

# OLED Lifetime System

## User Manual

Manual Version: 3.0.A

Product code: E621/E622/E641/E642

Product Version: 1.0.0

Software Version: 1.0.0

## Contents

1. User Interface .....	3
2. Connection.....	3
3. Setup .....	4
i. SMU Settings .....	5
ii. Measurement Settings.....	5
iii. Sweep Settings .....	6
iv. File Saving Settings.....	6
4. Sweeps.....	7
5. Lifetime.....	7
i. End Condition (TIME) .....	9
ii. End Condition (Decay).....	9
iii. Initial Parameter.....	9
iv. Final Parameter .....	9
v. Outputs.....	10
6. File Outputs .....	11

## 1. User Interface

The user interface is split into two main sections (Figure 1). The menu bar allows the user to navigate between sections of the program and the Settings/Measurements section is where the program functions are controlled and displayed.

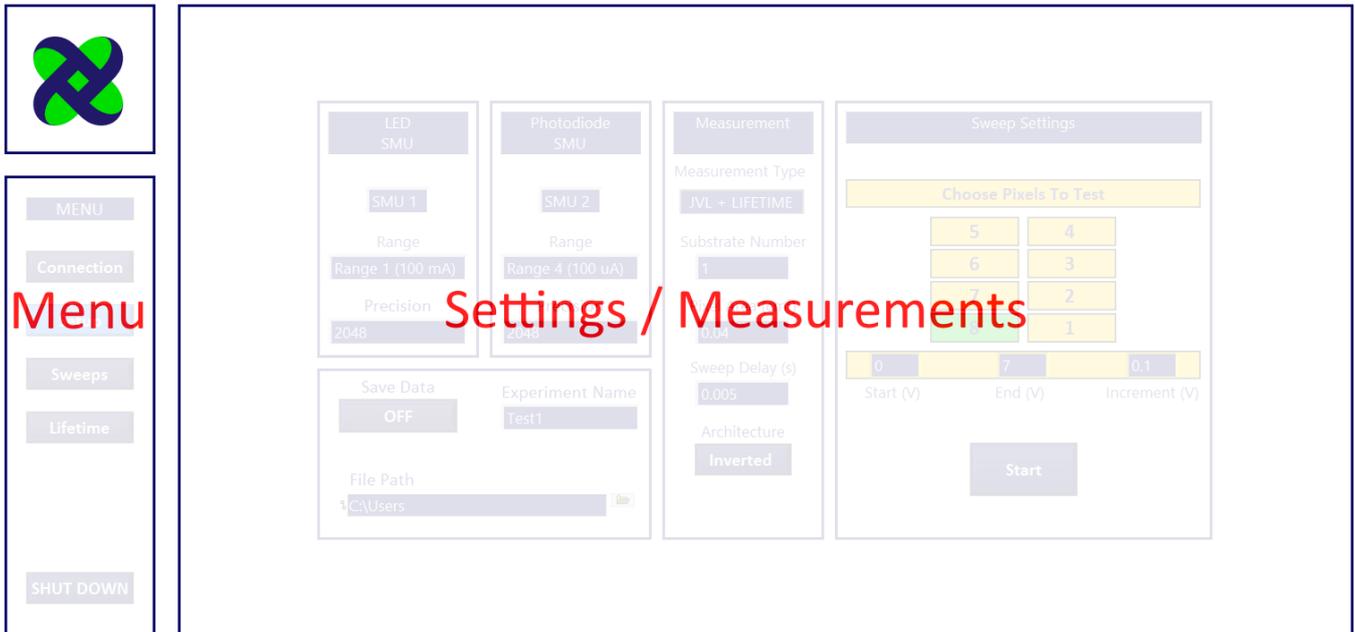


Figure 1: The layout of the program showing the menu on the left and the Settings/Measurements on the right.

## 2. Connection

The first part of the program is the Connection menu, which appears upon starting (Figure 2). This is where the address of the X100 is input and connection is attempted. For the X100 connection, choose between USB and Ethernet by clicking the 'Connection' drop down menu. Choose between a Smart Board and a manual board in the 'Board Type' menu.

