VFD Controlled 3 Phase induction motor operate on 1 phase supply

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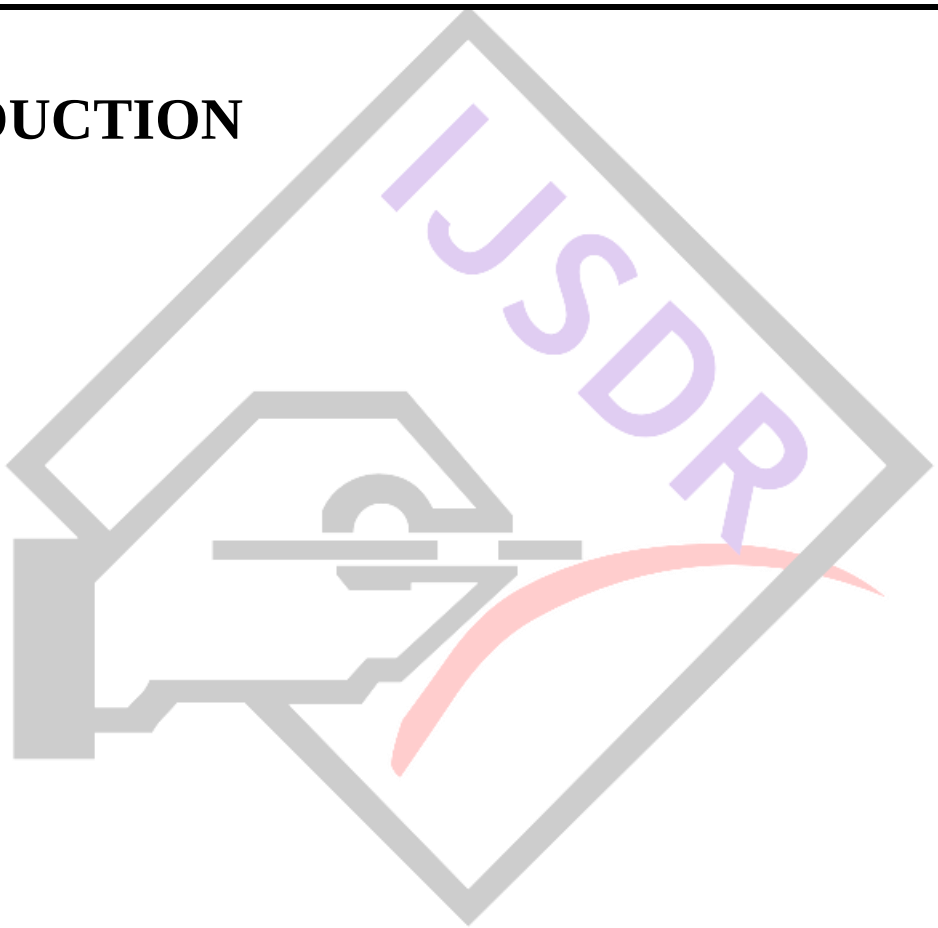
CHAPTER 1

INTRODUCTION



INTRODUCTION

The lack of three phase supply is becoming a major problem in many countries. With the ever-increasing number of 3 phase supply need for various operation so conversion of single phase supply to three phase supply is must, In the past, single-phase to three-phase conversion systems were made possible by the connection of passive elements capacitors and reactors with autotransformer converters. Such kind of system presents well known disadvantages and limitations. So to overcome from this disadvantages the newly adopted thyristors and power electronics devices were used mainly thyristors like SCRs, MOSFETs, GTOs etc. The project is about 'single phase to three phase conversion system using IGBTs.

Since the beginning of the solid state power electronics, the semiconductor devices were the major technology used to drive the power processors. Looking at the semiconductor devices used in the former controlled rectifiers and comparing them with the new technologies it makes possible to figure out the astonishing development. Beyond the improvement related to power switches, it was also identified a great activity in terms of the circuit topology innovations in the field of three-phase to three-phase, single- phase to single phase and three-phase to single- phase conversion systems. The single-phase induction motor drives by the three-phase induction motor drives in some low-power industrial applications.

In the various industrial applications the induction motor is mostly used. The loads on induction motor always vary as per its application but speed of induction motor is constant & cannot match with the load demand. If load on induction motor decrease, the speed of induction motor cannot be decreases as per the load. Hence it takes rated power from supply so the energy consume by the motor is same. Hence there is energy consumption is same during load varying condition also.

To overcome this problem a VFD is used in industrial application to save the energy consumption and electricity billing. Variable frequency drive (VFD) usage has increased dramatically in industrial applications. The VFDs are now commonly (VFD). This device uses power electronics to vary the frequency of input power to the motor, thereby controlling motor speed.

Over the years, three-phase motors, more than single phase motors have been the main consideration in industries due to certain parameters such as; efficiency, torque ripples and power factor. In rural areas, in order to operate machine tools and rolling mills as well as in low power industrial application for robotics, where a three phase utility may not be available, high-performance converters are typically used to run the three-phase motor drives. Low losses and cost effectiveness are the very important properties for these converters various single-phase to three-phase converters have been proposed with at least 6 switches. An alternative for the reduction of losses in these converters is that the number of power switches is reduced. Many components-minimized structures are proposed in literatures.

Pulse Width Modulated (PWM) inverter systems are used in a wide variety of applications as a front-end power- conditioning unit in electric drives, uninterruptible power supplies, high voltage DC transmission, Active power filters, reactive power compensators in power systems, Electric vehicles, Alternate energy systems and Industrial processes. The inverters realize dc-to-ac power conversion and in the most commonly used voltage source inverter configuration. The dc-input voltage can be obtained from a diode rectifier or from another dc source such as a battery. A typical voltage source PWM inverter system consists of rectifier, DC-link, PWM inverter along with associated control circuit and the load. Most modern voltage source inverters are controlled using a wide variety of pulse width modulation schemes, to obtain output ac voltages of the desired magnitude and frequency shaped as closely as possible to a since wave. Analysis of PWM inverter system is required to determine the input-output characteristics for an application specific design, which is used in the development and implementation of the appropriate control algorithm.

Three different topologies have been proposed for multilevel inverters: diode-clamped (neutral-clamped) capacitor- clamped (flying capacitors) and cascaded multi cell with separate dc sources. In addition, several modulation and control strategies have been developed or adopted for multilevel inverters including the following: multilevel sinusoidal pulse width modulation (PWM), multilevel selective harmonic elimination, and space-vector modulation (SVM)

1.1 Problem Overview:

The lack of three phase supply is becoming a major problem in many countries. With the ever-increasing number of 3 phase supply need for various operation so conversion of single phase supply to three phase supply is must, In the past, single-phase to three-phase conversion systems were made possible by the connection of passive elements capacitors and reactors with autotransformer converters. Such kind of system presents well known disadvantages and limitations. So to overcome from this disadvantages the newly adopted thyristors and power electronics devices were used mainly thyristors like SCRs, MOSFETs and GTOs etc. The project is about ‘single phase to three phase conversion system using IGBTs

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1.2 Objectives of Dissertation:

1 The objective of the project is to make three phase power as reliable and efficient power source.

2 Circuit modules can be made to work near their maximum efficiency all the time.

3 To develop the maximum reliable 3 phase power which will ensure that operate 1 HP three phase motor on it.

4 We design a power electronics devices switching 0-180 degree calculation for low ripples and maximum output.

Sub Objectives of the Project:-

1. To Study the Working of power electronics devices:

In this project we will study the actual working of power electronic devices. We will also study that how much supply we have to apply on controller and power electronics devices to get required appropriate output.

2. Selection of Appropriate Components Required:

In this part of the system we will select the components required of specific and appropriate ratings for power supply circuit, power electronics devices such as MOSFET, IGBT, controller, etc.

3. Design of Block and Circuit Diagram:

Another objective of our project is to study and design block diagram and circuit for proposed system.

