
DIGITAL RADIOMETER

MODELS Q203 & Q203 PAR

USER HANDBOOK



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USER HANDBOOK

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1. INTRODUCTION

The Irradian portable digital Quantum radiometer models Q203 and Q203 PAR are versatile direct reading instruments designed specifically for measuring photosynthetic active radiation (PAR 400 to 700nm) in units of $\mu\text{mol.m}^{-2}.\text{s}^{-1}$ (micro Einstein. $\text{m}^{-2}.\text{s}^{-1}$).

The model Q203 can also be configured to measure irradiance between 400 and 1000nm (or 700nm) in W.m^{-2} and illuminance in lux.

These alternative measurement units are obtained through interchangeable cosine corrected filter rings which adapt the detector response to correspond to the desired spectral sensitivity profile.

Both radiometers comprises of a Q203 handheld display unit with battery, DET203QR laboratory detector and integral amplifier, with interconnecting cable, and a PAR-Cos cosine corrected filter ring. Model Q203 also includes a RFF-Cos (or RFF-Vis-Cos) irradiance filter ring and CIE-Cos illuminance filter ring. The meters also include a RS232 interface cable, calibration certificate and carrying case.

The Q203 may be used in applications such as Agriculture, Horticulture, Plant Growth studies, Biology, Liminology (with under water detectors), Environmental studies and Illumination engineering.

2 SPECIFICATION

DISPLAY UNIT

Controller:	80C51 8bit micro-processor with a 3.1684MHz clock.	
Memory	On board non volatile RAM for calibration factors and set-up parameters.	
Key Operation	8 switch key board with 11 LED indicators.	
Power Switch	Microprocessor reset at switch on. Unit settings stored prior to shut down.	
Serial Interface	Three wire RS232 serial interface. 4800 baud, no parity, 1 stop bit.	
Integration Time	0.33s	
Conversion Scale	17 bit	
Accuracy:	Measurement accuracy ± 1 digit with a linearity error of $<1\%$.	
Display:	4½ digit LCD display. Character height 10mm.	
Display illumination:	A LED back light can be switched on to illuminate the display for readings in low ambient light situations.	
Power Supply:	9 volt PP3 battery.	
Power Consumption:	Shut down mode	$<5\mu\text{A}$
	Operating	10 - 20mA
	LED back light	$\sim 20\text{mA}$
Battery Life	~ 50 hours without backlight use	

2 SPECIFICATION (continued):

Ranges: i) PAR (*both models*)
Up to 5 full scale decades measuring from*:
0 to 1.9999 $\mu\text{mol.m}^{-2}.\text{s}^{-1}$
0 to 19.999 $\mu\text{mol.m}^{-2}.\text{s}^{-1}$
0 to 199.99 $\mu\text{mol.m}^{-2}.\text{s}^{-1}$
0 to 1999.9 $\mu\text{mol.m}^{-2}.\text{s}^{-1}$
0 to 19999 $\mu\text{mol.m}^{-2}.\text{s}^{-1}$
Resolution 0,0001 $\mu\text{mol.m}^{-2}.\text{s}^{-1}$ on range 1.

ii) Illuminance (*Q203 model only*)
Up to 6 full scale decades measuring from*:
0 to 1.9999 lux
0 to 19.999 lux
0 to 199.99 lux
0 to 1999.9 lux
0 to 19999 lux
0 to 19999 x 10 lux
Resolution 0,0001 lux on range 1.

iii) Irradiance (*Q203 model only*)
Up to 6 full scale decades measuring from*:
0 to 19.999 mW.m^{-2}
0 to 199.99 mW.m^{-2}
0 to 1999.9 mW.m^{-2}
0 to 19.999 W.m^{-2}
0 to 199.99 W.m^{-2}
0 to 1999.9 W.m^{-2}
Resolution 0,001 mW.m^{-2} on range 1.

* Ranges available on request.

Calibration Absolute calibration accuracy $\pm 3\%$ CIE, $\pm 7.5\%$
PAR & RFF, traceable to NPL & BSI standards.
Photopic colour correction integrated error of
 $\pm 1\%$ over visible spectrum.

2 SPECIFICATION (continued):

Front Panel Controls:

RANGE Select auto ranging or manual range control.
UNITS Select between PAR ($\mu\text{mol.m}^{-2}.\text{s}^{-1}$), (m)W.m⁻² or LUX to match the filter ring fitted to the detector.

Select AUX for any special filter rings or accessories if fitted.
ZERO Initiates a zero or background measurement routine on all five ranges.

