ABSTRACT

The amount of light is an important issue in several scenarios ranging from scenic design, light pollution study, robot's navigation, occupational health and safety, illumination engineering, agriculture, medical appliances and many more. It is typically determined by using an illumination meter. The meter, also known as lux meter is used to measure the density of light in area which measured in lx unit. It is used in photometry as a measure of the intensity, as perceived by the human eye of light that hits or passes through a surface. As in normal meter, the lux value was obviously a displayed value, and hardly used for embedded application as well as for lighting monitoring considering its expensive price. This limits the lighting monitoring in certain critical field. Therefore, in this paper, we present our initial works on the development of simple lux meter that is applicable and suitable for daily life activities.

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Chapter – 1 Introduction

1.1 Basic Information

Lux meter or light meter is a device which measures the brightness of light in lux. It is usually used in photography, cinematography, scenic design, and architectural light design and also in illumination.

The lux is the SI derived unit of illuminance and luminous emittance, measuring flux per unit area. It is equal to equal to one lumen per square meter. The measuring unit of lux meter is lux or cd/m^2 (since 1 lux=1 cd/m^2).

To construct the lux meter BH 1750FVI light sensor was used. BH 1750FVI is a digital Ambient Light Sensor having I2C interface. This IC is suitable for obtaining the ambient light data. It is possible to detect wide range at high resolution.

1.2 Objectives :

The objectives are:

- To design the infrastructure of lux meter
- To configure and construct the inner circuit and mechanism
- To construct the lux meter and give it a commercial look
- Finally measure the light density of a certain place using the lux meter

1.3 Reasons for choosing this project

The project was to construct a lux meter. The main reason to choose this project was to minimize the consumption of energy basically electric energy. Along with this lux meter is helpful in photography, cinematography, scenic design etc.

Light is a fundamental need of our daily life. In educational purposes, shopping malls, school, college, universities, we need light. We normally use daylight, but at night, dark condition we have to use artificial light. We can get artificial light by transforming another form of energy, in this case mostly electric energy. We can calculate the sufficient amount of light at each sections. Using the lux meter we can control the amount of light by doing this we can achieve the desired light condition. By this extra use of light can be eliminated. Therefore minimization of energy was achieved. The whole purpose is to measure the illumination level in the interior and to switch off or reduce the output level of luminaires. This can greatly reduce the energy burden of the building by significantly increasing the efficiency of its lighting system. It is therefore recommended to use light meters in lighting systems, especially in rooms where one cannot expect users to pay attention to manually switching off the lights. Examples include hallways, stairs, big halls, shopping malls and big halls

Lux meter is used in the field of photography also. In photography, a light meter is often used to determine the proper exposure for a photograph. Typically a light meter will include either digital or analog electronic circuit, which allows the photographer to determine which shutter speed and f-number should be selected for an optimum exposure, given a certain lighting situation and film-speed.

1.4 Review of other projects

This section explains some previous projects on lux meter and their analysis procedure.

- On December, 2013 a project was done about lux meter by Zubair khan. The objective of the project was to design and develop an inexpensive and accurate light intensity meter basically using only electronics components. It also provides an opportunity to apply the knowledge of electronics module to design a prototype of a product.

  The application of this project was

  - Sensitive Medical Equipment.
  - Checking lamp or fluorescent tube light illumination.
  - Automatic solar tracking device.
  - Measurement Sunlight lux in day time.
  - light sampling
  - Checking light intensity in the room.
  - Automatic streetlights intensity controlled [1]

- Another project was done on Digital Light Meter by Ak Muhammad Saufi during 2011.the objective of that project was to measure the level of light at a sensor and to display the value of the lux in a qualitative manner on the LCD and to collect data recorded. Finally to give an idea of the light cycle for duration of data collected

  •This project aims to measure the level of light at a sensor,

  •Display the value of the lux in a qualitative manner on the LCD,

  •In addition, to record that to a file along with a time the measurement was taken.

  •The output data should give us an idea of the cycle of light over the course of a day or week or however long the data is collected for.

  In this project, it is based on a microcontroller using a light dependent resistor as a sensor of light, to build a light meter. At nighttime, the meter detects the light condition for that current time period. This will show the amount of light, in a light environment. The meter will able to give current light reading in 5 modes in qualitative manner. In addition, another prototyping shield can be attach on top of the microcontroller, it will inform the amount of light and also the temperature in an environment, and this feature will be called a light and temperature data logger. This feature enables to track the amount of light and temperature in an environment. The main goal of this final year project is to implement all that we have studied to create something new and making things more useful. It is also to prove our practical knowledge to increase the productivity.

