16ECT72 - RF AND MICROWAVE ENGINEERING

Unit IV – Microwave Tubes and Measurements

Reflex Klystron

Course Handling Faculty

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Course Outcome 4

CO4	Explain the operation of Microwave Tubes and Measuring Techniques

Learning Outcome 1

LO1	Explain the operation of Microwave Tubes

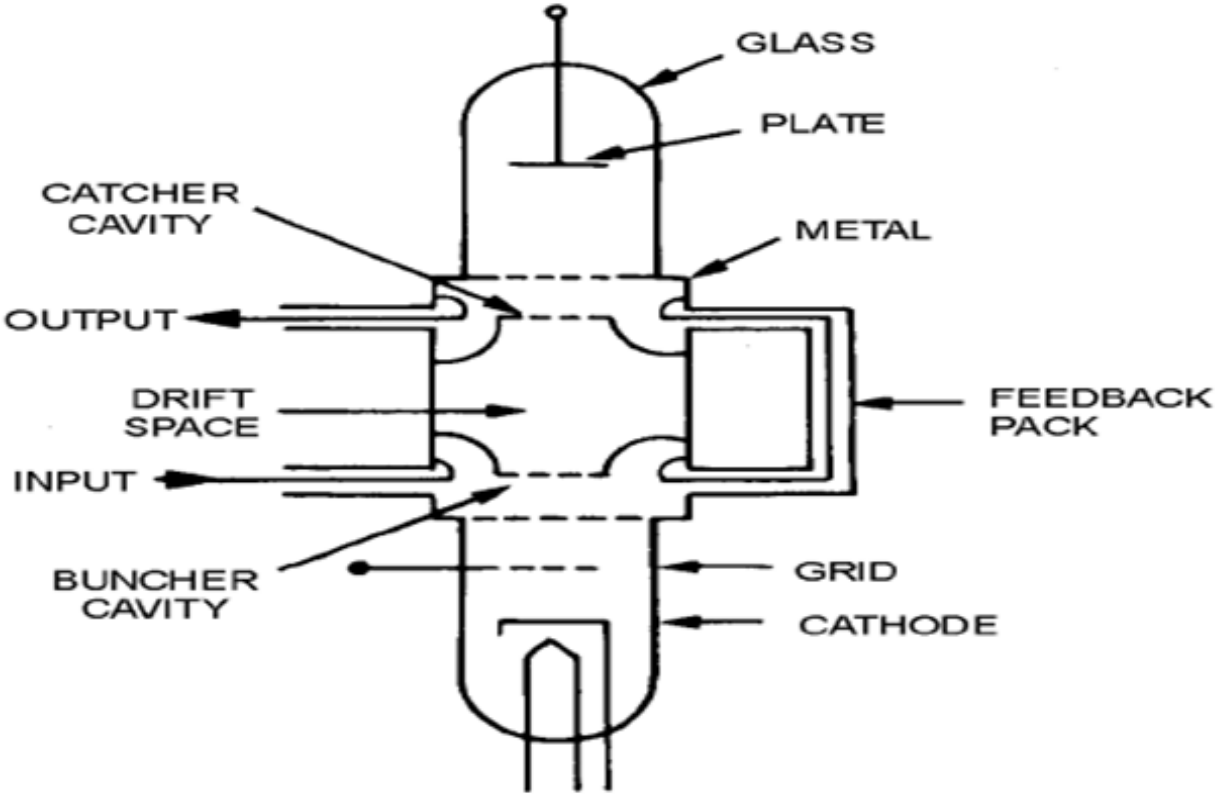
Klystron

- Klystron is a vacuum tube that can be used either as a generator or as an amplifier of power, at microwave frequencies.
- Two basic configurations of klystron tubes are,
  - ✓ Two (Multi) cavity klystron – low power microwave amplifier
  - ✓ Reflex Klystron – low power microwave oscillator