HOLD/RUN Display is held at present reading until HOLD button is pressed again.

Select to run or hold a special mode.
MODE Select between AVERAGE, MIN, MAX and INTEGRATE modes.

FUNCTION/RESET Press to reset function values to zero.

RESET Press to return to normal measurement mode from Manual range mode or special modes. Note the display hold is not reset.

⓪ Power on / off button.

⊗ Display backlight on off button.
 Display backlight will switch off after a programmable delay, factory setting 60 secs.

Connectors: 8 pin DIN type detector connector.
 5 pin DIN type RS232 connector.

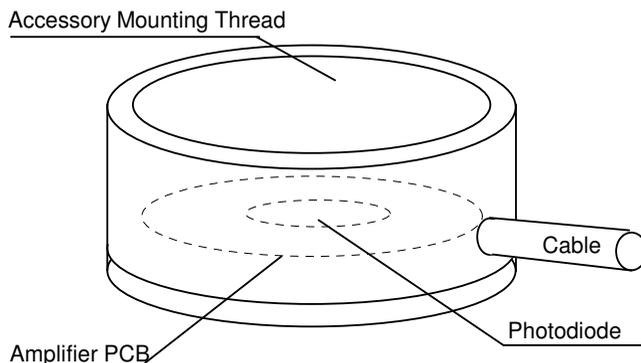
Temperature Range: 0 to 40°C. 80% RH.

Dimensions: 150 x 80 x 45mm.
 High impact polystyrene.

Weight: 350g

2 SPECIFICATION (continued):

LABORATORY DETECTOR, Model DET203QR



The DET203QR laboratory detector comprises of a aluminium housing, photodiode and PCB assembly.

Detector: 33mm² silicon photodiode

Temperature Coefficient: <0.3 %/°C

Amplifier Gain 2x10⁹ V/A to 2x10³ V/A

Current to Frequency 0 - 0.5Mhz

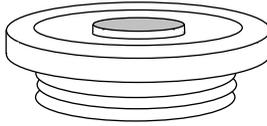
Linearity Error: <1% across ranges

Temperature Range: Operation: -10 to +60°C
Storage: -20 to +70°C

Detector Housing: Black anodised aluminium alloy housing.
Each optical accessories screws into the detector housing on a 1.125" x 20 T.P.I.
The detector amplifier is connected to the display unit via a multicore cable to a eight pin DIN type connector.

2 SPECIFICATION (continued):

RADIOMETRIC FLAT FILTER RING, Model RFF-Cos



- Spectral Response: Refer Figure 1.
- Angular Response: Accurately cosine corrected to Lambert's Cosine Law. Maximum error is less than $\pm 3.5\%$ from true response to 70° from normal incidence, reference Figure 6.
- Filter ring assembly: Black anodised aluminium alloy ring with screw thread 1.125" x 20 T.P.I. Multiple coloured filter glasses individually selected to flatten the silicon photodiode response across the visible and near infra-red spectrum. Specially profiled acrylic diffuser for high accuracy cosine angular response.

RFF-Cos Filter Ring with DET203QR Detector
Typical Spectral response

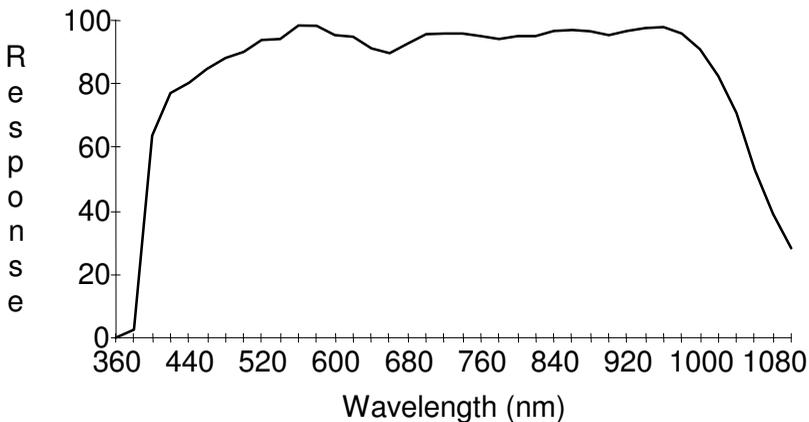
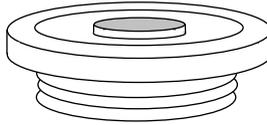


Figure 1

2 SPECIFICATION (continued):

PHOTOPIC FILTER RING, Model CIE-Cos



Spectral Response: Refer Figures 2, 5 and Section 8.

