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Experiment No:

Title: - Study of microwave components and equipment.

Instruments & Components: -
Flanges, Twisted wave guide, wave guide tees, Directional Coupler, Attenuator, Isolators, Circulators, Matched terminator, Slide screw tuner, Slotted Section, Tunable probe, Horn antennas, Movable Short, Detector mount

Theory: -
A pipe with any sort of cross- section that could be used as a wave guide or system of conductors for carrying electromagnetic wave is called a wave guide in which the waves are truly guided.

(1) FLANGES: - Flanges are used to couple sections of wave guide components. These flanges are designed to have not only mechanical strength but also desirable electric characteristics.

(2) TWISTED WAVEGUIDE: - If a change in polarization direction is required, twisted section may be used. It is also called rotator.

(3) WAVE GUIDE TEE: - Tees are junctions which are required to combine or split two signals in a wave guide. Different type of tees are:

(a) H - PLANE TEE: - All the arm of the H- plane Tee lies in the plane of the magnetic field which divides among the arm. This is thus a current or parallel junction.

(b) E- PLANE TEE: - It lies in the plane of electric field. It is voltage or series junction. In this signal is divided in to two parts having same magnitude but in opposite phase.

(c) MAGIC TEE: - If another arm is added to either of the T-junction. Then a hybrid T-junction or magic tee is obtained. The arm three or four is connected to arm 1&2 but not to each other.

(4) DIRECTION COUPLER: - The power delivered to a load or an antenna can be Measured using sampling technique in which a known fraction of the power is Measured so that the total may be calculated. A number of coupling units used for such purpose are known as directional coupler.

(5) ATTENUATORS: - It consists of a resistive wane inside the wave guide to absorb microwave power according to its position w.r.t side wall of the waveguide. Attenuation will be maximum if the wane is placed at center

Fixed Attenuators: In this the position of resistive wane is fixed, it absorbs constantamount of power.

Variable Attenuators: - In this the position of resistive wane can be changed with thehelp of micrometer.

(6) ISOLATORS: - Ferrite is used as the main material in isolator. Isolator is a microwave device which allows RF energy to pass through in one direction with very little loss, while RF power in the reverse direction is absorbed.

(7) CIRCULATORS: - A microwave circulator is a multi-port junction device where the power may flow in the direction from 1 to 2, 2 to 3, & so on...

(8) MATCHED TERMINATION: - A termination producing no reflected wave at any transverse section of the wave guide. It absorbs all the incident wave. This is also equivalent to connecting the line with its characteristic impedance.

(9) SLOTTED SECTION: - A length of wave guide in which a non-radiating slot is cut on the broader side. This is used to measure the VSWR.

(10) SLIDE SCREW TUNER: - A screw or probe inserted at the top of wave guide (parallel to E) to develop susceptance the magnitude & sign of which is controlled by depth of penetration of screw and it can be moved along the length of wave guide.

(11) H – PLANE BEND: - An H-plane bend is a piece of wave guide smoothly bends in a plane parallel to magnetic field for the dominant mode (Hard bend).

(12) E – PLANE BEND: - An E-plane bend is a piece of wave guide smoothly bends in a plane of electric field (Easy bend).

(13) HORN ANTENNAS: - The components which radiates & intercept EM energy is of course the antenna. The open-ended wave guide, in which the open end is flared so that it looks like a horn, is called horn antenna. There are several types of horns – Sectional E-plane horn, Sectional H- plane horn and Pyramidal horn.

(14) MOVABLE SHORT: - It is adjustable load which moves along the length of wave guide and adjusted to get SWR.

<u>Precautions:</u>

1. Handle all components with care and do not allow any damage to take place.
2. Do not rub/scratch the inner polished surfaces of the components with any sharp edged body.
3. If demonstrating any assembly of components, ensure that there is no cross threading and proper tightening.

Conclusion:

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Experiment No:

Title: To study the radiation pattern and gain of horn antenna.

Components required: ATS 20/ATS 40 antenna trainer kit, connecting probes (Teflon), PC with Printer and Horn antenna.

Theory:

A horn antenna is used to transmit radio waves from a waveguide (a metal pipe used to carry radio waves) out into space, or collect radio waves into a waveguide for reception. It typically consists of a short length of rectangular or cylindrical metal tube (the waveguide), closed at one end, flaring into an open-ended conical or pyramidal shaped horn on the other end. The radio waves are usually introduced into the waveguide by a coaxial cable attached to the side, with the central conductor projecting into the waveguide to form a quarter-wave monopole antenna. The waves then radiate out the horn end in a narrow beam. However in some equipment the radio waves are conducted between the transmitter or receiver and the antenna by a waveguide, and in this case the horn is just attached to the end of the waveguide. In horns installed outdoors, suchas the feed horns of satellite dishes, the open mouth of the horn is often covered by a plastic sheet which is transparent to the radio waves, to keep out moisture.

