

# ILT1700 INSTRUCTION MANUAL

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TECHNOLOGIES

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# Contents

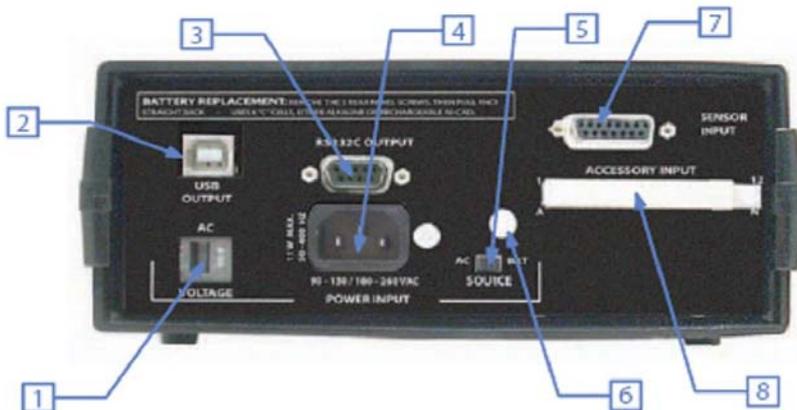
<b>1. Quick Reference Guide</b>	<b>6</b>
<b>1.1 Rear Panel Set Up:</b> .....	<b>6</b>
1.1.1 International Power Settings .....	6
1.1.2 Power Cord .....	6
1.1.3 Select AC Power Source .....	6
1.1.4 Plug In Detector .....	6
1.1.5 For More Information .....	6
<b>1.2 Front Panel Set Up:</b> .....	<b>6</b>
1.2.1 Turn Power On .....	6
1.2.2 Store Sensitivity Factors .....	6
1.2.3 Display Data .....	6
1.2.4 Bias Selection .....	6
1.2.5 Zero The Detector .....	6
1.2.6 Select Measurement Mode .....	6
<b>1.3 Begin to Measure</b> .....	<b>6</b>
1.3.1 Check the Detector .....	6
1.3.2 Zero the Detector .....	6
1.3.3 Operating in D.C. Signal Mode .....	6
1.3.4 Operating in Integrate Mode .....	6
<b>2. Controls</b>	<b>7</b>
<b>2.1 Front Panel</b> .....	<b>7</b>
2.1.1 Power Controls .....	7
2.1.2 Function Controls .....	7
2.1.3 Readout Display .....	7
2.1.4 Display Selector .....	7
2.1.5 Factor Selector .....	8
2.1.6 Changing Factors .....	8
2.1.7 Bias Voltage .....	8
2.1.8 Auto Range .....	8
2.1.9 Percentage Mode .....	8
<b>2.2 Rear Panel</b> .....	<b>8</b>
2.2.1 Battery Replacement.....	8
2.2.2 AC Voltage .....	8
2.2.3 USB.....	9
2.2.4 RS232C Digital Output .....	9
2.2.5 Power Input.....	9
2.2.6 Power Source .....	9
2.2.7 Sensor Input .....	9
2.2.8 Accessory Input/Output.....	9
2.2.9 Batter Access Knob.....	9
<b>3. Operation</b>	<b>9</b>
<b>3.1 Power Selection</b> .....	<b>9</b>
3.1.1 AC Power .....	10
3.1.2 Internal Battery Power .....	10
3.1.3 External Mobile or Battery Power .....	10
<b>3.2 C.W. Measurements</b> .....	<b>10</b>
3.2.1 Zeroing .....	10
3.2.2 Range Selection .....	11
3.2.3 Programming .....	11

3.2.4	Percent Mode .....	11	
3.2.5	Readout (Scientific Notation) .....	12	
3.2.6	Darkroom Readings .....	12	
<b>3.3</b>	<b>Integration Measurements .....</b>	<b>12</b>	
3.3.1	Integration Zero .....	13	
3.3.2	Long term integration .....	13	
3.3.3	Flash measurements.....	13	
3.3.4	Averaging .....	13	
3.3.5	Readout (Scientific Notation) .....	14	
3.3.6	Darkroom Integration .....	14	
<b>3.4</b>	<b>Bias Selection .....</b>	<b>14</b>	
3.4.1	Vacuum Photodiode Bias .....	14	
3.4.2	Flash Bias.....	14	
3.4.3	Low Level Bias .....	14	
<b>4.</b>	<b>Outputs</b>		<b>15</b>
<b>4.1</b>	<b>LCD Displays .....</b>	<b>15</b>	
4.1.1	Mantissa (3 & 1/2 digits plus sign) .....	15	
4.1.2	Exponent (1 & 1/2 digits plus sign) .....	15	
4.1.3	Sensitivity Factor Designator (0-9) .....	15	
<b>4.2</b>	<b>Recorder Output.....</b>	<b>15</b>	
4.2.1	Voltage Range .....	15	
4.2.2	Auto Ranging Considerations .....	15	
4.2.3	Negative Readings .....	15	
4.2.4	Output Impedance .....	16	
4.2.5	Character Format .....	16	
4.2.6	Word String Format .....	16	
<b>4.3</b>	<b>NEW USB AND RS232.....</b>	<b>170</b>	
4.3.1	Data Collection.....	17	
4.3.2	Serial Output....	17	
4.3.3	PC Cable Connection.....	17	
4.3.4	Software .....	17	
4.3.5	Plug and Cable Requirements .....	17	
<b>5.</b>	<b>Inputs</b>		<b>18</b>
<b>5.1</b>	<b>Light Sensors .....</b>	<b>18</b>	
5.1.1	International Light Detectors .....	18	
5.1.2	User and Custom Detectors .....	18	
<b>6.</b>	<b>Accessory Input</b>		<b>19</b>
<b>6.1</b>	<b>Remote Control .....</b>	<b>19</b>	
<b>6.2</b>	<b>Test Pins.....</b>	<b>19</b>	
<b>6.3</b>	<b>DC Power .....</b>	<b>19</b>	
<b>6.4</b>	<b>Analog Output .....</b>	<b>19</b>	
<b>7.</b>	<b>Precautions</b>		<b>19</b>
<b>8.</b>	<b>Applications</b>		<b>19</b>
<b>8.1</b>	<b>Current and Conductance Measurements .....</b>	<b>20</b>	
8.1.1	Polarity .....	20	
8.1.2	Input Cable .....	20	
8.1.3	Overload... ..	20	

<b>8.2 Flux Density Measurements .....</b>	<b>21</b>	
8.2.1 Photometric illuminance.....	21	
8.2.2 Radiometric Irradiance .....	21	
<b>8.3 Flux Measurements .....</b>	<b>22</b>	
8.3.1 Laser Measurements .....	22	
8.3.2 Wide Beam Flux Measurements .....	23	
<b>8.4 Health Hazard Measurements .....</b>	<b>24</b>	
<b>8.5 Radiance / Luminance Measurements .....</b>	<b>24</b>	
<b>8.6 LED Measurements .....</b>	<b>24</b>	
<b>8.7 Transmission Measurements .....</b>	<b>24</b>	
<b>8.8 Reflectance Measurements .....</b>	<b>24</b>	
8.8.1 Specular Reflectance .....	25	
8.8.2 Diffuse Reflectance .....	25	
<b>8.9 Spatial Response .....</b>	<b>25</b>	
8.9.1 Lambertian Response .....	25	
8.9.2 Field Baffle .....	25	
8.9.3 Narrow Angle (Luminance/Radiance) .....	25	
8.9.4 Uniform Receiver Sensitivity .....	26	
<b>8.10 Temporal Response .....</b>	<b>26</b>	
8.10.1 Low Duty Cycle (fast pulse) .....	26	
8.10.2 High Peak Amplitude .....	26	
<b>9. General Specifications .....</b>		<b>27</b>
<b>9.1 Current Measurement Accuracy.....</b>	<b>27</b>	
<b>9.2 Optical Accuracy.....</b>	<b>27</b>	
<b>9.3 Radio Frequency Interference.....</b>	<b>27</b>	
<b>9.4 Size and Weight .....</b>	<b>27</b>	
9.4.1 Size .....	27	
9.4.2 Weight .....	27	
<b>9.5 Environmental Specifications .....</b>	<b>27</b>	
9.5.1 Operating temperature range .....	27	
9.5.2 Storage temperature range .....	27	
9.5.3 Operating and storage relative humidity .....	27	
<b>10. Maintenance and Repair .....</b>		<b>27</b>
10.1 Preventive Maintenance .....	27	
10.2 Battery Caution.....	27	
10.3 Board Replacement.....	27	
10.4 Computer Reinitialization Procedure .....	28	
10.5 ILT1700 Handle Operation .....	28	
10.6 Fuse Replacement.....	28	
10.7 Schematic .....	28	
<b>11. One Year Warranty .....</b>		<b>28</b>
<b>12. Schematics .....</b>		<b>29</b>
13.1 Photo Sensitive Device Wiring .....	33	
<b>13. Sample Program .....</b>		<b>30</b>

# 1. Quick Reference Guide

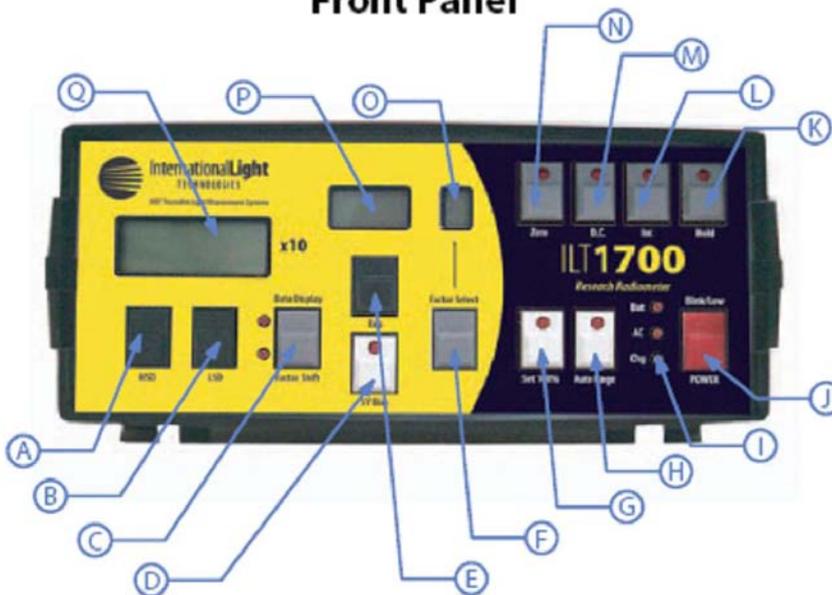
**Rear Panel**



1. AC Voltage Select Switch
2. USB Connector
3. 9-pin RS232C Serial Connector
4. AC Power Cord Connector
5. Power Source Select Switch
6. Battery Access Pull Knob
7. Detector Input Connector
8. Accessory Input Connector (protective cover shown)

NOTE: The Accessory input/output connector may be marked 'ACCESSORY INPUT', However, This connector is actually an input/output connector. Please refer to section 4.2 for further information.

**Front Panel**



- |                                   |                          |                      |
|-----------------------------------|--------------------------|----------------------|
| A. Most Significant Digit Button  | G. Set 100% Button       | M. DC Mode Button    |
| B. Least Significant Digit Button | H. Auto Range Button     | N. Zero Button       |
| C. Data/Factor Display Button     | I. Power Indicator LEDs  | O. Factor Number LCD |
| D. 5 Volt Bias Button             | J. Power Button          | P. Exponent LCD      |
| E. Exponent Button                | K. Hold Button           | Q. Main LCD          |
| F. Factor Select Button           | L. Integrate Mode Button |                      |

**WARNING: BE SURE TO CHECK AC VOLTAGE SELECT SWITCH AND POWER SOURCE SELECT SWITCH PRIOR TO TURNING ON YOUR ILT1700.**

## 1.1 Power

### 1.1.1 International Power Settings

Switch AC voltage selector switch to 220 or 115 VAC as applicable. Select 115 VAC for use on power systems between 90 and 130 VAC (JP, US, CA). Select 230 VAC for use on power systems between 180 and 260 VAC (EC, AU).

### 1.1.2 Power Cord

Connect power cord to power input then into main wall socket. The standard male power plug on the back of the ILT1700 accepts power cords from many different countries and power systems.

### 1.1.3 Select AC Power Source

Switch AC / BAT selector to AC position for operation using an alternating current power supply. The internal lithium batteries will automatically recharge whenever the ILT1700 is plugged into an external power supply. The rechargeable Batteries(NICAD ONLY) must initially be charged before the first use on battery power.

### 1.1.4 Plug In Detector

Connect detector to sensor input via the 15 pin D-Sub-Min connector labeled SENSOR INPUT. The D connector is wider on the top than on the bottom. The plug must be aligned properly with the socket for the two to mate.

### 1.1.5 For More Information

Refer to section 2.2 for more detailed information

## 1.2 Front Panel Set Up:

### 1.2.1 Turn Power On

Press POWER switch. AC LED indicator should be illuminated. If not check rear panel switch to ensure it is in the AC position. (see section 10.4 if unit does not power up)

### 1.2.2 Store Sensitivity Factors

Enter sensitivity factor from detector calibration certificate.

- a. Press Factor Display button.
- b. Press FACTOR SELECT button until 0 appears in window above button.
- c. Enter sensitivity factor by pressing MSD, LSD & EXP buttons. Enter the number and exponent as it is shown on your calibration certificate. This factor is now permanently stored as factor number 0.
- d. Repeat steps b & c for additional factors. Ten factors can be stored in this manner. Remember to increment button to next factor number before entering new factors.

### 1.2.3 Display Data

Press DATA/FACTOR/DISPLAY button. ILT1700 is now ready to display data.

### 1.2.4 Bias Selection

Press 5V Bias button if you are using vacuum photodiode type detector (SED240 or SED220), or for flash measurements.

### 1.2.5 Zero The Detector

Cover detector with opaque object, wait ten seconds and press ZERO button. For ambient zero simply press zero button for over one second and release. (will subtract current zero from all future readings) To return to internal zero, unplug the detector and press zero.

### 1.2.6 Select Measurement Mode

Select measurement function by pressing either D.C. (signal) button or INT button for continuous or integrated readings. Remember INT will sum up the signal over that integration time and D.C. mode will read the average steady state light levels.

## 1.3 Begin to Measure

### 1.3.1 Install Detector

Plug a detector into the Sensor Input. Select the appropriate calibration factor for that sensor combination using the factor select button.

### 1.3.2 Zero the Detector

First you must decide if you want a dark zero, or an ambient zero. An ambient zero will subtract the ambient light levels from future readings, remove the black protective cap and press zero for over one second. If you want a dark zero, assure the black cap is on or cover sensor with an opaque object, wait 10 seconds then press zero for over one second. Wait for zero LED to turn off. (for high gain and thermopile detectors, do not hold the sensor while zeroing, and be sure to completely block all light with an opaque object)

### 1.3.3 Operating in D.C. Signal Mode

The ILT1700 default operating mode is D.C.(signal) mode. If the D.C. LED is not lit, press the D.C. button to enter D.C. mode. The ILT1700 samples continuously, updating the display every half second.

To measure as a percentage of a known peak value, first establish the peak condition, then press the SET 100% button. ILT1700 reads as a PERCENTAGE of the set value.

To measure within a fixed range, turn off the Auto Range feature by pressing the **AUTO RANGE** button. The exponent on the display will not change when the Auto Range LED is off. The ILT1700 default setting is Auto Range On.

Hold a reading temporarily by pressing the HOLD button. This freezes the display for use in a darkroom.

### 1.3.4 Operating in Integrate Mode

Press the INT button to begin integrating (summing) all readings. This feature is useful for making dose measurements.

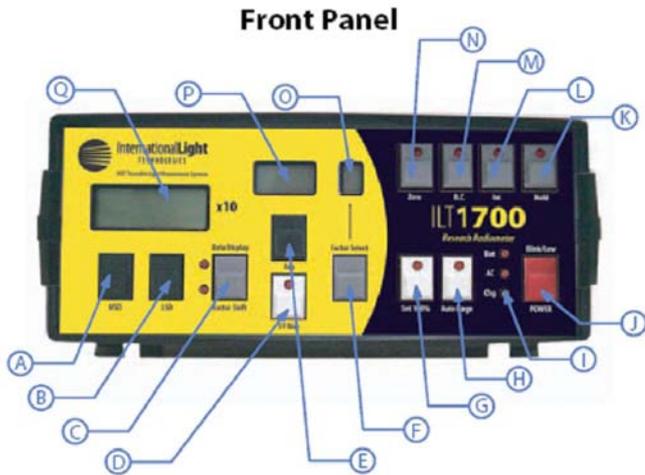
Press the HOLD button to temporarily pause the display. The integration continues, however, allowing you to write down interim readings.

Press the HOLD button again to continue displaying the ongoing integration.

Note: the Zero level that you set previously is subtracted continuously from all integrated readings. You can reset the Zero and integral in Integrate mode by pressing the ZERO button in the dark or ambient condition.

Press the D.C. button to stop the integration.

