INSTRUCTION MANUAL

NR-LITE2 Net Radiometer

Revision: 3/13

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Figures

Tables

NR-LITE2 Net Radiometer

1. Introduction

The NR-LITE2 is a high-output thermopile sensor which measures the algebraic sum of incoming and outgoing all-wave radiation (both short-wave and long-wave components). Incoming radiation consists of direct (beam) and diffuse solar radiation plus long-wave irradiance from the sky. Outgoing radiation consists of reflected solar radiation plus the terrestrial long-wave component.

The NR-LITE2 is equipped with PTFE-coated (polytetrafluoroethylene) sensor surfaces. This results in a robust design which provides easy maintenance and good sensor stability. However, this design is slightly less accurate than the more traditional radiometers which use plastic domes.

Before using the NR-LITE2, please study:

- Section 2, *Cautionary Statements*
- Section 3, *Initial Inspection*
- Section 4, *Quick Start*

2. Cautionary Statements

- Although the NR-LITE2 is rugged, it is also a highly precise scientific instrument and should be handled as such.

- Care should be taken when opening the shipping package to not damage or cut the cable jacket. If damage to the cable is suspected, consult with a Campbell Scientific applications engineer.

- When installing the NR-LITE2, use only the support arm to rotate the NR-LITE2. Using the sensor head to rotate the instrument may damage it.

3. Initial Inspection

- Upon receipt of the NR-LITE2, inspect the packaging and contents for damage. File damage claims with the shipping company.

- The model number and cable length are printed on a label at the connection end of the cable. Check this information against the shipping documents to ensure the correct product and cable length are received.

- Refer to Section 3.1, *Ships With*, to ensure that parts are included.

3.1 Ships With

(1) WRR traceable calibration certificate
(1) Mounting arm from original manufacturer
(1) Bird stick from original manufacturer
(1) ResourceDVD

4. Quickstart

Please review Section 7, *Operation*, for wiring, CRBasic programming, and Edlog programming.

4.1 Siting Considerations

1. Mount the sensor so that no shadow will be cast on it at any time of day from obstructions such as trees, buildings, the mast, or structure on which it is mounted (1 in FIGURE 4-1).

2. To avoid shading effects and to promote spatial averaging, the NR-LITE2 should be mounted at least 1.5 m above the ground surface. It is recommended that the NR-LITE2 be mounted to a separate vertical pipe at least 25 ft from any other mounting structures (2 in FIGURE 4-1).

3. Orient the sensor towards the nearest pole to avoid potential problems from shading (3 in FIGURE 4-1).

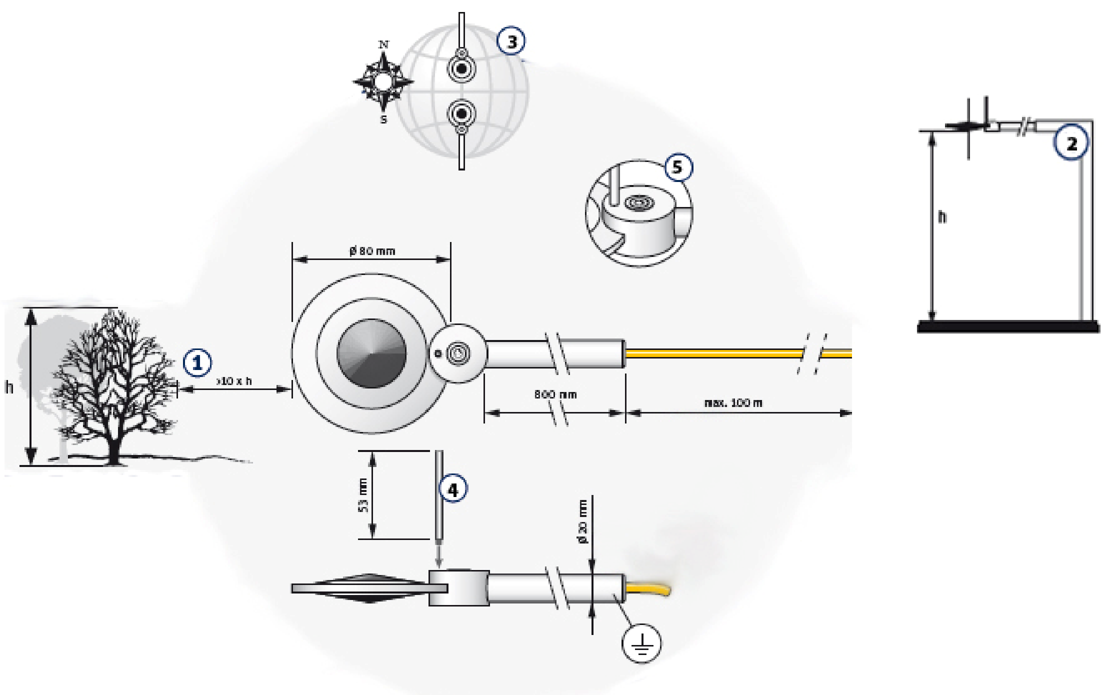


FIGURE 4-1. Siting and mounting diagram for the NR-LITE2

4.2 Mounting

The mounting bracket kit, pn 26120, is used to mount the NR-LITE2 directly to a vertical pipe, or to a CM202, CM204, or CM206 crossarm. Mount the sensor as follows:

1. Screw in the bird repellent stick, which is shipped with the calibration documentation (4 in FIGURE 4-1).

2. Attach the 26120 mounting bracket to the vertical mounting pipe, or CM200-series crossarm using the provided U-bolt (FIGURE 4-2).

3. Insert the sensor's support arm into the mounting block of the mounting bracket kit. Make sure the sensor points in the direction of the arrows that appear after the word **SENSOR** on top of the bracket (FIGURE 4-2).

4. Perform a coarse leveling of the sensor using the sensor's bubble level (5 in FIGURE 4-1).

5. Tighten the four screws on top of the mounting bracket to properly secure the support arm so that it does not rotate (FIGURE 4-2).

CAUTION Do not attempt to rotate the instrument using the sensor head or you may damage the sensor — use the support arm only.

6. Perform the fine leveling using the two spring-loaded leveling screws—one on the front and the other on the back of the bracket (FIGURE 4-2).

