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Radial Re-Entrant Gridded Input Resonant Cavity For UHF Band Inductive Output Tubes

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I Introduction

The Inductive Output Tube (IOT)is a vacuum electron tube which is capable of amplifying RF power with high efficiency. It is popularly used as high power source in communication transmitters and particle accelerators operating at ultra-high frequency (UHF) band [1]. The schematic of IOT is shown in Figure 1 [2]. The major assemblies are the electron gun, two resonant cavities (input and output), input and output couplers, collector and focusing magnet.

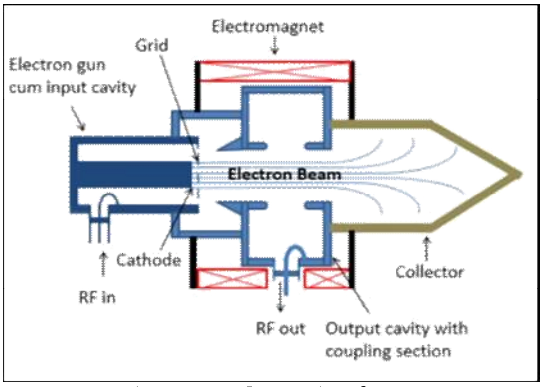

Figure 1.Schematic of IOT

In IOT, a gridded electron gun is used to emit electron beam of desired specifications. The RF drive signal is applied between cathode and grid. The electron beam is thus velocity modulated within the gun itself. A negative DC bias voltage relative to cathode potential is applied to the grid. It shuts off the electrons whenever there is no drive signal present. The velocity and density-modulated beam is further accelerated through an aperture in the grounded anode towards the output section by the influence of DC beam voltage applied at the anode. Amplified output power is extracted via an output system. Focusing of electron beam is desirable to overcome the natural tendency of the beam to spread. It also facilitates the passage of beam through the anode aperture with minimum interception leading no harm to the device's efficiency. The electron beam is dissipated in a copper collector of traditional design, either air cooled or liquid cooled, depending on the power level involved.

The paper discusses the design and development of input resonant cavity which is the most critical part of an IOT. The RF cavities are the key components responsible for proper beam modulation and efficient RF amplification. In IOT, the input cavity is integrated with the electron gun to produce the pre-bunched beam from the input section. The interaction gap for electron beam and input RF is the cathode-grid gap while the input RF signal is applied at the coaxial gap between the inner and outer conductor.

II. Design approach of radial-reentrant input cavity

The radial re-entrant cavities have the general shape of flat pillboxes with the center post. The schematic of a radial re-entrant cavity is shown in Figure 2. In such cavities, the radial distance between the inner and outer walls is larger than the height of the cavity (r_1 - r_0> h).

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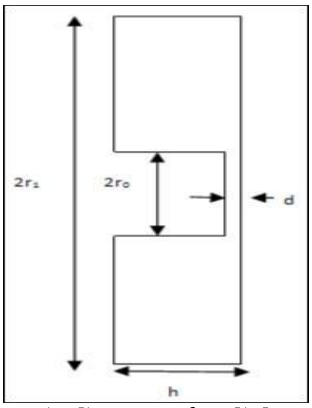

Figure 2. Schematic diagram of radial re-entrant cavity

The inductance and capacitance of a general radial re-entrant cavity structure can be calculated using mathematical relations given in Fujisawa's paper [3].The radial re-entrant cavity operating at UHF frequency i.e. 350 MHz here has been designed in SUPERFISH codeshown in Figure 3. The electric field profile obtained from SUPERFISH is shown in Figure 4. It shows the maximum electric field lies in the narrow gap (extreme left; drawn in red color).

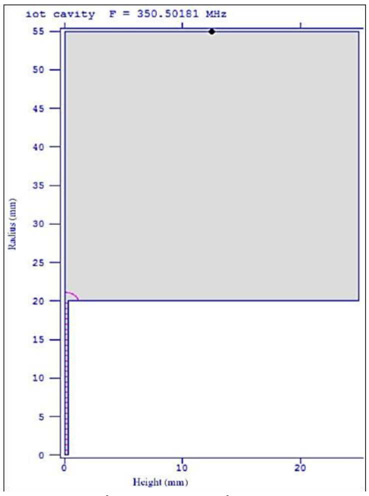

Figure 3. Radial re-entrant cavity resonating at 350.50 MHz in SUPERFISH

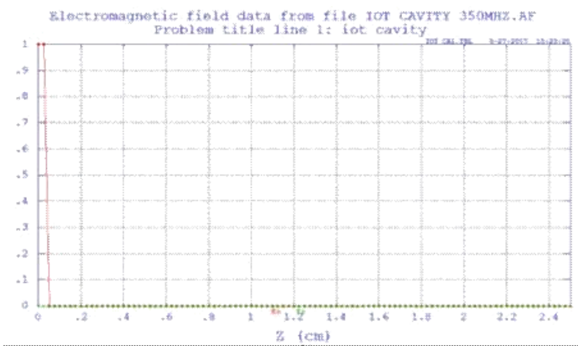

Figure 4. Plot of E field in the gap and with respect to height of cavity

III. Integration of input cavity and gun

Practically, the input cavity will be integrated with the electron gun as shown in Figure 5 and hence, for supporting the grid, the BFE should be connected to it. As the grid has a DC bias voltage, for connecting them together, they must be short and so, having the same potential [4].

