ILT1400 INSTRUCTION MANUAL

InternationalLight
TECHNOLOGIES

10 Technology Drive
Peabody, MA 01960
Ph: 978-818-6180
Fax: 978-818-6181
Web: www.intl-lighttech.com

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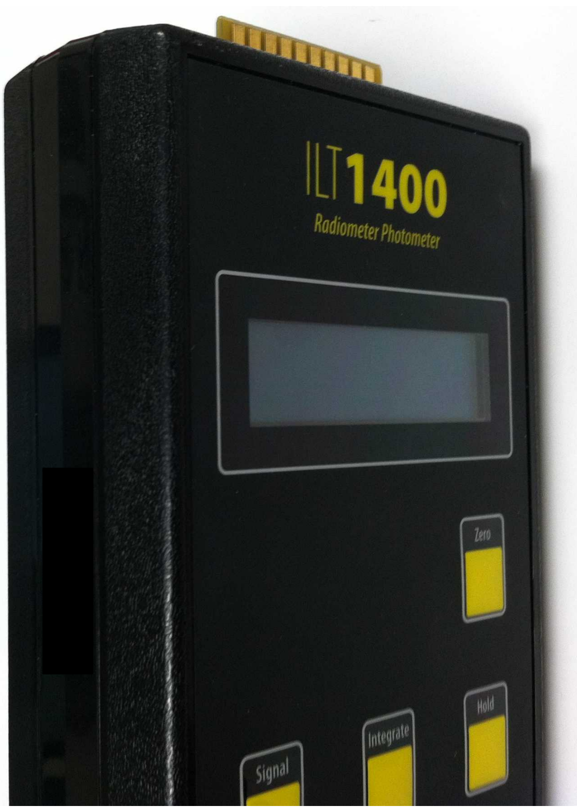
INSTRUCTION MANUAL:

ILT1400

Radiometer / Photometer



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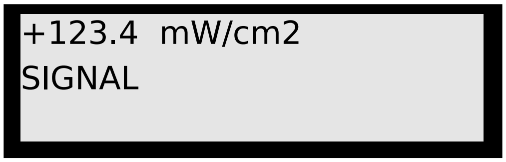
1.1 DISPLAY



The ILT1400 uses a two line, thirty-two (32) character "Supertwist" Liquid Crystal Display (see above) to portray numerical data, units, mode of operation, and instrument status alphanumerically in bit-mapped graphics. If the instrument is turned on without a detector plugged in, the display will instruct the user to 'SHUT POWER OFF', 'PLUG DETECTOR IN', in order to properly initialize the ILT1400 system.

The top line displays sixteen (16) characters, representing the most recent data and units from the detector. The detector data is displayed in three or four digit (depending on digit reliability) decimal form with a + / - sign. The SI or English optical units are displayed to the right of this numerical data in standard abbreviated form, such as mW/cm^2 (milliwatts per square centimeter), with the prefix scaling by 1000 as the data autoranges, from femto- (10^{-15}) to mega- (10^6). A typical reading for the top line of the display, for example, would be +123.4 mW/cm^2.

The bottom line also displays sixteen (16) characters of information, representing the mode of operation and the instrument status. The mode of operation, such as 'SIGNAL', 'HI INTEG', 'LO INTEG', or 'ZEROING' is continuously displayed on the left side of the bottom line. The characters to the right are reserved for blinking status messages such as 'HOLD', 'OVR RNG', 'NO OFF' and 'BAT LO', with up to two status messages being alternately displayed. In continuous measurement mode, the bottom line of the display will typically read 'SIGNAL', with the status display blank unless the hold button was depressed or an error situation arises.

1.2 BUTTONS

The five buttons on the front surface of the ILT1400 were designed with ease of operation in mind, with the microprocessor making most decisions for the user.

The 'ON/OFF' button turns the instrument on or off. A detector must be plugged in for the ILT1400 to properly initialize when first turned on. The instrument will automatically turn itself off to preserve the battery life if no buttons are pressed for a period of ten (10) minutes.

The 'SIGNAL' button selects the continuous wave "signal" measurement mode, for continuous monitoring of a light source. The detector memory establishes the detector limits and autoranging units to provide an immediate answer in an easily understood format.

The 'INTEGRATE' button selects the integration mode that was last used, 'HI INTEG' or 'LO INTEG'. Pressing the 'INTEGRATE' button again during integration will reset the integration register to start over at zero, while remaining in the same mode. To select the alternate integration mode, simply press the 'INTEGRATE' button twice within one second and the range will change from 'HI' to 'LO' or vice versa.

The 'ZERO' button causes the instrument to null the present reading to zero. Zeroing can be performed in both the signal and integration modes to subtract ambient light from future readings. Also, the programming mode can be accessed by pressing the 'ZERO' button within 1 second after hitting the 'OFF' button.

The 'HOLD' button temporarily freezes the display to hold a reading for convenience when measuring in a darkroom, or in similar situations where it may be inconvenient to read the LCD display in 'SIGNAL' mode. In integration mode, the 'HOLD' button freezes the latest summation on the display, yet continues to internally integrate, so that intermediate data can be taken without disrupting the integration. Pressing the 'HOLD' button again will unfreeze the LCD to once again display the internal integration without disruption. Pressing the 'INTEGRATE' button again while in 'HOLD' status will reset the integration to start over from zero.

The 'BACKLIGHT' button (ILT1400BL models only) turns the backlight for the LCD on or off.

1.3 INPUTS / OUTPUTS

The ILT1400 contains one I/O connector, the detector card edge connector.

The detector card edge connector performs several functions besides carrying the signal from the detector to the ILT1400. TTL Serial data is accessed through this card edge using a special connector adapter (A512). This connector also provides a selection of positive and negative bias voltages for almost all IL detector configurations, and provides the input for information from the detector memory concerning calibration and units. See section 4.3 for a pinout and general description of the card edge connector.

2. OPERATION - QUICK REFERENCE

2.1 ON / OFF

2.1.1 Turning On the ILT1400

```
SHUT POWER OFF
PLUG DETECTOR IN
```

A detector must be plugged in when the ILT1400 is first turned on for the instrument to properly initialize and interrogate the detector for calibration factors, range limitations and units information. The instrument will display the message shown above if the unit is turned on without a detector present, and will automatically shut off in thirty seconds. This same message is displayed if the detector is removed while the instrument is running. To remedy this situation, simply turn off the ILT1400, plug in the detector you wish to use, and turn the unit on. The instrument will then initialize itself and enter signal mode automatically.

As an added feature for the EXPERIENCED USER, the ILT1400 will operate in 'PROGRAM' mode by pressing the 'OFF' button, followed by the 'ZERO' button within 1 second, when turning off the instrument.

2.2 SIGNAL MODE

2.2.1 Signal

```
+123.4  mW/cm2
SIGNAL
```

The ILT1400 automatically begins operating in 'SIGNAL' mode when turned on with a detector plugged in. Pressing the 'SIGNAL' button in any mode will initiate operation in 'SIGNAL' mode for constant wave measurement. This mode is desirable when measuring any constant source. The unit reads the average steady state light level over a period of 0.5 seconds, then takes a "rolling average" with the last two readings, to smooth out unwanted noise.

```
++++++  mW/cm2
SIGNAL         OVR RNG
```

If the incoming light exceeds the maximum measurement range of the detector, the ILT1400 will blink 'OVR RNG' in the status register display, and the data display will show plus signs instead of numbers ('++++++ W/cm2') on the top line.

```
-123.4   mW/cm2
SIGNAL
```

Any signal that goes below the detector's minimum sensitivity, or "zero floor", will display 000.0 on the LCD. An alternate zero level can also be set using the 'ZERO' button, as described below. If the light level drops below the set zero level, a negative reading will result.

2.2.2 Zero

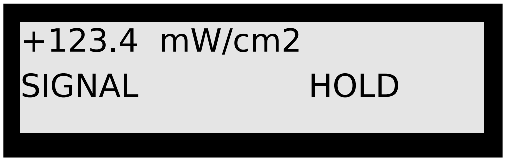
```
+0.000  uW/cm2
ZEROING
```

```
+0.000  nW/cm2
SIGNAL
```

If you cover up the detector and press the 'ZERO' button while in 'SIGNAL' mode, 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, or unwanted reflections from a single source. If an additional light is turned on, the differential magnitude will appear on the display, exclusive of the previous room light. If the level drops below the ambient zero level, the reading will display a negative number. We recommend limiting unwanted background light to less than 10 percent of the overall reading in order to minimize the effect of variable ambient conditions.

The 'ZERO' button can also be used to subtract a specific wavelength band from future readings with a constant source. The instrument can be zeroed with a sharp cut or a narrow bandpass filter in front of the detector. Future readings will nullify the effect of all wavelengths that were allowed to pass through the known filter during zeroing. CHECK THE ZERO BEFORE TAKING A MEASUREMENT. The last zero level is stored in memory, even after the unit is shut down. Failure to check the zero is the biggest cause for erroneous readings.

2.2.3 Hold



Pressing the ‘HOLD’ button while in ‘SIGNAL’ mode will freeze the last reading on the display, and the word ‘HOLD’ will blink in the status register of the LCD. To resume constant wave measurement, simply press the ‘SIGNAL’ button or toggle the ‘HOLD’ button again and the instrument will return to ‘SIGNAL’ mode (with the same zero level as before).

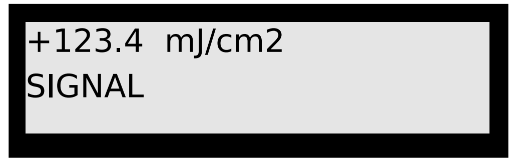
2.3 INTEGRATE MODE

The ILT1400 can integrate light, summing up all the energy over time and subtracting ambient energy. The user can select between two overlapping integration ranges, ‘HI’ and ‘LO’ ‘INTEG’, for measuring either high or low level sources. When the ‘INTEGRATE’ button is pressed, the instrument begins integrating in the measurement range that was last used, ‘HI’ or ‘LO’, even if the instrument had been turned off. The alternate range can be selected by pressing the ‘INTEGRATE’ button twice within one second. ‘HI INTEG’ mode is desirable for most applications, due to its wide dynamic range and very low noise. ‘LO INTEG’ is useful for applications requiring high gain for low signal levels.

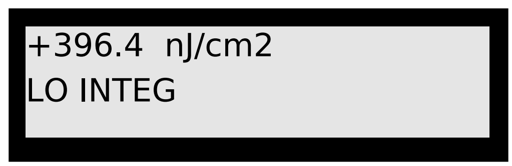
While integrating, the instrument will not automatically shut off after ten (10) minutes as it normally does in ‘SIGNAL’ mode. This allows the user to perform integrations for extended periods of time. If the ‘HOLD’ button is pressed during integration, however, the blinking message ‘HOLD’ will appear in the status register and the instrument will automatically shut off after ten (10) minutes unless a keypress is detected. The ‘HOLD’ feature freezes the display but the instrument continues to integrate while in Hold.

2.3.1 High Integrate / Low Integrate

The best way to differentiate between the high and low integrate modes is to simply describe how the ILT1400 operates internally. The ILT1400 uses a current-to-frequency converter and highly accurate digital bandwidth modulation to digitize the incoming signal data for use by the microprocessor. In ‘SIGNAL’ mode, the instrument automatically switches between the high (5.0 decades) and low (4.5 decades) auto-ranging measurement ranges with an overlap hysteresis for a total of over 7 decades of dynamic range. The user must select either ‘HI INTEG’ or ‘LO INTEG’ by pressing the ‘INTEGRATE’ button twice within one second. Most users will find that the wide dynamic range and low noise of the ‘HI INTEG’ mode make it ideal for all but the very lowest level applications, where ‘LO INTEG’ is required.



In ‘HI INTEG’ mode, the range for an incoming signal is limited to the top 5.0 decades of the measurement range of the detector, capable of measuring from 3.5 nanoAmps to 350 microAmps with the digital frequency values summed in a 5 byte (256^5) register. With an external power supply, the instrument can integrate the maximum signal for more than four months, or can integrate the minimum signal for more than 34,000 years! Since a typical signal will fall somewhere between the maximum and minimum in the measurement range, the only practical limit to integration time is the battery life. The ILT1400 draws a mere 26 milliAmps in its low power CMOS circuitry, allowing non-stop integration with four new alkaline cells for approximately 54 hours. Please contact an Applications Engineer at our manufacturing facility for more information on battery life and use of external power supplies.



In ‘LO INTEG’ mode, the range for an incoming signal is limited to the bottom 4.5 decades of the measurement range of the detector, overlapping with the ‘HI INTEG’ range by 2 decades. The measurement range in ‘LO INTEG’ mode is from 10 picoAmps to 400 nanoAmps. The added gain (256 times) and sensitivity of this mode are provided at the expense of a narrower dynamic range, and are limited by increased noise on the low end.

