INSTRUCTION MANUAL

IRTS-P Precision Infrared Temperature Sensor

Revision: 9/06

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IRTS-P Precision Infrared Temperature Sensor

1. General Description

An infrared temperature sensor (IRTS) is a non-contact means of measuring the surface temperature of an object by sensing the infrared radiation given off. IRTS are widely used for measurements of leaf, canopy, and average surface temperature. With contact sensors it is difficult to avoid influencing the temperature, maintain thermal contact, and provide a spatial average.

By mounting the infrared sensor at an appropriate distance from the target, it can be used to measure an individual leaf, a canopy, or any surface of interest.

The IRTS-P is an infrared temperature sensor calibrated to output the signal for the target temperature with the same output voltage as if a Type K thermocouple were sensing the target temperature. A separate type K thermocouple is used to measure the temperature of the sensor body. The sensor body temperature is used to correct the target temperature for greater accuracy.

2. Specifications

Power Requirements	None: self-powered
Accuracy	±0.3°C from -10° to 55°C (±0.1°C when sensor body and target are at the same temperature)
Repeatability	0.05°C from -10° to 55°C
Mass	Less than 100 grams
Dimensions	6.3 cm long by 2.3 cm diameter
Response Time	Less than 1 second to changes in target temperature
Output Signal	2, type K, twisted, shielded pair thermocouple outputs (15 ft each), one for target temperature, one for sensor body temperature. The sensor body temperature is used to make a correction for target temperature.
Optics	Silicon lens
Wavelength Range	6 to 14 micrometers
Field of View	3:1 field of view (at 3 meters from sensor the FOV is a 1 meter diameter circle)
Operating Environment	Highly water resistant, designed for continuous outdoor use; temperature range: -10° to 55°C

3. Installation

The field of view for infrared sensors is calculated based on the geometry of the sensor and lens. However, optical and atmospheric scatter and unwanted reflections from outside the field of view may influence the measurement. Under typical conditions, 80 to 90 percent of the IR signal is from the field of view and 10 to 20 percent is from the area surrounding the field of view. If the target surface is small, for example a single leaf, try to mount the sensor close enough that the surface extends beyond the field of view.

To obtain the desired view of the canopy or surface of interest, the IRTS-P is often mounted separately from a met station tower. A hole threaded for a standard tripod camera mount screw (1/4 inch diameter; 20 threads per inch) can be used to mount the sensor to a user-supplied support.

The IRTS-P can be mounted to a Campbell Scientific tripod or tower with the UT018 Crossarm (Figure 3-1.) A mounting kit (Stainless steel bolt, 2 washers, and 2 nuts PN 14475) is included with the IRTS-P that can be used to attach the sensor to the crossarm (Figure 3-2.)

FIGURE 3-1. IRTS-P on UT018 Crossarm

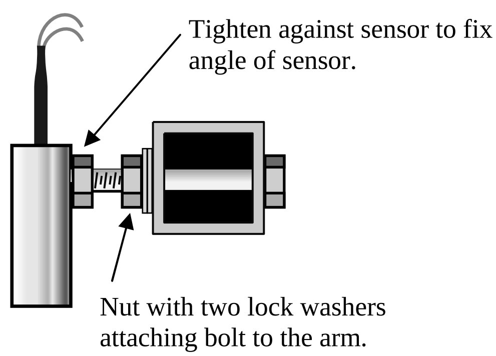
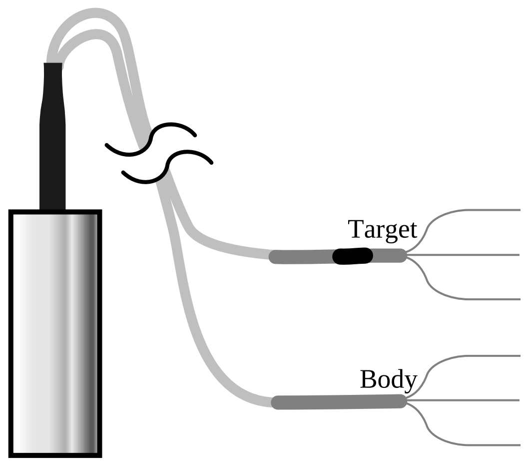


