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**Active filter two version 1.0**

**DELTA AUDIO**

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**Jens Rasmussen**

# 1 Introduction

This document is a guide on how to use the Active filter two printed circuit boards. The PCB is intended to make prototyping active filter easier.

For the unit to work correctly you need an external power supply unit capable of delivering +- 15V and a current of about 100mA per filter module.

I present a complete list of components for the filter section, and give examples of what values to use for the input section and gain adjustment stages. Much more on this later, for now just read on and see what this little module can do for you.

Happy reading and building.

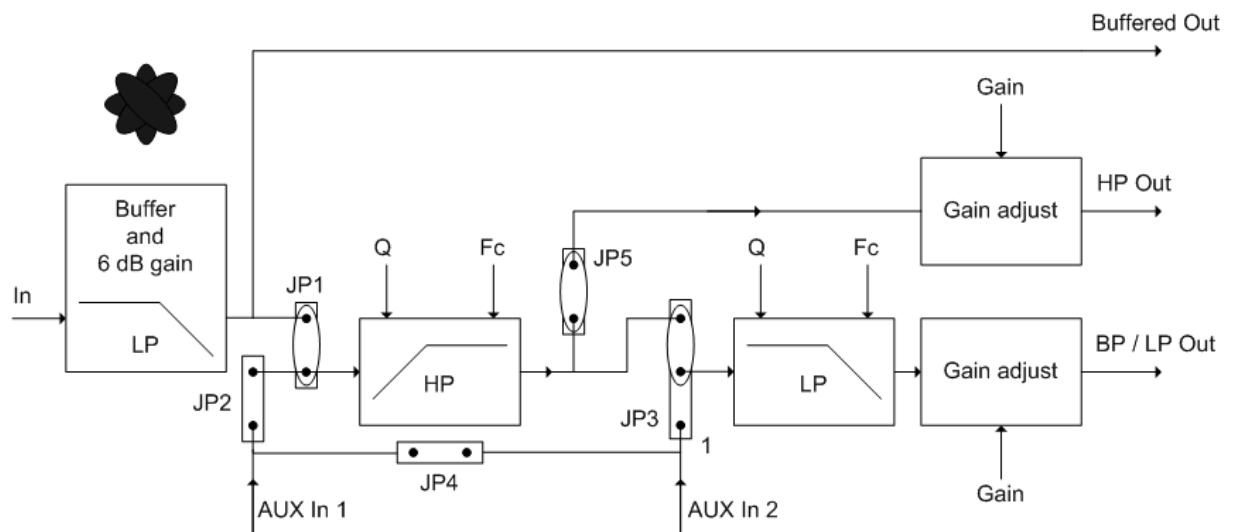
Jens Rasmussen

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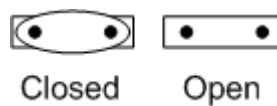
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## 2 Overview

A PCB module can be configured to make the following filter.



**Figure 1: Block schmatic of the PCB**



With the jumpers you can configure the PCB to different setups, there is a detailed configuration plan later in the manual, but for now just consider the possibilities you need and see if the module can solve this for you.

If you have questions at this point please don't hesitate to contact me ☺

### 3 The schematics and BOM

Each component has a three digit designator. The first two digits refer to the section of the schematic, and the last digit refers to the component number in that section. An example could be C041, which is C1 in section four.

When reading this chapter, please keep a copy of the schematics in hand for easy reference.

#### 3.1 Input filter and buffer

The input filter has three major functions in the active filter.

1. Set the input impedance.
2. Cut of HF noise signals.
3. Boost the signal to improve the signal to noise ratio.

The input filter and buffer are made by the components around IC1A, and the opamp IC1. When building this active filter you do not need to design this stage of the filter unless your source's signal amplitude is different from around 1 V RMS.

I have already designed an unbalanced input stage that suits signal levels of 1 V, so all you need is, to mount the components specified in the parts list, and you are ready to populate the rest of the filter. If not, you must design the resistors around the opamp for a differential input buffer stage.

