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ABSTRACT

This paper presents a design and implementation of single phase AC Drive to drive and speed control of an 1-phase induction motor using the PIC 16F72 Microcontroller. The use of this PIC microcontroller yields enhanced operations, fewer system components, lower system cost and increased efficiency. The control algorithm is based on the constant volts-per-hertz principle because the exact speed control is needed. Reflective object sensors which are mounted on concrete frame are used to detect accurate edge position of revolving stage. The PWM control signals are generated by the PIC16F72 controller to drive the IGBT based single phase AC Drive.

The power section in this includes rectifier (converter) and filter which provide dc output with less distortion from single phase ac input supply. Then the main stage comes is inverter where by controlling the firing of power devices(e.g. IGBT) by pulse width modulation produced by the PIC controller using the control algorithm based on the constant volts-per-hertz principle, the motor is rotated with the load maintaining the volt-hertz ratio constant.[9]

KEYWORDS

PWM,1-Phase Induction Motor, VSI ,IGBT Driver.

I.INTRODUCTION

Any collection of mechanical and electro-mechanical components, which when connected together will move a load, as a “drive”. When speaking to these people, an AC drive may be considered by them as the variable frequency inverter and motor combination.

People in the electrical field and electrical suppliers usually refer to a variable frequency inverter unit alone, or an SCR power module alone (when discussing DC drives) as the “drive” and the motor as the “motor”.

To preserve the environment and to reduce green-house effect gas emissions, governments around the world are introducing regulations requiring white goods manufacturers and industrial factories to produce more energy efficient appliances. Most often, this goal can be reached by an efficient drive and control of the motor speed.[1] This is the reason why appliance designers and semiconductor suppliers are now interested by the design of low-cost and energy-efficient variable speed drives. Because of their high robustness, reliability, low cost and high efficiency ( 80%), AC induction motors are used in many industrial applications . However, induction motors can only run at their rated speed when they are connected to the main power supply. This is the reason why variable frequency drives are needed to vary the rotor speed of an induction motor. The most popular algorithm for the control of an induction motor is the V/f control approach using a natural pulse-width modulation (PWM) technique to drive a voltage-source inverter (VSI). The aim of this application note is to show how these techniques can be easily implemented on a PIC based variable frequency drive dedicated to power control applications.[2] The requirements of electrical drive systems increases by the request of more performance, higher integration, easier to program and lower cost.[9]

II.SYSTEM DEVELOPEMENT

The basic circuit diagram of the PIC controlled single phase inverter is shown in Figure 1.

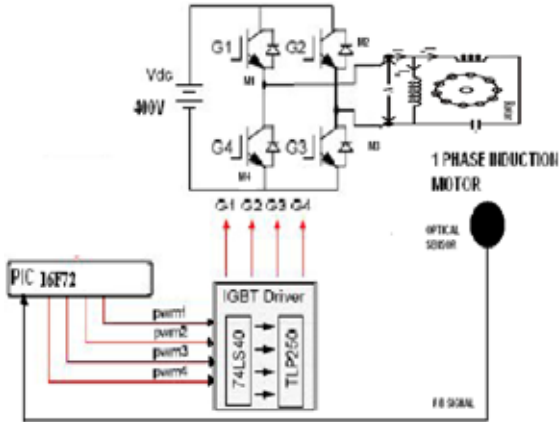


Figure 1. PIC controlled single-phase PWM inverter

Hardware setup procedure can be divided into two sections: the control and power circuit. Electrical isolation between control circuit and power circuit is provided by the optically coupled devices.

CONTROL CIRCUIT DESIGN

The control circuit section is composed of three parts namely PC, PIC board and IGBT driver. PIC 16F72 is programmed to produce gate pulses. The reference wave amplitude adjusts the amplitude of the generated AC voltage and the Reference wave frequency determines the frequency of the generated AC voltage.[8]

1MBH50D-060 coded IGBTs are used in PWM inverter circuit. IGBTs are voltage controlled devices and it requires a minimum gate threshold voltage of about 12-V for establishing the rated collector-to-emitter conduction.[9]

This requirement makes it difficult to directly interface an IGBT to PIC. For proper operation of IGBTs, correct power levels are required ( $V_{ge(th)}=15\text{ V}$  and  $I_c= 50\text{ mA}$ ). Voltage and current

levels of DSP output signals fail to operate the IGBTs. IGBT driver circuit amplifies PIC output signal to the required level for triggering the IGBTs and isolates the DSP from the power circuit.[4] TLP250 ICs are commonly used driver ICs for IGBTs. However, PIC output signals does not have enough current level to activate the TLP250. 74LS40 NAND gate IC is used to amplify the current value of signals from PIC at a gain of 50/2. [5]

In the buffer circuit (74LS40) if two inverter gates are connected back to back, the two inversion functions would "cancel" each other out so that there would be no inversion from input to final output. DSP output signals

are now ready to activate TLP250. TLP250 consists of a light emitting diode and an integrated photo detector. The output waveform will have the same waveform as the input waveform except the magnitude and power.