Angular Response: Accurately cosine corrected to Lambert's Cosine Law. Maximum error is less than $\pm 3.5\%$ from true response to 70° from normal incidence, reference Figure 6.

Filter ring assembly: Black anodised aluminium alloy ring with screw thread 1.125" x 20 T.P.I. Multiple coloured filter glasses individually selected for close matching to V_λ . Specially profiled acrylic diffuser for high accuracy cosine angular response.

CIE-Cos Filter Ring with DET203QR Detector
Typical Spectral Response

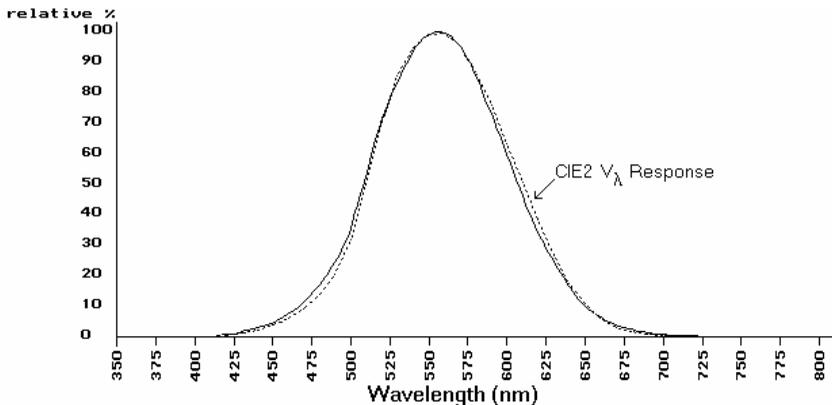
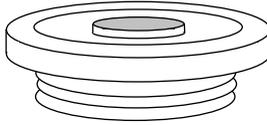


Figure 2

2 SPECIFICATION (continued):

PAR FILTER RING, Model PAR-Cos



Spectral Response: Refer figure 3.

Angular Response: Accurately cosine corrected to Lambert's Cosine Law. Maximum error is less than $\pm 3.5\%$ from true response to 70° from normal incidence, reference section 7.

Filter ring assembly: Black anodised aluminium alloy ring with screw thread 1.125" x 20 T.P.I.
Multiple coloured filter glasses individually selected . Specially profiled diffuser for high accuracy cosine angular response.

PAR-Cos Filter Ring with DET203QR Detector
Typical Spectral response

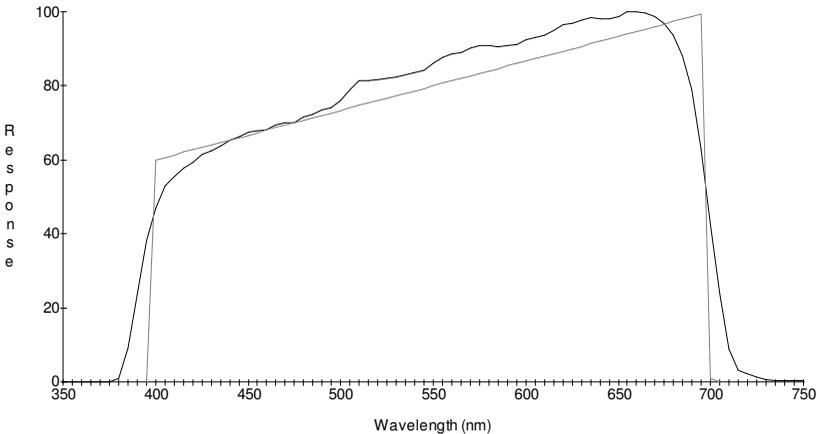
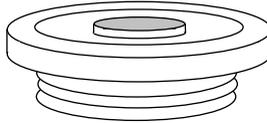


Figure 3

2 SPECIFICATION (continued):

RADIOMETRIC FLAT FILTER RING, Model RFF-Vis-Cos



Spectral Response: Refer Figure 4.

Angular Response: Accurately cosine corrected to Lambert's Cosine Law. Maximum error is less than $\pm 3.5\%$ from true response to 70° from normal incidence, reference Section 9.

Filter ring assembly: Black anodised aluminium alloy ring with screw thread 1.125" x 20 T.P.I. Multiple coloured filter glasses individually selected to flatten the silicon photodiode response across the visible and near infrared spectrum. Specially profiled diffuser for high accuracy cosine angular response.

