apogee

INSTRUMENTS

HEATED PRECIPITATION DETECTOR

Model SG-050

Rev: 3-Jan-2025

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CERTIFICATE OF COMPLIANCE

apogee
INSTRUMENTS
721 West 1800 North
Logan, UT 84321

Certificate of Quality Assurance
Heated Precipitation Detector
Model SG-050-SS

Serial Number	:	1001
Manufacture Date	:	Jan-2025
Test Date	:	Jan-2025
Operating Environment	:	-40 to 60 C
IP Rating	:	IP67
Country of Origin	:	USA

To whom it may concern:

We hereby confirm that the model series listed above are void of caustic or toxic chemicals. Products do not employ high voltages, nor emit harmful electrical or optical emissions. Products are not designed for medical applications or for use on humans.

The instruments have been tested and are in good working order. Furthermore, all accessories along with the instruments have been carefully packaged to prevent damage in shipping.

Technical Manager : *Jacob Bingham*   Date : 02-Jan-2025

Please keep this document for your records

Website: www.apogeeinstruments.com E-mail: techsupport@apogeeinstruments.com Ph: (435)792-4700 Fax: (435)787-8268

INTRODUCTION

Precipitation is a widely measured, fundamental weather variable. It can vary significantly in terms of timing, duration, intensity, amount, and phase, depending on location, season, weather patterns, and atmospheric conditions.

Precipitation detectors are instruments designed to measure frequency and total length of precipitation. Some precipitation detectors can only detect liquid precipitation, while heated precipitation detectors (HPDs) can measure liquid and solid precipitation (e.g., sleet, snow, hail). The principle of the heated precipitation detector from Apogee is measurement of surface permittivity via a sensitive capacitance circuit.

In addition to being preferred for sleet, hail, and snowfall, a major advantage of using heated precipitation detectors is their accuracy in measuring precipitation timing in short time frames. Precipitation gauges require a larger volume of precipitation for measurement. Unheated precipitation detectors depend on their environment for natural evaporation from the wind, sun, and air on a scale of minutes or hours. Conversely, heated precipitation detectors facilitate evaporation to occur on a scale of seconds or minutes. The evaporation rate is proportional to the customized evaporation heating level set by the user. Heated precipitation detectors are more sensitive than other precipitation measurement devices, can detect shorter wet and dry periods, and provide precise start and stop timing measurements of precipitation events.

Power for detector heating can be difficult or impossible to source at some field sites. To address this, heated precipitation detectors can minimize power consumption by using the minimum heater level required to maintain the preset temperature level. This preset temperature level (default 5 °C), the maximum heater allowance to be used in temperature maintenance (default 100%), and evaporation assistance (default 100%) can each be customized independently by the user.

Typical applications of precipitation detectors include monitoring of instantaneous, daily, monthly, and annual precipitation events in weather networks, agricultural fields, man-made surfaces, and water balance studies. Precipitation is often the limiting factor to plant growth, and as a result, influences crop and forest productivity. Precipitation data are required for estimating availability of water resources, determining conditions of road surfaces, forecasting floods, and monitoring droughts.

Apogee Instruments heated precipitation detectors are affordable, all-weather precipitation detectors with no moving parts. They use a high accuracy, capacitance circuit to measure permittivity of the top surface mounted on the cell. Analog-to-digital circuitry is used to convert the signal from the capacitance detector to an SDI-12 output. A filtering algorithm is used to minimize the influence of random noise, temperature changes, and heater fluctuations on the precipitation signal.

