# Implementation of V/F Controlled Induction Motor Drive using Digital Signal Processor

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*Abstract*--- This paper presents the high processing speed and the control accuracy of the DSP which allows sophisticated control technique to be used to build the circuit. The control circuit designed is realized on a digital signal processor TMS320LF2812 based on voltage/frequency (v/f). Which is specially designed to have an accurate control on the three phase induction motor. The controller in the circuit consists of faster generation of the voltage and frequency inputs of sine wave in PWM. The inner sine generation using the voltage and frequency components, the speed control of a three phase induction motor can be handled accurately and a smoother control can be obtained. The experimental results for the speed (v/f) control of the three phase induction motor drive controlled by a digital signal processor 2812 chip has been observed with the effectiveness of the proposed scheme.

## I. INTRODUCTION

Induction motors are the most main powered common motors used in industrial Motion control systems, as well as in home appliances. Simple and rugged design, Low-cost, low maintenance 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 different applications. The main problem with AC motor is the controlling of AC motor is more complex than DC motor. But in the last two decades, with the evolution of power semiconductor devices and power electronic converters, the Induction Motor (IM) is also well established in the controlled-speed area. [1]

High performance Digital Signal processor (DSP) introduction makes complicated control algorithms, such as flux vector control available and flexible, which means that Alternating Current (AC) motors can be applied to accurate motor speed control as DC motor. Meanwhile, an AC induction motor, compared with a DC motor, is relatively inexpensive, since the windings consist of metal bars which are cast into steel laminations that make up the remainder of the rotor and the stator windings can easily be inserted in slots in stator laminations. An asynchronous motor, at least the cage variety, has no brushes, no moving parts other than the rotor, and virtually no maintenance. As a result, AC motors are progressively replacing DC machines in variable-speed applications. [1]

## II. MOTOR MODEL

Asynchronous motors are based on induction. The least expensive and most widely spread induction motor is the squirrel cage motor. The wires along the rotor axis are connected by a metal ring at the ends resulting in a short circuit. There is no current supply needed from outside the rotor to create a magnetic field in the rotor. This is the reason why this motor is so robust and inexpensive. The stator phases create a magnetic field in the air gap rotating at the speed of the stator frequency (We). The changing field induces a current in the cage wires which then results in the formation of a second magnetic field around the rotor wires. As a consequence of the forces created by these two fields, the rotor starts rotating in the direction of the stator field but at a slower speed (Wr). If the rotor revolved at the same frequency as the stator then the rotor field would be in phase with the stator field and no induction would be possible. The difference between the stator and rotor frequency is called slip frequency (Slip = We -Wr). [2]

## III. CIRCUIT DIAGRAM

For obtaining variable speed/voltage control of induction motors, various DC-AC converters (inverters) are used to drive the motors. Here the IGBT (Insulated Gate Bipolar Transistor) Module shown in fig has the three diode bridge rectifier with capacitors which gives the rectified DC voltage to IGBT. The function of the inverter is to change a DC input voltage to a symmetric AC output of desired magnitude and frequency. A typical three phase inverter is shown in the figure below. A balanced set of sinusoidal voltages are fed as input to the inverter to obtain a constant rectified DC voltage, which is again smoothed through the DC link capacitor(s). The semiconductor switches are eventually driven by the smoothed DC voltage. The output voltage may be fixed or variable at a fixed or variable frequency. Variable voltage can be obtained by varying the gain of the inverter, which is usually done by using Pulse Width Modulation (PWM) control within the inverter A typical voltage source converter performs the voltage and frequency conversion in two stages: ac to dc as a first stage and dc to ac for the second stage. Although the three phase six-step inverter offers simple control and low switching loss, lower order harmonics are relatively high resulting in high distortion of the current wave (unless significant filtering is performed). On the other hand, PWM inverter offers less harmonic contents than six-step inverter. The basic three-phase voltage-source converter is shown in Fig. 1

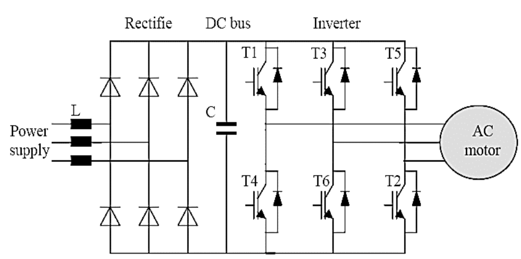


Fig. 1: IGBT Based Three Phase Inverter Fed by 3 PWM

Circuitries for detecting over current rise in temperature are also built-in. Such modules are called intelligent Power Module. [3]

