Power Factor Improvement

The following devices and equipments are used for Power Factor Improvement.

- Static Capacitor
- Synchronous Condenser
- Phase Advancer

1. Static Capacitor

We know that most of the industries and power system loads are inductive that take lagging current which decrease the system power factor . For Power factor improvement purpose, Static capacitors are connected in parallel with those devices which work on low power factor.

2. Synchronous Condenser

When a Synchronous motor operates at No-Load and over-exited then it’s called a synchronous Condenser. Whenever a Synchronous motor is over-exited then it provides leading current and works like a capacitor. When a synchronous condenser is connected across supply voltage (in parallel) then it draws leading current and partially eliminates the re-active component and this way, power factor is improved. Generally, synchronous condenser is used to improve the power factor in large industries.

3. Phase Advancer

Phase advancer is a simple AC exciter which is connected on the main shaft of the motor and operates with the motor's rotor circuit for power factor improvement. Phase advancer is used to improve the power factor of induction motor in industries. As the stator windings of induction motor takes lagging current 90° out of phase with Voltage, therefore the power factor of induction motor is low. If the exciting ampere-turns are excited by external AC source, then there would be no effect of exciting current on stator windings. Therefore the power factor of induction motor will be improved. This process is done by Phase advancer.

Three-Phase Drives

- The armature circuit is connected to the output of a three-phase controlled rectifier.
- Three-phase drives are used for high-power applications up to megawatt power levels.
- The ripple frequency of the armature voltage is higher than that of single-phase drives and it requires less inductance in the armature circuit to reduce the armature ripple current.
- The armature current is mostly continuous, and therefore the motor performance is better compared with that of single-phase drives.
- Similar to the single-phase drives, three-phase drives may also be subdivided into:
  - Three-phase half-wave-converter drives.
  - Three-phase semiconverter drives.
  - Three-phase full-converter drives.
  - Three-phase dual-converter drives.

Three-Phase Half-Wave-Converter Drives

A three-phase half-wave converter-fed dc motor drive operates in one quadrant and could be used in applications up to a 40-kW power level. The field converter could be a single-phase or three-phase semiconverter. This drive is not normally used in industrial applications because the ac supply contains dc components.

With a three-phase half-wave converter in the armature circuit, Eq. (10.19) gives the armature voltage as

$$V_a = \frac{3\sqrt{3}V_m}{2\pi}\cos\alpha_a \qquad \text{for } 0 \le \alpha_a \le \pi \tag{15.22}$$

where V_m is the peak phase voltage of a Y-connected three-phase ac supply. With a three-phase semiconverter in the field circuit, Eq. (10.69) gives the field voltage as

$$V_f = \frac{3\sqrt{3}V_m}{2\pi}(1 + \cos\alpha_f) \qquad \text{for } 0 \le \alpha_f \le \pi \tag{15.23}$$

Three-Phase Full-Wave-Converter Drives

- A three-phase full-wave-converter drive is a two-quadrant drive without any field reversal, and is limited to applications up to 1500 kW.
- During regeneration for reversing the direction of power
- However, the back emf of the motor is reversed by reversing the field excitation.
- The converter in the field circuit should be a single- or three-phase full converter.

With a three-phase full-wave converter in the armature circuit, Eq. (10.25) gives the armature voltage as

$$V_a = \frac{3\sqrt{3}V_m}{\pi}\cos\alpha_a \qquad \text{for } 0 \leq \alpha_a \leq \pi \tag{15.26}$$

With a three-phase full converter in the field circuit, Eq. (10.25) gives the field voltage as

$$V_f = \frac{3\sqrt{3}V_m}{\pi}\cos\alpha_f \qquad \text{for } 0 \leq \alpha_f \leq \pi \tag{15.27}$$

Three-Phase Dual-Converter Drives

- Two three-phase full-wave converters are connected in an arrangement similar to Figure 15.15a.
- Either converter 1 operates to supply a positive armature voltage, V_a or converter 2 operates to supply a negative armature voltage, $-V_a$.
- It is a four-quadrant drive and is limited to applications up to 1500 kW.
- The field converter can be a full-wave converter.
- If converter 1 operates with a delay angle of

