ADVANCED HYBRID SMART GRID

A Project report submitted in partial fulfilment

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Bachelor of Technology

In

ELETRICAL ENGINEERING

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CERTIFICATE

To whom it may concern

This is to certify that the project work entitled (**ADVANCED HYBRID SMART GRID)** is the bona fide work carried out by **(SOHAM NANDI(11701618026) SOURO BISWAS(11701618019) SHAYAK GANGULY(11701618027) ANKIT GUPTA(11701618060)** , a student of B.Tech in the Dept. of Electrical Engineering, RCC Institute of Information Technology (RCCIIT), Canal South Road, Beliaghata, Kolkata-700015, affiliated to Maulana Abul Kalam Azad University of Technology (MAKAUT), West Bengal, India, during the academic year 2021-22, in partial fulfillment of the requirements for the degree of Bachelor of Technology in Electrical Engineering and this project has not submitted previously for the award of any other degree, diploma and fellowship.

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ABBREVIATIONS AND ACRONYMS

OLED – Organic Light Emitting Diode

Transformer-

Pin terminal-

SOC – System on a chip

IC - Integrated Circuit

PCB – Printed Circuit Board (Veroboard)

µC – Micro Controller (Arduino Nano)

Battery-

Inductor-

Capacitor-

MOSFET-

COM – Common LED - Light Emitting Diode

POT – Potentiometer

SMPS – Switch Mode Power Supply

USB – Universal serial bus

ABTRACT

In these days disruption of power supply is very common issue faced by majority in which any fault in feeder or main distribution lines lead to a complete blackout due to which whole system will be out of order and functionality of industries will be stopped.

But smart grid system has capability to secure the system on the spot by handling emergencies because they possess the ability of automatic rerouting in case of any fault current . Smart Grids are not only providing the link between consumers and utilities moreover they enable users to handle their electricity usage systematically like we use online banking from anywhere any time.

Management of electricity in well-organized matter will clearly lead to cost reduction. One of the interesting application is smart meters. With the help of smart meters we need not to wait a whole month to get electricity bill rather we can see reading and receive bill daily online which will obviously save money for consumers and save electricity or power for whole country which will provide support in economical stability of the country.

Coming toward the precautions as this system has wide range of technical data and equipment along with automation equipments and protocols, so most important thing will be to ensure whether the system is properly installed because, if there will be no loop holes in deployment of this technology, smart grids on global level will bring revolution in power sector same as internet did transformation in the World of IT

Applications of a Smart Grid System

Deployment of Digital Technology in smart grids ensures the reliability, efficiency and accessibility to the consumers regarding all utilities which count towards the economic stability of the nation. Right at the start of transition time it become perilous to execute testing, to improve the technology by up gradation, developing and maintaining standards on a standard threshold and also application of these efficient grids serve all these problems

Basic applications of smart grids are

- *They improve the adeptness of transmission lines*
- *Quick recovery after any sudden breakage/disturbance in lines and feeders*
- *Cost Reduction*
- *Reduction of peak demand*
- *They possess the ability to be integrated with renewable energy sources on a large level which leads to sharing of load and reduction of load on large scale*

(INTRODUCTION)
CHAPTER 1

Historical development of the electricity grid

The first **alternating current power grid** system was installed in 1886 in **Great Barrington, Massachusetts**.At that time, the grid was a centralized unidirectional system of **electric power transmission, electricity distribution**, and demand-driven control.

In the 20th century, local grids grew over time and were eventually interconnected for economic and reliability reasons. By the 1960s, the electric grids of developed countries had become very large, mature, and highly interconnected, with thousands of 'central' generation power stations delivering power to major load centres via high capacity power lines which were then branched and divided to provide power to smaller industrial and domestic users over the entire supply area. The topology of the 1960s grid was a result of the strong economies of scale: large coal-, gas- and oil-fired power stations in the 1 GW (1000 MW) to 3 GW scale are still found to be cost-effective, due to efficiency-boosting features that can be cost-effective only when the stations become very large.

Power stations were located strategically to be close to fossil fuel reserves (either the mines or wells themselves or else close to rail, road, or port supply lines). Siting of hydroelectric dams in mountain areas also strongly influenced the structure of the emerging grid. Nuclear power plants were sited for the availability of cooling water. Finally, **fossil fuel**-fired power stations were initially very polluting and were sited as far as economically possible from population centres once electricity distribution networks permitted it. By the late 1960s, the electricity grid reached the overwhelming majority of the population of developed countries, with only outlying regional areas remaining 'off-grid'.

Metering of electricity consumption was necessary on a per-user basis in order to allow appropriate billing according to the (highly variable) level of consumption of different users. Because of limited data collection and processing capability during the period of growth of the grid, fixed-tariff arrangements were commonly put in place, as well as dual-tariff arrangements where night-time power was charged at a lower rate than daytime power. The motivation for dual-tariff arrangements was the lower night-time demand. Dual tariffs made possible the use of low-cost night-time electrical power in applications such as the maintaining of 'heat banks' which served to 'smooth out' the daily demand, and reduce the number of turbines that needed to be turned off overnight, thereby improving the utilisation and profitability of the generation and transmission facilities. The metering capabilities of the 1960s grid meant technological limitations on the degree to which **price signals** could be propagated through the system.

From the 1970s to the 1990s, growing demand led to increasing numbers of power stations. In some areas, the supply of electricity, especially at peak times, could not keep up with this demand, resulting in poor **power quality** including **blackouts**, power cuts, and **brownouts**. Increasingly, electricity was depended on for industry, heating, communication, lighting, and entertainment, and consumers demanded ever-higher levels of reliability.

Towards the end of the 20th century, electricity demand patterns were established: domestic heating and **air-conditioning** led to daily peaks in demand that were met by an array of 'peaking power generators' that would only be turned on for short periods each day. The relatively low utilisation of these peaking generators (commonly, **gas turbines** were used due to their relatively lower capital cost and faster start-up times), together with the necessary redundancy in the electricity grid, resulting in high costs to the electricity companies, which were passed on in the form of increased tariffs.

In the 21st century, some developing countries like China, India, and Brazil were seen as pioneers of smart grid deployment

Modernization opportunities

Since the early 21st century, opportunities to take advantage of improvements in electronic communication technology to resolve the limitations and costs of the electrical grid have become apparent. Technological limitations on metering no longer force peak power prices to be averaged out and passed on to all consumers equally. In parallel, growing concerns over environmental damage from fossil-fired power stations have led to a desire to use large amounts of **renewable energy**. Dominant forms such as **wind power** and **solar power** are highly variable, and so the need for more sophisticated control systems became apparent, to facilitate the connection of sources to the otherwise highly controllable grid.[9] Power from **photovoltaic cells** (and to lesser extent **wind turbines)** has also, significantly, called into question the imperative for large, centralised power stations. The rapidly falling costs point to a major change from the centralised grid topology to one that is highly distributed, with power being both generated *and* consumed right at the limits of the grid. Finally, growing concern over **terrorist** attacks in some countries has led to calls for a more robust energy grid that is less dependent on centralised power stations that were perceived to be potential attack targets.[10]

Definition of "smart grid”

The first official definition of Smart Grid was provided by the **Energy Independence and Security Act of 2007 (EISA-2007)**, which was approved by the US Congress in January 2007, and signed to law by **President George W. Bush** in December 2007. Title XIII of this bill provides a description, with ten characteristics, that can be considered a definition for Smart Grid, as follows:
"It is the policy of the United States to support the modernization of the Nation's electricity transmission and distribution system to maintain a reliable and secure electricity infrastructure that can meet future demand growth and to achieve each of the following, which together characterize a Smart Grid: (1) Increased use of digital information and controls technology to improve reliability, security, and efficiency of the electric grid. (2) Dynamic optimization of grid operations and resources, with full cyber-security. (3) Deployment and integration of distributed resources and generation, including renewable resources. (4) Development and incorporation of demand response, demand-side resources, and energy-efficiency resources. (5) Deployment of 'smart' technologies (real-time, automated, interactive technologies that optimize the physical operation of appliances and consumer devices) for metering, communications concerning grid operations and status, and distribution automation. (6) Integration of 'smart' appliances and consumer devices. (7) Deployment and integration of advanced electricity storage and peak-shaving technologies, including plug-in electric and hybrid electric vehicles, and thermal storage air conditioning. (8) Provision to consumers of timely information and control options. (9) Development of standards for communication and interoperability of appliances and equipment connected to the electric grid, including the infrastructure serving the grid. (10) Identification and lowering of unreasonable or unnecessary barriers to adoption of smart grid technologies, practices, and services."

The European Union Commission Task Force for Smart Grids also provides smart grid definition as:

"A Smart Grid is an electricity network that can cost efficiently integrate the behaviour and actions of all users connected to it – generators, consumers and those that do both – in order to ensure economically efficient, sustainable power system with low losses and high levels of quality and security of supply and safety. A smart grid employs innovative products and services together with intelligent monitoring, control, communication, and self-healing technologies in order to:

Better facilitate the connection and operation of generators of all sizes and technologies.

Allow consumers to play a part in optimising the operation of the system.

Provide consumers with greater information and options for how they use their supply.

Significantly reduce the environmental impact of the whole electricity supply system.

Maintain or even improve the existing high levels of system reliability, quality and security of supply.

Maintain and improve the existing services efficiently."

A common element to most definitions is the application of digital processing and communications to the power grid, making data flow and **information management** central to the smart grid. Various capabilities result from the deeply integrated use of digital technology with power grids. Integration of the new grid information is one of the key issues in the design of smart grids. Electric utilities now find themselves making three classes of transformations: improvement of infrastructure, called the *strong grid* in China; addition of the digital layer, which is the essence of the *smart grid*; and business process transformation, necessary to capitalize on the investments in smart technology. Much of the work that has been going on in electric grid modernization, especially substation and distribution automation, is now included in the general concept of the smart grid.

Early technological innovations

Smart grid technologies emerged from earlier attempts at using electronic control, metering, and monitoring. In the 1980s, **automatic meter reading** was used for monitoring loads from large customers and evolved into the **Advanced Metering Infrastructure** of the 1990s, whose meters could store how electricity was used at different times of the day.[12] **Smart meters** add continuous communications so that monitoring can be done in real-time, and can be used as a gateway to **demand response**-aware devices and "smart sockets" in the home. Early forms of such **demand side management** technologies were **dynamic demand** aware devices that passively sensed the load on the grid by monitoring changes in the power supply frequency. Devices such as industrial and domestic air conditioners, refrigerators, and heaters adjusted their duty cycle to avoid activation during times the grid was suffering a peak condition. Beginning in 2000, Italy's Telegestore Project was the first to network large numbers (27 million) of homes using smart meters connected via low bandwidth **power line communication**. Some experiments used the term **broadband over power lines** (BPL), while others used wireless technologies such as **mesh networking** promoted for more reliable connections to disparate devices in the home as well as supporting metering of other utilities such as gas and water.[9]

Monitoring and synchronization of wide-area networks were revolutionized in the early 1990s when the **Bonneville Power Administration** expanded its smart grid research with prototype **sensors** that are capable of very rapid analysis of anomalies in electricity quality over very large geographic areas. The culmination of this work was the first operational Wide Area Measurement System (WAMS) in 2000. Other countries are rapidly integrating this technology — China started having a comprehensive national WAMS when the past 5-year economic plan was completed in 2012.

The earliest deployments of smart grids include the Italian system *Telegestore* (2005), the mesh network of **Austin, Texas** (since 2003), and the smart grid in **Boulder, Colorado** (2008). See below.

Features

The smart grid represents the full suite of current and proposed responses to the challenges of electricity supply. Because of the diverse range of factors, there are numerous competing taxonomies and no agreement on a universal definition. Nevertheless, one possible categorization is given here.

Reliability

The smart grid makes use of technologies such as state estimation, that improve **fault detection** and allow **self-healing** of the network without the intervention of technicians. This will ensure a more reliable supply of electricity and reduce vulnerability to natural disasters or attacks.

Although multiple routes are touted as a feature of the smart grid, the old grid also featured multiple routes. Initial power lines in the grid were built using a radial model, later connectivity was guaranteed via multiple routes, referred to as a network structure. However, this created a new problem: if the current flow or related effects across the network exceed the limits of any particular network element, it could fail, and the current would be shunted to other network elements, which eventually may fail also, causing a **domino effect**. See **power outage**. A technique to prevent this is load shedding by **rolling blackout** or voltage reduction (brownout).

Flexibility in network topology

Next-generation transmission and distribution infrastructure will be better able to handle possible bidirectional energy flows, allowing for **distributed generation** such as from photovoltaic panels on building roofs, but also charging to/from the batteries of electric cars, wind turbines, pumped hydroelectric power, the use of fuel cells, and other sources.

Classic grids were designed for a one-way flow of electricity, but if a local sub-network generates more power than it is consuming, the reverse flow can raise safety and reliability issues.[19] A smart grid aims to manage these situations.[9]

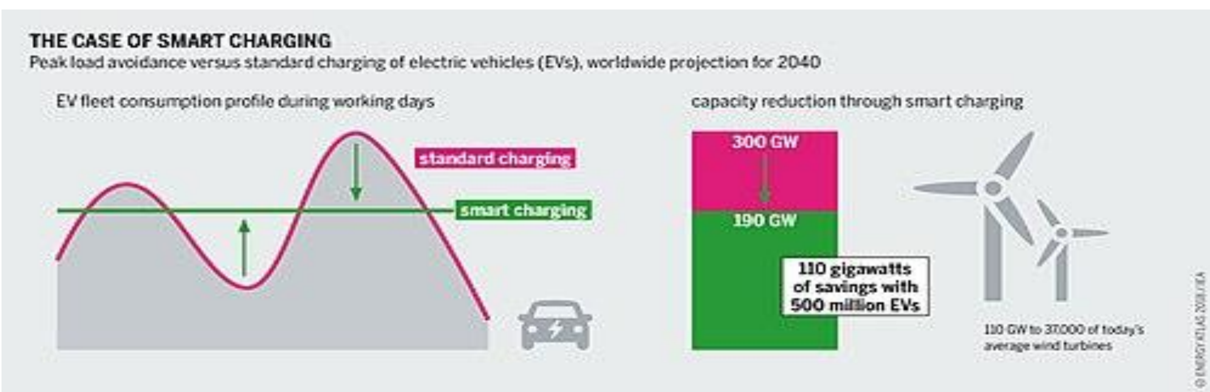
Efficiency

Numerous contributions to the overall improvement of the efficiency of energy infrastructure are anticipated from the deployment of smart grid technology, in particular including demand-side management, for example turning off air conditioners during short-term spikes in electricity price, **reducing the voltage when possible on distribution lines Archived** 2013-06-27 at the **Wayback Machine** through Voltage/VAR Optimization (VVO), eliminating truck-rolls for meter reading, and reducing truck-rolls by improved outage management using data from Advanced Metering Infrastructure systems. The overall effect is less redundancy in transmission and distribution lines, and greater utilization of generators, leading to lower power prices

Load adjustment/Load balancing

The total load connected to the power grid can vary significantly over time. Although the total load is the sum of many individual choices of the clients, the overall load is not necessarily stable or slow varying. For example, if a popular television program starts, millions of televisions will start to draw current instantly. Traditionally, to respond to a rapid increase in power consumption, faster than the start-up time of a large generator, some spare generators are put on a dissipative standby mode.[A smart grid may warn all individual television sets, or another larger customer, to reduce the load temporarily[20] (to allow time to start up a larger generator) or continuously (in the case of limited resources). Using mathematical prediction algorithms it is possible to predict how many standby generators need to be used, to reach a certain failure rate. In the traditional grid, the failure rate can only be reduced at the cost of more standby generators. In a smart grid, the load reduction by even a small portion of the clients may eliminate the problem.

Peak curtailment/leveling and time of use pricing



To reduce demand during the high-cost peak usage periods, communications and metering technologies inform smart devices in the home and business when energy demand is high and track how much electricity is used and when it is used. It also gives utility companies the ability to reduce consumption by communicating to devices directly in order to prevent system overloads. Examples would be a utility reducing the usage of a group of electric vehicle **charging stations** or shifting temperature set points of air conditioners in a city.[20] To motivate them to cut back use and perform what is called peak curtailment or peak leveling, prices of electricity are increased during high demand periods and decreased during low demand periods.[9] It is thought that consumers and businesses will tend to consume less during high-demand periods if it is possible for consumers and consumer devices to be aware of the high price premium for using electricity at peak periods. This could mean making trade-offs such as cycling on/off air conditioners or running dishwashers at 9 pm instead of 5 pm. When businesses and consumers see a direct economic benefit of using energy at off-peak times, the theory is that they will include the energy cost of operation into their consumer device and building construction decisions and hence become more energy efficient.