2.3.2 Zero

The automatic zero function allows the user to eliminate the effect of background light, reflections, or unwanted wavelengths to isolate and integrate only the energy source of interest. The microprocessor automatically subtracts the integral of the zero level energy from the overall integral. To perform this function properly, the background light source that you are subtracting should be fairly stable and/or much less in magnitude than the light source of interest. A good “rule of thumb” is to limit ambient light to under 10 percent of the measured source, thereby minimizing the effect of ambient light variation. By placing a baffle between the light source and the detector during zeroing, ambient light and any incidental reflections from the primary source will be continuously subtracted from the integral. Covering the detector completely during zeroing will establish a very low zero reference, so that the integral will be the sum of all the energy reaching the detector.

+0.000 uW/cm2
ZEROING

+0.000 NW/cm2
SIGNAL

The simplest method for setting the zero level for integration is to press the 'ZERO' button while in 'SIGNAL' mode. If you press the 'ZERO' button when in 'INTEGRATE' mode, the display will indicate that the instrument is 'ZEROING' and then return to 'SIGNAL' mode. This allows the user to evaluate the stability of the subtracted source. When the 'INTEGRATE' button is pressed to begin integration, the ILT1400 will continuously subtract the new zero level from the present integral and from future integrations, until a new zero level is set. BE SURE TO CHECK THE ZERO BEFORE TAKING A MEASUREMENT. The last zero is stored in memory even after the unit is shut down. Failure to check the zero is the biggest cause for erroneous readings. To check the zero, cover the detector or source being measured. If the reading is other than zero, press the zero button to reset with the light source removed.

2.3.3 Hold

+123.4 mJ/cm2
HI   INTEG   HOLD

+396 nJ/cm2
LO   INTEG   HOLD

While in 'INTEGRATE' mode, the 'HOLD' button functions to freeze or unfreeze the display, acting as an alternate action "toggle" switch. When you press 'HOLD', the most recent integral is continuously displayed on the LCD, and the word 'HOLD' blinks in the status register. The ILT1400 continues to integrate internally, however. To resume this transparent integration, simply hit the 'HOLD' button again to unfreeze the LCD and continue to display the UNINTERRUPTED integration. This feature is quite useful for taking intermediate readings without affecting the ongoing integration reading. If you press 'INTEGRATE' after holding a reading in integrate mode, the instrument will abandon the previous integration, return to 'INTEGRATE' mode, and begin integrating again from zero.

Please note that although the auto shut-off feature is automatically disabled during integration, when the 'HOLD' feature is activated, the auto shut-off feature will cause the instrument to turn off after ten (10) minutes of inactivity. The automatic shutoff is once again disabled when integration is resumed to provide long term integration measurements.

2.4 Disabling the Automatic Shut-Off Feature

We recommend turning the ILT1400 off when not in use, in order to prolong the life of the batteries. The instrument will automatically turn itself off after a period of ten minutes when in 'SIGNAL' mode. This automatic shut-off feature can be temporarily or permanently disabled. To do this, first press the 'OFF' button with the instrument on, followed within one second by the 'ZERO' button.

PROGRAM MODE
ON/OFF TO EXIT
SIGNAL

AUTO SHUT-OFF
ENABLED   (10 min)

The ILT1400 will display the message 'PROGRAM MODE', 'ON/OFF TO EXIT'. Press the 'ZERO' button to select the 'AUTO SHUT-OFF' menu. The 'ZERO' button selects through the numerous changeable 'MENU' screens.

AUTO SHUT-OFF
DISABLED   (temp.)

AUTO SHUT-OFF
DISABLED   (PERM.)

Press the 'INTEGRATE' button to 'INCREMENT' the bottom line between three choices: 'ENABLED (10 min)' for auto shut-off, 'DISABLED (temp.)' to temporarily disable the auto shut-off for one measurement session, and 'DISABLED (PERM.)' to permanently disable the shut-off feature for use with external power supplies. Press 'HOLD' to 'ENTER' the selection in the detector EEPROM or the change in RAM will be reset the next time the instrument is turned on. Permanent changes such as 'ENABLED (10 min)' and 'DISABLED (PERM.)' always must be 'ENTERed', since they must be stored in permanent

EXPERIENCED USER REFER TO SECTION 6.3 ON PROGRAMMING BEFORE EXPERIMENTING WITH THE 'PROGRAM MODE' CAPABILITIES.

Press the 'ON/OFF' button to 'EXIT' the programming mode and return to 'SIGNAL' mode. The message 'NO OFF' will blink in the status register in 'SIGNAL' mode to indicate that the automatic shut-off has been disabled. 'DISABLED (temp.)' will be reset to 'ENABLED (10 min)' when the instrument is turned off. 'DISABLED (PERM.)' or 'ENABLED (10 min)' is permanently stored in the detector EEPROM memory.

```
+12.34  mW/cm2
SIGNAL              NO OFF
```

To provide for long duration integration (more than 24 hours), the automatic shut-off feature does not apply to the 'INTEGRATE' modes, except for the case where the 'HOLD' button has been pressed to pause an integration, causing the ILT1400 to turn off in ten minutes if no buttons are pressed, providing that the automatic shut-off feature has not been disabled. The ILT1400 can also be custom programmed to accommodate specialized applications. Please consult an Applications Engineer at our manufacturing facility for additional information.

2.5 System flashes "NO CAL"

The double EEPROM (Electrically Erasable Programmable Read Only Memory) in the "L" connector for the ILT1400 can be erased. The most common cause is static electricity or a large arch of power sometimes caused by turning on very high powered lamp, which send out a surge of electricity. If the system flashes "NO CAL" you will have to follow the steps in chapter 6 to self program your calibration factors, being sure to press hold at the end. If this does not successfully restore the calibration factor, then sensor will need EEPROM replacement. Please contact our service dept for further assistance.

3. INPUTS - DETECTORS

3.1 GENERAL

All ILT1400 detectors attach to the card edge at the top of the ILT1400 meter. The "L" listed in the detector model number signifies the use of the detector card edge connector required for connection to the ILT1400 Meter (ie. SEL, XRL, SPL).The detector card edge connectors have been carefully designed so that detectors and extension cables can be plugged onto the card edge both frontward and backward. The card edge itself consists of 10 connection lines, referenced below.

LINE 1: "DODM" - EEPROM Out and "BUSYNOT"
LINE 2: "DIDM" - EEPROM input and "DATA"
LINE 3: "SKDM" - Clock for EEPROM
LINE 4: "CSDM" - Chip Select for EEPROM or Printer
LINE 5: "GARD" - Signal Return
LINE 6: "INPUT" - Current Signal Input
LINE 7: "GND" - Ground
LINE 8: "RQSNDNOT" - Request to Send (Not)
LINE 9: "-5V" - Negative 5 Volts
LINE J: "+5V" - Positive 5 Volts

The multiple voltage levels available through the ILT1400 card edge make it possible for the instrument to maximize the performance of detectors with different bias requirements. Each detector in the ILT1400 system is dedicated to a particular combination of input optics, filters, and photosensitive device. The EEPROM located inside each detector head informs the ILT1400 of the specific calibration, units, and range limitations of the dedicated combination. The following several sections explain the general types of photosensitive devices used in our detectors.

3.2 XRL140 - UV STABILIZED SILICON PHOTODIODE DETECTOR

The XRL140 Photoresist and XRL340 Attenuated Photoresist version combine a silicon cell with Photoresist A or B filters in a special low profile remote probe (13 mm x 42 mm dia.). The XRL140 probe can also be custom filtered with our narrow band, sharp cut and other band pass filters to meet customer's spectral requirements. Please contact one of our technical support representatives for assistance with custom sensor.

XRL140A: Dynamic Range: $2.22e^{-8}$ to $7.78e^{-2}$ W/cm ^{2} Measurement Range: 320-475

XRL340A; Dynamic Range: $2.50e^{-7}$ to $8.75e^{-1}$ W/cm ^{2} Measurement Range: 320-475 nm

XRL140B Dynamic Range: $5.26e^{-8}$ to $1.84e^{-1}$ W/cm^2 Spectral Range: 326 - 401 nm

XRL340B Dynamic Range**:** $5.26e^{-7}$ to $1.84e^{+0}$ W/cm^2 Spectral Range**:** 326 to 401 nm

XRL140T254 Dynamic Range: $3.33e^{-7}$ to $1.17e^{+0}$ W/cm² Measurement range: 249-259 nm, CW 254 nm

3.3 SSL001A – SUPER SLIM UV PROBE

This "Super Slim" UV probe is a 0.64 mm2 silicon detector with built in UV filter. It was designed for use in very low profile applications, such as printed circuit board and printing plate exposure assemblies. Care should be taken when using the SSL001A slim probe to avoid excessive strain or crimping of the cable and/or scratching the surface of the diode.

Dynamic Range: $1.11e^{-5}$ to $9.00e^{-1}$ W/cm² (limit exposure to prevent heat damage). Spectral Range: 260 - 400 nm. Dimensions: 29 x 38 x 2 mm

3.4 SEL033 - UV STABILIZED SILICON PHOTODIODE DETECTOR

The SEL033 base detector contains a specially coated 0.33 cm^2 UV stabilized silicon cell with a quartz window. The SEL033 is one of our most commonly used sensors. It can be used with a large assortment of filters, input optics and calibrations and covering the broad spectrum of 200-1100 nm.

SEL033/QNDS2/W Solar Head: Dynamic Range: $5.00e^{-7}$ to $1.75e^{+0}$ W/cm². Measurement Range: 200-1100 nm.

SEL033/F/QNDS3/HNK15 Laser Power Head. Dynamic Range: $6.10e^{-4}$ to $2.00e^{+2}$ W. Measurement Range:400-1064 nm

SEL033/Y/W Photometric Head: Dynamic Range: $5.98e^{-2}$ to $2.09e^{+5}$ lux. Spectral Range: 400-700 nm.

SEL033/UVA/TD UVA head: Dynamic range:$2.50e^{-8}$ to $8.75e^{-2}$ W/cm^2. Measurement range: 315-390 nm.

SEL033/F/W Flat Radiometric Head: Dynamic Range: $7.69e^{-9}$ to $2.69e^{-2}$ W/cm². Measurement Range: 400 -1064 nm.

SEL033/F/R Narrow Field Radiance Head: Dynamic Range: $1.30e^{-7}$ to $4.55e^{-1}$ W/cm²/sr. Spectral Range: 400-1064 nm.

3.5 SEL240 and SEL220 - SOLAR BLIND VACUUM PHOTODIODE DETECTOR

The SEL240 utilizes a 50 mm² active area Vacuum photodiode with quartz window (visible blocking) to provide accurate measurement in the Deep Ultraviolet while excluding all Visible and Infrared radiation, with a spectral range from 185-320 nm, with a240 nm peak. The SEL220 includes a fused silica window allowing measurements from 160-320 nm, with a 220 nm peak.

SEL240/UVB1/TD: Sharp Cut UVB Detector Head Dynamic Range: $1.11e^{-5}$ to $1.11e^{-1}$ W/cm². Measurement Range: 265-332 nm.

SEL240/UVB/W UVB phototherapy sensor: Dynamic Range: $1.54e^{-6}$ to $1.54e^{-2}$ W/cm². Measurement Range:275-310 nm.

SEL240/QNDS2/TD Germicidal Head For low pressure mercury lamps: Dynamic Range: $3.33e^{-5}$ to $3.33e^{-1}$ W/cm². Measurement Range: 185 - 310 nm.

SEL240/NS254/TD Narrowband Head: Dynamic Range: $2.08e^{-6}$ to $2.08e^{-2}$ W/cm². Measurement range: 249-259 nm 254 CW.

SEL240/T2ACT5 UV Actinic Head:
Dynamic Range: $1.49e^{-7}$ to $1.49e^{-3}$ effective W/cm².
Spectral range: 190-400 nm (Also doubles as an Effective Germicidal Radiation Head for measurement in accordance with the IES Luckiesh and DIN standards: 235-307 nm Effective Germicidal).

SEL220/NS185 Narrow Band Germicidal / Ozone Head: Dynamic Range: $2.50e^{-7}$ to $2.50e^{-3}$ W/cm². Measurement Range: 165-200 nm.

3.6 SEL005 - UV-VISIBLE GaAsP DETECTOR

The SEL005 base detectors contain a 5.2 mm² Gallium-Arsenide-Phosphide detector with quartz window. The SEL005 is most commonly used in applications requiring IR blocking and is required for use with most of the WBS wide band filters due to their secondary response in the NIR.

SEL005/UVA/TD Solar UVA Head: Dynamic Range: $2.33e^{-7}$ to $8.14e^{-1}$ W/cm². Measurement Range: 315-390 nm.

