

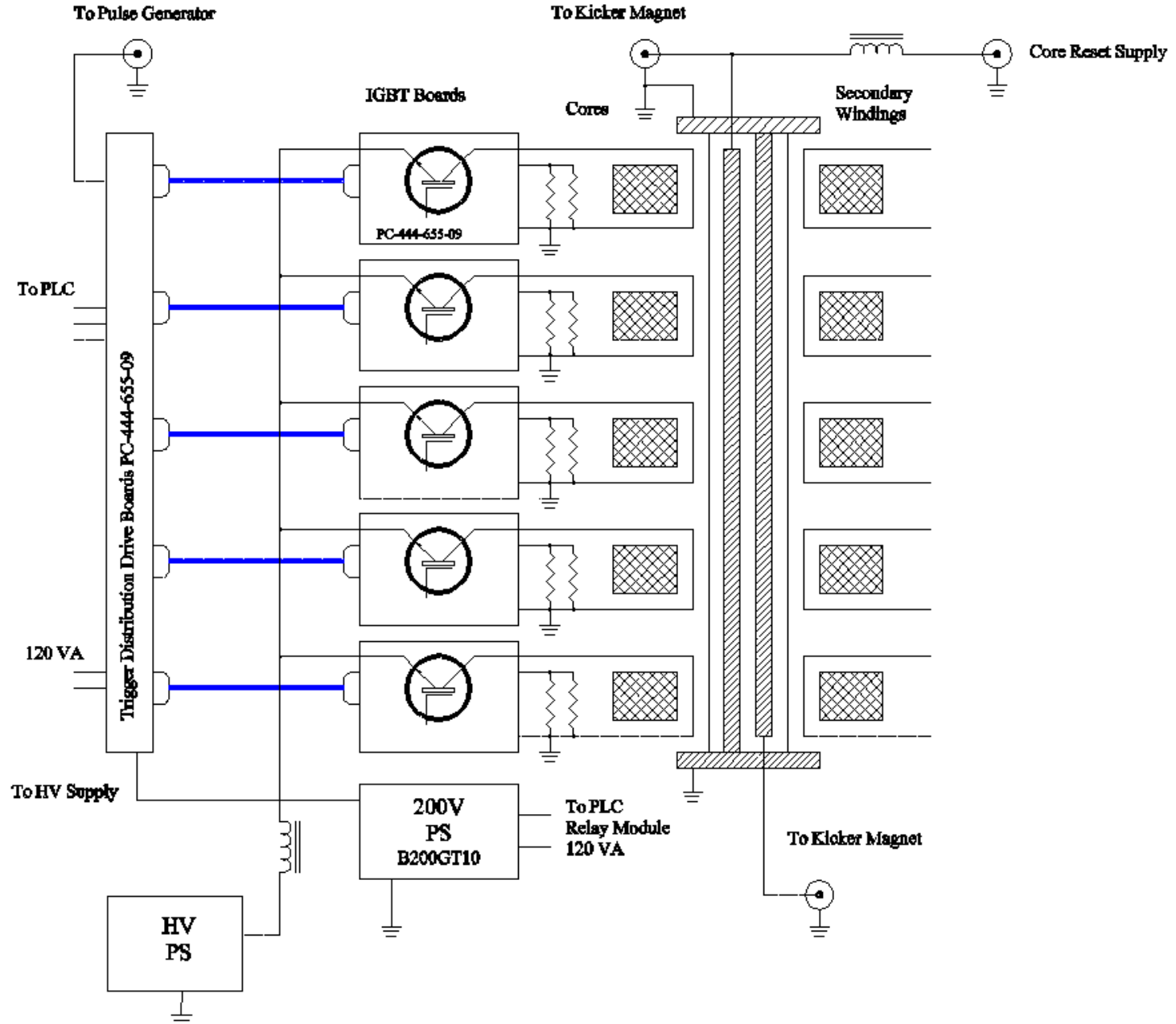
Operation of the SPEAR III Kicker System

Chris Pappas

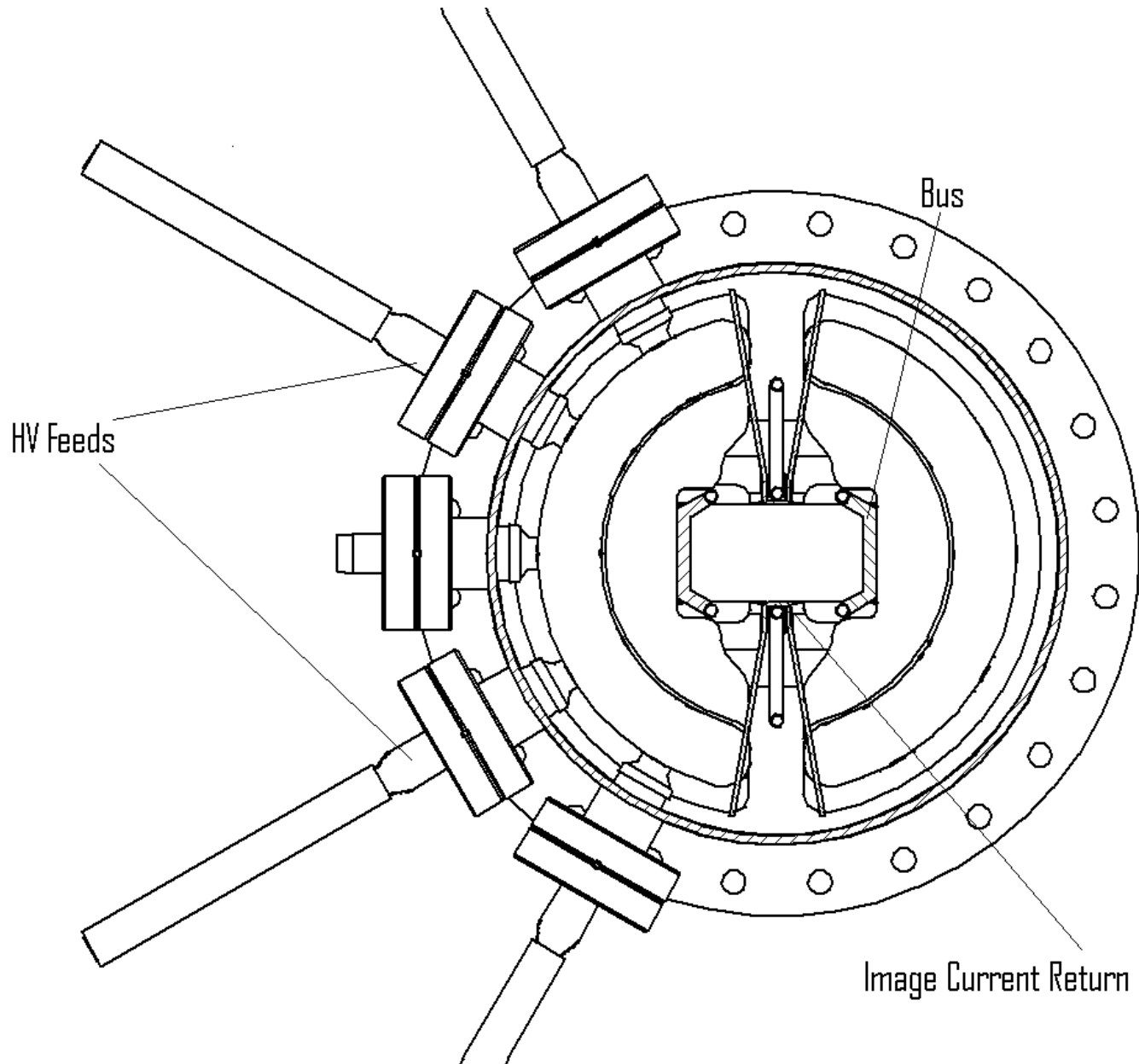
SPEAR III Kicker System Requirements & Specs.

• Parameter	K1	K2	K3
• Beam Energy	3.3 GeV	3.3 GeV	3.3 GeV
• Bend Angle	2.2 mrad	1.2 mrad	2.2 mrad
• Magnet Length	1.2 m	0.6 m	1.2 m
• Magnet Aperture	60X34 mm	60X34 mm	60X34 mm
• Magnitude B	20 mT	22 mT	20 mT
• Magnetic Gain	8.7 μ T/A	8.7 μ T/A	8.7 μ T/A
• Current	2381 A	2619 A	2381 A
• Output Voltage	20 kV	10 kV	20 kV
• Rise/Fall Time	<375 ns	<375 ns	<375 ns
• Pulse Width	<750 ns	<750 ns	<750 ns
• PRF	10 Hz	10 Hz	10 Hz

