Dual Axis movable RF Coupler for the 75 MHz Heavy Ion RFQ

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Abstract

A 75 MHz prototype Heavy Ion RFQ consisting of 1.34m modulated vanes is installed in the vacuum chamber for RF characterization at Pelletron Accelerator Facility (PAF), Mumbai. The power is fed to RFQ via inductive loop and coupling to RFQ has been optimized experimentally based on the loop dimension and position. This magnetic loop coupler is used to feed power up to 1 KW and can be moved along two perpendicular directions to get the desired coupling. Design of the dual axis movable RF Coupler and measurements made are discussed.

Introduction

A 75 MHz heavy ion RFQ is being developed at PAF, BARC-TIFR. The beam dynamics design [1] and electromagnetic design [2] of this RFQ was completed and a 1.42 m prototype RFQ with 1.34 m of modulated vanes (see Fig. 1) is fabricated to study RF characteristics [3] & power coupling methods.

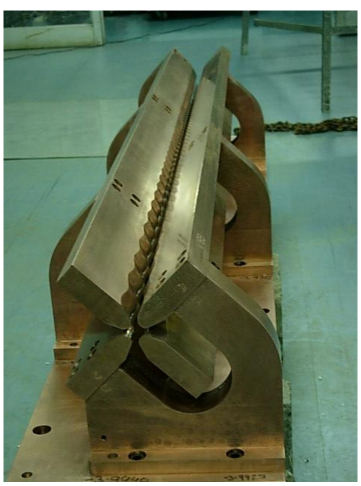

Fig. 1 Fabricated Model of Prototype RFQ

The resonant structure of the RFQ consists of four electrodes called vanes, assembled in quadrupolar symmetry on support posts called stems arranged on a base plate. The resonant structure consisting of vanes, stems and base plate is enclosed in a vacuum chamber made of stainless steel.

Design of RF Coupler Assembly

The RF coupler, which is a crucial part of an accelerating structure, couples the RF power from the source to the accelerating cavity. In RFQ, magnetic coupling is employed to transmit RF power brought via coaxial cable/coaxial transmission line to the RFQ. The advantage of the antenna loop coupler is that it can be easily adjusted to achieve better coupling. The coupler dimensions, position and orientation must be optimized for maximum power transfer to the accelerating structure. Pick-up RF coupler senses the fraction of RF power inside accelerating cavity for the stabilization and monitoring of the RF field inside cavity.

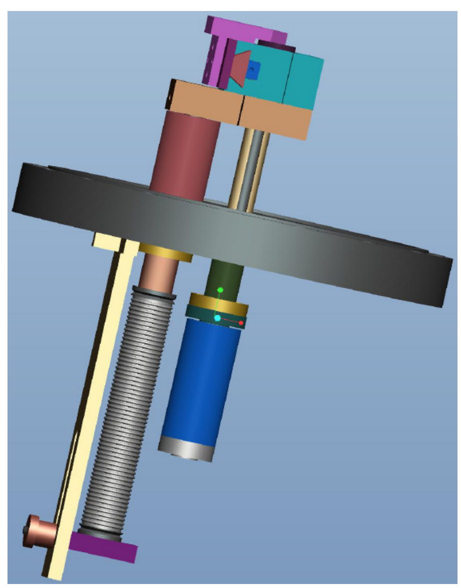

Fig. 2 CAD Model of Dual Axis movable RF Coupler Assembly

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The design of UHV compatible dual-axis movable RF Coupler Assembly (see Fig. 2) consists of a 8" CF flange with bellow arrangement for 60mm in/out motion, rotational micrometer arrangement for 40mm left/right motion and a 50 ohm N-type RF connector for coupling RF power. It has two platforms namely the Major (SS304) platform and Minor (ceramic) platform. The minor platform has arrangement for fixing the magnetic loop antenna (see Fig. 3). The major platform moves in/out and minor platform moves left/right for optimization of magnetic loop position.

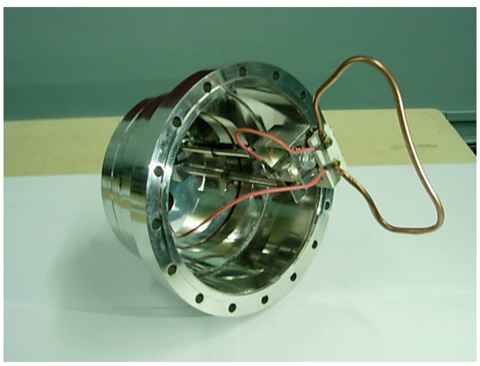

Fig. 3 Inductive Loop Coupler installed on the Dual Axis Stage

At reference, the minor platform is at the same distance from the RFQ as the wall of vacuum chamber. A reducer flange connects the RF coupler assembly flange to the vacuum chamber (see Fig. 4) and maintains the minor platform at the reference level.

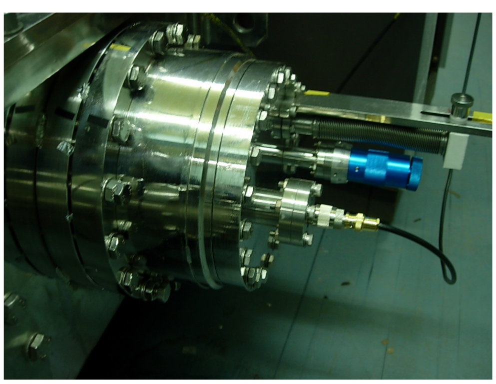

Fig. 4 RF Coupler Assembly installed in RFQ Chamber

The linear in/out position is measured along the scale mounted on the outer flange. The left/right position is measured on the gauge scale.

Coupling Loop Optimization

The dual-axis movable RF Coupler Assembly was connected to the prototype RFQ chamber. The optimization of inductive loop antenna shape, dimension and location from stem centre was carried out in air using Agilent E5071C Vector Network Analyzer (VNA). The Loop area was optimized by minimizing S11 and S22 parameters. For critical coupling condition the S-parameters S12 and S21 should be equal.

Magnetic loops made from copper wire (2mm diameter) of different dimensions were installed on the UHV compatible dual-axis movable Coupler Assembly. The coupling factor was adjusted by the in/out motion of loop antenna. Under best matching condition (loop dimension of 17cm x 8cm), ρ (reflection coefficient) = 0.05, SWR = $(1 + \rho) / (1 - \rho)$ =1.1 and β (coupling coefficient) = 1 / SWR = 0.91 was measured in air. It was observed that the left/right motion of loop antenna had little effect on the coupling.

To couple medium RF power up to 1 KW, magnetic loop of copper tube of optimized dimensions was fabricated and tested in air. The best coupling was achieved when either end of magnetic loop was soldered to N-type RF connector and ground respectively.

Conclusion

The dual axis movable RF Coupler was designed, fabricated, installed, tested and optimized for best coupling conditions.

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References

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[2] N. Mehrotra et al., Electromagnetic Design Study of RFQ, InPAC-2009.

[3] N. Mehrotra et al., RF Testing of 75 MHz Prototype Heavy Ion RFQ, InPAC-2011.