When the appropriate board address has been input, click 'Connect'. If the address is acceptable, the program will connect to the board and the Xtralien logo will turn from red to green. The program will then automatically switch to the 'Setup' section.

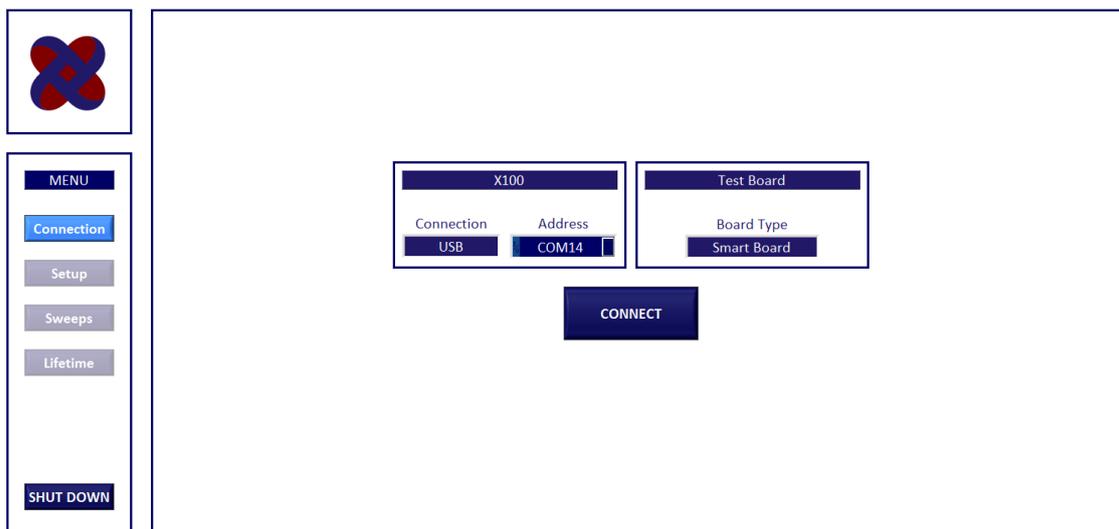


Figure 2: Connection panel. Choose an address for the X100.

### 3. Setup

The setup panel (Figure 3) is where the source measure unit (SMU), file saving and JV sweep settings are input.

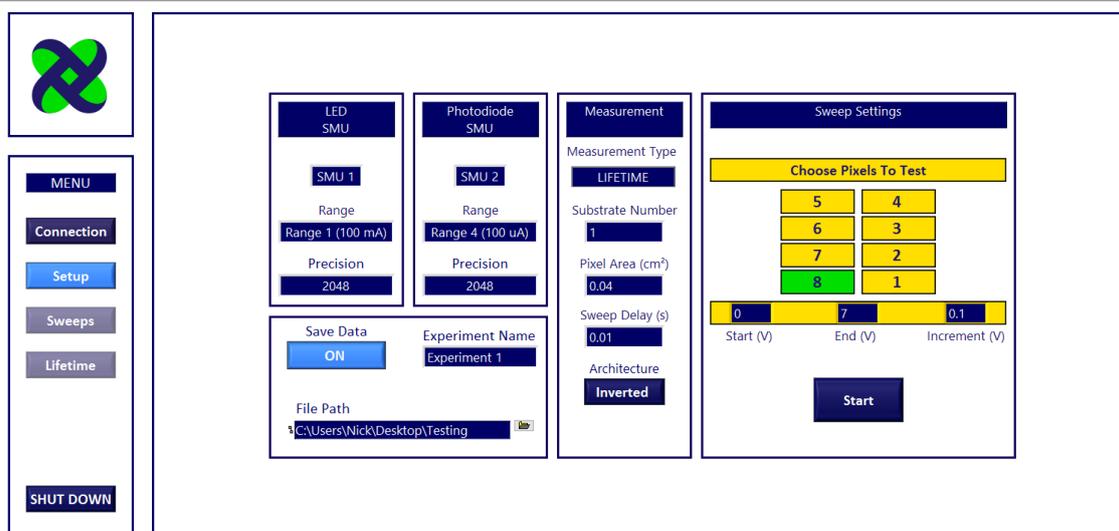


Figure 3: Enter settings in the Setup panel.

