ARPN Journal of Engineering and Applied Sciences

www.arpnjournals.com

EXPERIMENTAL STUDY FOR ENHANCEMENT THE THREE-PHASE INDUCTION MOTOR USING MICROPROCESSOR TMS320F

Khalid G. Mohammed
Department of Electrical Power and Machine Engineering, University of Diyala, College of Engineering, Baquba, Diyala Province, Iraq
E-Mail: khalid_alkaisee@engineering.uodiyala.edu.iq

ABSTRACT

This paper offers applicable method to control the AC three-phase induction motor squirrel-cage by using the microprocessor TMS320F (manufactured by Texas Instrument, USA). This new version of Digital Signal Processing (DSP) controllers permits project of smart controllers for AC and DC electric motors which can yield improved task, a smaller amount system device, lesser system price and bigger effectiveness. Most of the controls methods on the inverter-fed AC induction motor derive with different schemes are classified into two main methods: scalar and vector methods. The V/f method is considered as scalar method while the Direct Torque Control (DTC) and Field Oriented Control (FOC) methods are presented under the vector methods. The different mentioned methods are also developed to subdivide into more specified methods such as direct and indirect FOC, speed sensor and speed sensor less FOC. In addition, DTC contains two techniques: Direct Self–Control (DSC) and Space Vector Modulation (SVC). All these methods share in their work mainly by using the software algorithm full speed verification of F28335 code which is created by using directly microprocessor such as TMS320F indirect by microcontroller (micro-computer as example). This present study introduces the design and implementation of high performance microprocessor TMS320F controller for operating three-phase induction motor via DC to AC inverter-fed. The inverter used is consisted of three arms- two levels of IGBs type G4PC50UD. The Pulse Modulation Unit is fabricated in the laboratory using eight ICs type SN74LS14N, 14 pins and six ICs type A3120, eight pins. The tests have been conducted in University of Diyala, College of Engineering, AC machine Laboratory which complemented with the expected results.

Keywords: inverter DC to AC; DSP controller; three-phase induction motor.

1. INTRODUCTION

There is a well-known fact that, the induction motor occupies 90 percent in the industrial factories, irrigation pumps, electric vehicles and railways trucks, wind turbines, home appliances and workshops of the whole kinds of electric motors [1] and [2] due to its features.

In spite of the great induction motor features, its problem is nonlinearity performance at staring and steady state operation with variable loads [3]. That means for example, when the electric control board is operating by classical control board i.e. using STAR/DELAT (Y/Δ) electric board. The (Y/Δ) electric board contains three contactors: the first is still connection to the first-three terminals of the motor while the third contactor making Y connection on the second-three terminal of the 3PIM. By using a suitable timer device, which converts the contactor Δ is connected to the second -three terminal of the 3PIM instead of contactor Y which becomes off. That was a brief description to the staring process of the 3PIM by using classical control board. At the staring with loading, the problem statement of the induction motor is being more complicated, the 3PIM draws normally high current may be two to three folds of its full load rated current without loading [4], while when the motor is loaded, the staring current folds 3 to 8 times of the rated current. If the specifications and precautions of the three contactors were not convince, the starting current may be damaged the contactors and the windings of the motor. The high starting current means additional costs for purchasing higher rating electric control board components [5] and [6] than the required control board.

After seventeenth of last century, the rapid development has been in the power electronic and advanced electronic devices as THYRISTOR, MOSFET and MICROPROCESSOR [7]. Many models of microprocessors were manufactured by Intel company as: MP4004 which was small size, low speed, memory, 4 bits/word, 45 instructions. Round 1970, MP8008 is appeared to be 8-bit data bus, 48 instructions but the speed rate, size of the memory and word capacity were still small. In 1973, MP8008 was developed to MP8080 to be faster 10 times, memory size become 64K and address bus had 16 lines. After four years, MP8085 was pronounced to have 246 instructions, high rate frequency, internal clock and system controller and the distinguish feature was decrease its cost. The next generations of MP: 8086, 8088, 8089, 80286.80388,80486 has been developed. In the nineteenth decade, MP Pentium models was dominated: size memory is 64 K, data speed rate is 66 MHz and more. The present DSP320 microcontroller has been developed through the current decade by Texas Instrument to be used widely in the industrial and academic applications. It is considered as a best select for an inserted AC induction motor application. The DSP micro family has many strategies and selections for the inserted designer to select. Furthermore, pin well-matched devices are presented in the DSP320FXXX and DSP320CXXX device family, which does it possible to use either scheme in the same hardware design. This provides the designer an easy journey track depending on the topographies and performance required in the application. In specific, this induction motor has been applied on the DSP320F device to support the three-phase induction motor application.