FIGURE 3-2. Mounting IRTS-P to UT018 Crossarm

4. Wiring

The IRTS-P has two thermocouple outputs. Each output is a pair of red and yellow wires. The pair labeled “Target” on the jacket near the wires is the output from the detector. The pair labeled “Body” is a thermocouple measuring the temperature of the sensor body. Previous versions of the sensor had a black band on the target cable to mark it. We recommend measuring the temperatures with differential voltage thermocouple measurements.



Target – Detector Temperature:

Yellow TC +	Differential High
Red TC –	Differential Low
Bare -	Ground

Sensor Body Temperature:

Yellow TC +	Differential High
Red TC –	Differential Low
Bare -	Ground

5. Example Programs

The datalogger program to measure the IRTS-P measures the thermocouple outputs to obtain the IRTS-P sensor body temperature and the apparent (uncorrected) temperature of the target.

The thermocouple temperature requires the temperature of the terminals to which the thermocouples are connected. The panel temperature is used as the reference for the CR23X, CR1000, and CR5000. The module temperature is not an accurate measurement of the CR10X panel temperature; a CR10XTCR is required to measure the reference temperature.

After measuring the thermocouple outputs, the sensor body temperature is used to calculate correction coefficients that are then used to correct the target temperature.

All three example programs measure the sensor once a second and output average values once an hour. The actual channels and outputs intervals need to be adjusted for the actual installation and application.

The equations implemented in the program are (Bugbee et.al. 1996)

Corrected Target Temperature, $CTT = ATT - SEC$
were ATT = Apparent Target Temperature,
and Sensor Error Correction,

$$SEC = (0.25 / P_{SB})((ATT - H_{SB})^2 - K_{SB});$$

$$P_{SB} = 49.9092 + 0.59237 \cdot SB + 0.00558 \cdot SB^2$$

$$H_{SB} = 4.2828 + 0.4248 \cdot SB - 0.00077 \cdot SB^2$$

$$K_{SB} = 52.0705 - 5.3816 \cdot SB + 0.387 \cdot SB^2$$

and $SB =$ Sensor Body Temperature

The three example programs measure the sensor once a second and output average sensor and target temperatures once an hour. In an actual installation the measurement and output intervals, and channels used may be changed to accommodate the other measurements and outputs.

TABLE 5-1. Wiring for Example Programs

Sensor/Lead	**Description**	**CR10X**	**CR23X**	**CR1000**
CR10XTCR	Reference Temp:		Not Used	Not Used
Black	Excitation	E3		
Red	Signal	SE1		
Clear	Ground	AG		
IRTS-P – Target/Black Band	Detector Temp			
Yellow	TC +	2H	1H	1H
Red	TC -	2L	1L	1L
IRTS-P – Body/No Band	Sensor Temp			
Yellow	TC +	3H	2H	2H
Red	TC -	3L	2L	2L
Bare wire	Shield	G	⏚	⏚

