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# Power Saving Using Variable Frequency Drive

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***Abstract*- As the demands of industrial needs varying the more outputs of the precise control of our basic electrical prime movers i.e. motor. As compared to AC motors the DC motors are easy to control but with increase in capacity they have their own limitations. Conversely AC motors particularly the Squirrel Cage induction motors are more economical but the speed control of these motor are quiet difficult because alteration of supply frequency is require. Nowadays with technological advance mentin drives system,the control of AC motors is more economically,easy to use and the control the range of speed both below and above the basespeed.According to the requirement, these drives can fundamentally alter the voltage and the frequency which is being fed to the motor using the technique called Pulse Width Modulation (PWM). Because of user friendly feature and reasonable cost these devices are gaining more popularity.As the Variable Frequency Device use the embedded system they can be programmed for automatic control reducing the manual intervention and interfaced to thecomputer.In the field of HVAC application the usage of Variable Frequency Drive have gained its number. Air handler, chiller, pumps and tower fans are the common application of VFD. A better understanding of Variable Frequency Drives with leads to improve in usage and determining of some appliances and High Voltage AC systems.A basic knowledge of operations, its terms, energy savings,and about the power factorsisma in aimof his dissertation also Harmonics mitigation by VFD and a simulation project to show how VFD is beneficial for energy savings. In addition to this paper will discuss the comparison between Variable Frequency Drives and of the technologies with respect to industrial standards.**

***Keywords*-VFD, Harmonics mitigation, Pulse width modulation (PWM)**

## I.INTRODUCTION

The industry of Variable Frequency Drive is growing rapidly and now it is more important for technician and the maintenance personnel to keep the installation of VFD running smoothly. The Variable Frequency Drive contains sufficient information for a technician to troubleshoot any AC Variable, virtually eliminating the need for manufacturer-specific manuals.

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. VFD control speed of motor by varying output voltage and frequency through sophisticated microprocessor controlled electronics device. VFD consists of Rectifier and inverter units. Rectifier converts AC in DC voltage and inverter converts DC voltage back in AC voltage.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.The main parts of Variable Frequency Drive (VFD) are the converter, inverter and the controller. The converter rectifies the AC input to DC and the inverter converts the DC to an adjustable frequency and adjustable voltage AC signal. Both must be adjustable to provide a constant volt to hertz ratio. A circuit filters the DC before it is sent to the inverter. The controller regulates the output voltage and frequency based upon feed-back signal from process. If the load is a pump, this is usually a pressure sensor.

Voltage source inverters use a silicon controlled rectifier to build a sine wave for input to the motor. The steps used to build waveform create harmonics that are reflected to the power source. The steps of waveform causes current pulse that make the motor cog at low frequencies and damage keyways and couplings may result. Current source inverters use an SCR to control the current to the motor. This is also done with multiple steps and has same problems with cogging and harmonics as the voltage source system. Many vendors only offer the voltage or current source systems for large horse power motors of over 300 HP.

## II. PROPOSED SYSTEM

The most types of adjustable speed loads are variable torque, constant torque and constant horse power loads.

Variable torque load require much lower torque at low speeds than at high speed. In this type of load, the horse power varies approximately as the square of the speed. This type of load is found in centrifugal fans, pumps and blower. One practical use of the VFD now is the household washing machine. For years, industrial washing machine have been employed VFDs on three phase motors. Today, VFD is low enough in cost to be incorporated into the home's washer.

The VFD provides its ability to change the rotational directional of motor. This allows the washing machine to be a front load type, thus using less water in cycle. The VFD allows for over speeding of motor to accomplish this and thus the clothes get much dryer while still in washing machine. This means that the drying time is reduced and saves electric costs overtime.

In contrast to the variable speed control method of mechanical and hydraulic speed drive, the electrical variable speed drives are basically the speed of electric motor itself, rather than a intermediary device controlled. Variable speed drives that control the speed of DC motors are loosely called DC Variable Speed Drives or simply DC Drives and those that control the Speed of AC motors are called AC Variable Speed Drive or simply AC Drives. Almost all the electrical VSDs are designed for operation from the standard three phase AC power system supply system.

## III. HARDWARE DESCRIPTION

The aim of the Power Electronic Drive Controller is to obtain optimum performance from the motor, to obtain the maximum power from it over as wide a speed range as is required, to achieve highest operating efficiency from the motor and to obtain the best dynamic performance possible. In all case it is it is necessary for the motor and the controller to be matched together carefully if overall optimum performance is to be achieved. Hence the starting point of exploration into Variable Frequency Drive must be the motor, how it works, how it develops torque and how to understand it when operating as Variable Speed Drive.

