Energy Efficient Power Management System Using Internet of Things

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ABSTRACT

Internet of Things (IoT) conceptualizes the idea of remotely connecting and monitoring real world objects (things) through the Internet. Energy saving is one of the main challenge in our day to day life of Electrical Engineering. Energy saving can be done only when the energy consumed by the load is monitored. Once monitored, suitable control methods can be adopted to operate the load in the optimized way to save energy. Even though there are lot of technologies and solutions available to effectively monitor and save energy consumption of load in house or industry, the internet of things (IoT) technology is proposed to monitor and minimize energy consumption of load. The proposed paper is to design a prototype of an Internet of Things (IoT) based Energy Management System in which IR Sensor is used connected to Arduino Microcontroller and the data is collected from ESP8266 Wi-Fi module mounted on Microcontroller and displayed on web page and the recorded values are stored in cloud (thingspeak). The proposed system is suitable for data collection and control the load in the Internet of Things (IoT) environment.

***Keywords* – Energy Efficient System, Power Management System, Energy Efficient Power Management System, Internet of Things**

I. INTRODUCTION

The proposed work provides energy efficient management by controlling ON/OFF of load with respect to person available to use it, even the load is controlled by the use of internet also. From anywhere in the world we can see our load at any required place either in OFF or ON state and also we can turn on or turn off it by using internet. In literal terms, Internet of Things is the interconnection of different types of devices which may be wearable or non-wearable. The impact of technology on business is prominent in know a days. With a major shift in the technological world, businesses need to adapt to trending technologies to stay ahead. It has bridged the gap between digital and physical realities. A crucial aspect of IoT is that it facilitates communication between devices and systems, which are miles apart, in real time. Prof. Dr.G.Umarani srikanth proposed a paper under the concept of power saving system using sensor over IoT [1].

Prof. Guneet Bedi, Ganesh Kumar venayagamoorthy, Rajendra singh, Richard R.Brooks, Kuang-Ching Wang. Carried out the review of IOT (internet of things) [2] .A transformation is underway in electric power and energy systems (EPESs) to provide clean distributed energy for sustainable global economic growth. Internet of Things (IoT) is at the forefront of this transformation imparting capabilities, such as real-time monitoring, situational awareness and intelligence, control, and cyber security to transform the existing EPES into intelligent cyber-enabled EPES, which is more efficient, secure, reliable, resilient, and sustainable. Additionally, digitizing the electric power ecosystem using IoT improves asset visibility, optimal management of distributed generation, eliminates energy wastage, and create savings [3][4]. IoT has a significant impact on EPESs and offers several opportunities for growth and development. There are several challenges with the deployment of IoT for EPESs. Viable solutions need to be developed to overcome these challenges to ensure continued growth of IoT for EPESs. The advancements in computational intelligence capabilities can evolve an intelligent IoT system by emulating biological nervous systems with cognitive computation, streaming and distributed analytics including at the edge and device levels[5][6]. This paper provides an assessment of the role, impact and challenges of IoT in transforming EPESs.

We can see ON/OFF of load with respect to presence of living thing in working area/room/place. This proposed work can be implemented in home, office, industries, railway compartment and for physically challenged people etc. This work consists of onboard computer, which consist of number of input and output ports. These onboard computers are commonly termed as Microcontrollers. The input output ports of Microcontroller are interfaced with different input and output modules depending on requirement. In other words micro controller acts as a communication medium for all the module involved in the project.

In this circuit consists of Motion sensor, Microcontroller, Driver circuit/Actuation chamber, wifi module, cloud and load in working place. If a person enters a Room, motion sensor detects it and sends information to Microcontroller. The Microcontroller reads it and activates the Transistor and Relay Driver circuit, the load is then turned ON. As and when the person left the room the load turns off. The On/off data is uploaded to cloud by wifi module and also from the cloud we can turn off/turn on the load by using internet [7][8].

An embedded system is a combination of software and hardware to perform a dedicated task. Some of the main devices used in embedded products are Microprocessors and Microcontrollers [9]. To realize the proposed Energy Efficient Power Management System following prototype model has been developed in the laboratory. It consist of IR sensor, Arduino Microcontroller, ESP8266 Wifi module, Thingspeak cloud storage. The interfacing of Microcontroller with the PC is done through arduino program written in arduino compiler of PC window and sent to microcontroller by a USB cable. The complexity of coding considerably intensifies as compared with PC, but once programmed the microcontroller works at its best since it is a committed embedded system. The design involves identifying the different components and assembling all of them and ensuring safe interfacing between all these components. Then coding process has to be done, which has to take care of the deferrals between two successive communications. The IR sensor connected at the input port of Arduino, load is connected at the output

port of Microcontroller. ESP8266 wifi module is connected to Microcontroller upload the values of data related to load in the Thingspeak cloud [10].

