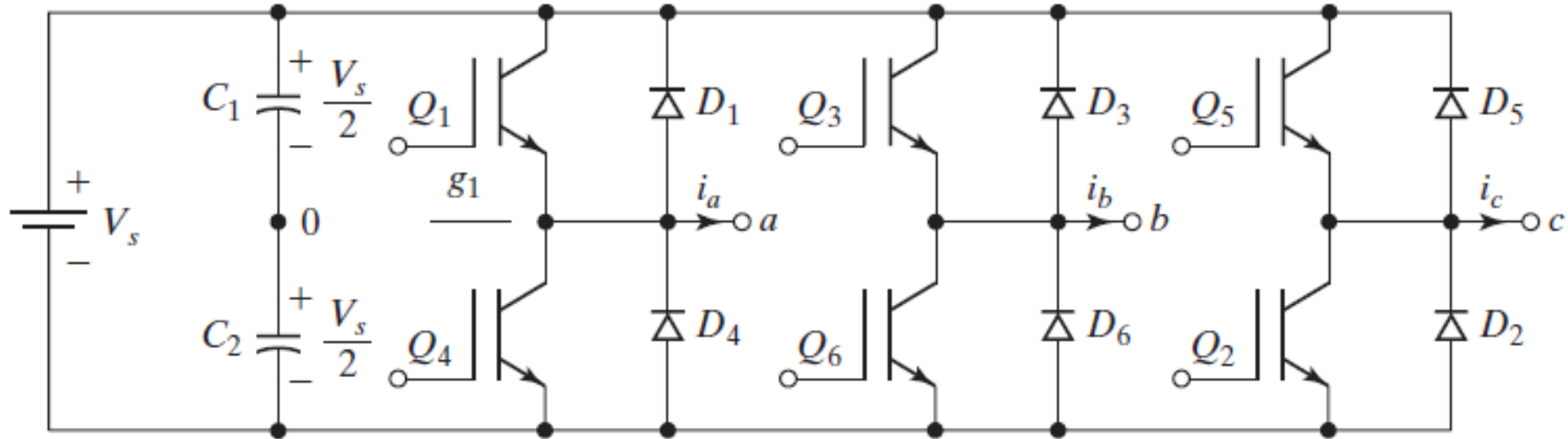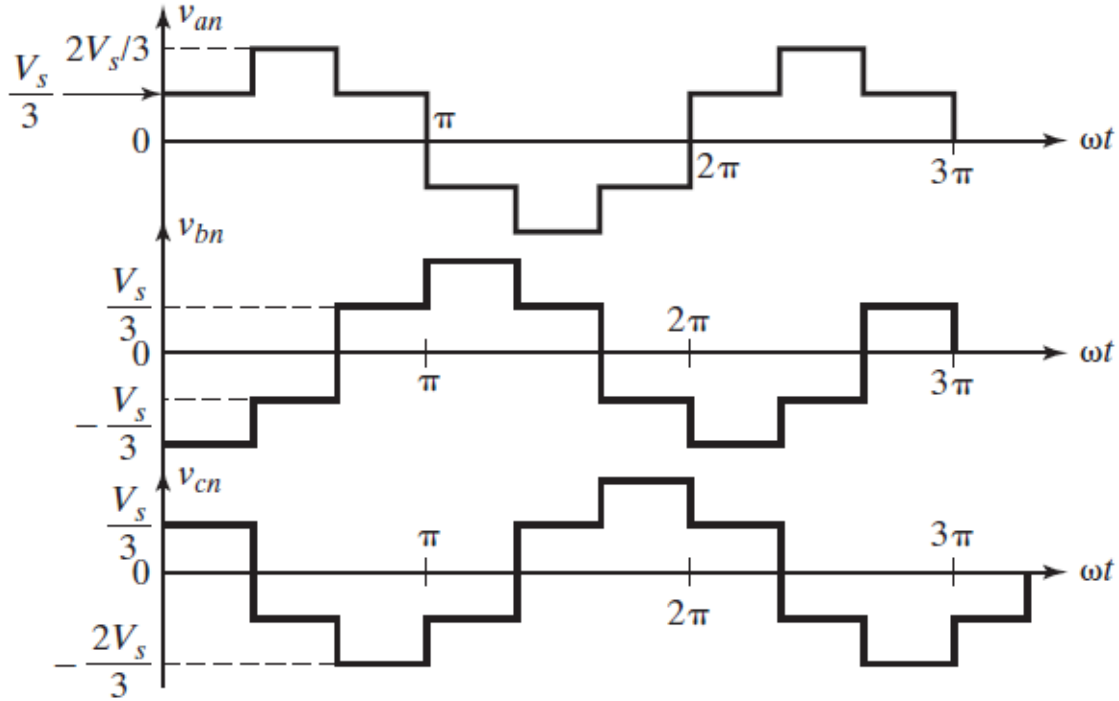## 1.2 Inverters

