

# Synchronisation of an Alternator

## Objective:

1. To study the synchronisation of the given synchronous generator with the main busbars by Three-Dark-lamp method.
2. To study the effect of the change in input to the alternator (under constant excitation) on output power, power angle and power factor.

## Theory:

The synchronous generator (FIG.1) can be connected to the busbars (represented by an equivalent generator) only when each of the voltages between R1 and R2, between Y1 and Y2, and between B1 and B2 is zero at every instant of time. This condition is fulfilled when the line voltages on the generator side are equal, at all instants of time, to the corresponding voltages on the busbar side. This is possible only if the following conditions are fulfilled:

- a. The voltages  $V_g$  and  $V_b$  are equal in magnitude and are in phase.
- b. Their frequencies are the same.
- c. The generator and the busbars have the same phase sequence.

When these conditions are fulfilled, the synchronising switch between the generator and the bus can be switched on. Fulfilment of these conditions is checked by the following method:

### **I. Synchronisation by three dark lamp method**

Connect the D.C. motor -synchronous generator as shown in FIG.2. Start the D.C. motor by switching on S1 and bring its speed to the synchronous speed of the generator (1500-rpm). Adjust the field excitation of the generator using Rf2 and Rf3 so that about rated voltage (400V, L-L) is obtained. Switch on the a.c mains switch S2 and adjust the variac so that  $V_b$  is 400 V. Let the phase sequence of the generator terminals RYB be the same as that of the respective terminals of the mains, RYB. The voltage phasors for this condition are shown in FIG.3. If the generator frequency is slightly more than that of the bus, then the phasors R1, Y1 and B1 move anti-clockwise relative to R2, Y2, and B2. The voltages across the lamps L1, L2, L3 (which are indicated by the phasors R1R2, Y1Y2, and B1B2) will increase & decrease simultaneously and therefore, the three lamps will brighten up and darken at the same time.

If the phase sequences are R1Y1B1 and R2 B2Y2, the phase diagram of voltages will be as shown in FIG.4. For this condition the voltages across lamps given by phasors R1R2, Y1Y2 and B1B2 are not equal to each other at the instant shown. Therefore the lamps go through their zero voltage one after the other. The phase sequences are thus different and can be corrected by interchanging any two terminals either on the generator side or on the bus side. When such a change is made *both the three-phase main switch S2 and the D.C. main switch S1 should be switched off.*

With the phase sequence corrected, if there is a large difference between the frequency of the generator and that of the bus, the lamps will brighten & darken in quick succession. By adjusting the speed of the generator, this rapidity can be

reduced, which indicates that the frequencies are coming closer and the lamps will brighten up & darken slowly.

The correct moment of synchronisation in this method is when all the lamps are completely dark, at which time all the voltages of her bus are exactly in phase with the corresponding voltages of the generator. At this moment the synchronising switch S3 is closed and the generator is synchronised with the mains.

After synchronisation do not allow the synchronous machine to run as a motor, i.e. do not allow the wattmeter to read negative. If it reads negative it means that the machine receives power from the a.c mains. In such a case, reduce the excitation of the D.C. motor so that the wattmeter reads a few positive watts.

## II. Study of the influence of the change in input power of the synchronous generator

After synchronisation  $I_f$  is kept constant and the prime -mover excitation  $I_{fpm}$  is slowly decreased taking care that the positive power is shown by the wattmeter which indicates that the machine is only generating. For each value of  $I_{fpm}$ ,  $I_a$ ,  $W$ ,  $V$ , and the power angle are noted. The power angle may be noted using a stroboscope. The generator may become unstable for higher values of current; care should be taken to switch off the a.c mains then.

Load of suitable values is connected to the D.C. busbar to absorb the D.C. power in the event the synchronous machine operates as a motor. This load is switched on before synchronisation.

