KHULNA UNIVERSITY OF ENGINEERING & TECHNOLOGY

KUET

COURSE NO.: ECE-2200

COURSE NAME: ELECTRONICS CIRCUIT DESIGN LAB.

PROJECT NAME

“Designing & Implementation of Second Order Low Pass Filter”

PROJECT SUPERVISOR:	SUBMITTED BY:
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OBJECTIVES:

After completing this experiment we'll be able

- To design a second order low pass filter with lower cutoff frequency of 300 Hz.
- To implement the circuit and observe the gradual attenuation of output voltage above 300 Hz.
- To measure the output voltage of the filter at different frequencies and plot a Gain Vs frequency graph in semi-logarithmic graph paper.
- To calculate the lower cut off frequency from the plotted graph and show whether it is close to 300Hz or not.
- To calculate the roll-off of the gain with per decade of frequency outside the cutoff frequency and show whether it is 40dB/decade or not; hence to prove whether the circuit is working as a second order filter or not.

INTRODUCTION:

Basically, an electrical filter is a circuit that can be designed to modify, reshape or reject all unwanted frequencies of an electrical signal and accept or pass only those signals wanted by the circuit's designer. In other words, they "filter-out" unwanted signals and an ideal filter will separate and pass sinusoidal input signals based upon their frequency.
In low frequency applications (up to 100kHz), passive filters are generally constructed using simple RC (Resistor-Capacitor) networks, while higher frequency filters (above 100kHz) are usually made from RLC (Resistor-Inductor-Capacitor) components. Passive filters are made up of passive components such as resistors, capacitors and inductors and have no amplifying elements (transistors, op-amps, etc) so have no signal gain, therefore their output level is always less than the input.

Filters are so named according to the frequency range of signals that they allow to pass through them, while blocking or "attenuating" the rest. The low pass filter only allows low frequency signals from 0Hz to its cut-off frequency, fc point to pass while blocking those any higher.

THEORY:

A low-pass filter (LPF) is a filter that passes signals with a frequency lower than a selected cutoff frequency and attenuates signals with frequencies higher than the cutoff frequency. The exact frequency response of the filter depends on the filter design. The filter is sometimes called a high-cut filter, or treble-cut filter in audio applications. A low-pass filter is the complement of a high-pass filter.

Low-pass filters exist in many different forms, including electronic circuits such as a hiss filter used in audio, anti-aliasing filters for conditioning signals prior to analog-to-digital conversion, digital filters for smoothing sets of data, acoustic barriers, blurring of images, and so on. The moving average operation used in fields such as finance is a particular kind of low-pass filter, and can be analyzed with the same signal processing techniques as are used for other low-pass filters. Low-pass filters provide a smoother form of a signal, removing the short-term fluctuations and leaving the longer-term trend.

Filter designers will often use the low pass form as a prototype filter. That is, a filter with unity bandwidth and impedance. The desired filter is obtained from the prototype by scaling for the desired bandwidth and impedance and transforming into the desired band form (that is low-pass, high-pass, band-pass or band-stop).

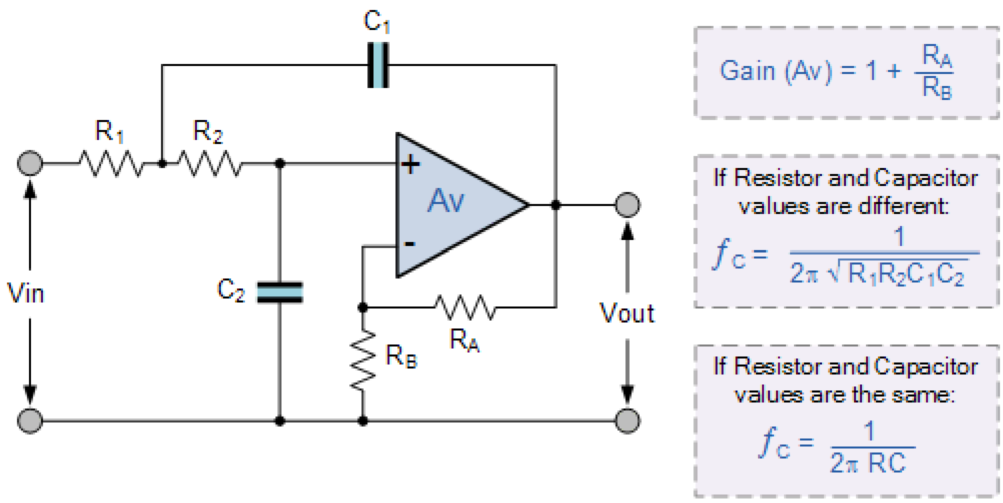

Fig 1: Circuit Diagram of second order low pass filter

This second order low pass filter circuit has two RC networks, R1 – C1 and R2 – C2 which give the filter its frequency response properties. The filter design is based around a non-inverting op-amp configuration so the filters gain, A will always be greater than 1. Also, the op-amp has a high input impedance which means that it can be easily cascaded with other active filter circuits to give more complex filter designs.

