Speed Control of Three Phase Slip Ring Induction Motor Using Chopper

[1]Mrs. Payal P Raval, [2]Dr H I Joshi, [3]Vaghela Krishnaraj, [4]Patel Mihir
[1]Lecture, [2]Lecture, [3]Student, [4]Student
R.C.Technical Institute, Ahmedabad

Abstract - **In recent years induction motors are the widely used electrical motors due to their reliability, low cost and robustness. But, characteristically the induction motor does not have the capability of variable speed operation. Due to this reason, formerly dc motors were applied in most of industry. But nowadays speed control methods of the induction motor have developed to their large scale used in almost all industries. The aim of this paper is to make a simple control system for speed variations of a Slip Ring Induction Motor as an extension to the available non slip power recovery system available for low power SRIMs. There are numerical methods to improve the Speed but most easy ways of speed control of a slip ring induction motor is either from the stator or rotor side. The system employed here is to control the speed via bridge circuit and on/off switch at the rotor side of this slip ring induction motor. Here the core system is to control the high power system by directly varying the rotor side current by using the single IGBT which is used as a chopper.**

keywords - **Induction motor, SRIM, slip ring rotor, ridge rectifier**

I. INTRODUCTION

Now a day's induction motor is widely used for industrial, commercial and residential application. Induction motor is used in numerous applications as the motor have low cost, high efficiency, wide speed range and robustness [1]. In the recent years, the wide applications of AC machines are useful than DC machines due to their simple and most robust construction without any mechanical commentators.

In this paper static resistance rotor based system to control speed of induction motor is developed using chopper control technique [2]. In this electric motor, speed is fixed while AC motor is connected to AC line. Motor speed is calculated by: Ns =120*f/p-slip, Where Ns= motor speed in RPM, f=frequency in Hz, p= number of poles. Now there are numbers of way to change the speed of motor for required application [3]. Chopper control technique is more effective and provides higher level of performance. Motor speed can be adjusted by changing the duty cycle of IGBT (chopper) [1].

A control system for slip ring rotor of induction motor makes use of thyristor in the secondary side as switch operating at a suitable preset pulse repetition rate. The slip rotor voltage is rectified and fed to a thyristor chopper for variable on time with variable duty cycle of which results in a variable speed [3]. The control of on time is a strong feedback from speed signals, so that the set speed remains nearly constant irrespective of load variations. It is clear that torque of the system varies with "on" time depending on the two probable exciting conditions: 1) when the thyristor switch is in parallel with the source (rectified rotor voltage) and external resistance; and 2) when the switch is in series with the source and external resistance. The entire representation runs good with the chopper type control and is generally essential and suitable to this motor. With large increase in the power ratings of the motors being under consideration, it is essential to modify the system to get the current demand on the rotor side.in the power ratings of the motors being under consideration, it is essential to modify the system to get the current demand on the rotor side.

II. SLIP RING ROTOR MOTORS

The Slip ring induction rotor machine contains a set of coils that are terminated in slip rings to which external resistance can be connected. By changing the value of resistance or rheostat connected to the rotor circuit, the speed/current and speed/torque curves can be generated and maximum torque can be generated at a relatively low current [4].

In general the slip ring motor is used mainly to start a high inertia load or a load that needs a very high starting torque across the full speed range. Through suitably choosing the resistors used in the secondary resistance or slip ring starter, the motor is able to generate maximum torque at a relatively low current from zero speed to full speed [4].

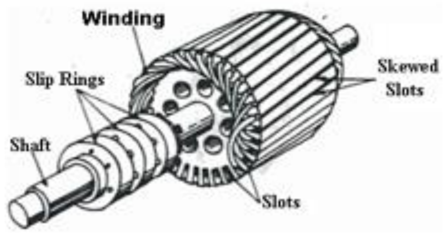


Fig. 1 Slip Ring Rotor

The other use of the slip ring motor is to offer a means of speed control. Torque curve of the motor can be effectively modified by the resistance connected to the rotor circuit and the motor speed can also be changed. Growing the value of resistance on the rotor circuit will change the speed of maximum torque down. So the resistance attached to the rotor is increased beyond the point where the maximum torque occurs at zero speed, the torque will be more reduced. When load has used with that value of a torque that increases with speed, the motor will activate at speed where the torque developed by the motor is equal to the load torque. Decreasing the load will affect the motor to speed up and increasing the load will affect the motor to slow down until the load and motor torque are equal. Worked in this manner, the slip losses are dissipated in the secondary resistors and can be very significant.

