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Speed Control of Induction Motor by Using Variable Frequency Drive

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ABSTRACT
The variable speed drive is focused on voltage amplitude control. However, its only control speed in constraint limits. The load on Induction Motor is not constant & vary as per load requirement. so speed must be change as per load. If the supply voltage decreased motor torque also decreases, for maintaining same torque, slip decreases hence speed falls and motor speed is directly proportional to supply frequency, hence to maintain a speed, the supply V/F ratio must be vary accordingly. But the speed is not vary proportion to application so it consume the rated power and it becomes economically disadvantages.
To overcome above problem a new concept of Variable Frequency Drive (VFD) is introduced. Adding a Variable Frequency Drive (VFD) to a motor driven system can offer potential energy saving in a system in which the load vary with time. The primary function of VFD in application is to provide energy saving, speed reduction of 20% can save energy upto 50%.
***Keywords* –** Adjustable frequency, inverter, frequency control circuit, single phase induction motor, variable speed drive

I. INTRODUCTION

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 & can not match with the load demand. If load on induction motor decrease, the speed of induction motor can not 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.

Variable Speed Drive (VSD)

This more generic term applies to devices that control the speed of either the motor or the equipment driven by the motor (fan, pump, compressor, etc.). This device can be either electronic or mechanical.

Adjustable Speed Drive (ASD*)*

Again, a more generic term applying to both mechanical and electrical means of controlling speed.

II. METHODOLOGY

The speed of induction motor is directly proportional to the supply frequency and no. of poles of motor. Variable speed drive by using frequency control method is commonly used to control and change the speed of single phase induction motor. It can vary the desired speed by changing the frequency using switching sequence of IGBT. To get low cost, high performance speed control circuit is design.

The block diagram of VFD is as shown in figure

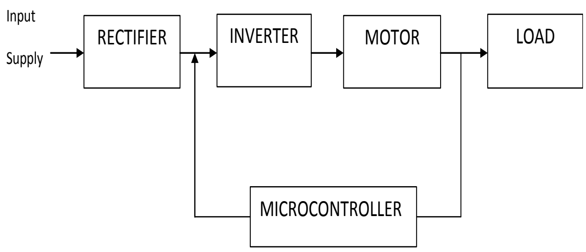

Fig.1. Block diagram of VFD

The VFD includes various following stages of operation:-

1.Rectifier Stage

A full wave bridge rectifier converts single phase or three phase 50 Hz power from standard utility supply to either fixed or adjustable Dc voltage.

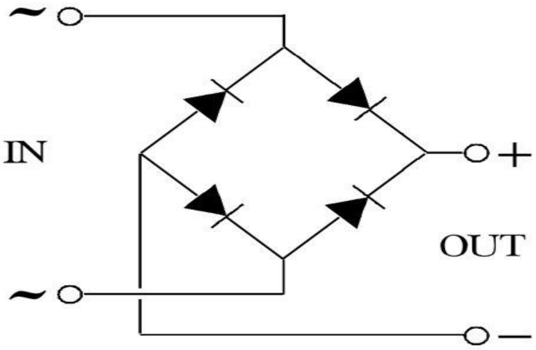

Fig.2. Diode Bridge Rectifier

One diagonal pair of rectifier will allow power to pass through only when the voltage is positive. A second diagonal pair of rectifier will allow power to pass through only when the voltage is negative. So two diagnal pair of rectifiers are required for each phase of power.

2. Inverter stage

Electric swithes-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 final section of the VFD is referred to as an "inverter**.**" 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.

Motor speed (rpm) is dependent upon frequency.

