BABAR

Magnet Power Supplies

a) Solenoid

b) Bucking Coil

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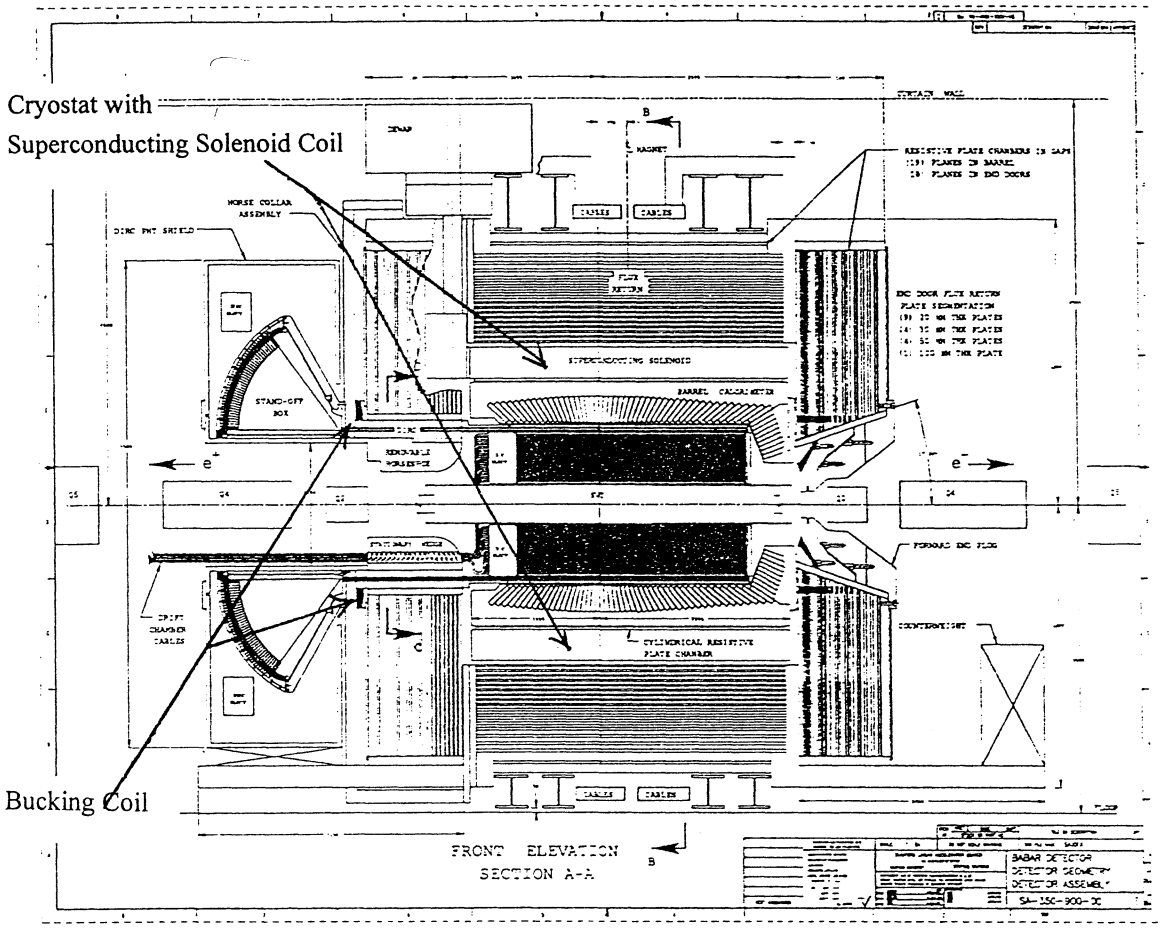
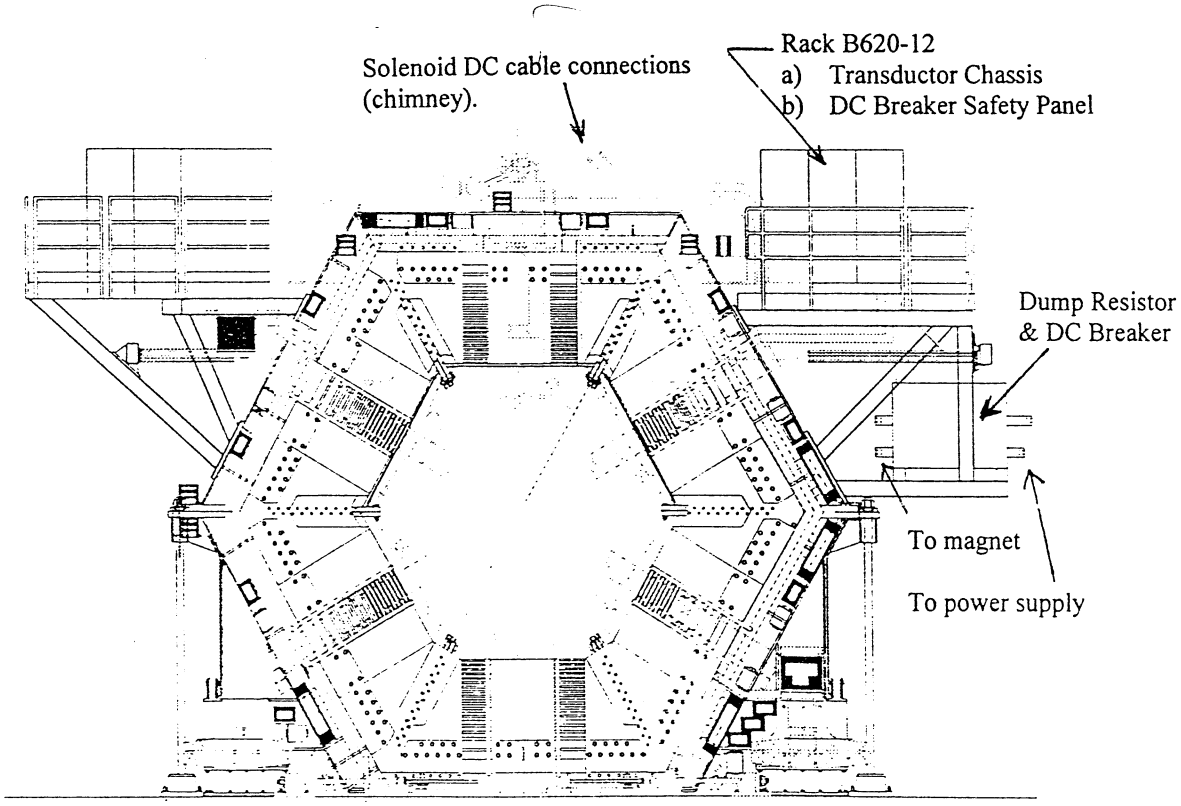


