PVMET™-200

User's Guide

04/17/18
Rev. 8

Introduction

The PVMET-200 weather station is a compact and economical solution for photovoltaic installations. It measures ambient air temperature, PV panel temperature, wind speed and direction, global irradiance, and is capable of measuring plane-of-array irradiance. The PVMET-200 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.

A1300 –	PVMET-200 Sensor Assembly Global Irradiance Sensor Ambient Temp. Sensor Anemometer
A2010	Plane-of-Array Sensor
A2101	PV Cell Temp. Sensor
A1020	Mounting Mast
PVMET-200	Instruction Manual

If the system was ordered with any accessories or optional sensors, they should be located while unpacking the system.

Optional accessories and sensors:

A2101	PV Cell Temp. Sensor
A3000	Mono-Mount
A2020	Global irradiance extended mounting bracket.

Installing the Weather Station

It is suggested that the system is operated at ground level to make sure that all components are working 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, global irradiance, and wind speed and direction 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° above the horizontal plane, must not block the global irradiance sensor. The PVMET-200 sensor assembly, which contains the ambient air temperature and wind speed and direction sensor, should be no closer than 10

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 to a support structure. This may be done by using the Mono-Mount, which is sold as an accessory to the PVMET-200. The mast may also be attached to a support structure using U-Bolts. Do not tighten the support structure to the PVMET-200 unit, as directional orientation will be required.

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. At this point, the entire unit should be secured to the support structure.

It is crucial that the device is oriented as precisely as possible. The wind direction measurement is directly related to this positioning.

Irradiance Sensors

The PVMET-200 uses two pyranometers to measure global and plane-of-array irradiance. The global pyranometer is directly attached to the sensor assembly and does not have to be adjusted in any way. The plane-of-array pyranometer is supplied with 25ft of cable and a solar panel mounting bracket. The plane-of-array pyranometer is user installed.

Both pyranometers are shipped with a protective cap on their lens. During installation, the cap should be removed exposing the opaque white lens.

<u>Global Irradiance</u>

The pyranometer is attached to the sensor assembly and is oriented to measure global irradiance. To accurately measure this quantity the sensor must be level, orientated either TRUE SOUTH or TRUE NORTH if you are in the northern or southern hemisphere respectively. Objects above 10° above the horizontal plane must not block the sensor. If the station is to be installed in the tropics (within 23° latitude of the equator) it is suggested that the A2020 global irradiance bracket is used to avoid potential shadowing. Alternatively, the global irradiance sensor can be remotely mounted.
Refer to the "*PVmet-200 Equatorial Solar Bracket Retrofit*" instruction manual for A2020 installation instructions.

Plane-of-Array Irradiance

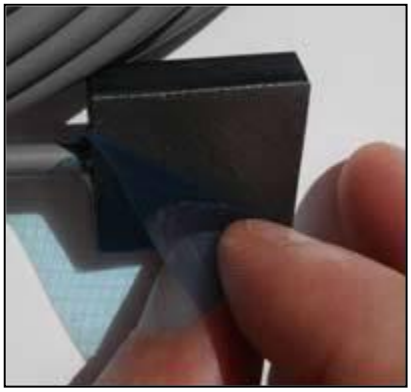
The plane-of array pyranometer is mounted on the side of the solar array. The sensor should be at the same zenith and azimuth angle as the solar array to correctly measure the plane-of-array irradiance.

PV Temperature Sensors

This sensor is designed to attach directly to any solar panel. When placed on the center back side 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 back of 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-200 unit and connect to the PV temperature sensor terminals.

If the cable length is insufficient for the installation, the 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, an accuracy derating factor of -0.125°C must be taken into account.

