



COLLEGE OF ENGINEERING AND TECHNOLOGIES
ALMUSTAQBAL UNIVERSITY

AC Power Converter

EET 307

Lecture 9

- Phase Control II -

(2025 - 2026)

Dr. Zaidoon AL-Shammari

Lecturer / Researcher

zaidoon.waleed@mustaqbal-college.edu.iq

Single Phase Half Wave AC Voltage Controller

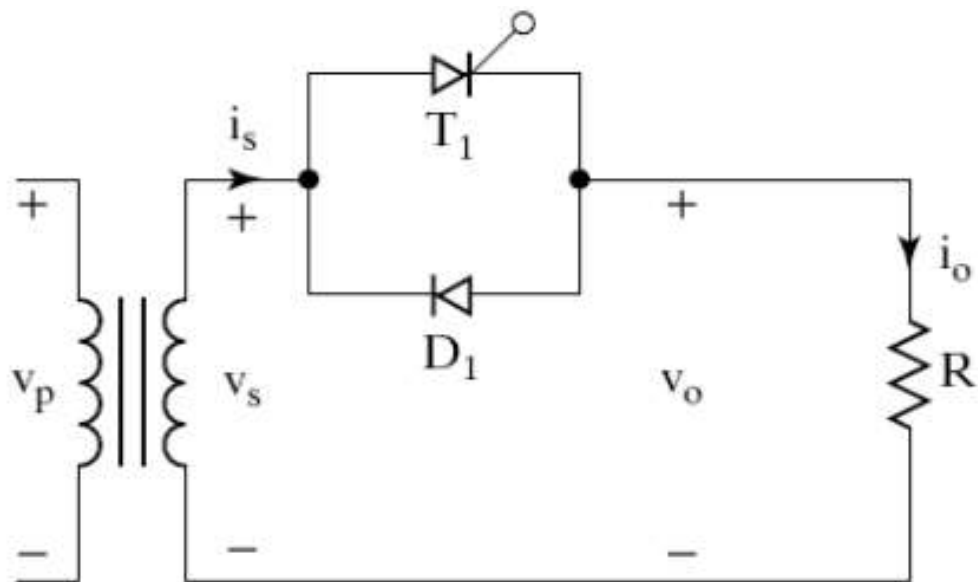
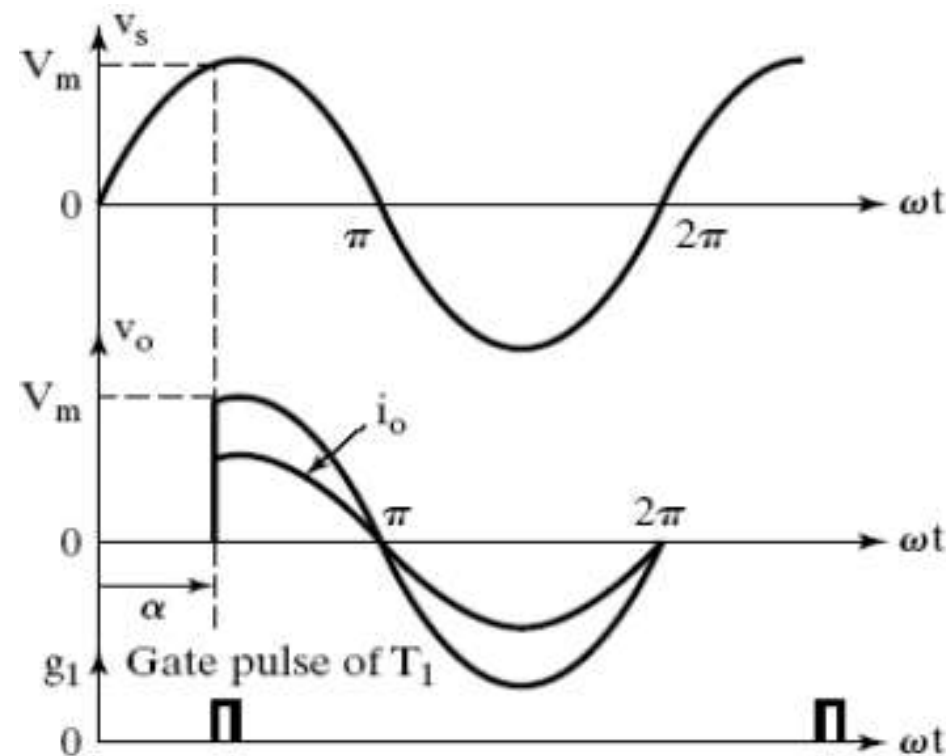


