Open Loop Volts/Hertz Speed Control of Induction Motor with Voltage Fed Inverter

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Abstract - *Volts/hertz(V/f) control technique has evidenced to be the foremost versatile within the industries, Out of the assorted ways of dominant Induction motors. The general theme of implementing V/f control has been given high importance because of its simplicity. One in all the fundamental needs of this theme is that the PWM inverters. In this, the PWM inverters are sculptural and their outputs can control the speed of the Induction Motor drives. Open-loop V/f control of induction motor analysis is done.*

***Key Words*:** **SPWM Technique, Open Loop V/f Speed Control, Three Phase Induction Motor, Inverter**

1. INTRODUCTION

This Frequency control is natural for adjustable speed applications. However, this can be precisely what the V/f management tries to realize. In most of the inverters, each square measure needed to be controlled. V/F drive consists of IGBTs primarily based PWM electrical converter firing circuit at the side of the module. If the magnitude relation of voltage to frequency is unbroken constant because the flux remains constant. The exploitation of this technique, the torque may be maintained around constant. This kind of management is typically called volts/hertz management. By varying voltage and frequency in steps, the torque and speed can be controlled. The torque is often maintained constant whereas the speed is varied. The tactic adopted the exploitation of the DSP processor. The voltage at variable frequency is obtained from the three-phase electrical converter. The potential arrangement for getting variable voltage and frequency is elaborated in the figure shown below.

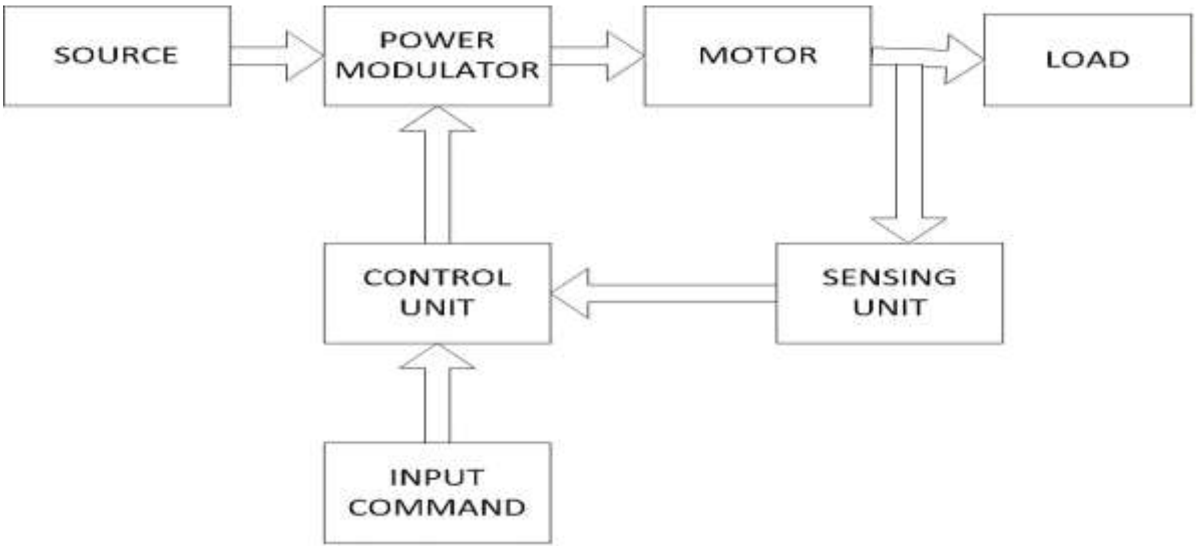

Fig -1: Block Diagram of Speed Control of Induction Motor

In this figure, the first step is to give a supply of power modulator drives the motor and the motor is connected with some load. One feedback path is coming from in between load and motor and fed on the control unit. Some external input command is given to the control unit. Using the control unit, we try to change in power modulator for achieving the desired output. The dc voltage remains constant and also the PWM technique is applied to vary each voltage and frequency at intervals the electrical converter. Using diode rectifiers, regeneration isn't possible, and also the electrical converter can generate harmonics in AC offers. Constant volts per hertz management is that the preferred scalar control that varies terminal voltage in proportion to the availability frequency to take care of the air gap flux at around the rated V/F magnitude relation particularly once the machine operates below its rated frequency. In this paper, the DC voltage is connected to the IGBT primarily based on the three-part electrical converter. The electrical converter output is controlled by the SPWM gating signal. By varied PWM signal, we tend to get needed speed control as we tend to acquire variable frequency, however constant V/f magnitude relation at the electrical converter output.

