V/F Method to Control the Speed of a Three Phase Induction Motor Using Micro Compiler

Anis Ahmad[1], Muhammad Sohaib Azeem[1], Imran Siddiq[2], Touqir Ahmad[1]
[1]Department of Electrical Engineering, Lahore Leads University, Lahore
[2]Department of Information Technology, Afro Asian Institute, Lahore
***Correspondence: Imran Siddiq,** imrancpe4u@gmail.com

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AC motors with induction drives are frequently working in industrial settings. The foundation of the sector is electric drive. Modern manufacturing is centered on the reliable induction motor. Due to their widespread use in various appliances as well as industrial automation and control, induction motors are frequently referred to as the workhorse of the industry. Although induction motors are constant speed, we often need variable speed for various industrial operations. For each wash cycle, a washing machine needs to run at a different speed. Mechanical gears were working in the past to achieve variable speed. However, modern power electronics and control systems have made such strides that we are able to replace the antiquated gear systems with electronic component-based motor control. Such an application of electronics enhances the motor's dynamic and steady state properties in addition to controlling its speed. Although there are other ways to regulate the speed of motors using variable/adjustable speed drives (VSD/ASD), we will only examine the V/F approach, which is a scalar form of speed control in this article. The speed management of induction motors is now simpler because to advancements in semiconductor technology and the usage of microcontrollers. The frequency and supply voltage affect the speed of an induction motor, so in this case we will adjust the frequency of the supply to alter the speed. In this system, the user-defined speed of the induction motor can be changed. By adjusting the IGBTs' firing angles, the discrepancy between the actual speed and the reference speed is reduced. The system is put to the test, and experimental findings for variable speed under varied load situations are recognized. In this process, the single-phase ac voltage (220V AC) is first converted into dc voltage (440V DC). This dc voltage is applied to an inverter, which again transforms it into three phase ac voltage, but its use allows us to adjust both the voltage level and frequency.

Keywords: Microcontroller, Programming, Numerically Efficient, Rectifier, Induction Motor, Micro Compiler.

Introduction

The basic structure block of the industrial drive system is the technical working instrument, or load, that may be kept in motion to do mechanical power with assistance of a rotor[1]. While the amplitude of the control variable can be controlled using the scalar technique, the magnitude and phase of the control variable can be controlled using the vector method[2]. Compared to the vector control method, scalar control is easier to implement, but it results in less dynamic comparison of an induction motor's performance with vector control[3]. A scalar control system can deliver adequate performance in variable-speed applications when a modest change in motor speed with load variation is acceptable[4]. The vector control method must be used, though, if precise control is necessary[5]. Here, we employed a scalar control method with voltage and frequency as the control parameters to adjust the speed of the induction motor[6]. Gearing or a belt may be used to transmit energy from the prime mover to the mechanical load[7]. Additionally, the transmission might be necessary to change rotary motion into linear motion and vice versa[8]. A drive is a mixture of a prime mover, a transmission, and a technical working load. An electric drive is one that employs an electric motor as its primary mover[9]. To obtain pace and torque control using the electric motors already in use, certain types of control equipment might be needed[10]. These controls, which can be used with either open loop or closed loop control, cause the motor to operate on a specific speed torque curve[11].