Side view of BaBar, looking East (Out from center of PEPII Ring)



West end view of BaBar (Backward), with Magnet Doors open.
DIRC side of magnet.
e- beam goes into this side, e+ beam comes out.

BaBar Superconducting Solenoid Specification

2-layer coil 1067 turns total (531 + 536 turns)
Wound inside a 35 mm thick aluminum liquid helium cooled cylinder

Coil ID:	3.02 m	Cryostat ID:	2.84 m
Coil OD:	3.10 m	Cryostat OD:	3.54 m
Coil length:	3.51 m	Cryostat length:	3.85 m

Conductor wound on end (large dimension along radius)

Conductor: Niobium-Titanium in an aluminum matrix
5.33 mm x 20.4 mm near the ends of each layer
8.89 mm x 20.4 mm in the center region of each layer

Inductance (coil inside the iron)	L = 2.58 Henry
Dump Resistor (air cooled)	Rd = 0.068 Ohm
Maximum current (acceptance test)	Id = 4811 Amperes
Nominal current (operating value)	In = 4600 Amperes
Magnetic field at coil center (~)	Bc = 1.5 Tesla
Stored energy at 4600 Amperes	W = 27.3 MegaJoules

Maximum charging rate (normally acceptable)	Max di/dt = 2.5 A/sec = 150 A/min
L di/dt at 2.5 A/sec	V(di/dt) = 6.45 Volts
Power supply to magnet cable resistance	Rc = 1.25 milliohms
Cable IR at 4600 Amperes	IxRc = 5.75 Volts
Discharge Time Constant with Dump	Td = 38 sec
Discharge Time Constant with PS connected	Tps = 2064 sec = 34.4 minutes

Two power supplies:

Superconducting Solenoid	4800 Amperes
Bucking Coil for DIRC	300 Amperes @ 90 Volts

Principal features:

Both power supplies use 480VAC input power.
Both power supplies are controlled via PEPII BitBus Power Supply Controllers.
Interlocks for equipment and personnel protection are hardwired.
Both power supplies are upstairs in Building 625.
Both BitBus PS Controllers upstairs, Rack 11 in Building 625.
Red rotating beacons in IR2 turn on when either power supply is on.

Solenoid:

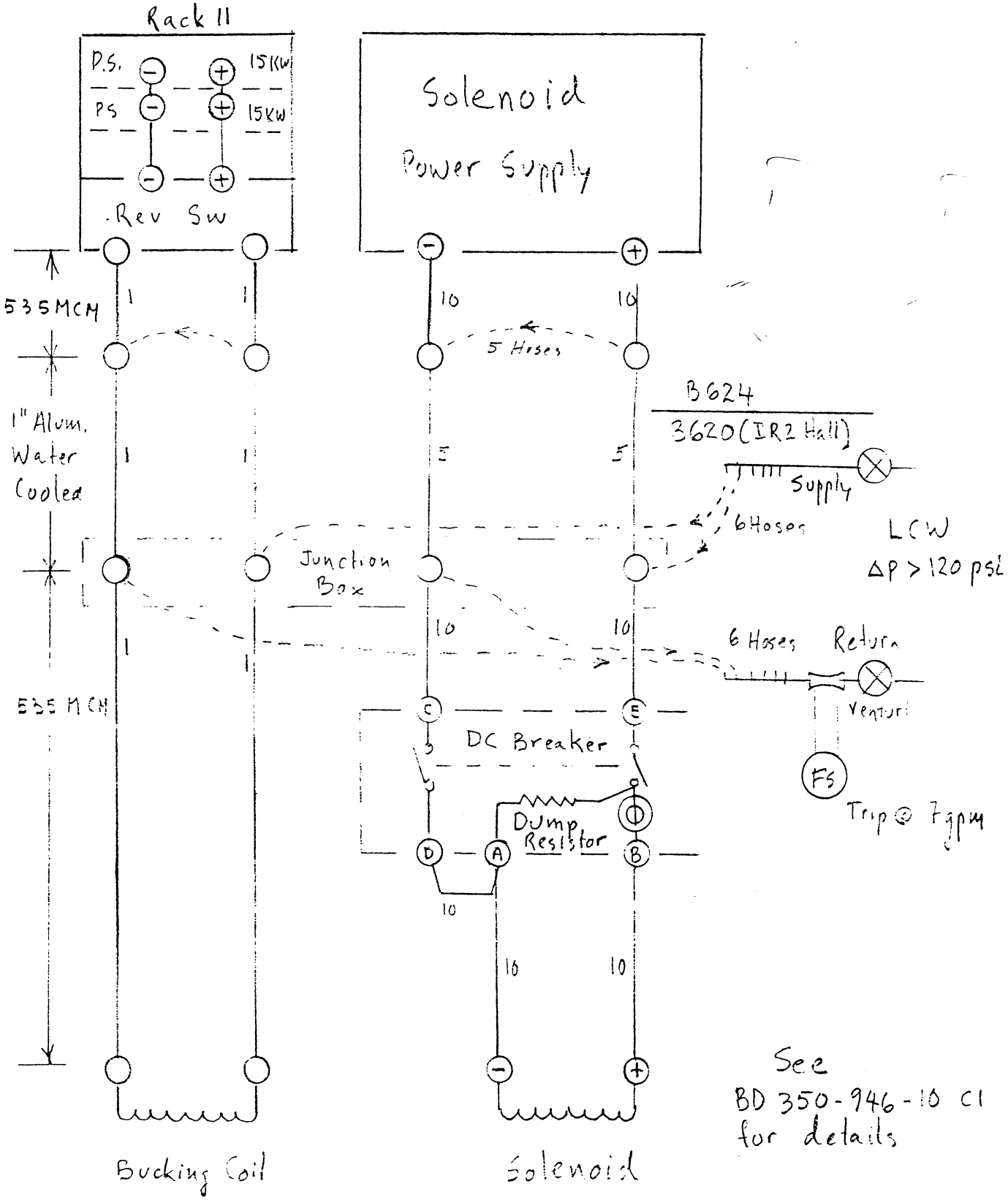
a) Ramp time to 4800 Amperes is about 30 minutes.
b) Dump Resistor is permanently connected across coil.
    Discharge Time Constant through Dump Resistor is 38 seconds.
c) Ansaldo Control System protects magnet and controls DC Breaker.
d) DC Circuit breaker disconnects power supply from magnet.
    Opening Breaker produces Fast Dump.
    Magnet protected by DC Breaker, if PS fails.
e) "Emergency off" buttons in various locations in IR2 will open DC breaker
    and discharge magnet through Dump Resistor.
e) When PS contactor is opened and the DC Breaker is not opened,
    magnet current decays through power supply diodes.
    It takes about 2 hours to reach zero Amperes.
f) Two current monitors are used:
    "Magnet Only", used by BitBus controller to regulate the current.
    "Power Supply", i.e. Magnet plus Dump Resistor.

