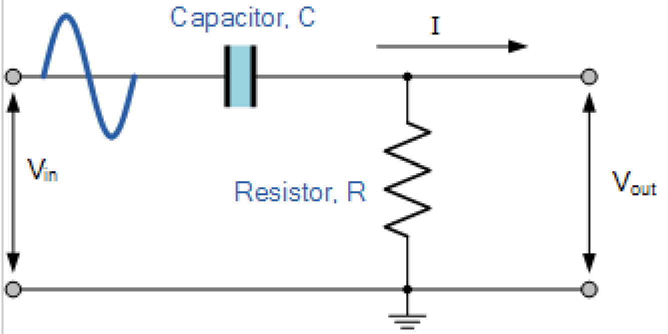
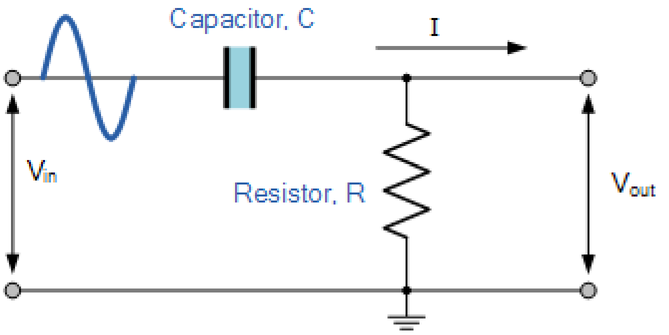


Passive High Pass Filter

A High Pass Filter is the exact opposite to the low pass filter circuit as the two components have been interchanged with the filters output signal now being taken from across the resistor

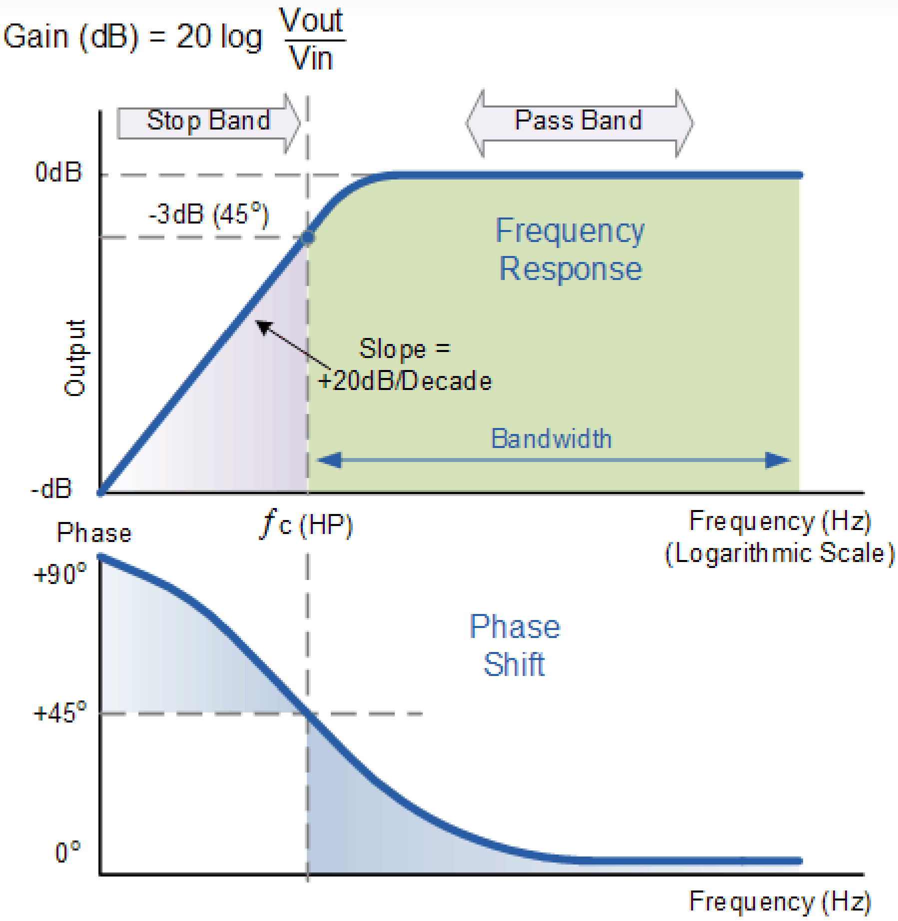
Where as the low pass filter only allowed signals to pass below its cut-off frequency point, $ƒc$, the passive high pass filter circuit as its name implies, only passes signals above the selected cut-off point, $ƒc$ eliminating any low frequency signals from the waveform. Consider the circuit below.