II. ENERGY MANAGEMENT SYSTEM

The objective of this paper is to save electric power to detect human using a IR sensor. We often leave the place without switching off lights, fans and Air Conditioner etc. Therefore electricity is getting wasted. Here we have done a power saving in which electricity cost will be saved by sensing the movement of people entering or by leaving out the room. If the sensor identifies that there are no persons present inside the room, then electrical appliances will be turned OFF automatically. If any person enters the room, automatically devices will be turned ON. If there is no user in the room, it switches off the lights, fans, or AC with the help of interface which is in between the switchboard of appliances and IR sensor. DC relay is also used for the turn ON and turn OFF of the electrical devices according to the output which is in micro controller circuit. How many appliances are turned on can also be checked through online. Figure shows the general block diagram representation of Efficient Energy Management System. It consists of the following important blocks.

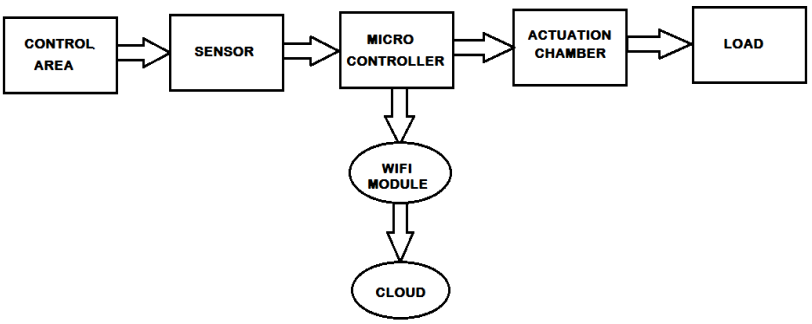

Fig-1. Block diagram representation of Efficient Energy Management System

1. CONTROL AREA

It is the place which is to be controlled and monitored. The power distribution to the load in control area is regulated with PIR sensor. The control area may be the home/office/industry/street/railway compartment etc…The load in the control area turned ON/OFF with respect to object detection in that zone by sensor.

2. SENSOR

It is a motion detection sensor to senses the Motion in control area and set it's output pin to br high 3.3 volt which is applied to Microcontroller. The output pin is zero (low) when there is no motion is detected, load is in off state.

3. MICRO CONTROLLER

Digital In pin of Arduino is connected to input side i.e, output pin of PIR. The Digital Out pin connects to load through actuation chamber. When pir is high Digital pin for which it is connected is high, up on writing suitable program the Digital Out pin set high i.e,3.3 volt which is applied to base of transistor in actuation chamber otherwise it is zero, load is off. ESP8266 wifi module is connected over it to upload the data. The program written in microcontroller provides desired output conditions for us as required from PIR to operate the load

4. ACTUATION CHAMBER / DRIVER CIRCUIT

Actuation Chamber involves a Relay operated by a Transistor as shown in figure 2. Transistor provides the necessary current required to turn on the Relay. Transistor BC547 acts as current amplifier. After receiving the base signal current from input (i.e, output of Arduino) the transistor get activated and operates in active region and performs current Amplification .The amplified current flow to the coil of the 12 volt relay. After getting the collector current in the range of 70 to100 milli amps the NC terminal of relay becomes NO and the NO becomes NC. The load is connected between common terminal and no Terminal. Hence when the relay is operated the no terminal connected to load operates it and the load becomes active. When the base signal current is zero for Transistor, collector current is zero. Then there is open circuit exist at NO Terminal of the Relay.

NPN Relay Switch Circuit

If a large enough positive current is now driven into the Base to saturate the NPN transistor, the current flowing from Base to Emitter (B to E) controls the larger relay coil current flowing through the transistor from the Collector to Emitter. Darlington transistor is designed to switch high-current loads. The particular model used in these examples is a TIP120 Darlington transistor

