Addendum Modbus Network Installation Guide for the PVP30kW, PVP75kW and PVP100kW Commercial Inverters

Overview

The PV Powered commercial inverters are supplied with a modbus connection for networking to utilize the Data Monitoring Module integrated into the PVP30kW, PVP75kW and PVP100kW models. This document explains how to connect an inverter to a modbus network using the modbus serial communication protocol. These inverters also utilize a web-based system for the Data Monitoring Module. The web-based Data Monitoring Module is explained in the product specific installation and operation manual.

This addendum targets PV installers and modbus network programmers. This document is a supplement to the complete installation guide for the appropriate inverter. Before you begin the steps described in this addendum, please read and follow the instructions in the installation guide for your inverter.

Modbus communication protocol

Modbus is a serial communications protocol for use with programmable logic controllers (PLCs). Modbus has become a standard communications protocol and is now the most commonly available means of communicating with industrial electronic devices such as the PV Powered inverters. Modbus also allows for communication between a modbus master and multiple slaves connected to the same network. RS-485 is the protocol standard used by PV Powered as the hardware's serial interface while modbus is the communication protocol that runs on the PV Powered inverters.

Networking using the modbus option

The following steps can be performed by a certified installer to complete your modbus network. These steps are explained in this document:

A. Field installation process (to be performed on-site)

The first three steps can be completed by a PV installer that does not have working knowledge of a modbus network:

1. Installing the modbus cable.
2. Using jumpers to set the pins.
3. Setting the modbus address for each slave inverter.

B. Modbus network configuration process (can be completed on-site or remotely)

The last two steps should be completed by the modbus network programmer:

1. Setting the communication parameters.
2. Using modbus commands.

A. Installation Process

Before you start, disconnect the power to the inverter.

DANGER
AC and DC voltages will still be present at the inverter AC and DC landing points unless utility connection circuit breaker and PV array inputs are disconnected.

DANGER
Risk of Electrical Shock. Allow five (5) minutes for internal power to dissipate prior to entering the enclosure cabinet. Ensure all terminals are voltage free with the use of a multimeter.

1. Installing the modbus cable

1. Route the cable from your master device on your RS-485 modbus network through the gland plate or knockout on the inverter using the appropriate water-tight conduit connections. Connections are made using insulated, twisted-pair communication cable rated for outdoor operation at 600V, such as Belden #9341.

   PVP30kW inverters: Use the ¾" knockout on the back left side of the upper section of the inverter.

   PVP75kW/PVP100kW inverters: The gland plate is a flat piece of metal covering the holes in the side of the inverter. Remove the gland plate and cut a hole in the desired location to allow access for the cable. Replace the gland plate.

