Experiment -1 : Spectrum Analyzer

20-08-2024

SAURABH KUMAR
SC22B146

Aim: To analyse the frequency spectrum of a highpass, a bandpass and a bandstop filter using spectrum analyser.

Verified
27/08/24

Components Required:

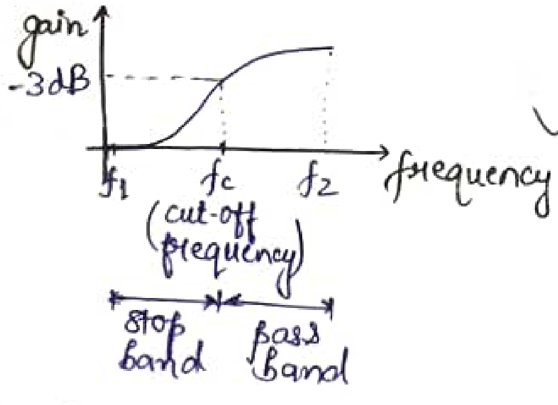
- Spectrum analyser
- Signal generator
- Highpass filter
- Bandpass filter
- Bandstop filter
- RF cables.

Theory:

Spectrum analyser – used in signal analysis by finding dominant frequency, power distribution, harmonics and bandwidth.

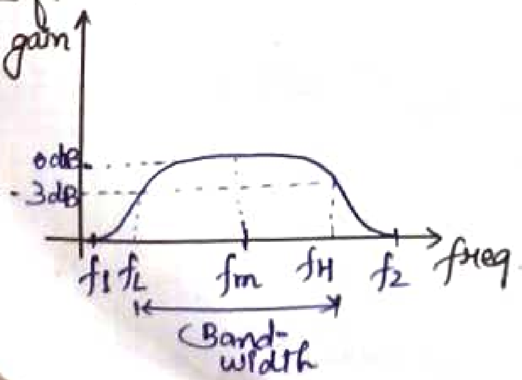
Signal generator – used in generating RF signals of required frequency and power-level.

High-pass filter:

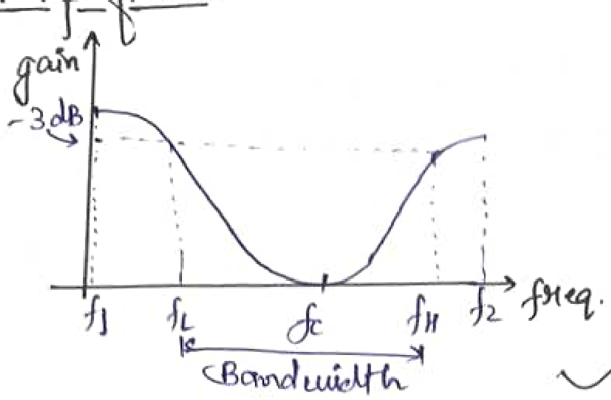


– (Mark the f_{max} which is obs. corresponding to Amp_{max}).

Band-pass filter:



Band stop filter:



(Mark f_{min})

Procedure:

1. RF cable is connected from signal generator to filter circuit input and then from filter output to the spectrum analyser input.
2. Linear frequency sweep is applied from 1 GHz to 3 GHz on signal generator.
3. The spectrum analyser is set to same range and the curve is noted.
4. Power value in dBm is noted and repeated for each filter.

Observations

High Pass Filter: Input reference → 10dBm

Frequency (GHz)	Power (dBm)
0.35	- ~~45.13~~ 25.1
0.45	-22.57
0.55	-20.21
0.65	-19.18
0.75	-16.66
0.85	-12.91
0.95	-9.66
1.05	~~-3.17~~ -6.14
1.15	~~+0.12~~ -3.17
1.25	~~1.32~~ 0.12
1.30	~~1.92~~ 1.32
1.35	1.92
1.45	4.26
1.55	6.12
1.65	6.12

Bandpass filter:

Frequency (GHz)	Power (dBm)
1.7	-22.95
1.8	-19.02
1.9	-13.80
2	-8.92
2.1	-5.03
2.2	0.32
2.26	3.05
2.31	4.20
2.4	3.69
2.465	3.27
2.50	1.87
2.55	-0.23
2.60	-3.33
2.65	-7.29

$f_1 = 1.7$ GHz

$f_2 = 2.65$ GHz

$f_L = 2.236$ GHz [Higher cutoff frequency]

$f_H = 2.5$ GHz [Lower cutoff frequency]

$P_{peak} = 4.93$ dBm

$f_{peak} = 2.399$ GHz

$P_L = 1.96$ dBm (-3 dBm point)

$P_H = 1.87$ dBm (-3 dBm point)

$f_c = \sqrt{f_H f_L}$

$= \sqrt{2.5 \times 2.236} = 2.364$

$W = f_H - f_L$

$= 2.5 - 2.236$

$= 0.264$ GHz

$Q = \frac{f_c}{W} = \frac{\sqrt{f_H f_L}}{f_H - f_L}$

$= \frac{2.364}{0.264}$

$= 8.954$

Bandstop filter :

Frequency (GHZ)	Power (dBm)
0.5	-28 ~~dBm~~ .18
0.599	-20.13
0.699	-44.39
1.1	-33
1.3	-34.81
1.5	-34.78
1.699	-34.03
1.8	-33.18
1.9	-32.75

$f_1 = 0.3$ GHZ
$f_2 = 2.2$ GHZ
$f_L = 1.070$ GHZ
$f_H = 0.715$ GHZ

$P_{peak} = -55.16$ dBm
$f_{peak} = 0.893$ dBm
$P_L = -52.56$ dBm (-3 dBm point)
$P_H = -52.37$ dBm (-3 dBm point)

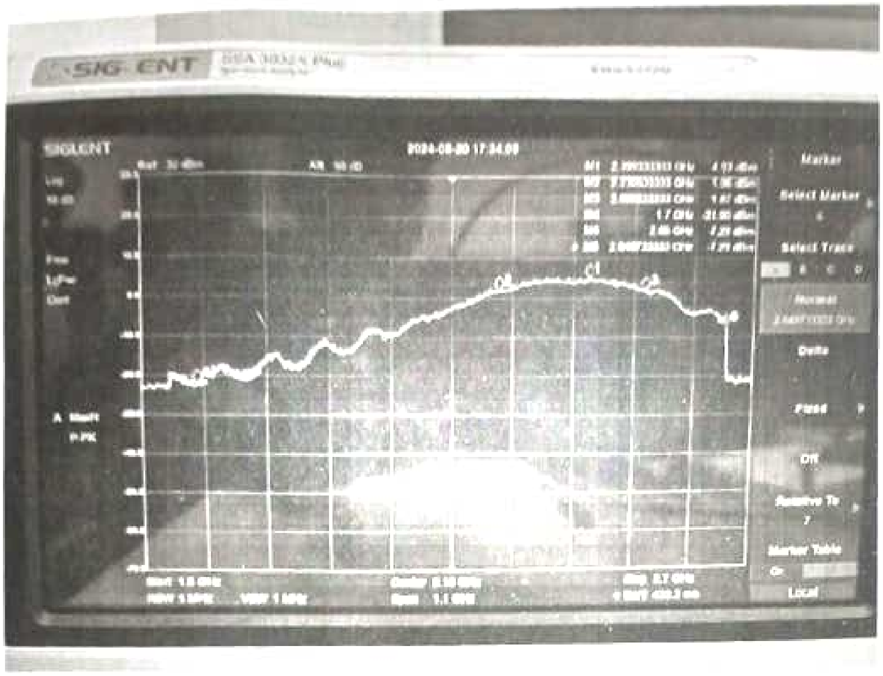
$$f_c = \sqrt{f_H f_L}$$
$$= \sqrt{1.070 \times 0.715} = 0.875 \text{ GHz}$$
$$W = f_H - f_L$$
$$= 1.070 - 0.715 = 0.355 \text{ GHz}$$
$$Q = \frac{f_c}{W}$$
$$= \frac{0.875}{0.355}$$
$$= 2.465$$

