SNS EXTRACTION KICKER POWER SUPPLY MANUFACTURE STATUS*

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Abstract

There are fourteen PFN power supplies, which will be installed in the SNS Extraction Kicker System. The Pulse Forming Network (PFN) power supplies for the SNS Extraction kicker were designed by Brookhaven. The basic configuration of the PFN is a lumped element Blumlein pulse forming network (BPFN). The PFN and power supply are fabricated by Applied Power Systems. The first-article PFN and power supply have been manufactured and were tested with a dummy load at the company and onsite with the prototype magnet. The PFN has been tested beyond its specification and has met all requirements including rise time, pulse flatness, amplitude and pulse repetition rate. Additional heat runs are scheduled. The transverse coupling impedance of the extraction kicker magnet with attached PFN has been measured. This paper will report on the SNS Extraction Kicker Power Supply engineering status, and will include output waveforms, impedance measurements, and production projections.

INTRODUCTION

Fourteen PFN power supplies will be installed in the SNS Extraction Kicker System. Each PFN power supply will energize one magnet, which is located in the Accumulator ring tunnel. Each PFN power supply consists of a PFN modulator tank and a charging power supply rack.

The PFN modulator is a Blumlein type pulse forming network. There are 15 high voltage and low inductance capacitors mounted in each side of the Blumlein PFN. A high voltage thyratron made from E2V is used as a high speed switch to discharge the PFN energy. Two 200 m long high voltage RF Cables connect the magnet to the PFN modulator tank. These two cables are connected from PFN tank to each magnet in the tunnel though cable tray and cable conduit. In the tank, a 25-Ohm matching resistor is connected in parallel with the Blumlein PFN. A ferrite saturable inductor is connected in serious between the PFN output and the matching resistor. A cooling system is used to cool the PFN modulator.

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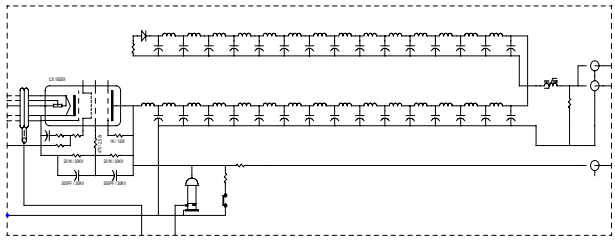

Figure 1: BPFN modulator Schematic diagram.

The charging power supply rack contains a 50 kV capacitor charging power supply, filament and reservoir power supply, and PLC controller. One 3U sub-rack, which contains a voltage monitor and a pulse monitor are installed in the power supply rack too.

Figure 2: Charging power supply rack picture.

The main specifications of the PFN modulator and charging power supply are listed as follows:

Operation voltage:	35	kV
Operation current (peak):	2.4	kA
Maximum Pulse repetition:	60	Hz
Pulse rise time:	200ns (1% to 95%)	
Pulse flat top time:	700	ns
Pulse flat-top tolerance:	+/- 3	%
PFN charging time:	14	ms
Kicker magnet inductance	0.7-0.8	uH
Beam Impedance Termination	~ 25	Ω

PFN MODULATOR AND CHARGING POWER SUPPLY RACK MANUFACTURE

Based on the SNS accumulator ring extraction kicker PFN modulator and magnet prototype test results, the first PFN modulator and Power supply rack article were designed. The first article PFN and power supply rack had been manufactured by Applied Power Systems at the end of last year. So far another four PFN and power supply sets have been made. All five sets have been shipped to Oak Ridge National Laboratory. There are two sets being assembled and tested. All 14 sets of PFN modulator and charging power supply are scheduled to be shipped to Oak Ridge National Laboratory before the end of this fiscal year.

Pictures of the first-article picture of charging power supply rack is shown in figure 2. Pictures of the first-article PFN modulator are shown in figures 3 and 4.

Figure 3: First-article PFN modulator outside picture.

Figure 4: First article PFN modulator inside picture.

PFN MODULATOR AND CHARGING POWER SUPPLY TEST AND MODIFICATIONS

The first article PFN modulator and charging power supply rack were tested at Applied Power Systems and at BNL. PFN modulator and charging power supply rack tests include three parts: hi-pot, waveform tune and 24-hour long-term heat run test. Because of the differences of the PFN capacitors and inductor values, each PFN has to be tuned individually in order to obtain the required load current waveform. The PFN tuning work mainly concentrated on the magnet current pulse rise time and current pulse flat top.

The first PFN modulator prototype magnet load current waveform is shown in figure 5. The PFN modulator capacitor bank changing waveform is shown in figure 6.

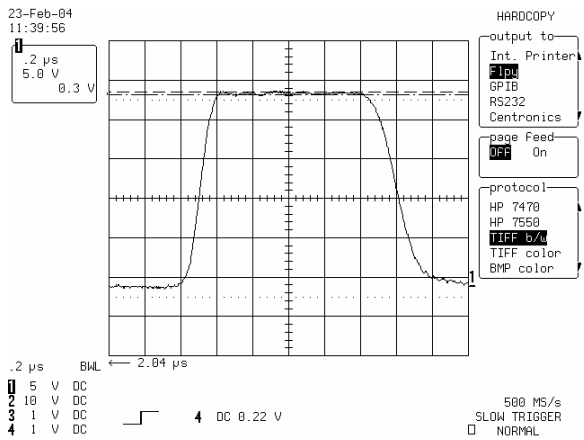

Figure 5: First article PFN modulator magnet load current waveform (peak current =2.4 kA at 35 kV).

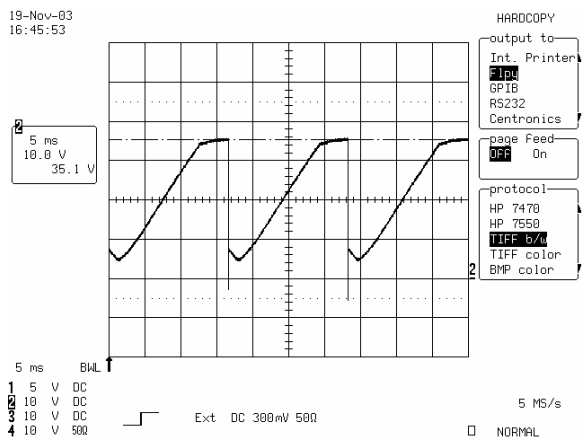

Figure 6: First-article PFN modulator capacitor bank charging voltage waveform (V_{peak}=35 kV, 60 Hz).

The PFN modulator and power supply acceptance test is based on a 24 hours long heat run test listed as follows:

- 35 kV (100 % of spec voltage), 60 PPS pulse test for 16 hours continuously, without interrupt and failure

- 40 kV (114 % of spec voltage), 60 PPS pulse test for 8 hours continuously, without interrupt and failure
- 45 kV (129 % of spec voltage), 30 PPS pulse test for 2 hours continuously, without interrupt and failure
- All interlocks test

The PFN modulator tank is cooled by transformer fluid. This fluid is Dow Corning 561 Polydimethysiloxane (PDMS) silicon fluid. It is used as a medium to cool the PFN modulator, as well as a high voltage isolation medium to reduce high voltage corona. A gear pump is used to circulate the fluid between the PFN modulator tank and a heat exchanger. Cooling water transfers PFN heat out from the heat exchanger. We had a problem with using a steel gear pump to pump the silicon fluid, because this silicon fluid has a very poor lubrication with steel material. The pump has been running more than 100 hours smoothly after a replacement of plastic (Polyphenylene Sulfide (PPS)) gear pump head (model MBV6VB made by SHERTCH).

PFN modulator cooling system diagram is shown in figure 7. And figure 8 shows a pump station picture.

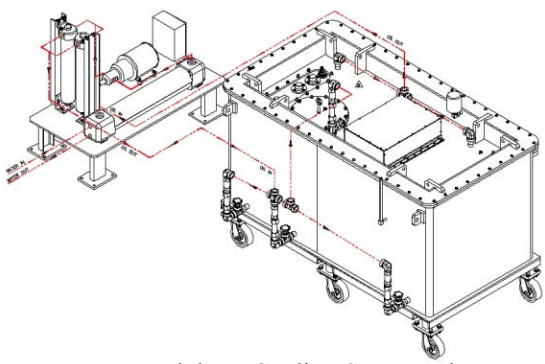

Figure 7: PFN Modulator Cooling System Diagram.

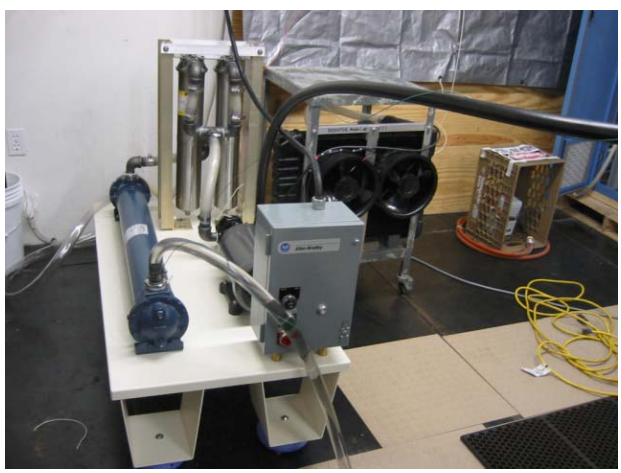

Figure 8: Cooling Pump Station Picture.

On the first PFN modulator, the transverse coupling impedance of the kicker system with attached PFN has been measured. In order to reduce the coupling impedance, the impedance matching resistor structure had to be changed to a coaxial structure. Figure 9 shows a coaxial modified structure matching resistor picture. The coupling impedance with a screen (SCRN) and with an added RC shunt (SCRN +RC) is shown in figure 10.

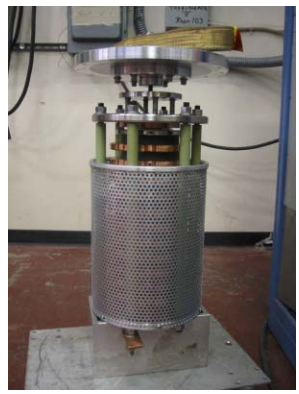

Figure 9: A coaxial modified structure matching resistor picture.

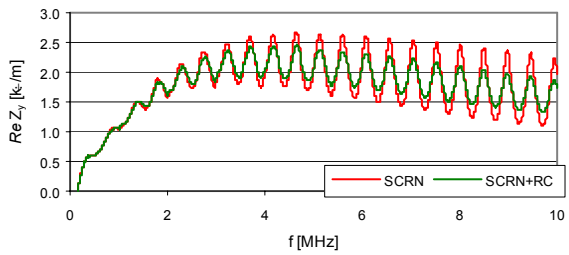

Figure 10: Transverse coupling impedance of unit.

CONCLUSION

The first-article PFN modulator and charging power supply has been tested and the design specification has been reached. Total five of PFN modulator and charging power supply have been shipped to Oak Ridge National Laboratory. The rest of the power supplies are being manufactured. All of them will be shipped to Oak Ridge National Laboratory in this fiscal year.

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