PVMET-75

User's Guide

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Introduction

The PVMET-75 weather station is a compact and economical solution designed to monitor the efficiency of photovoltaic installations. It measures ambient airtemperature, PV panel temperature and either global or plane of array irradiance. The PVMET-75 is Sunspec compliant and uses a 2-wire half duplex serial port for Modbus communication to a host.

Unpacking the System

When unpacking the system the following components should be located.

A1102 – PVME -75 Sensor Assembly
A2101 – PV Cell Temperature Sensor
A1020 – Sensor Assembly Mounting Mast
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If the system was ordered with any accessory, it should be located while unpacking the system. The available accessories for the PVMET-75 are listed below.

A2101 – PV Cell Temperature Sensor
A3000 - Mono-Mount
A3010 – Tripod Galvanized Steel

If any of the components are missing, RainWise Inc. should be contacted.

Installing the Weather Station

It is suggested that you operate your system at ground level and make sure that all components operate properly prior to installation.

If any of the components are damaged or malfunctioning upon receipt, RainWise should be contacted.

Site Requirements and Considerations

Ambient air temperature and global irradiance can be affected by obstructions and local topography. Each site is different and presents challenges in its own unique way. Any object, in excess of 10 degrees above the plane of the irradiance sensor, must not block the sensor. The PVMET-75 sensor assembly, which contains the ambient air temperature, should be no closer than 4 times any obstruction's height and should be placed away from any dark, heat-absorbing surface.

When roof-mounting the sensor assembly, the unit should be mounted toward an edge of the roof preferably on the prevailing wind side of the building and should be at least 2 1/2 feet above the roofline. Avoid locating the station near any heat sources such as chimneys or vents.

Installation

Weather Station

Mount the support mast securely. This may be done by using the Mono-Mount or Tripod, which is sold as an accessory to the PVMET -75. The mast may also be attached to a support structure using U-Bolts. Do not tighten the support structure to the PVMET-75 unit; it will need to be oriented to the correct direction.

Rotate the assembled unit until the electronics enclosure faces TRUE SOUTH or TRUE NORTH if you are in the northern or southern hemisphere, respectively. Secure the support mast to the assembly. Rotation is prevented by lining up the two holes in each mast.

Irradiance Sensor

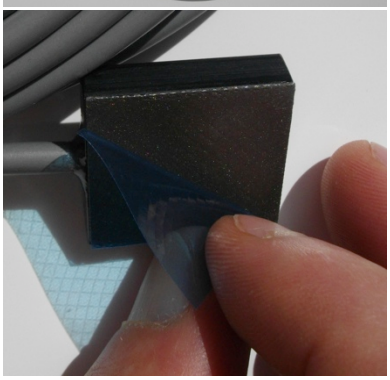
The pyranometer is attached to the sensor assembly and when orientated correctly will measure global or plane or array irradiance. To accurately measure this quantity, the sensor must be adjusted to the appropriate angle. This is done by using a 5/32" or 4mm Allen wrench to loosen the adjustable mounting bracket to the correct angle.

PV Temperature Sensors

This sensor is designed to attach directly to any solar panel. When placed on the center of the back of the panel, it accurately measures the temperature of the panel.

Prior to installation of the PV temperature sensor onto the PV panel, the installation area of the panel back should be thoroughly cleaned. This cleaning will ensure a good bond between sensor and panel and allow for accurate panel temperature readings.

After cleaning, peel off the protective adhesive tape on the temperature sensor and stick it onto the panel. Firmly press the sensor into place. Refer to the picture below. The cable should be secured within 8 inches of the temperature-sensing element.



