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Manual
SunLab Busbar To Busbar (B2B)

Acknowledgement

This is the manual of the SunLab B2B. If you have any questions, please contact:

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Foreword

Aim of this manual
This manual aims to inform users or any other person dealing with the SunLab B2B about its operation, its options, the procedures that need to be followed and its safety instructions. Any use other than described in the manual, or operation without any knowledge of the content of this manual is strongly discouraged and will lead to expiry of guarantee.

Location of the manual in the document system
In addition to this manual, another manual is available on calibrating the SunLab B2B. Only persons authorised by SunLab are allowed to calibrate the SunLab B2B.

Reading instructions
This manual contains various kinds of safety instructions. The meaning of these safety instructions is explained below.

Table 1.1 *Safety instruction*

Safety instruction	*Meaning*
TIP	Comment with suggestions and advice for the user, making is easier to conduct tasks.
NOTE	Instruction with additional information to draw the user's attention to possible problems with the SunLab B2B.
CAUTION	Comment that points to the danger of severe damage to the SunLab B2B or the product/sample if the user does not strictly follow the procedures.
WARNING	The user may injure himself (badly) or severely damage the product.

1 Introduction

1.1 Purpose

The SunLab B2B is solely intended to measure the resistance of the 'fingers' between two 'busbars' of a solar cell, see Figure 2.2. For a three busbar type cell, the cell has to be rotated 180° to measure between the other pair of busbars.

The front side grid resistance of a solar cell is an important parameter when optimising cell efficiency. Various parameters may be of influence such as the contact resistance of the grid with emitter and finger and busbar resistance. In optimising the front side of the grid, focus lies on well-conducting fine line fingers with high aspect ratio. The Corescan of SunLab BV was designed to measure the contact resistance. In addition, the SunLab B2B is able to measure the resistance of the fingers between the two busbars very precisely.

The instrument measures the resistance of all fingers between the two busbars as Rbb in mΩ. All fingers are linked to each other in a parallel manner: 1/Rbb = ∑1/finger resistance between the two busbars. The finger resistance per length unit R1is R1 = Rbb x number of fingers, divided by finger length.

1.2 Discouraged and unintended use

It is not allowed to use the SunLab B2B for other measurements than resistance measurement. The SunLab B2B is not suitable for use in damp areas. The normal environment temperature is around 25 degrees Celsius (+/- 10 degrees).

WARNING Users are not allowed to open the metal case by means of removing the bottom plate. This is not allowed because the case contains 110/230 Volt.

1.3 User conditions

The SunLab B2B is suitable for placement in laboratories, workshops or office spaces, provided that there is sufficient clean space. Avoid damage or dirt to the equipment as much a possible. Outdoor use of the SunLab B2B is possible in case of good weather conditions, but due note should be taken of the fact that the equipment is sensitive to dampness. The SunLab B2B is a precision device containing sensitive components, even in closed condition.

1.4 Noise

The SunLab B2B produces hardly any acoustic noise.

2 Description

2.1 Lay-out

The SunLab B2B consists of a measuring surface with two positioning strips onto which the solar cell which is to be measured is placed. Two measuring arms are located above the solar cell, which can be moved across the busbars over the solar cell that is to be measured. Next the measuring arms are placed onto the solar cell, thus making the probes contact the busbars of the solar cell that is to be measured. The measurement will automatically start and the resistance value can subsequently be read from the display.