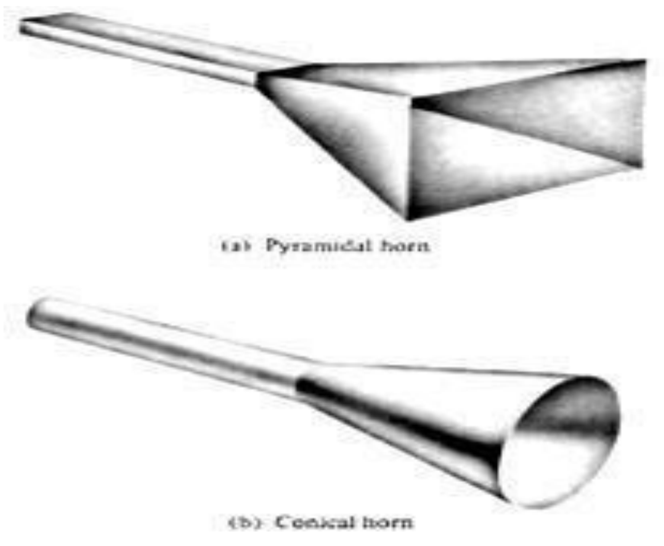

Figure 1: Aperture antenna configuration a) Pyramidal Horn b) Conical horn

A horn antenna serves the same function for electromagnetic waves that an acoustical horn does for sound waves in a musical instrument such as a trumpet. It provides a gradual transition structure to match the impedance of a tube to the impedance of free space, enabling thewaves from the tube to radiate efficiently into space. If a simple open-ended waveguide is used as an antenna, without the horn, the sudden end of the conductive walls causes an abrupt impedance change at the aperture, from the wave impedance in the waveguide to the impedance of free space, (about 377 ohms). When radio waves travelling through the waveguide hit the opening, this impedance-step reflects a significant fraction of the wave energy back down the guide toward the source, so that not all of the power is radiated. This is similar to the reflection atan open-ended transmission line or a boundary between optical mediums with a low and high index of refraction, like at a glass surface. The reflected waves cause standing waves in the waveguide, increasing the SWR, wasting energy and possibly overheating the transmitter. In addition, the small aperture of the waveguide (less than one wavelength) causes significant diffraction of the waves issuing from it, resulting in a wide radiation pattern without much directivity.

To improve these poor characteristics, the ends of the waveguide are flared out to form a horn. The taper of the horn changes the impedance gradually along the horn's length. This acts like an impedance matching transformer, allowing most of the wave energy to radiate out the endof the horn into space, with minimal reflection. The taper functions similarly to a tapered transmission line, or an optical medium with a smoothly-varying refractive index. In addition,the wide aperture of the horn projects the waves in a narrow beam.

The horn shape that gives minimum reflected power is an exponential taper. Exponential horns are used in special applications that require minimum signal loss, such as satellite antennasand radio telescopes. However conical and pyramidal horns are most widely used, because they have straight sides and are easier to design and fabricate.

Radiation Pattern:

The waves travel down a horn as spherical wave fronts, with their origin at the apex of the horn. The pattern of electric and magnetic fields at the aperture plane at the mouth of the horn, which determines the radiation pattern, is a scaled-up reproduction of the fields in the waveguide. However, because the wave fronts are spherical, the phase increases smoothly from the edges of the aperture plane to the center, because of the difference in length of the center point and the edge points from the apex point. The difference in phase between the center point and the edgesis called the phase error. This phase error, which increases with the flare angle, reduces the gain and increases the beam width, giving horns wider beam widths than similar-sized plane-wave antennas such as parabolic dishes. At the flare angle, the radiation of the beam lobe is down about -20 dB from its maximum value. As the size of a horn in wavelengths is increased, the phase error increases, giving the horn a wider radiation pattern. Keeping the beam width narrow requires a longer horn (smaller flare angle) to keep the phase error constant. The increasing phase error limits the aperture size of practical horns to about 15 wavelengths; larger apertures would require impractically long horns. This limits the gain of practical horns to about 1000 (30 dBi) and the corresponding minimum beam width to about 5 - 10°.

Procedure:

A. Transmitter section:

1) Set the control to manual (M) of the transmitter section.
2) Set the count to memory location 0001.
3) Set the desired frequency of the transmitter (fr) using front panel controls of transmitter.
4) Press Enter this will save the transmitting frequency.
5) Mount the LPDA on the stand provided and connect it to RF OUT of transmitter.

B. Receiver section:

1) Now set the control to manual (M) of the receiver section.
2) Set the count to memory location 0001.
3) Set the frequency of the Receiver same as that of transmitter using front panel controls.
4) Press Enter, this will save the Receiving frequency.
5) Connect Horn antenna to RF IN of receiver section.

C. Stepper Unit:

1) Connect Trigger output of stepper unit to input STEPPER of receiving section.
2) Set the control to manual (M) of the stepper unit section.
3) Set the step size of stepper motor to 5° using front panel controls.

D. Transferring readings:

1) Now set the control to Auto (A) of the receiver section.
2) Note down the memory location on receiver section.
3) Now set the control to Auto (A) of the stepper unit section.
4) Readings of the received power will be automatically gets store in receiver section.
5) Now connect RS232 cable of PC to receiver section.
6) Open antenna software on PC and select comport 1/comport 2.
7) Press MENU button of receiver section till a SERIAL MODE YES.
8) Now press ENTER of receiver section so that readings will be uploaded to PC.

E. Taking readings:

1) Press ENTER on keyboard radiation pattern will be generated.
2) Note down the maximum gain displayed on the screen.
3) Take printout of radiation pattern and locate -3dB gain from the max gain both on each side of 0 dB reference line and calculate the angle difference as HPBW.

Conclusion:

Questions:

1. List the merits, demerits, and applications of horn antenna.
2. Define Radiation pattern and Half Power Beamwidth of Antenna.

List the merits, demerits, and applications of horn antenna.

Merits of Horn Antennas:

1. High Gain: Horn antennas offer high gain, which means they can focus and direct electromagnetic waves effectively. This makes them suitable for long-distance communication and radar systems.
2. Low Cross-Polarization: Horn antennas typically have low cross-polarization, which means that they radiate and receive signals with minimal polarization variation. This is important for maintaining the integrity of signal transmission in certain applications.
3. Wide Bandwidth: Horn antennas often exhibit a wide operating bandwidth, allowing them to work across a range of frequencies without significant loss in performance. This makes them versatile for various applications.
4. Low VSWR (Voltage Standing Wave Ratio): Horn antennas tend to have low VSWR, indicating that they efficiently transmit and receive signals without significant signal reflection.
5. Simple Design: Horn antennas have a relatively simple and robust design, which makes them easy to manufacture and maintain.
6. Low Side Lobes: They can be designed to have low side lobes, reducing interference and focusing the antenna's energy in the desired direction.