Fig.: Halfwave AC phase controller (Unidirectional Controller)



Single Phase Half Wave AC Voltage Controller

Equations

Input AC Supply Voltage across the Transformer Secondary Winding.

$$v_s = V_m \sin \omega t$$

$$V_S = V_{m(RMS)} = \frac{V_m}{\sqrt{2}} = \text{RMS value of secondary supply voltage.}$$

Output Load Voltage

$$v_o = v_L = 0 ; \text{ for } \omega t = 0 \text{ to } \alpha$$

$$v_o = v_L = V_m \sin \omega t ; \text{ for } \omega t = \alpha \text{ to } 2\pi .$$

Output Load Current

$$i_o = i_L = \frac{v_o}{R_L} = \frac{V_m \sin \omega t}{R_L} ; \text{ for } \omega t = \alpha \text{ to } 2\pi .$$

$$i_o = i_L = 0 ; \text{ for } \omega t = 0 \text{ to } \alpha .$$

Single Phase Half Wave AC Voltage Controller

$$V_{i(RMS)} = V_s = \frac{V_m}{\sqrt{2}} = \text{RMS value of input supply voltage}$$

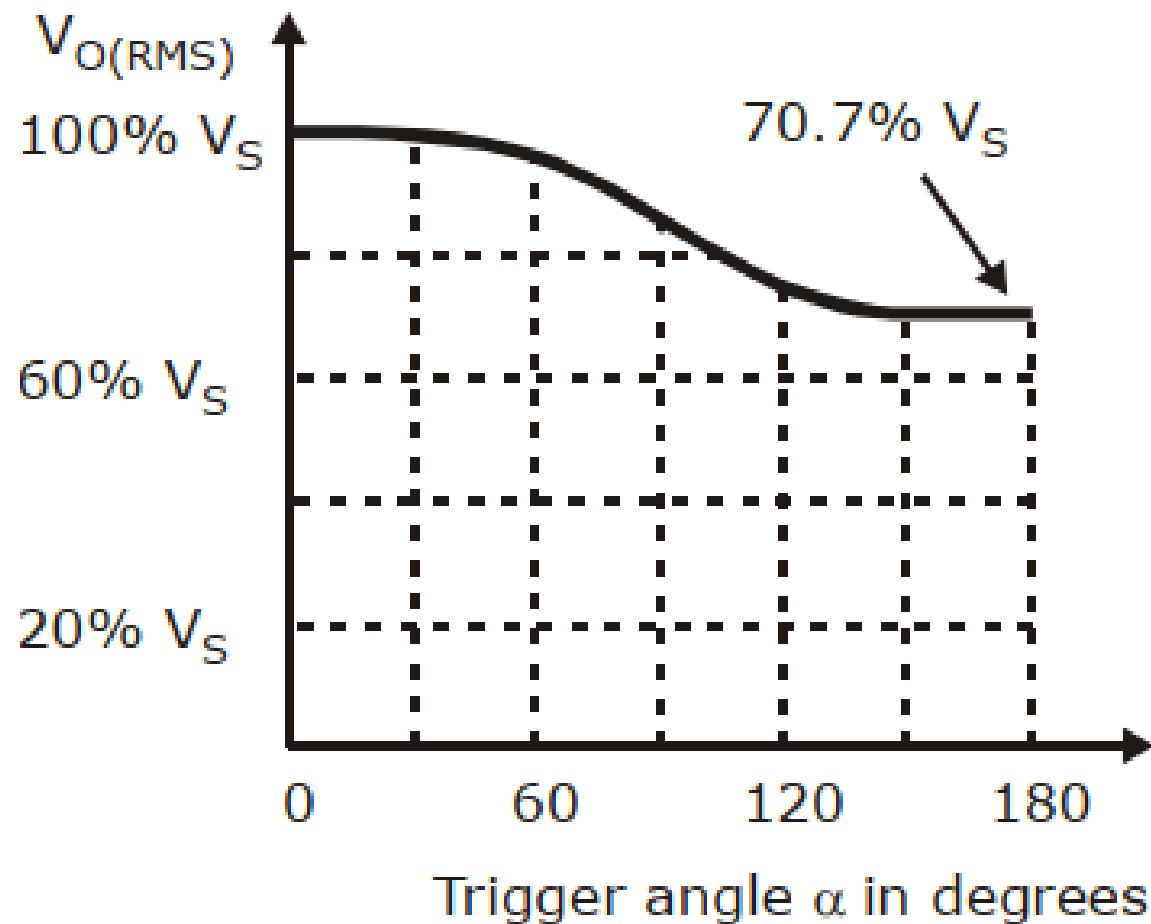
$$V_{O(RMS)} = \frac{V_m}{\sqrt{2}} \sqrt{\frac{1}{2\pi} \left[(2\pi - \alpha) + \frac{\sin 2\alpha}{2} \right]}$$