RFF-VIS-Cos Filter Ring with DET203QR Detector
Typical Spectral response

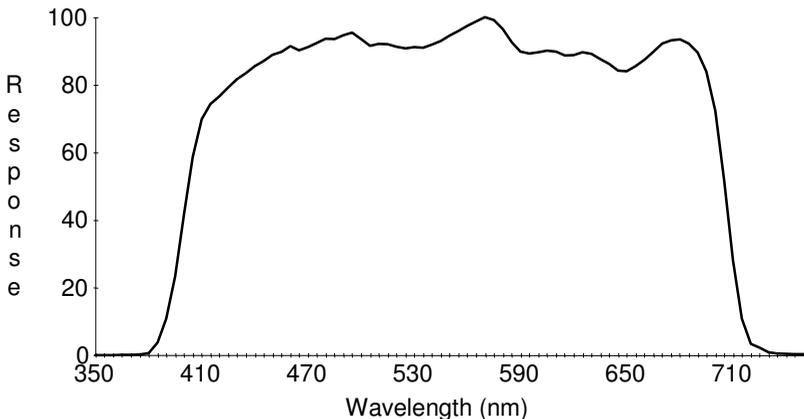


Figure 4

3 OPERATION

SETTING UP

- 1) With the unit OFF, plug the detector 8 way connector into the socket on the top of the display unit.
- 2) Carefully screw the required filter ring to the detector housing. Note: Clean the white diffuser on the filter rings if they are marked or dirty.
- 3) Press and release the power switch on the Q203 display key pad. The micro controller will initiate with the display momentarily showing:-



The radiometer will now search for the optimum range on the detector amplifier. A typical display is shown below.



An LED will illuminate indicating the units. This will be the same units prior to the last power off.

- 4) Press and release the *UNITS* switch to select the correct units required. For illuminance measurements with the CIE-Cos photopic filter ring, the correct units are lux. For irradiance measurements with the (Vis-)RFF-Cos radiometric filter ring, the correct units are $\text{mW}\cdot\text{m}^2$ or $\text{W}\cdot\text{m}^2$ and with the PAR-Cos filter ring the PAR LED will light.
- 5) It is recommended that the radiometer amplifier is nulled periodically. Place the supplied blanking cover over the filter ring. Press and release the *ZERO* switch and the display will momentarily show:-



3 OPERATION (continued):

- 6) The micro controller will now measure the amplifier offset on each of the gain ranges and store these values in the non volatile memory. All subsequent measurements will first have one of these offsets subtracted before displaying the measurement.

At the end of the nulling sequence the display will typically show:-



- 7) Remove the light cover from the detector. The equipment is now ready for use.

AVERAGE

When the light is unstable, press and release the MODE switch. The radiometer will now switch to manual ranging, Manual LED on, if not yet previously in manual ranging. The Average LED will now switch on, but the Units LED will remain unchanged.

To start an average sequence press and release the HOLD/RUN switch. Immediately the display will show a fluctuating signal, reflecting the light source fluctuations. After a short time the amplitude of the fluctuations will decrease and the display will begin to show a reading which represents the average light level during the period of the measurement.

At any time the averaging process can be halted by pressing the HOLD/RUN button.

At any time the averaging sequence can be reset by pressing and releasing the FUNCTION RESET switch.

If the light level fluctuations are large and any one reading causes the detector amplifier to overload at this range the averaging process will be terminated and the display will show:-



To avoid an overload conditions RESET the radiometer and Manually change the RANGE to a lower lever. e.g. from a 34.00 range to 34.0.

3 OPERATION (continued):

MIN & MAX LEVELS

During an average measurement sequence the maximum and minimum values attained in the period are recorded. Press *HOLD* to halt the averaging sequence. Press the *MODE* button to select between *Average*, *Min* and *Max*. Note the Integrate display may overload and show - 0 L -. It is also possible to view a *MIN* or *MAX* recording sequence by selecting *MIN* or *MAX* prior to selecting *RUN*.

Press *FUNCTION RESET* to set the maximum and average values to zero and the minimum to - 0 L -. Note the *FUNCTION RESET* will operate during a measurement sequence or in the *HOLD* mode.

INTEGRATE

For measurements of the integrated dosage or exposure press the *MODE* switch to select *Integrate*. Press the *RUN* switch to start the measurement. The display will now autorange as the dosage increases.

Note the detector amplifier will not autorange and as with Average measurements if the amplifier overloads the display will show - 0 L - and the measurement will halt.

