Requirements for kicker magnets in the 100 KeV line

January 23, 1995

1.0 Introduction

When hazardous conditions arise, the Personnel Safety System (PSS) at CEBAF accelerator turns off the electron beam. It accomplishes this by three separate means and two distinct technologies. When a PSS fault occurs, Programmable Logic Controllers (PLCs) turn off the 100 KV power supply within 200 ms [ref.1]; Control Electrode Driver stops the electron emission into the accelerator within 10 μs [ref.2]; and kicker magnets at the emittance aperture in the 100 KeV line deflect the beam within 100 μs. The first technique uses dedicated software and hardware while the second and third techniques use the PSS permission signals to provide personnel safety.

Conceptually, the kicker electro-magnet has two coils so wound that the current in one coil opposes the current in the other. Thus, the coils compensate each other's fields to produce no net magnetic field. A PSS fault (loss of PSS permission), stops the current through one coil. The resulting magnetic field steers the beam away from its path.

These magnets are part of the overall PSS system and this document is a part of the overall PSS documentation.

This kicker magnet requirements document is for the use of PSS designers, technicians and machine operators.

1.1 References

1. CEBAF Accelerator's Personnel Safety System documents
2. CEBAF Electron Gun Control Documents

2.0 Requirements

2.0.1 There will be two kicker magnets: one for vertical and the other for horizontal deflection.

2.0.2 There will be two PSS permissions for each magnet. Within 100 μs after the loss of any PSS permissions, the net magnetic field of the kicker magnets will be such that the beam deflects from its normal path and hits the aperture wall.

2.0.3 Loss of current in the non-interlocked coil ,in either horizontal or vertical direction will open a PSS monitored relay.

2.0.4 The power supplies will have controllable current settings over a specified range.

2.0.5 Setup and test procedures to evaluate the proper functioning of the magnets should be available prior to system installation.

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2.0.3 Loss of current in any coil will open a PSS monitored relay.

2.0.4 The power supplies will have controllable current settings over a specified range.

2.0.5 LEDs will indicate the status of power supplies, PSS permissions and relays.

2.0.6 Setup and test procedures to evaluate the proper functioning of the magnets will be available prior to system installation.

Kicker Magnets and Controls
February 3, 1995

Biflar windings make up the air core kicker magnets. The current in one wire is in opposite direction to the current in the other, resulting in no net magnetic field.

For normal operation, the switches interlocked to the PSS stay closed (current flowing through both windings) A PSS fault will open the switch, preventing current flow in one winding, resulting in beam deflection.

Figure 1 shows the concept.

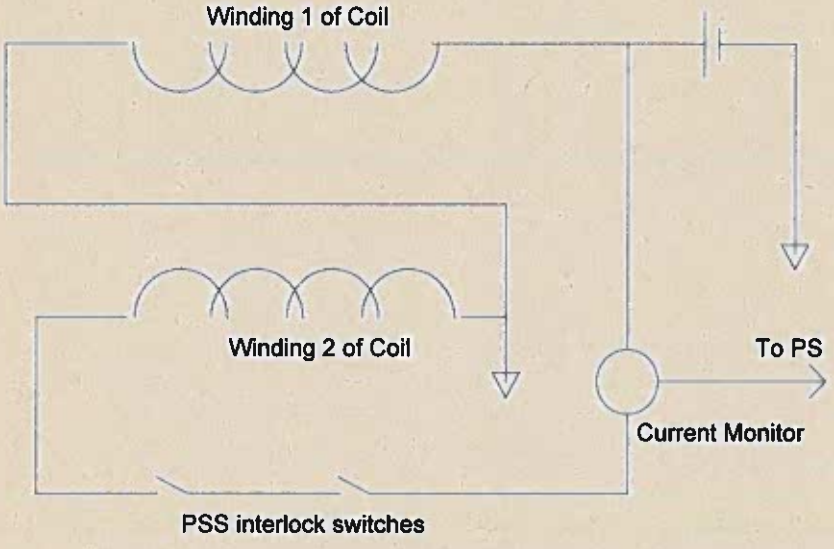


Figure 1

Calculations

See figures 2 & 3
Magnetic rigidity of 100 KeV electrons = 1124 gauss. cm.
Radius of magnet coil = 'r'
Aperture radius = 'a'
Distance from the center of the field to the edge of aperture ='d' .