$$V_{O(RMS)} = V_s \sqrt{\frac{1}{2\pi} \left[(2\pi - \alpha) + \frac{\sin 2\alpha}{2} \right]}$$

$$V_{dc} = \frac{\sqrt{2}V_s}{2\pi} (\cos \alpha - 1)$$

When ' α ' is varied from 0 to π . V_{dc} varies from 0 to $\frac{-V_m}{\pi}$

Single Phase Half Wave AC Voltage Controller



- The output load voltage has a DC component because the two halves of the output voltage waveform are not symmetrical with respect to '0' level.
- The input supply current waveform also has a DC component (average value) which can result in the problem of core saturation of the input supply transformer.
- The half wave ac voltage controller using a single thyristor and a single diode provides control on the thyristor only in one half cycle of the input supply.

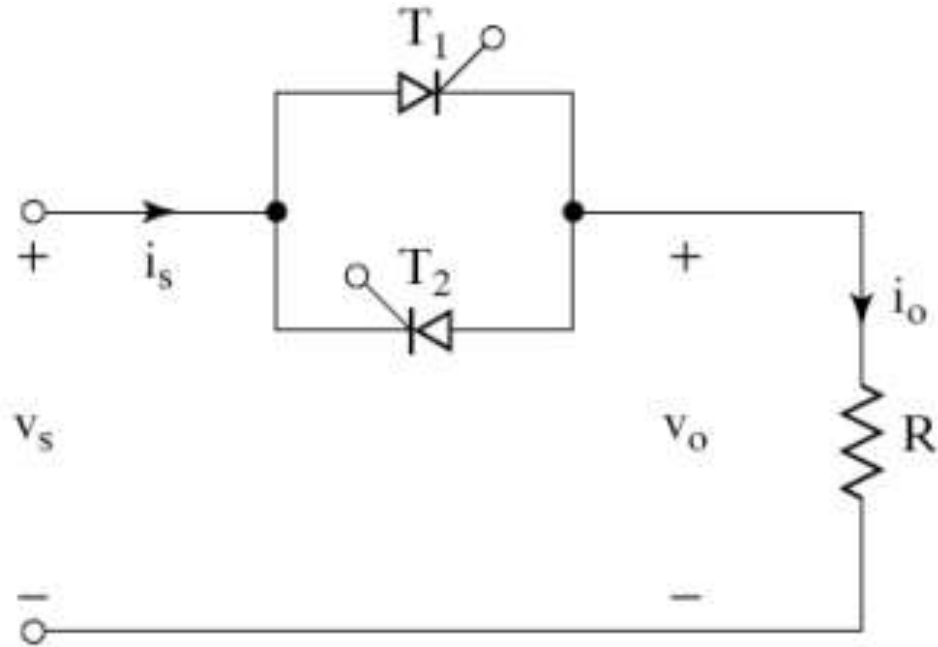
- Hence ac power flow to the load can be controlled only in one half cycle.
- Half wave ac voltage controller gives limited range of RMS output voltage control.
- Because the RMS value of ac output voltage can be varied from a maximum of 100% of V_S at a trigger angle $\alpha = 0$ to a low of 70.7% of V_S at $\alpha = \pi$ Radians.
- These drawbacks of single phase half wave ac voltage controller can be over come by using a single phase full wave ac voltage controller.