### Report:

Power output,  $P=$

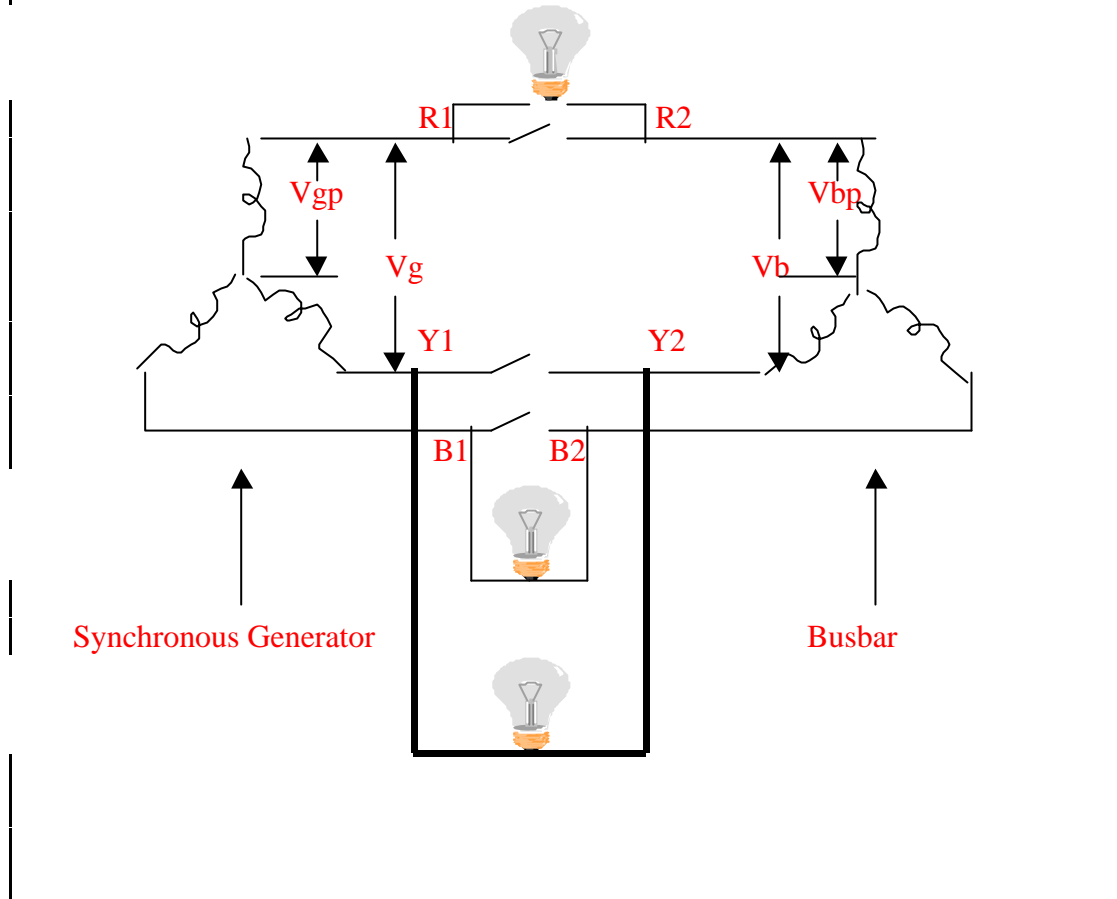
1. Calculate the power factor in each case,  $\cos \phi = P/(1.73 V I_a)$
2. Plot power  $P$  against  $\delta$  (on X-axis) for different excitations.
3. Plot p.f against  $P$  (on X-axis) for different excitations.
4. Plot  $I_a$  against  $P$  (on X-axis) for different excitations.
5. Suppose lamps 2 & 3 were cross-connected as shown in FIG.5, how will the lamps glow for

- Correct phase sequence
- Incorrect phase sequence?

