INDUCTION REGULATOR

Objective:

Using a wound rotor induction motor an *Induction Regulator*, study the effect of rotor position on the output voltage of the regulator. Also study its behaviour under load condition and verify the results from theoretical considerations.

Theory:

A wound rotor induction machine can be operated as an ' *Induction Regulator'* to produce a constant frequency variable voltage supply system.

The schematic connection diagram of a 3-phase induction regulator is shown in FIG.1. Note that one of the two members (stator and rotor) is connected to the 3-phase supply in the normal fashion. One end of each of the three phases of the other member (which has six terminals is also connected to the supply, **taking care that R of the first member and R2, one end of the corresponding phase of the second member, are connected to the same supply phase, and similarly, Yand Y2, and B and B2. The three free terminals R1, Y1, and B1 give the three - phase variable voltage supply.**

It is interesting to note that, for this condition of working, the induction machine is operating as a polyphase, phase-shifting transformer, with the only difference that the e.m.f induced in the secondary member is a result of the rotating magnetic field produced in the primary, and therefore, the magnitude of the secondary voltage is independent of he rotor position, although the relative phasor position of the induced secondary voltage with respect to its primary counterpart is determined by the rotor position.

The phasor diagrams shown in FIG.2 indicate the relative position of the voltage phasors in the primary and secondary windings of the three phases, from which the relative position of the voltage across the terminals R1, Y1, B1 have been estimated. The output voltage per phase varies over a range of Vo =Vp + K*Vs to Vp-K*Vs, where K is the transformation ratio.

For K= 1, Vo = 0 to 2Vp.

An important feature of the induction regulator is that the control f the output voltage is associated with the phase shift.

Pre-experiment quiz

1. Explain the basic principle of the induction motor.
2. Compare the workings of the transformer & the induction motor at standstill.
3. A transformer with a movable secondary has the magnetic axis of its primary & secondary displaced from each other by an angle θ. The voltage induced in the secondary will be maximum for the following value of θ.

a. 90deg.
b. 0 deg.

c. 60 deg.
d. 45 deg.

4. What type of rotor should the induction motor have for operating it as an induction regulator?
5. In an induction regulator, explain why the e magnitude of the secondary voltage is independent of the rotor position.
6. What is the effect of the change in the rotor position of the secondary induced e.m.f?
7. Does the secondary e.m.f change the magnitude and/or the phase of the output voltage?

Apparatus:

The machine and the equipment required in this experiment are shown in the circuit diagram of FIG.1. List the instruments required with their ranges. Record the specifications of he machine.
Induction Machine Voltage- 400 V (delta), Amps -5.3
Rotor volts -153 V, 50 Hz, Rotor amps - 9
R.P.M- 1415

Procedure:

a. Determination of the transformation ratio

1. Connect the stator of the induction machine in star.
2. Leave the rotor on open circuit and connect a voltmeter Vr across two of the rotor terminals
3. Apply a suitable voltage Vsi (line) to the stator winding and record Vsi (line) and Vr (line).
4. Remove the supply connections of the stator and leave the voltmeter Vs connected across the stator lines. Open circuit the stator. Using a variac, apply Vr (line) as measured in item 3 above across the rotor terminals and record the new voltmeter reading Vs2 (line) in the stator voltmeter.

The transformation ratio (Rotor:Stator) of the induction machine is given by

$$2 V_r/(V_{s1}+V_{s2}).$$

This procedure is necessary because the magnetic coupling between the rotor & stator of an induction machine is not *stiff* as in the case of a transformer

b. Output voltage as a function of rotor position

1. Connect the machine as in FIG.1. Keep the output terminals open -circuited.
2. Apply 85 V (line) across the rotor terminals through a 3-phase variac.
3. Move the rotor with hand slowly and adjust its position to yield minimum output voltage. Note the corresponding angular position of the rotor on the cardboard 'angle dial' and assume this position to be zero.

