DE-40(DEE)

NUST COLLEGE OF

ELECTRICAL AND MECHANICAL ENGINEERING

Three Phase Boost Inverter using Push-Pull Converter Topology

<u>A PROJECT REPORT</u>

DE-40 (DEE)

Submitted by

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BACHELORS

IN

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PROJECT SUPERVISOR

Dr. Taosif Iqbal

NUST COLLEGE OF

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DEDICATION

This project is dedicated to our parents, their efforts and all the prayers were with us during the project. It is also dedicated to our teachers and all the technical staff who really helped us for the completion of this project.

CERTIFICATE OF APPROVAL

It is to certify that the project "**THREE PHASE BOOST INVERTER**" was done by **NC Osama Ahmad Awan, GC Muhammad Abdullah and GC Muhammad Ezaan Ajmal** under the supervision of **Dr. Taosif Iqbal.**

This project is submitted to **Department of Electrical Engineering**, College of Electrical and Mechanical Engineering (Peshawar Road Rawalpindi), National University of Sciences and Technology, Pakistan in partial fulfilment of requirements for the degree of Bachelors of Engineering in Electrical engineering.

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DECLARATION

We hereby declare that no portion of the work referred to in this Project Thesis has been submitted in support of an application for another degree or qualification of this of any other university or other institute of learning. If any act of plagiarism found, we are fully responsible for every disciplinary action taken against us depending upon the seriousness of the proven offence, even the cancellation of our degree.

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ACKNOWLEDGEMENTS

It is a great pleasure of writing a report is acknowledging efforts of many people whose names may not be appear on the title page, but their hard work, friendship, cooperation, and understanding were with us to the production of this report.

Here we would like to mention the support and guidance given by our supervisor Dr Taosif Iqbal. His availability and prompt responses to our issues aided us in successfully finishing this job. Our department (Department of Electrical Engineering) is responsible for enabling us to complete this project and produce outcomes.

ABSTRACT

This project gives a design of three phase enhance Inverter. It essentially takes DC power source as an enter and produce high voltage AC as an output, similar to strength as an electrical wall outlet. Inverters are used for many programs, as in situations where low voltage DC resources which include batteries, solar panels, or gasoline cells no longer to be converted. One instance of the sort of scenario could be converting electric strength from a vehicle battery to run laptop, tv, or mobile cellphone.

The approach, in which the low voltage DC power is inverted, is finished in steps. the first being the conversion of the low voltage DC power to a high voltage DC supply, and the second one step being the conversion of the high DC source to an AC waveform using pulse width modulation. another approach to finish the favored outcome might be to first convert the low voltage DC strength to AC, after which use a transformer to reinforce the voltage to a hundred and twenty volts or 220 volts.

The inverter subsequently has 3/single phase output to run AC appliances. every phase has an AC voltage of a hundred and twenty or 220 volts.

TABLE OF CONTENT

CHAPTER 1 INTRODUCTION

1.1 Introduction of Our Project:

This mission is a superb instance of tracking &controlling all operations of 3-section output and offering it safety via intelligent software program in the arduino. The goal of this mission is to govern i.e. to ON/OFF switching and velocity manipulate of 3-segment output and defend from high voltage & over load from everywhere within the global. For this cause we will use Arduino UNO. in this challenge we're making first Push pull converter then 3 segment inverter to pressure AC 3 segment load. Many industries had been quick to make use of this era, with hundreds of thousands of handsets currently in use. As new models with "ought to have" capabilities hit the marketplace, older fashions emerge as surely nugatory and if now not recycled, come to be in landfill. With this in thoughts, we‘ve designed the venture to work with Arduino.

1.1.1 Problems Facing in Project & Overcome These Problems:

The primary troubles of the existing system is given underneath
i. the primary purpose of the project is to broaden 3-section inverter that gives 3 levels for the output from unmarried DC source.
ii. force three-phase output gadget with single DC deliver.
iii. secure &smooth control of pace of 3-phase device through the use of improve Converter.
iv. complete tracking.
v. protection of load from excessive voltage & high cutting-edge.

1.2 Scope:

i. secure & clean manage of three-phase load by the usage of push pull converter technology.
ii. complete tracking.
iii. safety of Load from Low /high voltage.

1.3 Application:

i. Industries.
ii. Home Appliances.
iii. everywhere single DC deliver is available, in which we can perform any 3 segment operations

1.4 Problem Statement:

The task is based totally on operation of 3 phase load the usage of 3 section inverter, The mission includes single DC supply to three-phase conversion and provides fault protection using push pull converter topology.

1.5 Thesis Outline:

This thesis is composed 5 chapters;

1st chapter: speak about the introduction of this assignment. in which we discuss about our software, scope, main block diagram, trouble announcement & thesis agency.

2nd Chapter: Will speak extra on principle and literature critiques that have been completed. element machine design, set of rules, element block diagram & rationalization of each component, mathematical modelling .

3rd Chapter: The dialogue could be on the software simulation of this assignment.

4th Chapter: Discusses the hardware of this task and paintings that can be performed.

5th Chapter: Discusses the conclusions and hints

CHAPTER 2 DETAIL SYSTEM DESIGN

2.1 Algorithm:

Figure 2.1 circuit diagram shows the full working of the project. Single DC supply used for the project. Current transformer connected to the supply in series to current sensing for the measuring and over current identification and potential transformer is connected to the supply in parallel to measure the voltage. CT and PT send their output to the Arduino that generates SPWM signals. Rectifier converts ac into dc. This DC signal is not a pure DC signal so we have used low pass filter to remove the ripples.

For Arduino operation we have used 5 V and for load we need 220V. We send DC signal to regulator and forward it to the Arduino. It then generates SPWM signals. Arduino will forward signal to the Driver Circuit that convert the single incoming signal into 6 signals. IGBT drive will create phase shift/ time delay and forward theses 6 signals to the IGBT's gate. IGBT give the output in form of 3 phase ac with 120 degree phase shift among two phases.

2.1.1Circuit Modelling :

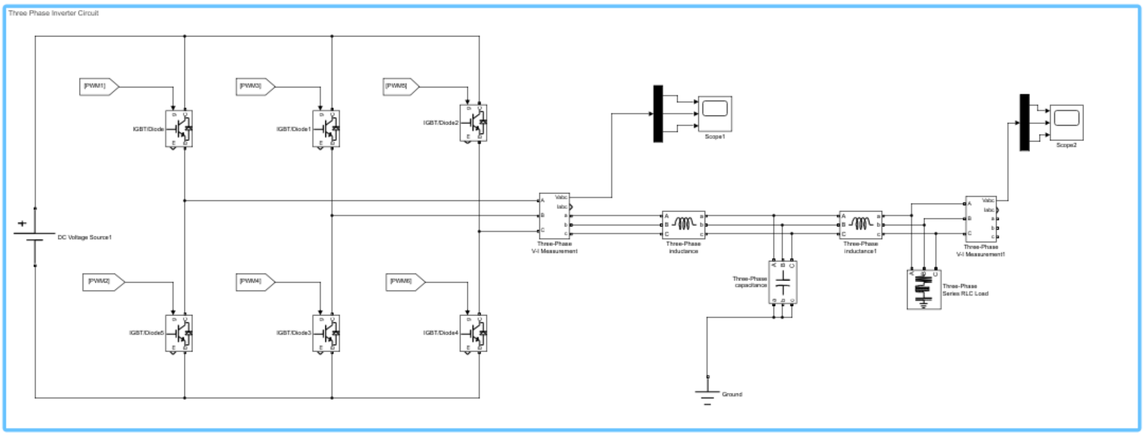

Fig 2.1 Circuit Diagram of Project

The circuit diagram of project shown in figure 2.1. In the starting with DC supply, it is connected with a push pull converter. This DC to DC converter then converts 12V DC to 220V DC.

Here is also six IGBTs used to achieve the same above defined. The output of IGBTs is fed to Filter circuit LCL for pure Sinusoidal Waveform.

In this project we are using 2 different supplies of 5 V and 220 V. 5 V supply is used to operate Arduino. 220 V supply is used to operate IGBT drive and 220 V is the main supply. Splitter's output signals connected to the IGBT drive from pin 2 to pin 7. IGBT's output (pin 12, 16, 19, 20, 24, 27, 28) is connected with the IGBT at their gate point. Output of IGBT (J7, J8, J9) is the main output points of the whole project where 3 Phase load is connected.[4]

2.1.2 Three Phase Inverter:

You can divide the world of electronics drives into two categories: AC and DC. An inverter circuit converters DC signal into pure signal. A DC drive typically controls a shunt wound DC motor, which has separate armature and field circuits. AC drives control AC induction motors, and-like their DC counterparts-control speed, torque, and horse power. A three phase load can run only at its rated speed when it is connected directly to the main supply. However, many applications need these operations. This is felt the most in applications where input power is directly proportional to the load requirment. In applications like the induction motor-based centrifugal pump, a speed reduction of 20% results in an energy savings of approximately 50%.

Driving and controlling the three phase load efficiently are prime concerns in today's energy conscious world. With the advancement in the semiconductor fabrication technology, both the size and the price of semiconductors have gone down drastically. This means that the user can replace an energy inefficient mechanical load drive and control system with a Constant Frequency. The inverter not only operates the load, but can improve the dynamic and steady state characteristics as well. In addition, the inverter can reduce the system's average energy consumption.

Although various three phase load operating techniques are in practice today, the most popular technique is by generating constant frequency supply, which has constant voltage to frequency ratio. This technique is popularly known as *VF control*. Generally used for Open loop systems, VF control caters to a large number of applications where the basic need is to operate the load and control the system efficiently. It is also simple to implement and cost effective.[9]

2.1.2.1 Application of *Inverter* as an example:

Let's take a brief look at a inverter application. In Fig. 1, you can see a simple application with a fixed speed fan. You could replace the 3-phase load starter with inverter to operate the fan at constant speed. Since you can operate the fan below its maximum speed, you can vary airflow by opearating the load instead of the air outlet damper.

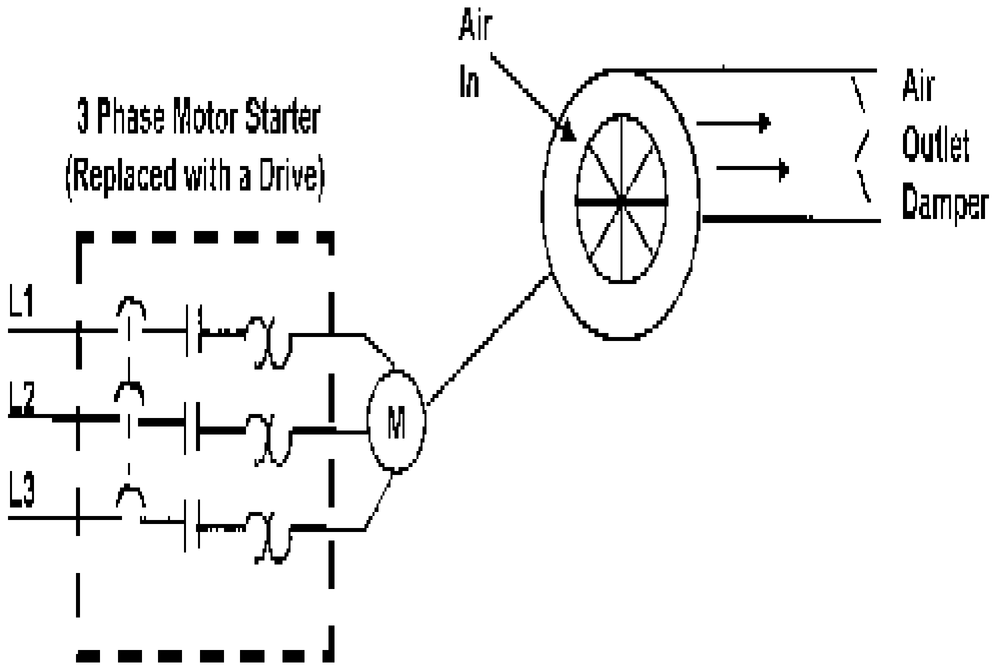

Fig 2.2Fixed Speed Fan Applications

An inverter can operate 3-phase loads. To understand how an Inverter operates, we will take a short review of AC loads. Fig. 2 shows the construction of an AC load. The two basic parts of this load, the rotor and stator, work through magnetic interaction. A load contains pole pairs. These are iron pieces in the stator, wound in a specific pattern to provide a north to south magnetic field.

