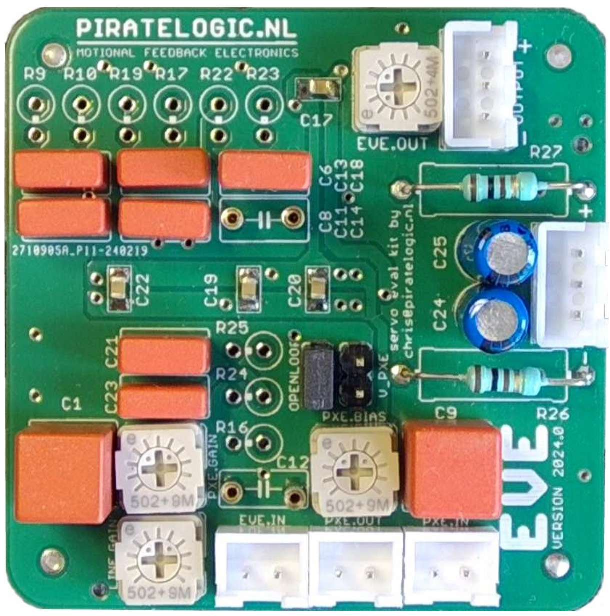
EVE

servo evaluation pcb

VERSION 2024.0



SUBJECT TO PERMANENT DEVELOPMENT

Contents

Before you start ....

Thank you for purchasing the EVE pcb, please note this manual is subject to permanent development so expect grammar & spell checks, corrections and improvements, read the ERRATA section before building EVE !!

Back in 2017 EVE was originally developed as a quick and dirty solution to add servo bass functionality to an ADAM A7 monitor in conjunction with a StarBass IV accelerometer equipped woofer. EVE 2024.0 basically follows an identical setup with the quick and dirty parts removed and has been optimized using user input to improve both its performance as well as its ease of implementation.

Prerequisites

In order to successfully assemble the pcb 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 / Copyright

Although this pcb has been developed with lots of love, tenderness and devotion and 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. The EVE circuit design is free for use both for hobby as well commercially.

Designing & building servo drive systems like described in this manual requires a thorough understanding of and working experience with the underlying electronics. An engineering degree and experience with component level board repair is strongly advised. This is NO starter project !!!!

Pricing & Availability

The EVE pcb including mounting studs, trimmers and jst xh sockets and with all bottom smd components factory mounted are available for 75 euro a piece by sending an email to chris*nospam*piratelogic.nl – replace *nospam* with the standard @. Pricing excludes VAT and shipment.

MAY THE MUSIC PASSING THROUGH THIS DEVICE

SOMEHOW HELP TO BRING JUST A LITTLE MORE PEACE

TO THIS TROUBLED WORLD

Bill of materials

All bottom side SMD components are factory mounted, all remaining parts including listed Cx and Rx are through-hole components which are not included with the EVE board as it values are setup dependent.

Part #	Value	Package	Note	Part #	Value	Package	Note
7812	78L12	SOT89-3		PXE.BIAS	5K	B25P	BOURNS 3386
7912	79L12	SOT89-3		PXE.GAIN	5K	B25P	BOURNS 3386
C1	1u	C050-075X075	WIMA 5MM MKT	PXE.IN	JST.XH.2	JST.XH.2	JST-XH 2.54 mm Pitch Connector
C2	1nN	805	NPO !	PXE.OUT	JST.XH.2	JST.XH.2	JST-XH 2.54 mm Pitch Connector
C3	1nN	805	NPO !	R1	1001	603	
C4	10-16	SMC_A		R2	2203	603	
C5	1nN	805	NPO !	R3	1001	603	
C6	CX	C050-035X075		R4	1001	603	
C7	1nN	805	NPO!	R5	1002	603	
C8	CX	C050-035X075	WIMA 5MM MKT	R6	1001	603	
C9	3u3	C050-075X075	WIMA 5MM MKT	R7	1001	603	
C10	10-16	SMC_A		R8	1001	603	
C11	CX	C050-035X075	WIMA 5MM MKT	R9	RX	0309V	0.25w 1% METAL FILM THROUGHOLE
C12	CX	C050-030X075	WIMA 5MM MKT	R10	RX	0309V	0.25w 1% METAL FILM THROUGHOLE
C13	CX	C050-035X075	WIMA 5MM MKT	R11	1001	603	
C14	CX	C050-035X075	WIMA 5MM MKT	R12	1002	603	
C15	100n	603	XR7	R13	2203	603	
C16	100n	603	XR7	R14	1001	603	
C17	100n	805	Topside XR7	R15	1001	603	
C18	CX	C050-035X075	WIMA 5MM MKT	R16	RX	0309V	0.25w 1% METAL FILM THROUGHOLE
C19	100n	805	Topside XR7	R17	RX	0309V	0.25w 1% METAL FILM THROUGHOLE
C20	100n	805	Topside XR7	R18	1001	603	
C21	CX	C050-035X075	WIMA 5MM MKT	R19	RX	0309V	0.25w 1% METAL FILM THROUGHOLE
C22	100n	805	Topside XR7	R20	1002	603	
C23	CX	C050-035X075	WIMA 5MM MKT	R21	1002	603	
C24	10-63	E2,5-5	grid 2.54 mm, diameter 5 mm	R22	RX	0309V	0.25w 1% METAL FILM THROUGHOLE
C25	10-63	E2,5-5	grid 2.54 mm, diameter 5 mm	R23	RX	0309V	0.25w 1% METAL FILM THROUGHOLE
C26	100n	603	XR7	R24	RX	0309V	0.25w 1% METAL FILM THROUGHOLE
C27	100n	603	XR7	R25	RX	0309V	0.25w 1% METAL FILM THROUGHOLE
EVE.IN	JST.XH.2	JST.XH.2	JST-XH 2.54 mm Pitch Connector	R26	RX	0414/15	2W 5% METAL FILM THROUGHOLE
EVE.OUT	5K	B25P	BOURNS 3386	R27	RX	0414/15	2W 5% METAL FILM THROUGHOLE
IC1	72	SO08	TL072	R28	1201	603	
IC2	74	SO14	TL074	R29	2201	603	
IC3	5532	SO08		R30	2201	603	
LINE.GAIN	5K	B25P	BOURNS 3386	R31	1001	603	
OPENLOOP	JUMPER	JUMPER	THROUGHOLE	R32	1001	603	
OUTPUT	JST.XH.3	JST.XH.3	JST-XH 2.54 mm Pitch Connector	T1	849	SOT23	BC849
POWER	JST.XH.3	JST.XH.3	JST-XH 2.54 mm Pitch Connector	T2	BCV62	SOT143B	
				V_PXE	OUTPUT	JP1	THROUGHOLE

