Swedish College of Engineering & Technology, RYK

Department of Electrical Engineering

MICROWAVE ENGINEERING – [ES-314]

Microwave Engineering Laboratory

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Micro wave Engineering

Experiment 1 Understanding Trainer

Objective

To understand the measuring characteristic of a line

Task

Use the manual and your course reference material to fill the following

Transmission signals are mean of conveying _____ or _____ from one point to another

Why the transmission lines are arranged in uniform patterns , during their study

_____
_____
_____
_____

Give examples of any two Balanced line, and provide one reason , that why they are included in this category

----

Why coaxial cable is categorized as unbalanced line

Which circuits parameters give rise to phenomena of induction and capacitance in transmission line

----

The three major sources of losses in RF transmission are

1. .
2. .
3. .

Characteristic impedance of a transmission line is _____ if its infinity long

What is the length of co-axial cable that is used in trainer

Experiment 2 Measuring the Characteristics of a Line

Objective:
Measuring the characteristics of a line

Characteristic of a shielded line: The coaxial lines used for the transmission of electromagnetic waves consist of an external conductor of cylindrical shape, with an inner conductor arranged along the axis of the former. The two conductors are separated by dielectric material of suitable features.

One of the advantages of this kind of lines is that these lines are intrinsically self-shielding, due to the geometry of the arrangement of the two conductors. Moreover the shielding features of the coaxial lines improve when the frequency increases.

From the electric point of view, a coaxial line can be considered as cascade of line of trunks. Each one of them can be represented as being composed of resistive, inductive and capacitive circuit elements of concentrated kind, as shown in the figue1.
R = ohmic resistance for unit length (100 m in this trainer)
G = conductance for unit length
C = Capacitance for unit length

The transmission characteristics of a line are described in the term of propagation. Constant γ and of characteristic impedance Z_0. These parameters are typical values for each single line. The same is true for the capacitance, the inductance, the resistance and the conductance for length unit. In the telecommunications field, these values are generally expressed per meter or kilometer, for practical reasons. In this case, the symbol used to indicate these magnitudes are the common symbols.
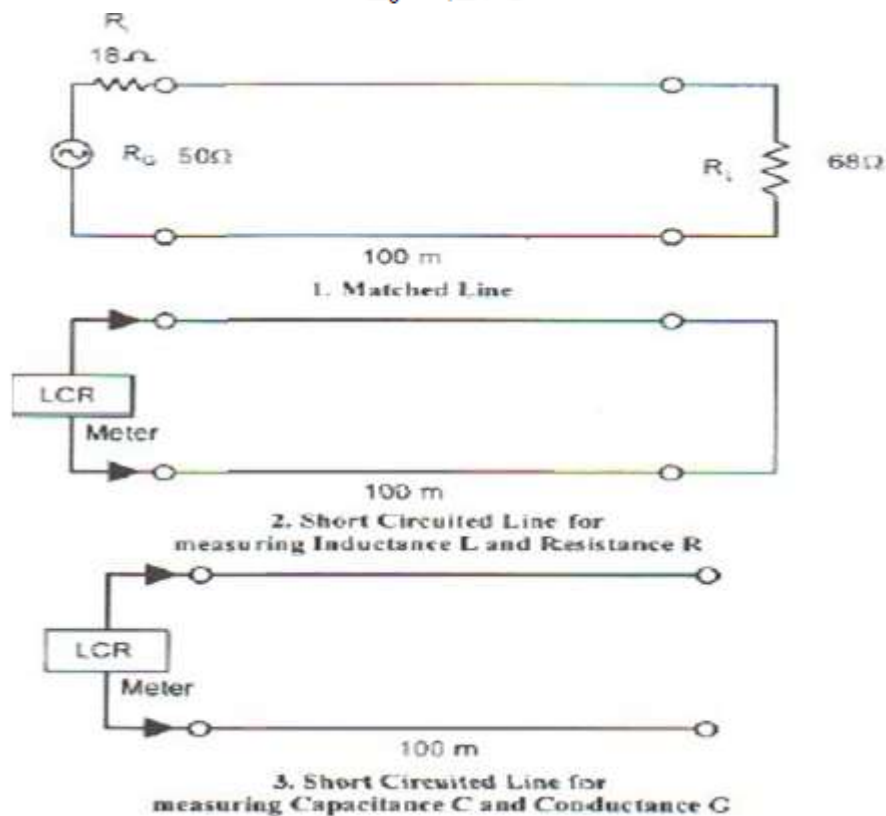
This experiment measures the characteristic parameters such as R, L, C, G, Z_0 and r for the transmission line included in this trainer.

Procedure:

1. Fig. 4 shows the modalities for the measurement to be performed.
2. Make connections as in fig. 5.
3. Both the inductance and ohmic resistance of the line are measured in series by short-circuiting end of the line and connecting the measuring instruments to the start of the line. The capacitance and the conductance are measure in parallel by operating on the open line.
4. The resistance R and the conductance G can be measured with an ohmmeter or DMM. For the conductance to be measured an ohmmeter is required which is able to perform resistance measurements with a range greater than $100M\Omega$.
5. For the measurement of series inductance L and the parallel capacitance C, a LCR meter or measuring bridge is required. The results of these measurements give values of R, L, C and G referred to the cable length that, in our case, is of 100 meters.
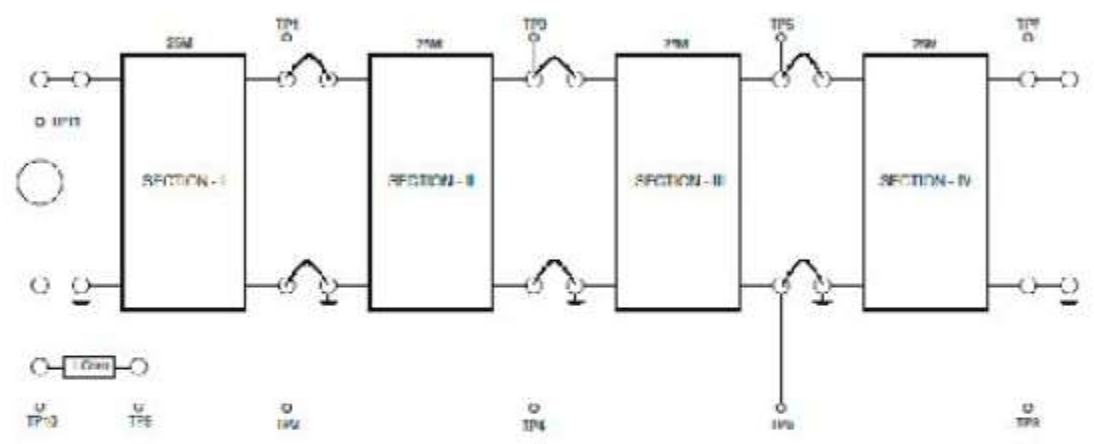
Z_0 can be measured by using the following formula:

$$Z_0 = \sqrt{L / C}$$

1. Matched Line

2. Short Circuited Line for measuring Inductance L and Resistance R

3. Short Circuited Line for measuring Capacitance C and Conductance G

TRANSMISSION LINE TRAINER

SECTION - I   SECTION - II   SECTION - III   SECTION - IV

WAVE FORM GENERATOR

LAB- 2 Measuring the Characteristic of a line

Define Shielded Line

What is the advantage of using shielded line transmission

Define and explain Propagation constant and characteristic impedance

Write down formulas to Calculate R, L , G, C, Zo

Lab Observation Work

What do you mean by Open circuit and closed circuit in Experiment 1

What is the Maximum and Minimum value of Rin and Rl available

----

What does Rin and Rl represent here

What is the maximum and minimum value of frequency variation knob on Trainer

----

What is the maximum and minimum amplitude available on trainer?

