

## Software Manual for the Economy LBIC Demo

### **Introduction**

This demonstration program is meant to show the capabilities of the infinityPV LBIC instruments in the economy series. LBIC or laser beam induced current mapping is a powerful characterization tool for solar cells. This technique gives you an image of where a solar cell produces electrical power when illuminated and where there might be defects that reduce the performance.

The LBIC instrument works by scanning the solar cell with a laser while measuring the electrical output. A computer program is then used to convert the raw electrical signal at each point to a color value and shows the result as a color-coded map of the relative efficiency.

One very important result is a much more accurate measure of the active area, which goes into the determination of the overall power conversion efficiency (PCE) of a solar cell.

Standard LBIC instruments have not gained much use, mainly because the technique that they use tend to be very slow. This has been overcome in our line of LBIC instruments, which can image an area of 25x25 cm in matter of about 10 seconds, in its fastest setting. A speed advantage of ca. 3 orders of magnitude. Together with the affordability, this means that our instruments are very suited for a laboratory characterizing of solar cells.

This demo software is very similar to the actual software that controls our LBIC instruments and can be used both as an appetizer, but also as a training software enabling a smooth transition to “the real thing”.

### **Installation**

This software has been tested and developed for a Windows 10 PC.

Go to our homepage <https://infinitypv.com/products/software/lbic-software> to download the *Economy LBIC Demo* software to your PC.

When the procedure has been completed you should have a link to the program on your desktop and in your programs list.



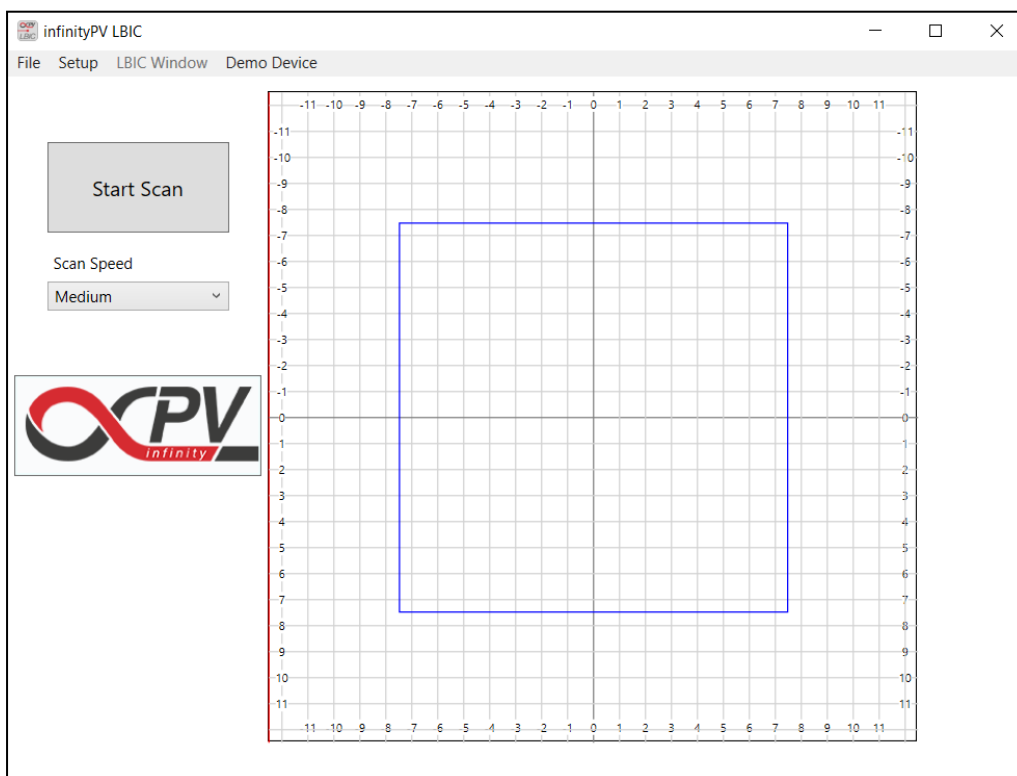
## Program introduction

With the actual instrument it would be connected to a PC with the control software (very similar to the demo software) and turned on. The solar cell to be imaged would then be placed on the horizontal measurement surface and connected electrically.

