Electronic Circuits Course Project
Band Pass Filter Fabrication

Project group 1, Batch B-2

Group guide:

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Introduction:

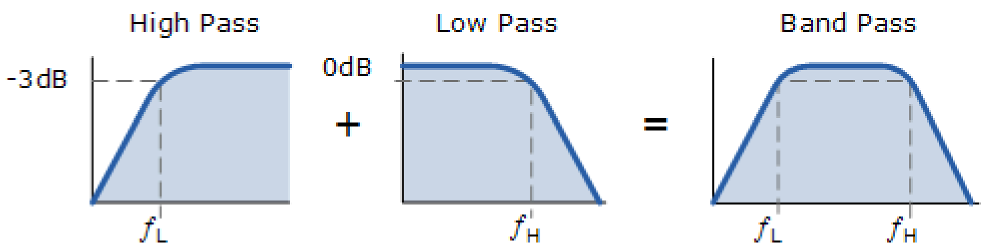


Fig. 1: Basic types of filters

It is sometimes desirable to have circuits capable of selectively filtering one frequency or range of frequencies out of a mix of different frequencies in a circuit. A circuit designed to perform this frequency selection is called a filter circuit, or simply a filter. A common need for filter circuits is in high-performance stereo systems, where certain ranges of audio frequencies need to be amplified or suppressed for best sound quality and power efficiency.

A filter is an AC circuit that separates some frequencies from others within mixed-frequency signals.

Audio equalizers and crossover networks are two well-known applications of filter circuits.

There are applications where a particular band, or spread, or frequencies need to be filtered from a wider range of mixed signals. Filter circuits can be designed to accomplish this task by combining the properties of low-pass and high-pass into a single filter. The result is called a band-pass filter. Creating a bandpass filter from a low-pass and high-pass filter can be illustrated using block diagrams: (Figure below)

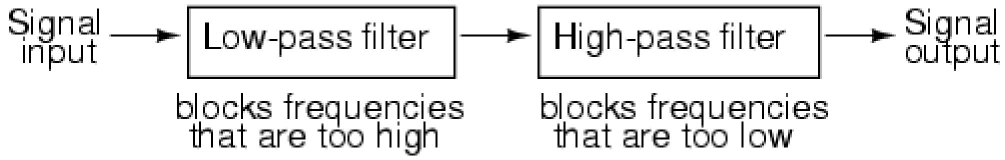


Fig. 2: System level block diagram of a band-pass filter.

What emerges from the series combination of these two filter circuits is a circuit that will only allow passage of those frequencies that are neither too high nor too low.

This cascading together of the individual low and high pass passive filters produces a low "Q-factor" type filter circuit which has a wide pass band. The first stage of the filter will be the high pass stage that uses the capacitor to block any DC biasing from the source. This design has the advantage of producing a relatively flat asymmetrical pass band frequency response with one half representing the low pass response and the other half representing high pass response as shown.

The higher corner point ($ƒ_H$) as well as the lower corner frequency cut-off point ($ƒ_L$) are calculated the same as before in the standard first-order low and high pass filter circuits. Obviously, a reasonable separation is required between the two cut-off points to prevent any interaction between the low pass and high pass stages. The amplifier also provides isolation between the two stages and defines the overall voltage gain of the circuit.

The bandwidth of the filter is therefore the difference between these upper and lower -3dB points. For example, suppose we have a band pass filter whose -3dB cut-off points are set at 200Hz and 600Hz. Then the bandwidth of the filter would be given as: Bandwidth (BW) = 600 – 200 = 400Hz.

The normalised frequency response and phase shift for an active band pass filter will be as follows.

While the above passive tuned filter circuit will work as a band pass filter, the pass band (bandwidth) can be quite wide and this may be a problem if we want to isolate a small band of frequencies. Active band pass filter can also be made using inverting operational amplifier.

So by rearranging the positions of the resistors and capacitors within the filter we can produce a much better filter circuit as shown below. For an active band pass filter, the lower cut-off -3dB point is given by $ƒ_{C1}$ while the upper cut-off -3dB point is given by $ƒ_{C2}$.

