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Speed Control of Induction Motor Drive Using Universal Bridge (MATLAB)

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***Abstract*-- When connected to 1- Phase or 3- phase supply connect motor runs, however there are many industrial and domestic application where speed variation is required, many techniques are used for speed variation like voltage control method, variable resistance method. This paper presents speed variation by universal Bridge which consist combination of IGBT & MOSFET and Diodes by changing the gate pulses of transistors speed control of induction motor. This method or control technique is called the variable frequency control. This method is used for single phase or three phase motor control with small modification in hardware and Software using Simulink it can be performed on computer and performance checked. This controller circuit consist microcontroller and power supply circuit. This power circuit Includes inverter which connected to PWM generator. To change modulation index readings observed by Simulink using MATLAB. We can also change the starting torque of motor to change the modulation Index.**

Keywords*-- single phase or three phase Motor; Microcontroller; Pulse Width Modulation Generator; IGBT*& MOSFET

I. INTRODUCTION

Induction motors are three phase machines where the synchronous speed of the stator revolving flux (N) is --- $N_s = 120 f / P$ (1)
Where f is the supply frequency in Hz and P is the number of poles. As the number of poles is not variable, varying the supply frequency would result in the variation in speed of the induction motor. Variation of the voltage should be in proportion to frequency, so that the torque developed inconstant over the speed range. This is in particular what variable frequency (V/f) control attempts to accomplish.

Fig. 1shows the per-phase equivalent circuit of an induction motor referred to stator side. Where,

r1 = Stator resistance per phase in Ω
X1 = Stator leakage reactance per phase in Ω
I1= Stator current per phase in A
Rc = 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
s = slip

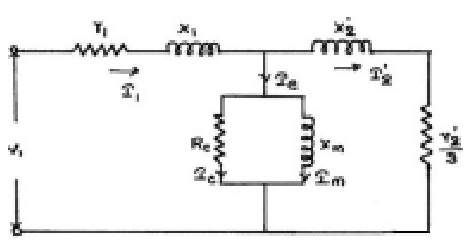

Fig. 1. Per-phase equivalent circuit referred to Stator side

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To maintain the motor flux, the (E1/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, this controller controls variation of speed changing the gate pulses of inverter through PWM generator. This paper is divided into two parts. The first part is the MATLAB Simulink simulation. The second part is the hardware implementation of the developed circuit.

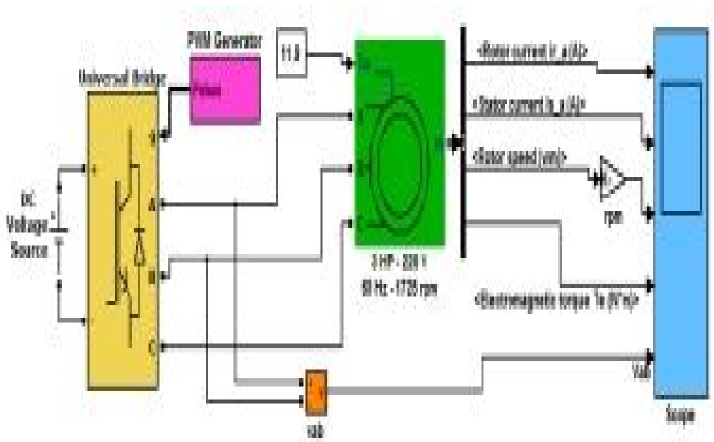

Fig. 2. Complete simulation model in Matlab Simulink

II. THREE-PHASE INVERTER SIMULATION

The circuit shown in Fig. 2 is simulated using MATLAB Simulink's SimPowerSystems software. The absolute circuit consists of a DC Voltage Source, PWM generator, Universal Bridge, Asynchronous machine and a Scope that displays the signals generated throughout the simulation.

