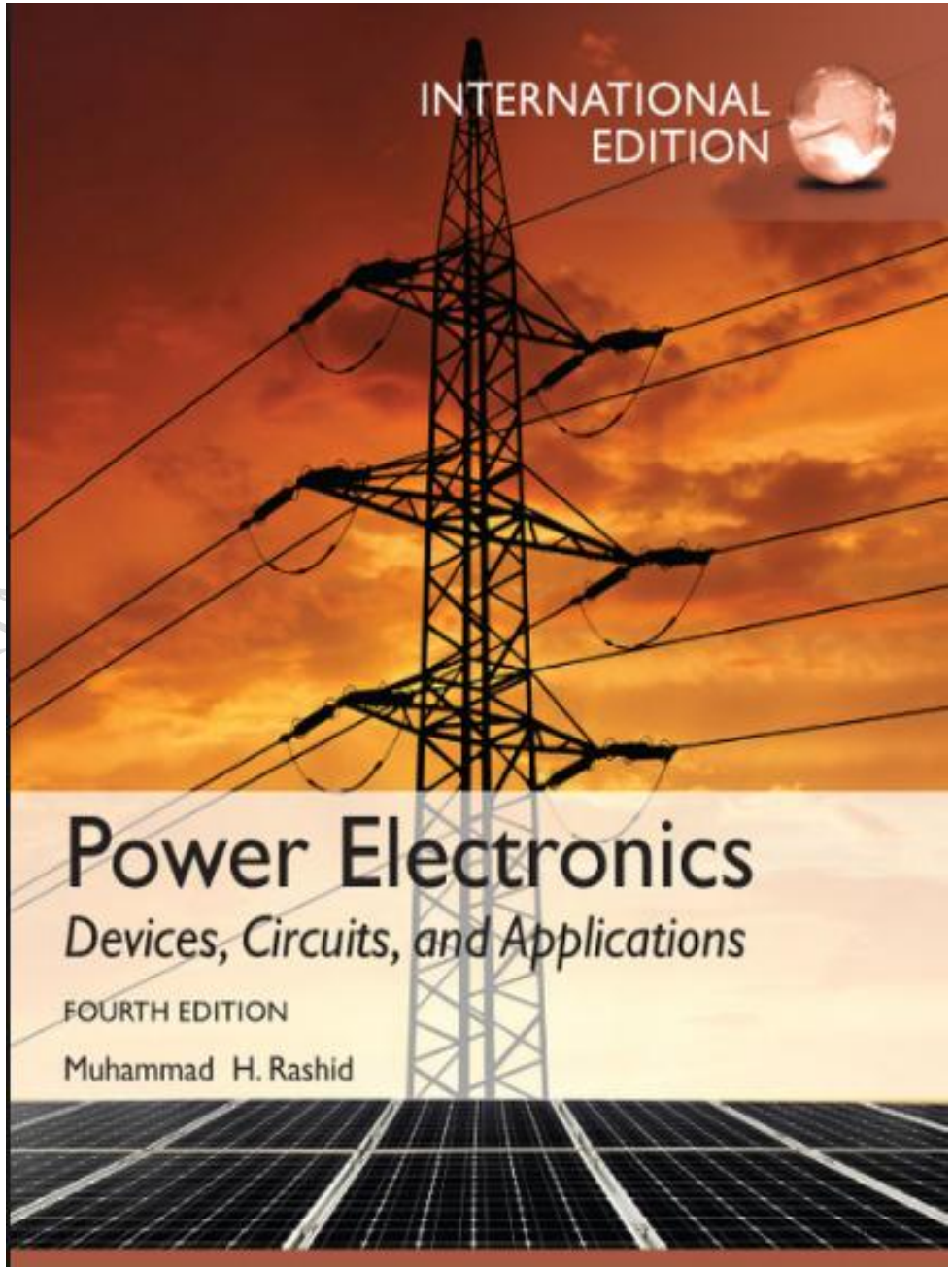
University of Technology
Laser and Optoelectronic Engineering Department
Power Electronics/2018-2019)
For the third years (Laser Engineering)