Units for integrated measurements of irradiance are $\text{mJ}\cdot\text{m}^{-2}$ or $\text{J}\cdot\text{m}^{-2}$, for illuminance, lux seconds (lux.s) and for PAR, $\mu\text{mol}\cdot\text{m}^{-2}$.

At the end of the integration period *HOLD* the display. Use the *MODE* switch to also display the *Min*, *Max* and *Average* values.

Press *FUNCTION RESET* to set the integrate, maximum and average values to zero and the minimum to - 0 L -. Note the *FUNCTION RESET* will operate during a measurement sequence or in the *HOLD* mode.

4 PAR MEASUREMENTS

(PAR-Cos filter ring fitted)

The Q203 radiometer measures the number of quanta (photons) of light between 400nm and 700nm incident on the diffuser input to the detector, per second. Measurement units are $\mu\text{mol.m}^{-2}.\text{s}^{-1}$ (equivalent to $\mu\text{Einstein.m}^{-2}.\text{s}^{-1}$). Conversion to number of photons $1 \mu\text{mol.m}^{-2}.\text{s}^{-1} = 6.02 \times 10^{17} \text{ quanta.m}^{-2}.\text{s}^{-1}$

For most applications the measurement plane is horizontal and a cosine corrected diffuser is fitted to the front of the detector assembly. If the working surface is not horizontal then placing the detector on or parallel to the worktop is a more representative measurement of irradiance.

Note that all the light sources in the hemisphere above the detector will contribute to the measurement. The sources may be obvious, lamps or windows or even walls or other reflecting surfaces. Take care not to shadow the detector during all measurements.

5 IRRADIANCE MEASUREMENTS

(RFF(-Vis)-Cos filter ring fitted)

Irradiance is the measurement of radiometric light per unit area, watts per meter, W/m^2 . The part of the spectrum to be measured is defined by the filter fitted onto the detector. Ideally the filter should have square edges and have a perfectly flat spectral response. With the RFF-Cos filter ring fitted the spectral region is typically 400 to 1060nm between the 50% response points (400 to 700nm with RFF-Vis).

In all applications it is vital to have some knowledge of the spectrum of the light source. For example a tungsten halogen lamp will have a spectral output similar to a black body source, with most of the output in the infra red region from 1000 to 2500nm and some visible output. A measurement of irradiance of this lamp with the RFF-Cos filter ring will only represent a small proportion of the total lamp output. Whereas the proportion of measured irradiance to total irradiance from a dichroic filtered tungsten halogen lamp is much higher.

When the Q203 is being used to measure monochromatic sources small adjustments should be made to correct for the non flat response. Please contact Irradian if further information is required.

As an alternative to single wavelength calibration (ref. Section 10) the radiometer could be calibrated for a particular type of source using a spectroradiometer.

For most applications the measurement plane is horizontal and a cosine corrected diffuser is fitted to the front of the detector assembly. If the working surface is not horizontal then placing the detector on or parallel to the worktop is a more representative measurement of irradiance.

Note that all the light sources in the hemisphere above the detector will contribute to the measurement. The sources may be obvious, lamps or windows or even walls or other reflecting surfaces. Take care not to shadow the detector during all measurements.

The RFF-Cos filter ring is cosine corrected (ref. Section 9). Measurement errors will increase as the angle of irradiance increases from the normal to the filter ring front surface.

6 ILLUMINANCE MEASUREMENTS

(CIE-Cos filter ring fitted)

Illuminance is the measurement of photometric light per unit area, lumens per meter, lux, or lumens per square foot, footcandle. For most applications the measurement plane is horizontal and a cosine corrected diffuser is fitted to the front of the detector assembly. If the working surface is not horizontal then placing the detector on or parallel to the worktop is a more representative measurement of the illuminance.

Note that all the light sources in the hemisphere above the detector will contribute to the illuminance measurement. The sources may be obvious, lamps or windows or even walls or other reflecting surfaces. Take care not to shadow the detector during all illuminance measurements.

- 1) Set up the radiometer as outlined in Section 3 with the illuminance filter ring fitted and the units set to lux.
- 2) Place the detector at the measuring point and record the value on the display. If the light levels are low it may be necessary to switch on the display back light.
- 3) The display can be read directly for all light levels from 0.0000 lux to 19 999 lux. Note however that for illuminance values of 20 000 to 199 990 lux, the x10 LED will illuminate and the displayed value must be multiplied by 10.