4. Overall Reduced Cost:

To reduced the cost and increase efficiency.

1.3 Outlines of Dissertation:

Chapter 2- Literature Review- This chapter includes the reviews of literature i.e. paper we have referred for our project.

Chapter 3- Objectives completed- This one includes the objectives of project that we have set during making of project.

Chapter 4- Significance of Topic- Topic of project mainly signifies that three phase motor can be run on single phase supply where three phase supply is not available like in household connection.

Chapter 5- Principle of Operation- This chapter includes how the MOSFET and IGBTs are used to generate three phase supply from single phase. That is our principle of operation.

Chapter 6- Project Development Stages- There are mainly 2 stage of project power circuit development and second one is inverter and conversion of 3 phase to single phase circuit.

Chapter 7- Hardware Design- Hardware design mainly contains the selection of component used in project. Microcontroller and IGBT are the main component of our hardware.

Chapter 8- Microcontroller Design- designing the microcontroller according to the required specifications and its accuracy is the part of microcontroller design.

Chapter 9- Block Diagram Description- Our whole project is described in a block format in this chapter. Here you can get the brief idea of project.

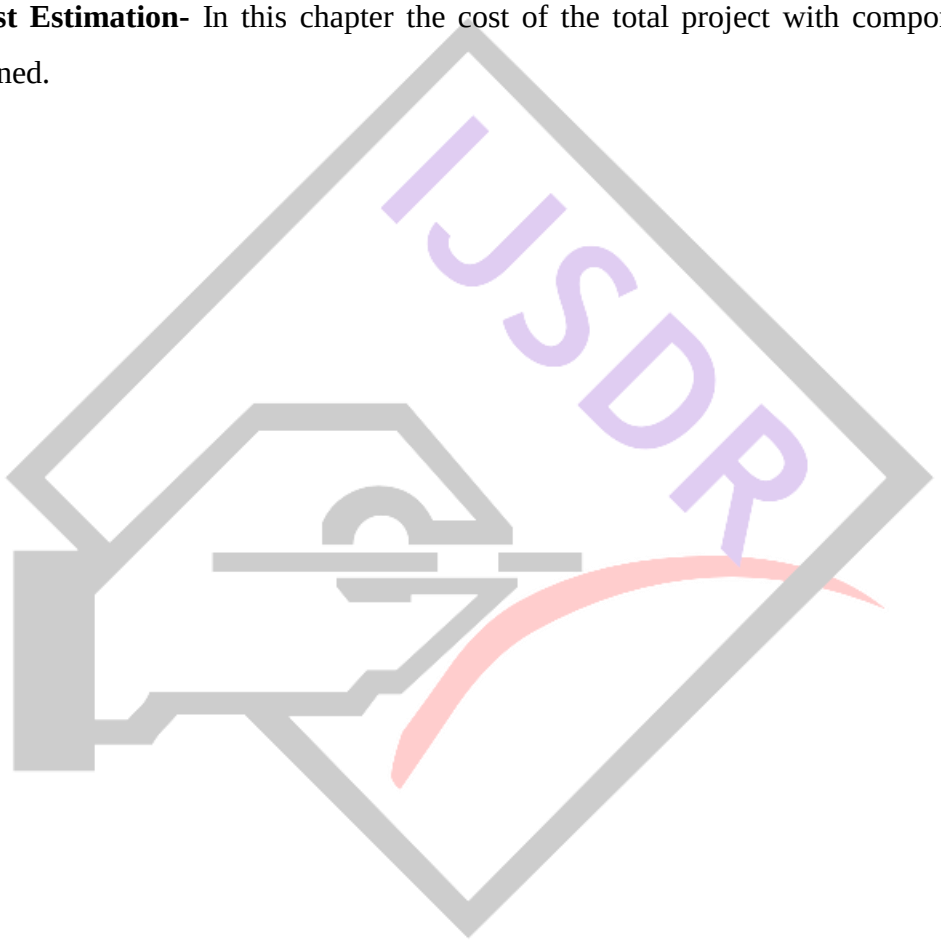
Chapter 10- Hardware Design Circuitry- In this chapter circuit diagrams of our project are included.

Chapter 11- Advantages and Disadvantages- Here we have briefed some advantages and disadvantages of our project.

Chapter 12- Applications- Our project can be used in various locations such as agriculture purpose.

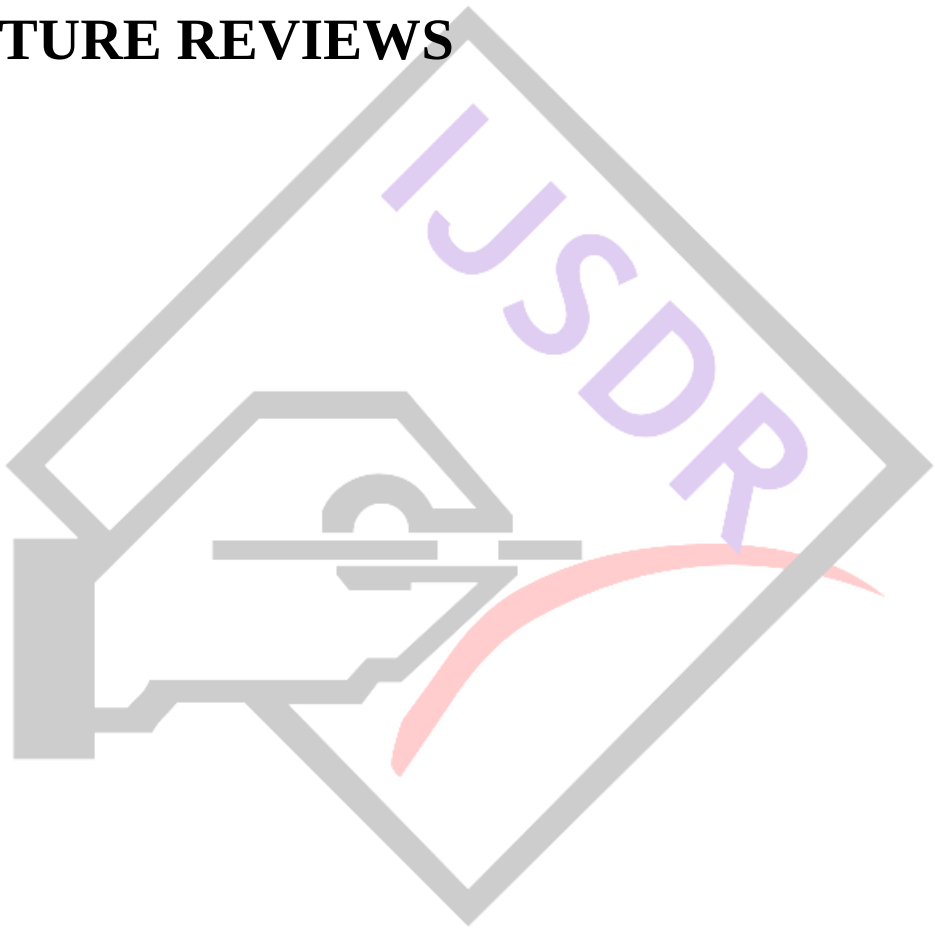
Chapter 13- Conclusion and Future Work- In this chapter we have concluded the project and also added some future scope point.

Chapter 14- Cost Estimation- In this chapter the cost of the total project with components used in the system are explained.



CHAPTER 2

LITERATURE REVIEWS



2 LITERATURE REVIEW

1. Thomas A. Lipo, summarized various stages of developments of VFD, which linked technological innovations in power components, like silicon controlled rectifier (SCR), gate turn off thyristor (GTO), insulated gate bipolar transistor (IGBT), Pulse width modulation (PWM) controlled.

2.Paresh C. Sen described the substitute of DC drive performance by AC frequency drive, as a result of sustained research work in area of power electronic components and micro-controllers.

