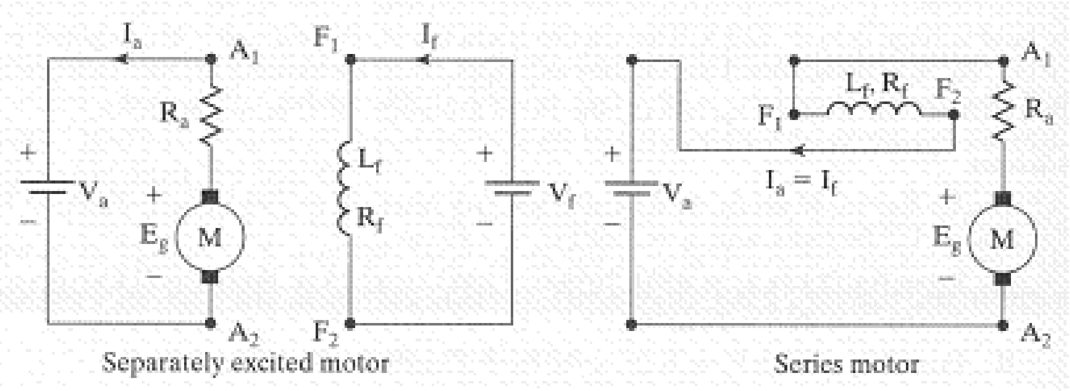
Breaking Operation of Separately Excited DC motor Drives

Regenerative braking:

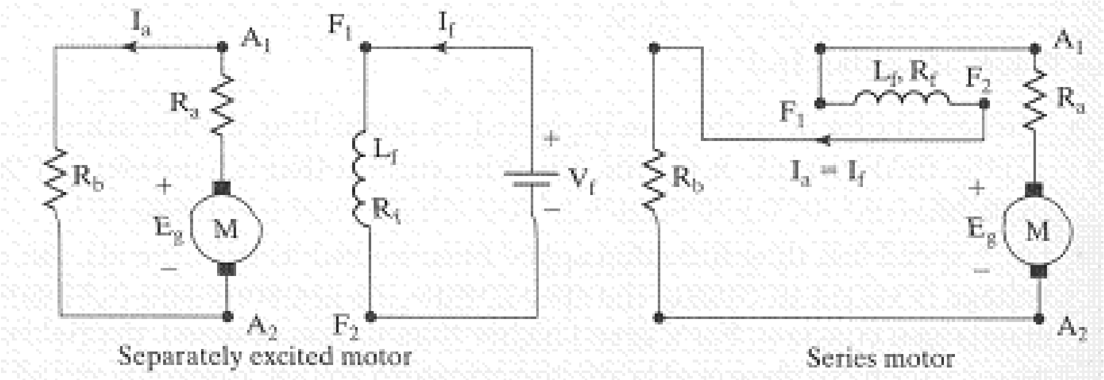
- The arrangements for regenerative braking are shown in Figure 15.7b.
- The motor acts as a generator and develops an induced voltage E_g. E_g must be greater than supply voltage V_a.
- The armature current is negative, but the field current is positive.
- The kinetic energy of the motor is returned to the supply.
- A series motor is usually connected as a self-excited generator.
- For self-excitation, it is necessary that the field current aids the residual flux. This is normally accomplished by reversing the armature terminals or the field terminals.



(b) Regenerative braking

Dynamic braking:

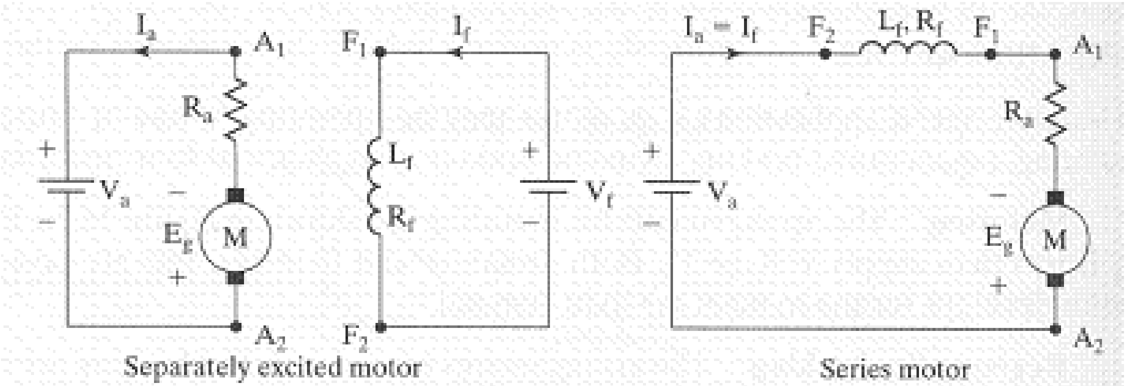
- The arrangements shown in Figure 15.7c are similar to those of regenerative braking, except the supply voltage V_a is replaced by a braking resistance R_b,.
- The kinetic energy of the motor is dissipated in R_b.



(c) Dynamic braking

Plugging:

- Plugging is a type of braking. The connections for plugging are shown in Figure 15.7d.
- The armature terminals are reversed while running. The supply voltage V_a and the induced voltage E_g act in the same direction.
- The armature current is reversed, thereby producing a braking torque. The field current is positive.
- For a series motor, either the armature terminals or field terminals should be reversed, but not both.



