DEVELOPMENT OF A DC 1MV POWER SUPPLY TECHNOLOGY FOR NB INJECTORS

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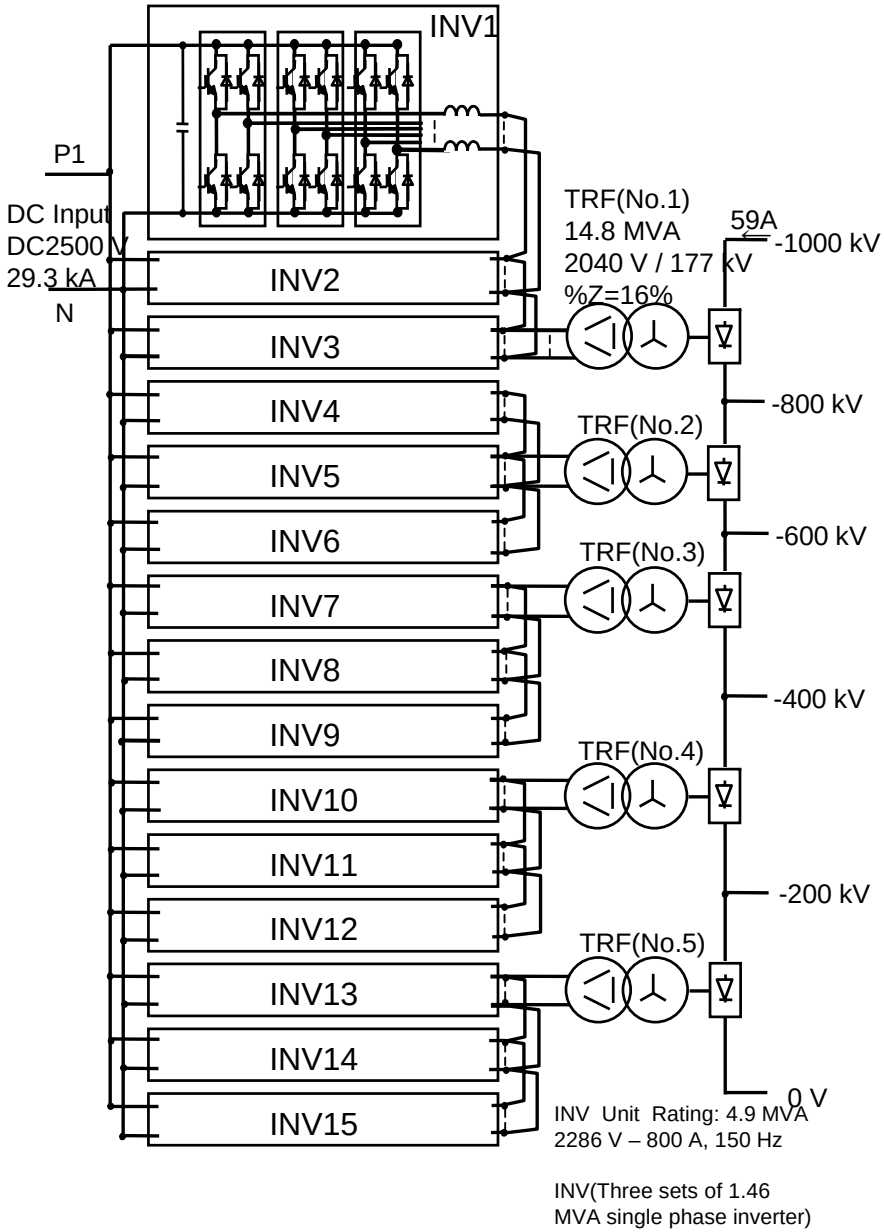
K. Watanabe, M. Kashiwagi, M. Hanada, T. Inoue,
M. Taniguchi, Y. Okumura, K. Sakamoto,
Y. Ono[1)], Y. Yamashita[1)], S. Kawashima[2)], and C. Yamazaki[2)]

Naka Fusion Research Establishment
Japan Atomic Energy Research Institute
[1)]Hitachi, [2)] Toshiba

Required functions for NBI power supply

1) DC UHV generation (regulation, switching)
   Inverter control PS (JT-60 N-NBI 500 kV PS)
2) DC UHV transmission (1 MV insulation)
   Prototype test
3) Surge suppression (protection of BS & PS)
   Core snubber (JT-60 N-NBI, MTF)

