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RESEARCH ARTICLE

SPEED CONTROL USING CLOSED LOOP VARIABLE FREQUENCY DRIVE

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ABSTRACT

There are various starting methods to start induction motors among them variable frequency System has more advantages. For controlling the speed of the induction motor we are using pwm technique based on current signature techniques as a feedback of closed loop system. For a all control methods rely on the pwm voltage waveform to control the motor. The difference between control methods lies in how they calculate the motors voltage needs at any given moment. Among these methods we are doing v/f control because it has advantages over all other methods. Hence we are controlling the speed of the motor by using variable frequency system.

INTRODUCTION

Machine is a versatile electric machine which uses in various field like its use to generate power at the generating stations, for constant speed, power factor correction, variable speed applications etc. Power factor control of induction machine is done by controlling D.C field excitation of it. The speed of operation is in synchronism with the supply frequency and hence for constant supply frequency they behave as constant speed motor irrespective of load condition. This is given by Ns=120f/p. Thus we are varying the frequency and thereby controlling the speed and making this motor suitable for variable speed applications. Here we are also monitoring the temperature to overlook the cumulative heat load of VFDs because this heat could have serious ramifications in terms of drive tripping, poor control and plant outages caused by high temperature.

Effect of load variation

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

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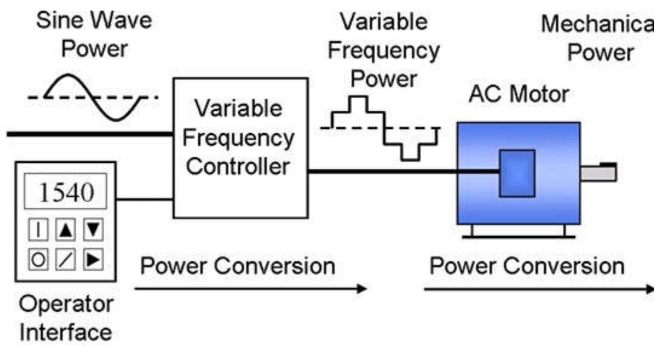
Variable frequency drive (VFD) usage has increased dramatically in industrial applications. This device uses power electronics to vary the frequency of input power to the motor, thereby controlling motor speed. This more generic term applies to devices that control the speed of either the motor or the equipment driven by the motor (fan, pump, compressor, etc.). This device can be either electronic or mechanical.

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



Abbreviations and Acronyms

VFDs are known as variable frequency drives.PWM which is abbreviated as pulse width modulation is used to trigger the H bridge inverter.

Units

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

Equations

Torque equation of the induction motor is given by;

$$T_e = 3(p/2)(R_r/s\omega_e)\frac{V_s^2}{(R_s + \frac{R_r}{s})^2+\omega_e^2(L_{ls}+L_{lr})^2}$$

Here we have p=no. of poles; R_r=rotor resistance measured in ohms; R_S=Stator resistance measured in ohms; V_S=Supply voltage.

Supply voltage of induction motor is given by;

$V=4.44*f*\Phi*T_{ph}*k_w$;

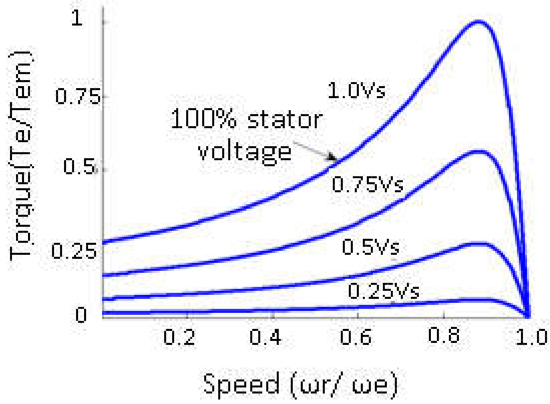
Here f is frequency in hertz, T_{ph}=turns per phase; k_W=winding constant.

Proposed System

The speed of Induction motor can be varied by varying the slip 'S' or number of poles 'p' or frequency of supply. The different methods of speed control of induction motor can be broadly classified in to scalar and vector control methods. In this work, scalar control methods are used. Hence only details of scalar methods are discussed here. The explanation of vector control method is beyond the scope of this thesis. The scalar methods of speed control can be classified as

Stator voltage control method

A very simple and economical method of speed control is to vary the stator voltage at constant supply frequency. The three-phase stator voltage at line frequency can be controlled by controlling the switches in the inverter. As seen from the equation (3.10) the developed torque is proportional to the square of the stator supply voltage and a reduction in stator voltage will produce a reduction in speed. Therefore, continuous speed control may be obtained by adjustment of the stator voltage without any alteration in the stator frequency. The salient features of stator voltage control method are: For low-slip motor, the speed range is very low. Not suitable for constant-torque load. Poor power factor. Used mainly in low power applications, such as fans, blowers, centrifugal pumps, etc.