3.Dennis P. Connors illustrated various types of Variable frequency drives (V.F.D) with their limitations and described basic relationships among drive voltage, frequency, torque, speed of the motor along with harmonic effect.

4.P. Y. Keskar , based on IEEE 519-1992 standard on Variable frequency drives (VFD) showed voltage and current harmonic order and their magnitude calculation methods. Before installation of VFD, appropriate harmonic analysis and mapping on impedance line diagram of plant could be powerful tool in deciding VFD hardware and other filters location.

5.Shivanagouda.B.Patil, M. S. Aspalli," Operating Three Phase Induction Motor Connected to Single Phase Supply ," International Journal of Emerging Technology and Advanced Engineering, ISSN 2250-2459, Volume 2, Issue 11, November 2012

6. Dong-Choon Lee, Member, IEEE, and Young- Sin Kim," Control of Single-Phase-to-Three-Phase AC/DC/AC PWM Converters for Induction Motor Drives,"

CHAPTER 3

OBJECTIVES COMPLETED

1. Generation of power supply kit:

- The power supply circuit consists of step-down transformer, full bridge rectifier, capacitors, 7805 regulator, LED, etc.
- The 230/15V step-down transformer converts 230V supply voltage to 15V.
- The full bridge rectifier rectifies the output and filter removes the ripple contents and converts this AC voltage to DC voltage. The 7805 regulator maintains 5V DC output constant which is given to the microcontroller as input supply.

2. Single phase to three phase conversion kit:

- In this using step down transformer it is possible to convert 230 to the 15 volt.
- This we can give to the 1N4007 rectifier, again we given these 15 volt to 7805 IC regulator, that filter out 15 volt and convert to the 5 volt. This supply given to the microcontroller.
- Again 15 volt supply is given to 7812 IC and converts it to the 12 volt. This 12 volt is given to MOSFET and also separately 230 volt supply given to MOSFET, with the help of conversion and programming of controller it is possible to convert single phase to three phase.

3. To increase overall efficiency of the system:

- In these using power electronic devices such as IGBT, MOSFET, capacitor and regulator increases the overall efficiency.

CHAPTER 4

SIGNIFICANCE OF TOPIC

4.1 Significance of Topic:

1.Three phase Induction Motor operate on single phase supply.

Single phase 230V, 50Hz AC supply is applied to the bridge rectifier. This bridge rectifier converts single phase AC input into DC which is filtered by two split capacitors. The pure DC supply is applied to the microcontroller. By using microcontroller can generate 3 phase by shifting technique. The output of controller is given to PWM, which generates 3 phases and given to inverter. The energy that a switching power converter delivers to a motor is controlled by Pulse Width Modulated (PWM) signals applied to the gates of the switches. PWM signals are pulse trains with fixed frequency and magnitude and variable pulse width.

An inverter is an electrical device that converts direct current (DC) to alternating current (AC).The converted AC can be at any required voltage and frequency with the use of appropriate transformers, switching and control circuits. The inverter performs the opposite function of a rectifier. A pure sine wave inverter produces a nearly perfect sine wave output (less than 3% total harmonic distortion) that is essentially the same as utility-supplied grid power.

2. Used in rural area due to lack of three phase supply.

In rural areas or villages due to lack of three phase supply we use single phase to three phase supply conversion method.

4.2. Constraints or Difficulties Faced:

Constraint to our project is we can run only 1HP motor on this circuit due to of Constraint power electronics equipments like IGBTs which cannot handle large power. But in future we will search for higher power components and run the motor which are of higher power.

CHAPTER 5

PRINCIPLE OF OPERATION

5. PRINCIPLE OF OPERATION:

Electric switches-power transistor or thyristor switch the rectified DC on and off, and a produce a current or voltage waveform at the desired new frequency. The inverter contains transistors that deliver power to the motor. The "Insulated Gate Bipolar Transistor" (IGBT) is a common choice in modern VFDs. The IGBT can switch on and off several thousand times per second and precisely control the power delivered to the motor. The IGBT uses a method named "pulse width modulation" (PWM) to simulate a current sine wave at the desired frequency to the motor.

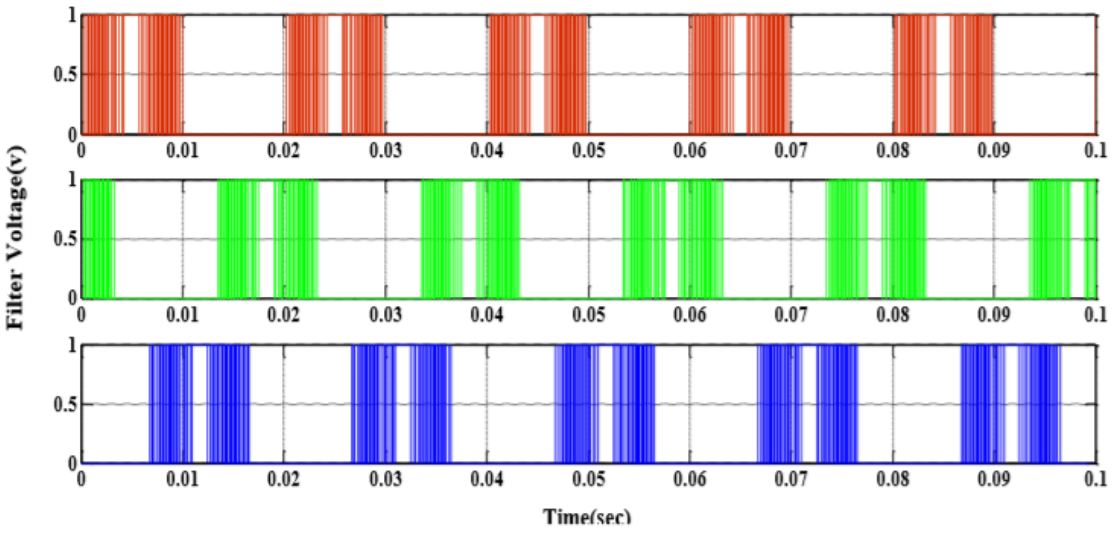


Fig.5.1

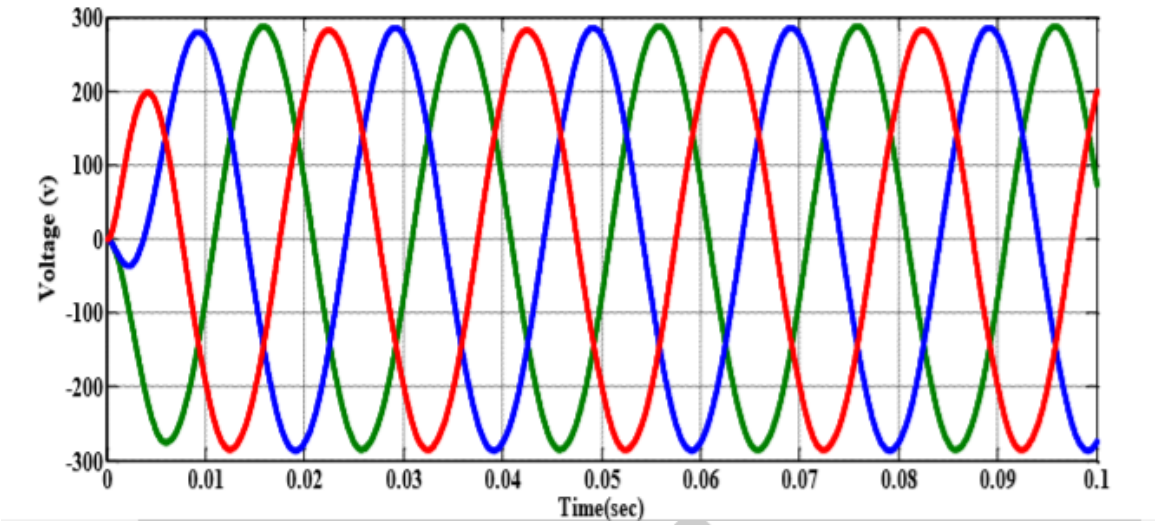


Fig.5.2

We are giving 230v supply to rectifier, for positive pulse two diodes are triggered and for negative another two diodes are triggered and AC supply is converted to DC. In inverting stage we are using six IGBT as inverter. Upper side three IGBT are called as positive group IGBT and lower side three IGBT are called as negative group IGBT. IGBT work in 180 degree mode of operation in which one IGBT from upper group and another two from lower group and after that one from lower group another two from upper group. Same procedure is followed by whole inverter circuit. Diodes are connected across each IGBT to limit the reverse current flowing through the inverter. In this way we are getting the three phase from middle of two IGBT.