The most common principle of this kind ,is the constant v/Hz principle which require s that the magnitude and frequency of the voltage applied to the stator of a motor maintain a constant ratio.by doing this the magnitude field in the stator field is kept constant level through the operating range. Thus, (maximum) constant torque production capability is maintained. When transient response is critical switching power converters also allows easy control of transient voltage and current applied to the motor to achieve faster dynamic response from motor theory

$$E_x = cf_x \phi_x$$

Where

$E_x = E_s$, $\phi_x$ Is stator flux, f is synchronous frequency in order to keep the $\phi_m$ constant. The ratio $\frac{E_x}{f_x}$ should remain constant. Assume that voltage applied to three phase AC induction motor is sinusoidal and neglect the motor drop across the stator resistor. Then we have $v_1 = E_m$ from which it is follows that if the ratio v/f remains constant with the change off, and then $\phi_m$ remains constant too and the torque is independent of the supply Frequency. In actual implementation, the ratio between the magnitude and frequency of the stator voltage is usually based on the rated values of these variables, or motor ratings. However, when the frequency and hence also the voltage are low, the voltage drop across the stator resistance cannot be neglected and must be compensated. At frequencies higher than the rated value. The constant V/Hz principle also have to be violated because, to avoid insulation break down, the stator voltage must not exceed its rated value. [4]. which shown in Fig 2.

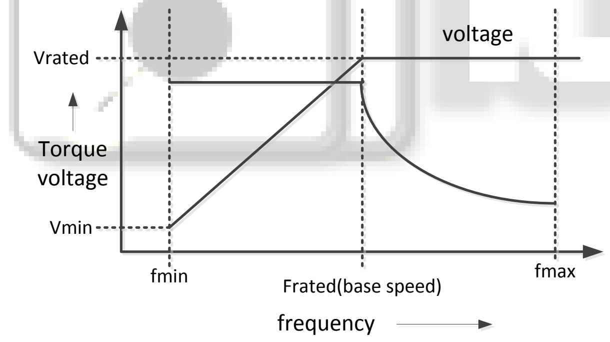


Fig. 2: Speed-Torque Characteristics with V/*F* Control

Open-loop speed control is used when accuracy in Speed response is not a concern such as in'HVAC (heating, ventilation and air conditioning), fan or blower applications. In this case, the supply frequency is determined based on the desired speed and the assumption that the motor' will roughly follow its synchronous speed. The error in speed resulted from slip of the motor is considered acceptable. When accuracy in speed response is a concern, closed-loop speed control can be implemented with the constant V/Hz principle through regulation of slip speed, where a modern controller such as PID, is employed to regulate the slip speed of the motor to keep the motor speed at its set value.[4]

A Digital Signal Processor (DSP) approach implementation of advanced motor drive systems requires the following features from a typical motor controller. Capability of generating multiple high frequency, high-resolution PWM waveforms, fast processing to implement advanced algorithms to minimize torque ripple, on line parameter adaptation, precise speed control etc. Implementing multiple features using the same controller (motor control, power factor correction, communication, etc.), making the complete implementation as simple as possible (reduced component count, simple board layout and manufacturing etc.), Implementing a flexible solution so that future modification can be realized by changing software instead of redesigning a separate hardware platform. A new class of DSP processors has addressed these issues effectively. These controllers provide the computational capability of a DSP core and integrate useful peripherals on chip to reduce the total chip size. The DSP family processor is becoming a best option for motor controlling purpose. [3]

To generate the c code for v/f strategy we use follow the process as shown figure. first develop the Matlab simulation and with help of CCS studio we generate c code. .c file convert into .out file with help of CCS and .out file to .ASCII file and load these file on DSP 2812 with help of VI DSP CODE COMPOSER..

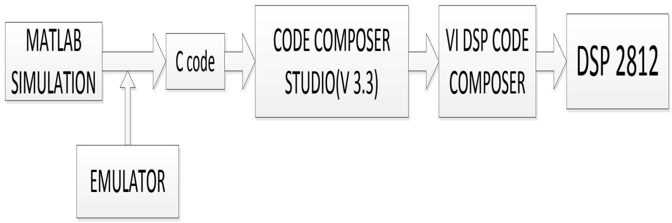


Fig. 3: file conversion process

PWM is widely used in power electronics to "digitalize" the power so that a sequence of voltage pulses can be generated by the on and off of the power transistors. The fundamental component has variable magnitude and variable frequency. [6] Pulse Width Modulation technique is used to generate the required voltage or current to feed the motor or phase signals.. Generally, the PWM schemes generate the switching position patterns by comparing three-phase sinusoidal waveforms with a triangular carrier. The sinusoidal pulse-width modulation (SPWM) technique produces a sinusoidal waveform by filtering an output pulse waveform with varying width. A high switching frequency leads to a better filtered sinusoidal output waveform. The desired output voltage is achieved by varying the frequency and amplitude of a reference or modulating voltage. The variations in the amplitude and frequency of the reference voltage change the pulse-width patterns of the output voltage but keep the sinusoidal modulation. here as shown in fig 4.