(d) Plugging

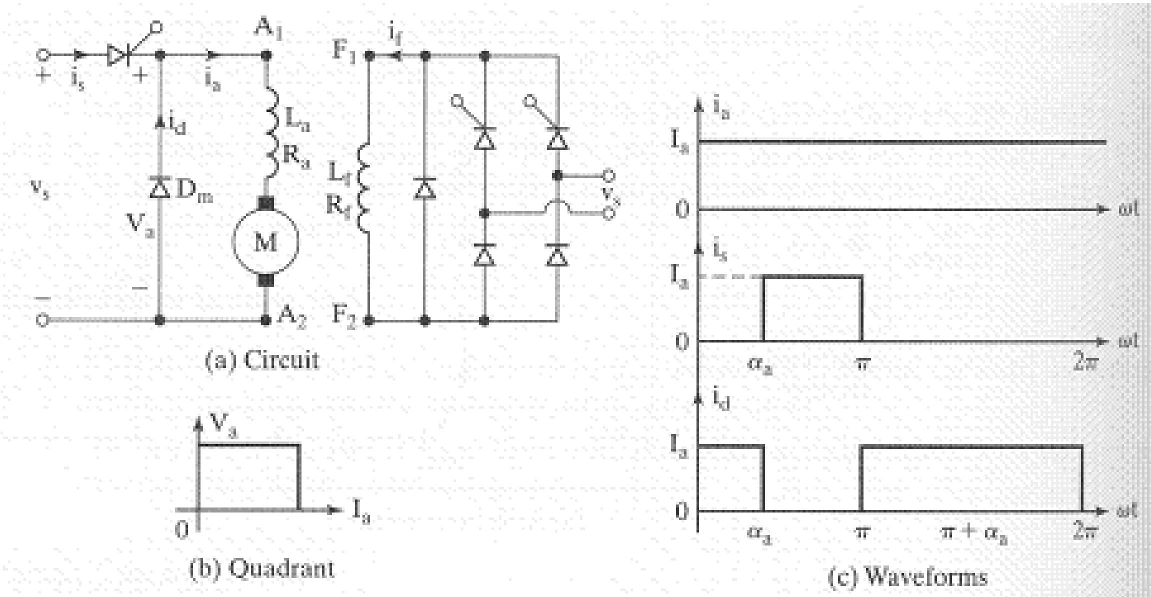
Single-phase Separately Excited Drives

Single-Phase Drives

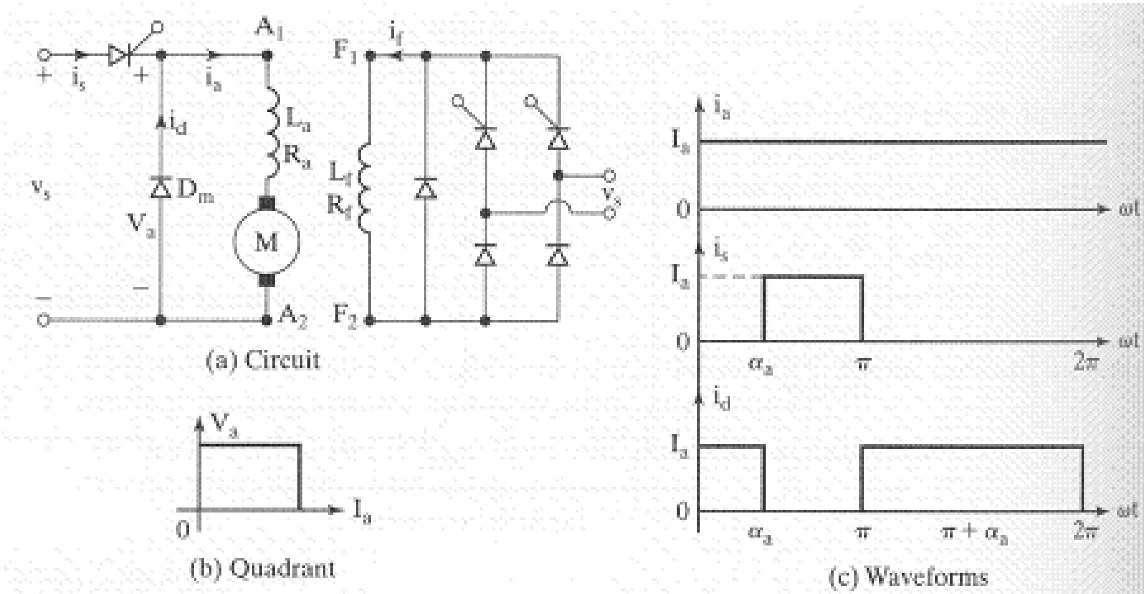
- Depending on the type of single-phase converters,
  - single-phase drives may be subdivided into:
  - Single-phase half-wave-converter drives.
  - Single-phase semi converter drives.
  - Single-phase full-converter drives.
  - Single-phase dual-converter drives.

Single-Phase Half-Wave-Converter Drives

- A single-phase half-wave converter feeds a dc motor, as shown below.
- The armature current is normally discontinuous unless a very large inductor is connected in the armature circuit.
- A freewheeling diode is always required for a dc motor load and it is a one-quadrant drive.
- The applications of this drive are limited to the 0.5 kW power level.
- Figure shows the waveforms for a highly inductive load.
- A half-wave converter in the field circuit would increase the magnetic losses of the motor due to a high ripple content on the field excitation current.



Single-Phase Half-Wave-Converter Drives



(a) Circuit
(b) Quadrant
(c) Waveforms

With a single-phase half-wave converter in the armature circuit, Eq. (10.1) gives the average armature voltage as