Bucking Coil:

a) Coil is water cooled.
b) PS has a reversing switch to "degauss" the chamber.
c) Two current monitors are used, ahead and after the reversing switch.

Solenoid Power Supply Specifications

Manufacturer	Dynapower
Maximum rating:	40 VoltsDC, 8000 Amperes, 320 KW Reconnectable transformer primary for 10, 20 or 40 Volts DC output (20 Volt connection used for BaBar)
Input power:	480 Volts AC, 3 phase for power 120 Volts AC, 1 phase for controls
Rectifier Transformers:	Two transformers, one Delta primary, one Wye primary 6 phase star connected secondary windings
Rectifier:	Two 6-phase SCR stars, connected in parallel through an interphase transformer
Freewheeling Diodes:	~~12~~ 8 in parallel, at input to filter
Filter:	L (iron core) and C (electrolytic bank)
Cooling:	Water (LCW, about 6 GPM)



BaBar Solenoid & Bucking Coil
DC Cable Plant

BaBar Solenoid
External Power Supply Interlocks

Connected directly into the Power Supply:

J3 Power Supply LCW Flow Switch in Building 625.
External Interlocks #1 Cable #RP28157

J4 DC Cable LCW Flow Switch in IR Hall West wall.
External Interlock #2 Cable #RP28161

J6 Ground Switch on Dump Resistor in IR Hall.
Switch is opened to check magnet insulation resistance.
Switch must be closed (magnet grounded) to run.
External Interlock #3 Cable #xxxx

J2 Remote OFF push button in Building 624 (Cryogenic Controls).
External Interlock #4 Cable RP 28156 and
Trunk Line RP28135

J5 Interlock to insure Magnet Doors are closed and Magnet Plugs are inserted.
This interlock bypasses PLC500 and acts directly on Main Contactor.
Cable #xxxx

