BTEE3011-Power Electronics

AC Voltage Regulator

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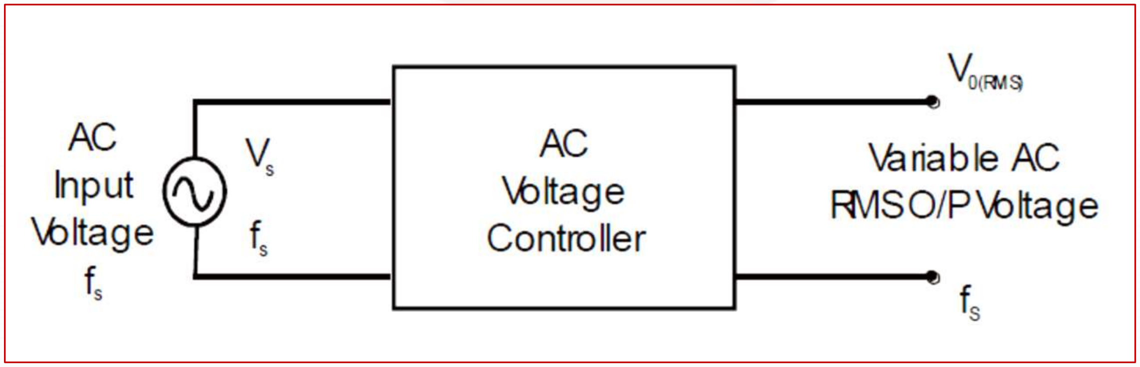
Recap

AC VOLTAGE CONTROLLERS:

- AC voltage controllers (ac line voltage controllers) are employed to vary the RMS value of the alternating voltage applied to a load circuit.

- An ac voltage controller is a type of thyristor power converter which is used to convert a fixed voltage, fixed frequency ac input supply to obtain a variable voltage ac output.

- The RMS value of the ac output voltage and the ac power flow to the load is controlled by varying (adjusting) the trigger angle ‘α’



Content

- ✓ Classification of AC voltage controller
- ✓ AC voltage controller controlling technique
- ✓ Single phase full wave ac voltage controller
- ✓ Three phase full wave AC voltage controller

Classification of AC voltage controller

The ac voltage controllers are classified into two types based on the type of input ac supply applied to the circuit.

- Single Phase AC Controllers.
- Three Phase AC Controllers.

Single phase ac controllers operate with single phase ac supply voltage of 230V RMS at 50Hz in our country.
Three phase ac controllers operate with 3 phase ac supply of 400V RMS at 50Hz supply frequency.
Each type of controller may be sub divided into

- Uni-directional or half wave ac controller.
- Bi-directional or full wave ac controller.

In brief different types of ac voltage controllers are

- Single phase half wave ac voltage controller (uni-directional controller).
- Single phase full wave ac voltage controller (bi-directional controller).
- Three phase half wave ac voltage controller (uni-directional controller).
- Three phase full wave ac voltage controller (bi-directional controller).

AC voltage controller controlling technique

There are two different types of thyristor control used in practice to control the ac power flow

