Date 17/11/2021

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DESIGN A LOWPASS FILTER AND HIGH PASS FILTER

OBJECTIVE

→ Design a low pass and highpass filter.
→ Calculate lower cutoff frequency and higher cut-off frequency
→ Calculate the gain.

Equipments required :-

→ Function generator
→ Bread Board
→ CRO/DSO

Components required :-

→ Resistor (10k)
→ Capacitor (0.01μF)

Theory

A filter is a circuit that passes a specific range of frequencies while rejecting other frequencies. A passive filter consists of passive circuit elements, such as capacitors, inductors & resistors. The most common way to describe the frequency response of a filter is to plot the filter voltage gain ($V_{out}/_{in}$) in dB as a function of frequency (f). The frequency at which the output power gain drops to 50% of the maximum value is called the cut-off frequency (f_c). When the dB voltage gain is plotted as a function of frequency on a semilog graph using straight lines to approximate the actual frequency response, it is called a Bode plot. A Bode plot is an ideal plot of the filter frequency response because it assumes that the voltage gain remains constant, until the cutoff frequency is reached. The

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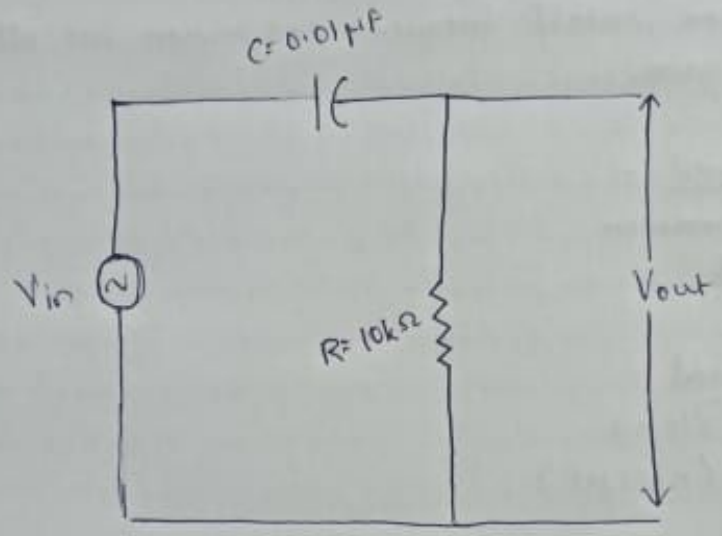

(Circuit diagram of high-pass filter)

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filter network voltage gain in dB is calculated from the actual voltage gain using the equation $A_{dB} = 20 \log A$, where $A = V_{out}/V_{in}$

A low pass filter (LPF) is designed to pass all frequencies below the cutoff frequencies and reject all frequencies above the cutoff frequencies. It is simply an RC series circuit across the input, the output taken across the capacitor. At the cutoff frequency, the capacitive reactance of the capacitor C is equal to the resistance of resistor R, causing the output voltage to be 0.707 times the input voltage. The expected cutoff frequency (f_c) of the low pass filter based on the circuit component values, can be calculated from:

$$R = \frac{1}{2\pi f_c C} \quad \therefore f_c = \frac{1}{2\pi RC}$$

A high pass filter (HPF) is designed to pass all frequencies above the cutoff frequencies and reject all frequencies below the cutoff frequencies. It is simply an RC series circuit across the input, with the output taken across the resistor. Similar to LPF expected cutoff frequency (f_c) of the HPF is gained as $f_c = \frac{1}{2\pi RC}$

Procedure :-

1) The circuit is setup as shown by taking the output across the capacitor. The input for the filter is taken from the output of function generator. The input of filter is also connected to channel of 2 of the CRO/DSO.
2) The frequency of input signal is varied over a wide frequency range (but the input amplitude is fixed). The values of V_{out} are noted for each frequency the corresponding gains are calculated.

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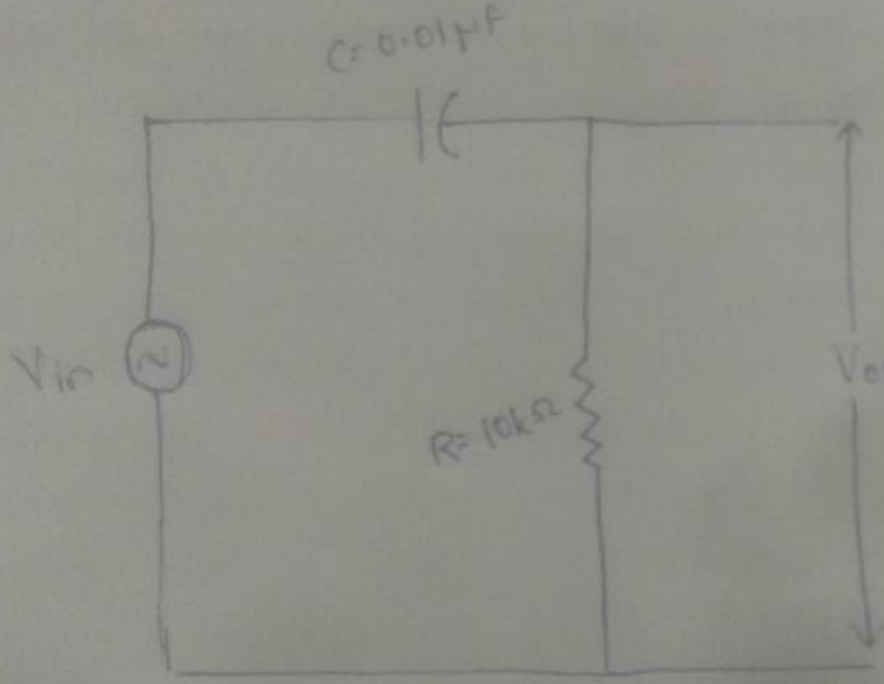