With a considerate of the induction motor utilities, it is possible to start with the design revealed here and implements the induction motor application based on the DSP micro device that uniforms what are needs.

The DSP microprocessor adjustments meets many purposes in the AC induction machine applications, such as: user control interface, measurement of motor location, computation of motion outline and calculation of error signal and PID compensation.

In the present paper, three-phase AC induction motor squirrel-cage has been operated using DC to AC inverter, three-arm, six switches IGBTs. The inverter six switches have been controlled by DSP controller type TMS320F which was programmed by assembly language.

2. SOFTWARE DESIGN

Generally, the software developed for the closed loop speed, voltage and current control system of AC induction motor, consists of the following routines [8]:

- Main program
- Speed counting subprogram
- Frequency correction subprogram
- Duty cycle calculations subprogram
- Compensation subprogram
- Interruption program

Important instructions and basic steps for installing the main software F28335eZdsp / CCStudio V3.3 which is set up by TEXAS INSTRUMENT

a) Install the first and second programs and then instruct RESTART.
b) Connect the USB computer with the DSP using the RS-232 cable.
c) Place a copy of the tidcs folder into the folder my project in CCStudio program.
d) A message arrives with options and definitions. After that select CONNECT.
e) Run the program from the cube mark F28335eZdsp / CCStudio V3.3
Note: Running the program in point 5 is only after connecting the DSP with the USB and turning on the connected voltage converter where a signal will appear on the program showing that the connection is correct or not.

f) Use DEBUG and choose CONNECT to make sure the DSP connection is achieved to the program software.
g) For the purpose of downloading the required code from the program to the DSP, the sequence of commands should be implemented: OPEN -DEBUG-SOURCE (double click to open the library) -the required code is appeared-RE BUILD all-
h) Go back to DEBUG again and do the following

DEBUG –RESET CPU (click)
DEBUG again-RESTART (click)
DEBUG again ---GO MAIN (click)
Now the code is uploaded to the chip

i) To see the output pulses, use the ENIMATE command in the left column.
j) Stopping the code can be done by using HALT command.

A. Main program

The main program (speed control program) is written first. The initialization segments of the program are to set the interrupt mask, ports control word, starting frequency and voltage, and the value of the desired speed. Input value of the desired speed can be loaded to the microcomputer by storing it in a specific memory location or by counting the date presented at the input port. This data is supplied from a variable frequency pulse generator. As the motor start running, the actual speed is measured by the speed counting subprogram, compared with desired speed, and then it is adjusted to the correct value.

B. Speed counting subprogram

The determination of the angular velocity (involves the measurement of angular rotation in a given interval) is achieved by counting the number of pulses transmitted by the shaft encoder (speed sensor) type E40S, Autonics Company. This program has been designed to sample and to measure the frequency of the signal from the shaft encoder during the measurement of speed, the input signal is checked every 20 microseconds in TMS320F.

C. Frequency correction subprogram

The data for a desired speed is sent from a specific memory location to the first register, while the data for the actual speed (measured by speed counting subprogram) is transferred from a specific memory location to the second register. The subprogram compares the actual speed with the desired speed (reference speed), so there are three conditions: if the desired speed equals to the actual speed, the delay (this number is selected as a 0.2 of the actual speed) represents 1/6 of the cycle (stored in pair register) will not change, while if the desired speed is larger than the actual speed the delay will be increased to correct the error in the speed and vis verse. Then the delay value is stored in a fixed memory location.