Sustainability

The improved flexibility of the smart grid permits greater penetration of highly variable renewable energy sources such as **solar power** and **wind power,** even without the addition of **energy storage.** Current network infrastructure is not built to allow for many distributed feed-in points, and typically even if some feed-in is allowed at the local (distribution) level, the transmission-level infrastructure cannot accommodate it. Rapid fluctuations in distributed generation, such as due to cloudy or gusty weather, present significant challenges to power engineers who need to ensure stable power levels through varying the output of the more controllable generators such as gas turbines and hydroelectric generators. Smart grid technology is a necessary condition for very large amounts of renewable electricity on the grid for this reason. There is also support for **vehicle-to-grid.**

Market-enabling

The smart grid allows for systematic communication between suppliers (their energy price) and consumers (their willingness-to-pay), and permits both the suppliers and the consumers to be more flexible and sophisticated in their operational strategies. Only the critical loads will need to pay the peak energy prices, and consumers will be able to be more strategic in when they use energy. Generators with greater flexibility will be able to sell energy strategically for maximum profit, whereas inflexible generators such as base-load steam turbines and wind turbines will receive a varying tariff based on the level of demand and the status of the other generators currently operating. The overall effect is a signal that awards energy efficiency, and energy consumption that is sensitive to the time-varying limitations of the supply. At the domestic level, appliances with a degree of energy storage or **thermal mass** (such as refrigerators, heat banks, and heat pumps) will be well placed to 'play' the market and seek to minimise energy cost by adapting demand to the lower-cost energy support periods. This is an extension of the dual-tariff energy pricing mentioned above.

Demand response support

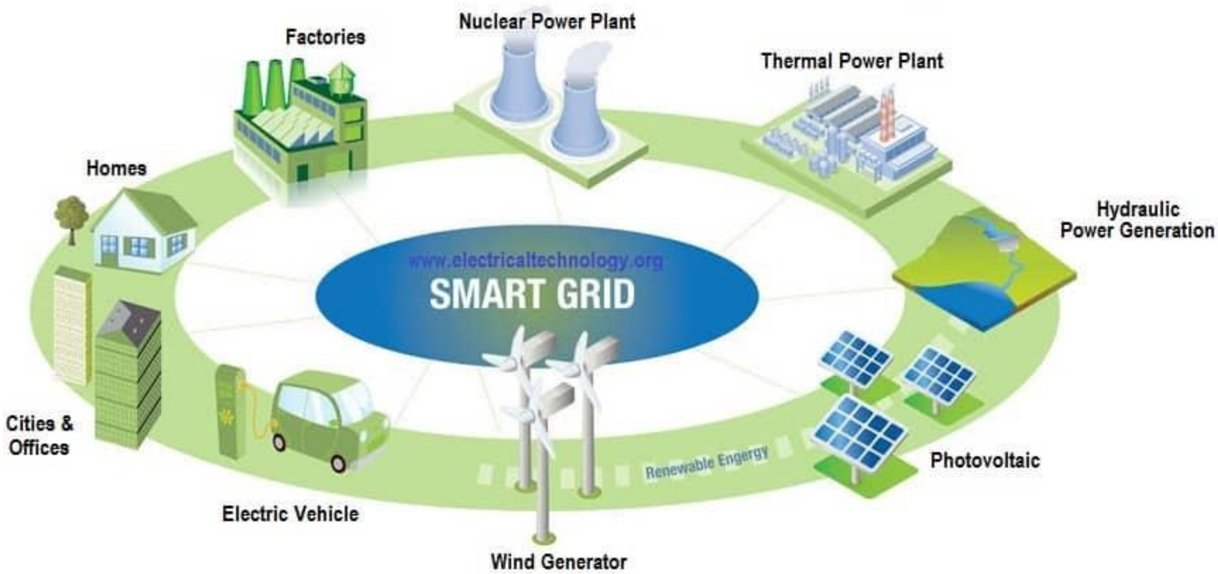
Demand response support allows generators and loads to interact in an automated fashion in real-time, coordinating demand to flatten spikes. Eliminating the fraction of demand that occurs in these spikes eliminates the cost of adding reserve generators, cuts **wear and tear** and extends the life of equipment, and allows users to cut their energy bills by telling low priority devices to use energy only when it is cheapest.

Currently, power grid systems have varying degrees of communication within control systems for their high-value assets, such as in generating plants, transmission lines, substations, and major energy users. In general, information flows one way, from the users and the loads they control back to the utilities. The utilities attempt to meet the demand and succeed or fail to varying degrees (brownouts, rolling blackout, uncontrolled blackout). The total amount of power demanded by the users can have a very wide **probability distribution** which requires spare generating plants in standby mode to respond to the rapidly changing power usage. This one-way flow of information is expensive; the last 10% of generating capacity may be required as little as 1% of the time, and brownouts and outages can be costly to consumers.

Demand response can be provided by commercial, residential loads, and industrial loads. For example, Alcoa's Warrick Operation is participating in MISO as a qualified Demand Response Resource,[24] and the Trimet Aluminium uses its smelter as a short-term mega-battery.

Latency of the data flow is a major concern, with some early smart meter architectures allowing actually as long as 24 hours delay in receiving the data, preventing any possible reaction by either supplying or demanding devices.

Advanced Hybrid smart Grid



CHAPTER 2 (THEORY)

1.1Introduction:-

Advanced hybrid smart grid is a type of smart grid which is fully operated by itself(let's take an example, suppose we have one grid which is manually operated now somehow due to some technical mismatch in load and sending end side technical glitch occurs. By using control and automation we can easily trigger our relay and disconnect the particular section of grid from the rest of the grid system. But after converting our grid system to advanced hybrid grid system we can easily manage the power at load and sending end , control the power factor, monitoring the particularly which section of consumes more power which section consumes less power, in which section of the transmission line fault may occur. All the process can be done by signal processing, data accusation, data optimisation, data processing in the system)

From the recent data, UK is now 44% of all meters are smart or advanced meter. As of 31st march of 2021 there were 24.2 million smart advanced meter in homes and small level industries out of which 19.2 were fully advanced active meters. https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/988831/Q1_2021_Smart_Meters_Statistics_Report.pdf
Germany and Denmark have taken a lead role in solar tech.(56%) and wind tech.(52%) respectively.

As India is targeted to carbon emission free up to 2070 that's why these 2 countries are major strategic partner of India. In recent days India has dealt with these two countries approx 10 bilion Dollers which indicates the importance of the green energy and all industries around this.

1.2Why India needs an advanced smart grid

To discuss about advanced smart grid our main concern should be how we can transmits our power to load side as max as possible and how the frequency plays the key role for grid failure .

At first let's us discuss about some key concept behind power system. Suppose we have one load which require constant reactive as well as active power but it is impossible to provide constant power without using smart grid. So somehow grid can't provide that much of reactive power or active power as a result dipping of voltage occur (reactive power is directly proportional to load voltage) and frequency goes down (active power is directly proportional to load angle and load angle controls generator inlet valve. If grid can't able to provide that amount of power at that synchronous generator provide that demand energy by there own kinetic energy .so kinetic energy goes down and synchronous speed as well as frequency goes down.)due to these effect power factor decreases which is harmful to overall grid system.

1.3Blackout 2012 India: Case study

In India power transmission sector are divided into three major centre

A. NLDC (National load dispatch centre):-

It has been constituted as per ministry of power, New Delhi dated 2nd of march 2005. In easy word it's main operation is to maintain constant frequency all across the India. Always gives the detail instruction to CLDC (Central load dispatch centre) that how much power they have to produced how much power demand by the load.

B. CLDC (central load dispatch centre):-

It has been constituted as per ministry of power ,New Delhi dated 2nd march 2005. Its main operation is to follow the further instruction o f NLDC and flow the demanded power to SLDC as per NLDC guide line.

C. SLDC(state load dispatch centre):-

It has been constituted as per ministry of power, New Delhi dated on 2nd march 2005. It's follows the CLDC guide line. And SLDC further instructed the different power supply organisation.

In the month of June July India always face rainy season. According to ministry of power Indian grid system is mainly network of five Gird. (**1). Northern (2) Southern (3) Central (4) Eastern (5) North-Eastern.**

The state of Punjab and Hariayana are situated in North-West side of India. Theses two states mainly connected through the central grid and northern grid.

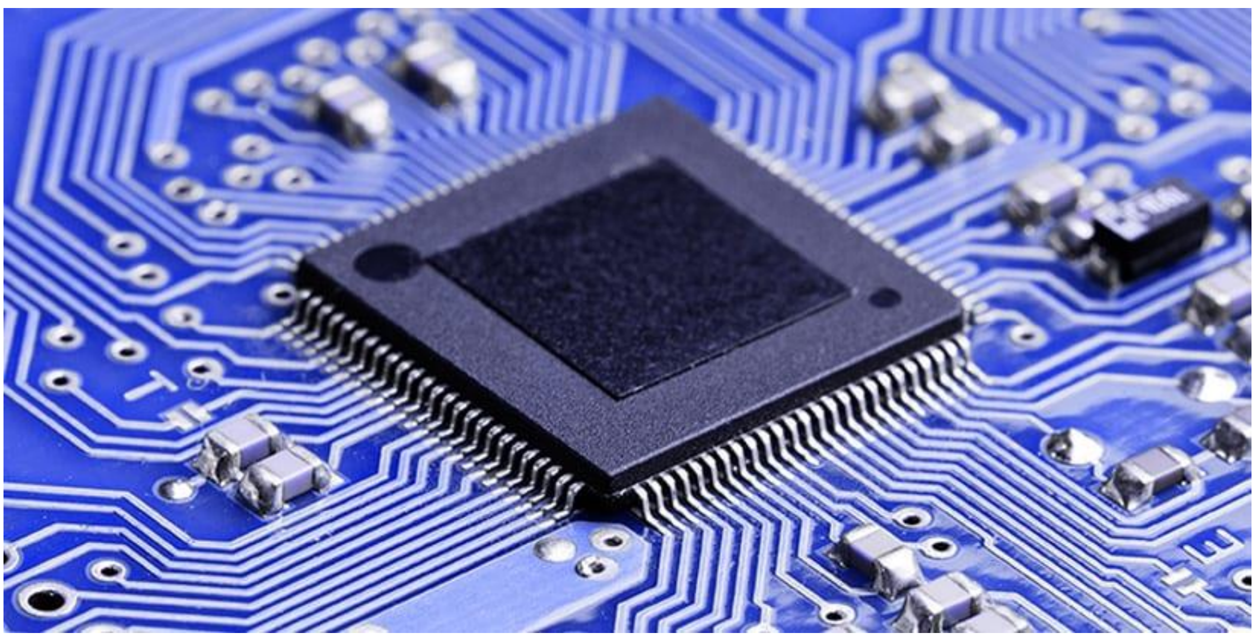
And Punjab and hariayna are plays the major role in the agriculture sector. On date 29th July of 2012

At midnight certainly there was huge energy demand faced by the state of Punjab (6000 MW only in 6hrs) due to the factor agricultural pumping, different kind of motoring system. To supply these power our generator station frequency goes down and due to some technical glitch NLDC can't able to disconnect that generator station from rest of the grid system. So as a result India was facing 2 days blackout.

After that incident to operate our grid with full safety and regulation we had to take power from Bhutan and India has decided to convert it's grid system to advanced hybrid grid system.

In the year 2013, India was decide to make hydro as well as solar into their major dc supply. Major advantage of dc supply as a power generator it's has zero transmission loss due to zero frequency. So India was set up two major hydro power station one is situated in Dibrugarh and other one is in Siliguri (under NHPC) and these are the dc supply of northern grid) .On the other hand all solar power station and plant are formed in Gujrat and Rajanthan to supply power in central grid. Now India requires power management system which convert our hybride grid system to fully advanced hybrid grid system.

MICROCONTROLER



2.1Microcontroller (MCU)

Microcontroller is a compact integrated circuit designed to govern a specific operation in an embedded system. A typical microcontroller includes a processor, memory and input/output (I/O) peripherals on a single chip.

Sometimes referred to as an embedded controller or microcontroller unit (MCU), microcontrollers are found in vehicles, robots, office machines, medical devices, mobile radio transceivers, vending machines and home appliances, among other devices. They are essentially simple miniature personal computers (PCs) designed to control small features of a larger component, without a complex front-end operating system (OS).

2.2How do microcontrollers work?

A microcontroller is embedded inside of a system to control a singular function in a device. It does this by interpreting data it receives from its I/O peripherals using its central processor. The temporary information that the microcontroller receives is stored in its data memory, where the processor accesses it and uses instructions stored in its program memory to decipher and apply the incoming data. It then uses its I/O peripherals to communicate and enact the appropriate action.

Microcontrollers are used in a wide array of systems and devices. Devices often utilize multiple microcontrollers that work together within the device to handle their respective tasks.

For example, a car might have many microcontrollers that control various individual systems within, such as the anti-lock braking system, traction control, fuel injection or suspension control. All the microcontrollers communicate with each other to inform the correct actions. Some might communicate with a more complex central computer within the car, and others might only communicate with other microcontrollers. They send and receive data using their I/O peripherals and process that data to perform their designated tasks.

2.3What are the elements of a microcontroller?

The core elements of a microcontroller are:

- The processor (CPU) -- A processor can be thought of as the brain of the device. It processes and responds to various instructions that direct the microcontroller's function. This involves performing basic arithmetic, logic and I/O operations. It also performs data transfer operations, which communicate commands to other components in the larger embedded system.
- Memory -- A microcontroller's memory is used to store the data that the processor receives and uses to respond to instructions that it's been programmed to carry out. A microcontroller has two main memory types:

1. Program memory, which stores long-term information about the instructions that the CPU carries out. Program memory is non-volatile memory, meaning it holds information over time without needing a power source.
2. Data memory, which is required for temporary data storage while the instructions are being executed. Data memory is volatile, meaning the data it holds is temporary and is only maintained if the device is connected to a power source.

- I/O peripherals -- The input and output devices are the interface for the processor to the outside world. The input ports receive information and send it to the processor in the form of binary data. The processor receives that data and sends the necessary instructions to output devices that execute tasks external to the microcontroller.

While the processor, memory and I/O peripherals are the defining elements of the microprocessor, there are other elements that are frequently included. The term *I/O peripherals* itself simply refers to supporting components that interface with the memory and processor. There are many supporting components that can be classified as peripherals. Having some manifestation of an I/O peripheral is elemental to a microprocessor, because they are the mechanism through which the processor is applied.

Other supporting elements of a microcontroller include:

- Analog to Digital Converter (ADC) -- An ADC is a circuit that converts analog signals to digital signals. It allows the processor at the center of the microcontroller to interface with external analog devices, such as sensors.
- Digital to Analog Converter (DAC) -- A DAC performs the inverse function of an ADC and allows the processor at the center of the microcontroller to communicate its outgoing signals to external analog components.
- System bus -- The system bus is the connective wire that links all components of the microcontroller together.
- Serial port -- The serial port is one example of an I/O port that allows the microcontroller to connect to external components. It has a similar function to a USB or a parallel port but differs in the way it exchanges bits.

2.4Microcontroller features

A microcontroller's processor will vary by application. Options range from the simple 4-bit, 8-bit or 16-bit processors to more complex 32-bit or 64-bit processors. Microcontrollers can use volatile memory types such as random access memory (RAM) and non-volatile memory types -- this includes flash memory, erasable programmable read-only memory (EPROM) and electrically erasable programmable read-only memory (EEPROM).

Generally, microcontrollers are designed to be readily usable without additional computing components because they are designed with sufficient onboard memory as well as offering pins for general I/O operations, so they can directly interface with sensors and other components.

Microcontroller architecture can be based on the Harvard architecture or von Neumann architecture, both offering different methods of exchanging data between the processor and memory. With a Harvard architecture, the data bus and instruction are separate, allowing for simultaneous transfers. With a Von Neumann architecture, one bus is used for both data and instructions.

