apogee instruments inc.

CRBasic

SI-121 1279 Custom Coefficients

Calibration Date: 22-Oct-2008

	C2	C1	C0
m(SB)	97544.5	1.64E+07	2.41E+09
b(SB)	72471.2	-2.79E+06	-2.96E+07

Use these coefficients under "Declare Constants" section in the example Campbell Scientific datalogger program

apogee instruments inc.

EdLog

SI-121 1279 Custom Coefficients

Calibration Date: 30-Apr-2008

	C2	C1	C0
m(SB)	0.97545	163.75064	24132.14132
b(SB)	0.72472	-27.94748	-296.26996

Use these coefficients in instructions 11&13 in the

apogee instruments inc.

SI-322 1090 Custom Coefficients

Calibration Date: 31-Jul-08

	C2	C1	C0
H(SB)	0.00935057	0.294573	-81.2689
K(SB)	-1.60764	121.844	6737.34
P(SB)	0.00152106	0.145395	142.763

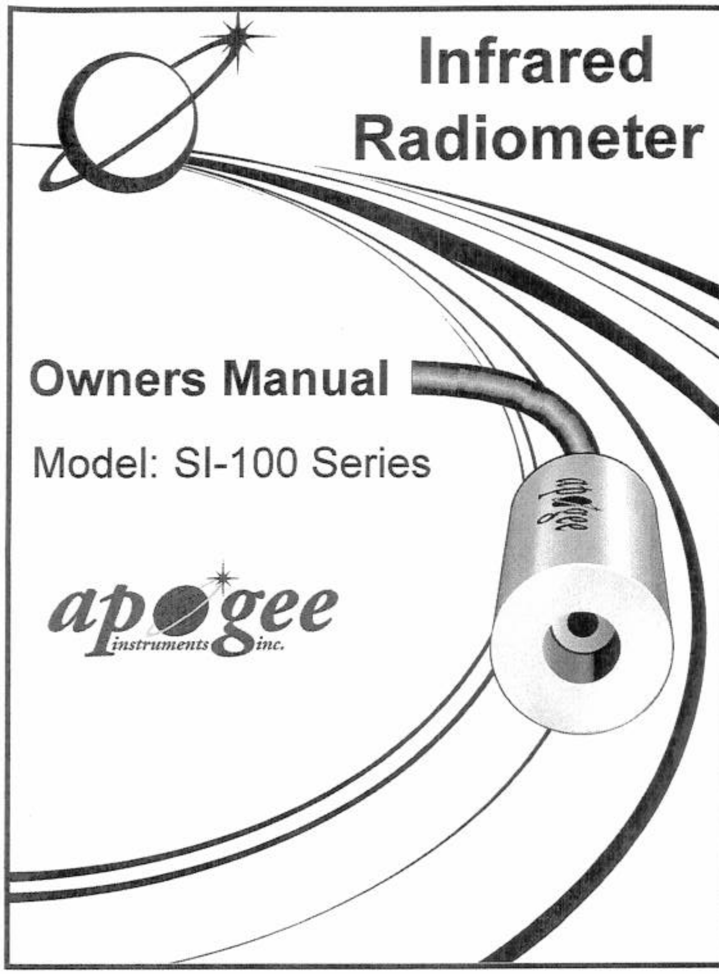
These coefficients will replace the standard coefficients in commands 3-5 of the example program

Specifications

		Precision	Precision Narrow
Field of view		22° half angle	18° half angle
Output	Target temp.	60 µV per °C difference from sensor body	40 µV per °C difference from sensor body
	Sensor body temp.	0-2500 mV	0-2500 mV
Accuracy	-10 to 65 °C	±0.2 °C absolute accuracy ±0.1 °C uniformity ±0.05 °C repeatability	
	-40 to 70 °C	±0.5 °C absolute accuracy ±0.3 °C uniformity ±0.1 °C repeatability and uniformity	
Optics		Germanium lens	
Wavelength range		8-14 µm (corresponds to atmospheric window)	
Response time		< 1 second to changes in target temperature	
Input power		2.5 V excitation	
Operating environment		-55 to 80 °C; 0 to 100 % RH (non-condensing) Water resistant, designed for continuous outdoor use	
Datalogger channels		1 differential (detector) and 1 single-ended (thermistor)	
Cable		4.5 meters twisted, shielded 4 conductor wire with Santoprene casing. Extra cable $2.95 per meter.	
Dimensions		6 cm long by 2.3 cm diameter	
Mass		190 g	
Warranty		1 year against defects in materials and workmanship	

apogee instruments inc.

435-792-4700
www.apogeeinstruments.com
techsupport@apogee-inst.com



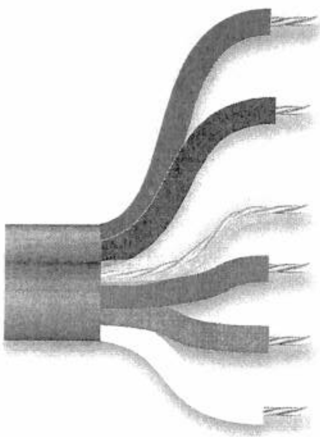
Infrared Radiometer

Owners Manual

Model: SI-100 Series

apogee instruments inc.

Wiring Diagram



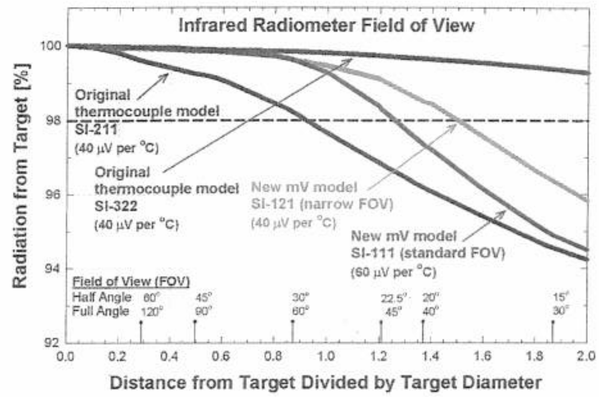
Red	High side of differential channel (positive thermopile lead)
Black	Low side of differential channel (negative thermopile lead)
Clear	Analog ground (thermopile ground)
Green	Single-ended channel (positive thermistor lead)
Blue	Analog ground (negative thermistor lead)
White	Excitation channel (excitation for thermistor)

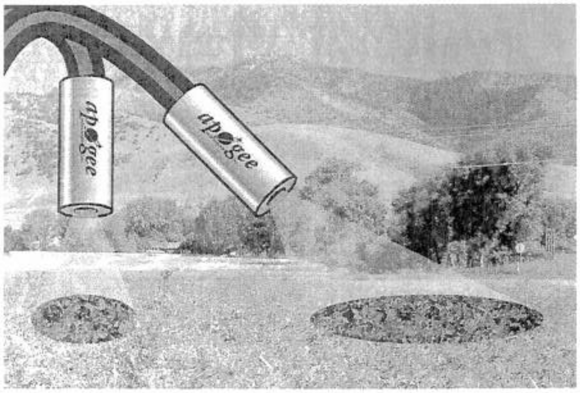
sample programming and instructions available online:
www.apogee-inst.com/programs

Field of View

Field of View (FOV) is reported as the half-angle of the apex of the cone formed by the target (cone base) and the detector (cone apex). The target is a circle from which 98% of the radiation being viewed by the detector is being emitted.

Model SI-111 half-angle = 22.0°
Model SI-121 half-angle = 18.0°



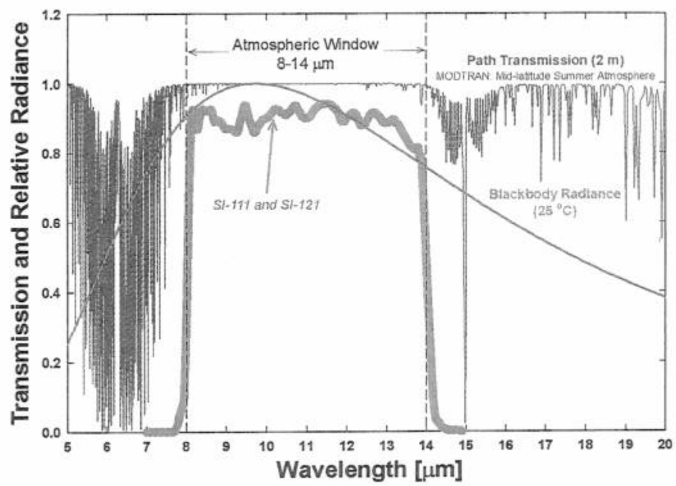


Mounting

The sensor's FOV (22° or 18°) determines the size of the target area viewed by the detector. This is also influenced by the height and angle at which you mount your IRR. The FOV extends unbroken until it reaches a solid target. Check to be sure you are not detecting unwanted areas within your target diameter, such as the sky.

About the Atmospheric Window

The 8-14 µm window of the IRR models corresponds to the atmospheric window. This minimizes the effects of water bands below 8 µm and above 14 µm.



Accuracy and Calibration

During calibration the sensor body temperature ranges from -5 to 45 °C at 10 °C increments. At each step the target temperature ranges from +20 to -15 °C relative to the sensor body temperature.

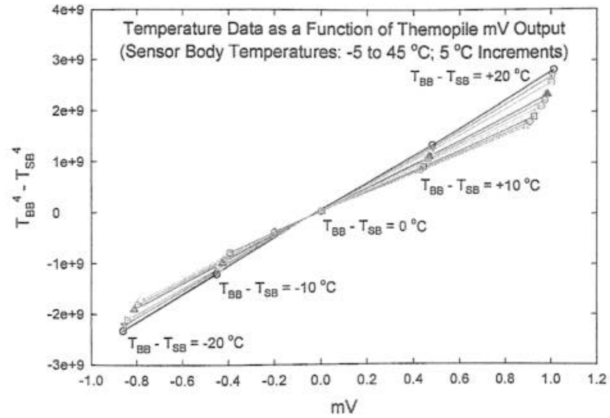
The output of IRR sensors follows the fundamental physics of the Stefan-Boltzmann Law, which states that radiation transfer is proportional to temperature raised to the fourth power (T^4). A version of the S-B equation proposed by Kalma et al. (Calibration of small infra-red surface temperature transducers, Ag. For. Met., 1988) is used to calibrate the sensors taking into account the effect of sensor body temperature (see graph shown above-right):

$$T_T^4 - T_D^4 = m \cdot mV + b$$

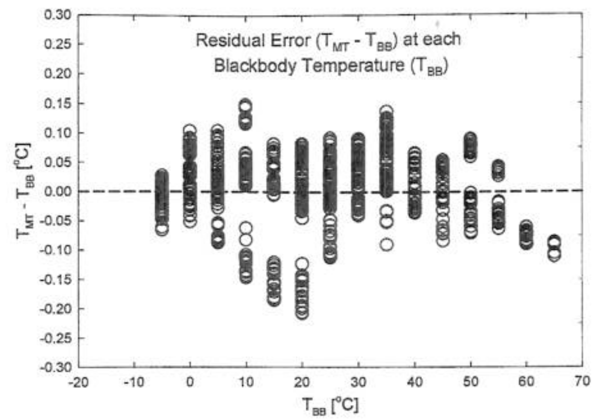
where T_T [K] is the target temperature (blackbody cone temperature during calibration), T_D [K] is the detector temperature, mV is the millivolt output of the detector and serves as a surrogate for emitted energy, m is the slope and b is the intercept. The coefficients m and b are derived during sensor calibration and are functions of the detector temperature.

To make temperature measurements, the equation can be rearranged to solve for T_T, which is calculated from the measured values of T_D and mV, and the calculated values of m and b (calculated from T_D):

$$T_T = (T_D^4 + m \cdot mV + b)^{1/4}$$



The graph below shows the residual error ($T_{MT} - T_{BB}$) where T_{MT} is measured temperature and T_{BB} is blackbody temperature).



Instructions for measuring and linearizing an Apogee Instruments precision infrared thermocouple sensor in a Campbell Scientific Inc (CSI) datalogger

Standard H, K and P Coefficients

Aug. 14, 2003

The equation being implemented is:
SEC = 0.25/Psb*[{(AppTarget T - Hsb)^2}-Ksb]
(see the original manuscript for derivation).

These instructions can be used in a subroutine for multiple sensors. The reference temperature (referenceT) for all thermocouples must first be measured as specified in the CSI multiplexer manual. The location numbers used in this example (10, 20, 30, 40, 110, 120, and 130) are arbitrary and can be changed.

Measure the apparent target temperature (output lead with the black band):

```
1:  Thermocouple Temp (differential) (P14)
     1: 1    Rep
     2: 21   2.5 mV 60 Hz Rejection Range
     3: 1    IN Channel
     4: 3    Type K (Chromel-Alumel)
     5: 1    REF TEMP LOC [referenceT]
     6: 10   LOC [AppTargetT]
     7: 1    Multiplier
     8: 0    Offset
```

Measure the Sensor Body Temp:

```
2:  Thermocouple Temp (DIFF) (P14)
     1: 1    Rep
     2: 21   2.5 mV 60 Hz Rejection Range
     3: 2    IN Channel
     4: 3    Type K (Chromel-Alumel)
     5: 1    REF TEMP LOC [referenceT]
     6: 20   LOC [SensorBodyT]
     7: 1    Multiplier
     8: 0    Offset
```

Calculate the P, H, & K Coefficients:

```
3:  Polynomial (P55)   (Psb coefficient)
     1: 1              Reps
     2: 20             X Loc [SensorBodyT]
     3: 110            F(X) Loc [Psb]
     4: 49.9092        C0
     5: .59237         C1
     6: .00558         C2

4:  Polynomial (P55)   (Hsb coefficient)
     1: 1              Reps
     2: 20             X Loc [SensorBodyT]
     3: 120            F(X) Loc [Hsb]
     4: 4.2828         C0
     5: .4248          C1
     6: -.00077        C2

5:  Polynomial (P55)   (Ksb coefficient)
     1: 1              Reps
     2: 20             X Loc [SensorBodyT]
     3: 130            F(X) Loc [Ksb]
     4: 52.0705        C0
     5: -5.3816        C1
     6: .387           C2
```

Calculate the sensor error correction factor (SEC) to correct for sensor body temperature:

```
6:  Z=1/X (P42)        {1/Psb}
     1: 110            X Loc [Psb]
     2: 110            Z Loc [Psb]

7:  Z=X*F (P37)        {0.25/Psb}
     1: 110            X Loc [Psb]
     2: 0.25           F
     3: 110            Z Loc [Psb]

8:  Z=X-Y (P35)        {ATT - Hsb}
     1: 10             X Loc [AppTargetT]
     2: 120            Y Loc [Hsb]
     3: 120            Z Loc [Hsb]

9:  Z=X*Y (P36)        {ATT - Hsb}^2
     1: 120            X Loc [Hsb]
     2: 120            Y Loc [Hsb]
     3: 120            Z Loc [Hsb]

10:  Z=X-Y (P35)       {subtract Ksb}
     1: 120            X Loc [Hsb]
     2: 130            Y Loc [Ksb]
     3: 130            Z Loc [Ksb]

11:  Z=X*Y (P36)       {calculate SEC}
     1: 110            X Loc [Psb]
     2: 130            Y Loc [Ksb]
     3:   30           Z Loc [SEC]
```

Finally, calculate the corrected target temperature (CTT):

```
12:  Z=X-Y (P35)       {AppTarget T - SEC}
     1: 10             X Loc [AppTargetT]
     2: 30             Y Loc [SEC]
     3: 40             Z Loc [CTT]
```