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Mitigation of Harmonics in Induction Motor using PWM Technique

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Abstract **-The number of industry applications in which induction motors are fed by static frequency inverters is growing fast and, although much has already been done within this field, there is still a lot to be studied regarding such applications. The advance of variable speed drives systems engineering increasingly leads to the need of specific technical guidance provision by electrical machines and drives manufacturers, so that such applications can be suitably designed in order to present actual advantages in terms of both energy efficiency and costs.**

In this paper, Pulse Width Modulation technique is using to mitigate the harmonics in induction motor which is developed by the rectifier, inverter and other power electronics devices. The PWM dc-to-ac inverter has been widely used in many applications such as uninterruptible power systems (UPS), motor drives, induction heating, etc., due to its circuit simplicity and rugged control scheme.

Keywords- **Harmonics, Induction Motor, PWM**

I. INTRODUCTION

Variable frequency ac drives are increasingly used for various applications in industry and traction. Due to the improvement of fast-switching semiconductor power devices, voltage source inverter (VSI) with PWM control, find particularly growing interest. Two basic concepts may be distinguished for small and medium-size drives the current controlled PWM has proved to be advantageous for big drives employing inverters with low switching frequency.

A new technique for high-frequency conversion has been proposed to reduce the component stress of voltage and current and the switching losses in the traditional PWM converter. The PWM inverter driving the machine is then required to excite the machine with these current commands. Various techniques have been devised by many researchers for controlling the output current of a PWM voltage-fed inverter. A current control technique has also been devised for three-phase PWM ac/dc converters. Switching frequency should be increased by decreasing switching losses to achieve higher power density and faster transient response in well known PWM dc–dc converters. A new active snubber cell is proposed to contrive a new family of PWM converters. This snubber cell provides perfectly zero voltage transition (ZVT) turn on and zero voltage transition (ZCT) turn off together for the main switch of a converter [1].

II. HARMONICS

Harmonics are familiar to the musician as the overtones from an instrument. They are the integer multiples of the instrument’s fundamental or natural frequency that are produced by a series of standing waves of higher and higher order [2]. The waveform of fig.1 shows a third harmonic which is in phase with the fundamental, a waveform that is a major portion of the square wave currents characteristic of single phase converters with inductive loads. The lower waveform shows a third harmonic of the same magnitude that is 180° out of phase with the fundamental, a major component of transformer exciting current Transformer exciting current, arc furnaces, SCR drives, rectifiers, and many other loads will produce harmonics in the utility lines. Most utilities limit the allowable harmonic current levels to the values shown in IEEE 519 [2].

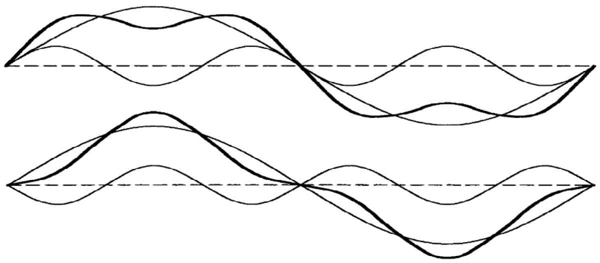

Fig.1 Sinusoidal wave form with harmonics

III. PWM TECHNIQUE

The PWM dc-to-ac inverter has been widely used in many applications such as uninterruptible power systems (UPS), motor drives, induction heating, etc., due to its circuit simplicity and rugged control scheme. In the proposed ZVS dc link technique, the switch voltage is clamped to the dc link voltage and PWM technique can be used to control the inverter output voltage. PWM Technique that uses a digital circuit to create a variable analog signal.

PWM is a simple concept open and close a switch at uniform, repeatable intervals. Analog circuits that vary the voltage tend to drift, and it costs more to produce ones that do not than it does to make digital PWM circuits. Output voltage from an inverter can also be adjusted by exercising a control within the inverter itself. The most efficient method of doing this is by PWM control used within an inverter.

The advantages possessed by PWM techniques are as under:

The output voltage control with this method can be obtained without any additional components. With the method, lower order harmonics can be eliminated or minimized along with its output voltage control. As higher order harmonics can be filtered easily, the filtering requirements are minimized. The main disadvantage of this PWM technique is that: SCRs are expensive as they must possess low turn-on and turn-off times [3-4].

