INSTRUCTION MANUAL

OF

NETWORK LABORATORY
[CODE: EEC271]

FOR

Third-Semester B.Tech. (*Electrical Engineering*)

CIRCUIT AND NETWORK LABORATORY
[Room No. 127, First Floor Academic Complex]
DEPARTMENT OF ELECTRICAL ENGINEERING
INDIAN INSTITUTE OF TECHNOLOGY (INDIAN SCHOOL OF MINES), DHANBAD
Semester: Monsoon
Session: 2022-2023

NETWORK LABORATORY [EEC271]

DEPARTMENT OF ELECTRICAL ENGINEERING
INDIAN INSTITUTE OF TECHNOLOGY (ISM), DHANBAD

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NETWORK LABORATORY

DEPARTMENT OF ELECTRICAL ENGINEERING
INDIAN INSTITUTE OF TECHNOLOGY (INDIAN SCHOOL OF MINES), DHANBAD

Laboratory Instruction

1. **All the students must be on or before the scheduled time for Lab-classes and be regular. It is very difficult to compensate the pending experiments. GROUP-A must report on the first day.**

2. All the students must wear shoes to avoid any electrical shocks. Student without shoes will not be allowed to perform experiments.

3. Students should come into the Lab-classes with lab manual, required stationaries, and calculators.

4. No power supply should be given to the circuit(s) until all the connection and layout are cross-checked by the concerned laboratory instructor in-charge.

5. During the Lab-class, no student should enter or leave the Lab without the permission of the concerned Instructor.

6. **Students are to submit the report (as per the specific format to be circulated on each day) of a particular experiment on the NEXT LAB DAY. Index sheet as per the format provided is to be attached with the report.**

7. **Students must get their report verified from the respective laboratory instructor/in-charge.**

Sukanta Das

Laboratory In-Charge
[S. DAS]
Associate Professor/EE

CIRCUIT AND NETWORK LABORATORY

DEPARTMENT OF ELECTRICAL ENGINEERING
INDIAN INSTITUTE OF TECHNOLOGY (INDIAN SCHOOL OF MINES), DHANBAD

Course: Network Laboratory (EEC271) [L-T-P: 0-0-2]
Program: III-B.Tech. (EE)
Semester: Monsoon
Session: 2022-2023

LIST OF EXPERIMENTS

Sl. No.	Title
1.	**Determination of Y-and Z- Parameters of Two-Port Network**
2.	**Study of Passive Low-Pass Filter**
3.	**Study of Passive High-Pass Filter**
4.	**Study of Passive Band-Pass Filter**
5.	**Simulation of Passive Low-Pass and High-Pass Filter**
6.	**Determination of ABCD-and H-Parameters of Two-Port Network**
7.	**Study of Passive Band-Reject Filter**
8.	**Study of Active Low-Pass and High-Pass Filter**
9.	**Study of Active Band-Pass and Band-Reject Filter**
10.	**Simulation of Active Low-Pass and High-Pass Filter**

Project Work*:

1.	**Design, Analysis, Simulation, Fabrication and Experiments on Passive and Active Filters**

*** Required to be done in consultation with the laboratory instructors and submitted before the Lab Exam.**

Sukanta Das
Signature of the Laboratory In-Charge

DEPARTMENT OF ELECTRICAL ENGINEERING
INDIAN INSTITUTE OF TECHNOLOGY (ISM), DHANBAD 826004

NETWORK LABORATORY

III-Semester B. Tech. (Electrical Engineering)

(Monsoon: 2022-2023)

Group wise tentative laboratory schedule

Group A

Phase -1:

Sub-Group	Day 1	Day 2	Day 3	Day 4	Day 5
Date:					
A1	1	2	3	4	5
A2	2	3	4	5	1
A3	3	4	5	1	2
A4	4	5	1	2	3
A5	5	1	2	3	4

Phase -2:

Sub-Group	Day 6	Day 7	Day 8	Day 9	Day 10
Date:					
A1	6	7	8	9	10
A2	7	8	9	10	6
A3	8	9	10	6	7
A4	9	10	6	7	8
A5	10	6	7	8	9

Group B

Phase -1:

Sub-Group	Day 1	Day 2	Day 3	Day 4	Day 5
Date:					
B1	1	2	3	4	5
B2	2	3	4	5	1
B3	3	4	5	1	2
B4	4	5	1	2	3
B5	5	1	2	3	4

Phase -2:

Sub-Group	Day 6	Day 7	Day 8	Day 9	Day 10
Date:					
B1	6	7	8	9	10
B2	7	8	9	10	6
B3	8	9	10	6	7
B4	9	10	6	7	8
B5	10	6	7	8	9

NETWORK LABORATORY

DEPARTMENT OF ELECTRICAL ENGINEERING
INDIAN INSTITUTE OF TECHNOLOGY (ISM), DHANBAD 826004

III-Semester B. Tech. (Electrical Engineering)

(Monsoon: 2022-2023)

Group wise tentative laboratory schedule

(Phase-1)

Group A

Sub-Group	Day 1	Day 2	Day 3	Day 4	Day 5
Date:					
A1	1	2	3	4	5
A2	2	3	4	5	1
A3	3	4	5	1	2
A4	4	5	1	2	3
A5	5	1	2	3	4

Group B

Sub-Group	Day 1	Day 2	Day 3	Day 4	Day 5
Date:					
B1	1	2	3	4	5
B2	2	3	4	5	1
B3	3	4	5	1	2
B4	4	5	1	2	3
B5	5	1	2	3	4

Exp. No.	Name of Experiments
1.	Determination of Y-and Z- Parameters of Two-Port Network
2.	Study of Passive Low-Pass Filter
3.	Study of Passive High-Pass Filter
4.	Study of Passive Band-Pass Filter
5.	Simulation of Passive Low-Pass and High-Pass Filter

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NETWORK LABORATORY

DEPARTMENT OF ELECTRICAL ENGINEERING
INDIAN INSTITUTE OF TECHNOLOGY (ISM), DHANBAD 826004

III-Semester B. Tech. (Electrical Engineering)

(Monsoon: 2022-2023)

Group wise tentative laboratory schedule

(Phase-2)

Group A

Sub-Group	Day 6	Day 7	Day 8	Day 9	Day 10
Date:					
A1	6	7	8	9	10
A2	7	8	9	10	6
A3	8	9	10	6	7
A4	9	10	6	7	8
A5	10	6	7	8	9

Group B

Sub-Group	Day 6	Day 7	Day 8	Day 9	Day 10
Date:					
B1	6	7	8	9	10
B2	7	8	9	10	6
B3	8	9	10	6	7
B4	9	10	6	7	8
B5	10	6	7	8	9

Exp. No.	Name of Experiments
6.	Determination of ABCD-and H-Parameters of Two-Port Network
7.	Study of Passive Band-Reject Filter
8.	Study of Active Low-Pass and High-Pass Filter
9.	Study of Active Band-Pass and Band-Reject Filter
10.	Simulation of Active Low-Pass and High-Pass Filter

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NETWORK LABORATORY [EEC271]

DEPARTMENT OF ELECTRICAL ENGINEERING
INDIAN INSTITUTE OF TECHNOLOGY (ISM), DHANBAD

INDEX SHEET

Name: **Admn. No.:**
Group/Sub-group: **Session: 2022-2023**

Exp. No.	Experiment(s) performed	Date of Experiment	Date of Submission	Grade	Instructor's Remarks & Signature
1.	Determination of Y-and Z-Parameters of Two-Port Network				
2.	Study of Passive Low-Pass Filter				
3.	Study of Passive High-Pass Filter				
4.	Study of Passive Band-Pass Filter				
5.	Simulation of Passive Low-Pass and High-Pass Filter				
6.	Determination of ABCD-and H-Parameters of Two-Port Network				
7.	Study of Passive Band-Reject Filter				
8.	Study of Active Low-Pass and High-Pass Filter				
9.	Study of Active Band-Pass and Band-Reject Filter				
10.	Simulation of Active Low-Pass and High-Pass Filter				

Project Work:

1.	Design, Analysis, Simulation, Fabrication and Experiments on Passive and Active Filters	-			

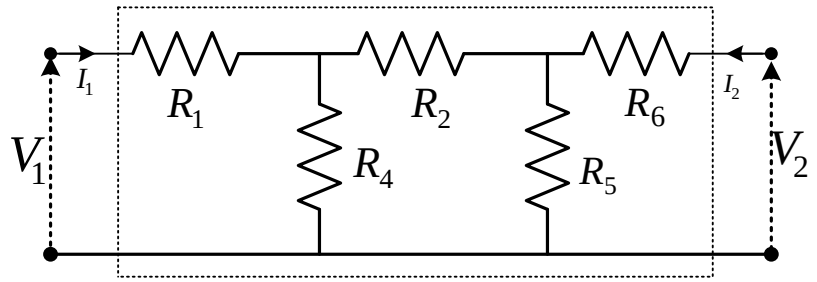
DEPARTMENT OF ELECTRICAL ENGINEERING INDIAN INSTITUTE OF TECHNOLOGY (ISM), DHANBAD		
NETWORK LABORATORY	**INSTUCTION MANUAL FOR EXPERIMENT NO.1: DETERMINATION OF Y- AND Z-PARAMETERS OF TWO-PORT NETWORK**	**DOC. NO.: IIT(ISM)/EE/CKT-01** **REVISION NO.: 4** **DATE: July, 2022**

OBJECTIVE: - To determine Y- and Z-parameters experimentally and verify them theoretically for a given two port network.

THEORY: -

Y-parameters	**Z-parameters**
Equations: $I_1 = Y_{11}V_1 + Y_{12}V_2$ $I_2 = Y_{21}V_1 + Y_{22}V_2$	**Equations:** $V_1 = Z_{11}I_1 + Z_{12}I_2$ $V_2 = Z_{21}I_1 + Z_{22}I_2$
Parameters: $Y_{11} = \left.\frac{I_1}{V_1}\right\|_{V_2=0}$ $Y_{12} = \left.\frac{I_1}{V_2}\right\|_{V_1=0}$ $Y_{21} = \left.\frac{I_2}{V_1}\right\|_{V_2=0}$ $Y_{22} = \left.\frac{I_2}{V_2}\right\|_{V_1=0}$ where, Y_{11} = Short-circuit input admittance Y_{12} = Short-circuit transfer admittance from port 1 to port 2 Y_{21} = Short-circuit transfer admittance from port 2 to port 1 Y_{22} = Short-circuit output admittance	**Parameters:** $Z_{11} = \left.\frac{V_1}{I_1}\right\|_{I_2=0}$ $Z_{12} = \left.\frac{V_1}{I_2}\right\|_{I_1=0}$ $Z_{21} = \left.\frac{V_2}{I_1}\right\|_{I_2=0}$ $Z_{22} = \left.\frac{V_2}{I_2}\right\|_{I_1=0}$ where, Z_{11} = Open-circuit input impedance Z_{12} = Open-circuit transfer inpedance from port 1 to port 2 Z_{21} = Open-circuit transfer impedance from port 2 to port 1 Z_{22} = Open-circuit output impedance

CIRCUIT DIAGRAM:-



[Note: Choose suitable values of circuit parameters]

EQUIPMENTS/INSTRUMENTS REQUIRED:-

Item No.	Name of Instrument	Quantity	Type	Range	Maker's Name	Serial No.

PROCEDURE:-

1. Connect the circuit as per the requirements for each case.
2. Measure current, voltage for each circuit and record them in Table 1 and Table 2.

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3. Determine the parameters experimentally from the data available in the Tables.
4. Now, express all the Y- and Z-parameters in terms of resistances (R_1, R_2, R_4, R_5 and R_6) for theoretical calculations and determine the parameters theoretically.
5. Record the theoretical values in corresponding tables.