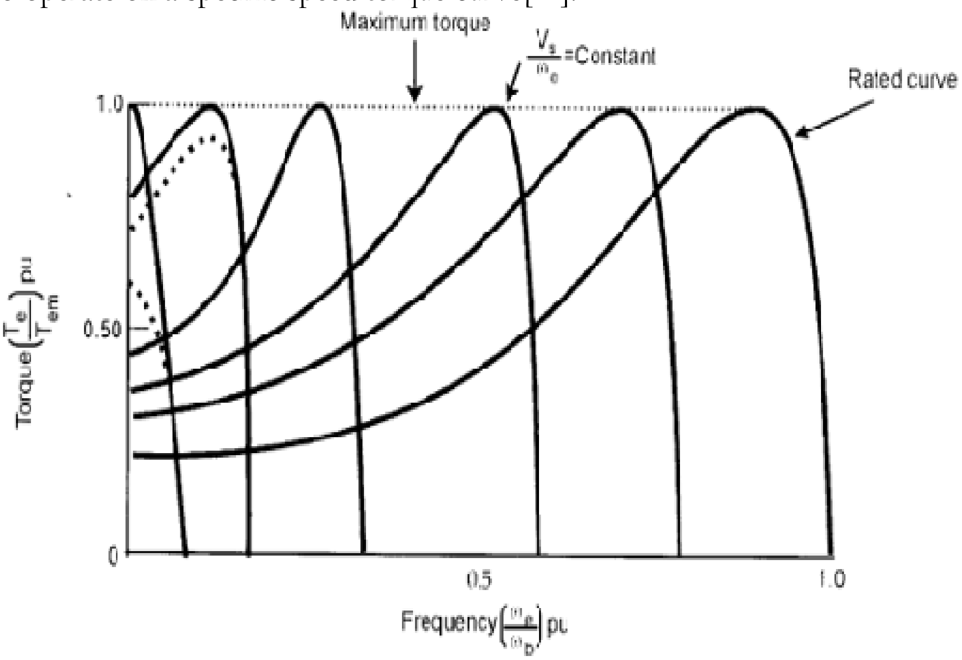

Figure 1. Torque speed graph of induction motor

Proposed Work and Analysis

The DSPIC30F2010 In the current work, a microcontroller is employed to run an induction motor through the V/F approach [12]. The following are some of the factors that contribute to the popularity of the microcontroller-based system:

1. Improved dependability and dependability [13].
2. Simplicity in attempting to construct changeable speed drives [14].
3. Low price and maximum precision [15].
4. The torque and speed aspects of the drive may be changed by modifying the drive's firmware [16].

This system's ease of use comes from the fact that anyone can use it without prior knowledge of microcontroller programming [17].

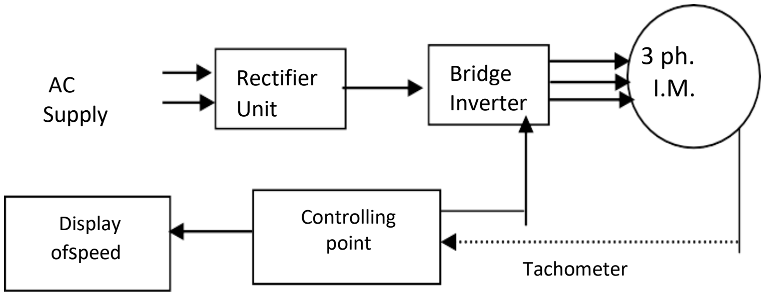

Figure : 2. The Block Diagram of the System

The block diagram of an induction motor's closed loop control using a DSPIC30F2010 microcontroller is shown in Figure . 2. A fully functional digital signal processor, the DSPIC is a 16-bit microcontroller with high performance and fast computation speed (DSP) [18]. It also functions as signal conditioning. To make control applications and signal processing easier, DSPIC has a few features, a motor control facility, and peripherals [19]. Code that is embedded supports it.PIC24 devices are only intended to be used as general-purpose microcontrollers [20].

The hardware consists of a speed sensor, microcontroller, rectifier, bridge inverter, squirrel cage induction motor, and switches for user interface [21]. According to the diagram, the rectifier receives a single phase A.C. supply The rectifier's DC output is received by the inverter, and the inverter's outcome three phase squirrel cage induction motor is linked to the three phase power source [22].The sensor measures the motor's speed and feeds back to the microcontroller, which then generates an error signal and sends it to the inverter [23]. The inverter's three-phase supply powers the motor at a user-specified speed [24].

Built in routines of MICROC Compiler (Algorithm)

1) **Delay_us**

Prototype void Delay_us(const time_in_us);

Returns Nothing.

Description Creates a software delay in duration of time_in_us microseconds (a constant). Range of applicable constants depends on the oscillator frequency.

Requires Nothing.

Example Delay_us(10); /* Ten microseconds pause */

2) **Delay_ms**

Prototype void Delay_ms(const time_in_ms);

Returns Nothing.

Description Creates a software delay in duration of time_in_ms milliseconds
Range of applicable constants depends on the oscillator frequency

Requires Nothing.

