Department of Electronics & Telecommunication Engineering

CLASS: B.E. E &TC VIII **SUBJECT: RMT**
EXPT. NO.: 3 **DATE:29/10/2020**
Roll No.: 42428

TITLE: To measure and plot mode characteristics of reflex klystron.

OBJECTIVE: 1. To study the characteristics of the reflex Klystron tube

2. To determine the it's electronic tuning range and Sensitivity

EQUIPMENTS:-

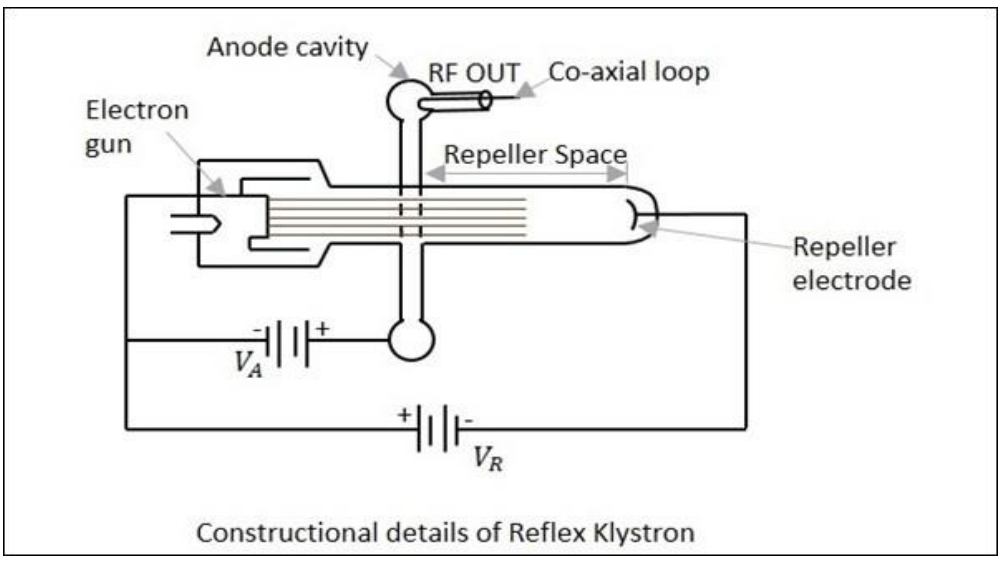
1. Klystron Power Supply
2. Klystron with mount
3. Cooling Fan
4. Isolator
5. Variable Attenuator
6. Frequency meter
7. X-Band detector
8. BNC-to-BNC cable
9. Oscilloscope

THEORY:

In the reflex klystron (also known as a 'Sutton' klystron after its inventor, Robert Sutton), the electron beam passes through a single resonant cavity. The electrons are fired into one end of the tube by an electron gun. After passing through the resonant cavity they are reflected by a negatively charged reflector electrode for another pass through the cavity, where they are then collected. The electron beam is velocity modulated when it first passes through the cavity. The formation of electron bunches takes place in the drift space

between the reflector and the cavity. The voltage on the reflector must be adjusted so that the bunching is at a maximum as the electron beam re-enters the resonant cavity, thus ensuring a maximum of energy is transferred from the electron beam to the RF oscillations in the cavity. The voltage should always be switched on before providing the input to the reflex klystron as the whole function of the reflex klystron would be destroyed if the supply is provided after the input. The reflector voltage may be varied slightly from the optimum value, which results in some loss of output power, but also in a variation in frequency. This effect is used to good advantage for automatic frequency control in receivers, and in frequency modulation for transmitters. The level of modulation applied for transmission is small enough that the power output essentially remains constant. At regions far from the optimum voltage, no oscillations are obtained at all. This tube is called a reflex klystron because it repels the input supply or performs the opposite function of a klystron.

There are often several regions of reflector voltage where the reflex klystron will oscillate; these are referred to as modes. The electronic tuning range of the reflex klystron is usually referred to as the variation in frequency between half power points—the points in the oscillating mode where the power output is half the maximum output in the mode. The frequency of oscillation is dependent on the reflector voltage, and varying this provides a crude method of frequency modulating the oscillation frequency, albeit with accompanying amplitude modulation as well.



Constructional details of Reflex Klystron

PROCEDURE:

Power Supply Setting:

1. Connect the 3-pin main power cord provided with instrument to the socket located at back panel of the instrument.
2. Check the power point of the lab, there should be proper earthing of mains connection.
3. Connect the power cord to the main socket and switch 'ON' the instrument keeping meter switch at 'V' position and switch ON the H.T. supply.
4. Rotate the beam voltage knob and observe the voltage variation at the meter, it should vary from 200 V to 450V approx.
5. Put the meter switch to Reflector Voltage position variation in the meter with the help of reflector knob, it should vary from -10V to -270V approx.
6. Make sure H.T. switch should be at "OFF" position and put 'OFF' the main power switch.
7. It shows instrument is working satisfactorily.

