Home Environment Monitoring And Lighting Control Using Cloud Mqtt Dashboard

Dhiraj Sunehra, Sathish Sandu

Abstract: Home environment monitoring and automation helps to secure the home from accidental hazards and provides convenience to the user. Due to the recent technological developments in the field of communications, several authors are implementing Internet of Things (IoT) based embedded systems. In this paper, we implement an embedded system based on IoT consisting two subsystems, one subsystem for monitoring various home environment parameters such as temperature, humidity, gas leakage, occurrence of any fire accident, and rain, and another subsystem for automatic lighting control in the home based on the measurement of light intensity. The system is built using Arduino Mega 2560, several sensors and NodeMCU as a Wi-Fi module. The necessary software is developed in Embedded C using the Arduino Integrated Development Environment (IDE). The sensor data is fed to the Arduino which checks the set threshold conditions, and then uploads the information about each environment parameter on to the Cloud Message Queue Telemetry Transport (MQTT) webserver as well as MQTT dashboard android application. PIR sensor detects any motion in the room and turns on the light in the presence of a living being inside the room. This helps saving the energy consumption. The SSR dimmer circuit and light dependent resistor (LDR) are used to control the light intensity of the bulb based on the lighting in the room.

Index Terms: Arduino Mega 2560, Automatic lighting control, Cloud MQTT Dashboard android app, Light Dependent Resistor, NodeMCU, PIR Sensor, Secure Home Environment.

1 INTRODUCTION

In today's world, automation has become important and is being used in many applications in our daily life. A Home Automation System (HAS) is a system where in home appliances or environment is controlled without much human involvement. It saves power, time and efforts and is more efficient than the conventional systems. Home environmental monitoring is a major Internet of Things (IoT) application, which involves monitoring the inside and outside environment of the home. By using IoT technology, user can create advanced Home Automations Systems that can improve the quality of the life. The objective of this paper is to develop a home environmental monitoring system to measure different parameters like temperature, humidity, occurrence of fire, occurrence of rain and presence of any hazardous gases. Monitoring of these parameters is not only helpful in homes, but also in industry and for weather forecasting. Another objective of this paper to provide a well organized and energy saving lighting system based on the lighting intensity in the room. The system adjusts the light brightness according to the presence of human being and light intensity in the room.

2 LITERATURE REVIEW

Khalil Ullah and M. Asadullah implemented a Bluetooth technology based home monitoring and controlling system which monitors the home environmental parameters such as soil moisture, temperature and humidity, and controls the appliances within the short range of 20 m using Bluetooth technology [1]. Zafar and Miraj implemented a real time temperature and humidity monitoring system with the help of Arduino in which they monitor only the temperature and humidity values and upload that data to ThingsSpeak webserver [2].

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Ravi Kishore and Aditya Valdas implemented an environmental monitoring system for safety of the employees, with the help of Losant MQTT based IoT platform, in which they monitor the gas leakage and flame occurrence continually [3]. Ying-Wen Bai and Yi-Te Ku implemented an automatic light intensity control system based on the lighting present in the room, with the help of Home light control module (HLCM) in which they used Passive Infrared Sensor (PIR) sensor for motion detection. RF module is used for transmitting and receiving data to each HLCM to control the light intensity [4]. Wahab implemented a home automation system which is based on IoT to control the electrical appliances such as the bulb and fan at home easily and efficiently via Wi-Fi for the personally disabled persons. The sensors monitor the motion, humidity and temperature of the house [5].

3 HARDWARE DESCRIPTION

3.1 Block diagram of the system

Figure 1 shows the block diagram of home environment monitoring and automatic lighting control system. The system consists of a central Arduino Mega 2560 board which interfaced with various sensors such as Temperature and humidity sensor (DHT11), Passive Infrared Sensor (PIR), IR flame sensor, MQ2 gas sensor, Rain sensor, LDR sensor and SSR dimmer circuit. The outputs from the sensors are sent by Arduino to the ESP8266 NodeMCU Wi-Fi module, which transmits the sensed data to the CloudMQTT webserver and MQTT dashboard android application.

