apogee® INSTRUMENTS

OWNER'S MANUAL

COMMERCIAL INFRARED RADIOMETER

Models SIL-111

Rev: 26-Sept-2022

APOGEE INSTRUMENTS, INC. | 721 WEST 1800 NORTH, LOGAN, UTAH 84321, USA
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CERTIFICATE OF COMPLIANCE

EU Declaration of Conformity

This declaration of conformity is issued under the sole responsibility of the manufacturer:

Apogee Instruments, Inc.
721 W 1800 N
Logan, Utah 84321
USA

for the following product(s):

Models: SIL-111
Type: Infrared Radiometer

The object of the declaration described above is in conformity with the relevant Union harmonization legislation:

2014/30/EU	Electromagnetic Compatibility (EMC) Directive
2011/65/EU	Restriction of Hazardous Substances (RoHS 2) Directive
2015/863/EU	Amending Annex II to Directive 2011/65/EU (RoHS 3)

Standards referenced during compliance assessment:

EN 61326-1:2013	Electrical equipment for measurement, control, and laboratory use – EMC requirements
EN 63000:2018	Technical documentation for the assessment of electrical and electronic products with respect to the restriction of hazardous substances

Please be advised that based on the information available to us from our raw material suppliers, the products manufactured by us do not contain, as intentional additives, any of the restricted materials including lead (see note below), mercury, cadmium, hexavalent chromium, polybrominated biphenyls (PBB), polybrominated diphenyls (PBDE), bis (2-ethylhexyl) phthalate (DEHP), butyl benzyl phthalate (BBP), dibutyl phthalate (DBP), and diisobutyl phthalate (DIBP). However, please note that articles containing greater than 0.1 % lead concentration are RoHS 3 compliant using exemption 6c.

Further note that Apogee Instruments does not specifically run any analysis on our raw materials or end products for the presence of these substances, but we rely on the information provided to us by our material suppliers.

Signed for and on behalf of:
Apogee Instruments, September 2022

Bruce Bugbee
President
Apogee Instruments, Inc.

CERTIFICATE OF COMPLIANCE

UK Declaration of Conformity

This declaration of conformity is issued under the sole responsibility of the manufacturer:

Apogee Instruments, Inc.
721 W 1800 N
Logan, Utah 84321
USA

for the following product(s):

Models: SIL-111
Type: Infrared Radiometer
The object of the declaration described above is in conformity with the relevant UK Statutory Instruments and their amendments:

2016 No. 1091	The Electromagnetic Compatibility Regulations 2016
2012 No. 3032	The Restriction of the Use of Certain Hazardous Substances in Electrical and Electronic Equipment Regulations 2012

Standards referenced during compliance assessment:

BS EN 61326-1:2013	Electrical equipment for measurement, control, and laboratory use – EMC requirements
BS EN 63000:2018	Technical documentation for the assessment of electrical and electronic products with respect to the restriction of hazardous substances

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Apogee Instruments, September 2022

Bruce Bugbee
President
Apogee Instruments, Inc.

UK
CA

INTRODUCTION

All objects with a temperature above absolute zero emit electromagnetic radiation. The wavelengths and intensity of radiation emitted are related to the temperature of the object. Terrestrial surfaces (e.g., soil, plant canopies, water, snow) emit radiation in the mid infrared portion of the electromagnetic spectrum (approximately 4-50 µm).

Infrared radiometers are sensors that measure infrared radiation, which is used to determine surface temperature without touching the surface (when using sensors that must be in contact with the surface, it can be difficult to maintain thermal equilibrium without altering surface temperature). Infrared radiometers are often called infrared thermometers because temperature is the desired quantity, even though the sensors detect radiation.

Typical applications of infrared radiometers include plant canopy temperature measurement for use in plant water status estimation, road surface temperature measurement for determination of icing conditions, and terrestrial surface (soil, vegetation, water, snow) temperature measurement in energy balance studies.