(Circuit diagram of high-pass filter)

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3) The values of gain frequency are plotted in a semilog graph paper and cutoff frequency is found out from it.

Observation Table :-

Band width cutoff frequency measurement (LPF)

Vin (Vpk-pk)	Frequency (Hz)	Vout (in volt)	gain in dB
10 V	50	10.1	0
	100	10.1	0.0864
	500	9.46	-0.432
	1k	7.6	-2.383
	2k	5.2	-5.679
	3k	4	-7.95
	4k	3.12	-10.11
	5k	2.56	-11.83
	6k	2.16	-13.31
	7k	1.92	-14.33
	8k	1.76	-15.089
	9k	1.60	-15.91
	10k	1.44	-16.832

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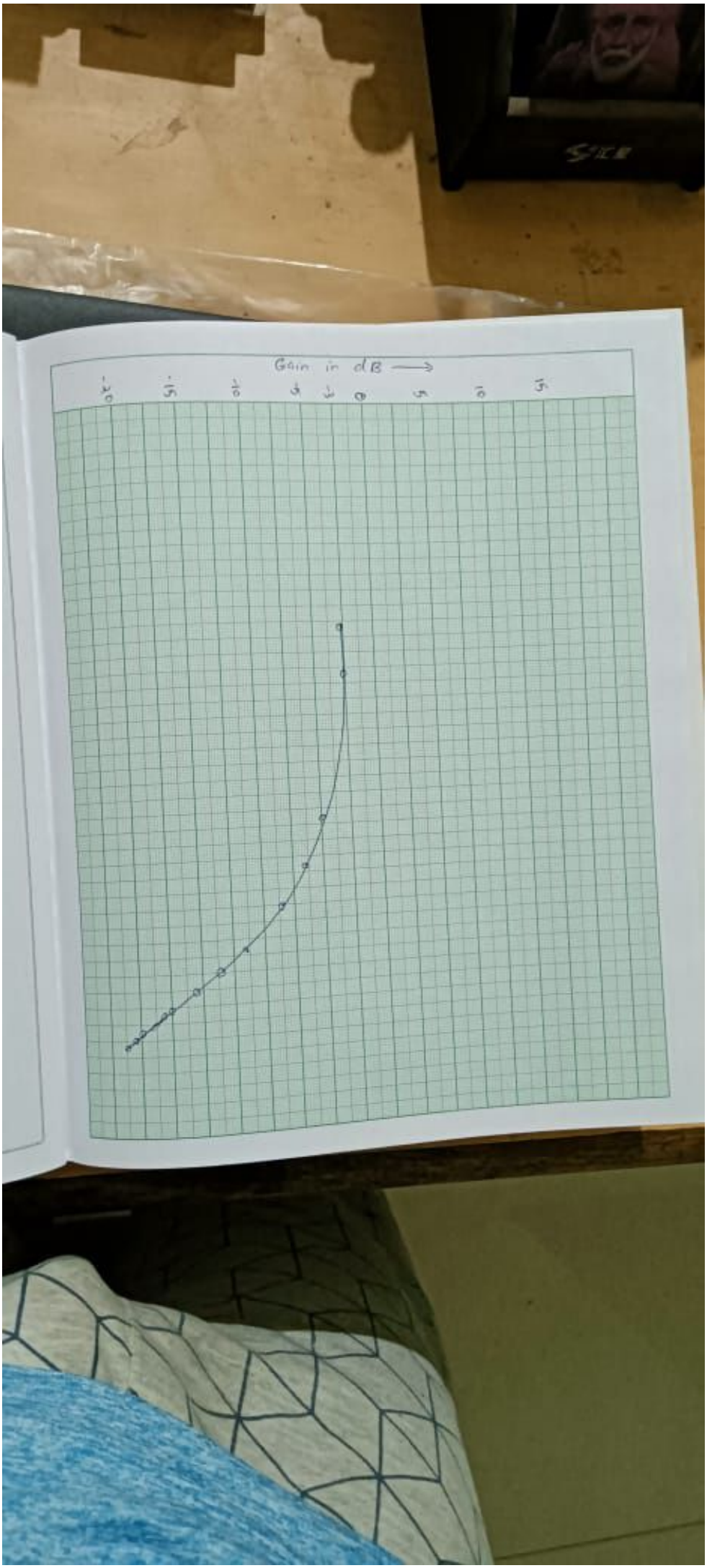
Gain in dB ⟶
-20
-15
-10
-5
-2
0
5
10
15