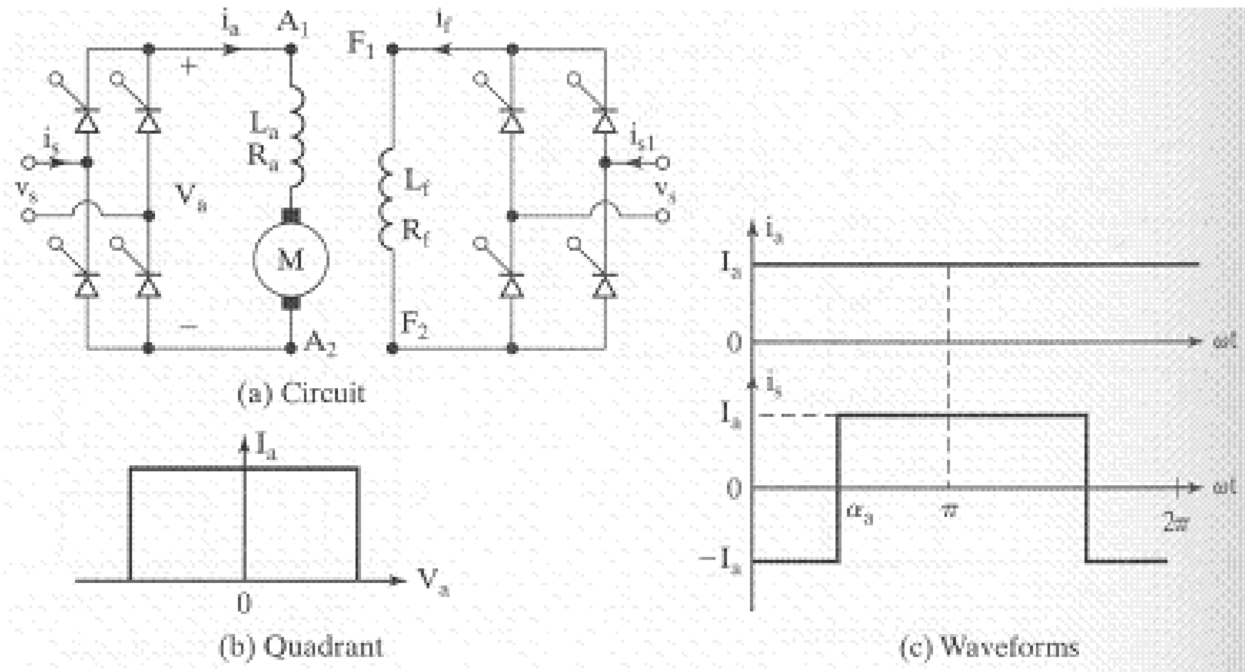
$$V_a = \frac{V_m}{2\pi}(1 + \cos \alpha_a) \qquad \text{for } 0 \leq \alpha_a \leq \pi \tag{15.13}$$

where V_m is the peak voltage of the ac supply. With a semiconverter in the field circuit, Eq. (10.52) gives the average field voltage as

$$V_f = \frac{V_m}{\pi}(1 + \cos \alpha_f) \qquad \text{for } 0 \leq \alpha_f \leq \pi \tag{15.14}$$

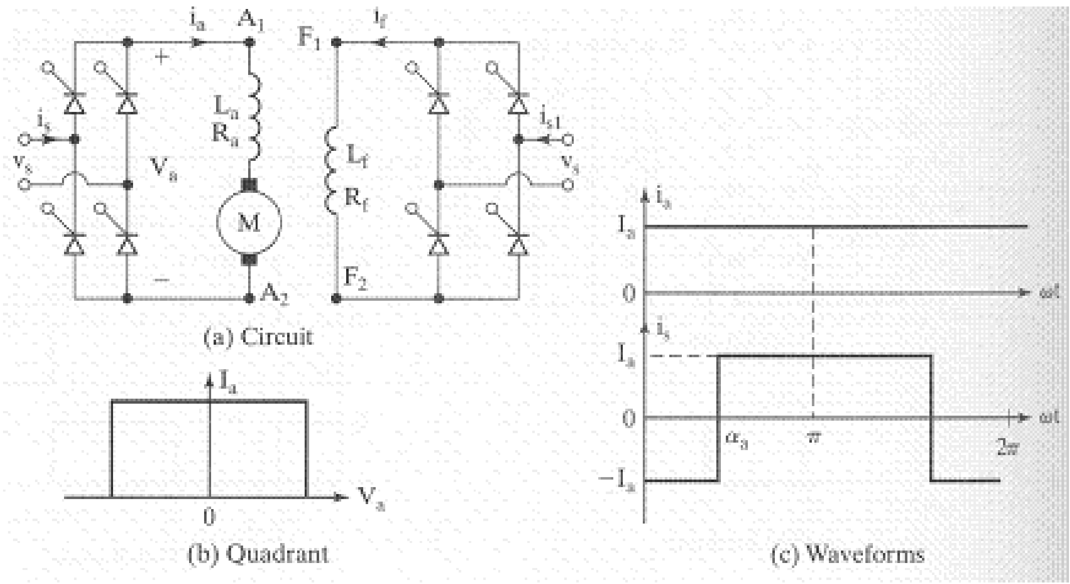
Single-Phase Full-Wave-Converter Drives

- The armature voltage is varied by a single-phase full-wave converter, as shown in Figure 15.13a.
- It is a two-quadrant drive, as shown in Figure 15.13b, and is limited to applications up to 15 kW.
- The armature converter gives + V_a or - V_a, and allows operation in the first and fourth quadrants.
- During regeneration for reversing the direction of power flow, the back emf of the motor can be reversed by reversing the field excitation.



