Example Campbell Scientific Datalogger Program for Temperature Measurements with Apogee Model IRR-P (Infrared Radiometer). All comments are in bold text.

```
;{CR10X}

*Table 1 Program
01:  1          Execution Interval (seconds)
```

Instruction string to measure the resistance of the thermistor and calculate the sensor body temperature. See the Instruction Manual for Campbell Sci. Model 109 Temperature Probe for details.

```
1:  AC Half Bridge (P5)
 1: 1           Reps
 2: 25          2500 mV 60 Hz Rejection Range (the range should at least match the excitation)
 3: 1           SE Channel
 4: 1           Excite all reps w/Exchan 1
 5: 2500        mV Excitation
 6: 1           Loc [ mV_thrm   ]
 7: 1.0         Mult
 8: 0.0         Offset

2:  Z=1/X (P42)
 1: 1           X Loc [ mV_thrm    ]
 2: 2           Z Loc [ 1_mV_thrm ]

3:  Z=X+F (P34)
 1: 2           X Loc [ 1_mV_thrm ]
 2: -1.0        F
 3: 3           Z Loc [ 2_mV_thrm]

4:  Z=X*F (P37)
 1: 3           X Loc [ 2_mV_thrm ]
 2: 24900       F
 3: 4           Z Loc [ R_thrm        ]

5:  Z=LN(X) (P40)
 1: 4           X Loc [ R_thrm       ]
 2: 5           Z Loc [ lnR_thrm   ]

6:  Z=X*F (P37)
 1: 5           X Loc [ lnR_thrm  ]
 2: 0.001       F
 3: 6           Z Loc [ Scaled_R     ]

7:  Polynomial (P55)
 1: 1           Reps
 2: 6           X Loc [ Scaled_R  ]
 3: 7           F(X) Loc [ SH_Coeffs ]
 4: .001129     C0
 5: .234108     C1
 6: 0.0         C2
 7: 87.7547     C3
 8: 0.0         C4
 9: 0.0         C5

8:  Z=1/X (P42)
 1: 7           X Loc [ SH_Coeffs ]
 2: 8           Z Loc [ SB_Temp_K ]

9:  Z=X+F (P34)
 1: 8           X Loc [ SB_Temp_K ]
 2: -273.15     F
 3: 9           Z Loc [ SB_Temp_C ]
```

Instruction to measure the mV output of the thermopile.

```
10:  Volt (Diff) (P2)
 1: 1          Reps
 2: 21         2.5 mV 60 Hz Rejection Range
 3: 2          DIFF Channel
 4: 11         Loc [ mV_tpile  ]
 5: 1.0        Mult
 6: 0.0        Offset
```

Calculation of m (slope) and b (intercept) coefficients for target temperature calculation.

```
11:  Polynomial (P55)
 1: 1          Reps
 2: 9          X Loc [ SB_Temp_C ]
 3: 12         F(X) Loc [ m_slope  ]
 4: 23253        C0
 5: 133.16       C1
 6: 1.1846       C2
 7: 0.0          C3
 8: 0.0          C4
 9: 0.0          C5

12:  Z=X*F  (P37)
 1:  12       X  Loc  [  m_slope    ]
 2:  99999    F
 3:  12       Z  Loc  [  m_slope    ]

13:  Polynomial (P55)
 1: 1          Reps
 2: 9          X Loc [ SB_Temp_C ]
 3: 13         F(X) Loc [ b_inter  ]
 4: 115.92       C0
 5: -5.3421      C1
 6: 0.22859      C2
 7: 0.0          C3
 8: 0.0          C4
 9: 0.0          C5

14:  Z=X*F  (P37)
 1:  13       X  Loc  [  b_inter    ]
 2:  99999    F
 3:  13       Z  Loc  [  b_inter    ]
```

Target temperature calculation based on m and b coefficients.

```
15:  Z=F x 10^n  (P30)
 1:  0.4      F
 2:  1        n,  Exponent of 10
 3:  14       Z  Loc  [  Exponent1   ]

16:  Z=F x 10^n  (P30)
 1:  0.025    F
 2:  1        n,  Exponent of 10
 3:  15       Z  Loc  [  Exponent2   ]

17:  Z=X^Y  (P47)
 1:  8        X  Loc  [  SB_Temp_K  ]
 2:  14       Y  Loc  [  Exponent1     ]
 3:  16       Z  Loc  [  1_SB_4Pow   ]

18:  Z=X*Y  (P36)
 1:  11       X  Loc  [  mV_tpile    ]
 2:  12       Y  Loc  [ m_slope      ]
 3:  17       Z  Loc  [  2_mVxm    ]
```

```
19:  Z=X+Y  (P33)
  1:  16        X  Loc  [  1_SB_4Pow   ]
  2:  17        Y  Loc  [  2_mVxm      ]
  3:  18        Z  Loc  [  3_Sum1      ]

20:  Z=X+Y  (P33)
  1:  13        X  Loc  [  b_inter     ]
  2:  18        Y  Loc  [  3_Sum1      ]
  3:  19        Z  Loc  [  4_Sum2      ]

21:  Z=X^Y  (P47)
  1:  19        X  Loc  [  4_Sum2      ]
  2:  15        Y  Loc  [  Exponent2   ]
  3:  20        Z  Loc  [  T_Temp_K    ]

22:  Z=X+F (P34)
 1: 20          X Loc [ T_Temp_K ]
 2: -273.15     F
 3: 21          Z Loc [ T_Temp_C ]

*Table 2 Program
02:  0.0        Execution Interval (seconds)

*Table 3 Subroutines
End Program
```

Explanation of Labels Used in the Program

mV_thrm = mV output of the thermistor.
1_mV_thrm = first step in converting the mV output of the thermistor to resistance.
2_mV_thrm = second step in converting the mV output of the thermistor to resistance.
R_thrm = resistance of the thermistor.
lnR_thrm = natural log of the resistance of the thermistor.
Scaled_R = intermediate step in converting the natural log of the resistance to temperature.
SH_Coeff = application of the Steinhart and Hart coefficients to convert the scaled resistance to the reciprocal of temperature.
SB_Temp_K = sensor body temperature in Kelvin.
SB_Temp_C = sensor body temperature in degrees Celsius.
mV_tpile = mV output of the thermopile (dependent on the temperature difference between the target and the sensor body).
m_slope = slope of the equation relating target and sensor body temperature to mV output of the thermopile.
b_inter = y-intercept of the equation relating target and sensor body temperature to mV output of the thermopile.
Exponent1 = exponent used to raise the sensor body temperature to the 4^{th} power.
Exponent2 = exponent used to calculate the 4^{th} root of the sum of the terms used to calculate the target temperature.
1_SB_4Pow = first calculation step; sensor body temperature (Kelvin) raised to the fourth power.
2_mVxm = second calculation step; mV output of the thermopile multiplied by m (slope).
3_Sum1 = third calculation step; sum of calculation steps one and two.
4_Sum2 = fourth calculation step; the sum of calculation step 3 and b (intercept).
T_Temp_K = target temperature in Kelvin; calculated by adding the temperature difference between the target and sensor body to the sensor body temperature.
T_Temp_C = target temperature in degrees C.

Wiring Instructions for Apogee Model IRR-P (Infrared Radiometer).

Red Wire = high side of differential channel (positive lead for thermopile)
Black Wire = low side of differential channel (negative lead for thermopile)
Clear Wire = analog ground (ground for thermopile)
Green Wire = high side of single-ended channel (positive lead for thermistor)
Blue Wire = analog ground (negative lead for thermistor)
White Wire = excitation channel (excitation for thermistor)