7. Route the sensor cable to the instrument enclosure.

8. Use cable ties to secure the cable to the vertical pipe or crossarm and tripod/tower.

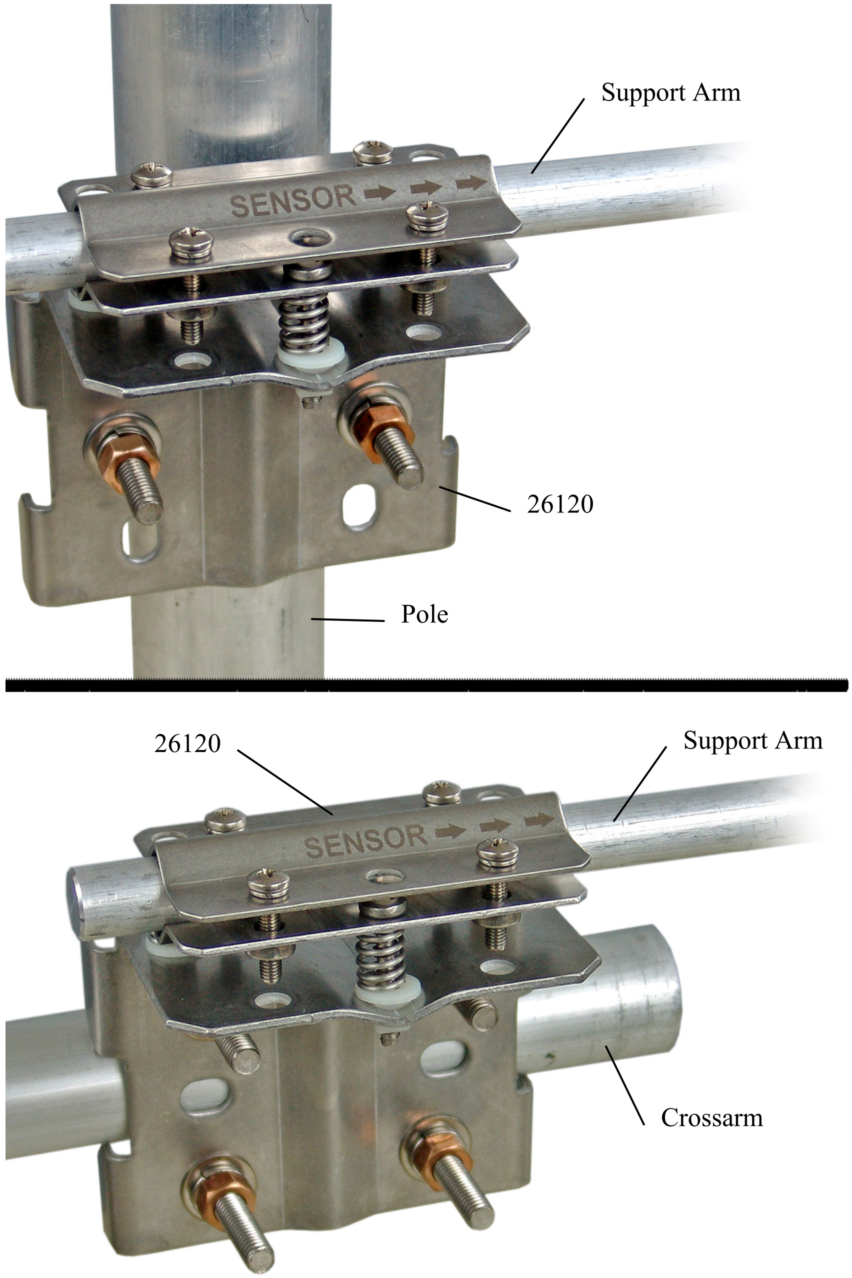


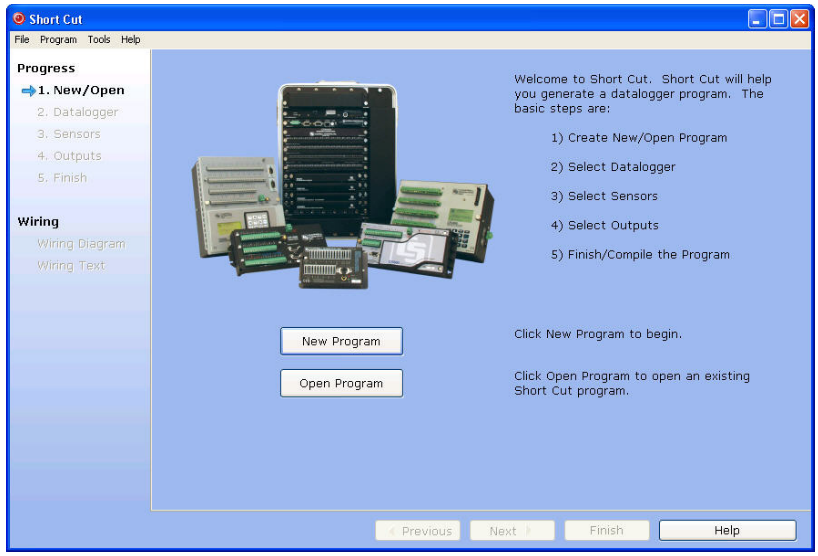
FIGURE 4-2. Mounting the NR-LITE2 onto a pole (top) and crossarm (bottom) via the 26120 Mounting Kit