EXPERIMENTAL DATA: -

Table 1: Data-sheet for Y-parameters (show separate circuit in each case)

Parameters	V_1 (V)	I_1 (mA)	V_2 (V)	I_2 (mA)	Experimental Value (unit)	Theoretical Value (unit)
Y_{11}						
Y_{12}						
Y_{21}						
Y_{22}						

Table 2: Data-sheet for Z-parameters (show separate circuit in each case)

Parameters	V_1 (V)	I_1 (mA)	V_2 (V)	I_2 (mA)	Experimental Value (unit)	Theoretical Value (unit)
Z_{11}						
Z_{12}						
Z_{21}						
Z_{22}						

SAMPLE QUESTIONS:-

1. All theoretical calculations have to be shown.
2. Compare the theoretical results with experimental result.
3. Remark on reciprocity and symmetry of the given two-port network.
4. Why Y-parameters are called short-circuit parameters and Z-parameters are called open circuit parameters?

REFERENCES:-

1. Network Analysis: Van Valkenburg.
2. Fundamentals of Electric Circuits: Charles K. Alexander & Matthew Sadiku.
3. Basic Electrical engineering: D.P Kothari & I.J Nagrath.
4. Electrical Engineering Fundamental: Vincent.D.Toro.

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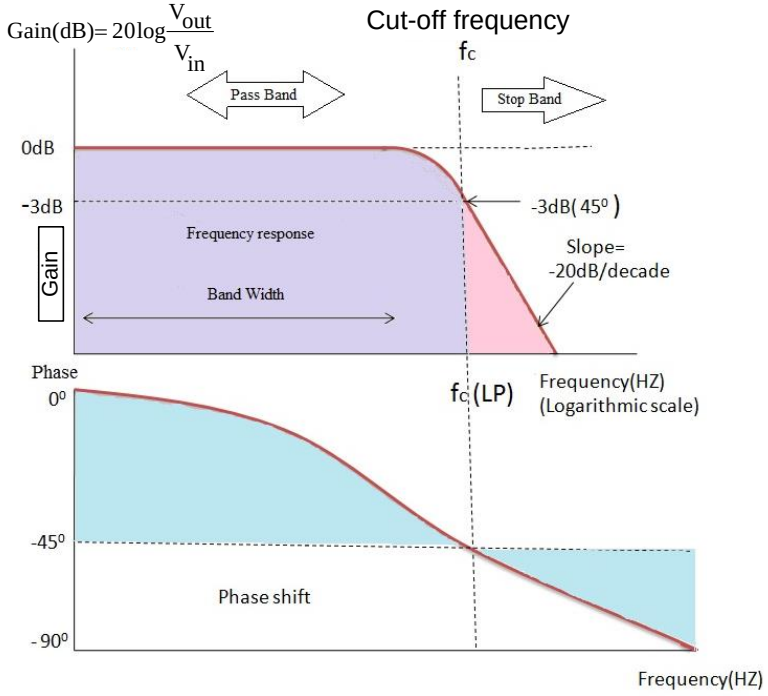
DEPARTMENT OF ELECTRICAL ENGINEERING INDIAN INSTITUTE OF TECHNOLOGY (ISM), DHANBAD		
NETWORK LABORATORY	**INSTUCTION MANUAL FOR EXPERIMENT NO.2: STUDY OF PASSIVE LOW-PASS FILTER**	**DOC. NO.: IIT(ISM)/EE/CKT-02** **REVISION NO.: 3** **DATE: July, 2022**

OBJECTIVE: - To study the operation of first- and second-order passive low-pass filter with amplitude response.

THEORY: A filter is a circuit that is designed to pass signals with desired frequencies and reject or attenuate others. Filters are the circuits used in radio and TV receivers to allow us to select one desired signal out of a multitude of broadcast signals in the environment. The bandwidths of filters used in communications systems vary from a fraction of a hertz to many megahertz, depending on the application. A filter is a **passive filter** if it consists of only passive elements R, L, and C. It is said to be an **active filter** if it consists of active elements (such as transistors and op amps) in addition to passive elements R, L, and C.

Passive filters: Passive low-pass filters may be of different orders and types.

- **First-Order Low-Pass Filter**:- A First-order low-pass filter consists of a single RL network (Fig. 1) or a single RC network (Fig. 2).
- **Second-Order Low-Pass Filter:-** A second-order low-pass filter consists of two RL pairs (Fig. 3) or two RC pairs (Fig. 4).



Low-pass filter

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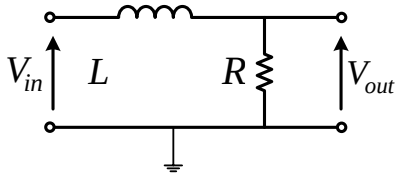
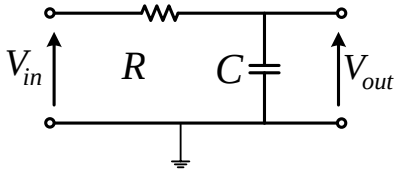
NETWORK LABORATORY	**INSTUCTION MANUAL FOR EXPERIMENT NO.2: STUDY OF PASSIVE LOW-PASS FILTER**	**DOC. NO.: IIT(ISM)/EE/CKT-02** **REVISION NO.: 3** **DATE: July, 2022**

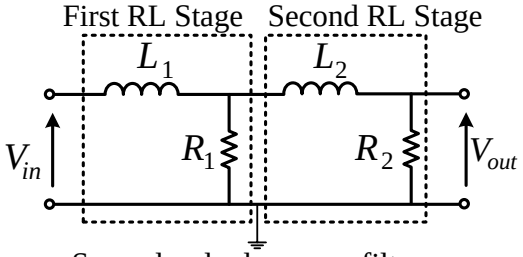
CIRCUIT DIAGRAM:-



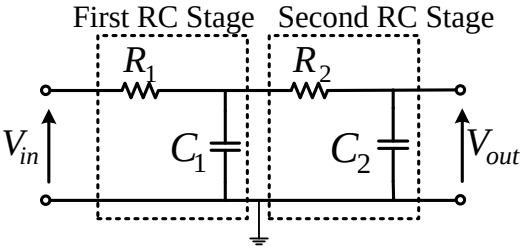
First order low-pass filter
(Inductive circuit)
Fig. 1



First order low-pass filter
(Capacitive circuit)
Fig. 2



Second order low-pass filter
(Inductive circuit)
Fig. 3



Second order low-pass filter
(Capacitive circuit)
Fig. 4

[Note: Choose suitable values of circuit parameters]

EQUIPMENTS/INSTRUMENTS REQUIRED:-

Item No.	Name of Instrument	Quantity	Type	Range	Maker's Name	Serial No.

Resistance, Inductance and Capacitance values

RESISTANCE				
	Switch-1	**Switch-2**	**Switch-3**	**Switch-4**
Step-1	100 Ω	10 kΩ	100 Ω	10 kΩ
Step-2	200 Ω	20 kΩ	200 Ω	20 kΩ
Step-3	500 Ω	50 kΩ	500 Ω	50 kΩ
Step-4	1 kΩ	100 kΩ	1 kΩ	100 kΩ
Step-5	2 kΩ	200 kΩ	2 kΩ	200 kΩ
Step-6	5 kΩ	1 MΩ	5 kΩ	1 MΩ

INDUCTANCE				
	Switch-1	**Switch-2**	**Switch-3**	**Switch-4**
Step-1	0.5 mH	4.7 mH	0.5 mH	4.7 mH
Step-2	0.75 mH	7.5 mH	0.75 mH	7.5 mH
Step-3	1 mH	9.4 mH	1 mH	9.4 mH
Step-4	1.5 mH	15 mH	1.5 mH	15 mH
Step-5	2 mH	20 mH	2 mH	20 mH
Step-6	3 mH	30 mH	3 mH	30 mH

CAPACITANCE				
	Switch-1	**Switch-2**	**Switch-3**	**Switch-4**
Step-1	0.5 nF	50 nF	0.5 nF	50 nF
Step-2	1 nF	100 nF	1 nF	100 nF
Step-3	2 nF	200 nF	2 nF	200 nF
Step-4	5 nF	500 nF	5 nF	500 nF
Step-5	10 nF	1 µF	10 nF	1 µF
Step-6	20 nF	2 µF	20 nF	2 µF

PROCEDURE:-

1. Connection is to be made as per the circuit diagram.
2. Connect the output of the function generator to the input of the circuit.

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3. Switch on the main power supply and function generator.
4. Gradually vary the frequency by rotating the pot of the function generator and observe the output.
5. Calculate the gain and draw a curve between Gain (dB) *vs* frequency (Hz).

EXPERIMENTAL DATA: -

Cut-off frequency: For RC circuit, $f_c = \frac{1}{2\pi RC}$ Hz and for RL circuit, $f_c = \frac{R}{2\pi L}$ Hz

Table 1: Data-sheet for passive low-pass and high-pass filters

Sl. No.	Input Frequency (Hz)	Input Voltage V_{in} (V)	Output Voltage V_0 (V)	Gain (dB) $20\log(V_0/V_{in})$

SAMPLE QUESTIONS:-

1. Study the frequency response curves for all the cases in semi-log graph paper.

REFERENCES:-

1. Electrical And Electronic Technology: Edward Hughes
2. Fundamentals of Electric Circuits: Charles K. Alexander & Matthew Sadiku.
3. Basic Electrical engineering: D. P Kothari & I. J. Nagrath.
4. Electrical Engineering Fundamental: Vincent. D. Toro.

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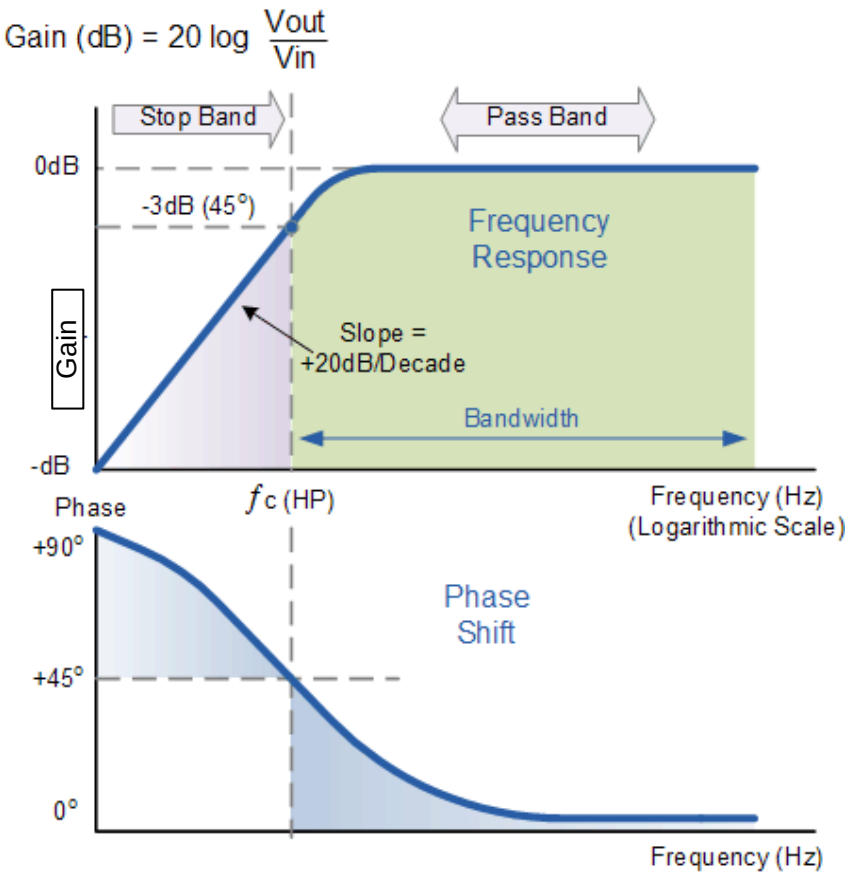
DEPARTMENT OF ELECTRICAL ENGINEERING INDIAN INSTITUTE OF TECHNOLOGY (ISM), DHANBAD		
NETWORK LABORATORY	INSTUCTION MANUAL FOR EXPERIMENT NO.3: STUDY OF PASSIVE HIGH-PASS FILTER	DOC. NO.: IIT(ISM)/EE/CKT-03 REVISION NO.: 3 DATE: July, 2022

OBJECTIVE: - To study the operation of first- and second-order passive high-pass filter with amplitude response.

