CHAPTER 1

INTRODUCTION

In India more than 5 million households are accessible to electricity and they are connected to the power grid. These 5 million households have energy meter to measure the energy consumption. We need more number of people to collect the energy consumption details from the energy meter and for the billing purpose. The internet spread across the India will provide solution to this problem. We can integrate the energy meter with the internet for the measurement of energy consumption and billing purpose and some additional operations like demand side load management.

1.1 ENERGY METER

Energy Meter or Watt-Hour Meter is an electrical instrument that measures the amount of electrical energy used by the consumers. Utilities are one of the electrical departments, which install these instruments at every place like homes, industries, organizations and commercial buildings to charge for the electricity consumption by loads such as lights, fans, refrigerator, and other home appliances. Industry uses heavy loads like three phase induction motor, water heaters etc.

The basic unit of power is watts and it is measured by using a watt meter. One thousand watts make one kilowatt. If one uses one kilowatt in one-hour duration, one unit of energy gets consumed. So energy measures the rapid voltage and currents, calculate their product and give instantaneous power. This power is integrated over a time interval, which gives the energy utilized over that time period. Utilized energy will be displayed on the meter and it will be noted down by the authority end person for the billing purpose.

1.1.1 Types of Energy Meters

The energy meters are classified into two basic categories, Such as

- Electromechanical Type Induction Meter
- Electronic Energy Meter

Energy meters are classified into two types by taking the following factors into considerations

- Types of displays analog or digital electric meter.
- Types of metering points: secondary transmission, grid, local and primary distribution.
- End applications like commercial, industrial and domestic purpose.
- Technical aspects like single phases, three phases, High Tension, Low Tension and accuracy class materials.

1.1.2 Evolution of Energy Meter

Electromechanical meter had been used for the measurement of energy consumption in the consumer end. Energy consumption details from the electromechanical meter must be gathered physically and these may involves some errors. Later electronic meters have been introduced and this meter replaces the electromechanical meter. Mechanical elements have been taken over by the electronic components and have more advantages than the electromechanical meter. The energy consumption details must be gathered physically in this meter as well.

To reduce the man power, we can move to Smart Energy Meter (SEM). SEM is different from the electronic meter because of their additional functionalities and features. This SEM includes electricity measurements, Automatic Meter Reading (AMR), two way communication

between the meter and the authority. Load profiling, pre-payment, remote disconnection and reconnection, power outage notification, tamper detection, and multi-tariffing is also possible with smart meters. The AMR is not an affordable solution, because it requires huge amount of capitalization for the establishment of communication network and to change the architecture of old electromechanical and electronic meter for the introduction of communication system in it.

Prepaid energy meter becomes more popular both in customer side and service provider side as it is efficient, cost effective, and it enhances system accountability. This meter provides various recharging scheme for the effectiveness of the people. The prepaid energy meter has some disadvantages which reduce the attractiveness of this meter. Some disadvantages are network connectivity, handheld equipment for the system up gradation and plan setting, demand side load management and some protection schemes.

Automatic Metering Infrastructure (AMI) offers two ways communication link and became more popular as it solves several problems while it integrated to energy meter. The main advantages to move to AMI-based smart energy meter are Demand Side Load Management (DSLM), remote tariff plan setting, billing information, remote connection and disconnection, fault detection, protection schemes, tampering protection etc. AMI consists of smart meter, meter data management and bi-directional communication system.

There are several communication protocols are available. They are public switched telephone network, Power Line Carrier (PLC) communication, Bluetooth, ZigBee, GSM and Wi-Fi. The communication part plays the crucial role in the smart energy meter as it should be more

effective. Public switched telephone network can be used to transfer the data between the meter and authority. This system require larger infrastructure so latter it was omitted in the implementation of SEM. Power line carrier (PLC) communication requires high carrier frequency for data communications. So this communication protocol was not used widely.

Later wireless communication protocols are introduced in the SEM like Bluetooth, ZigBee, GSM, and Wi-Fi. Integration of Bluetooth with SEM offers the authority to collect the energy consumption details using the specified Bluetooth device by connecting that specified device with the SEM Bluetooth network. The disadvantage of this system is person from the authority station come nearer to the SEM to collect the energy consumption from the meter. This system cannot be accessed from the remote location and changes in the plan to be modified in the kit, and remote up gradation is not passible in this system. ZigBee based smart energy meter are also implemented and they too have short range coverage. So they are not developed widely.

Global System for Mobile communication (GSM) had been integrated with the smart energy meter to transfer the data from the energy meter to authority. The authority don’t want to visit the energy meter to collect the energy consumption details, tariff plan changing, billing calculation, demand side load management. This all can be done remotely by sending the message from the authority to meter and vice versa. This system had been developed and implemented widely. The main disadvantage of this system is evaluation of communication network. The communication network had been developed from 1st generation network (1G) to 4th generation network (4G VOLTE). The cost of the hardware will be higher for the latest communication network. Nowadays network availability will

be very low for the 2nd generation network so that this system didn't implemented widely.

Demand side load management (DSLM) had been implemented in the smart energy meter to manage the peak hour demand. There are several techniques available on DSLM they consists of direct load control, rebates, and subsidies programme and incentivized tariff plan and some programme that will improve efficient usage of electricity during the demand period

The remote up gradation requires huge data transfer from authority to energy meter. This cannot be possible in wireless network like Bluetooth, ZigBee, and GSM. This can be done by wired communication network but the cost of the operation will be higher. This is the main disadvantage of the existing network. To overcome this we need a wireless technology for the fast data transfer between the authority and the energy meter.

To overcome the disadvantages mentioned we are going to implement a smart energy meter that has Wi-Fi to exchange details between the authority and the energy meter. The remote up gradation is possible in this meter. The Wi-Fi will be connected with the internet connection. The information will be transferred to the webserver. For this communication between devices and web page we use controlling device along with IOT.

1.2 INTERNET OF THINGS

The Internet of Things (IoT) is the network of devices such as vehicles, and home appliances that contain electronics, software, actuators, and connectivity which allows these things to connect, interact and exchange data. The IoT involves extending internet connectivity beyond standard devices, such as desktops, laptops, smartphones and tablets to any range of traditionally dumb or non-internet enabled physical devices and everyday

objects. Embedded with technology, these devices can communicate and interact over the Internet, and they can be remotely monitored and controlled.

Figure 1.1 Representation of IoT

The definition of the Internet of things has evolved due to convergence of multiple technologies, real-time analytics, machine learning, commodity sensors, and embedded systems. Traditional fields of embedded systems, wireless sensor networks, control systems, automation (including home and building automation), and others all contribute to enabling the Internet of things.

An IoT ecosystem consists of web-enabled smart devices that use embedded processors, sensors and communication hardware to collect, send and act on data they acquire from their environments. IoT devices share the sensor data they collect by connecting to an IoT gateway or other edge device where data is either sent to the cloud to be analyzed or analyzed locally. Sometimes, these devices communicate with other related devices and act on the information they get from one another. The devices do most of the work without human intervention, although people can interact with the devices for instance, to set them up, give them instructions or access the data.

CHAPTER 2

LITERATURE SURVEY

Loss, P. A. V., et al. (1998) [1] Single phase electrical energy meter based on a microcontroller from Microchip Technology from PIC family. This electronic meter does not possess any rotating parts, and the energy consumption can be easily read from a four digits display. Besides that, energy consumption is stored in the microcontroller's EEPROM memory. This action is necessary to ensure a correct measurement even in the event of an electrical outage or brown out. As soon as the supply is restored, the meter restarts with the stored value. As this meter is compatible with the electromechanical ones, no additional costs will be incurred by the utile companies in their replacement. A single- phase energy meter prototype has been implemented in the lab to provide measurement up 10 A load current from a 127V line voltage. The observed accuracy was better than 97%.

Haque, M. M., et al. (2011) [2] Single phase digital prepaid energy meter based on two microcontrollers and a single phase energy meter IC. This digital prepaid energy meter does not have any rotating parts. The energy consumption is calculated using the output pulses of the energy meter chip and the internal counter of microcontroller (ATmega32). A microcontroller (ATtiny13) is used as a smart card and the numbers of units recharged by the consumers are written in it. A relay system has been used which either isolates or establishes the connection between the electrical load and energy meter through the supply mains depending upon the units present in the smart card. Energy consumption (kWh), maximum demand (kW), total unit recharged (kWh) and rest of the units (kWh) are stored in the ATmega32 to ensure the accurate measurement even in the event of an electrical power outage that can be easily read from a 20×4 LCD. As soon

as the supply is restored, energy meter restarts with the stored values. A single phase prepaid energy meter prototype has been implemented to provide measurement up to 40A load current and 230V line to neutral voltage. Necessary program for microcontrollers are written in c-language and compiled by Win-AVR libc compiler.

Berthier, R., et al. (2011) [3] It is critical to develop an effective way to monitor advanced metering infrastructures (AMI). To ensure the security and reliability of a modernized power grid, the current deployment of millions of smart meters requires the development of innovative situational awareness solutions to prevent compromised devices from impacting the stability of the grid and the reliability of the energy distribution infrastructure. To address this issue, we introduce a specification-based intrusion detection sensor that can be deployed in the field to identify security threats in real time. This sensor monitors the traffic among meters and access points at the network, transport, and application layers to ensure that devices are running in a secure state and their operations respect a specified security policy. It does this by implementing a set of constraints on transmissions made using the C12.22 standard protocol that ensure that all violations of the specified security policy will be detected. The soundness of these constraints was verified using a formal framework, and a prototype implementation of the sensor was evaluated with realistic AMI network traffic.

