

## Light Emitting Diodes (LEDs)

Volt-Ampere characteristics of the LED have to be measured in two modes: pulsed (part A) and continuous (part B). Running LED continuously produces a noticeable amount of heat, while running it in the pulsed mode allows minimizing and neglecting self-heating effect.

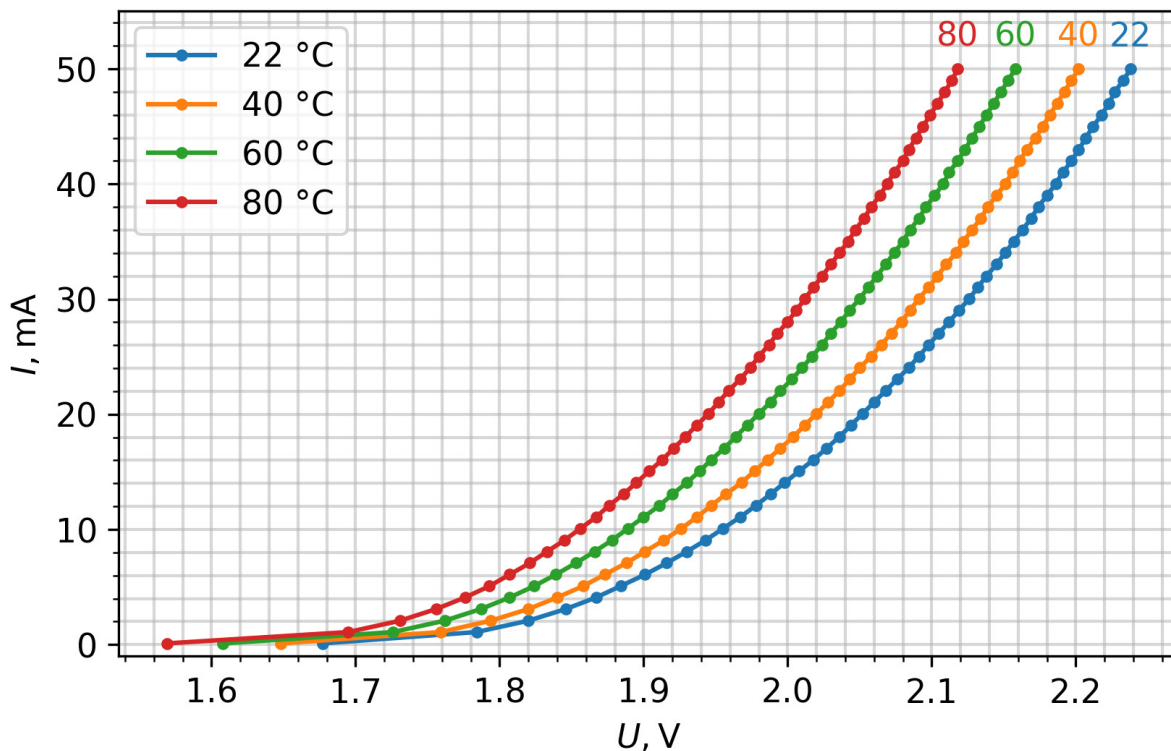
Students have to be able to run the automated  $I_{LED}(U_{LED})$  measurement procedure and extract the required point by visually interpolating data for required values of  $I_{LED}$ .

The temperature of PCB is controlled by changing the current of the heating circuit. The heating and temperature measurement parts of this Experiment are identical to the Experiment 1.

### Part A: Volt-ampere characteristics at different temperatures (5.0 points)

A.1 (2.5 pt.)

Graph  $I_{LED}(U_{LED})$  has to be accurate (in right range) and smooth.



