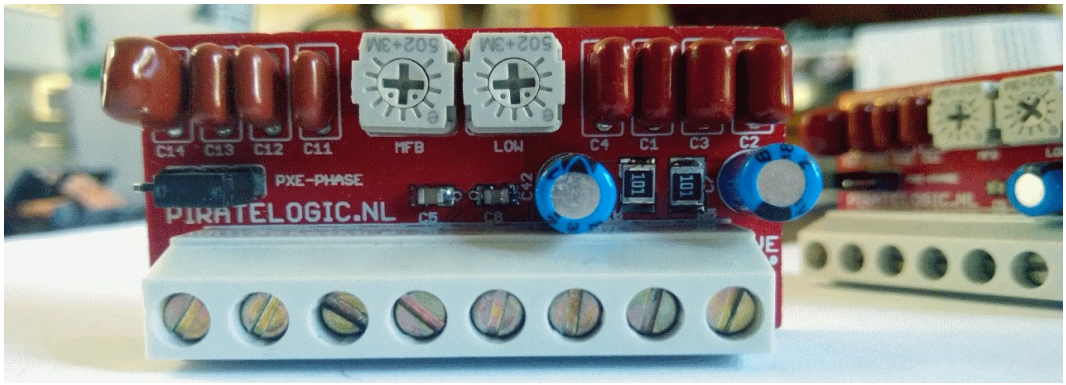
PIRATELOGIC
AUDIO ELECTRONICS

EVE

construction manual

STARBASS MOTIONAL FEEDBACK LOOP

DRAFT



Contents

Before you start ....

Thank you for purchasing EVE, prior to assembly please verify the kit contains the below listed parts, incase something is missing or damaged please contact us immediatly. Please note this manual is still **draft** so expect grammar & spell checks, incorrect and or incomplete info.

Bill of materials

The components indicated in **red** are **not included in the kit** as they are to be individually calculated for each specific enclosure as described in this document.

C6	100n	C0805K	X7R 100V Ceramic Capacitor
C7	47uf 35V	E2,5-5	Electrolytic Capacitor
C8	100n	C0805K	X7R 100V Ceramic Capacitor
C9	100n	C0805K	X7R 100V Ceramic Capacitor
C10	47uf 35V	E2,5-5	Electrolytic Capacitor
C11	see text	C050-030X075	Polypropylene Film Capacitor
C12	see text	C050-030X075	Polypropylene Film Capacitor
C13	see text	C050-030X075	Polypropylene Film Capacitor
C14	470n	C050-030X075	Polypropylene Film Capacitor
C15	3n3	C0805K	X7R 100V Ceramic Capacitor
IC1	78L12	SOT89	Voltage regulator
IC2	79L12	SOT89	Voltage regulator
IC3	TL084D	SO14	Quad OpAmp
LOW	5K	B25P	POTENTIOMETER
MFB	5K	B25P	POTENTIOMETER
PXE-PHASE		JP2	JUMPER
R1	see text	R0805D	Film resistor
R2	see text	R0805D	Film resistor
R3	see text	R0805D	Film resistor
R4	see text	R0805D	Film resistor
R5	10	R1210	Film resistor
R6	1001	R0805D	Film resistor
R7	102	R0805D	Film resistor
R8	1001	R0805D	Film resistor
R9	1002	R0805D	Film resistor
R10	10	R1210	Film resistor
R11	see text	R0805D	Film resistor
R12	see text	R0805D	Film resistor
R13	102	R0805D	Film resistor
R14	2202	R0805D	Film resistor
R15	2202	R0805D	Film resistor
R16	see text	R0805D	Film resistor
R17	1002	R0805D	Film resistor
R18	2202	R0805D	Film resistor
R19	see text	R0805D	Film resistor
R20	4702	R0805D	Film resistor
T1	BCV62	SOT143B	Current Mirror
T2	BC849	SOT23	NPN transistor
X1	V+	W237-8P	WAGO SREW CLAMP
PCB	EVE 2017.0		Eve printed circuit board

Prerequisites

In order to successfully assemble the kit the following prerequisites are needed.