Koay, B.S., et al. (2003) [4] Presently electronics energy measurement is continuously replacing existing technology of electro-mechanical meters especially in China and India. By the year 2004, digital meter will start replacing electromechanical meters in Singapore. A wireless digital energy meter will definitely offer greater convenience to the meter

reading task. Bluetooth technology is chosen as a possible wireless solution to this issue. In this paper, we present the design and implementation issues of a Bluetooth-Enabled Energy Meter. The Energy Reader can collect the energy consumption reading from the Energy Meter wirelessly based on Bluetooth. Two methods, which can retrieve the meter reading with little human intervention, are proposed and implemented in the targeted applications. They are AMR (Automatic Meter Reading) and the APM (Automatic Polling Mechanism). Few commercial applications are suggested to apply for the Bluetooth-Enabled Energy Meter.

Lešek Franek, et al. (2013) [5] Prepaid energy meters are relatively widespread in the world. These meters allow for distribution of electricity in developing and politically unstable countries. In developed countries, prepaid meters help distributors to solve problems with defaulters and they help underprivileged customers to better control the finances spent on consumption of energy. Currently smart metering technologies are being tested and introduced on the market. The Smart Meters bring significant changes in the measurement and billing of energy consumption.

Md. Masudur Rahman, et al. (2015) [6] Every management system is trying to make automatic, portable and remote control. This work presents a novel smart energy meter for an automatic and superior metering and billing system. The integration of the Arduino and GSM Short Message Service (SMS) provide the meter reading system with some automatic functions that are predefined. Firstly, we have simulated the project in PROTEUS 8.0 then successfully implemented on the circuit board in laboratory. The proposed energy meter system can incorporate with embedded controller and GSM modem to transmit the data like consumed energy in kWh, generated bill, security services (line Cut/On) over GSM

mobile network such as data can be then fed and integrated into existing energy management systems located at power companies or organizations to provide the services among the customers without man-power. Our implemented project is able to provide all required services remotely for metering and billing with high fidelity.

Peter Palensky, et al. (2011) [7] Energy management means to optimize one of the most complex and important technical creations that we know :the energy system. While there is plenty of experience in optimizing energy generation and distribution, it is the demand side that receives increasing attention by research and industry. Demand Side Management (DSM) is a portfolio of measures to improve the energy system at the side of consumption. It ranges from improving energy efficiency by using better materials, over smart energy tariff swith incentive for certain consumption patterns, up to sophisticated real-time control of distributed energy resources. This paper gives an overview and taxonomy for DSM, analyzes the various types of DSM, and gives an outlook on the latest demonstration projects in this domain.

CHAPTER 3

EXISTING SYSTEM

3.1 INTRODUCTION

In existing system, electromechanical meter had been used for the measurement of energy consumption in the consumer end. Energy consumption details from the electromechanical meter must be gathered physically and these may involves some errors. Then electromechanical meter had been replaced by electronic meter and it will calculate the energy consumed by measuring the input voltage and current. The authority end person should visit the meter to collect the unit consumed for the billing purpose. There will be a wide range of tariff plans are available depending upon the consumption of energy. Later communication device are added to the meter for the data transmission between meter and the authority. Addition of GSM with meter had a wide reach among the customer.

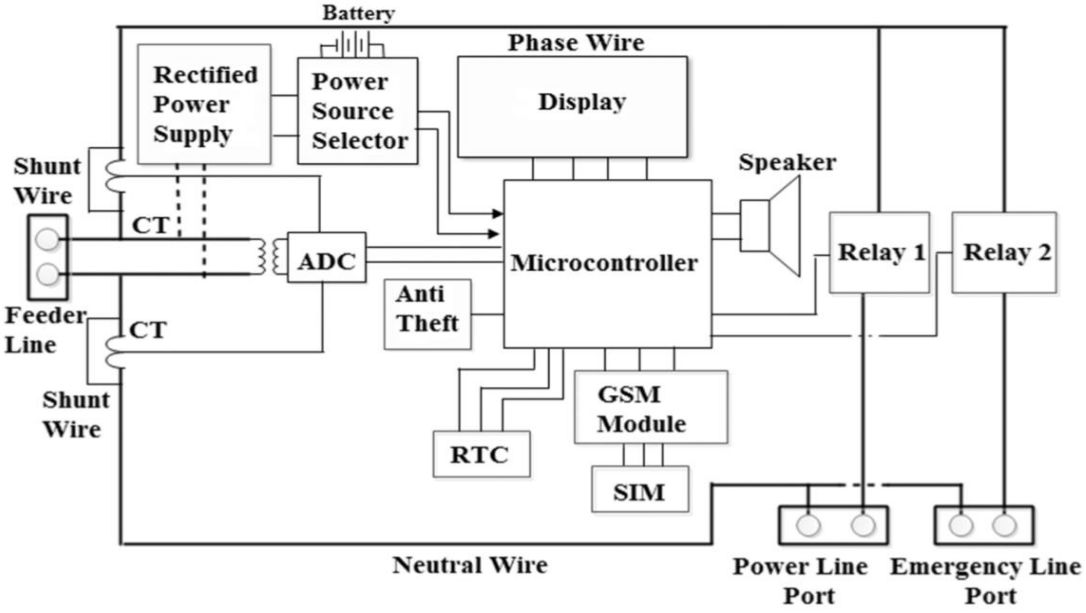

Figure 3.1 Block diagram of existing system

3.2 PROBLEM DESCRIPTION

In existing system, they GSM module for the communication purpose and data's are transmitted in the form of messages, this uses 2G network for the communication purpose. The mobile networks had been developed to 4G networks so there will be less in 2G network towers and companies stopped their production of 2G SIM cards. The communication isn't effective because of development of the network. The message sending system will be slower because of the lesser coverage of network and traffic gets increased. Some meters are available without communication module, in that authority end person need to visit the meter for the collection of data and it should be processed. This process requires huge amount of man power and there will be chance of error in the reading measurement and billing calculation. Live data monitoring doesn't available in any of the system and basic protection scheme also not available in the meter. It requires some additional power source to store the data without losing it.

In order to reduce the man power for the billing and metering purpose, increase the communication strength between the meter and authority end, for live data monitoring at the authority end, better notification system, no need of separate power source to store the data in the microcontroller and to have some basic protection scheme we use smart energy meter with ESP8266-12E.

CHAPTER 4

PROPOSED SYSTEM

4.1 INTRODUCTION

Proposed smart energy meter consists of four main systems such as metering system, demand side load management, recharging scheme and protection scheme. This system consists of three terminals. They are meter end, user end and authority end and each has its own identification. These three terminals are connected by means of internet and data will be transmitted among them. SEM can be remotely accessed by the authority end for the plan setting, billing purpose, remote connection and disconnection and during demand period. The meter will send data to the webserver (Authority end) and it will send email notification regarding the meter status and authority send instruction to the meter end over the internet.

4.2 METERING ARCHITECTURE

The hardware of the smart energy meter will be cheaper and simpler than the other conventional energy meter. Proposed SEM's metering architecture consists of current transformer (CT), potential transformer (PT), timer IC and microprocessor (ATmega328P) etc. The input current will be measured using current transformer (CT) and voltage will be measured using potential transformer (PT). This CT and PT will generate the analog signal with respect to input voltage and current and signal will be fed to the microcontroller. To calculate energy consumption it requires time in addition to voltage and current, microcontroller has an inbuilt timer and it will last for milliseconds. So Real time clock (RTC) can be integrated with microcontroller to measure time and it is used to count number of days for

billing purpose. ESP8266-12E will be connected to microcontroller and make a way to connect internet with microcontroller, in which data can be transmitted through the internet between the authority, meter and consumer.

Microcontroller calculates power, energy utilized based on the input voltage and current signal. Along with the calculated details input voltage, input current and time and date will be displayed on the LCD display and it will be updated regularly. It also shows the tampering condition, demand condition and Remote connection and disconnection status.

