High-voltage Pulse Generator

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Abstract - This report is devoted to the design study of the high-voltage pulse generator providing pulsed voltage ~350 kV in ~60 Ohm resistive load with the rise time of ~5 ns and ~2.5 ns and FWHM is ~200 ns and ~25 ns, respectively.

1. Electric circuit of the generator

Liquid-filled forming lines charged from the Marx generator are used for receiving the voltage pulse (Fig.1). Line impedance filled by glycerin is ρ=3.8 Ohm, electric length is 17 ns. Line impedance filled by oil is ρ=6.5 Ohm, electric length is 3.4 ns. Marx generator capacity is C=28 nF. Line charge current is limited by the inductive resistors set with total values L=1.26 mH and R=430 Ohm. The forming line switches on the 54 Ohm resistive load through the switch S. For correctly defining of output generator voltage, additional line between the switch and the load (1 m long, impedance ~60 Ohm) is used. The oil forming line is switched on the load by the switches S_1 and S_2 separated by the line with impedance 30 Ohm and electric length 1 ns (Fig. 1b). The inductance Lp equal to 60 μH.

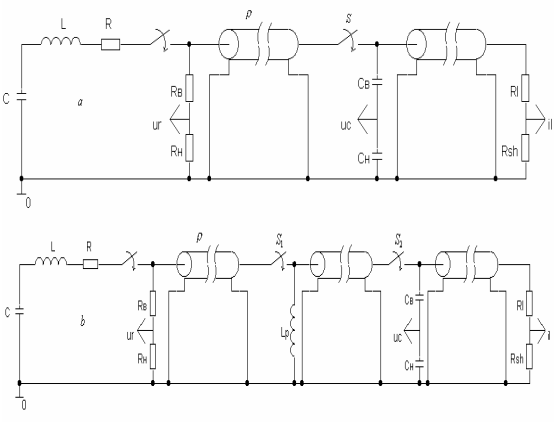

Fig. 1. Generator electrical scheme with glycerin (a) and oil FL (b).

The output Marx generator voltage is measured by an active divider $R_B - R_H$. The load current is measured by the 0.17 Ohm resistive shunt. For voltage measurement after the switch the capacitive divider $C_B - C_H$ with additional resistor R_{cor}=1555 Ohm is used. The load voltage was determined by the formula $U_{cor}(t) = U_C(t) + \frac{1}{R_{cor}C_H}\int_0^t U_C(t)dt$ with $R_{cor}C_H$ ~840 ns. The voltage amplitude counted out in 8 ns after the pulse starting and till the moment of coming on-site of the capacitive divider of pulse part reflecting from the resistive load.

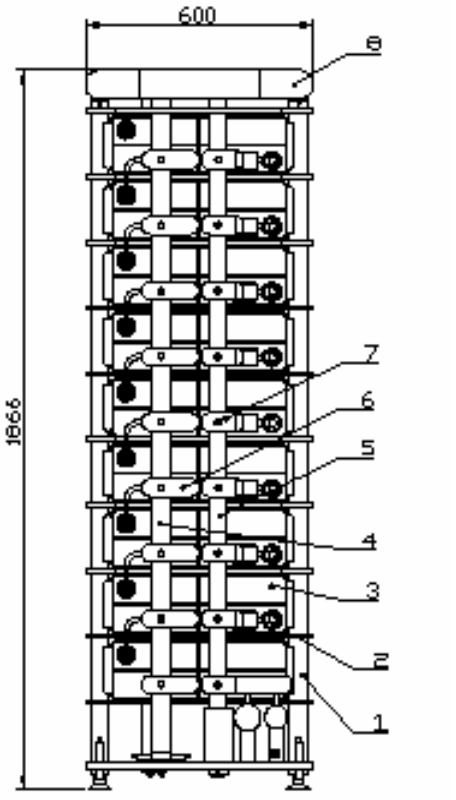

Fig. 2. Marx generator design.

2. Design of the generator

Marx generator consists of 9 stages in each of which pulse capacitors IC-100/0.25 are used (Fig. 2). The framework of the generator is formed by the caprolon studs (1) and shelves from the plexiglas (2) for capacitors setting. The charging current is limited by the resistors (4) and (5) established along high-voltage and earth sides of the generator. The generator stages are switched by two-electrode discharges with remov-

able (6) and stationary (7) electrodes. Electrodes of the discharges are closed by operated mechanical drive. The voltage pulse arising on the high-voltage electrode (8) is imposed to an electrode (1) connected to the central electrode of the forming line (Fig. 3-4). The line is formed by the coax (3)-(4), its length is limited by the insulators (2) and (5). The diameter ratio of glycerin line electrodes is 407/260 mm and oil line is 407/350 mm. The switching discharger is formed by the electrodes (6) and (7), its inner volume is limited by the insulators (5) and (8) and filled with nitrogen compressed up to 10 atm. The switch gap changes from 9 mm up to 18 mm. After it breaks down the voltage through the coax (10)-(11) applies to the resistive load (12) installed inside tube (13). The load line is filled by compressed up to 6 atm SF_6 gas. The capacitive divider (9) and the current shunt (14) are builded in the load line. For shortening pulse front during operation of oil forming line the switch with two electrode gaps (1)-(2) and (4)-(5) builded in the insulator (3) are used (Fig. 4).

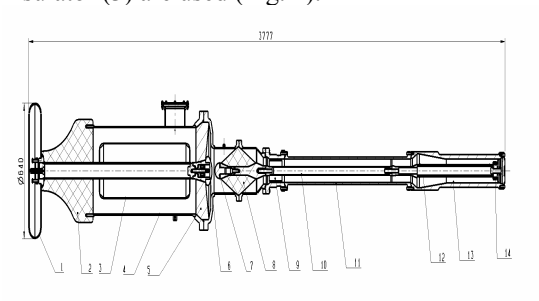

Fig. 3. Glycerin FL and load design.

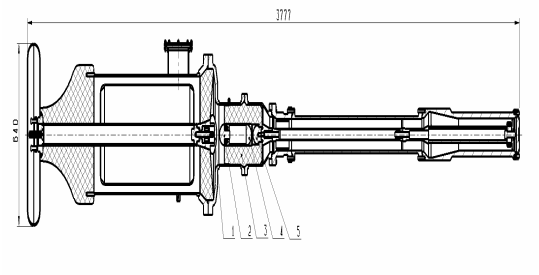

Fig. 4. Oil FL and load design.

3. Tests results

3.1. Generator with glycerin forming line

Tests were carried out at Marx charging voltage 30-50 kV. The pressure in the switch is changed within 5-10 atm. The generator current and the voltage waveforms are shown in Fig. 5. The forming line during ~5.8 μs is charging up to ~460 kV (Fig. 5a). After the switch closed the voltage pulse appears on the load. Pulse front is ~4 ns between levels 0.1-0.9 from the peak value ~350 kV (Fig. 5c). The voltage pulse FWHM is ~210 ns (Fig. 5b), the load current is ~6 kA. Waveforms superposition of 100 shots shows the load voltage reproducibility within ±3%.

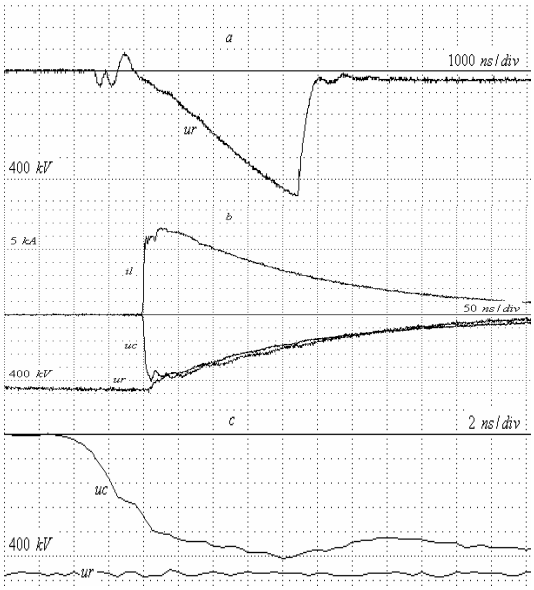

Fig. 5. Waveforms for glycerin FL.

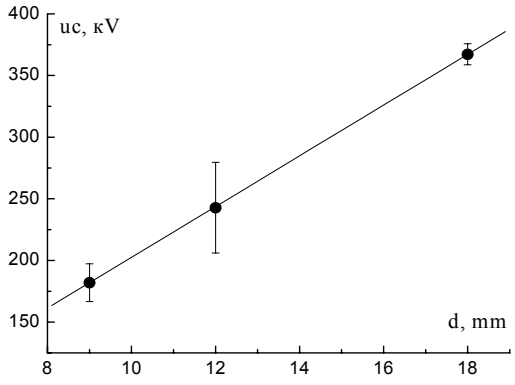

Fig. 6. Load voltage as a function of switch gap.

Fig. 6 shows load voltage as a function of switch gap. The gap increase from 9 to 18 mm is followed by the load voltage growth from ~180 to ~370 kV.

3.2. Generator with oil forming line

The load pulse front ~2.5 ns is realized by the gaps in the first and second switches 19 mm and 4 mm accordingly. The increase of the gap in the second switch is lead to the shortening of the load voltage front. The waveforms of 100 generator shots at 1 min. interval in automated charging regime are showed in

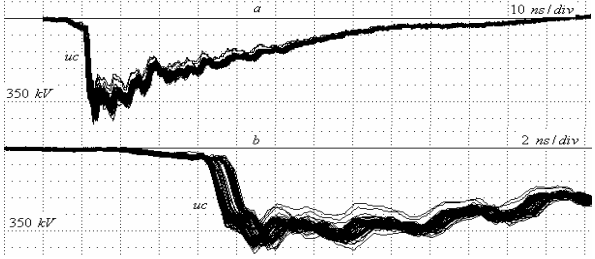

Fig. 7. Waveforms for oil FL.

Fig. 7. The pulse front duration is ~2.5 ns, the voltage pulse FWHM is ~28 ns.

4. Conclusion

Project development is executed and generator tests for obtaining of voltage pulse with amplitude ~350 kV on the 60 Ohm load are made. The pulse front for glycerin and oil forming line are ~5 ns and ~2.5 ns, FWHM are ~200 ns and ~28 ns accordingly. Switches operating ranges as a function of charging voltage and gas pressure are determined. The test data demonstrate high shot to shot repeatability of the load voltage and the possibility of it's changing within 180-370 kV.

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