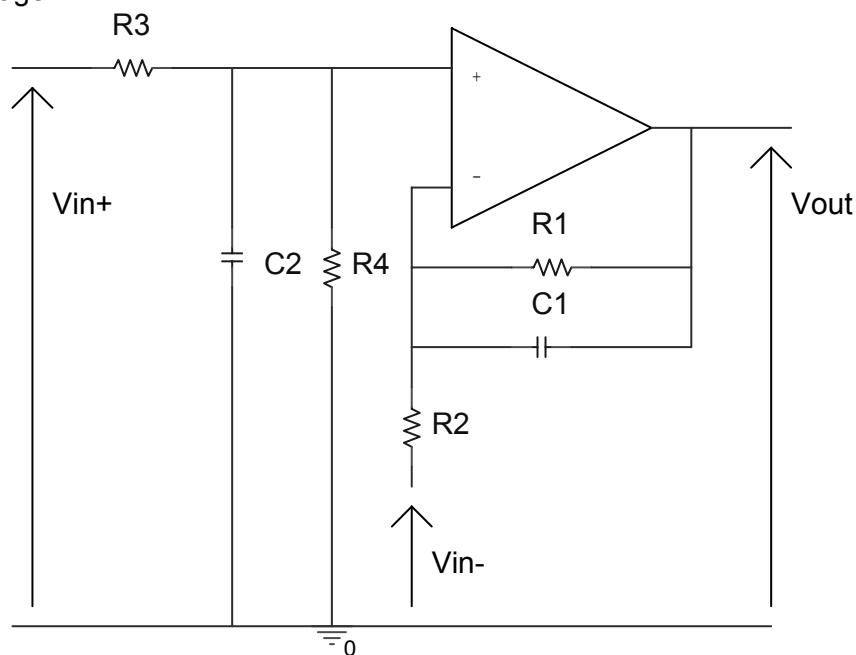


Figure 2: Input buffer and gain

Components	Value	Components on PCB	Value I used
R1, R2, R4	10 kohm	R001, R002, R004	10 kohm
R3	100 ohm	R003	100 ohm
C1, C2	100 pF	C001, C002	100 pF

Table 1: Components in unbalanced input

### 3.2 The Sallen and Key HP filter

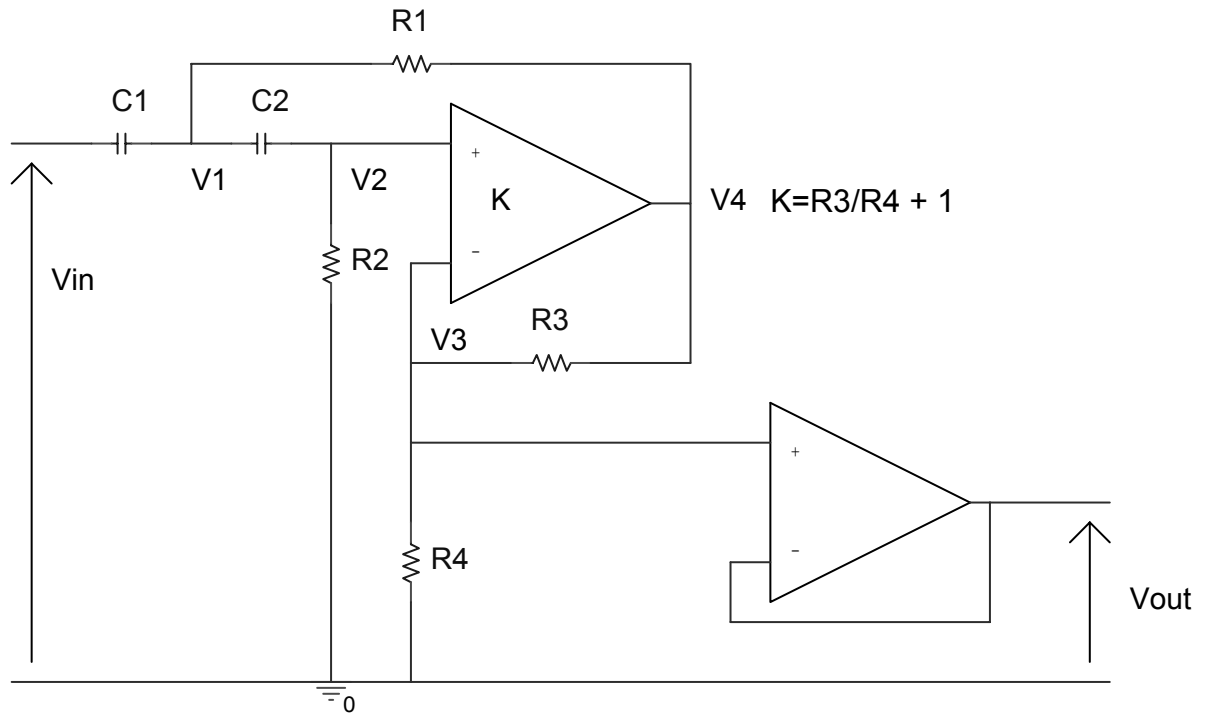


Figure 3: Sallen and Key HP section

To design a filter the describing parameters are the Q and cutoff frequency  $f_c$ . The transferfunction is like this:

$$H_{HP}(s) = \frac{s^2}{s^2 + \left( \frac{1}{C_1 \cdot R_2} + \frac{1}{C_2 \cdot R_2} + \frac{1-K}{C_1 \cdot R_1} \right) \cdot s + \frac{1}{C_1 \cdot R_1 \cdot C_2 \cdot R_2}}$$

