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EMI MEASUREMENT FOR TPS BOOSTER KICKER AND SEPTUM SYSTEMS*

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Abstract

The purpose of this paper is to estimate the conducted and radiated Electromagnetic Interference (EMI) for subsystems in the TPS booster ring. A LISN (Line Impedance Stabilizing Network) system with a wide frequency range was conducted to measure the EMI spectrum of pulsed magnet system. The radiated EMI was tested by magnetic field probe, which the measurement frequency range is 100 kHz ~ 3 GHz. A stray current was tested by wide frequency current transformer in order to measure the conducted current for kicker and septum systems. According to the experiment results, the stray current could flow through the other subsystems or booster chamber, and it might be affected the stability of booster operation. Therefore reducing and eliminating the interference of EM waves will be a very important issue. The EMI prevention scheme will be continued.

INTRODUCTION

According to the experience of synchrotron operation, Electromagnetic Compatibility (EMC) is one affected factor for beam stability [1]. Electromagnetic Interference (EMI) also be an issue of TLS because of the limited space and top-up mode operation [2]. For TPS project, top-up mode injection will also be the basic operation mode in the future. Therefore, injection magnets will produce conducted and radiated EMI similar to TLS existing condition [3]. In order to eliminating and reducing interference between injection sections, a good EMI design should be implement in the beginning. Firstly, a good impedance match between pulsed power supply and magnet (load) should be notice carefully. Reducing EMI level by using appropriate EMI filters from power source could also reduce conducted EMI [4]. Secondly, the grounding scheme will design based on the TLS experience. Every kicker will have exclusive grounding bus directly connect to grounding networks. The spray current will also collect by several routs in order to increasing efficiency. Finally, the EMI enclosure is proved effective and will implement to kicker magnet and its pulser. All three steps are the total solutions to reduce conducted and radiated EMI of TPS pulsed magnets.

TPS PULSED MAGNETS LOCATIONS

The pulsed magnets in TPS are divided into 3 parts, shown as Fig. 1. The first part is booster injection section; there are one booster injection septum and one kicker included. The booster injection magnets guide the electron beam from LINAC to booster ring. After increasing the electron beam energy from 150 MeV to 3.0 GeV, the electron beam extract to the second part - booster extraction section. There are 2 booster extraction kickers and two septa in booster extraction section. Passing by the BTS (booster to storage ring) section, the electron beam is inject to the storage ring by 4 kickers and two septa (2 AC septum).

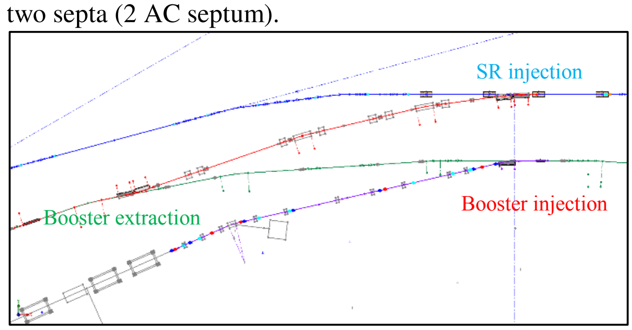

Figure 1: TPS pulsed magnets position.

GROUNDING SCHEME

According to TLS experience, the grounding scheme of TPS injection section as shown in Fig. 2. Every pulsed magnet will have exclusive grounding bus directly connect to TPS grounding networks. Because of the pulser and pulsed magnet are placed in different location, the grounding routes are connected separately for conduct stray current independently. Thus, paths of spray currents have no interchange between other subsystems.

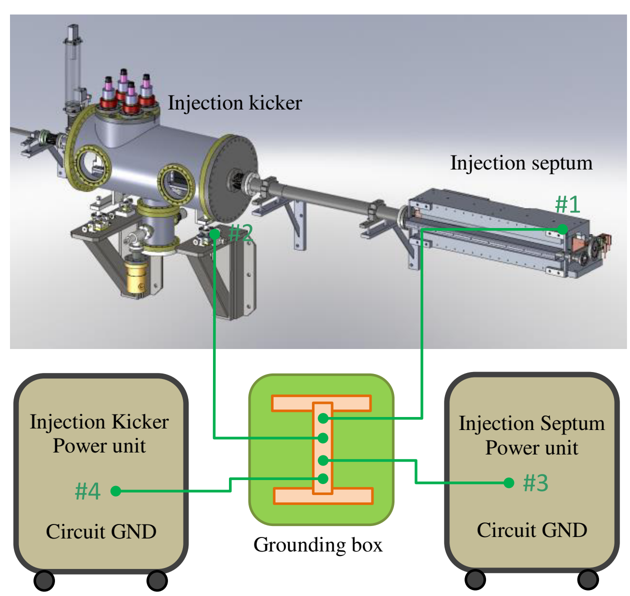

Figure 2: TPS injection pulsed magnets grounding scheme.

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GROUNDING CURRENTS FOR BOOSTER KICKER AND SEPTUM

Figure 3 showed the grounding current from the case of septum magnet during septum firing. All pulsed magnet grounding currents are connected by 38mm^2 cross section copper wire in order to eliminate the stray current rapidly. The size of copper wire is sufficient to flow the stray current into TPS grounding system. A Fluke i1000s current transformer (Signal output ratio: 100 mV/A) is used to measure the grounding current. The time duration of the septum grounding current is 350 µs, which is the same as septum pulse duration. The maximum peak to peak current is 11 A.

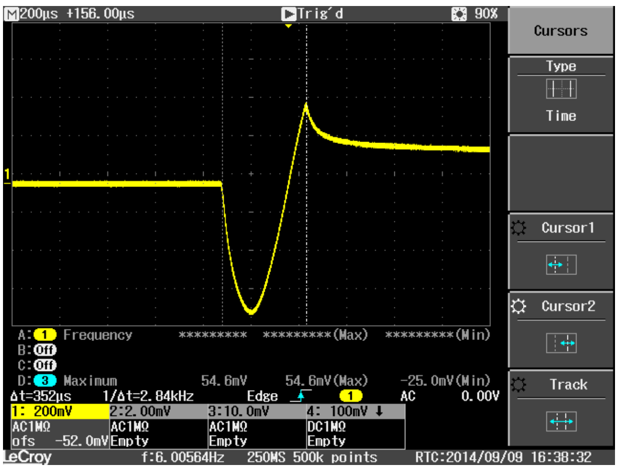

Figure 3: Grounding current (#1) for septum fire.

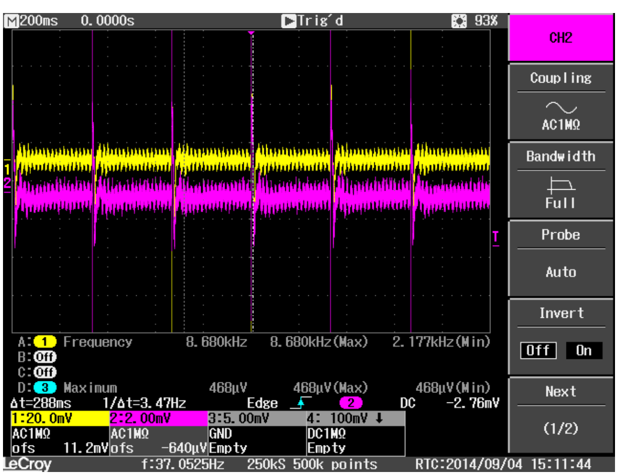

Figure 4: Grounding current (#4) for kicker fire.

Figure 4 showed the grounding current from the power unit of kicker pulser during kicker firing. Because of the frequency of kicker pulse if higher than septum, a Pearson current transformer (Signal output ratio: 0.01 V/A) is used to measure the grounding current. Compare the Fluke i1000s (yellow line) and Pearson (pink) CT, the maximum peak to peak current is about 0.8 A. The repetition rate of kicker magnet is 3Hz, which is shown in the experimental result.

Figure 5 showed the grounding current from the power unit of kicker pulser during kicker and septum fire simultaneously. According to the experimental results, the septum ground current is more distinct than kicker stray current. The shape of wave form and time duration between kicker and septum are also different. Not only the ground path of kicker power unit could notice the septum wave from, but also the booster chamber could detect the septum pulse current. The possible reason is the peak current of septum magnet is several thousand amperes, and the total power is much higher than kicker magnet. Compare to the grounding current from the case of septum shown in Fig. 3, the time duration of septum pulse is also about 350 µs.

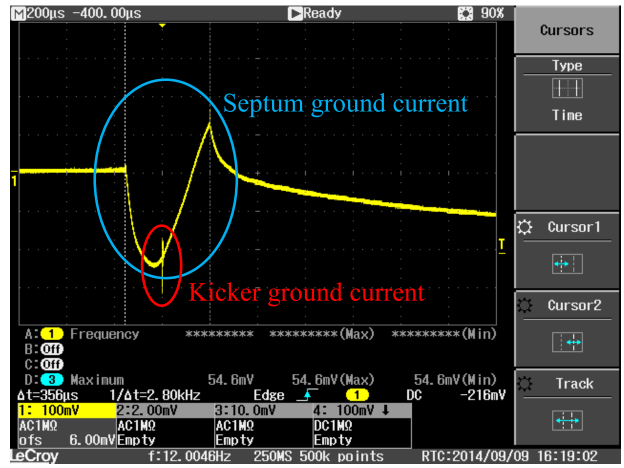

Figure 5: Grounding current (#4) for kicker and septum fire simultaneously.

