LNCT GROUP OF COLLEGES
"WORKING TOWARDS BEING THE BEST"

Name of Student: ______________________________

Enrolment No.:______________________________

Class: ______________________________

Section: ______________________________

Session: ______________________________

LAKSHMI NARAIN COLLEGE OF TECHNOLOGY & SCIENCE
श्रद्धावान लभते ज्ञानम्

Communication Network & Transmission Lines
[EC-505] Lab Manual

Name Of Faculty:

Vision and Mission of the Department

Vision

To be world-wide recognized for adopting and keeping innovation and entrepreneurship mindset as abreast of learning to produce professionals as valuable, ethical and moral resource for industry and society.

Mission

- To establish an ecosystem where students could grow with innovative practices followed in communication engineering.
- Adopt the global approaches to transform the young aspirant into engineering professional catering the society with ethical and patriotic zeal.
- Facilitate and felicitate the learners to have close interactions with the industry experts and researchers for keeping them updated of the current and future needs of the society.
- To develop the mindset of learners for being innovative and entrepreneurial in becoming successful professional.

Program Specific Outcomes (PSO's)

- PSO1: To analyze, design and develop solutions of real time problems and industry needs.
- PSO2: Ability of effectively communicating with the professionals and preparation of reports, documents and presentation while working in teams.
- PSO3: Knowledge and understanding of latest developments in the field of VLSI, Embedded system, Networking, Matlab and other major tools necessary for keeping pace with the industry.
- PSO4: Ability of solving complex engineering problems with ethical and law full approach to prevent the society and environment from adverse impacts.

Program Educational Objectives (PEO's)

Student will be able to

1. The graduate will have the knowledge and skills of analog and digital communication in providing necessary solutions to the real world problems.
2. The graduate will be able to design, develop, analyze and implement the modern tools and systemsinvolving principles of electronics and telecommunication engineering.
3. The graduate will be following the ethical practices of the core industry and supporting software industry in providing most acceptable solution to the society.
4. The graduate will have the innovative mindset of learning and implementing the latest technological advancements and research outcomes in the electronic hardware and software to keep pace with the rapiddevelopmentsin socio economic world.

Code of Conducts for the Laboratory

- All bags must be left at the indicated place.
- The lab timetable must be strictly followed.
- Be **PUNCTUAL** for your laboratory session.
- Noise must be kept to a minimum.
- Workspace must be kept clean and tidy at all time.
- Handle the experiment kit and interfacing its with care.
- All students are liable for any damage to the accessories due to their own negligence.
- Students are strictly **PROHIBITED** from taking out any items from the laboratory.
- Students are **NOT** allowed to work alone in the laboratory without the Lab Supervisor
- Report immediately to the Lab Supervisor if any malfunction of the accessories, is there.
- Before leaving the lab Place the stools properly.
- Please check the laboratory notice board regularly for updates.

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Name of Student:_Enrolment No.:__

Sl. No.	Title of the Experiment	Date of Experiment	Date of Submission	Remark
1	To study the Gain response of K Derived T Low-Pass Filter			
2	To study the Gain response of K Derived T High-Pass Filter			
3	Study of the Gain response of m-derived Low Pass Filter			
4	Study of the Gain response of m-derived High Pass Filter			
5	Study of the Gain response of Tschebyscheff Low-Pass Filter			
6	Study of the Gain Response of Tschebyscheff High-Pass Filter			
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8	Measuring the input impedance of the line.			
9	Measuring the attenuation of line.			
10	Fault localization within the line.			

Experiment 1

Objective:

To study the Gain response of K Derived T Low-Pass Filter

Equipment's Needed:

1. Analog board **AB49**.
2. Function Generator **ST4060**.
3. Oscilloscope.
4. 2mm patch chord

Theory:

Constant K-derived filter:

In this filter, the series and shunt impedance are such that, $Z_1 Z_2 =$

$$R_o^2 = K \text{ (constant)}$$

Where, R_o is a real number independent of frequency. It is conventionally known as design impedance of the section. Any filter, where this relationship is maintained is known as Constant K or Prototype filter figure 1 represents the T and **π** configuration of typical passive filter.

Low Pass filters:

It is the simplest type of filter which allows all frequencies, up to the specific cutoff frequencies, to pass through it and attenuates all other frequencies above cutoff frequencies. Figure 3 represents the configuration of low pass filter. Low pas filter has inductor in series and capacitor in shunt arm, at lower frequencies the impedance of inductor (**ω**L) is very low and impedance of capacitor (1/**ω**C) is very high so series arm behaves as a short and shunt arm behave as an open terminal. Thus, the output is equal to input at lower frequencies. But as the frequency increases the value of impedance of inductor increase and capacitor decreases due to that output start decreasing from its constant value. At very high frequency the series arm behaved like an open circuit; which, results as zero output i.e.($V_{out} = 0$).

Cutoff frequency of low pass filter is

$$fc = 1/ \pi \sqrt{(LC)} \qquad \text{.........(1)}$$

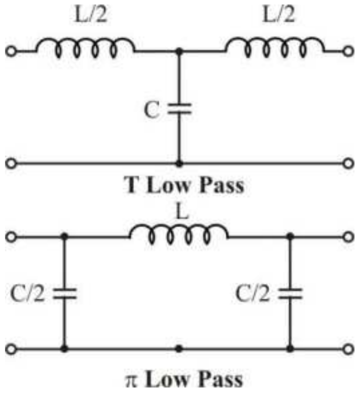


Fig.1 T and πconfiguration of LPF

And, design impedance

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

$$\text{Gain (db)} = 20 \log | V_{out} / V_{in} | \text{ i.e.}$$

Gain Roll off rate is –20db / decade.

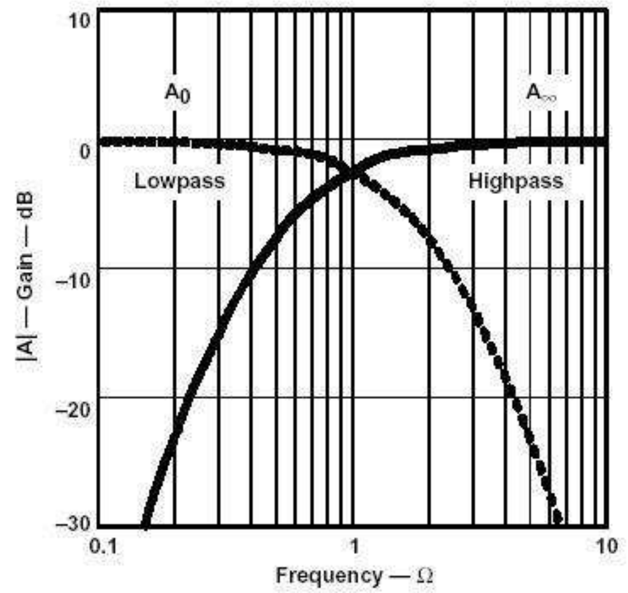
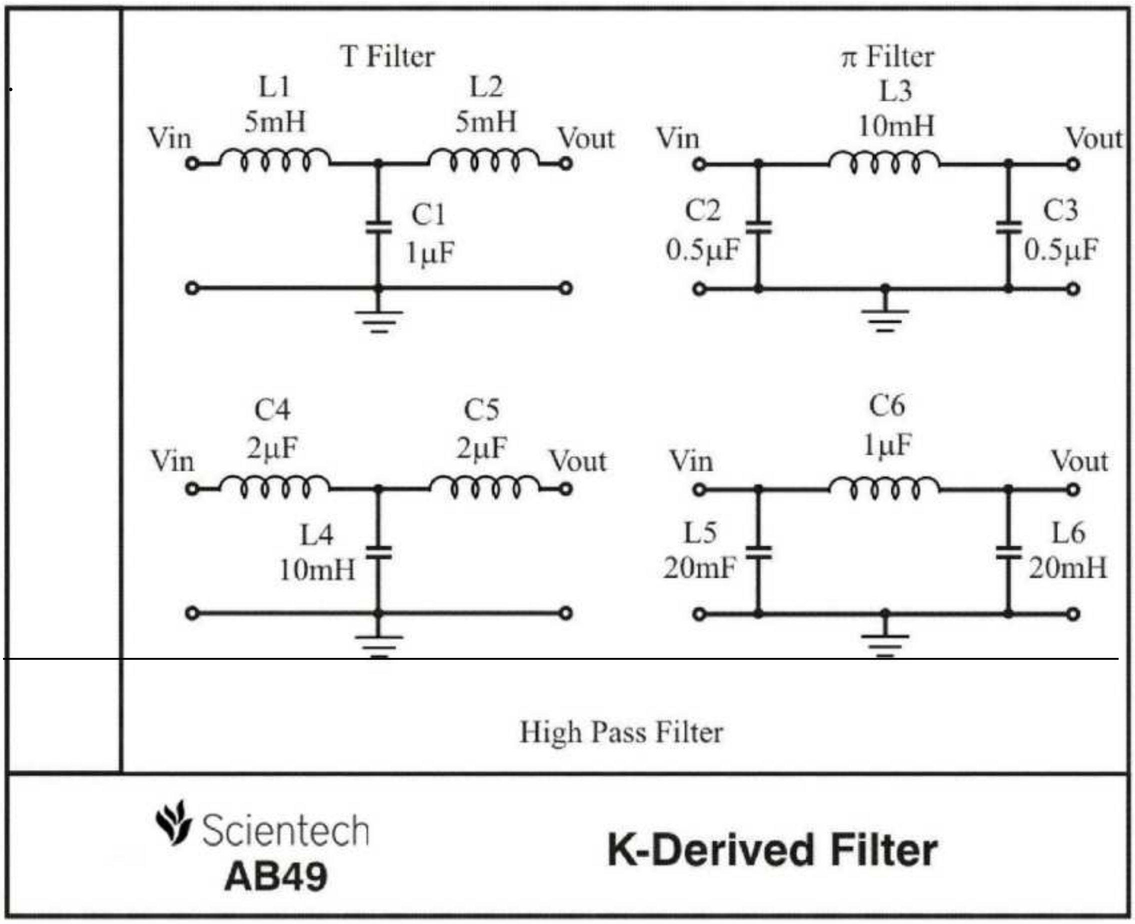


Fig. 2 Gain Response of low-Pass Filter& High-Pass Filter

Circuit diagram:

Circuit used to study the Gain response of K Derived T Low-Pass Filter is shown below



Procedure:

- Connect function generator at V_{in} of K Derive T Low-Pass Filter **AB49** board and observe the input amplitude on oscilloscope CH I.

1. Set the value of function generator at $4V_{p\text{-}p}$, 100Hz Sine wave signal.
2. Observe the output waveform between points V_{out} on oscilloscope CH II.
3. Calculate the Voltage Gain ($A_V = V_{out} / V_{in}$) and gain in db.
4. Repeat the process for various frequency ranges up to 100 KHz and plot the graph between frequency and gain (db).
5. Note the value of frequency for which there is -3db gain, this frequency is known as cut off frequency, or the frequency at which, output voltage $V_{out} = 0.707\ V_{in}$.
6. Calculate the cutoff frequency by Equation 1 and determine the difference between real and measure cutoff frequency.
7. Calculate the Bandwidth of T Low-Pass Filter.

Note:

The cutoff frequency of low pass filter, when L is 10mH and C is 1 µF is 3.14 KHz.

Result:

Cut off frequency of K Derive T Low-Pass Filter f_c = …………………..

Bandwidth of K Derive T Low-Pass Filter = ……………………………

Experiment 2

Objective:

To study the Gain response of K Derived T High-Pass Filter

EquipmentsNeeded:

1. Analog board **AB49**.
2. Function Generator **ST4060**.
3. Oscilloscope.
4. 2mm patch chords.

Theory:

High Pass filters:

A high pass filter is reverse of a low pass filter. This filter attenuates all frequency below cutoff frequency and allows passing all other frequency above cutoff frequency. Figure 4 represents the configuration of low pass filter. A high pass filter is consisting of capacitor in series and inductor in shunt arm, at lower frequencies the impedance of capacitor ($1/\omega C$) is very high and impedance of inductor (ωL) is very low so series arm behaves as an open terminal and shunt arm behave as an short. Thus, the output is zero at lower frequencies. But as the frequency increases the value of capacitor impedance decreases and inductor increase due to that output start increasing from its zero value. At very high frequency the series behave like a short and shunt arm behaved like an open terminal which results as output equal to input i.e. ($V_{out} = V_{in}$).

Cutoff frequency of low pass filter is

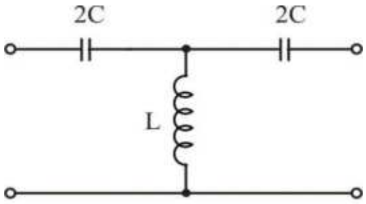
$$fc = 1/\, 4\, \pi\, \sqrt{}\,(LC) \qquad \text{............(1)}$$

And design impedance

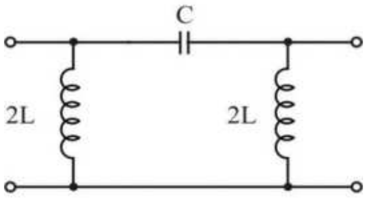
$$R_O = \sqrt{}L/C$$

$$\text{Gain (db)} = 20 \log |\, V_{out} / V_{in}$$

i.e. Gain Roll off rate is –20db / decade.



T High Pass

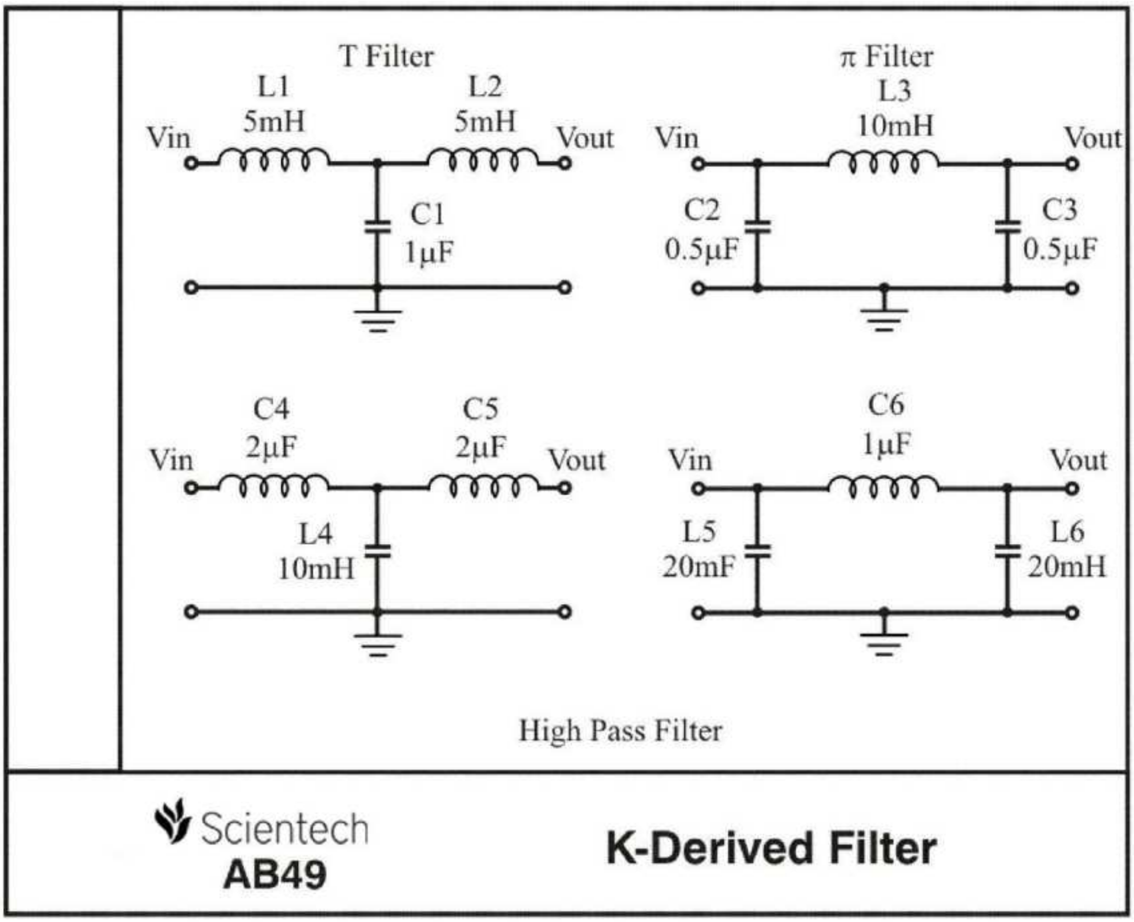


π High Pass

Fig.1 T and configuration of HPF

Circuit diagram:

Circuit used to study the Gain response of K Derived T High-Pass Filter is shown below.



Procedure:

- Connect function generator at V_{in} of K Derive T High-Pass Filter **AB49** board and observe the input amplitude on oscilloscope CH I.

1. Set the value of function generator at $4V_{p-p}$, 100Hz Sine wave signal.
2. Observe the output waveform between points V_{out} on oscilloscope CH II.
3. Calculate the Voltage Gain ($A_V = V_{out} / V_{in}$) and gain in db.
4. Repeat the process for various frequency ranges up to 100 KHz and plot the graph between frequency and gain (db).
5. Note the value of frequency for which there is -3db gain, this frequency is known as cut off frequency, or the frequency at which, output voltage $V_{out} = 0.707\ V_{in}$.
6. Calculate the cutoff frequency by Equation 1 and determine the difference between real and measure cutoff frequency.
7. Calculate the Bandwidth of T High-Pass Filter.

Note:

The cutoff frequency of high pass filter, when L is 10mH and C is 1 μF is 796 Hz. For ideal high pass filter the bandwidth is infinity, but for practical condition it is impossible to achieve.

Result:

Cut off frequency of K Derive T High-Pass Filter f_c = ……………

Bandwidth of K Derive T High-Pass Filter = ………………

Experiment 3

Objective:

Study of the Gain response of M-derived Low Pass Filter

EquipmentsNeeded:

1. Analog board **AB48**.
2. Function Generator **ST4060**.
3. Oscilloscope.
4. 2mm patch chords.

Theory:

M derived filter: there are two disadvantages of the constant K derived filters-

1. The attenuation does not increase rapidly beyond cut off frequencies(j)
2. Characteristic impedance varies widely in the pass band from the desired value.

In order to overcome these disadvantages of constant K filters a special type of filter called m-derived filter, has been implemented. An m-derived filter is a filter that mostly removes these two disadvantages here it is possible to design a filter to have a same impedance throughout the pass band and stop band like prototype(or K derived) filter, but with a different degree of attenuation outside the pass band. In the m derived filter, it becomes possible to get very rapid attenuation rise in the stop band and just beyond the cut –off frequency. However, it falls to provide constant characteristic impedance over the entire pass band.

The prototypes sections are identical to that of the m-derived sections except the series arm at T-section is multiplied by m and shunt arm of **Π** sections are divided by m. In case of m-derived filters 'm' is a constant whose value is to be determined. The constant 'm' has been assumed to be less than 1 but greater then 0.

For m-derived T-section low pass filter f_c is given by the relation

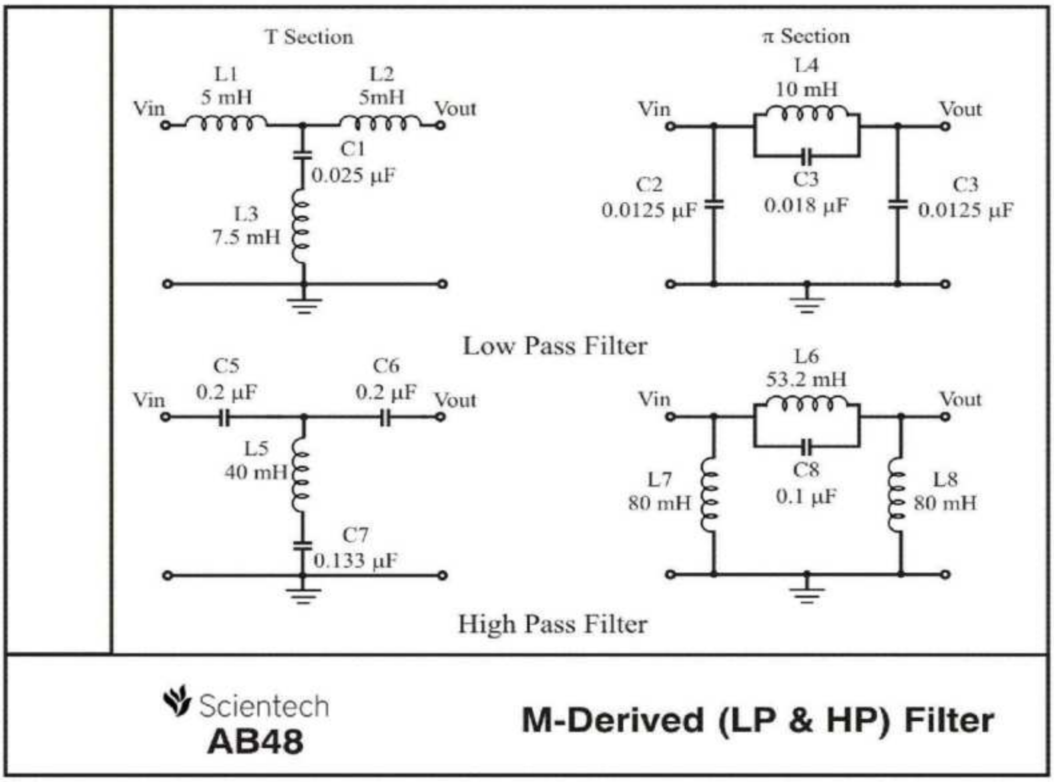
$F_c = 1/\pi\sqrt{LC}$

And for m-derived high pass is fc is given by relation

$F_c = 1/4\pi\sqrt{LC}$

Circuit diagram:

Circuit used to study the Gain response of m-derived band pass filter is shown below.



Procedure:

1. Connect function generator at V_{in} of m-derived low pass filter **AB48** board and observe the input amplitude on oscilloscope CH I.
1. Set the value of function generator at $3V_{p\text{-}p}$, 100Hz Sine wave signal.
2. Observe the output waveform between points V_{out} on oscilloscope CH II.
3. Calculate the Voltage Gain ($A_{V}=V_{out} / V_{in}$) and gain in dB.
4. Increase the frequency with the margin of 500Hz up to 100 KHz and calculate the gain (dB).
5. Note the value of frequency for which there is +3db gain, this frequency is known as cut off frequency, or the frequency at which, output voltage $V_{out} = 0.707\ V_{in}$.
6. Calculate the bandwidth of m-derived band pass filter.

Note:

When L is 20 mH and C is 0.05 μF the value of cutoff frequency of a low pass filter is 10 KHz.

Result:

Cut off frequency of m- derived low pass filter fc = ...

Experiment 4

Objective:

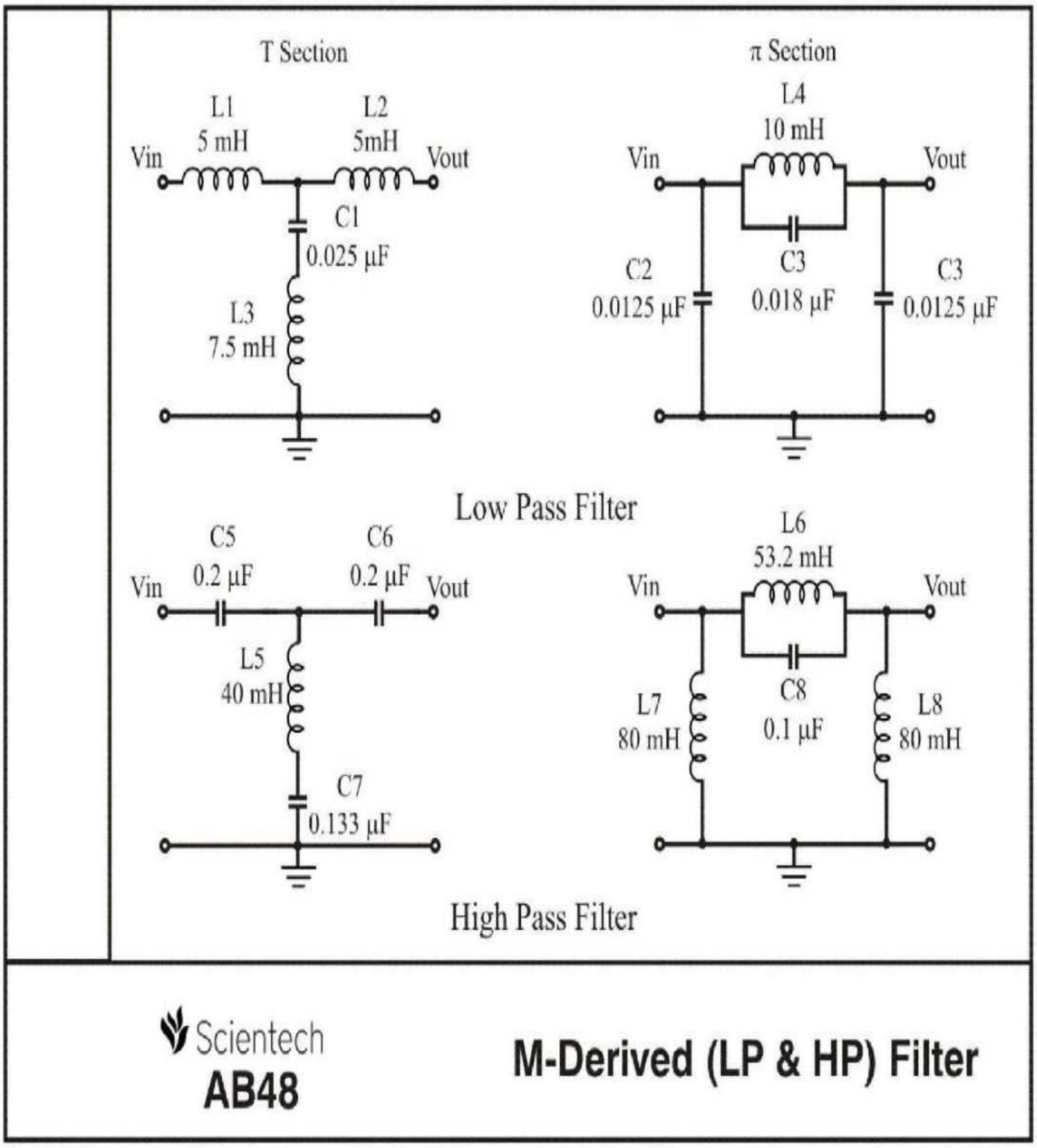
Study of the Gain response of m-derived High Pass Filter

EquipmentsNeeded:

1. Analog board **AB48**.
2. Function Generator **ST4060**.
3. Oscilloscope.
4. 2mm patch chords.

Circuit diagram:

Circuit used to study the Gain response of m-derived high pass filter is shown below.



Procedure:

- Connect function generator at V_{in} of m-derived high pass filter **AB48** board and observe the input amplitude on oscilloscope CH I.

1. Set the value of function generator at $3V_{p-p}$, 100Hz Sine wave signal.
2. Observe the output waveform between points V_{out} on oscilloscope CH II.
3. Calculate the Voltage Gain ($A_V = V_{out} / V_{in}$) and gain in dB.
4. Increase the frequency with the margin of 100Hz up to 100 KHz and calculate the gain (dB).
5. Note the value of frequency for which there is 3db gain, this frequency is known as cut off frequency, or the frequency at which, output voltage $V_{out} = 0.707\ V_{in}$.
6. Calculate the cutoff frequency,determines the difference between real and measure cutoff frequency.
7. Calculate the Bandwidth of m-derived high pass filter.

Note:

When L is 20 mH and C is 0.05 µF the value of cut off frequency of high pass filter is 2.5 KHz.

Result:

Cut off frequency of m-derived high pass filter fc = ……………..

Experiment 5

Objective:

Study of the Gain response of Tschebyscheff Low-Pass Filter

Equipments Needed:

1. Analog board **AB54**.

2. DC power supplies +12V and -12V from external source or **ST-2612 Analog Lab**.

3. Function Generator **ST-4060**.

4. Oscilloscope.

5.2mm patch chords.

Theory:

Low Pass Filter : It is a frequency selective circuit, which passes signals of frequency below it's high cut off frequency (f_H) and attenuates signals of frequency above f_H The ideal low pass filter has a constant gain A_F from 0 to high cut off frequency (f_H) at f_H the gain is 0.707 * A_F. And after f_H it decreases at a constant rate with an increase in frequency **i.e**. when input frequency is increased tenfold (one decade), the voltage gain is divided by 10.

$$\text{Gain (db)} = 20 \log | V_{out} / V_{in} |$$

i.e. Gain Roll off rate is –20db / decade.

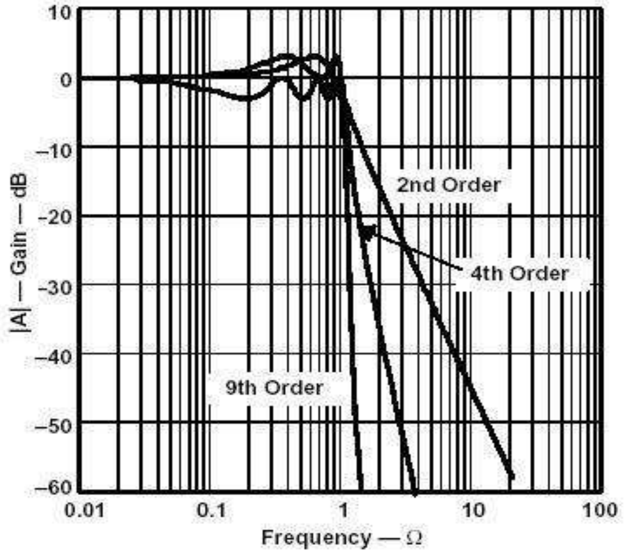
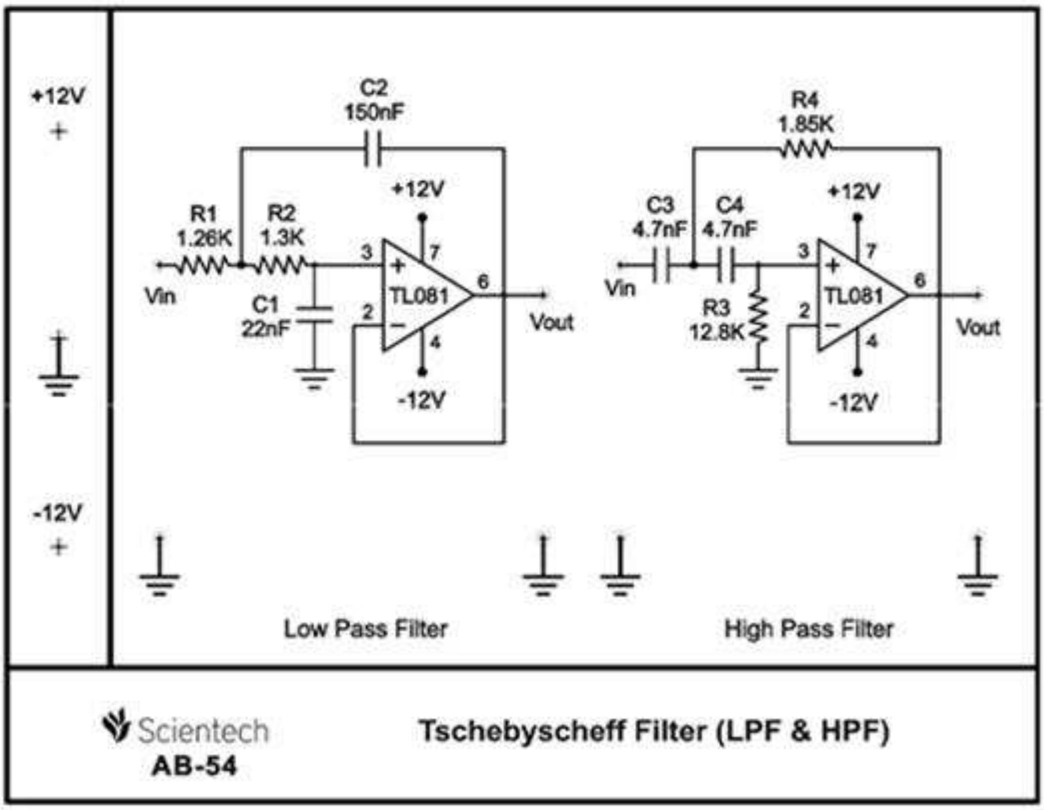


Fig. Gain Responses of Tschebyscheff Low-Pass Filters

Circuit Diagram:

Circuit used to study theGain response of Tschebyscheff Low -Pass Filter is shown below:



Procedure:

•Connect +12V and -12Vvariable dc power supplies at their indicated position from external source or **ST2612 Analog Lab**.

1.Connect $2V_{p-p}$, 100Hz Sine wave signal at the input (between points V_{in} and gnd) of Tschebyscheff Low-Pass Filter **AB54** board (with unity gain) and observe the same on oscilloscope CH I.

2. Observe the output waveform between points $V_{out}$and gnd. on oscilloscope CH II.

3. Calculate the Voltage Gain ($A_{V=}V_{out}/ V_{in}$) and gain in db.

4. Repeat the process for various frequency range up to 3KHz and plot the graph between frequency and gain (db).

5. Note the value of frequency for which there is +3db passband ripple.

6. Note the value of frequency for which there is -3db gain, this frequency is known as cut off frequency.

7. Calculate Bandwidth of Tschebyscheff Low-Pass Filter .

Result:

Cut off frequency of Tschebyscheff Low-Pass Filter f_c = …………………..

3db passband ripple frequency =…………………..
Bandwidth of Tschebyscheff Low-Pass Filter =…………………

Experiment 6

Objective:

Study of the Gain Response of Tschebyscheff High-Pass Filter

Equipments Needed:

1. Analog board **AB54**.

2. DC power supplies +12V and -12V from external source or **ST2612 Analog Lab**.

3. Function Generator **ST4060**.

4. Oscilloscope.

5.2mm patch chords.

Theory:

High Pass Filter:

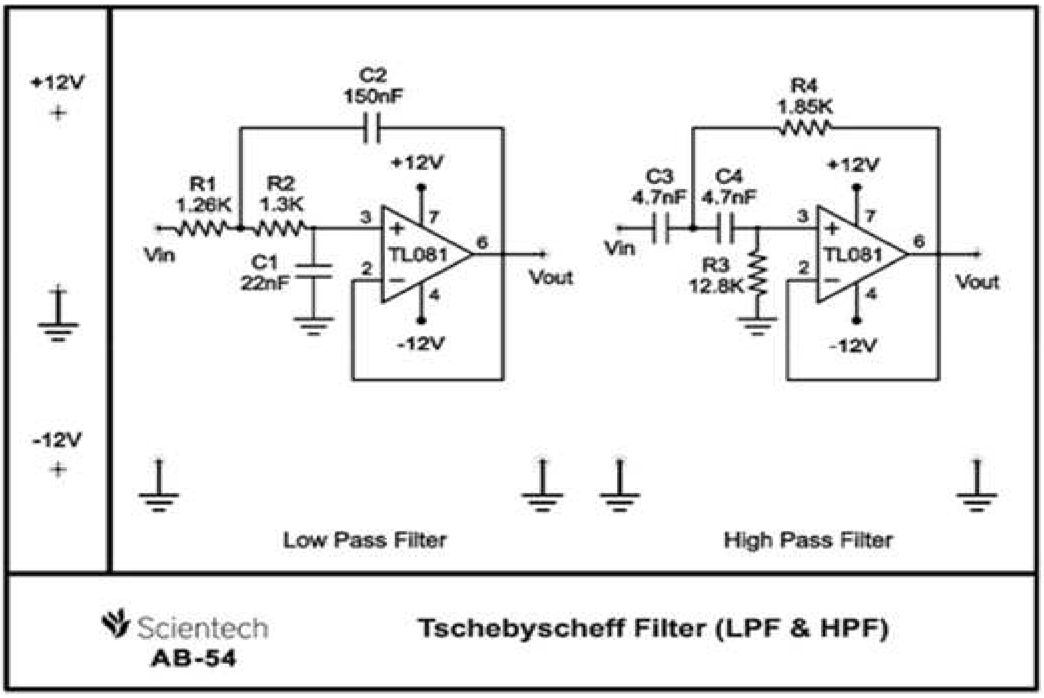
It is a frequency selective circuit, which passes signals of frequencies above it's low cut off frequency (f_L) and attenuates signals of frequencies below f_L.In ideal high pass filter, when $f < f_L$ gain is increased at a constant rate has a constant rate with an increase in frequency. At f_L the gain is $0.707 * A_F$. And above f_L it has constant gain of A_F. Below f_L when input frequency is increased tenfold (one decade), the voltage gain is multiplied by 10.

$$\text{Gain (db)} = 20 \log | \text{Vout} / \text{Vin} |$$

i.e. Gain Roll off rate is –20db / decade.

Circuit Diagram:

Circuit used to study the Gain Response of Tschebyscheff High-Pass Filter is shown below:



Procedure:

•Connect +12V and -12V variable dc power supplies at their indicated positionfrom external source or ST2612 Analog Lab.

1.Connect $2V_{p-p}$, 3KHz Sine wave signal at the input (between points V_{in} and gnd)of Tschebyscheff High-Pass Filter AB54 board(with unity gain) and observe thesame on oscilloscope CH I.

2.Observe the output waveform between points $V_{out}$and gnd. on oscilloscope CHII.

3.Calculate the Voltage Gain ($A_{V=}V_{out}/ V_{in}$) and gain in db

4.Repeat the process for various frequency range up to 1MHz and plot the graphbetween frequency and gain (db).

5.Note the value of frequency for which there is +3db passband ripple.

6.The frequency range for which the output amplitude is 3dB down the unity gain(this will give two valves of frequency f_L and f_H, the lower 3dB frequency and higher 3dB frequency respectively)

7. Calculate Bandwidth of Tschebyscheff High-Pass Filter.

Note: For ideal high pass filter the bandwidth is infinity, but for practical condition it is impossible to achieve.

Result:

Cut off frequency of Tschebyscheff High-Pass Filter fc=…

3db passband ripple frequency =…………………..

Bandwidth of Tschebyscheff High-Pass Filter =…………………

Experiment 7

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 a cascade of line 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 figure1.
R = ohmic resistance for unit length (100m in this trainer)

L = inductance for unit length

G=conductance
C = capacitance for unit length

The transmission characteristics of a line are described in terms of propagation. Constant g 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. shows the modalities for the measurement to be performed.

2. Make connections as in figure 4.

3. Both the inductance and the ohmic resistance of the line are measured in seriesby short-circuiting end of the line and connecting the measuring instruments to the start of the line. The capacitance and the conductance are measured in parallel by operating on the open line.

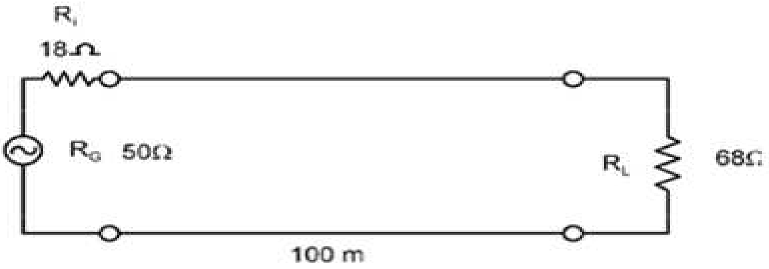
4. The resistance R and the conductance G can be measured with an ohmmeter orDMM. For the conductance to be measured an ohmmeter is required which is able to perform resistance measurements with a range greater than 100 MW.

5. For the measurement of series inductance L and the parallel capacitance C, a

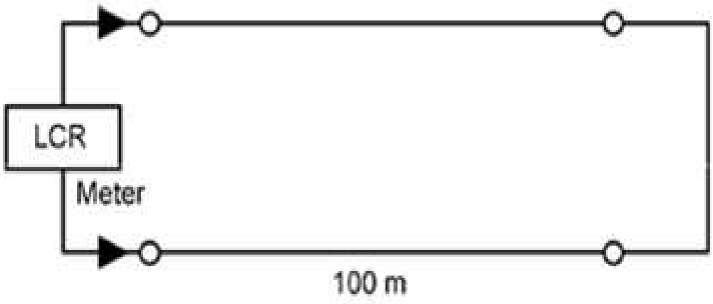
LCR meter or measuring bridge is required. The results of these measurements give values of R, L, C and G referred to the cable length that, in our case, is of 100 meters.

Z_0 can be measured by using the following formula:

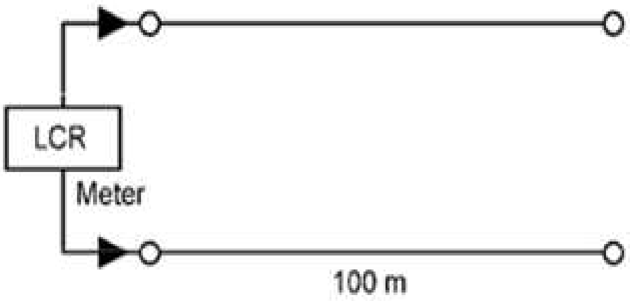
$Z_0 = \sqrt{(L/C)}$



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

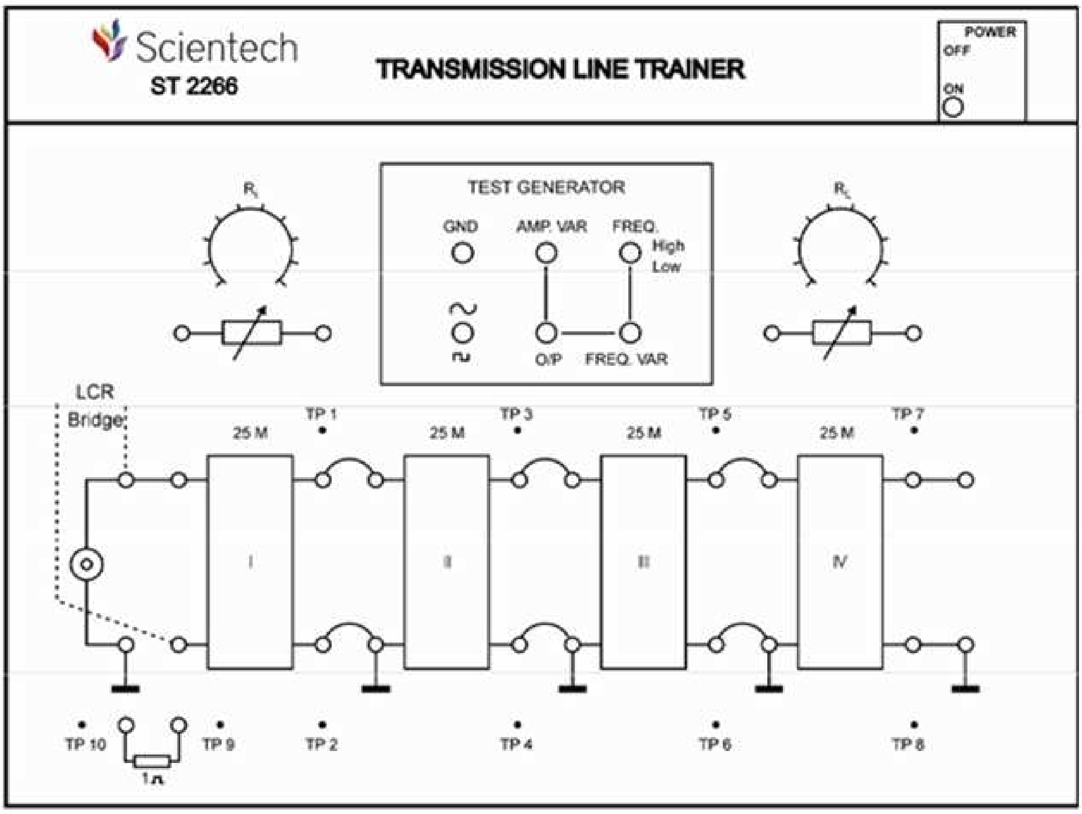


Fig. Transmission Line Trainer

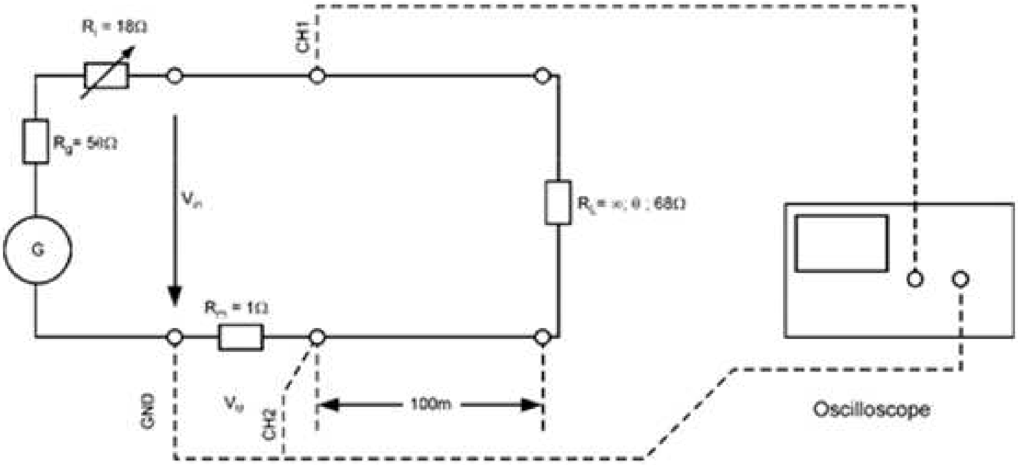
Experiment 8

Objective: Measuring the input impedance of the line.

Theory: The input impedance of the line depends on features like the ohmic resistance, the conductance, the inductance and the capacitance. It is also related to the resistance that loads the line at the opposite end and to both the frequency and voltage of the signal. The purpose of the first part of the test is to measure the input impedance of the line under different load conditions:

1. Line terminated with matched load
2. Open line
3. Short-circuited line.

In the second part of thetest, we will measure the phase displacement between the input voltage and current, under the 3 conditions of line termination. When the modulus and the phase displacement are known the impedance vector is fullyidentified.



Procedure:

1. Adjust R_i and R_L for 18W and 68W respectively with the help of DMM.
2. Make the connections as shown in figure 7.
3. A 1W resistance in series between the generator and the transmission line as Shown, in figure 12 allows to measure the value of input current.
4. Set the input at $0.4_{p\text{-}p}$ and freq 100 KHz of sine-wave (both measurement onCRO).
5. Take readings of V_{in} and V_m (across 1W) on oscilloscope.
6. Calculate the input impedance according to the following formula:

$$Z_{in} = V_{in} / I = V_{in} / V_m \infty\ 1\Omega$$

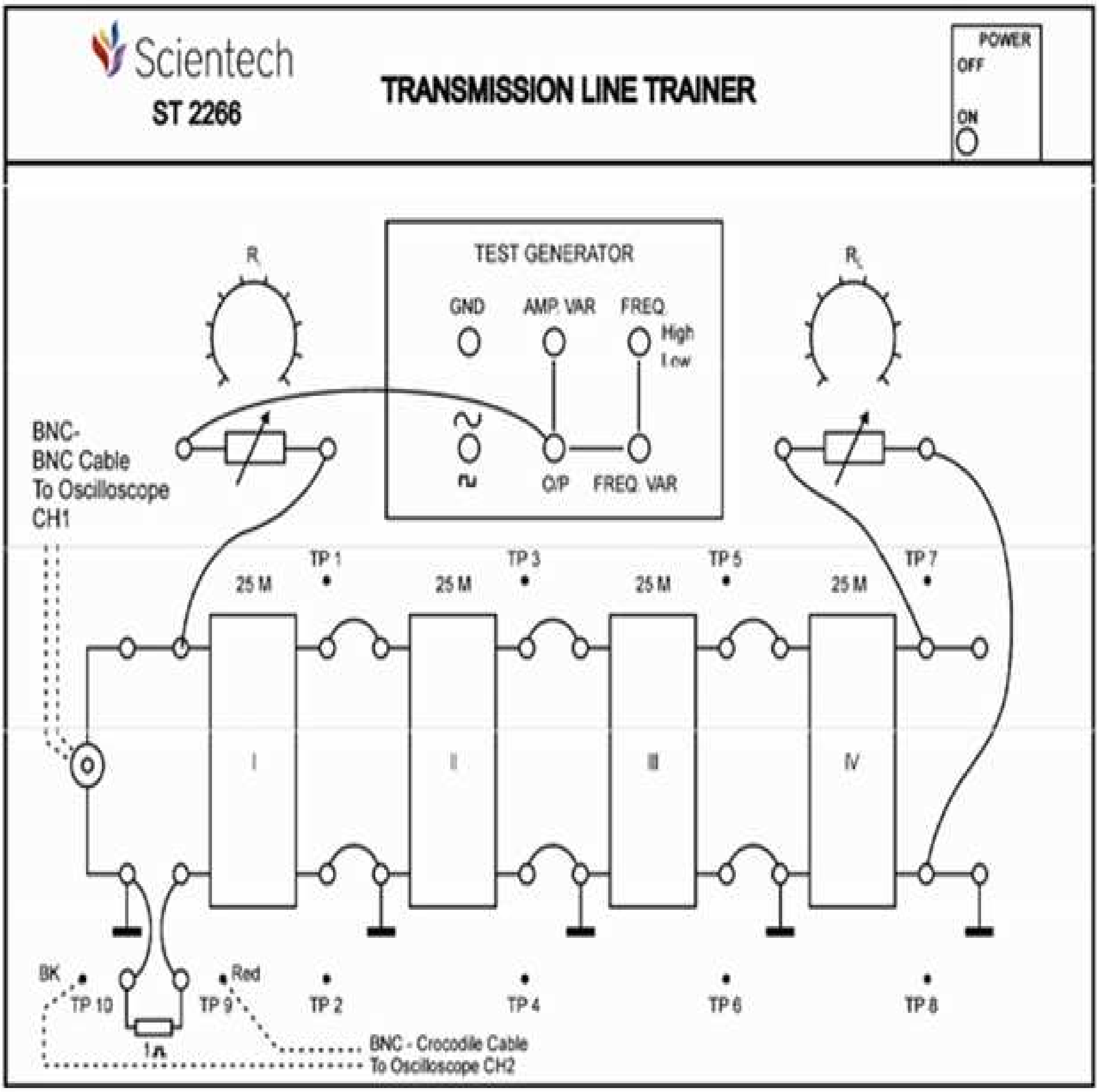
7. Change the frequency to 1MHz and note the values of V_{in} and V_m at this frequency.

8. Note down these results. The input impedance at 100 KHz is around 80 Ω and at 1 MHz is around 50Ω.

Repeat the experiment with shorted and open line and use the following formulas to

Compute the impedance when line is open circuited Zoc and when short circuited Zsc.

$$Zoc = \frac{Voc}{Ioc} \qquad Zsc = \frac{Vsc}{Isc}$$



Experiment 9

Objective: Measuring the attenuation of line.

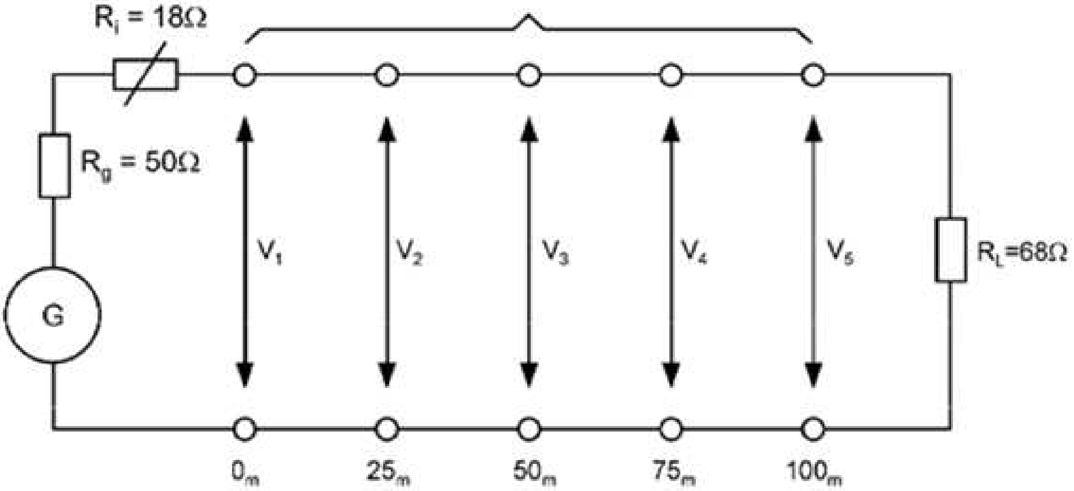
Theory:

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 input
V_2 = amplitude of signal at output
a = attenuation for given length

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



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 50W from the previous experiment. The short-circuited resistance of the line when measured with Digital Multimeter is shown to be 18W. Therefore; the total effective resistance of the line is 68W. For optimum power transfer we should have the source resistance and terminating resistance also as 68W. Assuming generator resistance R_g as 50W we must connect 18W 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 18 W using DMM and RL to 68W 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 18 W and 68 W respectively with the help of DMM.
2. Make connections as shown in figure 9.
3. Set the sine-wave frequency to approximately 100 KHz and level to 0.4 V.
4. Oscilloscope CH 1 shows applied input CH 2 shows outputs.
5. Measure signal level at Input, and at 25, 50, 75, and 100 m lengths.
6. Tabulate as under:

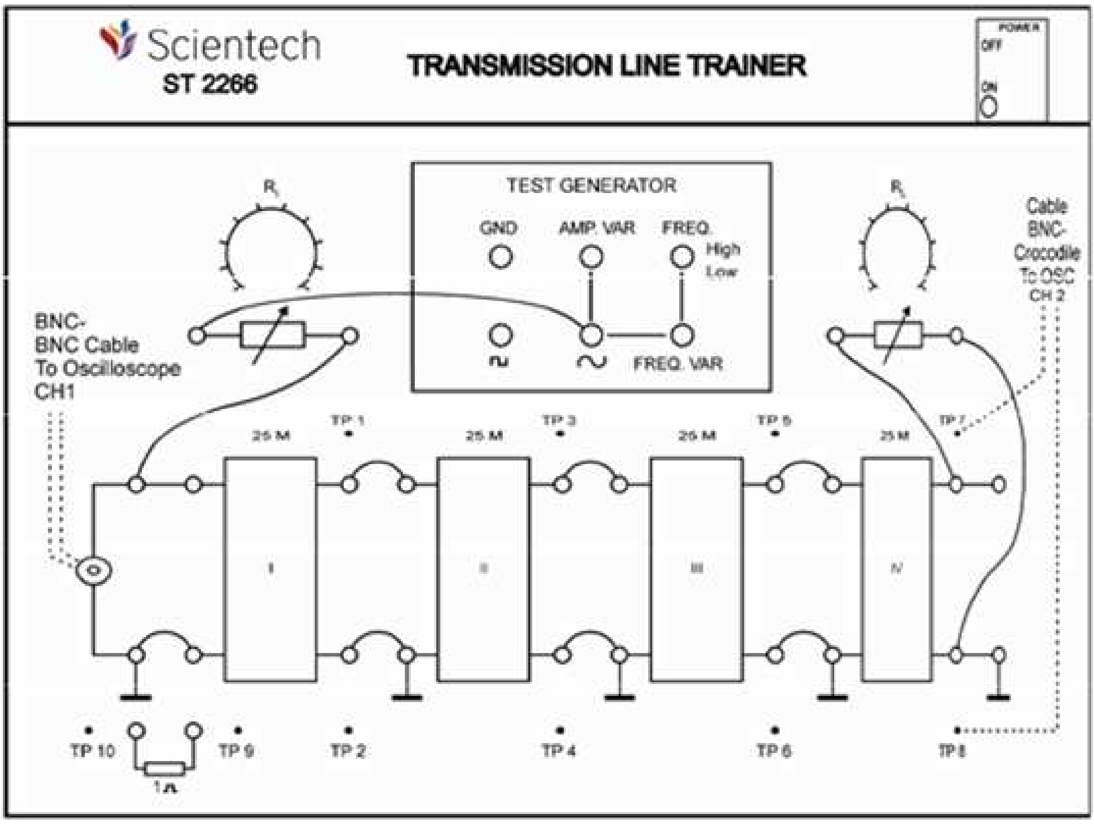
Length (m)	V1 (Input)	V2 (Output)
25		
50		
75		
100		

7. Now, calculate the attenuations in dB at various lengths by the formula given below:

$$a = 20 \text{ Log } V_2 / V_1$$

8. The attenuation is approximately -2 dB at 100 m.

9. Try the same with open-ended line and short-ended line.



Experiment 10

Objective: Fault localization within the line.

Theory:

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 input 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 input signal. For the fault to be pinpointed, it is necessary to determine, the frequency value at which a voltage minimum occurs at the input. 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)] ¥ l

Where,
l = line length in meters
l’ = distance in mts of the point of fault referred to the input of the line.

Procedure:

1. Make connections as shown in figure 20 a. Note that the line is broken at 50 mLength.

2. Set oscilloscope channel 1 to 0.1 V/ div.

3. Adjust the sine generator for output of 0.4 V_{p-p} (4 div deflection on CH 1)

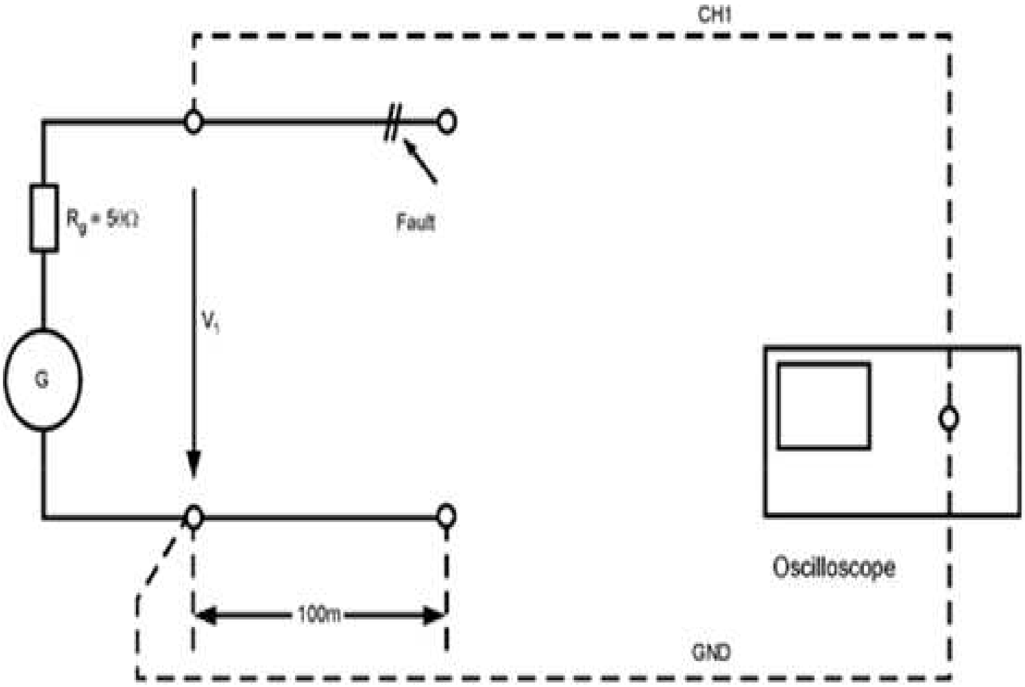
4. Keep the frequency variable control at the minimum position.

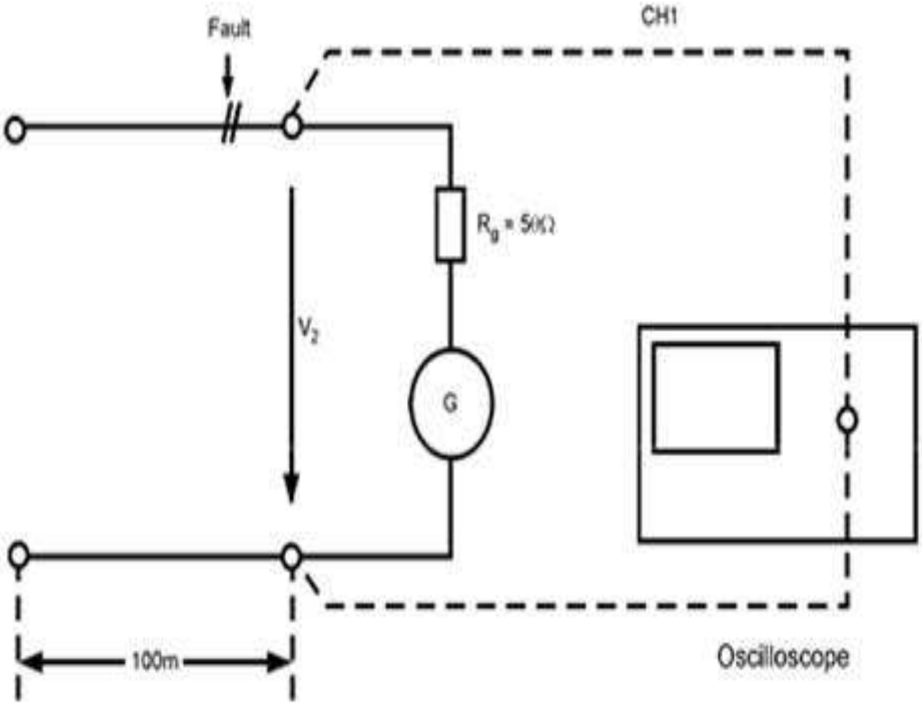
5. Gradually increase the frequency and note the frequency at which the signal onCRO falls to minimum. This frequency is f1.

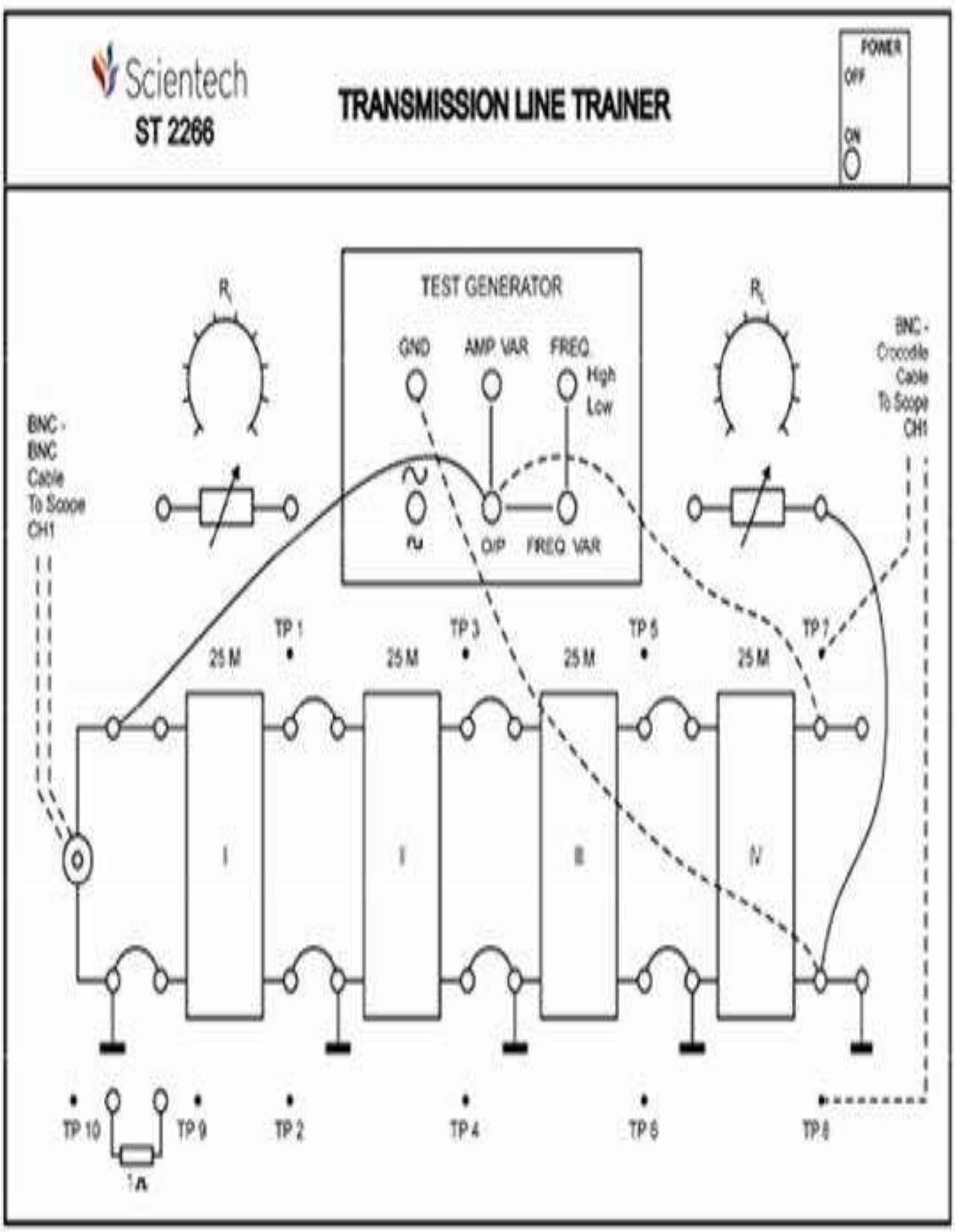
6. Repeat the test at the other end of the line as shown in figure 20 b and note theFrequency at which signal on CRO falls to minimum. This is f2.

7. Enter these values in the formula and calculate the distance of break point fromthe input.

For the fault generated at 50 m f1 and f2 are 900 KHz approximately.


CH1
R_g = 50Ω
Fault
V_1
G
Oscilloscope
100m
GND


Fault
CH1
R_g = 50Ω
V_2
G
Oscilloscope
100m


Scientech
ST 2266
TRANSMISSION LINE TRAINER
POWER
OFF
ON
TEST GENERATOR
GND
AMP VAR
FREQ
High
Low
O/P
FREQ VAR
R_L
R_L
BNC - BNC Cable To Scope CH1
BNC - Crocodile Cable To Scope CH1
TP 1
TP 3
TP 5
TP 7
25 M
25 M
25 M
25 M
I
II
III
IV
TP 10
TP 9
TP 2
TP 4
TP 6
TP 8
1Ω