Design considerations

Main design steps

Designing a low note system starts with choosing main design parameters like desired sound pressure level, dispersion pattern, power bandwidth etc. for the most of it designing a MFB system follows identical rules and logic with the exception of some important design considerations unique to MFB that need highlighting:

- Driver choice: as the feedback loop will put extra electrical and mechanical stress on your driver carefully selecting an appropriate driver should be your first step. Failure to do so will almost always result in sub optimal system performance and in worst case scenario defective drivers.
- Accelerometer selection: depending on your driver choice several accelerometer options are available.
- Loop design: to *optimally* tune your driver – enclosure combination for a flat frequency response. I've put emphasis on *optimal* because like with gourmet food the art includes not just selecting appropriate ingredients but also cooking times, savouring and presentation. Initially you are after reaching a flat FR response but don't feel obliged to keep it that way, there is nothing wrong with building your own *sound*. Remember that it was mostly loudness (physiologic volume control) which made (makes?) vintage equipment popular. Give it a try.
- Enclosure design : your driver choice together with loop design gives you a ballpark figure for the required Vbox. Contrary to reflex enclosures where Vbox, port length and diameter all play important design roles servo enclosures main box parameter is just one : Vbox.

Driver choice

Let's start with the most important selection criteria : forcing driver cone movement to mimic the incoming electrical waveform requires extra power which has its thermal consequences for the driver motor system and requires extra care not to exceed thermal power handling and safe operating areas, specially since closed cabinets lack motor cooling by natural convection. Next to thermal handling the extended cone excursion also puts considerable stress on the drivers VC quality & mounting, it's spider and surround.

When making a choice take the following into consideration :

- **Cone size / material** : make sure the driver cone maintains pistonic motion in the area mfb will be active in. The larger the driver the harder it will be for it to maintain pistonic operation. *For high SPL designs daisy chaining multiple smaller diameter drivers might yield better results then a single large one, small lightweight & sturdy cones are favourable over large and heavy ones.*
- **High BL**: to maximise mfb control over the driver cone movement a strong motor system is required.
- **High Xmax** : depending on the desired power bandwidth and used cabinet Q the driver needs to linearly move as much air as possible.
- **Low CMS** : a too high value in combination with MFB will severely affect distortion figures due to the deformation of the surround caused by the cones pumping action . This is especially comes into play with Qbox designs above 0.7.
- **Ventilated polepiece** : to allow convection of heat away from the voice coil as quickly as possible. Note that since MFB required a closed cabinet the temperature inside the enclosure will be considerably higher compared to vented enclosures. Aluminium cones exhibit better heat transfer characteristics then carbon / non metalic models.
- **High temp voicecoil former** : usage of vintage – paper – voicecoil formers severely restrict the powerhandling.

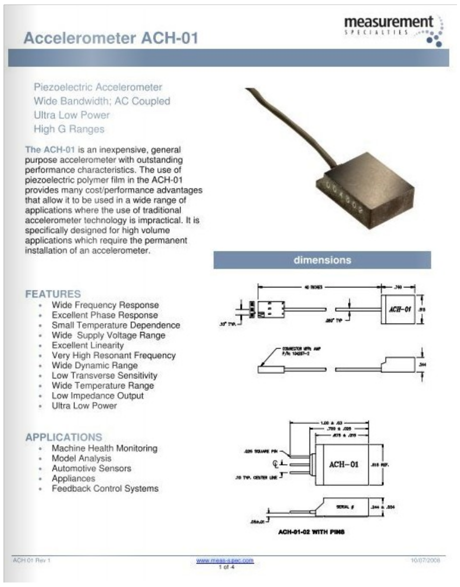
Accelerometer Selection

Although EVE can be tailored to work with a wide variety of accelerometers the best results are obtained in conjunction with the Piratelogic StarBass sensors. Third party sensors might also work but have not been tested extensively and might require additional tuning for optimal performance.

The original Philips MFB sensor

When planning on using a Philips MFB woofer equipped with the original BFW11 sensor such mounted in the AD12100/MFB note you will have to compensate for the combination of their low capacitance of the used pxe element (1n5) and 10M *brown – black – blue* gate resistor resulting in a lower pole of 10.61hz. Without proper loop compensation the resulting phase shift will introduce subsonic instabilities below 100hz. For more information google the 545 service manual and lookup the circuitry around TS549 for further details. All StarBass sensors have their lower pole sit at 2.7hz making them suitable for use from 27hz and upwards.

Measurement specialities ACH-01



measurement SPECIALTIES

Accelerometer ACH-01

Piezoelectric Accelerometer
Wide Bandwidth; AC Coupled
Ultra Low Power
High G Ranges

The ACH-01 is an inexpensive, general purpose accelerometer with outstanding performance characteristics. The use of piezoelectric polymer film in the ACH-01 provides many cost/performance advantages that allow it to be used in a wide range of applications where the use of traditional accelerometer technology is impractical. It is specifically designed for high volume applications which require the permanent installation of an accelerometer.

FEATURES

- Wide Frequency Response
- Excellent Phase Response
- Small Temperature Dependence
- Wide Supply Voltage Range
- Excellent Linearity
- Very High Resonant Frequency
- Wide Dynamic Range
- Low Transverse Sensitivity
- Wide Temperature Range
- Low Impedance Output
- Ultra Low Power

APPLICATIONS

- Machine Health Monitoring
- Model Analysis
- Automotive Sensors
- Appliances
- Feedback Control Systems

dimensions

ACH 01 Rev 1 www.meas-spec.com 1 of 4 10/07/2008

When planning on using the ACH-01 accelerometer please note the following:

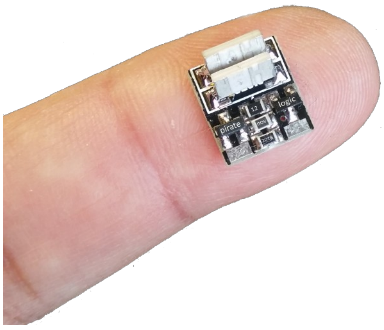
- Although shielded from above the sensors ceramic baseplate is not shielded and will pickup hum & noise if left untreated.
- When mounted on a carrier construct make sure to take precautions against the pickup of base strain induced non axial information.