4.3 BLOCK DIAGRAM

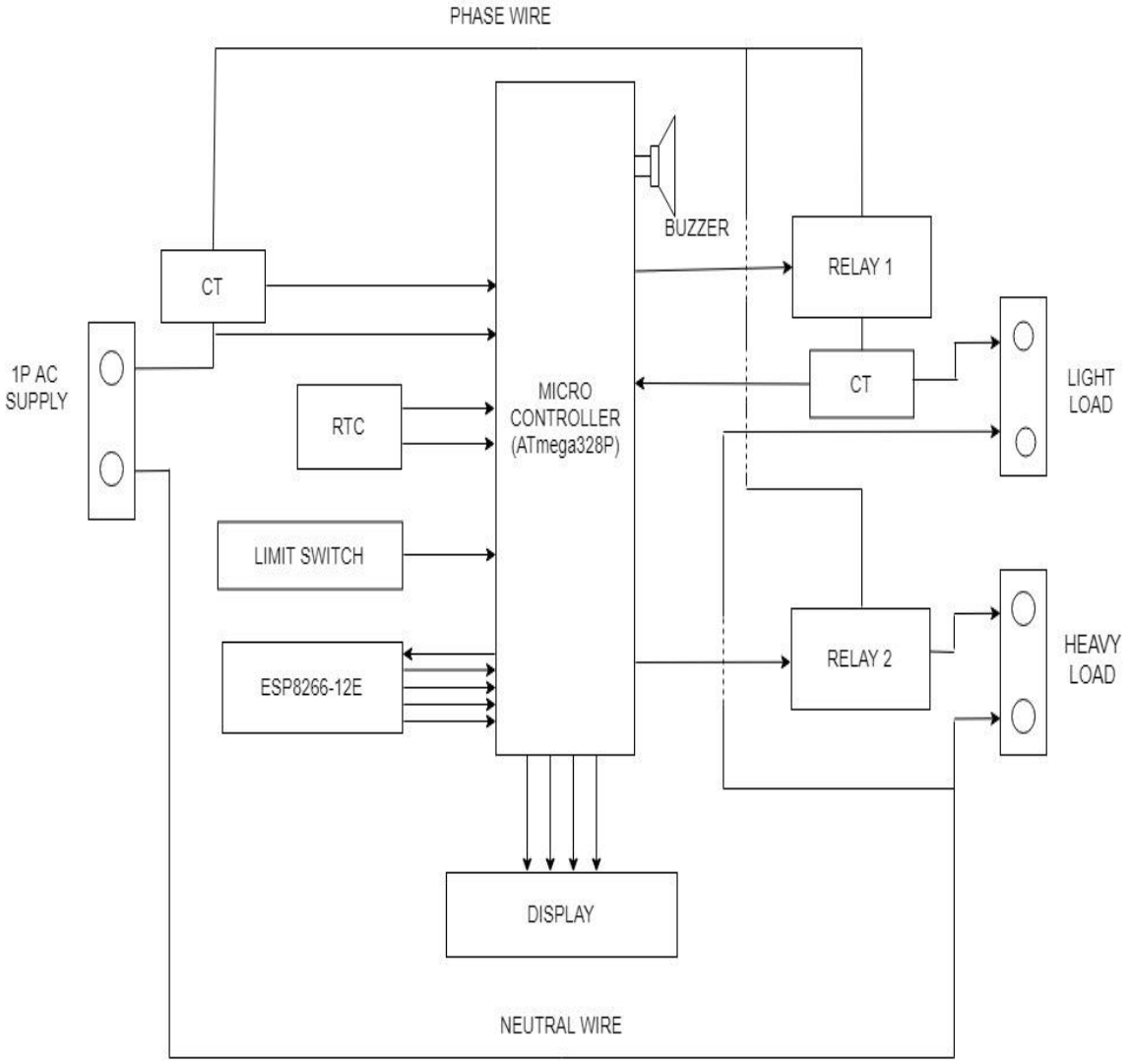

Figure 4.1 Block diagram of SEM

4.4 DEMAND SIDE LOAD MANAGEMENT

Introduction of demand side load management with SEM offers more effective power utilization during the demand period. Without load shedding the user can use allocated load during the high demand period. DSLM can be remotely accessed over the internet with the communication module embedded with the SEM.

To establish load management in SEM by remote access, loads are classified into heavy load and light load based on their power consumption. High-power consuming loads like air conditioner, water heater, refrigerator and water pumps etc. are comes under heavy load and this will be connected to separate relay. Small wattage loads like lamps, fans are considered as light load and they are connected to separate relay. Power consumption limit will be assigned in the SEM to use the assigned power during demand period.

During demand period command will be send to the SEM over the internet. The SEM will disconnect the heavy load by switching off the relay connected to heavy load. The light load will be connected to the supply. There will be certain limit will be assigned by the authority in the meter to utilize power during the high demand period. If connected load is less than or equal to the assigned limit, the relay will be switched on and system run on light load condition and wait for the normal condition. If connected load is higher than the assigned limit, the buzzer will make a beep sound and switch off the light load relay for 30 sec. After 30sec the relay will be switched on and connected load will be again checked. If load exceeds the assigned limit the same process will be repeated out. This check process will take place for 3 times. Any of the 3 times if load is less than or equal to the assigned limit then the relay of the light load will be switched on. If the load

is higher than the assigned value during the 3 times light load relay will be switched off and wait for the normal condition. During the 30sec time interval the consumer should adjust the load to make the load less than or equal to the limit. The light load and heavy load will be switched back to the normal condition when the authority sends command to the SEM that there will be no demand period. Then the system will be back to the normal condition.

4.5 FLEXIBLE TARIFF SETTING AND MODE SWITCHING

Remote connection, disconnection, switching between payment modes and tariff plan configuration can be controlled from the authority end remotely. The main feature of this SEM is tariff plan setting and remote mode switching. SEM can be setup as either prepaid connection or post-paid connection from the authority end. For prepaid connection user can choose any of the tariff plan according to their requirements. This all can be controlled remotely from the authority end.

4.6 RECHARGING SCHEME

There are two types of recharging scheme are available in this system. They are post-paid connection and prepaid connection. The user can choose any of the two types according to their requirement.

For prepaid connection we need to recharge for a certain amount like mobile prepaid connection. The meter will start to reduce the balance for the consumption of electricity. When the balance reaches the certain limit i.e., XX it will send a notification to the user regarding the balance going to be exhaust. When the balance goes below the zero the meter will send a notification to the user such as the balance gone below zero and your meter

supply will be disconnected from the mains. The user needs to recharge the meter balance for the continuous use.

For post-paid connection the bill will be calculated for n number of days, after n numbers of days the bill for the energy consumption will be send to the user and the authority. The user should pay the bill within the limited number of days for the continuous use of power supply. If user doesn't pay the bill within the limited number of days the meter will be disconnected remotely by the authority. For the reconnection the user should pay the bill with the penalty.

4.7 PROTECTION SCHEME

SEM has some protection schemes like over voltage protection, under voltage protection and tampering protection. If the voltage reaches above the high voltage fixed limit means the meter will disconnect the equipment form the supply and wait for the normal condition. If the voltage gone below the low voltage limit means it will disconnect the equipment's form the supply and wait for the normal condition.

SEM has constructed with the limit switch, this will protect the meter from the tampering. When the meter gets opened for the illegal activity it will disconnect the equipment form the supply and shows the indication in the display. To get back to the normal condition authority person should visit the meter and need to reset it.

4.8 AUTHORITY END

Authority end consists of web server, where the data's of the user will be stored. They have a monitoring screen, control switches, mode switching switch, master control switch for connection and reconnection.

From the web page they can monitor real time billing status and unit consumption of the user and can control the demand period, switches between the postpaid and prepaid plan. They can remotely connect and disconnect the switches.

4.9 CIRCUIT DIAGRAM

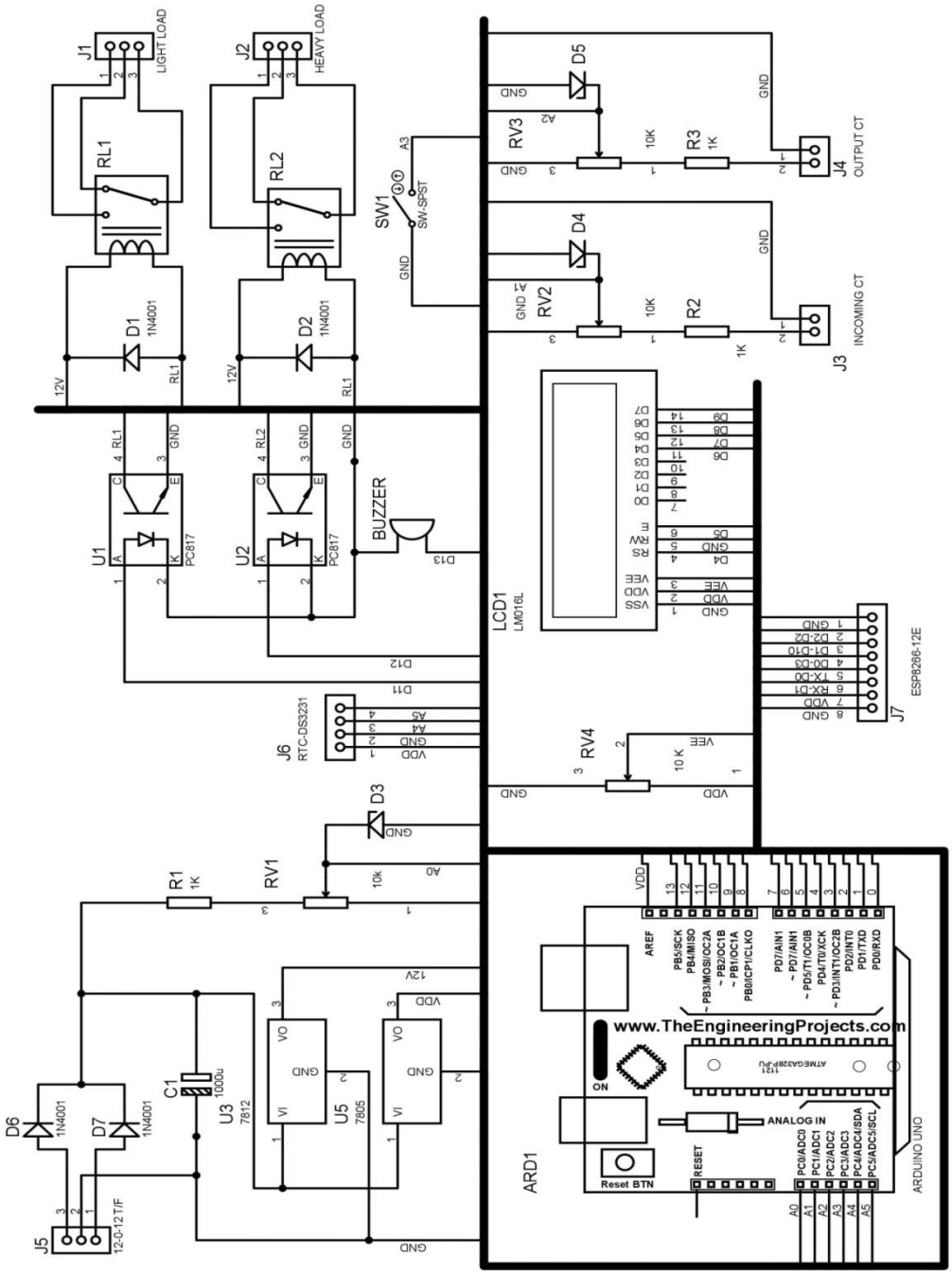

Figure 4.2 Circuit diagram of SEM

CHAPTER 5

SOFTWARE AND HARDWARE IMPLEMENTATION

5.1 SOFTWARE SPECIFICATION

5.1.1 Arduino IDE

The Arduino Integrated Development Environment - or Arduino Software (IDE) - contains a text editor for writing code, a message area, a text console, a toolbar with buttons for common functions and a series of menus. It connects to the Arduino and Genuino hardware to upload programs and communicate with them.