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In Figure 5, the tapered (conical) endplate at BFE angle i.e. 67º which is already simulated in electron gun design for this IOT has a grid centered in it [5]. This is the most practical realization of the IOT input cavity. The cavity has been designed and developed to check the performance of the integrated cavity-grid structure. The full assembly has been designed in CST microwave studio and the corresponding field pattern obtained in CST is shown in Figure 6. The electric field distribution is shown which is concentrated at the gap and is parallel to the axis of cavity. The resonant frequency from Eigen-mode analysis of the cavity combined with grid comes out to be 358 MHz.

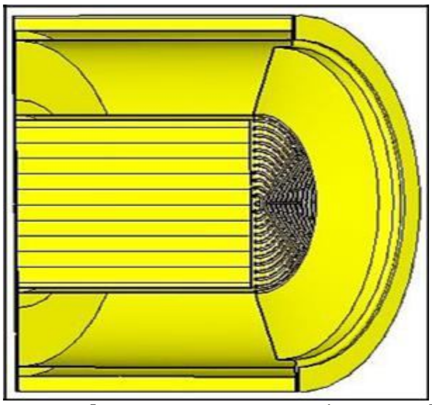

Figure 5. Electron gun-cum-cavity assembly

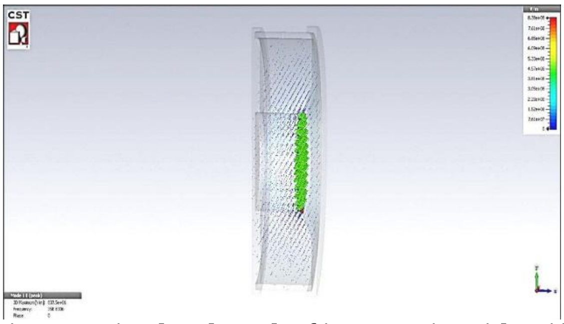

Figure 6. Simulated result of input cavity with grid

This cavity assembly has been developed from aluminum material having one solid inner conductor, one hollow outer conductor, one cylindrical endplate, one conical endplate with grid attached at the center of it and a loop coupler as shown in the Figure 7.

Figure 7. Fabricated cavity assembly

IV. Results and Discussions

The cathode-grid interaction gap is maintained at 0.56 mm keeping breakdown issues into account and the RF characterization of this assembly gives the resonant frequency at 369.5 MHz as shown in the plot of Vector Network Analyzer (VNA) (Figure 8).The results obtained from the simulation and measurement are compared in Table 1 explaining the obtained resonant frequency of the reentrant cavity with tapered endplate at BFE angle and grid at 0.56 mm gap.

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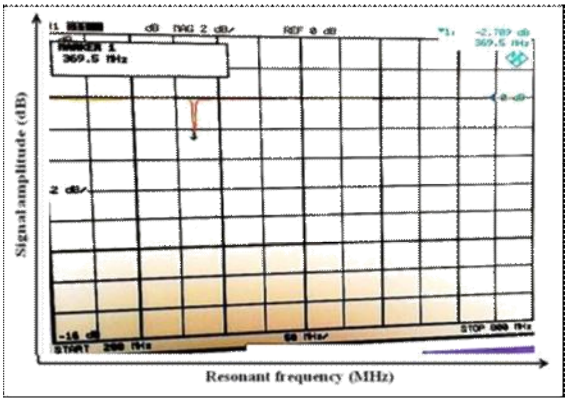

Figure 8. VNA plot showing resonant frequency in cavity

Table 1. Resonant frequency of tapered BFE angle cavity with grid in simulation and measurement

Resonant frequency	**Simulated (CST)**	**Measured (VNA)**
	358 MHz	369.5 MHz

V. Conclusion

A study of coaxial and radial reentrant cavities has been carried out initially to bring out the better structure to be used and it is concluded that radial reentrant structure is more promising to use as an input cavity for UHF IOT with the TM_{010} resonating mode. The field distribution in this type of cavity is very dominant and is desirable.

As a radial cavity is more in diameter and lesser in height, it makes it easier to conjoin it with cathode and grid of electron gun which is the ultimate practical input cavity deployed in IOTs.

Hence, this cavity design is suitable for an IOT operating in UHF range.

VI. References

[1] Geoffrey T Clayworth et al., “The IOT-A new, environmentally-friendly tube for UHF television transmitters”, International Broadcasting Convention, 1992, pp. 45 – 50.

[2] Meenu Kaushik, LM Joshi, “Inductive Output Tube: A promising microwave source for high power applications”, International Journal of Electronics & Communication Technology (IJECT), Vol. 6, Issue 1, Spl- 1 Jan- March 2015.

[3] K, Fujisawa, “General treatment of klystron resonant cavities”, IRE Trans. Microw. Theory Tech., vol. MTT-6, no. 10, 1958, pp. 344-358.

[4] Meenu Kaushik, Ayan Kumar Bandyopadhyay and LM Joshi, “ RF design of output resonator and conjoined input cavity with gridded electron gun for UHF inductive output tube”, Second National Conference on Recent Developments in Electronics (NCRDE-2017), University of Delhi south campus, pp 48-51, February 17-18, 2017.

[5] Meenu Kaushik and LM Joshi, “Design of spherical electron gun for ultra high frequency, CW power Inductive Output Tube”, AIP Proceedings, 2nd International Conference on Communication Systems (ICCS-2015), BKBIET, Pilani, October 18-20, 2015.