SMART POWER SECURITY SYSTEM

A Thesis

Submitted to the department of Electrical and Electronic Engineering

Of

BRAC UNIVERSITY

By

Md. Enzamul Haque* - 12321072

Imrul Azam Jony* - 12121051

Mir Shadman Ali* -12321007

Md. Toriqul Islam* -12321047

Supervised by

AVIJIT DAS

Lecturer, Department of Electrical and Electronic Engineering

BRAC University, Dhaka

Date of Submission: 19/04/2017

DECLARATION

We, hereby declare that except where specific reference is made to the work of others, the contents of this dissertation are original and have not been submitted in whole or in part for consideration for any other degree or qualification in this, or any other University. We, hereby declare that this report is our own work and effort and that is has not been submitted anywhere for any award. This thesis is based on results found by ourselves.

All the contents provided here is totally based on our own labor dedicated for the completion of the thesis. Where other sources of information have been used, they have been acknowledged and the sources of information have been provided in there reference section.

Signature of Supervisor

Signature of Author

Md. Enzamul Haque

Imrul Azam Jony

Mir Shadman Ali

Md. Toriqul Islam

Date of Submission: 19/04/2017

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Moreover, there are other people that are needed to be thanked are our class mates who supported us always with everything.

Lastly, our gratitude towards the Faculty members of Department of Electrical and Electronics Engineering & Department of Computer Science and Engineering, BRAC University from where we gained all our knowledge to successfully complete our thesis work.

ABSTRACT

Digital Bangladesh is still lacking of electricity. Electricity is the major source of power for most of the country's economic activities. So to decrease the power losses our team come up with a solution by planning to design a system consists of Arduino connected with voltage and current sensors in electrical lines of bulbs, fans and air conditioning of different rooms in an office building. From the sensors we will get voltage and current rating of the different devices, from this rating Arduino will calculate the power of different devices. We will program the Arduino in such a way that it will track the peak and off peak hours of the office. When the office is closed during weekends or after office time is finished Arduino will keep track of the power consumed in different rooms. If in off peak hours Arduino finds that there is power consumption in the rooms it will send a message using GSM alerting the authorities that electricity is being stolen from the building or being wasted. And from which room‟s electricity is being stolen and it will locate the room and stop the current flowing in the load.

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List of all Figures:

Abbreviations:

SW: Switch

SMS: Short Message Service

GSM: Global System for Mobile

LCD: Liquid Crystal Display

POT: Potentiometer

SMPS: Switched Mode Power Supply

SIM: Subscriber Identity Module

GPRS: General Packet Radio Service

MO: Mobile Originated Messaging

MTSMS: Mobile terminated Short Message Service

PDU: protocol data unit

RTC: Real time clock

PCB: Printed circuit board

UARTs: Universal asynchronous receiver-transmitter

SPI: Serial peripheral interface

Chapter 1

Introduction

Electricity is one of the major resources in this century. It is the most important source of power for most of the country‟s economic activities. Moving towards energy sustainability will require modifications not only in the way energy is supplied but also in the way it is used as well (14). Many times after office hours we do not turn off light or fan at the time of deserting the room, as a result electricity is being wasted or someone is using the energy without any permission.

To come up with a solution and to decrease the power consumption rate “Smart power security system”” can be a smart solution for this problem. Since energy sources are limited and it has become our need to save as energy as possible (15). In this scenario, our smart power security system can be a great option as it will track the peck and off peck hours of the office. When the office is closed during weekends or after office time is finished the meter will keep tracking the power consumption of different rooms. If in off peck hours the power consumption in any room occurs it will send a message to the authorities that electricity is being wasted moreover for the security purpose, the system will automatically stop the current flow of that room.

As the usage of traditional meters has been slowly declining with the advancement in technology as rapid changes has been made to encounter the problems occurred by the traditional meter. So with the great development in the field of technologies smart power security system can be a good option to decrease the power consumption of our country.

1.1 MOTIVATION

Around the world it has been seen that development of technology now-a-days in every field is necessary. Automation is common in every sector of development. Decrease the rate of power consumption is very important in a country like Bangladesh, where Smart power security system can be a good option, as meter plays a key role in measuring the consumption of electrical energy in individual offices and households. The tremendous amount of advancing technology in the electrical side has made us curious that we have come up with an effective and secured solution by creating a meter which can aware us about the extra power consumption in the offices during off pick hours.

Moreover, to decrease the power consumption using meter in an automatic way which made us interested to work in this different and digital project.

1.2 Scopes

The thesis deals with the power consumption which can be reduced by using smart power security system. The main purpose of our system is that we are saving energy in an automatic system using this smart power security system.

The charm of our system is that it secured the electric line to be use by another person without permission, which is one of the major problem in Bangladesh. Moreover it saves the wasting power which can be very much beneficial of us.

1.3 FEATURES

Our system will have some powerful features for the users. From the user perspective he/ she can get to know about the power consumption of their rooms when he/ she is not in the room. He/ She also get a massage in there phone through GSM, that there is power consumption in that room.

However, the users will get the benefit as there will be auto turn off of loads so that he/ she can save the wasting power consumption.

On the other hand there will be a fixed threshold power in our meter so if there is any extra load using by other users the meter will detect that and it will auto turn off the meter and no power consumption will occurs.

1.4 OBJECTIVES

1. Power measurer through monitor: Our system will give the auto power consumption after 5 section in the monitor.

2. Saving power: Our smart system will auto turn off the load as we will give a fixed threshold voltage in the meter. So this can save huge amount of electricity.

3. Warning through SMS: Our proposed meter will give a SMS to the user if there is any power consumption occurs in the office room after the office hour.

4. Cost efficiency: Our smart system is low in cost but it can save a huge amount of electricity which can be beneficial for our country.

CHAPTER 2

BACKGROUND

When we were discussing and planning for our thesis project we had to go through many papers and websites. Kulkarni and Chaphekar discusses in their journal that day by day the household electrical energy is becoming important for our lives and it is becoming difficult to monitor energy in today‟s life.[16]. So to control and monitor our energy consumption we have decided to make smart power security system. The system we designed will be used in an office floor which will work alongside with a regular power meter. Each office room will be representing an entire load. The smart system will be connected with current sensors to measure the energy consumption in every five second and show it in the LCD monitor. We will code the smart system in such a way that after office hour if the power consumption go beyond a fixed threshold power it will send a SMS using GSM and turn off the power consumption of the room, Also a SMS will be send to a concerned party and He/ She can check the room for any current line thefts and if there are any other reasons for power overflows.

Furthermore, we have used a manual SW in the smart meter for ON/OFF button for the bulb representing the load. It represents the switch to turn on or off the bulb.

Chapter-3

Hardware Components

3.1 Introduction:

In this chapter, a brief description of the hardware components will be shown with their work in the project, data sheets and diagrams with pin configuration.

List of components:

1. LM2596 DC-DC Converter.
2. GSM900A.
3. DS1302 Real Time Clock Module.
4. Potentiometer
5. Manual Switch.
6. Bread Board.
7. LCD Monitor 16×2.
8. 5V 2 Channel Relay Module (RLYM-0504).
9. ACS712-30A Current Sensor Module (SEN-0712).
10. Arduino.
11. Bulb Holder.
12. Bulb.

3.2 Component Description:

1. LM2596 DC-DC Converter:

The Buck Converter

In a SMPS circuit a DC output voltage must be lower than DC input circuit, to do that we need the Buck Converter. A rectified AC or any DC supplies can be used in the DC input. The Buck Converter maintains a continuous output by storing the energy in the inductor L, during the transistor switch „on" period (Fig. 3.1.1), and in the transistor switch „off" (Fig. 3.1.2) period a continuous voltage is supplied to the load.

AC or DC Input

The buck converter is a form of DC to DC converter that can take an input from any DC sources or a DC derived from an AC source (fig. 3.1.3) .For our thesis we are using an AC source (main line). The AC input to the rectifier circuit could be imputed from AC mains supply, or using a step down transformer for lower voltage.

Specification

The LM2596 series (fig. 3.1.4) has all the active functions for a step-down (buck) switching regulator, which can drive a 3-A load with excellent line and load regulation. These devices have output voltages of 3.3 V, 5 V, 12 V, and adjustable output version. This series operates at a switching frequency of 150 kHz. It has a 3-A Output Load Current with an input Voltage Range up to 40 V. Furthermore, this has high efficiency and uses Readily Available Standard Inductors with a thermal Shutdown and Current-Limit Protection.