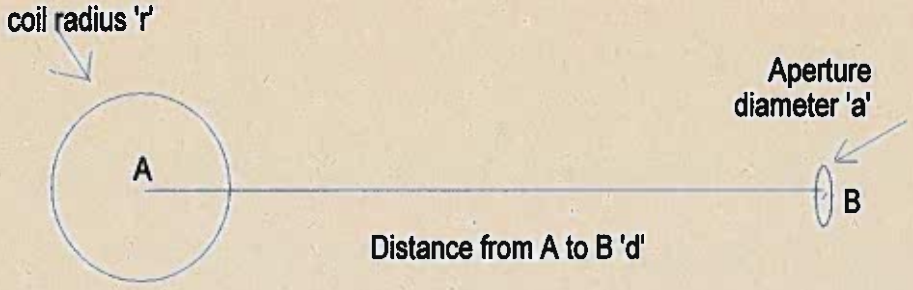


Figure 2

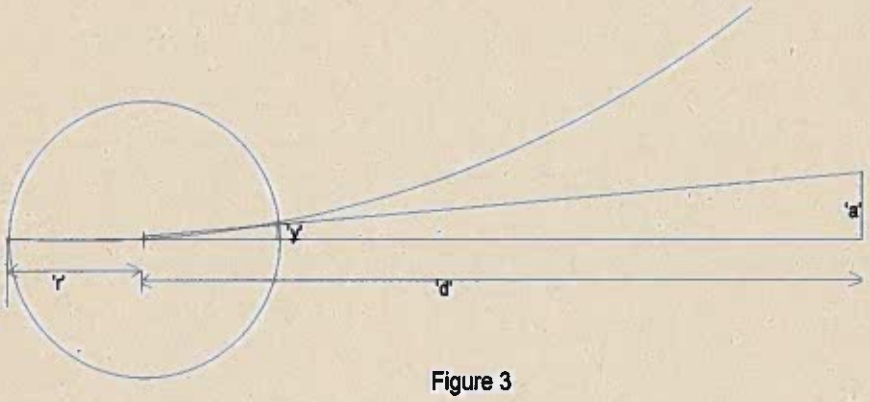


Figure 3

$y = ar/d$
Radius 'R' of the electron orbit = $s^2/8y$, where s, the sagitta = 4r.
$B.(4r)^2\ d/8a = 1124$ gauss.cm, $B.2r = 1124.a/d$
With a = 0.1725 cm and d = 50 cm, B.2r = 3.88 gauss.cm $\quad \ell = 2r$

$\hookrightarrow B\ell$

Implementation

Magnets

The magnet parameters are:

Number of Coils	4 -- 2 for vertical and 2 for horizontal deflection
Number of turns	220
Composition	bifilar wire
Inductance	600 μhenries
Resistance	7Ω

An aluminum block, with a hole that goes around the beam pipe, houses coils wound around aluminum spools. Figure 4 shows the arrangement. Diodes across the windings protect against the back emf in the coil ($\varepsilon = L.di/dt$), which occurs during the interruption of current.

