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1 OVERVIEW

Congratulations! You are now the proud owner of the most sophisticated, easy to use and portable instruments for measuring Ultra Violet (UV) radiation.

To allow you to get the most out of your portable UV spectro-radiometer, please take time to read this manual before using the instrument for the first time. The patented Solatell® technology allows a complete UV spectrum from low UVC up to and beyond the start of blue visible light (475 nm) to be captured and displayed graphically with just a single button press. Many novel and useful features have been designed into the Solatell instruments that allow powerful spectral analysis of UV light to be done in seconds.

Solatell technology is the result of an in-depth research and development program to develop portable, hand-held instruments for the rapid and accurate measurement of Ultra Violet radiation. The range measured is from short wavelength UVC, used for surface cure in industrial processes; through UVB, the cause of sunburn in humans and also used by industry; to UVA, the predominant UV energy region from the Sun reaching the Earth's surface, used widely by industry for depth of cure; and on into the deep violet region above 400nm wavelength.

It is assumed that the reader of this manual will have some appreciation of the use of UV within their own process, research area or sphere of concern, though the actual UV wavelength and intensity may well be only vaguely known. This instrument will help you discover more about your process in easy steps, and will enable you to examine closely both the wavelength and intensity information from any UV light source, be it the Sun or a low pressure Mercury lamp, for instance.

The instrument provides a display that shows, in graphical form, the intensity of the UV entering the Sensor against the wavelength. *An example is shown in Figure 1.*

The figure shown is only an example, and the intensity units have been deliberately omitted. However, the Solatell instrument as supplied is intensity calibrated in 'radiometric' units - generally $\mu W/cm^2/nm$ or $mW/cm^2/nm$ - which are the correct units for the measurement of the power contained in light **falling onto** a surface, known as ***irradiant*** power, or the ***irradiance*** of the light at a given distance from a light source.

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NB ***Irradiance*** must not be confused with the radiant intensity of light energy being emitted **from** a light source, which is known as the ***radiance.*** The Solatell instruments are designed to allow the user to measure precisely the amount of light at a specific wavelength or band of wavelengths which is incident upon the process under investigation

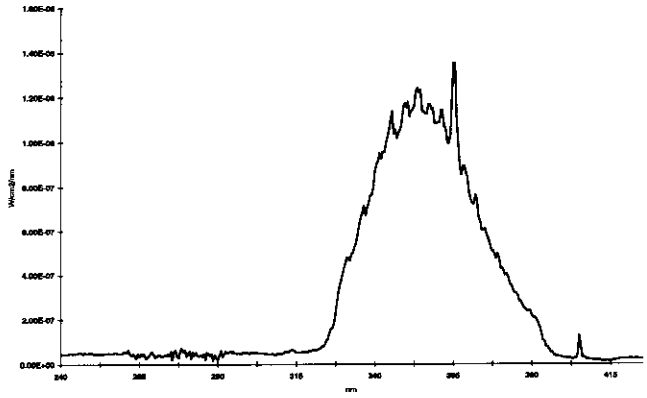

Figure 0 Continuous spectra from a mercury black light

2 HARDWARE

A standard Solatell measuring system normally comprises the following items :-

1. Sola-Sensor 2000 UV spectroradiometric detector head
2. Sola-Scope 2000 graphical display handheld (hardware) unit
3. Connecting cable between items 1 and 2
4. Power supply for recharging item 2
5. RS232 lead for connecting to PC

As will become obvious, the Sola-Scope is actually only the read-out device for the spectral intensity information gathered by the Sola-Sensor device attached to it.

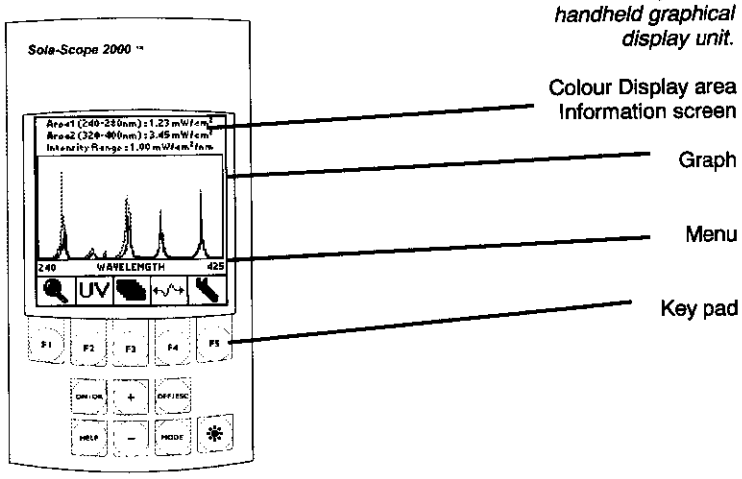

Figure 1 Sola Scope 2000

3 TECHNICAL INFORMATION

(Skip to section 4 if you just want to get started!)
It is important to know **both** the **wavelength and intensity** of the UV radiation to be able to judge the effectiveness of the radiation in achieving a desired effect. For this, the spectral content as well as the intensity is needed from a measuring instrument, generally referred to as a **spectroradiometer**. This is the role of the Sola-Scope, which provides both wavelength and intensity information in a clear and easy to understand graphical form. Units of measurement for spectroradiometers are usually $W/cm^2/nm$, reflecting the fact that wavelength is taken into account.

The graphical display unit is the analysis and read-out device for the spectral intensity information gathered by the Sola-Sensor device attached to it. At the heart of the Sola-Sensor is the Solatell® technology, a patented single optical component, transparent to UV down to approximately 220nm. Once UV light enters this optical component it is constrained within it until it ends up striking elements of a photo-diode detector array as a focused dispersed image. The position of the illuminated portion(s) of the detector array determines the **wavelength** of the UV light, and the number of photons striking a detector element within a certain sample time corresponds to the **intensity** of the UV light at that wavelength. This means then that the entire photo-diode array is illuminated at the same time in the presence of broadband UV radiation. This array is scanned by the Sola-Sensor control electronics at the end of the sample time, thus acquiring the UV spectrum in a single sample.

Accuracy is the essence and this requires a calibration procedure to determine which wavelength each detector element represents. The calibration procedure uses a calibrated light source (calibrated by the *National Physical Laboratory, UK*). The sensitivity of each detector element and its corresponding wavelength position on the focal plane can then be characterised.

These calibration sensitivities are then used as exact adjustments when the photo-diode array is scanned in use, to yield the actual intensity of the UV radiation falling on each detector element in radiometric units of $\mu W/cm^2/nm$. Clearly, a reasonable amount of digital signal processing is required when the Sola-Sensor is being used, to convert the photon counts from each of the detector elements over the range of interest to radiometric units, while also taking the calibration data into account.

The spectral intensity data is finally converted to a high speed asynchronous serial data stream which can be sent via the connecting cable to the Sola-Scope.