SEL005/WBS320/TD UV Curing Head: Dynamic Range: $1.82e^{-7}$ to $6.36e^{-1}$ W/cm². Measurement Range: 250-400 nm.

SEL005/NS335/TD Narrow Band UV Curing Head: Dynamic Range: $2.33e^{-6}$ to $8.14e^{+0}$ W/cm². Measurement Range: 330-340 nm.

SEL005/TLS312/TD UVB narrow band phototherapy: Dynamic Range: $2.50e^{-6}$ to $8.75e^{-2}$ W/cm². Measurement Range: 312 nm CW.

3.7 SEL623 THERMOPILE DETECTOR

The SEL623 series detectors utilizes a 4 mm^2 multi-junction thermopile detector with quartz window and built in preamplifier to provide a nearly flat spectral response over the extremely wide range of 200 to
4200 nm. The multi-junction thermopile is designed to measure the average power of high peak power, low duty cycle pulsed lasers. The SEL623 is also useful for high intensity applications such as solar irradiance measurement.
SEL623/H/N/K15: Laser Power Probe: Dynamic Range: $3.00e^{-3}$ to $3.00e^{+1}$ W. Measurement Range: 200-2100 nm.
SEL623/K9: Solar Irradiance Probe: Dynamic Range: $2.00e^{-5}$ to $9.67e^{-2}$ W/cm². Measurement Range: 200-4200 nm.
SEL623/SCS695/W IR Hazard Head: Dynamic Range: $8.57e^{-5}$ to $4.14e^{-1}$ W/cm^2. Measurement Range: 695 - 2100 nm.

3.6 Additional Photodetectors

Below is a list of the additional detectors available for use with the ILT1400. Since our product line is continuously growing please visit out website for an updated list if you cannot find your detector listed.

SEL007/U IR InGaAs Detector	7 mm^2 detector with spectral range from 850-1700nm.
SEL100/U Broadband Silicon Detector	100 mm^2 silicon detector, quartz window. Spectral Response: 200-1100nm, 950nm peak.
SEL185/U Gold Cathode Vacuum UV Detector	50 mm^2 active area Au Cathode Vacuum photodiode.Spectral Range: 160-240nm, 185nm peak.
SEL320/U UV Gallium Nitride	Provides Uniform sensitivity from 200-320 nm. Dimensions: 20 x 42 mm dia.
SEL324/U Broadband Silicon	Large 324 mm^2 active area silicone detector. Dimensions: 20 x 42 mm dia.
SEL365/U UV Gallium Nitride	Provides Uniform sensitivity from 200-365 nm. Dimensions: 20 x 42 mm dia.
SEL624/U Multi-junction Thermopile Detector	4 mm^2 thermopile detector with KBr window. Spectral range: 0.2-40 micron, flat > 1.0 micron.
SEL625/U Multi-junction Thermopile Detector	4 mm^2 thermopile detector with BaF2 window. Spectral range: 0.2-15 micron, flat > 1.0 micron.
SPL024F Laser Power / Irradiance Probe	1.2 mm2 silicon detector in pen-like housing with 5.5 mm aperture opening, internal integrating sphere, and F Flat Filter. Measurements in W or W/cm².
SPL024Y Photopic Pen Probe	1.2 mm2 silicon detector in pen-like housing with 5.5 mm aperture opening, internal integrating sphere, Y Filter, Measurement in Lumens or lux.
SPL025F Radiance Pen Probe	1.2 mm2 silicon detector in pen-like housing with radiance optics, and F Flat Filter, readout in W/cm²/sr.
SPL025Y Contact Luminance Pen Probe	1.2 mm2 silicon detector in pen-like housing with luminance optics, Y Filter. Measurement in cd/m2.
SCL110 Illuminance Probe	Photopic response from 400-700nm with a .64 mm dia active area silicon detector.
SCL144 Bilirubin Phototherapy Probe	Spectral response from 422-488nm with a stable silicon detector.

4. OUTPUTS

4.1 DISPLAY MESSAGES

```
+1.234  mW/cm2
SIGNAL            HOLD
```

```
+2.34  J/cm2
HI     INTEG      BAT LO
```

The 32 character Liquid Crystal Display simultaneously displays two lines of information. The top line displays the four digit decimal numerical data and the appropriate auto-ranged optical units. The numerical data appears in three or four digit decimal form, providing a minimum resolution of 0.5 % to ensure reliable, easy to read information. The alphanumeric units, displayed to the right of the decimal data, are automatically ranged in the following standard three decade SI prefix increments: f- ("femto", 10^{-15}), p- ("pico", 10^{-12}), n- ("nano", 10^{-9}), µ- ("micro" , 10^{-6}), m- ("milli", 10^{-3}), k- ("kilo", 10^{3}), M- ("Mega", 10^{6}). The base units are dependent on the type of detector and calibration, and can be chosen from the following list or custom specified: Amperes, Watts, W/cm^2 (Watts per square centimeter), $W/cm^2/sr$ (Watts per square centimeter per steradian), $W/cm^2/nm$ (Watts per square centimeter per nanometer), lm/ft^2 or fc (lumens per square foot, or foot-candles), lux or lm/m^2 (lux, or lumens per square meter), fL (foot-Lamberts), E/cm^2 (Einsteins per square centimeter), cd/cm^2 (Candelas per square centimeter), cd/m^2 (Candelas per square meter). When integrated, these same units become Coulombs, Joules, J/cm^2, etc, respectively.

The bottom line displays the present mode of operation and the instrument status, to indicate the type of measurement being performed as well as any special conditions that exist, such as a low battery. Error messages appear in the instrument status register or across the entire display to alert the user to special situations, and are listed below along with the standard mode of operation messages.

```
SHUT POWER OFF
PLUG DETECTOR IN
```

'SHUT POWER OFF, PLUG DETECTOR IN': This message appears across the entire screen when either the instrument is turned on without a detector plugged in, or the detector is removed during normal operation. The ILT1400 will automatically turn itself off within 30 seconds after this message appears. Press the 'ON/OFF' button to turn the instrument off, plug in a detector, and press the ‘ON/OFF’ button again to turn the ILT1400 on and enter ‘SIGNAL’ mode.

```
+12.34  fc
SIGNAL
```

```
+132.8  lux
SIGNAL
```

‘SIGNAL’: This message is displayed continuously in the ‘mode of operation’ register (lower left corner of the LCD) after the ‘SIGNAL’ button has been pressed, indicating that the instrument is in constant wave measurement mode.

```
+123.4  cd*s/ft2
HI  INTEG
```

```
+22.7  lm*s/m2
LO  INTEG
```

‘HI INTEG’ or ‘LO INTEG’: One of these messages is displayed continuously in the ‘mode of operation’ register (lower left corner of the LCD) after the ‘INTEGRATE’ button has been pressed, indicating that the instrument is in light integration mode. Press the ‘INTEGRATE’ button twice within one second to alternate between the ‘HI’ and ‘LO’ integration ranges. Press the integrate button once to reset the integral register in that mode to zero.

```
+0.000  uW/cm2
ZEROING
```

```
+0.000  nW/cm2
SIGNAL
```

‘ZEROING’: This message is displayed temporarily in the ‘mode of operation’ register (lower left corner of the LCD) after the ‘ZERO’ button has been pressed, measuring the present light level and subsequently returning to ‘SIGNAL’ mode while subtracting this ambient light from future readings.

```
+0.123  mW/cm2
SIGNAL              HOLD
```

```
+1.234  J/cm2
HI  INTEG    HOLD
```

‘HOLD’: This message will blink in the ‘status’ register (lower right corner of the LCD) after the ‘HOLD’ button has been pressed, activating the ‘HOLD’ feature. The most recent reading will be frozen on the data display. To remove the ‘HOLD’ status, toggle the ‘HOLD’ button again or hit a function key (‘SIGNAL’, ‘INTEGRATE’, or ‘ZERO’) to select a new mode of operation.

```
+154.9  nAmpere
SIGNAL              BAT LO
```

```
+22.7  Coulomb
HI  INTEG    BAT LO
```

‘BAT LO’: This message will blink in the ‘status’ register (lower right corner of the LCD) when the 6 VDC battery voltage drops below 4.95 V. The instrument will operate for approximately 54 hours before the ‘BAT LO’ error status appears. The ILT1400 internal computer will continue to operate until the battery voltage falls below 4.7 V, (approximately 10 hours after ‘BAT LO’ appears), but accuracy can no longer be guaranteed. An external power supply between 5 Volts and 15 Volts DC (an automobile battery, for example) can be used where continuous use is expected.

```
++++++  W/cm2
SIGNAL          OVR RNG
```

```
++++++ J/cm2
LO  INTEG    OVR RNG
```

‘OVR RNG’: This message will blink in the ‘status’ register (lower right corner of the LCD) when the input detector signal exceeds the measurement range of the system. In addition, plus signs take the place of numerals in the data display, so that the top line will read ‘++++++ W/

cm2'. If the signal over ranges in 'LO INTEG' mode, hit the 'INTEGRATE' button twice within one second to switch to 'HI INTEG' mode and a higher signal range.

```
PROGRAM MODE
ON/OFF TO EXIT
```

```
AUTO SHUT-OFF
ENABLED  (10 min)
```

'PROGRAM MODE, ON/OFF TO EXIT': This message appears across the entire screen when entering the 'PROGRAM' mode by pressing the 'ZERO' button within 1 second after pressing the 'OFF' button. We strongly recommend that EXPERIENCED USERS refer to section 6.3 before attempting to use this mode. Press 'ZERO' to select through the list of changeable 'MENU' screens. Press 'SIGNAL' to 'SELECT' the digit or line to be changed. Press 'INTEGRATE' to 'INCREMENT' the digit or line that has been selected. Press 'HOLD' to 'ENTER' a change permanently in the detector EEPROM. All changes, whether 'ENTERed' or not, appear as a temporary change in the RAM. Press 'ON/OFF' to 'EXIT' this mode at any time.

```
+123.4  mW/cm2
SIGNAL              NO OFF
```

```
+22.7  J/cm2
HI  INTEG    NO OFF
```

'NO OFF': This message will blink in the 'status' register (lower right corner of the LCD) when the automatic 10 minute shutoff feature has been disabled. This indicates that a previous user selected 'AUTO SHUT OFF' 'DISABLED' using the programming mode capabilities.

4.2 SERIAL OUTPUT

Detector Edge Connector Pinout:

LINE 1: "DODM" - EEPROM Out and "BUSY NOT"
LINE 2: "DIDM" - EEPROM Input and "DATA"
LINE 3: "SKDM" - Clock for EEPROM
LINE 4: "CSDM" - Chip Select for EEPROM or Printer
LINE 5: "GARD" - Signal Return
LINE 6: "INPUT" - Current Signal Input
LINE 7: "GND" - Ground
LINE 8: "RQSNDNOT" - Request to Send (Not)
LINE 9: "-5V" - Negative 5 Volts
LINE J: "+5V" - Positive 5 Volts

Request to Send ("RQSNDNOT") and Chip Select ("CSDM") are held low. An external button can be wired between "RQSNDNOT" and "GND" to provide remote sampling. When the switch is closed, connecting PIN 2 to PIN 4, the ILT1400 will send a continuous stream of data at a rate of one line (one reading) per second. The output is expressed in digital exponential notation. The ILT1400 transmits data once every 0.5 seconds.

For users who wish to connect to a computer, the A512 Serial Adapter cable (mini-USB connector) is available and outputs serial UART data with a direct correlation to the value displayed on the LCD display. This is typically used for an immediate hard copy of time variation or optical profiling measurements. We provide Complimentary LabVIEW® Virtual Instrument drivers on our website: http://www.intl-lighttech.com/library/software/

For the more experienced users who wish to connect to a computer or data collecting device we provide detailed information on the data format. One of the big advantages of the serial output is the ability to interface directly with most computer user ports without buying an expensive hardware adapter. A small machine language (or even BASIC) program can often make a direct connection possible. We can also provide a copy of a very basic program to get users started.

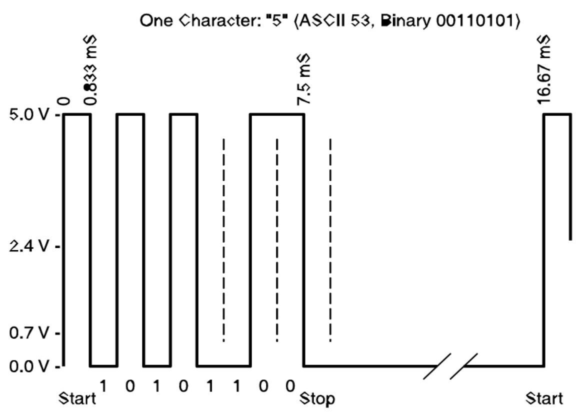
The ILT1400 Serial Output Port transmits a 12 byte, fixed field scientific notation reading (4 numerical mantissa digits with a +/- sign and decimal point, the letter e, 2 exponent digits with a +/- sign, a carriage return, and line feed).

