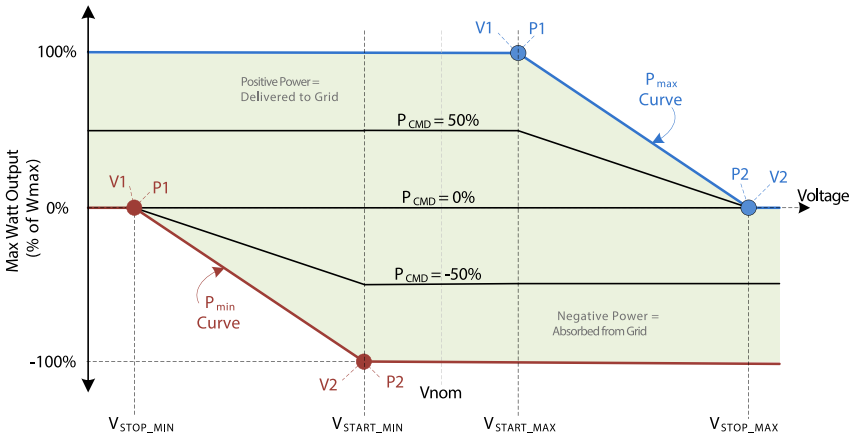

Figure 24 - Volt/Watt Configuration

For power commands less than ±100% W MAX, the PCS will linearly adjust the commanded power from the respective min/max V START voltage to the corresponding min/max V STOP voltage, as illustrated by the PCMD = ±50% lines in Figure 24. For the P MAX curve, the V START voltage will always be the first point in the array, while the V STOP voltage will be the last. For the P MIN curve, the VSTART voltage will always be the last point in the array, while the VSTOP voltage will be the first point..

If one or both Volt/Watt P MAX and P MIN curves are enabled and are presently causing the user's real power command to be clamped, the "Volt-Watt Active" warning bit will be asserted in ***REG 40131 – PCS Warnings.*** If both the P MAX and P MIN curves are enabled and overlap (i.e., portions of the P MIN curve are above portions of the P MAX curve), and the measured grid voltage falls within one of the overlapping regions, then the resulting power limit will be the one closest to zero (i.e., the lower of the absolute value of the two).

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⚠ CAUTION ⚠

For the Volt-Watt curves (P MAX or P MIN), the voltage of each consecutive point in the curve must be higher than the previous point. Failure to meet this requirement will result in the curve being disabled and an **Invalid User Configuration** fault will be asserted. The offending curve is reported in ***REG 41131 – User Configuration Error Status (LSW)*** or ***REG 41143 – User Configuration Error Status (MSW).***

Frequency/Watt Control

To support grid frequency stabilization during over-frequency and under-frequency conditions, the PCS may be optionally configured to automatically generate real power commands based on the grid frequency measured at the PCS terminals. This behavior is implemented using a configurable array of Frequency-Watt points that are used to specify frequency-based P MAX and P MIN curves. These curves can contain between 2 to 10 points, and up to three independent P MAX and P MIN curves can be configured. Each curve must contain a minimum of two points. The P MAX curves are defined using the registers found in SunSpec Model 134. The P MIN curves are defined using the registers found in Trystar Extension Model 64307.

Figure 25 illustrates a basic Frequency-Watt P MAX curve (shown in blue) and P MIN curve (shown in red), each consisting of two points. At the endpoints, to the left of the lowest point and to the right of the highest point, the Watt level remains constant (i.e., flat lines). The frequency points are defined in units of Hertz. The corresponding power limits are defined as a percentage of the PCS's maximum output power setpoint (W MAX) configured in ***REG 40167***. When the Frequency Watt curves are enabled, the user's real power command will be clamped below the values specified by the P MAX curve and above the values specified by the P MIN curve.

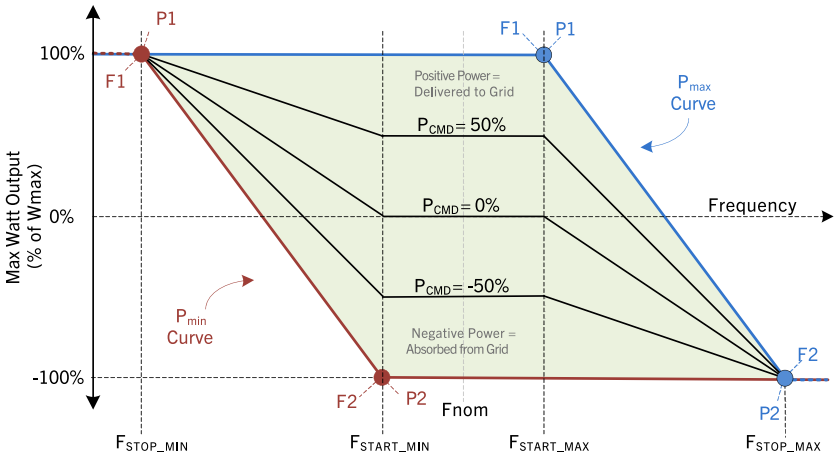

Figure 25 - Frequency/Watt Configuration

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In general, the P MAX curve is intended to reduce the power being delivered to the grid during over-frequency conditions, while the P MIN curve is meant to increase the power during under-frequency conditions. The power limit is not required to stop at 0%, as shown in the figure it may continue beyond the X-axis. For example, a P MAX point P2 that is configured with a negative value as shown indicates that for high over-frequency conditions the PCS will be forced to absorb power from the grid. Similarly, a P MIN point P1 configured with a positive value indicates that for extreme under-frequency conditions the PCS will be forced to deliver power to the grid.

For power commands less than ±100% W MAX, the PCS will linearly adjust the commanded power from the respective min/max F START frequency to the corresponding min/max F STOP frequency, as illustrated in Figure 25. For the P MAX curve, the F START frequency will always be the first point in the array, while the F STOP frequency will be the last. For the P MIN curve, the F START frequency will always be the last point in the array, while the F STOP frequency will be the first.

CAUTION

For the Frequency-Watt curves (P MAX or P MIN), the frequency of each consecutive point in the curve must be higher than the previous point. Failure to meet this requirement will result in the curve being disabled and an **Invalid User Configuration** fault will be asserted. The offending curve is reported in ***REG 41131 – User Configuration Error Status (LSW)*** or ***REG 41143 – User Configuration Error Status (MSW).***

If one or both Frequency/Watt P MAX and P MIN curves are enabled and are presently causing the user's real power command to be clamped, the "Frequency-Watt Active" warning bit will be asserted in ***REG 40131 – PCS Warnings.*** If both the P MAX and P MIN curves are enabled and overlap (i.e., portions of the P MIN curve are above portions of the P MAX curve), and the measured grid frequency falls within one of the overlapping regions, then the resulting power limit will be the one closest to zero (i.e., the lower of the absolute value of the two).

Output Power and Current Limiting

The PCS implements a selectable power fold back function to prevent the AC power and/or current from exceeding the max ratings as defined in ***REG 40142 – Continuous Volt-Ampere Capability*** and ***REG 40149 – Max RMS AC Current Capability.*** For both cases (power or current limit), the power fold back priority can be set using ***REG 41168 – Power Foldback Mode Select.***

Setting register 41168 = 0 configures proportional fold back. In this case, both the real and reactive power (or current) are reduced proportionally to meet the max rating. Operating in this mode will maintain the desired power factor at the expense of reducing both the real and reactive power.

Setting register 41168 = 1 provides real power priority, reducing the reactive power to meet the max rating. Setting register 41168 = 2 provides reactive power priority, reducing the real power to meet the max

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rating. In both cases, if the lower priority setpoint is reduced to zero, the higher priority setpoint will then begin folding back as well.

Anti-Island Detection

While online and operating in Grid Tie mode, each PCS provides independent anti-islanding protection by monitoring the grid voltage and frequency for instability. Islanding can occur when a distributed generation source continues to energize a portion of the utility grid (the island) after the utility has stopped providing power.

The PCS provides two methods of detecting island conditions. The first is a ***passive*** detection mechanism that relies on the measured AC line values and does not disturb the output. This method generally detects island conditions quickly, on the order of 10's of milliseconds. One drawback to this method is that it isn't guaranteed to detect island conditions when the PCS power output is very closely matched to the local loads, usually within ±5%.

The second method is an ***active*** detection mechanism that uses very small perturbations to the output. The detection time for this method is longer than the ***passive*** method (100's of milliseconds instead of 10's of milliseconds), however it can detect an island condition even when the PCS power output is very closely matched to the load conditions.

Anti-Islanding can be enabled or disabled and the selection of one or both detection methods can be configured using ***REG 41236 – Anti-Island Detector Enable.*** The PCS behavior when an island is detected can be configured using ***REG 41237 – Anti-Island Detector Mode Select.***

Grid Fault Ride Through

The PCS provides highly configurable grid fault ride through functionality to individually address low and high frequency ride through (LFRT, HFRT) conditions as well as low and high voltage ride through (LVRT, HVRT) scenarios. For each condition, two curves can be defined by the user; one representing the "must trip" criteria and one representing the "momentary cessation" criteria.

Figure 26 below shows a generic example of the trip and cessation curves. If the grid voltage/frequency exceeds the inner-most trip thresholds but has not yet exceeded the specified cessation or trip durations, i.e.,, crosses from the green region into the orange region, the PCS will continue to operate normally but will transition to the ***Ride Through Active*** state to indicate that a ride through event has been triggered and is currently being timed. If the voltage/frequency exceeds the "momentary cessation" curve's threshold and duration (shown with blue lines), i.e., crosses the blue line into the yellow region, the PCS will remain connected to the grid but will stop processing power and will transition to the ***Ride Through Passive*** state. If the voltage/frequency returns to near nominal levels, i.e., crosses back over the blue line from the yellow region, the PCS will go back to processing power per the user setpoints, returning to the ***Ride Through Active*** state.

If the voltage/frequency exceeds the "must trip" curve's threshold and duration (shown with red lines), i.e., crosses the red line into the pink region, the PCS will trip off and go to the ***Offline*** state, or immediately go to the ***Fault*** state if ***REG 41344 – Auto-Resume Timeout*** is set to zero.

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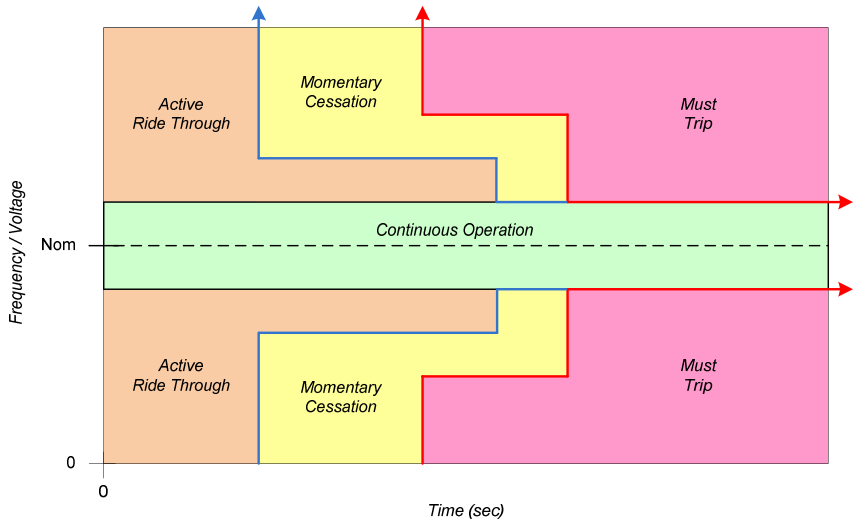

Figure 26 - Ride Through Cessation and Trip Curves

Note: The “momentary cessation” and “must trip” curves are independently programmable. For this reason, the “must trip” curve will always take priority over the “momentary cessation” curve if the curves (blue and red lines) intersect.

NOTE: The “momentary cessation” and “must trip” curves are independently programmable. For this reason, the “must trip” curve will always take priority over the “momentary cessation” curve if the curves (blue and red lines) intersect.

Low/High Voltage Ride Through

The Low/High Voltage Ride Through (L/HVRT) “trip” curves are implemented using configurable arrays of X-Y points to allow the user to define multiple voltage/duration boundary conditions. Two different trip curves are defined, one for low voltage trips and one for high voltage trips. These curves are defined using the registers found in the SunSpec “Must Disconnect” Models 129 and 130, respectively. These models provide up to 20 points to create the curve. It is not required that all 20 points be defined and used - a separate register is used to specify the actual number of points defined in the array

Figure 27 illustrates the factory default L/HVRT curves, which are compliant with the CA Rule 21 default values defined in Table 8. LD1. LD7 represent the points in the low voltage trip array defined in Model 129, whereas HD1..HD4 represent the points in the high voltage trip array defined in Model 130. Note that the first line segment is extended horizontally to the left or vertically based on the slope of the first pair of points, and that the curve after the last point is always extended horizontally to the right.

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Table 8 - CA Rule 21 Default L/HVRT Settings

Region	Voltage (%)	Ride Through Until (s)	Operating Mode	Max Trip Time
HV2	> 120	0	n/a	100ms
HV1	> 110	12	Momentary Cessation	100ms
Normal	88 ≤ V ≤ 110	Indefinite	Continuous Operation	n/a
LV1	< 88	20	Mandatory Operation	100ms
LV2	< 70	10	Mandatory Operation	100ms
LV3	< 50	1	Momentary Cessation	100ms

⚠ CAUTION ⚠

The points in the voltage trip curve arrays must adhere to the following rules. Failure to meet these restrictions will result in an ***Invalid User Configuration*** fault. The offending table is reported in ***REG 41131 – User Configuration Error Status.***

- Line segments are defined by two adjacent points and must be either horizontal or vertical (i.e., the duration or voltage value must be the same for any two adjacent points) – ramped segments are not supported
- A curve must contain at least one line segment (i.e., two points minimum)
- The duration value for each point must be equal to or longer than the previous point
- The voltage value for each point must be equal to the previous point or closer to the nominal voltage than the previous point

The Low/High Voltage Ride Through (L/HVRT) “momentary cessation” curves are defined using the exact same point definitions and programming requirements as the “trip” curves described above, with each curve supporting up to 20 points. These curves are implemented using the registers found in the SunSpec “Extended Curve” Models 139 and 140, respectively. Note that CA Rule 21 requires “momentary cessation” for High Voltage Region 1, and for Low Voltage Region 3. For these cases, a single line segment (i.e., 2 points) is sufficient to meet this requirement as shown by the blue points in Figure 27 below.

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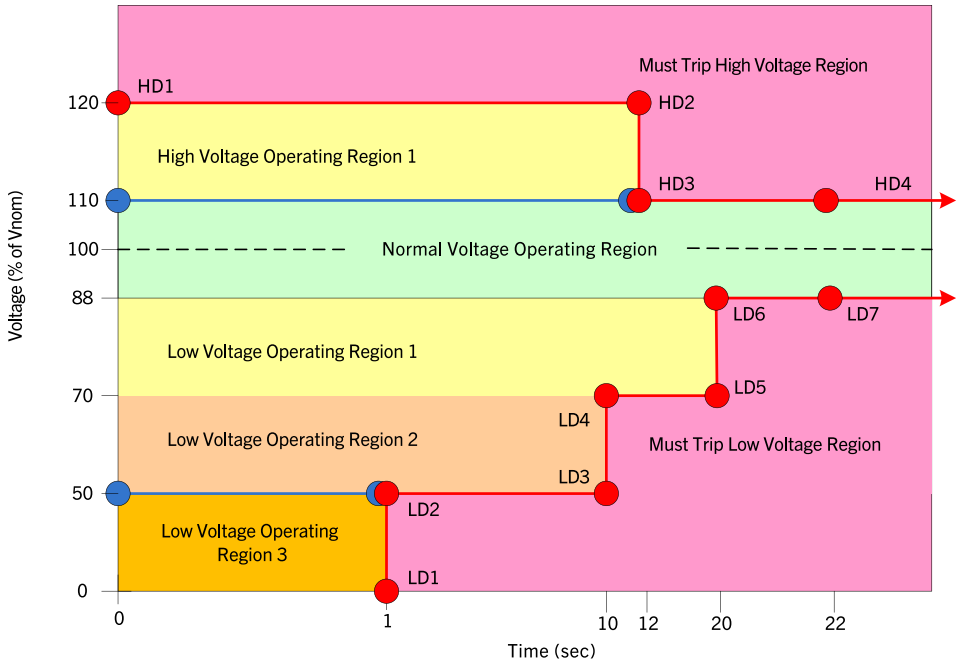

Figure 27 - Voltage Ride Through CA Rule 21 Configuration

For the High Voltage Ride Through "momentary cessation" curve, any voltage threshold set above the Maximum Active Ride Through V MAX (see Electrical Specifications) will be forced to this value and the "HVRT Active Override" warning bit will be set in ***REG 40131 – PCS Warnings.*** Similarly, if the High Voltage Ride Through Momentary Cessation function is not enabled, then a default curve with a threshold set to the Maximum Active Ride Through Voltage and a duration of zero will be used and the "HVRT Active Override" warning bit will be set. If in this case it is undesirable for the PCS to operate with momentary cessation under high line voltage conditions, then the user should configure the High Voltage Trip function with an immediate trip threshold at the Maximum Active Ride Through Voltage threshold.

For the "trip" curves, if a valid curve has not been selected or enabled, or if there is an error in the selected curve points, the ***Default Grid High/Low Voltage Threshold*** registers ***(REG 41169/41170)*** will be used to define the immediate disconnect threshold.

REG 41240 – AC Connection Type is used to determine which AC voltages are monitored. When this register is set for a four-wire interface, all three line-to-line voltages are monitored as well as the three individual line-to-neutral voltages. When this register is set for a three-wire interface, only the three line-to-line voltages are monitored.

Low/High Frequency Ride Through

The Low/High Frequency Ride Through (L/HFRT) "trip" curves are implemented using configurable arrays of X-Y points to allow the user to define multiple frequency/duration boundary conditions. Two different trip curves are defined, one for low frequency trips and one for high frequency trips. These curves are defined using the registers found in the SunSpec "Frequency Ride Through" Models 135 and 136, respectively.

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These models provide up to 20 points to create the curve. It is not required that all 20 points be defined and used - a separate register is used to specify the actual number of points defined in the array.

Figure 28 illustrates the factory default L/HFRT curves, which are compliant with the CA Rule 21 default values defined in Table 9. LD1.. LD4 represent the points in the low frequency trip array defined in Model 135, whereas HD1..HD4 represent the points in the high frequency trip array defined in Model 136. Note that the first line segment is extended horizontally to the left or vertically based on the slope of the first pair of points, and that the curve after the last point is always extended horizontally to the right.

Table 9 - CA Rule 21 Default L/HFRT Settings

Region	Frequency (Hz)	Ride Through Until (s)	Operating Mode	Max Trip Time
HF2	> 62.0	0	n/a	100ms
HF1	> 60.5	299	Mandatory Operation	100ms
Normal	58.5 ≤ f ≤ 60.5	Indefinite	Continuous Operation	n/a
LF1	< 58.5	299	Mandatory Operation	100ms
LF2	< 57.0	0	n/a	100ms

⚠ CAUTION ⚠

The points in the voltage trip curve arrays must adhere to the following rules. Failure to meet these restrictions will result in an ***Invalid User Configuration*** fault. The offending table is reported in ***REG 41131 – User Configuration Error Status.***

- Line segments are defined by two adjacent points and must be either horizontal or vertical (i.e., the duration or voltage value must be the same for any two adjacent points) – ramped segments are not supported
- A curve must contain at least one line segment (i.e., two points minimum)
- The duration value for each point must be equal to or longer than the previous point
- The voltage value for each point must be equal to the previous point or closer to the nominal voltage than the previous point

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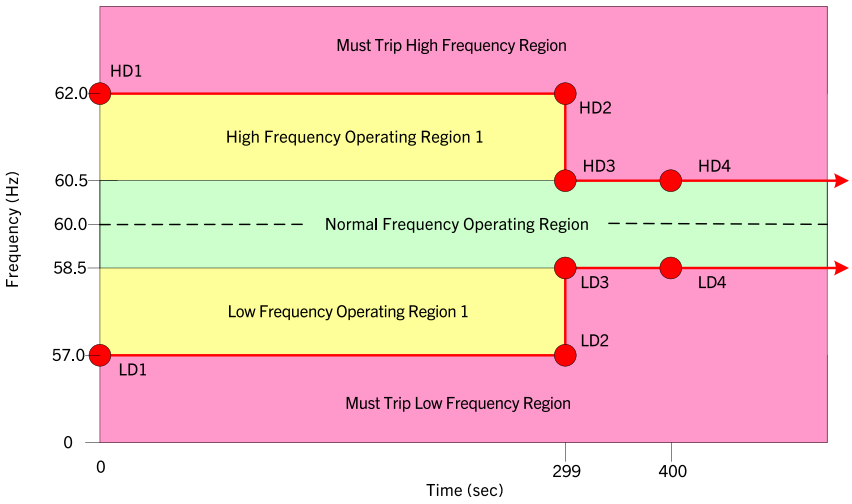

Figure 28 - Frequency Ride Through CA Rule 21 Configuration

The Low/High Frequency Ride Through (L/HFRT) “momentary cessation” curves are defined using the exact same point definitions and programming requirements as the “trip” curves described above, with each curve supporting up to 20 points. These curves are implemented using the registers found in the SunSpec “Extended Curve” Models 143 and 144. Note that by default, “momentary cessation” is not required for CA Rule 21, so no points are shown in Figure 28 above and these curves are disabled by default.

For the “trip” curves, if a valid curve has not been selected or enabled, or if there is an error in the selected curve points, the ***Default Grid High/Low Frequency Threshold*** registers (***REG 41171/41172***) will be used to define the immediate disconnect threshold. For the “momentary cessation” curves, if a valid curve has not been selected or enabled, the cessation feature will not be used and the PCS will remain enabled and active during any “trip” ride through events.

Grid Forming (Island) Operating Mode

When configured for Grid Forming (Island) mode (see ***REG 41167*** and ***REG 41144***), the PCS operates as an AC voltage source that is capable of running in parallel with other voltage sources, such as diesel generators, wind turbines, or other grid forming PCS’s. For systems requiring both grid tie as well as Island mode operation, the PCS relies on an external static transfer switch (STS) to isolate the micro-grid from the utility in the case of grid faults and to reconnect seamlessly to the grid when the faults are cleared. Local loads are connected to the micro-grid side of the switch such that they can remain powered by the island during a grid fault.

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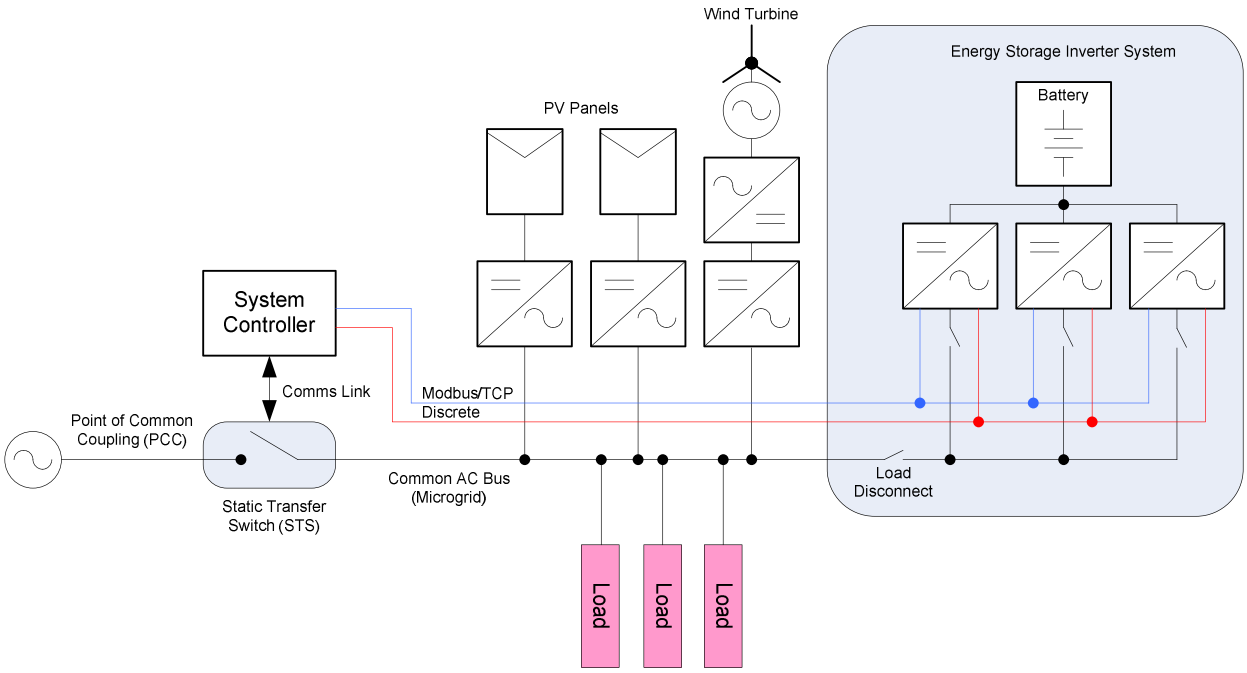

Figure 29 - Island Mode Capable System Block Diagram

When operating in Grid Forming mode, the PCS accepts voltage and frequency commands from the user. ***REG 42795 – Grid Form Voltage Command*** sets the nominal voltage of the Island and ***REG 42796 – Grid Form Frequency Command*** sets the nominal frequency. When the PCS is first powered on, or any time the PCS mode is changed from Grid Tie to Grid Forming, these registers are initialized with the values from ***REG 40168 – Voltage at the PCC*** and ***REG 40185 – Nominal Frequency at the ECP,*** respectively. The user may subsequently change the nominal island voltage or frequency using these command registers.

Droop controllers are used to regulate the exchange of active and reactive power with the Island or "micro-grid" in order to keep the frequency and amplitude under control. Droop methods are based on the self-regulation capability of the synchronous generator in gridconnection mode, in which the impedance between the generators and the grid is considered inductive, decreasing the delivered active power when the grid frequency increases and decreasing the injected reactive power when the grid voltage amplitude increases.

By default, the droop controllers operate with zero active and reactive power when the grid frequency and voltage are equal to their commanded setpoints. The PCS also provides two offset registers, ***REG 42797 – Grid Form Real Power Offset*** and ***REG 42798 – Grid Form Reactive Power Offset*** that allow the user to offset these zero bias points. These registers default to the values defined in ***REG 42805 – Grid Form Real Power Offset Turn-On Default*** and ***REG 42808 – Grid Form Reactive Power Offset Turn-On Default*** any time the PCS is being turned on in grid forming mode. These values are typically set to zero. However, the user can change the offsets as needed, for instance to offset the power drawn from one bank of batteries compared to the others, or to force power into one bank for charging purposes.

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Initiating Grid Forming Operation

Similar to Grid Tie operation, when first powered up in Grid Forming mode, the PCS's internal DC and AC contactors are both open. Prior to operating the PCS, it must first be commanded to close these contactors by first writing a "1" to ***REG 40247*** – ***Connection Control*** followed by writing a "1" to ***REG 41123*** – ***Set Operation.*** The PCS response to these commands depends on the state of the AC voltage sensed at the PCS terminals.

If a valid microgrid is already present (determined by ***REG 42826*** – ***42829)***, i.e., powered by some other resource, then the PCS will perform a similar internal pre-charge process as Grid Tie mode and will then close the DC and AC contactors and go to the ***Standby*** state. At this point the PCS can be turned on by writing a "4" to ***REG 41123*** – ***Set Operation.*** The PCS will then begin operating in Grid Forming mode using the voltage and frequency sensed at the AC terminals, and then ramp to the user's commanded setpoints ***(REG 42795 - 42796)*** using the ramp rates configured in ***REG 42801 & 42804.***

If no AC voltage is present (must be below 10 VRMS line-to-line), the microgrid must be black started by the PCS. In this case, the PCS will first perform the internal DC pre-charge process and will then close DC and AC contactors and go to the ***Standby*** state. When the PCS is then turned on by writing a "4" to ***REG 41123,*** it will begin ramping the voltage to the user's commanded setpoints ***(REG 42795 - 42796)*** at the rate specified in ***REG 42812*** – ***Grid Form Startup Voltage Slew Rate.***

If the PCS is commanded to "connect" but the sensed AC voltage is above the maximum black start voltage (10 V RMS) and a valid microgrid is not present ***(REG 42801 & 42804),*** then the PCS will go to the ***Charge Wait*** state and wait for one of these two conditions to be true. Similarly, if the PCS has already connected and is in the ***Standby*** state (i.e., not yet turned on), and the microgrid is no longer valid or the sensed voltage rises above the maximum black start voltage, the PCS will open both contactors and go to the ***Charge Wait*** state.

Once the PCS is on and operating in Grid Forming mode, any changes to the user's commanded voltage or frequency setpoints ***(REG 42795 - 42796)*** will cause the PCS to ramp to the new setpoints at the ramp rates configured in ***REG 42801 & 42804.***

When the PCS is turned on into an existing microgrid in either Grid Tie mode or in Grid Forming, it will sense the present phase rotation of the AC voltage and store this in a non-volatile register. Any time the PCS is black started in Grid Forming mode, it will turn on and operate with the phase rotation stored from the last time the PCS was operated. For systems that are intended to operate in both Grid Tie and Grid Forming modes and are sensitive to phase rotation, the operator should first start the PCS in Grid Tie mode (i.e., synchronized to an existing AC voltage) to set the intended phase rotation and ensure that this is used the first time the PCS is black started in Grid Forming mode.

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Parallel Black Start

The local microgrid can be black started by multiple PCS units operating in parallel. To do so, they all need to be started at the exact same point in time. In order to meet this requirement, all PCS units must be tied to the same physical RS-485 serial bus, and the dedicated Modbus broadcast device address of zero must be used when turning the PCS on (writing a "4" to ***REG 41123 – Set Operation).***

It is recommended that ***REG 42812 – Grid Form Startup Voltage Slew Rate*** be configured for the default slew rate or slower when black starting multiple PCS's at the same time. Otherwise, slight voltage mismatches when ramping at extremely fast rates can cause noticeable currents to circulate between units. These currents will not cause harm to the PCS, but when combined with local loads at startup, this could cause nuisance over-current trips and failure to reliably black start the microgrid.

Parallel black start is not possible if all PCS units cannot be attached to the same physical RS

485 serial bus. In this case, black starting the microgrid is still possible, but requires a manual black start process by the operator. In this scenario, a single PCS must first be black started by itself. If the local loads are greater than the power ratings of a single unit, they must be disconnected from the PCS's during the manual black start procedure. Once the first unit has finished black starting and the local voltage has been established, the remaining PCS units will synchronize to the first unit and may then be individually turned on. Once all units are operating, the local loads may then be attached.