1) DC -1 MV UHV generation



1 MV, 59 A, 1,000 s,

10%pp, cutoff < 200 μs

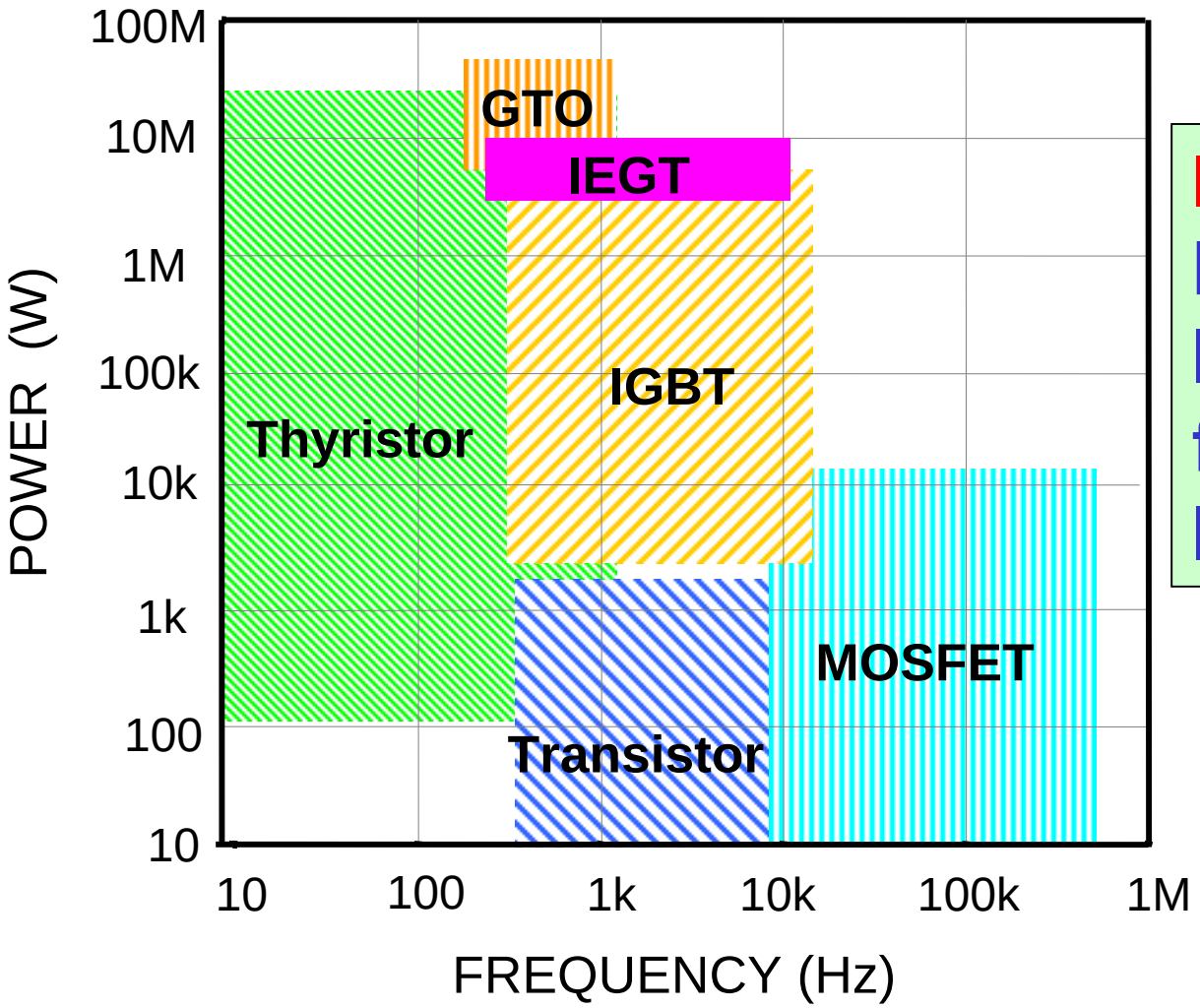
- **No DC SW**
- **Inverter : regulation, switching at AC side**