- ESD safe working environment : EVE contains ESD sensitive jFet devices, please adhere to guidelines for safe handling of ESD sensitive components during assembly of the sensors.
- SMD soldering station : the EVE design uses surface mount technology and requires handling and use of an appropriate soldering station to avoid thermal damage to the used parts when soldered onto the PCB.

Warranty / Disclaimer

Although this kit has been developed with lots of love, tenderness and devotion we can only guarantee 100% operation for ready & assembled EVE.

Although EVE has been tested with numerous MFB enclosures it is subject to constant research and development and as such no guarantees and/or warranties can be given for the correct / optimal/failure free working of the module. No responsibility is taken for any damage resulting from the use of this module.

Pricing

Bare EVE printed circuit boards without components are available for 15 euro per set of 2. An EVE kit containing the PCB and parts listed in black on the BOM on page 3 costs 35 euro for a set of 2. Pricing excludes VAT and shipment.

Consultancy

Upon request a prebuild and tested EVE module can be ordered which has been tailored for use with a specific StarBass / Driver / Enclosure setup. Please contact chris at piratelogic dot nl for more information.

Copyright

MAY THE MUSIC PASSING THROUGH THIS DEVICE

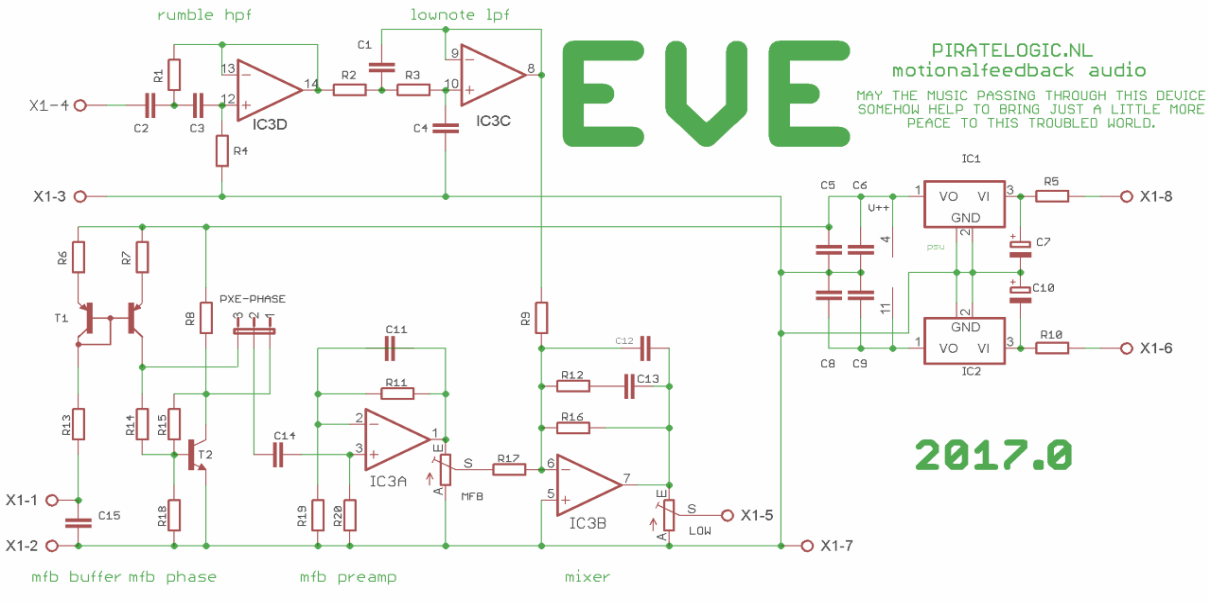
SOMEHOW HELP TO BRING JUST A LITTLE MORE PEACE

TO THIS TROUBLED WORLD

EVE Kit

EVE was originally developed to add a motional feedback loop to an ADAM A7 monitor in conjunction with a StarBass equipped woofer., it contains all logic to add MFB to existing active enclosures or newly build low frequency systems.