CHAPTER 6

PROJECT DEVELOPMENT STAGES

1. Development of power supply kit:

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CHAPTER 7

HARDWARE DESIGN

7.1 Component Selection:

7.1.1 LM7805 Voltage Regulator:

- The LM78XX series of three terminal regulators is available with several fixed output voltages making them useful in a wide range of applications. One of these is local on card regulation, eliminating the distribution problems associated with single point regulation.
- The voltages available allow these regulators to be used in logic systems, instrumentation and other solid state electronic equipment. Although designed primarily as fixed voltage regulators these devices can be used with external components to obtain adjustable voltages and currents.
- The LM78XX series is available in an aluminum TO-3 package which will allow over 1.0A load current if adequate heat sinking is provided. Current limiting is included to limit the peak output current to a safe value. Safe area protection for the output transistor is provided to limit internal power dissipation.

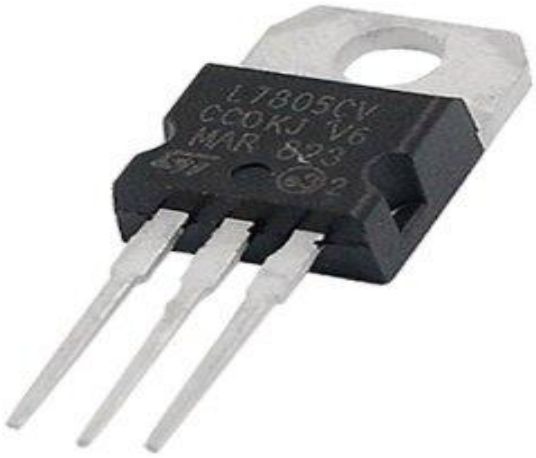


Fig 7.1.1 LM7805 Voltage Regulator

- If internal power dissipation becomes too high for the heat sinking provided, the thermal shutdown circuit takes over preventing the IC from overheating. Considerable effort was expanded to make the LM78XX series of regulators easy to use and minimize the number of external components.
- It is not necessary to bypass the output, although this does improve transient response. Input bypassing is needed only if the regulator is located far from the filter capacitor of the power supply. The LM7805 consist of terminals. First terminal is for the input voltage of specific range. The second terminal is for the ground and third terminal is for the output voltage of 5V.

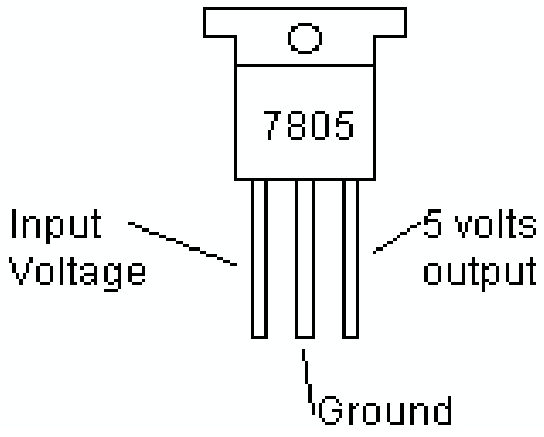


FIG 7.1.1 Connection Diagrams of LM7805

Features:

- Output current in excess of 1A
- Internal thermal overload protection
- No external components required
- Output transistor safe area protection
- Internal short circuit current limit
- Available in the aluminum TO-3 package

7.1.2 Color Code for Resistors:

- Carbon-composition and carbon film resistors are too small to have the resistance value printed on their housings. Therefore, bands of color are used to represent the resistance value.
- The first and second band represents the numerical value of the resistor and the color of the third band specifies the power-of-ten multiplier. The color bands are always read from left to right starting with the side that has a band closer to the edge.
- For carbon-composition and carbon film resistors, the common tolerances are 5%, 10%, and 20%, indicating that the actual value of the resistor can vary from the nominal value by ±5%, ±10% and ±20%. If the band is gold, it specifies a 5% tolerance; silver specifies a 10% tolerance; if no band is present, the tolerance is 20%.
- Note that the color-code system for capacitors is very similar to that of resistors except there is a fifth band representing the temperature coefficient. This band is the first one closest to one end of the capacitor. The other four fall into the same order as mentioned for resistors. In this case, the second, third, and fourth bands are used to determine the capacitance. The fifth band represents the tolerance of the capacitor.

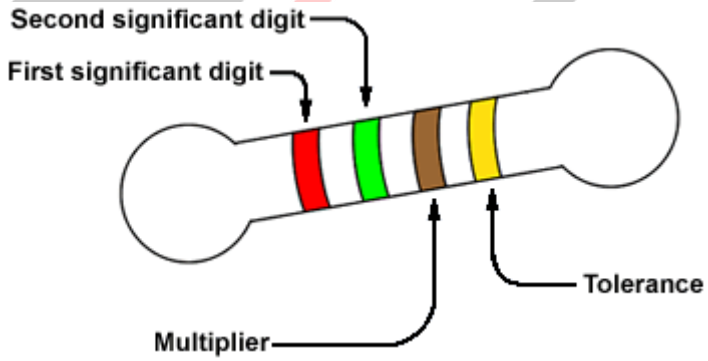


Fig 7.1.2 Resistor Coding

7.1.3 Resistance:

- The electrical resistance of a circuit component or device is defined as the ratio of the voltage applied to the electric current which flows through it:

$$R = \frac{V}{I}$$

If the resistance is constant over a considerable range of voltage, then Ohm's law, I= V/R, can be used to predict the behavior of the material. Although the definition above involves DC current and voltage, the same definition holds for the AC application of resistors

7.1.4 MOSFET:

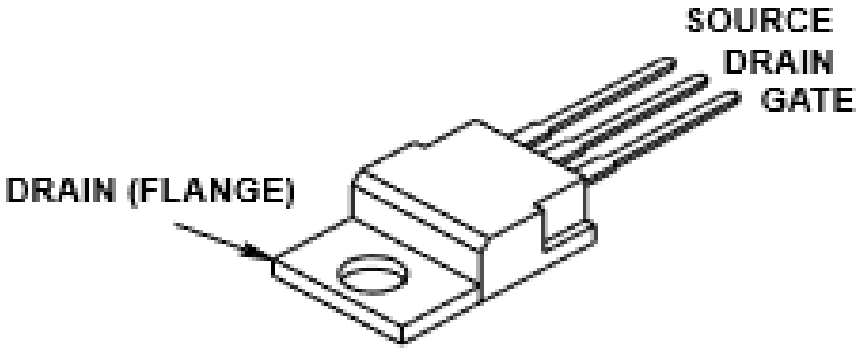


Fig.7.1.4

These are N-Channel enhancement mode silicon gate power field effect transistors. They are advanced power MOSFETs designed, tested, and guaranteed to withstand a specified level of energy in the breakdown avalanche mode of operation. All of these power MOSFETs are designed for applications such as switching regulators, switching convertors, motor drivers, relay drivers, and drivers for high power bipolar switching transistors requiring high speed and low gate drive power. These types can be operated directly from integrated circuits.

