BABU BANARASI DAS UNIVERSITY, LUCKNOW

A

PROJECT REPORT

ON

PREPAID ENERGY METER WITH THEFT DETECTION

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PROJECT GUIDE
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ABSTRACT

Arduino based Prepaid Electricity Meter is a system which makes the billing of electricity consumption by a user prepaid. The primary application of this project is to calculate the energy consumption based on the number of pulses generated in the electricity meter, and subsequent deduction of money from the balance amount. This makes the user aware of the consumption of electricity but also reduces human effort of door to door billing, as the system would send timely and appropriate messages to the registered user in case of low balance in the system. The system is designed to make it tamper proof and in case of any external human intervention, it would report the Electricity Board about the same and switch off the power supply. An auto detection system for electricity theft has been employed which allows to tackle the menace of electricity theft faced by electricity boards to make sure that no un-authorized usage of electricity takes place. Tamper proofing of the system makes sure that there is no intentional tampering of the electricity meter to alter or stop the billing of electricity consumption.

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INTRODUCTION

Electrical metering instrument technology has come a long way from the original bulky meters with heavy magnets and coils to the recent electronic meters. There have been many innovations those have resulted in size & weight reduction in addition to improvement in features and specifications. Despite of the rapid development in majority of the sectors in India only few developments are made in electricity sector. As limited non-renewable resources are present in our daily life, electricity is one of them which are utilized in every country [1].Electric energy is a vital resource in everyday life and a backbone of every industry. As electricity is limited resource its proper use and measurement is very important. In Conventional metering system to measure power consumption the energy provider company hire persons who visit each house and record the meter reading manually. These meter readings are used for electricity bill calculation and this bill sent to consumer house by post. This makes the system sluggish and laborious [2][3]. The human error can open an opportunity for corruption due to human interventions. So the problems arise in the billing systems which make them inaccurate and inefficient. The availability of wireless communication media has made the exchange of information fast, secured and accurate. Communication media like the internet, GSM networks, etc. exists everywhere. Wireless meter reading puts more control into the hands of both utilities and consumers by giving them more detailed information about power consumption. This allows utilities to better regulate the power supply. So, remote & wireless meter reading system with prepaid technique is becoming a trend now. 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 [4]. 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. 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 [5][6]. Magnets can also saturate current transformers or potential transformers in electronic meters, though countermeasures are common. Different nontechnical and technical methods were proposed in the past to detect

electricity pilfering. Although periodic inspection can substantially reduce electricity theft but such measure requires large manpower and huge labour[7]. Some of the technical ways to detect pilferage are use of central observer meter at secondary terminals of distribution transformer, harmonic generator, genetic support vectormachines, extreme learning machine and power line impedance technique [8][9]. However, these technical approaches can be effectively implemented only if proper communication is ensured between the central control station and the appropriate test points. Traditional electromechanical meters still widely used today are prone to drift over temperature and time as a result of the analog and mechanical nature of the components in these meters [10]. Collection of meter readings is also inefficient, because a meter reader has to physically be on- site to take the readings. This method becomes more problematic and costly. There exists chance for missing bills, absence of consumer etc.

BLOCK DIAGRAM

The block diagram representation of the project is shown in figure 1. It simplifies the system into various blocks for better visualization and interpretation. It describes the various blocks of the system and shows which components receive output from the Arduino and which ones provide an input to the Arduino. Some work as sensors and other as actuators.

A five Volt power supply provides power to the system. The current and the LDR(Light Dependent Resistor) sensors provide an input after sensing the flow of current and the LED pulses to the Arduino. The LCD module receives inputs.
From the Arduino for displaying customary messages to the user and for sending SMS alerts in case of electricity theft and system tampering. The GSM module interfaced to the Arduino is responsible for sending alerts. A single phase 220V electricity meter counts the units being consumed by the load. A SPDT relay is used to trigger the load ON or OFF.

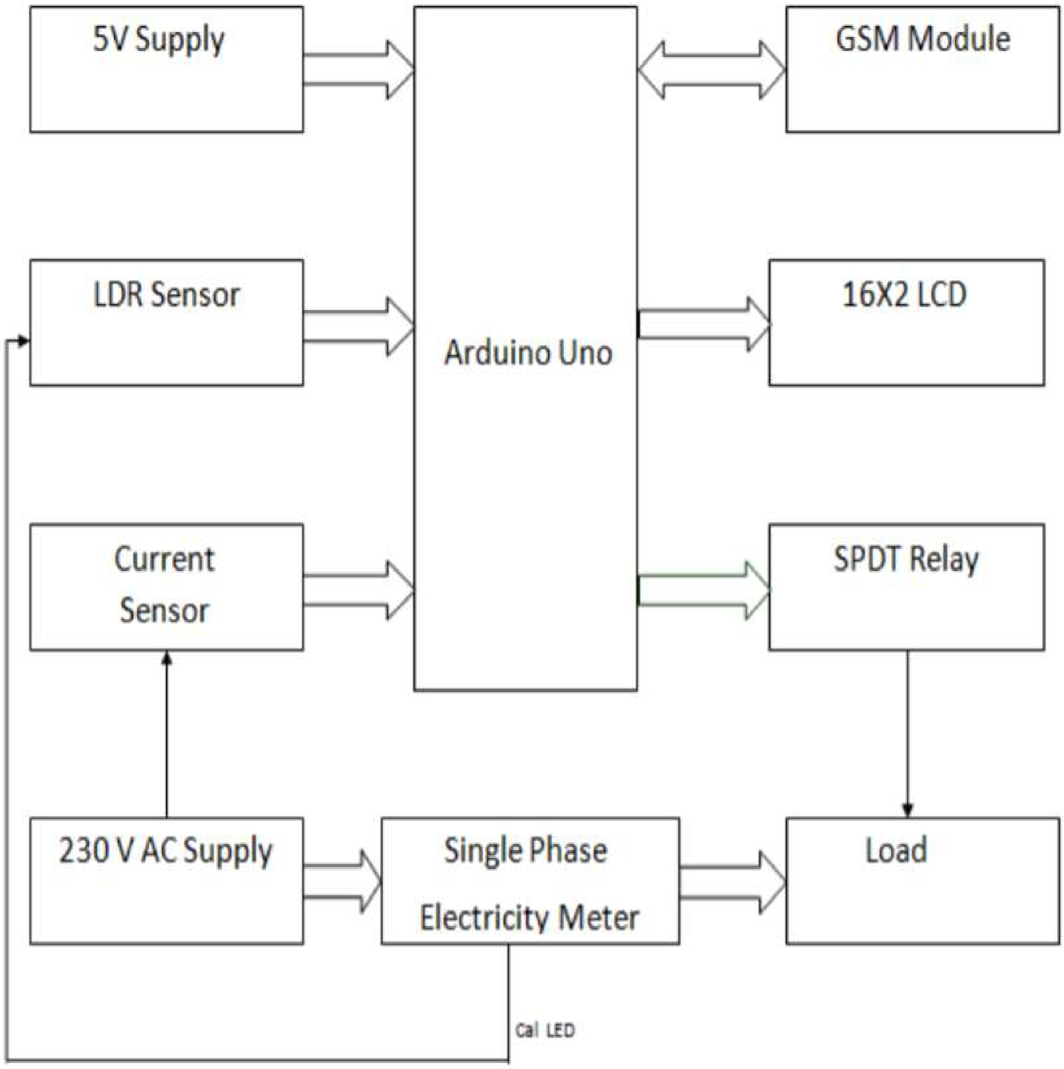

Fig.1 Block Diagram of Prepaid Energy Meter

HARDWARE SPECIFICATIONS

1. ATmega8 Microcontroller
2. Current Sensor
3. SIM 800 GSM Module
4. LCD Display
5. Relay
6. Relay Driver IC
7. Voltage Regulator IC
8. Crystal Oscillator
9. Resistors
10. Capacitors
11. Transistors
12. Cables and Connectors
13. Diodes
14. PCB and Breadboard
15. LED
16. Transformer/ Adopter
17. Push Buttons
18. Switches
19. IC
20. IC Socket
21. Energy Mater
22. Loads

SOFTWARE SPECIFICATIONS

1. Arduino Compiler
2. MC Programming Language C

ATmega Microcontroller

A Microcontroller is a tiny computer on a single chip and it is also termed as a control device. Similar to a computer, the Microcontroller is made with a variety of peripherals like input & output units, memory, Timers, serial data communications, programmable. The applications of Microcontroller involve embedded applications & automatically controlled devices like medical devices, remote control devices, control systems, office machines, power tools, electronic devices, etc. There are **various kinds of Microcontrollers available** in the market like 8051, PIC and AVR microcontroller. This article gives brief information about AVR Atmega8 microcontroller.

In 1996, AVR Microcontroller was produced by the "Atmel Corporation". The Microcontroller includes the Harvard architecture that works rapidly with the RISC. The features of this Microcontroller include different features compared with other like sleep modes-6, inbuilt ADC (analog to digital converter), internal oscillator and serial data communication, performs the instructions in a single execution cycle. These Microcontrollers were very fast and they utilize low power to work in different power saving modes. There are different configurations of AVR microcontrollers are available to perform various operations like 8-bit, 16-bit, and 32-bit. Please refer the below link for; Types of AVR Microcontroller

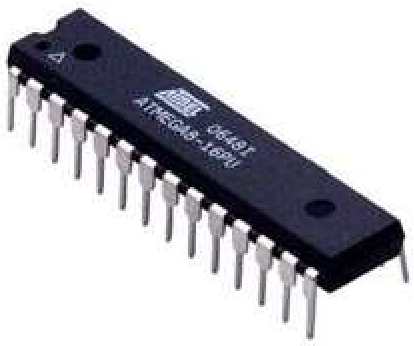

Fig. 2: Atmega Microcontroller

The **main feature of Atmega8 Microcontroller** is that all the pins of the Microcontroller support two signals except 5-pins. The Atmega8 microcontroller consists of 28 pins where pins 9,10,14,15,16,17,18,19 are used for port B, Pins 23,24,25,26,27,28 and 1 are used for port C and pins 2,3,4,5,6,11,12 are used for port D.