4. Now, move the rotor by hand, and for every 10-deg. mechanical displacement on either side of this zero position record the output voltage. Also record the primary phase voltage, the secondary induced phase voltage, the secondary input voltage per phase, for each rotor position.
5. Using these readings, plot the voltage diagrams (similar to FIG.2) and compare the measured values with those estimated.

c. Load test on induction regulator

1. Connect the machine as in FIG.1 and apply 85 V (line) across the rotor terminals through a 3- phase variac.
2. Adjust the rotor position for maximum output voltage.
3. *Block the rotor at this position throughout the range of the experiment. A torque will be felt when the rotor is blocked.*
4. Load the machine and gradually vary the magnitude of load up to a value such that the output current m is 2.5 A. Do not exceed this value of current in the stator circuit as otherwise the heating would be excessive.
5. Using the results of the test, determine the variations of efficiency, power factor, output voltage, and input current against power output. Also plot the voltage/rotor angle curve of the machine at no load.
6. Draw phasor diagrams and determine the effective phase -shift of he output to input voltages, for different values of the rotor angle.

Conclusions

Study the above characteristics and arrive at suitable conclusions.

Data Sheet

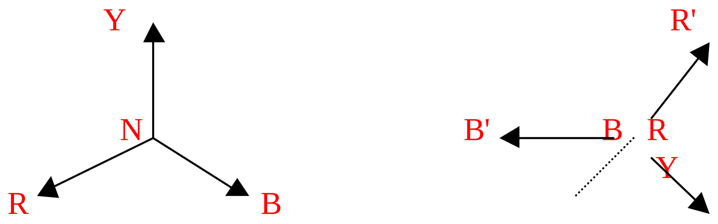
S. No.	Rotor Input					Stator side		
	Ir	Vrph	Vr1	Wr1	Wr2	Vs1	Vs2	Columns for V1, Is, Ws1, Ws2

Post experimental quiz

1. Identify the positions of the rotor with respect to the stator for giving the conditions of boost and buck of he output voltage.
2. What happens to the mutual inductance at θ = 90 deg.?
3. During the course of this experiment if the rotor is not blocked what will happen to the system?
4. What are the other methods of regulating the voltage? Compare them.
5. Where are induction regulators used in practice?

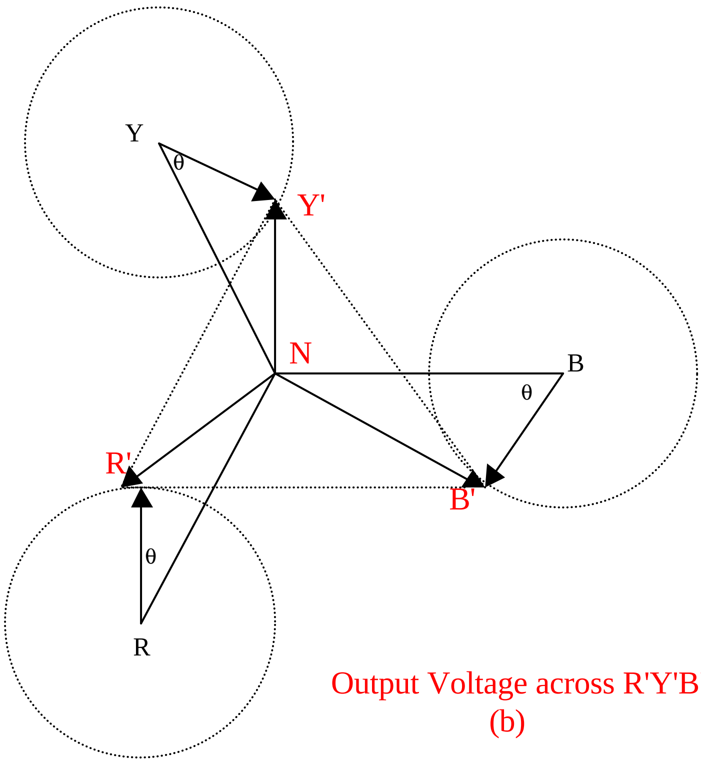
FIG.2 & FIG.1 respectively are given on the following two pages

FIG.2



Primary Voltage Phasors   Secondary Voltage Phasors

(a)



Output Voltage across R'Y'B'

(b)

FIG.1

3-phase 400V, 50 Hz