Earlier the Variable Speed Motors have been DC motors and they reigned supreme in this field since electricity has been put to practical use. However there is an increasing area of application where the DC motor is unable to satisfy the performance required or cope with environment specified. In some cases it is the lack of commutator or brush gear which can decide on the use of an AC Motor. In others it is the need for speeds above those achievable with a DC motor in yet other it may be wish to apply a Variable Speed Controller to an existing fixed motor. It may even be the ready availability of an AC motor which is the deciding factor. Whatever the reason may be, the availability of a wide range of Variable Frequency Drive system is leading to a steady increase in the use of AC variable speed motor drives throughout the industry and this trend is clearly going to continue.

## IV. VFD OPERATION

The Variable Frequency Drive comprises the parts - a input Rectifier unit, a inverter unit and a DC bus. 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 a 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.

In a basic DC-link variable frequency motor controller, the input AC power is converted to DC, filtered and then converted to variable frequency DC by an inverter A set of SCR switches are used to convert the DC to three phase AC power to drive induction motor. Bypass diodes are needed for reactive power flow and to clamp the voltage to that of DC supply. The filter supplies a DC voltage to the inverter that is largely independent of load current due to filter capacitor. The inverter tends to keep the current constant. The AC to DC converter output may be fixed or variable (voltage or current) depending on the type of inverter and the filter used.

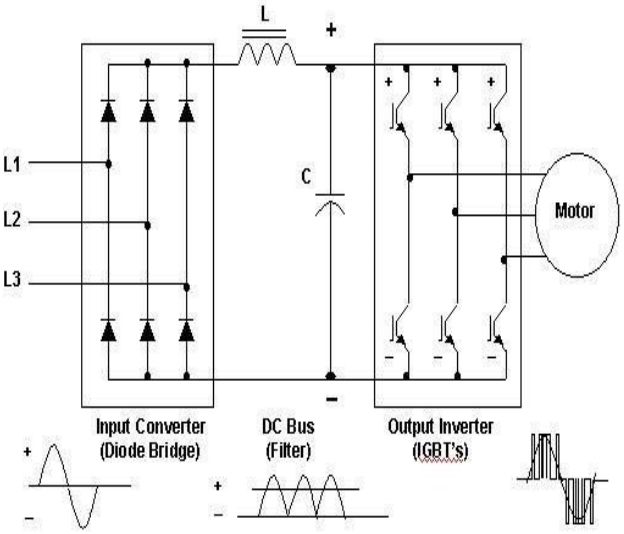


Fig. 1 Basic VFD.

In a square wave inverter, each input is connected alternatively to the positive and negative power supply outputs to give a square wave approximation to an AC waveform at a frequency that is determined by gating of

switches. The voltage in each output line phase shifted by 1200 to provide a three phase source.

Nowadays the Insulated Gate Bipolar Transistor (IGBT) present in inverter which used to switch ON and OFF of the DC bus at specific intervals. Thus a variable AC voltage and frequency is being created by the inverter. The output sine waveform is being shown in figure. The control circuit present in the power circuit is signaling from the drives to turn ON at the positive half cycle or negative half cycle of a power device. This clears that as long as the power device remains ON, the output voltage remains higher. Also for frequency point of view the higher the frequency states for longer the power device ON.

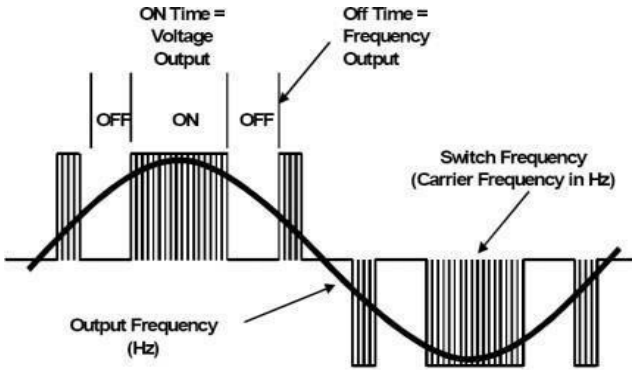


Fig. 2 Drive Output waveform.

Therefore higher the carrier frequency higher the resolution for PWM (Pulse Width Modulation) contains. The typical carrier frequency ranges from 3KHz to 4 KHz or 3000 to 4000 times per second as compared with older SCR based carrier frequency which ranges from 250 to 500 times per second. Thus it is clear as much as higher the carrier frequency higher will be the resolution of output waveform. It is also noted that the carrier frequency decreases the efficiency of the drive because it led to increase the heat of the drive circuit.

Variable Speed Drives (VSDs) take place of a starter. They have both starting capability and overload protection built in. In fact the microprocessor control the most drives provides additional protection against other faults (such as under-voltage, over-voltage, ground fault, loss of phase.