The High Pass Filter Circuit



In this circuit arrangement, the reactance of the capacitor is very high at low frequencies so the capacitor acts like an open circuit and blocks any input signals at V_{IN} until the cut-off frequency point ($ƒ_C$) is reached. Above this cut-off frequency point the reactance of the capacitor has reduced sufficiently as to now act more like a short circuit allowing all of the input signal to pass directly to the output as shown below in the filters response curve.

Frequency Response of a 1st Order High Pass Filter



The **Bode Plot** or Frequency Response Curve above for a passive high pass filter is the exact opposite to that of a low pass filter. Here the signal is attenuated or damped at low frequencies with the output increasing at +20dB/Decade (6dB/Octave) until the frequency reaches the cut-off point (fc) where again $R = Xc$. It has a response curve that extends down from infinity to the cut-off frequency, where the output voltage amplitude is $1/\sqrt{2} = 70.7\%$ of the input signal value or -3dB (20 log (Vout/Vin)) of the input value.

Also we can see that the phase angle (Φ) of the output signal **LEADS** that of the input and is equal to **+45^{o}** at frequency fc. The frequency response curve for this filter implies that the filter can pass all signals out to infinity. However in practice, the filter response does not extend to infinity but is limited by the electrical characteristics of the components used.

The cut-off frequency point for a first order high pass filter can be found using the same equation as that of the low pass filter, but the equation for the phase shift is modified slightly to account for the positive phase angle as shown below.

Cut-off Frequency and Phase Shift

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

$$Phase\ Shift\ \phi = arctan\ \frac{1}{2\pi fRC}$$

$$A_V = \frac{V_{OUT}}{V_{IN}} = \frac{R}{\sqrt{R^2 + Xc^2}} = \frac{R}{Z}$$

$$\text{at low } f: \; Xc \to \infty, \; \text{Vout} = 0$$
$$\text{at high } f: \; Xc \to 0, \; \text{Vout} = \text{Vin}$$

High Pass Filter Example No1

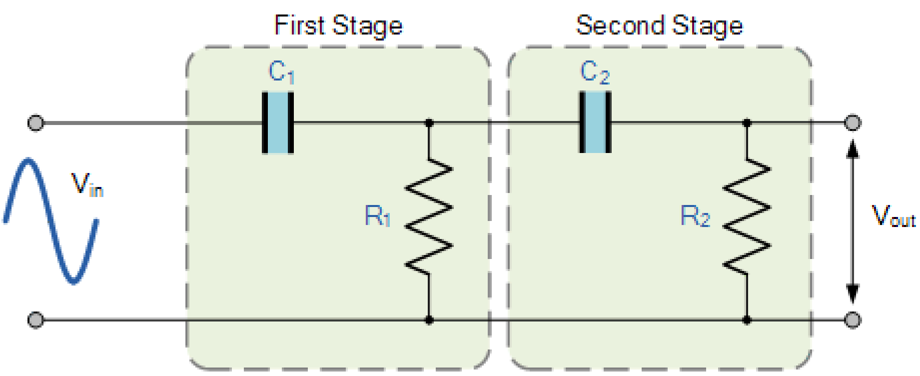
Calculate the cut-off or "breakpoint" frequency (fc) for a simple passive high pass filter consisting of an 82pF capacitor connected in series with a 240kΩ resistor.

$$fc = \frac{1}{2\pi RC} = \frac{1}{2\pi \times 240{,}000 \times 82 \times 10^{-12}} = 8{,}087\,Hz \text{ or } 8kHz$$

Second-order High Pass Filter

Again as with low pass filters, high pass filter stages can be cascaded together to form a second order (two-pole) filter as shown.

Second-order High Pass Filter



The above circuit uses two first-order filters connected or cascaded together to form a second-order or two-pole high pass network. Then a first-order filter stage can be converted into a second-order type by simply using an additional RC network, the same as for the 2^{nd}-order low pass filter. The resulting second-order high pass filter circuit will have a slope of 40dB/decade (12dB/octave).

As with the low pass filter, the cut-off frequency, fc is determined by both the resistors and capacitors as follows.

make the impedance of each following stage 10x the previous stage, so $R_2 = 10*R_1$ and $C_2 = 1/10$th of C_1.