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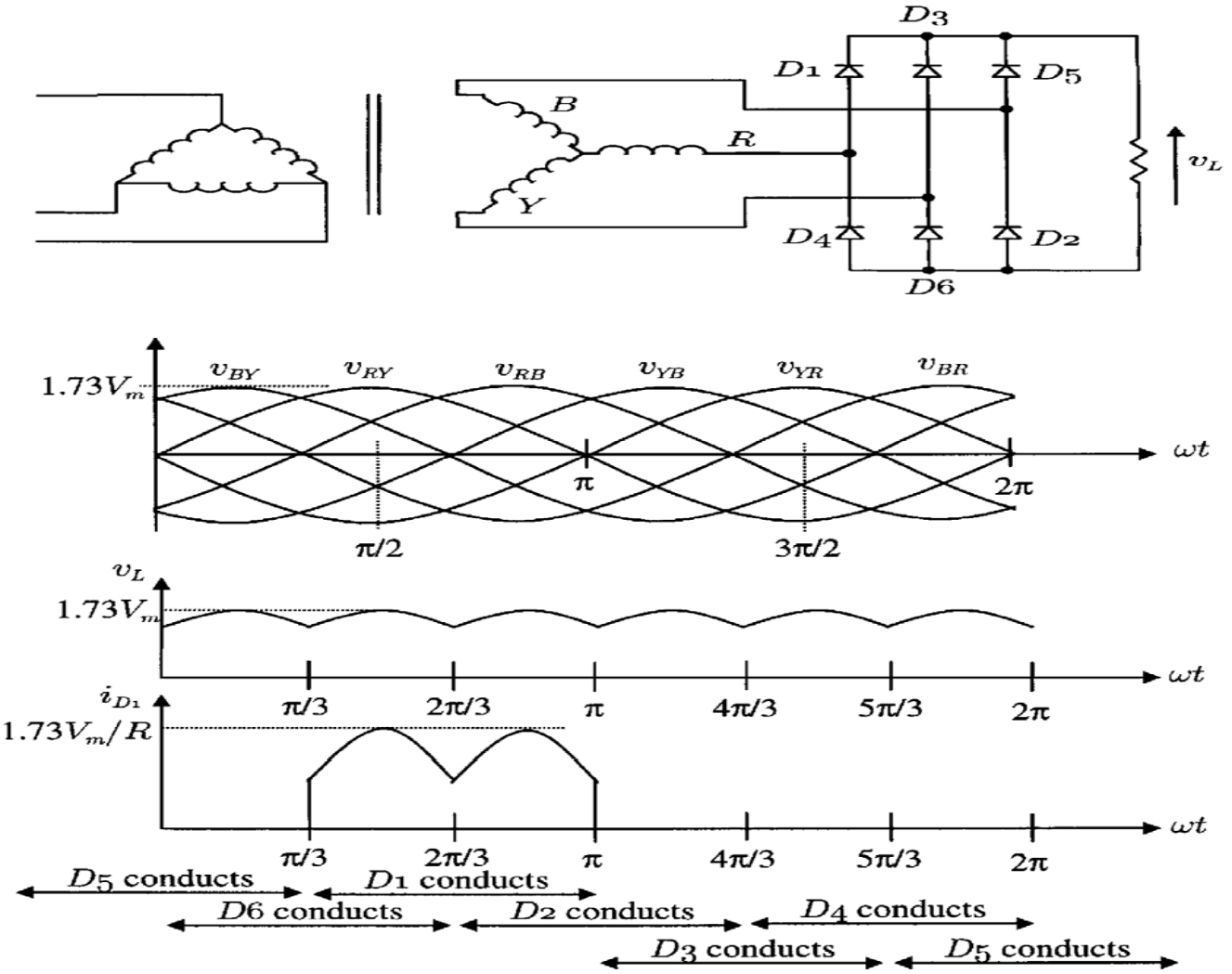
Ref: Power Electronics 4th edition/ Muhammed H. Rashid

Lecture No.9

Three-Phase Bridge Rectifiers

Three-phase bridge rectifiers are commonly used for high power applications because they have the highest possible transformer utilization factor for a three-phase system.



The diodes are numbered in the order of conduction sequences and the conduction angle of each diode is **2π=3**. The conduction sequence for diodes is **12, 23, 34, 45, 56, and 61**. The line voltage is **1.73** times the phase voltage of a three-phase star-connected source.

The average values of the output can be found as:

$$V_{dc} = \frac{6}{2\pi}\int_{\pi/3}^{2\pi/3} \sqrt{3}\ V_m \sin\theta\, d\theta$$

Or,

$$V_{dc} = V_m \frac{3\sqrt{3}}{\pi} = 1.654\ V_m$$

Similarly, the rms value of the output voltage can be found as:

$$V_L = \sqrt{\frac{9}{\pi}\int_{\pi/3}^{2\pi/3} (V_m \sin\theta)^2 d\theta}$$

Or,

$$V_L = V_m\sqrt{\frac{3}{2} + \frac{9\sqrt{3}}{4\pi}} = 1.655\ V_m$$

The rms current in each transformer secondary winding can also be found as:

$$I_s = I_m\sqrt{\frac{2}{\pi}\left(\frac{\pi}{6} + \frac{\sqrt{3}}{4}\right)} = 0.78\ I_m$$

The rms current through a diode is:

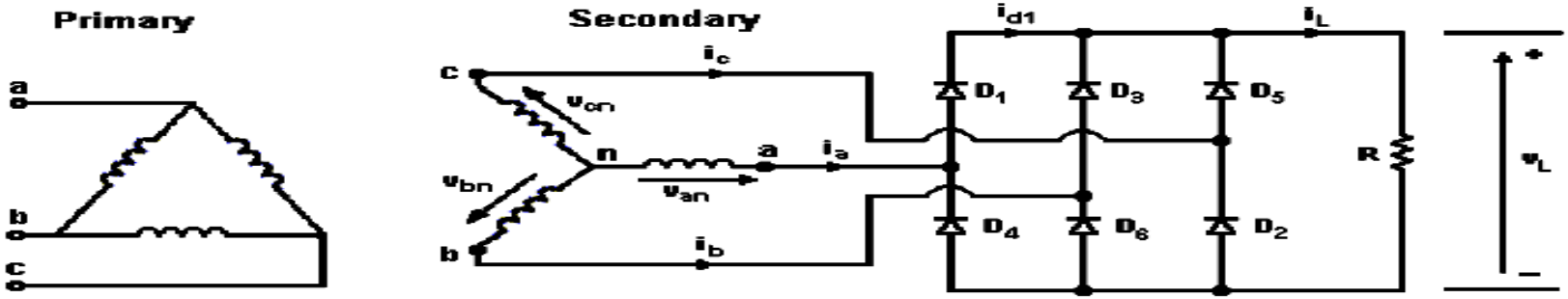
$$I_D = I_m\sqrt{\frac{1}{\pi}\left(\frac{\pi}{6} + \frac{\sqrt{3}}{4}\right)} = 0.552\ I_m$$

Where, $\mathbf{I_m = 1.73\ V_m/R}$.

→ The dc output voltage is slightly lower than the peak line voltage or 2.34 times the rms phase voltage.
→ The Peak Repetitive Reverse Voltage (V_{RRM}) rating of the employed diodes is 1.05 times the dc output voltage.
→ The Peak Repetitive Forward Current (I_{FRM}) rating of the employed diodes is 0.579 times the dc output current.

Example 3.4

A three-phase rectifier has a purely resistive load of R. Determine
a. The efficiency
b. The form factor
c. The ripple factor



Solution

a. Efficiency, $\eta = \frac{P_{dc}}{P_L}$

Now: $P_{dc} = V_{dc} \times I_{dc}$ $P_L =$

Since: $V_L \times I_L$

$$V_{dc} = V_m \frac{3\sqrt{3}}{\pi} = 1.654\ V_m$$

$$I_{dc} = \frac{V_{dc}}{R} = \frac{1.654 V_m}{R}$$

$$V_L = V_m\sqrt{\frac{3}{2}+\frac{9\sqrt{3}}{4\pi}} = 1.655\ V_m$$

$$I_L = \frac{V_L}{R} = \frac{1.655V_m}{R}$$

b. Form factor:

$$\eta = \frac{(1.65V_m)^2R}{(1.655V_m)^2R} = 99.85\%$$

c. Ripple factor:

$$FF = \frac{1.655V_m}{1.654V_m} = 1.0008$$

$$RF = \sqrt{\left(\frac{V_L}{V_{dc}}\right)^2 - 1} = \sqrt{FF^2 - 1}$$

= 4%

e. V_m = peak line to neutral voltage But V_{dc} =

$1.654V_m = 280.7$ V

$$\Rightarrow V_m = \frac{280.7}{1.654} = 169.7V$$

PIV = peak inverse value of secondary line to line voltage

= 169.7×3 = 293.9 Volt

e. The average diode current I_{dc} is given by:

$$I_{dc} = \frac{2\times 2}{2\pi}\int_0^{\pi/6} I_m \cos\omega t \quad d(\omega t)$$

$$I_{dc} = \frac{2I_m}{\pi}\sin\left(\frac{\pi}{3}\right) = 0.318I_m$$

If the average load current is I_{dc} and each diode is on for 120° of a cycle of 360° then average diode current = 1/3 × average load current

$$I_d = \frac{I_{dc}}{3} = \frac{60}{3} = 20A$$

$$\therefore I_m = \frac{20}{0.318} = 62.83A$$

W.1 The single-phase full wave rectifier has a purely resistive load of R, determine:
a)The efficiency,
b) The ripple factor RF,
c)The peak inverse voltage PIV of diode NOTE: Drive any formula that used in solution

W.2 The single-phase half wave rectifier has R-L load with R= 5Ω and L= 6.5mH. The input voltage V_s=220V at 50Hz, determine:
a) The average diode current
b) The rms diode current
c) The rms output current
d) The average output current
NOTE: Drive any formula that used in solution

H.W3 The single-phase full wave rectifier has a purely resistive load of R, and I_L =10A and average power = 100Watt, determine:
-The efficiency,
-The form factor and ripple factor,
-The peak inverse voltage PIV of diode, NOTE: Drive any formula that used in solution

H.W4 The diode in the single-phase half wave rectifier has a reverse recovery time of t_{rr} = 150μsec and the source voltage V_s = 200V at frequency = 5 kHz. Calculate the average output voltage.

H.W5: Design the single phase half wave rectifier supply the HeNe laser tube. The voltage across tube is 1.8kV and the current pass through tube is 10mA. The designer has two diodes with PIV=1.5kV and saturation current are I_{s1}=100μA and I_{s2}=120μA respectively.