Microcontroller processors can be based on complex instruction set computing (CISC) or reduced instruction set computing (RISC). CISC generally has around 80 instructions while RISC has about 30, as well as more addressing modes, 12-24 compared to RISC's 3-5. While CISC can be easier to implement and has more efficient memory use, it can have performance degradation due to the higher number of clock cycles needed to execute instructions. RISC, which places more emphasis on software, often provides better performance than CISC processors, which put more emphasis on hardware, due to its simplified instruction set and, therefore, increased design simplicity, but because of the emphasis it places on software, the software can be more complex. Which ISC is used varies depending on application.

When they first became available, microcontrollers solely used assembly language. Today, the C programming language is a popular option. Other common microprocessor languages include Python and JavaScript.

MCUs feature input and output pins to implement peripheral functions. Such functions include analog-to-digital converters, liquid crystal display (LCD) controllers, real-time clock (RTC), universal synchronous/asynchronous receiver transmitter (USART), timers, universal asynchronous receiver transmitter (UART) and universal serial bus (USB) connectivity. Sensors gathering data related to humidity and temperature, among others, are also often attached to microcontrollers.

2.5Types of microcontrollers

Common MCUs include the Intel MCS-51, often referred to as an 8051 microcontroller, which was first developed in 1985; the AVR microcontroller developed by Atmel in 1996; the programmable interface controller (PIC) from Microchip Technology; and various licensed Advanced RISC Machines (ARM) microcontrollers.

A number of companies manufacture and sell microcontrollers, including NXP Semiconductors, Renesas Electronics, Silicon Labs and Texas Instruments.

2.6Microcontroller applications

Microcontrollers are used in multiple industries and applications, including in the home and enterprise, building automation, manufacturing, robotics, automotive, lighting, smart energy, industrial automation, communications and internet of things (IoT) deployments.

One very specific application of a microcontroller is its use as a digital signal processor. Frequently, incoming analog signals come with a certain level of noise. Noise in this context means ambiguous values that cannot be readily translated into standard digital values. A microcontroller can use its ADC and DAC to convert the incoming noisy analog signal into an even outgoing digital signal.

The simplest microcontrollers facilitate the operation of electromechanical systems found in everyday convenience items, such as ovens, refrigerators, toasters, mobile devices, key fobs, video game systems, televisions and lawn-watering systems. They are also common in office machines such as photocopiers, scanners, fax machines and printers, as well as Smart meters, ATMs and security systems.

More sophisticated microcontrollers perform critical functions in aircraft, spacecraft, ocean-going vessels, vehicles, medical and life-support systems as well as in robots. In medical scenarios, microcontrollers can regulate the operations of an artificial heart, kidney or other organs. They can also be instrumental in the functioning of prosthetic devices.

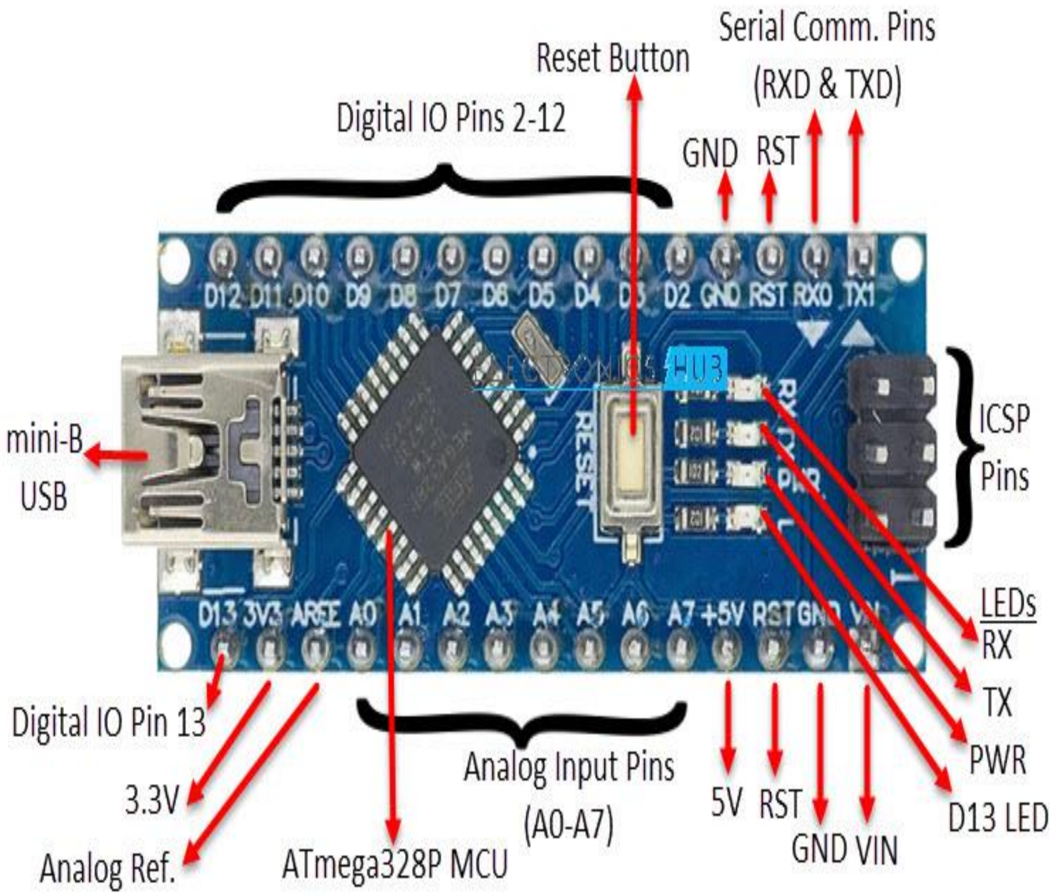
2.7ARDUINO NANO:-

The Arduino Nano is Arduino's classic breadboard friendly designed board with the smallest dimensions. The Arduino Nano comes with pin headers that allow for an easy attachment onto a breadboard and features a Mini-B USB connector.

SPECIFICATION OF NANO

Board	**Name**	Arduino® Nano
	SKU	A000005
Microcontroller	ATmega328	
USB connector	Mini-B USB	
Pins	**Built-in LED Pin**	13
	Digital I/O Pins	14
	Analog input pins	8
	PWM pins	6
Communication	**UART**	RX/TX
	I2C	A4 (SDA), A5 (SCL)
	SPI	D11 (COPI), D12 (CIPO), D13 (SCK). Use any GPIO for Chip Select (CS).
Power	**I/O Voltage**	5V
	Input voltage (nominal)	7-12V
	DC Current per I/O Pin	20 mA
Clock speed	**Processor**	ATmega328 16 MHz
Memory	**ATmega328P**	2KB SRAM, 32KB flash 1KB EEPROM

	Weight	5gr
Dimensions	**Width**	18 mm



2.8ARDUINO IDE INSTALLATION

After learning about the main parts of the Arduino UNO board, we are ready to learn how to set up the Arduino IDE. Once we learn this, we will be ready to upload our program on the Arduino board.

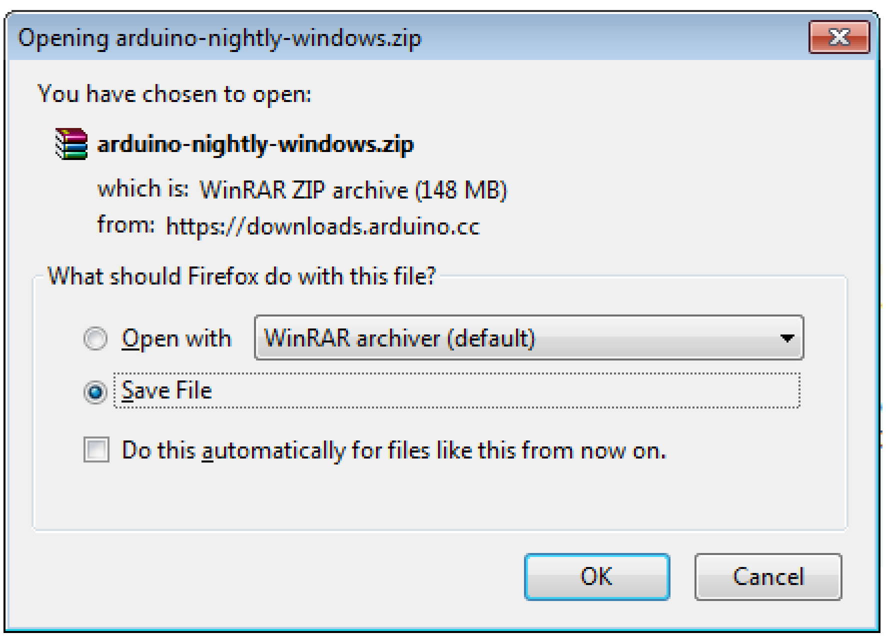
In this section, we will learn in easy steps, how to set up the Arduino IDE on our computer and prepare the board to receive the program via USB cable.

Step 1 – First you must have your Arduino board (you can choose your favorite board) and a USB cable. In case you use Arduino UNO, Arduino Duemilanove, Nano, Arduino Mega 2560, or Diecimila, you will need a standard USB cable (A plug to B plug), the kind you would connect to a USB printer as shown in the following image.

In case you use Arduino Nano, you will need an A to Mini-B cable instead as shown in the following image.

Step 2 – Download Arduino IDE Software.

You can get different versions of Arduino IDE from the Download page on the Arduino Official website. You must select your software, which is compatible with your operating system (Windows, IOS, or Linux). After your file download is complete, unzip the file.



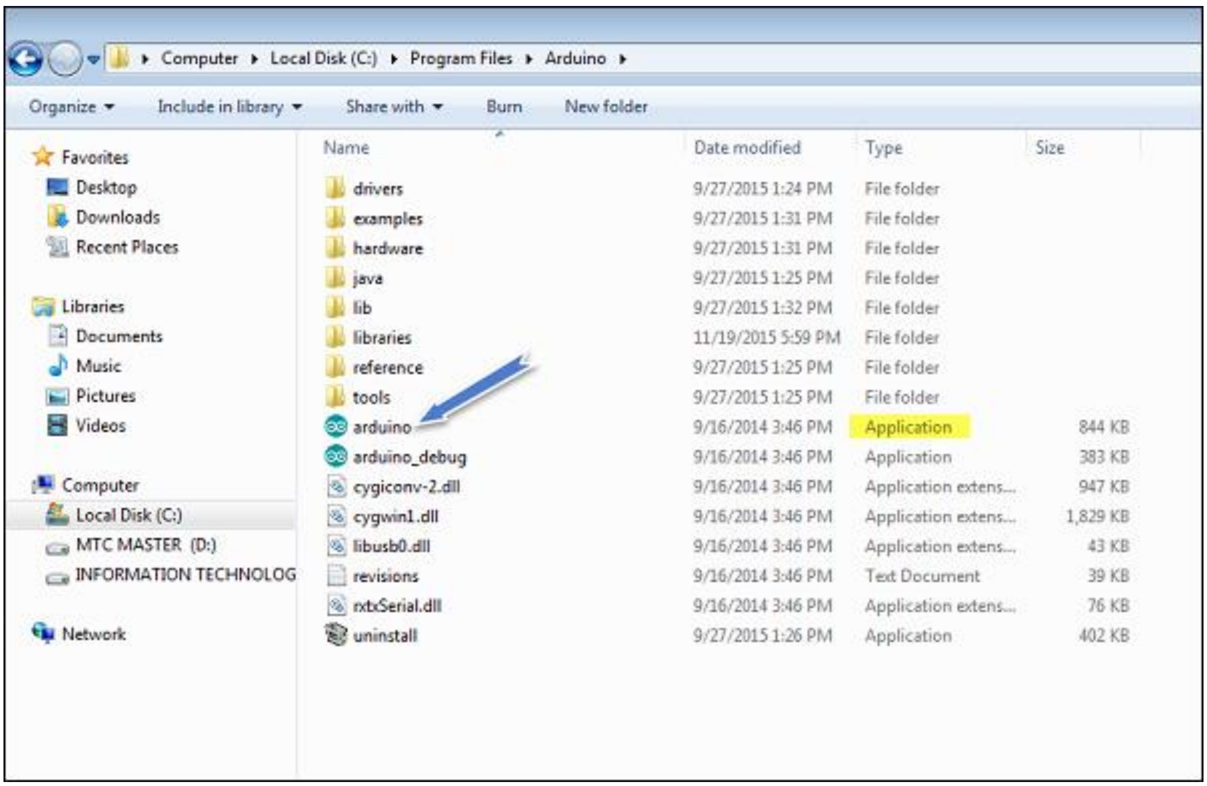
Step 3 – Power up your board.

The Arduino Uno, Mega, Duemilanove and Arduino Nano automatically draw power from either, the USB connection to the computer or an external power supply. If you are using an Arduino Diecimila, you have to make sure that the board is configured to draw power from the USB connection. The power source is selected with a jumper, a small piece of plastic that fits onto two of the three pins between the USB and power jacks. Check that it is on the two pins closest to the USB port.

Connect the Arduino board to your computer using the USB cable. The green power LED (labeled PWR) should glow.

Step 4 − Launch Arduino IDE.

After your Arduino IDE software is downloaded, you need to unzip the folder. Inside the folder, you can find the application icon with an infinity label (application.exe). Double-click the icon to start the IDE.



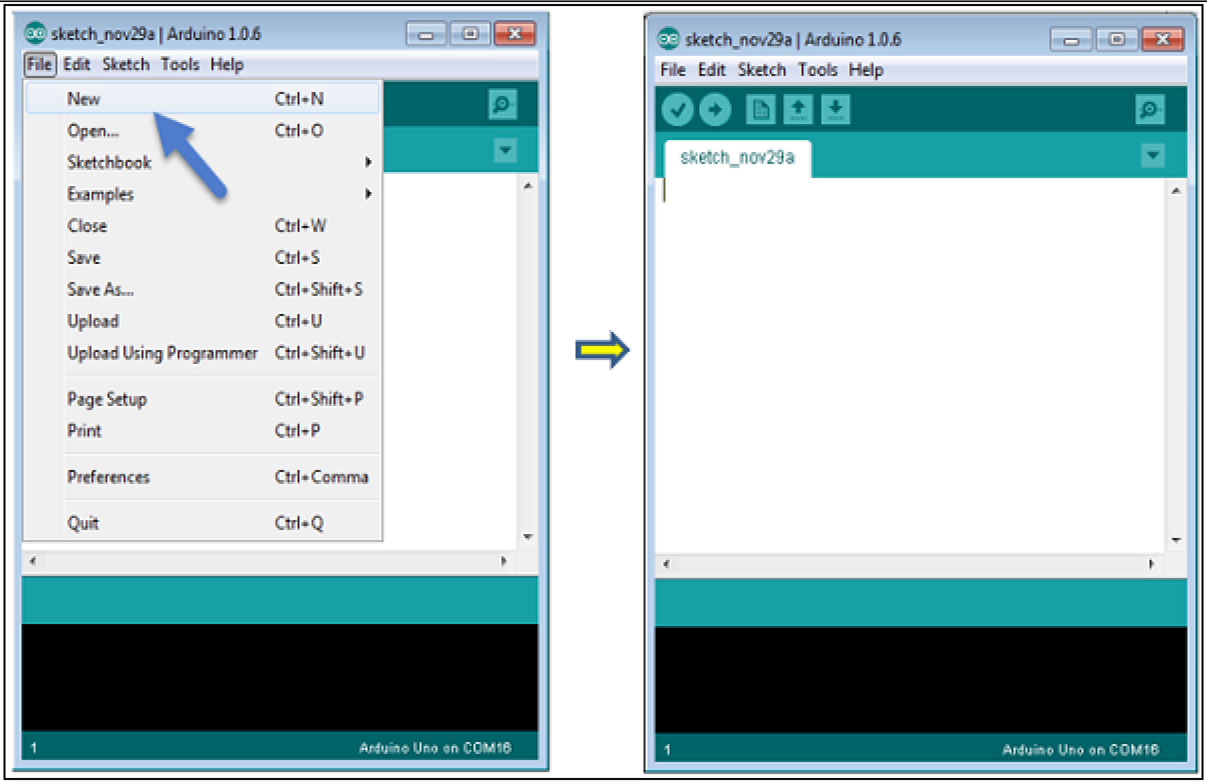
Step 5 − Open your first project.

