Project Report On

IoT Based Smart Energy Meter

In partial fulfilment of the requirements for the degree of

Bachelor of Technology** in **Electrical Engineering

by

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CERTIFICATE

This is to certify that the project on **"IoT based Smart Energy Meter "** is a bonafide work presented by :

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As a partial fulfilment for award of **DEGREE IN BACHLEOR OF ELECTRICAL ENGINEERING** as laid down by Sardar Patel College Of Engineering during academic year 2015-2019

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ABSTRACT

With increasing energy demand the world is moving towards the renewable energy sources. At the same time utility companies are facing huge distribution losses. Utility companies have use extra manpower to collect readings which increases operational cost and also causes errors.
All these problems are addressed by the Smart Meter

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1 Introduction

1.1 Motivation

The energy network we have now was designed for a time when energy needs were much simpler. It was sourced from big, mostly coal burning power stations which were linked in a National Grid and served the whole country. 50 years ago, we had little consciousness of the need to save energy or reduce carbon emissions. But as this understanding and our knowledge has grown, we realise we must find ways to reduce our carbon emissions and integrate new technologies, like electric cars and solar and wind energy.

The smart grid will:

- Mean we can better match supply and demand
- Help us be more efficient, greener and waste less energy
- Help energy be more secure and reliable
- Mean unexpected power outages can be tackled faster
- Mean we can plan for the number of power stations we'll need in future with greater accuracy

A smart meter incentivises both you and your supply company to make more efficient use of energy. You will have a display which tells you how much energy you are using at any time. That will remind you to turn off unused halogen lights, or machines unnecessarily left on stand-by. It might remind you not to fill your kettle with more water than you need when you see the amount of energy consumed by boiling water. Your supply company can use a smart meter to create and sell you a half hourly tariff which will cost you more at peak times and much less and when national (or local) energy needs are less. The meters send automatic readings to your energy supplier at least once a month, so you will receive accurate, not estimated, bills.

1.2 Objectives

- Ease and transperency in the billing process
- Reduce energy theft losses
- Offer dynamic tariff to consumer
- Effective load management
- Improved customer service

2 Literature Survey

2.1What are electricity meters (energy meters)?

An electricity meter is a device which measures the total electrical energy (or electricity) consumed by the appliances which draw electrical energy from the main power supply at a house or an official space and so on. Electricity meters are a common sight in the households today. When you look at a meter, what do you see? You see a few digits on it. What do these digits signify? These numbers (the reading on the meter) tell you how many units of electricity (mentioned as kWh in the meter) have you consumed so far. And your electricity bill is entirely dependent on this meter.

The reading on the meter is cumulative. So to determine the consumption reading of a particular month, the difference between the readings of that month and the previous month is calculated. The value which you get is the electricity consumption of that particular month. Now if this reading is small, it means that your consumption is low and consequently your electricity bill will be lower and if the reading is large, it means that your consumption is high and consequently your electricity bill will also be high.

2.2Types of electricity meters

The electricity meters come in different types. These are:

2.2.1 Electromechanical meter

Electromechanical meters were very common in India few years ago. They still are very popular in the rural areas where the penetration of the modern technology is not as high as it is in the urban areas. The working of electromechanical meters is fairly simple. There is a non-magnetic metallic disc attached to it internally which rotates depending upon the power passing through it. So if the power passing through is high, then the disc rotates faster and when the passage of the power is low, the disc rotates slower. The rate of the rotation in turn decides the reading on the electricity meter. Higher the number of rotation, higher is the reading and vice-versa. Since there is rotation of a disc involved, it is bound to consume some electrical energy itself to facilitate the rotations. The power of around 2 Watts is consumed to make it rotate and this power consumption is not registered on the meter.

2.2.2 Electronic meter:

meters are becoming increasingly popular now-a-days in urban areas. An electronic meter has a LED/LCD display on which the readings of the electricity consumption of the connected appliances. The readings are digital in the electronic meters in contrast to the electromechanical meters. These are much more efficient than the electromechanical meters in the sense that they do register every small unit of electricity consumed.

2.2.3 Smart meter:

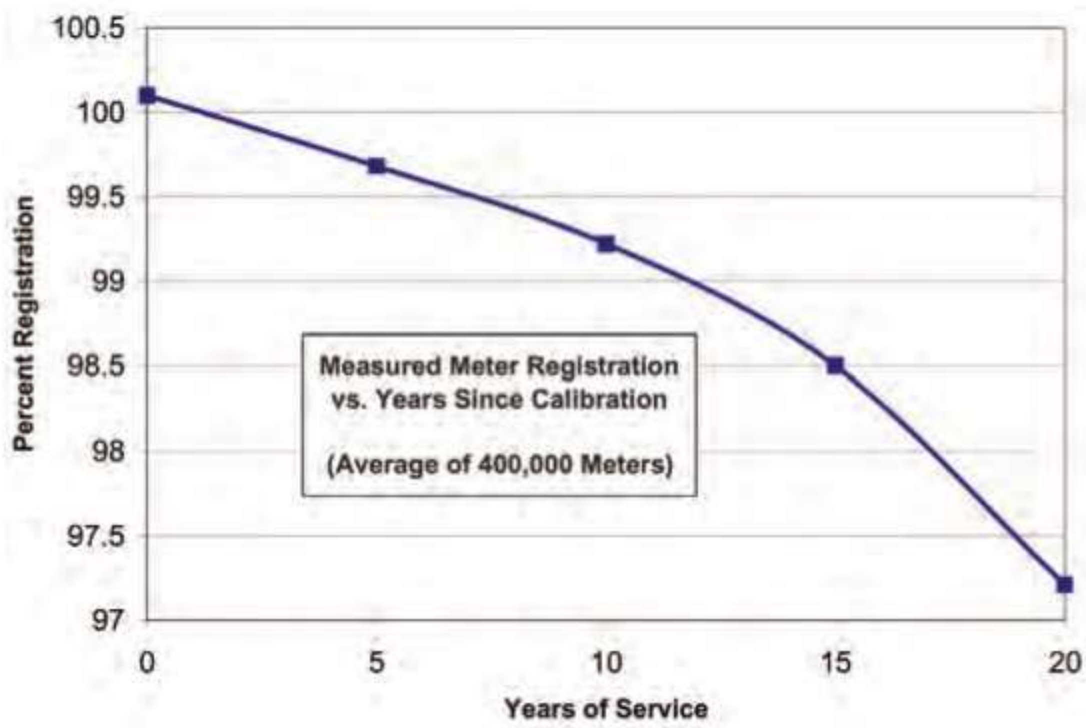
Smart meters are the newest addition to the type of electricity meters. They look similar to electronic meters but they are better than both the electromechanical meters and the electronic meters in the sense that in addition to providing the usual services of a regular meter, they are connected back to the utility through the internet. It means that there is no need of an official from the utility (which provides you electricity) to come at your doorstep and take the meter readings. The readings are automatically sent by the internet.

