EXPERIMENT NO.3

Objective: To perform slip power recovery using thyristorised Rectifier Bridge converter for wound rotor induction motor.

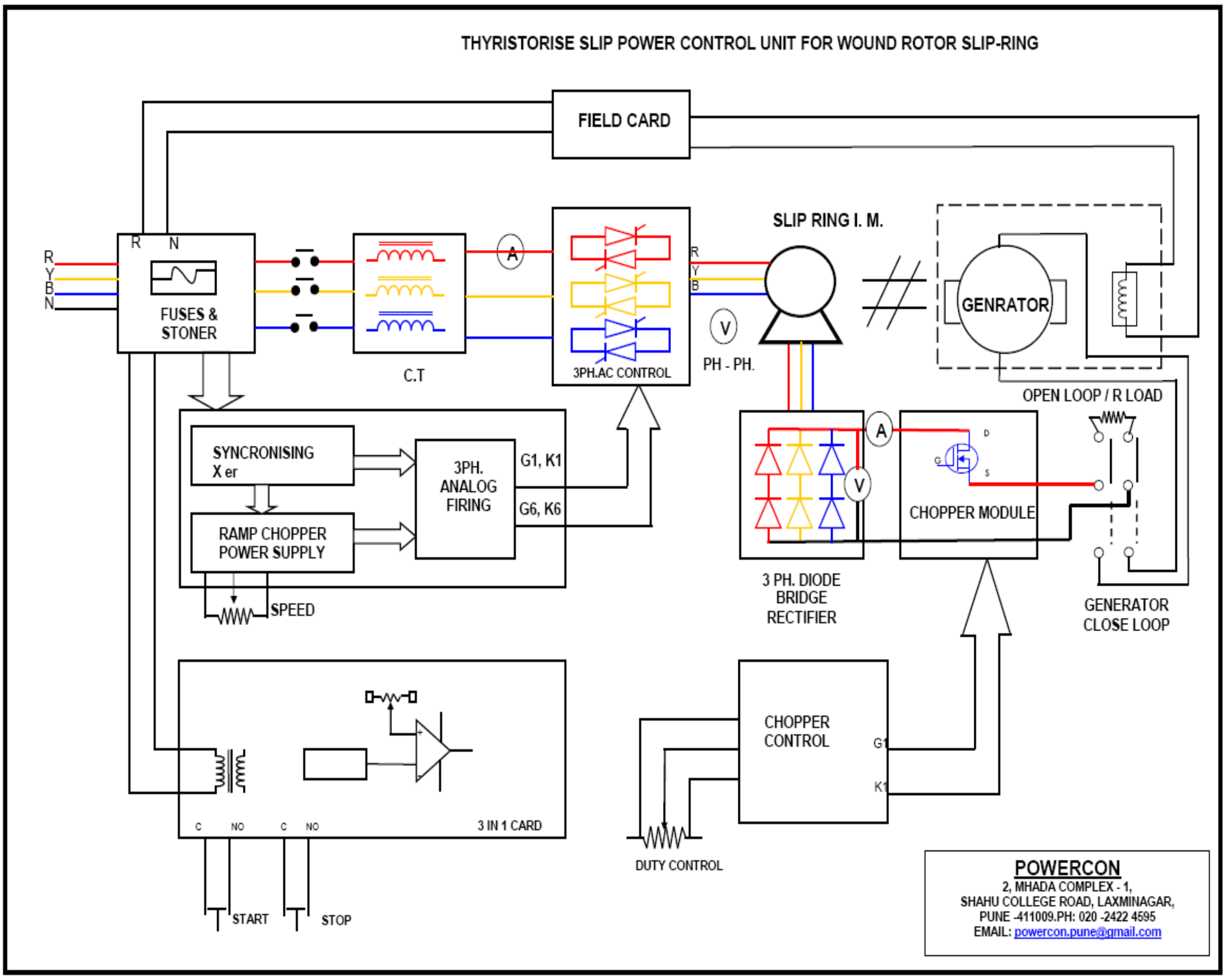
Apparatus required:

1) Three phase SLIP POWER CONTROL kit [POWERCON].
2) C.R.O. Dual Trace. (unearthed CRO)
3) Three phase slip ring induction motor with generator & R load.
4) Three 40 watts lamp & one each 40,40,100,100,200,200 watts
5) Attenuator type C.R.O. probe.