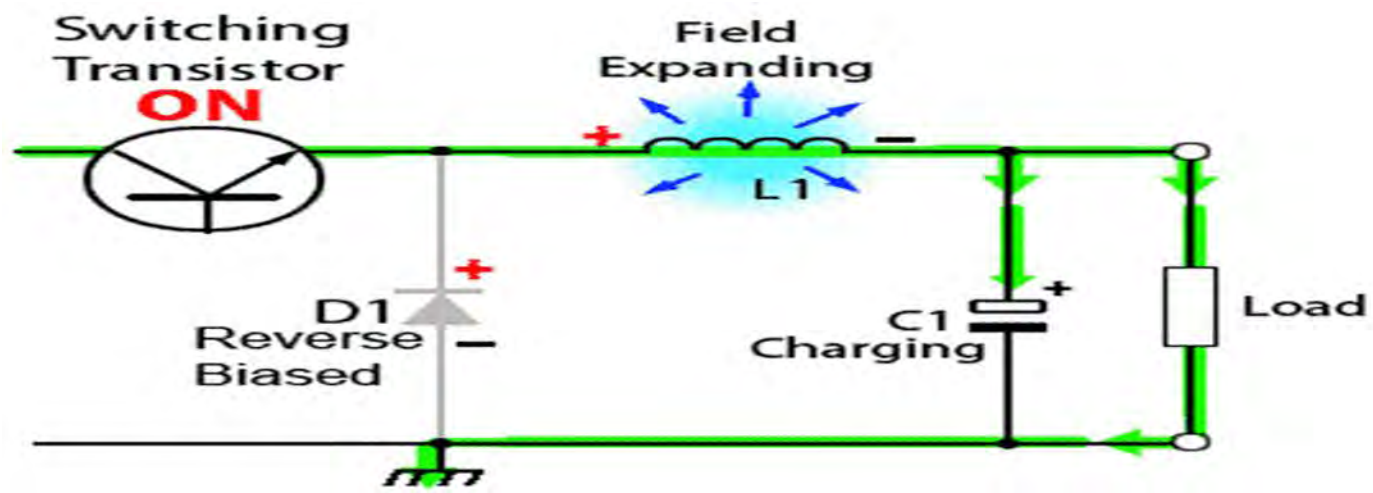


Fig 3.2.1: Transistor switch 'on' period

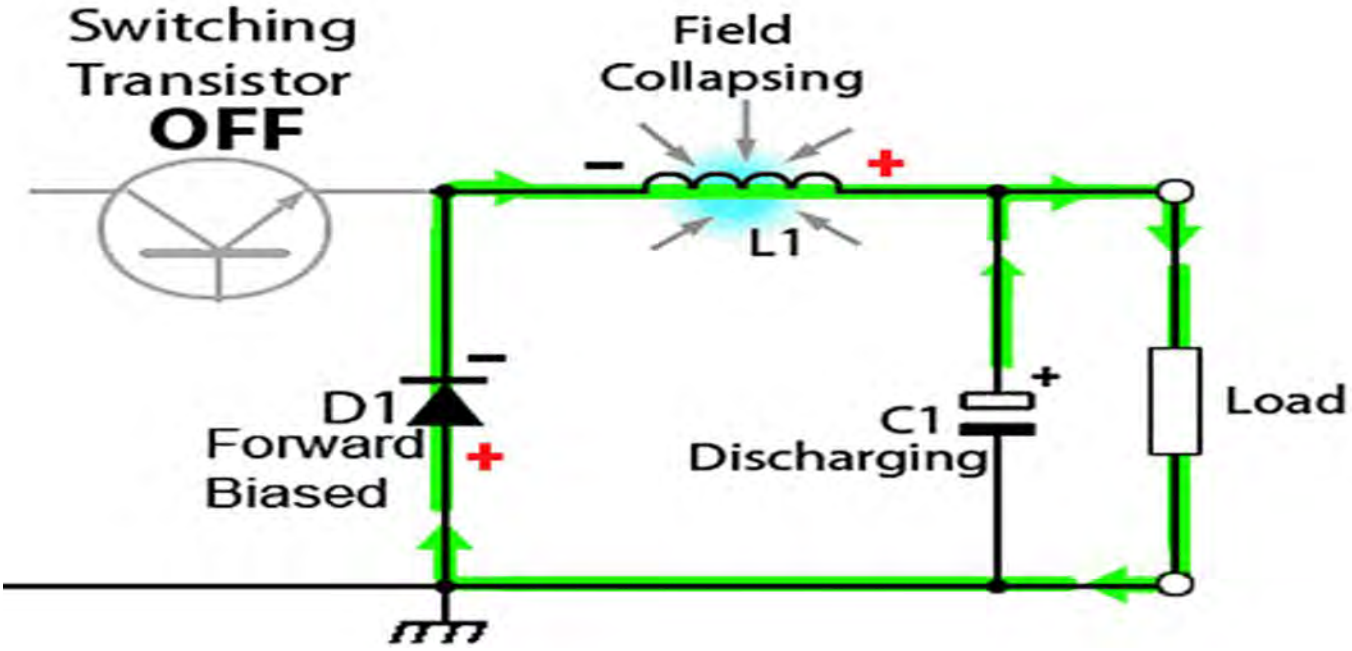


Fig. 3.2.2: Transistor switch 'off' period

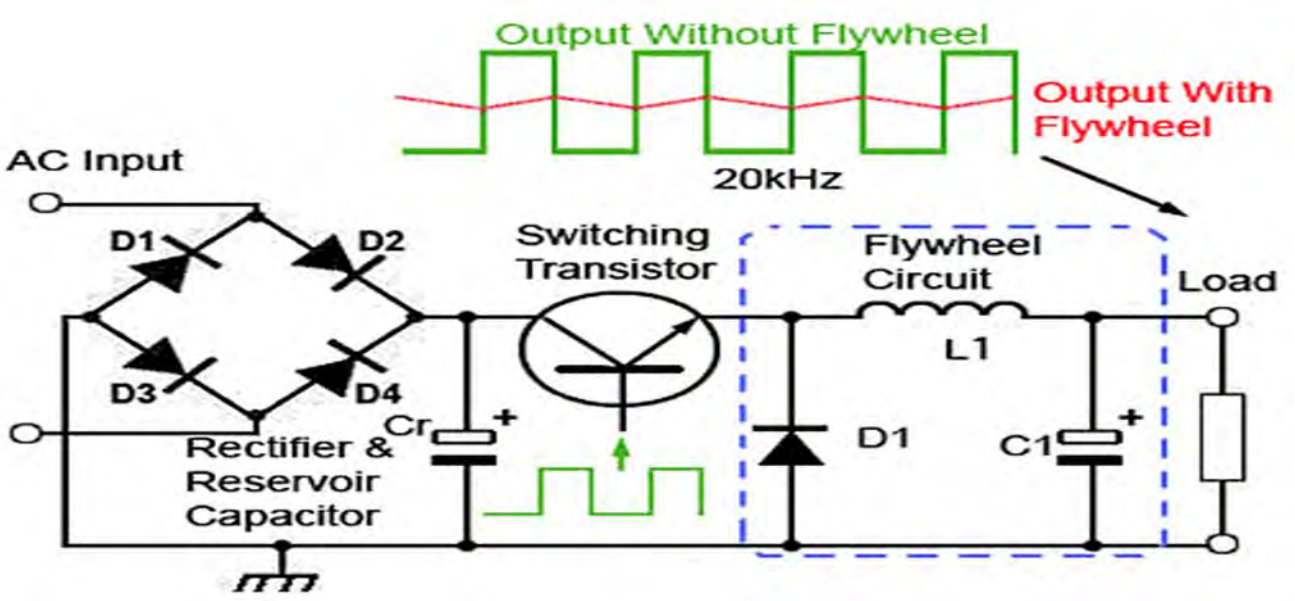


Fig. 3.2.3: the Buck Converter

Fig. 3.2.4: LM2596 DC-DC Converter

2. GSM900A

GSM Shield

The GSM shield by Arduino works like a mobile phone. By inserting a SIM it can be used to send/ receive messages and make/receive calls just like a mobile phone. We can use this functions by plugging the GSM shield into the Arduino board and then plugging in a SIM card with GPRS coverage.

This GSM Modem can work with any GSM network operator with SIM card with GPRS coverage. Its RS232 port can be used to communicate and develop embedded applications such as SMS Control, data transfer, remote control and logging can be easily developed.

This can be connected to PC serial port directly or to any microcontroller through MAX232 [3].

The different components of the GSM shield is shown in Fig. 3.1.5.

SIM900A

The SIM900A is a complete Dual-band GSM/GPRS solution in a SMT module which delivers GSM/GPRS 900/1800MHz performance.

Specification

It provides point to point MO and MTSMS cell broadcast, also providing Text and PDU mode for SMS via GSM/GPRS.

Fig. 3.2.5: GSM900A

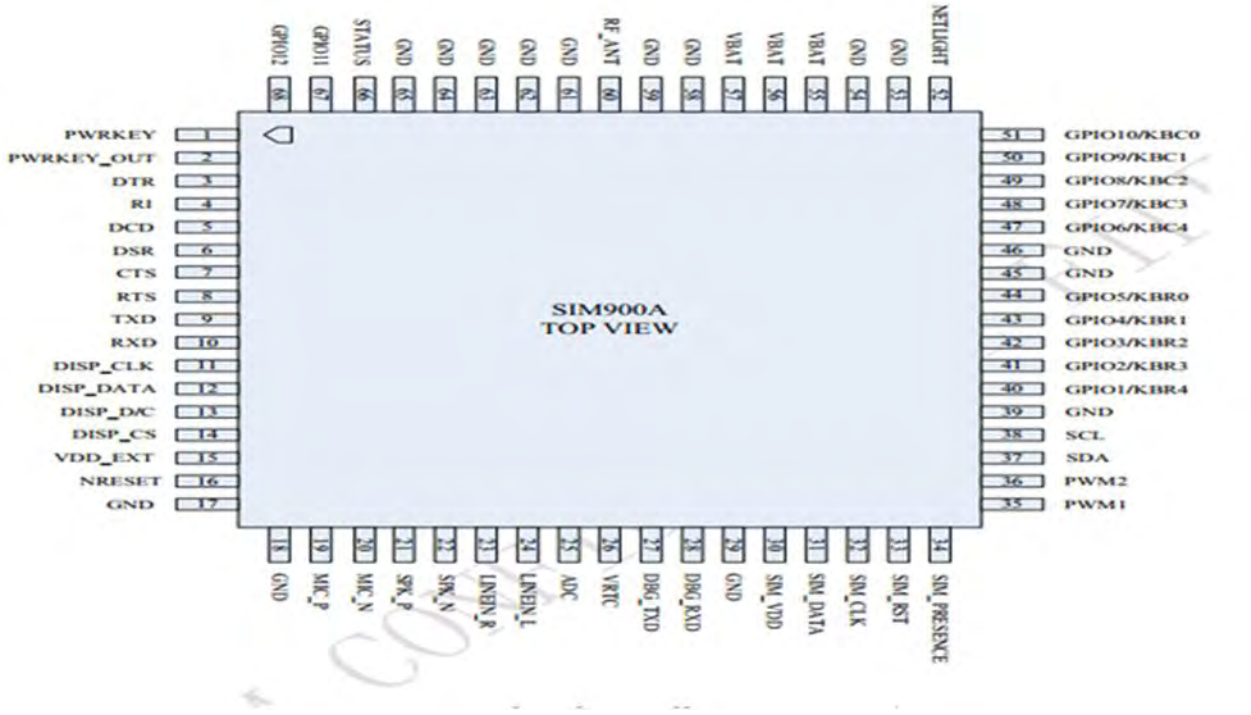


Fig. 3.2.6: SIM900A pin out diagram

3. DS1302 Real Time Clock Module

DS1302 Real Time Clock Module with Battery CR2032

A Real Time Clock Module with CR2032 battery backup with a DS1302 chip. The DS1302 chip contains a real-time clock/calendar providing seconds, minutes, hours, day, date, month, and year information and 31 bytes of static RAM to keep track of time. It communicates with a microprocessor.

Specification

Serial I/O for Minimum Pin Count, 2.0V to 5.5V full Operation. Uses Less than 300nA at 2.0V. Single-Byte or Multiple-Byte (Burst Mode) Data Transfer for Read or Write of Clock or RAM.