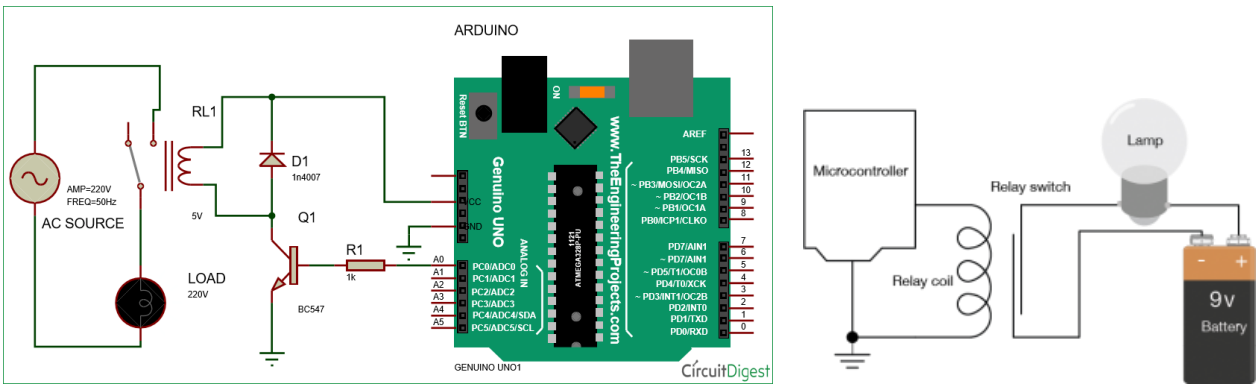

Fig -2. Driver circuit with Arduino combination

5. WIFI MODULE

ESP8266 wifi module is used to upload the data from micro controller to cloud (thingspeak). The wifi module connected over Arduino uses RX, TX receiving and transmission pins, connected by jumper wire. It does not control any action here. Its job is to collect the data to be transmitted from micro controller and upload it in cloud by using the IP address of Thingspeak. The internet mobile hotspot provides wifi by writing username and password of mobile hotspot in program for uploading data of ESP in micro controller after compilation an runESP8266 connects to wifi and start working, the values can be seen on the term. Make sure that user internet is good (3G/4G) then only proper transmission takes place. if not esp not work proper and problem/error of writing/uploading data can be seen.

6. CLOUD

Cloud storage is meant to store the data in Thingspeak, and also to monitor and control the load from thingspeak. ThingSpeak is a free web service that lets you collect and store sensor data in the cloud and develop Internet of Things applications. The ThingSpeak web service provides apps that let you analyze and visualize your data in MATLAB, and then act on the data. Sensor data can be sent to ThingSpeak from Arduino, Raspberry Pi, BeagleBone Black, and other hardware. Getting started with thingspeak By writing IP address of Thingspeak in wifi program for ESP8266 the location is set to thingspeak cloud. The ON/OFF of rooms takes Logic 1/0 respectively. If high (ON/ logic 1) the graph in field 1 of thingspeak rises, if low (OFF/logic 0) graph falls.

7. LOAD

Load may be a lamp/fan etc…load consumes electric power from supply. If motion present due to presence of object inside a room, IR detects and passes information to Arduino. Then Arduino make actuation chamber to active state. The relay turns ON the load and the Load becomes ON and values are uploaded to cloud by wifi. If we want to control the load we control the load even from the thingspeak website as well. Thus makes the internet of things which control the load using internet. The power consumption of load is monitored and controlled. If we want message alert we can also use GSM module here but we stick with IOT and embedded system containing arduino connected to sensors and esp and uploads the vales in thingspeak. Load is placed inside a control area if needed outside the control area as we

III. INTERNET OF THINGS

Internet of things includes Arduino microcontroller, communication, programming and wifi module, thingspeak sections.

A. Arduino Microcontroller

Arduino is a microcontroller board based on 8-bit ATmega328P microcontroller as shown in figure 3. Along with ATmega328P, it consists of other components such as crystal oscillator, serial communication, voltage regulator, etc. to support the microcontroller.