Schematic diagram



Schematic description

The audio signal enters at X1-4 where it passes high pass filter (hpf) around IC3D to set the lower bandwitdh pole, the following IC3C lowpass filter (lpf) sets the upper bandwidth pole. Both filters follow a standard 2nd order Sallen Key setup. Refer to the ***Crossover points*** section for example values. It is advised to feed EVE at X1-4 from a low output impedance to avoid it from negatively affecting the hpf around IC3D.

The StarBass accelerometer signal enters at X1-1 where it is buffered & copied by the current mirror T1 into the phase switch around T3 to allow the usage of third party sensors with different output phase.

The output of the phase switch is amplified by IC3A to match the level of the incoming signal from IC3C, C11 and R11 set the upper pole for the accelerometer signal, C14 and R20 the lower pole, use R19 to adjust sensor gain.

IC3B sums the outputs from IC3C and IC3A, C12 limits the upper bandwidth of the mfb loop, R12 and C13 allow the feedback loop to be shaped to match specific enclosure Q values. The input to the power amplifier is taken from X1-5. IC1 and IC2 are standard voltage regulators to allow EVE from being operated from the poweramp rails (max +/- 35V). please see ***Powering EVE*** and the ***Errata*** at the end of this document.

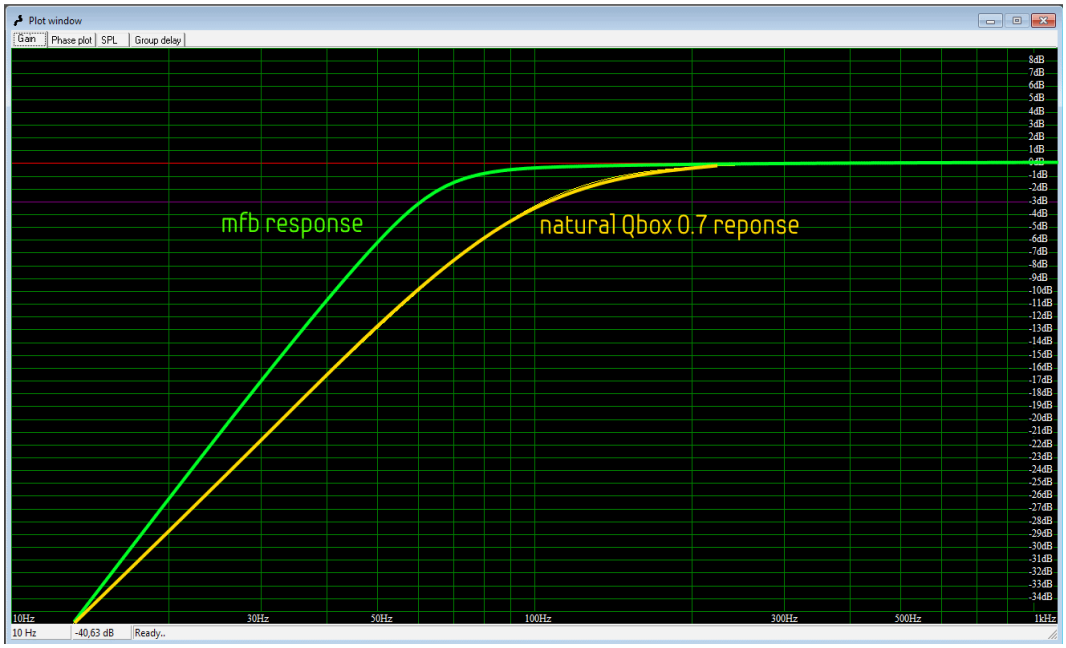
Configuring the MFB loop

Being designed as a generic mfb correction module EVE such supports a wide variety of driver, enclosure and amplifier combinations. Because of this generic setup it is not possible to provide a common set of component values which will work for all configurations. To assist the user in determining which values will suit a particular setup best the following information is given.

Enclosure size, F3box and Qbox

The first step is to choose the lower frequency pole for your mfb box, F3**mfb**. As a lower limit keep the drivers physical resonance frequency F**c**, i.e. don't choose 40hz when your drivers F**c** is 60hz. Failure to comply will result in an inefficient system with a driver trying to perform excursions beyond its physical limit possibly resulting in permanent damage to the driver motor.