Once the software starts, you have two options −

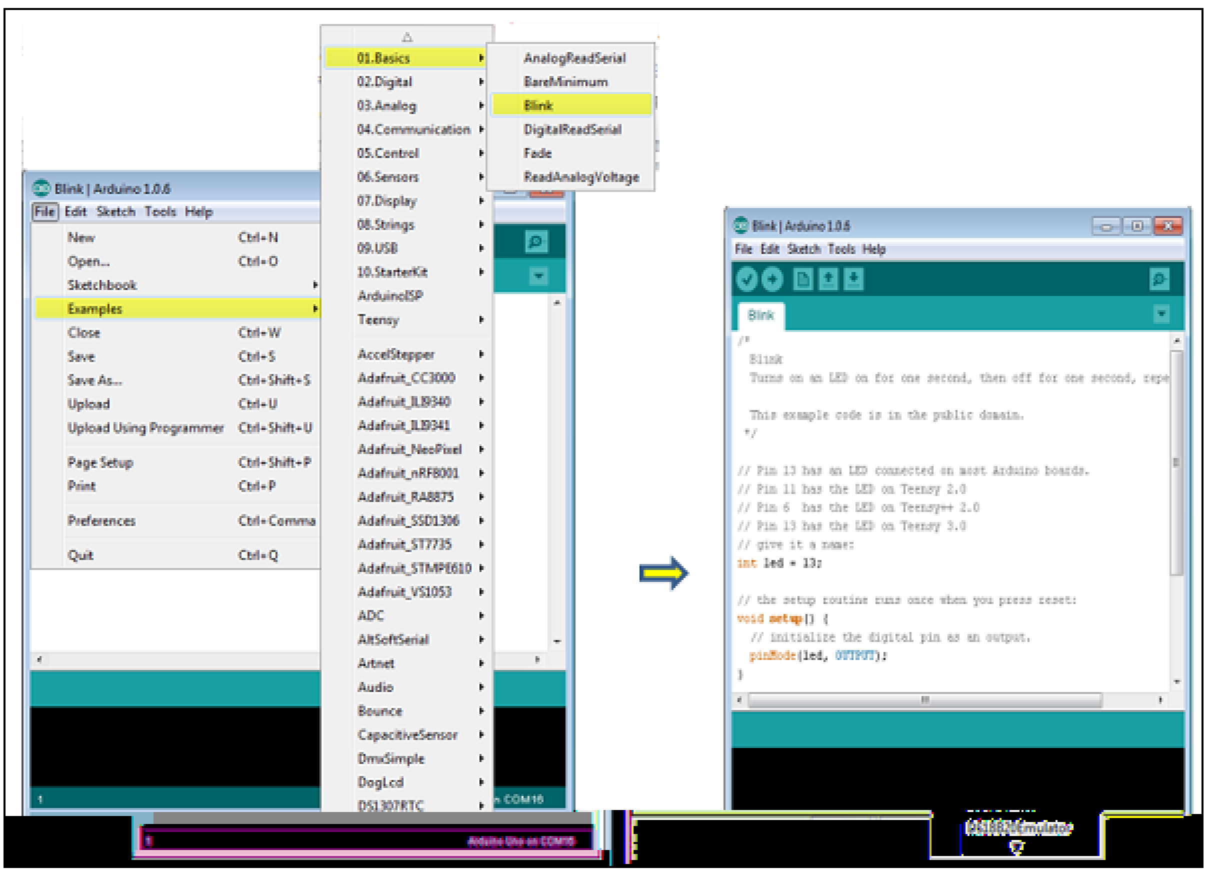
Create a new project.

Open an existing project example.

To create a new project, select File → **New**.



To open an existing project example, select File → Example → Basics → Blink.

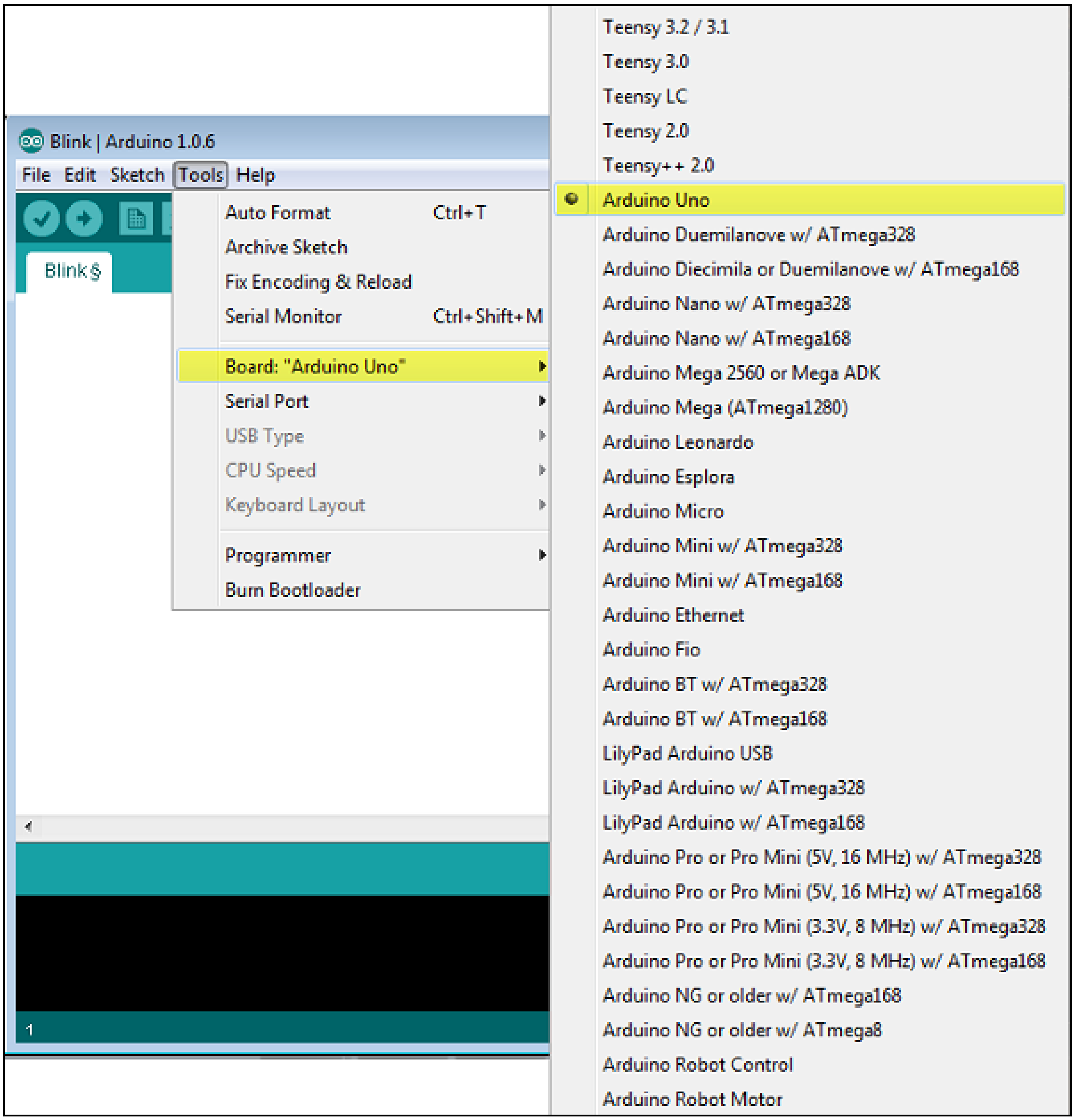


Here, we are selecting just one of the examples with the name **Blink**. It turns the LED on and off with some time delay. You can select any other example from the list.

Step 6 − Select your Arduino board.

To avoid any error while uploading your program to the board, you must select the correct Arduino board name, which matches with the board connected to your computer.

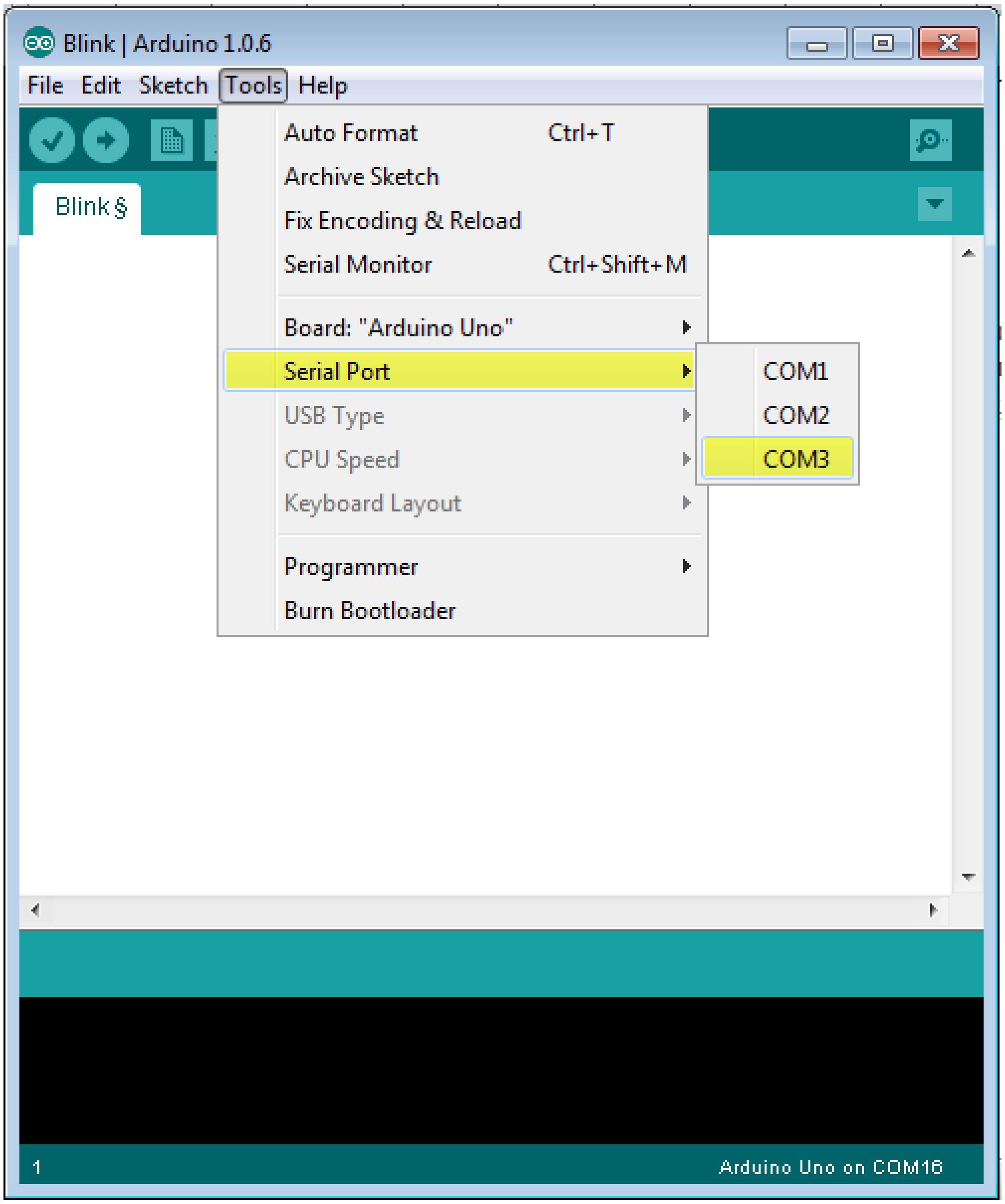
Go to Tools → Board and select your board.



Here, we have selected Arduino Uno board according to our tutorial, but you must select the name matching the board that you are using.

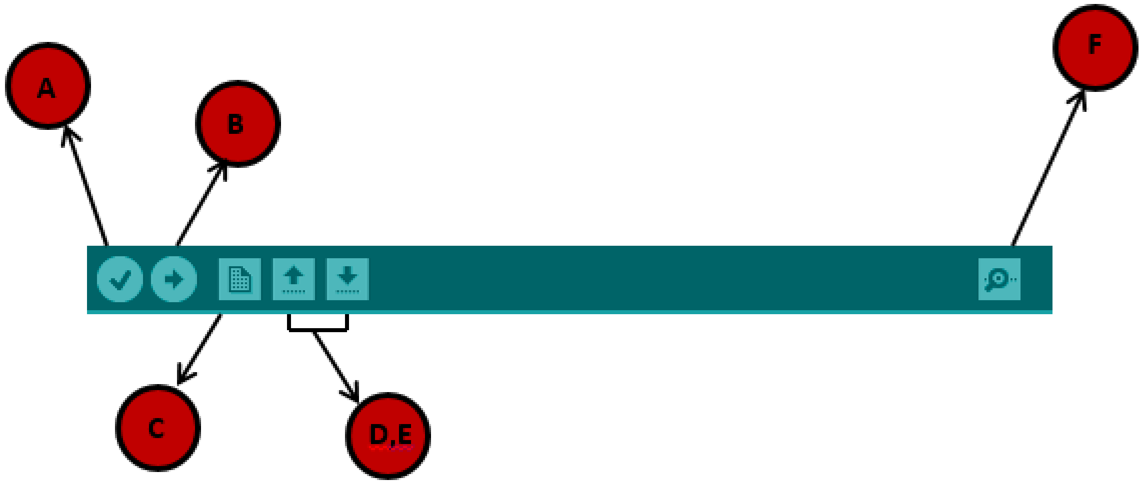
Step 7 – Select your serial port.

Select the serial device of the Arduino board. Go to **Tools → Serial Port** menu. This is likely to be COM3 or higher (COM1 and COM2 are usually reserved for hardware serial ports). To find out, you can disconnect your Arduino board and re-open the menu, the entry that disappears should be of the Arduino board. Reconnect the board and select that serial port.



Step 8 – Upload the program to your board.

Before explaining how we can upload our program to the board, we must demonstrate the function of each symbol appearing in the Arduino IDE toolbar.



A – Used to check if there is any compilation error.

B – Used to upload a program to the Arduino board.

C – Shortcut used to create a new sketch.

D – Used to directly open one of the example sketch.

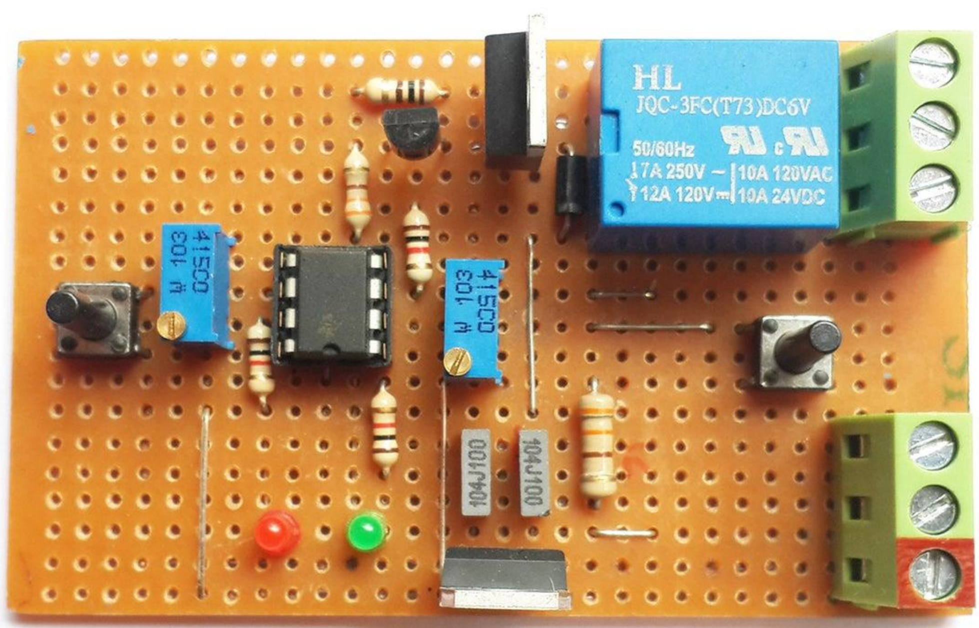
E – Used to save your sketch.

F – Serial monitor used to receive serial data from the board and send the serial data to the board.

Now, simply click the "Upload" button in the environment. Wait a few seconds; you will see the RX and TX LEDs on the board, flashing. If the upload is successful, the message "Done uploading" will appear in the status bar.

Note – If you have an Arduino Mini, NG, or other board, you need to press the reset button physically on the board, immediately before clicking the upload button on the Arduino Software.