Connected into Power Supply Controller Chassis 340-260

Mag Fault 0 DC Breaker open

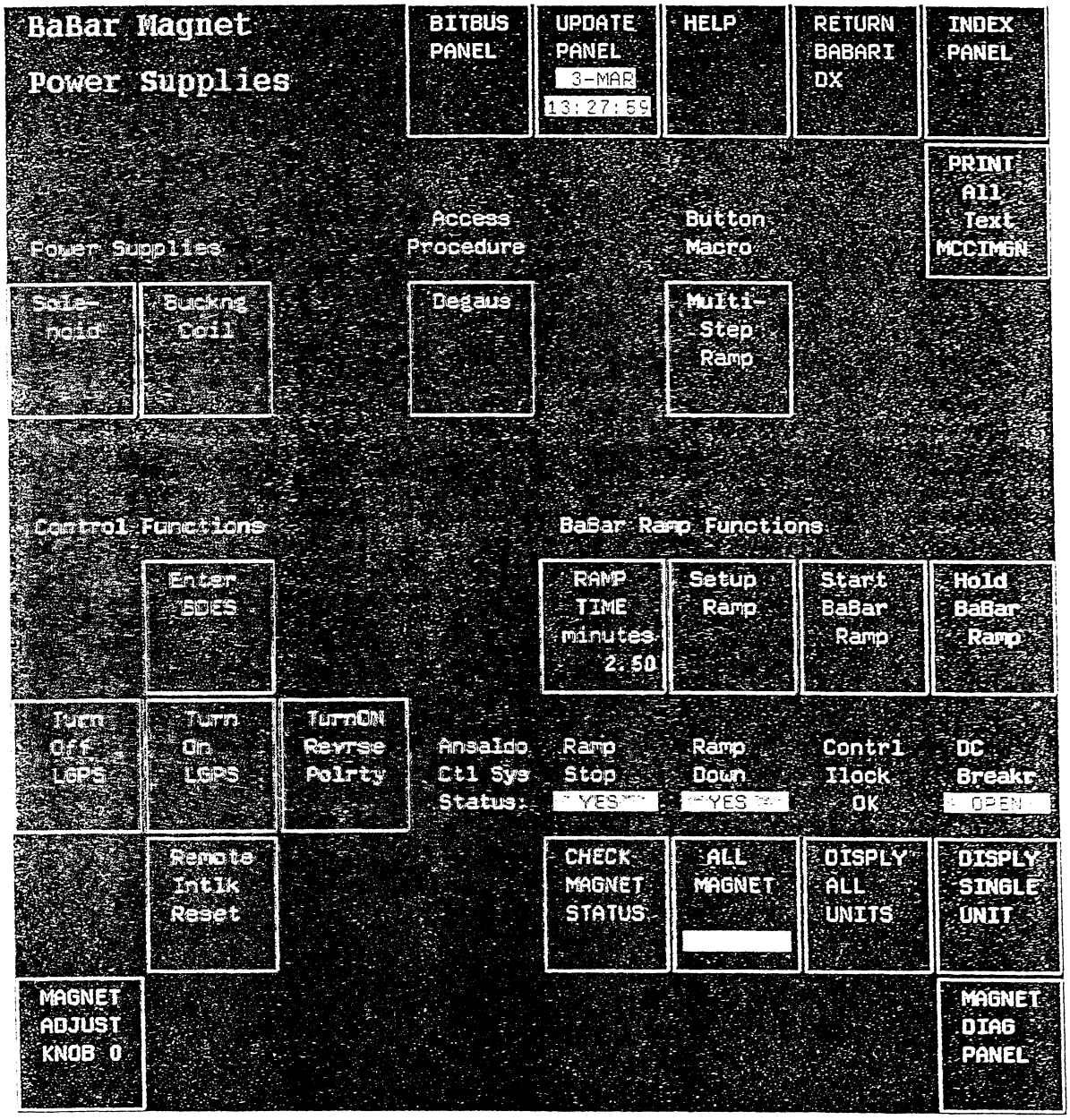
Mag Fault 1 Interlocks from Cryogenic Control System

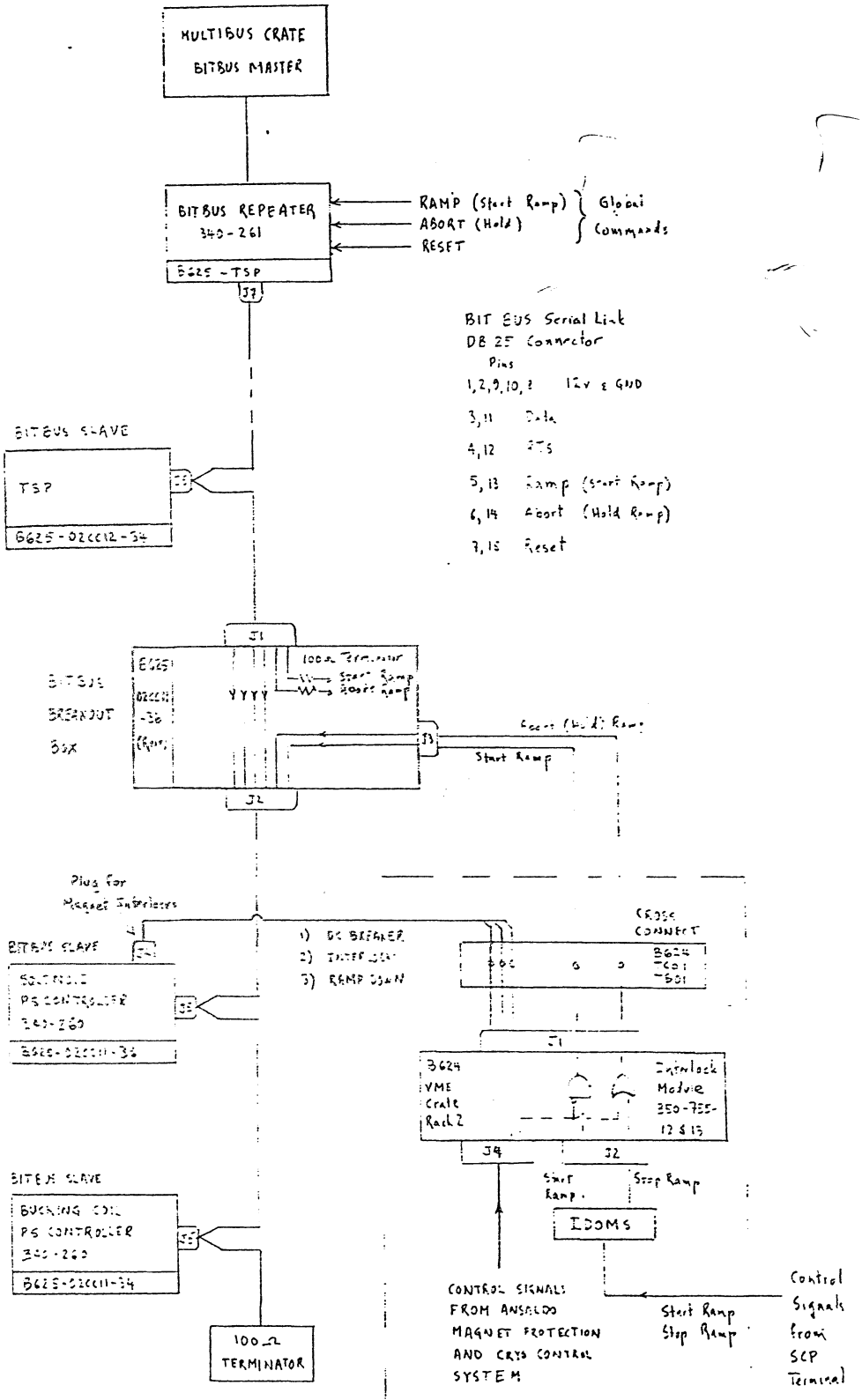
Mag Fault 2 Ramp Down
(Note: Since SCP controls do not provide for a "Ramp Down" Subroutine, this command from the magnet protection system will turn off the power supply instead of ramping down the current.

