

## Which Reference Cell do I need?

ReRa Solutions provides various kinds of Reference Cells. In this document, the main differences between the various cells are described.

### Shunted Reference Cell

The ReRa Shunted Reference Cell comes with an internal 500mΩ resistor (shunt) connected to the cell. By measuring the voltage over this resistance, the current delivered by the cell is known and therefore the irradiance of the light. This is an easy and commonly used method, because you can use a simple voltmeter to determine the light irradiance. The calibration value for a shunted reference cell is the voltage that it will produce at 1000Wm<sup>-2</sup> solar light.

### Open Reference Cell

The ReRa Open Reference Cell has a 4-wire connection to the cell. Since there is no external resistor connected to the solar cell, the complete IV-curve of this cell can be measured. These cells are therefore fully calibrated and will be delivered with the following parameters:  $V_{oc}$ ,  $I_{sc}$ ,  $J_{sc}$ ,  $V_{mpp}$ ,  $I_{mpp}$ , Efficiency and Fill Factor.

To measure the irradiance with an Open Reference Cell, you need to measure its current. It is very tempting to take a DMM and measure the current with the current measurement option of the DMM. However, this is completely the wrong way of measuring an Open Reference cell. A DMM measures the current over an internal resistor. This resistor is normally unknown and can be anything the manufacturer of the DMM decides. In figure 1 an IV-curve is shown. The straight lines indicate different DMM resistors. The crossing of the straight line with the IV-curve will be the current measured by the DMM. This value is indicated with the red horizontal lines.

The calibrated short circuit current of the solar cell is defined as the current when the voltage equals zero. As can be seen in figure 1 a 500mΩ resistor value results in a perfect current value for the cell. The error is negligible. However, if the resistor would be 10 Ω, the measured value will be lower than the real value. The red horizontal line shifted down by a small amount. If the internal resistance of the DMM would be 100 Ω then the measured current is almost 30% of the real value. It must be clear now that the used resistors in a DMM are unknown, so the measurements can never be trusted!

The only correct way to measure an Open Reference Cell is by using an active load like a Keithley Sourcemeter. An active load forces the solar cell at zero voltage. For this it is required to have 4 wires. Two wires to measure the voltage and two wires to feed the current.