4.3 Use SCWin to Program Datalogger and Generate Wiring Diagram

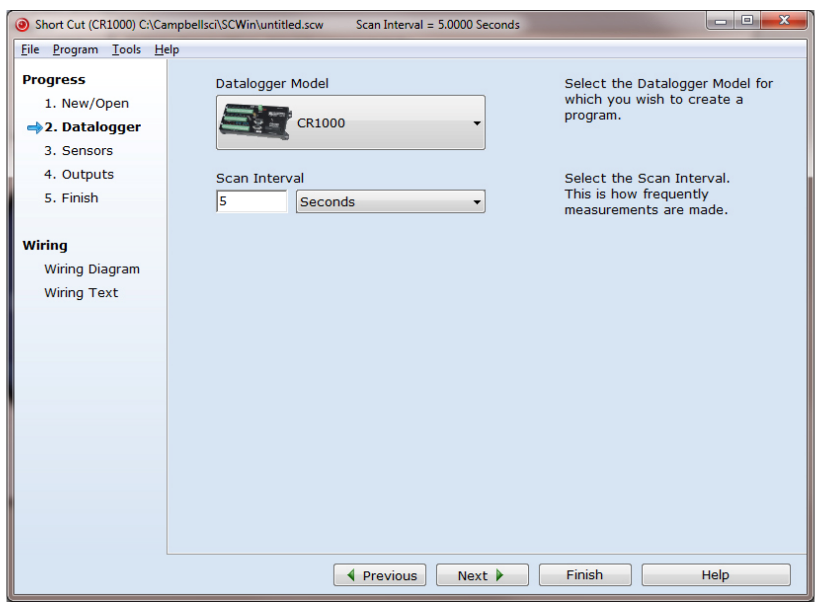
The simplest method for programming the datalogger to measure the NR-LITE2 is to use Campbell Scientific's SCWin Program Generator.

NOTE The SCWin example provided here is for no wind speed correction. SCWin also supports dynamic wind speed correction; refer to the SCWin help for more information.

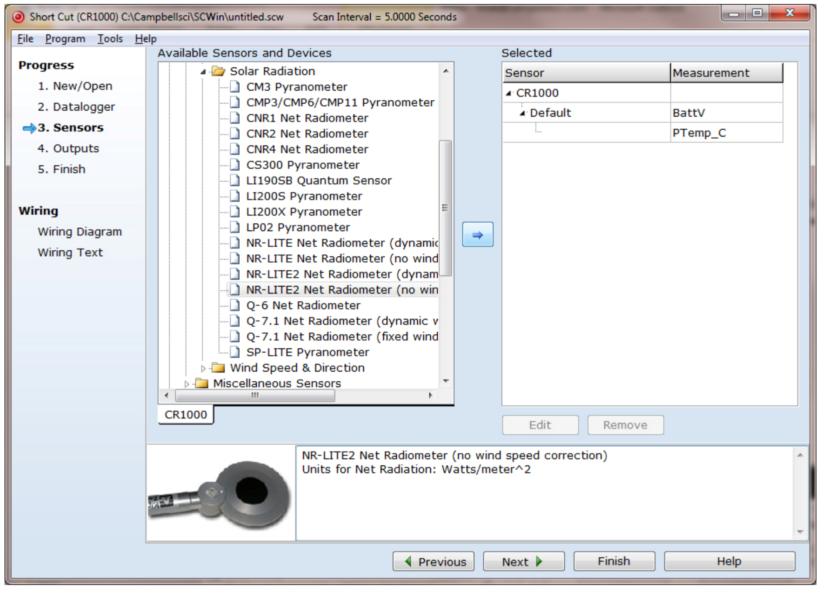
1. Open Short Cut and click on **New Program**.



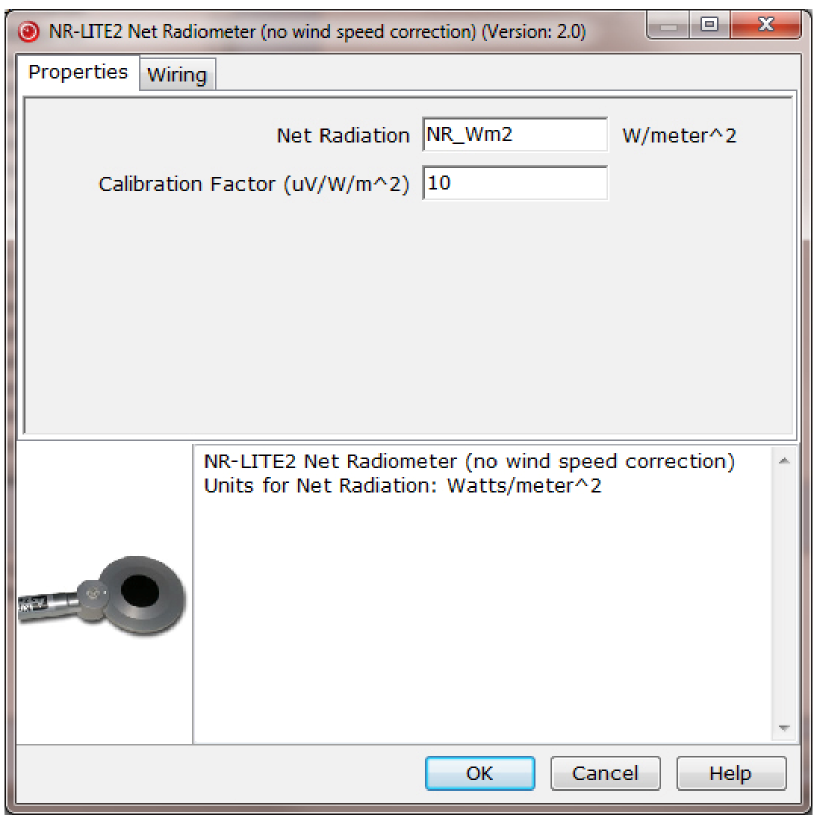
2. Select the datalogger and enter the scan interval.



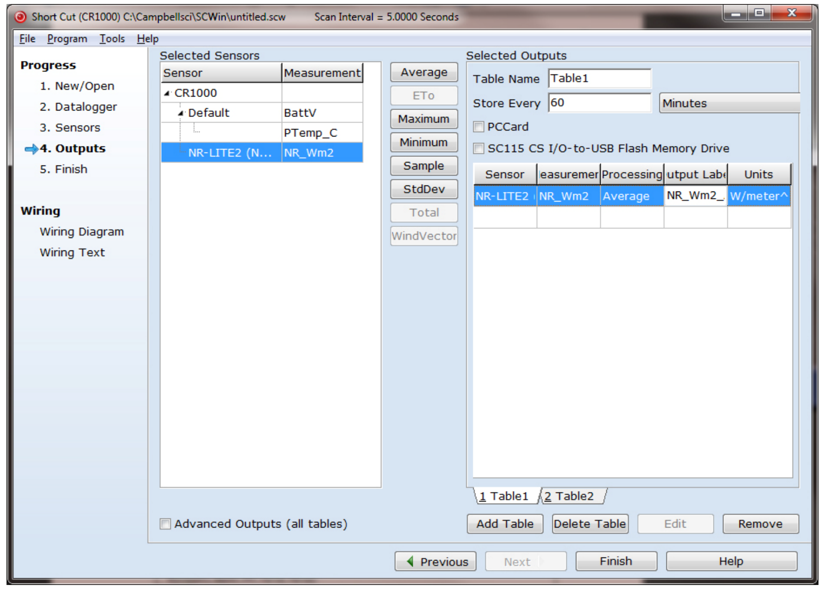
3. Select **NR-LITE2 Net Radiometer (no wind speed correction),** and select the **right arrow** (in center of screen) to add it to the list of sensors to be measured, and then select **Next**.



