A LOW JITTER PULSE GENERATOR BASED ON TWO-STAGE STORAGE MODULE

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Abstract

At present, the detonator application that use pulsed generator is widely. It is required that the delay of the generator is less than one hundred μs, and the jitter is less than several μs. A scheme for a low jitter pulse generator based on two-stage storage module is described. The thyristor is used for the first stage of the generator, the UV-illumination gas switch is used for the second stage of the generator. Between them, the pulsed transformer is used for connecting. The test result shows, the delay of the generator is 35.1μs, and the jitter of the generator attaches to 0.22μs. It can meet the application. In addition, the generator has several advantages, such as simple structure, safe and expansion characteristic.

INTRODUCTION

With the development of pulsed power technology, some new points were required [1, 2]. Such as, higher di/dt, lower jitter and smaller volume. Sometimes, it is required that the generator output a square wave which is lower than 10 V to be locking signal. For this reason, the trigged voltage of the generator should lower, electric control thyristor could meet it. However, the di/dt of the circuit is conditional upon open velocity of the thyristor, circuit inductance, and usually can not suffice consumer. So, the thyristor was used for the primary switch, while the UV-illumination gas switch was used for the secondary switch searching for the low jitter characteristic. In addition, the impulse transformer was designed to connect the first and second stage, which was convenient for expansion to search higher energy and voltage.

BASIC STRUCTURE OF THE PULSE GENERATOR

The sketch diagram of the pulse generator is shown in Fig. 1. The whole equipment includes AC transformer, control system and the generator. The generator consists of primary capacitors, a primary thyristor switch, impulse transformer, secondary capacitors, secondary peak gas switch, transmission line and dummy load.

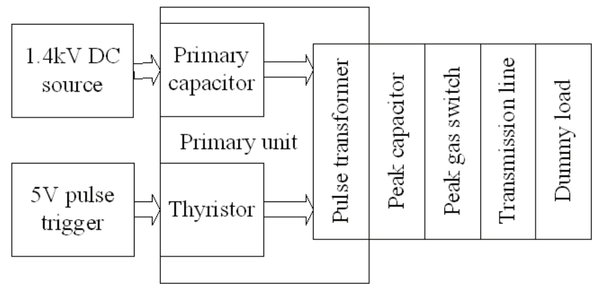

Figure 1: Sketch diagram of the pulse generator.

The primary capacitors are composed of two 10μF/2kV capacitors in parallel. The rated voltage of the thyristor is 2 kV, which can be triggered by a 5V pulsed voltage. The pulsed transformer is home-made, in which the transformation ratio is 1:5, and the volt-second product is higher than 14V·ms.

The secondary stage includes peak capacitors, peak switch, transmission line and dummy load. The peak capacitor are composed of two 0.22μF/8kV capacitors in parallel. The peak switch is made of low jitter UV-illumination gas switch, in which the desinged breakdown voltage is 3-7kV, and the air pressure in the switch is 0.1MPa. The transmission line in fact is a 5 m 10 kV DC cable. And the 1.2Ω high power resistor is used for dummy load.

CIRCUIT SIMULATION

Figure 2 shows the equivalent circuit of the pulse generator. In the figure, Cprimary is the equivalent capacitance of the primary capacitor. Thyristor is 2 kV primary switch. TX1 is pulsed transformer. Cpeak is the peak capacitor. L1, L2 and L3 is equivalent capacitance in the circuit.

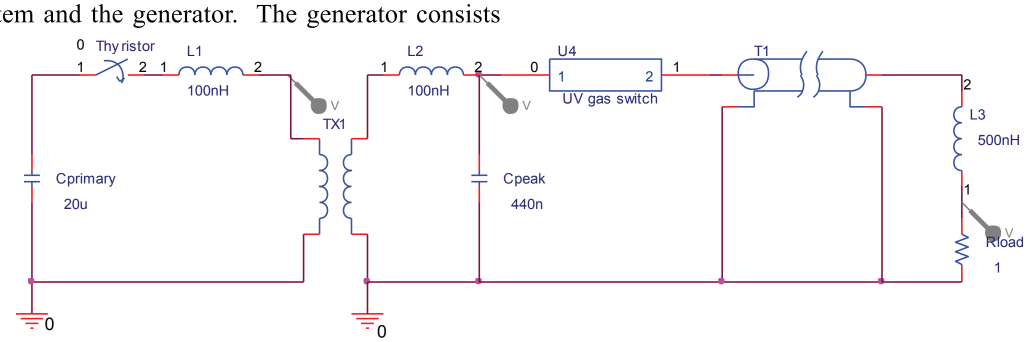

Figure 2: Equivalent circuit of the pulse generator.