- Pin -1 is the RST (Reset) pin and applying a low-level signal for a time longer than the minimum pulse length will produce a RESET.
- Pin-2 and pin-3 are used in USART for serial communication
- Pin-4 and pin-5 are used as an external interrupt. One of them will activate when an interrupt flag bit of the status register is set and the other will activate as long as the intrude condition succeeds.
- Pin-9 & pin-10 are used as a timer counters oscillators as well as an external oscillator where the crystal is associated directly with the two pins. Pin-10 is used for low-frequency crystal oscillator or crystal oscillator. If the internal adjusted RC oscillator is used as the CLK

source & the asynchronous timer is allowed, these pins can be utilized as a timer oscillator pin.

- Pin-19 is used as a Master CLK o/p, slave CLK i/p for the SPI-channel.
- Pin-18 is used as Master CLK i/p, slave CLK o/p.
- Pin-17 is used as Master data o/p, slave data i/p for the SPI-channel. It is used as an i/p when empowered by a slave & is bidirectional when allowed by the master. This pin can also be utilized as an o/p compare with match o/p, which helps as an external o/p for the timer/counter.
- Pin-16 is used as a slave choice i/p. It can also be used as a timer or counter1 comparatively by arranging the PB2-pin as an o/p.
- Pin-15 can be used as an external o/p of the timer or counter compare match A.
- Pin-23 to Pins28 have used for ADC (digital value of analog input) channels. Pin-27 can also be used as a serial interface CLK & pin-28 can be used as a serial interface data
- Pin-12 and pin-13 are used as an Analog Comparator i/ps.
- Pin-6 and pin-11 are used as timer/counter sources.

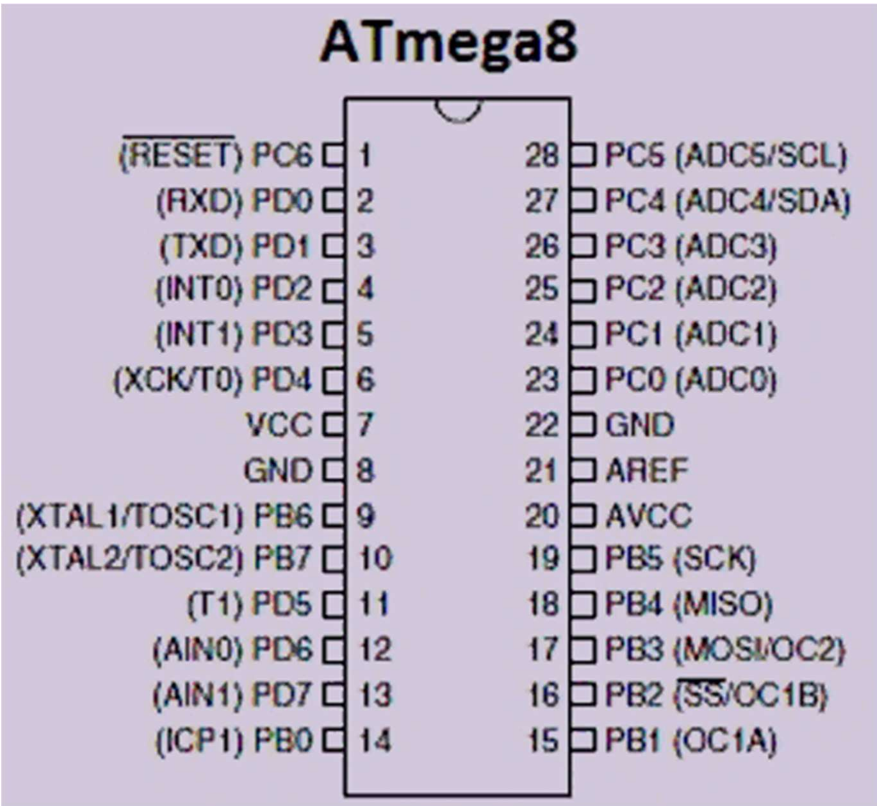

Fig. 3: ATmega8 Pin Diagram

Current Sensor

The invention of electricity has led to a revolutionary change in the life of humans. We invented many innovative applications of electricity to make our daily life easier. Today almost all of our equipment runs on electricity. The flow of charge is known as Current. Different devices need a different amount of current based on their functional requirements. Some devices are so sensitive that they get damaged when a high amount of current is delivered to them. So, to save such a situation and monitor the amount of current required or being used in an application, measurement of current necessary. This is where the Current Sensor comes into play. One such sensor is the ACS712 Current Sensor.

Current flowing through a conductor causes a voltage drop. The relation between current and voltage is given by Ohm's law. In electronic devices, an increase in the amount of current above its requirement leads to overload and can damage the device.

Measurement of current is necessary for the proper working of devices. Measurement of voltage is Passive task and it can be done without affecting the system. Whereas measurement of current is an Intrusive task which cannot be detected directly as voltage.

For measuring current in a circuit, a sensor is required. ACS712 Current Sensor is the sensor that can be used to measure and calculate the amount of current applied to the conductor without affecting the performance of the system.

ACS712 Current Sensor is a fully integrated, Hall-effect based linear sensor IC. This IC has a 2.1kV RMS voltage isolation along with a low resistance current conductor.

Working Principle

Current Sensor detects the current in a wire or conductor and generates a signal proportional to the detected current either in the form of analog voltage or digital output.

Current Sensing is done in two ways – Direct sensing and Indirect Sensing. In Direct sensing, to detect current, Ohm's law is used to measure the voltage drop occurred in a wire when current flows through it.

ACS712 Current Sensor uses Indirect Sensing method to calculate the current. To sense current a liner, low-offset Hall sensor circuit is used in this IC. This sensor is located at the surface of the IC on a copper conduction path. When current flows through this copper conduction path it generates a magnetic field which is sensed by the Hall effect sensor. A voltage proportional to the sensed magnetic field is generated by the Hall sensor, which is used to measure current.

The proximity of the magnetic signal to the Hall sensor decides the accuracy of the device. Nearer the magnetic signal higher the accuracy. ACS712 Current Sensor is available as a small, surface mount SOIC8 package. In this IC current flows from Pin-1 and Pin-2 to Pin-3 and Pin-4. This forms the conduction path where the current is sensed. Implementation of this IC is very easy.

ACS712 can be used in applications requiring electrical isolation as the terminals of the conduction path are electrically isolated from the IC leads. Thus, this IC doesn't require any other isolation techniques. This IC requires a supply voltage of 5V. Its output voltage is proportional to AC or DC current. ACS712 has a nearly zero magnetic hysteresis.
Where Pin-1 to Pin-4 forms the conduction path, Pin-5 is the signal ground pin. Pin-6 is the FILTER pin that is used by an external capacitor to set the bandwidth. Pin-7 is the analog output pin. Pin-8 is the power supply pin.

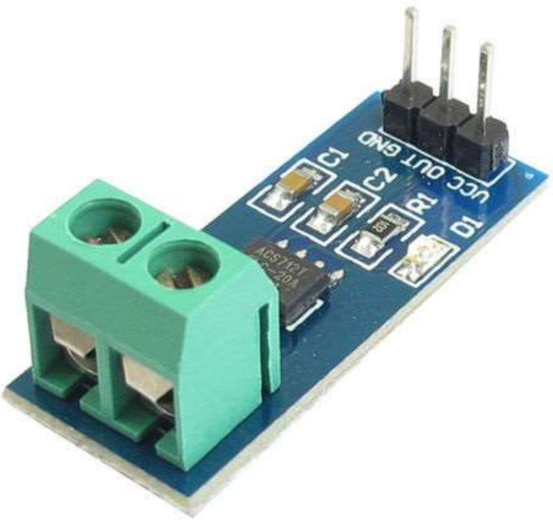

Fig. 4: Current Sensor

SIM800 GSM Module

SIM800 is a quad-band GSM/GPRS module designed for the global market. It works on frequencies GSM 850MHz, EGSM 900MHz, DCS 1800MHz and PCS 1900MHz. SIM800 features GPRS multi-slot class 12/ class 10 (optional) and supports the GPRS coding schemes CS-1, CS-2, CS-3 and CS-4. With a tiny configuration of 24*24*3mm, SIM800 can meet almost all the space requirements in users' applications, such as M2M, smart phone, PDA and other mobile devices. SIM800 has 68 SMT pads, and provides all hardware interfaces between the module and customers' boards. SIM800 is designed with power saving technique so that the current consumption is as low as 1.2mA in sleep mode. SIM800 integrates TCP/IP protocol and extended TCP/IP AT commands which are very useful for data transfer applications.

SIM800 Features:

- Support up to 5*5*2 Keypads.
- One full function UART port, and can be configured to two independent serial ports.
- One USB port can be used as debugging and firmware upgrading.
- Audio channels which include a microphone input and a receiver output.
- Programmable general purpose input and output.
- One SIM card interface.
- Support Bluetooth function.
- Support one PWM.
- PCM/SPI/SD card interface, only one function can be accessed synchronously.
- Power supply 3.4V ~ 4.4V
- Typical power consumption in sleep mode is 1.2mA
- Frequency bands GPRS multi-slot class 12
- Support SIM card: 1.8V, 3V
- Serial Port: Can be used for AT commands for data stream
- USB Port: Can be used as debugging and firmware upgrading

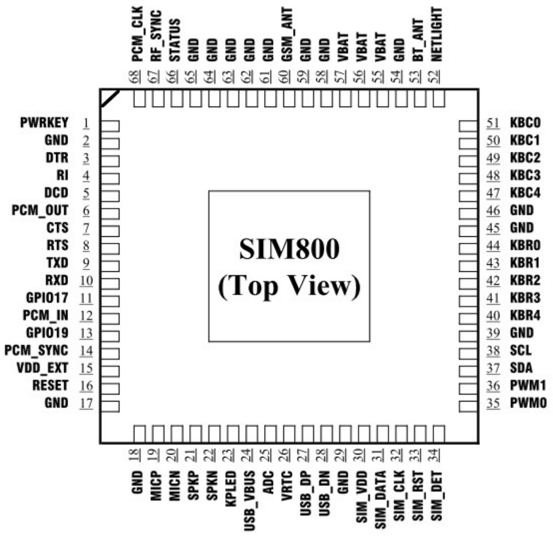

Fig.5: SIM800 Pin Diagram

LCD Display

A liquid crystal display or LCD draws its definition from its name itself. It is a combination of two states of matter, the solid and the liquid. LCD uses a liquid crystal to produce a visible image. Liquid crystal displays are super-thin technology display screens that are generally used in laptop computer screens, TVs, cell phones and portable video games. LCD's technologies allow displays to be much thinner when compared to a cathode ray tube (CRT) technology.

