Accelerator Laboratory

Flux Concentrator Modulator Development

KEKB injector linac

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18th KEKB Accelerator Review Committee

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Requirements of Flux Concentrator

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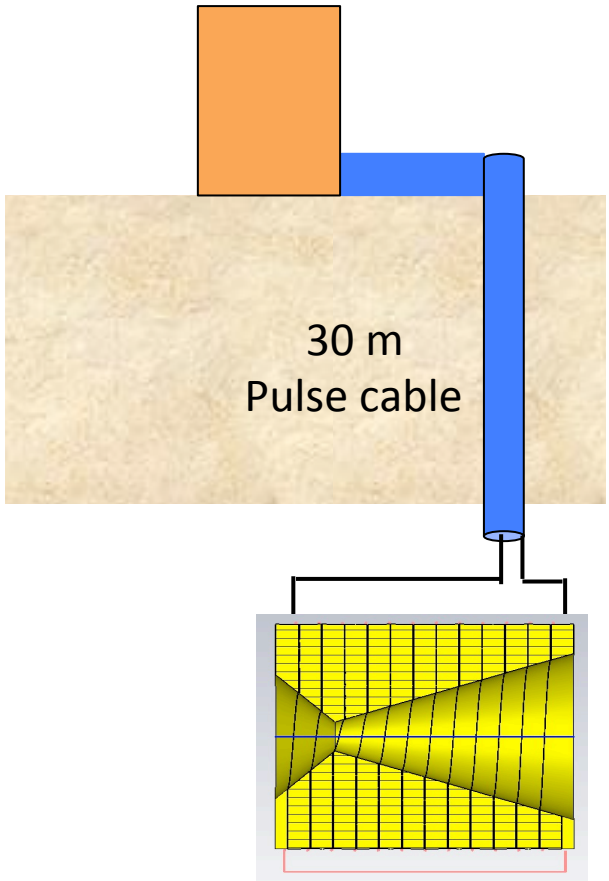
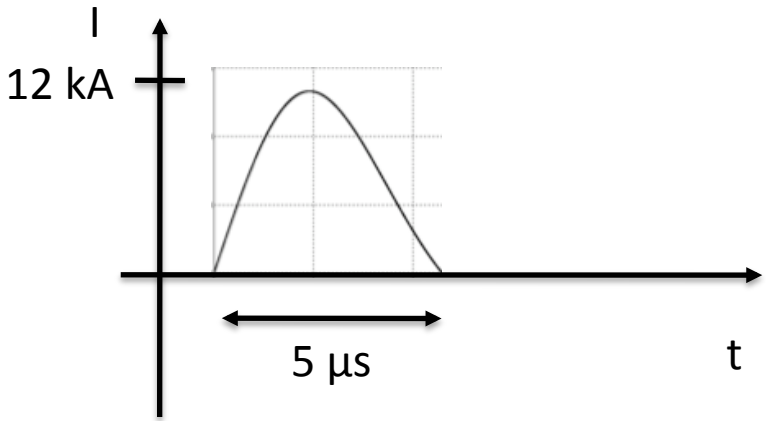
Modulator



Flux Concentrator(~ 1 μH)

- Half-sine 5 μs pulse
- 12 kA peak current
- Amplitude stability 0.3%(p-p)
- 50 pps

Flux Concentrator
Current Pulse



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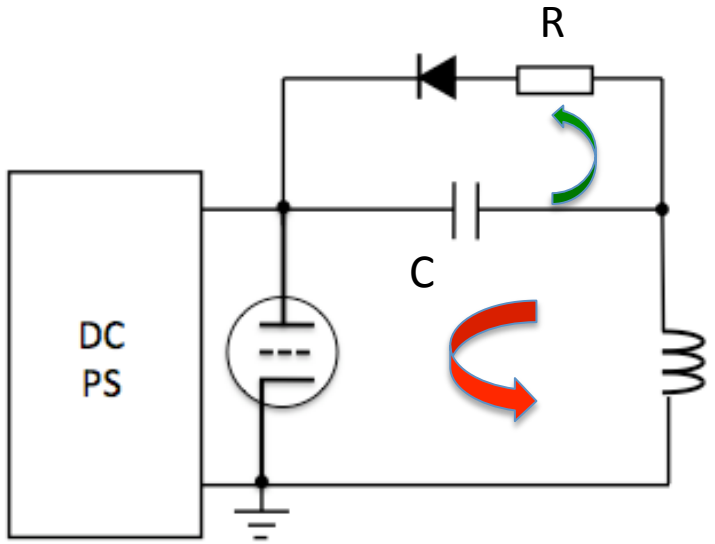
Principle of Operation