The results demonstrated that the digital light meter is functioning as per intended design, and meeting the overall project objectives. The project is successfully implemented, within a timeframe which total cost estimated at $ Some typical applications of the equipment can be used for monitoring and recording light sensitivity and temperature such as light testing in the factory, home, office, farming, hospital, laboratory and food storage for preservation. It can also be used for trending on condition change for analysis or investigation. The project has achieved its objective by demonstrating measurements of light levels in a different environment, able displaying the value of the lux in a qualitative manner on an LCD, measurements were recorded during a certain period of time, and data collected over the course of a day providing an idea of the cycle of light. The written program plan was successful when tested using software and results were achieved as expected. Applying the program to the hardware circuit show some inaccuracy due to some source of errors regarding the light sensor used for the project. Throughout this experience in the final year project, a lot of knowledge has been gained especially in designing the program code, electronic circuitry, testing the sensor and output devices and the project itself. The opinions and tips from the supervisor also helped in solving the problems during the process of this project such as type of sensor, electronic component, how it is to be demonstrated etc. The theoretical part that has been studied was able to be applied to practical on tasks especially when implementing the circuit and carrying out the test on the project. Above all, working on the light meter was enjoyable, and know that the project was functional. Moreover, being self-motivated, and analytical in ways on how to develop individual performances were achieved, as well as how to give commitment to the project. [2]

1.5 Uniqueness of this project

The main uniqueness of this project i.e. Lux meter which was done by us is very simple. There are no complicated connections in internal circuit of this project. The cost was reasonable and very low compared to other lux meter. We were able to give a nice commercial look which was slim and very handy. It was quiet efficient to its purposes.

1.6 Literature review

We have studied some literatures regarding lux meter to make this project more efficient and less costly. This section explains some previous literature on lux meter and their analysis procedure.

- A paper was published in November 2010 about low-cost cell-phone-based digital lux meter. The amount of light is an important issue in several scenarios ranging from scenic design, light pollution study, illumination engineering, and agriculture. It is typically determined by using a portable digital light or lux meter. By realizing that the proliferation of cell phones is currently tremendous, the purpose of this paper was for the first time a low-cost cell phone based digital light meter. The innovative idea comes from the fact that the digital camera built into the cell phone is functioned as a two-dimensional light sensitive device and the captured image can be made diffuse. In this way, the diffused image is correlated to the corresponding light level by the built-in microprocessor of the cell phone and our specific algorithm embedded. Our experiment using a typical cell phone embedded with a digital camera and our JAVA program will be discussed.[3]

- Another paper on development of a webcam based lux meter was published in 2013 IEEE Symposium on Computers & Informatics (ISCI).As we know the amount of light is an important issue in several scenarios ranging from scenic design, light pollution study, robots navigation, occupational health and safety, illumination engineering, agriculture, medical appliances and many more. It is typically determined by using an illumination meter. The meter, also known as lux meter is used to measure the density of light in an area which measured in lx unit. It is used in photometry as a measure of the intensity, as perceived by the human eye of light that hits or passes through a surface. As in normal meter, the lux value was obviously a displayed value, and hardly used for embedded application as well as for lighting monitoring considering its expensive price. This limits the lighting monitoring in certain critical field. Therefore, in this paper, they present their initial works on the development of a webcam based lux meter that is applicable and suitable for lighting monitoring as well as the ability to be used in embedded application. A series of controlled images are taken, and image processing is applied to the images. The results of image processing are statistically analyzed and a linear relationship between lux value and average grayscale has been obtained with satisfactory R2. The linear function is tested and the results are justified where the algorithm for low cost webcam-based digital lux meter has been successfully developed. [4]

Chapter – 02 DESIGN AND CONSTRUCTION

2.1 Methodology & Planning

Methodology & Planning adopted in approaching the design and to get the final product showing below through a flow chart:

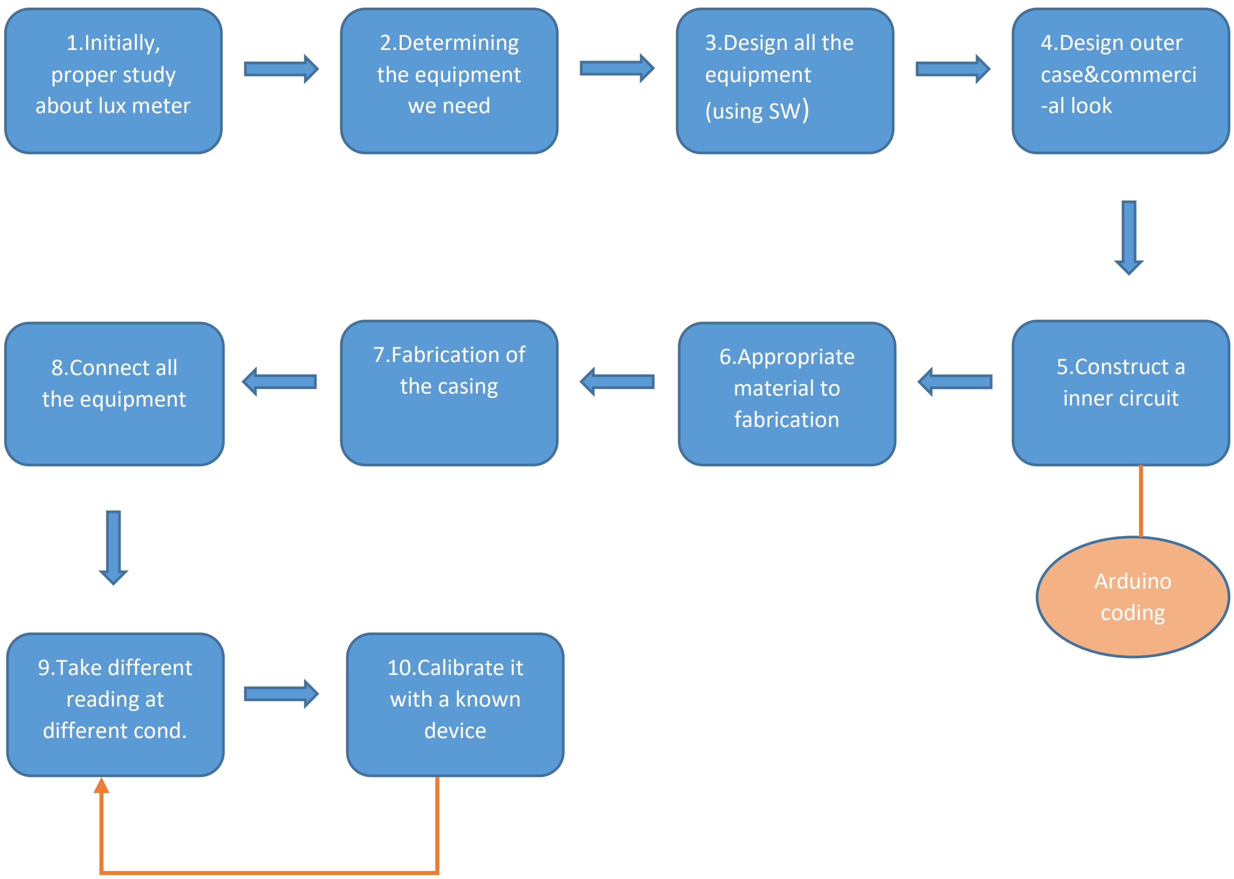

Figure 2.1: Flow chart of working procedure.

2.2 Approximate time frame for every steps using Gantt chart

Task	Start date	Duration
1	1/15/2019	7
2	1/22/2019	7
3	1/29/2019	14
4	2/5/2019	5
5	2/12/2019	9
6	2/19/2019	2
7	3/5/2019	8
8	3/19/2019	3
9	4/12/2019	1
10	4/12/2019	2

