THE PULSED POWER SUPPLIES OF THE SESAME BOOSTER AND STORAGE RING

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Abstract

SESAME the Synchrotron Radiation Light Source in Allan (Jordan) consists of an 800 MeV injector (original from BESSY I, Berlin, Germany) and a 2.5 GeV Storage Ring. Injection into the Booster is done by an electrostatic Septum and one stripline kicker. Extraction out of the Booster is done by means of a bumper magnet, a strip-line-line kicker and a direct driven in-vacuum septum. Injection into the Storagering is done by a direct driven out-off vacuum septum and one kicker. The pulses of all septa are full sine, the ones of the kicker half sine with exception of the extraction kicker (flat-top). Extraction Kicker and Storage ring injection kicker are switched by Thyratron, all others via transistors. This report describes the injection and extraction optics and the results of the commissioning.

BOOSTER INJECTION

A 2 µs long electron-pulse from the 20 MeV Microtron is deflected by an electrostatic septum into the Booster. The advantage of an electrostatic septum is having a septum sheet of 0.1 mm only compared with2-3 mm typical for a magnetic septum. The disadvantage of this septum is the needed high voltage of 100 kV, which is not stable due to occasional sparking. The 100 kV is provided by a step-up-transformer (1:250) with a LC circuit on the primary side. The parameters of the Booster injection septum are given in Table 1. Fig.1 shows the cross section of the septum together with the one for the injection kicker. Figure 2 gives the schematic circuit diagram for the power supply of the electrostatic septum.

Table 1: Parameter of the Booster Injection Septum

Injection Septum (Electro static)		
Beam Energy	20	MeV
Deflection angle	14.3	deg
Septum length	0.5	m
Septum radius	2	m
Electric field	10	kV / mm
Electrode Distance	10	mm
Transformer ratio	250 : 1	
Half sine pulse width	250	µs
Charging inductance	620	µH
Charging capacitance	10	µF
Charging voltage	400	V
Charging unit (FUG-MCP 350-1250)	1.25 / 250	kV / mA

The electrons entering the Booster off axis are oscillating and get a kick opposite to the septum, which prevents them from hitting the septum sheet after 4 turns. The kicker is an in-vacuum strip-line (one turn). The plates are separated by 94 mm. The kicker pulse is a half sine, provided by a LC circuit. The Parameters are given in Table 2. The electrons are injected in the falling slope of the pulse. Overall several 128ns long turns in the booster can be overlaid from the pulse of the Microtron (multi turn injection). Table 2 gives the parameter of the kicker power supply, Fig. 3 gives a schematic circuit diagram, which is the same also for the storage ring injection kicker.

Table 2: Parameter of the Booster Injection Kicker

Injection Kicker (In-Vacuum-strip-line, Half sine)		
Beam Energy	20	MeV
Deflection angle	4	mrad
Magnetic length	0.3	m
Distance conductor	0.094	m
Magnetic field	1	mT
Current	50	A
Half sine pulse width	4	µs
Magnet inductance	1	µH
Charging Conductance	1.6	µF
Charging voltage	60	V
Charging unit (FUG-MCP 350-1250)	1.25 / 250	kV / mA

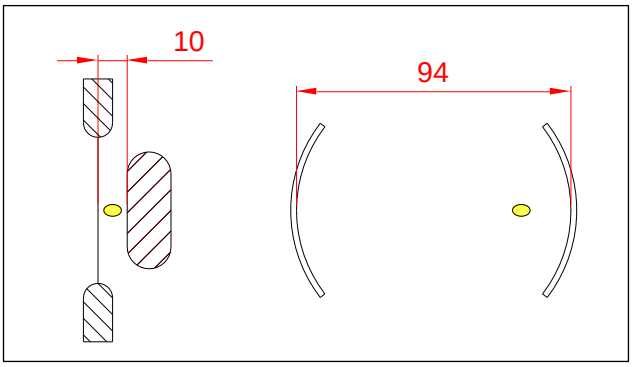

Figure 1: Cross-section of the Booster Injection Septum and Kicker.

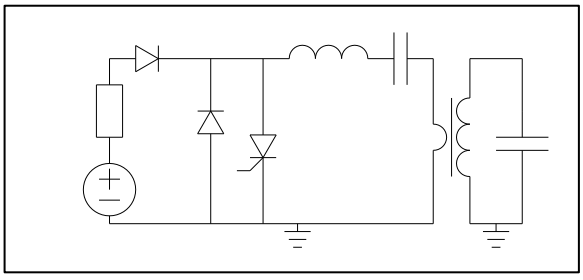

Figure 2: Schematic Circuit diagram of the electrostatic Septum.

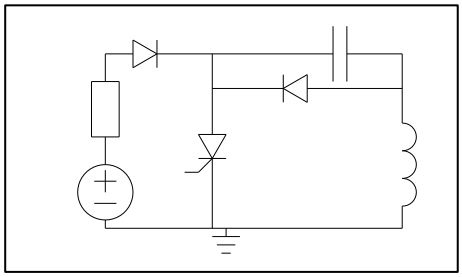

Figure 3: Schematic circuit diagram of the injection kicker.

BOOSTER EXTRACTION

For extraction out of the Booster the electrons are moved towards the extraction septum by a fast corrector magnet (Bumper). Then a fast kick with a flat top moves the beam further out into the path of the extraction septum. The Bumper magnet is the same as used for orbit correction but with fewer windings. The pulse is a full sine from a LC circuit. The parameters are given in Table 3. Fig.4 gives a schematic circuit diagram for the Bumper PS, which is the same for the other full sine circuits: the Booster extraction and storage ring injection septum.

Table 3: Parameter of the Booster Extraction Bumper

Extraction Bumper (Magnetic, Full sine)		
Beam Energy	0.8	GeV
Deflection angle	3	mrad
Magnetic length	0.17	m
Magnetic pole gap	78	mm
Yoke Lamination thickness	1	mm
Magnetic field	47	mT
Current	50	A
Full sine pulse width	3.5	ms
Magnet inductance	700	µH
Charging capacitance	440	µF
Charging voltage	75	V
Charging unit (DELTA-SM 400 AR4)	400 / 2	V / A

The extraction kicker is built from four rods in a vacuum vessel, vertical separated by 19 mm, horizontal by 30 mm. The rods which are vertical separated are electrically connected and form one side of the magnetic loop. The centre of the rods is off centred by 20 mm compared to the stored beam, which coincides with the orbit of the beam when moved by the bumper. This open design constitutes no obstacle for the injected beam, but allows short distances in the horizontal to get a high magnetic field. The parameters of the extraction kicker are given in Table 4. Fig. 5 shows the cross section of the septum together with the one for the injection kicker. Fig. 6 gives a schematic circuit diagram for the septum power supply.

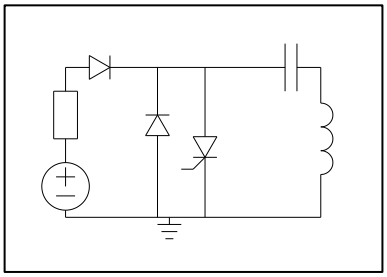

Figure 4: Schematic circuit diagram of the Bumper PS.

Table 4: Parameter of the Booster Extraction Kicker

Extraction Kicker (In-Vacuum-strip-line, flat top)		
Beam Energy	0.8	GeV
Deflection angle	2.0	mrad
Magnetic length	1	m
Distance conductor	30	mm
Magnetic field	5	mT
Magnetic Inductance	1	µH
Delay line length	19	m
Delay line properties (RG 214 50 Ω)	100 250	pF/m nH/m
Current	300	A
Rise-time/flat-top	40/ 190	ns
Charging voltage	30	kV
Charging unit (FUG-CP-35-35000)	35 / 1	kV / mA

The Kicker is located one section before the septum. The septum is an in vacuum direct-driven magnet built by four blocks of laminated iron to form quasi a sector magnet. The conductor side, which forms the septum sheet, is changing in width at the entrance of 0.5 mm to 2 mm. The parameters for the Booster extraction septum are given in Table 5.

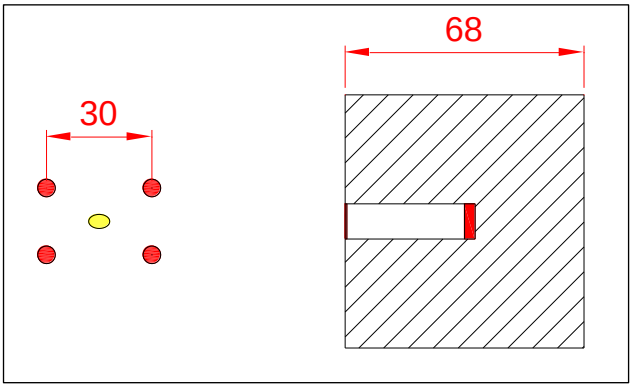

Figure 5: Cross-section of Booster Extraction Septum and Kicker.

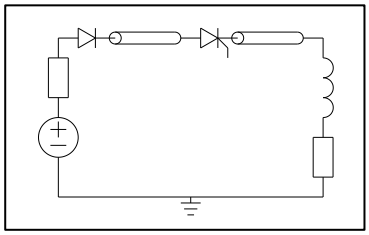

Figure 6: Schematic circuit diagram of the extraction kicker.

Table 5: Parameter of the Booster Extraction Septum

Extraction Septum (Magnetic, Full sine)		
Beam Energy	0.8	GeV
Deflection angle	10	deg
Magnetic length	1	m
Radius	5.73	m
Magnetic pole gap / width	10 / 38	mm / mm
Yoke material	Laminated iron	
Magnetic field	0.465	T
Current	3700	A
Full sine pulse width	0.92	ms
Magnet inductance	6	µH
Charging conductance	3.5	mF
Charging voltage	174	V
Charging unit (DELTA-SM 400 AR4)	400 / 2	V/ A

STORAGE-RING-INJECTION

While the injection and extraction elements of the Booster are the old BESSY ones concerning the magnets it selves, the injection septum and the injection kicker magnet of the storage-ring are new ones, as the complete storage ring. The injection septum is an out of vacuum direct driven septum, comparable to the ALBA design. Both the septum and the kicker have been made by Danfysik. The incoming beam passes through a 13 x 13 mm pipe sandwiched by the conductor, all glued into the 15 x 20 mm gap of the magnet yoke. The chamber for the stored beam is made from soft iron to shield stray fields from the septum magnet. The pulse-form is also full-sine. The parameters are given in Table 6. Fig.7 shows the cross section of the septum together with the one for the injection kicker.

Table 6: Parameter of the Storage Ring Injection Septum.

Injection Septum(Magnetic, Full sine)		
Beam Energy	0.8	GeV
Deflection angle	9	deg
Magnetic length	0.75	m
Magnetic pole gap / width	15 / 20	mm
Lamination thickness	0.5	mm
Magnetic field	0.6	T
Current	6200	A
Inj.Beam vacuum aperture	13 x 13	mm
Stored Beam vacuum pipe	Soft iron	
Septum sheet thickness	3	mm
Full sine pulse width	700	µs
Magnet inductance	2.5	µH
Charging capacitance	5.82	µF
Charging voltage	153	V
Charging unit (Delta SM 400-AR-4)	400 / 2	V / A

The incoming beam is oscillating and gets a kick five cells behind the injection point, at a location it passes the centre, the kick reduces the oscillation of the incoming beam but induces oscillation to the stored beam, but in summa both oscillation allow the two beams to stay from the septum sheet and are then damped. The vacuum chamber of the kicker is made from ceramic with a 1.5 µm thick Ti layer. The thickness is a compromise between damping of the fast pulse and heating by the mirror current. The magnet is a C magnet with 15 mm thick Ferrite yokes. The pulse is half sine from a LC circuit; the parameters are given in Table 7.

Table 7: Parameter of the Storage Ring Injection Kicker.

Injection Kicker (Magnetic, Half-Sine)		
Beam Energy	0.8	GeV
Deflection angle	2.0	mrad
Magnetic length	0.3	m
Magnetic pole gap / width	38 / 100	mm
Yoke Ferrite thickness	15	mm
Magnetic field	17	mT
Current	500	A
Ti thickness	0.15	µm
Full sine pulse width	1.1	µs
Magnet inductance	1	µH
Charging capacitance	36	nF
Charging voltage	5.0	kV
Charging unit (FUG-CP-14-6500)	6.5 / 2	kV / mA
Switch EEV (CX 1159)		

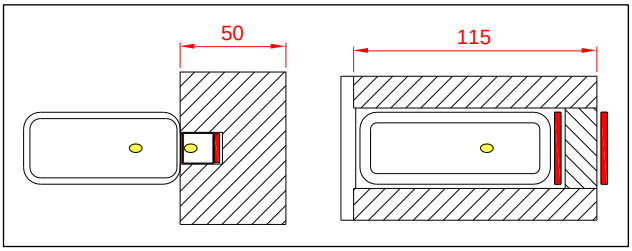

Fig.7: Cross-section Storage-ring Injection Septum and Kicker.

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