IV. MODELING OF INDUCTION MOTOR WITHOUT USING ANY MITIGATION TECHNIQUE

The simulation model of induction motor without using any mitigation technique is show in fig. 2. In this model, rectifier is used to convert AC to DC and inverters are used to convert DC to AC. The IGBT's are used to design the inverter. Pulse generator are using for triggering purpose of inverter [5-6]. 60 Hz frequency is used as fundamental frequency. 5 HP, 460 Volts, 60 Hz, 1750 RPM induction motor has been used for simulation purpose. 90 volts, 3- phase source is used for supply source. A step up transformer used to step up the voltage [7].

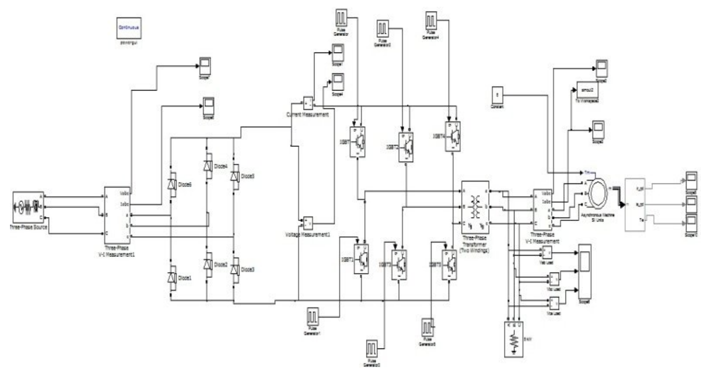

Fig.2 MATLAB Model of induction motor without using any technique

V. RESULTS OF INDUCTION MOTOR WITHOUT USING PWM

A. *Source Voltage*

A 3- phase AC source is used to supply the induction motor. Voltage waveform is shown in fig.3.

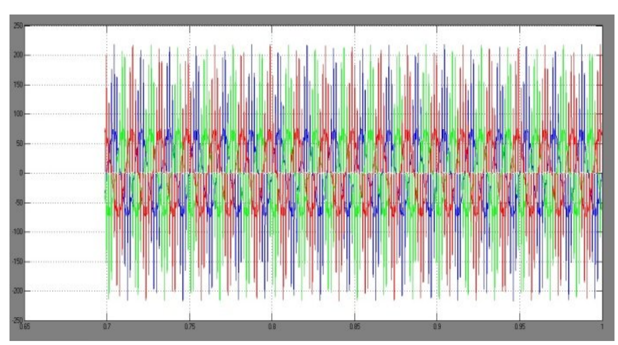

Fig.3 Source voltage

B. Rectifier Output

As discussed above about rectifier in chapter 4 that rectifier is used to convert AC to DC. The result of rectifier is showing in fig. 4

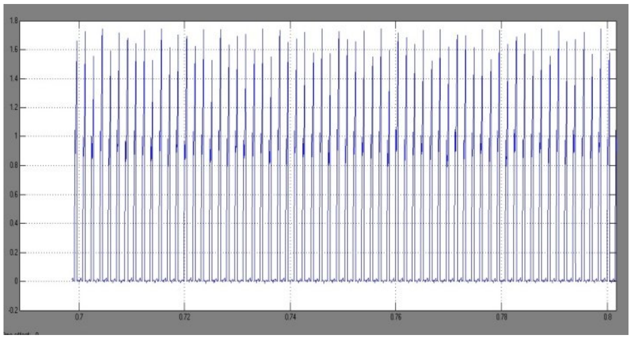

Fig.4 Rectifier Voltage

C. Inverter Output

The result of inverter output is showing in fig.5 which is sinusoidal waves. The output of inverter fed into induction motor.

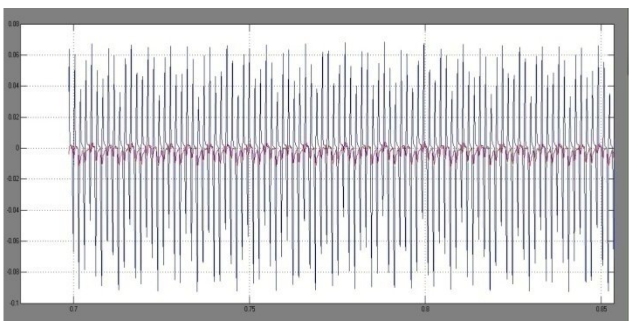

Fig.5 Inverter Voltage

D. Rotor Output

Rotor and stator current is shown in fig 6 and fig. 7. This output is not pure because of many harmonics.

