Brighton Webs Ltd

statistics for energy and the environment

The resistance of light dependent resistor falls falls as the illuminance increases. They can be used to build a simple, low cost photometric device.

They appear to work well with medium to high light levels (greater than 10 lux). Unlike photodiodes they do not saturate at high light levels. The spectral response is similar to that of the human eye with the greatest sensitivity being in the green range (approx. 500 - 550 nm). The relationship between illuminance and resistance is non-linear being a straight line when plotted on a log-log graph. Whilst some suppliers do provide datasheets, information can be limited to the range of resistance at at light levels and a typical resistance at some representative point. Thus it can be necessary to perform some form of calibration, although without reference to some absolute standard, the results should be used for measuring relative illuminance, rather then absolute illuminance.

This page is evolving as experiments are completed and should be viewed as "lab report" on a single component rather than a generic "datasheet".

Calibration

The relationship between illuminance and resistance is given by:

$$\frac{I}{I_o} = \left(\frac{R}{R_o}\right)^A$$

I_O and R_O are the reference values of illuminance and resistance respectively, in the example below they are 100 lux and 20k respectively. The problem is to obtain the value of A which will allow us to determine illuminance from resistance which can be readily measured with a meter. Typically the value of A is in the range -0.7 to -0.9.

Light Source

A convenient means of providing a variable light source is to use an incandescent light bulb and vary the intensity by taking measurements at different distances, the inverse square law can then be used to create a table of relative illuminances. The inverse square law is often expressed in this form:

$$\frac{I_1}{I_2} = \left(\frac{D_2}{D_1}\right)^2$$

Thus:

$$I_2 = I_1\left(\frac{D_1}{D_2}\right)^2$$

If the illuminance of a light source is measured as 100 lux at a distance of 1 metre, the illuminance at 2 metres will be 25 lux, the calculation is shown below:

$$I_2 = 100\left(\frac{1}{2}\right)^2 = 25$$

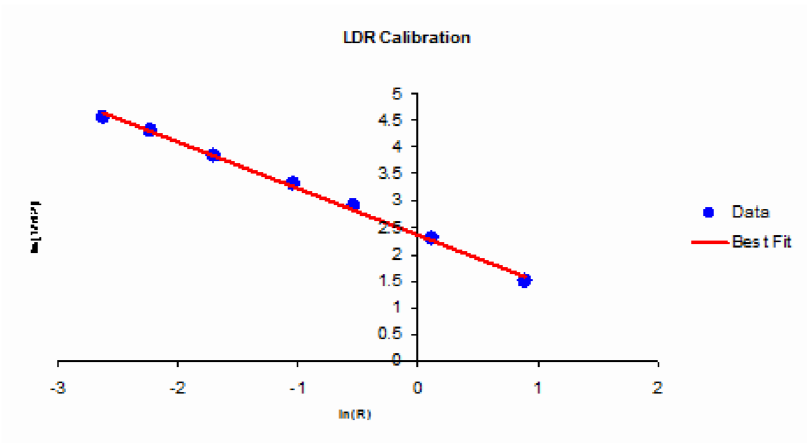
This allows us to use the square of the reciprocal of the distance as measure of relative illuminance and with a little help from Excel we can estimate the value of A in the equation above.

Test Data

The table below is a sample dataset:

D (metres)	R (k)	$\ln(D^{-2})$	ln(R)
3.71	96.4	-2.622	4.569
3.04	74.4	-2.224	4.309
2.33	46.4	-1.692	3.837
1.68	27.6	-1.038	3.318
1.30	18.2	-0.525	2.901
0.94	10.0	-0.124	2.303
0.64	4.4	-0.893	1.482

A graph of these values looks like this:

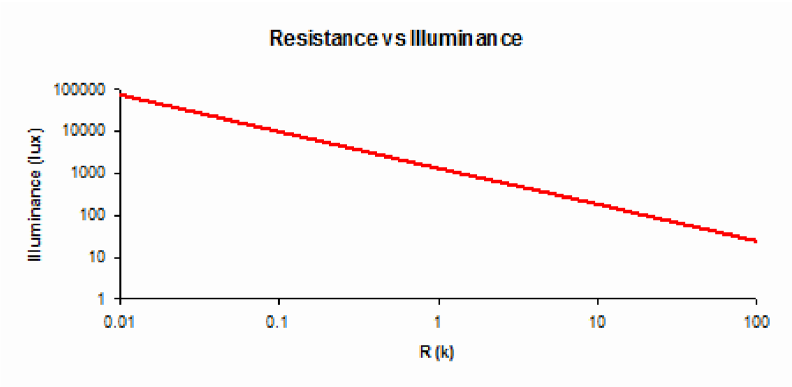


The slope of this line, which is the value of A is -0.87.

Using the value for A and the typical resistance gives a formula which allows a resistance measurement to converted into illuminance, for the test devices this is:

$$I = 100\left(\frac{R}{20}\right)^{-0.87}$$

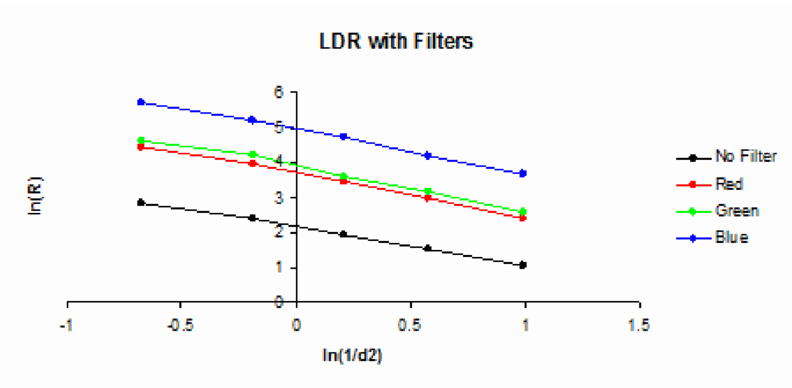
This gives the following log-log curve for illuminance and resistance:



At the time of writing, the reliable working range of this particular device has not been explored, it maybe, that the range is less than that implied by the above graph.

Response to Filtered Light

Whilst knowing something about the intensity of a light source is useful, the spectrum is also interesting. An example is the selection of light sources for investigating solar panel performance. If a filter is placed between the light source and the light dependent resistor, its response to different wavelengths can be investigated. The graph below shows the result of applying different filters and varying the intensity by changing the distance between the source and the light dependent resistor.



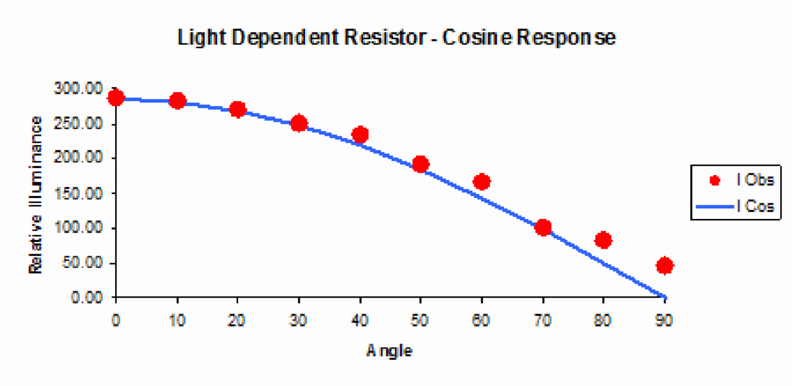
Whilst the magnitude of the response to varying wavelengths is different, the sensitivity is the same.

Cosine Response

When making observations of a ray of light striking a sensor, it is necessary to know how the relationship between the angle of incidence and the response of the sensor. The ideally, this should conform to Lamberts cosine law:

$$I = I_{Beam} \cos(\theta)$$

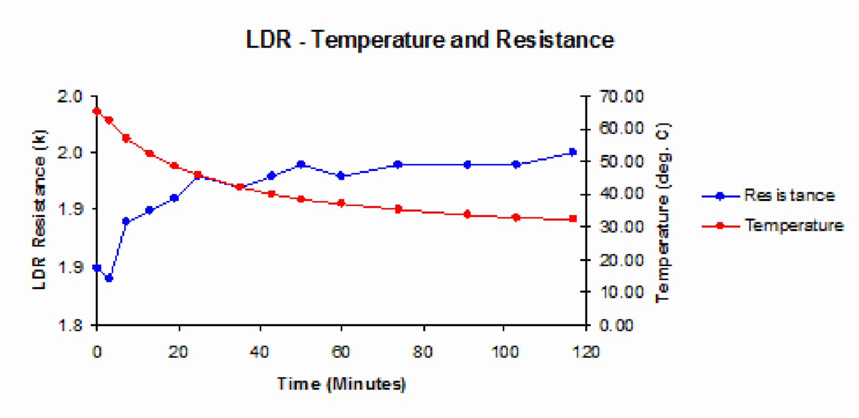
The graph below shows the results of an experiment in which a light source was rotated around a light dependent resistor:



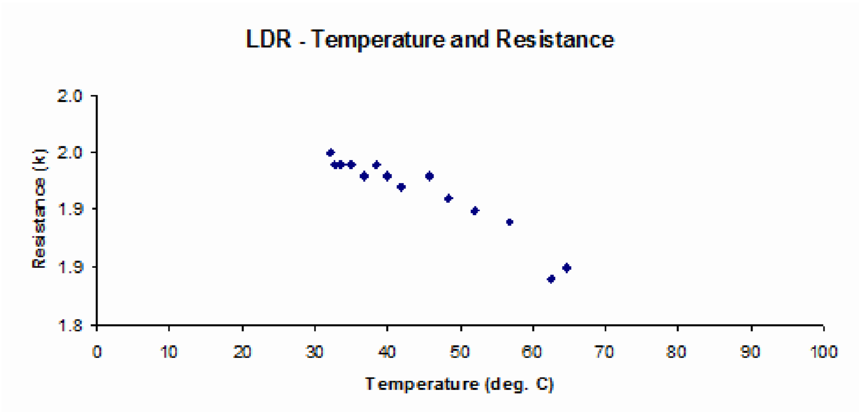
The red dots show the experimental results and the blue line is what Lamberts cosine law predicts. Allowing for defects in the experimental method, there is a reasonable agreement between theory and practice, thus it may be possible to use a light dependent resistor in applications where angle of incidence is one of the parameters.

Temperature Response

The component tested had similar behavior to a thermistor. If the level of illuminance was held constant (by placing the device in a dark room with an 100 watt incandescent light bulb) and the temperature varied (by immersing the device in a bowl of hot water which was allowed to cool), the resistance increased as the temperature declined. The results of this experiment as shown below, the first graph shows resistance and temperature plotted against time:



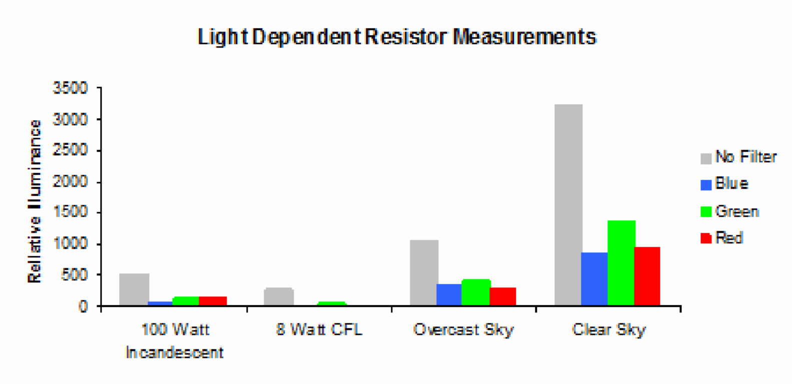
The second graph shows resistance plotted against temperature:



The relationship between temperature and resistance was not completely investigated. It appears that the resistance of an LDR is a function of both illuminance and temperature. In many applications this is not a problem if the device is mounted in such a way that variations in temperature are small and the level of illuminance does produce extreme variations (in the case of the component tested, this might be 20k - 1k). However, when the resistance is very low, as is the case when the component is oriented towards the sun, a situation where the temperature of the component will rise due to solar heating, the effects of temperature change appear to be significant.