4. Define the name of the public variable and enter the calibration factor. The public variable defaults to **NR_Wm2**. The calibration factor is unique to each sensor. This value is provided on the certification of calibration that is shipped with your sensor. After entering the information, click on OK, and then select **Next**.



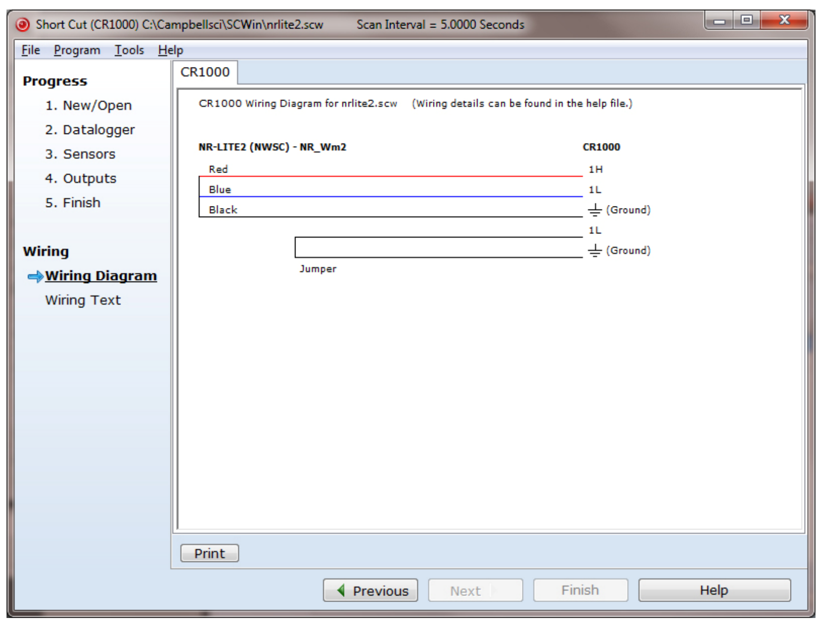
5. Choose the outputs and then select **Finish**.



6. In the Save As window, enter an appropriate file name and select **Save**.

7. In the Confirm window, click **Yes** to download the program to the datalogger.

8. Click on **Wiring Diagram** and wire according to the wiring diagram.



5. Overview

The NR-LITE2 is used for measuring solar and far infrared radiation balance. This balance is known as the net (total) radiation. Its upwards facing sensor measures the solar energy and far infrared energy that is received from the entire hemisphere (180° field of view). Its downwards facing sensor measures the energy received from the surface of the soil. The two readings are automatically subtracted and the result converted to a single output signal. This output represents the net radiation (which can be interpreted as meaning the radiative energy that is seen at the surface) and is expressed in Watts per square meter (W m^{-2}).

The NR-LITE2 is designed for continuous outside use. The sensor surfaces are coated with PTFE. This ensures sensor stability, long life, and easy maintenance compared to the more usual radiometers fitted with plastic domes. However, it does have some disadvantages, particularly a higher sensitivity to wind speed with a subsequent lessening of accuracy. It is, though, possible to correct for the wind speed sensitivity if the sensor is installed in a system where wind speed is also being measured.

Although net radiometers are usually used in meteorology to measure radiation balance, the NR-LITE2 can also be used to measure indoor climate radiative stress.

The NR-LITE2 is manufactured by Kipp & Zonen, but cabled for use with Campbell Scientific dataloggers. Its cable can terminate in:

- Pigtails that connect directly to a Campbell Scientific datalogger (cable termination option –PT).
- Connector that attaches to a prewired enclosure (cable termination option ─PW).

5.1 Electrical Properties

The thermopile consists of a number of thermocouples connected in series, essentially providing a highly sensitive differential temperature sensor. The thermopile generates a voltage output — the sensor itself is passive, and so no power supply is required.

The upwards and downwards facing sensor surfaces are connected to the upper and lower thermopile junctions respectively, allowing the sensor to measure the differential temperature (FIGURE 5-1). This temperature differential can be measured to a high accuracy (in the order of 0.001 degrees), and is proportional to the net radiation.

The thermopile determines the electrical characteristics of the instrument. Both upper and lower facing sensors have a field of view of 180 degrees, and their angular characteristics conform closely to the cosine response (see following sections).

The electrical sensitivity for the thermopile changes with temperature, and no nominal sensitivity value is available.

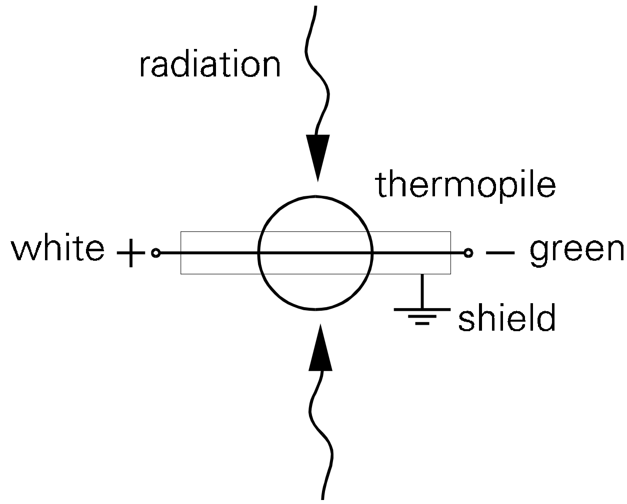


FIGURE 5-1. Electrical circuit for the NR-LITE2 Net Radiometer

5.2 Spectral Properties

The upwards facing sensor is calibrated for solar radiation wavelengths. The following assumptions are made:

- The downwards facing sensor has the same sensitivity. However, since the two sensors may not be perfectly symmetrical, this assumption may not always be true, but differences are small.
- The NR-LITE2's sensitivity is the same for both solar and infrared radiation.