Piratelogic Starbass Sensors

All StarBass accelerometers feature a low distortion design with a current output, shielding against EMI, RF and static electricity.

For pricing and availability visit piratelogic.nl .

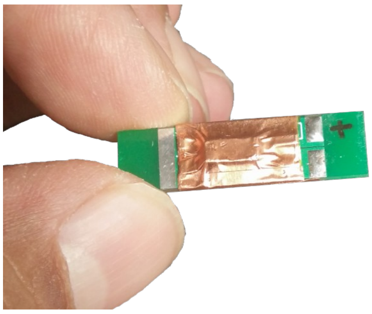
Piratelogic offers accelerometer products for a wide variety of low note drivers ranging from small 0.8inch VC home use to large 4 inch pro models, drivers using an extended pole piece for BL over Xmax linearisation and low profile drivers. To assist the user in the selection process the following information is given.



Starbass ClingOn

Low MMS 2P motional feedback accelerometer for use with pole piece extended motors, designed to be vertically mounted against the outer voice coil former. Available with 3 primary axis, see **Motor assembly variants** for more info. The ClingOn is 11mm wide, 12mm high and 6mm thick., the standard coax connection cable length is 10cm. Typical sensitivity is 1mV/G.

Current status : production v2023



Starbass Stripper

Low MMS 2P motional feedback accelerometer for use with voice coil diameters between 20 and 25 mm, designed to be mounted horizontally inside the voice coil former. Typical sensitivity is 1mV/G.

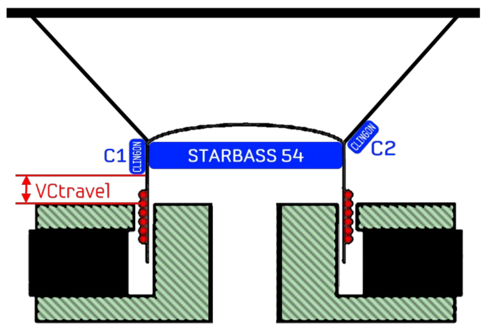
Current status : beta 1, samples available.

Starbass 54

Low MMS 2P motional feedback accelerometer for use with voice coil diameters between 30 and 54 mm or 1.25" - 2", designed to be mounted inside the voice coil former. Typical sensitivity is 1mV/G.

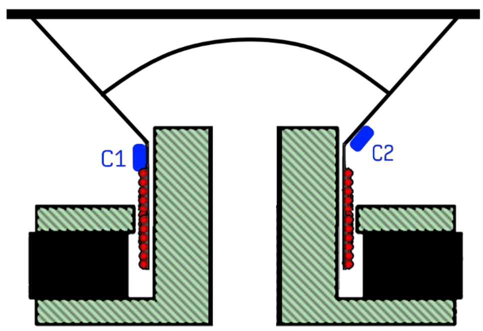
Current status: production version 6, in stock.

ClingOn variants C1, C2, C3



Accelerometer and placement choices for the most used driver motor structure:

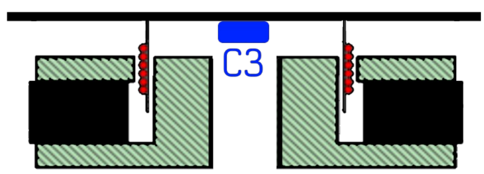
1. StarBass 54 requires disassembly of the dustcap, best quality feedback signal for VC diameters between 1.5 and 2 inch. Balanced loading, between 3 and 4 grams addition to MMS.
2. ClingOn C1 with 90° primary axis, no dustcap disassembly required, usability depends on VCtravel, risk of unbalanced loading with low MMS cones.
3. ClingOn C2 with 45° primary axis, no dustcap disassembly required, Risk of unbalanced loading with low MMS cones, risk of cone breakup information pickup.



Accelerometer and placement choices for extended polepiece motor structures:

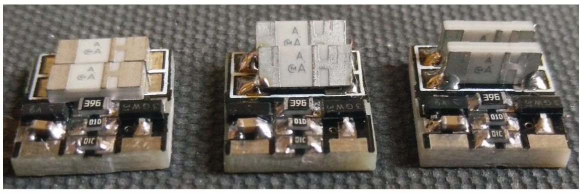
Due to the used of an extended pole piece the use of a StarBass 54 is ruled out. This setup has successfully been tested with Peerless XLS10 and WaveCor SW023 chassis.

1. ClingOn C1 with 90° primary axis, no dustcap disassembly required, usability depends on Vctravel, risk of unbalanced loading with low MMS cones.
2. ClingOn C2 with 45° primary axis, no dustcap disassembly required, Risk of unbalanced loading with low MMS cones, risk of cone breakup information pickup.



Accelerometer and placement choices for flat panel motor structures:

ClingOn C3 with 0° primary axis, usage of ClingON accelerometers with this type of motor structure has not been tested but is given in response to a DIYaudio post by Lejonkungen investigating it's use with a TangBand w3-1876 .



C1:90° C2:45° C3:0°

When ordering ClingOn accelerometers please indicated the desired primary axis,

- ClingOn C1 : 90°
- ClingOn C2: 45°
- ClingOn C3: 0°

Please note that all StarBass sensors register axial acceleration info only with complete absence of non axial information caused by VC deformation, while at the same time don't suffer from transformation effects such as the case with pickup-coil based systems.

Loop design

Being designed as a generic mfb correction module EVE supports a wide variety of driver, enclosure and loopgain choices. Because of this generic setup it is not possible to provide a common set of component values, to assist the user with making educated choices the following information is given. **Servo / Motional feedback does not work with Helmholtz resonator based enclosures such as bass reflex boxes.**