- Types of inverters used for AC machine drive
    - Six-step inverters
    - Voltage source inverters (VSIs)
- They provide variable AC voltages and currents at desired frequency and phase for the drive of AC machines.
- The DC supply input to the inverter is derived either from a battery as in the case of electric vehicles or from a rectified AC source with controlled or uncontrolled rectifiers

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- The DC supply input to the six-step inverter is derived from a rectified AC source with controlled rectifiers (or battery)

- The DC supply input to the VSI is derived from a rectified AC source with uncontrolled rectifiers (or battery)
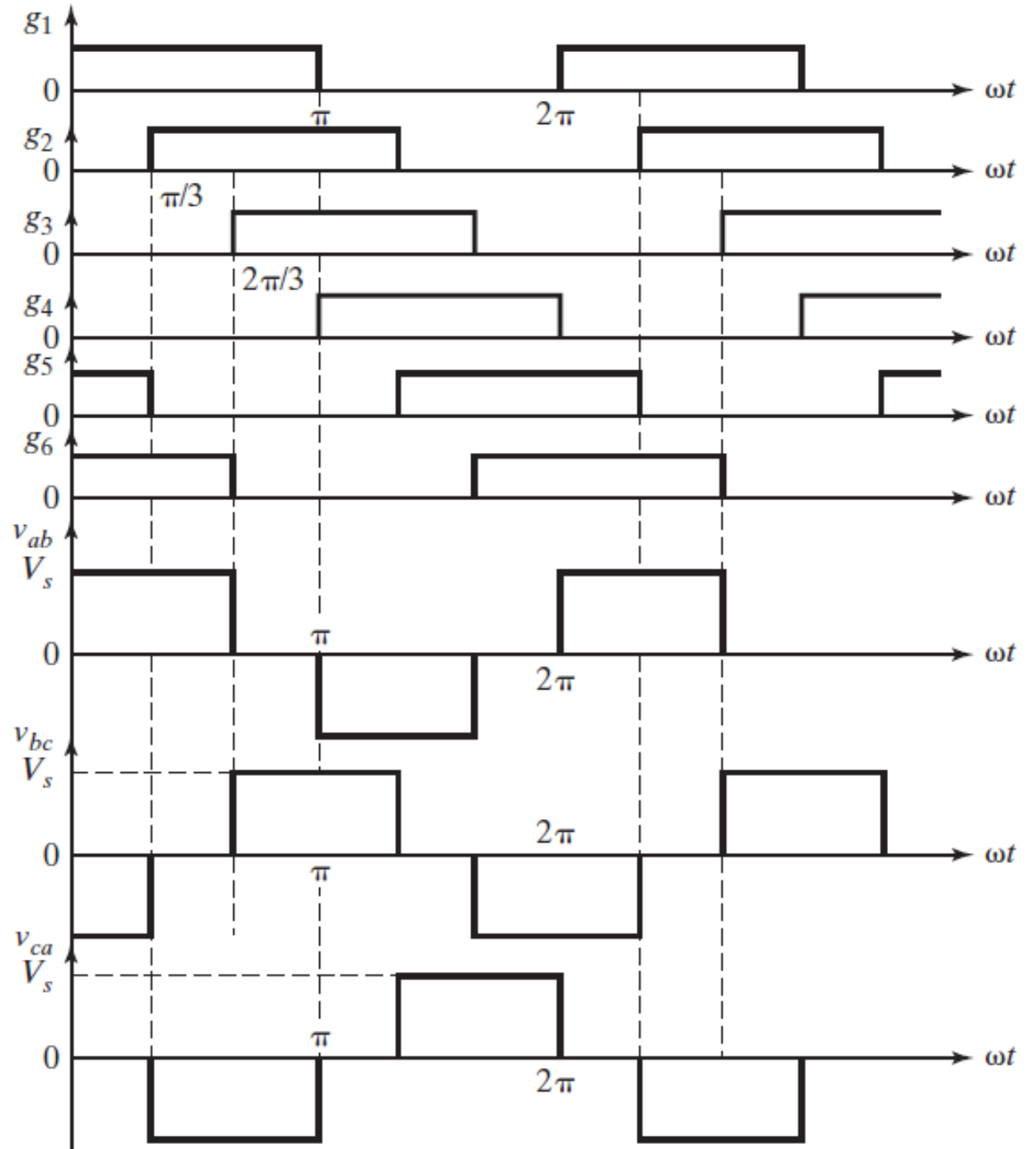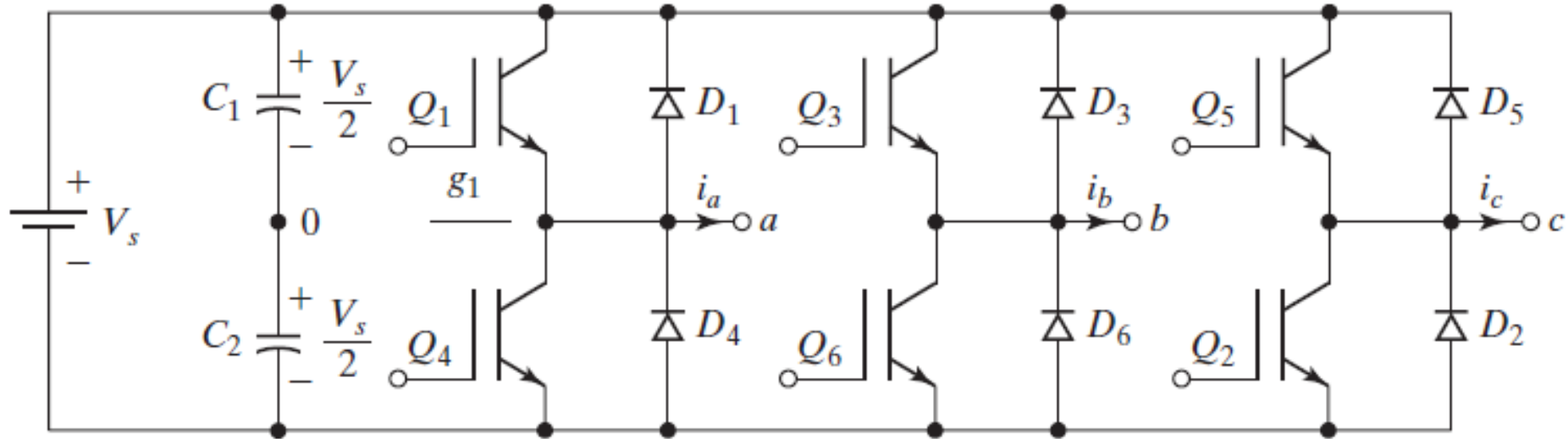
Six-step inverter