- **Ripple : need large C**
- **Stored energy : small C**

High frequency 150 Hz

GTO → IEGT

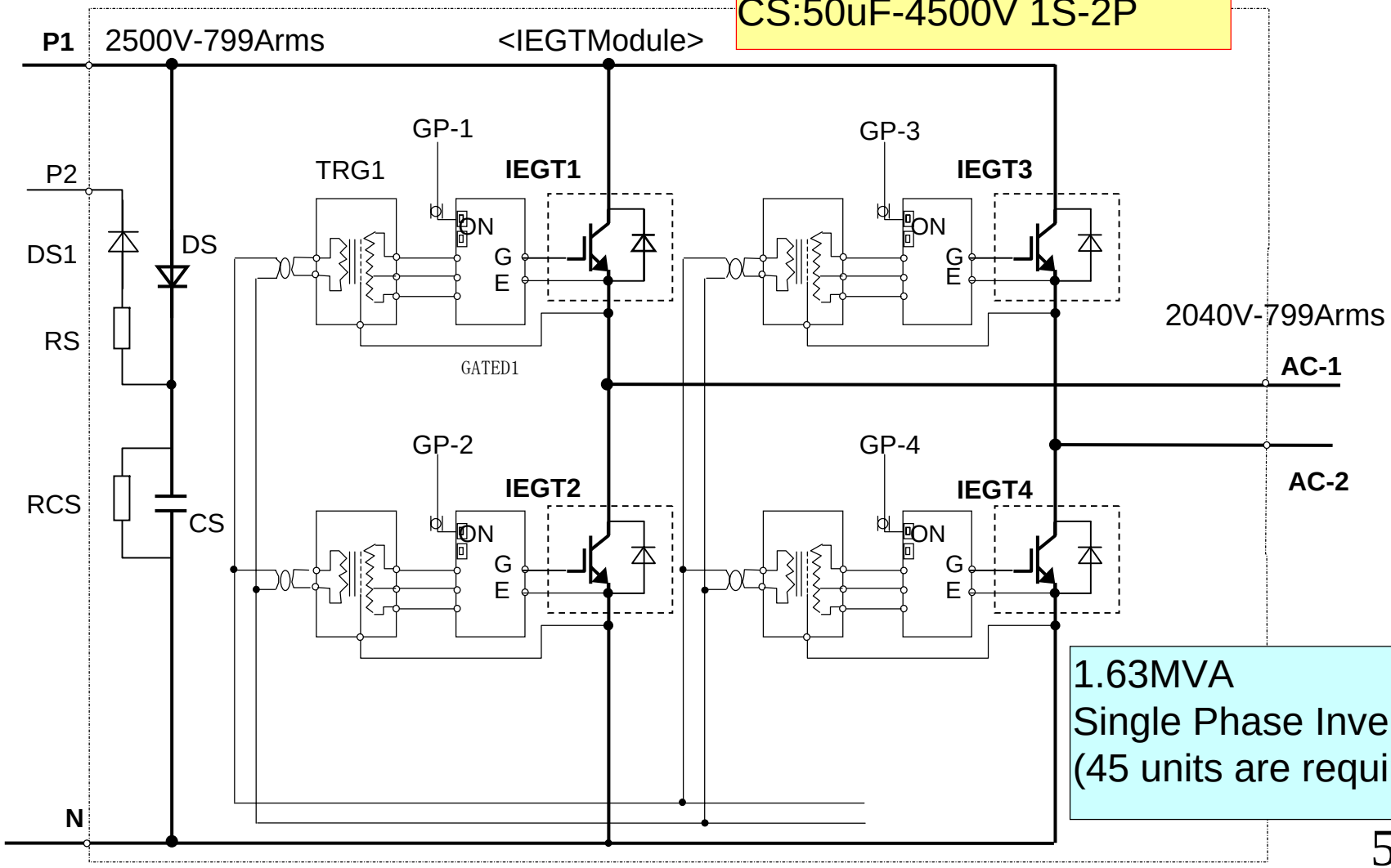
Comparison of power devices



IEGT can control high power (GTO level) and high frequency (IGBT level) AC power

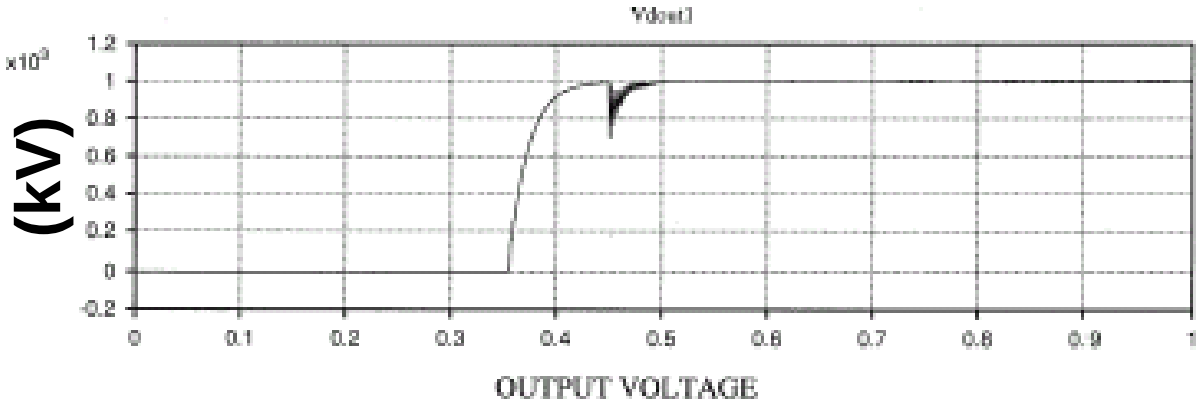
IEGT inverter power supply

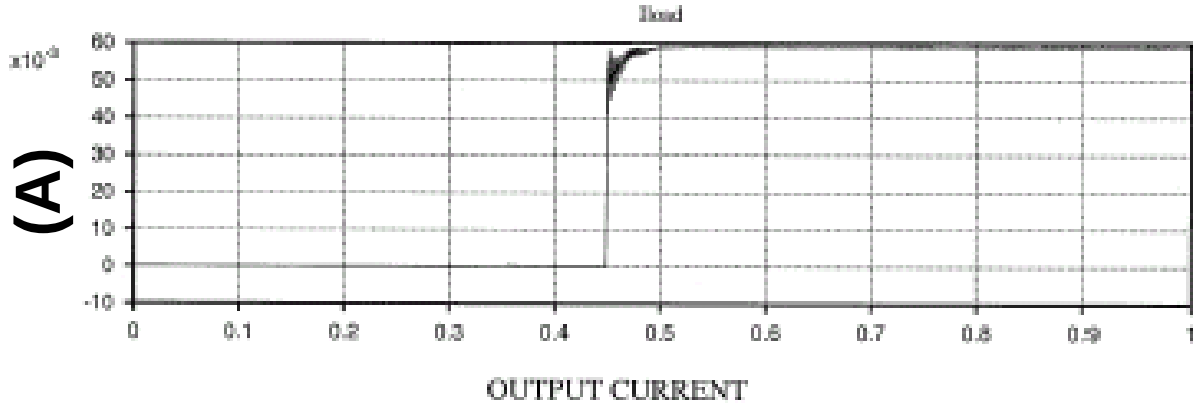
IEGT:ST1500GXH24
4.5kV-1500A
CS:50uF-4500V 1S-2P



1.63MVA
Single Phase Inverter
(45 units are required)

EMTDC simulation of IEGT power supply





Performance

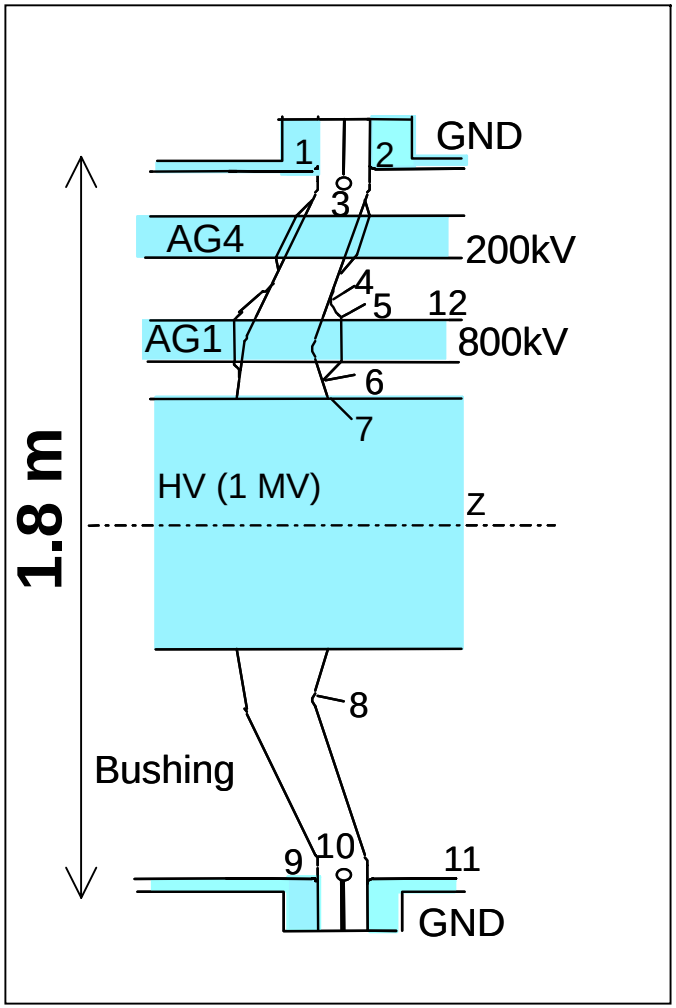
- **Rising t : 50 ms**
- **Ripple <10%pp**
- **Cut off <200 μs**

Inverter loss will be decreased from 1.6 MW (GTO) to 0.5 MW (IEGT)

2) DC UHV transmission

Transmit DC UHV from power supply to the beam source

Multi-conductor bushing (DC - 1MV, with intermediate voltages)

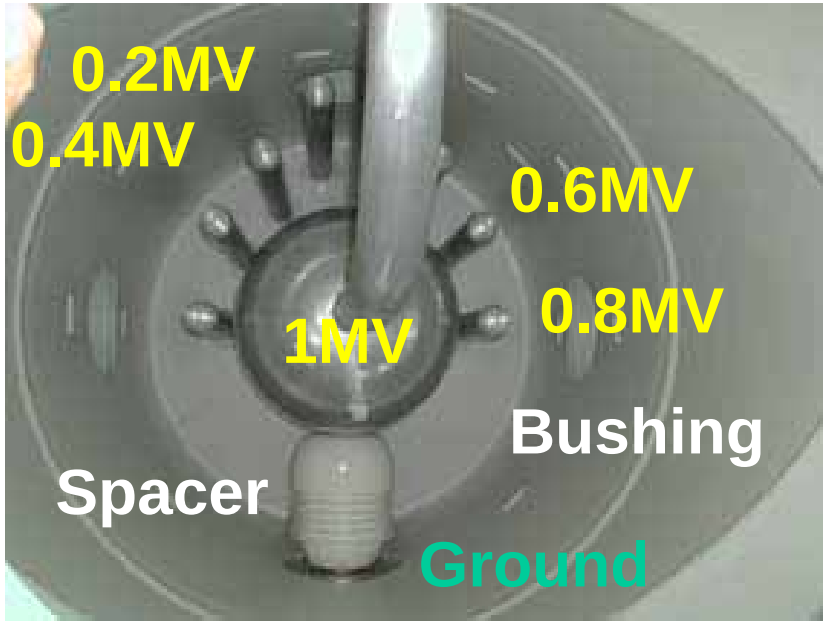


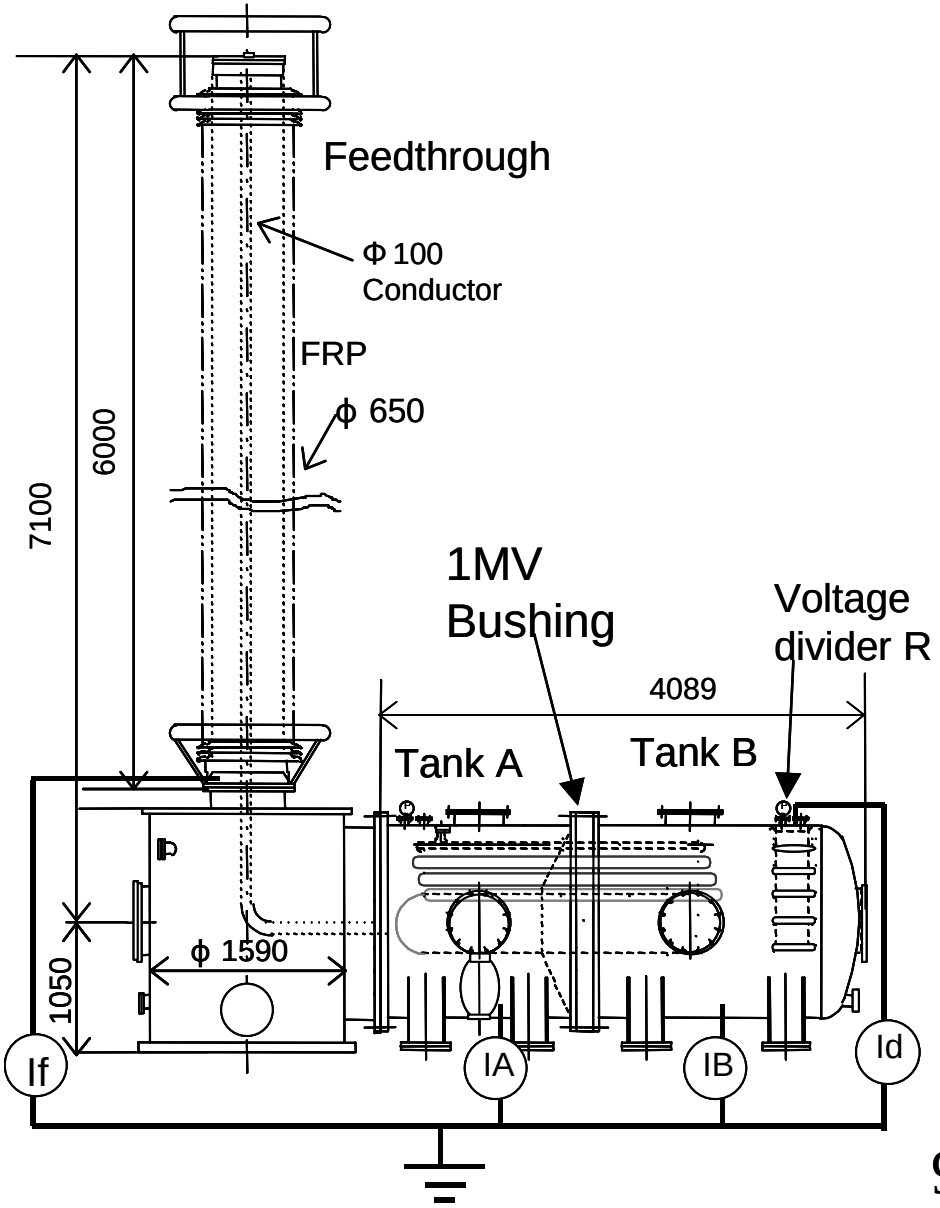
Electric field design

No.	Position	Insulation	E-designed (kV/mm)	Edsgn criter (kV/mm)	Ebd (kV/mm)
1	Triple junction	Surface	6.0	7.0	11
2	Triple junction	Surface	6.7	7.0	11
3	Insert electrode	Solid(epoxy)	9.2	10.0	17
4	Concave point	Surface	5.5	7.0	11
5	Triple junction	Surface	2.7	7.0	11
6	Concave point	Surface	5.0	7.0	11
7	Triple junction	Surface	1.8	7.0	11
8	Concave point	Surface	3.3	7.0	11
9	Triple junction	Surface	4.0	7.0	11
10	Insert electrode	Solid(epoxy)	2.2	10.0	17
11	Duct bottom	Gas	1.2	1.5	1.8
12	AG1 surface	Gas	5.0	5.0	8.8

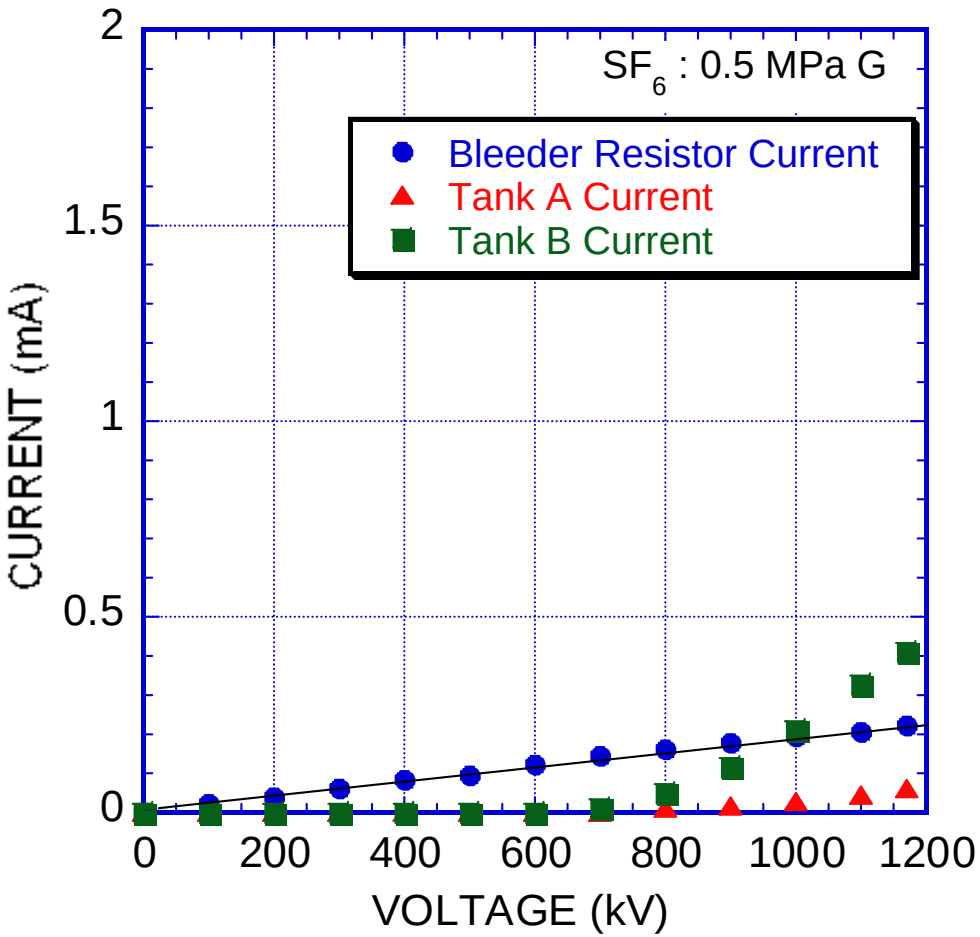
Prototype transmission line (TML)

A view of the bushing





DC UHV test of the prototype TML

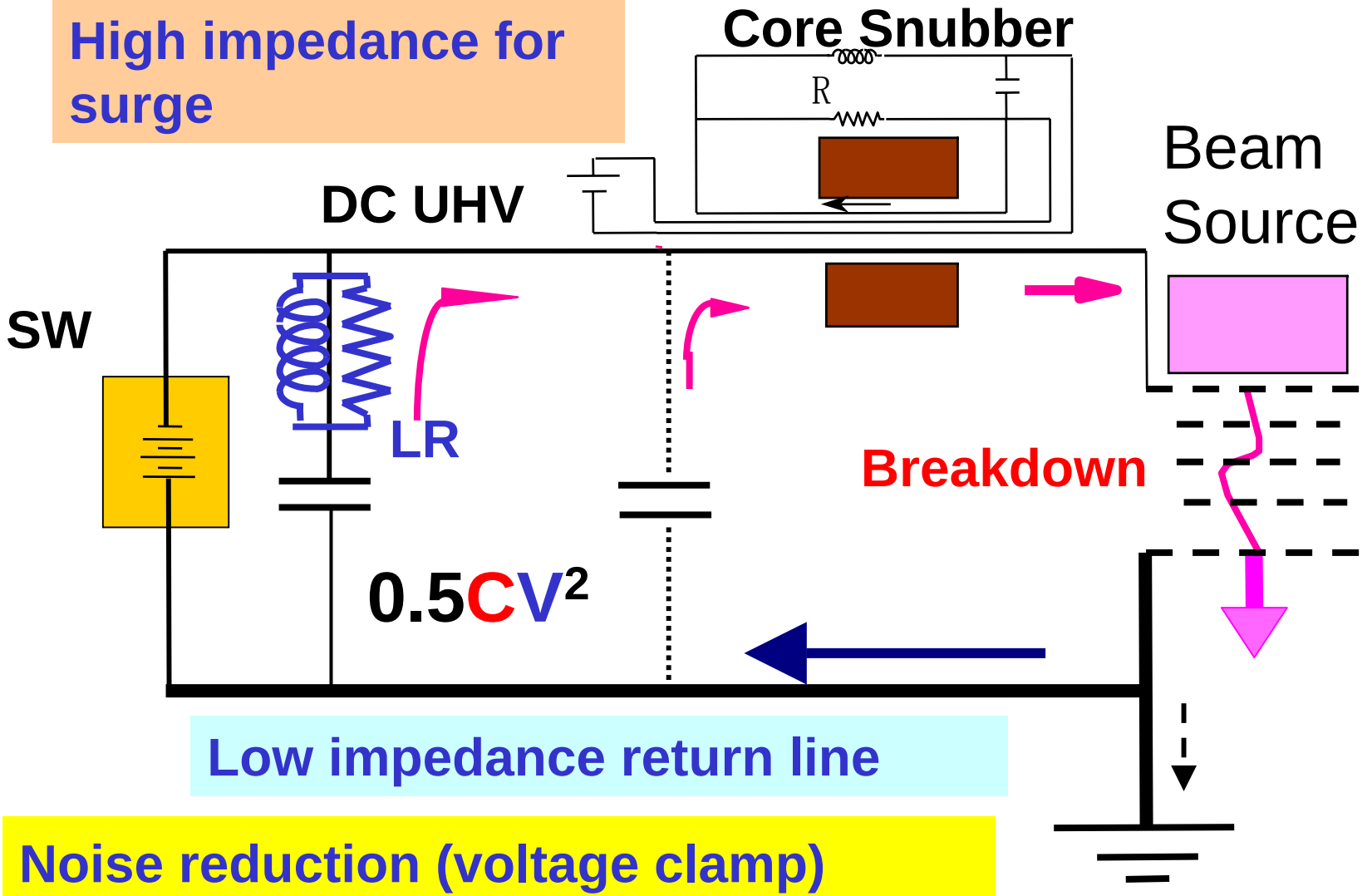


DC -1,170 kV was sustained for 300 s
No breakdown

Leak current < 0.4 mA

3) Surge suppression

High impedance for surge



Low impedance return line

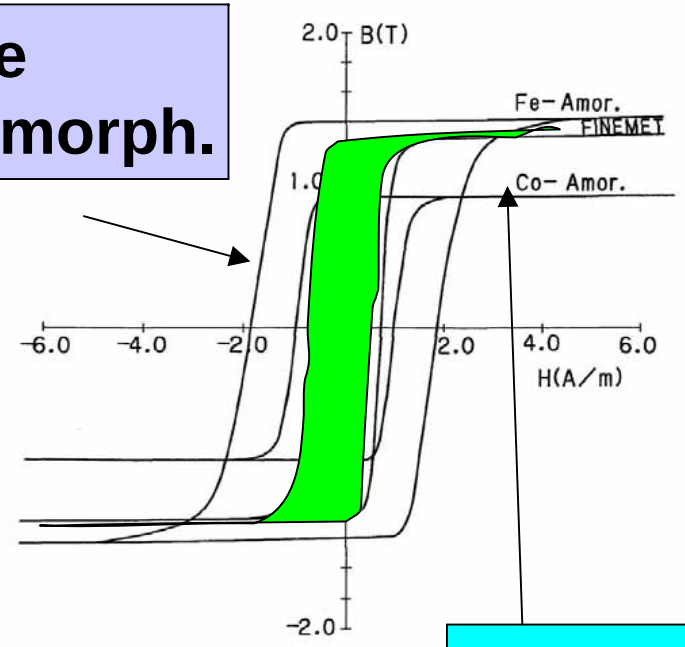
Noise reduction (voltage clamp)

Core snubber

High efficiency core snubber

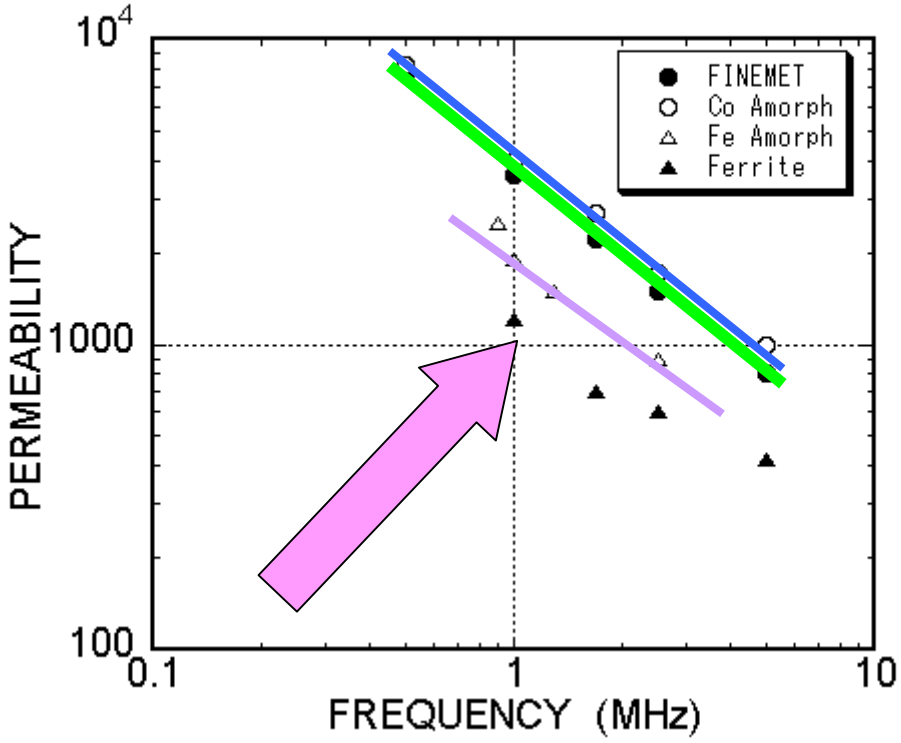
High B_{ms}, High permeability (pulse), Low cost

Fe Amorph.



FINEMET (Fe)

Co Amorph.



SUMMARY

- Major technologies essential for the 1 MV NBI power supply have been developed.

(Inverter PS, Transmission line, Surge suppression)

Important

Noise reduction and surge suppression for power supply control and diagnostic circuit are essential for high reliability.