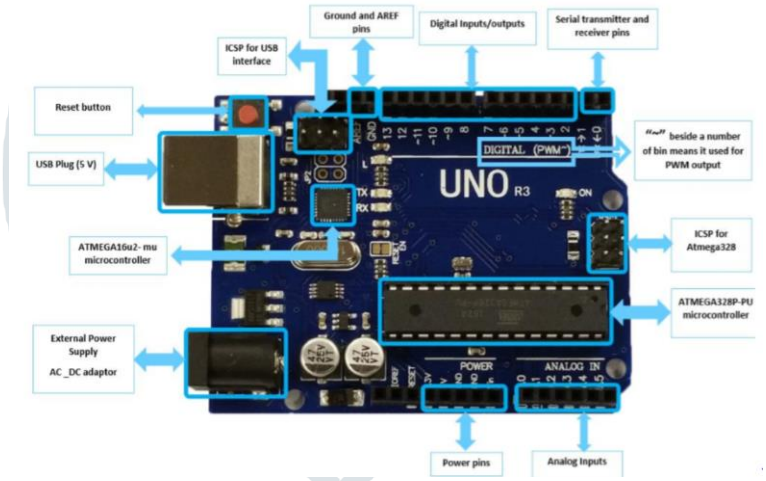

Fig-3. Arduino Uno R3 Hardware

Arduino Uno has 14 digital input/output pins (out of which 6 can be used as PWM outputs), 6 analog input pins, a USB connection, A Power barrel jack, an ICSP header and a reset button. The Arduino Uno is a microcontroller board based on the ATmega328 (datasheet). It has 14 digital input/output pins (of which 6 can be used as PWM outputs), 6 analog inputs, a 16 MHz ceramic resonator, a USB connection, a power jack, an ICSP header, and a reset button. It contains everything needed to support the microcontroller; simply connect it to a computer with a USB cable or power it with a AC-to-DC adapter or battery to get started. The Uno differs from all preceding boards in that it does not use the FTDI USB-to-serial driver chip. Instead, it features the Atmega16U2 (Atmega8U2 up to version R2). Arduino Uno to ATmega328 Pin Mapping When ATmega328 chip is used in place of Arduino Uno, or vice versa, figure 4 shows the pin mapping between the two.

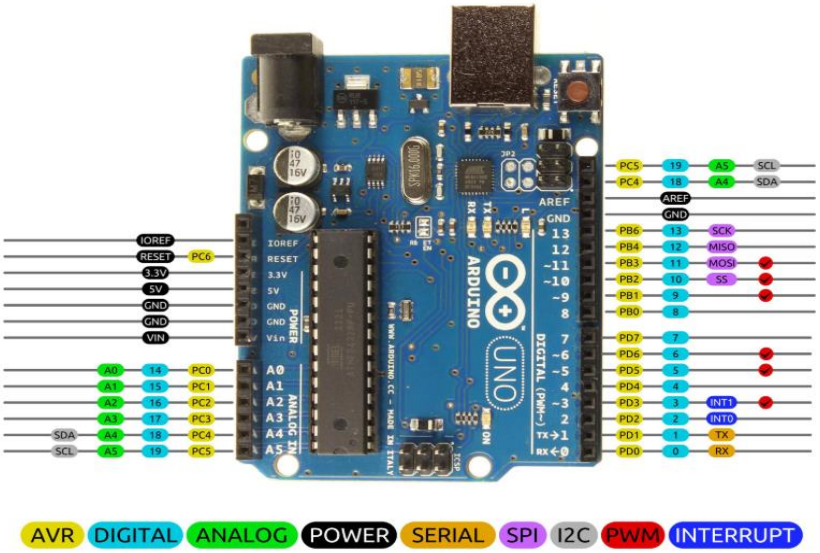

Fig-4. Arduino Uno pin out details

B. COMMUNICATION

The Arduino Uno has a number of facilities for communicating with a computer, another Arduino, or other microcontrollers. The ATmega328 provides UART TTL (5V) serial communication, which is available on digital pins 0 (RX) and 1 (TX). An ATmega16U2 on the board channels this serial communication over USB and appears as a virtual com port to software on the computer. The '16U2 firmware uses the standard USB COM drivers, and no external driver is needed. However, on Windows, an .inf file is required. The Arduino software includes a serial monitor which allows simple textual data to be sent to and from the Arduino board. The RX and TX LEDs on the board will flash when data is being transmitted via the USB-to-serial chip and USB connection to the computer (but not for serial communication on pins 0 and 1). A Software Serial library allows for serial communication on any of the Uno's digital pins. The ATmega328 also supports I2C (TWI) and SPI communication. The Arduino software includes a Wire library to simplify use of the I2C bus; see the documentation for details. For SPI communication, use the SPI library.

C. PROGRAMMING

The Arduino Uno can be programmed with the Arduino software (download). Select "Arduino Uno from the Tools > Board menu (according to the microcontroller on your board). For details, see the reference and tutorials.

The ATmega328 on the Arduino Uno comes pre burned with a boot loader that allows you to upload new code to it without the use of an external hardware programmer. It communicates using the original STK500 protocol (reference, C header files). You can also bypass the boot loader and program the microcontroller through the ICSP (In-Circuit Serial Programming) header; see these instructions for details.

The ATmega16U2 (or 8U2 in the rev1 and rev2 boards) firmware source code is available. The ATmega16U2/8U2 is loaded with a DFU boot loader, which can be activated by:

- On Rev1 boards: connecting the solder jumper on the back of the board (near the map of Italy) and then resetting the 8U2.
- On Rev2 or later boards: there is a resistor that pulling the 8U2/16U2 HWB line to ground, making it easier to put into DFU mode.