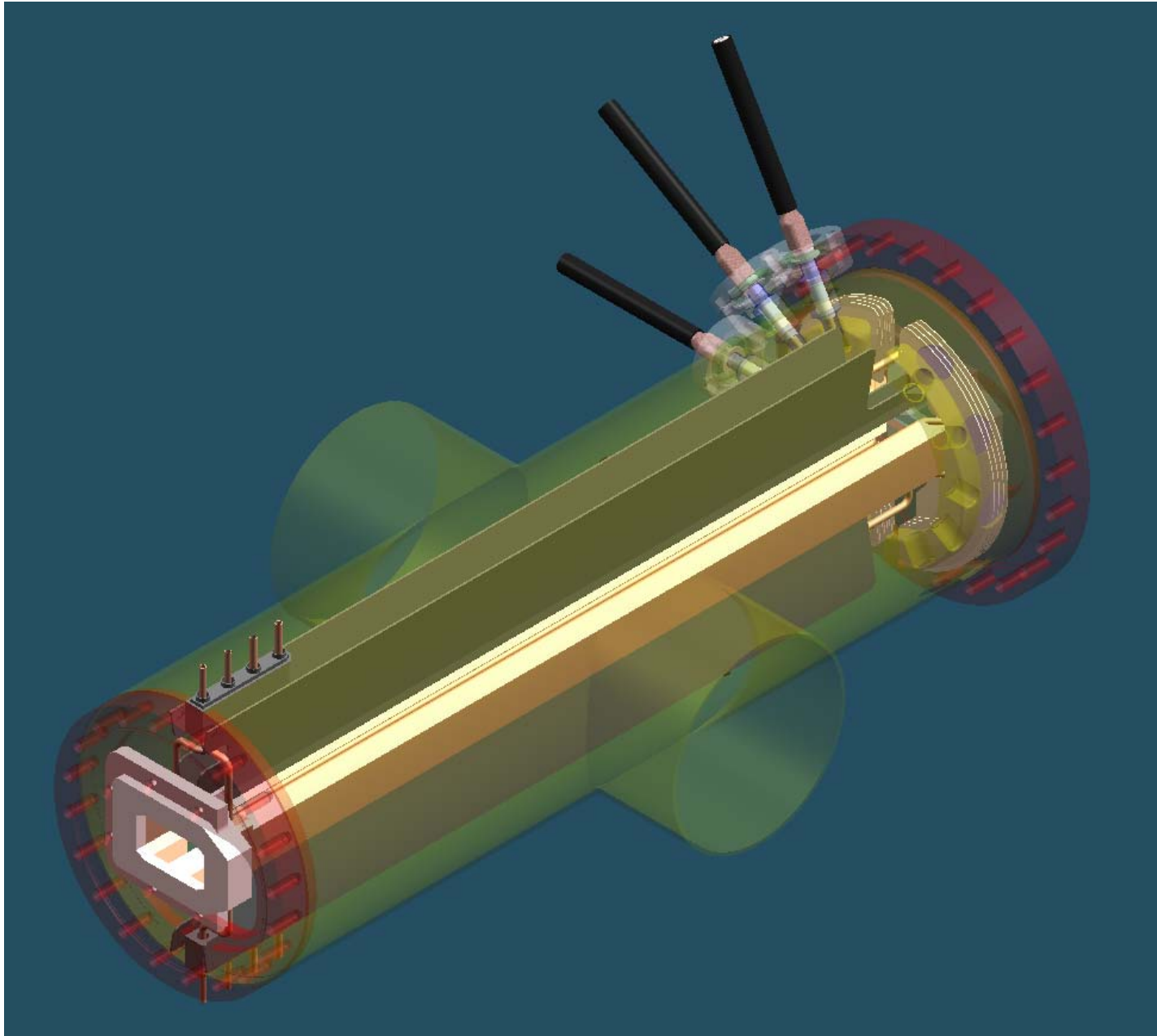
Schematic of K2 Modulator



Magnet Cross Section



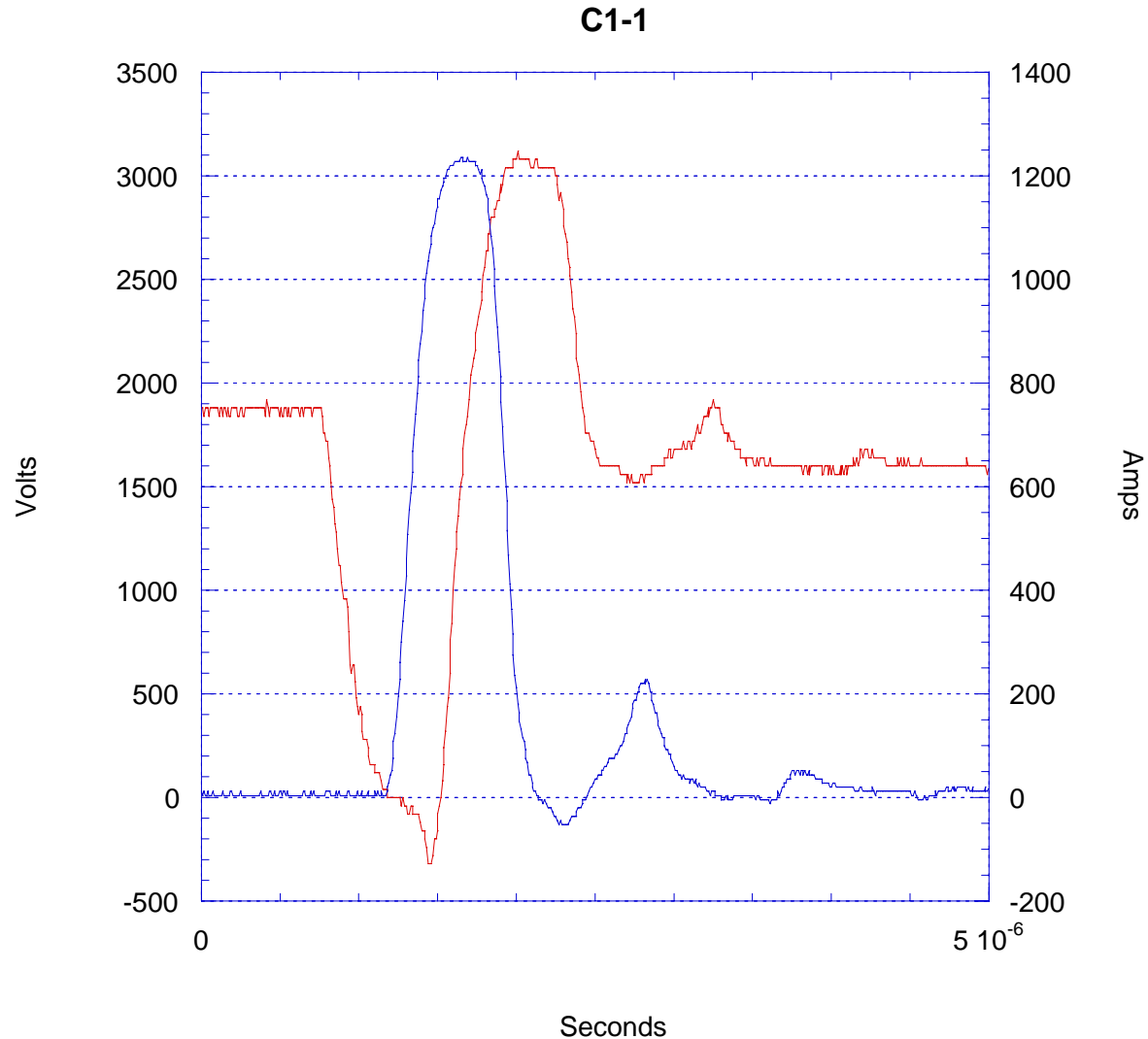
K2 Solid Model



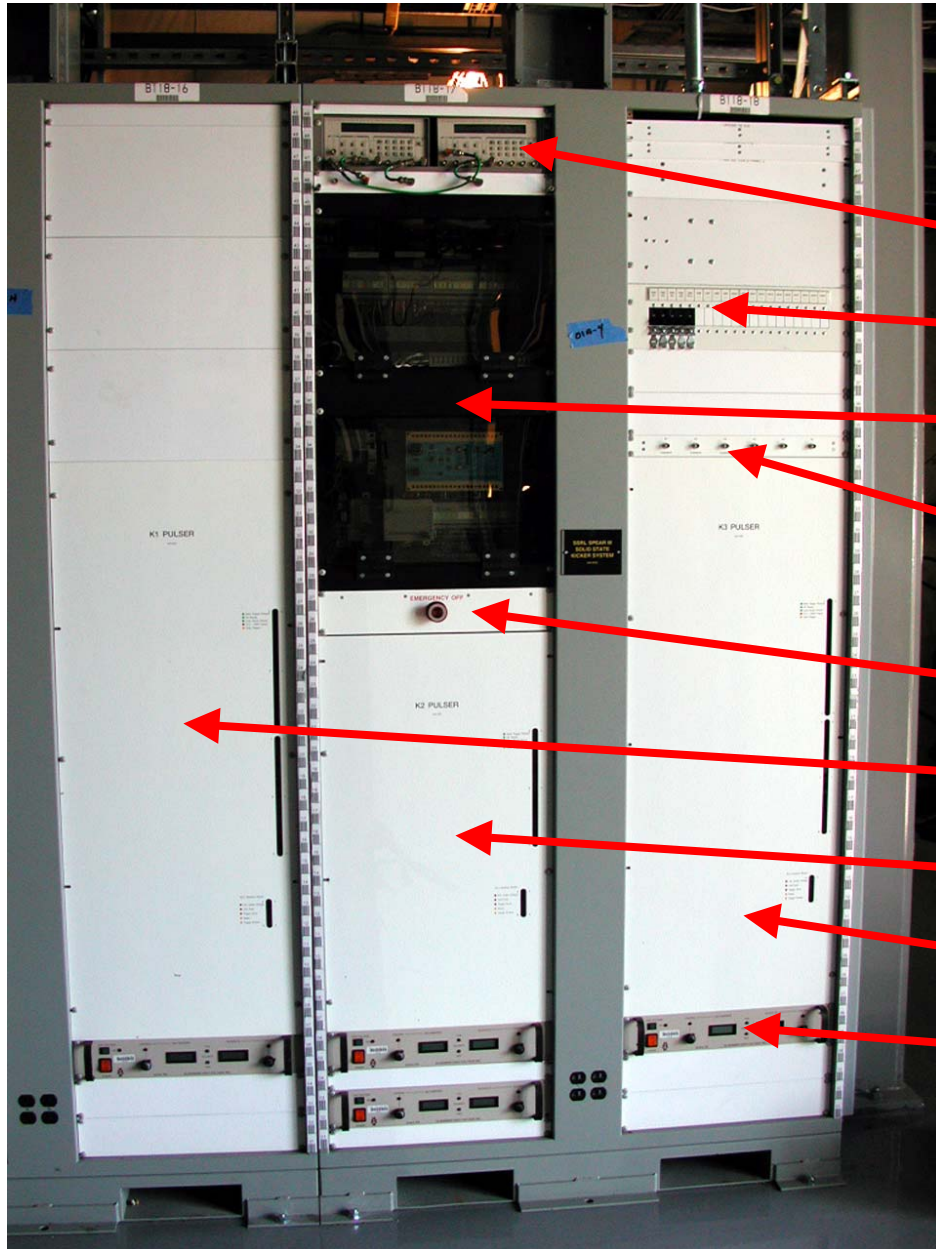
Output Current & IGBT Voltage

Collector Voltage

Cable Current