CONDUCTED EMI TEST FOR BOOSTER INJECTION SEPTUM

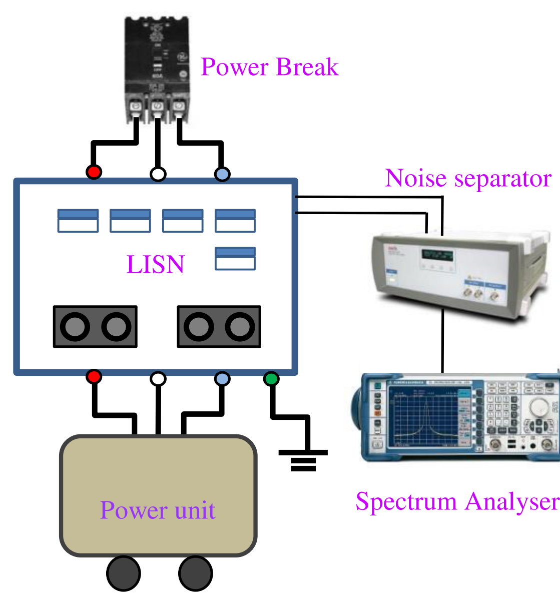

Figure 6: Experimental setup for conducted EMI measurement.

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Figure 6 showed the experimental setup of LISN test for TPS booster injection septum. The LISN system is EMCIS (Model: LN4-50) and the spectrum analyzer is R&S FSL-3. The power line was directly connected to the power break in the TPS pulsed magnets core area. The all experimental results showed total noise under test

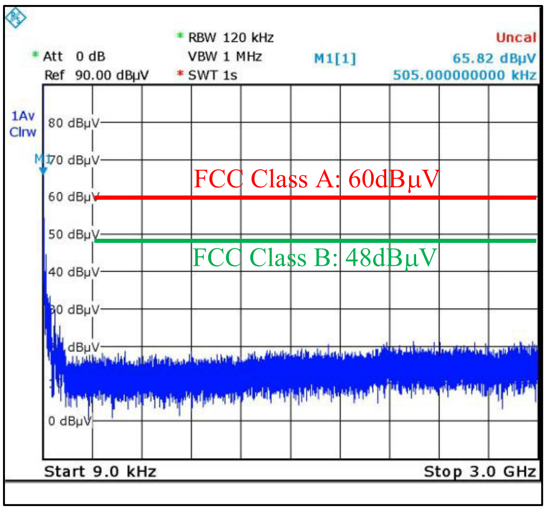

Figure 7-1: Conducted EMI for system Standby.

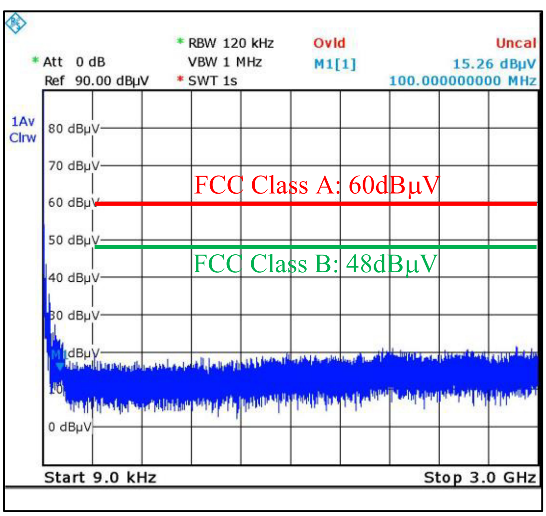

Figure 7-2: Conducted EMI for 100 V firing.

The power break supplied pulser and their control system were located in core area; while the septum magnet and pulser were located in tunnel. Because conducted EMI could affect the other systems by electric network, the tested point was set to the downstream of the power break. Fig. 7-1 showed conducted EMI of TPS booster septum under standby from 1.6 MHz to 30 MHz. Fig. 7-2 showed conducted EMI of same septum under 100 V firing. Both spectrum showed the conducted EMI are under FCC B class standard. There are no apparent differences between two statuses. The possible reason could be the excitation frequency of septum is 3 kHz, which is much lower than measurement frequency. And the pulser system also installed the EMI filter.

CONCLUSION

According to the experiment results of conducted EMI and grounding current for subsystems in the TPS booster ring. TPS subsystems already taken the precaution to reduce the conducted EMI into power networks. With EMI filter, the noise level is lower than FCC Class B standard. The radiated EMI was tested by magnetic field probe, which the measurement frequency range is 100 kHz ~ 3 GHz. There is no hotspot of radiated EMI in this frequency range around the pulsed magnet systems. The stray currents were tested by wide frequency current transformer, and the grounding currents are positive correlation to the waveform of kicker/septum pulse shape. The stray current could flow through the other subsystems or booster chamber, and it might be affected the stability of booster operation. Therefore reducing and eliminating the interference of electromagnetic waves will be a very important issue. The EMI prevention scheme will be continued.

REFERENCES

[1] Clayton R. Paul, “Introduction to electromagnetic Compatibility”, Wiley, 1992.
[2] Y.-H. Liu et al., “Analysis and Reduction Electromagnetic Interference to ICTs Caused by Pulsed Power Supply Excitation in NSRRC”, THPCH187, EPAC’06, Edinburgh, UK (2006).
[3] Y.-H. Liu et al., “The EMI Reduction of pulsed magnet in NSRRC”, TU6RFP014, PAC’09, Vancouver, Canada (2009).
[4] Yung-Hui Liu et al., “Conductive EMI Reduction to Kicker Magnet Power Supply in NSRRC”, THPPD059, IPAC’12, Louisiana, USA (2012).