Problems with the electromechanical meter

Although the electromechanical meters have been quite common in the past years, there are certain problems that are attributed to them. Since electromechanical meters consist of moving parts, they are bound to undergo some wear and tear with the passage of time.

In a study conducted by Analog Devices Inc. USA, it was found that the accuracy of a electromechanical meter deteriorates subject to the various environmental factors such as humidity, dust and dirt which significantly affect the operating accuracy of the electromechanical meter. Factors like corrosion, worn out gears and insects can render the electromechanical meter unable to capture the electricity consumption of a property accurately. The mechanical gear lubricants may dry up resulting in the breaking in the gear teeth which adversely affects the gear ratio. Also, the electromechanical meters may get mis-calibrated if they experience a sudden shock or vibration which may cause a jolt or a sudden stoppage of the rotating disk.

The change in accuracy of electromechanical meters as it ages is shown below in a graph.



Source: Electric Power Research Institute (http://www.epri.com/Pages/Default.aspx)

Electronic meters are a better than electromechanical meters because they do not contain moving parts in it which might get affected due to the various factors as listed above. Also they provide not only the consumed units (as is the case of electromechanical meters) but they also provide other information like the instantaneous and maximum rate of usage demands, voltages, power factor and so on.

2.3 Smart Meter National Programme

With electricity demand expected to rise by 79 percent in the next 10 years, India is on a path of transforming its energy mix with innovation. Along with enhancing energy production, the nation also needs to cut Aggregate Technical and Commercial (AT&C) losses to below 12% by 2022, and below 10% by 2027.

Enabling India to achieve this imperative is the smart grid, the first step of which, is the creation of Advanced Metering Infrastructure. A new range of ‘smart meters’ can bring efficiency to how India manages its electricity, by checking data-entry errors and billing efficiencies, and cutting the costs of manual meter reading through web-based monitoring system.

With its pioneering role in India's energy efficiency journey, EESL's Smart Meter National Programme (SMNP) is working to eventually replace 25 crore conventional meters with smart meters across India.

By bringing standardized solutions based on the GPRS technology, these meters will ease integration in the sector, while cutting capital costs and boosting efficiency in billing and collection. Customers will also benefit from accurate bill readings, and real-time understanding of their electricity usage, catalysing a pan-India movement towards energy efficiency.

Our proven model of bulk procurement, aggregation of demand, and monetisation of savings will be the approach to roll out smart meters. This roll-out is proposed under the Build-Own-Operate-Transfer (BOOT) model, wherein EESL will undertake all the capital and operational expenditure with zero upfront investment from states and utilities. EESL will therefore, receive a nominal Internal Rate of Return that is reflected in a mutually agreed upon, automated payback structure.

In the larger scheme of things, the programme will holistically promote the Indian manufacturing industry while creating more direct and indirect jobs. The programme is expected to better billing efficiency by 75 to 100 percent while increasing the revenues of the utility companies to Rs. 1,38,100 crore.

2.4 GSM based automatic energy meter reading system with instant billing

H.G.Rodney Tan,C.H. Lee, V.H.Mok, "Automatic power meter reading system using GSM network" The 8th 'International Power Engineering Conference' IPEC(2007)

The technology of e-metering (Electronic Metering) has gone through rapid technological advancements and there is increased demand for a reliable and efficient Automatic Meter Reading (AMR) system. This paper presents the design of a simple low cost wireless GSM energy meter and its associated web interface, for automating billing and managing the collected data globally. The proposed system replaces traditional meter reading methods and enables remote access of existing energy meter by the energy provider. Also they can monitor the meter readings regularly without the person visiting each house. A GSM based wireless communication module is integrated with electronic energy meter of each entity to have remote access over the usage of electricity. A PC with a GSM receiver at the other end, which contains the database acts as the billing point. Live meter reading from the GSM enabled energy meter is sent back to this billing point periodically and these details are updated in a central database. A new interactive, user friendly graphical user interface is developed using Microsoft visual studio .NET framework and C#. With proper authentication, users can access the developed web page details from anywhere in the world. The complete monthly usage and due bill is messaged back to the customer after processing these data.

3 OPERATION

3.1 Electromechanical

The most common type of electricity meter is the electromechanical watt-hour meter.[14][15]

On a single-phase AC supply, the electromechanical induction meter operates through electromagnetic induction by counting the revolutions of a non-magnetic, but electrically conductive, metal disc which is made to rotate at a speed proportional to the power passing through the meter. The number of revolutions is thus proportional to the energy usage. The voltage coil consumes a small and relatively constant amount of power, typically around 2 watts which is not registered on the meter. The current coil similarly consumes a small amount of power in proportion to the square of the current flowing through it, typically up to a couple of watts at full load, which is registered on the meter.

The disc is acted upon by two sets of induction coils, which form, in effect, a two phase linear induction motor. One coil is connected in such a way that it produces a magnetic flux in proportion to the voltage and the other produces a magnetic flux in proportion to the current. The field of the voltage coil is delayed by 90 degrees, due to the coil's inductive nature, and calibrated using a lag coil.[16] This produces eddy currents in the disc and the effect is such that a force is exerted on the disc in proportion to the product of the instantaneous current, voltage and phase angle (power factor) between them. A permanent magnet acts as an eddy current brake, exerting an opposing force proportional to the speed of rotation of the disc. The equilibrium between these two opposing forces results in the disc rotating at a speed proportional to the power or rate of energy usage. The disc drives a register mechanism which counts revolutions, much like the odometer in a car, in order to render a measurement of the total energy used.

