Lux Meter

Project Outline

The goal of this project is to measure the intensity of light as it appears to the human eye. As a standard measure of light intensity, the unit **illuminance** will be used.

$$E_v = \frac{I}{r^2}$$

E_v	illuminance
I	luminous intensity
r	distance

To get a better sense as to how the illuminance(lux value) varies, the table 1 lists the lux values in practical lighting conditions.

Illumination condition	**Illuminance**
Full moon	1 lux
Street lighting	10 lux
Home lighting	30 to 300 lux
Office desk lighting	100 to 1 000 lux
Surgery lighting	10 000 lux
Direct sunlight	100 000 lux

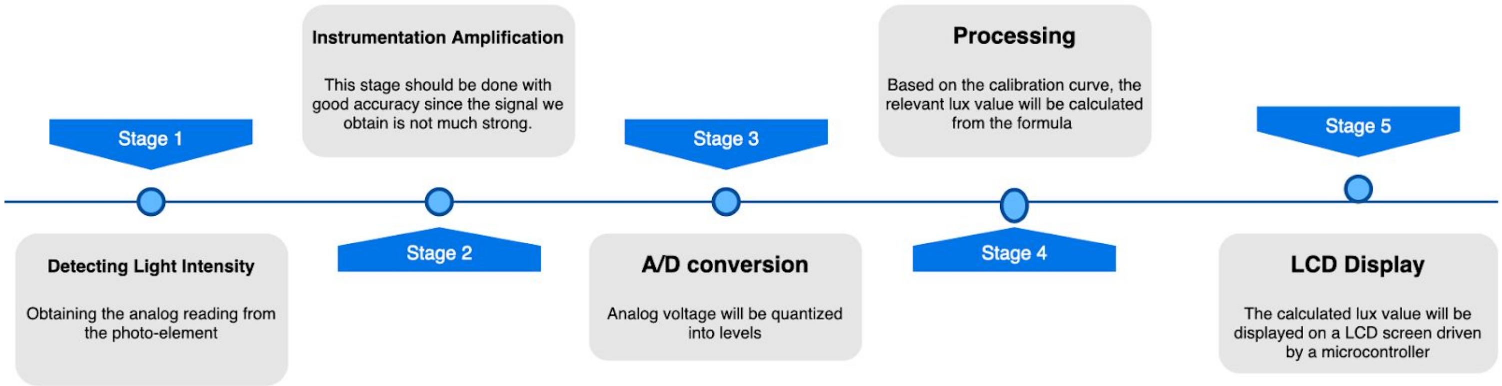
(Table 1 - Lux values at different illumination conditions)

As per the provided criteria for the Laboratory project[1] and the above table, we intend to develop a lux meter having a range of (0- 1000 lux)

Based on the comparisons and facts listed in this document, we have decided to use photo transistors to measure the light intensity.[2] A stage of calibration will be done in order to find out the correlation between the signal produced by the phototransistor and the actual lux value. Therefore calibration will be done with respect to a handheld lux meter.

[1] *"You need to design a Lux meter that is able to measure white and coloured LED light* ***under normal laboratory conditions****". (EN2090 - Laboratory Practise II - Lux Meter Project Description)*

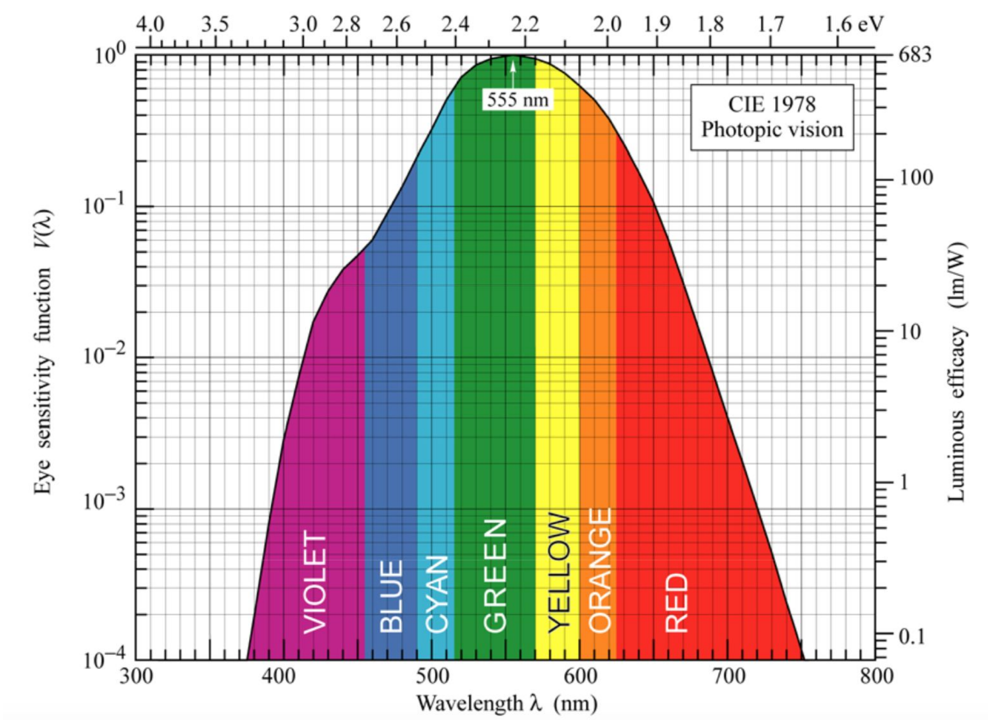
Block Diagram



Sensitivity of the human eye

This sensitivity curve will be of vital importance when selecting the photo element. A photo element having a similar spectral sensitivity curve as the human eye will produce best results.

