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.

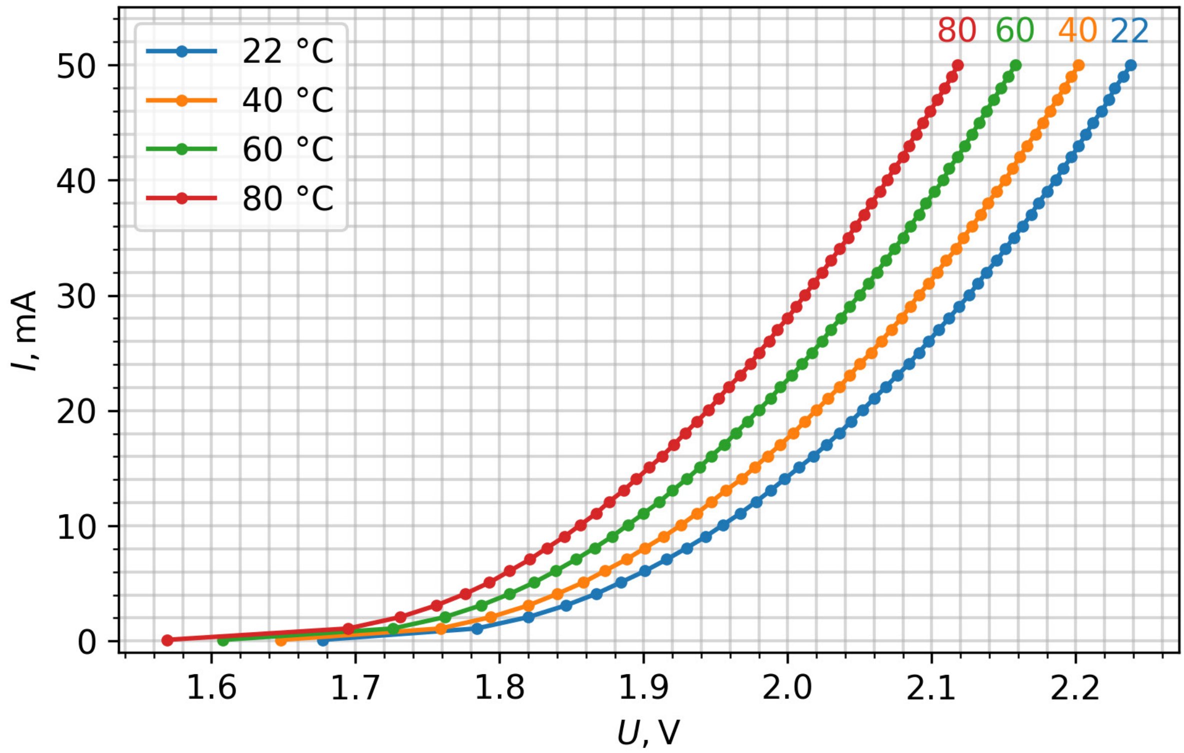
Students have to be able to run the automated $I_{\text{LED}}(U_{\text{LED}})$ measurement procedure and extract the required point by visually interpolating data for required values of I_{LED}.