3.SOLAR CHARGE CONTROLLER



3.1SOLAR CHARGE CONTROLLER UNIT

Solar Charge Controller Unit is a device that controls the charging process of the battery, monitors the status of the battery also generates alarms when required. Before microcontrollers, analog charge controllers were used. Nowadays microcontroller-based solar charge controllers are quite popular. The benefit of these CCUs is that we can use MPPT or PWM algorithms for controlling the charging process. These algorithms help to harness maximum power from the PV panel. Even nowadays displays could be interfaced to show the Battery Voltage, Current, and Load

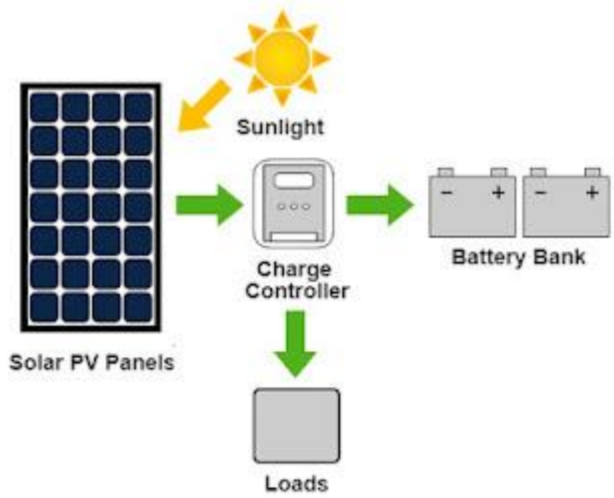
Specification of solar charge controller:-

Solar Charge Controller (6A)		
Sl. No.	Parameters	Specification
1.	Charging Current	Maximum 6 Amps
2.	Load Current	Maximum 6 Amps
3.	SPV Module Capacity	75Wp
4.	Battery Voltage	12V / 24V Automatic Switching
5.	Solar Panel Voltage	12V / 24V Automatic Switching
6.	Solar Panel Open Circuit Voltage	21V / 42V DC Maximum
7.	No Load Power	< 5 mA
8.	Charging Algorithm	PWM
9.	Dimension	178 x 100 x 51
10.	Protection Class	IP30
11.	Specific Temperature Range	-20°C to +50°C

3.2Why solar charging unit required??

At first we need to require how the solar output generated. Whenever photons are hits our solar panel electron start to flow under photo electric effect. But the problem is solar energy is very unpredictable that’s why we need store this energy as well as use this energy as a output power. Here again one problem we face that battery always require constant voltage to charge. To do that solar charge controller comes into account. Solar charge controller protects our battery from overcharging as well as over discharging.

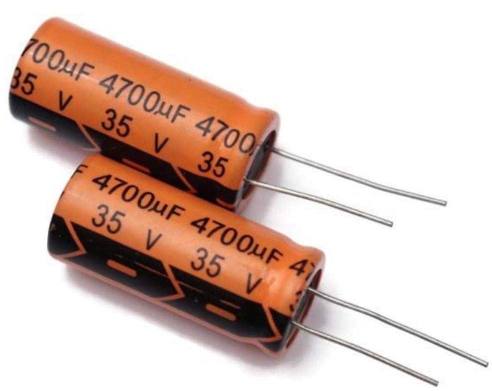
A typical **Solar DC system** , two terminal solar panel to access the solar output power, six terminal of solar charge controller (2 terminal draws the output power of solar panel, 2 terminal is to charge the battery as well as operate the load.) 2 terminal to access the controlled dc power.



3.3Item we require to make solar charging controller:

3.3.1Capacitor 470uf:-

capacitor, device for storing electrical energy, consisting of two conductors in close proximity and insulated from each other. A simple example of such a storage device is the parallel-plate capacitor. If positive charges with total charge +*Q* are deposited on one of the conductors and an equal amount of negative charge −*Q* is deposited on the second conductor, the capacitor is said to have a charge *Q*.

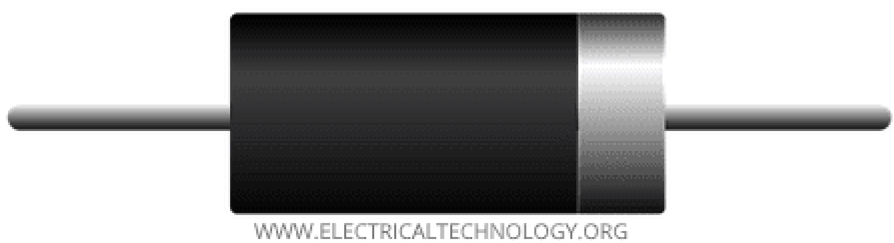


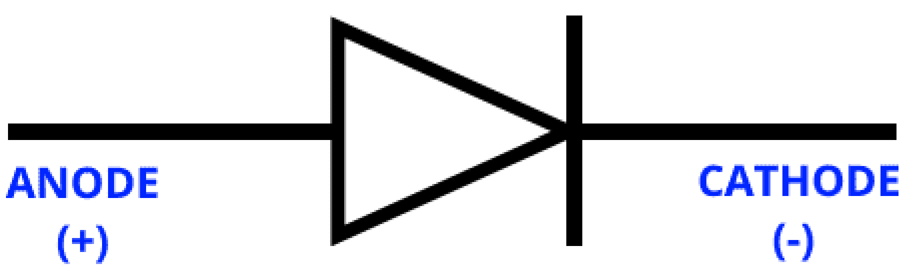
Capacitors have many important applications. They are used, for example, in digital circuits so that information stored in large computer memories is not lost during a momentary electric power failure; the electric energy stored in such capacitors maintains the information during the temporary loss of power. Capacitors play an even more important role as filters to divert spurious electric signals and thereby prevent damage to sensitive components and circuits caused by electric surges.

3.3.2IN4007:-

Diode, an electrical component that allows the flow of current in only one direction. In circuit diagrams, a diode is represented by a triangle with a line across one vertex.

The most common type of diode uses a *p-n* junction. In this type of diode, one material (*n*) in which electrons are charge carriers abuts a second material (*p*) in which holes (places depleted of electrons that act as positively charged particles) act as charge carriers. At their interface, a depletion region is formed across which electrons diffuse to fill holes in the *p*-side. This stops the further flow of electrons. When this junction is forward biased (that is, a positive voltage is applied to the *p*-side), electrons can easily move across the junction to fill the holes, and a current flows through the diode. When the junction is reverse biased (that is, a negative voltage is applied to the *p*-side), the depletion region widens and electrons cannot easily move across. The current remains very small until a certain voltage (the breakdown voltage) is reached and the current suddenly increases.

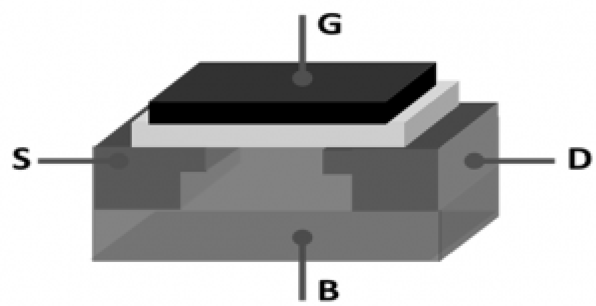




Light-emitting diodes (LEDs) are *p-n* junctions that emit light when a current flows through them. Several *p-n* junction diodes can be connected in series to make a rectifier (an electrical component that converts alternating current to direct current). Zener diodes have a well-defined breakdown voltage, so that current flows in the reverse direction at that voltage and a constant voltage can be maintained despite fluctuations in voltage or current. In varactor (or varicap) diodes, varying the bias voltage causes a variation in the diode's capacitance; these diodes have many applications for signal transmission and are used throughout the radio and television industries. (For more detail about these and other types of diodes, *see* semiconductor device.)

Early diodes were vacuum tubes, an evacuated glass or metal electron tube containing two electrodes—a negatively charged cathode and a positively charged anode. These were used as rectifiers and as detectors in electronic circuits such as radio and television receivers. When a positive voltage is applied to the anode (or plate), electrons emitted from the heated cathode flow to the plate and return to the cathode through an external power supply. If a negative voltage is applied to the plate, electrons cannot escape from the cathode, and no plate current flows. Thus, a diode permits electrons to flow from cathode to plate but not from plate to cathode. If an alternating voltage is applied to the plate, current flows only during the time when the plate is positive. The alternating voltage is said to be rectified, or converted to direct current.

3.3.4IRF740

- A MOSFET is a four-terminal device having source(S), gate (G), drain (D) and body (B) terminals. In general, The body of the MOSFET is in connection with the source terminal thus forming a three-terminal device such as a field-effect transistor. MOSFET is generally considered as a transistor and employed in both the analog and digital circuits. This is the basic **introduction to MOSFET**. And the general structure of this device is as below :
- 

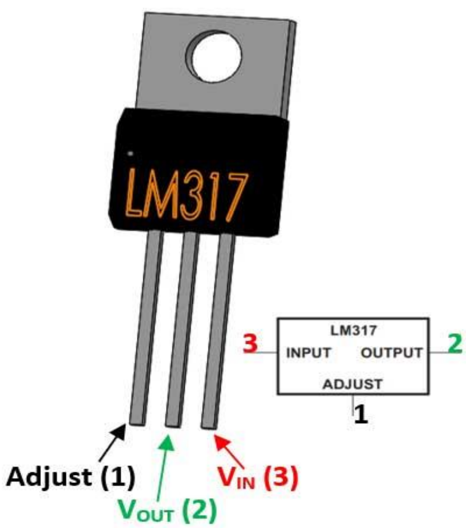
MOSFET
- From the above **MOSFET structure**, the functionality of MOSFET depends on the electrical variations happening in the channel width along with the flow of carriers (either holes or electrons). The charge carriers enter into the channel through the source terminal and exit via the drain.
- The width of the channel is controlled by the voltage on an electrode which is called the gate and it is located in between the source and the drain. It is insulated from the channel near an extremely thin layer of metal oxide. The MOS capacity that exists in the device is the crucial section where the entire operation is across this.

- **3.3.5Pot**

A potentiometer is **a three-terminal resistor with a sliding or rotating contact that forms an adjustable voltage divider**. If only two terminals are used, one end and the wiper, it acts as a variable resistor or rheostat

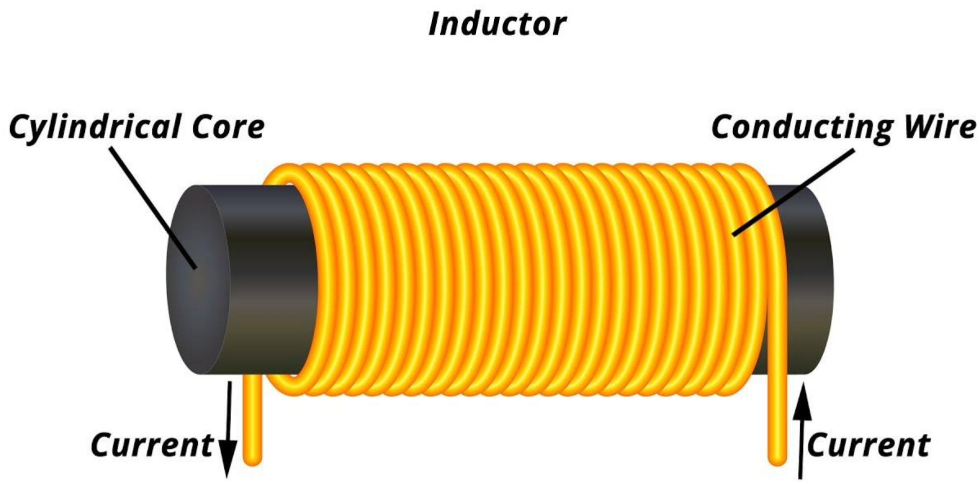
- **3.3.6LM314T**

The LM317 is an adjustable 3−terminal positive voltage regulator capable of supplying in excess of 1.5 A over an output voltage range of 1.2 V to 37 V. This voltage regulator is exceptionally easy to use and requires only two external resistors to set the output voltage. Further, it employs internal current limiting, thermal shutdown and safe area compensation, making it essentially blow−out proof. The LM317 serves a wide variety of applications including local, on card regulation. This device can also be used to make a programmable output regulator, or by connecting a fixed resistor between the adjustment and output.



3.3.7Inductor 1mH

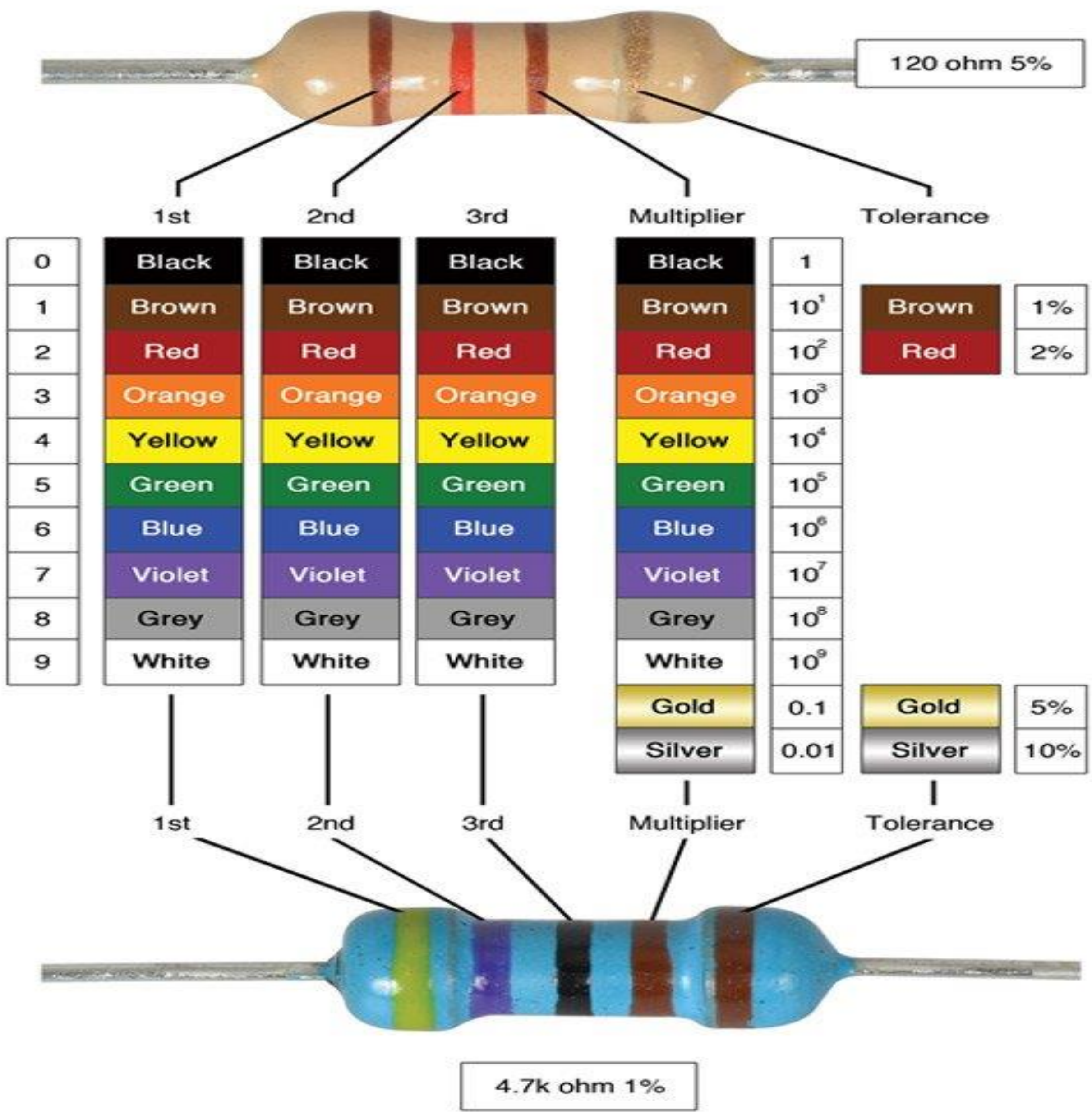
An inductor is a passive component that is used in most power electronic circuits to store energy in the form of magnetic energy when electricity is applied to it. One of the key properties of an inductor is that it impedes or opposes any change in the amount of current flowing through it. Whenever the current across the inductor changes it either acquires charge or loses the charge in order to equalize the current passing through it. The inductor is also called a choke, reactor or just coil.



- **3.3.8Resistor (5K,4.3K,10K)**

A passive electrical component with two terminals that are used for either limiting or regulating the flow of electric current in electrical circuits.