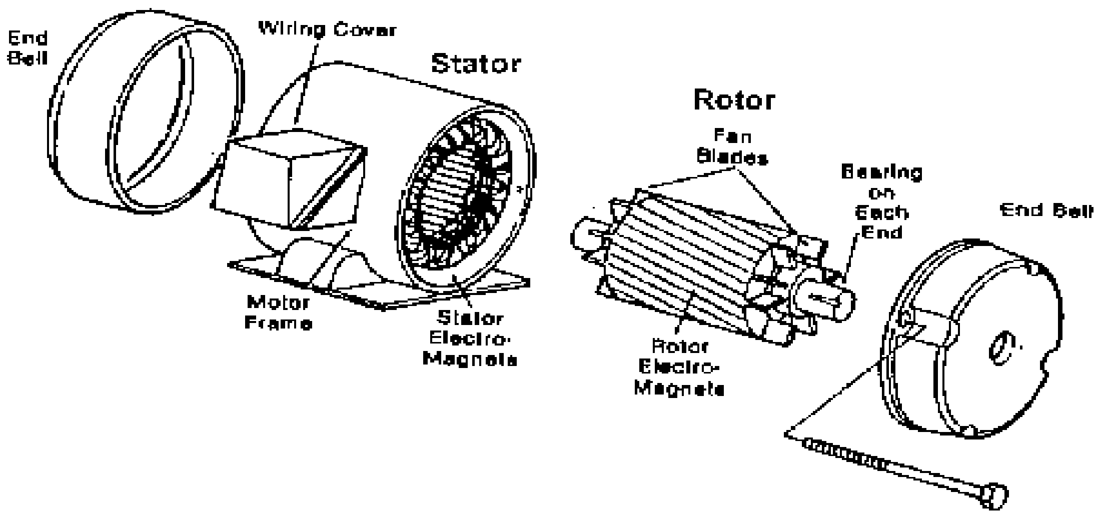

Fig 2.3 Basic Construction of three phase load

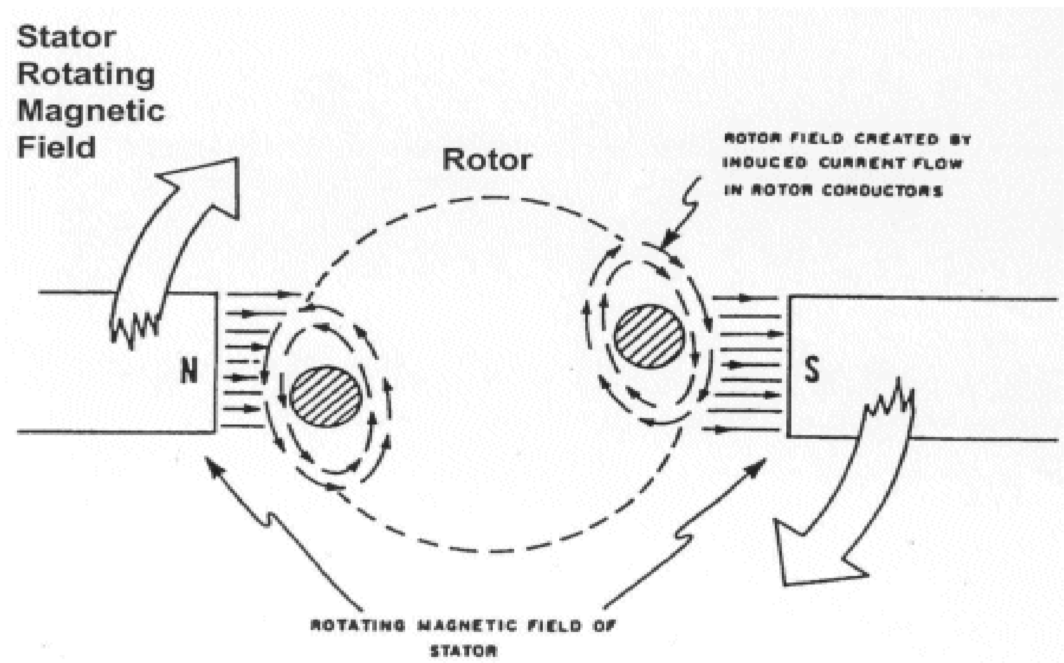

Fig 2.4 Operating principles of this AC load

With one pole pair isolated in a motor, the rotor (shaft) rotates at a specific speed is called the base speed. The number of poles and the frequency applied determine this speed. When a magnetic field passes through the conductors of the rotor, the rotor takes on magnetic fields of its own. These rotor magnetic fields will try to catch up to the rotating fields of the stator. However, it never does this difference is called slip. Slip is the difference between the rotor speed and the rotating magnetic field in the stator.

$$Ns = \frac{120\,f}{p}$$

This formula shows the synchronous speed of the induction motor.

$$Shaftspeed\ = \frac{120\,f}{p} - \ slip$$

F = Frequency applied to the motor

P = Number of motor poles

We can also conveniently adjust the speed of a motor. You could adjust motor speed by adjusting the number of poles, but this is a physical change to the motor. It would require rewinding, and result in a step change to the speed. So, for convenience, cost-efficiency, and precision, we change the frequency. Fig.2.5 shows the torque-developing characteristic of this system: the Volts per Hertz ratio (V/Hz). We change this ratio to change motor torque. A load connected to a 460V, 60 Hz source has a ratio of 7.67. As long as this ratio stays in proportion, the load will develop rated torque. A inverter also provides many different frequency outputs. At any given frequency output of the inverter, you get a new torque curve.

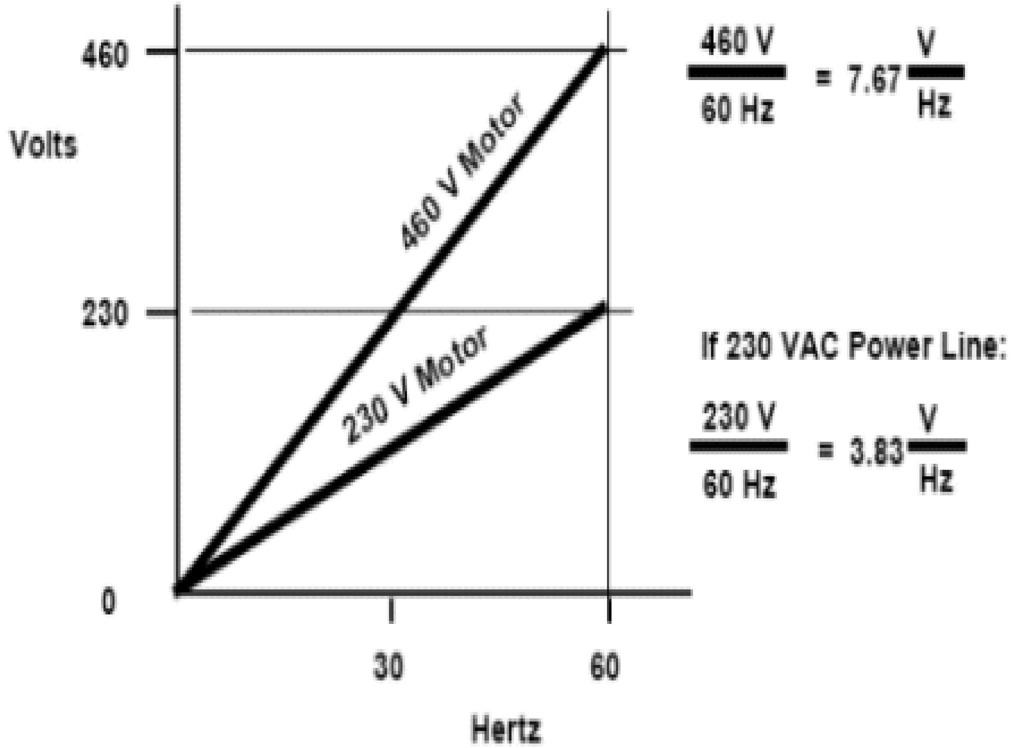

Fig 2.5

Volts/Hertz Ratio

2.1.2.2 How *Inverter Operates the load*:

Just how does a inverter provide the frequency and voltage output necessary to operate a load? That's what we'll look at next. Fig. 6 shows a basic PWM drive. All PWM drives contain these main parts, with subtle differences in hardware and software components

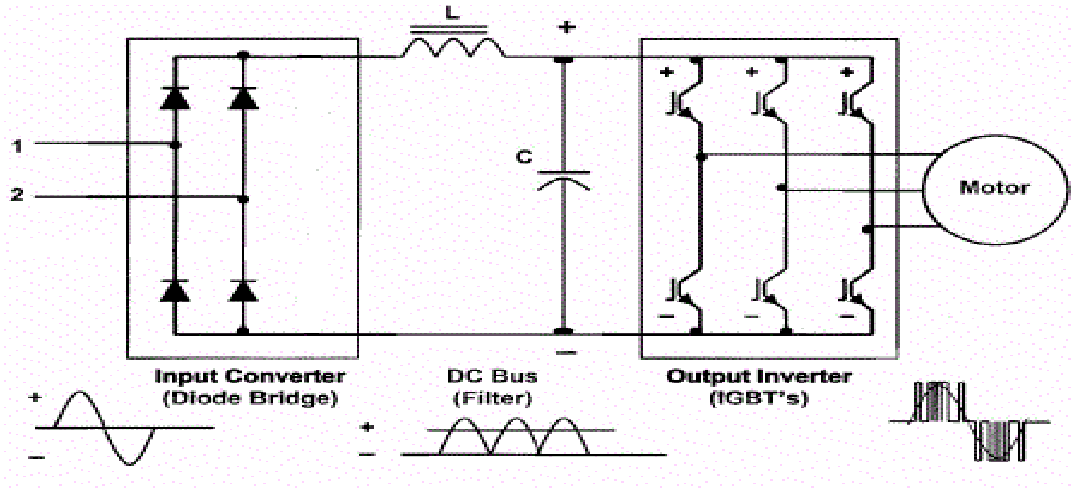

Fig 2.6 Basic PWM Drive Components

The inverter accept single DC input power. The input section of the inverter is the converter. It step up the DC input Power. The next section is of IGBTs which convert high power DC into high power AC.

The output is then filtered for Pure Sinusoidal Waveform. The inductor (L) and the capacitor (C) works together for pure AC component. The smoother ac waveforms as output waveforms from the inverter. The AC bus is the final section of the inverter. As the name implies, this section inverts the DC voltage back to AC. But, it does so in a constant voltage and frequency output. How does it do this? That depends on what kind of power devices your inverter uses. In the early 1990s, those gave way to using Insulated Gate Bipolar Transistor (IGBT) technology, which will form the basis for our discussion. Today's inverters use **Insulated Gate Bipolar Transistors (IGBTs)** to switch the DC bus on and off at specific intervals. In doing so, the inverter actually creates a constant AC voltage and frequency output.

The inverter control board signals the power device's control circuits to turn "on" the waveform positive half or negative half of the power device. This alternating of positive and negative switches recreates the 3 phase output. The longer the power device remains on, the higher the output voltage. The less time the power device is on, the lower the output voltage as shown in Fig.2.7. Conversely, the longer the power device is off, the lower the output frequency.

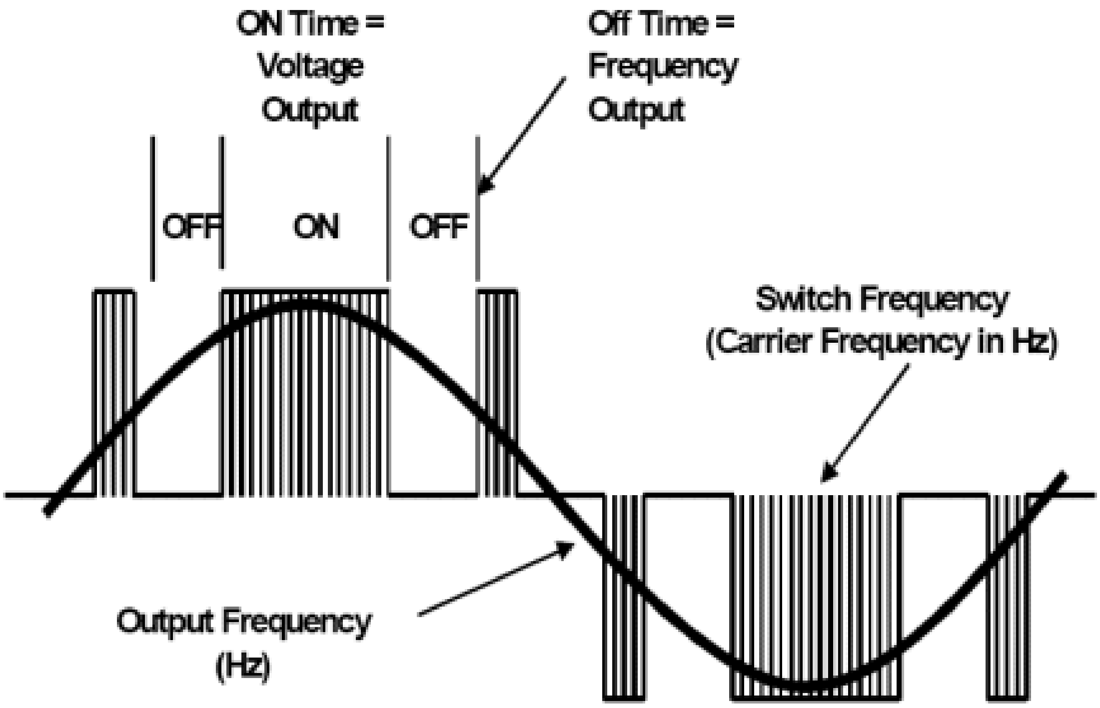

Fig 2.7 Inverter Output Waveform Components

The speed at which power devices switch on and off is the carrier frequency, also known as the switch frequency. The higher the switch frequency, the more resolution each PWM pulse contains.

2.1.3 Salient Points of Inverter Control:

The operating control of the three phase load is directly proportional to the supply frequency and the number of poles of the load. Since the number of poles is fixed by design, the best way to control the three phase load.

