Homework 3

Page 95, Chinese textbook

Question 2

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.

Question 3

Single-phase Bridge controlled rectifier, $U_2 = 100V$, $R = 2\Omega$, The value of L is very large, when $\alpha = 30°$:

(1) Draw the waveforms of u_d 、 i_d 、 and i_2

(2) Solve the rectified average output voltage of U_d ,、 the current of I_d and the RMS value of transformer secondary current of I_2

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

Question 5

Single-phase Bridge controlled rectifier, $U_2 = 200V$, $R = 2\Omega$, The value of L is very large, back electromotive force E=100V, when $\alpha = 45°$:

(1) Draw the waveforms of u_d 、 i_d 、 and i_2

(2) Solve the rectified average output voltage of U_d ,、 the current of I_d and the RMS value of transformer secondary current of I_2

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

Question 7

Considering a three-phase half-wave controlled rectifier circuit under a resistive or inductive load, respectively, draw the rectifier voltage waveform $\mathrm{u_d}$ when the trigger signal of phase a disappeared.

Question 11

Considering a three-phase half-wave controlled rectifier circuit with $\mathrm{U_2} = 100\mathrm{V}$, under a resistive and inductive load with $\mathrm{R} = 5\Omega$ and very large inductance, when $\alpha = 60°$:

(1) Draw the waveform of u_d, i_d and i_{VT_1};

(2) Calculate U_d, I_d, I_{dVT}, and I_{VT}.

Answer 3.2

There isn't a problem of DC magnetization in this transformer.

In the transformer secondary winding of the single-phase full wave controlled rectifier, the current flows in opposite directions during the positive and negative half cycle. Besides, the waveform is symmetrical. The average current of the whole cycle is zero. So there isn't a problem of DC magnetization in this transformer.

1. When the VT_1 is turned on, the thyristor VT_2 parallels with both transformer secondary windings through the VT_1, so the maximum forward and reverse voltage of the thyristor is $2\sqrt{2}U_2$. When the VT_2 is turned on, the condition is similar.

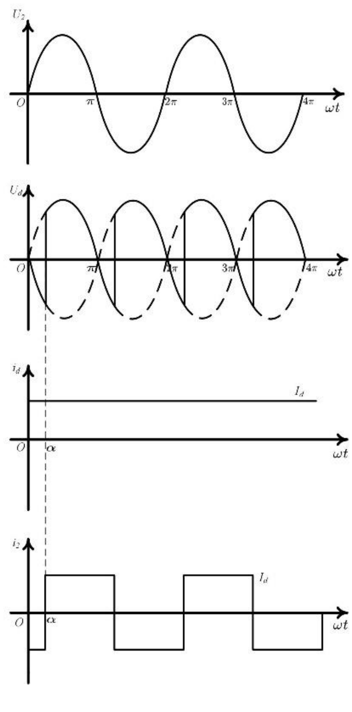
2. Assume that trigger angle is α.

For the resistance loads, when phase position in $0 \sim \alpha$, there is no thyristor turned on, so the output voltage is 0. When phase position in $\alpha \sim \pi$, the VT_1 of the single-phase full wave controlled thyristor is turned on. The VT_1 and the VT_4 of the single-phase bridge controlled thyristor are turned on. And the output voltage is equal to the supply voltage. When phase position in $\pi \sim \pi+\alpha$, there is no thyristor turned on, so the output voltage is zero. When phase position in $\pi+\alpha \sim 2\pi$, the VT_2 of the single-phase full wave controlled thyristor is turned on. The VT_2 and the VT_3 of the single-phase bridge controlled thyristor are turned on. And the output voltage is equal to the supply voltage.

For the inductive loads, when phase position in $\alpha \sim \pi+\alpha$, the VT_1 of the single-phase full wave controlled thyristor is turned on. The VT_1 and the VT_4 of the single-phase bridge controlled thyristor are turned on. And the output voltage is equal to the supply voltage. When phase position in $\pi+\alpha \sim 2\pi+\alpha$, the VT_2 of the single-phase full wave controlled thyristor is turned on. The VT_2 and the VT_3 of the single-phase bridge controlled thyristor are turned on. And the output voltage is equal to the supply voltage.

With all these mentioned above, the curves of output voltage for the different loads are the same.

Answer 3.3



1.

2.

average output vlaue of voltage and current

$$U_d = \frac{1}{\pi}\int_{\alpha}^{\pi+\alpha} \sqrt{2}\sin\omega t d(\omega t) = 0.9U_2\cos\alpha = 0.9 \times 100 \times \cos\frac{\pi}{6}V = 77.9423V$$

$$I_d = \frac{U_d}{R} = \frac{77.9423V}{2\Omega} = 38.97115A$$

RMS value of transformer sec*ondary current*

$$I_2 = I_d = 38.97115A$$

3.

max*imum vlotage of the thyristor*

$$U_{\max} = \sqrt{2}U_2 = \sqrt{2} \times 100V = 141.421V$$

the RMS value of the current of the thyristor

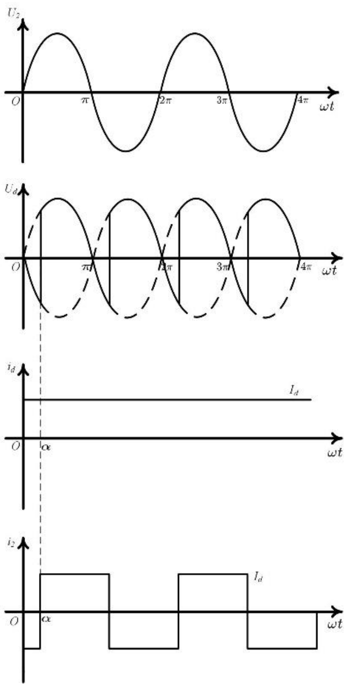
$$I_{VT} = \frac{I_d}{\sqrt{2}} = \frac{38.97115}{\sqrt{2}}A = 27.5568A$$

the rated voltage and the current of the thyristor considering the safety margin are

$$U_N = (2\text{~}3) \times 141.4V = 283\text{~}424V$$

$$I_N = (1.5\text{~}2) \times 27.5568A = 41.3352\text{~}55.1136A$$

Answer 3.5



1.

2.

the rectified average output voltage and current

$$U_d = 0.9U_2\cos\alpha = 0.9 \times 200 \times \cos\frac{\pi}{4}V = 127.279V$$

$$I_d = \frac{U_d - E}{R} = \frac{127.279 - 100}{2}A = 13.6395A$$

the RMS value of transformer sec*ondary current*

$$I_2 = I_d = 13.6395A$$

3.

max*imum vlotage of the thyristor*

$U_{\max} = \sqrt{2}U_2 = \sqrt{2} \times 200V = 282.843V$

the RMS value of the current of the thyristor

$$I_{VT} = \frac{I_d}{\sqrt{2}} = \frac{13.6395}{\sqrt{2}}A = 9.64458A$$

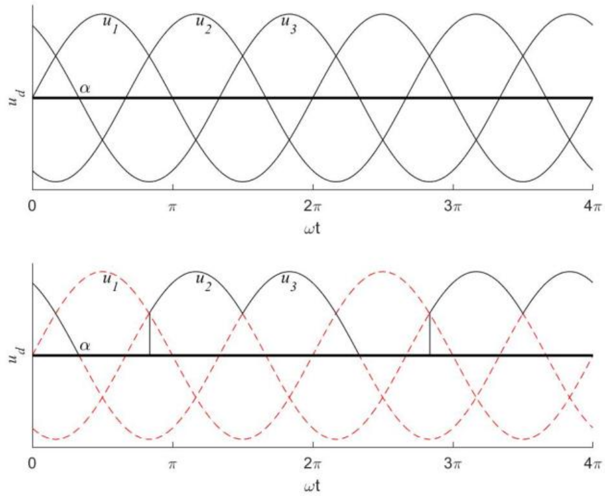
the rated voltage and the current of the thyristor considering the safety margin are

$U_N = (2 \sim 3) \times 282.843V = 565.686 \sim 848.529V$

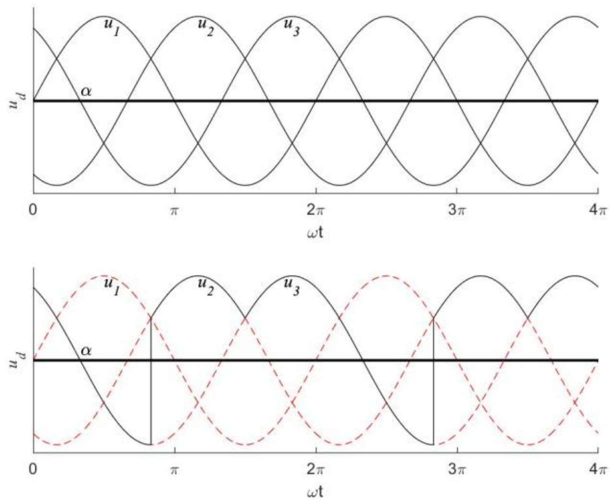
$I_N = (1.5 \sim 2) \times 9.64458A = 14.46687 \sim 19.28916A$

Answer 3.7

When the load is a resistor, the waveform of u_d:

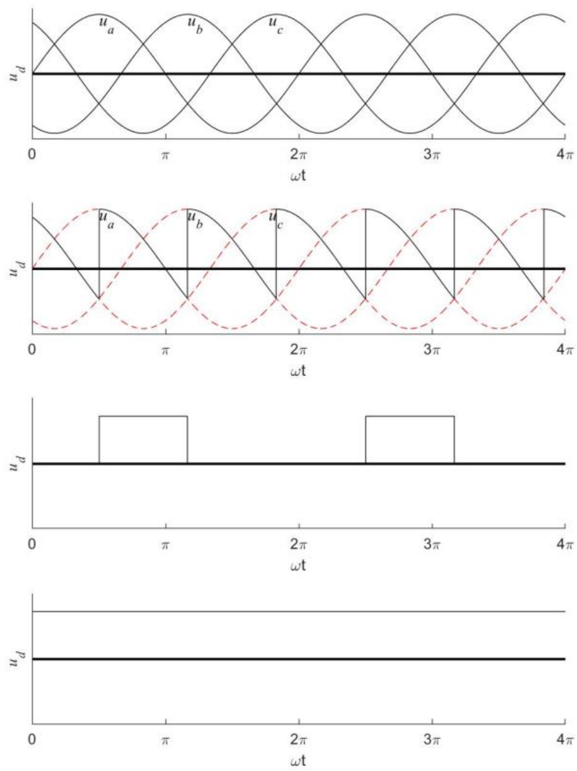


When the load is a inductance, the waveform of u_d:



Answer 3.11

1.



2.

$$Because\ \alpha = \frac{\pi}{3} > \frac{\pi}{6}$$

$$U_d = \frac{1}{\frac{2\pi}{3}} \int_{\frac{\pi}{6}+\alpha}^{\pi} \sqrt{2} U_2 \sin \omega t d(\omega t) = \frac{3\sqrt{2}}{2\pi}\left(1+\cos\left(\frac{\pi}{6}+\alpha\right)\right) = 0.675 U_2 \left(1+\cos\left(\frac{\pi}{6}+\alpha\right)\right)$$

$$= 0.675 \times 100 \times \left(1+\cos\left(\frac{\pi}{6}+\frac{\pi}{3}\right)\right) V = 67.5 V$$

$$I_d = \frac{U_d}{I_d} = \frac{67.5}{5} A = 13.5 A$$

$$I_{dVT} = 0.368 \times 13.5 A = 4.968 A$$

$$I_{VT} = 0.577 \times 13.5 A = 7.7895 A$$