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Three Phase AC MOTOR Speed Controller by Using variable Frequency Controlling Technique

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ABSTRACT—An induction motor can run only at its rated speed when it is connected directly to the main supply. However, many applications need variable speed operations. This is felt the most in applications where input power is directly proportional to the cube of motor speed. The motor user can replace an energy inefficient mechanical motor drive and control system with a Variable Frequency Drive (VFD). The VFD not only controls the motor speed, but can improve the motor's dynamic and steady state characteristics as well. In addition, the VFD can reduce the systems average energy consumption. Although various induction motor control techniques are in practice today, the most popular control technique is by generating variable frequency supply, which has constant voltage to frequency ratio. This technique is popularly known as VF control. Generally used for open-loop systems, VF control caters to a large number of applications where the basic need is to vary the motor speed and control the motor efficiently. It is also simple to implement and cost effective. The PIC18F452 series of microcontrollers have three on-chip hardware PWM modules, making them suitable for 3-phase motor control applications. This report explains how these microcontrollers can be used for 3-phase AC induction motor control.

Keywords—VFD Technique, PIC microcontroller; IGBT Drivers.

I.INTRODUCTION

An induction motor can run only at its rated speed when it is connected directly to the main supply. However, many applications need variable speed operations. This is felt the most in applications where input power is directly proportional to the cube of motor speed. The motor user can replace an energy inefficient mechanical motor drive and control system with a VariableFrequency Drive (VFD). The motor's dynamic and steady state characteristics as well. In addition, the VFD can reduce the systems average energy consumption. Although various induction motor control techniques are in practice today, the most popular control technique is by generating variable frequency supply, which has constant voltage to frequency ratio. This technique is popularly known as VF control. Generally used for open-loop systems, VF control caters to a large number of applications where the basic need is to vary the motor speed and control the motor efficiently. It is also simple to implement and cost effective. The PIC18F452 series of microcontrollers have three on-chip hardware PWM modules, making them suitable for 3-phase motor control applications. This report explains how these microcontrollers can be used for 3-phase AC induction motor control

II.LITERATURE SURVEY

Frequent problem in IM speed at rated value at base speed also an overload To operate the IM at desire speed for some industrial applications we required method which is suitable and provides ease of handling. As the project name -V/F speed controlling technique for 3-phase AC motor -indicates that it will control the speed of three phases AC IM and will control the acceleration and deceleration of motor

Acceleration and deceleration: It will control the acceleration and deceleration of themotor by controlling the change of the supply frequency to the motor with respect to time.

By increasing frequency: It will drive the motor beyond the base speed as at basespeed, the voltage and frequency reach the rated values. The starting current requirement is lower .It will increase the

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stable operating region of the motor. Includes the history of AC motor speed controlling technology ,the most significant aspect of the AC motor speed controlling technology. It clearly gives us the idea of the level of
gives the brief idea of the previous work carried out by different others providing the depth of exploration of AC motor speed controller.deals with design point of target i.e. the propose system designing. It includes controlling circuit design and power circuit design for 3-phase AC power supply.gives the final conclusion and application of the report and it predicts the future scope of whole investigation VFD not only controls the motor speed, but can improve theabstraction of the designing of AC motor speed controller

III.EXISTING SYSTEM

SPEED CONTROL TECHNIQUES

Stator Voltage Control In this method the stator frequency is maintained constantand only the stator voltage is varied the speed in IM Thus the speed control the stator supply voltage V1 is reduced from V1(rated value) to bV1 where b<1.

Controlling the Number of Poles we know that the synchronous speed is given by, Ns **= 120** so it is possible to change the synchronous speed by changing the number of poles.

Change in Stator Resistance This control basically the voltage control because whenwe change the rheostat connected in the stator circuit, a part of supply voltage will drop across the rheostat. As rheostat is reduced, towards the run position the stator voltage is increased and the speed also increased.

Using External Rotor Resistance In this method as the value of critical slips Smcorresponding to the maximum torque increases with increase in the value of rotor resistance. So the motor speed changes from N1 to N2 where N2 < N1, thus speed decreases with increase in the rotor resistance.

V/F Control The proposed system overcomes all these disadvantages of conventionalmethods used to control the IM speed. It gives smooth control of speed for 3- phase AC IM. The overall block diagram of the power and control circuit for the motor control demo board. The main single phase supply is rectified by using a diode bridge rectifier. The ripple on the DC bus is filtered by using an electrolytic capacitor. The filtered DC bus is connected to the IGBT-based 3-phase inverter, which is controlled by the PIC18F452. The inverter output is a 3-phase, variable frequency supply with a constant voltage-to-frequency ratio. A potentiometer connected to AN1 sets the motor frequency. Push button keys are interfaced for issuing commands, like Run/Stop and Fwd/Rev, to the microcontroller. Acceleration and deceleration features are implemented to change the motor frequency smoothly. Times for both of these features are user selectable and can be set during compile time. LEDs are Provided for Status/Fault indications like Run/Stop, Forward/Reverse,Undervoltage, Overvoltage, etc. The PWM outputs are generated by on-chip hardware modules on the PIC18F452. These are used to drive the IGBT drivers through opto isolators. Each IGBT driver, in turn, generates complementary signals for driving the upper or lower halves of the 3-phase inverter. It also adds a dead time of 540 ns between the respective higher and lower switch driving signals. The IGBT driver has a shutdown signal (SD) which is controlled by an over current protection circuit. The driver also has its own on-chip fault monitoring circuit for driver power supply under voltage conditions. Upon any overcurrent or under voltage event, the outputs are driven low and remain low until the time the Fault condition is removed.

