15/11/2023

LAB1 – BASICS OF OPTO-ELECTRONICS

LED CHARACTERIZATION

In this Lab we will focus on the characterization of several LEDS

Available Material

i. Several LEDS, Breadborads and cables, Resistors of different values
ii. Multimeter to check their values!!!
iii. Photodetector
iv. Analog discovery
v. Lens and gratings of different types
vi. The Datasheets of the components

INTRODUCTION

The photo-effect is phenomenon of ejecting electron from the metal surface by an incident photon. The energy conservation gives the relation between the photon energy hν, the kinetic energy of electron and the work function parametrized with voltage. In the LED there is an inverse process of internal photo-effect: an electron and a hole with small energies recombine and emit a photon. The relation between the threshold voltage Uc at which the LED starts to emit light and the energy of the photon is:

$qUc \approx h\nu + const;$

where the qe is the charge of the electron. The constant in the equation above has small dependence on the material, from which the LED is made. The kinetic energies of the recombining electrons are negligible, i.e. much smaller than the energy of the emitted photon. Approximately we can assume that different diodes in the experimental set are made of materials with similar material constant.

Measuring the voltage drop U_c at which the LED starts to emit lighty

1. Using the values of the datasheet calculate the resistor that needs to be put in series with every LEDS in order to obtain the desired forward voltage at the nominal current
2. Once found try to find the closest resistor available and build the circuit on the breadboard
3. Try to think of a way to measure the current in the LED. Hint: you can measure the resistor precisely
4. Apply a sine using the wave generator with and amplitude starting at 1V and increasing slowly (steps of 0.5 V) up to the point you reach the maximum brightness

of the LED. Observe when you can see the emission of the LED and take note of this value Uc.

5. Create a Math channel that display the current in the LED
6. Create a Math channel that display the voltage across the LED
7. Plot the characteristic I-V of the LED. Before to start to put the points on the graphics think about the coordinate scales. It is better if your data fits well the entire area
8. On the V-I characteristic you can see almost linear segment with high slope at higher currents. Draw straight line, which touches this segment. (You can use a linear interpolation or any means you wish). Write the voltage of the crossing points Uc into table for all the LEDs
9. Compare these threshold voltages for each LED with the voltage drop when they start to emit light Uc
10. Take a look at the low slope in the V-I characteristic at low currents. Notice that the slope is almost the same

    for each of the LEDs. How you can explain this fact?

Table I: Experimental results for the voltage drop at which each LED starts to emit light.

№	Colour	U_c[V]
1	red	
2	yellow	
3	green	
4	blue	

Increase the speed of the excitation and observe the behaviour for the different LEDs. Some seem to be slower than others?

What could be the reason?