Fig. 3.2.7:DS1302 Real Time Clock Module

4. Potentiometer

10K Potentiometer

We are using a 10k potentiometer which is an adjustable potentiometer. Turning the pot causes the resistance to change. Connecting VCC to an outer pin, GND to the other, and the center pin will have a voltage can be varied from 0 to VCC depending on the rotation of the pot.

Fig. 3.2.8: Potentiometer

5. Manual Switch

Pushbutton Switches

These switches resemble the touch-feedback design. Between a plunger and button collar an elastomer seal is bonded. An O-ring seals the button.

Fig. 3.2.9: Pushbutton switch

6. Bread Board

Specifications

It has a pitch of 2.54mm ,terminal strips of 300 Tie-point, distribution strips of 100 Tie-point, rated Voltage / Current of 300V / 3 to 5A, insulation resistance of 500MΩ / DC500V, withstanding Voltage of 1,000V AC / 1 minute, wire range of 29AWG to 20AWG, temperature Range of -25°C to +80°C, strip Length : 7mm to 8mm.

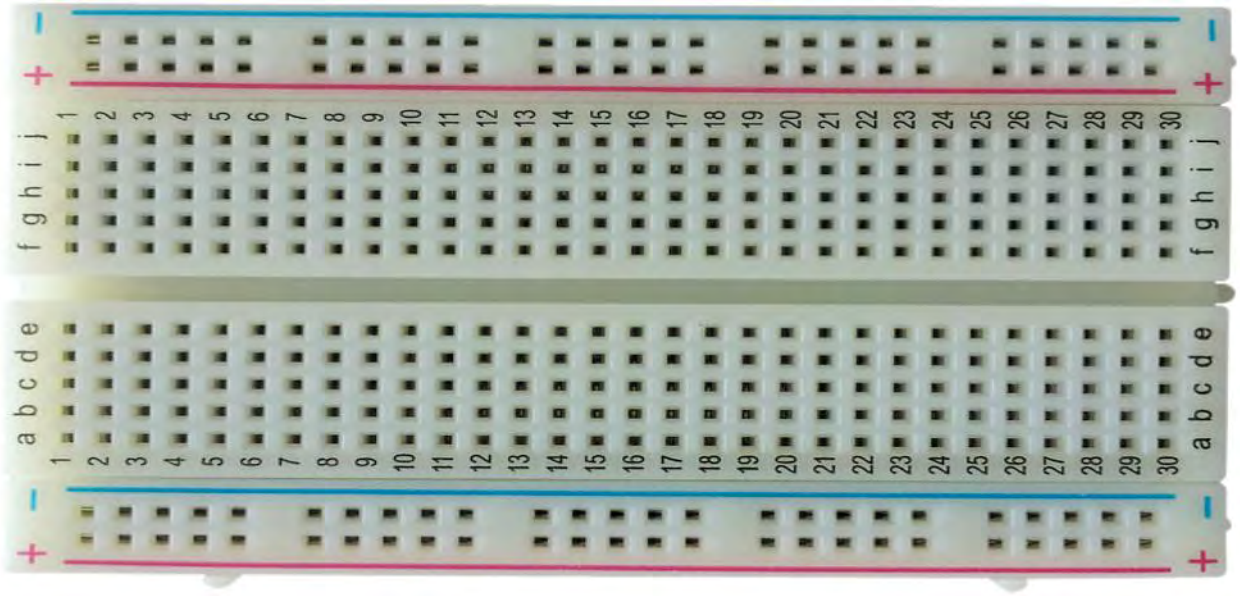


Fig. 3.2.10: Bread Board

7. LCD Monitor 16×2

Liquid Crystal Display

LCD (Liquid Crystal Display) screen is an electronic display module used for a wide range of applications it has a 16x2 LCD meaning it can display 2 lines with 16 characters each.

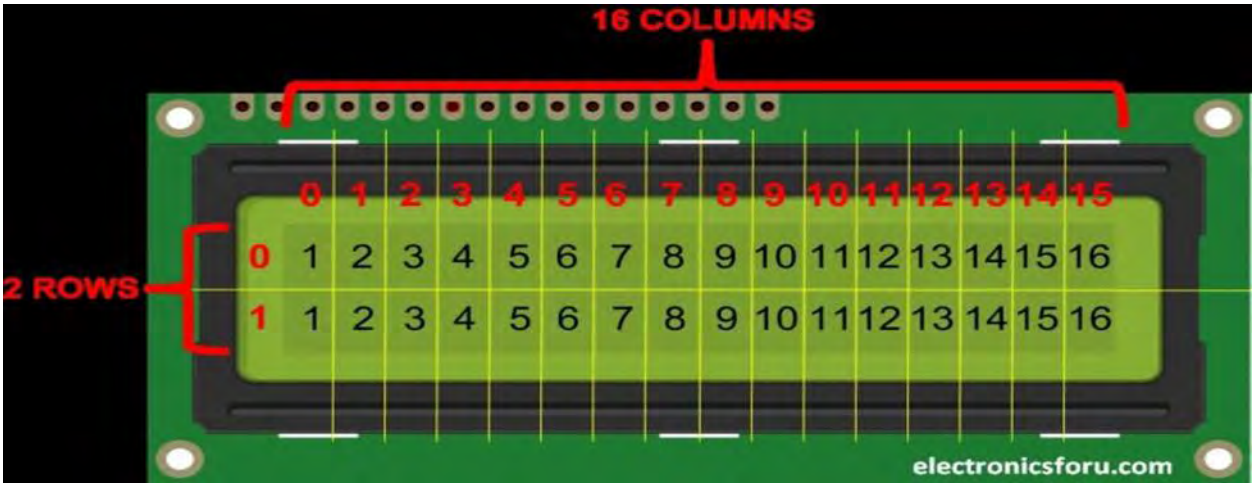


Fig. 3.2.11: LCD monitor 16×2

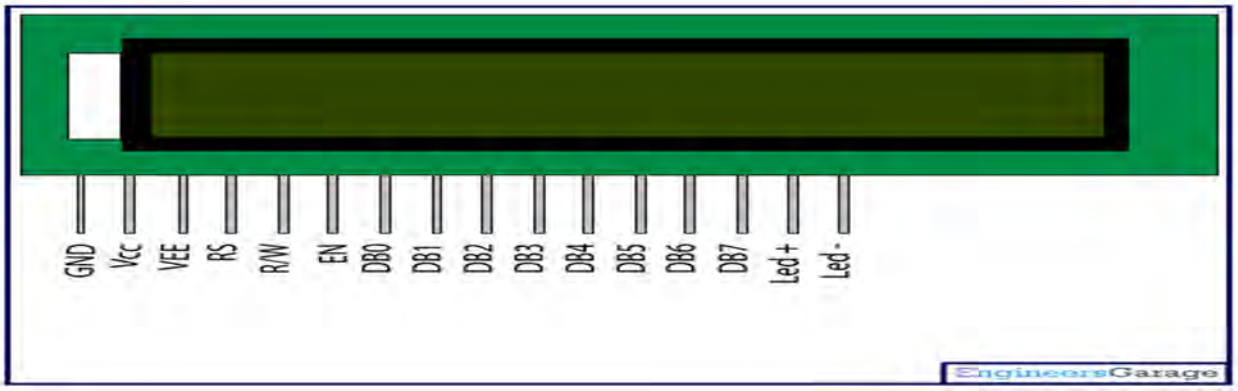


Fig. 3.2.12: LCD monitor pin diagram

8. 5V 2 Channel Relay Module (RLYM-0504)

Description

Microcontroller can only handle low voltage and/or current. Therefore, a relay module is used as a switch as it can handle large amount of voltage and/or current. There is no connection between the low voltage circuit operated by the microcontroller and the high power circuit. The relay protects low voltage circuit operated by a microcontroller and the high power circuit from each other.

Specification

It has an on-board EL817 photoelectric coupler with photoelectric isolating anti-interference ability strong also an on-board 5V, 10A / 250VAC, 10A / 30VDC relays. The relay long life can absorb 100000 times in a row, module can be directly and MCU I/O link, with the output signal indicator, module with diode current protection, short response time and a PCB Size: 45.8mm x 32.4mm.

Fig. 3.2.13: 5V 2 Channel Relay Module

VCC: 5V DC

COM: 5V DC

IN1: high/low output

IN2: high/low output

GND: ground

Fig. 3.2.14: 5V 2 Channel Relay Module pin diagram

9. ACS712-30A Current Sensor Module (SEN-0712)

Description

The ACS712 provides economical and precise solutions for AC or DC current sensing. The device allows for easy implementation by. The device is made up of a precise, low-offset, linear Hall circuit with a copper conduction path located near the surface. It calculates how much current is being supplied from an AC or DC source.

Specification

The current sensor has a low-noise analog signal path. Device bandwidth is set via the new FILTER pin. 5 µs output rise time in response to step input current. Has a bandwidth of 80 Hz. Total output error 1.5% at TA = 25°C. 1.2 mΩ internal conductor resistance. 2.1 kVRMS minimum isolation voltage from pins 1-4 to pins 5-8. 5.0 V, single supply operation. 66 to 185 mV/A output sensitivity. Output voltage proportional to AC or DC currents. Factory-trimmed for accuracy. Extremely stable output offset voltage. Nearly zero magnetic hysteresis. Ratiometric output from supply voltage.