4.2.1 Baud Rate

The ILT1400 is factory set to an asynchronous baud rate of 1200 BPS. Baud rate is the number of bits per second transmitted in each word. In this case, there are 10 bits transmitted per character, which translates to a maximum of 120 characters per second. In actual practice, however, the ILT1400 computer sends character data only half the time, resulting in one transmitted character every 1/60 of a second. This is typical for asynchronous data transmissions.

4.2.2 Character Format

The 20 bits that make up each character word are comprised of 1 start bit, 8 data bits, and 11 stop bits. The extra 10 stop bits provide a necessary delay to allow the microprocessor to perform its other duties. Thanks to crystal control, the length of a single character (before the stop bit) is exactly 7.5 milliseconds, followed by a stop bit delay of exactly 9.17 milliseconds. The following diagram shows the voltage waveform for the serial character format of the number “5”. The binary number is transmitted in reverse order, from least to most significant digit. The most significant digit is always a binary zero (+ 5 Volts), which ensures a negative leading edge to the first stop bit.



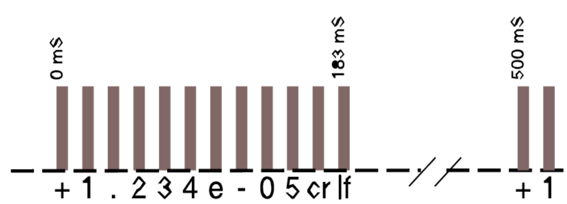
ASCII	Decimal	Hex	Binary
LF	10	0a	0 0 0 0 1 0 1 0
CR	13	0d	0 0 0 0 1 1 0 1
+	43	2b	0 0 1 0 1 0 1 1
-	45	2d	0 0 1 0 1 1 0 1
.	46	2e	0 0 1 0 1 1 1 0
0	48	30	0 0 1 1 0 0 0 0
1	49	31	0 0 1 1 0 0 0 1
2	50	32	0 0 1 1 0 0 1 0
3	51	33	0 0 1 1 0 0 1 1
4	52	34	0 0 1 1 0 1 0 0
5	53	35	0 0 1 1 0 1 0 1
6	54	36	0 0 1 1 0 1 1 0
7	55	37	0 0 1 1 0 1 1 1
8	56	38	0 0 1 1 1 0 0 0
9	57	39	0 0 1 1 1 0 0 1
e	101	65	0 1 1 0 0 1 0 1

4.2.3 Voltage Levels & Current Drive

The output voltage level on PIN 3 (“DATA”) of the DIN connector is capable of driving one TTL load. The voltage swing will be a full five (5) Volts instead of the typical TTL voltage of four (4) Volts. The serial word will be in negative logic for the printer (positive logic for the EEPROM). In negative logic, a logic ‘ONE’ will be between 0.0 and 0.8 Volts and a logic ‘ZERO’ will be between 2.4 and 5.0 Volts. The output line is capable of ‘sinking’ 1.3 milliAmps, and of ‘sourcing’ much more than 100 microAmps, which conforms to the one TTL load requirement. The inverted Request to Send line (“RQSNDNOT”) on PIN 1 of the DIN connector will initiate transmission of the data string when pulled to a voltage below +0.8 Volts, provided that the Chip Select line “CSDM” is also low.

4.2.4 Word String Format

The ILT1400 sends out a string of serial words (characters) to transfer the displayed data to other equipment, such as a printer or computer. The interface sends out exactly twelve (12) characters to portray the line of data. The first character is a ‘+’ or ‘-’ sign for the mantissa. The second character is the first digit of the mantissa. The third character is a decimal point. The fourth, fifth, and sixth characters are the remainder of the 4 digit mantissa. The seventh character is the lower case letter ‘e’ to separate the mantissa from the exponent. The eighth character is a ‘+’ or ‘-’ sign for the exponent. The ninth and tenth characters are the 2 digit exponent. The eleventh character is a carriage return. The twelfth character is a line feed.



4.2.5 Plug and Cable Requirements

We offer the A510 25-pin, A512 Serial Adapter, and the A511 9-pin RS232 Adapter Cables as *optional* accessories to the ILT1400 to facilitate easy connection of the ILT1400 to a serial device such as a printer or computer. Please contact one of our sales representatives for ordering information

It is also possible to use one of the many commercially available Serial-to-USB adapters to interface the ILT1400 to a USB printer or the USB port of a computer. (requires A511 sold seperately)

5. OPTICAL CALIBRATION

5.1 N.I.S.T. TRACEABLE FACTORY CALIBRATION

All ILT1400 systems are first calibrated electronically to accurately measure signal data in absolute current units (Amperes). The detector is then tested in our optical calibration lab against N.I.S.T. traceable optical D.R.I.P. (Detector Response Inter-comparison Program) standards to determine the detector's particular "sensitivity factor", in terms of Amperes per Optical Unit that you specify. The ILT1400 microprocessor divides the detector current by this calibration factor to obtain the final units. The sensitivity factor is programmed into the detector EEPROM memory along with the alphanumeric units, range limitations, manufacture date, last calibration date, serial number, and default zero level. We do not recommend changing any of this stored calibration information. Our calibration standards come directly from N.I.S.T. to provide maximum accuracy and accountability.

6. PROGRAM MODE - OPERATION

WARNING: THE N.I.S.T. TRACEABLE INTERNATIONAL LIGHT CALIBRATION PROVIDED WITH YOUR ILT1400 IS VALID ONLY FOR THE SENSITIVITY FACTOR AND UNITS SPECIFIED ON YOUR CALIBRATION CERTIFICATE. PROGRAMMING IS NOT RECOMMENDED FOR INEXPERIENCED USERS.

PROGRAM MODE
ON/OFF TO EXIT

To enter 'PROGRAM' mode, begin with the ILT1400 turned on and a detector plugged in. Next, press the 'OFF' button and within 1 second press the 'ZERO' button. The LCD message 'PROGRAM MODE', 'ON/OFF TO EXIT' will appear. You can get out of 'PROGRAM' mode at any time by pressing the 'ON/OFF' button. When in 'PROGRAM' mode, the push buttons assume alternate functions:

The 'MENU' button (ZERO button) scrolls the display through the 11 programmable menu screens. Four of these screens allow the user to make a permanent change in the EEPROM (Electrically Erasable Programmable Read Only Memory) located in each detector head, or a temporary change in just the RAM (Random Access Memory) located in the instrument itself. The user can disable/enable the 10 minute automatic shut-off feature, change the displayed units, and change or adjust the factory set calibration factor. The remaining 7 menu screens can be viewed by the user but not changed, except during factory recalibration. The serial number, date the instrument was last calibrated, original sensitivity factor & units of calibration, maximum and minimum current limits, and date the instrument was manufactured can all be viewed.

The 'SELECT' button (SIGNAL button) moves the position of the blinking cursor underneath the specific digit that the user wishes to change using the 'INCREMENT' button. The cursor moves to the right, wrapping around to the first digit on the left after passing the last digit on the right. When a number or word is to be scrolled, the 'SELECT' button changes the direction that the 'INCREMENT' button will scroll, indicating either 'UP' (up) or 'dn' (down).

The 'INCREMENT' button (INTEGRATE button) changes the value of the digit or line that is highlighted by the cursor. The value of a highlighted numerical digit will be increased by 1, wrapping around to 0 after passing 9. In the 'AUTO SHUT-OFF' screen, this button allows selection between 3 different modes, changing the entire bottom line of the display. In the 'UNITS SELECT' and 'ADJ' modes, the 'INCREMENT' button increments the screen in either the 'UP' or 'dn' direction, chosen using the 'SELECT' key.

The 'ENTER' button (HOLD button) permanently stores any changes in a screen in the detector EEPROM memory. If this button is not pressed, the changes will appear temporarily in the instrument's RAM memory, but will be restored to the original EEPROM values if the unit is turned off. When a screen is 'ENTERed', the menu advances to the next screen.

The 'EXIT' button (ON/OFF button) simply exits the user from 'PROGRAM MODE', returning immediately to 'SIGNAL' mode and initiating any temporary or permanent changes in operation.

6.1 'PROGRAM MODE' - Quick Reference:

6.1.1 MENU # 1:

```
PROGRAM MODE
ON/OFF TO EXIT
```

'ZERO' button: To advance the 'MENU' to screen # 2.

'ON/OFF' button: To 'EXIT' the programming mode at any time.

```
AUTO SHUT-OFF
ENABLED (10 min)
```

```
AUTO SHUT-OFF
DISABLED  (temp.)
```

'ZERO' button: To advance the 'MENU' to screen # 3.

'INTEGRATE' button: To 'INCREMENT' the bottom line between three choices: 'ENABLED (10 min)', 'DISABLED (temp.)', and 'DISABLED (PERM.)'.

'HOLD' button: To 'ENTER' a change permanently. Changes that were not entered will be reset when the instrument is turned off.

'ON/OFF' button: To 'EXIT' the programming mode at any time.

6.1.3 MENU # 3:

```
+123.4 Nw/cm2
UNITS SELECT    UP
```

```
+123.4  nW/cm2
UNITS SELECT    dn
```

'ZERO' button: To advance the 'MENU' to screen # 4.

'SIGNAL' button: To 'SELECT' the direction that the list of units increments, either 'UP' or 'dn' (down).

'INTEGRATE' button: To 'INCREMENT' through the list of units in the up or down direction, selecting the units shown on the display. UNITS CHANGES DO NOT AFFECT THE NUMERICAL VALUE OF THE READING.

'HOLD' button: To 'ENTER' a change permanently. Changes that were not entered will be reset when the instrument is turned off.

'ON/OFF' button: To 'EXIT' the programming mode at any time.

'PROGRAM MODE' - Quick Reference (continued):

WARNING: THE N.I.S.T. TRACEABLE CALIBRATION PROVIDED BY INTERNATIONAL LIGHT WITH YOUR ILT1400 IS VALID ONLY FOR THE SENSITIVITY FACTOR AND UNITS SPECIFIED ON YOUR CALIBRATION CERTIFICATE.

6.1.4 MENU # 4:

```
+12.19 pW/cm2
FACTOR  1.000e+00
```

```
+123.4 nW/cm2
FACTOR 9.876e-05
```

'ZERO' button: To advance the 'MENU' to screen # 5.

'SIGNAL' button: To 'SELECT' the digit that you wish to increment.

'INTEGRATE' button: To 'INCREMENT' the digit that you selected. A factor change will immediately affect the numerical value displayed, but not the units.

'HOLD' button: To 'ENTER' a change permanently. Changes that were not entered will be reset when the instrument is turned off.

'ON/OFF' button: To 'EXIT' the programming mode at any time.

6.1.5 MENU # 5:

```
+123.3 nW/cm2
ADJ UP 9.876e-05
```

```
+123.3 nW/cm2
ADJ dn 9.876e-05
```

'ZERO' button: To advance the 'MENU' to screen # 6.

'SIGNAL' button: To 'SELECT' the direction that you wish to increment the sensitivity factor, either 'UP' or 'dn'
(down).

'INTEGRATE' button: To 'INCREMENT' the least significant digit of the sensitivity factor in the up or down direction for minor adjustments. The displayed reading immediately reflects this adjustment.

'HOLD' button: To 'ENTER' a change permanently. Changes that were not entered will be reset when the instrument is turned off.

'ON/OFF' button: To 'EXIT' the programming mode at any time.

'PROGRAM MODE' - Quick Reference (continued):

```
SERIAL NUMBER
0123456
```

6.1.7 MENU #7

```
+123.4 nW/cm2
IL CAL 9.876e-05
```

6.1.8 MENU # 8:

```
CALIBRATION DATE
Da20  Mo03  Yr98
```

6.1.9 MENU # 9:

```
MANUFACTURED
Da22  Mo11  Yr97
```

6.1.10 MENU # 10:

```
DETECTOR CURRENT
MAX  COUNT  6AD8
```

6.1.11 MENU # 11:

```
DETECTOR CURRENT
min      1.000e-11
```

'ZERO' button: To advance the 'MENU' to the next screen. FOLLOWING MENU # 11, THE DISPLAY RETURNS TO MENU # 1.

'ON/OFF' button: To 'EXIT' the programming mode at any time.

ANY CHANGES THAT WERE ENTERED USING THE 'HOLD' BUTTON WERE PERMANENTLY SAVED IN THE DETECTOR'S CONSTANT MEMORY. ALL UN-ENTERED CHANGES WILL BE TEMPORARILY STORED IN RAM, AFFECTING THE OPERATION OF THE INSTRUMENT ONLY UNTIL THE POWER IS TURNED OFF.