The torque developed by the three phase load (e.g induction motor) is directly proportional to the ratio of the applied voltage and the frequency of supply. By varying the voltage and the frequency, but keeping their ratio constant, the torque developed can be kept constant throughout the speed range. This is exactly what VF control tries to achieve. Figure 2.2 shows the typical torque-speed characteristics of the induction motor, supplied directly from the main supply. The torque-speed characteristics of the VF control reveal the following:

i. The starting current requirement is lower.
ii. The stable operating region of the motor is increased. Instead of simply running at its base rated speed (N_B), the motor can be run typically from 5% of the synchronous

speed (N s) up to the base speed. The torque generated by the motor can be kept constant throughout this region.

iii. At base speed, the voltage and frequency reach the rated values. We can drive the motor beyond the base speed by increasing the frequency further. However, the applied voltage cannot be increased beyond the rated voltage. Therefore, only the frequency can be increased, which results in the reduction of torque. Above the bases peed, the factors governing torque become complex.

iv. The acceleration and deceleration of the motor can be controlled by controlling the change of the supply frequency to the motor with respect to time.

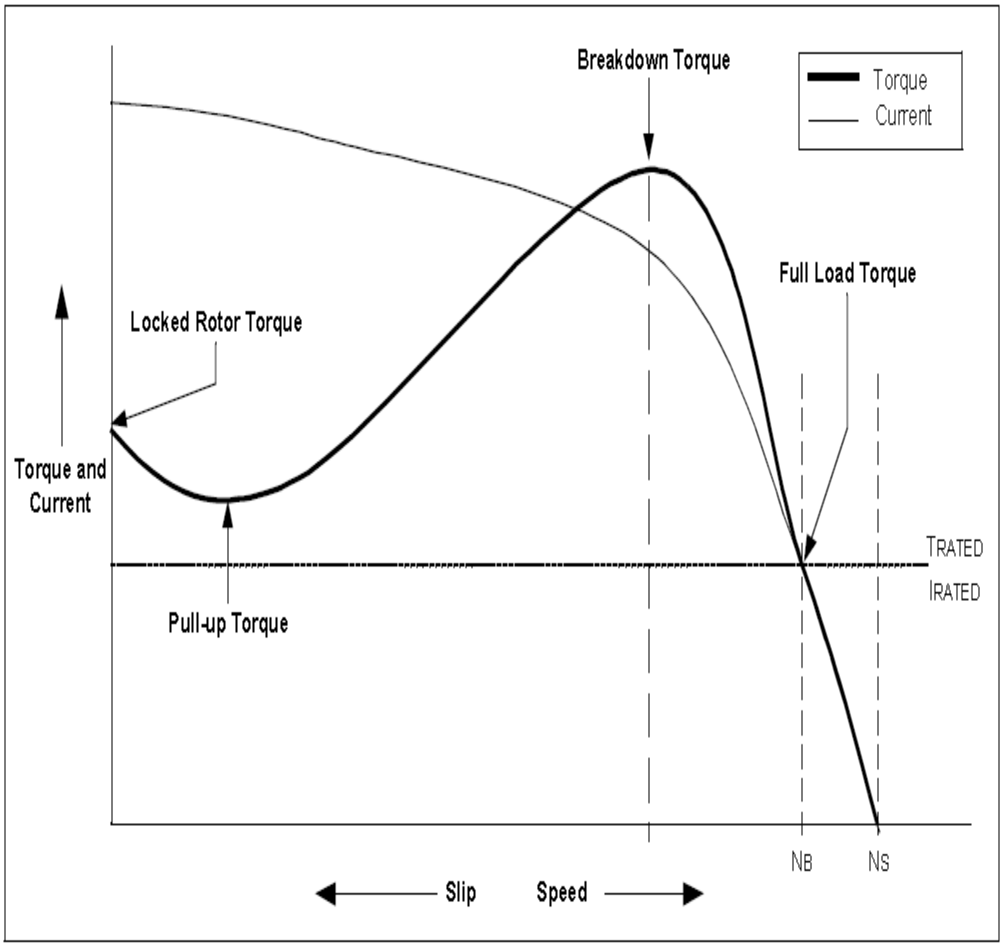

Fig 2.8 Torque-Speed Characteristics of The Load

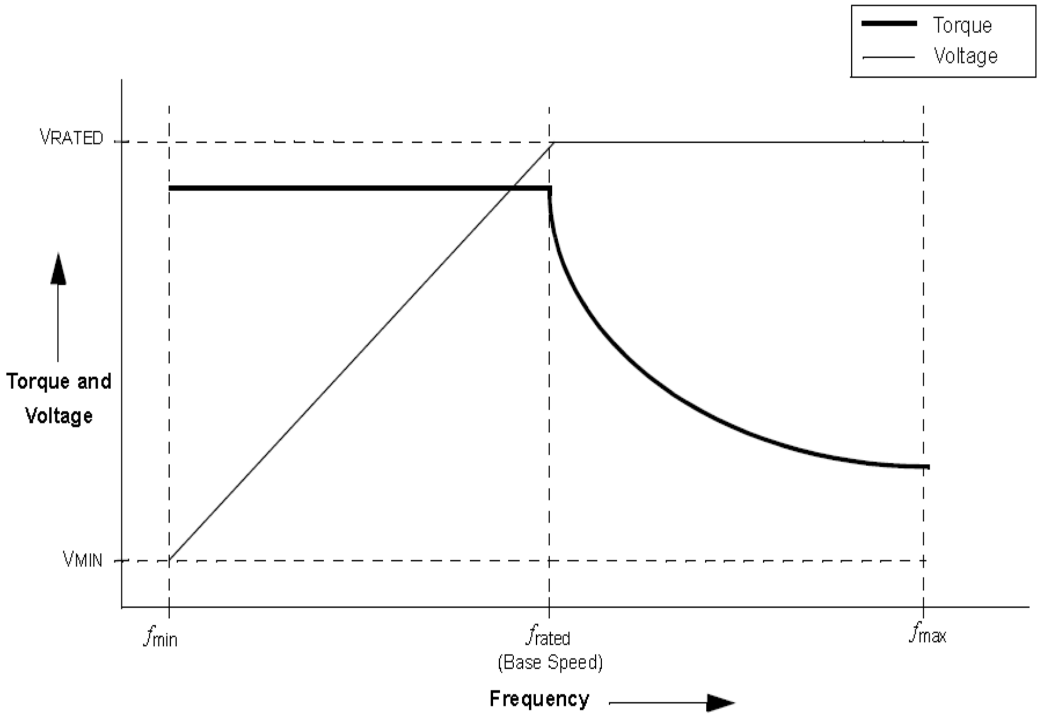

Fig 2.9 Torque-Speed Characteristics of Induction Motor

2.1.4 Three Phase Load Drive:

The 3-phase load is connected to a 3-phaseinverter bridge. The power inverter has 6 switches that are controlled in order to generate3-phase AC output from the DC bus. PWM signals, generated from the Arduino, control these 6 switches. Switches IGBTH1 through IGBTH3, which are connected to DC+, are called upper switches. Switches IGBTL1 through IGBTL3, connected to DC- are called lower switches.

The amplitude of phase voltage is determined by the duty cycle of the PWM signals. While the load is running, three out of six switches will be on at any given time; either one upper and two lower switches or one lower and two upper switches. The switching produces a rectangular shaped output waveform that is rich in harmonics. The inductive nature of the load filters this supplied current to produce a 3-phase sine wave with negligible harmonics. When switches are turned off, the inductive nature of the windings oppose any sudden change in direction of flow of the current until all of the energy stored in the windings is dissipated. To facilitate this, fast recovery diodes are provided across each switch.

These diodes are known as freewheeling diodes. To prevent the DC bus supply from being shorted, the upper and lower switches of the same half bridge should not be switched on at the same time. A dead time is given between switching off one switch and switching on the other. This ensures that both switches are not conductive at the same time as each one change states.

2.2 Block Diagram:

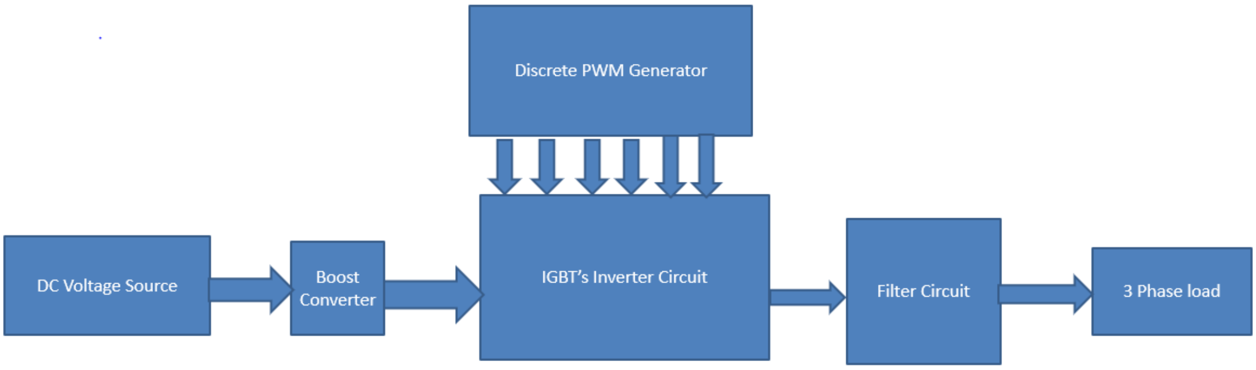

Fig 2.10 Block Diagram

2.3 Explanation of Each Part:

2.3.1 Three Phase Load:

The three phase load must be one of man's most useful inventions. In the manufacturing industries they are used in large numbers, to drive lathes, drilling and milling machines, augers, conveyors, cranes, hoists, lifts, fans and steel rolling equipment.

In the process industries they are used to pump liquids and gases. They are used in transport to start engines, operate windscreen wipers, open and close windows and power electric vehicles. In domestic situations they are used in washing machines, clothes dryers, cookers, fridges, freezers, vacuum cleaners, food mixers, audio / video equipment, cameras, clocks etc.

They are popular because they are compact, reliable, and cheap, need little attention, and are convenient to use. They can be provided in a wide range of sizes and can be designed to have different characteristics for various applications.
Also, there is a readily available supply of electricity. They may be regarded as an energy converter. It is supplied with electrical energy and provides mechanical energy as an output as shown in Figure 2.10.

There are AC loads and DC loads. There are a number of different types of loads under each heading. They may be classified by their power rating. This may be given in Watts or Horsepower. One Horsepower is the equivalent of 746 Watts. Power ratings range from a few watts, such as those used in electric clocks, through to a few kilowatts, such as those used in domestic, agricultural and light duty industrial situations, to large motors in the order of tens of megawatts. These are used in heavy duty industrial situations such as mining, quarrying and cement plants. Motors are also classified by the way in which their windings are interconnected motors are classified depending on the environment in which they are intended to be used. For example, very high temperature locations, damp locations, dust laden locations and explosive locations. The basic requirement of an electric motor is that it should provide rotational drive. The motor is fixed in position and drives a mechanical system directly or via gears, belts etc. Motors depend for their operation on the interaction between two magnetic fields. Electric current, flowing through windings consisting of copper wire produce both of these magnetic fields. Some small loads use permanent magnets to produce one of the magnetic fields.

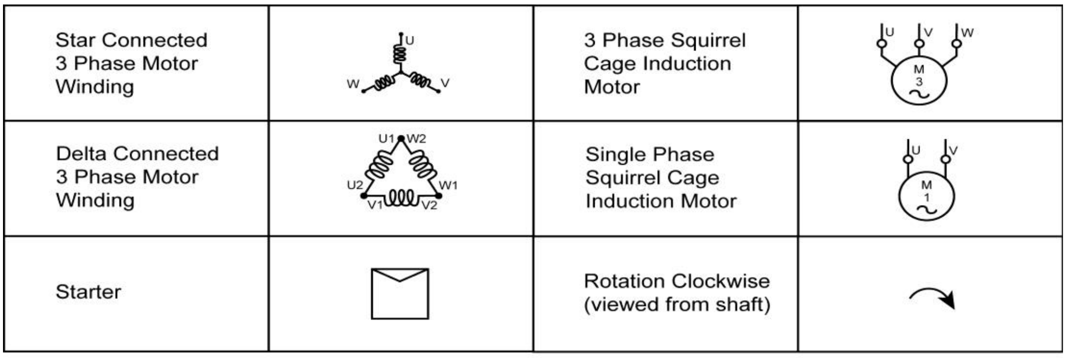

Fig 2.11 load Related Symbols

2.3.2 Catagories of Load:

There are two types of loads.

i. Single phase load.

ii. Three phase load.

2.3.2.1 Single-Phase *load*s:

When a single-phase supply is connected to a single windings it provides an alternating rather than a rotating magnetic field and the rotor will not turn. However, single-phase loads will run successfully provided that an initial start is given to it. They will run in either direction depending on the direction of the initial start.

This initial start is produced by providing an artificial phase, which simulates a two-phase supply. In order to create this artificial phase, single-phase loads are manufactured with two separate windings. These windings are connected in parallel with each other during starting.

One winding is called the Main Winding (or Run Winding), while the other winding is called the Auxiliary Winding (or Start Winding). The main winding is always left in circuit, but the auxiliary winding may be disconnected once the operation is started.

They are in common use, particularly in domestic, agricultural and commercial spheres. Single-phase loads cannot compete with the performance or efficiency of three-phase loads. They are more troublesome, mainly on account of the ancillary starting equipment required. They are also physically larger than equally rated three-phase loads.