Cautions:

6) **Use unearthed cro only to observe the waveforms.**
7) Do not watch control & power signals simultaneously on oscilloscope.

Circuit diagram:



Theory:

Power circuit:

DC drives are extensively used in the industry for variable speed application. But as cage type induction motors are introduced, which are better machines (AC) than DC machines with improved ruggedness, low cost, smaller size & higher efficiency. No major maintenance is needed due to absence of commutators and brushes for AC machines. Speed of the AC machines can be varied by varying the stator voltage and frequency of supply voltage.

To develop torque in AC machine the rotating magnetic field produced in air gap by three phase supply reacts with rotor. Thus torque in induction motor is created by stator induction effect.

The various methods of speed control of an Induction Motor are as stated below:

1. Stator voltage control.
2. Variable voltage, variable frequency control
3. Variable current, variable frequency control
4. Slip power regulation

Besides all three methods, voltage control method is simple. The circuit used for this method is shown in figure 1 and its associated waveforms of output voltage (phase to phase, line to line) along with firing angle are shown in figure 2. In stator voltage, controller two thyristor are connected in anti-parallel configuration in each phase. The operation of the circuit with the inductive load is as follow:

It is known that for firing angle. The individual load current per phase is sinusoidal and lags behind the cores pending phase voltage by‘ pi 2’. The effective control takes place for p1/2 alpha 5 p1/6. For complete control, the trigger pulse width should be ‘pi-alpha’ and not less than pi/3. The control action can be divided into two parts:

1. For pi/2 < alpha < 2pi/3
2. For pi/2 < alpha < 5pi/6

For p1/2 < alpha < 2p1/3, either two or all the three phases conduct at any instant. The load voltage will assume wither the phase-voltage curve or half the line voltage depending upon the value of ‘alpha’. The load voltage waveform of phase A is shown in fig. 2. Due to the purely inductive load, the current per phase per half-cycle flows from ‘alpha’ to ‘2 (pi-alpha), hence the duration of current per phase per half-cycle is 2 (pi-alpha). SCR1 of phase R is triggered at ‘alpha’ and since both the phases Y and B are already in conduction, the load voltage follows the curve of ER. This continues upto the instant 1 when conduction in phase B reduces to zero.

The current from phase R flows to phase Y only and load voltage assumes the curve of E(R-Y)/2. This will continue upto instant2 when SC-6 of phase B is triggered.

Now the current will flow from phase R to both phase Y and phase B. Hence the load voltage will assume the curve of EA. At the instant 3 the current in phase Y reduces to zero and current flows from phase R to B. This will continue upto instant 4 at which SCR-2 is triggered, and current flows in all the three phases. Therefore the load voltage takes up the curve of EA in the negative half. This continues up to the instant 5 when current is phase 'R' reduces to zero.

The phase R current remains zero until SCR-4 is triggered to allow current in the negative direction. If this is done at the instant 6, the current flows in all the three phases and the load voltage assumes the phase-voltage waveform. This continues upto the instant 7 when the current in phase B becomes zero and current flows from phase Y to R only. The load voltage takes up the waveform of E(R-Y)/2. This state will continue till the instant 8 when SCR-3 is triggered an all the three phases conduct. The load voltage follows the curve of ER.

At the instant 9, the phase Y stops conduction and current flows from phase B to R. The load voltage takes up the curve E(R-B)/2 and continues upto the instant 10 when SCR-5 pf phase 6 is triggered. At this state, all the three phases conduct and the load voltage follows the curve of EA.