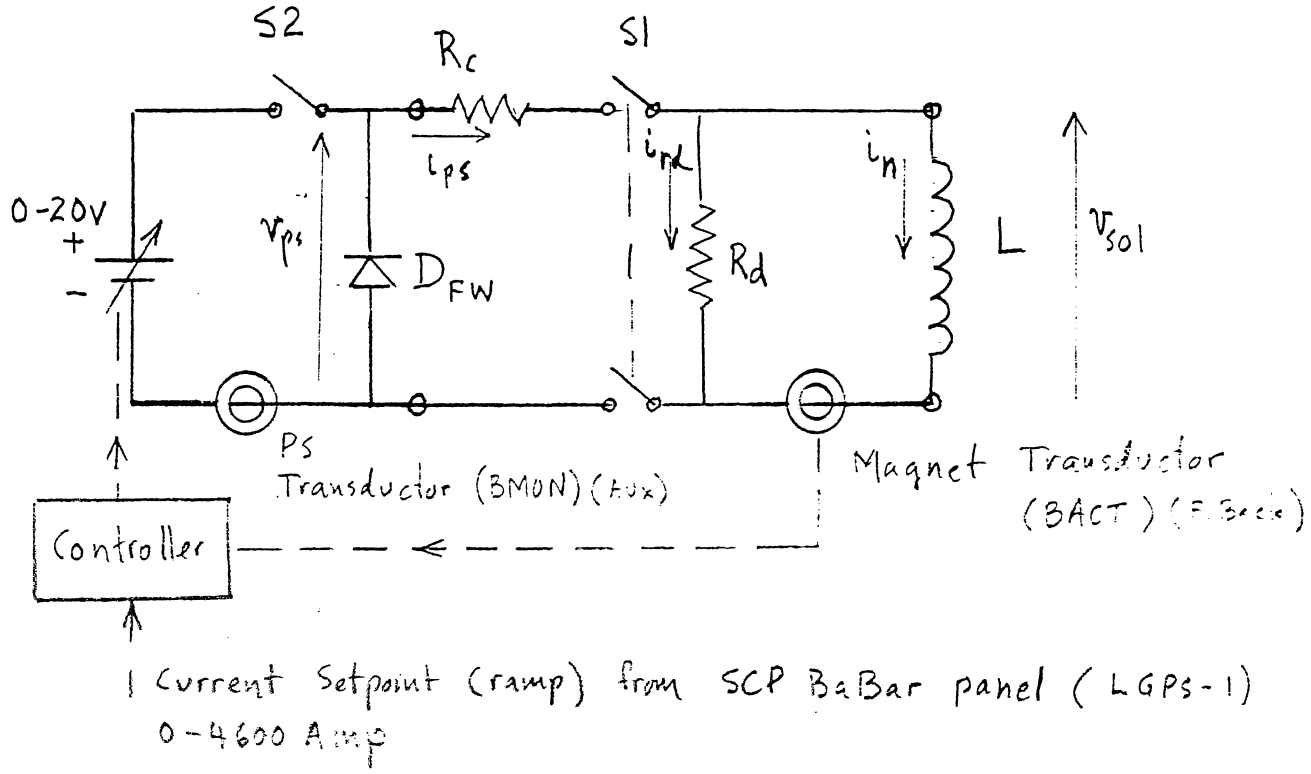
Mag Fault 3 Not used

Regulating Transductor (J1) "Magnet only" current transductor installed inside Dump Resistor Box, with Transductor Driver chassis in Rack 12 on top of magnet

Auxiliary Transductor (J2) Interlock bypassed with jumper in plug J2.
The Auxiliary transductor is the transductor inside the power supply. This transductor measures the power supply current (magnet + dump). The interlock from this Transductor is part of the internal power supply interlock system controlled by the power supply PLC500


BaBar Magnet
Power Supplies
BITBUS PANEL
UPDATE PANEL
3-MAR
13:27:59
HELP
RETURN BABARI DX
INDEX PANEL
PRINT All Text MCCIMGN
Power Supplies
Access Procedure
Button Macro
Sole-noid
Bucking Coil
Degaus
Multi-Step Ramp
Control Functions
BaBar Ramp Functions
Enter SDES
RAMP TIME minutes 2.50
Setup Ramp
Start BaBar Ramp
Hold BaBar Ramp
Turn Off LGPS
Turn On LGPS
TurnON Revrse Polrty
Ansaldo Ctl Sys Status:
Ramp Stop
YES
Ramp Down
YES
Contrl Ilock OK
DC Breakr
OPEN
Remote Intlk Reset
CHECK MAGNET STATUS
ALL MAGNET
DISPLY ALL UNITS
DISPLY SINGLE UNIT
MAGNET ADJUST KNOB 0
MAGNET DIAG PANEL