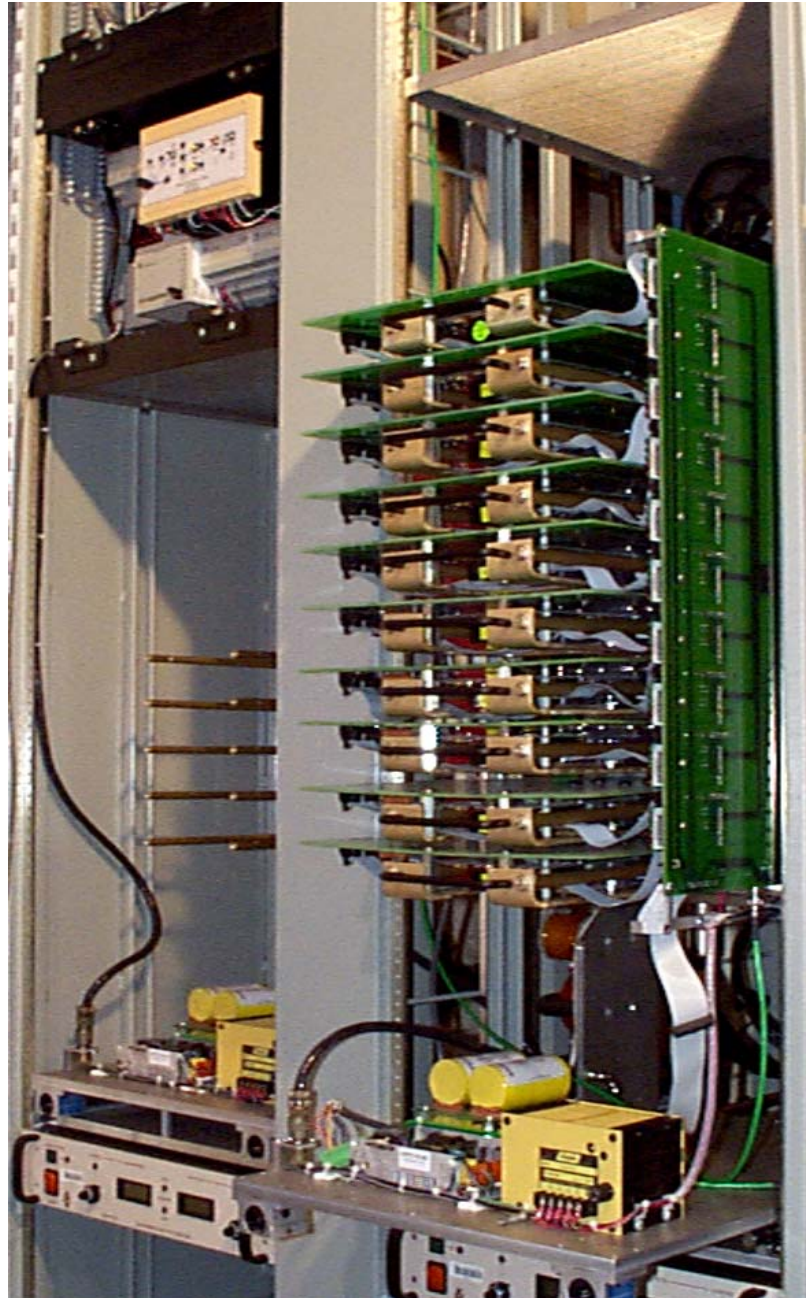


B118 Racks 16-18 Layout

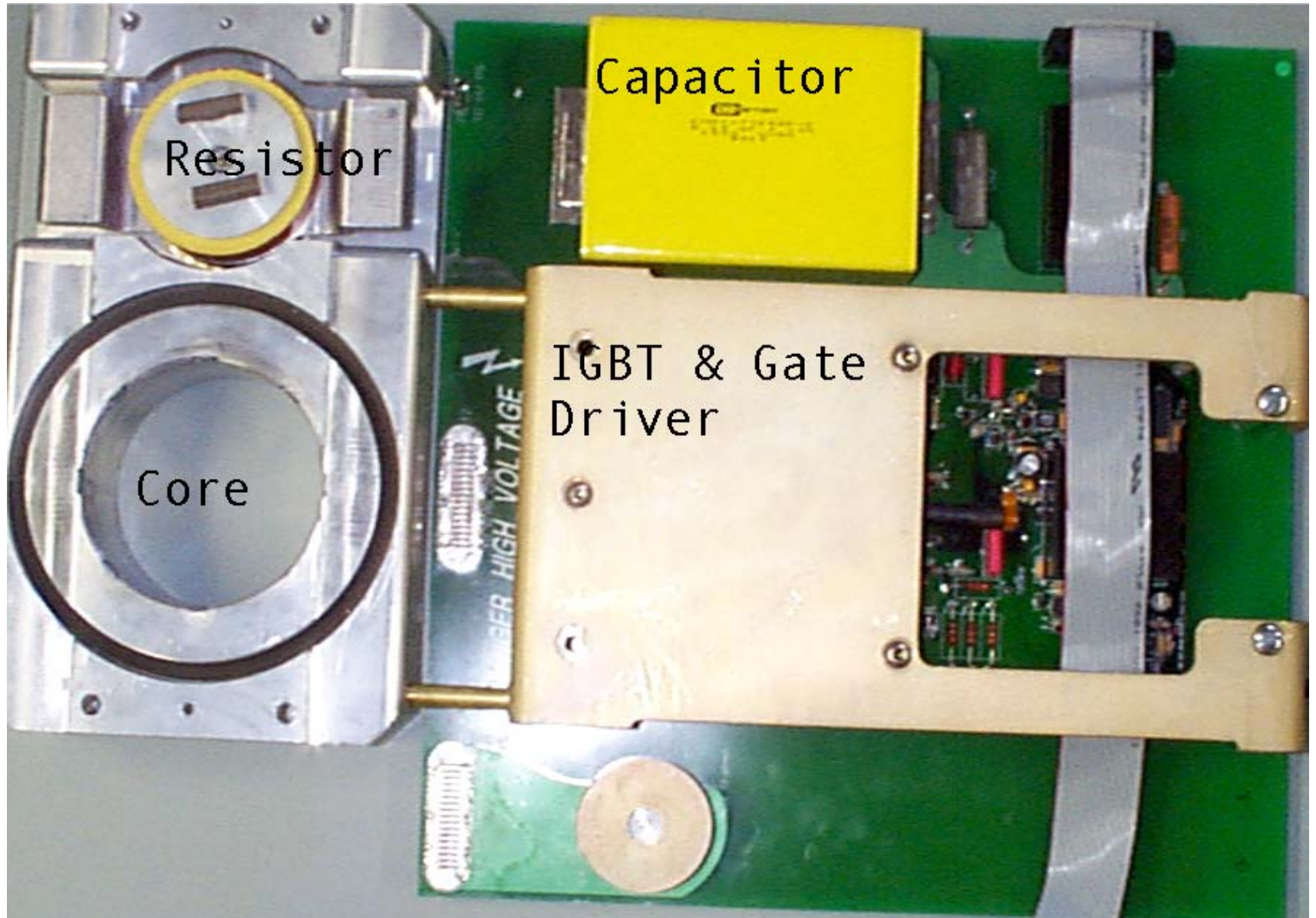


- SRS Trigger Generators
- AC Breakers
- Allen Bradley PLC
- Current Monitor Patch Panel
- Emergency Off
- K1 Modulator
- K2 Modulator
- K3 Modulator
- HVDC Power Supplies