4 UV SPECTRAL MEASUREMENTS - QUICK START

To get to know the instrument you can experiment with the graphical display unit without the sensor connected. All functions described are available, except for the sampling function that requires the sensor attached.

4.1 Setting-up

Connect the Sola-Sensor to the Sola-Scope by means of the supplied 4 core cable. If required, connect the power supply cable to the Sola-Scope and mains supply.

4.2 Switching On

Once you have set-up the Sola-Scope and Sola-Sensor as above you are now ready to power up. To switch on, press the **ON** KEY.

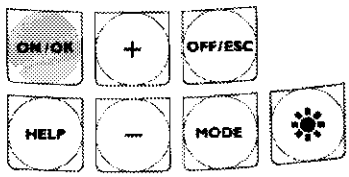

Figure 3 ON KEY

After initialisation the graph mode screen will appear as *Figure 4*.
An explanation of the function icons at the bottom of the screen is in section 6

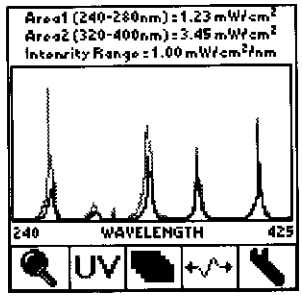

Figure 4 Graph mode screen

Function Control.

If the screen is not clear the contrast needs to be altered. To vary the contrast, press **ESC** KEY and then use the + and – KEYS. The colour of the

band of blue down the right hand side of the screen should be a medium to light blue, the Solatell logo should be magenta and the background a greenish yellow.

4.3 Switching Off

The Sola-Scope automatically switches off after a six-minute absence of keystrokes. It gives three warning beeps after five minutes, and three more beeps five seconds before switching off. To switch the Sola-Scope off manually, hold the **OFF** KEY down for 5 seconds.

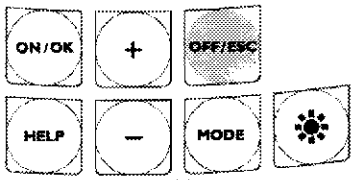

Figure 5 OFF KEY

4.4 Mode Key

There are three modes available via the **MODE** KEY. See

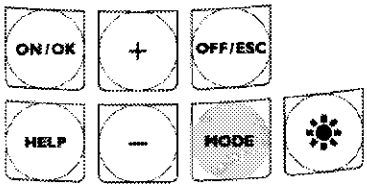

Figure 6 MODE KEY

The three modes are:-
GRAPH MODE see figure 4
BAR MODE see figure 9
RADIOMETER MODE see figure 10
See section 5 Mode Control for detailed explanation of these modes.

4.5 Sample Key ✱

Now that the Sola-Scope is ready to use you can prepare to collect the first sample from your UV source. For your first scan, we suggest you use **Auto-Scan.** Auto-Scan is accessed by **pressing and holding** the ✱ **SAMPLE** KEY for 2 seconds.

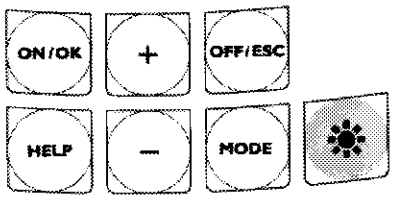

Figure 7 SAMPLE KEY

Auto-scan automatically assesses the lamp's intensity (how "bright" the source is) and thereby selects the appropriate sample time (the "brighter" the source the shorter the sample time required). Auto-scan can take a few seconds and once complete, the "intensity range" will be displayed at the top of the graph and bar chart screens and the graph should fill the screen. If the graph does not fill the screen you need to use the **– KEY** to decrease the intensity range before sampling again with a simple press of the **SAMPLE** KEY. From now on, when sampling this lamp you can set the intensity range yourself (using the + and – KEYS) and simply **press** the **SAMPLE** KEY.

As the Sola-Sensor is collecting the UV, the Sola-Scope will display a blue bar indicating the progress of the sample. The previous graph will be displayed and you are able to continue working with this data until sampling is complete.

If the scope has reset or never been used, two factory collected sample graphs will be displayed in black and red. When the Sola-

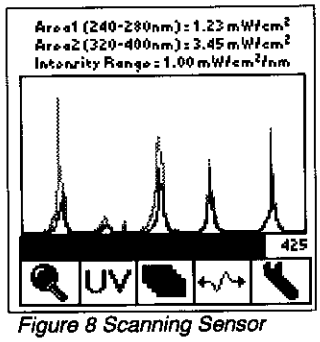

Figure 8 Scanning Sensor

Sensor has finished collecting data, the screen will update and your data will be displayed in black. The previous black graph will now be displayed in red.

If you wish to abort a scan at any time press F2 UV KEY and the F1 STOP KEY.

4.6 Help Key

At any time pressing the **HELP** KEY will bring an explanation of the current function of the Scope onto the screen. To return to the menu control press **ESC** KEY.

5 MODE CONTROL

The **MODE** KEY allows you to toggle between **GRAPH**, **BAR** and **RADIOMETER** MODEs.

5.1 Graph Mode

This is the default mode. See *Figure 4*. Graph Mode is the graphical representation of the sample data – plotting intensity against wavelength. There are two graphs displayed – the black line is the latest sample and the red line is a previous sample. (Note: the red line is only displayed when the two graphs have similar intensities). The graph gives you an instant picture of the lamp type "finger print" and state of the lamp. You will quickly become experienced at recognising different "finger-prints" and also changes in the lamp. For instance the graph shown in *Figure 1* is a Medium Pressure Mercury bulb.

The red line can be either the previous (last) graph that was shown in black or a user selected graph. The red graph options are to be found in the VIEW SETTINGS : User Preferences screen. See Section 6.6 for explanation.

At the top of the screen are two radiometric values and the intensity range for your latest sample (the black graph. The two default wavebands for the radiometric setting are 240 – 280 nm and 320 – 400 nm. These can be changed in the VIEW SETTINGS : User Preferences screen to match your process. See section 6.6.1 View Settings.

The intensity range tells you the maximum intensity possible on the current sample time setting. This can be changed for the next sample by pressing the + KEY for a more powerful lamp and – KEY for a less intense lamp. For a more detailed explanation of sample time / intensity range and Smart Scan see Section 8 Smart Scan Automation including Smart Scan.

You are now able to further analyse the sample data using the functions described in Section 6 Function Control.

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5.2 Bar Mode

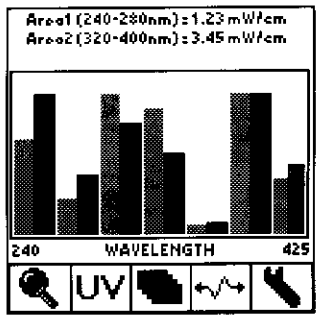

Figure 9 BAR MODE

BAR MODE is reached by pressing the **MODE** KEY. The screen will then look like *Figure 9 Bar Mode.* This screen allows you to compare two samples visually very easily. The width of the bars can be altered in the VIEW SETTINGS : User Preferences screen. The default bar width is 10nm. You are now able to further analyse the sample data using the functions described in Section 6.6.1 View Settings. **Note** Red bars will only be displayed if intensity range is the same as current data.