The disc is supported by a spindle which has a worm gear which drives the register. The register is a series of dials which record the amount of energy used. The dials may be of the *cyclometer* type, an odometer-like display that is easy to read where for each dial a single digit is shown through a window in the face of the meter, or of the pointer type where a pointer indicates each digit. With the dial pointer type, adjacent pointers generally rotate in opposite directions due to the gearing mechanism.

3.2Electronic

Electronic meters display the energy used on an LCD or LED display, and some can also transmit readings to remote places. In addition to measuring energy used, electronic meters can also record other parameters of the load and supply such as instantaneous and maximum rate of usage demands, voltages, power factor and reactive power used etc. They can also support time-of-day billing, for example, recording the amount of energy used during on-peak and off-peak hours.

As in the block diagram[*where?*], the meter has a power supply, a metering engine, a processing and communication engine (i.e. a microcontroller), and other add-on modules such as RTC, LCD, communication ports/modules and so on.

The metering engine is given the voltage and current inputs and has a voltage reference, samplers and quantisers followed by an ADC section to yield the digitised equivalents of all the inputs. These inputs are then processed using a digital signal processor to calculate the various metering parameters.

The largest source of long-term errors in the meter is drift in the preamp, followed by the precision of the voltage reference. Both of these vary with temperature as well, and vary wildly because most meters are outdoors. Characterising and compensating for these is a major part of meter design.

The processing and communication section has the responsibility of calculating the various derived quantities from the digital values generated by the metering engine. This also has the responsibility of communication using various protocols and interface with other addon modules connected as slaves to it.

RTC and other add-on modules are attached as slaves to the processing and communication section for various input/output functions. On a modern meter most if not all of this will be implemented inside the microprocessor, such as the real-time clock (RTC), LCD controller, temperature sensor, memory and analogue to digital converters.

3.3Smart Meter

Smart meters go a step further than simple AMR (automatic meter reading). They offer additional functionality including a real-time or near real-time reads, power outage notification, and power quality monitoring. They allow price setting agencies to introduce different prices for consumption based on the time of day and the season.

Another type of smart meter uses nonintrusive load monitoring to automatically determine the number and type of appliances in a residence, how much energy each uses and when. This meter is used by electric utilities to do surveys of energy use. It eliminates the need to put timers on all of the appliances in a house to determine how much energy each uses

3.3.1Features of Smart Meter

Time of day metering

Time of Day metering (TOD), also known as Time of Usage (TOU) or Seasonal Time of Day (SToD), metering involves dividing the day, month and year into tariff slots and with higher rates at peak load periods and low tariff rates at off-peak load periods. While this can be used to automatically control usage on the part of the customer (resulting in automatic load control), it is often simply the customer's responsibility to control his own usage, or pay accordingly (voluntary load control). This also allows the utilities to plan their transmission infrastructure appropriately. See also Demand-side Management (DSM).

3.3.2Accuracy

Electricity meters are required to register the energy consumed within an acceptable degree of accuracy. Any significant error in the registered energy can represent a loss to the electricity supplier, or the consumer being over billed. The accuracy is generally laid down in statute for the location in which the meter is installed. Statutory provisions may also specify a procedure to be followed should the accuracy be disputed. For the United Kingdom, any installed electricity meter is required to accurately record the consumed energy, but it is permitted to under-read by 3.5%, or over-read by 2.5%.[33] Disputed meters are initially verified with a check meter operating alongside the disputed meter. The final resort is for the disputed meter to be fully tested both in the installed location and at a specialist calibration laboratory.[34] Approximately 93% of disputed meters are found to be operating satisfactorily. A refund of electricity paid for, but not consumed (but not vice versa) will only be made if the laboratory is able to estimate how long the meter has been misregistering. This contrasts with gas meters where if a meter is found to be under reading, it is assumed that it has under read for as long as the consumer has had a gas supply through it.[35]

3.3.3Tampering and security

Meters can be manipulated to make them under-register, effectively allowing power use without paying for it. This theft or fraud can be dangerous as well as dishonest.

Power companies often install remote-reporting meters specifically to enable remote detection of tampering, and specifically to discover energy theft. The change to smart power meters is useful to stop energy theft.

When tampering is detected, the normal tactic, legal in most areas of the United States, is to switch the subscriber to a "tampering" tariff charged at the meter's maximum designed current. At US$0.095/kWh, a standard residential 50 A meter causes a legally collectible charge of about US$5,000.00 per month. Meter readers are trained to spot signs of tampering, and with crude mechanical meters, the maximum rate may be charged each billing period until the tamper is removed, or the service is disconnected.

A common method of tampering on mechanical disk meters is to attach magnets to the outside of the meter. Strong magnets saturate the magnetic fields in the meter so that the motor portion of a mechanical meter does not operate. Lower power magnets can add to the drag resistance of the internal disk resistance magnets. Magnets can also saturate current transformers or power-supply transformers in electronic meters, though countermeasures are common.

Some combinations of capacitive and inductive load can interact with the coils and mass of a rotor and cause reduced or reverse motion.

All of these effects can be detected by the electric company, and many modern meters can detect or compensate for them.

The owner of the meter normally secures the meter against tampering. Revenue meters' mechanisms and connections are sealed. Meters may also measure VAR-hours (the reflected load), neutral and DC currents (elevated by most electrical tampering), ambient magnetic fields, etc. Even simple mechanical meters can have mechanical flags that are dropped by magnetic tampering or large DC currents.

Newer computerised meters usually have counter-measures against tampering. AMR (Automated Meter Reading) meters often have sensors that can report opening of the meter cover, magnetic anomalies, extra clock setting, glued buttons, inverted installation, reversed or switched phases etc.

Some tampers bypass the meter, wholly or in part. Safe tampers of this type normally increase the neutral current at the meter. Most split-phase residential meters in the United States are unable to detect neutral currents. However, modern tamper-resistant meters can detect and bill it at standard rates.