The program uses both SMUs on the X100. The 'LED SMU' is used for setting an LED voltage and reading the LED current. The 'Photodiode SMU' is used for measuring the photodiode current.

The various settings are as follows:

## i. SMU SETTINGS

**LED SMU / Photodiode SMU:** Allocate a SMU to either the LED or Photodiode connections, based on which BNC port they are connected to.

**Range:** Accuracy range of board (must be set on software AND on hardware). Default for the LED is range 1 and the Photodiode is range 4. Table 1 shows the maximum current allowed at each range. The LED current is usually in the mA range, therefore a range of 1 or 2 is preferable. The photodiode is in the nA to  $\mu\text{A}$  range, thus range 4 and 5 are appropriate.

Range	Maximum Current
1	100 mA
2	10 mA
3	1 mA
4	100 $\mu\text{A}$
5	10 $\mu\text{A}$

Table 1 Maximum current per range for the Xtralien X100.

**Precision:** Sample number taken per measurement. A higher precision may provide more accurate measurements, however this also reduces the speed at which measurements occur. The default precision is 2048.

## ii. MEASUREMENT SETTINGS

### Measurement Type:

Choose from:

**JV:** Takes a JV sweep measurement of the LED.

**JVL:** Takes a JVL sweep measurement of the LED and PD.

**LIFETIME:** Skips the sweep measurement and opens the lifetime measurement settings.

Note: This option will not give you any JV data, therefore estimating the starting voltage of a lifetime measurement may be difficult.

**JVL + LIFETIME:** Takes a JVL sweep and then continues to the lifetime measurement settings.

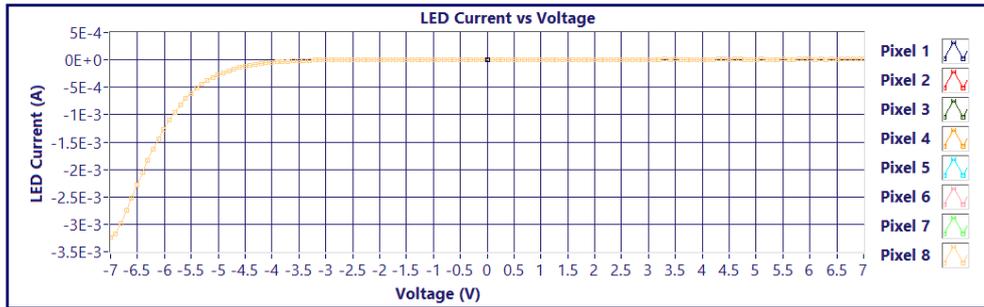
**Substrate Number:** Enter the current substrate number that you are measuring. This will be used during filename generation.

**Pixel Area:** Enter the area of the pixels being tested.

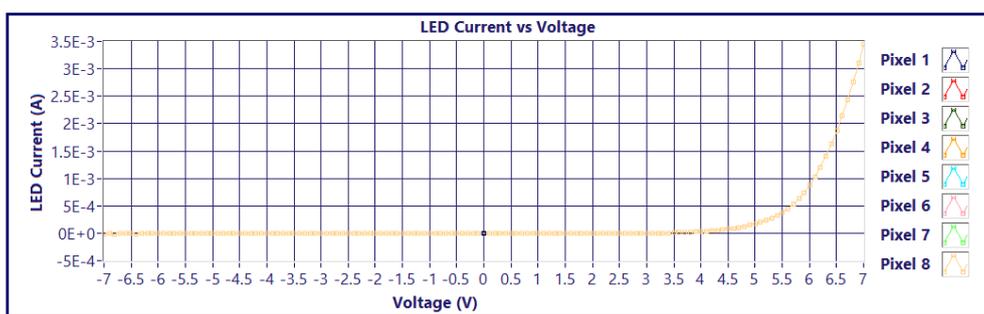
**Sweep Delay (s):** Time between each measurement during the sweep.

