Design and Development of 3 Phase PWM Inverter

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Abstract— The study of design and development of PWM inverter is developed to have the variable speed or control of speed of an Induction motor. As we know that the 3-phase induction motor is a constant speed motor. So, for different operations we need different revolutions per minute (rpm). In this model, we going to give the pulse width modulated output from the inverter to the 3-phase induction motor. As due to the pulses we can have control over the speed of the induction motor and even harmonics are also reduced. We have provided in the simulation in Psim (Power Simulation). For different values of the inputs with load (3-phase induction motor), the output have been tested. In this, we also have attached the data sheets of the various components that are used in the hard model. The use of On-Off controllers with IGBTs switches, a D.C. source and a 3 –phase A.C source from function generator for the controller.

Key words: PWM, Inverter, 3-Phase, Induction Motor, Psim, IGBTs, AC Source, PSIM

I. INTRODUCTION

Motors are widely used due to its high efficiency and robust nature. A three phase induction motor is basically a constant speed motor so it's somewhat difficult to control its speed. The speed control of induction motor is done at the cost of decrease in efficiency and low electrical power factor. Pulse width modulation (PWM) is a powerful technique for controlling analog circuits with a microprocessor's digital outputs. PWM is an inductor driven by a voltage source modulated as a series of pulses resulting in a sine like current in the inductor. AC drives that use PWM techniques have varying levels of performance based on control algorithms. There are four basic types of control for AC drives today. These are Volts per Hertz, Sensor less Vector Control, Flux Vector Control, and Field Oriented Control. There are many methods used but PWM has advantages like cheap cost, efficiency up to 90%, low power consumption as it have very low impedance and therefore a low voltage drop and low power dissipation.

Pulse width modulation is an effective method of speed control of an induction motor. And thus allowing the motor to be applied in the area requiring speed control. Available techniques to control speed of induction motor are: varying the slip by changing rotor resistance or terminal voltage and varying synchronous speed by changing number of poles or supply frequencies changing rotor resistance requires wound rotor induction motor and any resistances inserted to the rotor circuit will reduce efficiency of machine. Changing terminal voltage has limited range of speed control changing the number of poles requires motor with special stator winding the best method is to change electrical frequency because it is applicable to any type of induction motor.

The speed of induction motor depends on the rate of rotation of its magnetic fields or the synchronous speed which is directly proportional to any electrical frequency. pwm technique is used to control the electrical frequency of the three phase voltage supplied to the motor from the insulated gate bipolar transistor inverter circuit hence allowing the speed to be varied with respect to the frequency of reference signal, input to PWM signal generator.

II. METHODOLOGY

The first stage was to get the reason for using PWM inverter. Inverter is basically an interface between DC source like photovoltaic cell and AC networks. There are many inverter topologies but output current distortion and efficiency are the two main parameters for the selection of inverters. But the output generated in single phase inverter is not pure sinusoidal signal instead it is a square wave. The output and circuit diagram is shown in fig. 1.It is a sine wave only with harmonics present. Like if we supply a fundamental sine wave with other sine wave with frequency the multiple of the fundamental then the output will be a square wave, which is shown in given figures. Fig. 2 includes fundamental and harmonics. So we are using PWM technique which helps to generate a type of sinusoidal wave.