Rather than requiring a physical press of the reset button before an upload, the Arduino Uno is designed in a way that allows it to be reset by software running on a connected computer. One of the hardware flow control lines (DTR) of the ATmega8U2/16U2 is connected to the reset line of the ATmega328 via a 100 nano farad capacitor. When this line is asserted (taken low), the reset line drops long enough to reset the chip. The Arduino software uses this capability to allow you to upload code by simply pressing the upload button in the Arduino environment. This means that the boot loader can have a shorter timeout, as the lowering of DTR can be well-coordinated with the start of the upload.

The Uno contains a trace that can be cut to disable the auto-reset. The pads on either side of the trace can be soldered together to re-enable it. It's labeled "RESET-EN". You may also be able to disable the auto-reset by connecting a 110 ohm resistor from 5V to the reset line; see this forum thread for details

D.ESP 8266 WIFI MODULE

ESP8266 is an UART-Wi-Fi transparent transmission module with ultralow power consumption, specially designed for the needs of a new connected world. It offers a complete and self-contained Wi-Fi networking solution, allowing it to either host the application or to offload all Wi-Fi networking functions from another application processor. ESP8266 has powerful on-board processing and storage capabilities that allow it to be integrated with the sensors and other application specific devices through its GPIOs with minimal development up-front and minimal loading during runtime. Its high degree of on-chip integration allows for minimal external circuitry, and the entire solution, including front-end module, is designed to occupy minimal PCB area.ESP8266 Serial Wi-Fi Wireless Transceiver Module is suitable for Uno, Mega 2560 and Nano. Also, ESP8266EX can be applied to any microcontroller design as a Wi-Fi adaptor through SPI/SDIO or UART interfaces. ESP8266EX integrates antenna switches, RF balun, power amplifier, low noise receive Amplifier, filters and power management modules.

Besides the Wi-Fi functionalities, ESP8266EX also integrates an enhanced version of Ten silica's L106 Diamond series 32-bit processor and on-chip SRAM. It can be interfaced with external sensors and other devices through the GPIOs. Software

Development Kit (SDK) provides sample codes for various applications. Es press if Systems' Smart Connectivity Platform (ESCP) enables sophisticated features including:

- Fast switch between sleep and wakeup mode for energy-efficient purpose;
- Adaptive radio biasing for low-power operation
- Advance signal processing • Spur cancellation and RF co-existence mechanisms for common cellular, Bluetooth, DDR, LVDS, LCD interference mitigation

❖ Low-power, highly-integrated Wi-Fi solution A minimum of 7 external components Wide temperature range: -40°C to +125°C

The ESP8266 ESP-01 module has three operation modes: 1. Access Point (AP) 2. Station (STA) 3. Both

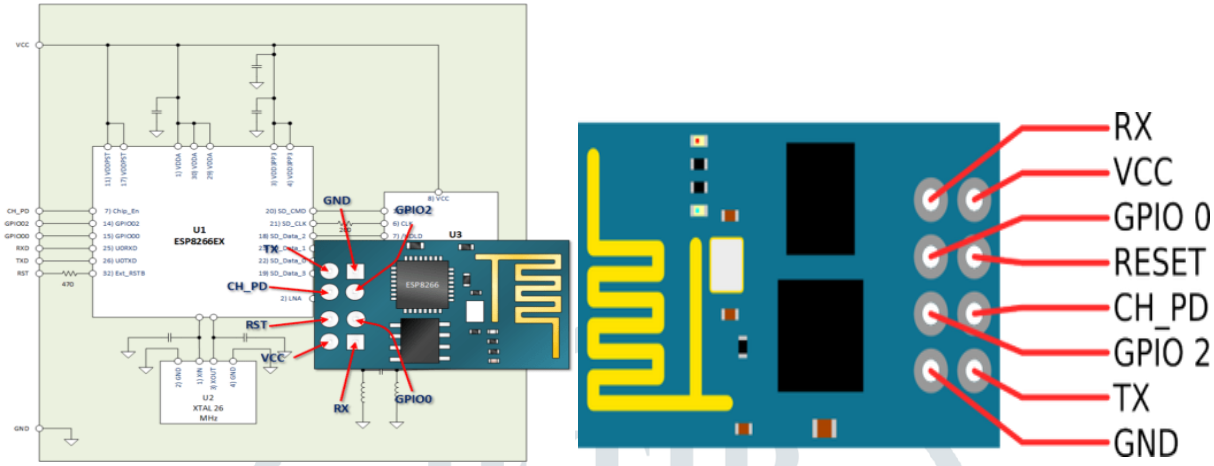

Fig-5. Schematic diagram of ESP-01 8266 and Wifi Module

In AP the Wi-Fi module acts as a Wi-Fi network, or access point (hence the name), allowing other devices to connect to it (refer Figure 5). This does not mean that you will be able to check your Face book from your device while the ESP-01 module is operating in the AP mode. It simply establishes a two way communication between the ESP8266 and the device that is connected to it via Wi-Fi. In STA mode, the ESP-01 can connect to an AP such as the Wi-Fi network from your house. This allows any device connected to that network to communicate with the module. The third mode of operation permits the module to act as both an AP and a STA Technology goes ahead exponentially with each year whether we do something or not. This chip was first time seen in August 2014, in ESP-01 version module, made by AI Thinker, a third-party manufacturer. This little module allows the MCU to connect to Wi-Fi network and create simple TCP/IP connections. Some of the important Applications of ESP8266-01are