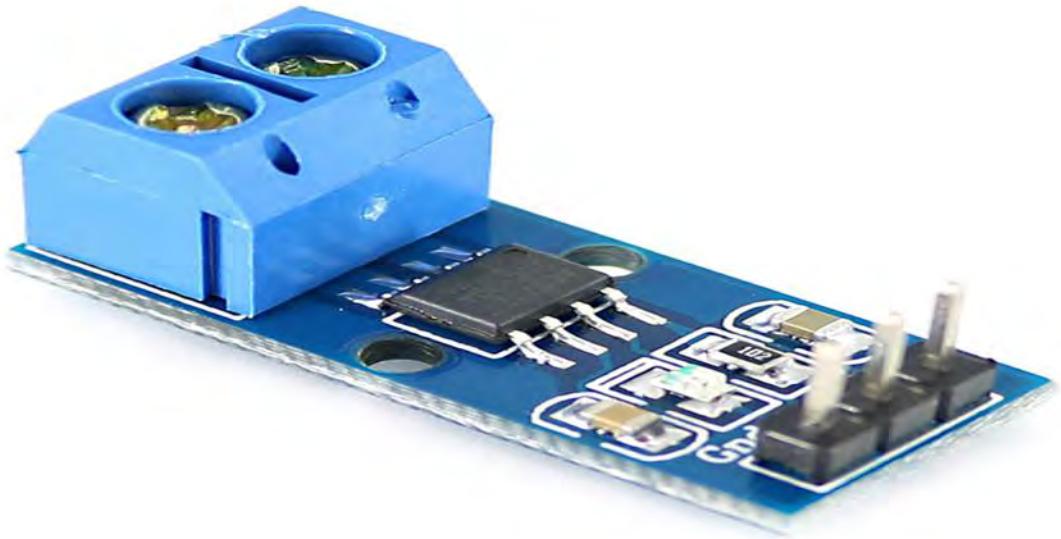


Fig. 3.2.15: ACS712-30A Current Sensor Module

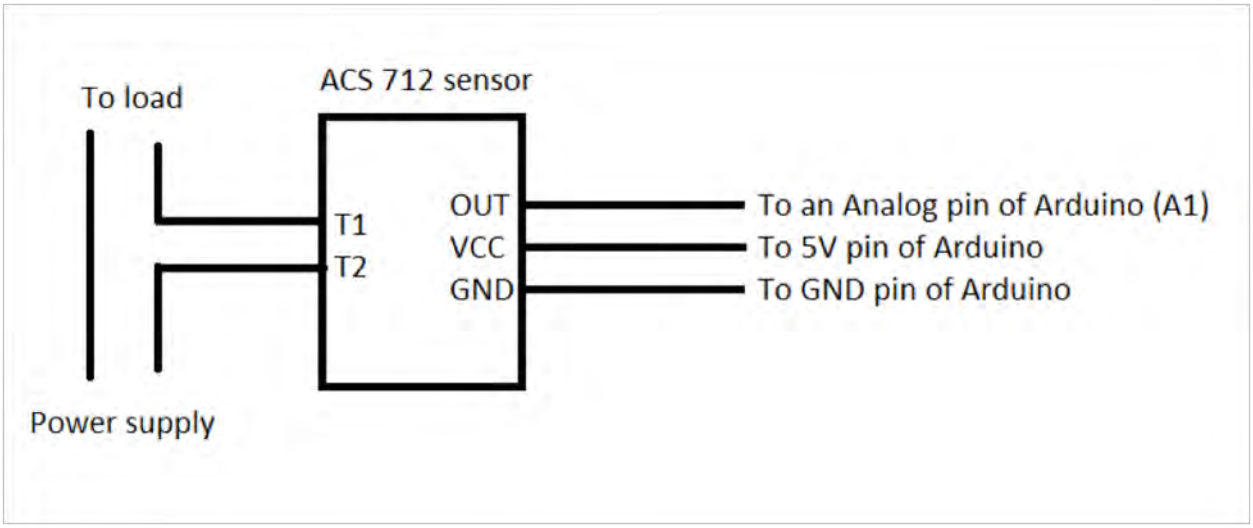


Fig. 3.2.16: ACS712-30A Current Sensor Module pin diagram

10. Arduino

Description

The Arduino Mega 2560 is a microcontroller board. It has 54 digital input/output pins. 16 analog inputs, 4 UARTs, a 16 MHz crystal oscillator, a USB connection, a power jack, an ICSP header, and a reset button. It can simply be connected to a computer with a USB cable or power it with an AC-to-DC adapter or battery to get started.

The Arduino is run by Arduino Integrated Development Environment or Arduino Software (IDE). The programs written in Arduino using IDE are called sketches. These sketches are written in text editor and are saved in file extensions. There are normal Arduino code files (no visible extension), C files (.c extension), C++ files (.cpp), or header files (.h).

Specification

The board can operate on an external supply of 6 to 20 volts. Supplying a voltage of less than 7V causes the 5V pin to supply less than five volts making the board unstable. If more than 12V is used, the voltage regulator may overheat and the board may be damaged. Therefore, the recommended range is 7 to 12 volts.

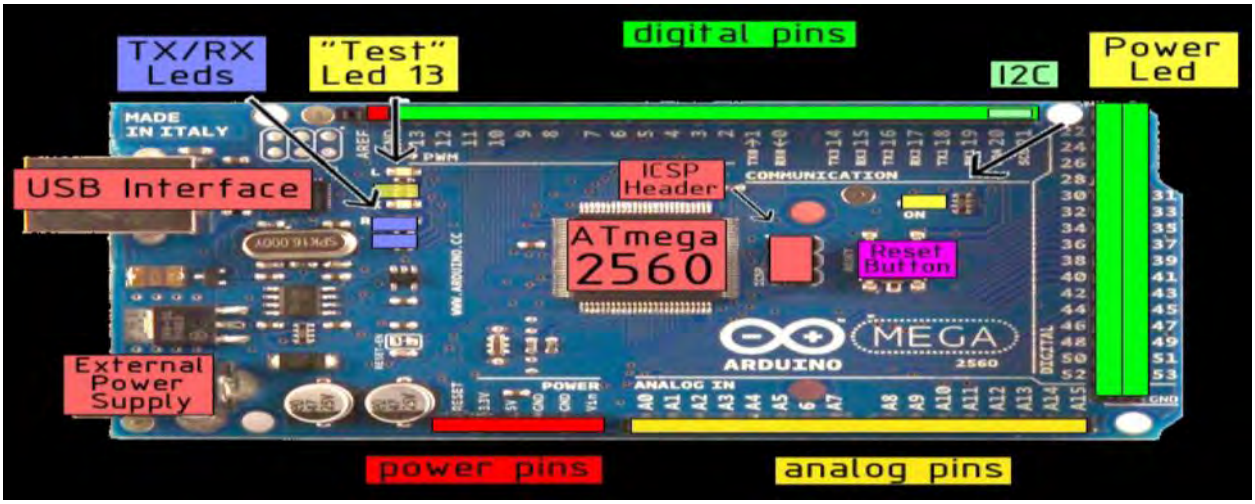


Fig. 3.2.17: Arduino Mega

11. Bulb Holder

Description

We are using a bulb holder that holds a bulb. It will be connected to a current sensor which will calculate the power consumption in the load. This each bulb holder represents a room number in an office building.

Fig. 3.2.18: Bulb holder

12. Bulb

Description

We are using bulbs with different power ratings, which will be put into bulb holders and will be representing a load. It will be connected to a current sensor through bulb holder.

Fig. 3.2.19: 25W Bulb

Chapter 4

Proposed System

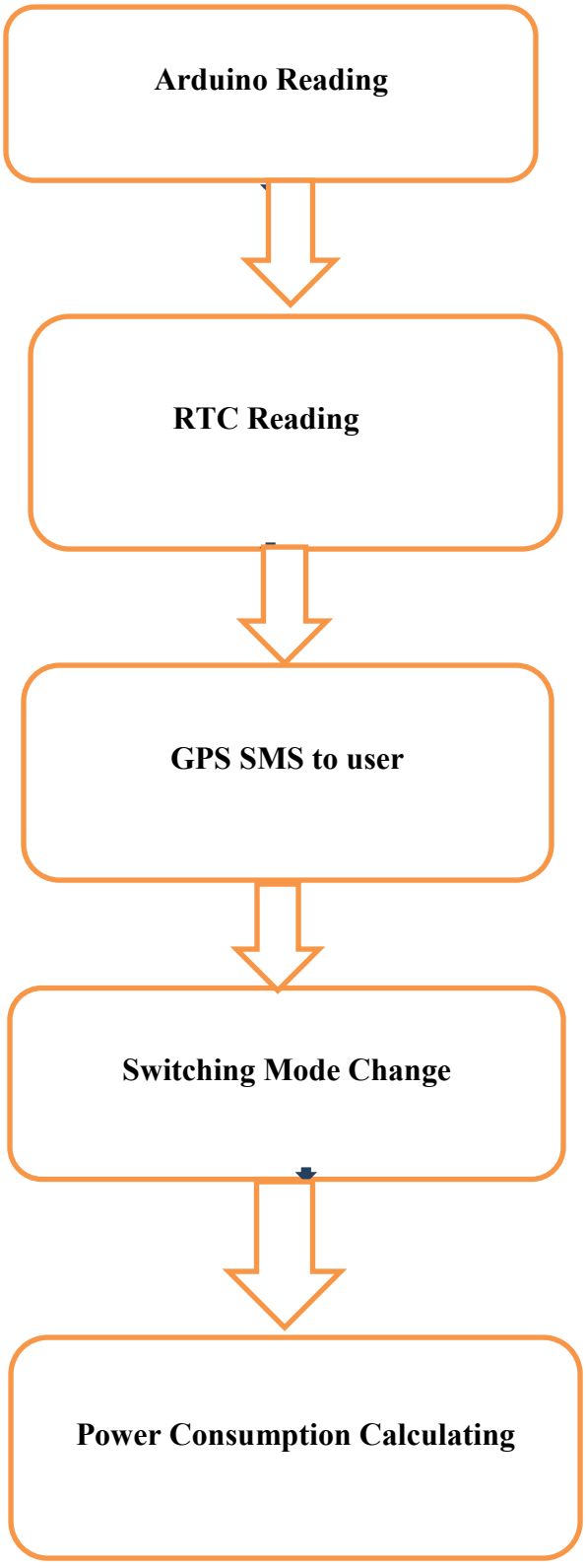
In this chapters we are going to discuss about our proposed work, how we planned to do our works. We will also describe here the use case, how user will use this smart system.

4.1 Proposed Work:

Our project smart power security system is a very complete system that can generate the whole power consumption measurement, additionally it sorts extra power consuming sources, send SMS to the user‟s œllphone to make user aware about the extra power consumption and switch the extra power consumption off. That is how it actually should work. Firstly, we started with the software part that was bit challenging. Then we started interfacing all the equipment with Arduino. Arduino is the main microcontroller for us that is controlling all other parts with C++ language. Hardware part came automatically with the need for interfacing all the equipment. Once all the interfacing were done, we calibrated the whole system according to our need. Currently we are providing the system for several bulbs, so it measures the power for consumed by the bulbs, and stop over power consumption after 5pm, over a threshold voltage. That is how we are currently running this system and in future we will apply this system for heavy loads.

Here, we will also describe shortly about our RMS calculations about this system.