CONVERSION FACTORS

1 lux	=	0.0929 footcandle
1 lux	=	1 candela @ 1 meter
1 lux	=	d ² candela @ d meters

7 COSINE ANGULAR RESPONSE

Irradiance is a measurement of the amount of light incident on a unit area (Watts.m^{-2}). Any detector will measure this reliably when measuring a beam of light perpendicular to the detectors surface, however, when measuring scattered light or light from an extended source the sensor must have an accurate response over its 180° field of view. More importantly, this response should be proportional to the cosine of the angle of light incident on the detector. This comes from the fact that the projected area of any surface at an angle of i is proportional to $\cos(i)$.

To ensure that the integration of light from all angles is correct, the cosine diffuser matches the angular response so that response of the detector decreases with $\cos(i)$ as the angle between the source and detector increases from 0 to 90° .

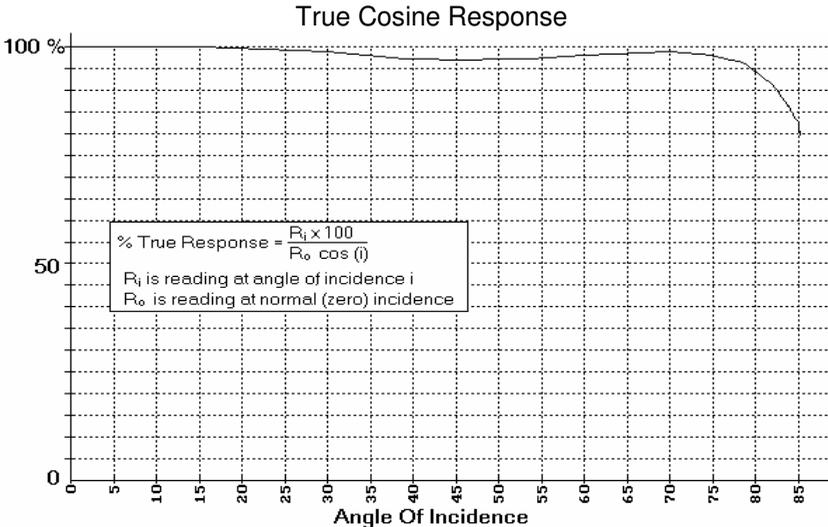


Figure 6

Irradian's cosine diffusers are corrected to match the cosine response to within $\pm 3.5\%$ up to angles of 70° . This ensures that the meter correctly reads illuminance or visible light flux density whether it is measuring light from an extended or a point source.

8 CALIBRATION DESCRIPTION

Irradian holds a number of quartz tungsten halogen and deuterium lamps, radiometers and a silicon photodiodes which are routinely calibrated by the National Physics Laboratory and other accredited laboratories in the UK.

Photometric Calibration

During manufacture each photopic filter is scanned for the best match to the CIE response. A graph of the final filter/detector response is provided. This data is available on request for importing into a spreadsheet.

The radiometer is calibrated for illuminance using a lamp of colour temperature 2855K \pm 50K.

Irradian estimates the absolute illuminance calibration error to be \pm 5% for a source of illuminant A at normal incidence. The errors mentioned in Sections 4 and 5, namely spectral response and cosine angular error, are small for most applications.

Radiometric Calibration

Both the visible / near infra red irradiance and the UVA irradiance filter rings are calibrated using monochromatic light. The wavelength is specified on the calibration certificate.

However either or both the filter rings can be calibrated with the radiometer to measure a particular source and made to exactly match that of a spectroradiometer covering the required spectral region. Spectroradiometric calibrations can be carried out on site or at our laboratory. Contact our calibration manager for further details.

Quantametric Calibration

PAR calibration is carried out using a solar simulated uniform source and an Irradian spectroradiometer.

As with all measuring equipment a routine calibration is recommended, typically annually, but with frequent use by a number of different users a shorter recalibration period may be necessary.