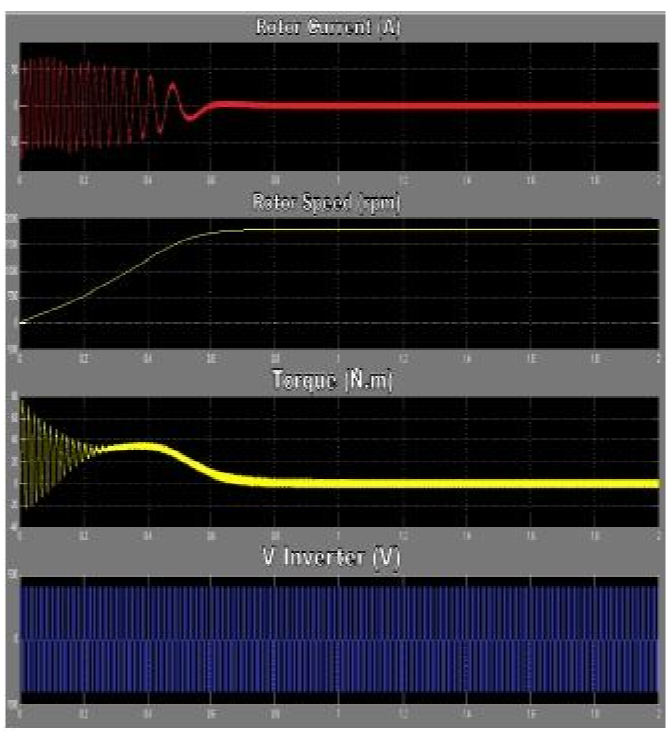

Fig. 3. Simulation waveforms obtained at m = 0.8 with no load

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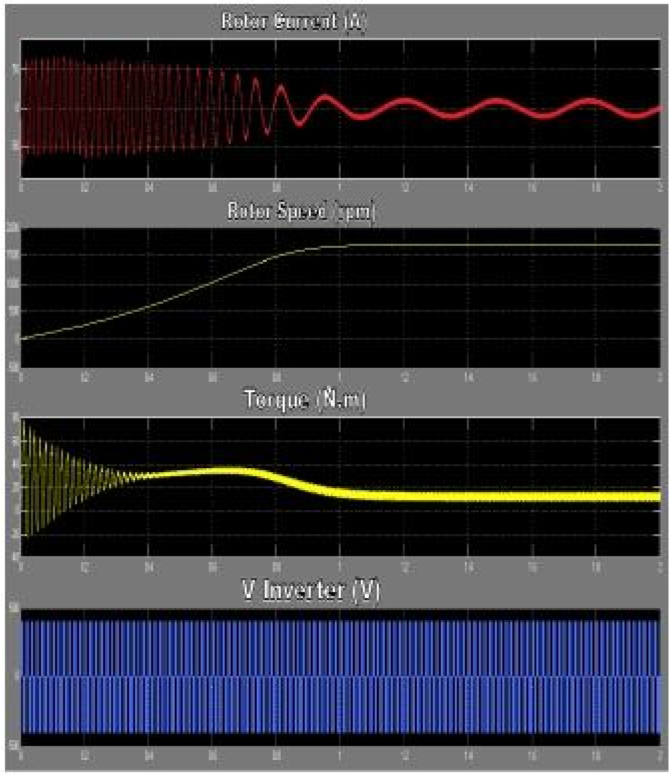

Fig. 4. Simulation waveforms obtained at m = 0.8 with constant load of11.9N-m

The technique used to control the frequency of the three phase voltage supplied to the motor from the Insulated Gate Bipolar Transistor (IGBT) inverter circuit is Pulse Width Modulation (PWM), which allows the speed to be varied with respect to the frequency of the reference signal, input to the PWM generator [3]. The carrier frequency and the modulation index were set to 1080Hz and 0.8 respectively. The simulation was done twice, first with no-load and then with a constant torque of 11.9N-m. No-load simulation results are shown in the Fig.3.

