

# A KICKER PULSE POWER SUPPLY WITH LOW JITTER

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## Abstract

The performance of kicker pulse power supplies is the main parameter to increase injection efficiency of storage ring that is an important issue for laboratory of synchrotron radiation research. The output current waveform of a kicker pulse power supply with low timing jitter is our goal for years that must satisfy the Top-Up mode injection requirement of NSRRC. In the past years kicker pulse power supplies of storage ring of NSRRC are immersed in isolation oil to sustain high voltage operational environment that led difficult to maintain, electronic component degrading and uneasy to tune parameters. Air-cooling and air-isolation is adopted in the new design structure for kicker pulse power supply system and an pre-trigger unit MA2709A is installed to trigger thyatron tube EEV1536A, a kicker pulse power supply with low timing jitter 1~2ns(p-p) is obtained and could satisfy for Top-Up mode injection and maintenance is more easier than before.

## 1 INTRODUCTION

The circuitry of pulser system of kicker power supply is very simple but the whole system is operated at high voltage (25kV) and high current (about 6000 amperes pulsed), so it's so dangerous for human to operate and maintain. There must be a special protection on the circuitry that is operated at high voltage environment. So the whole pulser system is sinked in oil tank except the charging power supply.

Maintenance of pulser system of kicker power supply is a laborious, dangerous and dirty work, no more to say to modify the circuitry of pulser system.

Based on the requirement of top-up mode injection, injection efficiency must increase so the timing jitter of kicker pulse power supply must be reduced, and injection rate increases several times cause loading of kicker pulse power supply rises leads to higher failure rate so that the mechanical structure should be simplified to shorten maintenance time.

Kicker magnet is redesigned for top-up mode injection and output specification of kicker pulse power supply is ought to change to about 20kV and 4500 amperes. Lower output voltage let us have confidence to design a new kicker pulse power supply with air-cooling and air-isolation, adopt an pre-trigger unit MA2709A to trigger thyatron tube EEV1536A low timing jitter output current waveform could obtain.

## 2 PERFORMANCE HISTORY OF THE KICKER PULSER

When thyatron switch is triggered on, the energy stored at charging capacitor will discharge a half sine current waveform through kicker power supply. This trigger timing of pulser system of kicker magnet is synchronized with 10Hz booster ring injection cycle, so every 0.1 second it must generate a pulse current to steer the injected beam from booster ring into storage ring. Figure 1 shows the circuitry of kicker pulse power supply.

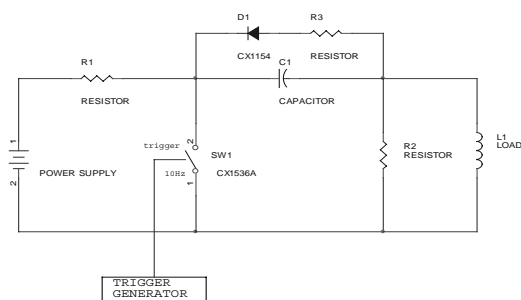


Figure 1 : circuitry of kicker pulse power supply

Figure 2 shows timing jitter output current waveform of kicker pulse power supply and it's about 25ns. At normal injection operation of NSRRC there is not a big problem on injection efficiency.

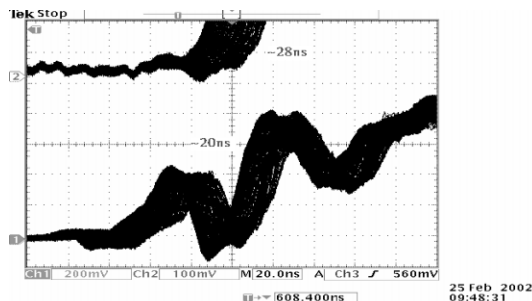


Figure 2 : timing jitter output current waveform of kicker pulse power supply

There are several sub-systems will modified for top-Up mode injection but vacuum chamber size shrinks is the most impact on the injection efficiency and the smaller size of vacuum chamber the more impact. At the situation lower timing jitter output current waveform of kicker

pulse power supply should be installed to cure low injection efficiency.

### 3 PRETRIGGERING OF THYRATRON TUBE CX1536A

The main thyatron switch used inside kicker pulse power supply is E2V 1536A(peak forward anode voltage is 50kV, peak forward anode current is 10kA), the data sheet gives the timing jitter is about 3~10ns but the actual value depends to a large extent on external circuit. Figure 3 shows the bias and trigger circuit connects to G1 and G2 of E2V 1536A thyatron tube.

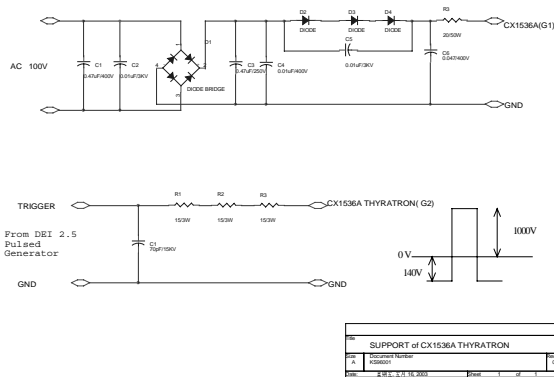


Figure 3 : bias & trigger circuit of E2V 1536A

At normal operation of kicker pulse power supply, the DC charging power is set at 25kV and the peak output current is about 6000 amperes, timing jitter output current waveform of kicker pulse power supply is about 25ns. It works fine for normal operation even the timing jitter is worse than that data sheet offers but should be reduced for the top-up mode injection.

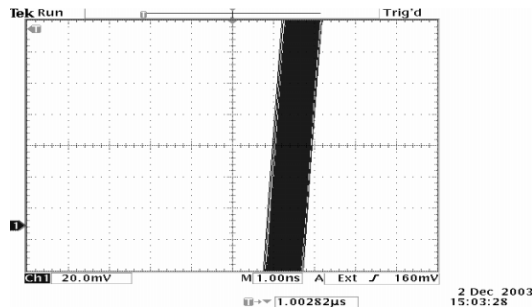


Figure 4 : timing jitter output current waveform of kicker pulse power supply with an E2V MA2709A as trigger unit

Proper operation of the thyatron requires a ~2us pre-trigger on grid1 (G1) and a 0.5us discharge trigger on grid2 (G2), delay by 0.5us. Both triggers, include 500 V on G1 and 1kV on G2, as well as a negative 150V to hold-off the anode voltage, will be provided by a

commercial trigger unit E2V MA2709A.

Instead of circuit showed at figure 3, an E2V MA2709A pre-trigger unit is installed as the trigger unit for E2V 1536A. Figure 4 shows very much improvement on timing jitter, it reduced from ~25ns to ~1ns and this performance is the best offered at the data sheet of E2V CX 1536A. It need warm-up time to let output current waveform of kicker pulse power supply reach 1ns timing jitter and figure 5 lists the table about the relation of timing jitter between warm-up time.

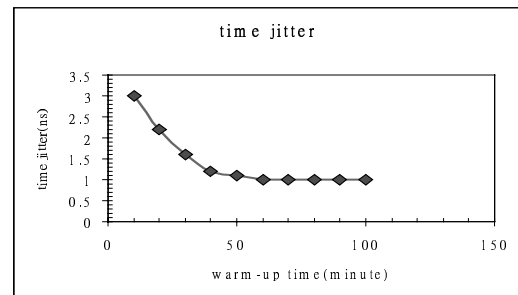


Figure 5 : timing jitter v.s. warm-up time

### 4 AIR COOLING AND AIR ISOLATION MECHANISM

In the past years kicker pulse power supplies of storage ring of NSRRC are immersed in isolation oil to sustain high voltage operational environment; it's very difficult to maintain, electronic component would degrade after several years and uneasy to tune parameters. To solve those problems air-isolation and air-cooling is adopted in the new design structure for kicker pulse power supply system.

Safety operation on high voltage environment is reached with volume of kicker pulse power supply is enlarged and utilizing some high voltage isolative material to isolate some critical high voltage point.

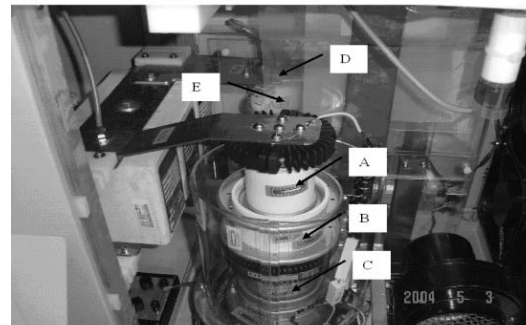


Figure 6 : test points inside of kicker pulse power supply

Lots of heat will be generate and temperature inside of kicker pulse power supply rise when it operates, especially when top-up mode injection proceed in the future temperature should go higher because the injection

rate increase and more heat will generate. Some fans are installed on rack of kicker pulse power supply and temperature on some location of critical components CX1536A and CX1154 are measured (figure 6) and figure 7 shows the table of temperature v.s. warm-up time.

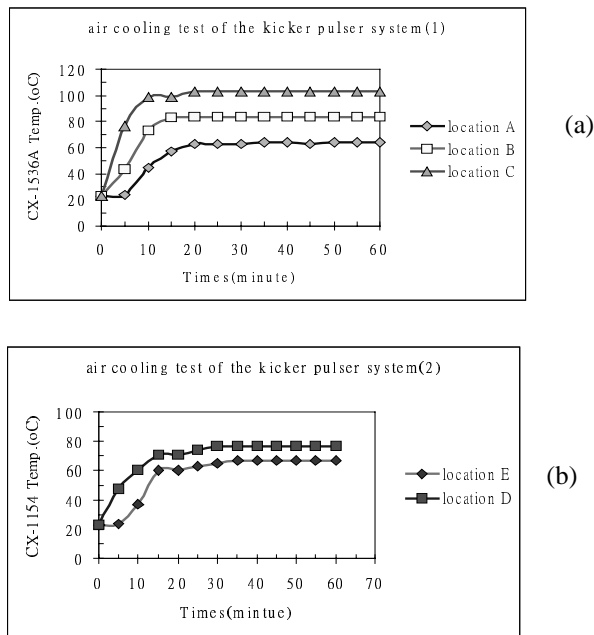


Figure 7 : temperature v.s. warm-up time  
(a) CX1536A (b) CX1154

Temperature of CX1536A and CX1154 is keep stable under 100°C after about 20 minutes warm-up time and that is under the maximum 120°C operational temperature of CX1536A and CX1154 this leave 20°C safe margin. Actually, the kicker pulse power supply is operated over 6 hours and temperature of CX1536A and CX1154 is not over 100 and inside of rack of kicker pulse power supply temperature is just rise from 23.5°C to 26.9°C.

## 5 CONCLUSION

There are several advantage on utilizing E2V MA2709A to be a triggering unit for CX1536A, easier to maintain, life time increase and better performance on timing jitter, especially timing jitter is improved from about 25ns to 1ns that is confident to increase injection efficiency.

Oil-cooling and oil-isolation are changed to air-cooling and air-isolation for new designed kicker pulse power supply that let us easier maintenance and more fine tuning of the circuit of kicker pulse power supply.

At top-up mode injection, injection rate is increase much more than that of decay mode operation so to design new kicker pulse power supply is wish it could get more ability to survival and can be quickly repaired. After several tests showed above, performance and reliability of

kicker pulse power supply is fine to install for future usage.

## 5 REFERENCES

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