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



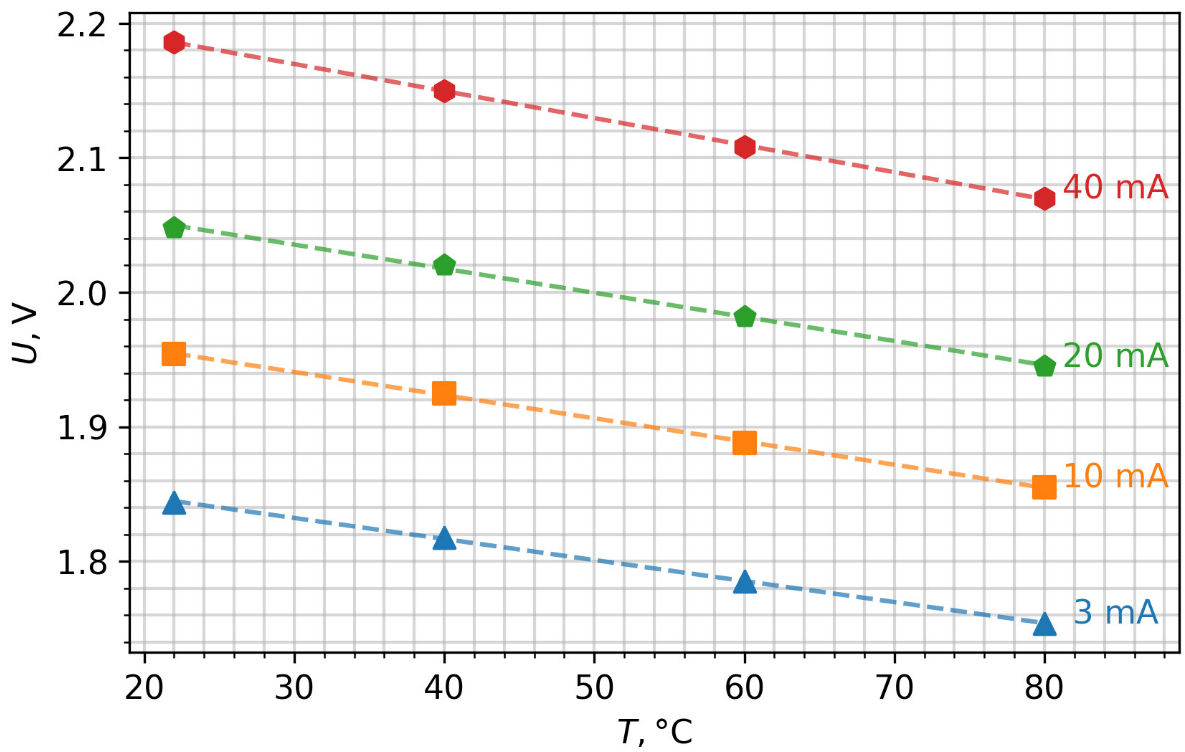
A.2 (1.0 pt.)

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

I_{LED} \ T	"Room" 22 °C	40 °C	60°C	80°C
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.

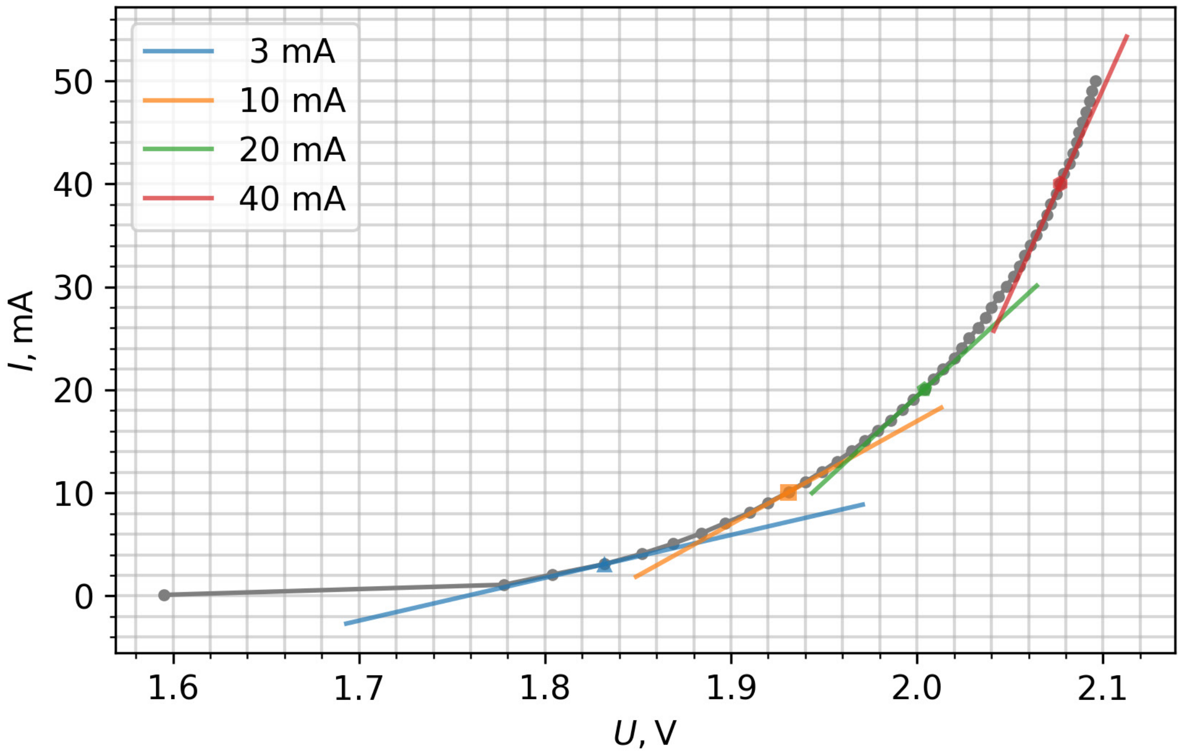


I_{LED}	3 mA	10 mA	20 mA	40 mA
$\left(\frac{\Delta U(I,T)}{\Delta T}\right)$	-1.55 mV/K	-1.7 mV/K	-1.8 mV/K	-2.0 mV/K

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

B.1 (1.5 pt.)