SPECIFICATIONS

Input Voltage Requirement	12 V DC
Current Draw	16 to 393 mA
Operating Environment	-40 to 60 C, 0 to 100% relative humidity
Ingress Protection Rating	IP67
Mass	50 g
Dimensions	6.5 cm diameter, 9.6 mm width, 8.03 cm length
Output	SDI-12

Ø66mm

80.3mm

16.8mm

10-32 Thread for mounting

XX-XXX
S/N:1001 CE

Locator Notch

9.6mm
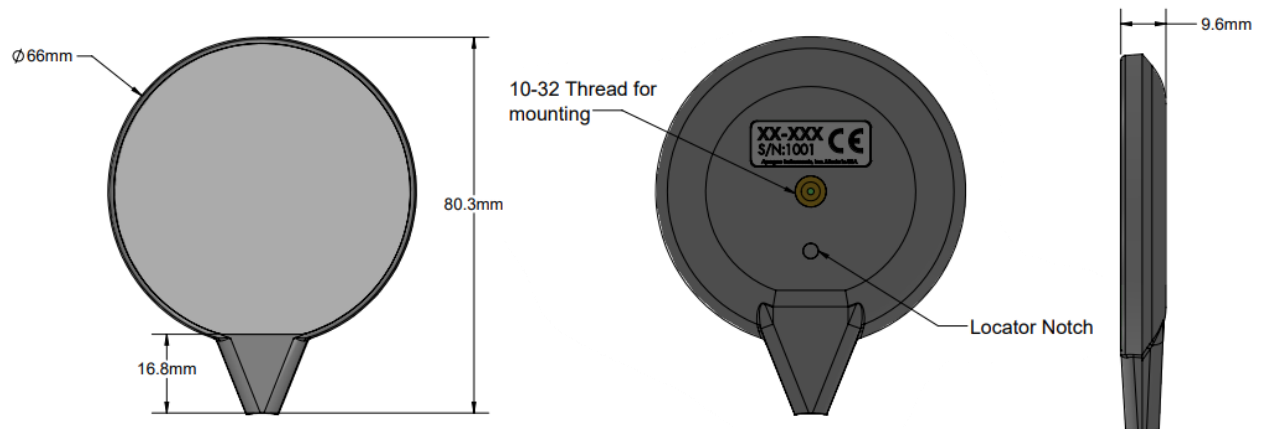
The current draw of the SG-050 is dependent on the duty cycle of the heater. The heater activates in response to detected temperature and moisture levels. The heater settings can be adjusted according to the instructions found in the Heating Extended Commands table in the Operation and Measurement Section of this manual.
