Simulation Study Of Harmonics Of An Induction Motor Drive And Elimination Of Harmonics

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Abstract— *The advancement of the semiconductor devices in the recent years made to control the induction motors drives used in the various industries. The various semiconductor devices used in the control circuit of various devices are thyristor, MOSFET, IGBT, etc. The control circuit consists of the semiconductor devices generate the harmonics as well as distort the input waveform of the drive .It is necessary to reduce the amount of distorted waveform given to device to achieve better performance . In this project, an attempt has been made to study about the harmonic estimation of induction motor drive using simulation software using Simulink tool of Matlab. The induction motor is modeled using simulation tool and it is supplied by a three-phase Voltage Source Inverter (VSI). The output of three-phase VSI is subjected to the harmonic analysis in terms of the THD. The SVPWM technique and LC passive filter is proposed to reduce the amount of distortion and also the attempt has been made for hardware implementation of the proposed system.*

Keywords— Harmonics, THD, Waveform Distortion

1. INTRODUCTION

Electrical machines are extensively used and core of most engineering system. These machines have been used in all kinds of industries. An induction machine is defined as an asynchronous machine that comprises a magnetic circuit which interlinks with two electric circuits, rotating with respect to each other and in which power transferred from one circuit to the other by electromagnetic induction. It is an electromechanical energy conversion device in which the energy converts from electrical to mechanical form. The energy conversion depends upon the existence in nature of phenomena interrelating magnetic and electric fields on the other hand, and mechanical force and motion on the other. The rotor winding in induction motors can be squirrel cage type or wound rotor type. Thus, the induction motors are classified into two groups:

- Squirrel cage
- Wound rotor induction motors

The squirrel cage induction consist of conducting bars embedded in slots in the rotor iron and short circuited at each end by conducting end rings. The rotor bars are usually made of copper, aluminum, magnesium or alloy placed slots. Standard squirrel cage rotors have no insulation since bars carry large currents at low voltages. Another type of rotor , called a form wound motor, carries a poly phase winding similar to three phase stator winding .The terminals of the rotor winding are connected to 3 insulated slip rings mounted on the rotor shaft. In a form wound factor, slips rings are connected to an external variable resistance which can limit starting current and associated rotor heating. During start up, inserting external resistance in the wound rotor circuit produces a higher starting torque with less starting current than squirrel cage rotors. In everyday life induction motors are extensively used in all most of the industrial applications with control circuit as demand by the loads. Different methods of speed control are variable stator voltage, V/f method and converter based control circuits. Since converter control method is more accurate, precise and cost effective with compact in size of control circuit, is used in various industrial applications. The induction motor connected with a power electronic control suffers with power quality issues like waveform distortion and harmonics. In this project an attempt has been made to simulation study of waveform distortion and harmonic analysis of an induction motor control with three phase voltage source inverter. The proposed system is simulated, results are analyzed and conclusions are drawn. A squirrel cage induction motor is constant speed motor when connected to a constant voltage and constant frequency power supply. If the load toque increases, the speed drops by a very small amount. It is there suitable for use in constant speed drive system. In addition, the availability of solid state controllers has also made possible to use squirrel cage induction motors in variable speed drive system. The squirrel cage induction motor is widely in both low performance and high performance drive applications because of its roughness and versatility.