III. ADDING THE EXTERNAL RESISTANCE

In the slip ring induction motor the external resistance for speed control is connected during starting condition and if rotor resistance high, starting torque is also high and the rotor current is low. Furthermore, the slip necessary to create maximum torque is directly proportional to the rotor resistance. The rotor resistance is increased in slip ring motor by adding external resistance [5]. If the rotor resistance is high, the slip is high, hence it's possible to achieve "pull-out" torque even at low speeds. Once the motor reaches its base speed or full rated speed, by way of the external resistance is removed and under standard running conditions, it behaves like as a squirrel cage induction motor.

The selection of the external resistance to be introduced in the rotor circuit during start-up will depend upon the torque requirement, without the minimum torque requirement generated by jeopardizing.

IV. STATIC ROTOR RESISTANCE CONTROL SYSTEM

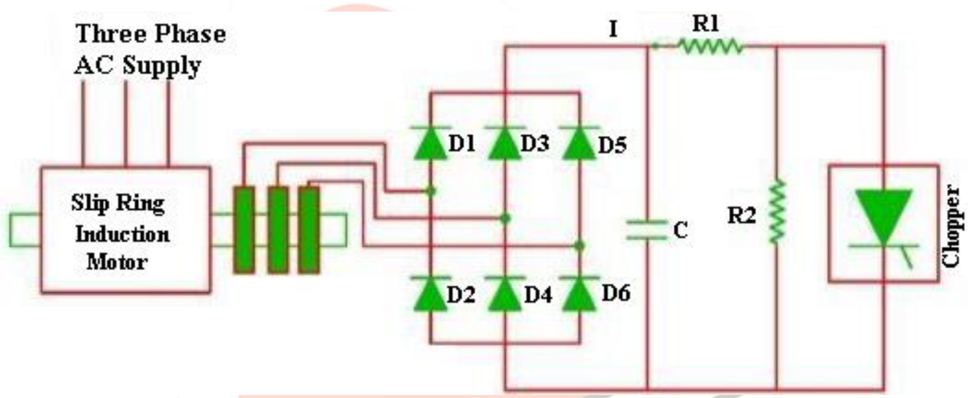


Fig. 2 Static Rotor Resistance Speed Control System

In this circuit consider a 3 φ AC supply that fed 3 φ asynchronous induction machine. The output is get to the bus selector which acts as a multiplexer giving us a wide range of output measurements essential to analyze the circuit and the outputs are observed by the scope which show us the detailed view of the measured output values such as speed and torque [6].

A simple resistance is used for the analysis of the output of static rotor resistance induction motor. For obtaining the preferred speed control, we have made a bridge circuit of considerable value in parallel acting as a load manipulator giving us the necessary control of the speed of the motor. To appropriately operate the bridge circuit triggering, a repetitive sequence is used at the GATE terminal of the bridge circuit so that a simple ON/ OFF control of the device is possible and a simpler control is predictable [8]. In this control system, the rotor resistance becomes R1 when chopper is turned on similarly the rotor resistance is equal to R1 + R2 when the chopper is in off condition. The actual rotor resistance: R = R1 (Ton) + R2 (T off) / (T on +T off).

The slip rotor induction motor speed can be varied by varying the rotor circuit resistance or rheostat, The rotor resistance can be changed by using a diode bridge rectifier and chopper as shown in figure 3 [7]. Speed can also be varied by varying the duty cycle of the gate pulses given to chopper.