Liquid crystal display is composed of several layers which include two polarized panel filters and electrodes. LCD technology is used for displaying the image in a notebook or some other electronic devices like mini computers. Light is projected from a lens on a layer of liquid crystal. This combination of colored light with the grayscale image of the crystal (formed as electric current flows through the crystal) forms the colored image. This image is then displayed on the screen.

An LCD is either made up of an active matrix display grid or a passive display grid. Most of the Smartphone's with LCD technology uses active matrix display, but some of the older displays still make use of the passive display grid designs. Most of the electronic devices mainly depend on liquid crystal display technology for their display. The liquid has a unique advantage of having low power consumption than the LED or cathode ray tube.

Liquid crystal display screen works on the principle of blocking light rather than emitting light. LCDs require a backlight as they do not emit light by them. We always use devices which are made up of LCD's displays which are replacing the use of cathode ray tube. Cathode ray tube draws more power compared to LCDs and is also heavier and bigger.

As mentioned above that we need to take two polarized glass pieces filter in the making of the liquid crystal. The glass which does not have a polarized film on the surface of it must be rubbed with a special polymer that will create microscopic grooves on the surface of the polarized glass filter. The grooves must be in the same direction as the polarized film. Now we have to add a coating of pneumatic liquid phase crystal on one of the polarizing filters of the polarized glass. The microscopic channel causes the first layer molecule to align with filter orientation. When the right angle appears at the first layer piece, we should add a second piece of glass with the polarized film. The first filter will be naturally polarized as the light strikes it at the starting stage.

Thus the light travels through each layer and guided on the next with the help of a molecule. The molecule tends to change its plane of vibration of the light to match its angle. When the light reaches the far end of the liquid crystal substance, it vibrates at the same angle as that of the final layer of the molecule vibrates. The light is allowed to enter into the device only if the second layer of the polarized glass matches with the final layer of the molecule.

glass and also cause a change in the angle of the top polarizing filter. As a result, a little light is allowed to pass the polarized glass through a particular area of the LCD. Thus that particular area will become dark compared to others. The LCD works on the principle of blocking light. While constructing the LCD's, a reflected mirror is arranged at the back. An electrode plane is made of indium-tin-oxide which is kept on top and a polarized glass with a polarizing film is also added on the bottom of the device. The complete region of the LCD has to be enclosed by a common electrode and above it should be the liquid crystal matter.

Next comes the second piece of glass with an electrode in the form of the rectangle on the bottom and, on top, another polarizing film. It must be considered that both the pieces are kept at the right angles. When there is no current, the light passes through the front of the LCD it will be reflected by the mirror and bounced back. As the electrode is connected to a battery the current from it will cause the liquid crystals between the common-plane electrode and the electrode shaped like a rectangle to untwist. Thus the light is blocked from passing through. That particular rectangular area appears blank.

Fig. 6: 16x2 LCD

RELAY

A relay is classified into many types, a standard and generally used relay is made up of electromagnets which in general used as a switch. Dictionary says that relay means ***the act of passing something from one thing to another,*** the same meaning can be applied to this device because the signal received from one side of the device controls the switching operation on the other side. So relay is a switch which controls (open and close) circuits electromechanically. The main operation of this device is to make or break contact with the help of a signal without any human involvement in order to switch it ON or OFF. It is mainly used to control a high powered circuit using a low power signal. Generally a DC signal is used to control circuit which is driven by high voltage like controlling AC home appliances with DC signals from microcontrollers.

An electromechanical relay is basically designed using few mechanical parts like Electromagnet, a movable armature, contacts, yoke, and a spring/frame/stand, these parts are showing in the **internal pictures of Relay** below. All these are arranged logically to form into a relay.

An Electromagnet plays a major role in the **working of a relay**. It is a metal which doesn't have magnetic property but it can be converted into a magnet with the help of an electrical signal. We know that when current passes through the conductor it acquires the properties of a magnet. So, when a metal winded with a copper wire and driven by the sufficient power supply, that metal can act as a magnet and can attract the metals within its range.

The following figure shows how a Relay looks internally and how it can be constructed,

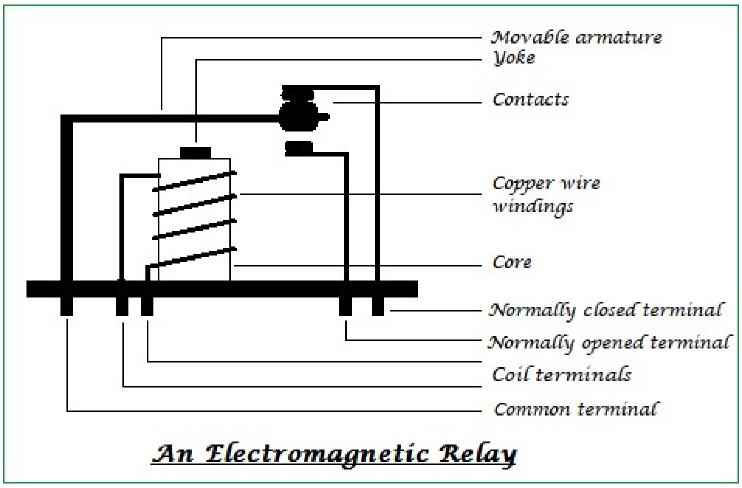

Fig.7: Electromagnetic Realy

On a casing, a core with copper windings (forms a coil) winded on it is placed. A movable armature consists of a spring support or stand like structure connected to one end, and a metal contact connected to another side, all these arrangements are placed over the core such that, when the coil is energized, it attracts the armature. The movable armature is generally considered as a common terminal which is to be connected to the external circuitry. The relay also has two pins namely ***normally closed and normally opened (NC and NO),*** the normally closed pin is connected to the armature or the common terminal whereas the normally opened pin is left free (when the coil is not energized). When the coil is energized the armature moves and is get connected to the normally opened contact till there exists flow of current through the coil. When it is de-energized it goes to its initial position.

The general **circuit representation of the relay** is as shown in the figure below

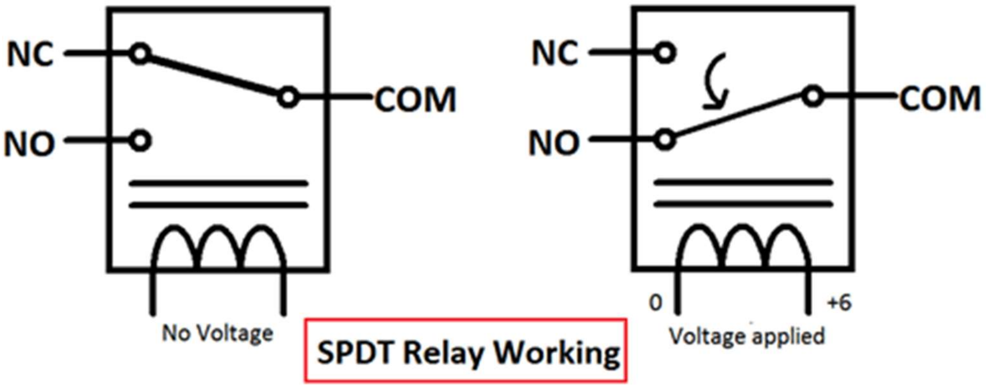

Fig.8: SPDT Realy Working

How Relay Works:

Relay in NORMALLY CLOSED condition:

When no voltage is applied to the core, it cannot generate any magnetic field and it doesn't act as a magnet. Therefore, it cannot attract the movable armature. Thus, the initial position itself is the armature connected in normally closed position (NC).

Relay in NORMALLY OPENED condition:
When sufficient voltage is applied to the core it starts to create a magnetic field around it and acts as a magnet. Since the movable armature is placed within its range, it gets attracted to that magnetic field created by the core, thus the position of the armature is being altered. It is now connected to the normally opened pin of the relay and external circuit connected to it function in a different manner.

Note: The functionality of the external circuit depends upon the connection made to the relay pins.

So finally, we can say that when a coil is energized the armature is attracted and the switching action can be seen, if the coil is de-energized it loses its magnetic property and the armature goes back to its initial position.

Relay Driver IC

A Relay driver IC is an electro-magnetic switch that will be used whenever we want to use a low voltage circuit to switch a light bulb ON and OFF which is connected to 220V mains supply. The required current to run the relay coil is more than can be supplied by various integrated circuits like Op-Amp, etc.Relays have unique properties and are replaced with solid state switches that are strong than solid-state devices. High current capacities, capability to stand ESD and drive circuit isolation are the unique properties of Relays. There are various ways to drive relays.Some of the Relay Driver ICs are as below.

- High side toggle switch driver
- Low side toggle switch driver
- Bipolar NPN transistor driver
- N-Channel MOSFET driver and
- Darlington transistor driver
- ULN2003 driver

Relay Driver IC Circuit

Relays are components that permit a low-power circuit to control signals or to switch high current ON and OFF which should be electrically isolated from controlling circuit.

The Required Components

- Zener Diode
- 6-9V Relay
- 9V Battery or DC Power Supply
- 2N2222 Transistor
- 1K Ohm Resistor
- Second Input Voltage Source

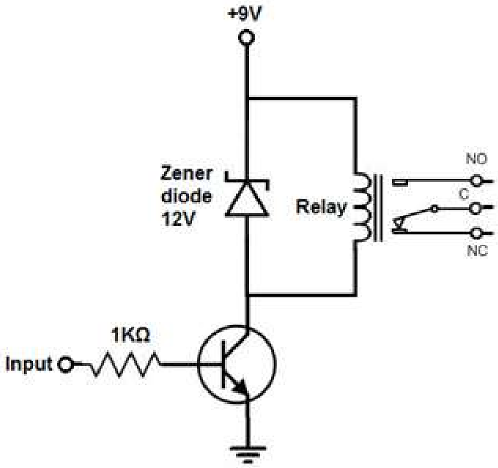

Fig. 9:Relay Driver IC Circuit

In order to drive the relay, we use transistor and only less power can be possibly used to get the relay driven. Since, transistor is an amplifier so the base lead receives sufficient current to make more current flow from Emitter of Transistor to Collector. If the base once gets power that is sufficient, then the transistor conduct from Emitter to Collector and power the relay.

