# EE236 Midsem Exam

Midsem Hands-on (40 marks + 10 marks bonus) Date: October 1, 2022

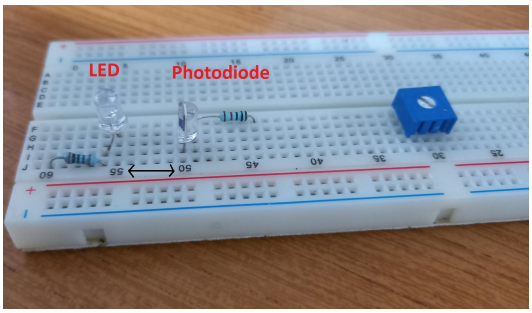
Instructions:

i This document is for the hands-on part of the exam. Check the power supply, digital multi-meters, arbitrary function generator and digital storage oscilloscope before starting.

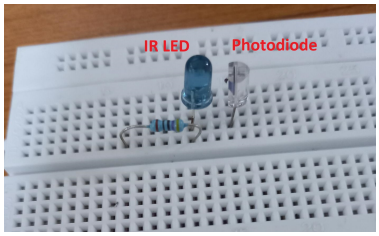
ii You may use previous handouts, supporting documents, your own net-lists and reports. Using the internet is strictly prohibited.

iii Make one document consisting of your observations, plots, results and answers. You will need to submit this document as your response.

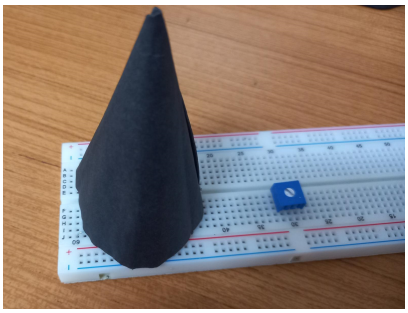
iv Refer the below diagram for component placement on bread-board part 2.



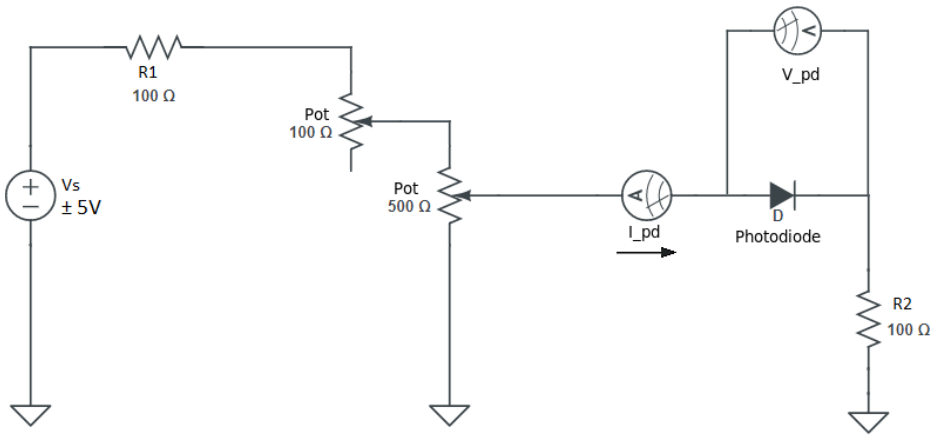

v Refer the below diagram for component placement on bread-board parts 3 and 4.




vi While measuring any characteristics, put the black cover on top of the setup to ensure light from outside does not fall on the photodiode. Make sure the potentiometer connections are outside the cover.



1. Obtain the dark I-V characteristics of the given photodiode for forward as well as reverse bias. Plot the $I_{pd}$ vs $V_{pd}$ and the log(abs($I_{pd}$)) vs $V_{pd}$ curves. The voltage should be varied using the potentiometers. Extract the ideality factor from the low forward bias ($0.1V - 0.4V$) region of the I-V data. (10 *marks*)

