Design Validation Of IH Type Drift Tube Resonator At IUAC

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Abstract. The High Current Injector (HCI) project at Inter University Accelerator Centre would use a Radio Frequency Quadrupole (RFQ), Drift Tube Linac (DTL) and low beta superconducting cavities to accelerate heavy ions having $A/q \leq 6$, from the high temperature superconducting electron cyclotron resonance ion source (HTS-ECRIS called PKDELIS) to the existing superconducting linear accelerator (SC LINAC). The DTL has been designed to accelerate ions from 180 keV/u to 1.8 MeV/u, using six Interdigital-H (IH) type RF resonators operating at 97 MHz. Complete design validation has been done on a full scale prototype resonator.

Keywords: RFQ, DTL, ECR, RF, Interdigital, IH Type, Cavity
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DRIFT TUBE LINAC

The DTL has been designed to accelerate ions from 180 keV/u to 1.8 MeV/u, using six Interdigital-H (IH) type RF resonators operating at 97 MHz. The required output energy of the DTL is decided by the minimum input velocity (beta = 0.06) required for the existing superconducting LINAC. IH type resonators are the preferred choice for multiple gap DTL applications due to their high shunt impedance values. Acceleration from 180 keV/u to 1.8 MeV/u is done by six independently phased IH type RF cavities. The beam dynamics and generation of the drift tube geometry is done using the LANA code [1]. A full scale prototype resonator has been fabricated for validating the design [2]. Frequency, voltage profile measurements and high power RF test have been done on a full size prototype resonator.

Fabrication of Prototype Resonator

Based on the electrical design by CST Microwave Studio, IUAC's first DTL tank is made of 845mm in diameter and 387 mm in length with 10 stems, two ridges and two end plates. All the solid modeling was done using Solid works and the design was verified for structural and cooling using Ansys12.0 software. The strategy we adopted was to fabricate the prototypes of all the DTL structures closest to the original design and validation by conducting various tests. If the tests give an acceptable result, then only we should proceed for the actual manufacturing of the parts on expensive copper material. So it was decided to prototype all the mechanical components and carry out the tests.

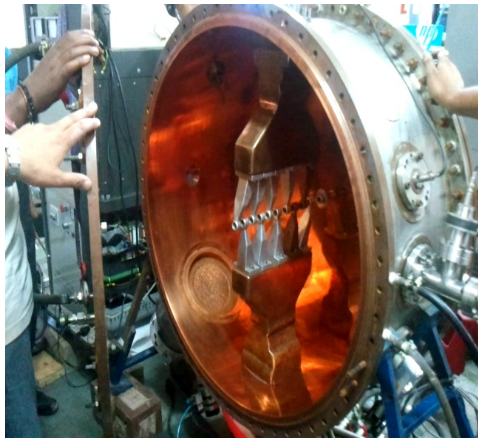


FIGURE 1. Prototype DTL resonator

RF TESTS ON PROTOTYPE DTL RESONATOR

Low Level RF Test

Information about the field distribution and mode orientation can be obtained by observing the coupling to E and H field components at various places in the cavity. This can be done by introducing perturbing objects of dielectric, ferrite or metal. Introduction of a dielectric object in a region of electric field produces a negative shift in the resonant frequency while introducing a metal object into a region of magnetic field causes a positive frequency shift. If both fields are present when a metal object is inserted the resulting frequency shift will depend on the relative strengths of the E and H fields. Small objects pulled through the cavity on a string can be used to map the field distributions of the modes. It has been shown by Slater and others [3], that the change in resonant frequency upon introducing a dielectric bead into the cavity field is given as in Eq. 1.

$$\frac{\Delta\omega}{\omega} = -\frac{\pi r^3}{U}\left[\varepsilon_0 \frac{\varepsilon_r - 1}{\varepsilon_r + 2} E_0^2\right] \tag{1}$$

Prototype cavity was aligned and bead pull measurements were done along the bean axis. Sapphire bead (ε_r ~ 13.2) of 3 mm diameter was used for this experiment. Experimental data were analyzed and axial electric field profile was plotted.

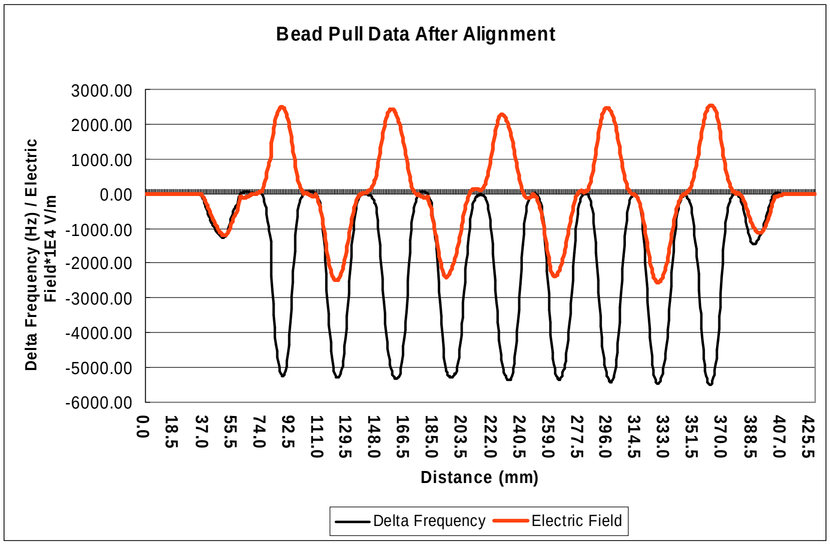


FIGURE 2. Axial Electric Field Profile of Prototype DTL resonator using Beadpull Technique