**Architecture:** Choose either Standard or Inverted, depending on the architecture of your device. Selecting 'Inverted' will set a negative voltage instead of a positive and display a measured negative current as positive (e.g. a sweep from 1 to 2 would actually be from -1 to -2). Figure 4 shows the same OLED pixel tested using both the standard and

inverted architecture settings. When using the inverted architecture, the software actually sweeps from 7 to -7 in steps of -0.1. The measured negative current is returned as a positive current.



Standard



Inverted

Figure 4: An OLED device tested using the standard and inverted settings.

### iii. SWEEP SETTINGS

**Pixels To Test:** Choose which pixels to perform a sweep on by clicking their corresponding buttons.

**Voltage Start (V):** Starting voltage of the sweep.

**Voltage End (V):** End voltage of the sweep.

**Increment (V) :** Voltage step during the sweep.

**Start:** Begin the sweep measurement. Only do this once all other settings have been chosen.

### iv. FILE SAVING SETTINGS

The file saving system generates a folder for each experiment and substrate, then saves .csv files within these.

Figure 3 shows a settings panel wherein the ‘Experiment Name’ field has the text ‘Experiment 1’ and the ‘Substrate Number’ is set to 1. The File Path is also displayed. If a JVL measurement type was selected, the resultant file would have the path:

C:\Users\Nick\Desktop\Testing\Experiment 1\Substrate 1\16-06-20 10-40-35 jvl pixel 1.csv

The file name uses the data and the time at which the measurements were taken. It is displayed in the format:

yy-mm-dd hh-mm-ss.

**Save Data:** Choose to save the data or not.

**File Path:** Path in which the experiment folder is generated.

**Experiment Name:** Name of folder in which experiment is saved.

## 4. Sweeps

The Sweeps panel (Figure 5) shows the sweep data as it is being measured. Click 'Finish Pixel' to finish a pixel measurement early. Click 'Cancel Sweeps' to stop all measurements and cancel the saving of data to file. A save file is created after every pixel sweep, therefore cancelling a sweep will not prevent previous pixels having been saved.

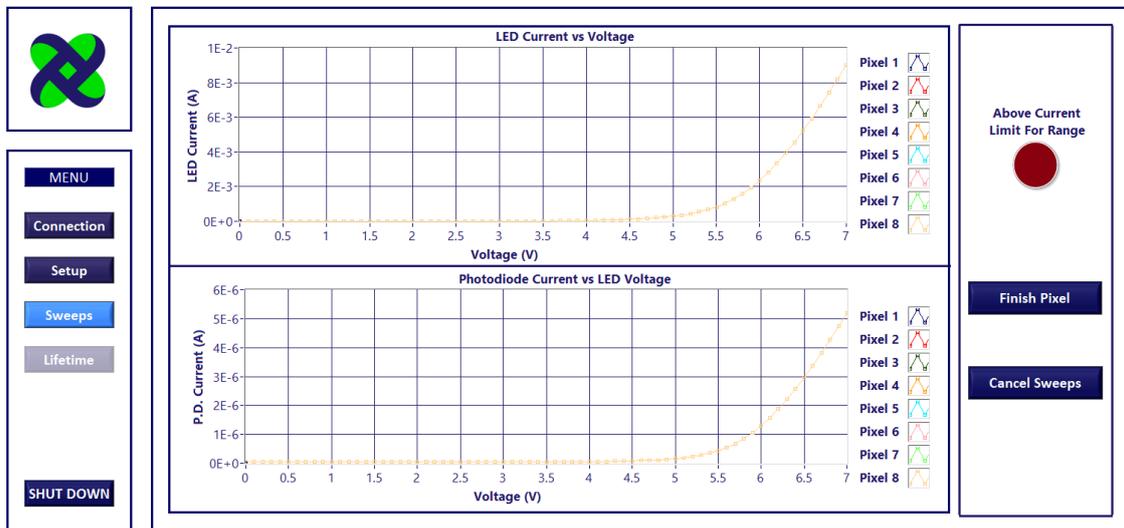


Figure 5: Sweep Panel showing plots of LED and photodiode current vs LED voltage.

