

Study of Variable Frequency Drive using Pulse Width Modulation

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Abstract:- This paper presents the working principle and simulation of PWM controlled Variable Frequency Drive. The performance of VFD is also described. The simulation model is simulated using ISIS Proteus and their results are also observed. The use of Variable Frequency Drive has been increased in industrial drive for speed control of induction motors .The common applications of VFDs are in air handler, chiller, pumps and tower fans .This paper is intended to provide a basic understanding of VFD terms, VFD operations and how VFD can be controlled using Pulse width modulation.

Keywords:- Principle of VFD, VFD using PWM ,Simulation Circuit and Analysis of results.

I. INTRODUCTION

The Variable Frequency Drive (VFD) industry is growing rapidly and it is now more important than ever for technicians and maintenance personnel to keep VFD installations running smoothly. Variable Frequency Drives (VFD) change the speed of motor by changing voltage and frequency of the power supplied to the motor. In order to maintain proper power factor and reduce excessive heating of the motor, the name plate volts/hertz ratio must be maintained. This is the main task of Variable Frequency Drive.

1. Variable Frequency Drive (AC drives) are used to stepless speed control of squirrel cage induction motors mostly used in process plants due to its ruggedness and maintenance free long life.
2. VFD control speed of motor by varying output voltage and frequency through sophisticated microprocessor controlled electronics device.
3. VFD consists of Rectifier and inverter units. Rectifier converts AC in DC voltage and inverter converts DC voltage back in AC voltage.

II. VFD OPERATION

For understanding the basic principles behind VFD operation requires understanding three basic section of VFD: the Rectifier unit, DC Bus and the Inverter unit.

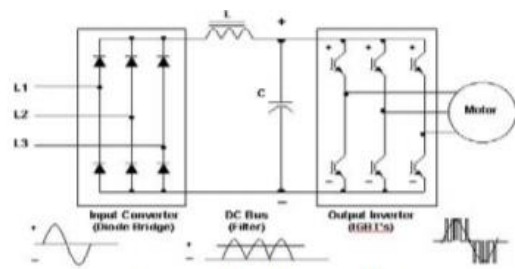


Figure 1: VFD Circuit Diagram

Fig :-1 VFD Circuit Diagram

The supply voltage is firstly pass through a rectifier unit where in gets converted into AC to DC supply, the three phase supply is fed with three phase full wave diode where it gets converts into DC supply. The DC bus comprises with a filter section where the harmonics generated during the AC to DC conversion are filtered out. The last section consists of an inverter section which comprises with six IGBT (Insulated Gate Bipolar Transistor) where the filtered DC supply is being converted to quasi sinusoidal wave of AC supply which is supply to the induction motor connected to it. As we know that the synchronous speed of motor (rpm) is dependent upon frequency. Therefore by varying the frequency of the power supply through VFD we can control the synchronous motor speed:

$$\text{Speed (rpm)} = \frac{(\text{Frequency in Hz}) * 120}{\text{No. of Poles}}$$

Frequency = Electrical Frequency of the power supply in Hz.
No. of Poles = Number of electrical poles in the motor stator.

Thus we can conveniently adjust the speed of a motor by changing the frequency applied to the motor. There is also another way to change the speed of the motor by changing the no. of poles, but this change would be a physical change of the motor. As the drive provides the frequency and voltage of output necessary to change the speed of a motor, this is done through Pulse Width Modulation Drives. Pulse width modulation (PWM) inverter produces pulses of varying widths which are combined to build the required waveform. As the frequency can easily variable as compared with the poles of the motor therefore speed control drive is termed as Variable Frequency Drive (VFD).