Microgrid Monitoring

When operating in a true microgrid with other distributed sources, the local voltage and frequency will vary based on factors such as the load conditions and the differences in power ratings, voltage/frequency references, droop gains, and impedances (real or virtual) between sources, etc. For a properly architected system that takes all of these into account, it should be possible to confine the overall acceptable range of operating voltage and frequency of the microgrid. The PCS provides a means to monitor the microgrid voltage and frequency and detect cases where they move outside the expected operating range. If the microgrid moves outside of the range specified by ***REG 42814/42815 – Grid Form Maximum/Minimum Operating Voltage*** or ***REG 42816/42817 – Grid Form Maximum/Minimum Operating Frequency,*** the PCS will turn off and transition to the Offline state. It will remain in this state until the microgrid returns to acceptable levels (determined by ***REG 42826 – 42829)*** or the user manually disables the PCS and attempts to restart the microgrid. In systems where the PCS(s) is the only source of power for the local microgrid, the latter will be necessary in order to bring the microgrid back up.

Single Unit Standalone Operation

For systems which use a single PCS as the only source of the local AC voltage, it is recommended that droop control and virtual impedance are turned off. By doing so, the PCS will act as an AC power supply, regulating the output voltage and frequency to the commanded setpoints without any additional droop due to load conditions. This can be done by setting the following configuration registers to zero:

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- ***REG 42819 – Grid Form Droop V/Q Proportional Gain***
- ***REG 42821 – Grid Form Droop W/P Proportional Gain***
- ***REG 42822 – Grid Form Virtual Inductance***
- ***REG 42824 – Grid Form Virtual Resistance***

For systems where multiple PCS units are operated in parallel, or in conjunction with other distributed sources, Trystar recommends using the default droop gains and virtual impedances. If necessary, contact Trystar technical support to discuss systems that require changes from these default settings.

Changing Operating Modes

The PCS operating mode may be manually changed from Grid Tie to Grid Forming (and vice versa) using ***REG 41144 – PCS Control Mode.*** When using this register to change operating modes, the PCS must first be disabled. Otherwise, any attempt to change modes by writing to this register while the PCS is operating will be ignored.

The operating mode can also be controlled by using the optional Island Control digital input pin (DIN) - see Low Voltage I/O, on page 23 for details on pin location and electrical requirements. ***REG 42813 – Island Control Input Pin Configuration*** is used to enable this pin, configure the input polarity as active high or active low, and to select Passive or Seamless mode changes as described below. When the Island Control pin is enabled, attempts to change the mode by writing to ***REG 41144 – PCS Control Mode*** will be ignored. However, this register may be read to indicate the present operating mode as determined by the hardware pin.

Passive Mode Changes

When configured for Passive mode changes, the state of the Island Control input pin is used to determine the mode based on the selected pin polarity. When this input pin changes state, the PCS is automatically turned off and transitioned to the ***Disabled*** state. Once in the ***Disabled*** state, the PCS will set ***REG 41144 – PCS Control Mode*** to the newly selected operating mode. At this point the user can then enable PCS operation as described on pages 29 and 42.

This mode may be useful for systems where an external resource is used to indicate that a mode change is necessary and to quickly disable all PCS's at the same time, but where additional action must be taken by the local system controller prior to re-enabling the PCS's in the new mode.

Seamless Mode Changes

When configured for Seamless mode changes, the Island Control input pin is used to seamlessly transition between Grid Tie and Grid Forming modes while the PCS is operating. In this configuration, an external utility interconnection relay is used to monitor the grid connection and to quickly disconnect the local microgrid under abnormal grid conditions and at the same time change the PCS operating mode to Grid Forming. The PCS remains enabled and continues to process power during this mode change. This same device is also used to determine when the grid has returned, and if it is safe to reconnect the local microgrid based on the voltage, frequency, and phase difference between the two being within specified tolerances. If so, it will then close the main grid interface

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contactor and automatically change the PCS operating mode back to Grid Tie.damage.

See Trystar Application Note **AN-0003** *"PCS-RS40 Seamless Transfer System Configuration"* for an example system which implements seamless transfers, along with details on configuring the various PCS support registers and real-world test data.

Reconnect/Resume Behavior

The behavior of the PCS when recovering from a frequency or voltage trip condition is highly configurable. The reconnection behavior is classified as either a "short- term" or "long-term" disturbance recovery. If the length of the disturbance is less than or equal to ***REG 41337 – Short Trip Time Duration*** the "Short" recovery configuration parameters apply, otherwise the "Long" parameters are used.

Figure 30 illustrates a disturbance and recovery event. When the voltage and/or frequency return to values between the maximum and minimum reconnect parameters ***(REG 41331 – 41334*** for Grid Tie operation, ***REG 42826-42829*** for Grid Forming operation), the PCS will wait for the applicable Short or Long delay time, ***REG 41338 or 41341***, depending on the length of the disturbance. Following this fixed delay time, an additional, random delay time can also be configured. The Short or Long random delay is configured by ***REG 41339 or 41342 - Short(Long) Event Resume Turn-On Window.*** This parameter specifies the length of the time window in which the PCS will randomly re-enable the output. Once enabled, if operating in Grid Tie mode, the output will slew to the set point based on the ***REG 41340 or 41343 - Short(Long) Event Resume Turn-On Ramp Time,*** which specifies the time to reach 100% capability defined by ***REG 40167 - Maximum Output Power.*** When resuming in Grid Forming mode, the PCS will immediately return to regulating the island voltage and frequency using the corresponding droop controllers.

During the period TGRID_OOT , the warning bit "Resume – Grid OOT" will be set. During TDELAY , the warning bit "Resume – Delay" will be set. Both bits can be found in ***REG 40131 – PCS Warnings.***

If TGRID_OOT exceeds ***REG 41344 – Auto-Resume Timeout***, the PCS will disable itself and transition to the Fault state. Setting the Auto-Resume Timeout = 0 disables the auto-resume feature, the PCS will immediately disable itself and transition to the ***Fault*** state.

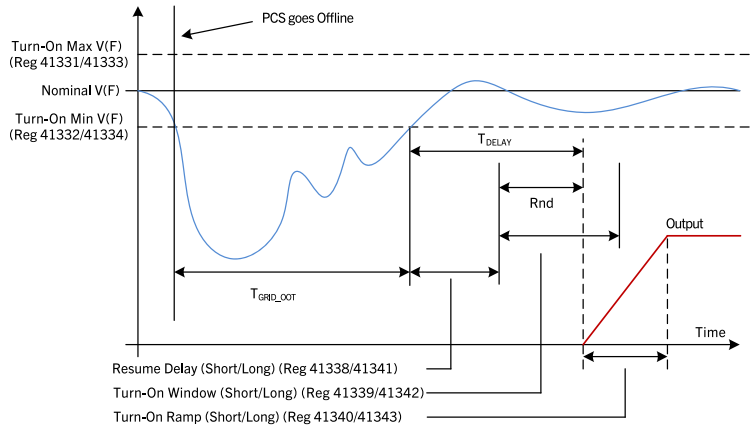

Figure 30 - Reconnect/Resume Behavior

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Operating States

A state machine is used to provide deterministic control and sequencing of the PCS hardware. Figure 31 illustrates the operating states as well as the transition logic employed in the system state machine. Each state is described in further detail below. As Figure 31 illustrates, the PCS is disabled and the power stage hardware will be inoperable until the PCS reaches the ***Standby*** state. Any attempts to turn the PCS on with ***REG 41123 – Set Operation*** will be ignored until the PCS reaches the ***Standby*** state.

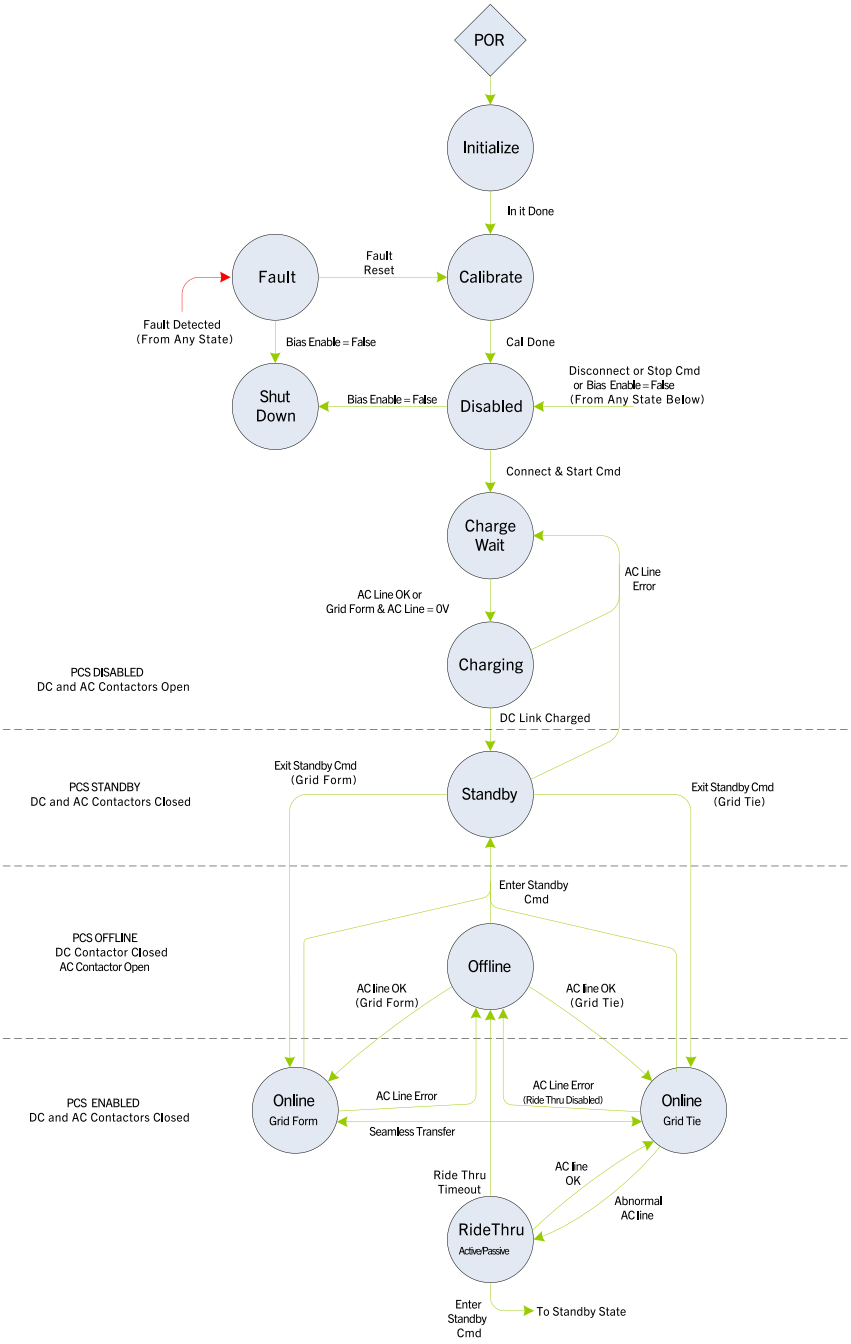

Figure 31 - PCS Control State Machine

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Initialize

The state machine resets to the ***Initialize*** state following a power-on-reset (POR) event. The firmware is initializing hardware peripherals, configuring variables, and performing self-health tests while in this state. Upon successful initialization, the PCS will auto-transition to the ***Calibrate*** state.

Calibrate

The ***Calibrate*** state is used to perform calibration of internal sensors and inputs. Following successful calibration, the PCS will auto-transition to the ***Disabled*** state.

Disabled

When in the ***Disabled*** state, both the DC input contactor and AC output contactor are open and all power devices are off. The PCS will transition to the ***Charge Wait*** state after receiving a "Start" command, ***REG 41123*** – ***Set Operation*** = ***1,*** if the following conditions are met:

1. Main E-Stop input is not active
2. ***REG 40247*** – ***Connection Control*** = Connect (1)

As the state diagram above indicates, once the PCS has been started and has proceeded past this state, a "Stop" command, ***REG 41123*** – ***Set Operation*** = ***2,*** a "Disconnect" command, ***REG 40247*** – ***Connection Control*** = ***0,*** or disabling the Bias Enable input pin will force the PCS to cease operation, open the input and output contactors, and transition back to this state.

Charge Wait

In the ***Charge Wait*** state, the PCS will monitor the AC line terminals. When a valid AC line connection is detected, based on resume voltage and frequency thresholds, ***REG 41331*** – ***41334*** for Grid Tie operation, ***REG 42826*** – ***42829*** for Grid Forming operation, the PCS transitions to the ***Charging*** state. Alternatively, if configured for Grid Forming operation and the AC line voltage is less than the maximum black start voltage (10 VRMS line-to-line), the PCS will transition to the ***Charging*** state.

Charging

In the ***Charging*** state, the internal pre-charge circuitry is enabled and the PCS waits until the internal DC link has been sufficiently charged. Once the DC link voltage has reached an acceptable level, the PCS will transition to the ***Standby*** state. During this transition, both the DC input and AC output contactors are closed. If the AC line is no longer valid while in the middle of the pre-charge process, charging will be terminated and the PCS will transition back to the ***Charge Wait*** state.

Standby

Once in the ***Standby*** state the PCS is ready for use. An "Exit Standby" command, ***REG 41123*** – ***Set Operation*** = ***4,*** must be sent to turn on the PCS, at which point it will transition to the ***Online*** – ***Grid Tie*** or ***Online*** – ***Grid Form*** state, depending on the selected operating mode. If the AC line is no longer valid while in the ***Standby*** state, the PCS will open the input and output contactors and transition back to the ***Charge Wait*** state.

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Turn-On Delay

The ***Turn-On Delay*** state is used to indicate when the PCS is about to turn on but is waiting for a configurable delay before operating. This can occur when transitioning from the ***Standby*** state to one of the ***Online*** states if ***REG 41335 – Initial Turn-On Window*** is set to a value other than zero (except when black starting in Grid Forming mode). This can also occur when resuming operation from the ***Offline*** state to one of the ***Online*** states if any of the Short or Long Resume Delay or Turn-On Window registers are set to a non-zero value ***(REG 41338, 41339, 41341, 41342).*** Once the configured delay time has expired, the PCS will transition from this state to one of the ***Online*** states based on the configured operating mode. For the sake of simplicity, this state is intentionally not shown in the state diagram above.

Online – Grid Tie

While in the ***Online – Grid Tie*** state, the PCS is connected to the grid and operating in Grid Tie mode, controlling the real and reactive grid power. If a fault occurs, the PCS will immediately turn OFF, open the input and output contactors, and transition to the ***Fault*** state.

If an abnormal grid condition is detected, the PCS will transition to either the ***Offline*** or ***Ride Through*** state, depending on configuration. Otherwise, the PCS will remain in this state indefinitely until an "Enter Standby" command is received, ***REG 41123 – Set Operation = 3,*** a "Stop" command is received, ***REG 41123 – Set Operation = 2,*** or a "Disconnect" command, ***REG 40247– Connection Control = 0,*** is received.

The PCS may transition from this state to the ***Online – Grid Form*** state if seamless transfers are enabled and the Island Control input pin has commanded a mode change due to abnormal grid condition – see Seamless Mode Changes on page 44 for more details.

Online – Grid Form

While in the ***Online – Grid Form*** state, the PCS is operating as an AC voltage source and actively regulating the AC output voltage and frequency. If a fault occurs, the PCS will immediately turn OFF, open the input and output contactors, and transition to the ***Fault*** state.

If the AC line falls outside of the voltage and frequency ranges specified in ***REG 42814-42817,*** the PCS will turn OFF, open the AC contactor, and transition to the ***Offline*** state. Otherwise, the PCS will remain in this state indefinitely until an "Enter Standby" command is received, ***REG 41123 – Set Operation = 3,*** a "Stop" command is received, ***REG 41123 – Set Operation = 2,*** or a "Disconnect" command, ***REG 40247– Connection Control = 0,*** is received.

The PCS may transition from this state to the ***Online – Grid Tie*** state if seamless transfers are enabled and the Island Control input pin has commanded a mode change due to the utility grid returning to acceptable conditions – see page 44 for more details.

Offline

While in the ***Offline*** state, the PCS has stopped processing power and the AC contactor is open. The PCS will monitor AC line conditions, and upon restoration, based on resume voltage and frequency thresholds

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(***REG 41331*** – ***41334*** for Grid Tie operation, ***REG 42826*** – ***42829*** for Grid Forming operation), reconnect and sequence back to one of the ***Online*** states based on the selected operating mode.

Otherwise, the PCS will remain in this state until an "Enter Standby" command is received, ***REG 41123*** – ***Set Operation*** = ***3***, a "Stop" command is received, ***REG 41123*** – ***Set Operation*** = ***2,*** a "Disconnect" command ***REG 40247***– ***Connection Control*** = ***0*** is received, the Offline duration exceeds the ***REG 41344*** – ***Auto-Resume Timeout*** period, or a fault occurs.

Ride Through

The ***Ride Through*** state is only possible if the PCS is configured for Grid Tie mode and has detected abnormal grid conditions, namely low or high frequency and/or low or high voltage. The PCS behavior for each of these four conditions is configurable. See Grid Fault Ride Through for configuration details. Note that the reported state will reflect the ride through condition, i.e., ***Ride Through Active*** or ***Ride Through Passive***, as appropriate.

The PCS will remain in the ***Ride Through*** state until grid conditions return to normal and the PCS transitions back to the ***Online*** – ***Grid Tie*** state, or grid fault conditions occur and the PCS transitions to the ***Offline*** state. Otherwise, the PCS will remain in the ***Ride Through*** state unless an "Enter Standby" command, ***REG 41123*** – ***Set Operation*** = ***3,*** a "Stop" command, ***REG 41123*** – ***Set Operation*** = ***2,*** or a "Disconnect" command, ***REG 40247***– ***Connection Control*** = ***0,*** is received.

Turn Off

When the PCS is operating in Grid Tie mode (i.e., in the ***Online*** – ***Grid Tie*** state) and is then turned off, it will transition to this state and begin ramping the AC current to zero at a rate defined in ***REG 41241*** – ***Grid-Tie Turn-Off Current Slew Rate.*** The PCS will remain in this state until the AC current reaches zero. For the sake of simplicity, this state is intentionally not shown in the state diagram above.

Fault

If a fault is detected in any of the operating states, the power stage is immediately turned OFF, the input and output contactors are opened, and the PCS transitions to the ***Fault*** state. The PCS will remain in this state until the latched fault information is explicitly cleared using ***REG 41122*** – ***Fault Reset.*** If any fault conditions still exist when the fault reset occurs, the PCS will remain in the ***Fault*** state. All attempts to enable or turn the PCS on are ignored while in the Fault state.

Shutdown

The ***Shutdown*** state is entered whenever the Bias On/Off discrete input (page 26), is deasserted. While in the ***Shutdown*** state, the PCS performs various housekeeping tasks before finally disabling the bias supply, shutting itself down.

Note that if the PCS happens to be operating, or in any state other than ***Fault*** or ***Disabled*** when the Bias On/Off input is de-asserted, the system will automatically sequence to ***Disabled*** before transitioning to ***Shutdown***.

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FAULT AND WARNING CONDITIONS

The PCS provides warning indicators and fault protection in the event of conditions that may cause damage to the equipment or injure personnel. The following sections describe each of the conditions monitored by the PCS.

Warnings

The PCS provides the warning indicators listed below. These warning flags do not prohibit operation, and will self-clear, requiring no user intervention. They are reported for informational purposes only. Each warning flag described below is reported in ***REG 40131 – PCS Warnings.*** The PCS can also indicate a warning by asserting an isolated output signal. See Outputs on page 27 for details on how to configure the isolated outputs.

High Inverter Current – Phase A, B, C

The PCS monitors the RMS inverter currents for each of the three phases and will set a flag (one per phase) if the current exceeds the threshold specified by ***REG 41268 – AC Over Current Warning Threshold.*** These flags will remain set until the respective current falls below the warning threshold less ***REG 41269 – AC Over Current Warning Recover Delta.***

High Grid Voltage

The PCS monitors the three RMS phase-to-phase AC line voltages and will set a warning flag (one per phase-to-phase voltage) if the voltage exceeds the threshold specified by ***REG 41271 – AC Over Voltage Warning Threshold.*** These flags will remain set until the respective voltage falls below the warning threshold less ***REG 41272 – AC Over Voltage Warning Recover Delta.***

PLL Not Locked

The PCS monitors the status of the internal phase lock loop (PLL) module that provides synchronization to the AC line and will set a warning flag if the PLL is not locked. This flag is cleared when the PLL regains lock.

Loss of Phase

The PCS monitors the zero crossings for each of the three AC line voltages and will set this warning flag any time a zero crossing does not occur on one or more of the three phases within the period specified by ***REG 40185 – Setpoint for Nominal Frequency at the ECP.***

AC Current Limit

The PCS will limit the AC output current to the value specified by ***REG 40149 – Max RMS AC*** Current Capability. When operating in Grid Tie mode, the PCS will actively clamp the AC current to this value and will set this warning bit any time the current is being limited. When operating in Grid Forming mode, dynamic virtual impedance is used to attempt to limit the output current, and this warning bit will be set to indicate that this virtual impedance is being used.

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DC Power Limit

At lower DC input voltages, the power capability of the PCS is limited by the ***Maximum DC Charge/Discharge Current*** ratings, ***REG 41238-41239.*** When operating in Grid Tie mode under these conditions the PCS actively limits the real AC power to keep from exceeding the DC current rating, and this bit is set. The bit is cleared when the AC power is no longer limited.

When operating in Grid Forming mode, this warning bit is set any time the available DC power is less than the rated power, indicating that the PCS may not be able to operate under maximum rated load conditions.

AC Power Limit

This bit is set when operating in Grid Tie mode and the combined real and reactive power commands exceed the continuous volt-ampere capability ***(REG 40142).*** Under these conditions, the PCS will actively limit the power using the priority scheme configured in ***REG 41168 – Power Foldback Mode Select.***

This bit is also set when operating in Power Factor Mode ***(REG 40257 – Power Factor Setpoint – Enable/Disable*** = 1) and the calculated reactive power command exceeds the maximum reactive power setpoint configured in ***REG 40173 – 40176.***

AC Current Overload

Regardless of operating mode (Grid Tie or Grid Forming), the PCS attempts to avoid overcurrent trip events by employing a cycle-by-cycle current limiting technique that turns off the inverter's switching outputs on a per-PWM period basis whenever the AC phase currents exceed the hardware capability. This warning bit will be set and remain on for roughly 1 second any time one of these fast limit events occur. This feature is meant to avoid tripping due to very fast load transient events, i.e., for only a few line cycles. Overload events that persist for several line cycles or longer will result in hardware over-current faults and will cause the PCS to immediately turn off, disconnect, and transition to the ***Fault*** state.

Resume – Grid OOT

This bit is set whenever the PCS is offline due to the grid being out of tolerance, T_{GRID_OOT} , as defined in Reconnect/Resume Behavior, page 45.

Resume – Delay

This bit is set during the resume time delay, T_{DELAY}, of a PCS reconnection attempt, as defined in Reconnect/Resume Behavior, on page 45.

Island Detected

This bit is set when an Island is detected and ***REG 41237 – Anti-Island Detector Mode Select*** is set to 1 = *"Enabled – Keep Running on Island Detect" or 3 = "Auto Resume".*

High DC/DC Input Current

The PCS monitors the DC/DC Converter input current and will set a flag if the current exceeds the threshold specified by ***REG 41295 – DC Over Current Warning Threshold.*** This flag will remain set until the DC current falls below the warning threshold less ***REG 41296 – DC Over Current Warning Recover Delta.***

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High DC/DC Temperature

This flag is set if the DC/DC temperature measurement exceeds a factory configured threshold (approximately 80 °C). This threshold is not user configurable.

High Inverter Temperature

This flag is set if the inverter temperature measurement exceeds a factory configured threshold (approximately 80 °C). This threshold is not user configurable.

High Ambient Temperature

The PCS measures the air temperature inside the enclosure and sets this flag if it exceeds a factory configured threshold (approximately 55 °C). This threshold is not user configurable.

Low Input Voltage

The PCS monitors the DC input and will set a flag if the voltage falls below the threshold specified by ***REG 41274 – DC Under Voltage Warning Threshold.*** The flag will remain set until the voltage rises above the warning threshold plus ***REG 41275 – DC Under Voltage Warning Recover Delta.***

High Input Voltage

The PCS monitors the DC input and will set a flag if the voltage exceeds the threshold specified by ***REG 41277 – DC Over Voltage Warning Threshold.*** The flag will remain set until the voltage falls below the warning threshold less ***REG 41278 – DC Over Voltage Warning Recover Delta.***

Fan Not Spinning 1,2,3

The PCS monitors tachometer feedback from the three cooling fans and will set the respective warning bit if the fan speed is below a factory configured threshold. These bits will remain set, even after the fans have been turned off. Only the successful operation of the fans will clear these bits. These thresholds are not user configurable.

HVRT Active Override

The PCS can only provide active ride through capability if the line voltage is below the “Active Ride Through V MAX” specification. If the user configures one of the High Voltage Ride Through Momentary Cessation regions with a voltage that exceeds the “Maximum Active Ride Through Voltage” specification, the voltage threshold for that region of the curve will be forced to the maximum allowable value and this warning bit is set. Similarly, if the High Voltage Ride Through Momentary Cessation function is not enabled, then a default curve with a threshold set to the “Maximum Active Ride Through Voltage” and a duration of zero will be used and this bit will be set.

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TVS Error

The PCS uses an AC filter when connected to the AC line voltage. This filter contains transient voltage suppression (TVS) devices to protect the supply from voltage spikes that may occur on the AC terminals. The PCS monitors the health of these TVS devices to ensure that they are still working properly. This warning bit will be set and remain latched if one or more of the TVS devices appear to be damaged. This bit may only be cleared by cycling the PCS bias power.

Volt-VAR Active

This warning flag is asserted any time the Volt-VAR grid support function is enabled and is presently forcing a non-zero reactive power command due to a grid over or under-voltage condition.

Volt-Watt Active

This warning flag is asserted any time the Volt-Watt grid support function is enabled and is presently clamping the user's real power command due to a grid over or under-voltage condition.

Frequency-Watt Active

This warning flag is asserted any time the Frequency-Watt grid support function is enabled and is presently clamping the user's real power command due to a grid over or under-frequency condition.

AC/DC Contactor Open

These warning flags are asserted any time the corresponding contactor is open.

Faults

The PCS provides the fault detection listed below. Whenever a fault occurs the PCS will automatically turn the power stage hardware OFF, open both input and output contactors, and transition to the ***Fault*** state. Any attempt to turn the PCS ON while it is in the ***Fault*** state will be ignored.

Each fault condition is latched and reported in ***REG 40129 – PCS Fault Status.*** The PCS can also indicate the presence of a fault condition by asserting an isolated output signal any time one or more latched fault bits are present. See Outputs on page 27 for details on how to configure the isolated outputs.

The PCS will remain in the ***Fault*** state and any latched fault flags remain set until explicitly cleared using ***REG 41122 – Fault Reset.*** Upon receiving the fault reset command, the PCS will attempt to clear all latched fault bits. If the faults are successfully cleared, the PCS will transition back to the ***Calibrate*** state and then to the ***Disabled*** state. If any faults fail to clear, the respective fault bits will remain latched, and the PCS will remain in the ***Fault*** state.

H/W and S/W Inverter Over-Current A, B, C

The PCS provides fast hardware protection for inverter over current conditions. It also monitors the RMS inverter currents for each of the three phases and will fault if any of the currents exceed the threshold specified by ***REG 41267 – AC Over Current Fault Threshold.***

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When operating in Grid Tie mode, the RMS over-current fault occurs immediately whenever the threshold is exceeded. When operating in Grid Forming mode, the RMS over-current event is timer-based and this fault will occur if the current exceeds the threshold for more than 5 seconds.

AC Over-Voltage AB, BC, CA

The PCS monitors the AC RMS line-to-line voltage for phases AB, BC, and CA, and will fault if any of the voltages exceed the threshold specified by ***REG 41270 – AC Over Voltage Fault Threshold*** while the AC contactor is closed.

Ride Through – Low/High Voltage, Low/High Frequency

When operating in Grid Tie mode and a trip condition occurs following a ride through event, LV(F)RT or HV(F)RT, the PCS will go ***Offline*** and wait for the grid to recover. Once recovered, the PCS will automatically resume operation. ***REG 41344 – Auto-Resume Timeout*** sets the maximum allowable time to wait for the grid to recover. Once this timeout has expired, the PCS will disable itself and transition to the ***Fault*** state. Upon transition, the fault bit corresponding to the ride through event that initiated the PCS going ***Offline*** is set.

Grid Island Condition

This bit is set if an island condition is detected and ***REG 41237 – Anti-Island Detector Mode Selec***t = 2, *"Fault on Island Detect".*

Emergency Stop

The PCS will assert a fault if the ESTOP hardware input is not actively driven.

Communications Heartbeat Fault

The PCS expects the system controller to write to ***REG 41121 – Controller Heartbeat*** once per second with a value equal to the previous value plus '1', or reset back to '0' at any time but not after a previous value of '0'. The PCS will monitor this register and assert the fault if it hasn't incremented by 1, or been reset to zero, within a 2 second period. This heartbeat fault checking is not armed until the first write to ***REG 41121*** occurs following a POR.

Power Down Error

This fault bit is set if the PCS fails to power down when the "Bias On/Off" discrete input is deasserted.

Invalid User Configuration

This bit indicates that the User has set an invalid configuration register or combination of registers. If this bit is set, see ***REG 41131 – User Configuration Error Status (LSW)*** and ***REG 41143 – User Configuration Error Status (MSW)*** to determine the offending register(s).

Invalid Model

This bit is set if the loaded product configuration is not compatible with the PCS Model. Please consult Trystar for the proper configuration file.

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H/W and S/W DC Input Over-Voltage

The PCS provides fast hardware protection for DC input over-voltage conditions. It also monitors the DC input voltage and will fault if it exceeds the threshold specified by ***REG 41276 – DC Over Voltage Fault Threshold.***

DC Input Over-Current

The PCS monitors the DC input current and will fault if it exceeds the threshold specified by ***REG 41294 – DC Over Current Fault Threshold.***

DC Input Under-Voltage

The PCS monitors the DC input voltage and will fault if it falls below the threshold specified by ***REG 41273 – DC Under Voltage Fault Threshold.***

DC Input Under-Voltage

The PCS monitors the DC input voltage and will fault if it falls below the threshold specified by ***REG 41273 – DC Under Voltage Fault Threshold.***

Over Temperature

This bit is set if one or more of the internal temperature sensors in the PCS reaches the associated factory fault threshold. ***REG 41132 – Factory Temperature Error Status*** can be read to determine the source(s) of the over-temperature fault.

Saturation Error A, B, C

These fault bits indicate that the inverter control output for the respective phase has saturated and that the inverter is no longer able to regulate the output.

AC Current Overload Trip

As described in AC Current Overload, page 51, the PCS uses a fast cycle-by-cycle current limiting technique that turns off the inverter's switching outputs on a per-PWM period basis whenever the AC phase currents exceed the hardware capability. This feature is meant to avoid over-current trip events due to very fast load transient events, i.e., for only a few line cycles. Overload events that persist for several line cycles or longer (approximately 100ms) will result in this fault bit being set.

