Homework 4

Question 4.1

Considering a single-phase bridge fully-controlled rectifier circuit, which harmonics are there in the rectifier output voltage and which one in it has the largest magnitude? Which harmonics are there in the second side current of the transformer and which ones in it are dominating?

Question 4.2

Considering a three-phase bridge fully-controlled rectifier circuit, which harmonics are there in the rectifier output voltage and which one in it has the largest magnitude? Which harmonics are there in the second side current of the transformer and which ones in it are dominating?

Question 4.3

Which harmonics are there in the rectifier output voltage and AC input current of the 12-pulse and 24-pulse rectifier circuit respectively?

Question 4.4

Considering a three-phase bridge fully-controlled converter connected to a EMF load with resistor and inductor, when R=1Ω, $L = \infty$, U_2= 220V, L_B= 1mH, $E_M = -400$V, $\beta = 60°$, calculate the

value of U_d, I_d and γ. How much active power is being sent back to the grid?

Answer 1

Considering that single-phase bridge fully-controlled rectifier circuit is a double pulse rectification circuit, we can see that the output voltage has 2k (k=1、2、3…) harmonics and 2^{nd} wave has the largest magnitude. Second side current of the transformer has 2k+1 harmonics, among which 3^{rd} and 5^{th} harmonics are dominating.

Answer 2

Considering that three-phase bridge fully-controlled rectifier circuit is a 6-pulse rectification circuit, we can see that the output voltage has 6k (k=1、2、3…) harmonics and 6^{th} wave has the largest magnitude. Second side current of the transformer has 6k±1 harmonics, among which 5^{th} and 7^{th} harmonics are dominating.

Answer 3

Rectifier output voltage of the 12-pulse rectifier circuit has 12k (k=1、2、3...) harmonics and AC input current of the 12-pulse rectifier circuit has 12k±1(k=1、2、3...) harmonics.

Rectifier output voltage of the 24-pulse rectifier circuit has 24k (k=1、2、3...) harmonics and AC input current of the 24-pulse rectifier circuit has 24k±1(k=1、2、3...) harmonics.

Answer 4

Based on these equations

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

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

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

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

$$\alpha + \beta = 180°$$

We can see:

$$U_d = \frac{-2.34U_2 \pi R \cos\beta + 3X_B E_M}{3X_B + \pi R} \approx -290.31\,(V)$$

$$I_d = \frac{-290.31 + 400}{1} = 109.69\,(A)$$

$$\gamma = \arccos\left(\cos(180-\beta) - \frac{2X_B I_d}{\sqrt{6}U_2}\right) - \alpha \approx 8.89°$$

The active power sent back to the grid would be:

$$P = |E_M I_d| - I_d^2 R \approx 31.84\,(KW)$$