Digital Multi Angle Illuminator

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***Abstract* – Illuminance can be measured by Lux meter. It can measure light intensity for an area example for working area. Light intensity is important since it must be measured correctly to know is it enough for a person to work. The scope of study is to discover light spread from other angles from the ambient light and the value will be appearing on the LCD screen. A hexagon shape can be used to measure illuminance from 60°, 90°, 120° and 180°. The sensors that are used are photoresistor PGM1200 series. This sensor will transfer the light luminance to current signals by using a voltage divider circuit connected to an Arduino. Arduino is used to convert from an analogue signal to digital signal then will be displayed the value on the LCD as it has been programmed. The multi angle Lux meter is calibrated using HIOKI Lux hi tester 3421 as a reference. As a result, the Multi angle lux meter can measured up to 600 Lux and at side angle of the lux meter have different of Lux.**

Keywords – Illuminance, Lux, photoresistor, luminance, hexagon

I. INTRODUCTION

Nowadays a good source of light is important for human. This is because most of the time people rely on the light to complete their job. Dr Victoria Revell, a chronobiologist at the University of Surrey states that "Light is critical for our health and wellbeing. Ensuring that we receive adequate light levels at the appropriate time of day benefit our alertness, mood, productivity, sleep patterns and many aspects of our physiology" [1]. People's health will be affected if there is a different source of lightings; the luminance is not suitable for the types of working. There is a certain standard that require how much typical illuminance measure in room whether it is suitable for the job [2].

Lux meter is the critical instrument to measure light become easier. The Lux meter became important because it can measure the light intensity in a room so that it can set a standard of illuminance. The standard value of the luminance according to types of room or workplace, it can save energy and provide a calm working area for people [1]. The sensors of the light meter work with photo cell but it also works well with photo resistor. These sensors have a similar function that resistance will decrease with increasing light intensity. Then it will deliver a current value so it can be measured. The amount of the current value will be calculated and converted to Lux value.

Currently Lux meter is widening its used. The Lux meter now is utilized in plantation industries. The correct level of light is a necessity for plant growth. Sufficient light is needed for photosynthesis to take place so that plants can flower and bear fruit. The device also used in photography and cinematography. Lux meter is used to identify the proper exposure for a photograph.

The digital multi angle illuminator is an innovation so that it can measure light intensity from any angle. It can be useful for plant growth. Enough lighting is good for photosynthesis, but if the light source is not in a correct angle it will affect the plant growth. It is same goes for human eyes; safe working environment can avoid unnecessary eye strain. Illuminator with multi angle can help to reduce the number of lighting in a room if it works efficiently. From the existing multi angle illuminator, the multi angle illuminator will be calibrated each time it's operating. The measurement of the Lux value has also limited to a small Lux value. The illuminator is built without an LCD to display the Lux value. As an extension of the previous work, the researcher of this paper improved an additional approach to improve the multi angle illuminator. The new approaches are using an Arduino to improvise the system. The calibration process is to set up the value of suitable resistor to get value output more accurately, to make the photo resistor can be measured up to 600lux and also to display the value on the LCD.

II. METHODOLOGY

A. *Arrangement of system*

The illumination of a surface is the number of lumens falling on it per unit area. Illuminance is measured in unit Lumens per square (lm/m^2) and it is equal to 1 Lux ($1\ lm/m^2 = 1lux$) [3]. The photoresistor that has been used for a sensor must consider a few conditions to produce an accurate value for the system. To perform an accurate value for the photoresistor a several steps must be performed. This is because to ensure the value of the voltage is accurate and stable. The voltage value is important so that the Arduino will read correctly then it can be converted to a digital value.

1) *Measuring voltage at photoresistor voltage divider circuit – Arduino point.*
   The measurement is taken at voltage divider point as in figure 1. The measurement is taken to know the lowest voltage during dark and highest voltage during bright lighting. The readings are used to write a program for the Arduino [9]. The program is to compare the voltage so it can display the illumination value.

2) *Selecting value of the resistor:*
   The resistor is selected after the measuring voltage process. The value of the resistor is more accurate to the programming so can be used for comparing the photoresistor voltage.