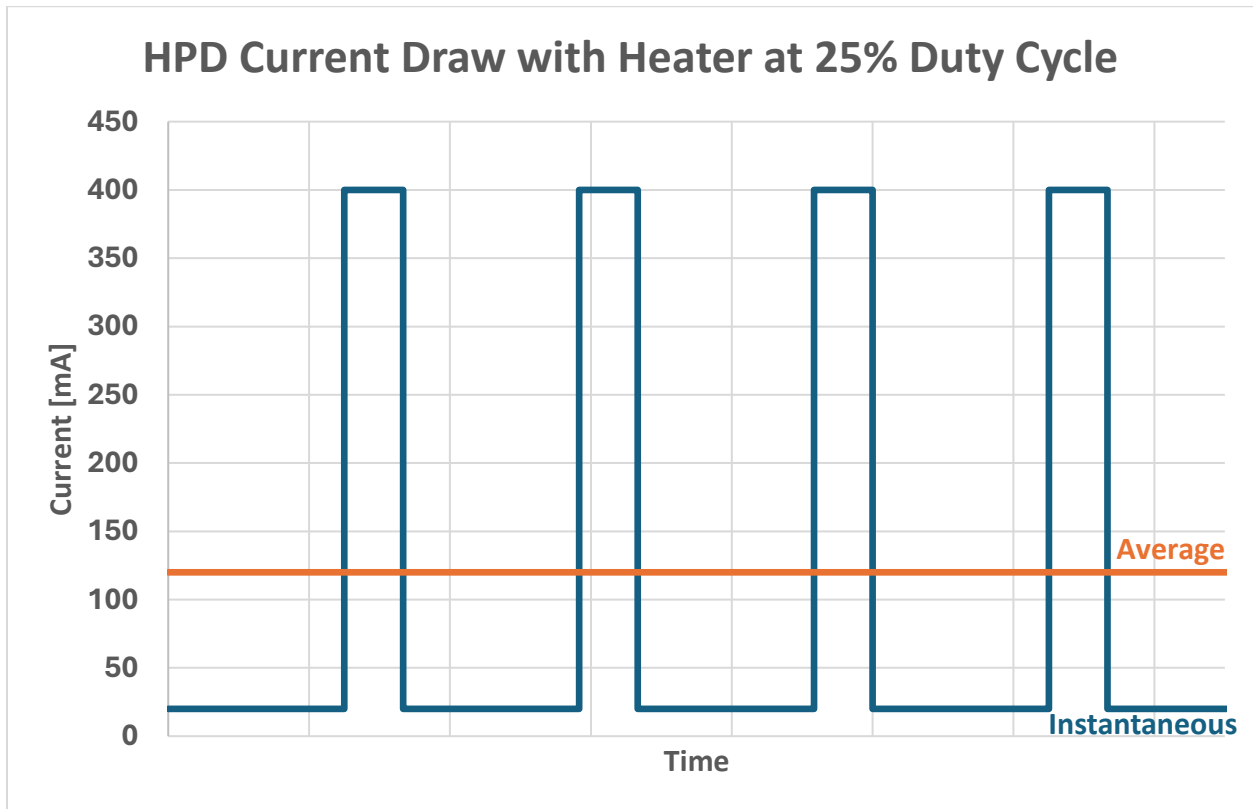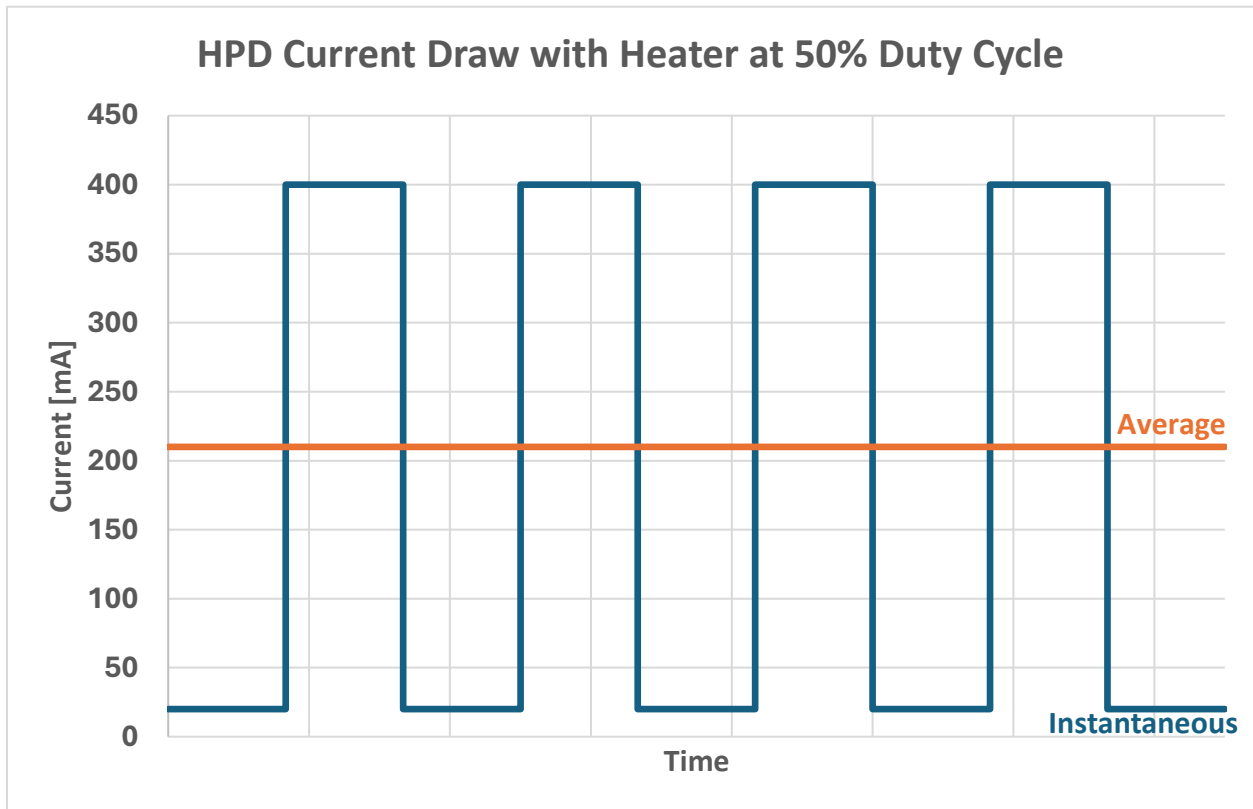
Power source for the heated precipitation detector must be rated to support the heater's maximum current draw of 400 mA, even when the heater is operating at a lower percentage duty cycle. While overall power consumption is reduced at lower percentage duty cycles, the heater still requires the full current capacity to function correctly. Keep this in mind when using multiple sensors and/or sensitive power sources such as non-standard outlets or solar panels.