Operating Procedure for power supply:

1. Connect the Klystron Mount to output socket of power supply.
2. Keep the beam voltage knob fully anti-clockwise position.
3. Keep the reflector voltage knob fully clockwise position.
4. Keep the H.T. switch at 'OFF'position.
5. **H.T. switch should be ON after warm up of klystron tube by switching ON PWR**.

Points to be remember always

1. **During operation of klystron, repeller does not carry any current and as such it may severely be damaged by electron bombardment. To protect repeller from such damage, the repeller negative voltage is always applied before anode voltage. Further,**

while modulating, repeller should never become positive with respect to the cavity. Also the repeller voltage should be varied in one direction only to avoid hysteresis in klystrons.

2. The heater voltage should be applied first and cooling should be provided simultaneously. After some time other voltages should be applied taking above precaution.
3. While measuring power, the frequency meter should be detuned each time because there is a dip in the output power when frequency meter is tuned.
4. To avoid loading of klystron, an isolator or alternatively some 3 db pad or attenuator should invariably be used between klystron and rest the set up.

SETUP_DIAGRAM:-

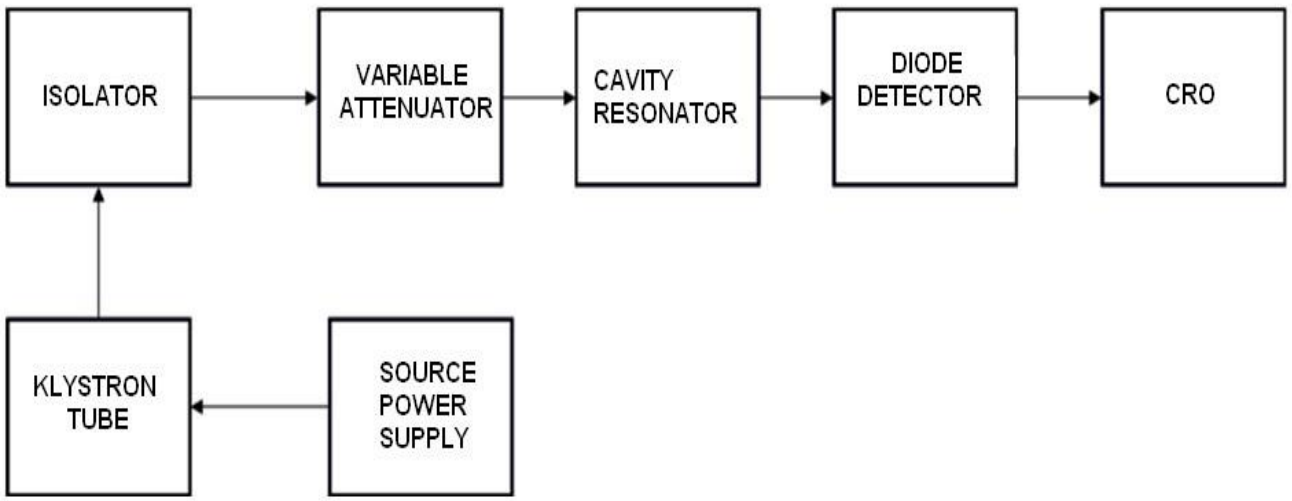


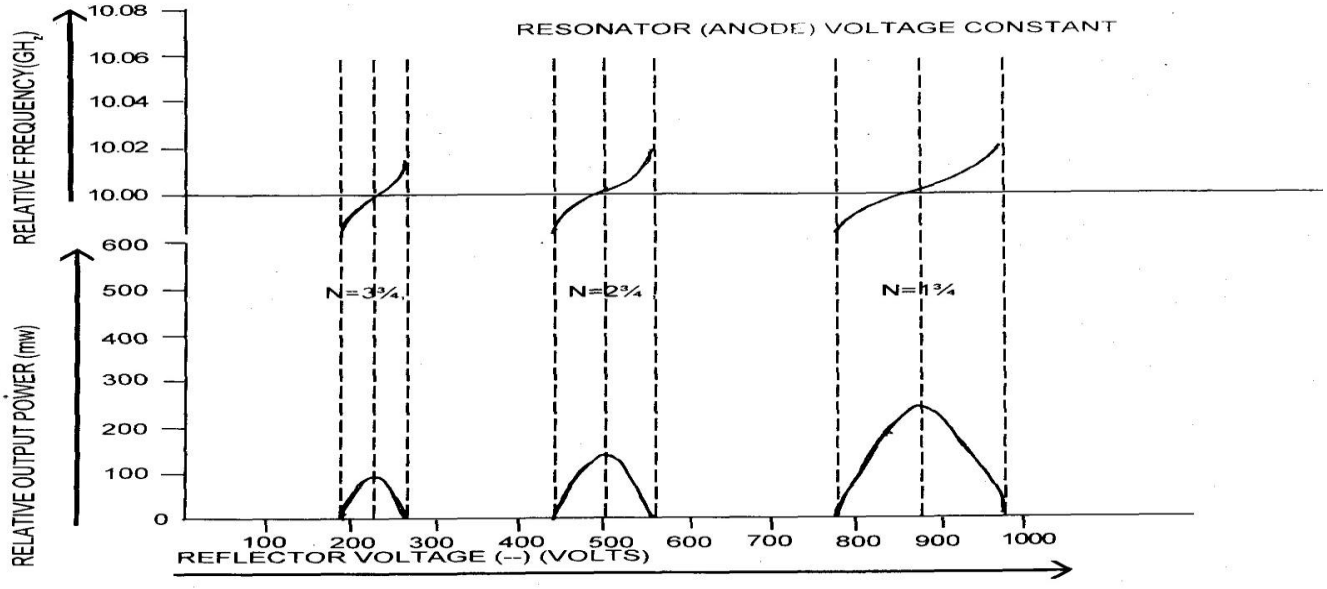
FIG1. Setup for Reflex Kylstron

PROCEDURE: CHARACTERISTICS OF REFLEX KLYSTRON

Square wave operation:

1. Connect the components and equipments as per set up
2. Set micrometer of variable attenuator around some position.
3. Set Mod selector switch to AM MOD position. Keep modulating frequency and amplitude knob somewhere at mid-position.
4. Beam voltage control knob to fully anticlockwise and reflector voltage control knob to fully clockwise and meter switch off position.
5. Rotate the knob of frequency meter at one side only.
6. Switch on the Klystron power supply, cooling fan and CRO.
7. Switch on the HT supply. Put on beam voltage switch and rotate the beam voltage knob clockwise slowly upto 250 V meter reading and observe beam current position, "The beam current should not increase more than 20 mA"
8. Change the reflector / repeller voltage and observe the maximum output. Tune the plunger of klystron mount ands detector for maximum output. Adjust AM modulating amplitude for undistorted output.
9. Note down output and frequency at this repeller voltage.