The main purpose of resistor is to reduce the current flow and to lower the voltage in any particular portion of the circuit. It is made of copper wires which are coiled around a ceramic rod and the outer part of the resistor is coated with an insulating paint


120 ohm 5%
1st
2nd
3rd
Multiplier
Tolerance
0
1
2
3
4
5
6
7
8
9
Black
Brown
Red
Orange
Yellow
Green
Blue
Violet
Grey
White
Gold
Silver
1
10¹
10²
10³
10⁴
10⁵
10⁶
10⁷
10⁸
10⁹
0.1
0.01
Brown 1%
Red 2%
Gold 5%
Silver 10%
4.7k ohm 1%

PWM Charge Controller

One of the most adopted charge controllers for storing the energy from the solar panel to the battery backup is the Pulse Width Modulation (PWM) charge controller. Here the input solar energy has to pass through a switching circuit to store in the battery backup. This switching circuit is controlled by ICCPET 2020 Journal of Physics: Conference Series 1712 (2020) 012023 IOP Publishing doi:10.1088/1742-6596/1712/1/012023 3 Battery Reference Voltage an oscillator whose pulse width is varying with the amount of energy stored in the battery backup. The block diagram of the solar PWM charge controller is as shown in figure 1. Figure 1. Conceptual model of solar PWM charge controller. If the energy in the battery backup is less then the pulse width high state will be large enough and the pulse width of low state will be a single spike. The nature of pulses during the heavy charging mode is as shown in the figure 2. Figure 2. The output of PWM oscillator during low battery storage. The output of the PWM oscillator is then connected to a switching circuit to control the battery charging. Here most of the time of an entire pulse cycle the switch remains on and the solar energy will be getting stored in the battery backup. When the battery backup is getting filled the on stage of the pulse width will reduce and the off stage of the pulse width will increase. The nature of the pulse during the 50 % charged battery stage is as shown in the figure 3. Figure 3. The output of PWM oscillator during 50% battery storage.

Pulse Width Modulation (PWM) is the most effective means to achieve constant voltage battery charging by switching the solar system controller's power devices. When in PWM regulation, the current from the solar array tapers according to the battery's condition and recharging needs

Charging a battery with a solar system is a unique and difficult challenge. In the old days, simple on-off regulators were used to limit battery outgassing when a solar panel produced excess energy. However, as solar systems matured it became clear how much these simple devices interfered with the charging process.

The history for on-off regulators has been early battery failures, increasing load disconnects, and growing user dissatisfaction. PWM has recently surfaced as the first significant advance in solar battery charging.

PWM solar chargers use technology similar to other modern high quality battery chargers. When a battery voltage reaches the regulation setpoint, the PWM algorithm slowly reduces the charging current to avoid heating and gassing of the battery, yet the charging continues to return the maximum amount of energy to the battery in the shortest time. The result is a higher charging efficiency, rapid recharging, and a healthy battery at full capacity.

In addition, this new method of solar battery charging promises some very interesting and unique benefits from the PWM pulsing. These include:

1. Ability to recover lost battery capacity and desulfate a battery.
2. Dramatically increase the charge acceptance of the battery.
3. Maintain high average battery capacities (90% to 95%) compared to on-off regulated state-of-charge levels that are typically 55% to 60%.
4. Equalize drifting battery cells.
5. Reduce battery heating and gassing.
6. Automatically adjust for battery aging.
7. Self-regulate for voltage drops and temperature effects in solar systems
8.
9.

MPPT CHARGE CONTROLLER

Using a solar panel or an array of panels without a controller that can perform Maximum Power Point Tracking (MPPT) will often result in wasted power, which ultimately results in the need to install more panels for the same power requirement. For smaller/cheaper devices that have the battery connected directly to the panel, this will also result in premature battery failure or capacity loss, due to the lack of a proper end-of-charge procedure and higher voltage. In the short term, not using an MPPT controller will result in a higher installation cost and, in time, the costs will escalate due to eventual equipment failure. Even with a proper charge controller, the prospect of having to pay 30-50% more up front for additional solar panels makes the MPPT controller very attractive. This application note describes how to implement MPPT using the most popular switching power supply topologies. There are many published works on this topic, but only a tiny portion of them show how to actually implement the algorithms in hardware, as well as state common problems and pitfalls. Even when using the simplest MPPT algorithm with a well-designed synchronous switching power supply, it can be expected that at least 90% of the panel's available power will end up in the battery, so the benefits are obvious. The topology presented in this application note is an inverse SEPIC, but the techniques used here can be applied to buck, boost and SEPIC converters. The buck converter is a special case, since it has a linear voltage transfer function when operating in Continuous Conduction Mode (CCM). This simplifies things a lot, and the MPPT controller can be implemented by operating directly on the converter duty cycle. The other topologies have a nonlinear voltage transfer function, and operating directly on the duty cycle will yield unpredictable results, especially at high duty cycles. In this case, the algorithm modifies the solar panel operating voltage by using a proportional integral (PI) control loop, which steers the voltage to the desired value. SOLAR PANEL MPPT The main problem solved by the MPPT algorithms is to automatically find the panel operating voltage that allows maximum power output. In a larger system, connecting a single MPPT controller to multiple panels will yield good results, but, in the case of partial shading, the combined power output graph will have multiple peaks and valleys (local maxima). This will confuse most MPPT algorithms and make them track incorrectly. Some techniques to solve problems related to partial shading have been proposed, but they either need to use additional equipment (like extra monitoring cells, extra switches and current sensors for sweeping panel current), or complicated models based on the panel characteristics (panel array dependent). These techniques only make sense in large solar panel installations, and are not within the scope of this application note. Ideally, each panel or small cluster of panels should have their own MPPT controller. This way the risk of partial shading is minimized, each panel is allowed to function at peak efficiency, and the design problems related to converters handling more than 20-30A are eliminated. A typical solar panel power graph (Figure 1) shows the open circuit voltage to the right of the maximum power point. The open circuit voltage (VOC) is obviously the maximum voltage that the panel outputs, but no power is drawn. The short-circuit current of the panel (ISC) is another important parameter, because it is the absolute maximum current you can get from the panel.

► Comparing the Two

If maximizing charging capacity were the only factor considered when specifying a solar controller, everyone would use a MPPT controller. But the two technologies are different, each with it's own advantages. The decision depends on site conditions, system components, size of array and load, and finally the cost for a particular solar power system.

► Temperature Conditions

An MPPT controller is better suited for colder conditions. As solar module operating temperature goes down, the Vmp1 increases. That's because the voltage of the solar panels operating at their peak power point at Standard Testing Conditions (STC is 25C°) is about 17V while the battery voltage is about 13.5V. The MPPT controller is able to capture the excess module voltage to charge the batteries. As a result, a MPPT controller in cool conditions can produce up to 20 – 25% more charging than a PWM controller.

In comparison, a PWM controller is unable to capture excess voltage because the pulse width modulation technology charges at the same voltage as the battery. However, when solar panels are deployed in warm or hot climates, their Vmp decreases, and the peak power point operates at a voltage that is closer to the voltage of a 12V battery. There is no excess voltage to be transferred to the battery making the MPPT controller unnecessary and negating the advantage of an MPPT over a PWM.

► Array to Load Ratio

In a scenario where the solar array is large relative to the power draw from the batteries by the load, the batteries will stay close to a full state of charge. A PWM controller is capable of efficiently maintaining the system without the added expense of an MPPT controller.

► Size of the System

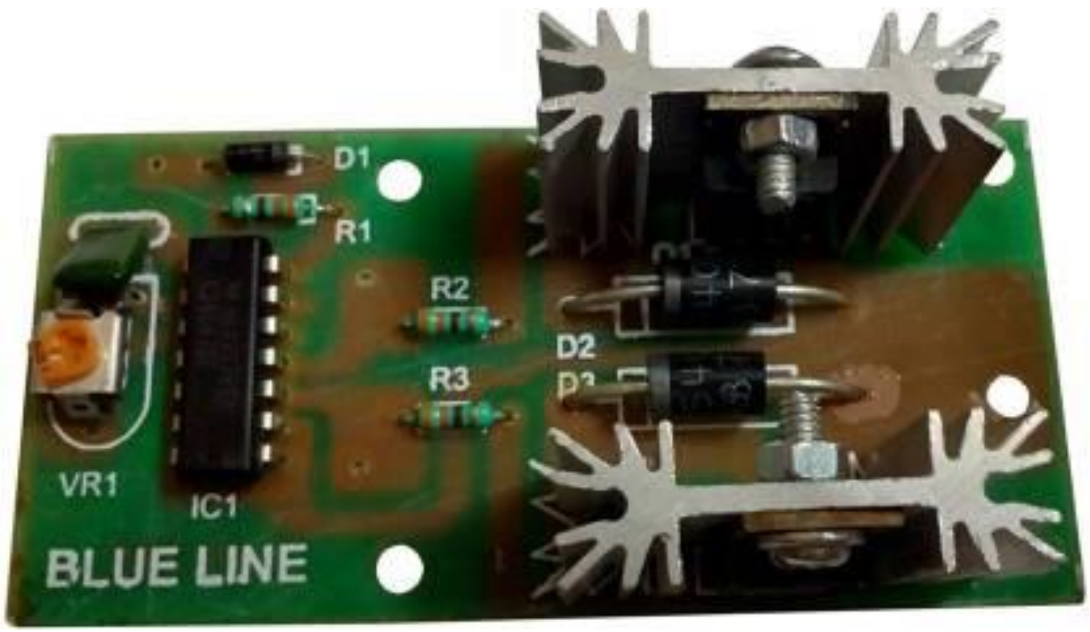
Low power systems are better suited to a PWM controller because:

- A PWM controller operates at a relatively constant harvesting efficiency regardless of the size of the array
- A PWM controller is less expensive that a MPPT, so is a more economical choice for a small system
- A MPPT controller is much less efficient in low power applications. Systems 170W or higher tickle the MPPT's sweet spot

► Type of Solar Module

Stand-alone off-grid solar modules are typically 36-cell modules and are compatible with both PWM and MPPT technologies. Some grid-tie solar modules on the market today are not the traditional 36-cells modules that are used for off-grid power systems. For example, the voltage from a 60-cell 250W panel is too high for 12-Volt battery charging, and too low for 24-Volt battery charging. MPPT technology tracks the maximum power point (thus MPPT) of these less expensive grid-tie modules in order to charge the batteries, whereas PWM does not.

4.INVERTER



4.1INTRODUCTION

An **inverter can be defined as** it is a compact and rectangular shaped electrical equipment used to convert direct current (DC) voltage to alternating current (AC) voltage in common appliances. The a**pplications of DC** involves several small types of equipment like solar power systems. **Direct current** is used in many of the small electrical equipment such as solar power systems, power batteries, power-sources, fuel cells because these are simply produced direct current.
Inverter

The basic role of an inverter is to change DC power into AC power. The AC power can be supplied to homes, and industries using the public utility otherwise power grid, the alternating-power systems of the batteries can store only DC power. In addition, almost all the household appliances, as well as other electrical equipment can be functioned by depending on AC power.

In some cases, generally, the input voltage is lesser whenever the output voltage is equivalent to the grid supply voltage of either 120 V otherwise 240 V based on the country. These devices are standalone devices for some applications like solar power. There are different types of inverters available in the market based on the switching waveform shape. An inverter uses DC power sources to provide an AC voltage to giving the supply to the electronic as well as electrical equipment.

4.2Working of Inverter

The **working of an inverter** is, it converts DC to AC, and these devices never generate any kind of power because the power is generated by the DC source. In some situations like when the DC voltage is low then we cannot use the low DC voltage in a home appliance. So due to this reason, an inverter can be used whenever we utilize solar power panel.

4.3Types of Inverters

Inverters are classified into two type’s namely single phase and three phases

4.3.1Single Phase Inverter

Single phase inverters are classified into two types namely half-bridge inverter & full bridge inverter
Half Bridge Inverter

The half-bridge **inverter** is an essential building block in the full bridge inverter. It can be built with two switches where each one of its capacitors includes an o/p voltage which is equivalent to Vdc2. Additionally, the switches balance each other, if one switch is activated then automatically another switch will deactivate.
Full Bridge Inverter

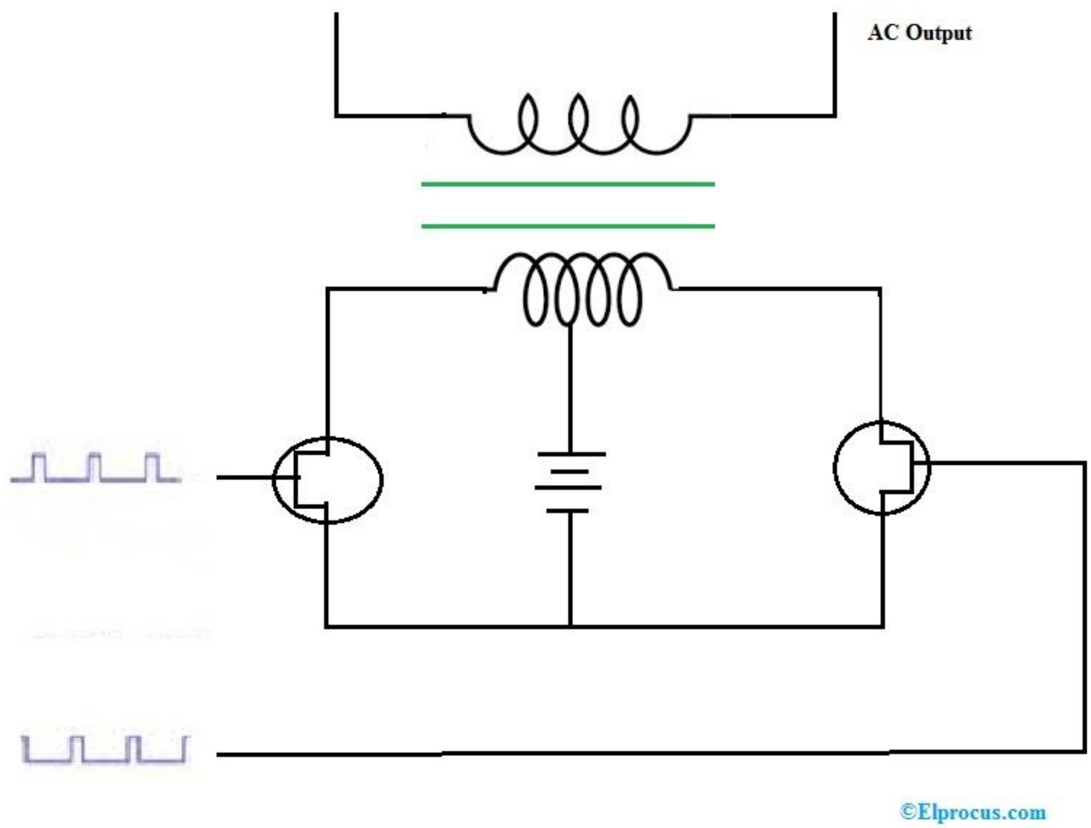
The **full bridge inverter circuit** converts direct current to alternate current. It can be achieved by opening as well as closing **the switches** within the correct series. This type of inverter has dissimilar operating states which depend on closed switches.

4.3.2Three Phase Inverter

A **three-phase inverter** is used to alter an input DC to a 3-phase output AC. Generally, its 3-arms are deferred with 120° of an angle to produce a 3-phase AC supply. The inverter control which has a 50% of the ratio as well as controlling can take place after every T/6 of the time T. The switches used in the inverter complement each other.
The **3-single phase inverters** place across the similar DC source, and the pole voltages within a 3-phase inverter are equivalent to the pole voltages within 1-phase half-bridge inverter. These inverters have two conduction modes such as 120°-mode of conduction & 180° mode of conduction.

4.4.4Inverter Circuit Diagram

There are many basic electrical circuits for the power devices, a transformer, and switching devices. The DC alteration to an AC can be attained by stored energy within the DC source like the battery. The entire process can be done with the help of switching devices which are constantly turned ON & OFF, and then stepping-up with the transformer.



Inverter Circuit Diagram

The input DC voltage can be turned ON/OFF by using power devices like **MOSFETs** otherwise power transistors. The changing voltage within the primary makes an alternating voltage at resultant winding. The working of the transformer is equivalent to **an amplifier** where the output can be increased from the voltage supply by the batteries to 120 V otherwise 240 V.
There are three frequently used inverter o/p stages are, a push-pull by center tap transformer, push-pull by half-bridge, and push-pull by the full bridge. This is most popular because of its ease and, definite results; but, it employs a huge transformer with lower efficiency. An easy push-pull direct current to an alternating current inverter by center tap transformer circuit can be shown in the below figure.