2. SIMULATION STUDY OF THE PROPOSED WORK

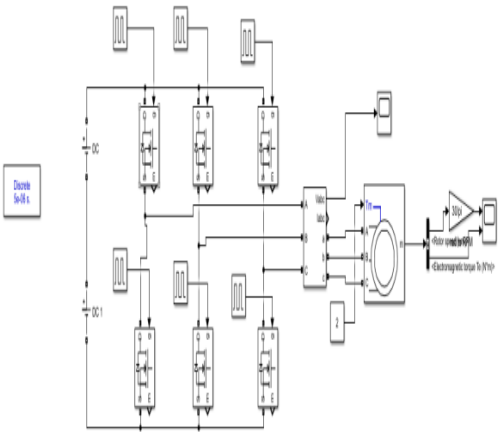

Fig 1Simulation model of induction motor without filter

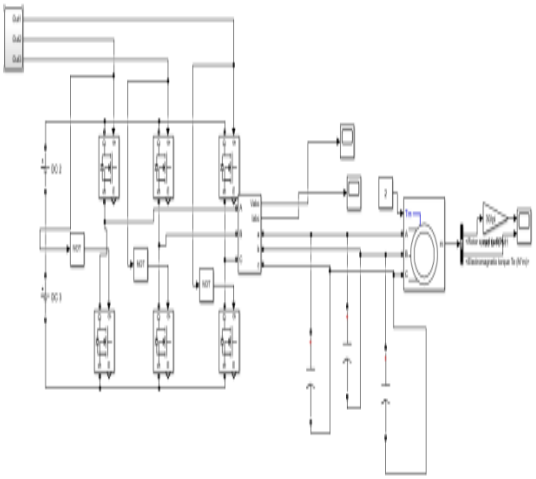

Fig 2 Simulation and control model of induction motor with passive filter

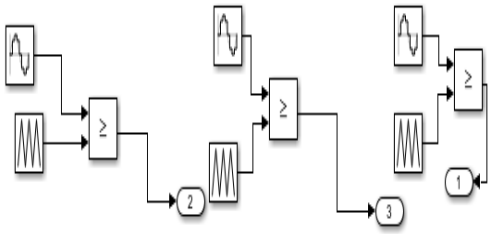

Fig 3 Simulation model of SVPWM

In the simulation study of proposed system an induction motor is supplied by three phase voltage source inverter. Three phase voltage source inverter modeled using MOSFETs. The proposed system a rectifier unit followed by three phase voltage source inverter. The fig 1 shows the simulation model of induction motor without the filter .Fig 2 shows simulation model of induction motor with a passive filter. In the present work in order to control of the motor ,SVPWM technique is implemented in the simulation.

Inductive load 1	5HP , 460V ,60HZ, 1750rpm
Inductive load 2	5HP , 460V ,60HZ, 1750rpm
$V_{dc} = V_{dc1} = V_{dc2} = V_{dc3}$ dc voltage	V_{dc}=400V
Fundamental frequency	F_S=50 Hz
Inverter switching frequency	F_{ch}=2khz-5kHz
Inductors	L=79.57mH,
Capacitors	C=2.14uF
Resistance	R=100 ohm

3. RESULTS AND ANALYSIS

The above simulation model is simulated using Simulink Matlab tool and results obtained as follows.
Fig 4 shows the waveform of harmonics without the filter. For the obtained waveform FFT analysis is carried out and estimated THD is 31.07% as shown in Table 2.

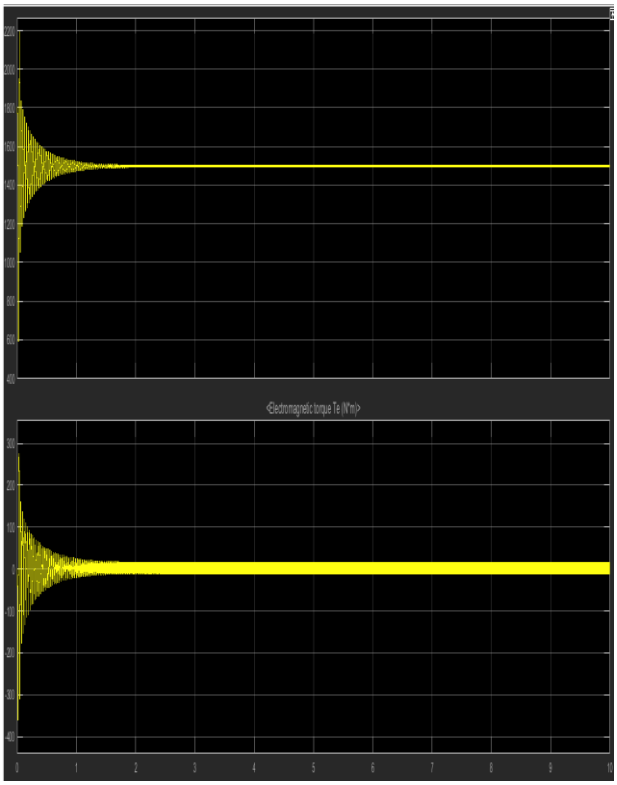

Fig 4 Waveform of harmonic analysis without filter

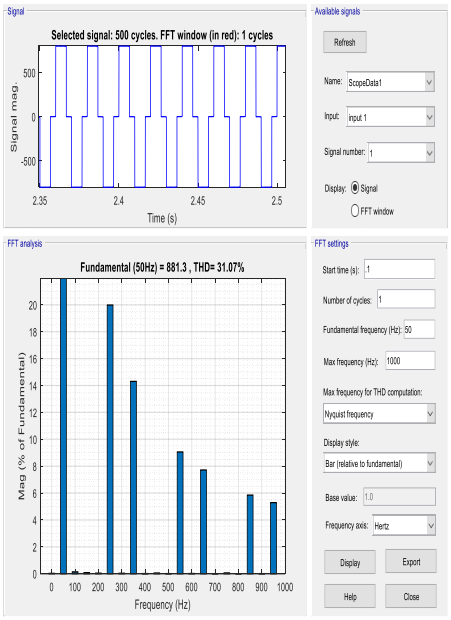

Fig 5 Harmonic analysis of induction motor without filter

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Sampling time     = 5e-06 s
Samples per cycle = 4000
DC component      = 0.2575
Fundamental       = 881.3 peak (623.2 rms)
THD               = 31.07%

