VVVF Techniques for Speed Control of Induction Motor

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Abstract—The main aim of this paper is to implement a Microcontroller Based Variable Frequency Power Inverter. Variable frequency can be generated by using this Inverter. AC voltage to control the speed of the induction motor. Speed control of induction motor is an improvement of all other techniques introduced before. When connected to single-phase main power supply, induction motors run at their rated speed, however there are many applications where variable speed operations are required. The operation of the circuit is controlled by using a microcontroller AT89S52. Generating variable frequency supply is a popular control technique. Although a range of induction motor control techniques are available, having a constant voltage to frequency ratio in order to attain constant (maximum) torque throughout the operating period. This control technique is known as variable frequency control. This paper emphasizes on the development of a general purpose universal board that is capable of controlling the speed of single or three phase induction motor with minor software and hardware modifications. The complete system consists of the control, driver and the power circuits. The power supply circuit and the microcontroller includes in control system. The full-bridge single-phase Pulse Width Modulation inverter includes in the power circuit. Simulation was completed using MATLAB Simulink software. The system was tested, implemented and the experimental results are examined and discussed.

Keywords—phase Inverter, LCD, Micro Controller (80s52).

I. INTRODUCTION

The fact of increase in losses cannot be neglected. But the advantages of ac machines conquer the disadvantages of ac machine. When specifying induction motors being cheaper in cost due to the absence of brushes, commutators and slip rings makes it advantageous for industrial and domestic use. They do not require more maintenance and also they are independent of the environment. The absence of brushes gives no spark. Hence it provides easy operation without causing harm to the humans. There are a lot of advantages of AC machines on DC machines. Now when talking about induction motors, the principle on which it runs is the Electro-Magnetic Induction. There are basically 2 types of induction motor – Single phase induction motor and three phase induction motor. Induction motors are three phase machines where the synchronous speed of the stator revolving flux (Ns) is given by,

\[ N_s = \frac{120f}{P} \]

Where f is the supply frequency in Hz and P is the number of poles. when the number of poles is not variable, varying the supply frequency would result in the variation in speed of the induction motor. The variation of the voltage should be in proportion to frequency, so that the torque developed is constant over the speed range. This is in particular what variable frequency (V/f) control attempts to accomplish. Below shows fig. 1 the per-phase equivalent circuit of an induction motor referred to stator side.

![Fig 1. Per-phase equivalent circuit referred to Stator side](image-url)

Where,

R1 = Stator resistance per phase in Ω
X1 = Stator leakage reactance per phase in Ω
I1 = Stator current per phase in A
Re = Shunt branch resistance in Ω
Xm = Magnetizing reactance in Ω
Ie = Per-phase no-load current in A
I2 = Rotor current per phase in A
I2' = Rotor Current per phase referred to stator in A
X2' = Standstill rotor reactance per phase referred to stator in Ω
r2' = rotor resistance per phase referred to stator in Ω
V1 = Stator voltage per phase in V
E1 = Stator induced emf per phase in V
To maintain the motor flux, the \((E/1/f1)\) ratio has to be kept constant. This paper presents the development of an efficient and versatile universal board which is used to control the speed of single or three phase machines with very minor modifications in software and hardware. It can be used in many different applications like stepper motor control. Many other variable frequency drive circuits have been proposed by several authors, but none of them turned out to be user friendly. The AT89C52 microcontroller is used, which unlike a manual controller, is able to store all the commands to generate the necessary waveforms to control the frequency of the inverter through proper design of switching pulses.

The PWM method which has been implemented these days have more drawbacks compared to the other methods. They are:

- Heating of the motor resulting in breakdown of the insulation. This is due to the transistor switching at high frequency.
- Non-regenerative operation
- Production of harmonics

Hence the PWM method has not been implemented as the drawbacks do not justify for the economical method of controlling the speed of the induction motor. Hence the safest method of controlling the speed of induction motor is the V/F method which is simple without any complexity. Hence the proposed method is compilation of V/F method and the advancement in new technology.

The variable frequency inverters are used in wide applications especially three phase induction motor drive traction and it is popular in many high power industrial applications, such as speed and torque control. Single phase induction motor (SPIM), which has a common using in residential applications, domestic such as dishwashers, clothes dryers, fans, pumps, etc.

The block diagram of proposed system i.e fig. 2 shows the speed control of induction motor using universal controller. The system includes Microcontroller-AT89S52, speed sensor, a single-phase inverter, IGBT, Transmitter, Two LCD screens and one Keypad. The input and the power flow from each of the component used are mentioned in the block diagram. This block diagram clearly specifies as from where to where and how the system works.

