Homework 3

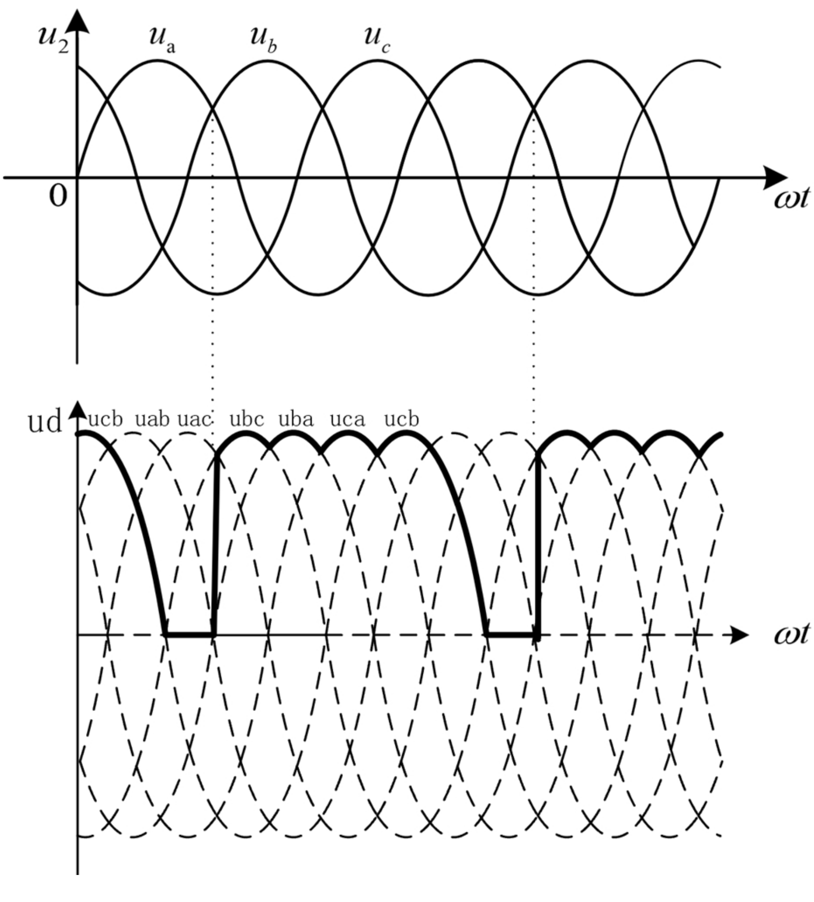
Page 95, Chinese textbook

Question 12

Considering a three-phase bridge fully-controlled rectifier circuit under a resistive load, if one thyristor cannot be conducted, what does the rectifier voltage waveform u_d look like? If one thyristor has been broken down and is a short circuit now, what is the influence on the other thyristors?

Solution:

Assuming that VT1 could not be conducted, and the firing angle α=0, then the waveform of u_d would look like:



If VT1 is broken down and is a short circuit now. When VT3 and VT5 is conducting, a short circuit can be formed between phase a and b or phase a and c. The increasing voltage may cause damage to VT3 and VT5.

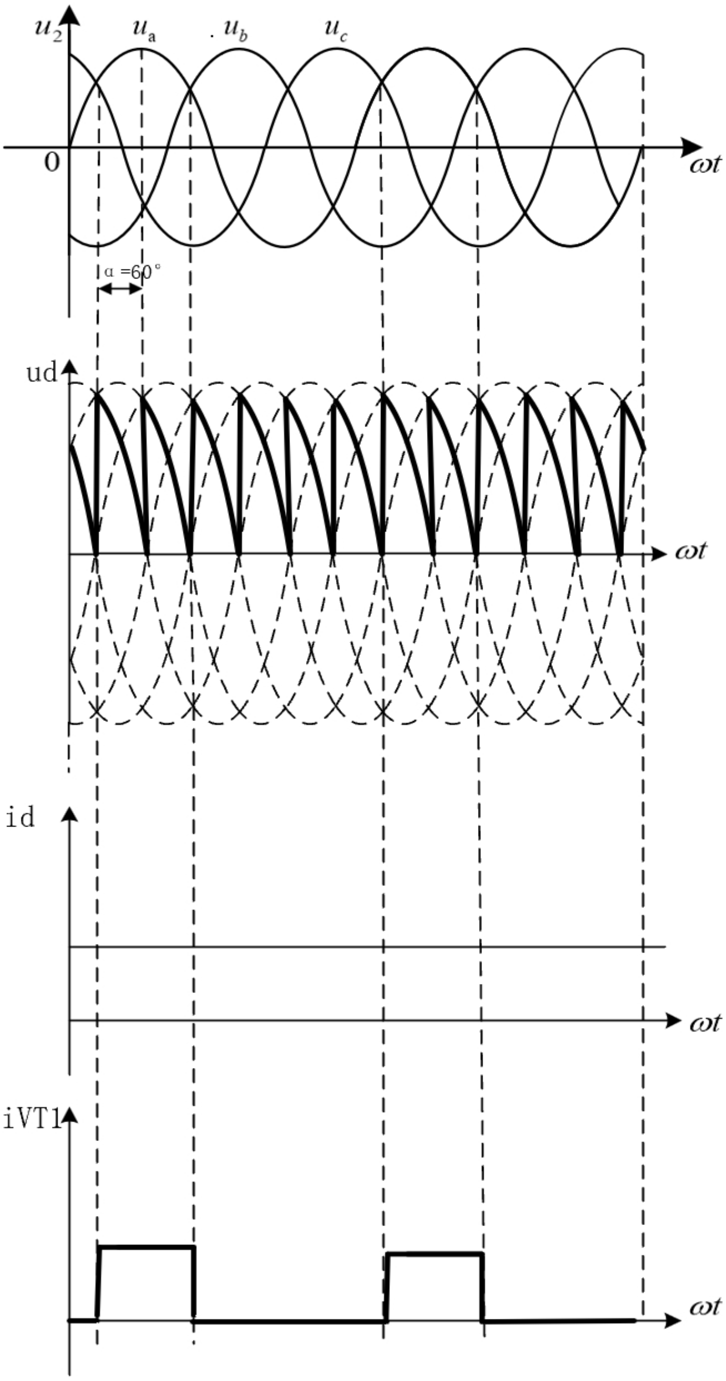
Question 13

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

1) Draw the waveform of u_d, i_d and i_{VT1};
2) Calculate U_d I_d I_{dVT} I_{VT}.

Solution:

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



2)

$$U_d = \frac{3}{\pi}\int_{\alpha+\frac{\pi}{3}}^{\alpha+\frac{2\pi}{3}} \sqrt{6}U_2 \sin\omega t \, d\omega t = 2.34U_2\cos\alpha = 117(V)$$

$$I_d = \frac{U_d}{R} = 23.4(A)$$

$$I_{dVT} = \frac{1}{3}I_d = 7.8(A)$$

$$I_{VT} = \frac{1}{\sqrt{3}}I_d \approx 13.51(A)$$

Question 15

Considering a three-phase half-wave controlled rectifier circuit connected to a EMF load with resistor and inductor, when $U_2 = 100V$, R = 1Ω, L = ∞, L_B = 1mH, $\alpha = 30°$, E = 50V,

calculate the value of U_d I_d γ and draw the waveform of $u_d,\ i_{VT1}\ and\ i_{VT2}$

Solution:

Since this is a three-phase half-wave controlled rectifier, we can see ΔU_d:

$$\Delta U_d = \frac{3X_B I_d}{2\pi}$$

$$X_B = 2\pi f L_B \ \ (f = 50Hz)$$

Meanwhile.

$$U_d = 1.17U_2 \cos\alpha - \Delta U_d$$

$$I_d = \frac{U_d - E}{R}$$

Solve these equations:

$$U_d = \frac{3X_B E + \pi R \times 1.17U_2 \cos\alpha}{3X_B + 2\pi R} \approx 94.63(V)$$

$$\Delta U_d = 1.17U_2 \cos\alpha - U_d \approx 6.7(V)$$

$$I_d = 44.63(A)$$

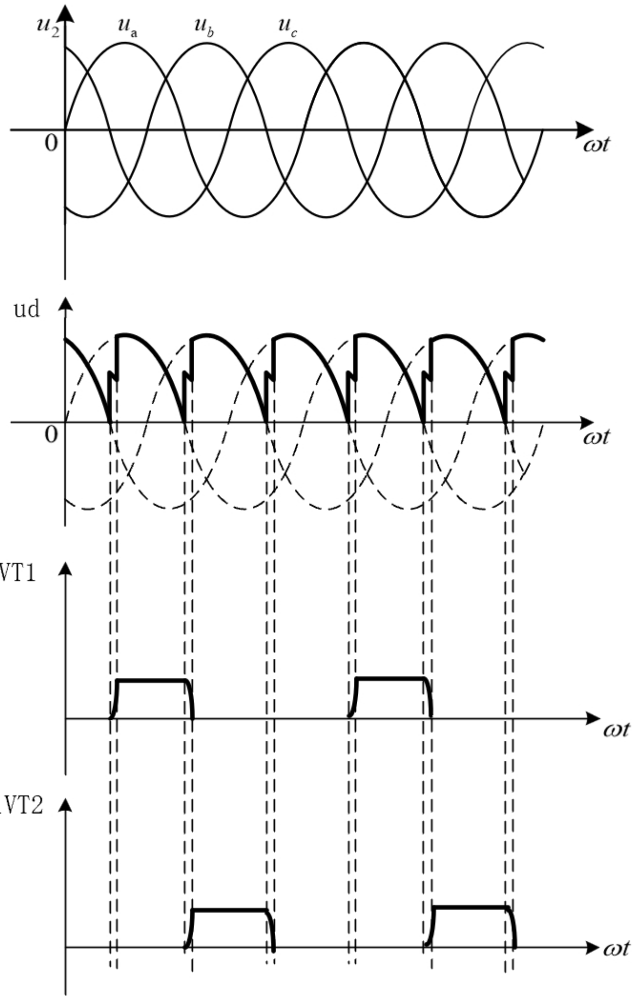
On account of:

$$\cos\alpha - \cos(\alpha + \gamma) = \frac{2I_d X_B}{\sqrt{6}U_2}$$

We can solve γ:

$$\gamma = \arccos(0.752) - 30° \approx 11.24°$$

The waveform of $u_d,\ i_{VT1}\ and\ i_{VT2}$ is shown as below:



Question 16

Considering a three-phase bridge uncontrolled rectifier circuit connected to a resistive and inductive load, with $R = 2\Omega$, $L = \infty$, $U_2 = 100V$, $X_B = 0.1\Omega$, calculate the value of U_d I_d I_{VD}, I_2, *and* γ, and draw the waveform of u_d i_{Vd} $i_{2\,2}$.

Solution:

Three-phase bridge uncontrolled rectifier circuit is equal to three-phase bridge fully-controlled rectifier with α being 0.

$$U_d = 2.34 U_2 \cos\alpha - \Delta U_d$$

$$\Delta U_d = \frac{3 X_B I_d}{\pi}$$

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

We can see:

$$U_d = \frac{2.34U_2\cos\alpha}{1+3X_B/\pi R} \approx 223.37(V)$$
$$I_d = 111.685(A)$$

$$\mathrm{I_{VD}} = \mathrm{I_d}/3 \approx 37.23(\mathrm{A})$$

$$\mathrm{I_2} = \sqrt{\frac{2}{3}}\mathrm{I_d} \approx 91.19(\mathrm{A})$$

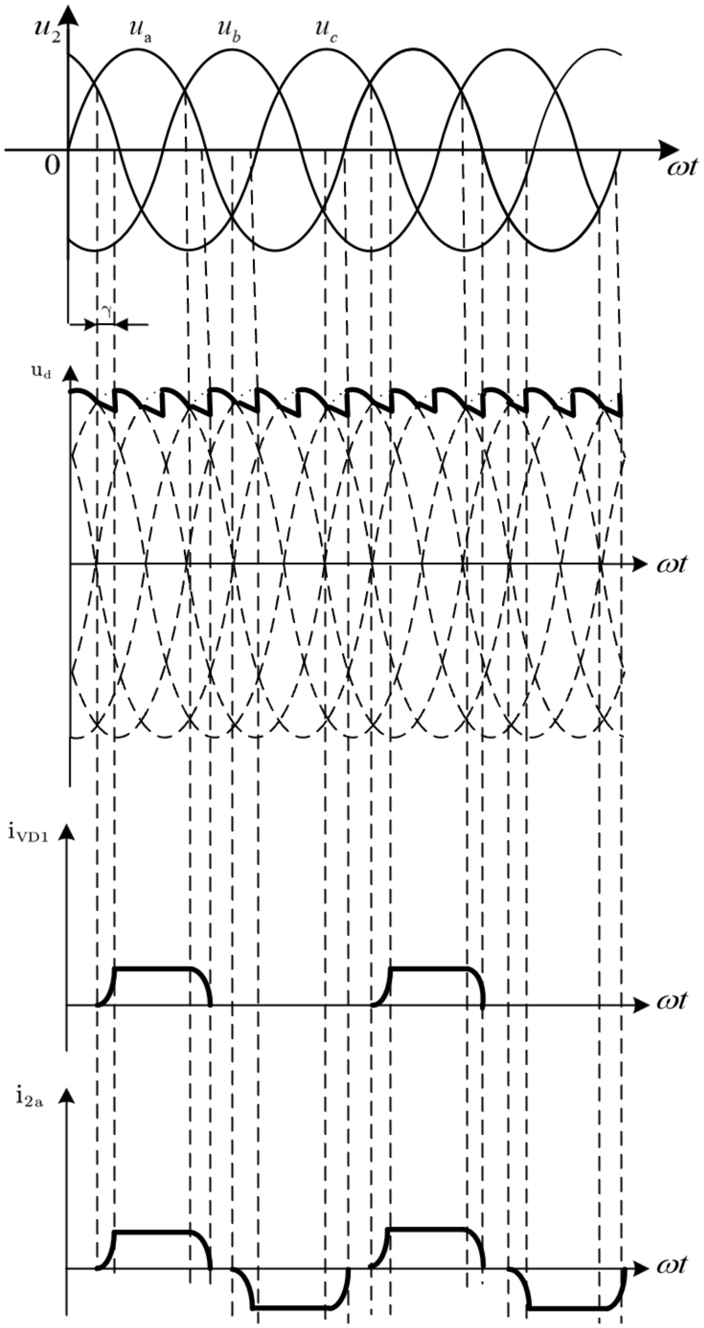
Since:

$$\cos\alpha - \cos(\alpha+\gamma) = \frac{2I_d X_B}{\sqrt{6}U_2}$$

We can solve the commutation angle:

$$\gamma = \arccos\left(1 - \frac{2I_d X_B}{\sqrt{6}U_2}\right) \approx 24.67°$$

The waveform of u_d i_{Vd} i_2 2.is shown as below:



Question 17

Considering a three-phase fully controlled bridge with back electromotive force resistive inductive load, when $E = 200V$, $R = 1\Omega$, $L = \infty$, $U = 220V$, $\alpha = 60°$.

① L_B=0 ; ② L_B=1Mh.

In both cases, calculate the values of U_d and I_d （also calculate γ）. Draw the waveforms of u_d and i_{VT} r.

Solution:

1) When L_B=0:

$$U_d = 2.34U_2\cos\alpha = 257.4(V)$$

$$I_d = \frac{U_d - E}{R} = 57.4(A)$$

2) When L_B=1Mh:

$$U_d = 2.34U_2\cos\alpha - \Delta U_d$$

$$\Delta U_d = \frac{3X_B I_d}{\pi}$$

$$I_d = \frac{U_d - E}{R}$$

We can see:

$$U_d = \frac{3X_B E + \pi R \times 2.34U_2\cos\alpha}{3X_B + \pi R} \approx 244.15(V)$$

$$I_d = 44.15(A)$$

$$\Delta U_d = 13.25(V)$$

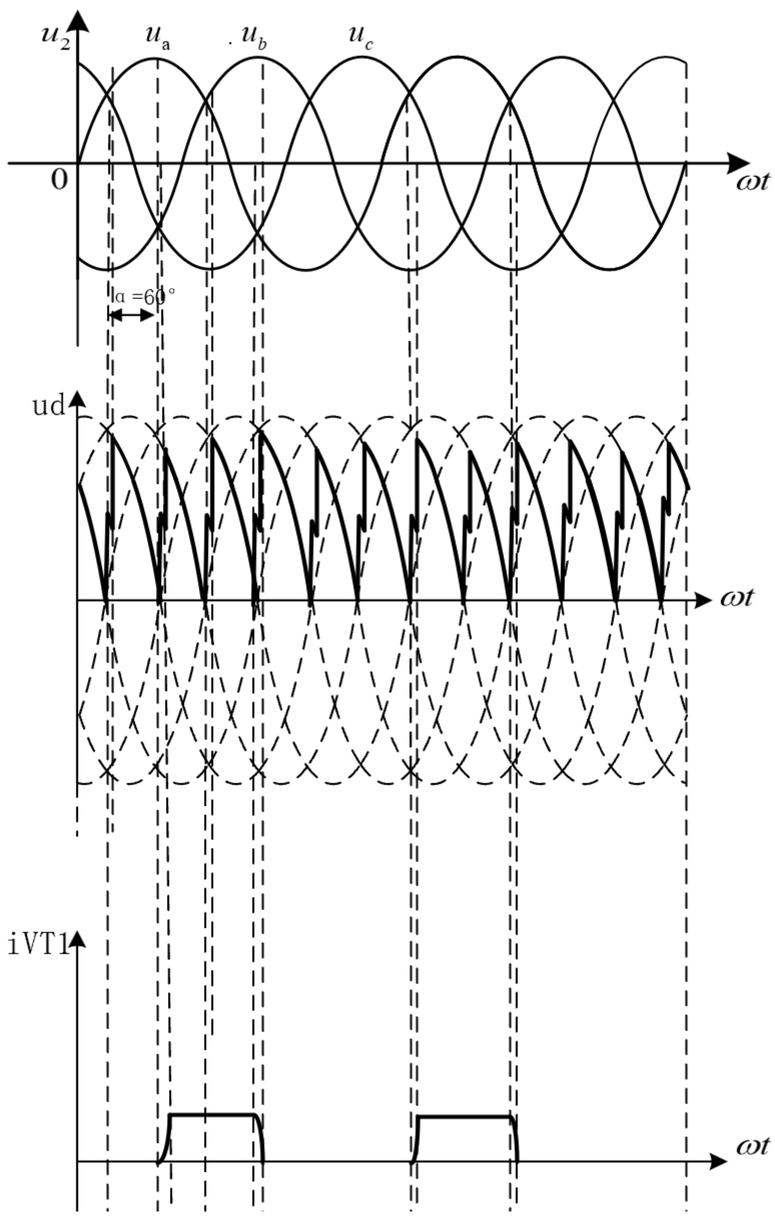
Since:

$$\cos\alpha - \cos(\alpha + \gamma) = \frac{2I_d X_B}{\sqrt{6}U_2}$$

We can solve the commutation angle:

$$\gamma = \arccos\left(\cos\alpha - \frac{2I_d X_B}{\sqrt{6}U_2}\right) - \alpha \approx 3.35°$$

The waveform is shown as below:



From VT1 to VT6, the latter one′s phase is lagged 60° to the former, and the shape of the waveform is totally the same.