If the measured current is above the Xtralien current limit at the chosen SMU range, the 'Above Current Limit' indicator will flash. The current limits for each range are displayed in Table 1.

## 5. Lifetime

This section of the program is used for controlling lifetime measurements. The lifetime measurement consists of two steps: 'Find Current' and 'Current vs Time'. The measurement can be programmed to start at a specific LED current, PD current, or fixed voltage. The first stage adjusts the voltage of the LED in order to 'find' this value.

The lifetime measurement requires a value to be fixed over time. As with the initialisation stage, this can be LED current, PD current or voltage. For example, the program could be told to start at an LED current of 20 mA and fix the PD current once this value is reached. The program will then adjust the voltage to keep the PD current fixed.

The lifetime measurements are taken over a chosen time period or current decay percentage. The voltage increment during the initialisation stage can be set to be slightly higher than the second stage, so the initial 'finding' of a current is faster.

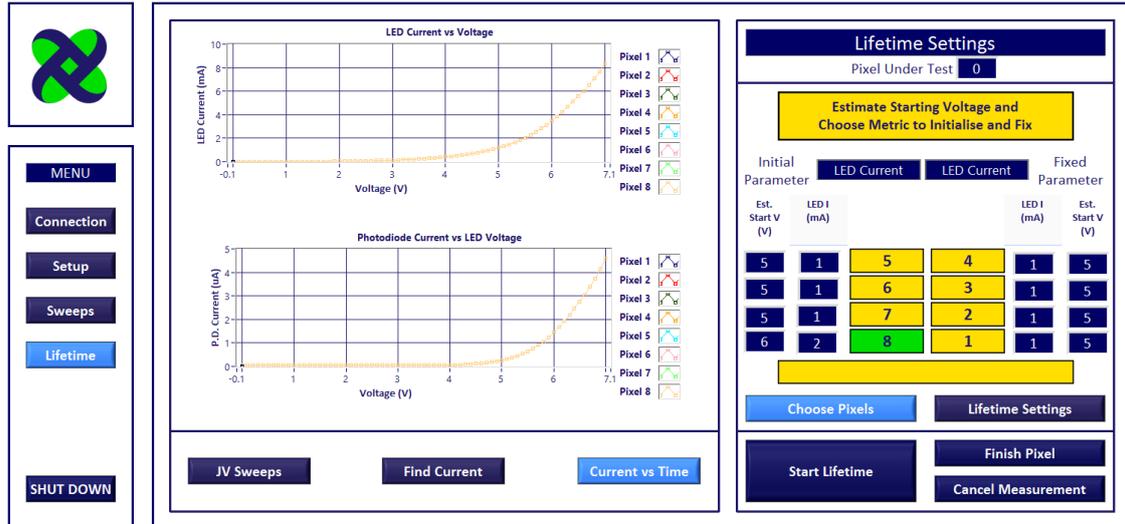


Figure 6: Sweeps from the JV / JVL measurements are displayed here for reference purposes.

Figure 6 shows the first screen of the lifetime section. Any sweeps taken during the JV / JVL measurement stage will be displayed here for reference. These can be viewed at any time by clicking the highlighted 'JV Sweeps' button beneath the plots. The plots will remain blank if no JV / JVL measurements were taken before the lifetime stage.

Figure 7a shows the 'Choose Pixels' menu, in which the user can set pixel choice and initial voltage / current settings for each pixel. As discussed above, the program requires an initialisation parameter and a parameter to keep constant during the measurement. Choose between these options by selecting LED Voltage, LED Current or Photodiode Current in the 'Initial Parameter' and 'Fixed Parameter' drop-down menus. The desired currents and estimate voltages can then be input for each pixel to be tested. The sweeps displayed in Figure 6 can be used to estimate the starting voltages.

