Review of Development of More Power Microwave Tubes

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Introduction

Reltron has characteristics comparable to klystron. They use same mechanism for beam bunch by the utilizing modulating cavity along with conversion of beam bunches to microwave by using an extraction cavity.

- Reltron does not necessitate outer magnetic field for guiding beam. Here beam suffers velocity modulation two times in cavity while in klystron beam is velocity modulated only one time.
- Within klystron, bunched beam drift in extraction cavity, while in reltron, beam bunches are post-accelerated.

Reltron is planned for elevated power microwave source. Speed controlling the and isolating the constant column into packs, and the bar groups are post-stimulated as they leave the changing depression. The bar that enters the modifying discouragement is non-relativistic. In the post-speeding up gap, groups get revived to relativistic rates.

Electron over whelming occurs in post acceleration gap as the faster electron accelerates subsequent time by quasi electric fields in post acceleration hole. The output is taken out from beam bunches as they enters extraction cavity, causes bunches to sluggish down previous to they are absorbed by beam collector.
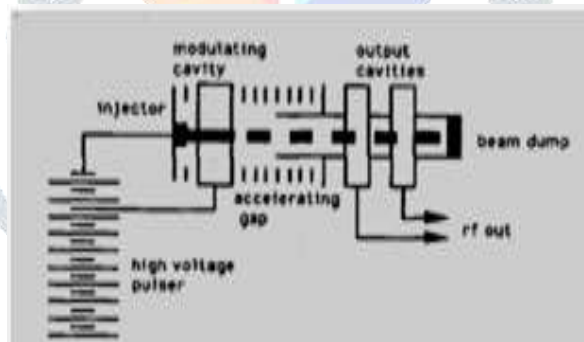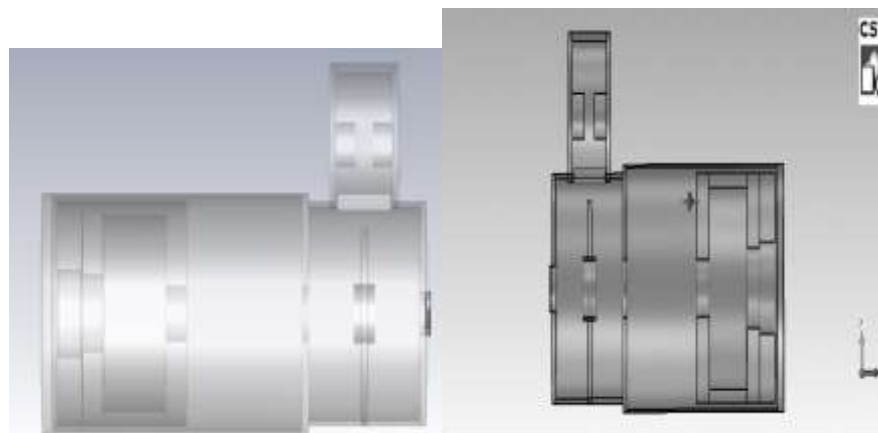

Fig. Schematic diagram of Super-Reltron tube

Fig:2Reltron design   **Fig:3 Accelerating cavity and bunching cavity**

It consists

- ➢ **Modulating Cavity**
- ➢ **Accelerating Gap**
- ➢ **Extraction Cavity**

Modulating Cavity:

It is a three pit segment of side couple, Behave like TTO (travel time oscillator). It comprises of two round and hollow pillbox pits (Two TTO's), couple to a transitional cavity by attractive opening. So it is a splitted depression which taking a shot at guideline of TTO.

Working of splitted modulating cavity:

SCO converts the large area steady electron beam into a highly density modulated beam by self-exited electromagnetic field.
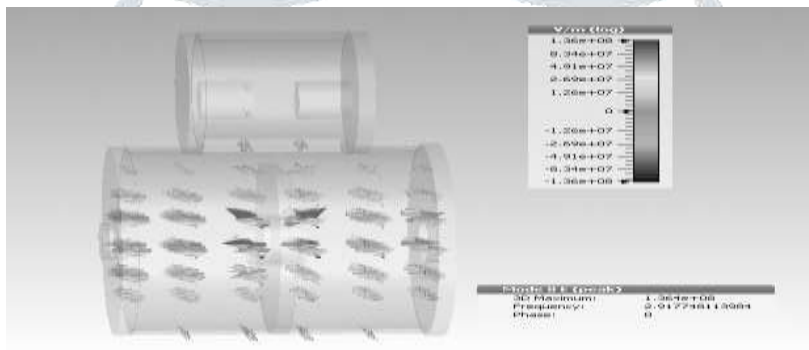

Fig: 4 Electric field distribution

We can calculate the change in kinetic energy when electrons enter and exit the cavity.

Kinetic energy of electron can be calculated by calculating the velocity and displacement through the first gap to second gap.

Velocity can be calculated by integrating the equation of motion.