Figure 1: Power interface and data comm sections on PVP30kW inverter

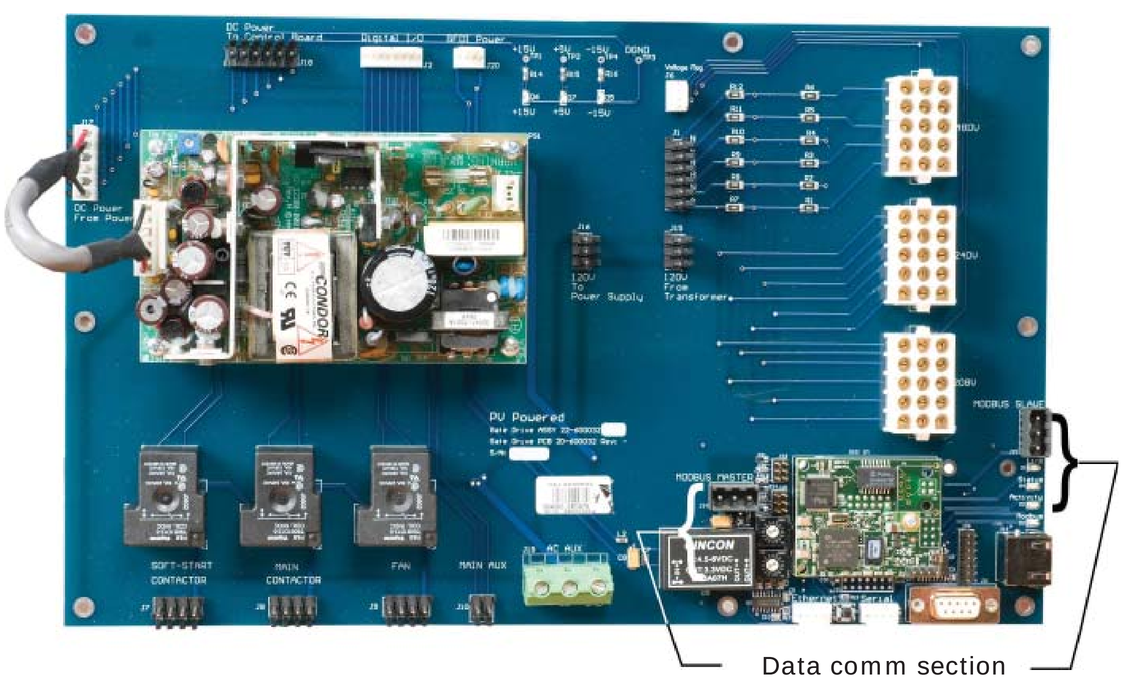

Figure 2: Close-up view of data comm section on the PVP30kW inverter

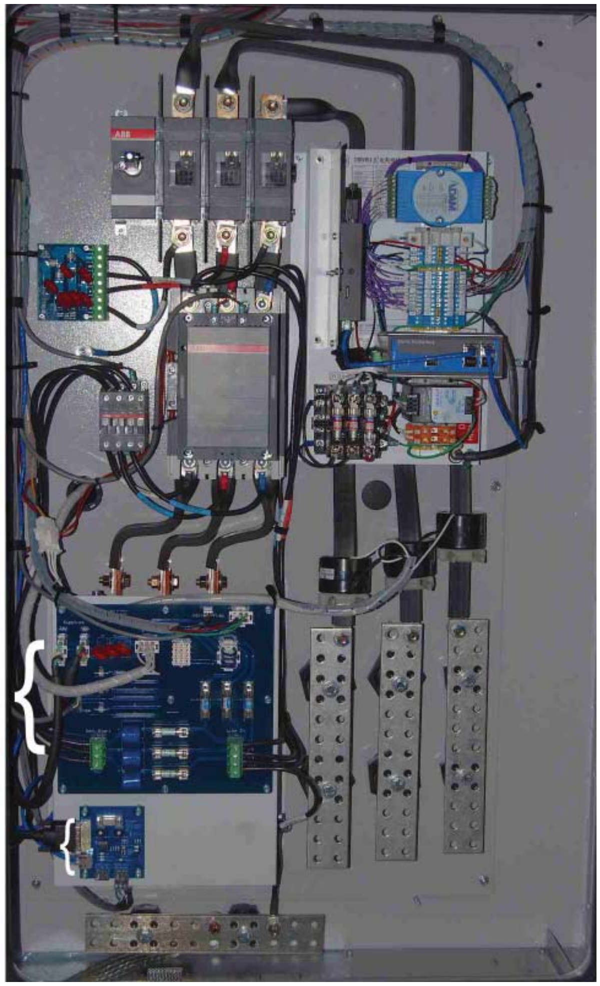

Figure 3: AC Distribution and the Comm X PCBs on the PVP75kW/PVP100kW inverters

2. Connect the modbus cable.

   The end of the modbus cable connects to the modbus slave connector on each inverter. The modbus master connector is not enabled at this time. The connection location depends on the inverter model you are installing.

   PVP30kW inverters: This connection resides on the data comm section in the upper cabinet of the inverter. See Figures 1 and 2 above. The MODBUS SLAVE connection is on the upper right of the data comm section. The connections are GND on top, plus (+) connection in the middle and minus (-) on the bottom. Refer to Figure 4 below.