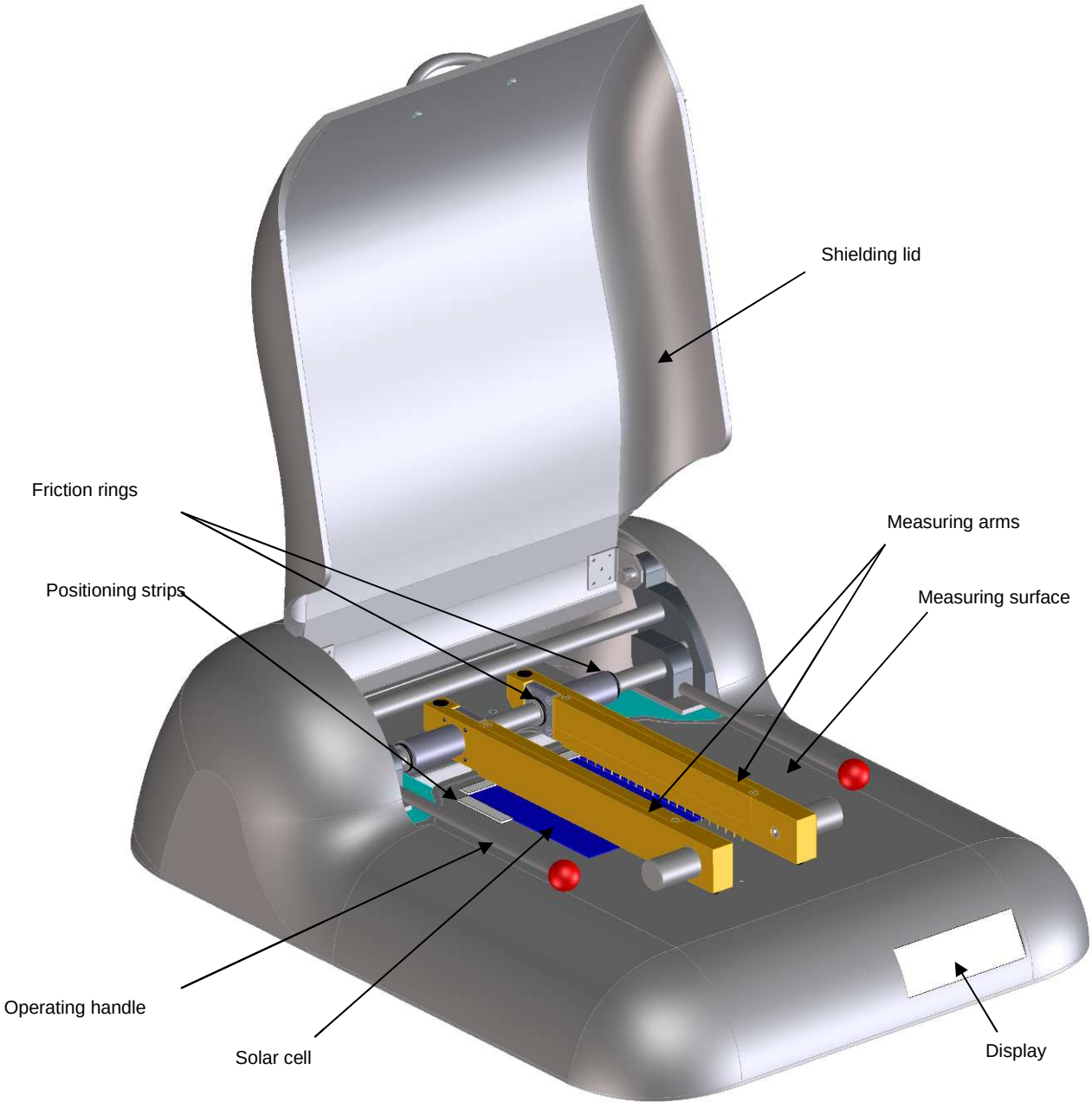


Figure 2.1 *SunLab B2B definitions of system components*

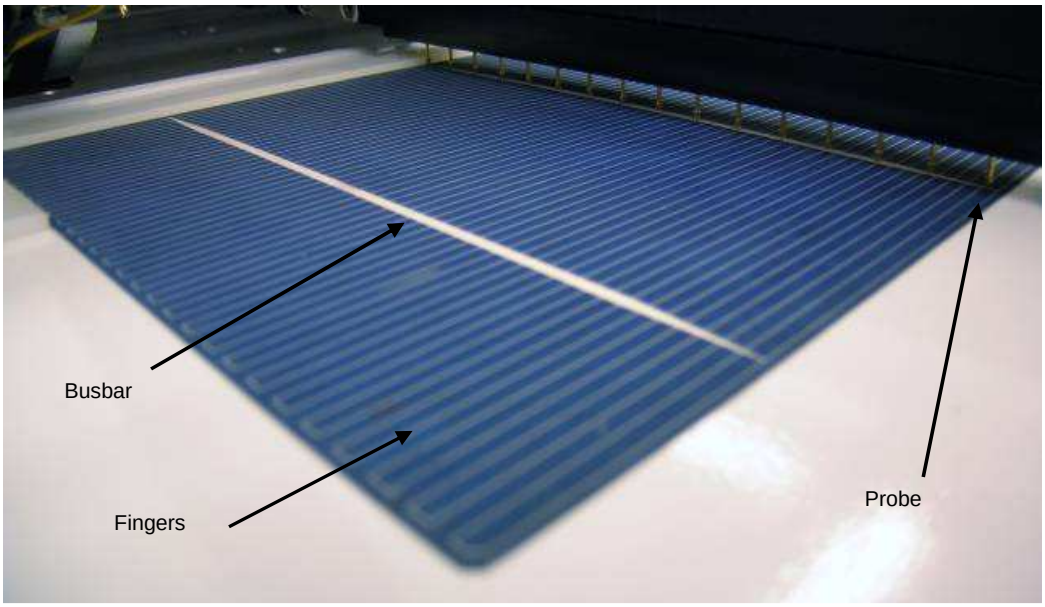


Figure 2.2 *SunLab B2B definitions (continued)*

2.2 Technical specifications SunLab B2B

2.2.1 General specifications

- Busbar contacts: 21 pairs of probes divided across two measuring arms. Subdivided in 11 current and 10 voltage probes per measuring arm.
- The cycle time for measuring the resistance is less than one second. This is the time that the measuring electronics need to determine a correct resistance value from the moment the measuring arms are placed onto the two busbars. The total cycle time, including placing the solar cell, depends on the user.
- Reads out directly in mΩ.
- The electronics have been designed in such a way that sparks arising from contact with the solar cell are prevented.
- Solar cell placement: X and Y-positioning strips 90° relative to each other.
- Solar cell shape: rectangle, square, semi-rectangle/-square. This device was not designed for round shaped solar cells.
- Cell dimensions: Length: 50-210µm, width: 50-210µm, thickness: 100-500µm.
- Busbar widths: 1 to 2 mm.
- Busbar distance: 20-150 mm.
- The functioning of the solar cell is not damaged by measuring.
- Shielding lid to protect from incident light.
- Connection to a PC is possible by means of a serial (RS232) port. A nine-pin cable (less than 2 metres long) has been included for making such a connection. The resistance value measured by the SunLab B2B can be saved in a Microsoft Excel template. This template is provided on an USB memory stick that is included.
- Downward force at least 1 N per probe.
- LCD display with two lines of 20 characters and backlight.
- Probe end is crown-shaped.

