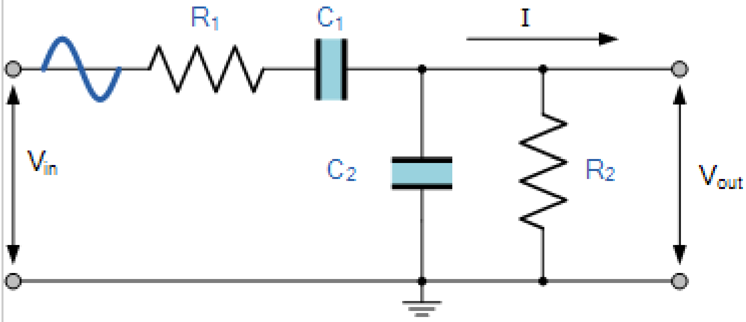


Passive Band Pass Filter

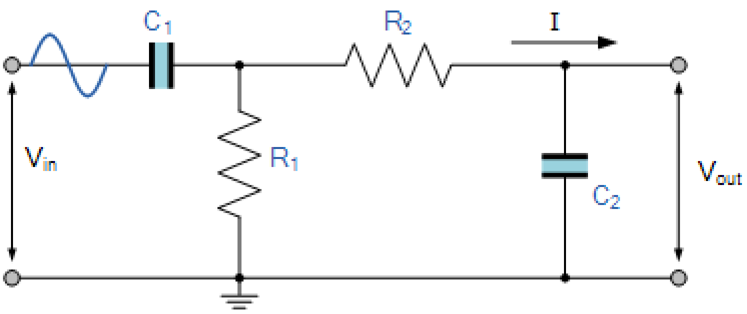
Passive Band Pass Filters can be made by connecting together a low pass filter with a high pass filter

Band Pass Filters can be used to isolate or filter out certain frequencies that lie within a particular band or range of frequencies. The cut-off frequency or fc point in a simple RC passive filter can be accurately controlled using just a single resistor in series with a non-polarized capacitor, and depending upon which way around they are connected, we have seen that either a Low Pass or a High Pass filter is obtained.

One simple use for these types of passive filters is in audio amplifier applications or circuits such as in loudspeaker crossover filters or pre-amplifier tone controls. Sometimes it is necessary to only pass a certain range of frequencies that do not begin at 0Hz, (DC) or end at some upper high frequency point but are within a certain range or band of frequencies, either narrow or wide.

By connecting or "cascading" together a single **Low Pass Filter** circuit with a **High Pass Filter** circuit, we can produce another type of passive RC filter that passes a selected range or "band" of frequencies that can be either narrow or wide while attenuating all those outside of this range. This new type of passive filter arrangement produces a frequency selective filter known commonly as a **Band Pass Filter** or **BPF** for short.