Demerits of Horn Antennas:

1. Size and Bulk: Horn antennas can be relatively large, especially at lower frequencies. This can make them impractical for some applications where compactness is essential.
2. Narrow Beamwidth: Some horn antenna designs have relatively narrow beamwidths, which means they have limited coverage area. This can be a limitation for applications requiring a broader field of view.
3. Complex Feeding: Achieving good performance with horn antennas often requires precise feeding techniques and optimization, which can be challenging for inexperienced designers.
4. Limited Directivity: While horn antennas offer high gain, they may not achieve the same directivity as more complex designs like parabolic reflectors.

Applications of Horn Antennas:

1. Radar Systems: Horn antennas are commonly used in radar systems due to their ability to provide high gain and low side lobes, making them suitable for target detection and tracking.
2. Microwave Communications: Horn antennas are used for point-to-point microwave communication links, such as in telecommunication networks, where their high gain and wide bandwidth are advantageous.
3. Satellite Communication: In satellite ground stations, horn antennas are used for uplink and downlink communication, thanks to their ability to focus signals effectively.
4. Radiometry: Horn antennas are employed in radiometry systems for remote sensing and environmental monitoring applications, where accurate measurements of microwave emissions are crucial.

5. Wireless Applications: Horn antennas can be found in some wireless communication systems, especially in point-to-point connections where a high-gain directional antenna is needed.
6. Testing and Measurement: Horn antennas are used in anechoic chambers and for antenna testing and measurement purposes due to their known radiation characteristics.
7. Scientific Research: They are used in scientific experiments and observations, such as radio astronomy, where precise and low-noise reception of weak signals is essential.

Define Radiation pattern and Half Power Beamwidth of Antenna.

Radiation Pattern:

A radiation pattern, also known as an antenna pattern, is a graphical representation or description of how an antenna radiates or receives electromagnetic energy in three-dimensional space. It shows the intensity or power distribution of electromagnetic waves as they propagate away from the antenna in various directions. The radiation pattern provides essential information about an antenna's directional characteristics, showing where it focuses or directs its energy and where it has lower or null radiation.

Half Power Beamwidth (HPBW):

The Half Power Beamwidth (HPBW) is a critical parameter of an antenna's radiation pattern that defines the angular width of the main lobe in which the radiation power is at least half (-3 dB) of the maximum power in the main lobe. In other words, the HPBW is the angular span of the main lobe where the radiation intensity is at or above half of its peak intensity.

The HPBW is often used as a measure of an antenna's directivity and its ability to focus energy in a specific direction. A narrower HPBW indicates higher directivity, as more of the antenna's energy is concentrated in a smaller angular region. A wider HPBW suggests a less directive or more omnidirectional antenna.

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Experiment No:

Title: Reflex Klystron as a Microwave source in laboratory and plot its mode characteristics

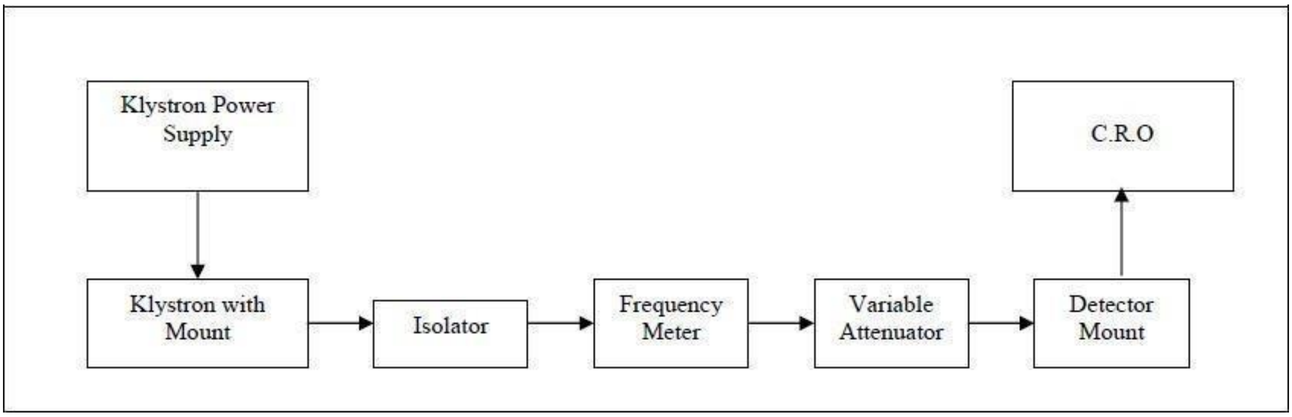
Objectives:

1. To study operation of reflex klystron.
2. To plot the mode characteristics of klystron
3. To observe frequency variation with Repeller voltage.

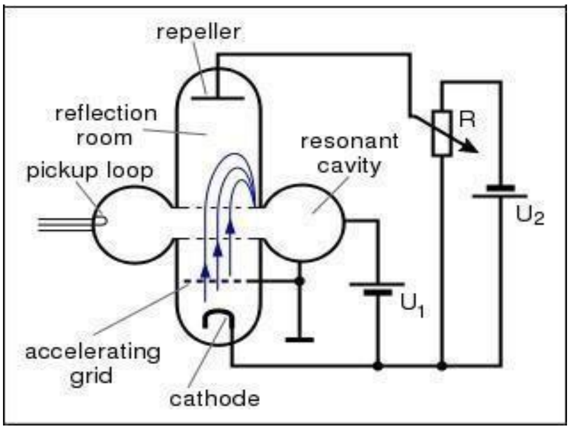
Apparatus:

1. Klystron Power Supply and Klystron with mount
2. Isolator
3. Frequency meter
4. Variable Attenuator
5. Slotted section with Probe carriage
6. CRO
7. Movable Short. etc.

Circuit diagram:



Theory:



The reflex klystron makes use of velocity modulation to transform a continuous electron beam into microwave power. Electrons emitted from the cathode are accelerated and passed through the positive resonator towards negative reflector, which reflects the electrons and the electrons turn back through the resonator. Suppose the RF- field exists between the resonators, the electron accelerated or retarded, as the voltage at an increased velocity and the retarded electrons leave at the reduced velocity. As a result, returning electrons group together in bunches. As the electron bunches pass through the resonator, they interact with the voltage at resonator grids. If the bunches pass the grid at such a time that the electrons are slowed down bythe voltage then energy will be delivered to the resonator, and the klystron will oscillate.