The table below shows the average current draw at each duty cycle.

Current Draw of the SG-050 Heated Precipitation Detector

Heater PWM Duty Cycle [%]	Average Current [mA]	Max Current [mA]
0	20mA	20mA
10	60mA	400mA
20	100mA	400mA
25	120mA	400mA
30	140mA	400mA
40	180mA	400mA
50	220mA	400mA
60	250mA	400mA
70	290mA	400mA
75	310mA	400mA
80	330mA	400mA
90	360mA	400mA
100	400mA	400mA
It is important to note that the heater operates using a PWM signal. Instantaneous current draw of the heater switches between 0% and 100%. The power supply must be able to supply 100% current even when used at lesser percentages.		

The following graphs demonstrate current usage at different duty cycles:

HPD Current Draw with Heater at 50% Duty Cycle

Current [mA] vs *Time*

Average (≈ 210 mA)

Instantaneous

HPD Current Draw with Heater at 25% Duty Cycle

Current [mA] vs *Time*

Average (≈ 120 mA)

Instantaneous

DEPLOYMENT AND INSTALLATION

Mounting

Apogee SG-050 heated precipitation detectors should be mounted in an open space with no obstructions where precipitation detection is desired. This ensures the cell's surface is in the same environment as the surrounding area.
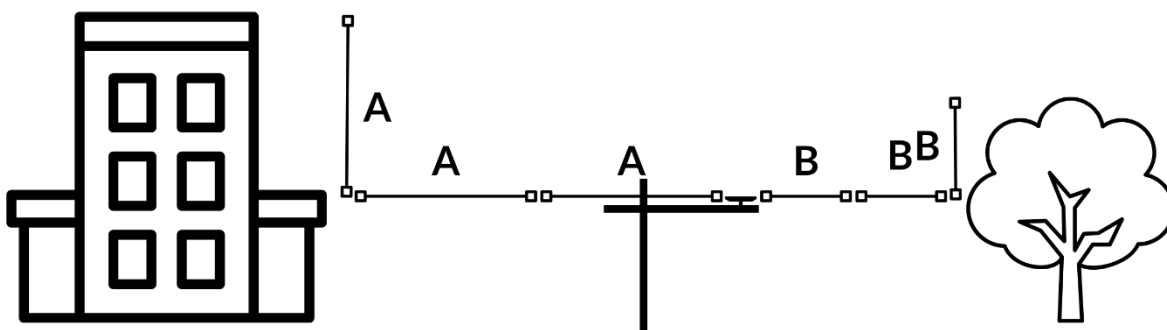
An Apogee Instruments model AM-260 mounting bracket can be used to mount the detector to a cross arm or pole. The AM-260 allows adjustment of the angle of the detector. It is recommended to mount the detector with a slight downward slope or tilting to the side by 20-30 degrees, ideally facing the most common sun direction. This will aid evaporation and reduce the impact of crosswinds to minimize moisture and debris build-up.

