Universal Industrial Current Loop Converter for LI-COR™ Sensors

(Amplifies LI-COR sensor current to industrial current loop level)

The UCLC is a special purpose amplifier that converts the micro-amp level current output of LI-COR1 light sensors to an industry standard current-loop level. The UCLC can be configured at the factory or by the end user for any one of three standard LI-COR sensors and any one of two popular current loop levels, through the manipulation of two plug-in jumpers. No soldering or other adjustments are required. The UCLC provides a simple interface between LI-COR sensors and current loop signal processing equipment including data loggers, PLCs, meters, industrial control equipment, HVAC and green house control systems.

LI-COR sensor	Typical full sun response	UCLC output (user selectable)
LI190 PAR sensor	13µA @ 2000 µE/m2s	1–5 or 4–20mA @ 0.0–16µA in
LI200 Pyranometer	100µA @ 1000 W/m2	1–5 or 4–20mA @ 0.0–125µA in
LI210 Photometer	40µA @ 100 klux (=9290 ftcd.)	1–5 or 4–20mA @ 0.0–50µA in

The calibration tag provided by LI-COR with each sensor in conjunction with the current loop gain can be used to compute the light level incident on the sensor with a high degree of accuracy. Instructions and re-calibration information are included with each shipment.

Specifications:
• Max. loop supply Voltage: 28 VDC
• Gain and offset accuracy: ±0.2%
• Supply Voltage variation effect:
less than 0.01% per Volt
• Min. loop supply Voltage:
3.5Volts+Rload*Imax
Imax =20 ma or 5 ma
• Temperature variation effect:
less than 0.01% per °C
• Operating Temperature: -30°C to +70°C
• NEMA 4 gasketed white polycarbonate
enclosure: 1.37“ x 1.96” x 2.55“ (4.15” w/glands)
gland nut or BNC at input, gland nut at output
Phoenix® beryllium/copper i/o terminals

Order item/option	**description**	**price ea.**
UCLC	standard UCLC with polycarbonate enclosure	$115
/BNC	BNC connector on input, instead of cord grip and terminals	add $10
/190, /200 or /210	preset input for LIxxx = 190, 200 or 210	no charge
/420 or /15	preset output for i = 4–20 ma or 1–5 ma	no charge
/special	preset current gain for a non-standard value	add $15
/HOBO	special circuit for use with Onset® HOBO data logger	add $10
/NE	no enclosure; amplifier electronics only	subtract $15

Example 1: UCLC/200/420UCLC pre-configured for 4–20 milliamp output from 0–125 microamp input, for use with LI200 Pyranometer, price $115 ea
Example 2: UCLC/BNC/190/420UCLC pre-configured for 4–20 milliamp output from 0-16 microamp input, for use with an LI190 Quantum PAR sensor with BNC input termination, $125 ea.

Thank you for your purchase of the EME Systems UCLC universal current loop converter.
The following instructions are provided to assist you in the installation and operation of your UCLC. While we have made every effort to protect the UCLC from faults, improper installation or misuse may result in incorrect readings, or at worst, failure of the UCLC. Please read this manual carefully before connecting power to the UCLC. If you have questions about the UCLC or any portion of this manual please contact EME Systems technical support between the hours of 9:00 AM to 5:00 PM PST at: (510) 848-5725, or (510) 848-5748 fax. You may also post your questions to us by e-mail at address: info@emesystems.com.