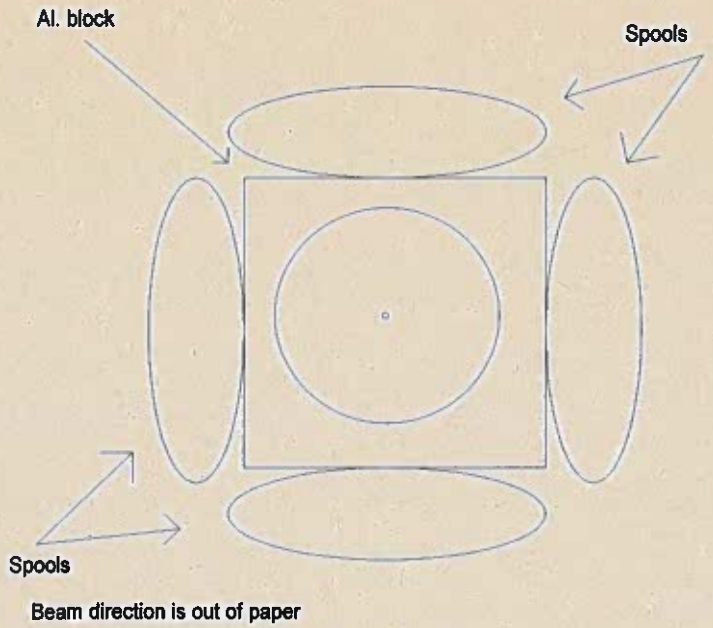


Figure 4

Power Dissipation in the coils

The power dissipation in the coils will be less than 1/4W, for 0.1A current.

Control Module

There will be separate, but identical control modules for the two magnets. The control module supplies current to the two coils, monitors current through the coils and monitors the PSS permissions.

The 24 V loop of the PSS system goes through two relays, arranged in series, in the control module. The status of each relay depends on the status of the current flowing through the coil assigned to it. The absence of current through the coil opens the relay. The PSS system detects the interruption to the voltage loop.

The control module also monitors the two PSS permissions. The absence of one or both permissions causes an interruption in the current through one coil. The resulting magnetic field deflects the beam on to the aperture. The relays in this circuit will handle 200 milliamps (max.) of current.

Packaging

The control module will conform to 3U eurostandard and will reside in the same enclosure as the PSS Beam Current Monitor System. LEDs on the

front panel will indicate the status of the PSS permissions, the power supply and the current through the coils. Front panel SMA connectors (HPBR-1414) will receive the PSS permissions. Back plane DIN connector's pin C32 will supply the 5V power at 1A min. to the control module. Pin C31 is the ground. Sub-miniature D connector on the control module will contain the relay contacts for the PSS's 24 V loop and power to the magnet coils. Figure 5 shows the control module.

