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Analysis and Simulation of Asynchronous Machine Connected with Load Accomplished with Chopper Control and PWM Based Inverter

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ABSTRACT

This paper presents the simulation analysis of pulse width modulation based induction motor drive. The main objective of this paper is analysis of asynchronous machine with PWM fed inverter and harmonic analysis of active and reactive power as well as voltage and current. Space vector pulse width modulation technique is used in various industrial applications. Variation in voltage and frequency supply to ac drives is produced from a voltage source inverter and space vector PWM is used frequently now a day due to their easy understanding. This work is based on a SVPWM based induction motor based on space vector theory. The simulation is done on MATLAB software and the simulation results obtained and analyzed.

KEYWORDS: *Pulse Width Modulation (PWM), Insulated gate bipolar transistor (IGBT), THD (Total harmonic distortion), STATCOM (static synchronous compensator), SVC (static VAR compensator), and UPQC unified power quality conditioner*

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INTRODUCTION

Now a days due to increased power quality problems by using of switch off/on introduction loads, nonlinear load and induction motor etc. in domestic and industries, power-quality (PQ) problems, such as harmonics, flicker, and imbalance have become serious concerns. In addition, lightning strikes on transmission lines, switching of capacitor banks, and various network Faults can also cause PQ problems, such as transients, voltage sag/swell, and interruption. On the other hand, an increase of sensitive loads involving digital electronics and complex process controllers requires a pure sinusoidal supply voltage for proper load operation. To meet power quality to the standard limits need some sort of compensation. In few years back to mitigate the power quality problems in distribution system by using passive filters like capacitor banks. Now these research going very fast to mitigate the power quality problems with help of power conditioning devices [1].

Following are the requirements of reactive power compensation: (1) it is required to supply/absorb reactive power to maintain the rated voltage to deliver the active power through the long transmission lines. This Voltage support helps in (a) reduction of voltage fluctuation at a given terminal of the long transmission line. (b) An increase in transfer of active power through a long transmission line (c) increases the stability. (2) Many Loads like motor loads require reactive power for their proper operation. This Load compensation helps in (a) improvement of power factor (b) balancing of real power drawn from the supply (c) better voltage regulation due to large fluctuating loads. (3) The modern industries use electronic controllers which are sensitive to poor voltage quality and will shut down if the supply voltage is depressed and may mal-operate in other ways if changes of the supply voltage is excessive. Many of these modern load equipment's itself uses electronic switching devices which then can Contribute to poor network voltage quality [2]

Three phase induction motors are most widely used motors for any industrial control and automation. It is often required to control the output voltage of inverter for the constant voltage/frequency (V/F) control of an induction motor. PWM (Pulse Width Modulation) based firing of inverter provides the

Best constant V/F control of an induction motor. Amongst the various PWM techniques, the sinusoidal PWM is good enough and most popular that provides smooth changeover of V/F, four quadrant operation, harmonic elimination, etc. in both closed and open loop applications. Three phase induction motors are reliable, robust, and highly durable and of course need less maintenance. They are often known as workhouse of motion industries. When power is supplied to an induction motor with specified frequency and voltage, it runs at its rated speed. Many advanced semiconductor devices are available today in power electronics market like BJT, MOSFET, IGBT, etc. For this paper IGBT (Insulated Gate bipolar transistor) is used as a semiconductor device. [3]

Model of inverter

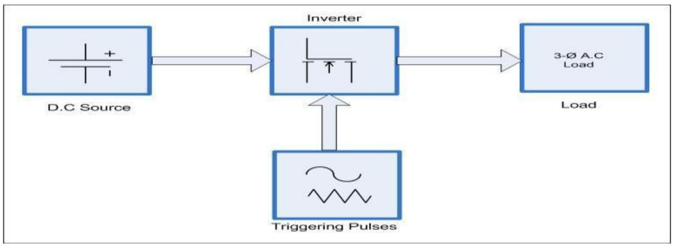

Figure 1 Block diagram of SPWM inverter

In this process a fixed input DC voltage is given to the inverter and a controlled ac output voltage is obtained by controlling on off periods of the inverter components. This method is most popular for controlling the output voltage and this method is

Known as pulse width modulation. By using this method lower order harmonics can be eliminated