Internal Factory Fault

This bit is set any time one or more internal factory faults occur in the PCS. ***REG 40133 – Factory Fault Status*** can be read to determine the source of the offending fault(s). In general, these factory fault conditions are related to circuitry internal to the PCS and should rarely occur unless there are hardware failures within the PCS or if very abnormal conditions occur outside the PCS. If the PCS is consistently reporting any of these conditions, contact Trystar technical support to discuss the appropriate course of action. Each of the factory faults is briefly described below in order to assist in this discussion.

- ***H/W and S/W DC Over-Current (A/B/C, top/bot)*** – The PCS uses a multi-phase DC/DC converter to boost the DC input voltage up to the desired internal DC link voltage used by the inverter. These fault bits are used to indicate over-current conditions within the DC/DC converter phases.

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- ***DC Current Imbalance (A/B/C)*** —These bits are used to indicate an imbalance condition within the three DC/DC converter phases.
- ***DC Link Over Voltage (H/W top/bot and S/W)*** — The PCS provides hardware-based over voltage protection for each internal DC link voltage (top and bottom), as well as software-based protection for the total combined link voltage. These bits are set any time one of these over voltage conditions occur.
- ***DC Link Voltage Imbalance*** —This fault occurs if the difference between the top and bottom DC Link voltages exceed the maximum imbalance threshold.
- ***Pre-Charge Timeout*** — The PCS contains active circuitry to charge the internal DC link voltage above the DC input voltage prior to closing the DC input contactor (i.e., while the PCS is in the ***Charging*** state). If the DC link voltage fails to charge within the expected timeframe, the pre-charge operation will be terminated, and this fault bit will be set.
- ***Bias Under Voltage*** — The PCS generates its internal control bias supply from the DC input voltage. If this internal bias supply ever drops below the minimum operating voltage, this fault bit will be set.
- ***Contactor Interlock*** — Under normal operating conditions, the internal DC link voltage in the PCS will always be higher than the rectified AC line voltage prior to closing the AC contactor. If the rectified line voltage is higher than the internal link voltage when attempting to close the AC contactor, large inrush currents and/or a DC link over-voltage could occur. The PCS's AC contactor controls will prevent closing the AC contactor under these conditions and will set this fault bit to indicate that this has occurred.
- ***DC/DC Communication Error*** —This fault bit will be set if any internal communications errors occur.
- ***Datalog Error*** — Datalogging information (discussed in Data Logging, page 58) is stored in non-volatile FLASH memory on the PCS controller. This fault bit is set whenever the PCS experiences an error when updating this FLASH memory, indicating possible corruption or loss of datalogging information.
- ***Invalid Factory Configuration*** — The PCS controller uses a non-volatile memory device for storing factory information specific to each unit, such as serial number and model information. This fault bit is set whenever the PCS experiences an error when reading or writing this memory, indicating the possible corruption of the factory information.
- ***Configuration EEPROM Error*** —This fault is fault bit is set whenever the PCS experiences an error when reading or writing configuration memory, indicating the possible corruption of the configuration settings. Note — frequently/cyclically modifying PCS configuration parameters can lead to memory device failure, resulting in this fault

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(see Access Level, page 80, for details on which registers are allowed to be updated frequently/cyclically).

- ***Calibration Error*** – Following a power-on reset, the PCS will perform a self-calibration of various internal sensors. This bit is will be set if the calibration correction for one or more of the sensors exceeds the maximum expected limits, indicating that one or more of the hardware sense circuits may be damaged.

REAL TIME CLOCK (RTC)

The PCS provides a real-time clock (RTC) function to allow recording of elapsed times as well as time stamping data log values.

⚠ CAUTION ⚠

The RTC needs to be set each time the PCS is powered on. Prior to each shutdown, the present time and date is stored in non-volatile memory. Upon a POR, the RTC will resume time/date keeping from this point until it is set by the user. See page 5, for information on setting the date and time.

Real Time Clock – Date Format

The RTC date is stored as a 32-bit data word with the following format:

Bits 31 - 24	Bit 23 – 16	Bit 15 - 14	Bit 13 - 0
Day	Month	n/a	Year

Real Time Clock – Time Format

The RTC clock time is stored as a 32-bit data word with the following format:

Bits 31 - 24	Bit 23 – 16	Bit 15 - 8	Bit 7 - 0
n/a	seconds	minutes	hours

Setting the Date and Time

For synchronization purposes, the data and time must always be set together. ***REG 41525 – RTC Set Date*** must be written to first, followed by a write to ***REG 41527 – RTC Set Time.*** See register details on page 127.

Reading the Date and Time

For synchronization purposes, the data and time must always be read together. ***REG 41529 – RTC Get Date*** must be read first, followed by a read of ***REG 41531 – RTC Get Time.*** See register details on page 127.

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DATA LOGGING

The PCS provides three types of data logging activities as described in the following paragraphs. Event Data Logging captures operating parameters on a fault or user configured trigger event. Fault History Logs provide time stamp and event counters for each fault source. Operating History Logs provide cumulative time spent operating under a variety of conditions as well as min/max values for critical parameters.

Event Data Logging

The Event Data logging feature is intended to capture operating data leading up to, and shortly after an event. Events can be the assertion of a system fault or a user configured “trigger” event.

Table 10 - Data Logging Parameters

Param #	Data Log Buffer Addr	Buffer Offset	Data Type	Parameter	Units
0	41572	0	U16	PCS State	Enum
1	41573-41574	1	U32	PCS Faults	Bitfield
2	41575-41576	3	U32	PCS Warnings	Bitfield
3	41577	5	U16	DC Input Voltage	0.1 V
4	41578	6	S16	DC Input Current	0.1 A
5	41579	7	U16	AC Voltage – Phase AB	0.1 V RMS
6	41580	8	U16	AC Voltage – Phase BC	0.1 V RMS
7	41581	9	U16	AC Voltage – Phase CA	0.1 V RMS
8	41582	10	U16	AC Voltage – Phase A	0.1 V RMS
9	41583	11	U16	AC Voltage – Phase B	0.1 V RMS
10	41584	12	U16	AC Voltage – Phase C	0.1 V RMS
11	41585	13	U16	AC Current – Phase A	0.1 A RMS
12	41586	14	U16	AC Current – Phase B	0.1 A RMS
13	41587	15	U16	AC Current – Phase C	0.1 A RMS
14	41588	16	S16	AC Real Power – P	10 W
15	41589	17	S16	AC Reactive Power – Q	10 VAR
16	41590	18	U16	AC Frequency	0.01 Hz
17	41591	19	S16	AC Power Factor	0.1 %
18	41592	20	S16	DC/DC Module – Temp Phase A	°C
19	41593	21	S16	DC/DC Module – Temp Phase B	°C
20	41594	22	S16	DC/DC Module – Temp Phase C	°C
21	41595	23	S16	Inverter Module – Temp Phase A	°C
22	41596	24	S16	Inverter Module – Temp Phase B	°C
23	41597	25	S16	Inverter Module – Temp Phase C	°C

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Param #	Data Log Buffer Addr	Buffer Offset	Data Type	Parameter	Units
24	41598	26	S16	Enclosure Internal Temp	°C
25	41599	27	S16	Command – Grid Real Power P	10 W
26	41600	28	S16	Command – Grid Reactive Power Q	10 VAR
27	41601	29	S16	Command – Grid Real Current D	0.1 A
28	41602	30	S16	Command – Grid Reactive Current Q	0.1 A
29	41603	31	S16	AC Real Current D	0.1 A
30	41604	32	S16	AC Reactive Current Q	0.1 A
31	41605	33	S16	AC Voltage – D	0.1 A
32	41606	34	S16	AC Voltage – Q	0.1 A
33	41607	35	U16	Inverter Current – Phase A	0.1 A RMS
34	41608	36	U16	Inverter Current – Phase B	0.1 A RMS
35	41609	37	U16	Inverter Current – Phase C	0.1 A RMS
36	41610	38	S16	Inverter Real Current D	0.1 A
37	41611	39	S16	Inverter Reactive Current Q	0.1 A
38	41612	40	S16	Inverter Voltage – D	0.1 V
39	41613	41	S16	Inverter Voltage – Q	0.1 V
40	41614	42	S16	DC Current – Top A	0.1 A
41	41615	43	S16	DC Current – Top B	0.1 A
42	41616	44	S16	DC Current – Top C	0.1 A
43	41617	45	S16	DC Current – Bottom A	0.1 A
44	41618	46	S16	DC Current – Bottom B	0.1 A
45	41619	47	S16	DC Current – Bottom C	0.1 A
46	41620	48	S16	Command – DC Current	0.1 A
47	41621	49	U16	DC Link Voltage	0.1 V
48	41622	50	U16	DC Link Voltage – Top	0.1 V
49	41623	51	U16	DC Link Voltage – Bottom	0.1 V
50	41624	52	U16	Anti-Island Power Adjust	0.01 %
51	41625	53	U16	Bias Voltage	0.01 V
52	41626-41627	54	U32	Factory Faults	Bitfield
53	41628-41629	56	U32	Inverter Warnings	Bitfield
54	41630-41631	58	U32	DC/DC Warnings	Bitfield
55	41632	60	U16	DC/DC State	Enum

Fault Events

The data logging parameters defined in Table 10 are sampled at the factory configured rate defined in ***REG 41533 – Fault Log Sample Period,*** and continuously buffered to RAM. When a fault event occurs, post trigger data is collected, after which the buffer is frozen and written to non-volatile memory. The PCS can store up to 12 buffers. The buffers are circular, such that a new fault event will cause the oldest buffer to be overwritten with the new data.

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To read the fault logs, the user should first read ***REG 41534 – Fault Log - # of Available Logs*** to determine how many logs contain valid data. Assuming one or more logs are valid, the user would then select the desired log to be read by writing to ***REG 41537 – Fault Log - Select Log.*** Note that this register is 0 based, where 0 corresponds to the oldest fault event and 11 to the newest. For example, if ***REG 41534*** = 4, there are 4 available logs; to read the oldest set ***REG 41537*** = ***0.***

Once the desired log has been selected, the header information can be read by writing a "1" to ***REG 41538 – Fault Log – Get Header,*** followed by a read of ***Data Log Buffer Registers 41572 – 41579.*** Table 11 defines the header data and format as read from the Data log buffer registers along with example data.

Table 11 - Fault Log Header Data Description

Data Log Read Buffer Address	Header Data Description	Example	Notes
41572	Time Stamp (MSW)	0x0000	e.g. = 1:48pm, see Real Time Clock – Time Format for details.
41573	Time Stamp (LSW)	0x300D	
41574	Date Stamp (MSW)	0x1503	e.g. = 3/21/2017, see Real Time Clock – Date Format for details.
41575	Date Stamp (LSW)	0x07E1	
41576	Sample Record Count	3223	
41577	Words per Record	61	
41578	Sample Period (ms)	1	Time between each record
41579	# of Post Trigger Samples	64	

In this example, the fault occurred at 1:48pm on 3/2/2017. There are 3,223 sample records, each containing 61, 16-bit words. The sample records were logged at 1ms intervals, and the last 64 records were logged after the fault occurred. Table 12 illustrates how this example buffer is organized.

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Table 12 - Fault Log Buffer Organization

		Data Log Read Buff Address			
		41572	....	41632	
		Parameter			
		PCS State	....	DC/DC State	**Time**
Pre-Fault Data →	Record 0	PCS State 0	....	DC/DC State$_0$	-3.158 sec
	Record 1	PCS State 1	....	DC/DC State$_1$	-3.157 sec
	. . .	. . .	....	. . .	
Fault Data →	Record 3158	PCS State 3158	....	DC/DC State 3158	0 sec
Post-Fault Data →	Record 3159	PCS State 3159	....	DC/DC State 3159	1 ms
	. . .	. . .	....	. . .	
	Record 3222	PCS State 3222	....	DC/DC State 3222	64 ms

With the header information, it is now possible to read as much or as little of the Fault Log as desired. Each record in the buffer is read individually by first writing the record number to ***REG 41539 - Fault Log – Get Selected Record,*** and then reading the selected data from the corresponding ***Data Log Buffer Registers.***

User Events

User Event data logging is intended to capture operating data leading up to and/or after a trigger event. The data logging parameters defined in Table 10 are available for capture. The selected parameters are sampled at the user configured sampling rate and continuously buffered to RAM. When a trigger event occurs, the buffer is frozen or filled, depending on the configuration.

Selecting Parameters

The user may select one or more of the data logging parameters defined in Table 10 by writing to ***REG 41544/41546 - User Log Variable Selection (LSW/MSW)***. These are two 32-bit registers where each bit can be considered an "enable" for the corresponding parameter in Table 10. The LSW register contains enable bits 0 – 31. The MSW register contains enable bits 32 – 63. Writing a "1" to specific bit positions means that the corresponding parameters will be captured.

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Table 13 - User Log Variable Selection Bit Assignment

Bit	Parameter Name
0	be
1	be
. . .	. . .
54	DC/DC Warnings
55	DC/DC State
56 - 63	Reserved for Future Use

As an example, if the user wished to capture PCS Faults, the DC Input Voltage, and the DC input Current they would write 0x0000001A to register 41544, and to capture Inverter Current Phase A, DC Current Top A, and DC Link Voltage they would write 0x00008102 to register 41546.

Setting the Sample Period and Post Trigger Size

The user can set the sample period by writing to ***REG 41543 - User Log Sample Period.*** Note that the User Event Log is fixed at 63,744 words. As a result, the number and size of the selected parameters, together with the sample period, will define the time duration of the captured data according to:

$$\text{Duration} = \frac{63{,}744 \text{ words}}{\text{K words / sample}} \text{ X } \text{SamplePeriod}$$

As an example, assume ***REG 41544 - User Log Variable Selection*** = 0x0000001A to log PCS Faults, the DC Input Voltage, and the DC input Current. Referencing Table 10, the number of words per sample, K, would be 4 since DC Input Voltage and Current are U16 parameters and PCS Faults is a U32.

If ***REG 41543 - User Log Sample Period*** = 10msec, then 159.36 seconds worth of data will be captured. If instead a 1 second sample period were used, then 4 hours, 25 min, and 36 secs of data would be captured.

The user can also configure how much of the log is dedicated to post trigger information using ***REG 41542 - User Log Post Trigger Percentage.*** This register is in units of %, so setting it to 0 would mean the entire log represents the time before the trigger event. A setting of 50% would mean half of the log occurred before the trigger and half after, while 100% implies all the log occurred after the trigger.

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Configuring the Trigger Mode

The PCS supports four trigger modes, as described below, by setting ***REG 41548 - User Log Trigger Mode*** accordingly.

Mode 0: Continuous Trigger Sampling is only controlled by ***REG 41541 - User Log Start/Stop.*** When register 41541 = 1, the selected parameters will be continuously sampled at the configured rate. The buffer is circular, so once filled, the oldest data will be overwritten with the latest sample.

Mode 1: Single Trigger Sampling is controlled by ***REG 41541 - User Log Start/Stop*** as well as Trigger 1. Register 41541 must equal 1 and the Trigger 1 conditions must be True for the trigger to be asserted.

Mode 2: Dual OR Trigger Sampling is controlled by R***EG 41541 - User Log Start/Stop*** as well as both Trigger 1 and 2. Register 41541 must equal 1 and either Trigger 1 conditions OR Trigger 2 conditions must be True for the trigger to be asserted.

Mode 3: Dual AND Trigger Sampling is controlled by ***REG 41541 - User Log Start/Stop*** as well as both Trigger 1 and 2. Register 41541 must equal 1 and both Trigger 1 conditions AND Trigger 2 conditions must be True for the trigger to be asserted.

Configuring Triggers

The PCS provides two user triggers. When configured for Single Trigger mode only Trigger 1 is used. Dual OR and Dual AND modes require both Trigger 1 and Trigger 2. Each trigger is configured by first selecting a parameter to trigger off. This is done using ***REG 41550(41556) - User Log Trigger1(2) Variable Selection.*** The value written to these registers corresponds to the parameter number in Table 10. For example, to trigger off the PCS Faults, the register should be set to “1”. To trigger off DC Input Voltage the register should be set to “3”.

The value in ***REG 41551(41557) - User Log Trigger1(2) Value Mask*** is logically AND’ed (bit-wise) with the selected variable. The main purpose of this register is to allow selection of a bit within a bit-field register as the trigger source. For example, the H/W DC Input Over Voltage fault is bit 10 of the PCS Faults register. To use this bit as a trigger source, the mask register would be set to 0x00000400. See ***REG 40129 – Fault Status*** for a complete list of the various fault and warning bits and their corresponding register bit positions. Note that the mask is always applied and should be set to 0xFFFFFFFF if no masking is required. To generate the trigger condition, the PCS compares the value of the masked, selected parameter to ***REG 41553(41559) - User Log Trigger1(2) Trigger Value. REG 41549(41555) - User Log Trigger1(2) Compare Type*** defines the type of compare to be used:

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0 = Less than (<) Masked Parameter < Register 41553(41559)

1 = Greater Than (>) Masked Parameter > Register 41553(41559)

2 = Equal to (=) Masked Parameter = Register 41553(41559)

3 = Not Equal to (!=) Masked Parameter != Register 41553(41559)

As an example, to trigger on the H/W DC Input Over Voltage Fault bit being asserted OR the DC Input Voltage being greater than 600V, the following register settings would be used:

Table 14 - User Log Trigger Configuration Example

Reg #	Reg Name	Value	Description
41548	Trigger Mode	2	Dual OR Trigger
41550	Trigger1 Variable Selection.	1	PCS Faults
41551	Trigger1 Value Mask	0x00000400	Select H/W DC Input Over Voltage Fault bit
41549	Trigger1 Compare Type	2	Equal to
41553	Trigger1 Trigger Value	0x00000400	H/W DC Input Over Voltage Fault bit asserted
41556	Trigger2 Variable Selection.	3	DC input Voltage
41557	Trigger2 Value Mask	0xFFFFFFFF	No masking
41555	Trigger2 Compare Type	1	Greater than
41559	Trigger2 Trigger Value	6000	600V with 0.1V scaling

Reading the Log

REG 41561 – User Log Status can be read to determine the status of the logger. A value of 1 or 2 means the logger is either waiting for a trigger or in the middle of capturing data. A value of 3 means the logger has finished capturing data and it's available to be read.

To read the log, the user should first read the header information by writing a "1" to ***REG 41562 – User Log Get Header,*** followed by a read of ***Data Log Buffer Registers 41572 – 41583.*** Table 15 defines the header data and format as read from the Data log buffer registers along with example data.

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Table 15 - User Log Header Data Description

Data Log Read Buffer Address	Header Data Description	Example	Notes
41572	Time Stamp (MSW)	0x0000	e.g. = 1:48pm, see Real Time Clock – Time Format for details.
41573	Time Stamp (LSW)	0x300D	
41574	Date Stamp (MSW)	0x1503	e.g. = 3/21/2017, see Real Time Clock – Date Format for details.
41575	Date Stamp (LSW)	0x07E1	
41576	Selected User Vars (MSW)	0x0000	PCS Faults, DC Input Voltage, DC Input Current selected
41577	Selected User Vars (LSW)	0x001A	
41578	Selected Factory Vars (MSW)	0	No factory variables selected
41579	Selected Factory Vars (LSW)	0	
41580	Sample Count	15,936	
41581	Words per Sample	4	
41582	Sample Period (ms)	10	Time between each record
41583	# of Post Trigger Samples	3,984	

In this example, the trigger occurred at 1:48pm on 3/2/2017. There are 15,936 samples, each containing 4, 16-bit words. The samples were logged at 10msec intervals, and the last 3,984 samples were taken after the trigger occurred. Table 12 illustrates how this example buffer is organized.

Table 16 - User Log Buffer Organization

		Data Log Read Buff Address			
		41572 - 41573	41574	41575	
		Parameter			
		PCS Fault	DC Vin	DC Current	**Time**
Pre-Trigger Data →	Sample 0	PCS Fault 0	DC Vin 0	DC Curr 0	-1.991 min
	Sample 1	PCS Fault 1	DC Vin 1	DC Curr 1	-1.990 min
	. . .	. . .	. . .	. . .	
Trigger Data →	Sample 11951	PCS Fault 11951	DC Vin 11951	DC Curr 11951	0 min
Post-Trigger Data →	Sample 11952	PCS Fault 11952	DC Vin 11952	DC Curr 11952	10 ms
	. . .	. . .	. . .	. . .	
	Sample 15,935	PCS Fault 15935	DC Vin 15935	DC Curr 15935	664 ms

With the header information, it is now possible to read as much or as little of the User Log as desired. Each record in the buffer is read individually by first writing the sample number to ***REG 41563 - User Log – Get Selected Sample Data,*** and then reading the selected data from the corresponding ***Data Log Buffer Registers.***

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Fault History Log

Fault Count Log

The PCS keeps track of the total number of occurrences for each of the faults defined in REG 40129 – PCS Fault Status. Each of the faults has an associated 16-bit counter organized as illustrated in Table 17.

Table 17 - Fault Count Buffer Organization

Index	Counter	Fault
o	Count – Fault Bit 0	H/W Over Current A
1	Count – Fault Bit 1	H/W Over Current B
. . .	. . .	. . .
31	Count – Fault Bit 31	AC Current Overload Trip

The user may read a single fault count or the entire buffer using ***REG 41569 – Operation Log – Read Fault Counts.*** This is a 16-bit register in which the LSB is used to specify the index of the first count to be read, and the MSB specifies the # of counters to read. After writing to register 41569, the counter can be read from the corresponding ***Data Log Buffer Registers.***

For example, to read all the counts, write 0x2000 to register 41569 and then read registers 41572 to 41596. The read buffer will be organized as follows:

Read Buffer Address	Counter
41572	Count – Fault Bit 0
41573	Count – Fault Bit 1
. . .	. . .
41603	Count – Fault Bit 31

To read a single count, say the H/W Over Current B count, write 0x0101 to register 41569 and then read register 41572.

Fault Time Stamp Log

The PCS records the date and time of the last six occurrences for each of the possible faults. Each of the time and date values is a 32-bit value, formatted as explained in Real Time Clock (RTC), on page 57.

The fault history buffers can be accessed by first specifying the fault by writing the bit location, as specified in ***REG 40129 – PCS Fault Status, to REG 41564 – Fault History Log – Set Fault Index. REG 41565 – Fault History Log - # of Entries for Specified Fault*** can then be read to determine how many, if any, fault occurrences have been logged, i.e., 0 through 6.

Writing a “1” to REG 41566 – Fault History Log – Get History Data for Specified Fault will load the fault history into the Data Log Buffer Registers. Table 18 illustrates how the history buffer data is arranged

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within the buffer. Note that the buffer is always loaded with six time and date stamps. The user must read REG 41565 – Fault History Log - # of Entries for Specified Fault to determine which, if any, are valid.

Table 18 - Fault History Buffer Arrangement

Data Log Buffer Address		Fault Occurrence
41572	MSW	Fault 1 - Date – ***Oldest***
41573	LSW	
41574	MSW	Fault 1 - Time – ***Oldest***
41575	LSW	
41576	MSW	Fault 2 - Date
41577	LSW	
41578	MSW	Fault 2 – Time
41579	LSW	
41580	MSW	Fault 3 – Date
41581	LSW	
41582	MSW	Fault 3 – Time
41583	LSW	
41584	MSW	Fault 4 – Date
41585	LSW	
41586	MSW	Fault 4 – Time
41587	LSW	
41588	MSW	Fault 5 – Date
41589	LSW	
41590	MSW	Fault 5 – Time
41591	LSW	
41592	MSW	Fault 6 – Date – ***Most Recent***
41593	LSW	
41594	MSW	Fault 6 – Time – ***Most Recent***
41595	LSW	

Operating History Logs

The operating history log is intended to record critical operating parameters over the life of the PCS. This data includes operating time, and min/max values of critical parameters, as detailed in the following sections.

Operating Time Log

The PCS keeps track of the cumulative time spent operating under a variety of conditions as defined in Table 19. Each counter is 32 bits long where each count represents 1 second.

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Table 19 - Operating Time Parameter Log

Index	Parameter
0	*Factory Data*
1	*Factory Data*
2	Time Powered On
3	Time in Fault State
4	Time in Disabled State
5	Time in Charge Wait State
6	Time in Charging State
7	Time in Standby State
8	Time in Turn-on Delay State
9	Time in Online – Grid Tie State
10	Time in Offline State
11	Time in Active Ride Through State
12	Time in Passive Ride Through State
13	Time in Online – Grid Form State
14	Time in Power Down State
15	Time in Test Mode State
16	Time Operating: TDC /DC < 10 °C
17	Time Operating: 10 < TDC /DC < 20 °C
18	Time Operating: 20 < TDC /DC < 30 °C
19	Time Operating: 30 < TDC /DC < 40 °C
20	Time Operating: 40 < TDC /DC < 50 °C
21	Time Operating: 50 < TDC /DC < 60 °C
22	Time Operating: 60 < TDC /DC < 70 °C
23	Time Operating: 70 < TDC /DC < 80 °C
24	Time Operating: 80 < TDC /DC < 90 °C
25	Time Operating: TDC /DC > 90 °C
26	Time Operating: TINV < 10 °C
27	Time Operating: 10 < TINV < 20 °C
28	Time Operating: 20 < TINV < 30 °C
29	Time Operating: 30 < TINV < 40 °C
30	Time Operating: 40 < TINV < 50 °C
31	Time Operating: 50 < TINV < 60 °C
32	Time Operating: 60 < TINV < 70 °C
33	Time Operating: 70 < TINV < 80 °C
34	Time Operating: 80 < TINV < 90 °C
35	Time Operating: TINV > 90 °C
36	Time Operating: TENC < 10 °C
37	Time Operating: 10 < TENC < 20 °C
38	Time Operating: 20 < TENC < 30 °C

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Index	Parameter
39	Time Operating: 30 < TENC < 40 °C
40	Time Operating: 40 < TENC < 50 °C
41	Time Operating: 50 < TENC < 60 °C
42	Time Operating: 60 < TENC < 70 °C
43	Time Operating: 70 < TENC < 80 °C
44	Time Operating: 80 < TENC < 90 °C
45	Time Operating: TENC > 90 °C
46	Time Operating: VDC_IN < 300 V
47	Time Operating: 300 < VDC_IN < 350 V
48	Time Operating: 350 < VDC_IN < 400 V
49	Time Operating: 400 < VDC_IN < 450 V
50	Time Operating: 450 < VDC_IN < 500 V
51	Time Operating: 500 < VDC_IN < 550 V
52	Time Operating: 550 < VDC_IN < 600 V
53	Time Operating: 600 < VDC_IN < 650 V
54	Time Operating: 650 < VDC_IN < 700 V
55	Time Operating: 700 < VDC_IN < 750 V
56	Time Operating: 750 < VDC_IN < 800 V
57	Time Operating: 800 < VDC_IN < 850 V
58	Time Operating: VDC_IN > 850 V
59	Time Operating: IDC_IN < -80 A
60	Time Operating: -80 < IDC_IN < -60 A
61	Time Operating: -60 < IDC_IN < -40 A
62	Time Operating: -40 < IDC_IN < -20 A
63	Time Operating: -20 < IDC_IN < 0 A
64	Time Operating: 0 < IDC_IN < 20 A
65	Time Operating: 20 < IDC_IN < 40 A
66	Time Operating: 40 < IDC_IN < 60 A
67	Time Operating: 60 < IDC_IN < 80 A
68	Time Operating: IDC_IN > 80 A
69	Time Operating: VAC < 200 VRMS
70	Time Operating: 200 < VAC < 250 VRMS
71	Time Operating: 250 < VAC < 300 VRMS
72	Time Operating: 300 < VAC < 350 VRMS
73	Time Operating: 350 < VAC < 400 VRMS
74	Time Operating: 400 < VAC < 450 VRMS
75	Time Operating: 450 < VAC < 500 VRMS
76	Time Operating: VAC > 500 VRMS
77	Time Operating: 0 < IAC < 5 ARMS
78	Time Operating: 5 < IAC < 10 ARMS

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Index	Parameter
79	Time Operating: 10 < IAC < 15 ARMS
80	Time Operating: 15 < IAC < 20 ARMS
81	Time Operating: 20 < IAC < 25 ARMS
82	Time Operating: 25 < IAC < 30 ARMS
83	Time Operating: 30 < IAC < 35 ARMS
84	Time Operating: 35 < IAC < 40 ARMS
85	Time Operating: 40 < IAC < 45 ARMS
86	Time Operating: IAC > 45 ARMS
87	Time Operating: P < -35 kW
88	Time Operating: -35 < P < -30 kW
89	Time Operating: -30 < P < -25 kW
90	Time Operating: -25 < P < -20 kW
91	Time Operating: -20 < P < -15 kW
92	Time Operating: -15 < P < -20 kW
93	Time Operating: -10 < P < -5 kW
94	Time Operating: -5 < P < 0 kW
95	Time Operating: 0 < P < 5 kW
96	Time Operating: 5 < P < 10 kW
97	Time Operating: 10 < P < 15 kW
98	Time Operating: 15 < P < 20 kW
99	Time Operating: 20 < P < 25 kW
100	Time Operating: 25 < P < 30 kW
101	Time Operating: 30 < P < 35 kW
102	Time Operating: P > 35 kW
103	Time Operating: IAC < 25 ARMS and TENC < 30 °C
104	Time Operating: IAC < 25 ARMS and 30 < TENC < 40 °C
105	Time Operating: IAC < 25 ARMS and 40 < TENC < 50 °C
106	Time Operating: IAC < 25 ARMS and 50 < TENC < 60 °C
107	Time Operating: IAC < 25 ARMS and TENC > 60 °C
108	Time Operating: IAC > 25 ARMS and TENC < 30 °C
109	Time Operating: IAC > 25 ARMS and 30 < TENC < 40 °C
110	Time Operating: IAC > 25 ARMS and 40 < TENC < 50 °C
111	Time Operating: IAC > 25 ARMS and 50 < TENC < 60 °C
112	Time Operating: IAC > 25 ARMS and TENC > 60 °C

The user may read a single operating time or up to a maximum of 32 times by using ***REG 41568 – Operation Log – Read Time Variables.*** This is a 16-bit register in which the LSB is used to specify the index of the first time to be read, and the MSB specifies the # of times to read. After writing to register 41568, the times can be read from the corresponding ***Data Log Buffer Registers.***

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For example, to read “Time Operating: P > 35kW”, write 0x0166 to register 41568 and then read registers 41572 and 41573 for the 32-bit time in secs, where 41572 holds the MSW and 41573 the LSW.

To read the three consecutive times: “Time Powered on”, “Time in Fault State”, “Time in Disabled State”, write 0x0302 to register 41568 and then read registers 41572 to 41577. The read buffer will be organized as follows:

Data Log Buffer Address		Operating Time
41572	MSW	Time Powered On
41573	LSW	
41574	MSW	Time in Fault State
41575	LSW	
41576	MSW	Time in Disabled State
41577	LSW	

Min/Max Log

The PCS keeps track of minimum and maximum values for the parameters listed in Table 20.