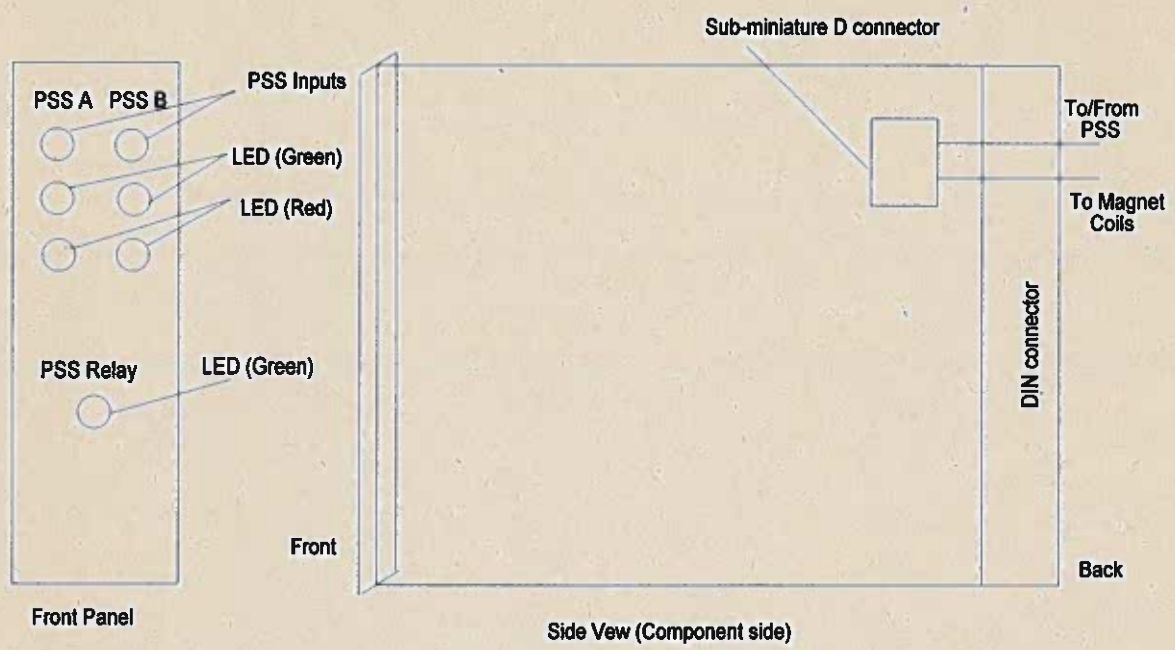
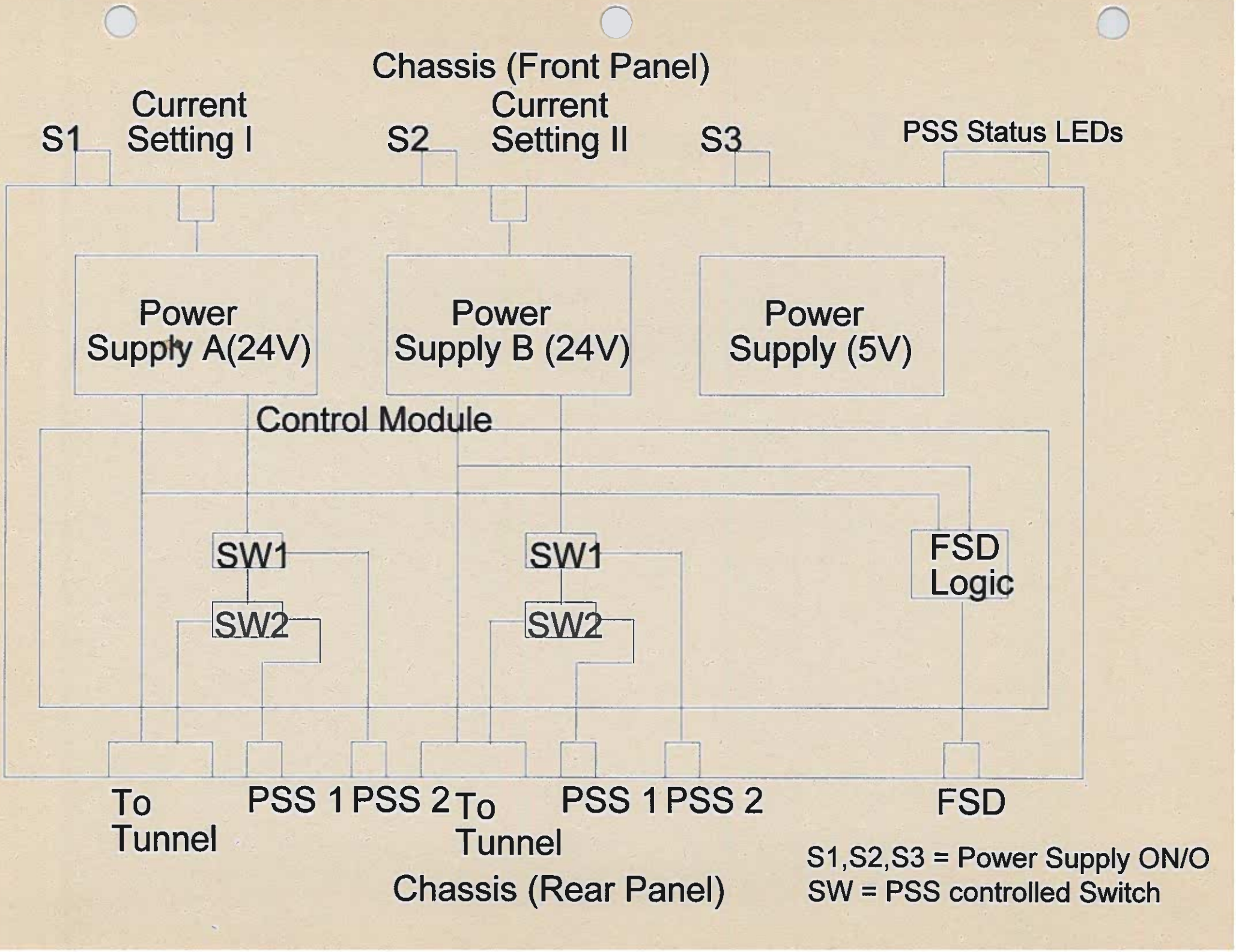