6.2 Disabling the Automatic Shut-Off

```
+123.4 mW/cm2
SIGNAL            NO OFF
```

```
AUTO SHUT-OFF
ENABLED  (10 min)
```

```
AUTO SHUT-OFF
DISABLED  (temp.)
```

```
AUTO SHUT-OFF
DISABLED  (PERM.)
```

The first menu screen the user encounters in 'PROGRAM' mode is 'PROGRAM MODE', 'ON/OFF TO EXIT'. When the 'MENU' (ZERO) button is pressed, the display scrolls to one of the 'AUTO SHUT OFF' screens portrayed above. When the 'INCREMENT' (INTEGRATE) button is pressed, the bottom line of the display changes between three different forms: 'ENABLED (10 min)',
'DISABLED (temp.)', and 'DISABLED (PERM.)'. After making the appropriate selection, press the 'ENTER' (HOLD) key to permanently store the change in the detector EEPROM. If the user leaves this screen without first 'ENTERing' the change, only the instrument's RAM

will be reset as soon as the power is turned off. The ILT1400 will then restore the original values from the detector EEPROM when turned on. When the automatic shut-off has been disabled, the instrument will blink the message 'NO OFF' in the status register of the LCD during 'SIGNAL' mode, shown above. Since the ILT1400 is programmed to allow integration for as long as necessary to complete a measurement, the instrument will never automatically shut off while actively integrating.

'ENABLED (10 min)' is the standard mode of operation, causing the instrument to automatically shut off if a keypress is not sensed within 10 minutes while in 'SIGNAL' mode. As mentioned above, while in 'INTEGRATE' mode, the ILT1400 will operate indefinitely without shutting off to provide for long term integration measurement sessions. However, if 'HOLD' is pressed while in 'INTEGRATE' mode, the instrument will automatically shut off in 10 minutes. Remember to hit 'ENTER' to permanently enable (or disable) the automatic shut-off feature.

'DISABLED (temp.)' causes the instrument to TEMPORARILY disable the automatic shut-off. This particular selection does not need to be 'ENTERed', since it is inherently a temporary change and will not be stored in the detector EEPROM. The instrument will reset to the previously established mode when the power is lost.

'DISABLED (PERM.)' causes the instrument to PERMANENTLY disable the automatic shut-off, until this feature is enabled again in program mode. Remember to hit 'ENTER' to permanently disable (or enable) the automatic shut-off feature.

6.3 Changing the Displayed Units

WARNING: CHANGING THE DISPLAYED UNITS MERELY CHANGES THE WORD, NOT THE ACTUAL READING. THE READING MUST BE SCALED BY CHANGING THE SENSITIVITY FACTOR. YOUR INTERNATIONAL LIGHT CALIBRATION IS VALID ONLY FOR THE SENSITIVITY FACTOR AND UNITS SPECIFIED ON YOUR CALIBRATION CERTIFICATE.

```
+123.4 lm/m2
UNITS  SELECT    UP
```

```
+123.4 lux
UNITS  SELECT    dn
```

Press the 'MENU' (ZERO) button to scroll to the 'UNITS SELECTION' menu screen. Use the 'SELECT' (SIGNAL) button to choose 'UP' or 'dn', changing the direction that you scroll in the list of units. Press the 'INCREMENT' (INTEGRATE) button to scroll to the next set of units in the up or down direction. Press the 'ENTER' (HOLD) button when you have selected the proper units if you would like the change to be stored permanently on the detector EEPROM. Please note that changing the displayed units merely changes the word portion of the display. The numerical readout will not be converted to the new units (except for unity conversions such as lm/m2 to lux, etc.). The mathematical conversion can, however, be accomplished by changing the sensitivity factor.

6.4 Changing the Sensitivity Factor

WARNING: THE N.I.S.T. TRACEABLE CALIBRATION PROVIDED BY INTERNATIONAL LIGHT WITH YOUR ILT1400 IS VALID ONLY FOR THE SENSITIVITY FACTOR AND UNITS SPECIFIED ON YOUR CALIBRATION CERTIFICATE. ALL CALIBRATION FACTORS REQUIRE THE USE OF THE EXACT COMBINATION OF SENSOR, FILTERS AND INPUT OPTICS THAT WERE USED DURING CALIBRATION.

We have designed the ILT1400 to accommodate the diverse needs of our customers. Our calibrations ensure N.I.S.T. traceable accuracy in absolute optical units. Since we recalibrate the complex electrical circuitry of our instruments before recalibrating to the N.I.S.T. optical D.R.I.P. standard, we recommend recalibration only by International Light Technologies. We do recognize, however, that some customers require the capability to optically self calibrate their own detectors to an in-house standard or to simply read the absolute current output of a detector in Amperes. Some users may also want to change back and forth periodically between the English and SI units systems. For these reasons and many more, we allow the EXPERIENCED USER the versatility to change the sensitivity factor that determines the reading displayed on the instrument.

The ILT1400 accurately measures over seven decades of low level current changes, from 10 picoAmperes to 350 microAmperes. The instrument is electronically calibrated to measure this current absolutely, in Amperes. The detector head is then calibrated in our labs against a N.I.S.T. traceable optical standard to obtain a sensitivity factor, in Amperes per desired Optical Unit, such as 1.876×10^{-3} Amps/Watt/cm^2.

The ILT1400 divides the measured current reading by the sensitivity factor to render an answer in the desired optical units. Naturally, the sensitivity factor for direct readout in Amperes is 1.000×10^{0} Amps/Ampere, a unity conversion factor.

Self calibrating an ILT1400 to an in-house standard is remarkably easy to accomplish. The instrument displays the ongoing signal reading even as the sensitivity factor is incremented. This allows the user to adjust the reading to an established optical standard in real time. For example, the sensitivity factor can be adjusted until the reading agrees with a previously calibrated detector's output. For production environments, the reading can be adjusted to an arbitrary number, such as 100.0, that relates to the maximum output of a lamp standard. Readings would thereafter be displayed in percent.

Converting to a different set of units, such as from foot-candles to lux is also quite simple. The conversion is 1 foot-candle = 10.76 lux. Multiply the sensitivity factor, in Amps/fc, by 1/10.76 fc/lux to obtain a new sensitivity factor in Amps/lux. With a foot-candle sensitivity factor of 2.152 x 10^{-3} Amps/fc, the new sensitivity factor for direct readout in lux would be 2.000 x 10^{-4} Amps/lux.

Since the sensitivity factor is given in Amperes per Optical Unit, a new factor can be calculated by measuring the current output of the detector in Amperes (sensitivity factor of 1.000 x 10^{0}) and dividing by the output of a calibrated detector or lamp standard in the desired Optical Units. A simpler trick for accomplishing this is to enter the value of the output (in Optical Units) of a calibrated detector or lamp standard as a sensitivity factor. The instrument will then read out the desired sensitivity factor as a reading. Enter that reading as the new sensitivity factor and adjust using the 'ADJust' mode. Remember that the sensitivity factor must be entered using scientific notation.

```
+9.29 fc
FACTOR 1.076e-03
```

```
+100.0 lux
FACTOR 1.000e-04
```

To change a sensitivity factor, first scroll to the 'FACTOR' menu using the 'MENU' (ZERO) key. Move the cursor to the mantissa or exponent digit you wish to change using the 'SELECT' (SIGNAL) key. Increment that digit using the 'INCREMENT' (INTEGRATE) button. As you increment the digit, the displayed reading will change immediately to indicate the results of the new sensitivity factor being changed. If you wish to permanently store the new factor on the detector memory, simply press the 'ENTER' (HOLD) button after changing the sensitivity factor.

The original sensitivity factor and units are permanently stored in an unchangeable menu screen for reference should the user desire to eventually return to the original N.I.S.T. traceable factory calibration.

```
+99.9 lux
ADJ  UP  1.000e-04
```

```
+100.1 lux
ADJ  dn  9.999e-04
```

To make fine adjustments to the sensitivity factor in order to match the output of an established detector or lamp standard, scroll to the 'FACTOR' menu using the 'MENU' (ZERO) key. Press the 'SELECT' (SIGNAL) button to change the direction the factor will be incremented, either 'UP' to increase or 'dn' to decrease. Press the 'INCREMENT' (INTEGRATE) button to increment the reading. You will notice that the reading decreases when the factor is increased, but keep in mind that the reading is only updated every half second if attempting to match the output of a calibrated standard. Remember to press 'ENTER' (HOLD) to permanently store the new factor.

Once again, we caution that only EXPERIENCED USERS use the programming capabilities of the ILT1400 to change sensitivity factors and optical units information. A misleading reading could lead to overexposure of phototherapy patients, underexposure of photoresists, or invalid research results. Only a N.I.S.T. traceable calibration can guarantee the accuracy of a reading. Over the years, we have calibrated light measurement equipment manufactured by hundreds of different companies for our customers. Many instruments have linearity problems, spectral inconsistencies, or simply display more resolution than the instrument is capable of measuring. It is unwise to rely on the accuracy of uncalibrated equipment.

Many companies calibrate detectors at the peak response wavelength of the detector, without the benefit of a 'flat' response. Measurements at different wavelengths could appear as much as 90 % lower than the actual reading, resulting in significant overexposure. When measuring a spectrally monochromatic source, such as a laser, it is imperative to calibrate detectors at the isolated wavelength unless a 'flat' response detector is used.

Many customers have relied on the output of lamp standards to provide a reference for calibrating measurement equipment. The amount of light emitted by some lamps can change as much as 5 % for a 1 % change in line voltage. Lamps degenerate significantly over time, losing as much as 50 % of their original brightness in the first thousand hours of use, even though the current is accurately regulated. Whenever a lamp standard is used, it is best to verify its output with calibrated measurement equipment to ensure accuracy.

6.5 Read-Only Menu Screens

MENU # 6:

```
SERIAL NUMBER
   0123456
```

MENU # 7:

```
+123.4 nW/cm2
IL  CAL   9.876e-05
```

MENU # 8:

```
CALIBRATION DATE
Da29  Mo03  Yr99
```

MENU # 9:

```
MANUFACTURED
Da29  Mo03  Yr98
```

MENU # 10:

```
DETECTOR CURRENT
MAX  COUNT  6AD8
```

MENU # 11:

```
DETECTOR CURRENT
Min   1.000e-11
```

The six View Only screens shown above cannot be reprogrammed by the user. They do, however, provide information that may be useful to some users. These screens are primarily used for factory calibrations.

Screen # 6 gives the serial number of the detector. This information is useful if the serial number sticker on the detector is lost or damaged.

Screen # 7 gives the original International Light Technologies sensitivity factor and the units of calibration. This is a useful reference if the user changes the sensitivity factor and subsequently wishes to return to the original N.I.S.T. traceable calibration.

Screen # 8 gives the date that the detector was last calibrated. Screen # 9 gives the date the detector was manufactured. These dates are shown in a Day, Month, Year format. 'Da29 Mo03 Yr91' refers to 29 March 1991, for example. These dates are important for retrieving previous calibration information from our files, and also alarm the user when his instrument has not been calibrated recently.

Screen # 10 gives the maximum current count in the current to frequency converter before the 'OVR RNG' message appears. The hexadecimal number 6AD8 is a typical value (350 microAmps). Screen # 11 gives the minimum current limit in Amperes for a down ranging limit. These screens are used by the factory calibrations engineer during recalibration.

6.6 SELF CALIBRATION

The 'PROGRAM' mode is provided for those EXPERIENCED USERS who wish to calibrate their detectors to their own specifications. It is possible to self calibrate silicon detectors to a higher degree of accuracy than the N.I.S.T. standard, not to mention the elimination of transfer errors. Refer to "Solar Cell Spectral Response Characterization," Edward F. Zalewski and Jon Geist,

Applied Optics, volume 18, number 23, 1 December 1979; and also, "Silicon Photodiode Absolute Spectral Response Self-Calibration," E.F. Zalewski and J. Geist, Applied Optics, volume 19, number 8, 15 April 1980.

The technique they outline is independent of former approaches to absolute radiometry, which are based on the thermal physics of blackbodies or electrical substitution radiometers. They rely on the high level of perfection achieved in the manufacture of UV enhanced planar silicon photodiodes to obtain an internal quantum efficiency within a few hundredths of one percent. Self calibration can achieve accuracies to within a few tenths of one percent over a wide spectral range. The National Institute of Standards and Technology blackbody measurement standard is accurate to six percent in the ultraviolet, one percent in the visible, and four percent in the infrared.

For many users, absolute measurements can be replaced with relative measurements. The ILT1400 can be self-calibrated to read out a number such as 100 when given an effective dose of light for a particular process. The unit can then be used to monitor any relative change in the received dose.