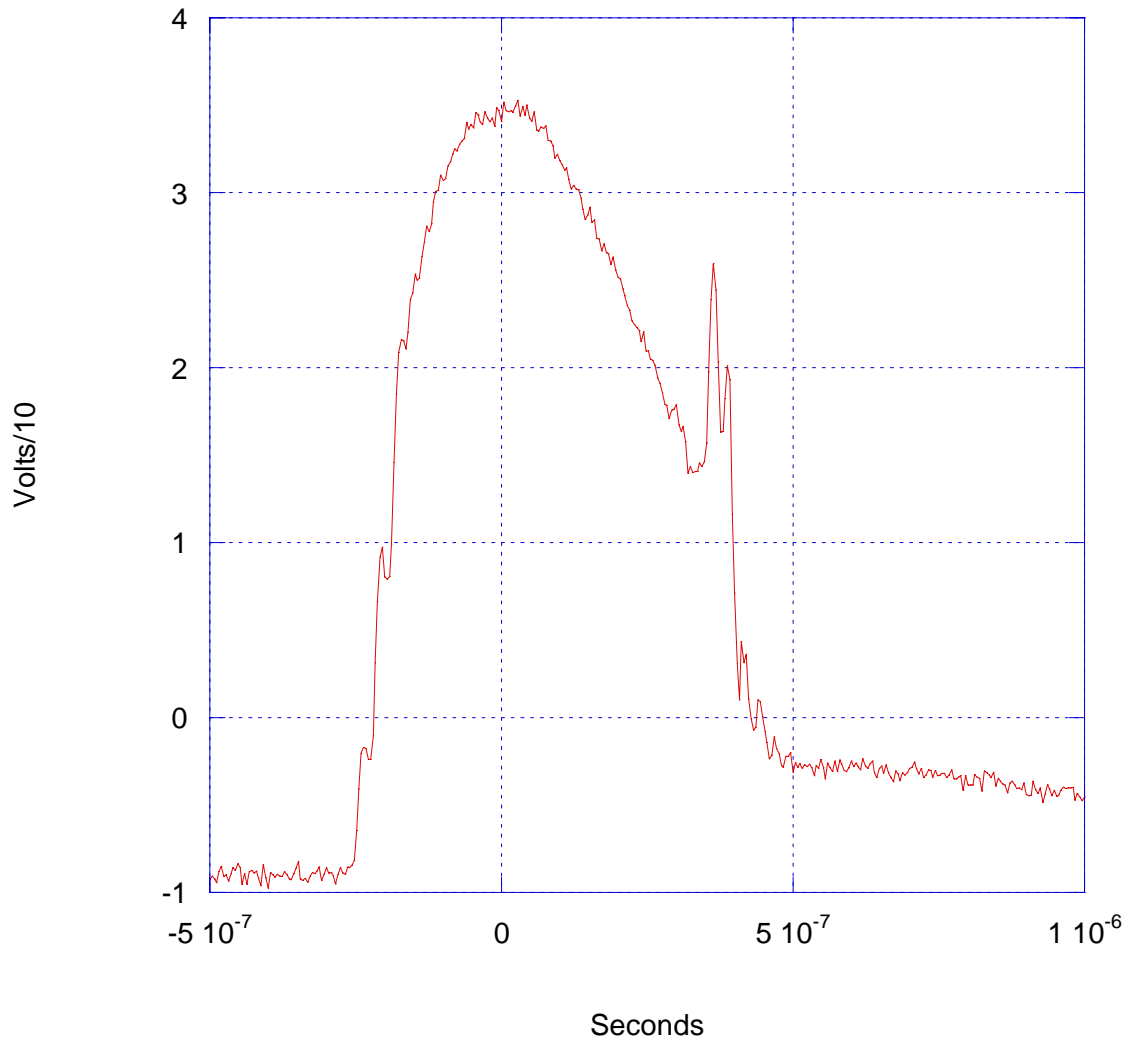
K2 & K3 Modulators



IGBT Driver



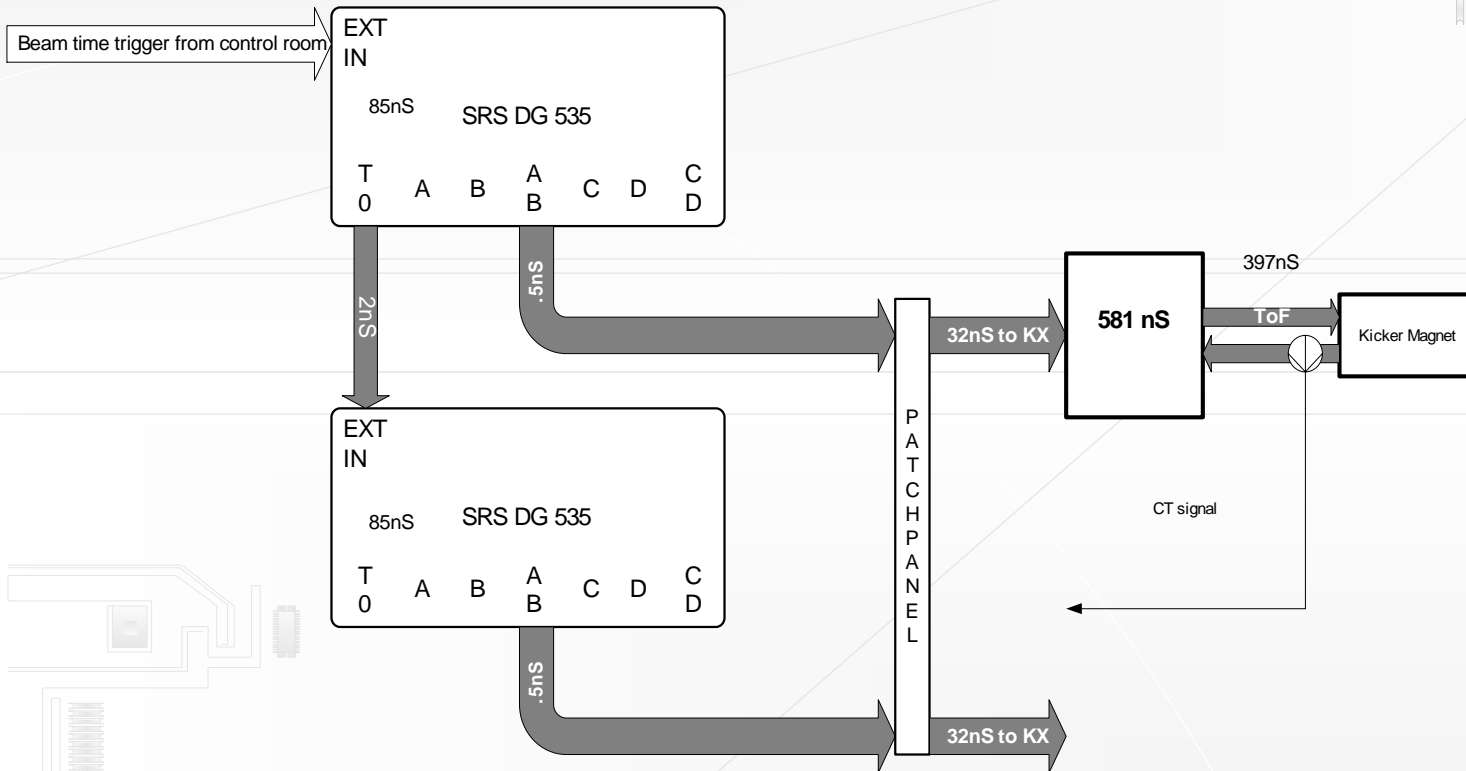
Gate Drive Pulse



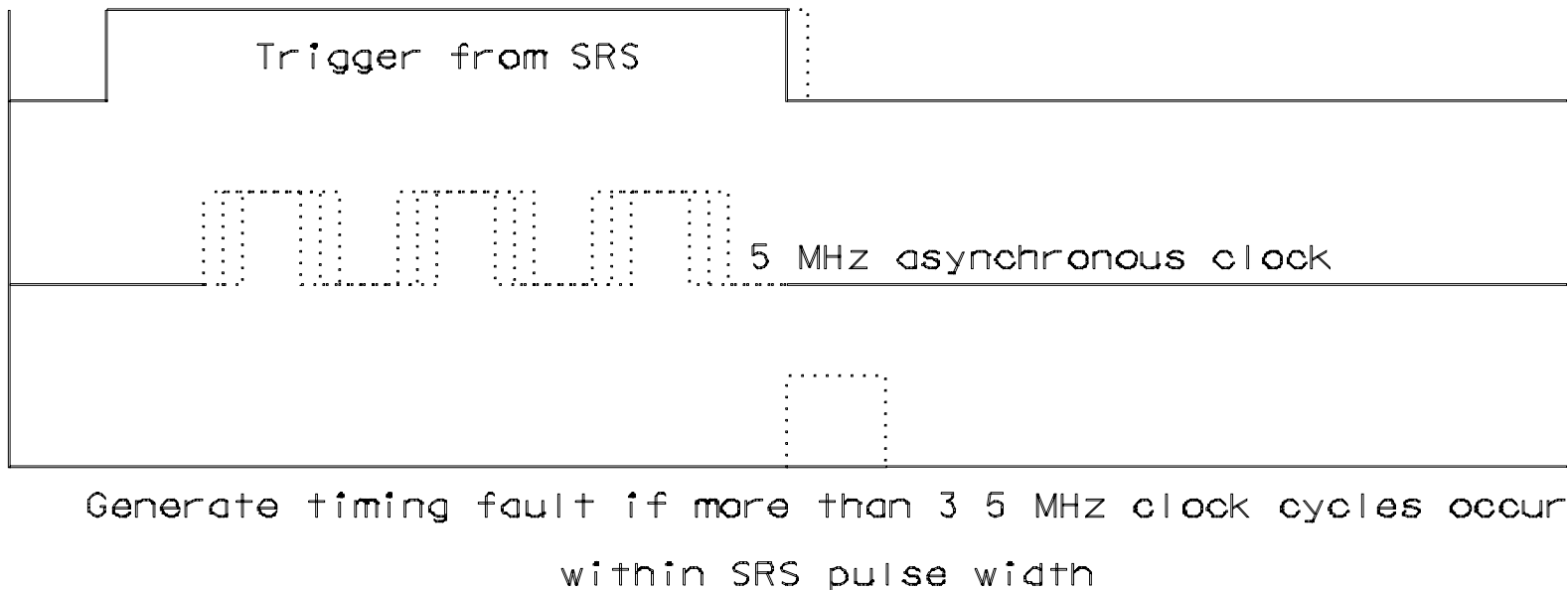
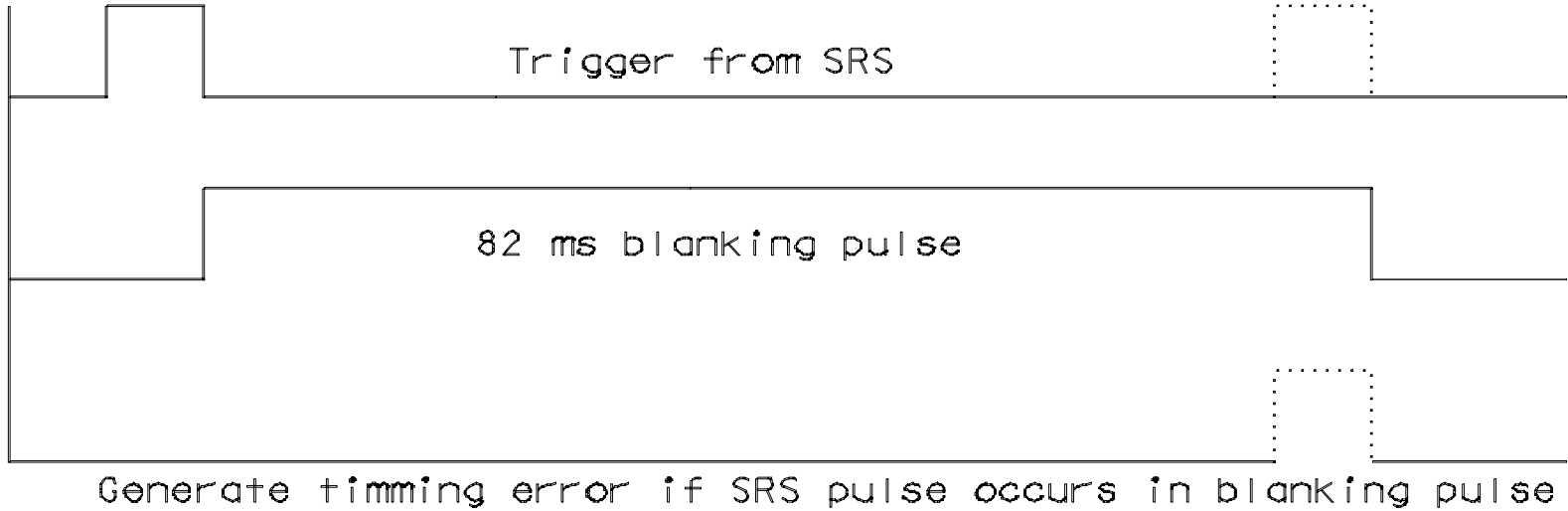
Timing Delays

