



**INTERNATIONAL JOURNAL OF ENGINEERING SCIENCES & RESEARCH  
TECHNOLOGY**

**Measurement of the illuminance using a Signal Conditioning Circuit**

**Sameer Pratap Singh<sup>\*1</sup>, Sathya P<sup>2</sup>**

<sup>\*1</sup> School of electronics engineering, VIT University, Vellore, Tamil Nadu, India

<sup>2</sup> Assistant Professor (senior), School of Electronics Engineering, VIT University, Vellore, Tamil Nadu, India

[Singh.sameer9415@gmail.com](mailto:Singh.sameer9415@gmail.com)

---

**Abstract**

Measuring the illuminance of light is needed in a lot of applications such as in the corrosion mapping of steel surfaces, in distance measurement and also in analytical ultracentrifuge. Illuminance is a measure of the perceived power of light per unit area. It is a measure of light intensity that is perceived by the human eye. When light with different illuminance is incident on a Light dependent resistor (LDR), its resistance varies according to the illuminance of the light falling on it. Making this LDR a part of a Signal conditioning circuit, we achieve an output voltage which depends on the change in the resistance of the LDR. Hence, by measuring the output voltage, the illuminance of the incident light on the surface is obtained and we establish a relationship between illuminance on the surface of the LDR and the distance of the light source..

**Keywords:** Singal Conditioninig Circuit.

---

**Introduction**

Luminous flux is often used as an objective measure of the useful power emitted by a light source, and is typically reported on the packaging for light bulbs. It provides an estimate of the apparent amount of light the bulb will produce, and is useful when comparing the luminous efficacy of incandescent and compact fluorescent bulbs. Illuminance is a measure of how much luminous flux is spread over a given area. One can think of luminous flux (measured in lumens) as a measure of the total "amount" of visible light present, and the illuminance as a measure of the intensity of illumination on a surface.

luminous intensity is a measure of the wavelength-weighted power emitted by a light source in a particular direction per unit solid angle. While luminous flux is the total perceived power emitted in all directions, Luminous intensity is the perceived power per unit solid angle.

With this experiment we are measuring the intensity of light falling on a given surface by using an LDR. When Light falls on an LDR its resistance varies depending on the intensity of light falling on it. As the intensity increases the resistance decreases. With the help of a signal conditioning circuit the analog signal (change in resistance) is converted into an output voltage which is used to measure the intensity of light. We can also notice that the

resistance of the LDR increases as the distance of the light source increases from the LDR indicating that the light illuminance that is incident on the surface of the LDR decreases with the increasing distance of the light source.

**Literature History**

Tiba. C and Leal S. S suggest a method of measuring illuminance in the meteorological station in Brazil illuminance is estimated using a model known as luminous efficacy in regions where only information on solar irradiation exists. They are statistical models which use meteorological variables and conditions of the sky to empirically correlate the relationship between illuminance and solar irradiation.<sup>[1]</sup>

Cui. D. X and Shi. J. F suggest a method of measurement of illuminance of quasi point source based on photon counting principle. Illuminance is measured from a circular area with diameter of 0.2 mm for the quasi-point imaging source on a photocathode.<sup>[2]</sup>

In the article published by Fiorentin P and Scroccaro A, the Photometric laboratory of the University of Padova makes use of multi luminance meters to measure illuminance. It makes use of its ability to identify the direction from which the light source is incident and its possibility in selecting and

analyzing that the different sources located at different locations have contributed to the luminance to what extent. [3]

The method used by me is a simple and a cost effective method of lux measurement which can be implemented and analyzed easily and in an effective way.

**Light Dependent Resistors** - are basically semiconductors whose resistance varies with the amount of light falling on it, hence it is photoconductive. In the dark, an LDR can have a resistance as high as a few mega ohms (MΩ), while in the light, an LDR can have a resistance as low as a few hundred ohms. If the frequency of the incident light exceeds a certain limit, the absorbed photons supply enough energy to the bound electrons to jump into the conduction band. The resulting free electrons and the holes conduct electricity, thereby lowering resistance.

**Signal Conditioning Circuit** - in electronics,

Many a times we need to manipulate an analog signal So that it can be used efficiently and effectively in the further processing. The inputs that can be given to the signal conditioning circuit include DC and AC voltage and current, frequency and electric charge. The sensors that are commonly used are accelerometer, thermocouple, thermistor, strain gauge, and LVDT or RVDT. Outputs for signal conditioning equipment can be voltage, current, frequency, timer or counter and other specialized outputs. The circuit, through processes such as amplification, filtering, converting, range matching, isolation etc makes the sensor output suitable for processing after conditioning. Types of devices that use signal conditioning include signal filters, instrument amplifiers, isolation amplifiers, digital-to-analog converters, translators and charge converters.

### Analysis

For a Wheatstone bridge:

$$V_a = V_{dc} \frac{R_a}{R_a + R_t}$$

$$V_b = V_{dc} \frac{R_b}{R_b + R_c}$$

In the balanced condition:

$$V_a = V_b$$

$$\text{or, } V_{dc} \frac{R_a}{R_a + R_t} = V_{dc} \frac{R_b}{R_b + R_c}$$

$$\text{or, } \frac{R_a}{R_a + R_t} = \frac{R_b}{R_b + R_c}$$

$$\text{or, } R_a \cdot R_b + R_a \cdot R_c = R_a \cdot R_b + R_b \cdot R_t$$

$$\text{or, } \frac{R_c}{R_b} = \frac{R_t}{R_a}$$

Now, when the physical condition changes  $R_t$  increases or decreases by  $\Delta R$  and the bridge is no longer in the balanced condition.

$$V_a \neq V_b$$

$$V_a = V_{dc} \frac{R_a}{R_a + (R_t + \Delta R)}$$

$$V_b = V_{dc} \frac{R_b}{R_b + R_c}$$

We assume all the resistors to be equal.

$$\text{i.e. } R_a = R_b = R_c = R_t = R$$

$$V_a = V_{dc} \frac{R}{R + (R + \Delta R)}$$

$$\text{or, } V_a = V_{dc} \frac{R}{2R + \Delta R}$$

$$V_b = V_{dc} \frac{R}{R + R}$$

$$\text{or, } V_b = V_{dc} \frac{R}{2R}$$

$$\text{or, } V_b = \frac{V_{dc}}{2}$$

Now,

$$\begin{aligned} V_{ab} &= V_a - V_b \\ &= V_{dc} \frac{R}{2R + \Delta R} - \frac{V_{dc}}{2} \\ &= \frac{V_{dc}}{2} \left[ \frac{2R - 2R - \Delta R}{2R + \Delta R} \right] \\ &= \frac{V_{dc}}{2} \left( \frac{-\Delta R}{2R + \Delta R} \right) \end{aligned}$$

Output Voltage for a differential amplifier is given by

$$\begin{aligned} V_0 &= \frac{-R_2}{R_1} (V_{ab}) \\ &= \frac{-R_2}{R_1} \left( \frac{-\Delta R}{2R + \Delta R} \right) \frac{V_{dc}}{2} \end{aligned}$$

Hence,

$$V_0 = \frac{R_2}{R_1} \left( \frac{\Delta R}{2R + \Delta R} \right) \frac{V_{dc}}{2}$$

### Proposed Methodology

The LDR is connected as one of the resistances of the Wheatstone bridge. Input Voltage ( $V_{dc}$ ) is connected across 2 junctions and the voltage at the other two junctions is fed to the non-inverting terminals of two op-amps. The op-amps are in Voltage follower configuration hence the voltage at the non-inverting terminal results into the output of the respective op-amps. These outputs are fed to the third op-amp which is acting as a differential amplifier. Hence the difference in the voltage at the two terminals of the op-amp is obtained as output. Hence the output of the circuit is the difference in the voltage at the two junctions of the Wheatstone bridge. When the value of the resistance of the LDR is same as the other resistances of the Wheatstone bridge, the bridge is in balanced condition and the

potential difference between the two junctions is 0 and the output voltage is 0. As the resistance of the LDR changes depending on the intensity of light falling on it, the bridge becomes unbalanced and hence a potential difference develops between the junction and we obtain an output voltage depending on the resistance change. Thus With the voltage obtained, the change in resistance of the LDR can be obtained and with that the intensity of light falling on the LDR can be obtained.

**Simulation**

A simulation of the circuit is done using Multisim as shown in Fig.1. The resistance of the LDR is changed manually indicating change in the intensity of light falling on the LDR and the corresponding change in the output voltage is observed showing the change in output voltage for the given change in intensity of light.

The output voltage is given by:

$$V_0 = \frac{R}{R + \Delta R} \frac{V_{dc}}{2}$$

Where resistance of the LDR is (R+ΔR) and the intensity of light in lux is given by

$$Lux = \frac{500}{R_{LDR}} lux$$

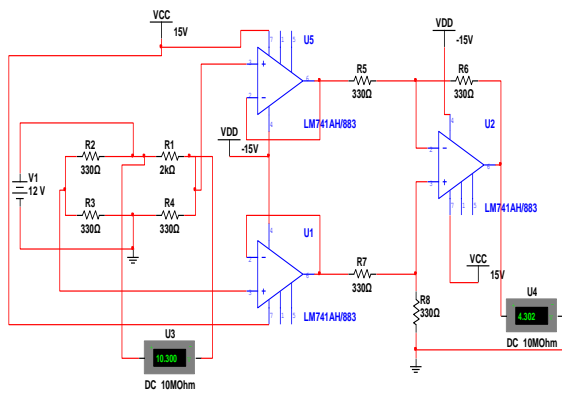


Fig 1. Proposed circuit diagram

TABLE 1: Variation of the output voltage with change in resistance of the LDR

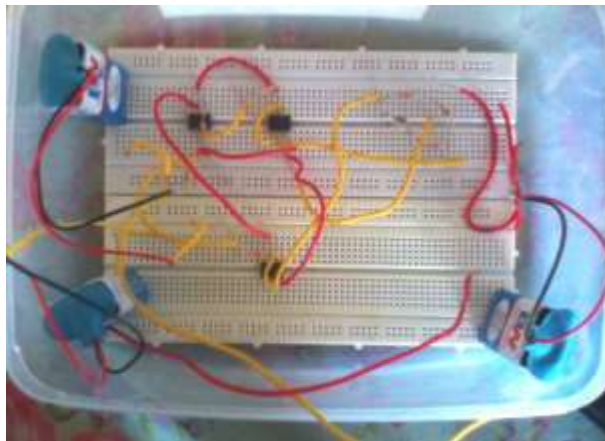
Resistance of the LDR (in ohms)	Light Intensity (in Lux)	Voltage across LDR (in volts)	Output Voltage(V <sub>o</sub> ) (in volts)
330	1515.15	6	2.109m
400	1250	6.58	0.55
600	833.33	7.74	1.74
800	625	8.49	2.49
1K	500	9.02	3.025
2K	250	10.3	4.302
4K	125	11.085	5.087
6K	83.3	11.374	5.376
8K	62.5	11.524	5.527
10K	50	11.616	5.619
20K	25	11.805	5.807
40K	12.5	11.901	5.904
60K	8.33	11.934	5.936
80K	6.25	11.960	5.953
100K	5.0	11.960	5.962
300K	1.67	11.994	5.989
500K	1.0	11.996	5.994
1M	0.5	11.996	5.998
3M	0.167	11.998	6.001
5M	0.1	11.999	6.001

From the table above we can infer that the voltage obtained at the output, and hence the potential difference developed across the junctions of the Wheatstone bridge is directly proportional to the intensity of light falling on the LDR. As the intensity increases, the output voltage increases but becomes constant at  $\frac{V_{dc}}{2}$  when the resistance is very large. This is because  $V_a$  is given by  $V_{dc} \frac{R}{(2R + \Delta R)}$ ; hence it becomes approximately 0 at very high value of LDR resistance. And hence  $V_b$ , which is equal to  $\frac{V_{dc}}{2}$  dominates. Moreover, when resistance of the LDR is equal to the other resistances, the output voltage is 0 as  $V_a = V_b$ . So we can find the intensity of light which when falling on the LDR produces the resistance equal to the resistance of the bridge's arms.

**Hardware Implementation**

A normal torch light was used as the light source for this experiment. The illuminance falling on the given surface varies with the distance from which the light is made incident on the surface. The light from a point light source spreads out uniformly in all directions, so as we move away from the source, less light reaches us.

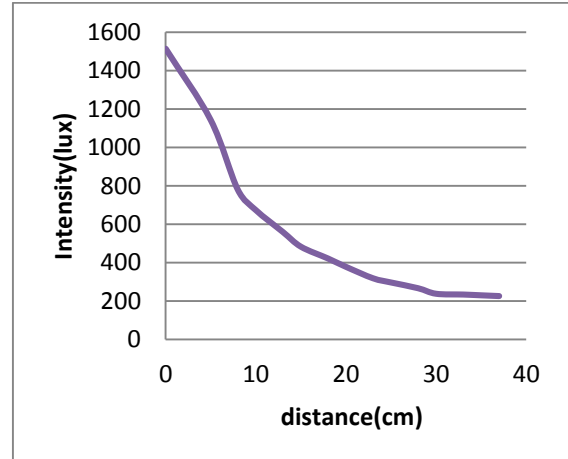
So if we take a point source like a candle than it will cause an illuminance of 1 lux on an object which is placed at a distance of 1 meter and an illuminance of ¼ lux on an object at a distance of 2 meters. So the illuminance varies following the inverse square law.



*Fig 2. The hardware circuit on breadboard.*

**TABLE 2: Variation in output voltage with variation in distance of the light source.**

Distance (cm)	Output Voltage (V)	R <sub>ldr</sub> (ohms)	Intensity (lux)
0	0	330	1515
5	0.35	437.4	1143
8	0.8	640.6	780.5
10	0.96	741.4	674.3
13	1.15	892.2	560.4
15	1.29	1033.6	483.7
18	1.41	1183.7	422.4
20	1.50	1320	378.8
23	1.63	1566.5	319.2
25	1.68	1682.2	297.2
28	1.75	1870	267.4
30	1.82	2096.4	238.5
33	1.83	2132.6	234.4
35	1.84	2170	230.4
37	1.85	2208.4	226.4



*Fig 3. Relationship between illuminance and the distance of the light source.*

**Result Analysis**

For an almost dark surrounding the voltage recorded was around 2.48V, which is approximately half of the supply voltage V<sub>dc</sub>(5 V) signifying that the resistance of the LDR is very high(in mega ohms) and in the dim light of the room, the voltage recorded was 2.08V. This voltage corresponds to an illuminance of 153 lux and it matches with the illuminance generated in interiors that that are rarely used for visual tasks just like the dim surrounding we maintained. It also shows that as the illuminance on the surface of the LDR increases, its resistance decreases and hence output voltage decreases.

Further a light source(torch light) is introduced and its distance from the surface of the LDR is varied and the corresponding output voltage measured. The light source at a distance of 15cm from the LDR is comparable to the lighting in a showroom or laboratory. The illuminance we achieved here is 484 lux while the actual illuminance for such an environment is around 500 lux We can see that as the distance of the light source increases, the illuminance of the light falling on the surface of the LDR is decreasing and is following the inverse square law. As the distances considered in this methodology are small the variation shows some variation from the inverse square law but is in accordance with the law as the change is greater at the nearer distances and then as the distance increases the change becomes less.

**Conclusion**

From the above analysis we are able to infer that as the illuminance increases on the surface of the LDR, the resistance of the LDR decreases and with the output voltage obtained from the signal

conditioning circuit, we can calculate the illuminance that is falling on the LDR and we can prepare a data sheet stating the voltage output for the corresponding light illuminance falling on its surface. The variation of illuminance on the surface of the LDR is achieved by varying the distance of the light source from LDR and the obtained data shows that the variation follows the inverse square law.

### References

- [1] Tiba, C and Leal, S.S. *Measuring and modelling illuminance in the semi-arid Northeast of Brazil. Scopus, Renewable energy. Volume 48. December 2012 pages 464-472.*
- [2] Cui, D.-X, Shi, J.-F., Li, H.-G, Sun, Y.-N, Cao, F. *Illuminance measurement of quasi-point source with photon counting method. Guangxue Jingmi Gongcheng/Optics and Precision Engineering. Volume 20, issue 4. April 2012, pages 733-738.*
- [3] Fiorentin P, Scroccaro A. *Illuminance from luminance measurement experimental results. Conference Record - IEEE Instrumentation and Measurement Technology Conference. 2011, Article number 5944027, Pages 254-259.*
- [4] Wyckoff, S(1999, February, 2002). *What is inside an LED?*
- [5] *Measure Light Intensity using Photodiode. WWW.EMANT.COM*
- [6] *www.technologystudent.com-LDR-Datasheet*
- [7] *Light Intensity verses distance. http://www.pasco.com*
- [8] *ESE Undergraduate Laboratory*
- [9] *Basics of Power Supplies -*
- [10] *Use of the HP E3631A Programmable*
- [11] *Power Supply. http://sustainabilityworkshop.autodesk.com/buildings/measuring-light-levels#sthash.JKVwQtHX.dpuf*