International Journal of Technical Innovation in Modern Engineering & Science (IJTIMES)
Impact Factor: 5.22 (SJIF-2017),e-ISSN:2455-2585
International Conference on Smart Cities (ICSC-2019)
Volume-05, Special Issue_March_2019.

DESIGN OF ADAPTIVE LIGHTING BASED SMART SYSTEM

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Abstract:- ***Smart systems and automated systems are two buzzwords in current trend of technology. However while these systems exist and are being built to suit the needs of the consumer andindustry it is important that they are energy efficient as well. This paper demonstrates design and implementation of an adaptive lighting based smart system implemented on an embedded system based on Arduino which would respond based on the inputs it receives from its environment such as the amount of lighting received on LDR and presence of human in that particular area detected by PIR sensor where it is deployed. Such a system will overcome the drawbacks of manual control and energy wastage.***

Keywords: Arduino, smart systems, LDR, PIR sensor, embedded system

1. Introduction

Interconnected, instrumented & intelligent systems are termed as "Smart Systems". They exhibit adaptive behavior according to the required function & the environment it is in. The enablers of such a system is IoT, which is driven by 3 key Processes- Sensors & actuators, Connectivity, People & processes. The base of any smart systems are sensors & actuators connected to other devices over which services & applications are built. The basic function of sensors is to collect data from its environment i.e the physical parameters such as temperature, light, sound & vibration, motion of objects, position, speed etc. This data will be only of any use if it is acted upon so, after receiving the data from sensors we place them on a network. Networks can be short range such as Wifi, Bluetooth, RFID while long range can be Mobile networks, WANs. Once the network inputs have been received it is converted to systems that integrate data, people & processes to improve decision making, save time, be efficient compared to the traditional systems which were either manual or only autonomous. Smart systems require minimal intervention and can be used for applications & industries which may require remote management.
While we create systems to suit wide variety of needs it is also important that they do not waste energy. Conservation of energy is a method to reduce energy demands, it is an important way of bringing down the electricity expenses while reducing the strain on environment. One of the primary ways to improve energy conservation in buildings is to use an energy audit. Especially in the field of lighting systems street lighting is one of the biggest electrical energy consumers. The costs of the electrical energy together with the environmental factors encourage municipalities to implement solutions to measure, analyze and reduce energy consumption in order to reduce spending and decrease maintenance costs [1].An energy audit is an inspection and analysis of energy use and flows for energy conservation in a building, process or system to reduce the amount of energy input into the system without negatively affecting the output. Electricity is needed for lighting, process control of the installation, heating, refrigeration and as driving power for machinery. It is usually generated and supplied by utility companies, but when electricity is generated on site, the efficiency factor results considerably higher. To increase saving potentials and the necessary investments to achieve the savings are much lower, compared with optimizing a plant in commercial operation, if energy efficiency is considered during the design and installation phases of a new plant.

A whole interconnected system can be controlled and managed by using different type of communication structures for power grid, a simple intelligent module can control and measure lamp parameters [2]. Light, sensors and controls can adapt to human productivity, energy efficiency, and wellness. Moreover drawbacks of manual solutions is that they suffer from higher implementation costs, timer based solutions which in turn wastes power in less populated regions. A sensor equipped lighting system can communicate with other lamp unit and a management system which operates or controls it centrally. Such a system finds major application in street lighting system which helps reduce maintenance cost [9]. Smart Lighting systems have applications in many areas such as monitoring in-home activity for elderly, saving energy using need-based lighting management in homes and offices. Smart lighting systems are becoming a backbone of IoT applications especially for smart cities as it can help improve public safety due to improved lighting, increase safety of traffic due to increased visibility of obstacles, help monitor environmental effects due to reduced energy consumption, lower operational costs, enable remote lighting management Thus installation of such a solution in a city serves as a backbone of a network in which services are delivered for the benefit of citizens, businesses and city government [3].

