Calculations for LDD100

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This document discusses calculation of various parameters of pulsed lasers from the data provided by the measurement output of the LDD100 laser diode driver.

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1. *Calculations with LDD100*

1.1 *QCL pulse switching measuring unit*

1.1.1 Generalities The measuring circuit contained in the LDD100 provides information about various laser pulse parameters (peak voltages, supply voltages, duty cycle, frequency). They are only estimated values, since exact measurement of short and strong pulses with diodes and averaging circuitry is difficult. Keep in mind that you should always measure the voltages on the LLH if you need accurate time and voltage data (see final paragraph). However, these data are useful for monitoring and surveillance purposes, and to give a rough estimation of the current parameters.

1.1.2 *Measured voltages*

- UHV: 1/2 of the average voltage, respective to VHT (user supplied high voltage)
- ULH: 1/2 of the average laser anode voltage, respective to VHT
- ULL: duty cycle dependent peak laser cathode voltage, respective to VHT
- UD: duty cycle dependent peak transistor drain voltage, respective to VHT
- UPI: 1/2 average internally reshaped drive voltage, respective to ground
- UPT: 1/2 average of a 37ns fixed length pulse, respective to ground

1.1.3 *Timing data*

1.1.3.1 Pulse frequency calculation UPT can be used to calculate the pulse frequency as follows:

$$f = f_0 \frac{2\mathrm{UPT} - v_{\mathrm{Plow}}}{v_{\mathrm{Phigh}} - v_{\mathrm{Plow}}}$$

where f_0 is a frequency constant, v_{Plow} and v_{Phigh} are the TTL pulser voltage limits. Actual values: $f_0 = \frac{1}{37ns}$, v_{Plow}=0.01V, v_{Phigh}=5V .

1.1.3.2 Duty cycle calculation UPI can be used to calculate the duty factor as follows:

$$df = \frac{2UPI - v_{\mathrm{Plow}}}{v_{\mathrm{Phigh}} - v_{\mathrm{Plow}}}$$

with v_{Plow} and v_{Phigh} as above. To get the real duty cycle, df must be corrected as follows:

$$dc = f_{\mathrm{LDD}} df = f_{\mathrm{LDD}} \frac{2UPI - v_{\mathrm{Plow}}}{v_{\mathrm{Phigh}} - v_{\mathrm{Plow}}}$$

to compensate for systematic errors in the LDD. Actual value is f_{LDD}=1.1 .

1.1.4 Laser peak current The laser peak current can be calculated by the measurement of the current through the series resistor Rs. This is provided by the values ULL and UD, which are rectifier outputs. To correct for the duty cycle, the rectifier values have to be taken into account with the following formula for a correction factor

$$p = 1 + \frac{\mathrm{Rds}}{\mathrm{Rc}dc}$$

where Rds and Rc are resistors in the rectifier circuit, dc is the duty cycle calculated as in the preceding paragraph. Actual values are Rds=10kΩ and Rc=10MΩ .

The corrected values for the peak laser cathode and transistor drain voltage are then given as follows:

$$\mathrm{ULL}_{peak} = p\mathrm{ULL} + \mathrm{Uds}$$

$$\mathrm{UD}_{peak} = p\mathrm{UD} + \mathrm{Uds}$$

where Uds is the voltage drop across the rectifier diode, actual value Uds=0.25V .

Finally, the laser peak current is then given by

$$I_{peak} = \frac{\mathrm{ULL}_{peak} - \mathrm{UD}_{peak}}{R_s}$$

where R_s is the series resistor, actual value R_s=0.85Ω .

1.1.5 Laser peak voltage The laser peak voltage is given by

$$U_{peak} = 2\mathrm{ULH} - \mathrm{ULL}_{peak}$$

where ULL_{peak} is the corrected peak value of ULL as calculated in the previous paragraph.

1.1.6 Average dissipation The average thermal dissipation of the laser is given by

$$\bar{P} = U_{peak} I_{peak} dc$$

where U_{peak} and I_{peak} are the peak values of laser voltage and current as calculated in the previous paragraphs, and *dc* is the (corrected) duty cycle.

1.1.7 Accuracy considerations The duty cycle (corrected) is accurate to about 5% for pulse lengths in the range 50ns to 150ns and pulse periods in the range 1μs to 10μs. Especially for short pulses, the accuracy can deteriorate to over 10%. These calculations and data are compared to the pulse lengths measured via the `LEMO` connectors of the LDD100. The TTL pulses generated by the TPG128 are always longer, due to losses in the LDD100.

Since the other calculations depend on the duty cycle data, they are in general even less accurate. The rectifier circuits used to measure the peak voltages show nonlinearities especially around 13V, and therefore the voltage may seem to saturate at a certain current for certain lasers. In addition, the change in laser impedance around threshold can generate remarkable nonlinearities compared to the above calculations.

If you need accurate values, proceed as follows:

- measure laser peak voltage, frequency and duty cycle using a two-channel oscilloscope (connected to the `LEMO` jacks of the LLH) in differential mode
- measure average current into the laser using the value given by the HV supply (or by an attached RMS amperemeter)
- calculate peak current by dividing average current by the duty cycle