# 2. Controls



## 2.1 FRONT PANEL

### 2.1.1 Power Controls

Before pressing the “POWER” button to turn the unit on, be sure you have selected the correct AC voltage (see 2.2.2) In the lower right hand corner are three LED’s and one POWER (on/off) button. If all the lights are off, the unit is completely turned off. If the ‘BAT’ light is lit, the power is coming from the six (6) internal rechargeable batteries and the unit will shut off after approx. 6 minutes. For longer durations, you must select one of the next three sources of power, as indicated by the ‘AC’ light: 115 volts AC, 230 volts AC, or 8 to 15 volts DC (through the auxiliary input). If the ‘CHG’ light is lit, the unit is off and the internal batteries are being charged. A blinking battery light indicates a low battery. Either the battery must be recharged or replaced as necessary (see section 2.2.1 for details). **CAUTION: DO NOT USE ALKALINE BATTERIES.** If the AC light blinks, the internal power supply voltages are out of regulation, which may mean the line voltage is too low or there has been a component failure in the system.

### 2.1.2 Function Controls

In the upper right hand quadrant of the front panel are the ‘FUNCTION’ Controls, consisting of four (4) push-buttons, marked ‘ZERO’, ‘D.C.’, ‘INT’, and ‘HOLD’. The unit will start up in the ‘D.C.’ state, ready to read average steady state light levels. The averaging is done over a period of exactly 0.5 second unless the level is extremely low. At that point, averaging of one second or two seconds will automatically be selected to get a better reading and smooth out unwanted noise.

If you cover up the detector and press the ‘ZERO’ button, the unit will take a reading of this low level and subtract that reading from all future readings, thereby establishing the ‘ZERO’ reference condition. This ‘ZERO’ can be any reference level, such as the ambient room illumination. If an additional light is turned on, the added magnitude will read out, exclusive of the room lights. **BE SURE TO CHECK THE ZERO BEFORE TAKING A MEASUREMENT.** Failure to do so is the biggest cause for erroneous readings. To return to internal zero, unplug the detector and press zero.

The button marked ‘INT’ stands for integrate. By pressing ‘INT’ the unit begins to sum up all the energy over time until you press ‘HOLD’, which terminates the integration and displays the final results. Integration is also useful for flash integrations and for long term averaging of irregular sources such as arc welding equipment. See section 3.3 for more details on integration.

The button marked ‘HOLD’ freezes the last D.C. reading or displays the sum of the integration. If you go back into the integrate mode by pressing ‘INT’, the sum will continue to be added to the previous integration. Pressing ‘ZERO’ or ‘D.C.’ will reset the display to zero and put the instrument in the D.C. mode.

### 2.1.3 Readout Display

The user gets readings from the Liquid Crystal Display characters (upper left quadrant of panel), with signal data displayed in either scientific notation or in percentage, and programmed sensitivity factors displayed in scientific notation. In scientific notation, the display gives the mantissa and the power of 10 exponent. The mantissa consists of three and a half digits that range from 1.000 to 9.99. The exponent can range from -19 to +19 which covers 39 decades of readout range. This is more than will ever be needed, but it does allow for large excursions of light level, as well as a wide variation of units used in measuring light.

For example if you wanted to make the system readout night levels of irradiance ( $W/cm^2$ ) with a photomultiplier, you might get answers as low as  $1.00e^{-15} W/cm^2$ . Likewise if you were reading the photometric light level in outer space, it might read  $1.000e^{+5} lux$ . In these examples the readout had to span 21 decades for two different applications. The letter “e” is used to designate the exponent part (to the base of 10).

### 2.1.4 Display Selector

The button marked ‘DATADISPLAY’ and ‘FACTOR SHIFT’ above and below respectively, is used to select whether the LCD Display will show light readings or the present sensitivity factor in use. There are two lights along the side of this button to show which mode the display is in. This toggles back and forth for each press of the button. The displaying of optical data was discussed in 2.1.3 above. In the factor mode four (4) more buttons become active to select any of 10 different sensitivity factors, or to change any factor (see 2.1.5 and 2.1.6 below).

### 2.1.5 Factor Selector

In the center of the panel is a bracketed area labeled 'FACTOR SHIFT', which has a button and a one digit readout. If the 'DATA DISPLAY' mode is set to factor, then the user can select any of 10 different user programmable sensitivity factors (0-9) that could apply to different detectors or to different combinations of detector, filter, and diffuser. These factors are obtained from the calibration certificate for your particular system. If you want to read out in current (amperes), dial in  $1.000e^0$ . See the next section for changing factors

### 2.1.6 Changing Factors

There are three BLACK buttons on the left side of the front panel used for changing the sensitivity factors. They are marked 'MSD', 'LSD', and 'EXP', which stand for Most Significant Digits, Least Significant Digits, and exponent, respectively. The 'MSD' button increments the left two digits of the mantissa, from 1.0 to 9. The 'LSD' button increments the right two digits of the mantissa, from 00 to 99. By holding these buttons down (when in 'FACTOR' mode), the mantissa digits will increment exponentially up to a higher value, from 1.000 to 9.99. The 'EXP' button performs a similar function, incrementing the exponent digit from  $e^{-19}$  to  $e^{+19}$ . A full explanation on factor entry is covered in section 3.2.3.

### 2.1.7 Bias Voltage

The white button (low center) labeled '5 V BIAS', reverse biases semiconductor detectors with 5 volts, or it adds an additional 5 Volt reverse voltage to any vacuum photodiode for a total reverse selection of 14 volts. In other words, a silicon detector can be operated without any bias (photovoltaic mode) for low level and D.C. readings, or with a 5 volt bias, which increases the speed of response for flash measurements. A vacuum photodiode always needs a bias, so it is wired in the connector to give a bias choice of either 9 volts (5 V bias light off), or 14 volts (5 V bias light on). The bias ON is always the right choice for vacuum photodiodes (see details in section 3.4.1).

### 2.1.8 Auto Range

The white button on the lower right side of the front panel, labeled 'AUTO RANGE', gives the user the option to limit the ranging ability of the system, so one can notice gross changes in readings at a glance due to either the 'HI' indication for too bright, or a very small mantissa for a level too low. The alternate action of this button selects or de-selects 'AUTO RANGE'. If you are over-ranged and wish to re-establish a new level, you must toggle the function into 'AUTO RANGE', then turn off the 'AUTO RANGE' mode again. See section 3.2.2 for more details on the use of this control.

### 2.1.9 Percentage Mode

The other white button in the lower right corner of the panel selects a relative mode by making the display reading equal 100.0, and referencing all subsequent readings to this original value. These readings are a percentage of that original value. This is very useful for making transmission measurements or reflectance measurements directly. You must establish a reference for the 100% value, by removing the filter between the light source and the detector or by using a white reflectance standard for the 100% condition.

There are many applications that require relative measurements, such as attenuation measurements through an optical system, or comparisons between two light sources. For example you could turn on one light and set to 100%. Then turn that light off and turn the unknown light on to read the relative value compared to the first lamp. Since percentage mode disables the auto-range, the largest relative reading possible is 1999% and the smallest is 0.1%.

## 2.2 REAR PANEL

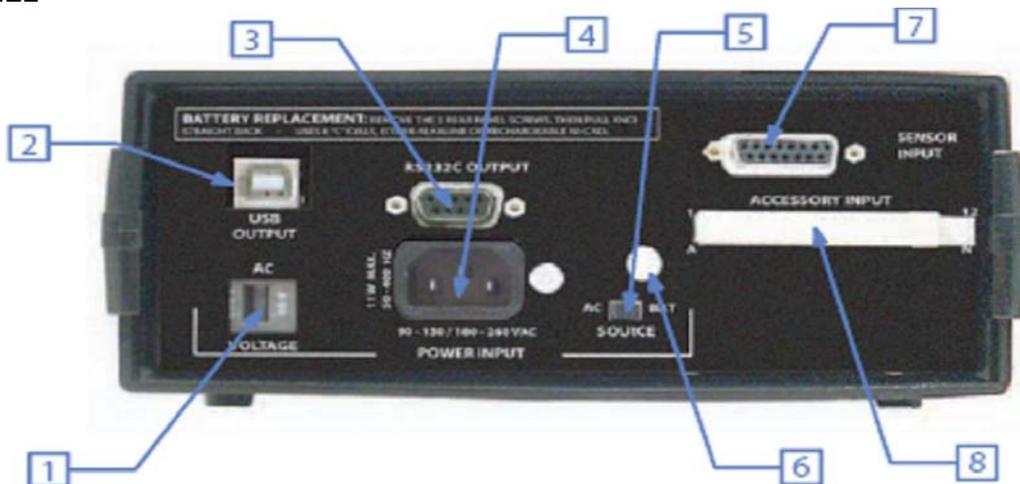
### 2.2.1 Battery Replacement

In the very upper left corner is a printed message which gives a brief description of how to insert or replace the internal batteries. The back panel is tricky to remove, especially on new units, because everything fits tightly. You must remove the three nickel-plated Phillips screws on older models. Note: The larger screw goes to the right of the power input connector. On Newer model there are 4 nuts, 2 beside the sensor input and two beside the RS232 connector and one Philips head screw at the power cord connector. Once you remove all screws, you must pull the back panel to the rear by pulling on battery access pull knob (see 6 in above diagram) with a pair of pliers. To avoid marring the knob, we suggest you put tape on the knob before you grasp it with the pliers. While pulling, you should direct your force up and down to work the assembly to the rear. Be careful when it lets go, so you do not allow it to move too rapidly. There are two battery wires that could be broken if care is not used. Also be careful to notice if one of the circuit boards is pulled back with the rear panel. It should NOT be pulled back. Free the board from the rear panel and carefully push the board back into position so it is even with the one above it. Set the rear panel assembly on a table close to the unit without stretching the two wires. You will now have free access to the battery compartment which holds six (6) 'C' (NICAD ONLY) cells.

### 2.2.2 AC Voltage

The ILT1700 will come with the AC switch set to 115VAC, it is very important that you check the switch prior to use. The two choices are 115 (90-130) Volts AC, which is common throughout most of North America, and 230 (180-240) Volts AC, which is common throughout most of Europe. In some parts of the world (Japan, for instance), the common voltage is 100 VAC, which is accommodated on the 115 VAC selection. You make a selection by inserting a pointed tool, such as a screwdriver, into the slot, to slide the switch left or right (115 or 230 volts respectively).

## 2.2 REAR PANEL



1. AC voltage
2. USB Connector
3. 9-pin RS232C serial connector
4. AC power cord connector

5. Power source select switch
6. Battery access pull knob
7. Detector input
8. Accessory I/O

### 2.2.3 USB Output

In the upper left side of the rear panel above the AC Voltage switch is an industry standard USB output. The new USB is 2.0 compatible and backwards compatible with USB 1.1. See section 4.5 for instructions on use.

### 2.2.4 RS232C Digital Output

This is an industry standard serial interface which is configured as a DCE device. Cables are available for conversion from DCE to DTE for use with PL 9 pin typical cable.

### 2.2.5 Power Input

Item 4 to the right of the AC Voltage switch is the 'POWER INPUT' connector. This is an international type of connector to accept the source of AC power. We provide a cable with an American type of plug on it. You may have to cut this plug off and replace it with one which is acceptable in your area. If you need to do this, be advised that the green/yellow wire is the GROUND (earth) line. The blue wire is the 'NEUTRAL', and the brown wire is the 'LINE' or live wire.

### 2.2.6 Power Source

To the right of the power input connector is a slide switch marked 'AC/BAT SOURCE'. This allows the user to select either internal battery operation (BAT), or external power from either Alternating Current (AC) or D.C through the auxiliary input.

### 2.2.7 Sensor Input

In the upper right hand corner of the rear panel is the 15 pin connector marked 'SENSOR INPUT'. This, of course, is where you plug in the light sensor or detector for measuring another parameter. The correct internal voltages for all International Light detectors are provided in the hardware. (see section 5.1.2 for connecting custom sensors).

### 2.2.8 Accessory Input/Output

Below the sensor input we have the 24 pin card edge connector marked 'ACCESSORY INPUT/OUTPUT'. This port is used for remote control applications, some obsolete spectroradiometer systems, production tests, analog output and for future new product developments (see section 6.0 for more on this).

### 2.2.9 Battery access knob

See 2.2.1 battery replacement on how to use knob.

## 3. Operation

### 3.1 Power Selection

The ILT1700 can operate from seven different sources of power as follows:

- Six internal Nicad Rechargeable 'C' cell batteries (purchase separately)
- External DC power supply or battery (8 to 15 VDC)
- Mobile power (thru cigarette lighter)
- 115 VAC/50-400 Hz (Power cord supplied)
- 90-100 VAC/60-400 Hz (Change plug on power cord as needed)
- 180-240VAC/50-400 Hz (Change plug on power cord)

Due to the varied applications and the world wide market, it has been necessary to offer a very universal instrument as far as power selection. The internal batteries are necessary for any application which requires on site inspections or site surveys, such as health hazard or field study applications.

External mobile power may be used to recharge the internal rechargeable batteries via a vehicle's cigarette lighter outlet, or the instrument may be powered directly from the vehicle. On occasion, an instrument must be used at a remote location where only a DC source of power is available. Typical applications might be in space vessels or in long term remote environmental stations that are solar powered. Last but not least, we will mention the most common power source: the locally available AC power from the line outlet. Several choices of input line voltage make the ILT1700 usable any where in the world.

### 3.1.1 AC Power

Section 2.2 described the location of the power socket (connector) on the rear panel. The ILT1700 is supplied with a two meter (7 feet) power cord that has the appropriate connector to mate with the instrument on one end and a plug that is approved in North America for compatibility with a standard 115 VAC wall outlet. **Before applying power, be sure to check the rear panel slide switch marked 'AC VOLTAGE'.** If the switch needs to be changed see 2.2.2. The instrument draws less than 11 watts, (about 10% of that consumed by a standard light bulb), so it can be used on very low power circuits.

### 3.1.2 Internal Battery Power

For many applications, it is necessary to carry the instrument around to survey different areas. The ILT1700 can be used with 6 re-chargeable nickel cadmium batteries, available from International Light as accessory number A417. (ILT will install, charge and test the batteries prior to use when the A417 is purchased.) These batteries will run the system for about five (5) hours on one charge, which is approximately 50 measurement sessions. Recharging typically takes 14 hours and can be done overnight. Battery installation can be accomplished by following the directions outlined in section 2.2.1.

### 3.1.3 External Mobile or Battery Power

External DC (direct current) power may be applied through pin 'C' of the accessory connector in the voltage range of 8 to 15 volts, where pin 'C' is positive, and pin 1 (or pin A) is the ground pin. This input is protected for reverse polarity, and handles a very large range of direct current. The ability to accommodate such a wide range permits use of even a solar battery that is nominally rated at 12 volts, yet varies substantially. Mobile power may be used to recharge the internal nickel cadmium batteries, making extended field use possible where AC power lines are not available. Another reason for using the external power is to avoid the automatic timed shut off. If field measurements are to be made throughout the day, an external battery (such as a 12 volt lantern battery or car battery) can be hooked up to the ILT1700 to run the unit for about three weeks at 9 hours a day.

## 3.2 C.W. Measurements

The 'C.W.' stands for 'Continuous Wave', which is also referred to as D.C. Measurements (a carry over from the electronics field, meaning Direct Current) or signal mode. In other words, we are referring to those measurements where the magnitude of the light level remains reasonably stable when averaged over any half second interval. The light output from a fluorescent lamp actually consists of pulses emitted 100-120 times per second (twice the line frequency), but we consider that to be C.W. since our eyes cannot detect the flicker. The instrument is similar to the eye, in that it integrates for a half second, displaying the average over that interval. If this average is repeatable, we will get the same reading on the instrument over a long measurement interval.

### 3.2.1 Zeroing

One of the most important controls on this instrument is the 'ZERO' button. This button does not do an internal zero, as some users might expect. It actually subtracts the present reading from itself and from all future readings. It also remembers this condition even if the unit is turned off. That means if the previous user set the zero to subtract a large amount of light, it will continue to subtract that same magnitude until you correct it. This can be a very powerful control if used correctly. For example, let's suppose you want to make a measurement of a light source, but you do not want to turn the room lights completely off. One method would be to make a measurement with the sample light on, and a second measurement with the sample off, and subtract the two from each other to give you the difference, which will be the value of the unknown source. Using the zero function you can do this automatically in just one measurement, without the external subtraction. Simply press the zero button when the sample light is off. Turn the sample on and read its contribution directly on the meter.

If your requirement is to read all the light present and you want the best possible zero, you must cover the detector with an opaque object (or place it face down on an opaque surface), wait ten (10) seconds, and press the 'ZERO' button. It takes several seconds to produce a low level zero due to the ranging over several decades plus the automatic extension of the sampling time when the signal gets small for increased sensitivity. This sampling can be as long as two (2) seconds and requires several sample periods to go down to its most sensitive range. If you are impatient, you can watch the exponent drop down three (3) decades below the level you want to measure. Then press 'ZERO' even though the number does not read zero, because it will be less than 0.1% of the level you are about to read, which is good enough for accuracy of one part in a thousand. For an absolute zero, you must have the detector covered extremely well to seal all light leaks, and then you must wait the full 10 seconds before the system settles down to the lowest level, before pressing the 'zero' button. Another method to restore the meter to absolute zero is to remove the detector and press the zero button.