2. V/f CONTROL OF INDUCTION MOTOR

Control of synchronous speed is achieved with the help of variation of the supply frequency. The induced voltage in stator windings varies directly with the supply frequency and air gap flux. The terminal voltage varies directly with flux and frequency which can be obtained when the stator voltage drop is neglected. It is thus obvious that the air gap flux will increase if the frequency is reduced without making any changes in supply voltage leading to an undesired condition. A variation in the terminal voltage to maintain the constant V/f ratio is observed. An attempt to control the speed is done by varying the frequency. When speed changes, it is observed that the torque of the motor reaches a maximum and becomes constant when the ratio of constant V/f is maintained. The flux produced is in proportion to the ratio of the voltage applied and supply frequency. The motor developed torque is in direct proportion to the stator produced magnetic field. Throughout the range of speed, the values of flux and torque can be held constant with the same variation concerning voltage and frequency. This function makes the V/f control easier than other methods of speed control techniques.

$$E \text{ or } V = 4.44\emptyset KTf$$

$$V/f = 4.44\emptyset KT$$

Where k denoted winding constant, T denoted turns number, f is frequency, $\emptyset$ is the flux.

3. Open Loop V/f Method Control:

This method gained high usage in regards to the methods used for controlling speed. These types of motor are widely used in industry because of its simplicity. Some of the advantages of this type of motor are low costs, simplicity in operation, and immunity to the error of the feedback signal [4]. Most induction motors with 50 Hz supply have been used with open-loop control for a constant speed of applications. In this operation, the variables under control are synchronous speed and stator frequency but somehow the synchronous speed gets slightly more than the rotor speed as a result of which control of motor speed is not possible. The rated current is thus exceeded largely by the stator current. The variation of the synchronous speed Ns and rotor speed poses a problem as it hampers in maintaining the speed of slip [5].

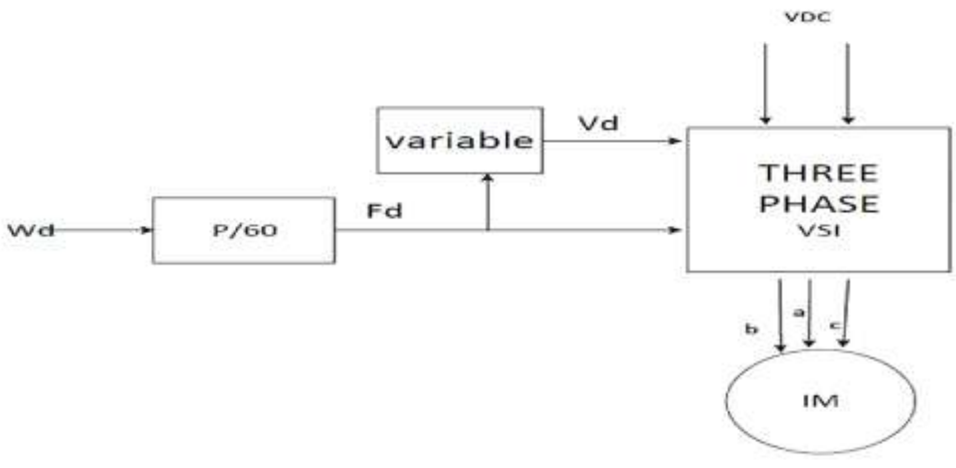

Fig -2: Block diagram of open-loop speed control of Induction motor

4. Simulation & Evaluation

To verify the experimental results, the simulation of sinusoidal PWM three-phase inverter feeding IM was made using MATLAB/SIMULINK and sim power system toolbox. The scheme of the system is shown in Fig.3. It consists of three important parts (three-phase induction motor bridge inverter circuit, PWM generator). The three-phase sine reference waves (sinewave (A), sinewave (B), and sinewave (C)) are comparing with the triangular carrier wave by using three relational operators and the intersection of these waves generates the gating signals (g1, g3, and g5) that applied to the upper switches (S1, S3, and S5), each of these gating signals are negated by using three logical operators (NOT) to produce gating signals (g4, g6, and g2) are applied to the lower switches (S4, S6, and S2) of the three-phase bridge inverter to generate three-phase AC output voltage waveform to feed the induction motor.