4.2 Work Flow:


Arduino Reading
RTC Reading
GPS SMS to user
Switching Mode Change
Power Consumption Calculating

4.3 Use case:

Smart power security system is an advanced security meter system that is very easy to use. There is a 16*2 liquid crystal display that will show the total power consumption and the real time. So, users will easily can get the total absolute reading of consumed power of the whole loads and after a time being it not only sends the message to the user about the over power consumption, if there occurs, but also stop itself the over consumption. So, user here is not needed to stop over consumption themselves, additionally getting aware about that. So it is very easy for the used to handle, just switching the system on and attach the system.

4.4 RMS Calculation:

There are several ways to measure real power consumption with voltage and load or current and load or voltage and current, we can measure the power consumption. But using voltage sensor to measure voltage is not so easy for heavier loads because heavier loads demands higher voltage. But all voltage sensors cannot take the load of all voltages and that is why it is a problem to use voltage sensors to measure voltage for higher sensitive loads such as air conditioner, micro oven etc. On the other hand, current sensors can sense both higher and lower currents that become more effective for our system and that is why we used here current sensors to measure real power. So our equation to measure real power is,

$$\mathbf{P = VI}$$

4.5 Working method

In our system we used a microcontroller Arduino, Uno to control all the components with C++ Coding. Our main task is to interface all equipment with Arduino as our need. Our project is to use for the AC current, so current sensor is connected with the source and from the sensor, we measure the current that is flowing to load 1 and load 2. Load1 and load 2 connected parallel with the current sensor. Current sensor senses the current flowing rate and from the RMS calculation, we can find the power consumption. We fit a threshold power manually if the consumed power gets higher than the threshold power, one load will be switched off automatically after the working hours. Loads are connected with relays through Arduino, Arduino controls the relays whether to on or off whether the depending on current sensor readings. There are also two switches to turn the loads on manually. So after working hours user can switch off load manually too.

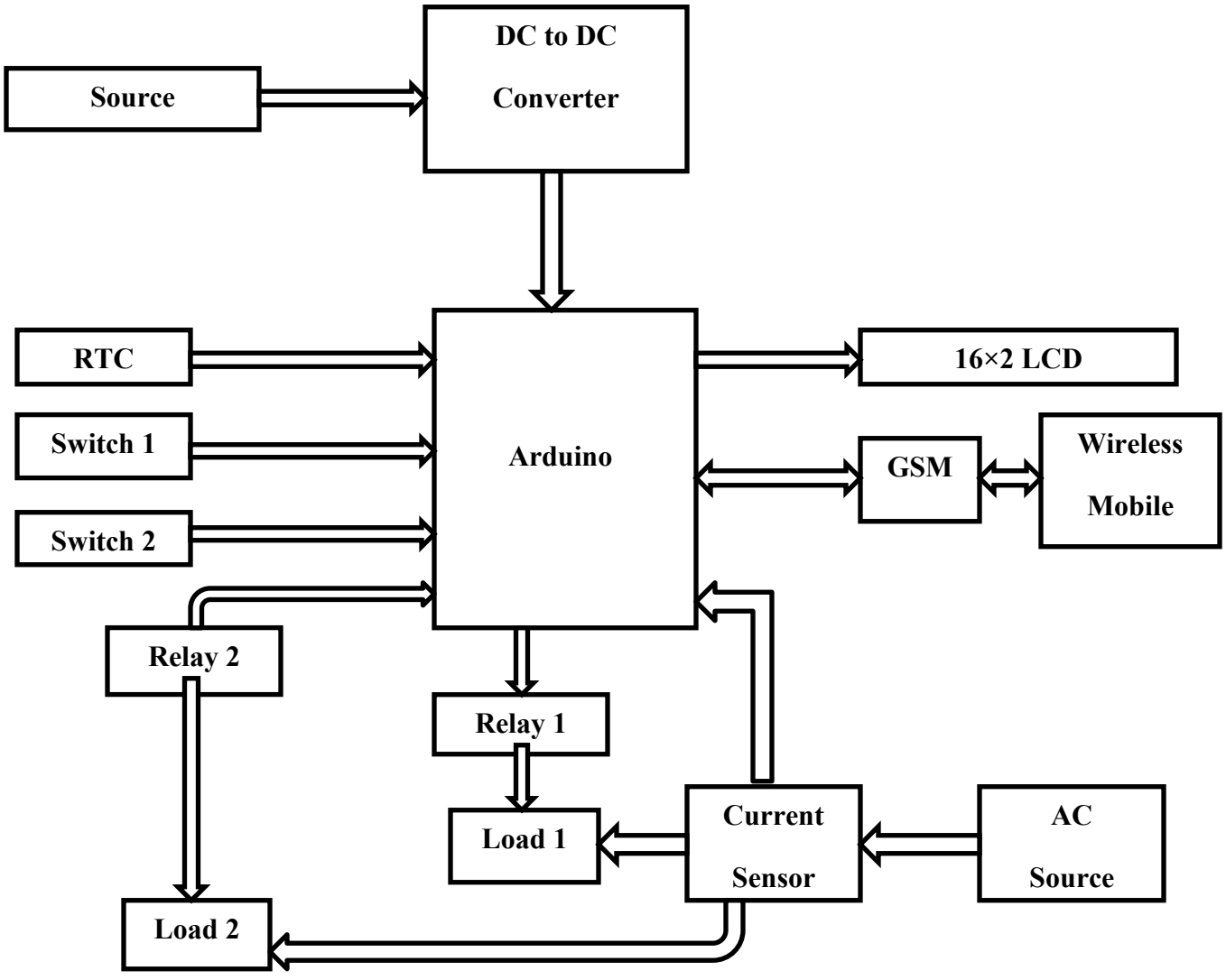
A 16*2 LCD is connected with Arduino, which shows the output of total power, if total power crosses the threshold power, Arduino send data to GSM, which sends immediate SMS to user‟s cell phone so that he/ she can get aware of the power loss. GSM is connected with a DC to DC converter to provide the right voltage, 100v to the GSM. A real time clock has been used to keep the measurement of time, which sends continuous data to the Arduino to maintain working hour & off hours. We have used two bulbs as load of two rooms.

Chapter 5

System Architecture

Here in this section, we will discuss about the internal architecture of the circuit.

