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Single Phase to Three Phase VFD Based Induction Motor

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Abstract: In our research paper, we are going to represent single phase to three phase VFD based induction motor working technique. There is various kind of topology available in theory of phase conversion method. In our Paper, we are going to use VFD for phase conversion. Many of us know that to control the speed of induction motor VFD is economically consider as energy saving option for us. We are using 3-Phase power from Single phase supply to control the speed & direction.

Index Terms - Phase Converter, Variable Frequency Drive (VFD), IGBT/MOSFET, Pulse Width Modulation (PWM), Induction Motor.

I. INTRODUCTION

The concept of our project is to control the rotation & speed of three phase induction motor by using VFD. We know that the induction motor can run only specific speed. VFD not only controls the speed but it also improves the characteristic of steady state as well. VFD also reduces the system energy consumption. We have design our project circuitry into two parts. First part in control circuit & second part is driver board. Previously single phase to three phase conversion was done by the combination of passive elements capacitors & reactor with auto-transformer converter. These arrangements have lots of limitation & disadvantages. So to overcome these disadvantages we are use thyristor & power electronic device such as SCR, IGBT and MOSFET. In our project we are going to use IGBT based inverter. It has simple structure & low cost design. When three phase induction motor driven by single phase sources after phase converter & auto-transformer, these caused more loss as compared to new topology. In India most of rural communities get single-phase AC power, so the three-phase induction motor driven by phase converter. These phase converter cannot easily obtained balanced output. In much rural area where only single-phase power is available, so we should convert single-phase power to three-phase power supply. In this paper we can understand the alternate solution of phase converter & drive three-phase induction motor at very low cost. It will improve the performance during start-up & high steady-state performance at line frequency.

II. BLOCK DIAGRAM OF PROPOSED SYSTEM

We have design circuit in such a way that a control circuit board which is operates on low voltage isolate with driver circuit operates on high voltage. It's make hardware more simple & easy for troubleshooting. The main single phase source is rectified by using a full wave bridge rectifier. The filtered DC bus is connected to the IGBT-based 3-phase inverter module, which is controlled by the PIC micro-controller.

From the inverter we get 3-phase supply. A potentiometer connected to micro-controller which sets the motor frequency. Push button keys are used to change the direction of the induction motor. LEDs are provided for status of indications like run/ stop, forward/reverse, under voltage, over-voltage, etc. The Pulse width modulation is generated from PIC micro-controller. These are used to drive IGBT driver through opto-coupler. The two board of circuit are connected in optically through opto-coupler.