   PVP75kW/PVP100kW inverters: This connection resides on the Comm X PCB in the lower left cabinet. See Figure 3 above. The MODBUS Slave connection is on the lower right of the PCB. See Figure 5 below.

   Connect the plus (+) cable to all plus (+) connections and the minus (-) cable to all other minus (-) connections so they correspond throughout the network.

   Note: The modbus master connections are reserved for future use.

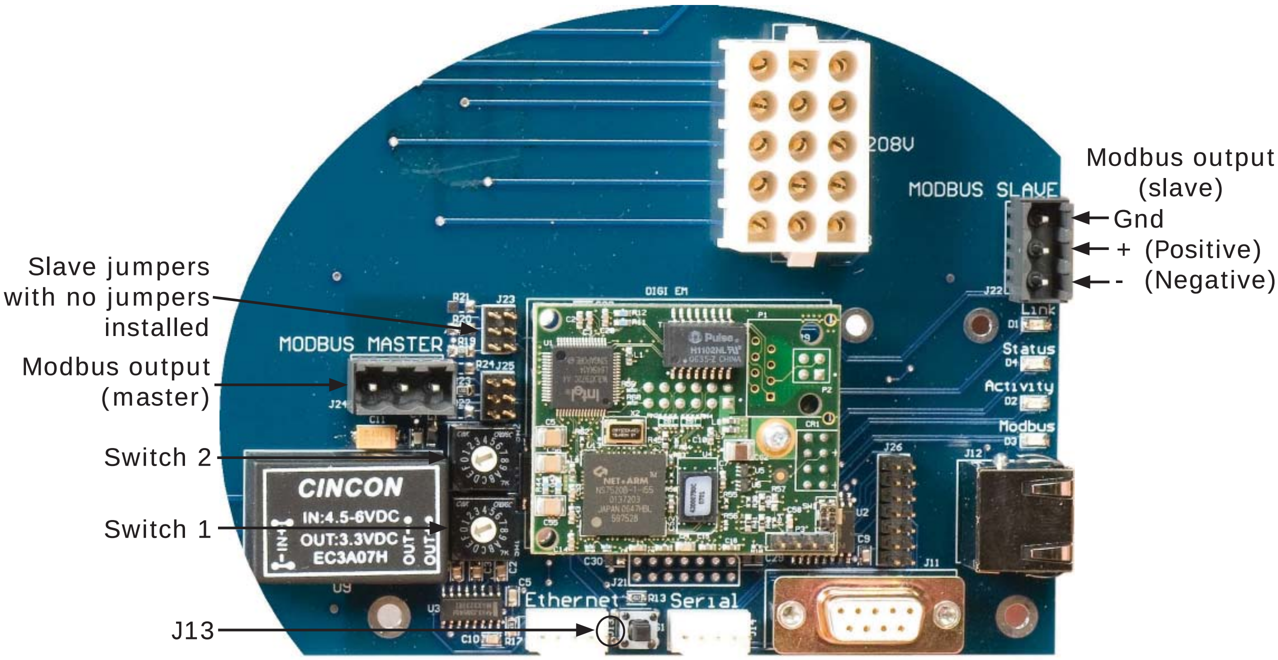

Figure 4: Data comm section of PVP30kW inverters

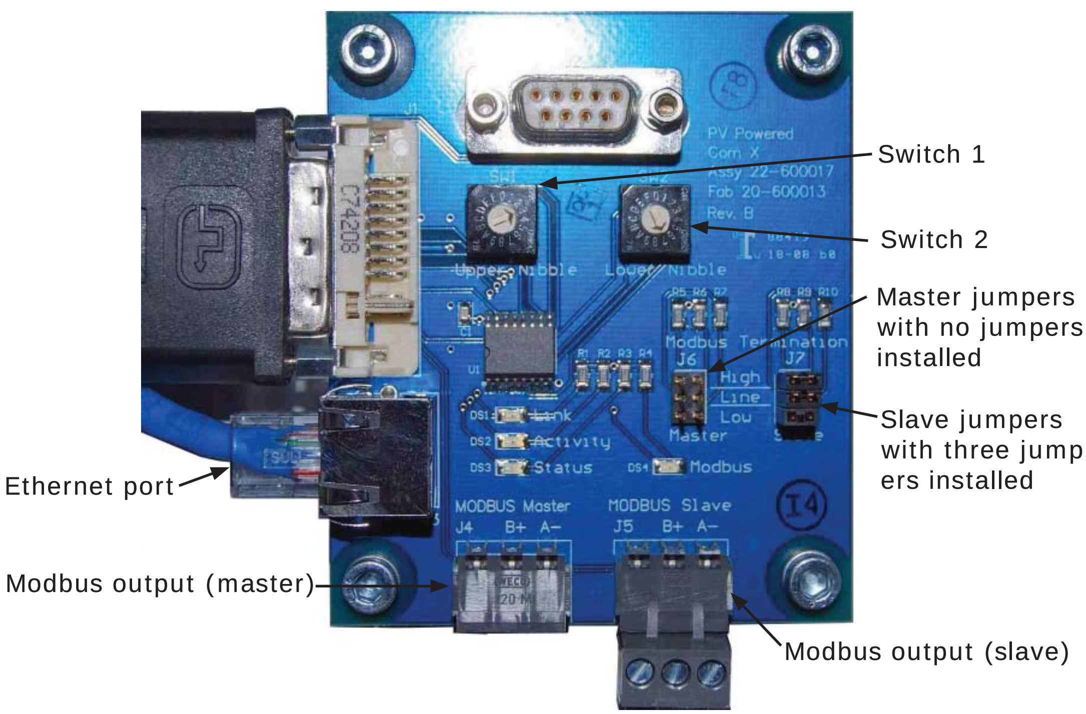

Figure 5: Comm X PCB for the PVP75kW/PVP100kW inverters

3. Connect a ground reference line to the third connection on the modbus slave connector. It is recommended that PV Powered devices have connected grounds when possible. The "ref line" (r connector) in Figure 6 below shows the ground connection.

   PVP30kW inverters: This is the top or GND connection of the MODBUS SLAVE connector.

   PVP75kW/PVP100kW inverters: This is the J5 connection of the MODBUS Slave connector.

   Note: If your modbus device does not have a ground connection, it is not required to connect it to a ground cable.

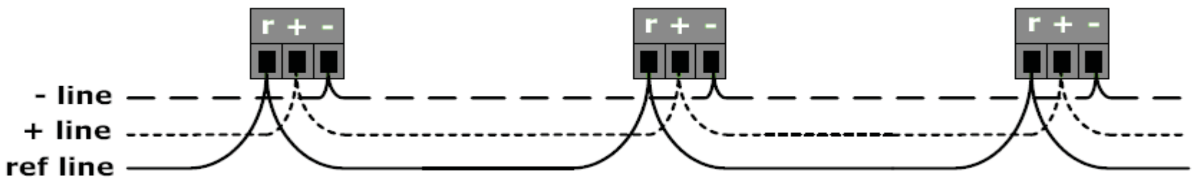

Figure 6. Daisy chain layout for RS-485 network

When multiple inverters or other modbus slave devices are connected to a single modbus master device, the multiple devices need to be connected in a daisy chain as shown in Figure 6. A daisy chain means that all plus (+) connections are chained together and all minus (-) connections are chained together across the network.

Other network layouts are not recommended when using the RS-485 standard.

Note: On the PVP30kW inverter, confirm that the 5-wire cable from the control board is connected to the J13 connector labeled Ethernet. This is required in order to collect the inverter's data by both modbus and Ethernet data monitoring. Refer to Figure 4 to verify the location of J13.

2. Using jumpers to set the pins

By default, the termination pins have all three slave jumpers installed when the inverter is shipped. By modifying the location of the jumpers on the termination pins you can make the following settings to an inverter:

- Terminate the network
- Set an inverter as a slave device
- Turn on biasing

Jumper setting options:

1. Terminate the network.

   The performance of your modbus network requires each end of the network to be terminated. When multiple devices are on a network in a daisy chain layout, a jumper is used to terminate the devices at each physical end of the network.