5.1 Block Diagram of the system



5.2 Real design pictures

Here are some real design pictures of our project -

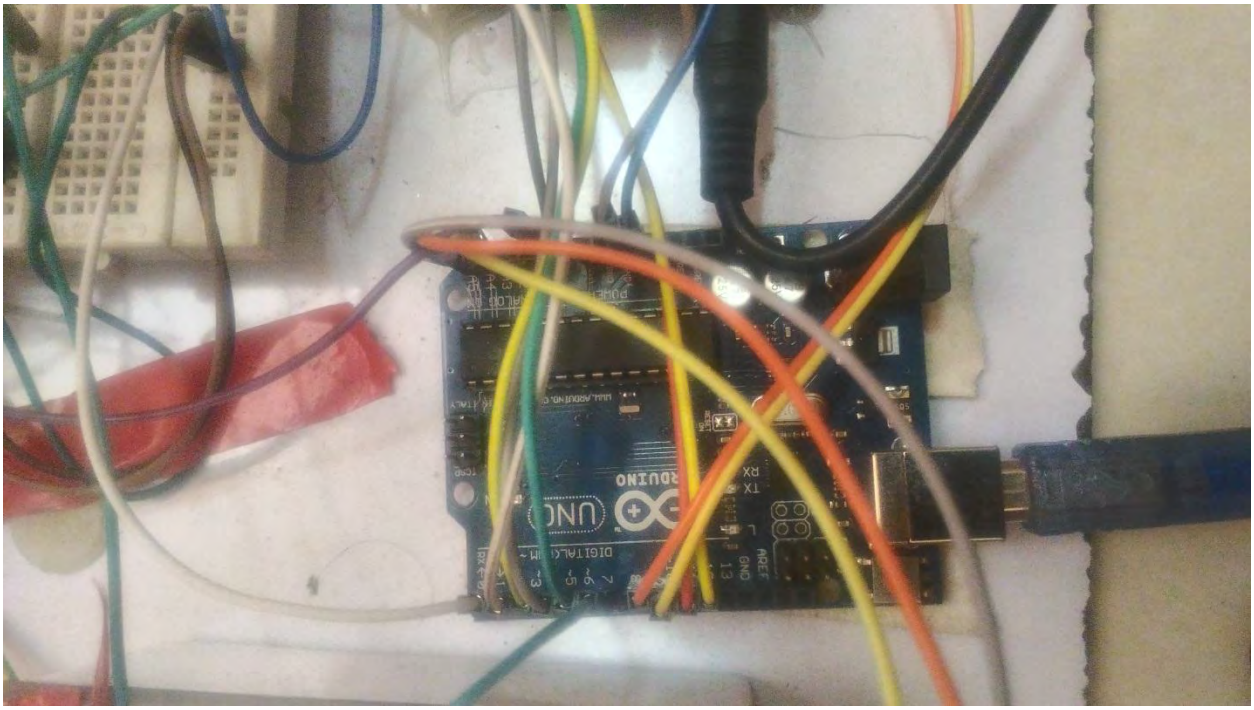


Fig. 5.2.1: Arduino

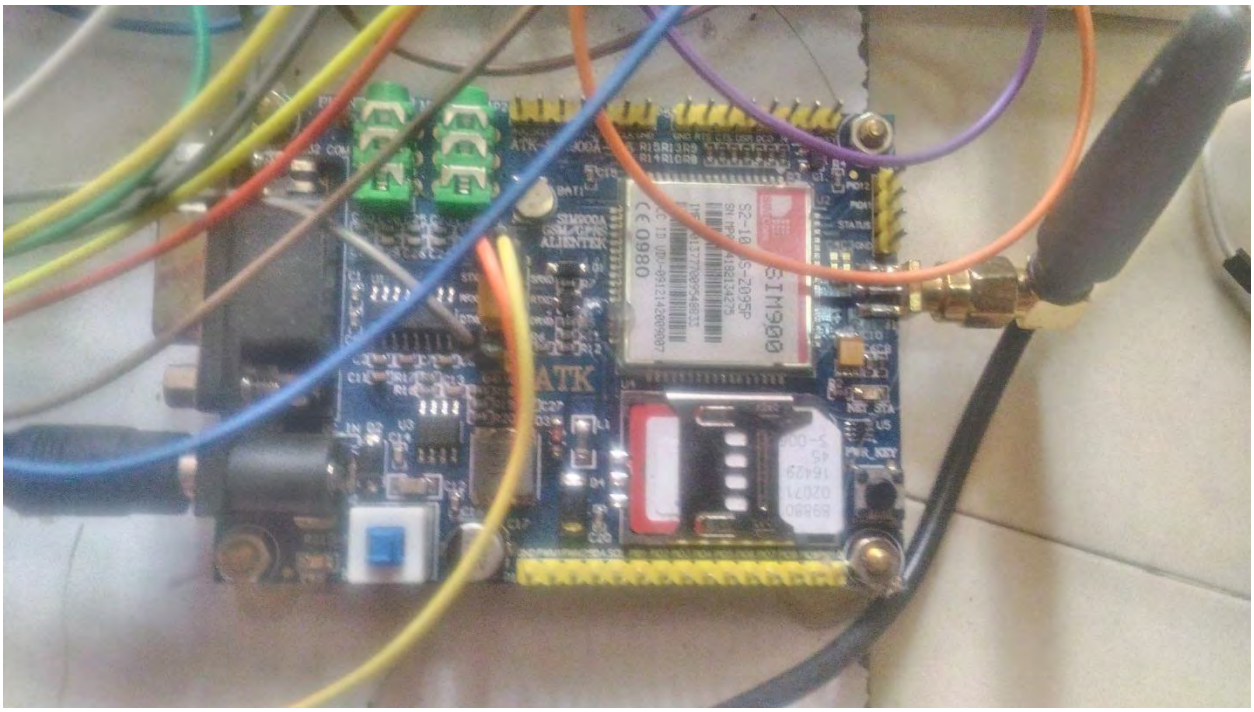


Fig. 5.2.2: GSM

Fig. 5.2.3: 16×2 LCD

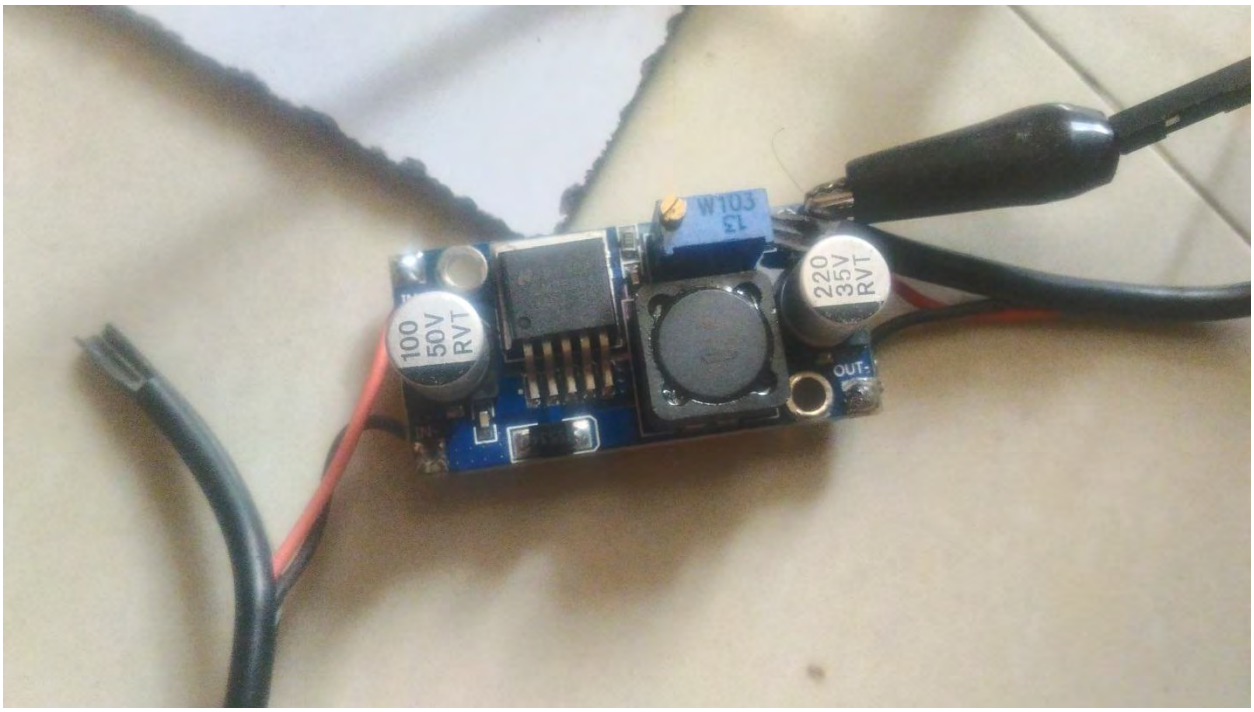


Fig. 5.2.4: DC to DC Converter

Chapter 6

Result and Analysis

The result of our system was very fruitful. We used two loads of different powers, one of 40 watts and another of 35 watt. For tolerance, our meter shows two power of 79 watt.

Threshold power = 60 w
Room 1 power consumption = 40 w
Room 2 power consumption = 35 w
Tolerance power consumption = 4 w

Total power consumption = 79 w

We took the result at approx. 8:30pm, which we considered as off hours, so the system switched off the bulb of Room 2 as the total power exceeds the threshold power 60 w. So, the bulb that we denoted as room 2 got switched off itself.