The characteristics of the induction motor can be studied from the waveforms obtained from the simulation. It can be seen that the speed of the rotor increases linearly and reaches the rated speed (1800 rpm) in 0.75 seconds. At the start, the torque increases but soon reduces to a minimum value when the rated speed of the rotor is reached. Fig. 4 shows the simulation results with full-load at 11.9N-m. As a mechanical load is applied, the rotor speed is observed to be 1700 rpm which is slightly lower than its rated speed.

III. HARDWARE IMPLEMENTATION

The hardware for the control, driver and the power circuit is designed and discussed.

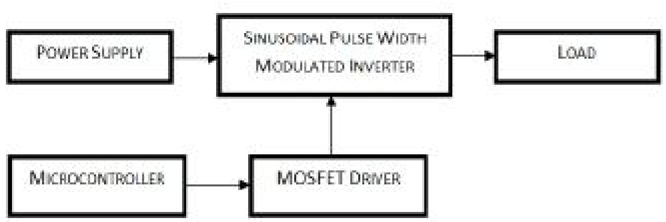

Fig. 5 shows the block diagram of the AC drive circuit.

A. Power Supply Circuit

The power supply circuit consists of a step-down transformer 230/15V which is passed through a single-phase bridge rectifier. The rectifier converts the alternating current (AC), to direct current (DC) and capacitor filters are used for smoothing out the DC. Fig. 6 shows the block diagram of a regulated power supply. The designed power supply circuit is

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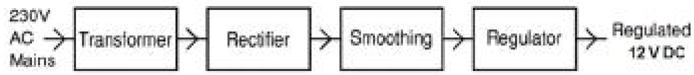

Fig. 6. Circuit diagram of the power supply circuit

B. Control Circuit

The control system consists of microcontroller AT89C52- 24PI. This controller circuit consist power supply, Microcontroller, Mosfet & IGBT and circuit controlled by controlling the gate signal. The Microcontroller circuit requires +5V DC power supply. The 15V from the 230V/15V transformer is rectified and a constant voltage of 5V DC is obtained with the help of voltage regulator IC7805. The switching schemes to the Metal Oxide Semiconductor Field Effect Transistors (MOSFET) are generated by microcontroller. This microchip is the controller circuit that is used to generate the modulating and the carrier signal for the inverter. Fig. 8 shows the PCB layout of the proposed controller.

Fig. 7. PCB showing buffer, microcontroller and power supply

The buffer permits the data transmission from the bus B to the bus A or vice-versa depending on the logic level. The connections lines can be effectively isolated by enabling the input (G) that can be used to disable the buffer. Fig. 10 shows the Schematic of the Control Circuit.

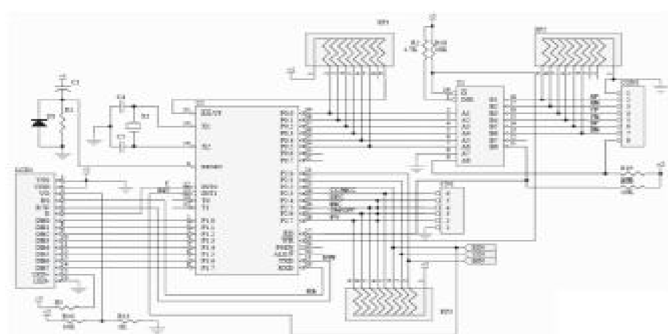

Fig. 8. Schematic of the control circuit

C. Driver Circuit

The driver circuit consist Universal Bridge using combination of IGBT, MOSFET driving the gate signal with high controllability Transistor Transistor Logic (TTL) or high capacitive loads. Fig. 11 shows the schematic of the Driver Circuit.

Fig. 12 shows the Driver PCB. The driver for the MOSFET is significant in the circuit development since it is used as an interface between inverter (high voltage part) and control circuits (low voltage part) [5].The driver circuit outputs are sent to the MOSFETs as triggering pulses. These output pulses were observed using an oscilloscope.

