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Improve The Speed Characteristics of Slip Ring Induction Motor By Thyristor Control On Rotor Side

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***Abstract* - The aim is to create a Simple control mechanism for speed variations of a HIGH POWER SRIM – Slip Ring Induction motor as an extension to the available Non slip power recovery mechanisms available for low power SRIMs. The most basic ways to control the speed of a slip ring induction motor is either from the STATOR OR ROTOR SIDE. The mechanism employed here is to control the speed via a Single thyristor acting as an ON/OFF switch at the rotor side of this slip ring induction motor. The core scheme here is to control the high power machine by directly varying the load current or the rotor side current by the single thyristor after conversion of the available load side current into the DC current by a 3 phase RECTIFIER BRIDGE made of 6 diodes respectively. Thus, all the AC power is converted into simple DC current and is controlled by the thyristor ON/OFF time giving the required speed control as the rotor current is directly proportional to speed and torque in an increasing power scenario as in this case. Even the losses due to non-slip power recovery can be considerably neglected because of the machines high power status. Thus, we are able to simply control a high power SRIM by just varying the amount of ON/OFF time of the thyristor at the rotor end efficiently.**

Thus, 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.

Keywords – Induction Motor, rotor, rectifier Bridge, Slip Ring.

I. INTRODUCTION

A closed-loop control system for an ordinary wound rotor induction motor makes use of thyristors in the secondary side as pulse width modulated dc switch operating at a suitable preset pulse repetition rate. The slip frequency rotor voltage is rectified and fed to a thyristor chopper, a variable ON time of which results in a variable speed. The ON time is controlled by a strong feedback loop from speed signals, so that the set speed remains nearly constant irrespective of load variations. It is observed that torque of the machine varies widely with ON time depending on the two possible extreme 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 scheme may be adopted as a brushless drive system. The whole schema runs good with the Chopper type control and is mostly essential and suitable to the low power class of motors. With considerable increase in the power ratings of the motors being used, we need to modify the system to meet the current demand on the rotor side .So, it is very irrevocable to use standard thyristors which give us a better current withstanding and proper output with decent switching speeds .

Thus, we modify the construction of the present mechanism by exclusively designing a rotor side speed control drive which serves as a basis for the high power slip ring induction motors rotor side control. This is thus achieved by a single thyristor controlling the entire flow of rotor current suitably converted at the DC end being in parallel with the load resistance. This new and unused mechanism of speed control provides us the simplest technique of controlling the entire scheme via the turn on and turn off of the single load side thyristor and gives us the much required high current tolerance.

This forms the brief introduction to the entire project analysis and motive and thus gives us a peep through to the entire project and the procedure involved and the desired result to be expected as the outcome of the project done.

II. SLIP RING OR WOUND ROTOR MOTORS

The slip ring or wound rotor motor is an induction machine where the rotor comprises a set of coils that are terminated in slip rings to which external impedances can be connected. The stator is the same as is used with a standard squirrel cage motor. By changing the impedance connected to the rotor circuit, the speed/current and speed/torque curves can be altered.

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The slip ring motor is used primarily to start a high inertia load or a load that requires a very high starting torque across the full speed range. By correctly selecting the resistors used in the secondary resistance or slip ring starter, the motor is able to produce maximum torque at a relatively low current from zero speed to full speed.

A secondary use of the slip ring motor, is to provide a means of speed control. Because the torque curve of the motor is effectively modified by the resistance connected to the rotor circuit, the speed of the motor can be altered. Increasing the value of resistance on the rotor circuit will move the speed of maximum torque down.

It the resistance connected to the rotor is increased beyond the point where the maximum torque occurs at zero speed, the torque will be further reduced. When used with a load that has a torque curve that increases with speed, the motor will operate at the speed where the torque developed by the motor is equal to the load torque. Reducing the load will cause the motor to speed up, and increasing the load will cause the motor to slow down until the load and motor torque are equal. Operated in this manner, the slip losses are dissipated in the secondary resistors and can be very significant.

Here the rotor connections are connected in star connection.

SPEED/TORQUE CHARACTERISTICS

For any electric motor the variation with the speed is all the more important for finding out its behaviour under different loading conditions and its application area. Below Speed/Torque characteristics curve is shown .

