PULSE GENERATORS FOR SEPTUMS AND BUMPS OF INJECTION AND EXTRACTION SYSTEMS NSLS-II BOOSTER

Batrakov A.M., Chernyakin A.D., Kiselev V.A., Pavlenko A.V., Senkov D.V.,Zhuravlev A.N.,
BINP SB RAS, Novosibirsk, 630090, Russia

Abstract

Pulse generators for injection and extraction systems of NSLS-II 3 GeV booster designed, manufactured and tested in BINP, Russia and installed and tested at BNL site. This report considers the details of bump injection septum and extraction septum pulse generators design, their parameters and results of inspection test in BINP. The design and electronics features control system of pulse generators are presented.

Finally, the first results of injection and extraction section commissioning at BNL site are reported.

INTRODUCTION

NSLS-II is a new third-generation storage-ring light source that is under construction at Brookhaven National Laboratory. The booster NSLS-II will accelerate electrons from 200 MeV to the nominal energy of 3 GeV. The repetition rate of the booster is 1 or 2 Hz, depending on the state of the injector. In order to reduce the requirement for the linac's beam charge, the booster injection was designed to provide beam stacking with 100 ms stacking time [1][2].

Pulsed magnets are used for the beam injection and extraction to the booster. Table 1 shows the parameters of the power systems for septums and bumps magnets.

Table 1: Pulsed Magnet Power System Parameters

Parameter	Injection septum	Extraction septum	Bump magnets
Energy, MeV	200	3000	3000
Field, T	0.111	0.8	0.46
Self-inductance, μH	1.8	2.1	55
Bank capacitance, μF	600	1200	900
Energy, J	6.5	108	325
Pulse duration, ½ sine μs	106	156	1500
Field error tolerance, %	±0.05	±0.02	±0.2
Peak Current, A	2800	10220	1500
Peak Voltage, V	215	510	870
Repeat time, ms	100	500	500
Power loss (2 Hz)W	10	150	200

*Work supported by the Ministry of Education and Science of the Russian Federation

The all three types of pulse generators: for injection septum, for extraction septum and for bumps have the same design. Small inductance and big pulse current in load excludes the distant location of generator from the load. So the generators are divided into 2 parts – first parts of generators are located in the service area and contain the control and trigger unit and the charger (Control Unit), the measuring electronics (VsDC) and the control systems (PSI and EVR [1]). The second high current parts (Pulser Unit) are mounted on girder under the targets magnet in the booster ring and contain the capacitance bank, powerful switch with the driver and the interface to magnets. The pulse generator block diagram is shown on Fig. 1.

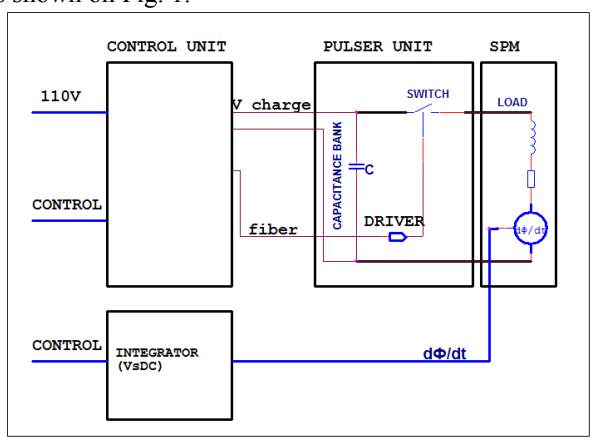

Figure 1: Pulse generator block diagram.

The charging source charges the capacitor bank up to the preset voltage. At the moment *"tstart"*, from the control system of Booster, which is before the bunch pass by, the control circuit opens the switch, which commutates the charged capacitor bank on the magnet as shown at Fig. 2. For the beam current bunch duration about 300 ns when it pass the magnet, the magnetic field variation not exceed $\pm 2 \cdot 10^{-4}$ of maximal current value.

The field stabilization system is based on field measuring coil and the BINP produced integrator VsDC [3]. This device is made in VME standard, it integrates the input signal since the moment of "start" signal (t1) up to the "stop" signal (t2), providing the integral of input signal $V_{out} = \int_{t1}^{t2} V_{in}(t) \cdot dt$ as a result. Measuring coils are installed into each septum and bump magnet. The EMF voltage $\varepsilon \approx \frac{d\Phi(t)}{dt}$ is induced at the coil and is applied to VsDC integrator. The integral value from

VsDC is proportional to magnetic field in septum (bump) at the moment *t2*, i.e. just before the bunch passage. The control system stabilize the measured field value: it compares it with the required one and changes the reference voltage value on the capacitor bank.

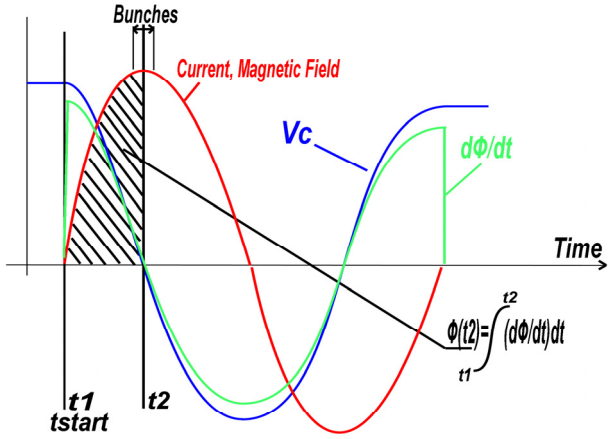

Figure 2: Current, voltage and magnetic field waveform.

SEPTUM MAGNETS POWER SUPPLIES

There are the General Atomic capacitors 325DM410 100 μF 2.5 kV is used in all three pulse generators. In the injection septum pulser unit is used one thyristor switch ELECTROVIPRYAMITEL TFI 353–1000–20, in the extraction septum are used two the same switches which commutate two part of capacitance bank. So in the each brunch pulse current do not exceeded 6kA. For the capacitance bank charge is used charging device based on Ultravolt C250 series device. In the injection septum control unit is used two 250 V 1 A Ultravolt PS, in the extraction septum control unit is used two 500 V 0.5 A device. The thyristor's drivers are triggering by fiber link. The fiber link is used for better noise reliability and decrease interference between these blocks and other pulse devices, such as kickers.

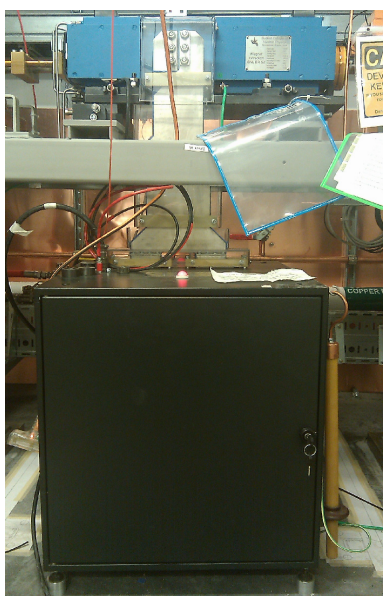

Figure 3: Extraction septum pulser unit.

The results of tests septums pulse generators at the BNL site are given on the Figures 4 - 7.

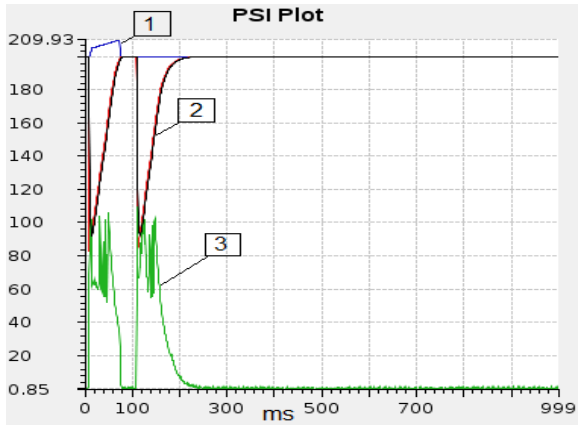

Figure 4: Stacking mode injection event septum pulse generator voltage waveforms. 1 – V:DAC, 2- V:C, 3- I:Charge.

In the Fig. 4 is shown the injection septum generator capacitance bank voltage, capacitance bank charging current waveforms in the stacking mode of booster. The long term stabilities of injection septum pulser capacitance bank voltage before pulse and injection septum magnetic field are given on Fig. 5.

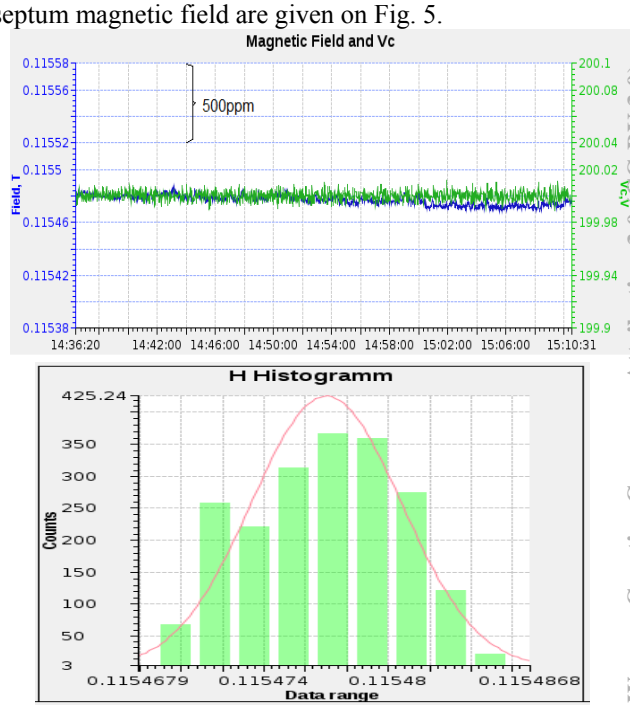

Figure 5: The injection septum long-term stability.

On the Fig. 6 and Fig. 7 are presented extraction septum generator capacitance bank voltage, capacitance bank charging current waveforms and long term stability of extraction septum magnetic field.

ISBN 978-3-95450-122-9

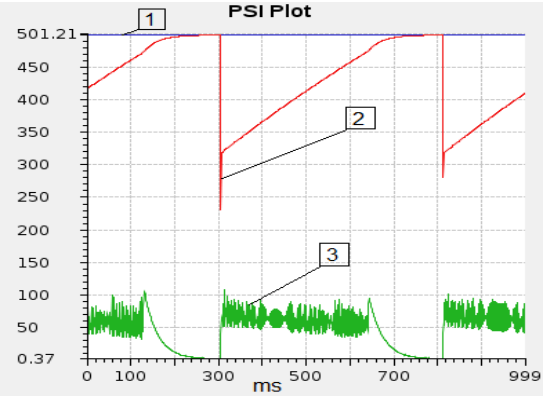

Figure 6: 2 Hz mode extraction events septum pulse generator voltage waveforms. 1 – V:DAC, 2- V:C, 3- I:Charge.

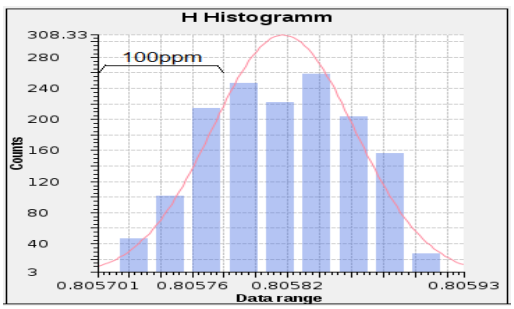

Figure 7: The extraction septum long-term stability.

BUMP MAGNETS POWER SUPPLY

All four bumps magnets are powered serially by bump pulser. The field in the all magnets must be identity, so for precision tuning are used additional inductors, connected in parallel with each bump magnet as shown on Fig. 8 [4].