ILT also offers a self calibration procedure to allow adding or removing of neutral density filters. Neutral density filters are available in three ranges: QNDS1 for 10 times reduction in sensitivity, QNDS2 for 100 times reduction in sensitivity, and QNDS3 for 1000 times reduction in sensitivity or attenuation.

To make the process easier, we have added an online QNDS self conversion calculator: http://www.intl-lighttech.com/library/calculators/qnds_calc.

Once you have determined your new calibration factor you must follow the steps in chapter 6 "PROGRAM MODE" to make the necessary adjustments to the existing calibration factor.

7. PRECAUTIONS

The ILT1400 has been designed to minimize problems due to improper operation of the instrument. The impact resistant, flame retardant, ABS construction of the outside plastic enclosure ensures durability in typical hand-held environments. The case is specially coated with Nickel inside to provide RF shielding which exceeds FCC requirements. Despite the durability that we have engineered into the ILT1400, our 25 years of experience in manufacturing laboratory instruments has shown us that users often overlook simple precautions that would prevent most mishaps from ever occurring.

A) Be certain to reset the zero level if you are in doubt about the level it was last set to. The ILT1400 stores the zero in the detector memory, even after the unit is off and the detector removed. The previous user may have set it to subtract a very high level, which will result in very low or possibly negative readings.

B) Use only quality batteries in your instrument. We have provided you with four top-quality, leak-proof, alkaline AA batteries. Do not use rechargeable batteries. Remember, also, to replace batteries when the 'BAT LO' message appears in the status register.

C) Use caution when measuring UV or high power sources. Proper goggles should be worn that absorb UV when in the proximity of applications using intense ultraviolet light, such as Phototherapy, UV curing, Photoresist exposure, and Printing Plate Lithography. We offer UV rejecting sunglasses (A26) that are specifically designed to block out all Ultraviolet wavelengths. Also, remember never to look directly into any laser beam, with or without protective eyewear.

D) Shipping Precautions: Always pack your instrument well when returning it to be recalibrated or repaired. A lack of packing material can cause the instrument to accelerate at an extreme rate. These 'G' forces can severely damage an instrument even when the outside carton shows no sign of abuse.

E) When unplugging detector heads from the top of the ILT1400, pull them straight off. Do not apply torque forces to the card edge connector in any way. Periodically rub the contacts of the edge connector with a rubber pencil eraser or similar nonabrasive material to remove dirt and corrosion which may have built up.

F) Do not attempt to modify the circuitry in your ILT1400. Tampering with the electronics will void the warranty. If modifications are necessary, we can provide schematics of the area to be modified and technical assistance.

8. APPLICATIONS

8.1 CURRENT AND CONDUCTANCE MEASUREMENTS

Most light detectors have a linear relationship between the incident irradiance and the current output as long as the device is biased correctly. The ILT1400 is a very sophisticated, programmable, current and conductance measurement 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. The instrument can be programmed to automatically display any measurable units over an unequalled dynamic range. The current produced by a standard I.L. device can be displayed by changing the sensitivity factor to 1.000 e^0.

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 photomultipliers and vacuum photodiodes. One of the simplest detector configurations uses a detector into an operational amplifier, configured in the trans-conductance mode, which produces a positive output voltage. We measure negative current from the sensitive input (pin 6) with respect to instrument signal ground (pin 7) or with respect to the signal guard (pin 5), depending on the bias requirements of the individual detectors. An alternate detector configuration for measuring Conductance is to connect the cathode of a semiconductor photodiode to the input and the anode to -5 Volts (PIN 9).

8.1.2 Overload

In order to protect the ILT1400, 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 10 milliAmperes of either positive or negative current, from D.C. to 100 MHz, for a short time (about 5 seconds). The input will also survive voltages of approximately plus or minus 5 volts for a similar short time duration. This type of protection offers good survival to most modern circuit accidents, and is designed to withstand most Radio Frequency pickup 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 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 in to 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. Since we have had a personal interest in withstanding this kind of damage, we have gone to great trouble to design the proper protection into the ILT1400.

8.2 FLUX DENSITY MEASUREMENTS

Flux density is properly defined as the density of light incident upon a surface. Flux is a measurement of light energy, typically expressed in Watts for radiometric measurements or in photopically weighted Lumens for photometric measurements. When a sample of this flux is measured over a standard area, the flux density can be calculated in units of flux per unit area, such as Watts per square centimeter or Lumens per square foot (foot-candles), for example. For this measurement to be accurate, the incoming light beam must overfill the detector (be larger than the entrance aperture). In all flux density measurements, the density will drop off as the measurement plane gets farther from a point light source. This concept, the “inverse square law”, means that the reading will be inversely proportional to the square of the relative distance from the light source. For example, if your ILT1400 reads a flux density of 36.0 mW/cm^2 when you are 1 meter from a source, it will read 1/4 of 36, or 9.00 mW/cm^2, when you move back twice as far, to 2 meters away. If you move back three times as far, to 3 meters, your ILT1400 will read 1/9 of 36, or 4.00 mW/cm^2.

Distant light from the sun, moon, and stars is far enough away to be considered infinite, so that even large changes in earth altitude produce negligible “inverse square law” errors. Keep in mind, however, that the atmosphere acts as both an attenuator and a diffuser. If you were to measure the radiometric irradiance of the sun from a high altitude weather balloon, the atmospheric attenuation would be significantly reduced at certain wavelengths, depending on ozone levels, etc. Also, on an overcast day, the clouds act as an excellent diffuser, causing light to shine equally from all portions of the sky. Even though the cloud ceiling may be very close compared with the distance to the sun, the “inverse square law” will not affect the measurement, because the detector will actually be measuring brightness (luminance or radiance), which does not change with distance. This is a special phenomenon which occurs whenever a uniform source is spatially wider than the acceptance angle of the detector. The area of the overcast sky is wider than the 180 degree acceptance angle of the detector. Luminance and radiance detectors typically have very narrow acceptance angles (2.5 degrees), for measuring the brightness of a uniformly radiating area source. When you back away from the uniform source, the detector “sees” a wider area of the source that is proportional to the square of the distance, exactly cancelling the drop in density expected from the “inverse square law”.

8.2.1 Radiometric Irradiance (W/cm^2)

Irradiance is the measurement of the density of light striking a surface. The most conventional units of measurement are Watts per square centimeter (W/cm^2), although some users prefer nonstandard units. We can provide detectors to measure in any system of units, or help you to convert from W/cm^2.

Irradiance measurements require a “flat” spectral response over the wavelength range of the light source. This ensures that light density in different regions of the spectrum is weighted evenly. There are two notable exceptions to this, Photometric Illuminance and Effective Irradiance. In both cases, the sensitivity to light at different wavelengths is weighted to correspond to the biological or chemical effect of those wavelengths. Photometric measurements match the human eye’s response to colors, since the eye sees green light proportionally better than violet or red, and cannot see ultraviolet or infrared light at all. An Effective Irradiance measurement uses a special function designed to match the needs 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 photoresist or polymer film, not the light source, since the light source emits a wide range of wavelengths of light. Some of those wavelengths will have a significant chemical effect, some will have proportionally less effect, and some none at all. In this way, the optical reading will be directly proportional to the effect on the chemical process. The integral of this is the Effective Energy ($Joules/cm^2$). This exposure measurement directly correlates to how much curing took place.

In any light measurement, it is important to realize exactly what light the detector is measuring. A flat response detector “sees” much more than visual light. It sees the Infrared light given off by your body or any warm object, as well as light from any Ultraviolet sources, none of which are visible by the human eye. Filters may be desired to block unwanted bands of light. More often, it is useful 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 edge reflections are less likely to be propagated down an array of multiple baffles. Use plenty of flat black paint to reduce reflections to a minimum. 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.

Spatially, the irradiance detector measures with a desirable Lambertian, or "cosine" response. This means that light shined directly at the detector will be sensed 100%, light from a 45 degree angle will be sensed 70.7%, and light from a 90 degree angle will not be sensed. This mimics the effect of light and reflected light shining on any flat surface, since at oblique angles, the effective area is reduced. For example, if you were to look at a round piece of paper on a table from a 45 degree angle, it would look like an oval with about one third less area than the actual circle had when viewed from above. Light shining onto the circle from a 45 degree angle also "sees" this reduced area oval, meaning that less light will hit the circle. The cosine response is important for measuring the actual amount of light that would fall on a given planar area from a multitude of sources.

Reference distance is also an important consideration. Your irradiance detector measures the flux density, which is dependent on the distance from the source and the "inverse square law" mentioned above. If you wish to know how much light is hitting a particular surface, simply place the detector at the same reference distance as that surface. If your application is UV Curing, place the probe in the curing oven where the process takes place. If your application is phototherapy, place the detector at the same distance from the exposure lamps to the plane of the patient's skin. If it is impossible to place the detector in the proper reference plane, the inverse square law can be used to accurately calculate the proper flux density if the source is an approximate point source.

8.2.2 Photometric Illuminance (lux or foot-candles)

Photometric Illuminance is the flux density of VISIBLE light per unit area. In common terms, it is the amount of "illumination" provided by natural and man made light sources, finding applications in artificial office lighting, emergency backup lighting, entrance and stairway lighting, parking lot illumination, and even behavioral research studies of sleeping habits under various lighting conditions. As was mentioned above, Photometric Illuminance is an Effective Irradiance measurement that is weighted to match the "photopic" eye response of the CIE "Standard Observer" curve. (We also manufacture detectors to match the "scotopic" night vision response). The photopically weighted unit of flux is the lumen, which can only be converted to optical Watts at specific wavelengths, since each wavelength is weighted differently. One Watt of flux at 555 nm is equivalent to 683 Lumens. Illuminance measurements are normally expressed in the SI units of Lumens per square meter, also called lux (lx). Occasionally Lumens per square centimeter, or phot (ph), are used. In the English system, units are expressed in Lumens per square foot, or foot-candles (fc). One foot-candle is equal to 10.76 lux. We recommend using lux, since they are recognized worldwide.

When making an illuminance measurement, the input aperture of the detector must be overfilled. In order to measure a beam that is narrower than the opening of the detector, simply move the detector back away from the source until the beam spreads out enough to completely flood the detector. Remember, of course, the implications of the "inverse square law". As you move back from the source, the flux density decreases exponentially as the inverse square of the relative distance from the source. This effect can be harnessed to measure an unusually bright source, by simply backing away from it to reduce the flux density.

A general rule in illuminance measurements is to always place the detector in the same reference plane as the surface that is illuminated. If you are measuring stairway illumination, for example, you would want to place the detector on the surface of the stair, not at eye level pointed at the stair. Illuminance measures all the light falling on a surface. Luminance, on the other hand, measures brightness similar to the way the human fovea (image analysis portion of the eye) analyzes a very narrow angular area.. For the stairway illumination example, illuminance is measured because it is a constant. The stairs and overhead lighting are fixed. Luminance, on the other hand, could be measured in an infinite number of different ways, depending on where the detector is placed and what it is aimed at. Luminance is usually reserved for uniformly radiating area sources, such as backlit signs or video monitors, whereas illuminance is used to measure how much light is falling on a surface. The reference plane for photometric illuminance detectors is the outside surface of a Teflon® diffuser (or first ring on a W diffuser). This surface should be placed in the same location as the surface that you wish to measure.

8.2.3 Phototherapy - UVA

There are many cosmetic and dermatologically therapeutic treatments involving exposure to Ultraviolet-A light (315 to 400 nm), the wavelength band which triggers melanin production in the epidermis. The standard detector for UVA measurement is the SEL033/UVA/TD. The typical unit will read out in Watts/cm^2 in 'SIGNAL' mode, and Joules/cm^2 in 'INTEGRATE' mode.

Typical UVA phototherapy exposure chambers utilize special fluorescent bulbs to generate UVA radiation. The output of these short wave fluorescent lamps tends to degenerate significantly over time. In fact, a typical UVA lamp output will degenerate 70% in just 6000 hours. A UVA Phototherapy Radiometer will enable a medical technician to monitor the output of the lamp array accurately in order to adjust the exposure time for the proper dose. Once a week or so, the technician (wearing protective eye wear) will simply check the average flux density (Watts/cm^2) at the reference plane of a typical patient's skin (inside the booth) to adjust the exposure times for that week based on the measured irradiance and the desired exposure.