To verify the experimental results, the simulation of SPWM three-phase electrical converter feeding IM was created by MATLAB/SIMULINK and sim power system. The theme of the system is shown in Fig.3. It consists of 3 major elements (three-phase bridge voltage source inverter circuit, PWM generator, and three-phase induction motor). The three-phase sine reference waves are compared with the triangular wave by 3 relative operators and additionally the intersection of these waves generates the gating signals (g1, g3, and g5) that applied to the higher switches (S1, S3, and S5), every of these gating signals are negated by victimization 3 logical operators (NOT) to supply gating signals (g4, g6, and g2) area unit applied to the lower switches (S4, S6, and S2) of the three-phase bridge electrical converter to return up with three-phase AC output voltage waveform to feed the induction motor.

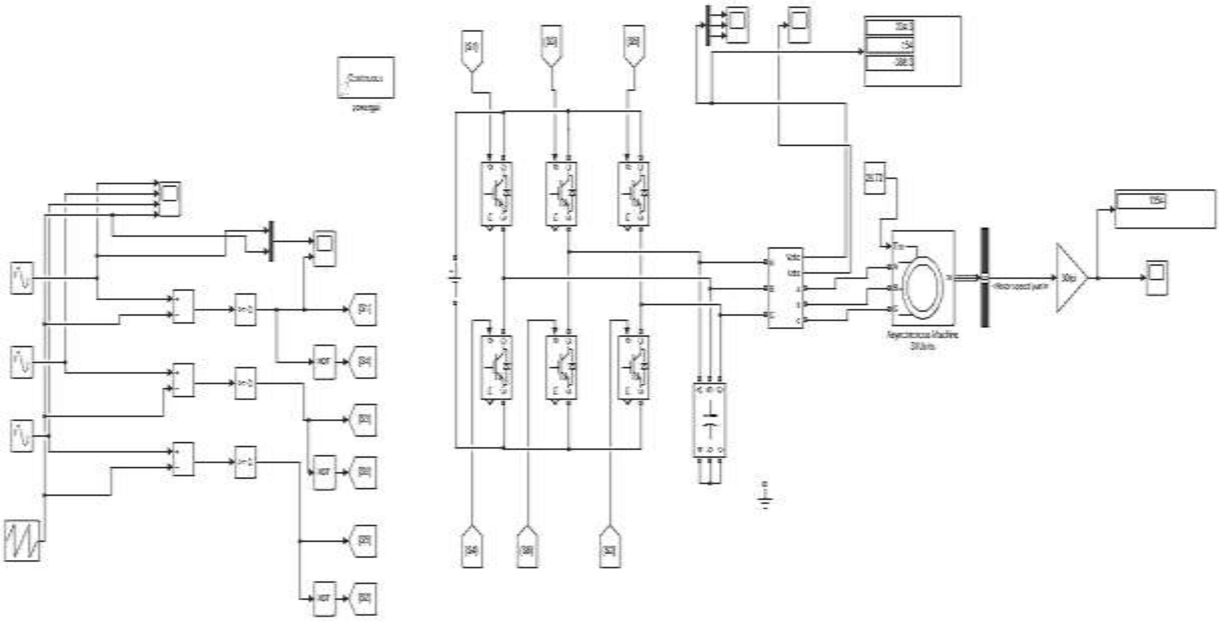

Fig -3: Simulation of open-loop V/f control of IM

The simulation circuit for the Inverter model is shown in Fig.3. A six pulse Inverter circuit with IGBT is formed. 180° mode of operation is used where each switch conduct for 180° of the cycle. IGBT pair in each arm i.e. S1, S4; S3, S6, and S5, S2 are turned on with a time interval of 180°. It means that S1 conduct for 180° and S4 for the next 180° of a cycle. Switch on the upper group i.e. at an interval of 120° the switches S1, S3, S5 will conduct. It implies that if S1 is fired at ωt=0°, then S3 must be fired at ωt=120° and S5 at ωt=240°. The lower group of switches will be fired in the same sequence. For our application, we require variable voltage as well as the variable frequency at the output of the inverter. Using PWM firing scheme, we can get a good control circuit. RL equivalent load of Induction motor is connected at the output. Anti-parallel diodes are connected across each IGBT to provide a path for inductor current to flow and protect IGBT. The simulation model of Sinusoidal PWM for Inverter firing is shown in Fig.4 Three sinusoidal signals of 50 Hz frequency with a 120° phase difference between them are used as modulating signals. The saw tooth waveform of 1 kHz frequency is used as a carrier signal for PWM. This produces three PWM outputs to be used as firing pulses for an upper group of inverter switches. NOT operation is done on these three PWM outputs to get firing pulses for a lower group of inverter switches. For a given load, Induction motor simulation is performed and voltage and current output across the load phase is observed.

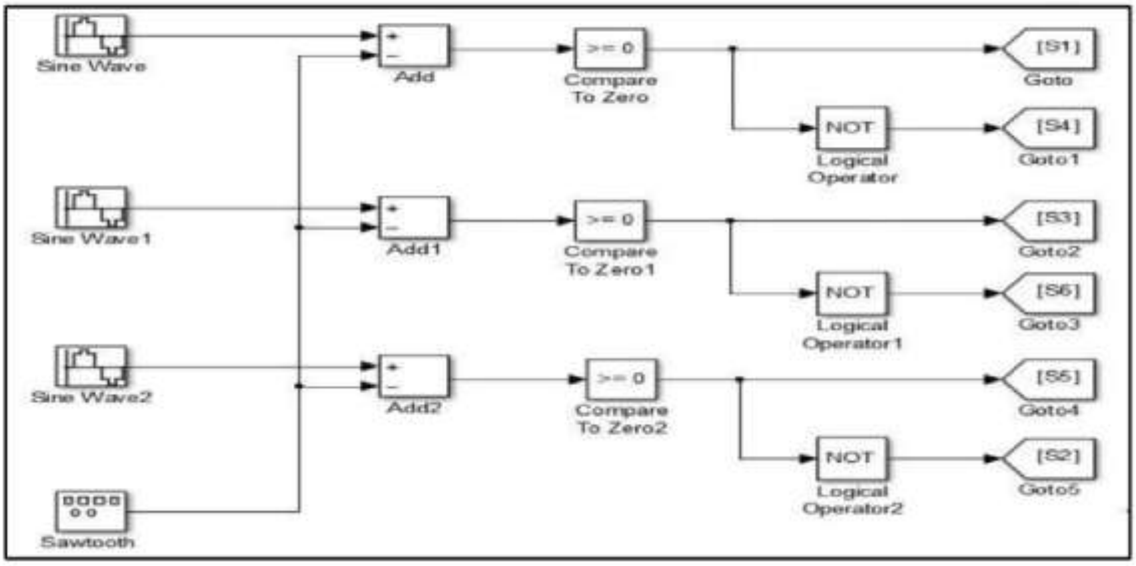

Fig –4: Simulation model of Sinusoidal PWM for Inverter

Simulation Results:

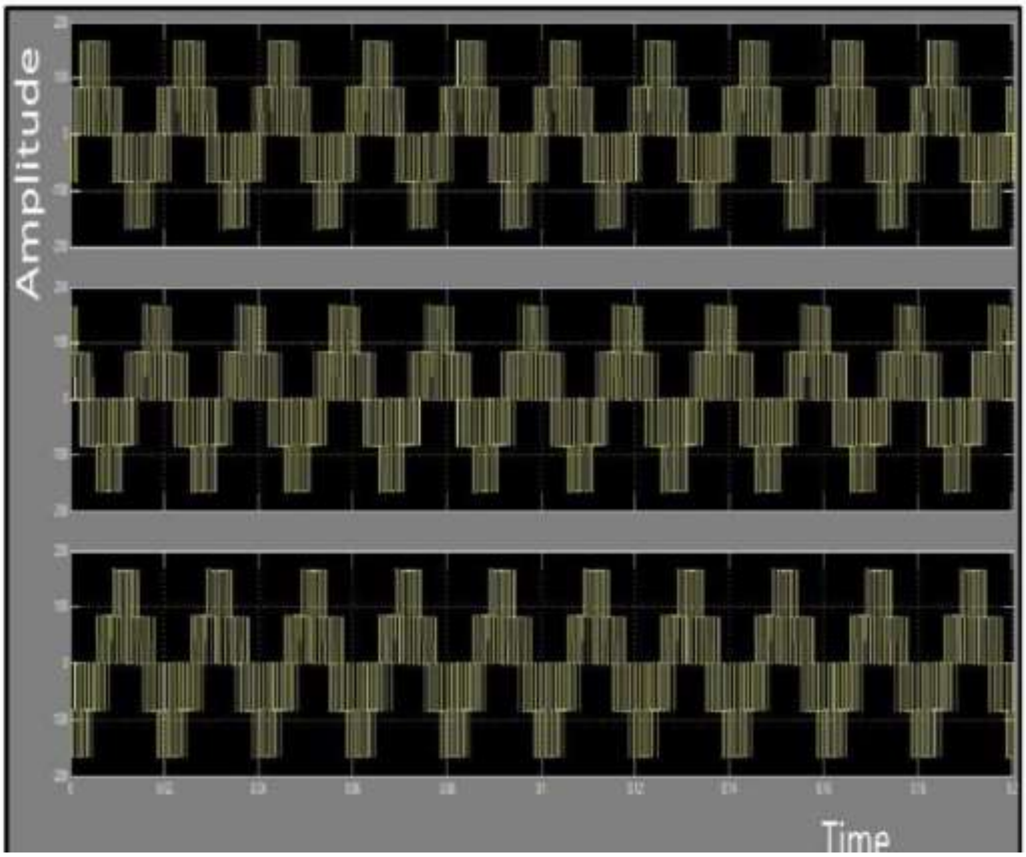

Fig –5: Voltage output waveform across the Inverter

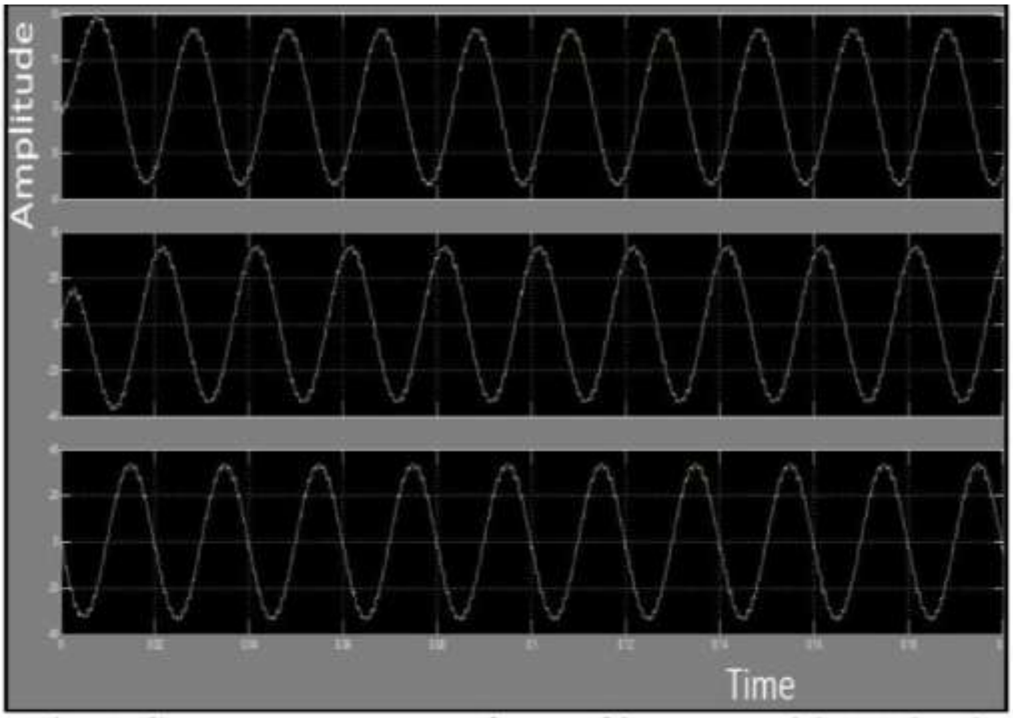

Fig –6: Current output waveform of the Inverter

Table -1: Results of open-loop V/f control of induction motor

Stator Voltage (V)	Modulation index (*mi*)	Supply Frequency (Hz)	Synchronous Speed (rpm) (as calculated)	Actual Speed (rpm) (as measured)
57.5	0.125	9	197.5	195
100	0.25	12.5	385	383
142.5	0.375	18.75	572.5	568.4
180	0.5	28	760	756.4
385	1	50	1500	1485

3. CONCLUSIONS

The open-loop V/f speed control of Induction motor by using Inverter with PWM firing is successfully simulated. A load of induction motor is supplied by the inverter output voltage and output voltage and current waveforms are observed. Anti-parallel diodes are connected across IGBTs to provide a path for the inductance load of the motor to discharge. The SPWM firing of Inverter gives a variable frequency three-phase voltage which maintains V/f ratio constant. The filter reduces unwanted harmonics which is fed to the three-phase inverter. The inverter output is controlled by the PWM gating signal. By varying the PWM signal we get required speed control as we obtain Variable frequency but constant V/f ratio at the inverter output.

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