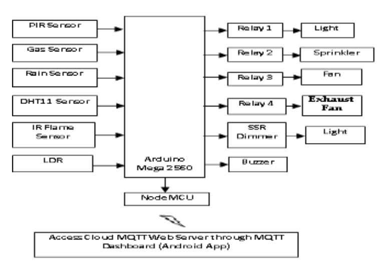

Fig. 1. *Block diagram of the home environment monitoring and automatic lighting control system*

3.2 Arduino Mega 2560

All Arduino boards use the Atmel Corporation's AVR family processors for their boards. The microcontrollers use modified Harvard architecture with single chip of a 8 or 16-bit Reduced Instruction Set Computers (RISC) architecture [6]. The Arduino Mega uses an AVR ATmega 2560 microcontroller. The board has 54 digital I/O pins (out of which 15 can be used as PWM outputs), 16 MHz crystal, USB connection, 4 serial hardware ports (UART), a power connector, ICSP programming connector and a reset button (Fig. 2). ATmega 2560 comes with 256KB non-volatile reprogrammable flash memory to store the program, 8KB volatile static RAM used to write or read data during program execution, 4KB byte addressable nonvolatile EEPROM to permanently store variables and recall them during program execution.

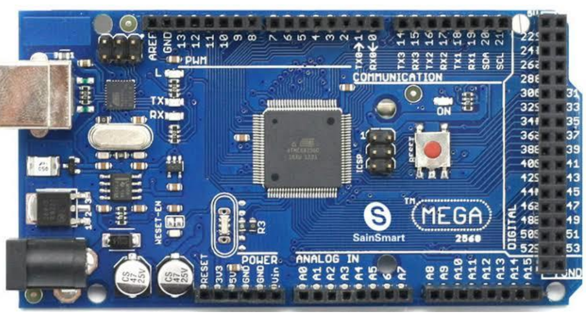

***Fig. 2**. Arduino Mega 2560 Board*

3.3 PIR Sensor

Passive Infrared (PIR) sensor is used to detect the motion of nearby human beings in its measuring range (Fig. 3). It works on high-low logic. If any motion is detected, its output is high (3.3V) and when there is no motion detected, its output is low (0V). PIR sensor accepts input voltage in the range of 4.5V to 12V, but 5V is recommended. It can measuring range is up to 7 m and operating temperature range is -20° to +80° Celsius [7].

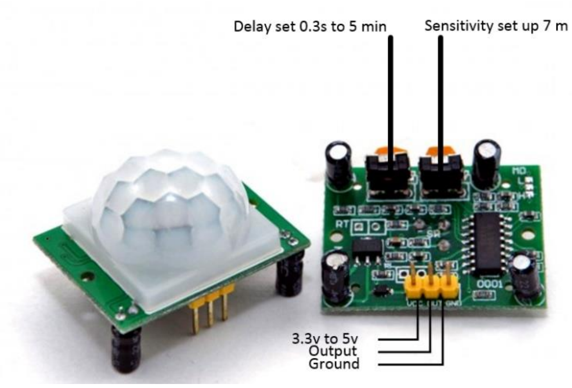

***Fig. 3.** PIR Sensor*

GND pin of PIR sensor is connected to the GND pin of the Arduino Mega 2560 board, Dout (digital output) pin is connected to the digital PWM pin 08 of the Arduino board, and V_{CC} pin is connected to the V_{CC} pin of the arduino board.

3.4 DHT11 Sensor

DHT11 sensor used as a weather sensor to read the temperature and humidity in the environment from time to time from the digital output pin (Fig. 4). DHT11 is having resistive type of humidity measurement component. For measurement of temperature, it is having a Negative temperature coefficient (NTC) type component. It can measure humidity within the range of 20% to 90% with an accuracy of ±5%, and temperature up to 100°C with an accuracy of ±1°C [8].

***Fig. 4**. DHT11 Sensor*

3.5 Rain Sensor

Rain sensor is used to detect the raindrops (Fig. 5). If any rain drops fall on the rain detecting plate, then the plate gets short circuited and the output is high. If no water drops falls on the rain detecting plate, then its output is low. This module has a power indicator LED, which turns on, in the event of rain detection; otherwise it is in off state. The rain sensor sensitivity can be adjusted using the potentiometer provided on the sensor [9].