2. Literature Review

Multiple users in wide areas can have various lighting requirement and preferences based on their activities and profile addressing this Lun-Wu YehEt.al [4] have proposed an automated system which gives feedback from light sensors carried by users.While meeting user needs this system utilizes minimum energy, considering two different models namely binary satisfaction model and continuous satisfaction model to measure satisfaction levels based on two parameters background and concentrated illumination.To support the effectiveness of their design they havepresented simulations and prototype result of the system architecture.

Harshil Shah[5] Et.alhave presented a solution for controlling street lights which overcomes the problems of existing systems a system which can conserve energy while giving optimal usage. The design is specific to address the issue of public lighting systems based on a MOSFET basic driver circuit to control the intensity of light along with LEDs (Light Emitting Diode)replacing HID (High Intensity Discharge) lamps due to their dimming feature and a better life cycle of LEDs. The proposed system works according to the darkness sensed and not upon the time slots since time slots don't consider seasonal changes.

Maximum contributor toenergy consumption in the world is home power consumption particularly consumed by lamps Ying-Wen Bai Et.al [6]in their work have studied and designed a system which will control different lights in different regions by incorporating an RF module to communicate data between each lighting module installed in the house, by detecting the presence of human in the room the lights are controlled based on different threshold values using Solid State Relays to turn the lights ON/OFF. The design they have proposed is not just autonomous but also consumes less power at low cost.
Ashish Pandharipande Et.al [7] have researched and implemented wireless sensors for lighting indoors using energy harvesting. This novel idea operates a wireless sensing prototype by harvesting energy from its immediate surrounding. A light sensor and a motion sensor detect the level of luminescence and occupancy in the room and a central controller which receives the sensing information determines the dimming level of that room. In practice to harvest ambient light they have considered low-powered ceiling mounted sensor to determine its suitable orientation.

3. Resources Used

3.1 Arduino Uno board

It is an open source hardware development boardbased on 8-bit Atmega 328p microcontroller designed to adapt to various types of sensors and be programmed for real-time applications. Arduino boards are preferred over microcontrollers to build small real time projects because of many factors such as they are easier to program, present in logic 5V and 3.3V makingarduino boards more versatile than microcontrollers, more instruction executing speed [8]. It has 14 digital input/output pins (of which 6 can be used as PWM outputs), 6 analog inputs, a 16 MHz crystal oscillator, a USB connection, a power jack, an ICSP header, and a reset button.Arduino does not require external hardware programmer since it is preprogrammed with a bootloader.

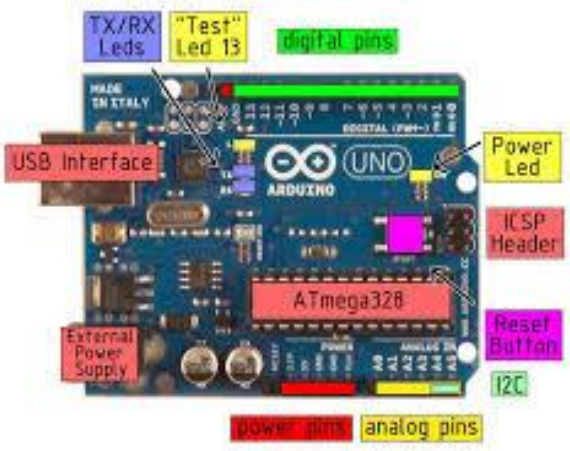


Fig.1 Arduino Uno board (Source: Octopart A000049)

3.2Light Dependent Resistor

Photo resistors interchange name with LDR (Light Dependent Resistor) which are used to detect or measure the light intensity. LDRs are nonlinear devices whose resistance changes depending upon the wavelength of light falling upon it. When light falls on the semiconductor, the semiconductor lattice absorbs the light photons and transfers some of its energy to the electrons. The excited electrons jump from valence band to conduction band and thus the free electrons carry the current [9].