2.3.2.2 Three-phase *Loads*:

This load is very robust and, because of its simplicity and trouble free features, it is the type of load most commonly employed for industrial use. They can be of Star and Delta Connection.

- **Star Connection:**

To make a star connection, the three finish ends are connected together. This connection point is referred to as the star point. The three-phase supply is connected to the three start ends.

Figure 2.19 illustrates the terminal block arrangement for a motor connected in star.

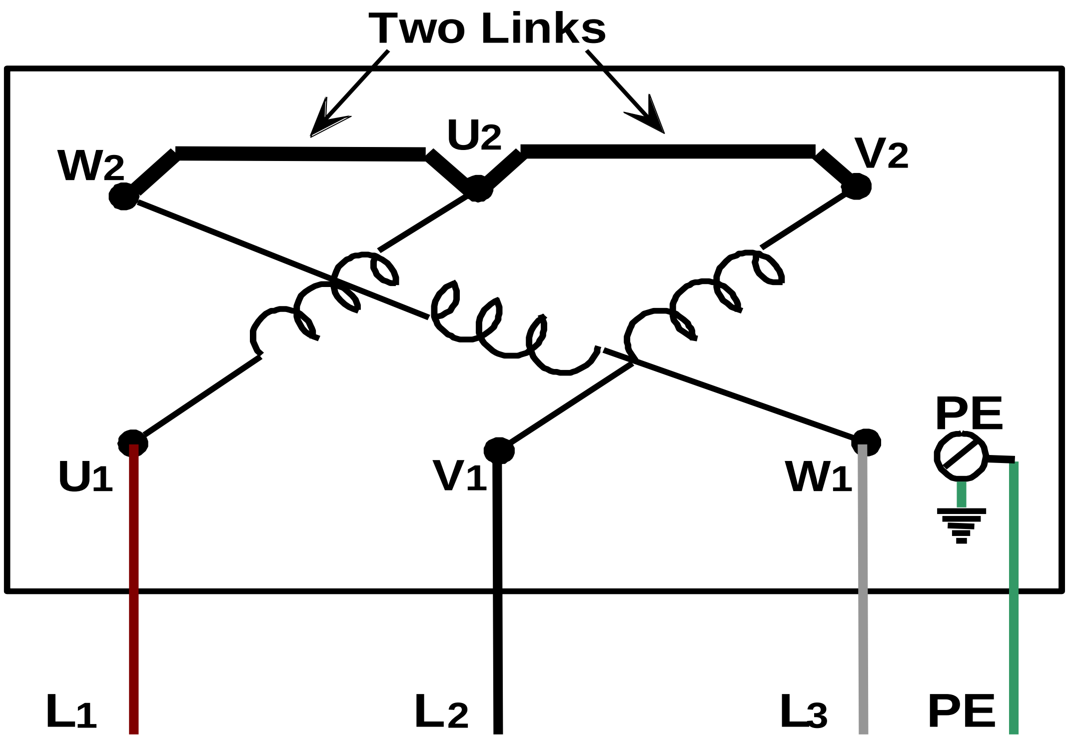

Fig 2.11 Star Connection

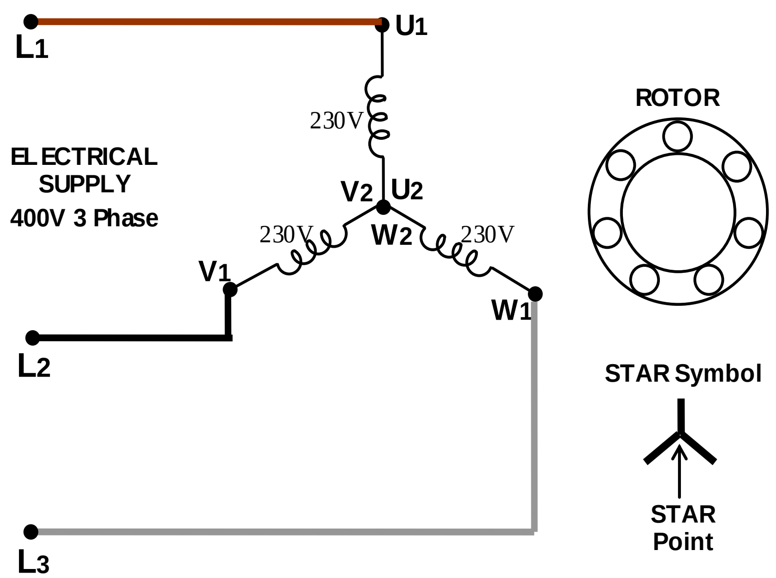

Fig 2.12 Load Connected In Star

When connected to a 400 Volt three-phase supply, a star connected motor will have 230 Volts across each winding. Some three-phase motor windings are only suitable for 230 Volts. If connected in delta in this situation, they will quickly burn-out. (Check motor nameplate).

- **Delta Connection:**

To make a delta connection, the finish end of load is connected to the start end of the next and so on. Figure 2.14 illustrates the terminal block arrangement for a motor connected in delta.

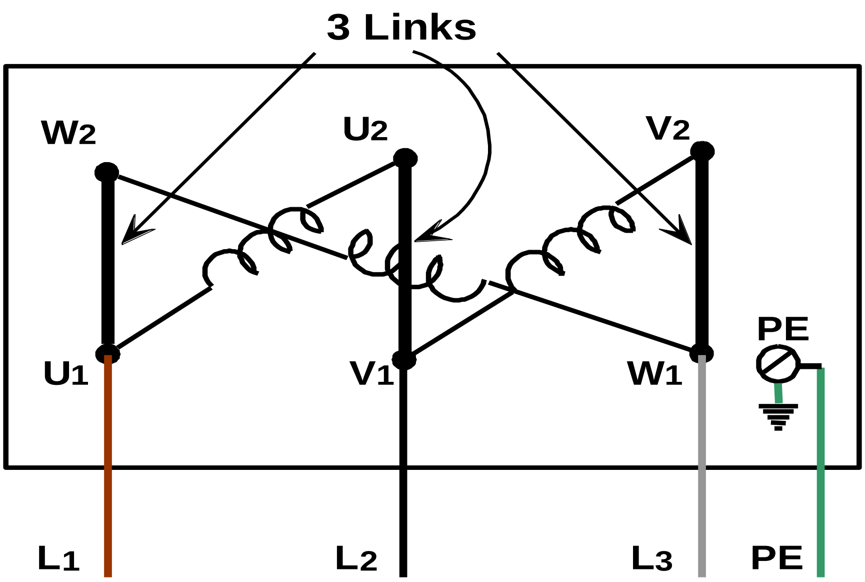

Fig 2.13 Delta Connection

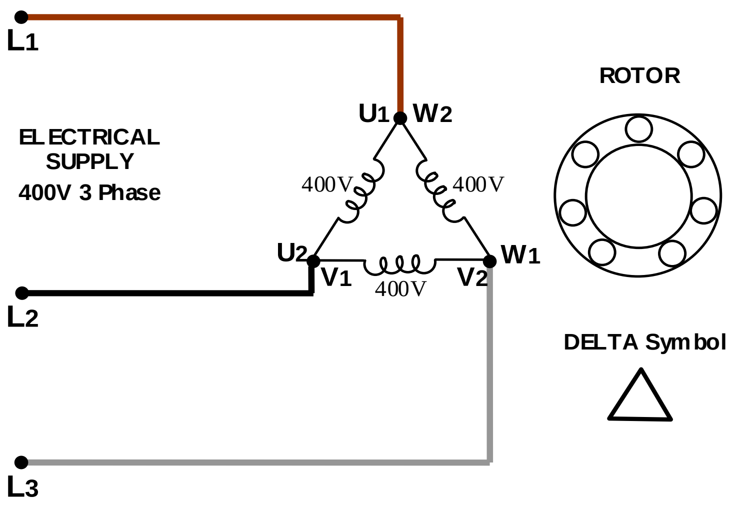

Fig 2.14 Load Connected In Delta

A three-phase load having windings rated for 400 Volts should be connected in delta to a 400 Volt three-phase supply. If connected in star in this situation it will only develop one third of its output power, and will stall under load.

A three-phase load having windings rated for 230 V may be connected in delta to a 230 Volt three-phase supply OR in star to a 400 Volt three-phase supply. This type of load is referred to as a Dual Voltage load. (The windings are rated for the lower of the two voltages).

2.3.3 Current Transformer:

In **electrical engineering**, a current transformer (CT) is used for measurement of electric currents. Current transformers, together with voltage transformers (VT) (potential transformers (PT)), are known as instrument transformers. When current in a circuit is too high to directly apply to measuring instruments, a current transformer produces a reduced current accurately proportional to the current in the circuit, which can be conveniently connected to measuring and recording instruments. A current transformer also isolates the measuring instruments from what may be very high voltage in the monitored circuit. Current transformers are commonly used in metering and **protective relays** in the **electrical power industry**.

2.3.3.1 Design of CT:

Like any other **transformer**, a current transformer has a primary winding, a **magnetic core**, and a secondary winding. The **alternating current** flowing in the primary produces a magnetic field in the core, which then induces a current in the secondary winding circuit. A primary objective of current transformer design is to ensure that the primary and secondary circuits are efficiently coupled, so that the secondary current bears an accurate relationship to the primary current.

The most common design of CT consists of a length of wire wrapped many times around a silicon steel ring passed over the circuit being measured. The CT's primary circuit therefore consists of a single 'turn' of conductor, with a secondary of many tens or hundreds of turns. The primary winding may be a permanent part of the current transformer, with a heavy copper bar to carry current through the magnetic core. Window-type current transformers (aka zero sequence current transformers, or ZSCT) are also common, which can have circuit cables run through the middle of an opening in the core to provide a single-turn primary winding. When conductors passing through a CT are not centered in the circular (or oval) opening, slight inaccuracies may occur.

Shapes and sizes can vary depending on the end user or switchgear manufacturer. Typical examples of low voltage single ratio metering current transformers are either ring type or plastic mounded case. High-voltage current transformers are mounted on porcelain bushings to insulate them from ground. Some CT configurations slip around the bushing of a high-voltage transformer or circuit breaker, which automatically centers the conductor inside the CT window.

The primary circuit is largely unaffected by the insertion of the CT. The rated secondary current is commonly standardized at 1 or 5 amperes. For example, a 4000:5 CT would provide an output current of 5 amperes when the primary was passing 4000 amperes. The secondary winding can be single ratio or multi ratio, with five taps being common for multi ratio CTs. The load, or burden, of the CT should be of low resistance. If the voltage time integral area is higher than the core's design rating, the core goes into **saturation** towards the end of each cycle, distorting the waveform and affecting accuracy.

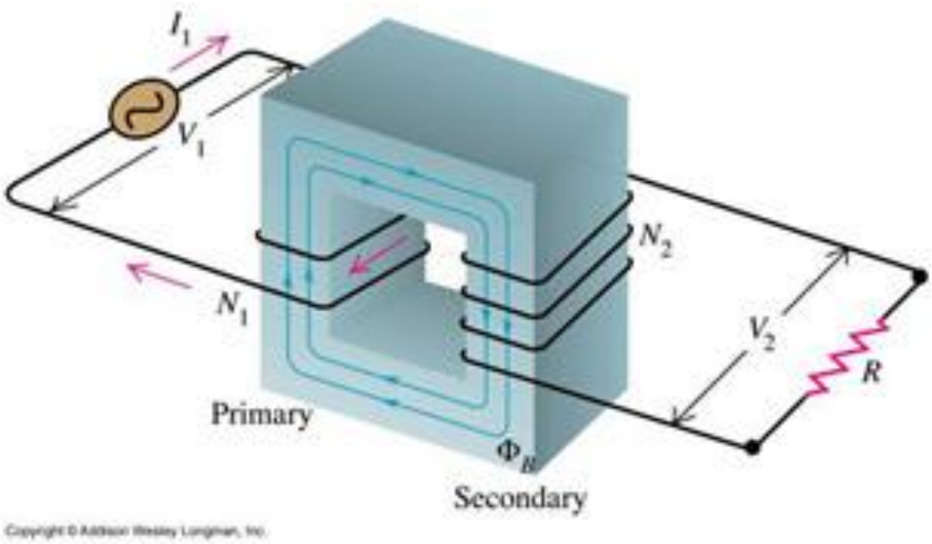

Fig 2.15 Current Transformer

2.3.3.2 Burden:

The secondary load of a current transformer is usually called the "burden" to distinguish it from the load of the circuit whose current is being measured.

The burden, in a CT metering **circuit** is the (largely **resistive**) **impedance** presented to its secondary winding. Typicalborden ratings for IEC CT are 1.5 VA, 3 VA, 5 VA, 10 VA, 15 VA, 20 VA, 30 VA, 45 VA & 60 VA. As for ANSI/IEEE burden ratings are B-0.1, B-0.2, B-0.5, B-1.0, B-2.0 and B-4.0. This means a CT with a burden rating of B-0.2 can tolerate up to 0.2 Ω of impedance in the metering circuit before its output current is no longer a fixed ratio to the primary current. Items that contribute to the burden of a current measurement circuit are switch-blocks, meters and intermediate conductors. The most common source of excess burden is the conductor between the meter and the CT. When substation meters are located far from the meter cabinets, the excessive length of wire creates a large resistance. This problem can be reduced by using CTs with 1 ampere secondary's, which will produce less voltage drop between a CT and its metering.[7]

2.3.4 Potential Transformer:

The instrument potential transformer (PT) steps down voltage of a circuit to a low value that can be effectively and safely used for operation of instruments such as ammeters, voltmeters, watt meters, and relays used for various protective purposes.

