BNL-105865-2014-TECH
EP&S No. 150;BNL-105865-2014-IR

Powering system for the E787 detector magnet

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February 1995

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EXPERIMENTAL PLANNING AND SUPPORT DIVISION

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I. Introduction.

A rare kaon decay, AGS Experiment 787, has been set up in the AGS SEB C4 branch of the low energy separated beam No. 3 (LESB III) beam line. The experiment uses a large detector equipped with a solenoidal field to measure the decay $K^+ \rightarrow \pi + \nu\bar{\nu}$. The main solenoid magnetic field is 10 kG and is created by sets of coils operating at a nominal current of 4300 Amperes, dc.

II. Power Supply Scheme.

The parameters of the detector magnet are: R = 0.0671 ohms L =0.6 hy. Thus the dc power required to operate at ~ 4500 A is 1.3 MW. The decision was made to use 2 each 600 KW (nominal rating) AGS experimental magnet SCR (Silicon Controlled Rectifier) PS's in series to operate the solenoid. The power supplies, operating in a master/slave configuration, are in phase and thus generate a large amount of fundamental 360 Hz voltage ripple and smaller amounts of subharmonic ripple (namely 60, 120, 240, --- Hz). In addition, fast SCR commutation spikes are generated at a 360 Hz rate, but which contain harmonic components up to 30-50 kHz.

From a current or field ripple requirement the magnet impedance attenuates all high frequency voltage components by a large amount (typically > 1000 times at 100 Hz) so that main field fluctuations would not be a problem. However, the large ripple voltages create fringing field problems which couple magnetically and capacitively to the nearby detector segments and electronic signal cables.

Thus, the PS decision included the use of a passive, damped LCRC filter on the dc output to attenuate the inherent PS output voltage ripples. The powering scheme is shown schematically in Fig. 1. The calculated filter response is shown in Fig. 2. We can see that the 360 Hz ripple should be reduced by a factor of 26, and the higher frequency components by larger amounts, to produce approximately 10 V peak-to-peak at the magnet terminals.

III. Filter Design.

The filter components consist of an old rectangular quadrupole as the inductor and fused electrolytic type capacitors constructed in 2 banks. One bank blocks the high dc current that would normally flow through the damping resistor. A shunt diode prevents reverse voltage on the capacitors.

During the past six months, the E787 group has been attempting to reduce their detector noise pickup to within acceptable levels. Several sources of 40-80 kHz noise were identified and corrected. A source of 360 Hz noise was also detected and pointed to the main magnet PS's.

It was noted that in constructing the passive filter, the inductor was inadvertently placed in the + output leg of the PS, which for historical reasons has been the ground leg of the experimental magnet PS's. While the filter provided adequate differential mode attenuation across the load terminals, it did not do any attenuating of the common mode voltages which are quite high.

IV. Operation and Measurements.

During the November 1994 AGS shutdown, the filter connections (choke and dc leads) were modified and the system was operated after the detector was put back together. The dc leads were re-routed so that + and - ran parallel to each other. Figure 3 shows the data from a run at 3000 amperes:

Fig. 3A - PS voltage output (sum of PS1 & PS2)
Fig. 3B - Filter voltage output
Fig. 3C - Filter output: V+ to ground (earth)
Fig. 4 - Filter output: at 2244 amperes.

The values for operation at 4300 amperes are typically lower since the main power supply ripple decreases as the SCR's are phased forward. When going from an operation at 3000 amperes to 4300 amperes, we expect a raw ripple reduction of an additional factor of 2.4. Some of the fast transients of Figures 3B and 4 are due to noise pickup in the loop connecting the oscilloscope ground and building or earth ground.