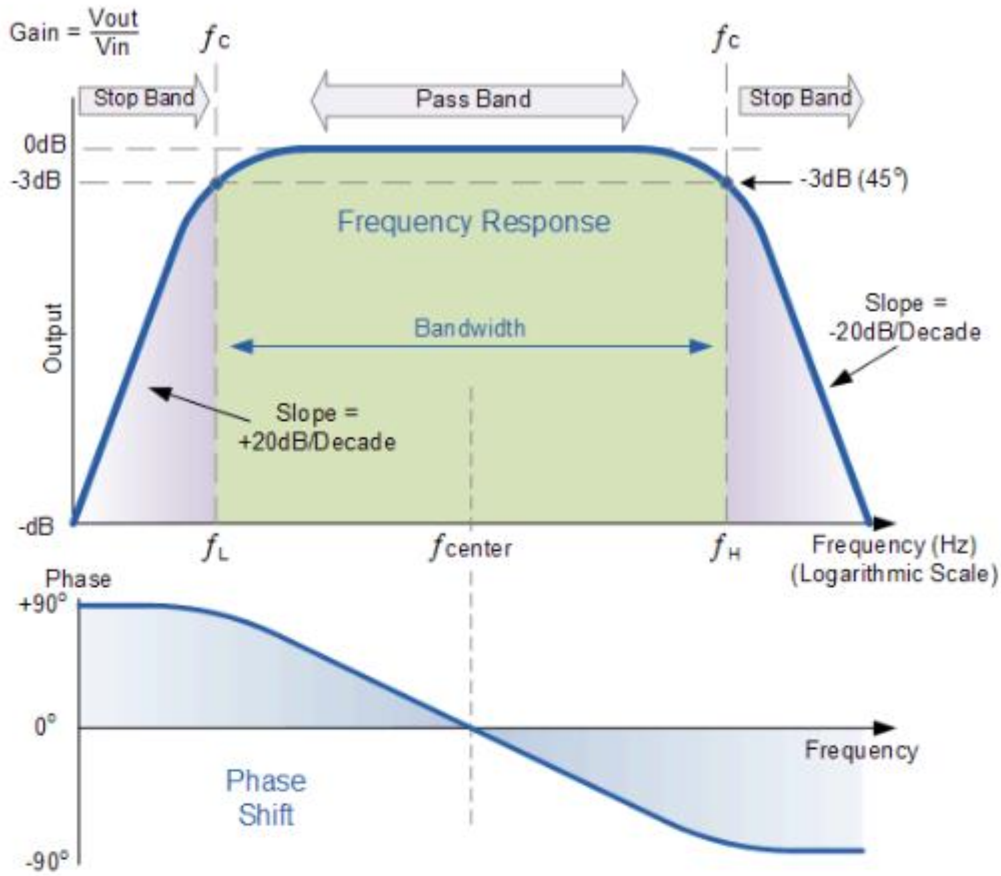


Fig. 3: Band pass filter in detail

Applications of BPF

- BPFs (Bandpass filters) are extensively used in wireless transmitters and receivers.
- The main function of this filter in a transmitter is to limit the bandwidth of the o/p signal to the band allotted for the transmission.
- This avoids the transmitter from interfering with further stations.
- In a receiver, a bandpass filter allows signals within a selected range of frequencies to be heard or decoded, while preventing signals at unwanted frequencies from getting through. A bandpass filter also optimizes the signal-to-noise ratio and sensitivity of a receiver.
- Bandpass filters are used in all types of instruments as well as in Sonar, Seismology and even medical applications like EEGs and Electrocardiograms.
- These filters are also extensively used in optics like lasers, LIDARS, etc.
- A BPF (Band Pass Filter) permits an exact frequency range to pass, while blocking frequencies that are lower and higher. A good application of a BPF is in Audio Signal Processing, where a particular range of frequencies of sound is required while removing the rest.