4.5Applications of Inverter

These are used in a variety of applications like tiny car adapters to the office, household applications, as well as large-grid systems.

- Inverters can be used as an UPS-Uninterruptible power supplies
- These can be used as standalone inverters
- These can be used in solar power systems
- An inverter is the basic building block of an SMPS- switched mode power supply.
- These can be used in Centrifugal fans, pumps, mixers, extruders, test stands. conveyors, metering pumps. and Web-handling equipmen

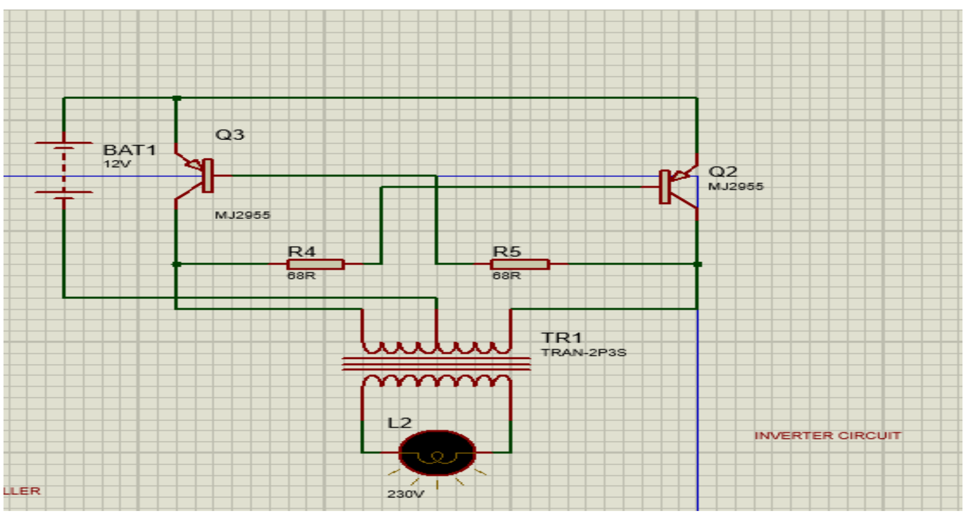
4. Theory behind inverter circuit:

The circuit of this inverter is dissimilar when compared to the commonly used inverters as it does not have involvement of a separate oscillator circuit to power up the fitted transistors. In place of that, in our circuit, both halves of the circuit functions like a re-generative process (just like full wave bridge rectifiers).

Whatever we do to balance both the parts of the circuit, there will always be a misbalance in the resistance values and transformers windings. This is the reason that both parts of the circuit can never operate at the same point of time.

Now suppose that the first part of the circuit starts conducting first. The biasing voltage for the first half is being fed by the second part's transformer winding through R2. As soon as the first part completes its conduction stage, the output of the battery is grounded by the collectors.

The process drains out any available voltage to the base through R2 and thus the conduction of the first part stops completely. At this instance, the transistors in the second part get the chance for conduction.



OLED DISPLAY

OLED display are electronic visual panels that harness organic light-emitting diodes (which, of course, is what the acronym OLED stands for) for their core illumination power. OLED is a type of electroluminescent display technology, in which an organic material layer generates light when molecules in the diode are agitated by an electric current.

As with many other display types, an OLED array can be used to present images, text, video and more on a screen or panel of almost any size, and the technology has been especially prevalent on the high-end home entertainment market over the past few years. Thanks to the unique strengths they deliver in terms of power and performance, OLED screens are also in increasingly widespread use as performance display tools across all industries and sectors today.

In this guide, we'll look more closely at exactly how OLED panels function, what the main strengths of the technology are when compared with more entry-level alternatives, and some of the brands whose products are currently excelling in a range of professional and industrial display settings

Battery

A Cell is a device that stores electricity in form of chemical energy. It is the smallest unit of a battery. We combine multiple cells mostly in series and call it a Battery. Inside a cell, a reversible chemical reaction occurs. When we charge a battery inside the cell the reaction goes forward then when we discharge the battery the reaction goes backward. Although it is a reversible chemical reaction, with every cycle a small percentage becomes irreversible. This is how batteries die after a period of time.

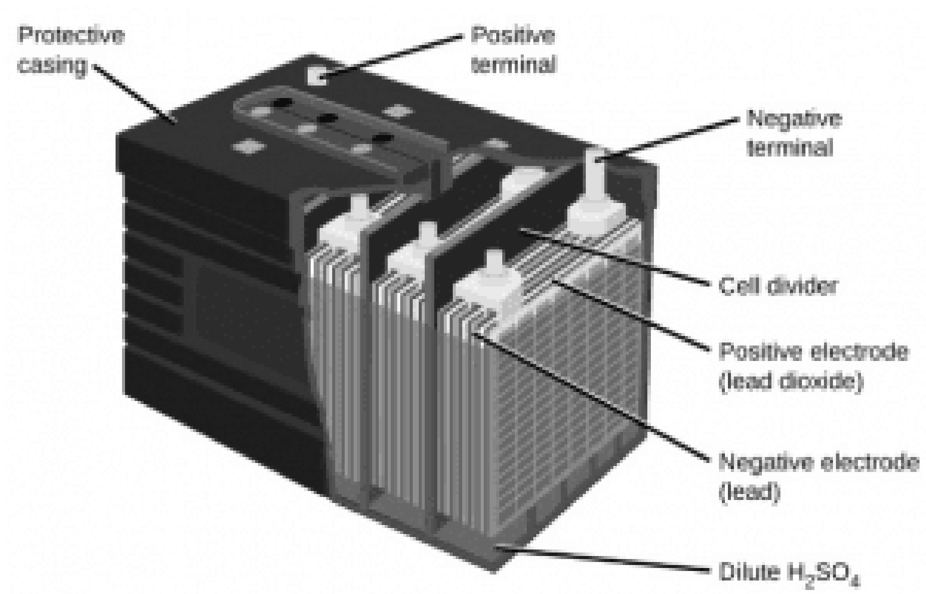
To prevent this scenario we need to handle batteries very carefully. There are certain things that need to be maintained while using a battery.
Temperature: Temperature is the worst enemy of a battery. It not just reduce battery life also reduces battery performence.
Deep Discharging: While discharging a battery we must never fully discharge a battery. If we fully discharge a battery the chemical reaction inside it becomes irriversible. Repetative deep discharging might kill the battery after a certain time.
Over Charging: Just like Over Discharing, Overcharging also damages a battery in the same way. Deruced capacity, bad peformence might occur due to overcharging.
Ventilation: Lead Acid batteries produces Hydrogen and Oxygen. Without proper ventilation during charging causes corotion in battery terminals.
Moisture: Moisture causes corotion in battery terminals.

LEAD ACID Battery:

Depending upon the chemistry there are different types of cells. Among all of them, Lead-Acid is the most popular and widely used everywhere. 12 Volt Lead Acid batteries are made by combining 6 Nos Lead-Acid Cells together. Every Cell has multiple negative and positive plates. One disadvantage is that these have low energy density and the advantage is robustness. Depending upon the construction of the plates there are two types of Lead Acid Batteries.

- Tubuler Battery
- Flat Plate Battery

Although the plate construction is different the chemical process remains the same. Typical construction is shown below



HARDWARE IMPLEMENTATION

CHAPTER 3

MAIN FEATURES OF THE PROTOTYPE

The key features of the prototype are:-

- It can operate the load under DC as well AC supply
- It will control the DC grid power as well AC grid power.
- Increases the stability of grid.
- Real time display status in OLED.
- ARDUINO NANO are control the load power.
- Auto cut off battery under any unstability.

Photograph of main charge controller board

Step by step operation of prototype

1. Solar charge controller takes dc power as well as ac power through input port.

   Here we use 3 I/P terminal (1 for renewable energy source 1 for non –renewable energy source and 1 for back up of any to I/P terminal.)
2. Arduino nano analysis the input power from I/P terminal. Nano has three operation mode if both supply are completly fine then it will allow both of them. Or if renewable energy source are in unstable mode then it will cut off. And only AC grid will operate And convert all supply into usable dc supply.
3. At the same time nano analysis the input current and voltage shows in the display OLED.
4. By inverter all the dc supply converted in ac supply and that ac supply converted into 230 volt ac by 12-230 volt transformer.

Component required

SL no.	component	Quantity
1	Veroboard	1
2	2pin terminal	3
3	Arduino nano	1
4	OLED DISPLAY	1
5	JUMPER WIRE	6-9
6	IN4007	5
7	CAPACITOR	3
8	INDUCTOR	3
9	POT	1
10	INVERTER KIT	1
11	BATTERY	1
12	ADAPTER	1
13	BULB	2
14	USB JACK	1

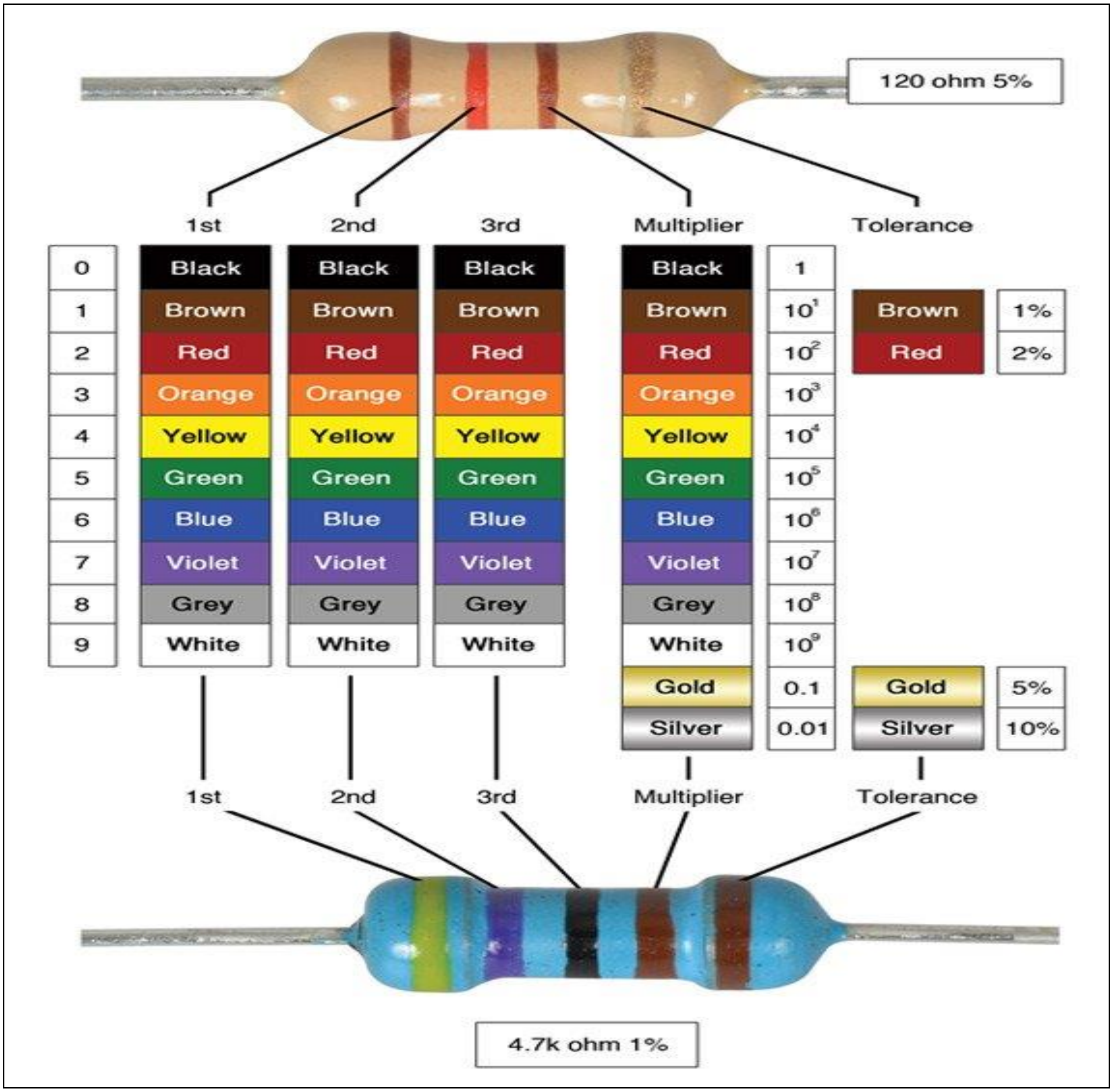
Appendix -A

(HARDWARE DISCRIPTION)

Resistor (5K,4.3K,10K)

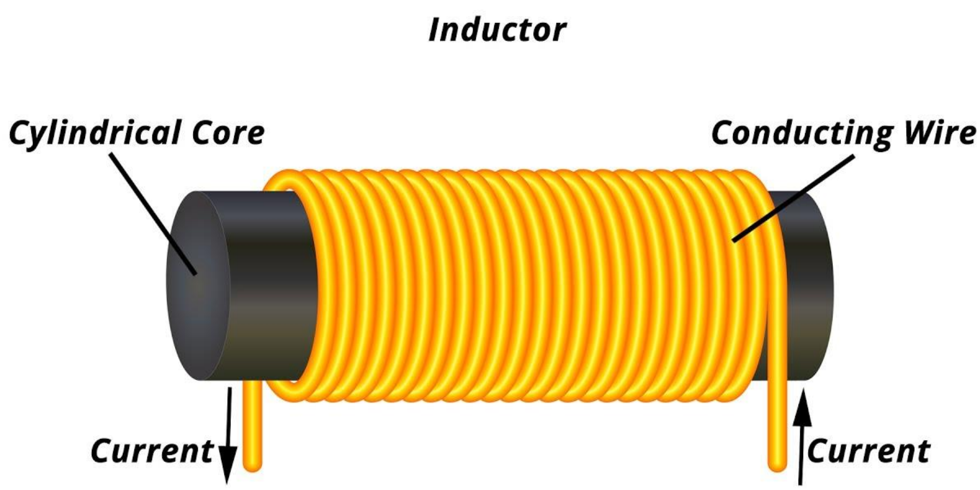
A passive electrical component with two terminals that are used for either limiting or regulating the flow of electric current in electrical circuits.

The main purpose of resistor is to reduce the current flow and to lower the voltage in any particular portion of the circuit. It is made of copper wires which are coiled around a ceramic rod and the outer part of the resistor is coated with an insulating paint



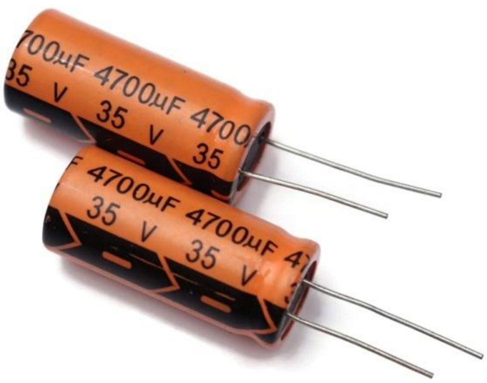
3.3.7Inductor 1mH

An inductor is a passive component that is used in most power electronic circuits to store energy in the form of magnetic energy when electricity is applied to it. One of the key properties of an inductor is that it impedes or opposes any change in the amount of current flowing through it. Whenever the current across the inductor changes it either acquires charge or loses the charge in order to equalize the current passing through it. The inductor is also called a choke, reactor or just coil



1Capacitor 470uf:-

capacitor, device for storing electrical energy, consisting of two conductors in close proximity and insulated from each other. A simple example of such a storage device is the parallel-plate capacitor. If positive charges with total charge $+Q$ are deposited on one of the conductors and an equal amount of negative charge $-Q$ is deposited on the second conductor, the capacitor is said to have a charge Q.