2.2.2 Electrical specifications

- Maximum measuring current: 110 mA nominal 100 mA (short circuit resistant) due to two constant power sources.
- Bidirectional measuring current to minimise thermal effects (thermal EMF).
- Maximum measuring voltage: 5 V.
- Accuracy (V/I): In measuring resistance, values ranging from 10 mΩ to 500 mΩ: 0.5% of the measuring value.
- The warming up time for maximum accuracy is 30 minutes.
- Processor speed: 11.0592 MHz.
- Inlet with switch and internal voltage control 110 and 230 Volts, 60/50Hz. European connection.
- Power supply AC in accordance with class III.

2.3 Shields and safety provisions

2.3.1 Shields

A current of 110 mA maximum runs through both measuring arms of the SunLab B2B. The difference in voltage never exceeds 5V. The voltage and current are so low that there is no need to shield these measuring arms.

The power supply of the SunLab B2B consists of 110 V or 230 V alternating current. This voltage is only present at the power supply connection of the printed circuit board (PCB). Therefore the user is never allowed to remove the metal bottom plate.

WARNING Users are not allowed to open the metal case by means of removing the bottom plate. This is because the device contains 110/230 V.

2.3.2 Safety provisions

In the instrument, voltage containing components are shielded to prevent contact. Also the instrument is designed to prevent getting stuck or cut. No further safety provisions are needed.

3 The operation of the machine

3.1 Process description

3.1.1 Operating principle

The SunLab B2B measures the resistance between two busbars of a solar cell. The electric measuring is done by means of two constant power sources of 100 mA. Two measuring arms with probes are placed onto the busbars. The measuring arms stay in place through friction rings which can be moved by hand. The measuring arms contain alternately current and voltage probes that are separately fixed. The 4-wire measurement principle is used. The current is sent through the solar cell starting from busbar 1 through the fingers to busbar 2. Next the current is sent in the opposite direction from busbar 2, through the fingers to busbar 1 (see Figure 2.2). The current probes are not activated until contact is made with the solar cell. A micro-controller measures the voltage across the two busbars. After that the resistance value is calculated by means of the measured voltage and current. After averaging both measurements the resistance value is given on the LCD display. Every 1.5 seconds this measurement is repeated and the value on the display is refreshed.

3.1.2 Operating conditions

1. Operating condition ‘replace solar cell’.

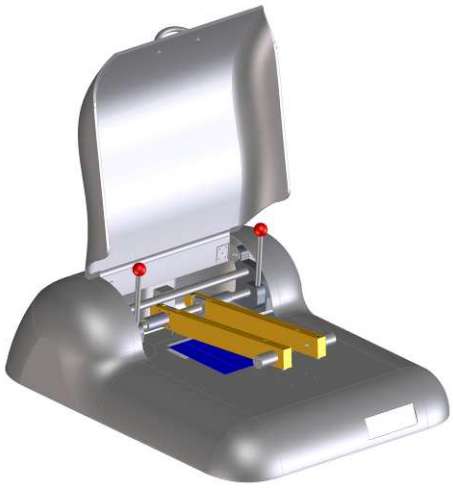


Figure 3.1 *Replace solar cell*

The shielding lid needs to be fully opened to stay open on its own. The operating handles (with red knob) are in the highest position. In this operating condition the SunLab B2B measuring arms are at distance from the measuring surface. A solar cell can now be placed against the positioning strips.

2. Operating condition ‘adjust width of measuring arms’.

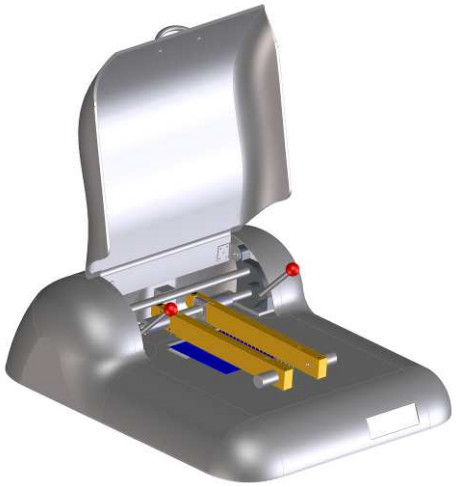


Figure 3.2 *Adjustment of the width of the measuring arms*

The operating handles are in the middle position. In this operating condition the SunLab B2B measuring arms only touching the measuring surface at the front side (closest to the user). The arms can now be aligned to the busbars of the solar cell that is to be measured. This can be done manually by slightly lifting the measuring arm (free from the surface) and by moving it in horizontal direction. When the measuring arms are aligned and it is the intention to repeat the measurement several times, the friction ring must be re-positioned.

