IEEE Transactions on Nuclear Science, Vol. NS-28, No. 3, June 1981

THE ALADDIN FREQUENCY ACCELERATING SYSTEM POWER AMPLIFIER: 140 KW AT CONSIDERABLY LESS THAN A DOLLAR A WATT*

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SUMMARY

Modern gridded power tubes offer enormous power gain and thus make possible very economical high power radio frequency systems provided that the often troublesome problems of stability can be solved. We have developed a grounded cathode 50 Mhz, 140 KW power amplifier that achieves a power gain of over 30 db to provide radio frequency power for the electron storage ring Aladdin. Because of the low drive power requirements and the simplicity of the mechanical and electrical design, the cost of this power amplifier, including development, was less than $100,000.

INTRODUCTION

Electron storage rings with energy in the one GeV range designed to achieve very high charge density electron beams so as to be high brightness sources of synchrotron radiation, require RF accelerating systems capable of producing enormous over voltage in order to provide adequate beam lifetime against Toucheck effect. Hence, lifetime, rather than synchrotron radiation energy loss per se, sets the peak energy gain per turn required and, therefore, the power level of the RF system. In Aladdin[1], the energy loss per turn at 1 GeV is 40 KeV while the RF voltage required for adequate lifetime is 250 KeV. Excitation of the RF cavity to this potential requires 30 kW and a one ampere circulating beam would require an additional 40 kW. It is expected that substantial "de Q ing" of the cavity will be required in order to achieve stability of the electron beam at high current. Therefore the RF power amplifier was designed to produce twice as much power as the cavity and maximum beam current require.

SYSTEM DESCRIPTION

In order to achieve this power level economically, a high transconductance power tetrode (EIMAC 4CW100000E) operating class AB in grounded cathode configuration was chosen. At the operating frequency (50.58 Mhz) the large input and output capacities of this tube made coaxial cavity grid and plate circuits an attractive and economical possibility. Because the operating frequency is fixed and the accelerating cavity has servo controlled coupling, a flat output transmission line is used. This allows the simplicity and economy, of a non adjustable output coupling system. The power amplifier circuit is shown schematically in Fig. 1.

With the high power gain of the output stage (>30 db) the intermediate power amplifier need only be capable of supplying 1 kW. This stage employs a 4CX1000 tetrode operating class AB.

For stability, both PA and IPA employ Hazeltine neutralization. Good construction practices have produced a system which, so far, gives no evidence of H.F. or L.F. parasites.

The IPA requires only 10 W of drive power to achieve 1 kW output. This is gotten from a 2N 6658 MOSFET transistor driven by the low level amplifier which also incorporates the AGC. While, nominally, the system operates at fixed frequency, the flexibility of limited frequency control was considered desirable. Hence, the Master oscillator is an inexpensive ($750) frequency synthesizer which can be controlled by the Aladdin control computer[2].

All system status sensors as well as the more important analog parameters are interfaced to the Aladdin control computer. However, the power up and power down sequences are hard wired into the transmitter control, thus the system can be operated in stand alone mode.

The P.A. Plate supply employs a twelve phase rectifier without low frequency filtering. The resultant small ripple in the output of the final amplifier is reduced adequately by the AGC. The plate supply does include a crow bar to protect the P.A. in case of arc down.

CONSTRUCTION

The IPA, low level RF stages and all power supplies except the final amplifier plate supply are housed in two standard relay racks. The final amplifier is mounted on a 40 foot cubical cabinet the top of which is the ground plane between input and output circuits. Cooling air for the output tube base travels up through the grid cavity and exits into the plate cavity which is mounted on top of the ground plane. Plate power and cooling water are brought down the central axis of the plate cavity. A Polyflon co-axial plate blocking capacitor is used for DC isolation. These details can be seen in Figures 2 and 3.

The final grid is fixed biased for class AB operation. However, at maximum power output a diode disconnects the grid bias supply and the tube shifts into Class C operation for higher efficiency. This feature also provides some protection in the event of parasitic oscillations by making sure that the grid will be driven rapidly into cut off during unstable operation. The long time constant of the grid circuit assures low average power output by forcing the circuit to operate as a blocking oscillator.

OPERATION

The transmitter has been operated at 70 KW output into a dummy load. A plate efficiency of 57% was measured. The operation was stable and no evidence of parasites was noted. Operation at higher power levels was not possible because of the power limitation of the dummy load.

The transmitter is installed and testing with the accelerating cavity has begun.

References

1 E.M. Rowe, et. al. Status of the Aladdin Project, IEEE Transactions on Nuclear Science, June 1981.

2 W.S. Trzeciak, The Aladdin Computer Control System, IEEE Transactions on Nuclear Science, June 1981.

*Work performed under NSF contract No. DMR 7708657

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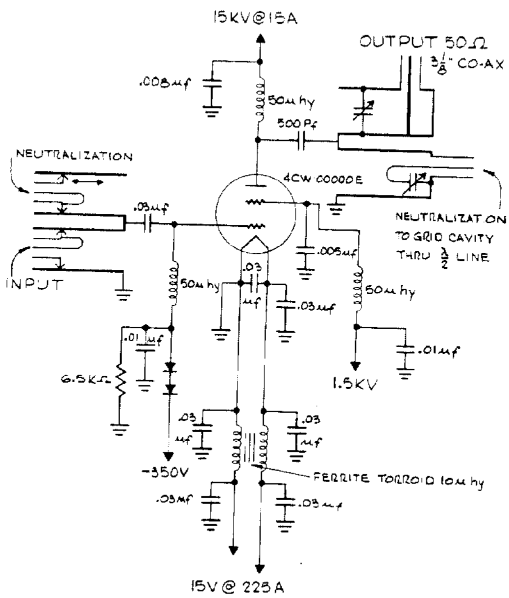

Fig. 1 Schematic of Power Amplifier circuit. Output line is pressurized at 15 PSI with SF_6.

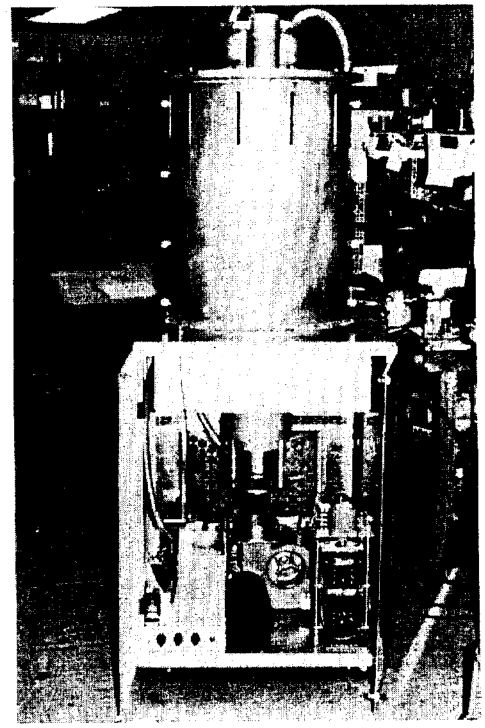

Fig. 3 Botton of Power amplifier enclosure. Blower Forces air up through grid cavity through flexible hose (not shown) whence it exits through slots near top of plate cavity.

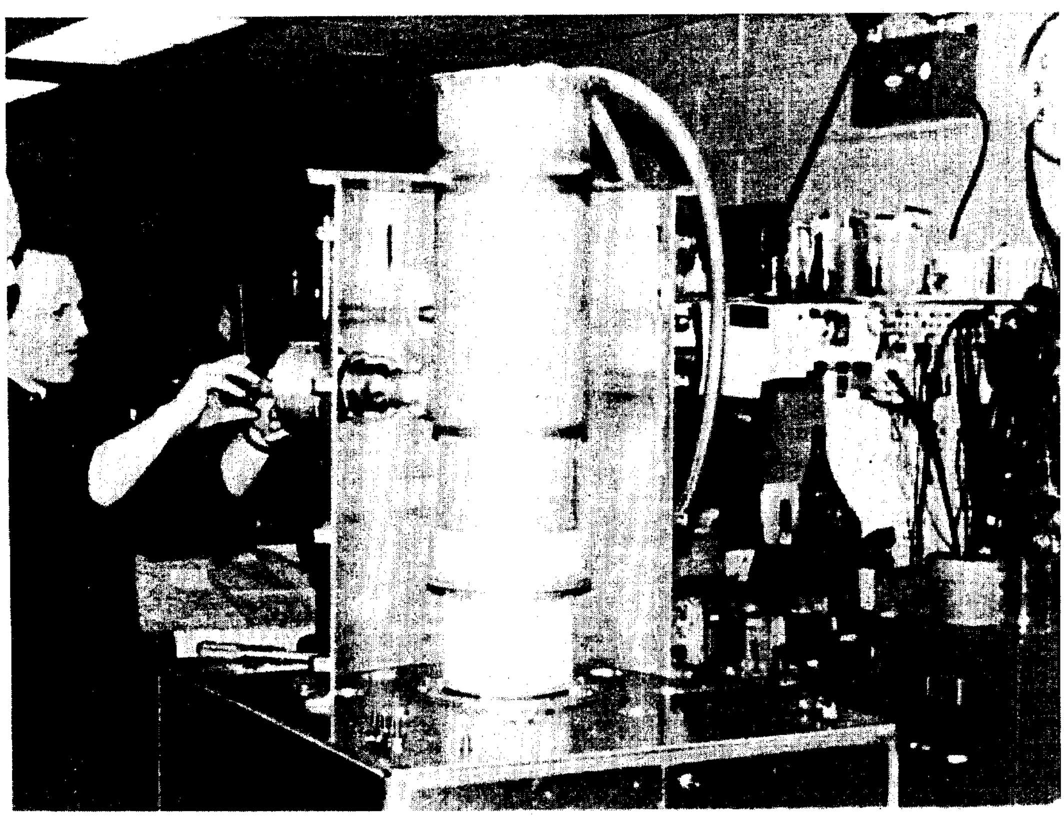

Fig. 2 Partially assembled plate cavity. Plate timing capacitor and output tap may be seen on the left.