Table 20 - Min/Max Parameter Log

Parameter Index	Parameters	Units	Data Type
0	Max – AC Voltage Phase AB	0.1 V RMS	U16
1	Max – AC Voltage Phase BC	0.1 V RMS	U16
2	Max – AC Voltage Phase CA	0.1 V RMS	U16
3	Max – AC Voltage Phase A	0.1 V RMS	U16
4	Max – AC Voltage Phase B	0.1 V RMS	U16
5	Max – AC Voltage Phase C	0.1 V RMS	U16
6	Max – AC Current Phase A	0.1 A RMS	U16
7	Max – AC Current Phase B	0.1 A RMS	U16
8	Max – AC Current Phase C	0.1 A RMS	U16
9	Max – Inverter Current Phase A	0.1 A RMS	U16
10	Max – Inverter Current Phase B	0.1 A RMS	U16
11	Max – Inverter Current Phase C	0.1 A RMS	U16
12	Max – Real AC Power (P)	10 W	S16
13	Max – Reactive AC Power (Q)	10 VAR	S16
14	Max – AC Frequency	0.01 Hz	U16
15	Max – DC Link Voltage	0.1 V	U16
15	Max – DC Link Top	0.1 V	U16
16	Max – DC Link Bottom	0.1 V	U16
17	Max – DC Input Voltage	0.1V	U16
18	Max – DC Input Current	0.1 A	S16

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19	Max – DC Current Phase A High Side	0.1 A	S16
20	Max – DC Current Phase B High Side	0.1 A	S16
21	Max – DC Current Phase C High Side	0.1 A	S16
22	Max – DC Current Phase A Low Side	0.1 A	S16
23	Max – DC Current Phase B Low Side	0.1 A	S16
24	Max – DC Current Phase C Low Side	0.1 A	S16
25	Max – 24V Bias	0.01 V	U16
26	Max – Temperature DC/DC Phase A	°C	S16
27	Max – Temperature DC/DC Phase B	°C	S16
28	Max – Temperature DC/DC Phase C	°C	S16
29	Max – Temperature Inverter Phase A	°C	S16
30	Max – Temperature Inverter Phase B	°C	S16
31	Max – Temperature Inverter Phase C	°C	S16
32	Max – Temperature Enclosure Air	°C	S16
34	Min – Real AC Power (P)	10 W	S16
35	Min – Reactive AC Power (Q)	10 VAR	S16
36	Min – AC Frequency	0.01 Hz	U16
37	Min – DC Input Current	0.1 A	S16
38	Min – DC Current Phase A High Side	0.1 A	S16
39	Min – DC Current Phase B High Side	0.1 A	S16
40	Min – DC Current Phase C High Side	0.1 A	S16
41	Min – DC Current Phase A Low Side	0.1 A	S16
42	Min – DC Current Phase B Low Side	0.1 A	S16
43	Min – DC Current Phase C Low Side	0.1 A	S16
44	Min – Temperature DC/DC Phase A	°C	S16
45	Min – Temperature DC/DC Phase B	°C	S16
46	Min – Temperature DC/DC Phase C	°C	S16
47	Min – Temperature Inverter Phase A	°C	S16
48	Min – Temperature Inverter Phase B	°C	S16
49	Min – Temperature Inverter Phase C	°C	S16
50	Min – Temperature Enclosure Air	°C	S16

The user may read a single parameter or up to a maximum of 64 parameters by using ***REG 41570 – Operation Log – Read Min/Max Variables.*** This is a 16-bit register in which the LSB is used to specify the index of the first parameter to be read, and the MSB specifies the # of parameters to read. After writing to register 41570, the parameters can be read from the corresponding ***Data Log Buffer Registers.***

For example, to read “Min – Temperature Enclosure Air”, write 0x0132 to register 41570 and then read register 41572.

To read the three consecutive parameters: “Min – Temp Inverter Phase A”, “Min – Temp Inverter Phase B”, “Min – Temp Inverter Phase C”, write 0x032F to register 41570 and then read registers 41572 to 41574. The read buffer will be organized as follows:

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Data Log Buffer Address	Parameter
41572	Min – Temperature Inverter Phase A
41573	Min – Temperature Inverter Phase B
41574	Min – Temperature Inverter Phase C

COMMUNICATIONS INTERFACE

The PCS is equipped with a Modbus RS485 communications interface. Modbus is an application layer messaging protocol that provides client/server communication between devices connected on different types of buses or networks.

Table 21 - Modbus Interface Specifications

Interface	RS-485
Data Transfer Method	Half duplex
Data Transfer Speed	User Configurable
Protocol	Modbus RTU over Serial Interface
Connector	D-Sub 15
Cable Type	Twisted Pair
Default Slave Address	1, User Configurable
Response Time	Time from receipt of message to beginning of reply: • 2.5ms max - Command/Instrumentation Registers • 8ms max - Configuration Registers

Modbus Overview

Modbus is a request/reply protocol and offers services specified by function codes, which are elements of Modbus request/reply protocol data units (PDUs). The MODBUS application protocol specifies that all requests are initiated by a client. The function code field indicates to the server what kind of action to perform and is coded in one byte. Valid codes are in the range of 1 ... 255 decimal (the range 128 – 255 is reserved and used for exception responses). When a message is sent from a Client to a Server device the function code field tells the server what kind of action to perform. Function code “0” is not valid. Sub-function codes are added to some function codes to define multiple actions. The data field of messages sent from a client to server devices contains additional information that the server uses to take the action defined by the function code. This can include items like discrete and register addresses, the quantity of items to be handled, and the count of actual data bytes in the field. The data field may be nonexistent (of zero length) in certain kinds of requests, in this case the server does not require any additional information. The function code alone specifies the action.

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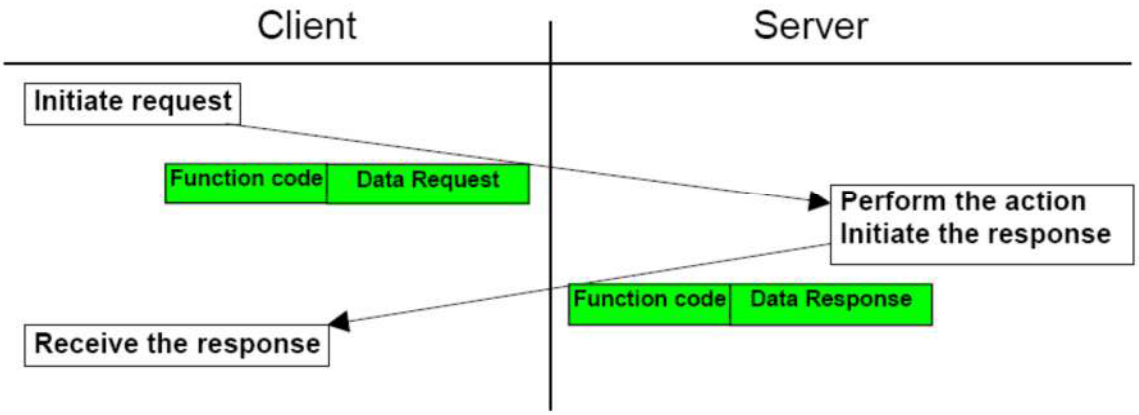
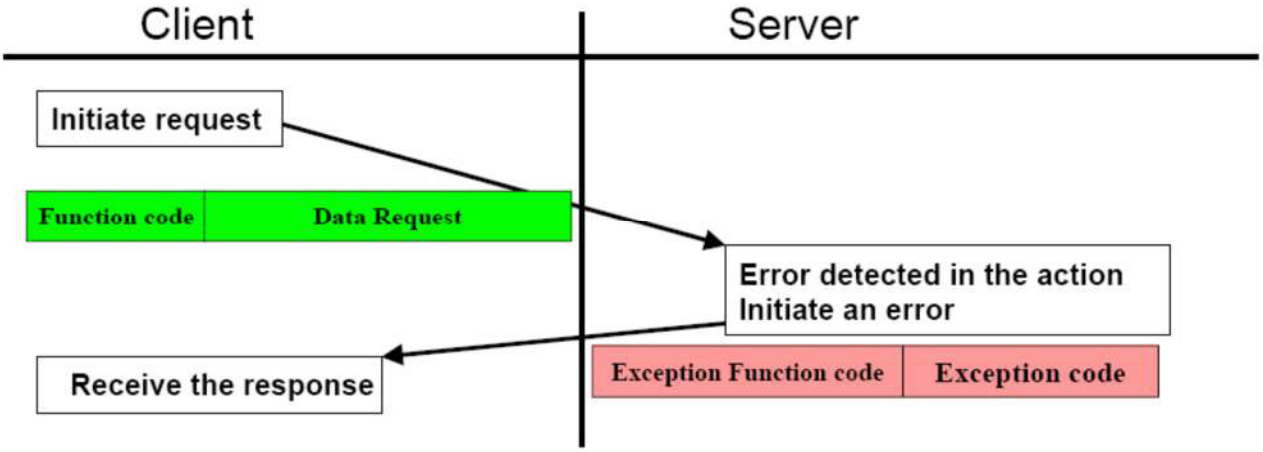
If no error occurs related to the Modbus function requested in a properly received Modbus ADU, the data field of a response from a server to a client contains the data requested. If an error related to the Modbus function requested occurs, the field contains an exception code that the server application can use to determine the next action to be taken. For example, a client can read the ON / OFF states of a group of discrete outputs or inputs or it can read/write the data contents of a group of registers. When the server responds to the client, it uses the function code field to indicate either a normal (error-free) response or that some kind of error occurred (called an exception response). For a normal response, the server simply echoes to the request the original function code.



For an exception response, the server returns a code that is equivalent function code from the request PDU with its most significant bit set to logic 1.



Physical Layer

The RS-485 physical interface conforms to the Modbus specification published on the **Modbus.org** site in 2002 (Modbus_over_serial_line_V1.pdf, Nov 2002).

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RTU Transmission Mode

Modbus supports two modes of transmission, ASCII (American Standard Code for Information Interchange), and RTU (Remote Terminal Unit). The PCS uses the more efficient RTU transmission mode. The Modbus specification defines the message frame or Serial Line PDU “Protocol Data Unit” as shown in Figure 32.

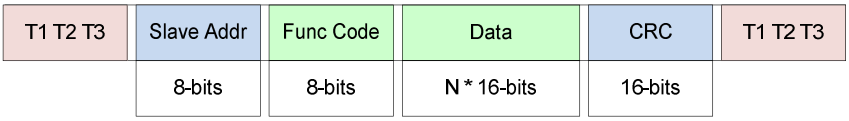

Figure 32 - RTU Message Frame (PDU) Format

Synchronization

The Modbus specification for synchronization is as follows: Frame synchronization is established by limiting the elapsed time between receipt of characters. The T1, T2, T3 items at the beginning and end of the frame depict approximately three character times of idle time. If three character times elapse without a new character or completion of a frame, then the pending message will be flushed, and the next byte received will be treated as the address field of the message frame.

Slave Address

The 8-bit slave address field defines the unique ID (1-247) of the slave device that is to receive the message sent by the master. When the slave sends a response, the slave address field informs the master which slave is communicating.

The PCS supports Slave Address 0, which is used for Modbus Broadcast Mode. In Broadcast Mode, the Modbus Master can send a message to all slaves on the network at the same time. In this mode, slaves do not reply to the Modbus Master. Using Broadcast Mode is useful when operating multiple PCS units in parallel and the user wants them all to respond to the same register commands simultaneously, such as when turning on or off or changing operating setpoints.

Function Code

The 8-bit function code tells the addressed slave what function to perform. If the slave is able to perform the requested function, the function code in the response will be that of the request. The slave will set the high order bit of the function code to one in the response to indicate an exception.

Data Field

The data field will vary in length according to which function is specified. This field contains information required by the slave to perform the specific function or it contains data collected by the slave in response to a query.

Modbus uses a ‘Big-Endian’ representation for addresses and data items. This means that when a numerical quantity larger than a single byte is transmitted, the most significant byte is sent first. For example, a 16-bit

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register size value of 0x1234 would be transmitted with the first byte sent being 0x12 then 0x34.

CRC Error Check

The two-byte error check field allows the master and slave devices to check messages for transmission errors. A Cyclic Redundancy Check (CRC) is performed by the master and the slave devices. The error checking assures that the master or slave does not react to messages that have changed during transmission.

The CRC-16 polynomial is used to compute the checksum for the message content. The formula for the CRC-16 polynomial is:

$$x^{16} + x^{15} + x^2 + 1$$

The checksum can be computed using the following algorithm:

1. Load a 16-bit register with all 1's.
2. Exclusive OR the first 8-bit byte of the message with the high order byte of the 16-bit register, putting the result in the 16-bit register.
3. Shift the 16-bit register 1 bit to the right.
4. If the bit shifted out to the right is a 1, exclusive OR the generating polynomial (1010 0000 0000 0001) with the 16-bit register. If the bit is a 0, do not modify the register.
5. Repeat steps 3 & 4 until 8 shifts have been performed.
6. Exclusive OR the next 8-bit byte of the message with the 16-bit register.
7. H Repeat steps 3 through 6 until all bytes of the message have been exclusive OR'd with the 16-bit register and shifted eight times.
8. The final content of the register is the CRC value

When the 16-bit CRC value is transmitted in the message, the low-order byte must be transmitted first, followed by the high-order byte.

Exception Response

There are two possible exception modes the PCS must handle:

- The PCS (slave) receives the request, but detects a communication error (parity, LRC, CRC, ...), no response is returned. The host will eventually process a timeout condition for the request.
- The PCS (slave) receives the request without a communication error, but cannot handle it (for example, if the request is to read a non–existent output or register), the PCS will return an exception response informing the host of the nature of the error.

When the PCS detects an error, it sends a response message to the host consisting of the function code (with high order bit set to one) and an error code (8-bits). The exception error codes are as follows:

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Table 22 - Modbus Exception Codes

Code	Name	Meaning
01	Illegal Function	The message function is not supported by the PCS.
02	Illegal Data Address	The address (in the write request) or start address (in the read request) referenced in the data field is not valid.
03	Illegal Data Value	The value or count specified in the data field is not allowable.

Function Code Descriptions

The PCS provides a subset of the available Modbus functions, namely functions 3 (Read Holding Registers), 6 (Preset Single Register), and 16 (Write Multiple Registers).

Read Holding Registers (Function Code 03)

This function code is used to read the contents of a contiguous block of registers. The request PDU specifies the starting register address and the number of registers. In the PDU registers are addressed starting at zero. Therefore, registers numbered 1-16 are addressed as 0-15.

The response includes the slave address, function code, length of response values in bytes, the response values, and error check. The data consists of two bytes for each register, with the binary content right justified within each pair. The first byte includes the high order bits and the second, the low order bits.

Request PDU:

Slave Addr	Func Code	Starting Address	# of Registers	CRC
8-bits	8-bits	16-bits	16-bits	16-bits

Response PDU:

Slave Addr	Func Code	Data Length	Data … Data		CRC
8-bits	8-bits	8-bits	16-bits	16-bits	16-bits

Error PDU:

Slave Addr	Error Code	Exception Code	CRC
8-bits	0x83	8-bits	16-bits

Here is an example request to read ***REG 40088-40090 - Current – Phase A/B/C ,*** from slave 10:

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Request		Response	
Field Name	*(Hex)*	*Field Name*	*(Hex)*
Slave Address	0A	Slave Address	0A
Function	06	Function	06
Register Address Hi	9D	Register Address Hi	9D
Register Address Lo	36	Register Address Lo	36
Register Value Hi	00	Register Value Hi	00
Register Value Lo	01	Register Value Lo	01
CRC Lo	crc_l	CRC Lo	crc_l
CRC Hi	crc_h	CRC Hi	crc_h

Write Multiple Registers (Function Code 16)

This function code is used to write a block of contiguous registers (1 to 123 registers). The requested written values are specified in the request data field. Data is packed as two bytes per register. The normal response returns the function code, starting address, and quantity of registers written.

Request PDU:

Slave Addr	Func Code	Starting Address	# of Registers	Byte Count	Register Values	CRC
8-bits	8-bits	16-bits	16-bits	8-bits	16-bits x n	16-bits

n = # of registers

Response PDU:

Slave Addr	Func Code	Starting Address	# of Registers	CRC
8-bits	8-bits	16-bits	16-bits	16-bits

Error PDU:

Slave Addr	Error Code	Exception Code	CRC
8-bits	0x90	8-bits	16-bits

Here is an example request to write 2 registers on Slave 10, ***REG 42260/42261 – Freq-Watt P MAX Curve 1: Point 1 – Frequency/Watts,*** to a value of 6100 (61Hz) and 10000 (100%):

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Request		Response	
Field Name	*(Hex)*	*Field Name*	*(Hex)*
Slave Address	0A	Slave Address	0A
Function	10	Function	10
Starting Address Hi	A5	Starting Address Hi	A5
Starting Address Lo	13	Starting Address Lo	13
# of Registers Hi	00	# of Registers Hi	00
# of Registers Lo	02	# of Registers Lo	02
Byte Count	04	CRC Lo	crc_l
Register Value Hi	17	CRC Hi	crc_h
Register Value Lo	D4		
Register Value Hi	27		
Register value Lo	10		
CRC Lo	crc_l		
CRC Hi	crc_h		

MESA-PCS MODBUS PROFILE

The MESA-PCS Modbus profile from the Modular Energy Storage Architecture (MESA) Alliance defines a comprehensive set of measured values and parameters as a standard interface for power conversion components in an energy storage system.

All MESA-compliant power conversion systems are, by definition, SunSpec devices. This means that they must include the Common Model at the top of their Modbus register map, and they must include the End Model at the end of their register map. Additionally, all MESA-compliant power conversion systems must implement a small number of SunSpec inverter models. The PCS implements the following Models:

Table 23 - SunSpec/MESA Models

Model ID	Description
1	Common Model
17	Serial Interface
103	3-Phase Inverter Model (Integer based)
120	Inverter Controls Nameplate Ratings
121	Inverter Controls Basic Settings
122	Inverter Controls Measurement and Status
123	Inverter Controls Immediate Controls
126	Static Volt-VAR Arrays
129	Inverter Controls LVRT Disconnect
130	Inverter Controls HVRT Disconnect
132	Volt-Watt P MAX Arrays

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Model ID	Description
134	Freq-Watt P MAX Arrays
135	Inverter Controls LFRT
136	Inverter Controls HFRT
139	LVRT Extended (Momentary Cessation) Arrays
140	HVRT Extended (Momentary Cessation) Arrays
143	LFRT Extended (Momentary Cessation) Arrays
144	HFRT Extended (Momentary Cessation) Arrays
145	Extended Settings
64800	MESA-PCS Extension
64300	Trystar-PCS Control and Status
64301	Trystar-PCS System Configuration
64302	Trystar-PCS Alarm Settings
64303	Trystar-PCS Turn-On and Resume Settings
64304	Trystar-PCS Firmware Update
64305	Trystar-PCS Datalogging
64306	Volt-Watt P MIN Arrays
64307	Freq-Watt P MIN Arrays
64308	Trystar-PCS Grid Forming Configuration & Control
0xFFFF	End Model

Register Properties

Register Number

The register Number listed in the tables below represents the Modbus identifier for each parameter. It is important to note that these register numbers are 1-based, meaning they start counting from 1. This differs from the physical address that is transmitted across the bus when accessing these registers. The physical addresses are 0-based, meaning they start counting from 0.

Notice: Offset of Modbus Register Numbers To read or write Modbus registers the "Address" is 1 less than the register number. Example: Address of Register 40001 is 40001 – 1 = 40000.

Access Level

The access level for each register is defined as follows:

W = Writeable – the parameter is writable by the user

R = Readable – the parameter is readable by the user

O = Operating – the parameter may NOT be written while the PCS is ON, writes to any parameter with this indicator will be ignored if the PCS is ON

C = Cyclical – the writeable parameter may be cyclically updated with no risk of damage

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⚠ CAUTION ⚠

Write (W) parameters must not be changed cyclically.

The majority of registers that can be modified using Modbus Write commands (W) are non-volatile and intended for long term storage of device configuration. Cyclical changing of these parameters will lead to failure of the non-volatile memory device.

Registers used for the immediate control and limitation are an exception and may be changed cyclically with no damage to the electronics. These registers are denoted with a cyclical (C) access designator.

SunSpec Data Formats

- **int:** signed integer value.
- **uint:** unsigned integer value
- **pad:** reserved field, used to round a Model to an even number of registers
- **acc:** accumulated value, used for ever increasing values that may rollover
- **enum:** enumerated value, used for status and state
- **bitfield:** a collection of bits, multi-valued alarms or state
- **string:** a null terminated or fixed length value
- **sunssf:** defines value to shift decimal point to left (negative) or right (positive)

SunSpec Data Type U16

U16 represents all unsigned, 16-bit integer values and consist of a single register. Values are stored in big-endian order.

Modbus Register	1															
Byte	0								1							
Bits	15	14	13	12	10	11	9	8	7	6	5	4	3	2	1	0

U16 Format	Range	Not Implemented Value
Integer	0 … 65534	0xFFFF
Acc16	0 … 65534	0x0000
ENUM	0 …. 65534	0xFFFF
Bitfield	0 …. 0x7FFF	0xFFFF
Pad	0x8000	Always returns 0x8000

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SunSpec Data Type S16

S16 represents all signed, 16-bit integer values and consist of a single register. Values are stored in big-endian order.

Modbus Register	1															
Byte	0								1							
Bits	15	14	13	12	10	11	9	8	7	6	5	4	3	2	1	0

S16 Format	Range	Not Implemented Value
Integer	-32767 … 32767	0x8000
sunssf	-10 … 10	0x8000

SunSpec Data Type U32

U32 represents all unsigned, 32-bit integer values and consist of two registers in big-endian order.

Modbus Register	1		2	
Byte	0	1	2	3
Bits	31 … 24	23 … 16	15 … 8	7 … 0

U32 Format	Range	Not Implemented Value
Integer	0 … 4,292,967,294	0xFFFF FFFF
Acc32	1 … 4,292,967,295	0x0000 0000
ENUM	0 … 4,292,967,294	0xFFFF FFFF
Bitfield	0 …. 0x7FFF FFFF	0xFFFF FFFF

SunSpec Data Type S32

S32 represents all unsigned, 32-bit integer values and consist of two registers in big-endian order.

Modbus Register	1		2	
Byte	0	1	2	3
Bits	31 … 24	23 … 16	15 … 8	7 … 0

S32 Format	Range	Not Implemented Value
Integer	-2,147,483,647 ….. 2,147,483,647	0x8000 0000

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SunSpec Data Type U64

U64 represents all unsigned, 64-bit integer values and consist of four registers in big-endian order.

Modbus Register	1		2	
Byte	0	1	2	3
Bits	63 ... 56	55 ... 48	47 ... 40	39 ... 32

Modbus Register	3		4	
Byte	4	5	6	7
Bits	31 ... 24	23 ... 16	15 ... 8	7 ... 0

S32 Format	Range	Not Implemented Value
Integer	0 … 9,223,372,036,854,775,806	0xFFFF FFFF FFFF FFFF
Acc32	1 … 9,223,372,036,854,775,807	0x0000 0000 0000 0000
ENUM	0 … 9,223,372,036,854,775,806	0xFFFF FFFF FFFF FFFF
Bitfield	0 …. 0x7FFF FFFF FFFF FFFF	0xFFFF FFFF FFFF FFFF

SunSpec Data Type String

String represents a variable length string value in a fixed size register range using a NULL (0 value) to terminate or pad the string. For example, up to 16 characters can be stored in 8 contiguous registers as follows:

Modbus Register	1		2		3		4		5		6		7		8	
Byte	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Character	E	X	A	M	P	L	E	spc	S	T	R	I	N	G	!	NULL

Not Implemented Value: all registers filled with NULL or 0x0000.

Register Models

The following sections tabulate the registers for each of the SunSpec and Trystar Extension models. The tables only include the implemented registers, Modbus reads of unimplemented registers will return the “Not Implemented” values.

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SunSpec Model 1 Registers – Common Model

Number	Data Type	Description	Units	Scale Factor (Reg #)	Factory Default	Min	Max	Access Level
Header:								
40001	U32	SunSpec ID - Allows discovery as a SunSpec compatible device.	n/a	n/a	0x53756E53	n/a	n/a	R
40003	U16	Model Identifier	n/a	n/a	1	n/a	n/a	R
40004	U16	Model Length - # of 16-bit registers to follow	n/a	n/a	66	n/a	n/a	R
Fixed Block:								
40005-40020	Str	Manufacturer	ASCII	n/a	"Trystar LLC."	n/a	n/a	R
40021-40036	Str	Model	ASCII	n/a	"PCS RS40"	n/a	n/a	R
40045-40052	Str	Version: **Byte 10..0:** Firmware Revision **Byte 11..12:** Release Code: '-R' – Production Release '-C' – Release Candidate '-E' – Experimental Debug Build	ASCII	n/a	n/a	n/a	n/a	R
40053-40068	Str	Serial number	ASCII	n/a	n/a	n/a	n/a	R
40069	U16	Modbus Device Address	n/a	n/a	1	1	247	RWO[1]

[1]New value will not take effect until next POR

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SunSpec Model 17 Registers – Serial Interface

Number	Data Type	Description	Units	Scale Factor (Reg #)	Factory Default	Min	Max	Access Level
Header:								
40071	U16	Model Identifier	n/a	n/a	17	n/a	n/a	R
40072	U16	Model Length - # of 16-bit registers to follow	n/a	n/a	12	n/a	n/a	R
Fixed Block:								
40077	U32	Baud Rate: Supported values = 4800, 19200, 38400, 57600, and 115200 (all others result in default of 57600)	bps	n/a	57600	4800	115200	RWO[1]
40079	U16	Bits Per Character	n/a	n/a	8	n/a	n/a	R
40080	U16	Parity: **0** = None; **1** = Odd; **2** = Even	ENUM	n/a	0	0	2	RWO[1]
40081	U16	Duplex: **0** = Full; **1** = Half	ENUM	n/a	1	n/a	n/a	R
40082	U16	Flow Control: **0** = None; **1** = Hardware flow control; **2** = Software (XON/XOFF) flow control	ENUM	n/a	0	n/a	n/a	R
40083	U16	Interface type: **0** = Unknown; **1** = RS232; **2** = RS485	ENUM	n/a	2	n/a	n/a	R
40084	U16	Protocol: **0** = Unknown; **1** = Modbus; **2** = Vendor Specific	ENUM	n/a	1	n/a	n/a	R

[1]New value will not take effect until next POR

[2]The number of **STOP BITS** (not included in model) is fixed at '1'

SunSpec Model 103 Registers – Three Phase Inverter (Fixed Point)

Number	Data Type	Description	Units[1]	Scale Factor (Reg #)	Factory Default	Min	Max	Access Level
Header:								
40085	U16	Model Identifier	n/a	n/a	103	n/a	n/a	R
40086	U16	Model Length - # of 16-bit registers to follow	n/a	n/a	50	n/a	n/a	R
Fixed Block:								
40087	U16	AC Current (sum of all phases)	0.1 A RMS	40091	n/a	n/a	n/a	R
40088	U16	Current – Phase A	0.1 A RMS	40091	n/a	n/a	n/a	R
40089	U16	Current – Phase B	0.1 A RMS	40091	n/a	n/a	n/a	R
40090	U16	Current – Phase C	0.1 A RMS	40091	n/a	n/a	n/a	R
40091	s16	Scale Factor – Current	sunssf	n/a	-1	n/a	n/a	R
40092	U16	Phase Voltage – AB	0.1 V RMS	40098	n/a	n/a	n/a	R
40093	U16	Phase Voltage – BC	0.1 V RMS	40098	n/a	n/a	n/a	R
40094	U16	Phase Voltage – CA	0.1 V RMS	40098	n/a	n/a	n/a	R
40095	U16	Phase Voltage – AN	0.1 V RMS	40098	n/a	n/a	n/a	R
40096	U16	Phase Voltage – BN	0.1 V RMS	40098	n/a	n/a	n/a	R

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Number	Data Type	Description	Units[1]	Scale Factor (Reg #)	Factory Default	Min	Max	Access Level
40097	U16	Phase Voltage – CN	0.1 V RMS	40098	n/a	n/a	n/a	R
40098	U16	Scale Factor – AC Voltage	sunssf	n/a	-1	n/a	n/a	R
40099	S16	AC Power	10 W	40100	n/a	n/a	n/a	R
40100	S16	Scale Factor – AC Power	sunssf	n/a	1	n/a	n/a	R
40101	U16	Line Frequency	0.01 Hz	40102	n/a	n/a	n/a	R
40102	S16	Scale Factor – Line Frequency	sunssf	n/a	-2	n/a	n/a	R
40103	S16	AC Apparent Power	10 VA	40104	n/a	n/a	n/a	R
40104	S16	Scale Factor – AC Apparent Power	sunssf	n/a	1	n/a	n/a	R
40105	S16	AC Reactive Power	10 VAr	40106	n/a	n/a	n/a	R
40106	S16	Scale Factor – AC Reactive Power	sunssf	n/a	1	n/a	n/a	R
40107	S16	Power Factor	n/a	40108	n/a	n/a	n/a	R
40108	S16	Scale Factor – Power Factor	sunssf	n/a	-3	n/a	n/a	R
40112	S16	DC Current	0.1 A	40113	n/a	n/a	n/a	R
40113	S16	Scale Factor – DC Current	sunssf	n/a	-1	n/a	n/a	R
40114	U16	DC Voltage – Input voltage measured at the input to the DC contactor	0.1 V	40115	n/a	n/a	n/a	R
40115	S16	Scale Factor – DC Voltage	sunssf	n/a	-1	n/a	n/a	R
40116	S16	DC Power	10 W	40117	n/a	n/a	n/a	R
40117	S16	Scale Factor – DC Power	sunssf	n/a	1	n/a	n/a	R
40118	S16	Cabinet Temperature	C	40122	n/a	n/a	n/a	R
40119	S16	Heatsink Temperature Inverter (Hottest of all measured)	C	40122	n/a	n/a	n/a	R
40121	S16	Heatsink Temperature DC/DC (Hottest of all measured)	C	40122	n/a	n/a	n/a	R
40122	S16	Scale Factor – Temperature	sunssf	n/a	0	n/a	n/a	R

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Number	Data Type	Description	Units[1]	Scale Factor (Reg #)	Factory Default	Min	Max	Access Level
40129	U32	Vendor Bitfield 1 – PCS Fault Status: **Bit 0** = H/W Over Current A Bit 16 = Ride Thru - High Freq **Bit 1** = H/W Over Current B Bit 17 = Island Condition **Bit 2** = H/W Over Current C Bit 18 = Reserved **Bit 3** = RMS Over Current A Bit 19 = Over Temperature **Bit 4** = RMS Over Current B Bit 20 = ESTOP **Bit 5** = RMS Over Current C Bit 21 = Communication Error **Bit 6** = DC Over Current Bit 22 = Power Down Error **Bit 7** = Grid AB Over Voltage Bit 23 = Invalid User Config **Bit 8** = Grid BC Over Voltage Bit 24 = Invalid Model **Bit 9** = Grid CA Over Voltage Bit 25 = Factory Fault **Bit 10** = H/W DC Over Voltage Bit 26 = Saturation Error A **Bit 11** = DC Over Voltage Bit 27 = Saturation Error B **Bit 12** = DC Under Voltage Bit 28 = Saturation Error C **Bit 13** = Ride Thru - Low Voltage Bits 29-30 = Reserved **Bit 14** = Ride Thru - High Voltage **Bit 15** = Ride Thru - Low Freq **Bit 16** = Ride Thru - High Freq **Bit 17** = Island Condition **Bit 18** = Reserved **Bit 19** = Over Temperature **Bit 20** = ESTOP **Bit 21** = Communication Error **Bit 22** = Power Down Error **Bit 23** = Invalid User Config **Bit 24** = Invalid Model **Bit 25** = Factory Fault **Bit 26** = Saturation Error A **Bit 27** = Saturation Error B **Bit 28** = Saturation Error C **Bits 29-30** = Reserved **Bit 31** = AC Current Overload Trip	Bitfield	n/a	n/a	n/a	n/a	R