9 CARE AND MAINTENANCE

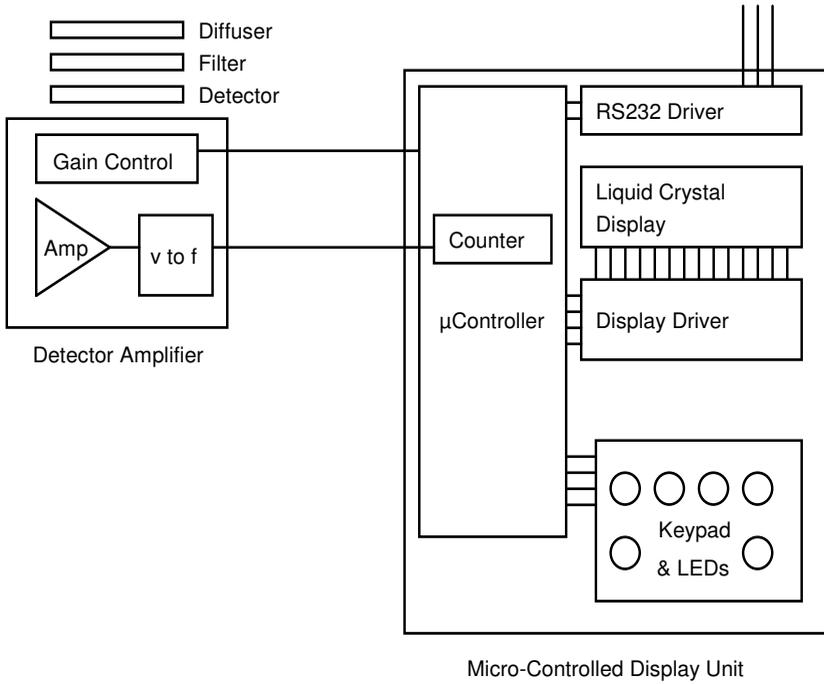
- 1) The Q203 display unit can be cleaned using a moist cloth with detergent. Do not use solvent or alcohol to clean surfaces.
- 2) The diffuser on each filter ring should be kept clean at all times.
- 3) The radiometer is a precision instrument, protect from shocks.
- 4) Avoid supporting the detector by the multi core cable.

10 OPTIONAL ACCESSORIES

The following items are available from Irradian:

- Levelling Plate (Three adjustable feet and built in spirit bubble)
- Waterproof Cosine and 4π detectors
- Extension cable
- Sample PC Software.

11 BLOCK DIAGRAM



12 PROGRAMMING VIA THE RS232 INTERFACE

Serial Port Settings: 4800 baud, no handshaking

Single letter commands

- S Toggle through possible gain ranges (manual mode)
Reset to autorange with R command.
- U Toggle through possible units, lux, UVA & Aux as applicable
- F Toggle through possible functions
- I Function reset
- H Toggles hold/go
- Z Zeros light meter
- R Resets light meter
- B Toggles backlight
- s Sends data continuously via the RS232
- o Sends one set of data via the RS232

12 PROGRAMMING VIA THE RS232 INTERFACE (continued):

12.1 Windows 3.1 & Windows 95

Setting up remote control via Microsoft TERMINAL.EXE

- 1) Connect the cable between the RS232 socket on the light meter and the COM port on the PC.
- 2) Switch on the light meter.
- 3) Run *Terminal* program.
- 4) Go to the *Settings / Communications* screen and set the baud to 4800 and the COM port to suit.
- 5) Go to the *Settings / Text Transfers* and select *Line at a time* with *1/10th second delay*.
- 6) Check the RS232 link by a switch to the manual range, LED on using the command 'S', (capital S).
- 7) Reset to the auto range, LED off using the command 'R', (capital R).
- 8) Type 'o' for one packet of data and 's' for continuous data. Type 's' to stop the data flow.
- 9) To save the terminal setup go to *File / Save As* and save the settings. When restarting the program the settings can be reloaded with *File / Load filename*. Now actions 4 and 5 can be omitted.

Logging data continuously to a file using Microsoft TERMINAL.EXE

- 1) Run the Terminal program with the correct settings.
- 2) Set up the radiometer and send the command 's' via Terminal to transmit data continuously from the radiometer.
- 3) Go to *Transfers / Receive Text File*. Enter filename for the stored data (e.g. log1.txt).
- 4) On entering the file name, Terminal will now store all the readings transmitted from the radiometer in a file *log1.txt*. The file is saved to the computer by pressing STOP on the terminal screen.

12 PROGRAMMING VIA THE RS232 INTERFACE (continued):

12.2 Windows 95, Windows 98 and later editions

Setting up remote control via Microsoft HYPERTERMINAL.EXE

- 1) Connect the cable between the RS232 socket on the light meter and the COM port on the PC.
- 2) Switch on the light meter.
- 3) Run the *HyperTerminal* program.
- 4) Enter a name for the session (e.g. Q203 etc.).
- 5) Select the type of connection required, either option 'direct to com 1' or 'direct to com 2' depending on which com port is to be used.
- 6) Enter the details for the serial connection: 4800 bits per second, 8 data bits, no parity, 1 stop bit and no flow control.
- 7) Click the properties icon or select via the *File / Properties* option to display the properties window.
- 8) Select the *Settings* tab and select Auto detect for the *Emulation* setting.
- 9) Click the *ASCII Setup* button. Enter 100 into the box marked *Line delay*. No other options are necessary. Click on OK to return to the main window.
- 10) Check the RS232 link by downloading a reading using the command 'o', (lowercase o). This also allows auto detect to correctly identify the meter settings, showing 4800 8-N-1 next to the Auto detect message in the status bar. A reading should appear in the main window if the connection has been made successfully.
- 11) To save the terminal setup go to *File / Save As* and save settings. When restarting the program the settings can be loaded directly by double-clicking on the *.ht icon that has been created. Now actions 4 to 9 can be omitted.

12 PROGRAMMING VIA THE RS232 INTERFACE (continued):

Logging data to a file using Microsoft HYPERTERMINAL.EXE

- 1) Run the HyperTerminal program with the correct settings.
- 2) Set up the radiometer and send the command 's' via HyperTerminal to transmit data continuously from the radiometer.
- 3) Go to *Transfer / Capture Text*. Enter the filename for the stored data and the location to save to. (e.g. C:\HyperTerminal\Capture.txt).
- 4) Press the *start* button to store all the readings transmitted from the radiometer in a file *Capture.txt*. The status bar will now show a highlighted 'Capture' message. The file is saved to the computer by selecting *Transfer / Capture Text / Stop*.
- 5) Send the command 's' again via HyperTerminal to stop the continuous transmission of data from the radiometer.

13 ENVIRONMENTAL CARE, RECYCLING AND DISPOSAL

The purpose of the European Commission WEEE directive (Waste Electrical and Electronic Equipment; 2002/96/EC) is to ensure that electrical and electronic products are recycled using the best treatments, recovery and recycling techniques that are currently available. This is so that high health standards and a lasting environmental protection can be achieved and maintained.

This product has been designed and manufactured using high quality materials and components, many of which can be recycled and reused.

Please remember to observe the local regulations that govern both the disposal of the packaging materials accompanying this product and any used batteries.

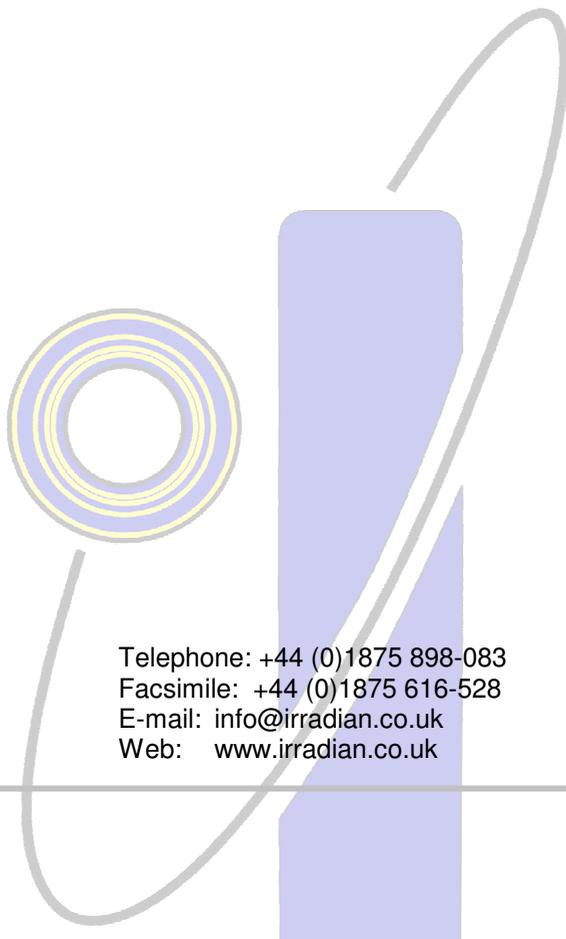


DO NOT DISPOSE OF THIS PRODUCT IN YOUR GENERAL WASTE BIN.

Please inform yourself about your local WEEE collection system which is available for electrical and electronic products that are marked with the symbol shown here.

When disposing of this meter, please use one of the following options:

- 1) Use your local designated WEEE collection facilities to dispose of the complete product (including cables, detectors, filters & accessories).
- 2) Return the complete product back to Irradian, marking it clearly as intended for WEEE disposal.



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