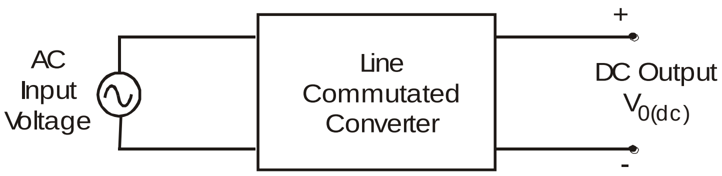
CONTROLLED RECTIFIERS

4.1 Line Commutated AC to DC converters



- Type of input: Fixed voltage, fixed frequency ac power supply.
- Type of output: Variable dc output voltage
- Type of commutation: Natural / AC line commutation

4.1.1Different types of Line Commutated Converters

- AC to DC Converters (Phase controlled rectifiers)
- AC to AC converters (AC voltage controllers)
- AC to AC converters (Cyclo converters) at low output frequency

4.1.2 Differences Between Diode Rectifiers & Phase Controlled Rectifiers

- The diode rectifiers are referred to as uncontrolled rectifiers .
- The diode rectifiers give a fixed dc output voltage .
- Each diode conducts for one half cycle.
- Diode conduction angle = 180^0 or π radians.
- We cannot control the dc output voltage or the average dc load current in a diode rectifier circuit

Single phase half wave diode rectifier gives an

Average dc output voltage $V_{O\ dc} = \frac{V_m}{\pi}$

Single phase full wave diode rectifier gives an

Average dc output voltage $V_{O\ dc} = \frac{2V_m}{\pi}$

4.2 Applications of Phase Controlled Rectifiers

- DC motor control in steel mills, paper and textile mills employing dc motor drives.
- AC fed traction system using dc traction motor.
- Electro-chemical and electro-metallurgical processes.
- Magnet power supplies.
- Portable hand tool drives

4.3 Classification of Phase Controlled Rectifiers

- Single Phase Controlled Rectifiers.
- Three Phase Controlled Rectifiers

4.3.1 Different types of Single Phase Controlled Rectifiers.

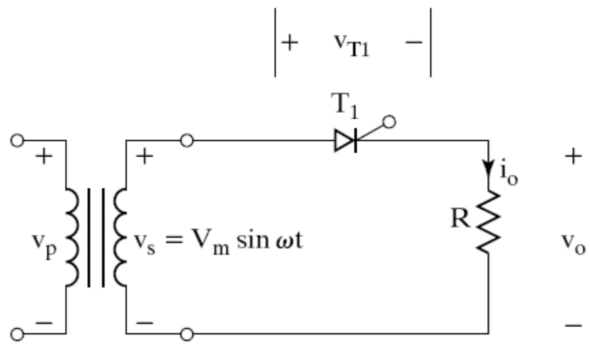
- Half wave controlled rectifiers.
- Full wave controlled rectifiers.
- Using a center tapped transformer.
- Full wave bridge circuit.
- Semi converter.
- Full converter.

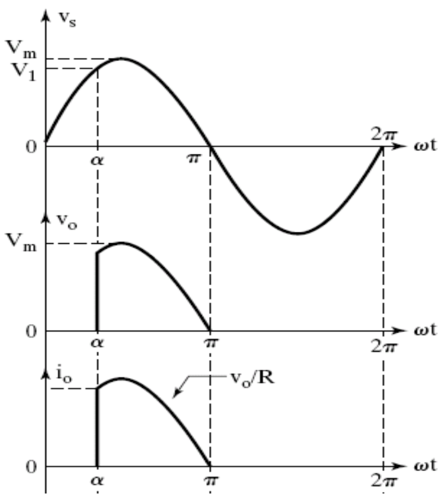
4.3.2 Different Types of Three Phase Controlled Rectifiers

- Half wave controlled rectifiers.
- Full wave controlled rectifiers.
- Semi converter (half controlled bridge converter).
- Full converter (fully controlled bridge converter).

4.4 Principle of Phase Controlled Rectifier Operation

Single Phase Half-Wave Thyristor Converter with a Resistive Load





Equations:

$$v_s = V_m \sin\omega t = \text{ i/p ac supply voltage}$$
$$V_m = \text{max. value of i/p ac supply voltage}$$
$$V_S = \frac{V_m}{\sqrt{2}} = \text{RMS value of i/p ac supply voltage}$$
$$v_O = v_L = \text{ output voltage across the load}$$

When the thyristor is triggered at $\omega t = \alpha$

$$v_O = v_L = V_m \sin\omega t;\ \ \omega t = \alpha \text{ to } \pi$$
$$i_O = i_L = \frac{v_O}{R} = \text{Load current;}\ \ \omega t = \alpha \text{ to } \pi$$
$$i_O = i_L = \frac{V_m \sin\omega t}{R} = I_m \sin\omega t; \omega t = \alpha \text{ to } \pi$$

Where $I_m = \frac{V_m}{R} =$ max. value of load current

4.4.1 To Derive an Expression for the Average (DC) Output Voltage across the Load

$$V_{O\ dc} = V_{dc} = \frac{1}{2\pi}\int_0^{2\pi} v_O.d\ \ \omega t\ ;$$
$$v_O = V_m \sin\omega t\ for\ \ \omega t = \alpha\ to\ \pi$$
$$V_{O\ dc} = V_{dc} = \frac{1}{2\pi}\int_\alpha^{\pi} V_m \sin\omega t.d\ \ \omega t$$
$$V_{O\ dc} = \frac{1}{2\pi}\int_\alpha^{\pi} V_m \sin\omega t.d\ \ \omega t$$

$$V_{O\ dc} = \frac{V_m}{2\pi}\int_\alpha^{\pi} \sin\omega t.d\ \ \omega t$$
$$V_{O\ dc} = \frac{V_m}{2\pi}\left[-\cos\omega t \Big/_{\alpha}^{\pi}\right]$$
$$V_{O\ dc} = \frac{V_m}{2\pi}\ \ -\cos\pi + \cos\alpha\ \ ;\ \ \cos\pi = -1$$
$$V_{O\ dc} = \frac{V_m}{2\pi}\ \ 1 + \cos\alpha\ \ \ ; V_m = \sqrt{2}V_S$$

Maximum average (dc) o/p
voltage is obtained when $\alpha = 0$
and the maximum dc output voltage

$$V_{dc\ max} = V_{dm} = \frac{V_m}{2\pi}\left(1+\cos 0\right) \ ; \ \cos\left(0\right) = 1$$

$$\therefore V_{dc\ max} = V_{dm} = \frac{V_m}{\pi}$$

$$V_{O\left(dc\right)} = \frac{V_m}{2\pi}\left(1+\cos\alpha\right) \ ; V_m = \sqrt{2}V_S$$

The average dc output voltage can be varied by varying the trigger angle α from 0 to a maximum of $180^0\left(\pi\right)$ radians

We can plot the control characteristic $\left(V_{O\left(dc\right)} \text{ vs } \alpha\right)$ by using the equation for $V_{O\left(dc\right)}$