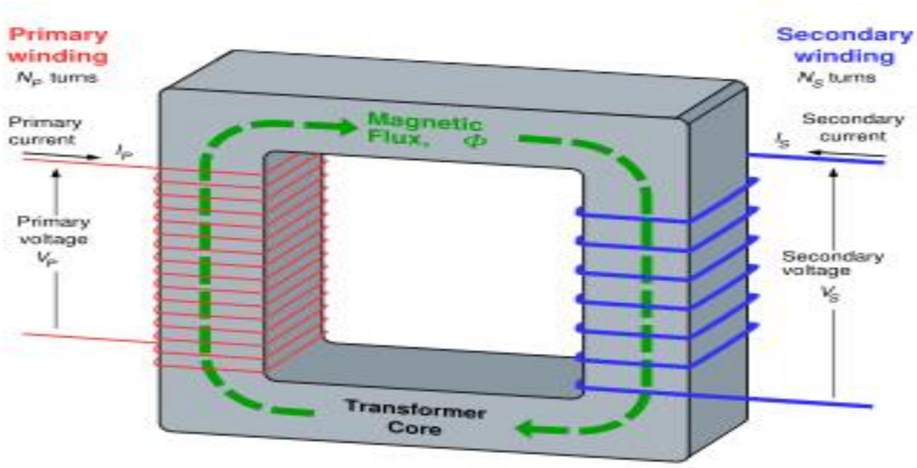

Fig 2.16 Potential Transformer (PT)

Potential transformers can be used with voltmeters for voltage measurements or they can be used in combination with current transformers for watt-meter or watt-hour meter measurements. they are also used to operate protective relays and devices for many other applications, since they are used in a monitoring capacity; they generally require much greater accuracy in design. Potential Transformer is designed for monitoring single-phase and three-phase power line voltages in power metering applications. Potential transformers are designed to provide as accurate a voltage step-down ratio as possible. To aid in precise voltage regulation, loading is kept to a minimum: the voltmeter is made to have high input impedance so as to draw as little current from the PT as possible. As you can see, a fuse has been connected in series with the PTs primary winding, for safety and ease of disconnecting the PT from the circuit. A standard secondary voltage for a PT is 120 volts AC, for full-rated power line voltage. Since the PT will be sized to step the system voltage down to this standard instrument level. The potential transformer is designed for measuring the voltages ranging in kV or even higher. The simple voltmeters may easily burn upon measuring these voltages.[8]

2.3.5 Rectifier:

A rectifier is an electrical device that converts alternating current (AC), which periodically reverses direction, to direct current (DC), which flows in only one direction. The process is known as rectification.

2.3.5.1 Bridge Rectifier (Full wave rectifier):

The first building block in the dc power supply is the full wave rectifier. The purpose of the full wave rectifier (FWR) is to create a rectified ac output from a sinusoidal ac input signal. It does this by using the nonlinear conductivity characteristics of diodes to direct the path of the current.

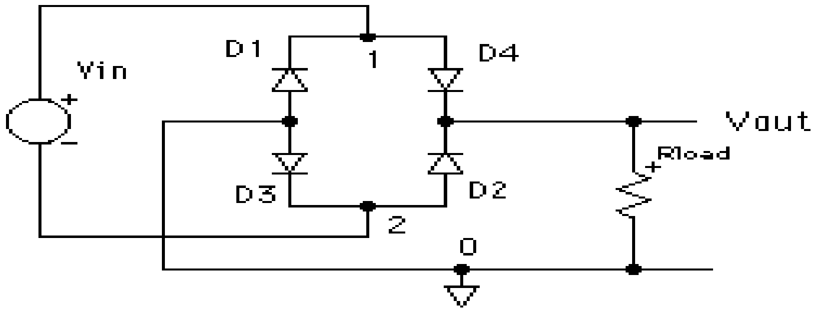

Fig2.17 Bridge Rectifier

- **Diode Current:**

Consider the current path in the diode bridge rectifier. In the positive half cycle of Vin, diodes D4 and D3 will conduct. During the negative half cycle, diodes D2 and D1 will conduct. As a result, the load will pass current in the same direction in each half cycle of the input.

Diode Voltages:

- **Forward Bias:**

i. If we consider a simple, piece-wise linear model for the diode IV curve, the diode forward current is zero until V bias>= V threshold, where V threshold is 0.6 V to 0.8 V. The current increases abruptly as V bias increases further. Due to this turn-on or threshold voltage associated with the diode in forward bias, we should expect a 0.6 to 0.8 V voltage drop across each forward biased diode in the rectifier bridge. In the case of the full wave rectifier diode bridge, there are two forward biased diodes in series with the load in each half cycle of the input signal.

ii. The maximum output voltage (across load) will be Vin- 2 V threshold, or V in - 1.4V.

iii. Since some current does flow for voltage bias below V threshold and the current rise around is V threshold is more gradual than the piece-wise model, the actual diode performance will differ from the simple model.

- **Reverse Bias:**
    i. In reverse bias (and neglecting reverse voltage breakdown), the current through the diode is approximately the reverse saturation current, I_o. The voltage across the load during reverse bias will be
    ii. $V_{out} = I_o R_{load}$.
    iii. In specifying a diode for use in a circuit, you must take care that the limits for forward and reverse voltage and current are not exceeded.

2.3.5.2 Filtered Full Wave Rectifier:

The filtered full wave rectifier is created from the FWR by adding a capacitor across the output. The result of the addition of a capacitor is a smoothing of the FWR output. The output is now a pulsating dc, with a peak to peak variation called ripple. The magnitude of the ripple depends on the input voltage magnitude and frequency, the filter capacitance, and the load resistance.

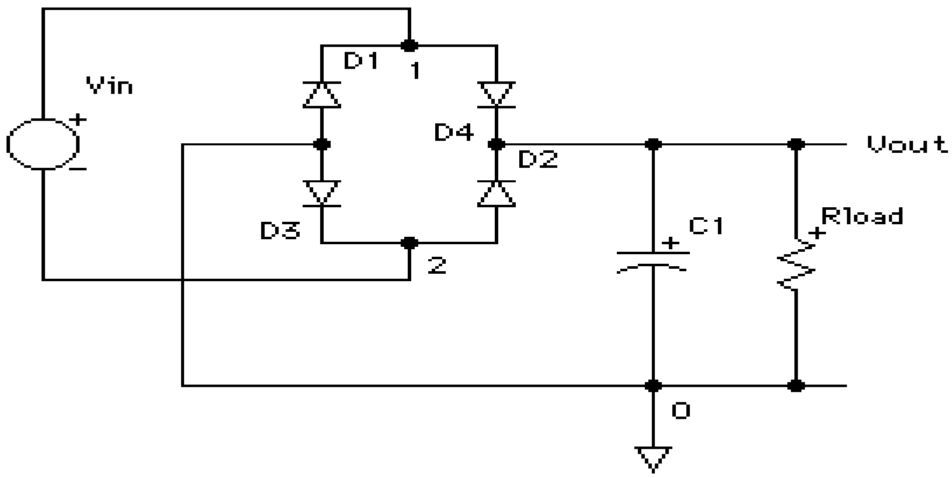

Fig 2.18 Filtered Full Wave Rectifier

To describe the source of the voltage ripple, consider the performance of the filtered full wave rectifier above. The input to the rectifier is a sine wave of frequency f. Let Vi be the full wave rectified signal input to the filter stage of the rectifier and Vo be the output. Vi can be approximated as the absolute value of the rectifier input, with frequency 2f.

2.3.6 Three Phase Inverter:

The dc to ac converters more commonly known as inverters, depending on the type of the supply source and the related topology of the power circuit, are classified as voltage source inverters (VSIs) and current source inverters (CSIs).Single-phase VSIs cover low-range power applications and three-phase VSIs cover medium to high power applications. The main purpose of these topologies is to provide a three-phase voltage source, where the amplitude, phase and frequency of the voltages can be controlled. The three-phase dc/ac voltage source inverters are extensively being used in motor drives, active filters and unified power flow controllers in power systems and uninterrupted power supplies to generate controllable frequency and ac voltage magnitudes using various pulse width modulation (PWM) strategies. The standard three-phase inverter has six switches the switching of which depends on the modulation scheme. The input dc is usually obtained from a single-phase or three phase utility power supply through a diode-bridge rectifier and LC or C filter.

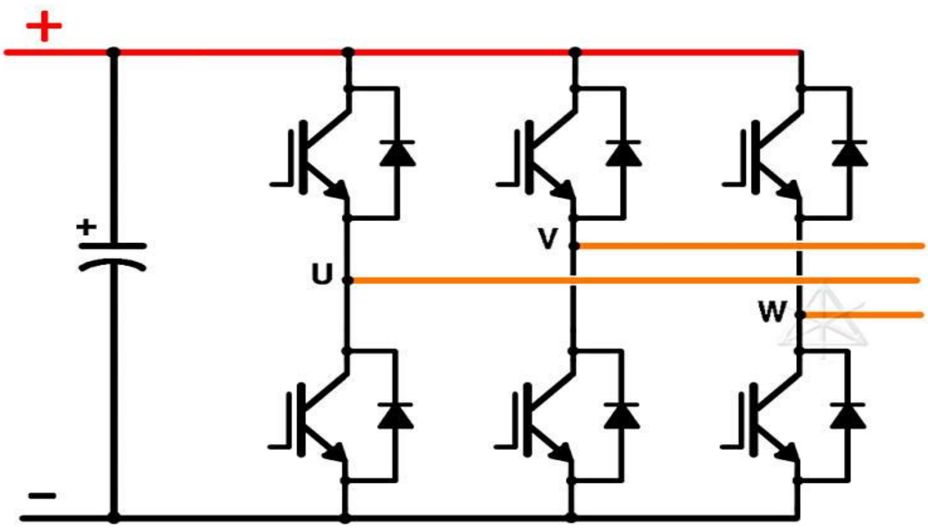

Fig 2.19 Three phase inverter

2.3.7 Arduino:

A arduino is an integrated chip that is often part of an embedded system. The arduino includes a RAM, ROM, I/O ports, and timers like a standard computer, but because they are designed to execute only a single specific task to control a single system, They are much smaller and simplified so that they can include all the functions required on a single chip.

In a arduino all that you have to do is to make proper connections of the pins and then feed a computer program into it. After that your arduino responds in accordance with the program that has been fed into it. In a arduino program you receive the inputs from a set of input pins that you specify and then process the input and produce your output on a set of output pins in form digital signal.

Fig 2.20 Arduino

2.4 Ports and Pins:

A arduino has some ports. Ports are PINs on the arduino that can be turned on and off by program. On means 5V and off means 0V or GND .This behavior is for OUTPUT mode. They can also be put in INPUT mode. In INPUT mode they can read what is the signal level on them (only on and off).If voltage is more than a threshold voltage (usually half the supply) it is reported as ON(1) otherwise OFF (0).This is how arduino control everything

.Majority of the PINs are PORT so you can hook up lots of gizmos to it.!!!They are of one byte which means 8 Bits all bits of them are connected to external pins and are available outside the chip. In smaller chips only some of the eight bits are available.

2.4.1 Overview of Arduino UNO:

Arduino is one of the most advanced microcontroller from Microchip. This controller is widely used for experimental and modern applications because of its low price, wide range of applications, high quality, and ease of availability. It is ideal for applications such as machine control applications, measurement devices, study purpose, and so on. The Arduino features all the components which modern microcontrollers normally have.