**Note: Currents for LED are in milliamps (mA) and currents for PD are in microamps (µA).**

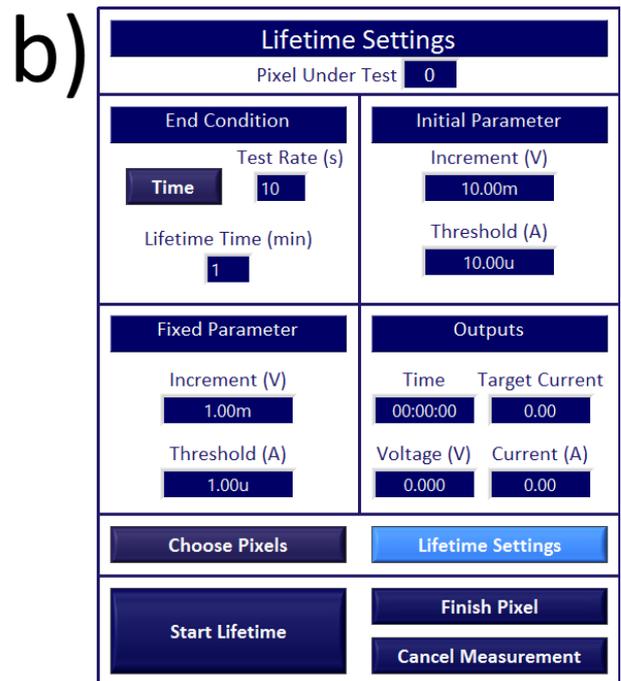
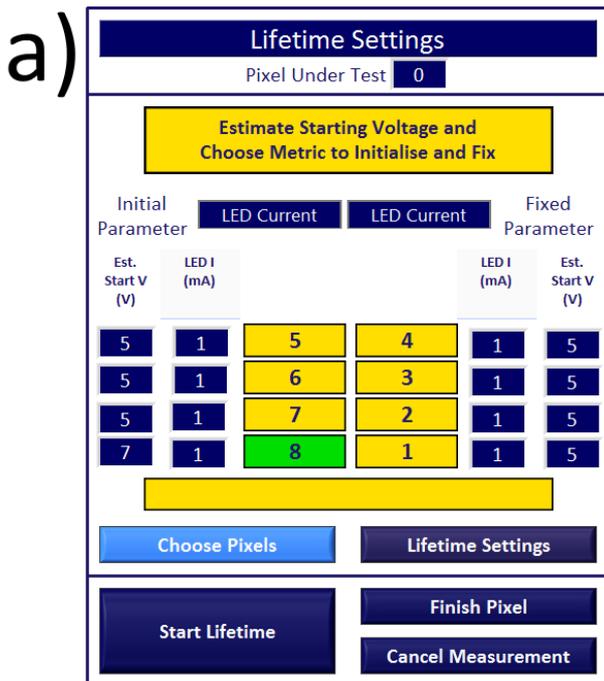


Figure 7: Lifetime settings showing a) pixels to test, initialization parameters and parameters to fix during measurement and b) end condition, current threshold settings and measurement outputs.

Figure 7b shows the ‘Lifetime Settings’ menu, wherein the measurement conditions are set. The end condition can be set to a fixed time (Figure 8a), or a percentage decay of a current ((Figure 8b). If the LED current is set to be fixed, this measured decay will be the PD current and if the PD current is set to be fixed, the measured decay will be the LED current.

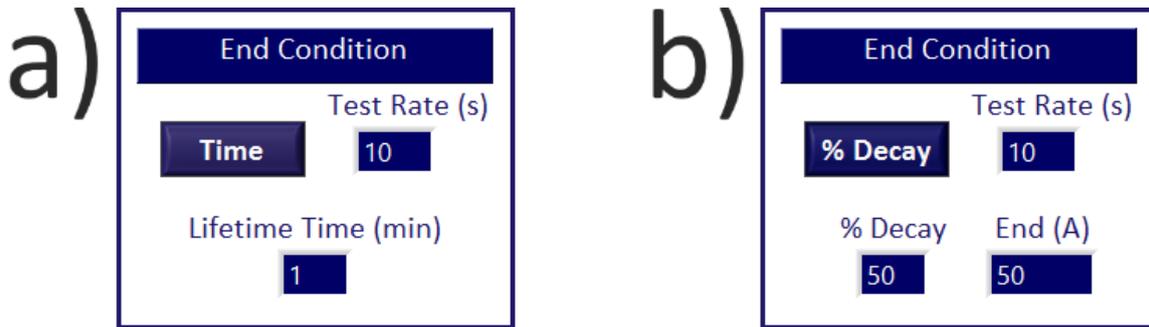


Figure 8: End conditions for lifetime measurements showing a) a set time and b) a percentage decay of LED or PD current.