Loop shaping

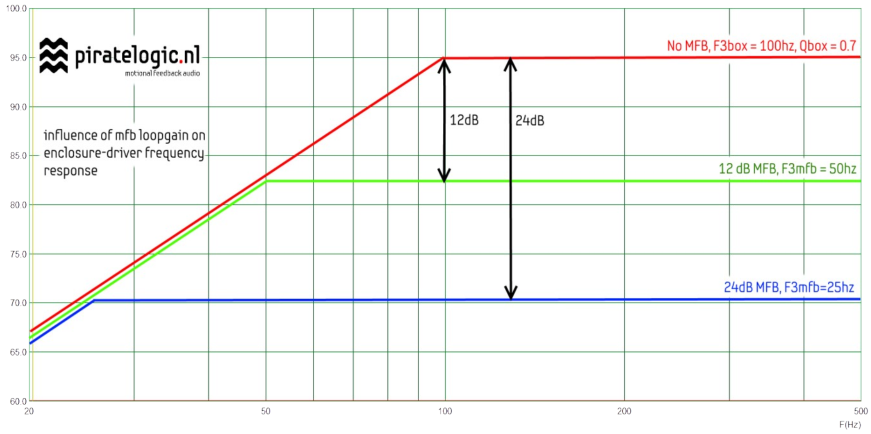
A well designed motional feedback loop will minimize an enclosure's influence on driver performance by keeping its voice coil under tight loop control. As long as both amplifier and driver operate within their *safe operating area and minimal phase margin between the voicecoil input and accelerometer output signals* you are presented with a high level of freedom in your feedback loop design. Historically – Philips – loop design was mainly focussed around minimizing enclosure sizes by compensating low-end roll off typical to small enclosures – F3box - by using a Linkwitz transform shaped loop. Small boxes, large sound marketing et al. If enclosure size is of less importance to you using a driver-box Q0.7 combination will require less loop shaping to compensate for F3box. Talk to your marketing folks.

Loop gain

Your next step involves choosing your desired loopgain, i.e. the amount of power sacrificed for the extra low extension. Philips designs were mainly designed around 10~12 db loopgain where the first series (532, 541, 544, 567, 545) where optimized for a low F3 (>30hz) combined with a high Q (>1) small box and the second (585,586, 587) for a medium F3 (>40hz), low Q (~0.7) larger box with a higher SPL. Loopgain determines:

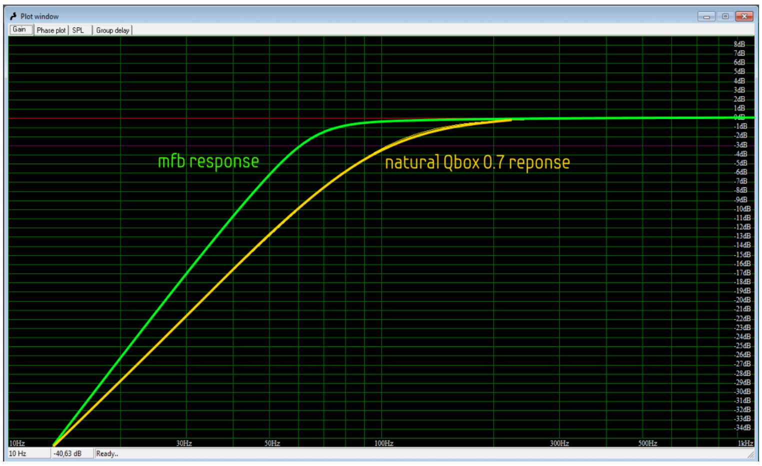
- The **F3mfb**, the higher the amount of gain the lower the resulting **F3mfb** will be.
- Maximum SPL, the 'extra' energy is rerouted to low extension.
- The amount of second and third harmonics suppression available

To illustrate the relation between loopgain and enclosure tuning the following graph is provided:



Enclosure design

- Firstly set the low frequency pole for your mfb box F3mfb equal to the driver physical resonance frequency F3driver or higher, choosing values below F3driver will severely limit driver efficiency due to usage outside it's physical limits.
- Secondly using the driver TS parameters calculate Vbox's – personal tool favourite WinISD : http://www.linearteam.org/ Start with an enclosure Q of 0.7. As displayed above 12dB MFB loopgain allows you to split F3box in half so if the desired lower frequency pole of your finished box F3mfb is 60hz the chosen F3box should be 120hz or lower.

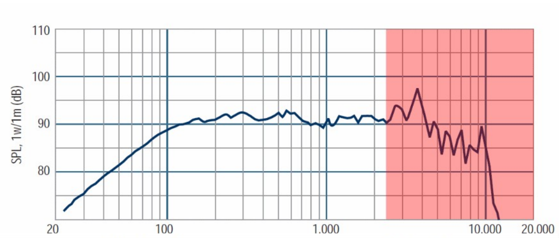


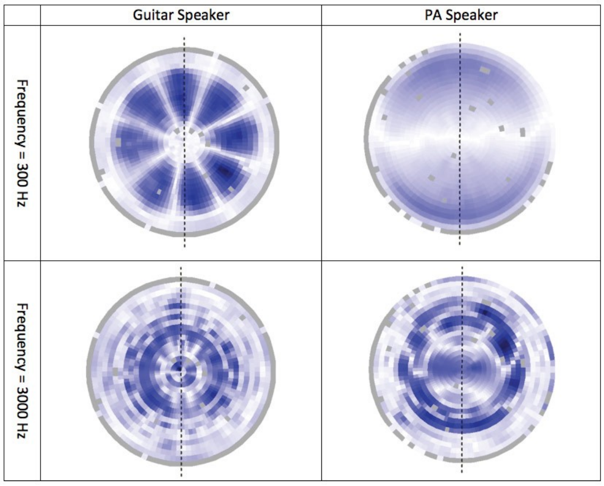
Example WINISD *response plot for a driver with a **Fc** of 60hz mounted in a sealed Q=0.7 enclosure with a natural **Fbox** of 120hz which is moved down to **Fmfb** of 60hz.*

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

Low Pass Filter

The 3rd step is to decide on a low pass filter frequency - **Flpf** - 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 **Flpf** at least 1 octave away from the first occurrence of cone breakup. In the example on the right cone breakup occurs in the red region onwards 2500hz making 1250hz or lower a valid choice for **Flpf**