For a more empirical calculation of the Effective Dose of UVA, simply place the detector in the booth at the level of the patient's skin and put the ILT1400 in 'INTEGRATE' mode. The instrument will automatically calculate the ongoing accumulated dose in Joules/cm^2. Remember to press 'HOLD' if you wish to terminate or pause the integration. If you hit 'HOLD' a second time, the instrument will unfreeze the display and return to the uninterrupted integration, allowing intermediate readings to be taken. Constant monitoring of fluorescent exposure booths is necessary, both to ensure a safe, effective ultraviolet dosage and to evaluate when the fluorescent lamps need replacement. As mentioned above, after only 6000 hours of use, a patient will need to be exposed for up to three times as long to accumulate the same treatment dose.

8.2.4 Phototherapy - UVB

Ultraviolet-B radiation consists of any light in the spectral band between 280 and 315 nm. For many phototherapy applications, this "Actinic" radiation can be replaced by UVA, since UVB often irritates or damages the skin, leading to skin cancer. For certain skin disorders, however, moderate doses of UVB light combined with certain drugs can be remarkably beneficial. Psoriasis, a skin irritation condition, can be controlled in this manner. Close monitoring of UVB lamp output and doses is ESSENTIAL, considering the dangers of overexposure as well as the lamp degradation problem mentioned above. Also, remember to always wear protective eye wear when working with short wavelength sources.

The technique for measuring UVB wavelength light is similar to the UVA radiometric irradiance dose measurement described above. The UVB detector should be placed at the same reference plane as the patient's skin. Be sure to use your UVB detector (SEL240/UVB1/TD, for example), not your UVA detector, for measuring UVB light. UVB light is much more dangerous than UVA, and your UVA detector will not sense any UVB light. Typical lamps may have a large UVA component, leading to misleading results if the wrong detector is used. All International Light Technologies detectors are clearly marked with detector type and serial number. If ever in doubt, simply check the engraved labels on the individual filter rings to be sure you are using the proper detector.

8.2.5 Hyperbilirubinemia Phototherapy - Blue Visible

Jaundice is a very common condition requiring medical attention in newborns. The yellow coloration of the skin and sclera in newborns with jaundice is the result of accumulation of unconjugated bilirubin, often referred to as neonatal hyperbilirubinemia.

Phototherapy is the primary treatment in neonates with unconjugated hyperbilirubinemia. Phototherapy employs blue wavelengths of light to alter unconjugated bilirubin in the skin. Our Hyperbilirubinemia probe is designed to match the wavelength specific photo-oxidation response of bilirubin to provide optimal measurement of the therapeutic radiation.

As with most phototherapy applications, it is important to place the detector in the same reference plane as the patient's skin. The fact that blue light is visible misleads most people into believing that it is much safer than ultraviolet light. Excessive doses of blue light constitute a significant health hazard. The U.S. National Institute of Occupational Safety and Health (NIOSH) has accurately defined the "Blue Hazard" wavelength band, and the maximum allowable daily dosage. Refer to NIOSH research publications for more information on Blue Hazards.

Another important factor to consider when exposing patients to intense blue light is the fact that many fluorescent hyperbilirubinemia lamps emit a significant amount of radiation in the UVA band (315 - 400 nm), which is not sensed by a bilirubin probe. We strongly recommend the use of protective eye wear, especially by medical technicians, who may not realize the ambient dose radiation they are exposed to over time.

8.2.6 ACGIH and NIOSH Actinic UV Hazard

ACGIH has extensively researched the effect of light at specific wavelengths on human skin. They accurately define the hazardous effects of ultraviolet light as a function of wavelength. This weighted spectral effect plot is referred to as the Actinic hazard function, with the relative hazard proportionally weighted from 200 nm to 315 nm (maximum hazard at 270 nm). NIOSH also recommends the use of the ACGIH standards to define hazardous working conditions. ACGIH updated the Actinic function by logarithmically extending this hazard data through the UVA to 400 nm. This revision is an important consideration. Although the effect of the UVA band is proportionally much less than that of the UVB and UVC bands, an intense UVA source poses a significant Actinic threat. We have custom designed our Actinic filter using thin film techniques to precisely match the new Actinic hazard function curve released by ACGIH, out to 400 nm. This is essential for accurate Effective Irradiance measurements. The ILT1400 combined with SEL240/T2ACT displays Effective Watts/cm^2, providing immediate, direct hazard readings when compared to Threshold Limit Values.

8.2.7 IES Luckeish and DIN Germicidal / UVC

The germicidal band is precisely defined by IES Luckeish and DIN standard curves. Light in this wavelength band acts as a germicide, killing germs and microorganisms. Many hospital operating rooms employ mercury arc lamps, shining germicidal light inside an open wound as the operation takes place to kill environmental germs. Almost 98% of a Low Pressure Mercury lamp output occurs at precisely 254 nm. The peak of the effective irradiance curve, however, is at 265 nm. Light from a Mercury lamp has only 85% of the effect that an equal amount of 265 nm light would have. Our SEL240/T2ACT5 germicidal detector weights the effect of all light in this band to its actual germicidal effect, regardless of the type of source used. A narrow band detector measuring only light at 254 nm can also be used (XRL140T254)

Broadband UVC measurements require a two step zeroing process. The SEL240/TD measures both UVB (280 to 315 nm) and UVC (200 to 280 nm) wavelength light. The SEL240/UVB1/TD combination adds a sharp cut filter (UVB1) to measure only UVB. The SEL240/TD can be used alone in a single step measurement for most general purpose Ultraviolet applications. Some users require readings that separate the UVB and UVC components, however. For that reason, we include the following three step measurement process for measuring both UVB and UVC individually:

STEP 1: MEASURE UVB AND UVC, RECORD DATA

Measure the incoming UVB + UVC light from your Ultraviolet source using the SEL240/TD detector configuration. RECORD THIS DATA.

STEP 2: MEASURE 90 % UVB, ADJUST DATA TO 100 % UVB

Next, remove the empty filter ring and replace it with the UVB1 filter ring, for the SEL240/UVB1/TD configuration. The UVB1 filter causes the detector to measure only the light in the UVB band. However, since the UVB1 filter has a transmission in the UVB of 90 %, this data must be adjusted to determine the actual amount of UVB light in the source. To do this, simply divide the UVB data by 0.90 to obtain a LARGER number. This is the amount of UVB light.

STEP 3: SUBTRACT STEP 2 FROM STEP 1 TO OBTAIN UVC

Finally, subtract the adjusted UVB data (STEP 2) from the UVB + UVC data recorded earlier (STEP 1). The result should be a positive number, since the UVB is a component of the overall reading. The answer is equal to the UVC output of the source.

8.2.8 Photoresist / UV Curing

In both Photoresist and UV Curing, chemical compounds are used for their ability to polymerize when exposed to light at certain wavelengths. Since these chemicals are only sensitive to certain characteristic spectral bands, a detector is required which measures only the wavelengths of interest, spectrally weighting the measurement to match the effect of each wavelength on the polymerization process. This type of measurement, referred to as Effective Irradiance (Watts/cm^2 & Joules/cm^2), is essential since the spectral output of exposure lamps does not match the required spectral dose. A flat radiometric irradiance detector would measure each wavelength equally to accurately reflect the lamp output, whereas an effective irradiance detector measures only the useful wavelengths, weighted proportional to their chemical effect, regardless of lamp output.

Photoresist applications involve selectively exposing photosensitive chemicals to short wavelength light to polymerize the material in a particular pattern for use in photolithography industries such as Printed Circuit Board manufacturing, Printing Plate production, and XRL140B provide low profile and durability for repeated use in these intense UV exposure production environments. The SEL240/QNDS3/TD is designed for use in Semiconductor Microlithography applications in the deep UV.

UV Curing applications typically involve exposing photosensitive inks, glues, and epoxies to short wavelength light for drying and hardening purposes. We offer the SEL005/WBS320/TD for this effective irradiance measurement. For continuous monitoring in particularly harsh environments we recommend, the RAMP18 (18” L right angle probe) or the new high temp fiber optics with high temp right angle adapter or diffuser.

We also manufacture a self-contained, lamp system profiling belt radiometer, the ILT400, for the harsh radiation and extreme physical punishment of conveyor belt production processes. The ILT400 has high ‘G’ force mounts and a low profile, solid machined aluminum encasement that is polished for high reflectivity to reduce temperature rise and UV damage. Consult with an IL Sales Engineer for more information on these new ILT products.

8.3 FLUX MEASUREMENTS

8.3.1 Laser Power - Radiometric Laser Power

Radiometric laser power is the absolute measurement of the spectral output power of a collimated, coherent beam of light in optical Watts. The detector uses a flat response filter to ensure radiometric accuracy. For this type of measurement, the laser beam must under-fill the input aperture of the detector, to completely capture the energy of the beam. Our standard laser power detectors use either the SEL033 (33 mm$^{2)}$ or the SEL100 (100mm$^{2)}$ silicon cell detector with a flat response filter with various input optics and a beam aiming aperture (K9 - 9mm dia. or K15 - 15 mm dia.). We offer other specialized detectors for varied dynamic and spectral ranges or applications requiring special capabilities, such as thermal averaging for pulsed lasers.

When measuring laser power, we recommend centering the beam on the detector with the detector face normal to the incoming light, although the detector allows a wide margin of error. The detector face will reflect a slight amount of light back at the laser, providing an accurate indication of any offset angle. Simply aim the reflected spot back at the laser output aperture by adjusting the angle of the detector, keeping the beam aimed at the center of the detector. Slight translation or angular offsets will not affect the reading (± 4.5 mm, ± 10 degrees), allowing wide under-filled beams and multiple laser sources, if necessary. Distance to the detector should not matter, provided the laser beam still under-fills the aperture.

8.3.2 Laser Power - Photometric Lumen Flux

Photometric laser power is the measure of the visible output of a laser, scaled to the eye's photopic response to light. This is useful for any application requiring a measure of the visibility of a laser source, for laser projection televisions, health hazards, spot illumination, medical laser output, special effects lasers, laser light shows, etc. The units of measurement for photometric flux is the Lumen (lm). This effective flux measurement is photopically weighted according to the CIE Photopic "Standard Observer" Eye Response curve. The same spatial considerations apply as for the laser power measurements in the previous section.

8.3.3 Radiometric - Total Watt Flux

Total Watt flux is the measure of the total flux output of a wide beam source or LED. This measurement requires an Integrating Sphere and flat response detector. The detector must be calibrated with the integrating sphere for accuracy in optical Watts. ILT offers the SEL033/F/INS250 which will provide direct readout in Watts on the ILT1400.

8.3.4 Photometric - Total Lumen Flux

Total Lumen flux is similar to total Watt flux for a wide beam source or LED, except that the flux being measured is restricted to the photopic (visible) portion of the spectrum. An Integrating Sphere is required for this type of measurement. ILT offers the SEL033/Y/INS250 which will provide direct readout in lumens on the ILT1400.

8.3.5 Photometric Intensity - Mean Spherical candle Power

To properly measure the total flux from an isotropically radiating 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 Integrating Sphere. Two of the standard intensity measurements would be the candela and the Watt/steradian for photometric and radiometric applications, respectively. An intensity measurement is the best indication of the 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 lamp, tending to block some of the output radiation. 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 detector calibrated to read out in foot-candles (lm/ft^2). 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 an integrating sphere and the Mean Spherical Candela (MSC) measurement is a 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. We at International Light Technologies are aware of how confusing these light measurement units and setups can be. Please contact us for assistance with your specific application.

8.4 RADIANCE / LUMINANCE (Brightness) MEASUREMENTS

Our eyes interpret image details over a relatively narrow angle (approximately 2.5 degrees). This is the zone of the fovea where we analyze an image, as opposed to the entire light sensitive region of the eye. For this reason, it is 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. In making FLUX DENSITY measurements of Illuminance or Irradiance we find that the magnitude of the measurement drops 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 UNIT AREA. In other words, we are summing up the output from an infinite number of Lambertian emitters (isotropic point sources) 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 Lumens per steradian per square meter ($lm/m^2/sr$ or nit). For Radiance, the units are Watts per steradian per square meter. There is also an old English unit, the foot-Lambert (fL) that is still in use. For conversion, 1 fL x 3.43 = nits.

To get the proper acceptance angle, you need our Radiance (R) barrel, an internally baffled barrel with a 1.5 degree field of view. The baffles are extremely important, because they remove the reflections from the wall of the tube, letting in only the "line of sight" rays coming through the center of the tube. Be careful that the detector is "looking" at an area located in the uniform part of the test surface. Also, if you back away too far from the test surface, the input angle will eventually be bigger than the test area, and inverse square law errors will occur.

Using the SEL033/F/R or the SEL033/Y/R the ILT1400 will readout directly in either $W/cm^2/sr$ or cd/m^2 respectively. Information on alternative detector combinations is available for luminance and contact luminance (or radiance) measurements from our technical support representatives.