5.3 Directional/Cosine Response

The measurement of the radiation falling on a surface (also known as irradiance or radiative flux) is based on two assumptions:

1. The sensor surface is spectrally black — that it absorbs all radiation from all wavelengths (Section 5.2, *Spectral Properties*).
2. That it has a true field of view of 180°.

These two properties, taken together, with which the net radiometer needs to comply, are generally known as the cosine response.

A perfect cosine response will show maximum sensitivity at an angle of incidence of zero degrees (perpendicular to the sensor surface) and zero sensitivity at an angle of incidence of 90 degrees (radiation passing over the sensor surface). At any angle between 0 and 90 degrees the sensitivity should be proportional to the cosine of the angle of incidence.

FIGURE 5-2 shows the behavior of a typical net radiometer. The vertical axis shows the deviation from ideal behavior, expressed in percentage deviation from the ideal value.

FIGURE 5-2. Cosine response of a typical net radiometer

5.4 Sensitivity to Wind Speed

The calibration of the NR-LITE2 is carried out at zero wind speed. At any other wind speed, the sensitivity will decrease. It has been shown that this decrease in sensitivity is less than 1% of reading per meter per second wind speed, and the effect is essentially independent of the radiation level.

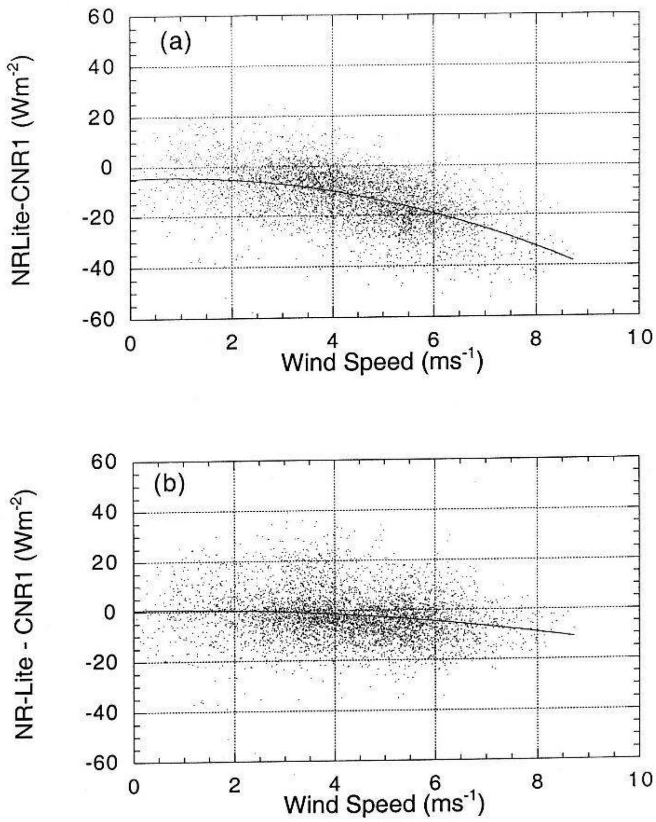
Net radiation readings can be corrected for wind speed sensitivity using the following equation, which was developed by Jerry Brotzge at the Oklahoma Climate Survey:

Wind Sensitivity equation for the NR-LITE2:

$$Rn,cor = Rn,obs \qquad U < 5\ m\ s^{-1}$$
$$Rn,cor = Rn,obs * (1.0 + A \times (U - 5.0)) \qquad U > 5\ m\ s^{-1}$$

Where,
- Rn,cor = Net radiation corrected for wind speed
- Rn,obs = Net radiation not corrected for wind speed
- U = Horizontal wind speed in m s^{-1}
- A = empirical constant derived from data = 0.021286

FIGURE 5-3 provides scatter plots showing the wind sensitivity for both the NR-LITE2 and CNR1 net radiometer models.



Differences between the NR-Lite and CNR1 as a function of wind speed for daytime conditions during 7 May — 6 June, 1998. (a) No correction. (b) Eq. (4) applied as a correction.

FIGURE 5-3. NR-LITE2 wind sensitivity

6. Specifications

Features:

- Compatible with most Campbell Scientific dataloggers
- Integrated bubble level ensures proper installation
- Includes rod that deters birds from roosting on the radiometer
- PTFE-coated absorbers are weather resistant without using a fragile plastic dome

Compatible dataloggers: CR800
CR850
CR1000
CR3000
CR5000
CR9000(X)
CR7
CR500
CR510
CR10(X)
CR23X

6.1 Spectral

Spectral range:	0.2 to 100 µm
Detector type:	Thermopile
Detector protection:	PTFE coating
Detector profile:	Conical

6.2 Directional

Directional error (0° to 60°C at 1000 W m^{-2}):	<30 W m^{-2}
Sensor asymmetry:	±5% typical, (±10% worst case)

6.3 Mechanical

Housing material:	Anodized aluminum
Cable material:	Polyurethane
Weight:	200 g
Cable length:	15 m (can be extended up to 100 m)

Physical dimensions (FIGURE 6-1)

Sensor:	8.0 cm (3.1 in) diameter
Support arm:	1.6 cm (0.6 in) diameter x 80 cm (31.5 in) L
Weight:	635 g (23 oz)

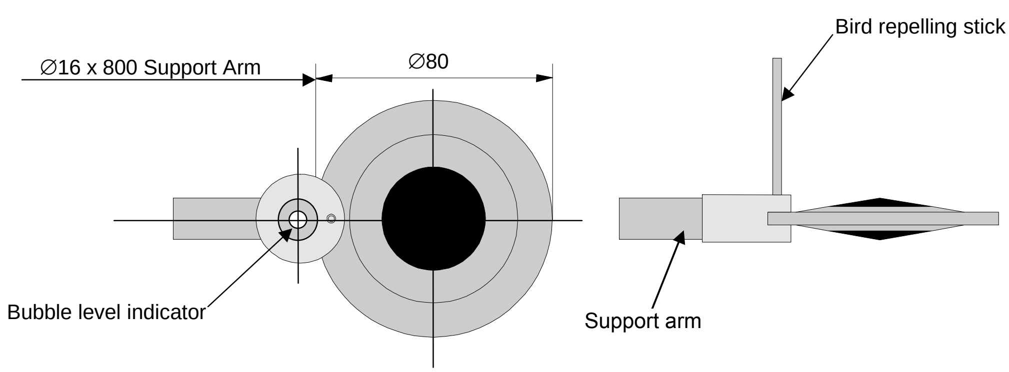


FIGURE 6-1. NR-LITE2's components and dimensions (in millimeters)

