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Performance Investigation on Buck Boost Converter with Induction Drive Using SVPWM Controller

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Abstract **- This article presents a SVPWM technique for inverter with two levels to operate the IM drive (induction motor) with Buck Boost converter. SVPWM are increasingly gained importance in high power industrial drive applications. SVPWM technique is preferred in order to decrease the THD value, switching losses and ripples. If any fault occurs in the main supply, the Buck Boost converter which acts as a battery storage device is used as supply to continuously drive the induction without any interruption. The main advantage of Buck Boost converter is it has continuous flow of input current. In the proposed scheme, the two-level SVPWM technique strategy fed IM has been modeled and simulated using MATLAB/SIMULINK software.**

Keywords**: MATLAB, SVPWM, Buck Boost Converter, Induction Motor**

I. INTRODUCTION

The 3 phase inverters fed IM are mainly utilized motor for elevated power industrial drive applications. The inverter topologies are currently used in hybrid electrical vehicles and electrical vehicles. The researcher fond in PWM method has been concentrated in past years. The space vector PWM reduces THD and also switching losses, ripples etc [1-9]. The PWM control techniques are most resolution in harmonic free atmosphere. The SVPWM produce less improved primary output with improved quality differenced with SPWM [15]. The aim of PWM method was to make an AC sinusoidal wave output degree and frequency might be controlled. The multilevel converter fed with IM is controlled using PWM method. The SVM technique is utilized to organize pulses to inverter [16]. DC-DC converters are used for the conversion of unregulated DC voltage into regulated DC voltage. The converter gives continuous input current [17]. The sinusoidal PWM inverter utilized in small and medium applications experiences from lower harmonics [19]. The frequency, input side voltage, voltage of the output, and total power are reliant to the developed and designed circuitry. The main purpose of the system is to create an AC output power obtained from a DC. The Buck Boost converter is used as a battery storage device which steps up the voltage from the battery and supplies the inverter. If in case of any fault or any interruption occurs in the main supply of inverter Buck Boost converter comes into operation. So the motor rotates continuously. It saves the lifetime of the induction motor.

II. BLOCK DIAGRAM

The overall diagram of the developed system is presented in Fig. 1. It include of an AC supply, rectifier, filter, Buck Boost converter, battery, inverter, PWM generator and induction motor. The major problem attained by the engineers is decrease the harmonic in inverter output.

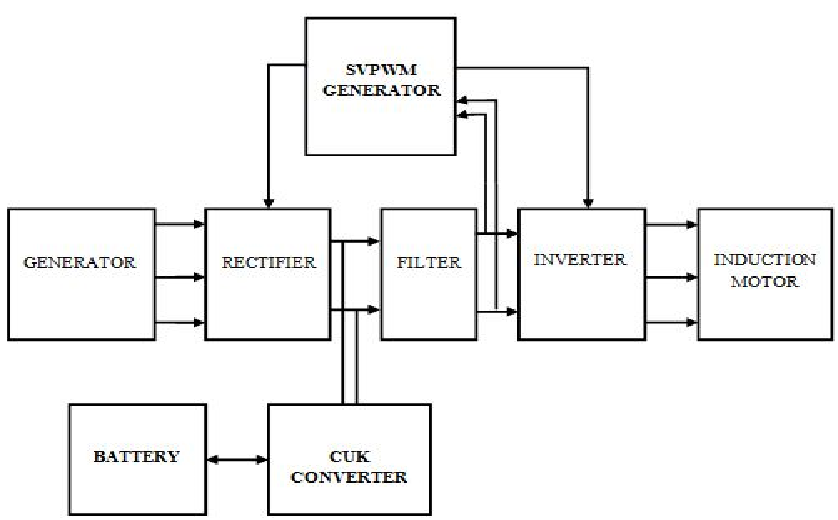

Fig. 1 Block Diagram

The 3 phase AC supply is converted to DC supply using the bridge rectifier. Filter is used to get the pure DC output. Buck Boost inverter is used as a battery charger. The rectifier output and the Buck Boost converter output are given to the filter and the filtered output is given to the inverter which is fed with the induction motor drive. The pulse generator is utilized to produce the pulses and given to the converter. The pulse generator uses the PWM technique for inverter called SVPWM. This helps the motor to drive efficiently.