***Fig. 5**. Rain sensor*

V_{CC} pin of rain sensor is connected to the V_{CC} pin of the Arduino Mega 2560 board, GND is connected to the GND pin of the arduino board. Either the digital pin or analog pin is used as output pin depending on the requirement. Here we use the analog pin as the output pin, and it is connected to the analog pin A2 of the arduino board.

3.6 Gas Sensor

MQ-2 Gas sensor is used for detection of the hazardous gases like Methane, Butane, LPG and Smoke (Fig. 6). MQ2 gas sensor is also called as Chemi-resistor. It has a sensing substance whose resistance changes, when it comes in contact with any harmful gases. Concentration of gas is measured using a voltage divider network. By using this sensor, we can measure gas concentration in the range of 200 to 10000ppm with an operating voltage of 3.3V to 5V [10].

***Fig. 6**. MQ-2 Gas Sensor*

V_{CC} pin of the gas sensor is connected to the V_{CC} pin of the Arduino Mega 2560 board, GND is connected to the GND pin of the arduino board. Either the digital pin or analog pin can be used as output pin depending on the requirement. In this work analog pin is used as output pin and it is connected to the analog pin A1 of the arduino board.

3.7 IR Flame Sensor

IR Flame sensor is used to detect if there is any flame source in the wavelength range of 760nm to 1100nm. It will give both analog and digital outputs when output is connected to the respected pins if output pin is connected to digital pin then it going to give High logic for flame detection and Low logic for no flame detected state and if output is connected to analog pin then it going to give values in the range of 0 to 1024 here if the values increased from 0 to 1024 drastically then there is warning of flame detection exist then led going to up in the sensor [11]. IR Flame sensor is shown in Fig. 7.

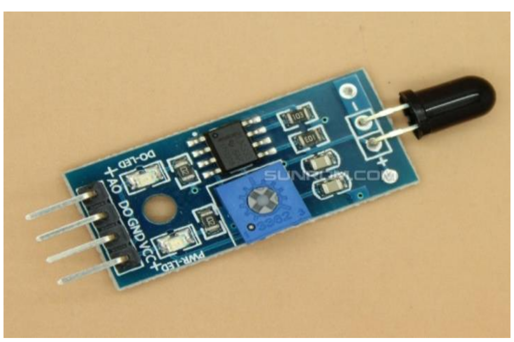

***Fig. 7**. IR Flame sensor*

V_{CC} pin of IR flame sensor is connected to the V_{CC} pin of the Arduino mega 2560 board, GND pin is connected to the GND pin of the Arduino board and Either digital pin or analog pin is used as output pin depending on our requirement but in this system analog pin as output pin so it is connected to the analog pin A3 of the Arduino board.

3.8 LDR Sensor to control SSR Dimmer circuit

LDR uses a semiconductor material for detecting the ambient light intensity (Fig. 8). When light falls on the LDR, its resistance decreases [12]. LDR is interfaced to the Arduino Mega 2560 to measure the intensity level of the light present in the room. Based on the intensity level measured by the LDR circuit, brightness of the bulb is controlled by a SSR Dimmer circuit. The SSR dimmer circuit is built using a Triac [13].

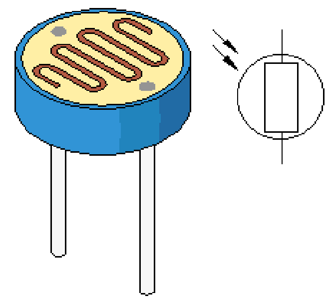

***Fig. 8**. Light Dependent Resistor*

3.9 Relay Module

Relay is an electro-mechanical module is used to turn ON/OFF a device by sending a small signal at the output. Fig.9 shows a 8- channel relay with 8-relays on a single PCB, but only 4 relays are used here. The input to the relays IN1, IN2, IN3, and IN4 are connected to the Arduino's 12, 11, 10 and 9 pins respectively, to turn ON the corresponding relay. The output pins of each relay consist of a common terminal (COM), normally open (NO) and normally closed (NC) [14].