Single phase Full Wave AC Voltage Controller

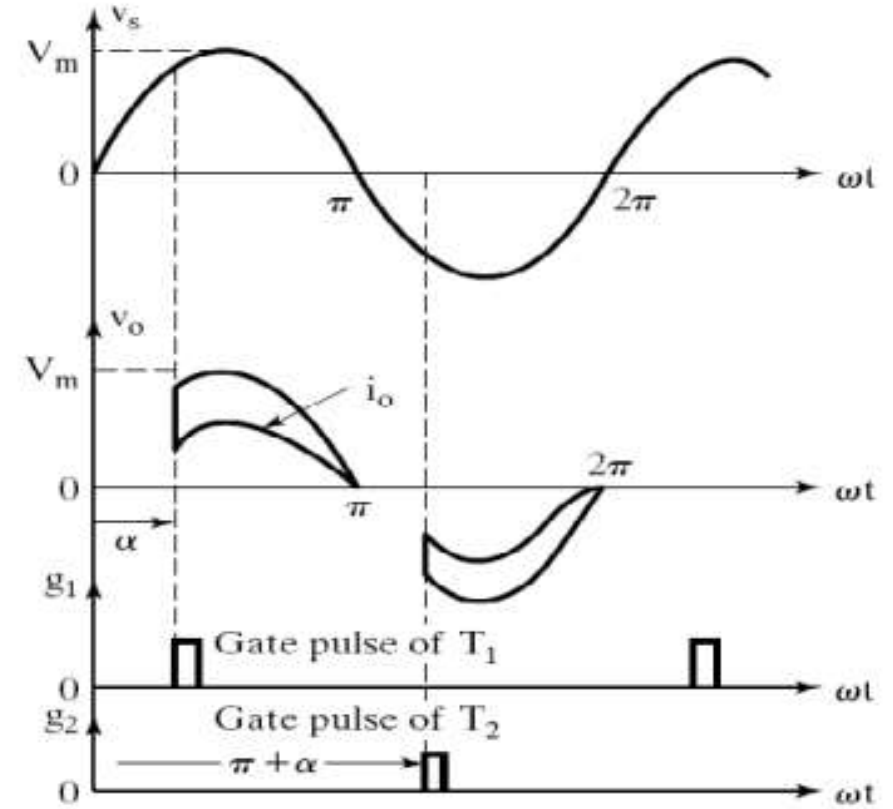
- Single phase full wave ac voltage controller circuit using two SCRs or a single triac is generally used in most of the ac control applications.
- The ac power flow to the load can be controlled in both the half cycles by varying the trigger angle ' α '.
- The RMS value of load voltage can be varied by varying the trigger angle ' α '.

- The input supply current is alternating in the case of a full wave ac voltage controller and due to the symmetrical nature of the input supply current waveform there is no dc component of input supply current i.e., the average value of the input supply current is zero.
- A single phase full wave ac voltage controller with a resistive load is shown in the figure below.
- It is possible to control the ac power flow to the load in both the half cycles by adjusting the trigger angle ' α '.

Single phase Full Wave AC Voltage Controller



Single phase full wave ac voltage controller



Waveforms of single phase full wave ac voltage controller

Single phase Full Wave AC Voltage Controller

- Hence the full wave ac voltage controller is also referred to as to a bidirectional controller.
- The thyristor T1 is forward biased during the positive half cycle of the input supply voltage.
- The thyristor T1 is triggered at a delay angle of ' α ' ($0 \leq \alpha \leq \pi$) radians.

Single phase Full Wave AC Voltage Controller

EQUATIONS

Input supply voltage

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

Output voltage across the load resistor R_L ;

$$v_O = v_L = V_m \sin \omega t ;$$

for $\omega t = \alpha$ to π and $\omega t = (\pi + \alpha)$ to 2π

Output load current

$$i_O = \frac{v_O}{R_L} = \frac{V_m \sin \omega t}{R_L} = I_m \sin \omega t ;$$

for $\omega t = \alpha$ to π and $\omega t = (\pi + \alpha)$ to 2π

Single phase Full Wave AC Voltage Controller

$$V_{L(RMS)} = V_s \sqrt{\frac{1}{\pi} \left[(\pi - \alpha) + \frac{\sin 2\alpha}{2} \right]}$$

$$V_{L(RMS)} \Big|_{\alpha=0} = \frac{V_m}{\sqrt{2}} = V_{i(RMS)} = V_s$$

$$V_{\alpha(RMS)} = V_s \sqrt{\frac{1}{\pi} \left[(\pi - \alpha) + \frac{\sin 2\alpha}{2} \right]}$$

$$V_s = \frac{V_m}{\sqrt{2}} = \text{RMS value of input supply voltage}$$

Applications of RMS Voltage Controller

- Speed control of induction motor (poly phase ac induction motor).
- Heater control circuits (industrial heating).
- Welding power control.
- Induction heating.
- On load transformer tap changing.
- Lighting control in ac circuits.
- Ac magnet controls