- Half sine wave generated by L-C resonant circuit
- Use thyratron as a switch
- Used at SLAC and IHEP

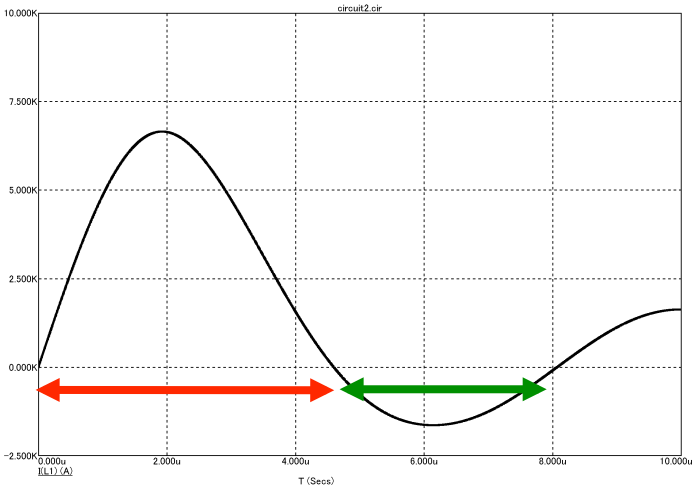


Basic circuit

$$I_{peak} = V_0 \cdot \sqrt{\frac{C}{L}}$$

$$\frac{T}{2} = \pi\sqrt{LC}$$

Load current(L)



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Strategy of FC Modulator

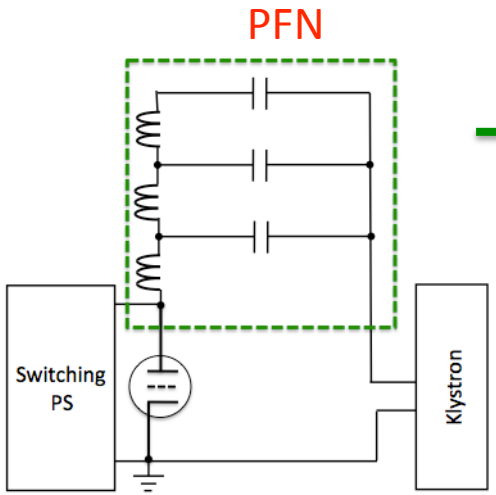
FC modulators are developed in two steps.

- Prototype 6 kA modulator
- KEKB klystron modulator is revised to FC modulator
- Established technology
- Low-cost and high maintainability

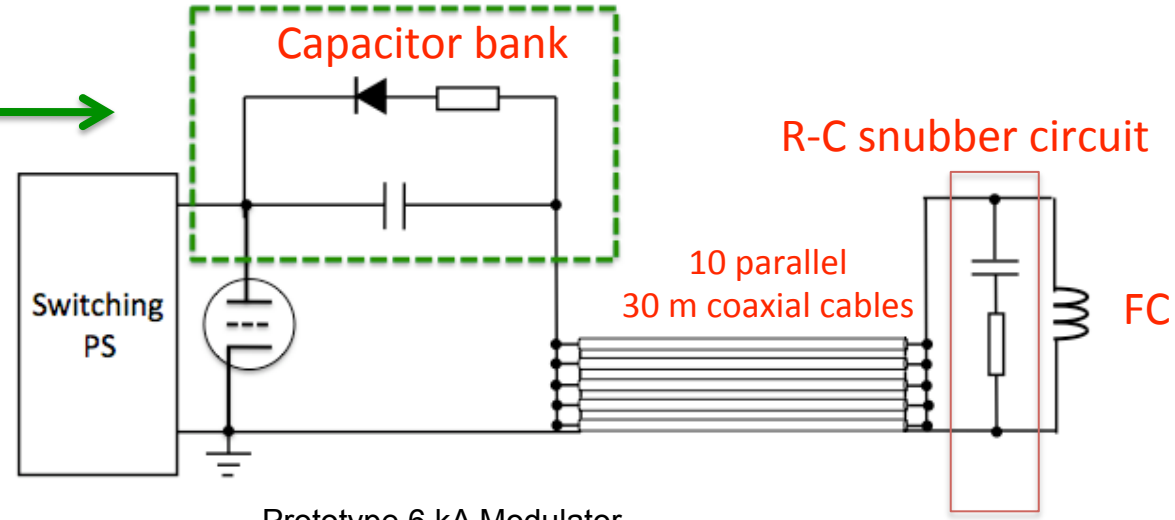
- Next step is 12 kA modulator

Prototype 6 kA modulator specification

Parameter	Specification
Capacitance	0.5 μF
Load inductance	~ 1 μH
Total inductance	~ 3 μH
Charging voltage	17 kV
Peak current	6 kA
Pulse width	5 μs
Repetition rate	50 Hz



KEKB modulator for S-band klystron
22.5 kV, 4.8 kA, 5.6μs pulses at 50 pps



Prototype 6 kA Modulator

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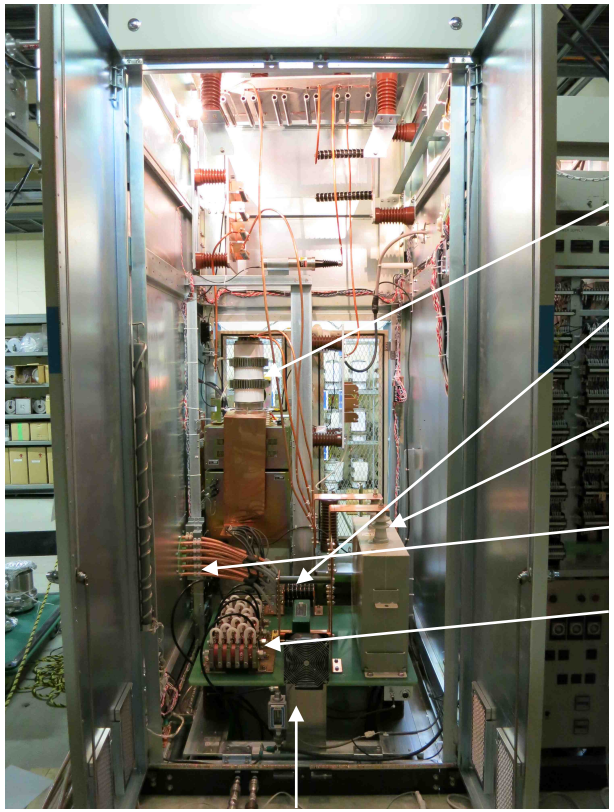
Prototype 6 kA Modulator

Klystron modulator
PFN unit



Capacitor bank unit

Inside view of the modulator

Front side view of the modulator

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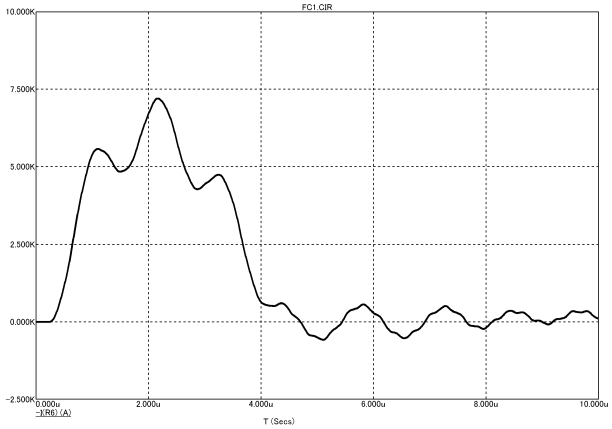
R-C Snubber Circuit

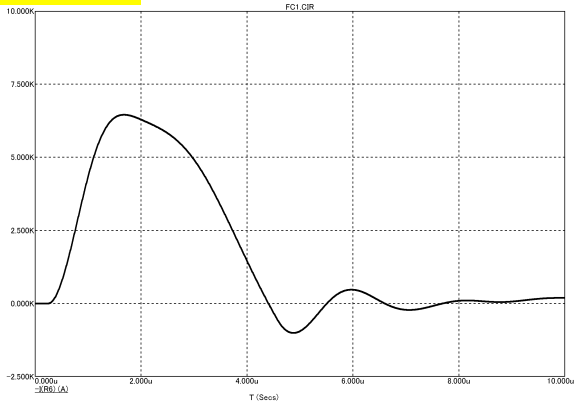
Load current waveforms simulated by a computer code Micro-Cap 9

R=2.5Ω

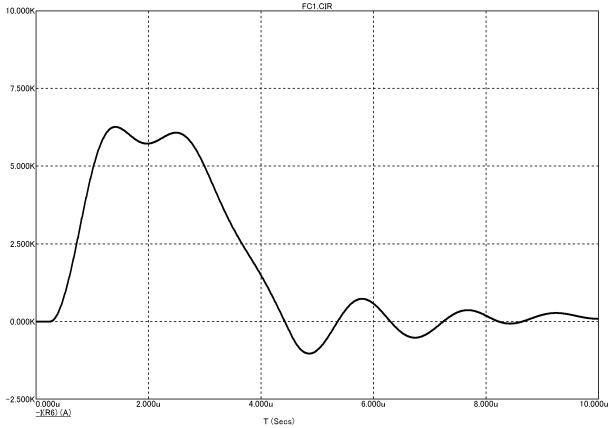
Without R-C snubber circuit



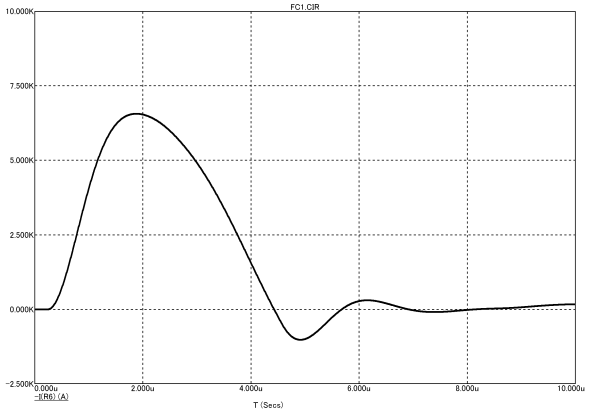
C=100nF



C =50nF



C =150nF



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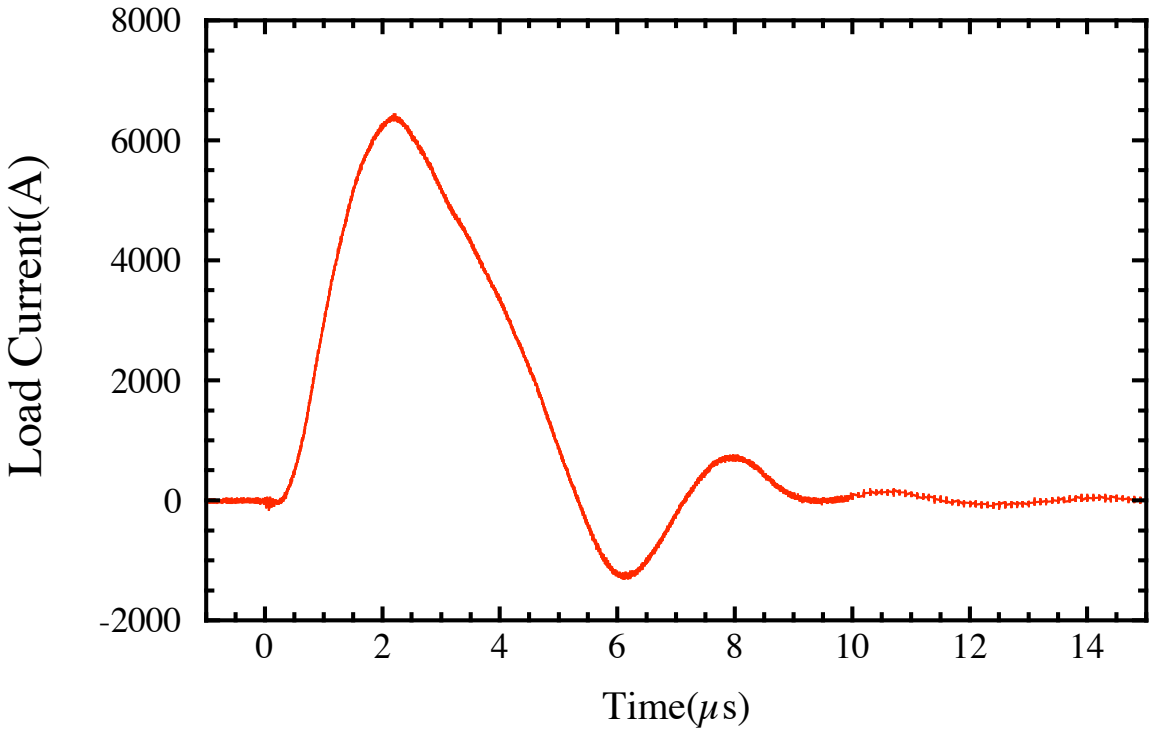
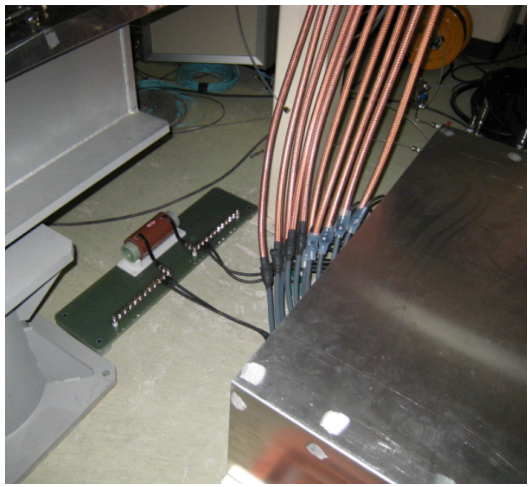
6kA Prototype Modulator Tests

Typical load current waveform at a charging voltage of 17 kV





Equivalent inductance load and C-R circuit

Use of 10 parallel Cables
30 m, 25 Ω, 40 kV Coaxial Cable

A peak current of 6000 A with a width of 5 μs has been successfully generated at 50 pps

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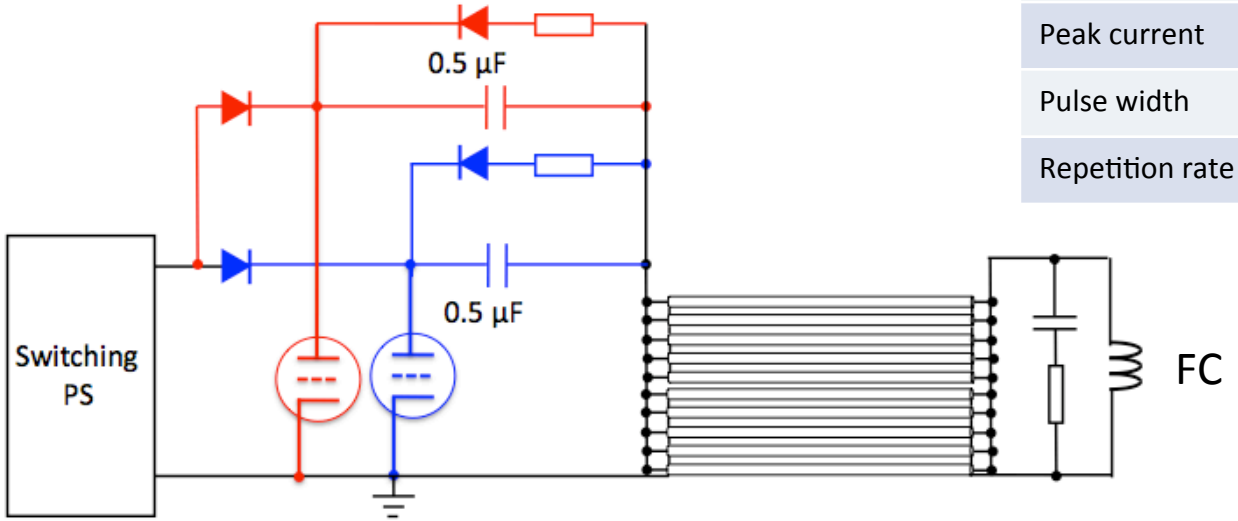
12 kA Modulator Design

- Based on a prototype modulator design
  Using two thyratrons
- Easy maintenance, low-cost
- Will be complete at the end of Nov.

12 kA modulator specification

Parameter	Specification
Capacitance	1.0 μF
Load inductance	~ 1 μH
Total inductance	~ 1.5 μH
Charging voltage	17 kV
Peak current	12 kA
Pulse width	5 μs
Repetition rate	50 Hz



12kA Modulator

20 Parallel 30m, coaxial cables

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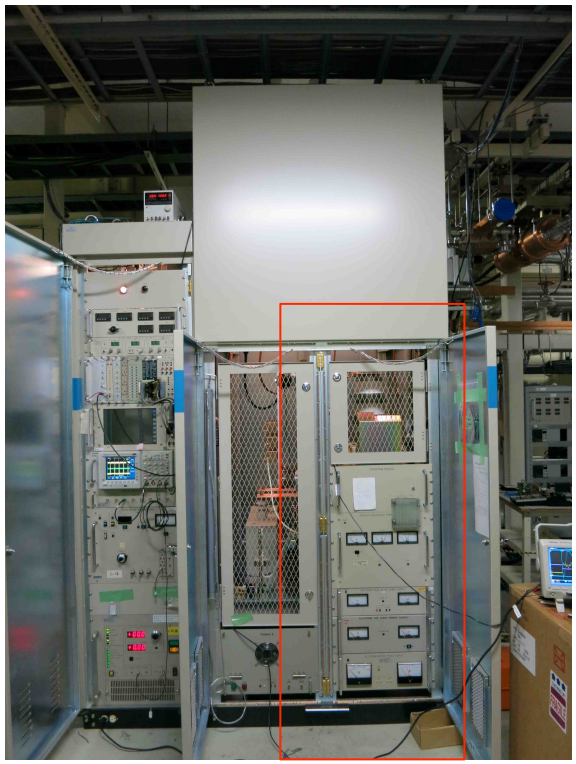
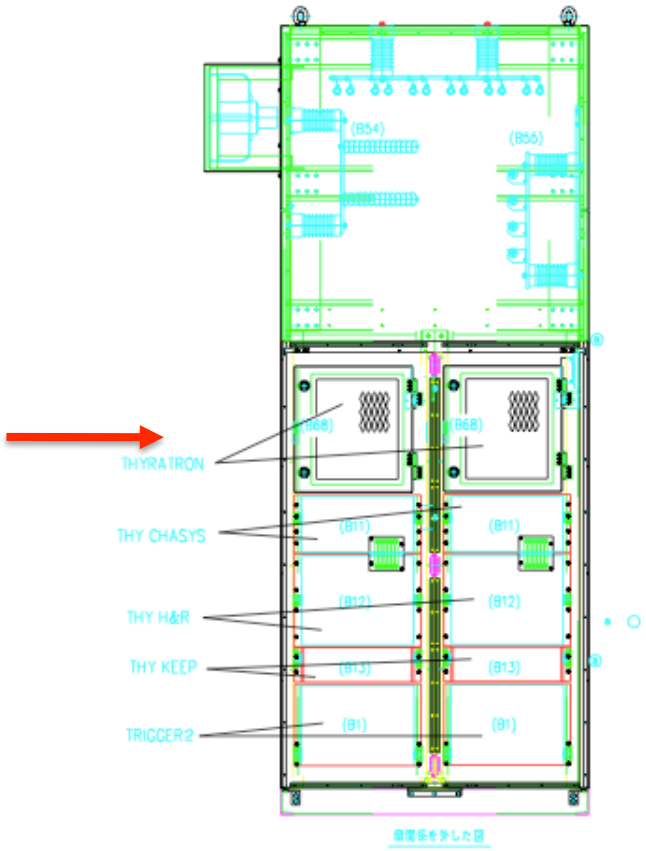
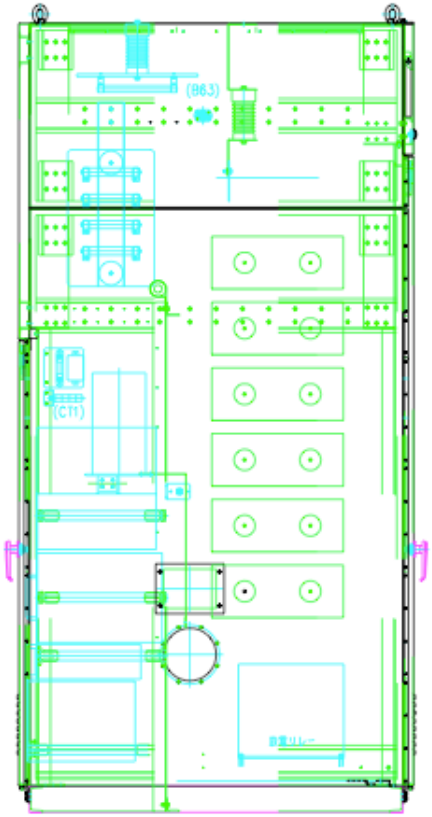
12 kA Modulator Design

•The capacitors, two thyratron units, other all parts without a charging PS and control units are housed in the KEKB modulator discharge cabinet.



KEKB modulator





Discharge cabinet

Possibility of Thyratron Replacement

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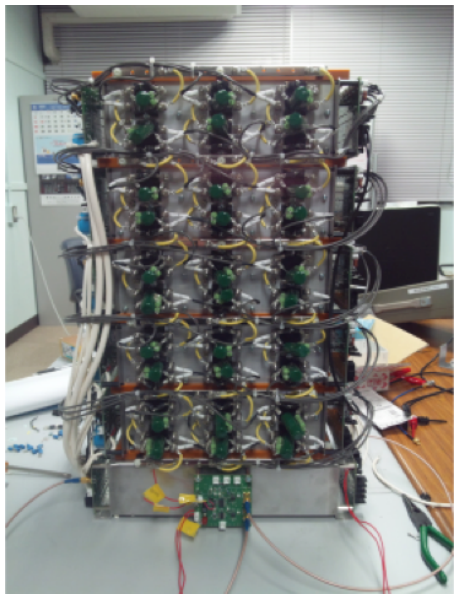
- Thyratron is short-life.
- Develop a solid-state switch to replace thyratrons
- Improve the reliability of the modulator

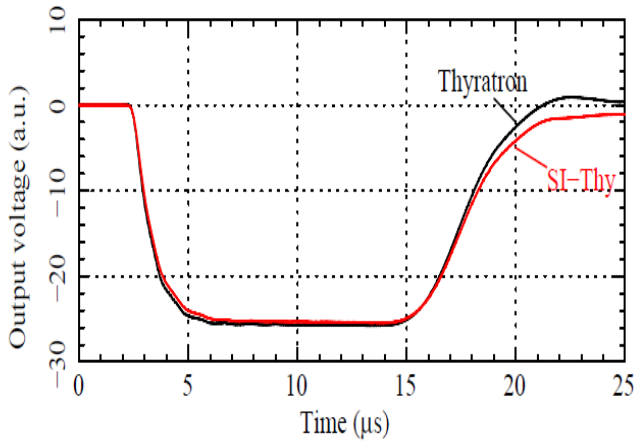
- PPJ Company



SI-Thyristors Switch

25 kV, 5kA, 10μs, 10 Hz
6Px10S SI-Thyristors Switch

Size : 300(W)x150(D)x500mm(H)



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Summary

•A prototype 6 kA modulator has been built by revising from the existing S-band modulator.

• A peak current of 6 kA with a width of 5 μs has been successfully generated at 50 pps.

•12 kA modulator is under design, which is based on prototype modulator design, and will be completed at the end of Nov.

• We have a plan to develop a solid-state switch to replace thyratorn to improve the reliability of the modulator.