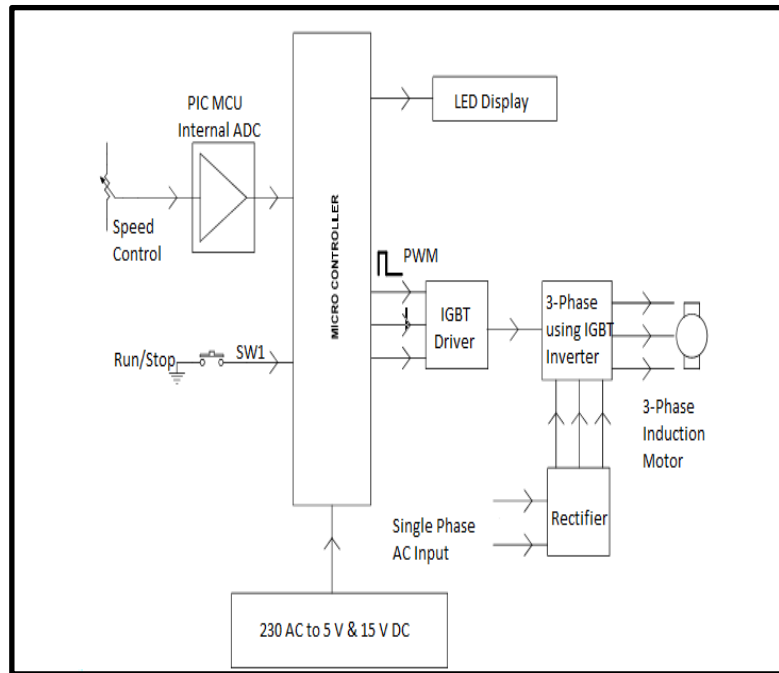


fig. 1 block diagram of the system

III. BASIC COMPONENT OF VFD

It is very important to know about working principle of VFD, because in many application 3-phase induction motor driven by VFD. It has very wide characteristics. If we compare conventional motor drive VFD plays an important role because it offers protection like under voltage, over-voltage & phase. Three components of VFD are Rectifier, DC bus & Inverter.

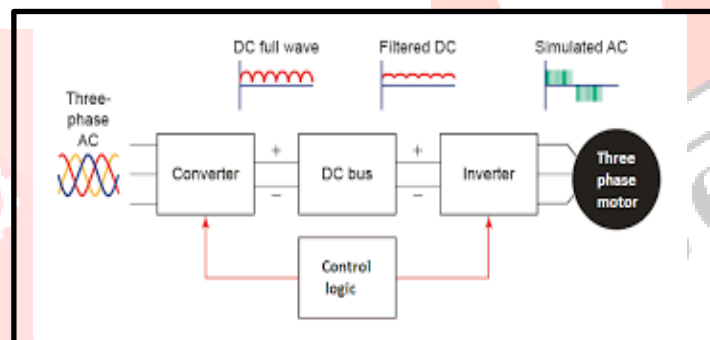


fig. 2 block diagram of VFD

A . Rectifier Stage

A bridge rectifier is a common part of electronic power supplies. A full-wave rectifier bridge converts three-phase 50 Hz power from a single phase 230V AC supply to either fixed or adjustable DC voltage. The system may include transformers for high voltage systems. The rectifier design will eliminate the content to which electrical harmonics are induced on the incoming supply.

B . DC Bus

DC bus in VFD has found its usage as the technology has evolved. Some of the applications of DC bus, common DC application when single rectifier unit acts as a source of power to many inverter units through common DC bus. This inverter unit can be connected to many motors. A resistor connected to DC bus can act as a brake resistor which dissipates surge power generated by fast decelerating load.

C . Inverter Stage

Inverter stage is made up of a combination of electronics switch such as thyristors, IGBT etc. It converts AC power from DC supply which we get from DC bus link. To convert AC supply we use a Pulse width modulation technique to vary output frequency & speed of the 3-phase induction motor. The high speed switching action of a PWM inverter results in less waveform distortion and hence decreases harmonic losses.

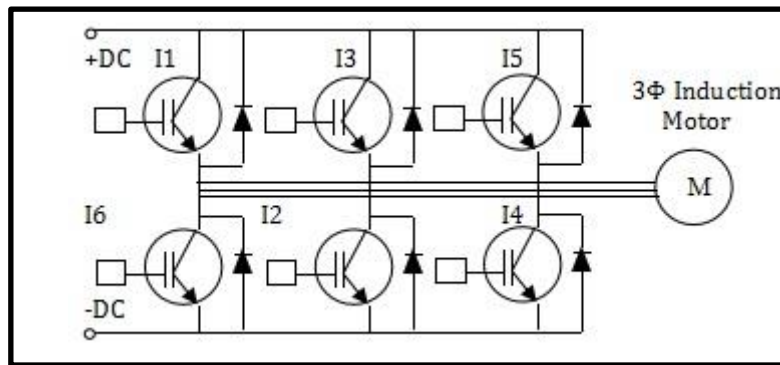


fig. 3 three phase full bridge inverter

D . Control System

A control circuit consist of microprocessor which perform various function like controlling, configuration, driver settings, running condition & fault detection in system. By this section we can control the speed of the motor as per requirement also we can select forward or reverse rotation of the unit. We have also added few features like torque limiting, overload & under load protection & fault identification.