3. Operating condition ‘Measure busbar resistance of solar cell’.

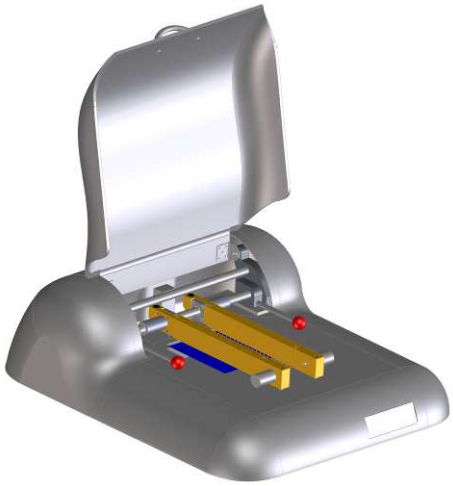


Figure 3.3 *Measure busbar resistance of solar cell*

In this operating condition, the measuring arms have been fully lowered by putting the operating handle in the lowest position. The device will now conduct a constant measuring cycle until the arms are lifted again, when power switch on the backside of the SunLab B2B is switched on. The shielding lid should be closed as the measurement can be sensitive to bright lights. Meanwhile the measurement continues and the measuring values are shown on the display.

3.2 Safety in general

Risks related to damages to the device or the solar cell may rise in particular when the SunLab B2B:

- is operated/cleaned and/or maintained by undertrained/uninstructed personnel,
- is operated or maintained in a negligent manner,
- is used for purposes other than described in Section 1.1.

All operators who are responsible for use of the SunLab B2B (operation, maintenance, cleaning, etcetera) should:

- have read and understood the entire manual,
- have sufficient knowledge and have acquired authorisation for carrying out the specific tasks,
- know their specific duties and authorisations.

WARNING Users are not allowed to open the metal case by means of removing the bottom plate. This is not allowed because the case contains 110/230 Volt.

3.3 Risk reducing measures

To reduce any risks of using the SunLab B2B, the following measures have been taken:

- Power supply AC/DC in accordance with class III. This means that the power supply has double insulation. Moreover in case of 'single faults' the output voltage is limited to 120% of the nominal output voltage (12*120% = 14.4V).

3.4 Safety regulations

The following safety regulations need to be observed while using the SunLab B2B:

- Only personnel designated by SunLab are allowed to conducts repair and dismantling of the Sunlab B2B.
- Before conducting maintenance work, the power must be switched off by means of the power switch located at the back of the device.
- Solutions to failures can be found in Table 4.1.
- All activities that are not mentioned in this manual or even explicitly excluded should only be carried out by SunLab personnel or by specifically designated persons.
- The measuring arms should not be kept in the highest position if unnecessary, see Figure 4.8. In this position closure of the shielding lid may result in unwanted and unexpected movement of the measuring arms and result in entrapment of the hand and/or damage of the probes.

Failure to follow these regulations may result in serious injury to persons or damage to the device.

4 Operating the machine

4.1 Operating elements

4.1.1 Overview of operating elements

The SunLab B2B is equipped with various operating elements, i.e.:

- on/off switch at the back of the device,
- measuring arms with operating handles and friction rings,
- RS232 interface at the back.

4.2 Starting up the SunLab B2B

4.2.1 General preparation

Prior to use, the SunLab B2B needs to be connected to the mains voltage. The connection for the mains voltage can be found on the right rear side of the device. The SunLab B2B is suitable for mains voltages 110V/230V 60 Hz/50Hz.

4.2.2 Preparation of the SunLab B2B

Before you can start measuring with the SunLab B2B, you need to switch on the device. The SunLab B2B is switched on when the lighting of the LCD is on. If the lighting is not on, you need to switch on the SunLab B2B by means of the on/off switch at the rear of the device. See Figure 4.1.

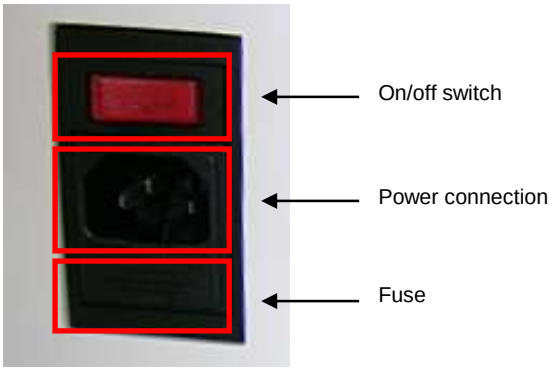


Figure 4.1 *On/off switch at the rear of the SunLab B2B*

TIP The SunLab B2B will produce the most accurate measurements after a warming up time of the device of 30 minutes.

4.2.3 Start of measurement

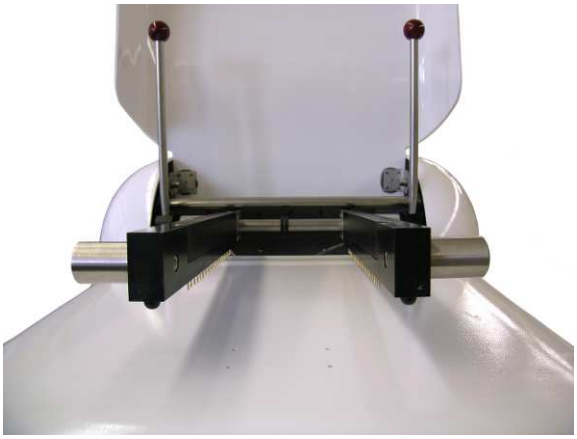


Figure 4.2 *Measuring arms in the position for placing or removing the solar cell*

1. The first step in conducting a measurement is the placement of the solar cell. Put the operating handles in the middle position, see Figure 4.2.
2. Place the solar cell between the positioning strips.
3. Move the measuring arms to position them straight above the two busbars. The measuring arms will be fastened by means of friction rings. These need to be shifted manually to enable movement of the arms across the axis. Afterwards, the rings need to be placed back such that the arms are fixed.
4. Bring the measuring arms in the lowest position. The voltage and current probes should now be aligned exactly on to the busbars. Repeat steps 1-4 if this is not the case.

