Homework 2

Page 95, Chinese textbook
Question 2.1

Figure 3-10 shows a single-phase full-wave controlled rectifier with a transformer center tap.

Is there a problem of dc magnetization in this transformer? Please explain:

(1) The maximum forward and reverse voltage of the thyristor is $2\sqrt{2}U_2$

(2) When the load is a resistor or an inductor, the waveform of the output voltage and current is the same as that of the Single-phase Bridge controlled rectifier.

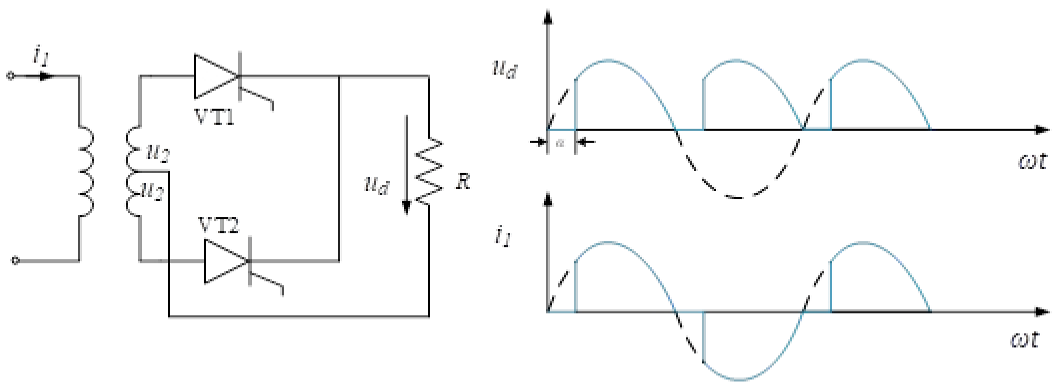


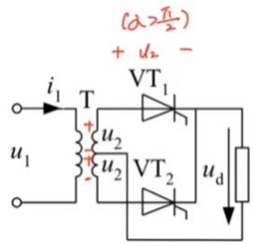
Figure 3-10 Single-phase full–wave controlled rectifier

Answer 2.1

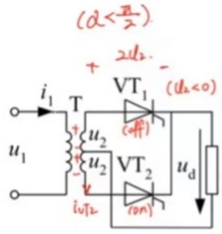
There is no problem of DC magnetization in the transformer. Within a period, the time of the current flowing through the VT1 and VT2 is identical. The magnitude of the current is the same, while the direction is reverse. Therefore, the average value of the current flowing through the transformer equals to 0. So there is no dc magnetization in the transformer.

(1) Choose VT1 to be analyzed:

When u2 >0,and VT1 and VT2 are neither conducting. If $\alpha > \frac{\pi}{2}$, the maximum forward voltage of the VT1 would be $\sqrt{2}U_2$ when $\omega t = \frac{\pi}{2}$.



When u2<0, VT2 is conducting and VT1 is off. If $\alpha < \frac{\pi}{2}$, the maximum reverse voltage of the VT2 would be $2\sqrt{2}U_2$ when $\omega t = \frac{3\pi}{2}$.



(2) Given that α in the single phase full-wave rectifier and single-wave bridge fully-controlled rectifier is the same.

When the load is the resistor, $u_d = i_d \cdot R$.

$0 < \omega t < \alpha$: both thyristors are not conducting, u_d=0.

$\alpha < \omega t < \pi$: VT1 is conducting while VT2 is blocked. u_d=u_2.

$\pi < \omega t < \alpha + \pi$: VT1 and VT2 are both blocked, u_d=0.

$\alpha + \pi < \omega t < 2\pi$: VT2 is conducting and VT1 is still blocked. u_d=-u_2.

Therefore, the waveform of u_d *and* i_d is basically identical with that of Single-phase Bridge fully-controlled rectifier with resistive load, which is presented as below.