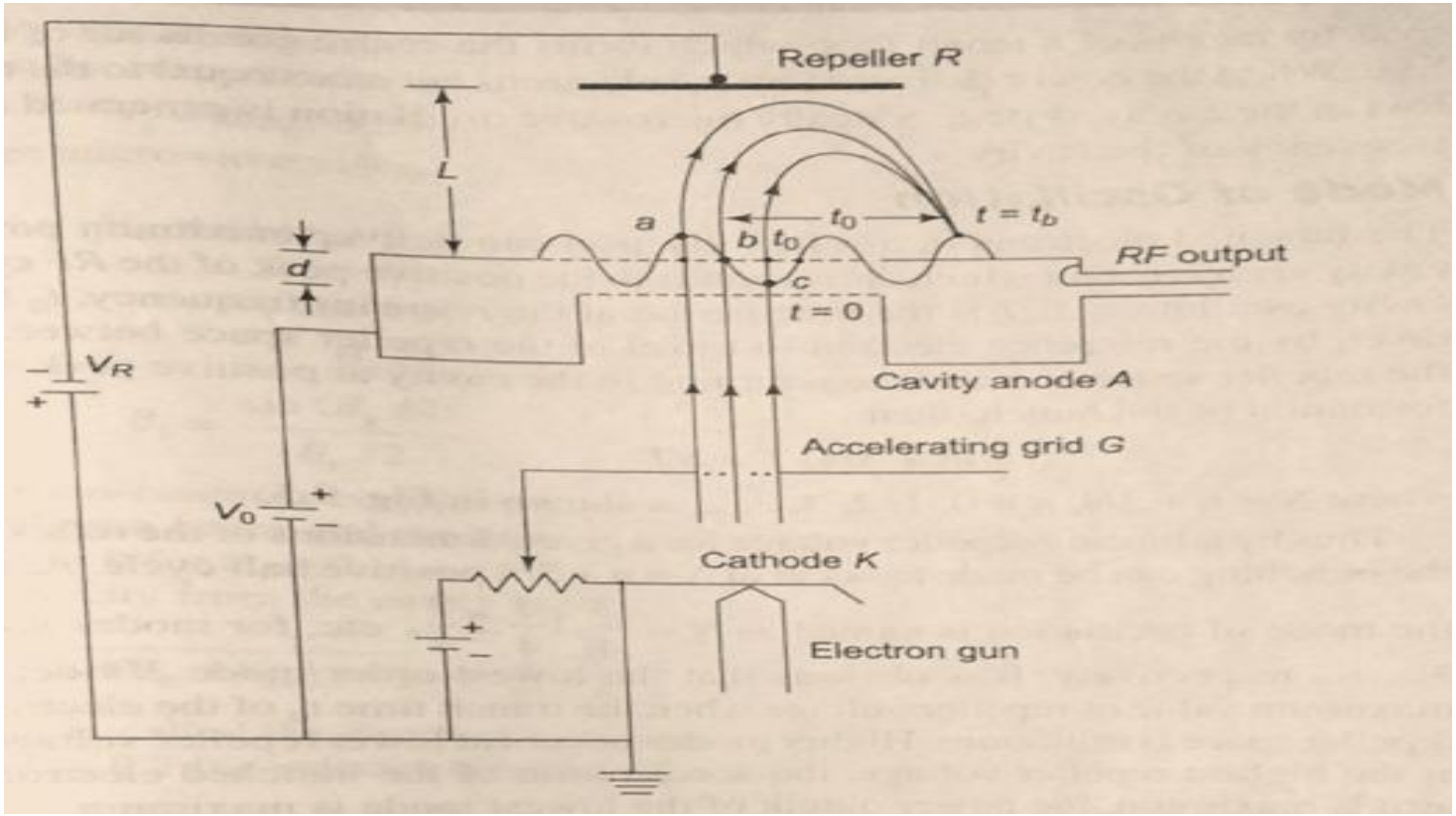
Reflex Klystron

- The reflex klystron has been the most used source of microwave power in laboratory applications.

Functional and Schematic Diagram



Reflex Klystron - Operation



Reflex Klystron - Construction

- A reflex klystron consists of an electron gun, a cavity with a pair of grids and a repeller plate as shown in the above diagram.
- In this klystron, a single pair of grids does the functions of both the buncher and the catcher grids.
- The main difference between two cavity reflex klystron amplifier and reflex klystron is that the output cavity is omitted in reflex klystron and the repeller or reflector electrode, placed a very short distance from the single cavity, replaces the collector electrode.