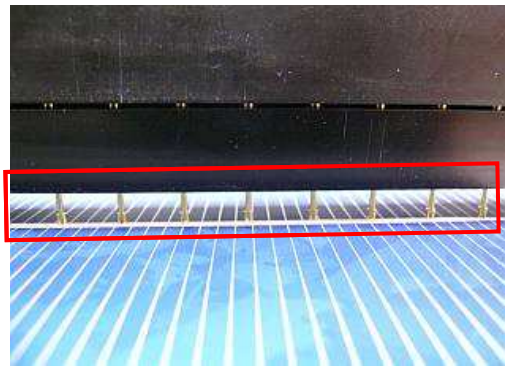


Figure 4.3 *Position of probes on busbar*

5. Once the alignment is correct, measurements will start automatically after the measuring arms have been lowered. The measured resistance value will immediately be shown in mΩ on the LCD display.

   The resistance value will be displayed with two decimal places. The SunLab B2B was designed to measure resistances ranging from 10 mΩ to 500 mΩ. Typical values of the resistance between the two busbars is approximately 20 mΩ to 50 mΩ.

   If the measuring arms are not in the lowest position, the probes will not make contact and the SunLab B2B will not start measuring. The text “Open circuit” is displayed as illustrated in Figure 4.5.

Figure 4.4 *Display*

4.2.4 Stop measurement

The measuring will automatically stop when the measuring arms are lifted. The LCD display will show the message indicated in Figure 4.5.

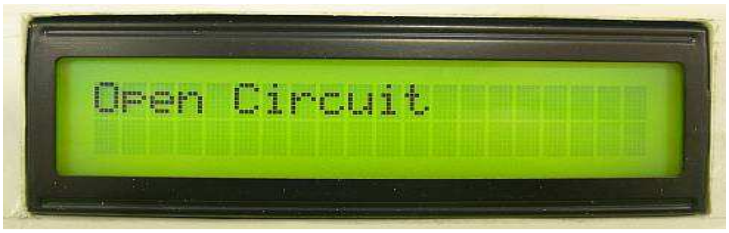


Figure 4.5 *Display 'open circuit'*

4.3 Transmitting measurement data to PC

The measured resistance value can be sent to a computer by means of a serial interface cable. This requires a standard RS232 (female/male) cable, which is supplied along with the B2B. This is a nine-pins cable with wires that need to be connected one-on-one (not a null modem cable!). The serial cable may not be longer than 2 metres.

The connection for the serial cable is at the rear side of the SunLab B2B.


Figure 4.6 *Interface connection SunLab B2B*

Once the SunLab B2B is connected to a computer with the RS232 cable, the resistance value can be shown by means of a terminal programme. A frequently used programme is 'HyperTerminal' of Microsoft. The settings for correct receipt of the resistance values are the following:

- baud rate: 9600
- parity: none
- data bits: 8
- stop bits: 1
- flow control: none

The resistance values measured by the SunLab B2B will be sent as ASCII strings and physical measuring values, as indicated in Figure 4.7.

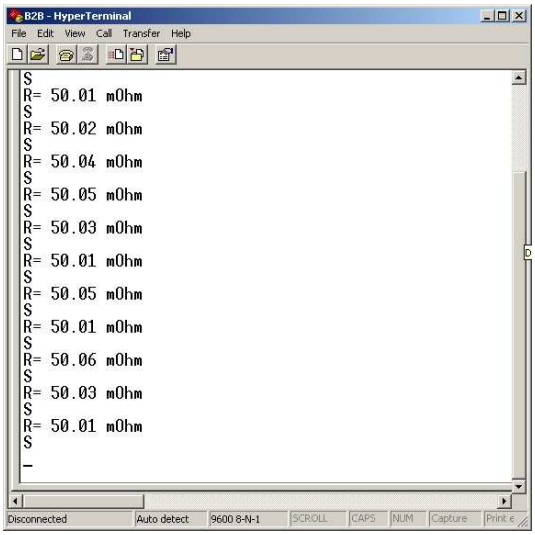


Figure 4.7 *Data format measuring results, HyperTerminal*

The resistance values are automatically sent by the SunLab B2B.

The provided Sunlab USB stick can be used to save the measurement data to a Microsoft Excel sheet. See section 4.4.

4.4 Saving measurement data on PC

A Microsoft Excel template is supplied along with the SunLab B2B to save the resistance values sent by the SunLab B2B on a PC. This Microsoft Excel template is available on the supplied USB memory stick.

The manual of this Excel template can be found in Appendix A.

4.5 Replacing probes

The measuring probes need to be replaced when excessive wear is detected. Worn measuring probes need to be removed and replaced by new ones. To ensure easy replacement, the measuring arms need to be in the highest position. See Figure 4.8.