## V. SIMULATION

Converters (VSC) are fed by Pulse Width Modulation (PWM) to the asynchronous machine. Since there is flexible control of torque and speed in DC machines, the same can be obtained by the combination of pulse width modulation technique with new control techniques for example- Field Orientation and Direct Torque Control methods. In this section a simulation of AC drive controlling an asynchronous machine is been described.

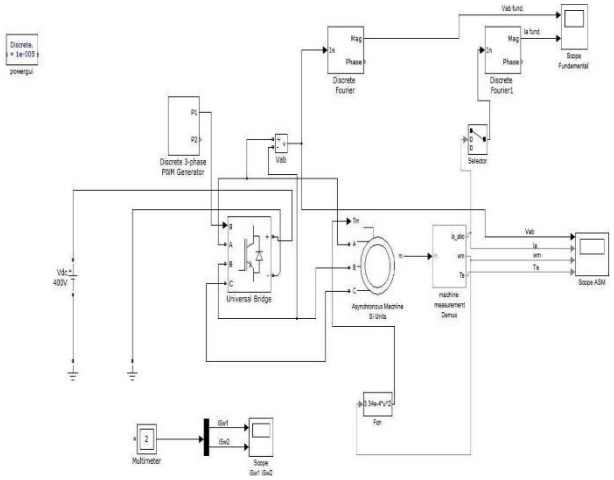

Fig.3 Simulation.

Table 1 Parameters of discrete three phase Pwm generator

| | |
|---|---|
| Type | 2 level |
| Mode of Operation | Un – synchronized |
| Carrier Frequency | 18×60 Hz (1080 Hz) |
| Internal generation of modulating signals | Selected |
| Modulation index m | 0.9 |
| Output voltage frequency | 60 Hz |
| Output voltage phase | 0 degrees |
| Sample time | 10e – 6 s |

Fig. 4 Full Voltage The Result Of Simulation By Pwm Motor Drive.

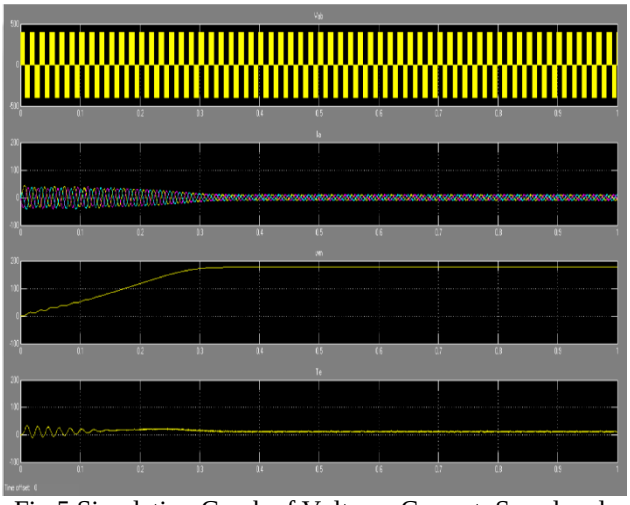

Fig.5 Simulation Graph of Voltage, Current, Speed and Torque of the Asynchronous Motor.

As noticed from switches 1 and 2 the switching current is antonymous to each other. The current flowing through IGBT points the positive current, whereas current through anti parallel diode points the negative current.

It is noted that the use of multi meter is not restrict to the block called universal bridge. The presence of numerous blocks in the libraries of Electrical Source and Measurement has parameter for measurement where we can select voltages, currents or saturable transformer fluxes. The use of multimeter block is also used to reduce current and voltage sensor into the model which makes it easier to follow.

The simulation result of fundamental speed is being calculated from a 4 pole Asynchronous motor of 3 HP and also the analysis of harmonics being calculated by using FFT tool of simulation of maximum frequency 5000 Hz.

## VI. CONCLUSION

After the detailed study of Variable Frequency Drive, it becomes possible to control the speed of electric motor as well as to conserve the electrical energy, as we know that the energy conservation has become an important subject to all over the world. Increase in efficient energy use, decrease in energy consumption and/or consumption from conventional energy sources is reduced that leads to the conservation of energy.

For high performance providing by the Variable Frequency Drive for maximum process productivity always required a complex engineering consideration. However rapid improvements in AC control technology combined with ready availability of standard fixed frequency of AC motor have increased the number of possible solution. With the process of pulse width modulation, the frequency given to the induction motor can be set in order to control the speed of the induction motor. Thus the consumption of electrical energy is depends on the load requirement. However the variation of frequency leads to the harmonics distortion which can be mitigate by several techniques of harmonics mitigation.

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