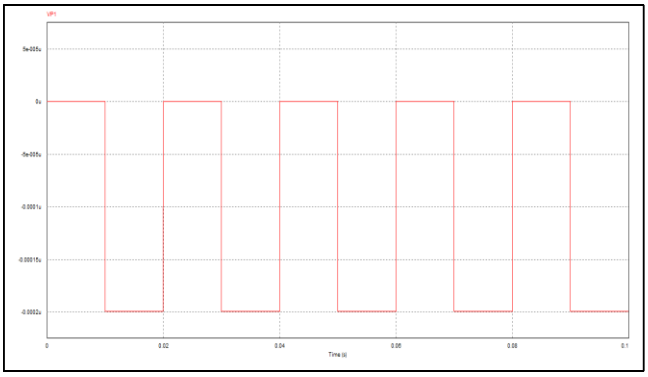

Fig. 1: Output of single phase inverter

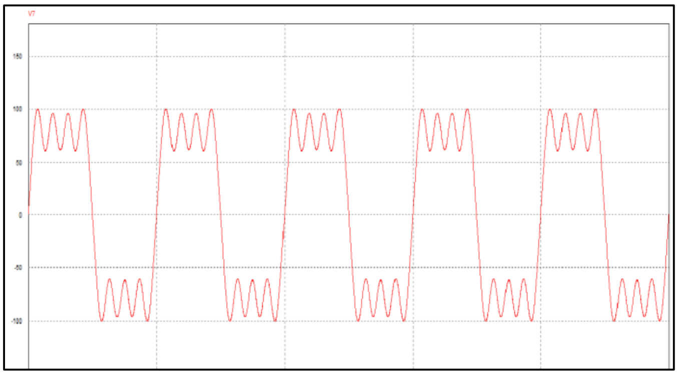

Fig. 2: Sine Wave and Harmonics

PWM is an inductor driven by a voltage source modulated as a series of pulses resulting in a sine like current in the inductor. The conduction period of switches in inverter are controlled in PWM inverter. Sometimes, there is single pulse or multiple pulse per half cycle of the output. The pulse width modulation is achieved by control circuits with the help of reference input.Two such topologies are described herein. In this paper, the SPWM (Sinusoidal Pulse Width Modulation) technique of unipolar and bipolar inverters is presented and the models are simulated in PSIM – Simulink.Variation of duty cycle of the PWM signal provides a voltages across the load in a specific pattern will appear to the load as AC signal. A pure sin wave is obtained after passing the signal through a low pass filter. The pattern at which the duty cycle of a PWM signal varies can be implemented using simple analogue components or a digital microcontroller. Either of the two basic topologies generate sinusoidal PWM that controls the output of the inverter. PWM signals find a wide application in modern electronics. Some of these reasons are

- Reduced Power Loss – switched circuits tend to have lower power consumption because the switching devices are almost always off (low current means low power) or hard-on (low voltage drop means low power).
- PWM signals are quite easy to generate. Many modern microcontrollers include PWM hardware within the chip; using this hardware often takes very little attention from the microprocessor and it can run in the background without interfering with executing code.
- The fact that the duty cycle of a PWM signal can be accurately controlled by simple counting procedures is one of the reasons why PWM signals can be used to accomplish digital-to-analogue conversion.
- The desired PWM technique should have the following characteristics:
- Good utilization of DC supplies voltage possibly a high voltage gain.
- Linearity of voltage control.
- Low amplitude of low order harmonic of output voltage to minimize the harmonic content of output currents.
- Low switching losses in inverter switches.

A. SPWM with Bipolar Voltage Switching

The upper and the lower switches in the same inverter legwork in a corresponding manner with one switch turned on and other turned off. Thus we need to consider only two independent gating signals and they are generated by comparing sinusoidal modulating wave Vm and triangular carrier wave Vcr.

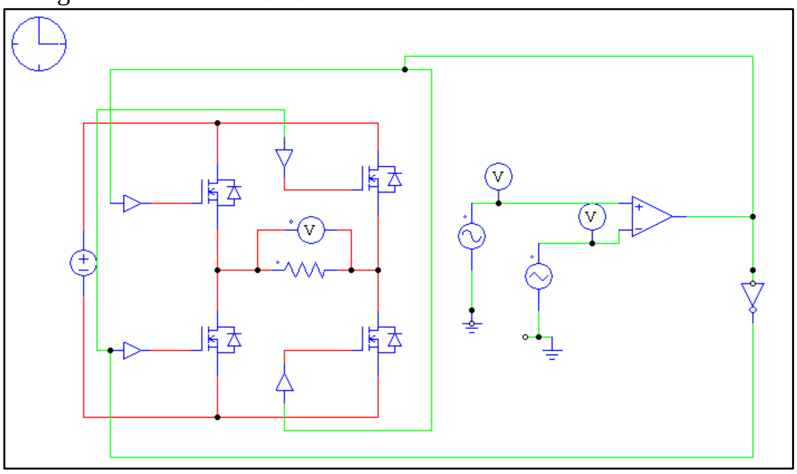

Fig. 3: Bipolar PWM Inverter

B. SPWM with Unipolar Voltage Switching

The unipolar modulation normally requires two sinusoidal modulating waves Vm and Vm- which are of same magnitude and frequency but 180 out of phase. The two modulating wave are compared through a common triangular carrier wave Vcr generating two gating signals for the upper two switches S1and S3can be observed that the upper two devices do not switch simultaneously, which is well-known from the bipolar PWM where all the four devices are switched at the same time. The inverter output voltage switches either between zero and +Vdc during positive half cycle or between zero and -Vdc during negative half cycle of the fundamental frequency this is called unipolar modulation.