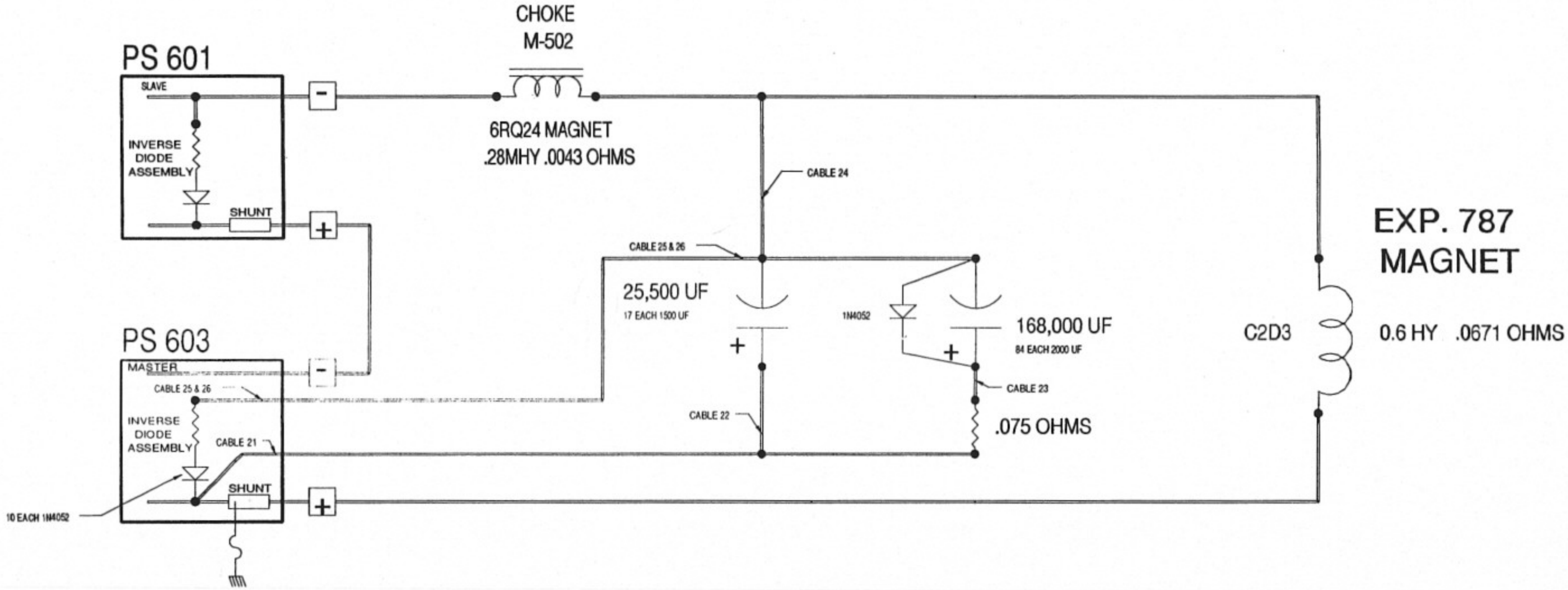