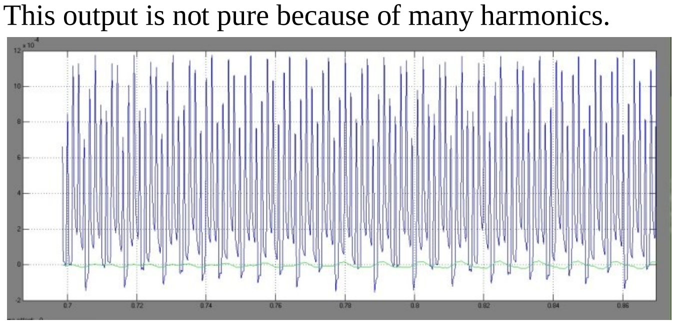

Fig.6 Rotor Output

E. Stator Output

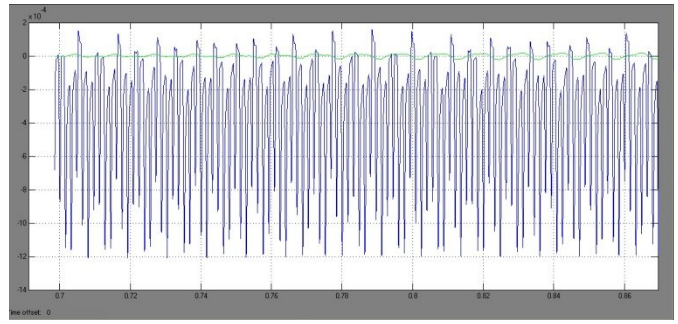

Fig.7 Stator Current

F. Rotor Torque

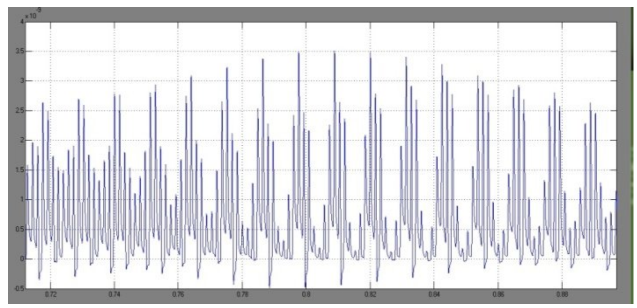

Fig.8 Rotor Current

G. Stator and Rotor Harmonics

Stator and rotor harmonics are shown in fig.9 and fig.10. Total Harmonics Distortion is 80.30 % in both stator and rotor currents. The fundamental frequency is 60 Hz.

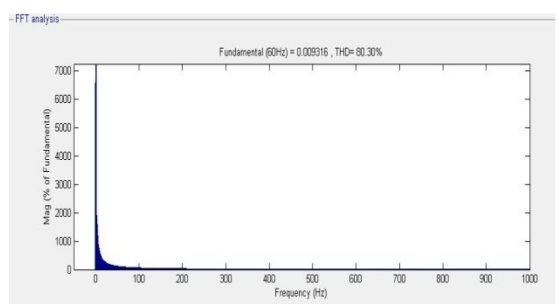

Fig.9 Stator Harmonics

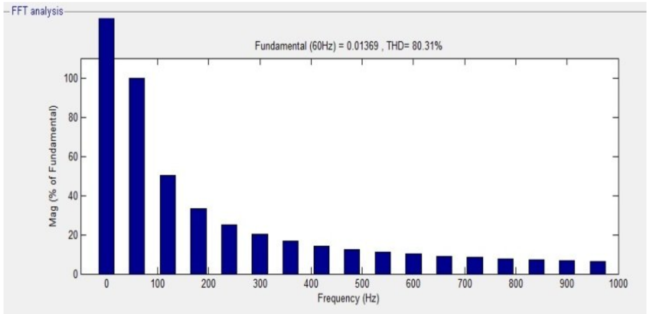

Fig. 10 Rotor Harmonics

VI. MITIGATE HARMONICS IN INDUCTION MOTOR USING PWM

The MATLAB simulation model is shown in fig.11. In this model sinusoidal Pulse Width Modulation is using to mitigate the harmonics which is 80.30 % as shown in fig.9 and fig.10. Supply source of 90 volts is used for induction motor. 5 HP, 460 Volts, 60 Hz, 1750 RPM induction motor is using for simulation purpose. 90 volts, 3- phase source is used for supply source. A step up transformer used to step up the voltage. . The rectifier is used to convert AC to DC and inverter is used for DC to AC. A snubber circuit is used between rectifier and inverter. RC filter is also used. A PWM generator is used to trigger the inverter [8].