4.METHODOLOGY

4.1Power calculation

Our first aim is to calculate the real power . For real power we need RMS voltage, RMS current and power factor. Theorical Introduction The PF is estimated according to the instantaneous values of the current and voltage measured on the load. Based on these quantities, it is possible to calculate the rms current, the rms voltage, P, S, and then the PF.

$$\mathrm{I_{RMS}} = \sqrt{\frac{\sum_{i=1}^{n} I_i{}^2}{n}}$$

$$\mathrm{V_{RMS}} = \sqrt{\frac{\sum_{i=1}^{n} V_i{}^2}{n}}$$

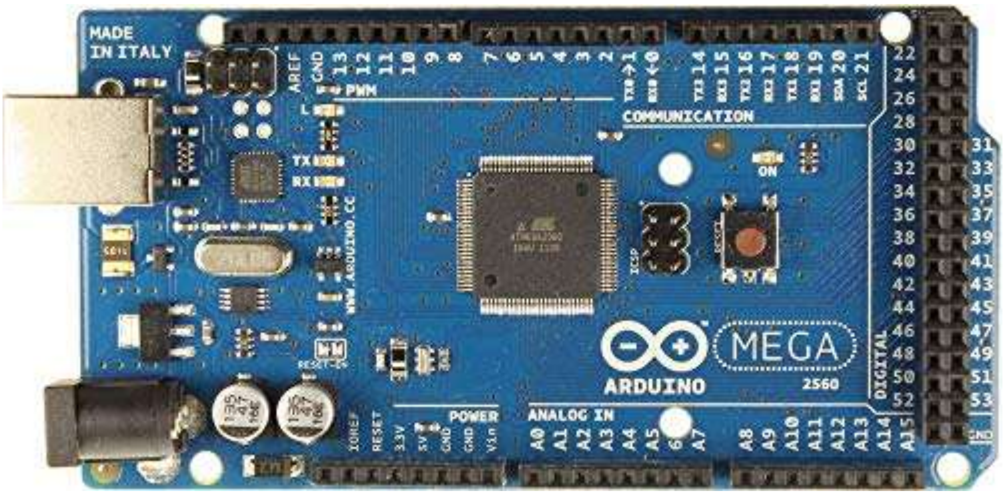
$$P = \frac{1}{n}\sum_{i=1}^{n} V_i \times I_i$$

$$S = V_{RMS} \times I_{RMS}$$

$$PF = \frac{P}{S}$$

4.2 Microcontroller

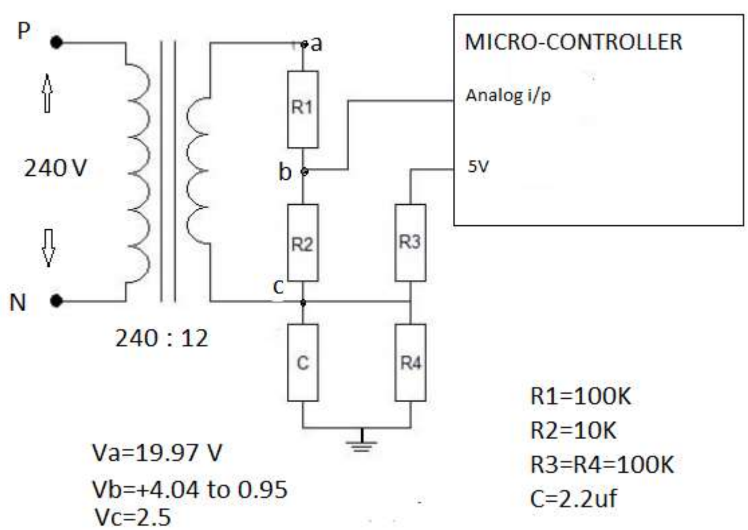
Arduino The board Arduino Mega 2560 was used in this article. It has 54 digital inputs and outputs, 16 analog inputs, and 256 kBof flash memory operating at 16 MHz .The device feeding is supplied by USB, which is connected to a computer. The Arduino has a 10-bit analog-to-digital converter (A/D). Therefore, the values read from 0 to 5 V (maximum permissible value) in the analog inputs are converted from 0 to 1023 bits. So, the resolution obtained is 5 V/1024 bits [13]. The function analogRead( ), used in Arduino programming for reading analog values, takes about 100 µs (0.0001 s) to read an analog input, so the maximum reading rate is about 10,000 times a second [13]. The tests determined that, on a 50 Hz cycle, Arduino can read approximately 200 samples of instantaneous values of voltage and current and measure the quantities simultaneously.



4.3Voltage measurement

Voltage Measurement

The circuit of Fig. 3 was used for the voltage measurement. The values of the passive elements are: *R1* = 100 k ohm; *R2* = 10 k ohm; *R3* = *R4* = 100 k ohm; *C* = 2.2 μF. The winding turns ratio of the transformer is approximately 20: 1.



The transformer and the resistors *R1* and *R2* reduce the supply voltage (230 VRMS) to safe levels regarding the

Arduino analog inputs (bellow 5 V). On the other hand, as the values read by *Arduino* analog inputs must be positive, *R3* and *R4* resistors are responsible for the offset required, so there are no negative values on the analog input. In other words, these resistors divide the continuous voltage 5 V (provided by *Arduino*) to 2.5 V at the node among *R3*, *R4*, *R2* and *C*. Therefore, the instantaneous values of the read voltage are increased by 2.5 V, so all of these values are positive. The capacitor *C* is simply used as a low-pass filter, filtering high frequency disturbances. Thus, the capacitor has an important role in the circuit, because the voltage signal would be floating without it, due to the high frequency components.

