Homework 6

Page 123, Chinese textbook Question 6.1

What is the purpose of the feedback diode in VSI? Why there isn't one in CSI?

Question 6.2

Consider a three-phase bridge VSI with 180° conduction angle. $U_{\mathrm{d}} = 100\mathrm{V}$. Try to derive the magnitude U_{UN1m} and RMS value U_{UN1} at base frequency in phase voltage magnitude U_{UV1m} and RMS value U_{UV1} at base frequency in output line voltage and RMS value of 5th order harmonic U_{UV5} in output line voltage.

Question 6.3

What are the main forms of multi-level inverter circuits? What are the characteristics of each?

Answer 6.1

When the load is inductive in a VSI, inactive power is required because of the nonlinear component inductor. In this circuit, the DC-side buck cap buffers the energy transmitted from the AC side. Therefore, anti-parallel diodes across switching device are required to provide channel for the inactive power transmitted from AC side. When the polarity of output voltage and current is the same, the current just flows through switching device. When the polarity of output voltage and current is reverse, current flows through feedback diodes.

However, DC side current is a constant value in a CSI, and inactive power can be buffered by DC side inductor. Therefore, when the power is transmitted from AC side to DC side, current does not change the direction, which still flows through switching device. To sum up, there is no anti-parallel diode required in a CSI.

Answer 6.2

We can know that the phase output load voltage could be calculated as:

$$U_{UN} = \frac{2U_d}{\pi}\left(\sin\omega t + \sum_{n=1}\frac{1}{n}\sin\omega t\right),\quad n = 6k \pm 1$$

Where we can calculate the amplitude of fundamental voltage U_{UN1m} and RMS value U_{UN1}:

$$U_{UN1m} = \frac{2U_d}{\pi} = \frac{200}{\pi} = 63.662\,(V)$$

$$U_{UN1} = \frac{2U_d}{\sqrt{2}\,\pi} = \frac{200}{\sqrt{2}\,\pi} = 45.0158\,(V)$$

Also, we can calculate the fundamental line voltage of amplitude U_{UV1m} and RMS value U_{UV1}:

$$U_{UV1m} = \frac{2\sqrt{3}\,U_d}{\pi} = \frac{200\sqrt{3}}{\pi} = 110.266\,(V)$$

$$U_{UV1} = \frac{2\sqrt{3}\,U_d}{\sqrt{2}\,\pi} = \frac{200\sqrt{3}}{\sqrt{2}\,\pi} = 77.9697\,(V)$$

5th order of harmonic component of output line voltage in RMS value could be calculated as:

$$U_{UV5} = \frac{2\sqrt{3}U_d}{5\sqrt{2}\pi} = \frac{200\sqrt{3}}{5\sqrt{2}\pi} = 15.5939\,(V)$$

Answer 6.3

There are three main forms of multi-level inverter circuits: Neutral Point Clamped (NPC) Inverter Circuit, Flying Capacitor Inverter Circuit, Cascaded H-Bridge Multilevel Inverter.

The flying capacitor inverter circuit uses more capacitor devices and the voltage on the capacitor is required to be controlled, so it is less commonly used; The Neutral Point Clamped inverter circuit has low harmonic output voltage and reduces the voltage borne by the thyristor, making it suitable for high voltage and large capacity applications; Cascaded H-Bridge inverter circuit: Each full bridge inverter circuit has an independent DC power supply, so the series connection of output voltage does not require a transformer. The more units are connected in series, the higher the output voltage and the waveform is closer to a sinusoidal wave.