Determine the value of the following

Resistance Per unit length				
Section1	Section2	Section3	Section 4	Total
Capacitance Per unit length				
Inductance Per Unit length				

Experiment 3 Measuring the Attenuation of a Line for a Balanced Line

Objective:
Measuring the attenuation of line.

The ohmic resistance R & the conductance G are responsible for energy dissipation in the form of heat. These losses, which determine the attenuation characteristics, are expressed in terms of "attenuation" "a" and can be calculated by:

$$a = 20 \log (V_2 / V_1)$$

Where V_1 = amplitude of signal at I/P
V_2 = amplitude of signal at O/P
a = attenuation for given length

In this experiment we will measure the attenuation for the different trunks of transmission line available on the trainer. See fig. 8
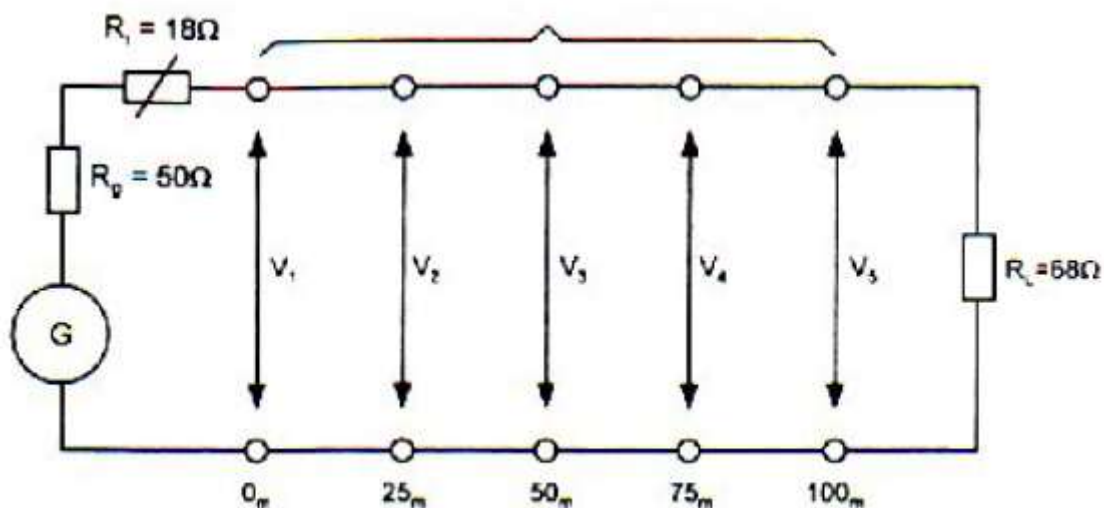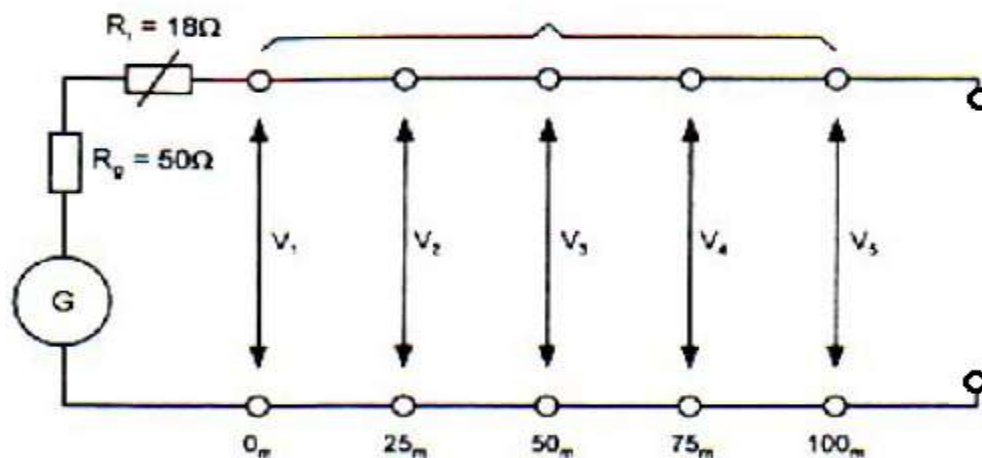

Fig. 8

Concept of matched line:
Though the concept of match line is not treated in detail in this manual but the subject is certainly known to the students from the theoretical course. We have already found out the characteristic impedance of the line as 50Ω from the previous experiment. The short-circuited resistance of the line when measured with Digital Multimeter is shown to be 18Ω. Therefore; the total effective resistance of the line is 68Ω. For optimum power transfer we should have the source resistance and terminating resistance also as 68Ω. Assuming generator resistance R_g as 50Ω we must connect 18Ω R_i in series with the generator to match the line. For this purpose, it is recommended that the student must set R_i to 18Ω using DMM and RL to 68Ω initially and this setting should be utilized for all the experiments wherever terminated line experiment is done.

Procedure:
1. Adjust R_i and R_L for 18Ω and 68Ω respectively with the help of DMM.
2. Make connections as shown in Fig. 9.
3. Set the sine-wave frequency to approx 100 KHz and level to 0.4V.
4. Oscilloscope CH 1 shows applied input CH2 shows outputs.
5. Measure signal level at Input, and at 25, 50, 75, and 100 m lengths.
6. Tabulate as under:

Length (m)	V₁ (input)	V₂ (output)
25		
50		
75		
100		

7. Now, calculate the attenuations in dB at various lengths by the formula given below : $a = 20 \, Log \, V_2 / V_1$
8. The attenuation is approx-2 dB at 100m.
9. Try the same with open ended line and short ended line.
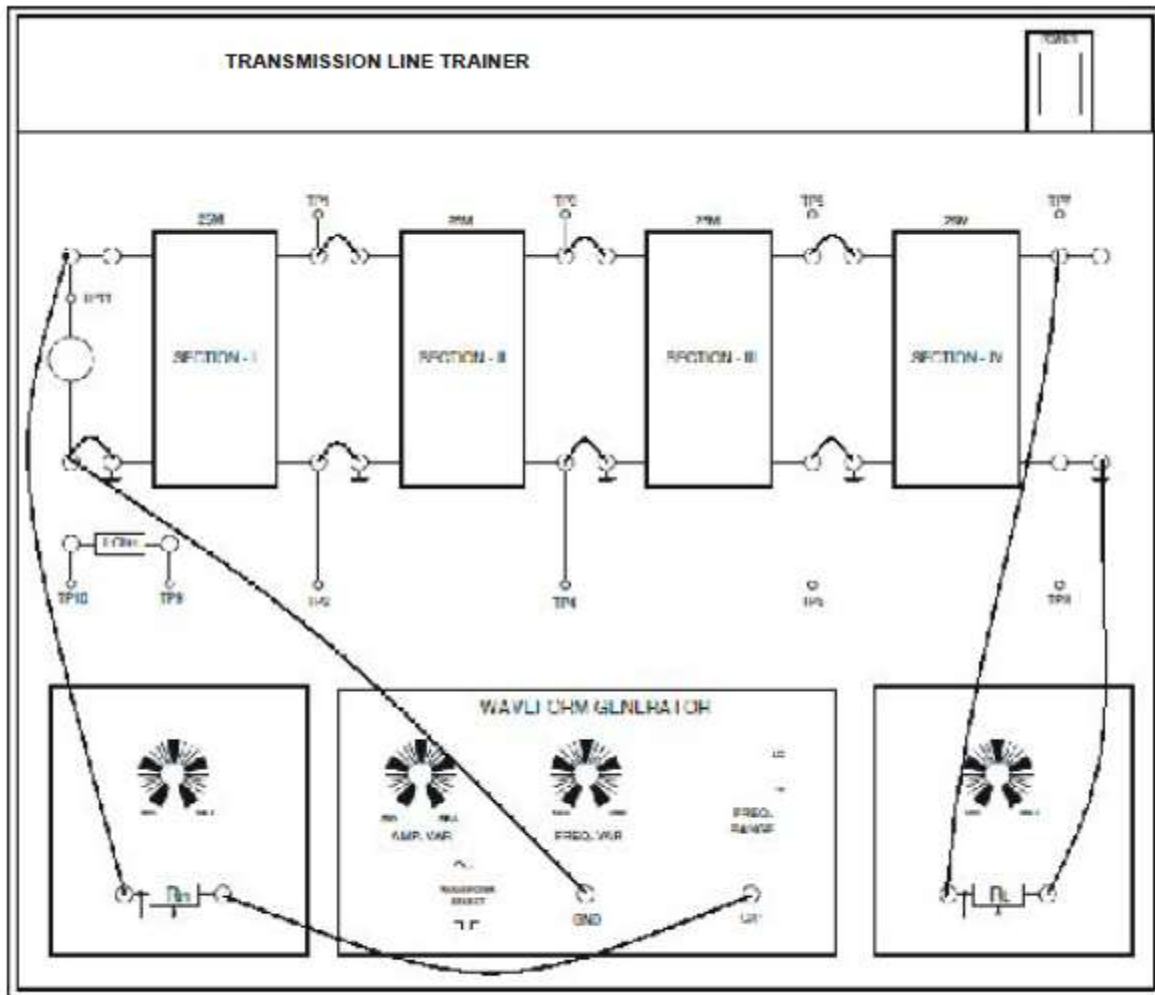
Fig. 9

Experiment 4 Measuring the Attenuation of a Line for a Open Line

Objective:
Measuring the attenuation of line.

The ohmic resistance R & the conductance G are responsible for energy dissipation in the form of heat. These losses, which determine the attenuation characteristics, are expressed in terms of "attenuation" "a" and can be calculated by:

$$a = 20 \log (V_2 / V_1)$$

Where V_1 = amplitude of signal at I/P
V_2 = amplitude of signal at O/P
a = attenuation for given length

In this experiment we will measure the attenuation for the different trunks of transmission line available on the trainer. See fig. 8

Fig. 8

Repeat the previous experiment, but this time , keep the transmission line open. And calculate the results

Length (m)	V$_1$ (input)	V$_2$ (output)
25		
50		
75		
100		

Experiment 5 Frequency Characteristic of the Line

Objective:
Frequency characteristic of the line

When the frequency of the I/P signal increases, the line attenuation due to both the ohmic resistance R and the conductance C progressively increases because of "Skin effect". Starting from a given frequency onwards, the line attenuation increases. The cut off frequency of the line is defined as the frequency at which the attenuation reaches the level of -3dB compared to the low frequency level -3dB is approximately down to 70%.

The purpose of this test is to measure the cut off frequency for the coaxial line provided in ST-2266. This measurement is performed with terminated line.
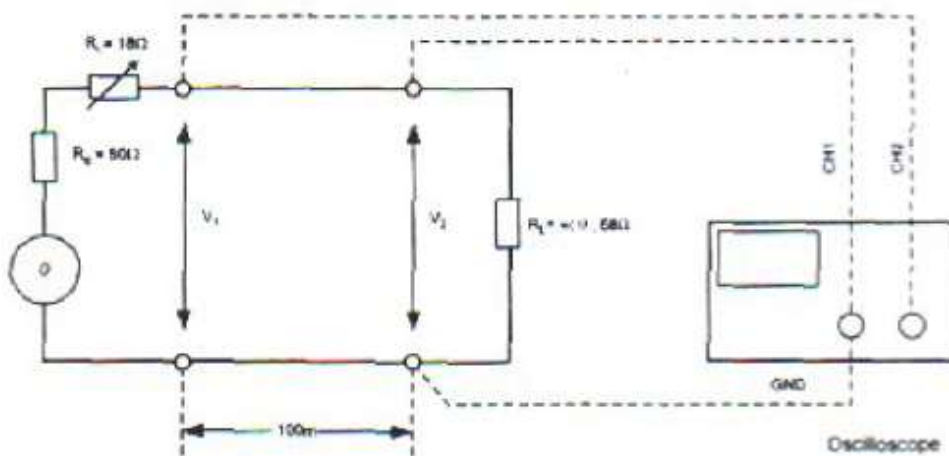
Procedure:

1.   Adjust R_i and R_L for 18Ω and 68Ω respectively with the help of DMM.
2.   Make connections as shown in Fig. 14.
3.   Set oscilloscope to 0.1V / div for both channels.
4.   Adjust the sine generator for and O/P of 0.2 V_{p-p} (2 div. deflection on CH1) and at frequency 40 KHz.
5.   At this point CH1 is reading 2 div. deflections and CH2 is reading 1.6 div. (This is due to the fix attenuation of the line)
6.   Now, vary the frequency of generator gradually keeping the input amplitude constant (observe CH 1 and maintain 2 div deflection by adjusting AMP VAR control) till the waveform at the end of 100 m line falls to -3dB (1.4 div of CH 2 on the oscilloscope).
7.   Note, the frequency on the oscilloscope. This frequency is known as the cut off frequency.
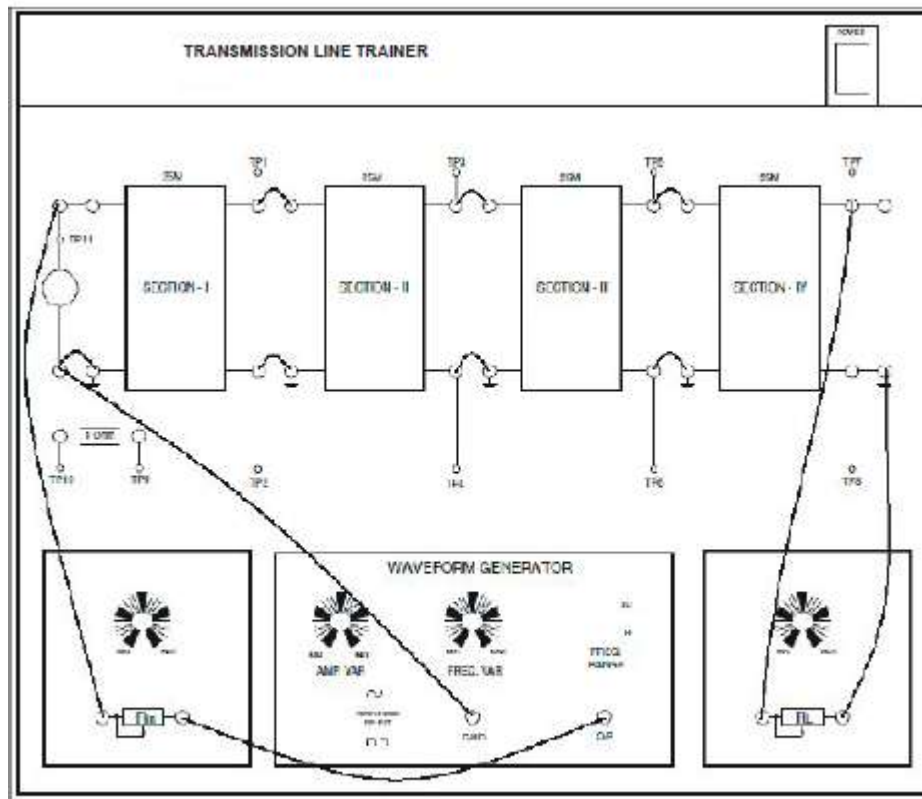
Fig. 14

For the cable used in this trainer this frequency is approximately _____ MHz.

Experiment 5 : Study of Stationary Waves

Objective:
Study of Stationary Waves

A line that has not been terminated with a load equal to its characteristic impedance is subject to a reflection phenomenon of the power from the remote end. The amount of the reflected power depends on the amount of mismatch between the characteristic impedance of the line and the load impedance. In the extreme cases of short-circuited line ($R_L = 0$) and open lie ($RL = \infty$) a situation of total reflection occur for either the current wave or the voltage wave. The purpose of this test is to study the establishment of the stationary waves within the line. See Fig. 15.

Procedure:
1.   Adjust R_i and R_L for 18Ω and 68Ω respectively with the help of DMM.
2.   Make connections as shown in Fig. 16.
3.   Set oscilloscope to 0.1 V / div for both channels.
4.   Adjust the sine generator for an O/P of $0.2V_{p-p}$ (2 div Deflection on CH 1) and at frequency 100 KHz.
5.   Observe the peak to peak voltages on CH 2 at 100 m and at intermediate sockets at 75 m, 50 m & 25 m and 0m.
6.   Tabulate results as under:

Distance	V_{p-p}
0 m	
25 m	
50 m	
75 m	
100 m	

SWR=

7. Repeat the above same experiment for different frequency

Distance	V_{p-p}
0 m	
25 m	
50 m	
75 m	
100 m	

New Frequency _____

SWR =
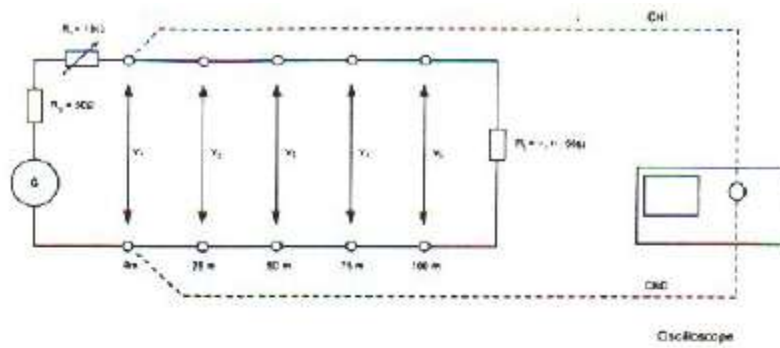
Fig. 15
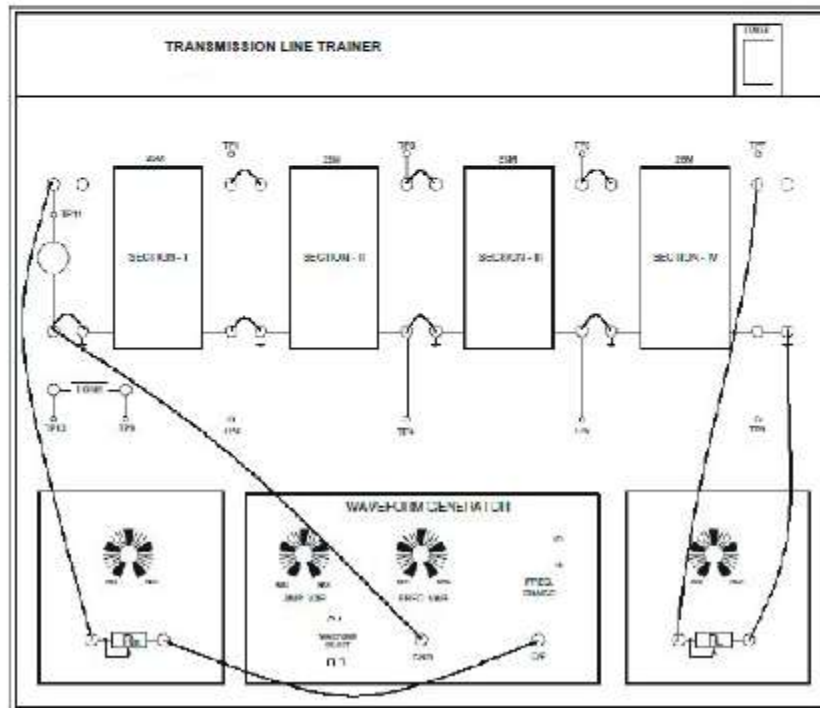
Experiment 7 : Fault Localization within the Line

Objective:
Fault localization within the line

The Localization of the faults within the line can be performed following different methods. The method shown here for performing this test is of special interest, being based upon the use of the phenomenon of the establishment of stationary waves. Let's assume that the line is broken at unknown point between two ends. If the line is connected to a signal generator, the wave will be reflected from the break point, and a stationary wave condition is established between the I/P and the breakpoint. The waves along the line have maximum and minimum points at regular intervals corresponding to ¼ of the wave-length of the I/P signal. For the fault to be pinpointed, it is necessary to determine, the frequency value at which a voltage minimum occurs at the I/P. This frequency is noted as f1. The same operation is repeated at the remote end, of broken cable, and obtaining f2 value. These values are substituted in the following formula:

$$l' = [f2 \, / \, (f1 + f2)] \times l$$

Where,
l = line length in meters
l' = distance in meters of the point of fault referred to the I/P of the line.

Procedure:

1. Make connection as shown in Fig. 20 a. Note that the line is broken at 50m length.
2. Set oscilloscope channel 1 to 0.1 V / div.
3. Adjust the sine generator for O/P of 0.4 V_{p-p} (4 div deflection on CH 1)
4. Keep the frequency variable control at the minimum position.
5. Gradually increase the frequency and note the frequency at which the signal on CRO falls to minimum. This frequency is f1.
6. Repeat the test at the other end of the line as shown in Fig. 20 b and note the Frequency at which signal on CRO falls to minimum. This is f2.
7. Enter these values in the formula and calculate the distance of break point from the I/P

For the fault generator at 50 m f1 and f2 are 900 KHz approx.
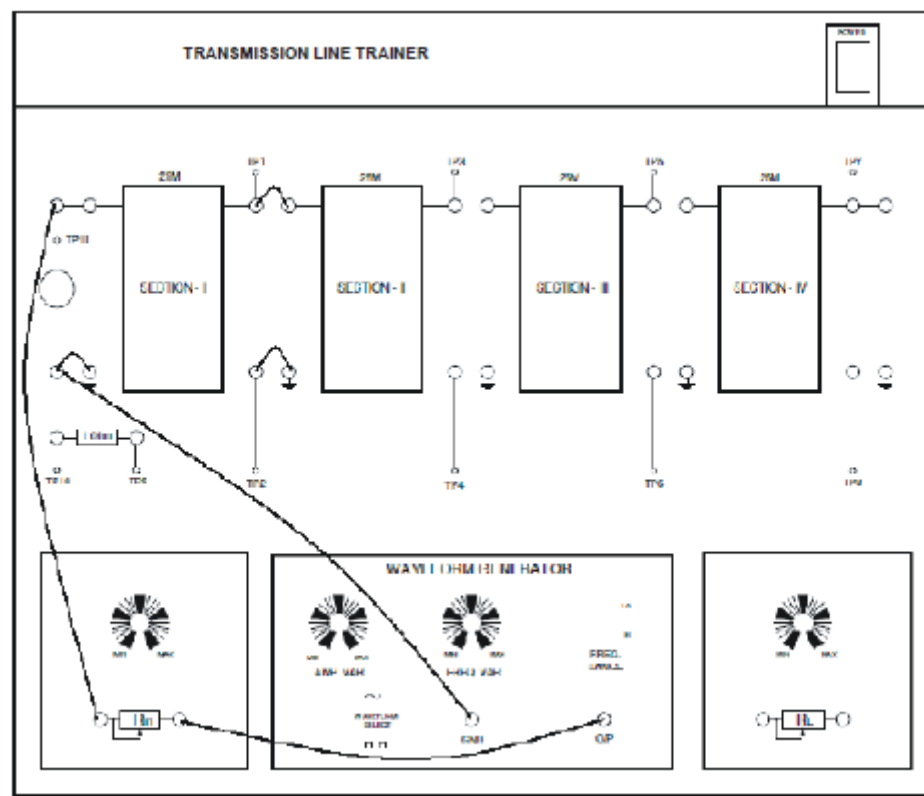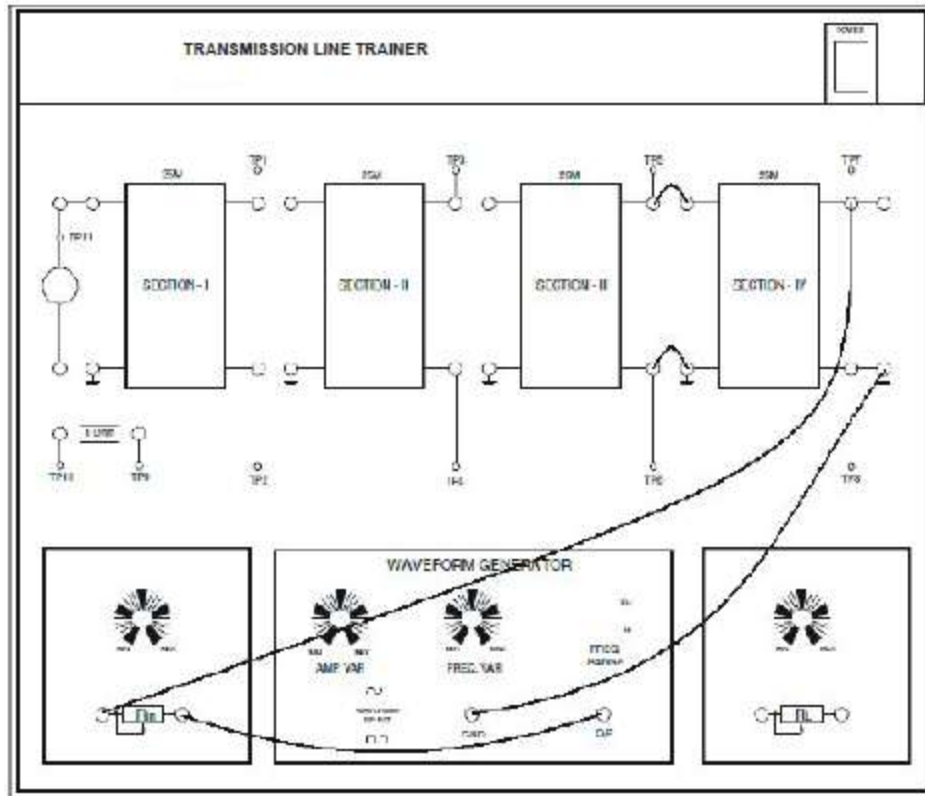
Calculations

Experiment 8 : Smith Chart Designing

Objective

To understand the construction of smith chart and plot certain points and regions on it

Question1 : What are the advantages of smith chart?

Question 2 : What are the disadvantages of smith chart

Question3 : What is normalized impedance

Question 4: Write a formula, which provides relation between impedance and reflection coefficient

Question 6 : Smith chart is drawn on which plane

Question 5: Draw Impedance plane and plot

- 24+j45   -12-32j   -22+2j
- Using a marker , highlight the area which is not valid for smith chart and provide the reason as well

Find the values for following.

Constant resistance circles				Constant Reactance Circle			
Values	Center		Radius	Values	Center		Radius
	X axis	Y axis	1/(r+1)		X axis	Y axis	1/x
R	R/(R+1)	0		X	1	1/x	
0		0		0	1		
0.5		0		0.5	1		
1		0		1	1		
2		0		2	1		
10		0		3	1		
infinity		0		4	1		

Step 1

Using the complex gamma plane, draw the above circles, Make sure to keep big scale, and use different colors for both set of circle.

Step 2

Mapping on Circle

Step 3

Draw ive image of reactance circle

Step 4

Cancel the invalid areas, and show the final result.

MAPPING POINTS ON SMITH CHART

For the following graph map General values of R in these portions
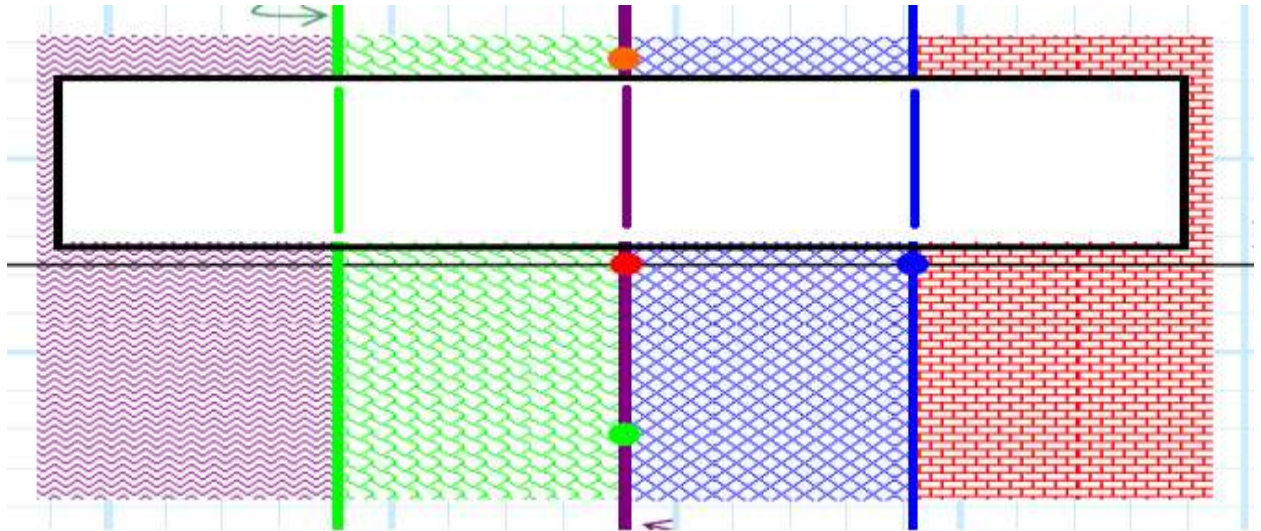
Write the Value of R , if same region above needs to be plotted in below
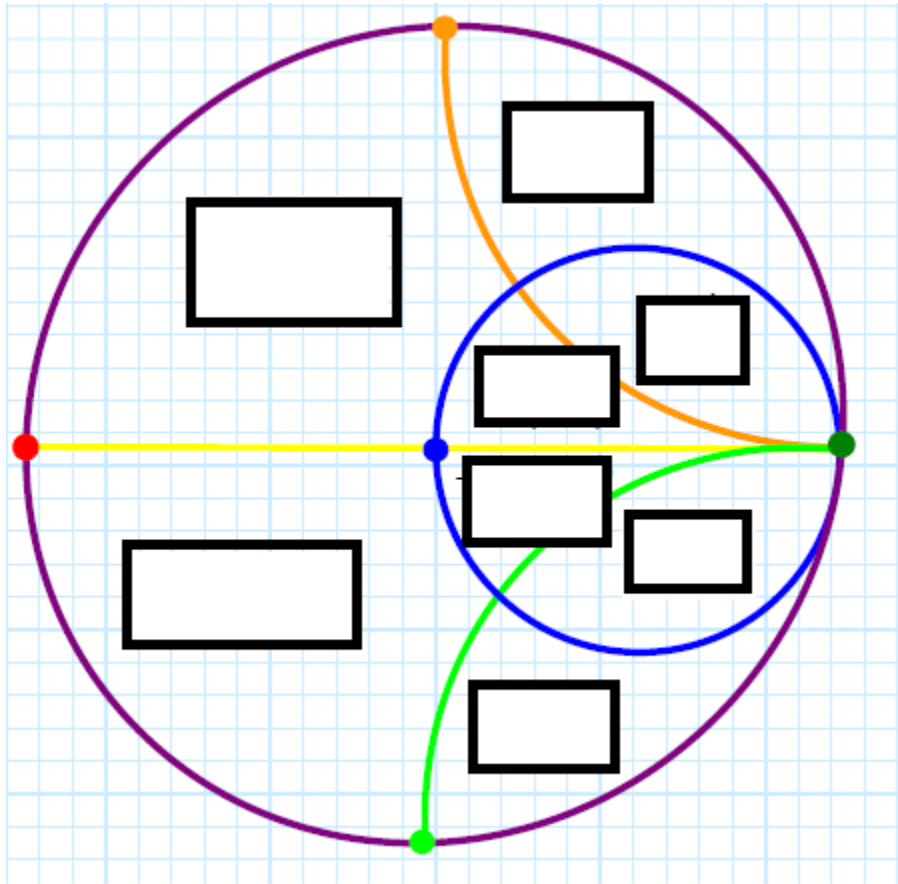

$r = 1.0$

Γ_r
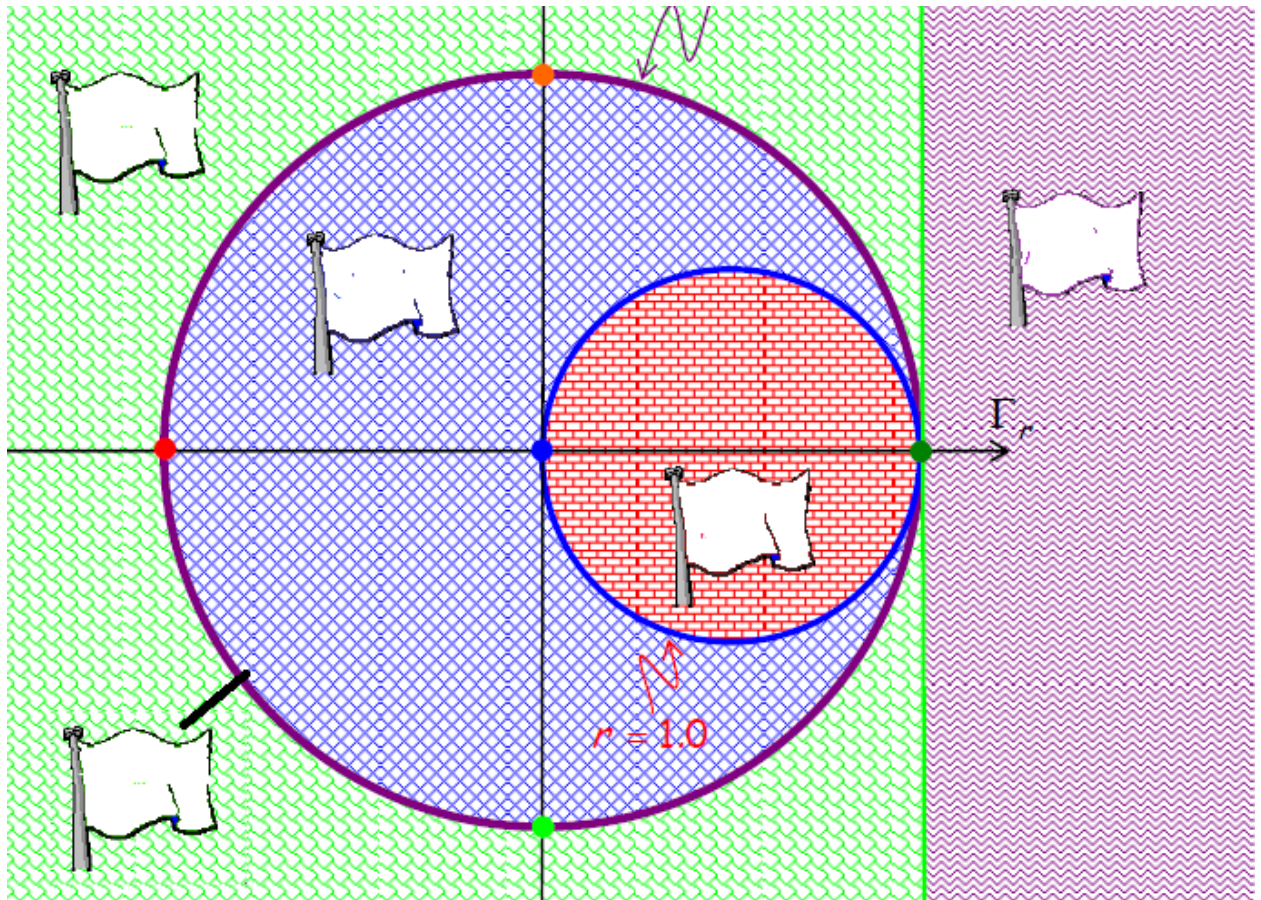
For the following graph map General values of R in these portions
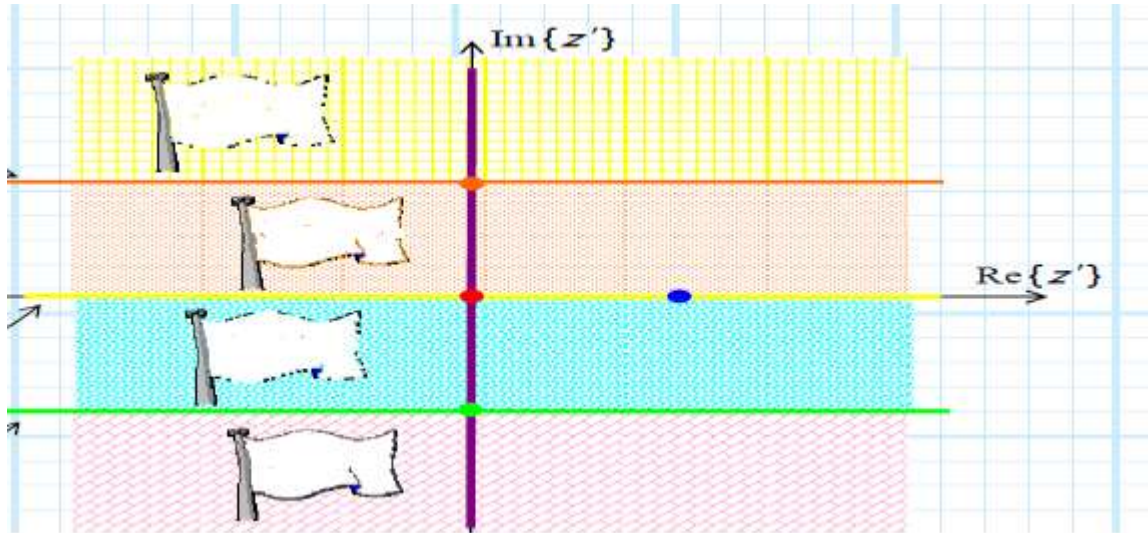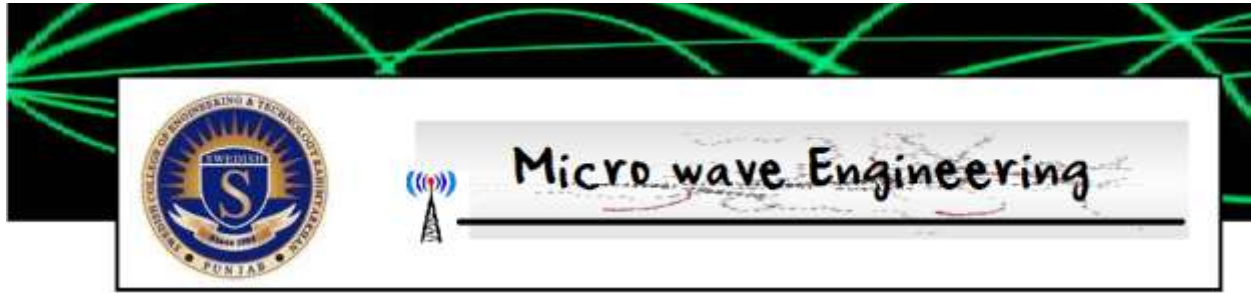

Write the Value of x , if same region above needs to be plotted in below
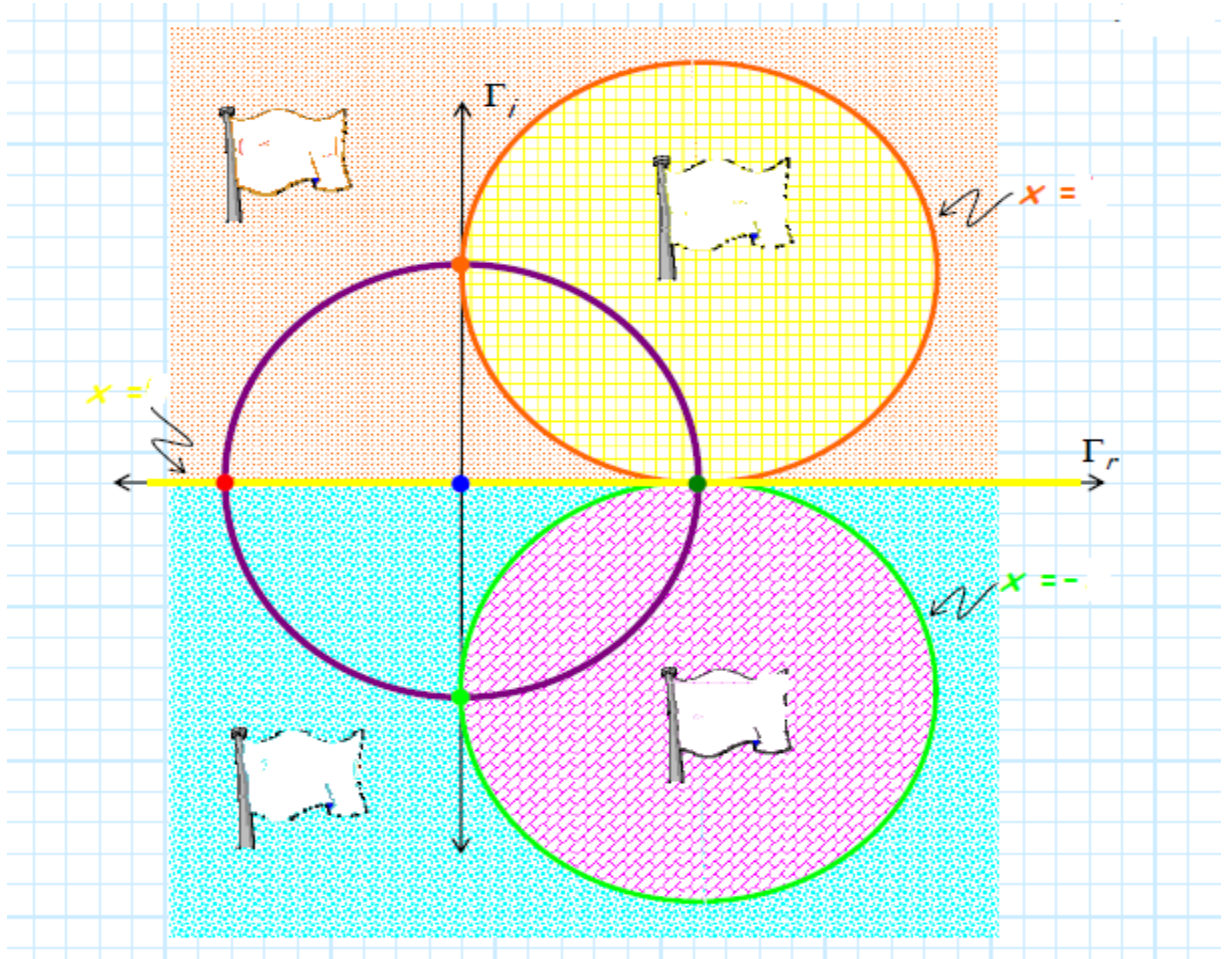
You will observe that out of all points we have plotted, we are getting a combination of 16 points, out of which 8 are valid. You are required to mark these points in graph below

Experiment 9: Understanding FK software

FK Smith-Plot is a Smith Chart plotting tool. You can observe an impedance value on a Smith Chart. It is particularly useful for studying transmission line and general microwave engineering. You can also use the software to perform graphical based impedance transformation.

Try Plotting different impedances on the software and note their values, SWR and VSWR
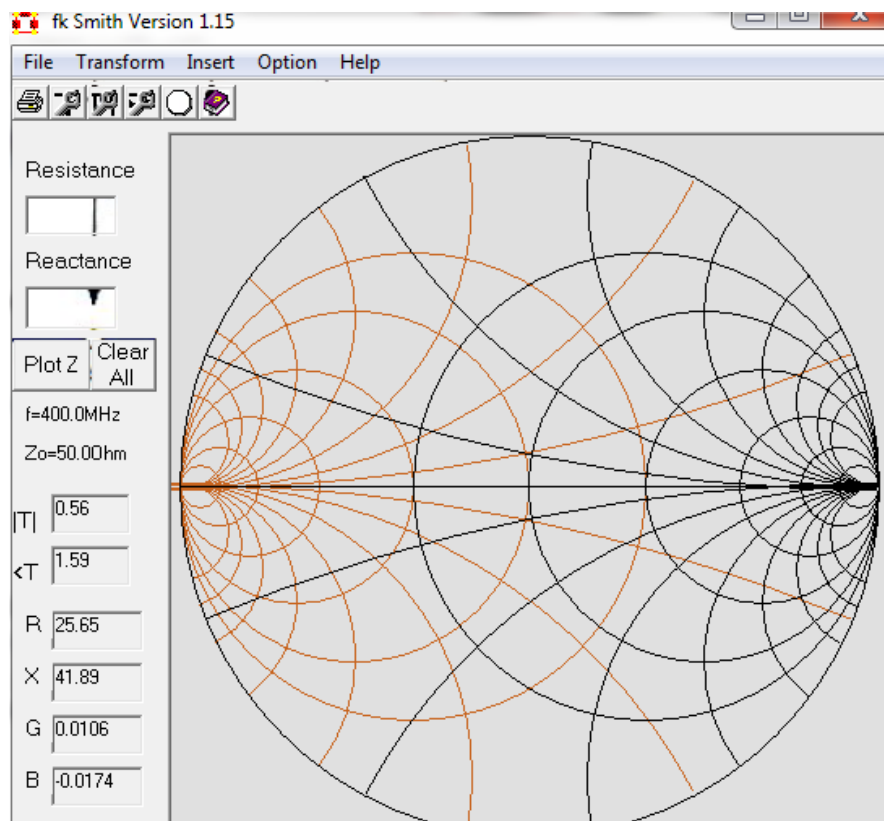
Experiment 10: Designing Attenuators FK software

Objective

To design a T attenuator on smith chart

Experiment
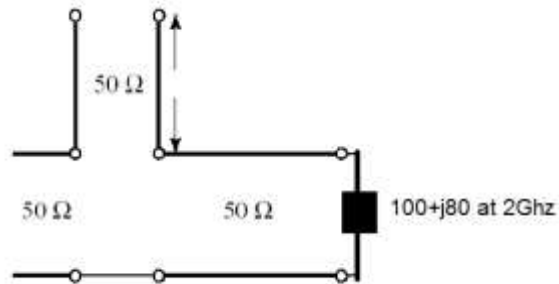
Design a T attenuator for given Values and draw their structure

Experiment 11: Designing a Stub- Series

Experiment 12: Designing a Stub- Parallel