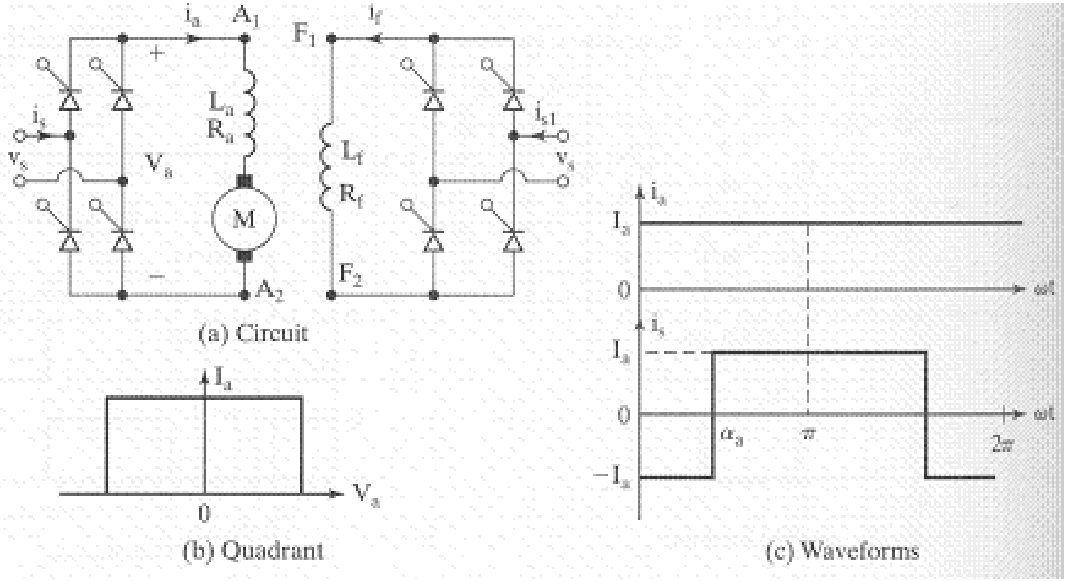
Single-Phase Full-Wave-Converter Drives

- The converter in the field circuit could be a full, or even a dual converter.
- The reversal of the armature or field allows operation in the second and third quadrants.
- The current waveforms for a highly inductive load are shown in Figure 15.13c for powering action.