THEORY: A filter is a circuit that is designed to pass signals with desired frequencies and reject or attenuate others. Filters are the circuits used in radio and TV receivers to allow us to select one desired signal out of a multitude of broadcast signals in the environment. The bandwidths of filters used in communications systems vary from a fraction of a hertz to many megahertz, depending on the application. A filter is a **passive filter** if it consists of only passive elements R, L, and C. It is said to be an **active filter** if it consists of active elements (such as transistors and op amps) in addition to passive elements R, L, and C.

Passive filters: Passive high-pass filters may be of different orders and types.

- **First-Order High-Pass Filter:-** A First-order high-pass filter consists of a single RL network (Fig. 5) or a single RC network (Fig. 6).
- **Second-Order High-Pass Filter:-** A second-order high-pass filter consists of two RL pairs (Fig. 7) or two RC pairs (Fig. 8).



High-pass filter

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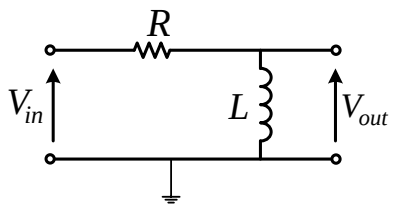
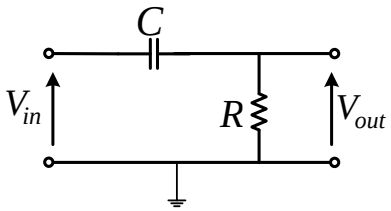
NETWORK LABORATORY	**INSTUCTION MANUAL FOR EXPERIMENT NO.3: STUDY OF PASSIVE HIGH-PASS FILTER**	**DOC. NO.: IIT(ISM)/EE/CKT-03** **REVISION NO.: 3** **DATE: July, 2022**

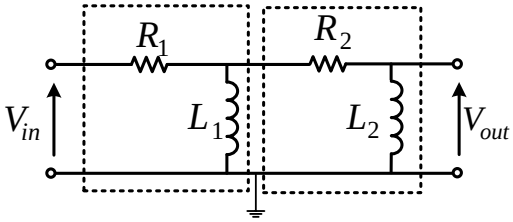
CIRCUIT DIAGRAM:-



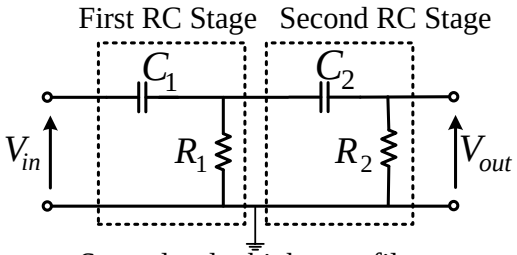
First order high-pass filter
(Inductive circuit)
Fig. 1



First order high-pass filter
(Capacitive circuit)
Fig. 2



Second order high-pass filter
(Inductive circuit)
Fig. 3



Second order high-pass filter
(Capacitive circuit)
Fig. 4

[Note: Choose suitable values of circuit parameters]

EQUIPMENTS/INSTRUMENTS REQUIRED:-

Item No.	Name of Instrument	Quantity	Type	Range	Maker's Name	Serial No.

Resistance, Inductance and Capacitance values

RESISTANCE				
	Switch-1	**Switch-2**	**Switch-3**	**Switch-4**
Step-1	100 Ω	10 kΩ	100 Ω	10 kΩ
Step-2	200 Ω	20 kΩ	200 Ω	20 kΩ
Step-3	500 Ω	50 kΩ	500 Ω	50 kΩ
Step-4	1 kΩ	100 kΩ	1 kΩ	100 kΩ
Step-5	2 kΩ	200 kΩ	2 kΩ	200 kΩ
Step-6	5 kΩ	1 MΩ	5 kΩ	1 MΩ

INDUCTANCE				
	Switch-1	**Switch-2**	**Switch-3**	**Switch-4**
Step-1	0.5 mH	4.7 mH	0.5 mH	4.7 mH
Step-2	0.75 mH	7.5 mH	0.75 mH	7.5 mH
Step-3	1 mH	9.4 mH	1 mH	9.4 mH
Step-4	1.5 mH	15 mH	1.5 mH	15 mH
Step-5	2 mH	20 mH	2 mH	20 mH
Step-6	3 mH	30 mH	3 mH	30 mH

CAPACITANCE				
	Switch-1	**Switch-2**	**Switch-3**	**Switch-4**
Step-1	0.5 nF	50 nF	0.5 nF	50 nF
Step-2	1 nF	100 nF	1 nF	100 nF
Step-3	2 nF	200 nF	2 nF	200 nF
Step-4	5 nF	500 nF	5 nF	500 nF
Step-5	10 nF	1 µF	10 nF	1 µF
Step-6	20 nF	2 µF	20 nF	2 µF

PROCEDURE:-

1. Connection is to be made as per the circuit diagram.
2. Connect the output of the function generator to the input of the circuit.

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DEPARTMENT OF ELECTRICAL ENGINEERING INDIAN INSTITUTE OF TECHNOLOGY (ISM), DHANBAD		
NETWORK LABORATORY	**INSTUCTION MANUAL FOR EXPERIMENT NO.3: STUDY OF PASSIVE HIGH-PASS FILTER**	**DOC. NO.: IIT(ISM)/EE/CKT-03** **REVISION NO.: 3** **DATE: July, 2022**

3. Switch on the main power supply and function generator.
4. Gradually vary the frequency by rotating the pot of the function generator and observe the output.
5. Calculate the gain and draw a curve between Gain (dB) *vs* frequency (Hz).

EXPERIMENTAL DATA: -

Cut-off frequency: For RC circuit, $f_c = \frac{1}{2\pi RC}$ Hz and for RL circuit, $f_c = \frac{R}{2\pi L}$ Hz

Table 1: Data-sheet for passive low-pass and high-pass filters

Sl. No.	Input Frequency (Hz)	Input Voltage V_{in} (V)	Output Voltage V_0 (V)	Gain (dB) $20\log(V_0/V_{in})$

SAMPLE QUESTIONS:-

1. Study the frequency response curves for all the cases in semi-log graph paper.

REFERENCES:-

1. Network Analysis: Van Valkenburg.
2. Fundamentals of Electric Circuits: Charles K. Alexander & Matthew Sadiku.
3. Basic Electrical engineering: D. P Kothari & I. J. Nagrath.
4. Electrical Engineering Fundamental: Vincent. D. Toro.

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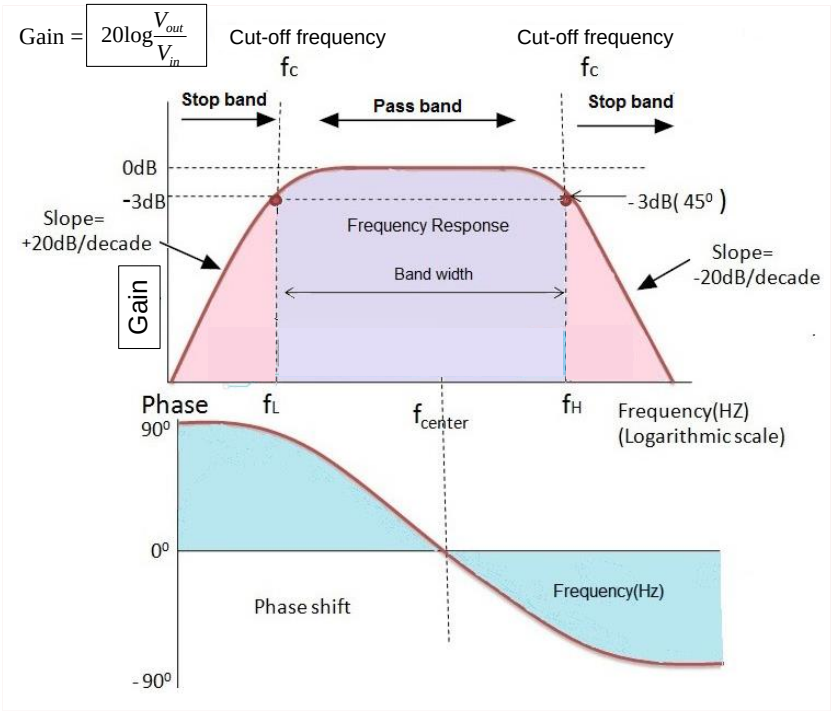
DEPARTMENT OF ELECTRICAL ENGINEERING INDIAN INSTITUTE OF TECHNOLOGY (ISM), DHANBAD		
NETWORK LABORATORY	INSTUCTION MANUAL FOR EXPERIMENT NO.4: STUDY OF PASSIVE BAND-PASS FILTER	DOC. NO.: IIT(ISM)/EE/CKT-04 REVISION NO.: 3 DATE: July, 2022

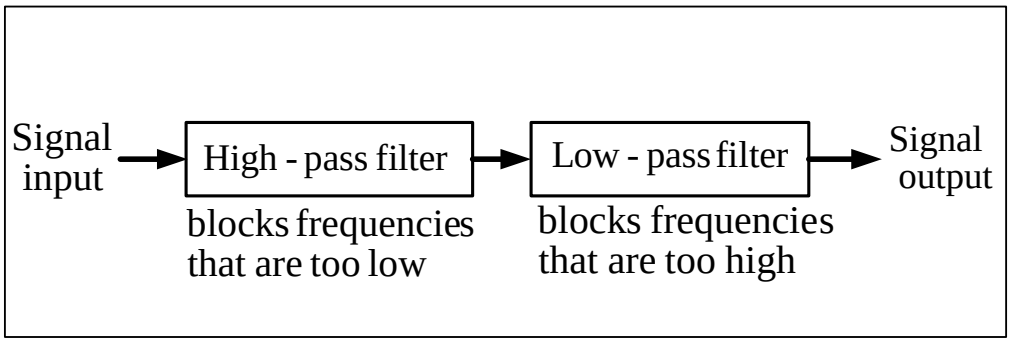
OBJECTIVE: - To study the operation of passive band-pass filter with amplitude response.

THEORY: A filter is a circuit that is designed to pass signals with desired frequencies and reject or attenuate others. Filters are the circuits used in radio and TV receivers to allow us to select one desired signal out of a multitude of broadcast signals in the environment. The bandwidths of filters used in communications systems vary from a fraction of a hertz to many megahertz, depending on the application. A filter is a **passive filter** if it consists of only passive elements R, L, and C. It is said to be an **active filter** if it consists of active elements (such as transistors and op amps) in addition to passive elements R, L, and C.

Band-Pass Filter: A band of frequency will be passed. This circuit consists of a series combination of high-pass stage and low-pass stage (Fig. 1, 3 & 4).



