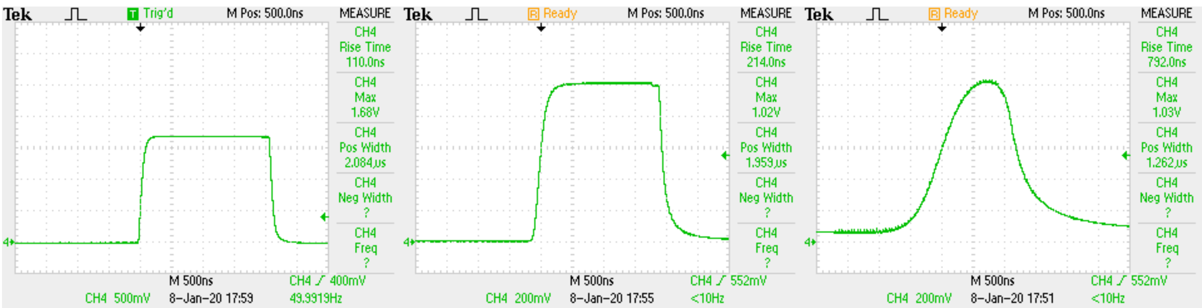
Measuring Threshold Accurately with the LIV100

Due to the nature of the current driver end stage, it is not possible to drive the shortest specified pulse durations at very low currents. The lower the current is, the longer the rise time of the driver will be. This seemingly negative drawback has been accepted as a design compromise to achieve the very square pulse shape (no overshoot) at all set currents.

We specify the minimum current to be the lowest current for which a square pulse fully reaching the set current can be achieved for a pulse duration of 2µs (F-version), 5µs (L-version) or 10µs (XL-version) respectively.

For example, the LIV100-F020 is specified with a maximum current of 20A and a minimum current of 0.1A. This means the lowest current for which a pulse duration of 2µs is guaranteed is 0.1A (= 100mA). Now the resolution of this unit is 5mA and it is indeed possible to drive currents below 100mA. However, the current pulse will only reach the set value if the pulse duration is long enough.



10A (in 165mΩ) *1A (in 1Ω)* *100mA (in 10Ω)*

Fig. 1: 2µs Pulses with LIV100-F020

Now consider the situation of using this system to measure the parameters of a laser diode with 250mA threshold and 2A maximum current. In order to not damage the laser at the maximum current, the operator may choose to use 1µs pulses for example. Considering the fact that the 250mA pulse will not reach its set current within 1µs, it is clear that the measured value for the threshold will be in error[1].

In order to solve this problem, the operator can perform the measurement in two steps as follows. In the following, we select the “first derivative” algorithm for determining the threshold as this is the most general and reproducible method. In all cases, we select the maximum number of current steps in order to ensure that there are enough data points to be able to determine the transition at threshold accurately.

First, measure the LIV curves over the full range required – in this case 0-2A using 1µs pulse width. This will give the correct result for the slope efficiency, but the threshold will be in error as discussed above.

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[1] In fact, the measured value will be too high since the output current will only actually reach the set value at high enough values of current, which in this example will be higher than the expected threshold current.