D. Duty cycle subprogram

The purpose of the Modulation technique is to transfer the information signals. It is known that the analog signals use continuous physical variables such as voltage amplitude or frequency variations to transmit information. In the electric machine derives analogue signal such as voltage, current or speed which is produced by specified sensors. Generally, in pulse modulation, any

ISSN 1819-6608
ARPN Journal of Engineering and Applied Sciences

www.arpnjournals.com

analog signal coming from sensor is sampled and then transmitted in the form of series pulses.

There are three types of pulse modulation: Pulse Amplitude Modulation (PAM), Pulse Width Modulation (PWM) and Pulse Position Modulation (PPM). The PAM is a modulation technique in which the signal is sampled at regular intervals, and each sample is made proportional to the amplitude of the signal at the instant of sampling [9].

The PWM is a term used to describe the use of a digital signal to generate an analog output signal. This signal is usually used to control the average carrying capacity such as motor speed control circuits. It can also be used to always produce symmetric output without using any other incorporated circuits by filtering or softening the PWM signal using a capacitor. In addition to providing extra costs, chips and interfaces, the pulse-assisted signal does not occur by drift over time because it is generated from a time base using a processor. The use of analog circuits to produce precise signals does not happen by conflicting a very tough task so the waveform alteration is measured a very effective and economy solution. The pulse width modification works by varying the average voltage level and this is done by creating a constant frequency signal but by presenting a variable pulse or by adapting it. The digital signal has a maximum value of 5V at the high logical state and its value is 0V when in low logical state. To produce a 2.5V signal then it is required ON to signal half the time and OFF for the second half and then take the average.

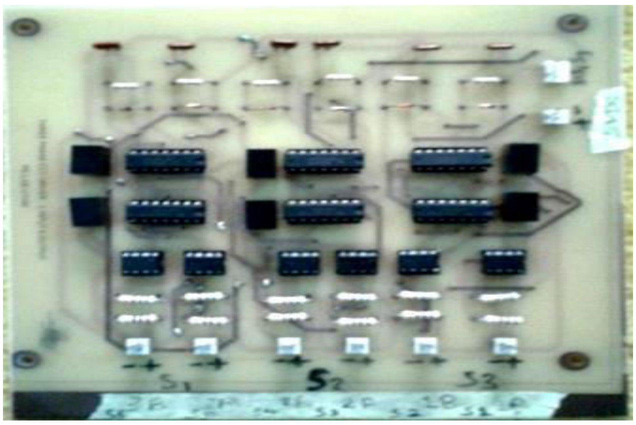

Figure-1. Pulse Width Modulation (PWM) circuit.

E. Compensation subprogram

The delay value representing the corrected frequency cannot be applied directly to the output ports because of the inverse relation between the delay value and the operating frequency for a certain value of the down counter clock frequency.

So 16/16 bits division has been used to get the appropriate quantity of compensation where the divisor (the delay) stored in pair register D and H the dividend is a fixed number equal to 0350 H selected for 50 KHz frequency of the counter clock. Then the compensated (or the corrected) delay value is stored in a specific memory location.

F. Interrupt subprogram

In many microprocessor applications it is desirable to interrupt the computing process to serve an external device. An interrupt can be performed by having a signal transmitted from an external device requesting attention of the microprocessor the TMS320F microprocessor has five interrupting lines; namely, TRAF, RSE.7.5, RST 6.5, RST 5.5, and INTR. activation any of these lines causes.

3. HARDWARE DESIGN

The DSP micro AC motor has been using to develop the application source code. The motor was designed for 400 VAC line to line and has a no-load speed of 1490 RPM.