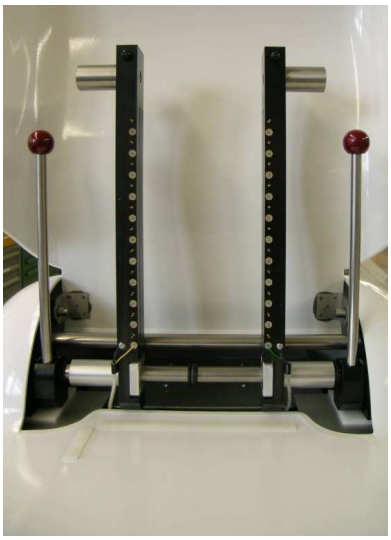


Figure 4.8 *Measuring arms in probe replacement position*

WARNING Don't leave the measuring arms in this position any longer than needed. In this position, closure of the shielding lid may result in unwanted and unexpected movement of the measuring arms and leads to entrapment of the hand and/or probe damage.

The arms are equipped with probes for voltage measuring and current pass through. Both types of probes are identical and can be ordered from SunLab.

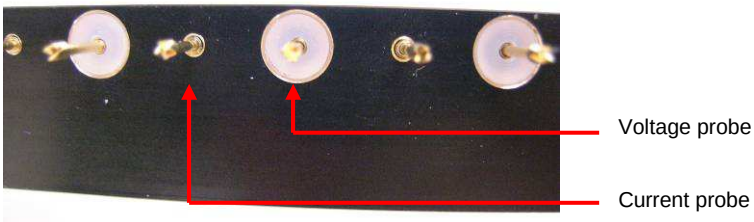


Figure 4.9 *Voltage probe and current probe close-up*

4.6 Calibrating the SunLab B2B

WARNING only personnel designated by SunLab are allowed to calibrate the Sunlab B2B. The calibration requires a calibration board with reference resistors and accompanying manual.

4.7 Checking the operation of the SunLab B2B

A test board has been supplied along with the SunLab B2B to check its operation. The test board contains the following components:

1) Test precision resistor 20 mΩ, accuracy 0.1%.
2) Brass strip.

The test board is shown on Figure 4.10.

Figure 4.10 *B2B test board for checking operation*

This panel can be used to conduct the following two measurements:

- Measurement 1: Check with test resistance. Place the test board under the measuring arms. The SunLab B2B will now show the measured resistance value. The value should be between 19.90 mΩ en 20.10 mΩ (maximum deviation of 0.5% from 20 mΩ).
- Measurement 2: Check with the brass strip. Rotate the panel 180 degrees. A resistance value of ≈ 0 mΩ should be displayed.

TIP The SunLab B2B will produce the most accurate measurements after a warming up time of the device of 30 minutes.

4.8 Transport

It is recommended to keep the packaging material of the SunLab B2B for future transport purposes.

4.8.1 Preparation for transport SunLab B2B

A number of steps need to be followed before the SunLab B2B is ready for transport:

1. Switch off the SunLab B2B with the main power switch at the rear of the device.
2. Remove solar cell, if any.
3. Disconnect the power cord.
4. Place a protective layer, e.g. bubble wrap, on the measuring surface.


Figure 4.11 *Example position measuring arms*

5. Put the arms in measuring position and fasten them with tie wraps in the holes intended for fastening. WARNING Fixing tie wraps in any other way than indicated on Figure 4.12 may cause problems when removing the tie wraps.

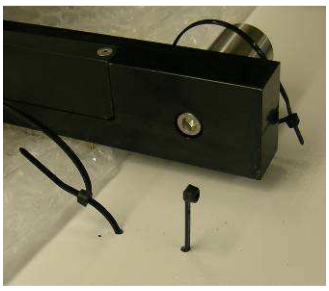


Figure 4.12 *Example of how to fasten tie wraps*

6. Place the preformed pillow between the measuring arms and the shielding lid and close it.

Figure 4.13 *Example of position of preformed pillow on measuring arms*

7. Wrap the B2B in at least four lengths of stretch foil to prevent the shielding lid from opening.
8. Place the SunLab B2B in its original box on the ground pillows and cover with the preformed pillows in the right order.

Figure 4.14 *Example of position of B2B in transport box*

4.8.2 Transporting the SunLab B2B

During transport the SunLab B2B needs to be secured and prepared in accordance with the instructions of Section 4.8.1. Moreover, the package needs to ensure sufficient protection for the type of transport that has been selected.

4.8.3 Maintenance

Except for the probes, which are sensitive to wear, the SunLab B2B is maintenance free. The surface can be cleaned with a dry, grease and dust free cloth.

4.9 Safety measures

If a technical failure occurs, you need to ensure that your own safety and the safety of others is not endangered by the failure itself or by remedying the failure. If in doubt please contact SunLab.

4.10 Failure table/diagnostic table

In principle, technical failures may only be remedied by authorised persons. The failure table below contains a list of possible failures of the SunLab B2B that may be remedied by the user.

Table 4.1 *Failure table/diagnostic table*

No.	*Failure/observation*	*Possible cause*
01	The SunLab B2B doesn't start up	The SunLab B2B is not connected to mains voltage. Or the power switch at the rear is not switched on.
02	Cannot switch on the SunLab B2B	The SunLab B2B is not connected to mains voltage. Or the power switch at the rear is not switched on.
03	Cannot switch off the SunLab B2B	The power switch has not been turned off or the power switch is broken.
04	The display has no light	The SunLab B2B is not switched on.
05	Display shows 'open circuit'	The measuring arms of the SunLab B2B have not been properly aligned to the solar cell.
06	The display switched between values	The measuring arms of the SunLab B2B have not been properly aligned to the solar cell.
07	The SunLab B2B shows inexplicable values when connected to the computer via the serial interface.	The settings of the serial port on the computer have not been properly adjusted. See Chapter 3 for the settings.
08	The SunLab B2B shows no values when connected to the computer via the serial interface.	Check the serial cable between the SunLab B2B and the PC. Don't use a null modem cable!