The peak value of the fundamental component of phase voltage is:

$$V_{1,peak,L-N} = \frac{2}{\pi} V_s$$

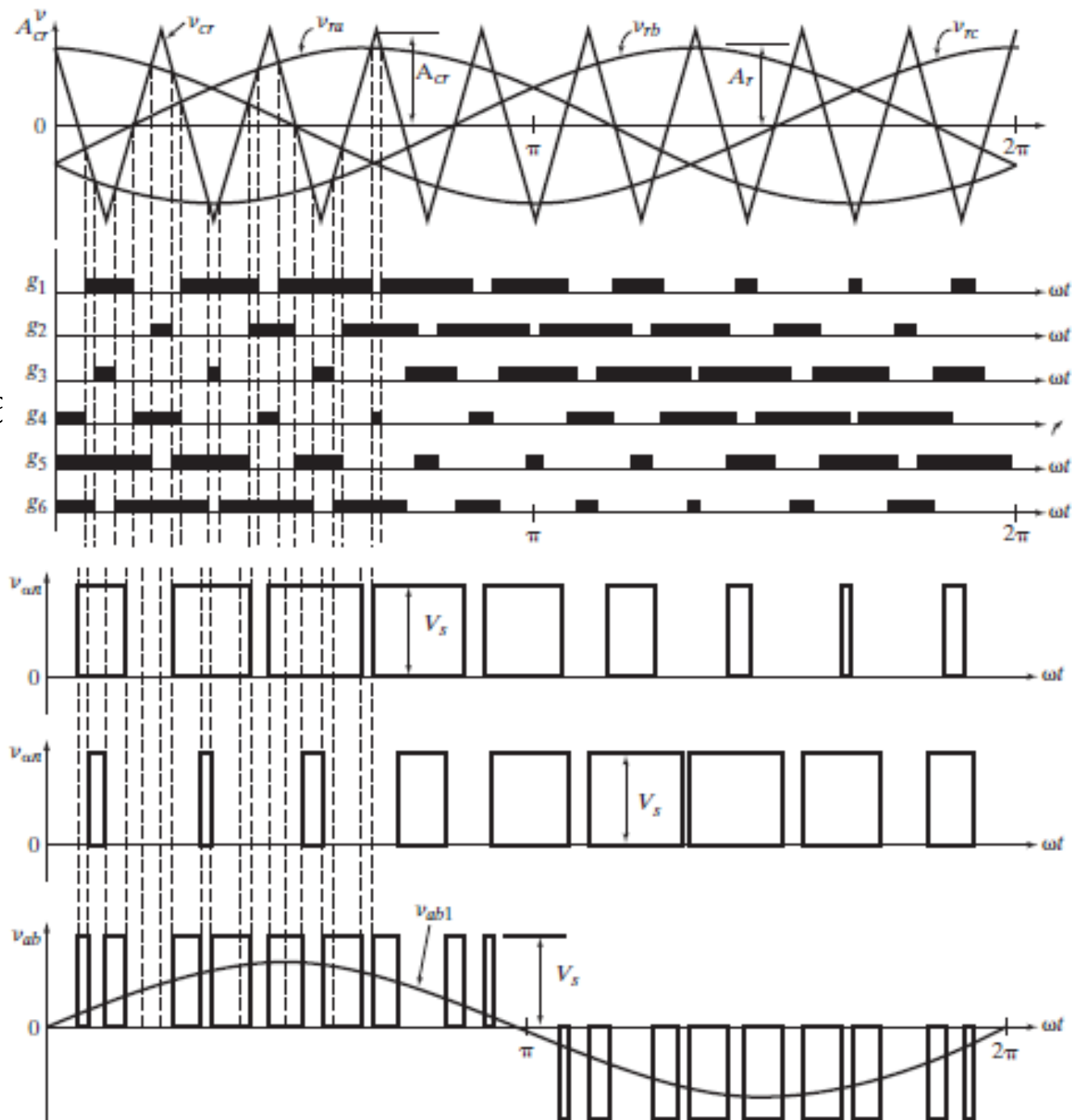Dr. Mahran Quraan

Voltage source inverter

Sinusoidal Pulse Width Modulation (SPWM)