Table 2.1: Working time frame

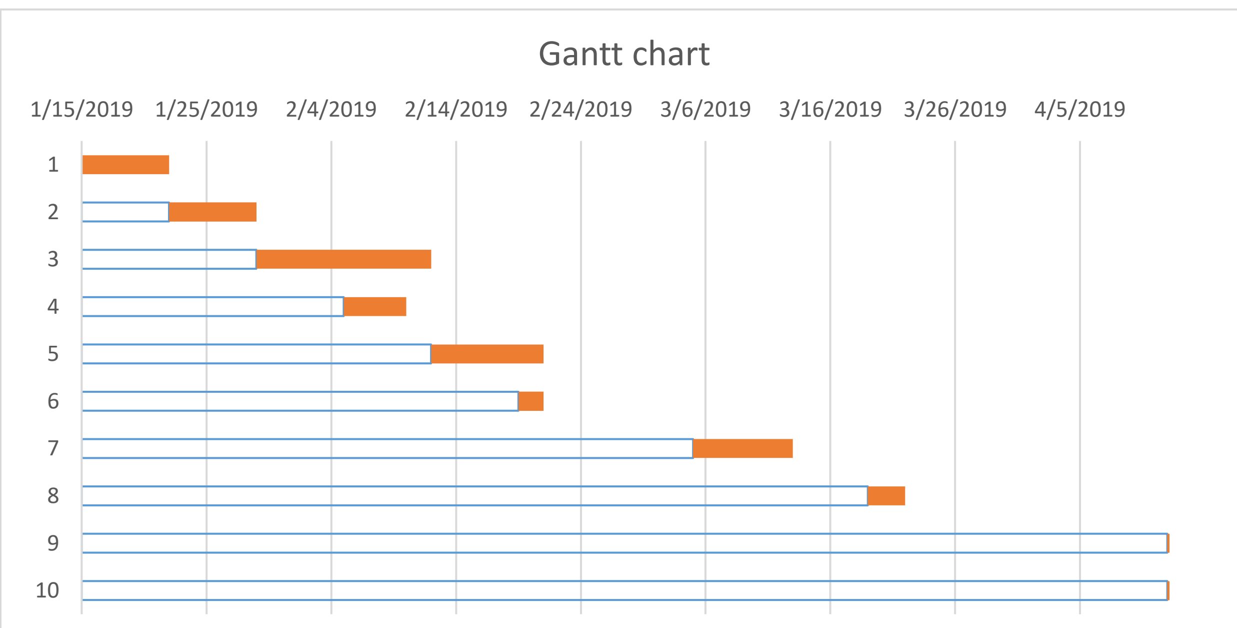

Figure2.2: Gantt chart

2.3 Pictures of key components/assemblies of the project.

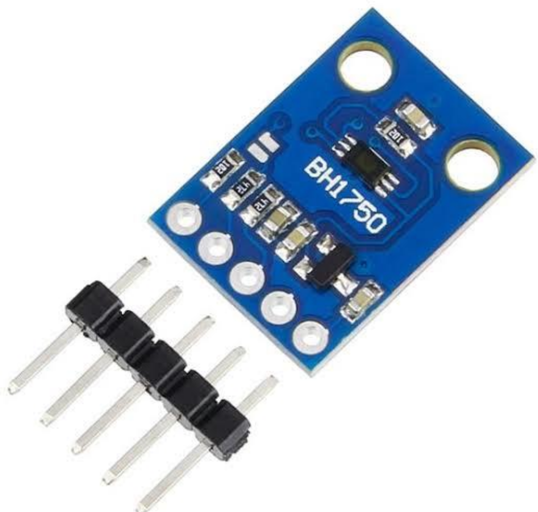

Figure2.3:BH1750fvi sensor.