What could be the maximum bandwidth for data transmission of the different LEDs

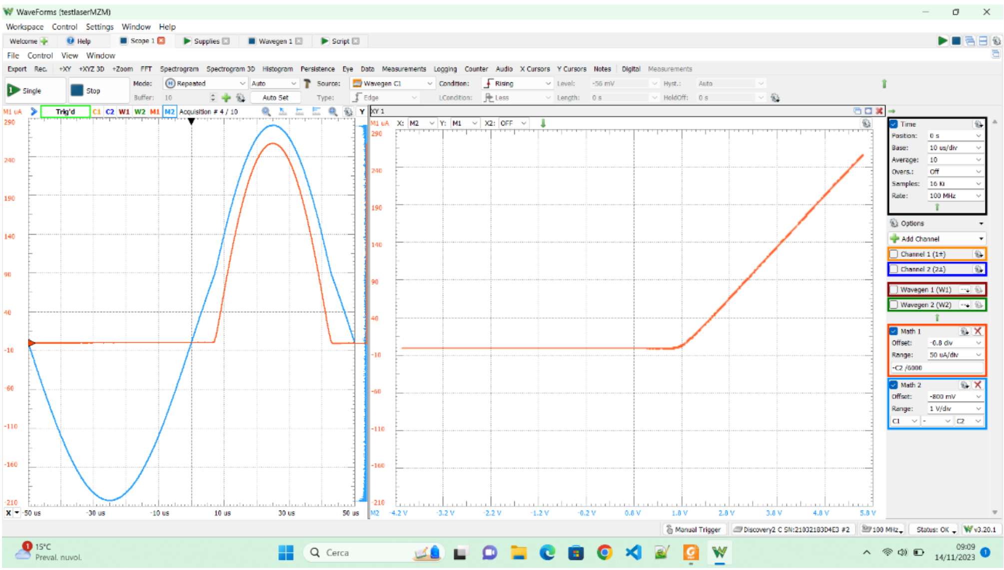

Figure 1 - screenshot of a measurement

MEASURING THE INTENSITY-CURRENT CURVE

Now we want to use the photodetector to measure the characteristic of the LED

11. Using the values of the datasheet try to think of a circuit to use the photodetector
12. Build the circuit and connect the analog discovery in order to measure the photocurrent
13. Try to get the characteristic of the different LEDs
14. Fit the graph you get (find the slope)
15. Find the threshold voltage where the intensity-current curve seems to start (linear projection on the zero axis)

OPTICAL MEASUREMENTS

Using the setup with the lens and grating measure the spacing of the spots and the distance between the grating and the screen.

1. Measure the diffraction angle:

$$\sin(\theta) = L/(L^2 + D^2)^{1/2} = \sin(\mathrm{arctg}(L/D))$$

Where D is the distance between the screen and the grating (try to be precise to the mm)

D is the center to center distance of the central spot to the first spot. Better to measure 2D the distance between the 2 first spot. Try to use different gratings. The screen might be too small though!!!

16. Calculate according to this angle the wavelength you get. Compare it with the datasheet
17. Now for each LED (except the IR) you will have a measurement of the wavelength (therefore frequency) and Uc. You can try to find the

FINDING THE PLANCK CONSTANT

Make a graphics using the experimental data from the wavelength and the threshold measurements

Fit the experimental points with a straight line that pass maximally close to the points. This straight line follows the approximate equation

qeUc ≈ hν + const. (2)

Determine the Plank's constant h = Δ(qeUc)=Δ(ν) from tangent of the angle between the straight line and the x-axis. Here Δ denotes difference for the segment of the straight line; difference in the x-axis and y-axis seggments. How is the value of the h = : : : J s that you have measured is in agreement with the know value of this fundamental constant? Fill the dots! What is the deviation 100 (hexp − h)=h = : : : %?

Try to redo the same with the intensity-current curves

Try to think of the different sources of errors in those experiments.

SIDE EXPERIMENT

LEDs has we will see can also be used as receivers when reverse biased.

18. Try to reversed biased with a large resistor in series (at least 100k) an LED and try to shine it with another LED of the same color.
19. Then try to reverse bias a blue and illuminate with a red.
20. Then inverse the situation. What could you observe? How can you explain the difference?

LAB REPORTS

The report for laboratory experiments must show in a concise way the activities carried out and the results obtained. It should contain the following parts:

Title, authors, etc.

Give the report a title, including the names of the group members who participated in the drafting. Include the date it was written.

Objectives and Specification

A brief description of the objectives of the laboratory experience, what is intended to be achieved, indicating the hypotheses and limitations. For example, for the measurements you can indicate the different information that were not precise or missing and you had to find for example in a datasheet.

Block Diagram

Show a diagram of the main components of the system, briefly describing their role and how they interact.

Components

A description of each component used. In order not to go on too long, in this section you will focus on the parts you developed yourself and not the elements given to you. It is therefore necessary to explain how it works, possibly with the help of graphs, diagrams, time diagrams.

Results

The results should offer the reader a good view of what you have done and possible how to repeat the measurements presented.

The results presented should be clear and fully explained . For example a graph should be explained in terms of the chosen coordinates (time, voltage, intensity,…).

Credits

Get into the habit of giving proper credit to the external resources you've used. If you show code that you didn't write, cite the source. If you show pictures that you didn't create, indicate the source. It is not enough to put the bibliography alone: it is necessary to cite the source in the text (possibly with reference to the bibliography).