This continues till the instant 11, when conduction in phase R reduces to zero and current flows from phase B to phase Y only. During this period, since the current in phase B is zero, the load voltage of that phase is also zero. This continues upto the instant 12 when SCR-1 of the phase R is triggered and the whole cycle repeats.

The waveform of the load current is the integration value of the load voltage, and since the voltage is composed of segments of sinusoids, the load current segments will also be sinusoids.

Procedure: 1
For --motor load --as open loop:

1. Please refer front panel for circuit.
2. Keep rocker switch to OFF position.
3. Connect 4 core wire input supply to the unit in proper R-Y-B-N sequence.

NOTE: - check the phase sequence of 3 phase sequence R, Y , B and N properly. Connect the RED wire for R-phase.

Connect the YELLOW wire for Y-phase.

Connect the BLUE wire for B-phase.

Connect the BLACK /GREEN wire for neutral.

<u>NOTE:</u> [ANY CHANGE IN PHASE SEQ. WILL CAUSE MALFUNCTIONING OF CIRCUIT.]

Check all the three phases are present or not. If not, then don't switch on the supply.

Check the phase voltages with voltmeter and assure that each phase voltage is above 200 V AC.

4. Keep the DUTY CYCLE pot at minimum position.
5. Connect three 40/60 W lamps on Left side panel upper lamp holder DUMMY LOAD.
6. Connect 6-pin jone's plug of 3ph slip ring Induction Motor to the unit front side & motor generator 4-pin jone's plug left panel of unit.
7. Keep loop mode switch on open loop mode.
8. Switch on the mains by rocker switch.
9. Connect two 40W to 400 watts step by step lamps on Left side lower lamp holder. Frits connect 40 watts lamp load. AS ROTOR ENGERGY (POWER) DECIPATOR LOAD.
10. Rocker switch glows.
11. Keep the DUTY CYCLE pot at minimum position
12. Press start button, output LED glows.
13. Very the DUTY CYCLE pot at minimum up to motor run position.
14. Wait for motor response increase the DUTY CYCLE pot clockwise and observe the motor speed, motor starts running slowly by soft start action.
15. Fill corresponding readings of ROTOR VOLTAGE &CURRENT observation table.
16. Observe output ROTOR VOLTAGE &CURRENT wave form.
17. Plot graph of speed vs. ROTER voltage.

Observation table for open loop:

S. no	**Pot position**	**STATOR Output voltage AC** (V=RY **OR** V=YB**OR** V=BR**)**	**STATOR Output Current AC** (A=R **phase)**	**ROTOR Output voltage DC**	**ROTOR Output Current DC**	**STATOR POWER**	**MOTOR Speed (rpm)**
1.							
2.							
3.							
4.							
5.							

Procedure: 2
For --motor load --as closed loop (with out load on motor):

Repeat steps 1 to 5 on from **Procedure: 1**

1. Connect 6-pin jone's plug of 3ph slip ring Induction Motor to the unit front side & motor generator 4-pin jone's plug left panel of unit.
2. Keep loop mode switch on CLOSE loop mode.
3. Switch on the mains by rocker switch.
4. Rocker switch glows.
5. Keep the DUTY CYCLE pot at minimum position
6. Press start button, output LED glows.
7. Very the DUTY CYCLE pot at minimum up to motor run position.
8. Wait for motor response increase the DUTY CYCLE pot clockwise and observe the motor speed, motor starts running slowly by soft start action.
9. Fill corresponding readings of ROTOR VOLTAGE &CURRENT observation table.
10. Observe output ROTOR VOLTAGE &CURRENT wave form.
11. Plot graph of speed vs. ROTER voltage.

Observation table for closed loop (with out load on motor):

S. no	**Pot position**	**STATOR Output voltage AC (V=**RY **OR V=**YB**OR V=BR)**	**STATOR Output Current AC (A=**R **phase)**	**ROTOR Output voltage DC**	**ROTOR Output Current DC**	**STATOR POWER**	**MOTOR Speed (rpm)**
1.							
2.							
3.							
4.							
5.							

