



Test results of gyrotron power supply of KSTAR* ECH system

2004. 4. 24

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**Work supported by KBSI*

Abstract

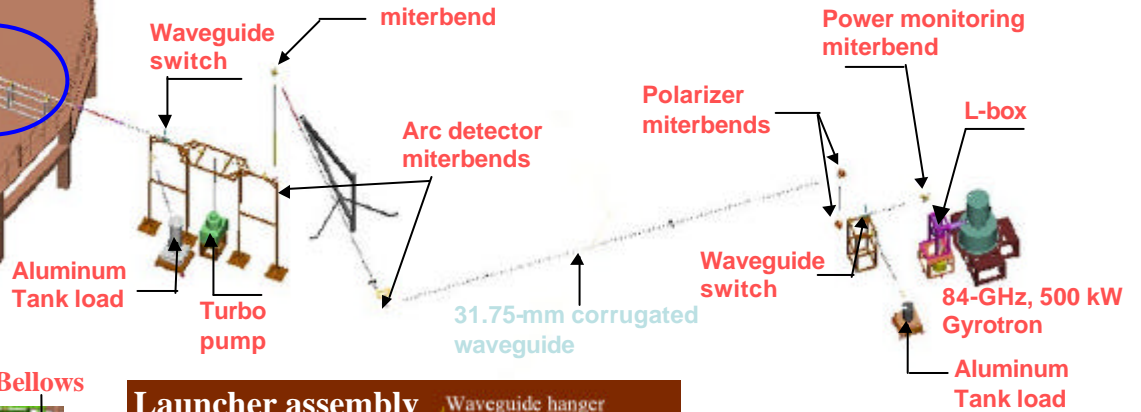
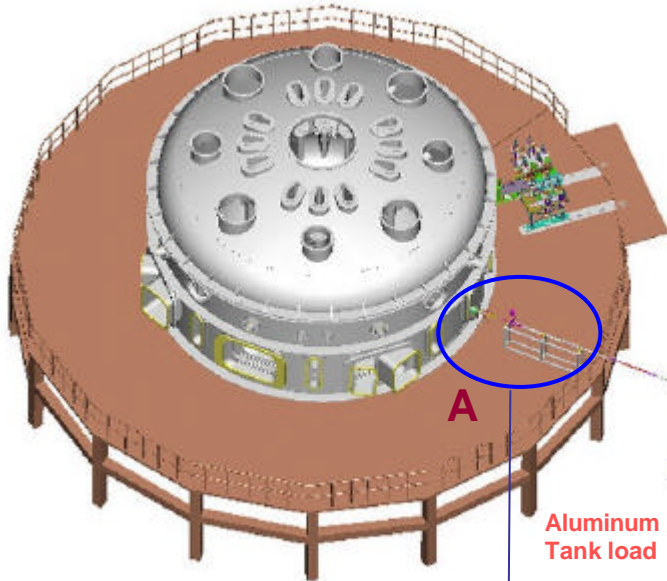
- The KSTAR ECH system uses a CPI 84 GHz gyrotron which is designed with the **CPD (Collector-Potential-Depression)** scheme. The gyrotron is capable of generating 500 kW RF power driven by **80-kV, 25-A electron beams**. The gyrotron of the CPD type requires two power supplies, a cathode power supply (CPS) and a body power supply. The cathode power supply produces electron beams of 25 A. The cathode-body potential difference of 80 kV is maintained by the body power supply between the cathode and the gyrotron body. Therefore, the body power supply is called the acceleration power supply (APS). The nominal applied voltage and output current of the CPS are -80 kV and 30 A, respectively, and those of the APS are +100 kV and 100 mA, respectively. The gyrotron operation voltages are -56 kV at the cathode by the CPS and +24 kV at the body by the APS with respect to the collector at the ground potential. **The system was tested with a resistor of 2.5 k as a dummy load.** We also confirmed that the fast switch-off prior to the high voltage crow-baring is capable of limiting the arc energy transfer less than 6 J using an in-house built arc-test zig. Conclusively, this test showed the power supply is properly designed and can be used for the gyrotron operation. In this paper, we present the detailed test skills and the test results.

KSTAR ECH system

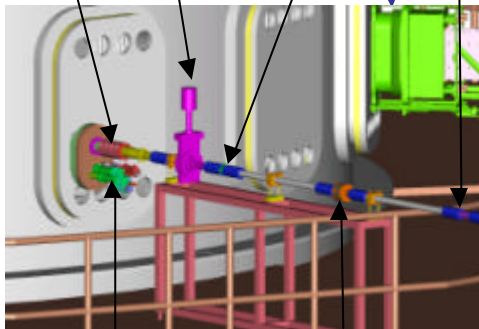
• Transmission line components:

1. Eight miter bends
- One power monitoring miter bend
- Three Regular miter bends
- Two Arc detector miter bends
- Two polarizer miter bends

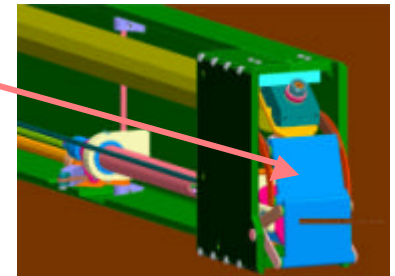
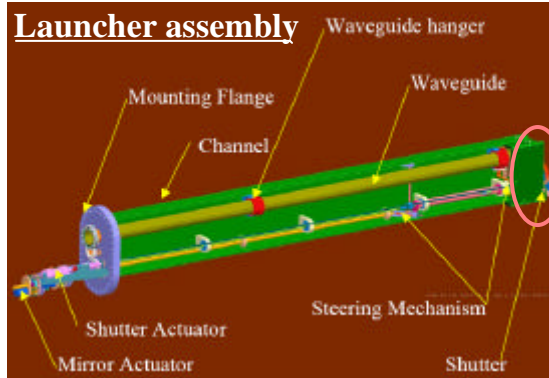
2. Two pump-out tees
3. Two waveguide switches
4. Two bellows
5. One 5 kV DC break
6. One RF gate valve
7. One Diamond window
8. Two water loads