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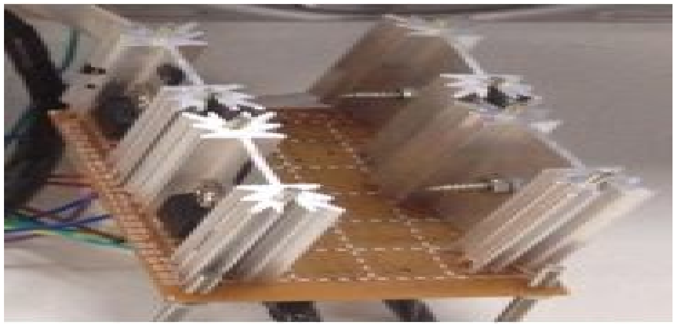


Fig. 9. Full-bridge single-phase inverter

D. Power Circuit

This circuit includes the Universal bridge using IGBT & MOSFETs. Inverter circuits convert DC to AC, transferring power from DC source to an AC load. A sinusoidal pulse width modulation inverter can control the speed of a single phase motor. Pulse width modulation offers a means to reduce the Total Harmonic Distortion (THD) of load current. The gating signals are produced by comparing triangular wave as carrier signal and sine wave as the modulating signal. The sine waves establish the frequency of the output waveform while the triangular waves establish the switching frequency of the MOSFET [5]. The microcontroller is programmed to generate the modulating and the carrier signals.
A single-phase inverter is chosen for the experimental setup.

IV. LABORATORY TEST AND RESULTS

The following test was conducted in the laboratory. A fan load was connected at the output of the inverter and the modulation index was varied using the selector switch
Input voltage: 100V DC
Output voltage: Single-phase 100V
Induction Motor rating: - 100V, 15/14W ,
50/60Hz
Switching frequency: Variable frequency, Variable duty-cycle
PIC controls: AT89C52-24PI

A. Table I Results Of The Experimental Set-Up

The variation of the inverter output voltage with modulation index is shown in

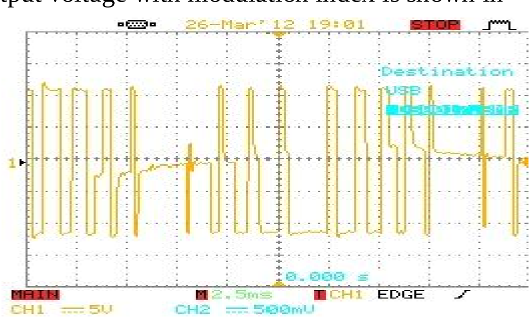
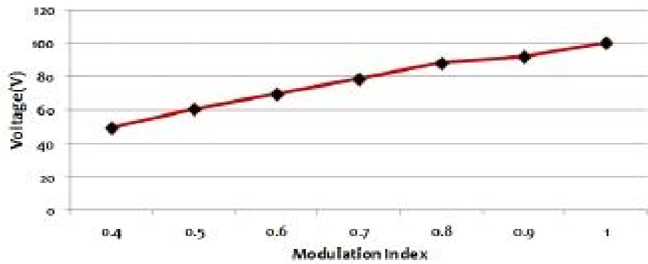


Fig. 10. For m = 0.7, f = 35H

The same controller can be used to control the speed of three- phase induction motor. There will be slight modification in the programming of the microcontroller and two more stages will be added to the driver circuit to drive six self-commutated semiconductor switches of the three-phase inverter bridge.



.Fig. 11shows the waveforms obtained across the load at different values of modulation index (m).

V. 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. The main aim of this project is to create a universal control board through which controlled a single or a three-phase induction motor, with slight software and hardware modifications. This universal board can hence be used for different kinds of laboratory applications and canal so help in enhancing the learning of different courses such as Electrical Energy Systems and Electromechanical system. The designed system was successfully fabricated and tested in the laboratory.