The microcontrollers are typically programmed using a dialect of features from the programming languages C and C++. In addition to using traditional compiler toolchains, the Arduino project provides an integrated development environment (IDE) based on the Processing language project. The Arduino project started in 2005 as a program for students at the Interaction Design Institute Ivrea in Ivrea, Italy, aiming to provide a low-cost and easy way for novices and professionals to create devices that interact with their environment using sensors and actuators. Common examples of such devices intended for beginner hobbyists include simple robots, thermostats, and motion detectors.

Programs written using Arduino Software (IDE) are called sketches. These sketches are written in the text editor and are saved with the file extension .ino. The editor has features for cutting/pasting and for searching/replacing text. The message area gives feedback while saving and exporting and also displays errors. The console displays text output by the Arduino Software (IDE), including complete error messages and other

information. The bottom righthand corner of the window displays the configured board and serial port. The toolbar buttons allow you to verify and upload programs, create, open, and save sketches, and open the serial monitor.

SETUP

This function is called once when a sketch starts after power-up or reset. It is used to initialize variables, input and output pin modes, and other libraries needed in the sketch.

LOOP

After setup has been called, function loop is executed repeatedly in the main program. It controls the board until the board is powered off or is reset. Most Arduino boards contain a light-emitting diode (LED) and a load resistor connected between pin 13 and ground, which is a convenient feature for many tests and program functions

Figure 5.1 Arduino software

5.1.2 Adafruit

Adafruit.io is a cloud service - that just runs it for you and you don't have to manage it. You can connect to it over the Internet. It's meant primarily for storing and then retrieving data but it can do a lot more than just that!

Adafruit IO can perform

- Display data in real-time, online
- Make everything internet-connected: Control motors, read sensor data, and more!
- Connect projects to web services like Twitter, RSS feeds, weather services, etc.
- Connect project to other internet-enabled devices
- All of the above is do-able for free with Adafruit IO

We are adafruit web service to monitor the data and send data to the meter.

Figure 5.2 Authority end web page (Adafruit)

5.1.3 IFTTT

If This Then That, also known as IFTTT is a free web-based service to create chains of simple conditional statements, called applets.

IFTTT employs the following concepts:

- Services (formerly known as channels) are the basic building blocks of IFTTT. They mainly describe a series of data from a certain web service such as YouTube or eBay. Services can also describe actions controlled with certain APIs, like SMS. Sometimes, they can represent information in terms of whether or stocks. Each service has a particular set of triggers and actions.
- Triggers are the "this" part of an applet. They are the items that trigger the action. For example, from an RSS feed, you can receive a notification based on a keyword or phrase.
- Actions are the "that" part of an applet. They are the output that results from the input of the trigger.
- Applets (formerly known as recipes) are the predicates made from Triggers and Actions. For example, if you like a picture on Instagram (trigger), an IFTTT app can send the photo to your Dropbox account (action).
- Ingredients are basic data available from a trigger—from the email trigger, for example; subject, body, attachment, received date, and sender’s address

We are IFTTT to send an email notification to the user regarding the meter Status

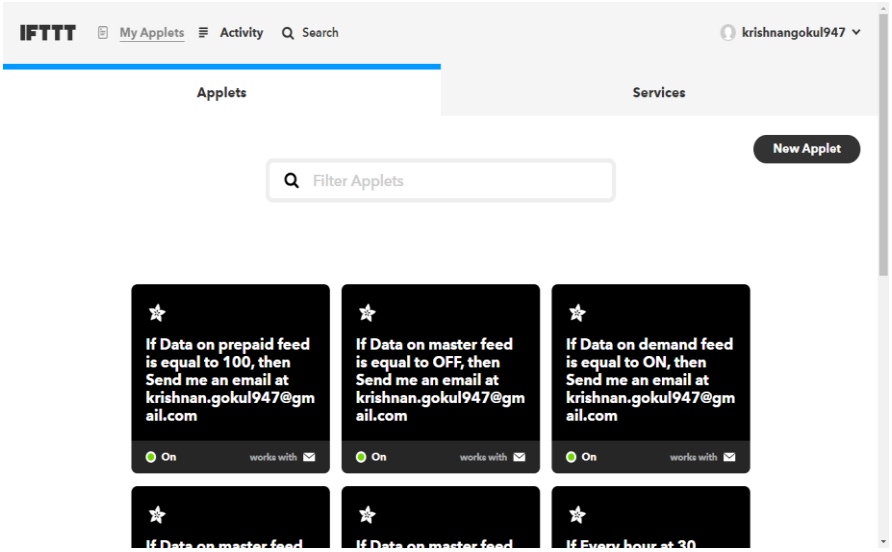

Figure 5.3 IFTTT applets in IFTTT site

5.2 HARDWARE DESCRIPTION

5.2.1 Arduino UNO

ARDUINO is open-source computer hardware and software company, project and user community that designs and manufactures microcontroller-based kits for building digital devices and interactive objects that can sense and control objects in the physical world. The project is based on microcontroller board designs, manufactured by several vendors, using various microcontrollers. These systems provide sets of digital and analog I/O pins that can be interfaced to various expansion boards ("shields") and other circuits. The boards feature serial communications interfaces, including USB on some models, for loading programs from personal computers. For programming the microcontrollers, the Arduino project provides an integrated development environment (IDE) based on the Processing project, which includes support for the C and C++ programming languages. The first Arduino was introduced in 2005, aiming to provide an inexpensive and easy way for novices and professionals to create devices that interact with their environment using sensors and actuators. Common

examples of such devices intended for beginner hobbyists include simple robots, thermostats, and motion detectors.

5.2.1.1 I/O Ports

Some pins for these I/O ports are multiplexed with an alternate function for the peripheral features on the device. In general, when a peripheral is enabled, that pin may not be used as a general purpose I/O pin. Additional Information on I/O ports may be found in the IC micro™ Mid-Range Reference Manual. It consists of 14 digital I/O ports and 6 analog I/O ports.

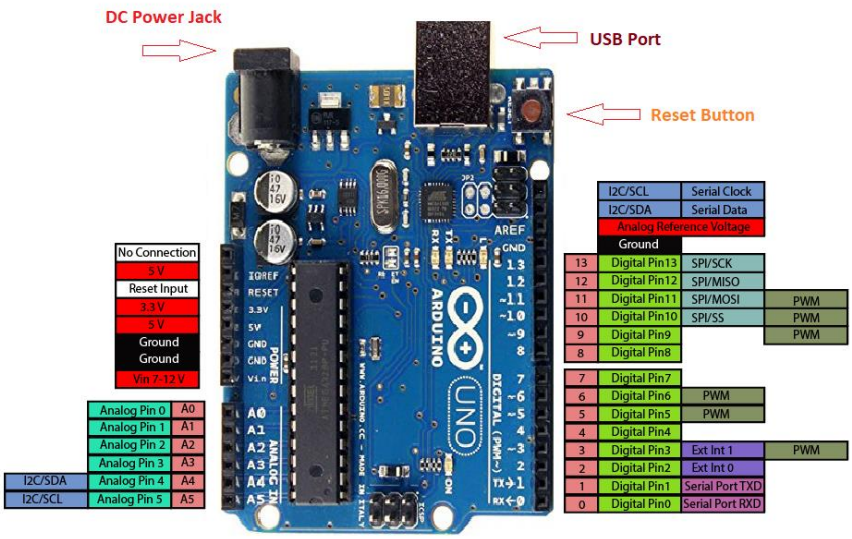

Figure 5.4 Arduino Uno board

5.2.1.2 Key Points

- This buffer is a Schmitt Trigger input when configured as an external interrupt
- This buffer is a Schmitt Trigger input when used in serial programming mode

- This buffer is a Schmitt Trigger input when configured as general purpose I/O and TTL input when used in the Parallel Slave Port mode (for interfacing to a microprocessor bus)
- This buffer is a Schmitt Trigger input when configured in RC oscillator mode

5.2.1.3 Memory Organization

There are three memory blocks in each of the MUC's. The program memory and Data Memory have separate buses so that concurrent access can occur.

5.2.1.4 Program Memory Organization

The devices have a 13-bit program counter capable of addressing 8K *14 words of FLASH program memory. Accessing a location above the physically implemented address will cause a wraparound. The RESET vector is at 0000h and the interrupt vector is at 0004h.

5.2.1.5 Data Memory organization

The data memory is partitioned into multiple banks which contain the General Purpose Registers and the special functions Registers. Bits RP1 (STATUS<6) and RP0 (STATUS<5>) are the bank selected bits.

5.2.1.6 Advantages

- Using an Arduino simplifies the amount of hardware and software development you need to do in order to get a system running.
- The Arduino hardware platform already has the power and reset circuitry setup as well as circuitry to program and communicate with the microcontroller over USB.

