Homework2

Page 42, Chinese textbook

Question 1.1

Comparing with the diode working on the analog electronic circuits, what are the structural characteristics of a power diode to make it endure high voltage and large current?

Question 1.3

What is the requirement to keep a thyristor in conduction mode (on state)? How to turn off a thyristor?

Question 1.4

Shaded area in Fig. 2-27 illustrates the current waveform of a thyristor in conduction mode. The maximum value of each current waveform is I_m, try to derive the average value I_{d1}, I_{d2}, I_{d3} and the effective value (RMS value) I_1, I_2, I_3 of each waveform.

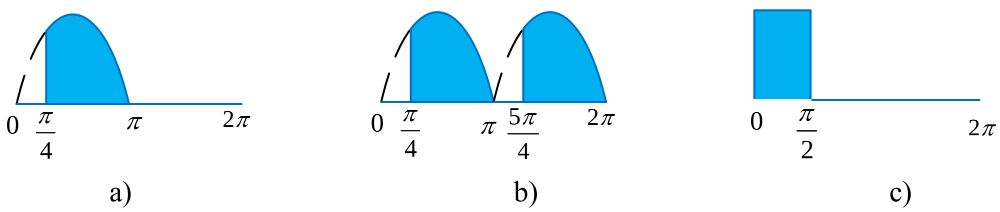

Fig.2-27 Thyristor current waveform

Question 1.5

In 1.4, if safety margin is not concerned, how much average current I_{d1}, I_{d2}, and I_{d3} can a 100A thyristor transfer, and how much is the corresponding maximum current I_{m1}, I_{m2}, I_{m3}, respectively?

Answer 1.1

1.Power diode usually has the vertically oriented structure where the current flows perpendicular to the wafer. However, in the circuits with information diode, the current flows parallel to the silicon wafer. The vertically oriented structure results in that the equivalent area of the current passing through a silicon wafer increases, which can significantly increase the flow capacity of a diode.

2.In comparison with the information electronic diodes, power diode gains a region called n^- drift region whose doping density is very low. This region's characteristic is close to the intrinsic semiconductor. Due to the low doping density, this region can withstand higher voltage than the information diode without n^- drift region.

3.Conductivity modulation: on the one hand, when the current flowing through the PN junction is low, the resistance is mainly the resistance of the n^- drift region whose resistance is high and constant. On the other hand, when the current flowing through the PN junction is high, the hole concentration will grow and reach a high level. In order to maintain the electric neutrality, the density of majority carrier will grow rapidly, leading to the result that the conductivity of the conduct drops fast.

Answer 1.3

The condition of thyristor's turn-off:

The thyristor could be regarded as that a PNP transistor, V_1, and an NPN transistor, V_2, combined together. If the circuit inject current to the gate, called I_G, the I_G flows in V_2's basic electrode. And I_G will be a part of the current of basic electrode I_{c2} and be amplified as the current of collector current, I_{c1}, which will promote the current of V_2's basic electrode farther. Therefore, the positive feedback is so strong that V_1 and V_2 have become fully saturated. To turn off the thyristor, the positive voltage applied to the positive pole has to be removed. Besides, apply the negative voltage to the positive pole. What's more, the current flowing through the thyristor should be reduced to the amount close to 0.

Answer 1.4

a)

$$I_{d1} = \frac{\int_{\frac{\pi}{4}}^{\pi} I_m \sin t dt}{2\pi} = \frac{\sqrt{2}+2}{4\pi} I_m$$

$$I_1 = \frac{\int_{\frac{\pi}{4}}^{\pi} {I_m}^2 \sin^2 t dt}{2\pi} = \sqrt{\frac{3}{8} + \frac{1}{4\pi}} I_m$$

b)

$$I_{d2} = \frac{2\times\int_{\frac{\pi}{4}}^{\pi} I_m \sin t dt}{2\pi} = \frac{\sqrt{2}+2}{2\pi} I_m$$

$$I_2 = \frac{2\times\int_{\frac{\pi}{4}}^{\pi} {I_m}^2 \sin^2 t dt}{2\pi} = \sqrt{\frac{3}{2} + \frac{1}{\pi}} I_m$$

c)

$$I_{d3} = \frac{I_m \times \frac{\pi}{2}}{2\pi} = \frac{1}{4} I_m$$

$$I_3 = \frac{\int_{\frac{\pi}{4}}^{\pi} {I_m}^2 dt}{2\pi} = \sqrt{\frac{3}{8}}\, I_m$$

Answer 1.5

$$I_{d1} = \frac{\sqrt{\frac{3}{8} + \frac{1}{4\pi}}}{\frac{\sqrt{2}+2}{4\pi}} \times 100 = 248.155A$$

$$I_{m1} = \frac{248.155}{\sqrt{\frac{3}{8} + \frac{1}{4\pi}}} = 368.06A$$

$$I_{d1} = \frac{\sqrt{\frac{3}{2} + \frac{1}{\pi}}}{\frac{\sqrt{2}+2}{2\pi}} \times 100 = 248.155A$$

$$I_{m1} = \frac{248.155}{\sqrt{\frac{3}{2} + \frac{1}{\pi}}} = 184.03A$$

$$I_{d1} = \frac{\sqrt{\frac{3}{8}}}{\frac{1}{4}} \times 100 = 244.949A$$

$$I_{m1} = \frac{244.949}{\sqrt{\frac{3}{8}}} = 400A$$