Example Delay_ms(1000); /* One second pause */

3) **Usart_Init**

Prototype void Usart_Init(const unsigned long baud_rate);

Returns Nothing.

Description Initializes hardware USART module with the desired baud rate.
Usart_Init needs to be called before using other functions from USART Library

Example This will initialize hardware USART and establish the communication at 2400 bps:
Usart_Init(2400);

4) **Usart_Data_Ready**

Prototype unsigned short Usart_Data_Ready(void);

Returns Function returns 1 if data is ready or 0 if there is no data.

Description Use the function to test if data in receive buffer is *ready* for reading.

Requires Usart_ini module must be initialized and communication established before

using this function.
Example If data is ready, read it:
int receive;
if (Usart_Data_Ready()) receive = Usart_Read;
5) **Usart_Read**
Prototype unsigned short Usart_Read(void);
Returns Returns the received byte. If byte is not received, returns 0.
Description Function receives a byte via USART. Use the function usart_data_ready to test if data is ready first.
Requires Usart_init module must be initialized and communication established before using this function.
Example If data is ready, read it:
int receive;
if (Usart_Data_Ready()) receive = Usart_Read();
6) **Usart_Write**
Prototype void Usart_Write(unsigned short data);
Returns Nothing.
Description Function transmits a byte (data) via USART.
Requires USART HW module must be initialized and communication established before using this function.
Example int chunk = 0x1E;
Usart_Write(chunk); /* send chunk via USART */
Below are the design considerations for each block.
Specifications of Design: -
Microcontroller DSPIC30F2010

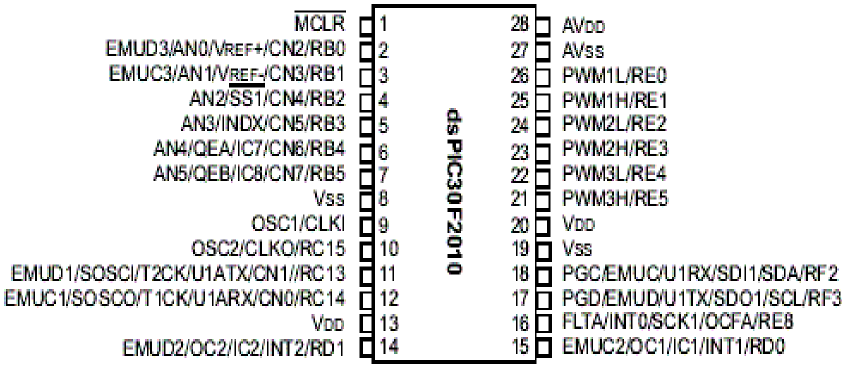

Figure 3. Pin Layout Microcontroller DSPIC30F2010

Peripheral Features
- - High current sink/source 25mA/25mA
- - Three 16-bit timer/counters
- - Four 16-bit Capture Input Functions
- - Two 16-bit Compare/PWM Output Functions
- - 3-wire SPI (supports all 4 SPI modes)
- - I²C Master and Slave mode
- - Addressable USART Module
- - Six Channel 10-bit Analog-to-Digital Converter

Motor Control PWM Features
- - Six PWM Output Channels
- - Four Duty Cycle Generators
- - Dedicated Time Base with Four Modes

- - Programmable Output Polarity
- - Dead-Time Control for Complementary Mode
- - Manual Output Control
- - Trigger for Synchronized A/D Conversions

Special Microcontroller Features

- - Power-On Reset
- - Power-up Timer (PWRT) and Oscillator Start-Up Timer (OST)
- - 1,000 erase/write cycles Enhanced Flash Program Memory
- - 1,000,000 typical erase/write cycles EEPROM Data Memory
- - Programmable Code Protection
- - Power Saving SLEEP mode

I/O and Packages

- - 20 I/O pins with individual direction control
- - 28-pin DIP

Rectifier Part: - A diode bridge
Rating of Diode: - 4Amp/100
Current of 380 watts flowing from diodes = = 0.9 A.440 Volt
Bridge rectifier O/P voltage = 440Volt A.C. x 1.414 = 622 Volt D.C
The PIV of the diode must be higher than 622V (with a +/- 10% tolerance).