III. SPACE VECTOR PWM

SVPWM is a technique in which a preset input supply is applied to the converter and obtained the output voltage. This voltage is applied to the converter. PWM technique is inner control technique and its given good result compared to external control. An appropriate PWM method is utilized to get the essential output of the system. SVPWM is modern technique which given good result compared to PWM.

SVM is a developed new algorithm for organizing the pulses and it's applied to inverter. The most objectives of SVM are a reduced amount of loss in switching operation, fewer THD, simple implementation and a smaller amount computational calculation. The benefit of this technique is improved flexibility in the option in output and input voltage of switching vector. Space Vector PWM method consists of 2 controls; one is direct and second one is vector control. In projected system used vector control. The vector control method is subdivided into two categories: direct vector control and indirect vector control.

A. Space Vector Concept

The proposed concept in the SVPWM technique is resulting from rotating AC magnetic field from output voltage. The stationary frame technique is presented in this modulation.

$$V_s = V_a + V_b e^{j\frac{2\pi}{3}} + V_c e^{-j\frac{2\pi}{3}} \quad (1)$$

The procedure of receiving the rotating SV is give details the SRF was measured in this section. In SRF let the 3 phase voltages are,

$$V_a = V_m \sin\omega t \quad (2)$$
$$V_b = V_m \sin(\omega t + 120) \quad (3)$$
$$V_c = V_m \sin(\omega t - 120) \quad (4)$$

Substituting equation (2), (3), (4) in equation (1)

$$V_s = \frac{3}{2} V_m [\sin\omega t - j\cos\omega t] \quad (5)$$

Space vector may also be written as

$$V_s = V_x + V_y \quad (6)$$

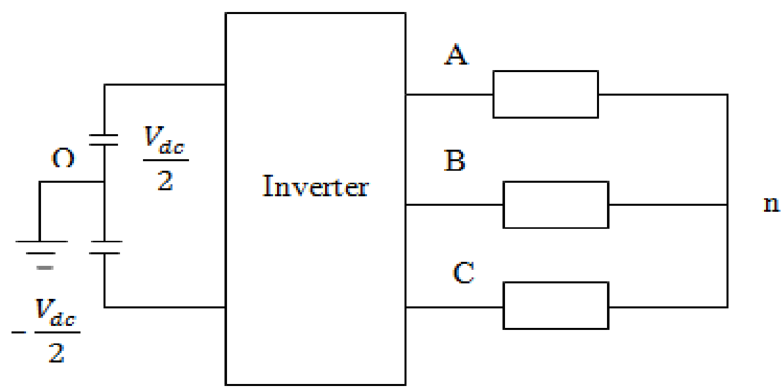

Fig. 2 Simplified Inverter Model

$$\begin{bmatrix} V_X \\ V_Y \end{bmatrix} = \begin{bmatrix} 1 & \frac{-1}{2} & \frac{-1}{2} \\ 0 & \frac{\sqrt{3}}{2} & \frac{-\sqrt{3}}{2} \end{bmatrix} \begin{bmatrix} V_{an} \\ V_{bn} \\ V_{cn} \end{bmatrix} \quad (7)$$

$$V_x = V_{an} - \frac{1}{2}[V_{bn} + V_{cn}]$$

$$V_x = \frac{3}{2} V_{an} \quad (8)$$

$$V_y = \frac{\sqrt{3}}{2}[V_{bn} - V_{cn}] \quad (9)$$

Let V_{ao}, V_{bo}, V_{co} be either $\frac{-V_{dc}}{2}$ or $\frac{V_{dc}}{2}$

$$V_{ao} = V_{an} + V_{no}$$
$$V_{bo} = V_{bn} + V_{no}$$
$$V_{co} = V_{cn} + V_{no}$$