SPEAR 3 KICKER SYSTEM TIMING Fig 2

- System Delay K1 or K2 = Btime +85nS + Channel Delay +500 pS + 3200 pS + 581nS + Time of Flight
- System Delay K3 = Btime +85nS + 2000pS +85nS + Channel Delay +500 pS + 3200 pS + 581nS + Time of Flight
- Time of Flight = 265ft * 1.5nS= 397.5nS



Timing Error Diagram



Programming the Output Voltage Definitions

Variable	Definition	Units
I	Magnet Current	Amps
N	Number of Cells	
V_o	HVPS Output Voltage	Volts
Z	Modulator Impedance	Ohms
M_g	Magnet Gain	Tesla/Amp
M_l	Magnet Length	meters
V_g	Voltage Gain	Tesla-meter/Volt
G_{dw}	Digital Word Gain	Tesla-meter/bit

Programming the Output Voltage

- Modulator output current
- Beam Kick
- Voltage gain of modulator
- The 3000 V supply is controlled by a 0-10 VDC reference which is programmed by a 16 bit word.
- Digital word gain (Tesla-meter/bit)

$$I = 2N \frac{V_0}{Z}$$

$$K = M_g M_l I$$

$$V_g = 2N \frac{M_g M_l}{Z}$$

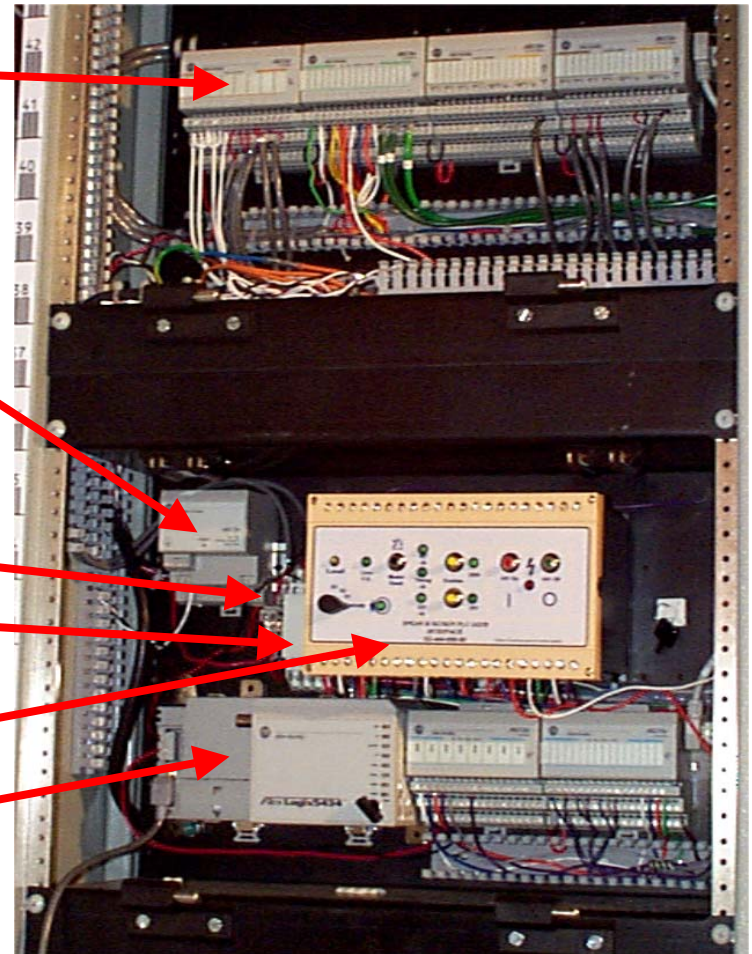
$$G_{dw} = 0.18N \frac{M_g M_l}{Z}$$

Table of Gains

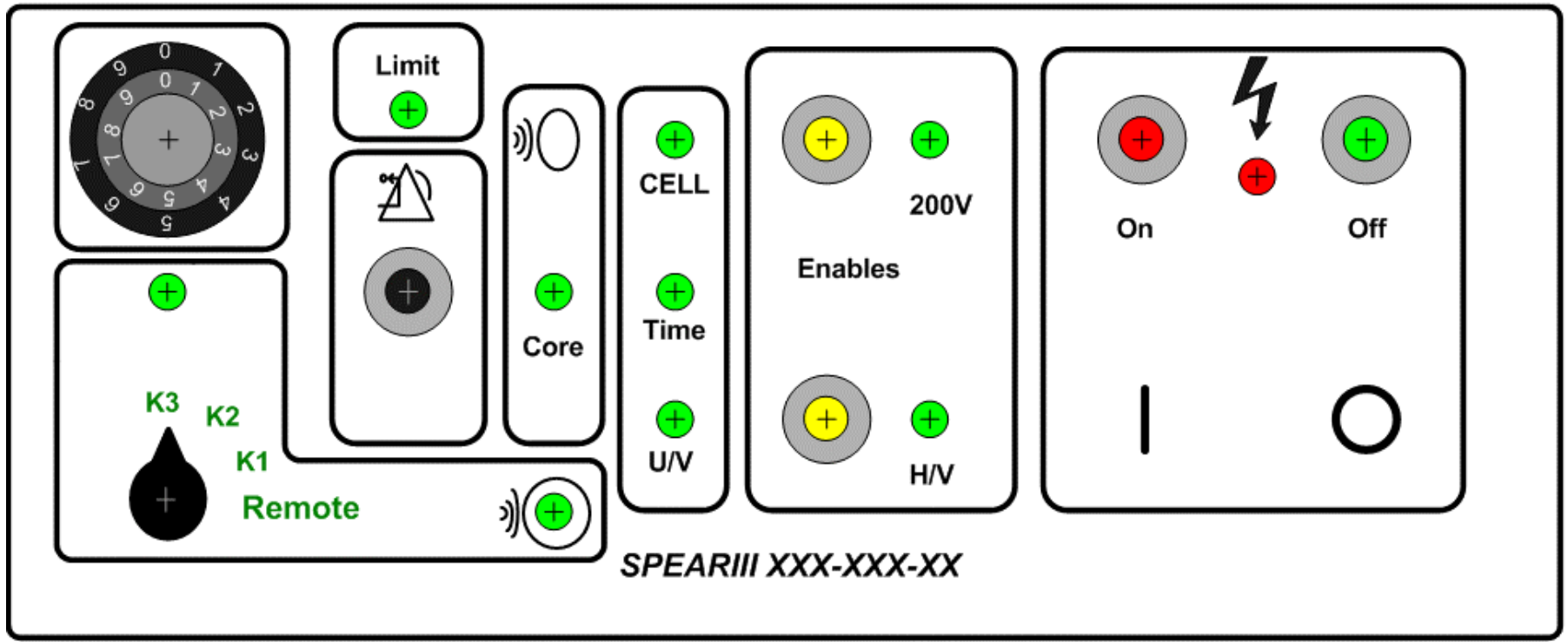
Kicker	Voltage Gain	Digital Word Gain
K1	1.55×10^{-5}	1.4×10^{-6}
K2	7.73×10^{-6}	0.71×10^{-6}
K3	1.55×10^{-5}	1.4×10^{-6}

PLC Chassis

- Input/Output Modules
- Power Supply
- AC Breaker
- Interlock Indicators
- Local Interface
- CPU Module

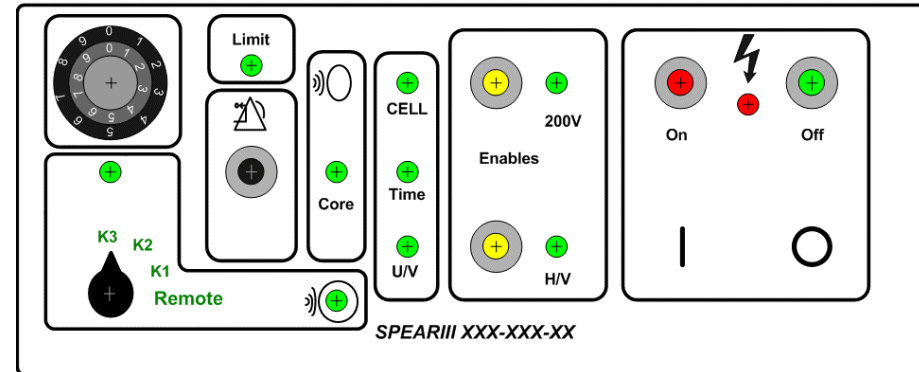


Local Control Interface



Operation on Local Mode

- **TURN ON**
- Select the kicker you want to run.
- Press the Reset button.
- Press 200 V Enable.
- Press HV Enable.
- Press HV ON button.
- Turn Pot to desired voltage.
- **TURN OFF**
- Press HV OFF button.
- Note. When controller is powered up all LEDs light for 2 seconds for a lamp test.



Troubleshooting in Local Mode

- Check Breakers in Rack 18 and in the PLC chassis.
- Make sure the PLC is in RUN mode.
- Check to see that all INTERLOCK indicators are illuminated.
- Make sure the EMERGENCY OFF button is not depressed.
- Make sure that the pulse width is less than 1 μ s, and the PRF is less than 10 Hz.
- Check the LED indicators on the trigger distribution board and the PLC interface board.

Fault Indicator LEDs

PLC Interface Board

- P.S. Under Voltage
- Cell Fault
- Trigger Error
- Reset
- Trigger Enable
- Main Trigger Present
- HV Ready
- Core Reset Permit
- O.C. / IGBT Failed
- Gate Trigger

PLC Interface Indicators

- **P.S. Under Voltage.** Indicates the 15 VDC power supply on the trigger distribution board is not working.
- **Cell Fault.** Could indicate a shorted IGBT, failure of a gate drive, or trigger distribution board.
- **Trigger Fault.** Indicates a PRF of greater than 10 Hz, or pulse width of greater than 1.1 μ s.
- **Reset.** Indicates that the system is being reset from a previous fault.
- **Trigger Enable.** Indicates the SRS is properly programmed, and the high voltage is enabled.

PLC Interface Board

- **P.S. Under Voltage**
- **Cell Fault**
- **Trigger Error**
- **Reset**
- **Trigger Enable**

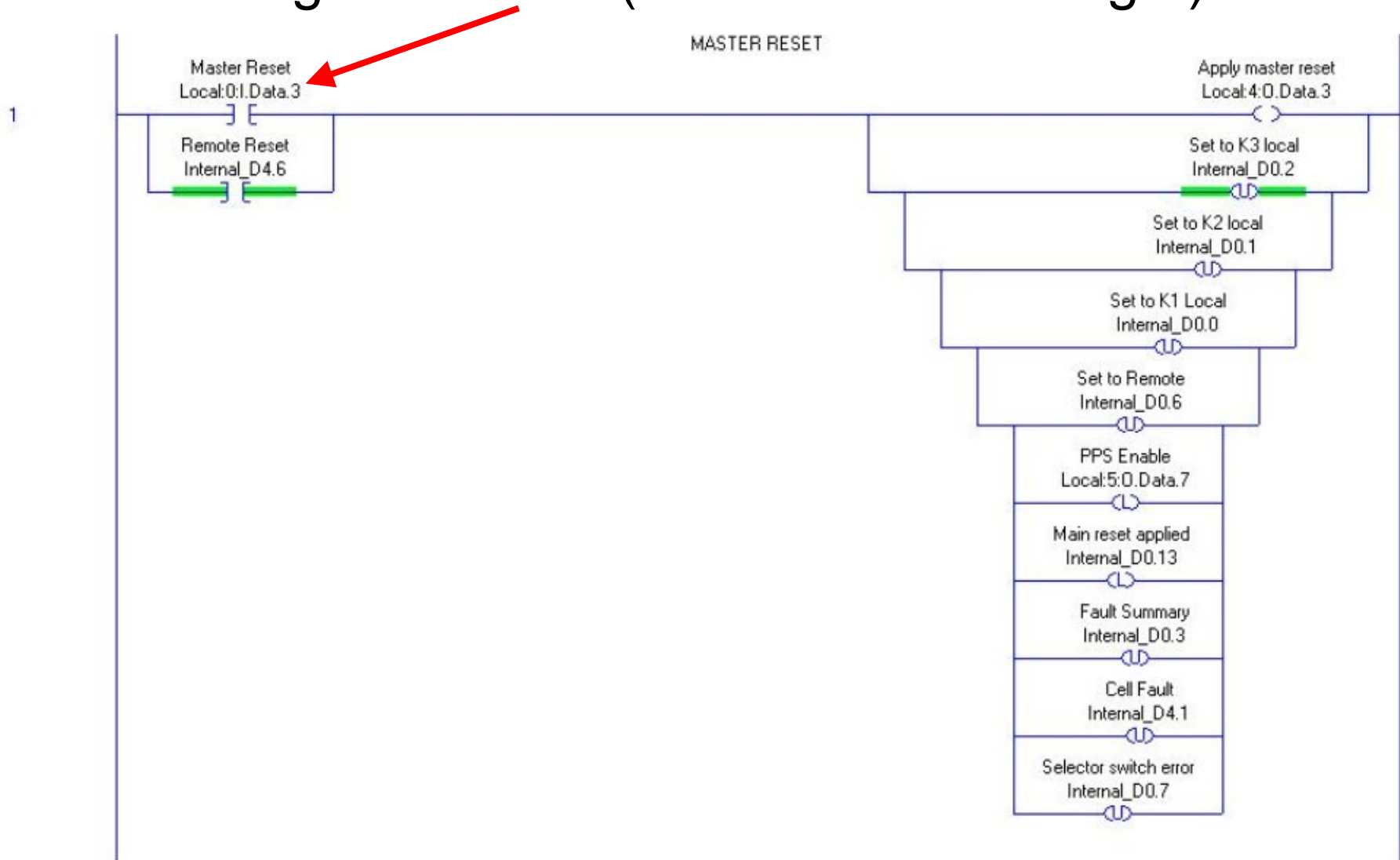
Indicators on Trigger Distribution Daughterboards.

- **Main Trigger Present.** Indicates that triggers are present on the distribution board.
- **HV Ready.** Indicates the 200 VDC supply is on.
- **Core Reset Permit.** Not used.
- **O.C./IGBT Failed.** Indicates a shorted IGBT or blown switch on the distribution board.
- **Gate Trigger.** Indicates gate pulses are preset at the IGBT.

- Main Trigger Present
- HV Ready
- Core Reset Permit
- O.C. / IGBT Failed
- Gate Trigger

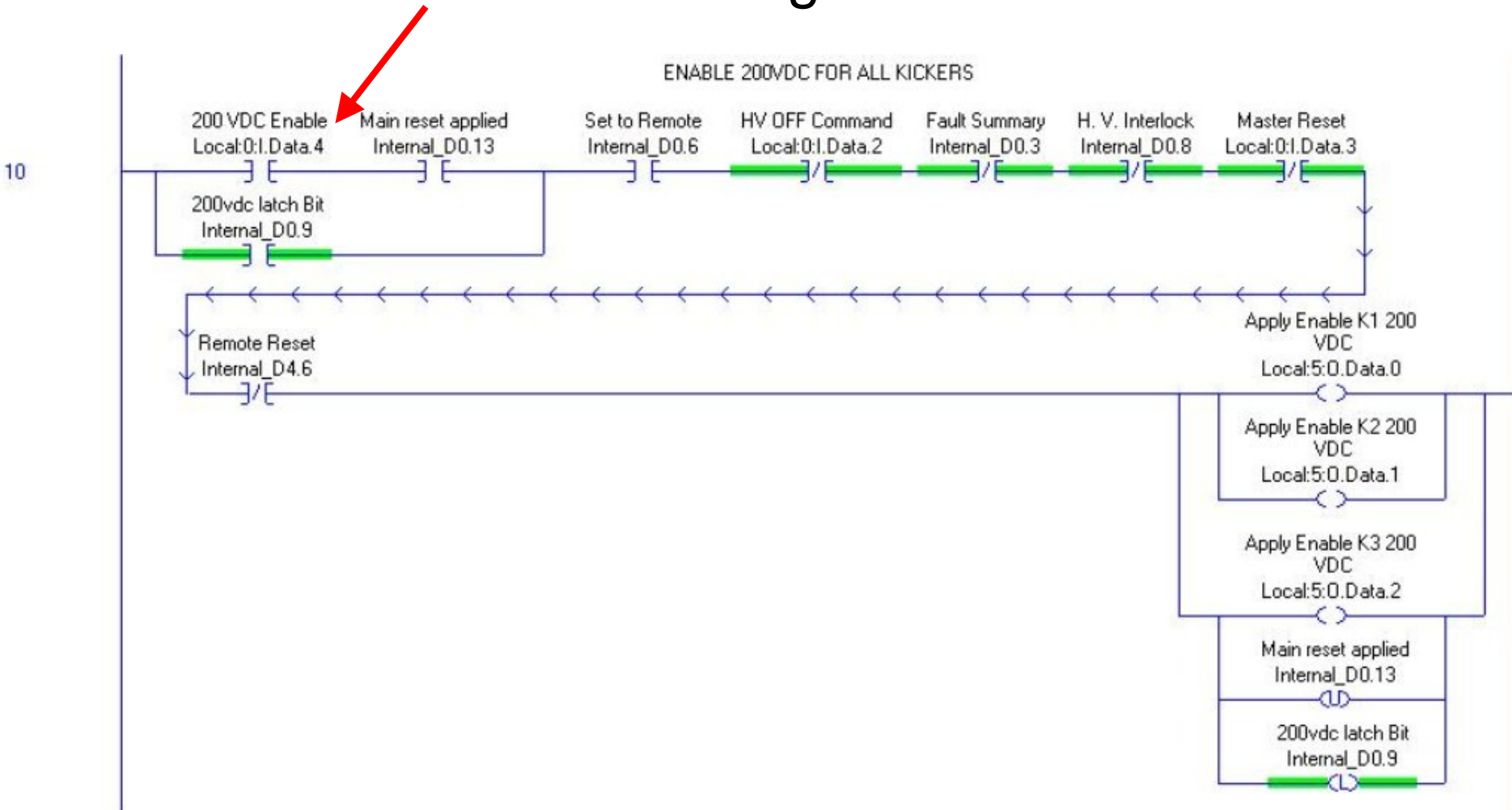
Operating in REMOTE mode with RSLogix5000

- Resetting the Kicker (Main Routine Rung 1).



Enable 200 VDC with RSLogix5000

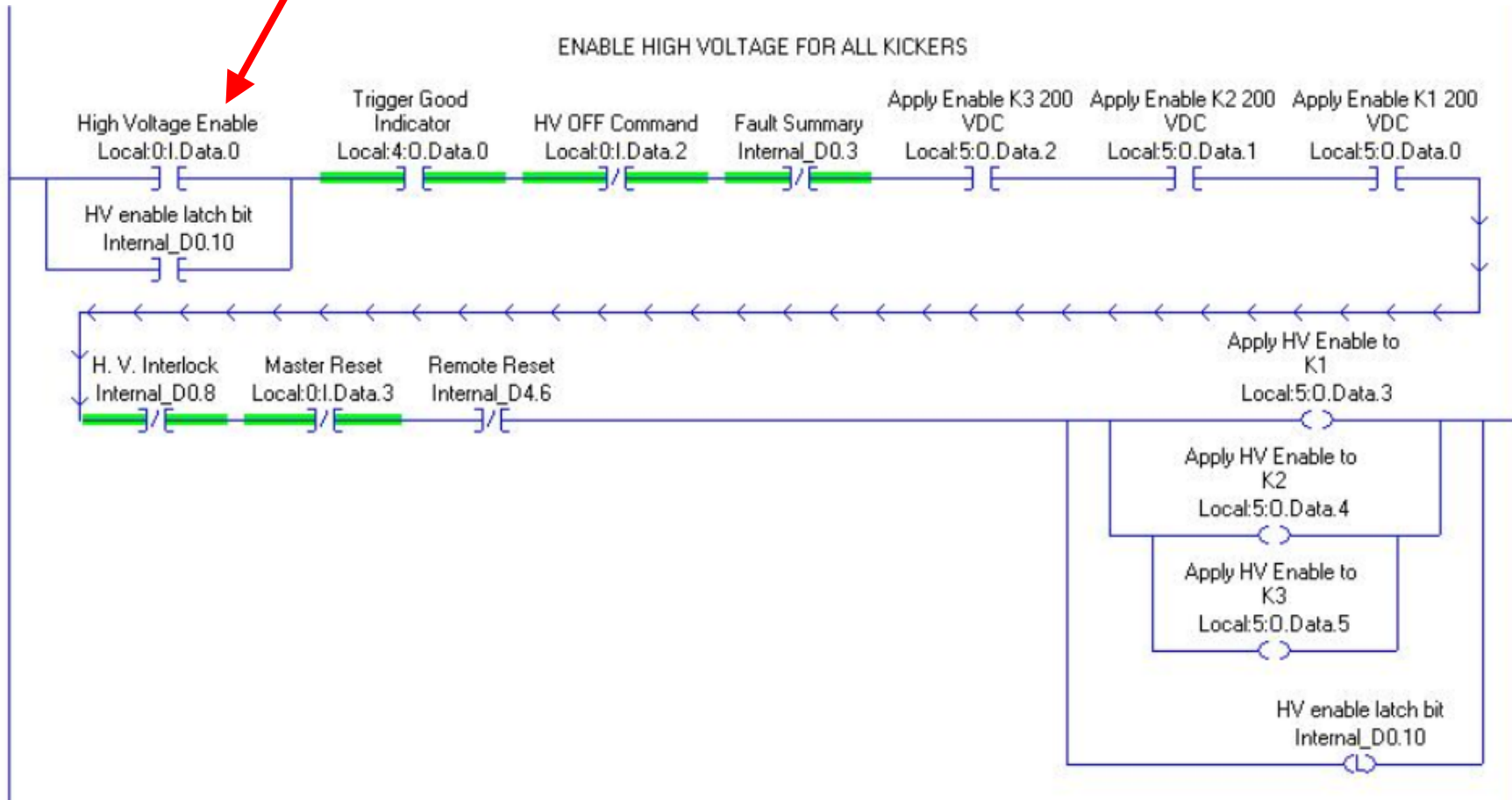
- Remote Subroutine Rung 10



HV Enable with RSLogix5000

- Remote subroutine, Rung 11.

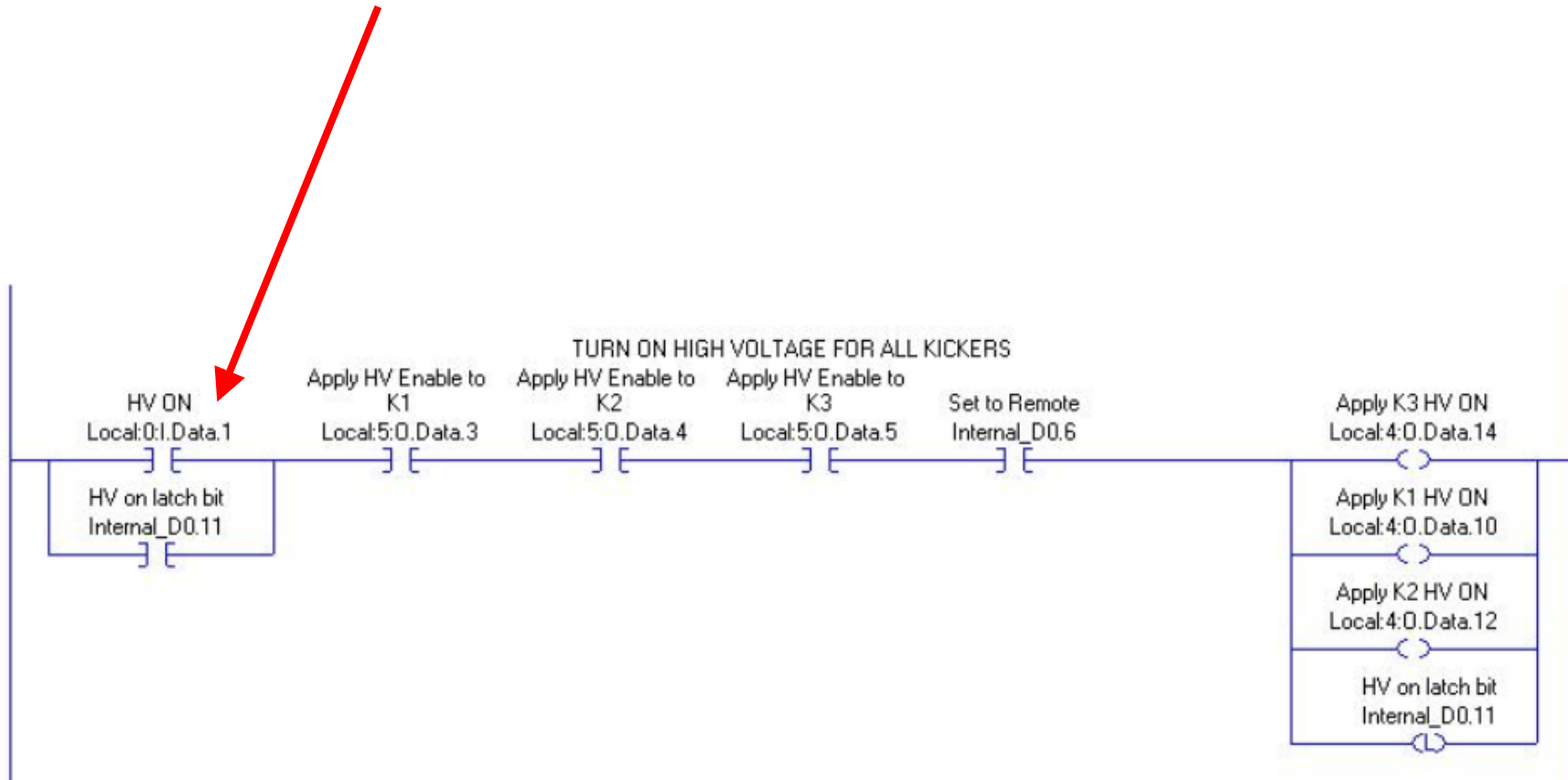
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Remote HV ON with RSLogix5000