Here are some real circuitry pictures of our results -

1. Primary state without any connection

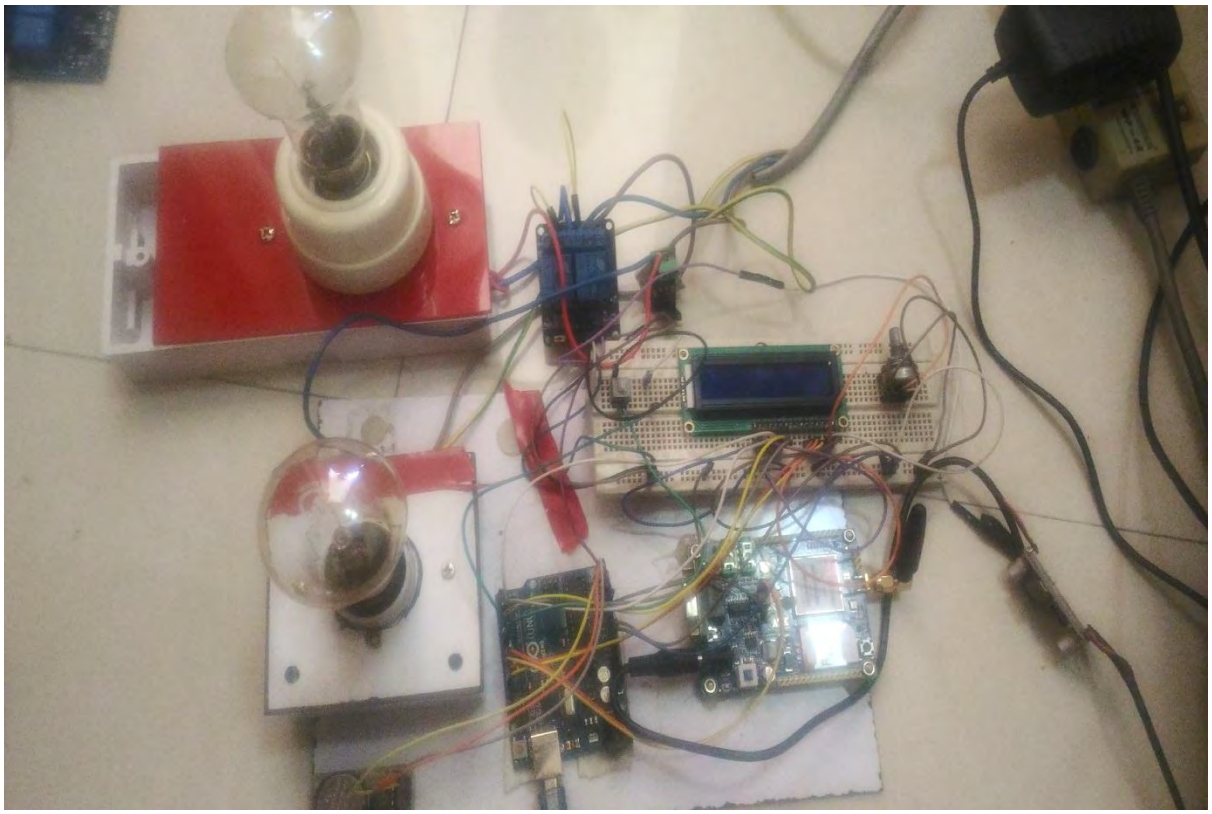


Fig. 6.1: Primary state without any connection

2. Time while working was off hour

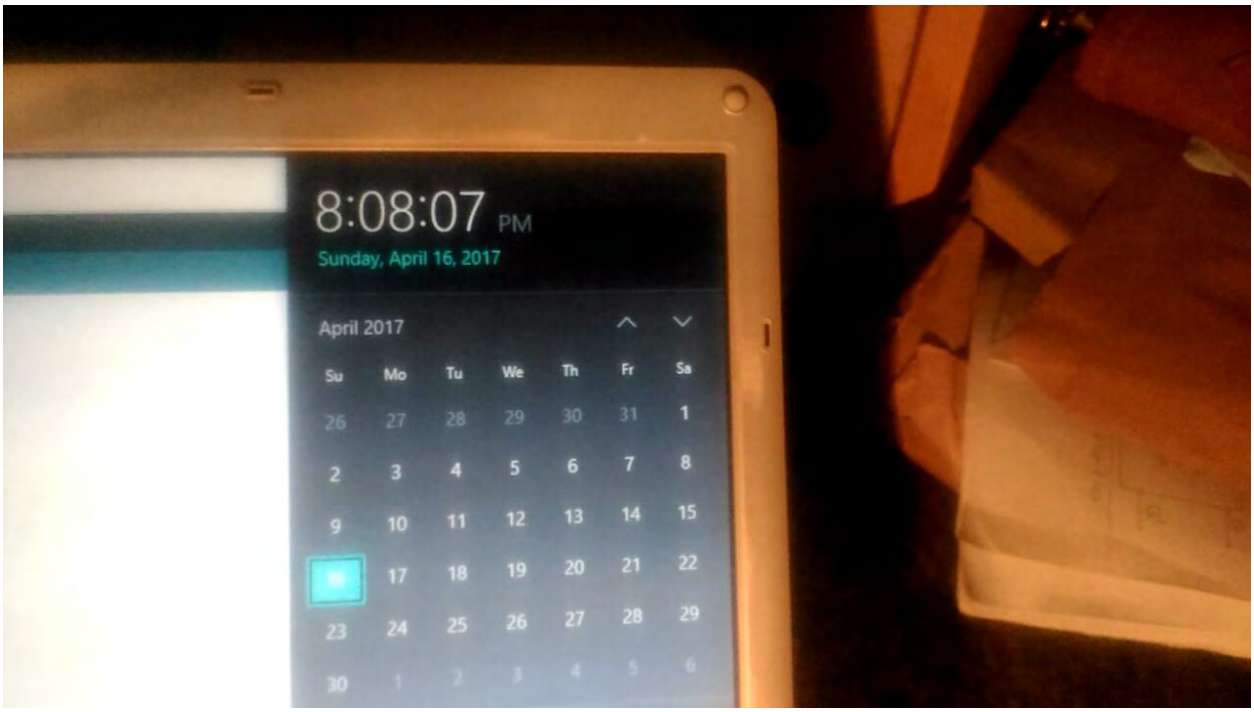


Fig. 6.2: Time while working was off hour

3. One bulb switching on and connections on

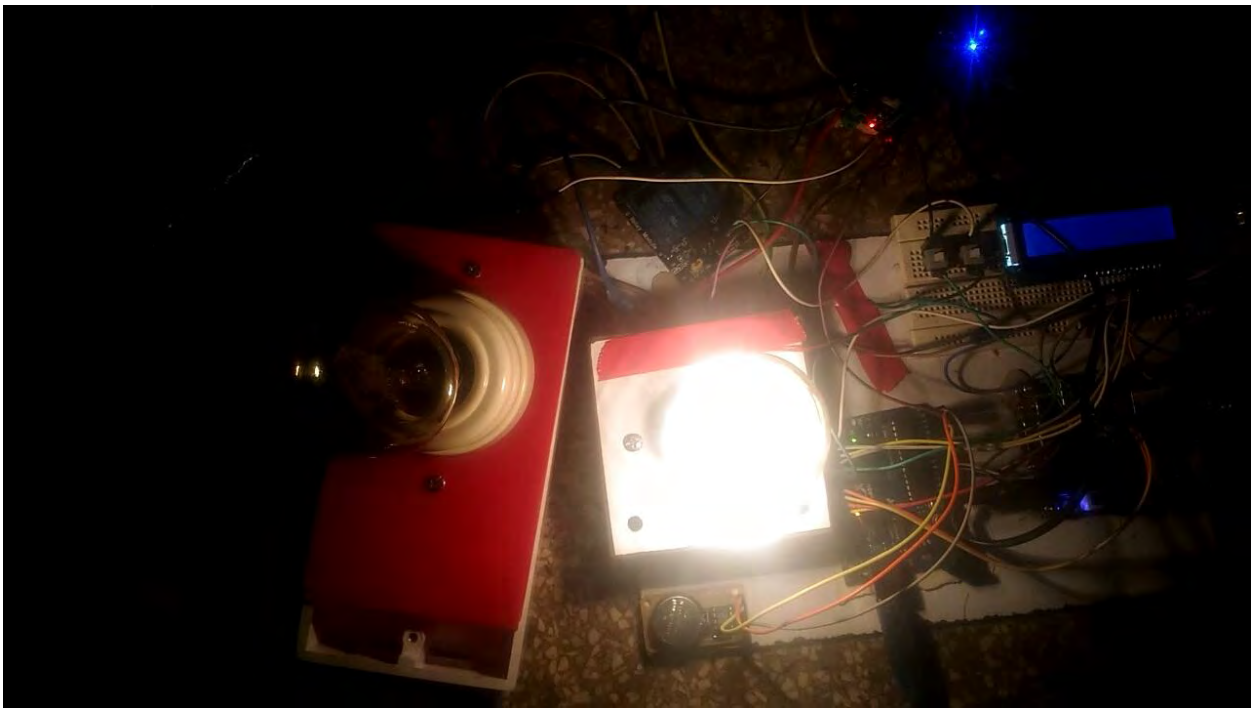


Fig. 6.3: One bulb switching on and connections on

4. State of Arduino software

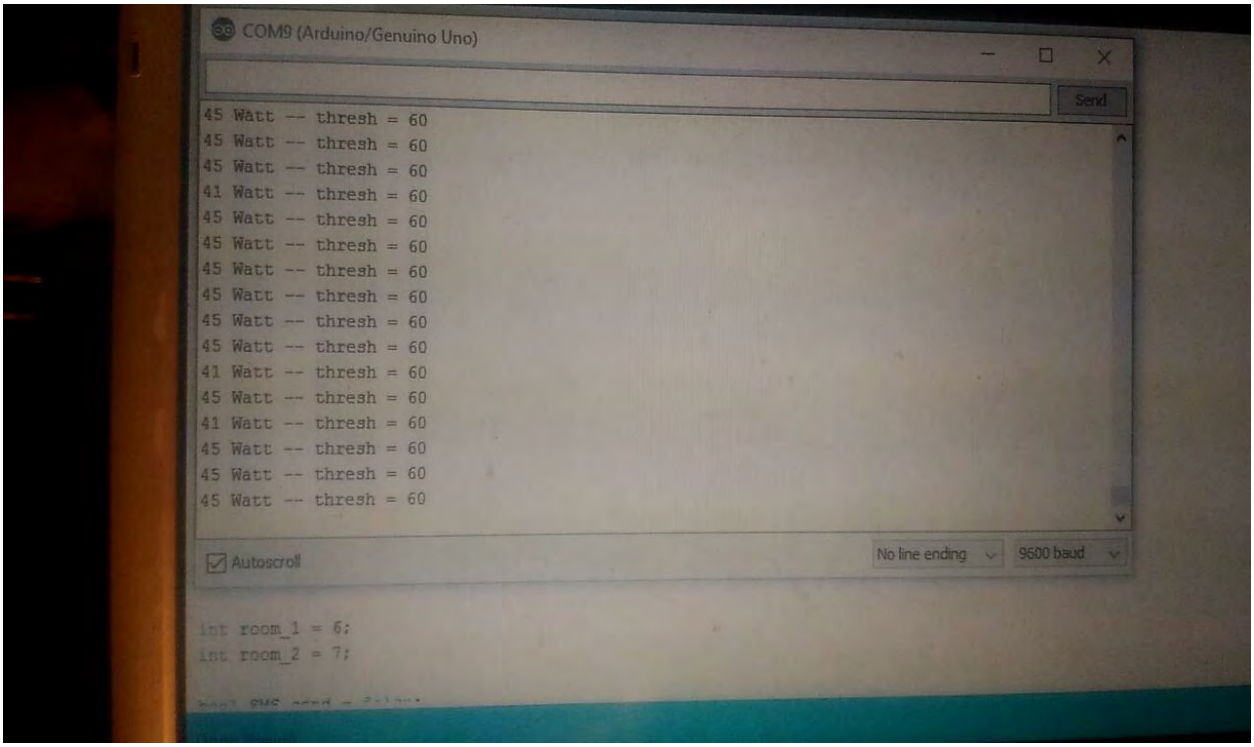


Fig. 6.4: State of Arduino software

5. Both loads on

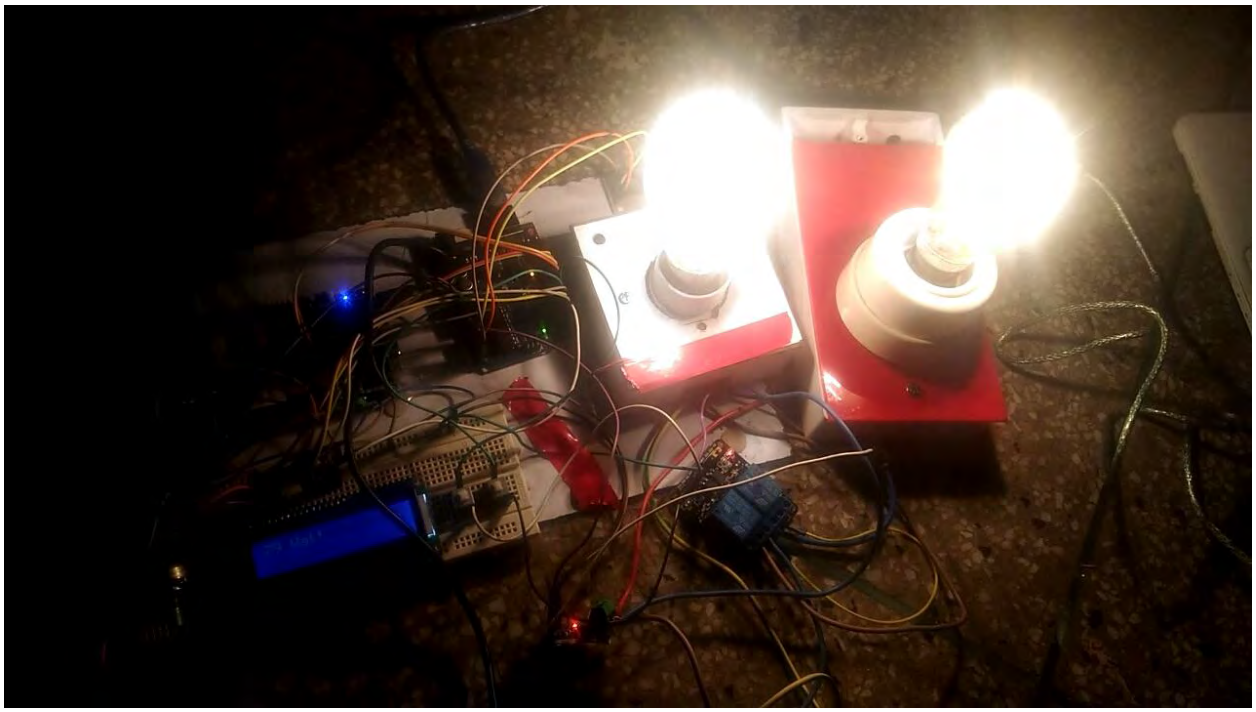


Fig. 6.5: Both loads on

6. Total power changed in Arduino software

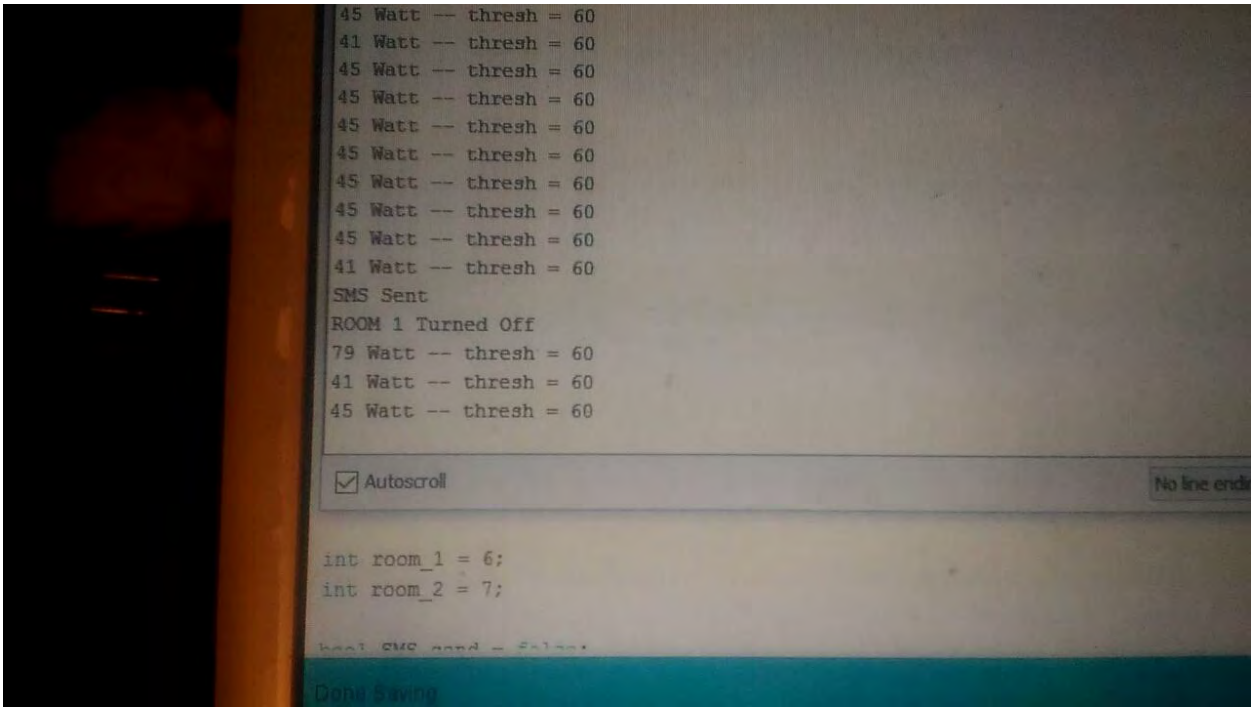


Fig. 6.6: Total power changed in Arduino software

7. Room 1 bulb turned off

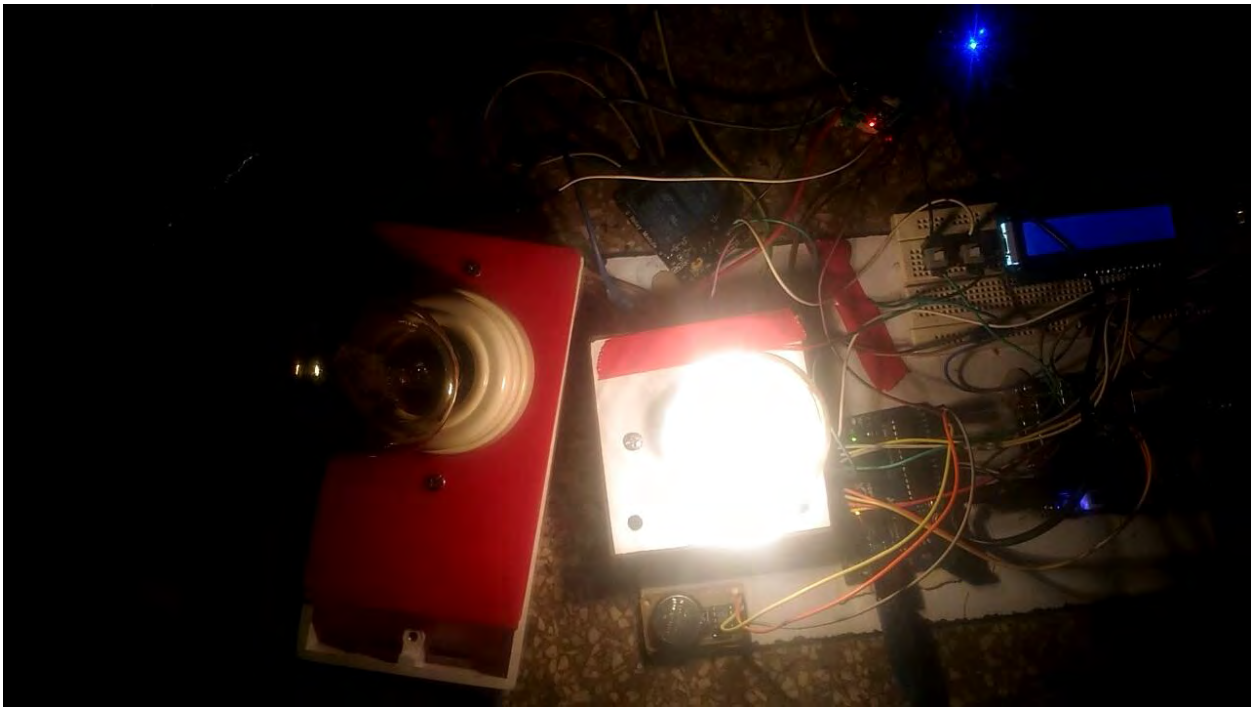


Fig. 6.7: Room 1 bulb turned off

8. SMS sent to the user number

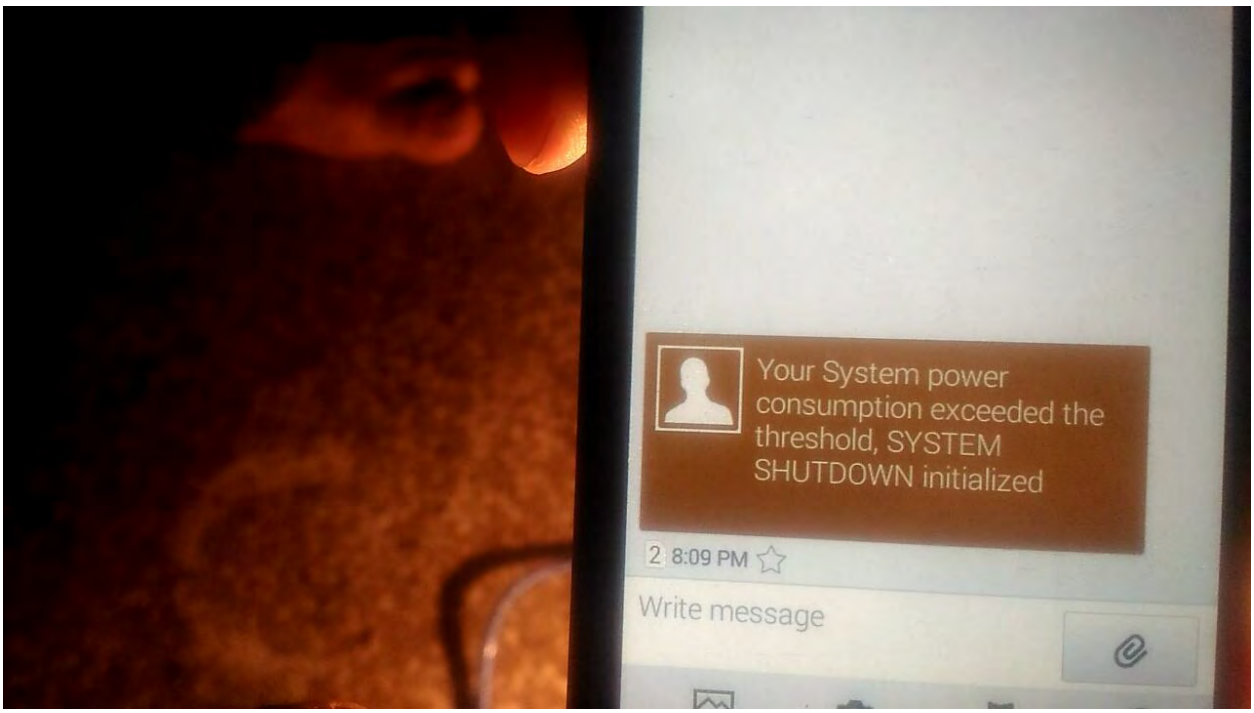


Fig. 6.8: SMS sent to the user number

Chapter 7

CONCLUSION

Now-a-days the single phase electronic meter are getting more advanced. Smart meters are now features many advantages which is very much beneficial in electronic system. An attempt has been made to make a smart power security system which can be used to measure voltage, current and calculate the power consumption of a working place. This data is used as a feedback to monitor the energy consumption and make the user aware when the load exceeds, also for the security purpose it will send a SMS to the user that there is power consumption in the specific room.

Moreover, this smart meter will auto turn off the loads if the specific load exceeds the given limit which will be fixed in the meter known as threshold voltage.