This is of course not possible with the demo version. Here different types of solar cells and accessories are instead selected from the main menu item *Demo Device*. A module with eight serially connected solar cells are selected by default.

## Program operation

Click on the program icon on your desktop to open the program main interface as shown below:



**Figure 1.** Main program interface.

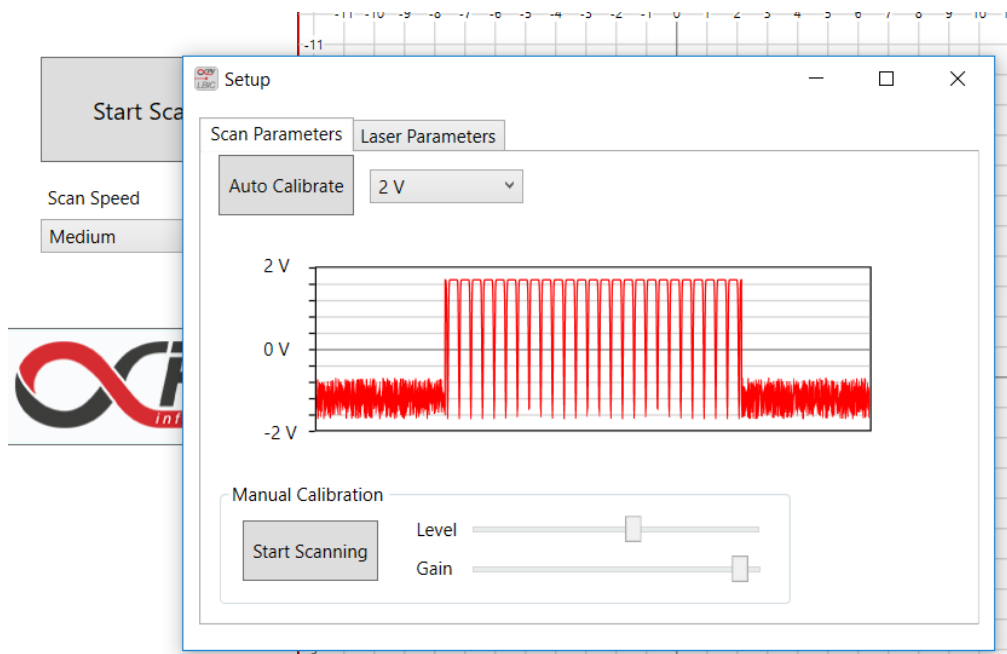
### The main window menu bar

<b>File</b>	Displays the exit program option
<b>Setup</b>	This opens the setup dialog (see below) to set gain and level parameters Voltage range and laser parameters
<b>LBIC Window</b>	If a LBIC scan has already been performed, the window showing the image can be reopened from here
<b>Demo Device</b>	Here you can select between the different demo devices (not actual solar cells)

Below the menu bar, on the left side, there is the button to start/stop an LBIC scan. Further down is a speed selector. The speed selected is very similar to that of the real instrument. The scan speed impacts the resolution, so the fast speed setting will result in a rather coarse image while the slow or very slow speed setting will result in an image with much finer detail.

The rectangular area in the center-right side is a representation of the interior instrument surface where the solar cell/module is placed. The maximum dimensions are 25x25 cm and you use the cursor to define the scan area delimited by the blue rectangle. Use the PC mouse to define the upper right-hand corner of the scan area by pressing the left button and then move the cursor to the left and down while holding the left button pressed. When the left button is released the scan-area is defined. As with the actual LBIC instrument the scan area must overlap part of the horizontal axis (x-axis). If you fail to do this, you will be notified.