When  $C_1 = C_2 = C$  and  $R_1 = R_2 = R$  the following simpler transferfunction can be used:

$$H_{HP}(s) = \frac{s^2}{s^2 + \frac{3-K}{C \cdot R} \cdot s + \frac{1}{C^2 \cdot R^2}} = \frac{s^2}{s^2 + \frac{\omega_c}{Q} \cdot s + \omega_c^2}$$

### 3.3 The Sallen and Key LP filter

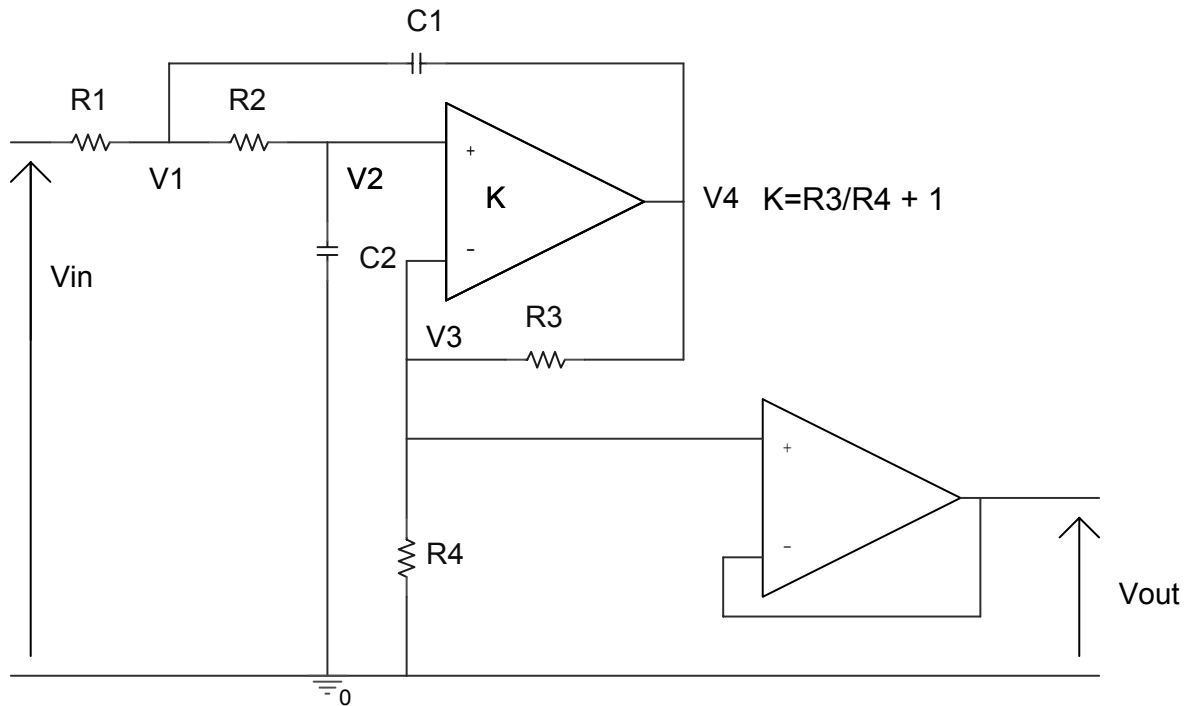


Figure 4: Sallen and Key LP section

To design a filter the describing parameters are the Q and cutoff frequency  $f_c$ . The transferfunction is like this:

$$H_{LP}(s) = \frac{\frac{1}{C_1 \cdot R_1 \cdot C_2 \cdot R_2}}{s^2 + \left( \frac{1}{C_1 \cdot R_1} + \frac{1-K}{C_2 \cdot R_2} + \frac{1}{C_1 \cdot R_2} \right) \cdot s + \frac{1}{C_1 \cdot R_1 \cdot C_2 \cdot R_2}}$$

When  $C_1 = C_2 = C$  and  $R_1 = R_2 = R$  the following simpler transferfunction can be used:

$$H_{LP}(s) = \frac{\frac{1}{C^2 \cdot R^2}}{s^2 + \frac{3-K}{C \cdot R} \cdot s + \frac{1}{C^2 \cdot R^2}} = \frac{\omega_c^2}{s^2 + \frac{\omega_c}{Q} \cdot s + \omega_c^2}$$

### 3.4 Design equations and components for the filter

Start by choosing a value for C,  $f_c$ ,  $R_3$  and Q. Please use the closest value available to the given values. Values I used for measurements are given to the right.