7.1.5 IGBT:

The Insulated Gate Bipolar Transistor is a power switch well suited for high power applications such as motor control, UPS and solar inverters, and induction heating. If the application requirements are well understood, the correct IGBT can easily be selected from the electrical properties provided in the manufacturers' datasheet. This application note describes the electrical parameters provided in the ON Semiconductor IGBT .

7.1.6 Printed Circuit Board (PCB):

- Printed circuit boards (PCBs) are by far the most common method of assembling modern electronic circuits. Comprised of a sandwich of one or more insulating layers and one or more copper layers which contain the signal traces and the powers and grounds, the design of the layout of printed circuit boards can be as demanding as the design of the electrical circuit.
- Most modern systems consist of multilayer boards of anywhere up to eight layers (or sometimes even more). Traditionally, components were mounted on the top layer in holes which extended through all layers. These are referred as through hole components. More recently, with the near universal adoption of surface mount components, you commonly find components mounted on both the top and the bottom layers. The design of the printed circuit board can be as important as the circuit design to the overall performance of the final system.
- PCB effects that are harmful to precision circuit performance include leakage resistances, IR voltage drops in trace foils, vias, and ground planes, the influence of stray capacitance, and dielectric absorption (DA). In addition, the tendency of PCBs to absorb atmospheric moisture (hygroscopicity) means that changes in humidity often cause the contributions of some parasitic effects to vary from day to day.
- Here we used the PCB for mounting the power supply unit, microcontroller, LCD module, battery charging circuit, etc.
- In general, PCB effects can be divided into two broad categories, those that most noticeably affect the static or dc operation of the circuit, and those that most noticeably affect dynamic or ac circuit operation, especially at high frequency.

CHAPTER 8

MICROCONTROLLER DESIGN

8 CONTROLLER PIN DIAGRAM:

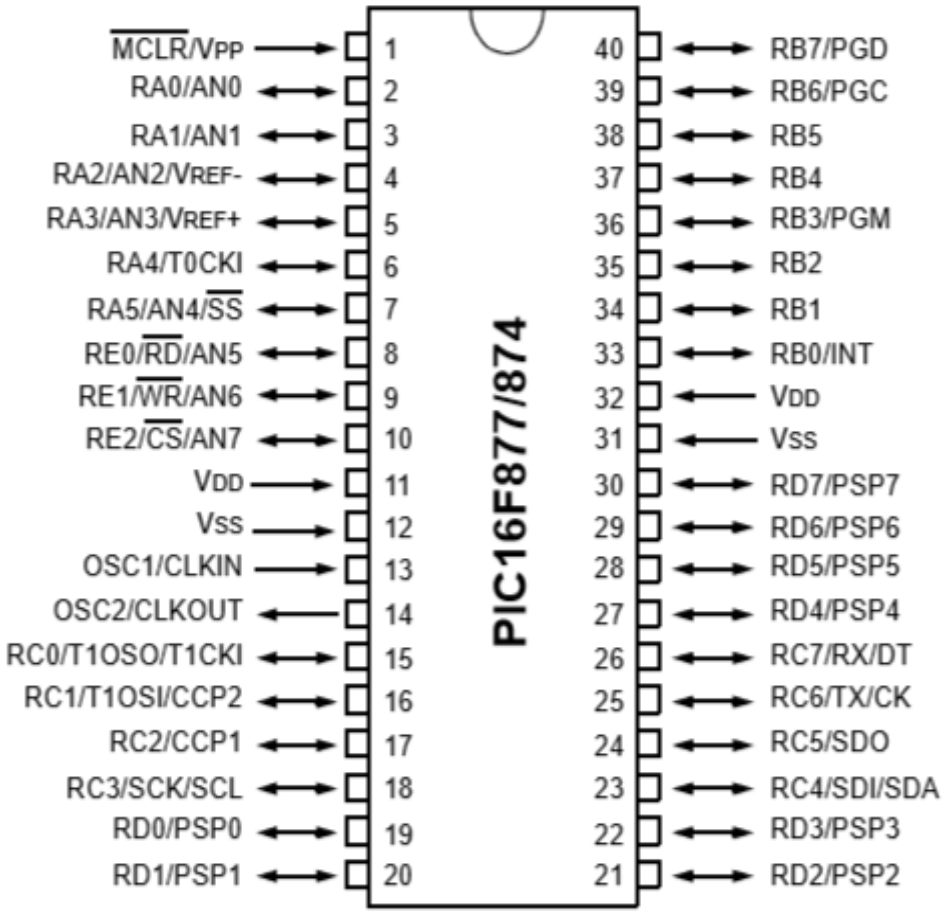


Fig.8

8.1 Peripheral features:

- Timer0:8 bit timer/counter with 8 bit prescaler.
- Timer1:16 bit timer/counter with prescaler, can be incremented during SLEEP via external crystal/clock
- Timer2:8 bit timer/counter with 8 bit period register, prescaler and postscalar
- 10 bit multi-channel analog-to-digital converter.
- Synchronous serial port SPI(Master mode) and I^2C(master/slave)
- Brown-out detection circuitry for brown-out reset (BOR)
- Two capture, compare, PWM modules.
  -capture is 16 bit max resolution in 12.5 ns
  -compare is 16 bit max resolution in 200 ns
  -pwm max resolution is 10 bit.

Key Features PIC Microcontroller Mid-Range Reference Manual (DS33023)	**PIC16F877**
Operating Frequency	DC-20 MHZ
FLASH Program Memory (14-bit Word)	8K
Data Memory	368
EEPROM Data Memory	256
Interrupt	14
I/O Ports	Ports A,B,C,D,E
Timer	3
Capture/compare/PWM modules	2
Serial Communications	MSSP,USART
Parallel Communications	PSP
10-bit Analog-to-Digital Module	8 input channels
Instruction Set	35 Instructions
RESETS (and Delays)	POR,BOR (PWRT,OST)

Table no.1

CHAPTER 9

BLOCK DIAGRAM DESCRIPTION

9. BLOCK DIAGRAM:

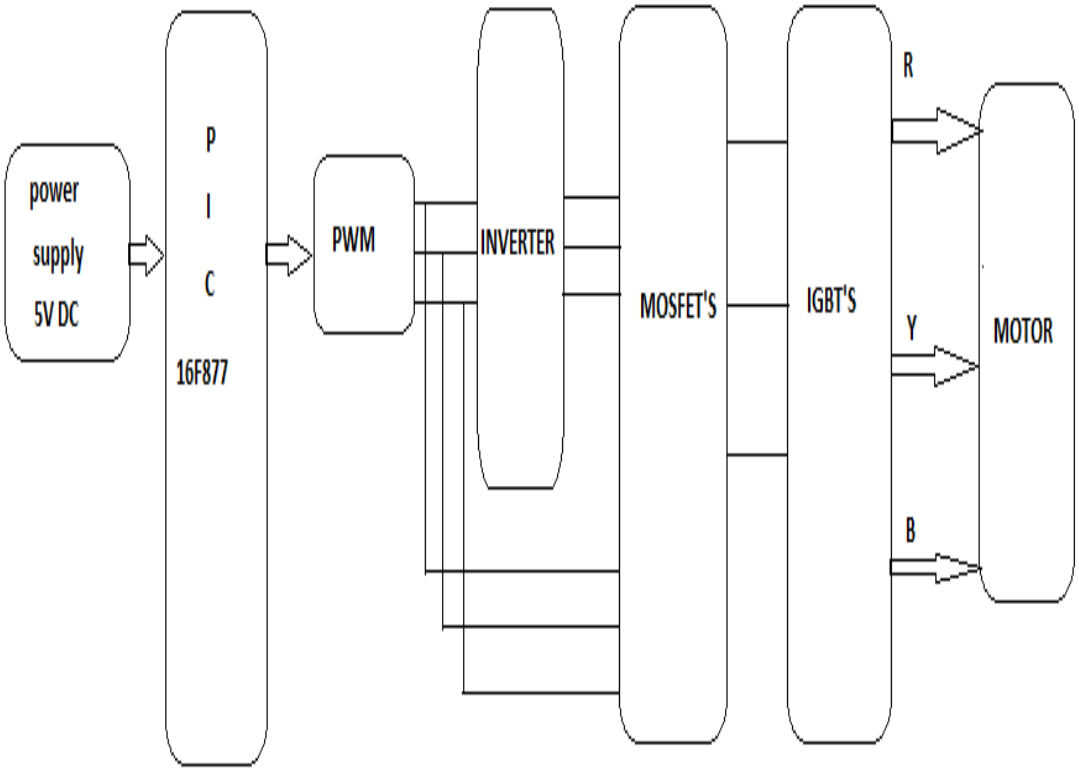


Fig.9

Power Supply-

The power supply circuit consist of step-down transformer, full bridge rectifier, capacitors, 7805 regulator, LED, maintained push button, etc.