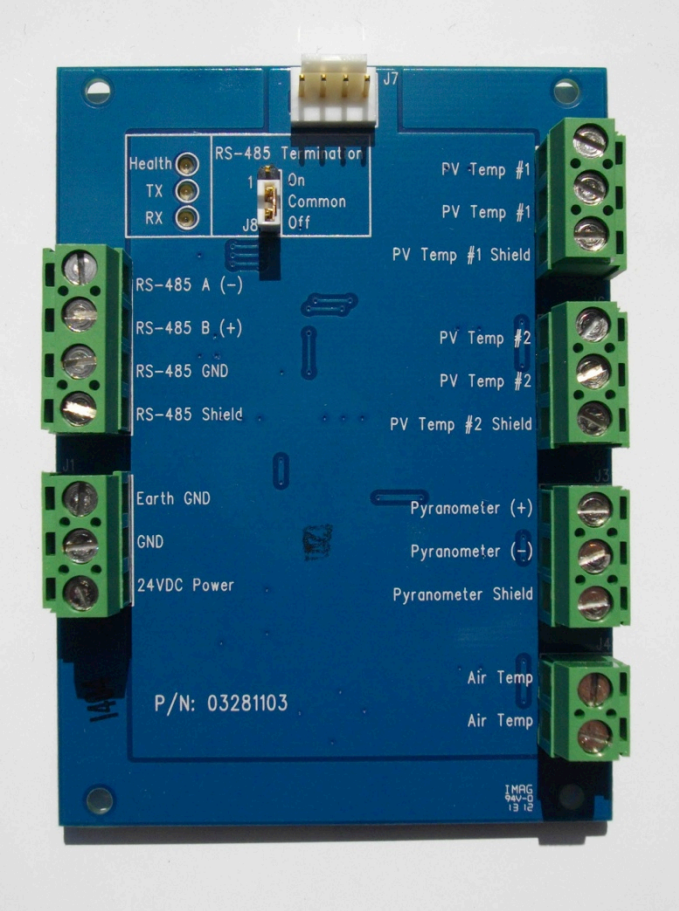
Run the cable back to the PVMET-75 unit and connect to the PV temperature sensor terminals.

If the cable length of 25ft. is insufficient for the installation, additional cable can be added to the existing cable. If this is done, an accuracy-derating factor must be added to

the overall temperature accuracy of this sensor. For every 100ft. of cable added, a derating factor of -0.125C must be taken into account.

Wiring

To enter the enclosure with a cable, the lid must first be removed. Remove the four Philips head screws from the back of the enclosure. Once the lid is removed, the circuit board is exposed. The inside of the enclosure will appear as below.



When replacing the cover, make sure that all installed cables are pinched by the black foam on the bottom of the enclosure. This will enable a weather tight seal.

Connecting External PV Sensor

The PV sensors are not polarity sensitive. Therefore, each signal wire is interchangeable. The sensor comes with a 25ft length of cable.

PV Temperature Terminals

PV Temp #1:	Signal
PV Temp #1:	Signal
PV Temp #1 Shield:	Cable Shield and Drain

Connecting RS-485

The PVMET-75 is supplied with a half duplex RS-485/422 serial port. The default firmware build supports RS-422 only. Custom firmware builds are addressable and support integration into RS-485 networks. Contact RainWise for further information.

Wiring connections are made using the 4-pin screw terminal inside of the PVMET-75 electronics enclosure. Cable is not supplied with the unit. The RS-485/422 lines are terminated with a 120 ohm resistor. This can be disabled by moving the termination jumper, located inside the unit, to the OFF position. This requires removing the enclosure cover. To do this, remove the 4 screws on the bottom side of the unit.

RS-485/422 Terminals

A (-) :	Negative RS-485
B (+) :	Positive RS-485
Gnd:	Signal Ground
Shield:	Cable Shield and Drain

RS-485 is rated to 4,000 feet (1,200m) at 90 kbps. The RS-485 port on the PVMET-75 is surge protected but not isolated.

Connecting the Power Supply

The power supply is nominally rated for 24VDC but can accept a voltage in the range of 10 to 30VDC. The inputs are reverse polarity, surge, overvoltage and over current protected. The power supply is not isolated.

Power Supply Terminals

Earth Gnd:	Earth or Chassis Ground
Gnd:	Negative Supply Voltage
24VDC:	Positive Supply Voltage

Connectivity Verification

Once the station is completely connected, the power supply should be turned on. When power is applied, the red “Health” LED should start flashing. This LED is the system’s heartbeat and indicates proper functionality. If the “Health” LED is solidly lit or off, RainWise Inc. should be called for further troubleshooting.