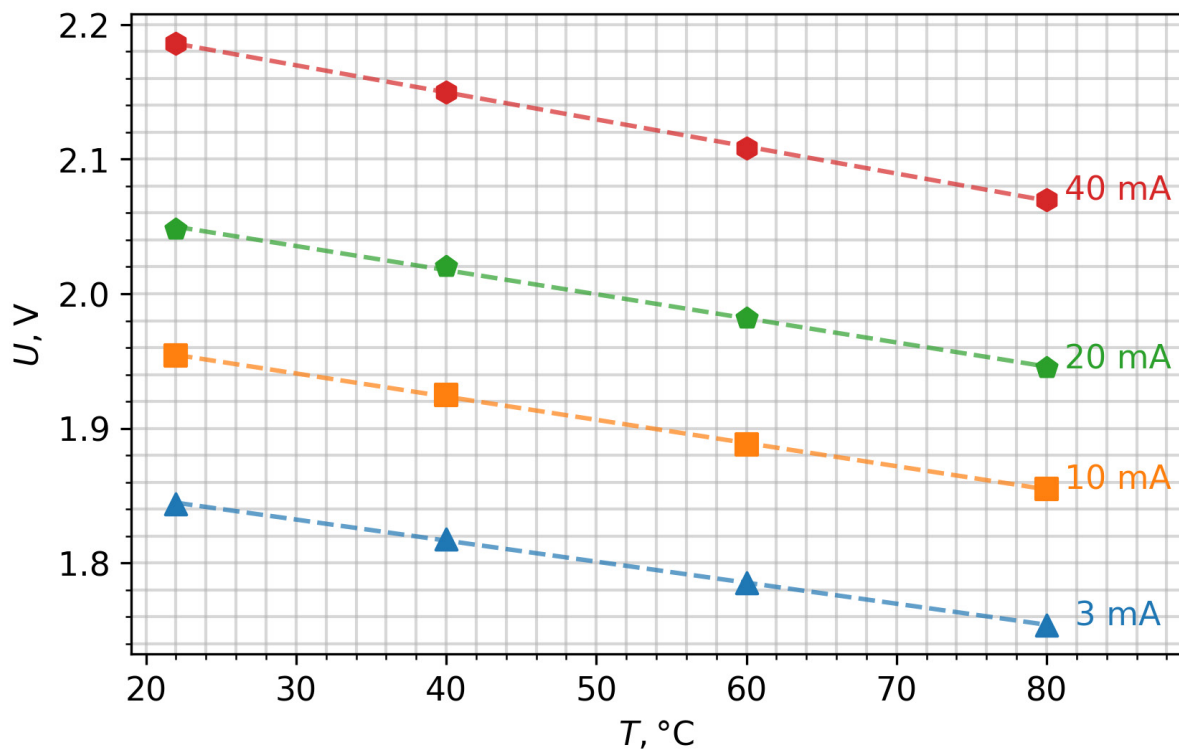
A.2 (1.0 pt.)

$U_{LED}(I_{LED}, T)$ :

$T$	“Room” <u>22</u> °C	40 °C	60°C	80°C
$I_{LED}$				
3 mA	1.844 V	1.818	1.785	1.754
10 mA	1.954	1.925	1.888	1.855
20 mA	2.048	2.02	1.982	1.945
40 mA	2.186	2.15	2.108	2.07

A.3 (1.5 pt.)

Graphed  $U_{LED}(I_{LED}, T)$  from A.2 data.  $U_{LED}(T)$  should show clear linear trend and be approximated graphically. The slope  $\left(\frac{\Delta U(I, T)}{\Delta T}\right)$  should also be calculated.