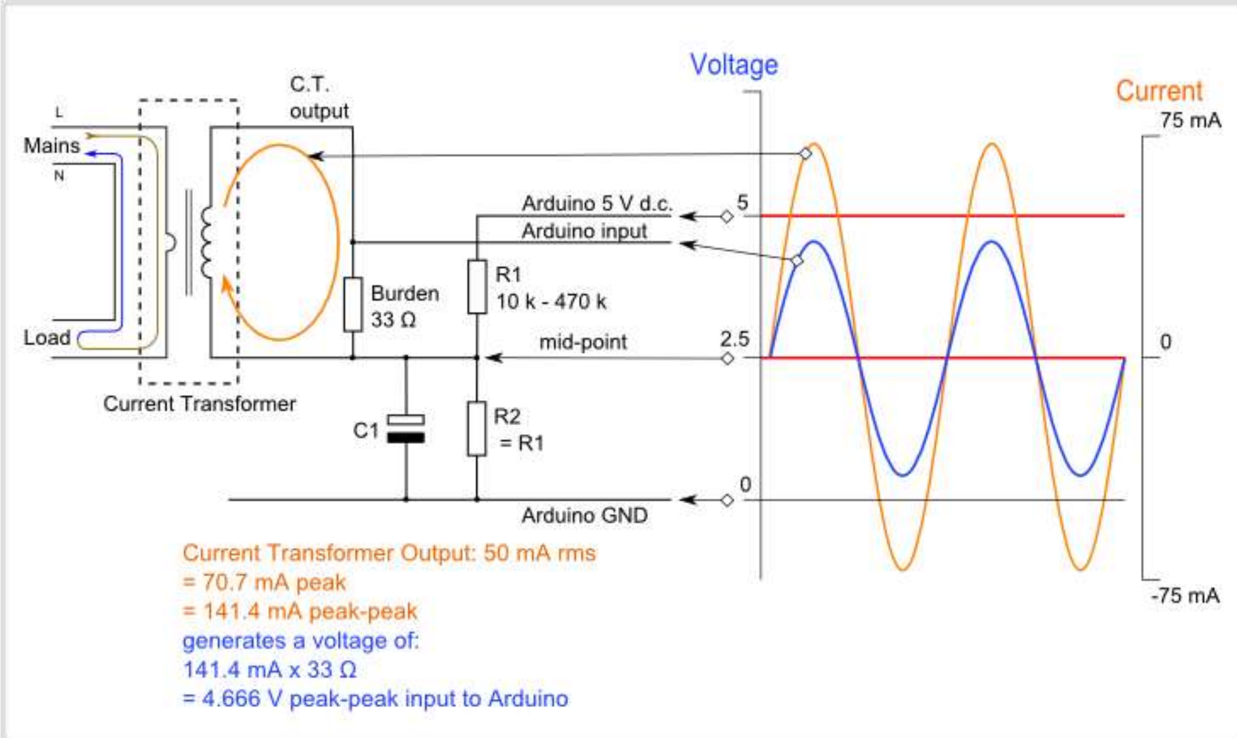
4.4Current Measurement

The current transformer is used for the current measurement. We have used SCT 013 current transformer. This current transformer has the turns ratio of 2000:1.

To connect a CT sensor to an Arduino, the output signal from the CT sensor needs to be conditioned so it meets the input requirements of the Arduino analog inputs, i.e. a positive voltage between 0V and the ADC reference voltage..

This can be achieved with the following circuit which consists of two main parts:

1. The CT sensor and burden resistor
2. The biasing voltage divider (*R1 & R2*)



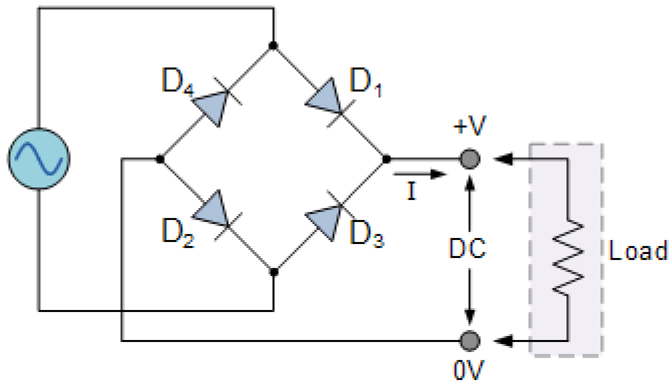
4.5Power supply

Power supply for the Arduino and GSM module

We need constant DC supply for the Arduino and GSM module. We have used transformer to step down the voltage and further connectead to full wave bridge rectifier. This single phase rectifier uses four individual rectifying diodes connected in a closed loop “bridge” configuration to produce the desired output.

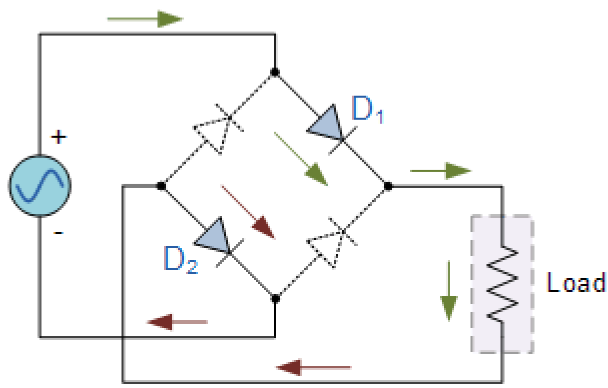
The main advantage of this bridge circuit is that it does not require a special centre tapped transformer, thereby reducing its size and cost. The single secondary winding is connected to one side of the diode bridge network and the load to the other side as shown below.

The Diode Bridge Rectifier



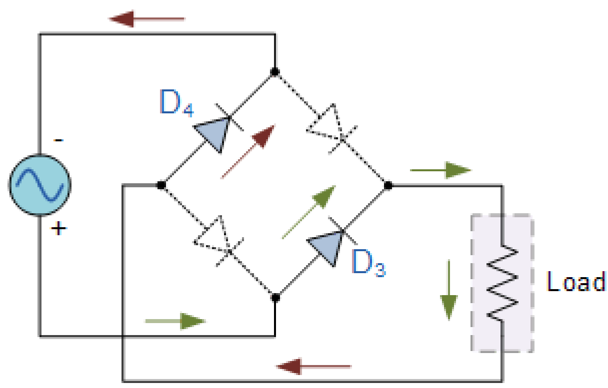
The four diodes labelled D_1 to D_4 are arranged in "series pairs" with only two diodes conducting current during each half cycle. During the positive half cycle of the supply, diodes D1 and D2 conduct in series while diodes D3 and D4 are reverse biased and the current flows through the load as shown below.

The Positive Half-cycle



During the negative half cycle of the supply, diodes D3 and D4 conduct in series, but diodes D1 and D2 switch "OFF" as they are now reverse biased. The current flowing through the load is the same direction as before.

The Negative Half-cycle



As the current flowing through the load is unidirectional, so the voltage developed across the load is also unidirectional the same as for the previous two diode full-wave rectifier, therefore the average DC voltage across the load is $0.637V_{max}$.

Typical Bridge Rectifier

However in reality, during each half cycle the current flows through two diodes instead of just one so the amplitude of the output voltage is two voltage drops (2*0.7 supply frequency (e.g. 100Hz for a 50Hz supply or = 1.4V) less than the input V_{MAX} amplitude. The ripple frequency is now twice the 120Hz for a 60Hz supply.)

