Speed Control of Three Phase Induction Motor using Boost Converter and Inverter

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Abstract: In many different sectors, power inverters are utilised to convert DC current to AC current. The technology for producing inverters has to advance as much as feasible given their significant significancein many sectors. In this study, we sought to use boost converters to regulate the velocity of induction motors in order to set the current inrush and voltage source harmonics in their ideal locations. Additionally, we used a PI controller to manage the boost converter's output voltage. The findings of the suggested method's simulation reveal that employing PI controllers in voltage control loop in the boost converters has an desired impact on the harmonics present in the inverter's output, which has an impacton the induction motor's performance as a consequence.

Keywords: IM drive, DC-DC converters, Voltage control loop, VF control.

I. INTRODUCTION

Controlling the supply of frequency to an induction motor is a common technique for regulating its speed. The inverters can make this happen. An inverter is a piece of technology that can convert DC electricity to AC voltage. Inverters have been utilised extensively in recent years to regulate the velocity of induction motors due to scientific advancements in manufacturing these tools. The inverter may produce alternating voltage that is identical to or below the source voltage thanks to its conventional construction. But because of the importance of these equipment in recent times, several field studies havebeen carried out, leading to significant modifications in the design and operation of these tools. An illustration would be an impedance base inverter, which is composed of a collection of capacitors and an impedance system that is positioned within the source of input voltage and the diode bridge. We'll get a converter with both buck and boost capabilities. The author of the source (Caceres and Barbi, 1999) has examined a novel one-phase boost converter topology. It should be possible to create AC voltage on the point of output utilising dual boost converters. Still, throughout the last 10 years, experts have given special attention to the manner in which these devices are started and controlled. As an illustration, presented an approach that utilises hysterisis control for initiating and controlling the IM drive. In order to minimise harmonic distortions, the research presented an easy approach for calculating an induction motor's current harmonics and optimised PWM switching sequences. Sources (Mohit et al., 2013) explored the development as well as control associated with a highly effective boost converter. Several authors have researched boosted rectifier control techniques.

II. METHODOLOGY

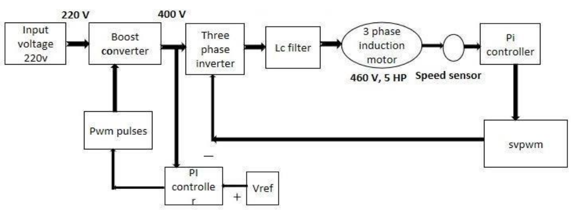


Fig 1: Block diagram of Speed Control

Structure of Boost Converters An electrical device known as an inverter or converter converts DC voltage to AC voltage. According to the needs that are managed by the appropriate transformers and circuits, the resultant electric power may result in any range or frequency. These transformers are used in power systems to alter or regulate a number of aspects, including frequency, voltage, the quantity of phases, reactive energy, and the load's quality of power. A straightforward kind of three-phase inverter is provided below in Figure 1.

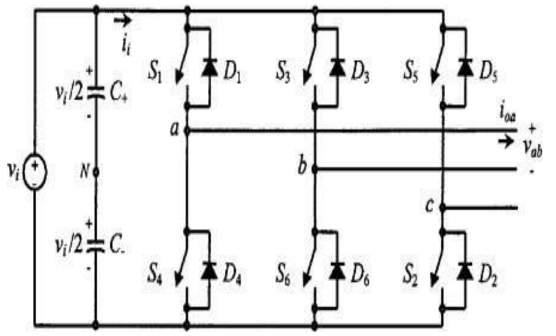


Fig 2: Voltage Source Converter Inverter topology

It is composed of six IGBTs, or isolated gate bipolar transistors, which are power transistors. The three- phase power inverter can produce the necessary waveforms by carefully timing the operation of its two switches (power transistors) on each of the arms. The fact that the inverters can only produce alternating electricity having a narrower range than DC power serves as one of their biggest drawbacksConsequently, boost rectifying devices are employed in the source side to increase the terminal voltage from the supply voltage. The fundamental design of above mentioned converter is shown in Figure

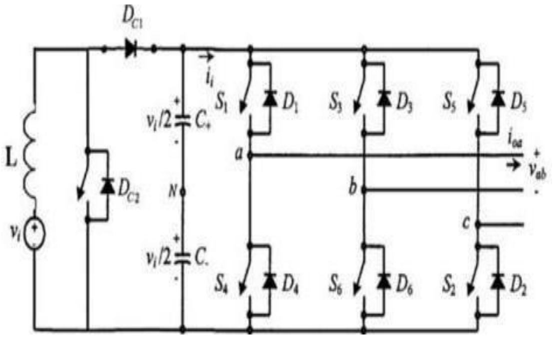


Fig 3: Boost converter associated with Three phase inverter

The boost ratio of the converter is provided below (Panov and Jovanovic, 2001):

$$\frac{V_o}{V_i} = \frac{1}{1-D} \qquad (1)$$

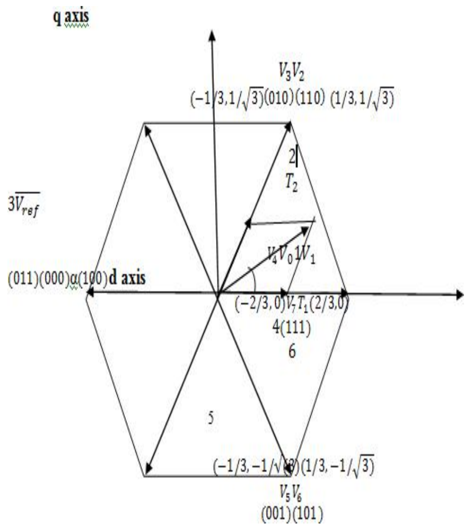
Where, D denotes the boost converter Duty ratio.

SPACE VECTOR BASED MODULATION STRATEGY FOR IM CONTROL

Space Vector Modulation (SVM) started out as a vector-based alternative to PWM. It is an improved way of producing sine waves that offers the machine an increased voltage along less overall distortion due to harmonics. Every modulating strategy deliver varied result using an appropriate basic component and minimal of distortions.

The on and off signals that regulate for the inverter with three phases are created using the space-vector approach. In comparison to the traditional SPWM inverter, which provides a 15% improvement with regard to dc side voltage utilisation and minimal harmonics. The voltage/frequency regulation approach, that depends on the concept of space-vector approach, is the regulation approach used by the inverter.

The presence of two extra null voltage states, is the key distinction among SVPWM versus SPWM. Keeping two null voltage positions as well as to each of the six feasible voltage vectors connected with VSI. Due to the presence of a third harmonic element, this attribute permits higher load voltage. SVPWM is also, sometimes, seen to be an eighth phase process as a result. [9]



$$\begin{bmatrix} V_d \\ V_q \end{bmatrix} = \frac{2}{3} \begin{bmatrix} 1 & -\frac{1}{2} & -\frac{1}{2} \\ 0 & \frac{\sqrt{3}}{2} & -\frac{\sqrt{3}}{2} \end{bmatrix} \begin{bmatrix} V_{an} \\ V_{bn} \\ V_{cn} \end{bmatrix} \ldots\ldots\ldots\ldots\ldots\ldots(3)$$

$$|V_{ref}| = \sqrt{V_d^2 + V_q^2} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(4)$$

$$\alpha = \tan^{-1}\left(\frac{V_q}{V_d}\right) \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(5)$$

THREE PHASE DRIVE SYSTEM

Compared to the use of three-phase synchronous machines, induction machines are more often used in variable speed drives. The synchronous velocity of this spinning field, which is determined whenever a supply with three phases is linked to a three-phase stator coil, is provided by

$$N_S = \frac{120 * f}{P} \quad \text{rpm}\ldots\ldots\ldots (6)$$

Where Ns = Synchronous Speed in rpm.

f = Supply Frequency in Hz.

P = No. of stator poles.

TOTAL HARMONIC DISTORTION

Calculating the sequence of harmonic that exist in the current or voltage signal using the total distortion of harmonics becomes a crucial step. It may also be used to assess the current or voltage at the output generated by an ac power source. Total harmonic distortion (THD) may also be used to detect non-sinusoidal wave standards. The proportion of the rms values of the harmonic elements in relation to the rms values of the fundamental element is known by thd, which is a index of the distortion of harmonics.

III. RESULTS AND DISCUSSION

Simulation Results

The simulation parameters are provided in the following table:

Sl.no	Parameters	Specifications
1.	Input voltage	220V
2.	Inductor	100mH
3.	capacitor	100μF
4.	Resistor	204Ω
5.	3 Phase Induction motor	50HP, 440V

After examining the outcomes of the suggested approach's simulations, we presented the schematic layout of the boost converter that had been modelled using the MATLAB programme Simulink. Boost converter with PI controller is shown in Figure (4). 220 V is the supply voltage. The supply voltage is converted by this converter using a inductor of 100 μH and a 100 μF capacitor.

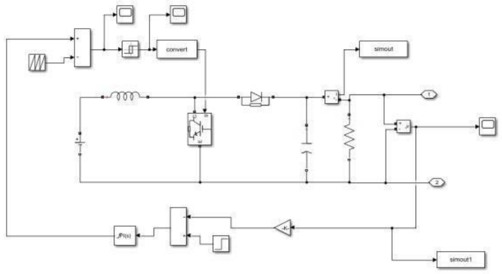


Fig 4: Simulation diagram of boost converter

An example of an a three-phase boost conversion is shown in Figure (5). As can be observed, the purpose of the converter is to regulate the voltage that is linked using LC filter and significantly lower the residual harmonics.

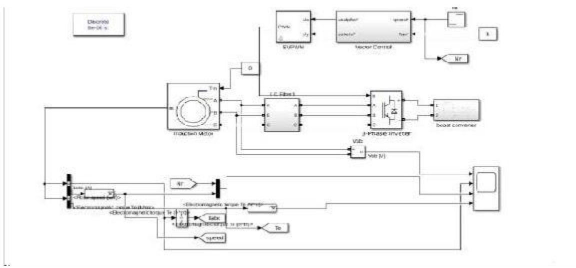


Fig 5: Simulation diagram of IM drive with boost converter

The results of induction motor is provided below in Fig 6:

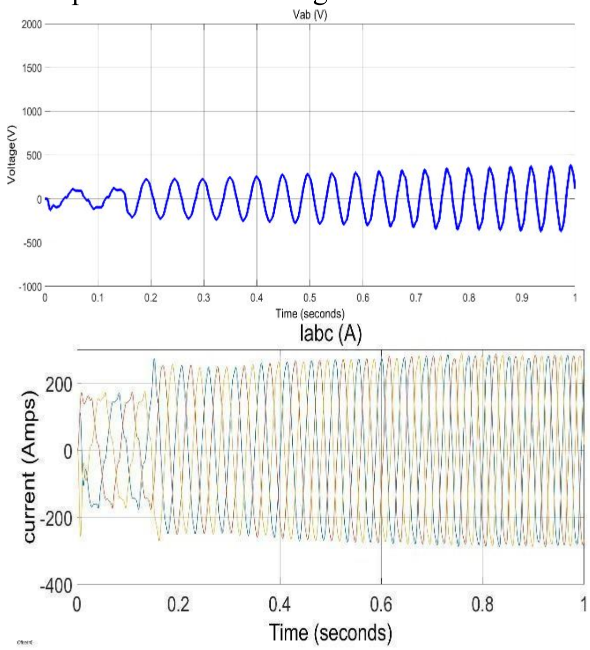


Fig 6: Output voltage of inverter and output current

In this, the speed reference is provided as 80 rad/s and the actual speed is measured and compared with the reference speed and also the induction motor voltage and current waveforms are also provided. The boost converter output voltage is provided below:

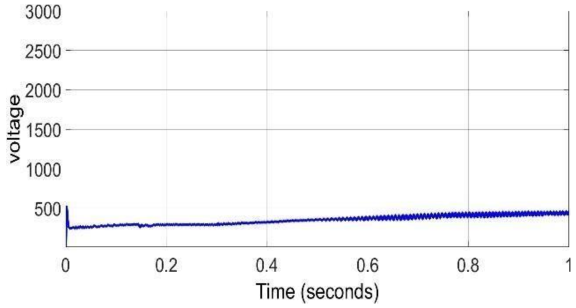


Fig 7: Diagram of output voltage of boost converter on PI

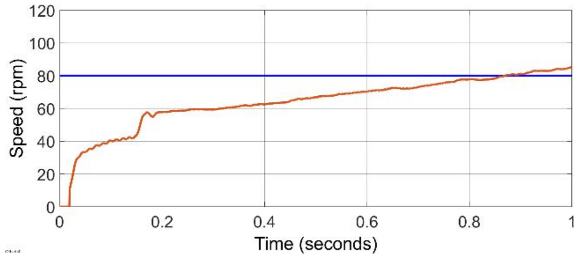


Fig 8: speed output

The %THD of the proposed induction motor drive system is provided below:

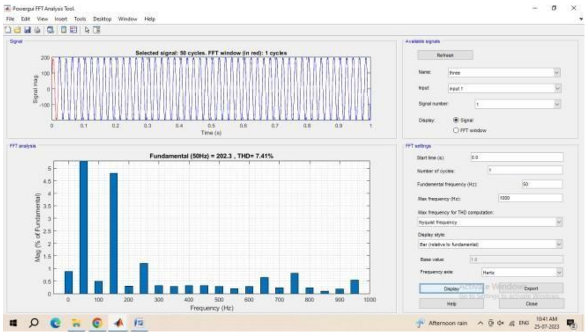


Fig 9: %THD of Induction Motor drive

The %THD is around 7.41%.

HARDWARE RESULT AND ANALYSIS

A hardware prototype model of proposed system with input voltage of 36V, 50 Hz is developed with 400V as output voltage with load resistance of 1000 ohm. The hardware parameters are provided below in the following Table 3.

TABLE 3
Hardware Parameters

IRF 250N MOSFET	200V, 30A
U1560-Diode	200-400-600V, 15A
Capacitor	1000μF, 25V 1000μF,100V
Transformer	12V, 1A
TLP-250 Driver IC	12V, 1.5A
CD 4050 Buffer IC	3-18V, 0.32mA
12V Regulator 7812	12V, 1A
IN 4007 Diode	700V, 1A
Arduino uno controller	7-12V, 20mA

Arduino UNO control is used for generating the pulses for the proposed converter and it is provided to driver circuit (TLP 250) in order to drive the MOSFETs IRF 250. The hardware prototype model is provided below in Figure 10.

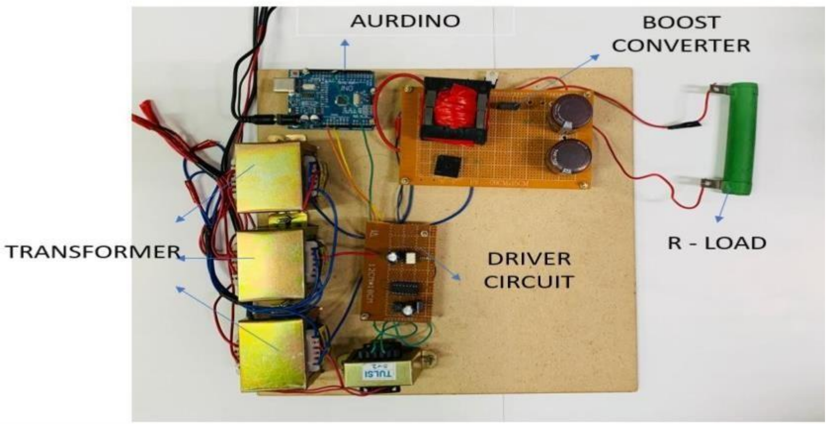


Fig 10: Hardware Prototype

fig 11: output voltage of Boost converter

Conclusion and Future scope

In this study, an induction motor's performance was managed via a boost converter. We employed a PI controller in order to lower the system's overall harmonic distortion and increase the effectiveness of the drives as the amount of distortion in the output of the inverters might affect its performance and lifespan. The induction motor stator and rotor parameters all underwent notable modifications as a result due to the PI controller's positioning. Additionally, the motor's current inrush has been significantly impacted by the increases that were identified.

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