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

4.1.1 Different 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° 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 $V_{dc} = \frac{V_m}{\pi}$

Single phase full wave diode rectifier gives an

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

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

\[
\begin{align*}
V_p & \quad \text{[Input Voltage]} \\
&T_1 \quad \text{[Thyristor]} \\
R & \quad \text{[Resistor]} \\
V_o & \quad \text{[Output Voltage]} \\
I_o & \quad \text{[Output Current]} \\
\text{[Diagram Image]}
\end{align*}
\]
Equations:

\[ v_i = V_m \sin \omega t = \text{i/p ac supply voltage} \]
\[ V_m = \text{max. value of i/p ac supply voltage} \]
\[ V_s = \frac{V_m}{\sqrt{2}} = \text{RMS value of i/p ac supply voltage} \]
\[ v_o = v_L = \text{output voltage across the load} \]

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 \( I_m = \frac{V_m}{R} = \text{max. value of load current} \)

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

\[ V_{dc} = V_{dc} = \frac{1}{2\pi} \int_{\omega t = 0}^{2\pi} v_o \omega t \]
\[ v_o = V_m \sin \omega t \text{ for } \omega t = \alpha \text{ to } \pi \]
\[ V_{dc} = V_{dc} = \frac{1}{2\pi} \int_{\omega t = \alpha}^{\pi} V_m \sin \omega t \omega t \]
\[ V_{dc} = \frac{1}{2\pi} \int_{\omega t = \alpha}^{\pi} V_m \sin \omega t \omega t \]
\[ V_{dc} = \frac{V_m}{2\pi} \int_{\omega t = \alpha}^{\pi} \sin \omega t \omega t \]
\[ V_{dc} = \frac{V_m}{2\pi} \left[ -\cos \omega t \right]_\alpha^\pi \]
\[ V_{dc} = \frac{V_m}{2\pi} \left[ -\cos \pi + \cos \alpha \right] = \cos \pi = -1 \]
\[ V_{dc} = \frac{V_m}{2\pi} \left[ 1 + \cos \alpha \right] \quad V_m = \sqrt{2}V_s \]
Maximum average (dc) o/p voltage is obtained when $\alpha = 0$
and the maximum dc output voltage

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

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

$$V_{o\ dc} = \frac{V_m}{2\pi} \ 1 + \cos \alpha \ ; \ V_m = \sqrt{2}V_s$$

The average dc output voltage can be varied by varying the trigger angle $\alpha$ from 0 to a maximum of 180° radians.

We can plot the control characteristic $V_{o\ dc}$ vs $\alpha$ by using the equation for $V_{o\ dc}$.

Source: http://elearningatria.files.wordpress.com/2013/10/ece-vii-power-electronics-10ec73-notes.pdf