Facing the sun

20°-30°

Cable Connectors

Apogee sensors offer cable connectors to simplify the process of removing sensors from weather stations for calibration; the entire cable does not need to be removed from the station and shipped with the sensor. When sending sensors in for calibration, only send the short end of the cable and half the connector.

The ruggedized M8 connectors are rated IP68, made of corrosion-resistant, marine-grade stainless-steel and designed for extended use in harsh environmental conditions. Inline cable connectors are installed 30 cm from the head.

Note: During installation, ensure that no strain is applied to the output cable. Excessive tension could compromise the seal and potentially allow water ingress.

Pins and Wiring Colors

All Apogee connectors have six pins, but not all pins are used for every sensor. There may also be unused wire colors inside the cable. To simplify datalogger connection, we remove the unused pigtail lead colors at the datalogger end of the cable.

White: SDI-12 Data Line

Red: Power Input (4.5-24 V DC)

Black: Ground (for sensor signal and input power)

Clear: Shield/Ground

If a replacement cable is required, please contact Apogee directly to ensure ordering the proper pigtail configuration.

Alignment

When reconnecting a sensor, align the arrows on the connector jacket and the orientation notch before tightening.

Align arrows when connecting

Tightening

Connectors are designed to be firmly finger-tightened only. There is an O-ring inside the connector that can be overly compressed if a wrench is used. Pay attention to thread alignment to avoid cross-threading. When fully tightened, 1-2 threads may still be visible.

- Hand tighten to snug
- Do not overtighten

Disconnection for extended periods

When disconnecting the sensor from a station for an extended period, cover the exposed half of the connector on the station with electrical tape or another protective method to shield it from water and dirt.

OPERATION AND MEASUREMENT

The SG-050 Heated Precipitation Detector employs capacitive-sensing circuitry to detect the presence of moisture. The output signal differentiates between wet and dry conditions, providing a clear indication of precipitation levels.

SDI-12 Command Set

The following is a brief explanation of the serial digital interface SDI-12 protocol instructions used in Apogee precipitation detectors. For questions on the implementation of this protocol, please refer to the official version of the SDI-12 protocol: http://www.sdi-12.org/specification.php (version 1.4, February 20, 2023).

Each command has a default setting recommended for general use but can be adjusted by the user to best suited to their environment, electrical power setup and measurement goals.

Overview:

During normal communication, the data recorder sends a packet of data to the sensor that consists of an address and a command. Then, the sensor sends a response. In the following descriptions, SDI-12 commands and responses are enclosed in quotes. The SDI-12 address and the command/response terminators are defined as follows:

Sensors come from the factory with the address of "0" for use in single sensor systems. Addresses "1 to 9" and "A to Z", or "a to z", can be used for additional sensors connected to the same SDI-12 bus.

 "!" is the last character of a command instruction. To be compliant with SDI-12 protocol, all commands must be terminated with a "!". SDI-12 language supports a variety of commands. Supported commands for the Apogee Instruments SF-421 are listed in the following table ("a" is the sensor address. The following ASCII Characters are valid addresses: "0-9" or "A-Z").

Supported Commands for Apogee Instruments, Inc. SG-050 Heated Precipitation Detectors

Start Verification Command	
Command	**Response**
aV!	1. Signal Offset [Hz] 2. Wetness Threshold [Hz] 3. Heater Temperature Setpoint [°C] 4. Maximum Heating Temperature [°C] 5. Cold Condition Maximum Heating Duty Cycle [%] 6. Evaporation Heating Duty Cycle [%] 7. Cold Condition Heating Setting (0 = disabled, 1 = enabled) 8. Evaporation Heating Setting (0 = disabled, 1 = enabled)