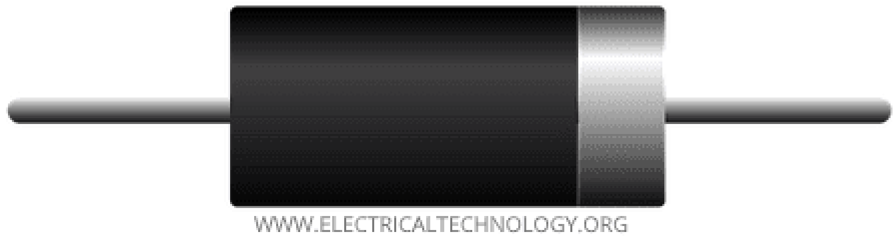


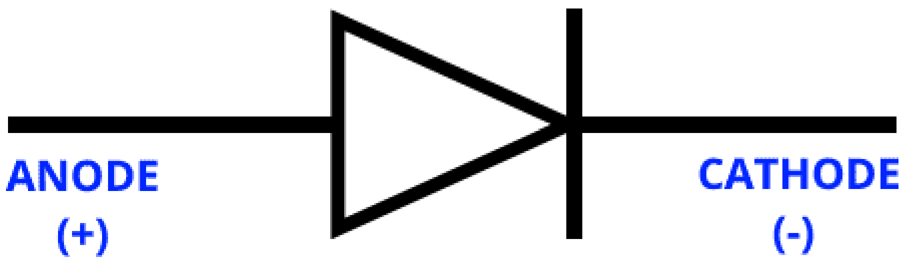
Capacitors have many important applications. They are used, for example, in digital circuits so that information stored in large computer memories is not lost during a momentary electric power failure; the electric energy stored in such capacitors maintains the information during the temporary loss of power. Capacitors play an even more important role as filters to divert spurious electric signals and thereby prevent damage to sensitive components and circuits caused by electric surges.

2IN4007:-

Diode, an electrical component that allows the flow of current in only one direction. In circuit diagrams, a diode is represented by a triangle with a line across one vertex.

The most common type of diode uses a *p-n* junction. In this type of diode, one material (*n*) in which electrons are charge carriers abuts a second material (*p*) in which holes (places depleted of electrons that act as positively charged particles) act as charge carriers. At their interface, a depletion region is formed across which electrons diffuse to fill holes in the *p*-side. This stops the further flow of electrons. When this junction is forward biased (that is, a positive voltage is applied to the *p*-side), electrons can easily move across the junction to fill the holes, and a current flows through the diode. When the junction is reverse biased (that is, a negative voltage is applied to the *p*-side), the depletion region widens and electrons cannot easily move across. The current remains very small until a certain voltage (the breakdown voltage) is reached and the current suddenly increases.

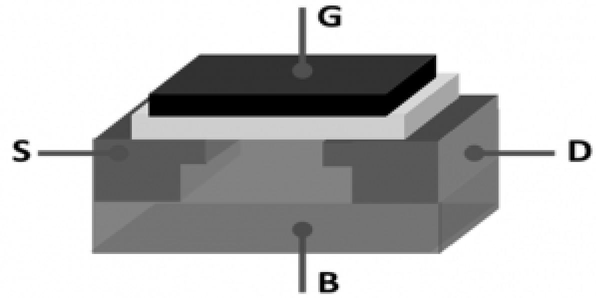




Light-emitting diodes (LEDs) are *p-n* junctions that emit light when a current flows through them. Several *p-n* junction diodes can be connected in series to make a rectifier (an electrical component that converts alternating current to direct current). Zener diodes have a well-defined breakdown voltage, so that current flows in the reverse direction at that voltage and a constant voltage can be maintained despite fluctuations in voltage or current. In varactor (or varicap) diodes, varying the bias voltage causes a variation in the diode's capacitance; these diodes have many applications for signal transmission and are used throughout the radio and television industries. (For more detail about these and other types of diodes, *see* semiconductor device.)

Early diodes were vacuum tubes, an evacuated glass or metal electron tube containing two electrodes—a negatively charged cathode and a positively charged anode. These were used as rectifiers and as detectors in electronic circuits such as radio and television receivers. When a positive voltage is applied to the anode (or plate), electrons emitted from the heated cathode flow to the plate and return to the cathode through an external power supply. If a negative voltage is applied to the plate, electrons cannot escape from the cathode, and no plate current flows. Thus, a diode permits electrons to flow from cathode to plate but not from plate to cathode. If an alternating voltage is applied to the plate, current flows only during the time when the plate is positive. The alternating voltage is said to be rectified, or converted to direct current.

3.3.4IRF740

- A MOSFET is a four-terminal device having source(S), gate (G), drain (D) and body (B) terminals. In general, The body of the MOSFET is in connection with the source terminal thus forming a three-terminal device such as a field-effect transistor. MOSFET is generally considered as a transistor and employed in both the analog and digital circuits. This is the basic **introduction to MOSFET**. And the general structure of this device is as below :
- 

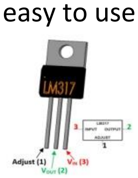
MOSFET
- From the above **MOSFET structure**, the functionality of MOSFET depends on the electrical variations happening in the channel width along with the flow of carriers (either holes or electrons). The charge carriers enter into the channel through the source terminal and exit via the drain.
- The width of the channel is controlled by the voltage on an electrode which is called the gate and it is located in between the source and the drain. It is insulated from the channel near an extremely thin layer of metal oxide. The MOS capacity that exists in the device is the crucial section where the entire operation is across this.

POT

Potentiometer is **a three-terminal resistor with a sliding or rotating contact that forms an adjustable voltage divider**. If only two terminals are used, one end and the wiper, it acts as a variable resistor or rheostat

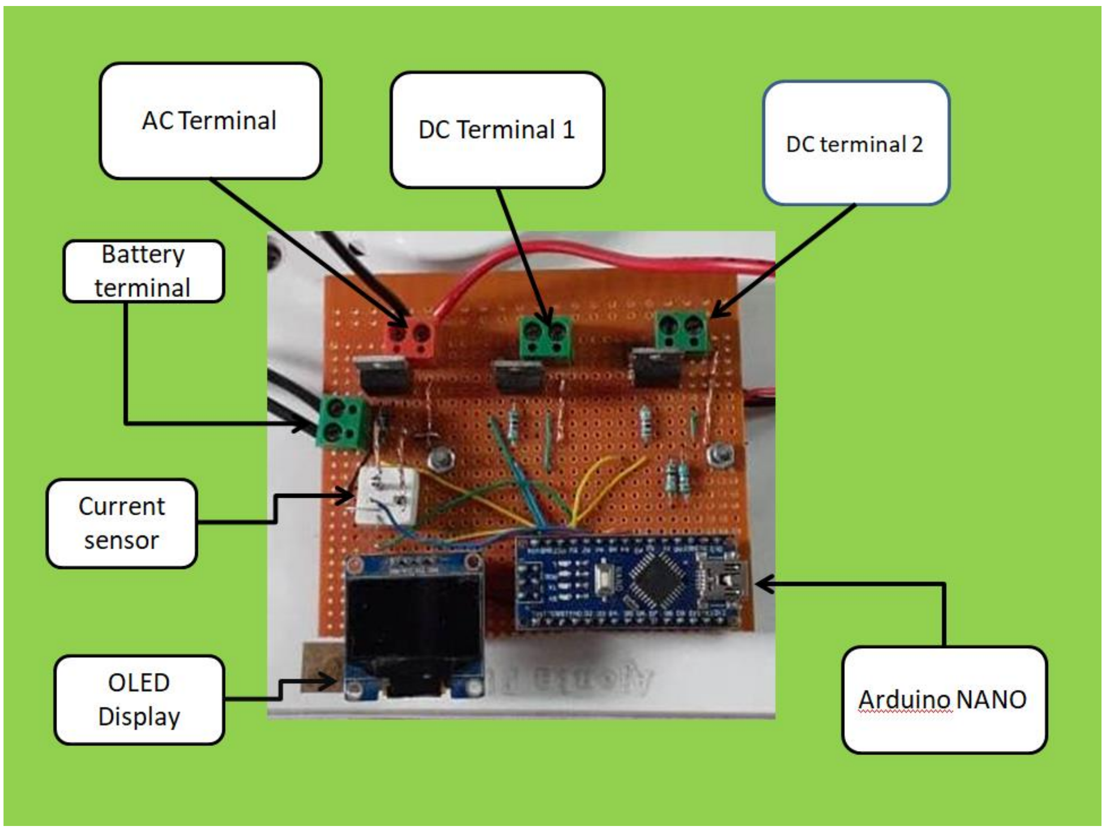
- **LM314T**

The LM317 is an adjustable 3−terminal positive voltage regulator capable of supplying in excess of 1.5 A over an output voltage range of 1.2 V to 37 V. This voltage regulator is exceptionally easy to use and requires only two external resistors to set the output voltage. Further, it



employs internal current limiting, thermal shutdown and safe area compensation, making it essentially blow−out proof. The LM317 serves a wide variety of applications including local, on card regulation. This device can also be used to make a programmable output regulator, or by connecting a fixed resistor between the adjustment and output.

Over view of solar charge controller



APPENDIX B

(SOFTWARE DISCRIPTION)

SOFTWARE CODING

```
#include <SPI.h>

#include <Wire.h>

#include <Adafruit_GFX.h>

#include <Adafruit_SSD1306.h>


#define SCREEN_WIDTH 128

#define SCREEN_HEIGHT 64

#define OLED_RESET     4

Adafruit_SSD1306 display(SCREEN_WIDTH, SCREEN_HEIGHT, &Wire, OLED_RESET);


void setup() {

 if (!display.begin(SSD1306_SWITCHCAPVCC, 0x3C)) {

  Serial.println(F("SSD1306 allocation failed"));

  for (;;);

 }

 display.clearDisplay();

 display.setTextSize(1);

 display.setTextColor(WHITE);

 display.setCursor(28, 0);

 display.println(F("Project Hub"));

 display.display();

 delay(1000);


 pinMode(2, OUTPUT);//Load
```

```
 pinMode(3, OUTPUT);//PS1

 pinMode(4, OUTPUT);//PS2

}


void loop() {

 float v = analogRead(A0) * 0.02710396;

 float i = analogRead(A7)*0.02710396 - 18.79846154;


 if (v < 10)

 {

  digitalWrite(2, LOW);

  digitalWrite(3, HIGH);

  digitalWrite(4, HIGH);

 }


 if (v > 11 && v < 13)

 {

  digitalWrite(2, HIGH);

  digitalWrite(3, HIGH);

  digitalWrite(4, HIGH);

 }


 if (v > 14)

 {

  digitalWrite(2, HIGH);

  digitalWrite(3, LOW);
```

```
  digitalWrite(4, LOW);
}

digitalWrite(LED_BUILTIN, HIGH);
delay(1000);
digitalWrite(LED_BUILTIN, LOW);
delay(1000);

display.clearDisplay();
display.setCursor(0, 0);
display.println(F("   RCCIIT"));
display.print("Volt: ");
display.print(v);
display.println(" V");
display.print("Curr: ");
display.print(i);
display.println(" A");
display.print("Powe: ");
display.print(v * i);
display.println(" W");
display.println("");

if (v < 10)
{
  display.println("Battery Low");
  display.println("Load Off");
```

```
 }


 if (v > 11 && v < 13)

 {

   display.println("Load On");

 }


 if (v > 14)

 {

   display.println("Battery Full");

   display.println("Charging Off");

 }

 display.display()

;}
```

LOGIC AND OPERATION

CHAPTER 4

INTRODUCTION

After assemble the entire components we still need to do how the prototype working that's why we are divided prototype into 3 major section

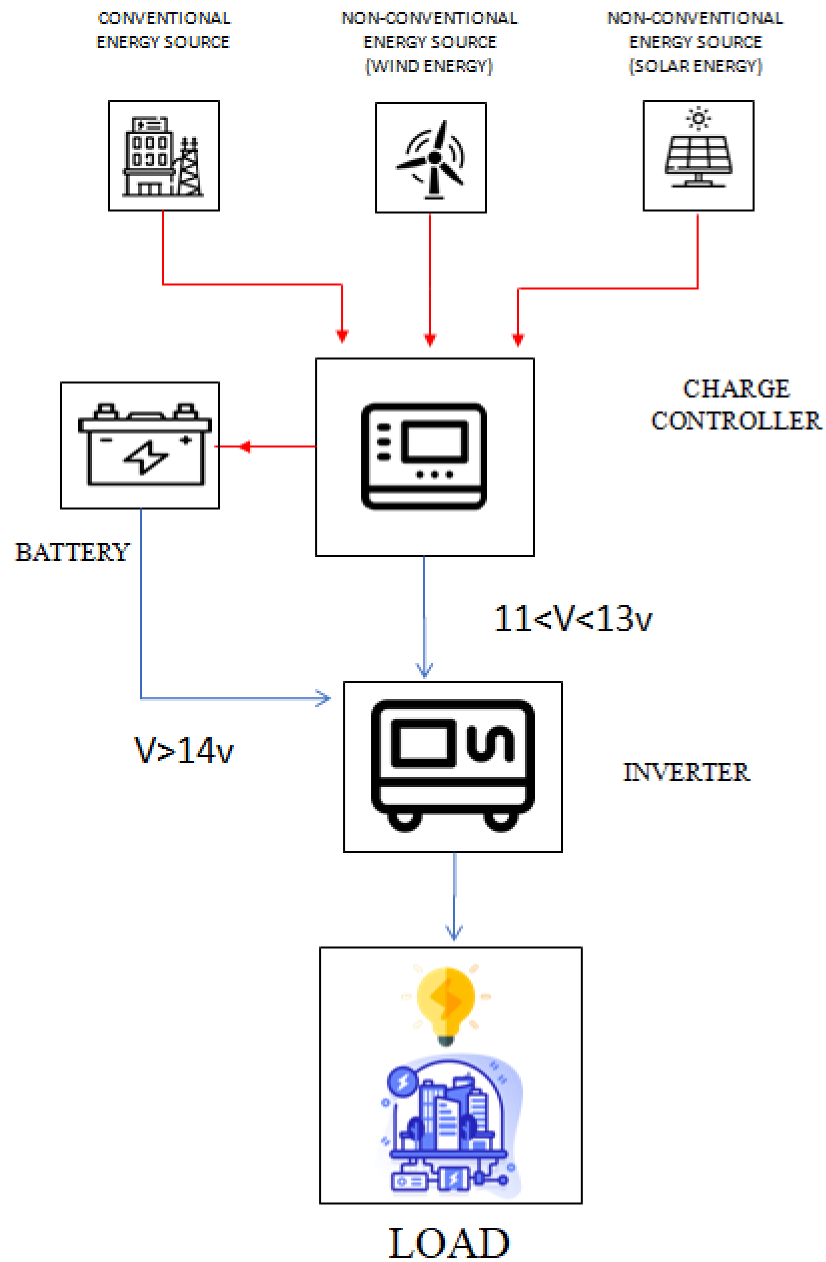
- **Solar charge controller section**
- **Inverter section**
- **Oled section**

Block Diagram

Principle and operation

This id the perfect example of power system. By using nano microcontroller it can easily analysis the in take power and Works according to our desire. OLED displays the real time data. Once any fault occur in the supply line that section easily cut from the rest of device. Rest of the system continues their operation.

BLOCK DIAGRAM



SL.NO.	COMPONENT	Cost
1	Veroboard	35*2=70
2	2pin terminal	16
3	Arduino nano	600
4	OLED DISPLAY	300
5	JUMPER WIRE	30
6	IN4007	10
7	CAPACITOR	15
8	INDUCTOR	15
9	POT	100
10	INVERTER KIT	500
11	BATTERY	1500
12	ADAPTER	1
13	BULB	25
14	USB JACK	400
	TOTAL	3700/-

Conclusion and future scope

CHAPTER 5

Conclusion

Here we developed a prototype which automatically fills a number of bottles with the help of a micro-controller. It will help in reducing human effort and error. Our circuit consists of ESP32 as a main controller, OLED as a display device, Stepper motor as a main driving gear, Pump to fill the liquid in the bottle. The prototype worked satisfactorily.

5.2 Result

The experimental model was made according to the circuit diagram and the results were as expected. The OLED displays properly the status of the operation at each step. After all the bottles are filled the circuit stops. Here special attention must be taken to design the relay driver. During the testing it was found that the DC pump creates much RFI (Radio Frequency Interference) which affect the stepper motor driver A4988. When the pump starts the driver malfunctioned and the stepper motor behaves strangely. One noise filter circuit also developed to reduce the interference.

5.3 Future work

In this developed prototype the bottles need to placed manually and after the filling user need to replace the bottle manually. In our future work we try to develop a system which fully automatically filling the bottles. we will also try to use IoT and connect with our module, then it can be controlled with the help of a remote device, which will make it to stop the circuit remotely in case of any error

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CHAPTER 6

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[8] Nisarg A Solanki, Pratik G Raj, Saumil P Patel, Charmish D Rajput, "Advanced hybrid grid", International Journal of Engineering Research & Technologyextremely thin layer of metal oxide. The MOS capacity that exists in the device is the crucial section where the entire operation is across this.

THANK YOU