Band-Pass Filter



Band-pass filter

Fig. 1

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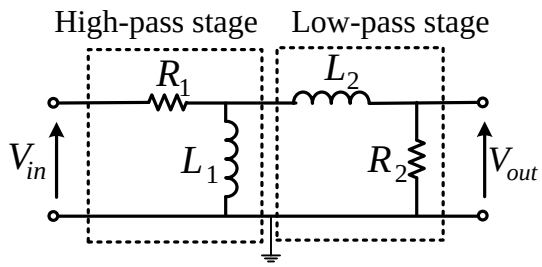
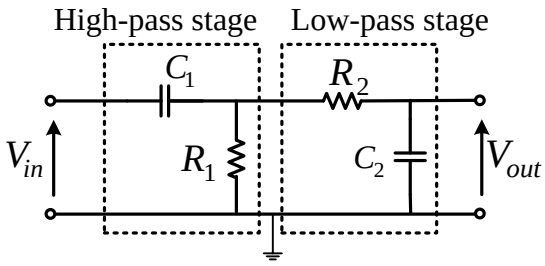
NETWORK LABORATORY	**INSTUCTION MANUAL FOR EXPERIMENT NO.4: STUDY OF PASSIVE BAND-PASS FILTER**	**DOC. NO.: IIT(ISM)/EE/CKT-04** **REVISION NO.: 3** **DATE: July, 2022**

CIRCUIT DIAGRAM:-



Band-pass filter
(Inductive circuit)

Fig. 3



Band-pass filter
(Capacitive circuit)

Fig. 4

[Note: Choose suitable values of circuit parameters]

EQUIPMENTS/INSTRUMENTS REQUIRED:-

Sl. No.	Name of Instrument	Quantity	Type	Range	Maker's Name	Serial No.

Resistance, Inductance and Capacitance values

RESISTANCE				
	Switch-1	**Switch-2**	**Switch-3**	**Switch-4**
Step-1	100 Ω	100 Ω	100 Ω	10 kΩ
Step-2	500 Ω	500 Ω	200 Ω	20 kΩ
Step-3	1 kΩ	1 kΩ	500 Ω	50 kΩ
tep-4	5 kΩ	5 kΩ	1 kΩ	100 kΩ
Step-5	10 kΩ	10 kΩ	2 kΩ	200 kΩ
Step-6	50 kΩ	50 kΩ	5 kΩ	1 MΩ

INDUCTANCE				
	Switch-1	**Switch-2**	**Switch-3**	**Switch-4**
Step-1	0.5 mH	0.75 mH	0.5 mH	4.7 mH
Step-2	1 mH	1.5 mH	7.5 mH	7.5 mH
Step-3	2 mH	3 mH	1 mH	9.4 mH
Step-4	4.7 mH	7.5 mH	1.5 mH	15 mH
Step-5	9.4 mH	15 mH	2 mH	20 mH
Step-6	20 mH	30 mH	3 mH	30 mH

CAPACITANCE				
	Switch-1	**Switch-2**	**Switch-3**	**Switch-4**
Step-1	1 nF	2 nF	0.5 nF	50 nF
Step-2	5 nF	10 nF	1 nF	100 nF
Step-3	10 nF	20 nF	2 nF	200 nF
Step-4	50 nF	50 nF	5 nF	500 nF
Step-5	100 nF	200 nF	10 nF	1 µF
Step-6	500 nF	1 µF	20 nF	2 µF

PROCEDURE:-

1. Connection is to be made as per the circuit diagram.
2. Connect the output of the function generator to the input of the circuit.
3. Switch on the main power supply and function generator.
4. Gradually vary the frequency by rotating the pot of the function generator and observe the output.
5. Calculate the gain and draw a curve between Gain (dB) *vs* frequency (Hz).

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DEPARTMENT OF ELECTRICAL ENGINEERING INDIAN INSTITUTE OF TECHNOLOGY (ISM), DHANBAD		
NETWORK LABORATORY	**INSTUCTION MANUAL FOR EXPERIMENT NO.4: STUDY OF PASSIVE BAND-PASS FILTER**	**DOC. NO.: IIT(ISM)/EE/CKT-04** **REVISION NO.: 3** **DATE: July, 2022**

TABULATION:-

Sl. No.	Input Frequency (Hz)	Input Voltage V_{in} (V)	Output Voltage V_0 (V)	Gain (dB) $20\log(V_0/V_{in})$

SAMPLE QUESTIONS:-

1. Study the frequency response curve for the band-pass filter in semi-log graph paper.

REFERENCE:-

1. Network Analysis: Van Valkenburg.
2. Fundamentals of Electric Circuits: Charles K. Alexander & Matthew Sadiku.
3. Basic Electrical engineering: D. P Kothari & I. J. Nagrath.
4. Electrical Engineering Fundamental: Vincent. D. Toro.

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DEPARTMENT OF ELECTRICAL ENGINEERING INDIAN INSTITUTE OF TECHNOLOGY (ISM), DHANBAD		
NETWORK LABORATORY	INSTUCTION MANUAL FOR EXPERIMENT NO.5: SIMULATION OF PASSIVE LOW-PASS AND HIGH-PASS FILTER	DOC. NO.: IIT(ISM)/EE/CKT-05 REVISION NO.: 3 DATE: July, 2022

OBJECTIVE: - To study the operation of first- and second-order passive low-pass and high-pass filter with the help of computer simulation tool.

- To analyze the effect of varying frequency to the output voltage of low-pass and high-pass filter.
- To observe the gain vs. frequency plot of RC low-pass and high-pass filter.

THEORY: A filter is a circuit that is designed to pass signals with desired frequencies and reject or attenuate others. Filters are the circuits used in radio and TV receivers to allow us to select one desired signal out of a multitude of broadcast signals in the environment. The bandwidths of filters used in communications systems vary from a fraction of a hertz to many megahertz, depending on the application. A filter is a **passive filter** if it consists of only passive elements R, L, and C. It is said to be an **active filter** if it consists of active elements (such as transistors and op amps) in addition to passive elements R, L, and C.

Passive filters: Passive filters may be of different orders and types.

- **First-Order Low-Pass Filter (1st-order LPF)**:- A First-order low-pass filter consists of a single RC (or RL) network (Fig. 3).
- **Second-Order Low-Pass Filter (2nd-order LPF):-** A second-order low-pass filter consists of two RC (or RL) pairs (Fig. 4).
- **First-Order High-Pass Filter (1st-order HPF):-** A First-order high-pass filter consists of a single RC (or RL) network (Fig. 5).
- **Second-Order High-Pass Filter (2nd-order HPF):-** A second-order high-pass filter consists of two RC (or RL) pairs (Fig. 6).

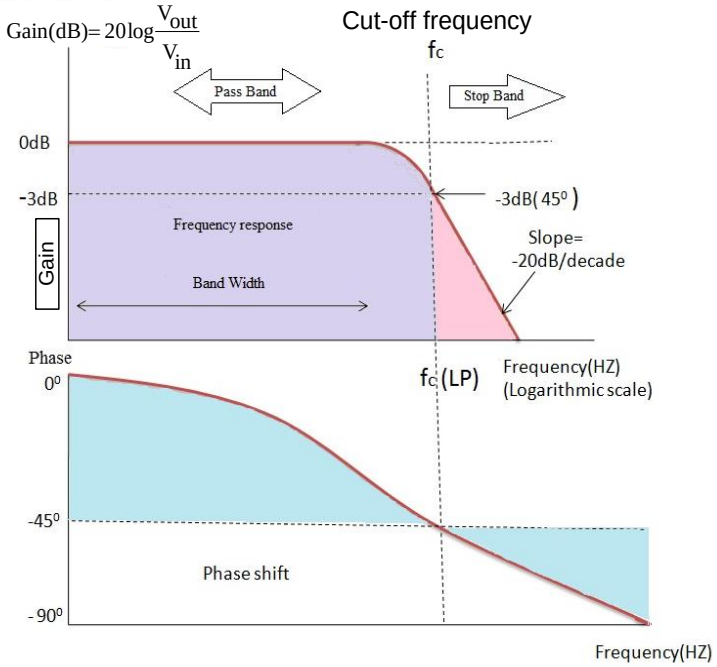

Fig.1. Frequency response of first-order LPF.

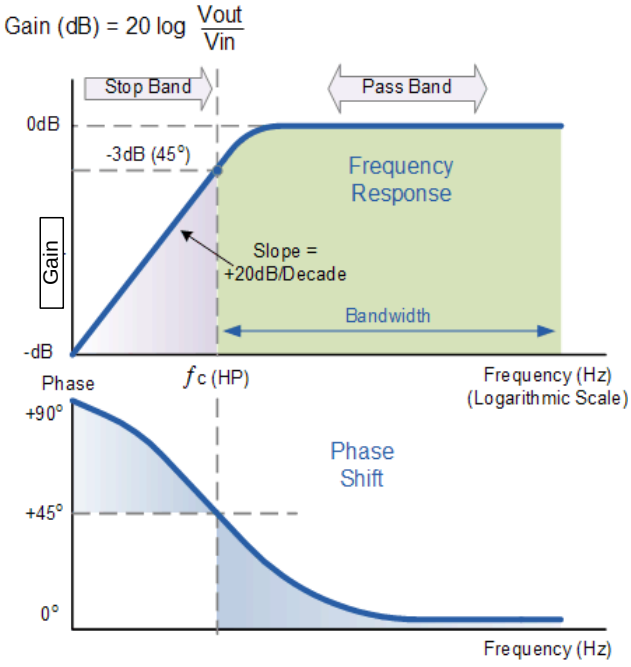

Fig.2. Frequency response of first-order HPF.

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NETWORK LABORATORY	INSTUCTION MANUAL FOR EXPERIMENT NO.5: SIMULATION OF PASSIVE LOW-PASS AND HIGH-PASS FILTER	DOC. NO.: IIT(ISM)/EE/CKT-05 REVISION NO.: 3 DATE: July, 2022

CIRCUIT DIAGRAM:-

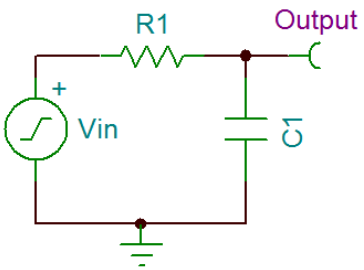

Fig.3. First-order low-pass filter.

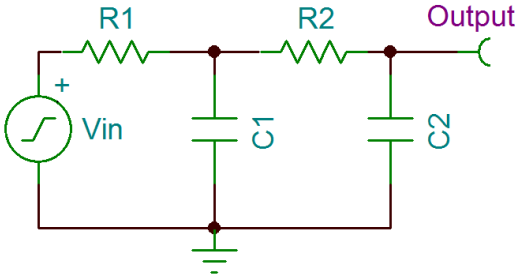

Fig.4. Second-order low-pass filter.

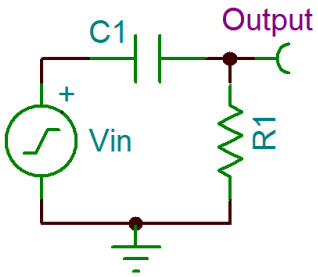

Fig.5. First-order high-pass filter.

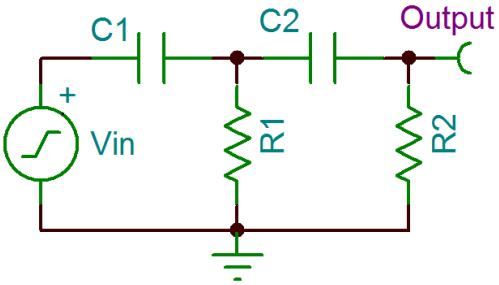

Fig.6. Second-order high-pass filter.

[Note: Choose suitable values of circuit parameters]

SIMULATION TOOL USED: TINA

PROCEDURE:-

To simulate the filter circuit follow these steps:

1. Open TINA, inserte necessary components & draw the circuit.
2. Assign values to all the components and set the analysis parameters.
3. Save the file and simulate the circuit.
4. Change the parameters value and observe the frequency response.

EXPERIMENTAL DATA: -

Cut-off frequency: For first-order circuit, $f_c = \frac{1}{2\pi R_1 C_1}$ Hz, and

for second-order circuit, $f_c = \frac{1}{2\pi\sqrt{R_1 R_2 C_1 C_2}}$ Hz

Table 1: Data-sheet for passive low-pass and high-pass filters

Filter Circuit	Parameters Value	Cut-off Frequency (Hz)	Gain (dB)	Phase (deg)
First-order LPF	R= , C=	Calculated: Simulated:		
Second-order LPF	R= , C=	Calculated: Simulated:		
First-order HPF	R= , C=	Calculated: Simulated:		
Second-order LPF	R= , C=	Calculated: Simulated:		

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SAMPLE QUESTIONS:-

1. What is cut-off frequency?
2. Calculate the value of cut-off frequency from the circuit and compare to the value which is desired from the frequency curve.
3. For all filters draw the frequency response curve.
4. Conclude the experiment with your observation.