Rasistor

A resistor is a passive electrical component with the primary function to limit the flow of electric current.

The choice of material technology is a specific to the purpose. Often it is a trade-off between costs, precision and other requirements. For example, carbon composition is a very old technique with a low precision, but is still used for specific applications where high energy pulses occur. Carbon composition resistors have a body of a mixture of fine carbon particles and a non-conductive ceramic. The carbon film technique has a better tolerance. These are made of a non-conductive rod with a thin carbon film layer around it. This layer is treated with a spiral cut to increase and control the resistance value. Metal and metal oxide film are widely used nowadays, and have better properties for stability and tolerance. Furthermore, they are less influenced by temperature variations. They are just as carbon film resistors constructed with a resistive film around a cylindrical body. Metal oxide film is generally more durable. Wirewound resistors are probably the oldest type and can be used for both high precision as well as high power applications. They are constructed by winding a special metal alloy wire, such as nickel chrome, around a non-conductive core. They are durable, accurate and can have very low resistance value. A disadvantage is that they suffer from parasitic reactance at high frequencies. For the highest requirements on precision and stability, metal foil resistors are used. They are constructed by cementing a special alloy cold rolled film onto a ceramic substrate.

Resistor characteristics

Dependent on the application, the electrical engineer specifies different properties of the resistor. The primary purpose is to limit the flow of electrical current; therefore the key parameter is the resistance value. The manufacturing accuracy of this value is indicated with the resistor tolerance in percentage. Many other parameters that affect the resistance value can be specified, such as long term stability or the temperature coefficient. In high frequency circuits, such as in radio electronics, the capacitance and inductance can lead to undesired effects. Foil resistors generally have a low parasitic reactance, while wirewound resistors are amongst the worst. For accurate applications such as audio amplifiers, the electric noise must be as low as possible. This is often specified as microvolts noise per volt of applied voltage, for a 1 MHz bandwidth. For high power applications the power rating is important. This specifies the maximum operating power the component can handle without altering the properties or damage. The power rating is usually specified in free air at room temperature. Higher power ratings require a larger size and may even require heat sinks. Many other characteristics can play a role in the design specification. Examples are the maximum voltage, or the pulse stability. In situations where high voltage surges could occur this is an important characteristic.

Voltage Regulator IC

A **voltage regulator** is one of the most widely used electronic circuitry in any device. A regulated voltage (without fluctuations & noise levels) is very important for the smooth functioning of many digital electronic devices. A common case is with micro controllers, where a smooth regulated input voltage must be supplied for the micro controller to function smoothly.

You may also like this article on **Regulated Power Supply**

Voltage regulators are of different types. In this article, our interest is only with IC based voltage regulator. An example of IC based voltage regulator available in market is the popular 7805 IC which regulates the output voltage at 5 volts. Now lets come to the basic definition of an IC voltage regulator. It is an integrated circuit whose basic purpose is to regulate the unregulated input voltage (definitely over a predefined range) and provide with a constant, regulated output voltage**.**

An IC based voltage regulator can be classified in different ways. A common type of classification is 3 terminal voltage regulator and 5 or multi terminal voltage regulator. Another popular way of classifying IC voltage regulators is by identifying them as linear voltage regulator & switching voltage regulator. There is a third set of classification as 1) Fixed voltage regulators (positive & negative) 2) Adjustable voltage regulators (positive & negative) and finally 3) Switching regulators. In the third classification, fixed & adjustable regulators are basically versions of linear voltage regulators.

Fixed Voltage Regulators

These regulators provide a constant output voltage. A popular example is the 7805 IC which provides a constant 5 volts output. A fixed voltage regulator can be a positive voltage regulator or a negative voltage regulator. A positive voltage regulator provides with constant positive output voltage. All those IC's in the 78XX series are fixed positive voltage regulators. In the IC nomenclature – 78XX ; the part XX denotes the regulated output voltage the IC is designed for. Examples:- 7805, 7806, 7809 etc.

A negative fixed voltage regulator is same as the positive fixed voltage regulator in design, construction & operation. The only difference is in the polarity of output voltages. These IC's are designed to provide a negative output voltage. Example:- 7905, 7906 and all those IC's in the 79XX series.

Adjustable Voltage Regulator

An adjustable voltage regulator is a kind of regulator whose regulated output voltage can be varied over a range. There are two variations of the same; known as positive adjustable voltage regulator and negative adjustable regulator. LM317 is a classic example of positive adjustable voltage regulator, whose output voltage can be varied over a range of 1.2 volts to 57 volts. LM337 is an example of negative adjustable voltage regulator. LM337 is actually a complement of LM317 which are similar in operation & design; with the only difference being polarity of regulated output voltage.

There may be certain conditions where a variable voltage may be required. Right now we shall discuss how an LM317 adjustable positive voltage regulator IC is connected. The connection diagram is shown below.

The resistors R1 and R2 determine the output voltage Vout. The resistor R2 is adjusted to get the output voltage range between 1.2 volts to 57 volts. The output voltage that is required can be calculated using the equation:

Vout = Vref (1+R2/R1) + Iadj R2
In this circuit, the value of Vref is the reference voltage between the adjustment terminals and the output taken as 1.25 Volt.
The value of Iadj will be very small and will also have a constant value. Thus the above equation can be rewritten as
Vout = 1.25 (1+R2/R1)
In the above equation, due to the small value of Iadj, the drop due to R2 is neglected.
The load regulation is 0.1 percent while the line regulation is 0.01 percent per volt. This means that the output voltage varies only 0.01 percent for each volt of input voltage. The ripple rejection is 80 db, equivalent to 10,000.
The LM 337 series of adjustable voltage regulators is a complement to the LM 317 series devices. The negative adjustable voltage regulators are available in the same voltage and current options as the LM 317 devices.
The voltage regulator using LM340 IC is the most used voltage regulator IC. As shown in the block diagram above, the built-in reference voltage
Vref drives the non-inverting input of the operational amplifier. There are many stages of voltage gain for the op-amp used here. This high gain helps the op
-amp to make the error voltage between the inverting and non-inverting terminals to be almost zero. Thus, the inverting input terminal vaue will also be the
Like other IC's, this IC also has thermal shutdown and current limiting options. Thermal shutdown is a feature that will turn off the IC as soon as the internal temperature of the IC rises above its preset value. This rise in temperature may mostly be due to excessive external voltage, ambient temperature, or even heat sinking. The preset cut-off temperature value for LM340 IC is 175° C. Because of thermal shutdown and current limiting, devices in the LM 340 series are almost indestructible.
When there is quite a distance (in cms) from the IC to the filter capacitor of the unregulated power supply, there may occur unwanted oscillations within the IC due to lead inductances within the circuit. In order to remove this unwanted oscillation, the capacitor C1 has to be placed as shown in the circuit.
Capacitor C2 is sometimes used to improve the transient response of the circuit.
Any device in the LM 340 series needs a minimum input voltage at least 2 to 3 V greater than the regulated output voltage. Otherwise, it will stop regulating. Furthermore, there is a maximum input voltage because of excessive power dissipation.

Crystal Oscillator

A crystal oscillator is an electronic oscillator circuit that is used for the mechanical resonance of a vibrating crystal of piezoelectric material. It will create an electrical signal with a given frequency. This frequency is commonly used to keep track of time for example wristwatches are used in digital integrated circuits to provide a stable clock signal and also used to stabilize frequencies for radio transmitters and receivers. Quartz crystal is mainly used in radio-frequency (RF) oscillators. Quartz crystal is the most common type of piezoelectric resonator, in oscillator circuits, we are using them so it became known as crystal oscillators. Crystal oscillators must be designed to provide a load capacitance.

There are different types of oscillator electronic circuits that are in use they are namely: Linear oscillators – Hartley oscillator, Phase-shift oscillator, Armstrong oscillator, Clapp oscillator, Colpitts oscillator. Relaxation oscillators – Royer oscillator, Ring oscillator, Multivibrator and Voltage Controlled Oscillator (VCO). Soon we are going to discuss in detail crystal oscillators like working and applications of a crystal oscillator.

A quartz crystal exhibits a very important property known as the piezoelectric effect. When mechanical pressure is applied across the faces of the crystal, a voltage which is proportional to mechanical pressure appears across the crystal. That voltage causes distortion in the crystal. The distorted amount will be proportional to the applied voltage and also an alternate voltage applied to a crystal it causes to vibrate at its natural frequency.

The below figure represents the electronic symbol of a piezoelectric crystal resonator and also quartz crystal in an electronic oscillator that consists of resistor, inductor, and capacitors.

Crystal Oscillator Circuit Diagram

The above figure is a 20psc New 16MHz Quartz Crystal Oscillator and it is one kind of crystal oscillators, that works with 16MHz frequency.

Generally, bipolar transistors or FETs are used in the construction of Crystal oscillator circuits. This is because operational amplifiers can be used in different low-frequency oscillator circuits which are below 100KHz but operational amplifiers do not have the bandwidth to operate. It will be a problem at the higher frequencies that are matched to crystals which are above 1MHz. To overcome this problem Colpitts crystal oscillator is designed. It will work at higher Frequencies. In this Oscillator, the LC tank circuit that provides the feedback oscillations has been replaced by a quartz crystal.

The crystal oscillator circuit usually works on the principle of the inverse piezoelectric effect. The applied electric field will produce a mechanical deformation across some materials. Thus, it utilizes the vibrating crystal's mechanical resonance, which is made with a piezoelectric material for generating an electrical signal of a particular frequency.

Usually, quartz crystal oscillators are highly stable, consist of good quality factor(Q), they are small in size, and are economically related. Hence, quartz crystal oscillator circuits are more superior compared to other resonators like LC circuits, tuning forks. Generally in Microprocessors and Micro controllers we are using an 8MHz crystal oscillator.

The equivalent electrical circuit also describes the crystal action of the crystal. Just look at the equivalent electrical circuit diagram shown in the above. The basic components used in the circuit, inductance L represents crystal mass, capacitance C2 represents compliance, and C1 is used to represent the capacitance that is formed because of crystal's mechanical moulding, resistance R represents the crystal's internal structure friction, The quartz crystal oscillator circuit diagram consists of two resonances such as series and parallel resonance, i.e., two resonant frequencies.