Graph $I_{\mathrm{LED}}(U_{\mathrm{LED}})$ 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
ΔU	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.)

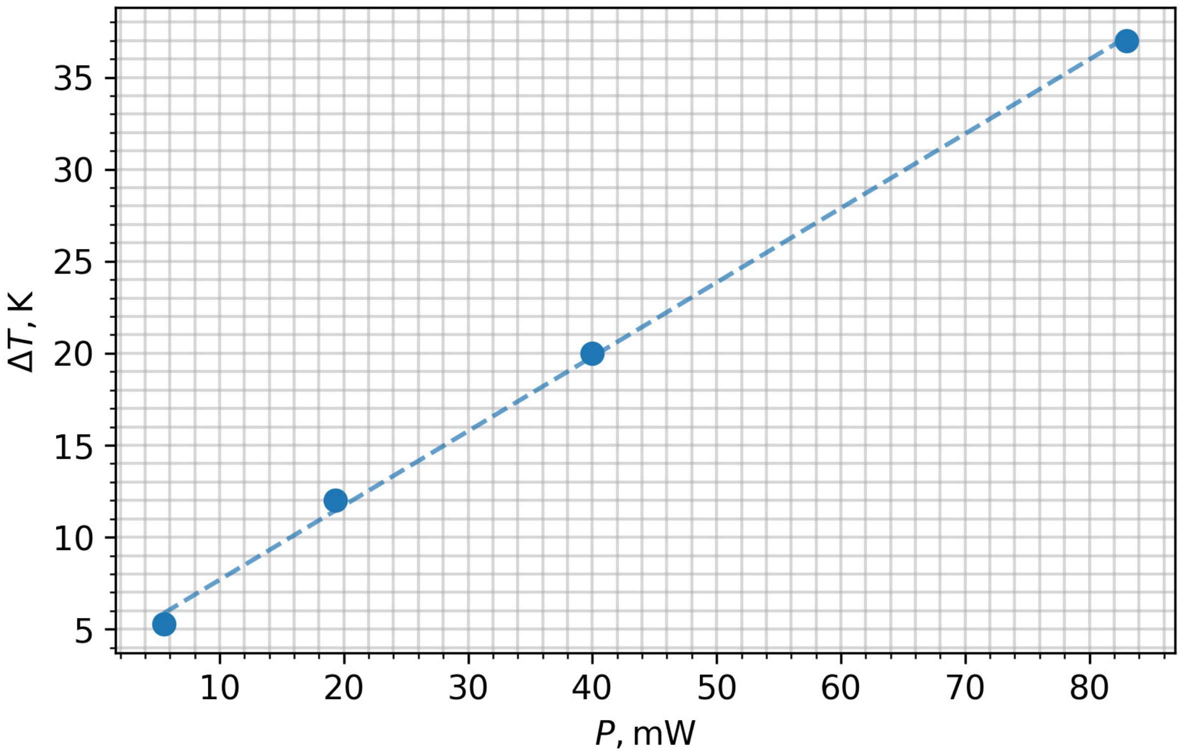
Graphed $\Delta T(P)$.

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

The generated heat is taken as electrical power: $P = I_{\text{LED}} \times U_{\text{LED}}$. 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 $\frac{\mathrm{d}}{\mathrm{d}P}\left(\Delta T(P)\right) = 400\ K/\mathrm{W}$.



I_{LED}	3 mA	10 mA	20 mA	40 mA
ΔT	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 $U_{\mathrm{LED}} = U_{\mathrm{20mA}}$ is calculated:

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

$I_{LED}(U_{\mathrm{20mA}}, 0°\mathrm{C}) = 13.3\ \mathrm{mA}$, $I_{LED}(U_{\mathrm{20mA}}, 40°\mathrm{C}) = 25.7\ \mathrm{mA}$.