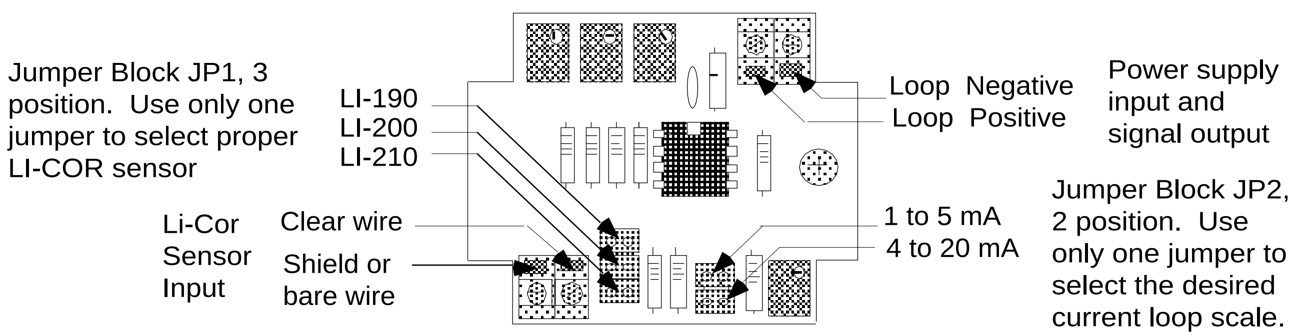
Configuring and connecting your UCLC:

1) You may have ordered your UCLC preconfigured for a certain LI-COR sensor. The calibration label on the side of the case will indicate this calibration.

2) All UCLC converters are enclosed in a protective cabinet. To gain access to the connection terminals and jumper blocks, remove the two corner screws using a standard screwdriver and lift up on the top. Notice that there is a copy of the connection diagram attached inside the lid of the enclosure.

The UCLC must be configured for the LI-COR sensor and current loop scale you wish to use. In most cases the UCLC will be shipped to you preconfigured for the appropriate LI-COR sensor and current loop scale you specified in your pur chase order. If so, you can skip to step 4 below.

3) You can skip this step if the UCLC has been preconfigured at the factory. Refer to the diagram below for the locations of jumper blocks JP1 and JP2. Each jumper block should have only one jumper in place. Choose the jumper position on JP1 that corresponds to the LI-COR sensor type you will be using. Choose the jumper position on JP2 that corresponds to the current loop scale appropriate for your logger or meter. To move the jumpers, pull them up and off the posts and plug them back into the desired position.



4) As is shown in the figure above, your UCLC amplifier has connections for the LI-COR sensor input at one end of the circuit board and the current loop at the other end. The UCLC input may be terminated with either a pair of black and white screw terminals or a BNC connector. The UCLC current loop output is always terminated with a pair of red and black color coded screw terminals regardless of which UCLC you have ordered.

4a) LIXXX-SZ (bare wire termination): LI-COR part numbers ending with “SZ” are terminated with a stripped and tinned bare coaxial cable. These sensors should be used with a standard UCLC amplifier. Through the gland nut, connect the inner conductor (green, white or clear) to the white color coded screw terminal and connect the outer wire (shield or tinned copper wire) to the neighboring black terminal.

4b) LIXXX-SA (BNC termination): LI-COR part numbers ending with a “SA” are terminated with a BNC connector and should be used with the UCLC-BNC amplifier. Simply align the connector with its mate on the outside of the UCLC-BNC and twist the two halves together. The BNC connectors should lock together when they are properly seated.

4c) Connect the red and black terminals on the opposite side of the UCLC circuit board to your current loop, with the red terminal connected the the more positive side of the loop. The red wire is usually connected to the positive power supply, and the black wire usually goes to the signal input of the data logger or meter.

5) Check all connections for correct polarity and make sure all wires are securely in place. Replace the top cover on the enclosure and tighten the corner screws. Take care not over tighten the cover screws as this may cause the cover to deform or “saddle” which can compromise the seal.

Notes

- A voltage of at least 3.5 volts must be maintained across the UCLC at all times. The necessary loop supply voltage will depend on voltage drops across other elements in the loop at full scale output. In the case of a data logger that loads the loop with a 100Ω resistance, its voltage drop at 20mA full scale would be 100 * 0.02 = 2 Volts. This would require a power supply of 3.5 + 2 = 5.5 Volts or greater. Another example is a data logger that loads the loop with a 250Ω resistance. In this case the voltage drop at 20mA full scale would be 250 * 0.2 = 5 Volts. That result means that a power supply of 3.5 + 5 = 8.5 Volts or greater would be necessary. If more resistance is in the total loop, a higher loop supply voltage would be required. The voltage across the UCLC should never exceed 28 volts. There is a Shottky diode in series with the loop at the amplifier input. The diode protects the circuit against polarity reversal.