- Home appliances & Home automation
- Smart plugs and lights
- Industrial wireless control
- Baby monitors & IP cameras
- Sensor networks &Wearable electronics
- Wi-Fi location-aware devices & Security ID tags

E. THINGSPEAK

ThingSpeak is a free web service that lets you collect and store sensor data in the cloud and develop Internet of Things applications. The ThingSpeak web service provides apps that let you analyze and visualize your data in MATLAB, and then act on the data. Sensor data can be sent to ThingSpeak from Arduino, Raspberry Pi, BeagleBone Black, and other hardware.

Getting started with thingspeak

This example shows how to create a new channel to collect analyzed data. You read data from the public ThingSpeak channel 12397 - Weather Station, and write it into your new channel. To learn how to post data to a channel from devices, see the device Examples and the API Reference.

Create a Channel

Sign In to ThingSpeak using your Math Works Account, or create a new Math Works account.

Click Channels > My Channels.

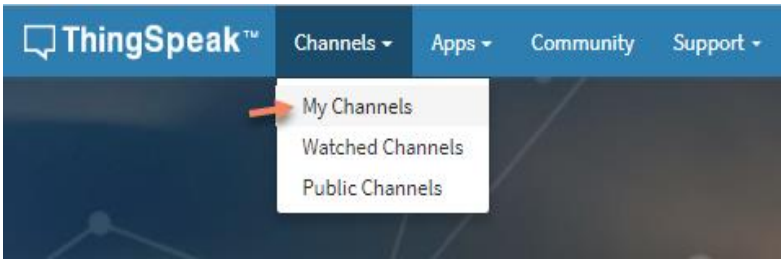

Fig-6. Selecting channel

On the Channels page, click New Channel**.** (As shown in figure 6)

Check the boxes next to Fields 1–3. Enter these channel setting values:

Name: energy efficient power management system using IOT

Field 1: room 1 active

Field 2: room 2 active
Field 3: room 3 active
Field 4: bulb 1 error
Field 5: bulb 2 error
Field 6: bulb 3 error
Click Save Channel at the bottom of the settings.
You now see these tabs:
Private View: This tab displays information about your channel that only you can see.
Public View: If you choose to make your channel publicly available, use this tab to display selected fields and channel visualizations.
Channel Settings: This tab shows all the channel options you set at creation. You can edit, clear, or delete the channel from this tab. (Refer figure 7).
Sharing: This tab shows channel sharing options. You can set a channel as private, shared with everyone (public), or shared with specific users.
API Keys: This tab displays your channel API keys. Use the keys to read from and write to your channel.
Data Import/Export: This tab enables you to import and export channel data.
Next Steps
Your channel is available for future use by clicking **Channels** > **My Channels**.