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Number	Data Type	Description	Units[1]	Scale Factor (Reg #)	Factory Default	Min	Max	Access Level
40131	U32	Vendor Bitfield 2 – PCS Warning Status: **Bit 0** = High AC Current A **Bit 1** = High AC Current B **Bit 2** = High AC Current C **Bit 3** = High DC Input Current **Bit 4** = High Grid Voltage AB **Bit 5** = High Grid Voltage BC **Bit 6** = High Grid Voltage CA **Bit 7** = High DC Voltage **Bit 8** = Low DC Voltage **Bit 9** = AC Current Limit **Bit 10** = DC Power Limit **Bit 11** = AC Power Limit **Bit 12** = Resume – Grid OOT **Bit 13** = Resume – Delay **Bit 14** = Island Detected **Bit 15** = PLL Not Locked **Bit 16** = High DC/DC Temp **Bit 17** = High Inverter Temp **Bit 18** = High Ambient Temp **Bit 19** = Fan 1 Error **Bit 20** = Fan 2 Error **Bit 21** = Fan 3 Error **Bit 22** = HVRT Active Override **Bit 23** = TVS Error **Bit 24** = Volt-VAR Active **Bit 25** = Volt-Watt Active **Bit 26** = Freq-Watt Active **Bit 27** = Loss of Phase **Bit 28** = Reserved **Bit 29** = AC Contactor Open **Bit 30** = DC Contactor Open **Bit 31** = AC Current Overload	Bitfield	n/a	n/a	n/a	n/a	R

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Number	Data Type	Description	Units[1]	Scale Factor (Reg #)	Factory Default	Min	Max	Access Level
40133	U32	Vendor Bitfield 3 – Factory Fault Status: **Bit 0** = H/W DC Over Current A - bot **Bit 1** = H/W DC Over Current B - bot **Bit 2** = H/W DC Over Current C - bot **Bit 3** = H/W DC Over Current A - top **Bit 4** = H/W DC Over Current B - top **Bit 5** = H/W DC Over Current C - top **Bit 6** = DC Over Current A **Bit 7** = DC Over Current B **Bit 8** = DC Over Current C **Bit 9** = DC Current Imbalance A **Bit 10** = DC Current Imbalance B **Bit 11** = DC Current Imbalance C **Bit 12** = H/W DC Link Over Voltage - top **Bit 13** = H/W DC Link Over Voltage - bot **Bit 14** = DC Link Over Voltage **Bit 15** = DC Link Voltage Imbalance **Bit 16** = Pre-charge Timeout **Bit 17** = Bias Under Voltage **Bit 18** = Contactor Interlock **Bit 19** = DC/DC Communication Error **Bit 20** = Datalog Error **Bit 21** = Invalid Factory Configuration **Bit 22** = Configuration EEPROM Error **Bit 23** = Calibration Error **Bits 24-31** = *Reserved*	Bitfield	n/a	n/a	n/a	n/a	R

[1]Units include applied scale factor register

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SunSpec Model 120 Registers – Nameplate Ratings

Number	Data Type	Description	Units[1]	Scale Factor (Reg #)	Factory Default	Min	Max	Access Level
Header:								
40137	U16	Model Identifier	n/a	n/a	120	n/a	n/a	R
40138	U16	Model Length - # of 16-bit registers to follow	n/a	n/a	26	n/a	n/a	R
Fixed Block:								
40139	U16	Device Type: 4 = PV; 82 = PV Storage	ENUM	n/a	82	n/a	n/a	R
40140	U16	Continuous Power Output Capability	10 W	40141	4000	n/a	n/a	R
40141	S16	Scale Factor - Continuous Power Output	sunssf	n/a	1	n/a	n/a	R
40142	U16	Continuous Volt-Ampere Capability	10 VA	40143	4000	n/a	n/a	R
40143	S16	Scale Factor - Continuous Volt-Ampere	sunssf	n/a	1	n/a	n/a	R
40144	S16	Continuous VAR Capability in Quadrant 1	10 VAR	40148	4000	n/a	n/a	R
40145	S16	Continuous VAR Capability in Quadrant 2	10 VAR	40148	4000	n/a	1	R
40146	S16	Continuous VAR Capability in Quadrant 3	10 VAR	40148	-4000	n/a	1	R
40147	S16	Continuous VAR Capability in Quadrant 4	10 VAR	40148	-4000	n/a	1	R
40148	S16	Scale Factor - Continuous VAR in Quadrant n	sunssf	n/a	1	n/a	n/a	R
40149	U16	Max RMS AC Current Capability (per phase): Current rating under nominal voltage and nominal power factor.	0.1 ARMS	40150	500	n/a	n/a	R
40150	S16	Scale Factor - Max RMS AC Current	sunssf	n/a	-1	n/a	n/a	R
40151	S16	Min Power Factor Capability in Quadrant 1: Cosine of phase angle between fundamental voltage and current using EEI sign convention, reference Figure 33	n/a	40155	0	n/a	n/a	R
40152	S16	Min Power Factor Capability in Quadrant 2	n/a	40155	0	n/a	n/a	R
40153	S16	Min Power Factor Capability in Quadrant 3	n/a	40155	0	n/a	n/a	R
40154	S16	Min Power Factor Capability in Quadrant 4	n/a	40155	0	n/a	n/a	R
40155	S16	Scale Factor – Power Factor	sunssf	n/a	-3	n/a	n/a	R

[1]Units include applied scale factor register

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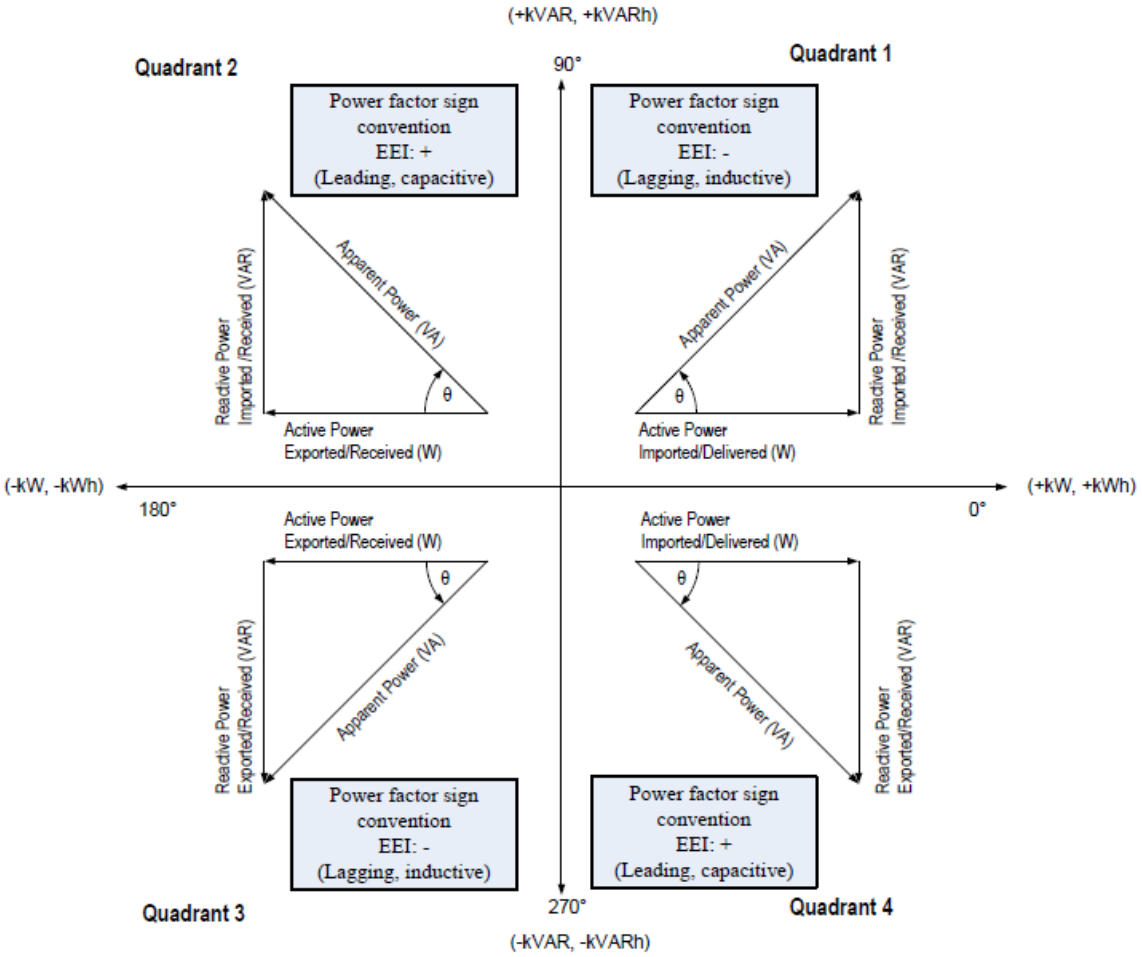

Figure 33 - EEI Power Factor Sign Convention

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SunSpec Model 121 Registers – Basic Settings

Number	Data Type	Description	Units[1]	Scale Factor (Reg #)	Factory Default	Min	Max	Access Level
Header:								
40165	U16	Model Identifier	n/a	n/a	121	n/a	n/a	R
40166	U16	Model Length - # of 16-bit registers to follow	n/a	n/a	30	n/a	n/a	R
Fixed Block:								
40167	U16	Maximum Output Power	10 W	40187	4000	0	4000	RWO
40168	U16	Voltage at the PCC (RMS, line-to-line)	0.1 VRMS	40188	4800	2080	4800	RWO
40173	S16	Maximum Reactive Power in Quadrant 1 (see Note 2 below)	10 VAr	40192	4000	0	4000	RWO
40174	S16	Maximum Reactive Power in Quadrant 2 (see Note 2 below)	10 VAr	40192	4000	0	4000	RWO
40175	S16	Maximum Reactive Power in Quadrant 3 (see Note 2 below)	10 VAr	40192	-4000	-4000	0	RWO
40176	S16	Maximum Reactive Power in Quadrant 4 (see Note 2 below)	10 VAr	40192	-4000	-4000	0	RWO
40177	U16	Ramp Rate for change in Power Setpoint	0.1 %WMAX/ SEC	40193	1000	1	10000	RW
40185	U16	Setpoint for Nominal Frequency at the ECP	0.01 Hz	40196	6000	4500	6500	RWO
40187	S16	Scale Factor – Real Power	sunssf	n/a	1	n/a	n/a	R
40188	S16	Scale Factor – Voltage at the PCC	sunssf	n/a	-1	n/a	n/a	R
40190	S16	Scale Factor – Min/Max voltages	sunssf	n/a	-1	n/a	n/a	R
40192	S16	Scale Factor – Reactive Power	sunssf	n/a	1	n/a	n/a	R
40193	S16	Scale Factor – Default Ramp Rate	sunssf	n/a	-1	n/a	n/a	R
40196	S16	Scale Factor – Nominal Frequency	sunssf	n/a	-2	n/a	n/a	R

[1]Units include applied scale factor register

[2]The PCS does not provide separate max VAr capability in each quadrant – a change to any one of 40173-40176 will be applied to all quadrants equally with the appropriate sign applied for the corresponding quadrant

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SunSpec Model 122 Registers – Measurement Status

Number	Data Type	Description	Units[1]	Scale Factor (Reg #)	Factory Default	Min	Max	Access Level
Header:								
40197	U16	Model Identifier	n/a	n/a	122	n/a	n/a	R
40198	U16	Model Length - # of 16-bit registers to follow	n/a	n/a	44	n/a	n/a	R
Fixed Block:								
40240	U16	Bit Mask indicating Active Ride Through Status: **Bit 0** = LVRT Active **Bit 2** = LFRT Active **Bit 1** = HVRT Active **Bit 3** = HFRT active	ENUM	n/a	n/a	n/a	n/a	R

[1]Units include applied scale factor register

SunSpec Model 123 Registers – Immediate Controls

Number	Data Type	Description	Units[1]	Scale Factor (Reg #)	Factory Default	Min	Max	Access Level
Header:								
40243	U16	Model Identifier	n/a	n/a	122	n/a	n/a	R
40244	U16	Model Length - # of 16-bit registers to follow	n/a	n/a	44	n/a	n/a	R
Fixed Block:								
40247	U16	Connection Control: **0** = Disconnect: Forces the PCS to open AC and DC contactors. **1** = Connect: Allows the PCS to close the AC and DC contactors. Note that the user must still "Start" the PCS using the MESA extension register 41123.	ENUM	n/a	0	0	1	RWC
40248	S16	Power Setpoint – % of W max	%	40266	0	-1000	1000	RWC
40252	U16	Power Setpoint – Enable/Disable: **0** = Disabled; **1** = Enabled	ENUM	n/a	0	0	1	RWC
40253	S16	Power Factor Setpoint	n/a	40267	1000	-1000	1000	RWC
40257	U16	Power Factor Setpoint – Enable/Disable: **0** = Disabled; **1** = Enabled (Ignored if **40265** is set to 1 to enable Reactive Power Setpoints)	ENUM	n/a	0	0	1	RWC
40259	S16	Reactive Power Setpoint – % of VAr max	%	40268	0	-1000	1000	RWC

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Number	Data Type	Description	Units[1]	Scale Factor (Reg #)	Factory Default	Min	Max	Access Level
40265	U16	Reactive Power Setpoint – Enable/Disable: **0** = Disabled; **1** = Enabled *(Ignored if **40257** is set to 1 to Power Factor Setpoints)*	ENUM	n/a	0	0	1	RWC
40266	S16	Scale Factor – Power Setpoint	sunssf	n/a	-1	n/a	n/a	R
40267	S16	Scale Factor – Power Factor Setpoint	sunssf	n/a	-3	n/a	n/a	R
40268	S16	Scale Factor – Reactive Power Setpoint	sunssf	n/a	-1	n/a	n/a	R

[1] Units include applied scale factor register

SunSpec Model 121 Registers – Basic Settings

Number	Data Type	Description	Units[1]	Scale Factor (Reg #)	Factory Default	Min	Max	Access Level
Header:								
40165	U16	Model Identifier	n/a	n/a	126	n/a	n/a	R
40166	U16	Model Length - # of 16-bit registers to follow	n/a	n/a	126	n/a	n/a	R
Fixed Block:								
40167	U16	Active Curve: **0** = No active curve, **1..3** = Active Curve 1..3	ENUM	n/a	2	0	3	RW
40168	U16	Volt-VAR Enable/Disable: **Bit 0**: 1 = Enable, 0 = Disable	BitField	n/a	0	0	1	RW
41658	U16	Number of Curves Supported	n/a	n/a	3	n/a	n/a	R
41659	U16	Number of Curve Points Supported	n/a	n/a	12	n/a	n/a	R
41660	U16	Scale Factor – Voltage	sunssf	n/a	-2	n/a	n/a	R
41661	S16	Scale Factor – Reactive Power	sunssf	n/a	-2	n/a	n/a	R
Repeating Block #1:								
41663	U16	Volt-VAR Curve 1: Number of Active Points in Array	n/a	n/a	4	1	12	RW
41664	U16	Volt-VAR Curve 1: Dependent Variable Ref (% of Reg **40173** – VARmax)	ENUM	n/a	2	n/a	n/a	R
41665	U16	Volt-VAR Curve 1: Point 1 – Voltage (% of Reg **40168** – Vref)	0.01 %	41660	9500	5000	15000	RW
41666	S16	Volt-VAR Curve 1: Point 1 – VAR (% of Reg **40173** – VARmax)	0.01 %	41661	5000	-10000	10000	RW
41667	U16	Volt-VAR Curve 1: Point 2 – Voltage (% of Reg **40168** – Vref)	0.01 %	41660	9900	5000	15000	RW
41668	S16	Volt-VAR Curve 1: Point 2 – VAR (% of Reg **40173** – VARmax)	0.01 %	41661	0	-10000	10000	RW
41669	U16	Volt-VAR Curve 1: Point 3 – Voltage (% of Reg **40168** – Vref)	0.01 %	41660	10100	5000	15000	RW

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Number	Data Type	Description	Units[1]	Scale Factor (Reg #)	Factory Default	Min	Max	Access Level
41670	S16	Volt-VAR Curve 1: Point 3 – VAR (% of Reg **40173** – VARmax)	0.01 %	41661	0	-10000	10000	RW
41671	U16	Volt-VAR Curve 1: Point 4 – Voltage (% of Reg **40168** – Vref)	0.01 %	41660	10500	5000	15000	RW
41672	S16	Volt-VAR Curve 1: Point 4 – VAR (% of Reg **40173** – VARmax)	0.01 %	41661	-5000	-10000	10000	RW
41673–41688	U16 S16	Volt-VAR Curve 1: Points 5 thru 12 – Voltage (% of Reg **40168** – Vref)	0.01 %	41660	10000	5000	15000	RW
		Volt-VAR Curve 1: Points 5 thru 12 – VAR (% of Reg **40173** – VARmax)	0.01 %	41661	0	-10000	10000	RW
41716	U16	Volt-VAR Curve 1: Read Only: **0** = Read/ Write; **1** = Read Only	ENUM	n/a	0	n/a	n/a	R
Repeating Block #2:								
41717	U16	Volt-VAR Curve 2: Number of Active Points in Array	n/a	n/a	4	1	12	RW
41718	U16	Volt-VAR Curve 2: Dependent Variable Ref (% of Reg **40173** – VARmax)	ENUM	n/a	2	n/a	n/a	R
41719	U16	Volt-VAR Curve 2: Point 1 – Voltage (% of Reg **40168** – Vref)	0.01 %	41660	9200	5000	15000	RW
41720	S16	Volt-VAR Curve 2: Point 1 – VAR (% of Reg **40173** – VARmax)	0.01 %	41661	3000	-10000	10000	RW
41721	U16	Volt-VAR Curve 2: Point 2 – Voltage (% of Reg **40168** – Vref)	0.01 %	41660	9670	5000	15000	RW
41722	S16	Volt-VAR Curve 2: Point 2 – VAR (% of Reg **40173** – VARmax)	0.01 %	41661	0	-10000	10000	RW
41723	U16	Volt-VAR Curve 2: Point 3 – Voltage (% of Reg **40168** – Vref)	0.01 %	41660	10330	5000	15000	RW
41724	S16	Volt-VAR Curve 2: Point 3 – VAR (% of Reg **40173** – VARmax)	0.01 %	41661	0	-10000	10000	RW
41725	U16	Volt-VAR Curve 2: Point 4 – Voltage (% of Reg **40168** – Vref)	0.01 %	41660	10700	5000	15000	RW
41726	S16	Volt-VAR Curve 2: Point 4 – VAR (% of Reg **40173** – VARmax)	0.01 %	41661	-3000	-10000	10000	RW
41727–41742	U16 S16	Volt-VAR Curve 2: Points 5 thru 12 – Voltage (% of Reg **40168** – Vref)	0.01 %	41660	10000	5000	15000	RW
		Volt-VAR Curve 2: Points 5 thru 12 – VAR (% of Reg **40173** – VARmax)	0.01 %	41661	0	-10000	10000	RW
41770	U16	Volt-VAR Curve 2: Read Only: **0** = Read/ Write; **1** = Read Only	ENUM	n/a	0	n/a	n/a	R
Repeating Block #3:								
41771	U16	Volt-VAR Curve 3: Number of Active Points in Array	n/a	n/a	4	1	12	RW

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Number	Data Type	Description	Units[1]	Scale Factor (Reg #)	Factory Default	Min	Max	Access Level
41772	U16	Volt-VAR Curve 3: Dependent Variable Ref (% of Reg **40173** – VARmax)	ENUM	n/a	2	n/a	n/a	R
41773	U16	Volt-VAR Curve 3: Point 1 – Voltage (% of Reg **40168** – Vref)	0.01 %	41660	9000	5000	15000	RW
41774	S16	Volt-VAR Curve 3: Point 1 – VAR (% of Reg **40173** – VARmax)	0.01 %	41661	1000	-10000	10000	RW
41775	U16	Volt-VAR Curve 3: Point 2 – Voltage (% of Reg **40168** – Vref)	0.01 %	41660	9500	5000	15000	RW
41776	S16	Volt-VAR Curve 3: Point 2 – VAR (% of Reg **40173** – VARmax)	0.01 %	41661	0	-10000	10000	RW
41777	U16	Volt-VAR Curve 3: Point 3 – Voltage (% of Reg **40168** – Vref)	0.01 %	41660	10500	5000	15000	RW
41778	S16	Volt-VAR Curve 3: Point 3 – VAR (% of Reg **40173** – VARmax)	0.01 %	41661	0	-10000	10000	RW
41779	U16	Volt-VAR Curve 3: Point 4 – Voltage (% of Reg **40168** – Vref)	0.01 %	41660	11000	5000	15000	RW
41780	S16	Volt-VAR Curve 3: Point 4 – VAR (% of Reg **40173** – VARmax)	0.01 %	41661	-1000	-10000	10000	RW
41781–41796	U16 S16	Volt-VAR Curve 3: Points 5 thru 12 – Voltage (% of Reg **40168** – Vref)	0.01 %	41660	10000	5000	15000	RW
		Volt-VAR Curve 3: Points 5 thru 12 – VAR (% of Reg **40173** – VARmax)	0.01 %	41661	0	-10000	10000	RW
41824	U16	Volt-VAR Curve 3: Read Only: **0** = Read/ Write; **1** = Read Only	ENUM	n/a	0	n/a	n/a	R

[1]Units include applied scale factor register

[2]Active curve data is only updated on POR

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SunSpec Model 130 Registers – HVRT Disconnect (Trip) Arrays

Number	Data Type	Description	Units[1]	Scale Factor (Reg #)	Factory Default	Min	Max	Access Level
Header:								
40481	U16	Model Identifier	n/a	n/a	130	n/a	n/a	R
40482	U16	Model Length - # of 16-bit registers to follow	n/a	n/a	210	n/a	n/a	R
Fixed Block:								
40483	U16	Active Curve: **0** = No active curve, **1** = Active Curve 1 **Note:** If Active Curve = 0, then "Default Grid High Voltage Threshold" register **41169** is used to define the immediate disconnect threshold.	ENUM	n/a	1	0	1	RWO
40484	U16	HVRT Enable/Disable: **Bit 0 :** 1 = Enable, 0 = Disable **Note:** If disabled, then "Default Grid High Voltage Threshold" register **41169** is used to define the immediate disconnect threshold.	BitField	n/a	1	0	1	RWO
40488	U16	Number of Curves Supported	n/a	n/a	1	n/a	n/a	R
40489	U16	Number of Curve Points Supported	n/a	n/a	20	n/a	n/a	R
40490	S16	Scale Factor – Disconnect Duration	sunssf	n/a	-2	n/a	n/a	R
40491	S16	Scale Factor – Disconnect Voltage (% of Vref, Reg **40168**)	sunssf	n/a	-1	n/a	n/a	R
40492	U16	Pad – Force even alignment	n/a	n/a	0x8000	n/a	n/a	R
Repeating Block #1:								
40493	U16	HVRTD Curve 1: Number of Active Points in Array	n/a	n/a	4	2	20	RW
40494	U16	HVRTD Curve 1: Point 1 – Ride Through Until Duration[2]	0.01 Sec	40490	0	0	6000	RW
40495	U16	HVRTD Curve 1: Point 1 – Voltage (% of Vref, Reg **40168**)	0.1 %	40491	1200	1000	1300	RW
40496	U16	HVRTD Curve 1: Point 2 – Ride Through Until Duration[2]	0.01 Sec	40490	1200	0	6000	RW
40497	U16	HVRTD Curve 1: Point 2 – Voltage (% of Vref, Reg **40168**)	0.1 %	40491	1200	1000	1300	RW
40498	U16	HVRTD Curve 1: Point 3 – Ride Through Until Duration[2]	0.01 Sec	40490	1200	0	6000	RW
40499	U16	HVRTD Curve 1: Point 3 – Voltage (% of Vref, Reg **40168**)	0.1 %	40491	1100	1000	1300	RW
40500	U16	HVRTD Curve 1: Point 4 – Ride Through Until Duration[2]	0.01 Sec	40490	2200	0	6000	RW
40501	U16	HVRTD Curve 1: Point 4 – Voltage (% of Vref, Reg **40168**)	0.1 %	40491	1100	1000	1300	RW

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Number	Data Type	Description	Units[1]	Scale Factor (Reg #)	Factory Default	Min	Max	Access Level
40502-40533	U16	HVRTD Curve 1: Points 5 thru 20 – Ride Through Until Duration[2]	0.01 Sec	40490	0	0	6000	RW
		HVRTD Curve 1: Points 5 thru 20 – Voltage (% of Vref, Reg **40168**)	0.1 %	40491	1200	1000	1300	RW
40542	U16	HVRTD Curve 1: Read Only: **0** = Read/Write; **1** = Read Only	ENUM	n/a	0	n/a	n/a	R
Repeating Block #2 (not used):								
40543	U16	HVRTD Curve 2: Number of Active Points in Array	n/a	n/a	0	n/a	n/a	R
40544	U16	HVRTD Curve 2: Point 1 – Ride Through Until Duration[2]	0.01 Sec	40490	0	n/a	n/a	R
40545	U16	HVRTD Curve 2: Point 1 – Voltage (% of Vref, Reg 40168)	0.1 %	40491	0	n/a	n/a	R
40592	U16	HVRTD Curve 2: Read Only: 0 = Read/Write; 1 = Read Only	ENUM	n/a	1	n/a	n/a	R
Repeating Block #3 (not used):								
40593	U16	HVRTD Curve 3: Number of Active Points in Array	n/a	n/a	0	n/a	n/a	R
40594	U16	HVRTD Curve 3: Point 1 – Ride Through Until Duration[2]	0.01 Sec	40490	0	n/a	n/a	R
40595	U16	HVRTD Curve 3: Point 1 – Voltage (% of Vref, Reg **40168**)	0.1 %	40491	0	n/a	n/a	R
40642	U16	HVRTD Curve 3: Read Only: **0** = Read/Write; **1** = Read Only	ENUM	n/a	1	n/a	n/a	R
Repeating Block #4 (not used):								
40643	U16	HVRTD Curve 4: Number of Active Points in Array	n/a	n/a	0	n/a	n/a	R
40644	U16	HVRTD Curve 4: Point 1 – Ride Through Until Duration2	0.01 Sec	40490	0	n/a	n/a	R
40645	U16	HVRTD Curve 4: Point 1 – Voltage (% of Vref, Reg **40168**)	0.1 %	40491	0	n/a	n/a	R
40692	U16	HVRTD Curve 4: Read Only: **0** = Read/Write; **1** = Read Only	ENUM	n/a	1	n/a	n/a	R

[1]Units include applied scale factor register

[2] The PCS will go Offline within a 100msec (max) trip delay, following the “Ride Through Until Duration”

[3] Active curve data is only updated on POR or when selected or enabled via registers 40483 and 40484

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SunSpec Model 132 Registers – Volt-Watt P MAX Arrays

Number	Data Type	Description	Units[1]	Scale Factor (Reg #)	Factory Default	Min	Max	Access Level
Header:								
42073	U16	Model Identifier	n/a	n/a	132	n/a	n/a	R
40166	U16	Model Length - # of 16-bit registers to follow	n/a	n/a	172	n/a	n/a	R
Fixed Block:								
42075	U16	Active Curve: **0** = No active curve, **1..3** = Active Curve 1..3	ENUM	n/a	2	0	3	RW
42076	U16	Volt-Watt Pmax Enable/Disable: **Bit 0** : 1 = Enable, 0 = Disable	BitField	n/a	0	0	1	RW
42080	U16	Number of Curves Supported	n/a	n/a	3	n/a	n/a	R
42081	U16	Number of Curve Points Supported	n/a	n/a	10	n/a	n/a	R
42082	S16	Scale Factor – Voltage	sunssf	n/a	-2	n/a	n/a	R
42083	S16	Scale Factor – Real Power	sunssf	n/a	-2	n/a	n/a	R
Repeating Block #1:								
42085	U16	Volt-Watt P MAX Curve 1: Number of Active Points in Array	n/a	n/a	2	2	10	RW
42086	U16	Volt-Watt P MAX Curve 1: Dependent Variable (% of Reg **40167** – Wmax)	ENUM	n/a	1	n/a	n/a	R
42087	U16	Volt-Watt P MAX Curve 1: Point 1 – Voltage (% of Reg **40168** – Vref)	0.01 %	42082	10600	5000	15000	RW
42088	S16	Volt-Watt P MAX Curve 1: Point 1 – Watts (% of Reg **40167** – Wmax)	0.01 %	42083	10000	-10000	10000	RW
42089	U16	Volt-Watt P MAX Curve 1: Point 2 – Voltage (% of Reg **40168** – Vref)	0.01 %	42082	12000	5000	15000	RW
42090	S16	Volt-Watt P MAX Curve 1: Point 2 – Watts (% of Reg **40167** – Wmax)	0.01 %	42083	0	-10000	10000	RW
42091-42106	U16 S16	Volt-Watt P MAX Curve 1: Points 3 thru 10 – Voltage (% of Reg **40168** – Vref)	0.01 %	42082	10000	5000	15000	RW
		Volt-Watt P MAX Curve 1: Points 3 thru 10 – Watts (% of Reg **40167** – Wmax)	0.01 %	42083	0	-10000	10000	RW
42138	U16	Volt-Watt P MAX Curve 1: Read Only: **0** = Read/Write; **1** = Read Only	ENUM	n/a	0	n/a	n/a	R
Repeating Block #2:								
42139	U16	Volt-Watt P MAX Curve 2: Number of Active Points in Array	n/a	n/a	2	2	10	RW
42140	U16	Volt-Watt P MAX Curve 2: Dependent Variable (% of Reg **40167** – Wmax)	ENUM	n/a	1	n/a	n/a	R
42141	U16	Volt-Watt P MAX Curve 2: Point 1 – Voltage (% of Reg **40168** – Vref)	0.01 %	42082	10600	5000	15000	RW
42142	S16	Volt-Watt P MAX Curve 2: Point 1 – Watts (% of Reg **40167** – Wmax)	0.01 %	42083	10000	-10000	10000	RW