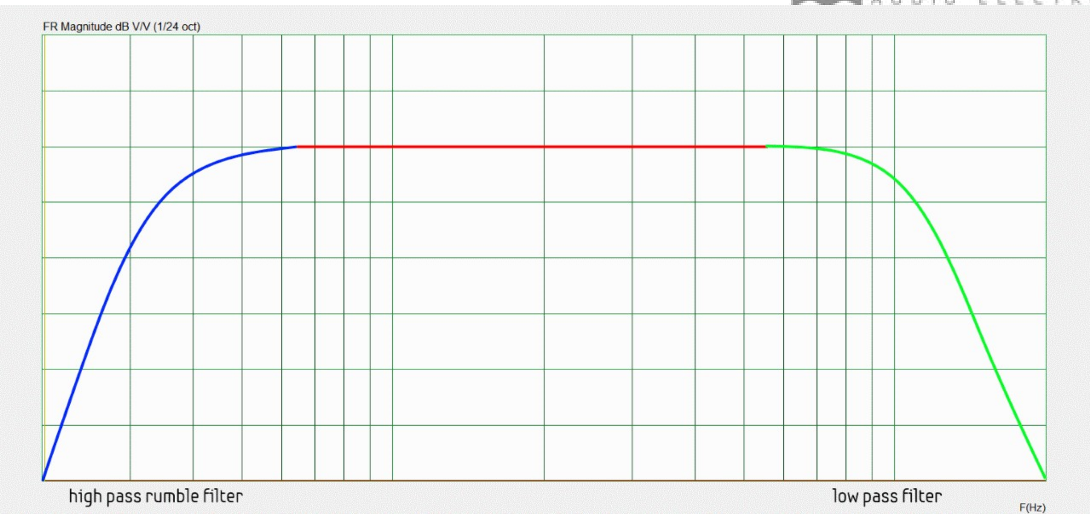


For mfb to work correctly driver cone motion requires to be *pistonic* in the area your loop is active in – voicecoil movement must mimic the cone without any partial vibrations like shown for the guitar speaker image (courtesy https://www.premierguitar.com) on the right.

None pistonic cone movement, often referred to as *cone breakup* introduces partial distortions which are not 'heard' by the accelerometer and thus not covered by the feedbackloop.

Crossover points

Using F3mfb and Flpf and F3box the component values for the desired crossover points can be calculated. The blue curve represents F3mfb and the green curve Flpf. 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.



4th order Rumble filter IC2C, IC2D Q=0.5		
C6,C8,C11,C13	R9,R10,R17,R19 (K)	Frequency (hz)
100	15	106
100	18	88
220	10	72
220	12	60
220	15	48
220	18	40
220	22	32

2nd order Lowpass filter IC2A Q=0.74				
R24,R25 (K)	C23 (nF)	C21(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

Rumble High Pass Filter

When choosing values for the rumble hpf be aware of the fact that the servoloop will attempt to correct cone motion right down to the lower pole of the EVE circuit, a 5hz sine originating from a wobbly recordplayer is copied to the connected driver no matter it's amplitude. In the oldskool days this was the reason why commercial amplifiers were often equipped with a so called "SubSonics" filter. Be careful not to set the rumble frequency too low, -3dB @ 10hz may look nice on your spec list but will severely stress any driver when connected to a 500 watt Class D amp. TIP : *perform a LF sweep before deciding on how low you want things to go .*

In case EVE is to be used with existing active enclosures it's build-in rumble and lowpass filters may need disabling:

- **Disabling the rumble filter** : omit **R9, R10, R17, R19** and replace **C6, C8,, C11,C13** with wire bridges.
- **Disabling the lowpass filter** : omit **C21, C23** and replace **R24, R25** with 0 ohm resistors.

Accelerometer settings

Bias

All StarBass accelerometers use a jFet transistor as impedance transformer with the pxe sensor element connected between it's gate and source. To obtain linear operation the jFet is biased into its ohmic region by setting Vgs to 0Vdc and placing a resistor over the pxe element which itself behaves like a capacitor :

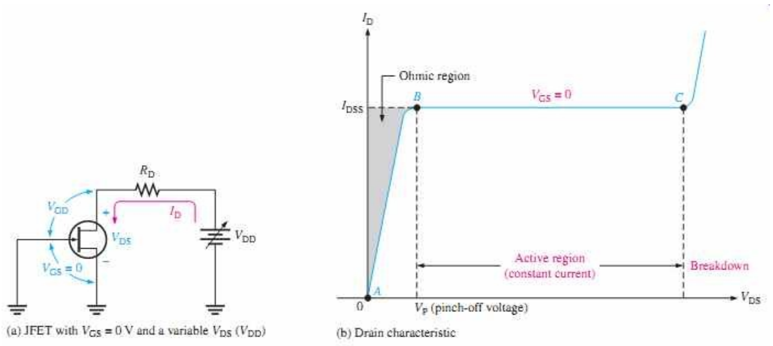


image courtesy of https://www.industrial-electronics.com/electrnc-dvcs-9e_8.html

To minimize StarBass distortion while maximizing it's output EVE2020 allows you to bias the pxe voltage between 4 and 8V using the PXE.BIAS potentiometer to accommodate for different Idss. For further information regarding jFet gate-source pinch off voltages see https://en.wikipedia.org/wiki/JFET

Gain

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. Longstroke drivers with a high Xmax will typically exhibit a relative high signal output when compared to standard drivers. To accommodate for this adjust **PXE.GAIN** which sets the gain for the incoming accelerometer signal.

Highpass filter

To avoid problems caused by the difference between the mirror output and opamp input DC levels a capacitor C8 was added to the circuit. The lower pole for the accelerometer signal Fpxe.low determines the low end loop stability and should be chosen at least at one tenth of F3mfb, too high values in respect to F3mfb will cause phase shift induced LF oscillations. Starting values for C8 and R19 are 680n and 120K setting Fpxe.low at 2hz. See also the topic *Amplifier bandwidth* in the chapter *Configuring the Servo Feedback Loop*.

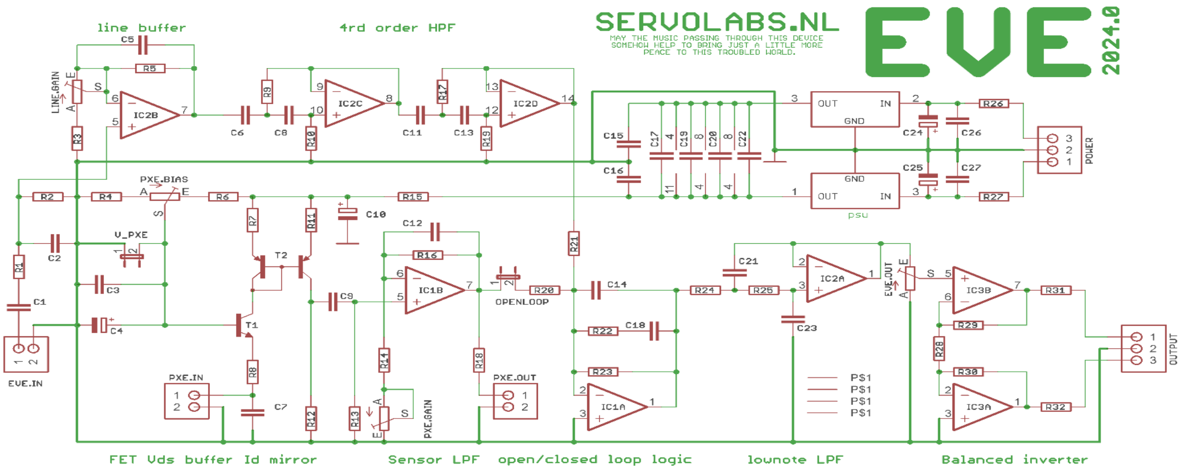
Lowpass filter

The high pole for the accelerometer signal – Fpxe.high – avoids driver breakup and sensor resonance from entering the summation signal at IC3b which gain bandwidth is determined by R21 // C12. With R21 = 100K a starting value half the low pass filter frequency Flpf should be used when calculating C12.