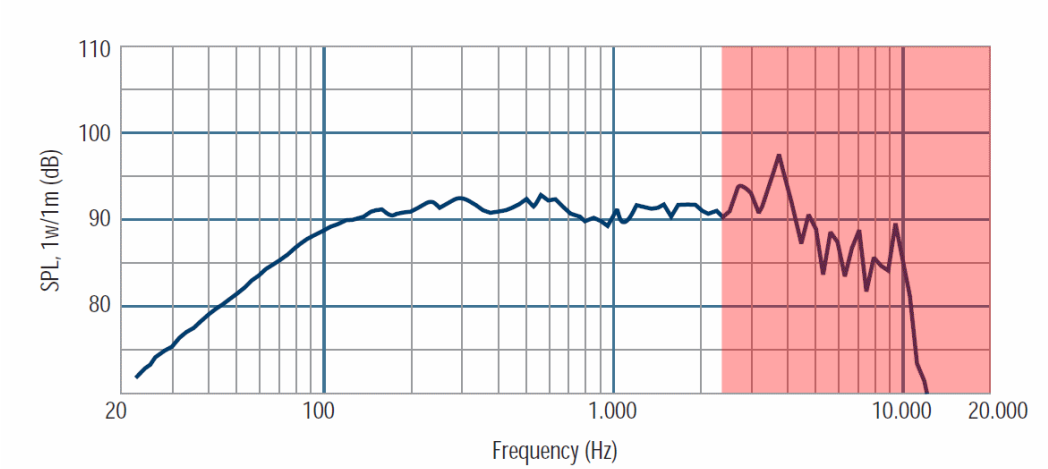
The second step is to choose enclosure dimensions using the selected driver T&S parameters and the standard closed box design formulas – to ease down on the involved math one may choose to use a program like WinISD. As a starting point choose an enclosure Q of 0.7. MFB allows you to split F3**box** in half so if the desired lower frequency pole of your finished box F3**mfb** is 60hz the chosen F3**box** should be 120hz or lower.



Example WINISD *response plot for a driver with a F**c** of 60hz mounted in a sealed Q=0.7 enclosure with a natural F**box** of 120hz which is moved down to F**mfb** of 60hz.*

Keep in mind that the higher Q**box** is chosen (= smaller box) the harder the driver will need to work to reach the required excursion, as such one is discouraged from using Q**box** values above 1 as it will severely limit the drivers efficiency and SPL.