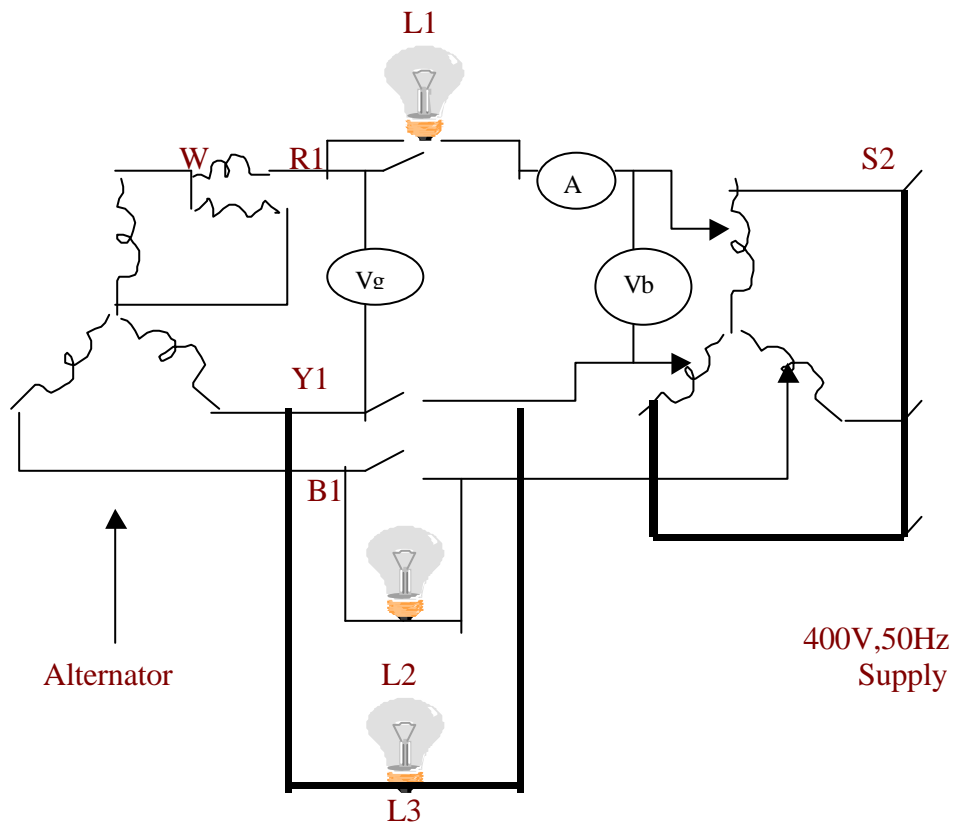
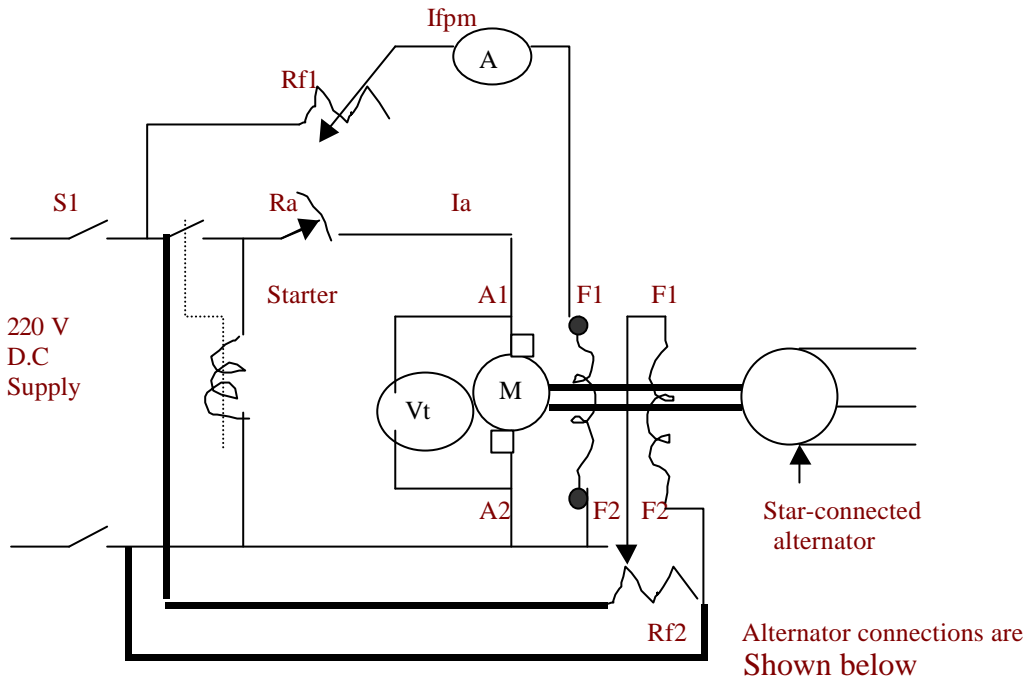
Draw phasor diagrams to justify your results.