Varying the frequency output of the VFD controls motor speed:

Speed (rpm) = frequency (hertz) x 120 / no. of poles

Example:

2-pole motor at different frequencies
3600 rpm = 60 hertz x 120 / 2 = 3600 rpm
3000 rpm = 50 hertz x 120 / 2 = 3000 rpm
2400 rpm = 40 hertz x 120 / 2 = 2400 rpm

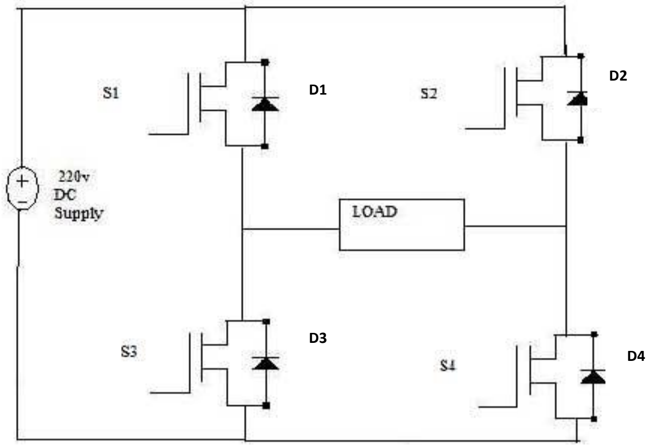

Fig.3.Inverter bridge using IGBT

Fig 3 shows the configuration of H-bridge inverter.
This inverter has four switches and operations of this inverter are;
S1-S3 ON: Both create short circuits across the DC source and are invalid.
S2-S4 ON: Both create short circuits across the DC source and are invalid.
S1-S4 ON: Applies positive voltage (Vs) to the load. The positive current (IL) passes through S1-S4 and the negative current (-IL) is through D1-D4.
S2-S3 ON: Applies negative voltage (-Vs) across the load. The positive current (IL) flows through D2-D3 and returns energy to the DC source. The negative current (-IL) flows through S2-S3 and draws energy from the supply.
S1-S2 ON: Applies zero volts across the load. The positive current's path is S1-S2 and the negative current's path is D1 – S2.
S3 - S4 ON: Applies zero volts across the load. The positive current's path is through D2 - D4 and the negative current's path is S3 - S4.

3.Control stage

An electronic circuit receives a feedback information from the driven motor and adjusts the output voltage or frequency to the selected values. Usually the output voltage is regulated to produce a constant ratio of voltage to frequency (V/Hz). Controllers may incorporate many complex control functions.

Converting DC to variable frequency AC is accomplished using an inverter. Most currently available inverters use pulse width modulation (PWM) because the output current waveform closely approximates a sine wave. Power semiconductors switch DC voltage at high speed, producing a series of short-duration pulses of constant amplitude. Output voltage is varied by changing the width and polarity of the switched pulses. Output frequency is adjusted by changing the switching cycle time by using microcontroller.

III. ADVANTAGES

As VFD usage in HVAC applications has increased, fans, pumps, air handlers, and chillers can benefit from speed control. Variable frequency drives provide the following advantages:

1. Energy savings:

The primary function of VFD is to provide energy saving. The VFD can save the energy upto 50%.

2. Low motor starting current:

At the time of starting the motor start with low frequency so it takes low current at starting therefore VFD can be used as starter.

3. Reduction of thermal and mechanical stresses on motors and belts during starts:

By using VFD the thermal and mechanical stress on motors and belts during starting get reduced hence chances of wear & tear of various part get decreased.

4. Simple installation:

As VFD is single unit and it does not required any concrete construction so its installation is simple.

5. Lower KVA

As VFD has nearly unity power factor it has lower KVA rating.

IV. APPICATIONS

Motor-driven centrifugal pumps, fans and blowers offer the most dramatic energy-saving opportunities. Many of these operate for extended periods at reduced load with flow restricted or throttled. In these centrifugal machines, energy consumption is proportional to the cube of the flow rate. Even small reductions in speed and flow can result in significant energy savings. In these applications, significant energy and cost savings can be achieved by reducing the operating speed when the process flow requirements are lower.

V. CONCLUSION

Hence we concluded that 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. The operating speed of a motor connected to a VFD is varied by changing the frequency of the motor supply voltage. This allows continuous process speed control.

Motor-driven systems are often designed to handle peak loads that have a safety factor. This often leads to energy inefficiency in systems that operate for extended periods at reduced load. The ability to adjust motor speed enables closer matching of motor output to load and often results in energy savings.

VFD can be used for the number of applications of Induction motor and speed can get control as per load requirement so energy consumption get reduced hence VFD becomes very reliable and economically beneficial.

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