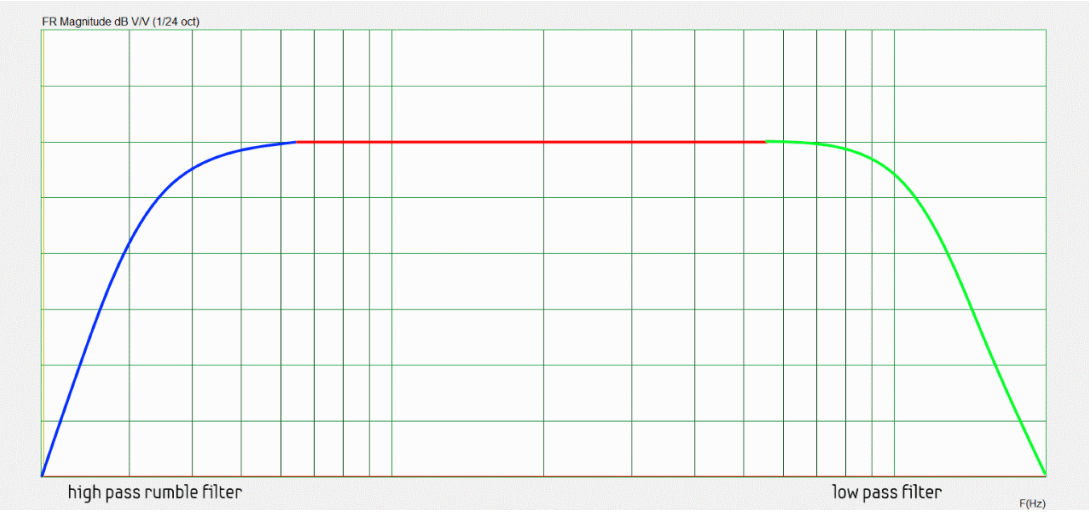
Low Pass Filter



The third step is to decide on a low pass filter frequency - **F1pf** - using the drivers datasheet as reference. EVE's onboard lowpass filter follows a 2nd order Sallen Key setup, as such it is advised to choose F1pf at least 1 octave below the first occurrence of cone breakup. In the example below cone breakup happens in the red region onwards 2500hz making 1250hz or lower a valid choice for **F1pf**

Crossover points

Using F3**mfb** and F1**pf** and F3**box** the component values for the desired crossover points can be calculated. The blue curve represents F3**mfb** and the green curve F1**pf**. These values were calculated using http://sim.okawa-denshi.jp/en/OPstool.php for the lowpass and http://sim.okawa-denshi.jp/en/OPseikiHikeisan.htm for the highpass filters.



Build and tested EVE modules are preconfigured for a Rumble filter frequency of 32hz and a lowpass filter frequency of 493hz.

2nd order Rumble filter IC3D Q=0.5

C2,C3 (nF)	R1, R4 (K)	Frequency (hz)
100	15	106
100	18	88
220	10	72
220	12	60
220	15	48
220	18	40
220	22	32
220	27	27
220	33	21

2nd order Lowpass filter IC3C Q=0.74

R2,R3 (K)	C4 (nF)	C1(nF)	Frequency (hz)	C12 (nF)
2.2	47	100	1055	1n5
3.3	47	100	703	2n2
3.9	47	100	595	2n7
4.7	47	100	493	3n3
2.7	100	220	397	3n9
3.3	100	220	325	4n7
3.9	100	220	275	5n6
4.7	100	220	228	6n8
5.6	100	220	191	8n2

Incase the module is to be used with existing active enclosures it's buildin rumble and lowpass filters may need disableing.

- **Disabling the rumble filter** : ommit **R1, R4** and replace **C2 ,C3** with wire bridges.
- **Disabling the lowpass filter** : ommit **C1, C4** and replace **R2, R3** with 0 ohm resistors.

Sensor gain.

The fourth step is to configure the MFB preamp IC3A. Acceleration sensor output is determined both by its sensitivity in mV/G as well as the drivers linear cone excursion - to reproduce a certain SPL a small diameter driver will need to perform larger excursions then a large diameter driver, as such the accelerometer output is depended on the driver cone diameter. Small drivers with a high Xmax – so called longstroke subwoofers - will exhibit a relative high signal output when compared to large drivers. To accommodate for this ajust **R19** which sets the gain for the pxe element, lower values result in more sensor signal gain. Allowable values are between 470R and 10K.

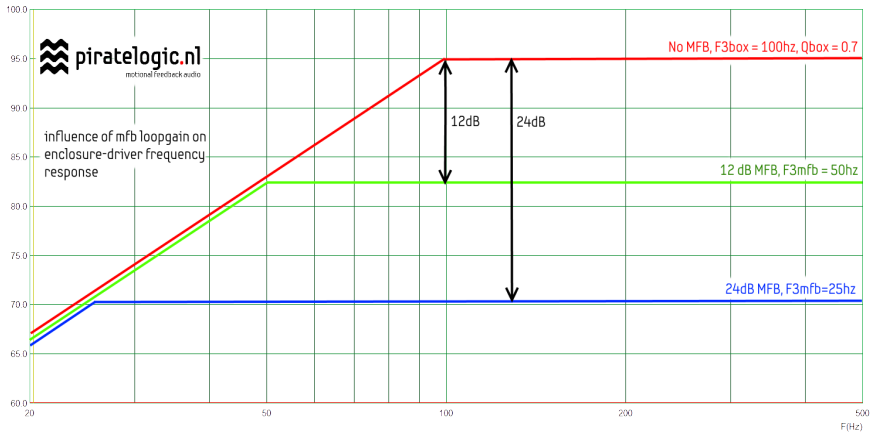
Sensor lowpass filter.