The peak value of the fundamental component of phase voltage is:

$$V_{1,peak,L-N} = \frac{MV_s}{2}$$
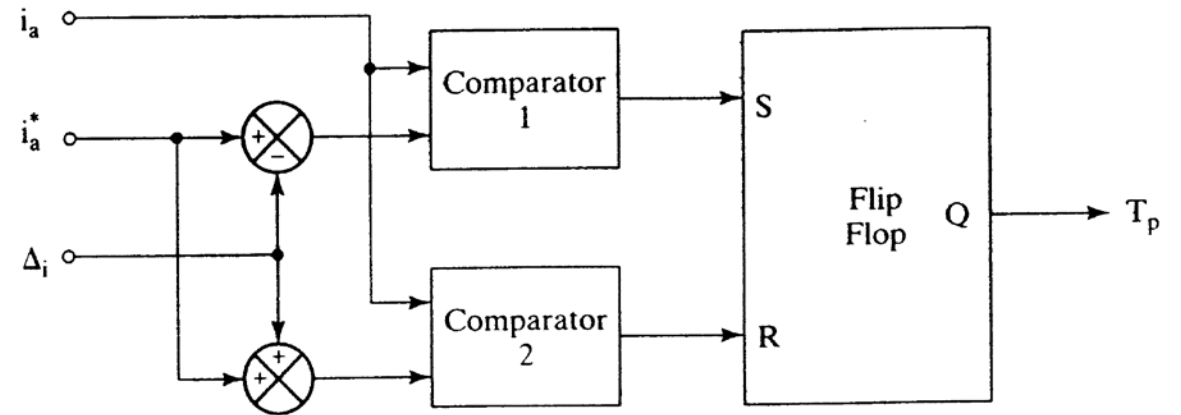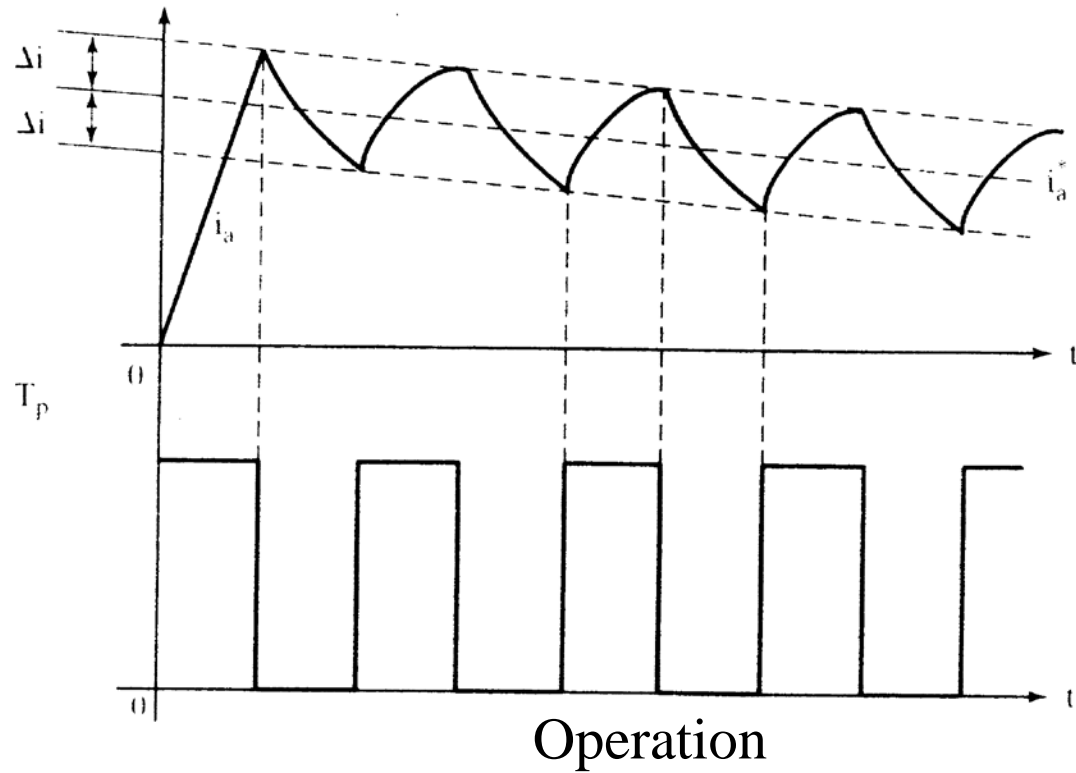
where M is the modulation index