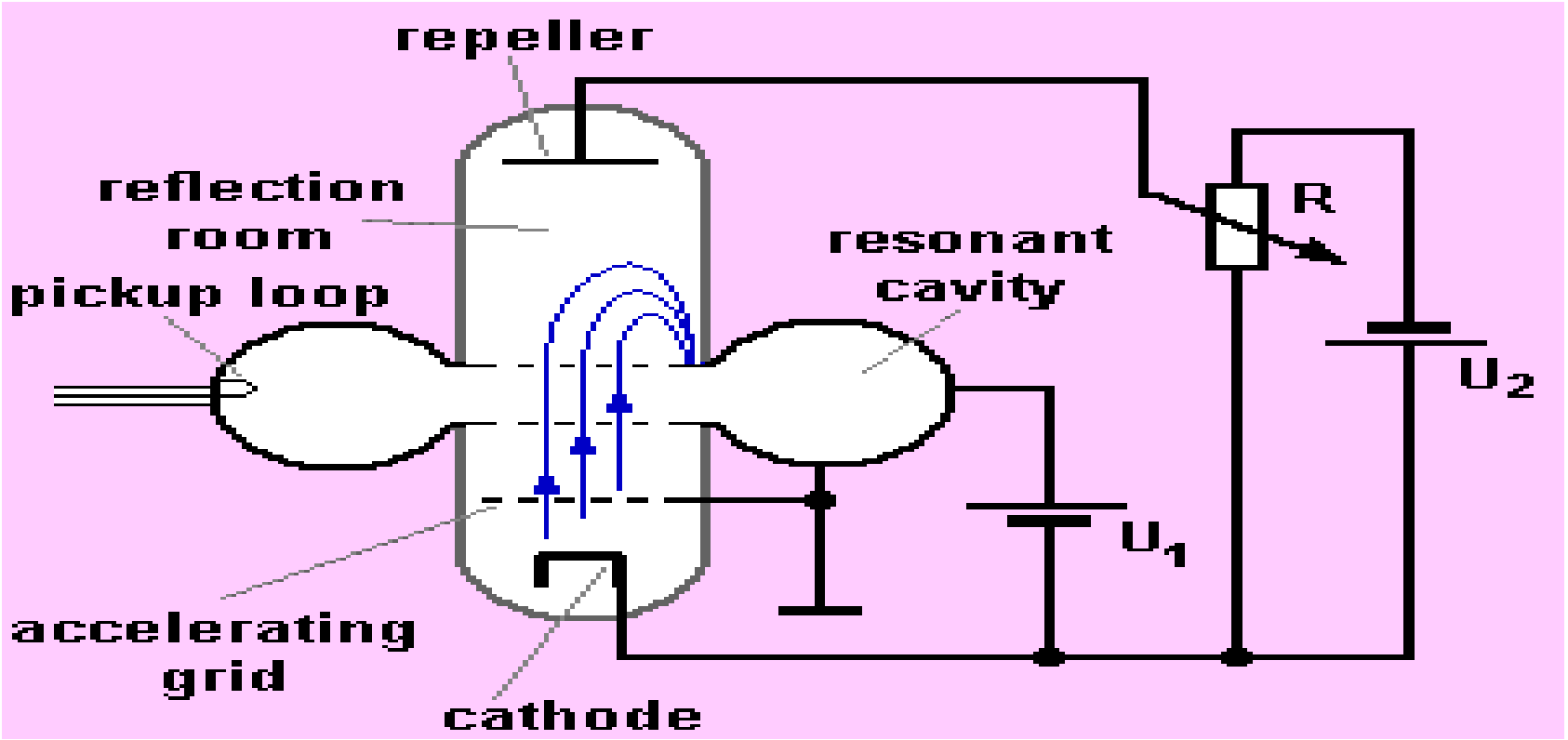
Reflex Klystron - Working

- The cathode emits electrons which are accelerated forward by an accelerating grid with a positive voltage on it and focused into a narrow beam.
- The electrons pass through the cavity and undergo velocity modulation, which produces electron bunching and the beam is repelled back by a repeller plate kept at a negative potential with respect to the cathode.