6.4 Environmental

Working temperature:	–30° to +70°C
Temperature dependence:	0.12% per °C

7. Operation

7.1 Wiring

The NR-LITE2 can be measured with a differential or single-ended channel on the datalogger; a differential channel is recommended.

FIGURE 7-1 provides the NR-LITE2 wiring. Datalogger connections are shown in TABLE 7-1 for differential measurements and TABLE 7-2 for single-ended measurements.

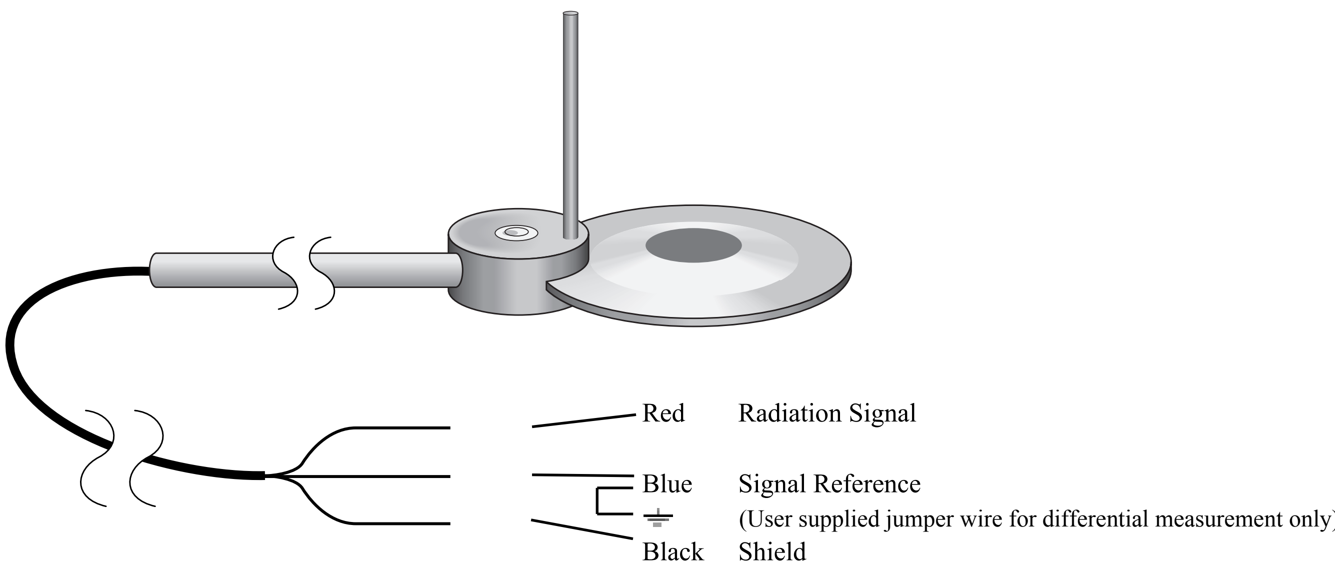


FIGURE 7-1. NR-LITE2 to datalogger connections

TABLE 7-1. Datalogger Connections for Differential Measurement

Function	**Color**	**CR10X, CR510, CR500**	**CR23X, 21X, CR7**	**CR800, CR850, CR1000, CR3000, CR5000, CR9000(X)**
Radiation Signal	Red	Differential H	Differential H	Differential H
Signal Reference	Blue	Differential L	Differential L	Differential L
	Jumper to	AG	⏚	⏚
Shield	Black	G	⏚	⏚

TABLE 7-2. Datalogger Connections for Single-Ended Measurement				
Function	**Color**	**CR10X, CR510, CR500**	**CR23X, 21X, CR7**	**CR800, CR850, CR1000, CR3000, CR5000, CR9000(X)**
Radiation Signal	Red	S.E. Channel	S.E. Channel	S.E. Channel
Signal Reference	Blue	AG	⏚	⏚
Shield	Black	G	⏚	⏚

7.2 Datalogger Programming

NOTE This section is for users who write their own datalogger programs. A datalogger program to measure this sensor can be generated using Campbell Scientific's Short Cut Program Builder Software. You only need to read the calibration portion of this section if using Short Cut.

The NR-LITE2 outputs a low-level voltage ranging from 0 to a maximum of about 15 mV. A differential voltage measurement (**VoltDiff()** in CRBasic or instruction **Volt (Diff) (P2)** in Edlog) is recommended because it has better noise rejection than a single-ended measurement. If a differential channel is not available, a single-ended measurement (**VoltSE()** in CRBasic or instruction **Volt (SE) (P1)** in Edlog) can be used. The acceptability of a single-ended measurement can be determined by simply comparing the results of single-ended and differential measurements made under the same conditions.

7.2.1 Input Range and Integration

Normally the 15 mV range for the 21X or CR7, the 25 mV range for the CR800, CR850, CR1000, CR10(X), or CR500/CR510, and the 50 mV range for the CR3000, CR5000, CR9000X, or CR23X are suitable.

The slow or 60 Hz rejection integration gives a more noise-free reading. A fast integration takes less power and allows for faster throughput.

7.2.2 Calibration Factor

Each NR-LITE2 is provided with a *Certificate of Calibration* by the manufacturer which shows the sensor serial number and a sensitivity or calibration factor. This calibration factor, after conversion, is used in the datalogger program. Always cross check to ensure that the serial number of your NR-LITE2 and the number on the calibration certificate are identical. The serial number and sensitivity are also shown on a small label attached to the connecting arm near the head of the sensor itself.