Operation

Hysteresis of Delta Modulation

It is an instantaneous current controller

The voltage applied to the load is determined by the following logic:

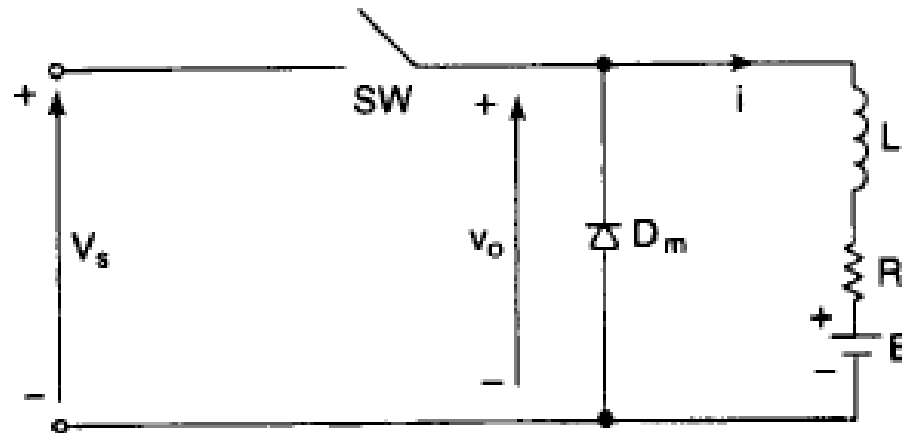$$i_a \leq \left(i_a^* - \Delta i\right) \Rightarrow \text{Set } v_{an} = \frac{V_s}{2}$$

$$i_a \geq \left(i_a^* + \Delta i\right) \Rightarrow \text{Set } v_{an} = -\frac{V_s}{2}$$

Realization of hysteresis controller

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1.3 DC-DC Converters (Chopper Circuits)

- They provide variable DC voltages for the drive of DC machines.
- The DC supply input to the converter is derived either from a battery as in the case of electric vehicles or from a rectified AC source with uncontrolled rectifiers
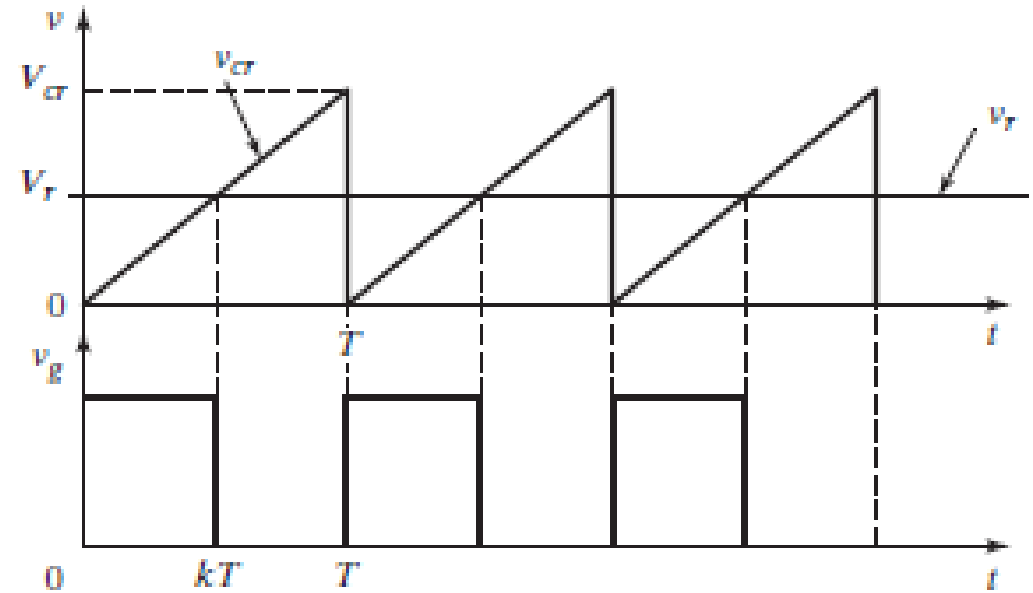
Pulse Width Modulation (PWM)

The peak value of the fundamental component of phase voltage is:

$$V_{o,avg} = kV_s$$
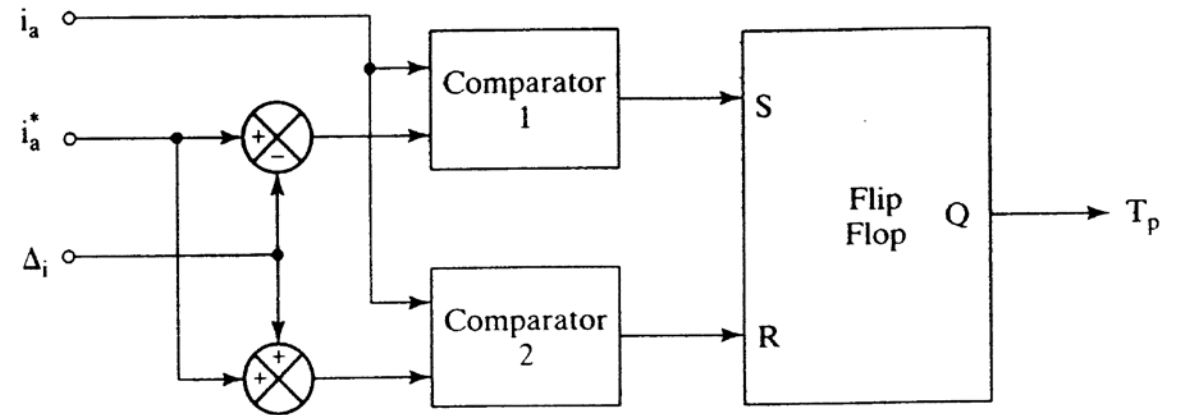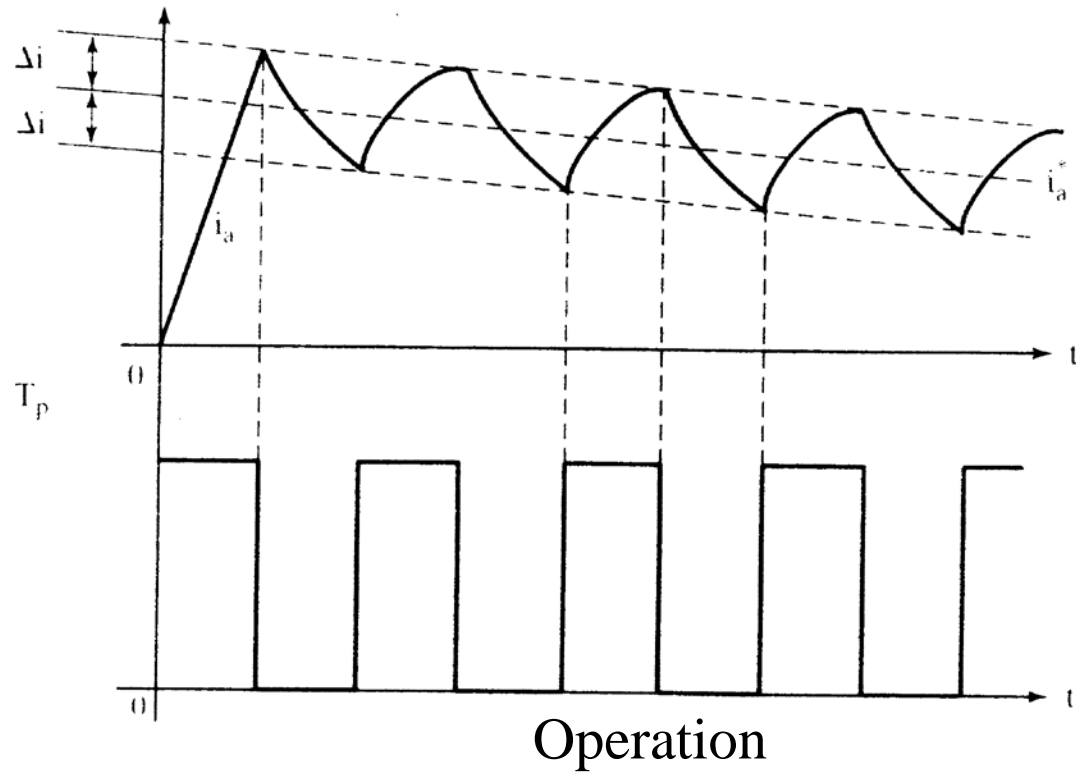
where k is the duty cycle