The eZdspTM F28335 as in Figure-2 has the following features:

- Operational speed is 150 MHz
- Floating point unit has 32-bit
- RAM is 68 Kbytes
- Flash memory is 512K bytes
- SRAM memory has 256K bytes
- Analog to Digital converter (A/D) with 16 input channels
- Input clock is 30 MHz
- Connector with line driver has the cable RS-232
- On board CAN 2.0 interface with line driver and connector
- Multiple Expansion Connectors (analog, I/O)
- Embedded USB JTAG Controller
- 5-volt only operation with supplied AC adapter
- JTAG emulation connector

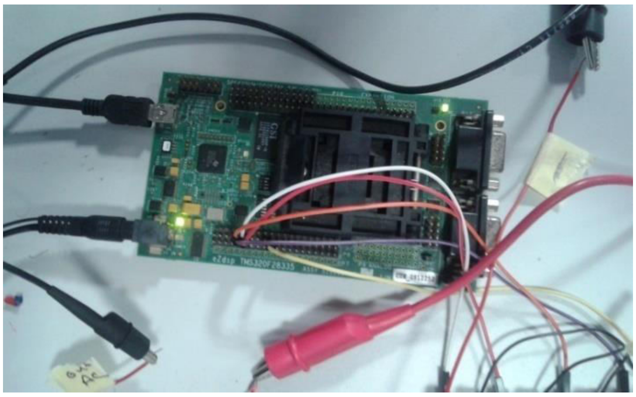

Figure-2. DSP controller (Texas Instrument, USA).

4. INTERFACING SOFTWARE AND HARDWARE

The circuit shown in Figure-3 is used to supply the required triggers to the six inversion IGBs. The 12-bits down counter (six SN74LS14N integrated circuit) has been loaded with the date received from ports B and C lower which represents half of the firing pulse applied to each thyristor. While the first six pins of port B are used to load the sequence date of the firing pulses to the D-Flip Flops (Six A3120 integrated circuit).

Multiplexing between the counter and the D-Flip flops has been done by hanging the output of the pin3 of port C from logic one to logic zero from D-Flip flop loading and from logic zero to logic one for counter loading. This process can be explained easily by the timing diagram shown in Figure-3.

The borrow has been fed to the RST 5.5 interrupt pin of the microprocessor, when the counting states are finished. Then the microprocessor proceeds to the next sequence and width of the firing pulse. The pulse width represents 1/3 of the operating frequency cycle which can be controlled easily by the microprocessor program.

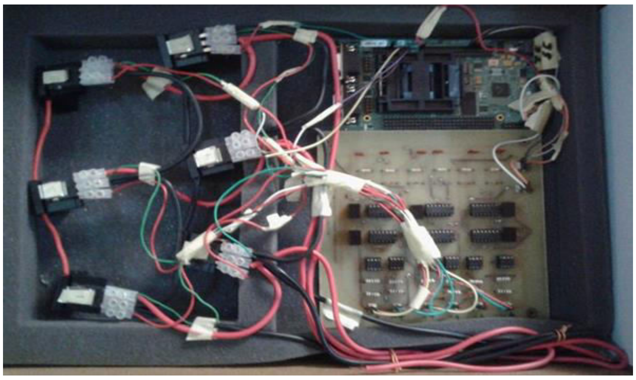

Figure-3. Complete designed and Implemented DC to AC inverter.

5. APPLIED CODE

The following TMS code is applied by interfacing the DSP of the inverter with laptop.

.

```
//     Lab7_2: TMS320F28335
//     (c) Frank Bormann
// FILE:  Lab7_2.c
const int analogInPin0 = A0;  // Analog input pin that the potentiometer is attached to
const int analogOutPin0 = 10; // Analog output pin that the LED is attached to

int sensorValue0 = 0;       // value read from the pot
int outputValue0 = 0;          // value output to the PWM (analog out)

const int analogInPin1 = A1;  // Analog input pin that the potentiometer is attached to
const int analogOutPin1 = 11; // Analog output pin that the LED is attached to

int sensorValue1 = 0;       // value read from the pot
int outputValue1 = 0;          // value output to the PWM (analog out)

void setup() {
// initialize serial communications at 9600 bps:
Serial.begin(9600);
}

void loop() {
// read the analog in value:
sensorValue0 = analogRead(analogInPin0);
// map it to the range of the analog out:
outputValue0 = map(sensorValue0, 0, 1023, 0, 255);
// change the analog out value:
analogWrite(analogOutPin, outputValue0);

// print the results to the serial monitor:
Serial.print("sensor0 = " );
Serial.print(sensorValue0);
Serial.print("\t output0 = ");
Serial.println(outputValue0);

// wait 2 milliseconds before the next loop
// for the analog-to-digital converter to settle
// after the last reading:
delay(2);

// read the analog in value:
sensorValue1 = analogRead(analogInPin1);
// map it to the range of the analog out:
outputValue1 = map(sensorValue1, 0, 1023, 0, 255);
// change the analog out value:
analogWrite(analogOutPin, outputValue1);

// print the results to the serial monitor:
Serial.print("sensor1 = " );
Serial.print(sensorValue1);
Serial.print("\t output1 = ");
Serial.println(outputValue1);
```