5.3 Radiometer Mode

To change to the radiometer mode from the graph mode, simply press the **MODE** KEY. You can toggle between **RADIOMETER**, **BAR** and **GRAPH** mode at any time, before or after sampling the UV source of interest.

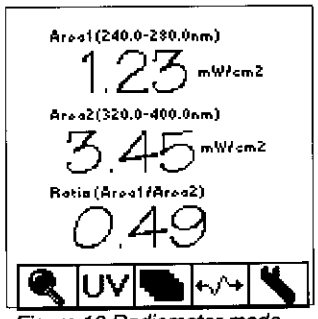

Figure 10 Radiometer mode

6 FUNCTION CONTROL

6.1 Quick Reference

The primary method of controlling the Sola-Scope 2000 is through the "soft" function (or **F**) KEYs. Use the function keys to select the function required. The icon above each key determines the keys function as listed:-

MAIN MENU

ICON	FUNCTION KEY	NAME	FUNCTION
	F1	EXAMINE	Zoom and trace mode
UV	F2	UV	scan type, trigger mode and sample time
	F3	FILE MANAGEMENT	Takes you into the top level of file management – the BANK menu. Save, retrieve and delete files.
	F4	RS232 COMMS	Communication set up between PC and Scope
	F5	PREFS	user preferences menu

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SUB-MENUS

ICON	FUNCTION KEY	NAME	FUNCTION
	**F1**	**SUB-MENUS**	
	Examine menu F1	X-Zoom In in GRAPH Mode	Zoom in on X-axis when in graph mode
	Examine menu F2	X-Zoom out in GRAPH Mode	Zoom out on X-axis when in graph mode
	Examine menu F1	X-Zoom In in BAR Mode	Zoom in on X-axis when in bar mode
	Examine menu F2	X-Zoom out in BAR Mode	Zoom out on X-axis when in Bar mode
	Examine menu F3	Y-Zoom in In GRAPH mode	Zoom in on Y-axis when in graph mode
	Examine menu F4	Y-Zoom out In GRAPH mode	Zoom out on Y-axis when in graph mode
	Examine menu F5	Toggle	Toggle between red (prior) and black (current) graphs.

UV	F2	SUB-MENUS	
		STOP SAMPLING	Stop sampling - available whenever sampling is occuring.
	UV menu F1	Continuous sample	Commences continuous sampling at the set sample time
	UV menu F2	Trigger	Sample sensor when triggered by signal from PC or PLC
	UV menu F4	Auto-scan	Function as press and hold SAMPLE key
	UV menu F5	Multi sensor	Allows scanning of multiple sensors.
	SUB menu	Sample sensor A	Triggers sensor A to sample when using multi-sensors.

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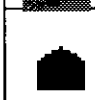
	F3	SUB-MENUS	
	BANK menu F1	RESET ALL	Resets all settings to default – N.B. all saved files will be deleted.
	BANK menu F3	FILE	Takes you to the second level of file management – the file menu. Displays files in highlighted bank.
	FILE menu F1	*LOAD*	Loads saved data from highlighted file into current
	FILE menu F2	*SAVE*	Saves current sample into highlighted file
	FILE menu F3	*STATS*	Lists file name, sensor used, and sample statistics
	FILE menu F4	*NAME*	Name file
	NAME menu F1	*CHARACTER TYPE*	Change character to upper, lower or numeric
	NAME menu F2	*NEXT CHAR*	Move to next character
	NAME menu F3	*DELETE CHAR*	Delete character
	NAME menu F4	*ACCEPT*	Accept settings
	NAME menu F5	*REJECT*	
	FILE menu F5	*DELETE*	Delete file
	BANK menu F4	NAME BANK	Allows naming of bank
	BANK menu F5	DELETE BANK	Delete complete bank

	F4	SUB-MENUS	
	COMMS menu F1	SEND	Current data to PC
	COMMS menu F2	SEND FILE	sends selected file to PC
	COMMS menu F3	SEND BANK	sends selected bank to PC
	COMMS menu F4	RECIEVE	Sends file from PC to Scope
	COMMS menu F5	PRINT	Sends data to mini-printer

	**F5**	**SUB-MENUS**	
No icon	PREFS menu F1	View Settings	Set up screen options
No icon	PREFS menu F2	Sensor Settings	Sample type options
No icon	PREFS menu F3	Log Settings	Continuous and trigger function settings
No icon	PREFS menu F4	Miscellaneous Settings	Language, auto power off, time and date
	sub menu F1	Cursor Up	Move cursor up the screen of options
	sub menu F2	Cursor down	Move cursor down the screen of options
	Sub menu F3	Select file	Select red line file name. This function is active when cursor is on "Red graph file" option
	Sub menu F4	Accept	Accept settings
	Sub menu F5	cancel	Cancel settings

To return to a previous screen press **ESC** KEY.

6.2 *Examine Function In Graph And Bar Mode*

(F1 Main Menu)

6.2.1 Determining the wavelength and intensity

F1 KEY allows you to determine the wavelength of a peak or trough when in **GRAPH** or **BAR** MODE. The cursor is in the shape of an arrow ↓ and the wavelength corresponding to its position is displayed at the top of the screen. The intensity of this selected wavelength is also displayed (see figure 11 Examine function Screen). When there is a red and black graph displayed, the colour of the arrow indicates which graph is being analysed. The black graph is the current sample. The red graph (when available) is either the previous sample or a stored sample.

To move the cursor along the graph using the + and - KEYS. To accelerate the cursor press and hold the + **and** - KEYS.

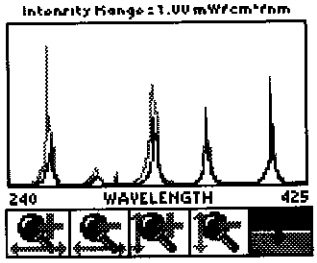


Figure 11 Examine function screen

Press **ESC** KEY at any time to return to the main menu.

6.2.2 Zooming in and out on X-Axis

(F1 and F2 EXAMINE menu)

Having traced along the graph you have spotted an unusual part in the graph that requires closer inspection. Easy - use the zoom in facility.

In **EXAMINE** menu (F1 from main menu) it is possible to zoom in and out on the position of the cursor. First position the cursor around the centre of the position you wish to zoom into. Select the **F1** KEY to zoom in or the **F2** KEY to zoom out. You can continue to zoom in or out by pressing the **F1 or F2** KEY respectively. Once zoomed in, you can continue to move the cursor along the graph using the + and - KEYS as described in the previous section. By moving along the graph you are also able to alter the focus or section of graph displayed.