ASYNCHRONOUS MACHINE

The Induction Motor has a stator and a rotor. The stator is wound for three phases and a fixed number of poles. It has stampings with evenly spaced slots to carry the three-phase windings. The number of poles is inversely proportional to the speed of the rotor. When the stator is energized, a moving magnetic field is produced and currents are formed in the rotor winding via electromagnetic induction. Based on rotor construction, Induction Motors are divided into two categories. In Wound-Rotor Induction Motors, the ends of the rotor are connected to rings on which the three brushes make sliding contact. As the rotor rotates, the brushes slip over the rings and provide a connection with the external circuit. In Squirrel-Cage Induction Motors, a "cage" of copper or aluminum bars encase the stator. These bars are then shorted by brazing a ring at the end connecting all the bars. This model is the more rugged and robust variant of the Induction Motor.

Working

When the stator winding is energized by a three-phase supply, a rotating magnetic field is set-up which rotates around the stator at synchronous speed Ns. This flux cuts the stationary rotor and induces an electromotive force in the rotor winding. As the rotor windings are short-circuited a current flows in them. Again as these conductors are placed in the stator's magnetic field, this exerts a mechanical force on them by Lenz's law. Lenz's law tells us that the direction of rotor currents will be such that they will try to oppose the cause producing them. Thus a torque is produced which tries to reduce the relative speed between the rotor and the magnetic field. Hence the rotor will rotate in the same direction as the flux. Thus the relative speed between the rotor and the speed of the magnetic field is what drives the rotor. Hence the rotor speed Nr always remains less than the synchronous speed Ns. Thus Induction Motors are also called Asynchronous Motors.

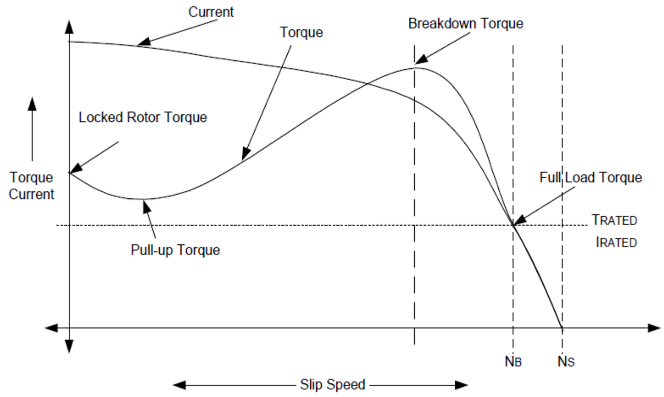

Figure 2 Torque slip characteristic of induction motor

INVERTER

A device that converts DC power into AC power at desired output voltage and frequency is known as Inverter. Phase controlled converters when operated in the inverter mode are called line commutated inverters. But line commutated inverters require at the output terminals an existing AC supply which is used for their commutation. This means that line commutated inverters can't role as isolated AC voltage sources or as variable frequency generators with DC power at the input. Therefore, voltage level, frequency and waveform on the AC side of the line commutated inverters can't be changed. On the other hand, force commutated inverters provide an independent AC output voltage of adjustable voltage and adjustable frequency and have therefore Much wider application. Inverters can be broadly classified into two types based on their operation:

- Voltage Source Inverters (VSI)
- Current Source Inverters (CSI)

Voltage Source Inverters is one in which the DC source has small or negligible impedance. In other words VSI has inflexible DC voltage source at its input terminals. A current source inverter is fed with adjustable current from a DC source of high impedance, i.e.; from an inflexible DC current source. In a CSI fed with stiff current source, output current waves are not affected by the load. [4]

INVERTER CONTROL

To control induction motor drives PWM inverters are very popular. Voltage source inverters mostly used to control both frequency and magnitude of voltage and current applied to motors. PWM fed induction motor drives gives better performance as compared to the fixed frequency induction motor drives.

A number of Pulse width modulation (PWM) schemes are used to obtain variable voltage and frequency from a Inverter to control IM drives But most widely used PWM techniques for three-phase VSI are Sine PWM (SPWM) and space vector PWM (SVPWM). But to reduce harmonic content & increase magnitude of voltage space vector PWM (SVPWM) is better than SPWM. Also space vector PWM technique (SVPWM) instead of sine PWM technique (SPWM) is utilized 15% more DC link voltage. So using SVPWM techniques for 3 phase inverter switches & Output of inverter is fed to speed control of IM drives. Simulation is done in a MATLAB/ SIMULINK.