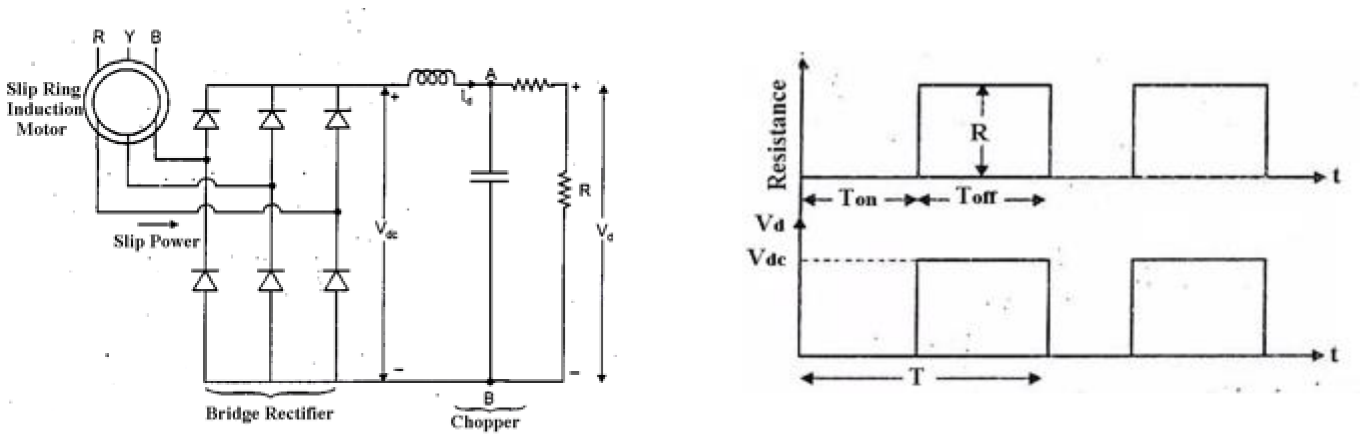


Fig. 3 Static Rotor Resistance Control and Waveform

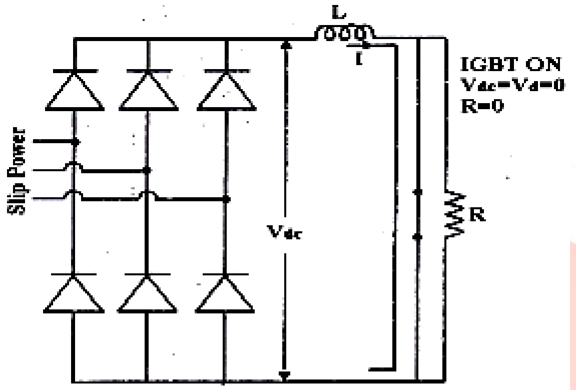


Fig. 4 When Chopper ON Vdc=Vd=0

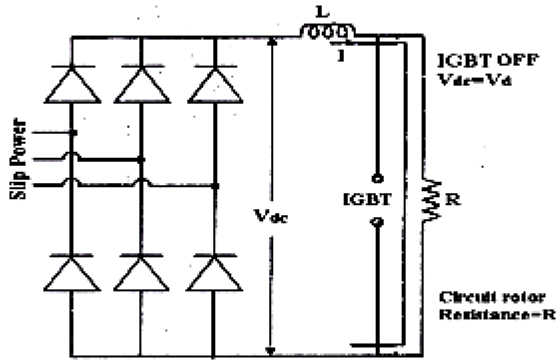


Fig. 5 When Chopper OFF Vdc=Vd

The chopper connects and disconnects the resistance R and full charge of C. While the chopper is on, the resistance is short-circuited and the current is passed through it i.e. Vdc = Vd., = 0 and R = 0. It is indicated as shown in figure 4 and while the chopper is off; the resistance is connected in the circuit and the dc link current I, flows through it. i.e. Vdc = Vd, and resistance in the rotor circuit is R.