$C_1 = 100 \text{ nF}$  ( $C_1$  is for freq multiplier of 1)  $R_3 = 22\text{k}\Omega$

$$R_4(Q) = \frac{Q \cdot R_3}{2 \cdot Q - 1}$$

$$R(f_c) = \frac{1}{2\pi f_c \cdot C_1}$$

$R_3$ [kohm]	Components on PCB	Value I used [kohm]
22.00	R200, R500	22.1

Table 2:  $R_3$

$R_4$ [kohm]	Q	Gain	Gain [dB]	Components on PCB	Value I used [kohm]
$\infty$	0.5	1	0.000	R220, R520	Nothing mounted
66.00	0.6	1.333	2.499	R219, R519	66.5
38.50	0.7	1.571	3.926	R218, R518	38.3
29.33	0.8	1.750	4.861	R217, R517	29.4
24.75	0.9	1.889	5.524	R216, R516	24.9
22.00	1.0	2.000	6.021	R215, R515	22.1
20.17	1.1	2.091	6.407	R214, R514	20.0
18.86	1.2	2.167	6.716	R213, R513	18.7
17.88	1.3	2.231	6.969	R212, R512	17.8
17.11	1.4	2.286	7.180	R211, R511	16.9
16.50	1.5	2.333	7.360	R210, R510	16.5
16.00	1.6	2.375	7.513	R209, R509	15.8
15.58	1.7	2.412	7.647	R208, R508	15.4
15.23	1.8	2.444	7.764	R207, R507	-
14.93	1.9	2.474	7.867	R206, R506	15.0
14.67	2.0	2.500	7.959	R205, R505	14.7
14.44	2.1	2.524	8.041	R204, R504	-
14.24	2.2	2.545	8.115	R203, R503	-
14.06	2.3	2.565	8.182	R202, R502	-
13.89	2.4	2.583	8.244	R201, R501	-

Table 3:  $R_4$  and Q

R [kohm]	$f_c$ [Hz]	Components on PCB	Value I used [kohm]
63.36	25.12	R310, R410, R610, R710	63.4
50.33	31.62	R309, R409, R609, R709	49.9
39.98	39.81	R308, R408, R608, R708	40.2
31.76	50.12	R307, R407, R607, R707	31.6
25.22	63.10	R306, R406, R606, R706	24.9
20.04	79.43	R305, R405, R605, R705	20.0
15.92	100.00	R304, R404, R604, R704	15.8
12.64	125.89	R303, R403, R603, R703	12.7
10.04	158.49	R302, R402, R602, R702	10.0
7.977	199.53	R301, R401, R601, R701	7.87

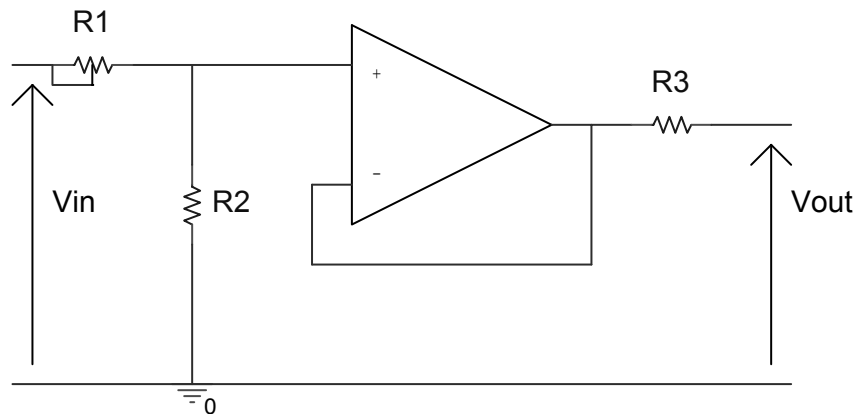
Table 4: R and  $f_c$



Capacitor	Multiplier	Components on PCB	Value I used
$C_{01} = 1\mu\text{F}$	x 0.1	C301, C401, C601, C701	1 $\mu\text{F}$
$C_1 = 100\text{nF}$	x 1.0	C302, C402, C602, C702	100nF
$C_{10} = 10\text{nF}$	x 10	C303, C403, C603, C703	10nF
$C_{100} = 1\text{nF}$	x 100	C304, C404, C604, C704	1nF

