



# **Light Dependent Resistor (LDR) Based Low Cost Light Intensity Measurement Circuit Design (LUX Meter)**

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**ABSTRACT:** Importance of light is very much high in our day-to-day lives as light is the basic source of energy and among the most abundant sources of energy. For most of the applications related to light, we need to have a proper data about the intensity of light so as to meet the standards set by the regulating authorities, etc. For the measurement of Light intensity, a simple design has been proposed which includes a comparator and LDR, which would give us the data about the light intensity at a very low cost. The resolution capability of the proposed design can be increased as per the needs thus saving unnecessary costs and hardware. The area and cost factor of the proposed design can further be reduced by making use of multi-input, multi-output comparator IC's. We are using an array of 741 Op-Amp comparators and a LDR (light dependent resistor) as our basic building block for our proposed design. A completely analog based electronic circuit has been proposed which will do the job of measuring intensity of light and the output value can be obtained in the form of LED bar graph. A twelve 5mm diameter Light Dependent Resistors (LDR) and twelve different 741 Op-Amps in a voltage divider configuration has been used. Thus, the resistor on each Op-Amp non-inverting input in the twelve different levels in percentage can be adjusted. The simulation of the proposed design has been done in National Instrument's "MultiSim" LabVIEW based workbench. Further, the comparison of proposed analog comparator based design with a current digital DSP based design in terms of price and resolution has been done. Light dependent resistor (LDR) based low cost light intensity measurement circuit design (lux meter) has been proposed which is a better replacement for the current high cost light intensity meter.

**KEYWORDS:** Lux meter, light intensity, light measurement, op-amp design, luminous intensity, lighting solutions, resolution

## **I. INTRODUCTION**

Accurate and quantifiable measurement of light is essential in creating desired outcomes in practical day to day applications as well as unique applications. From measuring the amount of light in a work space surface, to ensuring emergency exits have proper illumination, light measurement and analysis is an important step in ensuring efficiency and safety. To perform these measurements, technicians often make use of lux meters which are specialized devices that measure the intensity of light falling on a surface, or "lux." [1] [8]

Luminous intensity is a measure of the wavelength-weighted power emitted by a light source in a particular direction per unit solid angle, based on the luminosity function, a standardized model of the sensitivity of the human eye. The SI unit of luminous intensity is the candela (cd), an SI base unit. The lux (symbol: lx) is the SI unit of illuminance and luminous emittance, measuring luminous flux per unit area. It is equal to one lumen per square meter. In photometry, this is used as a measure of the intensity, as perceived by the human eye, of light that hits or passes through a surface. It is analogous to the radiometric unit, watts per square meter, but with the power at each wavelength weighted according to the luminosity function, a standardized model of human visual brightness perception. In English, "lux" is used in both singular and plural. [2]



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Here are some examples of the illuminance provided under various conditions:

0.0001 lux	Moonless, overcast night sky (starlight) [3]
3.4 lux	Dark limit of civil twilight under a clear sky[4]
50 lux	Family living room lights (Australia, 1998) [5] [6]
320 - 500 lux	Office lighting[5] [7] [9] [10] [11]
10000–25000 lux	Full daylight (not direct sun)[3]

Photometry deals with the measurement of visible light as perceived by human eyes. The human eye can only see light in the visible spectrum and has different sensitivities to light of different wavelengths within the spectrum. When adapted for bright conditions (photopic vision), the eye is most sensitive to greenish-yellow light at 555 nm. Light with the same radiant intensity at other wavelengths has a lower luminous intensity. The curve which measures the response of the human eye to light is a defined standard, known as the luminosity function. This curve, denoted  $V(\lambda)$  or  $V(\lambda)$ , is based on an average of widely differing experimental data from scientists using different measurement techniques. For instance, the measured responses of the eye to violet light varied by a factor of ten. [8]

## II. MATERIALS AND METHODS

Measuring the intensity of light is very important nowadays in the field of LED lighting solutions for different places like offices, homes, etc. The light intensity measurement is also required in the field of testing and experimentation like photolithography setup, green house effects, etc. The process that is required for knowing the value of intensity of light today is very complex and require very high amount of programming in digital circuits as well as the cost factor is also very high. The sensor that is commonly used for the process is a complex CMOS image sensor which also increases the cost factor. Various different vendors of electronic measurement manufacturers use a very common design, i.e. a digital design based on microcontroller or a DSP IC. This design is very complex for a newbie to understand and it is very expensive too.

So in this field of electronics, a very simple, robust, cheaper and easy to use circuit has been proposed for the requirement of measuring intensity of light. The proposed design is based on LDR (Light Dependent Resistor) as a sensor and a LED bar graph has been used as output with respect to intensity of light. The cost can go down up to 5 to 6 times using our proprietary circuit design for the same work.

## III. PROPOSED DESIGN

A completely analog based electronic circuit has been proposed which will do the job of measuring intensity of light and the output value can be obtained in the form of LED bar graph. A twelve 5mm diameter Light Dependent Resistors (LDR) has been used as the 12 input sensors for detecting light. Twelve different 741 Op-Amps in a voltage divider configuration with non-inverting inputs connected to LDR and a fixed or variable adjustable resistor in a voltage divider configuration has been used. The inverting inputs are connected to a 2K voltage divider circuit. Thus, the resistor on each Op-Amp non-inverting input in the twelve different levels in percentage can be adjusted. The resistance value of all 12 LDR's has been set as same/fixed i.e. (12 K $\Omega$ ). The resistance values of the 2K $\Omega$  resistors have been maintained uniformly by using 1% tolerance ¼ watt metal film resistors for the inverting inputs of Op-Amps. A voltage divider of 800  $\Omega$  is to 50 K $\Omega$  at the output of all twelve 741 Op-Amps has been used, so that the uniformity is maintained on the output of all 12 Op- Amps. The output of each Op-Amp has been connected to twelve different 3mm 20mA Cree LED in a bar graph level display formation or combination of 12 different individual LED's can be used to act as a graph when placed with each other. The circuit is powered by a common 9 volt battery that is cheaply available in the market too. This design can be modified and its resolution can be increased, as per our needs, by increasing the number of 741 Op-Amp IC's. Any other type of comparator can also be used for this job and therefore this circuit is not limited to only 741 Op- Amp.

The area and cost factor of the proposed design can further be reduced by making use of multi-input, multi-output comparator IC's. As the 741 Op Amps are having very high input impedance, the current usage for this design has been reduced to a large extent. The resolution capability of the proposed design can also be increased as per the needs, thus saving unnecessary costs and hardware. Further, different configuration of readymade IC's for comparators can also be

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used to fabricate this design. By this area of the hardware can be modified and reduced by using those IC's which house multiple number of comparators on a single die.

The working principle of this circuit is based on the individual principle of a single 741 Op-Amp comparator or any general purpose comparator with a voltage divider configuration on both inputs. The inverting input of the 741 Op-Amp is connected in voltage divider of 2 KΩ resistors. As input voltage of 9 volts has been provided to the whole circuit, the voltage at the inverting input of 741 Op-Amp will be 4.5 volts. The non-inverting input of the 741 Op-Amp has been connected to the LDR and a variable resistor or a fixed value resistor in a voltage divider configuration as shown in the figure 1.

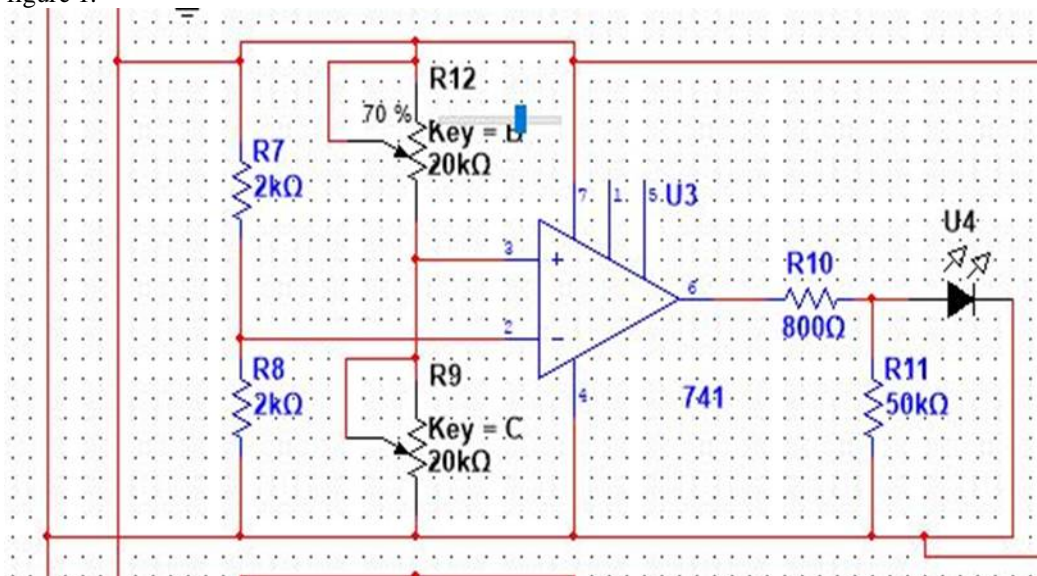


Fig.1. Single module of the LUX meter (R12 is supposed to be a 12k ohm LDR)

Now when the light falls on the LDR, the voltage across the LDR varies according to the value of the variable resistor which is pre-set by us. Thus if the voltage across the variable resistor is more than the voltage at the inverting input of the Op-Amp, the output goes high and LED starts glowing. We can now pre-set the 12 different variable resistors at a difference of 5% to each other as shown in figure 2. Thus a resolution of 12 different steps for a particular input light intensity has been obtained. For higher resolution, more 741 Op-Amp comparators and LDR's are needed, as every Op-Amp will need its own LDR as a light sensor.

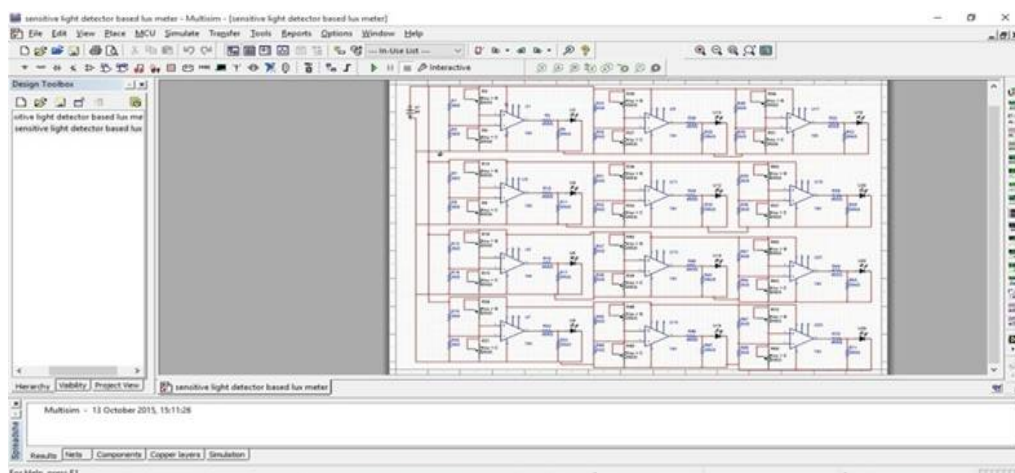


Fig.2. LUX meter with a resolution of 12

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## IV. RESULTS AND DISCUSSION

Further, the comparison of proposed analog comparator based design with a current digital DSP based design in terms of price and resolution is shown in figure 3. It has been seen that the trend goes in favor of proposed analog comparator based design as the price differences are quite high. As observed from graph, at a low resolution, the price of analog comparator based design is lower than the digital DSP based design by a margin of 900 INR. As the resolution increases, the margin of price difference between the proposed design and current digital design still remains high. At average resolution, the price of digital based LUX meter is 2600 INR while as for the same resolution, proposed design costs only 1500 INR. At high resolution, cost of the proposed design is 2500 INR only while as for the same resolution, the cost of DSP based digital LUX meter is 5000 INR i.e. double than that of the proposed design. Consequently, the average cost reduction in proposed analog based LUX meter design is around 50% as compared to digital system based meters. Thus a great cost difference is seen between the proposed designs with respect to current DSP based design.

Table 1: Simulation Results

LUX VALUE (LUMINOUS INTENSITY)	Voltage Drop on 1 <sup>st</sup> LDR	Voltage Drop on 2 <sup>nd</sup> LDR	Voltage Drop on 3 <sup>rd</sup> LDR	Voltage Drop on 4 <sup>th</sup> LDR	Voltage Drop on 5 <sup>th</sup> LDR	Voltage Drop on 6 <sup>th</sup> LDR	Voltage Drop on 7 <sup>th</sup> LDR	Voltage Drop on 8 <sup>th</sup> LDR	Voltage Drop on 9 <sup>th</sup> LDR	Voltage Drop on 10 <sup>th</sup> LDR	Voltage Drop on 11 <sup>th</sup> LDR	Voltage Drop on 12 <sup>th</sup> LDR	Number of LEDs Lit Up
1-10	8.40	7.80	7.40	6.85	6.45	5.99	5.78	5.50	5.24	5.01	4.68	4.57	1
10-100	8.30	7.71	7.20	6.75	6.35	5.89	5.68	5.40	5.14	4.90	4.58	4.47	2
100-500	8.23	7.59	7.04	6.56	6.15	5.66	5.46	5.17	4.90	4.67	4.45	4.21	3
500-1000	8.15	7.44	6.85	6.35	5.91	5.40	5.20	4.90	4.64	4.40	4.19	4.01	4
1000-5000	8.04	7.26	6.63	6.09	5.64	5.10	4.90	4.61	4.34	4.10	3.89	3.74	5
5000-10000	7.90	7.04	6.35	5.78	5.31	4.90	4.56	4.26	4.00	3.76	3.56	3.44	6
10000-35000	7.71	6.75	6.00	5.40	4.90	4.50	4.15	3.85	3.60	3.37	3.17	3.00	7
35000-39999	7.44	6.35	5.50	4.90	4.40	4.00	3.66	3.37	3.13	2.90	2.70	2.50	8
40000-44999	7.04	5.78	4.90	4.26	3.76	3.37	3.00	2.70	2.50	2.30	2.20	2.00	9
45000-49999	6.35	4.90	4.00	3.26	2.90	2.50	2.26	2.00	1.80	1.70	1.60	1.40	10
50000-54999	4.90	3.37	2.50	2.00	1.70	1.50	1.30	1.10	1.00	0.90	0.80	0.70	11
55000-60000	.010	.050	.030	.020	.020	.010	.010	.010	.010	.010	.000	.000	12

The simulation of the proposed design has been done in National Instrument's "MultiSim" LabVIEW based workbench. The simulation results are tabulated in table 1.

## V. CONCLUSION

Light dependent resistor (LDR) based low cost light intensity measurement circuit design (lux meter) has been proposed which is a better replacement for the current high cost light intensity meter. Technicians and lighting solutions engineers who don't want to spend much money on a single lux meter can buy this low cost designed meter and can get their job done easily. For low cost operations, this design is perfect and much more feasible to buy and use because of its simple and easy to use design.

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The simulation results showed that the proposed design performs better with the increase of the resolution of the circuit by using more and more comparators and at the same time we can save money as the proposed design is much cheaper than a current DSP based meter. Following is the graph showing the difference in prices between a DSP based circuit design and our analog design for the purpose of LUX meter.

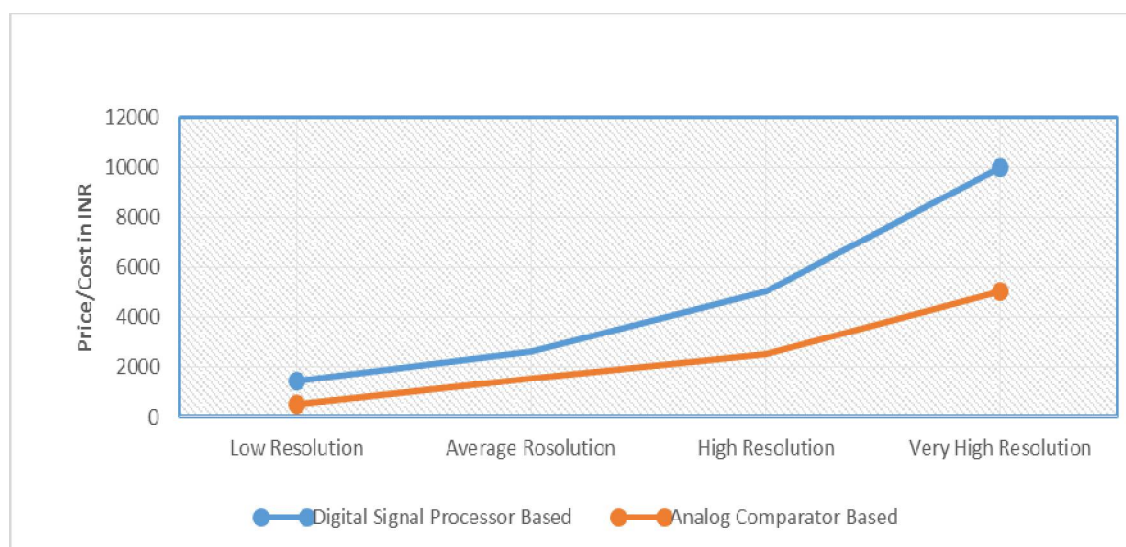


Fig.3. Comparison between analogue comparator based design (proposed) and DSP based design

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