III. Different Harmonic Control Methods Analysis

A. Increase Harmonic Compensation Device

By adding passive filter or active filter, once or more harmonics produced by a UPS rectifier can be compensated. The passive filter schematic diagram is shown in Fig. 4. It can be seen that the filter inductor (L_{A1}, L_{B1}, L_{C1}) and filter capacitor (C_1, C_2, C_3) present a low impedance characteristic to 5th and 7th harmonics and can effectively filter the suppression; The input inductoris (L_A, L_B, L_C) is used as a input current waveform correction which can improve the effect of the resonant filter circuit[8]. The active filter schematic diagram is shown in Fig. 5. By the instruction current detection circuit and compensation current generation circuit, it can detect the power side harmonic component and generate a additional signal opposite [9]. And can suppress harmonics dynamically. The active filter can compensate harmonics in different size and frequency [10].

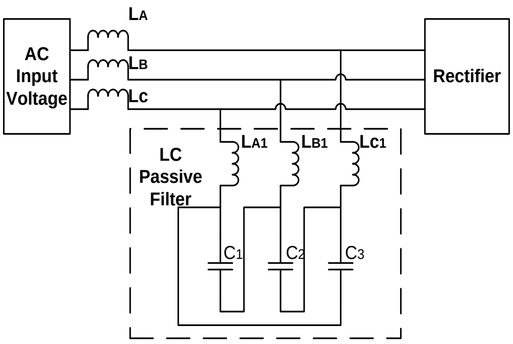

Fig. 4. Passive Filter.

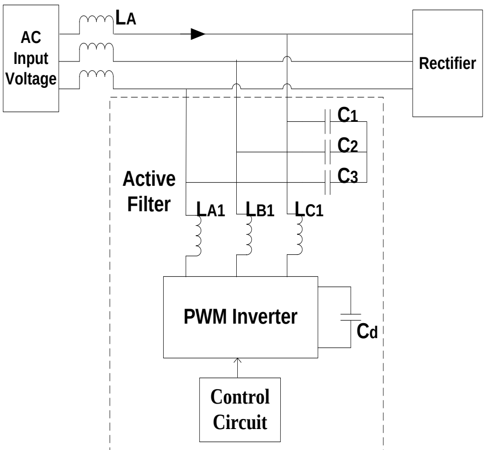

Fig. 5. Active filter.

B. Improve UPS Rectifier's Structure

12 pulse and IGBT rectifier are two feasible methods.

The diagram of 12 pulse rectifier is shown in Fig. 6. The circuit is composed of two 6 pulse rectifier, connected in parallel and with the same polarity. By different connection of the transformer, the phase difference between the two rectifier bridges is 30^o[11]. Taking A phase current as an example, assuming that the AC input voltage is pure sine wave and the trigger delay angle α =0, the Fourier series equations of this two rectifier bridge are:

$$\begin{cases} i_{a1}(\omega t) = \dfrac{2\sqrt{3}}{\pi} I_d \sin \omega t + \dfrac{2\sqrt{3}}{\pi} I_d \sum\limits_{\substack{n-6k\pm 1 \\ k=1,2\cdots}} (-1)^k \dfrac{1}{n} \sin \omega t \\ i_{a2}(\omega t) = \dfrac{2\sqrt{3}}{\pi} I_d \sin \omega t + \dfrac{2\sqrt{3}}{\pi} I_d \sum\limits_{\substack{n-6k\pm 1 \\ k=1,2\cdots}} \dfrac{1}{n} \sin \omega t \end{cases} \tag{9}$$

So the total input current $i_a(\omega t)$ Fourier series equation is:

$$i_a(\omega t) = \frac{4\sqrt{3}}{\pi} I_d \sin \omega t + \frac{4\sqrt{3}}{\pi} I_d \sum_{\substack{n=12k\pm 1 \\ k=1,2\cdots}} \frac{1}{n} \sin \omega t \tag{10}$$

From the equations, the input current harmonics of 12 pulse rectifier is $n = 12k \pm 1$, $k = 1,2\cdots$, the maximum harmonic component appears in the 11th, accounting for 1/11 of the fundamental, without 5th or 7th harmonic[12]. Compared with 6 pulse rectifier, the harmonic content is reduced and the total harmonic distortion rate will decrease, so it can reduce the input current harmonic pollution of rectification part effectively.

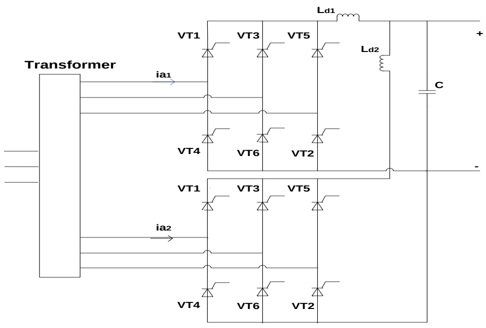

Fig. 6. 12 Pulse thyristor rectifier.

IGBT rectifier uses full control device instead of thyristor, uses PWM control mode instead of phase controlled rectifier[13] and its schematic diagram is shown in Fig. 7. By modulation, IGBT rectifier can make the input current track the input voltage waveform, absorb sinusoidal current in the same phase with voltage and will only produce a very small pulse because of the high ordered harmonic associated with triangular carriers[14]. So the input current waveform is close to sine wave, the power factor is close to 1 and each harmonic content is small. It can be use to reduce the harmonic content [15].

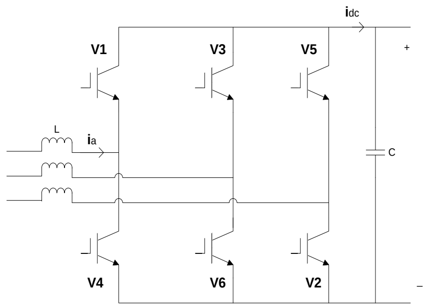

Fig. 7. IGBT rectifier.