Apogee Instruments SIL-111 infrared radiometers consist of a thermopile detector, germanium filter, precision thermistor (for detector reference temperature measurement), signal processing circuitry mounted in an anodized aluminum housing, and a cable to connect the sensor to a measurement device. All radiometers also come with a radiation shield designed to minimize absorbed solar radiation, but still allowing natural ventilation. The radiation shield insulates the radiometer from rapid temperature changes and keeps the temperature of the radiometer closer to the target temperature. Sensors are potted solid with no internal air space and are designed for continuous temperature measurement of terrestrial surfaces in indoor and outdoor environments. The SIL-111 sensors output an analog voltage that is directly proportional to the infrared radiation balance of the target (surface or object the sensor is pointed at) and detector, where the radiation balance between target and detector is related to the temperature difference between the two.

SENSOR MODELS

Model	Output
SIL-111	**Voltage**
SIL-411	SDI-12

A sensor's model number and serial number are located on a label near the pigtail leads on the sensor cable. If you need the manufacturing date of your sensor, please contact Apogee Instruments with the serial number of your sensor.

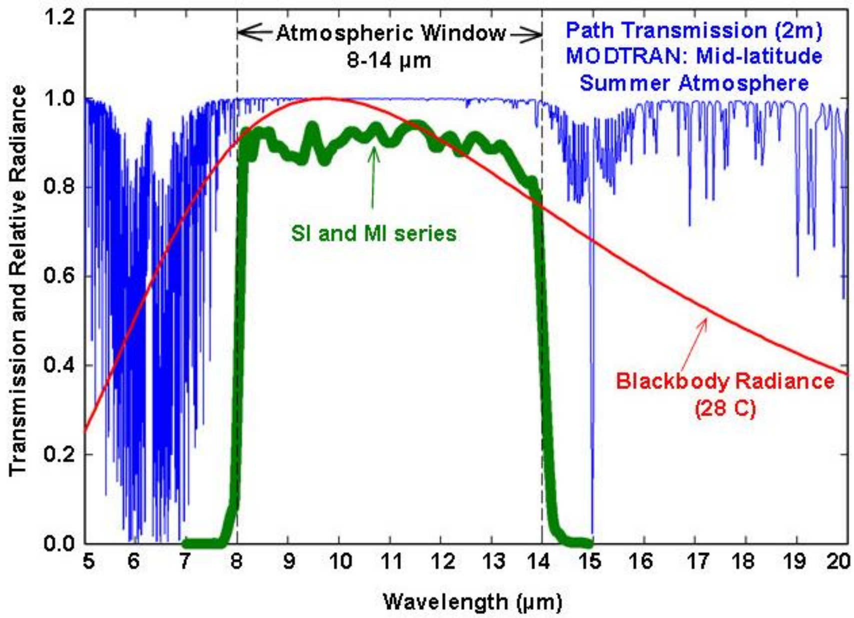
SPECIFICATIONS

	SIL-111
Approximate Sensitivity	50 µV per C difference between target and detector temperature
Output from Thermopile	Approximately -3.3 to 3.3 mV for a temperature difference from -55 to 55 C
Output from Thermistor	0 to 2500 mV (typical, depends on input voltage)
Input Voltage Requirement	2500 mV excitation (typical, other voltages can be used)
Calibration Uncertainty (0 to 50 C), when target and detector temperature are within 20 C	0.5 C
Measurement Repeatability	Less than 0.05 C
Stability (Long-term Drift)	Less than 2 % change in slope per year when germanium filter is maintained in a clean condition (see Maintenance and Recalibration section below)
Response Time	0.6 s, time for detector signal to reach 95 % following a step change
Field of View	22° half angle
Spectral Range	8 to 14 µm; atmospheric window (see Spectral Response below)
Operating Environment	-50 to 80 C; 0 to 100 % relative humidity (non-condensing)
Dimensions	23 mm diameter, 60 mm length
Mass	190 g (with 5m of lead wire)
Cable	5 m of six conductor, shielded, twisted-pair wire; TPR jacket (high water resistance, high UV stability, flexibility in cold conditions); pigtail lead wires

Calibration Traceability

Apogee SIL series infrared radiometers are calibrated to the temperature of a custom blackbody cone held at multiple fixed temperatures over a range of radiometer (detector/sensor body) temperatures. The temperature of the blackbody cone is measured with replicate precision thermistors thermally bonded to the cone surface. The precision thermistors are calibrated for absolute temperature measurement against a platinum resistance thermometer (PRT) in a constant temperature bath. The PRT calibration is directly traceable to the NIST.