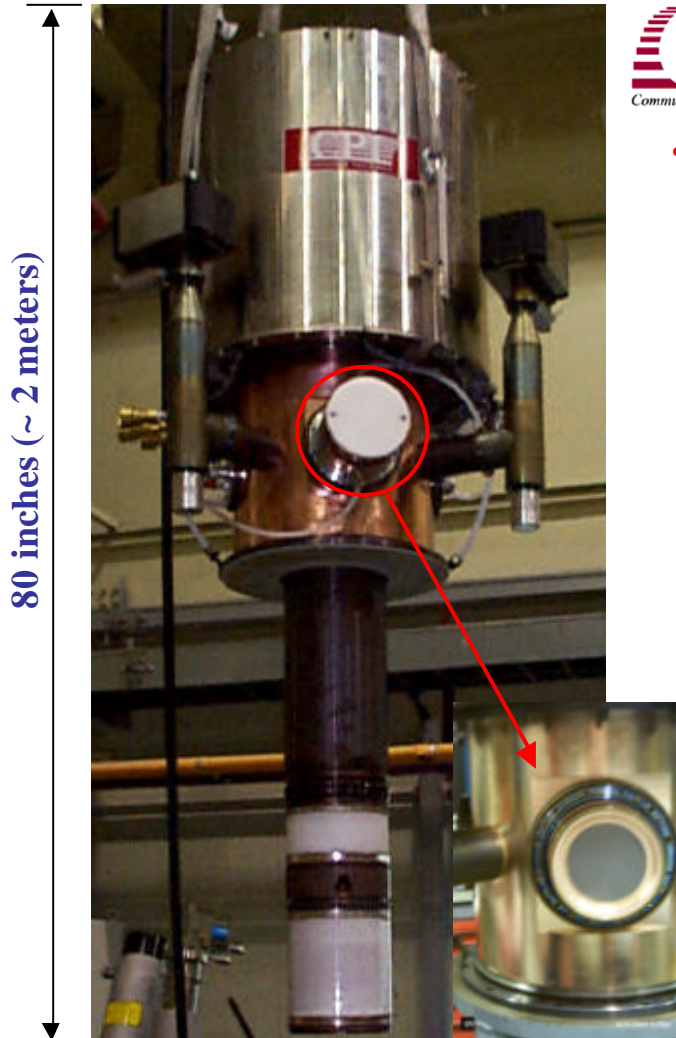
Launcher input RF gate valve Diamond window Bellows



Launcher gear assembly 5 kV DC break



84-GHz, 500 kW gyrotron

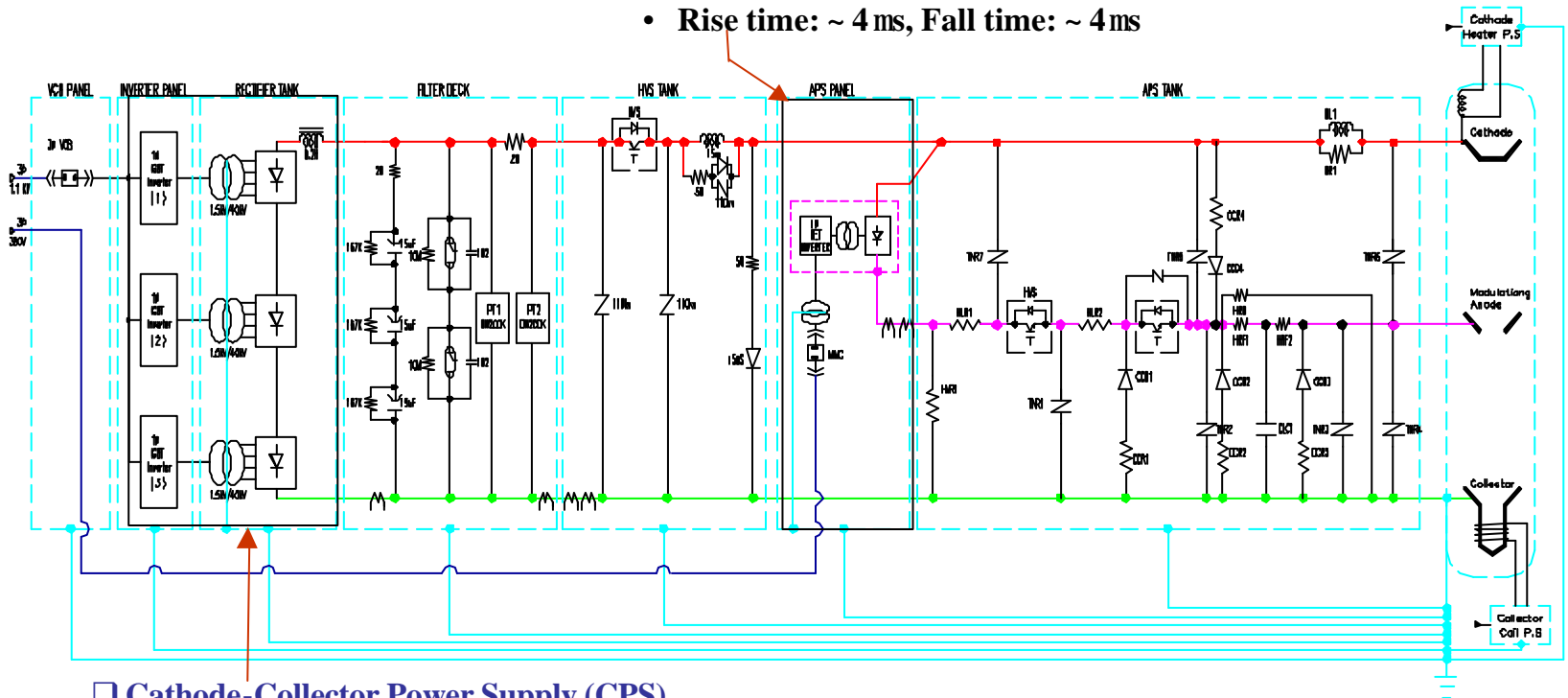


- **Specifications of Gyrotron (CPI VGB8084)**
 - Frequency: 84 GHz with 0.1 GHz bandwidth
 - Power: 500 kW with duration of 2 sec pulse
 - Gun Type: Diode-gun with cathode of 40.6 mm-radius
 - Cavity mode: TE_{15,4,1} (31-kG focusing field)
 - $a = 1.4$ (80 kV and 25 A)
 - Collector Potential Depression
 - Cathode-Collector Voltage: -56 kV
 - Cathode-Body Voltage: -80 kV
 - Beam Current: 25 A
 - Heater voltage: 28 V, Heater current: 9 A
 - Efficiency: 40 %
 - RF output mode: TEM₀₀ Gaussian mode with linear polarization
 - Diamond window: edge-cooled single-disk with 2.0-inch (50.8 mm) aperture and 0.059-inch (1.5 mm) thickness