High Power RF Test

Resonator was assembled and a water cooled power RF coupler was installed. 10 kW RF amplifier was used to power the resonator. Coupler was optimized using network analyzer. We maintained the vacuum better than 5X10^{-5} torr. After initial conditioning at ~20 Watts for 18-20 hrs, we could jack up the power at high ramp rate. We observed multipactoring at around 60 - 70 watts input power. Resonator was tested upto 6 kW input power for about 100 hours.

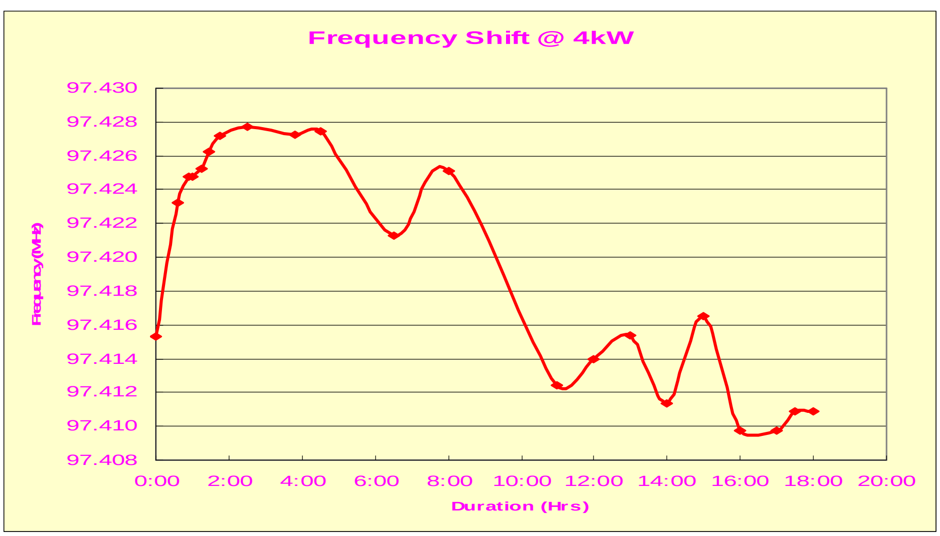
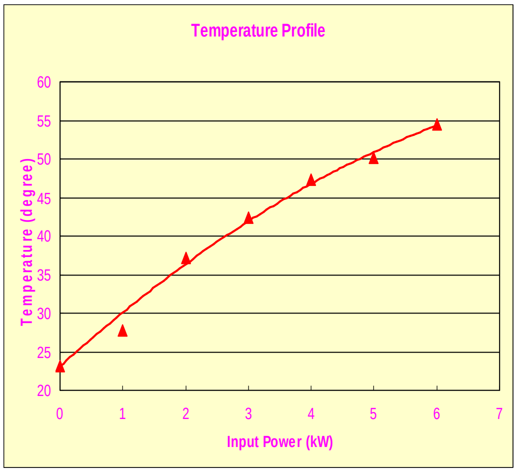
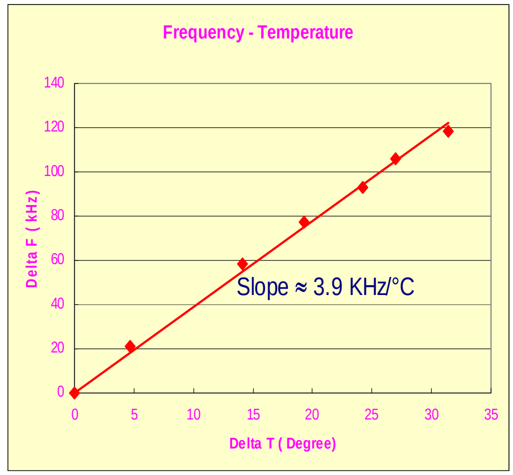


FIGURE 3. Frequency variation with time at 4 kW input power

Frequency and temperature variation has been measured. Temperature was measured on the outer tank where ridge base is assembled. These tests have validated the complete resonator design parameters, power coupler and efficiency of water cooling.





(a) (b)

FIGURE 3. (a) Temperature profile of ridge with increasing input power and (b) change in resonance frequency with change in temperature of ridge.

CONCLUSION

Complete design validation has been done on a full scale prototype resonator. Low level RF tests using bead pull technique were carried out. These tests validated the design frequency and electric field profile along the beam axis. High power RF tests have also been completed successfully. Prototype has been tested upto 6 kW input power. These tests have validated the complete resonator design parameters,

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