CR10X Example Program

```
;{CR10X}
;
*Table 1 Program
  01:  1            Execution Interval (seconds)

;Measure CR10XTCR Reference Temperature

1:  Temp (107) (P11)
  1:   1            Reps
  2:   1            SE Channel
  3:   3            Excite all reps w/E3
  4:   1            Loc [ RefTemp   ]
  5:   1.0          Mult
  6:   0.0          Offset

;Measure IRt/c apparent target temperature
```

```
2:  Thermocouple Temp (DIFF) (P14)
   1:    1                 Reps
   2:    21                2.5 mV 60 Hz Rejection Range
   3:    2                 DIFF Channel
   4:    3                 Type K (Chromel-Alumel)
   5:    1                 Ref Temp (Deg. C) Loc [ RefTemp   ]
   6:    2                 Loc [ AppTargT  ]
   7:    1.0               Mult
   8:    0.0               Offset

;Measure Sensor Body Temp

3:  Thermocouple Temp (DIFF) (P14)
   1:    1                 Reps
   2:    21                2.5 mV 60 Hz Rejection Range
   3:    3                 DIFF Channel
   4:    3                 Type K (Chromel-Alumel)
   5:    1                 Ref Temp (Deg. C) Loc [ RefTemp   ]
   6:    3                 Loc [ SenBodyT  ]
   7:    1.0               Mult
   8:    0.0               Offset

;Calculate P, H, & K Coefficients

4:  Polynomial (P55)
   1:    1                 Reps
   2:    3                 X Loc [ SenBodyT  ]
   3:    4                 F(X) Loc [ Psb       ]
   4:    49.9092           C0
   5:    0.59237           C1
   6:    0.00558           C2
   7:    0.0               C3
   8:    0.0               C4
   9:    0.0               C5

5:  Polynomial (P55)
   1:    1                 Reps
   2:    3                 X Loc [ SenBodyT  ]
   3:    5                 F(X) Loc [ Hsb       ]
   4:    4.2828            C0
   5:    0.4248            C1
   6:    -0.00077          C2
   7:    0.0               C3
   8: 0.0                  C4
   9: 0.0                  C5

6:  Polynomial (P55)
   1:    1                 Reps
   2:    3                 X Loc [ SenBodyT  ]
   3:    6                 F(X) Loc [ Ksb       ]
   4:    52.0705           C0
   5:    -5.3816           C1
   6:    0.387             C2
   7:    0.0               C3
   8:    0.0               C4
   9:    0.0               C5
```

```
;Calculate correction factor (SEC)

7:  Z=1/X (P42) ;   {1/Psb}
   1:    4                  X Loc [ Psb       ]
   2:    4                  Z Loc [ Psb       ]

8:  Z=X*F (P37) ;   {.25/Psb}
   1:    4                  X Loc [ Psb       ]
   2:    0.25               F
   3:    4                  Z Loc [ Psb       ]

9:  Z=X-Y (P35) ;   {ATT - Hsb}
   1:    2                  X Loc [ AppTargT  ]
   2:    5                  Y Loc [ Hsb       ]
   3:    5                  Z Loc [ Hsb       ]

10:  Z=X*Y (P36) ;   {ATT - Hsb}^2
   1:    5                  X Loc [ Hsb       ]
   2:    5                  Y Loc [ Hsb       ]
   3:    5                  Z Loc [ Hsb       ]

11:  Z=X-Y (P35) ;   {subtract Ksb}
   1:    5                  X Loc [ Hsb       ]
   2:    6                  Y Loc [ Ksb       ]
   3:    6                  Z Loc [ Ksb       ]

12:  Z=X*Y (P36) ;   {calculate SEC}
   1:    4                  X Loc [ Psb       ]
   2:    6                  Y Loc [ Ksb       ]
   3:    7                  Z Loc [ SEC       ]

;Calculate corrected target temperature (CTT)

13:  Z=X-Y (P35) ;
   1:    2                  X Loc [ AppTargT  ]
   2:    7                  Y Loc [ SEC       ]
   3:    8                  Z Loc [ CTT       ]

14:  If time is (P92)
   1:    0                  Minutes (Seconds --) into a
   2:    60                 Interval (same units as above)
   3:    10                 Set Output Flag High (Flag 0)

15:  Real Time (P77)
   1:    1220               Year,Day,Hour/Minute (midnight = 2400)

16:  Average (P71)
   1:    3                  Reps
   2:    1                  Loc [ RefTemp   ]

17:  Average (P71)
   1:    1                  Reps
   2:    8                  Loc [ CTT       ]
```

```
*Table 2 Program
   02:  0.0000          Execution Interval (seconds)

*Table 3 Subroutines

End Program

-Input Locations-
1 RefTemp   1 2 1
2 AppTargT  1 2 1
3 SenBodyT  1 3 1
4 Psb       1 3 3
5 Hsb       1 4 3
6 Ksb       1 2 2
7 SEC       1 1 1
8 CTT       1 0 1
```