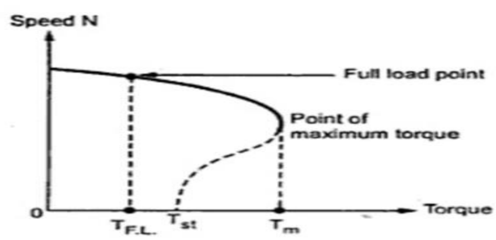

Fig. 1 Speed Torque characteristics

III. APPLICATIONS

Because a slip ring motor is used primarily to start a high inertia load or a load that requires a very high starting torque across the full speed range, slipring motors are best utilised (but not limited to) the following applications:

- Overhead Cranes and Hoists.
- Crushers
- Mill applications
- Mixers

Advantages

oHigh start-up torque
o Low starting current
o Minimal heat build-up on rotor (as heat is dissipated via external resistors)
o Can be stopped & started more often than a conventional induction motor .

IV. EFFECT OF ADDING EXTERNAL RESISTANCE

Adding external resistance to the rotor of a slip ring induction motor, makes the rotor resistance high during starting, thus the rotor current is low and the starting torque is maximum. Also, the slip necessary to generate maximum torque is directly proportional to the rotor resistance. In slip ring motors, the rotor resistance is increased by adding external resistance. If the rotor resistance is high, the slip is more, thus it's possible to achieve "pull-out" torque even at low speeds. When the motor reaches its base speed (full rated speed), as the external resistance is removed and under normal running conditions, it behaves in the same way as a squirrel cage induction motor.

The choice of the external resistance to be introduced in the rotor circuit during start-up will depend upon the torque requirement or limitation in the stator current, without jeopardising the minimum torque requirement.

V. CONTROL OF SRIM BY SINGLE THYRISTOR

Circuit Diagram:

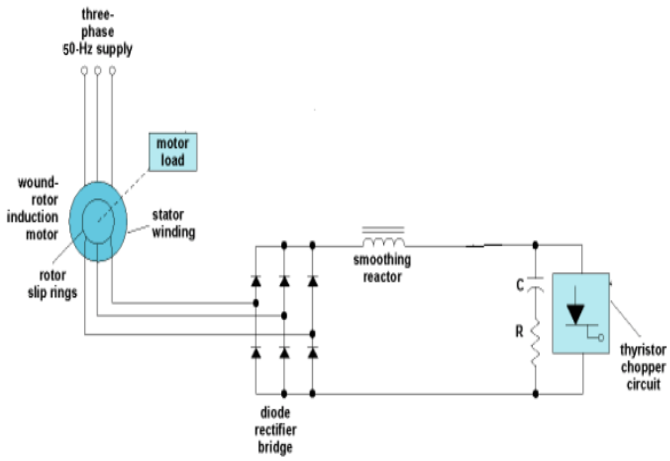

Fig :2 Circuit for Static Rotor Resistance Control

Working:

The circuit basically involves a 3 φ AC supply fed 3 φ asynchronous induction machine i.e. slip ring induction motor also called as the wound rotor induction motor here in this case. The output is fed to the Bus selector which acts as

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a multiplexer giving us a wide range of output measurements essential to analyse the circuit and the outputs are graphically observed by the scope which provides us the detailed view of the measured output values such as torque, current and speed.

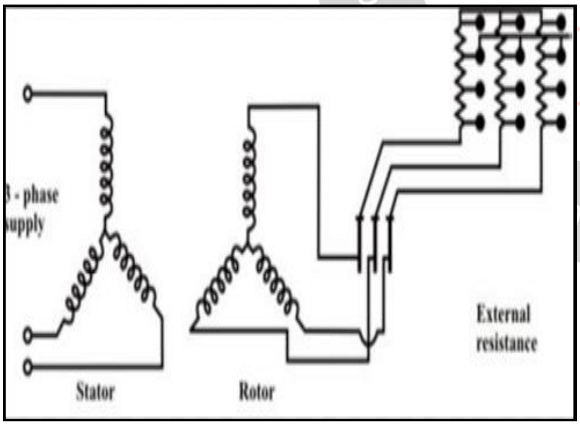
A simple R – load is used for the analysis of the output of SRIM. To this load, for obtaining the desired speed control we establish a thyristor of considerable value in parallel acting as a load manipulator giving us thus the essential control over the motor by drop down rotor current control of the machine. To suitably manipulate the thyristor triggering, a step signal is used at the GATE terminal of the thyristor so that a simple ON/ OFF control of the device is possible and a simpler control is expected. A wide range of other triggers depending on the desired characteristics can be chosen.