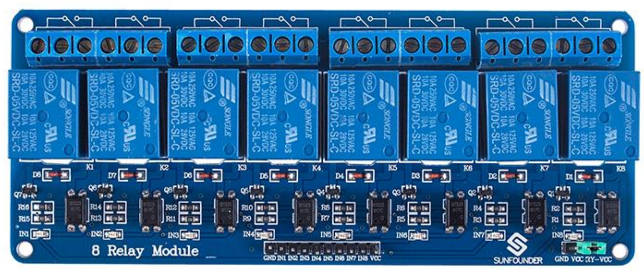

***Fig. 9.** 8-Channel Relay*

3.10 NodeMCU

NodeMCU stands for Node Micro Controller Unit, an open source platform based on IoT that is used to connect the devices to the internet. NodeMCU is based on the firmware ESP8266, a low cost chip with inbuilt Wi-Fi module to connect to the Internet [15]. Here NodeMCU is used to the upload sensor data on to the MQTT webserver (Fig. 10).

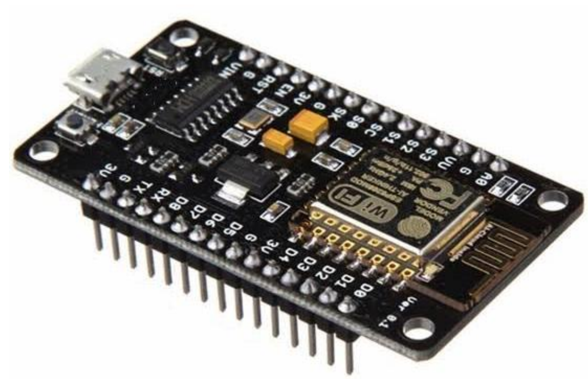

***Fig. 10.** NodeMCU Module*

4 SOFTWARE TOOLS

4.1 Arduino Integrated Development Environment

The Arduino IDE contains a text editor for writing the code. In Arduino IDE, we write the program in Embedded C. These programs called sketches are saved with .ino file extension. Later the program debugged and uploaded on to the Arduino board. Arduino IDE runs on MAC OS X, Linux, and Windows and it is an open source software [6].

4.2 Embedded C Language

Embedded C Language is the soul of the processor and it will be used in each and every embedded system projects. Each processor is associated with an embedded software. Embedded C language is mainly used to program the microcontroller.

4.3 Cloud MQTT Web server

MQTT protocol is a lightweight publish and subscribe system, where you can publish and receive messages as a client. With this protocol, multiple devices like constrained devices with low bandwidth can be communicated, thus it is called simple messaging protocol. This protocol widely used in IoT applications. MQTT allows to send a command to control an output or can read from a sensor and publish it [16].

4.4 MQTT Dashboard Android Application

There are many open source applications available to subscribe or publish for MQTT clients. We are using MQTT Dashboard android application for displaying the sensors data, obtained from the Cloud MQTT.

5 RESULTS AND DISCUSSION

5.1 Schematic Diagram

The schematic diagram of the Home Environment Monitoring and Automatic Lighting Control System using Arduino Mega 2560 and Cloud MQTT Server is shown in Fig. 11.

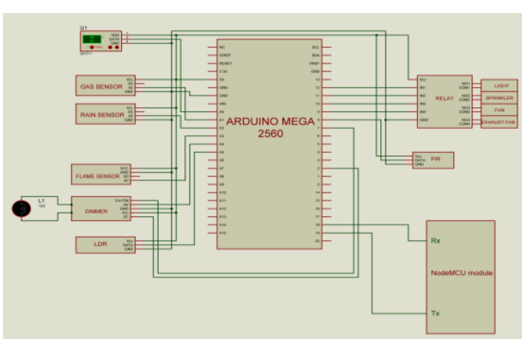

Fig.11. *Schematic Diagram*

Here analog voltage pin of dimmer is connected to analog pin A4, zero cross detector pin is connected to digital pin 02, control pin is connected to digital pin 07, and relay inputs IN1, IN2, IN3 and IN4 are connected to pins 12, 11, 10 and 9 pins of the arduino respectively to control the Light, Sprinkler, Fan and Exhaust Fan. The interfacing of other modules with the Arduino is discussed earlier.