Inference:

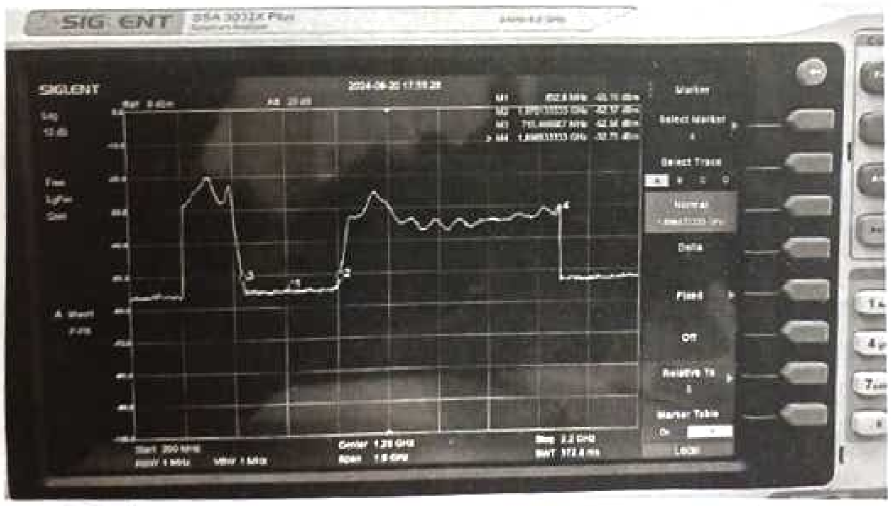
It is found that the cable offer an attenuation of around -2 to -3 dBm as noted above. The expected characteristics of the high pass, band pass and band-stop filter are also obtained.

RESULTS OBTAINED AT LAB:

Band Pass Filter:



Band Stop Filter:

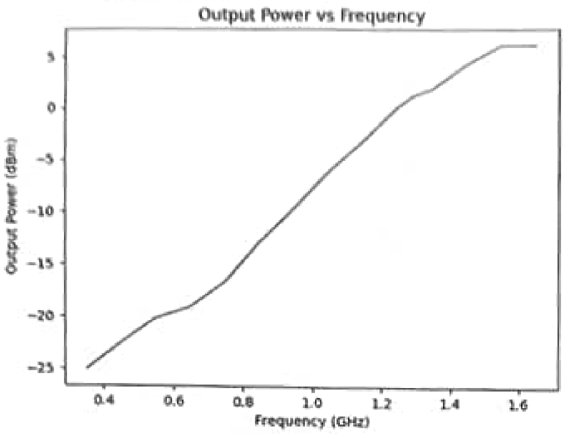


LAB 1

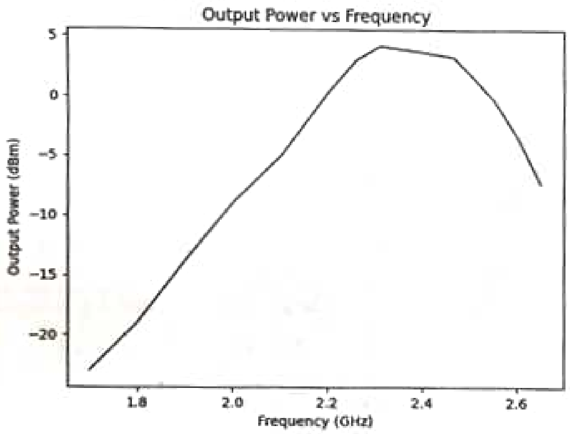
Spectrum Analyser

GRAPH PLOT USING PYTHON

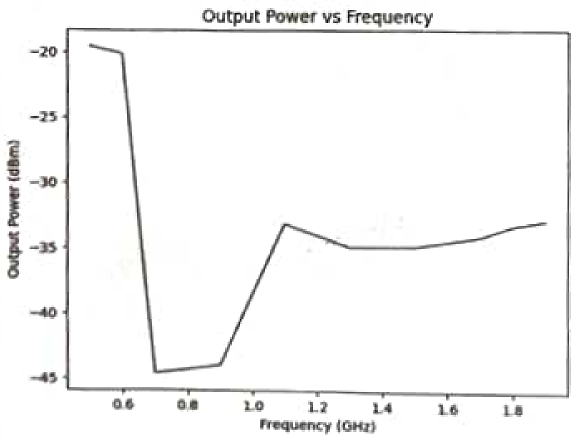
High Pass Filter:



Pass Band Filter:



Band Stop Filter



Experiment-2: Multi-Hole Directional Coupler

27-08-2024

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Verified
3/9/24

Aim: To study the function of multi-hole directional coupler by measuring the following parameters:

① To measure main-line and auxiliary-line VSWR
② To measure the coupling factor and directivity.

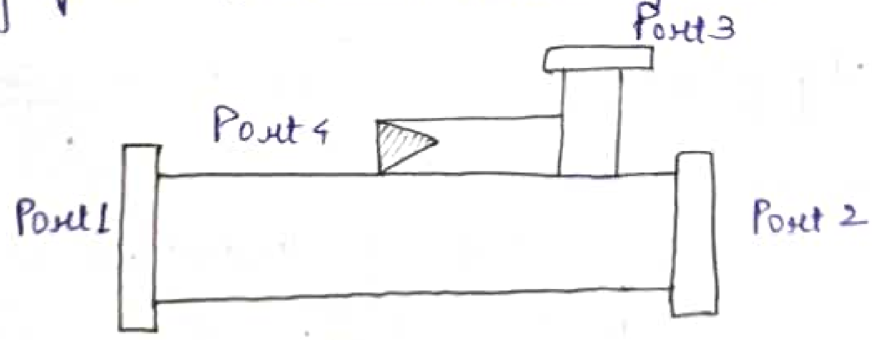
Equipments Required:

- Microwave sources
- Isolator
- Frequency meter
- Variable Attenuator
- Slotted line
- Tunable probe
- Detector Mount
- Matched Terminator
- MHD coupler
- Waveguide stand
- Cables & accessories
- VSWR meter

Theory:

A directional coupler is a device with which it is possible to measure the incident and reflected waves separately. It consists of two-transmission line, the main arm and auxiliary arm, electromagnetically coupled to each other.

The power entering port 1, the main-arm gets divided between port 2 and 3 and almost no power comes out in port 4. Power entering port 2 is divided between port 1 and 4.