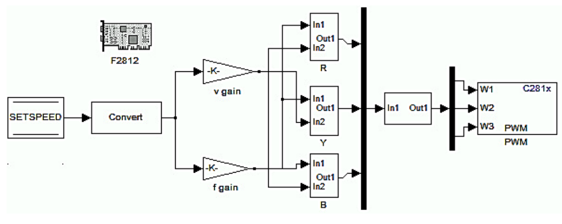


Fig. 4: Matlab simulation.

We choose the gain in that manner so v/f ratio maintain constant in operating range. According to speed multiply with gain a change in magnitude of voltage and frequency of 3 phase sine wave and these sine wave compare with the triangular wave and generate the PWM pattern.

The speed sensor has most common ways to sense motor speed on the shaft is the use of the enhanced quadrature encoder pulse (eQEP) module is used for direct interface with a linear or rotary incremental encoder to get position, direction, and speed information from a rotating machine for use in a high-performance motion and position-control system. Sensor generate a number of pulses per rotor revolution. According to that pulse speed will be displayed on LCD display.[3]

## IV. Experiment Setup And Software Design

### *A. Hardware*

(1) DSP TMS320LF2812

(2) INDUCTION MOTOR

(3) IPM based IGBT power module.

(4) QEP sensor card

(5) DSO

(6) Host PC

(7) Eddy current dynamometer as Load

Induction Motor Parameter

| PARAMETER | RATING |
|---|---|
| No. of pole | 4 |
| NO. of phase | 3 |
| Voltage | 415 (star) |
| Supply frequency | 50 Hz |
| HP rating | 0.75 kw |
| Current rating | 1.8A |
| Rated speed | 1415 rpm |

### *B. Connection Procedure*

- Connect the 34 pin cable from the MICRO - 2812 to power module (IPM) along with the QEP or proximity signal conditioning card.
- Connect the 26 pin cable from the MICRO - 2812 to power module (IPM).
- Connect the feedback cable between motor and QEP or proximity signal conditioning card.
- Connect the serial port from the PC to 9 - pin termination of the DSP trainer.
- Connect the motor terminals R, Y, B to the U, V, and W terminals in IPM Power Module.

### *C. Experimental Procedure*

- Verify the connections as per the connection procedure and Wiring Diagram.
- Switch ON the MICRO - 2812 DSP trainer kit.
- Power ON the IPM (PEC16DSM01) and MCB.
- Check whether shut down LED "SD" glows or not. If 'SD' LED glows, press the Reset switch, the LED gets OFF.
- Download the program to the MICRO - 2812 Kit by following the downloading procedure.
- Verify the PWM waveform and QEP sensor output which are terminated in the power module.
- After ensuring all the connection, apply the input voltage to the IPM power module (DC Rail voltage (600V), which is shown in the power module voltmeter).
- Now the motor starts to rotate in the set speed.
- By using the switches increment(S2) and decrement(S3) set the speed of the motor
- The actual speed of the motor will be displayed in the LCD and PC.
- To measure the load current of the motor, externally connect one AC ammeter in series with any one phase.

### *D. Experimental Results*

For the experimental research of control schemes,

Where experimental motor is induction motor Stator winding is star connection. We used DSO to measure voltage and current of motor, and take result into display and check the PWM waveform. The waveform measured is shown in the Fig 8. The experimental results show this Control scheme has goodness in performance, higher Control precision, rapid dynamic response and also it has wide range of applications. The results are shown fig 9.and connection of whole experiment setup shown in fig 10

Open loop v/f control

The open loop speed control (v/f) of the Induction

Operating condition.

| TIME (SECOND) | SPEED(RPM) |
|---|---|
| 0 | 300 |
| 21 | 600 |
| 41 | 900 |
| 61 | 1200 |
| 81 | 1000 |

*Results of experiment setup*

| SET SPEED | MOTOR SPEED | V | F | V/F |
|---|---|---|---|---|
| 300 | 288 | 42 | 9.90 | 4.24 |
| 600 | 593 | 84 | 19.80 | 4.24 |
| 900 | 991 | 126 | 27.00 | 4.24 |
| 1200 | 1193 | 168 | 39.60 | 4.24 |