VI. THREE-PHASE FULL-WAVE BRIDGE RECTIFIER.

Each three-phase line connects between a pair of diodes: one to route power to the positive (+) side of the load, and the other to route power to the negative (-) side of the load. Polyphase systems with more than three phases are easily accommodated into a bridge rectifier scheme for simple conversion of AC to DC .

Smoothing Reactor

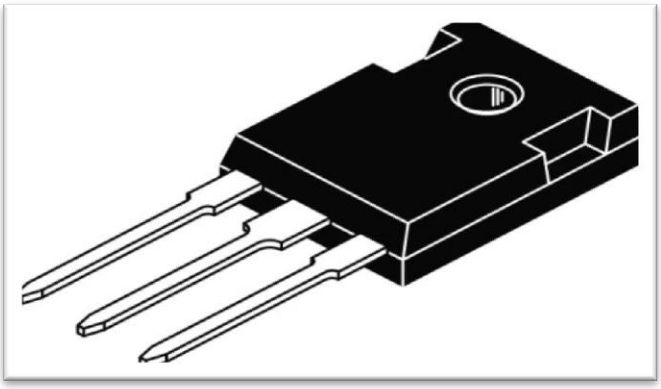
DC systems often require a smoothening of the direct current wave shape to reduce losses and improve system performance. Series reactors inserted in DC systems offer this response and additionally operate as current limiting devices in the event of a. fault.



- Connected in the series with the converter
- Decreases harmonics voltage and current in the DC line
- Smooth the ripple in DC current and prevents the current from becoming discontinuous

IGBT Thyristor

Insulated Gate Bipolar Transistor (IGBT) is a new high conductance MOS gate-controlled power switch .An IGBT combine the recompense of BJTs and MOSFETs . It has input characteristics of a MOSFET and output characteristics of a BJT. That means it has high input impedance and low on-state conduction loss .But it has no second breakdown problem like the BJTs.



IGBTs are mainly used in power electronics applications, such as inverters, converters and power supplies, were the demands of the solid state switching device are not fully met by power bipolar and power MOSFETs. High-current and high-voltage bipolar are available, but their switching speeds are slow, while power MOSFETs may have higher switching speeds, but high-voltage and high-current devices are expensive and hard to achieve.

The advantage gained by the insulated gate bipolar transistor device over a BJT or MOSFET is that it offers greater power gain than the standard bipolar type transistor combined with the higher voltage operation and lower input losses of the MOSFET.

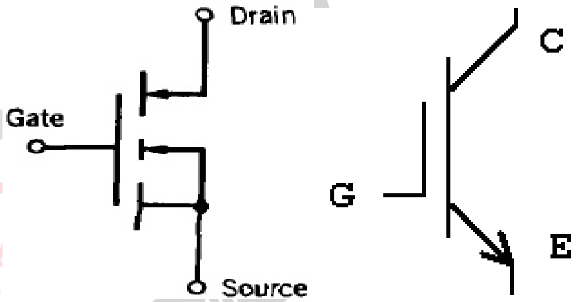


Fig.3 Cross sectional view and circuit symbol of IGBT

The IGBT is a three-terminal electronic component, and these terminals are termed as emitter, collector and gate. Two of its terminals namely collector and emitter are associated with a conductance path and the remaining terminal 'G' is associated with its control. It has fast switching speed. Frequency of operation can be as high as 20Khz.