Use the *Setup* menu item to open the setup window as shown below.



**Figure 2.** The setup window

Use the *Auto Calibrate* button to set appropriate level and gain parameters. The electric response from solar cells may of course vary greatly. This procedure helps to optimize the output to produce the highest resolution.

This task can also be performed manually with level and gain sliders after pressing the *Start Scanning* button.

In the actual instrument the laser would be scanning along the vertical axis (y-axis) in the center.

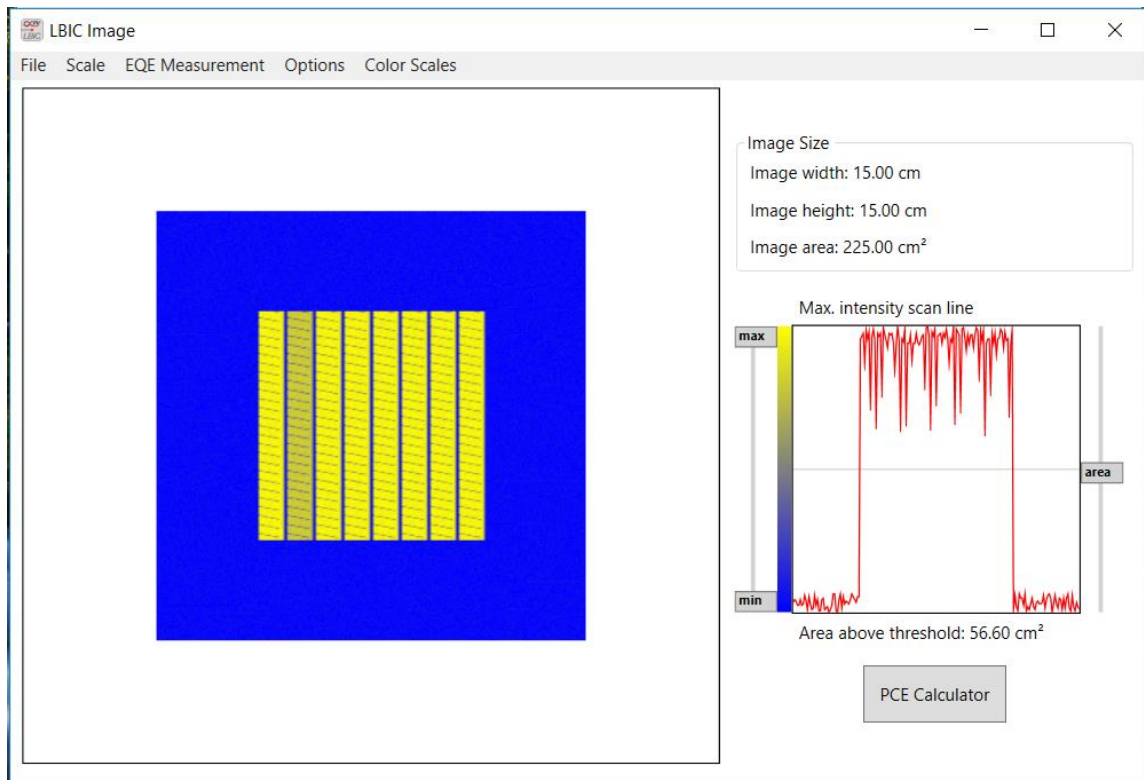
A selection of voltage ranges can be selected from the combobox (in this case marked 2 V). This range should be selected so that the signal is as large as possible without being clipped.

Some of our LBIC instruments are fitted with more than one laser (e.g. a blue 405 nm and a red 635 nm laser). The output of these can be controlled from the *Laser Parameters* tab item.

When you have finished setting up the instrument, close the setup window and start scanning by pressing the *Start Scan* button in the main interface.

You should then see a red line indicating the laser position move from left to right in the selected scan area.