Measurement Commands	
Command	**Response**
aM! aMC! aC! aCC! aR0! aRC0!	1. Wet/Dry Flag [Boolean] (Dry = 0, Wet = 1)
aM1! aMC1! aC1! aCC1! aR1! aRC1!	1. Wet/Dry Flag [Boolean] (Dry = 0, Wet = 1). Wet indicates that precipitation of any form is on its surface, increasing the signal a significant amount. 2. Detector signal [hz] (amount in Hz that the signal is slowed down by capacitance from moisture) 3. Detector Surface Temperature [°C] 4. Heater Duty Cycle [%] (0-100%, 0% = Heater off, 100% = Heater fully on)
Send Identification Command	
Command	**Response**
aI!	Example: 014 Apogee SG-0501.0B011234<CR><LF>

```
014 Apogee SG-0501.0B011234<CR><LF>
 │││     │    │   │ ││ │
 │││     │    │   │ ││ └── Serial number: 1234
 │││     │    │   │ │└──── Board Revision: 01 ('B' + 2 characters)
 │││     │    │   │ └───── Firmware Version Number: 1.0
 │││     │    │   └─────── Sensor Model Number: SG-050
 │││     │    └─────────── Company Name: Apogee
 │││     └──────────────── SDI-12 Compatibility Number: 1.4
 │└────────────────────── Sensor Address: 0
```

Heating Extended Commands				
Command	**Description**	**Example**	**Default**	**Max**
aXHOTT<+/-Maximum Temperature [°C]>!	Sets the maximum temperature in degrees Celsius that the detector can be heated to in wet or cold conditions. If the detector temperature is dry and above this temperature, the heater will not turn on. For safety, lower this setting around flammable materials or if skin contact is possible to prevent burns.	**0XHOTT+55!** SDI-12 address of 0, Maximum heating of 55°C.	60.0°C	60.0°C
aXCOLDT<+/- Temperature Threshold [°C]>!	Sets the temperature in degrees Celsius above which the heating circuitry will attempt to maintain the HPD in cold conditions. A lower setting uses less energy in cold conditions while a higher setting detects mixed or solid precipitation sooner.	**0XCOLDT+5!** SDI-12 address of 0, Temperature Threshold of 5°C.	5.0°C	

Command	Description	Example	Default	Max
aXCOLDDC<+Maximum Duty Cycle [%]>!	Sets the maximum duty cycle of the heater for cold condition heating with a range of 0 to 100%. If the temperature is below the cold threshold, the maximum duty cycle is the highest heater level for the device to maintain. A low level is more energy efficient in cold conditions, but a high level melts frozen precipitation sooner upon surface contact.	**7COLDDC+75!** SDI-12 address of 7, maximum duty cycle of heater 75% for cold condition heating.	25%	
aXCOLDON!	Enables cold condition heating.		Cold condition heating is on	
aXCOLDOFF!	Disables cold condition heating. Heater will not attempt to maintain the minimum cold temperature threshold.		Cold condition heating is on	
aXEVAPDC<+Duty Cycle [%]>!	Sets the duty cycle of the heater for evaporation heating with a range of 0 to 100%. Low levels are more energy efficient and high levels speed up evaporation for more accurate timing.	**1EVAPDC+25!** SDI-12 address of 1, duty cycle of heater is set at 25% for evaporation heating.	100%.	
aXEVAPON!	Enables evaporation heating.		Evaporation heating is on.	
aXEVAPOFF!	Disables evaporation heating.		Evaporation heating is on.	

MAINTENANCE AND RECALIBRATION

The Heated Precipitation Detector will arrive fully calibrated. In dry conditions, the output signal should read close to zero. To verify calibration at any point, completely dry the instrument, then check that its signal falls within the expected signal range.

SDI-12 commands can be used to correct data received from an instrument that has an offset baseline reading.

