SSC DETECTOR SOLENOID DESIGN NOTE #12

TITLE: Cold Dump Resistor

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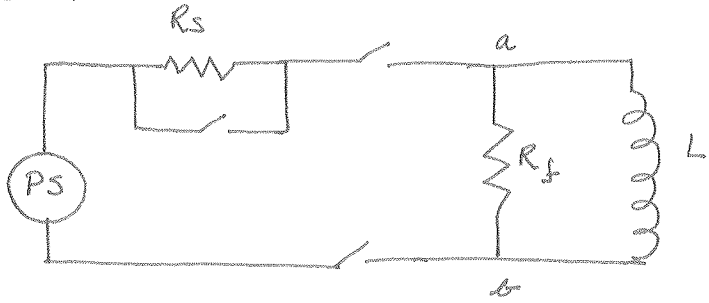
I. Circuit



Assume: 1) $E = 750\,MJ$; one 8-m module
2) $I = 10\,kA$; req'd for adequate quench safety

then $L = 15\,H$

II. Charging Voltage

Assume: A charging time of 1 hour

so, since

$$V_{ab}\,(\text{charge}) = L\,dI/dt,$$

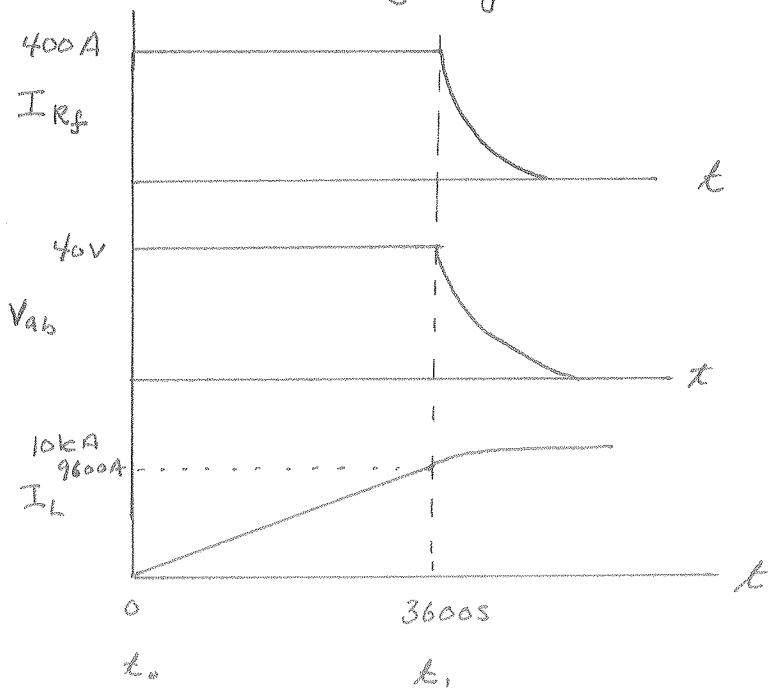
$$V_{ab}\,(\text{charge}) \sim 40\,V$$

(For a 2-hour charge, V_{ab} (charge) $\sim 20\,V$)

III. Discharge Voltage & Fast Dump Resistor

Assume: 1) V_{ab} (fast dump) $= 1\,kV$
2) $R_f = 0.1\,\Omega$; for quench safety

IV. Magnet Charging



V. Power & Energy Dissipation in R_f

$$t_1 - t_0 = \frac{L\,\Delta I}{V_{ab}\,(\text{charge})} = \frac{15\,(9600\,A)}{40} = 3600\ s$$

$$P_{R_f}(t = t_0 \to t_1) = I_{R_f}^2 R_f$$

$$= (400\,A)^2 (0.1\,\Omega)$$

$$= 16\ kW$$

$$E_{R_f}(t = t_0 \to t_1) = (16\,kW)(3600\,s) = 57.6\ MJ$$

$$E_{R_f}(t = t_1 \to \infty) = 16\,kW \int_0^{t'=\infty} e^{-\frac{2R}{L}t'}\,dt'$$

$$t' = t - 3600\,s$$

$$E_{R_f}(t_1 \to \infty) = (16\,kW)\left(\frac{1}{2}\frac{L}{R}\right)$$
$$= 1.2\ MJ$$

And $E_{R_f}(\text{total}) = 58.8\ MJ$

1) If this energy were used to boil water, 6.8 gal would be boiled during this charge.

2) If this energy were used to boil L He ($L_{vap} = 2.6\ kJ/L$), 22.6 kL would be boiled during this charge.

3) If this energy were absorbed by the sensible heat of helium from 4.2 K to 300 K ($\Delta h = 1543\ J/g$ at 1 atm), 38.1 kg of He would be warmed up. During the constant heat portion of the charge ($t = 0 \to 3600\,s$) the He flow rate to absorb 16 kW with the sensible heat to 300 K would be 10 g/s.

VI. Conclusion

It is simply unreasonable to use a fast dump resistor at 4.2 K without a diode to eliminate the charging heat load.