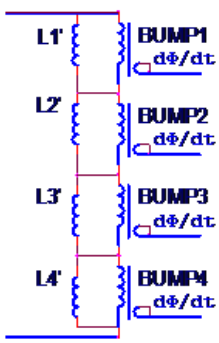

Figure 8: Bumps magnet current precision tuning.

The pulser unit construction is similar to injection septum pulser, but with the greater number of capacitors. There are nine General Atomic capacitors 325DM410 100 µF 2.5 kV is used in bumps pulser. For the capacitance bank charge is used three 1kV 0.25A Ultravolt PS located in control unit. The thyristor's driver is triggering by fiber link. The results of tests bumps pulse generator at the BNL site are given on Figures 9, 10. On the Fig. 9 and are presented bumps generator capacitance bank voltage, capacitance bank charging current waveforms and on the Fig. 10 are shown long term stability of bumps magnetic field.

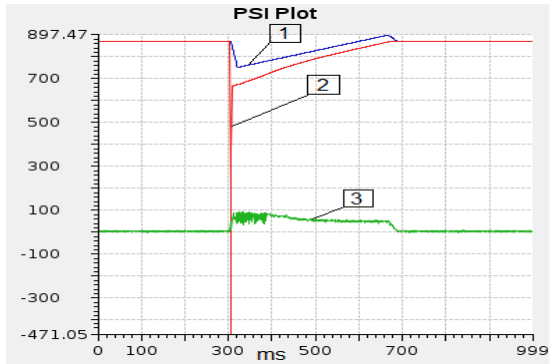

Figure 9: 1 Hz mode extraction events Bumps pulse generator voltage waveforms. 1 – V:DAC, 2- V:C, 3- I:Charge.

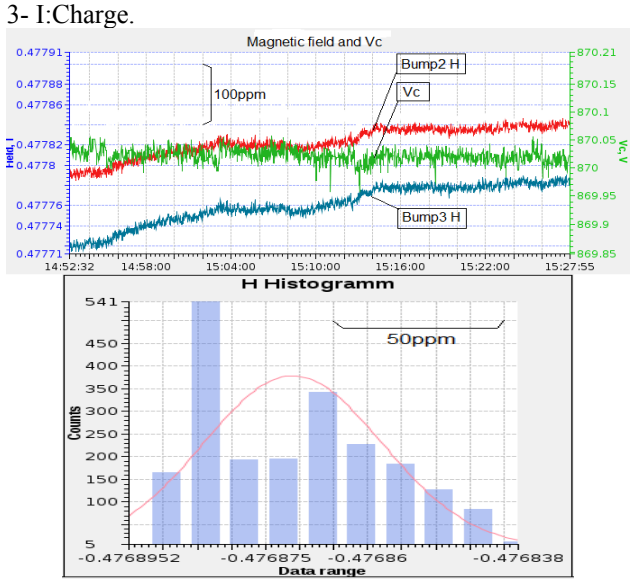

Figure 10: The Bumps field long-term stability.

CONCLUSION

All pulse generators have been completely constructed and assembled at the NSLS-II booster. Integrated tests were carried out and gave good results. The injection and extraction sections of the booster are ready for accelerator start-up.

REFERENCES

[1] T. Shaftan et all, "NSLS-II Booster Design", NSLS-II Technical note, 0061, BNL, USA, 2009.

[2] R. P. Fliller, R. Heese, S. Kowalski, J. Rose, T. Shaftan, G. Wang "Beam Stacking in the NSLS-II Booster," TUPEC041, Proceedings of IPAC'10, Kyoto, Japan.

[3] A. Batrakov, A. Pavlenko, I. Ilyin, "Electronics for Precise Measurements of Accelerator Pulsed Magnets," THPEA033, these proceedings.

[4] A. Zhuravlev, V. Kiselev et all, "Pulsed Magnets for Injection and Extraction Sections of NSLS-II 3 GeV Booster," THPME033, these proceedings.