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Research Article

VARIABLE FREQUENCY DRIVES AND ITS ENERGY SAVINGS

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ABSTRACT

This paper discuss the speed control of ac motors by using variable frequency drives (VFD). The speed of ac motors is a direct function of frequency, since the stator windings are inductive in nature the reactance varies with frequency.
As frequency is increased, winding reactance increases right along with it. This increase in the reactance would result in decrease of stator current if the VFD output voltage remain constant.
The ac voltage output by a VFD is made to vary in proportion to the applied frequency, so that the stator current will remain in the good operating limits throughout the speed range of the VFD.
This correspondence is called the voltage to frequency ratio, abbreviated as " "ratio or " " ratio.

INTRODUCTION

The Motors are being used worldwide in industrial or domestic level. Among all the motors ac induction motors are used most commonly and extensively due to their large number of applications. But there is need to eliminate the speed associated with ac induction motor and to run in very efficient way.

For that matter, many devices are used to control the speed of the motor but the best among all the devices is variable frequency drive (VFD).

There is a direct relation between the speed of the motor and the frequency of the motor. Therefore varying the frequency of ac voltage the motor speed can be adjusted to a desirable value.

$$N = \frac{120\,F}{P} \quad (1)$$

Where N is speed of the motor (RPM)
F is the frequency of motor (Hz)

P is the number of poles.

There is another way of changing the speed of the motor by changing the number of poles but this change would be physical change of the motor which is not feasible. As the frequency can be easily varied as compared to the poles of the motor, therefore speed control derive is termed as the variable frequency drive.

Constant V/F Ratio Operation

VFDs maintain the output voltage to frequency (V/F) ratio constant at all speeds.[1]

$V = 4.44\ \phi_m\ f\ N$ (2)

Or

$V/F = 4.44\ N\ \phi_m$ (3)

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

If the same amount of voltage is applied at the reduced frequency the magnetic flux would increase and saturate the magnetic core, significantly distorting the motors performance The magnetic saturations 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 the speeds flux must be maintained constant at rated value which is basically done by keeping the voltage to frequency (V/F) ratio constant[3].

The variable frequency drives are very important for HVAC system where a large power is consumed before motor reaches at its full speed and a very huge amount of inrush current is being drawn by the motor cause's great loss of energy. This

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starting current can be reduced by making use of variable frequency drives and thus it saves energy up to large extend. There are various applications of VFD in different applications like fans , pumps , tower cooling system, microwaves , air conditioners, ships propulsion system, it has been said that from the energy consumed by the ac motors, 10% goes ideal and 12%-15% is lost. [4]When motor doesn't run at full load so there is great desire off user to reduce this energy wastage and this can be possible only by making use of device like variable frequency drive because its biggest advantage is the energy savings.[8]

The VFD are made by power electronics devices, in that devices it consists the rectifiers , inverters and the third and one of the most important part is microcontroller.

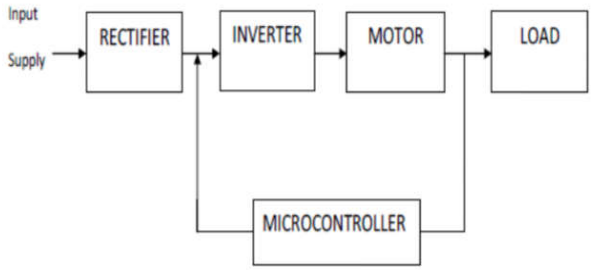

Fig 1.1 Block Diagram Of Vfd

A rectifier is an electronic device which can convert alernatative current into direct current. This ac single phase, 50 Hz supply are converted into dc supply and this rectified supply given to the input of the inverter.[5] The microcontroller required a dc supply that the reasons the rectifier are used. Inverter is an electronic device that convert direct current into alternating current. The inverter does not produces any power, the power is provided by the dc source.

The microcontroller are used for the controlling the speed of an induction motor. The microcontroller regulates the o/p voltage and frequency for controlling the speed of the induction motor.[4]

Working Principle

VFD comprises of three major sections as described below and each section has its key importance