Appendix A Manual for Microsoft Excel log template

A template is available in Microsoft Excel for saving the resistance values measured by the SunLab B2B onto the computer.

The below procedure is based on computer configuration with operating system Windows XP. For other operating systems the user might have to check on the details of similar procedures.

Definitions
The sheet 'B2B_logsheet' consists of:

- Column A containing the resistance values (two decimals),
- Column B containing the date and time,
- The button 'Read resistor value' for reading out the resistance values,
- The option 'Serial port' for selecting the correct serial port.

Working method
The most recent resistance value is copied in the active cell when the user clicks the button 'Read resistor value'.

If the active cell, which is a random cell that can be selected with the cursor, already contains a resistance value, the programme will ask if the active cell must be overwritten.

For each of the measured resistance values, the date and time will be logged in the adjacent column. The selection will automatically move to the next cell when copying data.

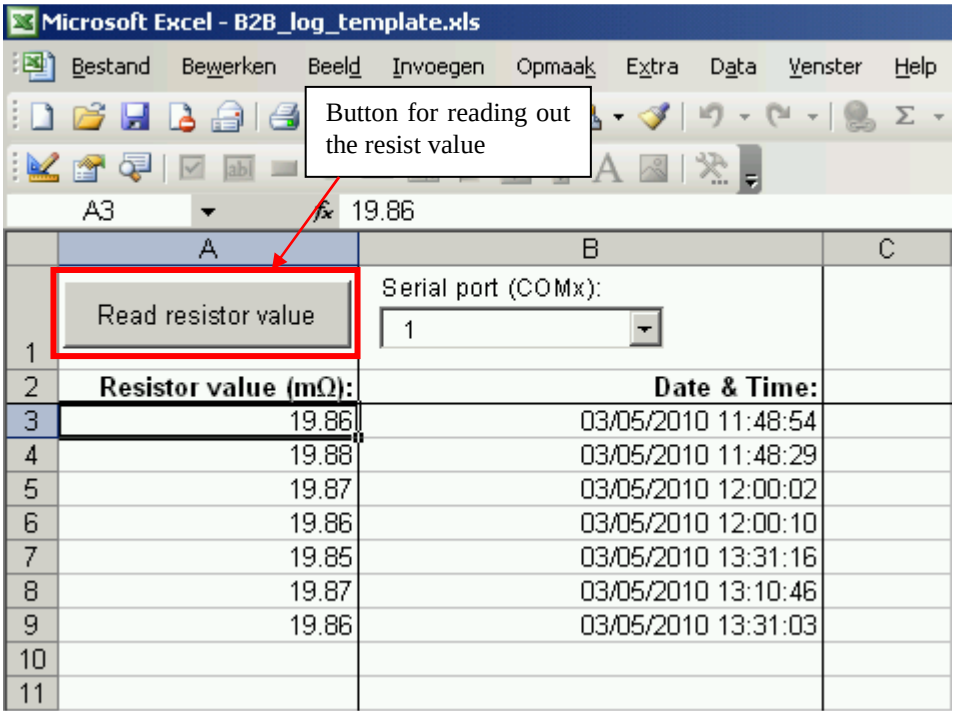


Figure A.1 *Excel log sheet 'Read resistor value'*

Adjust serial port
When the SunLab B2B is connected to the serial port of a PC, the Excel file ‘log template’ must be adjusted to the correct serial port.

	A	B	C
1	Read resistor value	Serial port (COMx): 1	
2	**Resistor value (mΩ):**	**Date & Time:**	
3	19.86	03/05/2010 11:48:54	
4	19.88	03/05/2010 11:48:29	
5	19.87	03/05/2010 12:00:02	
6	19.86	03/05/2010 12:00:10	
7	19.85	03/05/2010 13:31:16	
8	19.87	03/05/2010 13:10:46	
9	19.86	03/05/2010 13:31:03	
10			

Figure A.2 *Excel log sheet 'Serial port'*

The correct COM port number can be found in the following way. The explanation applies to PCs onto which Windows XP Service Pack 2 has been installed.