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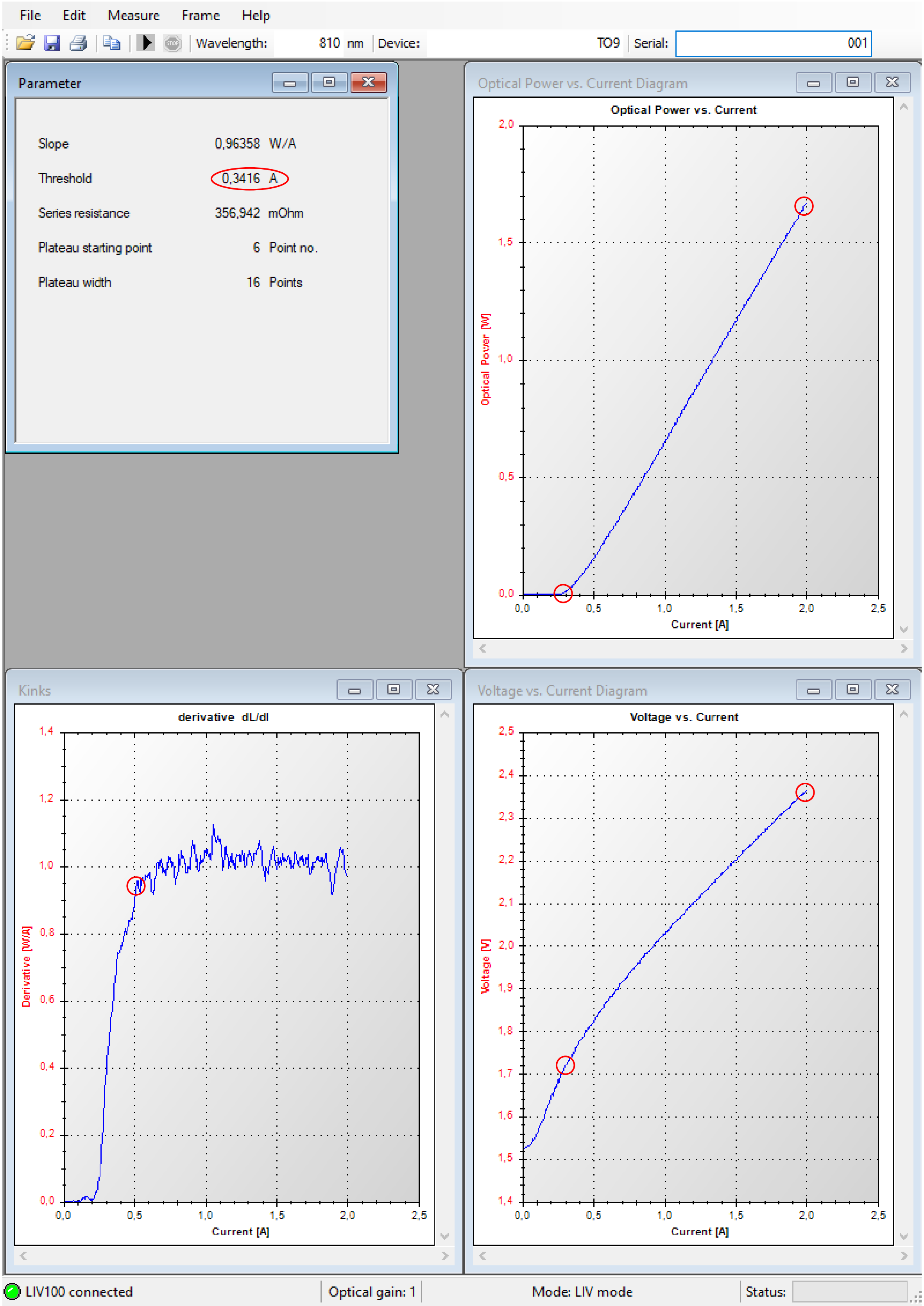

Fig. 2: LIV sweep, 5mA-2A with 1µs pulse duration. The points marked in red are the data points used in the discussion below.

Next, set the current sweep from 0 (actually, the lowest resolved current, which in this example is 5mA) to some value above threshold with a much longer pulse duration. A useful algorithm to determine the optimum pulse duration for the threshold determination is to use the same thermal loading of the laser diode as it would experience under the original test conditions. In general, the thermal loading of the laser at maximum current is given by:

$$E_{thermal} = P_{thermal} \cdot T_{pulse}$$

$$Where: P_{thermal} = P_{electrical} - P_{optical} = (V \cdot I) - P_{optical}$$

For the example shown above:

$$V = 2.4V \; at \; 2A \Rightarrow P_{electrical} = 4.8W$$

$$P_{optical} = 1.7W$$

$$\Rightarrow P_{thermal} = 3.1W$$

$$T_{pulse} = 1\mu s \Rightarrow E_{thermal} = 3.1W \cdot \mu s$$

The threshold measured in the sweep shown above using 1µs pulses is 0.34A. Using this as a first approximation and reading the values from the voltage graph, the thermal load at threshold[2] will be 0.34A x 1.74V = 0.59W ~ 0.6W. Note that the optical power at threshold is essentially zero, so the thermal load is equal to the electrical power input.

Therefore, at threshold, we can drive the laser with a longer pulse duration to achieve the same thermal load ($E_{thermal}$) as follows:

$$T_{pulse,threshold} = \frac{E_{thermal}}{P_{threshold}} = \frac{3.1W \cdot \mu s}{0.6W} = 5.2\mu s$$

From the derivative graph, we see that we should drive the laser up to about 500mA in order to be far enough above threshold. One should not drive to a higher current at the longer pulse duration in order to not overburden the laser diode. Note that the pulse separation must also be set correspondingly longer, in order to run the laser at the same duty cycle as for the full LIV sweep. In the present example, the LIV sweep was run at 1µs pulse duration and 100µs pulse separation (1% duty cycle). Therefore, for the threshold sweep, the parameters should be 5.2µs pulse duration and 500µs pulse separation. Using these settings, we obtain the results shown on the following page.