The 230/12V step-down transformer converts 230V supply voltage to 12V.

The full bridge rectifier rectifies the output and filter removes the ripple contents and converts this AC voltage to DC voltage. The 7805 regulator maintains 5V DC output constant which is given to the microcontroller as input supply.

PIC16F877 Controller-

- Timer0:8 bit timer/counter with 8 bit prescaler

- Timer1:16 bit timer/counter with prescaler ,can be increamented during SLEEP via external crystal/clock
- Timer2:8 bit timer/counter with 8 bit period register, prescaler and postscalar
- 10 bit multi-channel analog-to-digital converter.
- Synchronous serial port SPI(Master mode) and I^2C(master/slave)
- Brown-out detection circuitry for brown-out reset (BOR)
- Two capture, compare, PWM modules
  -capture is 16 bit max. resolution in 12.5 ns
  -compare is 16 bit max. resolution in 200 ns
  -pwm max resolution is 10 bit.

PWM Technique-

The sinusoidal PWM technique is very popular for industrial converters. In this technique, an isosceles triangle carrier wave of frequency fc is compared with the fundamental frequency f sinusoidal modulating wave and the points of intersection determines the switching points of power devices. Two important parameters of the design process are amplitude modulation index ma= Vr/Vc, where Vris the peak amplitude of reference control signals, Vcis the peak amplitude of the carrier wave, and the frequency modulation index mf= fc/fr, where the frequency of the carrier wave and fr is the reference sinusoidal signal frequency and fr determines the magnitude and frequency of output voltage, fc determines switching frequency of power semiconductor devices. Multilevel converters are mainly controlled with sinusoidal PWM extended to multiple carrier arrangements of two types: Level Shifted (LS-PWM), which includes Phase Disposition (PD-PWM), Phase Opposition Disposition (POD- PWM) and Alternative Phase Opposition Disposition (APOD-PWM) or they can be Phase Shifted (PS-PWM). In present topology PD is used.

Inverter circuit-

Inverter circuit contains simply NOT Gate, which converts signal from 1 to 0 and 0 to 1,
This inversion of PWM signal is takes place for giving signals to MOSFET i.e [1 0 1] is without inversion and with inverter [0 1 0] for its operation to generate 3 phase supply.

Power electronics devices-

1. “MOS”-metal-oxide-semiconductor structure

MOSFET is a four-terminal device: gate (G), source (S), drain (D) and body (B)

Two kinds of MOSFETs: n-channel (NMOS) and p-channel (PMOS) devices

The device structure is basically symmetric in terms of drain and source.Source and drain terminals are spec ified by the operation voltage The MOSFET uses the field effect to operate – the attraction or repulsion of charge carriers through an applied voltage – but this device has a twist that has allowed it to become the predominant technology for silicon based FETs. The MOSFET structure has dominated primarily due to the availability of a high quality oxide (SiO2, or silicon dioxide) for the silicon system.

2. IGBT- Insulated Gate Bipolar Transistor

The Insulated Gate Bipolar Transistor (IGBT) is a minority-carrier device with high input impedance and large bipolar current-carrying capability. Many designers view IGBT as a device with MOS input characteristics and bipolar output characteristic that is a voltage-controlled bipolar device. To make use of the advantages of both Power MOSFET and BJT, the IGBT has been introduced. It's a functional integration of Power MOSFET and BJT devices in monolithic form. It combines the best attributes of both to achieve optimal device characteristics The IGBT is suitable for many applications in power electronics, especially in Pulse Width Modulated (PWM) servo and three-phase drives requiring high dynamic range control and low noise. It also can be used in Uninterruptible Power Supplies (UPS), Switched-Mode Power Supplies (SMPS), and other power circuits requiring high switch repetition rates. IGBT improves dynamic performance and efficiency and reduced the level of audible noise. It is equally suitable in resonant-mode converter circuits. Optimized IGBT is available for both low conduction loss and low switching loss.

CHAPTER 10

HARDWARE DESIGN CIRCUITRY

10.1. Power Supply Circuit:

- The power supply circuit consist of step-down transformer, full bridge rectifier, capacitors, 7805 regulator, LED, maintained push button, etc.
- The 230/12V step-down transformer converts 230V supply voltage to 12V.
- The full bridge rectifier rectifies the output and filter removes the ripple contents and converts this AC voltage to DC voltage. The 7805 regulator maintains 5V DC output constant which is given to the microcontroller as input supply.