Spectral Response



Spectral response of SIL series infrared radiometers. Spectral response (green line) is determined by the germanium filter and corresponds closely to the atmospheric window of 8-14 µm, minimizing interference from atmospheric absorption/emission bands (blue line) below 8 µm and above 14 µm. Typical terrestrial surfaces have temperatures that yield maximum radiation emission within the atmospheric window, as shown by the blackbody curve for a radiator at 28 C (red line).

DEPLOYMENT AND INSTALLATION

The mounting geometry (distance from target surface, angle of orientation relative to target surface) is determined by the desired area of surface to be measured. The field of view extends unbroken from the sensor to the target surface. Sensors must be carefully mounted in order to view the desired target and avoid including unwanted surfaces/objects in the field of view, thereby averaging unwanted temperatures with the target temperature (see Field of View below). **Once mounted, the green cap must be removed.** The green cap can be used as a protective covering for the sensor when it is not in use.

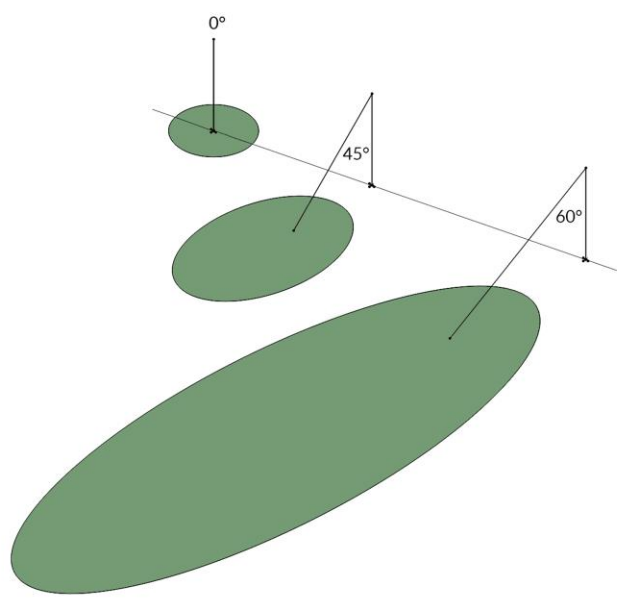
An Apogee Instruments model AM-250 mounting bracket is recommended for mounting the sensor to a cross arm or pole. The AM-250 allows adjustment of the angle of the sensor with respect to the target and accommodates the radiation shield designed for SIL-111 infrared radiometers.

Field of View

The field of view (FOV) is reported as the half-angle of the apex of the cone formed by the target surface (cone base) and the detector (cone apex), as shown below, where the target is defined as a circle from which 98 % of the radiation detected by the radiometer is emitted.

Sensor FOV, distance to target, and sensor mounting angle in relation to the target will determine target area. Different mounting geometries (distance and angle combinations) produce different target shapes and areas, as shown below.

Model	Half Angle	Mounting Height (m)	FOV Area (m²)		
			0°	45°	60°
SIL-111	22°	1.0	0.51	1.90	11.26
SIL-111	22°	2.0	2.05	7.58	45.0
SIL-111	22°	3.0	4.62	17.1	101.3