Directional coupler

The coupling factor is defined as

$$\text{coupling (dB)} = 10 \log_{10}\left[\frac{P_1}{P_3}\right], \text{ where port 2 is terminated.}$$

$$\text{Isolation (dB)} = 10 \log_{10}\left[\frac{P_2}{P_3}\right], \text{ where } P_1 \text{ is matched.}$$

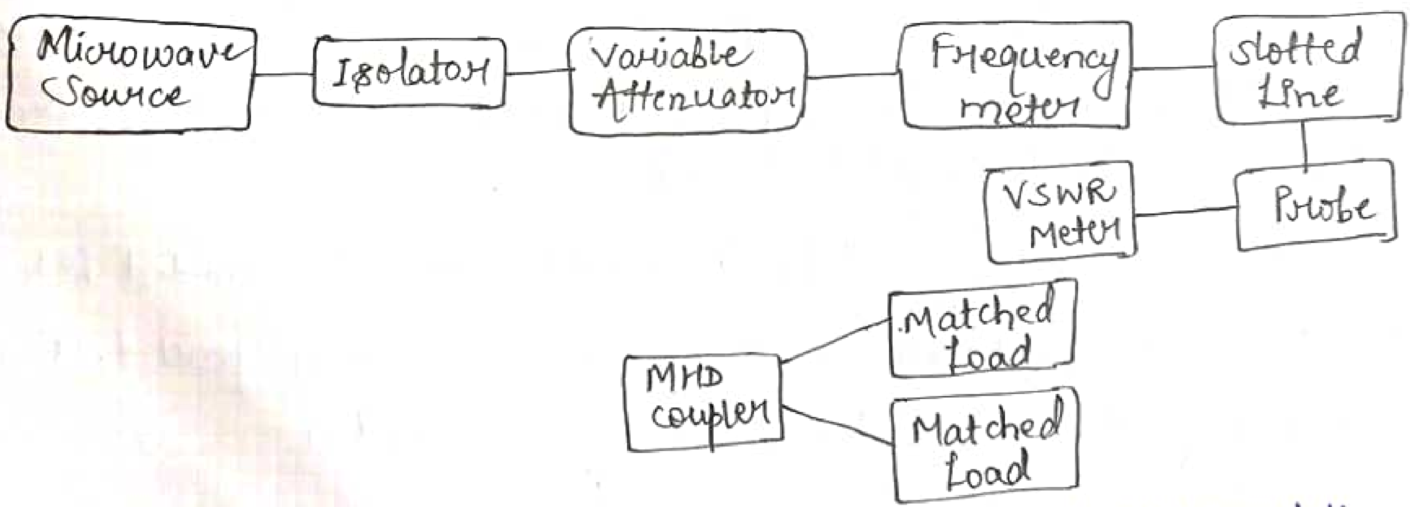
$$\text{Loss (dB)} = 10 \log_{10}\left[\frac{P_1}{P_2}\right]$$

$$\text{Directional } D \text{ (dB)} = \text{Isolation} - \text{coupling}$$

$$= 10 \log_{10}\left[\frac{P_2}{P_1}\right]$$

The directivity of the coupler is a measure of separation between incident and reflected wave.

Procedure :



Setup for measurement of VSWR and MHD coupler

① Setup the equipments as shown above.
② Energize the microwave source for particular frequency operation and measure the incident power P through VSWR meter.
③ Connect port 1 to the slotted line, terminate port 2 and connect the probe to port 3.

Measure power out from port 3 (P_3) through VSWR meter.

(4) Now, terminate P_2 and connect P_3 and measure power from P_2.

(5) Then, connect P_2 to the slotted line, terminate P_1 and connect probe to P_3 and measure power out from P_3 which is equivalent as from P_4 power out when power enter P_1. Hence, we mark this power as P_4, or P_3 when P_1 is matched.

(6) Calculate the coupling, isolation, directivity and loss of this MHD.

Observations:

(A) When port 2 is terminated

$$P_1 = -32.7 \text{ dB}$$

$$P_3 = -35.8 \text{ dB}$$

$$\text{Coupling} = 10\log_{10}\left(\frac{P_1}{P_3}\right) = -32.7-(-35.8)$$
$$= 3.1 \text{ dB}$$

$$P_2 = -33.6 \text{ dB}$$

$$\text{Loss} = 10\log_{10}\left(\frac{P_1}{P_2}\right) = -32.7-(-33.6)$$
$$= 0.9 \text{ dB}$$

(B) When port 1 is terminated

$$P_2 = -32.7 \text{ dB}$$

$$P_3 = -8.0 \text{ dB}$$

$$\text{Isolation} = 10\log_{10}\left(\frac{P_2}{P_3}\right) = -32.7-(-8.0)$$
$$= 24.7 \text{ dB}$$

$$\text{Directivity} = \text{Isolation} - \text{Coupling}$$
$$= 24.7 - 3.1$$
$$= 21.6 \text{ dB}$$

Inference :

We analyzed the ~~attenuat~~ function of multi-hole directional coupler by measuring various power-in and power-out with the help of VSWR meter and calculated the following parameters:

Coupling = 3.1 dB
Isolation = 24.7 dB
Directivity = 21.6 dB
Loss = 0.9 dB

The coupler we had is approximately 3 dB coupler.

Experiment-3 : Study of Klystron

Redo in graph paper
17/9/24

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Part-A

Aim: To determine the frequency and wavelength in a rectangular waveguide working on TE_{10} mode.

Materials Required:

- Klystron tube
- Klystron power supply
- Klystron Mount
- Isolator
- Frequency Meter
- Variable Attenuator
- Slotted section
- Tunable Probe
- VSWR Meter
- Waveguide stand
- Movable short matched termination

Theory:

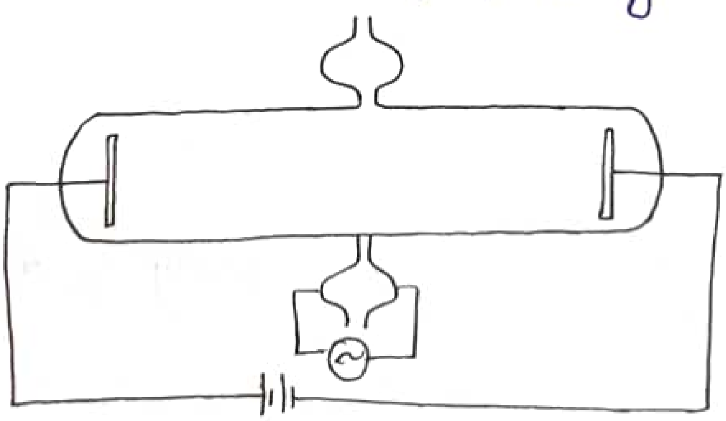
For dominant TE_{10} mode in rectangular waveguide, λ_0, λ_g and λ_c are related as:

$$\frac{1}{\lambda_0^2} = \frac{1}{\lambda_g^2} + \frac{1}{\lambda_c^2},$$

λ_0 : Free space wavelength
λ_g : Guided wavelength
λ_c : cutoff wavelength.

For TE_{10} mode, $\lambda_c = 2a$, where a : broader dimension of waveguide

Also, $c = \lambda f$, c : velocity of light
f : frequency.