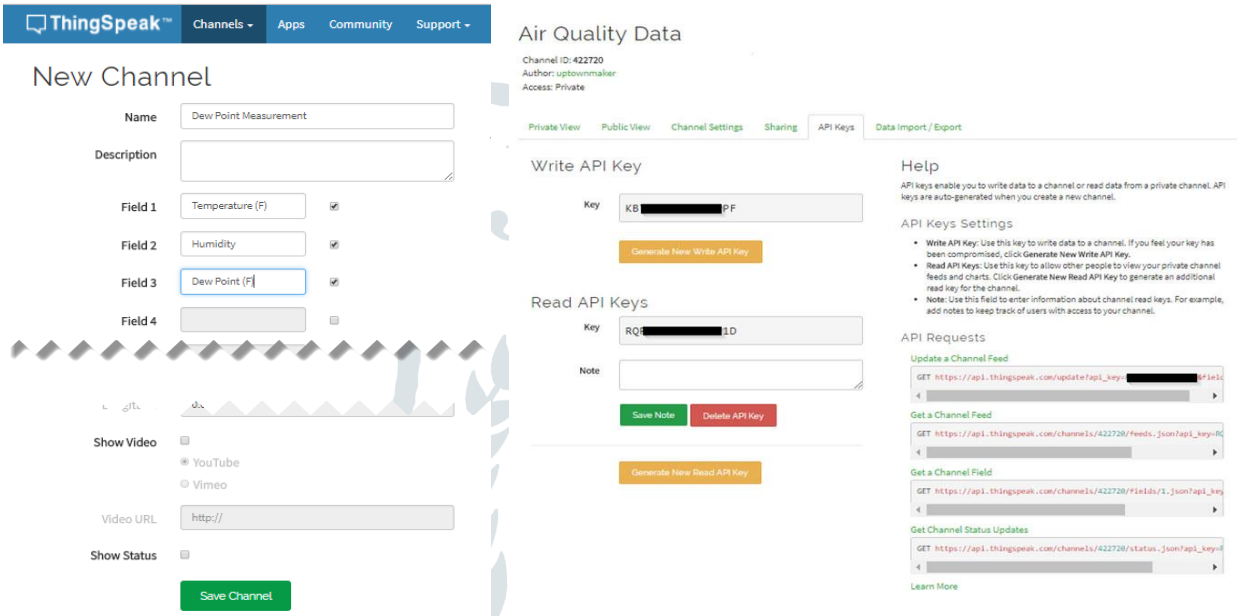

Fig-7. Creating fields in channel & Write key details

Analyze Your Data

This example shows how to read temperature and humidity data from ThingSpeak channel 12397, which collects weather-related data from an Arduino device. You write the temperature and humidity data into your Dew Point Measurement channel, along with the calculated dew point data. Then use ThingSpeak to visualize the results on your channel

Prerequisite Steps

This example requires that you have already performed these steps:
Sign In either to your Math Works Account or ThingSpeak account, or create a new Math Works account.
Create a Channel as your power management channel. (Refer Figure 8)
Read Data from a Channel
Read the bulb 1, bulb 2, bulb3 active or not in the channel in Fields 1,2 and 3 and bulb1 error , bulb 2 error, bulb 3 error write that data to Fields 4,5 and 6 respectively, of your channel with respect to variations detected by arduino from sensors uploaded to thingspeak.
readChId = 12397;
writeChId = 92671;
Save your Write API Key to a variable.
writeKey = 'F6CSCVKX42WFZN9Y';
To find your Channel ID and Write API Key, refer to Channel Info on the **My Channels** tab.
Write code in arduino compiler save and run the code. Upload it in arduino micro controller

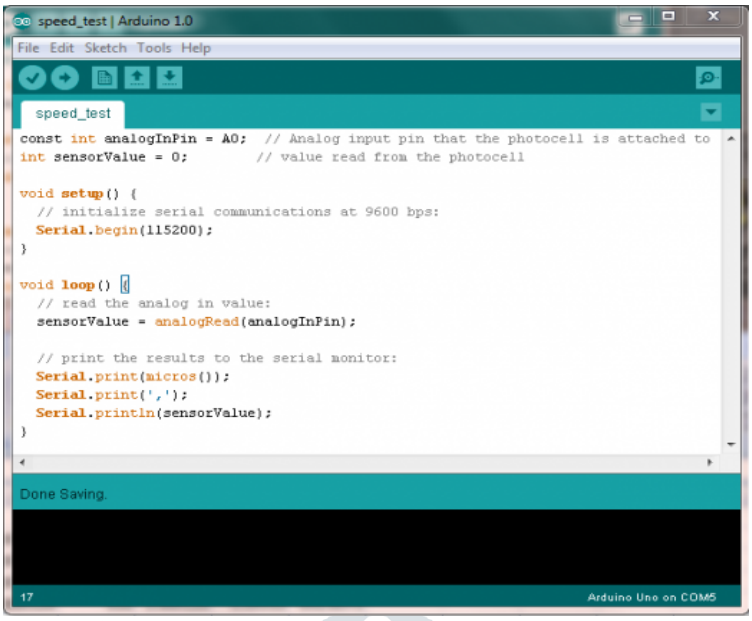

Fig-8. Writing code in arduino

IV. HARDWARE RESULTS

This Proposed work "ENERGY EFFICIENT POWER MANAGEMENT SYSTEM" gives the results as shown in following way.