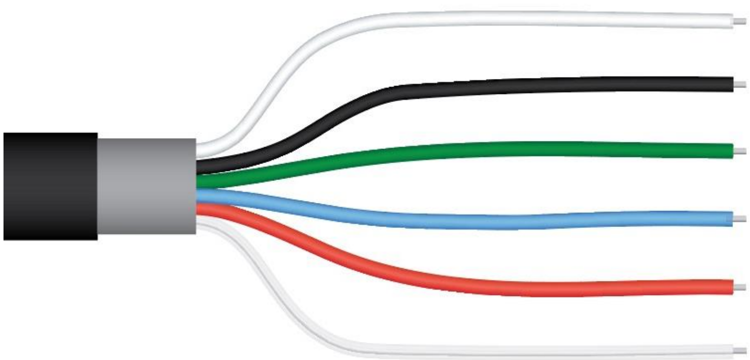


A simple FOV calculator for determining target dimensions based on infrared radiometer model, mounting height, and mounting angle, is available on the Apogee website: https://www.apogeeinstruments.com/irr-calculators.

OPERATION AND MEASUREMENT

The SIL-111 radiometer outputs two signals: a voltage from the thermopile radiation detector (proportional to the radiation balance between target and detector) and a voltage from the thermistor (proportional to the magnitude of the excitation voltage and resistance of thermistor). The voltage output from the thermopile is an electrically-isolated bipolar (polarity is dependent on temperature difference between sensor and target) signal in the microvolt range and requires a high-resolution differential measurement. The voltage output from the thermistor can be measured with a single-ended measurement. In order to maximize measurement resolution and signal-to-noise ratio, the input range of the measurement device should closely match the output range of the infrared radiometer. **DO NOT connect the thermopile (white and black wires) to a power source. The detector is self-powered and applying voltage will damage it.** Only the red wire should be connected to a power source.

Wiring for SIL-111



White: High side of differential channel (positive thermopile lead)

Black: Low side of differential channel (negative thermopile lead)

Green: Single-ended channel (positive thermistor lead)

Blue: Analog ground (negative thermistor lead)

Red: Excitation channel (excitation for thermistor)

Clear: Shield/Ground

Sensor Calibration

Apogee SIL-111 infrared radiometers are calibrated in a temperature-controlled chamber that houses a custom-built blackbody cone (target) for the radiation source. During calibration, infrared radiometers (detectors) are held in a fixture at the opening of the blackbody cone but are thermally insulated from the cone. Detector and target temperature are controlled independently. At each calibration set point, detectors are held at a constant temperature while the blackbody cone is controlled at temperatures below (10 C), above (10 C), and equal to the detector temperature. The detector temperatures are 10, 25, and 40. Data are collected at each detector temperature set point, after detectors and target reach constant temperatures.

All Apogee SIL-111 analog infrared radiometers have sensor-specific calibration coefficients determined during the custom calibration process. Unique coefficients for each sensor are provided on a coefficient certificate (example shown below).

apogee INSTRUMENTS
721 West 1800 North
Logan, UT 84321

Certificate of Calibration
Apogee Instruments Infrared Radiometer
SIL-100 Series

Calibration Overview

Model/Serial Number	:	**SIL-111_Example**
Calibration Date	:	10-Jul-2020
Recommended Recalibration Date	:	10-Jul-2022
Mean of Differences from Target	:	0.001 °C
Target Temperature Uncertainty (95% confidence)	:	**0.133 °C**
Maximum Difference from Target	:	0.148 °C
Minimum Difference from Target	:	-0.119 °C
Maximum Detector Response	:	1.379 mV
Minimum Detector Response	:	-0.804 mV
Average Output Sensitivity	:	66.794 µV / °C

Custom Calibration Coefficients

CRBasic

	C2	C1	C0
m	81170.5	7187980	1334780000
b	2295.07	245405	-6557540

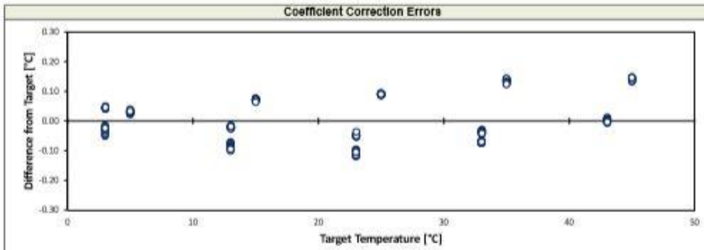
See the SI-100 series manual for how to apply these coefficients in determining target temperatures.