REFERENCES:-

1. Electrical and Electronic Technology: Edward Hughes (Revised by: John Hiley, Keith Brown, and Ian McKenzie Smith).
2. Introductory Circuit Analysis: Robert L. Boylestad
3. Fundamentals of Electric Circuits: Charles K. Alexander, and Matthew Sadiku
4. Engineering Circuit Analysis: William H. Hayt, Jack Kemmerly, and Steven M. Durbin
5. Electrical Engineering Fundamental: Vincent. D. Toro

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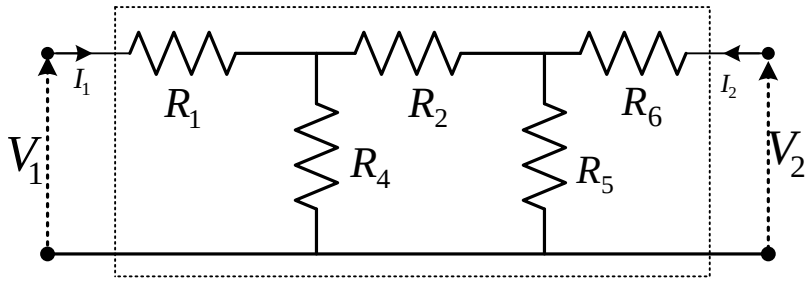
DEPARTMENT OF ELECTRICAL ENGINEERING INDIAN INSTITUTE OF TECHNOLOGY (ISM), DHANBAD		
NETWORK LABORATORY	**INSTUCTION MANUAL FOR EXPERIMENT NO.6: DETERMINATION OF ABCD- AND h-PARAMETERS OF TWO-PORT NETWORK**	**DOC. NO.: IIT(ISM)/EE/CKT-06** **REVISION NO.: 3** **DATE: July, 2022**

OBJECTIVE: - To determine ABCD- and *h*- parameters experimentally and verify them theoretically for a given two port network.

THEORY: -

ABCD-parameters	***h*-parameters**
Equations: $V_1 = AV_2 + B(-I_2)$ $I_1 = CV_2 + D(-I_2)$	**Equations:** $V_1 = h_{11}I_1 + h_{12}V_2$ $I_2 = h_{21}I_1 + h_{22}V_2$
Parameters: $A = \left.\frac{V_1}{V_2}\right\|_{I_2=0}$ $B = \left.\frac{V_1}{-I_2}\right\|_{V_2=0}$ $C = \left.\frac{I_1}{V_2}\right\|_{I_2=0}$ $D = \left.\frac{I_1}{-I_2}\right\|_{V_2=0}$ where, *A*= Open-circuit voltage ratio *B*= Negative short-circuit transfer impedance *C*= Open-circuit transfer admittance *D*= Negative short-circuit current ratio	**Parameters:** $h_{11} = \left.\frac{V_1}{I_1}\right\|_{V_2=0}$ $h_{12} = \left.\frac{V_1}{V_2}\right\|_{I_1=0}$ $h_{21} = \left.\frac{I_2}{I_1}\right\|_{V_2=0}$ $h_{22} = \left.\frac{I_2}{V_2}\right\|_{I_1=0}$ where, h_{11} = Short-circuit input impedance h_{12} = Open-circuit reverse voltage gain h_{21} = Short-circuit forward current gain h_{22} = Open-circuit output admittance

CIRCUIT DIAGRAM:-



[Note: Choose suitable values of circuit parameters]

EQUIPMENTS/INSTRUMENTS REQUIRED:-

Item No.	Name of Instrument	Quantity	Type	Range	Maker's Name	Serial No.

PROCEDURE:-

1. Connect the circuit as per the requirements for each case.
2. Measure current, voltage for each circuit and record them in Table 1 and Table 2.

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DEPARTMENT OF ELECTRICAL ENGINEERING INDIAN INSTITUTE OF TECHNOLOGY (ISM), DHANBAD		
NETWORK LABORATORY	**INSTUCTION MANUAL FOR EXPERIMENT NO.6: DETERMINATION OF ABCD- AND h-PARAMETERS OF TWO-PORT NETWORK**	**DOC. NO.: IIT(ISM)/EE/CKT-06** **REVISION NO.: 3** **DATE: July, 2022**

3. Determine the parameters experimentally from the data available in the Tables.
4. Now, express all the ABCD- and *h*-parameters in terms of resistances (R_1, R_2, R_4, R_5 and R_6) for theoretical calculations and determine the parameters theoretically.
5. Record the theoretical values in corresponding tables.

EXPERIMENTAL DATA: -

Table 1: Data-sheet for ABCD-parameters (show separate circuit in each case)

Parameters	V_1 (V)	I_1 (mA)	V_2 (V)	I_2 (mA)	Experimental Value (unit)	Theoretical Value (unit)
A						
B						
C						
D						

Table 2: Data-sheet for *h*-parameters (show separate circuit in each case)

Parameters	V_1 (V)	I_1 (mA)	V_2 (V)	I_2 (mA)	Experimental Value (unit)	Theoretical Value (unit)
h_{11}						
h_{12}						
h_{21}						
h_{22}						

SAMPLE QUESTIONS:-

1. All theoretical calculations have to be shown.
2. Compare the theoretical results with experimental result.
3. Why ABCD parameters are called transmission line parameters ?
4. Applications of ABCD and *h* parameters?

REFERENCES:-

1. Network Analysis: Van Valkenburg.
2. Fundamentals of Electric Circuits: Charles K. Alexander & Matthew Sadiku.
3. Basic Electrical engineering: D.P Kothari & I.J Nagrath.
4. Electrical Engineering Fundamental: Vincent.D.Toro.

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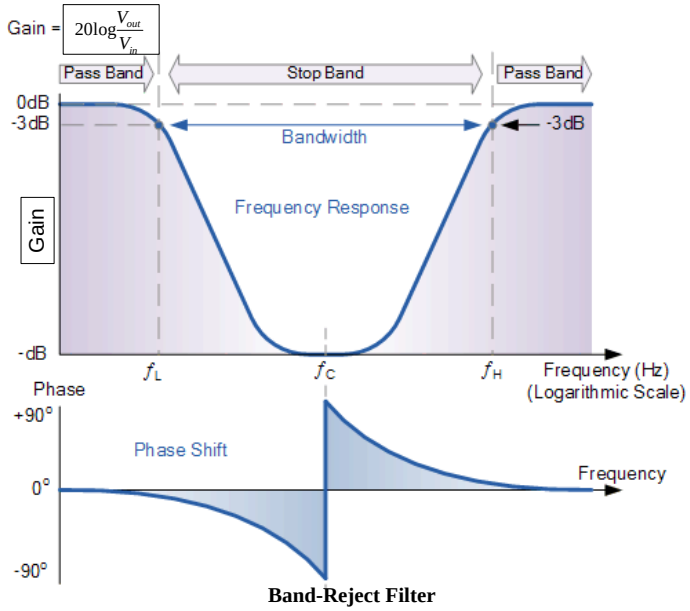
DEPARTMENT OF ELECTRICAL ENGINEERING INDIAN INSTITUTE OF TECHNOLOGY (ISM), DHANBAD		
NETWORK LABORATORY	INSTUCTION MANUAL FOR EXPERIMENT NO.7: STUDY OF PASSIVE BAND-REJECT FILTER	DOC. NO.: IIT(ISM)/EE/CKT-07 REVISION NO.: 3 DATE: July, 2022

OBJECTIVE: - To study the operation of passive band-reject filter with amplitude response.

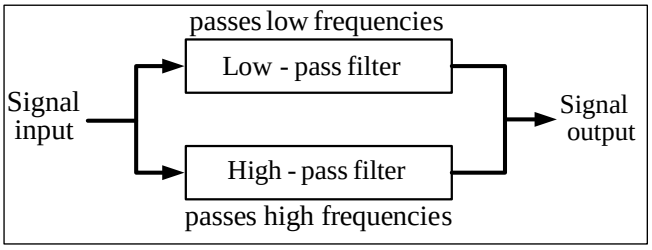
THEORY: A filter is a circuit that is designed to pass signals with desired frequencies and reject or attenuate others. Filters are the circuits used in radio and TV receivers to allow us to select one desired signal out of a multitude of broadcast signals in the environment. The bandwidths of filters used in communications systems vary from a fraction of a hertz to many megahertz, depending on the application. A filter is a **passive filter** if it consists of only passive elements R, L, and C. It is said to be an **active filter** if it consists of active elements (such as transistors and op amps) in addition to passive elements R, L, and C.

Band-Reject Filter: A band of frequency will be attenuated. This circuit consists of a parallel combination of high-pass stage and low-pass stage (Fig. 1, 2 & 3).



Band-Reject Filter

CIRCUIT DIAGRAM:-



Band-reject filter
Fig. 1

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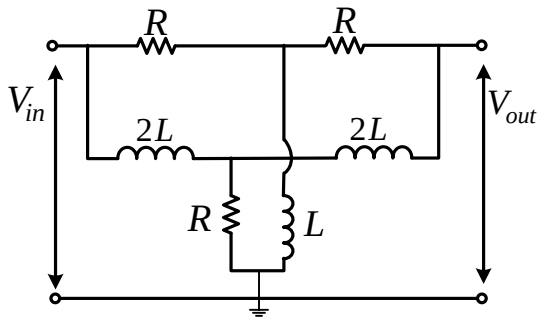
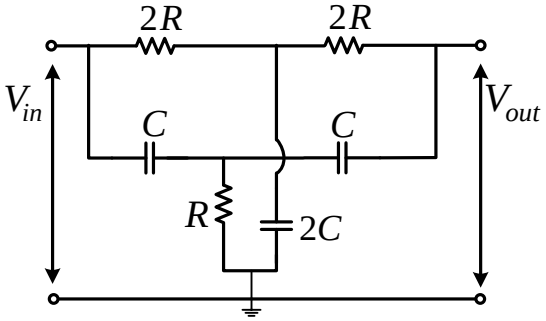
NETWORK LABORATORY	**INSTUCTION MANUAL FOR EXPERIMENT NO.7: STUDY OF PASSIVE BAND-REJECT FILTER**	**DOC. NO.: IIT(ISM)/EE/CKT-07** **REVISION NO.: 3** **DATE: July, 2022**



Band-reject filter
(Inductive circuit)
Fig. 2



Band-reject filter
(Capacitive circuit)
Fig. 3

[Note: Choose suitable values of circuit parameters]

EQUIPMENTS/INSTRUMENTS REQUIRED:-

Sl. No.	Name of Instrument	Quantity	Type	Range	Maker's Name	Serial No.