6.2.3 Zooming in and out on Y-Axis

F3 and **F4** KEYs in the EXAMINE function zoom in and out on the Y-Axis.

6.2.4 Toggle function

To toggle between the black and red graphs, use **F5** KEY.

Press **ESC** KEY at any time to return to the main menu.

6.3 UV Function

(F2 main menu)
The UV FUNCTION accesses the different sampling type functions allowing continuous sampling, externally triggered sampling, the input of a custom calibration, an auto-ranging sample and the selection and control of multiple sensors.

6.3.1 *Continuous sample*

(F1 UV menu)
Activating the continuous mode will cause the Sola Scope to sample and update the screen on a continuous basis. The current intensity range and other sample settings will be used. To **stop** sampling press F1 **STOP** KEY.

This option is useful when measuring several lamps in turn, finding the point of peak irradiation of a lamp or watching for a change in transmission. When in this mode the Sensor and the Scope will cycle as follows:

1. Scan (at the current sample time);
2. Upload data from Sensor to Sola-Scope;
3. Scope redraws screen.

Note that the time this sequence takes depends on the intensity of the lamp and the number of scans selected for smart-scan (see section 6.6.2 on Sensor Prefs.)

If you want the sample data automatically sent to the PC, the logging setting in the LOG SETTINGS PREF MENU must be set to spectra.

6.3.2 *Trigger*

(F2 UV menu)
This feature allows UV scans to be triggered by a PC via RS232 DSR signal, and the resultant data uploaded automatically at 19200 Baud rate.
The purpose is to allow a sample to be initiated by an external signal. By selecting F2 on the UV menu, the Sola-Scope 2000 waits for a high pulse

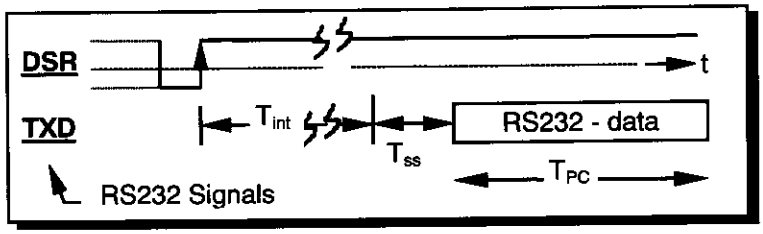


Figure 12 RS232 trigger circuit

(>5volts wrt 0v) on the DSR line. This can be achieved by connecting the DTR and DSR lines together.

Sequence is :-

1. The control signal is the DSR input to the *Sola-Scope*, connected to the DTR line of the PC. When this line rises, (from low to high) a sample is initiated as if the **Sample** button had been pressed.
2. The sample data will be collected.

3. The raw data must then go from the Sensor to the Scope, taking T_{int} (around 250mS).
4. After this time the data will start to be sent to the PC without handshaking, so the PC software needs to be capable of receiving files of more than 1024 Kbytes in one go.
5. Sola-Term 2 software can then initiate scans and can accept this data automatically whenever the **Start** button in Sola-Term 2 is pressed.

Relevant Pins

Output	**Pin**
DSR	6
DTR	4
0 volts	5

6.3.3 Auto-ranging

(F4 UV menu)
This function is the same as auto-scan, i.e. holding down the sample key and is described in Section 4.5 Sample Key.

6.3.4 Multiple Sensors

(F5 UV menu)
Use this function to control sampling from multiple sensors. To set-up, you need to connect one sensor at a time, hold the F key you want to associate with that sensor and the scope will 'learn' to use that sensor, on that F key. For example connect sensor 1 to the scope and hold down F1, it will then store that sensor's address at F1, so from then on pressing F1 will scan that sensor. Once set up, the multiple sensors menu scans the relevant sensor when pressing F1-F5.

6.4 File Management Function

Once you have taken a reading of an UV lamp you may want to store the data in battery backed RAM so you can refer to it later (e.g. upload it to a PC or use as a base line). It is not essential to save the data but it will be lost if you press the sample key again.

The filing system is divided into 9 banks (named Bank A – I) of 10 files (named 0 – 9). Therefore there is a set of functions to deal with the naming, selection and deleting of banks and a set of functions dealing with the naming, selection and deleting of individual files.

Bank J of files is a special bank of files, used (for example) for user calibration data. Bank J files are stored in EEROM this means they are very 'safe'. For example, if the Sola-Scope 2000 is left on a shelf for a year, the battery-backed RAM would probably lose its memory, but the EEROM will never lose its files. The EEROM bank has 8 files. (refer to supplier if Bank J is required).

6.4.1 Bank Menu

(F3 main menu)

This is the first level of the file management system. This screen allows you to select and name a bank of files. You can also delete a bank of files.

F1 KEY **!** is the reset button. This resets **all** Scope options to their default and clears all files. **USE WITH CAUTION.**

Use **F3** File Menu KEY to select the bank of files highlighted. See section 6.4.2 for more detail. **F4** KEY allows you to name a bank and **F5** KEY deletes a whole bank of files.

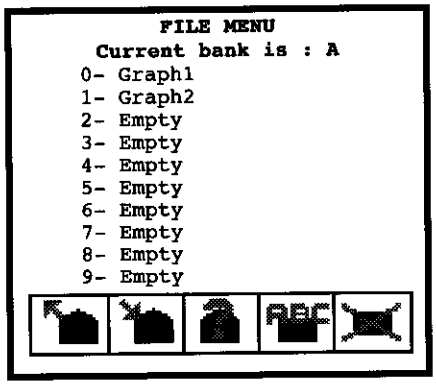


Figure 13 File menu

6.4.2 File Menu

(F3 Bank Menu)
This is the second level of the file management system. This screen allows you to select and load a file, save a file, delete and name a file.

F1 KEY opens / loads the highlighted file to current. Use the **+ and –** KEYS to select the required file.

To store your current data, once you have highlighted the bank of files you wish to use using the **+ and –** KEYS to select the required file, press **F2** KEY to save.

There are 90 file areas available in 9 banks of 10 files. When used, the file area is stamped with the scan number. The file data can be viewed using **F3**.

F4 allows you to rename the selected file.

F5 deletes the selected file. You will be asked if you wish to delete the file. Press **F1** KEY to continue or **F5** to keep file.

6.5 Communication Function

6.5.1 *Printing to mini-printer*

(F1 COMMS MENU)
This function prints the current sample data to the optional portable printer.

6.5.2 *Send selected file when using a terminal emulator*

(F2 COMMS MENU) If using Sola-Term 2000 see section 10.
To download data from your Sola-Scope 2000 to your PC running a terminal emulator. The data can then be further analysed using a spreadsheet program, such as Microsoft Excel.

The wavelength range of data uploaded to the PC is set in the **VIEW PREFS** menu. Once the PC and Scope are connected as described above, turn on the Sola-Scope 2000.

- Press **F4 COMMS** function and select **F2** PC SEND function to send current data.