- Bandpass filters are used in communication systems for selecting a specific signal from a range of signals.

Circuit Diagram:

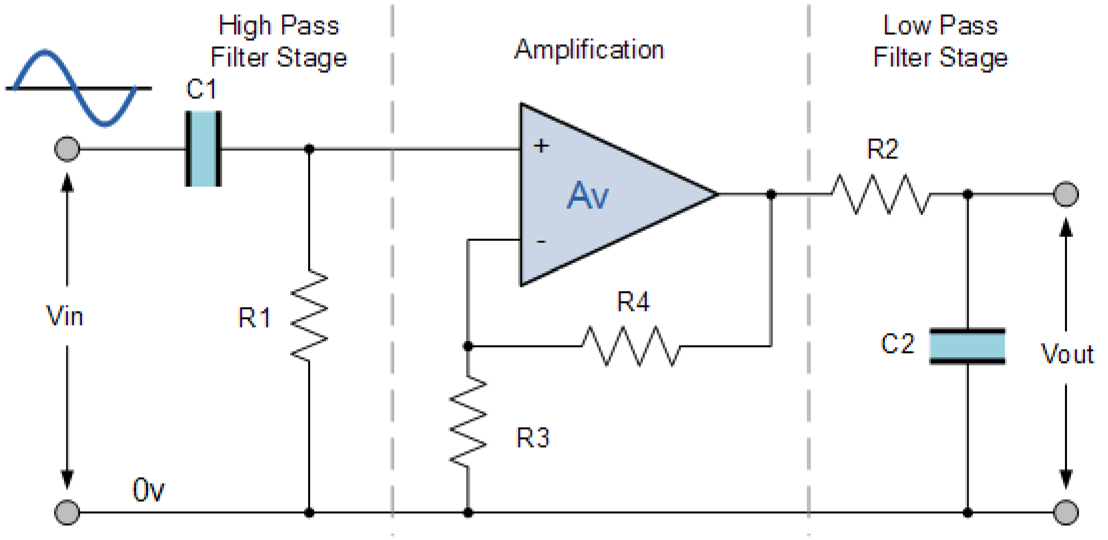


Fig. 4: Theoretical circuit diagram

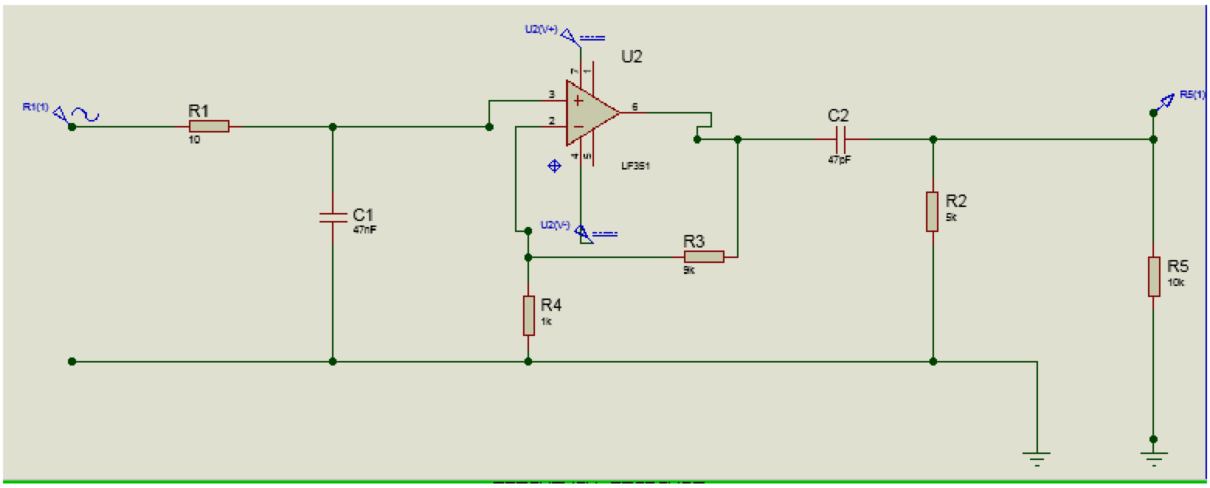


Fig. 5: Circuit diagram constructed in Proteus

Simulation Graph:

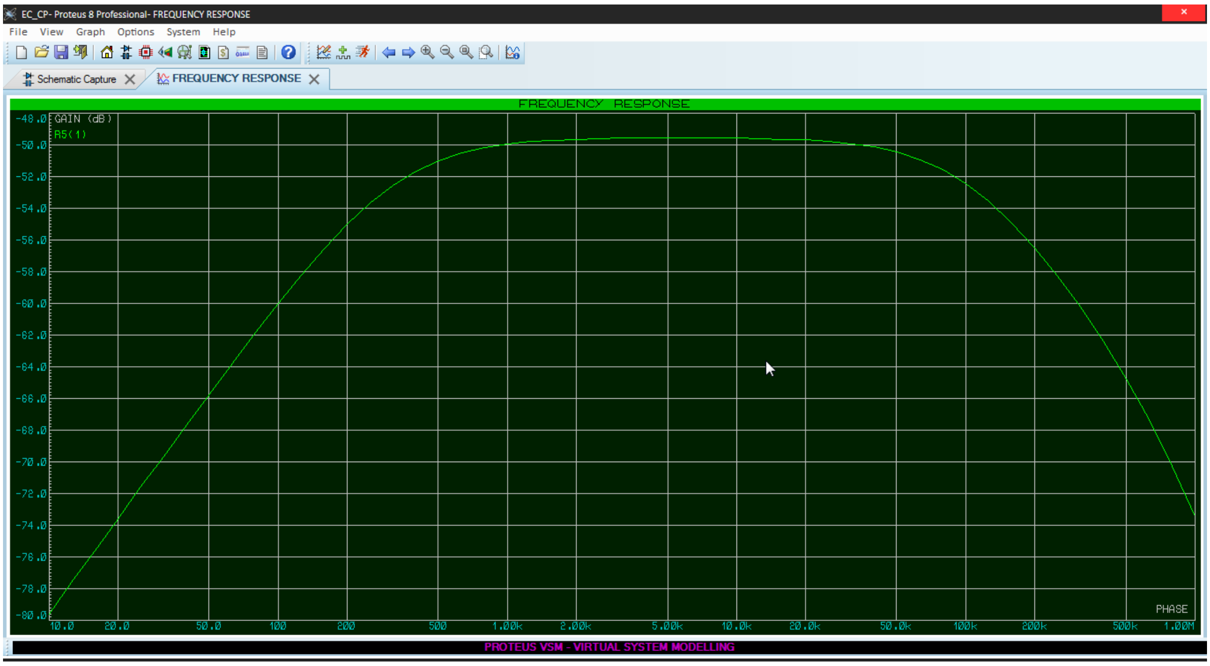


Fig. 6: Simulated output obtained in Proteus

Theoretical formula used:

$$fc_1 = \frac{1}{2\pi R_1 C_1}, \quad fc_2 = \frac{1}{2\pi R_2 C_2}$$

Fig. 7: Formula to calculate cut-off frequencies

Selection of hardware components:

We considered the following ICs for the project:

IC ADA8009 is a new IC which can function as a band pass filter, however it is not available in India.

