BNL-105147-2014-TECH

Booster Technical Note No. 103;BNL-105147-2014-IR

Stability of screen and grid power supplies for the RF power amplifier for proton cavity

M. Meth

December 1987

Collider Accelerator Department

Brookhaven National Laboratory

U.S. Department of Energy

USDOE Office of Science (SC)

DISCLAIMER

STABILITY OF SCREEN AND GRID POWER SUPPLIES

FOR THE RF POWER AMPLIFIER FOR PROTON CAVITY

AD

Booster Technical Note

No. 103

M. METH

DECEMBER 30, 1987

ACCELERATOR DEVELOPMENT DEPARTMENT

Brookhaven National Laboratory

Upton, N.Y. 11973

STABILITY OF SCREEN AND GRID POWER SUPPLIES

FOR THE RF POWER AMPLIFIER FOR PROTON CAVITY

M. Meth
December 30, 1987

The RF power amplifier for proton acceleration is described in Booster Technical Note 92. The amplifier employs an EIMAC 4CM300,000 tetrode. The stability of the gap voltage is dependent on the voltage stability of the screen grid and control grid power supplies.

The gap voltage is 22.5KV; it is reasonable to impose a stability of ±1% or ±225 volts for the gap voltage. The gap voltage is a linear function of the plate current, therefore the plate current must be stable to ±1%. In terms of the sensitivity functions for the screen and control grids

$$\frac{\Delta I}{I} = S^{I}_{E_{c2}} \frac{\Delta E_{c2}}{E_{c2}} + S^{I}_{E_{c1}} \frac{\Delta E_{c1}}{E_{c1}}$$

The tube has an amplification of grid 2 with respect to grid 1 (designated by μ_2) of 4.5. The relationship between the two sensitivity functions is $S^{I}_{E_{c1}} = \mu_2 \frac{E_{c1}}{E_{c2}} S^{I}_{E_{c2}}$. Thus, it is only necessary to calculate $S^{I}_{E_{c2}}$. This can be readily done from the published tube characteristics.

Static Regulation

Figure 1 is a plot of I as a function of E_{c2} at E_b=12KV and E_{c1}=-200 volts. The slope at E_{c2}=1100 volts, a typical point on the load line near cut off, is .053 A/volt. The value of I at this point is 18 Amperes. The sensitivity function is evaluated from

$$\frac{\Delta I}{I} = \frac{E_{c2}}{I} \frac{dI}{dE_{c2}} \frac{\Delta E_{c2}}{E_{c2}}$$

with, $S^{I}_{E_{c2}} = \frac{E_{c2}}{I} \frac{dI}{dE_{c2}}$

and at the given operating point is equal to 3.23. The function $S^{I}_{E_{c2}}$ is evaluated as 2.64.

The sensitivity function can also be evaluated in terms of the tube transconductance (gm).

$$S^{I}_{E_{c1}} = \frac{E_{c1}}{I} \, gm$$

and $S^{I}_{E_{c2}} = \frac{E_{c2}}{I} \frac{gm}{\mu 2}$

From the constant current characteristics the value of gm is 0.24 Ampere/volt at E_{c2} = 1100 volts and I = 18 Amperes.

Allowing each supply to introduce a maximum error of ±0.5%

$$\frac{\Delta E_{c2}}{E_{c2}} = \pm 0.15\%$$

and $$\frac{\Delta E_{c1}}{E_{c1}} = \pm 0.19\%$$

The sensitivity function decreases with increasing plate current. For equal errors from the two supplies the regulation of the supplies are specified as ±0.15% or less.

Since the screen power supply has a much higher power rating than the grid supply, it is reasonable to allow the screen supply to introduce a larger error than is introduced by the grid supply. Allowing the ratio of errors to be 4:1, the regulations become

$$\frac{\Delta E_{c2}}{E_{c2}} = \pm 0.25\%$$

$$\frac{\Delta E_{c1}}{E_{c1}} = \pm 0.075\%$$

This yields a more reasonable specification.

Dynamic Regulation

The RF bypassing of the screen is given in Figure 2. The .0114μF capacitor is incorporated within the tube socket. The 30-50 ohm resistor is a parasitic suppression and the 0.1μF capacitor is a bypass for the power supply. From the load lines published in Tech. Note 92 the maximum screen grid current occurs at maximum beam loading and full-voltage cycle. The current is determined from the load line and is given in Figure 3. The maximum ripple voltage produced by the screen current will be at the injection frequency of 2.4Mhz.

The charge transported per pulse is approximately 0.28×10^{-6} coulombs and the ripple voltage across the supply is ± 1.25volts (±0.11%). Thus, the supply need not regulate for beam loading.

Screen Supply Parameters

The electrical parameters of the screen supply are tabulated

Voltage	:	2,000 volts maximum, adjustable.
Current	:	3A maximum
Power	:	6KW
Regulation	:	± 0.25% or less

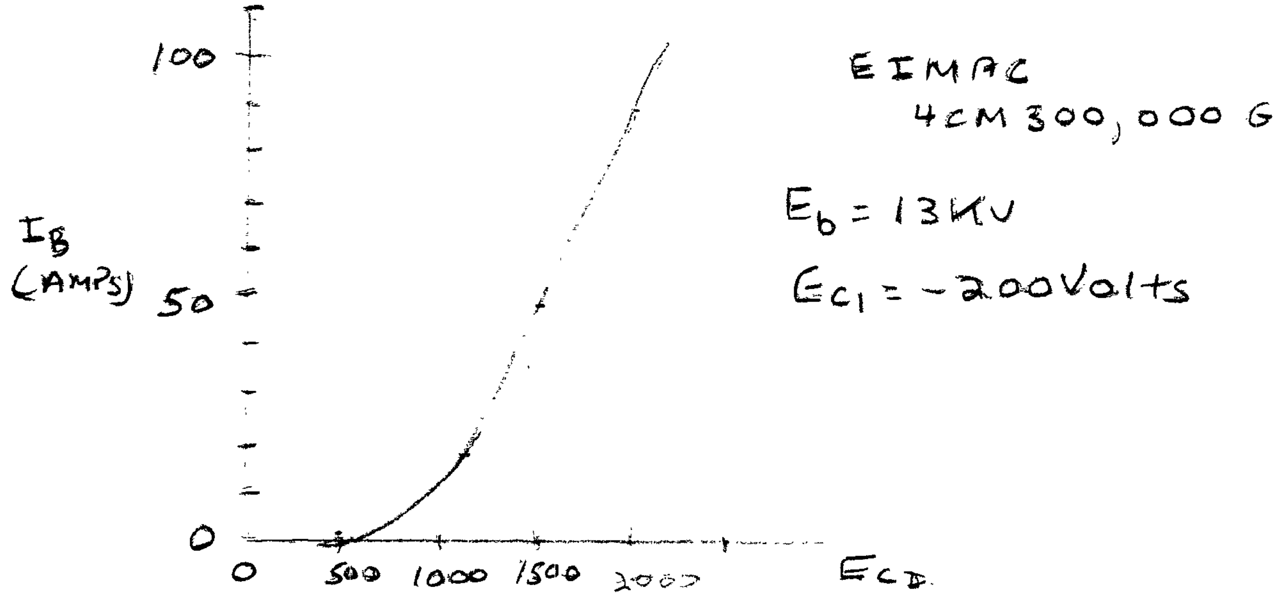

FIG 1
PLOT OF I_B AS A FUNCTION OF E_{c2}

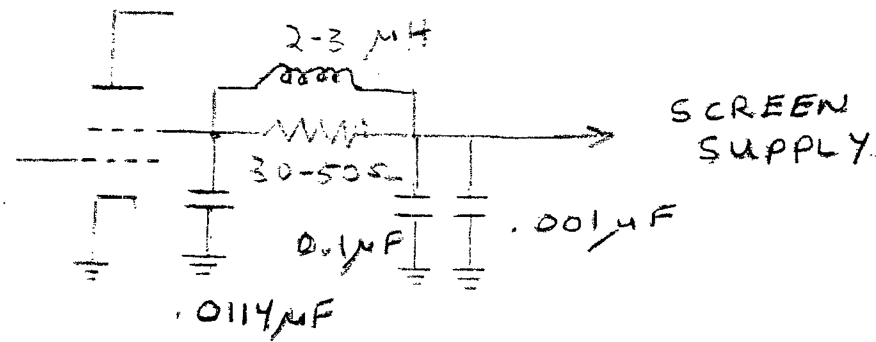

FIG 2
SCREEN CIRCUIT

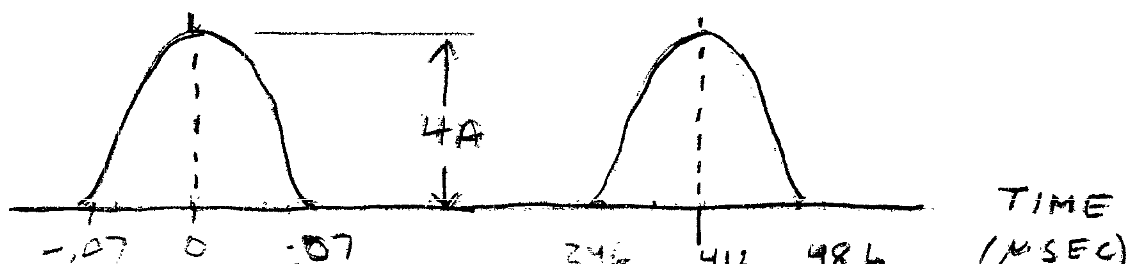

FIG 3
WAVEFORM OF MAXIMUM SCREEN CURRENT

SP 11037A