Individual settings are explained here:

**i. END CONDITION (TIME)**

**Test Rate (s):** The time between measurements.

**Lifetime Time (min):** The time until the end of the lifetime testing.

**ii. END CONDITION (DECAY)**

**Test Rate (s):** The time between measurements.

**% Decay:** The % of current at which lifetime test will end.

**End (A):** The current at which the test will end (calculated from the first measurement once the test begins).

**iii. INITIAL PARAMETER**

**Increment (V):** This is the increase/decrease in voltage while the program is finding the desired starting current. Increase this step size if the program is taking too long to find the initial current.

**Threshold (A):** This is the amount by which the measured current can be different to the set current during initial setup.

**iv. FINAL PARAMETER**

**Increment (V):** This is the increase/decrease in voltage while the program is running the lifetime test. This can be smaller than the initial increment, as the voltage will already be close to providing the desired current value.

**Threshold (A):** This is the amount by which the measured current can be different to the desired current during lifetime measurement.

## v. OUTPUTS

**Time (hh:mm:ss):** Time since the beginning of the lifetime measurement.

**Target Current (A):** Current that the program is attempting to maintain via voltage alterations.

**Voltage (V):** LED Voltage

**Current (A):** This will be constantly measured and the voltage will be adjusted until the current is within the threshold of the target current.

Figure 9 shows the program during the 'Finding Current' stage. The voltage is decreasing until the target current (in this case an LED current of 2 mA) is reached. Once this has been found, the lifetime measurement begins.

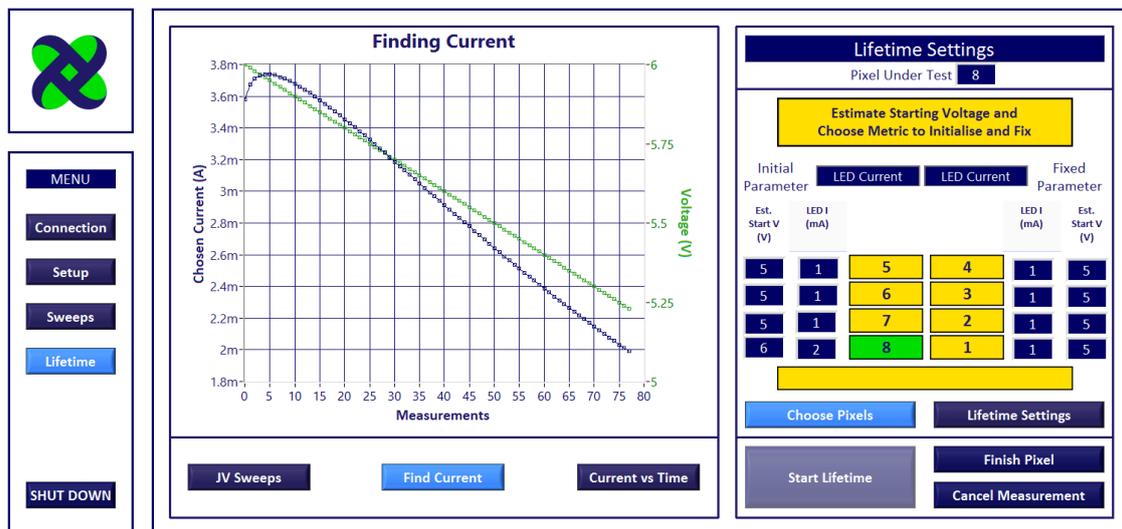


Figure 9: The program during the 'Finding Current' stage. The lifetime measurement will start once the measured current is within the threshold of the target current.

Figure 10 shows a lifetime measurement in progress. PD current and voltage are displayed on the plot and LED current can be seen in the Output section of the lifetime settings. The data displayed on the plot can be chosen via the controls beneath each vertical axis.