α_{a1}, Eq. (10.25) gives the average armature voltage as

$$V_a = \frac{3\sqrt{3}V_m}{\pi}\cos\alpha_{a1} \qquad \text{for } 0 \le \alpha_{a1} \le \pi \tag{15.28}$$

If converter 2 operates with a delay angle of α_{a2}, Eq. (10.25) gives the average armature voltage as

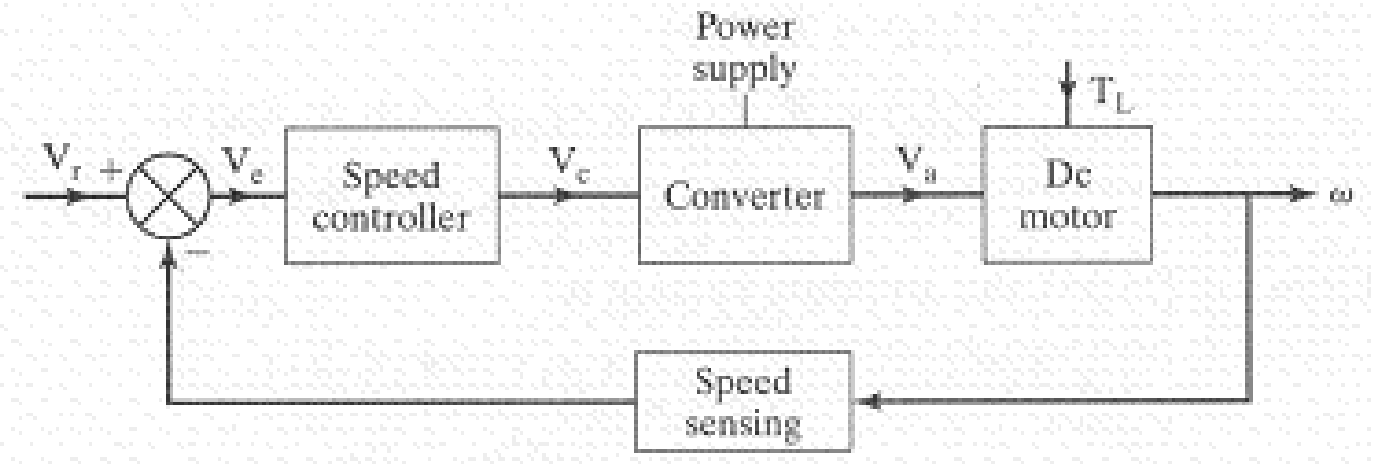
$$V_a = \frac{3\sqrt{3}V_m}{\pi}\cos\alpha_{a2} \qquad \text{for } 0 \le \alpha_{a2} \le \pi \tag{15.29}$$

With a three-phase full converter in the field circuit, Eq. (10.25) gives the average field voltage as

$$V_f = \frac{3\sqrt{3}V_m}{\pi}\cos\alpha_f \qquad \text{for } 0 \le \alpha_f \le \pi \tag{15.30}$$

Closed-Loop Control of DC Drives

- The speed of dc motors changes with the load torque.
- To maintain a constant speed, the armature (and or field) voltage should be varied continuously by varying the delay angle of ac-dc converters or duty cycle of dc-dc converters.
- In practical drive systems it is required to operate the drive at a constant torque or constant power; in addition, controlled acceleration and deceleration are required.
- Most industrial drives operate as closed-loop feedback systems.
- A closed-loop control system has the advantages of improved accuracy, fast dynamic response, and reduced effects of load disturbances and system nonlinearities.



Closed-Loop Control of DC Drives

- The block diagram of a closed-loop converter-fed separately excited dc drive is shown in Figure 15.25.
- If the speed of the motor decreases due to the application of additional load torque, the speed error V_e increases.
- The speed controller responses with an increased control signal V_c, change the delay angle or duty cycle of the converter, and increase the armature voltage of the motor.
- An increased armature voltage develops more torque to restore the motor speed to the original value.
- The drive normally passes through a transient period until the developed torque is equal to the load torque.