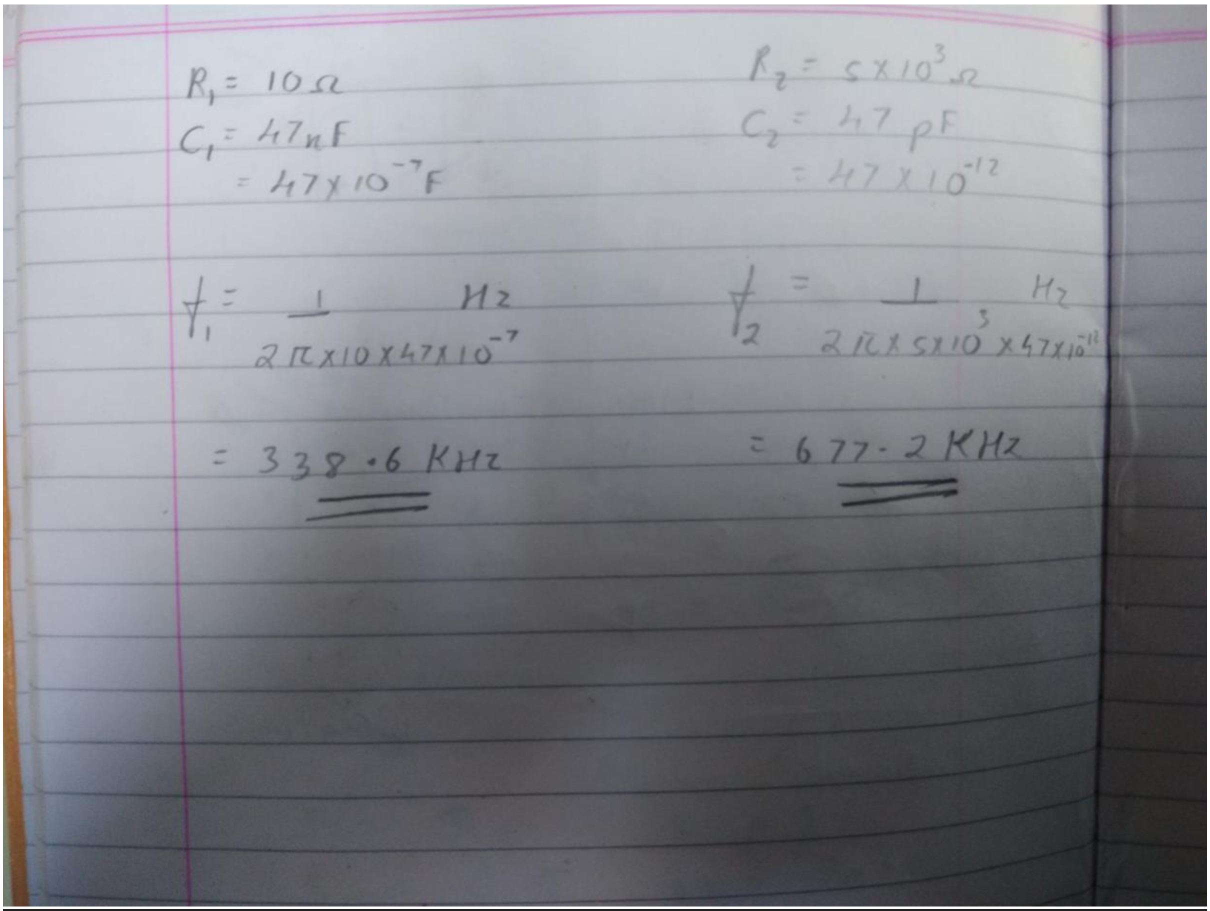
IC AF420 is an extremely fast IC which would be ideal for a filter circuit, but was rejected due to high cost.

We finally settled upon IC LM351 as it is relatively fast and also affordable.

Hardware implementation:

Fig. 8: Completed filter

Calculations & Theoretical results:



$R_1 = 10\Omega$

$C_1 = 47nF$

$= 47 \times 10^{-7} F$

$R_2 = 5 \times 10^{3} \Omega$

$C_2 = 47 pF$

$= 47 \times 10^{-12}$

$f_1 = \frac{1}{2\pi \times 10 \times 47 \times 10^{-7}} Hz$

$= 338.6 KHz$

$f_2 = \frac{1}{2\pi \times 5 \times 10^{3} \times 47 \times 10^{-12}} Hz$

$= 677.2 KHz$

Fig. 9: On paper theoretical cut-off frequencies

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