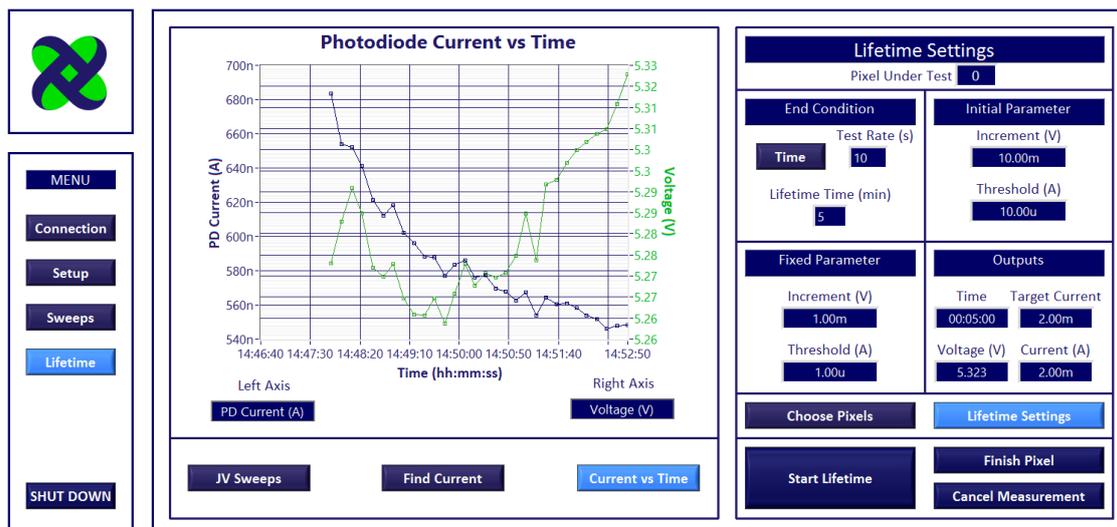


Figure 10: Lifetime measurement showing LED and PD current over time.

## 6. File Outputs

The CSV output file of a JVL measurement contains LED voltage, LED current, PD current, current density and device area. An example file is shown in Figure 11.

	A	B	C	D	E	F	G
1	Voltage (V)	LED Current (mA)	PD Current (mA)	PD Current Density (mA/cm <sup>2</sup> )		Device Area (cm <sup>2</sup> )	
2	4.003	2.53E-01	1.64E-04	4.11E-03		4.00E-02	
3	4.103	2.78E-01	1.77E-04	4.41E-03			
4	4.203	3.13E-01	1.94E-04	4.86E-03			
5	4.303	3.57E-01	2.14E-04	5.36E-03			
6	4.403	4.08E-01	2.38E-04	5.96E-03			
7	4.503	4.64E-01	2.63E-04	6.57E-03			
8	4.603	5.28E-01	2.95E-04	7.37E-03			
9	4.703	6.00E-01	3.32E-04	8.29E-03			
10	4.803	6.83E-01	3.72E-04	9.31E-03			

Figure 11: CSV file output of a JVL measurement.

The CSV file output of a LIFETIME measurement includes the Time, LED Voltage, LED Current and PD current. The example in Figure 12 shows a measurement in which LED current was kept constant at 2 mA.

	A	B	C	D	E	F	G	H	I	J
1	Time (s)	Voltage (V)	LED (mA)	PD (mA)						
2	0	5.344	2.00E+00	5.37E-04						
3	10.069	5.37	2.00E+00	5.24E-04						
4	20.134	5.372	2.00E+00	5.20E-04						
5	30.24	5.369	2.00E+00	5.17E-04						
6	40.346	5.366	2.00E+00	5.12E-04						
7	50.371	5.365	2.00E+00	5.11E-04						
8	60.407	5.363	2.00E+00	5.12E-04						
9	70.633	5.359	2.00E+00	5.07E-04						
10	80.671	5.361	2.00E+00	5.09E-04						

Figure 12: CSV file output of a LIFETIME measurement.