- The I/O pins of the microcontroller are typically already fed out to sockets/headers for easy access (This may vary a bit with the specific model).
- On the software side, Arduino provides a number of libraries to make programming the microcontroller easier.
- The simplest of these are functions to control and read the I/O pins rather than having to fiddle with the bus/bit masks normally used to interface with the Atmega I/O (This is a fairly minor inconvenience).
- More useful are things such as being able to set I/O pins to PWM at a certain duty cycle using a single command or doing Serial communication.
- The advantages of using an Arduino over just using the underlying microcontroller.
- The whole point of the "Arduino Platform" is to allow for easy and fast prototyping.
- Being able to just hook up an LCD and be able to display messages on it in a matter of minutes, instead of hours, is just amazingly powerful and convenient when you have an idea in your head and just want to see if it works.
- When you need more control and are actually thinking on converting your prototype into a real product, then yes, you need to get deep down into the microcontroller and get rid of all the excess fat, trim the circuit to just the bare bones, optimize the code, etc.
- For prototyping, the Arduino platform gives you a lot of pre-wiring and free code libraries that will let you concentrate on testing your idea instead of spending your time building supporting circuitry or writing tons of low level code.

5.2.2 NodeMCU

NodeMCU is a LUA based interactive firmware for Expressif ESP8622 Wi-Fi SoC, as well as an open source hardware board that contrary to the $3 ESP8266 Wi-Fi modules includes a CP2102 TTL to USB chip for programming and debugging, is breadboard-friendly, and can simply be powered via its micro USB port.

NodeMCU is a Wi-Fi SOC (system on a chip) produced by Espressif Systems. It is based ESP8266 -12E Wi-Fi module. It is an highly integrated chip designed to provide full internet connectivity in a small package.

It can be programmed directly through USB port using LUA programming or Arduino IDE. By simple programming we can establish a Wi-Fi connection and define input/output pins according to your needs exactly like arduino, turning into a web server and a lot more.

NodeMCU is the Wi-Fi equivalent of ethernet module. It combines the features of Wi-Fi access point and station + microcontroller. These features make the NodeMCU extremely powerful tool for Wi-Fi networking. It can be used as access point and/or station, host a web server or connect to internet to fetch or upload data.

5.2.2.1 Features

- Open-source
- Arduino-like hardware
- MicroUSB port
- Reset/Flash buttons
- Interactive and Programmable
- Low cost

- ESP8266 with inbuilt Wi-Fi
- USB to UART converter
- GPIO pins

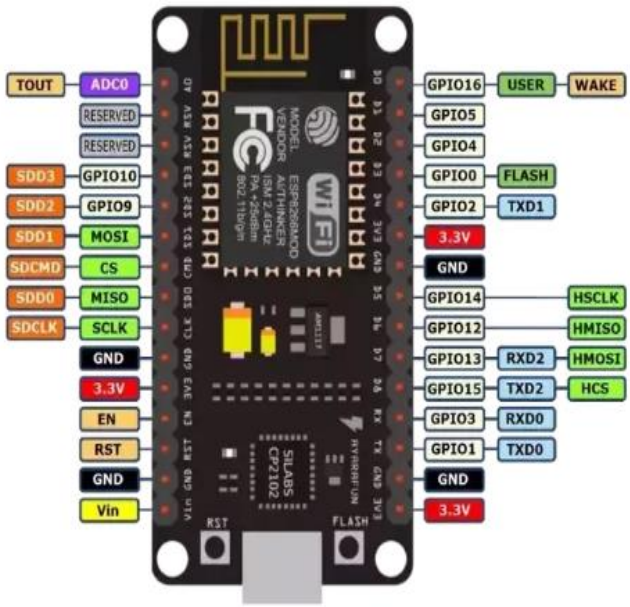

Figure 5.5 NodeMCU board (ESP8266-12E)

5.2.3 Liquid Crystal Display

A liquid crystal display (LCD) is a flat panel display, electronic visual display, or video display that uses the light modulating properties of liquid crystals. Liquid crystals do not emit light directly. LCDs are available to display arbitrary images (as in a general-purpose computer display) or fixed images which can be displayed or hidden, such as preset words, digits, and 7-segment displays as in a digital clock. They use the same basic technology, except that arbitrary images are made up of a large number of small pixels, while other displays have larger elements. An LCD is a small low cost display. It is easy to interface with a micro-controller because of an embedded controller (the black blob on the back of the board). This controller is standard across many displays (HD 44780) which means many

micro-controllers (including the Arduino) have libraries that make displaying messages as easy as a single line of code.

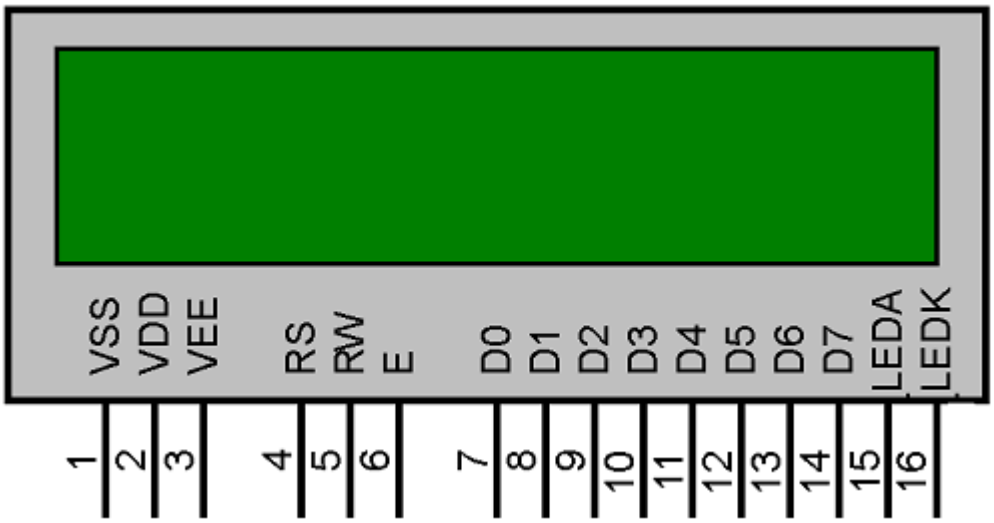

Figure 5.6 LCD display unit

LCDs are used in a wide range of applications including computer monitors, televisions, instrument panels, aircraft cockpit displays, and signage. They are common in consumer devices such as video players, gaming devices, clocks, watches, calculators, and telephones, and have replaced cathode ray tube (CRT) displays in most applications. They are available in a wider range of screen sizes than CRT and plasma displays, and since they do not use phosphors, they do not suffer image burn-in. LCDs are, however, susceptible to image persistence.

A 16x2 LCD display is very basic module and is very commonly used in various devices and circuits. These modules are preferred over seven segments and other multi segment LEDs. The reasons being: LCDs are economical; easily programmable; have no limitation of displaying special & even custom characters (unlike in seven segments), animations and so on. A 16x2 LCD means it can display 16 characters per line and there are 2 such lines. In this LCD each character is displayed in 5x7 pixel matrix. This LCD has two registers, namely, Command and Data.

Table 5.1 Pin description of LCD display

Pin No	**Function**	**Name**
1	Ground (0V)	Ground
2	Supply voltage; 5V (4.7V – 5.3V)	Vcc
3	Contrast adjustment; through a variable resistor	V_{EE}
4	Selects command register when low; and data register when high	Register Select
5	Low to write to the register; High to read from the register	Read/write
6	Sends data to data pins when a high to low pulse is given	Enable
7	8-bit data pins	DB0
8		DB1
9		DB2
10		DB3
11		DB4
12		DB5
13		DB6
14		DB7
15	Backlight V_{CC} (5V)	Led+
16	Backlight Ground (0V)	Led-

5.2.4 Power Supply Unit

Power supply is a reference to a source of electrical power. A device or system that supplies electrical or other types of energy to an output load or group of loads is called a power supply unit or PSU.

5.2.4.1 Transformer

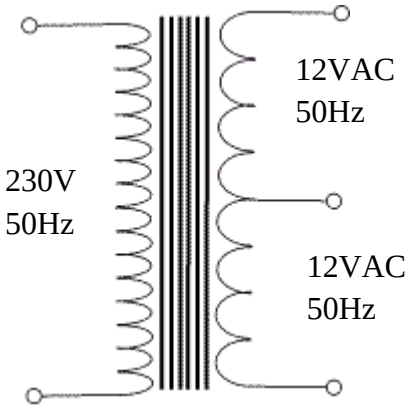

Figure 5.7 12-0-12V Step down Transformer

Transformers convert AC electricity from one voltage to another with little loss of power. Transformers work only with AC and this is one of the reasons why mains electricity is AC.

Step-up transformers increase voltage, step-down transformers reduce voltage. Most power supplies use a step-down transformer to reduce the dangerously high mains voltage to a safer low voltage.

The input coil is called the primary and the output coil is called the secondary. There is no electrical connection between the two coils; instead they are linked by an alternating magnetic field created in the soft-iron core of the transformer. The two lines in the middle of the circuit symbol represent the core. If voltage is stepped down current is stepped up.

5.2.4.2 Full Wave Rectifier and smoothing

In a Full Wave Rectifier circuit two diodes are now used, one for each half of the cycle. A multiple winding transformer is used whose secondary winding is split equally into two halves with a common centre tapped connection, (C). This configuration results in each diode conducting in turn when its anode terminal is positive with respect to the transformer centre point C producing an output during both half-cycles, twice that for the half wave rectifier so it is 100% efficient.