The frequency is primarily determined by the dimensions of resonant cavity. Hence by changing the volume of the resonator, mechanical tuning of the klystron is possible. A small frequency change can be obtained by adjusting Repeller voltage. This is called electronic tuning. Following figure shows the internal structure of reflex klystron.

Procedure:

1. Connect the components and equipment as shown in the block diagram.
2. Set the variable attenuator at the minimum attenuation position.
3. Set the mod. Switch of klystron power supply at AM position, beam voltage control knob to fully anti-clock wise and Repeller voltage control knob to fully clock wise.
4. Rotate the knob of the frequency meter at one side fully.
5. Connect CRO with detector.
6. Switch on the klystron power supply and cooling fan.
7. Put on the beam voltage switch and rotate the beam voltage knob slowly up to 270V(max) and observe the beam current which do not increase more than 20 mA. Do not change the beam voltage while taking the readings.
8. Change the Repeller voltage slowly and observe stable square wave with highest peak topeak amplitude.
9. Tune the plunger of klystron mount for maximum output.
10. Rotate the frequency meter slowly and stop at that position, where there is lowest output on CRO. Read frequency meter between two horizontal red lines and vertical marker.
11. Change the Repeller voltage and read the voltage and frequency for each Repeller voltage to get different modes of the klystron.
12. Note the readings in tabular column for every Repeller voltage and draw the graph for klystron modes.

Basic precautions:

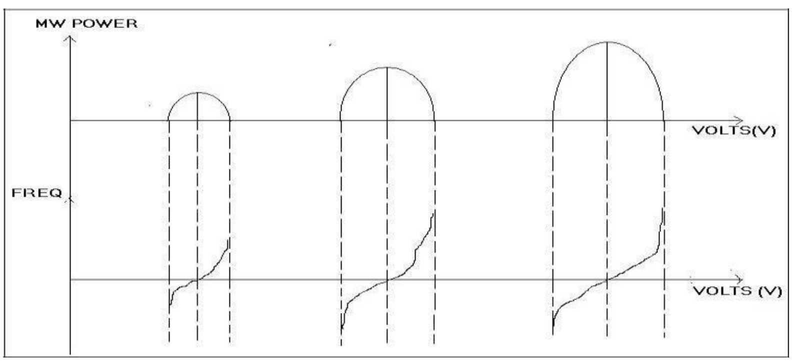
1. Do not look into open end of waveguide while power is on it may damage retina.
2. The Repeller negative voltage should be always applied before beam voltage.
3. The Repeller voltage should be varied in one direction to avoid hysteresis in klystron.
4. Once Beam voltage is applied first, cooling should be provided simultaneously.
5. Frequency meter should be detuned after each frequency measurement.
6. To avoid loading of the klystron an isolator/attenuation should invariably be used.

Observation Table:

Beam voltage (Vo) = V
Beam current (I) = mA.

Sr. No.	Repeller Voltage(V_R)	Output Voltage on CRO (Volts)	Frequency(GHz)
Mode-1			
Mode-2			
Mode-3			
Mode-4			

Sample Graph



Result:

Conclusion:

Questions:

1. What is velocity modulation?
2. What is bunching?
3. List the application of reflex klystron.
4. Importance of multicavity klystron?
5. Write a note on mode of oscillations.

References:

1.M. Kulkarni, “Microwave and Radar engineering”, 3rd edition, Umesh Publications
2.M L Sisodia& G S Raghuvanshi, “Basic Microwave Techniques and Laboratory Manual”, NewAge International (P) Limited, Publishers.

What is velocity modulation?

It is the key procedure for any microwave tube. This is the process in which basic velocity of the electron beam is changed according to RF Input. In Reflex Klystron, velocity modulation refers to the periodic variation in the electron beam’s velocity as it travels through the device.

What is Bunching?

Bunching is the process of grouping particles, like electrons, into concentrated packets or bunches rather than having them evenly spaced along their path, typically achieved through alternating electric or magnetic fields.

List the application of reflex klystron?

Mainly used in laboratory as microwave source, Radar Systems, Particle Accelerators, Industrial Heating, Electronics Countermeasures (ECM)

Importance of multicavity klystron?

High Power Generation: Multicavity klystrones are capable of generating high levels of RF (radio frequency) power, making them essential in applications requiring strong signal amplification.

Amplification and Oscillation: They are employed as amplifiers and oscillators in particle accelerators, radar systems, and communication devices, where consistent and powerful RF signals are needed.

Wide Frequency Range: Multicavity klystrones can operate across a broad range of frequencies, providing versatility for applications in different domains, from microwave communication to research.

Write a note on mode of oscillations?

The mode of oscillation in a reflex klystron is determined by the cavity geometry and the electron beam's interaction with the resonant cavities.

Key points about the mode of oscillation in a reflex klystron:

Cavity Resonance: Reflex klystrons consist of a series of resonant cavities, including a buncher cavity and a catcher cavity. These cavities are designed to be resonant at the desired microwave frequency.

Electron Beam Interaction: Electrons are emitted from the cathode and accelerated towards the buncher cavity. The buncher cavity exerts a force on the electrons, causing them to bunch together.

Frequency Determination: The mode of oscillation, or the specific microwave frequency produced, is primarily determined by the dimensions and resonant properties of the cavities, as well as the velocity of the electron beam.

Interaction Between Cavities: After passing through the buncher cavity, the bunched electrons are directed toward the catcher cavity.

Tunability: Reflex klystrons can be tuned to operate at different frequencies by adjusting the voltage and dimensions of the cavities. This tunability makes them suitable for various microwave applications.

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Experiment No:

Title: To study the characteristics of the Gunn diode oscillator.