3) *Controlled lighting:*
   The lighting in the room must be controlled so that the measurement is more accurate. The light brightness is controlled by using a dimmer for incandescent light and also the height of the light source is measured. The height of the light source is measured so that the lighting height is constant and only lighting brightness is varied.

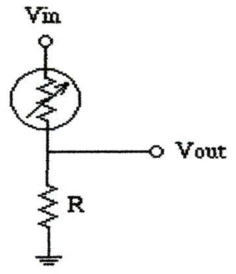

Figure 1: Photoresistor voltage divider circuit

4) *Types of lighting:*
   This step is to know what type of lights that the sensor can be measured accurately. Fluorescent light has flickered so it will interrupt the voltage value during measurement. LED and incandescent light is more suitable for the calibration of the sensor.

Digital Multi Angle Illuminator that applies Arduino and photoresistor as a component to measure luminance by depending voltage difference. The photoresistor resistance will be decreased with increasing the light intensity. The Digital Multi Angle Illuminator is based in two main components Arduino and photoresistor. The Arduino is the main part of the system. It will read the analogue voltage from the voltage difference of the photoresistor. Then the programming is to display the Lux value on the LCD. Figure 2 show how the illuminator work.

The illuminator is constructed with a hexagon shape. The shape is chosen because it has many angles so that the sensor can be placed. Two numbers of photoresistor are placed on the hexagonal prism as in figure 3. The purpose of the sensor is to analyse the light distribution. The main sensor is at the top of the prism similar with the certified Lux meter sensor position.

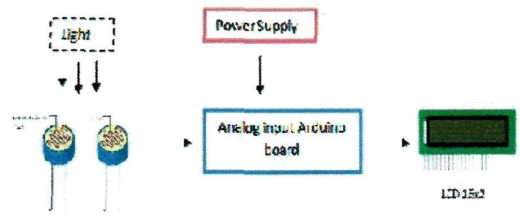

Figure 2: System flow of digital multi angle Lux meter

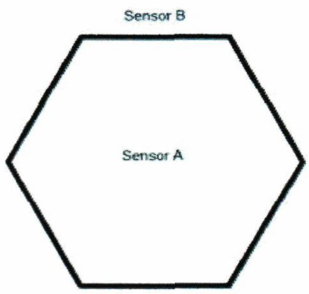

Figure 3: Layout for sensor placement on hexagon prism

B. Software description

In this project, the Arduino is programme using Arduino software. The software is built with compiler and then can be uploaded directly to the Arduino board. Since the Arduino is the main part of the system it will read the analogue voltage from the photoresistor voltage divider circuit. From the figure, the process is beginning with the switch. When the switch is on the photoresistor will sense the light difference. The voltage is connected to the Arduino analogue input. The programme will read the voltage value and display to LCD if it high or low voltage. The system flow is according to figure 4.

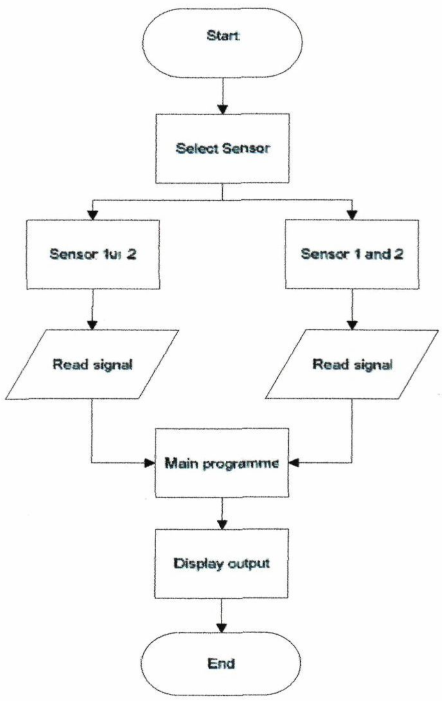

Figure 4: Flowchart of the system

C. Arduino

The Arduino is the new platform for electronic work. Arduino board in figure 5 show its specification. This device can control and sense more than other microcontroller. Arduino can be used to develop any interactive jobs include Digital Lux Meter. This Arduino board consist of analogue to digital converter, analogue input, digital pins, regulated 5V supply and others. The main part of the Arduino is it used ATmega168 microcontroller.