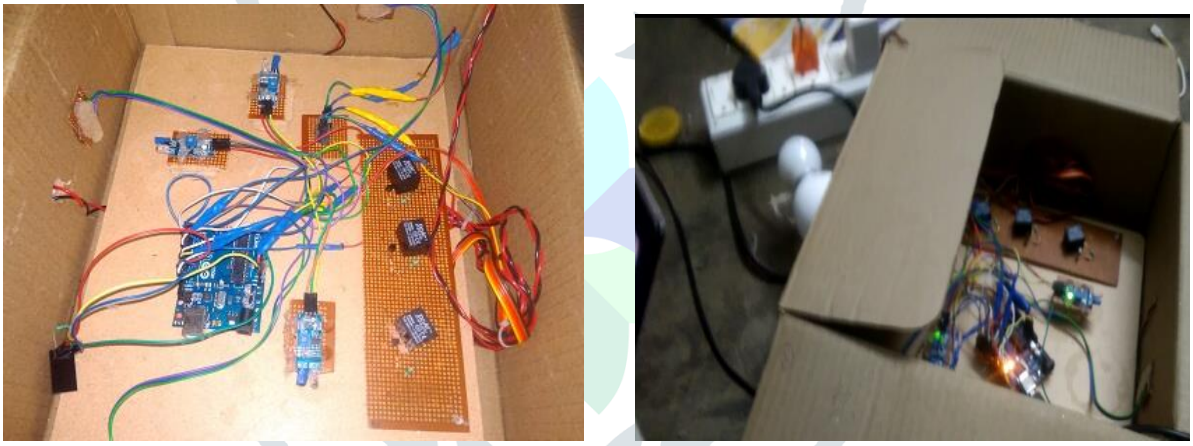

Fig-9. Load off when no detection

When no sensor is detected bulb 1, bulb 2, bulb 3 are turned off (shown in figure 9)
When sensor 1 only detected then bulb 1 only glows ON
When sensor 2 only detected then bulb 2 only glows ON
When sensor 3 only detected then bulb 3 only glows ON
When sensor 1 and sensor 2 are detected then bulb 1 and bulb 2 glows ON
When sensor 2 and sensor 3 are detected then bulb 2 and bulb 3 glows ON
When sensor 3 and sensor 1 are detected then bulb 3 and bulb 1 glows ON (Shown in figure 11)
When sensor 1, 2 and 3 are detected bulb 1, bulb 2, bulb 3 are glows ON

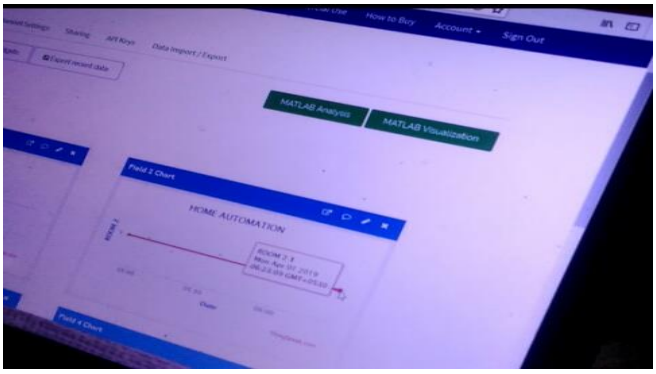

Fig-10. Uploaded value in the cloud when load ON

By writing command 1 in thingspeak bulb 1 glows on and writing command 2 bulb 1 glows off
By writing command 3 in thingspeak bulb 1 glows on and writing command 4 bulb 2 glows off
By writing command 5 in thingspeak bulb 1 glows on and writing command 6 bulb 3 glows off (Figure 10)

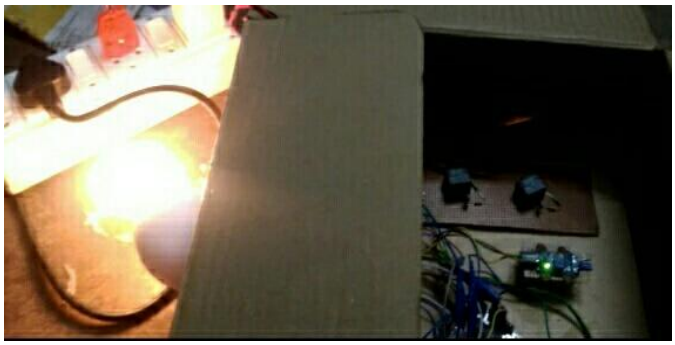

Fig-11. Load on when command passed in internet

VI. CONCLUSION

Based on the testing and analysis, it can be concluded that this prototype works well. The main function of this system is automation, control, monitoring, and security. Automation and remote control enables users to operate the electronic device even when users are not at home. Monitoring function can help users to estimate the cost of electricity usage for any electronic device. Security functions may provide a sense of security to users when they're not at home because the system will work continuously and report any suspicious activity that detected by the sensor. It is expected that this prototype can be the basis for further smart home development with better security and Embedded Infrastructure and Devices in the Internet of Things (IoT) Ecosystem.

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