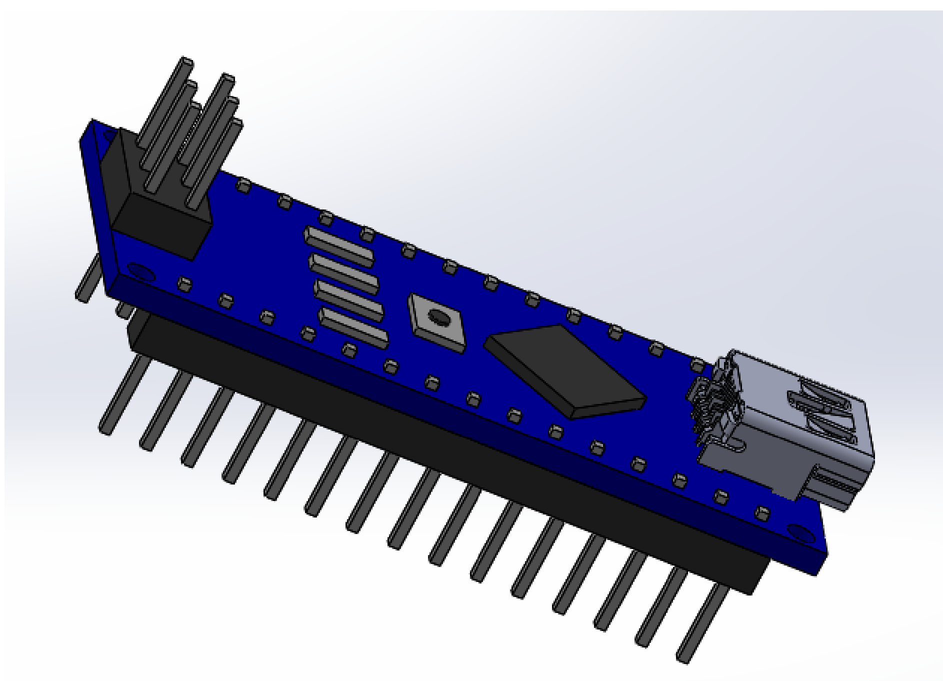

Figure2.4: Arduino Nano SW drawing

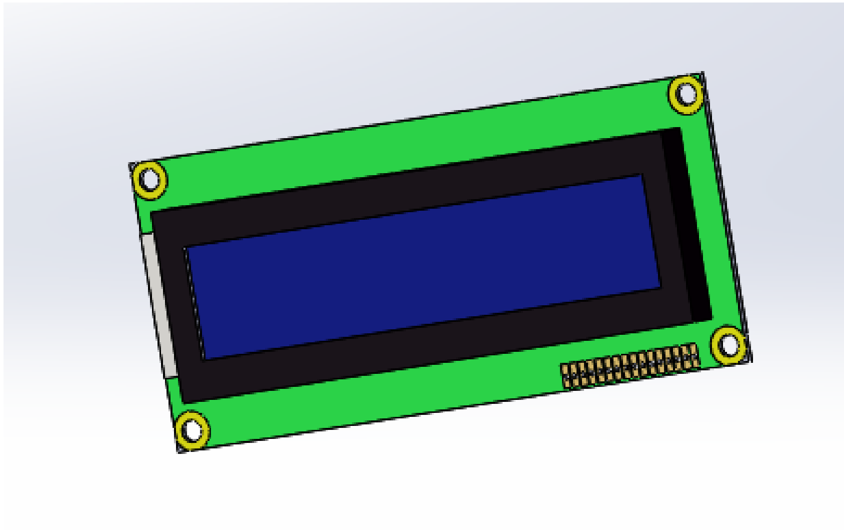

Figure2.5:16*2 LCD display

Figure2.6: Bulk module

Figure2.7: Back and front casing SW design

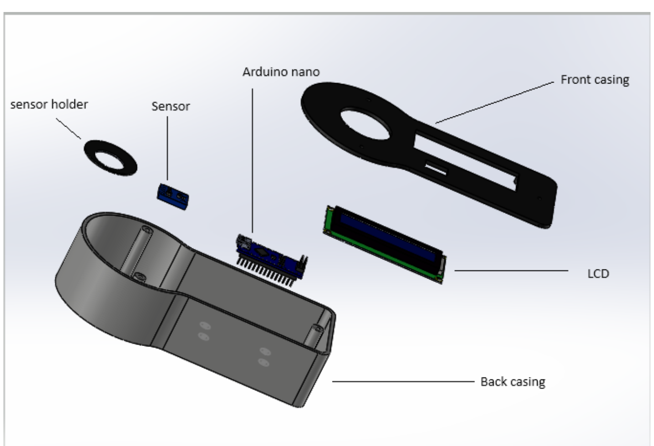

Figure2.8: Exploded view of components

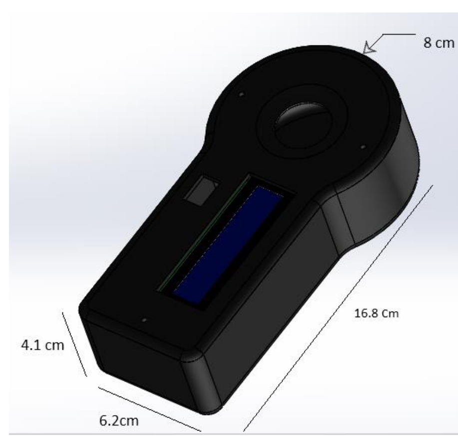

Figure2.9:3d view SW drawing

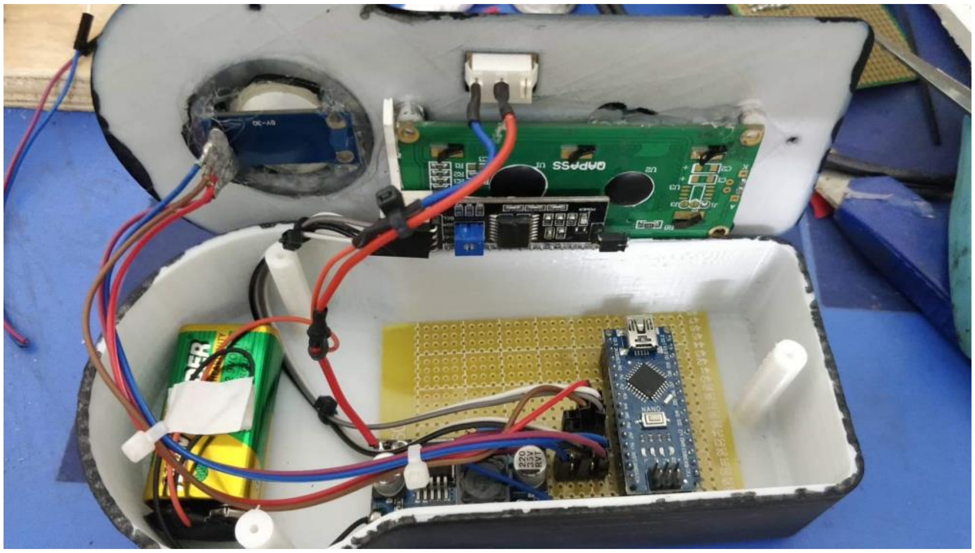

Figure2.10: internal set up of the lux meter

Figure2.11: Final product

2.4 Bill of Material and Specification

Material/Component	Price(tk)
Bh1750fvi sensor	550
16*2 LCD display	250
Arduino Nano	280
Vero board	20
wire	20