Band Pass Filter Circuit

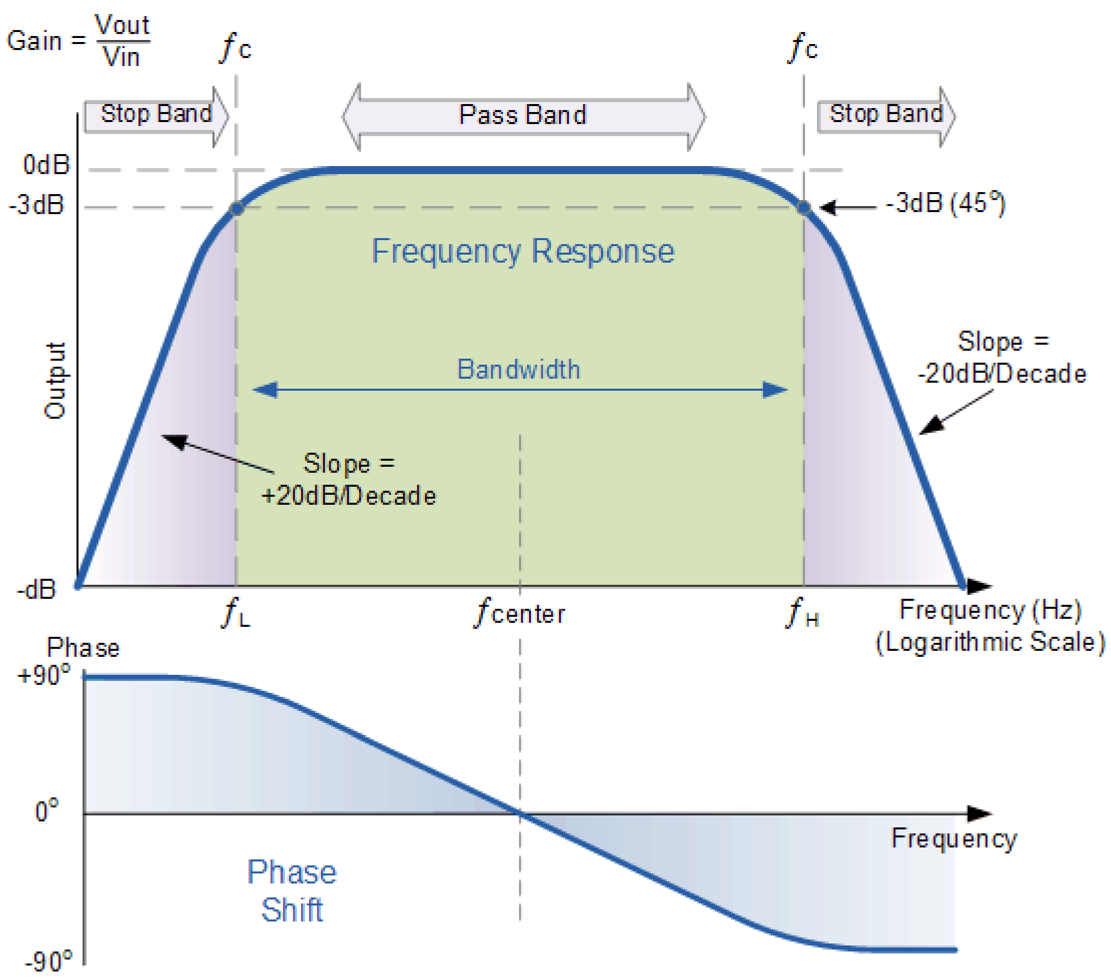


Unlike the low pass filter which only pass signals of a low frequency range or the high pass filter which pass signals of a higher frequency range, a **Band Pass Filters** passes signals within a certain "band" or "spread" of frequencies without distorting the input signal or introducing extra noise. This band of frequencies can be any width and is commonly known as the filters **Bandwidth**.

$f_H - f_L$. Clearly for a pass band filter to function correctly, the cut-off frequency of the low pass filter must be higher than the cut-off frequency for the high pass filter.

The “ideal” **Band Pass Filter** can also be used to isolate or filter out certain frequencies that lie within a particular band of frequencies, for example, noise cancellation. Band pass filters are known generally as second-order filters, (two-pole) because they have “two” reactive component, the capacitors, within their circuit design. One capacitor in the low pass circuit and another capacitor in the high pass circuit.

Frequency Response of a 2nd Order Band Pass Filter



The **Bode Plot** or frequency response curve above shows the characteristics of the band pass filter. Here the signal is attenuated at low frequencies with the output increasing at a slope of +20dB/Decade (6dB/Octave) until the frequency reaches the “lower cut-off” point f_L. At this frequency the output voltage is again $1/\sqrt{2} = 70.7\%$ of the input signal value or **-3dB** (20*log(V_{OUT}/V_{IN})) of the input.

The output continues at maximum gain until it reaches the “upper cut-off” point f_H where the output decreases at a rate of -20dB/Decade (6dB/Octave) attenuating any high frequency signals. The point of maximum output gain is generally the geometric mean of the two -3dB value between the lower and upper cut-off points and is called the “Centre Frequency” or “Resonant Peak” value fr. This geometric mean value is calculated as being $fr^2 = f_{(UPPER)} \times f_{(LOWER)}$.