   PVP30kW inverters: Remove jumpers one and three and leave the jumper on the middle pair of pins of J23 for a network with only one slave device or for the device on the end of a network.

   PVP75kW/PVP100kW inverters: Remove jumpers one and three and leave the jumper on the middle pair of pins of J7 for a network with only one slave device or for the device on the end of a network.

2. Set the slave devices.

   PVP30kW inverters: Remove the three jumpers from all the J23 pins for any device in the middle of your network.

   PVP75kW/PVP100kW inverters: Remove the three jumpers from all the J7 pins for any device in the middle of your network.

3. Set the biasing.

   Biasing sets the voltage levels on the network cables. It is not required but can make communications more reliable as it maintains a constant voltage level on the data lines of an inactive or idle network. Only one device on the network needs to have the biasing jumpers installed.

   PVP30kW inverters: Install a jumper on the first pair and last pair of pins of J23.

   PVP75kW/PVP100kW inverters: Install a jumper on the first pair and last pair of pins of J7.

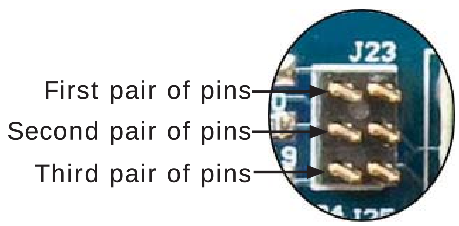

Figure 7: J23 pins on data comm section of PVP30kW

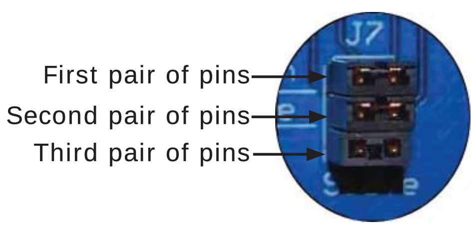

Figure 8: J7 pins with jumper terminators on Comm X PCB of PVP75kW/PVP100kW inverter

3. Setting the modbus address for each slave device

A modbus network containing slave devices requires a unique address for each slave. This allows the master device to identify and communicate with each slave. The modbus network administrator must assign an unique modbus address to each PV Powered inverter.

To set the address:

1. Determine each slave address.

   The addresses are represented using the hexadecimal representation of digits 0 through 9 and letters A through F. For example, slave 1 is set to 01, slave 10 is set to 0A, and so forth. Refer to the following inverter address conversion table to select a unique address for each slave device by locating the number of the slave device in the "Address" column. Move right to the "Switch" column to find the converted address value of this slave device.

   Note: 0 is not an allowed address.

Address	Switch		Address	Switch		Address	Switch		Address	Switch		Address	Switch	
	1	2		1	2		1	2		1	2		1	2
1	0	1	21	1	5	41	2	9	61	3	D	81	5	1
2	0	2	22	1	6	42	2	A	62	3	E	82	5	2
3	0	3	23	1	7	43	2	B	63	3	F	83	5	3
4	0	4	24	1	8	44	2	C	64	4	0	84	5	4
5	0	5	25	1	9	45	2	D	65	4	1	85	5	5
6	0	6	26	1	A	46	2	E	66	4	2	86	5	6
7	0	7	27	1	B	47	2	F	67	4	3	87	5	7
8	0	8	28	1	C	48	3	0	68	4	4	88	5	8
9	0	9	29	1	D	49	3	1	69	4	5	89	5	9
10	0	A	30	1	E	50	3	2	70	4	6	90	5	A
11	0	B	31	1	F	51	3	3	71	4	7	91	5	B
12	0	C	32	2	0	52	3	4	72	4	8	92	5	C
13	0	D	33	2	1	53	3	5	73	4	9	93	5	D
14	0	E	34	2	2	54	3	6	74	4	A	94	5	E
15	0	F	35	2	3	55	3	7	75	4	B	95	5	F
16	1	0	36	2	4	56	3	8	76	4	C	96	6	0
17	1	1	37	2	5	57	3	9	77	4	D	97	6	1
18	1	2	38	2	6	58	3	A	78	4	E	98	6	2
19	1	3	39	2	7	59	3	B	79	4	F	99	6	3
20	1	4	40	2	8	60	3	C	80	5	0	100	6	4