In general, we know that, in the design of microprocessors and microcontrollers, crystal oscillators are used for the sake of providing the clock signals. For instance, let us consider 8051 microcontrollers, in this particular controller an external crystal oscillator circuit will work with 12MHz that is essential, even though this 8051 microcontroller (based on model) is capable to work at 40 MHz (max) have to provide 12MHz in most of the cases because for a machine cycle 8051 requires 12 clock cycles, so that to give effective cycle rate at 1MHz (taking 12MHz clock) to 3.33MHz (taking the maximum 40MHz clock). This particular crystal oscillator which is having cycle rate at 1MHz to 3.33MHz is used to generate clock pulses that are required for the synchronization of all the internal operations.

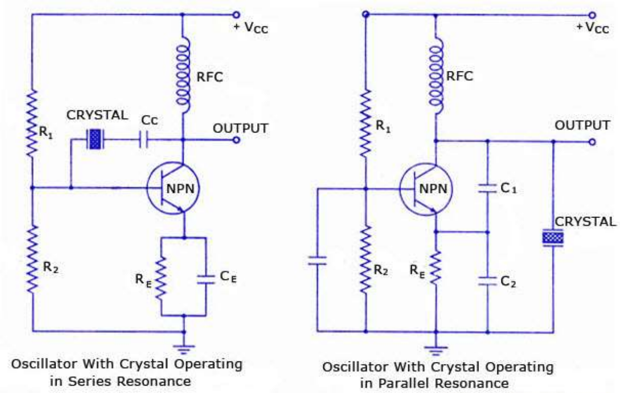

Fig. 10: Circuit diagram of Crystal Oscillator

Diodes

Although in the real world, diodes can not achieve zero or infinite resistance. Instead, a diode will have negligible resistance in one direction (to allow current flow), and very high resistance in the reverse direction (to ***prevent*** current flow). A diode is effectively like a valve for an electrical circuit.

Semiconductor diodes are the most common type of diode. These diodes begin conducting electricity only if a certain threshold voltage is present in the forward direction (i.e. the "low resistance" direction). The diode is said to be "***forward biased***" when conducting current in this direction. When connected within a circuit in the reverse direction (i.e. the "high resistance" direction), the diode is said to be "***reverse biased***".

The diode is said to be "***forward biased***" when conducting current in this direction. When connected within a circuit in the reverse direction (i.e. the "high resistance" direction), the diode is said to be "***reverse biased***".

A diode only blocks current in the reverse direction (i.e. when it is reverse biased) while the reverse voltage is within a specified range. Above this range, the reverse barrier breaks. The voltage at which this breakdown occurs is called the "reverse breakdown voltage".

When the voltage of the circuit is higher than the reverse breakdown voltage, the diode is able to conduct electricity in the reverse direction (i.e. the "high resistance" direction). This is why in practice we say diodes have a high resistance in the reverse direction – not an infinite resistance.

A PN junction is the simplest form of the semiconductor diode. In ideal conditions, this PN junction behaves as a short circuit when it is forward biased, and as an open circuit when it is in the reverse biased. The name diode is derived from "di–ode" which means a device that has two electrodes. Diodes are commonly used in many electronics projects and are included in many of the best Arduino starter kits.

Diode Symbol

The symbol of a diode is shown below. The arrowhead points in the direction of conventional current flow in the forward biased condition. That means the anode is connected to the p side and the cathode is connected to the n side.

We can create a simple PN junction diode by doping pentavalent or donor impurity in one portion and trivalent or acceptor impurity in the other portion of silicon or germanium crystal block.

These dopings make a PN junction in the middle part of the block. We can also form a PN junction by joining a p-type semiconductor and n-type semiconductor together with a special fabrication technique. The terminal connected to the p-type is the anode. The terminal connected to the n-type side is the cathode.

Working Principle of Diode

A diode's working principle depends on the interaction of n-type and p-type semiconductors. An n-type semiconductor has plenty of free electrons and a very few numbers of holes. In other words, we can say that the concentration of free electrons is high and that of holes is very low in an n-type semiconductor.

Free electrons in the n-type semiconductor are referred to as majority charge carriers, and holes in the n-type semiconductor are referred to as minority charge carriers.

A p-type semiconductor has a high concentration of holes and a low concentration of free electrons. Holes in the p-type semiconductor are majority charge carriers, and free electrons in the p-type semiconductor are minority charge carriers.

Unbiased Diode
Now let us see what happens when one n-type region and one p-type region come in contact. Here due to concentration differences, majority carriers diffuse from one side to another. As the concentration of holes is high in the p-type region and it is low in the n-type region, the holes start diffusing from the p-type region to the n-type region.
Again the concentration of free electrons is high in the n-type region and it is low in the p-type region and due to this reason, free electrons start diffusing from the n-type region to the p-type region.
The free electrons diffusing into the p-type region from the n-type region would recombine with holes available there and create uncovered negative ions in the p-type region. In the same way, the holes diffusing into the n-type region from the p-type region would recombine with free electrons available there and create uncovered positive ions in the n-type region.

Forward Biased Diode
Now let us see what happens if a positive terminal of a source is connected to the p-type side and the negative terminal of the source is connected to the n-type side of the diode and if we increase the voltage of this source slowly from zero.
In the beginning, there is no current flowing through the diode. This is because although there is an external electrical field applied across the diode, the majority charge carriers still do not get sufficient influence of the external field to cross the depletion region. As we told that the depletion region acts as a potential barrier against the majority charge carriers.

Reverse Biased Diode
Now let us see what happens if we connect the negative terminal of the voltage source to the p-type side and positive terminal of the voltage source to the n-type side of the diode. At that condition, due to electrostatic attraction of the negative potential of the source, the holes in the p-type region would be shifted more away from the junction leaving more uncovered negative ions at the junction.
In the same way, the free electrons in the n-type region would be shifted more away from the junction towards the positive terminal of the voltage source leaving more uncovered positive ions in the junction.
As a result of this phenomenon, the depletion region becomes wider. This condition of a diode is called the reverse biased condition. At that condition, no majority carriers cross the junction, and they instead move away from the junction. In this way, a diode blocks the flow of current when it is reverse biased.

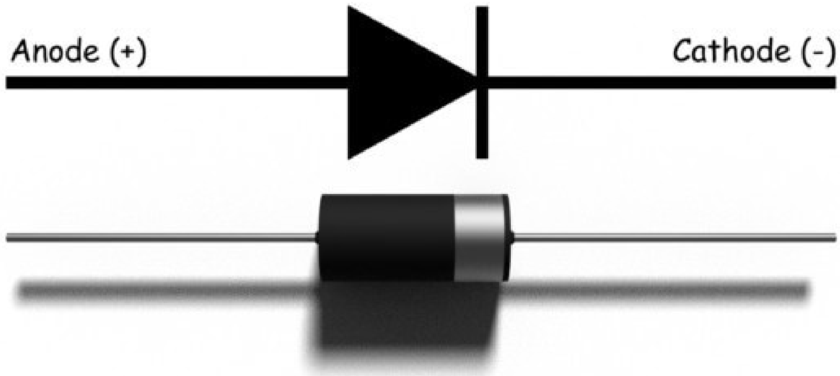

Fig 11: Diode

Capacitors

A capacitor is a two-terminal, electrical component. Along with resistors and inductors, they are one of the most fundamental **passive** components we use. You would have to look very hard to find a circuit which *didn't* have a capacitor in it.
What makes capacitors special is their ability to **store energy**; they're like a fully charged electric battery. *Caps*, as we usually refer to them, have all sorts of critical applications in circuits. Common applications include local energy storage, voltage spike suppression, and complex signal filtering.

Circuit Symbols

There are two common ways to draw a capacitor in a schematic. They always have two terminals, which go on to connect to the rest of the circuit. The capacitors symbol consists of two parallel lines, which are either flat or curved; both lines should be parallel to each other, close, but not touching (this is actually representative of how the capacitor is made. Hard to describe, easier to just show:

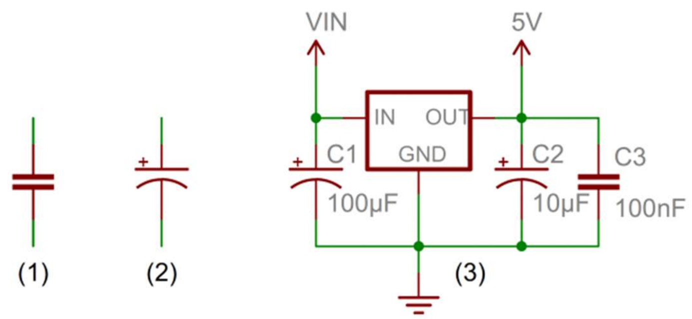

Fig. 12: Circuit Symbol of Capacitor

How a Capacitor Is Made

The schematic symbol for a capacitor actually closely resembles how it's made. A capacitor is created out of two metal plates and an insulating material called a **dielectric**. The metal plates are placed very close to each other, in parallel, but the dielectric sits between them to make sure they don't touch.
The dielectric can be made out of all sorts of insulating materials: paper, glass, rubber, ceramic, plastic, or anything that will impede the flow of current.

The plates are made of a conductive material: aluminium, tantalum, silver, or other metals. They're each connected to a terminal wire, which is what eventually connects to the rest of the circuit.

The capacitance of a capacitor -- how many farads it has -- depends on how it's constructed. More capacitance requires a larger capacitor. Plates with more overlapping surface area provide more capacitance, while more distance between the plates means less capacitance. The material of the dielectric even has an effect on how many farads a cap has. The total capacitance of a capacitor can be calculated with the equation:

How a Capacitor Works

Electric current is the flow of electric charge, which is what electrical components harness to light up, or spin, or do whatever they do. When current flows into a capacitor, the charges get "stuck" on the plates because they can't get past the insulating dielectric. Electrons -- negatively charged particles -- are sucked into one of the plates, and it becomes overall negatively charged. The large mass of negative charges on one plate pushes away like charges on the other plate, making it positively charged.
The positive and negative charges on each of these plates attract each other, because that's what opposite charges do. But, with the dielectric sitting between them, as much as they want to come together, the charges will forever be stuck on the plate (until they have somewhere else to go). The stationary charges on these plates create an electric field, which influence electric potential energy and voltage. When charges group together on a capacitor like this, the cap is storing electric energy just as a battery might store chemical energy.