High Pass Filter Summary

We have seen that the **Passive High Pass Filter** is the exact opposite to the low pass filter. This filter has no output voltage from DC (0Hz), up to a specified cut-off frequency ($ƒc$) point. This lower cut-off frequency point is 70.7% or **-3dB** (dB = -20log V_{OUT}/V_{IN}) of the voltage gain allowed to pass.

The frequency range "below" this cut-off point $ƒc$ is generally known as the **Stop Band** while the frequency range "above" this cut-off point is generally known as the **Pass Band**.

The cut-off frequency, corner frequency or -3dB point of a high pass filter can be found using the standard formula of: $ƒc = 1/(2\pi RC)$. The phase angle of the resulting output signal at $ƒc$ is **+45$^{\mathbf{o}}$**. Generally, the high pass filter is less distorting than its equivalent low pass filter due to the higher operating frequencies.

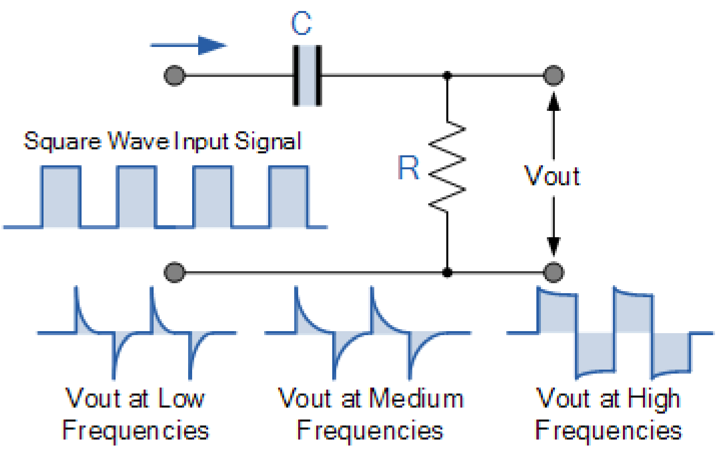
A very common application of this type of passive filter, is in audio amplifiers as a coupling capacitor between two audio amplifier stages and in speaker systems to direct the higher frequency signals to the smaller "tweeter" type speakers while blocking the lower bass signals or are also used as filters to reduce any low frequency noise or "rumble" type distortion. When used like this in audio applications the high pass filter is sometimes called a "low-cut", or "bass cut" filter.

The output voltage Vout depends upon the time constant and the frequency of the input signal as seen previously. With an AC sinusoidal signal applied to the circuit it behaves as a simple 1st Order high pass filter. But if we change the input signal to that of a "square wave" shaped signal that has an almost vertical step input, the response of the circuit changes dramatically and produces a circuit known commonly as an **Differentiator**.

The RC Differentiator

Up until now the input waveform to the filter has been assumed to be sinusoidal or that of a sine wave consisting of a fundamental signal and some harmonics operating in the frequency domain giving us a frequency domain response for the filter. However, if we feed the **High Pass Filter** with a **Square Wave** signal operating in the time domain giving an impulse or step response input, the output waveform will consist of short duration pulse or spikes as shown.

The RC Differentiator Circuit



71 Comments

Join the conversation

- *Ganpudi Jain*

  1. Design low pass constant-k type T-section and π-section filter with fc = 8KHz and R0 = 600 ohm. Compute α and β for the filters for f = 10 KHz and 20 KHz. Also determine the frequency at which the attenuation is 20 dbs
  2. For the given low pass constant k-type filter determine the nominal characteristic impedance and the cut-off frequency. Also draw π-section low pass filter.

  3. A high pass constant-k filter with fc = 30 KHz is when used with terminating resistance of 500 ohm. Design a suitable T-section and π-section filter.Also determine
  (i) Design a suitable T-section and π-section filter
  (ii) Determine the frequency required to produce a maximum attenuation at 20 KHz.
  (iii) Determine the attenuation constant for the frequency at 20 KHz and 40 KHz.
  (iv) Determine the phase constant for the frequency at 20 KHz and 40 KHz.
  (v) Calculate the Zot and Zoπ at 10 KHz.
  4. Suppose you were installing a high-power stereo system in your car, and you wanted to build a simple filter for the” tweeter” (high-frequency) speakers so that no bass (low-frequency) power is wasted in these speakers. Modify the schematic diagram below with a filter circuit of your choice:

Part II
6. The following circuit shows one form of filter.