Edlog

	C2	C1	C0
m(BB)	0.81171	71.88052	13347.93348
b(BB)	0.02295	2.45407	-65.57606

Use these coefficients in Edlog programs for older Campbell Scientific dataloggers.

Coefficient Correction Errors



Calibration Procedure

An Infrared Radiometer (IRR) combines a thermopile detector and a National Institute of Standards and Technology (NIST) traceable thermistor to measure a mV response proportional to the thermal radiation balance between the target temperature and the thermopile temperature (sensor body temperature). IRRs are placed in a temperature controlled housing, which is thermally insulated from a blackbody cone. The housing, pointed at a blackbody cone, is temperature cycled through various sensor body set-points. The blackbody cone temperature (measured with NIST traceable thermistors) is likewise cycled through multiple temperature set-points relative to each sensor body temperature set-point. A linear fit is used to model each sensor body set-point with the respective blackbody cone set-points versus the thermopile signal at those set-points. The slopes and y-intercepts of all linear fits corresponding to each sensor body temperature are then fit to a second order polynomial in order to adequately interpolate between the calibrated set-points. These two sets of second order polynomial coefficients represent the custom calibration coefficients as given above.

Traceability

All thermistors are measured for accuracy in a constant temperature bath that is directly traceable to the NIST. The overall measurement system uncertainty for all the bath and measurement allowances combined for error is typically less than 0.1°C and completely traceable to National Standards.

Technical Manager : Jacob Bingham

Date : 10-Jul-2020

Please keep this document for your records

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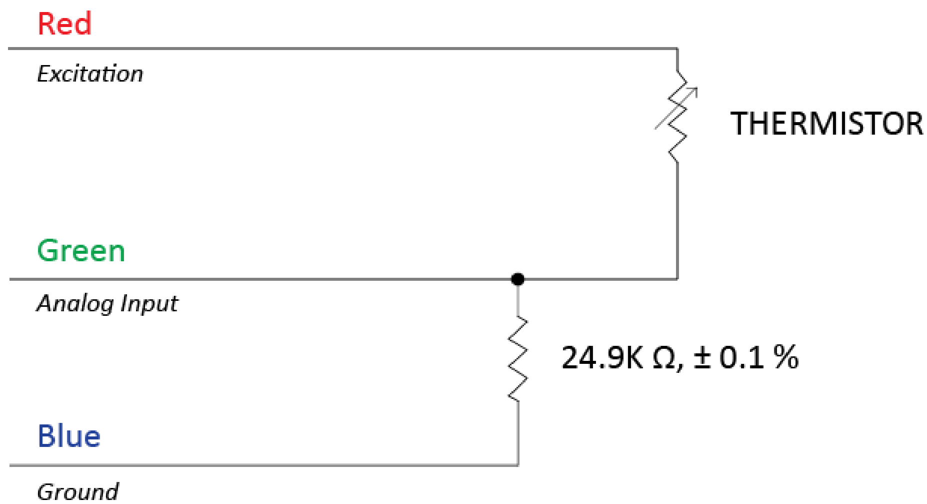
Calibration overview data are listed in box in upper, left-hand corner; sensor specific calibration coefficients are listed in box in upper, right-hand corner; temperature errors are shown in graph; and calibration date is listed below descriptions of calibration procedure and traceability.

Temperature Measurement with Internal Thermistor

Measurement devices (e.g., datalogger, controller) do not measure resistance directly, but determine resistance from a half-bridge measurement, where an excitation voltage is input across the thermistor and an output voltage is measured across the bridge resistor.



An excitation voltage of 2.5 V DC is recommended to minimize self-heating and current drain, while still maintaining adequate measurement sensitivity (mV output from thermistor per C). However, other excitation voltages can be used. Decreasing the excitation voltage will decrease self-heating and current drain but will also decrease thermistor measurement sensitivity. Increasing the excitation voltage will increase thermistor measurement sensitivity but will also increase self-heating and current drain.