Capacitor Bank: -

Rating of connected capacitor: - 470µF/450V
2series and 2parallel 380Watt
D.C. Current= 0.6Amp.624V
As a rule of thumb, 1000F is used for 1Amp, and 500F is used for 0.6Amp.

Initially, the user selects a speed range from three modes: S1=1440(rpm), and with the aid of the start key, S2=1200(rpm) and S3=500(rpm) [25]-[27]. After selecting the speed range, the motor approaches the reference speed at no-load as the supplied voltage increases [28]-[31]. As the load increases, the motor speed steadily decreases; this speed is recognized by the speed sensor and translated to voltage in the feedback circuit [32]-[36]. In the controller, the real speed is compared to the legal speed, and if it is smaller, the controller decreases the total timeframe (T) of PWM, raising t/T and O/P voltage of PWM, i.e., Vout = [(t/T) x Vin][37]-[40]. By keeping the v/f ratio steady, the PWM waveform created by the inverter drives the induction motor at a steady velocity [41],[42].

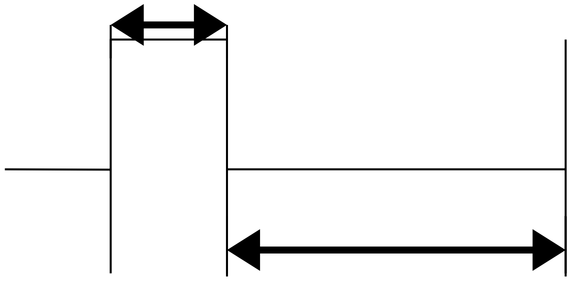

Figure 4. Shows total period of the PWM pulse

IGBT:

Rating of IGBT: - 60A/900V IGBT voltage > 624VIGBT current > 0.6Amp.
Mechanical load arrangement for Three Phase Squirrel Cage Induction Motor0.6 H.P. (380 watt), 3 Phase, 1Amp, 440V, 1440rpm
P.W.M O/P voltage= $(\Delta t)/T*Vin$
Wherever,

In this research the speed of the motor is being investigated using sensors, voltage, frequency, and controlling parameters [43]-[45].

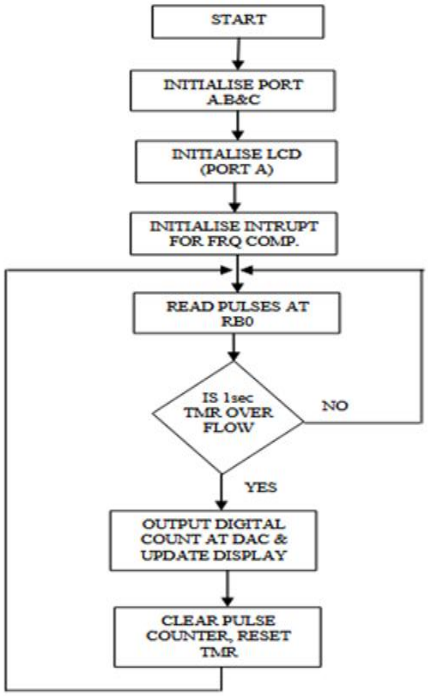

Figure 5. Flowchart Mian Circuit Diagram

The inverter angle changes from the operating angle when a load is present [30-34]. Given the range of load power taken into consideration in this pacific scenario, ranging from 40% minimum to 80% maximum [46]-[50]. (As shown in results)

Delay time is 10µs to 100 ms.

Implementation

For this project, selected a voltage control inverter, an uncontrolled bridge rectifier, a DSpic2010 microcontroller, and a squirrel cage induction motor.

Δt = ON time (constant)

T = Total period of time

Vin = Supply voltage

The motor's speed, terminal voltage, supply frequency, and v/f ratio have all been shown on the display.

Results and Discussion

In the section on results and discussion, the measured results obtained from speed control strategies for variable voltage and frequency in different cases are compared and discussed in the table given below. As we can see the entire hardware setup has been created and put through testing. The 1440 RPM, 230V, 1Amp, and 0.5 HP motor has been put through its paces under various loads and speeds. Below are the results catalogued.

CASE 1: Comparing measured (r.p.m) results of motor at no load.