A band pass filter is regarded as a second-order (two-pole) type filter because it has “two” reactive components within

$$fc = \frac{1}{2\pi RC} \ Hz$$

Then clearly, the width of the pass band of the filter can be controlled by the positioning of the two cut-off frequency points of the two filters.

Band Pass Filter Example No1.

A second-order **band pass filter** is to be constructed using RC components that will only allow a range of frequencies to pass above 1kHz (1,000Hz) and below 30kHz (30,000Hz). Assuming that both the resistors have values of 10kΩ, calculate the values of the two capacitors required.

The High Pass Filter Stage

The value of the capacitor C1 required to give a cut-off frequency f_L of 1kHz with a resistor value of 10kΩ is calculated as:

$$C_1 = \frac{1}{2\pi f_L R} = \frac{1}{2\pi x 1{,}000 x 10{,}000} = 15.9\,nF$$

Then, the values of R1 and C1 required for the high pass stage to give a cut-off frequency of 1.0kHz are: R1 = 10kΩ and to the nearest preferred value, C1 = 15nF.

The Low Pass Filter Stage

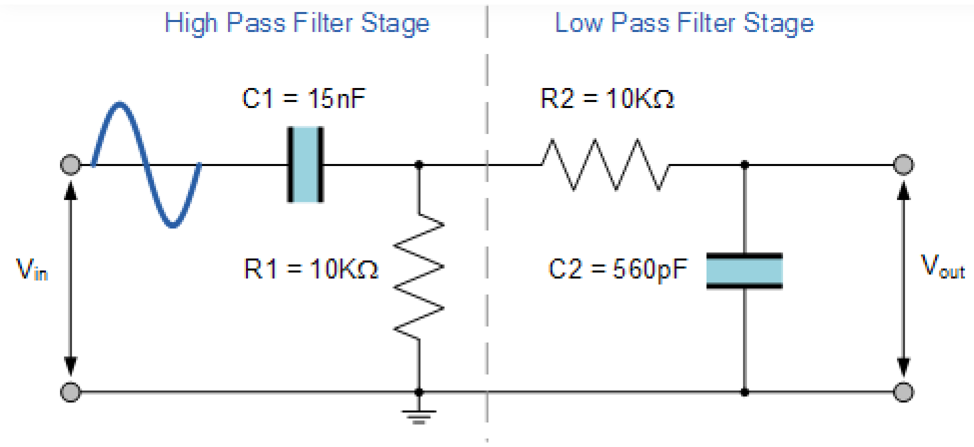
The value of the capacitor C2 required to give a cut-off frequency f_H of 30kHz with a resistor value of 10kΩ is calculated as:

$$C_2 = \frac{1}{2\pi f_H R} = \frac{1}{2\pi x 30{,}000 x 10{,}000} = 530\,pF$$

Then, the values of R2 and C2 required for the low pass stage to give a cut-off frequency of 30kHz are, R = 10kΩ and C = 530pF. However, the nearest preferred value of the calculated capacitor value of 530pF is 560pF, so this is used instead.

With the values of both the resistances R1 and R2 given as 10kΩ, and the two values of the capacitors C1 and C2 found for both the high pass and low pass filters as 15nF and 560pF respectively, then the circuit for our simple passive **Band Pass Filter** is given as.

Completed Band Pass Filter Circuit



Band Pass Filter Resonant Frequency

We can also calculate the “Resonant” or “Centre Frequency” ($ƒr$) point of the band pass filter were the output gain is at its maximum or peak value. This peak value is not the arithmetic average of the upper and lower -3dB cut-off points as you might expect but is in fact the “geometric” or mean value. This geometric mean value is calculated as being $ƒr^2 = ƒc_{(UPPER)} \text{ x } ƒc_{(LOWER)}$ for example:

Centre Frequency Equation

$$fr = \sqrt{f_L \ x \ f_H}$$

Where, $ƒ_r$ is the resonant or centre frequency
$ƒ_L$ is the lower -3dB cut-off frequency point
$ƒ_H$ is the upper -3db cut-off frequency point

and in our simple example above, the calculated cut-off frequencies were found to be $ƒ_L$ = 1,060 Hz and $ƒ_H$ = 28,420 Hz using the filter values.