Types of Capacitors

There are all sorts of capacitor types out there, each with certain features and drawbacks which make it better for some applications than others.

When deciding on capacitor types there are a handful of factors to consider:

- **Size** - Size both in terms of physical volume and capacitance. It's not uncommon for a capacitor to be the largest component in a circuit. They can also be very tiny. More capacitance typically requires a larger capacitor.
- **Maximum voltage** - Each capacitor is rated for a maximum voltage that can be dropped across it. Some capacitors might be rated for 1.5V, others might be rated for 100V. Exceeding the maximum voltage will usually result in destroying the capacitor.
- **Leakage current** - Capacitors aren't perfect. Every cap is prone to leaking some tiny amount of current through the dielectric, from one terminal to the other. This tiny current loss (usually nanoamps or less) is called leakage. Leakage causes energy stored in the capacitor to slowly, but surely drain away.
- **Equivalent series resistance (ESR)** - The terminals of a capacitor aren't 100% conductive, they'll always have a tiny amount of resistance (usually less than 0.01Ω) to them. This resistance becomes a problem when a lot of current runs through the cap, producing heat and power loss.
- **Tolerance** - Capacitors also can't be made to have an exact, precise capacitance. Each cap will be rated for their nominal capacitance, but, depending on the type, the exact value might vary anywhere from ±1% to ±20% of the desired value.

Transistor

The transistor is a semiconductor device that can both conduct and insulate. A transistor can act as a switch and an amplifier. It converts audio waves into electronic waves and resistors, controlling electronic current. Transistors have a very long life, smaller in size, can operate on lower voltage supplies for greater safety, and required no filament current. The first transistor was fabricated with germanium. A transistor performs the same function as a vacuum tube triode but using semiconductor junctions instead of heated electrodes in a vacuum chamber. It is the fundamental building block of modern electronic devices and found everywhere in modern electronic systems.

A transistor is a three-terminal device. Namely,

- Base: This is responsible for activating the transistor.
- Collector: This is the positive lead.
- Emitter: This is the negative lead.

The basic idea behind a transistor is that it lets you control the flow of current through one channel by varying the intensity of a much smaller current that’s flowing through a second channel.

Types of Transistors:

There are two types of transistors is present; they are bipolar junction transistors (BJT), field-effect transistors (FET). A small current is flowing between the base and the emitter; the base terminal can control a larger current flow between the collector and the emitter terminals. For a field-effect transistor, it also has the three terminals, they are gate, source, and drain, and a voltage at the gate can control a current between source and drain. The simple diagrams of BJT and FET are shown in the figure below:

As you can see, transistors come in a variety of different sizes and shapes. One thing all of these transistors have in common is that they each have three leads.

- **Bipolar Junction Transistor:**

A Bipolar Junction Transistor (BJT) has three terminals connected to three doped semiconductor regions. It comes with two types, P-N-P and N-P-N.

P-N-P transistor, consisting of a layer of N-doped semiconductor between two layers of P-doped material. The base current entering the collector is amplified at its output.

That is when PNP transistor is ON when its base is pulled low relative to the emitter. The arrows of the PNP transistor symbol the direction of current flow when the device is in forwarding active mode.

N-P-N transistor consisting a layer of P-doped semiconductor between two layers of N-doped material. By amplifying current the base we get the high collector and emitter current.

That is when NPN transistor is ON when its base is pulled low relative to the emitter. When the transistor is in ON state, the current flow is in between the collector and emitter of the transistor. Based on minority carriers in the P-type region the electrons moving from emitter to collector. It allows the greater current and faster operation; because of this reason, most bipolar transistors used today are NPN.

Modes of biasing:

Following are the different modes of transistor base biasing:

***1. Current biasing**:*

As shown in Fig.1, two resistors RC and RB are used to set the base bias. These resistors establish the initial operating region of the transistor with fixed current bias.

The transistor forward biases with a positive base bias voltage through RB. The forward base-emitter voltage drop is 0.7 volts. Therefore the current through RB is $I_B = (V_{cc} - V_{BE}) / I_B$

2. Feedback biasing:

Fig.2 shows the transistor biasing by the use of a feedback resistor. The base bias is obtained from the collector voltage. The collector feedback ensures that the transistor is always biased in the active region. When the collector current increases, the voltage at the collector drops. This reduces the base drive which in turn reduces the collector current. This feedback configuration is ideal for transistor amplifier designs.

3. Double Feedback Biasing:

By using two resistors RB1 and RB2 increase the stability concerning the variations in Beta by increasing the current flow through the base bias resistors. In this configuration, the current in RB1 is equal to 10 % of the collector current.

4. Voltage Dividing Biasing:

Voltage divider biasing in which two resistors RB1 and RB2 are connected to the base of the transistor forming a voltage divider network. The transistor gets biases by the voltage drop across RB2. This kind of biasing configuration is used widely in amplifier circuits.

PCB & Breadboard

A breadboard is used to make up **temporary circuits** for testing or to try out an idea. No soldering is required so it is easy to change connections and replace components. Parts are not damaged and can be re-used afterwards.

Almost all the Electronics Club website projects started life on a breadboard to check that the circuit worked as intended.

Connections on Breadboard

Breadboards have many tiny sockets (called 'holes') arranged on a 0.1" grid. The leads of most components can be pushed straight into the holes. ICs are inserted across the central gap with their notch or dot to the left.
Wire links can be made with single-core plastic-coated wire of 0.6mm diameter (the standard size), this is known as 1/0.6mm wire. I suggest buying a pack with several colours to help identify connections, red for +Vs wires, black for 0V, and so on.

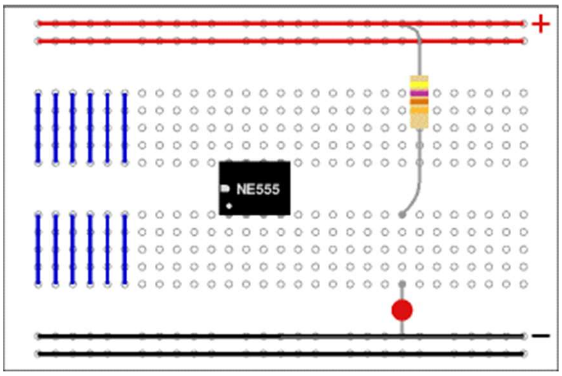

Fig.13: Breadboard

The top and bottom rows are linked **horizontally** all the way across as shown by the **red** and **black** lines on the diagram. The power supply is connected to these rows, + at the top and 0V (zero volts) at the bottom.

I suggest using the upper row of the bottom pair for 0V, then you can use the lower row for the negative supply with circuits requiring a dual supply (e.g. +9V, 0V, -9V).

The other holes are linked **vertically** in blocks of 5 with no link across the centre as shown by the **blue** lines on the diagram. Notice how there are separate blocks of connections to each pin of ICs.

Larger Breadboards

On larger breadboards there may be a break halfway along the top and bottom power supply rows. It is a good idea to link across the gap before you start to build a circuit, otherwise you may forget and part of your circuit will have no power!

Building a Circuit on Breadboard

Converting a circuit diagram to a breadboard layout is not straightforward because the arrangement of components on breadboard will look quite different from the circuit diagram.

When putting parts on breadboard you must concentrate on their **connections**, not their positions on the circuit diagram. The IC (chip) is a good starting point so place it in the centre of the breadboard and work round it pin by pin, putting in all the connections and components for each pin in turn.

What's a PCB?

Printed circuit board is the most common name but may also be called "printed wiring boards" or "printed wiring cards". Before the advent of the PCB circuits were constructed through a laborious process of point-to-point wiring. This led to frequent failures at wire junctions and short circuits when wire insulation began to age and crack.

A significant advance was the development of wire wrapping, where a small gauge wire is literally wrapped around a post at each connection point, creating a gas-tight connection which is highly durable and easily changeable.

As electronics moved from vacuum tubes and relays to silicon and integrated circuits, the size and cost of electronic components began to decrease. Electronics became more prevalent in consumer goods, and the pressure to reduce the size and manufacturing costs of electronic products drove manufacturers to look for better solutions. Thus was born the PCB.

PCB is an acronym for *printed circuit board*. It is a board that has lines and pads that connect various points together. In the picture above, there are traces that electrically connect the various connectors and components to each other. A PCB allows signals and power to be routed between physical devices. Solder is the metal that makes the electrical connections between the surface of the PCB and the electronic components. Being metal, solder also serves as a strong mechanical adhesive.

Terminology

Now that you've got an idea of what a PCB structure is, let's define some terms that you may hear when dealing with PCBs:

- **Annular ring** - the ring of copper around a plated through hole in a PCB.
- **DRC** - design rule check. A software check of your design to make sure the design does not contain errors such as traces that incorrectly touch, traces too skinny, or drill holes that are too small.
- **Drill hit** - places on a design where a hole should be drilled, or where they actually were drilled on the board. Inaccurate drill hits caused by dull bits are a common manufacturing issue.
- **Finger** - exposed metal pads along the edge of a board, used to create a connection between two circuit boards. Common examples are along the edges of computer expansion or memory boards and older cartridge-based video games.
- **Mouse bites** - an alternative to v-score for separating boards from panels. A number of drill hits are clustered close together, creating a weak spot where the board can be broken easily after the fact. See the SparkFun Protosnap boards for a good example.
- **Pad** - a portion of exposed metal on the surface of a board to which a component is soldered.
- **Panel** - a larger circuit board composed of many smaller boards which will be broken apart before use. Automated circuit board handling equipment frequently has trouble with smaller boards, and by aggregating several boards together at once, the process can be sped up significantly.

LED

As is evident from its name, LED (Light Emitting Diode) is basically a small light emitting device that comes under "active" semiconductor electronic components. It's quite comparable to the normal general purpose diode, with the only big difference being its capability to emit light in different colors. The two terminals (anode and cathode) of a LED when connected to a voltage source in the correct polarity, may produce lights of different colors, as per the semiconductor substance used inside it.