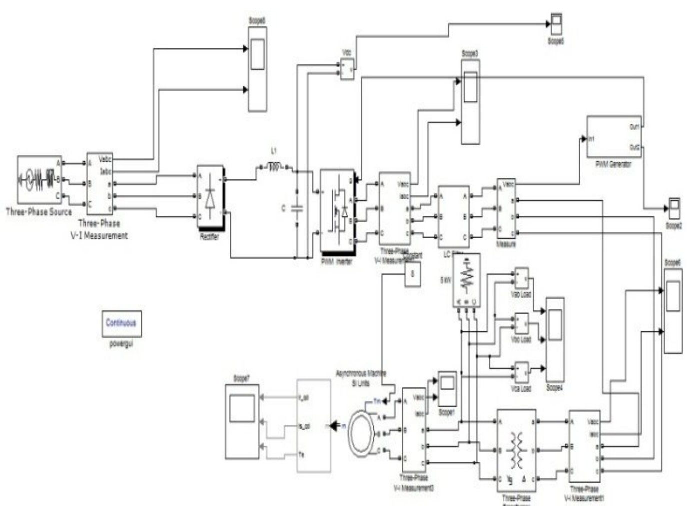

Fig. 11 Simulation model of induction motor with using PWM

VII. RESULTS OF INDUCTION MOTOR USING PWM

Source Voltage

The source voltage waveform is shown in fig. 12 volts. Here, 3- phase supply source is used.

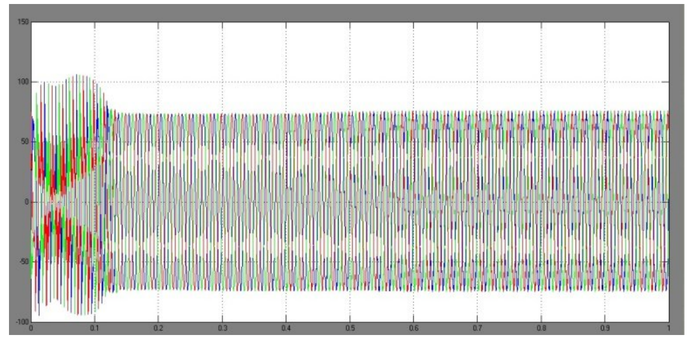

Fig. 12 Source Voltage

Rectifier and Inverter Output

The rectifier voltage and inverter voltage waveform is shown in fig.13 and fig. 14. Fig.13 shows the DC output waveform and fig.14 shows AC waveform.

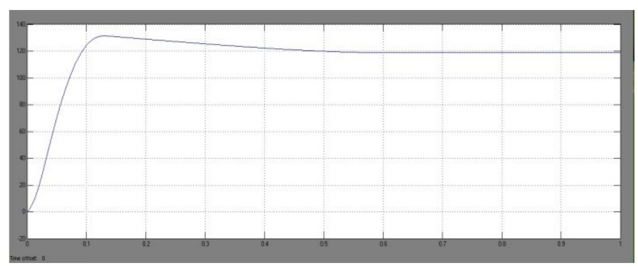

Fig. 13 Rectifier Voltage

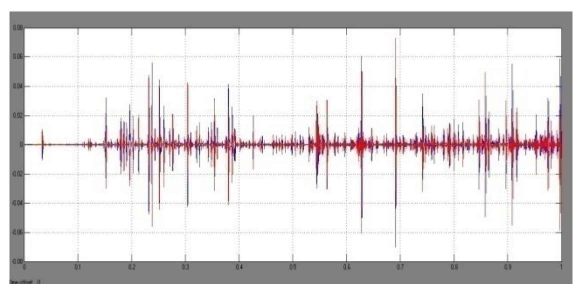

Fig. 14 Inverter Voltage

Rotor Output

The rotor voltage and stator voltage of induction motor is shown in fig. 15 and fig. 16.