Coefficient Extended Commands			
Command	**Description**	**Example**	**Default**
aXCAL!	Starts an automatic calibration of the signal offset in Hz. The signal offset in Hz is automatically set using the average of the next 10 seconds of measurements. The HPD should have a dry surface when automatic calibration is taking place.	**4XCAL!** SDI-12 address of 4, start an automatic calibration routine.	
aXCAL<+Signal Offset in Hz>!	Sets the offset calibration coefficient manually to the given value.	**4XCAL+32580!** SDI-12 address of 4, signal offset of 22000.	0
aXWET<+Wetness Threshold in Hz>!	Sets the wetness threshold for the signal that determines whether it is a precipitation event. Low thresholds better capture small precipitation events while higher thresholds eliminate false precipitation detections caused by non-precipitation factors (dew, frost, animals, wind, etc.) affecting the surface.	**0XWET+1200!** SDI-12 address of 0, wetness threshold of 1200.	1500 Hz.

TROUBLESHOOTING AND CUSTOMER SUPPORT

Insufficient Power Availability

In the event of a heated precipitation detector drawing more power than available, it may temporarily stop recording. To resolve this, test that the power source can meet the required capacity, restore sufficient power, and reset the heated precipitation detector to resume operation.

Independent Verification of Functionality

Apogee heated precipitation detectors yield an independent resistance that is proportional to surface permittivity levels. A quick and easy check of functionality of the thermistor can be accomplished with an ohmmeter. To check the circuit, connect the lead wires of the ohmmeter to the red and white wires from the detector. The resistance should read 10 kΩ (10,000 ohms) at 25 C. If detector temperature is less than 25 C, resistance will be higher. If detector temperature is greater than 25 C, resistance will be lower. Connect the lead wires of the ohmmeter to the white and black wires from the detector. The resistance should read 24.9 kΩ and should not vary. Connect the lead wires of the ohmmeter to the red and black wires from the sensor. The resistance should be the sum of the resistances measured across the red and white wires, and white and black wires (e.g., 10 kΩ plus 24.9 kΩ at 25 C).

Compatible Measurement Devices (Dataloggers/Controllers/Meters)

Measurement of thermistor resistance requires an input excitation voltage, where 2.5 V DC is recommended. A compatible measurement device should have the capability to supply the necessary voltage. The sensitivity (mV output from thermistor per C) of the temperature measurements varies with the excitation voltage and varies as a function of temperature. With an excitation voltage of 2.5 V DC, the sensitivity is lowest near the ends of the measurement range, -50 and 70 C. A compatible measurement device (e.g., datalogger or controller) should have resolution of at least 0.6 mV in order to produce temperature resolution of less than 0.1 C across the entire temperature measurement range (less than 0.05 C from -35 to 45 C). An example datalogger program can be found on the Apogee webpage at https://store-0oei9zu.mybigcommerce.com/content/Heated-Precipitation-Detection-Sensor.CR1X.

Modifying Cable Length

When the detector is connected to a measurement device with high input impedance, detector output signals are unaffected by splicing additional cable in the field. Tests have shown that if the input impedance of the measurement device is 1 mega-ohm or higher, there is negligible effect on the sensor, even after adding up to 100 meters of cable. See the Apogee webpage for details on how to extend sensor cable length (http://www.apogeeinstruments.com/how-to-make-a-weatherproof-cable-splice/). For cable extensions, shielded, twisted pair cable is recommended to minimize electromagnetic interference. This is particularly important for long lead lengths in electromagnetically noisy environments. The precision bridge resistors are located at the pigtail end of the cable. Thus, the SG-050 cable should not be shortened, otherwise the bridge resistor will be removed.

RETURN AND WARRANTY POLICY

RETURN POLICY

Apogee Instruments will accept returns within 30 days of purchase as long as the product is in new condition (to be determined by Apogee). Returns are subject to a 10% restocking fee.

WARRANTY POLICY

What is Covered

All products manufactured by Apogee Instruments are warranted to be free from defects in materials and craftsmanship for a period of four (4) years from the date of shipment from our factory. To be considered for warranty coverage an item must be evaluated by Apogee.