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The charging voltage of primary capacitor can climb to 1.4kV, while the breakdown voltage of UV-illumination gas switch achieves 7kV. Fig. 5 shows the typical waveforms of the key point in the generator. In the figure, UTX1 is primary voltage waveform on the pulse transformer, Upeak is charging voltage waveform on the peak capacitor, and Uload is charing voltage waveform on the load.

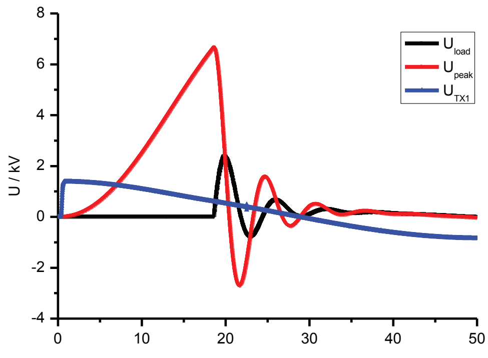


Figure 3: Calculation voltage waveform of equivalent circuit.

In can be seen from Fig. 3 that the charging time on the pulse transformer is higher than 20 µs. Therefore, the volt-second product is greater than 14V·ms. In addition, the charging voltage waveform on the peak capacitor can be equivalence which on the peak switch, the risetime is approximately 18µs. So the jitter of the generator largely depends on the breakdown jitter of the peak switch. The low jitter UV-illumination gas switch is designed to reduce or erase statistical delay in order to reduce the jitter of the generator [3, 4].

DESIGN OF THE UV-ILLUMINATION GAS SWITCH

Figure 4 shows the structure of the UV-illuminated switch. The switch system consisted of a UV gap and a main gas gap. The main gas gap was designed uniform field, while the UV gap was designed nonuniform field. The UV illuminated gap consists of tungsten rod, ceramic insulator and cathode. Mallet alloy was used for main electrodes on which the surface was smoothed. Acryl glass was used for supporting insulators. In this study, the insulation characteristic between tungsten rod and triggered plane is a very important facter. So, they are separated by a thin ceramic insulator.

The breakdown delay of gas gap consists of statistic delay and formation delay [5]. Therefore, the jitter of the gas switch depends on the jitter of the statistic delay and formation delay. If the electrical field is uniform, the formation delay is much less than statistic delay. So, the jitter of the gas switch largely depends on the jitter of statistic delay.

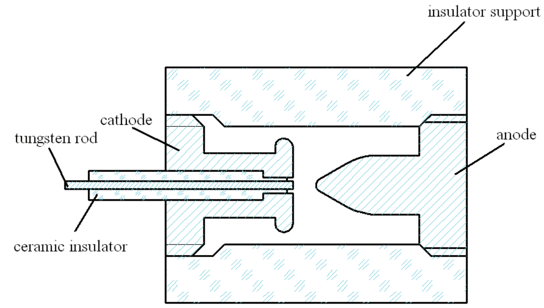


Figure 4: Sketch of UV illumination switch.

The UV illuminated circuit was designed a capacitance-resistance coupling structure. The parameter of UV illuminated circuit assures that UV illuminated gap was breakdown successfully before the main electrodes breakdown, shown in Fig. 5 [6]. In the figure, Cs=5pF is equivalent capacitance between the main gap, Cuv=40pF is the equivalent capacitance between UV gap, Cg=2pF is equivalent capacitance between tungsten rod and ground, Ruv=75kΩ, Rg=150kΩ, RL=1Ω. The simulation result is shown in Fig. 6. the stay capacitance makes the voltage waveform between the UV gap lag, but can not effect the ratio. When the voltage between the main gap attains 7 kV, the voltage between the UV gap climbs to 2 kV.

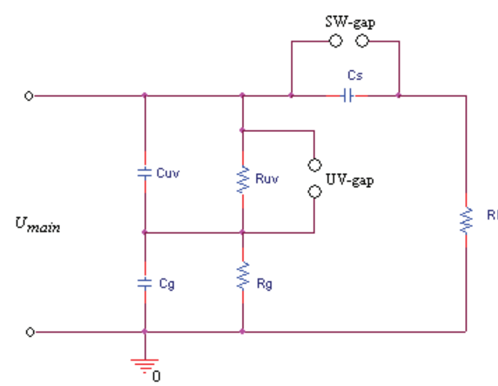


Figure 5: Sketch of UV illumination switch.

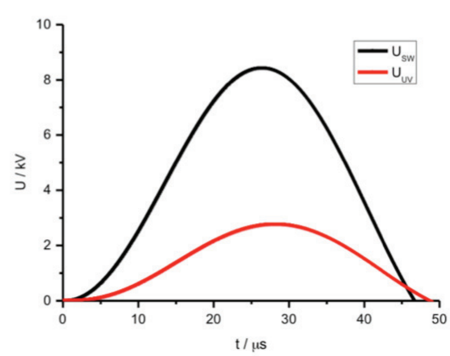
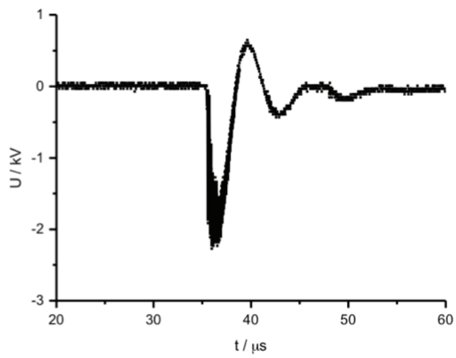


Figure 6: Calculation voltage waveforms.

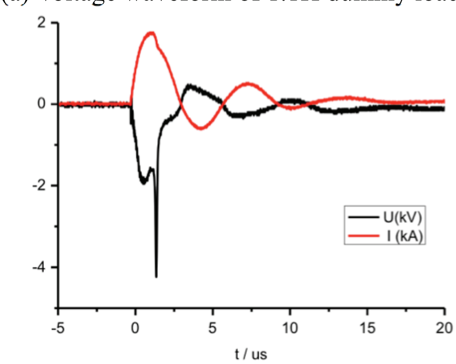
EXPERIMENTAL RESULT

The voltage waveform on 1Ω dummy load is shown in Figure 7(a). The voltage peak is about 2.3 kV. The measurement result accords with the simulation. The voltage and current waveform on 1.1Ω nickel chromium triangle is shown in Fig. 7(b). The voltage peak is about 2 kV, while the current peak is approximate 1.8kA, and risetime is 0.73 μs. It is analysed that the peaked wave on the voltage waveform is contributed by the circuit inductance.

Figure 8 shows the typical breakdown waveforms of twenty shots under constant condition, in which CH1 and CH2 are the waveforms respectively trigger voltage and output voltage. From Fig.7, it can be seen that the delay of the generator is 35.1μs, and the jitter of the generator attaches to 0.22μs. In addition, the generator has excellent expansion characteristic. It could be used in series to improve output voltage and power.



(a) Voltage waveform of 1.1Ω dummy load



(b) V and I of 1.1Ω nickel chromium alloy

Figure 7: Voltage and current waveform on the load.

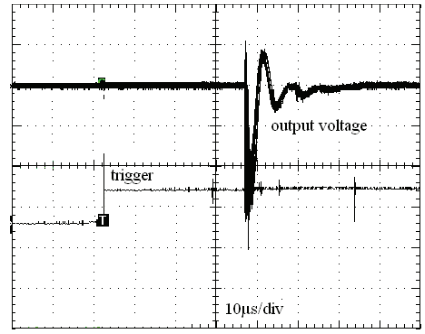


Figure 8: Typical waveform of the generator.

CONCLUSION

A scheme for a low jitter pulse generator based on two-stage storage module is described. The thyristor is used for the first stage of the generator, the UV-illumination gas switch is used for the second stage of the generator. Between them, the pulsed transformer is used for connecting. A capacitance-resistance coupling structure was designed to produce UV light which triggered the switch to decrease the breakdown jitter. The test result shows, the risetime of the current is 0.73μs, the peak value of the current is 1.8kA on 1.1Ω load. The delay of the generator is 35.1μs, and the jitter of the generator attaches to 0.22μs.

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