Switch	15
Battery	30
Bulk module	60
3D print of casing	500
TOTAL	1725

Table 2.2: Material/Component

Chapter – 3 Working Methodology

3.1 Illustration of the setup works

The setup and connections were so easy and simple.

Block Diagram:-

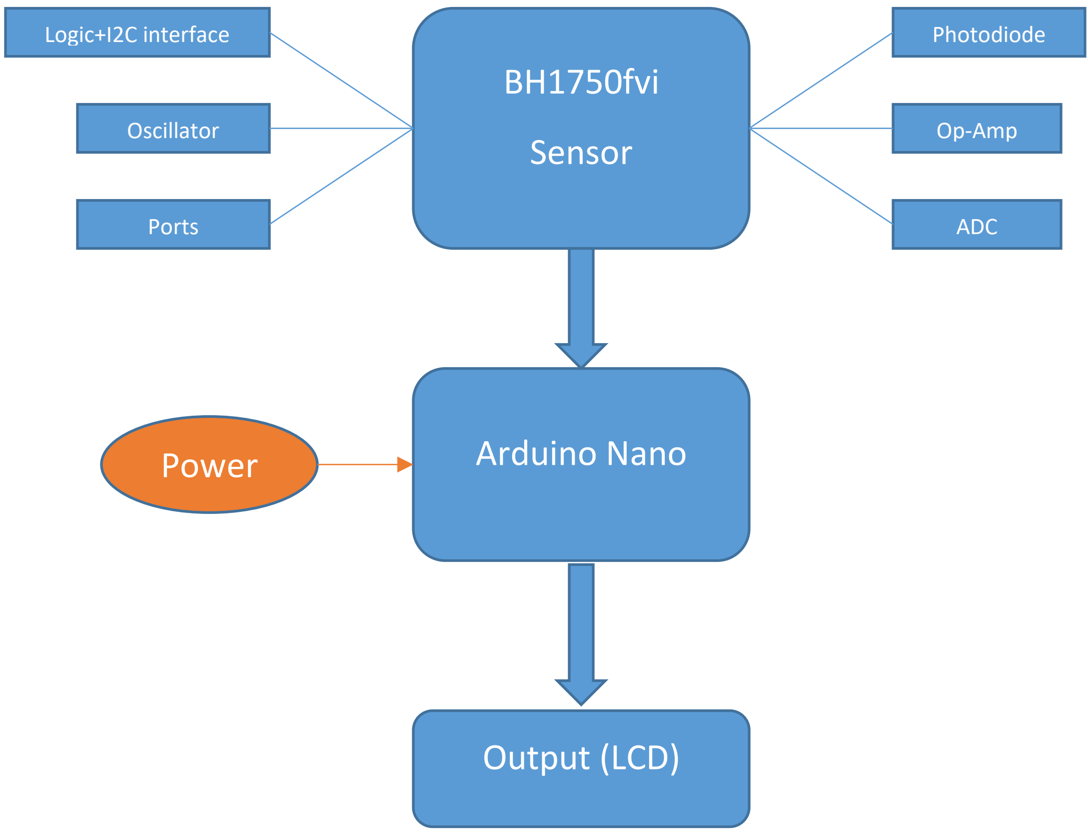

Figure 3.1: System Block diagram

Setup Illustration:-

The light particles i.e. photon molecules heat the deflection region of photo diode of bh1750fvi light sensor and give the data in voltage. Bh1750fvi light sensor has five ports. VCC and GND are connected to the power source. SCL, SDA & ADD are connected to Arduino's SCL, SDA & ADD respectively.