Arduino program is written in C++. The Arduino program comes with its own software which is Arduino. From the software voltage from analogue input can be observed by using serial monitoring tools. It must be programmed into the system so that it can read from the analogue input pins. This tool is helpful since it can measure voltage. While it can measure analogue voltage it will convert the analogue voltage into a digital value. It uses this formula:

$$\text{ADC value} = \frac{Voltagae\ on\ pin(mV) * 1024}{5000(mV)}$$

1024 value come from 10bits of Arduino ADC so from that digital value can be measured. This value will help to program the Digital Multi Angle Illuminator.

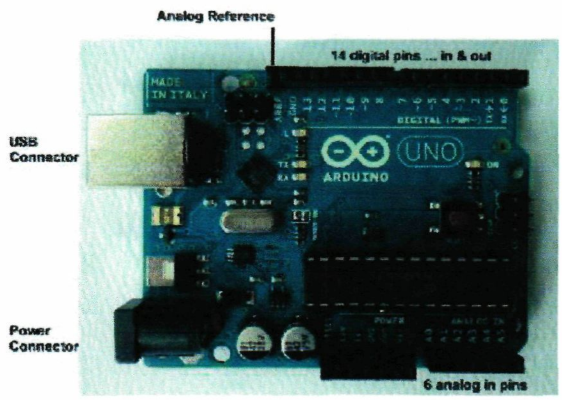

Figure 5: Arduino UNO board

D. Photoresistor

Photoresistor is a simplest semiconductor which is a variable resistor that depends on lights that fall on it. The semiconductor is made from cadmium sulfide (CdS). The resistance is inversely with the amount of light. The resistance will decrease if the amount of light is increases. If photoresistor sense enough high frequency of light falling on it, the semiconductor will absorbed photons and give enough energy for electron to jump into conduction band [12]. The consequence of the movement is the free electron (and its hole partner) conducting electricity then will lowering the resistance.

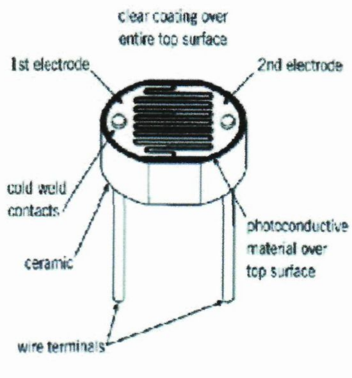

Figure 6: Photoresistor construction

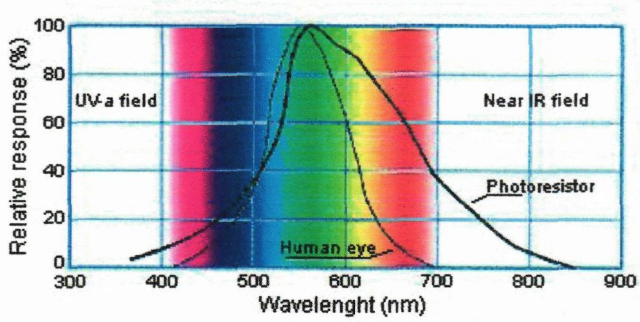

Figure 7: Photoresistor relative spectral response

As it designed for measuring room illuminance, the photoresistor should have a high sensitivity similar to human eyes. Figure 6 illustrate the construction of photoresistor. The photoresistor is tested at 10 lux with a filament tungsten lamp and it preillumantion testing at 400 lux. The resistance if in the dark condition is about 4MΩ and at 10 lux condition the resistance reduce to 2-5 KΩ. The wavelength value for photoresistor is important so that it can be as an illuminator sensor. The PGM1200 has 560 spectral peak (nm) which is in the range of visible spectrum. The relative spectral response is as shown in figure 7.

E. Full Circuit Design

The circuit diagram as shown in figure 6 consists of Arduino, 2 photoresistor PGM1200, 2 switches, 5 resistors and 1 potentiometer. The power supply for the Arduino is 9V and then it can supply 5V for each component. Resistor R1 and R2 is to control the voltage before it enters the analogue input at the Arduino. The resistor value is selected during calibration. Switch SW1 and SW2 is for selecting the display of the 2 sensors. It can display either one or 2 values on the LCD. The contrast of the LCD can be adjusted by the 10K Ohm potentiometer.

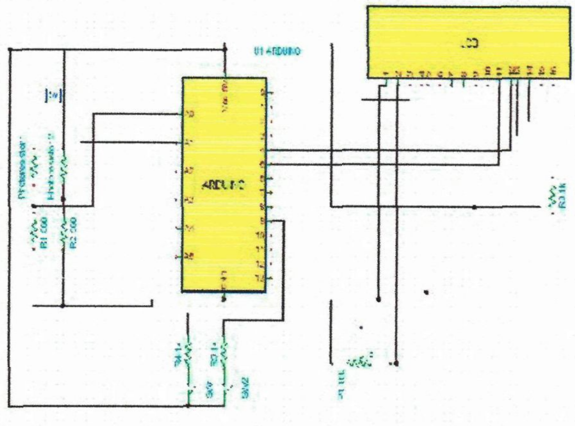

Figure 8: Digital Multi Angle Lux Meter Circuit Diagram

II. RESULT AND DISCUSSION

A. Calibration result by adjusting resistor value.

The calibration process is the most challenging part. Since the sensor that has been used is produced unstable voltage at a high intensity of light. The multi angle simulator is calibrated with HIOKI Lux meter.

The resistors are selected after a calculation for voltage divider circuit. The resistor is selected because it produced small voltage than others. Next, the two values are selected to spot which will produce better voltage value. The value of the resistor is selected is 510 Ohm and 620 Ohm. The result is as shown in the table 1.

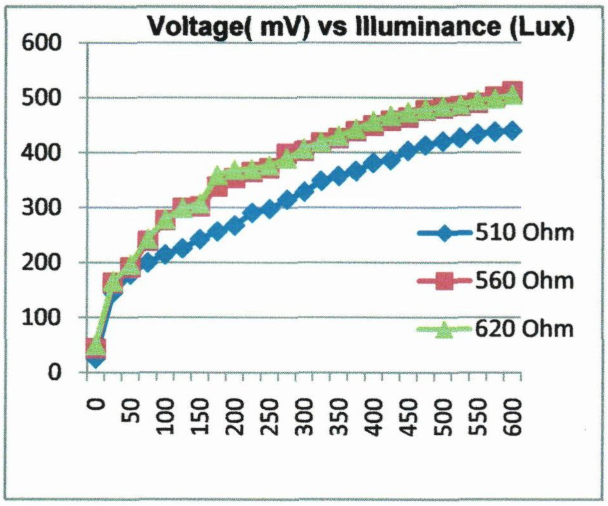

Figure 7: Voltage(mV) vs Illuminance (Lux)

TABLE 1

Calibration by adjusting resistors value

LUX(lm/m^2)	560 OHM	510 OHM	620OHM
0	44	26	50
25	163	146	166
50	191	179	196
75	239	200	243
100	277	215	279
125	299	226	299
150	302	243	307
175	338	257	359
200	354	268	369
225	365	291	370
250	372	298	377
275	398	315	390
300	403	329	407
325	418	349	419
350	426	358	430
375	439	367	443
400	449	382	457
425	458	387	467
450	464	404	473
475	477	414	479
500	481	421	484
525	485	427	487
550	490	434	495
575	501	438	498
600	511	440	505

From the graph 1, the voltage for 510 Ohm is more linear and lower than other two resistors. Since the voltage from 560 and 620 Ohm resistor is moderately high and less linearity then 510 Ohm, so 510 Ohm is selected for the voltage divider photoresistor circuit. For the reason that, the low voltage and the voltage increases more linear than others it will assist in programming the Arduino much better.

From the graph also the voltage value is becoming a constant value when it is near to 600 Lux. Since it will become straight line it will give a sign that it is difficult to get a Lux value more than 600 lux.

B. Result for Measurement Lux for each angle

TABLE 2

Measurement Lux for each angle

Illuminance (Lux)	Multi Angle Lux meter (Lux)			
	Side A	Side B	Side C	Side D
300	300	10	10	10
250	250	10	10	10
200	200	10	10	10
150	150	10	10	10
100	100	5	5	5
50	50	1	1	1

The range of the illuminance is measured from 300 Lux to 50 Lux. The light source is placed 1.6m above the Lux meter. The Lux meter sensor is perpendicular to the light source so the shade is uniform for every angle. The calibration process is done in a dark room, only one source of light is used. The type of lighting is 100w incandescent light. The dimmer switch is used to make a range of lux from 50 lux to 300 Lux maximum from 1.6m height.