- If the UCLC is to be used with a voltage input logger or meter, the current loop must be terminated with a resistor. This will convert the loop current into a corresponding voltage. The red wire should be connected to the positive supply voltage and the black wire should be connected to the logger's signal input with a precision resistor (±1% or better) between the signal input and ground. Choose a termination resistor according to Ohm's law: R = E / I where R is the resistor value, E is the maximum input voltage of your logger and I is either 5 or 20mA depending on the position of JP2. Consult your data logger manual or contact EME Systems for more information.
- The amplifier should be placed as close to the LI-COR sensor as possible. If the sensor and the meter or logger are spaced far apart (greater than 50 feet) the bulk of the distance should be between the UCLC and the logger or meter, not between the sensor and the UCLC. This will minimize the effect of noise and electro-magnetic interference. In extreme cases, where halide lamps or strong noise sources are present, use shielded, twisted pair cable between the data logger and the UCLC.

- There is a small reverse bias across the input, 0.2 volts, so any resistance across the input will result in a current flow that cannot be distinguished from a signal. Because of this, a short circuit or resistor placed across the input is not equivalent to zero input signal. Only an open input is equivalent to zero signal. Do not allow leakage paths in parallel with the LI-COR sensor. The photodiode in the LI-COR sensor is a current source and will operate fine with the small reverse bias.

Calculations:

In order to convert the UCLC's loop current into your sensor's units of light, you will have to program your equipment to multiply the net loop current, times the LI-COR sensor's multiplier, divided by the UCLC's current loop gain. Net loop current is equal to the total loop current minus the offset current of either 4ma or 1 ma. The LI-COR multiplier is a calibration constant printed on the tag that accompanies each LI-COR sensor. Drop the minus sign.

$$\textbf{Light Level} = \frac{\textbf{(net loop current) * (LICOR multiplier)}}{\textbf{(UCLC current loop gain)}}$$

Refer to the chart below to find the current loop gain corresponding to the jumper position selected for your UCLC.

Table of UCLC current loop gain for various jumper settings and for LICOR sensor types

	JP2-1) 1 to 5 mA	JP2-2) 4 to 20 mA
JP1-1) LI-190	0.25 mA/µA	1.00 mA/µA
JP1-2) LI-200	0.032 mA/µA	0.128 mA/µA
JP1-3) LI-210	0.08 mA/µA	0.32 mA/µA

Example calculations:

Example 1: Suppose you will be using your UCLC in conjunction with a Quantum PAR sensor (LI-190), and that its individual calibration tag states a multiplier of -164.5µE/m^{2}s per µA. Drop the minus sign. You use a the 4 to 20 mA loop. The proper gain setting for your UCLC is 1.00 mA/µA (1st row , 2nd column in above table). The c conversion is:

light level in µE/m^{2}s = [(net loop current) / 1.00]* 164.5 = (net loop current)*(164.5 µE/m2s per mA)

at a total current level of 10 ma, the net loop current is 6 ma, so the light level is 987 µE/m^{2}s

Example 2: Suppose you will be using your UCLC in conjunction with a Pyranometer sensor (LI-200), and that its individ ual calibration tag that states a multiplier of -9.8W/m2 per µA.. Drop the minus sign. You choose a 4 to 20 mA current loop. The proper gain setting for your UCLC is 0.128 mA/µA (2nd row, 1st column in above table). The conversion is:

light level in W/m^2= [(net loop current)/0.128] * 9.8 = (net loop current)*(76.56 W/m^2 per mA)

at a total current of 14.5 ma, the net loop current is 10.5 ma. The light level is 804 W/m^2

Example 3: Suppose you will be using your UCLC in conjunction with a Photometric sensor (LI-210), and its individual calibration tag that gives a multiplier of -2.42 klux/µA. Drop the minus sign. You use a 4 to 20 mA current loop. The proper gain setting for your UCLC is 0.32 mA/µA (3rd row, 2nd column in above table). The formula is:
light level in klux = [(net loop current)]/0.32]*2.42 = (net loop current)*(7.56 klux per mA)
at a total current of 17 ma, the net loop current is 13 ma, so the light level is 98.28 klux

Note: 1 footcandle = 10.76 lux.