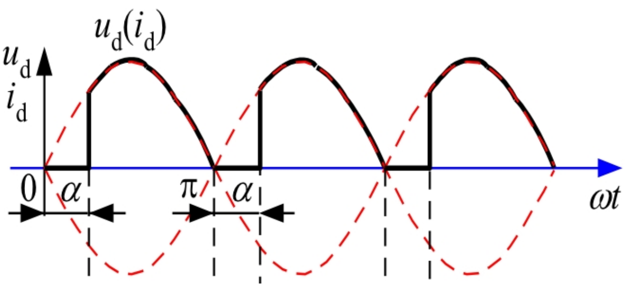


Fig1 The waveform of Single-phase Bridge fully-controlled rectifier with resistive load

When the load is inductive, assuming that the induction is large enough. In this case, i_d **can be considered as a constant variable**, which also applies to Single-phase Bridge fully-controlled rectifier with large inductive load.

For u_d:

$0 < \omega t < \alpha$: VT2 is conducting and VT1 is blocked. u_d=-u_2.

$\alpha < \omega t < \pi + \alpha$: VT1 is conducting and VT2 is blocked. u_d=u_2.

$\pi + \alpha < \omega t < 2\pi$:VT1 is blocked while VT2 is conducting. u_d=-u_2 .

Hence, the waveform of u_d is the same as that of Single-phase Bridge fully-controlled rectifier.

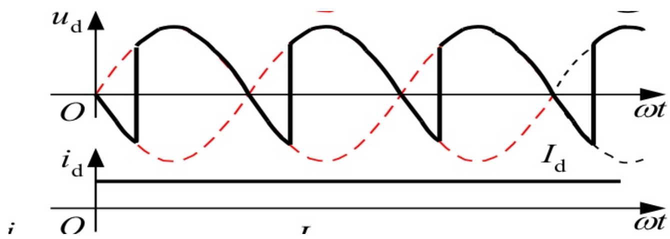


Fig2 The waveform of Single-phase Bridge fully-controlled rectifier with inductive load

Question 2.2

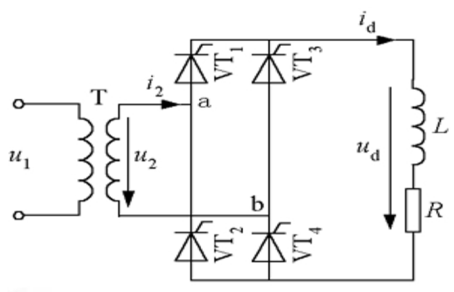
Single-phase Bridge controlled rectifier, *U2=100V, R=2Ω*, The value of L is very large

when α = 30°

(1) Draw waveform of ud, id and i2.

(2) Compute the rectifier's output average voltage U_d, current I_d and RMS value of I_2

(3) Determine the rated voltage and current of the thyristor considering the safety margin.



Answer 2.2

(1) The waveform required (α = 30°) is shown as below:

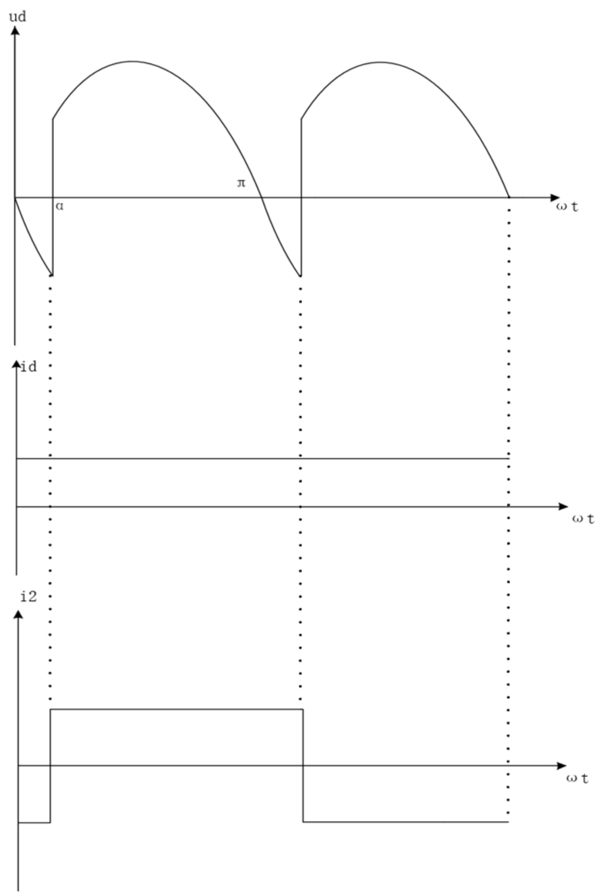


Fig3 The waveform of ud, id and i2

（2）

$$U_d = 0.9U_2\cos\alpha = 0.9\times100\times\frac{\sqrt{3}}{2}\approx77.94V$$

$$I_d = \frac{U_d}{R} = 38.97A$$

$$I_2 = I_d = 38.97A$$

（3）The maximum reverse voltage U_{RP} of the thyristor would be:

$$U_{RP} = \sqrt{2}U_2\approx141.42V$$

The RMS value of the current I_{VT} flowing through the thyristor would be:

$$I_{VT} = I_d\div\sqrt{2}\approx27.56A$$

Considering the safety margin, the rated voltage U_N and rated current I_N would be:

$$U_N = (2 \sim 3) U_{RP} = 282.84 \sim 424.26V$$

$$I_N = (1.5 \sim 2) I_{VT} \div 1.57 = 26.33 \sim 35.11A$$

Question 2.3

The circuit of the single-phase bridge half-controlled rectifier circuit in series of thyristors (VT_1 and VT_2 in the bridge are thyristors) is shown in Figure 3-12, U_2=100V, resistance and inductance load, R=2Ω, and L value is large. When $\alpha = 60°$, calculate the effective value of the current flowing through the device, and draw the waveforms of u_d, i_d, i_{VT} and i_{VD}.

Answer 2.3

The waveform of f u_d, i_d, i_{VT} and i_{VD} is shown as below:

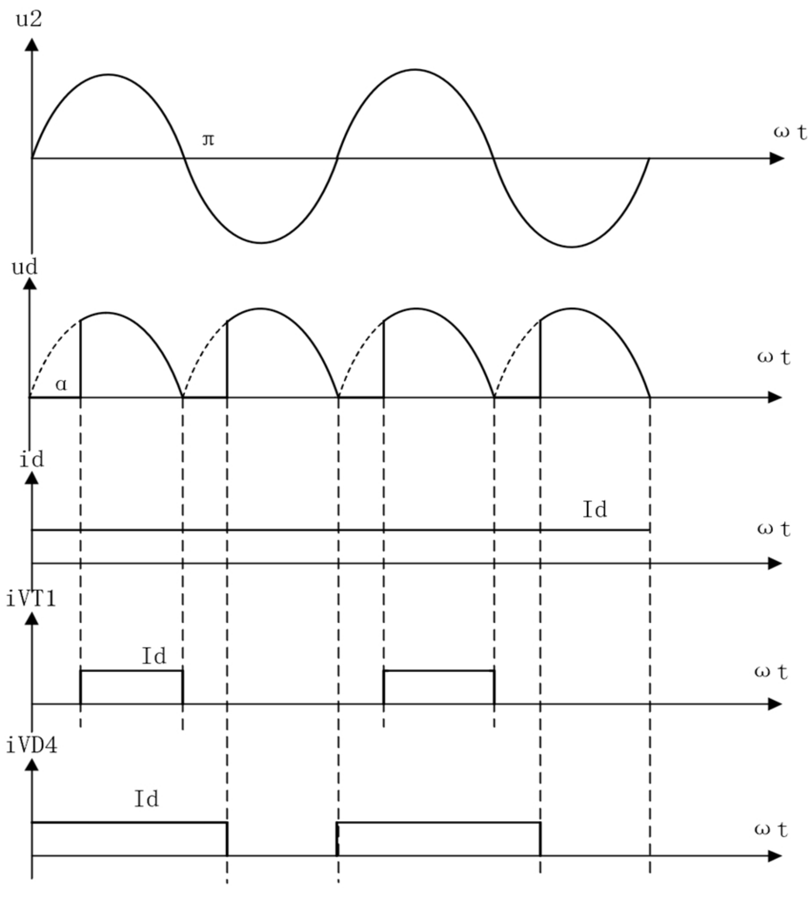


Fig4 The waveform of u2 ud, iVT and iVD

The average value of U_d would be:

$$U_d = \frac{1}{\pi}\int_{\alpha}^{\pi} \sqrt{2}U_2 \sin\ \omega t\ d(\omega t) = 0.9U_2\frac{1+\cos\alpha}{2} = 67.5V$$