In this case, the v/f method is used to control the speed of a three-phase induction motor using a microcontroller discussing with two different types of result graphs given below in Figure (6) and Figure (7). For the purpose of comparing the techniques, we are utilizing Figure (7), which represents the work of another author. Because the system's specification and the motor's ratings are same for both system using for comparison, as can be seen in the Figure s, both Figure s depict the same motor speed at no load, which is 1432 rpm approximately.

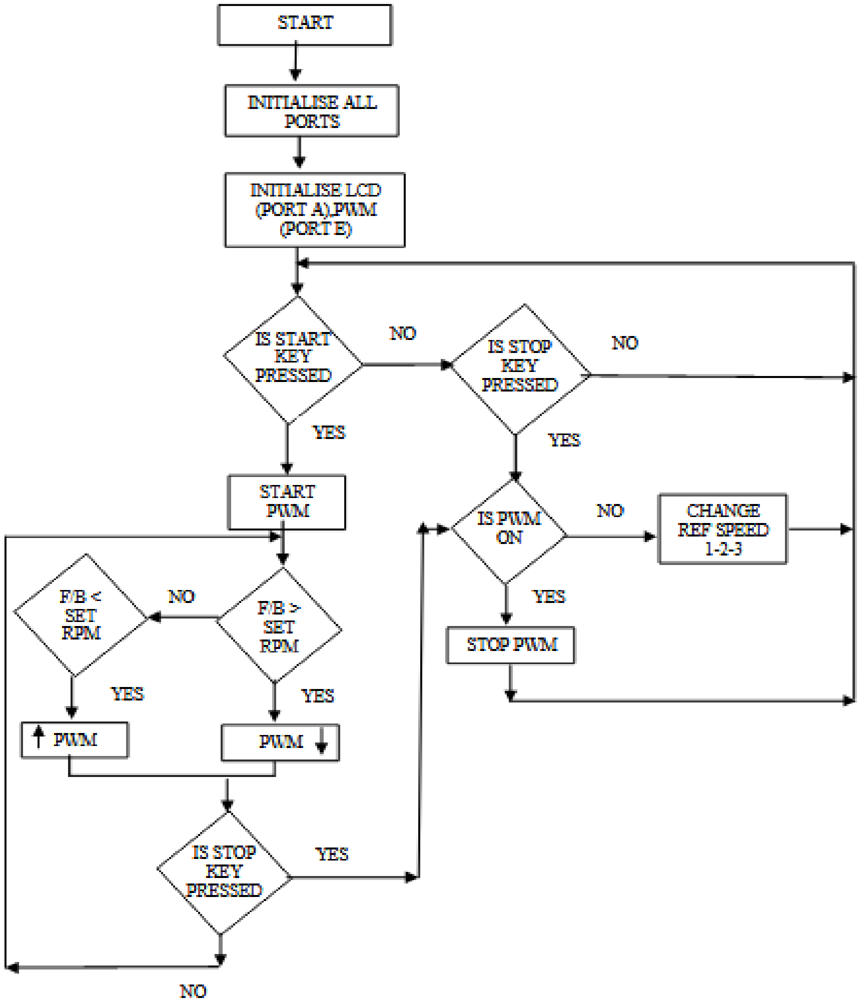

Figure 6. Feedback Diagram

Table 1: Results

Motor Speed range Selection	**Load (gms)**	**Vl at motor terminal (Volts)**	**Frequency of Inverter (Hz)**	**Ratio of v/f**	**Speed of motor (RPM)**
Motor at no load					
S3(500)rpm	0	96	18	6	505
S2(1200)rpm	0	145	36	5	1221
S1(1440)rpm	0	186	36	5	1432
Motor with load					
S3(500)r.p.m	500	134	37	4	506
S2(1200)rpm	500	164	45	4	1132
S1(1440)rpm	500	166	46	3	1158

CASE 2: Comparing measured (r.p.m) results of motor at full load.

In this instance, the applying load is 500(gms) at the system the speed of the motor is decrees at once butt after the strategy speed of motor increase fast and reaches at required speed. The Figure (8) represents the v/f method is used to control the speed of a three-phase induction motor using a microcontroller and motor speed (r.p.m) which nearest of required speed. And the Figure (9) showing other author's work. We can see in graph our work is more reliable than author's because the system showing nearest rpm from required speed rpm. These are the more results to show the performance of the V/F Method.