Troubleshooting:

1) UCLC appears to be dead, the loop current is stuck at zero regardless of light conditions:
   - 1a) Check to see if the protective red cap on the LI-COR sensor has been removed. Remove it!
   - 1b) Check loop supply voltage and polarity at the red and black terminals of the UCLC circuit board. A Shottky diode in series with the loop protects the circuit against reverse polarity.
   - 1c) Check the sensor polarity, make sure that the inner sensor wire is connected to the white terminal and the outer shield wire is connected to the black terminal on the UCLC input.
   - 1d) Check the screw terminal connections, make sure all of the wires are clamped solidly in place. The sensor wire should be clamped in the terminal, not loose underneath it. The wire in the center conductor is delicate; be sure it is not broken.
   - 1e) Check if the jumpers for selecting sensor type and loop gain are correctly seated.
   - 1f) Check for evidence of water inside the cabinet. In regions of extreme humidity or precipitation it may be wise to place a dessicant such as silica gel inside of the UCLC cabinet
   - 1g) Has there been a lightning strike in close proximity? Although the UCLC is protected against excess or reversed power supply voltages, it can not be expected to survive catastrophic extremes.

2) UCLC seems to be responding to light on the sensor, but the output is wrong:
   - 2a) Check the position of the jumpers JP1 and JP2, against the desired calibration. A copy of the calibration diagram is fixed on the lid on the inside the lid of the enclosure.
   - 2b) Check to see if the protective red cap on the LI-COR sensor has been removed. Remove it! Also, check if the light sensor has become dirty. If you see that this is case, clean the sensor with water, a soft detergent (if necessary) and a non-abrasive cloth or sponge. Do not use alcohol, other organic solvents, or abrasive detergents which could cause irreparable damage to your sensor.
   - 2c) Check that the loop supply voltage is adequate for the UCLC. Refer to the notes in the "connections" section for power supply requirements.
   - 2d) Check the value of the resistor that converts current into voltage at the input of your data logger (if it is accessible).
     See step 4 below.
   - 2e) Place the LI-COR sensor in full unobstructed sunlight. You should see a significant increase in loop current. Indoor lighting does not compare in intensity to full sunlight. The standard currents we use to set the full scale loop currents are designed to accommodate full tropical sunlight conditions. If you will be using your sensor in generally low-light conditions, say indoors or in the arctic or under a plant canopy, you may wish to select a higher gain setting to bring the signal into the dynamic range of your data logger. Please consult the LI-COR literature and references or consult EME systems for special requirements.
   - 2f) Check for leakage across the sensor, due to moisture, damaged cable, or other causes.

3) The UCLC is working but the loop current is unstable under constant lighting conditions:
   - 3a) Check all of the connections to the screw terminals. Make sure all connections are tight and secure
   - 3b) Check for an AC component in the loop power supply. The power supply should be filtered DC.
   - 3c) Is the sensor too close to a strong electromagnetic field, such as a halide lamp or a motor? Route the sensor cable away from AC power lines or outlets. Do not run the sensor cable in a conduit with AC wiring. Use shielded, twisted pair cable in extreme cases.

4) Often the UCLC is part of a system with a sensor, a UCLC, an analog to digital converter, and several layers of soft ware routines to display or log readings. You want to know if the final reading is correct:
   Lacking an independent means of measuring light intensity, you must rely on the LiCOR sensor. Most quality digital multimeters can measure DC current down to 0.1 microamp or better. Disconnect the LiCOR sensor from the UCLC and connect it directly to the multimeter and observe the microamp reading. Multiply the reading in milliamps by the calibration multiplier provided by LICOR with the sensor. Without changing the light level, reconnect the sensor to the UCLC and to the rest of your system. If the readings agree, violá. But if they disagree, you will have to check the various stages to find the problem. You can measure the output current of the UCLC directly with an ammeter to see if the transconductance gain is correct. If so, the problem is not with the UCLC, rather it lies in the input conversion in the data logger, or in the calculations made by the software.