C12	Sensor cut-off frequency	C12	Sensor cut-off frequency
2n2	7200 hz	8n2	1940 hz
3n3	4822 hz	10n	1591 hz
3n9	4080 hz	15n	1061 hz
4n7	3386 hz	22n	723 hz
5n6	2842 hz	33n	482 hz
6n8	2340 hz	47n	338 hz

Module technical information

Schematics



Line buffer

The line buffer circuitry performs the following functions:

- The incoming audio signal arrives at EVE.IN, passes DC blocker C1 which together with R2 forms a 1st order high pass 0.8hz.
- To minimize EVE's rf input susceptibility lowpass filter R1,C2 is set at 160Khz.
- Buffer gain can be set between 2.6 and 11x with LINE.GAIN and is low passed at 16 Khz.

4th order high pass

The lower bandwith pole for the incoming line buffer signal is set by the 4th order HPF build around IC2c and IC2d.

PXE input buffer

The pxe input buffer processes the incoming accelerometer current signal and performs the following functions:

- The accelerometer current souce signal enters EVE at PXE.IN where it passes rf filter R8,C7 which corner frequency is set to 16 Khz.
- To adapt for jFet Vgs variations EVE allows the accelerometer bias voltage set for optimal linear operation by setting PXE.BIAS voltage for T1, the standard StarBass bias voltage is 6V.
- The output of the current mirror T2 arrives at IC1b low pass is provided by IC1a, for measurement purposes the accelerometer signal is made available via PXE.OUT. Use the **OPENLOOP** jumper to perform open/closed loop measurements.

Loop Mixer

The buffered, amplified and lowpassed StarBass signal arrives at IC1a where it is summed with the incoming audio signal via R20, C14, C18, R22 and R23 are used for setting loop gain and shaping. The signal then passes the 2nd oder lowpass filter IC2A.

EVE.out level control

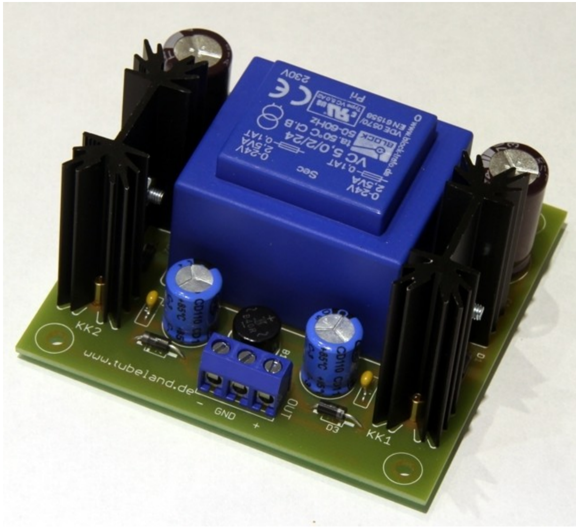
An additional potentiometer EVE.OUT was added to allow EVE output to be controlled during test to avoid loop instabilities from destroying connected drivers as most commercial power modules omit a level control. IC3A/B form a balanced inverter pair allowing EVE to be connected to poweramps featuring a balanced input.

Powering EVE

7812 and 7912 are standard voltage regulators to allow EVE from being operated from the power amp rails, Eve's current draw is 40mA max, use R26 and R27 to bleed of excessive rails (regulator inputs are max +/- 35V).

Power requirements

The EVE current draw at +/- 12V is 40mA max.. The onboard 78L12 and 79L12 regulators allow EVE to be powered directly from a maximum rail voltage of +/- 35V without the use of the rails bleeders R26 and R27 which can be omitted using wire bridges. When powering EVE from higher voltage rails use these to bleed of the extra voltage. The shapes for R33 and 34 allow usage of 1 Watt resistors which with a current draw of 40mA and a value of 680 ohms allow for a maximum voltage drop of 25V resulting in a maximum admissible rail voltage of +/- 60V.



In case EVE is to be used as a stand-alone module please provide for a symmetrical psu capable of delivering +/- 15V @ 80mA minimum such as done by this kit:

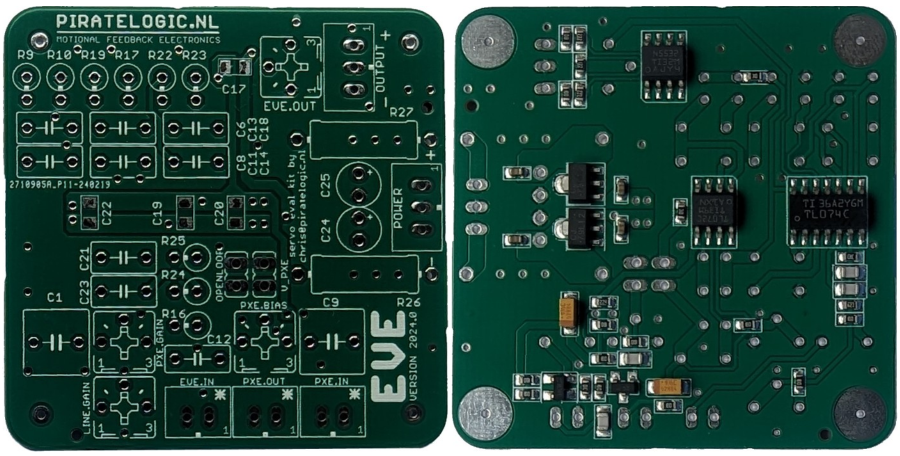
https://www.tubeland.de/product_info.php?products_id=13:

Choosing Components

EVE's primary goal is to offer a bare bone *proof of concept* servo loop solution and has been designed with cost effective readily available non-exotic parts in mind. The used opamps date back to 1978 and by no means represents the state of the art in opamp design. However since servo loops typically operate in the LF domain it's specs are more then sufficient for the task at hand, refer to the TL072, TL074 and 5532 datasheets for further information.

Module layout

Module Photo



PCB top layer – part names

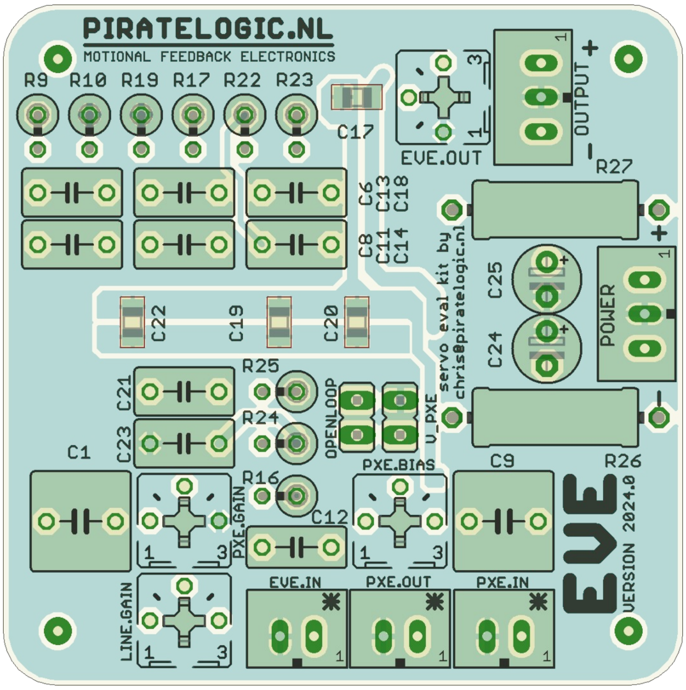
EVE2024 maintains the 2020 version 50x50mm footprint but has been updated to include several circuit updates.

All top layer thru hole components are industry standards parts, no exotic parts are used.

Top side decoupling capacities C17, 19, 20 and 22 are to be soldered by the user and provided in the kit.

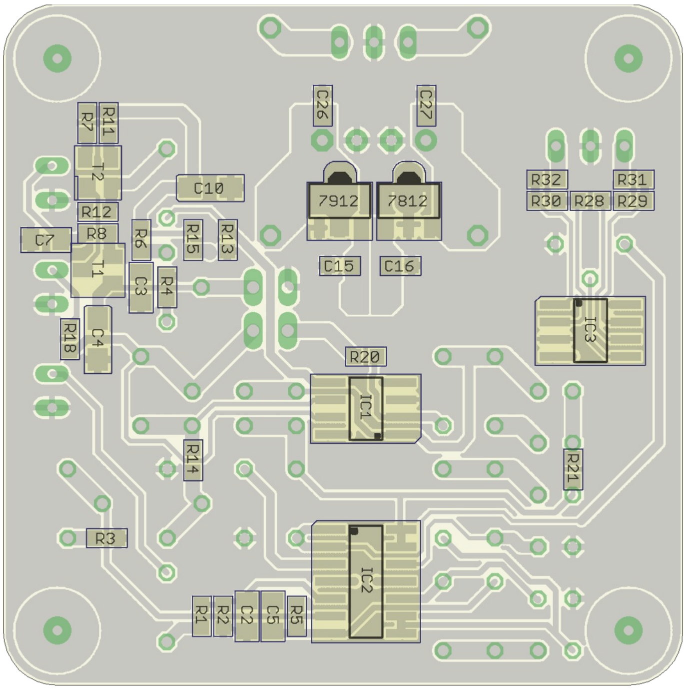
The user is free to choose capacities brands of their own liking, the footprints allow placement of both standard polyester and polypropylene types.

The used potentiometers are standard single turn Bourns cermet types, the connector are JST xh types with a pin distance of 2.54mm.



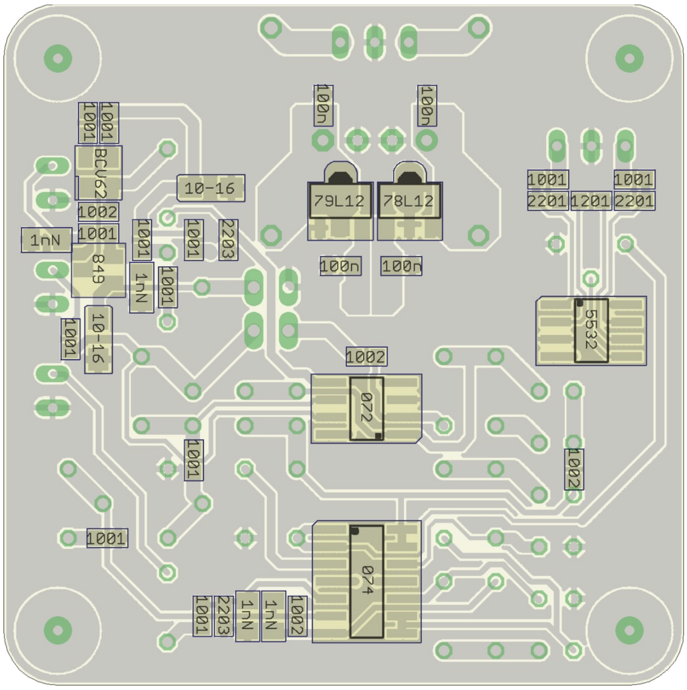
PCB bottom layer – part names

Unlike EVE 2020 the new 2024 comes with all bottom SMD parts factory mounted.