Although we can use four individual power diodes to make a full wave bridge rectifier, pre-made bridge rectifier components are available “off-the-shelf” in a range of different voltage and current sizes that can be soldered directly into a PCB circuit board or be connected by spade connectors.

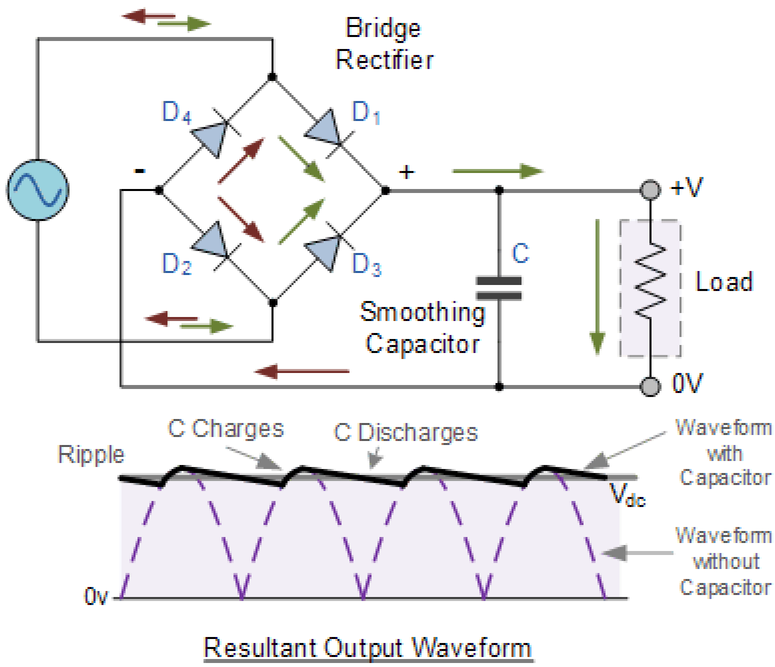
The image to the right shows a typical single phase bridge rectifier with one corner cut off. This cut-off corner indicates that the terminal nearest to the corner is the positive or +veoutput terminal or lead with the opposite (diagonal) lead being the negative or -ve output lead. The other two connecting leads are for the input alternating voltage from a transformer secondary winding.

The Smoothing Capacitor

We saw in the previous section that the single phase half-wave rectifier produces an output wave every half cycle and that it was not practical to use this type of circuit to produce a steady DC supply. The full-wave bridge rectifier however, gives us a greater mean DC value (0.637 Vmax) with less superimposed ripple while the output waveform is twice that of the frequency of the input supply frequency.

We can improve the average DC output of the rectifier while at the same time reducing the AC variation of the rectified output by using smoothing capacitors to filter the output waveform. Smoothing or reservoir capacitors connected in parallel with the load across the output of the full wave bridge rectifier circuit increases the average DC output level even higher as the capacitor acts like a storage device as shown below.

Full-wave Rectifier with Smoothing Capacitor



4.6Solid State Relay

Unlike electro-mechanical relays (EMR) which use coils, magnetic fields, springs and mechanical contacts to operate and switch a supply, the solid state relay, or SSR, has no moving parts but instead uses the electrical and optical properties of solid state semiconductors to perform its input to output isolation and switching functions

Just like a normal electro-mechanical relay, SSR's provide complete electrical isolation between their input and output contacts with its output acting like a conventional electrical switch in that it has very high, almost infinite resistance when nonconducting (open), and a very low resistance when conducting (closed). Solid state relays can be designed to switch both AC or DC currents by using an SCR, TRIAC, or switching transistor output instead of the usual mechanical normally-open (NO) contacts.

While the solid state relay and electro-mechanical relay are fundamentally similar in that their low voltage input is electrically isolated from the output that switches and controls a load, electro-mechanical relays have a limited contact life cycle, can take up a lot of room and have slower switch speeds, especially large power relays and contactors. Solid state relays have no such limitations.

Thus the main advantages solid state relays have over conventional electro-mechanical relays is that they have no moving parts to wear out, and therefore no contact bounce issues, are able to switch both “ON” and “OFF” much faster than a mechanical relays armature can move, as well as zero voltage turn-on and zero current turn-off eliminating electrical noise and transients.

Solid state relays can be bought in standard off-the-shelf packages ranging from just a few volts or amperes to many hundreds of volts and amperes of output switching capability. However, solid state relays with very high current ratings (150A plus) are still too expensive to buy due to their power semiconductor and heat sinking requirements, and as such, cheaper electro-mechanical contactors are still used.

Similar to an electro-mechanical relay, a small input voltage, typically 3 to 32 volts DC, can be used to control a much large output voltage, or current. For example 240V, 10Amps. This makes them ideal for microcontroller, PIC and Arduino interfacing as a low-current, 5-volt signal from say a micro-controller or logic gate can be used to control a particular circuit load, and this is achieved with the use of opto-isolators.

Solid State Relay Input

One of the main components of a solid state relay (SSR) is an opto-isolator (also called an optocoupler) which contains one (or more) infra-red light-emitting diode, or LED light source, and a photo sensitive device within a single case. The opto-isolator isolates the input from the output.

The LED light source is connected to the SSR’s input drive section and provides optical coupling through a gap to an adjacent photo sensitive transistor, darlington pair or triac. When a current passes through the LED, it illuminates and its light is focused across the gap to a photo-transistor/photo-triac.