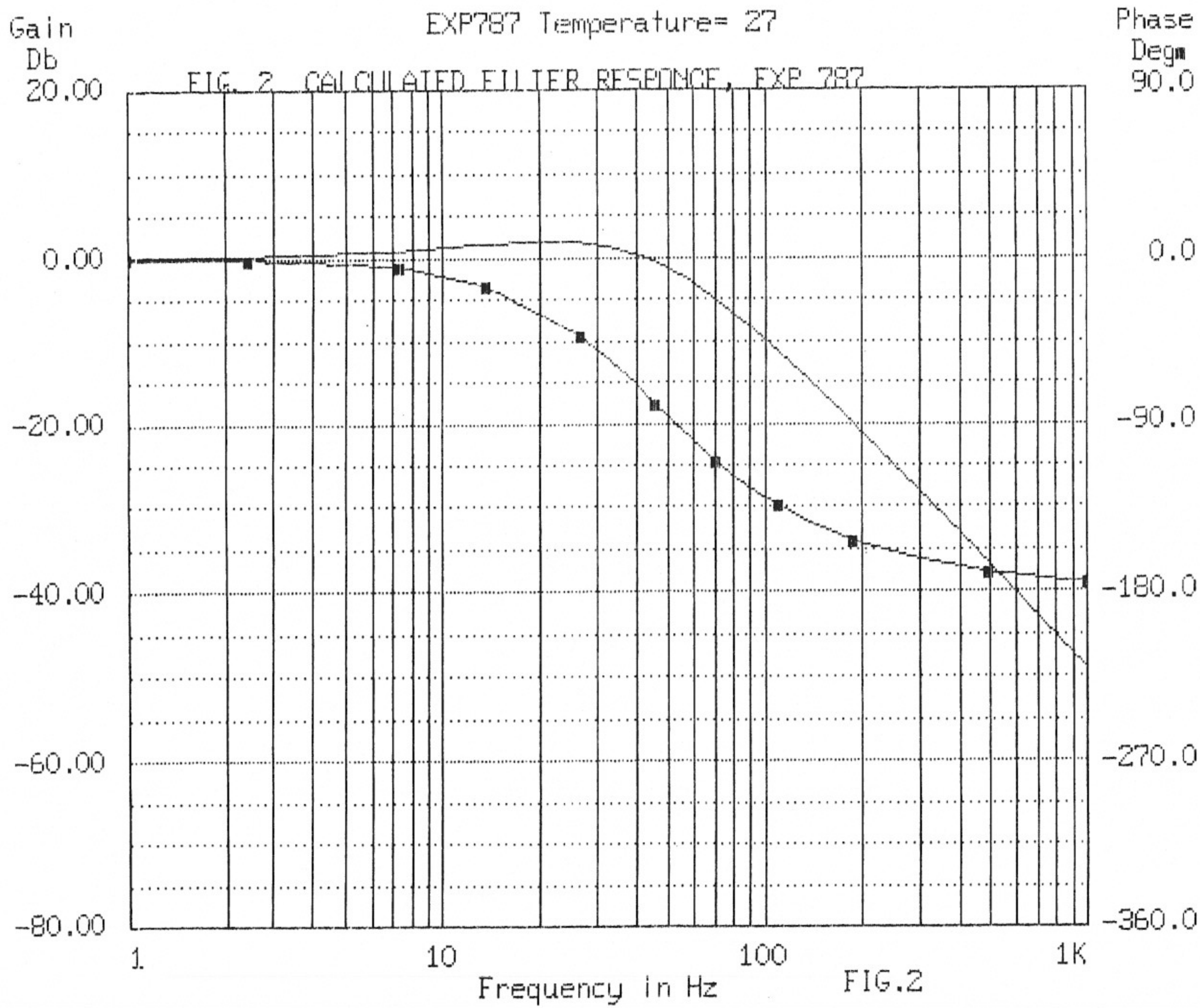


