Opamp_LowPassFilter -- Overview

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Design of Low Pass Filter using IC 741 Operational Amplifier

Objectives:

- To identity the function of each pin of IC 741
- To construct a low pass filter using discrete and active components
- To design the filter parameters for the given cut-off frequency
- To plot the frequency response of the low pass filter
- To verify and analyze the practical characteristic of the low pass filter

Components:

- IC 741
- Bread board
- Regulated power supply
- Function generator
- Oscilloscope
- Resistors
- Capacitors
- Connecting wires

Theory:

- Active filters consist of active elements like op-amps in conjunction with resistor and capacitor networks.
- Use of active elements provides:
  - excellent gain and so signal will not be attenuated.
  - excellent isolation properties - so they can be designed and tuned independently, easily with minimal interaction
  - high input impedance and low output impedance - there is no problem of loading the preceding and succeeding stage.
- A Low Pass Filter passes the input that are within pass band (i.e., lower than the cut off frequency) and attenuates frequencies higher than the cut off frequency.
- The gain of the active element is governed by the resistors R1 and RF.
- The pass band gain of the band pass filter is given by

$$A_f = \left(1 + \frac{R_{f1}}{R_1}\right)\left(1 + \frac{R_{f2}}{R_2}\right)$$

- The laplace tarnsfer function of the band pass filter is given by
$$\frac{V_o(s)}{V_{in}(s)} = \left(\frac{1}{1+sR_lC_l}\right)\left(\frac{sR_hC_h}{1+sR_hC_h}\right)$$
- The frequency tarnsfer function of the band pass filter is given by
$$\frac{V_o(j\omega)}{V_{in}(j\omega)} = \left(\frac{1}{1+j\omega R_lC_l}\right)\left(\frac{j\omega R_hC_h}{1+j\omega R_hC_h}\right)$$
$$\frac{V_o(jf)}{V_{in}(jf)} = \left(\frac{1}{1+j2\Pi fR_lC_l}\right)\left(\frac{j2\Pi fR_hC_h}{1+j2\Pi fR_hC_h}\right)$$
$$\frac{V_o(jf)}{V_{in}(jf)} = \left(\frac{1}{1+j\frac{f}{f_{c1}}}\right)\left(\frac{j\frac{f}{f_{c2}}}{1+j\frac{f}{f_{c2}}}\right)$$
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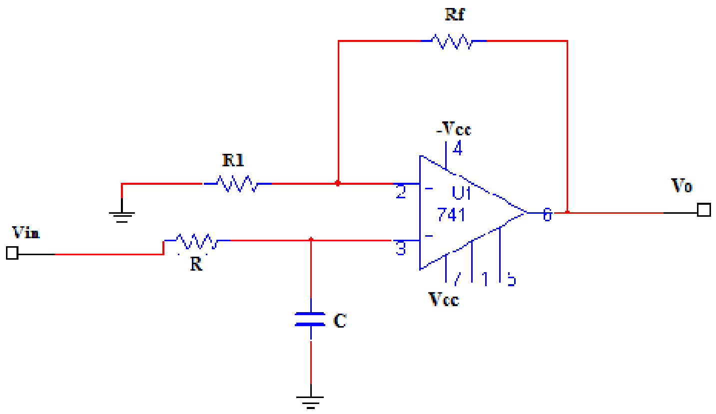
- The cut-off frequency of the filter is given by
$$f_h = \frac{1}{2\Pi RC}$$
- The frequency response of the filter is given by
$$M = \frac{1}{\sqrt{1+\left(\frac{f}{f_h}\right)^2}}$$
$$\Phi = tan^{-1}\left(\frac{f}{f_h}\right)$$

Opamp_LowPassFilter -- Procedures

Step 1

Prepare the circuit as shown below



Step 2

- Select a sine wave of 2 volts peak to peak from the function generator as the input voltage to the circuit
- vary its frequency over a range including the cut-off frequency range to note down the output voltage .

Step 3

S.No	Operating frequency f(Hz)	Output voltage (volts) V_o	Gain= $M = 20log_{10}\left(\frac{V_o}{V_{in}}\right)dB$

Step 4

- Plot the magnitude response on a semilog graph sheet.
- Calculate the roll-off rate from the graph

Step 5

- Obtain the phase angle at each operating frequency from the Oscilloscope's X-Y mode

Step 6

S.No	Operating frequency f(Hz)	Phase angle from CRO

Step 7

- Plot the phase response

Step 8

- Identify the pass band,stop band and transmission band of the filter from the graph.
- Calculate the 3-dB frequency from the graph

Step 9

Result:

Cut-off frequency value :

- Derived value =
- Practical value =

Roll-off rate value

- Derived value =
- Practical value =

Passband range ____________________

Stopband range ____________________