III. CONSTANT V/F RATIO OPERATION

All Variable Frequency Drives (VFDs) maintain the output voltage – to – frequency (V/f) ratio constant at all speeds for the reason that follows. The phase voltage V, frequency f and the magnetic flux ϕ of motor are related by the equation:-

$$V = 4.444 f N \phi_m \text{ or}$$

$$V/f = 4.444 \times N \phi_m$$

Where N = number of turns per phase.
 ϕ_m = magnetic flux

If the same voltage is applied at the reduced frequency, the magnetic flux would increase and saturate the magnetic core, significantly distorting the motor performance. The magnetic saturation can be avoided by keeping the ϕ_m constant. Moreover, the motor torque is the product of stator flux and rotor current. For maintaining the rated torque at all speeds the constant flux must be maintained at its rated value, which is basically done by keeping the voltage – to – frequency (V/f) ratio constant. That requires the lowering the motor voltage in the same proportion as the frequency to avoid magnetic saturation due to high flux or lower than the rated torque due to low flux.

IV. CIRCUIT DIAGRAM

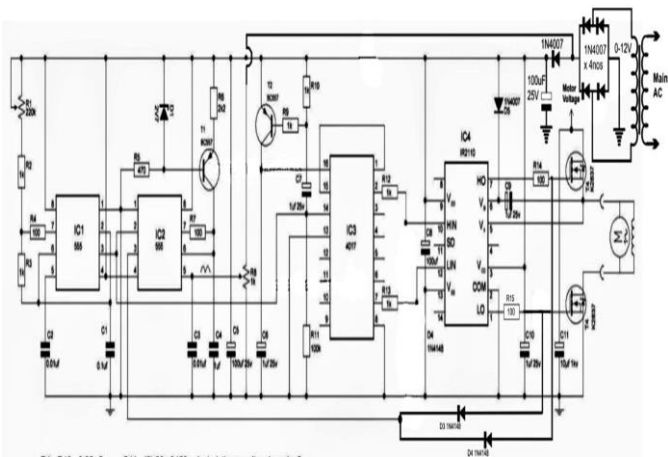


Fig :-2 Circuit Diagram

V. SOFTWARE DESIGN

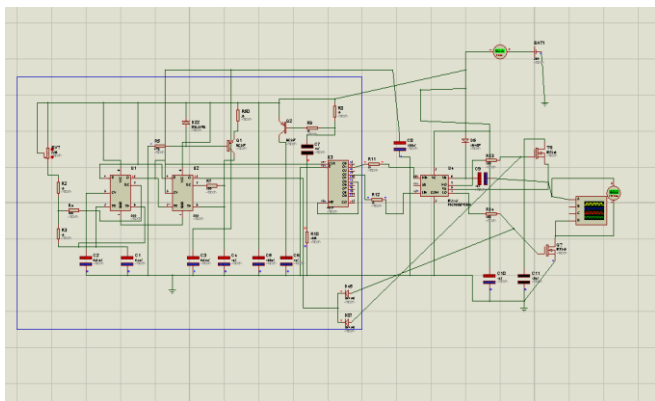


Fig 3:- Simulation Circuit of VFD

For variable speed control of AC electrical machines several power electronics switches such as IGBTs, MOSFETs and GTO use as forced – commutation method. Earlier techniques such as the DC motor and Thyristor Bridge which are replaced with new techniques such as Voltage Sourced Converters (VSC) are fed by Pulse Width Modulation (PWM) to the asynchronous machine. As the flexibility of speed and torque control with DC machine, the same can be obtained by the combination of pulse width modulation technique with modern control technique such as Field Oriented Technique or Direct Torque Control methods. In this section a simulation of AC drive controlling an asynchronous machine is been described.