Then by substituting these values into the above equation gives a central resonant frequency of:

$$fr = \sqrt{f_L \ x \ f_H} = \sqrt{1{,}060 \ x \ 28{,}420} = 5{,}48\,kHz$$

Band Pass Filter Summary

A simple passive **Band Pass Filter** can be made by cascading together a single **Low Pass Filter** with a **High Pass Filter**. The frequency range, in Hertz, between the lower and upper -3dB cut-off points of the RC combination is know as the filters “Bandwidth”.

The width or frequency range of the filters bandwidth can be very small and selective, or very wide and non-selective

(Unity). To provide an output signal with a voltage gain greater than unity, some form of amplification is required within the design of the circuit.

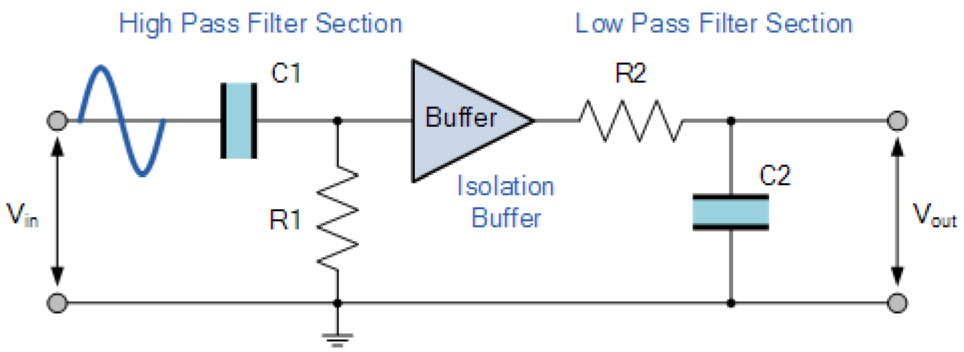
A **Passive Band Pass Filter** is classed as a second-order type filter because it has two reactive components within its design, the capacitors. It is made up from two single RC filter circuits that are each first-order filters themselves.

If more filters are cascaded together the resulting circuit will be known as an "n^{th}-order" filter where the "n" stands for the number of individual reactive components and therefore poles within the filter circuit. For example, filters can be a 2^{nd}-order, 4^{th}-order, 10^{th}-order, etc.

The higher the filters order the steeper will be the slope at n times -20dB/decade. However, a single capacitor value made by combining together two or more individual capacitors is still one capacitor.

Our example above shows the output frequency response curve for an "ideal" band pass filter with constant gain in the pass band and zero gain in the stop bands. In practice the frequency response of this Band Pass Filter circuit would not be the same as the input reactance of the high pass circuit would affect the frequency response of the low pass circuit (components connected in series or parallel) and vice versa. One way of overcoming this would be to provide some form of electrical isolation between the two filter circuits as shown below.

Buffering Individual Filter Stages



One way of combining amplification and filtering into the same circuit would be to use an Operational Amplifier or Op-amp, and examples of these are given in the Operational Amplifier section. In the next tutorial we will look at filter circuits which use an operational amplifier within their design to not only to introduce gain but provide isolation between stages. These types of filter arrangements are generally known as **Active Filters**.