1. First section is the rectifier section
2. Dc bus
3. Inverter section [8]

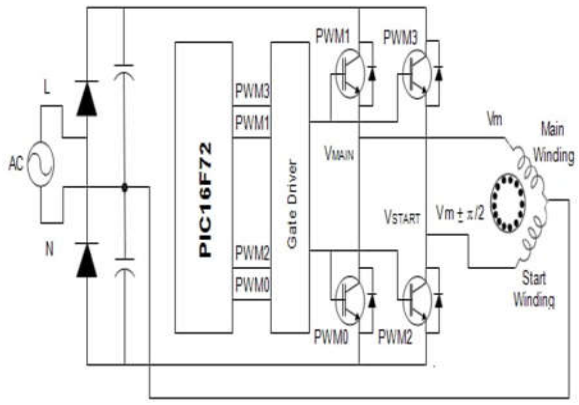

Fig 1.2 Circuit Diagram Of Vfd

Rectifier

This section comprise of diodes transistor or SCR. But usually diode are used because of low cost .ac voltages coming from main line has positive and negative feeds. When these voltages are fed into bridge type configuration of diodes of this rectifier section. The negative peaks are vanished only positive feeds retain.[7]

DC BUS

Dc buses are used to store the voltages coming from ac to dc converter. This consists of capacitors and some other items like inductors in order to smooth the power supply coming from the previous section. This ripple are further removed by storing voltages in this dc bus.[9]

Microcontroller Based Pwm

Pulse width modulation is the basic technique used well widely for controlling motor speed and frequency. This can be done by using microcontroller. In this research we selected the range 12.5 Hz to 50Hz frequency using PWM. The basic principle of PWM is a sine wave which is generated in the microcontroller and further superimposed on a triangular wave. This results in a square wave which is then fed to inverter section the width of this square wave can be controlled by changing the duty cycle of the pulse. [8]

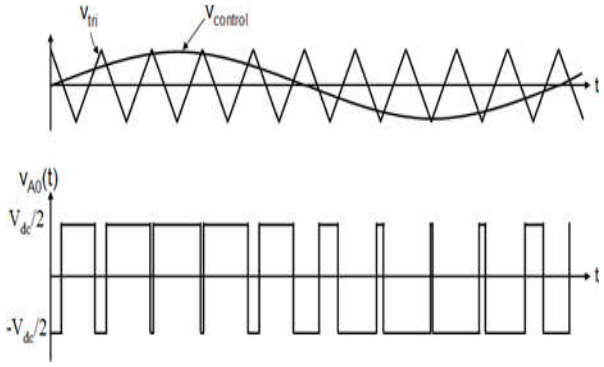

Fig 1.3 pwm representation

Basically duty cycle describes the time for which pulse waveform turned on and off thus by switching the waveform between two discreet levels the square wave is approximated with a sine wave of desired duty cycles[7]7. A PWM representation is shown in figure 1.3.

Advantages

Large energy savings at lower speed, Reduces noise and vibration level, Reduction of thermal and mechanical stress, Increased life of rotating components ,Improved power factor,Reduction in KVA, High efficiency of motor.

Applications

For the purpose of saving energy VFD are generally used in fan, blowers, pumps, conveyors, HVAC application in the 3-phase induction motor.[7]

RESULT

From the above discussion and findings we have deduced some useful results that this drive VFD is very beneficial for industrial and home appliances as it increases the efficiency of electrical equipment and saves great amount of energy. And as

we know that their exist a direct relation between energy and current i.e.

$P=I^2 \times R$

P= Power (watts)
I= Load Current (amperes)
R= Load Resistance (ohms)

So by reducing the current the power will also be reduced.

CONCLUSION

We have seen from the above discussion and results that variable frequency drive is the best solution for fixing inherent motor issues and energy saving can be best tackled by this drive. Other techniques like Soft starter does not prove as much efficient as does variable frequency drive because there are many benefits of variable frequency drive like it provides a control over motor starting and stopping, Likewise it gives versatility to motor action. Over load protection, power reduction when not needed and dynamic torque control are other key features of variable frequency drives. We can suggest that in a country like INDIA this device is of great use because we strongly need energy consumption minimization and for that matter VFD should be used with HVAC systems in industries and house hold appliances. The only drawback associated with this device is cost. It's quite costly and maintenance is also required. But still the importance of variable frequency drive cannot be denied.

Future Scope

By keeping in mind the present form of VFD it seems quite impossible that it will undergo any change in future. But as the technology is making progress rapidly and new researches are being put forwarded by people anything can be predicted. Emerging technologies like FPGA's, advancement in DSP, genetic algorithm, Fuzzy logic, innovative PWM techniques and revolution in power electronics field can lead us to experience any miraculous device. Furthermore VFD's can also be miniaturized using NANO technology. This miniature form of VFD would be very helpful in small device and thus energy saving would be possible in small levels as well.

Proposed Improvement

By designing this device we can now bring a lot of improvements in this drive. Like we can introduce a numeric key pad through which desired value of frequency can be given as input. That's how load will be driven at frequency of our own choice. Furthermore we can remotely monitor the speed and frequency of drive using a GSM module. And start and halt operation of drive can also be controlled from distant place.

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