MULTIBUS CRATE
BITBUS MASTER
BITBUS REPEATER
340-261
B625 - TSP
J7
RAMP (Start Ramp)
ABORT (Hold)
RESET
Global Commands
BIT BUS Serial Link
DB 25 Connector
Pins
1,2,9,10,? 12V & GND
3,11 Data
4,12 RTS
5,13 Ramp (start Ramp)
6,14 Abort (Hold Ramp)
7,15 Reset
BITBUS SLAVE
TSP
B625-02CC12-34
J1
J2
J3
BITBUS BREAKOUT BOX
100Ω Terminator
Start Ramp
Abort Ramp
Start Ramp
Plug for Magnet Interlocks
1) DC BREAKER
2) INTERLOCK
3) RAMP DOWN
BITBUS SLAVE
SOLENOID PS CONTROLLER
340-260
B625-02CC11-34
CROSS CONNECT
B624 J01
B601
B624 VME Crate Rack 2
Interlock Module
340-755-12 & 13
J4
J2
Start Ramp
Stop Ramp
IDOMS
BITBUS SLAVE
BUCKING COIL PS CONTROLLER
340-260
B625-02CC11-34
100Ω TERMINATOR
CONTROL SIGNALS FROM ANSALDO MAGNET PROTECTION AND CRYO CONTROL SYSTEM
1) DC BREAKER
2) INTERLOCKS
3) RAMP DOWN
4) RAMP STOP (HOLD)
Start Ramp
Stop Ramp
Control Signals from SCP Terminal
B625
B624



Simplified BaBar Solenoid and Power Supply Circuit

L	= 2.58 Henries	Superconducting Solenoid inductance
Rd	= 68 milliohms	Dump Resistor (air cooled)
Rc	= 1.25 milliohms	DC cable resistance

S1	DC Breaker (2-pole) for Solenoid Dump
S2	Fictitious switch to simulate "turning power supply off".
Dfw	Freewheeling Diodes
In	Current in Solenoid
Ird	Current in Dump Resistor
Ips	Current from power supply
Vsol	Voltage across Solenoid terminals
Vps	Power supply terminal voltage

In normal operation:

a) Power supply is in V mode (voltage regulated).
b) Power supply Transductor is not in control loop.
c) Magnet Transductor is in control loop,
and is used for both current feedback and magnet current measurement.
d) S1 and S2 are closed for normal operation.
e) S1 (DC Breaker) is opened to initiate a "Fast Dump".
f) Opening S2 starts a slow current decay,
(approximately exponential decay, with 34 minute time constant)

$$e_{p.s} = i_{magnet} \times R_{cable} + L_{magnet} \frac{di_{mag}}{dt}$$

a) During a current ramp, $L \frac{di}{dt}$ = constant

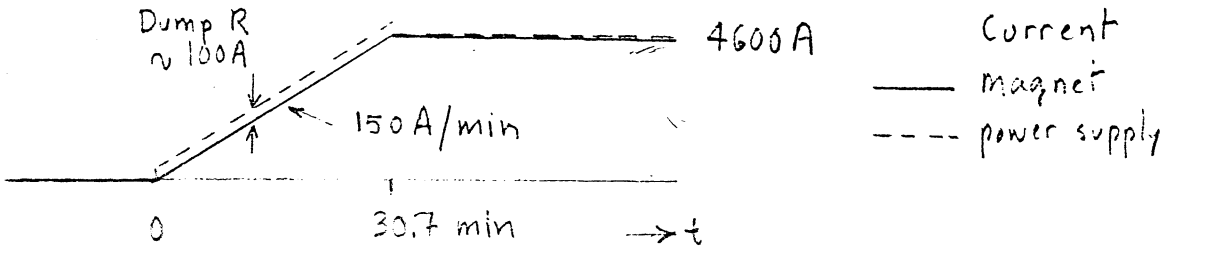
b) If $e_{p.s.}$ is constant, $\frac{di}{dt}$ changes exponentially with time constant given by L/R

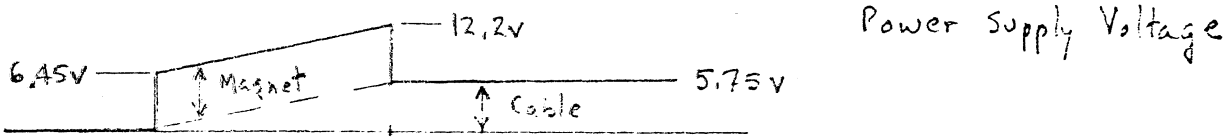
c) As long as there is a current in the power supply, the p.s output voltage can be controlled between

-0.7 Volts (FW Diode voltage)

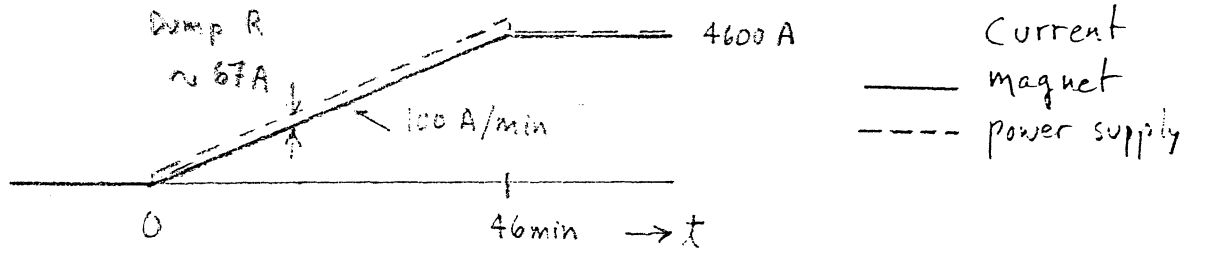
and

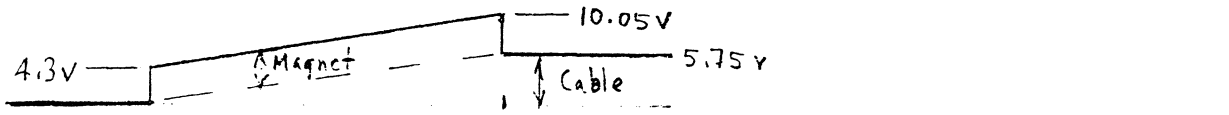
$+20.0$ Volts (Max p.s. output)





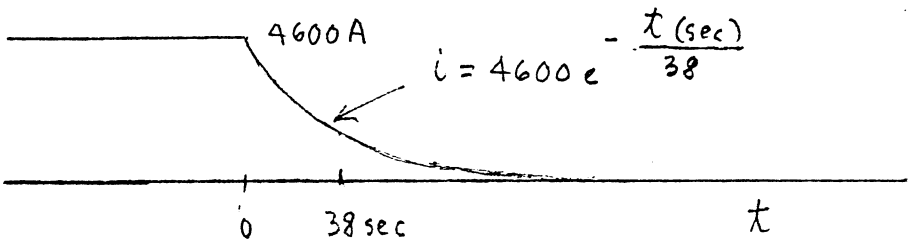
a) Current & P.S. Voltage @ 150 Amp/min



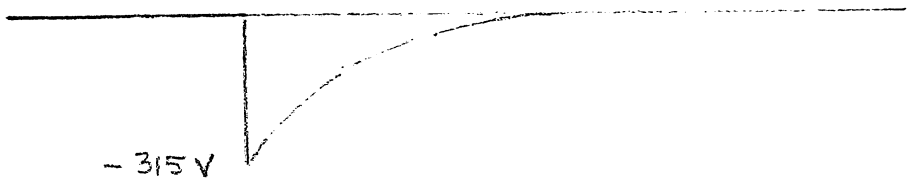


b) Current & P S Voltage @ 100 A / min

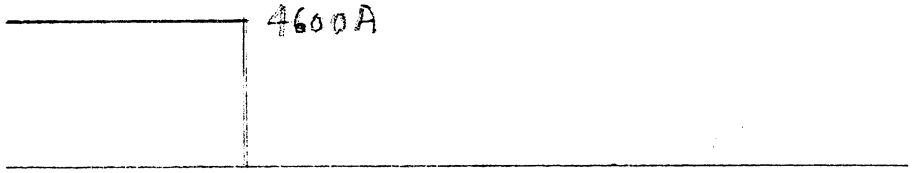
Solenoid Magnet Charging



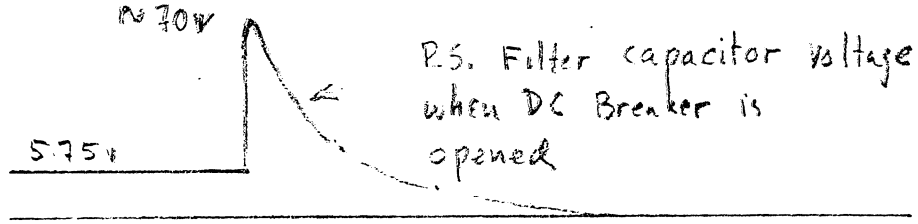
Magnet current



Magnet voltage



P.S. current

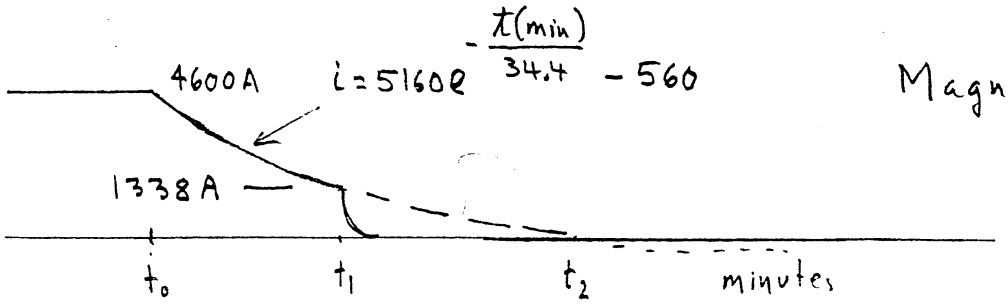


P.S. voltage

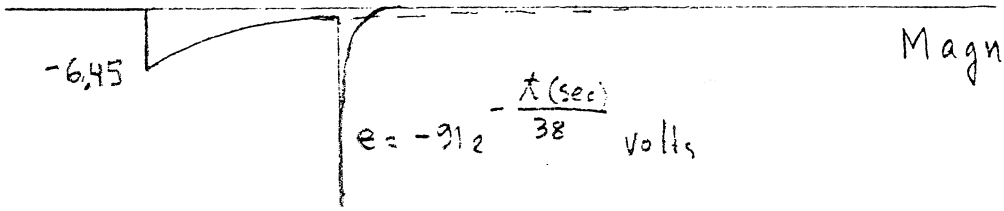
a) DC Breaker opened @ 4600 A.
PS contactor opened at the same time

b) PS Filter Capacitor discharges through permanently connected 200 Ω bleeder with 35 sec time constant

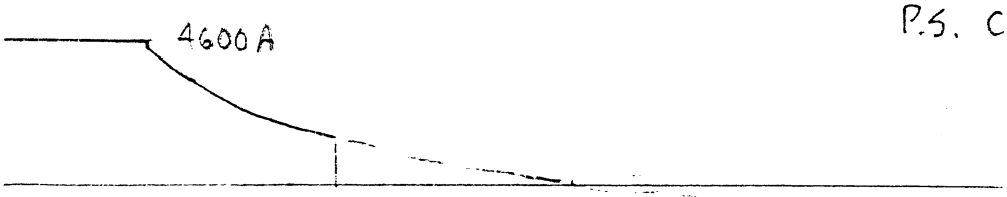
c) There is considerable liquid helium boil-off, and recovery of cryo system may take 1-2 hours.