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Number	Data Type	Description	Units[1]	Scale Factor (Reg #)	Factory Default	Min	Max	Access Level
42143	U16	Volt-Watt P MAX Curve 2: Point 2 – Voltage (% of Reg **40168** – Vref)	0.01 %	42082	11000	5000	15000	RW
42144	S16	Volt-Watt P MAX Curve 2: Point 2 – Watts (% of Reg **40167** – Wmax)	0.01 %	42083	0	-10000	10000	RW
42145-42160	U16 S16	Volt-Watt P MAX Curve 2: Points 3 thru 10 – Voltage (% of Reg **40168** – Vref)	0.01 %	42082	10000	5000	15000	RW
		Volt-Watt P MAX Curve 2: Points 3 thru 10 – Watts (% of Reg **40167** – Wmax)	0.01 %	42083	0	-10000	10000	RW
42192	U16	Volt-Watt Pmax Curve 2: Read Only: **0** = Read/Write; **1** = Read Only	ENUM	n/a	0	n/a	n/a	R
Repeating Block #3:								
42193	U16	Volt-Watt P MAX Curve 3: Number of Active Points in Array	n/a	n/a	2	2	10	RW
42194	U16	Volt-Watt P MAX Curve 3: Dependent Variable (% of Reg **40167** – Wmax)	ENUM	n/a	1	n/a	n/a	R
42195	U16	Volt-Watt P MAX Curve 3: Point 1 – Voltage (% of Reg **40168** – Vref)	0.01 %	42082	10300	5000	15000	RW
42196	S16	Volt-Watt P MAX Curve 3: Point 1 – Watts (% of Reg **40167** – Wmax)	0.01 %	42083	10000	-10000	10000	RW
42197	U16	Volt-Watt P MAX Curve 3: Point 2 – Voltage (% of Reg **40168** – Vref)	0.01 %	42082	10600	5000	15000	RW
42198	S16	Volt-Watt P MAX Curve 3: Point 2 – Watts (% of Reg **40167** – Wmax)	0.01 %	42083	0	-10000	10000	RW
42199-42214	U16 S16	Volt-Watt P MAX Curve 3: Points 3 thru 10 – Voltage (% of Reg **40168** – Vref)	0.01 %	42082	10000	5000	15000	RW
		Volt-Watt P MAX Curve 3: Points 3 thru 10 – Watts (% of Reg **40167** – Wmax)	0.01 %	42083	0	-10000	10000	RW
42246	U16	Volt-Watt P MAX Curve 3: Read Only: **0** = Read/Write; **1** = Read Only	ENUM	n/a	0	n/a	n/a	R

[1]Units include applied scale factor register

[2] Active curve data is only updated on POR

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SunSpec Model 134 Registers – Frequency-Watt Pmax Arrays

Number	Data Type	Description	Units[1]	Scale Factor (Reg #)	Factory Default	Min	Max	Access Level
Header:								
42247	U16	Model Identifier	n/a	n/a	134	n/a	n/a	R
42248	U16	Model Length - # of 16-bit registers to follow	n/a	n/a	184	n/a	n/a	R
Fixed Block:								
42249	U16	Active Curve: **0** = No active curve, **1..3** = Active Curve 1..3	ENUM	n/a	1	0	3	RW
42250	U16	Frequency-Watt P MAX Enable/Disable: **Bit 0**: 1 = Enable, 0 = Disable	BitField	n/a	0	0	1	RW
42254	U16	Number of Curves Supported	n/a	n/a	3	n/a	n/a	R
42255	U16	Number of Curve Points Supported	n/a	n/a	10	n/a	n/a	R
42256	S16	Scale Factor – Frequency	sunssf	n/a	-2	n/a	n/a	R
42257	S16	Scale Factor – Real Power	sunssf	n/a	-2	n/a	n/a	R
Repeating Block #1:								
42259	U16	Freq-Watt P MAX Curve 1: Number of Active Points in Array	n/a	n/a	2	2	10	RW
42260	U16	Freq-Watt P MAX Curve 1: Point 1 – Frequency	0.01 Hz	42256	6100	5000	7000	RW
42261	S16	Freq-Watt P MAX Curve 1: Point 1 – Watts (% of Reg **40167** – Wmax)	0.01 %	42257	10000	-10000	10000	RW
42262	U16	Freq-Watt P MAX Curve 1: Point 2 – Frequency	0.01 Hz	42256	6500	5000	7000	RW
42263	S16	Freq-Watt Pmax Curve 1: Point 2 – Watts (% of Reg **40167** – W MAX)	0.01 %	42257	-10000	-10000	10000	RW
42264-42279	U16 S16	Freq-Watt P MAX Curve 1: Points 3 thru 10 – Frequency	0.01 Hz	42256	6300	5000	7000	RW
		Freq-Watt P MAX Curve 1: Points 3 thru 10 – Watts (% of Reg **40167** – Wmax)	0.01 %	42257	0	-10000	10000	RW
42316	U16	Freq-Watt P MAX Curve 1: Read Only: **0** = Read/Write; **1** = Read Only	ENUM	n/a	0	n/a	n/a	R
Repeating Block #2:								
42317	U16	Freq-Watt P MAX Curve 2: Number of Active Points in Array	n/a	n/a	2	2	10	RW
42318	U16	Freq-Watt P MAX Curve 2: Point 1 – Frequency	0.01 Hz	42256	6050	5000	7000	RW
42319	S16	Freq-Watt P MAX Curve 2: Point 1 – Watts (% of Reg **40167** – Wmax)	0.01 %	42257	10000	-10000	10000	RW
42320	U16	Freq-Watt P MAX Curve 2: Point 2 – Frequency	0.01 Hz	42256	6250	5000	7000	RW
42321	S16	Freq-Watt P MAX Curve 2: Point 2 – Watts (% of Reg **40167** – Wmax)	0.01 %	42257	-10000	-10000	10000	RW

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Number	Data Type	Description	Units[1]	Scale Factor (Reg #)	Factory Default	Min	Max	Access Level
42322-42337	U16 S16	Freq-Watt P MAX Curve 2: Points 3 thru 10 – Frequency	0.01 Hz	42256	6300	5000	7000	RW
		Freq-Watt P MAX Curve 2: Points 3 thru 10 – Watts (% of Reg **40167** – Wmax)	0.01 %	42257	0	-10000	10000	RW
42374	U16	Freq-Watt P MAX Curve 2: Read Only: **0** = Read/Write; **1** = Read Only	ENUM	n/a	0	n/a	n/a	R
Repeating Block #3:								
42375	U16	Freq-Watt P MAX Curve 3: Number of Active Points in Array	n/a	n/a	2	2	10	RW
42376	U16	Freq-Watt P MAX Curve 3: Point 1 – Frequency	0.01 Hz	42256	6002	5000	7000	RW
42377	S16	Freq-Watt P MAX Curve 3: Point 1 – Watts (% of Reg 40167 – Wmax)	0.01 %	42257	10000	-10000	10000	RW
42378	U16	Freq-Watt P MAX Curve 3: Point 2 – Frequency	0.01 Hz	42256	6102	5000	7000	RW
42379	S16	Freq-Watt P MAX Curve 3: Point 2 – Watts (% of Reg **40167** – Wmax)	0.01 %	42257	-10000	-10000	10000	RW
42380-42395	U16 S16	Freq-Watt P MAX Curve 3: Points 3 thru 10 – Frequency	0.01 Hz	42256	6300	5000	7000	RW
		Freq-Watt P MAX Curve 3: Points 3 thru 10 – Watts (% of Reg **40167** – Wmax)	0.01 %	42257	0	-10000	10000	RW
42432	U16	Freq-Watt P MAX Curve 3: Read Only: **0** = Read/Write; **1** = Read Only	ENUM	n/a	0	n/a	n/a	R

[1]Units include applied scale factor register

[2] Active curve data is only updated on POR

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SunSpec Model 135 Registers – LFRT Disconnect (Trip) Arrays

Number	Data Type	Description	Units[1]	Scale Factor (Reg #)	Factory Default	Min	Max	Access Level
Header:								
40693	U16	Model Identifier	n/a	n/a	135	n/a	n/a	R
40694	U16	Model Length - # of 16-bit registers to follow	n/a	n/a	210	n/a	n/a	R
Fixed Block:								
40695	U16	Active Curve: **0** = No active curve, **1** = Active Curve 1 ***Note:*** If Active Curve = 0, then "Default Grid Low Frequency Threshold" register **41172** is used to define the immediate disconnect threshold.	ENUM	n/a	1	0	1	RW
40696	U16	LFRT Enable/Disable: **Bit 0** : 1 = Enable, 0 = Disable ***Note:*** If disabled, then "Default Grid Low Frequency Threshold" register **41172** is used to define the immediate disconnect threshold.	BitField	n/a	1	0	1	RW
40700	U16	Number of Curves Supported	n/a	n/a	1	n/a	n/a	R
40701	U16	Number of Curve Points Supported	n/a	n/a	20	n/a	n/a	R
40702	S16	Scale Factor – Disconnect Duration (0.01 Sec units shown below are for default scale factor, can be changed to 0.1 or 1.0 Sec using this register)	sunssf	n/a	-2	-2	0	RW
40703	S16	Scale Factor – Disconnect Frequency	sunssf	n/a	-2	n/a	n/a	R
40704	U16	Pad – Force even alignment	n/a	n/a	0x8000	n/a	n/a	R
Repeating Block #1:								
40705	U16	LFRT Curve 1: Number of Active Points in Array	n/a	n/a	4	2	20	RW
40706	U16	LFRT Curve 1: Point 1 – Ride Through Until Duration[2]	0.01 Sec	40702	0	0	50000	RW
40707	U16	LFRT Curve 1: Point 1 – Frequency	0.01 Hz	40703	5700	4000	6000	RW
40708	U16	LFRT Curve 1: Point 2 – Ride Through Until Duration[2]	0.01 Sec	40702	29900	0	50000	RW
40709	U16	LFRT Curve 1: Point 2 – Frequency	0.01 Hz	40703	5700	4000	6000	RW
40710	U16	LFRT Curve 1: Point 3 – Ride Through Until Duration[2]	0.01 Sec	40702	29900	0	50000	RW
40711	U16	LFRT Curve 1: Point 3 – Frequency	0.01 Hz	40703	5850	4000	6000	RW
40712	U16	LFRT Curve 1: Point 4 – Ride Through Until Duration[2]	0.01 Sec	40702	40000	0	50000	RW
40713	U16	LFRT Curve 1: Point 4 – Frequency	0.01 Hz	40703	5850	4000	6000	RW

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Number	Data Type	Description	Units[1]	Scale Factor (Reg #)	Factory Default	Min	Max	Access Level
40714-40745	U16	LFRT Curve 1: Points 5 thru 20 – Ride Through Until Duration[2]	0.01 Sec	40702	0	0	50000	RW
		LFRT Curve 1: Points 5 thru 20 – Frequency	0.01 Hz	40703	4000	4000	6000	RW
40754	U16	LFRT Curve 1: Read Only: **0** = Read/Write; **1** = Read Only	ENUM	n/a	0	n/a	n/a	R
Repeating Block #2 (not used):								
40755	U16	LFRT Curve 2: Number of Active Points in Array	n/a	n/a	0	n/a	n/a	R
40756	U16	LFRT Curve 2: Point 1 – Ride Through Until Duration[2]	0.01 Sec	40702	0	n/a	n/a	R
40757	U16	LFRT Curve 2: Point 1 – Frequency	0.01 Hz	40703	0	n/a	n/a	R
40804	U16	LFRT Curve 2: Read Only: **0** = Read/Write; **1** = Read Only	ENUM	n/a	1	n/a	n/a	R
Repeating Block #3 (not used):								
40805	U16	LFRT Curve 3: Number of Active Points in Array	n/a	n/a	0	n/a	n/a	R
40806	U16	LFRT Curve 3: Point 1 – Ride Through Until Duration[2]	0.01 Sec	40702	0	n/a	n/a	R
40807	U16	LFRT Curve 3: Point 1 – Frequency	0.01 Hz	40703	0	n/a	n/a	R
40854	U16	LFRT Curve 3: Read Only: **0** = Read/Write; **1** = Read Only	ENUM	n/a	1	n/a	n/a	R
Repeating Block #4 (not used):								
40855	U16	LFRT Curve 4: Number of Active Points in Array	n/a	n/a	0	n/a	n/a	R
40856	U16	LFRT Curve 4: Point 1 – Ride Through Until Duration[2]	0.01 Sec	40702	0	n/a	n/a	R
40857	U16	LFRT Curve 4: Point 1 – Frequency	0.01 Hz	40703	0	n/a	n/a	R
40904	U16	LFRT Curve 4: Read Only: **0** = Read/Write; **1** = Read Only	ENUM	n/a	1	n/a	n/a	R

[1]Units include applied scale factor register

[2] The PCS will go Offline within a 100msec (max) trip delay, following the “Ride Through Until Duration”

[3] Active curve data is only updated on POR or when selected or enabled via registers 40695 and 40696

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SunSpec Model 136 Registers – HFRT Disconnect (Trip) Arrays

Number	Data Type	Description	Units[1]	Scale Factor (Reg #)	Factory Default	Min	Max	Access Level
Header:								
40905	U16	Model Identifier	n/a	n/a	136	n/a	n/a	R
40906	U16	Model Length - # of 16-bit registers to follow	n/a	n/a	210	n/a	n/a	R
Fixed Block:								
40907	U16	Active Curve: **0** = No active curve, **1** = Active Curve 1 ***Note:*** If Active Curve = 0, then "Default Grid Low Frequency Threshold" register **41171** is used to define the immediate disconnect threshold.	BitField	n/a	1	0	1	RWO
40908	U16	HFRT Enable/Disable: **Bit 0** : 1 = Enable, 0 = Disable ***Note:*** If disabled, then "Default Grid High Frequency Threshold" register **41171** is used to define the immediate disconnect threshold.	n/a	n/a	1	n/a	n/a	R
40912	U16	Number of Curves Supported	n/a	n/a	20	n/a	n/a	R
40913	U16	Number of Curve Points Supported	sunssf	n/a	-2	-2	0	RW
40914	S16	Scale Factor – Disconnect Duration (0.01 Sec units shown below are for default scale factor, can be changed to 0.1 or 1.0 Sec using this register)	sunssf	n/a	-2	n/a	n/a	R
40915	S16	Scale Factor – Disconnect Frequency	sunssf	n/a	-2	n/a	n/a	R
40916	U16	Pad – Force even alignment	n/a	n/a	0x8000	n/a	n/a	R
Repeating Block #1:								
40917	U16	HFRT Curve 1: Number of Active Points in Array	n/a	n/a	4	2	20	RW
40918	U16	HFRT Curve 1: Point 1 – Ride Through Until Duration[2]	0.01 Sec	40914	0	0	50000	RW
40919	U16	HFRT Curve 1: Point 1 – Frequency	0.01 Hz	40915	6200	5000	7000	RW
40920	U16	HFRT Curve 1: Point 2 – Ride Through Until Duration[2]	0.01 Sec	40914	29900	0	50000	RW
40921	U16	HFRT Curve 1: Point 2 – Frequency	0.01 Hz	40915	6200	5000	7000	RW
40922	U16	HFRT Curve 1: Point 3 – Ride Through Until Duration[2]	0.01 Sec	40914	29900	0	50000	RW
40923	U16	HFRT Curve 1: Point 3 – Frequency	0.01 Hz	40915	6050	5000	7000	RW
40924	U16	HFRT Curve 1: Point 4 – Ride Through Until Duration[2]	0.01 Sec	40914	40000	0	50000	RW
40925	U16	HFRT Curve 1: Point 4 – Frequency	0.01 Hz	40915	6050	5000	7000	RW

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Number	Data Type	Description	Units[1]	Scale Factor (Reg #)	Factory Default	Min	Max	Access Level
40926-40957	U16	HFRT Curve 1: Points 5 thru 20 – Ride Through Until Duration[2]	0.01 Sec	40914	0	0	50000	RW
		HFRT Curve 1: Points 5 thru 20 – Frequency	0.01 Hz	40915	7000	5000	7000	RW
40966	U16	HFRT Curve 1: Read Only: **0** = Read/Write; **1** = Read Only	ENUM	n/a	0	n/a	n/a	R
Repeating Block #2 (not used):								
40967	U16	HFRT Curve 2: Number of Active Points in Array	n/a	n/a	0	n/a	n/a	R
40968	U16	HFRT Curve 2: Point 1 – Ride Through Until Duration[2]	0.01 Sec	40914	0	n/a	n/a	R
40969	U16	HFRT Curve 2: Point 1 – Frequency	0.01 Hz	40915	0	n/a	n/a	R
41016	U16	HFRT Curve 2: Read Only: **0** = Read/Write; **1** = Read Only	ENUM	n/a	1	n/a	n/a	R
Repeating Block #3 (not used):								
41017	U16	HFRT Curve 3: Number of Active Points in Array	n/a	n/a	0	n/a	n/a	R
41018	U16	HFRT Curve 3: Point 1 – Ride Through Until Duration[2]	0.01 Sec	40914	0	n/a	n/a	R
41019	U16	HFRT Curve 3: Point 1 – Frequency	0.01 Hz	40915	0	n/a	n/a	R
41066	U16	HFRT Curve 3: Read Only: **0** = Read/Write; **1** = Read Only	ENUM	n/a	1	n/a	n/a	R
Repeating Block #4 (not used):								
41067	U16	HFRT Curve 4: Number of Active Points in Array	n/a	n/a	0	n/a	n/a	R
41068	U16	HFRT Curve 4: Point 1 – Ride Through Until Duration[2]	0.01 Sec	40914	0	n/a	n/a	R
41069	U16	HFRT Curve 4: Point 1 – Frequency	0.01 Hz	40915	0	n/a	n/a	R
41116	U16	HFRT Curve 4: Read Only: **0** = Read/Write; **1** = Read Only	ENUM	n/a	1	n/a	n/a	R

[1]Units include applied scale factor register

[2] The PCS will go Offline within a 100msec (max) trip delay, following the “Ride Through Until Duration”

[3] Active curve data is only updated on POR or when selected or enabled via registers 40907 and 40908

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SunSpec Model 139 Registers – LVRT Extended (Momentary Cessation) Arrays

Number	Data Type	Description	Units[1]	Scale Factor (Reg #)	Factory Default	Min	Max	Access Level
Header:								
41825	U16	Model Identifier	n/a	n/a	139	n/a	n/a	R
41826	U16	Model Length - # of 16-bit registers to follow	n/a	n/a	60	n/a	n/a	R
Fixed Block:								
41827	U16	Active Curve: **0** = No active curve, **1** = Active Curve 1	ENUM	n/a	1	0	1	RWO
41828	U16	LVRTX Enable/Disable: **Bit 0** : 1 = Enable, 0 = Disable	BitField	n/a	1	0	1	RWO
41832	U16	Number of Curves Supported	n/a	n/a	1	n/a	n/a	R
41833	U16	Number of Curve Points Supported	n/a	n/a	20	n/a	n/a	R
41834	S16	Scale Factor – Duration	sunssf	n/a	-2	n/a	n/a	R
41835	S16	Scale Factor – Voltage (% of Vref, Reg **40168**)	sunssf	n/a	-1	n/a	n/a	R
41836	U16	Curve Type: **1** = Cease to Energize	n/a	n/a	1	n/a	n/a	R
Repeating Block #1:								
41837	U16	LVRTX Curve 1: Number of Active Points in Array	n/a	n/a	2	2	20	RW
41838	U16	LVRTX Curve 1: Point 1 – Ride Through Until Duration[2]	0.01 Sec	41834	0	0	6000	RW
41839	U16	LVRTX Curve 1: Point 1 – Voltage (% of Vref, Reg 40168)	0.1 %	41835	500	0	1000	RW
41840	U16	LVRTX Curve 1: Point 2 – Ride Through Until Duration[2]	0.01 Sec	41834	100	0	6000	RW
41841	U16	LVRTX Curve 1: Point 2 – Voltage (% of Vref, Reg **40168**)	0.1 %	41835	500	0	1000	RW
41842-41877	U16	LVRTX Curve 1: Points 3 thru 20 – Ride Through Until Duration[2]	0.01 Sec	41834	0	0	6000	RW
		LVRTX Curve 1: Points 3 thru 20 – Voltage (% of Vref, Reg **40168**)	0.1 %	41835	0	0	1000	RW
41886	U16	LVRTX Curve 1: Read Only: **0** = Read/Write; **1** = Read Only	ENUM	n/a	0	n/a	n/a	R

[1]Units include applied scale factor register

[2] The PCS will go Offline within a 100msec (max) trip delay, following the “Ride Through Until Duration”

[3] Active curve data is only updated on POR or when selected or enabled via registers 41827 and 41828

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SunSpec Model 140 Registers – HVRT Extended (Momentary Cessation) Arrays

Number	Data Type	Description	Units[1]	Scale Factor (Reg #)	Factory Default	Min	Max	Access Level
Header:								
41825	U16	Model Identifier	n/a	n/a	140	n/a	n/a	R
41826	U16	Model Length - # of 16-bit registers to follow	n/a	n/a	60	n/a	n/a	R
Fixed Block:								
41889	U16	Active Curve: **0** = No active curve, **1** = Active Curve 1	ENUM	n/a	1	0	1	RWO
41890	U16	HVRTX Enable/Disable: **Bit 0** : 1 = Enable, 0 = Disable	BitField	n/a	1	0	1	RWO
41894	U16	Number of Curves Supported	n/a	n/a	1	n/a	n/a	R
41895	U16	Number of Curve Points Supported	n/a	n/a	20	n/a	n/a	R
41896	S16	Scale Factor – Duration	sunssf	n/a	-2	n/a	n/a	R
41896	S16	Scale Factor – Voltage (% of Vref, Reg **40168**)	sunssf	n/a	-1	n/a	n/a	R
41898	U16	Curve Type: **1** = Cease to Energize	n/a	n/a	1	n/a	n/a	R
Repeating Block #1:								
41899	U16	HVRTX Curve 1: Number of Active Points in Array	n/a	n/a	2	2	20	RW
41900	U16	HVRTX Curve 1: Point 1 – Ride Through Until Duration[2]	0.01 Sec	41896	0	0	6000	RW
41901	U16	HVRTX Curve 1: Point 1 – Voltage (% of Vref, Reg **40168**)	0.1 %	41897	1100	1000	1300	RW
41902	U16	HVRTX Curve 1: Point 2 – Ride Through Until Duration[2]	0.01 Sec	41896	1200	0	6000	RW
41903	U16	HVRTX Curve 1: Point 2 – Voltage (% of Vref, Reg **40168**)	0.1 %	41897	1100	1000	1300	RW
41904-41939	U16	HVRTX Curve 1: Points 3 thru 20 – Ride Through Until Duration[2]	0.01 Sec	41896	0	0	6000	RW
		HVRTX Curve 1: Points 3 thru 20 – Voltage (% of Vref, Reg **40168**)	0.1 %	41897	1200	1000	1300	RW
41948	U16	HVRTX Curve 1: Read Only: **0** = Read/Write; **1** = Read Only	ENUM	n/a	0	n/a	n/a	R

[1]Units include applied scale factor register

[2] The PCS will go Offline within a 100msec (max) trip delay, following the “Ride Through Until Duration”

[3] Active curve data is only updated on POR or when selected or enabled via registers 41889 and 41890

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SunSpec Model 143 Registers – LFRT Extended (Momentary Cessation) Arrays

Number	Data Type	Description	Units[1]	Scale Factor (Reg #)	Factory Default	Min	Max	Access Level
Header:								
41949	U16	Model Identifier	n/a	n/a	143	n/a	n/a	R
41950	U16	Model Length - # of 16-bit registers to follow	n/a	n/a	60	n/a	n/a	R
Fixed Block:								
41951	U16	Active Curve: **0** = No active curve, **1** = Active Curve 1	ENUM	n/a	1	0	1	RWO
41952	U16	LFRTX Enable/Disable: **Bit 0** : 1 = Enable, 0 = Disable	BitField	n/a	1	0	1	RWO
41956	U16	Number of Curves Supported	n/a	n/a	1	n/a	n/a	R
41957	U16	Number of Curve Points Supported	n/a	n/a	20	n/a	n/a	R
41958	S16	Scale Factor – Duration (0.01 Sec units shown below are for default scale factor, can be changed to 0.1 or 1.0 Sec using this register)	sunssf	n/a	-2	-2	n/a	RW
41959	S16	Scale Factor – Frequency	sunssf	n/a	-2	n/a	n/a	R
41960	U16	Curve Type: **1** = Cease to Energize	n/a	n/a	1	n/a	n/a	R
Repeating Block #1:								
41961	U16	LFRTX Curve 1: Number of Active Points in Array	n/a	n/a	2	2	20	RW
41962	U16	LFRTX Curve 1: Point 1 – Ride Through Until Duration[2]	0.01 Sec	41958	0	0	50000	RW
41963	U16	LFRTX Curve 1: Point 1 – Frequency	0.1 %	41959	4000	4000	6000	RW
41964	U16	LFRTX Curve 1: Point 2 – Ride Through Until Duration[2]	0.01 Sec	41958	0	0	50000	RW
41965	U16	LFRTX Curve 1: Point 2 – Frequency	0.1 %	41959	4000	4000	6000	RW
41966-42001	U16	LFRTX Curve 1: Points 3 thru 20 – Ride Through Until Duration[2]	0.01 Sec	41958	0	0	50000	RW
		LFRTX Curve 1: Points 3 thru 20 – Frequency	0.1 %	41959	4000	4000	6000	RW
42010	U16	LFRTX Curve 1: Read Only: **0** = Read/Write; **1** = Read Only	ENUM	n/a	0	n/a	n/a	R

[1]Units include applied scale factor register

[2] The PCS will go Offline within a 100msec (max) trip delay, following the “Ride Through Until Duration”

[3] Active curve data is only updated on POR or when selected or enabled via registers 41951 and 41952

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SunSpec Model 144 Registers – HFRT Extended (Momentary Cessation) Arrays

Number	Data Type	Description	Units[1]	Scale Factor (Reg #)	Factory Default	Min	Max	Access Level
Header:								
42011	U16	Model Identifier	n/a	n/a	144	n/a	n/a	R
42012	U16	Model Length - # of 16-bit registers to follow	n/a	n/a	60	n/a	n/a	R
Fixed Block:								
42013	U16	Active Curve: **0** = No active curve, **1** = Active Curve 1	ENUM	n/a	1	0	1	RWO
42014	U16	HVRTX Enable/Disable: **Bit 0** : 1 = Enable, 0 = Disable	BitField	n/a	1	0	1	RWO
42018	U16	Number of Curves Supported	n/a	n/a	1	n/a	n/a	R
42019	U16	Number of Curve Points Supported	n/a	n/a	20	n/a	n/a	R
42020	S16	Scale Factor – Duration (0.01 Sec units shown below are for default scale factor, can be changed to 0.1 or 1.0 Sec using this register)	sunssf	n/a	-2	n/a	n/a	R
42021	S16	Scale Factor – Frequency	sunssf	n/a	-1	n/a	n/a	R
42022	U16	Curve Type: **1** = Cease to Energize	n/a	n/a	1	n/a	n/a	R
Repeating Block #1:								
42023	U16	HVRTX Curve 1: Number of Active Points in Array	n/a	n/a	2	2	20	RW
42024	U16	HVRTX Curve 1: Point 1 – Ride Through Until Duration[2]	0.01 Sec	42020	0	0	50000	RW
42025	U16	HFRTX Curve 1: Point 1 – Frequency	0.1 %	42021	7000	5000	7000	RW
42026	U16	HVRTX Curve 1: Point 2 – Ride Through Until Duration[2]	0.01 Sec	42020	0	0	50000	RW
42027	U16	HFRTX Curve 1: Point 2 – Frequency	0.1 %	42021	7000	5000	7000	RW
42028-42063	U16	HVRTX Curve 1: Points 3 thru 20 – Ride Through Until Duration[2]	0.01 Sec	42020	0	0	50000	RW
		HVRTX Curve 1: Points 3 thru 20 – Frequency	0.1 %	42021	7000	5000	7000	RW
42072	U16	HVRTX Curve 1: Read Only: **0** = Read/Write; **1** = Read Only	ENUM	n/a	0	n/a	n/a	R

[1]Units include applied scale factor register

[2] The PCS will go Offline within a 100msec (max) trip delay, following the “Ride Through Until Duration”

[3] Active curve data is only updated on POR or when selected or enabled via registers 42013 and 42014

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SunSpec Model 145 Registers – Extended Settings

Number	Data Type	Description	Units[1]	Scale Factor (Reg #)	Factory Default	Min	Max	Access Level
Header:								
42853	U16	Model Identifier	n/a	n/a	145	n/a	n/a	R
42854	U16	Model Length - # of 16-bit registers to follow	n/a	n/a	8	n/a	n/a	R
Fixed Block:								
42856	U16	Nominal Ramp Down Rate [3]	0.1 % I_max/sec [2]	42862	2000	n/a	n/a	R
42858	U16	Emergency Ramp Down Rate	0.1 % I_max/sec [2]	42862	60000	n/a	n/a	R
42862	U16	Scale Factor - Current Ramp Rate (% Imax/sec)	sunssf	n/a	-1	n/a	n/a	R

[1]Units include applied scale factor register

[2] I_max defined in register 40149

[3] Nominal Ramp Down Rate can be adjusted using register 41241

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SunSpec Model 64800 Registers – MESA PCS Extension

Number	Data Type	Description	Units[1]	Scale Factor (Reg #)	Factory Default	Min	Max	Access Level
Header:								
41117	U16	Model Identifier	n/a	n/a	64800	n/a	n/a	R
41118	U16	Model Length - # of 16-bit registers to follow	n/a	n/a	8	n/a	n/a	R
Fixed Block:								
41119	U16	Local/Remote Control: **0** = Remote; **1** = Local (HMI)	ENUM	n/a	0	n/a	n/a	R
41120	U16	PCS Heartbeat: This read-only register is incremented by '1' by the PCS once per second, resetting back to zero after reaching a value of 32,767 (0x7FFF).	n/a	n/a	0	n/a	n/a	R
41121	U16	Controller Heartbeat: The PCS expects this register to be written by the Host Controller once per second with a value equal to the previous value plus '1', or reset back to '0' at any time but not after a previous value of '0'. Failure to do so will result in a Fault condition (Communication Error). Checking for the incrementing heartbeat value is not enabled until the first write to this register occurs following a POR.	n/a	n/a	0	0	0xFFFF	RWC
41122	U16	Fault Reset: **0** = No Action; **1** = Reset Faults This register is auto cleared to zero after a write.	ENUM	n/a	0	0	1	RWC
41123	S16	Set Operation: **1** = Start the PCS (pre-charge and connect DC and AC contactors) **2** = Stop the PCS (disconnect DC and AC contactors) **3** = Enter Standby Mode (stop processing power) **4** = Exit Standby Mode (start processing power) This register is auto cleared to zero after a write.	ENUM	n/a	0	0	4	RWC

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Trystar Extension Model 64300 Registers – Control and Status

