POWER SUPPLY SYSTEM FOR SESAME BOOSTER

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Abstract

The SESAME[1] Booster, with a circumference of 38.4 m, has several bending magnets, focusing and defocusing quadrupoles and also the injection and extraction septums and kickers. There will be one ramping power converter which supplies a series of 12 dipole magnets. Also 12 focusing magnets family and 6 defocusing magnets family are supplied separately with two ramping power converters. Technical issues of all the ramping and pulsed power supplies needed for the SESAME Booster are discussed in this paper.

INTRODUCTION

SESAME Synchrotron facility will comprise a 2.5 GeV electron Storage Ring that will generate synchrotron radiation, a 22 MeV Microtron pre-accelerator and the 800 MeV Booster. The Booster is composed of 12 dipole magnets, 12 focusing quadrupole (QF) magnets and 6 defocusing quadrupole (QD) magnets which form three families of magnets. Each magnet family is supplied by one ramping power converter. During acceleration of the electrons in the Booster, the magnetic field in all these magnets has to be synchronously increased from low values at injection of 22 MeV to high values at the final extraction energy of 800 MeV. Fig. 1 shows the Booster cell arrangement with two dipoles, two QF's and one QD.

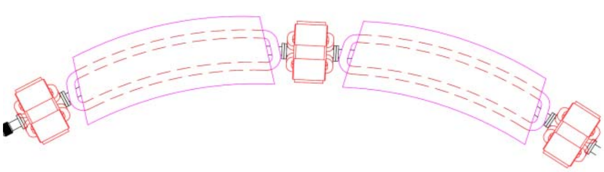

Figure 1: A Typical Booster cell arrangement.

In addition, there are four pulsed power supplies for the four separate injection/extraction magnets for the incoming to and outgoing from Booster. These power supplies are available from BESSY I Booster and are already under tests at SESAME.

DIPOLE POWER CONVERTER

Unlike the BESSY I Booster [1, 2], the so-called *White Circuit* topology is not employed at SESAME to supply the three families of Booster magnets. The main reasons were the old age of the BESSY I white circuits and the need for replacement of many parts and at the same time the lack of some spare parts. However at SESAME Booster unlike the 10Hz repetition rate of BESSY I, the operation cycle will be limited to 1 Hz. The power converters rating is based on extraction energy with 10% safety margin for the cables drops and operation issues. Fig. 2 shows the current and voltage of the dipole magnet series [3]. The stability requirement of the output current is of 100 ppm and the tracking between different families should be better than 0.2%. As a consequence, a modular IGBT solution will be preferred to the common SCR controlled rectifier technology.

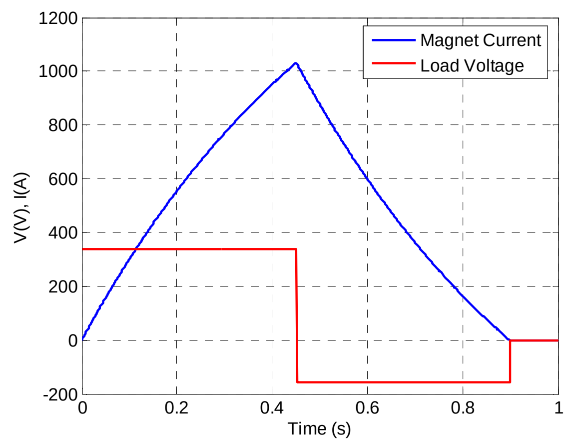

Figure 2: Current/Voltage waveform for the dipole magnet family.

