The SSC RFQ-DTL Matching Section Buncher Cavities

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Abstract

The RFQ-DTL matching section of the SSCL Linear Accelerator matches the 2.5 MeV H^- beam from the RFQ into the acceptance of the 70 Mev Drift Tube Linac (DTL). To provide longitudinal phase space tuning, two rf buncher cavities with a resonant frequency of 427.617 MHz and with a maximum E_oTL of 160 kV are required. To meet the limited space requirements, it was decided to use double gap buncher cavities.

I. INTRODUCTION

The primary goal of the RFQ-DTL matching section is to match 2.5 MeV beam from the RFQ into the acceptance of the DTL. experiencing a minimal growth in beam emittance. The main components consist of two RF buncher cavities and four Variable Field Permanent Magnet Quadrupoles (VFPMQ). It is required that these devices along with beam diagnostics fit into a length of only 534 mm. A drawing of the matching section is shown in Figure 1.

Because of the limited space available it was decided to use two double gap cavities instead of the much larger single gap pillbox type cavity. The cavities are required to have a resonant frequency of 427.617 MHz and provide a maximum E_oTL of 160 kV. However the small size of the double gap did present a challenge in coupling 30 kW of pulse RF power as well providing water cooling, fine tuning and probes for sampling the RF fields.

II. MECHANICAL DESIGN

A drawing of the cavity is shown in Figure 2. The cavity is formed from a section of rectangular slabline transmission line with a washer type structure which forms the double accelerating gap.

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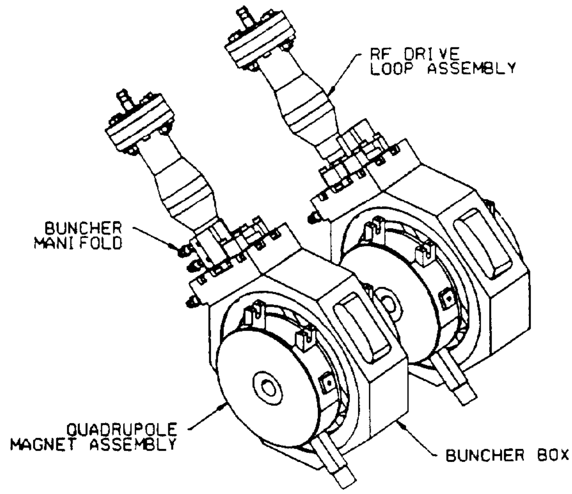

Figure 1: RFQ-DTL matching section.

The cavity is designed such that it can be housed in an octagonal diagnostic chamber. Vacuum is supported by the chamber which eliminates resonant frequency shifts due to pressure deflection on the cavity. The cavities are oriented at 45 degrees with respect to the vertical with the accelerating gaps near the bottom. The maximum power dissipation in the cavity due to RF conductor losses is 30 watt with most of that in the center conductor. Water cooling is provided by water channels that are brazed into the cap and extend the length of the center conductor. This also provides temperature stabilization of the cavity. The cooling water will be derived from the Temperature Control Unit (TCU) of the RFQ. It is expected that the temperature fluctuation will be no greater than 0.4 degrees Celsius. The corresponding frequency change will be 2.9 kHz which is well inside the bandwidth of the cavity (43 kHz) . Inductive coupling is used to excite the cavity. Calculations and measurements on a cold model indicate that a loop area of 0.5 cm^2 is required to achieve matched coupling. It is estimated that only 5 milliwatts of power is dissipated on the loop and water cooling is not required. In the actual design, the loop area will be somewhat greater than required and there will be the capability of rotation so that the desired coupling can be achieved. For phase and amplitude regulation an rf sample is derived from a inductive loop thru a type N connector assembly located at the top of the cavity. Because of the severe space limitations at the top of the cavity, fine frequency tuning using a rotatable loop was not possible. Instead this is accomplished through installation of a capacitive slug at the bottom of the cavity which couples into the electric field from the accelerating gap. With a travel of 30 mm and with the closest approach to the bottom of the washer being 23 mm a tuning range of 200 kHz can be achieved.

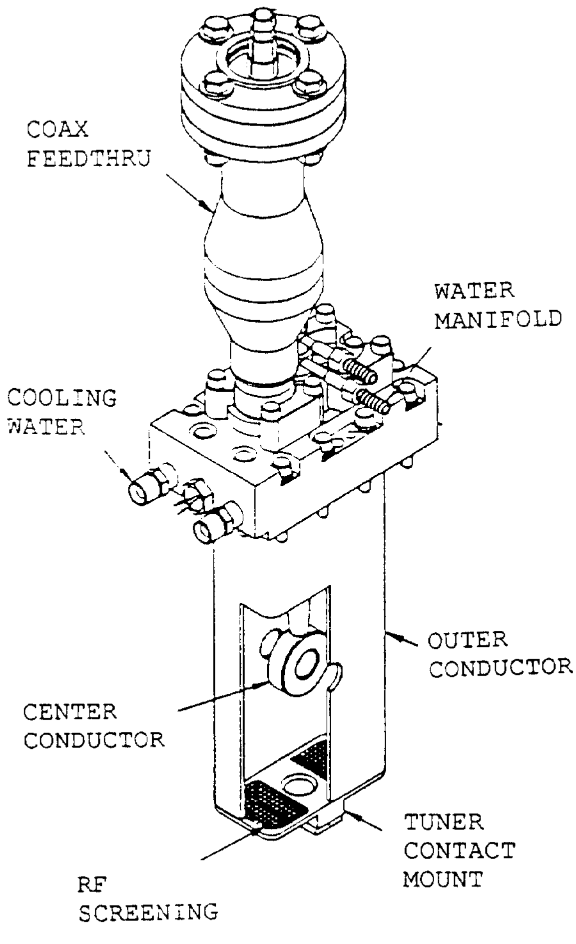

Figure 2: Double gap buncher cavity.

III. MAFIA CALCULATIONS

The 3D code MAFIA was used to set the resonant frequency and calculate the shunt impedance and quality factor of the fundamental mode. These turned out to be 800 $k\Omega$ and 5000 respectively. This quality factor is approximately four times smaller than that calculated for the pillbox type cavity. Hence the double gap buncher will be less sensitive to mechanical disturbances. The transit time factor was calculated to be 0.7 . Also calculated were electric field sensitivities as a function of small displacements of the center conductor. These results were used to specify mechanical tolerances.

IV. CERAMIC FEEDTHRU ASSEMBLY

A drawing of this assembly is shown in Figure 3 . It is basically a coaxial transmission line that undergoes a transition from o.d. $1\frac{5}{8}$ inch (air) to o.d. $\frac{7}{8}$ inch (vacuum). Providing the barrier between air and vacuum is a ceramic cylinder. The two main considerations in the design of this unit is to minimize the VSWR and minimize the electric fields near the surface of the ceramic. To investigate this problem use was made of the 3D code HFSS to calculate the reflection coefficient and electric field values. It was found that to keep the values of electric fields within acceptable values (1.5 kV/cm) it was necessary to use a relatively large ceramic. This accounts for the bulge in the structure. Also of consideration in the design of this assembly is the distance between the ceramic and the actual coupling loop. During the filling time of the cavity the loop, because its small self reactance (compared to 50Ω), behaves essentially as a short circuit [1]. This sets up a standing wave on the transmission line with the voltage maximum being located a distance $\lambda/4$ away from the coupling loop (with an effective length assigned to the loop). To minimize the electric stress on the ceramic it is desirable to locate the ceramic as close to the loop as possible or $\lambda/2$ away. Because of space constraints in the actual design this distance could be made no smaller than 0.17 wavelengths. However calculations show that the electric field values are within acceptable values. Using the other option of locating the ceramic at a distance $\lambda/2$ would invite multipactoring problems.

V. SUMMARY

Two double gap buncher cavities are being constructed for the SSCL RFQ-DTL matching section. It is expected that RF conditioning will take place within the next several months.

VI. REFERENCES

[1] Vojtech Pacak, SSCL, *private communication*

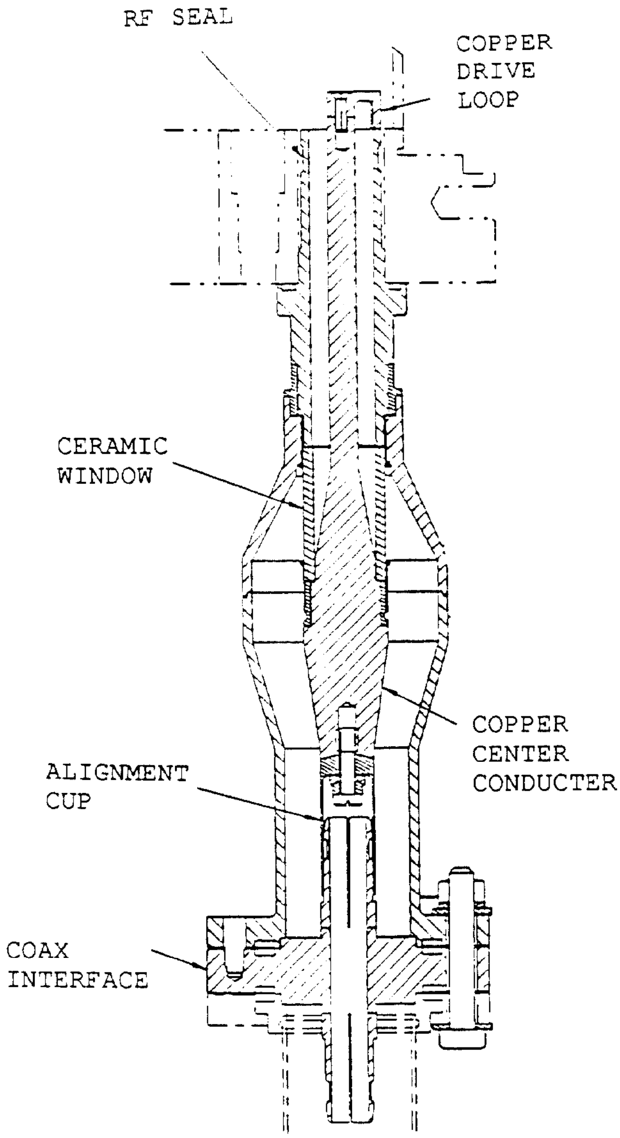

Figure 3: Ceramic feedthru assembly.