- Active filters contain active devices such as transistors or op-amps so as to give gain as well as filtering action.

- The main advantage of active filters is that their performance can be made to be more independent of the signal source and load impedances.

- An iterative process is usually used to choose the best of the many possible designs for a particular application.

Passive filters are simple.
Performance depends on source and load.

Active filters give more reliable performance.

Many designs for specific purposes.

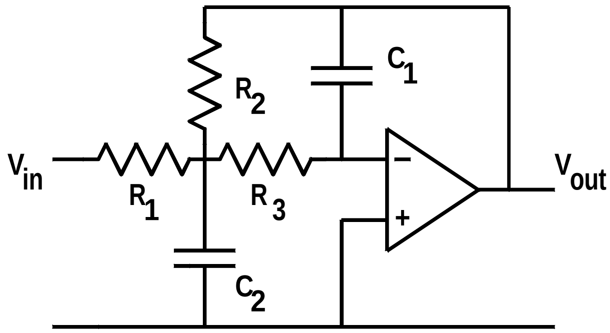
We examine audio frequency filters which use op-amps.

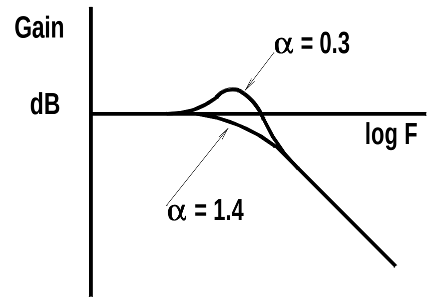
Three filter types

- Low pass
- High pass
- Band pass

Use an iterative process for design.

A set of equations is given for each filter.
Many possible values for R and C
Avoid extreme values of R and C.
Use values of R within the range 100Ω to $1M\Omega$ and values for C within the range $1nF$ to $1\mu F$.

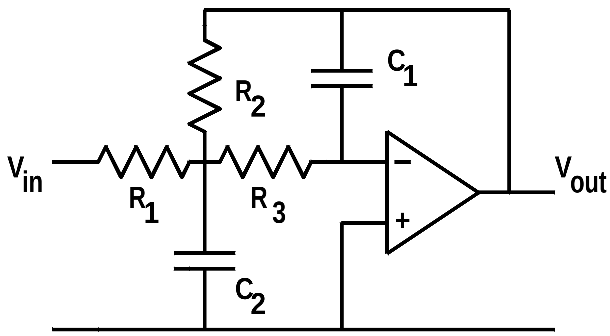


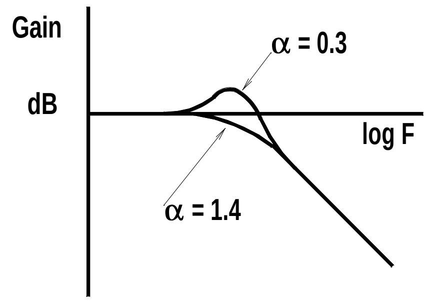


Guess initial values for components and follow through the calculation to see if the other dependant components have reasonable values.
Repeat the calculations with a better guess.

Peaking factor, α, describes the sharpness of the edge of a low or high pass filter.

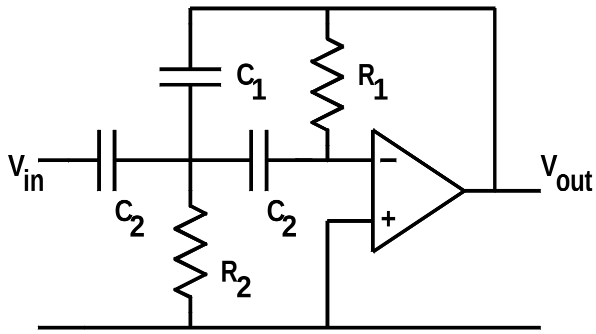
α	0.1	0.3	1.0	1.4
dB peaking	20	10	3	0
Gain increase	10	3.16	1.4	1.0