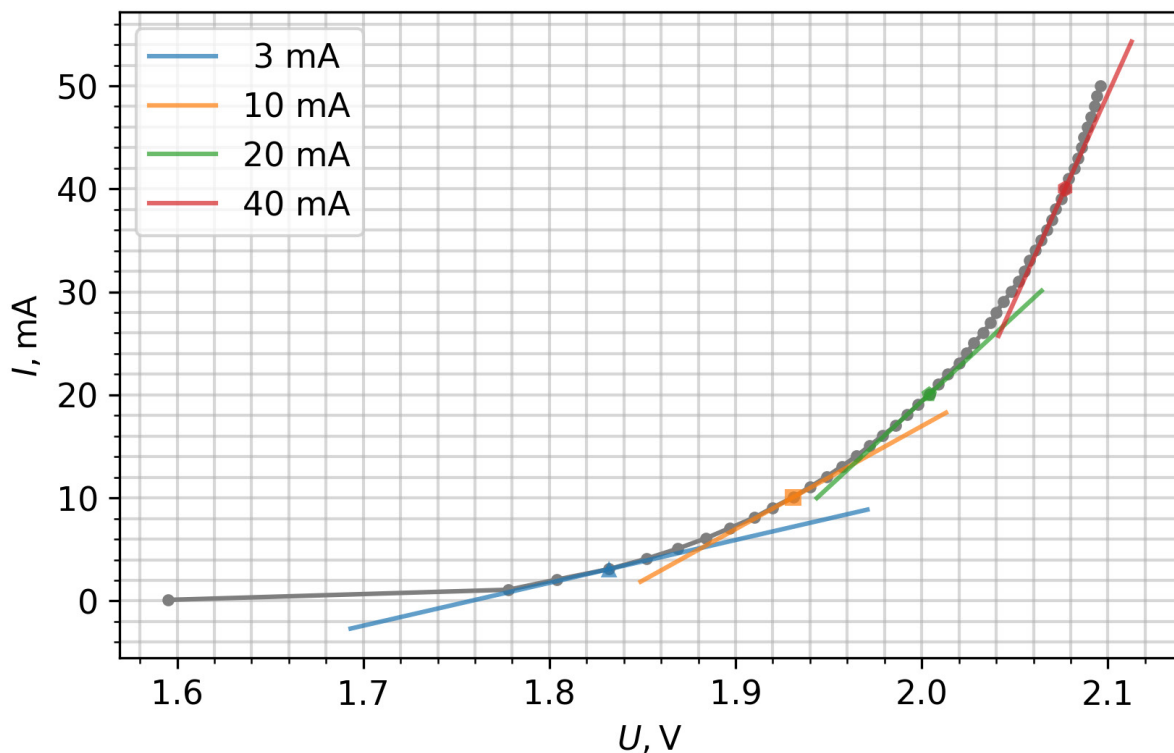


$I_{LED}$	3 mA	10 mA	20 mA	40 mA
$\left(\frac{\Delta U(I, T)}{\Delta T}\right)$	-1.55 mV/K	-1.7 mV/K	-1.8 mV/K	-2.0 mV/K

**Part B: Measurement of the LED Volt-Ampere characteristics at continuous driving current (3.5 points)**

B.1 (1.5 pt.)

Graph  $I_{LED}(U_{LED})$  has to be accurate (in right range) and smooth.



$I_{LED}$	3 mA	10 mA	20 mA	40 mA
$U_{LED}$	1.83 V	1.93 V	2.00 V	2.08 V
$\Delta U$	0.014 V	0.024 V	0.048 V	0.106 V
$T_j$	~ 32.3 °C	~43 °C	~49 °C	~76.5 °C
$T_{PCB}$	~ 25–30 °C	~ 30–35 °C	~ 33–37 °C	~ 35–40 °C

B.2 (0.5 pt.)

The dynamic resistance of the LED has to be calculated as derivative at the asked values of  $I_{LED}$ .

$I_{LED}$	3 mA	10 mA	20 mA	40 mA
$\frac{dI}{dU}$	41.6 mA/V	100 mA/V	166.7 mA/V	400 mA/V

B.3 (1.5 pt.)

Graphed  $\Delta T(P)$ .