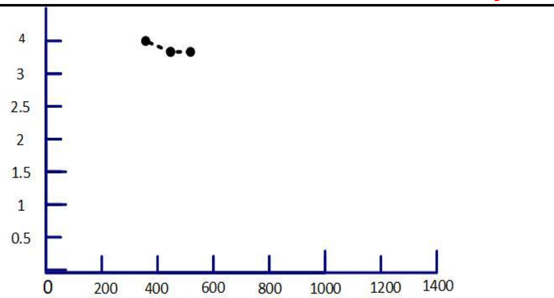

Figure 7. V/F speed with motor at No load

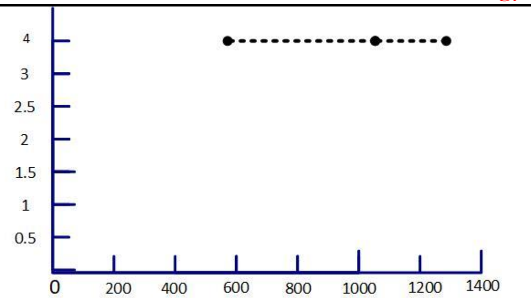

Figure 8. V/F speed with motor at No load

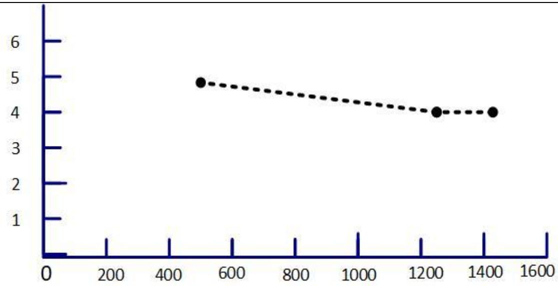

Figure 9. V/F speed with motor on load

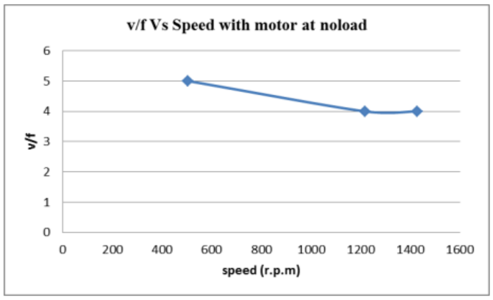

Figure 10. V/F speed with motor on load

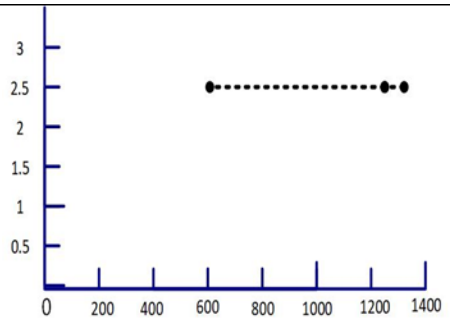

Figure 11. V/F Speed with graph for load

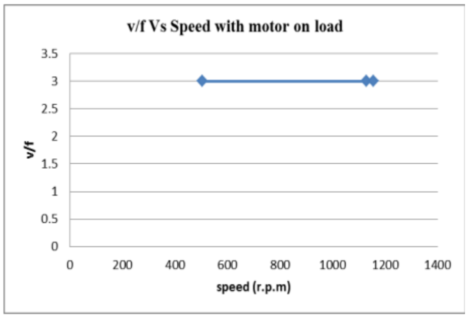

Figure 12. V/F Speed with graph for load

Conclusion

Induction motors operate at rated speed with no load when they are connected directly to the supply. When a motor is loaded, its speed begins to decline. As a result, the v/f approach is utilized to constantly operate the motor at less than maximum speed, both with and without load. The PIC microcontroller is used to generate the PWM waveform and analyze the motor speed. The research includes two algorithms: one that monitors motor speed and the other that generates error signals based on stated and real-world speeds and modifies the frequency (f) and the voltage (v) of the PWM waveform.

Recommendation

If the v/f ratio is kept constant, a motor will operate at variable speed both with and without a load.

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