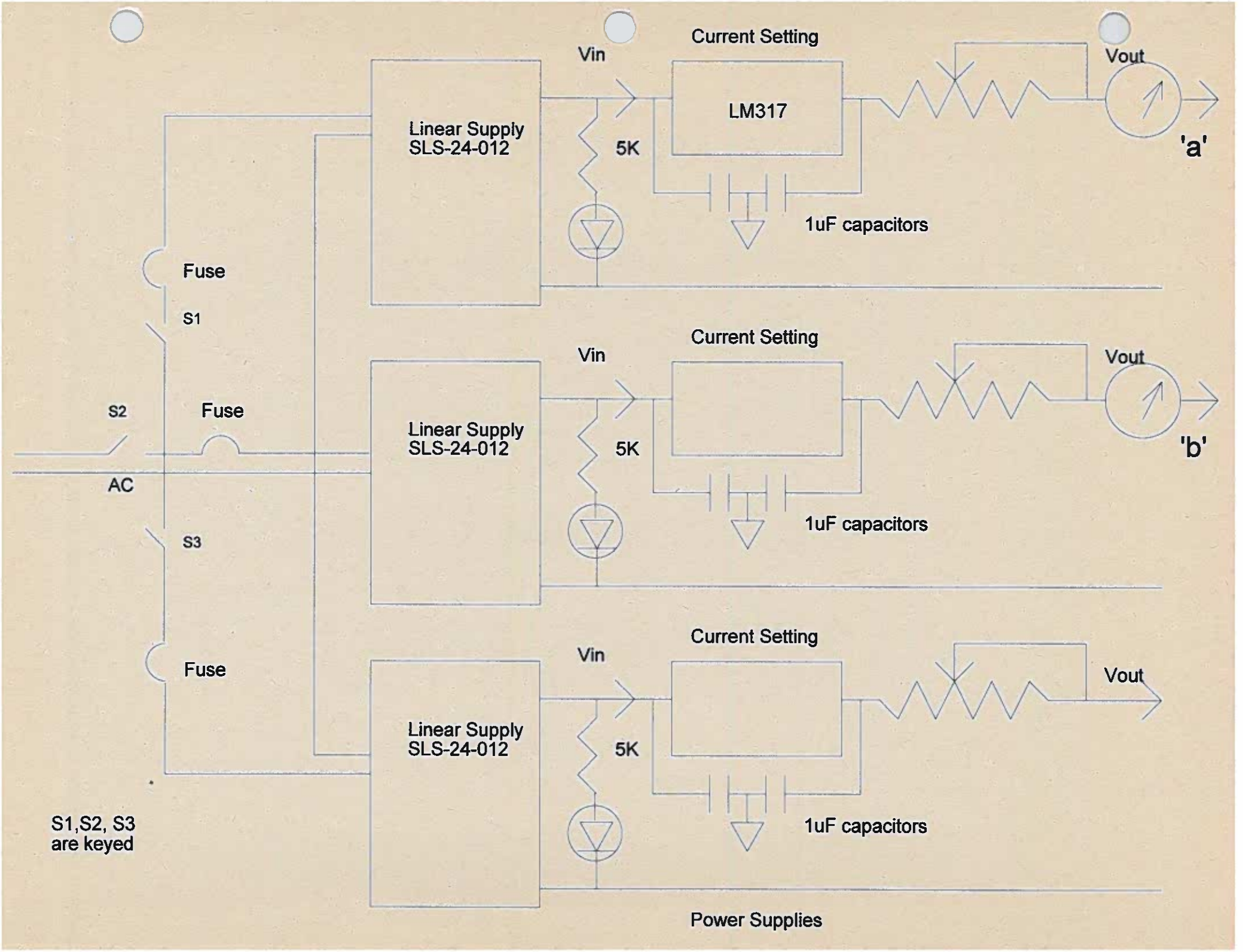