### 3.2.2 Range Selection

Most users will find the auto range mode the best choice when using the Radiometer. This is the initialization default mode which will display any magnitude automatically, as long as a proper previous zero had been performed (see the previous section) and the correct sensitivity factor is programmed and selected (see the next section). There are two other range choices, that may apply for special circumstances. If many repetitive measurements are to be made, it is often desirable to turn the auto range mode off, which essentially freezes the range exponent, so the user is alerted to a large change in signal by the fact that the mantissa will either show several zero digits, for a low reading, or will read 'HI', to indicate an upward range change. In scientific notation, you could experience a tenfold change in the light level, which might go unnoticed because the exponent is the only obvious digit that changed. By turning the automatic feature off, it becomes more obvious that a significant change has occurred. Another reason to turn the auto range off is to read a zero that occurs quickly as described under 'zeroing in section 3.2.1 above. The third range choice is 'percent mode', and is described in section 3.2.4.

### 3.2.3 Programming

The Radiometer performs subtraction, as mentioned in the zeroing section (3.2.1). It also calculates ratios as described in the next section (3.2.4), but for most measurements it is required to scale the answers by a sensitivity factor in order to read directly in your desired optical units. This scaling is done internally by dividing the electrical current coming from the input device by one of ten (10) sensitivity factors, and then displaying the result in floating point arithmetic, on the front panel. These answers can range from  $0.00 \times 10^{-19}$  to  $9.99 \times 10^{+19}$ .

3.2.3.1 Current Measurements - If you want to read the electrical current, you may select a factor of  $1.00 \times 10^{+0}$  (which is 1). The answer will be displayed in amperes. These are good units for any sensor that is not calibrated, because a subsequent calibration would permit you to reconstruct the absolute data. The best policy is to obtain a calibration sensitivity factor for the detector assembly at the time of purchase, so that direct readings can be obtained immediately.

3.2.3.2 Entering Factory Calibrated Factors - The factory calibration provides a sensitivity factor that appears on the calibration certificate in units with amperes (A) in the numerator and the desired readout units in the denominator. When the instrument divides the current (amperes) by this factor, the ampere term drops out leaving the final desired optical units on the display.

You may store ten factors (in registers 0 to 9) for future selection. Each factor is designated by a number in the factor select window. (See 3.2.3.3 below) We suggest that you store  $1.000 \times 10^{+0}$  as one of the entries, for reading in units of current (amperes)

To enter a factor, turn the instrument on, toggle the 'DATA DISPLAY' button to 'FACTOR SHIFT', then increment the 'FACTOR' to read the register you wish to change (0 to 9). Now use the three black buttons marked 'MSD', 'LSD', AND 'EXP' to enter the number in scientific

notation, just as it appears on the calibration certificate. By holding a button in, the display will begin to roll faster, so you can rapidly increment to a number some distance away. As you approach the desired number, pulse the button one step at a time

3.2.3.3 Sensitivity Factor Selection (0-9) - The last window is the 'FACTOR SHIFT' readout. It shows the user which of 10 stored factors has been selected. Each detector/filter/optic combination has a unique calibration factor therefore one detector can require several factors for different combinations or readout units. Also at different wavelengths there may be additional sensitivity factors, so the wavelength would determine the 'FACTOR SHIFT' number used. This is changed by switching to the 'FACTOR' mode on the DISPLAY switch, and then incrementing the 'FACTOR SHIFT' button to arrive at the desired factor number.

3.2.3.4 Self Calibration Technique - These factors may also be used for customizing readouts in relative units that pertain to your particular system. For example; an optical throughput, in a hypothetical system, may be adjusted at the factory to a particular magnitude, such as 150 ( $1.500 \times 10^{+2}$  on display). By selecting the right factor, you can make the instrument also read 150 for that desired magnitude. The ILT1700 can then be used for a subsequent quality control check to adjust production units to have the same nominal output. Another relative application could be to obtain a precise correlation between departments. A standard source would be used as a reference so all measurement systems would be set to read the same from the same source. This type of 'in house' calibration can provide an accuracy better than one percent, without having to refer back to the reference source very often, especially if using a silicon detectors which are generally more stable than standard sources.

Self Calibrating Procedure: (ZERO METER FIRST)

- A. Enter the ultimate display reading into one of the 10 factor registers, by pressing the DATA DISPLAY button to 'FACTOR SHIFT' mode, and by using the MSD and LSD buttons to enter the number (in scientific notation).
- B. Switch back to the 'DATA' mode and take a reading. Record this on paper for the next step.
- C. Enter the reading from step 'B', into one of the 10 registers as you did in step 'A'. You can use the same register, the last number is no longer needed.
- D. Now switch back to the 'DATA' mode again and read the same optical signal. It should display the number you were trying to calibrate to in the first place.

### 3.2.4 Percent Mode

There are two very common optical uses for the percent mode, transmission and reflectance. Both measurements require the use of a stable light source. By stable, I mean that it will remain constant during the measurement procedure. Modest accuracy can be achieved with a line powered lamp, but for good long term repeatability, we recommend an electronic regulator. (The visible output from an incandescent lamp changes 3% for each 1% change in voltage). The first step is to set up baffles so the light travels directly from the lamp

to the detector, and not via a reflection from some other surface. The second step is to put an aperture between the light and the detector that is smaller in diameter than the size of the sample filter to be measured.

Next make an opaque shutter that can be put over the aperture to make a zero measurement. With the light cut off, press 'ZERO'. Now remove the shutter without moving any of the baffles or aperture. Press 'SET 100%', which will be your reference condition. The meter will read 100.0 at this time. Now tape or mount your sample filter over the aperture (again without changing the physical location of baffles or aperture), and read the transmission directly on the ILT1700.

There are many spectral factors that must be considered when making a transmission measurement. If you want to know the transmission at one wavelength, it will be necessary to use an interference filter to establish monochromatic light before inserting the unknown filter. A lamp plus monochromator can be used to create a tunable monochromatic source, for making a full spectral transmission plot of the sample filter. A 100% reading must be established at each wavelength since the source/monochromator combination will not be constant at each wavelength. Often it is required to determine the attenuation of an unknown filter material for a particular source used in your system. In that case the only way to get the same spectrum, is to duplicate the light used in the system in question. (Reflectance and system throughput are two more examples of uses for the percent mode. See section 8.8 for details.)

### 3.2.5 Readout (Scientific Notation)

Most people with a technical background are completely familiar with scientific notation, and will have no difficulty interpreting the data on the display. For the remaining users and as a review, we will briefly describe the notation and how it relates to the readout.

There are two major parts to the readout: 1) The mantissa is a three and a half (3 1/2) digit detailed portion of the answer. It is designed to give at least 3 digits of resolution, with the smallest increment less than one part in 200 for a readable answer better than 0.5%. 2) The second part is the exponential portion, that tells which decade the mantissa belongs in. In other words, the exponent is a multiplier by powers of 10. If the exponent is zero, you would multiply by ten raised to the zero power, which is the same as multiplying by one. Likewise, an exponent of three (3) would mean you multiply by one thousand (1000), and so on. This system is necessary to handle the extremely large change in light magnitude, and the tremendous variation in measurement units. As an example, your eye can see in an environment which can have a brightness change of one million to one. If you couple this with the variety of optical units, you can span more than 21 decades of readout. Our instrument has been designed with the ability to display magnitudes over 39 decades, just in case you come up with a new variation. When in the 'FACTOR' mode, the display also reads out in scientific notation, which is the same as presented on the calibration certificate.

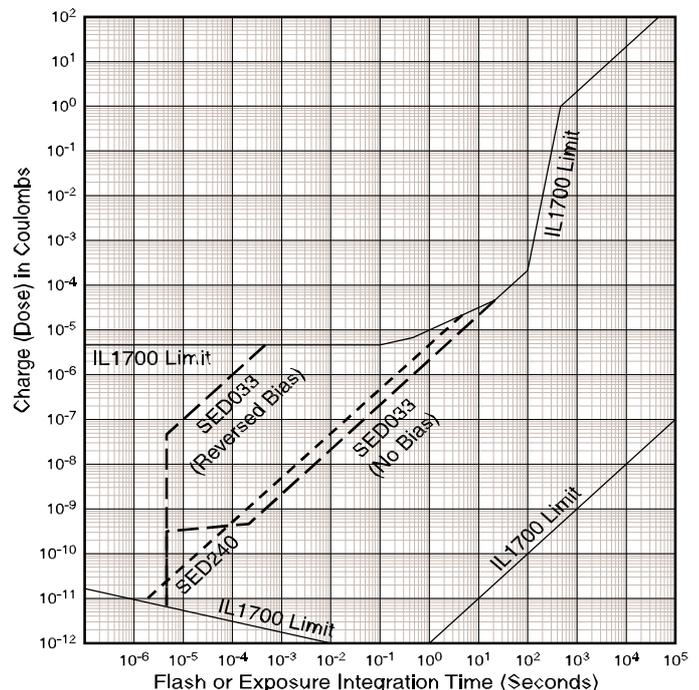
There is one more mode of readout which is the percent mode. By pressing 'SET 100%' the system will read in relative units, referenced to the magnitude existing when the 'SET 100%' was pressed. The exponent will not be used in this mode of operation, and auto ranging is turned off.

### 3.2.6 Darkroom Readings

The liquid crystal display relies upon reflectance of available light therefore it will not readout in the dark. Our solution was to locate the 'HOLD' button on the right hand side of the instrument, where it can be easily found in the dark. With your fingers along the right side of the meter, you can press the hold button when in total darkness. The display will hold the reading present when the 'HOLD' button was pressed. This feature also applies to flash integrations, where the final integral will be held on the display until another function button is pressed.

### 3.3 Integration Measurements

The ILT1700 is capable of integrating energy in a flash of light at microsecond speeds as well as integrating for over eighteen years, and everything in between.(with some limitations). The chart below shows the charge conditions that can be measured. The chart covers a very large dynamic range, which can be misleading at a glance. On the lower right side of the chart the instrument is limited by detector current. On the lower left side, the limitation is due to charge insufficiency. The upper left corner is restricted by peak current limitations of the detector. The upper middle is limited by the conversion rate of the instrument. Finally the highest charges (upper centers) are limited by maximum detector current again. Even with all of those boundaries, the ILT1700 operates over more than 6 decades of charge ranges and more than a dozen decades of time ranges. To relate this chart to optical measurements you must multiply the energy you wish to measure, in units of either Joules or Joules per centimeter square, by the sensitivity factor of your detector. This product will give the charge that can be plotted on this chart. By the way, a Joule is equal to a Watt\*second, in case your units are broken out into the power component.



### 3.3.1 Integration Zero

A 'ZERO' state for integration is when the first derivative of the output is zero. In other words, a non-changing output. To get this state, the integral of any unwanted input signal must be measured and subtracted from the integral of the total signal. 'Unwanted' can mean ambient light or some detector dark current contribution. An example may be the best way to shed some 'light' on the subject. Suppose we are in a room with two table lamps in it, called 'A' and 'B'. 'A' is left on so you can see what you are doing, and 'B' is the sample lamp to be measured. With 'B' off, you would press 'ZERO' so the signal dose from 'A' will be ignored. The ILT1700 must measure this incoming signal from 'A', which will subsequently be removed from the total integral. This requires subtracting the product of 'A' times the integral time from the total integral produced by 'A' and 'B' together. Fortunately, this is all done for you by the internal computer. Another thing that is done automatically is the zeroing of the dose accumulation registers at the time you press the 'INT' button. If you zeroed on 'A' and never turned 'B' on, the accumulated dose should be essentially zero, or equal to any small change in 'A' as compared to its value when the 'ZERO' button was pressed. This change can be positive or negative, depending upon whether 'A' got a little brighter or dimmer, respectively. It is reasonable to make sure your sample lamps dose is much greater than any zeroed dose, to be sure that small changes in the ambient will not effect the accuracy of the final result. **A good rule of thumb is to try to keep your signal contribution at least 10 times larger than the ambient contribution.** This may require working in the dark, which can be done by either remote control from another room or by pressing the hold button while still in the dark, and then taking the data with the lights turned on (See section 3.3.6 for more on this).

### 3.3.2 Long Term Integration

Any integration longer than one second is considered long term integration. In this state, the ILT1700 keeps up with the incoming signals, and presents an updated readout of the progress every 1/2 second. A proper zero should be done prior to use of integration. As soon as the 'INT' button is pressed, the integration begins. When the 'HOLD' button is pressed the integration ends and reads out the final integral. If you wish to continue integration without restarting, adding the new dose to the old dose, just press 'INT' again, and 'HOLD' when you want to stop. If you want to start over again from zero, then press 'D.C.' or 'ZERO' before the 'INT' button. If you press 'INT' two times in a row, the system will start a new integration at the time of the second press. This can be useful for multiple exposures, assuming the light is momentarily off to permit time for readout or transfer to a computer or printer. A press of 'INT' starts the next cycle without any other buttons being pressed.

There is no limit to how long you can integrate. The system will maintain perfect accuracy for over 18 years even if the signal is the maximum permitted into the ILT1700. There is no loss of accuracy for extended integrations, and the auto ranging keeps track of the magnitude no matter how large it gets.

### 3.3.3 Flash measurements

The procedure for making flash measurements requires the use of three other function buttons. We start with the '5V BIAS' button. IT IS NECESSARY to reverse bias the detector to make the detector respond faster, as well as to be able to handle the high peak currents without saturating and also to provide bias compliance to an input charge circuit which temporarily holds the charge long enough for the precision charge measurement to be performed. In other words the red '5V BIAS' LED should be lit when making any flash measurement at speeds faster than one second. The 'ZERO' button is used to cancel out any unwanted ambient contribution that is present before and during the flash (see previous section). Next, press the 'INT' button just before the flash is to occur, or if you wish, you may use the 'FLASH not' output line (pin 9) to activate the flash event (see section 6.1 for details). The summation registers will be instantly zeroed and the integration will commence. Two and a half (2.5) seconds after the flash, press the 'HOLD' button to freeze the final result. This extra time is required to fully dump the charge from a temporary holding circuit on the front end of the input system and be displayed by the computer. This permits high speed measurements to occur faster than the computer can keep up with the input. This feature allows the system to handle 6 decades of high speed charge ranges at a sacrifice of summation speed. In fact, it can take up to 2.5 seconds to produce a final answer to 0.1% resolution. This does not pose any difficulty in any application that can operate in a 'one-shot' mode. However, if there are multiple flashes, you must use a shutter to capture one flash, or integrate for a known number of flashes, and divide the answer by that number. Often it is possible to turn off the power supply to the flash lamp after the required number of flashes has occurred. This will permit the summation time (2.5 seconds) to occur.

### 3.3.4 Averaging

As mentioned above on the subject of multiple flashes, the system can be used to find the average of many flashes. This is done by integrating throughout many flashes. By maintaining a count of the flashes and dividing by that number, you will arrive at the average output from one flash. Another form of averaging is that which occurs as the result of a very irregular light output. An example of such a source is an arc welding process. If you wished to find the average ultraviolet dose the welder might receive during a work day, you could leave the Radiometer running in the integrate mode all day long, or you could integrate for a reasonable length of time to determine the dose for part of a day, then multiply by the number of daily portions representative in the work day to find the total accumulation

### 3.3.5 Readout (Scientific Notation)

The display reads the total dose in scientific notation (see section 3.2.5 for an explanation). When integrating, the readout is a summation of light over a period of time. The units of readout become the product of the Illuminance or Irradiance times time. As an example, suppose you were integrating to determine the exposure for UV curing. The detector would be reading instantaneous irradiance in units of Watts per Square centimeter ( $\text{W}/\text{cm}^2$ ), but the exposure would be in 'Watt seconds per square centimeter' ( $\text{W} \cdot \text{sec}/\text{cm}^2$ ), and since a Watt second is equal to a Joule it would be in Joules per square centimeter ( $\text{J}/\text{cm}^2$ ). If you are dealing with small doses, the answer may be expressed in millijoules per square centimeter ( $\text{mJ}/\text{cm}^2$ ), by multiplying the answer by 1000, and similarly in microjoules per square centimeter ( $\mu\text{J}/\text{cm}^2$ ) by multiplying by 1,000,000. For example if the instrument displays ' $1.234 \times 10^{-2} \text{ J}/\text{cm}^2$ ', you can multiply by 1000 to get  $12.34 \text{ mJ}/\text{cm}^2$  as your answer.

### 3.3.6 Darkroom Integration

When integrating in the dark, you must be able to easily find two buttons. The first is the 'INT' which can easily be found by placing the palm of your hand on the right side of the instrument and feeling over for the second button from the right with your thumb. In a similar manner, you will locate the 'HOLD' button to stop the integration. This is the easiest to find since it is the first button in from the right side. Once 'HOLD' has been pressed the lights may be turned on to make the readout without changing the reading. It is also possible to operate the instrument with a remote cable from another room, and to print the answers on a small printer, or by sending the data to a computer over the RS232C or USB interface (see sections 4. & 6. for more on this).

## 3.4 Bias Selection

As mentioned in section 2.1 (front panel controls), there is a bias button labeled '5V BIAS'. This raises the input node of the input amplifier up to +5 volts which, in turn, reverse biases a silicon detector with 5 volts. If it is a vacuum photodiode, it adds another 5 volt bias to the 9 volts that is already applied to the cathode of the phototube, making the total reverse bias of 14 volts. See the following sections for more details.

### 3.4.1 Vacuum Photodiode Bias

Vacuum Photodiodes always require a bias voltage to operate properly. All of the International Light Vacuum Photodiodes will operate properly with a bias between 9 and 75 volts. We recommend operating them at the 14 volts provided with the bias ON, so the readings correlate with our calibration lab, and with previous instruments that applied 12 and 15 volts. Another advantage to the larger voltage is the improvement in peak current capability, for maximizing the dynamic range of flash measurements. The difference in D.C. readings between 9 and 15 volts bias, is only about 1%, but to gain that extra accuracy, use it with the '5V BIAS' light on.

### 3.4.2 Flash Bias

Detector bias has the most significant effect on system performance in flash measurements. Semiconductor devices gain in three ways when placed in a reverse biased condition, as opposed to the photovoltaic mode (zero bias). The first improvement is to reduce the junction capacitance, which makes the instantaneous photo current get to the photometer faster, rather than being delayed as a junction charge. The second improvement is the elimination of junction saturation. This happens because the instantaneous photocurrent produces an  $I \cdot R$  drop across the top transparent electrode, which in turn allows the junction voltage to become forward biased, causing junction saturation. The third advantage has to do with the method used to measure the charge from a flash. In order to make the radiometer operate at speeds faster than the clock time of the computer, it is necessary to temporarily store the flash charge, so the charge digitizing circuitry can withdraw this charge and measure it. This temporary storage can handle  $2.00 \times 10^{-6}$  coulombs, so the instrument maintains 6 decades of dynamic range even down to nanosecond speeds. Below 100 microseconds the limitation is due to the peak current of the detector, not the instrument. Our SED033 is designed to handle more than 2.0 milliamps, to still provide 3 decades of useful range at 1 microsecond. By combining this basic capability along with a neutral density attenuator, one can make fast measurements, spanning four or five decades. Anything below one microsecond is not recommended, since a multitude of detector speed limitations, including impedance matching etc., cause inaccuracy.

### 3.4.3 Low Level Bias

When making low light level measurements, it is important to minimize the detector leakage current. With a semiconductor, this can be done by using it in the photovoltaic mode, with NO BIAS on it at all. This also minimizes the temperature effects on the detector due to changes in the internal shunt resistance. Vacuum Photodiodes must always have a bias on them, so they should be operated with the '5 V BIAS' light ON. As part of the detector design, we have minimized detector leakage through the coaxial cable by keeping the current carrying lead at the same potential as the shield lead, even in the reverse bias mode. Vacuum Photodiodes have a good low light level attribute, the absence of  $1/f$  noise. This low frequency (thermal) noise, can be a serious problem for D.C. measurements when using semiconductors. The vacuum photodiode noise advantage tends to compensate for the higher semiconductor responsivity, making them continue to be a very effective transducer, especially for the short wave length measurements in the UV, and for their ability to reject the longer unwanted wavelengths.

# 4. Outputs

## 4.1 LCD Displays

There are actually 12 positions that are computer controlled on the LCD Displays, assuming you count the signs and the decimal points. These are divided up into 8, 3, & 1, for the Mantissa, the Exponent and the Factor selection, respectively.

### 4.1.1 Mantissa (3 & 1/2 digits plus sign)

If we ignore the decimal points, the main LCD Display presents numbers that range from (+/-) 0 to 1999, which is commonly referred to as three and a half digits. The auto ranging capability in the instrument is used to try to maximize the readability of this display, by keeping the number above 199. In this way, the readout is always going to have a resolution better than 0.5%. If the auto ranging is turned off, the number is allowed to drop down to zero. To complete the scientific notation format, the mantissa display presents the sign of the magnitude and always keeps one significant digit to the left of the decimal point. When in percent mode, the Mantissa display moves the decimal point to any of three positions to display numbers that range from 00.00 up to 1999 percent.

### 4.1.2 Exponent (1 & 1/2 digits plus sign)

To be able to span a very great range of light magnitudes, it is necessary to present the answer in scientific notation. The mantissa above would be lost without the exponential terms to determine the magnitude range in powers of 10. The number 10 is raised to the exponential value shown in the exponent window. It can range from -19 through 0 to +19, covering 39 decades of magnitude change. This may sound like it is much more than needed, but we have already had requirements that use 22 of the 39 decades, due to the wide variety of light measurement units, and the extremely wide dynamic range of user measurement needs.

### 4.1.3 Sensitivity Factor Designator (0-9)

The last window is the 'FACTOR SELECT' readout, which shows the user which of 10 stored factors is selected. These factors are held in 10 registers that remain stored even when the power is turned off. The LCD factor designator tells you which factor has been selected out of the 10 choices from 0 to 9. See section 3.2.3.2 for more on changing these factors.

## 4.2 Recorder/Analog Output

The recorder output/analog output is on pin 8 with respect to pin 1 or A on the accessory jack. Refer to 4.21 and 4.22 for more information.

### 4.2.1 Voltage Range

The voltage is designed to be compatible with most strip chart and X-Y recorders, and yet provide a large enough signal to avoid excessive noise pickup. For these reasons, we have selected a range from 0 to 1.0 volt (1000 millivolts). The output will be a voltage that is exactly 10% of the reading of the mantissa. In other words, a mantissa reading of 7.65 would produce .765 volts. If the unit auto ranges (front panel readout of > 9.99 or < 1.000), the recorder output increases or drops by a factor of ten, so the chart scale will stay between 100 and 1000 millivolts, so as to avoid chart recorder overrange. By keeping track of the number of times the plot makes a 10 to 1 range change, it is possible to know your absolute value on each range.

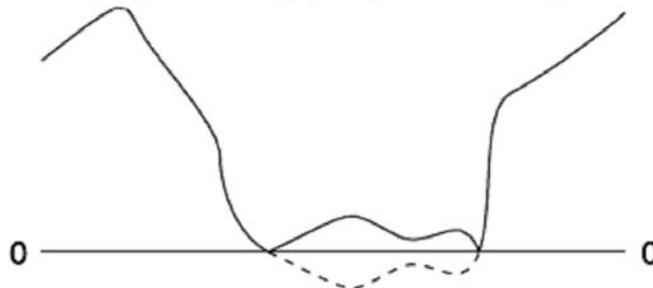
When in the 100% mode, the output reads 10 millivolts per percent, if under 100% (99.0% = 990 mV). When over 100% the output drops a decade to read one millivolt per percent (199% = 199 mV).

### 4.2.2 Auto Ranging Considerations

As briefly mentioned above in section 4.2.1, the chart recorder will automatically stay between 100 to 1000 millivolts. If you are plotting a changing light level, or the output from a spectral scan, the output will abruptly change when either voltage level is reached. It is very obvious from the plot what happened, and what magnitude to place on the data. For example: if the plot is going down and hits the 100 mV lower boundary, the chart recorder will jump to the full scale (1000 mV) position and the plot will continue to come down from that new point of reference. Likewise if it is rising when reaching the 1000 mV boundary, it will drop down to 100 mV and continue on up from that point on. This makes it very convenient for unattended plotting, because you never have to worry about overranging the recorder, or about losing valuable data. If you have an application where you want the chart to go to the traditional zero, you may turn off the auto ranging and the plot will proceed down to zero without autoranging. (You should turn off auto with the meter reading a signal that is close to max. signal.)

### 4.2.3 Negative Readings

Since there is no such thing as negative light, we elected to use a unipolar Digital to Analog (D/A) Converter. This is fine if zero was properly set, and if your ambient conditions do not change throughout the experiment. From our own experiences, we have found that mistakes get made which make the reading occasionally go negative. for example:



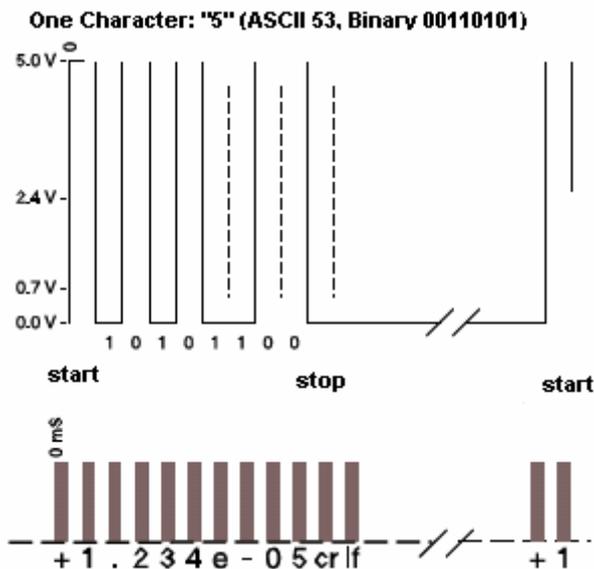
The data will not get lost since the absolute value of the negative reading will be sent out to the recorder. From the plot it is fairly easy to determine that the reading is negative, since the curve comes back up after it hits zero. If in doubt, it would be wise to rerun the experiment.

#### 4.2.4 Output Impedance

The recorder output found on accessory jack impedance is 409 ohms with a 1 microfarad capacitor across it. This gives much less than a 0.1% error when looking into a 1 megohm chart recorder, and gets rid of most radio frequencies. If you want to get rid of all computer generated spikes as well as 60 cycle power noise, we recommend putting a 100 microfarad electrolytic capacitor across the recorder output, preferably located at the chart recorder.

#### 4.2.5 Character Format

The ten (10) bits that make up each character word are comprised of one (1) start bit, eight(8) data bits, and at least one(1) stop bit. Since there is a little delay between words, you can count on at least two stop bits to be present in case your system needs that extra time. The following diagram shows the voltage waveform for this serial word.



#### 4.2.6 Word String Format

The ILT1700 sends out a string of serial words (characters) to transfer the displayed data to other equipment, such as a printer, computer, or modem. There are four different modes of readout: 'auto-range', 'fixed-range', 'percent' and 'factor'. In the first two modes the interface sends out ten (10) to twelve (12) characters with the last being a 'carriage return'. In the percent mode, the port transmits nine (9) characters, with the last being a 'carriage return'. In the first two cases, the extra three (3) or four (4) characters are sent for the exponent including an 'e' to separate the mantissa from the exponent. This makes it very easy for most receiving systems to input the data, using an 'input' statement. If you find difficulty bringing the data string into the computer, you can bring it in as an ASCII text string, then use the letter 'e' along with string manipulation commands to separate the mantissa from the exponent. Since the serial bus is an open circuit when not in use, electrical noise could be picked up on the line before data is transmitted. If this causes a problem, a 47 kilohm resistor can be tied from pin 11 to the active line (either pin 2 or pin3) to pull the signal up to +11 when no data is being transmitted. To guard against receipt of erroneous information, the string can be interrogated for the nine (9) characters before the carriage return, thus rejecting any bogus transmissions from the open line.

## 4.3 NEW USB and RS232

The current model ILT1700 now has improved features for computer connection. The first is the inclusion of a new USB 2.0 compatible (backwards compatible with USB 1.1) output port for sending measurement data to any USB equipped PC. The second upgrade is the replacement of the older 25 -pin D-sub, RS232 serial output connector with a more commonly available 9-pin D-sub connector. Note: The 0-1V output jack has been eliminated on the rear panel, but 0-1V output is still available using the accessory I/O connector, refer to section 6.5 for further information)

### 4.3.1 Setting up a Com port

If you intend to use the new USB port please note the following: You must install a USB driver prior to using the USB port. You should have received a CD with your purchase. If you do not have the CD you will need to contact ILT to obtain a copy.

Upon plugging the ILT1700 into a USB port on a PC, the computer's operating system will detect the instrument and will need to be pointed to the directory where you have extracted the driver .zip file in order to properly install the driver. The installer will install a virtual Com port for the new device. Please make a note of which com port you have selected as you will need this information when running the LabVIEW® drivers. \_\_\_\_\_

## 4.5.2 Serial output

Serial output information for both the RS232 and USB port is as follows:

Baud rate:	4800	Start bits:	1
Data bits:	8	Stop bits:	1
Parity:	None	Hardware:	None or Hardware

## 4.5.3 PC cable connection

ILT1700 to PC cable: DCE to DCE null modem male to female:

ILT1700 end (DB9 Male)    PC Cable End (DB9 Female)

Pin 3 Transmit data-----	Pin 2 Receive data
Pin 5 System Ground-----	Pin 5 System ground
Pin 7 RTS-----	Pin 8 CTS
Pin 4 DTR -----	Pin 6 DSR

## 4.5.4 Software

The ILT1700.VI driver is a sample LabVIEW® program that allows the end user to perform data acquisition with an ILT1700 Research Radiometer. The VI will run in LabVIEW® 8.2 Full Development System and offers the ability to record readings in either DC, or integrate mode as well as to calculate the percentage of a baseline reading. The data is saved in a tab-delimited text file that can be opened with Excel. Users with LabVIEW® 8.2 Full Development System can customize the VI to meet their unique application requirements.

We also offer an ILT1700.VI program for customers who do not own a copy of LabVIEW® Full Development System. The application is a fully compiled, run-time version of the VI driver. Users can run the program, obtain data from an ILT1700 meter and save it into a file. The program is available for Windows 2000, XP and VISTA.

After you install your COM PORT drivers (4.5.1) you will need to install the complimentary Virtual ILT1700-USB program. (Full installation and operation instructions are provided in the file named ILT1700\_README on the CD.) This software program provides the maximum flexibility and functionality available without sacrificing ease of use. This VI executable displays incoming data in real time and allows the user to save data to a text file for importation into a spreadsheet program.

# 5. Inputs

## 5.1 Light Sensors

The primary purpose of the ILT1700 is to measure light. For this reason we will address the detection input first. We offer a full line of light detection probes which can generally cover any application area one might have. In a few special cases, the user may want to design his own, or may ask us to make a special probe for his/her application. Consult the factory for assistance in that area.

### 5.1.1 International Light Detectors

Light sensors are generally designed for a band of wavelengths, and for a range of magnitude. The ILT1700 has one of the widest dynamic ranges of any instrument available. It can span 10 decades change in irradiance levels, which is equal to or greater than most detectors. By using attenuators, such as the QNDS-3, the dynamic range is pushed up by a factor of 1000 to handle very intense sources. By using a SHD high gain detector or high gain lens (L30) the system can be made more sensitive by a factor of 100.

The SED series detectors were also designed to handle hostile environments. The housing is machined aluminum, which forms a rugged case. "O" ring grooves are designed in to offer a sealed option for dirty environments, and for underwater applications. The underwater model (prefixed with SUD) comes with a 30 meter (100 feet) cable and is pressure tested for 40 meter underwater depth.

The most popular detector is the SED033. This is a silicon detector which has a 33 square millimeter receiving surface, and quartz windows to make it usable down to 200 nanometers wavelength. It is specially made to optimize the dynamic range by maximizing the internal shunt resistance, and by minimizing the series resistance, to enhance low level detection and high current linearity, respectively. The large area makes it usable for optical power detection from lasers and fiber optics, as well as to increase its sensitivity for irradiance and illuminance measurements.

Two vacuum photodiodes (SED240 and SED220) are also very popular for their ability to exclude infra-red, and for their low noise in D.C. operation. A vacuum photodiode does not have 1/F noise, common with all semiconductors. Also, the leakage current is much lower than semiconductors. The light sensing surface has a lower sensitivity, but by making a larger receiver, the sensitivity is recovered, without excessive leakage current. The 'solar blind' SED240 (usable band 200-320) and SED220 (165-320 nm) have the desirable property of rejecting all energy above 320 nanometers. This feature offers short wave detection, even in the presence of abundant long wave radiation. The SED005 UV-Visible GaAsP Detector extends the detection from the short wave UV through the UVA band up to the red portion of the visible (250-675 nm), and yet rejects the infra-red.

For very flat response and long wave detection, we offer the SED623 thermopile detector, which has a built in preamplifier, to transform the tiny light induced voltage signal into an amplified current compatible with the input of the ILT1700. The dynamic range of a thermopile is limited to 4 decades ( $2e^{-5}$  to  $5e^{-1}$  watts per square cm), but the extremely flat spectral response from 200 to 3000 nanometers, often offsets this range limitation.

The full line of detectors offered by ILT covers spectral ranges from 160 nm out to 40,000 nm. All of which can not be covered in this brief review. Please contact the factory for assistance with your requirements.

### 5.1.2 User and Custom Detectors

The detector input port has been designed to be compatible with many types of input devices other than light sensors. Other devices for measuring current, humidity, temperature, nuclear radiation sound levels, weight, etc., are all possible attachments. The 15 pin 'D' connector has several bias voltages available, as well as the front panel controlled 5 volt bias. The system measures negative current (positive electron flow) on pin 6. The return path for the current can be either instrument signal ground (pin 7) or the -9 volt bias available on pin 1. In either case if the front panel bias is selected (5 V BIAS), the input voltage will be raised by 5 additional volts. In other words, if you chose to put the return line to the ground pin 7, the input will rise up to +5 which will reverse bias the input device by 5 volts. This feature also makes it possible to work with photo-conductive devices such as cadmium sulfide or cadmium selenide, by measuring the photoconductance. If the -9 Volt bias is the return, and the 5 V BIAS is selected, there will be a net total of 14 volts across the sensor. To minimize leakage current in a coaxial cable, we provide a 'guard' pin called 'bias common', located on pin 9. This always stays at the same potential as the input pin 6, to minimize cable leakage, even if the actual detector is reverse biased. Be careful not to connect this to ground, since this point is elevated to +5 volts when the 5V BIAS button is pressed.

In addition to these sensor related pins, we have made +5 volts and +15 volts available for other specialized preamplification circuitry, and for other accessory probes. No more than 10 milliamps should be drawn from +15, 5 mA from -9, and less than 50 mA from +5.

I will give an example of the hookup for a two wire silicon detector, since that is the most likely device to be used by a customer. The cathode should go to the input pin 6, the anode and the shield of the coaxial cable should be connected to pin 7. With the 5V BIAS off, the detector will operate in the photovoltaic mode. With the 5V BIAS on, the detector would be reverse biased by 5 volts. For more specific assistance with hooking up a special user device, please contact the factory.

# 6. Accessory I/O

On the middle right side of the instrument rear panel is the 24 pin card edge connector, marked 'ACCESSORY INPUT' or ACCESSORY INPUT OUTPUT (on newer models). This connector permits access to circuitry for test purposes, as well as for special user functions. The two most important functions are remote control and auxiliary power, as described below.

## 6.1 Remote Control

Remote operation for continuous wave (D.C) measurements requires only the RS232C port, with the function set to the auto-range mode. Data will be transmitted when requested via the RQS (ReQuest to Send) line on that interface.

Flash measurements require more control over, and coordination with the instrument, through the 'ACCESSORY PORT'. Either external switch control or standard computer logic will activate the four functions equivalent to the front panel push buttons. The (inverted) FLAS output, goes low once the ILT1700 is ready to integrate. This logic level can be used to trigger the flash lamp, or 'handshake' with a computer device to complete a two way protocol. The following is a list of user inputs:

Pin#	Mnemonic	True Level	Description
10	/ZERO	Low	Zero (not)
L	/SWDN	Low	D.C. (not)
J	/INTG	Low	Integrate (not)
K	/HOLD	Low	Hold (not)
9	/FLAS	Low	Flash (not): output

If mechanical activation is required, a switch closure between any of the above listed inputs, with respect to ground, will activate that function. It is only necessary to

keep the switch closed for 50 milliseconds to assure sampling response from the internal computer. Contact bounce less than 1 millisecond is allowed for reliable operation.

Digital logic, or the output from a computer user port, can be used if it is TTL compatible or if the drive can 'sink' at least 1 milliamp, to a voltage level below 0.8 volts, and allow the level to rise above 3.5 volts (essentially no sourcing necessary) upon release. The low state is the 'true level' in each case. The description, on the previous chart, shows which function key the low state will equate to.

When the ILT1700 is ready to integrate, it will pull pin 9 to a voltage level less than 0.8 volts (assuming the current load is less than 1.3 mA). This occurs in less than 8 milliseconds after /INTG is pulled low. That line can be used to activate a flash lamp for fully automatic operation.

A fully automatic system would pull '/ZERO' low as part of the initialization routine to cancel out any ambient conditions. Some time later, when a test lamp was in position, '/INTG' would be pulled low for more than 50 milliseconds, or until '/FLASH' was sensed. Three seconds

after that '/HOLD' would be pulled low for 50 mS, and RQS would be sent to the RS232C port until serial data begins to be received. The data would be processed, and a new lamp would be inserted in the test station, and '/SWDN' would be pulled low to zero out the integration register. '/INTG' would be pulled low again to start the next cycle, and so on. The 'AUTO-RANGE' feature should be on to handle any magnitude of light source, and the '5V BIAS' generally should be on to increase the detector speed and to handle the large instantaneous charge from the flash.

## 6.2 Test Pins

There are accessory pins that are used during the system test at the factory, but a user normally will not be concerned with any of these except possibly for pin 11 (VRAM), which tests the 'keep alive' voltage for the continuous memory. This should be greater than 2 volts when measured with a high input impedance volt meter, with respect to ground (found on pins A, or 1). Pin 3 is the +5 volt logic power supply voltage, which can be used for external logic as long as it draws less than 50 milliamps.

## 6.3 DC Power

When the internal batteries are used, the instrument automatically turns itself off after about 6 minutes. For field testing, continuous measurements may be desired or it may be beneficial to recharge the internal Nickel-Cadmium batteries from a mobile power source. In either case the Auxiliary input can be used as found on pin C. This auxiliary D.C. (direct current) power must have a potential between +8 and +15 volts with respect to the ground pins(A or 1). This range was chosen to permit use of normal mobile power. We offer an accessory called the A401, which provides a cigarette lighter plug, cable, and accessory connector for such mobile use. If mobile power is not available, the instrument may be operated from any 12 volt battery capable of supplying 380 milliamps for the duration of the experiment.

## 6.4 Analog Output

An analog output pin is available on the accessory connector. It is brought out on pin 8, which uses any of the ground pins 1, A or N, as the signal return path. This signal called RECO.

# 7. Precautions

The ILT1700 has been designed to minimize problems due to improper operation of the instrument. From our 40 years of manufacturing instruments, we have found a few abuses that can cause trouble, as follows:

1) We strongly recommend using only NiCad C-cell rechargeable batteries. Alkaline batteries may leak and destroy the meter if left installed or if accidentally charged. You can buy NiCad rechargeable batteries locally or purchase our rechargeable batteries (A417) that have been proven to operate for over 10 years without any damage due to leakage. When a nickel cadmium battery goes dead, it does not destroy the life of the battery. In fact it is a good idea to run NiCads down to the low limit on occasion, to prevent a charge 'memory' effect

2) If operation is required outside the United States, be sure to check the voltage switch before putting 230 volts into the line cord.

3) Shipping can be a problem if the internal batteries are left inside the instrument. The high 'G' forces associated with a dropped carton, can dislodge a battery that can thereby become destructive to the circuitry inside.

4) Another suggestion regarding shipping. Always ship instrument in A405 case, with additional padding. We have found damage to circuitry even though the shipping carton shows no obvious abuse on the outside. This happens because a lack of packing forces the instrument to decelerate at such a high rate, that P.C. boards etc. can become dislodged.

5) Be sure to check the zero if you are in doubt about when it was last set. The zero level is remembered after the power is turned off. The previous user may have set it to subtract a very high level, which will produce erroneous results for your next measurement.

6) Be careful when measuring UV sources. There are many industrial uses for Ultraviolet light, in UV curing, Photo Resist exposure systems, Printing plate lithography, etc. Proper goggles should be worn that absorb the UV. If in doubt, we offer UV rejecting sun glasses (A26) that are specifically designed to block out all UV.

## 8. Applications

### 8.1 Current and Conductance Measurements

Most light detectors have a linear relationship between the incident irradiance and a current output, as long as the device is biased correctly. For this reason the ILT1700 is a very sophisticated, programmable, current and conductance measuring instrument. Current is measured in the units of Amperes, while conductance is measured in units of Siemens, where a Siemen is the reciprocal of the resistance unit known as the Ohm. There are many other types of transducers that also have an output which is a change of current or conductance. These devices cover measurements in the fields of temperature, pressure, humidity, ionizing radiation, Ph, Voltage, weight, magnetic force, and so on. Since the instrument can be programmed to make the input stimulus read directly in recognized units, it becomes very useful for many other applications above and beyond the measurement of optical radiation.

The ILT1700 has one of the largest dynamic ranges of any instrument on the market. It will read to better than two digit resolution, from  $1e^{-12}$  to  $2e^{-3}$  Amperes and read conductance from  $2e^{-13}$  to  $4e^{-4}$  Siemens (formerly mhos), each of which cover more than nine (9) decades. In addition, it has the ability to integrate these signals from microsecond speeds to 18 years.

#### 8.1.1 Polarity

Most light sensitive devices can be configured to produce a negative current (positive electron flow) easier than a positive current. This is especially true of vacuum photodiodes. Also, one of the simplest detector configurations uses a detector into an operational amplifier, configured in the transconductance mode, to produce a positive output voltage. For this reason, we have chosen to measure negative current from the sensitive input pin 6 with respect to instrument signal ground (pin 7), or with respect to the input guard voltage (pin 9 called 'bias common'), which stays at the same potential as the input even if you apply the 5V BIAS. In other words, by turning on the 5V BIAS, the input (pin 6) and the guard (pin 9) will rise up to +5 volts, with respect to the instrument ground (pin 7). This input configuration permits front panel bias selection for a two terminal device, using the input and the ground. It also allows for a coaxial shield connection at the input potential, using a three wire configuration. This eliminates the shielded cable leakage current. The 3 wire configuration is necessary for measurements below the nanoamp range.

#### 8.1.2 Input Cable

As described above in section 8.1.1, the three pins that are used for current or conductance, are pins 6, 7 & 9, which are the input, ground, and input guard (or bias common), respectively.

#### 8.1.3 Overload

In order to protect the IL1700 we have designed the input to take a great deal of overload. There is a limit, however, due to the sensitive nature of the measured signals. It is impossible to completely protect the input from every kind of abuse. Generally speaking, the input will take about 100 milliamps, either positive or negative current, from DC to 100MHz, for a short time (about 5 seconds). The input will also survive voltages of approximately plus or minus 15 volts for a similar short time durations. This type of protection offers good survival to most modern circuit accidents, and is designed to withstand more R.F.(radio frequency) pick up that may be present in typical user environments. One of the most common R.F. sources is the igniter for arc lamps. These lamps generate about 30,000 volts at about 1 MHz, during ignition. The induced radiation from this process, has been known to destroy volt-ohm meters and other instruments, even when they are not plugged into anything. The coupling is strictly radio frequency transmission to a nearby circuit. This type of damage is not a rare occurrence. If you operate many arc lamps, as we do in our calibration lab, you will find that these problems arise. Since we have had a personal interest in withstanding this kind of damage, we have gone to a great extent to design the proper protection into the ILT1700.

## 8.2 FLUX DENSITY MEASUREMENTS

Most light measurements will be of this type, where flux refers to the rays of light, and density refers to the number of rays per unit area, falling on a measurement plane some distance from a point source of light. This is also the case where the light source will overfill the front of the detector. As an example, the lumen is a unit of flux in the photometric system of measurements. If we wish to measure this flux density, we will select a standard area measurement, such as the square meter, and therefore measure lumens per square meter, commonly referred to as the lux.

Radiometric measurements have the equivalent analogy, which will be developed in 8.2.2. In all flux density measurements, the density will drop off as the measurement plane gets farther from a point light source. This concept makes the reading inversely proportional to the square of the distance from the light source.

### 8.2.1 Photometric Illuminance

(lux, phot, lm/sq.ft, fc, cd, etc) As mentioned above, flux density measurements determine the quantity of optical flux in a unit area. If this measurement is 'Weighted' with the eye response functions (standard observer), the measurement is an Illuminance measurement. Since the photo-optically 'weighted' unit of flux is the lumen, we can measure lumens per square meter (lux), lumen per square centimeter (phot), and the lumen per square foot (fc).

Other units of area are possible but are not commonly used. ILT recommends using lux, since the SI units are recognized world wide. The ILT1700 can be used to measure in any of these units just by reprogramming to a new sensitivity factor. To convert from foot candles to lux, just multiply the number of foot-candles by 10.76 for an answer in lux. If you want to convert a foot-candle sensitivity factor to a lux sensitivity factor, just divide the fc factor by 10.76. For direct reading in both fc and lux you can store both factors in the ILT1700 and toggle between the two factors using the factor select button.

When making an illuminance measurement, it is necessary to overfill the input aperture. To measure lumens per unit area, the detector must have an area less than that of the beam. This area can be much smaller than those defined in the units being used. Obviously a square meter would be an impractical detector size. The input area doesn't even have to be some particular decimal division of a square meter. This area variable is calibrated into the sensitivity factor as part of the calibration procedure. In general there is a practical size that is small enough to be used in most applications, yet large enough to get a good signal to the detector. If you have an application to measure the uniformity profile of a relatively small spot of light, it would be necessary to reduce the detector input down to a

very small hole. This new configuration could be recalibrated by transferring the calibration from the original arrangement to that of the new input structure. The only requirement is a stable light source that is uniform over an area larger than both input configurations. This light is read by the original calibrated detector to determine the Illuminance. The detector is changed to a combination with the small aperture and replaced in the same field of illuminance. The ratio of the original measurement to the new measurement is the factor to multiply the new reading by to get absolute readings. You can also divide the original sensitivity factor by this same ratio to get the new factor with the small aperture. This can be stored in another register for future use.

We previously mentioned the requirement for an eye response spectral sensitivity for Illuminance measurements (obtain "CIE standard observer" data for specifics). In addition to the proper spectral response, the detector must have a proper Lambertian spatial response (Cosine function). See the subsequent section called "SPATIAL RESPONSE", toward the end of this document, for more details on this.

There is another physical parameter that must be considered when making Illuminance measurements, which is the reference plane. Many International Light detectors use a "Wide Eye" diffuser on the front on the detector to create the Lambertian spatial response. This input device establishes the reference plane as the first groove made by the intersection of this diffuser assembly and the next optical element. This groove is located 6.5 millimeters in from the front of the detector. If the distance to the light source is quite large, the reference distance is not very critical, but if that distance is just a few millimeters, then it becomes very important to place the detector reference at the correct distance. For flat Teflon and Flashed Opal diffusers, the first surface is the reference distance.

### 8.2.2 Radiometric Irradiance

Irradiance measurements are very much like Illuminance measurements except the spectral response is ideally "flat" over the spectral range of the light source. An exception to this is "Effective Irradiance" which, like the photopic measurement, has a special spectral response function. This function depends on the need of the user. Usually it is designed to match the action spectrum of some chemical reaction, or polymerization process. UV Curing is a good example of an "Effective Irradiance" application. The detector should be designed to match the action spectrum of the photo resist or polymer film, not the light source. In that way the reading will be directly proportional to the optical effect on that substance, and the integral of the "Effective

Irradiance”, known as “Effective Energy” or dose, will directly correlate with the amount of curing that took place. Since the ILT1700 is capable of integrating, you can obtain energy readings directly in absolute units, to control exposures for industrial applications and for photo therapy. We stock hundreds of glass and thin film filters to match many different applications. Contact ILT for more specific information on a custom design for your needs.

Lets get back to the classical Irradiance measurement. You would have a “flat” response detector, such as a thermopile, and a light source that is restricted to output within the “flat” region of the detector. Some coatings for thermopiles are “flat” from 200 to 60,000 nanometers, so almost every light source will fall in that “flat” region. So why doesn’t everyone use thermopiles? For one thing a thermopile is limited to a low reading of about 20 microwatts per square centimeter, while quantum detectors, such as silicon cells, can be used to measure less than 20 picowatts per square centimeter. The difference is a million to one in sensitivity. For another reason, thermopiles measure everything including the infrared output from your hands and body as well as the room heating radiator, and finally the thermopile measures all regions of the light source, while you may not be interested in the output from most of the emitted spectrum. By the way if you do have a strong optical signal, and want flat response, we offer three thermopiles for the ILT1700. Call the factory for details. For the most part, your application will either need more sensitivity or will require a selected spectral coverage.

After all this talk about spectrum we have not even covered the units of measurement. Flux in the radiometric field is normally measured in optical watts. Occasionally some people use ergs per second, joules/sec., Langley’s/minute, E-Viton’s, plus quanta flux in microEinsteins. Due to the programmable nature of the ILT1700, we can handle these different units. Our sales staff is very knowledgeable in helping you with specific conversions for your application. The most commonly used units are watts.

As mentioned for Illuminance, Irradiance is the radiometric parameter for flux density measurement. Therefore we must choose area dimensions to complete the units. Most people agree on the centimeter, however occasionally meters are required. When combined together we have watts per square centimeter ( $W/cm^2$  or  $W/m^2$ ). The cosine spatial response is also required for Irradiance measurements. See “SPATIAL RESPONSE”, section 8.7, later on in this document.

In addition, the reference distance is defined by the first groove between the diffuser and subsequent optical elements. Exceptions to that would be for applications that use a flat opal, diffuse white plastic, or flat teflon diffuser, in which case the first surface is the reference distance. For some applications that either sense the light directly on the surface of the cell, or on the cell behind a transmissive filter, the reference distance is slightly in front of the cell surface.

Each piece of glass that is in front of the actual sensitive surface, moves the reference slightly forward. It requires some sophisticated measurements to accurately define the effective reference plane for each particular combination of elements. In most cases it is not necessary to calculate the reference this closely, but if the source is less than 100 millimeters, you should precisely define that plane or use a detector that establishes a well defined reference plane . Consult the factory for help in this endeavor.

For both Illuminance and Irradiance measurements, it is often important to baffle the measurement environment. For example, an open lamp on an optical bench will radiate in all directions. Anyone moving near this lamp, becomes a secondary reflecting source of optical radiation which is sure to change the reading. Baffles and black satin cloth curtains, are very helpful in isolating the experimental area. A hole down the optical axis, should have a sharp edge to avoid reflections from the edge itself. Also square holes are better than round holes, since the edge reflections are less likely to be propagated down an array of multiple baffles. Last, but not least, use plenty of flat black paint. If you are working in the infrared, you might want to get some “3M Black Velvet” which is known to absorb all the way out to 60 microns.

## 8.3 Flux Measurements

We started out discussing flux density measurements, rather than flux alone. Even though this seems backwards, the measurement of flux has many more geometric possibilities, so we are addressing this second.

### 8.3.1 Laser Measurements

You might measure lasers for two reasons. If the final use of the laser is for humans to see, you probably would choose photometric units. An example of this is for laser projection television. On the other hand, the end use may be a ‘point of sale’ scanner which is sensed by a photomultiplier or silicon cell, so radiometric measurements are indicated (see below).

8.3.1.1 Radiometric Laser Power - The optical watt is still the most popular flux measuring unit. This is almost exclusively true for laser applications. Laser flux is often easier to contend with since the beam is like a thread of power, whose position, direction and spectrum are clearly defined and known. Tunable lasers have caused more difficulty in the spectrum determination, but simpler spectral dispersive devices are available to come to that rescue. Here it will be assumed that the user knows the wavelength of the laser, or else a flat response detector and filter combination is used, so the wavelength will make very little error. A detector should be used that has a defined spatial response for both angle and for translational sensitivity. An ideal angle response would be isotropic, which is available by using a large area silicon cell (SED033, SED100 and

SED324) or our INS250 integrating sphere. They will measure the beam from off axis angles equally. They both also have a uniform sensitivity across the entrance aperture, which eliminates translational errors. When high power sources are used, it is necessary to attenuate the beam. Attenuation inherently occurs with the integrating sphere. Due to expense and size, most people choose a detector with a narrow beam adapter on it, such as the SED033/F/HNK15. This is designed to have a cosine spatial response which accepts an off axis angle of +/- 8 degrees with only a 1% error, and translational error of +/- 5 millimeters off axis for another 1% error. It is generally quite easy to keep within these limits, without any special effort. Of course you should try to keep the input beam normal to the detector and on the center line of the detector axis. By the way, distance should not matter when making laser power measurements, as long as the beam underfills the detector input receiving surface. The sensitivity factor that is dialed into the ILT1700 is in Amperes per Watt (A/W) at the laser wavelength. Generally the wavelength should be specified at the time of calibration, or picked from a chart of multi-wavelength calibrations. It is possible to record 10 factors in the ILT1700 for each of 10 different wavelengths. To make an accurate reading, you select the correct factor from registers 0 through 9, and the instrument will read directly in optical watts.

8.3.1.2 Photometric Lumen Flux - Everything applies to photometric laser measurements as it does for radiometric measurements, except that the detector must have a photopic spectral response or a photometric monochromatic calibration, to match the 'CIE standard observer' curve. The photometric flux is measured in lumens. The calibration will therefore be in units of Amperes per lumen (A/lm). The same spatial considerations apply as for the radiometric measurement in the previous section.

### 8.3.2 Wide Beam Flux Measurements

An integrating sphere is the ideal receiver for wide beam measurements, especially if the beams are converging or diverging. Wide beam sources are accurately measured by catching all the light in the beam. The large opening of the integrating sphere input port (which is 37.6mm diameter) makes this an easy task. For diverging beams, it is necessary to be close enough to insure that the outer edge of the beam is still smaller than the input port diameter. The uniform sensitivity of the port makes it possible to measure the total flux entering the hole. In addition the sphere acts as an attenuator and provides a uniform signal to the detector. Large solid angles can be accommodated. In fact one steradian of flux can be measured by establishing the point source at 34.7 millimeters distance away from the user port. This makes it very easy to make beam candela (lumen/steradian) measurements, since you would be measuring with a solid angle of one steradian. The receiving cone for other solid angles can also be measured with a great deal of accuracy, since the distances are large and uncertainties are minimized. If the distance to the input port is large with respect to the port diameter (37.6mm), then the calculation reduces approximately to the area of the input port (11.10 cm<sup>2</sup>), divided by the distance squared. In other words, if you were 10 centimeters away from the rim of the port, you would divide 11.10 by 100 and get the solid angle to be 0.111 sr.

If the sphere is calibrated to read optical watts, it can still be used to measure irradiance by overfilling the input port. By dividing the number of watts measures, by the input area (11.1 cm<sup>2</sup>), you get the irradiance in watts per square centimeter. If it is calibrated in lumens, then by dividing by the input area in square feet (11.95e<sup>-3</sup>), we will get the number of lumens per square foot which is equal to foot candles.

8.3.2.1 Radiometric (Total Flux/Watts) - A sensitivity factor is required for a flat response detector and sphere combination in units of Amperes per Watt (A/W). If a flat response is not available, the calibration must be performed at the wavelength or wave band of interest. The optical radiation must under-fill the sphere port hole to be totally quantized in optical power in the beam.

8.3.2.2 Photometric Flux (Lumens) - A sensitivity factor is required for a photopically responsive detector and sphere combination in units of Amperes per Lumen (A/lm). The same spatial conditions apply as in 8.3.2.1 above.

8.3.2.3 Photometric Intensity (mean Spherical Candle Power) - To properly measure the total flux from a source, one must "catch" all the radiation regardless of the emission direction. A sphere is the ideal choice for this application, since you can put the lamp right inside the sphere. Two of the standard intensity measurements would be the candela and the watts/steradian for photometric and radiometric applications respectively. An intensity measurement is the best indication of total efficiency of a lamp, since it indicates its ability to convert electrical power to optical flux.

Isotropic intensity is equivalent to a point source that radiates equally in all directions. This is not physically very practical since most lamps require electrodes and a holder to support the light, which tends to block some of the output radiation. Many lamps produces a close approximation for many applications. A lamp with a reflector behind it would radiate a great deal in one direction, but the same intensity units are often used so this combination can be compared to an isotropic radiator. The units of beam intensity for these applications, are beam candela (or beam candle power). For this situation, the measurement is best performed with an illuminance meter. Beam intensity is then calculated by multiplying the illuminance by the distance in feet squared, to get this equivalent intensity in one direction. If the output of the source may be used in all directions, then the Mean Spherical Candela (MSC) measurement is better indication of performance. On the other hand, if the output from the source is used in one direction, then beam intensity measurements would be more appropriate. These could be expressed in lumens per steradian (or watts/steradian) in a given orientation, or in units of beam candela as previously mentioned. To make total flux measurements in an integrating sphere requires either a "flat" response or a photopic response, detector sphere combination for the radiometric or photometric measurement respectively. The radiometric calibration would be in units of Amperes per Watt per Steradian, and the photometric calibration would be in either Amperes per Lumen per Steradian, or Amperes per Candela.

## 8.4 Health Hazard Measurements

Applications that measure the effect of light on human beings (or a chemical process) requires readings in effective dose. Light at different wavelengths must be weighted proportional to the effect that each wavelength has on the tissue. The ACGIH (American Conference of Government and Industrial Hygienists) has specifically defined several hazard bands which are recommended by NIOSH (National Institute of Occupational Safety and Health), namely, the UV Actinic, Blue Hazard, and IR bands. The ACGIH Actinic curve exactly weights the hazardous effect of doses at each wavelength in the UVC, UVB, and UVA bands. Using our ACT5 filter to precisely match this function, you can read a direct Threshold Limit Value effective dose measurement of the effective hazardous dosage. Remember, of course, to place the detector at the same nominal reference distance from the source as the typical human subject would be located. For more information on the Actinic Hazard function, see ACGIH website:

[www.ACGIH.org](http://www.ACGIH.org)

## 8.5 Radiance / Luminance Measurements

Our eyes interpret image details over a relatively narrow angle. This is the zone of the fovea where we analyze an image. For this reason it has become very important to measure light in a similar fashion to relate to the visual effect. This photometric concept is called Luminance or brightness, and the radiometric equivalent is called Radiance. For Illuminance or Irradiance discussed in 8.2, the magnitude of the measurement will drop off inversely proportional to the square of the distance from a point source to the detector. This is true because the light is being spread out in two dimensions (area), as one backs away from a source, hence the square function. In making Luminance or Radiance measurements, we are determining the output from a surface, as a function of flux per solid angle per area. In other words, we are summing up the output from an infinite number of Lambertian emitters over some test surface area. We measure this by looking at the area with a very narrow acceptance angle to intercept a small area inside the uniform sample emitting surface. Changes in the distance do not change the reading, since the area being measured increases directly proportional to the square of the distance, which is in direct opposition to the inverse square attenuation as a function of distance. In other words the two functions cancel to give us a constant reading. This is why luminance is a constant value for a surface, no matter where it is measured. The units for quantizing Luminance are, cd/m<sup>2</sup>, lumens per steradian per square meter (nit) or foot-lambert (fL), (1 fL = 3.43 nits) and for Radiance they are watts per steradian per square meter. To get the proper acceptance angle we offer the "PIN" probe or the Radiance Barrel "R" which has a 1.5 degree field of view, or you must restrict the field of view with a baffled tube. The baffles are required to remove the reflections from the wall of the tube, and allow measurement of only the "line of sight" rays. Be careful that the detector is "looking" at an area, located in the uniform part of the test surface. If you back away from the surface too far, the input angle will eventually be bigger than the test area, and errors will occur.

## 8.6 LED Measurements

Since most L.E.D. applications involve visibility by humans, it is often better to measure the photometric intensity in millicandelas, which more nearly relates to the ability to be seen by a human observer. We have an accessory called 'LED' which is specifically designed for this application. It permits the measurement of beam intensity on the optical axis of the L.E.D. source, which is where most of the radiation is concentrated. It provides a holder, custom designed, baffled tube, photometric filter and calibration to read directly in millicandelas with an ILT1700. We also offer the New SED324/YK113 Photometric detector to conform to CIE 127 standards which include condition A and condition B LED measurements. Includes SAR scanned calibration on a CD. Consult the factory for more information.

## 8.7 Transmission Measurements

The ILT1700 has been designed to perform the multiplying and dividing necessary to read in percent transmission. By pressing the 'SET 100%' button, the present magnitude is normalized to read 100%. Any change in this reading will show the relative percentage to that of the original number. In addition to the ILT1700 and an appropriate detector, filter, diffuser combination, you will need a light source that is stable over the time interval used for the measurements. Keep in mind that a 1% change in the lamp current often produces a 3% change in the light output. Regulation is therefore important. Also be sure to let your lamp warm up before making measurements. Another important requirement is an aperture and baffles. The aperture is necessary to define the central optical area of the sample filter. An exception to this rule occurs if using a narrow beam from a source such as a laser. The beam defines its own aperture. The next step is to select an optical bandwidth that is of interest. The light source or the receiving detector is filtered to this desired region. Now you are ready to make everything physically stable for the measurements. The full scale reading (100%) is taken through the limiting aperture before the sample is placed behind this aperture. Then the sample is inserted and the attenuation is directly indicated in percent as a digital readout on the ILT1700.

## 8.8 Reflectance Measurements

Reflectance is similar to transmission (see 8.7), with a few more complications. The ultimate use determines if it is important to measure specular reflectance, diffuse reflectance, or both. Most objects around the room are diffuse reflectors, or close approximations. So if the result relates to how well a human can see something, then diffuse would be appropriate. A mirror is a specular reflector designed to bounce the light at an angle that is equal, around the normal to the surface. Many surfaces (such as a coated paper), have a specular component as well as a diffuse component.

### 8.8.1 Specular Reflectance

All reflectance measurements require some special fixtures. In this case you must have a detector holder that can be swept in an angular arc of 90 degrees about a rotational point which has a holder for the flat sample reflector. A stable light source is directed across the top of this rotational point to some distance (x) which hits the properly filtered detector. The button called 'SET 100%' is pressed to establish the unattenuated condition for reference. The reflector is then placed directly over this rotational point, at an angle of 45 degrees to the source. The detector is rotated, also about this same point, for an angle of 90 degrees or until a peak output is found by watching the meter readings. It is important that the distance (x) is still the same as it was before moving the detector. The sample surface must be flat in order to reproduce the same beam divergence as present without any reflector present. There are many variations to this method, depending upon the ultimate use of the reflector. Obviously if the reflector is a curved surface this would not work. It may be necessary to use a setup similar to the diffuse measurement in an integrating sphere, or use a goniophotometer to integrate the output over the entire divergent reflectance angle. These methods are beyond the scope of this manual however.

### 8.8.2 Diffuse Reflectance

In the previous paragraph, we mentioned two techniques for measuring diffuse reflectance, namely by use of an integrating sphere or by integrating the total reflectance using a goniometer. Both methods require very special equipment, and will be lightly discussed here, since it would be impossible to do the subject justice in a document of this nature. In the first case, a collimated light beam projects through an integrating sphere, out an opposite port on the other side. A detector, with the desired spectral response, is placed in the sphere surface orthogonal to this beam, so as to be blind to either of the other ports. The 'ZERO' button is pressed with the sample port open. Then a white reflectance standard is placed in the sample port, with a surface such as barium sulphate, magnesium oxide etc. and the 'SET 100%' button is pressed. Now the standard is removed, and the sample is replaced in the sample port. The display on the ILT1700 then reads the diffuse reflectance relative to the standard reflectance. If the standard had a reflectance of 98% then you must divide the answer by .98 to get the absolute sample reflectance. This type of measurement does not measure the specular component, since it is reflected back out the beam entrance port and lost. Other angular geometries are required to include the specular component. The application dictates what is to be measured.

## 8.9 Spatial Response

Spatial response refers to the change in responsivity as a function of translational displacements (x or y), and with angular displacements (pitch, yaw, and roll). Or the measure of a detector's relative sensitivity as a function of incident wavelength.

### 8.9.1 Lambertian Response

Lambertian response is in reference to a particular angular response proportional to the cosine. In other words the cosine of the angle normal to the face of the detector is one or 100%. As the angle goes off axis and becomes parallel to the face of the detector, the reading goes to zero, as does the cosine of the same angle (90 degrees). At 45 degrees the cosine is 0.707, which means that the detector should read the rays with 70.7% of the value produced by the same rays entering normal to the input device.

The reason this spatial response is necessary for accurate measurements is that it matches the spatial response of a perfect absorbing surface. Since Irradiance and Illuminance, are measurements of light falling on a surface, the cosine is compatible with these measurements. An analogy of the perfect absorber might be considered as being a small hole in a piece of sheet metal, placed over a well. All the light that goes in that hole will be absorbed by the deep well hole underneath. None will get reflected back up out of the same hole. If we analyze the effect of a change of angle, such as the sun moving from high noon to sunset, we will see that less light can make it into the hole at sunset, because the effective area of the hole is smaller as you view it from an oblique angle. This reduction in area is directly proportional to the cosine of the angle normal to this surface. On polar plotting paper, the cosine makes a circle, which is convenient when comparing the ideal response with that of an actual plot.

### 8.9.2 Field Baffle

There are times when you should restrict the field of view to delete oblique angles. In a lab environment, you may be working with a light source on an optical bench. The only light of interest is from that source, yet light bounces off the people in the room and back to the detector, creating errors in the readings. This means that you are better off to restrict the field of view if you know there are no sources to be measured, at the oblique angles. This can be done with external baffles, or with our accessory hood (H). Baffles can be made from sheet metal cut to form a sharp edged hole in the middle. A square hole is actually better than a round hole, since it is less likely to create reflections in a multi-baffle array. Also, black velvet is excellent for dividing off test areas from the rest of the rooms lighting. If it is necessary to have light travel down a tube, you can thread the inside of the tube to reduce the wall reflections.

When making luminance or Radiance measurements, it is absolutely necessary to restrict the field of view to one that 'sees' only an intended test area of a reflecting surface, or rear lit surface. Baffles can be used to implement this kind of measurement without resorting to expensive optics.

### 8.9.3 Narrow Angle (Luminance/Radiance)

As just mentioned, there is a requirement for a narrow field of view when making Luminance and Radiance measurements (see section 8.5). This can be accomplished with lenses as in our Radiance barrel (R) accessory. In some applications it is accomplished by using a telescope where

the light is picked up from a small spot in the image plane. This is very nice for measuring the brightness of an illuminated segment of an alpha numeric display, or for measuring the dot brightness on the face of a CRT. Unfortunately these systems are very expensive. Another alternative is to use simple lenses to image a small portion of a test field, onto an aperture which has a detector behind it. This is very effective especially if the source is a repetitive configuration in a production situation. A custom set up can be made to specifically measure that one small emitting surface. Our Radiance accessory has a 1.5 degree field of view, with the objective lens being about one inch in diameter. This is effective as long as the target is larger than one inch. If you must back up from it, the target requirement gets bigger by the distance times  $2 * (\tan 1.25)$ , plus some margin for error. If you were a foot away, the target should be at least 2 inches in diameter.

#### 8.9.4 Uniform Receiver Sensitivity

As mentioned in section 8.3, the best receiver for uniformity is the input port of an integrating sphere. The uniformity we now are talking about is that which is measured perpendicular to the optical axis, over the input surface. For Flux measurements it is necessary to have this uniformity, so that small errors in centering the beam do not contribute to much of a change in the measured reading. Our narrow beam adapter (HNK15) attachment, is designed to accept a few millimeters of axial misalignment without appreciable changes in the reading. This is necessary to allow for non critical positioning of laser beam measurements.

### 8.10 Temporal Response

This refers to the light time response. There are many factors that should be considered when measuring fast light pulses, including the need for instantaneous information, or whether dose information is adequate. To obtain instantaneous data, the entire electrical system, including the final oscilloscope, must be properly designed and matched. This includes the connecting cable, characteristic impedances, and matching amplifiers. In most cases it is necessary to put a preamplifier in the detector head to match the high impedance of the detector to the coaxial cable. When you do this, the dynamic range is limited to a few decades at best, and auto ranging is not practical. For these reasons we have chosen to concentrate on dose measuring, which generally matches the ultimate goal of the light pulse, and is compatible with the same detectors used for c.w. measurements. When we say 'ultimate goal', we mean that the energy in a pulse is generally the factor that determines its effectiveness to perform work, and therefore is the best figure of merit when making a measurement. Capacitance is one of the properties of a detector that is very detrimental to fast instantaneous measurements, but does not produce an error when integrating, since it just tends to store the charge for subsequent removal. By designing charge measuring electronics into the instrument, we can rely on charge

storage in both the detector and in a capacitor on the front end of the system. By measuring with a 5 volt reverse bias on the detector, we now eliminate junction saturation due to internal series resistance voltage drop in the detector, plus we store the charge in the capacitance of the detector (approx 4 nanofarads for SED033), the coaxial cable (approx 0.23 nanofarads), and the 390 nanofarad capacitor located on the front end of the amplifier. At 5 volts bias, the system can temporarily store more than 1 microcoulomb of charge, which is quantized in one measurement cycle (half of a second). The lowest charge of 10 picocoulomb, will still have a 5% resolution, providing a pulse dynamic range of five decades. There are other limitations, such as the maximum current output from the detector, and the intrinsic speed of the detector itself which will be covered separately below.

#### 8.10.1 Low Duty Cycle (fast pulse)

The ILT1700 can measure a single fast pulse as long as the pulse rise time is generally greater than 5 microsecond, and the peak detector current is less than 2.0 milliamps. These limitations refer to the SED033 detector, which generally gives the best performance for flash measurements. The vacuum photodiodes are very fast devices, but the peak output current is about 1.0 microamperes, which is a limitation to high speed, high magnitude light sources. (attenuators can be used to decrease sensor sensitivity) If one wishes to measure a continuous stream of pulses, the ILT1700 has a unique capability of averaging the reading, even if the duty cycle is extremely low. This of course is also limited by the boundaries of the peak current, and intrinsic detector speed. Another method for measuring low duty cycle signals, is to integrate while counting the number of flashes. Then divide the total integral by the number of flashes to get the average charge in one flash. Still another technique is to integrate for a known period of time, and then divide by the number of seconds to get the average reading/sec. Data is updated exactly every half second.

#### 8.10.2 High Peak Amplitude

If you have a very bright C.W. source that would produce more than 2 milliamps from the detector, the instrument will read "HI" on the display. If the peak current is the result of a high amplitude flash, the limit usually is due to the detector saturation. The most often used silicon detector (SED033) can operate up to 2.0 peak milliamps before saturation, while the vacuum photodiodes (SED240 or SED220), have a peak less than 1.0 microamperes. In flash mode, there system may not read "HI" because the measurement integral does not detect the peak. ILT offers attenuation filters (QNDS1, QNDS2, QNDS3) for attenuation by a factor of 10, 100, and 100 respectively. To test, simply add the QNDS filter, without changing the calibration factor and the output should drop by the same attenuation rate as that of the filter. (ie QNDS1 x 10)

You can easily determine the current levels:

1. enter a calibration factor of 1, and select that factor, or
2. multiply the readings taken by the calibration factor being used. Both provide the detector current in amperes.

**For further applications assistance, check out our complimentary handbook on our website.**

## 9. General Specifications

### 9.1 Current Measurement Accuracy

Display - Full scale accuracy of +/- 0.2% from 2 milliamp to 100 nanoamp, +/- 0.5% from 100 nanoamp to 1 nanoamp, and +/- 1% below .1 nanoamp.

RS232C - same as for display above.

Recorder - plus or minus 1%, +/-4 millivolts.

### 9.2 Optical Accuracy

Optical Accuracy is a very difficult entity to address, because it changes with wavelength. The tolerances we mention below are exclusive of NIST uncertainty to absolute, which can vary from less than 1% in the visible to over 6% in the ultraviolet and over 4% in the infrared.

200-250 - plus or minus 21% of I.L. working standards (+/- 5% for N.I.S.T. transfer)

250-400 - plus or minus 4.5% of I.L. working standards (+/- 1% for N.I.S.T. transfer)

400-960 - plus or minus 3.0% of I.L. working standards (+/- .31% for N.I.S.T. transfer)

970-1000- plus or minus 4.5% of I.L. working standards (+/- .58 for N.I.S.T. transfer)

1000-1100 - plus or minus 5% of I.L. working standards (+/- 2.93.% for N.I.S.T. transfer)

### 9.3 Radio Frequency Interference

Output Emissions - This equipment generates and uses radio frequency energy and if not used properly, that is, in strict accordance with the manufacturer's instructions, may cause interference to radio and television reception. It has been type tested and found to comply with the limits for a class B computing device in accordance with the specifications in subpart J of part 15 of FCC rules, which are designed to provide reasonable protection against such interference in a residential installation. However, there is no guarantee that interference will not occur in a particular installation.

Input Signal Interference - Since the normal measurement range of electrical currents and charges are extremely small, input errors can occur from large sources of radio frequency emission. The input is especially vulnerable to 'pick up' if the input cable is not shielded. All International Light detectors use shielded input cable which is also necessary for any user provided input device.

### 9.4 Size and Weight

**9.4.1 Size** 9 cm High x 22 cm Wide x 24 cm Deep  
(3.5" x 8.7" x 9.4")

**9.4.2 Weight** 2.3 Kg (5.1 pounds)

### 9.5 Environmental Specifications

#### 9.5.1 Operating temperature range

5 to 40 degrees Celsius

#### 9.5.2 Storage temperature range

-30 to +60 degrees Celsius

#### 9.5.3 Operating and storage relative humidity

0 to 90 %

## 10. Maintenance and Repair

### 10.1 Preventive Maintenance

Remove batteries and store the ILT1700, along with detector/filters and optics in the A405 carrying case and a small amount of desiccant (silica gel) when not in use for an extended time period. The optical windows should be cleaned, from time to time, with methyl alcohol or other window cleaning fluid.

### 10.2 Battery Caution

ILT recommends the use of rechargeable batteries only as battery leakage from alkaline batteries can cause severe damage to the ILT1700.

### 10.3 Board Replacement

The ILT1700 has been designed so that each of the four printed circuit boards can be exchanged without affecting the calibration accuracy. The first two boards may be removed by removing the rear panel. First you must remove the computer board (middle board), by wiggling from side to side as you pull to the rear. Once it is slightly free, apply an upward force as you pull to the rear, in order to clear the power socket assembly. The amplifier board (top board), should be removed second, by sliding to the rear while wiggling from side to side. It is necessary to remove the top cover to remove the power board (bottom board) and the front panel. The power board is the third to be removed by taking out three screws that fix the board to the bottom cover. Once the hold down screws are out, the power board will slide to the rear, leaving the front panel with board attached, free to be lifted straight up. Leave the front panel attached to the board for protection of the Liquid Crystal Displays (LCD's). Reassembly is done in reverse order. The amplifier board goes in the third slot down from the top, and the computer board goes in the third slot up from the bottom.

The best way to determine which board is defective is by substitution. If alternate boards are not available, you may use the schematics to look for a problem. First start with the power board. Measure all the output voltages. Next assemble the power board, front panel board and computer board. Turn the unit off and momentarily short pins 1 and 11 on the rear panel accessory connector, which will reinitialize the memory, then turn the unit on again. You should read  $2.55e^{-10}$  on the display after 5 series of "1's" blink on the display, then all the lights should function normally. If the readings are erratic or completely wrong, the computer board may be at fault. If a single digit or lamp is not functioning, it probably is associated with the front panel board. Assuming the results so far are ok, now remove the computer board, then insert the amplifier board, and reinsert the computer board in last. If the readings do not change with the input, you probably have a problem with the amplifier board or the detector. To tell which one is at fault, insert a 5.1 megohm 5% resistor into pins 5 and 6 of the input connector. With the same sensitivity factor set in

above ( $1.000e^{-0}$ ), and with the '5 VOLT BIAS' light on, you should read  $9.80e^{-7}$  +/- 5% on the display. If not then the problem is most likely in the amplifier board and not the detector. If it passes all these tests, the problem is with the detector, or you may have an intermittent contact, which cleaned itself in the process of removing the circuit boards.

It is wise to rub a pencil eraser across the board contacts before reinserting them back into the unit. Contact corrosion is often a problem with all electronic equipment, especially after many years.

## 10.4 Computer Re-initialization Procedure

The ILT1700 radiometer is a computer operated instrument. The computer chip in the radiometer, not unlike other computer chips, is susceptible to 'lock-up' when unrecognized conditions or signals are received. Some of the typical symptoms of a ILT1700 computer 'lock-up' are as follow:

- LCD display will not change
- One or more of the LED's remain on.
- One or more of the buttons may not work.

If a user experiences any erratic behavior from the ILT1700 a computer 'lock-up' may be the problem. The can be easily reset by the following procedure:

1. Turn ILT1700 Radiometer OFF.
2. Hold MSD button down, turn power on,
3. Release MSD button
4. The LCD display will blink for a few seconds, telling you that the re-initialization is being performed.
5. The calibration factor for your detector should then be re-entered into the instrument..

Please contact the factory if you require further clarification or if this reset procedure does not correct the problem.

## 10.5 Handle Operation

The handle on the ILT1700 is capable of rotating 360 degrees when pulled away from its pivot points. The handle was designed to move easily when pulled from these points. Unnecessary force may cause harm to the handle.

## 10.6 Fuse Replacement

The ILT1700 has a built in fuse to prevent extensive damage in the event the power selection switch is improperly set prior to plugging the ILT1700 into 230VAC. Customer should always double check the power and source selections on the rear panel prior to plugging in the ILT1700. To change the fuse, follow the steps listed in 10.2 Board replacement above. Once you have removed the power board, locate the fuse next to the AC power cord input. The system comes with a BUSS AGC 1/4A 250V UL approved fuse. Replacement fuse should be available locally replacement.

## 10.7 Schematics

Due to the sophisticated nature of the computer control and low level amplification, we do not recommend that the user attempt to make repairs, except by way of board replacement. Specialized equipment is necessary to find the subtle problems that occur with these circuits, and to recalibrate them to original specifications. Schematics can be provided, however, to assist in finding certain power voltages and input/output pin numbers etc. and for the unusual situation where no other alternative is available. Please contact a technical support rep. for schematics.

# 11. One Year Warranty

The equipment you have purchased from International Light, Inc. has been expertly designed and was carefully tested and inspected before being shipped. If properly operated in accordance with the instructions furnished, it will provide you with excellent service. The equipment is warranted for a period of twelve (12) months from date of purchase to be free of defects in material or workmanship.

This warranty does not apply to damage resulting from improper set up, accident, alteration, abuse, loss of parts or repair by other than International Light Technologies. The equipment will be repaired or replaced, at our option, without charge to the owner for parts or labor incurred in such repair. This warranty shall not apply unless the equipment is returned for our examination with all transportation charges prepaid to International Light Technologies, 10 Technology Drive, Peabody, MA 01960. International Light Technologies has no other obligation or liability in connection with said equipment.

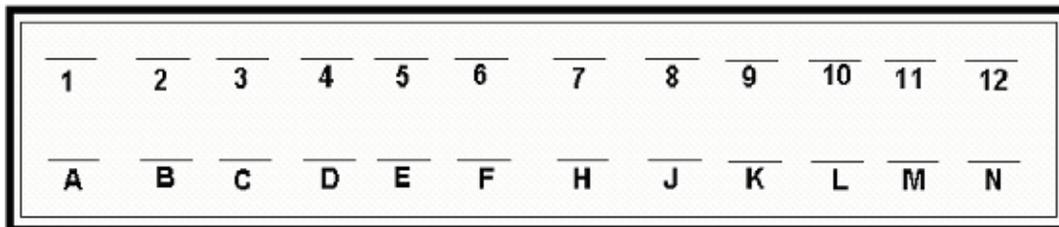
# ILT1700 Detector & Accessory Connector Pinout Addendum

## ACCESSORY PORT

- |                          |                         |
|--------------------------|-------------------------|
| 1. GROUND                | A. GROUND               |
| 2. +11                   | B. +9                   |
| 3. +5                    | C. AUX (AUXILARY POWER) |
| 4. NO CONNECTION         | D. SPARE                |
| 5. NO CONNECTION         | E. SPARE                |
| 6. SPARE                 | F. NO CONNECTION        |
| 7. SPARE                 | H. NO CONNECTION        |
| 8. RCO (RECORDER OUTPUT) | J. INTG/ (INTEGRATE)    |
| 9. FLAS (FLASH)          | K. HOLD/                |
| 10. ZERO                 | L. SWDN/ (SWITCH DOWN)  |
| 11. NO CONNECTION        | M. ACCS (ACESSORY)      |
| 12. RES (RESET NOT)      | N. GROUND               |

Use EDAC Inc. #305-024-500-202 connector or equivalent.

## Looking at the back of the ILT1700



**Pitch: 0.156" (3.96 mm)**

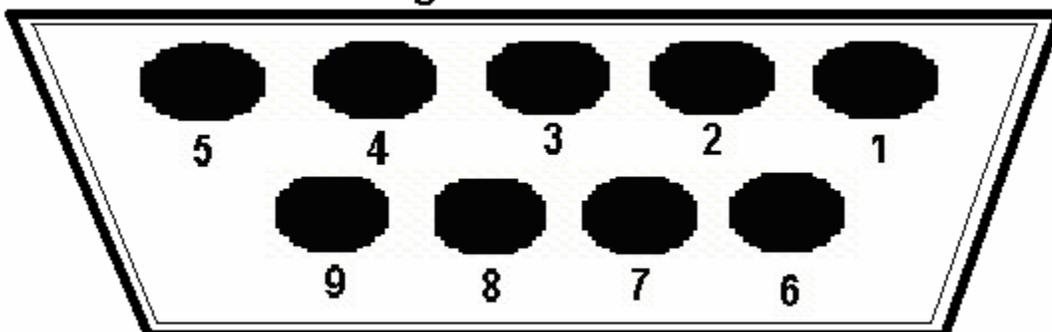
**# of contacts: 24 (12 x 12)**

**Card Thickness: 0.062" (1.57 mm)**

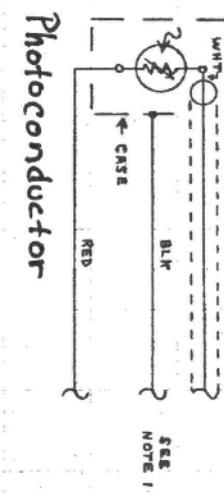
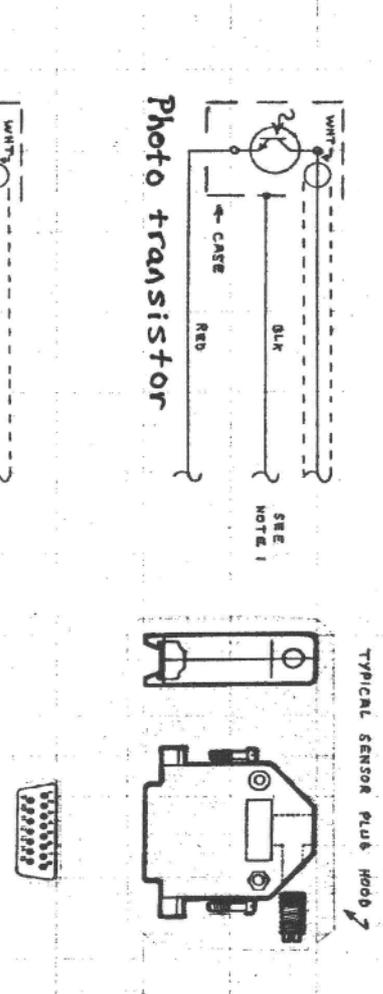
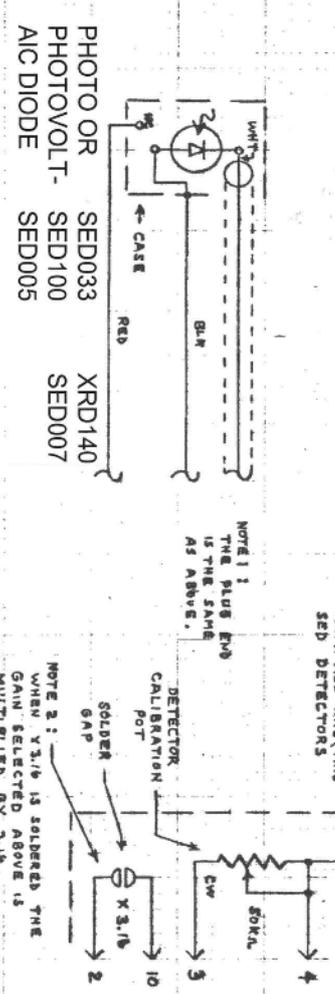
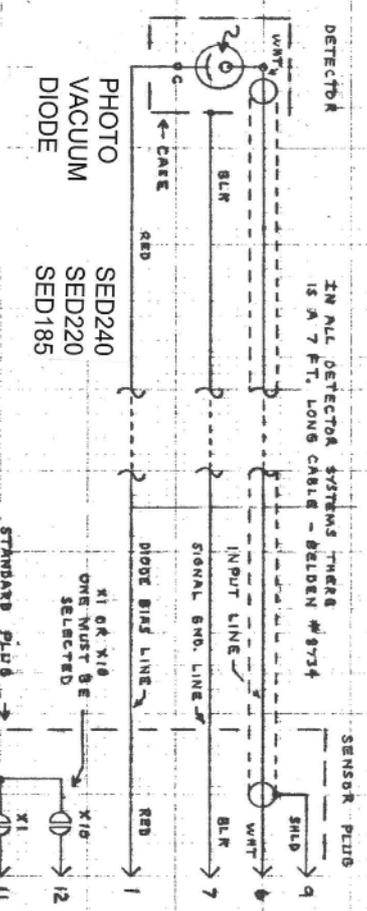
## RS232 9 PIN CONNECTOR

