COLLEGE OF ENGINEERING AND TECHNOLOGIES
ALMUSTAQBAL UNIVERSITY

# AC Power Converter

## EET 307

## Lecture 7

## - ON-OFF Control Technique -

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# ON-OFF Control Technique



- The basic principle of on-off control technique is explained with reference to a single phase full wave ac voltage controller circuit shown below.

- The thyristor switches T1 and T2 are turned on by applying appropriate gate trigger pulses to connect the input ac supply to the load for ‘n’ number of input cycles during the time interval tON .

# ON-OFF Control Technique



- The thyristor switches T1 and T2 are turned off by blocking the gate trigger pulses for 'm' number of input cycles during the time interval tOFF .

- The ac controller ON time tON usually consists of an integral number of input cycles.

# AC Voltage Control Circuit

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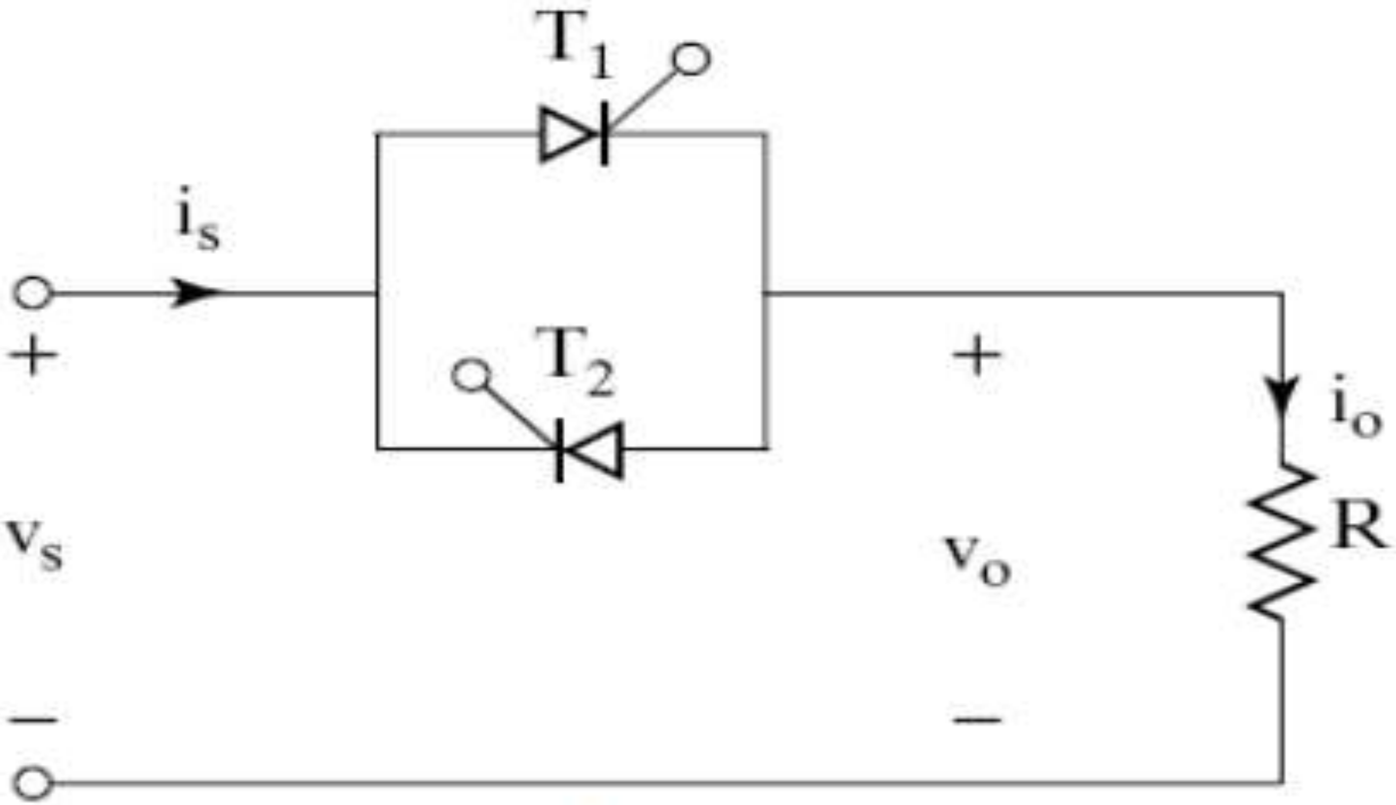
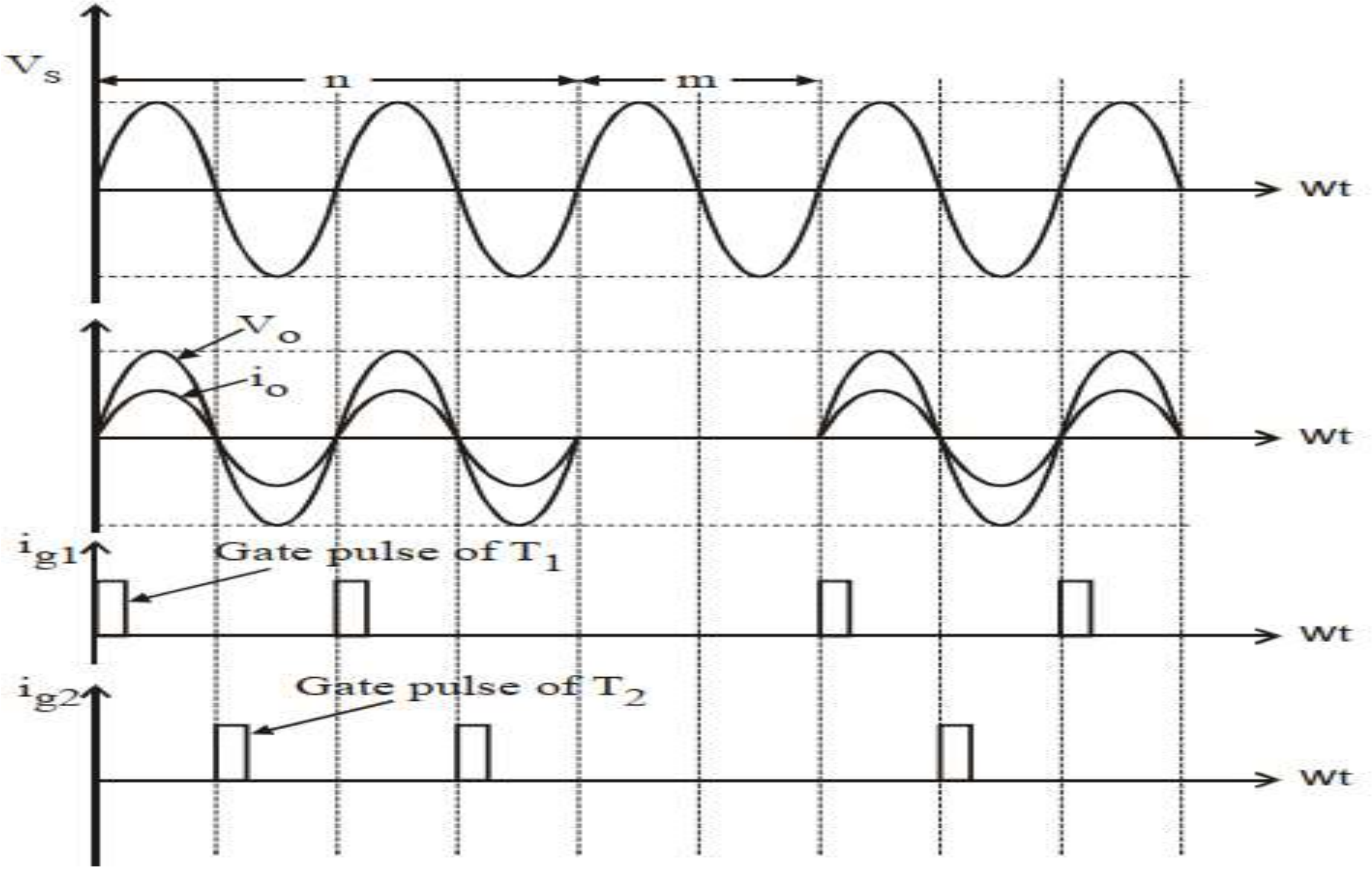