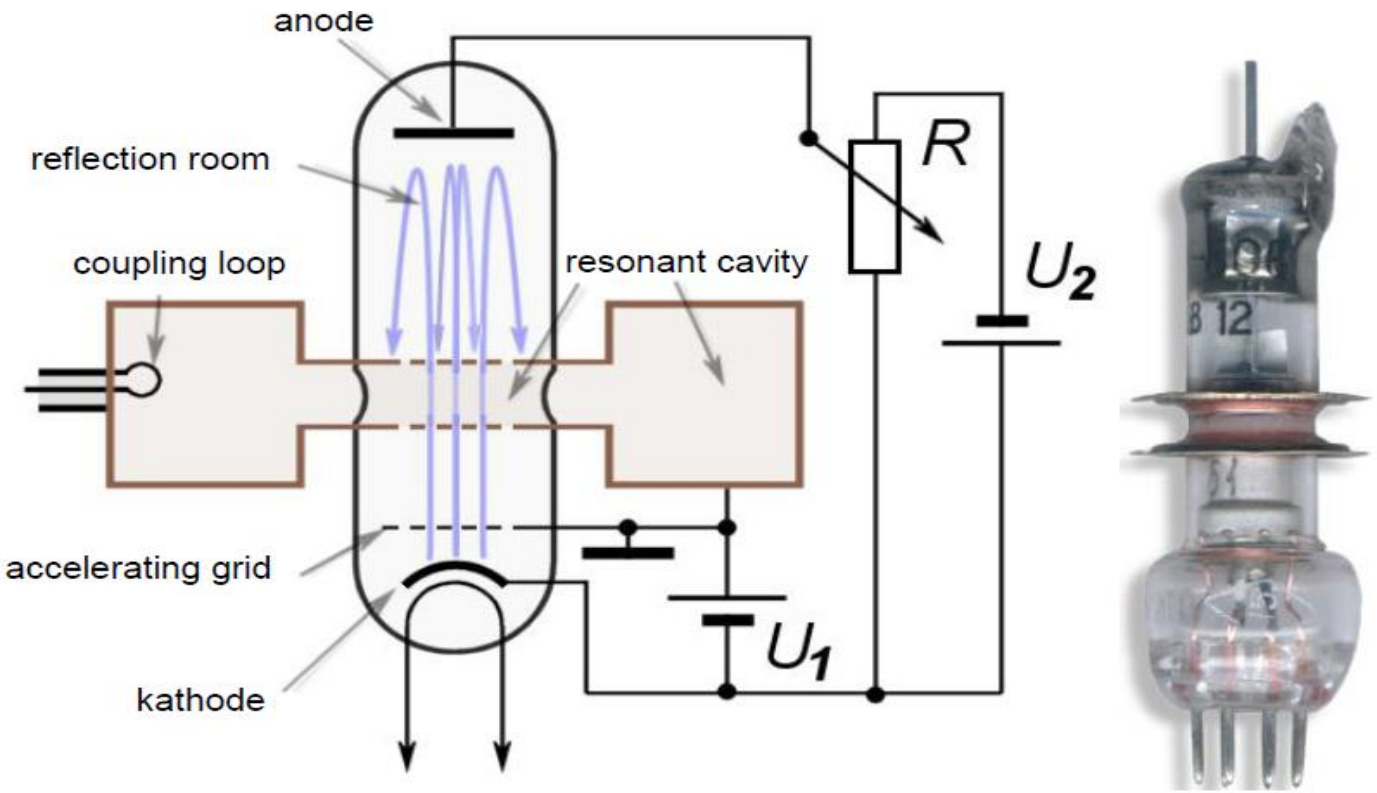
Reflex Klystron - Working

- On return, the electron beam once again enters the same grids which act as a buncher, thereby the same pair of grids acts simultaneously as a buncher for the forward moving electron and as a catcher for the returning beam.

