

Harmonic Analysis of The Inverter Output Voltage

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Abstract. This article mainly used Fourier series type SPWM inverter output voltage waveform for the quantitative harmonic analysis. This paper expounds the main reason for the harmonic of the inverter. In this paper, the quantitative harmonic analysis method to eliminate the harmonic pollution green grid provides a theoretical basis.

Introduction

With the rapid development of power electronic technology and computer control technology, the application of frequency converter to realize AC motor speed control is gradually replace the traditional DC speed regulation system. And it is recognized as one of the most promising of a speed control method. Highlight the advantages of frequency converter speed range is wide. Inverter control precision is high. Inverter energy saving effect is good. It is our production and life brought a lot of convenience. Due to the principle of the inverter structure is generally adopts the rectifier and inverter, output voltage synthesis using PWM control technology, it is bound to produce a large number of harmonic component. It caused serious harmonic pollution to the power supply system. At the same time, it makes the motor run also brings efficiency decline, loss increase and low power factor become harmful.

The generation of inverter harmonic

Refers to the inverter device of AC power supply AC power converter constant voltage and frequency of the variable frequency and voltage. In terms of its principle structure, frequency converter is mainly composed of rectifier circuit, filter circuit, inverter circuit and the control and protection circuit, etc. Principle diagram is shown in figure 1.

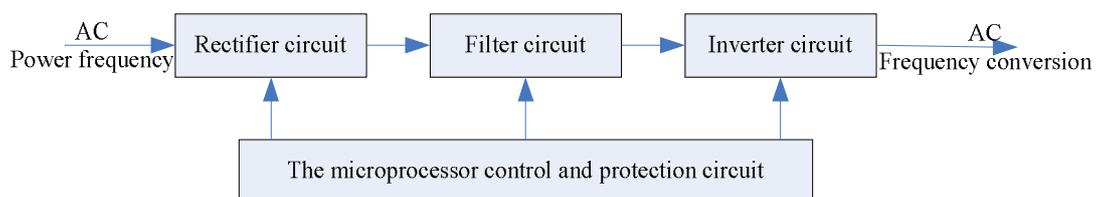


Fig 1. The principle of frequency converter structure diagram

Rectifier circuit function is through the power semiconductor diode power frequency alternating current into direct current. Filter circuit is through or inductance components pulsating DC into a smooth direct current DC. Inverter circuit function is through the power semiconductor devices to convert the DC frequency and voltage adjustable alternating current. Control and protection circuit of the control core is microprocessor. They can adjust the voltage or frequency control and the over-voltage and over-correct protection circuit. Circuit analysis from the point of view of the rectifier circuit and inverter circuit system signal occurred in AC - DC - AC nonlinear transformation. They will produce a large number of harmonic component. So rectifier circuit and inverter circuit is the primary sources of inverter harmonic generation. This article only carries on the quantitative analysis of harmonic voltage of inverter.

Harmonic analysis of inverter

Frequency converter in the inverter AC is not connected to power grid. It is directly connected to the load, it belongs to the passive inverter. Working process is the output rectifier circuit DC inverter for adjustable frequency of the alternating current supply load again. The commonly used power electronic devices of inverter circuit for general thyristors, insulated gate transistor and power FET. Based on the insulated gate bipolar transistor type SPWM inverter as an example analysis of the output voltage harmonic component. Three-phase inverter main circuit is shown in figure 2.

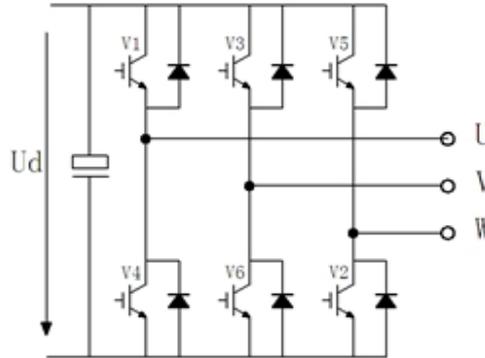


Fig 2. Three-phase voltage type bridge inverter circuit

Type SPWM inverter using sinusoidal pulse width modulation technology. Carrier for bipolar triangular wave u_c , The angular frequency is ω_c . The modulation wave sine wave u_r . Its angular frequency is ω_r . Assuming that $\omega_c=3\omega_r$. The intersection of the two wave control insulated gate bipolar transistor V1- V6 of the switching sequence and the conduction angle. To produce the output voltage closer to the sine wave output voltage, as shown in figure 3.

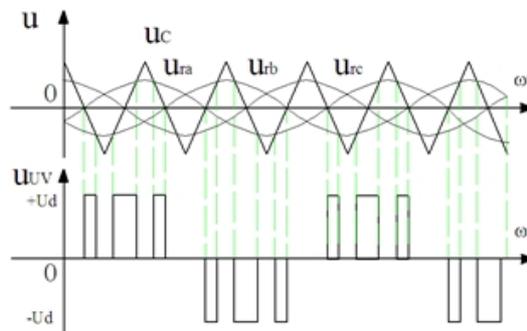


Fig 3. Dual polarity SPWM modulation waveform

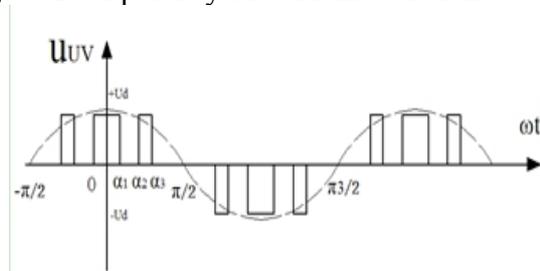


Fig.4 Type SPWM inverter output voltage waveform

In order to analysis and calculation is convenient, the inverter output voltage waveform figure 3 U_{uv} left $\pi/2$ in figure 4. The sequence pulse is an even function. In the Fourier expansion $U_0=0, b_n=0$. Only cosine items a_n , such as formula (1).

$$\begin{aligned}
u_{UV} &= \sum_{n=1}^{\infty} a_n \cos(nw_r t) = \frac{2}{p} \int_0^p U_d \cos(nw_r t) d(w_r t) \\
&= \frac{2U_d}{np} \left[\begin{aligned} &\sin na_1 + \sin na_3 - \sin na_2 + \cos np \sin na_1 \\ & - \cos np \sin na_3 - \cos np \sin na_2 \end{aligned} \right] \cos(nw_r t)
\end{aligned} \tag{1}$$

When the n is an even number n=2,4,6... an=0 ; When the n is odd n=1,3,5... Considering the characteristic of $\sin\alpha_1 = \sin\alpha_2$. The formula (1) is transformed into the following expression.

$$\begin{aligned}
u_{UV} &= \sum_{n=1}^{\infty} a_n \cos(nw_r t) = \frac{2U_d}{np} [\sin na_1 - \sin na_2 + \sin na_3] \cos(nw_r t) \\
&= \frac{2U_d}{p} \left[\sin a_3 \cos(w_r t) + \frac{1}{3} \sin 3a_3 \cos(3w_r t) + \frac{1}{5} \sin 5a_3 \cos(5w_r t) + \dots \right]
\end{aligned} \tag{2}$$

From the above inverter circuit output voltage can be concluded that in the expression. Type SPWM inverter output voltage in theory in addition to provide load of fundamental wave, it also has a lot of time harmonic component. Mainly 3, 5, 7, 9... Harmonics. Every harmonic amplitude depends on the expression of the harmonic number n, and phase Angle α_3 values. α_3 values and is closely related to the carrier the angular frequency of ω_c . So it is possible that some of wave amplitude. Some odd harmonic amplitude is small or zero. In fact due to the symmetry of three-phase bridge type inverter output line voltage, there is no 3 odd times harmonic component. Through good SPWM control scheme at the same time, we select the appropriate frequency modulation and amplitude modulation coefficient. Change the phase Angle α_1 , α_2 and α_3 can eliminate or reduce the harmonic component, such as 5, 7 times, 13 second-class.

The harm of inverter harmonic

The harmonic pollution caused by the frequency converter is usually caused by the transmission, the electromagnetic radiation and the induction coupling in three ways, other users of the power grid can not work properly or cause electrical accidents. The harm of harmonics is mainly reflected is voltage waveform distortion of public power grid, increase power transformer and induction motor copper loss and iron loss, efficiency decline, noise, etc. Power capacitors are over current, over heat and over voltage; Electrical switches and protective equipment produce insulation damage, tripping error and protection of false operation, etc. It should be noted that the higher harmonics will also be on the computer, communications equipment, instrumentation, television and audio equipment, carrier remote control equipment to produce interference, resulting in communication interruption, the measurement results are not allowed, the use of functional quality decline.

Conclusions

In this paper, type of SPWM inverter output voltage harmonic based on sine wave modulation angular frequency ω_r as a benchmark of Fourier series expansion. If the carrier triangular wave angular frequency ω_c as a benchmark to get another Fourier series expansion. Actually no matter in what form, the output of the inverter harmonic should contain $k\omega_r$ and $n\omega_c$ these two kinds of harmonic. The carrier triangle wave angular frequency ω_c average value of 1Khz-15Khz. Due to the carrier frequency value is relative taller, it easily eliminated by filter. Because of inverter harmonic interference, in short, the public power grid and electric equipment to produce all kinds of hazards. Widely used in all kinds of frequency converter, we must pay attention to the inverter harmonic interference. Be suppressed by using reasonable technology.

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