The main idea behind the project is to minimize power consumption as electricity is a major resource for every developing country. As we can see in so many cases in factory or offices users forget to turn off the light/fans after left the room. It‟s a huge waste of electricity. So in this case our smart power consumption system can be a great option to reduce this wasting power through our proposed design system.

Furthermore, this meter will secure users not to use same line without permission of the owner as it will give you the message through GSM.

We are also using manual switch which can perform directly if there is any problem occurs in the system.

At last Bangladesh is suffering from lack of electricity to reduce this problem our meter can be a great option. It can save huge amount of electricity also in security purpose it can be a good option as well.

FUTURE WORKS

The future scope of this whole project is pretty large. Now in future we can think of implementing this model for three phase system by using SPI metering ICs which will provide more parameters.

Then we will try to make a feedback design using logic circuits to handle multiple heavy loads for different locations. This feedback design circuit using logic gates connected with Arduino will make our project more efficient and more effective.

We will also think about the cost efficiency in the future. In the future if we can reduce the cost of this meter it will be very beneficial for the users.

Furthermore, in a country like Bangladesh electricity is one of the major resource of our country. So to reduce the wasting power this system can be a great option if we can develop this meter in the future. If we can design this meter in a proper way in coming future this system can be a great asset in the sector of power consumption.

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