When the scan is completed the LBIC image window will appear as shown below.



**Figure 3.** The LBIC Image window.

The LBIC Image is displayed in the area on the left. The default color scale is blue to yellow signifying low to high electrical response. On the right side the dimensions of the image are shown.

Below that a graph with the line scan with the highest intensity is shown.

To the left of this graph are sliders that control the color range. The minimum and maximum are automatically set to the minimum and maximum raw data values obtained. You can use these sliders to enhance how the raw data values are interpreted as color values.

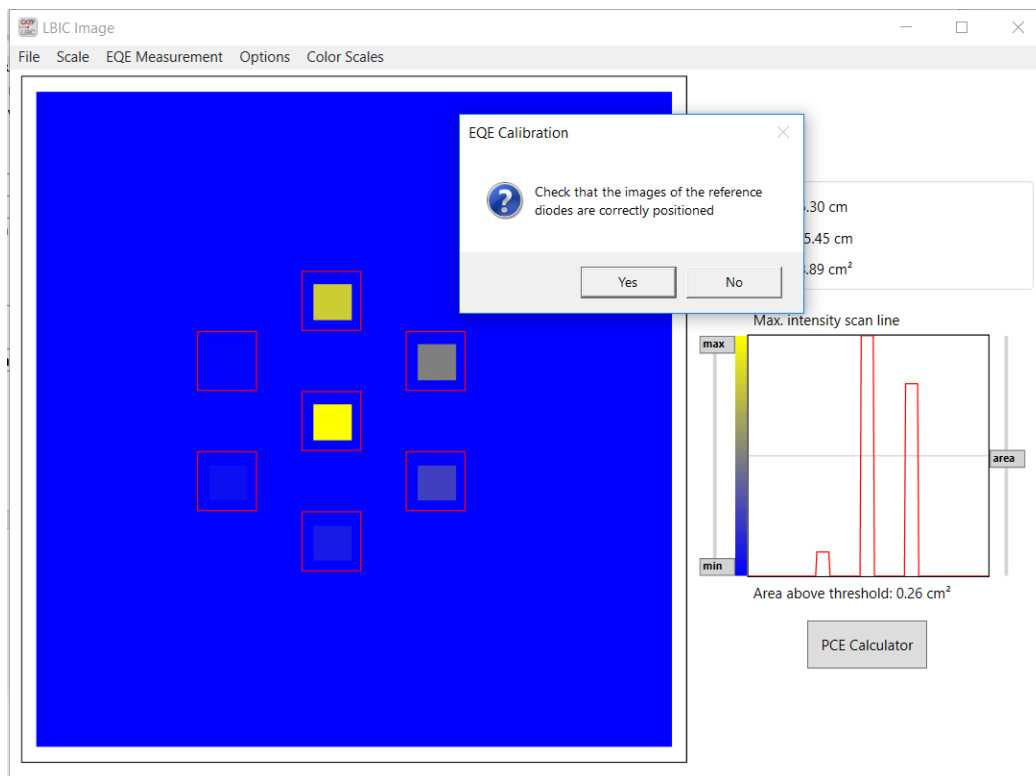
To the right of the graph is a slider setting the threshold for calculating the active area, which is shown below the graph.

This area determination is very useful for calculating the precise power conversion efficiency (PCE). Other data obtained from electrical characterization are needed for this calculation ( $V_{oc}$ ,  $I_{sc}$ , fill factor and lamp power). If you already have these data you can press the *PCE Calculator* button to do this.