Table 5: C and frequency multiplier

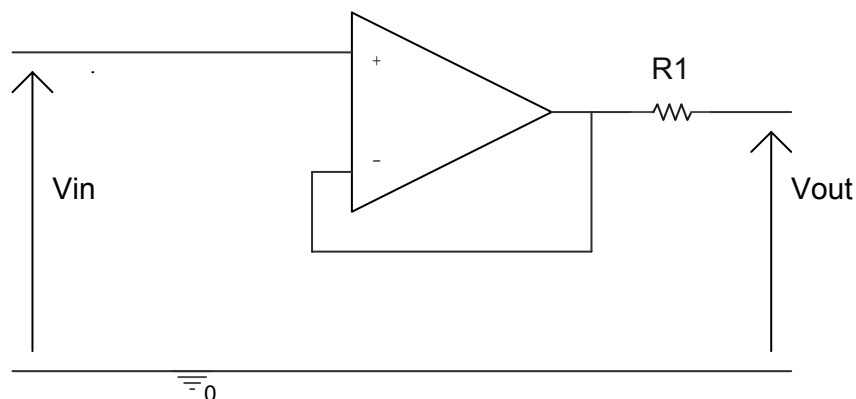
### 3.5 Output Buffer and gain adjust



Components	Components on PCB	Value [ohm]	Value I used [ohm]
R1	R801, R901	22k pot multiturn	22.0k
R2	R802, R902	10k	10.0k
R3	R803, R903	100	100

Table 6: Components in gain adjust and output buffer

### 3.6 Buffered output



Components	Components on PCB	Value [ohm]	Value I used [ohm]
R1	R100	100	100

Table 7: Components in buffer

## 4 What components to choose

The following section is a guide to choose your components for your active cross over. Please note the following table to make sure your components fit in the drilled PCB

Components	Hole size
Opamp sockets	0.8 [mm]
Capacitors	0.8 [mm]
Resistors	0.8 [mm]
Jumpers / connectors	1.0 [mm]
Mounting holes	3.2 [mm]

**Table 8: Holes in the PCB**

### 4.1 Opamps

Several opamps can be used for the crossover. The PCB layout is made for dual opamps with standard 8 pin DIL casing. I recommend low noise types. I have made a list with some of the types I like to use.

Type	Approximate Price US\$
MC33078P	1
NE5532	1
LM833N	2
OPA2134	3

**Table 9: List of opamps**

If you don't want to spend too much money on opamps I recommend using the OPA2134 for buffer and treble section and the LM833N, NE5532 or MC33078 for the rest. However it's completely up to the designer of the crossover to choose the opamps, since there are so many different types to choose from I have no chance of testing them all. If you are in doubt of what type to get, feel free to contact me for help.

### 4.2 Capacitors

I prefer polypropylene (PP) capacitors for signal processing, but polyethylene (PE) can also be used. The PCB has room for box capacitors sized 7x7 [mm] in the filter sections. The pitch distance is 2 modules (about 5 mm). To get a good accuracy between the wanted frequency response and the final result please only use 5% or better tolerances. A cheap way of obtaining good tolerances is by means of a capacitor meter to measure a bunch of cheaper 10 % capacitors. I use a Monacor CM-200, it ranges from 200pF to 20mF; witch is all I need for my projects.

The caps for decoupling the supply (Designators C801–C804 and C901–C904) are boxed 100nF caps sized 2.5x7 [mm] with a pitch distance of 2 modules (about 5 mm)

The lager caps for supply decoupling (Designators C900 and C800) are your favorite electrolytic 100µF cap, which must be rated at 25V or more. The maximum diameter is about 10.5 [mm] and a pitch distance of 5 [mm]

### 4.3 Resistors

The PCB is made for ¼ watt resistors. To get a good accuracy between the wanted frequency response and the final result please use 1% or better tolerances from the E96 or E192 range, or combine different values in parallel to get the needed resistor value.

## 4.4 Jumpers and Headers

To configure the filter you need a lot straight headers that fit with a jumper. These are similar to the ones found on computer motherboards and other computer gear. I use single line headers and cut them to the length (number of pins) needed.

Number of pins	Number of header modules
1x20 or 2x20	8 or 4
1x4 or 2x4	8 or 4
1x2	13
1x3	2

**Table 10: Headers for jumpers**

Depending on how you will use the module, a number of jumpers is needed. It's a good idea to get different colors for this, because it can make it easier to distinguish between different setups. Anyway a total of 15 jumpers for every board will be enough to fit most needs. Just order a bunch and keep track of them because the module is useless without them.

## **5 How to use the filter module**

The filter module is designed to be as versatile as possible. When operating the filter, always turn the following power amplifiers off!