Reflex Klystron oscillator



Reflex Klystron oscillator



Working

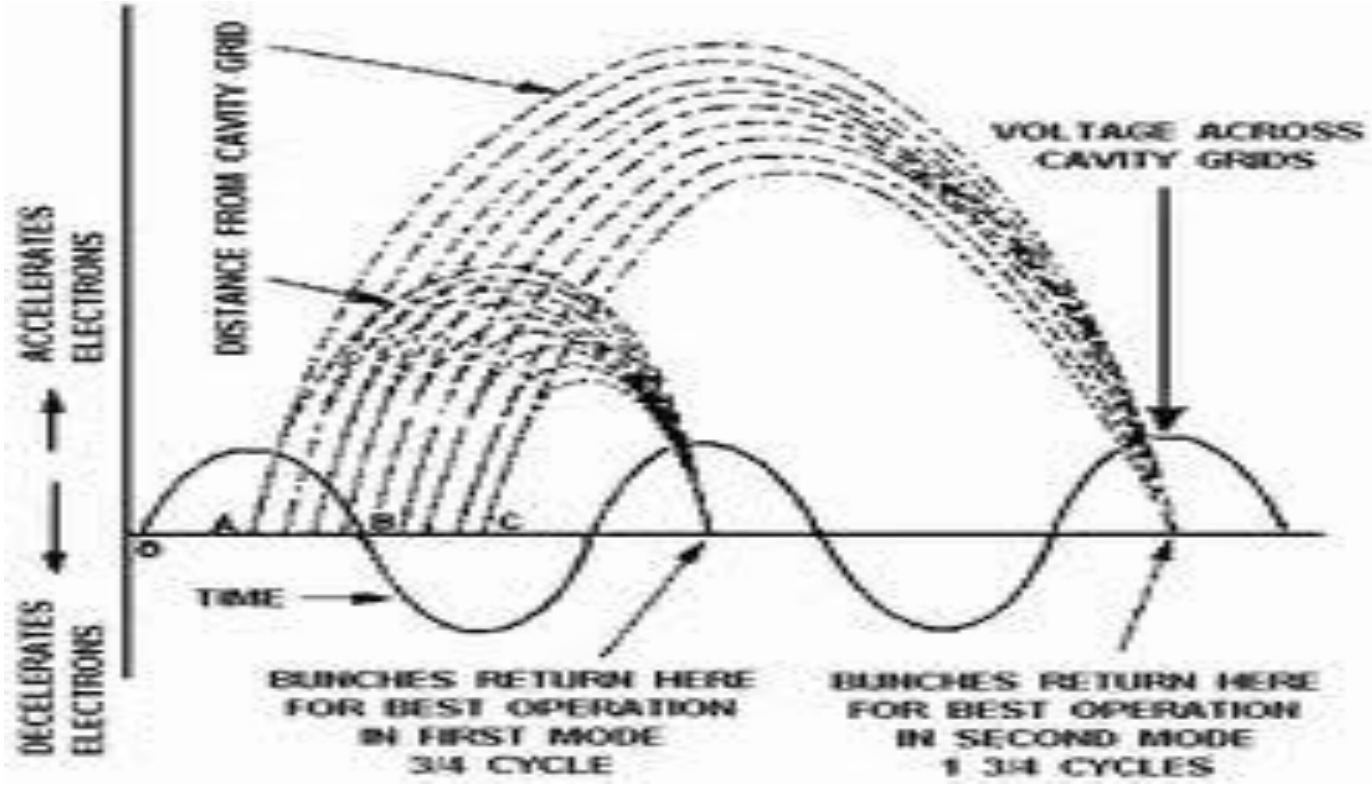
- The feedback necessary for electrical oscillations is developed by reflecting the electron beam, the velocity modulated electron beam does not actually reach the repeller plate, but is repelled back by the negative voltage.
- The point at which the electron beam is turned back can be varied by adjusting the repeller voltage.
- Thus the repeller voltage is so adjusted that complete bunching of the electrons takes place at the catcher grids, the distance between the repeller and the cavity is chosen such that the repeller electron bunches will reach the cavity at proper time to be in synchronization.
- Due to this, they deliver energy to the cavity, the result is the oscillation at the cavity producing RF frequency.