Table 1: Inverter address conversion for switches 1 and 2

2. Set the switch address on each slave device.

The slave address for each PV Powered inverter is set using two rotary switches. Each switch is hexadecimal, containing 0 through 9, followed by A through F. Set the switches using the following guideline:

- The first switch is always set to the value in the “1” column below the “Switch” heading

- The second switch is always set to the value in the “2” column below the “Switch” heading

For example, if you are setting the address of the first slave device, inverter 1 of your network, to the hexadecimal address 05, the first switch is set to 0, the first digit of the hexadecimal address, and the second switch is set to 5, the second digit of the address.

Switch 2

Switch 1

Figure 9: Rotary switches for setting the inverter number on the PVP30kW

PVP30kW inverters: The switches are located to the right and below the MODBUS MASTER. They are stacked with SW2 on top and SW1 on the bottom as they appear in Figure 9.

Switch 1 Switch 2

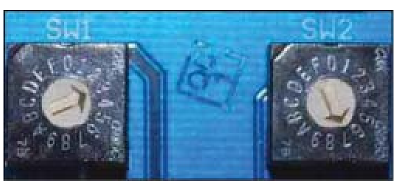

Figure 10: Rotary switches for setting the inverter number on the PVP75kW/PVP100kW

PVP75kW/PVP100kW inverters: The switches are located near the center of the Comm X PCB and are labeled SW1 and SW2.

If you need more device addresses than the 100 listed in the above table, refer to a complete digital to hexadecimal conversion table.

Note: Some modbus master devices do not allow addresses above the decimal value of 126. PV Powered recommends keeping the number of slave devices between 2 and 100.

B. Network configuration process

1. Setting the communication parameters

The RS-485 modbus master communication settings need to be set to the values in Table 2. This allows your modbus master device to communicate with the inverter. Follow the instructions in the manual for your master device to complete these settings.

Parameter	Setting
Baud	9600
Parity	N
Data bits	8
Stop bit	1
Flow control	None

Table 2: Communication settings

2. Using modbus commands

PV Powered inverters provide basic modbus commands. The supported commands are listed in the following table.

Command Name	Command Number	Description
Read Holding Register	03	Retrieves the voltage, power and energy values from the inverter.
Write (Preset) Single Register	06	Enables/disables the inverter.
Return Slave ID	17	Returns a text string containing the ID number of the inverter.

Table 3: Supported modbus commands

Format of modbus commands and responses

Each of the following command sections contain two tables. The first table describes the format of a modbus command request while the second table contains the format of the command's response.

Then the next section, *Modbus register maps*, provides additional information about these commands and their valid registers.

Read Holding Register

The **Read Holding Register** command is used frequently. Typically the modbus master continually reads the values from registers containing the desired information.

Command Information	Command Layout
Slave ID	nn (1-126)
Command number	03
First register MSB	xx
First register LSB	xx
Number of registers MSB	xx
Number of registers LSB	xx
CRC LSB	xx
CRC MSB	xx

Table 4: Format for Read Holding Register, command 03

Response Information	Response Layout
Slave ID	nn (1-126)
Command number	03
Number of bytes of data	n
Fist register MSB	xx
First register LSB	xx
Second register MSB	xx
Second register LSB	xx
Nth register MSB	xx
Nth register LSB	xx
CRC LSB	xx
CRC MSB	xx

Table 5: Format for Read Holding Register, response to command 03

Write Single Register

The **Write Single Register** command is used to write to one of the command registers found in Table 13. Using this command does not change the inverter's data in registers described in Tables 10, 11 or 12.