### POWER CIRCUIT DESIGN

The power circuit section is composed of four parts namely full bridge inverter circuit, DC power supply, LC filter and load(induction motor). PWM inverters include semiconductor

devices with nonlinear characteristics and can generate dominant harmonics in the system. The waveform quality of the sensitive load is improved by putting an LC filter at the output of the PWM inverter. In order to design an LC filter, there are many methods available. Optimum performance can be obtained by using [6] in simulation and experimental studies. A rule of thumb in control theory is that the frequencies of such a configuration have to have at least a factor of 10 between them to decouple

the effects. According to this rule, for 50-Hz fundamental frequency, resonance frequency has to be at least 500-Hz, pulse frequency of the inverter output has to be at least 5000-Hz. Resonance frequency is determined by the product of L and C.[9]

### III.PERFORMANCE ANALYSIS

Principle of speed control The inverter unit controls the speed of a single-phase induction motor by changing the frequency,  $f$ , of the voltage applied to the motor. The inverter changes the frequency,  $f$ , by changing the ON/OFF cycle of the six switching elements, and the rotational speed (N) of the motor changes in proportion to the expression in formula (1).

$$N = 120 \cdot f \cdot (1-s) / P \dots \dots \dots (1)$$

N: Rotational speed [r/min]

F: Frequency [Hz]

P: Number of poles of a motor

S: Slip

In addition, to make the voltage applied to the winding have a sine-wave shape, the inverter controls the ON/OFF duty cycle. The ON/OFF time is controlled so that the average voltage applied to the motor becomes a sine-wave shape by comparing the triangular wave called a carrier signal with the sine-wave shaped signal waveform generates PWM signals.[9]

The generated torque T of the motor is shown by the formula (2). From this relation, it can be said that the torque will also be constant by making  $V/f$ , the ratio of voltage V to frequency f, constant.

$$T = K \cdot I \cdot V / f \dots \dots (2)$$

☒ Torque [N•m]

Power supply voltage [V]

Motor current [A]

Frequency [Hz]

Constant

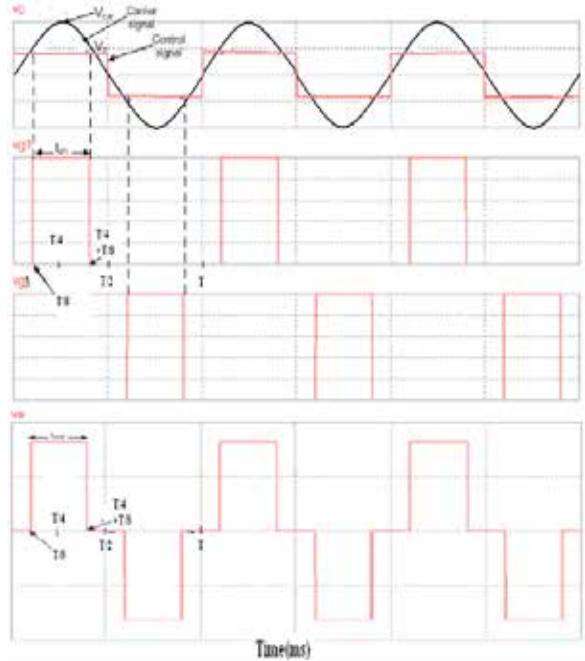


Figure 2.Sinusoidal-Pulse-Width-Modulation (SPWM)

In sinusoidal pulse width modulation there are multiple pulses per half-cycle and the width of the each pulse is varied with respect to the sine wave magnitude. Figure 3. shows the gating signals and output voltage of SPWM with unipolar switching. In this scheme, the switches in the two legs of the full-bridge inverter are not switched simultaneously, as in the bi-polar scheme. In this unipolar scheme the legs A and B of the full-bridge inverter are controlled separately by comparing control square wave  $v_{car}$  with carrier sinusoidal signal  $v_c$  and  $-v_c$  respectively. This SPWM is generally used in industrial applications. The number of pulses per half-cycle depends upon the ratio of the frequency of modulating signal to the carrier sinusoidal signal. The frequency of control signal or the modulating signal sets the inverter output frequency ( $f_o$ ) and the peak magnitude of control signal controls the modulation index  $m_a$  which in turn controls the rms output voltage. The area of each pulse corresponds approximately to the area under the sine wave between the adjacent midpoints of off periods on the gating signals. If  $t_{on}$  is the width of  $n$ th pulse, the rms output voltage can be determined by Modulation index ( $m$ ). The inverter output voltage is determined in the following:

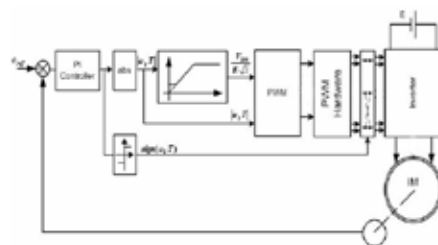
When  $V_{carrier} > V_{control}$ ,  $V = V_{dc}/2$  (1)

When  $V_{carrier} < V_{control}$ ,  $V = -V_{dc}/2$  (2)

**Also, the inverter output voltage has the following features:**

- PWM frequency is the same as the frequency of  $V_{control}$
- Amplitude is controlled by the peak value of  $V_{carrier}$
- Fundamental frequency is controlled by the frequency of  $V_{carrier}$

### Close Loop Speed Control



### Figure 3. Block-diagram of a V/F Speed Control Loop System

This principle can be used to build a speed control loop in which the difference between the desired speed and the measured speed feeds a PI controller that determines the stator voltage frequency. To decrease the complexity of the controller, the input of the V/f law and of the space vector PWM algorithm is the absolute value of the stator voltage frequency. If the output of the PI controller is a negative number, two of the switching variables driving the power transistors of the inverter are interchanged. It should be noticed that the control principle described here can only be used in applications where the speed is kept constant whatever the load torque. Applications where the load torque must be kept constant whatever the motor speed require stator current measurements and more sophisticated control principles.

### IV.CONCLUSION

The idea behind this project is to develop an accurate, reliable, inexpensive and user friendly system which will provide an speed control of single phase load (single phase induction motor) using low-cost microcontroller so that the expenses toward the electricity and manpower can be minimized and more efficient data analysis can be made possible. This can be achieved while maintaining simplicity, ease of use, ease of implementation and ease of maintenance.

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