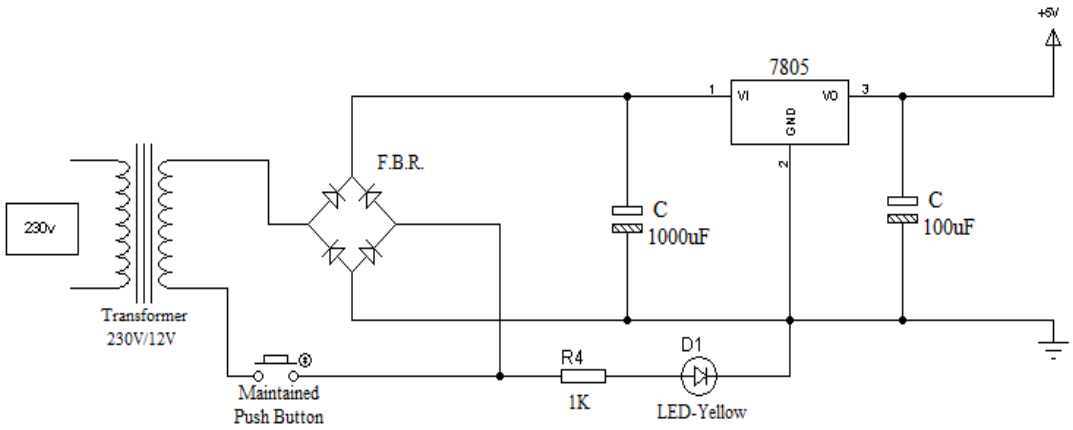
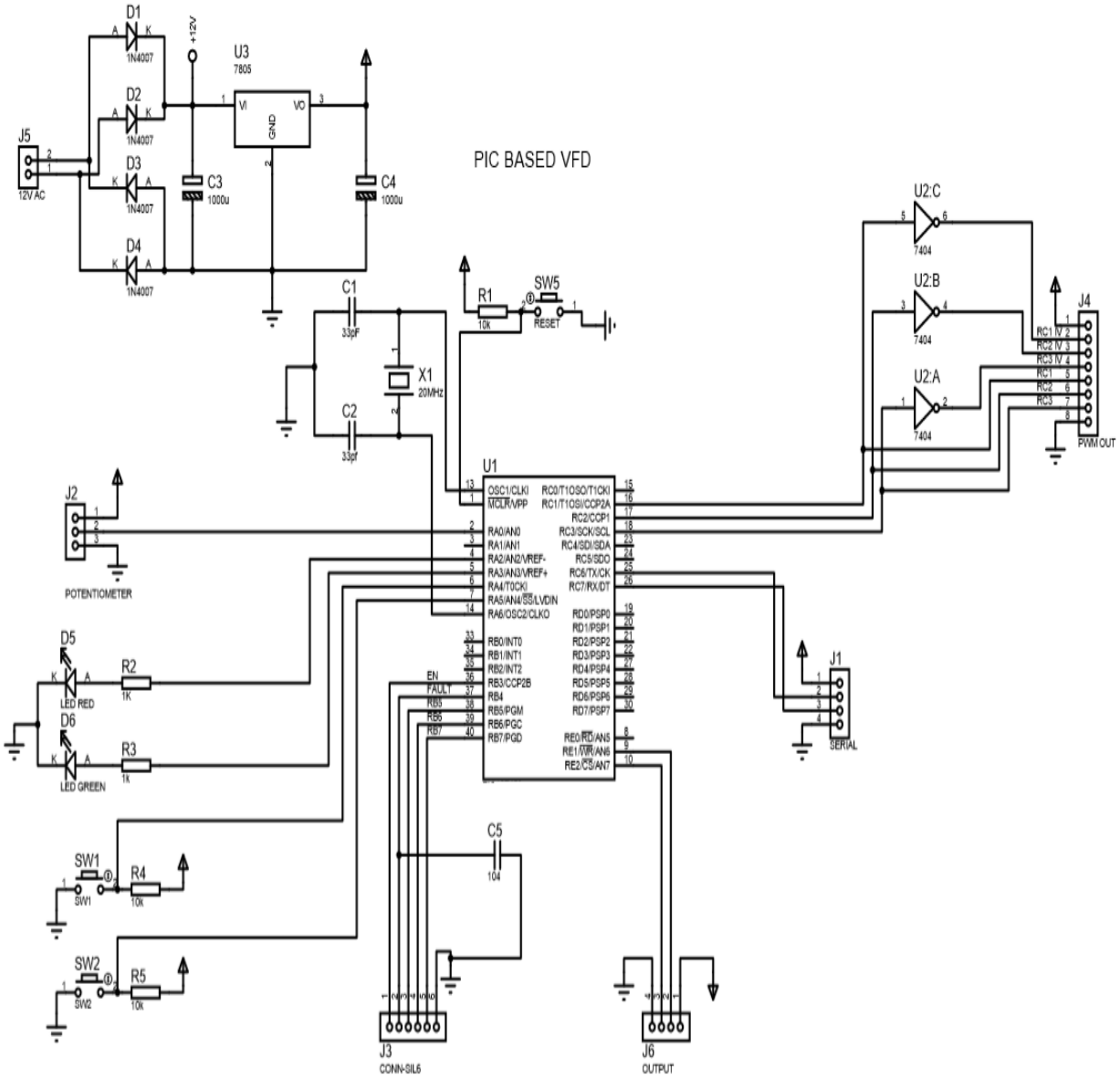


Fig 9.3: Design of Power Supply Circuit

10.2. Circuit Diagram:



CHAPTER 11

COMPERATIVE TESTING RESULTS

CHAPTER 12

ADVANTAGES & DISADVANTAGE

ADVANTAGES:

- 1.We can use 3 phase induction motor on 1 phase supply.
- 2.Fast switching through IGBT.
- 3.Energy saving.

DISADVANTAGES:

- We can use limited HP rating of I.M.

CHAPTER 13

APPLICATIONS

12. APPLICATION

- Irrigation pumps for agriculture purpose.
- Used for rural area water pumping.
- Applicable in industries.

CHAPTER 14

CONCLUSION AND FUTURE SCOPE

13.1 CONCLUSION

In this paper diode clamped Multilevel Inverter required only two battery source. A three level equal step switching control has been applied to obtain a multilevel ac output. This paper presents a single-phase to three-phase conversion system that improves the local power quality for linear and non-linear loads, and guarantees unity power factor at the single- phase feeder. The inverter controls the local power quality, producing three-phase, symmetrical and sinusoidal voltages. It also controls the single-phase power flow, by adjusting the local voltage amplitude and phase angle.

Three phase asynchronous induction motors are widely used in industrial applications due to their features of low cost, high reliability and less maintenance. Due to the need for three-phase electricity in today's remote areas for agriculture work where three phase power is not available easily, in those areas these single phase to three phase converters are use full. Operating a three phase induction motor using single phase supply has been presented. The developed single phase to three phase conversion hardware setup is tested on a three phase 1hp, 415V, 50Hz induction motor with loading in power electronics laboratory.

From the experimental setup and results chapter it is clear that the developed hardware satisfactory converts from single phase power to three phase power. The developed system is useful in remote areas where three phase supply is not available easily. Applications of single phase to three phase converter are: 1. In Irrigation Pumps for Agriculture purpose. 2. Rural Area Water Supply. Also VFDs provide the most energy efficient means of capacity control. This drive comes in a lead role for energy saving products for the all industries using electrical motors. Adding a variable frequency drive (VFD) to a motor-driven system can offer potential energy savings in a system in which the loads vary with time.

13.2. FUTURE SCOPE:

This project is applicable in future for Irrigation water supply, Industrial applications, and Commercial applications.

CHAPTER 15

COST ESTIMATION

Name of Equipment	Quantity	Price(Rs)	Total(Rs)
Transformer	1	400	400
IGBT	6	25	150
MOSFET	12	30	360
Wire	3	80	160
PIC controller	1	350	350
Bridge rectifier	1	30	30
Capacitors	8	2	16
PCB	2	40	80
LED	2	2	4
Diode	20	2	40
Toggle switch	2	12	24
Wooden Plate	1	520	520
Plug	1	20	20
IC LM7805	1	20	20
IC LM7812	4	20	80
Other		3000	3000
Resistors	30	2	60
TOTAL			5314

Table 14.1: Cost Estimation

APPENDIX A

BRIEF DATA OF PROTOTYPE

A.1 Power Supply Circuit Specifications:

- Input Voltage : 230V
- No. of phases : single phase
- Supply frequency : 50Hz
- Current capacity : 1A
- Output voltage: 5V

A.2 Single Phase To Three Phase Conversion Specification:

- Input voltage: 230V
- No of Input Phases**:** single phase
- Supply frequency: 50Hz
- No of output Phases**:** three phase
- Input current: 3A
- Output voltage: 415V
- Output current: 12A