### ***The LBIC image menu bar***

<b>File</b>	Menu items for closing the window and copying to the clipboard
<b>Image Type</b>	Select either LBIC image or EQE image This menu item is only shown after an EQE calibration has been completed
<b>Scale</b>	Select a different scale to enlarge or decrease the image size
<b>EQE Measurement</b>	Calibrate the response function to display an EQE map instead of the LBIC map This calibration can only be performed on the EQE reference device selected in the main window menu ( <i>Demo Device</i> ) In another menu item the response function can be shown graphically
<b>Options</b>	Use the cursor to select an area (default), measure a length or measure area in the LBIC image
<b>Color Scales</b>	Two different color scales are available: blue to yellow or gray scale

## EQE Calibration and EQE images



**Figure 4.** EQE Calibration

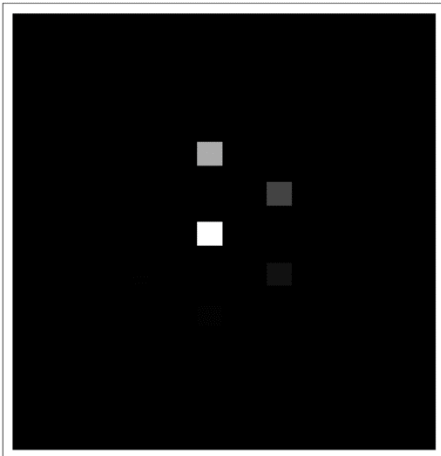
The raw data can also be presented as an EQE (external quantum efficiency) map. This requires that the electrical response is calibrated. With the actual LBIC instrument this is done by first inserting an EQE reference device (in this case from the *Main menu*) and scanning this with the selected scanning parameters. This device has seven diodes with known EQE responses to the selected laser wavelength.

When you select the *Start EQE Calibration* menu item (under *EQE Measurement* in the menu bar) the program will try to locate areas in the data corresponding to these seven diodes. The areas found will be highlighted with red rectangles in the LBIC image and you will be prompted to accept these positions in a message box.

The absolute EQE value, at a given laser wavelength, of each of these diodes are known and the raw data values obtained are then combined to create a lookup function converting raw data values to EQE values.

The color values of the image (now an EQE image) are scaled according to this look-up function.



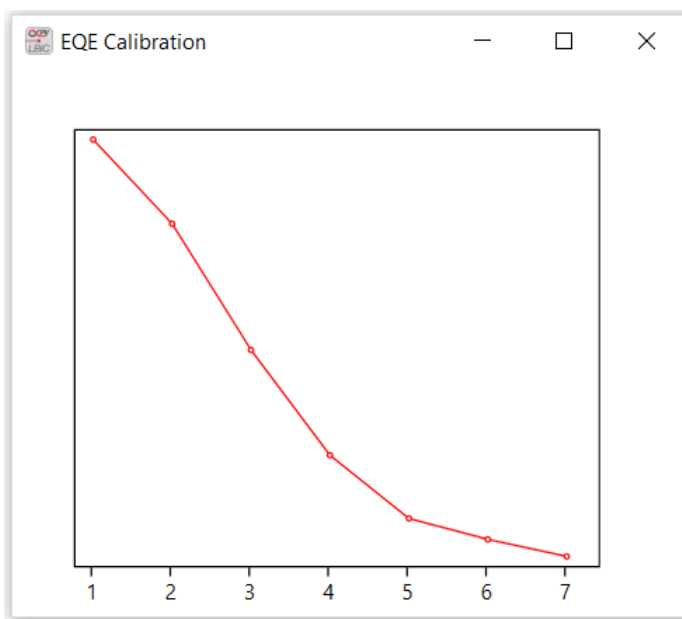


**Figure 5.** EQE map of the reference device. Here shown using the gray scale option.

### ***EQE imaging of other devices***

After calibrating the EQE look-up function other solar cell devices can now be imaged. You close the LBIC window and select another device from the main menu window. There is one very important caveat: All the **parameters** selected in the *Setup window* **must be the same** as for the reference device and the **base line level must be set to zero** for both the calibration device and for subsequent other solar cell devices to be investigated.

The look-up function can be shown using the *Show EQE function* menu item (under *EQE Measurement*).



**Figure 6.** EQE look-up function determined in the EQE calibration.