Universal Industrial Current Loop Converter for LI-COR™ Sensors

(Amplifies LI-COR sensor current to industrial current loop level)
Version C 20-Nov-2008

The UCLC is a special purpose amplifier that converts the micro-amp level current output of LI-COR 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 by internal switch settings. The UCLC provides a simple interface between LI-COR sensors and current loop signal processing equipment such as data loggers, PLCs, meters, industrial control equipment, HVAC and green house control systems.

LI-COR sensor	Typical full sun response	UCLC output (user selectable)
LI200 Pyranometer	100µA @ 1000 W/m2	4–20mA @ 0.0–125µA in
LI210 Photometer	40µA @ 100 klux (=9290 ftcd.)	4–20mA @ 0.0–50µA in
LI190 PAR sensor	13µA @ 2000 µmoles/m2s	4–20mA @ 0.0–16µA or 0.0 to 12.5 µA in
special low light setting	10 klux or 500 µmoles/m2s	4–20 mA @ 0.0 to 3.5 µA 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. Revision C of the UCLC moves to surface mount technology, RoHS and CE. compliant, configuration by DIP switch instead of jumpers, and adds the low light setting.

Specifications:
- Max. UCLC terminal Voltage: 26 VDC
- Gain and offset accuracy: ±0.2% on factory setting.
- Supply Voltage variation effect:
  less than 0.01% per Volt
- Min. loop supply Voltage: 4 Volts + burden * 0.02
- Temperature variation effect:
  less than 0.01% per °C
- Operating Temperature: -20°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**
UCLC	standard UCLC with polycarbonate enclosure
/BNC	BNC connector on input, instead of cord grip and terminals
/NE	no enclosure; amplifier electronics only
/200	preset input for LI200, 0–125 µA input to 4–20 mA output
/210	preset input for LI210, 0–50 µA input to 4–20 mA output
/190/16	preset input for LI190, 0–16 µA input to 4–20 mA output
/190/12.5	preset input for LI190, 0–12.5µA input to 4–20 mA output
/HG	preset input for high gain, 0–3.5 µA input to 4–20 mA output

Example 1: UCLC/200 = UCLC pre-configured for 4–20 mA output from 0–125 µA input, for use with LI200 Pyranometer,.

Example 2: UCLC/BNC/190/12.5 = UCLC pre-configured for 4–20 mA output from 0-12.5 µA input, for use with an LI190 Quantum PAR sensor with BNC input termination.

The HG setting is typically used with the LI-210 photometer or the LI-190 PAR sensor at low indoor or underwater light levels. Any UCLC setting can be used with any of the LI-COR sensors, as full scale light conditions dictate.

Configuring and connecting your UCLC:

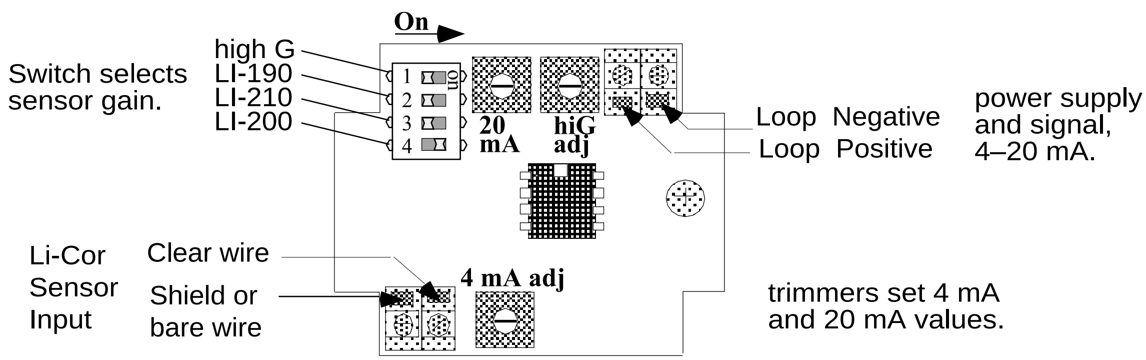
1) You may have ordered your UCLC pre-configured for a certain LI-COR sensor. The calibration label on the side of the case will indicate this calibration.

2) To gain access to the connection terminals and jumper blocks, remove the two corner screws using a standard screw-driver and lift up on the top. Notice that there is a copy of the connection diagram inside the lid of the enclosure.

3) Skip to step 4 if the UCLC has been pre-configured at the factory. Refer to the diagram below for the locations of switch and the adjustment trimmers. Choose the switch position that corresponds to the LI-COR sensor type you will be using.

LI-200 Pyranometer, gain = 125 µA full scale input: switch 4 ON, others OFF
LI-210 Photometer, gain = 50 µA full scale input: switch 3 ON, others OFF
LI-200 Quantum PAR sensor, gain = 16 µA full scale input: switch 2 and 1 ON, others OFF
LI-200 Quantum PAR sensor, gain = 12.5 µA full scale input: switch 2 ON, others OFF
Hi Gain for low light levels, gain = 3.50 µA full scale input: switch 1 ON, others OFF

For best accuracy, the trimmer should be adjusted per calibration instructions on page 6.



4) As is shown in the figure above, the UCLC amplifier has connections for the LI-COR sensor input at one corner and the current loop at the opposite corner. The current loop output is always terminated with a pair of red and black color coded screw terminals, while the input for the LI-COR sensor will be either a BNC connector or a pair of screw-down terminals coded black and green/white.

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 to the white/greenish 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 to lock.

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. The data logger may require a resistor to convert current to voltage.

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.

Installation Notes

• A voltage of at least 4 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 250Ω resistance, its voltage drop at 20mA full scale would be 250 * 0.02 = 5 Volts. This would require a power supply of 4 + 5 = 9 Volts or greater. . The voltage across the UCLC should not exceed 26 volts. There is a Schottky 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 0.02 Amp.

• The amplifier should be placed near the LI-COR sensor. The LI-COR sensors come with cable lengths of 10 or 50 feet. The 4-20 mA loop will minimize the effect of noise and electro-magnetic interference. In cases where halide lamps or motors or other strong noise sources are present, use shielded, twisted pair cable between the data logger and the UCLC. for best results.

• 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 well 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 4 mA 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 switch settings and for LICOR sensor types

sensor	switch setting	gain factor	full scale
LI-200 Pyranometer	#4 only ON	0.128 mA/µA	125 µA
LI210 Photometer	#3 only ON	0.32 mA/µA	50 µA
LI-190 Quantum PAR	#2 & #1 ON	1.0 mA/µA	16 µA
LI-190 Quantum PAR	#2 only ON	1.28 mA/µA	12.5 µA
high gain, low light	#1 only ON	4.57143 mA/µA	3.5 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^2s per µA. Drop the minus sign. The gain setting for the UCLC is 1.00 mA/µA from the table above. The conversion math is:
light level in µE/m^2s = [(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^2s

Example 2: Suppose you will be using your UCLC in conjunction with a Pyranometer sensor (LI-200), and that its individual calibration tag that states a multiplier of -9.8W/m2 per µA.. Drop the minus sign. The gain setting for your UCLC is 0.128 mA/µA. The conversion math 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. The gain setting for your UCLC is 0.32 mA/µA. The conversion math 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 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/green 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 switches for selecting sensor type and loop gain are correct.
   - 1f) Check for evidence of water inside the cabinet. In regions of extreme humidity or precipitation it may be wise to place a desiccant 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 switches.
   - 2b) Be sure the protective red cap on the LI-COR sensor has been removed, or if there is dirt or debris.
   - 2c) Check that the loop supply voltage is high enough.
   - 2d) If accessible, check the the resistor that converts current into voltage at the input of your equipment.
   - 2e) 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 underwater, you may wish to select a higher gain setting.
   - 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 microamps 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 conversion math in the data logger or software.

This manual is available online at <http://www.emesystems.com/pdfs/UCLC_Manual_RevD.pdf>.
EME Systems technical support (California): (510) 848-5725, or (510) 848-5748 fax. You may also post your questions to us by e-mail at address: info@emesystems.com.
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UCLC re-calibration:

The switches in the UCLC set the rough gain factor appropriate for each sensor, and then the trimmers set the gain to the precise value. The diagram below shows the location of the switch and the gain trimmers. Use a precision current sink at the input and an accurate DMM to read the output current

Offset 4 mA trim: With a zero µA current sink (open circuit) applied to the UCLC input adjust the 4mA trim. 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 20 mA trim: Set the switch for the proper gain factor as shown on page 4. Note that most setting have only one switch ON and the others OFF. The exception is the LI-190 with gain of 1.28 mA/µA, which has both switches #1 and #2 set to ON. With a full scale sink current applied to the input, adjust the 20 mA trimmer. In the case of the 1.28 mA/µA, first adjust the 20MA trimmer and then the high gain trimmer.

High gain trim: This is used to set full scale output of 20 mA when the switch position #1 only is ON. The input current then should be 3.5 µA input for 20 mA output. This setting is used when low light conditions are expected, indoors or underwater for example. The high gain trim is also used in conjunction with the 20mA trim when the 1.28 mA/µA gain is desired for the LI-190 Quantum PAR sensor. In that case, both switch #2 and #1 will be set to ON.

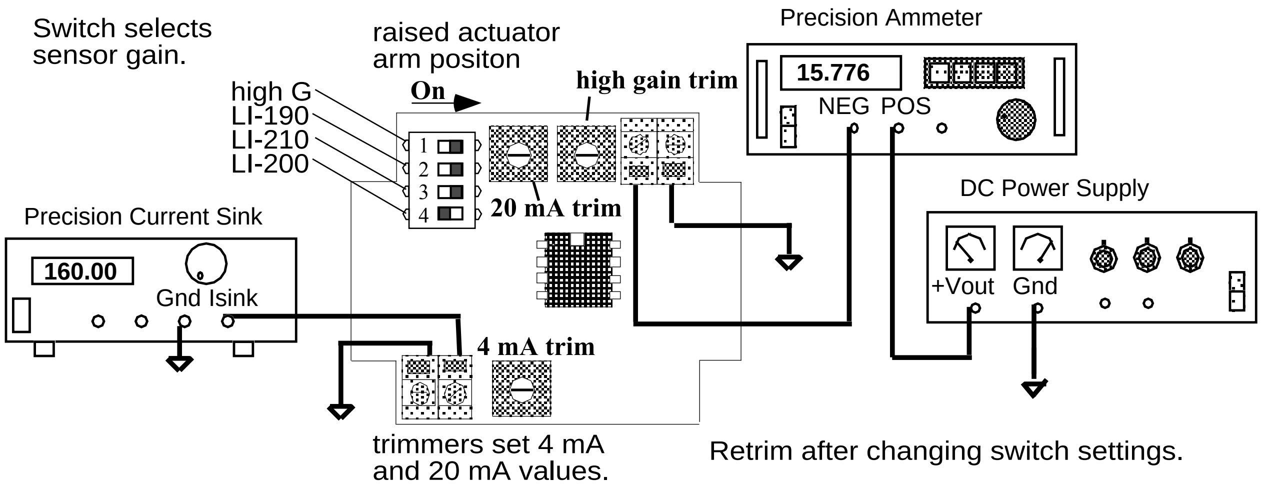


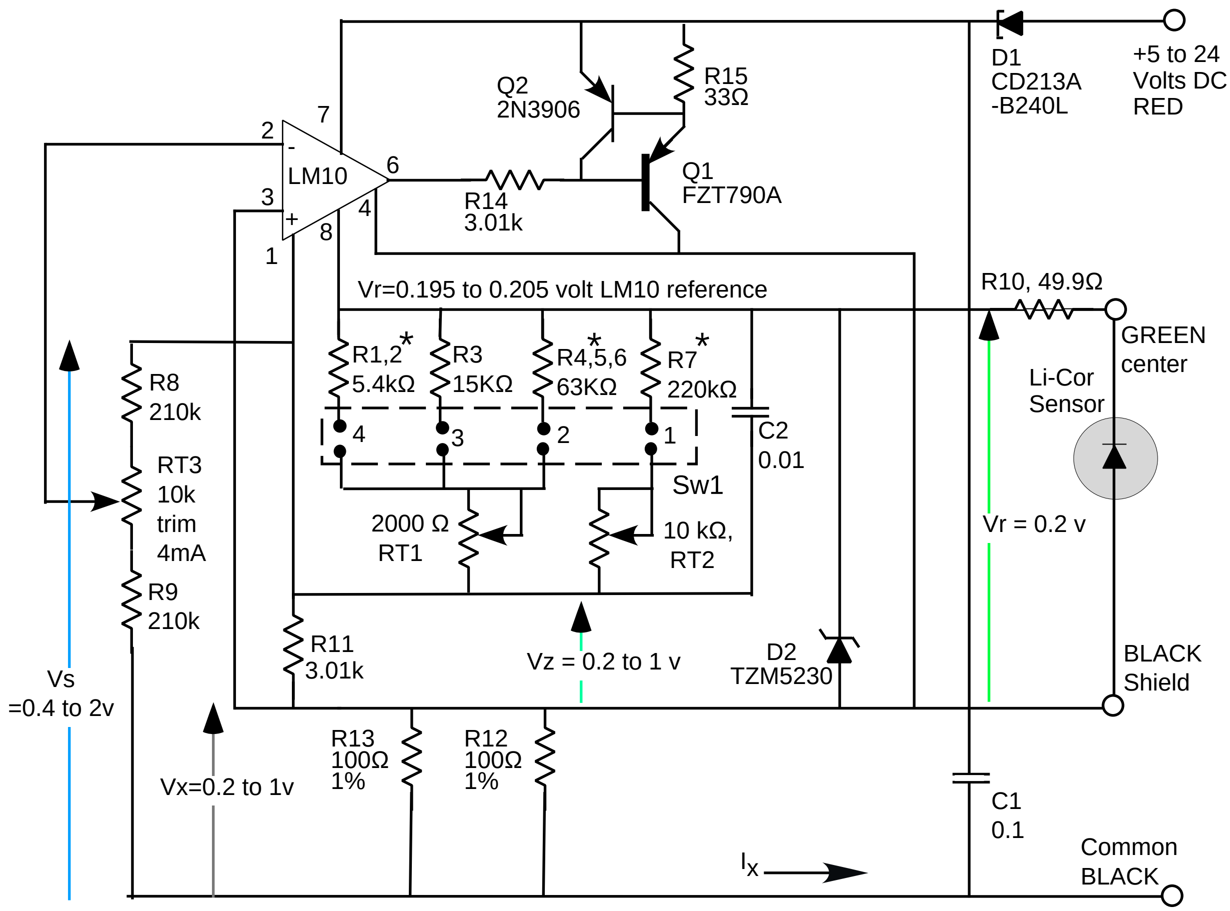
Figure 3. Calibration connections and adjustments

Notes:

• When the switch positions are changed, the gain will be close to the new target value, within a couple of percent. However, the trimmers will have to be adjusted for best results.

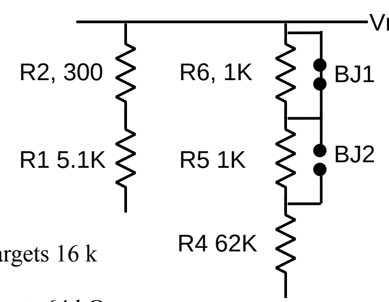
• The LI190 setting can be further trimmed by adding or subtracting a 1kΩ resistor via solder jumpers located on the bottom of the circuit board. Please refer to the technical circuit description.

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



UCLC Schematic, © 2005, 2008 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.



	Sw1 position	
Pyranometer LI200	4	4–20 mA for 0–125 µA
Pyranometer LI210	3	4–20 mA for 0–50 µA
Quantum PAR LI190	2	4–20 mA for 0–12.5 µA
Quantum PAR LI190	2+1	4–20 mA for 0–16 µA
High gain	1	4–20 mA for 0-3.5 µA

Notes:

R1,R2=5400Ω is 2 resistors, 5100 Ω in series with 300 Ω, and with 1 kΩ on the trimmer targets 16 k

R3=15 kΩ is 1 resistors, and with 1 kΩ on the trimmer targets 16.0 kΩ

R4,R5,R6 = 63 k is 3 resistors, 62 kΩ in series with 1 kΩ and 0 kΩ, and with 1 kΩ trim targets 64 kΩ.

Note that shorting pads BJ1 and BJ2 on the back of the PCB allow R4+R5+R6 to be 62k, 63k or 64k, to adjust for Vr tolerance.

If trim will not reach low enough, then apply solder to BJ2 short R5. If trim will not reach high enough, then cut BJ1, R6 in circuit.

R7 is individually trimmed to target 228571Ω with the 10 kΩ trimmer.

R7 alone gives 3.5 µA full scale, and in parallel with R4,5,6 it gives 16 µA full scale.

R1, R2, R3 and R4 are 0.1% precision 0805.

Sensor is reverse biased 0.2 volts.

Calibration: -

With zero input current set RT3 to 4mA. Apply currents of 12.5,16, 50 and 125 µA to amplifier input, moving jumper Sw1 to the appropriate position. Adjust RT1, RT2 to full scale output (20mA). Repeat to converge.

Theory, volts measured as noted on schematic, V- & V+ wrt loop (-). R12||R13 = Rx

$Vs = Vx + Vz$ $Vz = Vr + (Iz * Rf)$ $V- = Vs*R9/(R8+R9) = Vs/2$ $V+=Vx$ $Ix = Vx/Rx$

==> V+=V- ==> $Vx = Vs*R9/(R8+R9) = (Vx+Vz)*R9/(R8+R9) = (Vx+Vr+Iz*Rf)*R9/(R8+R9)$

if R8=R9 and Rx=50Ω and Vr=0.2 volt, then $Ix = (0.2 + Iz*Rf) / 50$

Rf is chosen to produce Iz*Rf = 0.8 volts at full scale, so (0.2 + 0.8) = 1 volt full scale and 1/50 = 20 mA output.

When the light input is zero, then Iz = 0 and Ix = 0.2 / 50 = 4 mA output.

Most of the current and power is carried by transistor Q1 rather than the LM10 op-amp. Transistor Q2 in conjuction with resistors R15 and R14 limits the fault current to about 35 milliamps.

Physical Dimensions: