Wireless Detection and Development of Cloud Based Light Intensity Monitoring System Using Raspberry PI

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Abstract: **Accurate and quantifiable measurement of light is essential in creating desired outcomes in practical day to day applications as well as unique applications such as traffic lighting system, Poultry Industry, Gardening, Museum lighting system, at emergency exits etc. Hence, Light measurement and analysis is an important step in ensuring efficiency and safety. Many of the industries are burdened with limited number of resources and real shortage of experts on their fields; real time remote monitoring presents an effective solution that minimizes their efforts and expenditures to achieve the desired results within time.**

This paper introduces real time remote Light intensity monitoring system using Raspberry Pi which enables the user to track the lighting system remotely. Raspberry pi is a low cost ARM powered Linux based computer which acts as a server, and it communicates with clients with LAN or external Wi-Fi module. The key feature of this system is light intensity being monitored instantaneously and data stored in the database for future use, and shown in the form of dynamic charts to the user according to the user requirement in a terminal device like Tablet or Smart Phone or any internet enabled device. This empowers experts to make right decisions at right time to get desired results.

Keywords: **Light Intensity; Wireless Detection; Raspberry Pi; Cloud Storage.**

I. INTRODUCTION TO RASPBERRY PI 3

The Raspberry Pi 3 Model B is the third generation Raspberry Pi. This powerful credit-card sized single board computer can be used for many applications and supersedes the original Raspberry Pi Model B+ and Raspberry Pi 2 Model B.

Whilst maintaining the popular board format the Raspberry Pi 3 Model B brings you a more powerful processor, 10x faster than the first generation Raspberry Pi.

Additionally it adds wireless LAN & Bluetooth connectivity making it the ideal solution for powerful connected designs.

Raspberry Pi 3 - Model B Technical Specification

Broadcom BCM2387 chipset 1.2 GHz Quad-Core ARM Cortex-A53 802.11 b g n Wireless LAN and Bluetooth 4.1 (Bluetooth Classic and LE)

1GB RAM

64 Bit CPU

4 x USB ports

4 pole Stereo output and Composite video port

Full size HDMI

10/100 Base T Ethernet socket br

CSI camera port for connecting the Raspberry Pi camera

DSI display port for connecting the Raspberry Pi touch screen display

Micro SD port for loading your operating system and storing data

Micro USB power source

Raspberry Pi 3 - Model B Features

Now 10x Faster - Broadcom BCM2387 ARM Cortex-A53 Quad Core Processor powered Single Board Computer running at 1.2GHz!

1GB RAM so you can now run bigger and more powerful applications

Fully HAT compatible

40pin extended GPIO to enhance your “real world” projects.

Connect a Raspberry Pi camera and touch screen display (each sold separately)

Stream and watch Hi-definition video output at 1080

Micro SD slot for storing information and loading your operating systems.

10/100 Base T Ethernet socket to quickly connect the Raspberry Pi to the Internet.

There are many applications for Light Meters such as measuring and maintaining adequate light levels in schools, hospitals, production areas, laboratories, passageways and more. Adequate light levels in the work place ensure a healthier and safer environment for people. Some of important locations and light intensity is shown in TABLE I

Location	Illuminance (Lux)
Warehouses, Homes, Theaters, Archives	150
Library(Reading Area)	200
Classroom	300
Laboratory	500
General office work	500

Table 1: Optimum Average Light Intensity at Various Locations

Consider following applications as an examples:

A. Traffic Lighting System

To ensure safety on the road, traffic lights need to be clearly visible for road users. The light intensity has to be sufficient under every (weather) condition, which set in legal standards. Over the course of time, the luminous intensity of traffic lights slowly decreases. Possible reasons are pollution of lenses or reflectors, aging of the light source or individual LED failure. Remote monitoring enables the road authority to carryout timely services, in such a way that traffic lights keep satisfying the statutory rules for optimal traffic safety.

B. Poultry Industry

Light Intensity is an important management factor in poultry industry to obtain optimal production. The intensity depends upon the age and type of housing being used, and type of chicken, be it broiler, breeder or layer. With blackout housing both male and female can be exposed to 3.5 fc from day one today six and then placed on 1 fc to 19 or 20 weeks. After 19 - 20 weeks the broiler breeders can be exposed to about 3.0 to 5.0 fc during the entire production period. Layers should be exposed to about .5 to 1.5 fc (One foot-candle =10.76 lux) for better production [4-6].

C. Plants Growth

Deficient light intensities tend to reduce plant growth, development and yield. This is because low amount of solar energy restricts the rate of photosynthesis. Below a minimum intensity, the plant falls below the compensation point. Compensation point is the metabolic point at which the rates of photosynthesis and respiration are equal so that leaves do not gain or lose dry matter. Photosynthesis significantly slows down or ceases while respiration continues. Likewise, excessive light intensity should be avoided.

D. Museum Lighting System

Light intensity is a primary consideration in museums to protect historic artifacts from damage. 5 to 10 foot-candles (approx. 50 to 100 lux) is currently considered to be the maximum allowable light level for very sensitive materials, such as prints, drawings, watercolors, dyed fabrics, manuscripts, and botanical specimens. Up to 15 foot-candles.

II. HARDWARE IMPLEMENTATION

A. LDR

A LDR (Light Dependent Resistor) is variable resistor, the resistance of the LDR is inversely proportional to the light intensity, and it exhibits maximum resistance in the absence of light and minimum resistance in the presence of light. LDR produces analog output voltage with respect to incident light, The Raspberry Pi computer does not have a way to read analog inputs. It is a digital-only computer. Compared to the Arduino, AVR or PIC microcontrollers that often have 6 or more analog inputs.

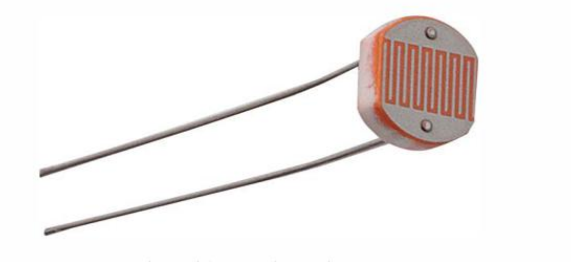

Fig.1: LDR

In electronics, signal conditioning means manipulating an analog signal in such a way that it meets the requirements of the next stage for further processing. Most common use is in analog-to-digital converters.

In control engineering applications, it is common to have a sensing stage (which consists of a sensor), a signal conditioning stage (where usually amplification of the signal is done) and a processing stage (normally carried out by an ADC and a micro - controller). Operational amplifiers (op-amps) are commonly employed to carry out the amplification of the signal in the signal conditioning stage.

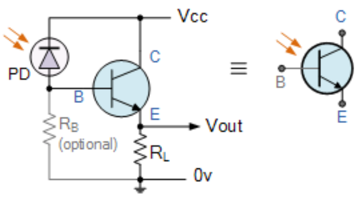

Fig 2: Light Sensors

A **Light Sensor** generates an output signal indicating the intensity of light by measuring the radiant energy that exists in a very narrow range of frequencies basically called "light", and which ranges in frequency from "Infra-red" to "Visible" up to "Ultraviolet" light spectrum.

The light sensor is a passive devices that convert this "light energy" whether visible or in the infra-red parts of the spectrum into an electrical signal output. Light sensors are more commonly known as "Photoelectric Devices" or "Photo Sensors" because the convert light energy (photons) into electricity (electrons).

Photoelectric devices can be grouped into two main categories, those which generate electricity when illuminated, such as *Photo- voltaic* or *Photo-emissive* etc., and those which change their electrical properties in some way such as *Photo-resistors* or *Photo-conductors*. This leads to the following classification of devices.

Photo-emissive Cells – These are photo devices which release free electrons from a light sensitive material such as cesium when struck by a photon of sufficient energy. The amount of energy the photons have depends on the frequency of the light and the higher the frequency, the more energy the photons have converting light energy into electrical energy.

Photo-conductive Cells – These photo devices vary their electrical resistance when subjected to light. Photoconductivity results from light hitting a semiconductor material which controls the current flow through it. Thus, more light increase the current for a given applied voltage. The most common photoconductive material is Cadmium Sulphide used in LDR photocells.

Photo-voltaic Cells – These photo devices generate an EMF in proportion to the radiant light energy received and is similar in effect to photoconductivity. Light energy falls on to two semiconductor materials sandwiched together creating a voltage of approximately 0.5V. The most common photovoltaic material is Selenium used in solar cells.

Photo-junction Devices – These photo devices are mainly true semiconductor devices such as the photodiode or phototransistor which use light to control the flow of electrons and holes across their PN-junction. Photo junction devices are specifically designed for detector application and light penetration with their spectral response tuned to the wavelength of incident light.

A **Photoconductive** light sensor does not produce electricity but simply changes its physical properties when subjected to light energy. The most common type of photoconductive device is the *Photo resistor* which changes its electrical resistance in response to changes in the light intensity.

Photo resistors are Semiconductor devices that use light energy to control the flow of electrons, and hence the current flowing through them. The commonly used *Photoconductive Cell* is called the **Light Dependent Resistor** or **LDR**.

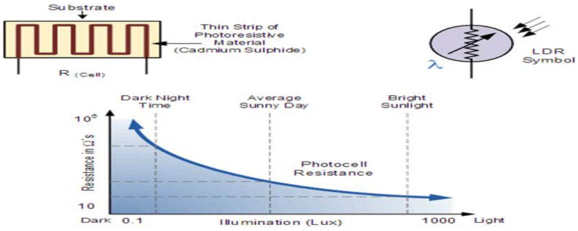

Figure 3: The Light Dependent Resistor Graph

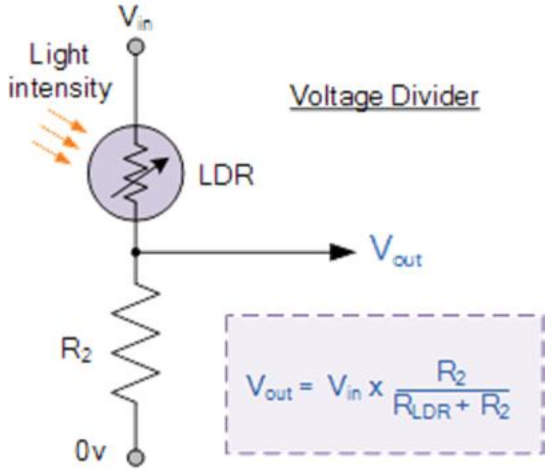

Figure 4: ORP12 Cadmium Sulphide photoconductive

B. ADC

Analog inputs are handy because many sensors are analog outputs, so we need a way to make the Pi analog-friendly. We can do that by wiring up an external ADC (Analog to Digital Converter) MCP 3208. The MCP 3208 acts as a bridge between digital and analog. It is a 12 bit 8 channel Analog to Digital converter. It uses the SPI bus protocol which is supported by the pi's GPIO header.

We need to enable the SPI interface on the raspberry pi by modifying the configuration file i.e., raspi-blacklist.conf the following command is used to open the configuration file sudo nano etcimodeprobe.dlraspi-blacklist.conJ. Add a '#' character in front of the line spi-bcm2708. Use CTRL-X, thenY, then return to save the file and exit. Reboot using following command sudo reboot. In order to read data from the SPI bus in Python we can install a library called 'pyspidev'. Know ready to use SPI protocol in raspberry pi. Configure the ADC input registers to select particular channeling the ADC and use bitwise operators to get desired output from the output registers.

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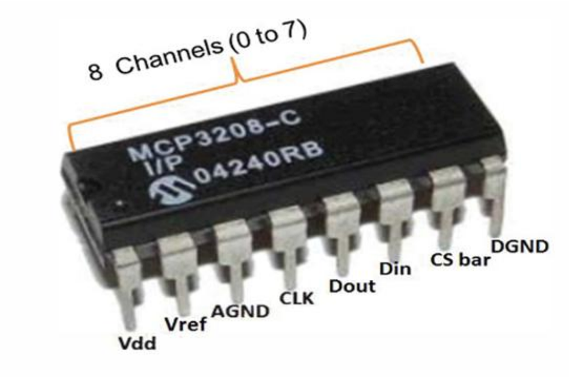

Figure 5. MCP 3208 Analog to Digital Converter

III. SIGNAL CONDITIONING CIRCUIT FOR LIGHT INTENSITY MEASUREMENT

Here we are using two signaling condition circuits

- Signal Condition Circuit Using Instrumentation Amplifier.
- Signal Condition Circuit Using Low Pass Filter.

Signal Condition Circuit Using Instrumentation Amplifier

Resistive sensors such as LDRs, RTD sand strain gages produce small percentage changes in resistance in response to a change in a physical variable such as light, temperature or force. One technique for measuring resistance is to force a constant current through the resistive sensor and measure the voltage output.

An instrumentation amplifier is a type of differential amplifier that has been outfitted with input buffer amplifiers, which eliminate the need for input impedance matching and thus make the amplifier particularly suitable for use in measurement and test equipment. Additional characteristics include very low DC offset, low drift, low noise, very high open-loop gain, very high common-mode rejection ratio, and very high input impedances. Instrumentation amplifiers are used where great accuracy and stability of the circuit both short and long-term are required.

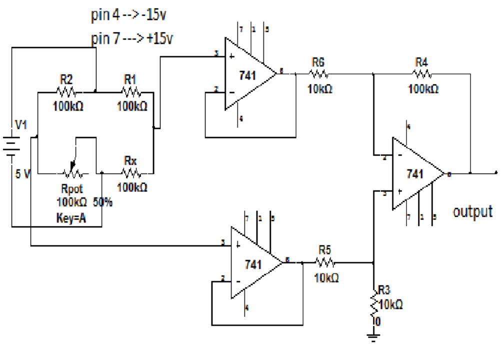

Figure 6: Signal Condition Circuit Using Instrumentation Amplifier

Circuit Description: Signaling condition means manipulating an analog signal in such a way that it meets the requirement of the next state for further processing. In our paper change in the resistance of the LDR due to light intensity then output voltage of bridge also changed. Based on this output of the instrumentation amplifier which is connected to the bridge circuit, will also amplified and the variation of the voltage will be changed. It is observed that due to limiting the input voltage the output voltage variation gets linearity up to a certain range. Here the instrumentation amplifier is of having a gain of 10. In this project bridge circuit is very sensitive. So it will get the output voltage based on the sensitivity of bridge.

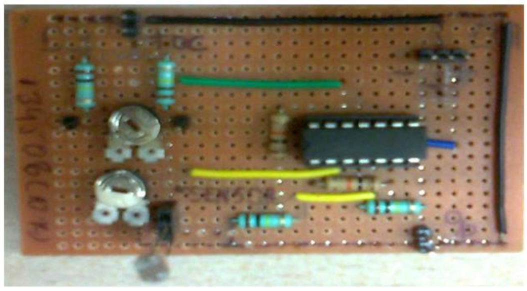

Figure 7: Hardware implementation of Signal Conditioning Circuit Using Instrumentation Amplifier

Signal Condition Circuit Using Low Pass Filter

The circuit diagram as shown in Figure 8. potential divider network and op-amp filter stage, whenever light fall on the LDR, resistance of the LDR changes drastically hence voltage across the pot increases, this voltage has noise due to noise sources like flickering lights, glare, and pulsating light sources and so on, to eliminate this noise we use the 3rd order low pass filter.

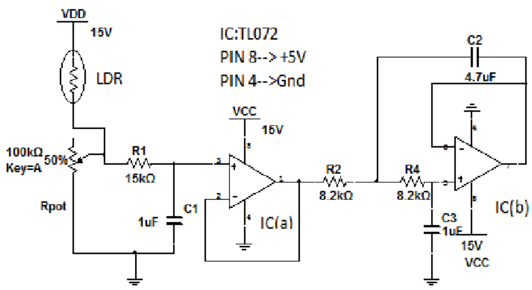

Figure 8: Signal Condition Circuit Using Low Pass Filter

The signal conditioning circuit is shown in figure. The output of the potential divider circuit given to 3rd order analog low pass filter. The filter is design with dual op-amp TL072 from Texas Instruments (TI) and which allows frequencies lower than 100Hz to pass and stops anything above this value. The LPF is here needed to reduce noise and unwanted high frequency transitions due to sudden flickering lights, pulsating light sources and so on. Ext the output from the LPF is fed to the first analog input channel of the ADCMCP 3208.

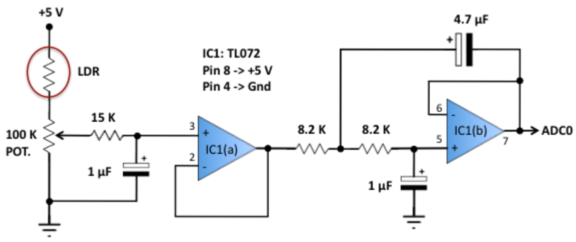

Fig.9: Signal conditioning circuit

Calibration of Light Dependent Resistor

The relationship between the resistance Rl and light intensity Lux for a typical LDR is

R_L =500/Lux K ohm (1)

With the LDR connected to 3.3K resistor,

The output voltage of the LDR is

$V_0 = 3.3^* R_{L/}(RL+3.3)$ (2)

From equation (1) and (2)

We obtain Light intensity Lux = $(1650/v_0 -500)/3.3$.

Design and Development

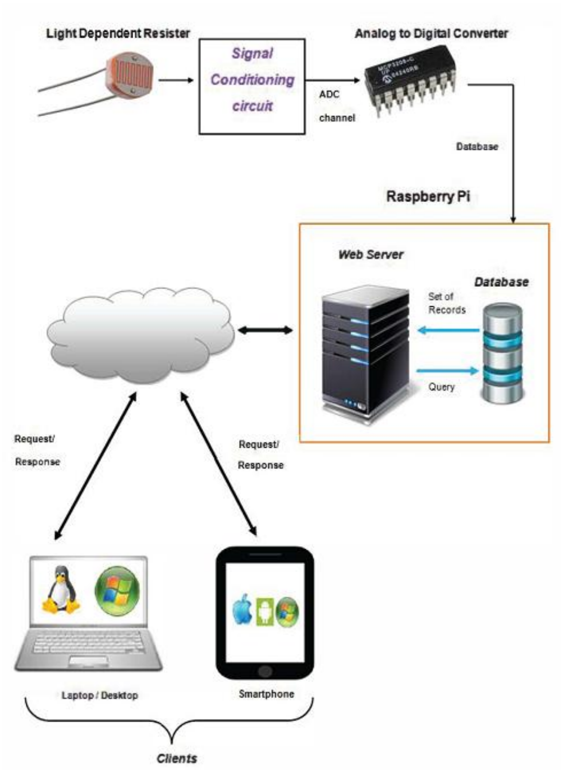

Fig 10: Block Diagram of Proposed System

signal from LDR is given to the signal conditioning circuit which is responsible to eliminate the noise, output of signal conditioning circuit given to the one of the analog channel of ADC which converts signal into digital signal, then the signal given to the GPIO (General Purpose input/output) of the Raspberry Pi.

A. Raspberry Pi as a Web server

The Raspberry Pi is a good choice for a web server that will not receive too much traffic, such as a testing server, or small intranet, as it doesn't have overheating problem. Apache is a web server application that we can install in the raspberry pi which allows to serve web pages. Use the following command to install Apache2, sudo apt-get install apche2 –yo Apache can serve HTML files over HTTP, and additional modules can serve dynamic web pages using scripting languages such as PHP.