Select the file to be uploaded in the usual way and the Scope will start uploading the data.
The data must now be filed.
Run your spreadsheet program and import your captured TXT file.
Select **tab delimitor** file. You can now use your spreadsheet as normal - plotting graphs etc as required.

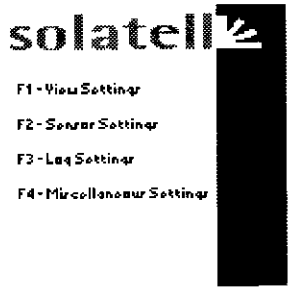


Figure 14 User preferences screen

6.5.3 *Send selected bank*

As above but selecting a bank.

6.5.4 Receive file

Downloads correctly formatted file from PC to Scope via your terminal emulator as above.

6.6 User Preferences Function F4

(F5 Main Menu)

The User Preferences function is broken down into four sections. F5 brings up the Prefs option menu. The four options are:-

- F1 - View Settings
- F2 – Sensor settings
- F3 – Log settings
- F4 – Miscellaneous settings

See figure 14.

6.6.1 View Settings F1.

In this screen you are able change all screen options. This includes wavelength range, the selection of the red graph, turning shade area on and off (giving a visual of the selected areas for radiometric readings in the graph mode), changing the radiometer wavebands and changing the bar width on the bar mode.

- **Wave-range Min and Max**. This is the range that the Scope uses when transferring data between file areas and PC. To alter you need to use **F1** and **F2** KEYs to move cursor to the value you wish to change. Use + and – keys to increase or decrease the value.

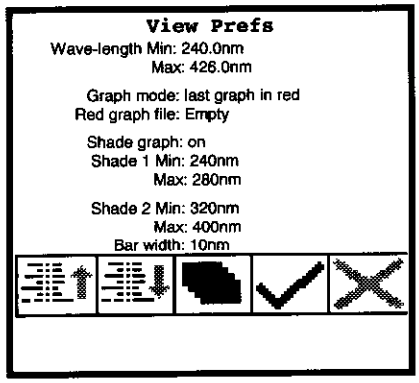


Figure 15 View settings screen

- **Graph mode options** are:-

Option	Effect
last graph in red	The previous sample is displayed in red
file graphed in red	The sample filed in named file area below is displayed in red
baseline	All values are displayed as a percentage of the red data in the named file.

- **Shade graph** on or off. If shade is "on" then the shade areas 1 and 2 are shown in blue and red respectively.

- **Shade 1 and 2 Min and Max.** Defines the radiometric regions displayed in all modes and the areas shaded. To alter this, use **F1** and **F2** KEYs to move cursor to the value you wish to change. Use + and – keys to increase or decrease the value.

- **Bar width.** You can vary the width of the bars in the BAR MODE. To alter, use **F1** and **F2** KEYs to move cursor to the value you wish to change. Use + and – keys to increase or decrease the value.

6.6.2 Sensor Settings F2

- **Stray light compensation.**: on or off see section 9 for explanation

- **Optimise speed:** This is the number of scans used by SMART SCAN. The fewer used, the faster the sampling is. Accuracy can be compromised if too few scans are used. The maximum number of Smart Scans are 7 scans. See Section 8 on Smart Scan for more detail.

- **Custom Calibration File**: To introduce your own calibration the relevant data needs to be stored in a designated file (usually Bank J). To select the file name move the cursor to **Custom cal file** field and then **F3** KEY to select a file in the usual way (select bank using + and – KEYs the F1 to accept bank; followed by selection of file in the same way).

6.6.3 Log Settings F3

- **Log to memory**: If **on,** sample data will be saved automatically into a file. Each subsequent sample will be filed in the consecutive file. The next log file is named in this screen of options.

- **Next log file**: This is the file that the first automatic sample save will take place. Use **F3** KEY to select bank and file name.

- **Overwrite files: on** or **off**. If **on** auto logging will overwrite previously saved sample data.

- **Logging range:** Defines allowable banks for auto save – either **one bank** or **all banks.**
- **Looping: on** or **off.** If **off,** stops saving once all file areas are full. Will not overwrite stored data.
- **Log to RS232: off, spectra.** Sends sample data to the RS232 port.

6.6.4 Miscellaneous Settings

- **Language**: Allows you to select displayed language. English only available at present.
- **Auto power off:** If **on** then Scope will automatically turn off if there are no key presses for more than 6 minutes.
- **Time:** To correct time the cursor will highlight hour, minute and second fields in turn. Use + and – keys to change.
- **Date** To correct date the cursor will highlight day, month, and year fields in turn. Use + and – keys to change.

7 UNDERSTANDING A UV SPECTRUM

To get the most out of the Sola-Scope it is necessary to have an appreciation of how a 'normal' spectrum from the UV source you are interested in measuring should look. To a certain extent, this appreciation will come from using the instrument of course, but it is worth mentioning some broad categories of UV light source and what to except in the way of spectral distribution from these sources.

These UV sources can be split into the following categories:-
Line spectra - e.g. From Mercury vapour discharge lamp.
Continuous spectra - e.g. from the Sun.
Examples of these two broad categories and valid interpretation of the resultant spectral distribution graphs obtained using Sola-Scope will be discussed briefly in the following sections.

The units of wavelength measurement for UV are nano-metres, usually abbreviated to 'nm'. The units of intensity measurement for UV are micro-Watts-per-centimetre-squared-per-nano-metre, usually abbreviated to $\mu W/cm^2/nm$ or $\mu W.cm^2.nm^{-1}$. These units can represent 1000 times more power if expressed in $mW/cm^2/nm$ or 1000 times less power if expressed in $nW/cm^2/nm$.

Note how the 'per nano-metre' part of the intensity units reflects that the Sola-Scope 2000 is a spectroradiometer, so is able to indicate the amount of irradiance power entering the instrument at each nm. (A radiometer as opposed to a spectroradiometer is only able to measure irradiance in a fairly broad band and is unable to give any wavelength information.

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7.1 Line Spectra

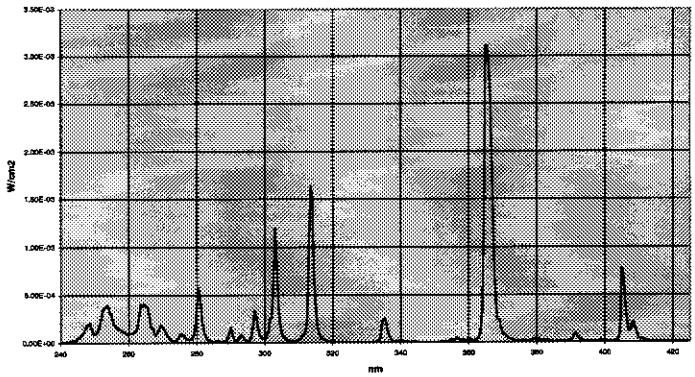

Figure 26 An example of a lamp with a line spectra "finger print"

Manufacturers of lamps tailor the output of their lamps by the addition of metal halides to the Mercury vapour. This has the effect of moving the concentration of UV energy up in wavelength, since pure low-pressure Mercury lamps tend to have the large majority of their UV photon energy output concentrated in the 254nm 'line'.