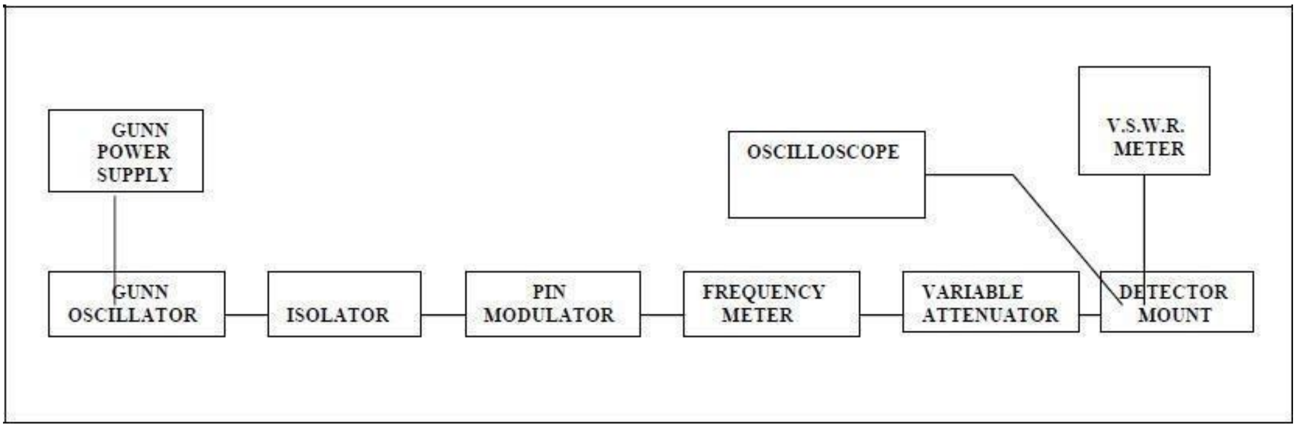
Objectives:

1.To study V-I Characteristics of Gunn Diode oscillator.

2.To study output power and frequency as a function of voltage.

Apparatus: 1. Gunn oscillator 2. Gunn power supply 3. PIN modulator 4. Isolator 5. Frequency meter 6. Variable attenuator 7. Detector mount 8. Waveguide stands 9. SWR meter, Cables, and Accessories.

Circuit Diagram:



Theory:

Gunn diodes are negative resistance devices which are normally used as low power oscillator at microwave frequencies in transmitter and also as local oscillator in receiver front ends. J B Gunn (1963) discovered microwave oscillation in Gallium arsenide (GaAs), Indium phosphide (InP) and cadmium telluride (CdTe). These are semiconductors having a closely spaced energy valley in the conduction band as shown in Fig. 4.1(a) for GaAs. When a dc voltage is applied across the material, an electric field is established across it. At low E-field in the material, most of the electrons will be located in the lower energy central valley Γ. At higher E-field, most of the electrons will be transferred in to the high-energy satellite L and X valleys where the effective electron mass is larger and hence electron mobility is lower than that in the low energy Γ valley. Since the conductivity is directly proportional to the mobility, the conductivity and hence the current decreases with an increase in E-field or voltage in an intermediate range, beyond a threshold value Vth as shown in Fig. 4.1(b). This is called the transferred electron effect and the device is also called „Transfer Electron Device (TED) or Gunn diode‟. Thus the material behaves as negative resistance device over a range of applied voltages and can be used in microwave.

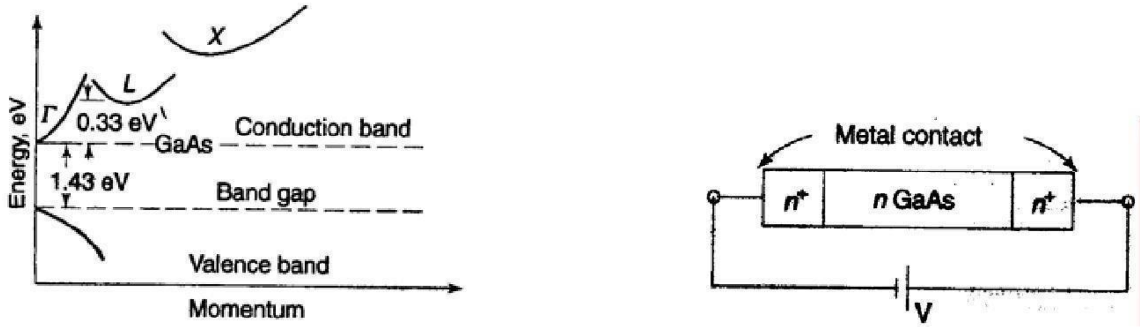


Figure 4.1(a)

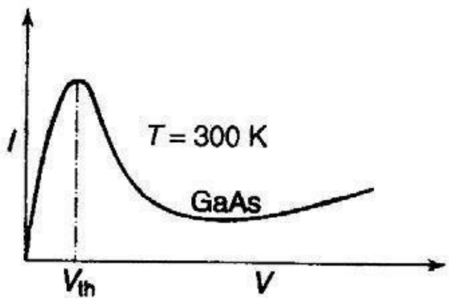


Figure 4.1(b)

The basic structure of a Gunn diode is shown in Fig. 4.2 (a), which is of n-type GaAs semiconductor with regions of high doping (n+). Although there is no junction this is called a diode with reference to the positive end (anode) and negative end (cathode) of the dc voltage applied across the device. If voltage or an electric field at low level is applied to the GaAs, initially the current will increase with a rise in the voltage. When the diode voltage exceeds a certain threshold value, Vth a high electric field (3.2 KV/m for GaAs) is produced across the active region and electrons are excited from their initial lower valley to the higher valley, where they become virtually immobile. If the rate at which electrons are transferred is very high, the current will decrease with increase in voltage, resulting in equivalent negative resistance effect.