Procedure: 3
For --motor load --as closed loop (with load on motor):

Repeat steps 1 to 6 on from **Procedure: 2**

1. Fix the DUTYCYCLE pot at one position.
2. Apply the load on motor and observe the response of it.
3. Fill corresponding readings of ROTOR VOLTAGE &CURRENT observation table.
4. Observe output ROTOR VOLTAGE &CURRENT wave form.
5. Plot graph of speed vs. ROTER voltage.

Observation table for closed loop (with load on motor):

S. no	**Load**	**STATOR Output voltage AC (V=**RY **OR V=**YB**OR V=BR)**	**STATOR Output Current AC (A=**R **phase)**	**ROTOR Output voltage DC**	**ROTOR Output Current DC**	**STATOR POWER**	**MOTOR Speed (rpm)**
1.							
2.							
3.							
4.							
5.							

Conclusions:

TEST POINT

TP WRT XXX	DESCRIPTION	AMPLITUDE	WAVEFORM	FREQ
TP1 WRT GND	Collector of R+	12V DC	ramp	-
TP2 WRT GND	Collector of Y+	12V DC	dc	
TP3 WRT GND	Collector of B+	12V DC	Square wave	100 Hz
TP4 WRT GND	Collector of R-	12V DC	dc	
TP5 WRT GND	Collector of y -	12V DC	H.F. Pulses	
TP6 ------- GND	Collector of B-	12V DC	GND	
TP7WRT GND	Ramp signal	12V DC	ramp	100 Hz
TP8 WRT GND	Duty cycle o/p	12V DC	Square wave	100 Hz
TP9 WRT STAR N	STATOR R PHASE O/P	230V AC	SINE wave	50 Hz
TP10 WRT STAR N	STATOR Y PHASE O/P	230V AC	SINE wave	50 Hz
TP11WRT STAR N	STATOR B PHASE O/P	230V AC	SINE wave	50 Hz
TP12 STAR N	STAR N	STAR N	STAR N	STAR N
TP13 WRT TP14	ROTER BRIDGE **+VE**	10-300 VDC	DC	
TP14	ROTER BRIDGE **-VE**	5V DC	Square wave	50 Hz
TP15 WRT TP16	ROTER CURRENT**+VE**	1 VDC	-	-
TP16	ROTER CURRENT**-VE**	1 VDC		
TP17 WRT TP18	ROTER O/P R&Y PHASE	10-300V AC		
TP17 WRT TP18	ROTER O/P R&Y PHASE	10-300V AC		
TP19 WRT TP17	ROTER O/P R&Y PHASE	10-300V AC	-	-
TP20 WRT TP21	GENRATOR ARMA **+VE**	20-150 VDC	DC	
TP21	GENRATOR ARMA **-VE**			-
TP22 WRT TP23	GENRATOR FIELD **+VE**	190 VDC	FULL WAVE	100 Hz
TP23	GENRATOR FIELD **-VE**	20-150 VDC		

USE UNEARTHED C.R.O. FOR OBSERVING ALL THE WAVEFORMS.

Control on panel:

CONTROL	**FUNCTION**
SPEED	Control amplitude of output.
DUTY CYCLE	Control duty cycle of chopper circuit.
START	Releases amplitude command applies AC input to Three phase AC controller.
STOP	Block amplitude command as well as AC input to Three phase AC controller.

Meters and indication on panel:

INDICATION	**FUNCTION**
ROTER INPUT VTG PHASE TO PHASE (VAC)	Indicates AC input voltage applied to STATOR Three phase AC controller.
ROTER INPUT CURRENT R PHASE T (AMP AC)	Indicates AC input CURRENT applied to STATOR R phase AC.
ROTER BRIDGE VTG (VDC)	ROTER BRIDGE OUTPUT VOLTAGE V DC
ROTER BRIDGE CURRENT (AMP DC)	ROTER BRIDGE OUTPUT CURRENT V DC
OUTPUT RED LED	Shows commands released and AC input to Three phase AC controller.