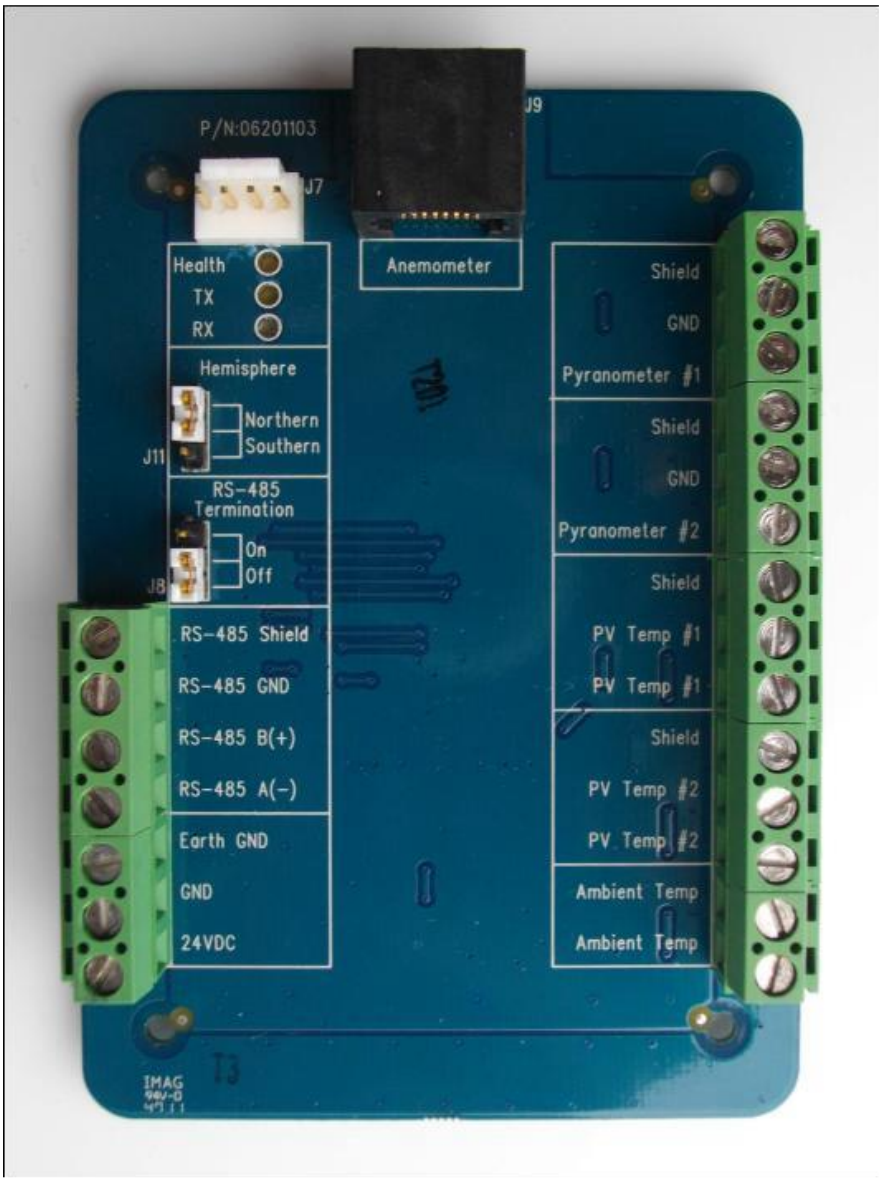
Anemometer

The anemometer is directly attached to the top of the sensor assembly. For correct wind direction operation, the PVmet-200 must be oriented correctly.

By default, the PVmet-200 is configured for operation in the Northern hemisphere. This only requires that the irradiance sensor faces due South. If the PVmet-200 is going to be used in the Southern hemisphere it must be mounted with the irradiance sensor facing North. In addition, the hemisphere jumper inside the PVmet-200 must be changed from Northern to Southern as shown in the image be in the wiring section.

Wiring

To enter the enclosure with a cable, the front cover 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.



Connecting Plane-of-Array and Global Irradiance Sensors

The irradiance sensors are polarity sensitive and the signal wires must go to the appropriate corresponding screw terminal. If either of the Irradiance sensors is not used they should be terminated with a 0-ohm shunt between the positive and negative signal.

Due to the Modbus register map, the Plane-of-Array and Global Irradiance sensors are not interchangeable. The global irradiance sensor connects to “Pyranometer #1” and the plane-of-array irradiance sensor connects to “Pyranometer #2”. Each is labeled on the printed circuit board.

Global Irradiance Sensor Terminals

Pyranometer #1:	Positive Signal
Ground:	Negative Signal
Shield:	Cable Shield and Drain

Plane-of-Array Sensor Terminals

Pyranometer #2:	Positive Signal
Ground:	Negative Signal
Shield:	Cable Shield and Drain

Connecting External PV Temperature Sensor

The PV sensors are not polarity sensitive. Therefore, each signal wire is interchangeable. The sensor comes with a 25ft length of the cable. If a temperature sensor is not used, it should be terminated with a 0-ohm shunt between the positive and negative signal.