Command Information	Command Layout
Slave ID	nn (1-126)
Command number	06
First register MSB	xx
First register LSB	xx
Data MSB	xx
Data LSB	xx
CRC LSB	xx
CRC MSB	xx

Table 6: Format for Write Single Register, command 06

Response Information	Response Layout
Slave ID	nn (1-126)
Command number	06
Number of bytes of data	n
First register MSB	xx
First register LSB	xx
Data MSB	xx
Data LSB	xx
CRC LSB	xx
CRC MSB	xx

Table 7: Format for Write Single Register, response to command 06

Return Slave ID

Command Information	Command Layout
Slave ID	nn (1-126)
Command number	11h

Table 8: Format for Return Slave ID, command 11h

Response Information	Response Layout
Slave ID	nn (1-126)
Command number	11h
Number of bytes of data	n
Data 1	xx
Data 2	xx
Data n	xx
CRC LSB	xx
CRC MSB	xx

Table 9: Format for Return Slave ID, response to command 11h

Modbus register maps

The following tables list the modbus registers with their location and a description of the data stored in the register. For more information describing the data format contained in column six, the "Format" column of each table, see Table 19 at the end of this document.

Description	Start Register	End Register	Nbr. of Registers	MB Address	Format	Range	Notes
Modbus base address = 0							
Inverter ID number	0	7	8	40001	ASCII	16 char	Unique number for each inverter
Firmware version	8	11	4	40009	ASCII	8 char	Example: V1.9
Inverter configuration	12	12	1	40013	UINT 16	0-2	AC Volt_code: 0=208; 1=240; 2=480
Map version	13	13	1	40014	UINT 16	2	Increment sequentially as the map changes

Table 10: Fixed information registers

Description	Start Register	End Register	Nbr. of Registers	MB Address	Format	Range	Notes
Modbus base address = 1000							
VoltsA L-N	1000	1001	2	41001	FLOAT	+/- 9999.9999	
VoltsB L-N	1002	1003	2	41003	FLOAT	+/- 9999.9999	
VoltsC L-N	1004	1005	2	41005	FLOAT	+/- 9999.9999	
Current A[1]	1006	1007	2	41007	FLOAT	+/- 9999.9999	
Current B	1008	1009	2	41009	FLOAT	+/- 9999.9999	
Current C	1010	1011	2	41011	FLOAT	+/- 9999.9999	
DC input voltage	1012	1013	2	41013	FLOAT	+/- 9999.9999	
DC input current[2]	1014	1015	2	41015	FLOAT	+/- 9999.9999	
Line frequency	1016	1017	2	41017	FLOAT	+/- 9999.9999	
Line kW	1018	1019	2	41019	FLOAT	+/- 9999.9999	
Total kWH delivered	1020	1021	2	41021	UINT 32	0 - 4.29 e9	

Table 11: Data registers

1. For the PVP30kW inverters, phase A current is calculated from phase B and C currents.
2. For the PVP30kW inverters, DC input current is not measured and always reports back as 0 amps.

Description	Start Register	End Register	Nbr. of Registers	MB Address	Format	Range	Notes
Modbus base address = 2000							
Inverter operating status (state)	2000	2000	1	42001	UINT 16	bit mapped	See Table 14
Inverter fault word 0	2001	2001	1	42002	UINT 16	bit mapped	See Table 15
Inverter fault word 1	2002	2002	1	42003	UINT 16	bit mapped	See Table 16
Inverter fault word 2	2003	2003	1	42004	UINT 16	bit mapped	See Table 17
Data comm status codes	2004	2004	1	42005	UINT 16	bit mapped	See Table 18

Table 12: Status and fault code registers

To set the following command registers, you need to use the **Write Single Register** command.

Description	Start Register	End Register	Nbr. of Registers	MB Address	Format	Range	Notes
Modbus base address = 3000							
Clear fault command	3000	3000	1	43001	UINT 16	CF hex	Write this value to clear faults and try a restart.
Disable inverter[3]	3001	3001	1	43002	UINT 16	DD hex	Write 0xDD to disable Write 0xEE to enable
Enable inverter	3002	3002	1	43003	UINT 16	EE hex	Write 0xDD to disable Write 0xEE to enable
Reset data comm section	3003	3003	1	43004	UINT 16	99 hex	Write 99 hex to this register to reset the Comm X board.