The Sola-Scope instrument is very useful for determining the requirement for cleaning of lamps, reflectors or quartz tubes in a number of applications by observing the ratio of short wavelength UV lines to longer wavelengths. See Section 11: "How Sola-Scope 2000 can improve your process" for more details.

7.2 Continuous Spectra

Solar radiation is continuous spectra and there are many lamps on the market that offer UV spectra similar to that of the Sun. The most commonly used is the Xenon lamp. These are often used in industry for accelerated weathering and other solar related experimentation, research and development. See figure 1 for an example of continuous spectra.

8 'SMART SCAN' AUTOMATION INCLUDING FINE TUNING

8.1 Overview Smart Scan

The Sola-Sensor measures the intensity of light by collecting the light for a set period of time, called the sample time. Varying the sample time gives the Sola-Sensor a huge dynamic range because it can measure a very bright light with a 10mS sample time or a light **20 000 times dimmer** with a 200s sample time.

The problem arises when different sample times are required for different parts of the spectrum of the same UV source. Smart Scan solves this problem by patching the scans of different sample times together at an early stage (in the Sola-Sensor), vastly increasing the range viewable in a 'single' scan. By performing up to six separate scans at varying sample times, the Smart Scan mode can produce results that are up to 64 times more accurate than those made without Smart Scan.

8.2 How Smart-Scan Works

The "intensity range" displayed at the Scope screen is directly related to sample time *X*. The number of scans performed by Smart-Scan is determined in Sensor Prefs **optimise speed** *n* (see section 6.6.3.on log settings).

In Smart Scan mode, the Sola-Sensor will perform an initial scan with a sample time of $X \times 2^{n-1}$. If this scan contains any saturation, the Sola Sensor will automatically perform a further scan at half the previous sample time, etc. This process of halving the sample time for successive scans will continue until either;

- a scan without saturation is detected,
- a total of *n* scans have been performed, (each at half the sample time of the previous), or
- the minimum sample time of 10 mS is reached.

For example, if a 16 second sample was initially chosen, the Sola-Sensor would perform scans at 16s, 8s, 4s, 2s, 1s, 0.5s and 0.25s, and combine the best non-saturated results.

8.3 Intensity Range and Sample Time

The minimum sample time required for a successful Smart Scan is intimately related to the intensity range of the UV source under investigation. It is important that the shortest sample time is sufficient to give an accurate measurement of the highest intensity, but is not so long that saturation still occurs. To achieve the optimum sample time it is necessary to know the

"Intensity Range" of the lamp. If known this can be changed using + and – KEYS in the opening screen mode. If unknown it is recommended that the Auto-Range feature be used.

8.4 Optimizing Speed or Choosing Number of Scans

The intensity of the smallest peak defines the maximum sample time. The largest intensity peak defines the minimum sample time. For lamps with a large variance between the smallest and largest peak you will need the maximum number of Smart Scans so the Optimum speed will have to be set to 7. The smaller the variance the fewer scans required. See Section 6.6.

It is recommended that Smart Scan with 7 scans be used for most applications as the norm. However there are instances where the use of Smart Scan will not yield satisfactory results and the optimum speed should be set to 1, these are;

- If the user is measuring a variable light source, which may be caused by flashing or movement of the light.
- If saturation is not present and quick readings are required. A measurement made without Smart Scan will take half the time of a measurement using Smart Scan with the maximum number of scans, but will obviously lose a degree of accuracy.

8.5 Saturation Dose

The saturation dose is displayed on the Scopes information screen. This is the opening screen and can be reached by pressing the **ESC** KEY when in graph mode. The saturation dose allows you to calculate the maximum intensity of a UV source measurable with your Sola Sensor and also the intensity range for a given sample time. Different sensors types have a different saturation dose rating.

Saturation dose is measured in J / cm^2 / nm.

Sample time = $\frac{\text{saturation dose}}{\text{intensity range}}$

Intensity range = $\frac{\text{saturation dose}}{\text{sample time}}$

9 STRAY LIGHT

The biggest problem when measuring a source such as sunlight is stray-light. The stray-light performance in Solatell optics is between $1x10^{-3}$ and $5x10^{-4}$ for monochromatic light. This means that, for example, a 400nm monochromatic spectral line of $1W/cm^2/nm$, will appear as a 'noise component' spread out across the rest of the spectrum fairly evenly at an attenuated level of between 10^{-3}, to $5x10^{-4}$. The reasons for this are primarily the diffraction grating not being perfect, but other sources of stray light can be reflections within the optics – Solatell has gone to a large effort to remove these as much as possible. The performance achieved in the Solatell optics is typical of a single grating spectrograph.

When a source such as sunlight is measured with such an instrument, there is a very large amount of visible light, with a vanishingly small amount of UV radiation as wavelength reduces, which reaches zero at between 290 and 300nm. Thus the visible and long wavelength UV radiation represents a massive stray light source when trying to measure the shorter wavelength power, which makes accurate measurement very difficult.

The stray light compensation feature of the Sola-Scope can take into account this stray light to an extent (but it must be switched on in the preferences menu - please check), which should reduce the short wavelength 'noise'. We recommend that you always use the longest integration time possible without saturation.

Stray light compensation is as follows:-
The detector array has 512 pixels. 424 of these are used by the detector array to measure the defracted UV. Of those remaining some are blacked out for dark current compensation and a few are used to measure the stray light falling on them. This allows computation of the stray light compensation – thus improving the accuracy of the instrument.
This technique is described in "Reliable Spectroradiometry" by Henry J. Kostkowski.

Stray light **compensation ON** option in the user preferences menu should be used with care and is should be OFF when measuring standard mercury type curing lamps.

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10 CONNECTING THE SOLA-SCOPE 2000 TO A PC VIA SOLATERM 2000

To send and receive data from your PC you need to be running Sola-Term 2000 or any Terminal Emulator software on your PC. Sola-Term 2000 is a Terminal Emulator that works in Windows environment.

A spreadsheet program, such as Microsoft Excel, can then be used to analyse the data. The wavelength range of data uploaded to the PC is set in the **VIEW PREFS** menu.

The steps are:
Run Sola-Term 2000 from the Icon in Windows (the first time you use Sola-Term 2000 you must **Install Sola-Term 2000** from the disc provided. To do this simply run **Setup** after inserting the disc into your PC).
Attach the 9 pin - 9 pin direct RS232 cable between your Sola-Scope 2000 and PC.
Turn on Sola-Scope 2000.
Use the window based software to copy files between your PC and Sola-Scope 2000.
Run your spreadsheet program and import your captured TXT file.
When using Sola-Term 2000 lite using the Excel button automatically imports and plots graphs for you.