The normalized frequency response of the second order low pass filter is fixed by the RC network and is generally identical to that of the first order type. The main difference between a 1st and 2nd order low pass filter is that the stop band roll-off will be twice the 1st order filters at 40dB/decade (12dB/octave) as the operating frequency increases above the cut-off frequency fc, point as shown.

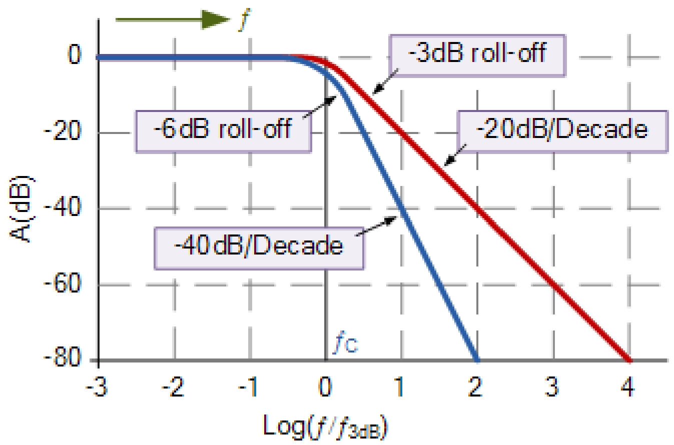

Fig 2: Normalized low pass frequency response

The frequency response bode plot above, is basically the same as that for a 1st-order filter. The difference this time is the steepness of the roll-off which is -40dB/decade in the stop band. However, second order filters can exhibit a variety of responses depending upon the circuit's voltage magnification factor, Q at the cut-off frequency point.

APPARATUS REQUIRED:

Sl. No.	Apparatus name	Ratings	Quantity
1	Op-amp	LM-741	01
2	Resistors	47k ,5.6k(2), 27k, 30.9k	05
3	Capacitors	0.1µf	2
4	Oscilloscope	50mHz	01
5	Breadboard	-	01
6	Function generator	5mhz	01
7	DC polar power supply	+15v,-15v	01
8	Connecting-wires	-	As required

CIRCUIT DIAGRAM:

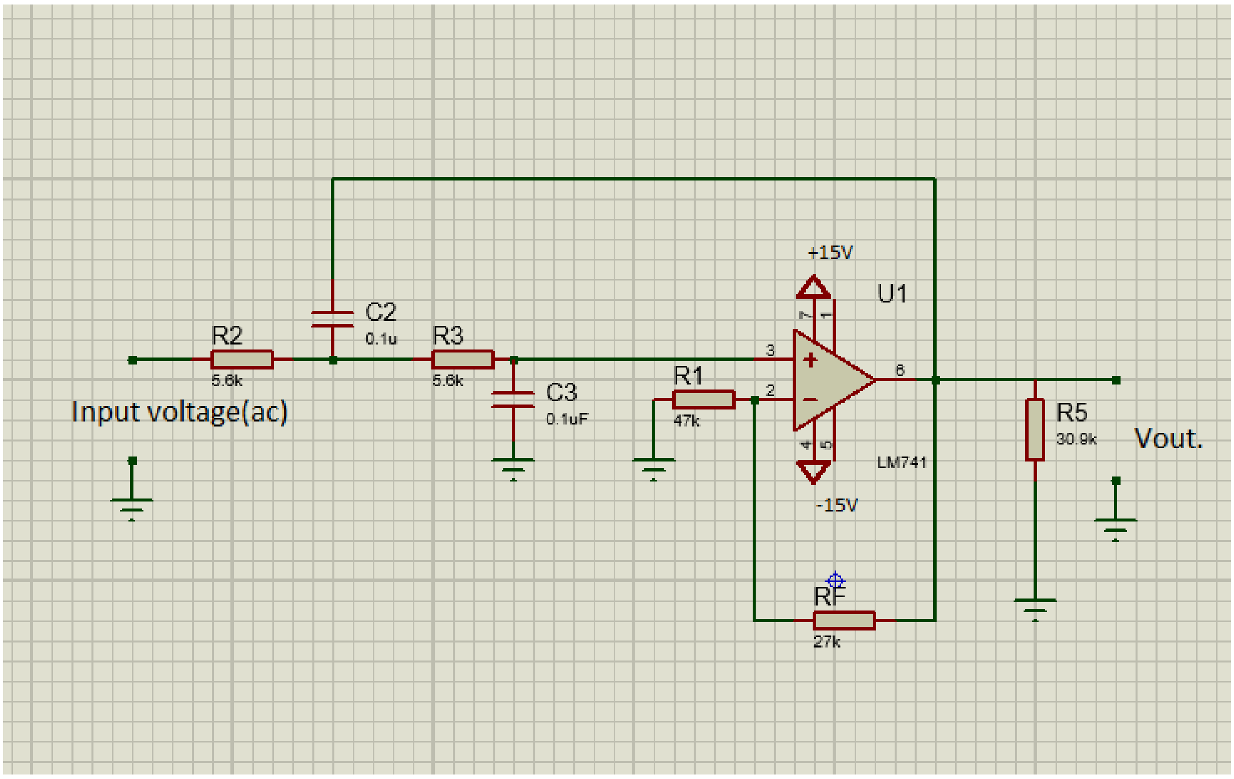

Fig 3: Circuit Diagram of second order low pass filter

EXPERIMENTAL DATA TABLE:

Frequency(Hz)	V_{out} (v)	V_{in} (v)	Gain	dB gain
30	4.8	3	1.6	4.08
60	4.8	3	1.6	4.08
90	4.8	3	1.6	4.08
120	4.4	3	1.47	3.32
150	4.25	3	1.42	3.025
180	4.2	3	1.4	2.92
210	4.1	3	1.307	2.71
240	3.9	3	1.3	2.28
270	3.6	3	1.2	1.58
300	3.4	3	1.13	1.08
600	1.08	3	0.36	8.87
900	0.511	3	0.17	15.37
1.2k	0.270	3	0.09	20.91
1.5k	0.196	3	0.065	23.7
1.8k	0.124	3	0.0413	27.67
2.1k	0.094	3	0.031	30.08
2.4k	0.078	3	0.0253	31.93
2.7k	0.06	3	0.02	34
3k	0.04	3	0.0133	37.50

CALCULATION:

Cut off frequency $f_H = \frac{1}{2\pi\sqrt{(R2*R3*C2*C3)}}$

$= \frac{1}{2\pi\sqrt{(5.6k*5.6k*0.1\mu*0.1\mu)}}$

=284Hz

From the graph, we calculated the cutoff frequency to be 276 Hz.

We know that,

Gain = $\frac{Vout}{Vin}$ and decibel gain = 20 log (gain)

For frequency=300Hz,

Gain $A_v = \frac{3.4}{3} = 1.13$ dB gain = 20 log (1.13) =1.08

For frequency=3kHz,

Gain $A_v = \frac{0.04}{3} = 0.0133$ dB gain = 20 log (0.0133) =-37.5

So, by increasing frequency 10 times, gain decreased 38.58dB.

DISCUSSION:

In this experiment we designed a second order low pass filter with lower cutoff frequency 284hz. With the designed circuit, we implemented the filter. Then with the help of oscilloscope we checked whether the output voltage is getting attenuated above 284 Hz or not. Then for a fixed input ac voltage of Vpp 3v. We measured the output voltage at different frequencies at recorded data.

With the data, we calculated gain at every frequency. Then plotted a dB gain vs frequency curve at the semi-logarithmic graph.

From the graph, we calculated that at 276 Hz, gain decreased 3db. So, the lower cutoff frequency(calculated) of the filter is 276Hz which is very close to 284(measured from the circuit). Below this frequency, gain remains constant. Thus, it works as a low pass filter with lower cut off 276hz.

Again, from the graph, at 300hz the gain was 1.08db and at 3khz gain was -37.50db. So, by increasing frequency 10 times, gain decreases 38.58db. Which is very much close to 40db/decade. This fulfills the requirement of a second order circuit. Thus, the circuit, perfectly work as a low pass second order filter.

CONCLUSION:

After completing this sessional, all objectives have been full filled with a little deviation. This project has been helpful with the learnings of designing low pass filter and other also.