POWER SUPPLIES FOR IHEP NEGATIVE HYDROGEN IONS SOURCE

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Abstract

The source of negative hydrogen ions is constructed at IHEP for the implementation of multiturn charge-exchange injection to increase the intensity of IHEP buster. Surface-plasma ion source (SPS) with Penning discharge is selected as source of H-minus ions. A set of power supplies for SPS which includes the extraction voltage power supply, the discharge power supplies, the hydrogen gas pulse valve power supply, cesium oven and cesium storage device temperature controllers was designed, constructed and tested on the equivalent loads. This set of power supplies will allow to commission and test the ion source with the beam extraction energy up to 25 keV and repetition rate of 25 Hz.

INTRODUCTION

For injection into IHEP LU-30 RFQ the source of H-minus ions should generate the beam with current not less than 50 mA, pulse duration up to 200 mks, repetition rate - 25 Hz, normalized rms emittance no more then 0,25 mm*mrad, e/H^- ratio < 5 providing a long-term stability and reproducibility of the parameters [1]. To provide these requirements surface-plasma ion source based on the Penning discharge cell with an axially symmetric emission aperture the two-stage system of cesium supply and pulsed gas valve is developed.

A power supply system which includes the extraction voltage power supply, the Penning gas discharge power supplies, the hydrogen gas pulse valve power supply, cesium oven and cesium storage device temperature controllers should provide the operation of the ion source.

GAS DISCHARGE POWER SUPPLIES

Gas discharge power supplies must provide the ignition of discharge, burning high-current pulsed glow discharge with a current up to 150 A in the conditions when the internal resistance of the discharge is less than 1 ohm with pulse durations of 25 up to 200 microseconds and pulse repetition rate of 25 Hz.

Gas discharge power supply consists of the following components: a thyristor unit, transistor unit, power supply, isolation transformer. The external view of the front panel is shown in Fig. 1.

Thyristor unit generates pulses with fixed amplitude of 800 V. These pulses are applied through the 30 ohms limiting resistance to the primary winding of the output isolation transformer for "ignition" of the high-current discharge which afterwards is picked up by the stabilized current of the transistor block.

Transistor unit generates amplitude-adjustable powerful current pulses with the stabilization on pulses top in the primary winding of output isolation transformer. The regulating element is the transistor MG400H1FK1.

Power supply unit is the power source for the transistor unit with the ability to turn off on the "alarm" signal received from the transistor unit. The power supply unit provides also the voltage for ± 12 V transistor and thyristor units.

Thyristor unit, transistor unit and power supply unit are designed in the same construction design «Vishnya»

Figure 1: General view of the gas discharge power supplies.

Discharging current generator prototype tests on the equivalent load were carried out. The 0.5 Ohm, 1 Ohm, 3 Ohms resistances of appropriate power were used as equivalent load. Tests were conducted at the pulses repetition rate of 25 Hz. The waveform of the output current on resistance of 1 Ohm is shown in Fig.2.

Tests of the gas discharge power supplies prototype were also conducted when working with the H-minus ion source of injector INR RAS linac. The waveforms of the ion source operating parameters are shown in Fig.3. The top beam (blue) is the voltage at the discharge, the lower beam (yellow) is the discharge current.

These tests demonstrated the ability of gas discharge power supply to provide the required parameters in various modes of source operation including the discharge ignition, the transition to a low-voltage (cesium) regime and work in conditions of intensive breakdowns in the 15 kV extraction gap.

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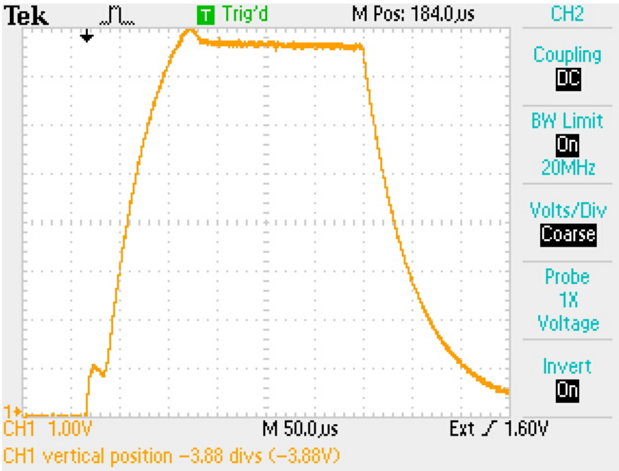

Figure 2: The output current of gas discharge power supplies. Vertical scale – 20 A/div, horizontal scale – 50 µs/div.

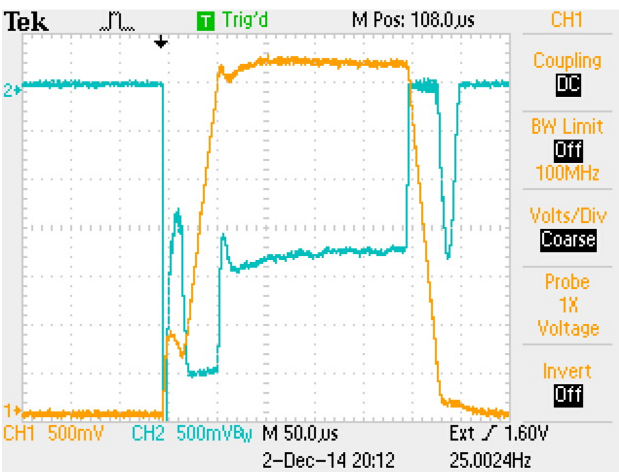

Figure 3: The oscillograms of voltage and discharge current of the H-minus ion source. The top beam (blue) is the voltage at discharge, 50 V/div. The lower beam (yellow) is the discharge current, 10 A/div. Horizontalscale - 50 µs/div.

GAS VALVE POWER SUPPLY UNIT

Gas valve power supply unit is designed for pulsed opening of solenoid valve for hydrogen gas feed into the discharge chamber of the H-minus ion source. This unit should provide the valve actuations with the pulse repetition rate of 25 Hz and should give the current pulses with the adjustable value of 50 A, duration of about 200 µs and stability no worse than ± 0,5%. The unit can control output current from the external reference of 0...+ 5 V value (with conversion scale 1V/10 A) and with the potentiometer installed on the gas valve power supply unit front panel.

The unit provides the current pulses monitoring through the valve with a scale of 1V/10 and the valve voltage monitoring with scale 1 V/10 V. This unit power consumption does not exceed 20 W with the network supply of 220 V 50 Hz.

The designed prototype was tested on the equivalent load (the resistance value of 1 Ohm) and on the acting gas valve. The current waveform for the unit tested on the acting gas valve is shown in Fig.4.

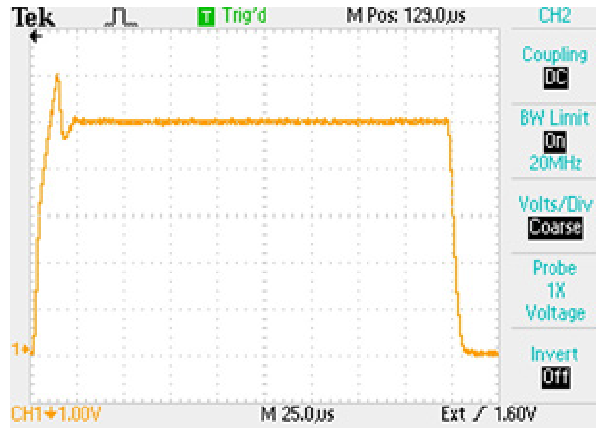

Figure 4: The waveform of the valve power supply output current. The vertical scale is 10 A/div, horizontal scale – 25 µs/div.

EXTRACTION VOLTAGE POWER SUPPLY

Extraction voltage power supply should provide pulses of the voltage amplitude Uo = 0 ... 25 kV with the extraction voltage instability no worse than ± 0,5 kV and the pulse repetition rate of 25 Hz. The extraction voltage power supply must withstand operation with frequent (continuous) breakdowns in the extraction gap at the current limitation less than 1 A in the breakdowns. The extraction voltage pulses of the 25 kV amplitude are formed at the pulse step-up transformer output at the forming line discharge with a characteristic impedance of 40 Ohms through the thyristor in the primary winding of the transformer. The transformer was made on the core with cross-section 25 cm2 with the number of turns in the primary winding W1 = 72 turns, in the secondary winding W2 = 2100 turns.

Output pulse amplitude stabilization is provided by capacitive – diode limiter made on 2 capacitors К75-15 with the capacitance of 0.1 µF connected in parallel, and 2 diodes КЦ201Е connected in series which are charged from the reference voltage rectifier to 25kV.

The short-circuit current magnitude on the load in this scheme is limited by the characteristic impedance of the forming line in the primary circuit. For the selected parameters of the characteristic impedance of 40 Ohm and the transformation ratio k = 29, the short-circuit current does not exceed 0.75 A in the secondary circuit.

The extraction voltage power supply consists of two units: thyristor unit and transformer unit. A thyristor unit contains the forming and the switching thyristor with a thyristor triggering device. The thyristor triggering device provides also the interlocking function. The transformer unit contains a pulse step-up transformer with the

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secondary voltage pulse amplitude of 25 kV and the capacitive – diode limiter of output voltage.

The tests of extraction voltage power supply were conducted at the pulse repetition rate of 25 Hz and the load resistance value of 100 kOhms. The waveforms of the extraction voltage output pulses are shown in Fig. 5 and Fig. 6. The waveforms in Fig. 5 shows that the amplitude of the output pulse is 25 kV.

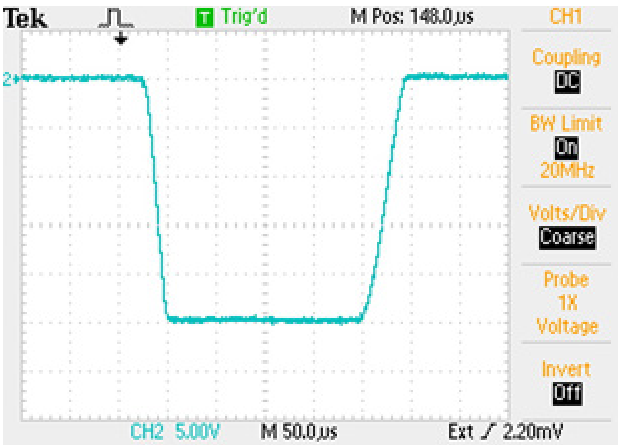

Figure 5: The waveform of the output pulse of extraction voltage power supply. Vertical scale - 5 KV/div, horizontal scale - 50 µS/div.

The pulse top in scale 500 V/div. given in Fig.6 shows that the instability of pulse peak is 200 V, or ± 100 V. This value of instability completely satisfies the requirements for the negative ion source power supply system.

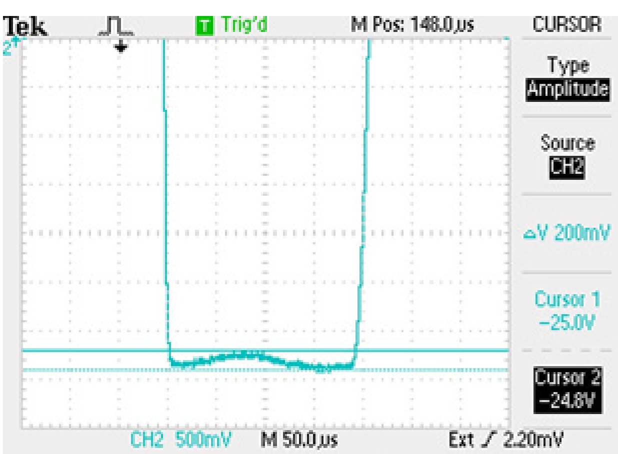

Fig. 6. Waveform of the output pulse top of extraction voltage power supply. Vertical scale - 500 V/div, horizontal scale - 50 µS/div.

CESIUM SUPPLY CONTROL SYSTEM

Cesium supply control system consists of two blocks. The first block controls the heater of the reservoir with cesium dichromate and titanium mixture and second controls heater of the cumulative volume in which the metal cesium predetermined vapor pressure is maintained directly at the gas-discharge entrance of H-minus ion source The heating of reservoir with tablets of cesium dichromate is performed up to the temperature that ensures the cesium dichromate decomposition and the metallic cesium release in the form of vapors to enter in the cumulative volume.

Tests on maximum current were performed on load equivalent – active resistance equivalent to the resistance of the heater element in the heated state. The tests were performed in long mode corresponding to the mode of cesium output in the gas discharge which has the time interval to two hours. During the tests load current instability did not exceed ± 0,4% with the input voltage change in the range 198...242 V.

CONCLUSION

The designed, constructed and tested ion source power supplies form the union required for autonomous operation of the H-minus ion source and beam generation with ion energy up to 25 keV and repetition rate 25 Hz.

REFERENCES

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