$R = R_L =$ **Load Resistance**

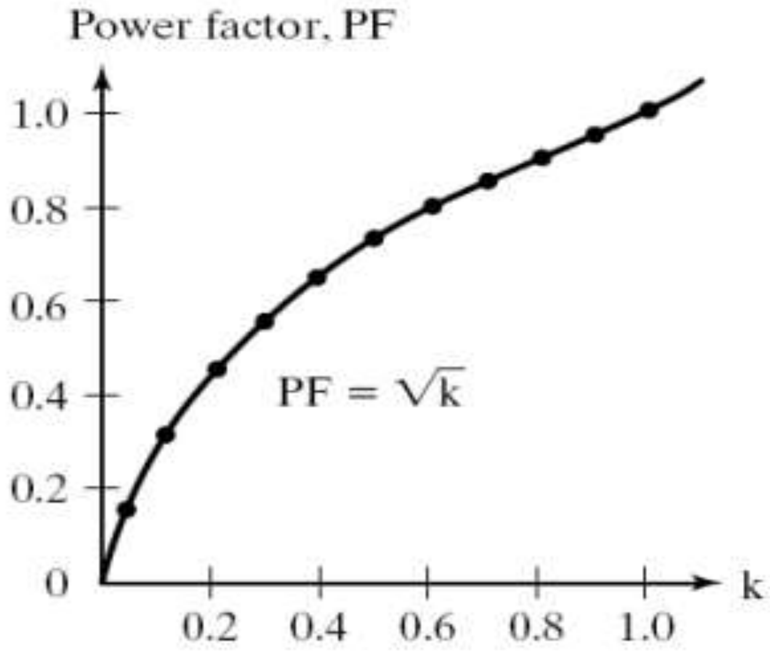
**Single phase full wave AC voltage controller circuit**

# AC Voltage Control Circuit



$n$ = Two input cycles. Thyristors are turned ON during $t_{ON}$ for two input cycles.

$m$ = One input cycle. Thyristors are turned OFF during $t_{OFF}$ for one input cycle



# ON-OFF Control Technique



- Thyristors are turned ON precisely at the zero voltage crossings of the input supply.

- The thyristor T1 is turned on at the beginning of each positive half cycle by applying the gate trigger pulses to T1 as shown, during the ON time tON .

- The load current flows in the positive direction, which is the downward direction as shown in the circuit diagram when T1 conducts.

# ON-OFF Control Technique



- The thyristor T2 is turned on at the beginning of each negative half cycle, by applying gating signal to the gate of T2, during tON .

- The load current flows in the reverse direction, which is the upward direction when T2 conducts.

- Thus we obtain a bi-directional load current flow (alternating load current flow) in a ac voltage controller circuit, by triggering the thyristors alternately.

# ON-OFF Control Technique



This type of control is used in applications which have high mechanical inertia and high thermal time constant (Industrial heating and speed control of ac motors).

Due to zero voltage and zero current switching of Thyristors, the harmonics generated by switching actions are reduced.

For a sine wave input supply voltage,

$$v_s = V_m \sin \omega t = \sqrt{2} V_S \sin \omega t$$

$$V_S = \text{RMS value of input ac supply} = \frac{V_m}{\sqrt{2}} = \text{RMS phase supply voltage.}$$

# Performance Parameters



If the input ac supply is connected to load for 'n' number of input cycles and disconnected for 'm' number of input cycles, then

$$t_{ON} = n \times T, \qquad t_{OFF} = m \times T$$

Where $T = \frac{1}{f}$ = input cycle time (time period) and

$f$ = input supply frequency.

$t_{ON}$ = controller on time = $n \times T$ .

$t_{OFF}$ = controller off time = $m \times T$ .

$T_O$ = Output time period = $\left(t_{ON} + t_{OFF}\right) = \left(nT + mT\right)$ .

We can show that,

Output RMS voltage $V_{O(RMS)} = V_{i(RMS)}\sqrt{\frac{t_{ON}}{T_O}} = V_S\sqrt{\frac{t_{ON}}{T_O}}$

$$V_{O(RMS)} = V_S\sqrt{\frac{n}{(m+n)}} = V_S\sqrt{k}$$

Where $V_{i(RMS)}$ is the RMS input supply voltage = $V_S$ .