Number	Data Type	Description	Units[1]	Scale Factor (Reg #)	Factory Default	Min	Max	Access Level
Header:								
41127	U16	Model Identifier	n/a	n/a	64300	n/a	n/a	R
41128	U16	Model Length - # of 16-bit registers to follow	n/a	n/a	36	n/a	n/a	R
Fixed Block:								
41129	U16	PCS Operating State: **0** = Initialize **1** = Fault **2** = Calibrate **3** = Disabled **4** = Charge Wait **5** = Charging **6** = Standby **7** = Turn-On Delay **8** = Online – Grid Tie **9** = Offline **10** = Active Ride Thru **11** = Passive Ride Thru **12** = Online – Grid Form **13** = Power Down **16** = Turn Off	ENUM	n/a	n/a	n/a	n/a	R
41130	U16	Register Operation Status - Updated after every parameter read or write: **0** = Operation completed successfully **1** = Illegal/unsupported Parameter ID **2** = write was attempted to a Read-Only Parameter **3** = read was attempted from a Write-Only Parameter **4** = write data is not within legal range **5** = Configuration Memory Hardware Error **6** = Configuration Memory CRC Mismatch **7** = Invalid password provided for operation **8** = Operation not allowed when the inverter is ON	ENUM	n/a	n/a	n/a	n/a	R

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Number	Data Type	Description	Units[1]	Scale Factor (Reg #)	Factory Default	Min	Max	Access Level
41131	U16	User Configuration Error Status Bits (LSW): **Bit 0** = Invalid Baud Rate **Bit 1** = LVRTD Table Error **Bit 2** = HVRTD Table Error **Bit 3** = LFRT Table Error **Bit 4** = HFRT Table Error **Bit 5** = Volt-VAR Curve 1 Error **Bit 6** = Volt-VAR Curve 2 Error **Bit 7** = Volt-VAR Curve 3 Error **Bit 8** = LVRTX Table Error **Bit 9** = HVRTX Table Error **Bit 10** = LFRTX Table Error **Bit 11** = HFRTX Table Error **Bit 12** = Volt-Watt P MAX Curve 1 Error **Bit 13** = Volt-Watt P MAX Curve 2 Error **Bit 14** = Volt-Watt P MAX Curve 3 Error **Bit 15** = Volt-Watt P MAX Curve 1 Error	Bitfield	n/a	n/a	n/a	n/a	R
41132	U16	Factory Temperature Error Status: **Bit 0** = Ambient Over Temp **Bit 1** = DC/DC Over Temp - A **Bit 2** = DC/DC Over Temp - B **Bit 3** = DC/DC Over Temp - C **Bit 4** = DC/DC Temp Imbalance **Bit 8** = Inverter Over Temp - A **Bit 9** = Inverter Over Temp - B **Bit 10** = Inverter Over Temp - C **Bit 11** = Inverter Temp Imbalance **Bit 12-15** = *Reserved*	Bitfield	n/a	n/a	n/a	n/a	R
41133	U16	Software Revision – Inverter Controller	n/a	n/a	n/a	n/a	n/a	R
41134	U16	Software Revision – DC/DC Controller	n/a	n/a	n/a	n/a	n/a	R
41135	U16	Software Revision – Bootloader	n/a	n/a	n/a	n/a	n/a	R
41136	U16	FPGA Revision	n/a	n/a	n/a	n/a	n/a	R

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Number	Data Type	Description	Units[1]	Scale Factor (Reg #)	Factory Default	Min	Max	Access Level
41137	U16	User Configuration Revision - The user may use this register to assign a revision code, allowing them to manage their changes to the default product configuration.	n/a	n/a	0	0	0xFFFF	RW
41138	U16	Factory Configuration Revision	n/a	n/a	n/a	n/a	n/a	R
41139	U16	Master Configuration Revision	n/a	n/a	n/a	n/a	n/a	R
41140	U16	Configuration Reset – Set User Values to Factory Defaults	n/a	n/a	0	0	0xFFFF	RW
41143	U16	User Configuration Error Status Bits (MSW): **Bit 0** = Volt-Watt P MIN Curve 2 Error **Bit 1** = Volt-Watt P MIN Curve 3 Error **Bit 2** = Freq-Watt P MAX Curve 1 Error **Bit 3** = Freq-Watt P MAX Curve 2 Error **Bit 4** = Freq-Watt P MAX Curve 3 Error **Bit 5** = Freq-Watt P MIN Curve 1 Error **Bit 6** = Freq-Watt P MIN Curve 2 Error **Bit 7** = Freq-Watt P MIN Curve 3 Error	Bitfield	n/a	n/a	n/a	n/a	R
41144	U16	PCS Control Mode: **0** = Grid Tie **1** = Grid Forming (island operation)	ENUM	n/a	0	0	1	RWC
41145	U16	Maximum DC Charge Current	0.1 A	41157	750	0	750	RWC
41146	U16	Maximum DC Discharge Current	0.1 A	41157	750	0	750	RWC
41157	S16	Scale Factor – Maximum DC Current	sunssf	n/a	-1	n/a	n/a	R

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Trystar Extension Model 64301 Registers – Configuration

Number	Data Type	Description	Units[1]	Scale Factor (Reg #)	Factory Default	Min	Max	Access Level
Header:								
41165	U16	Model Identifier	n/a	n/a	64301	n/a	n/a	R
41166	U16	Model Length - # of 16-bit registers to follow	n/a	n/a	98	n/a	n/a	R
Fixed Block:								
41167	U16	PCS Control Mode Power-On Default: **0** = *Grid Tie* **1** = *Grid Forming (island operation)*	ENUM	n/a	0	0	1	RW
41168	U16	Power Foldback Mode Select: **0** = Foldback Real and Reactive proportionally (i.e., Fixed Power Factor) **1** = Foldback Reactive first (i.e., Real Power Priority) **2** = Foldback Real first (i.e., Reactive Power Priority)	ENUM	n/a	0	0	2	RW
41169	U16	Default Grid High Voltage Threshold (% of Reg **40168** – Voltage at the PCC) If Active Curve = 0 (Reg **40483**) or HVRT = Disabled (Reg **40484**) then this register is used to define the immediate disconnect threshold.	0.1 %	41255	1100	1000	1200	RWO
41170	U16	Default Grid Low Voltage Threshold (% of Reg **40168** – Voltage at the PCC) If Active Curve = 0 (Reg **40271**) or LVRT = Disabled (Reg **40272**) then this register is used to define the immediate disconnect threshold.	0.1 %	41255	880	0	1000	RWO
41171	U16	Default Grid High Frequency Threshold If Active Curve = 0 (Reg **40907**) or HFRT = Disabled (Reg **40908**) then this register is used to define the immediate disconnect threshold.	0.01 Hz	41256	6050	5000	9000	RWO
41172	U16	Default Grid Low Frequency Threshold If Active Curve = 0 (Reg **40695**) or LFRT = Disabled (Reg **40696**) then this register is used to define the immediate disconnect threshold.	0.01 Hz	41256	5850	3000	6000	RWO

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Number	Data Type	Description	Units[1]	Scale Factor (Reg #)	Factory Default	Min	Max	Access Level
41236	U16	Anti-Island Detector Enable: **0** = Disabled **1** = Passive Detection Only **2** = Active Detection Only **3** = Both Pass and Active Detection	ENUM	n/a	2	0	3	RW
41237	U16	Anti-Island Detector Mode Select: **1** = Enabled – Keep Running on Island Detect **2** = Enabled – Fault Off on Island Detect **3** = Enabled – Go Offline on Island Detect and Auto Resume when Grid Returns	ENUM	n/a	2	1	3	RW
41238	U16	Maximum DC Charge Current – Power-On Default	0.1 A	41257	750	0	750	RW
41239	U16	Maximum DC Discharge Current – Power-On Default	0.1 A	41257	750	0	750	RW
41240	U16	AC Connection Type: **0** = Three-Wire Interface, Transformerless **1** = Four-Wire Interface, Transformerless **2** = Three-Wire Interface, with Isolation Transformer	ENUM	n/a	0	0	2	RWO
41241	U16	Grid-Tie Turn-Off Current Slew Rate	ARMS/s	n/a	100	1	3000	RW
41255	S16	Scale Factor – Default Grid Voltage Thresholds	sunssf	n/a	-1	n/a	n/a	R
41256	S16	Scale Factor – Default Grid Frequency Thresholds	sunssf	n/a	-2	n/a	n/a	R
41257	S16	Scale Factor – DC Maximum Currents	sunssf	n/a	-1	n/a	n/a	R

[1]Units include applied scale factor register

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Trystar Extension Model 64302 Registers – Alarms

Number	Data Type	Description	Units[1]	Scale Factor (Reg #)	Factory Default	Min	Max	Access Level
Header:								
41165	U16	Model Identifier	n/a	n/a	64302	n/a	n/a	R
42012	U16	Model Length - # of 16-bit registers to follow	n/a	n/a	62	n/a	n/a	R
Fixed Block:								
41267	U16	AC Over Current Fault Threshold	0.1 Arms	41317	550	0	550	RW
41268	U16	AC Over Current Warning Threshold	0.1 Arms	41317	520	0	540	RW
41269	U16	AC Over Current Warning Recover Delta	0.1 Arms	41317	25	10	100	RW
41270	U16	AC Over Voltage Fault Threshold (line to line)	0.1 Vrms	41316	5900	0	5900	RW
41271	U16	AC Over Voltage Warning Threshold (line to line)	0.1 Vrms	41316	5760	0	5900	RW
41272	U16	AC Over Voltage Warning Recover Delta (line to line)	0.1 Vrms	41316	50	10	1000	RW
41273	U16	DC Under Voltage Fault Threshold	0.1 V	41318	3100	3100	8200	RW
41274	U16	DC Under Voltage Warning Threshold	0.1 V	41318	3300	3000	8200	RW
41275	U16	DC Under Voltage Warning Recover Delta	0.1 V	41318	50	10	1000	RW
41276	U16	DC Over Voltage Fault Threshold	0.1 V	41318	8400	0	8400	RW
41277	U16	DC Over Voltage Warning Threshold	0.1 V	41318	8300	0	8400	RW
41278	U16	DC Over Voltage Warning Recover Delta	0.1 V	41318	50	10	1000	RW
41279	U32	Alarm Output 1 - PCS Fault Mask The bit fields correspond to **Register 40129 – PCS Fault Status**. Setting a mask bitfield to “1” will cause that fault to drive the Alarm output. Setting multiple mask bits to “1” logically OR’s them together.	ENUM	n/a	0xFFFF FFFF	0	0xFFFF FFFF	RW
41281	U32	Alarm Output 1 - PCS Warning Mask The bit fields correspond to **Register 40131 – PCS Warning Status.** Setting a mask bitfield to “1” will cause that warning to drive the Alarm output. Setting multiple mask bits to “1” logically OR’s them together.	ENUM	n/a	0	0	0xFFFF FFFF	RW
41283	U32	Alarm Output 2 - PCS Fault Mask The bit fields correspond to **Register 40129 – PCS Fault Status.** Setting a mask bitfield to “1” will cause that fault to drive the Alarm output. Setting multiple mask bits to “1” logically OR’s them together.	ENUM	n/a	0	0	0xFFFF FFFF	RW

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Number	Data Type	Description	Units[1]	Scale Factor (Reg #)	Factory Default	Min	Max	Access Level
41285	U32	Alarm Output 2 - PCS Warning Mask The bit fields correspond to **Register 40131 – PCS Warning Status.** Setting a mask bitfield to "1" will cause that warning to drive the Alarm output. Setting multiple mask bits to "1" logically OR's them together.	ENUM	n/a	0xFFFF FFFF	0	0xFFFF FFFF	RW
41287	U16	Alarm Output Pin Polarity: **Bit 0:** Alarm Output 1 Polarity Value 0 = High-Z when status is True Value 1 = Drive output low when status is True **Bit 1:** Alarm output 2 Polarity Value 0 = High-Z when status is True Value 1 = Drive output low when status is True	ENUM	n/a	0	0	3	RW

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Number	Data Type	Description	Units[1]	Scale Factor (Reg #)	Factory Default	Min	Max	Access Level
41288	U32	Alarm Output 1 - PCS State Mask: Setting the mask bitfield to "1" will cause the Alarm output to be asserted while the PCS is in that operating state. Setting multiple mask bits to "1" logically OR's them together. **Bit 0** = Initialization **Bit 1** = Fault **Bit 2** = Calibrate **Bit 3** = Disabled **Bit 4** = Charge Wait **Bit 5** = Charging **Bit 6** = Standby **Bit 7** = Turn On Delay **Bit 8** = Online – Grid Tie **Bit 9** = Off-Line **Bit 10** = Ride Thru Active **Bit 11** = Ride Thru Passive **Bit 12** = Online – Grid Form **Bit 13** = Power Down **Bit 14** = *Reserved* **Bit 15** = *Reserved* **Bit 16** = Turn Off **Bit 17-31** = *Reserved*	ENUM	n/a	0xFFFF FFFF	0	0xFFFF FFFF	RW

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Number	Data Type	Description	Units[1]	Scale Factor (Reg #)	Factory Default	Min	Max	Access Level
41290	U32	Alarm Output 2 - PCS State Mask: Setting the mask bitfield to "1" will cause the Alarm output to be asserted while the PCS is in that operating state. Setting multiple mask bits to "1" logically OR's them together. **Bit 0** = Initialization **Bit 1** = Fault **Bit 2** = Calibrate **Bit 3** = Disabled **Bit 4** = Charge Wait **Bit 5** = Charging **Bit 6** = Standby **Bit 7** = Turn On Delay **Bit 8** = Online – Grid Tie **Bit 9** = Off-Line **Bit 10** = Ride Thru Active **Bit 11** = Ride Thru Passive **Bit 12** = Online – Grid Form **Bit 13** = Power Down **Bit 14** = *Reserved* **Bit 15** = *Reserved* **Bit 16** = Turn Off **Bit 17-31** = *Reserved*	ENUM	n/a	0xFFFF FFFF	0	0xFFFF FFFF	RW
41292	U16	Alarm Output 1 – Function Mask: Setting the mask bitfield to "1" will cause the Alarm output to be asserted when the selected function/action is active. Setting multiple mask bits to "1" logically OR's them together. **Bit 0** = Inverter PWM Outputs Enabled **Bit 1-15** = *Reserved*	ENUM	n/a	0xFFFF FFFF	0	0xFFFF FFFF	RW

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Number	Data Type	Description	Units[1]	Scale Factor (Reg #)	Factory Default	Min	Max	Access Level
41293	U16	Alarm Output 2 – Function Mask: Setting the mask bitfield to "1" will cause the Alarm output to be asserted when the selected function/action is active. Setting multiple mask bits to "1" logically OR's them together. **Bit 0** = Inverter PWM Outputs Enabled **Bit 1-15** = *Reserved*	ENUM	n/a	0	0	0xFFFF	RW
41294	U16	DC Over Current Fault Threshold	0.1 A	41319	950	0	950	RW
41295	U16	DC Over Current Warning Threshold	0.1 A	41319	800	0	950	RW
41296	U16	DC Over Current Warning Recover Delta	0.1 A	41319	25	10	100	RW
41316	S16	Scale Factor – AC Voltage	sunssf	n/a	-1	n/a	n/a	R
41317	S16	Scale Factor – AC Current	sunssf	n/a	-1	n/a	n/a	R
41318	S16	Scale Factor – DC Voltage	sunssf	n/a	-1	n/a	n/a	R
41319	S16	Scale Factor – DC Current	sunssf	n/a	-1	n/a	n/a	R

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Trystar Extension Model 64303 Registers – Turn-On and Resume Settings

Number	Data Type	Description	Units[1]	Scale Factor (Reg #)	Factory Default	Min	Max	Access Level
Header:								
41329	U16	Model Identifier	n/a	n/a	64303	n/a	n/a	R
41330	U16	Model Length - # of 16-bit registers to follow	n/a	n/a	42	n/a	n/a	R
Fixed Block:								
41331	U16	Grid Tie Turn-On Max AC Voltage (% of Reg **40168** – Voltage at the PCC) Grid voltage must be below this limit for PCS to resume operation.	0.1 %	41361	1100	1000	1200	RW
41332	U16	Grid Tie Turn-On Min AC Voltage (% of Reg **40168** – Voltage at the PCC) Grid voltage must be above this limit for PCS to resume operation.	0.1 %	41361	880	500	1000	RW
41333	U16	Grid Tie Turn-On Max Frequency Grid frequency must be below this limit for PCS to resume operation.	0.1 Hz	41362	605	500	700	RW
41334	U16	Grid Tie Turn-On Min Frequency Grid frequency must be above this limit for PCS to resume operation.	0.1 Hz	41362	585	400	600	RW
41335	U16	Initial Turn-On Window Random turn-on window used when transitioning from Standby to Online.	0.1 sec	41363	0	0	65534	RW
41336	U16	Initial Turn-On Ramp Time	0.1 sec	41363	10	1	10000	RW
41337	U16	Short Trip Time Duration Maximum time spent Offline to be considered a “Short Trip” event. Time greater than this threshold are considered “Long Trip” events.	0.1 sec	41363	600	0	65534	RW
41338	U16	Short Event Resume Delay Auto-resume turn-on delay for “Short Trip” events.	0.1 sec	41363	600	0	65534	RW
41339	U16	Short Event Resume Turn-On Window Random turn-on window, following the resume delay (**41338**), when returning Online following a “Short Trip” event.	0.1 sec	41363	0	0	65534	RW
41340	U16	Short Event Resume Turn-On Ramp Time Time to reach Reg **40167** - Maximum Output Power	0.1 sec	41363	10	1	10000	RW

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Number	Data Type	Description	Units[1]	Scale Factor (Reg #)	Factory Default	Min	Max	Access Level
41341	U16	Long Event Resume Delay Auto-resume turn-on delay for “Long Trip” events.	0.1 sec	41363	600	0	65534	RW
41342	U16	Long Event Resume Turn-On Window Random turn-on window, following the resume delay (**41341**), when returning Online following a “Long Trip” event.	0.1 sec	41363	0	0	65534	RW
41343	U16	Long Event Resume Turn-On Ramp Time Time to reach Reg **40167** - Maximum Output Power	0.1 sec	41363	10	1	10000	RW
41344	U16	Auto-Resume Timeout How long to wait for the grid to return to within tolerance and resume operation. If the timeout expires, the PCS will disable itself and transition to the Fault state. A value of 0 disables the auto-resume feature, the PCS will immediately disable itself and transition to the Fault state.	sec	41364	3600	0	65534	RW
41345	U16	Ride Through Recover Delay When in the ***Ride Through Passive*** state, if the grid voltage/frequency return to within normal levels or a less stringent Active ride through region, the PCS will first wait for this delay time before turning back on and going to the ***Online – Grid Tie or Ride Through Active*** states.	ms	41365	1000	0	65534	RW

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Number	Data Type	Description	Units[1]	Scale Factor (Reg #)	Factory Default	Min	Max	Access Level
41350	U16	Resume Status: **Bit 0** = AC Frequency Too High **Bit 1** = AC Frequency Too Low **Bit 2** = AC Voltage Vab Too High **Bit 3** = AC Voltage Vbc Too High **Bit 4** = AC Voltage Vca Too High **Bit 5** = AC Voltage Vab Too Low **Bit 6** = AC Voltage Vbc Too Low **Bit 7** = AC Voltage Vca Too Low **Bit 8** = AC Voltage Van Too High **Bit 9** = AC Voltage Vbn Too High **Bit 10** = AC Voltage Vcn Too High **Bit 11** = AC Voltage Van Too Low **Bit 12** = AC Voltage Vbn Too Low **Bit 13** = AC Voltage Vcn Too Low **Bit 14** = Resume Delay Active	BitField	n/a	n/a	n/a	n/a	R
41361	S16	Scale Factor – Voltage Thresholds	sunssf	n/a	-1	n/a	n/a	R
41362	S16	Scale Factor – Frequency Thresholds	sunssf	n/a	-1	n/a	n/a	R
41363	S16	Scale Factor – Turn-On Times	sunssf	n/a	-1	n/a	n/a	R
41364	S16	Scale Factor – Timeout	sunssf	n/a	0	n/a	n/a	R
41365	S16	Scale Factor – Ride Through Recover Delay	sunssf	n/a	3	n/a	n/a	R

[1]Units include applied scale factor register

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Trystar Extension Model 64304 Registers – Firmware Update

Number	Data Type	Description	Units[1]	Scale Factor (Reg #)	Factory Default	Min	Max	Access Level
Header:								
41373	U16	Model Identifier	n/a	n/a	64304	n/a	n/a	R
41374	U16	Model Length - # of 16-bit registers to follow	n/a	n/a	148	n/a	n/a	R
Fixed Block:								
41375	U16	Firmware Update – Jump to Bootloader Command	n/a	n/a	0	0	1	RWO
41377	U16	Firmware Update – Data Transmission Object, Word 1 (DTO_WRD1) **MSB** = Data Byte 0; **LSB** = Count	n/a	n/a	0	n/a	n/a	R
41378	U16	Firmware Update – Data Transmission Object, Word 2 (DTO_WRD2) **MSB** = Data Byte 2; **LSB** = Data Byte 1	n/a	n/a	0	n/a	n/a	R
41379	U16	Firmware Update – Data Transmission Object, Word 3 (DTO_WRD3) **MSB** = Data Byte 4; **LSB** = Data Byte 3	n/a	n/a	0	n/a	n/a	R
41380	U16	Firmware Update – Control Receive Object, Word 0 (CRO_WRD0) **MSB** = Count; **LSB** = Command	n/a	n/a	0	0	65535	RWC
41381	U16	Firmware Update – Control Receive Object, Word 1 (CRO_WRD1) **MSB** = Data Byte 1; **LSB** = Data Byte 0	n/a	n/a	0	0	65535	RWC
41382	U16	Firmware Update – Control Receive Object, Word 2 (CRO_WRD2) **MSB** = Data Byte 3; **LSB** = Data Byte 2	n/a	n/a	0	0	65535	RWC
41383-41505	U16	CRO_WRD3 … CRO_WRD125	n/a	n/a	0	0	65535	RWC
41506	U16	Firmware Update – Control Receive Object, Word 126 (CRO_WRD126) **MSB** = Data Byte 252; **LSB** = Data Byte 251	n/a	n/a	0	0	65535	RWC

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Trystar Extension Model 64305 Registers – Datalogging

Number	Data Type	Description	Units[1]	Scale Factor (Reg #)	Factory Default	Min	Max	Access Level
Header:								
41523	U16	Model Identifier	n/a	n/a	64305	n/a	n/a	R
41524	U16	Model Length - # of 16-bit registers to follow	n/a	n/a	126	n/a	n/a	R
Fixed Block:								
41525	U32	Real Time Clock – Set Date This register is used to set the date using the following format: **BITS [13..0]** = Year **BITS [15..14]** = not used **BITS [23..16]** = Month **BITS [31..21]** = Day Example: 3/21/2017 would be 0x150307E1 **NOTE:** ***For synchronization purposes, the Date is internally latched upon writing the Set Time Register, 41527. If the user fails to write to register 41527, the date will NOT be set. To correctly set the date and time, the user should write to register 41525, followed by a write to 41527.***	ENUM	n/a	0	0	0x1F0C FFFF	RWC

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Number	Data Type	Description	Units[1]	Scale Factor (Reg #)	Factory Default	Min	Max	Access Level
41527	U32	Real Time Clock – Set Time This register is used to set the time using the following format: **BITS [7..0]** = Hours **BITS [15..8]** = Minutes **BITS [23..16]** = Seconds **BITS [31..24]** = not used Example: 1:48pm would be 0x0000300D **NOTE:** ***For synchronization purposes, writing to this register also latches the data written to register 41525. To correctly set the date and time, the user should write to register 41525, followed by a write to 41527.***	ENUM	n/a	0	0	0x003B 3B17	RWC
41529	U32	Real Time Clock – Get Date Returns the Date in the following format: **BITS [13..0]** = Year **BITS [14]** = Set Status: 0 = Date has not been set since POR 1 = Date has been set since POR **BITS [15]** = not used **BITS [23..16]** = Month **BITS [31..21]** = Day	ENUM	n/a	n/a	n/a	n/a	R

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Number	Data Type	Description	Units[1]	Scale Factor (Reg #)	Factory Default	Min	Max	Access Level
41531	U32	Real Time Clock – Get Time Returns the Time in the following format: **BITS [7..0]** = Hours **BITS [15..8]** = Minutes **BITS [23..16]** = Seconds **BITS [30..24]** = not used **BITS [31]** = Set Status: 0 = Time has not been set since POR 1 = Time has been set since POR **NOTE:** ***For synchronization purposes, the Time data is internally latched when register 41529 is read. To correctly read the time, the user must first read register 41529, followed by a read to 41531.***	ENUM	n/a	n/a	n/a	n/a	R
41533	U16	Fault Log - Sample Period	ms	n/a	1	n/a	n/a	R
41534	U16	Fault Log – Number of Available Logs Returns the number of logs containing valid data.	n/a	n/a	n/a	0	12	R
41535	U16	Reserved Factory Command Register	ENUM	n/a	n/a	n/a	n/a	R
41536	U16	Reserved Factory Status Register	ENUM	n/a	n/a	n/a	n/a	R
41537	U16	Fault Log – Select Log Used to select a log from which to read header and/or data from.	n/a	n/a	0	0	11	RWC
41538	U16	Fault Log – Get Header Get the header for the selected log using register **41537**. Header data will be placed in **Data Log Read Buffer 41572-41635.** **0** = NOP **1** = Fetch Data	ENUM	n/a	0	0	1	RWC
41539	U16	Fault Log – Get Selected Record Writing the desired sample record # to this register will load that data from the log specified by register **41537** into the **Data Log Read Buffer 41572 41635.**	n/a	n/a	0	0	0xFFFF	RWC

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Number	Data Type	Description	Units[1]	Scale Factor (Reg #)	Factory Default	Min	Max	Access Level
41540	U16	Reserved Factory Command Register	ENUM	n/a	n/a	n/a	n/a	R
41541	U16	User Log – Start/Stop Used to start the data logger and arm the trigger. **0** = Stop **1** = Start	ENUM	n/a	0	0	1	RWC
41542	U16	User Log – Post Trigger Percentage Defines how much of the buffer is used for storing post trigger data.	%	n/a	0	0	100	RWC
41543	U16	User Log – Sample Period Sets the time between samples for the User Log. See page 62 for details on selecting the sample period.	ms	n/a	10	1	30000	RWC
41544	U32	User Log – Variable Selection (LSW) See page 61 for details.	n/a	n/a	1	0	0xFFFF FFFF	RWC
41546	U32	User Log – Variable Selection (MSW) See page 61 for details.	n/a	n/a	0	0	0xFFFF FFFF	RWC
41548	U16	User Log – Trigger Mode See page 63 for details. **0** = Continuous **1** = Single **2** = Dual OR **3** = Dual AND	ENUM	n/a	0	0	3	RWC
41549	U16	User Log – Trigger 1 Compare Type See page 63 for details. **0** = Less Than **1** = Greater Than **2** = Equal To **3** = Not Equal To	ENUM	n/a	0	0	3	RWC
41550	U16	User Log – Trigger 1 Variable Selection See page 63 for details.	n/a	n/a	0	0	63	RWC
41551	U32	User Log – Trigger 1 Value Mask See page 63 for details.	n/a	n/a	0	0	0xFFFF FFFF	RWC
41553	U32	User Log – Trigger 1 Value See page 63 for details.	n/a	n/a	0	0	0xFFFF FFFF	RWC

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Number	Data Type	Description	Units[1]	Scale Factor (Reg #)	Factory Default	Min	Max	Access Level
41555	U16	User Log – Trigger 2 Compare Type See page 63 for details. **0** = Less Than **1** = Greater Than **2** = Equal To **3** = Not Equal To	ENUM	n/a	0	0	3	RWC
41556	U16	User Log – Trigger 2 Variable Selection See page 63 for details.	n/a	n/a	0	0	63	RWC
41557	U16	User Log – Trigger 2 Value Mask See page 63 for details.	n/a	n/a	0	0	0xFFFF FFFF	RWC
41559	U32	User Log – Trigger 2 Value See page 63 for details.	n/a	n/a	0	0	0xFFFF FFFF	RWC
41561	U16	User Log – Status **0** = Idle **1** = Capturing (no Trigger) **2** = Capturing (Triggered) **3** = Finished	ENUM	n/a	n/a	n/a	n/a	R
41562	U16	User Log – Get Header Get the header for the User Log. Header data will be placed in **Data Log Read Buffer 41572-41635.** See page 65 for details on the header information. **0** = NOP **1** = Fetch Data	ENUM	n/a	0	0	1	RWC
41563	U16	User Log – Get Selected Sample Data Writing the desired sample record # to this register will load that data from the User log into the **Data Log Read Buffer 41572-41635.**	n/a	n/a	0	0	0xFFFF	RWC
41564	U16	Fault History Log – Set Fault Index Write the bit # of the corresponding fault bit in register **40129 PCS Fault** Status for which to read the fault history.	n/a	n/a	0	0	63	RWC
41565	U16	Fault History Log – # of Entries for Specified Fault Returns the # of fault that have been stored for the fault specified by register **41564**.	n/a	n/a	n/a	n/a	n/a	R

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Number	Data Type	Description	Units[1]	Scale Factor (Reg #)	Factory Default	Min	Max	Access Level
41566	U16	Fault History Log – Get History Data for Specified Fault Writing a "1" will load the history data for the fault specified by register **41564** into the **Data Log Read Buffer 41572-41635.** **0** = NOP **1** = Fetch Data	ENUM	n/a	0	0	1	RWC
41567	U16	Reserved Factory Command Register	ENUM	n/a	n/a	n/a	n/a	R
41568	U16	Operation Log – Read Timer Variables See page 67 for additional details. **MSB** = # of variables to be read; **LSB** = Variable Index	ENUM	n/a	0	0	0xFFFF	RWC
41569	U16	Operation Log – Read Fault Counts See page 66 for additional details. **MSB** = # of variables to be read; **LSB** = Variable Index	ENUM	n/a	0	0	0xFFFF	RWC
41570	U16	Operation Log – Read Min/Max Values See page 71 for additional details. **MSB** = # of variables to be read; **LSB** = Variable Index	ENUM	n/a	0	0	0xFFFF	RWC
41571	U16	Reserved Factory Command	ENUM	n/a	n/a	n/a	n/a	R
41572-41635	U32	Datalog – Read Buffer	n/a	n/a	n/a	n/a	n/a	R

Trystar Extension Model 64306 Registers – Volt-Watt P_{min} Arrays

Number	Data Type	Description	Units[1]	Scale Factor (Reg #)	Factory Default	Min	Max	Access Level
Header:								
42433	U16	Model Identifier	n/a	n/a	64306	n/a	n/a	R
42434	U16	Model Length - # of 16-bit registers to follow	n/a	n/a	172	n/a	n/a	R
Fixed Block:								
42435	U16	Active Curve: **0** = No active curve, **1..3** = Active Curve 1..3	ENUM	n/a	1	0	3	RW
42436	U16	Volt-Watt Pmin Enable/Disable: **Bit 0 :** 1 = Enable, 0 = Disable	BitField	n/a	0	0	1	RW
42440	U16	Number of Curves Supported	n/a	n/a	3	n/a	n/a	R
42441	U16	Number of Curve Points Supported	n/a	n/a	10	n/a	n/a	R