PV Temperature Terminals

PV Temp #2:	Signal
PV Temp #2:	Signal
PV Temp #2 Shield:	Cable Shield and Drain

Connecting RS-485

The PVMET-200 is supplied with a half-duplex RS-485 serial port. Wiring connections are made using the 4-pin screw terminal inside of the PVMET-200 electronics enclosure. Cable is not supplied with the unit. The RS-485 lines can be terminated with a 120-ohm resistor. This can be enabled by moving the termination jumper, located inside the unit, to the "ON" position. This requires removing the enclosure cover. To do this, remove the 4 screws on the bottom side of the unit.

RS-485 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 (1,200 m) at 90 kbps. The RS-485 port on the PVMET-200 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 overcurrent protected. The power supply is not isolated.

Power Supply Terminals

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

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.

SunSpec and Modbus

The PVMET-200 follows the SunSpec standard. Refer to the official SunSpec specifications for application information. The full register map is listed below. The PVMET-200 has the following default communication settings:

Serial/ General

Baud Rate: 9600
Parity: None
Stop Bits: 1

RS-485

Interface Mode: 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-200"	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 _Speed	int16	m/s	0	Measured	Wind Speed
0076	0076	1	E_BaseMet_Wind _Direction	int16	Degrees	0	Measured	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	Measured	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
0205	0205	1	Baud Rate	uint16	N/A	N/A	9600	Baud Rate, 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 200 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 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 but does not require an address. It can only be used with a point-to-point RS-485 connection.

Changing the Baud Rate

The baud rate can be set to either 9600 or 19200. Modbus register 205 contains the unsigned 16-bit baud rate. Writing to this register will update the device's baud rate. If an attempt is made to set the baud rate to anything other than 9600 or 19200 the device will default to 9600. The device must be power cycled for the new baud rate to take effect. The baud rate is stored in flash memory and will remain until it is changed again.

The baud rate can be changed using either the BAUD command or directly through Modbus. Refer to the Command Mode instructions to set the baud rate using the command mode.

Command Mode

By default, the PVMET-200 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-200 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","SOLAR2","WSPD","WDIR","CHIP_TEMP",!076

Key:

HDR : Identifier, HDR= Header, MSG= Message, REC= Data Record, MAX= Maximums and MIN= Minimums.

AIR TEMP	: 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.
SOLAR2	: Plane-of-Array irradiance.
WSPD	: Wind speed.
WDIR	: Wind direction.
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 corresponds 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, 0,180,29.3,!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. Upon 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:

Rainwise Inc PVmet-200 Version: 1.1 Build 001 Jun 17

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

Baud Rate: BAUD

Description: The baud rate maybe set to either 9600 bps or 19,200 bps. Modbus device address can be viewed or changed using this command. The default is baud rate is 9600.

Values: ?,9600, 19200

Syntax (Read): BAUD=?
Syntax (Write): BAUD=19200

Sample Read Response:

19200

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 the 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-200 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 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-200 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-200 is equipped with an RS-485 serial port.

RS-485

Baud rate:	9600 bps
Parity:	None
Data bits:	8
Stop bits:	1
Flow Control:	None
Interface mode:	2-Wire Half Duplex

Software

The PVMET-200 is designed to work with an RS-485 SunSpec compliant host. A terminal emulator program is required to change settings.

Material Specifications

Sensor Assembly:

RoHS Compliant

Mast:	Polyvinyl Chloride
Heat Shields:	Acrylonitrile Butadiene Styrene
Insolation Sensor Bracket:	Delrin
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 Compliant

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

Electronics:

RoHS Compliant

Physical:

Packaged Weight:	7 lbs
Packaged Dimensions:	6cm x 20.3cm x 20.3cm (10.25” x 8” x 8”)

Hardware Specifications

Power Specifications:

Power Requirements:	10 to 30VDC at 50mA

Operating Environment:

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

Pyranometer Sensors:

Range:	0 to 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:	+/- 0.3°C (0.54°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)

Anemometer:

Operational Temperature:	-40 to 60°C (-40 to 140°F)

Speed

Range:	0 - 67 m/sec (150 mph)
Accuracy:	Greater of 0.45m/sec. (1 mph) or 5%
Threshold:	0.89m/sec. (2 mph)

Direction

Range:	360°
Resolution:	22.5°
Accuracy:	+/- 22.5°
Threshold:	0.9 m/sec. (2 mph) at a 10° deflection.

RS-485 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)

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 or damage due to a lightning strike or power surge. 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.