UCLC re-calibration:

The jumpers in the UCLC select certain popular values of the transconductance gain. If you need to recalibrate or t to set an intermediate value of gain, it is possible to do so. The diagram below shows the location of the gain trimmers. Use a precision current sink at the input and an accurate DMM to read the output current

Offset trim: With a zero microamp current sink (open circuit) applied to the UCLC input adjust the offset trim until the precision ammeter displays the proper offset. This will be either 1 or 4 mA depending on the loop gain setting you have chosen. Do not short circuit the input: as this will cause current to flow, due to the 0.2 volt bias across the input. Zero signal input occurs when the input is an open circuit.

Gain trim: With a 16µA sink applied to the input and jumper JP1 in the LI-190 (highest) position adjust the trimmer for the LI-190 (top, right trimmer) until the precision ammeter displays the full scale output current for the jumper setting you have chosen. This will be either 5 or 20 milliamps depending on the position of jumper JP2. Repeat this procedure for the remaining two JP1 positions, LI-200, LI210 using reference current sinks of 125 and 50 µA respectively. Adjust only the trimmer associated with the sensor type selected.

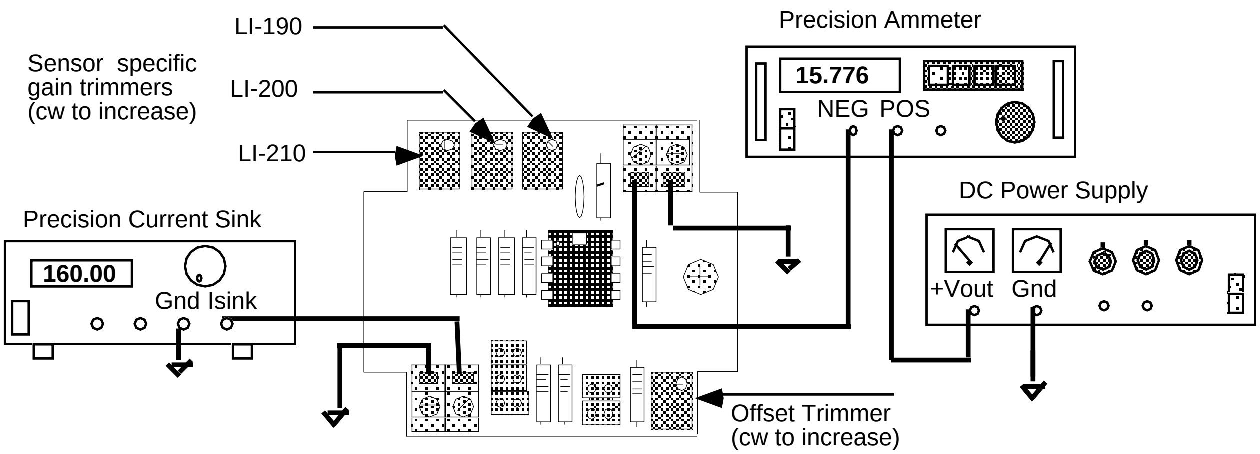


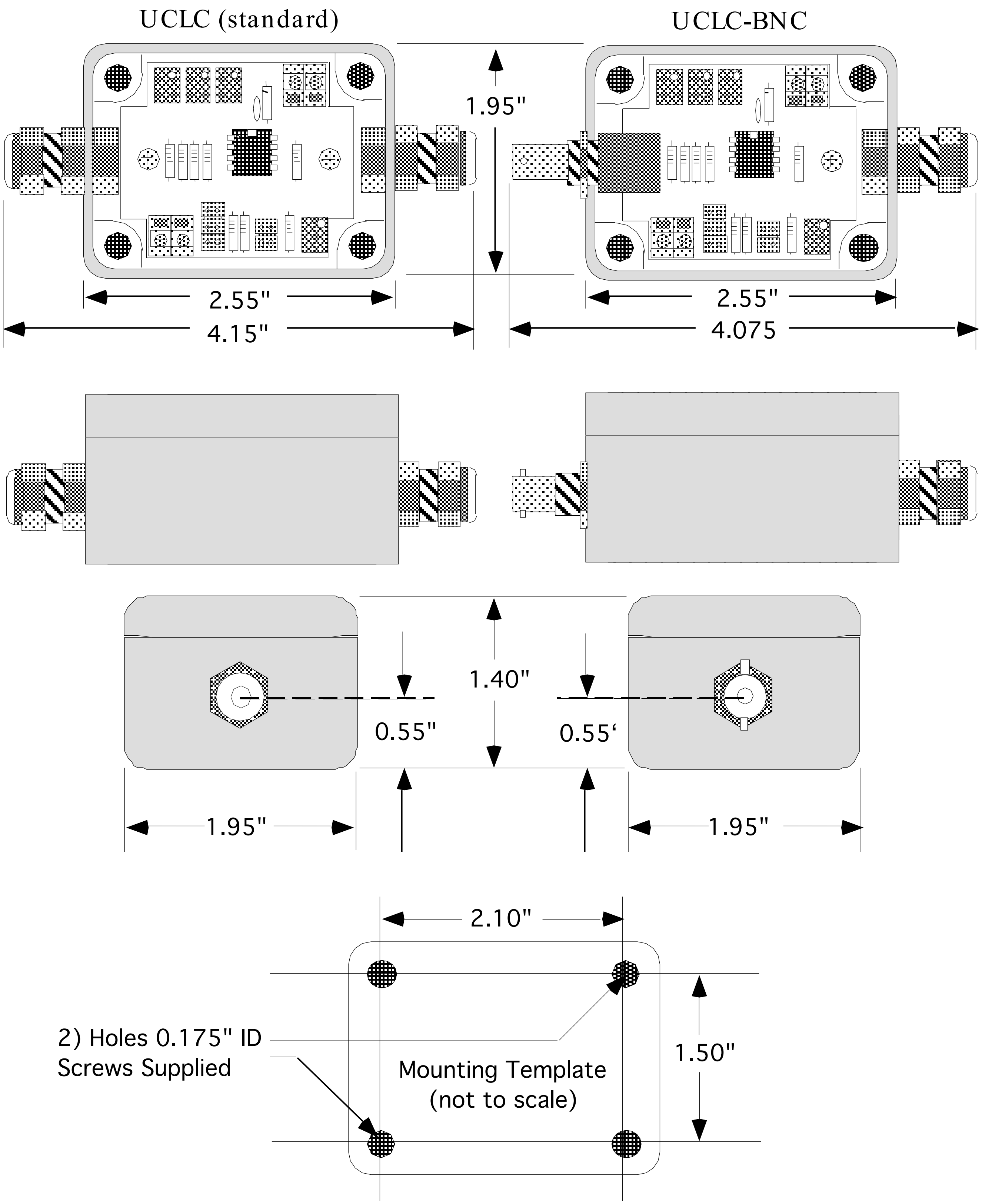
Figure 3. Calibration connections and adjustments

Notes:

- A UCLC can be calibrated to match an individual LI-COR sensor so that a given light level incident on the sensor will result in a predetermined current output. This is done by using the sensor calibration data to calculate the current the sensor will produce when exposed to a certain light level. Set the precision current sink to this current and apply this to the UCLC's input. Adjust the first stage gain trimmer until the UCLC's output matches the desired loop current. Be sure the position of JP1 (sensor type) matches the LI-COR sensor you will be using. Alternatively, a calibrated light source such as LI-COR's 1800-02 Optical Radiation Calibrator can be used to match the UCLC to an LI 190 or LI210 sensor. Place the sensor in the calibrator and adjust the gain trimmer to match the loop current you desire for the given light level. Keep in mind the both of the foregoing procedures will match the UCLC to one particular sensor. If you ever wish to use the UCLC with another sensor you will have to repeat the calibration procedures.