The microcontroller provides the variable frequency pulse width modulation (PWM) signal that controls the applied voltage on the gate drive, which provides the required PWM frequency with fewer harmonic at the output of the power inverter. Single phase variable frequency inverter consists of full bridge diode rectifier is fed from 230Vac power supply; the rectifier bridge is used to convert the AC supply voltage to a DC voltage. The output voltage of the rectifier bridge is smoothed using a capacitor which helps to remove its ripples. Then the fixed DC voltage is fed to the single bridge IGBT inverter, which receives the DC voltage and converts it to AC voltage with variable frequency to feed the motor under control.

The microcontroller has been programmed to vary the frequency of the PWM signal that controls the frequency of the voltage applied at the gate drives, and as a result of this we can control the frequency of the inverter.

### III. METHODOLOGY

**Micro controller:** This section forms the control unit of the whole project. This section basically consists of a Microcontroller with its associated circuitry like Crystal...
with capacitors. Reset circuitry and Pull up resistors (if needed) and so on. The Microcontroller forms the heart of the project because it controls the devices being interfaced and communicates with the devices according to the program being written.

**89S52**: The microcontroller 89S52 with Pull up resistors at Port0, Port1, Port2 and Port3 and crystal oscillator of 11.0592 MHz crystal in conjunction with couple of capacitors of is placed at 18th & 19th pins of 89S52 to make it work (execute) properly.

**Liquid-crystal display (LCD)** is a flat panel display, electronic visual display that uses the light modulation properties of liquid crystals. Liquid crystals do not emit light directly. LCDs are available to display arbitrary images or fixed images which can be displayed or hidden, such as preset words as well as digits and 7-segment displays as in a digital clock.

**EEPROM**: EEPROM (also written E²PROM and pronounced e-e-prom or simply e-squared), which stands for Electrically Erasable Programmable Read-Only Memory, is a type of non-volatile memory used in computers and other electronic devices to store small amounts of data that must be saved when power is removed, e.g., calibration tables or device configuration. When larger amounts of more static data are to be stored (such as in USB flash drives) other memory types like flash memory are more economical. E²PROMs are realized as arrays of Floating-gate transistors. In 1983, Greek American George Perlegos at Intel developed the Intel 2816, which was built on earlier EPROM technology, but used a thin gate oxide layer so that the chip could erase its own bits without requiring a UV source. Perlegos and others later left Intel to form Seeq Technology, which used on-device charge pumps to supply the high voltages necessary for programming E²PROMs.

**IGBT**: The Insulated Gate Bipolar Transistor (IGBT) is a minority-carrier device with high input impedance and large bipolar current-carrying capability. Many designers view IGBT as a device with MOS input characteristics and bipolar output characteristics that is a voltage-controlled bipolar device. To make use of the advantages of both Power MOSFET, BJT and the IGBT has been introduced. It is a functional integration of Power MOSFET as well as BJT devices in monolithic form. It combines the best attribute of both to achieve optimal device characteristics.

**IGBT driver IC**: The IR2110/IR2113 are high voltage, high speed power MOSFET and IGBT drivers with independent high and low side referenced output channels. Proprietary HVIC as well as latch immune CMOS technologies enable ruggedized monolithic construction. Logic inputs are compatible with standard LSTTL or CMOS output, down to 3.3V logic. The output drivers feature a high pulse current buffer stage designed for the minimum driver cross-conduction. Propagation delays are matched to simplify use in a high frequency applications. The floating channel can be used to drive an IGBT or N-channel power MOSFET in the high side configuration which operates up to 500 or 600 volts.

**INDUCTION MOTOR**: AC induction motors are the most common motors used in industrial motion control systems as well as in main powered home appliances. Simple and rugged design, low-maintenance, low cost and direct connection to an AC power source are the main advantages of AC induction motors. Various types of AC induction motors are available in the market. Different motors are suitable for the different applications. Although AC induction motors are easier to design than DC motors, the speed as well as the torque control in various types of AC induction motors require a greater understanding of the design and the characteristics of these motors. This application note discusses the basics of an AC induction motor; the different types and their characteristics, the selection criteria for different applications.

**IV. CONCLUSION**

This paper presents a versatile variable frequency drive system to vary the supply voltage and frequency to the stator of the Induction Motor and control its speed efficiently. This universal board can hence be used for...
different kinds of laboratory applications and can also help in enhancing the learning of different courses such as Electrical Energy Systems and Electromechanical system. This is a low cost system and can be used efficiently for the speed control of the induction motor by building up an application. This reduces time consumption and hence proves to be a next level technology.

REFERENCES