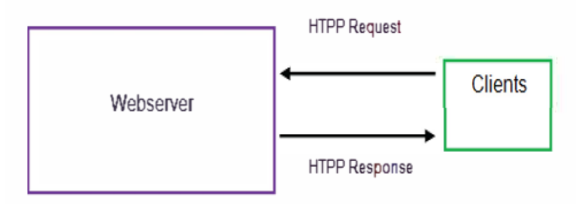

Figure 11: Serve and client Communication

We can store Acquire in the database, developed web application stored in the server. Client can access the system with IP address through computer or Smart phone or Tablet or any other internet enabled device.

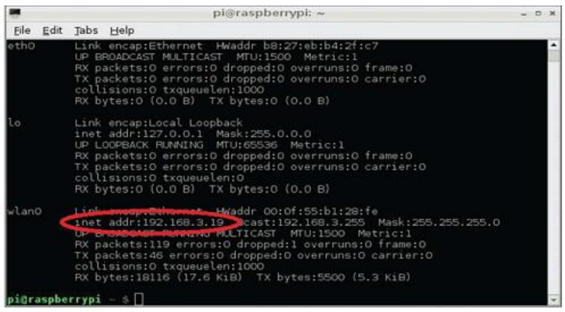

Figure 12: System IP address

B. Evaluation

The purpose of evaluation is to evaluate the performance of proposed system.

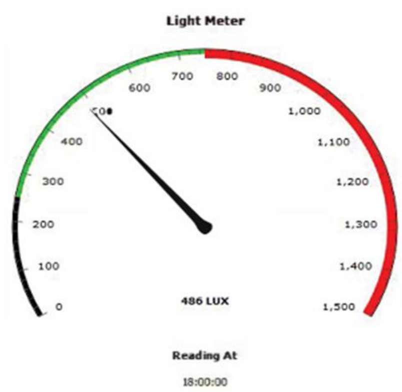

Fig 13: Light Meter

log_id	Date	zone	Light_intensity
1	2014-12-15	LAB	428.4
2	2014-12-16	LAB	435.5
3	2014-12-17	LAB	416.8
4	2014-12-18	LAB	524.4
5	2014-12-19	LAB	530.2
6	2014-12-20	LAB	524.6
7	2014-12-21	LAB	509.2

Fig 14: Sample data for Week (15/12/2014 to 21/12/2014)

Fig.13 shows the light meter which shows instantaneous light intensity. If we observe the Fig.14 in between 11 to 15 hours' light intensity recorded less than the average light intensity (500 LUX). It is also showing maximum light intensity, minimum light intensity and average light intensity with date, time and location.Fig.7.3 shows week report (15112/2014 to 2111212014), it helps data analyst to understand average light intensity of each day. If we observe the Fig.7.3 in between 15/12/2014 to1711212014 the light intensity recorded less than the average light intensity (500 LUX) and there is sudden change in light intensity on the day 1811212014 where it is recoded more than the average light intensity. It is also showing maximum light intensity, minimum light intensity and average light intensity with date and location

Maximum Light Intensity:

Date	zone	Light Intensity(LUX)
2014-12-19	LAB	530.2

Minimum Light Intensity:

Date	zone	Light Intensity(LUX)
2014-12-17	LAB	416.8

Average Light Intensity:

Light Intensity(LUX)
481.3000008719308

Fig 15: Week Report from 15/12/2014 to 21/12/201

IV. CONCLUSION

The Facility manger will have skill, training and experience but lagging with lack of information to take action immediately. In the paper, we have proposed and developed cloud based light intensity monitoring system. This helps to Facility manger to take necessary action at right time, with proper controlling with can achieve desired results. To evaluate the system, we have considered laboratory as an example but it can be used at various applications like traffic light monitoring, poultry lighting and museum lighting etc. to avoid damage.

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