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Power supply system for corrector magnets of the European X-Ray Free-Electron Laser

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Abstract

The total length of the European XFEL is 3.4 km. The electron beam parameters are corrected by about 300 corrector magnets, each powered by an individual power supply. BINP performed the development, production and delivery of the power supply system for the corrector magnets. For the powering of the corrector magnets, seven types of precision power supplies with output currents of up to 10 A and output voltages of up to 70 V were developed. To ensure high reliability of the power supply system BINP developed a "redundancy" system, which enables remote replacement of a faulty power supply with a spare one.

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1. Introduction

The European X-ray Free-Electron Laser (XFEL) is designed for generation of synchrotron radiation with an intensity of 27 000 bunches per second, a wavelength of 0.05 to 4.7 nm, and a peak brightness of $5 \cdot 10^{33}$ ph/(s·mm²·mrad²·0.1% bandwidth). To attain the above parameters it is necessary to have an electron beam of extreme quality. The XFEL structure comprises a linear superconducting accelerator with maximum electron energy of 17.5 GeV, several photon tunnels with undulators, and premises for experiments. The total length of the tunnels is 5.77 km (Fig. 1). The XFEL magnetic system structure includes 296 corrector electromagnets:

- Injector tunnel (XTIN) – 13 pcs.
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- Entrance shaft (XSE) – 12 pcs.
- Linac tunnel (XTL) – 122 pcs.
- Shaft 1 (XS1) – 35 pcs.
- Distribution tunnel 1 (XTD1) – 32 pcs.
- Distribution tunnel 2 (XTD2) – 44 pcs.
- Distribution tunnel 3 (XTD3) – 22 pcs.
- Distribution tunnel 4 (XTD4) – 7 pcs.
- Distribution tunnel 5 (XTD5) – 9 pcs.

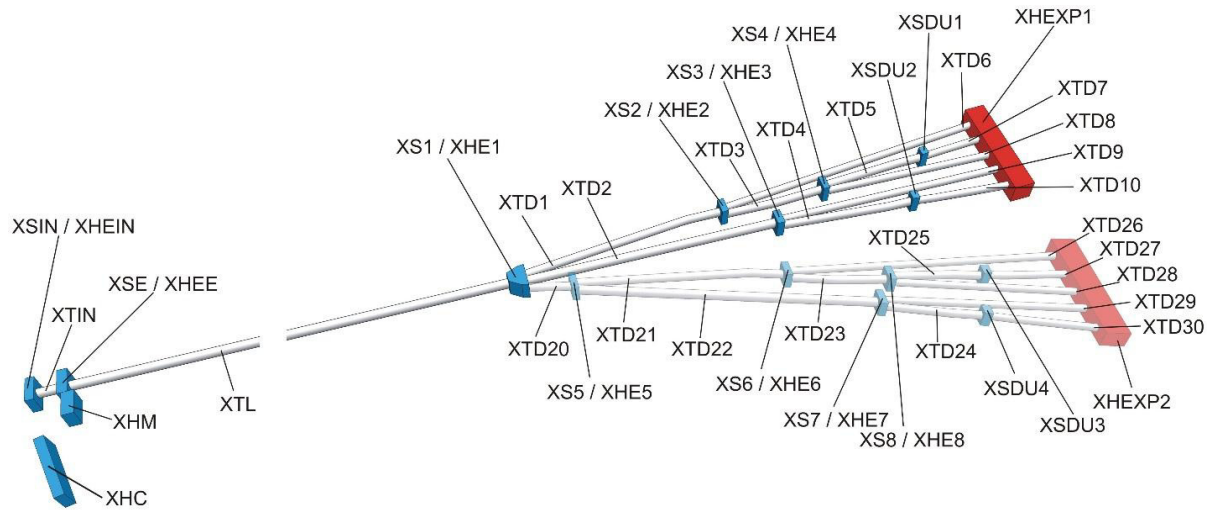


Fig. 1. XFEL nomenclature.

In accordance with the requirements to the magnetic system, each corrector electromagnet shall be powered by a separate precision current source (magnet power supply, MPS). The MPS required parameters are given in Table 1.

Table 1. Requirements to corrector power supplies.

Parameter	Specified Value	Unit
Output current, max.	$\pm 5 / 10$	A
Output voltage, max.	$\pm 70 / 60$	V
Minimum current setting step	< 4	ppm
Short-term current deviations (up to 1 sec)	< 10	ppm
Long-term current deviation (1 sec to several years)	< 100	ppm
Temperature coefficient of output current drift	< 6	ppm/K
Output current non-linearity	< 20	ppm
Efficiency of power part	> 90	%
Mean time between failures (MTBF)	$> 100\,000$	hrs

2. Structure of power supplies.

The power supplies for the XFEL corrector magnets are divided into two groups, with maximum output currents of 5 A and 10 A. Since the corrector electromagnets have different resistances, power supplies with different maximum output voltages were required. The result is seven types of the power supplies, the maximum values of their output parameters shown in Table 2.

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