Read more Tutorials inFilters

- 1. Capacitive Reactance
- 2. Passive Low Pass Filter
- 3. Passive High Pass Filter
- 4. Passive Band Pass Filter
- 5. Active Low Pass Filter
- 6. Active High Pass Filter
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- *Ahmed morsy*

  Very nice information

  Posted on April 26th 2022 | 11:11 am
  Reply
- *gracia*

  muucha gracia

  Posted on March 22nd 2022 | 2:43 pm
  Reply
- *Tariq Baig*

  Nice

  Posted on December 19th 2021 | 1:33 pm
  Reply
- *SANJIT MANDAL*

  kindly sent me circuit diagram for LN B range up to 6 .8 G HZ

  Posted on September 18th 2021 | 1:54 pm
  Reply
- *Surender Dalal*

  this fillter is effect on little on bass

  Posted on September 18th 2021 | 2:53 am
  Reply
- *Mohammed Elgaily*

  There are two conditions in band pass filter (narrow- and wide-band), and we all know the center frequency has two equation, the first one is for wide-band pass filter which equal to (square root for (f1*f2)), and the second one is for narrow-band pass filter which equal to ((f1+f2)/2).

  My question is when we use the first equation and the second equation for find the center frequency of band pass filter?

is the bandwidth, and the more selective is the filter. While a low value of Q the wider is the bandwidth and less selective is the filter. A BPF with a Q of less than 10 is defined as wide, while a BPF with a Q greater than 10 is defined as narrow.
Q = fc / Bandwidth = fc / (fh – fl) where: fc = sqr-root(fh*fl)

Posted on August 12th 2021 | 3:31 pm
Reply
    - *Suman Kumar*

      Geometric mean, due to logarithmic scale and averaging the critical frequencies and so named center frequency. In narrow band pass filter the critical frequencies are so close that we can take the average of frequencies to get center frequency rather to take logarithmic of frequencies.

      Posted on August 12th 2021 | 2:58 pm
      Reply
- *Suman Kumar*

  Can we connect first low pass filter and then high pass filter to get band pass filter, in that working is not changed of band pass filter?

  Posted on August 12th 2021 | 5:10 am
  Reply
- *zoya*

  hi

  Posted on March 31st 2021 | 1:52 pm
  Reply
- *Deekshitha*

  What is the magnitude for the above examples

  Posted on January 24th 2021 | 6:21 am
  Reply
- *Francis Jansz*

  Hello . I am Looking at having a Simple High Pass First order Filter At 7000 kHz at ,4 Ohms impedience. What value Capacitor and Resisters will I need and how can I wire them please I am a novice please send me The Parts Zlist and it’s Valued plus a simple Wiring Diagram .
  Kind Rgds
  Francis Jansz
  Passive High Pass Filter. ,7000.<,kHz at 4 Ohms

  Posted on October 18th 2020 | 4:09 am
  Reply
- *Steve Rohe*

  I am making a radio bandpass filter at 3.975khz I am using 3kohm R1 and 29nf C1 for HP and 15nf C2 and 2kohm R2…what wattage value should I use? Would 1/4 watt resistors be ok?

  Posted on June 24th 2020 | 5:27 pm
  Reply
- *Vartul Sharma*

Posted on June 23rd 2019 | 10:23 am
Reply

- *Zubair ali*

  Hi

  Hallo

  Posted on December 01st 2018 | 4:34 pm
  Reply
- *Geeta mulik*

  exllent

  Posted on November 13th 2018 | 2:58 am
  Reply
- *Laxman Darekar*

  How many db are required at Af point ?

  Posted on November 01st 2018 | 3:58 pm
  Reply
- *Rajat Panwar*

  ?

  Posted on September 28th 2018 | 3:44 am
  Reply
- *tim o'hare*

  am looking for a BCB bandpass filter to restrict my local am stations from interfering with listening to vlf signals(aka non-directional beacons). can you help me?
  best regards
  tim o'hare
  spokane,wash.

  Posted on August 22nd 2018 | 2:11 am
  Reply
- *Sarvani*

  Characterstics of bandpass filter

  Posted on August 08th 2018 | 4:02 pm
  Reply
- *Carlo*

  I want to make this passive filter but I don't know if the sequence of low-pass and high-pass filter matters. So I'm trying to have to lower cutoff at 20Hz and upper cutoff at 250Hz. Is it EXTREMELY important to have the high-pass filter placed before the low-pass, or can this be neglected and able to be switched around?

  Posted on June 07th 2018 | 4:24 am
  Reply
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