Table 13: Command registers

3. Reading this register returns 0 after bootup, or either DD after a disable or EE hex after an enable command is sent.

Response values for status and fault registers

The following tables contain the status and fault bitmap information for each status register in Table 12. The command's response values are returned as hexadecimal values which you need to convert to the decimal value in order to understand the returned information.

Description	Hex Value	Decimal Value
Modbus register number = 42001		
Powering up	0	0
Transformer pre charge	1	1
Contractor delay	2	2
Idle	10	16
Peak power tracking	15	21
Faulted (fault words 0, 1, 2 below provide details about the fault type)	80	128

Table 14: Inverter operating status (state) values

In tables 15 through 17, each type of fault in the "Description" column can have a value of "0" indicating no fault or a "1" indicating a fault.

Description	Bit Nbr.	Hex Value	Decimal Value
Modbus register number = 42002			
Module fault	15	8000	32768
Undefined	14	4000	16384
Undefined	13	2000	8192
Voltage fault	12	1000	4096
Undefined	11	800	2048
Ground fault	10	400	1024
Low power fault	9	200	512
CPU load fault	8	100	256
Undefined	7	80	128
Over current fault	6	40	64
Pre-charge fault	5	20	32
Undefined	4	10	16
Undefined	3	8	8
Heatsink temperature fault	2	4	4
Watchdog timer fault	1	2	2
Ambient temperature fault	0	1	1

Table 15: Fault word 0

Description	Bit Nbr.	Hex Value	Decimal Value
Modbus register number = 42003			
Undefined	15	8000	32768
Undefined	14	4000	16384
Undefined	13	2000	8192
Undefined	12	1000	4096
Undefined	11	800	2048
Fan 2 fault	10	400	1024
Fan 1 fault	9	200	512
Over current phase C	8	100	256
Over current phase B	7	80	128
Over current phase A	6	40	64
Drive C hi fault	5	20	32
Drive C lo fault	4	10	16
Drive B hi fault	3	8	8
Drive B lo fault	2	4	4
Drive A hi fault	1	2	2
Drive A lo fault	0	1	1

Table 16: Fault word 1

Description	Bit Nbr.	Hex Value	Decimal Value
Modbus register number = 42004			
Undefined	15	8000	32768
Undefined	14	4000	16384
Undefined	13	2000	8192
Undefined	12	1000	4096
PLL fault	11	800	2048
AC overvoltage fault	10	400	1024
AC undervoltage fault	9	200	512
AC under frequency fault	8	100	256
AC over frequency fault	7	80	128
Undefined	6	40	64
DC under voltage fault	5	20	32
DC overvoltage fault	4	10	16
Floating power supply fault	3	8	8
-15V fault	2	4	4
+15V fault	1	2	2
+5V fault	0	1	1

Table 17: Fault word 2

Description	Bit Nbr.	Hex Value	Decimal Value
Modbus register number = 42005			
OK		0	0
Rebooting		1	1
Inverter communication fault		2	2
Web post fault		4	4
DNS server fault		5	5

Table 18: Inverter data comm status word

Data Format	Description	Notes
ASCII	Two ASCII characters per register	For a text string the left most character is in the lowest register number.
UINT16	Unsigned integer: 16 bits	Range: 0 to 65535
SINT16	Signed integer: 16 bits	Range: -32767 to +32767
UINT 32 (requires two registers)	Unsigned integer: 32 bits	Range: 0 to 4,294,967,295
SINT 32 (requires two registers)	Signed integer: 32 bits	Range: -2,147,483,647 to +2,147,483,647
FLOAT (requires two registers)	IEEE 754 standard 32-bit floating point number	

Table 19: Data formats for registers

Information about the Data Monitoring Module

For additional information on how to use the modbus Data Monitoring Module, contact PV Powered Customer Service and Technical Support at 1-877-312-3832.