The calibration factor included on the *Certificate of Calibration* is in units of $\mu V/(W\ m^{-2})$, which needs to be converted to units of $(W\ m^{-2})/mV$ for the multiplier parameter in the datalogger program. To convert the units, divide the calibration factor into 1000. For example, if the calibration factor is 15.8 $\mu V/(W\ m^{-2})$, the multiplier is:

$1000/15.8 = 63.29\ (W\ m^{-2})/mV$

7.2.3 Example Programs

7.2.3.1 CR3000 Example Program without Wind Speed Correction

Shown below is an example program written for the CR3000 datalogger. TABLE 7-3 provides the wiring for the example program. In this example, the datalogger measures the output from the sensor every 5 seconds and outputs the average net radiation every hour. The calibration factor used will only apply for one specific sensor. A new value will need to be calculated for every different sensor based on the *Certificate of Calibration* for that sensor (Section 7.2.2, *Calibration Factor*).

TABLE 7-3. Wiring for CR3000 Example

Color	Function	CR3000 Channels
Red	Radiation Signal	1H
Blue	Signal Reference	1L
Jumpered to		⏚
Black	Shield	⏚

```
'CR3000

'Declare Variables and Units
Public BattV
Public NR_Wm2

Units BattV=Volts
Units NR_Wm2=W/meter^2

'Define Data Tables
DataTable(Table1,True,-1)
  DataInterval(0,60,Min,10)
  Average(1,NR_Wm2,FP2,False)
EndTable

DataTable(Table2,True,-1)
  DataInterval(0,1440,Min,10)
  Minimum(1,BattV,FP2,False,False)
EndTable

'Main Program
BeginProg
  Scan(5,Sec,1,0)
    'Default Datalogger Battery Voltage measurement BattV
    Battery(BattV)
    'NR-LITE2 Net Radiometer (no wind speed correction) measurement NR_Wm2
    VoltDiff(NR_Wm2,1,mV50,1,True,0,_60Hz,100,0)
    'Call Data Tables and Store Data
    CallTable(Table1)
    CallTable(Table2)
  NextScan
EndProg
```

7.2.3.2 CR1000 Example Program with Wind Speed Correction

Shown below is an example program written for the CR1000 datalogger. TABLE 7-4 provides the wiring for the example program. Besides measuring the NR-LITE2, the program also measures wind speed and applies the correction factor as described in Section 5.4, *Sensitivity to Wind Speed*. Average net radiation and wind speed are output every hour.

TABLE 7-4. Wiring for CR1000 Example

Color	Function	CR1000 Channels
Red	Radiation Signal	2H
Blue	Signal Reference	2L
Jumpered to		⏚
Black	Shield	⏚

```
'CR1000

'Declare Variables and Units
Dim WindCor_7
Public BattV
Public WS_ms
Public WindDir
Public NR_Wm2
Public CNR_Wm2

Units BattV=Volts
Units WS_ms=meters/second
Units WindDir=Degrees
Units NR_Wm2=W/m^2
Units CNR_Wm2=Watts/meter^2

'Define Data Tables
DataTable(Table1,True,-1)
  DataInterval(0,60,Min,10)
  Average(1,WS_ms,FP2,False)
  Sample(1,WindDir,FP2)
  Average(1,NR_Wm2,FP2,False)
  Average(1,CNR_Wm2,FP2,False)
EndTable

DataTable(Table2,True,-1)
  DataInterval(0,1440,Min,10)
  Minimum(1,BattV,FP2,False,False)
EndTable

'Main Program
BeginProg
  Scan(5,Sec,1,0)
    'Default Datalogger Battery Voltage measurement BattV
    Battery(BattV)

    '05103 Wind Speed & Direction Sensor measurements WS_ms and WindDir
    PulseCount(WS_ms,1,1,1,1,0.098,0)
    BrHalf(WindDir,1,mV2500,1,1,1,2500,True,0,_60Hz,355,0)
    If WindDir>=360 Then WindDir=0

    'NR-LITE2 Net Radiometer (dynamic wind speed correction)
    'measurement NR_Wm2 and CNR_Wm2
```

```
    VoltDiff(NR_Wm2,1,mv25,2,True,0,_60Hz,100,0)
    If WS_ms>=5 Then
      CNR_Wm2=NR_Wm2*(1+0.021286*(WS_ms-5))
    Else
      CNR_Wm2=NR_Wm2
    EndIf
    'Call Data Tables and Store Data
    CallTable(Table1)
    CallTable(Table2)
  NextScan
EndProg
```

7.2.3.3 CR10(X) Example Program without Wind Speed Correction

Shown below is an example program written for the CR10(X) datalogger. TABLE 7-5 provides the wiring for the example program. In this example, the datalogger measures the output from the sensor every 60 seconds and outputs the average net radiation every hour.

The calibration factor used will only apply for one specific sensor. A new value will need to be calculated for every different sensor based on the *Certificate of Calibration* for that sensor (Section 7.2.2, *Calibration Factor*).

TABLE 7-5. Wiring for CR10X Example (without Wind Correction)

Color	Function	CR10X Channels
Red	Radiation Signal	1H
Blue	Signal Reference	1L
Jumpered to		AG
Black	Shield	G

```
;{CR10X}
;
*Table 1 Program
  01: 60         Execution Interval (seconds)

1: Volt (DIFF) (P2)
  1:  1          Reps
  2:  3**        25 mV Slow Range          ;range code for CR10(X) datalogger
  3:  1*         DIFF Channel
  4:  1*         Loc [ Net_rad ]
  5:  63.29      Mult                      ;Multiplier for specific sensor
  6:  0.0        Offset                    ;in units of (W m^-2)/mV (see above)

2: 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)

3: Real Time (P77)
  1:  110        Day,Hour/Minute (midnight = 0000)

4: Average (P71)
  1:  1          Reps
  2:  1          Loc [ Net_rad ]
```

7.2.3.4 CR10X Example Program with Wind Speed Correction

This example measures the NR-LITE2 using a single-ended input and instruction **Volt (SE) (P1)**. The program also measures wind speed and applies the correction factor as described in Section 5.4, *Sensitivity to Wind Speed*. Average net radiation and wind speed are output every hour. TABLE 7-6 provides the wiring for this example program.