Note that the “first derivative” graph will show if the laser is being excessively heated by the longer pulse duration. The graph should rise to a stable, constant value above threshold and not roll over. Rollover would indicate that the diode is heating and a shorter pulse duration should be chosen.

As expected, the threshold is lower than the value measured before. Note that since the optical power is very low near threshold, the averaging option (LIV Mode tab of the settings menu) should be used appropriately for best results.

[2] These values (shown in red circles in the graph above) are readily obtained from the graphs using the “mouseover” function.

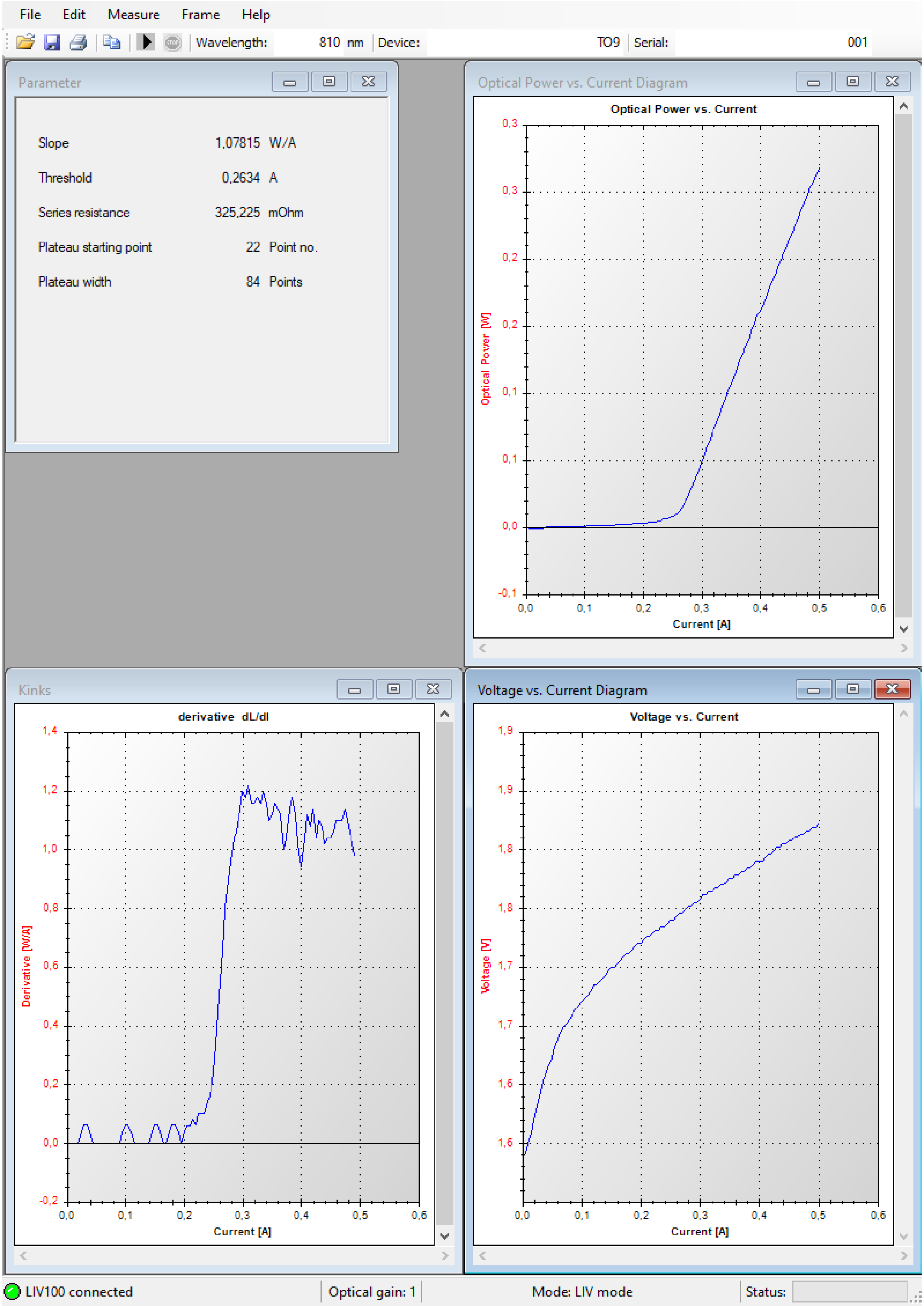

Fig. 3: LIV sweep, 5mA-2A with 5.2µs pulse duration. The points marked in red are the data points used in the discussion below.