Schematic circuit drawing of power supply

Acceleration Power Supply (APS: Cathod-Body Power Supply)

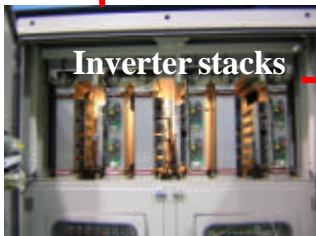
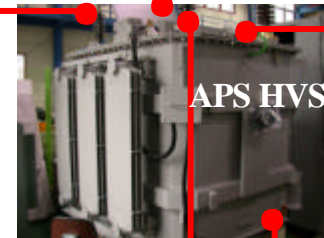
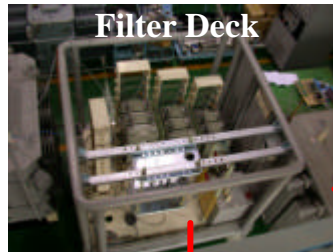
- 100 kV, 100 mA
- Pulse width: 10 ms ~ 10 sec
- Rise time: ~ 4 ms, Fall time: ~ 4 ms



Cathode-Collector Power Supply (CPS)

- -85 kV, 30 A
- Pulse width: 10 ms ~ 10 sec
- Crowbar switch system: Two ignitrons with each trigger modules
- Rise time: ~ 4 ms, Fall time: ~ 4 ms

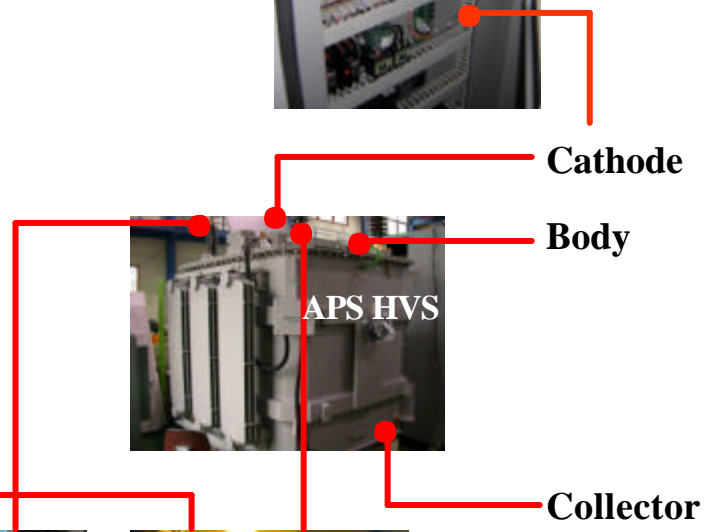
Configuration of power supply



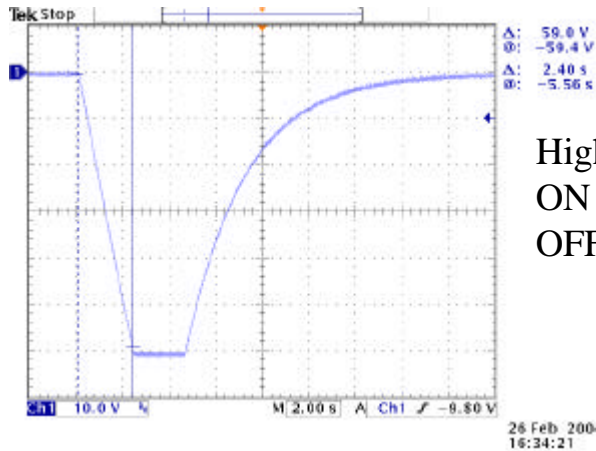
Cathode

Body

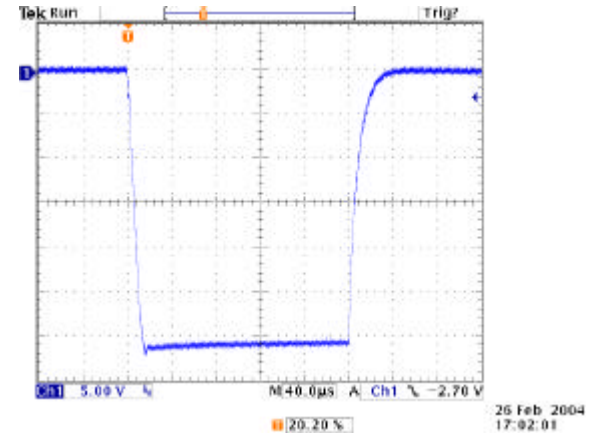
Collector



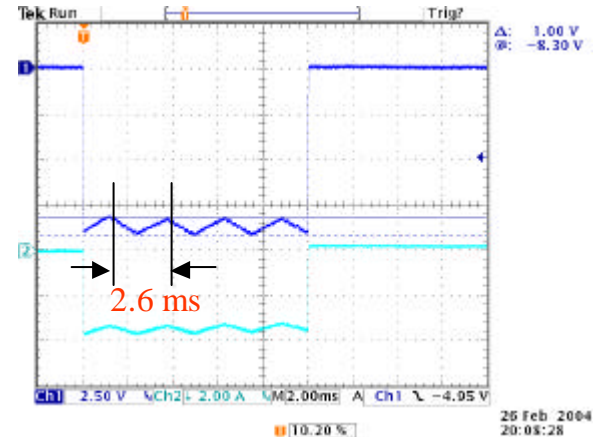
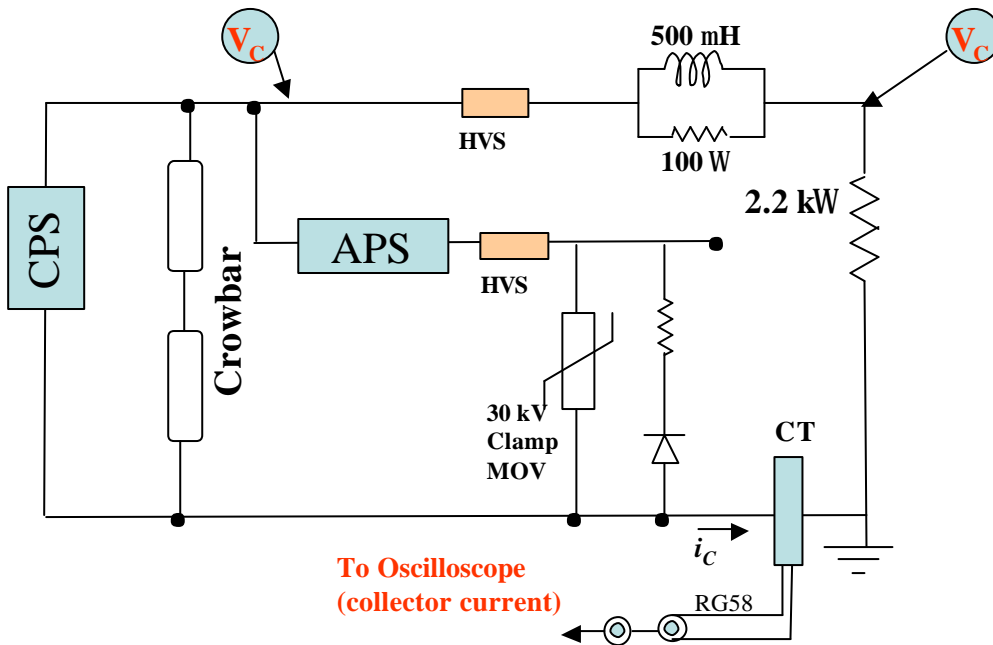
CPS