Figure 1

EXP. 787 POWER SUPPLY AND FILTER SCHEME.



EXP787 Temperature= 27
FIG. 2 CALCULATED FILTER RESPONCE, EXP 787
Gain
Db
20.00
0.00
-20.00
-40.00
-60.00
-80.00
Phase
Degm
90.0
0.0
-90.0
-180.0
-270.0
-360.0
1
10
100
1K
Frequency in Hz

FIG.2

50V/CM
AC Coupled

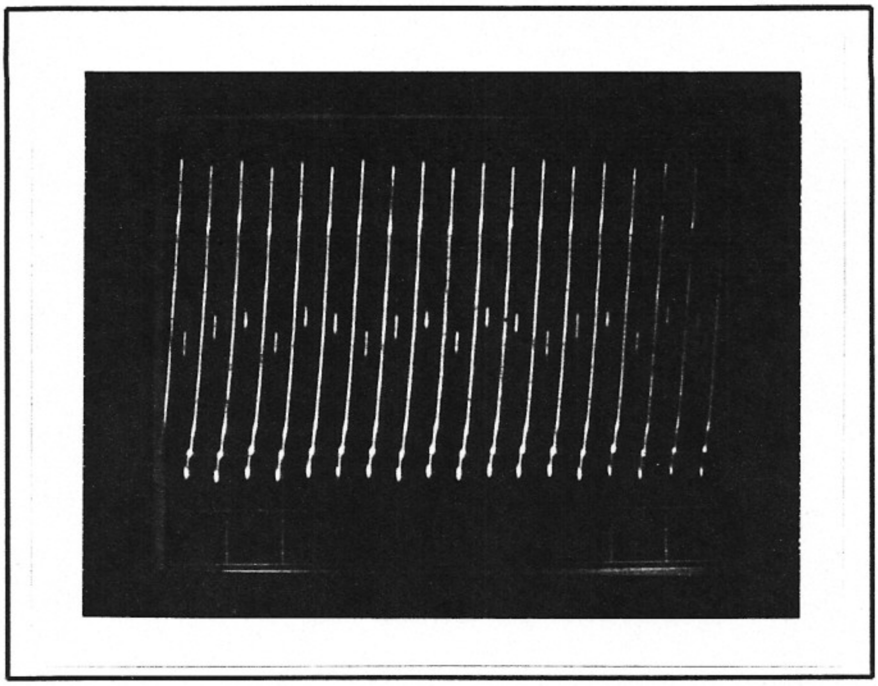


Fig. 3A

5MS/CM

PS voltage output (sum of PS1 & PS2)
PS Output @ 195VDC, 3000amp.

5V/CM
AC Coupled

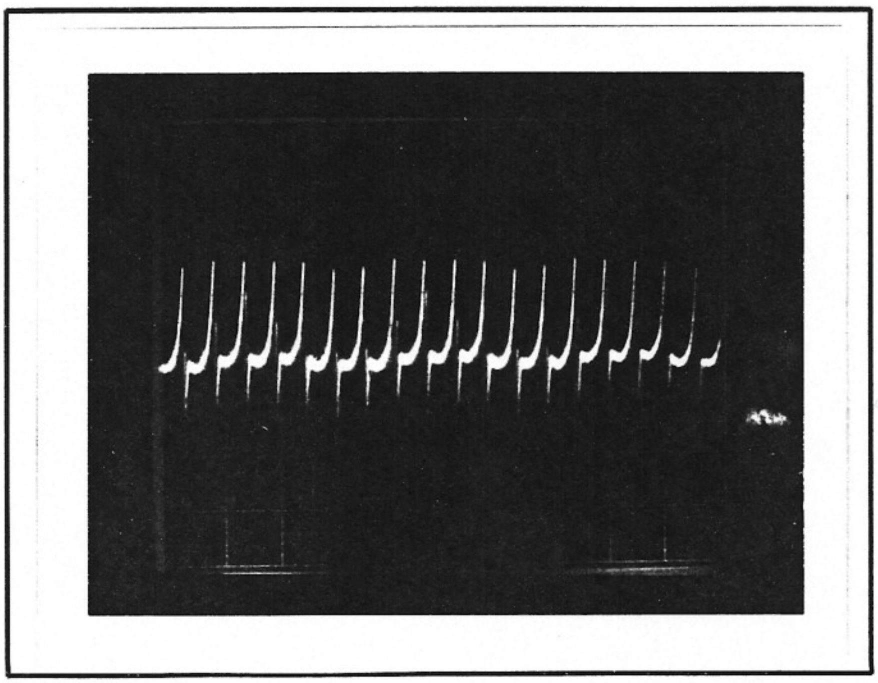


Fig. 3B

5MS/CM

Filter voltage output.
PS Output @ 195VDC, 3000amp.

200mV/CM
AC Coupled

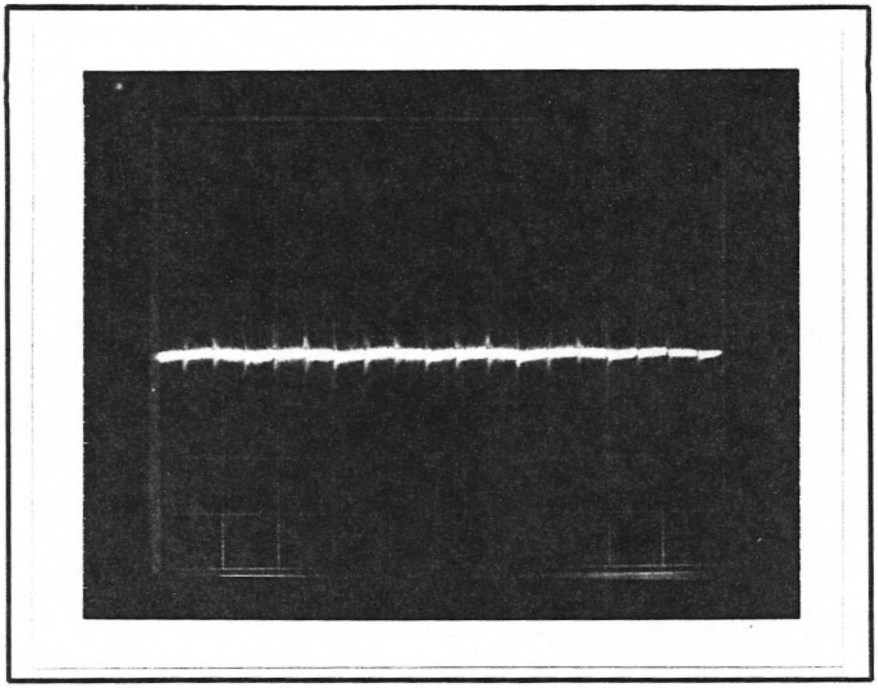


Fig. 3C

5MS/CM

Filter output: V+ to ground (earth).

PS Output @ 195VDC, 3000amp.

20V/CM
AC Coupled

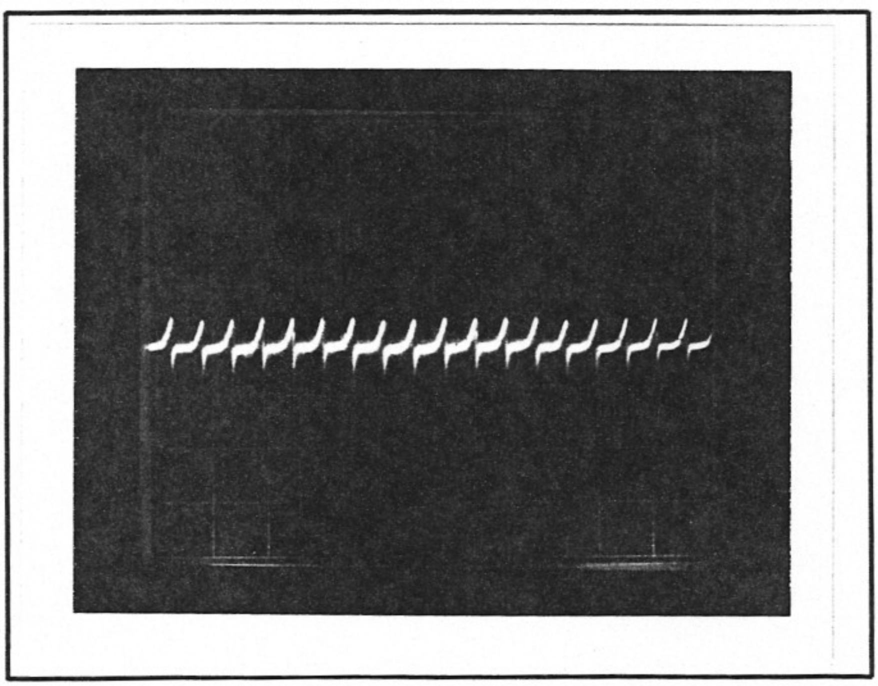


Fig. 4

5MS/CM

Filter voltage output.

PS Output @ 137.7VDC, 2244 amp.