5.2 Flowchart

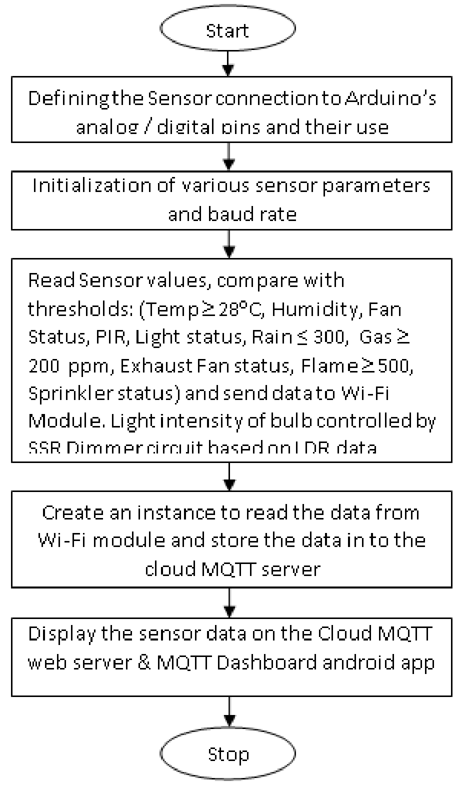

Fig. 12. *Flowchart of the sequence of events that take place in the home environment and automatic lighting control system*

5.3 Experimental Setup

Figure 13 shows the experimental setup of Wi-Fi based Home environment monitoring and automatic lighting control system. The PIR sensor, rain sensor, temperature and humidity (DHT11) sensor, IR flame sensor, Gas sensor (MQ2), SSR Dimmer, LDR, Node MCU module and relays are interfaced to the Arduino Mega2560 board. Two fans, Two lights and a sprinkler are connected using a eight channel relay. The relays are switched on/off depending upon sensor data threshold values. The Arduino board requires a DC voltage of 7-12 V or it can be operated using the USB port of a laptop which provides 5V. The transmit pin of Arduino is connected to the receive pin of NodeMCU.

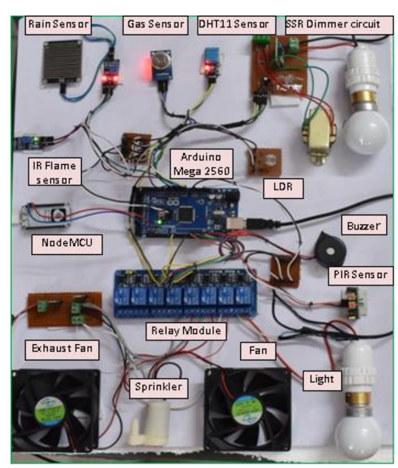

Fig. 13. *Experimental Setup*

5.4 Experimental Results

Various experiments are conducted to validate the working of various sensors used in the home environment monitoring and automatic lighting control system. A hand is placed before the PIR sensor to detect any motion in the room. When the motion is detected, it indicates the presence of a living being inside the room and the HAS will turn on the light in the room through the relay 1 as shown in Fig. 14.

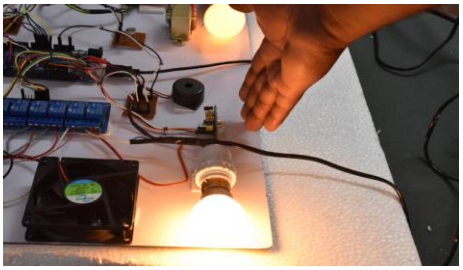

Fig. 14. *Setup showing PIR sensor used for detection of a living being*

Figure 15 shows the PIR sensor status in the Cloud MQTT Dashboard android application as “Motion Detected” and the Light status is shown as ON. Temperature and Humidity sensor (DHT 11) is used to measure the temperature and humidity in the room. The measured temperature and humidity values at an epoch are 77% and 29°C respectively. If DHT11 sensor temperature value is less than the threshold, i.e. 28°C, then the Fan is in OFF state, and if temperature is greater than the threshold value, then the Fan will be in ON state (Fig. 15).

Fig. 15. *Cloud MQTT Dashboard showing Motion Detected, ON status of the Light, Temperature and Humidity information*

Figure 16 shows the rain sensor with water drops placed on the rain detecting plate. Figure 17 shows the rain status as ‘YES’ on the Cloud MQTT dashboard.