Working of IGBT

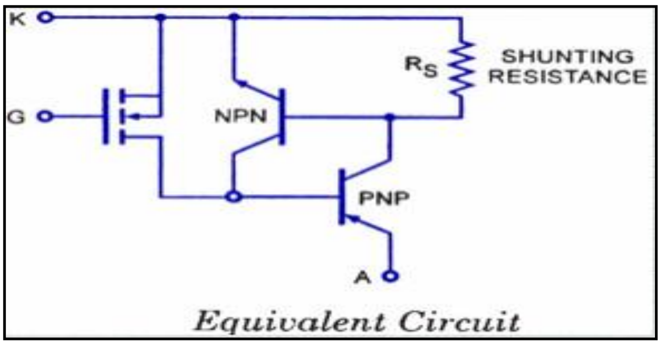


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Fig: No 4 Equivalent Circuit

The IGBT is four layer N-P-N-P device with a MOS-gated channel connecting the two N-type regions. When the gate is made positive with respect to the source (emitter) for turn-on, n carriers are drawn into the p-channel near the gate region ,this results in a forward bias of the base of the npn-transistor, which thereby turns on.

An IGBT is turned on just by applying a positive gate voltage to open the channel for n carriers and is turned off by removing the gate voltage to close the channel.

Regular operation, the shunting ,resistor Rg keeps the emitter current of the N-P-N transistor very low ,which keeps N-P-N very low .However ,For satisfactorily large emitter current Ia significant emitter injection may occur in the N-P-N transistor, causing N-P-N to boost , in thiss case the four layer device may latch ,accompanied by loss of control by the MOS gate . In this event the device may be turned off by lowering emitter current Ia below some holding value ,as is typical of a thyristor.

Simulink Circuit

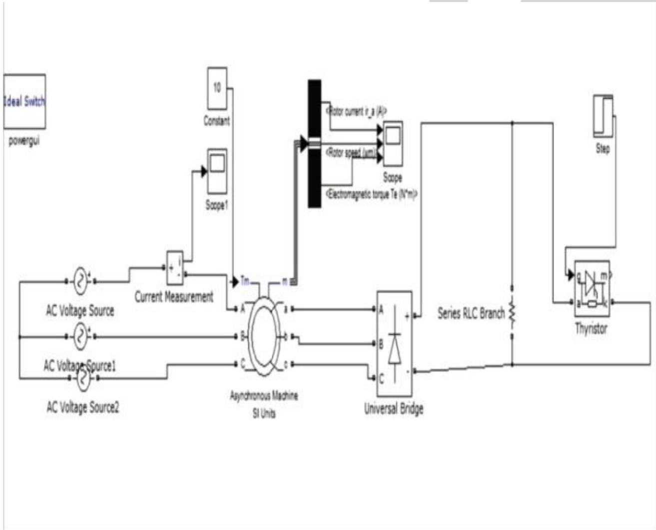

Fig.5 SIMULINK circuit for single thyristor control

OUTPUT CHARACTERISTICS

Similar output will be getting after successfully doing project on the MATLAB software .

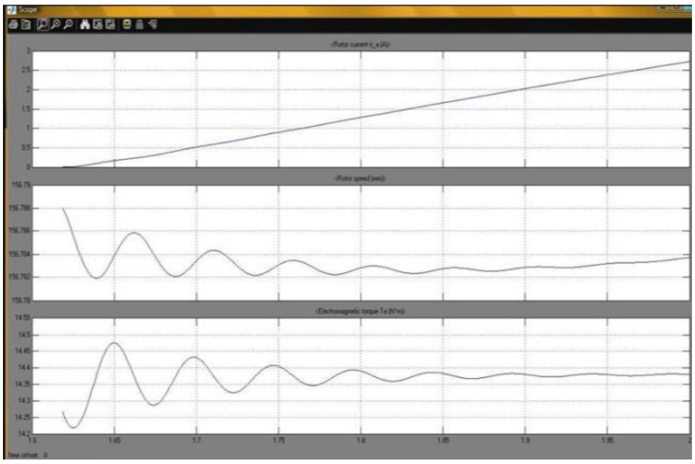

Fig: 6 OUTPUT PLOT showing O/P TORQUE and SPEED of rotor

VII. Conclusion

The construction of the present mechanism has been exclusively modified by designing a rotor side speed control drive which serves as a basis for the high power slip ring induction motors rotor side control. This is thus achieved by a single thyristor controlling the entire flow of rotor current suitably converted at the DC end being in parallel with the load resistance. This mechanism provides us the simplest technique of controlling the entire scheme via the turn on and turn off of the single load side thyristor and gives us the much required high current tolerance which is not possible and if possible not economically viable as in the case of the Insulated GATE bi polar transistors.

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