Fig 5. Control Module

Locations

The control module will reside in the injector service building, in the PSS rack. The magnets will be in the tunnel.


Chassis (Front Panel)
S1
Current Setting I
S2
Current Setting II
S3
PSS Status LEDs
Power Supply A(24V)
Power Supply B (24V)
Power Supply (5V)
Control Module
SW1
SW2
SW1
SW2
FSD Logic
To Tunnel
PSS 1
PSS 2
To Tunnel
PSS 1
PSS 2
FSD
Chassis (Rear Panel)
S1,S2,S3 = Power Supply ON/O
SW = PSS controlled Switch


Current Setting
Vin
Vout
LM317
Linear Supply
SLS-24-012
5K
'a'
1uF capacitors
Fuse
S1
Current Setting
Vin
Vout
S2
Fuse
Linear Supply
SLS-24-012
5K
'b'
AC
1uF capacitors
S3
Current Setting
Fuse
Vin
Vout
Linear Supply
SLS-24-012
5K
1uF capacitors
S1,S2, S3
are keyed
Power Supplies

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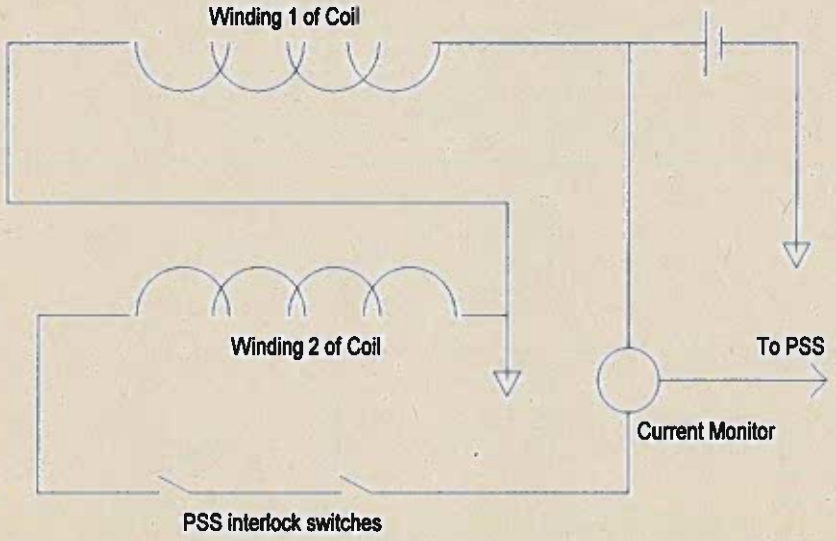

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Test Procedures for Kicker Magnets
January 23, 1995

Operator actions are in normal print. The results the operator should observe are in italics. The chassis is in the PSS rack in the injector service building. The back panel of the chassis has 3 locks, labelled A, B and C. Keys labelled A&B turn on/off power supplies A and B. Key labelled C turns on/off power supply C. The chassis backpanel has PSS A and PSS B permissions (inputs).

Setup

1. Ensure that the PSS permissions are active.
2. Setup low beam current (< 2.5 μA).
3. Turn on all three power supplies using the keys.

Beam path should remain unchanged. PSS relay at the backpanel should close.

Verification Power Supplies

1. Ensure that the PSS permissions are active.
2. Turn off power supply A. *PSS relay at the backpanel should open.*
3. Turn on power supply A.
4. Turn off power supply B. *PSS relay at the backpanel should open.*
5. Turn on power supply B.
6. Turn off power supply C. *PSS relay at the backpanel should open.*
7. Turn on power supply C.

Power supply failures cause PSS relay to open. Beam path remains unchanged.

Verification PSS interlocks

1. Remove permission PSS A. *Beam should not go through the aperture. Note that the front panel LEDs indicate loss of PSS permission A.*
2. Reconnect PSS A.
3. Remove permission PSS B. *Beam should not go through the aperture. Note that the front panel LEDs indicate loss of PSS permission B.*
4. Reconnect PSS B.

Loss of any PSS permission causes beam to steer away from the aperture.