The line voltages

$$V_{an} + V_{bn} + V_{cn} = 0 \quad (10)$$

Modified Equation (8) and we get

$$V_{an} + V_{no} + V_{bn} + V_{no} + V_{cn} + V_{no} = V_{ao} + V_{bo} + V_{co}$$
$$3V_{no} = V_{ao} + V_{bo} + V_{co}$$
$$V_{no} = \frac{1}{3}[V_{ao} + V_{bo} + V_{co}]$$
$$V_{ao} = V_{an} + \frac{1}{3}[V_{ao} + V_{bo} + V_{co}]$$
$$V_{an} = V_{ao} - \frac{1}{3}V_{ao} - \frac{1}{3}[V_{bo} + V_{co}]$$

Therefore,

$$V_{an} = \frac{2}{3}V_{ao} - \frac{1}{3}[V_{bo} + V_{co}] \quad (11)$$

Similarly,

$$V_{bn} = \frac{2}{3}V_{bo} - \frac{1}{3}[V_{ao} + V_{co}] \quad (12)$$

$$V_{cn} = \frac{2}{3}V_{co} - \frac{1}{3}[V_{ao} + V_{bo}] \quad (13)$$

$$\begin{bmatrix} V_{an} \\ V_{bn} \\ V_{cn} \end{bmatrix} = \frac{1}{3}\begin{bmatrix} 2 & -1 & -1 \\ -1 & 2 & -1 \\ -1 & -1 & 2 \end{bmatrix}\begin{bmatrix} V_{ao} \\ V_{bo} \\ V_{co} \end{bmatrix} \quad (14)$$

In this, two-level three phase inverter is preferred, therefore 2^3=8 vectors

For (0, 0, 0) and (1, 1, 1) i.e. vector V_0 and V_7

$$V_{ao} = V_{bo} = V_{co} = 0$$
$$\text{and } V_{an} = V_{bn} = V_{cn} = 0$$
$$V_X = V_Y = 0$$

Substitute $V_X = V_Y = 0$ in equation (6) gives,

$$V_0 \text{ and } V_7 = 0\angle 0° \quad (15)$$

For V_1 (1, 0, 0)

$$V_{a0} = \frac{V_{dc}}{2}$$
$$V_{bo} = V_{co} = -\frac{V_{dc}}{2}$$

Substitute V_{a0}, V_{bo} and V_{co} in equation (14)

$$\begin{bmatrix} V_{an} \\ V_{bn} \\ V_{cn} \end{bmatrix} = \frac{1}{3}\begin{bmatrix} 2 & -1 & -1 \\ -1 & 2 & -1 \\ -1 & -1 & 2 \end{bmatrix}\begin{bmatrix} \frac{V_{dc}}{2} \\ \frac{-V_{dc}}{2} \\ \frac{-V_{dc}}{2} \end{bmatrix}$$

This gives,

$$\begin{bmatrix} V_{an} \\ V_{bn} \\ V_{cn} \end{bmatrix} = \begin{bmatrix} \frac{2}{3}V_{dc} \\ -\frac{1}{3}V_{dc} \\ -\frac{1}{3}V_{dc} \end{bmatrix}$$

(i.e.),

$$V_{an} = \frac{2}{3}V_{dc}$$
$$V_{bn} = V_{cn} = -\frac{1}{3}V_{dc}$$

Substitute the above two equations in equation (8) and (9) gives,

$$V_x = \frac{3}{2} \times \frac{2}{3}V_{dc}$$
$$V_x = V_{dc}$$

$$\text{And } V_y = \frac{\sqrt{3}}{2}\left(-\frac{1}{3}V_{dc} + \frac{1}{3}V_{dc}\right)$$
$$V_y = 0$$

Therefore $V_s = V_x + V_y$ gives,

$$V_1 = V_{dc}\angle 0° \quad (16)$$

For V_2(1, 1, 0)

$$V_{ao} = V_{bo} = \frac{V_{dc}}{2}, V_{c0} = -\frac{V_{dc}}{2}$$

Substitute V_{a0}, V_{bo} and V_{co} in equation (14)

$$\begin{bmatrix} V_{an} \\ V_{bn} \\ V_{cn} \end{bmatrix} = \frac{1}{3}\begin{bmatrix} 2 & -1 & -1 \\ -1 & 2 & -1 \\ -1 & -1 & 2 \end{bmatrix}\begin{bmatrix} \frac{V_{dc}}{2} \\ \frac{V_{dc}}{2} \\ \frac{-V_{dc}}{2} \end{bmatrix}$$

And

$$V_{an} = V_{bn} = \frac{1}{3}V_{dc} \ , V_{cn} = -\frac{2}{3}V_{dc}$$

Substitute the above two equations in equation (8) and (9) gives,

$$V_x = \frac{1}{2}V_{dc}$$
$$\text{And } V_y = \frac{\sqrt{3}}{2}V_{dc}$$

Therefore $V_s = V_x + V_y$ gives,

$$V_2 = V_{dc}\angle 60° \quad (17)$$

For V_3(0, 1, 0)

$$V_{ao} = V_{co} = -\frac{V_{dc}}{2}, V_{b0} = \frac{V_{dc}}{2}$$

Substitute V_{a0}, V_{bo} and V_{co} in equation (14)

$$\begin{bmatrix} V_{an} \\ V_{bn} \\ V_{cn} \end{bmatrix} = \frac{1}{3}\begin{bmatrix} 2 & -1 & -1 \\ -1 & 2 & -1 \\ -1 & -1 & 2 \end{bmatrix}\begin{bmatrix} -\frac{V_{dc}}{2} \\ \frac{V_{dc}}{2} \\ \frac{-V_{dc}}{2} \end{bmatrix}$$

$$V_{an} = V_{cn} = -\frac{1}{3}V_{dc}, \ V_{bn} = \frac{2}{3}V_{dc}$$

Substitute the above two equations in equation (8) and (9) gives,

$$V_x = -\frac{1}{2}V_{dc}$$
$$\text{And } V_y = \frac{\sqrt{3}}{2}V_{dc}$$

Therefore $V_s = V_x + V_y$ gives,

$$V_3 = V_{dc}\angle 120° \quad (18)$$

For V_4(0, 1, 1)

$$V_{a0} = -\frac{V_{dc}}{2}, V_{bo} = V_{co} = \frac{V_{dc}}{2}$$

Substitute V_{a0}, V_{bo} and V_{co} in equation (14)

$$\begin{bmatrix} V_{an} \\ V_{bn} \\ V_{cn} \end{bmatrix} = \frac{1}{3}\begin{bmatrix} 2 & -1 & -1 \\ -1 & 2 & -1 \\ -1 & -1 & 2 \end{bmatrix}\begin{bmatrix} -\frac{V_{dc}}{2} \\ \frac{V_{dc}}{2} \\ \frac{V_{dc}}{2} \end{bmatrix}$$

$$V_{an} = -\frac{2}{3}V_{dc} \ , V_{bn} = V_{cn} = \frac{1}{3}V_{dc}$$

Substitute the above two equations in equation (8) and (9) gives,

$$V_x = -V_{dc}$$

$$\text{And } V_y = 0$$

Therefore $V_s = V_x + V_y$ gives,

$$V_4 = V_{dc}\angle 180° \quad (19)$$

For $V_5(0, 0, 1)$

$$V_{ao} = V_{bo} = -\frac{V_{dc}}{2}, V_{c0} = \frac{V_{dc}}{2}$$

Substitute V_{a0}, V_{bo} and V_{co} in equation (14)

$$\begin{bmatrix} V_{an} \\ V_{bn} \\ V_{cn} \end{bmatrix} = \frac{1}{3}\begin{bmatrix} 2 & -1 & -1 \\ -1 & 2 & -1 \\ -1 & -1 & 2 \end{bmatrix}\begin{bmatrix} -\frac{V_{dc}}{2} \\ -\frac{V_{dc}}{2} \\ \frac{V_{dc}}{2} \end{bmatrix}$$

$$V_{an} = V_{bn} = -\frac{1}{3}V_{dc}, V_{cn} = \frac{2}{3}V_{dc}$$

Substitute the above two equations in equation (8) and (9) gives,

$$V_x = -\frac{1}{2}V_{dc}$$

$$\text{And } V_y = -\frac{\sqrt{3}}{2}V_{dc}$$

Therefore $V_s = V_x + V_y$ gives,

$$V_5 = V_{dc}\angle 240° \quad (20)$$

For $V_6(1, 0, 1)$

$$V_{ao} = V_{co} = \frac{V_{dc}}{2}, V_{b0} = -\frac{V_{dc}}{2}$$

Substitute V_{a0}, V_{bo} and V_{co} in equation (14)

$$\begin{bmatrix} V_{an} \\ V_{bn} \\ V_{cn} \end{bmatrix} = \frac{1}{3}\begin{bmatrix} 2 & -1 & -1 \\ -1 & 2 & -1 \\ -1 & -1 & 2 \end{bmatrix}\begin{bmatrix} \frac{V_{dc}}{2} \\ -\frac{V_{dc}}{2} \\ \frac{V_{dc}}{2} \end{bmatrix}$$

$$V_{an} = V_{cn} = \frac{1}{3}V_{dc}, V_{cn} = -\frac{2}{3}V_{dc}$$

Substitute the above two equations in equation (8) and (9) gives,

$$V_x = \frac{1}{2}V_{dc}$$

$$\text{And } V_y = -\frac{\sqrt{3}}{2}V_{dc}$$

Therefore $V_s = V_x + V_y$ gives,

$$V_6 = V_{dc}\angle 300° \quad (21)$$

The eight vectors are calculated above which forms the hexagon.

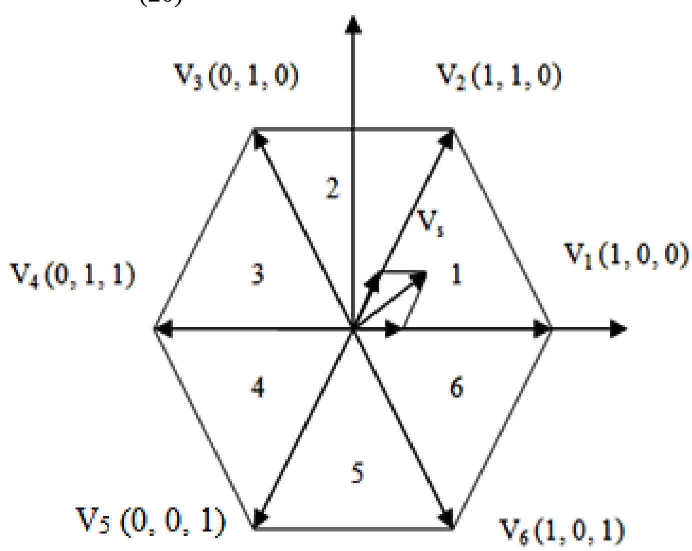

Fig. 3 Vector diagram of SVPWM

IV. SIMULATION RESULTS AND DISCUSSION

The proposed system develops the AC-DC-AC converter fed to 3 phase IM in MATLAB/SIMULINK with 3 phase PWM controller. The simulation model for SVPWM contains of seven blocks which is shown in fig. 4.

The generator is utilized to produce 3 sine waves among changeable amplitude and frequency. These 3 PWM signals are away from phase with everyone with 120 degrees. The two of the block inputs are converter required voltage and frequency. The low pass filter is utilized to remove quick transients from bus voltage. The 3 phase structure can be transformed to the 2 phase αβ scheme utilizing the αβ transformation block. The αβ vector is utilizing to establish the αβ in which to the lies in voltage vector.

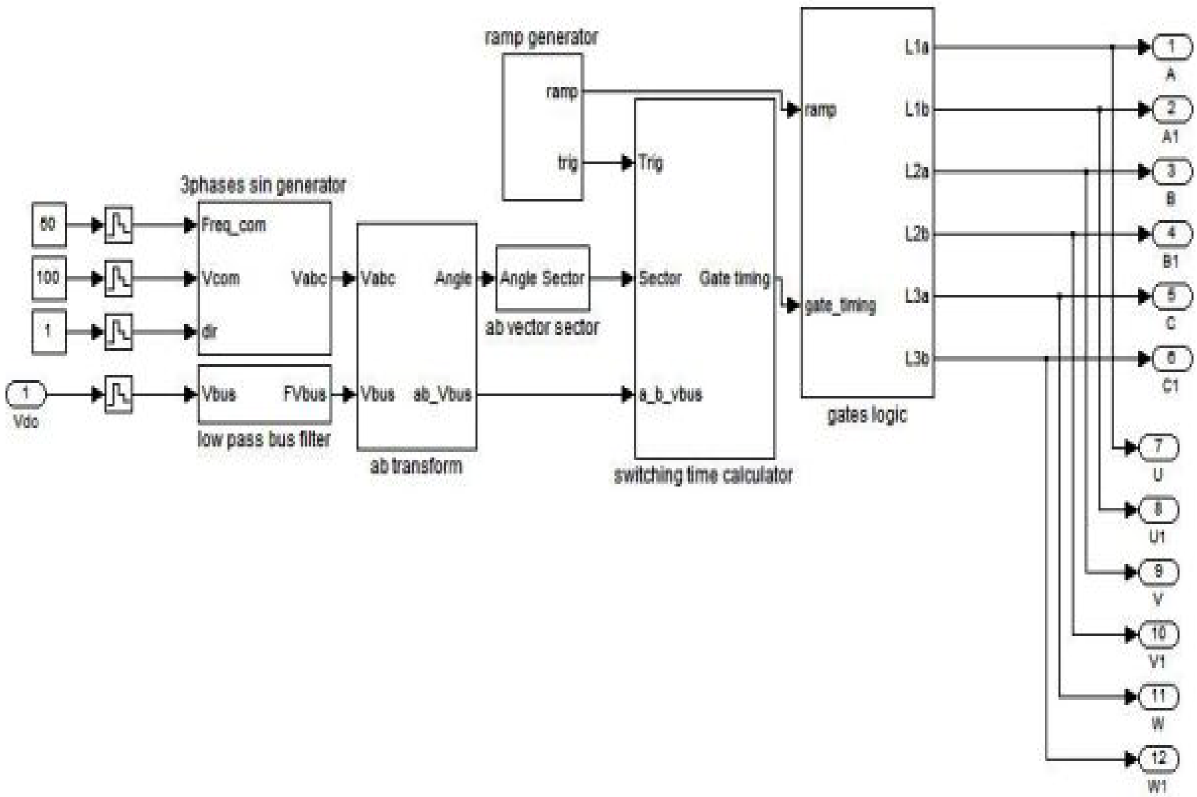

Fig. 4 Simulink Model for SVPWM

The αβ is separated into 6 variant sectors; everyone is spaced with 60 degrees. This unitary ramp is utilized as time support for switching cycle. The switching cycle time is used to calculate the voltage vector (VV) functional to the IM. The VV deception in block input sector. The timing progression from switching cycle calculator and ramp producer are established by gates. It evaluated the gate timing and ramp signals to trigger the switches in appropriate time. It evaluated the ramp signal and gate signals to start the switches at the exact time. The developed system is replicated and output is presented.

The IM speed is almost below the Ns speed and it is presented in fig. 6. The motor torque is presented in fig. 7. The motor torque is constant when motor speed reaches at Ns.

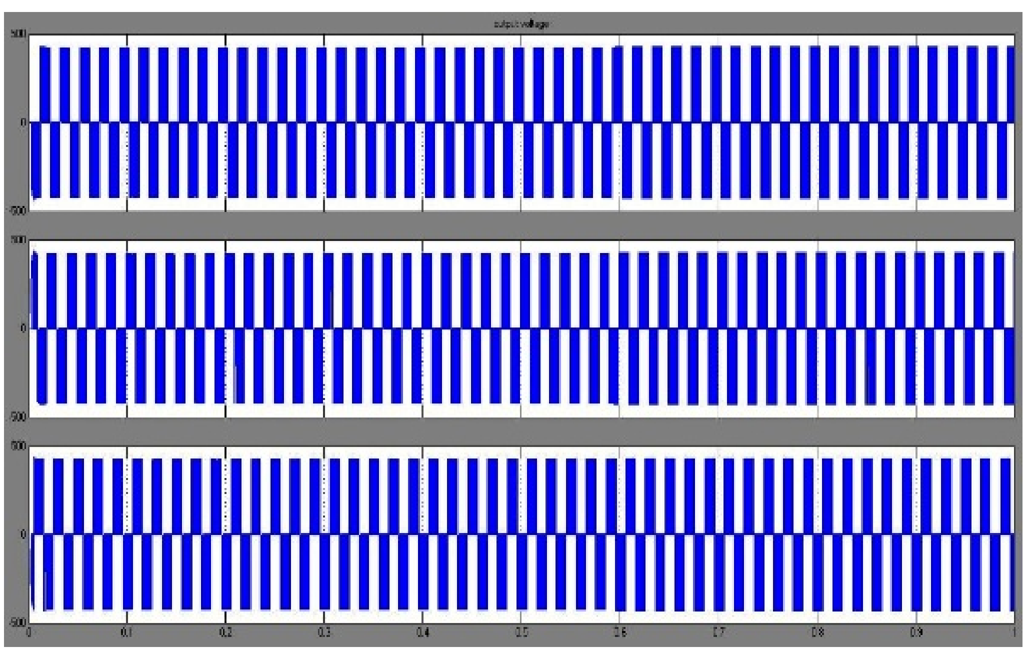

Fig. 5 Output Voltage

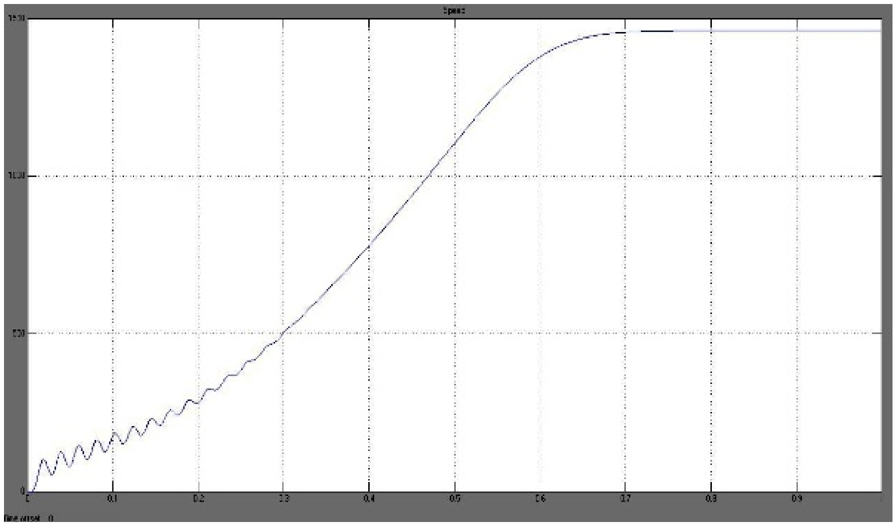

Fig. 6 Rated Speed

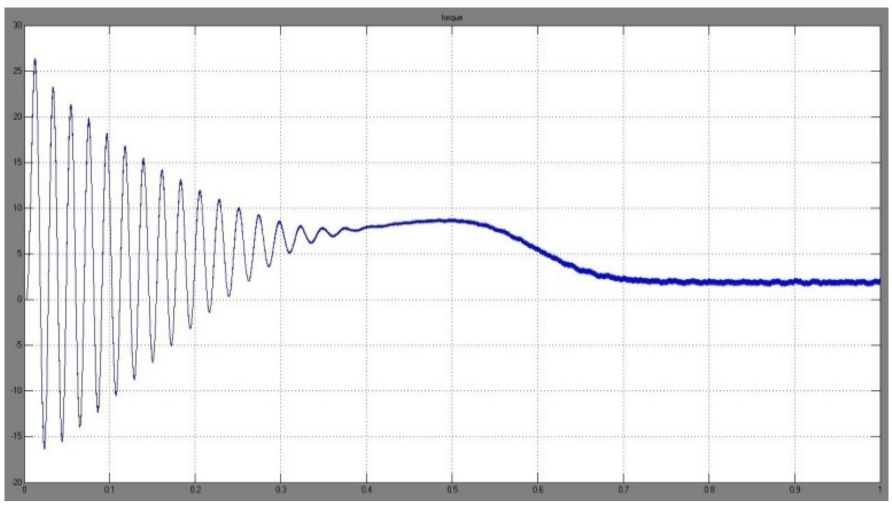

Fig. 7 Motor Torque

The figure 8 presents the THD for current of inverter is about 0.26%. The frequency value is 50Hz and the total harmonic distortion is noted for the 10 number of cycles.

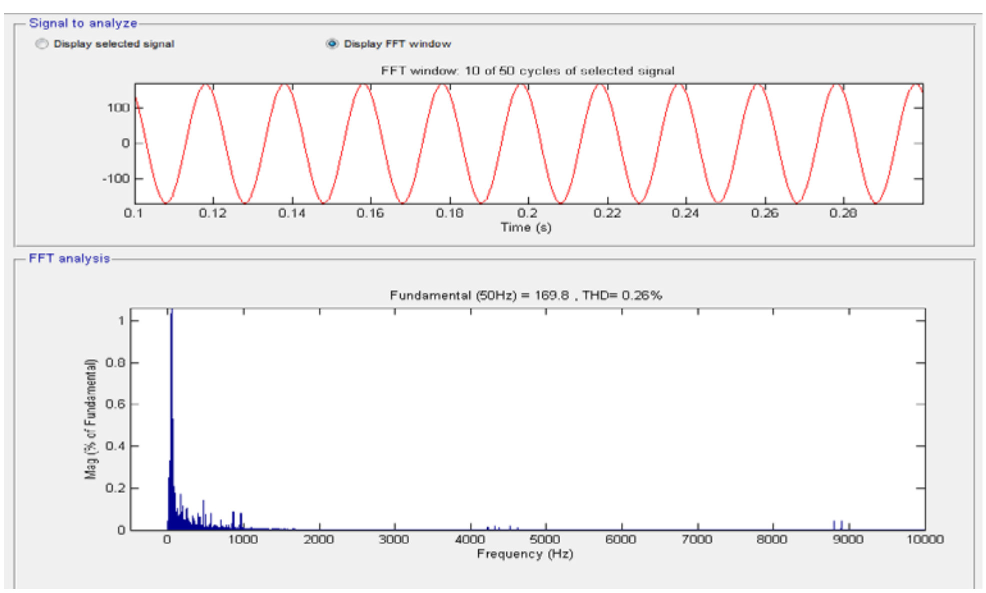

Fig. 8 The FFT Window Displaying THD

V. CONCLUSION

A SV modulation based IM with the Buck Boost converter is proposed. The proposed Inverter fed IM is simulated using SIMULINK. It is clearly shows that simulation results Space Vector PWM methods is better than overall an Pulse width modulation technique which gives less THD in an inverter current of about 0.26%, which is under the permissible limit and also increased primary voltage with 15 percentage and soft control of IM. This can be reduced by the Buck Boost converter because of its continuous input current flow. These results are clearly visible in scopes. The performance of the induction motor is obtained. The presented topology is very suitable for low to high power applications and also for high current cases such as hybrid electric vehicles.

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