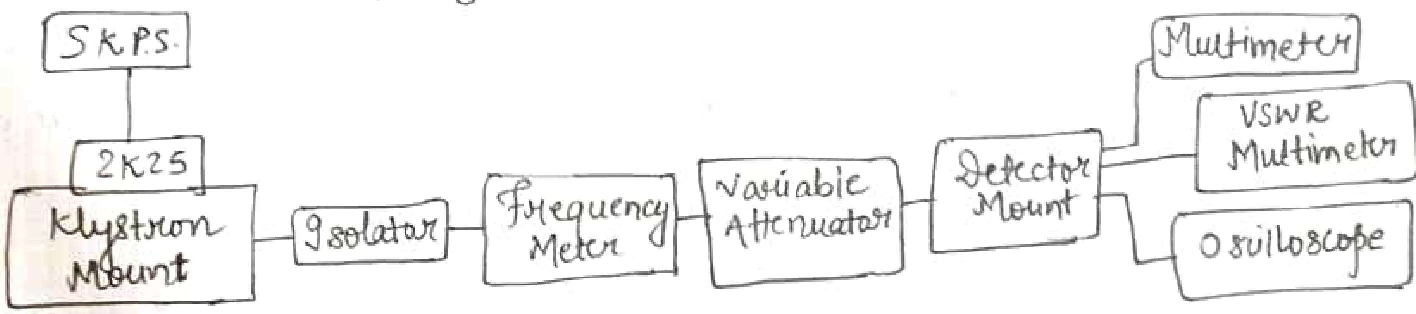


The reflex klystron make use of velocity modulation to transform a continuous electron beam into microwave power.

Electrons emitted from cathode accelerates towards the anode and passes through the positive resonator towards negative reflector, which retards the speed of electron and finally reflects the electrons, leading to electron turning back through resonator at different speed.

The accelerated electrons leave the resonator at an increased velocity and the retarded electrons leave at reduced velocity. The electron leaving the resonator will need different time to return due to change in velocities. As a result, returning electrons group together in bunches. As the electron bunches pass through the resonator, they ~~intersect~~ interact with voltages at resonator grids. If the bunches pass the grid at such a time that the electrons are slowed down by the voltage, then the energy will be delivered to the resonator and klystron will oscillate.

Setup for study of klystron tube:



Procedure:

① set the beam voltage (V_B) = 285 V, typically V_B should lie within the range 280 to 300 V.

② set the reflector voltage (V_R) to such a value that you obtain the maxima at the output voltage node using CRO for ~~such~~ a given position of the probe on the wave guide

③ Now, determine the position of the first maximum using the Vernier scale. Also, move the probe to and fro to measure the position of other maximas as well, ensuring V_R remains fixed.

④ Measure four such maxima to calculate a minimum of three set of λ_g. Now, take the mean value of λ_g's obtained to reduce the error involved in the measurement such as parallax error and other random errors.

Ensure that

$$\frac{\lambda_g}{2} = \left| P_i^{max} - P_{i+1}^{max} \right|, \quad P: \text{position of probe.}$$

⑤ Now, using a normal scale, measure the dimension of the waveguide to calculate the value of f_c, which in return help to calculate λ_c.

Now, use the formula, discussed in the theory section to find the value of λ, which in return gives the value of $f_{res}(1)$.

⑥ To verify experimentally obtained value, rotate the frequency meter until we obtain the minima at the CRO, to measure $f_{res}(2)$ using frequency meter.

⑦ Calculate the error obtained using the $f_{res}(2)$ and $f_{res}(1)$.

$$\lambda_g\,(\text{avg.}) = \sum_{i=1}^{3} \lambda_{g_i}$$

$$f_c = \frac{c}{2}\sqrt{\left(\frac{m}{a}\right)^2 + \left(\frac{n}{b}\right)^2} \quad \text{for } TE_{10} \Rightarrow m=1, n=0$$

$$\lambda_c = \frac{2 \times a}{1} \;; \quad f_c = \frac{c}{2} \times \frac{m}{a} = \frac{cm}{2a} = \frac{c}{2a}$$

$$\Rightarrow \lambda_c = 2a ; \quad f_c = \frac{c}{2a}$$

Observation:

$x_1^{max} = 8.61$ cm

$x_2^{max} = 10.80$ cm

$x_3^{max} = 12.91$ cm

$x_4^{max} = 15.10$ cm

Now, obtain the values of $\frac{\lambda g}{2} = \Delta x_{ij}^{max}$; $i = j+1$

$$\Rightarrow \lambda g(i) = 2\Delta x_{ij}$$

$$\lambda g^{(1)} = 2 \times 2.199\,cm = 4.398\,cm$$

$$\lambda g(2) = 2 \times 2.101\,cm = 4.202\,cm$$

$$\lambda g(3) = 2 \times 2.166\,cm = 4.332\,cm$$

$$\Rightarrow \lambda g\,(avg) = 4.310\,cm$$

$$\lambda c = 2a = 2 \times 2.5 = 5cm$$

$$\therefore \frac{1}{\lambda_0} = \sqrt{\left(\frac{1}{4.310}\right)^2 + \left(\frac{1}{5}\right)^2}$$

$$= 0.3063\,cm^{-1}$$

$$\Rightarrow \frac{c}{\lambda_0} = f_{res}(1) = 9.1896 \times 10^9\,Hz$$

$$\approx 9.2\,GHz.$$

Procedure:

Now repeat the same experiment, but with the output voltage node connected to the VSWR meter. Here, we measure wavelength using the concept that between two $\rho = 0$ point, there is a difference of $\frac{\lambda g}{2}$ distance. Repeat the steps as before.

Observation:

$x_1 = 8.8$ cm

$x_2 = 10.71$ cm

$x_3 = 12.81$ cm

$x_4 = 15.0$ cm

$\therefore \lambda_g(1) = 2 \times 1.91 = 3.82\,cm$

$\lambda_g(2) = 2 \times 2.1\,cm = 4.2\,cm$

$\lambda_g(3) = 2 \times 2.19\,cm = 4.38\,cm$

$\lambda_g\,(avg.) = 4.13\,cm$

$\lambda_c = 2a = 5cm$

$$\therefore \frac{1}{\lambda_0} = \sqrt{\left(\frac{1}{5}\right)^2 + \left(\frac{1}{4.13}\right)^2}$$

$$= 0.31404\ cm^{-1}$$

$$\therefore f_{res}(2) = 9.421 \times 10^9\ Hz$$
$$\approx 9.4\ GHz$$

Now, on measuring $f_{res.}(2)$ using frequency meter, we get $f_{res}(2) = 9.6\ GHz$.

Error using CRO $= \frac{9.2 - 9.6}{9.6} \times 100\%$

$= -4.1667\%$

Error using VSWR meter $= \frac{9.4 - 9.6}{9.6} \times 100\%$

$= -2.08334\%$

Part - B

Aim: To study the characteristics of reflex klystron tube.

Equipments Required: Same as part A.

Procedure:

① For a given position of the probe in the waveguide, sweep the reflector voltage from the minimum value to maximum negative voltage of −142 V, and observe the value of voltage obtained at CRO.
Using $V_{ref} = 1$, also compute the power in dBm. Measure I value as well.

② Now, plot the graph of power (in dBm) vs. the reflector voltage to study the characteristics of reflex klystron tube.