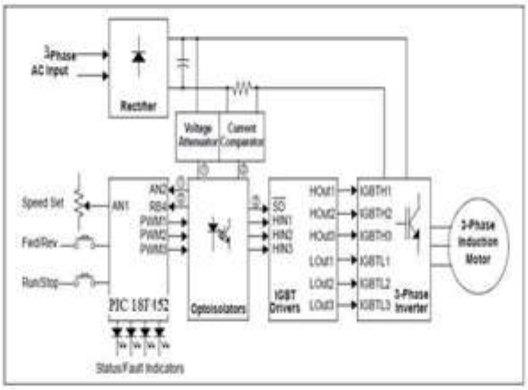

Fig-1 Block diagram of Proposed System

SYSTEM DESIGN

Over Current Protection A non-inductive resistor is connected between the common source point of the inverter and the power ground. Voltage drop across this resistor is linearly proportional to the current flowing through the motor. This voltage drop is compared against the reference voltage signal, through an opto isolator (linear opto coupler), which represents overcurrent limit. There are three possible ways to compare these voltage signals:

- Using an external comparator
- Using the PIC18F452 on-chip comparator
- In software, by reading the voltage drop across the resistor through one of the ADC channels

The design discussed in this application note implements an external comparator. It's output drives the shutdown signal of the driver through an opto isolator (opto coupler). At the same time, this signal is provided to RB4. By using the PORTB interrupt-on-change feature, the microcontroller responds to Fault detection and stops the motor. Overvoltage and Under

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voltage Protection To implement voltage protection, the DC bus voltage is attenuated by a potential divider. The resulting signal is fed to AN2 through an opto isolator (linear opto coupler). The application monitors the voltage via periodic A/D conversions of the value on RA2; if the voltage falls outside of a preset range, the motor is stopped.

Motor Drive

The 3-phase induction motor is connected to a 3-phase inverter bridge as shown in Figure 3.The power inverter has 6 switches that are controlled in order to generate 3-phase AC output from the DC bus. PWM signals, generated from the microcontroller, control these 6 switches. Switches IGBTH1 through IGBTH3, which are connected to DC+, are called upper switches. Switches IGBTL1 through IGBTL3, connected to DC are called lower switches. The amplitude of phase voltage is determined by the duty cycle of the PWM signals. While the motor is running, three out of six switches will be on at any given time; either one upper and two lower switches or one lower and two upper switches. The switching produces a rectangular shaped output waveform that is rich in harmonics. The inductive nature of the motors stator windings filters this supplied current to produce a 3-phase sine wave with negligible harmonics. When switches are turned off, the inductive nature of the windings oppose any sudden change in direction of flow of the current until all of the energy stored in the windings is dissipated. To facilitate this, fast recovery diodes are provided across each switch. These diodes are known as freewheeling diodes. To prevent the DC bus supply from being shorted, the upper and lower switches of the same half bridge should not be switched on at the same time. A dead time is given between switching off one switch and switching on the other. This ensures that both switches are not conductive at the same time as each one change states.

Control

Members of the PIC18F452 family of microcontrollers have three 10-bit PWMs implemented in hardware. The duty cycle of each PWM can be varied individually to generate a 3-phase AC waveform as shown in figure 4. The upper eight bits of the PWM"s duty cycle is set using the register CCPRxL, while the lower two bits are set in bits 4 and 5 of the CCPxCON register.

The PWM frequency is set using the Timer2 Period register. Because all of the PWMs use Timer2 as their time base for setting the switching frequency and duty cycle, all will have the same switching frequency. To derive a varying 3-phase AC voltage from the DC bus, the PWM outputs are required to control the six switches of the power inverter. This is done by connecting.

The PWM outputs to three IGBT drivers (IR2109). Each driver takes one PWM signal as input and produces two PWM outputs, one being complementary to the other. These two signals are used to drive one half bridge of the inverter: one to the upper switch, the other to the lower switch. The driver also adds a fixed dead time between the two PWM signals.

Phase Sine Waveform Synthesis

Along with the three PWM modules, the 16-bit Timer1 hardware module of PIC18F452 is used to generate the control signals to the 3-phase inverter. This is done by using a sine table, stored in the program memory with the application code and transferred to the data memory upon initialization. Loading the table this way minimizes access time during the run time of the motor. Three registers are used as the offset to the table. Each of these registers will point to one of the values in the table, such that they will always have a 120-degree phase shift relative to each other. This forms three sine waves with 120 degrees phase shift to each other.

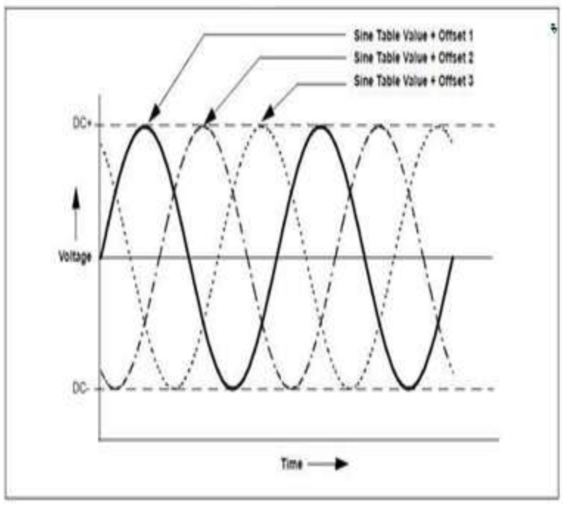

Fig-2 Synthesis of 3-Phase Sine Waveform from a Sine Table

A potentiometer connected to a 10-bit ADC channel (AN1) determines the motor frequency. The microcontroller uses the ADC results to calculate the PWM duty cycle and thus, the frequency and the amplitude of the supply to the motor. For smooth frequency transitions, the channel AN1 is converted at every 4ms. The Timer1 reload value is based on the ADC result (AN1), the main clock frequency (FOSC) and the number of sine table entries (36 in the present application).After every Timer1 overflow, the value pointed to by the offset register on the sine table is read. The value read from the sine table is scaled based on the motor frequency input. The sine table value is multiplied with the frequency input to find the PWM duty cycle and is loaded to the corresponding PWM duty cycle register. Subsequently, the offset registers are updated for next access. If the motor direction key is pressed, then PWM1, PWM2 and PWM3 duty cycle val5ues are loaded to PWM2, PWM1 and PWM3 duty cycle registers, respectively. The new PWM duty cycle values will take effect at the next Timer2 overflow. Also, the duty cycle will remain the same until the next Timer1 overflow occurs, as shown in Figure 5. The frequency of the new PWM duty cycle update determines the motor frequency, while the value loaded in the duty cycle register determines the amplitude of the motor supply.

V/F Control Firmware While the PIC18F452 microcontroller makes 3-phase motor control possible, it is the firmware that makes VF control straightforward. In addition to maintaining the sine table and driving the PWM modules to produce the AC output (previously described in the "3-Phase Sine Waveform Synthesis" section), the firmware interprets control inputs and system status to sense and act on Fault conditions. It also manages other features of motor control, such as direction, acceleration and deceleration (as described below). The VF control firmware uses a set of defined routines and parameters for operation. Users can change these parameters as needed for their applications. The firmware can also be incorporated as the motor control core of a larger application, using the parameters to pass information between sections of the code. An overview of the firmware‟s logic flow is provided in Figure 7 and Figure 8. A complete list of parameters and defined functions is provided in Tables 1 through 4. Users are encouraged to download the complete source code of the firmware from the Microchip web site (www.microchip.com) and examine the application in more detail.

IV.CONCLUSION

1. In Case of Squirrel cage induction motor the slip cannot be increase above certain limit, the operating speed range is very less. By applying the V/F control we can get the large operating range by keeping V/F ratio constant.
2. VF control provides a simple and cost efficient method for open-loop speed control of 3-phase induction motors. A lowcost VF solution can be implemented using the PIC18F452 family of devices. With three dedicated PWM modules implemented in hardware, it is ideal for controlling 3-phase induction motors. Additional on-chip resources, like multiple timers and ADC, allow users to easily implement safety and control features, such as current and voltage protection and configurable acceleration and deceleration time.

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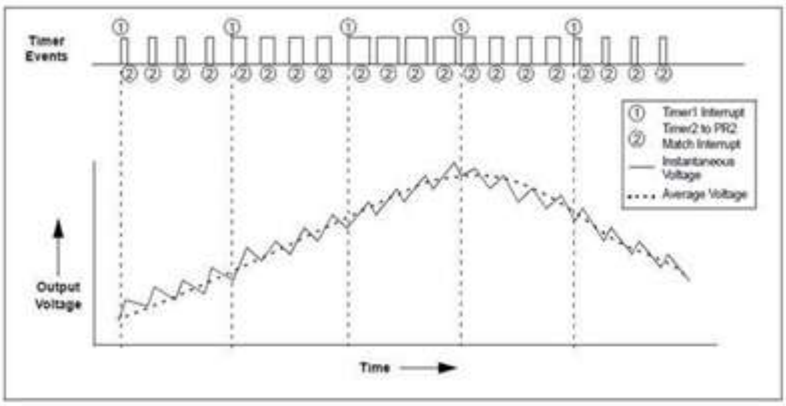

Fig-3 Timer1 Overflow ,PWM Duty Cycle and Output voltage