1. Select ‘Start’
2. Select ‘Control panel’
3. Select ‘System’

Figure A.3 *Windows control panel*

4. Select sheet ‘System properties’

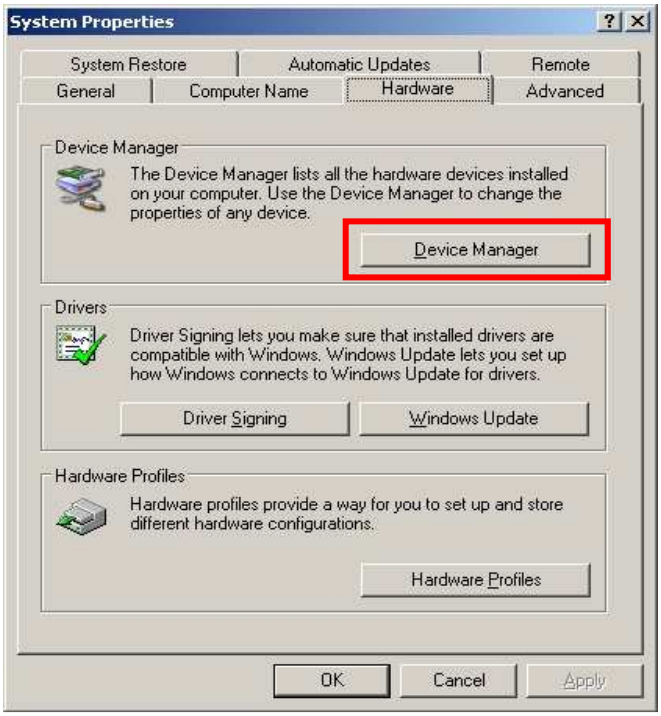


Figure A.4 *Windows system properties*

5. Click on ‘Ports’ (COM & LPT)
6. A list of all serial ports is shown.

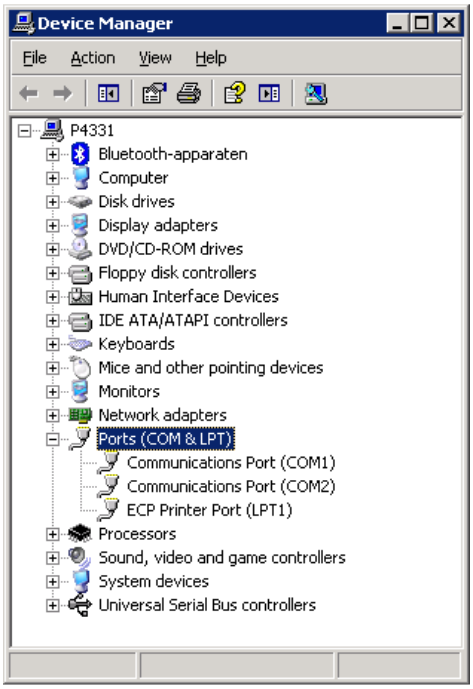


Figure A.5 *Windows device manager*

Time-out report
If the SunLab B2B does not transmit a resistance value, or if the SunLab B2B is not connected, a time-out will occur after five seconds. In that case the Excel template will show the following message:

Figure A.6 *Excel log sheet time-out report*

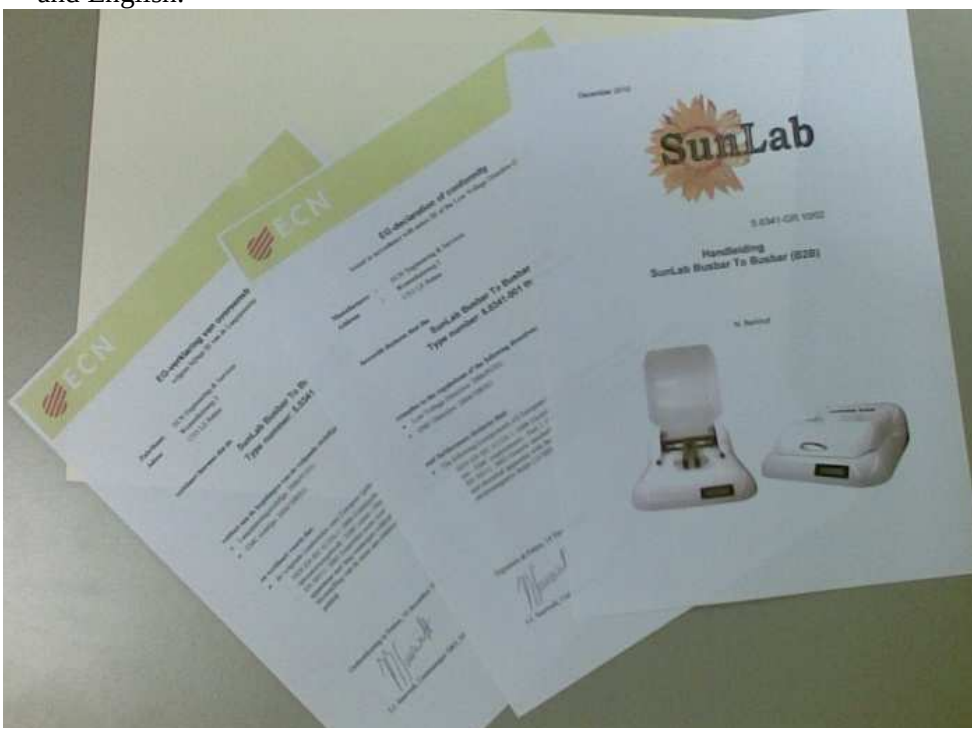
After confirming (click on OK) a new attempt can be made to save the current resistance value. If the notification persists, this may be due to the following causes:
- B2B is not switched on,
- B2B is not connected to the serial port of the PC,
- Wrong settings for the COM port,
- COM port is already in use by another application on the PC.

Appendix B What is supplied along with the B2B?

1. A SunLab B2B.

2. A zip bag with power cord, RS232 cable and USB memory stick.

3. An envelope with Dutch and English manuals and an EC declaration of conformity in Dutch and English.



4. A test board with reference resistor.