

SWITCHING POWER SUPPLY FOR THE PFL KICKER MAGNET

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Abstract

SI-thyristor is expected as a solid-state high power switching semi-conducting device for the kicker magnet in the circular accelerator. Current rise has reached to 100kA/μs. We noticed this characteristic and tried the use it for the pulse forming line(PFL). Preliminary results of the proto-type power supply of 20kV-120ns, with various impedance, although the intention is 75kV-100ns, are presented.

1 INTRODUCTION

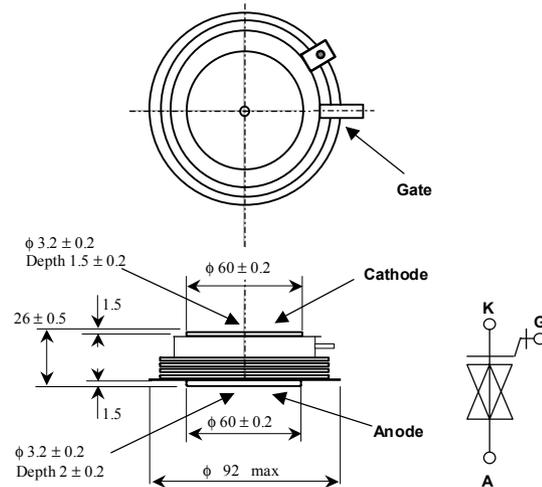
Static Induction type semi-conductors were invented by Dr.J.Nishizawa in 1970's [1,2] for diode and transistor. Static induction thyristor (SI-thyristor) is recently noticed as it's superior characteristics for high voltage and high current applications such as,

- (1) A low "ON state voltage drop" characteristics.
- (2) The high speed switching and low loss characteristic.
- (3) The high blocking voltage.
- (4) High current rise rate.
- (5) High current characteristics.

As consideration these caharacteristics, SI-thyristor is expected as a solid-state high power switching semi-conducting device for the kicker magnet in the circular accelerator. We noticed this characteristic and tried to use it for the pulse forming line (PFL). Although the intention is 75kV-100ns as shown in Table 1, preliminary test of the proto-type power supply of 20kV-120ns with various impedance, has been performed[3].

A solid-state switch is also implemented as the high power switch for the KEKB injection kicker magnet power supply and one of the thyratrons has been replaced to the SI-thyristor [3,4]. The switch has been successfully operated at 20kV voltage, 1.3kA peak current and 2 μsec pulse width under 50 Hz repetition rate.

The use of the solid-state switch in the pulsed magnet must be considered seriously under heavy duty repetition and consideration of the equipment life. Recently research and development using SI-thyristor started in the accelerator field, such as high power switch for the driver of the klystron pulse modulators [5].



Repetitive peak off-state voltage: 4000V
Reverse conducting type
Non-alloyed Flat-wafer pellet
Press-pack ceramic housing
On-state current: 600A(RMS)
Peak one cycle surge on-state current: 5500A
Critical rate of rise of on-state current: 150kA/μs

Figure 1: Reverse Conducting Static Induction Thyristor Type PS1600PA4071

2 PROTO-TYPE SWITCHING POWER SUPPLY FOR THE PFL KICKER MAGNET

Specification of the kicker magnet parameter for the several hadron accelerator are shown in Table 1. First of all, we performed the test of current rise using a sample, RT103, Toyo-Denki-NGK. Although the catalogue data is 100kA/μs, the current rise was made sure up to 283kA/μs. A 45kV modulator using this device for klystron [5] had been done in advance and we tried to test for the PFL kicker using this module [6]. After the good results, we set about making a R&D module for exclusive use to test the PFL kicker using new type of RS1600PA40T1-NGK as shown in Fig.1. Following the specification as shown in table 1, aim of the proto-type power supply are set as, 70kV of charged voltage, 7kA of output current, 5Ω of impedance, less than 120ns of rise time and 1.1μs of pulse width, but first goal was set as, 20-40kV of charged voltage and current depend on

the impedance between 10 Ω to 50 Ω . Over view of the demonstrated modulator is shown in Figures 2 and 3. Figure 4 shows a schematic drawing of the test circuit of SI-thyristor unit. Deterioration in current rise was observed. This may be considered by the inductance around load resistor and CT and the modification trial

using head-up condensers of various capacitor. Results of the load current waveforms, as shown in Figure 5, are satisfy except of the charged voltage. After that, we are going to make the modulator for the 50GeV abort kicker.

Table 1

Pulsed Power Supply for the Kicker Magnet at the KEK-PS and JHF

| | Extraction Kicker KEK-12GeV PS | Extraction Kicker 500MeV BSTR | Extraction Kicker JHF-3GeV-RCS | Injection Kicker JHF-50GeV-PS | Abort Kicker JHF-50GeV-PS |
|-------------------------------------|-----------------------------------|----------------------------------|-----------------------------------|----------------------------------|------------------------------|
| Voltage(kV) | +70~-40 | 65 | 80 | 80 | 40 |
| Current(kA) | +6~-3 | 1.3 | 8 | 8 | 8 |
| Pulse width(μ s) | 1.1 | 0.12 | 1.2 | 1.2 | 6 |
| Current Rise(ns) | 80 | 40 | 80 | 70 | 1,100 |
| Field Rise(ns) | 150 | 70~80 | 250 | 250 | 1,100 |
| Field Fall(ns) | | 70~80 | | | |
| Flatness(%) | ± 1 | ± 1 | ± 1 | ± 1 | |
| Repetition(Hz) | 1/2.2 | 20 | 25 | 25pps x 4bursts | 1/3.6 |
| Impedance of magnet (Ω) | 12.5 | 25 (distributed magnet) | 10 (lumped magnet) | 10 | 2.2 μ H / 5 Ω |

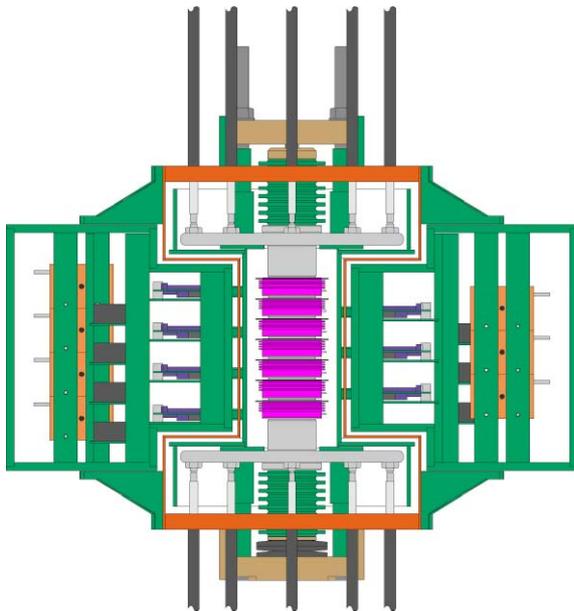


Figure 2: Drawing of seven series SI-thyristor stack.



Figure 3: Picture of SI-thyristor module and PFL cable.

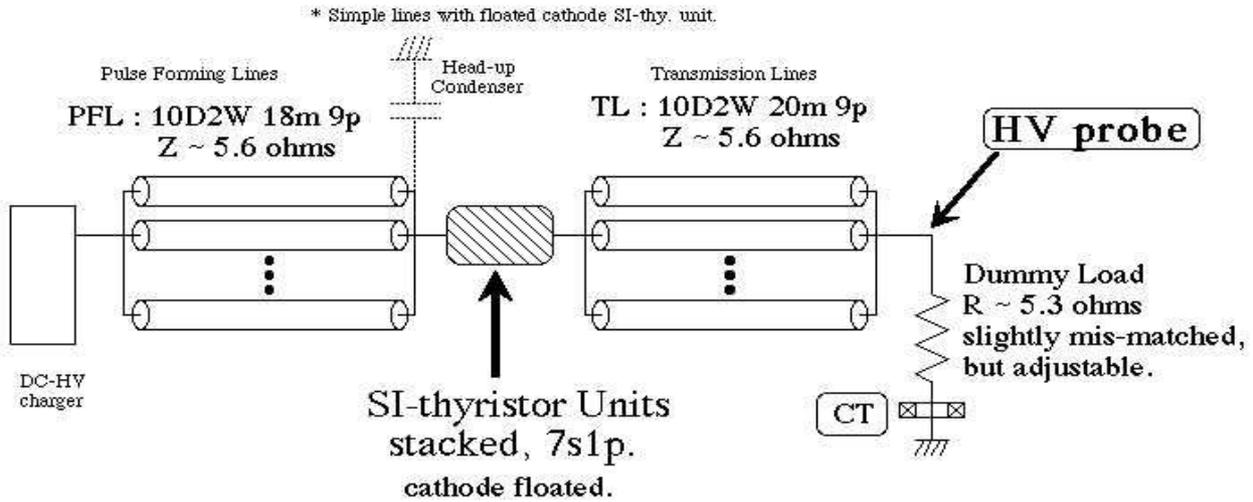


Figure 4: Schematic drawing of test circuit of SI-thyristor.

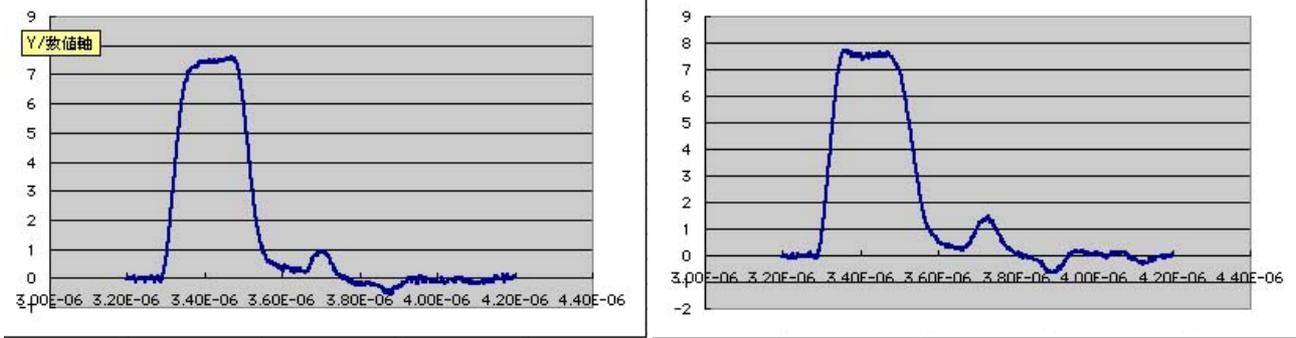


Figure 5: Load current waveforms measured by CT
Left: no capacitor, Right: 349PF co-ax. Cables attached

3 CONCLUSION

Prototype power supply for the trapezoidal waveform PFL kicker magnet of 20kV SI-thyristor switch has been successfully performed. Deterioration in current rise due to the inductance around load resistor and CT are improved by using the speed up capacitor. System has been operated under various cable impedance.

In this prototype power supply, SI thyristors are covered by cylindrical copper and it is hard for maintenance. Then, improved type power supply has just made in order to replace the broken SI-thyristor easily and will be tested.

Authors are going to aim the application for the J-PARC 50GeV abort kicker power supply with high speed diode to cut the reflection.

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