The TX and RX LEDS are used to indicate when the station is transmitting, (TX), or receiving, (RX), data over the modbus line.

SunSpec and Modbus

The PVMET-75 follows the SunSpec standard. Refer to the official SunSpec specifications for application information. The full register map is listed below. The PVMET-75 has the following default communication settings:

Serial/ General

Baud Rate 9600
Parity None
Stop Bits 1

RS-232

Flow control None

RS-485

2-Wire Half Duplex

Modbus

Device ID 60

Register Map:

Start	End	#	Name	Type	Units	Scale Factor	Contents	Description
0001	0002	2	C_SunSpec_ID	uint32	N/A	N/A	"SunS"	Well-known value. Uniquely identifies this as a SunSpec Modbus Map
0003	0003	1	C_SunSpec_DID	uint16	N/A	N/A	0x0001	Well-known value. Uniquely identifies this as a SunSpec Common Model block
0004	0004	1	C_SunSpec_Length	uint16	registers	N/A	65	Length of common model block
0005	0020	16	C-Manufacturer	String(32)	N/A	N/A	"Rainwise_Inc"	Well-known value
0021	0036	16	C-Model	String(32)	N/A	N/A	"PVmet-100"	Manuf specific value
0037	0044	8	C-Options	String(16)	N/A	N/A	"0"	Manuf specific value
0045	0052	8	C-Version	String(16)	N/A	N/A	"1"	Manuf specific value
0053	0068	16	C_Serial Number	String(32)	N/A	N/A	"Serial"	Manuf specific value
0069	0069	1	C_DeviceAddress	unint16	N/A	N/A	60	Modbus Id
0070	0070	1	C_SunSpec_DID	int16	N/A	N/A	307	Start of next Device
0071	0071	1	C_SunSpec_Length	int16	N/A	N/A	11	Device Model Block Size
0072	0072	1	E_BaseMet_Air Temperature	int16	°C	-1	Measured	Ambient Air Temperature
0073	0073	1	E_BaseMet_Relative Humidity	int16	%	0	N/A	Relative Humidity
0074	0074	1	E_BaseMet_Barometric _Pressure	int16	Hpa	0	N/A	Barometric Pressure
0075	0075	1	E_BaseMet_Wind_Spee d	int16	m/s	0	N/A	Wind Speed

0076	0076	1	E_BaseMet_Wind_Direction	int16	Degrees		0	N/A	Wind Direction
0077	0077	1	E_BaseMet_Rain	int16	Inches		0	N/A	Rainfall
0078	0078	1	E_BaseMet_Snow	int16	Inches		0	N/A	Snowfall since last poll
0079	0079	1	E_BaseMet_PPT_Type	int16	Inches	N/A		N/A	Precipitation Type (WMO 4680 SYNOP code reference)
0080	0080	1	E_BaseMet_Electric_Field	int16	V/m		0	N/A	Electric Field
0081	0081	1	E_BaseMet_Surface_Wetness	int16	kOhms		0	N/A	Surface Wetness
0082	0082	1	E_BaseMet_Soil_Moisture	int16	%		0	N/A	Soil Moisture
0083	0083	1	C_SunSpec_DID	int16	N/A		0	302	Well-known value. Uniquely identifies this as a SunSpec Irradiance Model
0084	0084	1	C_Sunspec_Length	int16	N/A		0	5	Variable length model block =(5*n), where n=number of sensors blocks
0085	0085	1	E_Irradiance_Global_Horizontal_1	uint16	W/m²		0	Measured	Global Horizontal Irradiance
0086	0086	1	E_Irradiance_Plane-of-Array_1	uint16	W/m²		0	N/A	Plane-of-Array Irradiance
0087	0087	1	E_Irradiance_Diffuse_1	uint16	W/m²		0	N/A	Diffuse Irradiance
0088	0088	1	E_Irradiance_Direct_1	uint16	W/m²		0	N/A	Direct Irradiance
0089	0089	1	E_Irradiance_Other_1	uint16	W/m²		0	N/A	Some other type Irradiance
0090	0090	1	C_SunSpec_DID	int16	N/A		0	303	Well-known value. Uniquely identifies this as a SunSpec Back of Module Temperature Model
0091	0091	1	C_Sunspec_Length	int16	N/A		0	2	Variable length model block =(5*n), where n=number of sensors blocks
0092	0092	1	E_BOM_Temp_1	int16	°C		-1	Measured	Back of module temperature
0093	0093	1	E_BOM_Temp_2	int16	°C		-1	Measured	Back of module temperature
0094	0094	1	EndOfSunspecBlock	uint16	N/A	N/A		0xFFFF	End of SunSpec Block
0095	0095	1	C_Sunspec_Length	uint16	N/A		0	0	Terminate length, zero
0200	0200	1	Modbus Id - Write Register	int16	N/A	N/A		60	Modbus device address, write register

