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PHYSICS AND TECHNIQUE OF ACCELERATORS

Power Supplies for the Corrective Electromagnets of the SRF SKIF Injection Complex

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Abstract—The power supplies presented in this article are used as part of the charged particle beam orbit correction system of the injection complex at SRF SKIF. The MPS-20 and MPS-6 (magnetic power supply) and PA-3 (power amplifier) power suppliers presented in the paper can provide electromagnets with currents reaching ±20, ±6, and ±3 A, respectively. All power sources are remotely monitored and controlled via the Ethernet and are made using modern components according to the Euromechanics standard.

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INTRODUCTION

The injection complex of the SRF SKIF includes a linear injector accelerator (linac), a booster accumulator (booster), and beam transport channels [1]. The beam parameters are corrected by corrective electromagnets that require individual power supply. The types of magnets are shown in Table 1.

1. POWER SUPPLY STRUCTURE

Table 2 shows the main parameters of the sources.

Table 1. Types of magnets and required power parameters

Magnet type	Quantity	Maximum supply current	Maximum supply voltage
Linac			
Concealer CK	8	±3 A	10 V
Grouping solenoid	5	5 A	10 V
Matching solenoid	1	5 A	10 V
Concealer CL	6	6 A	2 V
Quadrupole QL (type 1)	5	6 A	2 V
Quadrupole QL (type 2)	2	15 A	5 V
Linac—Booster Canal			
Dipole	4	20 A	15 V
Corrector CX1	4	6 A	24 V
Corrector CY	3	6 A	24 V
Booster			
Sextupol	16	±6 A	60 V
Corrector CX	12	±5 A	8 V
Corrector CY	16	±5 A	8 V
Corrector CX1	8	±5 A	8 V
Channel Booster Synchrotron			
Corrector CX1	11	6 A	9 V
Corrector CY	11	6 A	9 V

The required power supply parameters are satisfied by the PA-3 (power amplifier) and MPS-6 and MPS-20 (magnet power supply) DC sources developed at the Institute of Nuclear Physics, Siberian Branch, Russian Academy of Sciences (INP SB RAS).

Table 2. Power supply parameters

Parameter	Value		
	PA-3	MPS-6	MPS-20
Output current range, A	[–3; 3]	[–6; 6]	[–20; 20]
Maximum output voltage, V	24	24 or 60	50
Output current error (at peak value), ppm A	≤500	≤500	≤100
Output current stability (within 24 h), ppm A	≤100	≤100	≤100
Temperature coefficient of current drift, ppm 1/K	40	40	40
Conversion frequency, kHz	100	60	50
Dimensions, mm	51 × 227 × 266	51 × 227 × 266	432 × 355 × 133

All crates of power supplies are made using the Euromechanics design (manufactured by Schroff). MPS-6 and PA-3 crates are eight-channel (6U size), and crates are controlled by external controllers. The MPS-20 is a single channel power source with an individual built-in controller. The MPS-6 output voltage dynamic range is optional (24 or 60 V) and is determined by the buffer power supply for the crate. Also, depending on the output voltage, the modes of dumping the accumulated energy of the magnet differ. All power supplies for the corrective electromagnets are housed in a Varistar type cabinet (dimensions 600 × 800 × 2000 mm) manufactured by Schroff.

Figure 1 shows a block diagram of power supplies. The control circuit includes a pulse width modulation controller (which includes an error signal amplifier, a sawtooth voltage generator, and a comparator) and voltage sensors. The output current is determined by the pulse width modulation of the output voltage of the bridge made on transistor switches. The low-pass filter suppresses the fundamental frequency of the H-bridge and its harmonics. Two noncontact Hall sensors independently measure the output current; one sensor is used for current regulation and the other for the monitoring system. Current data is transmitted to an external control controller, which also sets the value of the output current.

2. POWER SUPPLY TESTS

Prototypes of power supplies were tested on specialized stands, where the stability of the output parameters was measured. Figure 2 shows the noise spectrum of the output signal from MPS power supplies in the range from 1 to 1000 Hz. The highest noise level (55 ppm A for the MPS-6 and 47 ppm A for the MPS-20) is reached at half the output current level, although even these values meet the stated output current accuracy requirement (Table 1). The measurements were carried out with an external precision instrument (output signal error ≤10^{-6}) by contactless current sensor.

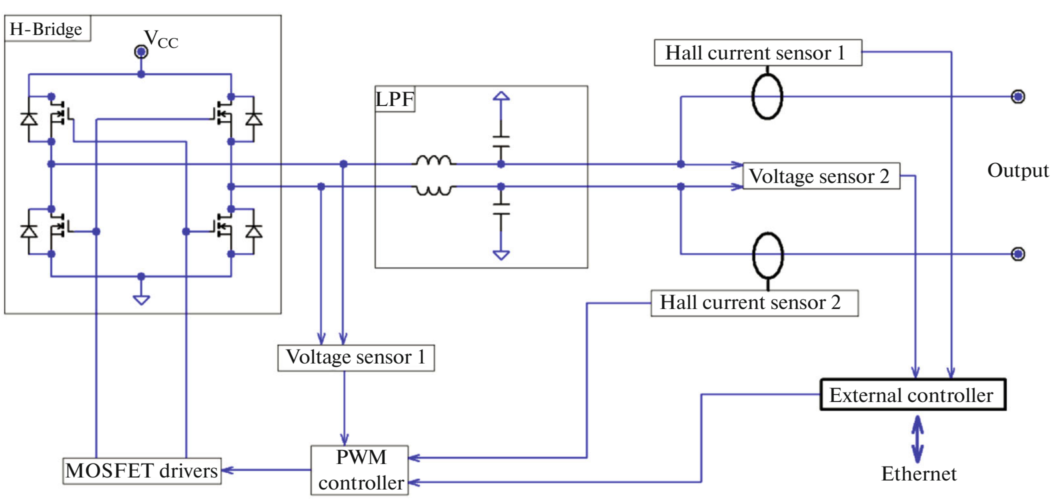

Fig. 1. Block diagram of DC power supplies for the injection complex at SRF SKIF. Vcc is the buffer supply voltage, LPF is the low-pass filter, Hall Current Sensor is the current compensated type sensor on the Hall element, MOSFET Drivers are MOS transistor gate drivers.

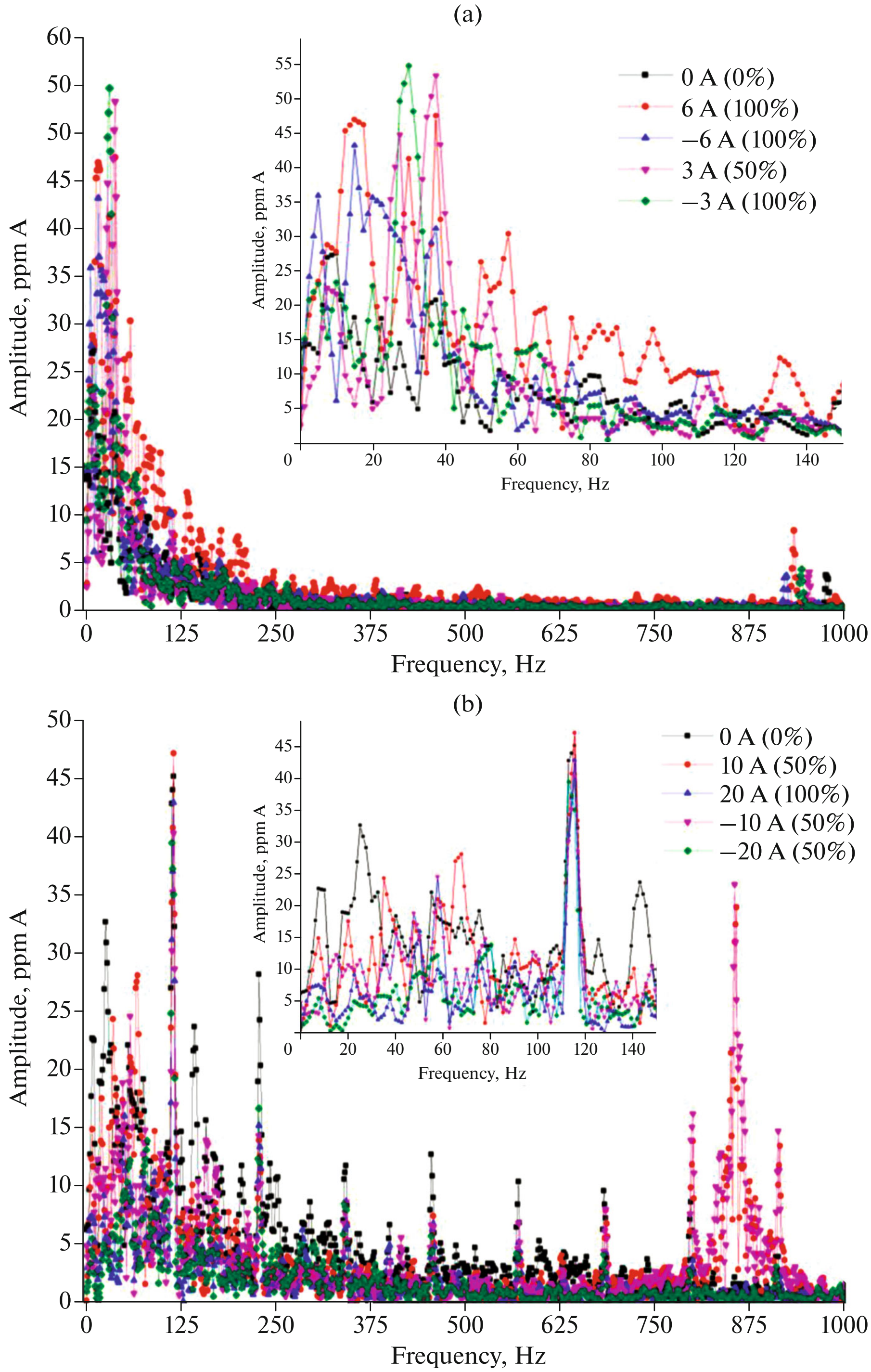

Fig. 2. Noise spectrum of MPS-6 (a) and MPS-20 (b) power supplies at different levels of output current.

Figure 3 shows the spread of the maximum value of the output current of MPS power supplies in 24 hours. The standard deviation meets the stated stability requirements (Table 1); both histograms have a pronounced normal distribution, and more than 95% of events fit into the double standard deviation. The measurements were carried out with an external precision instrument (output signal error $\leq 10^{-6}$) by contactless current sensor.

CONCLUSIONS

The required number of channels to excite the corrective electromagnets of the injection complex has

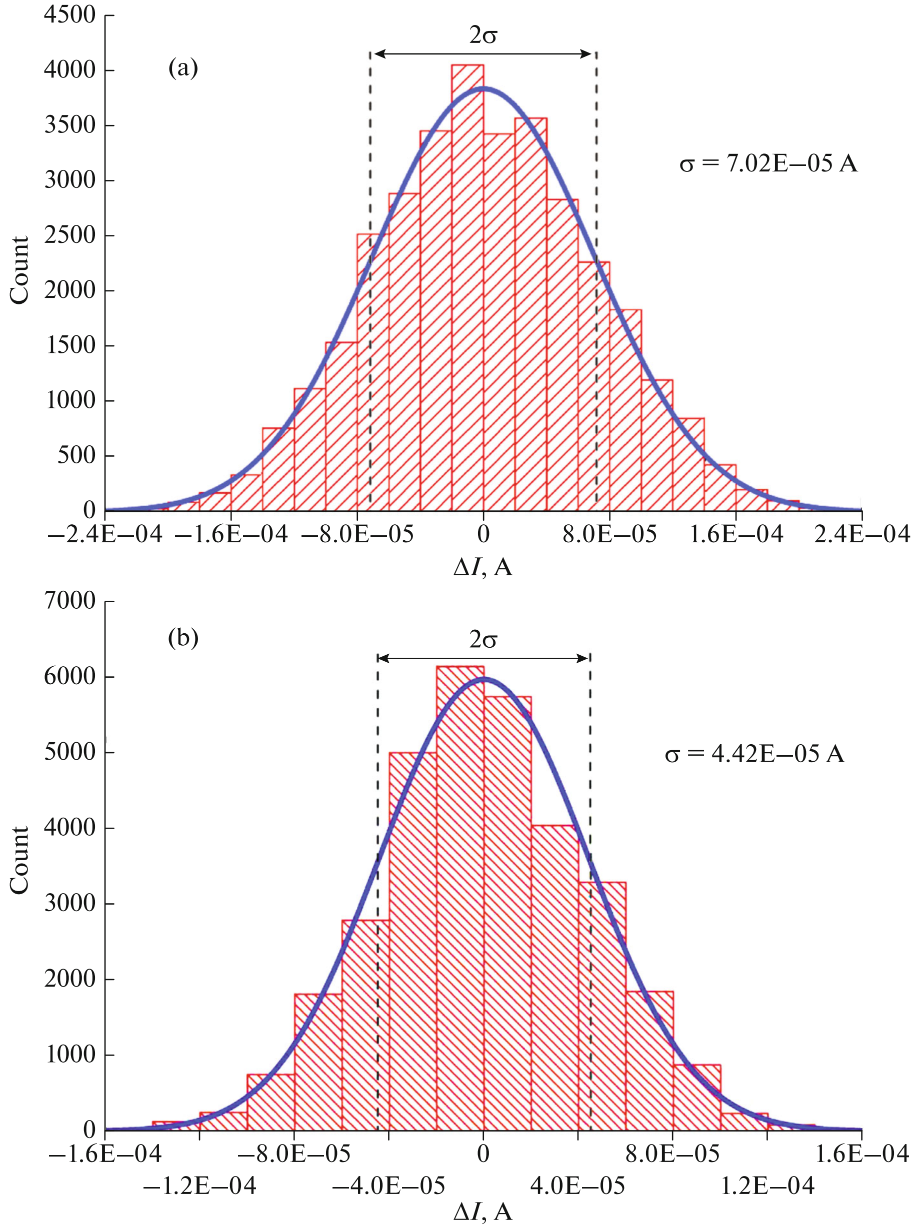

Fig. 3. Output current stability of MPS-6 (a) and MPS-20 (b) power supplies for 24 h. The horizontal axis shows the deviation of the current from the set value [A]; the numbers of registered events are along the vertical axis.

been produced. All manufactured power supplies have been adjusted and laboratory tested and are in safekeeping, awaiting work with the beam.

CONFLICT OF INTEREST

The authors declare that they have no conflicts of interest.

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