200 кV PULSE MODULATOR FOR POWER SUPPLY OF VEPP-5 INJECTION COMPLEX ELECTRON GUN

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This paper describes a new 200 kV pulse modulator for the VEPP-5 complex preinjector electron gun. The pulse former is based on the solid state IGBT-switch and the new high turn ratio pulse transformer (PT). New design allows to simplify the performance of charge device due to the decrease of primary voltage and decrease of power consumption because of partial energy recuperation to the primary circuit.

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1. PULSE FORMER

The electron gun is required to generate electron bunches with energy 200 kV, pulse current 10 A and

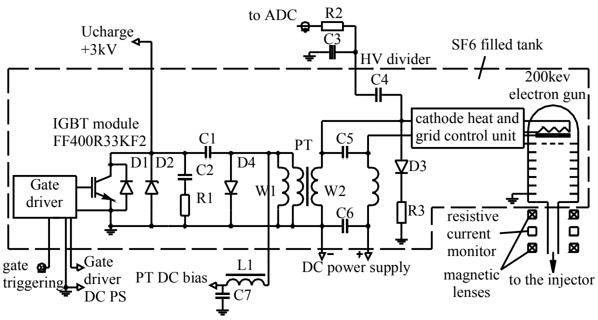

Fig.1. Pulse former circuit

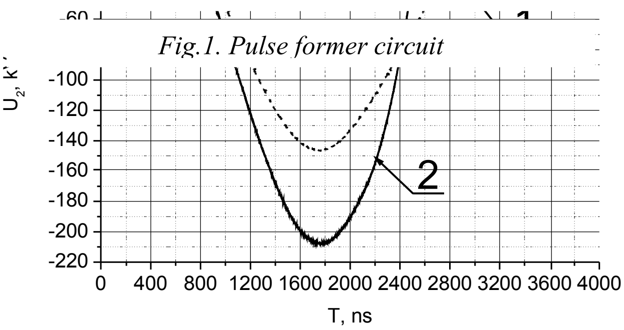

Fig.2. Voltage waveform on the PT secondary winding at different voltage levels

pulse duration 2 ns. As the equivalent capacitance of secondary circuit including the gun and PT capacitance is equal to 100 pF then it is discharged with pulse current only by 200 V that is by 0.1% of nominal voltage. Thus the load of the modulator is capacitance. Similarly to the previous modulator variant [1] high voltage pulse forming is based on the resonant charge of secondary capacitance through the step up pulse transformer. Pulse former circuit is presented in fig.1. After IGBT gate drive pulse comes the primary capacitor C1 discharges through PT with the turns ratio k=72.3 and generates a voltage pulse with the cosine rising edge on the secondary capacitance. When the first half-wave of primary current is completed the energy returns from the secondary capacitance to the primary storage C1 through the reverse diode D1 mounted into the IGBT module and pulse trailing edge of cosine wave of the same duration as the rising one is generated (fig.2 curve 1). However, as the flux density in PT core is limited by the saturation flux density then at the voltage $U_2 > \frac{2\Delta B_S S W_2}{t_{\phi p}}$ (ΔB_S is the PT core flux density swing from the initial value $\approx -B_r$ up to the saturation induction B_S) the pulse fall time is shortened at the expense of magnetization inductance quick decrease (fig.2 curve 2). After the pulse reverse overshoot is limited by the diode D4 and D3R3 circuit. R1C2 circuit decreases the voltage rise rate at the IGBT collector protecting in this way the switch from overshootings which are occurred during reverse diode D1 recovery. Figure 3 shows the wave-

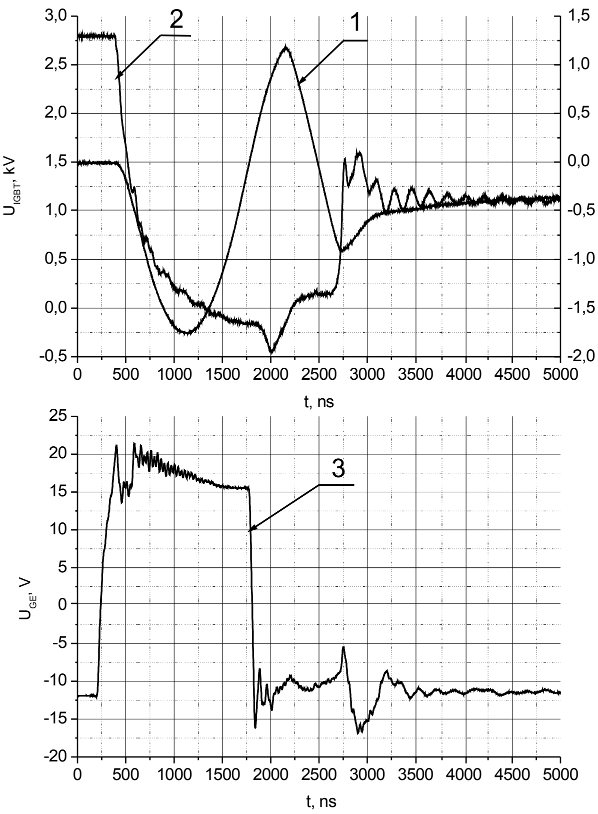

Fig.3. Waveforms of collector (2) and gate (3) voltages and current (1) of 200kV gun modulator switch

forms of PT primary current (curve 1) and the IGBT collector (curve 2) and gate (curve 3) voltages at the nominal secondary voltage.

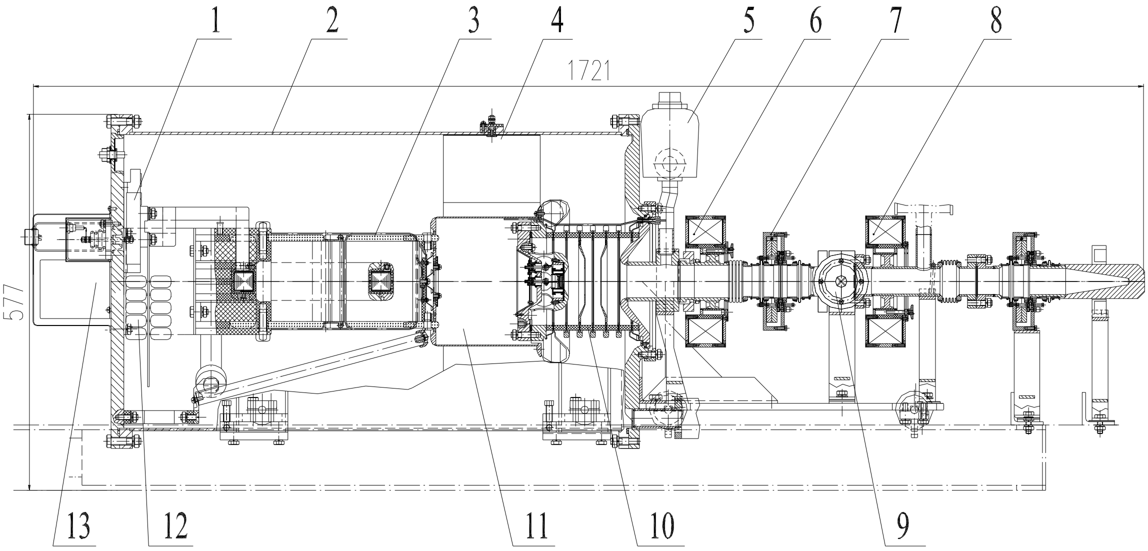

Fig.4. 200 kV gun and pulse modulator design
1 – IGBT module, 2 – SF6 filled tank, 3 – PT, 4 – capacitive divider, 5 – magnetodischarge pump, 6,8 – magnetic lenses, 7 – beam current resistive monitor, 9 – gate, 10 – accelerating tube, 11 – cathode heat and grid control unit, 12 – primary circuit capacitive storage unit, 13 – biasing choke

2. MODULATOR DESIGN

200kV gun together with the pulse modulator design is shown in fig.4. To decrease the primary circuit inductance the primary capacitance (12) and switch (1) are placed in common SF6 filled tank (2) with PT (3) and gun under pressure 1.7 atm. (see fig.4). Water cooling is provided in the design of the IGBT module FF400R33KF2 support cover. Triggering pulse at the input of the IGBT driver is removed when the module temperature exceeds 70ºC. Decreasing of PT bias current less than 9A is registered with the help of a shunt and is also led to IGBT triggering removal. Secondary voltage measurement is carried out with the help of the capacitive divider (4 in fig.4). The divider upper arm is constructive capacitance of the high-voltage electrode (11 in fig.4) onto the foil-clad glass reinforced textolite plate and lower arm is the lumped capacitance placed outside of tank. PT design is similar to the design described in [1]. Secondary winding is winded with a polyethylene isolated wire of an external diameter 0.8 mm. Use of two parallel branches of secondary winding lets to transfer the supply voltage to the gun control unit.

3. TEST RESULTS

The modulator behavior was tested on the equivalent capacitance in nominal mode during 8 hours.

REFERENCES

1. V.E.Akimov, I.V.Kazarezov et al. 200 keV electron beam pulse source for the complex VEPP-5 preinjector // *VANT. Series “Nuclear physics research*”. 2001, № 3.

200 кВ ИМПУЛЬСНЫЙ МОДУЛЯТОР ДЛЯ ПИТАНИЯ ЭЛЕКТРОННОЙ ПУШКИ ИНЖЕКЦИОННОГО КОМПЛЕКСА ВЭПП-5

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Описывается новая версия 200 кВ-го модулятора электронной пушки для инжекционного комплекса ВЭПП-5. Формирователь импульсов выполнен на твердотельном IGBT ключе; для снижения напряжения на ключе при сравнительно малом импульсном токе импульсный трансформатор выполнен с увеличенным числом витков вторичной обмотки и большим коэффициентом трансформации.

200 кВ ІМПУЛЬСНИЙ МОДУЛЯТОР ДЛЯ ЖИВЛЕННЯ ЕЛЕКТРОННОЇ ГАРМАТИ ІНЖЕКЦІЙНОГО КОМПЛЕКСУ ВЕПП-5

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Описується нова версія 200 кВ-го модулятора електронної гармати для інжекційного комплексу ВЕПП-5. Формувач імпульсів виконаний на твердотільному IGBT ключі; для зниження напруги на ключі при порівняно малому імпульсному струмі імпульсний трансформатор виконаний зі збільшеним числом витків вторинної обмотки і великим коефіцієнтом трансформації.