     0 Hz  (DC):          0.26     90.0°
    50 Hz  (Fnd):       881.29     30.0°
   100 Hz  (h2):          1.23    -50.5°
   150 Hz  (h3):          0.72     25.1°
   200 Hz  (h4):          0.39    -38.2°
   250 Hz  (h5):        176.11    -30.1°
   300 Hz  (h6):          0.32     18.8°
   350 Hz  (h7):        126.07     29.5°
   400 Hz  (h8):          0.13     68.1°
   450 Hz  (h9):          0.48     79.6°
   500 Hz (h10):          0.11    -31.2°
   550 Hz (h11):         79.83    -30.7°
   600 Hz (h12):          0.18      3.1°
   650 Hz (h13):         68.01     29.1°
   700 Hz (h14):          0.08     43.1°
   750 Hz (h15):          0.53     83.7°
   800 Hz (h16):          0.06    -43.8°
   850 Hz (h17):         51.55    -31.2°
   900 Hz (h18):          0.10     -3.4°
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Table 2 Harmonic analysis of induction motor without filter

Proposed system is simulated with a filter as shown in fig 2 and its output waveform is shown Table 3 with a THD of 10.95%

Fig 6 Waveform of harmonic analysis with filter

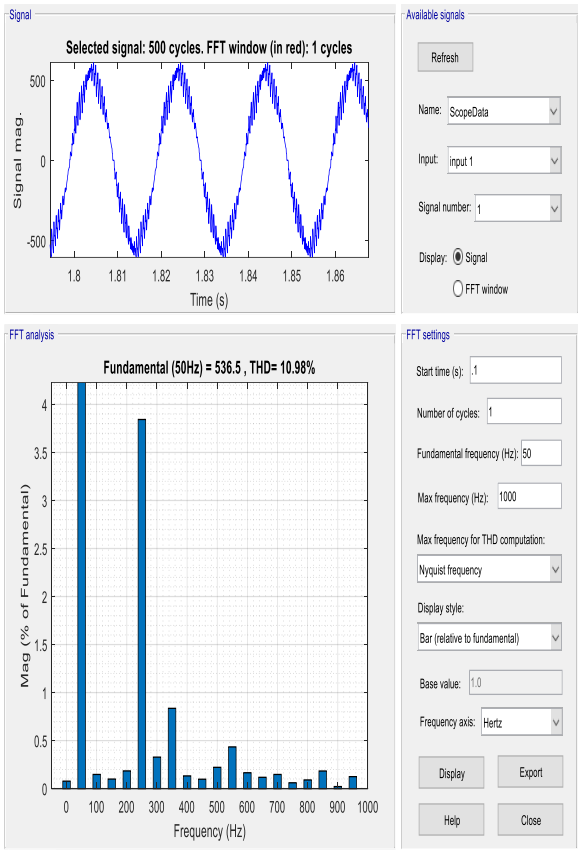

Fig 7 Harmonic analysis of induction motor with filters

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Sampling time     = 5e-06 s
Samples per cycle = 4000
DC component      = 0.4166
Fundamental       = 536.5 peak (379.4 rms)
THD               = 10.98%

     0 Hz  (DC):          0.42     90.0°
    50 Hz  (Fnd):       536.51     18.1°
   100 Hz  (h2):          0.79    -65.0°
   150 Hz  (h3):          0.53    -68.6°
   200 Hz  (h4):          0.99    102.0°
   250 Hz  (h5):         20.62     95.3°
   300 Hz  (h6):          1.76     -2.9°
   350 Hz  (h7):          4.48      1.1°
   400 Hz  (h8):          0.71    226.6°
   450 Hz  (h9):          0.52    -18.1°
   500 Hz (h10):          1.19      8.3°
   550 Hz (h11):          2.33    267.7°
   600 Hz (h12):          0.89    213.9°
   650 Hz (h13):          0.63     61.2°
   700 Hz (h14):          0.79     30.5°
   750 Hz (h15):          0.33    110.2°
   800 Hz (h16):          0.48     35.5°
   850 Hz (h17):          0.98    108.3°
   900 Hz (h18):          0.12    -30.7°
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Table 3 Harmonic analysis of induction motor with filter

It is observed that due to the presence of semiconductor device in rectifier and three stage voltage source inverter, the input waveform of the induction motor is distorted with THD of 31.07% and is reduced to level of 10.95% with filter. The torque waveform of the induction motor with and without filter of simulation study is also presented. In this work SVPWM procedure is utilized to decrease the

higher scale harmonious as well as total harmonic distortion.