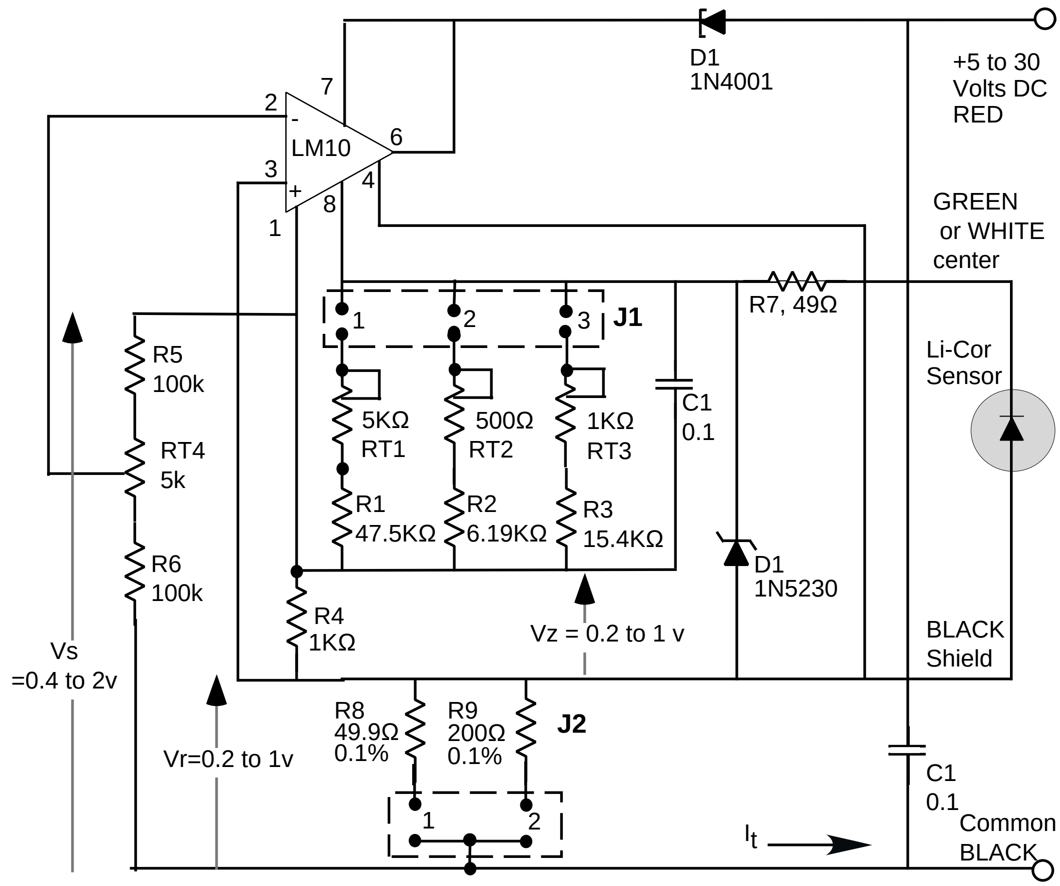
- LI-COR recommends that all LI-COR LI-XXX sensors be returned to them for recalibration every two years.

Physical Dimensions:



UCLC Schematic, © 2001 EME Systems.

The information contained herein is provided as an aid to resolving questions about the amplifier and its application. It is not meant for general distribution and remains the exclusive property of EME Systems.



J1 position	
Quantum LI190	1
Pyranometer LI200	2
Photometric LI210	3

J2 position	
4–20 ma	1
1–5 ma	2

Calibration:
With zero input current set RT4 to 1 or 4mA for selected scale (J2).
Apply currents of 12.5,125 and 50µA to amplifier input, moving jumper J1 to the appropriate position. Adjust RT1, RT2,RT3 to full scale output (5 or 20mA)

Theory:
Vs = Vr + Vz   Vz = .2 + (Iz * Rf)   V- = Vs/2   V+=Vr
==> Vr = Vz = I * Rr   with Rr= 50Ω or Rr=200Ω
Vz from 0.2 to 1.0 in each setting, for 12.5µamp, 125µamp, 50µamp
Sensor is reverse biased 0.2 volts.