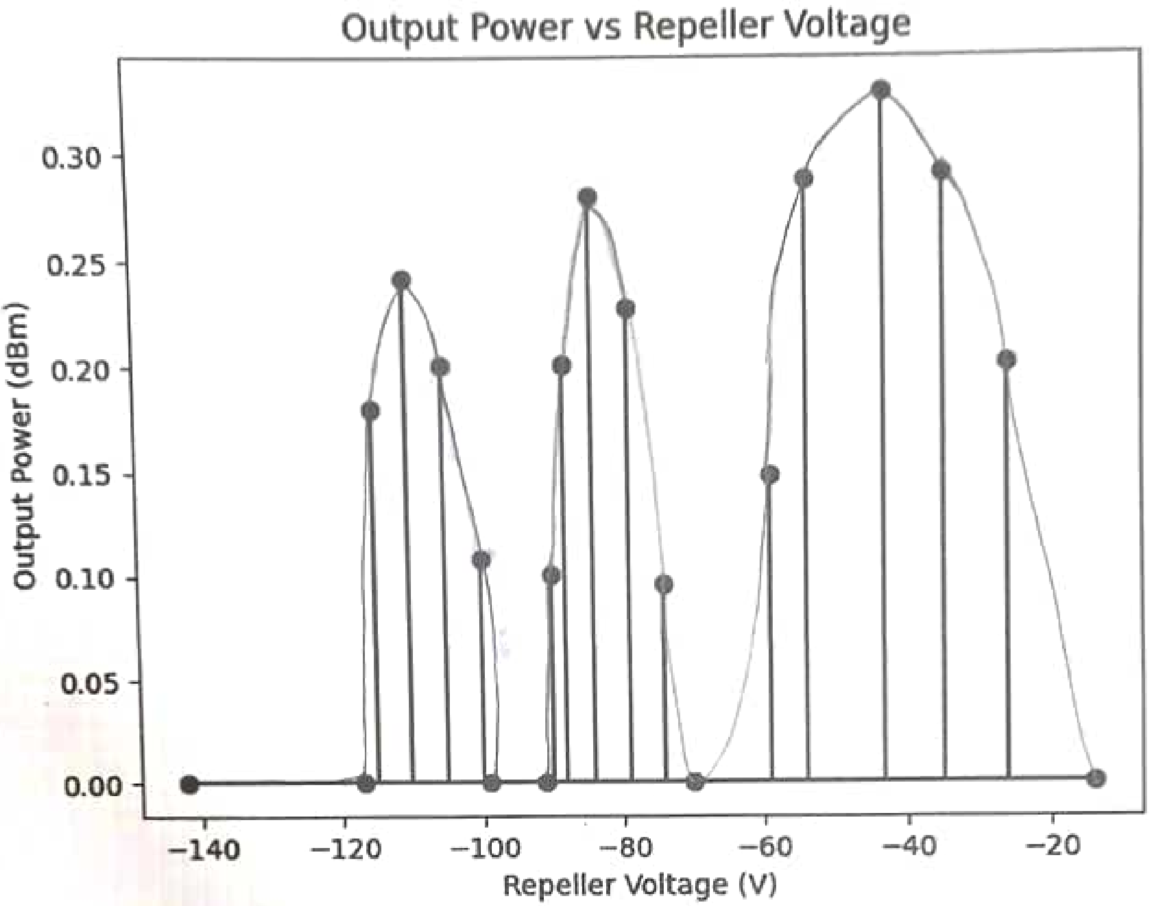
Observation:

(Repeller)

Rep. voltage (V)	Current (A)	~~Power~~	Voltage CRO (V)	Power (10^{-2} dB)
-43	0.019		44	0.328
-54	0.019		27.5	0.287
-59	0.019		5.5	0.148
-26	0.019		10.08	0.200
-35	0.019		28.18	0.29
-14	0.019		1.0	0
-70	0.019		1.0	0
-74	0.019		3	0.095
-79	0.019		13.6	0.226
-84	0.019		25	0.279
-88	0.019		~~25~~ 10	0.279
-90	0.019			0.2
-91	0.019		3.198	0.101
-99	0.019		1	0
			1	0
-100	0.019		-3.4759	0.108215
-105	0.019		10.2	0.2
-110	0.019		16.21	0.242
-115	0.019		7.93	0.1799
-117	0.019		1	0

LAB3
Study of Klystron

GRAPH PLOT USING PYTHON



Experiment - 4 : Gunn Diode Characteristics

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Aim: To study V-I characteristics of Gunn Diode

Equipment Required:

- Gunn Oscillator
- Gunn power supply
- PIN Modulator
- Isolator
- Frequency Meter
- Variable Attenuator
- Detector Mount
- Waveguide stands
- SWR Meter
- Cables and accessories

Verified
8/10/24

Theory:

The Gunn Oscillator is based on negative differential conductivity effect in bulk semiconductors, which has two conduction bands minima separated by an energy gap (greater than thermal Agitational energies). A disturbance at the cathode gives rise to high field region, which travels towards the anode. When this high field domain reaches the anode, it disappears and another domain is formed at the cathode and starts moving towards anode and so on. The time required for domain to travel from cathode to anode (transit time) gives oscillation frequency.

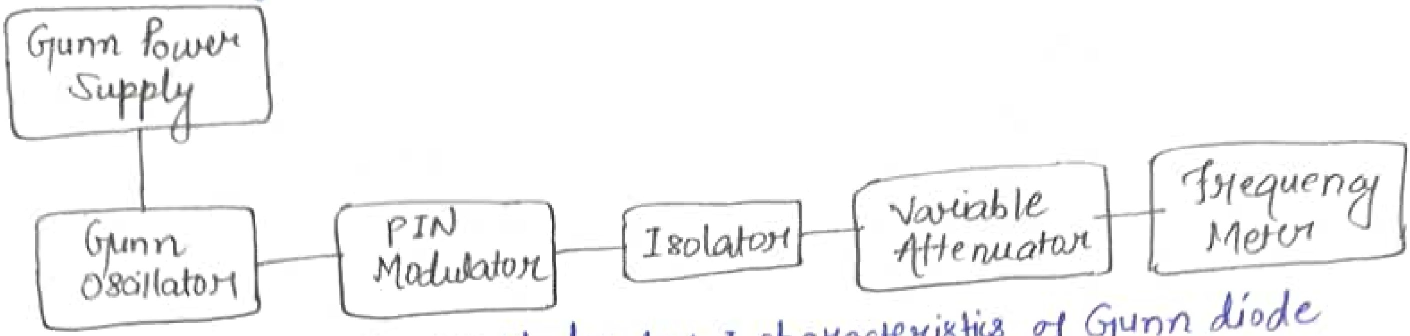
In Gunn oscillator, the Gunn diode is placed in a resonant cavity. In this case, the Oscillation frequency is determined by cavity dimension than by diode itself.

Although gunn oscillators can be amplitude-modulated with the bias voltage, we have used separate PIN modulator through PIN diode for square wave modulation.

A measure of the square wave capability is the modulation depth, i.e., the output ratio between 'ON' and 'OFF' state.

Procedure:

① set the components and equipments as shown below.



Setup for study of V-I characteristics of Gunn diode

② Initially set the variable attenuator for maximum attenuation.

③ set the micrometer of Gunn Oscillator for required frequency of operation.

④ Switch ON the Gunn Power Supply VSWR Meter and cooling fan.

⑤ Turn the meter switch of Gunn Power Supply to voltage position.

⑥ Measure the Gunn diode current corresponding to the various voltage controlled by Gunn bias knob through the panel meter and meter switch. Do not exceed the bias voltage above 10 volts.

⑦ Plot the voltage and current reading and measure the threshold voltage which corresponds to maximum current.

Observation:

Position of maxima	$\Delta x_{ji} = x_j - x_i$
9.8 cm	—
10.5 cm	0.7 cm
11.2 cm	0.6 cm
12.5 cm	1.3 cm

$\Delta x_{(avg.)} = 0.866$ cm

$\Rightarrow \lambda_{(avg.)} = 2 \times \Delta x_{avg.}$

$= 1.732$ cm

$\therefore f_{req.} = c \sqrt{\left(\frac{1}{\lambda_{avg.}}\right)^2 + \left(\frac{1}{a}\right)^2} = 11.2$ GHz.

Inferences

Gunn diodes are special kind of diodes which behave like a normal diode for a particular voltage range, i.e., 0V to threshold voltage for that particular diode, where current increases as the voltage increases but when the voltage difference cross it, the current starts decreasing. This is due to electrons move to higher energy valley when the voltage applied cross the threshold and thus the stability of electrons decreases and therefore the current decreases.

We found the ~~the~~ frequency of the microwave signal by finding minima and calculating λ_g.

Part-2

Although gunn oscillator can be amplitude-modulated with bias voltage, we have used separate PIN modulator through PIN diode for square wave modulation.

A measure of the square-wave capability is the modulation depth, i.e., the output ratio between 'ON' and 'OFF' state.

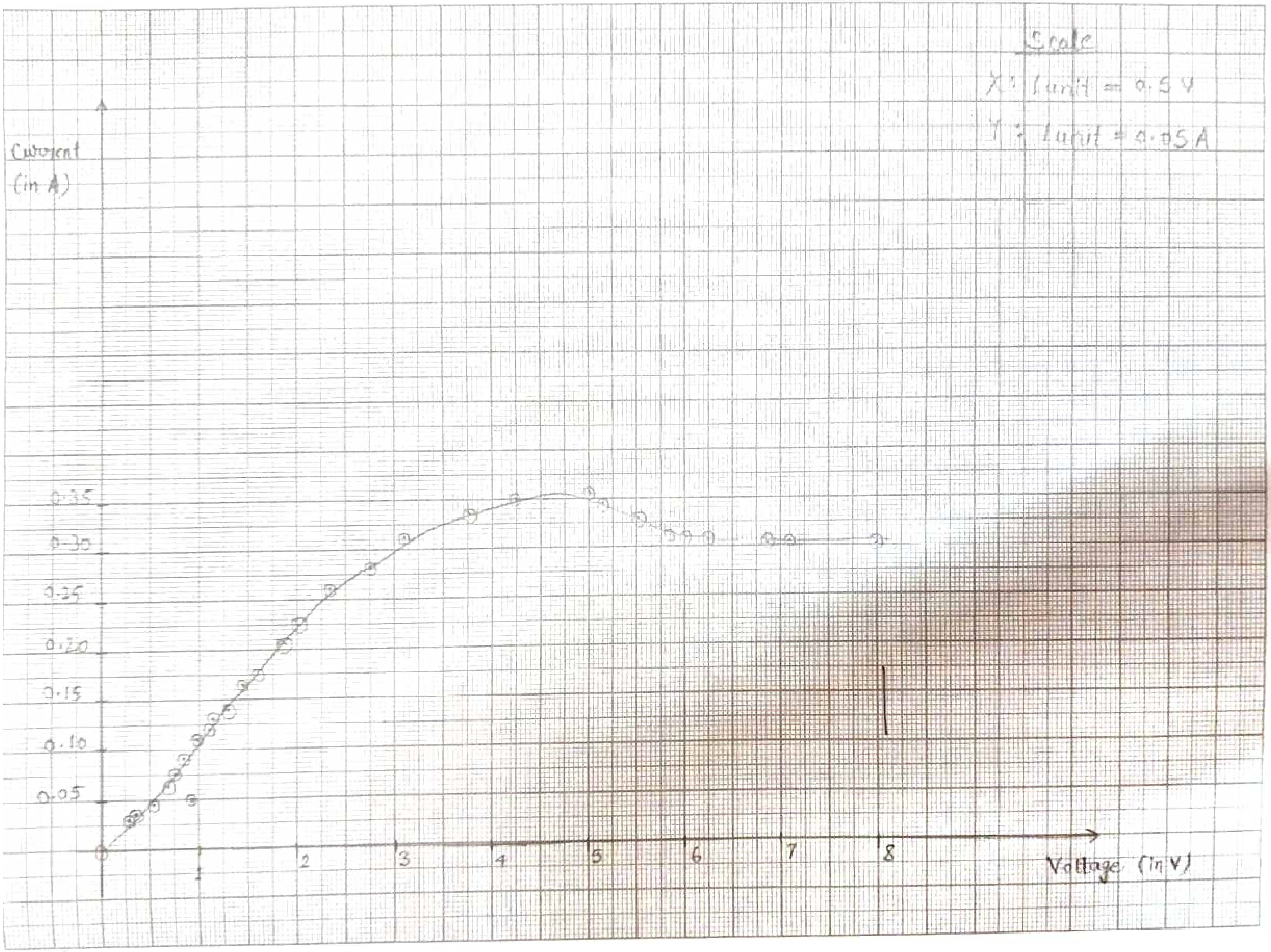
Observation

Current (in A)	Voltage (in V)
0	0
0.028	0.37
0.032	0.41
0.047	0.55
0.061	0.66
0.075	0.75
0.082	0.8
0.05	0.87
0.108	0.97
0.121	1.08

0.127	1.13
0.145	1.27
0.168	1.48
0.185	1.64
0.205	1.84
0.224	1.99
0.259	2.38
0.281	2.69
0.307	3.10
0.338	3.79
0.35	4.21
0.352	5.02
0.349	5.14
0.342	5.51
0.336	5.77
0.33	5.98
0.326	6.18
0.319	6.86
0.317	7.17
0.307	8.1
0.295	

Inference

We can see that the current increases as the voltage increases, reaches a peak and decreases thereafter with increasing voltage. Hence, we can observe the characteristic property of Gunn diode, with threshold voltage of 4V.


Scale
X: 1unit = 0.5 V
Y: 1unit = 0.05 A
Current
(in A)
0.35
0.30
0.25
0.20
0.15
0.10
0.05
1
2
3
4
5
6
7
8
Voltage (in V)

Experiment - 5: Time Domain Reflectometry

SC22B146
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Aim: To study the characteristics of coaxial cable (50Ω, 75Ω) using time-domain reflectrometer (TDR) in time domain.

Equipments Required:

Verified
15/10/2024

- Time domain reflectometer (TDR)
- Load: 50Ω, 75Ω open and short
- Cathode Ray Oscilloscope (CRO)
- 50Ω coaxial cable
- 75Ω coaxial cable
- Lossy coaxial cable
- TCC-BNC connector

Theory:

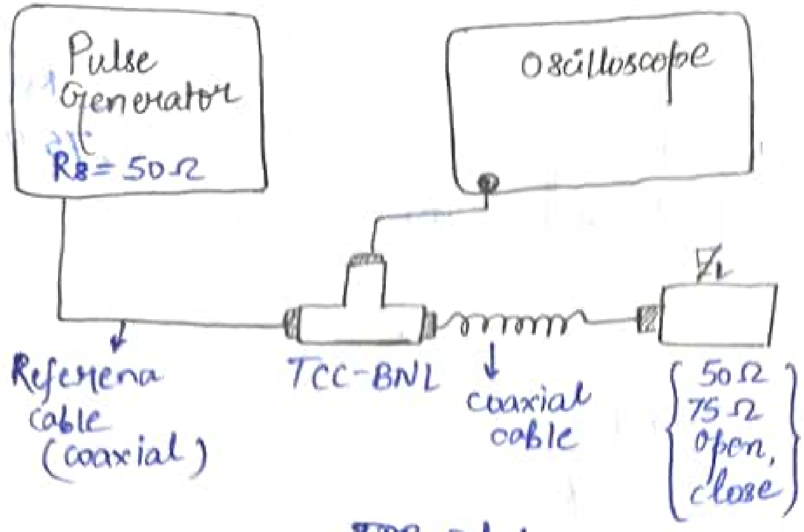
A time-domain reflectometer (TDR) is an electronic instrument used to determine the characteristics of electrical lines by observing reflected pulse.