4. EXPERIMENTATION

The work id also extended to the hardware implementation of the proposed system with the filter circuit. Filter circuit consists of L and C elements. In this circuit utilizes a torriodal inductor and capacitor of 37µH & One micro farad are utilized. Fig 8 shows the experimental setup. The input current waveform of the induction motor without and with filter is as shown in fig 9 &10. It is observed that without the filter the current waveform is highly distorted and with filter distortion level is reduced.

Fig 8 experimental setup.

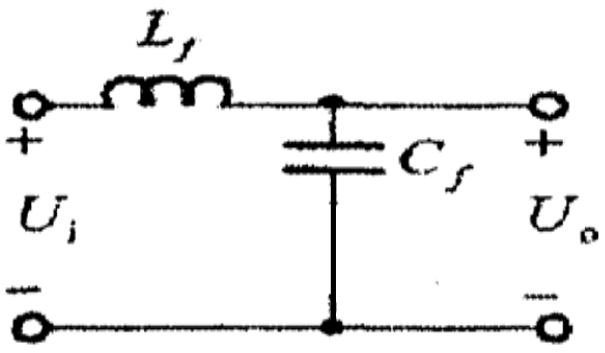

Fig 8(a)filter circuit

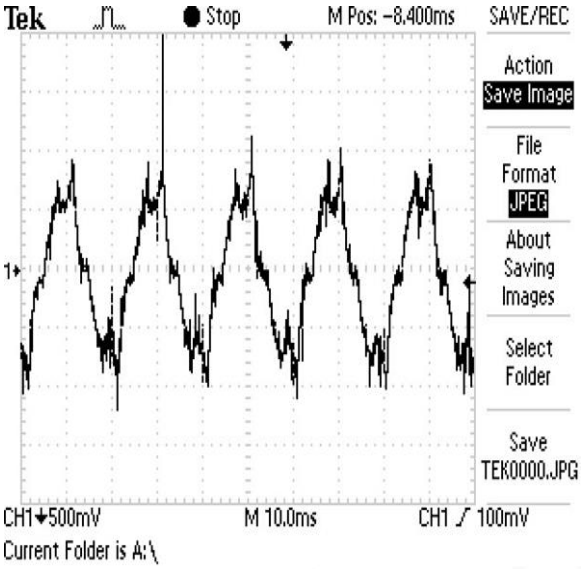

Fig 9 Waveform of input current without filter

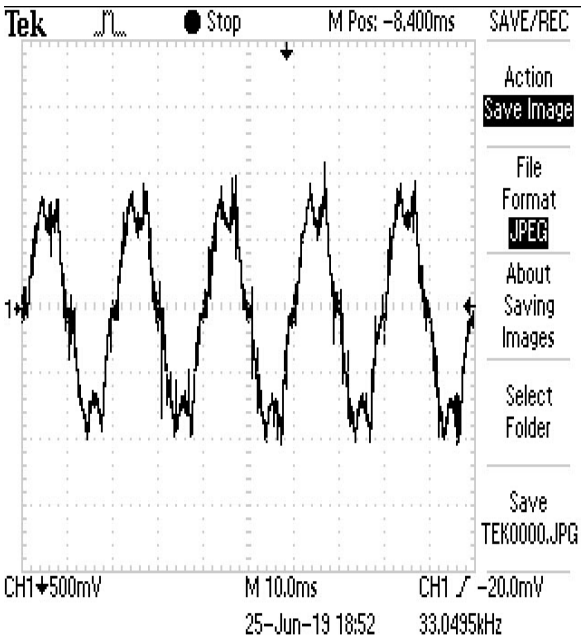

Fig 10 waveform of input current with filter

5. CONCLUSION

In this proposal work, an attempt has been made to simulation study of harmonics of induction motor drive. Simulation study is carried out by modelling of an induction motor with SVPWM technique and obtained results are analysed with following important conclusions:

- The induction motor controlled by three phase voltage inverter without filter leads to the waveform distortion with THD of 31.07%,
- The induction motor controlled by three phase voltage inverter with filter leads to the waveform distortion with THD of 10.95%,

- The hardware implementation also shows the waveform distortion and reduction of THD with filter.

  Finally, from the study it gives an idea about the study of harmonic analysis of induction motor very much important in terms of waveform distortion which disturbs the performance of the motor.

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