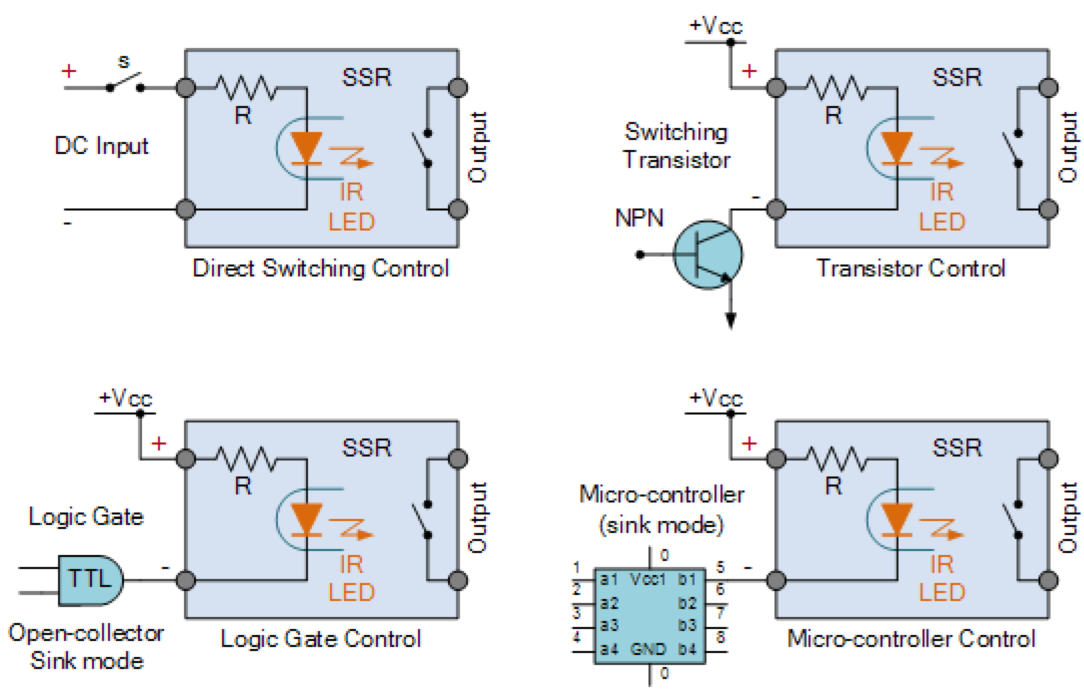
Thus the output of an opto-coupled SSR is turned "ON" by energising this LED, usually with low-voltage signal. As the only connection between the input and output is a beam of light, high voltage isolation (usually several thousand volts) is achieved by means of this internal opto-isolation.

Not only does the opto-isolator provide a higher degree of input/output isolation, it can also transmit dc and low-frequency signals. Also, the LED and photo-sensitive device could be totally separate from each other and optically coupled by means of an optical fibre.

The input circuitry of an SSR may consist of just a single current limiting resistor in series with the LED of the opto-isolator, or of a more complex circuit with rectification, current regulation, reverse polarity protection, filtering, etc.

To activate or turn "ON" a sold state relay into conduction, a voltage greater than its minimum value (usually 3 volts DC) must be applied to its input terminals (equivalent to the electro-mechanical relay coil). This DC signal may be derived from a mechanical switch, a logic gate or micro-controller, as shown.

Solid State Relay DC Input Circuit



4.7 GSM

Global System for Mobile communications is a standard developed by the European Telecommunications Standards Institute (ETSI) to describe the protocols for second-generation (2G) digital cellular networks used by mobile devices such as mobile phones and tablets. It was first deployed in Finland in December 1991.[2] As of 2014, it has become the global standard for mobile communications, operating in over 193 countries and territories. The @other@ technology is in the US, Verizon and Sprints "CDMA". This has been presented and voted on but is not a standard. GSM is the only standard for mobile phones. 2G networks developed as a replacement for first generation (1G) analog cellular networks, and the GSM standard originally described a digital, circuit-switched network optimized for full duplex voice telephony. This expanded over time to include data communications, first by circuit-switched transport, then by packet data transport via GPRS (General Packet Radio Services) and EDGE (Enhanced Data rates for GSM Evolution, or EGPRS).

Subsequently, the 3GPP developed third-generation (3G) UMTS standards, followed by fourth-generation (4G) LTE Advanced standards, which do not form part of the ETSI GSM standard.

SIM900A Modem can work with any GSM network operator SIM card just like a mobile phone with its own unique phone number.

SIM900A GSM/GPRS modem is plug and play modem with RS232 serial communication supported. Hence Advantage of using this modem will be that its RS232 port can be used to communicate and develop embedded applications.

Applications like SMS Control, data transfer, remote control and logging can be developed. SIM900 modem supports features like voice call, SMS, Data/Fax, GPRS etc.

SIM900A modem uses AT commands to work with supported features.

Note that to be connected to a cellular network, the modem requires a SIM card provided by a network provider.

Power Requirement

This board requires external power supply of ~12V and can draw up to ~2A of current at its peak.

Indicators

It has two LED indicators as,

ON: It shows that the Modem is getting powered and is switched on.

NET: This network LED blinks when the modem is communicating with the radio network.

Network LED

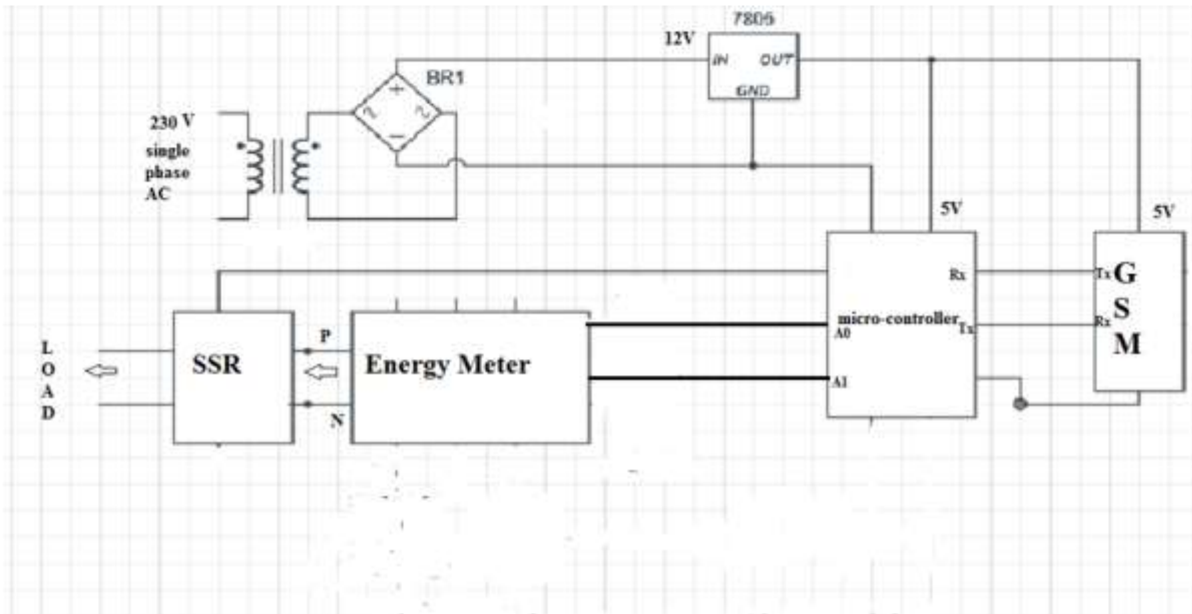
When modem is powered up, network LED blink every second and after network registration it will start to blink after every 3 seconds. This shows that the modem is registered with the network.