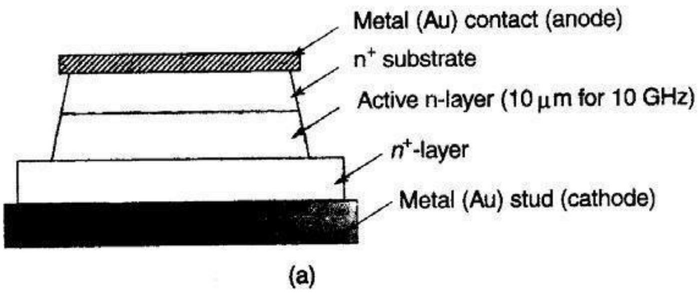


Figure 4.2(a)

Since GaAs is a poor conductor, considerable heat is generated in the diode. The diode will be bonded into a heat sink (Cu-stud). The electrical equivalent circuit of a Gunn diode is shown in Fig. 4.2 (b), where Cj and – Rj are the diode capacitance and resistance, respectively, Rs includes the total resistance of lead, ohmic contacts, and bulk resistance of the diode, Cp and Lp are the package capacitance and inductance, respectively. The negative resistance has a value that typically lies in the range –5 to –20 ohm.

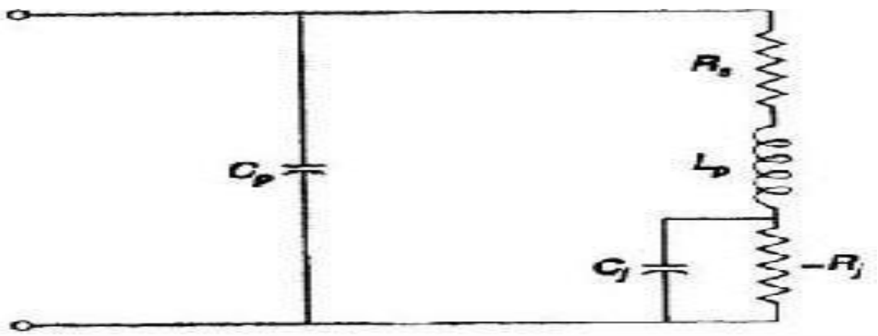


Figure 4.2(b)

Gunn Oscillator:

In a Gunn Oscillator, the Gunn Diode is placed in a resonant cavity. In this case the oscillation frequency is determined by cavity dimension than by the diode itself. Although Gun Oscillator can be amplitude-modulated with the bias voltage, we have used separate PIN modulator through PIN diode for square wave modulation.

Procedure:

1. First connect the Gunn test bench as shown in block diagram (a). Switch on the Gunn power supply.

2. The Gunn bias is adjusted to 9V (below 10V).

3. The micrometer of the Gunn oscillator is varied.

4. The tunable frequency meter is tuned until there is a dip in the ammeter.

5. The operating frequency can be taken in terms of GHz.

6. The Gunn oscillator micrometer reading and the corresponding frequency are shown in the frequency conversion charts.

7. Similar frequency conversion charts are provided for the frequency meter reading.

8. Note the frequency corresponding to Gunn oscillator micrometer reading and the frequency corresponding to frequency meter reading.

9.Both the frequency readings should be the same.

10. The above procedure is repeated for different values of the Gunn oscillator micrometer values.

11.For V-I characteristics of Gunn connect the test bench as block diagram.

12. Vary Gunn supply voltage from minimum (i.e. 0V to 6V), note down the Corresponding Gunn current when it is in current (I) mode. 13. Plot graph between Gunn supply voltage Vs Gunn supply current.

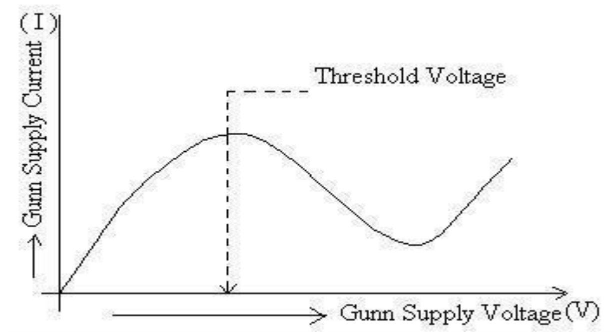
Basic precautions:

Do not keep Gunn bias knob position at threshold position for more than 10-15 seconds. Reading should be obtained as fast as possible. Otherwise, due to excessive heating, Gunn diode may burn.

Observations:

Sr.No.	Gunn supply voltage	Gunn supply current

Sample graph:



Result:

Conclusion:

Questions:

1. What is GUNN diode ?
2. Draw the equivalent Circuit for GUNN?
3. What are the different modes in GUNN diode oscillator?
4. How many junctions are there in GUNN?
5. Explain the transferred electron effect in GUNN?
6. What are applications of GUNN?

References:

1.M. Kulkarni, "Microwave and Radar engineering", 3rd edition, Umesh Publications.

2.M L Sisodia& G S Raghuvanshi, "Basic Microwave Techniques and Laboratory Manual", NewAge International (P) Limited, Publishers.

What is GUNN diode?

Gunn diode is bulk semiconductor device. It is based on Transferred Electron Effect. The effect was found by Gunn to be exhibited by gallium arsenide, Indium phosphide. Latter on it was observed that the effect was also exhibited by cadmium telluride and indium arsenide. The transferred electron effect is also known as Gunn Effect.

Draw equivalent circuit for GUNN diode?

What are different modes in GUNN diode oscillator?

There are following possible modes for Gunn oscillations. Different modes are there depending of drift velocity of domain which in turn depends on applied electric field

1 Transit time domain mode: Sustaining velocity for GaAs is 10 cm/s. When drift velocity of domain equals to sustaining velocity the mode is transit time mode. Obviously for this type of mode oscillation time period is transit time.

2. Delayed domain mode: Main drawback of delayed mode is that its conversion efficiency is low. To overcome this drawback at positive end domain is collected when applied field is less than the threshold feld (EE). Thus for the given length of GaAs slice, velocity at which domain is collected, increases thus decrease in transit time of domain.

