VI. Induction Regulators

Induction Regulators

An induction voltage regulator enables a smooth variation of the output voltage, whereas in a tap-changer transformer, the output voltage can be controlled only in discrete steps. In induction voltage regulator, the output voltage is controlled by varying the angle between the magnetic axes of primary and secondary windings. In tap-changer, the output voltage is regulated by altering the turns ratio.

Three-phase induction regulator. A three-phase induction voltage regulator resembles closely a three-phase slip-ring induction motor. The rotor carries the primary winding and the stator has the secondary winding as in the case of single-phase type. Three-phase primary winding is connected in star, whereas the 3-phase secondary is connected in series with the load as shown in Fig. 1. In large sizes, the induction regulator is oil-immersed in a tank like an ordinary transformer. Rotor movement is carried out in the same manner as in a single-phase induction regulator.

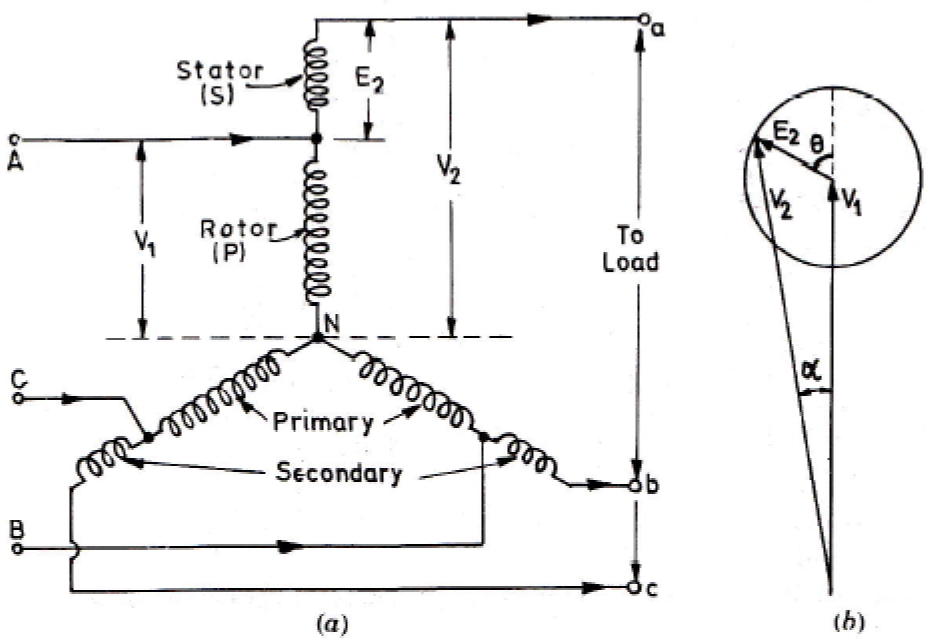

Fig. 1 (*a*) Connection diagram of a 3-phase induction regulator (*b*) Voltage phasor diagram for any one phase.

When the induction voltage regulator is connected to 3-phase supply, three-phase currents in the three phase primary winding produce a constant amplitude rotating magnetic field as in a 3-phase induction motor. This rotating magnetic field induces e.m.fs. in the secondary winding whose magnitudes depend only on the ratio of primary to secondary turns and are independent of the rotor position. When the rotor position is changed with respect to stator, the magnitude of secondary e.m.fs. remains constant but their phase is altered with respect to primary voltages. The output voltage V_2 is the phasor sum of primary voltage V_1 and the constant secondary e.m.f. E_2 induced by the rotating magnetic field. For fixed primary voltage, the locus of output voltage V_2 is a circle with centre at the tip of phasor V_1 and of radius E_2. Thus maximum output voltage $V_2 = V_1 + E_2$ is obtained when E_2 is in phase with V_1 and minimum voltage $V_2 = V_1 - E_2$ is available when E_2 is in phase opposition to V_1.

The induction regulator has the following advantages over a variable autotransformer:

- A continuous stepless variation of the output voltage is possible.
- No sliding electrical connections are necessary.

However, the induction regulator suffers from the disadvantages of higher leakage inductances, higher magnetizing current, and higher costs.

Application

- The equipment may thus be termed a phase-shifting transformer and as such is a useful piece of laboratory equipment for a.c. meter testing and similar applications.

- It is also used to advance the phase of the grid voltages of grid – controlled mercury – arc rectifiers. When the apparatus is arranged as a booster (Fig.2) the secondary voltage is added to that of the primary as shown in the phasor diagram (Fig.3).

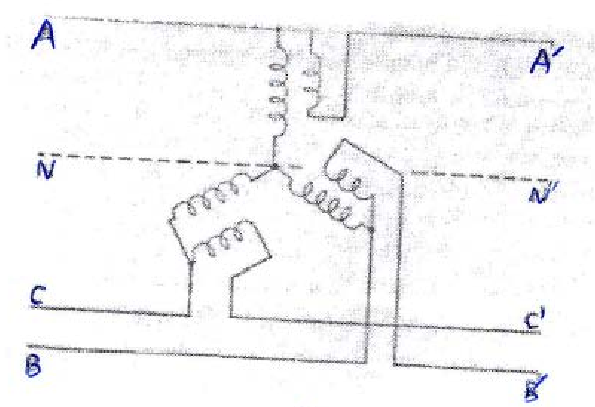

Fig. (2)

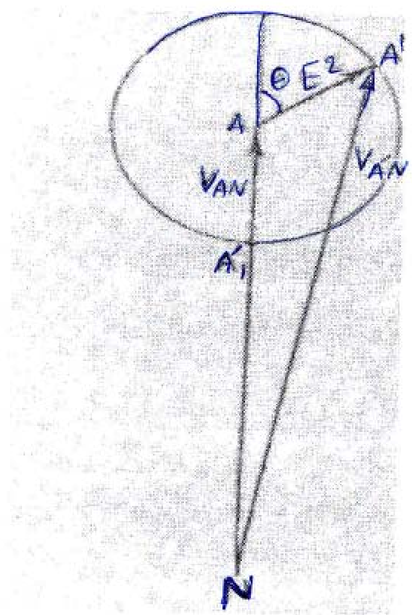

Fig. (3)

As the rotor axis changes, the phasor $V_{AA'}$ rotates relative to the phase voltage of the supply V_{AN} and over (180^o) of rotor displacement the output voltage varies from a minimum $V_{A'1N}$ to a maximum $V_{A'2N}$.

Induction regulators of this type are used in distribution networks to boost the voltage of a feeder or alternatively to compensate for variable input voltage, and have many applications in laboratories and testing plants where variable voltage is required.