Resistance, Inductance and Capacitance values

RESISTANCE				
	Switch-1	**Switch-2**	**Switch-3**	**Switch-4**
Step-1	100 Ω	100 Ω	100 Ω	10 kΩ
Step-2	500 Ω	500 Ω	200 Ω	20 kΩ
Step-3	1 kΩ	1 kΩ	500 Ω	50 kΩ
tep-4	5 kΩ	5 kΩ	1 kΩ	100 kΩ
Step-5	10 kΩ	10 kΩ	2 kΩ	200 kΩ
Step-6	50 kΩ	50 kΩ	5 kΩ	1 MΩ

INDUCTANCE				
	Switch-1	**Switch-2**	**Switch-3**	**Switch-4**
Step-1	0.5 mH	0.75 mH	0.5 mH	4.7 mH
Step-2	1 mH	1.5 mH	7.5 mH	7.5 mH
Step-3	2 mH	3 mH	1 mH	9.4 mH
Step-4	4.7 mH	7.5 mH	1.5 mH	15 mH
Step-5	9.4 mH	15 mH	2 mH	20 mH
Step-6	20 mH	30 mH	3 mH	30 mH

CAPACITANCE				
	Switch-1	**Switch-2**	**Switch-3**	**Switch-4**
Step-1	1 nF	2 nF	0.5 nF	50 nF
Step-2	5 nF	10 nF	1 nF	100 nF
Step-3	10 nF	20 nF	2 nF	200 nF
Step-4	50 nF	50 nF	5 nF	500 nF
Step-5	100 nF	200 nF	10 nF	1 µF
Step-6	500 nF	1 µF	20 nF	2 µF

PROCEDURE:-

1. Connection is to be made as per the circuit diagram.
2. Connect the output of the function generator to the input of the circuit.
3. Switch on the main power supply and function generator.
4. Gradually vary the frequency by rotating the pot of the function generator and observe the output.
5. Calculate the gain and draw a curve between Gain (dB) *vs* frequency (Hz).

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DEPARTMENT OF ELECTRICAL ENGINEERING INDIAN INSTITUTE OF TECHNOLOGY (ISM), DHANBAD		
NETWORK LABORATORY	**INSTUCTION MANUAL FOR EXPERIMENT NO.7: STUDY OF PASSIVE BAND-REJECT FILTER**	**DOC. NO.: IIT(ISM)/EE/CKT-07** **REVISION NO.: 3** **DATE: July, 2022**

TABULATION:-

Sl. No.	Input Frequency (Hz)	Input Voltage V_{in} (V)	Output Voltage V_0 (V)	Gain (dB) $20\log(V_0/V_{in})$

SAMPLE QUESTIONS:-

1. Study the frequency response curve for the band-reject filter in semi-log graph paper.

REFERENCE:-

1. Network Analysis: Van Valkenburg.
2. Fundamentals of Electric Circuits: Charles K. Alexander & Matthew Sadiku.
3. Basic Electrical engineering: D. P Kothari & I. J. Nagrath.
4. Electrical Engineering Fundamental: Vincent. D. Toro.

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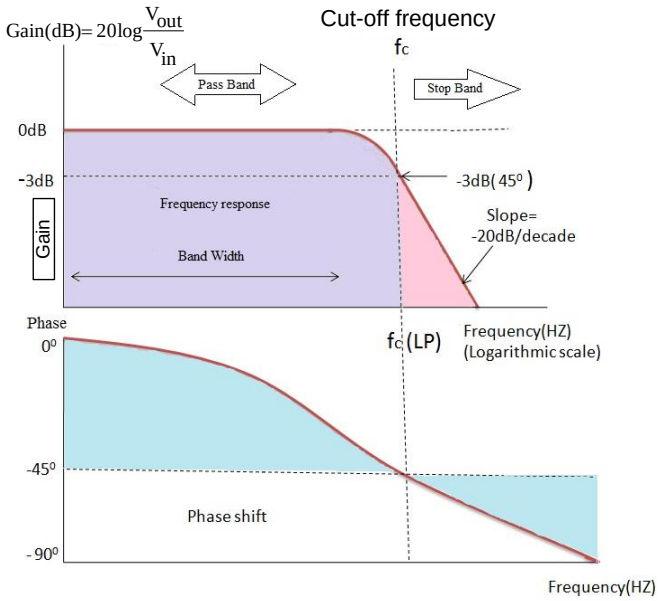
DEPARTMENT OF ELECTRICAL ENGINEERING INDIAN INSTITUTE OF TECHNOLOGY (ISM), DHANBAD		
NETWORK LABORATORY	**INSTUCTION MANUAL FOR EXPERIMENT NO.8: STUDY OF ACTIVE LOW-PASS AND HIGH-PASS FILTER**	**DOC. NO.: IIT(ISM)/EE/CKT-08** **REVISION NO.: 3** **DATE: July, 2022**

OBJECTIVE: - To study the operation of active low-pass and high-pass filter with amplitude response.

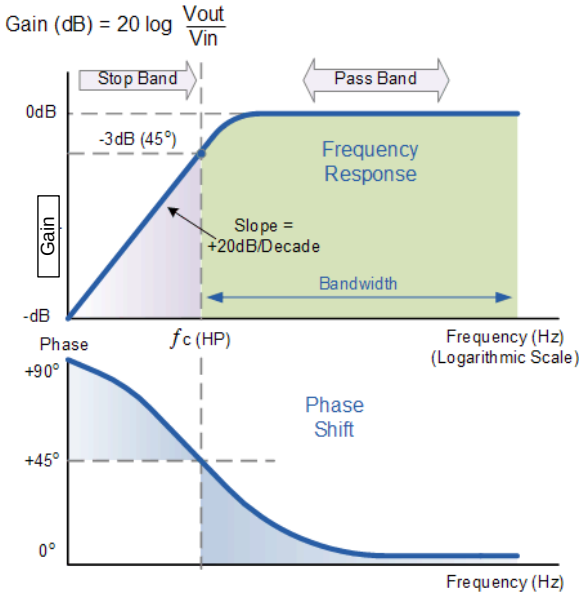
THEORY: A filter is a circuit that is designed to pass signals with desired frequencies and reject or attenuate others. Filters are the circuits used in radio and TV receivers to allow us to select one desired signal out of a multitude of broadcast signals in the environment. The bandwidths of filters used in communications systems vary from a fraction of a hertz to many megahertz, depending on the application. A filter is a **passive filter** if it consists of only passive elements R, L, and C. It is said to be an **active filter** if it consists of active elements (such as transistors and op amps) in addition to passive elements R, L, and C.

Active filters: Active low-pass and high-pass filters may be of different orders and types such as:

- **First-Order Low-Pass Filter**:- A First-order low-pass filter consists of a single RC network (Fig. 1).
- **First-Order High-Pass Filter:-** A First-order high-pass filter consists of a single RC network (Fig. 2).
- **Second-Order Low-Pass Filter:-** A second-order low-pass filter consists of two RC pairs (Fig. 3).
- **Second-Order High-Pass Filter:-** A second-order high-pass filter consists of two RC pairs (Fig. 4).



Low-Pass Filter



High-Pass Filter

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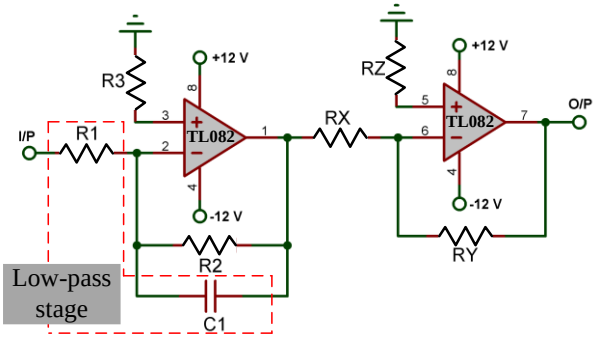
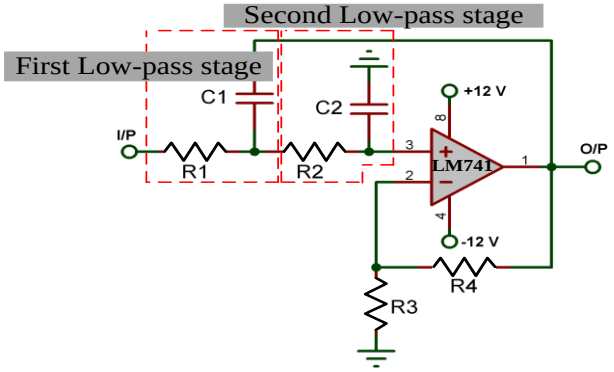
NETWORK LABORATORY	INSTUCTION MANUAL FOR EXPERIMENT NO.8: STUDY OF ACTIVE LOW-PASS AND HIGH-PASS FILTER	DOC. NO.: IIT(ISM)/EE/CKT-08 REVISION NO.: 3 DATE: July, 2022

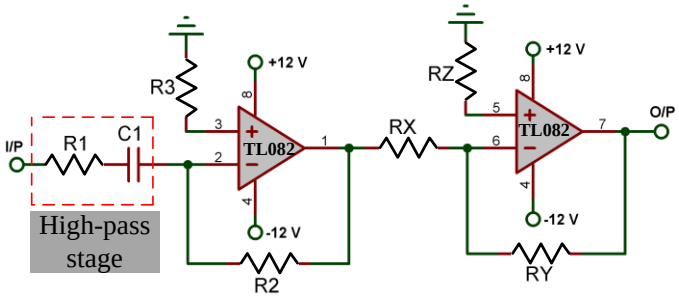
CIRCUIT DIAGRAM:-



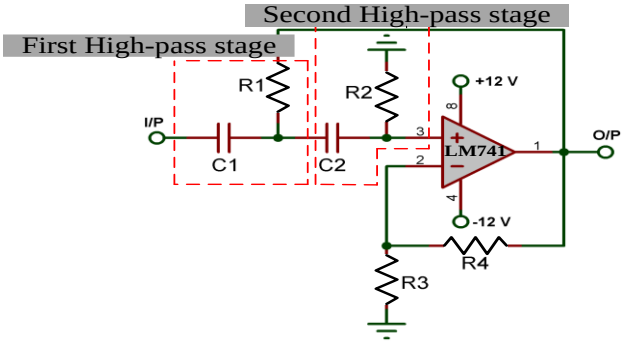
First order low-pass filter
Fig. 1



Second order low-pass filter
Fig. 3



First order high-pass filter
Fig. 2



Second order high-pass filter
Fig. 4

EQUIPMENTS/INSTRUMENTS REQUIRED:-

Sl. No.	Name of Instrument	Quantity	Type	Range	Maker's Name	Serial No.

PROCEDURE:-

1. Connection is to be made as per the circuit diagram.
2. Connect the output of the function generator to the input of the circuit.
3. Switch on the main power supply and function generator.
4. Gradually vary the frequency by rotating the pot of the function generator and observe the output.
5. Calculate the gain and draw a curve between Gain (dB) *vs* frequency (Hz).

EXPERIMENTAL DATA: -

Cut-off frequency: For RC circuit, $f_c = \dfrac{1}{2\pi RC}$ Hz

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Table 1: Data-sheet for Active low-pass and high-pass filter

Sl. No.	Input Frequency (Hz)	Input Voltage V_{in} (V)	Output Voltage V_0 (V)	Gain (dB) $20\log(V_0/V_{in})$

SAMPLE QUESTIONS:-

1. Study the frequency response curves for all the cases in semi-log graph paper.

REFERENCES:-

1. Network Analysis: Van Valkenburg.
2. Fundamentals of Electric Circuits: Charles K. Alexander & Matthew Sadiku.
3. Basic Electrical engineering: D. P Kothari & I. J. Nagrath.
4. Electrical Engineering Fundamental: Vincent. D. Toro.