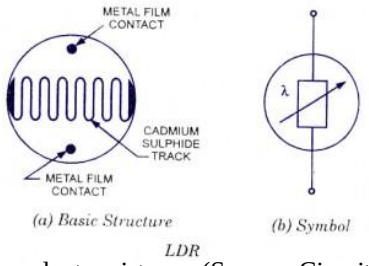


Fig.2 Light dependent resistance (Source: CircuitsToday LDR)

3.3 Passive Infrared Sensor

The most commonly used motion detectors are PIR sensors , the main components which make up a PIR sensor work is the an air-tight sealed metal can which has the IR sensor built in it shown in two figures below and the other main component is the Fresnel Lens which concentrates light to a point providing greater range of IR. The sensor is made up of two different slots which detect whenever a body passes by radiating warmth and causes positive and negative differential change causing the change in pulses detected by the slots [10].

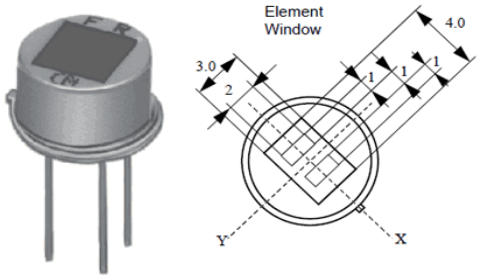


Fig.3 Metal Can of the PIR sensor (Source: Adafruit) Fig.3 Structure of the metal can (Source: Adafruit)

3.4 Dimmer Module

This board is used for controlling dimming of AC sources on 16 levels of control the central element which drives this module is a Triac which is similar to a diode or a transistor. Input of dimmer module are 4-bit digital pins which can be connected to the I/O of the Arduino. Based on different combinations of 1s and 0s on each of these digital pins the intensity can be varied from 0 to 100% [11].

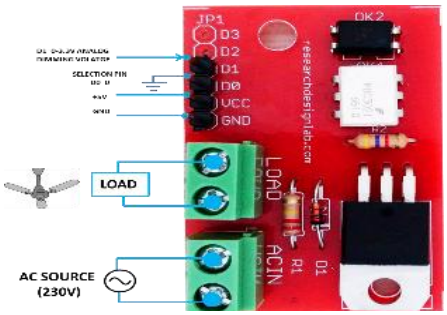


Fig.2 Analog Dimmer module (Source: research design lab)

4. Issue addressed

Public lighting systems are enlightened for 13 hours per day implying that a large amount of electricity is consumed by these systems contributing to almost 30% of total electricity in any region. [13] Shows that Public lights around different regions of the world Europe Union, USA, United Kingdom and France contributes to more than 800 billion KW of energy consumption.

India in the FY2013 consumed about 8,478 GWh of electricity in addition to that public lighting systems in India have poor infrastructure which incurs large maintenance costs of around 10-15% of Municipal budget [14]. The large energy consumption is due to the fact that public lights utilize conventional lighting systems which operate for a long period of time without a purpose. Moreover traditional and conventional methods of lighting systems contribute to CO2 emissions and light pollution. This makes one think and naturally raise a question is there a way we can conserve energy by controlling the amount of artificial light?

As a solution to this problem we have designed a reliable, energy saving, cost-effective system which will respond to the changes it senses from its environment such as presence of a body due to variation in temperature caused by the moving body emitting infrared energy in the surroundings detected by PIR sensor and the amount of light is sensed by the LDR sensor. We have designed this system keeping in mind optimal management and control system.