CR23X Example Program

```
;{CR23X}
;
*Table 1 Program
   01:  1               Execution Interval (seconds)

;Measure Panel Reference Temperature

1:  Panel Temperature (P17)
   1:    1              Loc [ RefTemp   ]

;Measure IRt/c apparent target temperature

2:  Thermocouple Temp (DIFF) (P14)
   1:    1              Reps
   2:    21             10 mV, 60 Hz Reject, Slow Range
   3:    1              DIFF Channel
   4:    3              Type K (Chromel-Alumel)
   5:    1              Ref Temp (Deg. C) Loc [ RefTemp   ]
   6:    2              Loc [ AppTargT  ]
   7:    1.0            Mult
   8:    0.0            Offset

;Measure Sensor Body Temp

3:  Thermocouple Temp (DIFF) (P14)
   1:    1              Reps
   2:    21             10 mV, 60 Hz Reject, Slow Range
   3:    2              DIFF Channel
   4:    3              Type K (Chromel-Alumel)
   5:    1              Ref Temp (Deg. C) Loc [ RefTemp   ]
   6:    3              Loc [ SenBodyT  ]
   7:    1.0            Mult
   8:    0.0            Offset
```

```
;Calculate P, H, & K Coefficients

4:  Polynomial (P55)
   1:    1                Reps
   2:    3                X Loc [ SenBodyT  ]
   3:    4                F(X) Loc [ Psb       ]
   4:    49.9092          C0
   5:    0.59237          C1
   6:    0.00558          C2
   7:    0.0              C3
   8:    0.0              C4
   9:    0.0              C5

5:  Polynomial (P55)
   1:    1                Reps
   2:    3                X Loc [ SenBodyT  ]
   3:    5                F(X) Loc [ Hsb       ]
   4:    4.2828           C0
   5:    0.4248           C1
   6:    -0.00077         C2
   7:    0.0              C3
   8:    0.0              C4
   9:    0.0              C5

6:  Polynomial (P55)
   1:    1                Reps
   2:    3                X Loc [ SenBodyT  ]
   3:    6                F(X) Loc [ Ksb       ]
   4:    52.0705          C0
   5:    -5.3816          C1
   6:    0.387            C2
   7:    0.0              C3
   8:    0.0              C4
   9:    0.0              C5

;Calculate correction factor (SEC)

7:  Z=1/X (P42) ;   {1/Psb}
   1:    4                X Loc [ Psb       ]
   2:    4                Z Loc [ Psb       ]

8:  Z=X*F (P37) ;   {.25/Psb}
   1:    4                X Loc [ Psb       ]
   2:    0.25             F
   3:    4                Z Loc [ Psb       ]

9:  Z=X-Y (P35) ;   {ATT - Hsb}
   1:    2                X Loc [ AppTargT  ]
   2:    5                Y Loc [ Hsb       ]
   3:    5                Z Loc [ Hsb       ]

10:  Z=X*Y (P36) ;   {ATT - Hsb}^2
   1:    5                X Loc [ Hsb       ]
   2:    5                Y Loc [ Hsb       ]
   3:    5                Z Loc [ Hsb       ]
```

```
11:  Z=X-Y (P35) ;   {subtract Ksb}
   1:    5                  X Loc [ Hsb       ]
   2:    6                  Y Loc [ Ksb       ]
   3:    6                  Z Loc [ Ksb       ]

12:  Z=X*Y (P36) ;   {calculate SEC}
   1:    4                  X Loc [ Psb       ]
   2:    6                  Y Loc [ Ksb       ]
   3:    7                  Z Loc [ SEC       ]

;Calculate corrected target temperature (CTT)

13:  Z=X-Y (P35) ;
   1:    2                  X Loc [ AppTargT  ]
   2:    7                  Y Loc [ SEC       ]
   3:    8                  Z Loc [ CTT       ]

14:  If time is (P92)
   1:    0                  Minutes (Seconds --) into a
   2:    60                 Interval (same units as above)
   3:    10                 Set Output Flag High (Flag 0)

15:  Real Time (P77)
   1:    1220               Year,Day,Hour/Minute (midnight = 2400)

16:  Average (P71)
   1:    3                  Reps
   2:    1                  Loc [ RefTemp   ]

17:  Average (P71)
   1:    1                  Reps
   2:    8                  Loc [ CTT       ]

*Table 2 Program
   02:  0.0000          Execution Interval (seconds)

*Table 3 Subroutines

End Program

-Input Locations-
1 RefTemp   1 3 1
2 AppTargT  1 2 1
3 SenBodyT  1 3 1
4 Psb       1 3 3
5 Hsb       1 4 3
6 Ksb       1 2 2
7 SEC       1 1 1
8 CTT       1 1 1
```