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High Pass filter :

Vin	frequency (in Hz)	Vout (in volt)	gain (in dB)
10 v	50	0.480	-26.37
	100	0.960	-20.35
	500	3.80	- 8.313
	1k	6.24	- 4.096
	2k	8.16	- 1.76
	3k	9.28	- 0.6490
	4k	9.2	- 0.424
	5k	9.76	- 0.211
	6k	9.92	- 0.069
	7k	9.92	- 0.069
	8k	10	0
	9k	10	0
	10k	10	0

Calculation :-

Calculated $f_c = 1/2\pi RC$		Measured f_c	
low-pass	high-pass	low-pass	high-pass
1.592 k	1.592 k	1.15 k	1.35 k

Conclusion :-

In this experiment, we came to know about the different types of filters and studied their frequency responses. These filters are used to modify audio signals in radio, transmitters etc.

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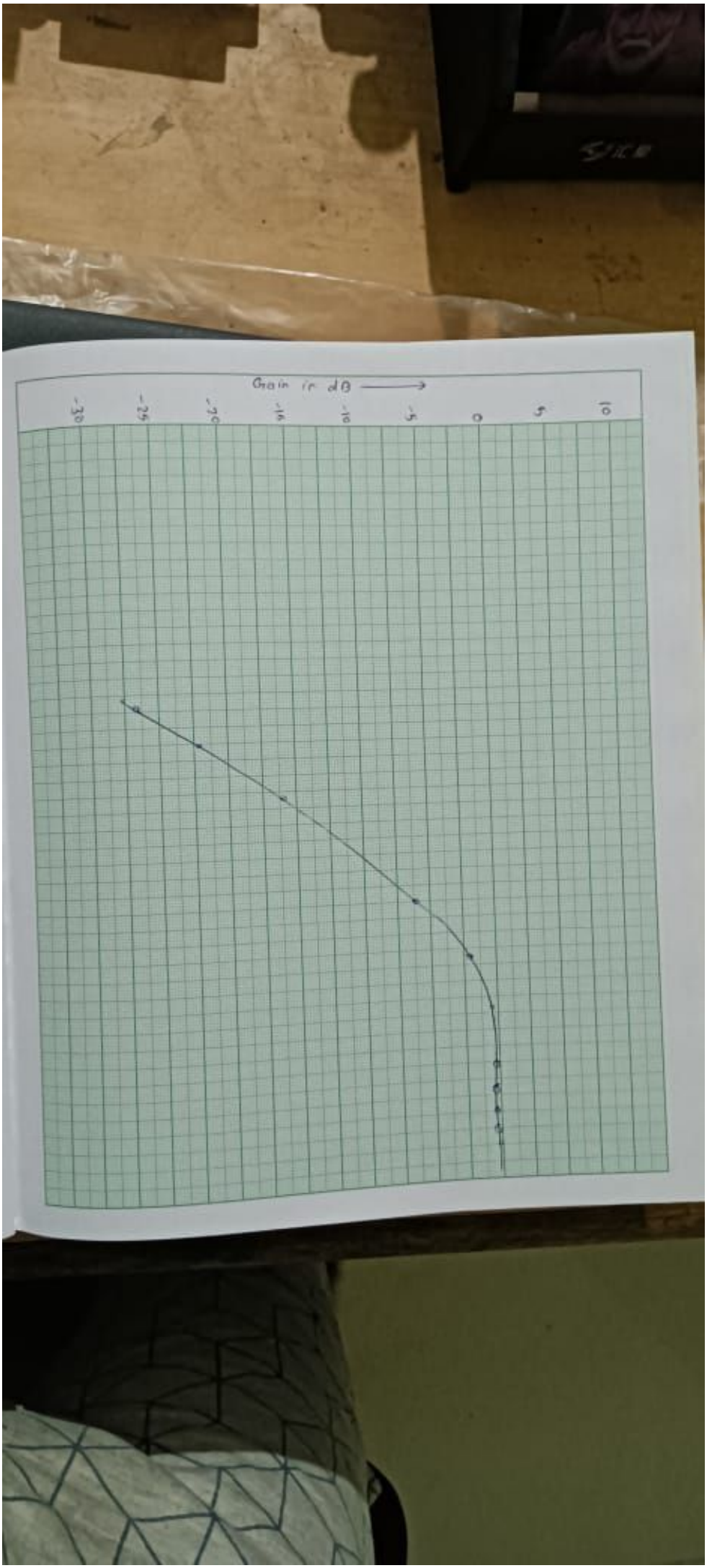
Gain in dB ⟶
-30
-25
-20
-15
-10
-5
0
5
10