

POWER SUPPLY AND PROTECTION SYSTEM OF THE NUCLOTRON BOOSTER IN THE NICA PROJECT

A. Kudashkin, V. Karpinsky, H. Khodzhbagiyani, A. Sidorin, JINR, Dubna, Russia

Abstract

The Nuclotron Booster in NICA project [1] is aimed to accelerate heavy ions up to 600 MeV/u to provide effective stripping before injection into the Nuclotron. The Booster power supply system consists of one powerful unit, providing maximum current of 12 kA and field ramp up to 1.2 T/s, and two additional units, that are used for the ring working point adjustment. The quench protection system is based on thyristor switches. Structure and parameters of the power supply system are presented.

At design of the Booster power supplies system (fig. 1) the requirement of consecutive connection of structural dipole magnets (total inductance 16.4 mH), quadrupole focusing (total inductance 0.6 mH) and defocusing (total inductance 0.6 mH) lenses is accepted for a basis. The main powerful source of the power supply system forms a demanded current (up to 12.1 kA) with the required magnetic field ramp of 1.2 T/s in the general chain according to a demanded cycle.

THE SYSTEM STRUCTURE AND DESTINATION

The Nuclotron-type design based on a window-frame iron yoke and a saddle-shaped superconducting winding is chosen for the Booster. The Nuclotron magnets include a cold (4.5K) window frame iron yoke and a superconducting winding made of a hollow NbTi composite superconducting cable cooled with two-phase helium flow at $T = 4.5\text{ K}$ [2]. A further development of the technology was proposed [3] to increase the efficiency of the magnetic system. In accordance with this proposal the single-layer winding bent dipole will be built to reduction the magnet cross section and AC losses in comparison with the straight double-layer winding dipole at the same aperture budget by means of the doubled structural current density in a winding.

The powerful power supply source consists of connected in parallel thyristor rectifiers PS1, 2, powered from a high-voltage net 6 kV. Each of sources “PS” is a 12 phase rectifier with nominal parameters of 180 V x 6.3 kA, and phase shift between voltages of 15 degree. Together PS1, 2 form 24 phases regulated thyristor rectifier with nominal output parameters 180 V x 12.6 kA, that allows to receive the magnetic field ramp of 1.2 T/s. The peak power of a source is 2.5 MW.

Two additional power supply sources of essentially smaller power are intended for flexible adjustment of an working point of the accelerator. One of them allows to change simultaneously a field gradient in focusing and defocusing lenses, another only in defocusing ones.

The power supply system includes also equipment of regulation, management and diagnostics.

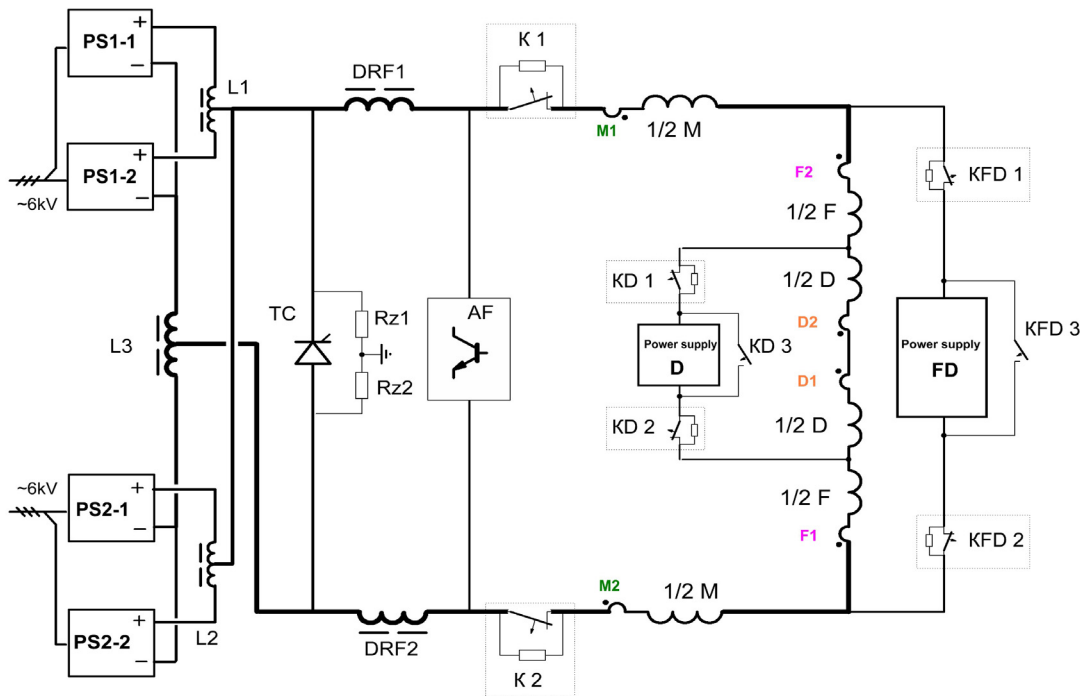
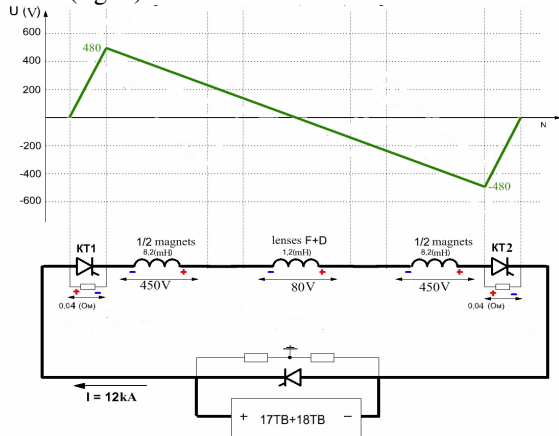


Fig. 1. The schematic diagram of the Booster power supply system (the explanation in the text).

QUENCH PROTECTION SYSTEM

The "switches" connected consistently with a chain of magnets and lenses are applied to evacuation of the accumulated energy from superconducting elements in case of superconductivity quench. They are controlled by a signal from detecting system that reacts on the occurrences of a normal phase in a superconductor. On the arrival of a control signal the switch is disconnected, and the energy, which has been saved up in the magnets, dissipates in resistors of the field dump, connected in parallel to the switches (fig. 2).



- Rated characteristics in the process of energy evacuation:
- The constant time output of energy 220ms,
- Total field damping resistance 0,080m,
- The voltage in the process of current output 980V.

Fig. 2. Potential on magnets and lenses

The dipole magnets (2 chains 1/2M) and quadrupole lenses (on 2 chains 1/2 F and 1/2 D) are connected through the switches of energy evacuation (K1, K2) to a source under the symmetric scheme concerning voltage supply. Inductance of groups and nominal resistance of dumping resistors are chosen so that the voltage on the current feed through concerning the ground potential have not exceed 500 V at the moment of energy evacuation. At the total voltage of $U = 1000 \text{ V } (\pm 500 \text{ V})$; and maximum current of $I = 12 \text{ kA}$ the resistance have to be equal to

$$R = \frac{U}{I} = 83mOm \cdot$$

At the total inductance of the magnetic system of $L = 17.6 \text{ mH}$ that corresponds to the evacuation process characteristic time of

$$t = \frac{L}{R} = 220ms ,$$

It is sufficient from the safety requirements.

THE SYSTEM ARRANGEMENT

Induction sensors of a magnetic field are established in the measuring magnets M 1, 2, lenses F 1, 2 and D 1, 2 (fig. 3). They are located near the Booster in the Sinchrophasatron building. Their output signals go to

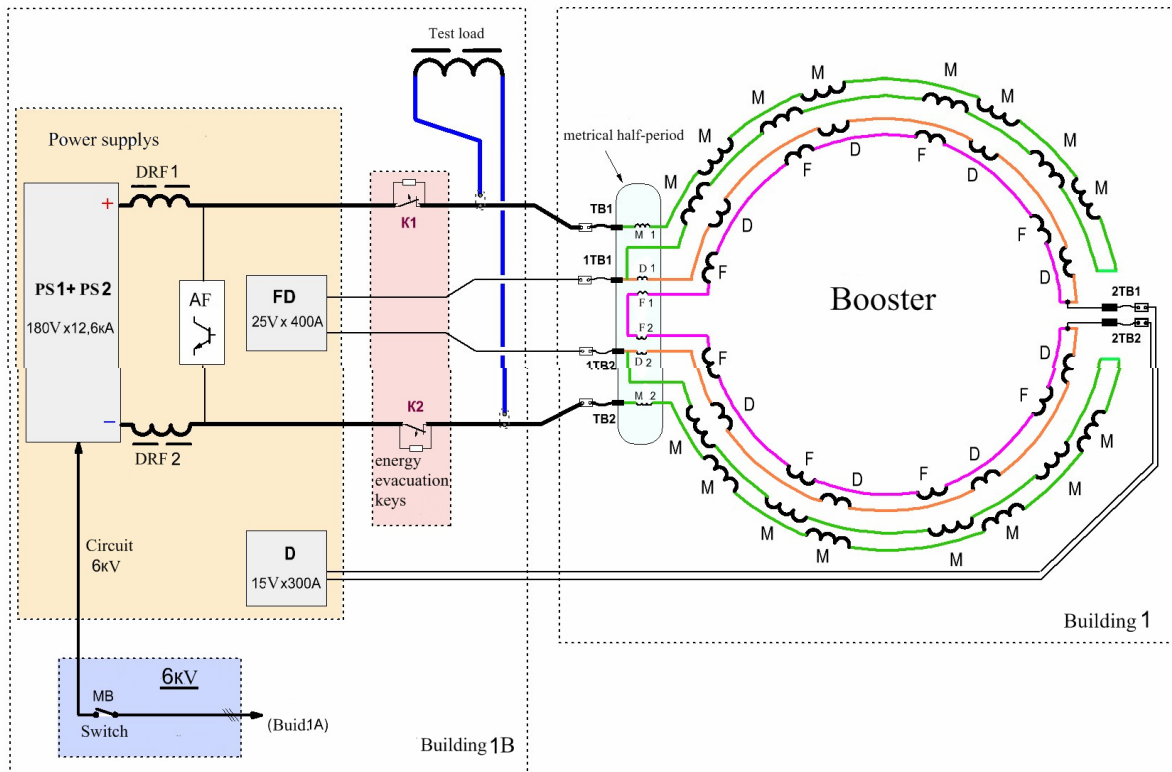


Fig. 3. The scheme of power supply system equipment arrangement.

All powerful equipment and the energy evacuation keys are located in the building 1B.

Filter throttles DRF1, DRF2 together with the active filter (AF) reduce level of current pulsations to the demanded level. Resistors Rz1 and Rz2 symmetrize the output voltage of the source concerning ground. Thyristor switch shunts the power supply source at the moment of energy evacuation. Additional source FD of addition current in to lenses with output parameters 25 V x 400 A is connected through the switches of energy evacuation KFD1, 2 to a chain of consistently connected lenses. The source of addition in to the lenses D with output parameters 15 V x 300 A is similarly connected to a chain of defocusing lenses through switches KD1, 2.

REFERENCES

- [1] NICA Conceptual Design Report, JINR, January 2008.
<http://www.jinr.ru/>
- [2] Khodzhibagiyani H.G., Smirnov A.A., The concept of a superconducting magnet system for the Nuclotron,
Proc. of the 12th Int. Cryogen. Eng. Conf., pp. 841-844, 1988.
- [3] H. Khodzhibagiyani, N. Agapov, A. Kovalenko, A. Smirnov, A. Starikov, Development of fast-cycling superconducting magnets at JINR» *Proc. of the CRYOPrague 06*, Prague, July 2006.