Application

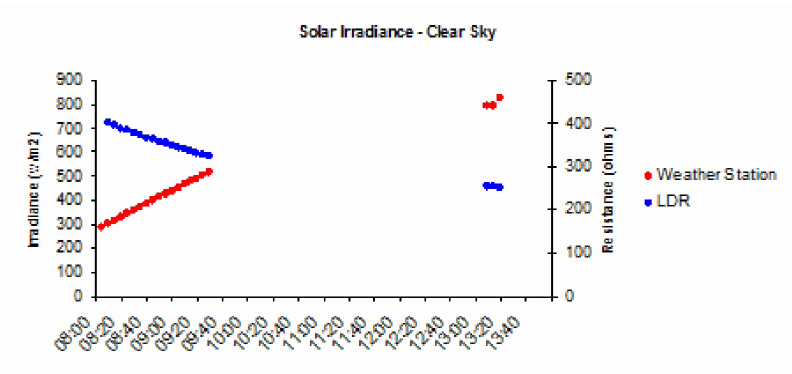
The authors interest in LDR is is as part of a piece of equipment which is intended to measure diffuse irradiance from a clouded sky. The illuminance under a cloudy sky is diffuse, thus a spectroscope can not be used, however an LDR used in conjunction with some fragments of red, green and blue stained glass can be instructive as shown in the graph below:



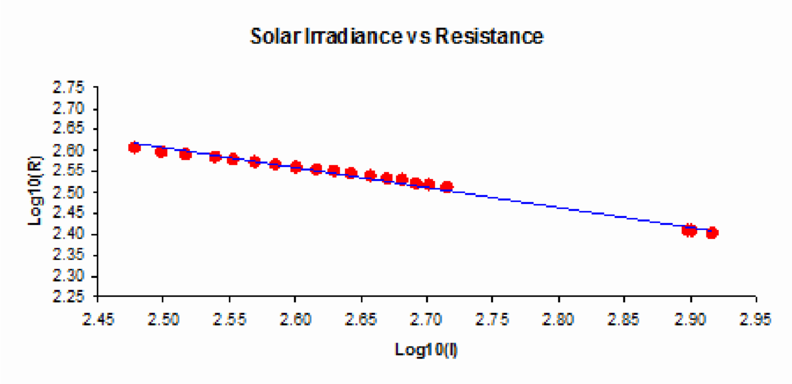
The relationship between the 100 watt incandescent bulb and the 8 watt CFL is more or less what is expected. The illuminant efficiency of the 8 watt CFL appears to by higher than the CFL mainly due to the lower intensity at the red end of the spectrum. This becomes clear when a CFL is used as an energy source for a device which responds to the near-infrared as there is no discernable heating. Whilst the observations made under clear and cloud skies should b treated with caution, it can be inferred that the main difference is intensity, rather than spectrum.

Response to Solar Radiation

The graphics below show the resistance of the sample device during periods of clear sky. On a clear day, it is possible to make a reasonable estimate the global horizontal irradiance (GHI). Also on clear and overcast days, the fluctuation in solar irradiance due to atmospheric conditions is minimal, thus it is possible to correlate the response of a solar device to a nearby weather station. The first graphic shows irradiance and resistance plotted over a morning. Sadly, cloud conditions did not allow the collection of a continuous stream of readings and the measurements had to be taken over two days.



The second graphic is a log-log plot of resistance against irradiance.



As the data points form a straight line, it would seem that an LDR can be calibrated to provide a reasonable estimate of solar irradiance. There are two caveats to this. The first is that an LDR is not a broadband device, having a response roughly in the range 300-1100 nm, whilst the spectrum of sun light is from 150-4000 nm. The second is the effect of temperature. At the time these readings were taken, the temperature response of the sample device is unknown.

It is planned to repeat the above experiment under an overcast sky.

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