**Figs 1-5 are given on the following pages**

FIG.1



**FIG.2**



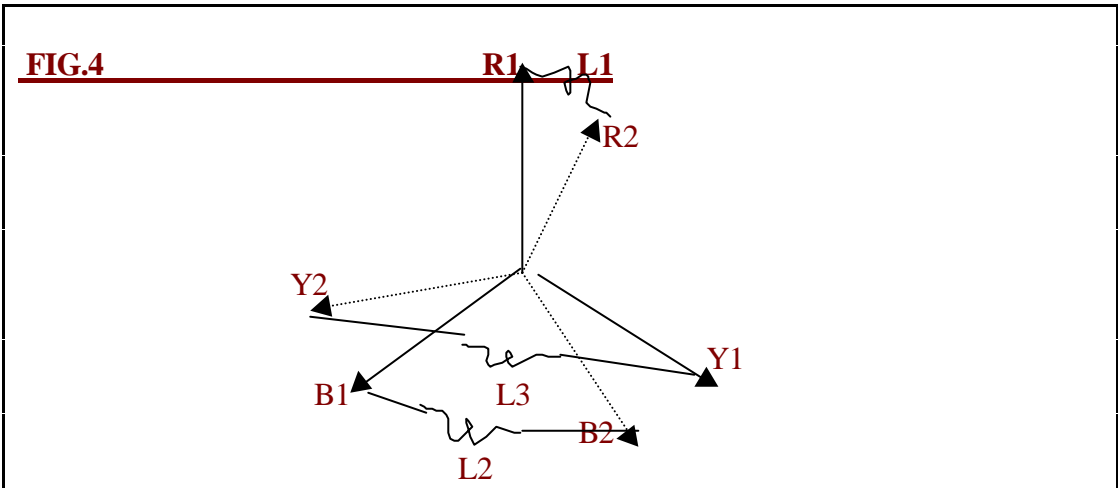
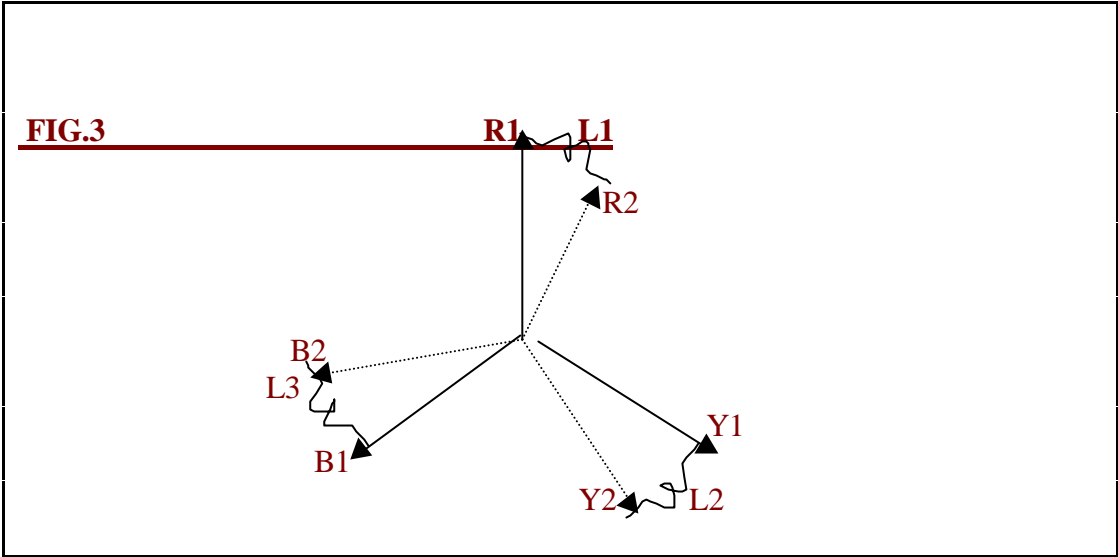


FIG.5