Then, the average value of I_d would be:

$$I_d = \frac{U_d}{R} = 33.75A$$

The effective value of current flowing through thyristor I_{VT} and diode I_{VD} would be:

$$I_{VT} = \sqrt{\frac{\int_{\alpha}^{\pi} I_d^2 d\omega t}{2\pi}} = \sqrt{\frac{1}{3}}I_d \approx 19.49A$$

$$I_{VD} = \sqrt{\frac{\int_{0}^{\pi+\alpha} I_d^2 d\omega t}{2\pi}} = \sqrt{\frac{2}{3}}I_d \approx 27.56A$$

Question 2.4

Considering a three-phase half-wave controlled rectifier circuit under a resistive or inductive load, respectively, draw the rectifier voltage waveform ud when the trigger signal of phase α disappeared

Answer 2.4

Assuming that α=0, the waveform of ud is shown as below:

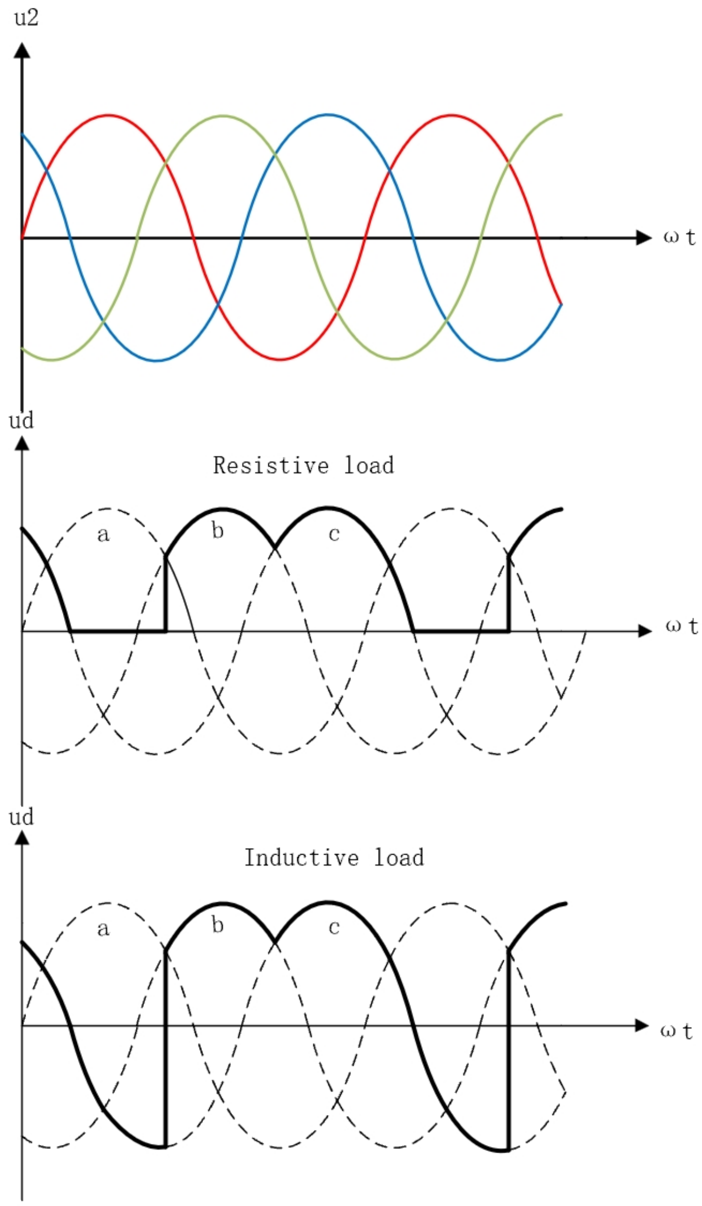


Fig5 The waveform of ud

Question 2.5

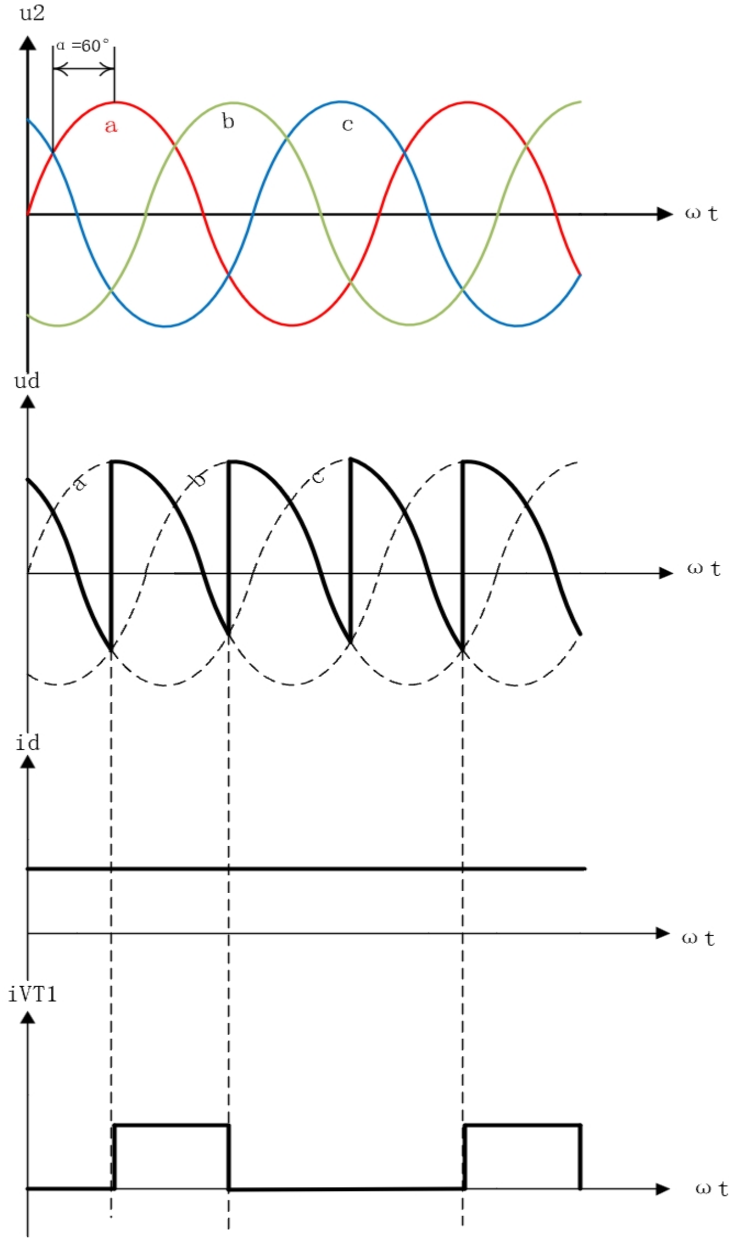
Considering a three-phase half-wave controlled rectifier circuit with U_2=100V, under a resistive and inductive load with R=5Ω and very large inductance, when α = 60°:

(1) Draw the waveform of u_d, i_d and i_{VT1} ;

(2) Calculate u_d, i_d , I_{dVT} , and I_{VT} .

Answer 2.5

（1） The waveform of u_d, i_d and i_{VT1} is shown as below:



(2)

$$U_d = 1.17U_2\cos\alpha = 1.17 \times 100 \times 0.5 = 58.5V$$

$$I_d = \frac{U_d}{R} = 58.5 \div 5 = 11.7A$$

$$I_{dVT} = I_d \div 3 = 3.9A$$

$$I_{VT} = \frac{I_d}{\sqrt{3}} \approx 6.75A$$