Frequency control method

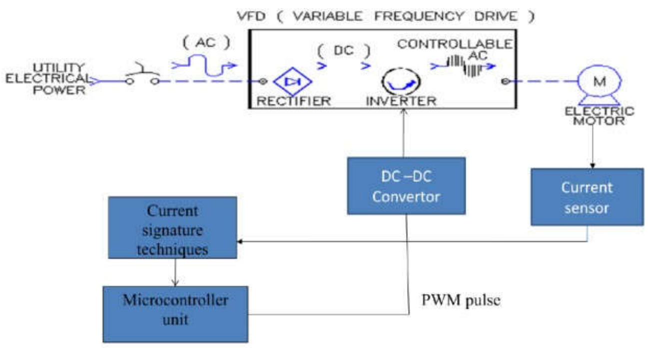
The torque and speed of induction motors can be controlled by changing the supply frequency but keeping the voltage constant. If the frequency is decreased keeping voltage constant, then saturation of air-gap flux takes place. At low frequency, the reactance will decrease and the motor current may be too high. If the frequency is increased above its rated value, then the air gap flux and rotor current decreases correspondingly, the developed torque also decreases. Due to these reasons this method of control is rarely used. The torque speed characteristics with frequency control.

Volts Hertz (V/F) control method:

The constant V/F control method is the most popular method of Scalar control. If an attempt is made to reduce the supply frequency at the rated supply voltage, the air gap flux Ψm will tend to saturate, causing excessive stator current and distortion of flux wave. Therefore, the region below the base or rated frequency should be accompanied by the proportional reduction of stator voltage so as to maintain the air gap flux constant. If the ratio of voltage to frequencyis kept constant, the flux remains constant. By varying the voltage and frequency the torque and speed can be varied. The torque is normally maintained constant while the speed is varied. This arrangement is widely used in the locomotives and industrial applications.

The purpose of the volts hertz control scheme is to maintain the air- gap flux of AC Induction motor constant in order to achieve higher run-time efficiency. The magnitude of stator flux is proportional to the ratio of stator voltage & the frequency. If ratio is kept constant the stator flux remains constant & motor torque will only depends upon slip frequency. In variablefrequency, variable-voltage operation of a drive system, the machine usually has low slip characteristics (i.e low rotor resistance), giving high efficiency. In spite of the low inherent starting torque for base frequency operation, the machine can always be started at maximum torque as indicated in Fig 3.8.The absence of high in-rush starting current in a direct- start drive reduces stress and therefore improves the effective life of the machine. By far the majority of variable-speed ac drives operate with a variable-frequency, variable-voltage power supply. Fig 3.8 shows the torque-speed characteristics [3] of the machine with constant V/F control method. Other than the variation in speed, the torque-speed characteristics of the V/F control reveal the following: The starting current is low.

The stable operating region of the motor is increased. Instead of simply running at its base/ rated speed (NB), the motor can be run typically from 5% of the induction speed (NS) up to the base speed. The torque generated by the motor can be kept constant throughout this region.



SPEED CONTROL OF MOTORS BY USING CLOSED LOOP VFD:

In our proposd system we are using a current sensor to measure the input current and giving that to the current signature techniques .And this current signature based upon the current value it gives signals to the microcontroller thereby controlling the input voltage to the motor by varying the frequency using PWM pulse technique. This gives a controllable ac. Thereby controlling the speed of the motor. Thereby it provides more advantages that it does not needs manual operation of vfds to control the speed of the motor its done by automatic by using this current signature techniques as a feedback for this closed loop vfd system.In our proposd system we are using a current sensor to measure the input current and giving that to the current signature techniques.

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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.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.

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

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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. 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 feed back 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 pulsewidth 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.

Conclusion

Hence we conclude 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 But the only drawback is overall cost of variable frequency induction motor drives are higher. Thus this offers more advantages way of speed control compared to others as its automatic .But the only drawback is that the efficiency of the inverter is wassted in one form as heat.sometimes this heat could have serious ramifications like tripping ,plant outages etc. A solution to cool this temperature has to be discussed in future.

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