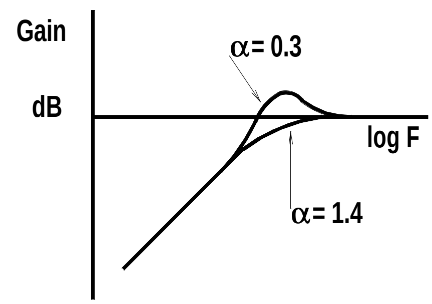




Low Pass Filter

$$\begin{aligned}
\text{Target design} \quad F &= \text{Cutoff frequency, } Hz \\
\alpha &= \text{Peaking factor} \\
A &= \text{gain} \\
\text{Initial Estimate} \quad C_1 & \; in \; \mu F \\
\text{Then} \quad C_2 &= \frac{4(1+A)C_1}{\alpha^2}\mu F \\
R_2 &= \frac{\alpha \times 10^6}{4\pi F C_1} \\
R_1 &= \frac{R_2}{A} \\
R_3 &= \frac{R_2}{1+A}
\end{aligned}$$





High Pass Filter

Target design F = cutoff frequency, Hz

α = peaking factor

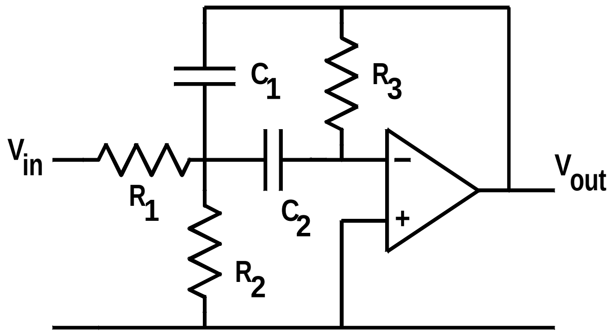
A = gain

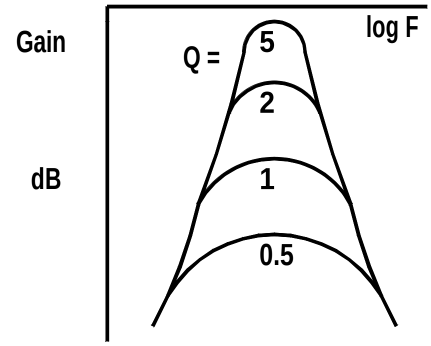
Initial estimate C_2 *in* μF

Then $C_1 = \dfrac{C_2}{A} \quad \mu F$

$$R_1 = \frac{(2A+1)\times 10^6}{2\pi F\alpha C_2}$$

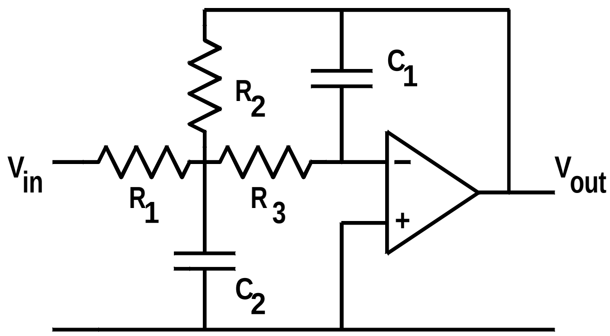
$$R_2 = \frac{\alpha A \times 10^6}{2\pi F C_2 (2A+1)}$$

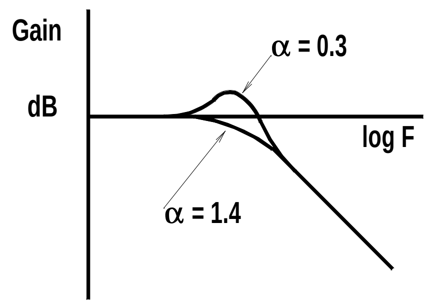




Band Pass Filter

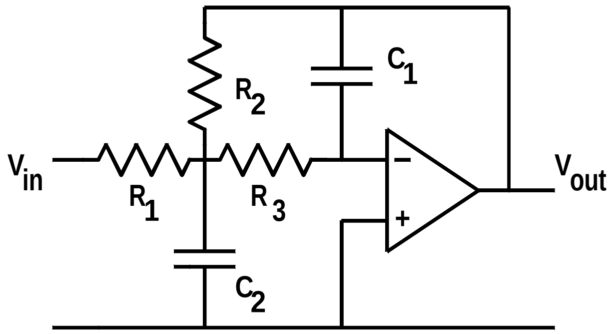
$$
\begin{aligned}
\text{Target design} \quad B &= \text{Bandwidth, } Hz \\
\text{Estimate} \quad C_1\, C_2 \quad in & \quad \mu F \\
\text{Then} \quad Q &= \frac{F}{B} \\
R_1 &= \frac{Q \times 10^6}{2\pi F A C_1} \\
R_2 &= \frac{1}{2\pi F Q (C_1 + C_2) \times 10^{-6} - \frac{1}{R_1}} \\
R_3 &= \frac{Q \times 10^6}{2\pi F} \left(\frac{1}{C_1} + \frac{1}{C_2} \right)
\end{aligned}
$$