The power converter is composed of 6 modules, connected in parallel, with 12 pulse rectification topology. Each module has the 4Q power converter in order to have good tracking even at low currents. During each Booster cycle, which is 1 second, an energy transfer occurs between the power converters and their magnets circuit. In order not to put huge reactive power on the electrical mains, the DC-link capacitors with total capacity of 1 Farad are employed. This capacitor is large enough to store 28kJ of magnet energy during the discharge time. The operating repetition rate of synchrotron is 1 Hz. Hence the rising and falling time for the current in the magnet take 0.9 second, which follows with a 0.1 second of rest in the magnets fields. Fig. 3 shows a simplified layout of 2 out of 6 modules for the dipole magnet power

[1] Synchrotron-light for Experimental Science and Applications in the Middle East is an independent intergovernmental organization developed under the auspices of UNESCO. It involves at present the following members: Bahrain, Cyprus, Egypt, Islamic Republic of Iran, Israel, Jordan, Pakistan, Palestinian Authority and Turkey.

converter and Table 1 its main parameters.

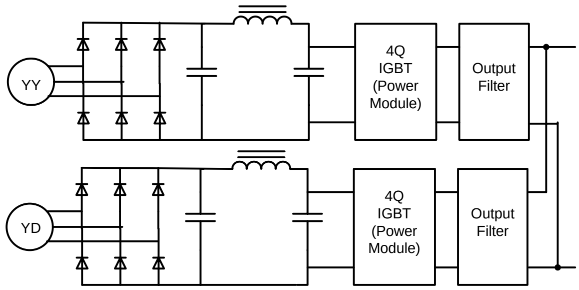

Figure 3: Simplified layout of 2 out of 6 modules for dipole magnet power converter.

Table 1: Dipole, QF/QD Power Converter General Parameters

PS Specs	Dipole	QD	QF
Output Current (ramped)	0-1050 A	110 A	120 A
Stability (8 hours)	100 ppm	100 ppm	100 ppm
Tracking	0.2%	0.2%	0.2%
Current setting	16 bit	16 bit	16 bit
Load Inductance	103 mH	45 mH	89 mH
Load Resistance (at 25 ^{0}C)	175 mΩ	370 mΩ	740 mΩ
Load Power (Peak)	375 kVA	6.3 kVA	14 kVA
Power (avg.)	76 kW	1.8 kW	4.2 kW

QF AND QD POWER CONVERTERS

The output of QF family and QD family power converters will simultaneously follow the one of the dipole with tracking better than 0.2% due to the tune shift limitations in the Booster during ramping process. In both cases the power supply is composed of a 12 pulse bridge rectifier and 4Q regulation with a DC-link capacitor in a small size compare to the dipole PS. Figure 4 shows a simplified layout of the QF/QD power converters.

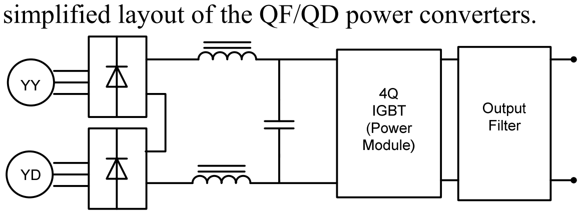

Figure 4: QF/QD Power Converter layout.

The typical waveform for the QF/QD power converters are given in Fig. 5, and the corresponding specifications are given in Table 1 [3].

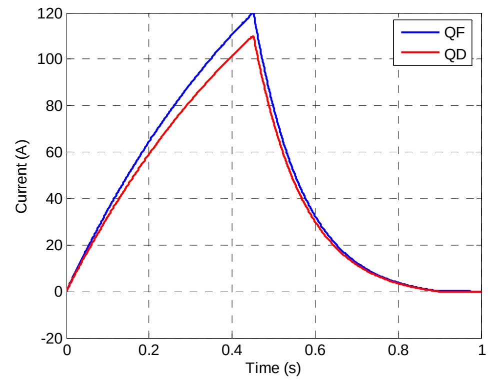

Figure 5: QF/QD typical current waveform.

PULSE MAGNETS POWER SUPPLIES

The injection of the 22 MeV beam from the Microtron to the Booster is performed by means of one 14.3 degree septum magnet and one injection kicker magnet. The extraction kicker magnet is connected physically to the injection one and the extraction septum magnet will eject the beam to the transfer line horizontally towards the Storage Ring. All the magnets and their power supplies are the repaired and modified ones from the BESSY I Booster.

INJECTION SYSTEM

The Booster injection system is based on one turn scheme with one kicker and the septum deflector. The electrostatic septum magnet is energized with a sinusoidal voltage of 100 kV from its power supply. This is composed of the electronic rack and low voltage to 500 V, connected to the pulse transformer in series with resonance capacitor and inductor. The alternating pulse duration is 500 μs and the repetition rate of the pulse unlike the BESSY I is 1 Hz. The electronic rack design is based on a capacitor discharge through the inductor via a thyristor SKT 12F08D, which the replacement is available on the market. In addition there is a capacitive voltage divider at the pulse transformer output to measure directly the output voltage. In Fig. 6 a simplified layout of injection septum PS is shown. See the waveform in Fig. 7.

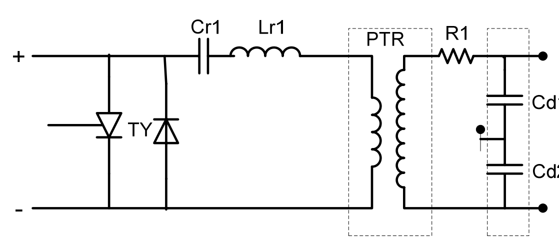

Figure 6: Simplified Injection Septum PS layout.

Figure 7: The injection septum voltage waveform.

The injection kicker magnet is a one-turn current loop coil with the nominal current of 200 A and the pulse duration of 4µs. The current supply (Fig .8) design is based on capacitor bank discharge through damping resistors via thyristor sets.

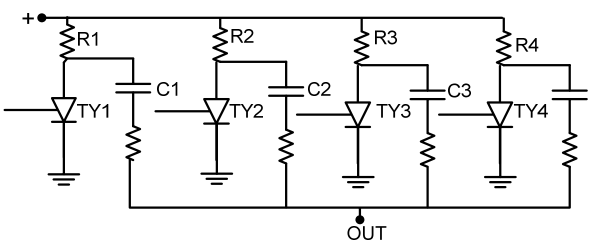

Figure 8: Simplified Injection kicker PS layout.

Table 2 gives the parameters related to the injection system of the Booster.

Table 2: Booster injection system general parameters

	Septum	Kicker
Deflection/kick	14.3^0	6.10^{-4} Tm
Rep. Rate	1 Hz	1 Hz
Field	100 kV/cm	0.2 mT
Length (effective)	50 cm	30 cm
Pulse duration	250 µs	4 µs

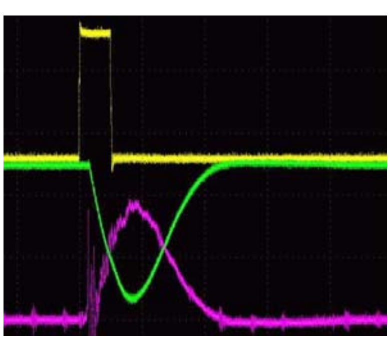

Figure 9: The injection kicker current (Green) measurement results. H:V /div.(100A:2us).

In Fig. 9 the green curve is the injection kicker current measured pulse with amplitude of 200 A and the pulse duration of 4 µs, in which the injected beam from Microtron will arrive just after the crest.

EXTRACTION SYSTEM

The Booster extraction system is composed of one extraction kicker and one active septum (see Table 3). The power supply design of septum magnet is based on a resonance circuit and the one for kicker is based on Pulse Forming Network (PFN) made of coaxial lines.

Table 3: Extraction system general parameters

	Septum	Kicker
Deflection/kick	10^0	5.10^{-3} Tm
Rep. Rate	1 Hz	1 Hz
Current/Voltage	5.2 kA	30 kV
Length (effective)	1 m	1 m
Pulse duration	500 µs	190 ns

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