The internal thermistor provides a temperature reference for calculation of target temperature. Resistance of the thermistor changes with temperature. Thermistor resistance (R_T, in Ω) is measured with a half-bridge measurement, requiring an excitation voltage input (V_{EX}) and a measurement of output voltage (V_{OUT}):

$$R_T = 24900\left(\frac{V_{EX}}{V_{OUT}} - 1\right) \qquad (1)$$

where 24900 is the resistance of the bridge resistor in Ω. From resistance, temperature (T_K, in Kelvin) is calculated with the Steinhart-Hart equation and thermistor specific coefficients:

$$T_K = \frac{1}{A + B\ln(R_T) + C(\ln(R_T))^3} \qquad (2)$$

where A = 1.129241 x 10^{-3}, B = 2.341077 x 10^{-4}, and C = 8.775468 x 10^{-8} (Steinhart-Hart coefficients).

If desired, measured temperature in Kelvin can be converted to Celsius (T_C):

$$T_C = T_K - 273.15 \,. \qquad (3)$$

Target Temperature Measurement

The detector output from SIL-111 radiometers follows the fundamental physics of the Stefan-Boltzmann Law, where radiation transfer is proportional to the fourth power of absolute temperature. A modified form of the Stefan-Boltzmann equation is used to calibrate sensors, and subsequently, calculate target temperature:

$$\mathrm{T_T}^4 - \mathrm{T_D}^4 = \mathrm{m} \cdot \mathrm{S_D} + \mathrm{b} \qquad (1)$$

where T_T is target temperature [K], T_D is detector temperature [K], S_D is the millivolt signal from the detector, m is slope, and b is intercept. The mV signal from the detector is linearly proportional to the energy balance between the target and detector, analogous to energy emission being linearly proportional to the fourth power of temperature in the Stefan-Boltzmann Law.

During the calibration process, m and b are determined at each detector temperature set point (15 C increments across a 10 C to 40 C range) by plotting measurements of $T_T^4 – T_D^4$ versus mV. The derived m and b coefficients are then plotted as function of T_D and second order polynomials are fitted to the results to produce equations that determine m and b at any T_D:

$$\mathrm{m} = \mathrm{C2} \cdot \mathrm{T_D}^2 + \mathrm{C1} \cdot \mathrm{T_D} + \mathrm{C0} \qquad (2)$$

$$\mathrm{b} = \mathrm{C2} \cdot \mathrm{T_D}^2 + \mathrm{C1} \cdot \mathrm{T_D} + \mathrm{C0} \qquad (3)$$

Where C2, C1, and C0 are the custom calibration coefficients listed on the calibration certificate (shown above) that comes with each SIL-111 radiometer (there are two sets of polynomial coefficients, one set for m and one set for b). Note that T_D is converted from Kelvin to Celsius (temperature in C equals temperature in K minus 273.15) before m and b are plotted versus T_D.

To make measurements of target temperatures, Eq. (1) is rearranged to solve for T_T [C], measured values of S_D and T_D are input, and predicted values of m and b are input:

$$T_T = \left(T_D^{\,4} + m \cdot S_D + b\right)^{\frac{1}{4}} - 273.15 \qquad (4)$$

Emissivity Correction

Appropriate correction for surface emissivity is required for accurate surface temperature measurements. The simple (and commonly made) emissivity correction, dividing measured temperature by surface emissivity, is incorrect because it does not account for reflected infrared radiation.

The radiation detected by an infrared radiometer includes two components: 1. radiation directly emitted by the target surface, and 2. reflected radiation from the background. The second component is often neglected. The magnitude of the two components in the total radiation detected by the radiometer is estimated using the emissivity (ε) and reflectivity (1 - ε) of the target surface:

$$E_{Sensor} = \varepsilon \cdot E_{Target} + (1-\varepsilon) \cdot E_{Background} \qquad (1)$$

where E_{Sensor} is radiance [W m^{-2} sr^{-1}] detected by the radiometer, E_{Target} is radiance [W m^{-2} sr^{-1}] emitted by the target surface, $E_{Background}$ is radiance [W m^{-2} sr^{-1}] emitted by the background (when the target surface is outdoors the background is generally the sky), and ε is the ratio of non-blackbody radiation emission (actual radiation emission) to blackbody radiation emission at the same temperature (theoretical maximum for radiation emission). Unless the target surface is a blackbody (ε = 1; emits and absorbs the theoretical maximum amount of energy based on temperature), E_{sensor} will include a fraction (1 – ε) of reflected radiation from the background.

Since temperature, rather than energy, is the desired quantity, Eq. (1) can be written in terms of temperature using the Stefan-Boltzmann Law, $E = \sigma T^4$ (relates energy being emitted by an object to the fourth power of its absolute temperature):

$$\sigma \cdot T_{Sensor}^{\;4} = \varepsilon \cdot \sigma \cdot T_{Target}^{\;4} + (1-\varepsilon) \cdot \sigma \cdot T_{Background}^{\;4} \qquad (2)$$

where T_{Sensor} [K] is temperature measured by the infrared radiometer (brightness temperature), T_{Target} [K] is actual temperature of the target surface, $T_{Background}$ [K] is brightness temperature of the background (usually the sky), and σ is the Stefan-Boltzmann constant (5.67 x 10^{-8} W m^{-2} K^{-4}). The power of 4 on the temperatures in Eq. (2) is valid for the entire blackbody spectrum.

Rearrangement of Eq. (2) to solve for T_{Target} yields the equation used to calculate the actual target surface temperature (i.e., measured brightness temperature corrected for emissivity effects):

$$T_{Target} = \sqrt[4]{\frac{T_{Sensor}^{\;4} - (1-\varepsilon) \cdot T_{Background}^{\;4}}{\varepsilon}} \; . \qquad (3)$$

Equations (1)-(3) assume an infinite waveband for radiation emission and constant ε at all wavelengths. These assumptions are not valid because infrared radiometers do not have infinite wavebands, as most correspond to the atmospheric window of 8-14 μm, and ε varies with wavelength. Despite the violated assumptions, the errors for emissivity correction with Eq. (3) in environmental applications are typically negligible because a large proportion of the radiation emitted by terrestrial objects is in the 8-14 μm waveband (the power of 4 in Eqs. (2) and (3) is a reasonable approximation), ε for most terrestrial objects does not vary significantly in the 8-14 μm waveband, and the background radiation is a small fraction (1 – ε) of the measured radiation because most terrestrial surfaces have high emissivity (often between 0.9 and 1.0). To apply Eq. (3), the brightness temperature of the background ($T_{Background}$) must be measured or estimated with reasonable accuracy. If a radiometer is used to measure background temperature, the waveband it measures should be the same as the radiometer used to measure surface brightness temperature. Although the ε of a fully closed plant canopy can be 0.98-0.99, the lower ε of soils and other surfaces can result in substantial errors if ε effects are not accounted for.

MAINTENANCE AND RECALIBRATION

Blocking of the optical path between the target and detector, often due to moisture or debris on the filter, is a common cause of inaccurate measurements. The filter in SI series radiometers is inset in an aperture, but can become partially blocked in four ways:

1. Dew or frost formation on the filter.
2. Salt deposit accumulation on the filter, due to evaporating irrigation water or sea spray. This leaves a thin white film on the filter surface. Salt deposits can be removed with a dilute acid (e.g., vinegar). **Salt deposits cannot be removed with solvents such as alcohol or acetone.**
3. Dust and dirt deposition in the aperture and on the filter (usually a larger problem in windy environments). Dust and dirt are best removed with deionized water, rubbing alcohol, or in extreme cases, acetone. **The plastic radiation shield should be removed if acetone is used to clean the filter as it can be damaged by acetone.**
4. Spiders/insects and/or nests in the aperture leading to the filter. If spiders/insects are a problem, repellent should be applied around the aperture entrance (not on the filter).