From the study the side A which is top of the Lux meter have the same value with the certified Lux meter. Then at the side angle of the Lux meter the light is at 10 Lux identical with every angle and remains unchanged until the luminance reduce to 100 Lux. The angle sensor measured 5 Lux for every angle. Finally at 50 Lux the angle only reads 1 Lux. From the table by reducing the luminance, shadow will occur at the side of the object. It is also illustrated that the shadow is becoming dark since there is not enough illumination.

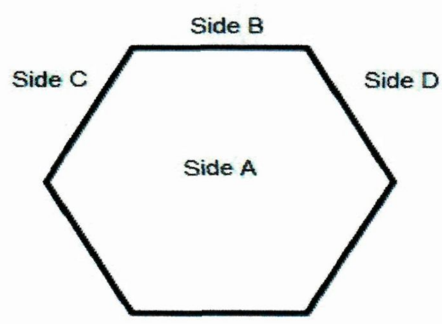

Figure 8 : Digital Lux meter layout

IV. CONCLUSION

As a conclusion the designing the Digital Multi Angle Lux meter is done when it shows the result. The digital lux meter can show a value from two of the sensors fairly splendid. It can measure room luminance in two sides of the angle. The calibration process is done when it can measure an accurate luminance in a room with an endorse lux meter. The sensors on the side of the lux meter provide a good reading since it can measure from a side. The side sensor will measure a different intensity of light even it belongs from a same source of light. This shows that there is shading if an object below the lighting.

Digital Multi Angle Lux meter can measure for industry that concerned about their employees health and energy saving. Since multi angle can measure light intensity from any angle, it can measure for more accurate position from any different light source. This digital device can show two values from the sensors at the same time, so it can compare the luminance from the light source. As a consequence it is able to save time for measuring the light from a different angle. In addition the device can help a presenter to show their products with a good lighting so it helps to improve the product appearance.

In a future research, the type of sensor will change since photo resistors have its limit at a certain voltage. The number of the sensors also will add up since using the Arduino platform. The Digital Multi Angle Lux Meter moves the conventional Lux meter one step further when it can compare between the angles.

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REFERENCES

[1] Martirano, L., "Lighting systems to save energy in educational classrooms," *Environment and Electrical Engineering (EEEIC), 2011 10th International Conference on*, vol., no., pp.1,5, 8-11 May 2011

[2] Fischer, D., "Interior lighting," *Electric Power Applications, IEE Proceedings B*, vol.133, no.2, pp.115,139, March 1986

[3] Patrick, Steven R., Dale R. Patrick, and Stephen W. Fardo. *Energy conservation guidebook.* Lilburn, GA: Fairmont Press ;, 1993.

[4] Illumination Fundamentals from Optical Research Associates LRC publications, and The Lighting Research Centre.

[5] Lindsey, Jack L. *Applied illumination engineering.* Lilburn, GA: Fairmont Press ; 1991

[6] Naik, Anita . "How light affects your health." *NetDoctor.co.uk - The UK's leading independent health website.* N.p., 1 Dec. 2011. Web. 20 May 2013.

[7] DiLaura, David L.. *The lighting handbook: reference and application.* 10th ed. New York, NY: Illuminating Engineering Society of North America, 2011.

[8] Gordon, Gary. *Interior lighting for designers.* 4th ed. New York: Wiley, 2003

[9] Nielsen, O.. *Methods of characterizing illuminance meters and luminance meters: performance, characteristics and specification.* Vienna, Austria: Central Bureau of the CIE, 1986.

[10] "SCHEMATICS - PHOTORESISTOR." *How to Build a Robot Tutorial - Society of Robots.* N.p., n.d. Web. 5 Mar. 2013.

[11] Diffenderfer, Robert. *Electronic devices: systems and applications.* Clifton Park, N.Y.: Thomson/Delmar Learning, 2005.

[12] Gulaan, *"LIGHT DEPENDENT RESISTOR (LDR)." Scribd.* N.p., n.d. Web. 6 May 2013.