Attachments deliver greater functionality for the LightBox: A Universal Multiplexer and Reference Cell deliver greater functionality to the Benchtop Light Simulator for Indoor Solar Cells and Sensors.

Executive Summary

Indoor photovoltaics are becoming important devices in the growth of energy harvesting technologies. They can be discovered powering wearables and IoT devices and sensors [1]. Lightricity recently introduced the LightBox Indoor Light Simulator and this has been well received by researchers, standards laboratories and those designing and developing products incorporating indoor photovoltaic (PV) cells. The feedback received indicated a need for reference cells and the need to characterise multiple samples simultaneously. To meet these requirements, we are introducing the LightBox Universal Multiplexer and a reference cell.

Introduction:

When performing any scientific experiment or analysis, it is imperative to know that the equipment you are using is both precise and accurate in order to have confidence in the results you obtain. In chemistry this involves the use of 'standards' and 'control samples' but what is the best route when evaluating the performance of indoor PV cells, this is where reference cells come to the fore, so what are reference cells?

Reference cells are tools for accurately evaluating solar cell performance. They serve as calibrated benchmarks that allow researchers and manufacturers to reduce measurement uncertainty and ensure consistency across different testing environments. In this paper we will explore how this is achieved. Secondly, we will review the Universal Multiplexer a small device that enables multiple cells to be characterised simultaneously, thereby improving efficiency and throughput. The Universal Multiplexer has been designed to work seamlessly with the LightBox.

Reference Cells:

Indoor PV cells exhibit a non-linear response to luminance, they also can have a varied response to the spectral profile of the indoor illumination and the irradiance they are exposed to. In a test and characterisation environment the challenge is exaggerated by factors such as the effect of temperature, the response time of the light source, the stability of the light emitted by the light source, the type and position of the light source etc. Furthermore, different indoor PV technologies, such as organic PV, amorphous Silicon, perovskites each have different characteristics.

The benefits of using a reference cell are to alleviate some of the factors that can influence the measurements made, enabling a more accurate comparison between tests, test locations and device types.

A reference cell is designed to have a spectral response similar to the solar cell under test, helping to minimise spectral mismatch errors when measuring light intensity. If you use a generic sensor that responds differently to portions of the solar spectrum, then changes in spectral content can lead to errors in estimating how much useful light the device really receives. Reference cells calibrate light sources (e.g. solar simulators) by providing a known current output under standard conditions.

Using a reference cell reduces uncertainties in measurement associated with variables such as temperature effects, angle of incidence (cosine response), irradiance non-uniformity, etc. Because the reference cell is exposed to essentially the same conditions as the device under test, many systematic errors cancel out or can be corrected more reliably.

Quality control, traceability and standards

Well-characterised reference cells are used for calibrating measurement instruments and solar simulators. Laboratories like NPL in the UK and NREL, NIST in the USA, use reference cells with rigorous traceable calibrations to maintain global standards. This ensures that cell-to-cell and lab-to-lab comparisons are meaningful.

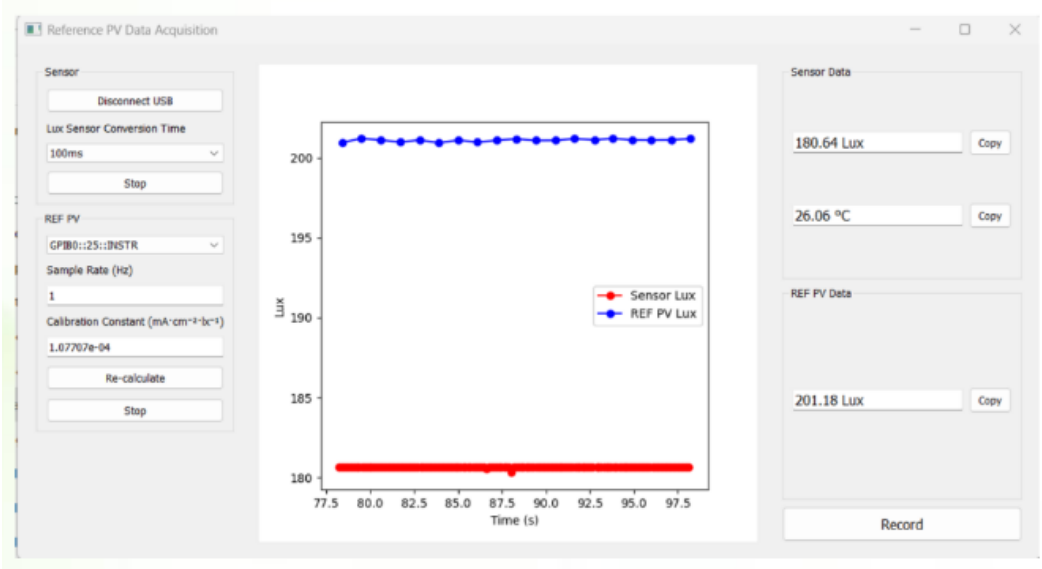
Lightricity Reference Indoor PV Cell:

Oxford, UK based Lightricity has developed a reference cell for the light intensity calibration of indoor artificial light sources. The spectral response engineered for artificial light (360 – 830 nm), the cell has no response in the Near Infra-Red and IR regions and does not require the use of optical filters. The full datasheet can be found at [2]: https://lightricity.co.uk/reference-indoor-pv-cell

The reference cell comes calibrated with a white LED 5000K with spectral match SA according to IEC standard "TS 62607-7-2:2023".

A software tool is included enabling the following parameters to be characterised as a function of time:

- Calibrated Light Intensity
- Non-calibrated light intensity from a built in digital ambient light sensor
- Temperature (°C) from a digital temperature sensor



Reference cells help ensure that performance claims (efficiency, power output, etc.) are reliable, comparable, and reflective of real operating conditions. They are essential for design optimisation, device selection, product certification, and assessing suitability for specific applications. With the continued growth of low energy wireless sensors enabling the IoT world, there is great interest in developing alternatives to batteries for powering these devices. Energy harvesting technologies have been shown to be reliable and able to power these sensors thereby enabling more sustainable systems and solutions. The use of indoor ambient light as an energy source is growing in popularity, however, there are numerous different technologies used in photovoltaic systems, including a variety of material systems, chemistries, processing routes and module designs. The variety of solar energy harvesters on the market offers a challenge to designers. The LightBox used in conjunction with the Reference cell enables the performance of the light Energy Harvesters to be compared, under a range of indoor light types and conditions.

Universal Multiplexer:

The LightBox was designed to evaluate single indoor PV devices, however, when evaluating the performance and characteristics of numerous devices, either of the same or different technologies it is more efficient to have the capability to perform measurements on multiple samples in a single run. Similarly, if the LightBox is used for quality control purposes, then rapid testing of multiple samples is a key requirement. To fulfil this function, we introduce the Universal Multiplexer that can drive most common source meters to rapidly switch between 8 devices.

The Universal Multiplexer offers the following features:

- 4 channel 4 wire mode, or, 8 channel 2 wire mode
- Very low leakage current: typically, 10pA; suitable for ultra-low power systems
- Low on-state resistance: 2W
- Wide voltage range: -5V to 5V
- High current capability: 150mA (max)
- Simple USB interface
- Software included.

The data sheet for the Universal Multiplexer can be found at [3] https://lightricity.co.uk/indoor-light-simulators/

Summary:

In summary, two versions of the Lightricity LightBox were introduced and following user feedback we are offering two add-ons:

1. A Universal Multiplexer to enable multiple samples to be characterised efficiently and
2. a Reference Cell, compliant with IEC standard "TS 62607-7-2:2023"

References:

1. Reaching a consensus on indoor photovoltaics testing, Hoye et al. Joule 9, 102127, October 15, 2025, Elsevier Inc.
2. Lightricity Reference Indoor Photovoltaic Cell, 2025
3. Lightricity Universal Multiplexer, 2025

Contact Information:

For further information, LightBox product enquiries and order information please visit: www.lightricity.co.uk