CR1000 Example Program

```
'CR1000

Dim SB, Psb, Hsb, Ksb, SenEC
Public PTemp_C, ATT_C, CTT_C

DataTable(IRTS-P,True,-1)
	DataInterval(0,60,Min,0)
	Average(1,ATT_C,IEEE4,0)
	Average(1,CTT_C,IEEE4,0)
EndTable

BeginProg

Scan(1,Sec,1,0)
	'Wiring Panel Temperature measurement PTemp_C:
	PanelTemp(PTemp_C,_60Hz)
	'IRTS-P Precision Infrared Temperature Sensor measurements ATT_C and CTT_C:
	'Measure apparent target temperature with IRTS-P.
	TCDiff(ATT_C,1,mV2_5C,1,TypeK,PTemp_C,True,0,_60Hz,1,0)
	'Measure IRTS-P sensor body temperature.
	TCDiff(SB,1,mV2_5C,2,TypeK,PTemp_C,True,0,_60Hz,1,0)
	'Calculate Psb, Hsb, & Ksb coefficients.
	Psb=49.9092+(0.59237*SB)-(0.00558*SB^2)
	Hsb=4.2828+(0.4248*SB)-(0.00077*SB^2)
	Ksb=52.0705-(5.3816*SB)+(0.387*SB^2)
	'Calculate correction factor.
	SenEC=(0.25/Psb)*((ATT_C-Hsb)^2-Ksb)
	'Calculate corrected target temperature.
	CTT_C=ATT_C-SenEC

	CallTable(IRTS-P)

NextScan
EndProg
```

CR5000 Example Program

```
Public RefT, TargetCorrT, TC(2), SensorCorr, Psb, Hsb, Ksb

Alias TC(1) = TargetApparentT
Alias TC(2) = SensorBodyT

DataTable (AllDat,1,-1)
    DataInterval (0,60,Min,10)
    Average (1,RefT,FP2,0)
    Average (2,TC(),IEEE4,0)
    Average (1,TargetCorrT,IEEE4,0)
EndTable

BeginProg
    Scan (1,Sec,3,0)
        PanelTemp (RefT,250)
        TCDiff (TC(),2,mV20C ,1,TypeK,RefT,True ,0,_60Hz,1.0,0)
        Psb = 49.9092 + 0.59237 * SensorBodyT - 0.00558 * SensorBodyT^2
        Hsb = 4.2828 + 0.4248 * SensorBodyT - 0.00077 * SensorBodyT^2
        Ksb = 52.0705 - 5.3816 * SensorBodyT + 0.387 * SensorBodyT^2
        SensorCorr = (0.25/Psb) * ((TargetApparentT - Hsb)^2 - Ksb)
        TargetCorrT = TargetApparentT - SensorCorr
        CallTable Alldat

    NextScan
EndProg
```

6. Maintenance

As with any optical sensor, it is important to keep the lens and view clean. Otherwise the sensor will be measuring the temperature of the obstruction instead of the surface of interest.

Clean the lens gently with a moistened cotton swab. Distilled water or alcohol works well for most dust/dirt. Salt deposits dissolve better in a weak acid solution (~0.1 molar).

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