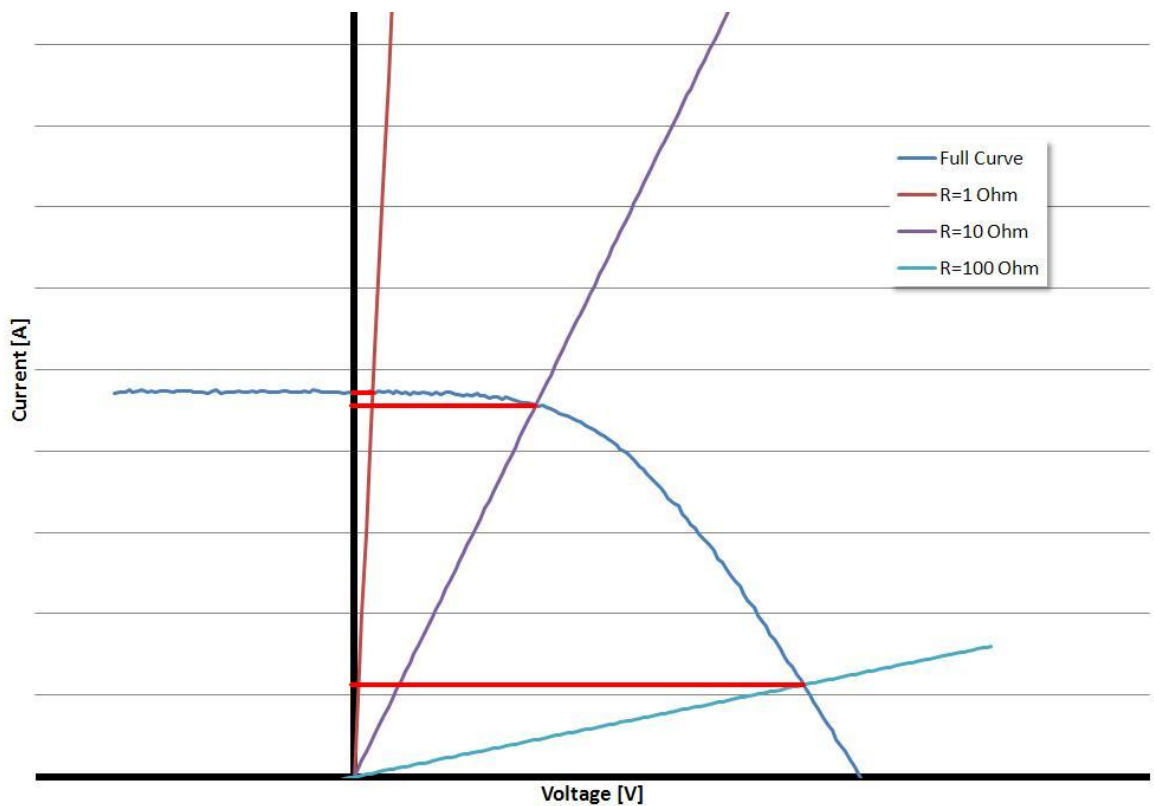


Figure 1: Measured voltage depending on shunt resistance selected

## Materials and filters

For perfect measurements it would be ideal to use a reference cell that has an identical quantum efficiency as the cell material you are working on. Unfortunately this is not always possible as many materials cannot be used as reference cells. In order to do correct measurements, you can use different types of materials or filters in your reference cell to simulate your kind of cell material. The standard ReRa cells use a Silicon reference cell with a Quartz window. These reference cells are perfect for the measurement of standard silicon cells. For other types of cell materials (i.e. Dye cells, organic cells) you can use our KG-filtered cells or GaAs cells. In figure 2 different materials and filters are shown.

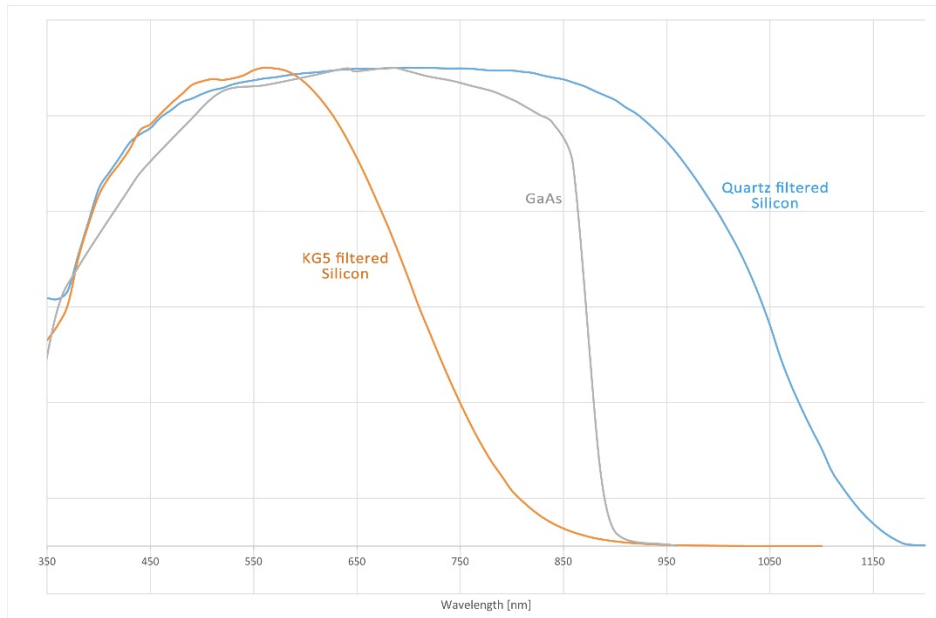


Figure 2: Overview of different materials and filters

Products	Material	Shunt	Typical Value	ReRa Product code
Shunted Silicon Reference Cell	Silicon	500mΩ	65 mV	RR-1001
Open Silicon Reference Cell	Silicon	-	130 mA	RR-1002
Shunted GaAs Reference Cell	GaAs	500mΩ	50 mV	RR-1004
Open GaAs Reference Cell	GaAs	-	100 mA	RR-1003
KG1 Shunted Reference Cell	KG1	1 Ω	70 mV	RR-1001 KG1
KG1 Open Reference Cell	KG1	-	70 mA	RR-1002 KG1
KG3 Shunted Reference Cell	KG3	1 Ω	65 mV	RR-1001 KG3
KG3 Open Reference Cell	KG3	-	65 mA	RR-1002 KG3
KG5 Shunted Reference Cell	KG5	1 Ω	60 mV	RR-1001 KG5
KG5 Open Reference Cell	KG5	-	60 mA	RR-1002 KG5

**More information:**

<https://www.rerasolutions.com/product-category/solar-reference-cells/>