(a) What is the name of this type of filter?
(b) Calculate the reactance of the capacitor at 100 Hz.
(c) What is the impedance of the circuit at 100 Hz..
(d) Calculate the break frequency for this filter.
(e) Calculate the output voltage at 100 Hz if VIN= 5 V.
(f) Sketch the characteristic of this filter, labelling all critical values
7. Design a constant k-type band pass T-section and π-section filter having cut –off frequencies of 2000 Hz and 5000 Hz with the characteristic impedance of 500 ohm. Find the resonant frequency.
8. Design a constant k-type band stop T-section and π-section filter having cut –off frequencies of 3000 Hz and 6000 Hz with the characteristic impedance of 500 ohm. Find the resonant frequency

Posted on April 23rd 2022 | 10:57 am
Reply

- *Abhi*

  Could you please send the solutions for the questions that you have sent here ??

  Posted on April 29th 2022 | 6:30 am
  Reply

- *Nebojsa Kolaric*

  Again great tutorail thank you

  Posted on April 16th 2022 | 2:32 pm
  Reply

- *Nitin*

  Thank you very much

  Posted on February 13th 2022 | 6:49 pm
  Reply

- *Ayad Fyad*

  Thank you very much>>>><<<<<

  Posted on December 04th 2021 | 9:01 pm
  Reply

  - *SANJIT MANDAL*

    requesting you send me

    Posted on December 05th 2021 | 6:36 am
    Reply

- *Junell Baruiz*

  Need to learn about this topic..

  Posted on November 24th 2021 | 1:39 pm
  Reply

- *Bob*

[Reply](#)

- *Sanjit Mandal*

  Kindly sent me circuit

  Posted on [September 15th 2021 | 11:24 am](#)
  [Reply](#)
- *Debasish Mahanta*

  Good

  Posted on [August 24th 2021 | 6:15 am](#)
  [Reply](#)
- *Mohammad Waseem Akram`*

  May I please know the application of Low Pass, High Pass, Band Pass and Band Stop Filter in communication circuits in detail??

  Posted on [June 01st 2021 | 10:47 am](#)
  [Reply](#)
- *Musa Sen*

  Thanks a lot, really clear and simple explanation

  Posted on [January 01st 2021 | 6:35 pm](#)
  [Reply](#)
- *Karm*

  Excellent and presicse text , that comes with age , think so , should be wrong that young minds Reach that stage early.

  Posted on [November 08th 2020 | 6:56 am](#)
  [Reply](#)
- *Francis Jansz*

  Hello. I need to construct a Passive High Pass Filter for my Super Bullet Tweeter
  The Tweeter specs are. 120 Watts Handling At 4 Ohms
  Crossover cut off Freq. 8000 to 9000 kHz. Prefered Slope is 18 DB.
  What value Capacitor In PF will I need and Value of Resisters will I need.
  Please confirm
  Francis Jansz

  Posted on [October 27th 2020 | 3:07 am](#)
  [Reply](#)
- *Francis Jansz*

  Hello
  I got a Pair of 4 Ohms Super Tweeters and it handles 30 Watts RMs . I need to have a High Pass Simple Filter to start from around 7 to 8000 KHz what Capacitor Value will I need in UF Rating your advise will be appreciated .
  Please send me The Values for the Passive Capacitor that will suit my Tweeter
  RGDS
  Francis Jansz

  Posted on [October 10th 2020 | 12:01 am](#)

- *Lahari*

  Plzz send 2 nd order high pass filter frequency response graph

  Posted on March 17th 2020 | 2:46 pm
  Reply
- *Wallace Martins*

  Can anyone help me with choke filter calculus input 100-230Vca?

  Posted on December 27th 2019 | 12:59 am
  Reply
- *Wello*

  It's fine

  Posted on November 08th 2019 | 10:37 am
  Reply
- *Ritesh Parkhi*

  in the equation y[n] = (1-alpha).y[n-1] + (1-alpha)(x[n]-x[n-1] of the high pass filter, what does the x[n] represents ?

  Posted on November 07th 2019 | 9:06 am
  Reply
  - More
- *Anuraag Arya*

  Nice

  Posted on October 24th 2019 | 11:00 am
  Reply
- *SANJIT MANDAL*

  Kindly sent me the (1). Thundering protection LNB in parabolic disk antenna system. (2). Filter downlink Audio circuit and analog to Digital to analog

  Posted on August 26th 2019 | 10:25 am
  Reply