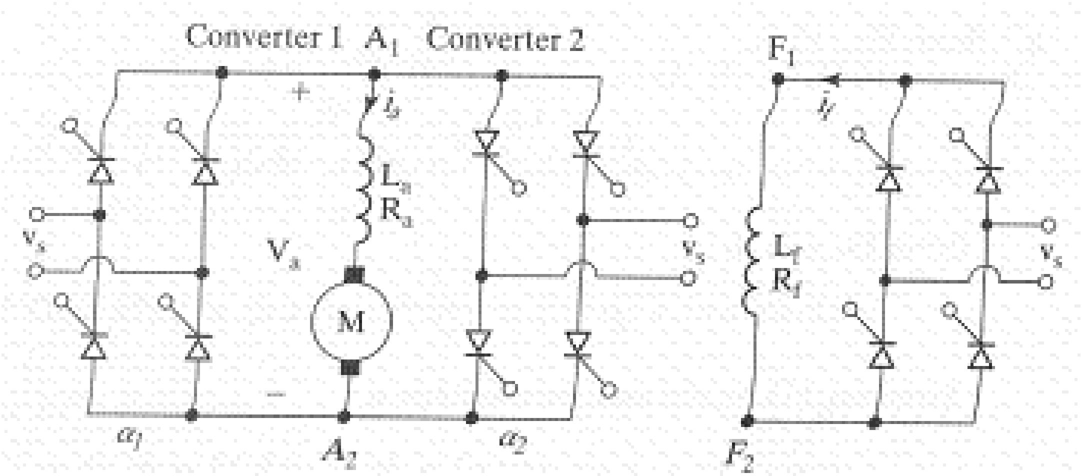
Single-Phase Full-Wave-Converter Drives

- The converter in the field circuit could be a full, or even a dual converter.
- The reversal of the armature or field allows operation in the second and third quadrants.
- The current waveforms for a highly inductive load are shown in Figure 15.13c for powering action.



Single-Phase Dual-Converter Drives

- Two single-phase full-wave converters are connected.
- Either converter 1 operates to supply a positive armature voltage, V_a, or converter 2 operates to supply a negative armature voltage, - V_a.
- Converter 1 provides operation in the first and fourth quadrants, and converter 2, in the second and third quadrants.
- It is a four-quadrant drive and permits four modes of operation: forward powering, forward braking (regeneration), reverse powering, and reverse braking (regeneration).
- It is limited to applications up to 15 kW. The field converter could be a full-wave or a dual converter.



Single-Phase Dual-Converter Drives

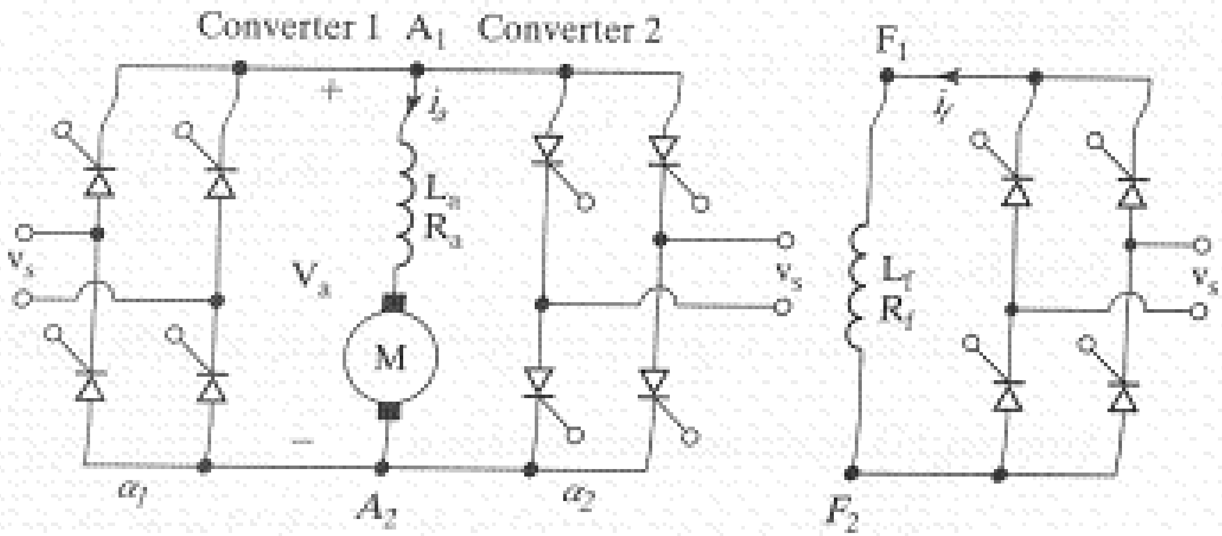


FIGURE 15.15

Single-phase dual-converter drive.

If converter 2 operates with a delay angle of α_{a2}, Eq. (10.16) gives the armature voltage as

$$V_a = \frac{2V_m}{\pi} \cos \alpha_{a2} \qquad \text{for } 0 \leq \alpha_{a2} \leq \pi \tag{15.20}$$

where $\alpha_{a2} = \pi - \alpha_{a1}$. With a full converter in the field circuit, Eq. (10.5) gives the field voltage as

$$V_f = \frac{2V_m}{\pi} \cos \alpha_f \qquad \text{for } 0 \leq \alpha_f \leq \pi \tag{15.21}$$