Changing the Modbus Device Address

The Modbus device can be changed using either the MBID command or directly through Modbus. Refer to the Command Mode instructions to set the address using the command mode.

Modbus register 40200 contains the unsigned 16-bit address. Writing to this register will update the device's Modbus address. The write request will be acknowledged but will change immediately after the response has been issued. The valid address range is 1 through 255. Write requests outside this range will not update the address. The address is stored in flash memory and will remain in affect permanently or until it is changed again.

In order to use the Modbus method to change a device address you must know the current device address. If you do not know the address and cannot scan for it, you will have to use the Command Mode. The command mode requires a PC and does not require an address. It can only be used with a point-to-point RS-485 connection.

Command Mode:

By default, the PVMET -75 will boot in Modbus mode and will not respond to the commands listed here. To enter the command mode issue three '+' characters one second apart. The PVMET -75 will return a message indicating that it is in command mode. After one minute of inactivity it will exit command mode and return to the default Modbus mode.

Commands must be terminated with a **<CR>** character. Responses begin and end with a **<CR><LF>**.
If the command syntax or parameters are incorrect the device will respond with **ERROR**. If the command is accepted, the device will respond with **OK**. Commands may not be chained together. Commands are not case sensitive.

Command Set

Get Column Headers: HEADER

Description: Returns a series of comma-delimited text descriptions. These descriptions are used to identify the type and order of the returned data in both **NOW** and **DOWNLOAD** commands.

Values: None
Syntax: HEADER

Sample Response:

HDR,"AIR TEMP","PV TEMP1","PV TEMP2","SOLAR","CHIP_TEMP",!213

Key:

HDR	: Identifier, HDR= Header, MSG= Message, REC= Data Record, MAX= Maximums and MIN= Minimums.
AIR TEMPT	: Current ambient air temperature.
PV TEMP1	: First current Back-of-Module temperature.
PV TEMP2	: Second current Back-of-Module temperature.
SOLAR	: Current global horizontal irradiance.
CHIP_TEMP	: CPU temperature.
!XXXX	: CRC-16 Checksum. *See Calculating the Checksum.*

NOTE: The parameter count may increase in future models.

Get Current Data: NOW

Description: Returns the current values in a comma-delimited format. The order of the data values correspond to the output of the HEADER command. **NO DATA** is returned if the unit has not received a transmission from the weather station.

Values: None
Syntax: NOW

Sample Response:

22.5,-40.0,-40.0,0, 29.3,!168

Auto Output: AUTO

Description: Automatically outputs current data every second. This is equivalent to issuing the NOW command every second. This mode will exit upon reception of any character. If no data is received from the weather station, the units will not output.

Values: None
Syntax: AUTO

Sample Response:

OK

Software Reboot: REBOOT

Description: Forces a soft reboot of the interface. On boot up the version information is output.

Values: None

Syntax: REBOOT

Sample Response:

None

Version Information: VERSION

Description: Returns firmware version information.