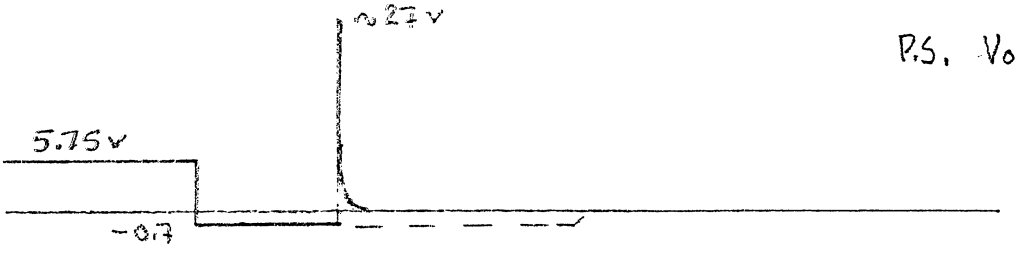
Magnet current



Magnet voltage



P.S. Current



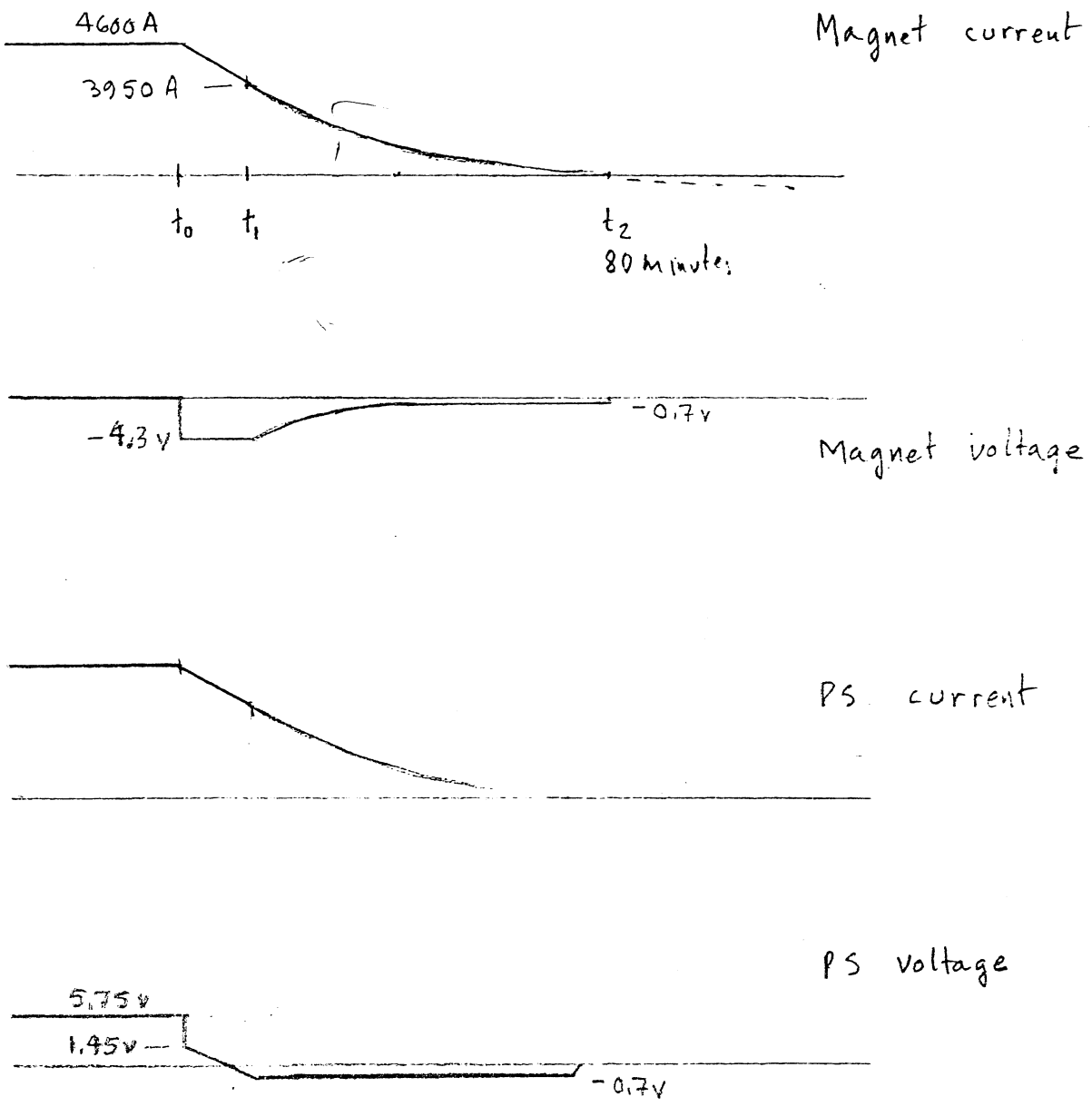
P.S. Voltage

t_0 – P.S contactor opens

t_1 – DC Breaker opens @ 34.4 min, when magnet current has reached an acceptable low limit (500 to 2000 A).

t_2 – Approximate time for current to reach zero if DC breaker is not opened (~ 76 min)

Solenoid Magnet Slow Discharge, followed by a Fast Dump



t_0 - start of linear ramp down @ 100 A/min

t_1 - current decay stops being linear after about 6-10 min

t_2 - Approximate time for current to reach zero if DC breaker is not opened (> 80 min)

Solenoid Magnet Slow Discharge, rate limited