The fifth step is to limit the bandwidth of IC3A to avoid driver breakup from entering the summation signal at IC3C. As a starting value half the low pass filter frequency (F_{1pf}) should be used when calculating the C11. The lower pole for the accelerometer signal is determined by C14 and R20 and already set to optimal values for use with StarBass accelerometers.

C11	Sensor cut-off frequency
2n2	7200 hz
3n3	4822 hz
3n9	4080 hz
4n7	3386 hz
5n6	2842 hz
6n8	2340 hz
8n2	1940 hz
10n	1591 hz
15n	1061 hz
22n	723 hz
33n	482 hz
47n	338 hz

MFB Loopgain

The sixth step is to configure the feedback loop. EVE has been designed for a loopgain between 12 and 20dB and although higher values are possible one is discouraged from doing so as it requires extensive tuning measures which are outside EVE's design scope.



Loop gain bandwidth

C12 limits the upper bandwidth of the mfb loop and it's value should be set to match the lowpass filter setting for IC3C. Please refer to *2nd order Lowpass filter IC3C* table on page 8 for C12 values.

MFB Loopshaping

Use R12 and C13 to compensate for the natural roll-off below F3box.

Building EVE

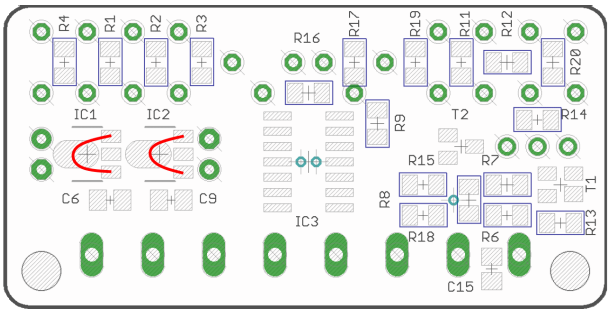
Power requirements

The EVE currentdraw at +/- 12V is 20mA max. When EVE is used to modify off the shelf active loudspeaker enclosures the best and easiest way to power EVE is to feed it off existing stabilized opamp rails where EVE supports rails between +/- 12 and 18V.

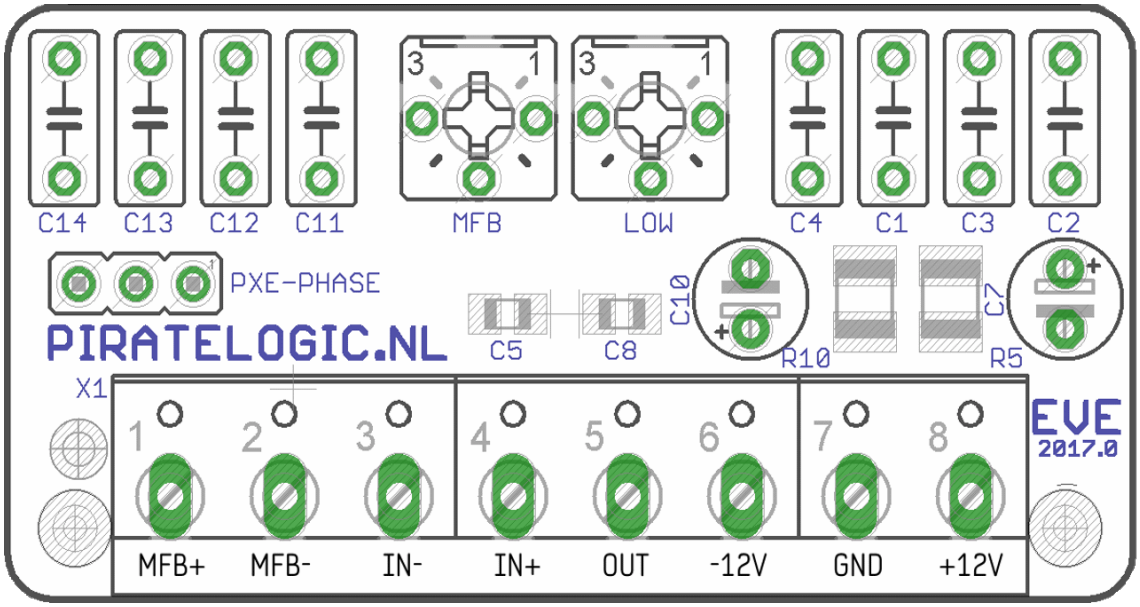
Incase no stabilized opamp rails exists the onboard 78L12 and 79L12 regulators allow EVE to be powered from a maximum rail voltage of +/- 35V.