Hysteresis of Delta Modulation

It is an instantaneous current controller

The voltage applied to the load is determined by the following logic:

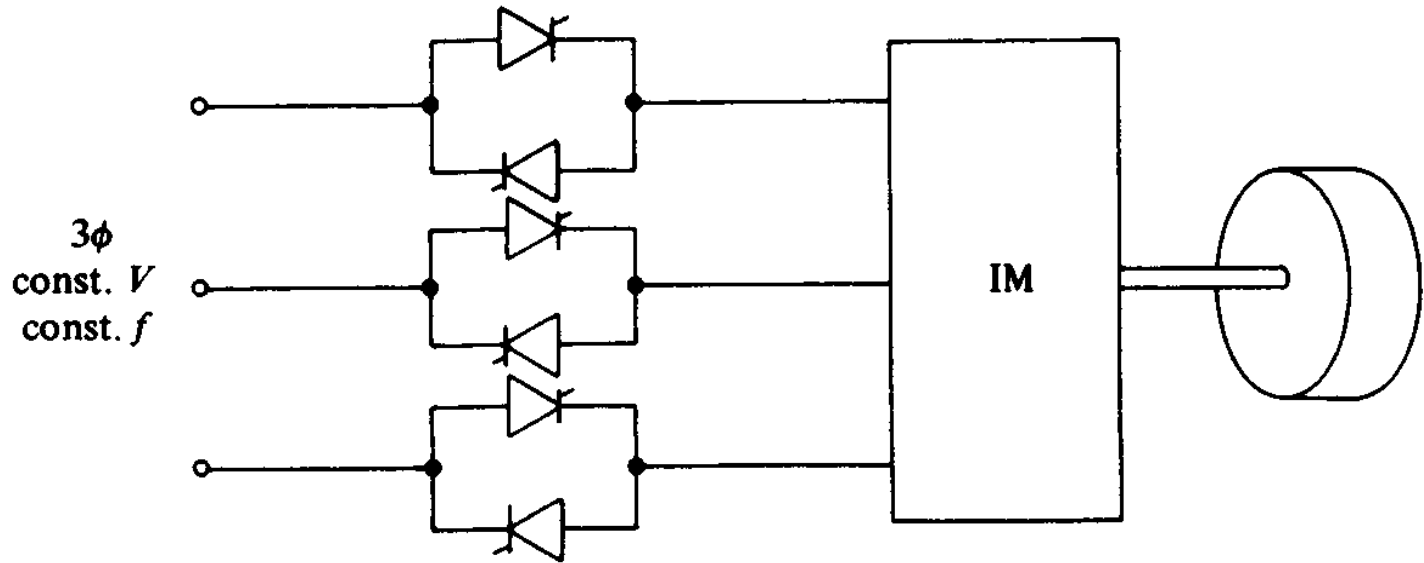$$i_a \leq \left(i_a^* - \Delta i\right) \Rightarrow \text{Set } v_{an} = \frac{V_s}{2}$$

$$i_a \geq \left(i_a^* + \Delta i\right) \Rightarrow \text{Set } v_{an} = -\frac{V_s}{2}$$

Operation

Realization of hysteresis controller

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1.4 AC voltage controllers

- They provide variable AC voltages and currents at fixed frequency.