Equation of motion:

$$m_e \frac{dv}{dt} = -q_e E_o \sin(\omega t + \theta)$$

By integrating the above equation

We get,

$$v(t, \theta) = v_o + \frac{q_e E_o}{m_e \omega} (\cos(\omega t + \theta) - \cos \theta)$$

Displacement can be calculated by the integrating the velocity equation.

$$z(t,\theta) = v_o t + \frac{q_e E_o}{m_e \omega}(\sin(\omega t + \theta) - \sin\theta - \omega t\cos\theta)$$

Above equation can calculate the K.E inside the first gap, by changing the magnitude of electric field from +ve to –ve. We can calculate change in velocity and displacement in second gap also.
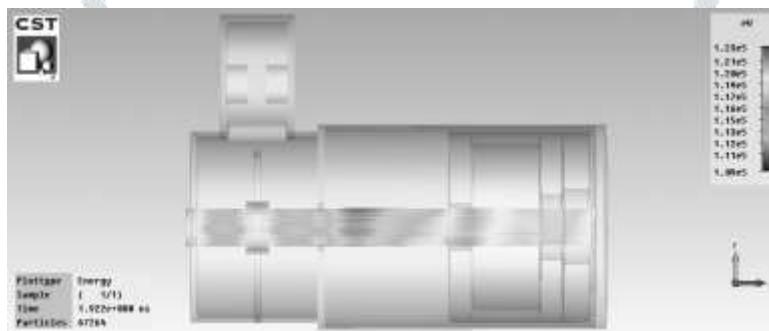
$$v(t,\tilde{t},v,\theta) = v - \frac{q_e E_o}{m_o \omega}(\cos(\omega t + \theta) - \cos\theta$$

Acceleration gap

The gap of after acceleration increases the velocity of beam which bunches second time before they penetrate   extraction cavity. This minimizes spread of electron's velocity.
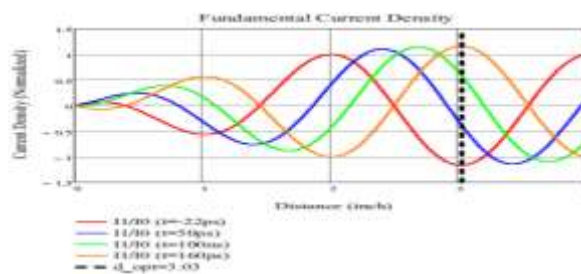
After electrons depart   modulating cavity, bunching in the ballistic condition takes place.

The electron K.E. is equal to the potential energy.

Fig:5 Accelerating beam from cathode to collector

$$\frac{1}{2}m_e v^2 = q_e(V_{AK} + V_{post}) + q_e M V_{gap}\sin(\omega t)$$

$$= q_e V_{beam} + q_e M V_{gap}\sin(\omega t)$$

$$= \frac{1}{2}m_e v^2{}_0 + q_e M V_{gap}\sin(\omega t),$$

Graph of normalized current density as a function of distance.

$$v(t) = v_o \sqrt{1 + \frac{MV_{gap}}{V_{beam}} \sin(\omega t)}$$

$$\approx v_o \left[1 + \frac{MV_{gap}}{2V_{beam}} \sin(\omega t) \right],$$

Above plot shows fundamental modulating current as it propagate through the longitudinal space.

Extraction Cavity

Microwave are removed from the pillar packs as they enters the extraction cavity. Each bundle of electrons turns into the source current that produce the EM waves.Extraction of Output power is depends upon the quality factor (Q) of the cavity. As the output cavity can be modeled as a parallel R-L-C circuit, where beam is the current source.

The magnitude of the impedance and the phase angle of impedance are

$$Z/R = \left[1 + Q^2 (\mu - \mu^{-1})^2 \right]^{-1/2}$$
$$\delta = \tan^{-1} \left[Q(\mu - \mu^{-1}) \right]$$

We can see the impedance and the stage edge are relies on the quality factor (Q) and reverberating recurrence of the cavity.

In hole the most extreme voltage is created when the shaft adjustment recurrence is equivalent to the cavity thunderous recurrence, and the hindering voltage happens simultaneously as the pinnacle current.

To look at the significance of value factor for removing the yield control, we need to inspect the net vitality lost by the pillar molecule over a swaying period as the capacity of electrical field quality parameter φ .

$$\varphi = \frac{eE_o a}{total voltage(KeV)}$$
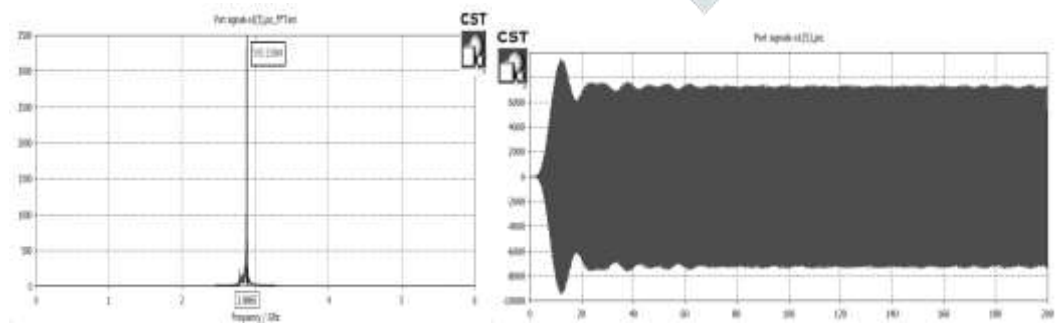
Fig: Operating Frequency and Output Power

Conclusion

Reltron is designed for elevated power high frequency resource which velocity modulates an electron beam in its modulating cavity.

References

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