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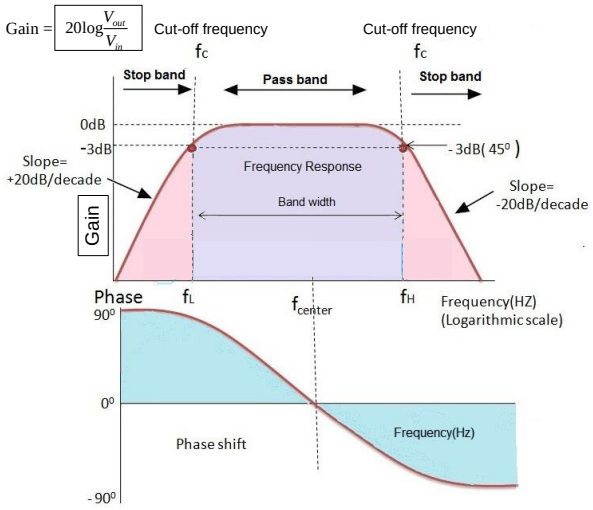
DEPARTMENT OF ELECTRICAL ENGINEERING INDIAN INSTITUTE OF TECHNOLOGY (ISM), DHANBAD		
NETWORK LABORATORY	INSTUCTION MANUAL FOR EXPERIMENT NO.9: STUDY OF ACTIVE BAND-PASS AND BAND-REJECT FILTER	DOC. NO.: IIT(ISM)/EE/CKT-09 REVISION NO.: 3 DATE: July, 2022

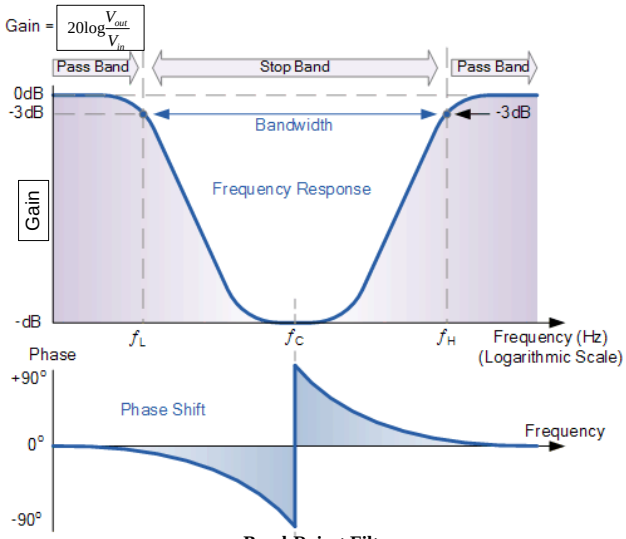
OBJECTIVE: - To study the operation of active band-pass and band-reject filter with amplitude response.

THEORY: A filter is a circuit that is designed to pass signals with desired frequencies and reject or attenuate others. Filters are the circuits used in radio and TV receivers to allow us to select one desired signal out of a multitude of broadcast signals in the environment. The bandwidths of filters used in communications systems vary from a fraction of a hertz to many megahertz, depending on the application. A filter is a **passive filter** if it consists of only passive elements R, L, and C. It is said to be an **active filter** if it consists of active elements (such as transistors and op amps) in addition to passive elements R, L, and C.

Band-Pass Filter: A band of frequency will be passed. This circuit consists of a series combination of high-pass stage and low-pass stage (Fig. 1).
Band-Reject Filter: A band of frequency will be attenuated. This circuit consists of a parallel combination of high-pass stage and low-pass stage (Fig. 2).



Band-Pass Filter



Band-Reject Filter

CIRCUIT DIAGRAM:

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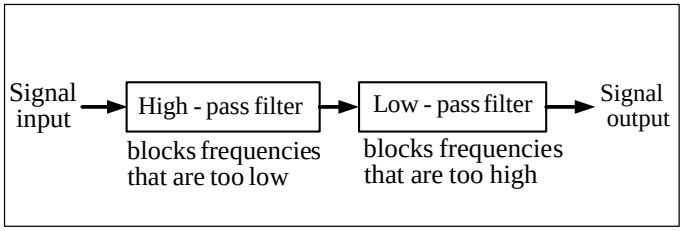
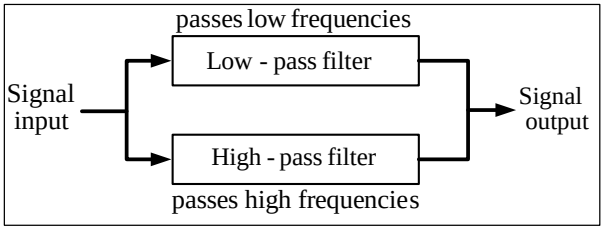
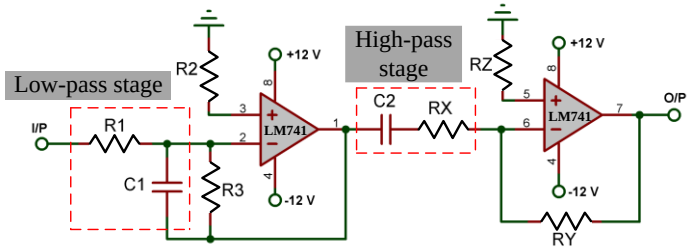
NETWORK LABORATORY	**INSTUCTION MANUAL FOR EXPERIMENT NO.9: STUDY OF ACTIVE BAND-PASS AND BAND-REJECT FILTER**	**DOC. NO.: IIT(ISM)/EE/CKT-09** **REVISION NO.: 3** **DATE: July, 2022**



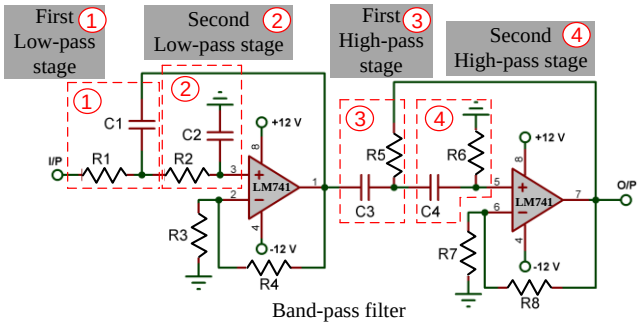
Band-pass Filter
Fig. 1



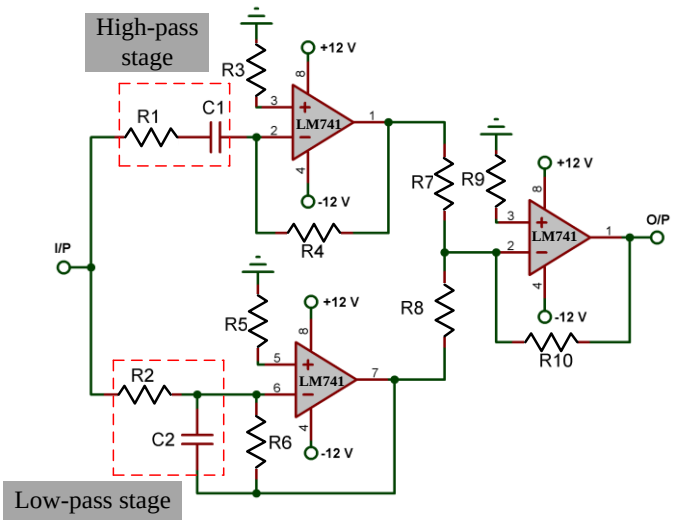
Band-reject Filter
Fig. 2



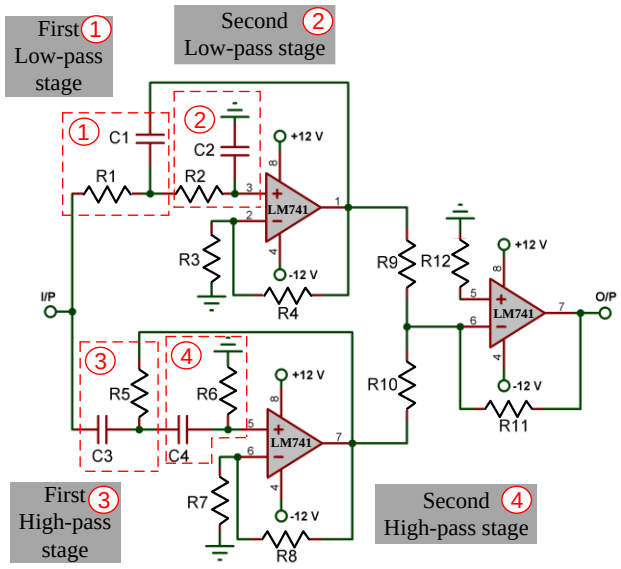
Band-pass filter
Fig. 3



Band-pass filter
Fig. 4



Band-reject filter
Fig. 5



Band-reject Filter
Fig. 6

EQUIPMENTS/INSTRUMENTS REQUIRED:-

Sl. No.	Name of Instrument	Quantity	Type	Range	Maker's Name	Serial No.

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NETWORK LABORATORY	**INSTUCTION MANUAL FOR EXPERIMENT NO.9: STUDY OF ACTIVE BAND-PASS AND BAND-REJECT FILTER**	**DOC. NO.: IIT(ISM)/EE/CKT-09** **REVISION NO.: 3** **DATE: July, 2022**

PROCEDURE:-

1. Connection is to be made as per the circuit diagram.
2. Connect the output of the function generator to the input of the circuit.
3. Switch on the main power supply and function generator.
4. Gradually vary the frequency by rotating the pot of the function generator and observe the output.
5. Calculate the gain and draw a curve between Gain (dB) *vs* frequency (Hz).

EXPERIMENTAL DATA: -

Cut-off frequency: For RC circuit, $f_c = \frac{1}{2\pi RC}$ Hz

Table 1: Data-sheet for Active low-pass, high-pass, band-pass and band-reject filters

Sl. No.	Input Frequency (Hz)	Input Voltage V_{in} (V)	Output Voltage V_0 (V)	Gain (dB) $20\log(V_0/V_{in})$

SAMPLE QUESTIONS:-

1. Study the frequency response curves for all the cases in semi-log graph paper.

REFERENCES:-

1. Network Analysis: Van Valkenburg.
2. Fundamentals of Electric Circuits: Charles K. Alexander & Matthew Sadiku.
3. Basic Electrical engineering: D. P Kothari & I. J. Nagrath.
4. Electrical Engineering Fundamental: Vincent. D. Toro.

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DEPARTMENT OF ELECTRICAL ENGINEERING INDIAN INSTITUTE OF TECHNOLOGY (ISM), DHANBAD		
NETWORK LABORATORY	INSTUCTION MANUAL FOR EXPERIMENT NO.10: SIMULATION OF ACTIVE LOW-PASS AND HIGH-PASS FILTER	DOC. NO.: IIT(ISM)/EE/CKT-10 REVISION NO.: 3 DATE: July, 2022

OBJECTIVE: - To study the operation of first- and second-order active low-pass filter (LPF) and high-pass filter (HPF) with the help of computer simulation tool.

- To analyze the effect of varying frequency to the output voltage of low-pass and high-pass filter.
- To observe the gain vs. frequency plot of low-pass and high-pass filter.

THEORY: A filter is a circuit that is designed to pass signals with desired frequencies and reject or attenuate others. Filters are the circuits used in radio and TV receivers to allow us to select one desired signal out of a multitude of broadcast signals in the environment. The bandwidths of filters used in communications systems vary from a fraction of a hertz to many megahertz, depending on the application. There are three major limitations to the passive filters considered in the previous experiments. First, they cannot generate gain greater than 1; passive elements cannot add energy to the network. Second, they may require bulky and expensive inductors. Third, they perform poorly at frequencies below the audio frequency range (300 Hz < f < 3,000 Hz). Nevertheless, passive filters are useful at high frequencies. **Active filters** consist of combinations of resistors, capacitors, and op-amps. They offer some **advantages** over passive *RLC* filters. First, they are often **smaller** and **less expensive**, because they do not require inductors. This makes feasible the integrated circuit realizations of filters. Second, they can provide **amplifier gain** in addition to providing the same frequency response as *RLC* filters. Third, active filters can be combined with buffer amplifiers (voltage followers) to isolate each stage of the filter from source and load impedance effects. This isolation allows designing the stages independently and then cascading them to realize the desired transfer function. However, active filters are less reliable and less stable. The practical limit of most active filters is about 100 kHz—most active filters operate well below that frequency. Filters are often classified according to their order (or number of poles) or their specific design type.