Clean inner threads of the aperture and the filter with a cotton swab dipped in the appropriate solvent. **Never use an abrasive material on the filter.** Use only gentle pressure when cleaning the filter with a cotton swab, to avoid scratching the outer surface. The solvent should be allowed to do the cleaning, not mechanical force.

It is recommended that infrared radiometers be recalibrated every two years. See the Apogee webpage for details regarding return of sensors for recalibration (http://www.apogeeinstruments.com/tech-support-recalibration-repairs/).

TROUBLESHOOTING AND CUSTOMER SUPPORT

Independent Verification of Functionality

The radiation detector in Apogee SIL-111 infrared radiometers is a self-powered device that outputs a voltage signal proportional to the radiation balance between the detector and target surface. A quick and easy check of detector functionality can be accomplished using a voltmeter with microvolt (µV) resolution. Connect the positive lead of the voltmeter to the white wire from the sensor and the negative lead (or common) to the black wire from the sensor. Direct the sensor toward a surface with a temperature significantly different than the detector. The µV signal will be negative if the surface is colder than the detector and positive if the surface is warmer than the detector. Placing a piece of tinfoil in front of the sensor should force the sensor µV signal to zero.

The thermistor inside Apogee SIL-111 radiometers yields a resistance proportional to temperature. A quick and easy check of thermistor functionality can be accomplished with an ohmmeter. Connect the lead wires of the ohmmeter to the red and green wires from the sensor. The resistance should read 10 kΩ at 25 C. If the sensor temperature is less than 25 C, the resistance will be higher. If the sensor temperature is greater than 25 C, the resistance will be lower. Connect the lead wires of the ohmmeter to the green and blue wires from the sensor. The resistance should read 24.9 kΩ and should not vary with temperature. Connect the lead wires of the ohmmeter to the red and blue wires from the sensor. The resistance should be the sum of the resistances measured across the green and white wires, and green and blue wires (e.g., 10 kΩ plus 24.9 kΩ at 25 C).

Compatible Measurement Devices (Dataloggers/Controllers/Meters)

SIL-111 radiometers have sensitivities in the microvolt range, approximately 60 µV per C difference between target and detector. Thus, a compatible measurement device (e.g., datalogger or controller) should have resolution of at least 3 µV (0.003 mV), in order to produce temperature resolution of 0.05 C. Measurement of detector temperature from the internal thermistor requires an input excitation voltage, where 2500 mV is recommended. A compatible measurement device should have the capability to supply the necessary voltage.

An example datalogger program for Campbell Scientific dataloggers can be found on the Apogee webpage at http://www.apogeeinstruments.com/content/Infrared-Radiometer-Analog.CR1.

Modifying Cable Length

When the sensor is connected to a measurement device with high input impedance, sensor output signals are not changed by shortening the cable or splicing on additional cable in the field. Tests have shown that if the input impedance of the measurement device is 10 MΩ or higher, there is negligible effect on the radiometer calibration, even after adding up to 50 m of cable. Apogee model SI series infrared radiometers use shielded, twisted pair cable, which minimizes electromagnetic interference. This is particularly important for long lead lengths in electromagnetically noisy environments. See Apogee webpage for details on how to extend sensor cable length (http://www.apogeeinstruments.com/how-to-make-a-weatherproof-cable-splice/).

Signal Interference

Due to the small voltage signals from the detector, care should be taken to provide appropriate grounding for the sensor and cable shield wire, in order to minimize the influence of electromagnetic interference (EMI). In instances where SIL-111 radiometers are being used in close proximity to communications (near an antenna or antenna wiring), it may be necessary to alternate the data recording and data transmitting functions (i.e., measurements should not be made when data are being transmitted wirelessly). If EMI is suspected, place a tinfoil cap over the front of the sensor and monitor the signal voltage from the detector. The signal voltage should remain stable at (or very near) zero.

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 for tracking of 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 in order 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 AGREE