V. SIMULATION AND RESULT

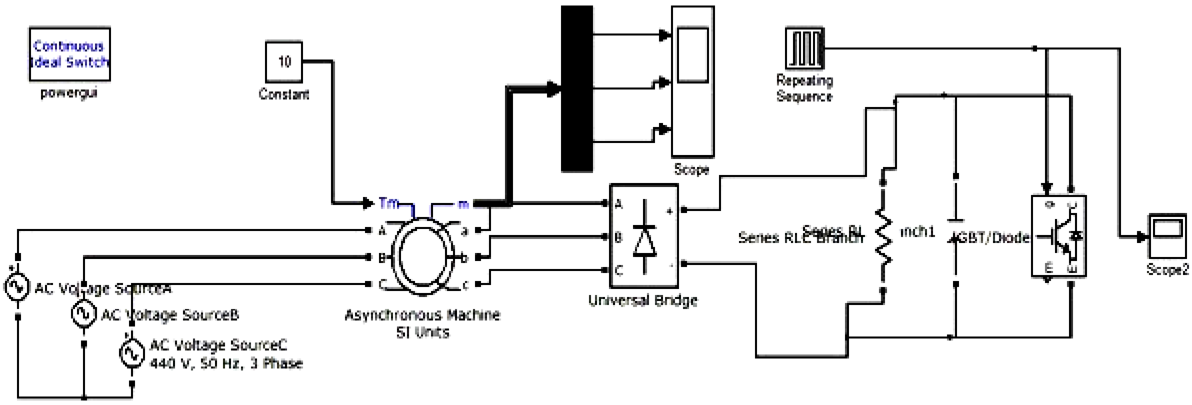


Figure.6 Simulink model for speed control of SRIM using chopper

For rotor side speed control of SRIM using chopper simulink diagram is presented in Fig. 6. The output power of rotor is given to three phase uncontrolled bridge rectifier. The output of the bridge rectifier is filtered and IGBT is connected as chopper across the external resister as shown in the figure. It is tested for 90% and 50 % duty cycle and output is presented in fig.7 and fig. 8 respectively. These results show clearly that by varying the duty cycle speed and torque also varies. Three phase, 5 hp, 440 V, 50 Hz, 1460 RPM SRIM is used in this simulation. In experimental circuit motor with same specification is used.

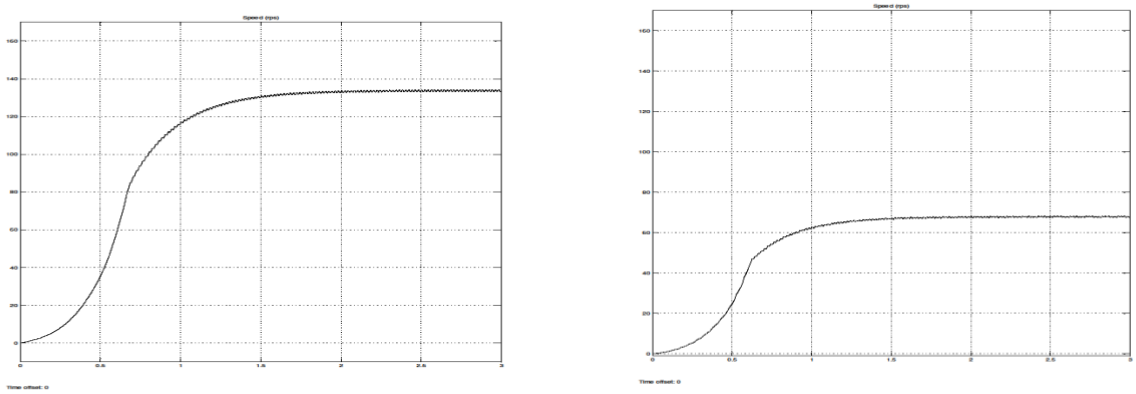
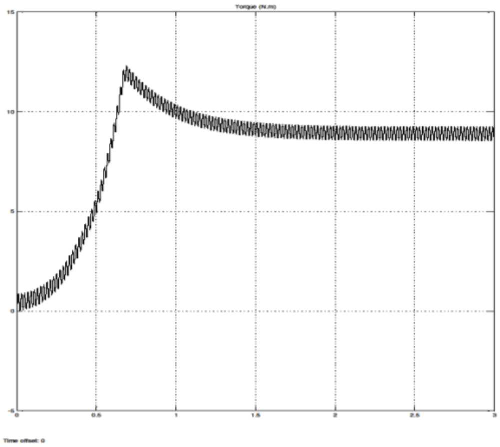