Values: None

Syntax: VERSION

Sample Response:

Modbus Device Address: MBID

Description: The Modbus device address can be viewed or changed using this command. The default is address is 60

Values: ?,1 - 255

Syntax (Read): MBID=?
Syntax (Write): MBID=60

Sample Read Response:

60

Sample Write Response:

OK

Serial Number: SERIAL

Description: The serial number of the device can be viewed or changed using this command. The serial number string is returned in SunSpec Common block.

Values: ?, character string (31 character limit)

Syntax (Read): SERIAL=?
Syntax (Write): SERIAL=ABC123

Sample Read Response:

ABC123

Sample Write Response:

OK

Command Mode: EXIT

Description: Exits from the command mode. Modbus is not functional in command mode.

Values: None

Syntax: EXIT

Sample Response:

Existing Command Mode...

Calculating the Checksum:

The PVMET -75 uses a 16 CRC checksum. The CRC uses the same polynomial as the one used in Xmodem transfers (XMODEM-CRC).
The Polynomial is as follows:

$x^{16} + x^{12} + x^5 + 1$

The CRC calculation starts at the first ASCII character of the response. Leading carriage return line feeds are not included. All characters are included in the calculation up until but not including the exclamation character. The checksum is represented as a hexadecimal number.

The following C example code can be used to calculate the checksum:

```
/* Global Variables */
unsigned short int acc;

/* ****************************************************************************
/* Initialize Accumulator
/* ****************************************************************************/
void
crc16Init(void)
{
  acc= 0;
}

/* ****************************************************************************
/* Add byte
/* ****************************************************************************/
void
crc16Add( unsigned short int _data )
{
    unsigned char n;

    for (n=8; n ;n--)
    {
      if ((acc & 0x8000)>0)
      {
        acc<<= 1;
        _data<<= 1;
        if ((_data & 256)!=0)
          acc++;
        acc^= 0x1021;
       }
       else
       {
            acc<<= 1;
            _data<<= 1;
            if ((_data & 256)!=0)
             acc++;
       }
    }
```

```
}

/* ***************************************************************************
/* Return CRC accumulator
/* ***************************************************************************/
unsigned short int crc16Acc(void)
{
  unsigned short int tmp= acc, retval;

  crc16Add(0);
  crc16Add(0);    // add two zeros to get a valid crc
  retval= acc;
  acc= tmp;       //restore acc

  return retval;
}
```

Software/Firmware Updates

The software or firmware in the PVMET -75 can be updated or changed using the RS-485 port. Make sure you read the update instructions carefully and be sure you are installing the correct software. As with all updates, there are risks associated with changing the flash memory.

Updates are loaded using a Windows based program called IAPflash. This program is supplied with the ".enc" file along with instructions. Windows is required to perform updates. No other operating systems are currently supported.

Minimum System Requirements

The PVMET -75 is equipped with an RS-485 serial port.

RS-485/422

Baud rate: 9600 bps
Parity: None
Data bits: 8
Stop bits: 1
Interface mode: 2-wire half duplex

Software

The PVMET-75 is designed to work with an RS-485 Sunspec compliant host. A terminal emulator program is required to change settings.

Maintenance

The station requires minimal maintenance. At least once a year, the station should be visually inspected. When visually inspecting the station, make sure that the front of the enclosure is facing the equator. Check to see if the sensor assembly is vertically level. When inspecting the PV cell temperature sensor, check for any damage to the sensor head or cabling.
The pyranometer should be thoroughly checked for cleanliness. Debris on the pyranometer is a common cause of low output readings. Deposits can accumulate on the sensor from evaporation of sprinkler irrigation water and dust, which can accumulate during periods of low rainfall. Any salt deposits should be dissolved and removed with vinegar and a soft cloth or q-tip. Dust and other organic deposits are best removed with water, rubbing alcohol or window cleaner. Never use an abrasive cleaner on the lens.

Calibration

Research indicates that the pyranometer output increases about 1% per year because of changes in the optical transparency of the diffusion disk. The station can be returned for recalibration every12 months. If this is not done the 1% increase in reading should be compensated for in the data acquisition software.

The temperature sensors generally have negligible drift over time and can not be calibrated. When they fail they generally fail to a short or open circuit. This causes their reported readings to go to either extreme.