- The AC input terminals are connected to a three-phase AC source at fixed voltage and frequency

- Applications: Fan and Pump drives

- The change of voltage is obtained at the expense of a low PF and considerable amount of harmonics

- The torque capabilities is also reduced

- The gate signals are synchronized to the phase voltages and shifted from each other by 60 degrees

- The power can flow only from a three-phase supply to the machine, and it can run only in one direction

- By using an appropriate firing angle, the motor can be soft started such that the motor starting current (starting torque) is restricted by motor voltage reduction, and hence increase the motor runtime
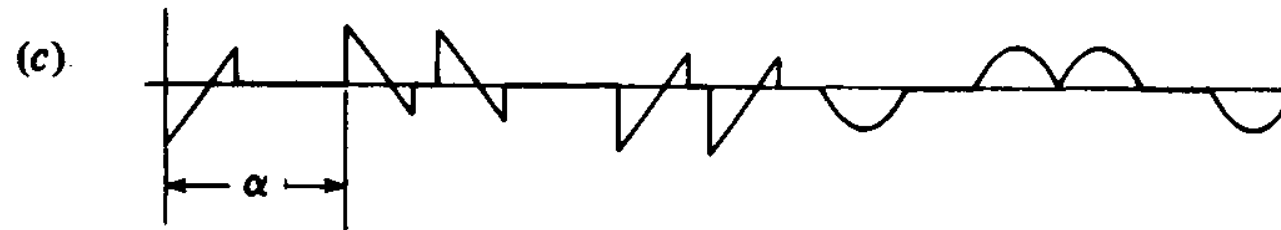
- The waveforms of motor voltages and currents are vary in three separate modes over the range of firing angle.

- If the firing angle is constant, the motor voltage and current waveforms vary with the motor power factor. Therefore, the analysis of this converter would be very complex because of interaction between the motor and controller

- The controller output voltage (input of motor) depends on both the state of controller and the state of the load. Therefore, simulation methods must be used.

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(a)

(b)

(c)

(i) phase voltages
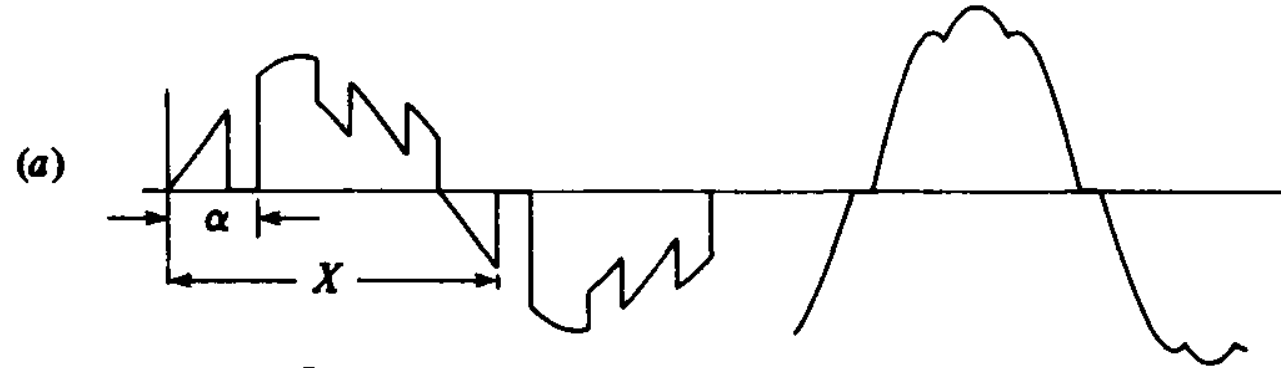
(ii) phase currents

(a) $\alpha = 60°$, $\phi = 45°$
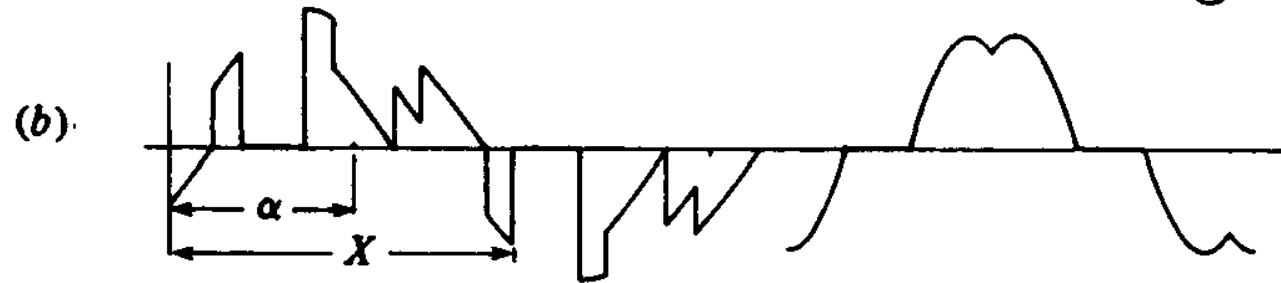
(b) $\alpha = 120°$, $\phi = 45°$.

(c) $\alpha = 120°$, highly inductive.

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