If using another terminal emulator you will need to set the following on your PC. **This is not necessary when running Sola-Term 2000**:-
Baud rate to 19200
8 bit
no parity
hardware or RTS/CTS handshaking

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10.1 Auto Upload Option (optional extra Sola Term 2000 lite)

Contact 4D Controls for unlock code to access this option
This feature allows UV scans to be initiated by a PC via RS232 DSR signal, and the resultant data uploaded automatically to your PC or Scope.

Sequence is :-
The control signal is the DSR input to the Sola-Scope 2000, connected to the DTR line of the PC. When this line rises, (from low to high) a sample is initiated as if the **Sample** button had been pressed. The sample will be taken over the current intensity range. The raw data must then go from the Sensor to the Scope, taking around 250mS. After this time the data will start to be sent to the PC without handshaking, so the PC software needs to be capable of receiving files of more than 1024 Kbytes in one go.

Sola-Term 2000 software can initiate scans and can accept this data automatically.

To stop sampling at any time, use F1 STOP KEY.

11 MERCURY PROBES

The Sola-Scope 2000 is able to take readings via a Mercury Probe. These shuttered probes are designed to be fixed in a permanent position and are activated by a solenoid. When the sample KEY is pressed the Scope activates the solenoid to open the shutter and take a sample.

For further information refer to you representative.

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12 PROBES

When using probes for access to lamps it is important to understand the correct method of use. The key things to remember are:-
A non-diffused probe is highly directional
The distance from the source is significant
When comparing two readings you must be certain that the probe was **fixed** in **exactly** the same location for both readings. *Your supplier can tell you about probe locators suitable for most applications.*

The probe is supplied with attenuation data built into the Dallas Chip attached to the probe end-plate. To obtain absolute readings the Scope automatically convolutes this data.

For further information on probes please refer to data sheet.

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13 DOSE VS PEAK IRRADIANCE AND THE STATE OF YOUR CURE

A typical UV curing bulb with an elliptical reflector focuses and concentrates the radiant power from the bulb.

Some light also misses the refelctor so is not focussed. This photon flux will behave with an ***inverse square law*** as it travels away from the bulb.
The effect of collecting and focussing the radiant power from the bulb will be approximately as illustrated in the graph in figure 15. A strong peak of illumination is obtained under the bulb on the axis of the ellipse. The size of this peak is called the **peak irradiance** I_o. For some curing processes, this power must be above a threshold power level I_t to start at all.
Notice the units are usually expressed as 'Watts per centimetre squared'.
Note also that :- **1 Watt = 1 Joule *per second.***

If a work piece (a product requiring UV irradiation) is then allowed to travel under the lamp, it will 'collect' the photon flux available to cure. The slower it travels, the more photon flux it will collect. It will therefore receive a certain UV **dose**. The dose will be directly related to **time**, as follows :-

Dose	Travel time (t)
D/2	T/2
D	T
2D	2T

Note
Some UV curing processes are entirely dose related – exhibiting 'reciprocity'. Others must reach the threshold irradiance before curing can start – exhibiting 'reciprocity failure'.

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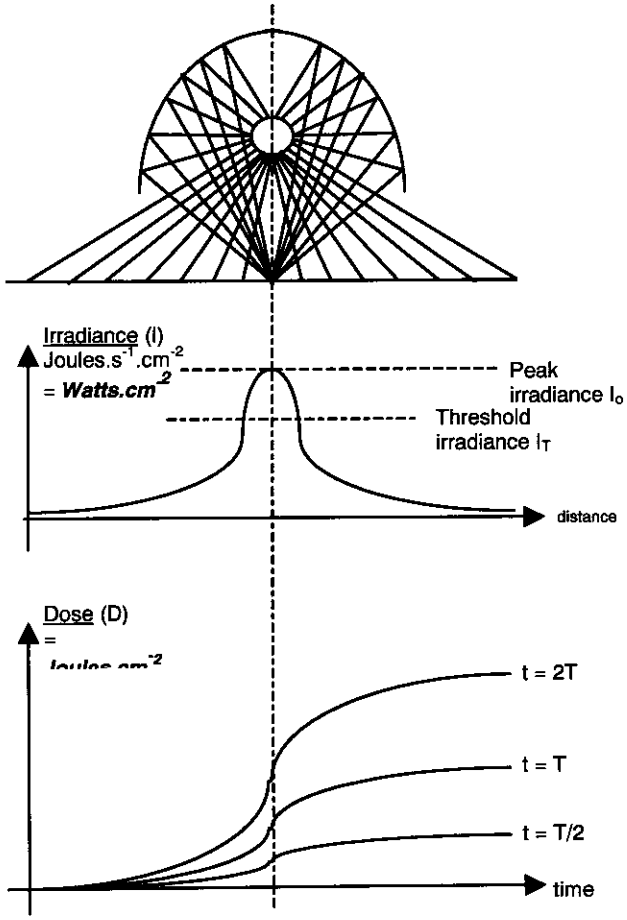

Figure 17 Illustration of the difference between peak and total irradiance.

14 HOW SOLA-SCOPE 2000 CAN IMPROVE YOUR PROCESS

14.1 Tips for Printers

The printer needs to know two basic things about his UV curing
a. Has my ink / coating cured properly?
b. If not, why not?

To answer both these questions you need to watch ***YOUR RATIOS.*** This is simple with the Sola Scope 2000 as the ratio is displayed in the radiometer mode. This ratio is calculated from the division of the total power in the short wavelength part of the spectrum (area 2) by the total power in the long wavelength part of the spectrum (area 1).

The suggested choice of areas 1 and 2 are
Area1 = 360 – 370nm
Area2 = 250 – 270nm
The ratio should remain fairly constant – within 0.5 of the best reading. If the figure starts increasing then something is wrong with the lamp.

Symptom	Diagnosis
Even drop off of intensity over all wavelengths	Ageing
A drop off in the shortwave intensities	Fogging
A drop off in the shortwave intensities	Dirt on lamps
Increased intensity output	Incorrect or inadequate cooling
Incorrect spectral output	Magnetron faults
Incorrect spectral output	Incorrect lamp fitted
Varying output over first 15 minutes from start up.	Start up problems with inferior lamps
Varying output over time.	Stability problems

14.2 Tips for Fibre Manufactures

An easy check on the state of the lamps is to watch the ratio of short to long wavelength UV intensities. A good early indication of possible process problems is a change in this ratio. See tips for printers.

This check needs a method of gathering light directly from the focus point either 1. where the fibre is, or 2. behind the reflector. This can be done as follows:-

1. **Spot check inside the quartz tube:** The Sola-Scope attached to sensor and **high temperature probe** allows the spectral intensity distribution to be measured directly as the fibre sees it as part of routine maintenance. The specially developed probe is sideways looking and is

designed to fit up through the exit iris and into the quartz tube. By rotating the probe, the sensor is able to gather UV data from all round. Using the UV ratio and readings of wavelength and intensity of the peaks of output to identify any of the problems listed below.