Working Principle:

A light-emitting diode is a two-lead semiconductor light source. It is a p–n junction diode that emits light when activated. When a suitable voltage is applied to the leads, electrons are able to recombine with electron holes within the device, releasing energy in the form of photons. This effect is called electroluminescence, and the color of the light (corresponding to the energy of the photon) is determined by the energy band gap of the semiconductor. Basically, LEDs are just tiny light bulbs that fit easily into an electrical circuit. But unlike incandescent bulbs, they don't have filaments that burn out, they use less electricity, and they don't get especially hot. They're illuminated solely by the movement of electrons in a semiconductor material, and they last just as long as a standard transistor. The life span of an LED surpasses the short life of an incandescent bulb by thousands of hours. Because of these advantages, tiny LEDs are one of the most popular technologies used to light LCD TVs.

LEDs have several advantages over conventional incandescent lamps, but their main advantage is **efficiency**. In incandescent bulbs, the light-production process involves generating a lot of heat (the filament must be warmed to illuminate). This energy is completely wasted unless you're using the lamp as a heater, because a huge portion of the available electricity isn't going toward producing visible light. LEDs generate very little heat, relatively speaking. A much higher percentage of the electrical energy is going directly to generating light, which cuts down the electricity demands considerably.

Per watt, LEDs output more lumens (or quantities of visible light) than regular incandescent bulbs. Light emitting diodes have a higher **luminous efficacy** (how efficiently electricity is converted to visible light) than incandescents – a 60-watt incandescent bulb can generate between 750-900 lumens, but you can get the same output from a LED bulb using only 6-8 watts. And that same LED bulb can last 25,000 hours, but the 60-watt incandescent is only likely to light up for about 1,200 hours. In other words, one LED bulb can last as long as 21 60-watt incandescent bulbs burned consecutively.

Fig 14: Light Emitting Diode

Push Button and Switch

A Push Button switch is a type of switch which consists of a simple electric mechanism or air switch mechanism to turn something on or off.

Depending on model they could operate with momentary or latching action function.

The button itself is usually constructed of a strong durable material such as metal or plastic. Push Button Switches come in a range of shapes and sizes. We have a selection of push button switches here at Herga.

Push button switches are used throughout industrial and medical applications and are also recognisable in everyday life.

For uses within the Industrial sector, push buttons are often part of a bigger system and are connected through a mechanical linkage. This means that when a button is pressed it can cause another button to release.

Push button switches are present in so many areas across different industries and for different uses here are some examples;

· Calculator buttons – a hand held calculator has lots of small push button switches

· Reset switches – these are usually small and require a tool to press to avoid accidental operation

· Stopping machinery – often around industrial machinery there will be an emergency stop button, sometimes these are located on the wall

Arcade gaming – these are usually brightly coloured to encourage people to play

Fig. 15: Push Button

Integrated Circuit

Integrated circuit (IC), sometimes called a chip or microchip, is a semiconductor wafer on which a thousand or millions of tiny resistors, capacitors, and transistors are fabricated. An IC can be a function as an amplifier, oscillator, timer, counter, computer memory, or microprocessor. An exact IC is categorized as either linear (analog) or digital depending on its future application. Integrated circuits distorted all that. The fundamental idea was to obtain a complete circuit, with lots of components and the connections between them, and reconstruct the whole thing in a microscopically tiny form on the surface of a piece of silicon. It was an incredibly clever idea and it has made possible all kinds of "microelectronic" gadgets ranging from digital watches and pocket calculators to Moon-landing rockets and arms with built-in satellite navigation.

How are Integrated Circuits Made?

How do we build a memory or processor chip for a computer? It all starts with a raw compound element such as silicon, which is chemically treated or doped to create it and it has different electrical properties.

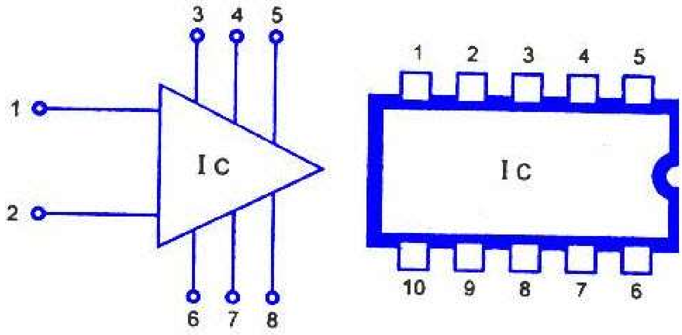

Fig. 16: IC Symbol

Doping Semiconductors

Conventionally, people think about equipment fitting into two neat categories: those that allow electricity to flow through them quite readily (conductors) and those that don't (insulators). Metals make up most of the conductors, while nonmetals such as plastics, wood, and glass are the insulators. In fact, the effects are far more complex than this, particularly when it comes to defining elements in the center of the periodic table (in groups 14 and 15), notably silicon and germanium. Usually, insulators are the elements that are prepared to perform more like conductors if we insert small quantities of impurities to them in a procedure known as doping. If you add antimony to silicon, you provide it slightly extra electrons than it would usually include the power to conduct electricity. Silicon "doped" that way is called n-type silicon. When you add boron instead of antimony, you take away some of silicon's electrons, leaving behind “holes” that work as “negative electrons,”; next, transport a positive electric current in the opposite way. Such type of silicon is called p-type. Putting areas of n-type and p-type silicon side by side to create junctions wherein electrons act in very attractive ways is the way in which we generate electronically, semiconductor devices like diodes, transistors, and memories.

Uses of Integrated Circuits

The integrated circuit uses a semiconductor material (read chips) as the working table and frequently silicon is selected for the task. Afterwards, electrical components such as diodes, transistors and resistors, etc. are added to this chip in minimized form. Electrical components are joined together in such a way that they are able to carry out multiple tasks and calculations. The silicon is known as a wafer in this assembly.

In this article, we have discussed about the integrated circuit briefly including what is an integrated circuit, how integrated circuits are made, and so on. Two types of methods have been used to build integrated circuits with the help of a doping semiconductor, inside chip plant. We have dealt with the different types of integrated circuits like digital integrated circuits, analog integrated circuits and finally mixed signals with examples. In addition uses of integrated circuit and applications of integrated circuits have also been discussed.

Linear ICs have continuously variable output (theoretically capable of attaining an infinite number of states) that depends on the input signal level. As the term implies, the output signal level is a linear function of the input signal level. Ideally, when the instantaneous output is graphed against the instantaneous input, the plot appears as a straight line. Linear ICs are used as audio-frequency (AF) and radio-frequency (RF) amplifiers. The *operational amplifier*(op amp) is a common device in these applications.

Digital ICs operate at only a few defined levels or states, rather than over a continuous range of signal amplitudes. These devices are used in computers, computer networks, modems, and frequency counters. The fundamental building blocks of digital ICs are logic gates, which work with binary data, that is, signals that have only two different states, called low (logic 0) and high (logic 1).

IMPLEMENTATION OF PREPAID SYSTEM

Electricity Metering The project presents a robust system which allows the consumer to use electricity by making payments in a prepaid manner, just like the recharge of a mobile SIM is carried out. The user can recharge his/her system account by sending a simple SMS to the system. This SMS recharges the User's account. The system also sends alerts to the user in case of low balance in the system to remind the user to recharge. The system cuts off the power supply when the balance of the system falls to zero based upon calculation of the amount of electricity being consumed by the load. The implementation is shown in Fig. 2. The load connected to the load side of the electricity meter is a bulb of 200 Watts. The SPDT relay is connected to the load on one side and is provided input from the Arduino for the triggering of the load. The single phase electricity meter is connected to 220 Volts 50 Hz AC supply. The LDR sensor is employed such that it receives maximum intensity of light when the Calibration LED blinks. The frequency of the blinking of the Cal.LED depends on the load connected to the load end of the meter. Higher loads correspond to increased frequency of LED blinks and vice versa is true for small value of loads connected. The LDR detects this blinking and the units consumed by the load are calculated.

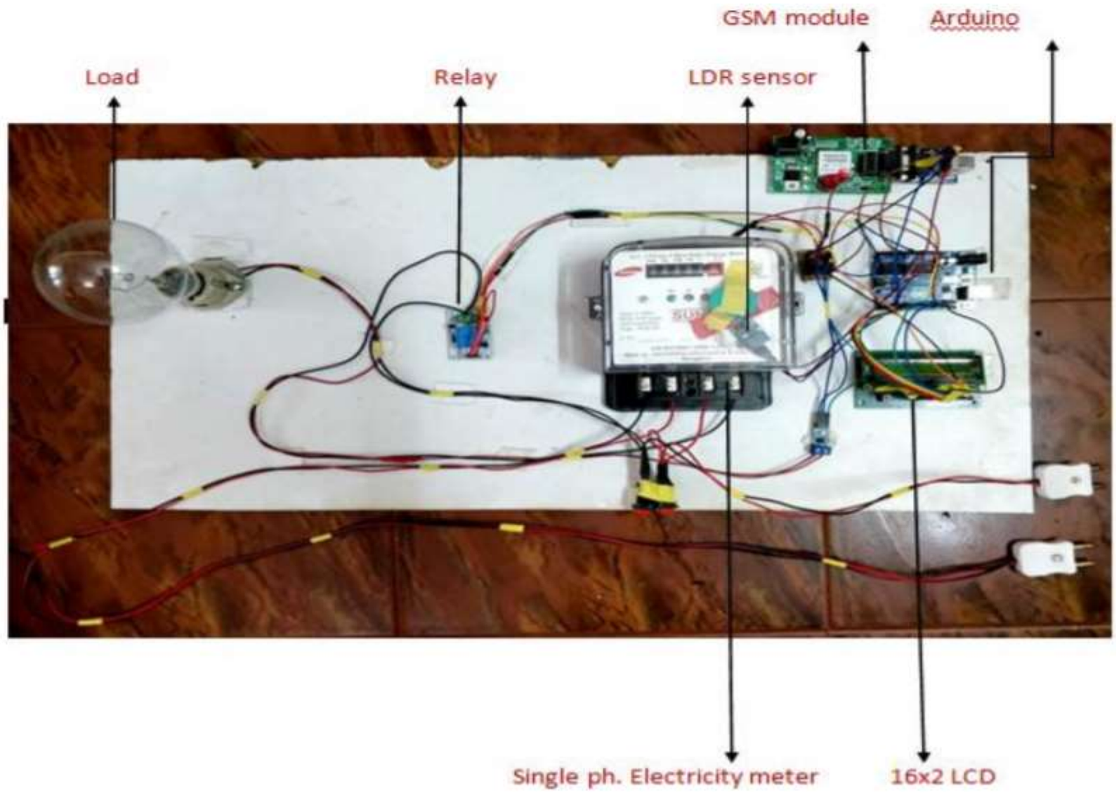

Fig. 17: Prepaid energy meter with theft detection Connection

ALGORITHM

Step 1: Initialise balance=1,count=0,units=0

Step 2: Check if (tampering) == yes goto step 3 else goto step 4.