1. Phase control

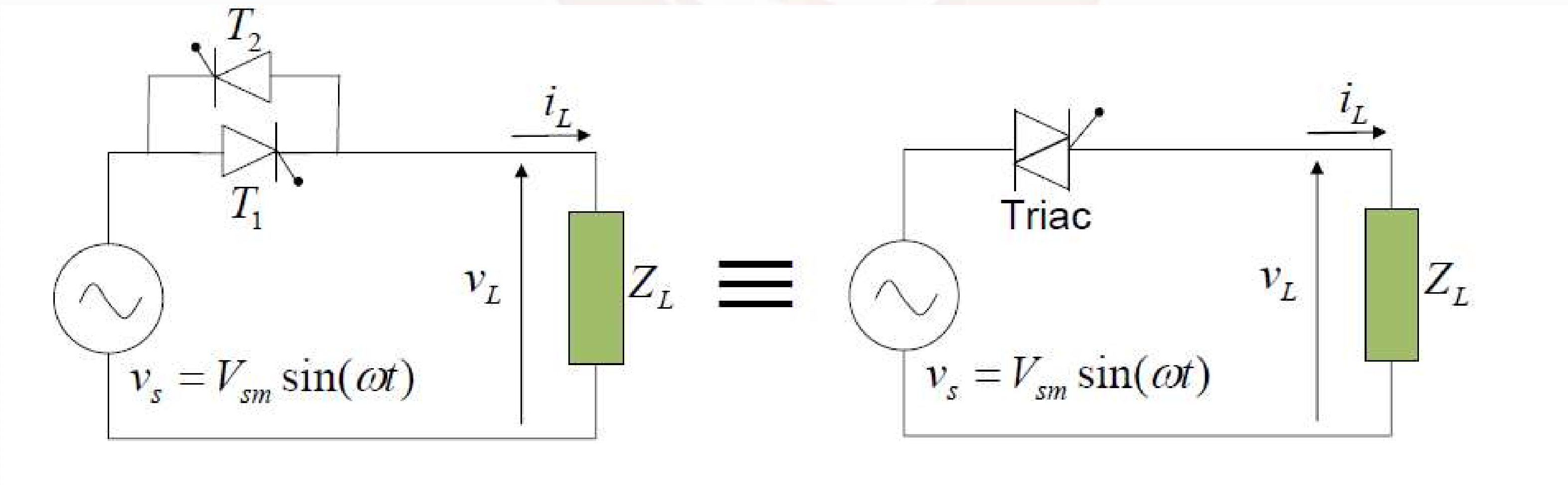
2. On-Off control

Contd....

PHASE CONTROL TECHNIQUE

- In phase control the Thyristors are used as switches to connect the load circuit to the input ac supply, for a part of every input cycle. That is the ac supply voltage is chopped using Thyristors during a part of each input cycle.
- The thyristor switch is turned on for a part of every half cycle, so that input supply voltage appears across the load and then turned off during the remaining part of input half cycle to disconnect the ac supply from the load.
- By controlling the phase angle or the trigger angle ‘α’ (delay angle), the output RMS voltage across the load can be controlled.

It is possible to control the ac power flow to the load in both the half cycles by adjusting the trigger angle 'α' . Hence the full wave ac voltage controller is also referred to as to a bidirectional controller.



Single phase full wave AC Voltage Controller with R load Operation

Mode-1- From 0 to π

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 $\alpha (0 \leq \alpha \leq \pi)$. Considering the ON thyristor T1 as an ideal closed switch the input supply voltage appears across the load resistor RL and the output voltage vo=vs.

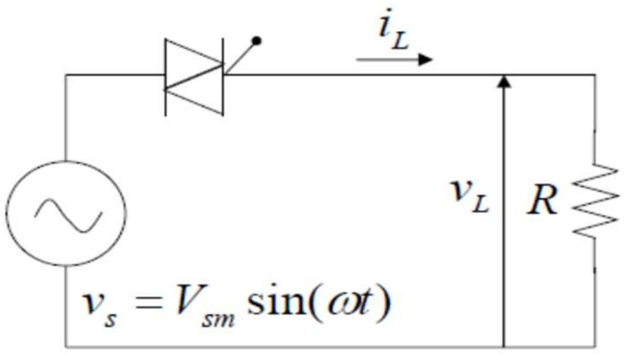
During $\omega t = \alpha$ to π radians. The load current flows through the ON thyristor T1 and through the load resistor RL in the downward direction during the conduction time of T1 from $\omega\alpha$ t = to π radians

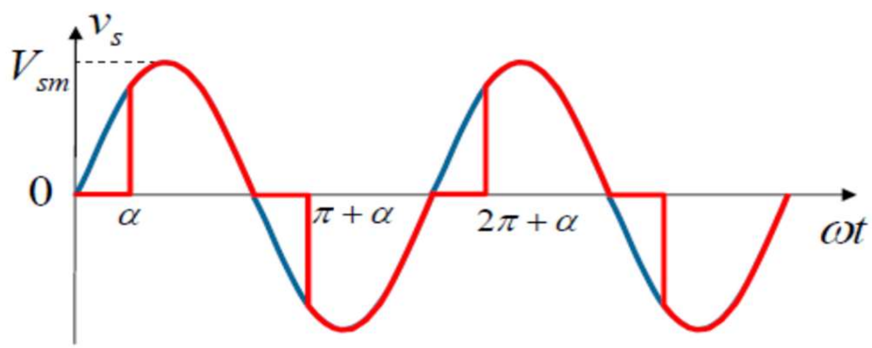
Single phase full wave AC Voltage Controller with R load Operation

Mode-2- From 0 to π

At $\omega t = \pi$, when the input voltage falls to zero the thyristor current (which is flowing through the load resistor R_L) falls to zero and hence T1 naturally turns off . No current flows in the circuit during $\omega t = \pi$ to $(\pi+\alpha)$. The thyristor T2 is forward biased during the negative cycle of input supply and when thyristor T2 is triggered at a delay angle $(\pi+\alpha)$, the output voltage follows the negative halfcycle of input from $\omega t = (\pi+\alpha)$ to 2π . When T2 is ON, the load current flows in the reverse direction (upward direction) through T2 during $\omega t = (\pi+\alpha)$ to 2π radians. The time interval (spacing) between the gate trigger pulses of T1 and T2 is kept at π radians or 1800 . At $\omega t = 2\pi$, the input supply voltage falls to zero and hence the load current also falls to zero and thyristor T2 turn off naturally.

1. Resistive Load

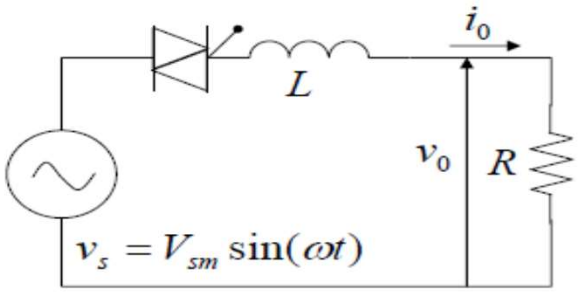




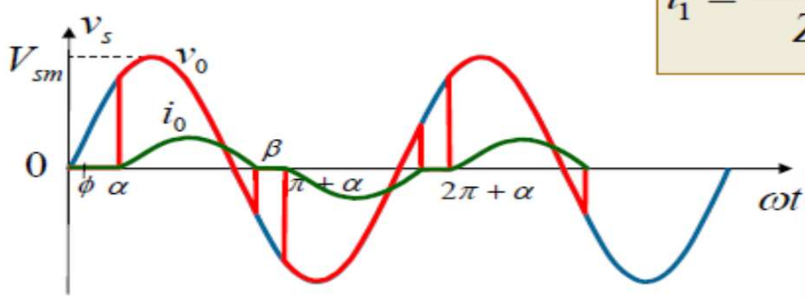
$$V_{0rms} = \sqrt{\frac{1}{\pi}\int_0^{\pi} v_L^2 d\theta} = \sqrt{\frac{V_{sm}^2}{\pi}\int_{\alpha}^{\pi} \sin^2\theta \cdot d\theta}$$

$$V_{0rms} = V_s\sqrt{\frac{1}{\pi}\left(\pi - \alpha + \frac{\sin(2\alpha)}{2}\right)}$$

2. Inductive Load



$$\theta = \tan^{-1}\left(\frac{\omega L}{R}\right)$$



Three cases to be distinguished:

i. $\alpha > \theta$
ii. $\alpha < \theta$
iii. $\alpha = \theta$

i) $\alpha > \theta$: Discontinuous current

Current equation is obtained similarly to Chapter 10 (single-phase controlled rectifier).

$$i_1 = \frac{\sqrt{2}V_s}{Z}\left[\sin(\omega t-\theta)-\sin(\alpha-\theta)e^{\left(\frac{R}{L}\right)\left(\frac{\alpha}{\omega}-t\right)}\right]$$

β is obtained by taking $i_1(\beta)=0$.

$$V_{0rms} = V_s\sqrt{\frac{1}{\pi}\left(\beta-\alpha+\frac{\sin 2\alpha}{2}-\frac{\sin 2\beta}{2}\right)}$$

ii) $\alpha < \theta$: ☹ Not Practical because conduction angle cannot exceed π

$\beta > \alpha + \pi$ ➡ Conduction in one alternance.

⬇

To be avoided

If triac gate pulse is large enough then we will obtain continuous conduction.

iii) $\alpha = \theta$: Continuous conduction

$\beta = \alpha + \pi$ ➡ $$V_{0rms} = \frac{V_{sm}}{\sqrt{2}} = V_{srms}$$

Three PHASE FULL WAVE AC VOLTAGE CONTROLLER R Load Output