To test modem, connect board serially to PC and send “ATE0” or “AT” through serial terminal. If “OK” response is received from the modem, then it means all is well.

AT Command Reference

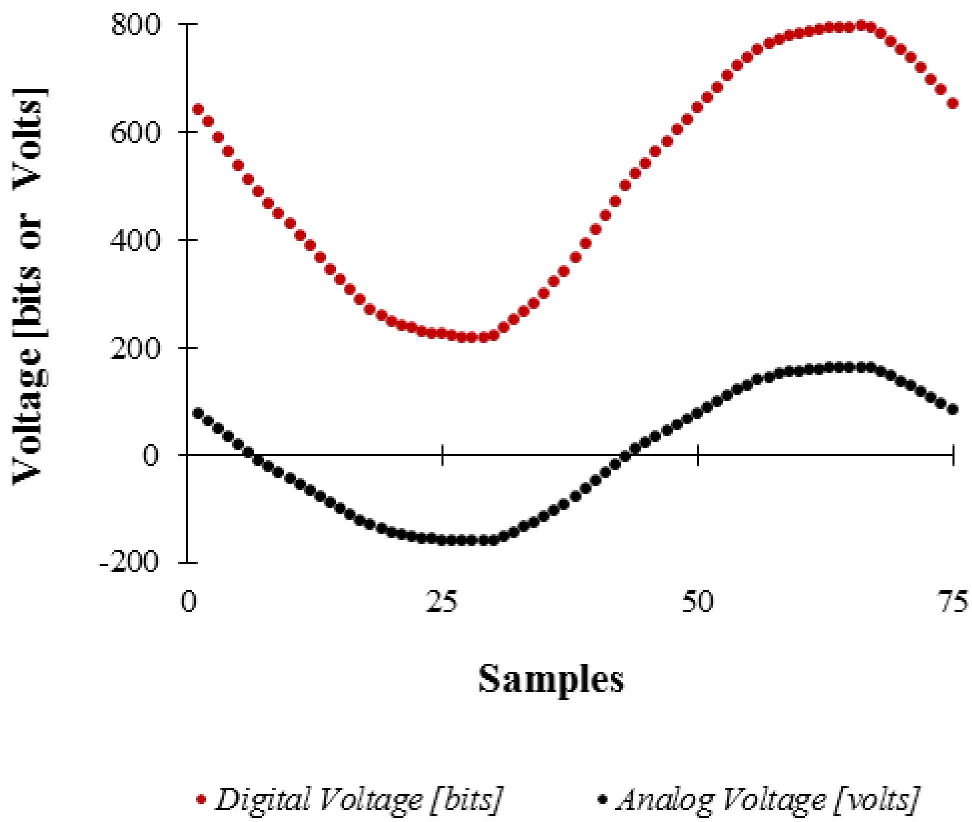
There are many AT commands for SIM900A modem, kindly go through ‘SIM900 AT Command Manual’

4.8 Block diagram.



4.9 Digital Data Processing

The read data from both voltage and current measurements are digital values from 0 to 1023 bits. Thus, it requires a programming logic that centralizes the waveforms on the horizontal axis and then converts these digital values to analog, considering the *Arduino* resolution (item B). On the current measurement, this data processing also considers the sensor sensibility (item C). Regarding the voltage measurement, the voltage divider and the transformer winding turns ratio must be taken into account (item D). To illustrate this process, Fig. 4 shows the waveform of the digital voltage (in red) and the analog voltage (in black), properly centered on the horizontal axis and converted. The read values come from the distribution grid, so there is a slight harmonic distortion on the waveforms



4.10 Arduino Program

```
float V[1000];

float I[200];

float P[200];

float Q[200];

float R[200];

void setup() {Serial.begin(9600);}


void loop() {
```

```
 P[0]=0; Q[0]=0; R[0]=0;
for(int n=0;n<200;n++)
{ int v = analogRead(A0);
  int i = analogRead(A1);
  V[n] = ((v* (5.0 / 1023.0))-2.5)*17.3*11;
//  I[n] = i----------;
  //for voltage
  P[n+1]=P[n]+V[n]*V[n];
  //for current
  Q[n+1]=Q[n]+I[n]*I[n];
  //for power
  R[n+1]=R[n]+V[n]*I[n];
}
float x=P[200]/200;
float Vr=sqrt(x);
float y=Q[200]/200;
float Ir=sqrt(y);
float P =R[200]/200;
float S = Vr*Ir;
float PF=P/S;
//
Serial.print("Vrms=");
```

```
Serial.print(Vr);
 Serial.print("  ");
 //
Serial.print("Irms=");
Serial.print(Ir);
 Serial.print("  ");
 //
Serial.print("Real Power=");
Serial.print(P);
 Serial.print(" ");
 //
 Serial.print("Apparant Power=");
Serial.print(S);
 Serial.print(" ");
 //
 Serial.print("PF=");
Serial.print(PF);
Serial.println();


}
```

5.Applications

- Measure the electicity consumed
- Send the information regarding real time power and power factor to the operator
- No need to send person to take reading.
- Save the energy consumption with respect to time. This information can be used to create the load profile.
- Operator can cut and restore the supply just by sending commands through SMS.

6 .Conclusions

- This energy meter can be used both for lilnear as well as non linear load
- Accurate readings are obtained for different loads
- Incentives can be provided to consumer according to his load profile

7.Future scope

- Energy theft can be effectively reduced by obtaining real time values after regular interval and creating data base for all consumers.
- Smart meter can be integrated with home automation
- The system can be expanded for two way power flow
- Prepaid facility can be given

8.References

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