5. Flow of Information

5.1 Flow Diagram

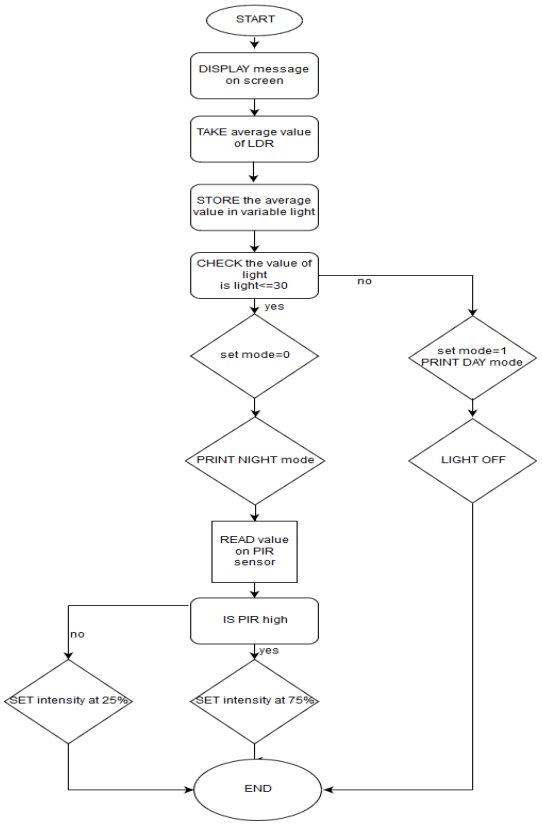


Fig 5. Flowchart of the working principle

When the power is turned on the LCD screen prints a message ‘smart lighting system’ and starts detecting the presence of light on LDR sensor. The microcontroller starts reading analog values of the input voltages of the LDR and takes the average of these values to store it in a variable ‘light’ which is compared with a threshold value, if that value is less than equal to the threshold value then it indicates night mode and further microcontroller reads the digital value of PIR sensor at 1 or 0. If the value is high intensity of light is set at 75% else at 25%, if the value of light is greater than the treshold value it indicate day mode and turns the lamp off.

5.2 Architectural Diagram

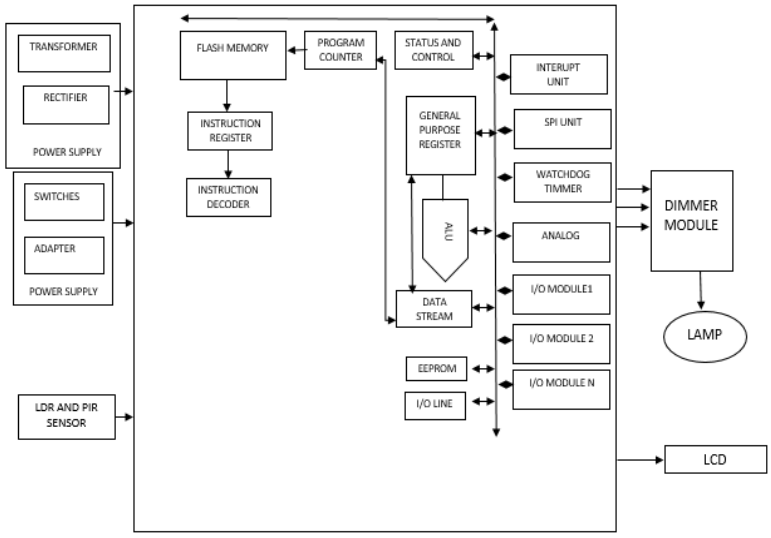
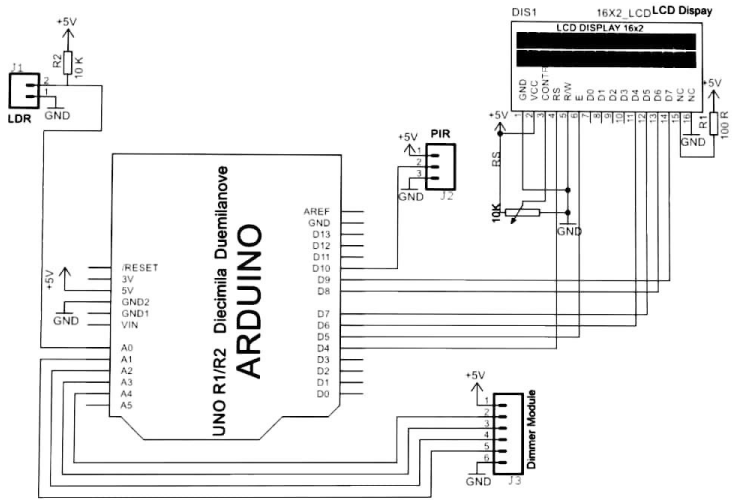


Fig 6. Architectural Diagram

The architecture of the Arduino is a Harvard architecture which stores data in data memory and code in the flash program memory and the software used to code is known as Arduino IDE. Arduino is widely used nowadays as a replacement to microcontrollers because it doesn't require the code to be burned [12].
The proposed design consists of two power sources the microcontroller on the Arduino board powered by a DC source such as an adapter whereas the dimmer module is powered by an AC source used to control the intensity of the lamp, the microcontroller reads analog and digital values of the LDR sensor and PIR sensor respectively based on two different conditions controls the luminescence and displays the result on the LCD screen.

