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

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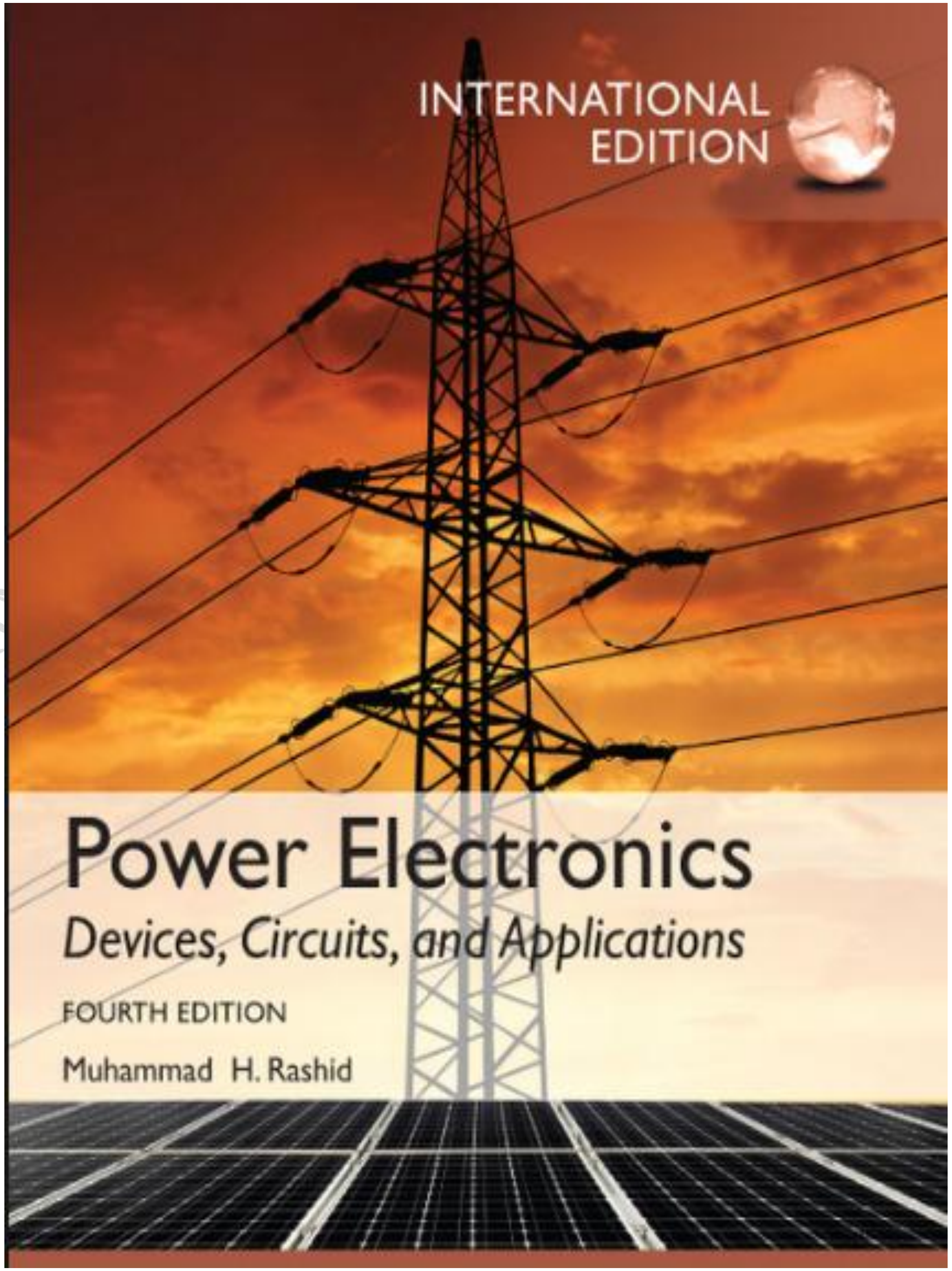


Ref: Power Electronics 4th edition/ Muhammed H. Rashid

Lecture No.3

AC-DC converter (Rectifiers)

Introduction

Certain terms will be frequently used in this lesson and subsequent lessons while characterizing different types of rectifiers. Such commonly used terms are defined in this section.

Let "f(t)" be the instantaneous value of any voltage or current associated with a rectifier circuit, then the following terms, characterizing the properties of "f(t)", can be defined.

Peak value of f(t) : As the name suggests f_{max}.

Average (DC) value of f(t) is (F_{av}) : Assuming f(t) to be periodic over

$$F_{av} = \frac{1}{T}\int_0^T f(t)dt$$

RMS (effective) value of f(t) is (F_{RMS}) : For f(t) , periodic over the time the time period T,

$$F_{RMS} = \sqrt{\frac{1}{T}\int_0^T f^2(t)dt}$$

Form factor of f(t) is (f_{FF}) : Form factor of 'f(t) ' is defined as:

$$f_{FF} = \frac{F_{RMS}}{F_{av}}$$

Ripple factor of f(t) is (f_{RF}) : Ripple factor of f is defined as:

$$f_{RF} = \frac{\sqrt{F_{RMS}^2 - F_{av}^2}}{F_{av}} = \sqrt{f_{FF}^2 - 1}$$

Ripple factor can be used as a measure of the deviation of the output voltage and current of a rectifier from ideal dc.