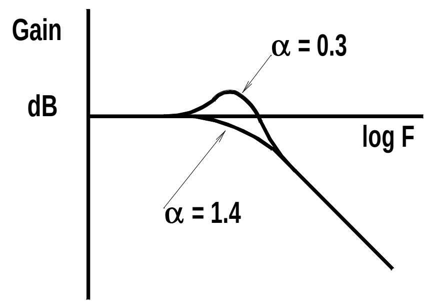




Design a low pass filter for a cutoff frequency of $1500Hz$, a gain of 12 and $3dB$ of peaking at the band edge.

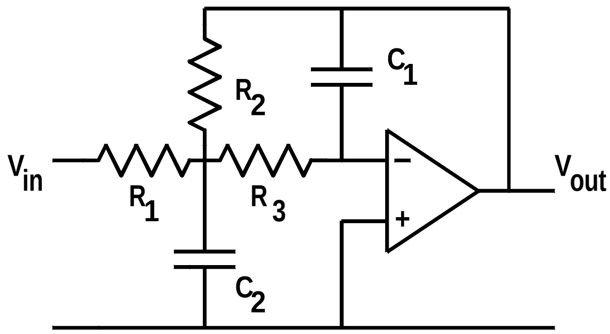
Use the circuit of Figure 48.1. A peaking of $3dB$ at the band edge corresponds to a peaking factor of $\alpha = 1$, from the table.

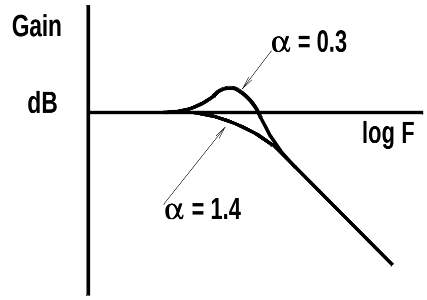




Estimate C_1 and use the formulae for C_2, R_1, R_2 and R_3.

It.	1	2	3	4	5	6	
C_1	1.0	.1	.01	.001	.0005	.0001	μF
C_2	52	5.2	.52	.052	.026	.005	μF
R_1	4.4	44	442	4.4k	8.8k	44k	Ω
R_2	53	530	5.3k	53k	106k	530 k	Ω
R_3	4.1	41	410	4.1k	8.2k	41k	Ω



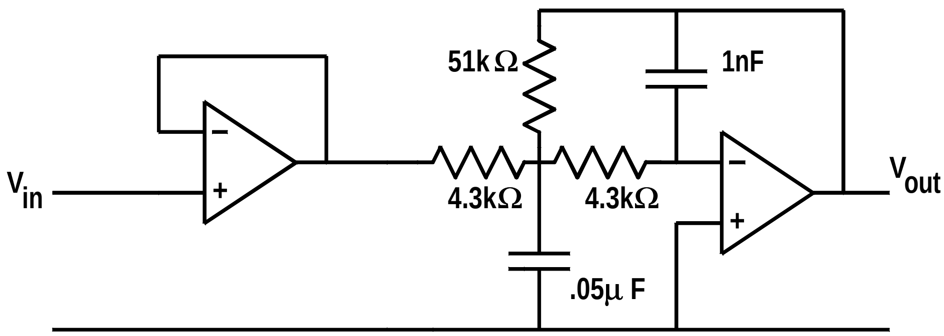


In principle, all of these calculations give valid and correct filter design values.

In practice, iterations 1, 2 and 3 have low resistances

Iteration 6 and any further iterations with smaller values of C_1 have over large values of R

In this example, iteration no 4 is a reasonable compromise.



We do not know the signal source resistance, so it is good practice to isolate the filter from the signal source by using a voltage follower stage in the input which has a high input impedance and low output impedance.