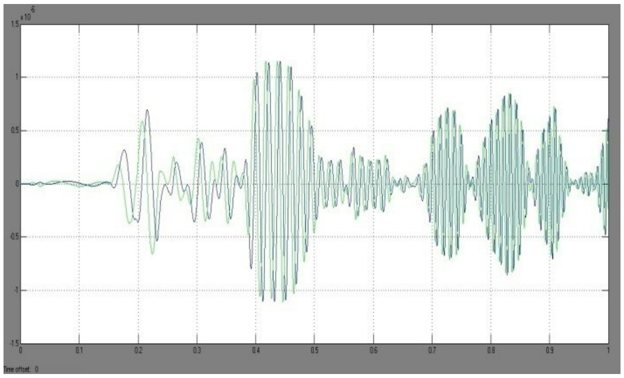

Fig.15 Rotor Output

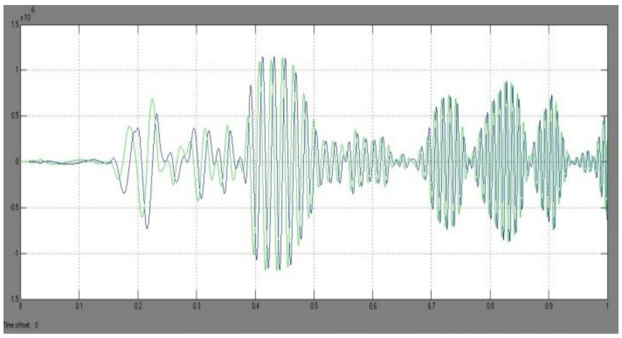

Fig.16 Stator Voltage

Rotor Torque

The rotor output is shown in fig.17.

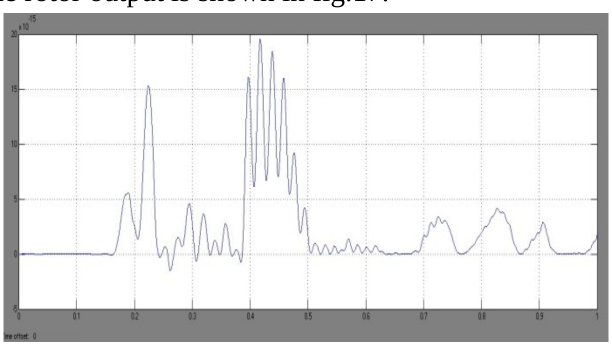

Fig. 17 Rotor Torque

Rotor Harmonics

The rotor current harmonics and stator current is shown in fig.18 and fig.19. This is mitigating harmonics by of the induction motor. Total Harmonics Distortion is 11.99 %.

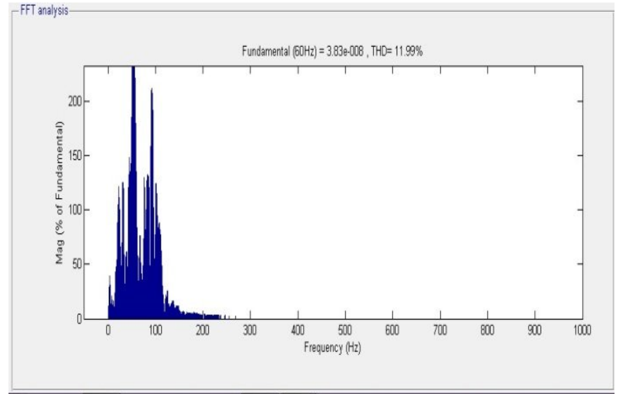

Fig.18 Mitigated Rotor Current Harmonics

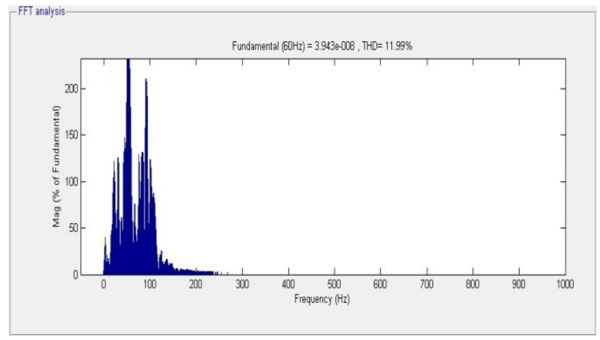

Fig.19 Mitigated Stator Current Harmonics

VIII. CONCLUSION

This paper presents a harmonics reduction technique which is using PWM generator to supply the induction motor. Rectifiers and inverters are also used to provide the supply to induction motor. Induction motors are widely used in industries. Harmonics can create many problems in induction motors which may be very dangerous for motor. So, it is very necessary to mitigate the harmonics and provide harmonics less supply to the induction motor. For this purpose PWM generators are used in supply. PWM technique is a technique which is used to mitigate the harmonics and speed control of induction motors. In this paper, total harmonics destructions (THD) are 80.99 % without using any mitigation technique and after using PWM technique, THD is controlled till 11.98 %. The stator and rotor voltage waveforms also get smoother.

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