Mode of Oscillation

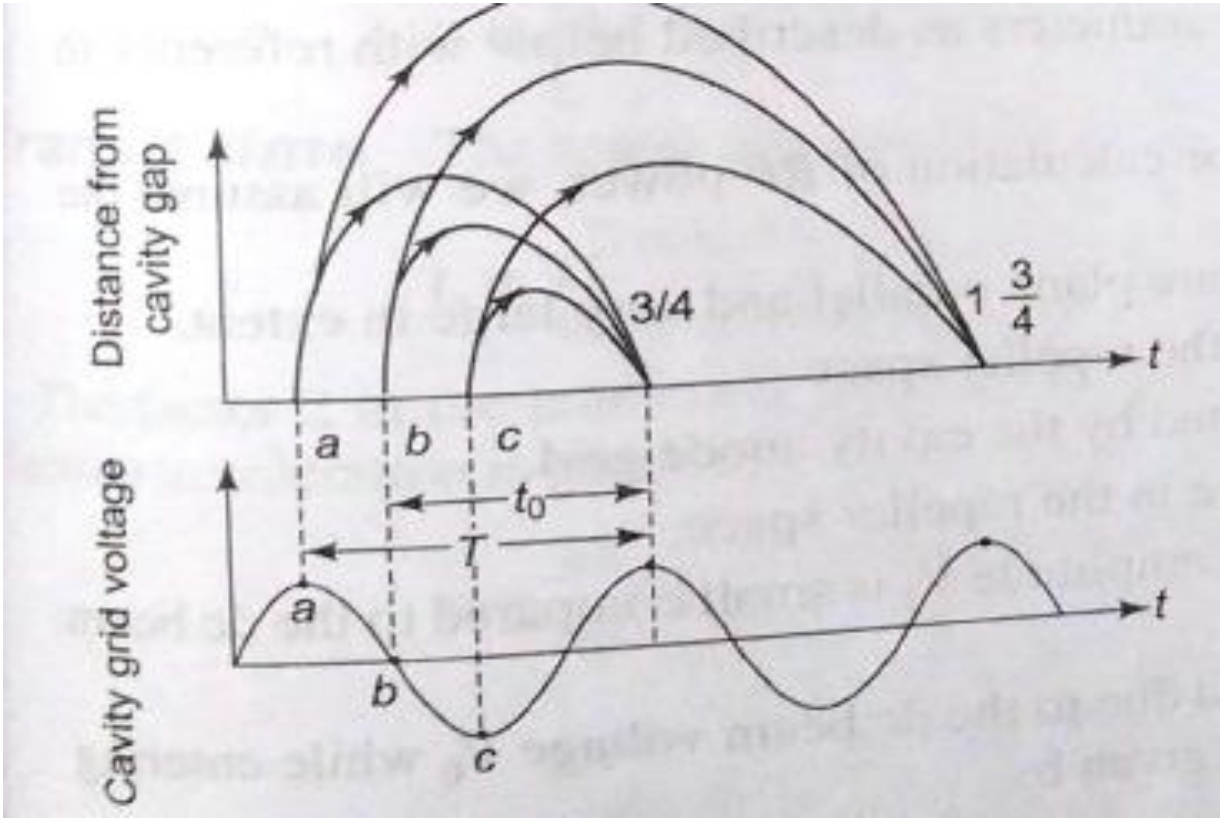
- The electrons should return after 1¾, 2 ¾ or 3 ¾ cycles – most optimum departure time.
- If **T is the time period at the resonant frequency**, t_o is the time taken by the reference electron to travel in the repeller space between entering the repeller space and returning to the cavity at positive peak voltage on formation of the bunch.
- Then, $t_o = (n + ¾)T = NT$, where $N = n + ¾$, $n = 0,1,2,3\ldots\ldots$

N – mode of oscillation

Reflex Klystron Modes



Reflex Klystron Modes



Performance Characteristics

1. Frequency: 4 – 200 GHz
2. Power: 1 mW – 2.5 W
3. Theoretical efficiency : 22.78 %
4. Practical efficiency : 10 % - 20 %
5. Tuning range : 5 GHz at 2 W – 30 GHz at 10 mW

Power output and Efficiency

- The power output of a reflex klystron is maximum if the bunched electrons on return cross the cavity gap field is positive maximum.
- The RF power delivered to the cavity is, $P_{RF} = 0.3986\, I_0 V_0 / N$

where,

I_0 - Beam current,

V_0 - DC beam voltage and

N- mode of oscillation

Power output and Efficiency

- It was practically proven that it was not possible to get ¾ mode in reflex klystron, so that N=1 ¾ mode leads to maximum RF power output and Efficiency

$$P_{RF} = 0.3986 \frac{I_0 V_0}{N} = 0.3986 \frac{I_0 V_0}{1\frac{3}{4}} = 0.227\, I_0 V_0$$

$$\eta_{max} = 22.7\%$$

- The repeller voltage, $|V_R| = 6.74 \times 10^{-6} \times f \times \frac{L\sqrt{V_0}}{N} - V_0$

where, L – repeller space, f – operating frequency, N- mode of oscillation and

V_0-beam voltage

Applications

The reflex klystrons are used in

1. Radar receivers
2. Local oscillator in microwave receivers
3. Signal source in microwave generator of variable frequency
4. Portable microwave links
5. Pump oscillator in parametric amplifier

References:

- Liao, S.Y., “Microwave Devices and Circuits”, Prentice Hall of India, 2006
- Annapurna Das and Sisir K Das, “Microwave Engineering”, Tata McGraw Hill Inc., 2009
- David M Pozar, “Microwave Engineering”, 3rd Edition John Wiley and Sons, Inc., 2005

Web References:

- ✓ https://electronicsdesk.com/reflex-klystron.html
- ✓ https://youtu.be/3MFHFuddLZI
- ✓ https://youtu.be/frY9ojmgh4o

THANK YOU...