[5]

Components of BH1750FVI are:-

- Photo Diode
- Op-Amp
- ADC(Analog to digital converter)
- Logic + I2C interface
- Oscillator
- Adder
- Ports(VCC, SDA, SCL,ADD & GND)

Arduino receives the output of bh17450fvi as it's input. Then it processes the data according to the code(command).The code was

```
/*
Connection:
VCC -> 5V
GND -> GND
SCL -> SCL
SDA -> SDA
ADD -> GND
*/
#include <Wire.h>
#include <BH1750.h>0
#include <LiquidCrystal_I2C.h>
//I2C pins declaration
LiquidCrystal_I2C lcd(0x27, 20, 4);
BH1750 lightMeter;
void setup(){
lcd.init(); // initialize the lcd
lcd.backlight();
Serial.begin(9600);
```

```
Serial.begin(115200);
// Initialize the I2C bus
Wire.begin();
lightMeter.begin();
Serial.println(F("BH1750 Test begin"));
/*lcd.print;*/
}
void loop() {
float lux = lightMeter.readLightLevel();
Serial.print("Light: ");
lcd.setCursor(2,0);
lcd.print("Light: ");
Serial.print(lux);
lcd.setCursor(2,1);
lcd.print(lux);
Serial.println(" lx66");
lcd.setCursor(8,1);
lcd.print(" lx");
```

```
delay(2000);
}
```

According to this code an output was processed. This output was sent to the liquid crystal display i.e. LCD and the final result appeared in the display. A bulk module was used to control the Arduino power.

3.2Experimental data.

Using the lux meter we get some values then compare it with other standard values.

Condition	Commercial product(lux)	Our pro(LUX)	% of error
1	29	27	6.896551724
2	33	28	15.15151515
3	164	134	18.29268293
4	165	139	15.75757576
5	174	169	2.873563218
6	180	171	5
7	334	297	11.07784431
8	480	347	27.70833333
9	503	470	6.560636183
10	1430	1219	14.75524476
11	1470	1387	5.646258503
12	3400	3300	2.941176471
13	4056	4065	-0.22189349
14	4886	4965	-1.61686451
15	7010	6908	1.455064194

Table 3.1: Data comparison [6]

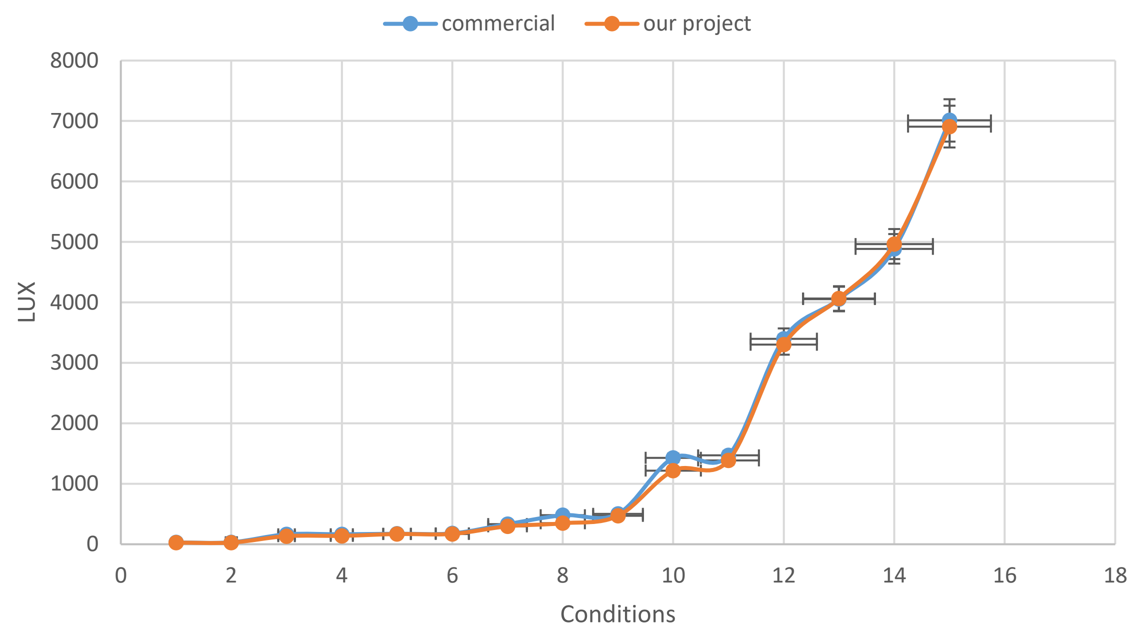

Figure 3.2:Commercial vs our Product in different condition

Conditions	Approximate value(avg) (lux)	Our product(lux)
public area with dark surrounding(20-50lx)	35	26
Family living room(50lx)	50	53
Office(80)	80	76
Full day light (not direct sun) (10000-25000)	10000-25000	13325