Simulation results

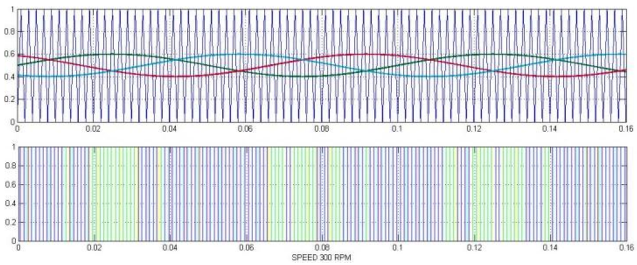


Fig. 5: PWM waveform 300 RPM

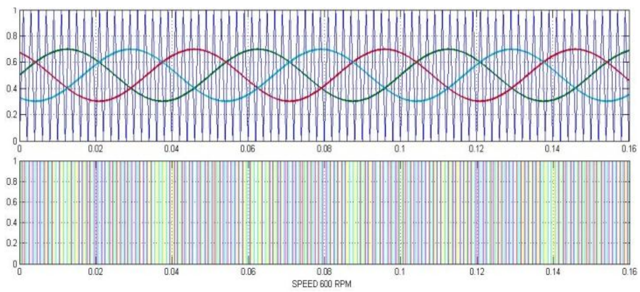


Fig. 6: PWM waveform 600 RPM

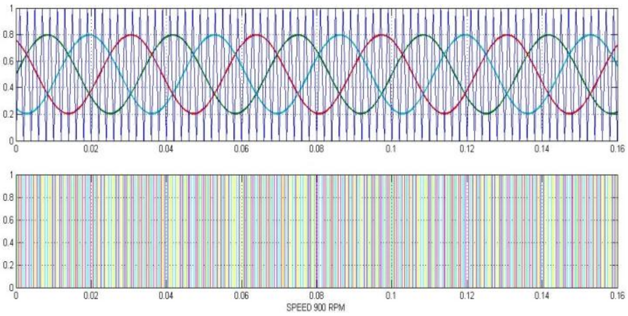


Fig. 7: PWM waveform 900 RPM

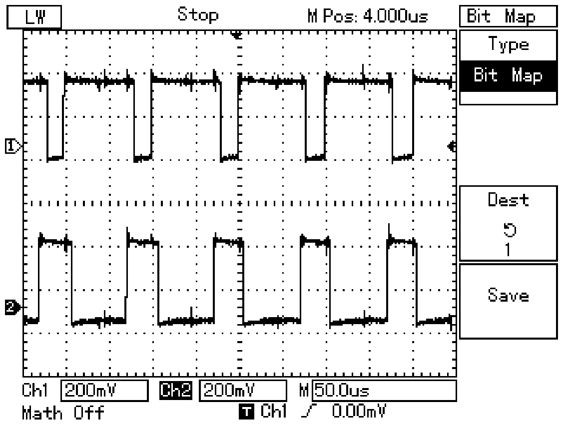


Fig. 8: PWM wave of IGBT 2 & 5

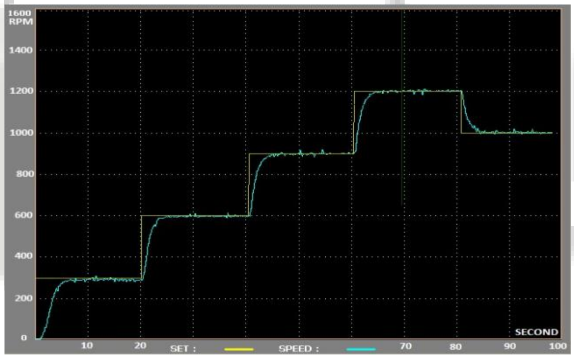


Fig. 9: Result of experiment

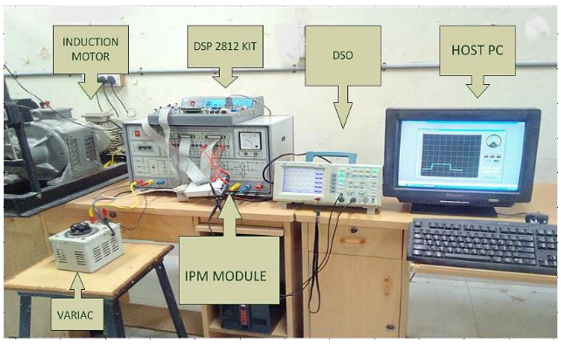


Fig. 10: Experimental setup

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