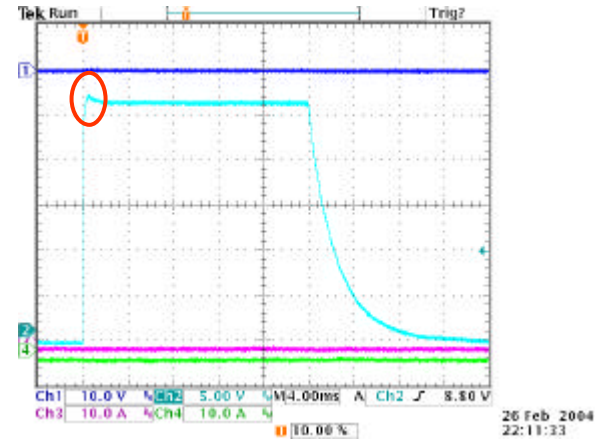
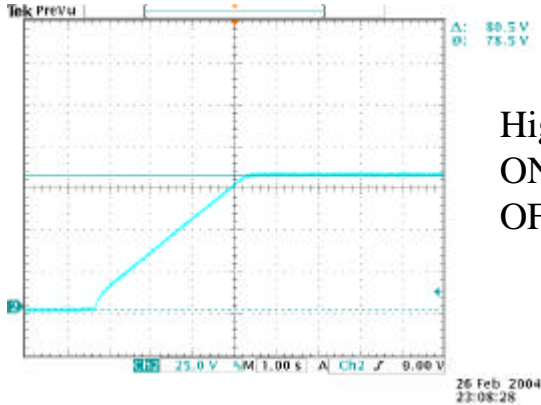
High Voltage ON/OFF
 ON time: 2.4 sec
 OFF time: 11 sec



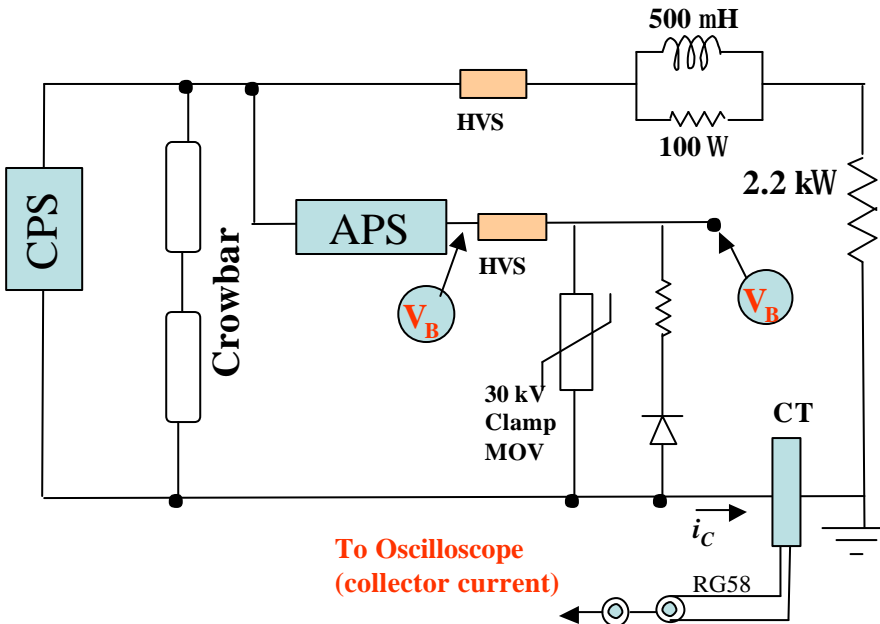
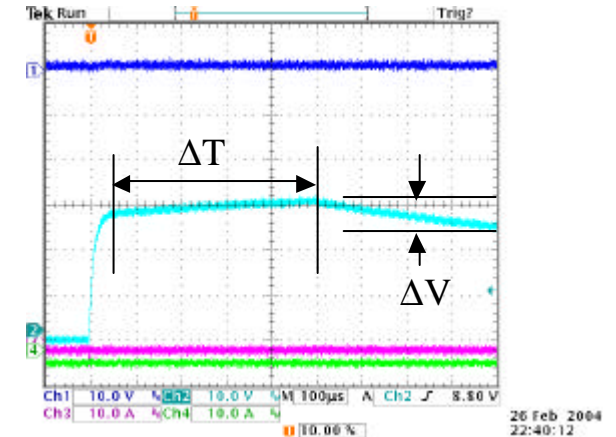
Rise time: 16 μ sec (for -30 kV)
 Fall time: 40 μ sec
 Ripple: 1 kV / 8.8 kV * 100 = 11 %
 Ripple : 2.6 ms (379 Hz)
 (Inverter : ~ 800 Hz)



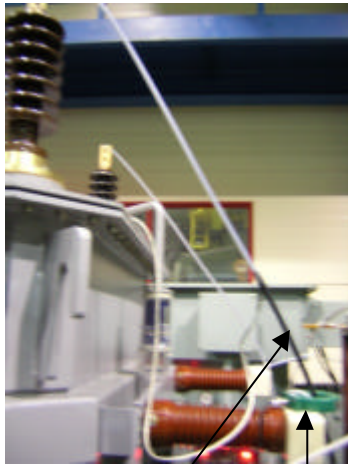
APS



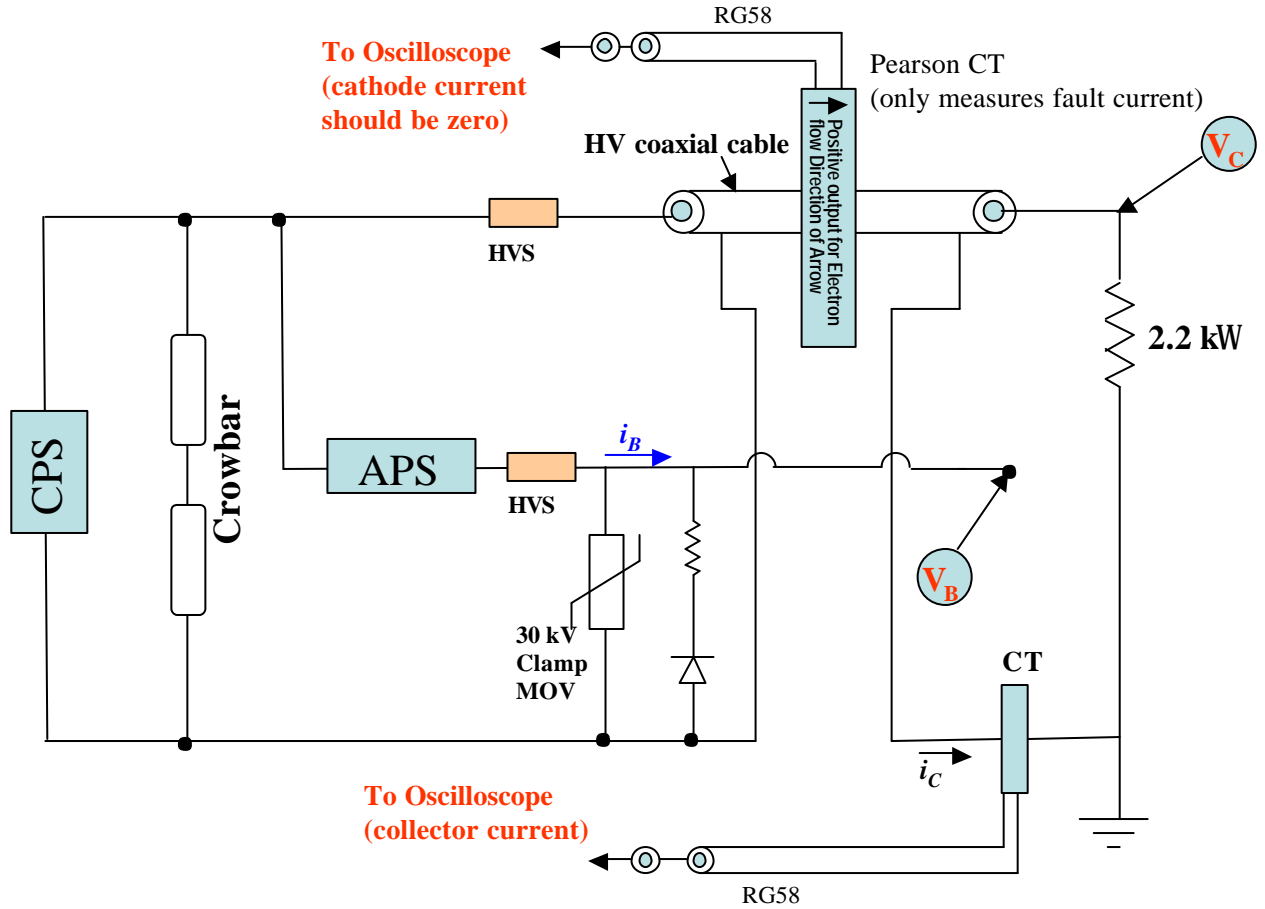
Rise time: 25 μ sec (for + 26 kV)
Fall time: 12 msec
Overshoot:
 $\Delta T \sim 460 \mu$ sec, $\Delta V \sim 1$ kV



MOV test



HV coaxial cable
Pearson CT



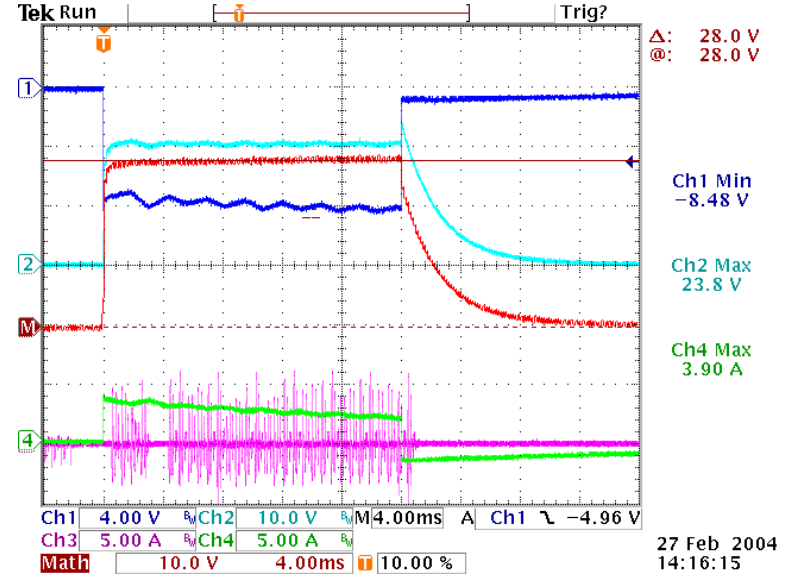
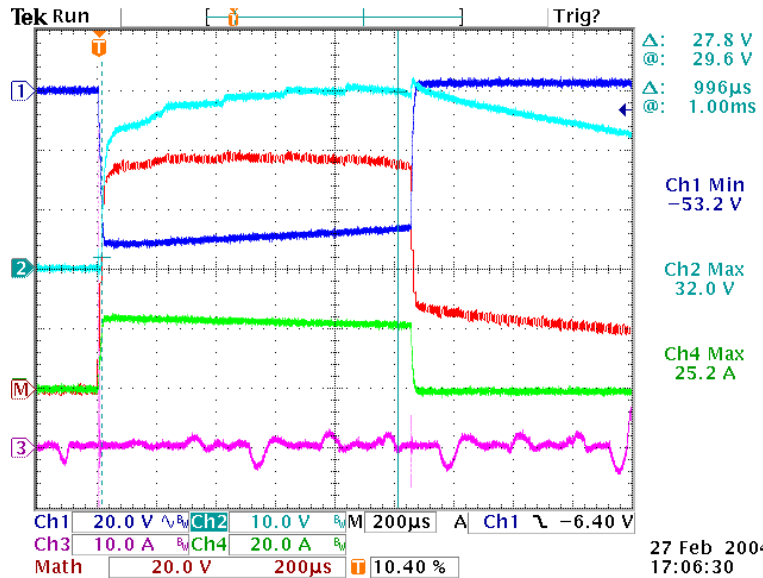
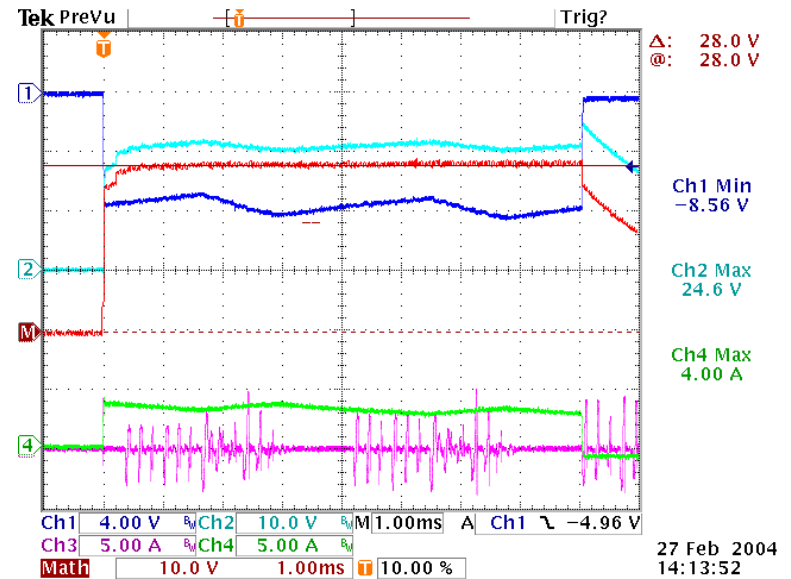
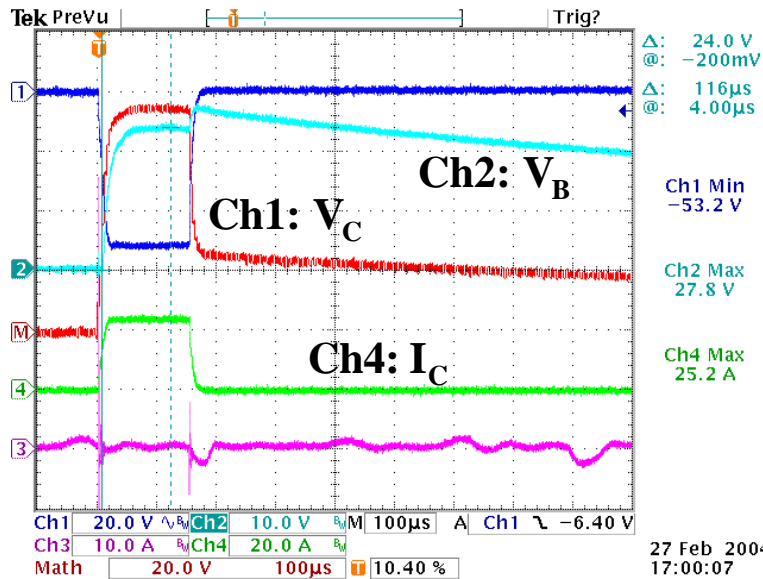
* APS

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V_B

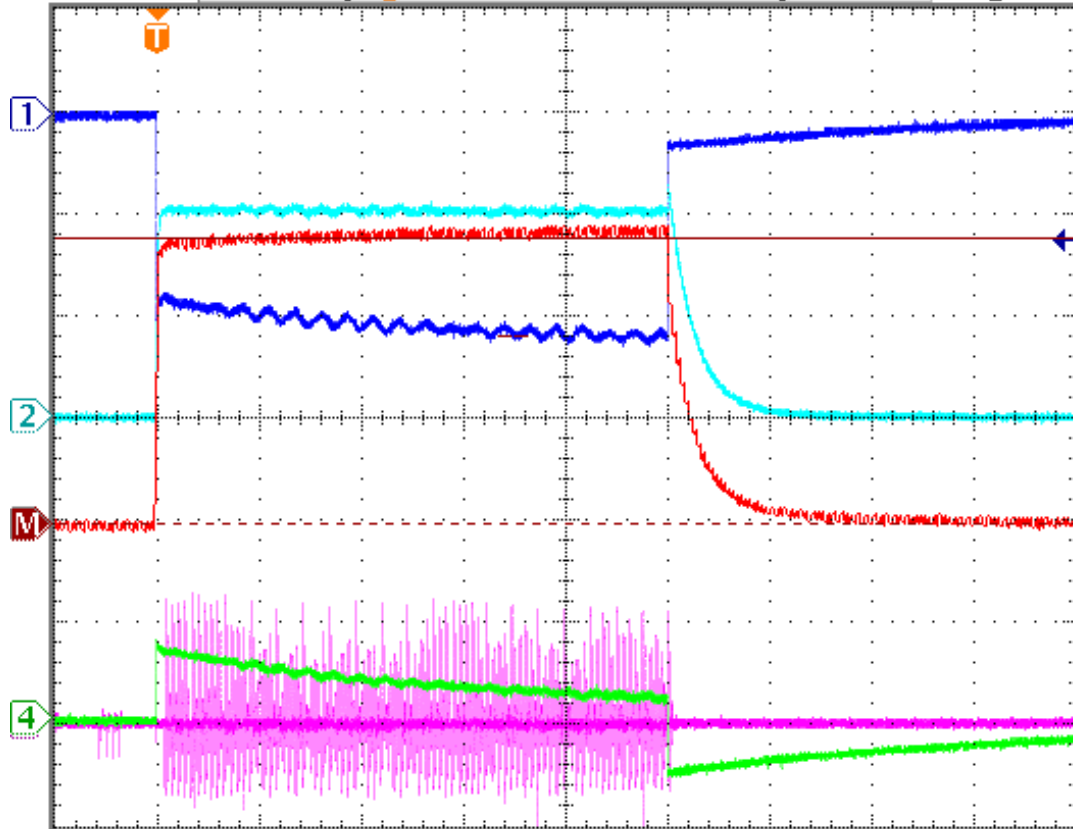
30 kV

MOV clamp



Tek Run

Trig?



Δ: 28.0 V
@: 28.0 V

Ch1 Min
-9.12 V

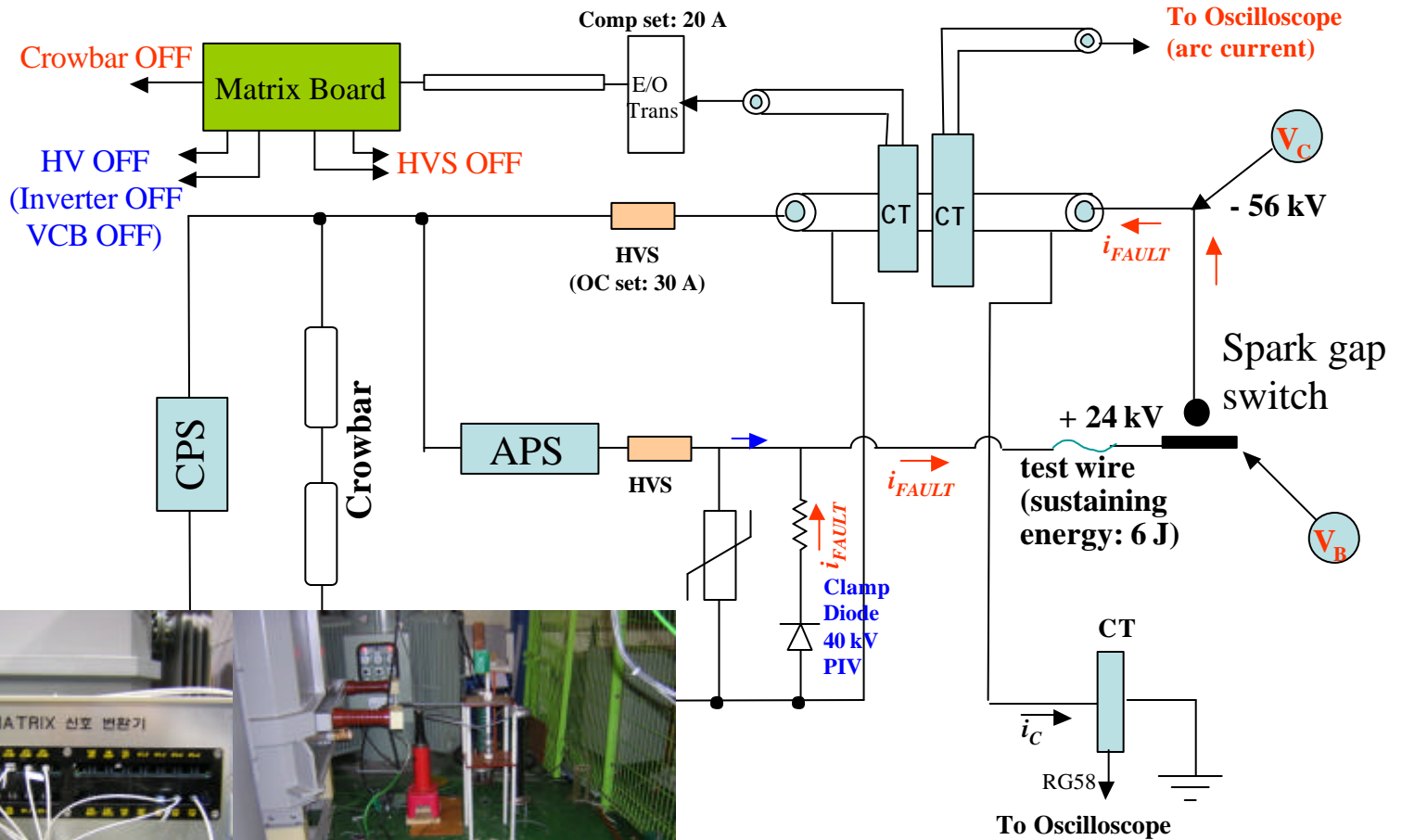
Ch2 Max
23.4 V

Ch4 Max
3.80 A

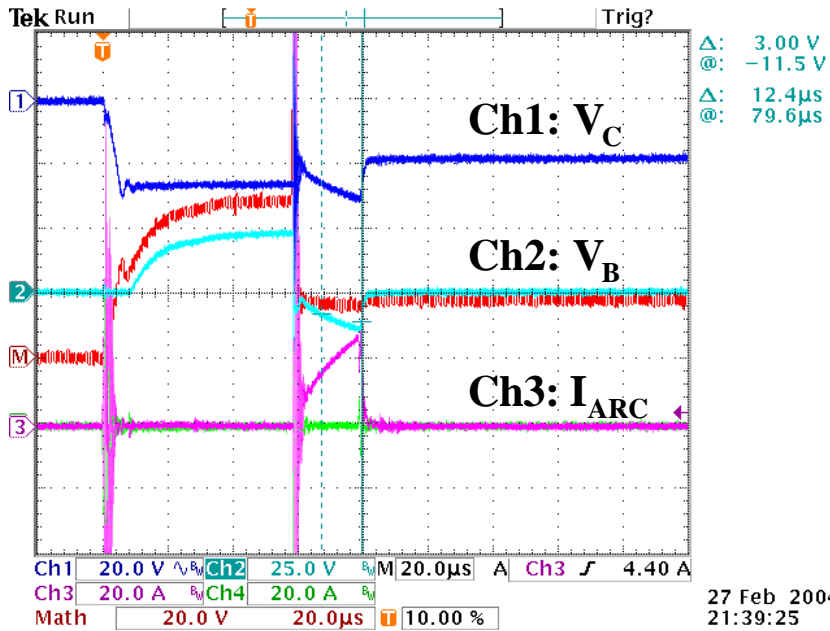
Ch1	4.00 V	B _w	Ch2	10.0 V	B _w	M	10.0ms	A	Ch1	↖	-4.96 V
Ch3	5.00 A	B _w	Ch4	5.00 A	B _w						
Math	10.0 V		10.0ms								

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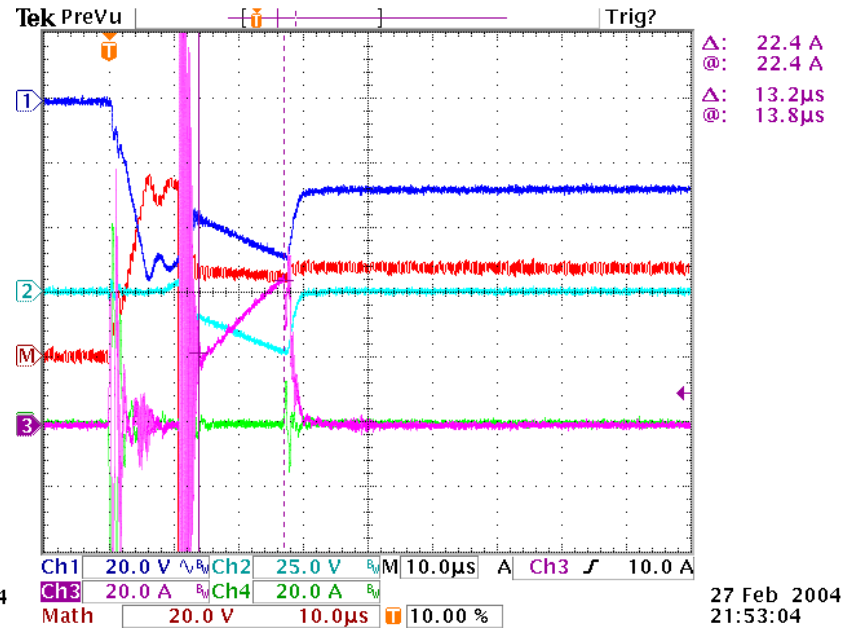
Arc test



* Arc test crowbar test, clamp diode test, Pearson CT fault test



$V_C = -30$ kV,
 $V_B = +25$ kV

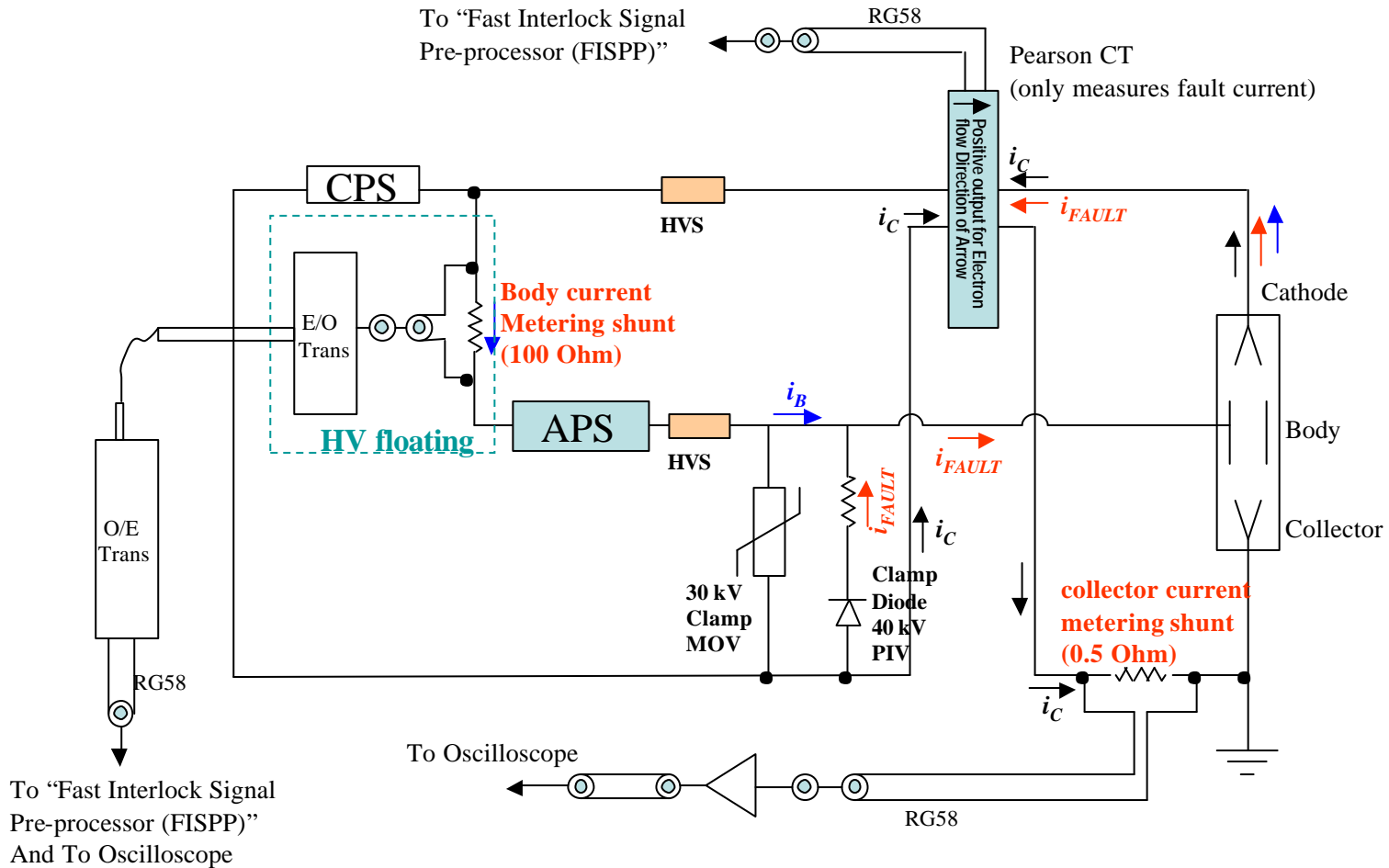


$V_C = -56$ kV,
 $V_B = +24$ kV

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Gyrotron power supply electronics



* Arc current between the cathode and body will be a major fault current