3. Quenched Domain Mode: Drawback of transit time and delayed domain mode is that maximum frequency produced is equal to transit time of domain. But it has been observed that resonant circuit connected to Gunn diode is able to resonate at much greater frequency than this with good conversion efficiency. To overcome this, in case of quenched domain mode is suggested. In this mode, the applied field is reduced below sustaining field during negative half cycle.

4. Limited space charge accumulation (LSA) mode: LSA mode is the simplest mode of operation and it consists of a uniformly doped semiconductor without any internal space charges.

How many junctions are there in GUNN diode?

Gunn diodes typically have three junctions ("n-type" region, the "intrinsic" or "i-type" region, and the "p-type" region)

Explain the transferred electron effect in GUNN diode?

The transferred electron effect involves the motion of electrons in the presence of a strong electric field within certain semiconductor materials, such as gallium arsenide (GaAs).

The transferred electron effect in a Gunn diode is a phenomenon where electrons in a strong electric field reach a constant drift velocity, causing the diode to exhibit negative differential resistance. This effect leads to the formation of electron domains and the generation of microwave signals in the diode.

What are applications of GUNN diode?

1 GUNN Oscillator: Since Gunn diode consists of negative resistance and is very thin, it can be used to generate as oscillator at microwave frequency.

2 GUNN diode amplifier: Due to negative resistance, Gunn diode can be used as an amplifier. Above 30 GHz of frequency also Gunn diode amplifier provides high power output and low noise with good efficiency.

3 GUNN diode as pump source in parametric amplifier: The majority parametric amplifiers use Gunn diode as pump source. They have advantage over IMPATT diodes of having much lower noise.

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Experiment No:

Title: Verification of Port Characteristics of Microwave Tees.

Objectives:

1.To verify the port characteristics of E, H plane Tee.

2.To study the characteristic E-H Planes Tee.

Apparatus: Klystron power supply, Klystron with mount, isolator, variable attenuator, Magic Tee, Matched termination, detector mount, CRO, H-Plane Tee, E-Plane Tee.

Circuit Diagram:

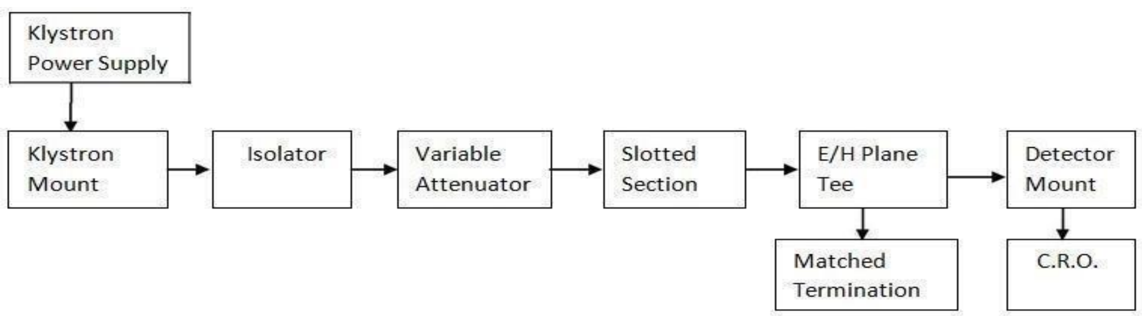
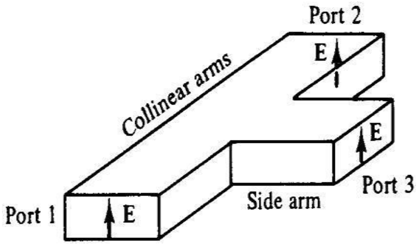


Figure1: Set up for E\H\Magic plane Tee Characteristics.

Theory:

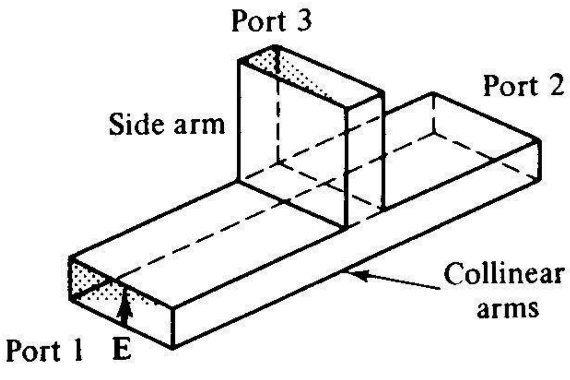
H Plane Tee:

It is clear from the sketch that an auxiliary waveguide arm is fastened perpendicular to the narrow wall of a main guide, thus it is a three-port device in which axis of the auxiliary or side arm is parallel to the planes of the magnetic field of the main of the main guide and the coupling from the main guide to the branch guide is by means of magnetic fields. Therefore, it is also known as H plane tee. The perpendicular arm is generally taken as input and other two arms are in shunt to the input and hence it is also called as shunt tee. Because of symmetry of the tee; equivalent circuit of H plane, when power enters the auxiliary arm, and the two main arms 1 and 2 are terminated in identical loads, the power supplied to each load is equal and in phase with one another. If two signals of equal amplitude and in same phase are fed into two main arms1 and 2, they will be added together in the side arm. **Thus, H plane tee is an 'adder'.**



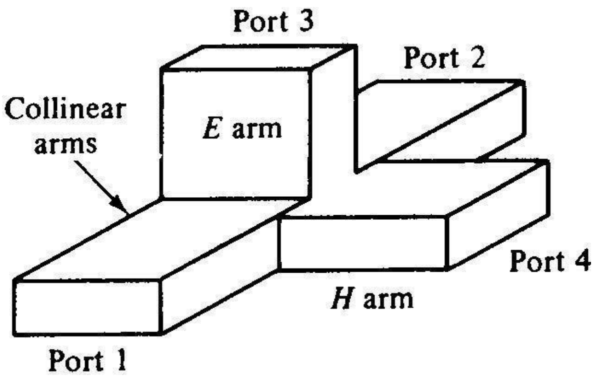
E Plane Tee:

It is clear from the sketch of the E plane tee that an auxiliary waveguide arm is fastened to the broader wall of the main guide. Thus, it is also a three-port device in which the auxiliary arm axis in parallel to the plane of the electric fields of the main guide, and the coupling from the main guide to the auxiliary guide is by means of electric fields. Therefore, it is also known as E plane tee. It is clear that it causes load connected to its branches to appear in series. So, it is often referred to as a series tee. As indicated in fig, the two main guide arms are symmetrical with respect to the auxiliary guide arm. As such if power is fed from the auxiliary arm, it is equally distributed in the two arms 1 and 2 when they are terminated in equal loads. However as depicted in the field configuration, the power flowing out in arm 1 is 180 out of phase to the one in arm 2. **As such tee is known as 'subtracter'.**



Magic Tee:

An interesting type of T junction is the hybrid tee, commonly known as 'magic tee' which is shown in fig. The device as can be seen from fig is a combination of the E arm and H plane tees. Arm3, the H arm forms an H plane tee and arm 4, the E arm, forms an E plane tee in combination with arms 1 and 2. The central lines of the two tees coincide and define the plane of symmetry, that is, if arms 1 and 2 are of equal length, the part of structure on one side of the symmetry plane shown by shaded area is the mirror image of that on the other. Arms1 and 2 are sometimes called as the side or collinear arm.



Magic of the MAGIC Tee:

The name is given because the way in which power divides among the various arms of Magic Tee. If power is fed into arm3, the electric field divides equally between arms 1 and 2 and the fields are in phase. Because of symmetry of the T junction, no net electric field parallel to the narrow dimension of the waveguide is excited in arm 4. Thus no power is coupled in port 4. Reciprocity demands no coupling in port 3 if power is fed in 4.Another property that results from the symmetry of the junction is, if power is fed in E or H arm, it is equally divided between arms 1 and 2. Further, magic tee being combination of E and H plane tees, if power is fed from arms 1 and 2, it is added in H arm (3) while is subtracted in E arm (4). A simple E-H tee has disadvantage of not being matched when seen from E and H arms when side arms are terminated in matched loads. The VSWR being > 2 the most commonly used method to reduce VSWR is to introduce discontinuity such as port iris in or near T junction to cancel out reflections occurring there in.

Procedure:

1. Connect the component as shown in the figure 1.

2. Connect the E plane, H Plane to the test bench and apply the input at 1 port and terminated another port with matched termination and observe the output to the ports as mentioned in the observation table.

Note down the port inputs and outputs.

Observations:

Repeller voltage:

Beam voltage:

Beam current:

Conclusion:

Questions:

1. Explain the properties of H-plane Tee using s-matrix.
2. Derive the S matrix of Magic Tee & Explain in detail any two application of Magic Tee. State and explain the properties of S parameters.

References:

1.M. Kulkarni, "Microwave and Radar engineering", 3rd edition, Umesh Publications 2.M L Sisodia& G S Raghuvanshi, "Basic Microwave Techniques and Laboratory Manual", New Age International (P) Limited.

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Experiment No:

Title: To Plot Standing Wave Pattern and Measure SWR for Open, Short, and Matched Termination at Microwave Frequency Using Slotted Section with Probe Carriage

Objectives:

The objective of this experiment is to study the standing wave pattern in a microwave transmission line, measure the Standing Wave Ratio (SWR), and observe the effects of different terminations (open, short, and matched) on the standing wave pattern. This experiment aims to provide students with hands-on experience in working with microwave frequencies and understanding the importance of impedance matching.

Equipment Needed:

1.Signal Generator: This generates the RF signal.

2.Power Meter: Measures the power of the signal.

3.Directional Coupler: Used to sample the signal without affecting the main signal.

4.Load: Represents the desired load (e.g., an antenna).

5.SWR Meter: This can be a standalone unit or a function integrated into some power meters.

Procedure:

Set Up the Equipment:

Connect the signal generator to the input of the directional coupler.

Connect the directional coupler output to the input of the load.

Connect the load to the power meter.

Set Frequency:

Set the signal generator to the frequency you want to test.

Calibrate the Power Meter:

Before taking any measurements, calibrate your power meter according to the manufacturer's instructions. This typically involves setting the meter to read zero when there's no signal.

Measure Forward Power (Pf):

Apply the signal and measure the power going towards the load (forward power).

Measure Reflected Power (Pr):

Measure the power reflected back from the load. This can be done by using a termination on the output of the directional coupler.

Calculate SWR:

Use the formula: $SWR = (1 + \sqrt{(Pr/Pf)}) / (1 - \sqrt{(Pr/Pf)})$

Interpret SWR:

SWR of 1 indicates a perfect match (ideal condition).

SWR above 1 indicates some amount of mismatch, which means not all power is being transferred to the load.

Optional: Plotting the Standing Wave Pattern:

For this, you would need to take measurements at multiple points along the transmission line (at intervals of $\lambda/2$ or $\lambda/4$). Record Pf and Pr at each point.

Plot the SWR along the transmission line. It should show a periodic pattern of high and low SWR points.

Theory:

Standing Waves: When a microwave signal is transmitted along a transmission line, it can create standing waves if it encounters impedance mismatches. These standing waves are characterized by nodes (points of minimum amplitude) and antinodes (points of maximum amplitude).

Standing Wave Pattern: The slotted section with the probe carriage is used to measure the electric field at different positions along the line. By moving the probe carriage, you can obtain readings at various points, allowing you to visualize the standing wave pattern.

SWR (Standing Wave Ratio): SWR is a measure of the degree of impedance matching in the transmission line. It is defined as the ratio of the maximum amplitude of the electric field (E_max) to the minimum amplitude (E_min) along the line. A high SWR indicates poor impedance matching, while a low SWR (typically 1:1 for a perfectly matched system) indicates good impedance matching.

Terminations: The experiment involves using open, short, and matched terminations. Open termination represents a high impedance, short termination represents a low impedance, and matched termination represents the correct impedance. These terminations will cause reflections and affect the standing wave pattern, which you will measure and analyze.

Conclusion: