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Torque Speed Characteristics for VSI Fed Squirrel Cage Three Phase IM Drive Using Multi Level Inverter

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Abstract: ***All induction motors are asynchronous motors. The asynchronous nature of induction-motor operation comes from the slip between the rotational speed of the stator field and somewhat slower speed of the rotor. Most induction motors today contain a rotational element (the rotor) dubbed as squirrel cage. Here in this paper torque speed characteristics of squirrel cage three phase IM drive is determined by using multi-level inverter. Instead of using 12 switches in conventional 3-level inverters, 6 switches are used in this topology. Reduced number of switches is the greatest contribution of this study.***
Keywords : Asynchronous Motor, Multi-Level Inverter, Reduced Components

I. INTRODUCTION

Lately, studies on conversion from DC to AC have become more widespread across the world. Particularly, an induction motor is powered by AC, while various conversion methods are applied to convert DC to AC. The use of inverters has become quite popular among these studies. Nevertheless, the shape of the sinusoidal signal obtained in conversion from DC to AC by classic inverters is far from desired quality. Thus, the inverter output voltage level is increased to improve the quality of the sinusoidal signal that is generated. Increasing the voltage level is inversely proportional to the amount of harmonics and it provides directly proportionate increase in efficiency. In this conversion process the converter must be easily applied and it must also be economical. For this reason, the cost of switches and control systems used in inverters must be in compliance with efficiency. Developing new topologies to keep these variables under control is inevitable. Multi-level inverters create an output voltage which is close to a sinusoidal form by combining different types of DC voltage levels applied as input [1, 2]. They are superior to classic two-level inverter topologies in terms of circuit structure.

II. VSI FED INDUCTION MOTOR DRIVE

In this three phase three level inverter six MOSFET are used as switches. For triggering of the gate of each MOSFET a pulse generator is used. Each pulse generator generates a triggering pulse at particular time. Since we want three levels of voltages at the output each pulse generator is given a particular phase angle and a particular phase shift. After that line voltages and phase voltages are measured and the output of multi-level inverter is fed to IM drive. So the AC voltage obtained from the inverter will now drive the conduction of Induction Motor. $+V_{DC}$, $-V_{DC}$ and 0 voltage values are obtained, at the output terminal of multi-level inverter. The technical details of the motor used are shown in table below.

Table: I Machine Parameters

RMS value of supply voltage (line-to-line)	400
Number of poles	4
Stator resistance	0.01379 ohm
Rotor resistance	0.1 ohm
Frequency	50Hz
Mutual Inductance	0.00769

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III. COMPUTER AIDED SIMULATION STUDIES

Simulation studies were carried out using the MATLAB/SIMULINK 2017 software and the graphs were obtained using Excel. Here the main Simulink block diagram is shown in figure 3.1 A continuous power gui block is used which supply power to all electrical components in the Simulink Diagram.

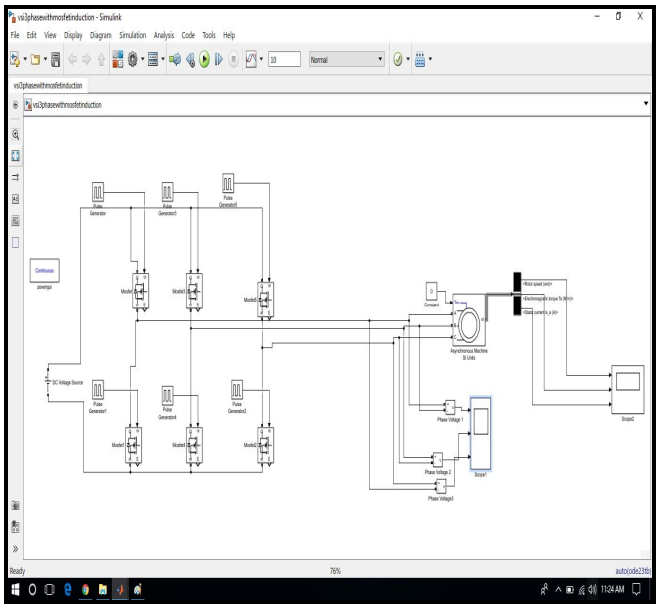


Fig 3.1: Simulink diagram of VSI Fed Drive

IV. OUTPUTS OBTAINED AFTER SIMULATION

Here the Torque Speed characteristics are studied with variation in rotor resistance of the motor.

A. Variation of Rotor speed with Rotor Resistance

Here we see as the rotor resistance increases the speed of the rotor decreases. This is shown in table and figure below.

Table II: Variation of speed with rotor resistance

Rotor resistance(ohm)	Speed of Rotor(rpm)
5	1042
10	936.1
15	883.8
20	851.9
25	830.9
30	816

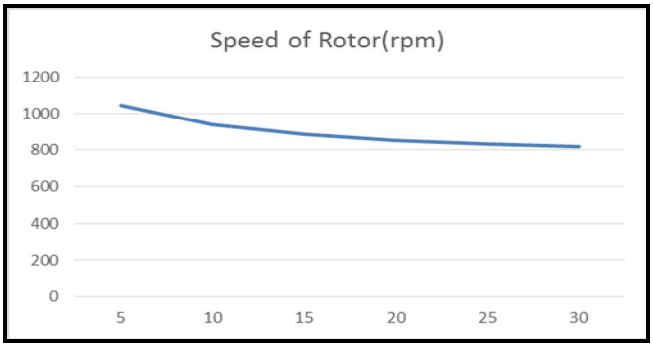


Fig 4.1: Variation of speed with rotor resistance

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B. Variation Of Torque With Rotor Resistance

Here variation of torque with rotor resistance is studied. Table 4.2 and figure 4.2 shows this variation.

Table: III: Rotor resistance versus Torque

Rotor resistance(ohm)	Torque(Nm)
5	-0.69
10	4.924
15	5.09
20	4.655
25	4.17
30	3.741

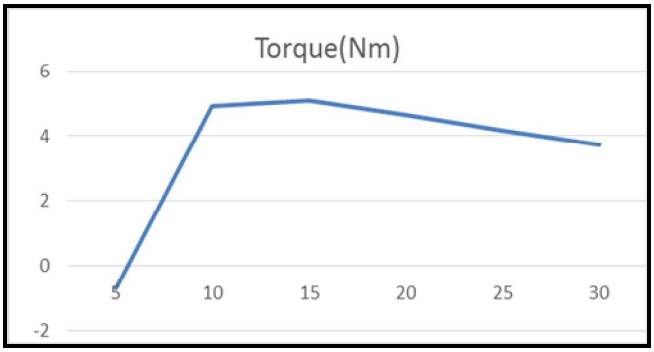


Fig 4.2: Rotor resistance versus Torque

V. TORQUE SPEED CHARACTERISTICS OF INDUCTION MOTOR WHILE VARYING ROTOR RESISTANCE

The resistance of the rotor circuit can be changed because the rotor circuit is brought out to the stator through slip rings. As the rotor resistance increases, the pull- out speed of the motor decreases, but the maximum torque remains constant. The advantage of this characteristic of wound rotor induction motors is the ability to start very heavy loads.

The maximum torque can be adjusted to occur at starting conditions by inserting a high resistance. Once the load starts to turn, the extra resistance can be removed from the circuit, and the maximum torque will shift up to near synchronous speed for normal operation. If the rotor is designed with high resistance, then the starting torque is high, but the slip is also high during normal operation. However, the higher the slip during normal operation, the smaller the fraction of power converted to mechanical power, and the lower the efficiency. A motor with a high rotor resistance has a high starting torque and poor efficiency during normal operation.

If the rotor resistance is low, then the starting torque is low and the starting current is high. However, the efficiency is high during normal operation. A compromise between high starting torque and good efficiency is needed.

Table IV:Torque speed characteristics with variation in rotor resistance

Rotor resistance (ohm)	Speed of Rotor (rpm)	Torque (Nm)
5	1042	-0.69
10	936.1	4.924
15	883.8	5.09
20	851.9	4.655
25	830.9	4.17
30	816	3.741

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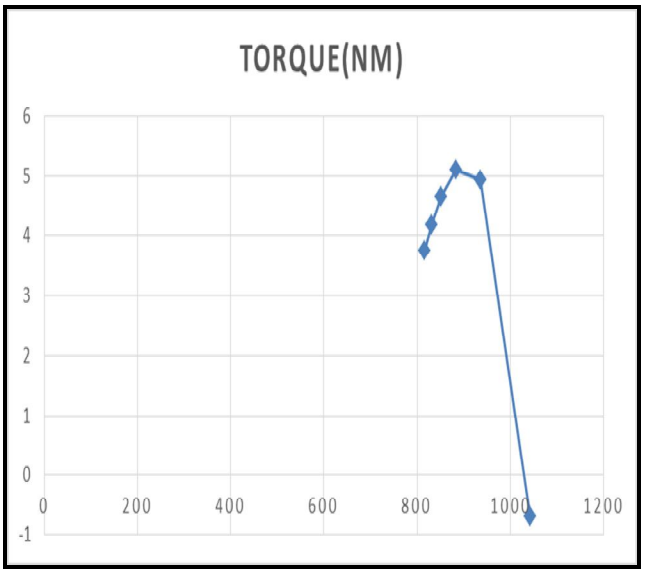


Fig 4.3: Obtained Torque Speed Curve

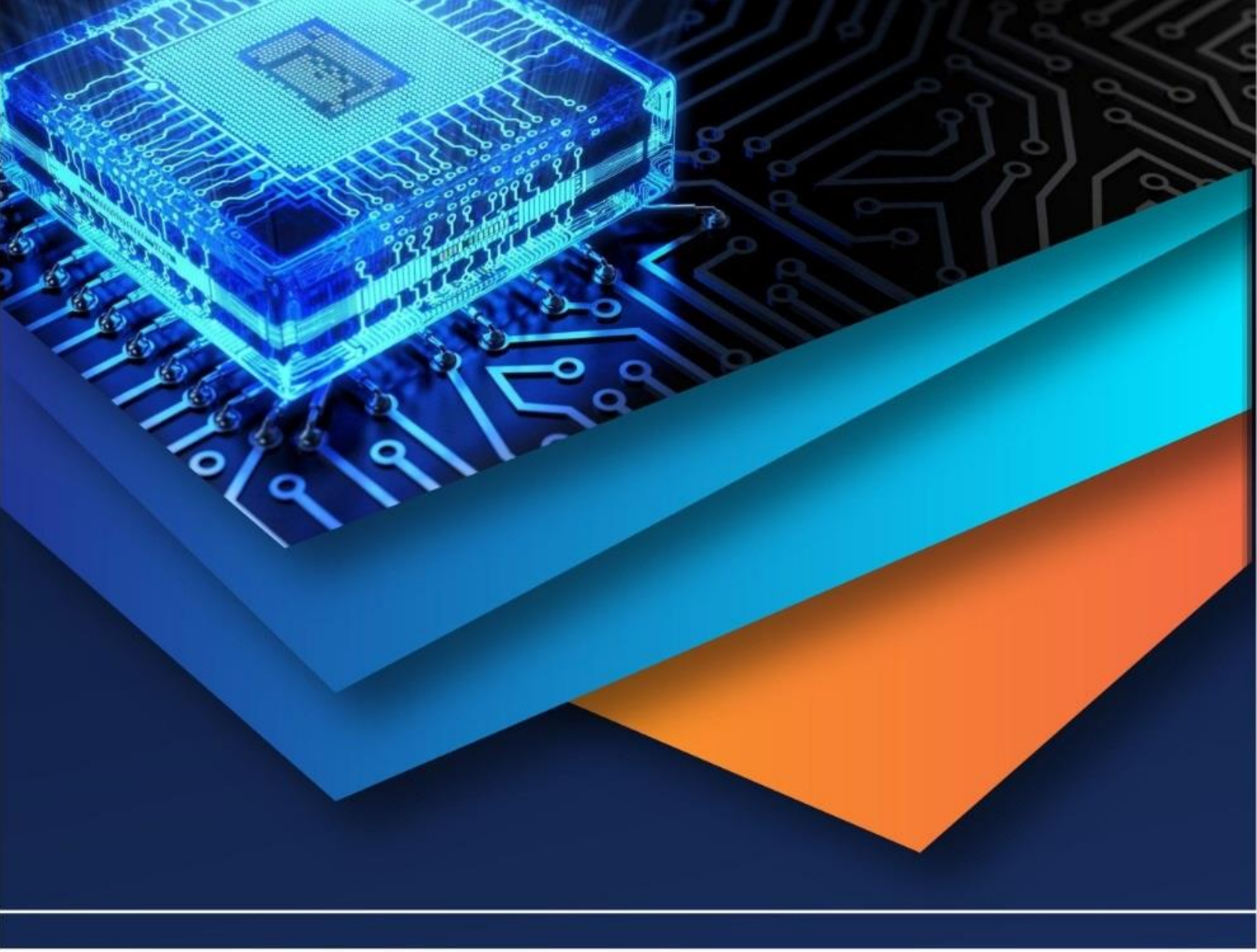
VI. CONCLUSION

In this study, the speed of a induction motor was controlled using a 6-switched 3-level inverter and the motor's parameters were analyzed by varying the rotor resistance. The results show that as the rotor resistance increases the rotor speed decreases. There is a maximum possible torque that the motor cannot exceed. This torque is called the pullout torque or breakdown torque and is 2 to 3 times the rated full torque of the motor.

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