2.4.2 Pin Diagrams Arduino UNO:

Chip is available in different types of packages. According to the type of applications and usage, these packages are differentiated. The pin diagram of a chip in different packages is shown in the figure3.5 below

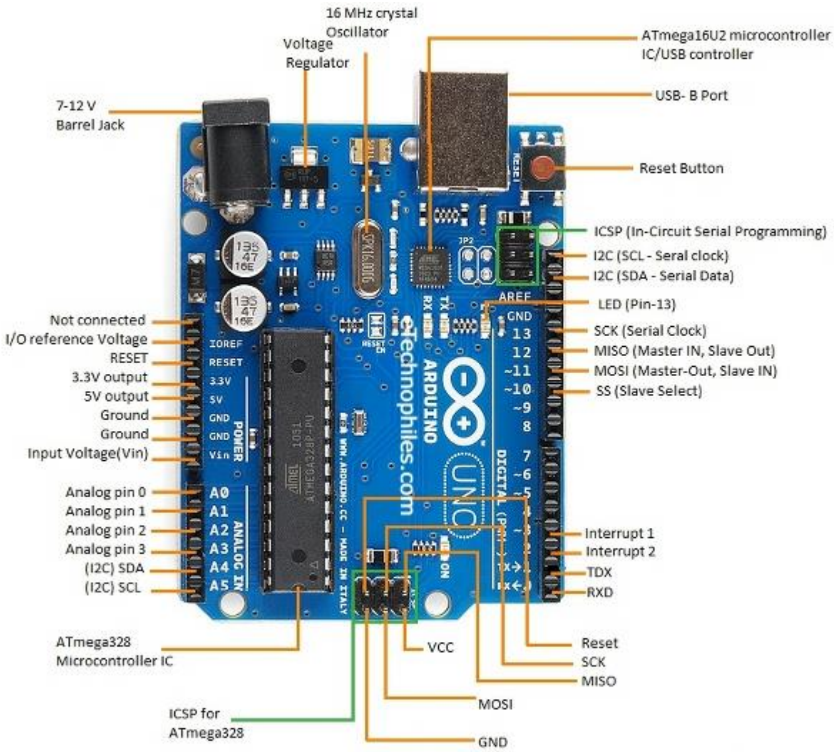

Fig 2.21 Pin Configuration

2.4.3 Filtered Full Wave Rectifier Modeling:

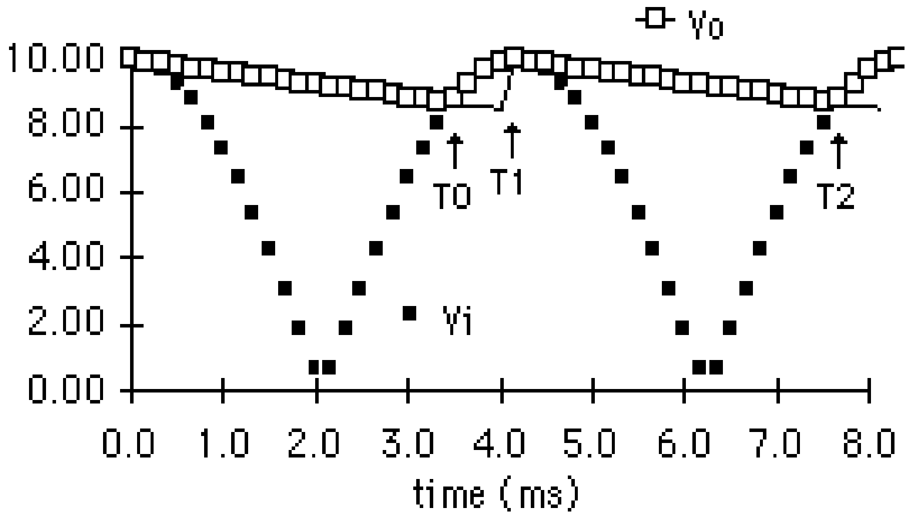

Fig 2.22 Output (V_i) and input (V_o) of a Filtered Full Wave Rectifier

In the time period from T0 to T1, the diode D1 (or D3, depending on the phase of the signal) is forward biased since Vi>VC1 (approximate the forward biased diode as a short circuit).The capacitor C1 charges and the voltage across the load R increases. From T1 to

T2, the diodes D1 and D2 are reverse biased (open circuit) because Vcap>Vi, and the capacitor discharges through the load R with a time constant of RC seconds.

The voltages between times T1 and T2 lie along a capacitor discharge curve. Along this line, $V_0(T) = V_{max} e^{\frac{(T-T_1)}{RC}}$

The peak to peak (pp) ripple is defined as the voltage difference between V max and Vmin.

$$V_r(PP) = V_0(T_1) - V_0(T_2) = V_{max} - V_{min}$$

$$V_0(T) = V_{max}\left[1 - e^{\frac{-(T-T_1)}{RC}}\right]$$

If C is large, such that RC >> T2 - T1, we can approximate the exponential

$$e^{\frac{-(T-T_1)}{RC}} \text{as } 1 - \frac{(T2-T1)}{RC} \text{ then } V_r(PP) = V_{max}\left(\frac{T_2-T_1}{RC}\right)$$

Since T2 - T1 ~ T/2, where T is the period of the sine wave, then

$$V_r(pp) = V_{max}\frac{T}{2RC} = \frac{V_{max}}{2fRC}$$

2.4.4 Driver IC ir2130:

This Driver IC is used with Arduino for driving the PWM signals to IGBTs with proper Switching.

Fig 2.23 Driver IC

CHAPTER 3 SIMULATIONS AND IMPLEMENTATION

3.1 System Integration & Interface:

3.1.1 Proteus:

PROTEUS allows professional engineers to run interactive simulations of real designs, and to reap the rewards of this approach to circuit simulation. And then, a range of simulator models for popular Arduino and a set of animated models for related peripheral devices such as LED and LCD displays, keypads, an RS232 terminal and more. It is possible to simulate complete Arduino systems and thus to develop the software for them without access to a physical prototype. In a world where time to market is becoming more and more important this is a real advantage.[14]

3.1.2 Overview:

Start the program by click the ISIS 7 Professional icon in Start Menu.

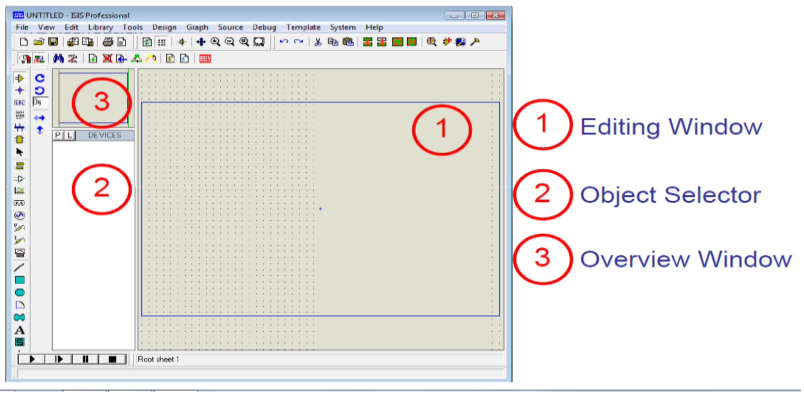

Fig 3.1: Professional User Interface

3.1.2.1 Selecting Components:

To select the component, click on Library > Pick Device / Symbol or just press “P”.

Parts	Keywords in “Pick Devices” Window
Ardunio	Arduino UNO
LED	LED-BIBY
Resistor	RESISTOR
Capacitor	CAPACITOR
Button	BUTTON

The selected component can be located on the left side window of the design diagram.

i. To put the component to the design sheet, just left click the component and put it to the sheet.
ii. To move the components, simply right click on the component (the component will be red-lighted), and left click and drag the component to the desired location. For power terminal and ground, the component is NOT selected from the library.
iii. Select the “inter-sheet terminal” icon at the left-side toolbar.
iv. Select POWER for your Vcc and GROUND as ground.

3.1.2.2 Component Parameter Settings:

i. Each component need to be set according to the specifications. For example the resistor or capacitor value need to define before any simulation can be done.
ii. To edit the component, select the component (right-click) and left-click to open the Edit Component dialog.
iii. The dialog is different according to the devices. Figure below shows the Edit Component Dialog of a resistor.
iv. Set the resister value in the resistance box.

3.1.3 Arduino language:

i. Currently, the most commonly-used language for embedded systems.
ii. “High-level assembly”.
iii. Very portable: compilers exist for virtually every processor.
iv. Easy-to-understand compilation.
v. Produces efficient code.

3.2 Software Simulations:

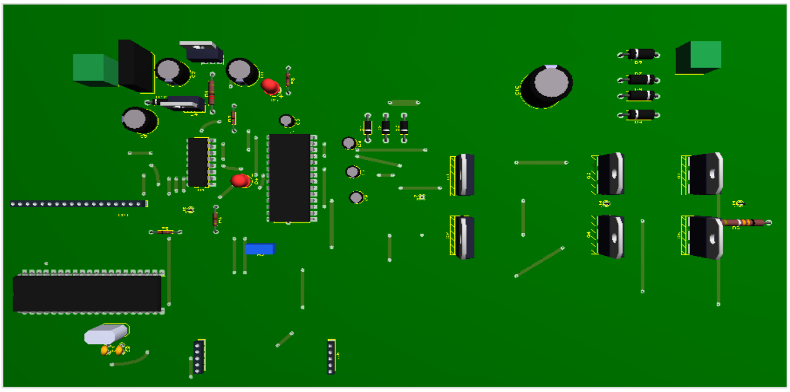

Fig 3.2 Top view of PCB Design

3.2.1 Working Principle:

Diagram shows the full working of the project. Single DC supply used for the project. Push pull converter then Steps up the DC from 12v to 250v Dc. The output of Converter is then fed to Inverter Circuit which then produces three phase AC output.

For Arduino operation we have used 5 V and for motor drive 15 V supply connected. Arduino will forward signal to the phase splitter that convert the single incoming signal into 6 signals. IGBT drive will create phase shift/ time delay and forward theses 6 signals to the IGBT’s gate. IGBT give the output in form of 3 phase ac with 120 degree phase shift among two phases.

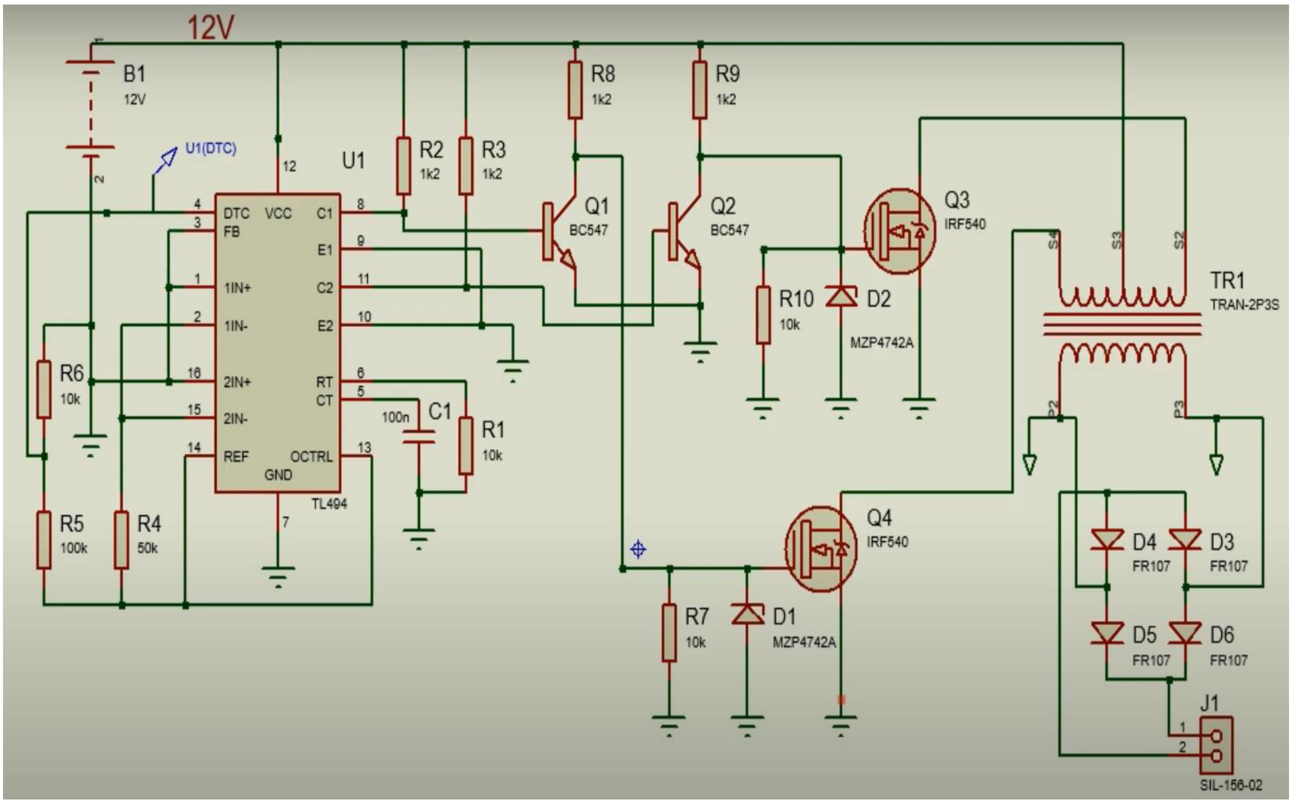

Fig 3.3 Push Pull (DC to DC) Converter

Fig 3.4 below shows the inverter Circuit that how DC converts it into AC waveform.