The circuit model of a typical three-phase voltage source Bridge inverter is shown in Figure, S1 to S6 are the six power switches that shape the output, which are controlled by the switching variables a, a", b, b", c and c". When an upper switches is switched on, i.e., when a, b or c is 1, the

Corresponding lower switches is switched off, i.e., the Corresponding a", „b or c"is 0.Therefore, the on and off states of the upper transistors S1, S3 and S5 can be used to Determine the output voltage. [5]

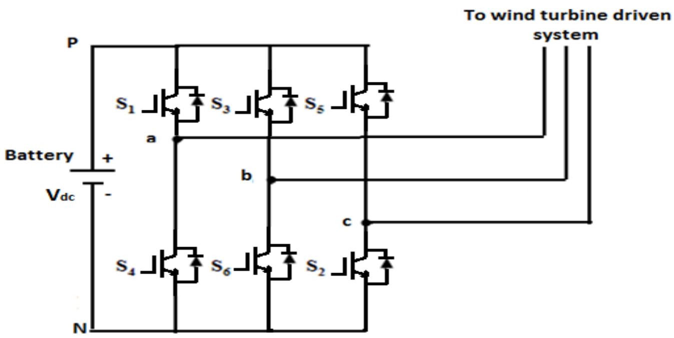

Figure 3 Six switch composition of converter

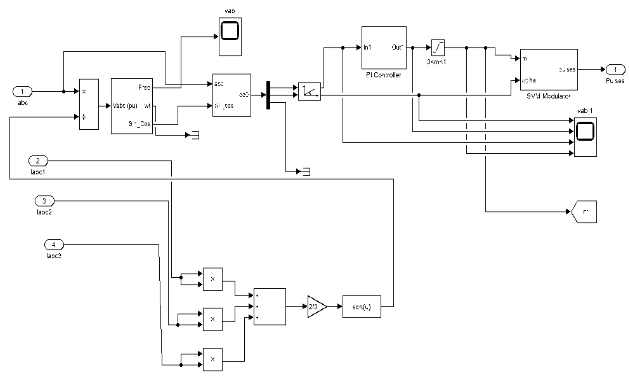

Figure4 Subsystem Of gate pulse generation

Gate pulse generation has been done with the help of SVM modulator accomplished with synchronous reference frame theory. Fig 5 shows that the generation of input currents of SVM modulator.

Control system of inverter

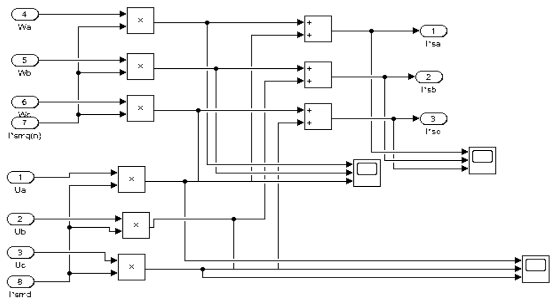

Figure 5Control system of inverter

CHOPPER

The concept used in this motor control is to implement the power switching device to chop the input source voltage. This method will cause the pulse-width of the AC voltage waveform to change. So, this method of AC voltage controller is called symmetrical pulse width modulation (PWM) figure 6 shows the circuit diagram of an AC The current in the inductive load always has a continuous path to flow regardless of its direction. To explain the operation of this circuit, three operating modes are proposed, namely active mode, freewheeling mode and dead time mode. The advantages of the AC chopper are simplicity, ability to control large amounts of power, low waveform distortion, high power factor and high response. [6]