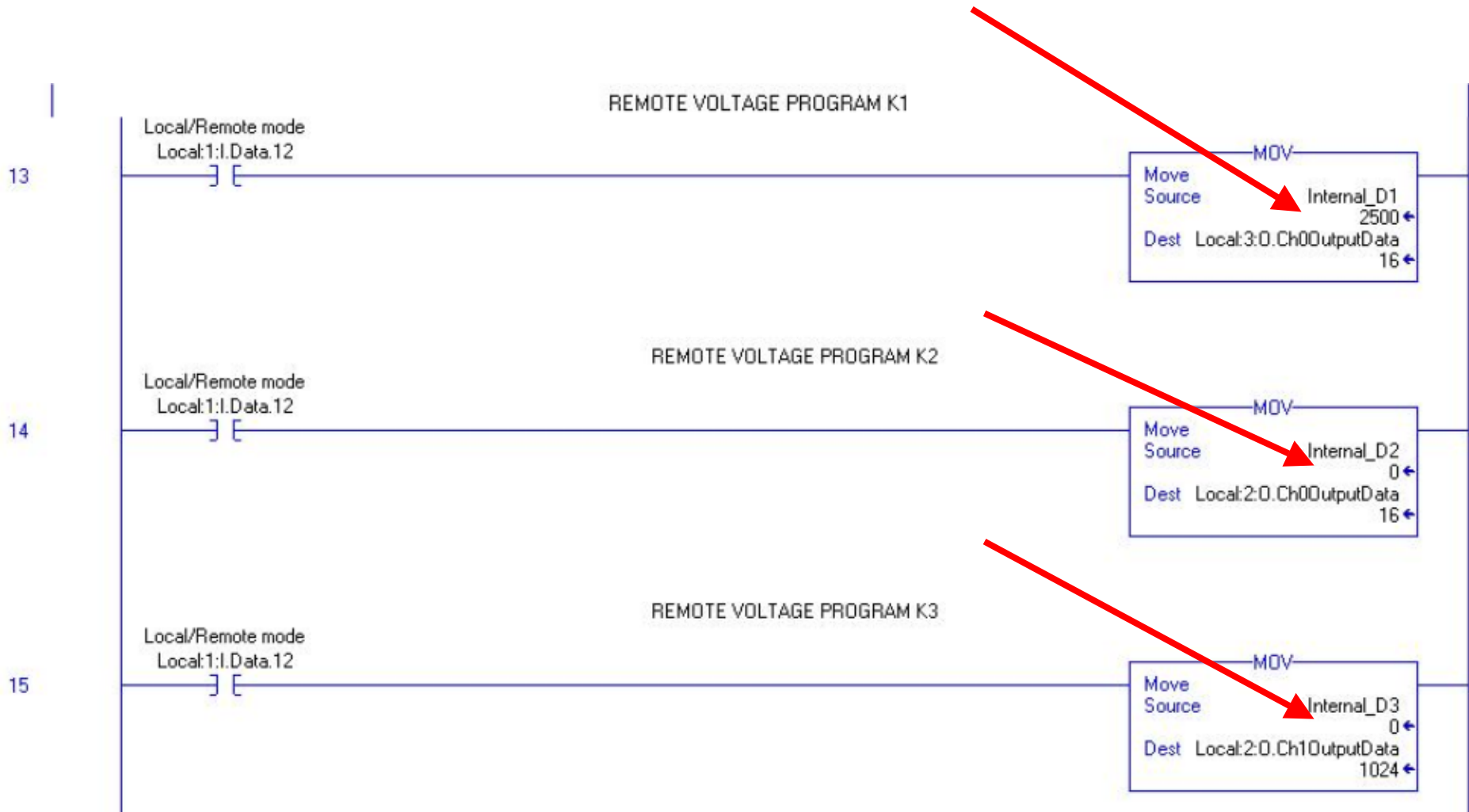
- Remote subroutine, Rung 12.

12



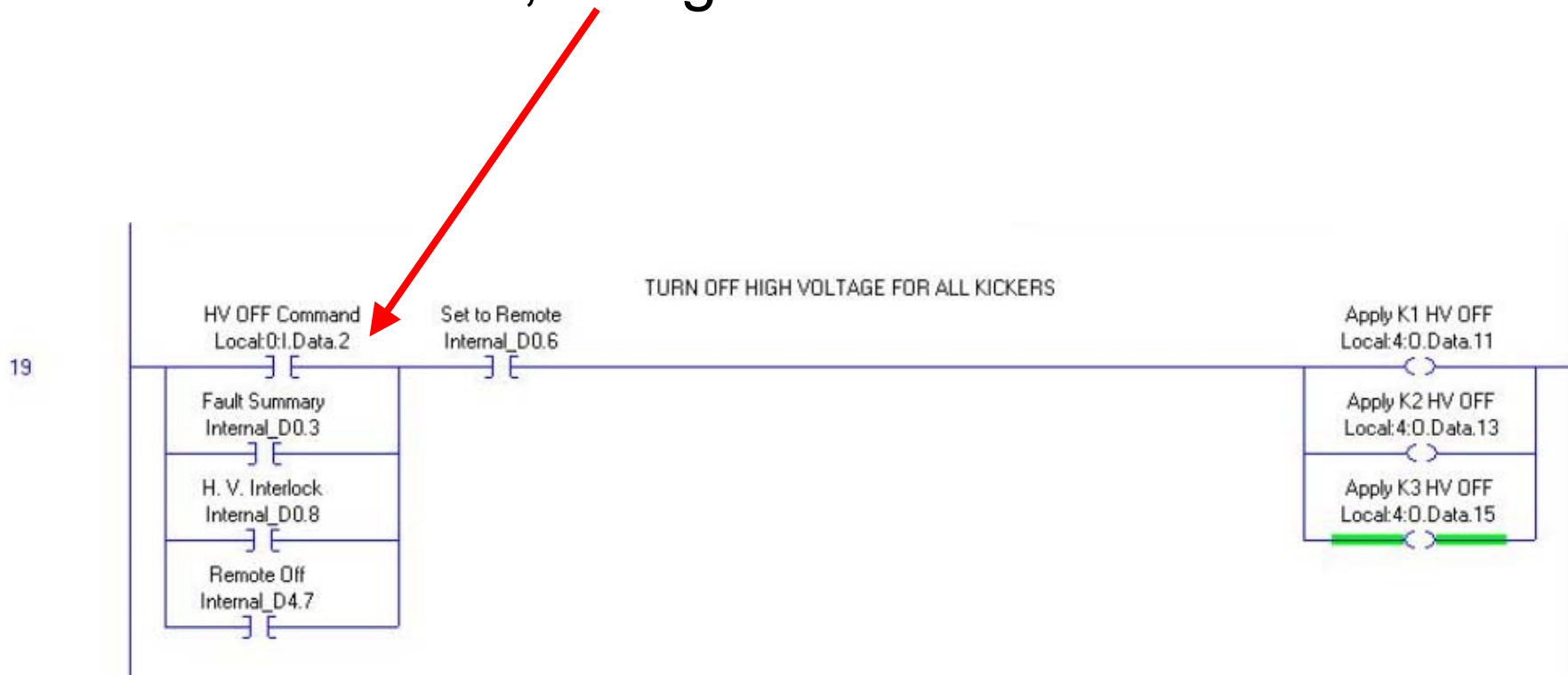
Voltage Programming with RSLogix5000

- Remote Routine Rungs 13,14 &15.



Remote TURN OFF with RSLogix500

- Remote routine, Rung 19.

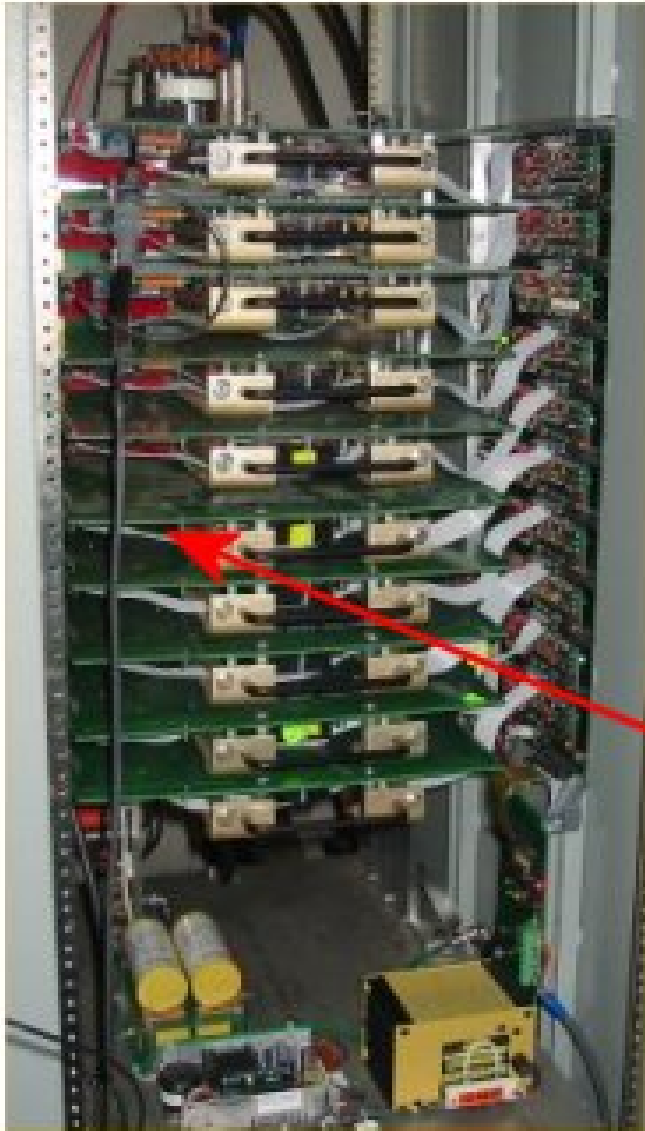


Safety



- Turn off all Breakers before servicing using kicker ELP.
- Back doors are interlocked.
- Front panels are NOT interlocked.
- Grounding sticks are located inside the back doors on each modulator.

HV Grounding



Grounding Post