Step 3: Send "Tampering detected" text message to the electricity board. Trigger relay to turn off load. int subsequent message on LCD.

Step 4: Check if (balance>1),if yes GoTo step 5 else goto Step 9 .

Step 5: Turn on the system, intimate the subscriber regarding the same.

Step 6: Compute the number of units remaining and update the balance.

Step 7: Check (if balance less than or equal to 5), if yes goto step 8.

Step 8: Send message to the subscriber regarding low System balance. Print "Low Balance" message on LCD.

Step 9: Check (theft),if yes, GoTo step 10 else GoTo step 11

Step 10: Intimate the electricity board by sending message "Theft is Detected".

Step 11: Open live terminal to receive message in the GSM module.

Step 12: Check for message, if message is received GoTo step 13 else goto step 11.

Step 13: Read message from memory and extract.

Step 14: Check, if (message received ==#).If yes,Update the system balance as balance =balance+10.

Step 15: Send message to user about recharge success and goto step 2.

FLOW CHART

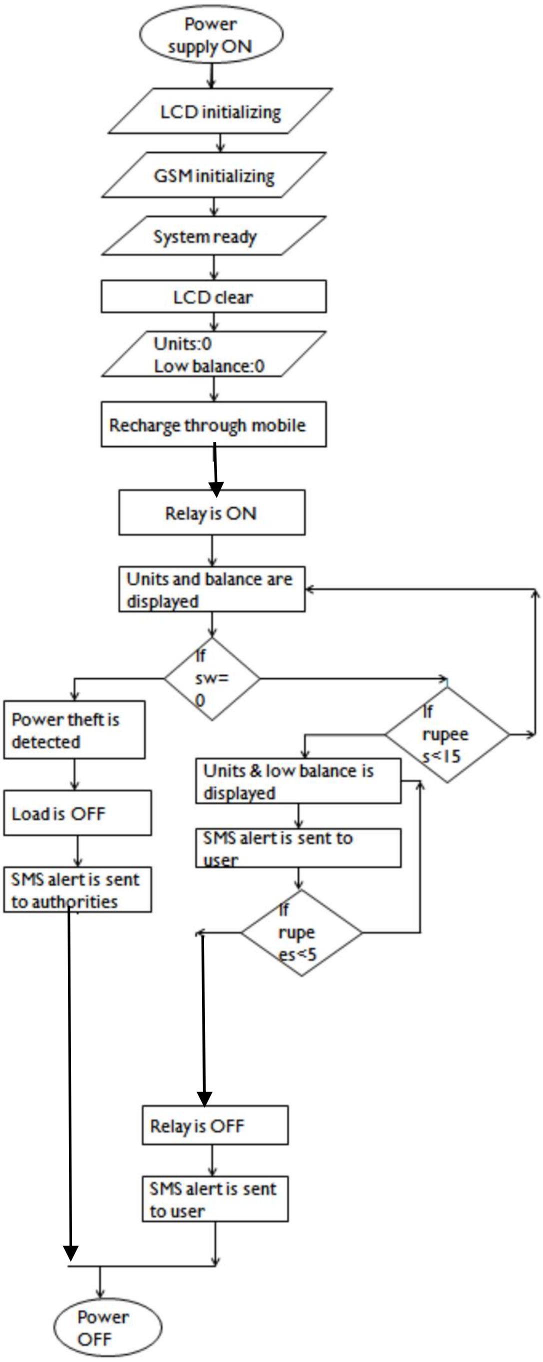

Fig. 18: Flow Chart of Programming

RESULTS AND DISCUSSION

The system switches the power supply ON only if the balance in the system is greater than or equal to 1 Rupees. The system calculates the amount of power consumed by the load connected and deducts the subsequently from the balance amount. The system sends alerts to the user as shown in figure.

1. The system balance is Re. 1 to remind the user to recharge.

2. When balance falls to 0 informing that power is cut off.

3. The system is recharged by the user.

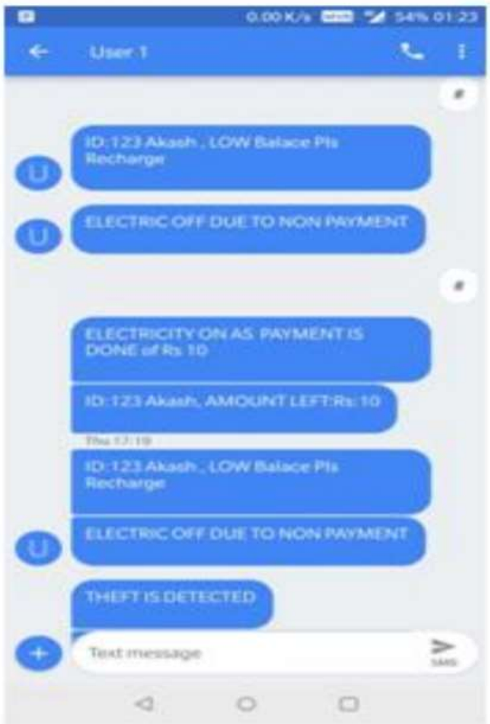

Fig. 19: SMS alerts received by user on the registered Number

The user can recharge the system simply by sending a SMS to the system (#-recharges the system for rupees 10).The system receives the message through the GSM module. After the message is received it is decoded by the Arduino based upon the code and recharges the system and sends alert to user that recharge of Rs 10 is done as shown in Fig.4 (considering # is sent by the user) and switches back the power ON by triggering the relay.

The system is made tamper proof by offering a simple mechanism where the system switches OFF the power supply by triggering the relay whenever the electricity meter protective casing is lifted or someone tries to force it open. This has been done so that the practice of manipulating the readings of the meter by the users to use electricity free of cost or at a much reduced cost is checked. The system intimates the electricity board whenever a user tries to utilize electricity even after the balance in his/her account falls to zero by employing a current sensor which senses the electricity owing through the load end of the meter even after the power supply is turned OFF after the balance has become zero. This keeps unauthorized usage of electricity in check by detecting theft of electricity at the household level as shown in Fig.5

Fig. 20: Alerts received when Tampering is detected.

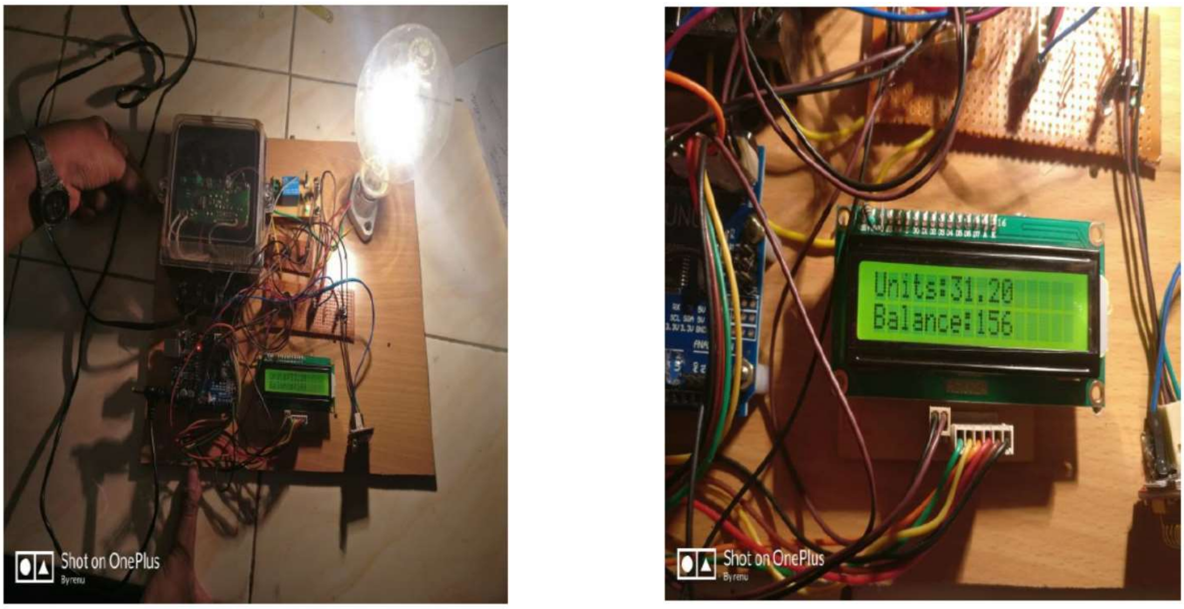

Fig. 21: Recharge is done and the balance & units goes on decreasing as the load consumes energy

CONCLUSION

The project Prepaid electricity meter with theft detection has been implemented successfully and has applications in households especially in rural areas. This system can be adopted widely because of its low cost and also because it stops revenue leakage to the already burdened electricity boards because of electricity theft. The main advantage of this project is its low cost solution for prepaid metering of electricity usage and also stops theft of electricity at household level. The facility of tamper detection stops any intrusions by the user into the electricity meter to alter or stop the calculation of units being consumed.

Prepaid energy meter with power theft detection is easy to install and beneficial for both energy provider and consumer. This project reduces the manual efforts and human errors, by monitoring all the parameters and functioning of the connections. Also by implementing this system we can control the usage of electricity on consumer side to avoid wastage of power. An attempt is made in this work to develop a system, which when interfaced with static electronic energy meter is avoided where in complexity of the circuit is reduced and cost also gets reduced of the meter. This system avoids electricity theft to large extent and makes the energy meter tamper proof. This meter increases the revenue of the Government by detecting the unauthorized tampering in the power lines

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