Photopic vision - *denoting vision in daylight or other bright light*



(Figure 1 - Courtesy of Rensselaer Polytechnic Institute)

Comparison of Different Types of Photo Elements

	PhotoDiode	**PhotoTransistor**	**LDR**
Principle of operation	This device operates in the reverse bias condition. When the photons strike the diode it creates an electron-hole pair. If this striking happens in the diodes depletion layer or one diffusion away from it, due to the built-in electric field in the depletion layer holes move toward the anode and electrons towards the cathode. This produces a photo current. The total current through the diode is the sum of the dark current and photocurrent, therefore a minimum dark current will give the maximum sensitivity to the photodiode.	The phototransistor uses the basic transistor concept as the basis of its operation. In fact a phototransistor can be made by exposing the semiconductor of an ordinary transistor to light. The light enters the base region where it causes hole electron pairs to be generated. This generation mainly occurs in the reverse biased base-collector junction. The hole-electron pairs move under the influence of the electric field and provide the base current, causing electrons to be injected into the emitter. As a result the photodiode current is multiplied by the current gain β of the transistor.	A photoresistor (or light-dependent resistor, LDR) is a light-controlled variable resistor. The resistance of a LDR decreases with increasing incident light intensity.A LDR is made of a high resistance semiconductor. In the dark, a LDR can have a resistance as high as several megohms (MΩ) and in the light, a LDR can have a resistance as low as a few hundred ohms.If incident light on a photoresistor exceeds a certain frequency, photons absorbed by the semiconductor give bound electrons enough energy to jump into the conduction_band. The resulting free electrons (and their hole partners) conduct electricity. Therefore resistance is lowered.
Pros	● Wide spectral response (190nm -2000nm) ● Less noisy ● The output is quite linear with incident light ● Fast output response.	● Phototransistors produce a higher current than photo diodes. ● relatively inexpensive, simple, and small enough to fit several of them onto a single integrated computer chip. ● Phototransistors are very fast and are capable of providing nearly instantaneous output.	● LDRs are cheap and available in many sizes and shapes. ● They need very small power and voltage for its operation.
Cons	● Small active area ● No internal gain therefore external amplification is needed. ● Less sensitive when compared with a phototransistor. ● As the characteristics are temperature dependent it has poor temperature stability.	● It is insensitive to incident light from other directions than particular narrow window unlike photoresistor which is sensitive to incident light from anywhere in front of it. ● It has nonlinear characteristic and it is temperature sensitive. ● They are more susceptible to electricity surges/spikes and EM energy from radiations.	● Highly inaccurate. ● Response time is considerably greater than photodiodes and phototransistors. ● The sensitivity and resistance range of the LDRs will vary from one device to another. ● Their sensitivity varies with the wavelength of the light incident on them.

Selecting a specific Photo element

We narrowed down the available options for the photo transistor. (Selected based on [2])

Model	Peak wavelength	Remarks
SFH 3310 	570nm	OSRAM Opto Semiconductors SFH Ambient Light Sensors feature spectral sensitivity adapted to human eye sensitivity.
TEMT6000 	570nm	TEMT6000 is a silicon NPN epitaxial planar photo-transistor in a miniature transparent mold for surface mounting onto a printed circuit board. The device is sensitive to the visible spectrum.

References

[1]https://www.ecse.rpi.edu/~schubert/Light-Emitting-Diodes-dot-org/Sample-Chapter.pdf
[2]https://www.mouser.co.uk/ProductDetail/OSRAM-Opto-Semiconductors/SFH-3310?qs=nTDII3UaDK7Q6k0dcfX6Lw==
[3]https://www.arrow.com/en/products/sfh3310/osram-opto-semiconductors

https://www.vishay.com/docs/84154/appnotesensors.pdf

PhotoTransistor Models

https://www.arrow.com/en/categories/optoelectronics/photoelement/phototransistors?promoGroupLevel=pl&filters=Peak+Wavelength:570

PhotoDiode Models

https://www.arrow.com/en/categories/optoelectronics/photoelement/photodiodes?page=3&sortBy=Type&sortDirection=desc

Reading materials

http://dergipark.gov.tr/download/article-file/465674

https://www.digikey.com/en/articles/techzone/2018/sep/how-to-use-photodiodes-and-phototransistors-most-effectively