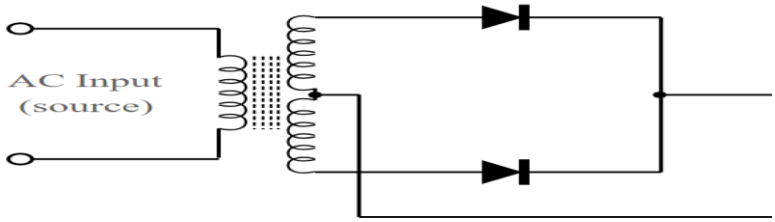

Figure 5.8 Full wave rectifier

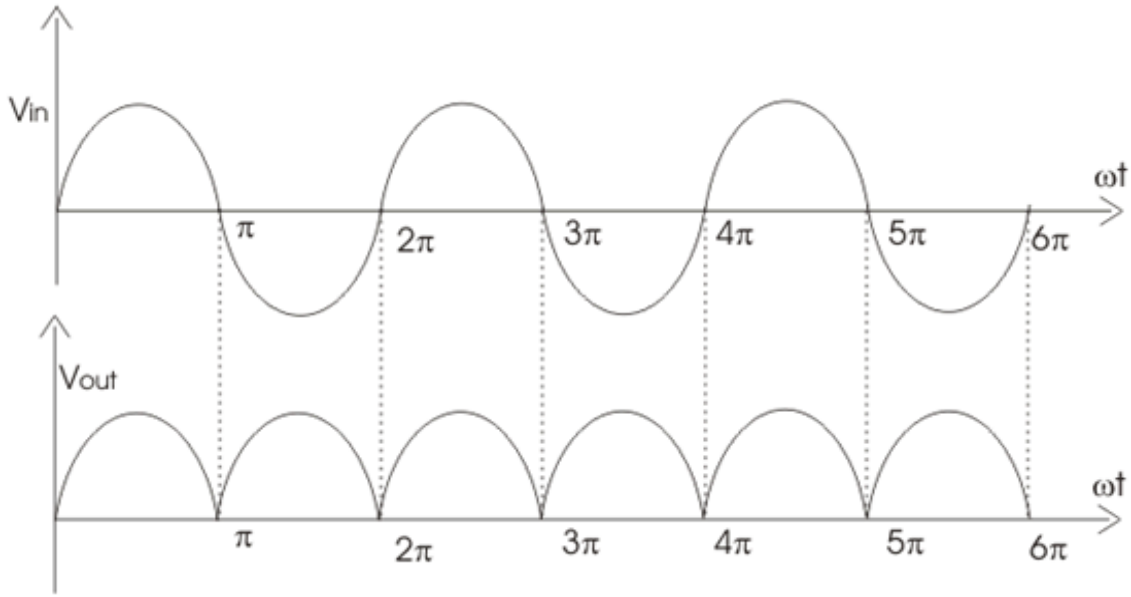

Figure 5.9 Waveform of Full wave rectifier

Smoothing is performed by a large value electrolytic capacitor connected across the DC supply to act as a reservoir, supplying current to the output when the varying DC voltage from the rectifier is falling. The diagram shows the unsmoothed varying DC (dotted line) and the smoothed DC (solid line). The capacitor charges quickly near the peak of the varying DC, and then discharges as it supplies current to the output. The smooth DC output has a small ripple. It is suitable for most electronic circuits.

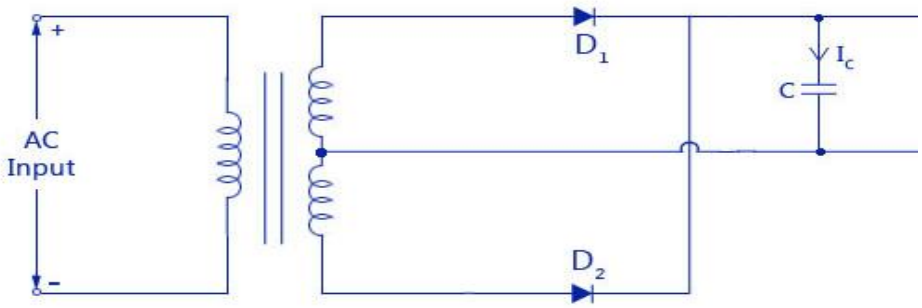

Figure 5.10 Full wave rectifier with capacitive filter

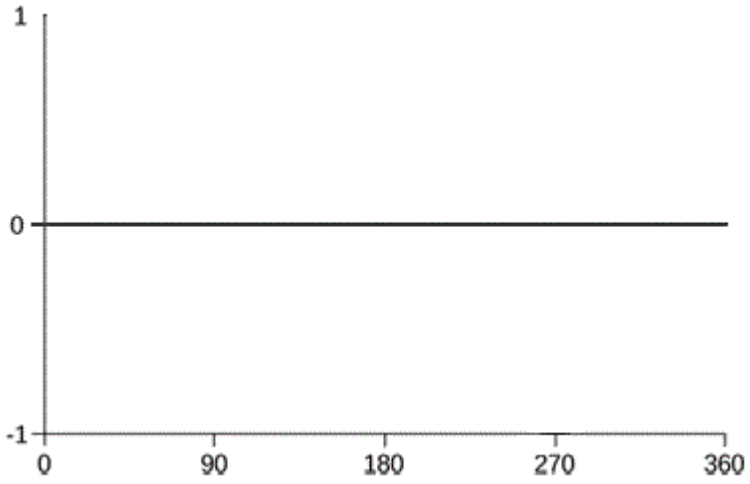

Figure 5.11 DC waveform after smoothing

5.2.5 Voltage Regulator

Voltage regulator ICs are available with fixed (typically 5, 12 and 15V) or variable output voltages. They are also rated by the maximum current they can pass. Negative voltage regulators are available, mainly for use in dual supplies.

The LM78XX series of three terminal regulators is available with several fixed output voltages making them useful in a wide range of applications. One of these is local on card regulation, eliminating the distribution problems associated with single point regulation. The voltages available allow these regulators to be used in logic systems, instrumentation, HiFi, and other solid state electronic equipment. Although designed primarily as fixed voltage regulators these devices can be used with external components to obtain adjustable voltages and current.

Many of the fixed voltage regulator ICs has 3 leads and look like power transistors, such as the 7805 +5V 1A regulator shown on the right. They include a hole for attaching a heat sink if necessary.

1. Positive regulator
    1. input pin
    2. ground pin
    3. output pin

    It regulates the positive voltage

2. Negative regulator
    1. ground pin
    2. input pin
    3. output pin

    It regulate the negative voltage

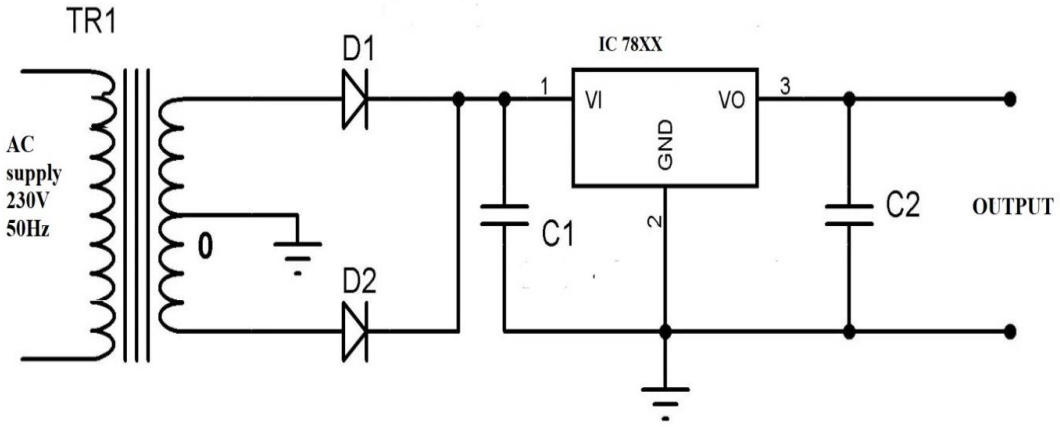

Figure 5.12 Full wave rectifier with voltage regulator

5.2.5.1 LM7812

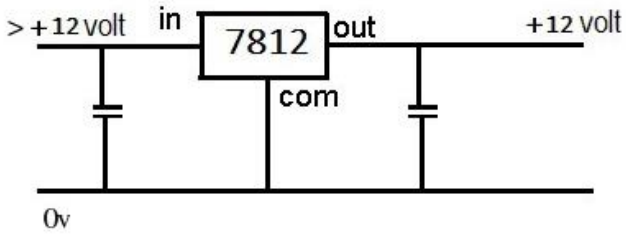

Figure 5.13 LM7812 voltage regulator pin diagram

The voltage regulator LM7812 is actually a member of the 78xx series of voltage regulator ICs. It is a fixed linear voltage regulator. The xx present in 78xx represents the value of the fixed output voltage that the particular IC provides. For LM7812 IC, it is +12V DC regulated power supply. This regulator IC also adds a provision for a heat sink. The input voltage to this voltage regulator can be up to 35V, and this IC can give a constant 12V for any value of input less than or equal to 35V which is the threshold limit.

5.2.5.2 LM7805

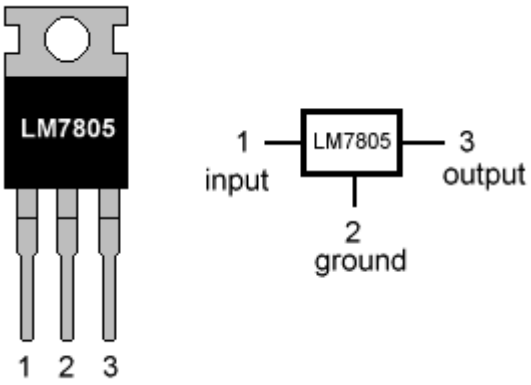

Figure 5.14 LM 7805 Voltage regulator pin diagram

The voltage regulator LM7805 is actually a member of the 78xx series of voltage regulator ICs. It is a fixed linear voltage regulator. The xx present in 78xx represents the value of the fixed output voltage that the particular IC provides. For 7805 IC, it is +5V DC regulated power supply. This regulator IC also adds a provision for a heat sink. The input voltage to this voltage regulator can be up to 35V, and this IC can give a constant 5V for any value of input less than or equal to 35V which is the threshold limit.

5.2.6 Relay

A relay is an electrically operated switch. Many relays use an electromagnet to operate a switching mechanism mechanically, but other operating principles are also used. Relays are used where it is necessary to control a circuit by a low-power signal (with complete electrical isolation between control and controlled circuits), or where several circuits must be controlled by one signal. The first relays were used in long distance telegraph circuits, repeating the signal coming in from one circuit and re-transmitting it to another. Relays were used extensively in telephone exchanges and early computers to perform logical operations.

Figure 5.15 T-Type 12V relay

A type of relay that can handle the high power required to directly control an electric motor or other loads is called a contactor. Solid-state relays control power circuits with no moving parts, instead using a semiconductor device to perform switching. Relays with calibrated operating characteristics and sometimes multiple operating coils are used to protect electrical circuits from overload or faults; in modern electric power systems these functions are performed by digital instruments still called "protective relays".

5.2.6.1 Basic Design and Operation

A simple electromagnetic relay consists of a coil of wire wrapped around a soft iron core, an iron yoke which provides a low reluctance path for magnetic flux, a movable iron armature, and one or more sets of contacts (there are two in the relay pictured).

The armature is hinged to the yoke and mechanically linked to one or more sets of moving contacts. It is held in place by a spring so that when the relay is de-energized there is an air gap in the magnetic circuit. In this condition, one of the two sets of contacts in the relay pictured is closed, and the other set is open. Other relays may have more or fewer sets of contacts depending on their function. The relay in the picture also has a wire connecting the armature to the yoke. This ensures continuity of the circuit between the moving contacts on the armature, and the circuit track on the printed circuit board (PCB) via the yoke, which is soldered to the PCB.

When an electric current is passed through the coil it generates a magnetic field that activates the armature, and the consequent movement of the movable contact(s) either makes or breaks (depending upon construction) a connection with a fixed contact. If the set of contacts was closed when the relay was de-energized, then the movement opens the contacts and breaks the connection, and vice versa if the contacts were open. When the current to the coil is switched off, the armature is returned by a force, approximately half as strong as the magnetic force, to its relaxed position. Usually this force is provided by a spring, but gravity is also used commonly in industrial motor starters. Most relays are manufactured to operate quickly. In a low-voltage application this reduces noise; in a high voltage or current application it reduces arcing.

When the coil is energized with direct current, a diode is often placed across the coil to dissipate the energy from the collapsing magnetic field at deactivation, which would otherwise generate a voltage spike dangerous to semiconductor circuit components. Some automotive relays include a diode inside the relay case. Alternatively, a contact protection network consisting of a capacitor and resistor in series (snubber circuit) may absorb the surge.

If the coil is designed to be energized with alternating current (AC), a small copper "shading ring" can be crimped to the end of the solenoid, creating a small out-of-phase current which increases the minimum pull on the armature during the AC cycle.

A solid-state relay uses a thyristor or other solid-state switching device, activated by the control signal, to switch the controlled load, instead of a solenoid. An optocoupler (a light-emitting diode (LED) coupled with a photo transistor) can be used to isolate control and controlled circuits.

5.2.6.2 Pole and Throw

Since relays are switches, the terminology applied to switches is also applied to relays; a relay switches one or more poles, each of whose contacts can be thrown by energizing the coil in one of three ways

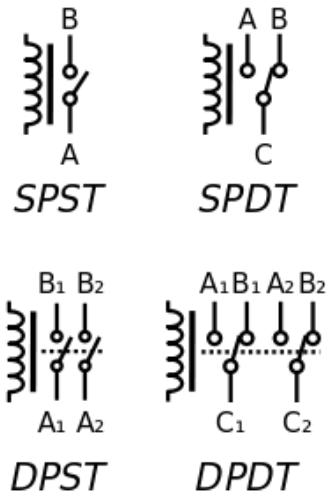

Figure 5.16 Circuits of basic relay

Circuit symbols of relays. (C denotes the common terminal in SPDT and DPDT types.)

- Normally-open (NO) contacts connect the circuit when the relay is activated; the circuit is disconnected when the relay is inactive. It is also called a Form A contact or "make" contact. NO contacts may also be distinguished as "early-make" or NOEM, which means that the contacts close before the button or switch is fully engaged.
- Normally-closed (NC) contacts disconnect the circuit when the relay is activated; the circuit is connected when the relay is inactive. It is also called a Form B contact or "break" contact. NC contacts may also be distinguished as "late-break" or NCLB, which means that the contacts stay closed until the button or switch is fully disengaged.
- Change-over (CO), or double-throw (DT), contacts control two circuits: one normally-open contact and one normally-closed contact with a common terminal. It is also called a Form C contact or "transfer" contact ("break before make"). If this type of contact utilizes a "make before break" functionality, then it is called a Form D contact.

The following designations are commonly encountered:

- SPST – Single Pole Single Throw. These have two terminals which can be connected or disconnected. Including two for the coil, such a relay has four terminals in total. It is ambiguous whether the pole is normally open or normally closed. The terminology "SPNO" and "SPNC" is sometimes used to resolve the ambiguity.
- SPDT – Single Pole Double Throw. A common terminal connects to either of two others. Including two for the coil, such a relay has five terminals in total.
- DPST – Double Pole Single Throw. These have two pairs of terminals. Equivalent to two SPST switches or relays actuated by a

single coil. Including two for the coil, such a relay has six terminals in total. The poles may be Form A or Form B (or one of each).

- DPDT – Double Pole Double Throw. These have two rows of change-over terminals. Equivalent to two SPDT switches or relays actuated by a single coil. Such a relay has eight terminals, including the coil.

5.2.7 DS-3231 RTC module

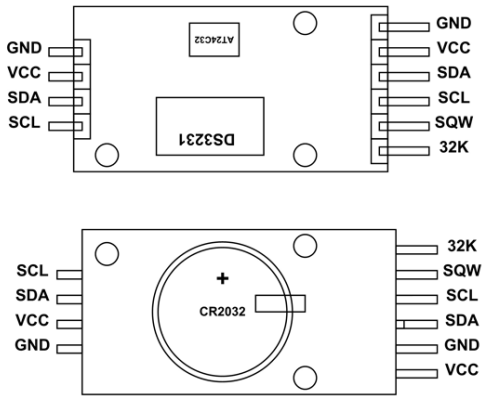

Figure 5.17 DS3231 Real Time Clock

RTC means Real Time Clock. RTC modules are simply TIME and DATE remembering systems which have battery setup which in the absence of external power keeps the module running. This keeps the TIME and DATE up to date. So we can have accurate TIME and DATE from RTC module whenever we want.

5.2.8 Buzzer

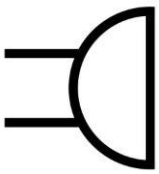

Figure 5.18 Buzzer

The buzzer produces sound based on reverse of the piezoelectric effect. The generation of pressure variation or strain by the application of electric potential across a piezoelectric material is the underlying principle. These buzzers can be used alert a user of an event corresponding to a switching action, counter signal or sensor input. They are also used in alarm circuits.

5.2.9 Current Transformer (CT)

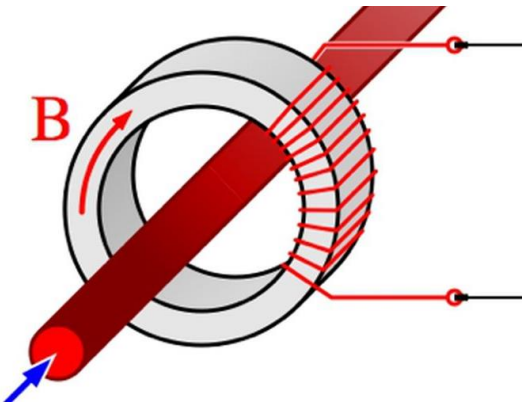

Figure 5.19 Current transformer

Current transformers for measurement and protection purposes are required throughout a power station auxiliary system. Most frequently it is convenient to locate these within switchgear, for which the bar-primary arrangement is the most suitable in terms of strength and simplicity.

Current transformers used on generator voltage busbar systems are also, in effect, bar-primary devices with features developed specifically to meet the requirements of the system. It is necessary to wind the secondary turns on the very large diameter toroidal core in order to provide the air clearance required to meet the 70 kV power frequency, 170 kV impulse-withstand insulation levels of the generator busbars. For a 660 MW machine, the rated busbar current is 20000 A so that, if the final secondary current is to be 5 A, a ratio of 20000:5 is required. With a bar-primary,

4000 secondary turns would thus be needed and some manufacturers consider it more economical to carry out this transformation in two stages. Main CTs installed at the generator bus bars having a ratio of, say, 20000: 20 are used in conjunction with additional interposing transformers of ratio 20:5. The interposing transformers are preferably located as close as possible to the generator busbars to minimize the length of leads required to carry 20 A.

This work like a step up transformer, voltage will be stepped up from primary to secondary and current value will be simultaneously stepped down from primary to secondary and current through the wire will be measured and analog signal will be fed to microcontroller.

We are using torroidal (Window) type current transformer. In wire will be inserted into the CT, with respect to current flow through the voltage will be generated by current transformer.

5.2.10 Limit Switch

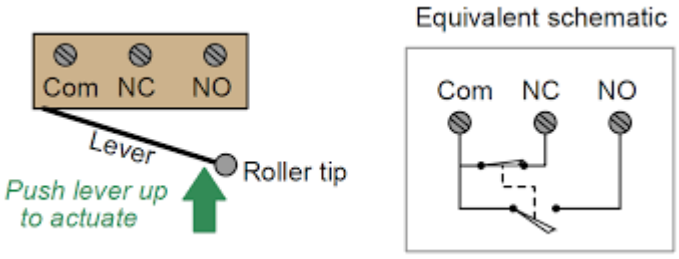

Figure 5.20 Limit Switch

In electrical engineering a limit switch is a switch operated by the motion of a machine part or presence of an object.