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Number	Data Type	Description	Units[1]	Scale Factor (Reg #)	Factory Default	Min	Max	Access Level
42442	S16	Scale Factor – Voltage	sunssf	n/a	-2	n/a	n/a	R
42443	S16	Scale Factor – Real Power	sunssf	n/a	-2	n/a	n/a	R
Repeating Block #1:								
42445	U16	Volt-Watt Pmin Curve 1: Number of Active Points in Array	n/a	n/a	2	2	10	RW
42446	U16	Volt-Watt Pmin Curve 1: Dependent Variable (% of Reg **40167** – Wmax)	ENUM	n/a	1	n/a	n/a	R
42447	U16	Volt-Watt Pmin Curve 1: Point 1 – Voltage (% of Reg **40168** – Vref)	0.01 %	42442	8000	5000	15000	RW
42448	S16	Volt-Watt Pmin Curve 1: Point 1 – Watts (% of Reg **40167** – Wmax)	0.01 %	42443	0	-10000	10000	RW
42449	U16	Volt-Watt Pmin Curve 1: Point 2 – Voltage (% of Reg **40168** – Vref)	0.01 %	42442	9400	5000	15000	RW
42450	S16	Volt-Watt Pmin Curve 1: Point 2 – Watts (% of Reg **40167** – Wmax)	0.01 %	42443	-10000	-10000	10000	RW
42451–42466	U16 S16	Volt-Watt Pmin Curve 1: Points 3 thru 10 – Voltage (% of Reg **40168** – Vref)	0.01 %	42442	10000	5000	15000	RW
		Volt-Watt Pmin Curve 1: Points 3 thru 10 – Watts (% of Reg **40167** – Wmax)	0.01 %	42443	-10000	-10000	10000	RW
42498	U16	Volt-Watt Pmin Curve 1: Read Only:**0** = Read/Write; **1** = Read Only	ENUM	n/a	0	n/a	n/a	R
Repeating Block #2:								
42499	U16	Volt-Watt Pmin Curve 2: Number of Active Points in Array	n/a	n/a	2	2	10	RW
42500	U16	Volt-Watt Pmin Curve 2: Dependent Variable (% of Reg **40167** – Wmax)	ENUM	n/a	1	n/a	n/a	R
42501	U16	Volt-Watt Pmin Curve 2: Point 1 – Voltage (% of Reg **40168** – Vref)	0.01 %	42442	9000	5000	15000	RW
42502	S16	Volt-Watt Pmin Curve 2: Point 1 – Watts (% of Reg **40167** – Wmax)	0.01 %	42443	0	-10000	10000	RW
42503	U16	Volt-Watt Pmin Curve 2: Point 2 – Voltage (% of Reg **40168** – Vref)	0.01 %	42442	9400	5000	15000	RW
42504	S16	Volt-Watt Pmin Curve 2: Point 2 – Watts (% of Reg **40167** – Wmax)	0.01 %	42443	-10000	-10000	10000	RW
42505-42520	U16 S16	Volt-Watt Pmin Curve 2: Points 3 thru 10 – Voltage (% of Reg **40168** – Vref)	0.01 %	42442	10000	5000	15000	RW
		Volt-Watt Pmin Curve 2: Points 3 thru 10 – Watts (% of Reg **40167** – Wmax)	0.01 %	42443	-10000	-10000	10000	RW
42552	U16	Volt-Watt Pmin Curve 2: Read Only: **0** = Read/Write; **1** = Read Only	ENUM	n/a	0	n/a	n/a	R

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Number	Data Type	Description	Units[1]	Scale Factor (Reg #)	Factory Default	Min	Max	Access Level
Repeating Block #3:								
42553	U16	Volt-Watt Pmin Curve 3: Number of Active Points in Array	n/a	n/a	2	2	10	RW
42554	U16	Volt-Watt Pmin Curve 3: Dependent Variable (% of Reg **40167** – Wmax)	ENUM	n/a	1	n/a	n/a	R
42555	U16	Volt-Watt Pmin Curve 3: Point 1 – Voltage (% of Reg **40168** – Vref)	0.01 %	42442	9400	5000	15000	RW
42556	S16	Volt-Watt Pmin Curve 3: Point 1 – Watts (% of Reg **40167** – Wmax)	0.01 %	42443	0	-10000	10000	RW
42557	U16	Volt-Watt Pmin Curve 3: Point 2 – Voltage (% of Reg **40168** – Vref)	0.01 %	42442	9700	5000	15000	RW
42558	U16	Volt-Watt Pmin Curve 3: Point 2 – Watts (% of Reg **40167** – Wmax)	0.01 %	42443	-10000	-10000	10000	RW
42559-42574	U16 S16	Volt-Watt Pmin Curve 3: Points 3 thru 10 – Voltage (% of Reg **40168** – Vref)	0.01 %	42442	10000	5000	15000	RW
		Volt-Watt Pmin Curve 3: Points 3 thru 10 – Watts (% of Reg **40167** – Wmax)	0.01 %	42443	-10000	-10000	10000	RW
42606	U16	Volt-Watt Pmin Curve 3: Read Only: **0** = Read/Write; **1** = Read Only	ENUM	n/a	0	n/a	n/a	R

[1]Units include applied scale factor register
[2] Active curve data is only updated on POR

Trystar Extension Model 64307 Registers – Frequency-Watt P_{min} Arrays

Number	Data Type	Description	Units[1]	Scale Factor (Reg #)	Factory Default	Min	Max	Access Level
Header:								
42607	U16	Model Identifier	n/a	n/a	64307	n/a	n/a	R
42608	U16	Model Length - # of 16-bit registers to follow	n/a	n/a	184	n/a	n/a	R
Fixed Block:								
42609	U16	Active Curve: **0** = No active curve, **1..3** = Active Curve 1..3	ENUM	n/a	1	0	3	RW
42610	U16	Frequency-Watt Pmin Enable/Disable: **Bit 0 :** 1 = Enable, 0 = Disable	BitField	n/a	0	0	1	RW
42614	U16	Number of Curves Supported	n/a	n/a	3	n/a	n/a	R
42615	U16	Number of Curve Points Supported	n/a	n/a	10	n/a	n/a	R
42616	S16	Scale Factor – Frequency	sunssf	n/a	-2	n/a	n/a	R
42617	S16	Scale Factor – Real Power	sunssf	n/a	-2	n/a	n/a	R

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Number	Data Type	Description	Units[1]	Scale Factor (Reg #)	Factory Default	Min	Max	Access Level
Repeating Block #1:								
42619	U16	Freq-Watt Pmin Curve 1: Number of Active Points in Array	n/a	n/a	2	2	10	RW
42620	U16	Freq-Watt Pmin Curve 1: Point 1 – Frequency	0.01 Hz	42616	5500	5000	7000	RW
42621	S16	Freq-Watt Pmin Curve 1: Point 1 – Watts (% of Reg **40167** – Wmax)	0.01 %	42617	10000	-10000	10000	RW
42622	U16	Freq-Watt Pmin Curve 1: Point 2 – Frequency	0.01 Hz	42616	5900	5000	7000	RW
42623	S16	Freq-Watt Pmin Curve 1: Point 2 – Watts (% of Reg **40167** – Wmax)	0.01 %	42617	-10000	-10000	10000	RW
42624-42639	U16 S16	Freq-Watt Pmin Curve 1: Points 3 thru 10 – Frequency	0.01 Hz	42616	6000	5000	7000	RW
		Freq-Watt Pmin Curve 1: Points 3 thru 10 – Watts (% of Reg **40167** – Wmax)	0.01 %	42617	-10000	-10000	10000	RW
42676	U16	Freq-Watt Pmin Curve 1: Read Only: **0** = Read/Write; **1** = Read Only	ENUM	n/a	0	n/a	n/a	R
Repeating Block #2:								
42677	U16	Freq-Watt Pmin Curve 2: Number of Active Points in Array	n/a	n/a	2	2	10	RW
42678	U16	Freq-Watt Pmin Curve 2: Point 1 – Frequency	0.01 Hz	42616	5750	5000	7000	RW
42679	S16	Freq-Watt Pmin Curve 2: Point 1 – Watts (% of Reg **40167** – Wmax)	0.01 %	42617	10000	-10000	10000	RW
42680	U16	Freq-Watt Pmin Curve 2: Point 2 – Frequency	0.01 Hz	42616	5950	5000	7000	RW
42681	S16	Freq-Watt Pmin Curve 2: Point 2 – Watts (% of Reg **40167** – Wmax)	0.01 %	42617	-10000	-10000	10000	RW
42682-42697	U16 S16	Freq-Watt Pmin Curve 2: Points 3 thru 10 – Frequency	0.01 Hz	42616	6000	5000	7000	RW
		Freq-Watt Pmin Curve 2: Points 3 thru 10 – Watts (% of Reg **40167** – Wmax)	0.01 %	42617	-10000	-10000	10000	RW
42734	U16	Freq-Watt Pmin Curve 2: Read Only: **0** = Read/Write; **1** = Read Only	ENUM	n/a	0	n/a	n/a	R
Repeating Block #3:								
42735	U16	Freq-Watt Pmin Curve 3: Number of Active Points in Array	n/a	n/a	2	2	10	RW
42736	U16	Freq-Watt Pmin Curve 3: Point 1 – Frequency	0.01 Hz	42616	5898	5000	7000	RW
42737	S16	Freq-Watt Pmin Curve 3: Point 1 – Watts (% of Reg **40167** – Wmax)	0.01 %	42617	10000	-10000	10000	RW
42738	U16	Freq-Watt Pmin Curve 3: Point 2 – Frequency	0.01 Hz	42616	5998	5000	7000	RW
42739	S16	Freq-Watt Pmin Curve 3: Point 2 – Watts (% of Reg **40167** – Wmax)	0.01 %	42617	-10000	-10000	10000	RW

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Number	Data Type	Description	Units[1]	Scale Factor (Reg #)	Factory Default	Min	Max	Access Level
42740-42755	U16 S16	Freq-Watt Pmin Curve 3: Points 3 thru 10 – Frequency	0.01 Hz	42616	6000	5000	7000	RW
		Freq-Watt Pmin Curve 3: Points 3 thru 10 – Watts (% of Reg **40167** – Wmax)	0.01 %	42617	-10000	-10000	10000	RW
42792	U16	Freq-Watt Pmin $_{min}$ Curve 3: Read Only: **0** = Read/Write; **1** = Read Only	ENUM	n/a	0	n/a	n/a	R

[1]Units include applied scale factor register

[2] Active curve data is only updated on POR

Trystar Extension Model 64308 Registers – Grid Forming Configuration & Control

Number	Data Type	Description	Units[1]	Scale Factor (Reg #)	Factory Default	Min	Max	Access Level
Header:								
42793	U16	Model Identifier	n/a	n/a	64308	n/a	n/a	R
42794	U16	Model Length - # of 16-bit registers to follow	n/a	n/a	58	n/a	n/a	R
Fixed Block:								
42795	U16	Grid Form Voltage Command (line-to-line)	0.1 Vrms	42836	n/a[2]	n/a[1]	n/a[1]	RWC
42796	U16	Grid Form Frequency Command	0.01 Hz	42837	n/a[3]	n/a[1]	n/a[1]	RWC
42797	S16	Grid Form Real Power Offset Command	0.1 % Wmax	42838	0	-1000	1000	RWC
42798	S16	Grid Form Reactive Power Offset Command	0.1 % VARmax	42838	0	-1000	1000	RWC
42799	U16	Grid Form Voltage Command Maximum	0.1 Vrms	42836	5080	3360	5280	RW
42800	U16	Grid Form Voltage Command Minimum	0.1 Vrms	42836	4160	0	5280	RW
42801	U16	Grid Form Voltage Command Slew Rate	Vrms/s	42839	480	1	28800	RW
42802	U16	Grid Form Frequency Command Maximum	0.01 Hz	42837	6500	4500	6500	RW
42803	U16	Grid Form Frequency Command Minimum	0.01 Hz	42837	4500	4500	6500	RW
42804	U16	Grid Form Frequency Command Slew Rate	0.01 Hz/s	42840	10	1	1000	RW
42805	S16	Grid Form Real Power Offset Turn-On Default	0.1 % Wmax	42838	0	-1000	1000	RW
42806	S16	Grid Form Real Power Offset Maximum	0.1 % Wmax	42838	1000	-1000	1000	RW
42807	S16	Grid Form Real Power Offset Minimum	0.1 % Wmax	42838	-1000	-1000	1000	RW
42808	S16	Grid Form Reactive Power Offset Turn-On Default	0.1 % VARmax	42838	0	-1000	1000	RW
42809	S16	Grid Form Reactive Power Offset Maximum	0.1 % VARmax	42838	1000	-1000	1000	RW

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42810	S16	Grid Form Reactive Power Offset Minimum	0.1 % VARmax	42838	-1000	-1000	1000	RW
42811	U16	Grid Form Power Offset Slew Rate	0.1 % Wmax/s	42841	1000	1	10000	RW
42812	U16	Grid Form Startup Voltage Slew Rate	Vrms/s	42839	4800	1	28800	RW
42813	U16	Island Control Input Pin Configuration: **0** = Disabled **1** = Passive Transfer – active high for Island Mode **2** = Passive Transfer – active low for Island Mode **3** = Seamless Transfer – active high for Island Mode **4** = Seamless Transfer – active low for Island Mode	ENUM	n/a	0	0	4	RWO
42814	U16	Grid Form Maximum Operating Voltage	0.1 % Vref	42842	1100	1000	1200	RW
42815	U16	Grid Form Minimum Operating Voltage	0.1 % Vref	42842	700	0	1000	RW
42816	U16	Grid Form Maximum Operating Frequency	0.01 Hz	42843	6200	5000	9000	RW
42817	U16	Grid Form Minimum Operating Frequency	0.01 Hz	42843	5800	3000	6000	RW
42818	S16	Grid Form Droop V/Q Proportional Gain Scale	n/a	n/a	-7	-12	12	RW
42819	U16	Grid Form Droop V/Q Proportional Gain	Vrms/ VAR	42818	2500	0	65535	RW
42820	S16	Grid Form Droop W/P Proportional Gain Scale	n/a	n/a	-7	-12	12	RW
42821	U16	Grid Form Droop W/P Proportional Gain	Hz/W	42820	50	0	65535	RW
42822	S32	Grid Form Virtual Inductance	nH	42844	600000	$-1x10^9$	$1x10^9$	RW
42824	S32	Grid Form Virtual Resistance	uOhm	42845	250000	$-1x10^9$	$1x10^9$	RW
42826	U16	Grid Form Max Reconnect Voltage (% of Vref)	0.1 % Vref	42842	1059	1000	1100	RW
42827	U16	Grid Form Min Reconnect Voltage (% of Vref)	0.1 % Vref	42842	867	0	1000	RW
42828	U16	Grid Form Max Reconnect Frequency	0.01 Hz	42843	6100	4500	6500	RW
42829	U16	Grid Form Min Reconnect Frequency	0.01 Hz	42843	5900	4500	6500	RW
42830	U16	Island Control Input - Grid Tie to Island Debounce & Delay	ms	42846	30	1	1000	RW
42831	U16	Island Control Input - Island to Grid Tie Debounce & Delay	ms	42846	40	1	1000	RW
42832	U16	Seamless Transfer Offline Timeout Delay	ms	42846	200	0	300	RW
42833	U16	Seamless Transfer to Island Voltage Ramp Up Delay	ms	42846	20	0	1000	RW
42836	S16	Scale Factor – Grid Form Voltage Command	sunssf	n/a	-1	n/a	n/a	R

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42837	S16	Scale Factor – Grid Form Frequency Command	sunssf	n/a	-2	n/a	n/a	R
42838	S16	Scale Factor – Grid Form Power Command	sunssf	n/a	-1	n/a	n/a	R
42839	S16	Scale Factor – Grid Form Voltage Slew	sunssf	n/a	0	n/a	n/a	R
42840	S16	Scale Factor – Grid Form Frequency Slew	sunssf	n/a	-2	n/a	n/a	R
42841	S16	Scale Factor – Grid Form Power Slew	sunssf	n/a	-1	n/a	n/a	R
42842	S16	Scale Factor – Grid Form Voltage Limits	sunssf	n/a	-1	n/a	n/a	R
42843	S16	Scale Factor – Grid Form Frequency Limits	sunssf	n/a	-2	n/a	n/a	R
42844	S16	Scale Factor – Grid Form Virtual Inductance	sunssf	n/a	-9	n/a	n/a	R
42845	S16	Scale Factor – Grid Form Virtual Resistance	sunssf	n/a	-6	n/a	n/a	R
42846	S16	Scale Factor – Mode Change Delays	sunssf	n/a	-3	n/a	n/a	R

[1]These min/max values are set by their corresponding command min/max configuration registers

[2] Initialized to ***REG 40168*** – ***Voltage at the PCC*** at POR and each time **PCS Mode** is changed from Grid Tie to Grid Forming

[3] Initialized to ***REG 40185*** – ***Nominal Frequency at the ECP*** at POR and each time **PCS Mode** is changed from Grid Tie to Grid Forming

[4]Units include applied scale factor registers

SunSpec Model 0xFFFF Registers – End Model

Number	Data Type	Description	Units[1]	Scale Factor (Reg #)	Factory Default	Min	Max	Access Level
Header:								
42863	U16	Model Identifier	n/a	n/a	0xFFFF	n/a	n/a	R
42864	U16	Model Length - # of 16-bit registers to follow	n/a	n/a	0	n/a	n/a	R

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SERVICING THE UNIT

The PCS is not field serviceable. If the unit needs to return to the manufacturer for evaluation and possible repair, consult the Return Material Authorization Policy of this document as to how to proceed. In removing the PCS from system installation, consult and follow the General Safety precautions.

MAINTENANCE AND UPGRADE

Electrical connections should be regularly checked for mechanical integrity and thermal degradation. Airflow must be maintained and unobstructed for maximum performance.

Firmware Updates

⚠ CAUTION ⚠

When performing PCS firmware updates, the software may automatically reset the values of the configuration registers back to their factory default values. The user must take care to save a copy of any custom settings prior to performing the firmware update.

It is important that the PCS remain powered for up to 5 sec following a firmware upgrade. This allows time for the application firmware to complete the configuration update. Removing bias power before the update is complete can corrupt the non-volatile, configuration memory.

The PCS supports in-system firmware updates. The Trystar-provided Power Studio™ Tool can be used to perform the update, or alternatively, the customer can incorporate the update functionality into their system controller. The firmware update register set is defined in page 126.

To begin the update process, the system controller must first write a 1 to ***REG 41375 – Jump to Bootloader Command.*** This causes the PCS to load and execute the bootloader image, after which the PCS will only respond to read/writes of registers 41376 through 41506. Once the update is complete, the bootloader provides a command to resume execution of the PCS application. Please consult FS-0057 – TMS28x CAN Bootloader Functional Specification for details on how to use these registers to update the application image.

The 4 LED status indicators on the front panel are used to provide Bootloader status and progress information. Table 5 defines each LEDs meaning when the bootloader is running.

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⚠ CAUTION ⚠

The Modbus Addresses provided in the Modbus Register Map table in FS-0057 should be replaced with the corresponding register addresses, 41376 through 41506, on page 126, Trystar Extension Model 64304 Registers – Firmware Update.

TRYSTAR POWER STUDIO™ TOOL

The Trystar Power Studio™ tool is a Microsoft Windows based Graphical User Interface (GUI), as shown in Figure 34, which can be used to easily configure and control the PCS. The tool communicates with the unit using Modbus and provides a simple, intuitive user interface. Some of the features provided by Power Studio™ include:

- Simple tabbed interfaces:
    - Dashboard
    - Configuration
    - Instrumentation
    - Software Upgrade
    - Datalogging
- Dashboard for PCS control and monitoring
- Multi-Target Support
- PCS configuration control, including:
    - Editing configurations
    - Downloading/uploading configurations
    - Archiving multiple configuration files

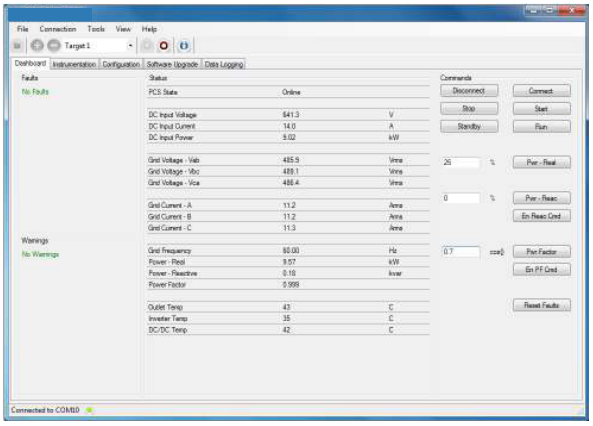

Figure 34 - Trystar Power Studio™ GUI

For detailed information and operating instructions, please refer to Trystar Power Studio™ Owners Manual.

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APPENDIX A – RECORDS OF CERTIFICATION

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Applicant:	Trystar, LLC	**Manufacturer:**	Trystar, LLC
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Country:	USA	**Country:**	USA

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Intertek Testing Services NA Inc.
545 East Algonquin Road, Arlington Heights, IL 60005
Telephone 800-345-3851 or 847-439-5667 Fax 312-283-1672

Standard(s):	Inverters, Converters, Controllers and Interconnection System Equipment for use with Distributed Energy Resources - Including Supplement SA [UL 1741:2021 Ed.3 (Including Supplement SA)] Power Conversion Equipment [CSA C22.2#107.1:2016 Ed.4]
Product:	Energy Storage Power Conversion System
Models:	OZPCS-RS40 may be followed by -PS; followed by -F or -B; followed by two numbers.

ATM for Report 103463292CRT-001 Page 1 of 1 ATM Issued: 28-Sep-2023
ED 16.3.15 (1-Jul-2022) Mandatory

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SUNSPEC ALLIANCE

THE SUNSPEC ALLIANCE HEREBY CERTIFIES THAT

Oztek Corp.

Product Name: OZpcs Power Conversion System

Product Models: OZpcs RS40

Product Description: OZpcs Grid Tied Energy Storage Power Conversion System

Category: Inverter

HAS BEEN ISSUED THIS SUNSPEC CERTIFIED PRODUCT AWARD FOR SUCCESSFUL TESTING AND CERTIFICATION OF THE

SunSpec Information Models 1, 17, 103, 120, 121, 122, 123, 126, 129, 130, 135, 136, 139, 140, 143, 144

AWARDED ON April 03, 2018

Thomas Tansy, Chairman

032-001

Certificate Number

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WARRANTY AND PRODUCT INFORMATION

Limited Warranty

What does this warranty cover and how long does it last? This Limited Warranty is provided by Trystar LLC. ("Trystar") and covers defects in workmanship and materials in your PCS. This Warranty Period lasts for 5 years from the date of purchase at the point of sale to you, the original end user customer, unless otherwise agreed in writing. You will be required to demonstrate proof of purchase to make warranty claims. This Limited Warranty is transferable to subsequent owners but only for the unexpired portion of the Warranty Period. Subsequent owners also require original proof of purchase as described in "What proof of purchase is required?" An extended warranty is available for purchase; contact Trystar Sales for details.

What will Trystar do? During the Warranty Period Trystar will, at its option, repair the product (if economically feasible) or replace the defective product free of charge, provided you notify Trystar of the product defect within the Warranty Period, and provided that through inspection Trystar establishes the existence of such a defect and that it is covered by this Limited Warranty.

Trystar will, at its option, use new and/or reconditioned parts in performing warranty repair and building replacement products. Trystar reserves the right to use parts or products of original or improved design in the repair or replacement. If Trystar repairs or replaces a product, its warranty continues for the remaining portion of the original Warranty Period or 90 days from the date of the return shipment to the customer, whichever is greater. All replaced products and all parts removed from repaired products become the property of Trystar.

Trystar covers both parts and labor necessary to repair the product, and return shipment to the customer via an Trystar-selected non-expedited surface freight within the contiguous United States and Canada. Alaska, Hawaii and locations outside of the United States and Canada are excluded. Contact Trystar Customer Service for details on freight policy for return shipments from excluded areas.

How do you get service? If your product requires troubleshooting or warranty service, contact your merchant. If you are unable to contact your merchant, or the merchant is unable to provide service, contact Trystar directly at:

USA

Telephone: 507-333-3990

Direct returns may be performed according to the Trystar Return Material Authorization Policy described in your product manual.

What proof of purchase is required? In any warranty claim, dated proof of purchase must accompany the product unless you have received written Return Material Authorization from Trystar stating that further proof of

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purchase is not required. Proof of purchase may be in any one of the following forms:

- The dated purchase receipt from the original purchase of the product at point of sale to the end user
- The dated dealer invoice or purchase receipt showing original equipment manufacturer (OEM) status
- The dated invoice or purchase receipt showing the product exchanged under warranty

What does this warranty not cover? Claims are limited to repair and replacement, or if in Trystar's discretion that is not possible, reimbursement up to the purchase price paid for the product. Trystar will be liable to you only for direct damages suffered by you and only up to a maximum amount equal to the purchase price of the product. This Limited Warranty does not warrant uninterrupted or error-free operation of the product or cover normal wear and tear of the product or costs related to the removal, installation, or troubleshooting of the customer's electrical systems. This warranty does not apply to and Trystar will not be responsible for any defect in or damage to:

a. The product if it has been misused, neglected, improperly installed, physically damaged or altered, either internally or externally, damaged from improper use or use in an unsuitable environment, or operated outside of the specified safe operating temperature regions

b. The product if it has been subjected to fire, water, generalized corrosion, biological infestations, or input voltage that creates operating conditions beyond the maximum or minimum limits listed in the Trystar product specifications including high input voltage from generators and lightning strikes

c. The product if repairs have been done to it other than by Trystar or its authorized service centers (hereafter "ASCs")

d. The product if it is used as a component part of a product expressly warranted by another manufacturer

e. The product if its original identification (trademark, serial number) markings have been defaced, altered, or removed

f. Any consequential losses that are attributable to the product losing power whether by product malfunction, installation error or misuse.

Disclaimer

Product

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RETURN MATERIAL AUTHORIZATION POLICY

Before returning a product directly to Trystar you must obtain a Return Material Authorization (RMA) number and the correct factory "Ship To" address. Products must also be shipped prepaid. Product shipments will be refused and returned at your expense if they are unauthorized, returned without an RMA number clearly marked on the outside of the shipping box, if they are shipped collect, or if they are shipped to the wrong location. When you contact Trystar to obtain service, please have your instruction manual ready for reference and be prepared to supply: .

- The serial number of your product
- Information about the installation and use of the unit
- Information about the failure and/or reason for the return
- A copy of your dated proof of purchase

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Return Procedure

Package the unit safely, using the original box and packing materials. Please ensure that your product is shipped fully insured in the original packaging or equivalent. This warranty will not apply where the product is damaged due to improper packaging. Include the following:

- The RMA number supplied by Trystar clearly marked on the outside of the box.
- A return address where the unit can be shipped. Post office boxes are not acceptable.
- A contact telephone number where you can be reached during work hours.
- A brief description of the problem.

Ship the unit prepaid to the address provided by your Trystar customer service representative.

If you are returning a product from outside of the USA or Canada - In addition to the above, you MUST include return freight funds and you are fully responsible for all documents, duties, tariffs, and deposits.

Out of Warranty Service

If the warranty period for your product has expired, if the unit was damaged by misuse or incorrect installation, if other conditions of the warranty have not been met, or if no dated proof of purchase is available, your unit may be serviced or replaced for a flat fee. If a unit cannot be serviced due to damage beyond salvation or because the repair is not economically feasible, a labor fee may still be incurred for the time spent making this determination.

To return your product for out of warranty service, contact Trystar Customer Service for a Return Material Authorization (RMA) number and follow the other steps outlined in "Return Procedure".

Payment options such as credit card or money order will be explained by the Customer Service Representative. In cases where the minimum flat fee does not apply, as with incomplete units or units with excessive damage, an additional fee will be charged. If applicable, you will be contacted by Customer Service once your unit has been received.

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OPTIONAL EXTENDED WARRANTY

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What does this warranty cover and how long does it last? This Limited Extended Warranty is provided by Trystar LLC. ("Trystar") and covers defects in workmanship and materials in your PCS. This Warranty extends the duration of warranty protection period to 10 years from the date of purchase at the point of sale to you, the original end user customer, unless otherwise agreed in writing. This Extended Warranty does not increase the duration of coverage for the cooling fans, which are considered a wear item. You will be required to demonstrate proof of purchase to make warranty claims. This Limited Warranty is transferable to subsequent owners but only for the unexpired portion of the Warranty Period. Subsequent owners also require original proof of purchase as described in "What proof of purchase is required?"

What will Trystar do? During the Warranty Period Trystar will, at its option, repair the product (if economically feasible) or replace the defective product free of charge, provided you notify Trystar of the product defect within the Warranty Period, and provided that through inspection Trystar establishes the existence of such a defect and that it is covered by this Limited Warranty.

Trystar will, at its option, use new and/or reconditioned parts in performing warranty repair and building replacement products. Trystar reserves the right to use parts or products of original or improved design in the repair or replacement. If Trystar repairs or replaces a product, its warranty continues for the remaining portion of the original Warranty Period or 90 days from the date of the return shipment to the customer, whichever is greater. All replaced products and all parts removed from repaired products become the property of Trystar.

Trystar covers both parts and labor necessary to repair the product and return shipment to the customer via an Trystar-selected non-expedited surface freight within the contiguous United States and Canada. Alaska, Hawaii and locations outside of the United States and Canada are excluded. Contact Trystar Customer Service for details on freight policy for return shipments from excluded areas.

How do you get service? If your product requires troubleshooting or warranty service, contact your merchant. If you are unable to contact your merchant, or the merchant is unable to provide service, contact Trystar directly at:

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Telephone: 507-333-3990

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purchase is not required. Proof of purchase may be in any one of the following forms:

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- The dated dealer invoice or purchase receipt showing original equipment manufacturer (OEM) status
- The dated invoice or purchase receipt showing the product exchanged under warranty

What does this warranty not cover? Claims are limited to repair and replacement, or if in Trystar's discretion that is not possible, reimbursement up to the purchase price paid for the product. Trystar will be liable to you only for direct damages suffered by you and only up to a maximum amount equal to the purchase price of the product. This Limited Warranty does not warrant uninterrupted or error-free operation of the product or cover normal wear and tear of the product or costs related to the removal, installation, or troubleshooting of the customer's electrical systems. This warranty does not apply to and Trystar will not be responsible for any defect in or damage to:

a. The product if it has been misused, neglected, improperly installed, physically damaged or altered, either internally or externally, or damaged from improper use or use in an unsuitable environment, or operated outside of the safe operating zones specified in the PCS-RS40 User's Manual.

b. The product if it has been subjected to fire, water, generalized corrosion, biological infestations, or input voltage that creates operating conditions beyond the maximum or minimum limits listed in the Trystar product specifications including high input voltage from generators and lightning strikes

c. The product if repairs have been done to it other than by Trystar or its authorized service centers (hereafter "ASCs")

d. The product if it is used as a component part of a product expressly warranted by another manufacturer

e. The product if its original identification (trademark, serial number) markings have been defaced, altered, or removed

f. Any consequential losses that are attributable to the product losing power whether by product malfunction, installation error or misuse.

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Product

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