TABLE 7-6. Wiring for CR10X Example (with Wind Correction)

Color	Function	CR10X Channels
Red	Radiation Signal	S.E. Channel 1
Blue	Signal Reference	AG
Black	Shield	G

```
;{CR10X}
;
*Table 1 Program
  01:  60          Execution Interval (seconds)

;measure 05103 wind speed

1:  Pulse (P3)
   1:  1           Reps
   2:  1           Pulse Channel 1
   3:  21          Low Level AC, Output Hz
   4:  1           Loc [ Wspd_m_s  ]
   5:  .0980       Mult
   6:  0           Offset

;measure NR-LITE2 net radiation

2:  Volt (SE) (P1)
   1:  1           Reps
   2:  3**         25 mV Slow Range
   3:  1*          SE Channel
   4:  2*          Loc [ Rn_obs    ]
   5:  63.29       Mult                 ;Multiplier for specific sensor
   6:  0           Offset               ;in units of (W m-2)/mV (see above)

;apply wind speed correction factor
;Rn,cor = Rn,obs*(1.0+0.021286*(U-5.0)) when U > 5 m/s

3:  If (X<=>F) (P89)
   1:  1           X Loc [ Wspd_m_s  ]
   2:  3           >=
   3:  5           F
   4:  30          Then Do
```

```
     4:  Z=X+F (P34)
        1:    1              X Loc [ Wspd_m_s  ]
        2:    -5             F
        3:    24             Z Loc [ scratch_1 ]

     5:  Z=X*F (P37)
        1:    24             X Loc [ scratch_1 ]
        2:    .021286        F
        3:    25             Z Loc [ scratch_2 ]

     6:  Z=X+F (P34)
        1:    25             X Loc [ scratch_2 ]
        2:    1              F
        3:    26             Z Loc [ scratch_3 ]

     7:  Z=X*Y (P36)
        1:    26             X Loc [ scratch_3 ]
        2:    2              Y Loc [ Rn_obs    ]
        3:    3              Z Loc [ Rn_cor    ]

8:  Else (P94)

     9:  Z=X (P31)
        1:    2              X Loc [ Rn_obs    ]
        2:    3              Z Loc [ Rn_cor    ]

10:  End (P95)

11:  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)

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

13:  Average (P71)
   1:    1              Reps
   2:    3              Loc [ Rn_cor    ]

14:  Average (P71)
   1:    1              Reps
   2:    1              Loc [ Wspd_m_s  ]
```

* Proper entries will vary with program and input channel assignments.

** 25 mV range for CR10(X) and CR510, the 50 mV range for CR23X, and the 15 mV range for 21X and CR7.

8. Maintenance

The radiometer is an 'all weather' instrument and is very stable, but should be handled with care. It requires little periodic maintenance, apart from cleaning the sensor surfaces carefully with a soft cloth using water or alcohol.

The NR-LITE2 should be recalibrated every two years. An RMA number is required before returning the sensor for recalibration; refer to the Assistance section in the beginning of this manual for more information.

9. Troubleshooting

9.1 Checking Sensor Operation

To effectively check the instrument's operation, you will need:

- NR-LITE2
- Voltmeter, range 0 to 50 mV, with an input impedance greater than 5000 Ohms
- Light source
- Table or bench

Position the radiometer so that its downward facing sensor is about 10 mm (0.4 in) above a flat surface (table or bench), and the upwards facing sensor is facing the light source (lamp). Do not touch the sensor head itself, as this will introduce thermal shocks. Hold the instrument only by its mounting arm at all times.

Follow the procedure outlined below:

1. Connect the NR-LITE2 wires to the voltmeter. Connect the red wire to the positive lead and the blue wire to the negative lead.

2. Select the most sensitive range on the voltmeter.

3. With the lamp switched off, read the sensor output signal — allow a minute or so for the signal to fully stabilize.

4. Switch on the lamp. The sensor should now produce a higher positive reading.

5. Turn the lamp off again, when the signal should slowly return to its original level, proving the sensor's sensitivity to light.

6. Turn the sensor upside down. The signal value should reverse in sign; a +10 mV signal should become a −10 mV signal. Don't worry if the two values are not exactly the same (up to 10% difference) as the sensor profiles can vary. After completing this test, return the sensor to its original orientation and let it stabilize.

7. Put your hand over the upper sensor. Assuming that your hand is at a higher temperature than the sensor, the positive reading should increase.

Conversely, if the sensor is warmer than your hand, the reading will decrease.

8. Check the radiometer's sensitivity to thermal shocks by touching the edge of the sensor (the blank metal) with your hand for some seconds. The resultant shock will result in a signal drift, or a zero offset that will take some time to settle back to zero.

9. Adjust the range of the voltmeter so that the expected full-scale output of the radiometer is about the same as the range of the voltmeter. A (theoretical) way to calculate the maximum expected output for normal meteorological applications is shown below:

   Max. expected radiation +1500 W m^{-2}

   Min. radiation –200 W m^{-2}

   Sensitivity of the net radiometer 10 μV/(W m^{-2})

   Expected output range of the radiometer is (1500 + 200) × 10 = 1700 × 10 = 17.0 mV or 0.017 V.

9.2 Radiometer Produces No Apparent Output

If your net radiometer does not appear to be working at all, do the following checks:

1. Check the instrument's sensitivity to radiation, following the procedure shown in Section 9.1, *Checking Sensor Operation*.

2. If this appears to produce no results, measure the impedance of the sensor across the red and blue wires. The impedance reading should be close to 2.3Ω. If it is virtually zero, a short circuit is indicated. If it is 'infinite', the thermopile is blown.

9.3 Readings Are Not As Expected

1. Under full sunlight, the expected radiation value is about 1000 W m^{-2}. Under lamps it may be greater. For indoor climate studies, smaller values are to be expected unless solar radiation is present. A typical value for a room when facing a wall and a relatively cold window is 50 W m^{-2}.

2. Are you using the correct calibration factor? Note that this factor is unique for each individual sensor as noted on the calibration certificate provided with that sensor. Did you convert the factor to the correct value for the datalogger program? (Section 7.2, *Datalogger Programming*.)

3. Check the datalogger program for errors.

If you cannot resolve your problems, please contact Campbell Scientific for further advice.

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