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Voltage source multilevel module converter valve test circuit research

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ABSTRACT

Voltage source multilevel module converter attracts more and more attention recently. The core component of the voltage source multilevel module converter is the valve based on IGBT. So the test circuit for the valve is very important, reliable test method can guarantee the converter valve design meet the operation requirement. This paper analyzes the valve voltage and current stress during the operation, and according to IEC standard test requirement, object, condition, introduces a kind of test circuit. Finally, through the simulation model, to verify the test circuit can provide the proper test condition for the voltage source multilevel module converter valve

1. Introduction

Recently the multilevel module converter's advantages in connecting renewable energy like wind farm, solar power plant, supplying the stable power for the remote island, improving the city grid quality make this kind of technology own very bright future. As another word, the MMC HVDC will be the key point of the future grid.

Now some countries already have planned MMC HVDC projects. For the reliable operation, we have to find reliable test method to test key component IGBT based valve, according to the IEC standard[1], the test circuit should can make the test valve sustain the similar voltage, current and temperature stress in the normal operation. Now the valve voltage degree can be even to 100kv, and the current degree can be to 1000A, like the LCC HVDC valve test, it's better to look for the equivalent circuit not the full bridge which needs the crazy budget.

The most important point of the test circuit is that how to make the valve stress as same as possible with normal operation by the lowest budget. In this paper, based on the operation analysis, the equivalent test circuit shows the similarity.

2. Test circuit research

2.1 Multilevel module converter operation analysis

Firstly, analyzing the multilevel module converter valve stress under normal operation condition can make the research object clearer. In this paper, by PSCAD, we construct 11 levels converter model, detailed topology see Fig 1.

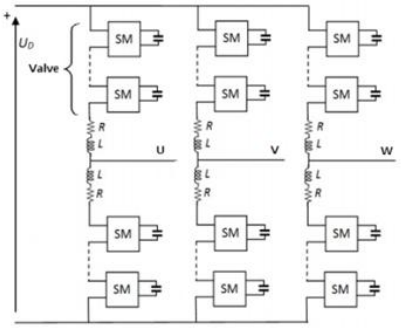

Fig. 1 Three-phase MMC converter topology

And, the sub model is half bridge type, the detailed scheme in Fig 2.

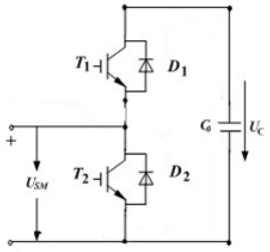

Fig. 2 Sub-Module scheme

Each sub module is a simple chopper cell composed of two IGBT switches, two anti parallel diodes and the energy stored capacitor. Valve is composed of 10 this kind of sub modules. NLM[2] method is adopted in control algorithm.

Fig 3 show the valve simulation result, the first is valve voltage waveform; the second is valve current waveform. In Fig 4, first is the sub module T2/D2 pair voltage waveform, second is sub module T2/D2 pair current waveform. DC voltage and P both reach 1.0 p.u, based on

the simulation waveform, it make clear that the equivalent test circuit should make the valve and sub module sustain the same voltage and current stress.

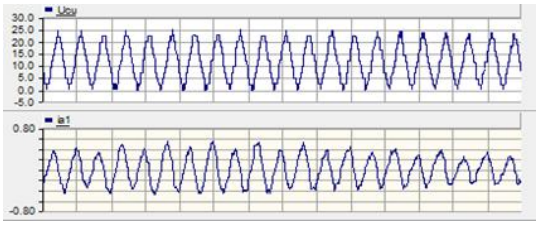

Fig. 3 Valve voltage, current waveform

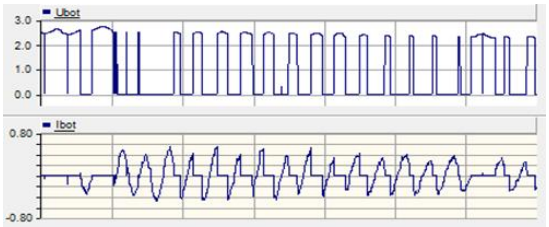

Fig. 4 Sub-Module T2/D2 pair voltage, current waveform

2.2 Equivalent test circuit

In the LCC type valve equivalent test circuit, the mainstream idea is using current injection method, high current section provide the required current stress, high voltage section provide the required voltage stress, both current and voltage section power requirement is very low compared to full bridge. So if the MMC type valve is similar with LCC type valve, we can take the similar idea. Compare these two kinds of valve, the different point is that, MMC type valve include the energy stored section capacitor, but inside LCC type valve, no this kind of energy stored section. The LC oscillation idea indicate that, if the test circuit include another energy stored section L, the power of the capacitor can shift to L, and shift back. We don't need high power current and voltage circuit section. The power shift between L and C can generate the same stress on the valve.

The concept circuit is showed in Fig 5

In the circuit, V1 is test object valve, V2 is auxiliary test valve, S1 and S2 are charging DC power, L is the oscillation reactor. Before the test begins, S1 and S2 charges the test valve V1 and auxiliary valve V2 respectively to rated voltage degree. During the test, the voltage U1 and U2 generated by V1 and V2 apply together on the reactor L, from the vector theory, controlling the degree difference between U1 and U2, can control the voltage on the reactor, and so test circuit current can be controlled.

2.3 Simulation and result analysis

Same with the chapter 2.1, we construct the equivalent test circuit by PSCAD, in the test controller, NLM method is adopted, control the reference sine voltage degree difference, make the valve current similar with normal full load operation as in Fig 3 and Fig 4.

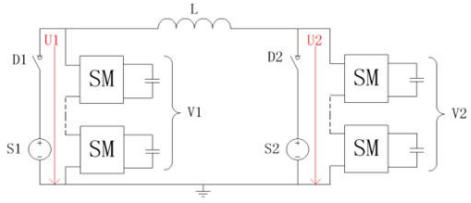

Fig. 5 Equivalent test circuit

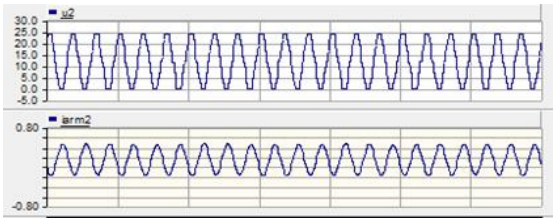

Fig. 6 Test valve voltage, current waveform

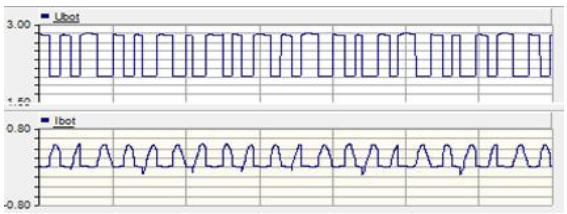

Fig. 7 Sub-Module T2/D2 pair voltage, current waveform

Fig 6 and Fig 7, show the relevant test waveform, Fig 6 show 10 sub modules series connected valve voltage and current waveform. Compare to the normal full load operation waveform, the voltage waveform nearly same, the current waveform has a little difference, because in the test circuit, U1 and U2 difference includes a constant DC component difference, so the current waveform include DC component. Fig 7 show the sub module T2/D2 pair voltage and current waveform, similarly, the voltage waveform nearly same with normal full load operation, but because of the DC difference, the current waveform has a little difference, but the rms value is almost same, for the long time operation test, IGBT module current stress can be considered same.

3. Conclusion

From the above simulation analysis, Even though the current waveform has a little difference, but the main idea is very suitable and economic, this test circuit provides a reliable test method for MMC valve.

참 고 문 헌

[1] IEC 62501: Voltage sourced converter(VSC) valves for High voltage direct current(HVDC) power Transmission electrical testing, 2009

[2]M. Guan, Z. Xu, Q. Tu, W. Pan, "Nearest level modulation for modular multilevel converters in HVDC transmission," Automation of Electric Power System, vol. 34, pp.64 68, Jan. 2010. (in Chinese)