

THE APPLICATION OF THYRISTOR AC POWER CONTROLLER IN BEPC MODULATORS

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Abstracts

Thyristor AC power controller is first applied in BEPC modulator. Here introduce the situation of its application. We applied initially thyristor AC power controller to BEPC individual modulators in 1995. We discovered that the thyristor AC power controller has a lot of advantage compared with induction voltage regulator, so we applied thyristor AC power controller to whole basically modulator in 1999. We have done the overall observe for them in this term. Now they are working well in BEPC modulators.

1. Introduce

The modulator is an important equipment in Linac. Our modulator is line-type modulator. Its output pulse high-voltage is 270KV, 350KV, output peak power is 80MW, 150MW. Before, we use induction voltage regulator as voltage regulation. Now, we make use of thyristor AC power controller to regulate output voltage. It has a lot of advantage. For example, Its volume is smaller, its weight is lighter, it can save electric energy and so on.

2. Main circuit of thyristor AC power controller

The three-phase ac input to the modulator can be any level from 0 to 380V by the use of thyristor AC power controller. The main circuit of Thyristor AC power controller is shown in Figure 1.

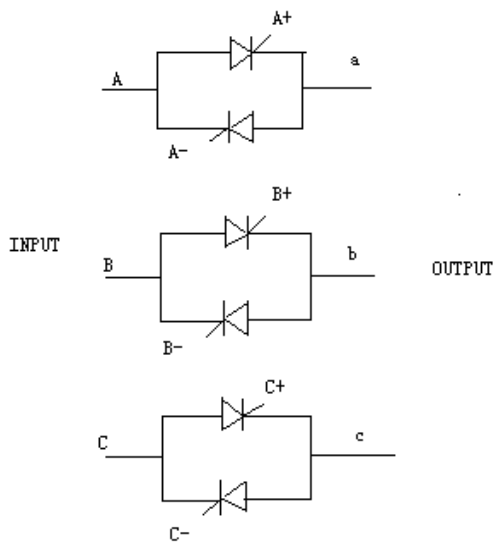


Figure 1: The main circuit of thyristor AC power controller

There are six thyristors. When this thyristor is triggered by pulse, it will operate. There are six trigger signal. They are arranged in order. These are A+→C-→B+→A-→C+→B-→A+. The phase difference is 60° each other. This six ordinal trigger pulse are produced by control circuit of thyristor AC power controller. Output voltage of thyristor ac power controller can be any level from 0 to 380V by means of adjusting thyristor's conduction angle.

3. Control circuit of thyristor AC power controller

There is automaton in control circuit of thyristor AC power controller. It is shown in Figure 2.

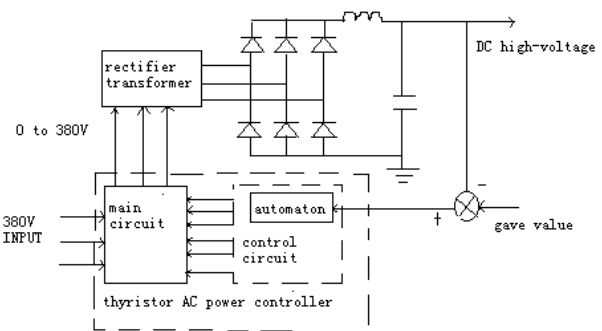


Figure 2: Control principle of thyristor AC power controller

It can improve modulator's output stability by the dc high-voltage feedback system. It only has a little change when power line voltage has a large change. Table 1 is shown the measure result of modulator's output stability.

Table 1: Modulator's output stability

No add de-Q'ing

Modulator's number	The change of power line voltage	The change of modulator's output
6#	1.4%	0.4%
10#	1.2%	0.4%

The input of AC enters thyristor AC power controller through three 100A filters which decouple the noise from the ac lines. Thus preventing possible RFI. Thyristor work in on-off state. They will produce a large harmonics interference, so must use filter to prevent this interference into the power circuit. These harmonics flowing into the power system source impedance

produce 0.35% distortion of Sine wave. This amount of distortion is acceptable from the standpoint of interference with communications and control system.

4. Low-frequency transient suppressor network

Low-frequency transient suppressor network connected from line to line of the primary of rectifier transformer was improved. Three thyrite resistors added. They are shown in Figure 3.

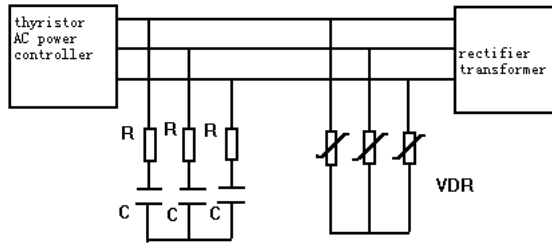


Figure 3: Improved low-frequency transient suppressor

The function of the three thyrite resistors are to provide a low-impedance load for the transient over voltage, to reduce the current in low-frequency transient suppressor network, to prevent resistors of transient suppressor network to take off from line because of over hot.

5. Saving electric energy

Using the thyristor AC power controller can save electric energy. We do the measure for situation of saving electric energy in BEPC running. The result of measure is shown in Table 2.

Table 2: Saving electric energy using the thyristor AC power controller

DC high voltage	indution voltage regulator (I')	thyristor AC power controller (I'')	current difference (I'-I'')	Saving eevergy (%)
3KV	11.78A	1.20A	10.58A	89.8%
6KV	12.21A	2.68A	9.53A	78.1%
9KV	12.73A	4.36A	8.37A	65.8%
12KV	13.61A	5.97A	7.64A	56.1%
15KV	14.98A	7.40A	7.58A	50.6%
18KV	16.17A	8.60A	7.57A	46.8%

The analyses of measure result:

(1) Look from measure result, current is smaller using thyristor AC power controller than induction voltage regulator in same dc high-voltage because the loss of induction voltage regulator is larger. These loss include Cu loss, Fe loss, hysteresis loss and vortex loss. Thyristor AC power controller consists of six thyristor, the loss is only voltage of thyristor. The efficiency of thyristor ac power controller is 99%, so using it in modulator is saving electric energy.

(2) Look from measure result, the current difference is not same in different dc high-voltage. Dc high-voltage is higher, the current difference is lower. The current difference is basically stable when dc high-voltage is high enough. The loss of induction voltage regulator include two part. One is fixed loss, the value is only relative with rated capacity. It is disrelation with load. The other is the loss of load. The value is variable following the load current value. When modulator's dc high-voltage is low, the fixed loss take effect mainly, it affect on this current greatly. Along with dc high-voltage rise, the loss of load take effect mainly, it affect on this current greatly. When dc high-voltage is high enough, the current difference is basically stable.

As for 80MW modulators, the output pulse high-voltage is generally 260KV, its dc high-voltage is about 18KV. Basis on Table 2, modulator's saving energy is 46.8% using thyristor AC power controller in comparison with induction voltage regulator.

Thyristor AC power controller's weight is about 20KG. Its volume is about 0.07cubic metre. It can be fixed in rectifier circuit of modulator.