A TDR measures reflections along a conductor by transmitting an incident signal and listening for its reflections.

The given setup permits selective phase and amplitude measurement of a sinusoidal voltage across a reflective load by means of standard 100 MHz oscilloscope.

The 50Ω 100 MHz pulse generator is connected using a reference cable and a BNC-TCC connector to the test coaxial cable allowing for a high impedance 1 MΩ probe to be connected to RF to measure the voltage at the input with perturbing the transmitted and received signals.

The test cable is loaded with 50Ω, 75Ω open circuit and short circuit loads to carry-out measurement.



TDR setup

Experiment ①: To analyse the open-ended transmission line using TDR technique.

Procedure:

① Turn ON the CRO and TDR. Connect the short-range output of the TDR to the channel-1 of CRO via a BNC-TCC connector using coaxial cable of 50Ω impedance.

② Observe the transmitted pulse after setting the TDR frequency to 100 MHz. These are sharp pulse of very small pulse width.

③ Now connect another coaxial line (the test cable) whose characteristic are to be observed at the other end of the TCC-connector.

④ Connect the other end of the test cable to an open-circuited load or leave it in air.

⑤ Observe the oscilloscope.

⑥ Repeat the experiment for 75Ω cable as well.

Observation:

(i) 50Ω test cable:

$V_t = 1.130$ V

$V_r = 600$ mV

$\Delta V = 530$ mV

(ii) 75Ω test cable:

$V_t = 980$ mV

$V_r = 550$ mV

$\Delta V = 430$ mV

Experiment-(ii): To analyse short-end T/L using TDR.

Procedure:

1. Repeat the procedure steps 1, 2 and 3 of experiment-(i).
2. Connect the other end of the test cable to a short-circuit load.
3. Observe the oscilloscope.
4. Repeat the same experiment for 50 Ω, 75 Ω test-cable.

Observations:

(i) 50 Ω test cable:

$V_t = 1.130\,V$

$V_r = \cancel{600\,mV}\ -590\,mV$

$\Delta V = \cancel{530\,mV}\ 1720\,mV$

(ii) 75 Ω test cable:

$V_t = 980\,mV$

$V_r = \cancel{550\,mV}\ -528\,mV$

$\Delta V = \cancel{430\,mV}\ 1508\,mV$

Experiment-(iii): To analyse the matched-end (50 Ω) T/L using TDR.

Procedure:

1. Repeat the procedure steps 1, 2, 3 of experiment-(i).
2. Connect the other end of the cable to a matched-end.
3. Observe the oscilloscope.
4. Repeat the same experiment for 50 Ω, 75 Ω test-cable.

Observation:

(i) 50 Ω test-cable:

$V_t = 1.130\,V$

$V_r = 2\,mV$

$\Delta V = 1.128\,V$

(ii) 75 Ω test-cable:

$V_t = 980\,mV$

$V_r = 0.3\,mV$

$\Delta V = 979.7\,mV$

Experiment-(iv) : To measure the characteristics impedance of a given transmission line TDR.

Procedure :

1. Connect the short range output of TDR to one CRO input using BNC-TCC connector and reference cable.
2. Measure the open-circuited amplitude of the generate pulse (V_{oc})
3. Connect the test cables (TL to be characterised) to the CRO through the BNC-TCC connector.
4. Measure the amplitude of the transmitted pulse V_i. Take into account the generator output impedance 'Rg' as 50 Ω.
5. Use $Z_0 = \frac{V_t}{V_{oc} - V_t} \times R_g$ to calculate the characteristic impedance of the test-cable.
6. Carry-out the experiment for a 50 Ω and a 75 line.

Observation and Calculation:

$R_g = 50\Omega$ (Generator output impedance)

(i) Test cable rated 50 Ω :

$V_{oc} = 600 mV$

$V_t = 1.130V$

$$Z_0 = \frac{V_t R_g}{V_{oc} - V_t} = 32.65\Omega$$

(ii) Test cable ~~rate~~ rated 75Ω

$V_{oc} = 980 mV$

$V_t = 550 mV$

$$Z_0 = \frac{V_t R_g}{V_{oc} - V_t} = \frac{550 \times 50}{98 - 550} = 75.46\Omega$$

Result:

Characteristic impedance of line rated 50 Ω , $Z_0 = 32.65\Omega$

Characteristic impedance of line rated 75 Ω, $Z_0 = 75.46\Omega$

Experiment - (V) : To measure the velocity of propagation and dielectric constant of a given transmission line using TDR.

Procedure:

① Connect the short-range TDR output to CRO input using a BNC - TCC connector and reference cable.

② Connect open-circuited test cable to the other end of the TCC connector, after measuring the physical length of the cable.

③ Measure the time-delay (Δt) between the transmitted and reflected pulses.

④ Calculate the velocity of propagation (v_p) using $V_p = \frac{2l}{\Delta t}$.

⑤ Calculate the dielectric constant of the coaxial line using

$$\epsilon_r = \left(\frac{c}{V_p}\right)^2.$$

⑥ Repeat the same experiment for test-cables rated 50 Ω and 75 Ω.

Observation:

$c = 3 \times 10^8$ m/s

(i) 50 Ω test-cable:

$l = 1.5$ m

$2l = 3$ m

$\Delta t = 16$ ns

$V_p = 3/16\times10^{-9} = 1.875 \times 10^8$ m/s

$\epsilon = \left(\frac{c}{V_p}\right)^2 = 2.56$

(ii) 75 Ω test-cable:

$l = 5$ m

$2l = 10$ m

$\Delta t = 45$ ns

$V_p = 2.22 \times 10^8$ m/s

$\epsilon = \left(\frac{c}{V_p}\right)^2 = 1.826$

Result:

50 Ω cable: $V_p = 1.875 \times 10^8$ m/s

$\epsilon_r = 2.56$

75 Ω cable: $V_p = 2.22 \times 10^8$ m/s

$\epsilon_r = 1.826$

Experiment (vi): To measure the attenuation constant of given T/L using TDR.

Procedure:

(1) Connect short range TDR output to a CRO using a reference cable end on a BNC - TCC connector. Measure the amplitude of the transmission pulse (V_t)

(2) Connect the open circuit test cable to the other end of the TCC connector. Measure the amplitude of the reflected pulse.

(3) Calculate the attenuation (in dB/100m) using

$$A\,(dB/100\,m) = 20\log_{10}\left(\frac{V_t}{V_r}\right) \times \frac{100}{2l}$$

(4) Repeat the experiment for 50Ω and 75Ω test cables.

Observation:

(i) 50Ω test cable:

$l = 1.5m$

$2l = 3m$

$V_{SC} = 600\,mV$

$V_r = 585\,mV$

$$A = 20\log\left(\frac{V_t}{V_r}\right) \times \frac{100}{2l} = 7.3302\ dB/100\,m$$

(ii) 75Ω test cable:

$l = 5m$

$2l = 10\,m$

$V_t = 550\,mV$

$V_r = 265\,mV$

$$A = 20\log\left(\frac{V_t}{V_r}\right) \times \frac{100}{2l} = 63.423\ dB/100\,m$$

Result:

50Ω cable : A = 7.3302 dB/100 m

75 cable : A = 63.423 dB/100 m.

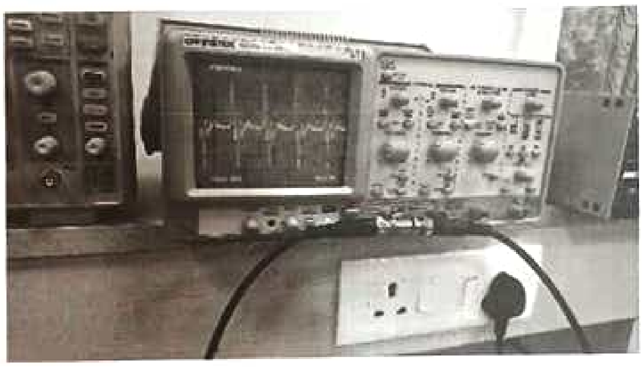
LAB 5

TDR – Time Domain Reflectometry

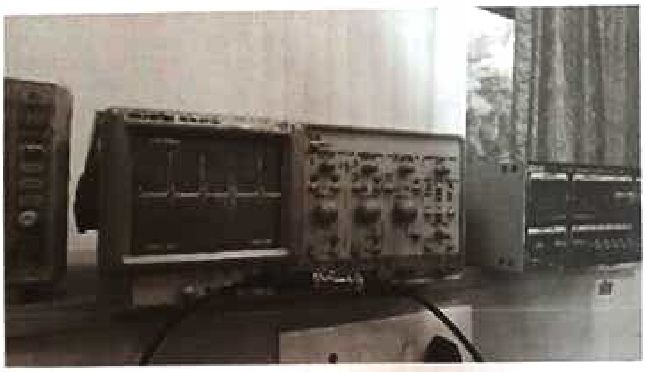
50 Ohm Test cable:

Open:

Short:



Matched:



Experiment - 6: Frequency Domain Reflectometry

SC22B146
SAURABH KUMAR

Verified
29/10/2024

Aim:

① To setup standing wave transmission line and observe the maxima and minima using frequency domain.
② To measure characteristic impedance of transmission line using frequency domain method.

Equipments Required:

- TL Analyser
- Different types of transmission lines
- CRO

Theory:

In a transmission line, standing waves are formed. The pattern of the standing wave depends on the load, for example, if it is shorted, current is maxima and voltage is minima, whereas when it is open-circuited, voltage maxima and current minima are formed, and when the load end is terminated with a load which is equal to the characteristic impedance of the T/L, the reflected wave is 'zero'. The T/L acts as an impedance transformer at electrical length $\lambda/4$.

Observation and Inference

When the load at the T/L is open-circuited, a voltage maxima and current minima is formed, but since the T/L acts as an impedance transformer of electrical length $\lambda/4$, repeated maxima and minima of a standing wave are observed along the line. The distance between 2 successive minimas is a half wavelength ($\lambda/2$).

When the load at the T/L is short-circuited, a voltage minima and current maxima is formed. Also, the T/L acts as an impedance transformer of electrical length $\lambda/4$, repeated minima and maxima of a standing wave are observed along the line. The distance b/w 2 successive maxima or minima is a half wavelength ($\lambda/2$).

Now, when the load is 50Ω, we can see that there is no standing wave are formed, that is, no power is reflected by the load. Hence, it can be said that the characteristic impedance of the coaxial cable is $50\ \Omega$.

[True reading $= 40\ \Omega$]

Expt 2 Then, the standing wave pattern in a $50\ \Omega$ transmission line is observed and it is observed that the standing waves were visible when

$Z_L = Z_0$, $\frac{Z_0}{2}$, $2Z_0$, $3Z_0$, $4Z_0$, open-circuited, short-circuited.

Stud... giv... ...

Study of dielectric constant of insulator in a T/L at a given frequency:

Expt 3

$l = 1m$

Frequency difference = $215 MHz - 130 MHz = 85 MHz = df$

$\therefore v_p = \frac{c}{\sqrt{\epsilon_r}}$

$\Rightarrow \epsilon_r = \left(\frac{c}{v_p}\right)^2$

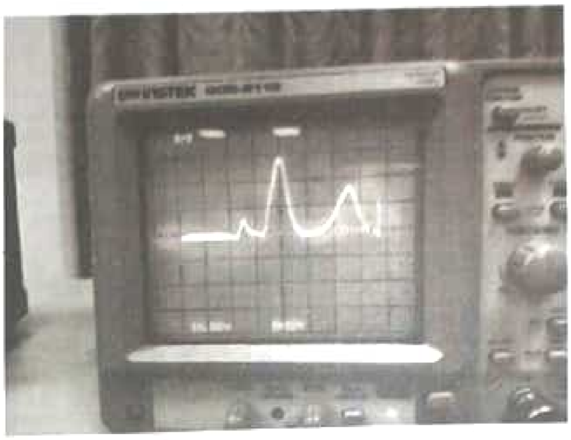
$= \left(\frac{\frac{3\times10^8}{2}}{85\times10^6\times1}\right)^2$

$= 3.11$

LAB 6
Frequency Domain Reflectometry

PART A

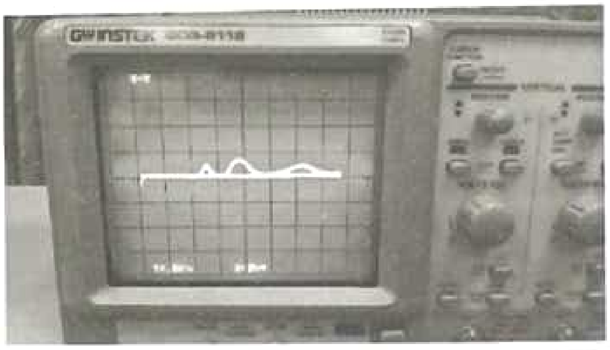
PART B



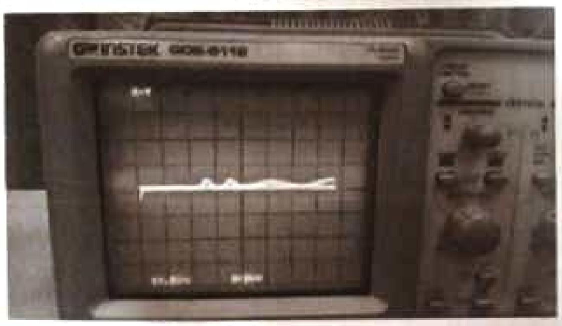
PART C

A) 50 ohms

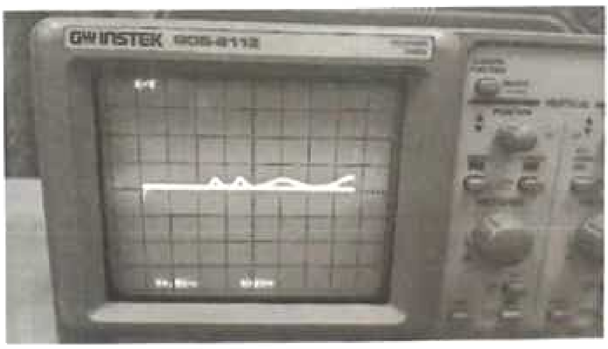
B) 25 ohms



C) 100 ohms



D) 150 ohms



E) 75 ohms

F) 200 ohms