- |           |                                |
|-----------|--------------------------------|
| 1. GROUND | PROTECTIVE GROUND              |
| 2. TRD    | TRANSMIT DATA, (NOT CONNECTED) |
| 3. RCD    | RECEIVED DATA                  |
| 4. DTR    | DATA TERMINAL READY            |
| 5. GROUND | SIGNAL GROUND                  |
| 6. DSR    | DATA SET READY                 |
| 7. RQS    | REQUEST TO SEND                |
| 8. CTS    | CLEAR TO SEND                  |
| 9. .      | NOT CONNECTED                  |

## Looking at back of ILT1700



REVISIONS		DATE	APPROVED
ZONE	LIB	DESCRIPTION	



INSTRUMENT SENSOR  
INPUT CONNECTIONS

PIN 1	-9V
PIN 2	NC
PIN 3	NC
PIN 4	NC
PIN 5	SIGNAL GROUND
PIN 6	- SENSOR CURRENT
PIN 7	SIGNAL GROUND
PIN 8	+5V
PIN 9	INPUT GUARDCOM.
PIN 10	NC
PIN 11	NC
PIN 12	NC
PIN 13	SIGNAL GROUND
PIN 14	SIGNAL GROUND
PIN 15	+14.5V

ITEM NO.	QTY	ISO. REQ'D	SIZE	PART OR IDENTIFYING NO.	DESCRIPTION OR IDENTIFICATION
LIST OF MATERIALS ON PARTS LIST					
MATERIALS:					
CONTRACT NO. 2058					
DRAWN: RAG					
DATE: 5/5/85					
SCALE: 1 OF 1					
REV: 1					

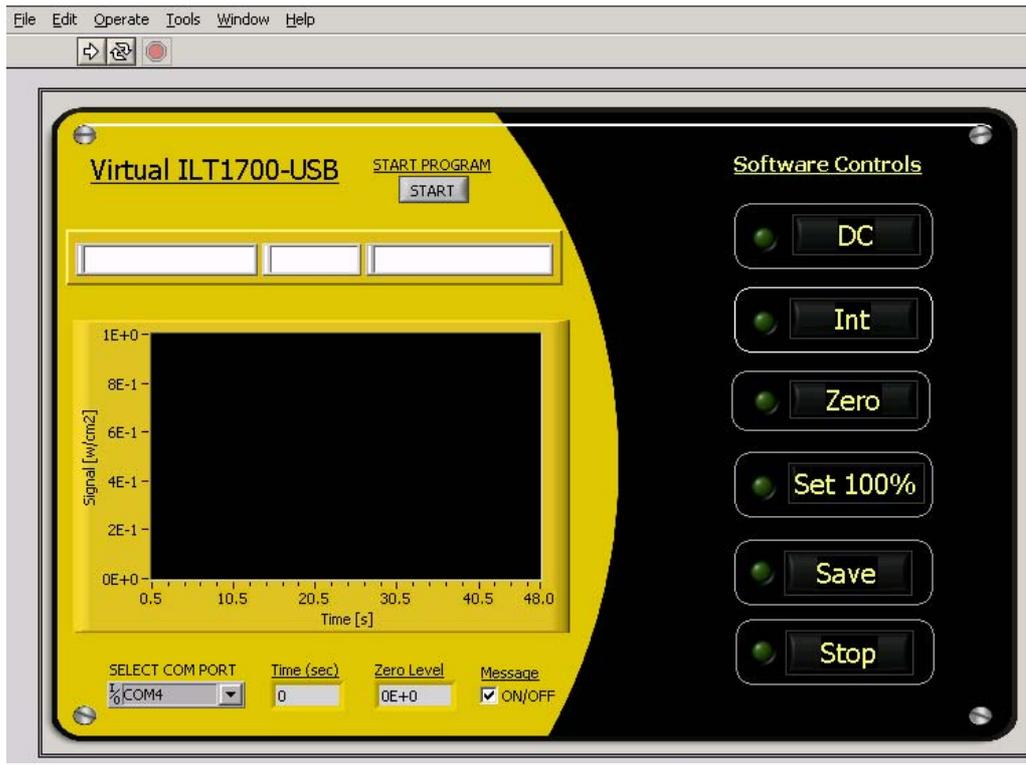


International Pyrite, Inc.  
HERSHFORD, MASSACHUSETTS 01930

## 12. Sample basic program (for reference only, note: baud rate 1400 in older system, 2800 in newer systems)

```
10 ' THIS PROGRAM IS CALLED "MANUAL SCAN"
20 ' THE RS232 PORT OF THE IL1700 IS USED TO SEND DATA INTO A
30 ' COMMUNICATIONS PORT ON AN IBM COMPATIBLE COMPUTER
40 ' YOU WILL REQUIRE A COMUNICATION MODEM CABLE SPECIFIC TO YOUR
50 ' COMPUTER. IF YOU PURCHASE THE WRONG CABLE YOUR COMPUTER WI LL
60 ' NOT RECEIVE DATA FROM THE IL1700.
100 '
101 'TO USE THIS PROGRAM:
102: STEP 1: CONNECT RS232 CABLE TO IL1700 AND COMPUTER
103 ' STEP 2: CONNECT DETECTOR TO REAR OF IL1700
104 ' STEP 3: SET PRINTER/COMPUTER SWITCH ON REAR OF IL1700 TO "PRINTER"
105 ' SEE "REAR PANEL" SECTION IN QUICK START GUIDE, IN IL1700 MANUAL
106 ' STEP 4: PLACE DISK IN DRIVE "A" OF COMPUTER
107 ' STEP 5: LOAD PROGRAM, RUN IT AND FOLLOW DIRECTIONS ON SCREEN
110 CLEAR
120 CLS:CLOSE
130 DIM A (200)
140 DIM A$(200)
150 X=0
151 ' REMARKS
160 ' 170-350 PRINTS TITLE, MENU SELECTIONS AND ALLOWS USER TO MAKE SELECTION.
161 ' ENTER KEY READS DATA, R KEY REPLACES LAST VALUE, Q QUILTS.
162 '
170 LOCATE 1, 32:PRINT "IL1700 RS232 PROGRAM"
180 LOCATE 2, 40:PRINT"MENU"
190 LOCATE 3, 20:PRINT"ENTER KEY: TAKES PRESENT READING FROM IL1700"
200 LOCATE 4, 20:PRINT"R: REDO: REPLACES LAST READING WITH CURRENT READING"
210 LOCATE 5, 20:PRINT"Q: QUILTS: ENDS PROGRAM. READINGS ARE STORED
230 REM BEGINNING OF LOOP TO ENTER DATA CHECKS INPUT FOR ENTER, R OR Q
240 LOCATE 10,1 :PRINT "HIT ENTER KEY, R, OR Q TO QUIT"
250 LOCATE 18, 50:PRINT:"LAST VALUE STORED: "
260 LOCATE 19, 53:PRINT"
270 LOCATE 19, 50:PRINT A(X)
280 LOCATE 17, 71:PRINT"MEMORY"
290 LOCATE 18, 70:PRINT: "LOCATION"
300 LOCATE 19, 72:PRINT X
310 SELECT$=INPUT$(1)
320 LOCATE 11, 1:PRINT"
330 IF ASC(SELECT$)=81 OR ASC(SELECT$)=113 THEN GOTO 490
340 IF ASC(SELECT$)=13 THEN GOTO 370
350 IF ASC(SELECT$)=82 OR ASC(SELECT$)=114 THEN GOTO 440
370 X=X+1
371 'REMARKS
372 ' THE NEXT 4 LINES OPEN COMMUNICATION PORT TO RECEIVE DATA
373 ' CONVERT DATA TO NUMERICAL VALUE AND STORES THE
374 ' NUMBER IN AN ARRAY CALLED A(X)
375 '
380 ' OPEN "com1:1200,n,8,2" AS #1
390 LINE INPUT #1, A$(X)
400 A(X)=VAL(A$(X))
420 CLOSE #1
430 GOTO 240
431 'REMARK
432 ' THE NEXT 4 LINES REPLACE PREVIOUSLY STORED DATA IN CASE THE
433 ' WRONG VALUE WAS ENTERED
440 IF X<1 THEN LOCATE 11, 1 :PRINT "YOU CANNOT CHANGE A PREVOUS VALUE YET!":GOTO 240 REM CANNOT CHANGE READING
UNTIL A READING IS STORED
450 LOCATE 11,1 :PRINT "YOU ARE REPLACING THE VALUE IN MEM. LOC. "X;" WITH PRESENT IL1700 READING:"
460 X=X-1
470 GOTO 310
471 'REMARK
480 'THE REMAINING LINES ASK THE USER IF THEY WANT TO QUIT
481 ' IF YES, ALL DATA VALUES ARE STORED ON THE DISK IN DRIVE A
482 ' UNDER THE NAME _DATA, IN ASCII FORMAT
483 '
490 LOCATE 11, 1:PRINT "ARE YOU SURE YOU WANT TO QUIT (y/n)"
495 SELECT$=INPUT$(1)
500 IF ASC(SELECT$) <>121 AND ASC(SELECT$)<>89 THEN LOCATE 11, 1: PRINT" " GOTO 240
501 OPEN "A:_DATE: FOR OUTPUT AS #2
502 FOR Y=1 TO X
503 PRINT#2, A(Y)
504 NEXT Y
505 CLOSE #2: CLS:PRINT"ALL DATA HAS BEEN STORED IN DATA FILE CALLED ' _DATA' "
510 IF ASC(SELECT$) <>121 AND ASC(SELECT$)<>89 THEN LOCATE 11, 1:PRINT " " GOTO240
520 CLOSE #2
530 END
```

## Virtual ILT1700-USB Manual



### A. INTRODUCTION

The ILT1700.VI driver is a sample LabVIEW<sup>®</sup> program that allows the end user to perform data acquisition with an ILT1700 Research Radiometer. The VI will run in LabVIEW<sup>®</sup> 8.2 Full Development System and offers the ability to record readings in either DC, or integrate mode as well as to calculate the percentage of a baseline reading. The data is saved in a tab-delimited text file that can be opened with Excel. Users with LabVIEW<sup>®</sup> 8.2 Full Development System can customize the VI to meet their unique application requirements.

We also offer an ILT1700.VI program for customers who do not own a copy of LabVIEW<sup>®</sup> Full Development System. The application is a fully compiled, run-time version of the VI driver. Users can run the program, obtain data from an ILT1700 meter and save it into a file. The program is available for Windows 2000, XP and VISTA.

### B. INSTALLATION OF THE USB PORT DRIVER (VCP)

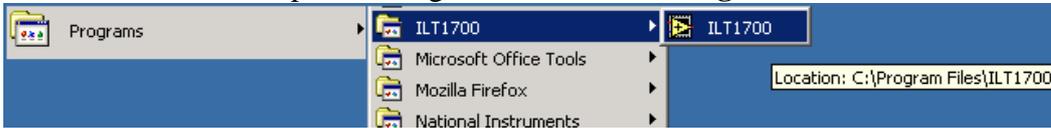
You will need your ILT1700 meter, a USB cable and your complimentary drivers CD. Connect the ILT1700 with a USB cable to a USB 2.0 port of your computer. The Found New Hardware Wizard will come up to assist you with installing the DLP-USB232M Virtual Com Port Driver (VCP). You need to insert your CD when requested (and select the ILT700USB\_Drivers folder as needed). Follow the install procedures until the installation of Com Port Driver is finished. To begin, Click on Start, Settings \Control Panel\System\Hardware\Device Manager\Ports in the Start Menu and double click on com port to check the Device Status of the USB Serial Port (COM#). In the general tab it should read "This device is working properly".

### C. INSTALLATION OF THE ILT1700 PROGRAM

If you have LabVIEW<sup>®</sup> 8.2 Full Development System and are an experienced LabVIEW<sup>®</sup> user, locate the ILT1700.VI in the ILT1700 folder and you can begin customization of the VI.

For users that do not own LabVIEW<sup>®</sup> follow the steps below to install the Virtual ILT1700-USB program:

- Insert the CD, open the V-ILT1700 folder on the CD and double click ILT1700Run -Time folder.
- Select the **setup.exe** file and double click the file to start the installation process.
- Continue to go through each screen and select **Next** until the installation is complete. (You will need to accept the terms and conditions).
- Click on **Finish**, and restart your computer.
- The Virtual ILT1700-USB program will be installed in the C:\Program Files\ILT1700 directory. The **ILT1700.exe** can be opened using **Start menu\All Programs\ILT1700**.



#### D. TAKING MEASUREMENTS

Before you begin, cover the detector connected to the ILT1700 with the black cap or an opaque object for about 10 seconds, (or disconnect the sensor from the back of the ILT1700 ) and press the zero button on the front of the ILT1700. Wait until the zero light shuts off and the DC light illuminates.



With the ILT1700 program up on your monitor, look for the drop down box in the lower left corner and select the assigned COM port. If you are not sure which COM port you are using, this information can be found in the Device Manager of your computer. Use Control Panel\System\Hardware\Device Manager\Ports in the Start Menu for information. The default COM port is set at COM4.

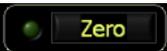
There are three buttons at the top left of the Screen.  = Run,  = run continuously,  = abort (For this application we only use the RUN button, do not use run continuously or abort)

To start the program click the **Run Arrow** button  and it will change to a darkened arrow . Read

and follow the instructions on the pop-up window, then click OK. (The check box  can be used to disable this pop-up message).

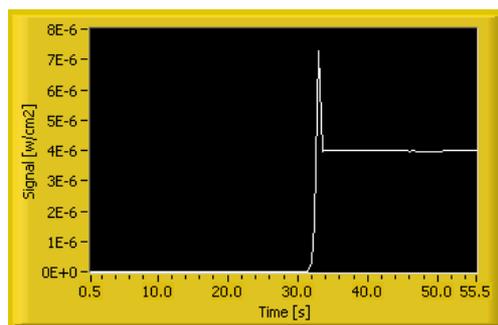


The Start button will flash yellow, Click on the start button to initiate data acquisition.

If you need to do a software zero, cover the detector connected to the ILT1700 with the black cap and press the **Zero** button . The LED indicator will turn green until complete and the Zero Level

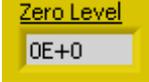
indicator should read . Assure the meter was already zero-ed prior to using the program.

The red LED of the **Signal/DC** indicator  should be blinking indicating that the program is acquiring data and the graph should show readings that match the display on the ILT1700.



Data Displays: Above the graph are three additional displays. The Left screen is the irradiance display, the center screen is the percentage display and the right is the integrate display. These displays will change values based on the features you select using the DC, SET 100%, and INT buttons.



If you need to do a software zero, cover the detector connected to the ILT1700 with the black cap and press the **Zero** button . The LED indicator will turn green until complete and the Zero Level indicator should read . Assure the meter was already zero-ed prior to using the program. Once you have zero-ed, the program should show readings as displayed on the ILT1700 meter.

The data can be saved at any point in a tab-delimited file by pressing the **Save** button .

Carefully read the pop up messages and follow the instructions. To stop  the program without saving the data, press the **Stop** button. To measure in percentage, click the **Set 100%** button

 to set the baseline 100% level. All future readings will be in percentage as a comparison to the 100% baseline reading. To measure accumulated dosage or total exposure, press the **Integrate** button

. The program will continue to integrate and show the total dosage in the integration window until you press **Save** or **Stop**. To exit or stop the program, always use the **Stop** or **Save** buttons as they assure that the COM port is properly closed. Try not to use the **Abort Execution** button  in the VI toolbar.

## E. TROUBLE SHOOTING

An error message in “VISA Read in ILT1700.VI” will appear in case that a wrong COM Port is selected or if the VCP driver is not properly working. To exit the message, click Stop and select the correct Com Port. Use Control Panel\System\Hardware\Device Manager\Ports in the Start Menu to locate the proper COM port or to check the proper working of the VCP driver.

## F. HARDWARE FEATURES

USB 2.0

Windows 2000, XP and VISTA

Bits per second: 4800

Data bits: 8

Parity: none

Stop bits: 1

Flow control: none