6. RESULTS AND DISCUSSSIONS

The experimental tests which are conducted on the designed and implemented power electronic derive with AC motor as shown in Figure-4 have approved a good quality. The tests show that the existence of the

ARPN Journal of Engineering and Applied Sciences

microprocessor TMS320F controller added activity and flexibility for operating the three-phase induction motor via DC to AC inverter-fed. The inverter used is consisted of three arms- two levels of IGBs type G4PC50UD. The Pulse Modulation Unit is fabricated in the laboratory using eight ICs type SN74LS14N, 14 pins and six ICs type A3120, eight pins. The tests have been conducted in University of Diyala, College of Engineering, AC machine Laboratory which complemented with the expected results as clarified in Figure-5.

Figure-4. Interfacing inverter derive with laptop and three-phase induction motor.

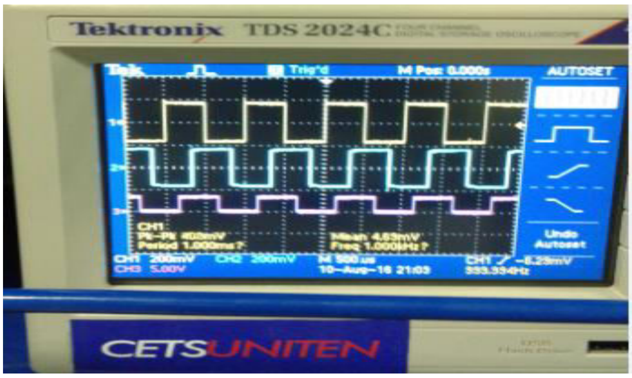

Figure-5. Interfacing inverter derive with laptop and three-phase induction motor.

7. CONCLUSIONS

The TMS320F construction versions can be treated to manufacture an actual AC three-phase induction motor squirrel cage request. The source program code and practical hardware solutions offered here can be useful to a choice of devices in both versions, depending on the hardware properties and bandwidth that the application necessitates.

REFERENCES

[1] F. Bouzidi and Y. Baghzouz. 2008. On the Optimal Efficiency of Split-Phase Induction Motors Under Light Load Conditions. in IEEE Conf.

[2] P. Enjeti and et al. 1991. Economic single phase to three phase converter technologiesfor fixed frequency output. in IEEE APEC Conf.

[3] B. K. Bose. 2000. Modern Power Electronics and AC Drives, Tennessee, USA: Prentice Hill PTR.

[4] Jimmie J. cathey Electric machines, Analysis and design applying matlab. pp:492-510.

[5] B. L. Theraja and A. Theraja. 1996. Electrical Technology, Chand and company limited.

[6] K. Mohammed. 2010. New Design Correlations for Single Phase Induction Motor. Journal of Engineering Sciences. 03: 134-144.

[7] Author: Stephen Bowling, Microchip Technology Inc., Chandler, AZ. PIC18CXXX/PIC16CXXX DC Servomotor Application.

[8] Saad Ahmed Salah. Speed Control of a Three-Phase Induction Motor Using Microprocessor. University of Baghdad. Thesis.

[9] Saba A. Shukry. 2004. Design of Optimal Communication Portable Full Duplex System. Thesis, University of Technology, Iraq.