Products not manufactured by Apogee (spectroradiometers, chlorophyll content meters, EE08-SS probes) are covered for a period of one (1) year.

What is Not Covered

The customer is responsible for all costs associated with the removal, reinstallation, and shipping of suspected warranty items to our factory.

The warranty does not cover equipment that has been damaged due to the following conditions:

1. Improper installation, use, or abuse.

2. Operation of the instrument outside of its specified operating range.

3. Natural occurrences such as lightning, fire, etc.

4. Unauthorized modification.

5. Improper or unauthorized repair.

Please note that nominal accuracy drift is normal over time. Routine recalibration of sensors/meters is considered part of proper maintenance and is not covered under warranty.

Who is Covered

This warranty covers the original purchaser of the product or other party who may own it during the warranty period.

What Apogee Will Do

At no charge Apogee will:

1. Either repair or replace (at our discretion) the item under warranty.
2. Ship the item back to the customer by the carrier of our choice.

Different or expedited shipping methods will be at the customer's expense.

How To Return an Item

1. Please do not send any products back to Apogee Instruments until you have received a Return Merchandise Authorization (RMA) number from our technical support department by submitting an online RMA form at www.apogeeinstruments.com/tech-support-recalibration-repairs/. We will use your RMA number to track the service item. Call (435) 245-8012 or email techsupport@apogeeinstruments.com with questions.

2. For warranty evaluations, send all RMA sensors and meters back in the following condition: Clean the sensor's exterior and cord. Do not modify the sensors or wires, including splicing, cutting wire leads, etc. If a connector has been attached

to the cable end, please include the mating connector – otherwise the sensor connector will be removed to complete the repair/recalibration. ***Note:*** *When sending back sensors for routine calibration that have Apogee's standard stainless-steel connectors, you only need to send the sensor with the 30 cm section of cable and one-half of the connector. We have mating connectors at our factory that can be used for calibrating the sensor.*

3. Please write the RMA number on the outside of the shipping container.

4. Return the item with freight pre-paid and fully insured to our factory address shown below. We are not responsible for any costs associated with the transportation of products across international borders.

Apogee Instruments, Inc.
721 West 1800 North Logan, UT
84321, USA

5. Upon receipt, Apogee Instruments will determine the cause of failure. If the product is found to be defective in terms of operation to the published specifications due to a failure of product materials or craftsmanship, Apogee Instruments will repair or replace the items free of charge. If it is determined that your product is not covered under warranty, you will be informed and given an estimated repair/replacement cost.

Products Beyond the Warranty Period

For issues with sensors beyond the warranty period, please contact Apogee at techsupport@apogeeinstruments.com to discuss repair or replacement options.

Other Terms

The available remedy of defects under this warranty is for the repair or replacement of the original product, and Apogee Instruments is not responsible for any direct, indirect, incidental, or consequential damages, including but not limited to loss of income, loss of revenue, loss of profit, loss of data, loss of wages, loss of time, loss of sales, accruement of debts or expenses, injury to personal property, or injury to any person or any other type of damage or loss.

This limited warranty and any disputes arising out of or in connection with this limited warranty ("Disputes") shall be governed by the laws of the State of Utah, USA, excluding conflicts of law principles and excluding the Convention for the International Sale of Goods. The courts located in the State of Utah, USA, shall have exclusive jurisdiction over any Disputes.

This limited warranty gives you specific legal rights, and you may also have other rights, which vary from state to state and jurisdiction to jurisdiction, and which shall not be affected by this limited warranty. This warranty extends only to you and cannot by transferred or assigned. If any provision of this limited warranty is unlawful, void, or unenforceable, that provision shall be deemed severable and shall not affect any remaining provisions. In case of any inconsistency between the English and other versions of this limited warranty, the English version shall prevail.

This warranty cannot be changed, assumed, or amended by any other person or agreement