10. Read frequency on frequency meter: - rotate the knob of frequency meter slowly and stop at that position, where there is lowest output on CRO. Read directly the frequency meter between two horizontal line and vertical marker. If micrometer type frequency meter is used, read the micrometer reading and use the frequency chart.
11. Change the reflector voltage on both sides i.e. positive and negative side slightly and note down the output and frequency. His is one set of reading for one mode.
12. Repeat the steps from 8 to 11 by changing repeller voltage to observe different modes of klystron.
13. Plot the mode characteristics on a graph paper giving reflector voltage versus power output and frequency.

14. Calculate the mode number n for each mode.



SHOWS THE EFFECT OF REFLECTOR VOLTAGE ON BOTH THE LEVEL & THE FREQUENCY OF THE OUTPUT OF A REFLEX KLYSTRON.

OBSERVATION TABLE:-

Beam Current= 14mA

Beam Voltage= 240V

Sr.	Repeller Voltage (V)	Output Voltage (V)	Frequency (GHz)
1	-221	1.07	11.110
2	-210	2.14	11.075
3	-192	1.07	11.030
4	-171	1.05	11.105
5	-163	2.10	11.075
6	-158	1.05	11.065
7	-150	0.99	11.090
8	-146	1.98	11.075
9	-140	0.99	11.070

CALCULATIONS:-

i. Knowing mode top voltage of two adjacent modes, mode number of the modes may be computed from equation below:-

$$\frac{N_2}{N_1} = \frac{V_1}{V_2} = \frac{(n+1)+\frac{3}{4}}{n+\frac{3}{4}}$$

Mode number $N_n = n + ¾$

$N_1 = 2.723+0.75=3.473$
$N_2 = 2.723+1.75=4.473$
$N_3 = 2.723+2.75=5.473$

ii. Knowing mode number, transmit time of each mode may be calculated from equation below:

$$t_1 = \frac{n+\frac{3}{4}}{f_{01}} = \frac{N_1}{f_{01}} sec$$

$t_1 = 0.3135ns$
$t_2 = 0.4038ns$
$t_3 = 0.4941ns$

iii. Calculate electronic tuning range, i.e. the frequency band from one end of the mode to the another

ETR for $N_1 = 0.08GHz$
ETR for $N_2 = 0.04GHz$
ETR for $N_3 = 0.02GHz$

iv. ETS may be calculated from equation below:

$$ETS = \frac{f_2 - f_1}{V_2 - V_1} \; MHz/V$$

F_2 and F_1 being half power frequencies in GHz and V_2 and V_1 are corresponding voltage for a particular mode. [Note half power point is 0.5 i.e. 50% of maximum value]

ETS for N_1 =2.758MHz/V

ETS for N_2 =3.078MHz/V

ETS for N_3 =2MHz/V

CONCLUSION:-

In this experiment, we have studied about the characteristics of reflex Klystron tube. Considering beam current and beam voltage as 14mA And 240V respectively we have calculated the number the tuning range, tuning sensitivity also the mode characteristics of reflex Klystron tube were observed.

REFERENCES:-

1. Microwave and Radar Engineering—M.Kulkarni
2. Basic Microwave Lab Manual—Sisodia