Do not use R5 and R10 as voltage droppers as these are only allowed to dissipate 50mW and are used for filtering the incoming power only.

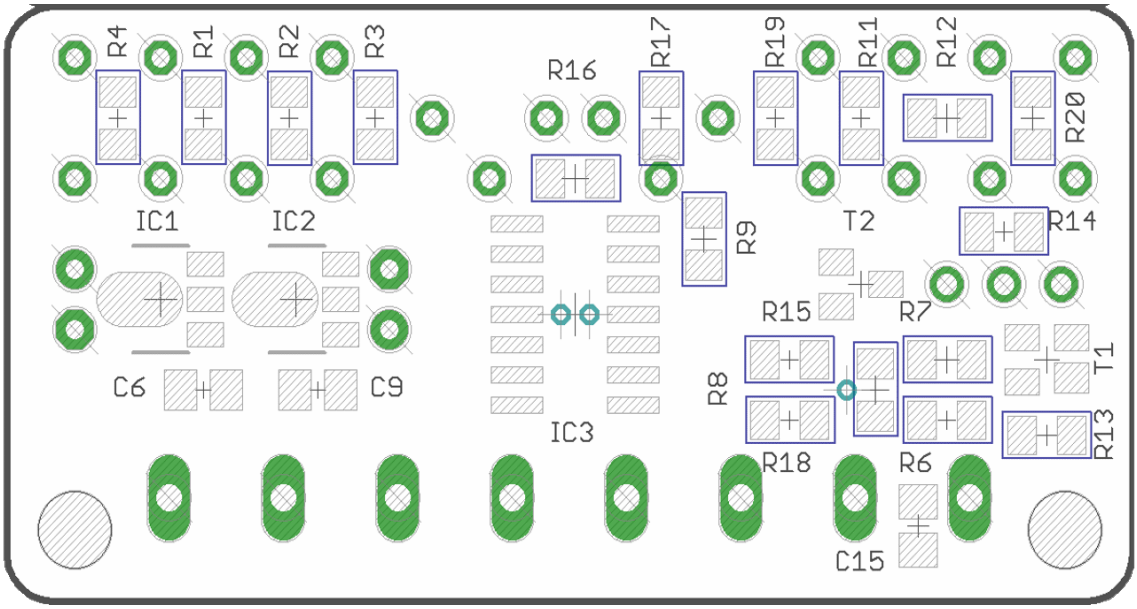
Incase of availability of regulated opamp rails the onboard regulators may be omitted and bypassed using 2 wire bridges:



Boardlayout – top layer

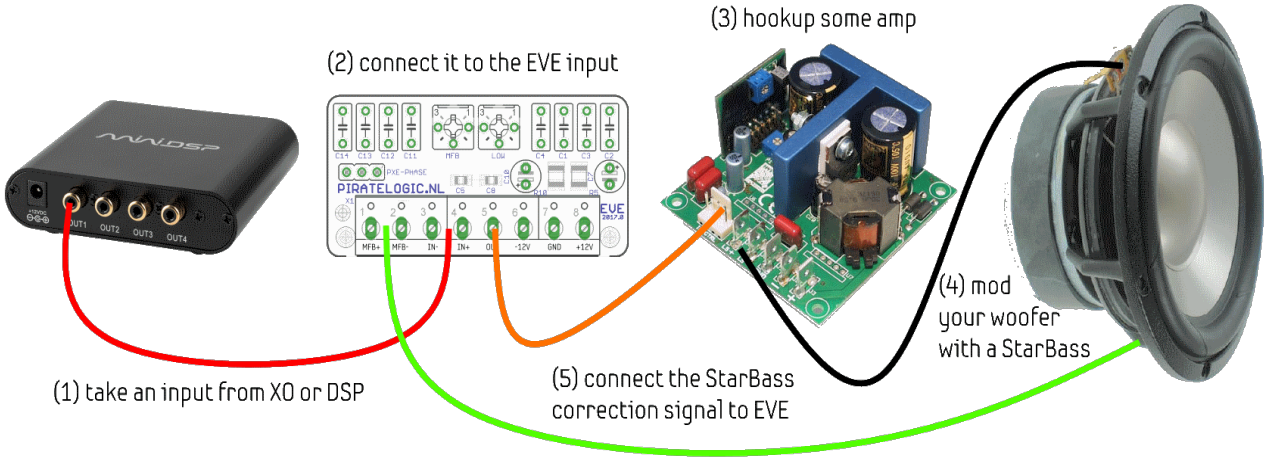


Boardlayout – bottom layer



Connections

Eve accepts standard asymmetric audio coming from either a mixer, preamp, phone or any other sound source and should be hooked up as shown below.



Overall design considerations

- MFB does not work with Helmholtz resonator based enclosures such as bass reflex boxes.
- The StarBass sensors have been tested successfully with a maximum loopgain of 20dB.

Acceleration Sensors

One of EVE's design criteria was to make it a Swiss Tool for building motional feedback loops. Next to a fully configurable filter and power section EVE has also been provisioned to support a large number of accelerometers ranging from the original Philips sensors to the latest StarBass models.

Exact component values cannot be given as they depend on (specimen) sensor sensitivity, frequency response, enclosure Q factor, driver diameter etc and as such are only available for known – fixed – setups.

Philips sensors

EVE supports the original Philips MFB sensors, both the original 532, 541,544,567 and 545 10M sensor as well as the 585, 586 and 587 33M sensors. As a starting point use a 3K3 resistor for R19 and a minimum of 3n3 for C11.

Measurement Specialities sensors

EVE has not been tested with the ACH01 sensor but should have no problems processing it's input. . As a starting point use a 3K3 resistor for R19 and a minimum of 3n3 for C11.

Piratelogic Little/One and StarBass sensors

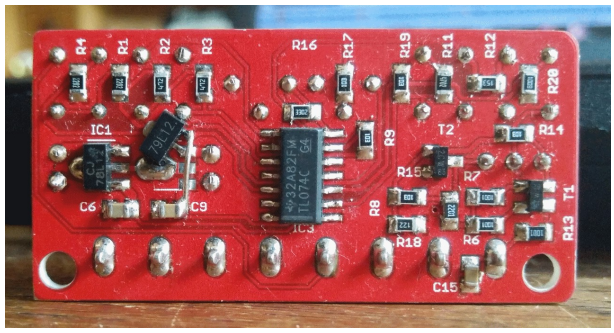
EVE supports the modern Piratelogic accelerometers, both Little/One and StarBass. As a starting point use a 1K resistor for R19 and a minimum of 1n for C11. For further information about Piratelogic acceleration sensors please refer to https://piratelogic.nl/?p=en.accelerometers.

Design considerations

An accelerometer output level is not fixed and depends on several factors such as driver cone excursion and diameter, cabinet Q factor and driver sensitivity. As such EVE component values for a certain driver-enclosure combination might need tweaking when either one is changed !

Errata

Version 2017.0 of the EVE pcb contains an error in the shape used for the negative voltage regulator IC2, a temporary workaround is shown here :.



Document Revisions

Prior to starting work please check if the date & time stamp at the footer of this page corresponds with the one in the online version at

https://piratelogic.nl/data/docs/products/eve/piratelogic.eve.2017.0.manual.en.pdf

01-08-18	initial version by CC
18-08-18	Added *Design considerations*, *Using EVE with existing active enclosures*.
04-09-18	Added *Configuring the MFB loop* section
07-09-18	Spelling / Grammar
26-09-18	Disclaimer / Pricing
05-10-18	Loopgain info added