APPENDIX B

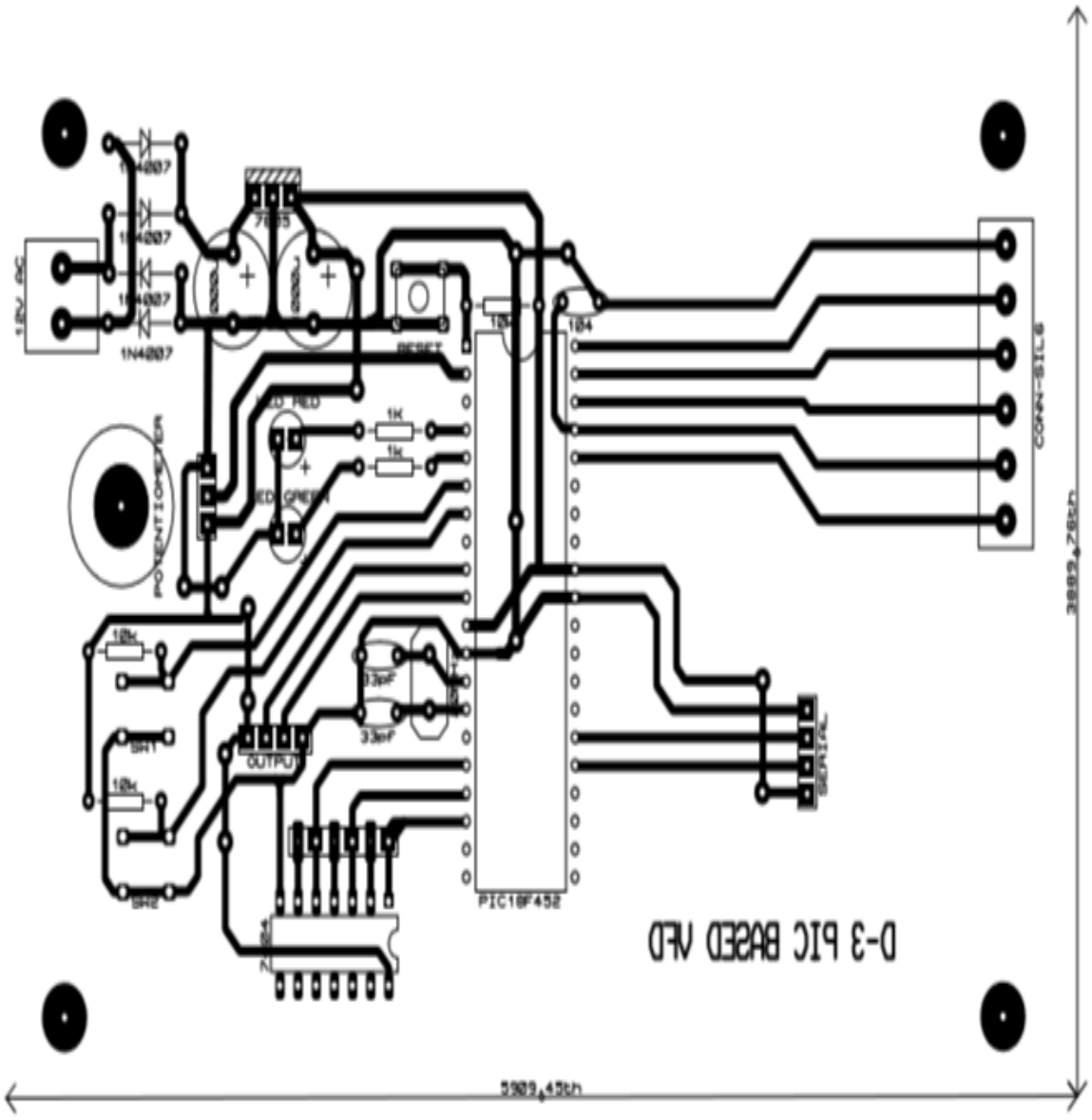
DATA OF CONTROLLER

Table no.1

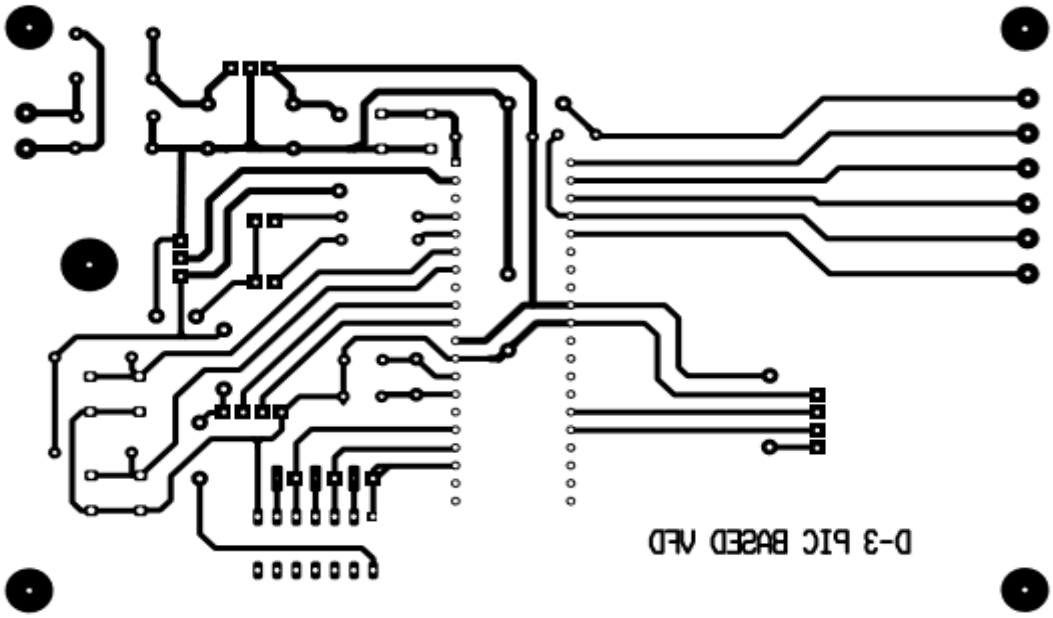
Key Features PIC Microcontroller Mid-Range Reference Manual (DS33023)	**PIC16F877**
Operating Frequency	DC-20 MHZ
FLASH Program Memory (14-bit Word)	8K
Data Memory	368
EEPROM Data Memory	256
Interrupt	14
I/O Ports	Ports A,B,C,D,E
Timer	3
Capture/compare/PWM modules	2
Serial Communications	MSSP,USART
Parallel Communications	PSP
10-bit Analog-to-Digital Module	8 input channels
Instruction Set	35 Instructions
RESETS (and Delays)	POR,BOR (PWRT,OST)

Table no.1

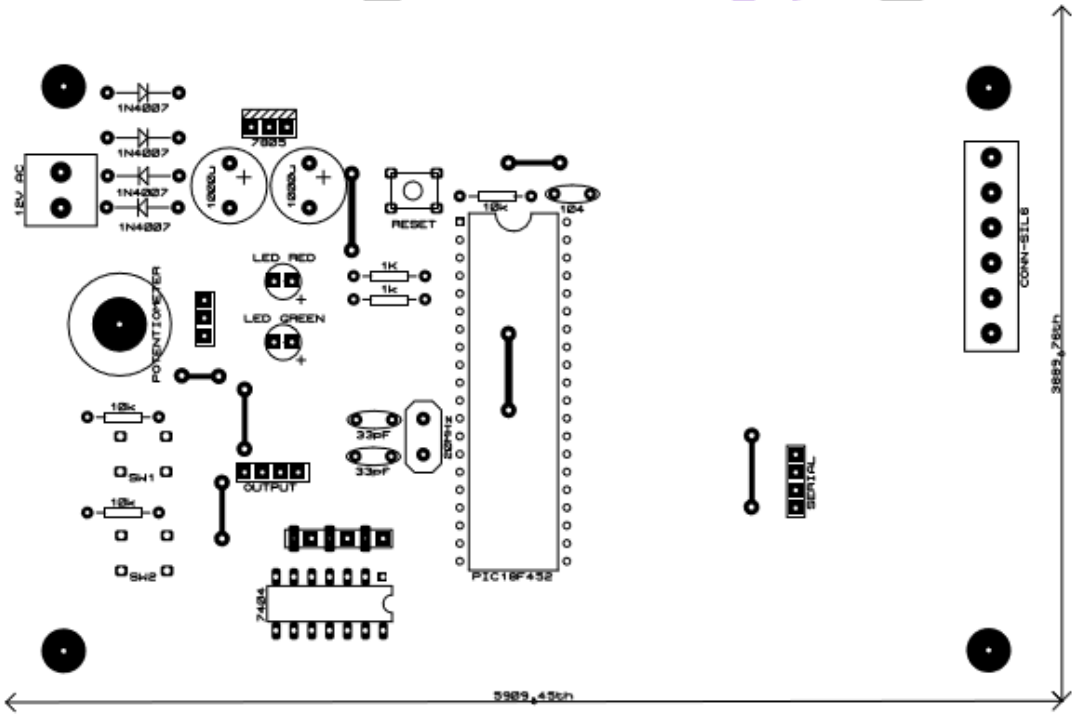
PCB LAYOUT:



Dig.PIC BASED VFD PCB TOP BOTTOM



Dig.PIC BASED VFD PCB BOTTOM



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