They are used for controlling machinery as part of a control system, as a safety interlocks, or to count objects passing a point A limit switch is an electromechanical device that consists of an actuator mechanically linked to

a set of contacts. When an object comes into contact with the actuator, the device operates the contacts to make or break an electrical connection.

Limit switches are used in a variety of applications and environments because of their ruggedness, ease of installation, and reliability of operation. They can determine the presence or absence, passing, positioning, and end of travel of an object. They were first used to define the limit of travel of an object; hence the name "Limit Switch".

Rarely, a final operating device such as a lamp or solenoid valve will be directly controlled by the contacts of an industrial limit switch, but more typically the limit switch will be wired through a control relay, a motor contactor control circuit, or as an input to a programmable logic controller.

CHAPTER 6

RESULT AND DISCUSSION

The actualized SEM displays the input voltage, input current, energy consumption, demand period status, voltage condition (either stable or not stable), tampering status, disconnection status by admin, time and date.

The actualized SEM is calibrated at the best level for its normal operating level. The SEM will send the email regarding type of connection i.e., Postpaid or prepaid. It will send the notification email to the user regarding the demand condition and maximum usable load current value.

6.1 NORMAL CONDITION STATUS

In normal operation, LCD display will routinely display the input voltage, input current, unit consumed, active power, date and time. Following figure shows the output of LCD.

Figure 6.1 Display statuses in SEM

6.2 POSTPAID AND PREPAID STATUS

If the user switch over between the postpaid and prepaid connection. SEM will send the notification email to the user regarding the type of connection and it will also send notification email to the user regarding the bill status.

Figure 6.2 Notification email regarding postpaid connection

Figure 6.3 Notification email regarding prepaid connection

6.3 DEMAND CONDITION STATUS

During demand period SEM will send notification email to the user regarding the condition and it will remind the amount of load to be used. SEM will also display the status on the LCD display.

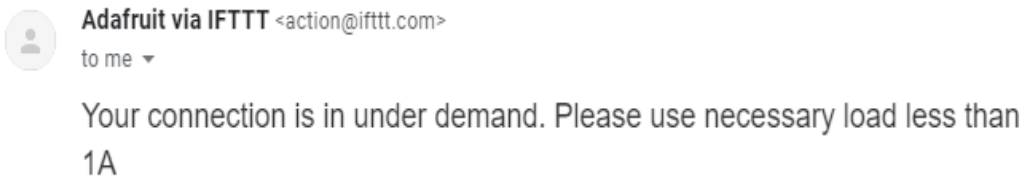

Figure 6.4 Notification email during demand condition

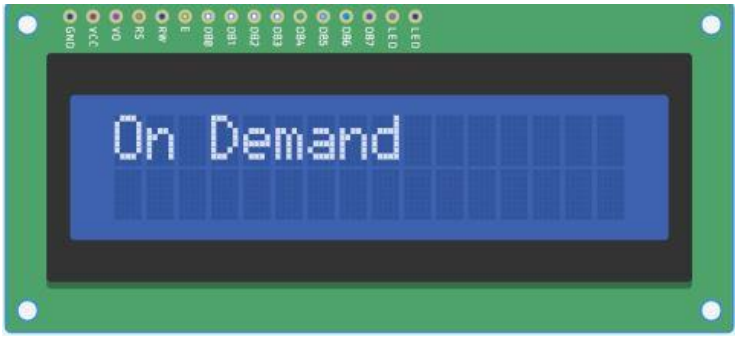

Figure 6.5 Display status during Demand period

6.4 REMOTE CONNECTION AND DISCONNECTION

Loads connected to the SEM can be remotely connected and disconnected. If the user didn't pay his postpaid bill or prepaid limit had been exhausted or authority want to open the connection. For any of those reasons authority can disconnect the load and they can reconnect it. If meter get disconnected it show status in the display of the meter and send notification email to the user.

Figure 6.6 Display status during disconnected condition

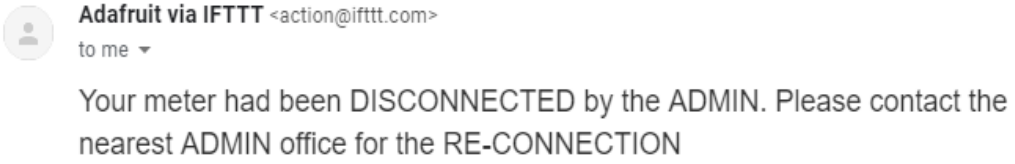

Figure 6.7 Email notification during disconnection of meter

6.5 PROTECTION SCHEME

If the meter got opened by the user for the illegal activity, SEM will disconnect the load from the meter and shows the indication on the display. For the reconnection user need to approach the nearest authority office.

Figure 6.8 Display status during Tampering condition

If the voltage of supply isn't stable it may be higher than the fixed value or lesser than the fixed value. If any of those conditions satisfies SEM will disconnect the load from the supply and display the status on the meter. Meter will wait and check for the normal condition, if normal condition satisfies SEM will connect the load with the supply

Figure 6.9 Display status during voltage unstable condition

6.6 HARDWARE SETUP

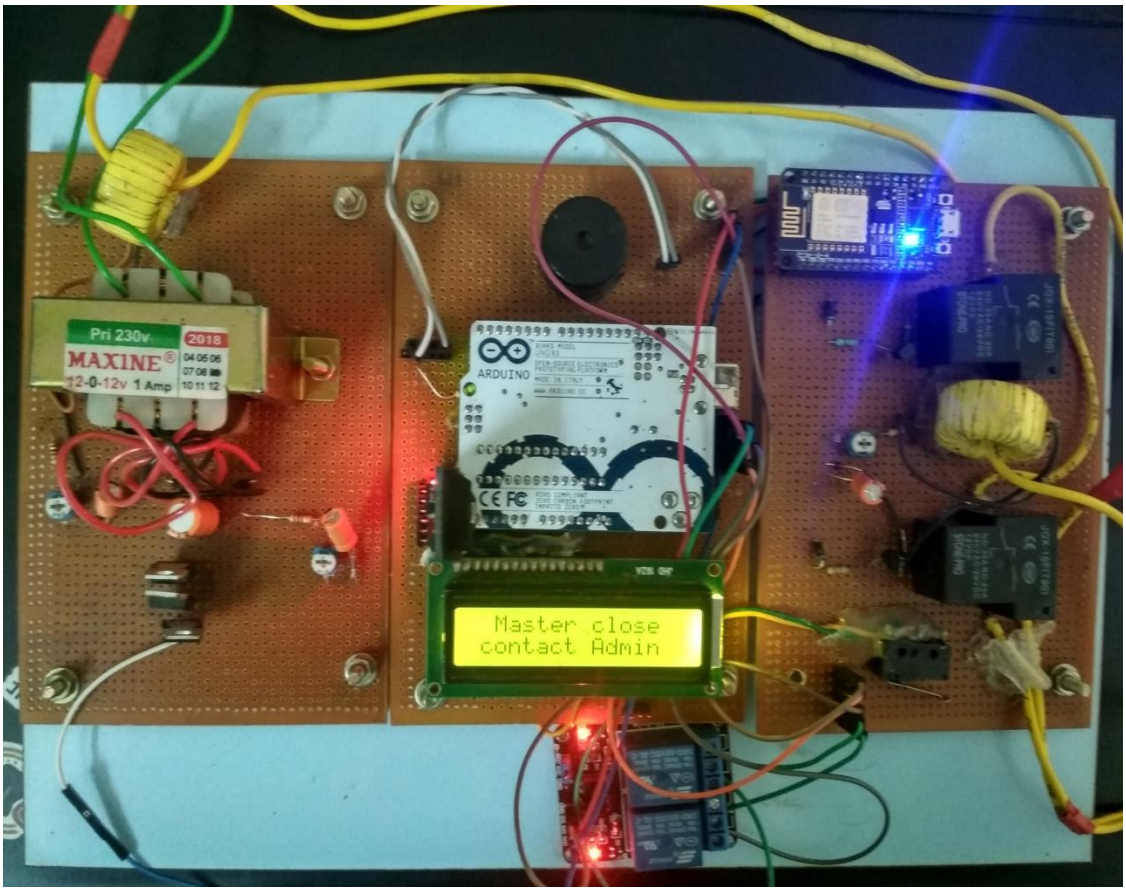

Figure 6.10 Proposed Hardware Setup

CHAPTER 7

CONCLUSION

In this project, an arduino and ESP8266-12E based SEM structure has been proposed for metering and billing purpose. SEM work on both postpaid and prepaid mode. SEM has DSLM choice and builds the benefit of SEM than the other accessibility meter in the market. DSLM can be controlled by sending data through the web service to the meter and it will enable the light load to consume energy. Cost of the recharging scheme is more effective than the accessible energy meter in the market. Tariff plan mode exchanging can be arranged and reconfigured remotely by using web service. It provides some additional notification to the user like remote disconnection of power, reconnection of power, demand period and type of connection alert to the user in the form of email. This meter also integrated with protection schemes like tampering protection, voltage protection and data can be monitored from the web service. This project could decrease the manpower and the consequent issues and some protection scheme had been implemented.

This actualized model can be further implemented by adding remote software update and connecting the meter with personal assistant like google assistant, alexa etc. To make automatic billing and controlling of equipment during demand period. Hence the project work mapped with program outcomes and program specific outcomes are attained.

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