IV. CONTROL & OPERATION

A . Control Circuit

As we already mentioned in our introduction part, that PIC microcontroller has inbuilt ADC. The pot gives signal to ADC. We have taken 6 hardware pin from PIC microcontroller. There are 2 types of PWM available first one is software based PWM & second is hardware based PWM. The disadvantage of software based PWM is that we need to synchronous at every machine cycle & need to update at every time. If one of the cycles missed during operation, PWM will get failed. As a result VFD not working properly or else IGBT get burn. In hardware based PWM, no need to update at every time once it configure it will work in multitasking mode. There are some register called SFR, we have take 6 pin from PIC microcontroller & configured that 6 pin through SFR. In PWM, there are two parameter i.e. frequency & duty cycle. In our project we need to vary duty cycle only. We have operates its 20 KHz to 40 KHz. As we change the width of the duty cycle, motor speed gets change accordingly. More the width higher the speed of induction motor. We are getting 6 pins from control circuit, 3-PWM of them are at lower side & rest of 3-PWM are a higher side.

B . Operation Circuit

Driver circuit board operates on 15 VDC supply. In driver board there are opto-coupler & IGBT driver IC. We have converted single phase 230 VAC supply to 350 VDC from rectifier circuit. We are isolate rectifier circuit from driver board because it gets heated. Induction motor is connected to 3-phase bridge inverter as shown in fig 3. The inverter bridge has 6 switches that are generate 3-phase AC supply output from the DC bus. We will get PWM signals from the PIC microcontroller that is control by 6 switches. Switches I1 through I3, which are connected to DC+, are called upper switches. Switches I4 through I6, connected to DC-, are called lower switches.

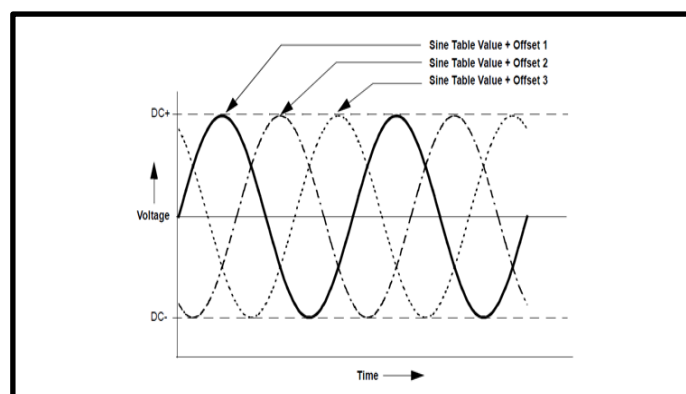


fig. 4 phase sin-wave from inverter bridge

The amplitude of phase voltage of pulse width modulation is determined by the duty cycle of the PWM signals. While the induction motor is running, three out of six switches will be ON at any specified time; either 1 upper or 2 lower switches or 1 lower and 2 upper switch. After switching action, we will get rectangular shaped output waveform which contains harmonics. The inductive nature of the 3 phase induction motor's stator windings 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 off low of the current until all of the energy stored in the windings is dissipated. To fast recovery, diodes are provided across each switch. These diodes are popularly known as freewheeling diodes. To avoid 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.

V. APPLICATION & FUTURE SCOPE

1. VFD use in crane operation & manufacturing unit
2. In pharmaceutical industries
3. Centrifugal chiller in HVAC industries
4. Rise demand in IOT based industry
5. Variable Frequency Drive Market is predicted to grow at approximately 6% by 2022
6. As per market research growth & investment opportunity increase by 2027

VI. CONCLUSION

In this project we can convert single phase supply to three phase supply & also controlling the speed of the three phase induction motor. We can vary the speed & direction as well. There are some indications which will provide the overall status of motor. If in case motor stop working, LED indication gives a signal to the operator. It also provides LED indication for forward & reversed direction of the motor. VFD helps to reduce electrical consumption of motors by reducing the amount of energy they consume, which is approximately 20% to 25%. The main features of VFD are smooth start of motor and energy conservation in different industrial applications.

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