Fast Rise-time Marx Generator Switch Design and Measurement

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Abstract. This paper introduces the concept and working principle of Marx generator and its gas switches. According to the theoretical basis, we studied the impact of the relative position of gas switches to its synchrony. Through to the isolation of the switch, we found that ultraviolet rays or other active particles of switching spark discharge process can promote the synchronization process, and carried out 1.5mm, 2.5mm and 3.0mm gap spacing of 10 level gas switches in the air discharge experiment of synchronization.

Keywords: Marx generator; gas switch; synchronicity; gas spacing.

1. Introduction

Marx generator due to its high voltage pulse amplitude output can count from dozens of kV to MV, therefore, is widely used in strong electromagnetic pulse field and is one of common power source in high power pulse technology [1-2]. Gas switches are widely used in high power pulse generator, this switch is not only suitable for conducting strong pulse electric current, large quantity of electric charge, also can be used to trigger more accurately. All kinds of gas switch can work under different conditions and air pressure [3]. Gas switch as a key component of generator, determines the output characteristic of the generator, the degree of synchronization of gas switch is very important for the design and operation of generator.

2. Generator gas switch design

Generator circuit principle diagram is shown in figure 1. Generator works by slow parallel high voltage capacitor charging, when charging capacitance stability, using gas switch series transient discharge breakdown characteristics, in order to achieve the objective of the voltage multiplier [3].

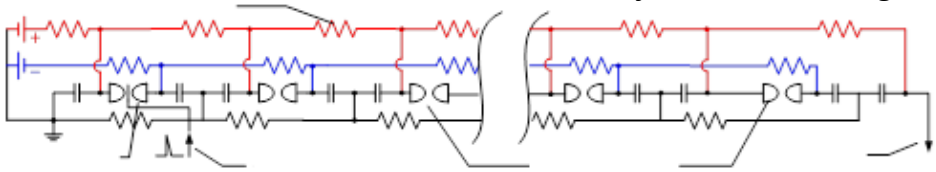

Figure 1 generator circuit principle diagram

The working process of the generator is to use a self-breakdown switch. The self-breakdown switch has the two electrodes. Generator self-breakdown gas switch structure diagram and its physical diagram are shown in figure 2. The selection of switch spacing, first we need to consider the gas properties and the size of the air pressure, second need to consider generator electrode between parasitic inductance, third need to regulate the gas spacing in the experiment.

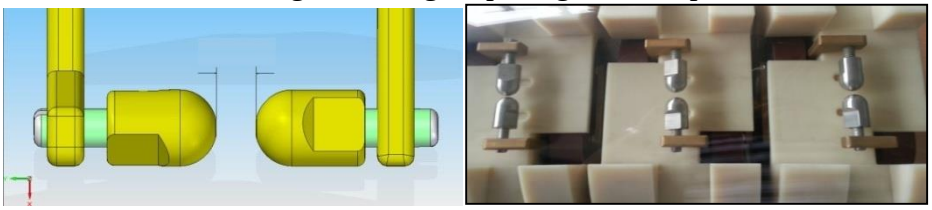

Figure 2 the structure and the real figure of self-breakdown gas switch

3. Gas switch synchronicities research

The standard of Marx generator output performance depends largely on the gas switch synchronicity. Its synchronicity refers to after the level 1 gas switch charging the trigger or external

trigger breakdown, the switch of level 2 to level n over-voltage breakdown in turn, will transfer the energy of energy storage capacitor to the load. Marx synchronicity is important to pulse amplitude, frontier, jitter and voltage superposition, and it has a direct link to the breakdown damage and charging power protection fault phenomenon.

In generator debugging, the switch is always out of sync phenomenon, through to control the switch spacing to adjust the gas switch breakdown voltage. Even though all levels of breakdown voltage meet switch synchronization requirements under the premise of the same switch out of sync breakdown happens. The reason is that the switching overvoltage of one switch is failed to reach the switch breakdown voltage, also may be the overvoltage shorter duration, even if the instantaneous voltage exceeds the breakdown voltage, the phenomenon could not happen eventually. At last it lead to the switch breakdown out of sync discontinuity in the pulse output and pulse rise-time become slow.

Figure 3 insulation sleeve

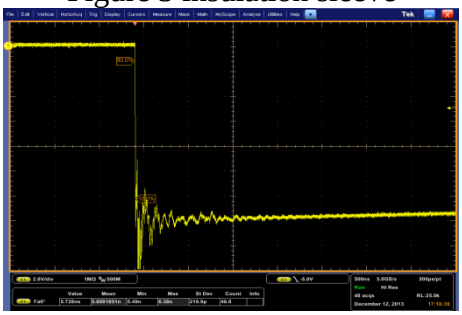

Figure 4 (a) pulse output waveform before the isolation

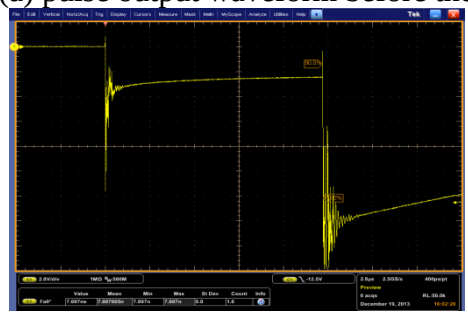

Figure 4 (b) pulse output waveform after the isolation

In order to study the effects of gas switch position for synchronous discharge, we use the insulating sleeve shown in figure 3, isolate one switch of the 10 levels switch synchronization in Marx generator for isolation switch, figure 4 and figure 4 (a) (b) show the switch isolation pulse output waveform comparison before and after.

By comparing the isolated waveform we can see that the Marx generator has good pulse output front without the insulation sleeve, it is about 5.7 ns. After the isolation, the pulse output rise-time intermission is about 10 us. After using the insulating sleeve for isolation, it is equivalent to change the relative position of the switch in the Marx generator structure, make the switch are not all in a line, even if meet the requirements of synchronous switch discharge, also can appear out of sync discharge phenomenon, which affect pulse output; When all the switch are in a straight line, switch breakdown discharge to produce ultraviolet ray and other active particles or rays will promote synchronous switch discharge, it may have a better pulse output.

4. Synchronous gas switch experimental measurement

To a designed self-breakdown gas switch, the breakdown voltage characteristics is determined by the gas gap distance. According to the related literature and design experience, within the scope of 1 mm to 4 mm spacing can not only reduce switch conduction time and the switch inductance, enables shorter pulse generator set up time and smaller time frames. Experiments generator single-stage charging voltage is about 50 kV, Marx generator pressure is normal, adjust the gas switch spacing of 1.5 mm, 2.0 mm and 3 mm, we measure the synchronicity Marx generator output amplitude and pulse edge (10% 90%) [4]. Experimental platform structures, as shown in figure 5, the charging and its output voltage are measured by external acquisition of high voltage pulse probe experiment, record different air gap distances of Marx generator output voltage amplitude and pulse up rise-time. 1.5 mm, 2.0 mm and 3.0 mm gap spacing of Marx generator output waveform is shown in figure 6, we can see from the figure of 1.5 mm distance under the condition of output pulse amplitude is about 22 kV and 5.3 ns pulse edge, 2.0 mm spacing pulse output amplitude under the condition of approximately 30 kV and 4.9 ns pulse edge. Under the condition of 3.0 mm distance between pulse output amplitude is about 36 kV and pulse rise-time is 3.1 ns.

Figure 5 experimental measurement platform

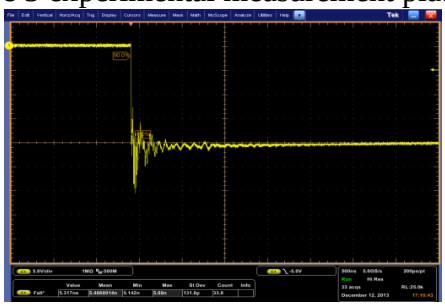

Figure 6 (a) 1.5 mm spacing pulse output

Figure 6 (b) 2.0 mm spacing pulse output

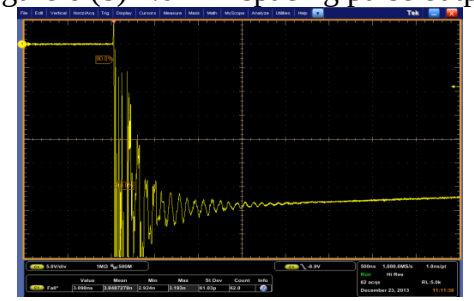

Figure 6 (c) 3.0 mm spacing pulse output

5. Conclusion

Marx generator is mainly introduced in this paper and the basic principle of gas switch, gas breakdown discharge switch synchronization process are analyzed, and good synchronization of Marx generator of the pulse output are measured by different air gap distance. In the study of

synchronous discharge process, we found that the switch is in a straight line, the breakdown discharge will produce ultraviolet or other active particles to promote synchronous switch discharge and pulse edge, it is conductive to design and debug of the gas switch of Marx generator in the future.

References

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