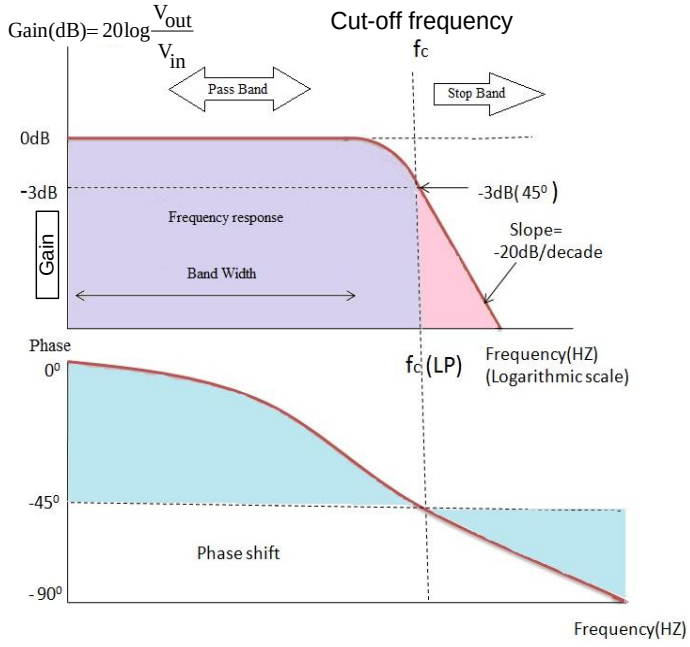

Fig.1. Frequency response of first-order LPF.

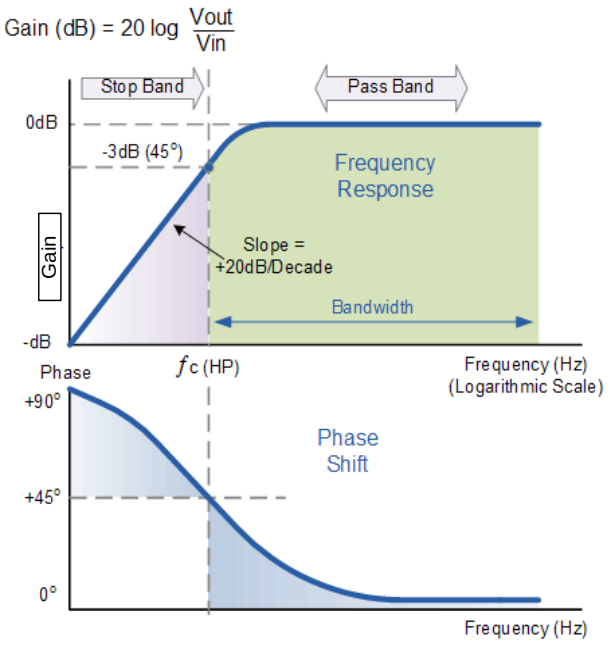

Fig.2. Frequency response of first-order HPF.

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First-order LPF: (See Fig.3) The frequency response of the circuit will be the same as that for the passive RC filter, except that the amplitude of the output is increased by the pass band gain, A_F of the amplifier.

For a non-inverting amplifier circuit, $A_F = 1 + \frac{R_3}{R_2}$

Gain of an active first-order LPF, $A_v = \frac{V_{out}}{V_{in}} = \frac{A_F}{\sqrt{1 + \left(f/f_c\right)^2}}$

where, f = frequency of the input signal in (Hz), and $f_c = 1/2\pi R_1 C_1$ = cut-off frequency in (Hz).

Thus, the operation of a low pass active filter can be verified from the frequency gain equation above as:

- $A_v \cong A_F$, at very low frequencies, $f < f$c,
- $A_v = \frac{A_F}{\sqrt{2}} = 0.707 A_F$, at the cut-off frequency, $f = f$c,
- $A_v < A_F$, at very high frequencies, $f > f$c.

Second-order LPF: (See Fig.4) As with the passive filter, a first-order low-pass active filter can be converted into a second-order low pass filter simply by using an additional RC network in the input path. The frequency response of the second-order low pass filter is identical to that of the first-order type except that the stop band roll-off will be twice the first-order filters at 40dB/decade (12dB/octave). Therefore, the design steps required of the second-order active low pass filter are the same.

First-order HPF: (See Fig.5)

In similar way we can find the gain for an active HPF, $A_v = \frac{V_{out}}{V_{in}} = \frac{A_F\left(f/f_c\right)}{\sqrt{1 + \left(f/f_c\right)^2}}$

- $A_v < A_F$, at very low frequencies, $f > f$c,
- $A_v = \frac{A_F}{\sqrt{2}} = 0.707 A_F$, at the cut-off frequency, $f = f$c,
- $A_v \cong A_F$, at very high frequencies, $f < f$c.

Second-order HPF: (See Fig.6) As with the passive filter, a first-order high pass active filter can be converted into a second-order high pass filter simply by using an additional RC network in the input path. The frequency response of the second-order high pass filter is identical to that of the first-order type except that the stop band roll-off will be twice the first-order filters at 40dB/decade (12dB/octave). Therefore, the design steps required of the second-order active high pass filter are the same.

Cut-off frequency: For first-order circuit, $f_c = \frac{1}{2\pi R_1 C_1}$ Hz, and

for second-order circuit, $f_c = \frac{1}{2\pi\sqrt{R_1 R_2 C_1 C_2}}$ Hz

CIRCUIT DIAGRAM:-

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NETWORK LABORATORY	INSTUCTION MANUAL FOR EXPERIMENT NO.10: SIMULATION OF ACTIVE LOW-PASS AND HIGH-PASS FILTER	DOC. NO.: IIT(ISM)/EE/CKT-10 REVISION NO.: 3 DATE: July, 2022

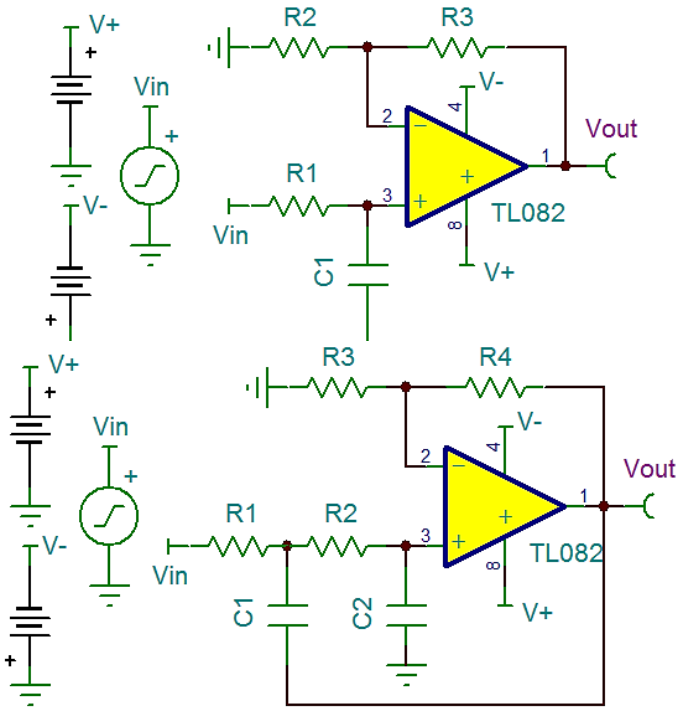

Fig.3. First-order low-pass filter.

Fig.4. Second-order low-pass filter.

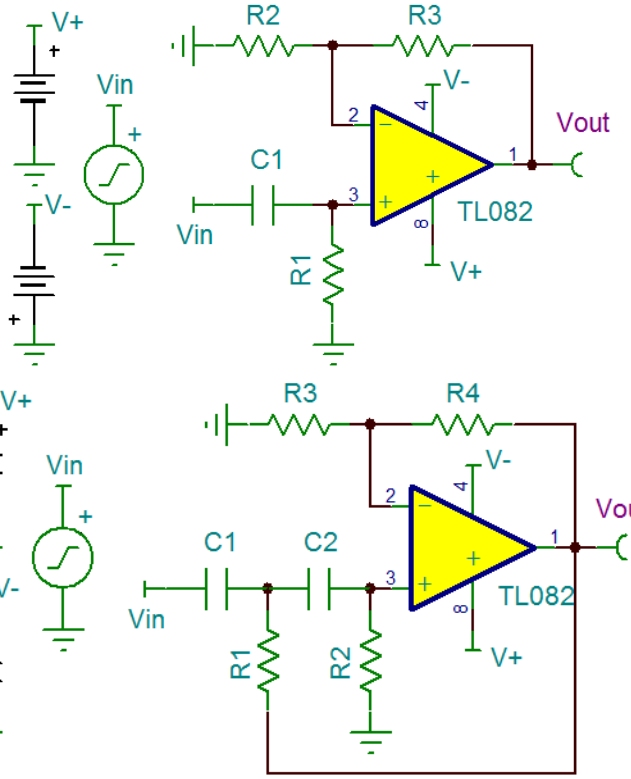

Fig.5. First-order high-pass filter.

Fig.6. Second-order high-pass filter.

[Note: Choose suitable values of circuit parameters]

SIMULATION TOOL USED: TINA

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NETWORK LABORATORY	**INSTUCTION MANUAL FOR EXPERIMENT NO.10: SIMULATION OF ACTIVE LOW-PASS AND HIGH-PASS FILTER**	**DOC. NO.: IIT(ISM)/EE/CKT-10** **REVISION NO.: 3** **DATE: July, 2022**

PROCEDURE:-

To simulate the filter circuit follow these steps:

1. Open TINA, inserte necessary components & draw the circuit.
2. Assign values to all the components and set the analysis parameters.
3. Save the file and simulate the circuit.
4. Change the parameters value and observe the frequency response.

EXPERIMENTAL DATA: -

Table 1: Data-sheet for active low-pass and high-pass filters

Filter Circuit	Parameters Value	Cut-off Frequency (Hz)	Gain (dB)	Phase (deg)
First-order LPF	R= , C=	Calculated: Simulated:		
Second-order LPF	R= , C=	Calculated: Simulated:		
First-order HPF	R= , C=	Calculated: Simulated:		
Second-order LPF	R= , C=	Calculated: Simulated:		

SAMPLE QUESTIONS:-

1. What is cut-off frequency?
2. Calculate the value of cut-off frequency from the circuit and compare to the value which is desired from the frequency curve.
3. For all filters draw the frequency response curve.
4. Conclude the experiment with your observation.

REFERENCES:-

1. Electrical and Electronic Technology: Edward Hughes (Revised by: John Hiley, Keith Brown, and Ian McKenzie Smith).
2. Introductory Circuit Analysis: Robert L. Boylestad
3. Fundamentals of Electric Circuits: Charles K. Alexander, and Matthew Sadiku
4. Engineering Circuit Analysis: William H. Hayt, Jack Kemmerly, and Steven M. Durbin
5. Electrical Engineering Fundamental: Vincent. D. Toro

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DEPARTMENT OF ELECTRICAL ENGINEERING INDIAN INSTITUTE OF TECHNOLOGY (ISM), DHANBAD		
NETWORK LABORATORY	**INSTUCTION MANUAL FOR PROJECT ON DESIGN OF FILTER CIRCUITS**	**DOC. NO.: IIT(ISM)/EE/CKT-Project REVISION NO.: 2**
		DATE: July, 2022

OBJECTIVE: - Design, Analysis, Simulation, Fabrication and Experiments on Passive and Active Filters

Students are advised to fulfil the following steps:

1. Design and analyse of the following Passive and Active Filters:
    a) First-Order Low-Pass Filter,
    b) First-Order High-Pass Filter,
    c) Second-Order Low-Pass Filter,
    d) Second-Order High-Pass Filter,
    e) Band-Pass Filter and
    f) Band-Reject Filter
2. Simulate each of the above filter circuits using computer simulation tool (like: TINA, PSpice)
3. Design the PCB footprint of the aforesaid circuits.
4. Fabricate and test the said circuits.
5. Make a report within three pages and submit after the completion of all the scheduled experiments of Monsoon Sem.

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