Figure 7 Speed (in rps) for duty cycle 90% and 50%



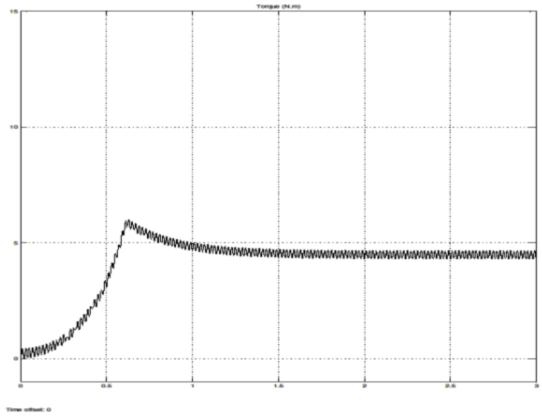


Figure 8 Torque (in N.m) for duty cycle 90% and 50 %

VI. HARDWARE SETUP AND RESULTS

In this paper, Static Rotor Resistance method is used for speed control of the induction motor. The block diagram of the basic circuit is exhibited in a hardware setup which is as shown in figure 9. The block diagram setup involves of IGBT which acts as a chopper that produces on/off cycles for speed control of induction motor.

A static resistance rotor method for speed control of three-phase induction motor is not so expensive circuit. Chopper switches, which disturbs the motor performance. Time IC is used here for variable duty cycle pulses.

In this hardware setup, the components used are: Diode (10A10), Capacitor (1000pf, 10000pf & 100 µF), Pot resistor (100k), Resistance (10k & 1k), Transformer (12-0-12), IC NE555 and IGBT FGH20N60SFDTU.

.

Figure 9 Hardware Setup of Slip-Ring Induction Motor with External Resistance (Rheostat)

Results of the Setup Hardware are:

Figure 10 Initial stage of output waveform

Figure11 By pressing a switch the width of pulse is increased

Figure 12 Speed Control of Induction Motor

VII. CONCLUSION

Static Rotor Resistance based system can be efficiently used for induction motor speed control along with bridge rectifier and chopper. Chopper technique can control speed of induction motor according to user's requirements. Here the chopper used for three phase slip ring induction motor speed control is designed and presented which is low cost and easy to operate. The effect of change of different value of external resistance and effect of chopper at different value for slip ring induction motor is analyzed. Based on the observations and results the following concepts can be concluded,

- Speed of slip ring induction motor can be increased with decrease in the external resistance added in the rotor circuit or increase in the value of duty cycle.
- This method is best suited for very high inertia loads, which requires a pull-out torque at almost zero speed and accelerate to full speed with minimum current drawn in a very short time period.

VII. ACKNOWLEDGMENT

We are using this opportunity to express our thankfulness to everyone who supported me for writing this review paper. We are also thankful for their invaluably advice and guidance during this work. We are honestly thankful to them for sharing their truthful and illuminating views on a number of issues related to this paper

REFERENCES

[1] A.E. Fitzgerald, Charles Kingsley, Jr. And Stephan D. Umans (2002). ―Electrical Machinery‖, McGraw-Hills Publications.
[2] Lavi and R. L. Polge, "Induction motor speed control with static inverter in the rotor", IEEE Trans, Power Appar.Syst., vol. 85 pp. 76-84, Jan. 1996.
[3] T. Hori. H. Nagase, and M. Hombu, "Induction Motor Control System", Industrial Electronics Handbook, J.D. Irwin, pp. 310-315, CRC Press, 1997.
[4] The story of the induction motor,by B. G. Lamme Proceedings of the American Institute of Electrical Engineers,Pages: 203 - 223,Year: 1921.
[5] "Rotor side Control of High Power Slip Ring Induction Motor using a Single Thyristor"IOSR Journal of Electrical and Electronics Engineering (IOSR-JEEE) e-ISSN: 2278-1676,p-ISSN: 2320-3331, Volume 9, Issue 2 Ver. VII (Mar – Apr. 2014), PP 49-53
[6] Rotor Side Speed Control Methods Using MATLAB/Simulink for Wound Induction Motor Rajesh Kumar, Roopali Dogra, Puneet Aggarwal

[7] Rabb Datta And v. t. Ranganathan, "Rotor side control of grid-connected wound rotor induction machine", Department of Electrical Engineering, Indian Institute of Science, Bangalore 560 012, India.