Peak to peak ripple of f(t) is f_{pp}: By definition $f_{pp} = f_{max} - f_{min}$ Over period T

Single-Phase Diode Rectifiers

There are two types of single-phase diode rectifier that convert a single- phase ac supply into a dc voltage, namely, single-phase half-wave rectifiers and single-phase full-wave rectifiers.. For the sake of simplicity the diodes are considered to be ideal, that is, they have zero forward voltage drop and reverse recovery time. This assumption is generally valid for the case of diode rectifiers that use the mains, a low-frequency source, as the input, and when the forward voltage drop is small compared with the peak voltage of the mains.

Single-Phase Half-Wave Rectifiers(R-Load)

The simplest single-phase diode rectifier is the single-phase half- wave rectifier. A single-phase half-wave rectifier with resistive load is shown in Figure below. The circuit consists of only one diode that is usually fed with a transformer secondary as shown. During the positive half-cycle of the transformer secondary voltage, diode D conducts. During the negative half-cycle, diode D stops conducting. Assuming that the transformer has zero internal impedance and provides perfect sinusoidal voltage on its secondary winding, the voltage and current waveforms of resistive load R and the voltage waveform of diode D are shown in Figure below.

→It is clear that the peak inverse voltage (PIV) of diode D is equal to V_m.

→Hence the Peak Repetitive Reverse Voltage (V_{RRM}) rating of diode D must be chosen to be higher than V_m to avoid reverse breakdown.

→ The Peak Repetitive Forward Current (I_{FRM}) rating of diode D must be chosen to be higher than the peak load current V_m/R.

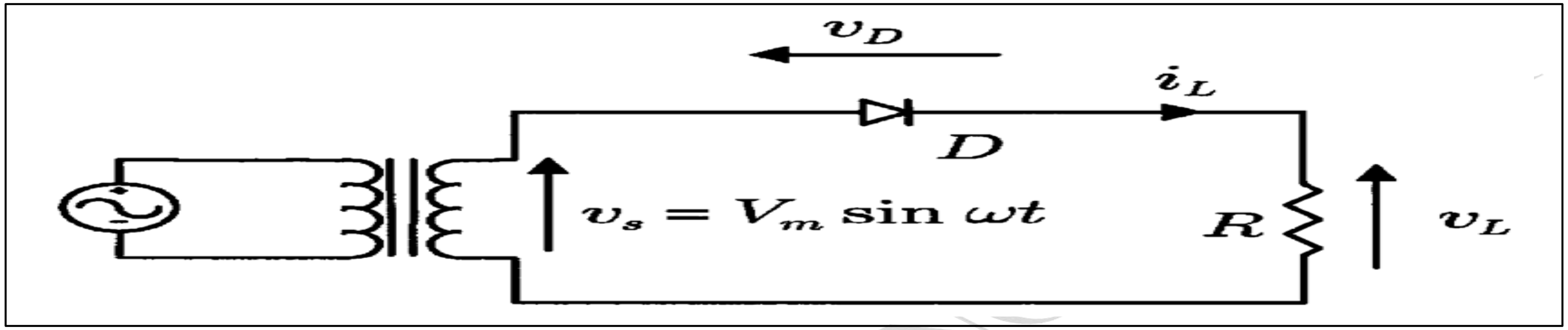
The average value of the load voltage v_L is V_{dc} and it is defined as: $V_{dc} = \frac{1}{T}\int_0^T v_L(t)dt$

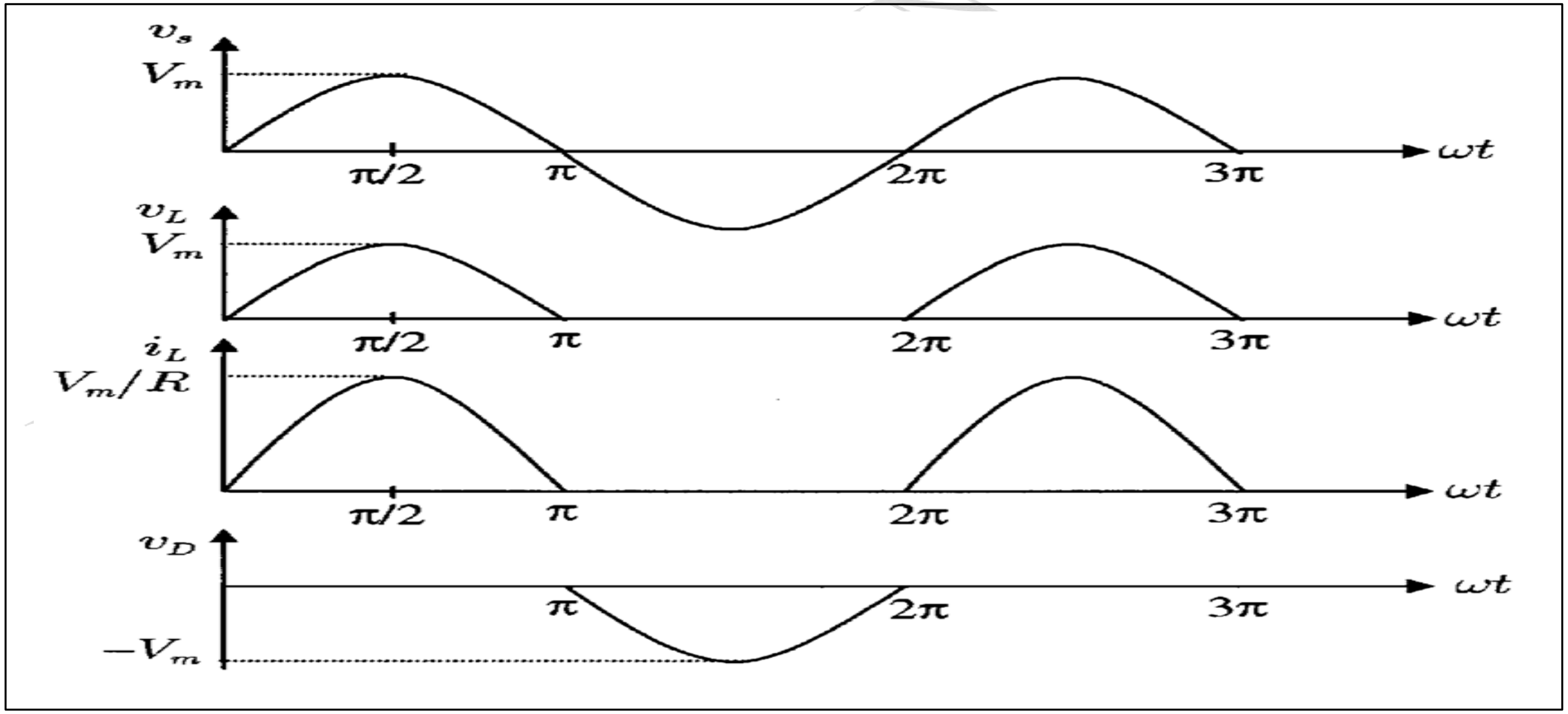
That load voltage $V_L(t)=0$, for the negative half-cycle. Note that the angular frequency of the source $\omega=2\pi/T$. Then:

$$V_{dc} = \frac{1}{2\pi}\int_0^{\pi} V_m \sin\omega t d(\omega t)$$

Therefore,

$$V_{dc} = \frac{V_m}{\pi} = 0.318\ V_m$$





The root-mean-square (rms) value of load voltage v_L is V_L, which is defined as:

$$V_L = \left[\frac{1}{T}\int_0^T v_L^2(t)\,dt\right]^{1/2}$$

In the case of a half-wave rectifier, $V_L(t)=0$ for the negative half-cycle, therefore,

$$V_L = \sqrt{\frac{1}{2\pi}\int_0^{\pi}(V_m \sin \omega t)^2\, d(\omega t)}$$

Or;

$$V_L = \frac{V_m}{2} = 0.5\ V_m$$

The average value of load current $\boldsymbol{i_L}$ is $\mathbf{I_{dc}}$ and because load R is purely resistive it can be found as:

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

The root-mean-square (rms) value of load current i_L is I_L and it can be found as:

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

In the case of a half-wave rectifier, And

$$I_{dc} = \frac{0.318\ V_m}{R}$$

$$I_L = \frac{0.5\ V_m}{R}$$

→The rectification ratio, which is a figure of merit for comparing the effectiveness of rectification, is defined as:

$$\frac{\mathbf{P_{dc}}}{\mathbf{P_L}} = \frac{\mathbf{V_{dc}I_{dc}}}{\mathbf{V_L I_L}}$$

In the case of a half-wave diode rectifier, the rectification ratio can be determined by:

$$= \frac{(0.318\ V_m)^2}{(0.5\ V_m)^2} = 40.5\%$$

→The form factor (FF) is defined as the ratio of the root-mean square value of a voltage or current to its average value,

$$FF = \frac{V_L}{V_{dc}} \quad \text{or} \quad \frac{I_L}{I_{dc}}$$

$$FF = \frac{0.5\ V_m}{0.318\ V_m} = 1.57$$

→The ripple factor (RF), which is a measure of the ripple content, is defined as:

$$RF = \frac{V_{ac}}{V_{dc}}$$

Where V_{ac} is the effective (rms) value of the ac component of load voltage V_L,

$$V_{ac} = \sqrt{V_L^2 - V_{dc}^2}$$

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

$$RF = \sqrt{1.57^2 - 1} = 1.21$$