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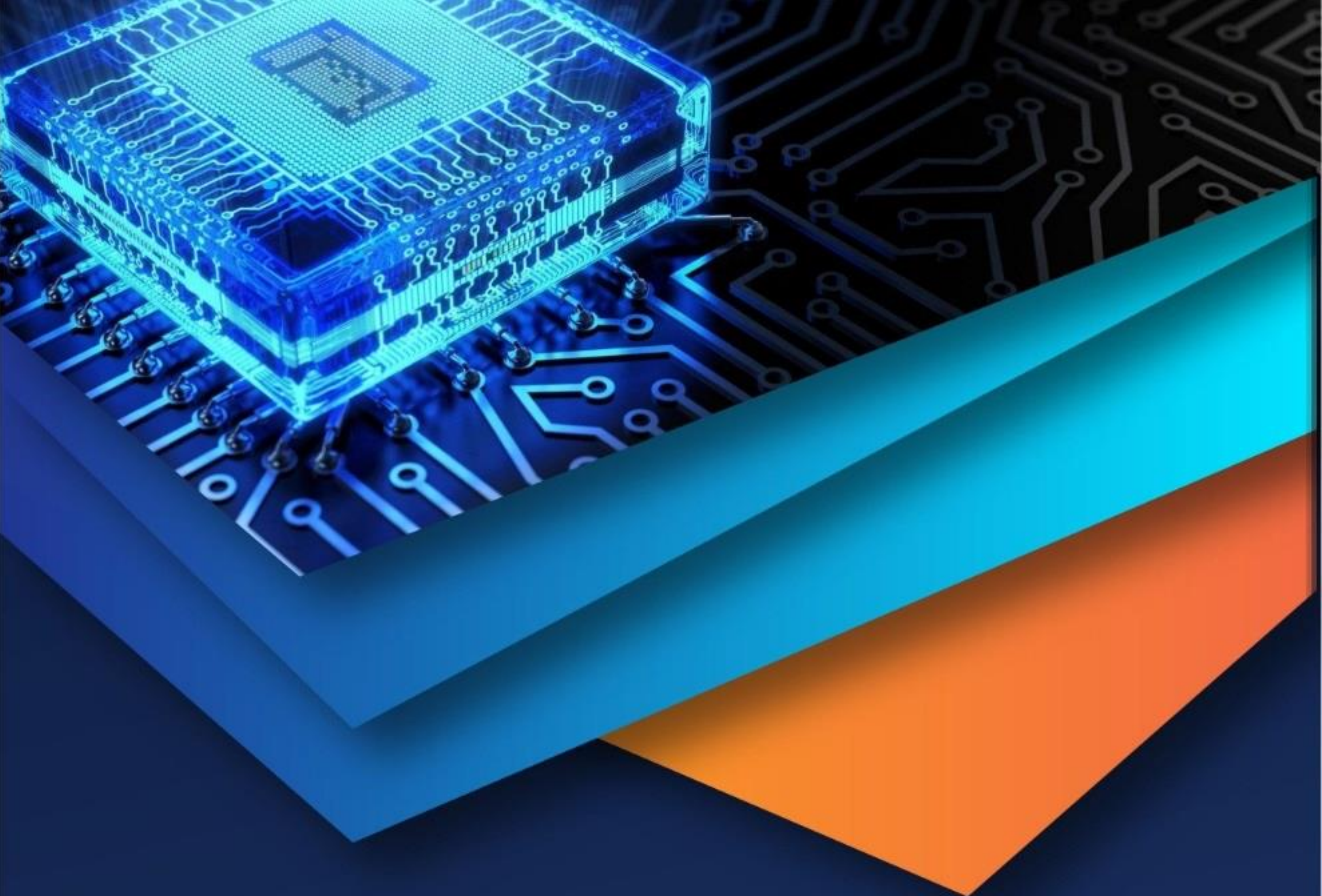

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