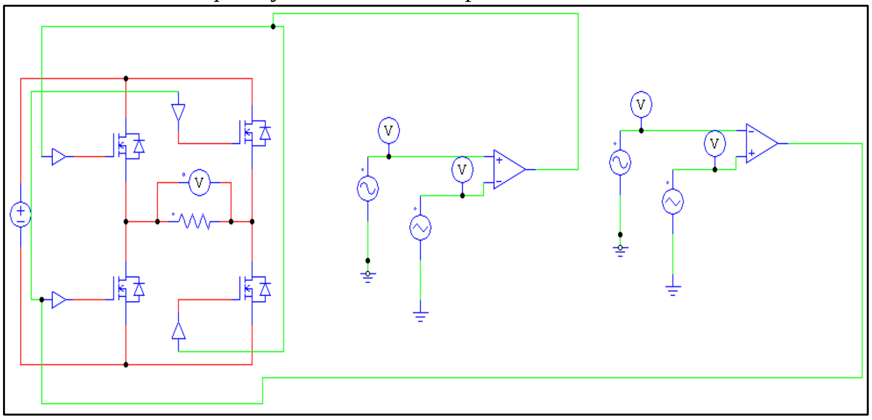

Fig. 4: Unipolar PWM Inverter

C. Three Phase Inverter

In this, similarly like the single phase inverter we are supplying 3-phase ac power of 0.8V is supplied from the function generator. The 3 phases are displaced by 120 phase shift. The carrier signal of 1V is compared in the op-amp. The output of these comparators is passed onto the power circuit containing switches. The output voltage and current is obtained in fig 6. The current wave is almost sinusoidal. The amplitude modulation index is less than 1 otherwise the data from the reference signal will be lost. The frequency of the carrier wave is 500Hz and 1 kHz. The load is taken that is squirrel cage induction motor. The output is taken for resistive and inductive load. The complete simulation is in fig. 5.

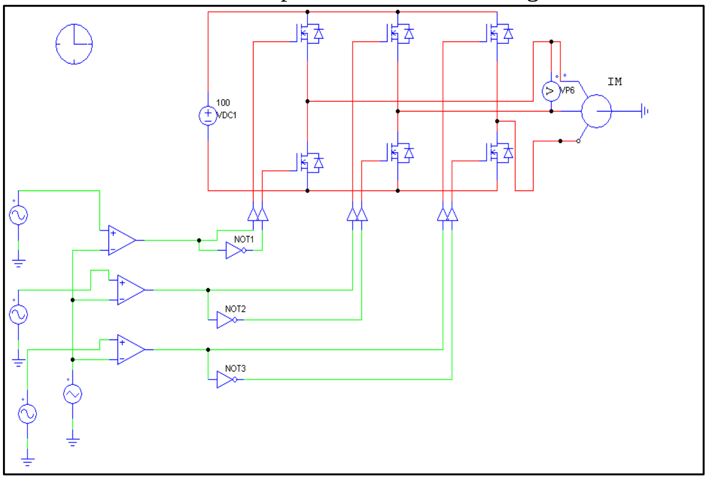

Fig. 5: Simulation of 3-phase PWM inverter

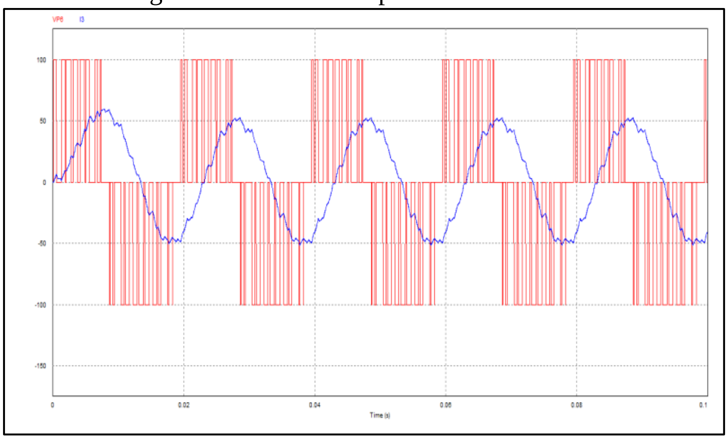

Fig. 6: Output of 3-phase PWM Inverter

Modulation index is the ratio of peak magnitudes of the modulating waveform and the carrier waveform. It relates the inverter’s dc-link voltage and the magnitude of pole voltage (fundamental component) output by the inverter. Now let ‘msin ( ) Vmωt’ be the modulating signal and let the magnitude of triangular carrier signal vary between the peak magnitudes of + lVc and - lVcmVmlVc. The ratio of the peak magnitudes of modulating wave ( ) and the carrier wave ( ) is defined as modulation-index (m). In other words:

$$M = Vm/Vc$$

And 0< M< 1.

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