VI. SIMULATION RESULT

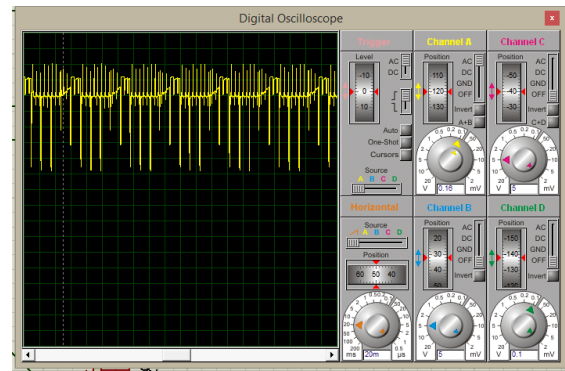


Fig 4:- Output waveform of upper IGBT

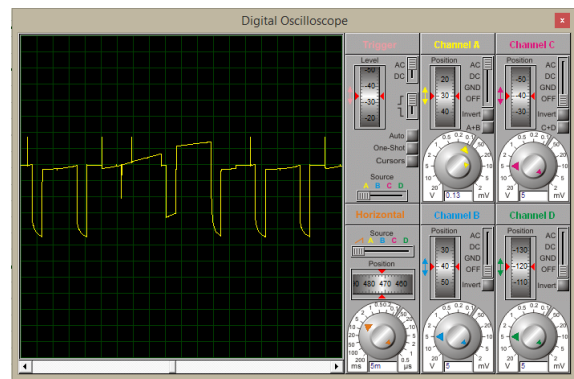


Fig 5:- output waveform of upper IGBT(Magnified)

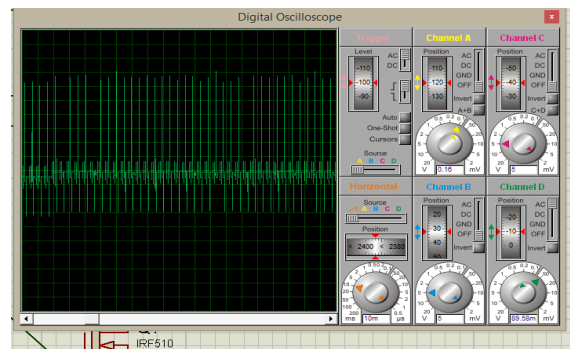


Fig 6:-Output waveform of lower IGBT

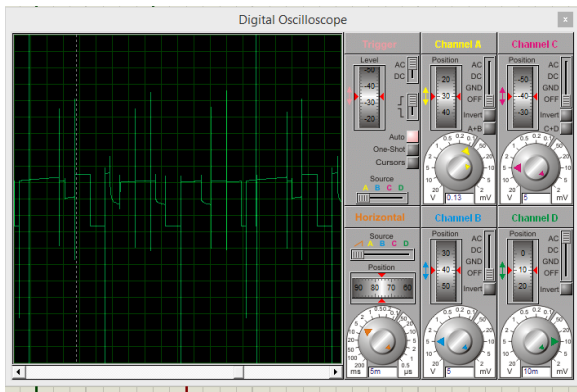


Fig 7:- Output waveform of lower IGBT(Magnified)

VII. HARDWARE RESULTS

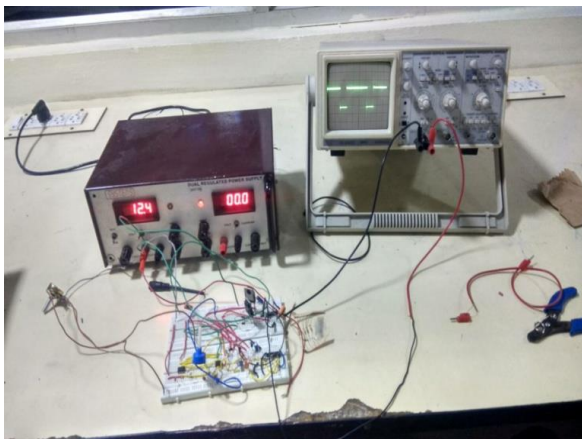


Fig 8:- Circuit with Waveform output

VIII. CONCLUSION

Hence, with the help of PWM regulation we're able to achieve variation of frequency. Thus, we can apply this technique for speed control of 1 phase Induction Motor.

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