# Performance Parameters



- **RMS Output (Load) Voltage**

$$V_{O(RMS)} = \left[ \frac{n}{2\pi(n+m)} \int_0^{2\pi} V_m^2 \sin^2 \omega t . d(\omega t) \right]^{1/2}$$

$$V_{O(RMS)} = \frac{V_m}{\sqrt{2}} \sqrt{\frac{n}{(m+n)}} = V_{i(RMS)} \sqrt{k} = V_S \sqrt{k}$$

$$V_{O(RMS)} = V_{i(RMS)} \sqrt{k} = V_S \sqrt{k}$$

Where $V_S = V_{i(RMS)}$ = RMS value of input supply voltage.

- **Duty Cycle**

$$k = \frac{t_{ON}}{T_O} = \frac{t_{ON}}{(t_{ON} + t_{OFF})} = \frac{nT}{(m+n)T}$$

Where, $k = \frac{n}{(m+n)}$ = duty cycle (d).

- **RMS Load Current**

$$I_{O(RMS)} = \frac{V_{O(RMS)}}{Z} = \frac{V_{O(RMS)}}{R_L}; \quad \text{for a resistive load } Z = R_L.$$

- **Output AC (Load) Power**

$$P_O = I^2_{O(RMS)} \times R_L$$

- **Input Power Factor**

$$PF = \frac{P_O}{VA} = \frac{\text{output load power}}{\text{input supply volt amperes}} = \frac{P_O}{V_S I_S}$$

$$PF = \frac{I_{O(RMS)}^2 \times R_L}{V_{i(RMS)} \times I_{in(RMS)}}; \qquad I_S = I_{in(RMS)} = \text{RMS input supply current.}$$

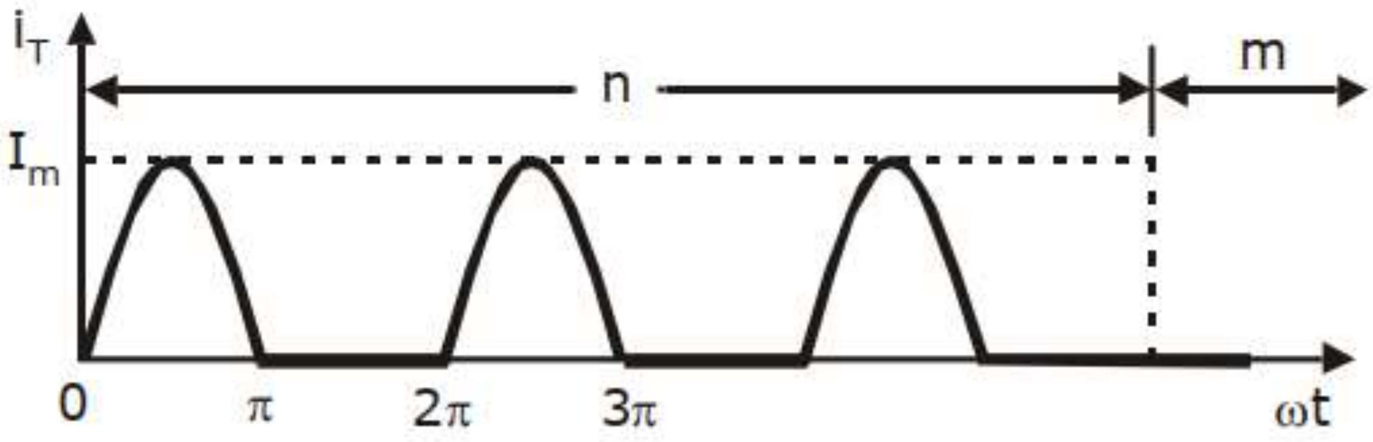
The input supply current is same as the load current $I_{in} = I_O = I_L$

Hence, RMS supply current = RMS load current; $I_{in(RMS)} = I_{O(RMS)}$.

$$PF = \frac{I_{O(RMS)}^2 \times R_L}{V_{i(RMS)} \times I_{in(RMS)}} = \frac{V_{O(RMS)}}{V_{i(RMS)}} = \frac{V_{i(RMS)}\sqrt{k}}{V_{i(RMS)}} = \sqrt{k}$$

$$PF = \sqrt{k} = \sqrt{\frac{n}{m+n}}$$

Waveform of Thyristor Current




Where $I_m = \dfrac{V_m}{R_L}$ = maximum or peak thyristor current.