For optimum performance Rainwise recommends the station be recalibrated every 12 months.

Material Specifications

Sensor Assembly:

RoHS Compliant

Mast:	Polyvinyl Chloride
Heat Shields:	Acrylonitrile Butadiene Styrene
Insolation Senors Bracket:	Anodized Aluminum
Hardware:	Stainless Steel and Nylon Locknut
Foam Gasket:	Vinyl and Acrylic

Enclosure:

RoHS Compliant
IP65 Rated Outdoor Enclosures
UL 94 V-2

Body:	Polycarbonate

Pyranometer Sensor:

RoHS Exempt

Body:	Anodized Aluminum with Cast Acrylic Lens
Cable:	Santoprene Jacket

Ambient Air Temperature Sensor:

RoHS Compliant

PV Panel Temperature Sensors:

RoHS Compliant

Body:	Anodized Aluminum
Adhesive Tape:	Acrylic, Titanium Diboride, and Aluminum
Cable:	Polyvinyl Chloride Jacket

Power and Communications Cable:

Cable:	Polyvinyl Chloride

Electronics:

RoHS Compliant

Hardware Specifications

Power Specifications:

Power Requirements:	10 to 30VDC at less then 50mA

Operating Environment:

Temperature:	-40°C to 60°C (-40 to 140°F)
Humidity:	0-100% Condensing

Pyranometer Sensor:

Range:	0-1750 W/m^2
Accuracy:	+/-5%
Cosine Response 45°	+/-1%
Cosine Response 75°	+/-5%
Operational Temperature:	-25 to 55°C (-13 to 131°F)

Ambient Air Temperature Sensor:

Range:	-40 to 80°C (-40 to 176°F)
Accuracy:	+/- 0.4°C (0.72°F)
Thermal Time Constant	30 sec.

PV Panel Temperature Sensors:

Range:	-40° to 80°C (-40 to 176°F)
Accuracy:	+/- 0.3°C (0.54°F)
Thermal Time Constant:	270 sec.
Cable Length	7.62m (25 ft)

RS-485/422 Serial Specifications:

Mode:	2-wire half duplex
Connector:	4-position screw terminal
Max Speed:	9600 bps
Max. Modbus Poll Rate:	100 ms
Termination:	120 ohms (internal jumper enable)

Physical:

Packaged Weight:	2.26kg (5 lbs.)
Packaged Dimensions:	58.42cm x 25.4cm x 20.32cm (23” x 10” x 8”)

Contact Information

RainWise Inc.
23 Creek Circle
Boothwyn, PA 19061 USA

Phone: (207)-288-5169

Warranty

RainWise, Inc. warrants RainWise, Inc. manufactured PVMET products against defects in materials and/or workmanship for a period of two years from the date of purchase and agrees to repair or replace any defective product without charge. Equipment supplied by RainWise but not manufactured by RainWise is covered by the particular warranty of that manufacturer.

IMPORTANT: This warranty does not cover damages resulting from accident, misuse or abuse, lack of reasonable care, the fixing of any attachment not provided with the product, unauthorized modifications or damage due to a lightning strike. RainWise, Inc. will not reimburse for take-down or installation charges. RainWise, Inc. will not pay for warranty service performed by a non-authorized repair service and will not reimburse the consumer for damage resulting from warranty service performed by a non-authorized repair service. No responsibility is assumed for any special, incidental or consequential damages.

To return a unit under this warranty, call (800)762-5723 within the continental US or (207)288-5169. The service department will document the need for repair/replacement and arrange such. Shipping costs from the customer to RainWise are borne by the customer, RainWise will cover return shipment. It is the customer's responsibility to see that the unit is properly packed, preferably in the original box, because damage occurring during return shipment is not covered by this warranty.

NOTE: No other warranty, written or oral, is authorized by RainWise, Inc. This warranty gives you specific legal rights, and you may also have other rights, which vary from state to state. Some states do not allow the exclusion of limitation of incidental or consequential damages, so the above exclusion and limitations may not apply to you.