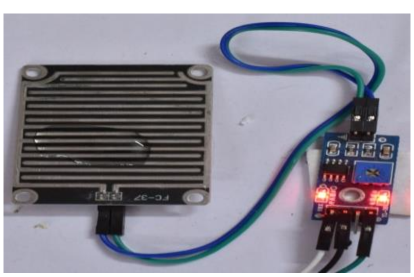

Fig. 16. *Rain sensor used for detecting the rain (water drops)*

The Gas sensor is used to detect the presence of any harmful gases such as LPG, methane, carbon monoxide, etc. in the room (Fig. 18). If any harmful gas is found in the room, then the exhaust fan turns on using relay 4 (Fig. 19). Also a buzzer alert is provided to alert the persons staying in the home.

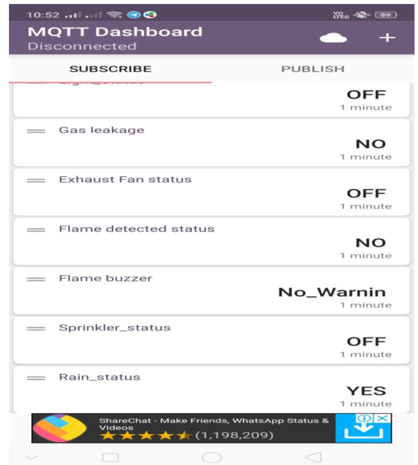

Fig. 17. *Cloud MQTT Dashboard Output showing Rain Status as ‘YES’*

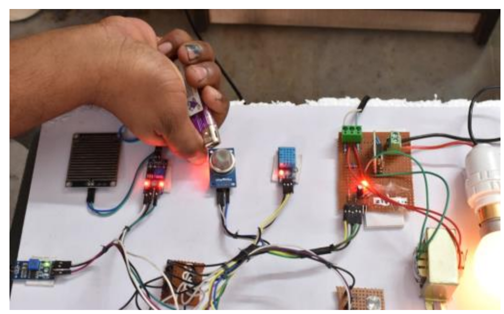

Fig. 18. *Setup for checking Gas Leakage using MQ2 sensor*

Fig. 19. *Exhaust Fan ON in case of a Gas leakage*

Figure 20 shows the corresponding gas leakage as “YES” and exhaust fan status as “ON” on the MQTT dashboard.

Fig. 20. *Gas Leakage status and Exhaust fan ON status in MQTT dashboard*

The IR flame sensor detects the occurrence of any flame in the home (Fig. 21). When a flame is detected, water sprinkler is turned on through relay 2 and a buzzer alert is provided to the persons staying in the home. A lighter is used here to test for occurrence of flame.

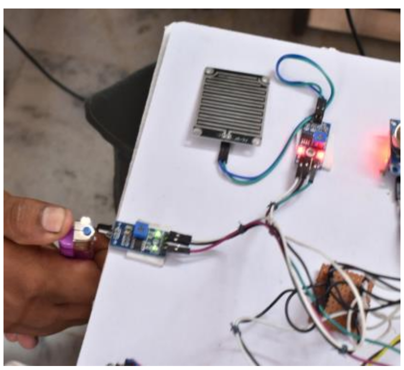

Fig. 21*. Setup for Flame Detection using a lighter*

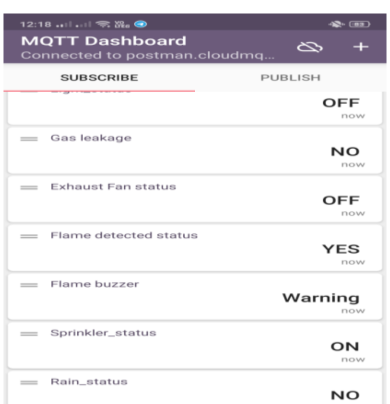

Figure 22 *shows the snapshot of Cloud MQTT dashboard with flame detected status as "YES", flame buzzer alert as "Warning" and Sprinkler status as "ON".*

The SSR dimmer circuit controls the brightness of the light in four cases depending on the light intensity in the room with the help of LDR circuit. In the case 1, light intensity with high brightness level is detected by the LDR in the room, then bulb is turned off (Fig. 23).

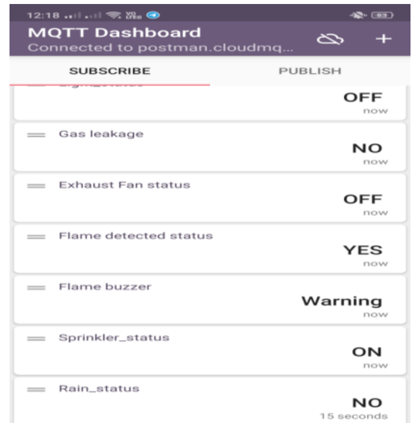

Fig. 22. *Flame detected, Buzzer Status and Sprinkler Status shown in MQTT Dashboard*

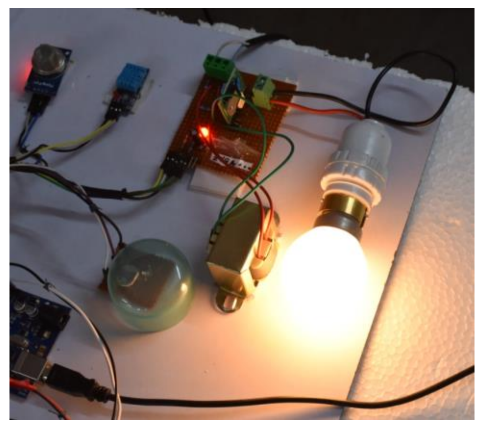

Fig. 23. *Case 1: High Room brightness then Light is OFF.*

In the case 2, natural lighting in the room is at medium level, so the LDR detects this light intensity, and then the bulb glows with normal brightness as shown in the Fig. 24.

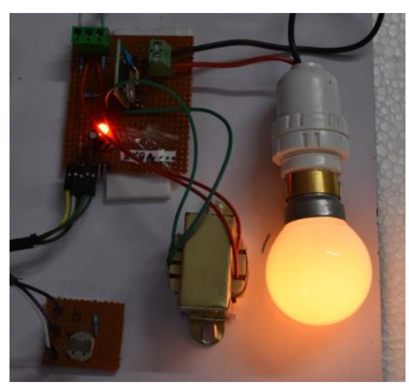

Fig. 24*. Case 2: Medium Room Brightness then Bulb glows with Normal Brightness*

In the case 3, low light intensity is detected by LDR in the room (semi transparent lid is placed over the LDR), then the bulb glows with higher brightness as shown in Fig. 25.

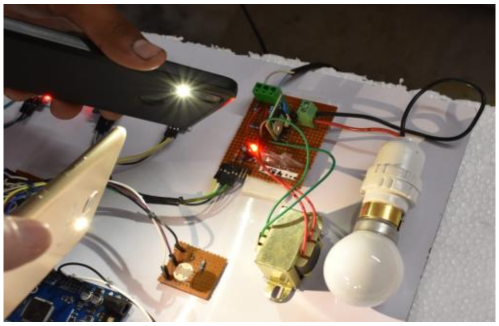

***Fig. 25**. Case 3: Room with low brightness (semi transparent lid placed over LDR) then Light glows with higher brightness*

In the case 4, the room is completely dark, with no light detected by the LDR (opaque object (lid) placed over the LDR), then bulb glows with maximum brightness level as shown in Fig. 26.

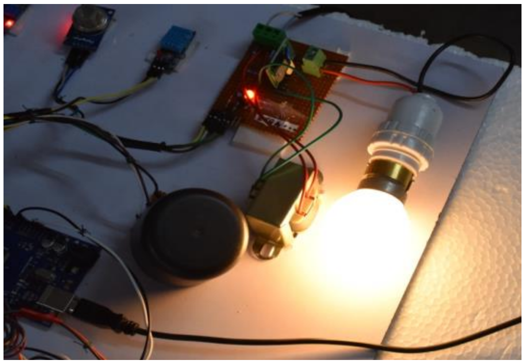

***Fig. 26**. Case 4: Room fully dark (Opaque object (lid) placed over LDR) then Light glows with Maximum Brightness*

6 CONCLUSIONS

A Home environment monitoring and automatic lighting control system is implemented to secure the home and turn on the lights in the presence of living beings in the room. The environment parameters and other sensor data can be monitored on the Cloud MQTT webserver as well as MQTT dashboard App. The Cloud MQTT webserver / MQTT dashboard can be accessed remotely using an internet enabled device such as smart phone or laptop.

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