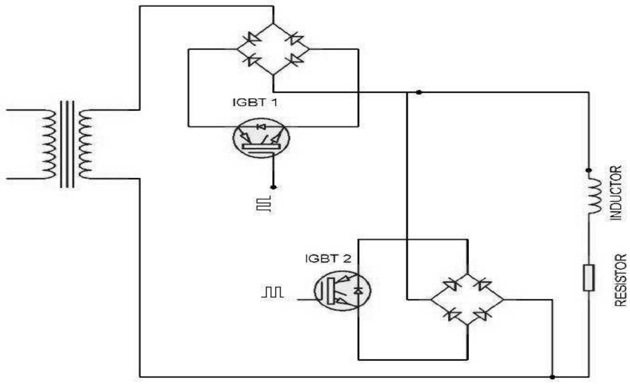

Figure 6 circuit diagram of symmetrical PWM AC chopper

This control system of inverter consists of three main subsystems. The first subsystem is voltage measurement block. This block measured three phase voltage of load side as it varies as voltage magnitude varies. This voltage is then converted to terminal voltage, line voltage and rms value of phase voltage. The next is controller. The Vt and Vt ref likewise Vdc and Vdc ref passes through controller. The output of this controller then passes through the PWM generator. This PWM generator compares the sinusoidal signal with the triangular wave and then generates the firing pulses by PWM modulation technique.

PROPOSED MODEL

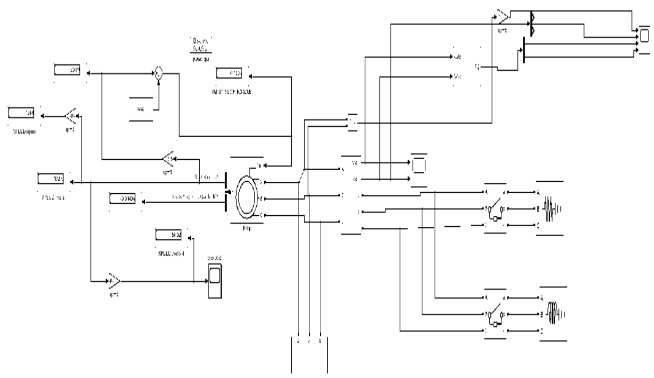

Figure 7 Model without PWM inverter

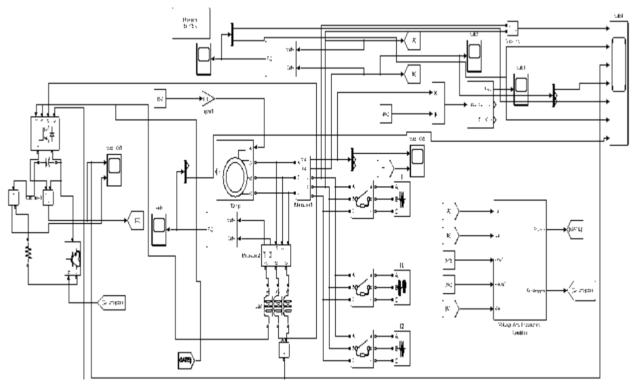

Figure 8 Model with PWM inverter

This proposed model describes the 7.5 Kw induction motor connected with appropriate loads and various measuring instruments to find out the variation in parameters at different stages and a PWM based inverter has been placed with a space vector control technique for the desired output. and the DC voltage is converted to AC voltage with the help of inverter and for the constant voltage magnitude and frequency a control system has been developed so that a constant voltage and frequency will be available to the load side or grid.

Various measurement system has been placed at various stages to measure all the parameters for the research and analysis at various stages of the system.