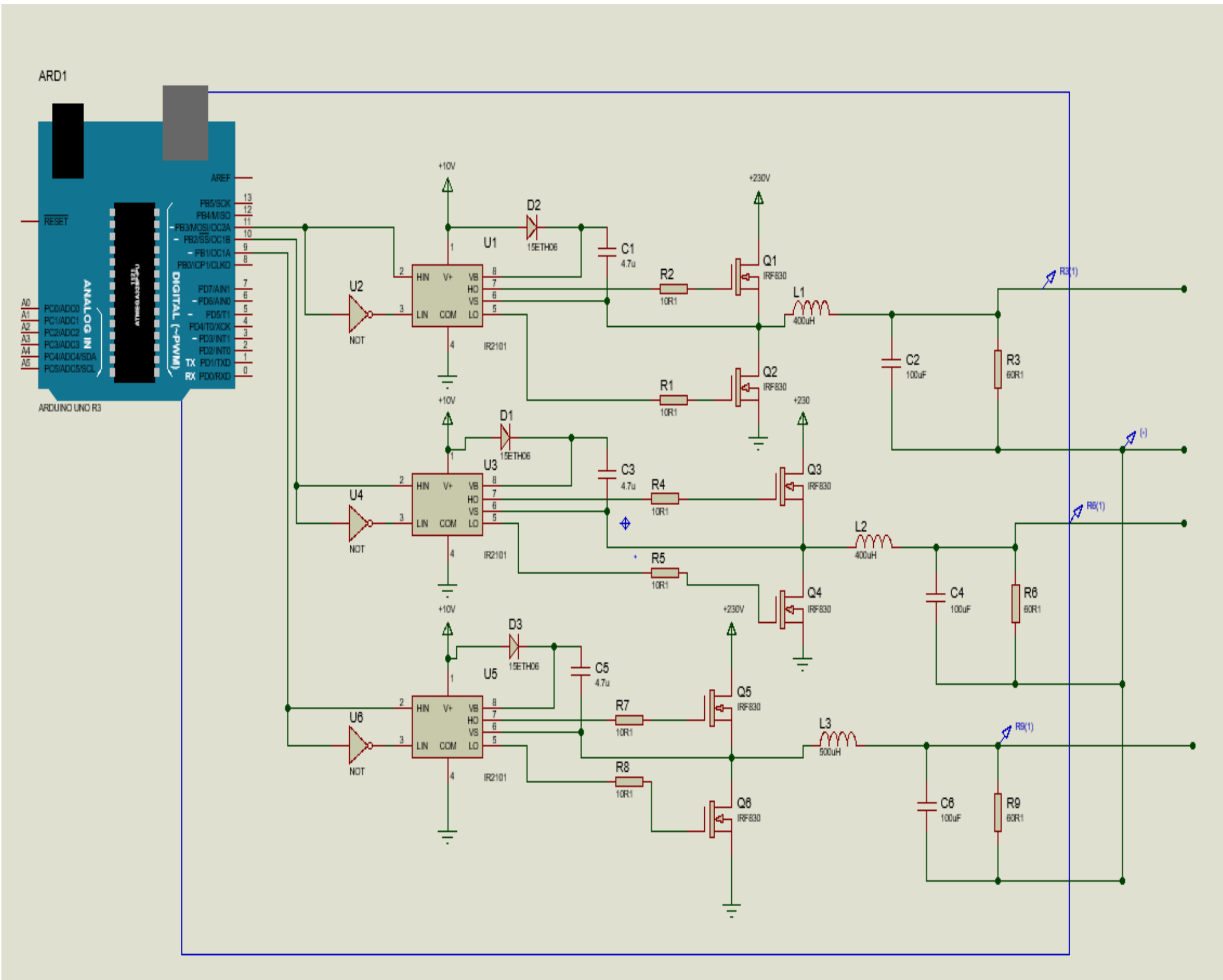

Fig 3.4 Inverter Circuit

Figure 3.5 shows the PCB layout of Booster Circuit:

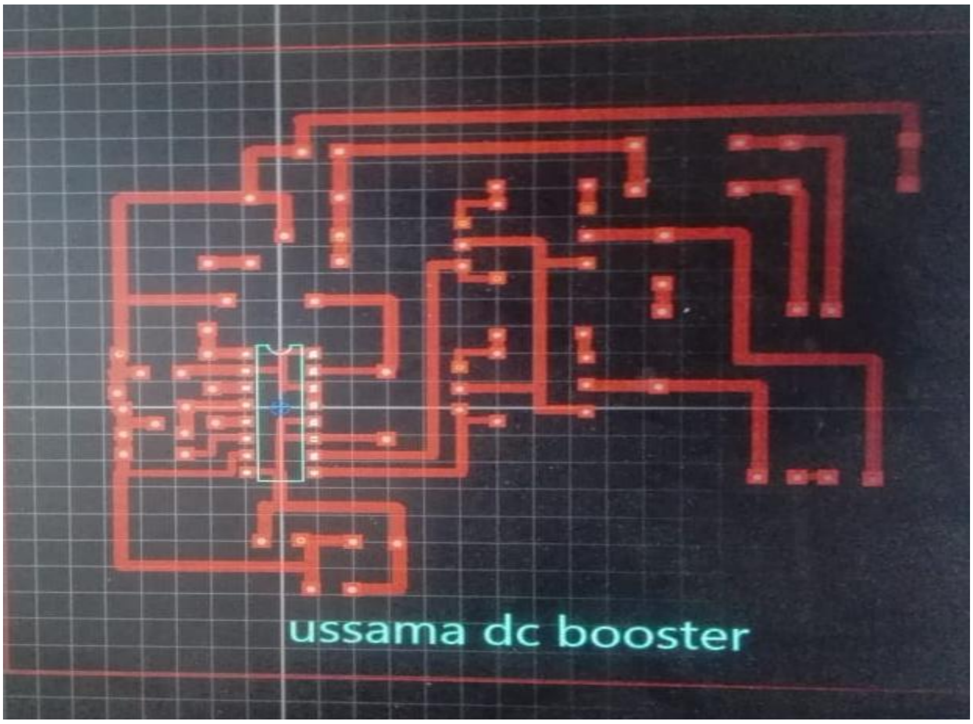

Fig 3.5 PCB layout of Boost Converter

Figure 3.6 below shows the PCB layout of Inveter Circuit:

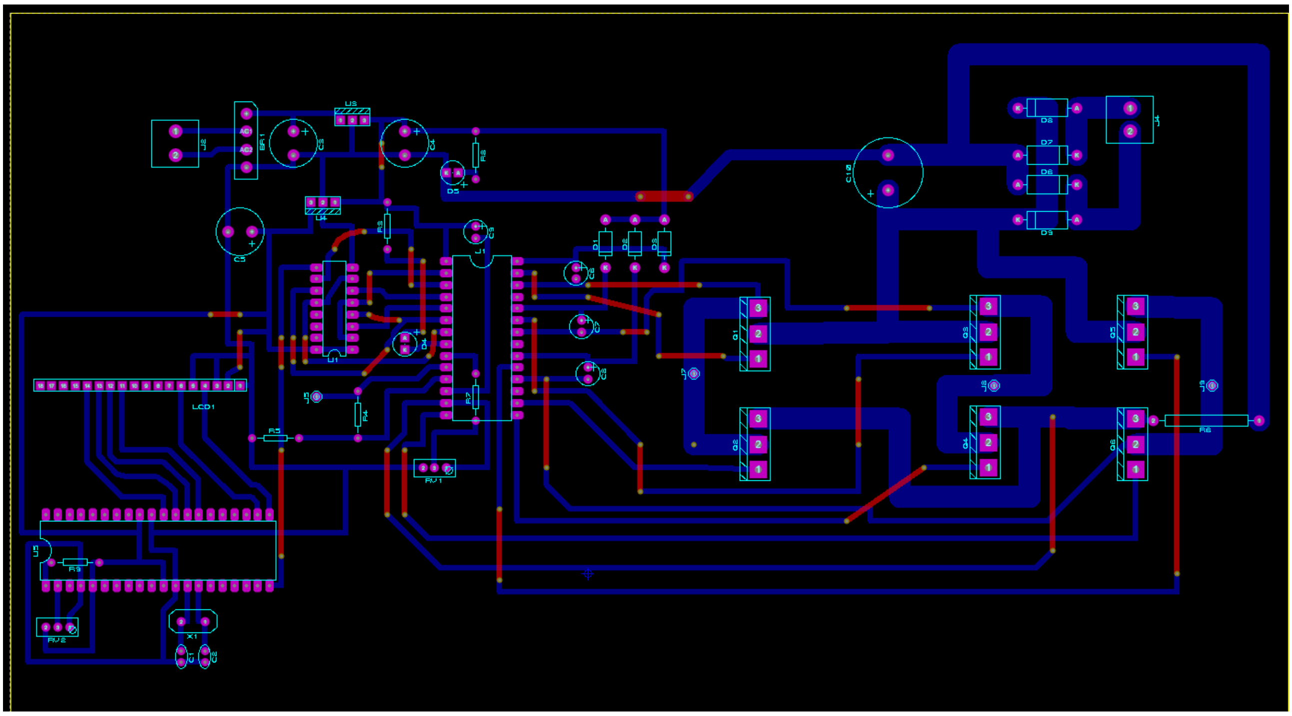

Fig 3.6 PCB layout of Inverter Circuit

Figure 3.7 below shows the output of Arduino which is three phase SPWM signals:

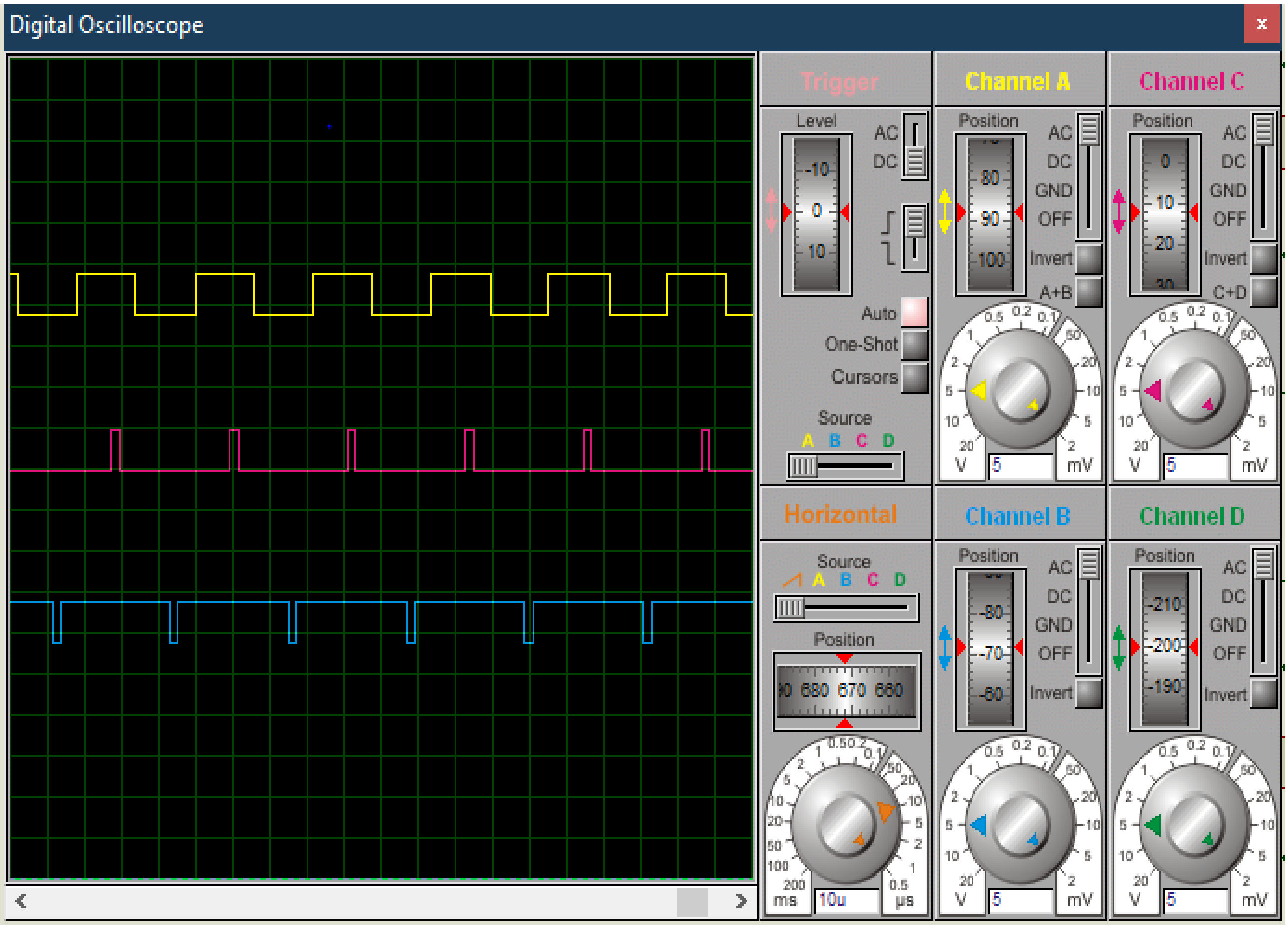

Fig 3.7 SPWM Signals

Figure 3.8 below shows the three phase AC output of Inverter Circuit:

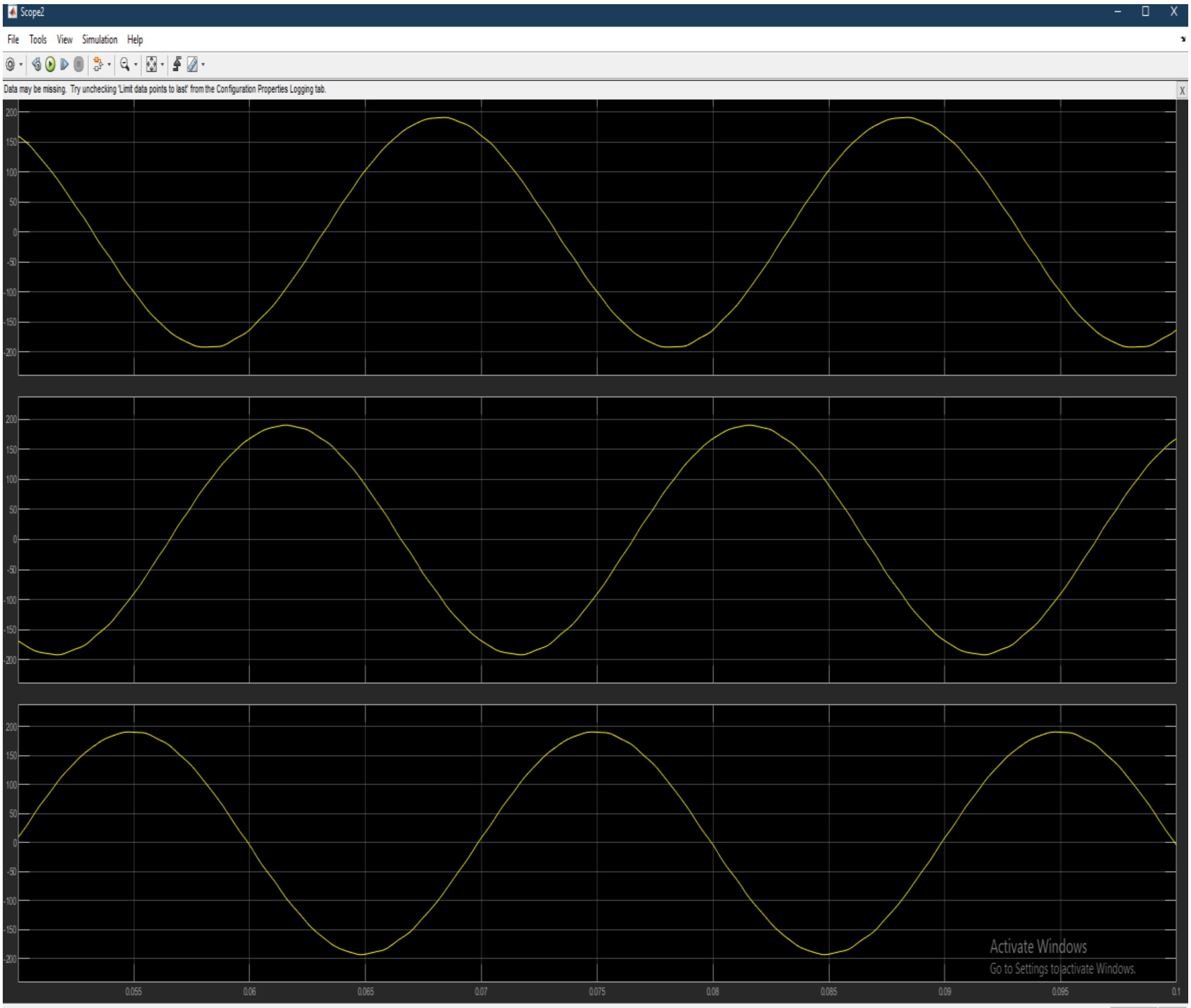

Fig 3.8 Three phase Sinusoidal Output

CHAPTER 4 HARDWARE DESIGNING

4.1. Hardware circuit:

The project was also implemented on hardware. A fully working prototype of the project was designed. The hardware circuit is shown below.

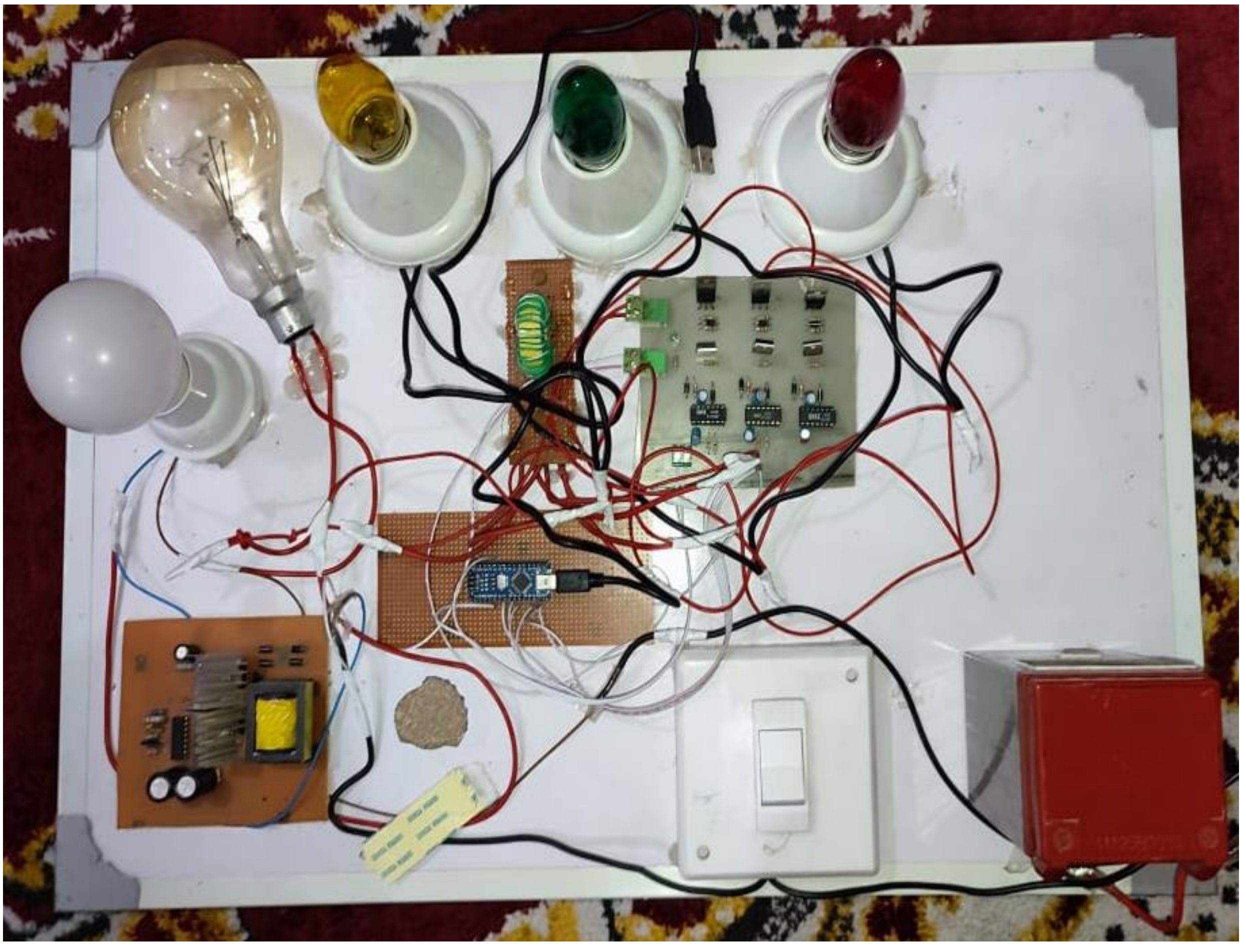

Fig 4.1 Hardware Circuit

4.2 Hardware Components:

Figure 4.2 shows the DC battery which we are using for input supply:

Fig 4.2 Battery

Figure 4.3 below shows the DC Booster (push pull converter) circuit:

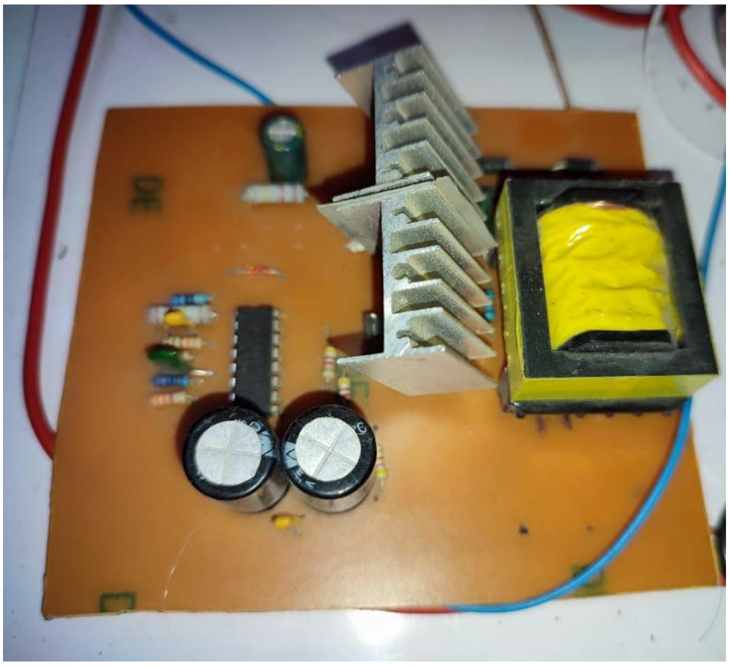

Fig 4.3 Push Pull Converter

Figure 4.4 below shows the Driver and Inverter Circuit:

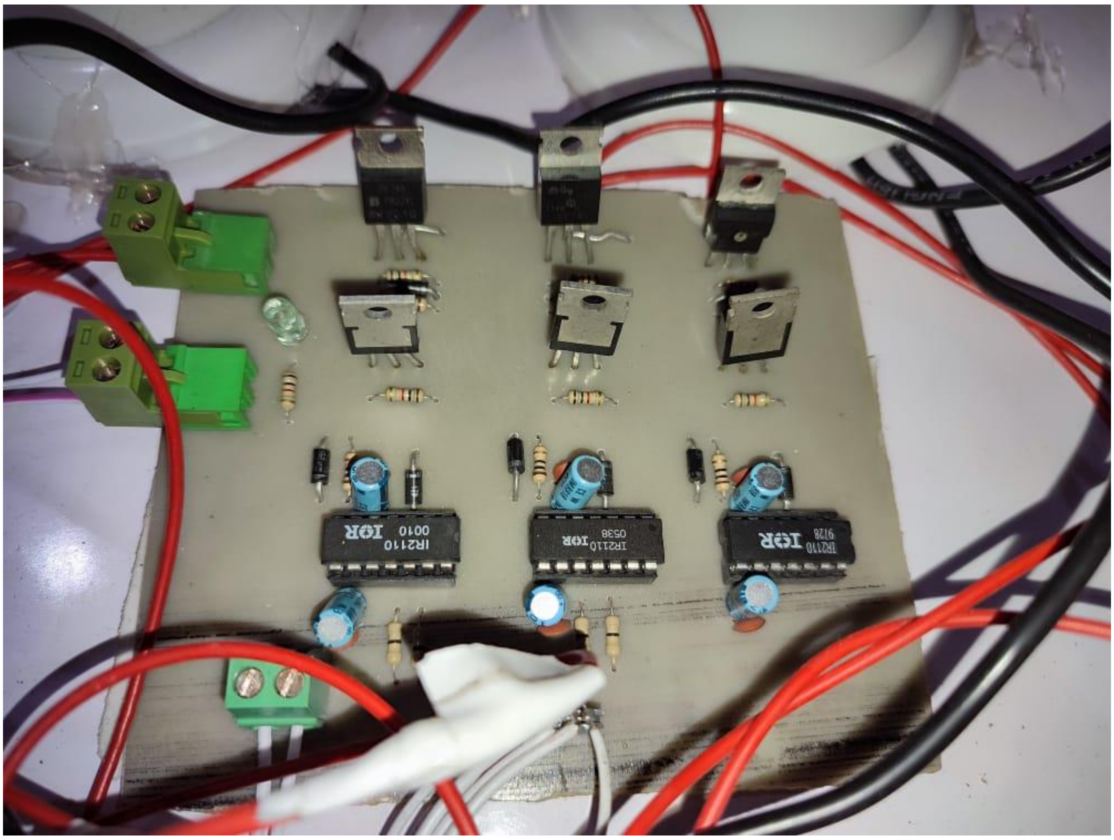

Fig 4.4 Inverter Circuit

Figure 4.5 below shows the filter circuit:

Fig 4.5 LC Filter Circuit

CHAPTER 5 CONCLUSION AND RECOMMENDATION

5.1 Conclusion:

Inverter provides a simple and cost efficient method for operation of 3-phase loads from DC supply. A low-cost solution can be implemented using the Arduino family of devices. With three dedicated PWM modules implemented in hardware, it is ideal for controlling 3-phase loads.

In simple automation system when Electricity are not provided, one can use inverter system which is simple and cost-effective.

- Inverter is designed considering some factors such as economic, available components and research materials, efficiency portability and durability.
- Performance of the project after testing will meet design specifications.
- The general operation will be independent on the user such as overloading the system, making wrong battery connection or using the wrong battery voltage.

5.2 Industrial Benefits:

As we know that 90% of industries uses Inverters. They are most common used in any kind of industry including it to be an electrical or otherwise, No matter what company produce but when it comes to load it is none other than three phase load. For large operation and for small operations three phase or fractional Horse Power (FHP) inverters are employed.

5.3 Domestic Benefits:

Our Home is a place where we see many three phase loads doing their jobs. Motor of refrigerator, water pump motor, cooler motor are some common examples.

5.4 Recommendation:

Further research could be done in the area of other energy sources like solar, wind mill, nuclear etc.

References

1) ABS Alaskan. (2006): DC to AC Power Inverters.

Retrieved from http://www.absak.com/basic/inverters.html.

2) Clayton Hall Mark (1986): ―IC Cookbook (Pin Configuration of all ICs) Publihsed by Mc-Gram Book Company.

3) EGG Data Book (1999): Edition General Data Sheet for all the Components.

4) Jacob Millman (1979): ―Micro Electronics‖ Published by Mc Gram-Hill Book Company.

5) Metha V.K. (2003): ―Principles of Electronics‖ Published by S. Chand and Company Ltd.

6) Robert L. Boyestad and Louis Nashelsky (2002): ―Electronics Device and Circuit Theory‖ (Eighth Edition) Published by Prentice Hall.

7) RJ. Maddock and MD Calcutt (1994): ―Electronics A Course for Engineers‖ Published by Longman Page 341-349.

THE END