5.3 Circuit Diagram



5.4 Implementation
5.4.1 Case study I

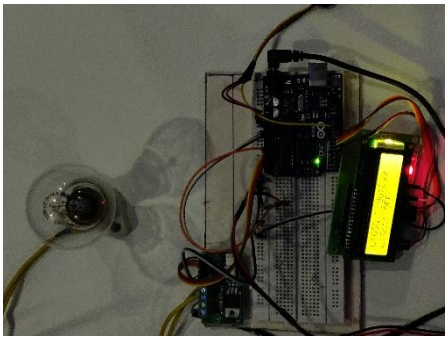


Fig 7. The lamp is in OFF state.

The Lamp will remain off when the average analog readings of light are greater than the threshold value because the microcontroller senses day light as indicated by the device LDR.

5.4.2 Case study II

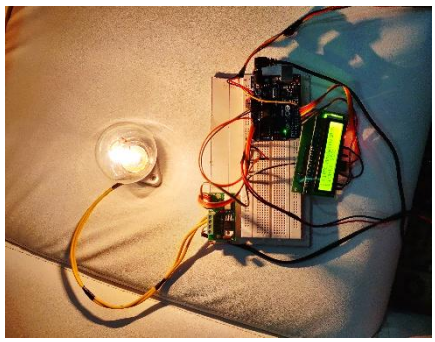


Fig 8. The lamp is in ON state.

The Lamp will remain on when the average analog readings of light are less than or equal to the threshold value because the microcontroller senses darkness as indicated by the passive device LDR however the digital value read by the microcontroller is low therefore the intensity of light is at 25%.

5.4.3 Case study III

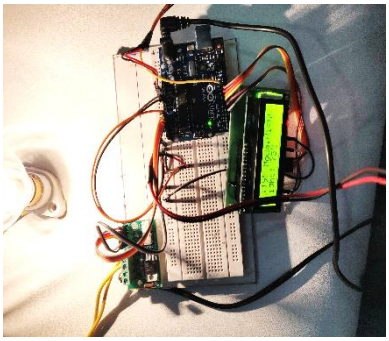


Fig 9. The lamp is in ON state with higher intensity.

The Lamp will remain on when the average analog readings of light are less than or equal to the threshold value because the microcontroller senses darkness as indicated by the passive device LDR however the digital value read by the microcontroller is low therefore the intensity of light is at 75%.

6. Conclusion

By referring all the results, it can be concluded that both hardware and software development of this project meet the objective of design. The project presents one of the simple and effective ways of saving energy automatically indoors and outdoors. This was achieved by the application of the microcontroller Atmega 328 and Passive Infra-red sensor, Light dependent resistor as the major building blocks. The solution to energy conservation is to eliminate time slot and introduce a system that could sense brightness environment and act accordingly so that seasonal change would not affect the intensity of street lights.

7. Future Scope

Home automation is a trending topic nowadays and when combined with communication technology like Zigbee can be used to monitor and control the lighting systems on smartphones. The client/user with the access to home server via smartphone will be able to remotely monitor the status at home through real-time monitoring and control the lights via a panel. Further this lighting can take user's choice into account, the dimming level can be adjusted on the level of area occupied, availability of sunlight. Smart lighting systems can go beyond adaptive dimming by combining heterogeneous light technologies.

In our future work we will use RF module to communicate between two lighting modules in order to pre control the lights by that we mean let's say a person goes from one area of the home or office say area A to another area of the office or home say area B assuming that both these areas have intelligent light modules attached will be able to communicate by predicting that the person is moving to a specific room so the lights of that room will be turned on in advance.

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