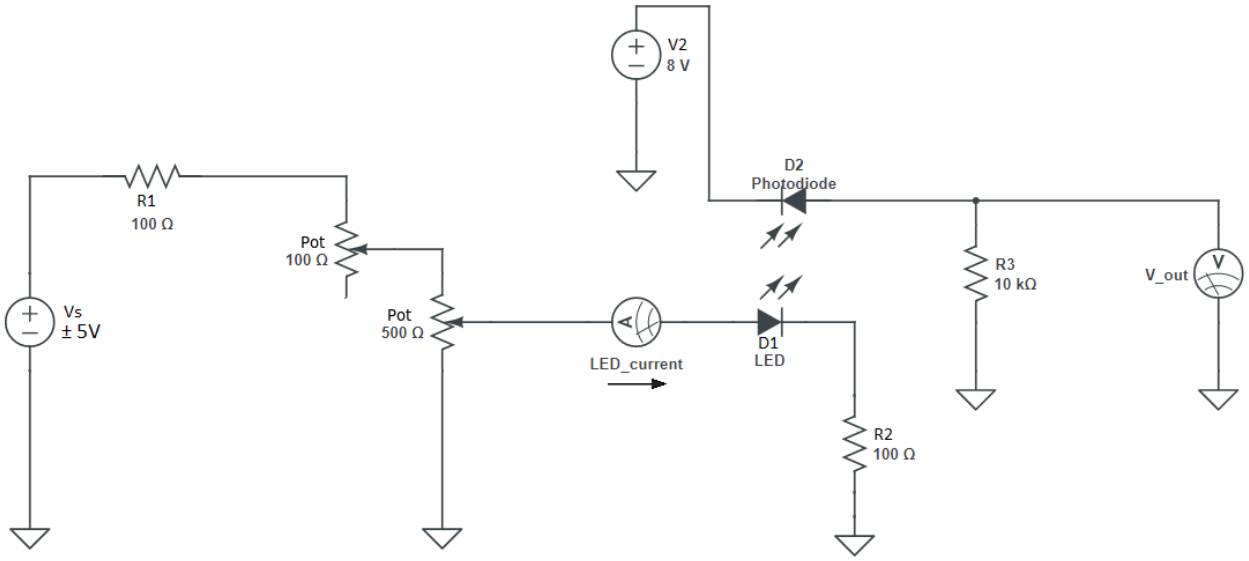



2. In this part, you need to find the response of photodiode for different lights and different intensities. 3 LEDs are provided, along with their current vs intensity data.

   i Choose any LED, say IR. Rig up the circuit shown below.
   **Note** : LED part of the circuit is same as the one used for part 1.

   ii Bias the IR LED to get the current corresponding to each intensity given in the IR LED table, and note down the output voltage $V_{out}$ which is proportional to the photodiode current under LED illumination.

   iii Repeat the same for other LEDs. You should have the responses of the photodiode for each LED at 3 given intensities.



Once you have all the readings, plot the following-

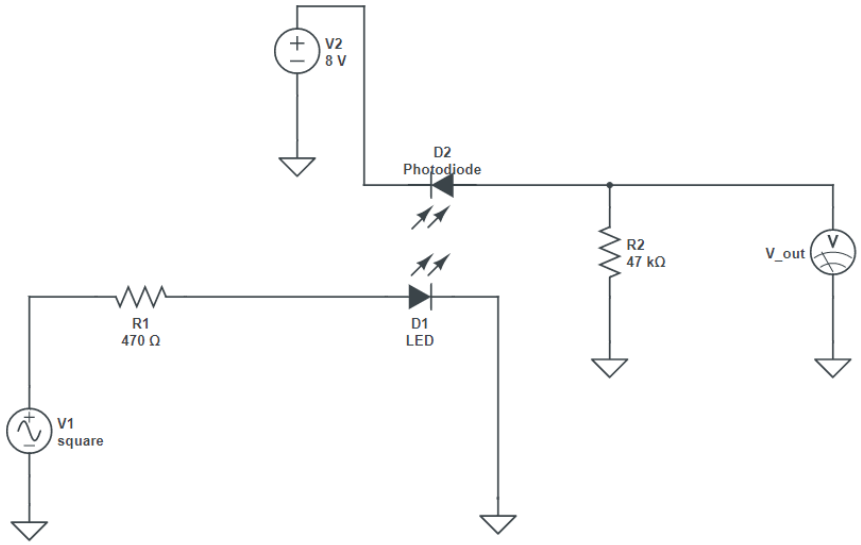
a $V_{out}$ vs wavelength (corresponding to the 3 LEDs) for each intensity. How would you explain the trend in $V_{out}$ vs wavelength? Assuming that the photodiode is made of silicon, what is the expected approximate value of $V_{out}$ at 1200 $nm$ illumination and 1000 $lux$ intensity? (12 *marks*)

b $V_{out}$ vs intensity for each LED. Explain the trend in $V_{out}$ vs intensity for any one LED. (8 *marks*)

3. In this part, you will be analyzing the transient characteristics of the photodiode. Rig up the circuit given below and use only the IR LED.

a Apply a pulse of amplitude $5V$ at $1kHz$ frequency and 50% duty cycle using the function generator. Observe photodiode output voltage on the DSO and measure its rise and fall times. (4 *marks*)

b Increase the frequency and notice the change in the output. What is the maximum frequency of LED switching that the photodiode can follow the input pulse? Which device processes limit the photodiode response during the LED on and off cycles? (6 *marks*)




Show the photodiode response ($V_{out}$) at a few frequencies to your TA.

4. **BONUS**: To be attempted only after finishing first 3 questions. (10 *marks*)

Replace the photodiode with a red LED (make sure it is reverse biased like the photodiode) and observe its switching response to the IR LED. How does it compare to the photodiode? What could be the difference in device architecture of the LED and the photodiode that can explain the difference in switching response?

**Current vs Intensity Data for each LED**

**Infra-RED Led**: $(\lambda = 950nm)$

| **Current** $(mA)$ | **Voltage** $(V)$ | **Intensity** $(lux)$ |
|---|---|---|
| 4.51 | 3.3 | 1000 |
| 5.17 | 3.6 | 1500 |
| 6.28 | 4.1 | 2000 |

**RED Led**: $(\lambda = 750nm)$

| **Current** $(mA)$ | **Voltage** $(V)$ | **Intensity** $(lux)$ |
|---|---|---|
| 2 | 2.7 | 1000 |
| 3 | 3.1 | 1500 |
| 4 | 3.7 | 2000 |

**BLUE Led**: $(\lambda = 450nm)$

| **Current** $(mA)$ | **Voltage** $(V)$ | **Intensity** $(lux)$ |
|---|---|---|
| 0.301 | 2.6 | 1000 |
| 0.416 | 2.6 | 1500 |
| 0.572 | 2.7 | 2000 |

You will only need to bias the LED with appropriate currents to obtain the corresponding intensities. Voltages are just given for reference.