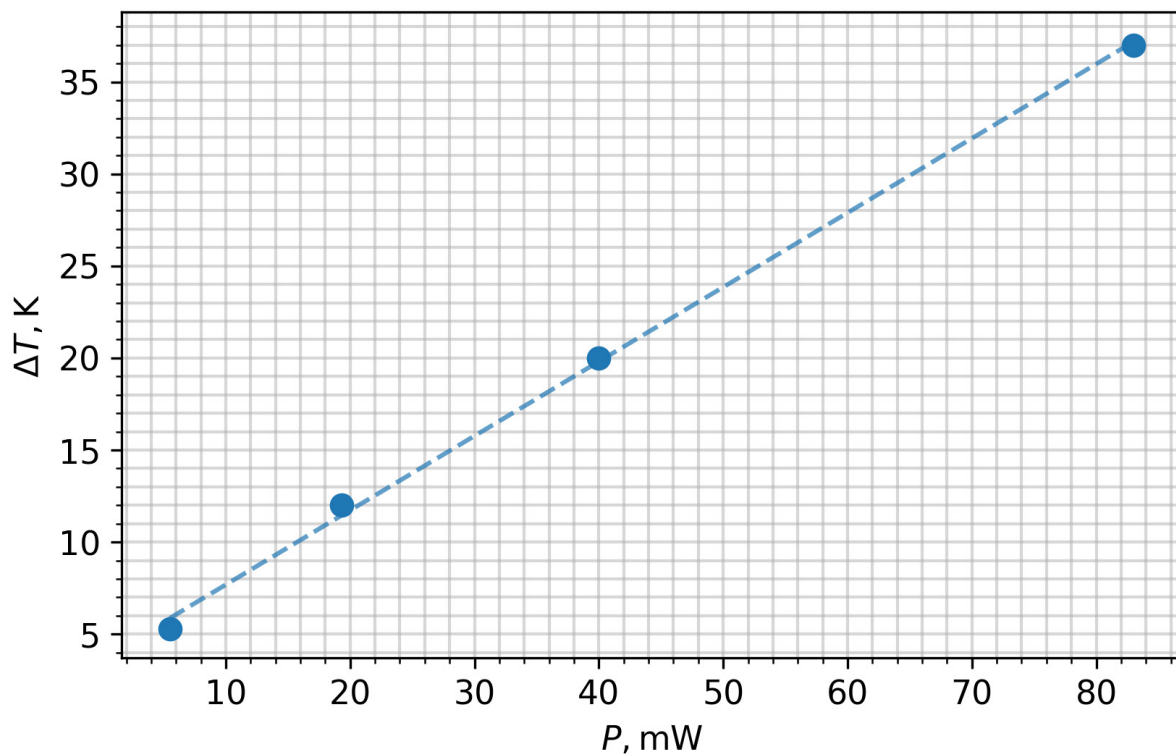
$\Delta T$  for each  $I_{LED}$  has to be calculated as  $\Delta T = \frac{U(\text{pulsed}) - U(\text{CW})}{\left(\frac{\Delta U(I,T)}{\Delta T}\right)} - (T_{PCB}(\text{CW}) - T_{PCB}(\text{pulsed}))$

from the data of A.2, B.1 and A.3.

Caution: during the measurement of B.1, the temperature of the PCB is not constant and rises up to 7 °C above the “room” temperature at higher currents. This has to be taken into account when calculating  $\Delta T$ .

The generated heat is taken as electrical power:  $P = I_{LED} \times U_{LED}$ . The energy emitted by the escaping light is neglected.

The graph should have a clear linear trend and approximated graphically. Thermal resistance is calculated as linear slope  $\frac{d}{dP} (\Delta T(P)) = 400 \text{ K/W}$ .



$I_{LED}$	3 mA	10 mA	20 mA	40 mA
$\Delta T$	5.0 K	12 K	20 K	37 K

**Part C: Calculation of the LED current drift due to the temperature (1.5 points).**

C.1 (1.5 pt)

The  $I_{LED}$  under constant  $U_{LED} = U_{20mA}$  is calculated:

$$I_{LED}(U_{20mA}, T) = 20 \text{ mA} - (T - T_{\text{room}}) \times \left( \frac{\Delta U(20 \text{ mA}, T)}{\Delta T} \right) \times \frac{dI(20 \text{ mA}, U)}{dU}.$$

$$I_{LED}(U_{20mA}, 0^\circ\text{C}) = 13.3 \text{ mA}, \quad I_{LED}(U_{20mA}, 40^\circ\text{C}) = 25.7 \text{ mA}.$$