8.5 L.E.D MEASUREMENTS

LED (light emitting diodes) are solid state lamps manufactured from semiconductor materials. Being narrow band emitters they illuminate in a specific visible color or in the infrared. Visible LEDs are available in the colors of blue, green, yellow, orange, or red. Light emitting diodes are recommended for both indicator and optical applications. Infrared LEDs are recommended as light sources for phototransistors.

IL offers a variety of products to measure luminance, illuminance, beam intensity (cd) total flux (W,lm) and mean spherical intensity (W/sr,cd) of LED.

The SPL024Y pen probe permits the measurement of the entire output of the L.E.D. source using a miniature contact integrating sphere. For customers requiring beam candela measurements of an L.E.D. source we also offer the SEL033/Y/LED. Both detectors provide simple measurements by inserting the LED into the small aperture of either sensor and obtaining direct readout of Lumens or Candela respectively on the ILT1400 display.

8.6 TRANSMISSION MEASUREMENTS

Transmission measurements are typically made as a ratio between two readings, usually expressed in percent.
For example, a typical transmission measurement might be to measure the illuminance passed through a tinted window compared to the illuminance directly from the light source. 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 of an incandescent bulb often produces a 3% change in the light output (refer to Planck's blackbody radiator equation for more information). Voltage regulation is therefore very important. Also be sure to let your lamp warm up sufficiently 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 is taken through the limiting aperture before the sample is placed behind this aperture. Then the transmission sample is inserted and the attenuated reading is taken. Simply divide the second reading by the first reading and multiply by 100 for a transmission reading in percent.

8.7 REFLECTANCE MEASUREMENTS

Reflectance is similar to transmission, 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 coated paper, have a specular component as well as a diffuse component.

All reflectance measurements require some special fixtures. In the case of Specular reflectance, you must have a detector holder that can be swept in an angular arc of 180 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 where it is reflected a standard distance to the detector. The reference condition is set by shining the light through the rotational point at the detector with the mirror removed. 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 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.
For diffuse reflectance, an integrating sphere or goniophotometer must be used to capture the diffuse components of reflectance, integrating the entire divergent reflectance angles. Both methods require very special equipment, and will be lightly discussed here. In the first case, a collimated light beam projects through an integrating sphere, out an opposite port on the other side (the "sample" port). 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. This reading is the 100% reference value. The standard is removed and replaced by the sample that you wish to reflect light off of. This reading is the diffuse sample value. If the standard had a reflectance of 98%, then you must first divide the standard reflectance by 0.98 before dividing into the diffuse sample value and multiplying by 100 for an answer in percent. A goniophotometer uses a computer driven, rotating mirror arm to measure total flux or total reflectance. This precision mechanical system can scan a reflector in at least a hemispherical solid angle for the most accurate description of reflectance, at great expense, however.

8.8 SPATIAL RESPONSE

8.8.1 Lambertian "Cosine" Response

Lambertian Response is in reference to a particular angular response which is proportional to the cosine of the incident angle. In other words, for the angle normal to the face of the detector (0 degrees), the magnitude is the cosine of 0 degrees, or 1.0 (100%). As the angle goes off axis and becomes parallel to the face of the detector, the reading goes to zero, since the cosine of 90 degrees is zero. At 45 degrees, the cosine is 0.707, which means that the detector should read the rays with 70.7% of the value produce 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.

8.8.2 Field Baffling

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 room 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 or rear-lit surface. Baffles can be used to implement this kind of measurement without resorting to expensive optics.

8.8.3 Narrow Angle (Luminance / Radiance)

As just mentioned, there is a requirement for a narrow field of view when making Luminance and Radiance measurements. This can be accomplished by 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 alphanumeric 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 setup can be made to specifically measure that on a small emitting surface. Our "R" barrel 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. The target requirement is calculated by multiplying the distance (measured from the target surface to the front lens of the R Barrel, in inches) times 2*tan(2.5/2), plus the 1 inch (25.4 mm) diameter of the input aperture and some margin for error. If you were 12 inches away, the detector 'sees' a circular target approximately 1.5 inches in diameter. Since the target should generally be much larger than the field of view of the detector, the target should be at least 2 inches in diameter when you are 12 inches away.

8.8.4 Uniform Linear Translation Response

The best type of detector setup for uniform receiver sensitivity is the input port of an integrating sphere, since any off axis beam will still be captured in the chamber. For flux measurements, it is necessary to have this uniformity so that small errors in centering the beam do not contribute to any error in the measured reading. Our narrow beam adapter (H/N/K15) 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 in laser beam measurements.

The SEL100/FQ/K15 allows the greatest margin of error in axial misalignments. The large, 100 square millimeter silicon cell is fitted with a 15 millimeter diameter conical aiming aperture with an attenuated "flat" response filter. The user is simply required to aim his laser beam inside the aperture for guaranteed linear continuity. Of course, if centering errors are compounded by an angular offset, the laser beam may not directly strike the silicon cell, causing significant errors in the readings. Centering and normalizing the detector to the incoming beam is a simple procedure and should not cause any problems

8.9 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 and the ability to discern whether dose information is accurate. To obtain instantaneous data with a traditional voltage or current measurement system, 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 also necessary to put a preamplifier in the detector itself to match the high impedance of the detector to the coaxial cable. When you use a system such as this, the dynamic range is limited to a few decades at best, and auto ranging is impractical.

For these reasons, we have chosen to design the ILT1400 for optimal dose measuring ability, which generally matches the ultimate goal of the light pulse and is compatible with the same detectors used for constant wave 'SIGNAL' measurements. 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 rely on charge storage in a capacitor on the front end of the system to even out surges in line voltage or measure low amplitude flashes. The ILT1400 can store approximately 10 nanoCoulombs of instantaneous flash charge. This allows the instrument to measure fluorescent lamps and unstable sources with accuracy averaged over a half second interval. The ILT1400 is not specifically designed to measure high amplitude flashes. We recommend at least full second of exposure to light when measuring with the ILT1400 depending on the light levels. The ILT1400 has the ability to extend measurement time when measuring low light levels so longer exposure times may be required. For this reason ILT recommend using the ILT1700 for pulsed light sources. Consult a Sales Engineer or review product specifications on line for information on the ILT1700 Flash Photometer systems available.
http://www.intl-lighttech.com/applications/photometry

8.9.1 Low Duty Cycle (Fast Pulse)

As mentioned above, the ILT1400 is not designed to maximize flash measurement performance. The instrument measures the continuous current from the detector with the added ability to measure peak surges that would otherwise exceed the current measurement range of the instrument. Fluorescent lamps are an example of a low duty cycle light source. The fluorescent bulb pulses at twice the line frequency, approximately 100 (EUR) or 120 (USA) times per second. This continuous stream of pulses is averaged to provide an accurate representation of the strength of the lamp. Momentary surges are also accommodated without disrupting measurement.

For applications involving high power, low duty cycle lasers, we offer a specialized thermopile detector, the SEL623/K9. This detector contains a built in preamplifier stage, and inherently averages the incoming reading, measuring the thermal average of the laser power.

8.9.2 High Peak Amplitude

The ILT1400 will not measure a continuous current signal greater than 350 microAmperes without displaying the 'OVR RNG' status message. Due to the charge measuring capability of the system, the ILT1400 can measure a flash current of as much as 2.2 milliAmps for a 5 microsecond flash. Longer duration flashes or higher amplitude peaks will cause detector saturation, since the charge storage capacity of the system is limited to 10 nanoCoulombs.

These peak current limitations may not mean much to most users, since the system reads out in optical units, not Amperes. Given the extremely wide dynamic range of the ILT1400, it is unlikely that you will encounter any difficulty measuring most sources of light. If a signal is below the lowest range of the detector, the display will read zero. If the signal exceeds the maximum range of the detector, the display will read 'OVR RNG'.

9. ILT1400 GENERAL SPECIFICATIONS

9.1 ELECTRICAL SPECIFICATIONS

9.1.1 System Power

The ILT1400 is provided with 4 quality AA alkaline batteries, for portable operation on 6 volts DC. The ILT1400 draws a mere 26 mA during constant operation, providing a typical usable operation period of 54 hours with fresh batteries.

The ILT1400 can also be operated on a wide variety of external power supplies, for extended operation time. The voltage regulator inside the unit accepts input voltages from 5 volts DC to 15 volts DC. In practical terms, this means that you can run the unit off of any DC power supply from a 5 volt computer source to a 12 volt automobile battery or alternator. The ILT1400 is equipped with an external 110V only AC power adapter plug to facilitate powering the ILT1400 from a 110V AC main (requires *optional* A516 AC Power Cable).

9.1.2 Signal Input (current)

The ILT1400 Radiometer/Photometer is capable of measuring detector input currents from a displayed resolution of 10 picoAmperes up to a maximum of 350 microAmperes.

9.1.3 Current Measurement Accuracy

The LCD display is capable of displaying full scale current measurement to an accuracy of ± 0.92% from 100 nA to 350 µA, ± 1.5% below 100 nA. The RS232 output provides the same accuracy. The analog recorder output is accurate to ± 1%, or ± 4 mV.

9.1.4 Radio Frequency Output Emissions

This equipment generates and uses radio frequency energy and if no used properly, 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. The ILT1400 encasement interior is coated with a special RF conductive shield to prevent any such interference.

9.2 OPTICAL ACCURACY

Optical accuracy is a very difficult entity to address, because it changes with wavelength and so varies by the exact detector combination used. The detectors calibration uncertainty is listed on the Optical Calibration Certificate and is in addition to the 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.

9.2.1 Radio Frequency Input Signal Interference

Since the normal measurement range of electrical currents and charges is extremely small, input errors can occur from large sources of radio frequency emission. The input is especially vulnerable to pickup if the input cable is not shielded. All ILT detectors use shielded input cable which is also necessary for any user provided input device.

9.3 SIZE AND WEIGHT

Size: 185 mm height x 100 mm width x 43 mm depth.
Weight: 555 grams.

Dimensions do not include detector heads or remote probes. Please visit the website for specific detector dimensions.

9.4 ENVIRONMENTAL SPECIFICATIONS

Operating temperature range: 5 to 40 degrees celsius.
Storage temperature range: -30 to +60 degrees celsius.
Operating and storage relative humidity: 0 to 90 percent.

10. MAINTENANCE AND REPAIR

10.1 PREVENTIVE MAINTENANCE

Since there are no moving parts except for the push button switches, the biggest problem over a long period of time is corrosion. Remove the batteries if the unit is not to be used for an extended period of time, and store the instrument in its carrying case or suitable plastic bag with a small amount of silica gel or other desiccant. The optical windows should be cleaned from time to time with methyl alcohol or other window cleaning fluid. Be certain that the detector card edge connector is not dirty, as well. Store the ILT1400 with the detector head removed, in order to prevent unnecessary stresses on the Printed Circuit Board edge connector.

10.2 BATTERY REPLACEMENT

To replace the batteries, you must remove the back cover of the instrument encasement according to the following procedure:

A. Remove the 4 Phillips head screws which fasten the back panel of the instrument. We recommend using a standard Phillips type screwdriver to avoid damaging the screw heads.

B. Carefully pull the back cover off, making sure not to pull off the battery wires which are still connected. The battery compartment is affixed to the back panel. Follow the instructions for battery polarity as marked on the battery compartment.

C. Carefully replace the back cover, taking care that all wires fit snugly inside. Naturally, be sure not to drop loose bits of wire or other conductive material inside the compartment. Squeeze the back cover in place tightly and replace the 4 screws.

10.3 DISASSEMBLY AND PC BOARD REPLACEMENT

The ILT1400 has been designed so that each of the 3 printed circuit boards can be exchanged without affecting the calibration accuracy of the system. If you suspect a component failure in your ILT1400, first check the connector contacts, buttons and batteries. The simplest way to determine if a board is defective is by substitution. If you have a back up meter, you may be able to try this option at your facility. If alternate boards are not available, the system would need to be returned to the factory for evaluation and repair.

For reference, the top board (viewing the instrument from the back) is the amplifier board. It has a square cut out in the middle where the battery compartment fits into the instrument. The middle board is the computer board. The bottom board is the instrument panel board, which contains the buttons and Liquid Crystal Display circuitry. Each board is fastened individually to the encasement. Also, take care when unplugging the flexible ribbon cables.

10.4 USER REPAIR POLICY

Due to the sophisticated nature of this 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, as well as for the unusual situation where no other alternative is available, or

11. ONE YEAR WARRANTY

International Light equipment is warranted for a period of twelve (12) months from the date of purchase to be free of defects in material or workmanship. This warranty does not apply to damage resulting from accident, alteration, abuse, and 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, Inc.; 10 Technology Drive; Peabody, MA 01960; USA. International Light Technologies, Inc. has no other obligation or liability in connection with said equipment. To see a full version of our terms and conditions, please visit out website:

http://www.intl-lighttech.com/services/terms-and-conditions-of-sale