2. **Spot check through the back reflector:** The Sola-Scope attached to sensor and special fine probe positioned with our specially designed probe positioner can take a measurement through special monitoring points provided by lamp manufacturers such as Fusion in the back reflector. This allows a check to be made whilst the fibre is running through the lamp system. Data can then analysed as above.

Symptom	Diagnosis
Even drop off of intensity over all wavelengths	**Ageing of bulb**
A drop off in the shortwave intensities	**Fogging of quartz tube**
A drop off in the shortwave intensities	**Dirt on bulb or reflector**
Increased intensity output	**Incorrect or inadequate cooling**
Imbalance between top and bottom of bulb	**Magnetron imbalance**
Incorrect spectral output	**Incorrect lamp fitted**
Varying output over first 15 minutes from start up.	**Start up problems with inferior bulbs**
Varying output over time.	**Power supply or cooling problems**

15 TROUBLE-SHOOTING

Symptoms	Problem	Solution
"When I try to switch the Sola-Scope on, the screen stays blank and the KEYS don't beep."	The batteries are flat.	Recharge the batteries or plug in the power supply.
"When I try to switch the Sola-Scope on, the screen stays blank but the keys beep."	The contrast is too low.	Switch the Sola-Scope off then on again. Wait five seconds. Press "esc", then press + repeatedly.
"When I try to scan, the graph is a flat line along the bottom."	1. The lamp is too dim for the intensity range selected. 2. There is no UV getting to the Sola-Sensor.	1. Use Auto Ranging 2. Make sure the "eye" is not obstructed.
"There are gaps in the graph"	1. The photo-diode array has saturated.	1. Increase the **Intensity range**. 2. You may need a greater light reduce.
"When I try to scan, the Sola-Scope replies 'No sensor'"	The sensor is not correctly connected.	Follow the "setting-up" instructions.
"When I try to scan, the Sola-Scope replies 'Checksum error'"	The cable is damaged.	Replace the cable.
"My readings increase over time even though my source remains constant"	The sensor is getting too hot	Allow the sensor to cool down.
I am getting saturation today but didn't yesterday.	1. Intensity range needs to increase. 2. The sensor is too hot	Allow the sensor to cool down.
The graph shows UVC but there this lamp has no UVC	There is a stray light problem	Stray light compensation preference needs to be **ON.**
I am comparing my Sola Scope radiometeric reading with a radiometer and they are not the same	The geometry of the two systems are different and the calibration of the radiometer is relative.	Refer to your supplier for technical information.
There is no red graph or red bars	The red sample has a different intensity range to the black (current) sample	Your samples are so different that they are not comparable on the Scope screen. Use Excel to compare them.

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16 SPECIFICATION

All specifications quoted as typical at 21 °C

16.1 Viewing Station – Sola Scope 2000

16.1.1 Mechanical

Dimensions	196 x 100 x 38 mm
Weight	400 g
Sealing	to IP55 display and keypad
Construction	Non-slip, tough ABS
Temperature range	-5 to 40 °C
Humidity	0 – 90 % non-condensing

16.1.2 Electrical

Processor	Siemens C509L
Power source	Internal: 4.8 v dc supplied by built in high capacity rechargable NiMH battery pack; External +12 v dc supplied by an internationally compatible and approved power supply.
Power Management	Efficient power supply circuit, power supply supervisor, high speed charger circuit.
Battery Life	10 hours with sensor connected 13 hours without sensor
Power indicator LED	Off operating from battery only, Red – battery fast charging in progress from external supply; Green – trickle charging from external supply.

16.1.3 User interface

Keypad	Membrane keypad 12 tactile buttons
Display	High visibility colour 128 x128 pixel matrix Liquid crystal graphical display with high speed controller

16.1.4 Interface connector

Type	Miniature 9-pin DIN for RS232, 7-wire serial port with Solatell serial lead
Serial compatibility	IBM PC 9 pin serial / RS232 port
Baud rate	Software selectable to 115 k baud
Serial signals	RXD, TXD, 0 v, DTR, DSR, RTS, CTS
ESD protection	to 15 k v on all RS232 signals
Other signals	SOL-DRIVE (+12 v), SOL-FB

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16.2 Sola Sensor 2000

16.2.1 Optics

General description	Single grating spectrograph optimised for Ultra violet Spectroradiometry using patented Solatell® monolithic optics, with 512 pixel UV enhanced detector array.
Entrance window	UV transparent sapphire, 4 mm dia. x 1 mm – sealed to IP55
Diffuser (optional)	Co-sine response UV transparent, 10 mm dia. x 1 mm – sealed to IP55
Wavelength range	235 nm to 475 nm
Spectral sampling	0.5 nm
Bandwidth	1 nm (+ 0.5 nm /- 0 nm)
Sensitivity	<10 nW / cm^2 / nm
Integration time	With Smart-Scan – automatically samples 6x while halving the sample time each scan, minimum sample starting time 320 m s, max sample time 200 s Without Smart-Scan – 10 m s to 200 s
Dynamic range	> 10^7
Stray light rejection ratio	10^3 Optical with additional Stray light rejection software compensation algorithm

16.2.2 Mechanical

Construction	Non-slip, tough ABS combined with aluminium.
Dimensions	118 x 69 x 32 mm
Weight	360 g
Temperature range	Storage -20 °C to +70 °C Operating -10 °C to +50 °C Full spec +15 °C to +30 °C
Humidity	0 to 80 % non-condensing

16.2.3 Electrical

Connector	Fischer 5 – way female gold plated, sealed to IP68 with mating connector, connecting to 4-way screened cable
Connections	0 V ; +5 V dc in ; RS485 – A/TXD ; RS485 – B/RXD ; EXT
Power requirement	Internal 3V NiMh sealed battery pack; External +5 V dc ; +/- 5 % ; 35 mA supplied by viewing station
Data comms.	RS485 serial asynchronous data at 250 k Baud to viewing station via proprietary Sola-Talk protocol, 2 wire, half duplex
Processor	Siemens C509L running at 6MHz
A to D conversion	10 bit

Temperature sensor	Linear semiconductor, accurate to 2 °C

16.3 Mains Power Supply/Charger

Must be of an approved type.

Note

Due to 4D Controls Ltd policy of continuous product improvement, specification is liable to change without notice. Please consult your supplier or 4D Controls direct for clarification if necessary.
Solatell is a registered trademark of 4D Controls Ltd. Patents in more than one country granted or pending on Solatell spectroradiometric technology.

Warranty
All Solatell products are guaranteed to be free from manufacturing defects for a period of 1 year, from date of purchase.
4D Controls Ltd does not warrant the use of Sola-Sensor/Sola-Scope for any particular application. As a general measuring instrument, Solatell Sola-Scope detectors require periodic recalibration, usually annually.

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