RESULTS

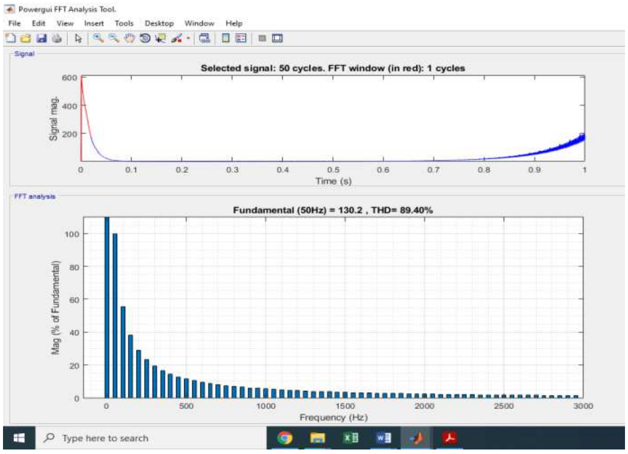

Figure 9FFT analysis before inverter

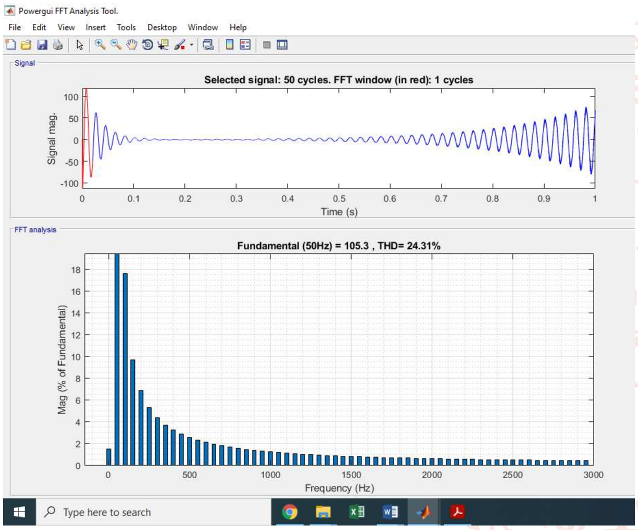

Figure 10FFT analysis after inverter

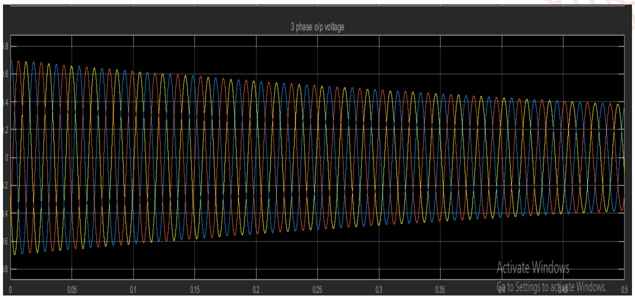

Figure 11Output voltage

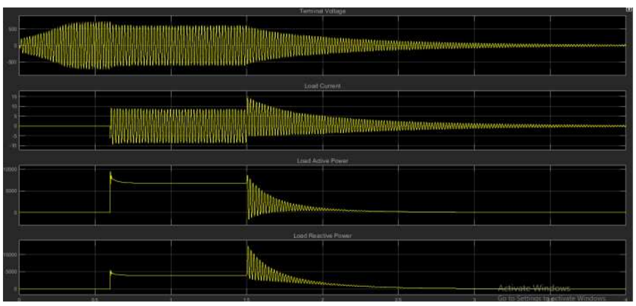

Figure 12Terminal voltage, current, active power and reactive power

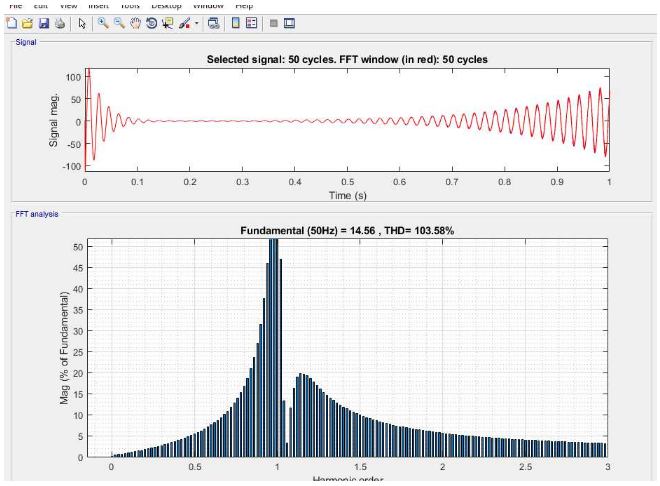

Figure 13 FFT analysis of proposed model without inverter

S.NO	PARAMETERS	
	Name of block	Specification
1	Induction motor	Power= 7.5 KW Stator resistance = 0.8ohm Inductance = 3 mH Rotor resistance = 0.8ohm Inductance = 3 mH
2	Connected load	Phase to phase voltage = 400 Frequency = 50
3	Inverter	Universal bridge = IGBT 3 arms

CONCLUSION

This paper presents an induction motor system connected with load in which PWM based inverter is used to produce three phase electricity generation. The whole model is simulated in MATLAB Simulink. Parameters taken has been described in the above table and the results are as shown in the above figures almost sinusoidal some more filtration has to be done accordingly to get the smooth output. In future we can work out on the total harmonic distortion has been reduced up to 24% by using PWM inverter before inverter THD value is near about 89%. THD can be reduced further by using different FACTS devices like SVC and STATCOM.

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