Table 3.2: Comparison with different value in different condition [7]

Chapter – 4 Results

4.1 Objectives completed and how they were completed.

- First objective was to design the infrastructure of the lux meter. We've successfully done it
- Second objective was to configure and construct the inner circuit and mechanism. We've done it according to the design that we've made.
- Third objective was to construct the lux meter and give it a commercial look. After finishing the above task we've constructed the casing and mounted the circuit and inner component into it. After that we've made the lux meter handy and small to give it a commercial look
- The fourth objective was to measure the light density of a certain place using the lux meter

4.2 Objectives not achieved or changed during the project duration.

All the four objectives were performed successfully, so there are no objectives that we've failed to achieve. We also did not change any objectives during the project duration

4.3 Limitations

- Absence of memory storage due to the failure of design. If we inserted a memory chip in the product than it will be contradictory to the internal design.
- Slower response in dark region because bh1750fvi sensor has slower response in low light region
- Failed to reduce the thickness due to usage of local components.
- Weight is larger than commercial product.

Chapter – 5 Conclusion

A lux meter is an equipment that measures brightness of falling on an object at a particular area. In other words, it properly gauges the intensity at which brightness appears to the human eye. Lux can be simply defined as a unit of measurement of illuminance or more accurately, brightness. It derives its name from candela, which is the standard unit of measurement for the power of light. In recent years, both scientists and industry authorities have come to the conclusion that light intensity is an important factor for productivity. In our country we waste a lot of light in various sections such as jewelry shop, billboard, shopping mall, restaurant etc. On the other hand, we don’t get sufficient light in rural area especially in school & college. As lux meter is not available due to its high range of cost so we construct a lux meter that is very reasonable in cost. If there is no proper light in school, college and office then it will affect the human eye sight. It can also be used for trending on condition change for analysis or investigation. That’s why we choose a simple lux meter for the purpose of daily life activities i.e. to compensate the energy basically electric energy. There are four objectives in our lux meter project. Firstly, we designed the infrastructure of our lux meter. Secondly, we configure and construct the inner circuit and mechanism. Thirdly we construct the lux meter and give it to a commercial look. And finally we measure the intensity of a light of a particular place by using lux meter. By this way we completed our four objectives properly and efficiently. The results demonstrated that the lux meter is functioning as per intended design, and meeting the overall project objectives. The project is successfully implemented, within a timeframe which total cost estimated at BDT 1750. A basic lux meter will cost you a couple of BDT 4000-12000. But the lux meter which we made is very cheap. But if mass production increases then the cost will be lower. It is important to look at what features come with each model and assess each on its merits. Cheaper lux meters may not offer the same level of accuracy that is needed in our industry. Receiving specific readings is imperative given the importance of quality light. Most lux meters can provide an accuracy to around five lux. Higher cost models could offer improve this level to 3 lux. A construction site can be dusty and dangerous so the size and portability of a lux meter should be considered. Our lux meter device is also small and very easy to operate. Businesses investigating purchasing lux meters should look for the above key features. The recommendation for lux meter is to save the data for different places. So that we can easily understand and analysis the lighting level of different places. Lux meter should be handy and slim so that it can carry anywhere.

Chapter – 6 Appendix

6.1 List of figures

6.2 Parameters

- 1 lux = lumen/m^2
- 1 lumen = 1 candela .sr

6.3 References

[1] https://www.scribd.com/doc/204342589/Light-intensity-meter-project-report

[2] https://slideplayer.com/slide/6101376/

[3] Sarun Sumriddetchkajorn and Armote Somboonkaew "Low-cost cell-phone-based digital lux meter", Proc. SPIE 7853, Advanced Sensor Systems and Applications IV, 78530L (9 November 2010); doi: 10.1117/12.870176; https://doi.org/10.1117/12.870176

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[6] “ELECTRIC PARK”;148Nawabpur Road, Taj Electric Market ,Dhaka-1100,Bangladesh.

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