PCB bottom layer – part values

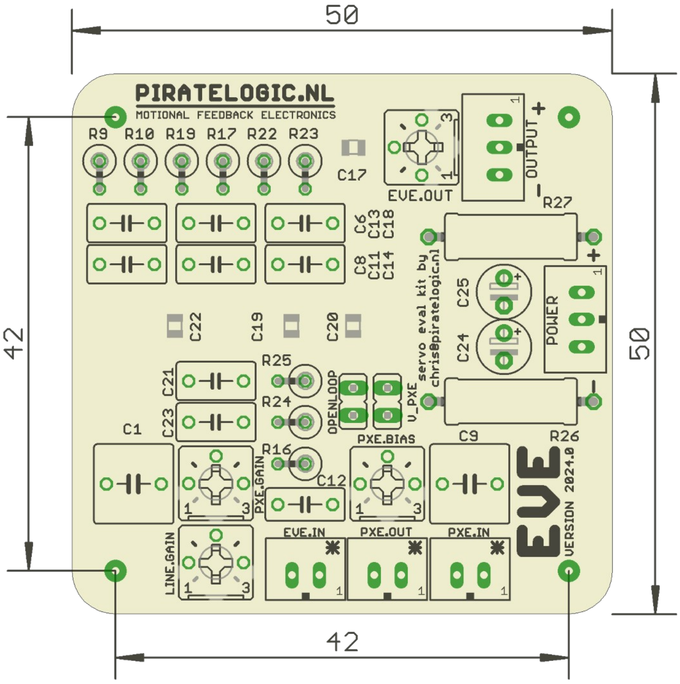
All SMD resistors are 0603 shaped 1%, unless otherwise noted all capacitors are 0603 XR7 5% and factory mounted using lead-free solder.



PCB dimensions

To allow easy mounting of the EVE module 4 mounting studs have been placed on the bottom PCB layer.

All dimensions in mm. Metric rulez, get used to it.



Tips & tricks

Buildup tips

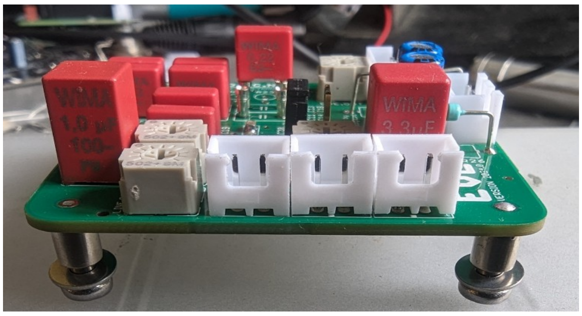
Mounting studs

For easy mounting of the EVE module 4 M3 studs are included which can be soldered onto EVE's bottom layer as displayed on the right.

The kit includes 4 M3 screws, when ordering your own make sure to use screws with a maximal length of 5mm

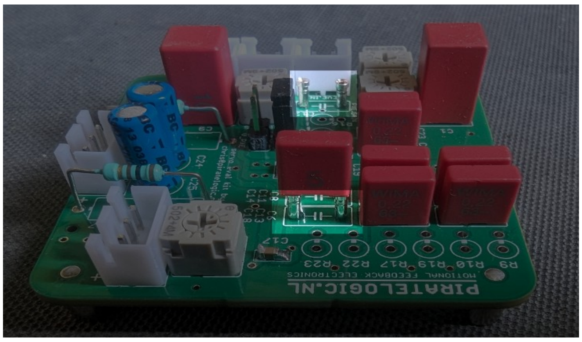
Component build order

When populating the EVE topside order your components height-wise, with the smaller components first. Shown component values are indicatory only and dependent on your desired setup.



Component sockets

To allow easy change of component values during loop and filter tuning it is advised to use IC sockets rather then solder them directly as indicated in the picture right, these pins were obtained from a standard DIL socket (mouser part 855-D2820-42) by cutting away the individual pins.



Start Cheap !

If this is your first MFB project and you have no prior experience installing acceleration sensors, it is advisable not to start using expensive amps & drivers, but start your learning curve using 2nd hand drivers like old Philips woofers that can be obtained for a few euros from local thrift stores.

The same applies to the connected amplifier, don't start with kilowatts but first do some tests with a limited (< 50 watts) power. Once your loop proves stable turn up the volume !

DIYaudio test case

It is outside the scope of this document to fully cover the physical and electronical ins & outs of the tuning process but I have attempted to collect the most important parts, for use-case information please refer to the excellent thread by Rob Campbell **MFB for ACI SV12 Drivers using Piratelogic Electronics** on DIYAUDIO available here:

https://www.diyaudio.com/forums/subwoofers/336070-mfb-aci-sv12-drivers-using-piratelogic-electronics.html

Basics

From a physics perspective a closed loudspeaker enclosure behaves like a spring-mass system, with its response transitioning from compliance dependant – controlled by the spider & surround - to purely mass controlled with F3box as the turning point inbetween. From an electronical perspective it behaves similar to a standard second order high pass filter with the corresponding 12 dB/Oct slope and 180° phase shift at **F3box**.

In order to do it's magic a well tuned MFB system will not only compensate for the -12dB slope below **F3box** but also introduce a phase shift to compensate for the natural 180° phase shift at **F3box** and thereby maintain phase neutral operation. Without the latter loop stability is in danger resulting in positive feedback making the loop oscillate at a frequency below **F3box**. Depending on available power and **F3box** this may result in very low – un hearable ! - freqency instabilities which ultimately will overheat and damage the driver motor system.

A well designed servo system will not only maintain shape between it's in en output but also keep them in phase.

Example ScanSpeak

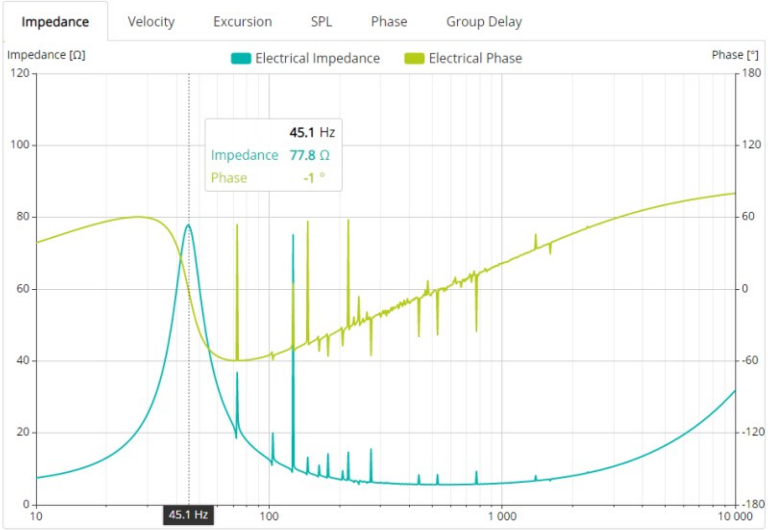
Free air response

With help of the excellent online loudspeaker database available at

http://www.loudspeakerdatabase.com/

the following simulation was made for a Scan-Speak 15W/8424G00.

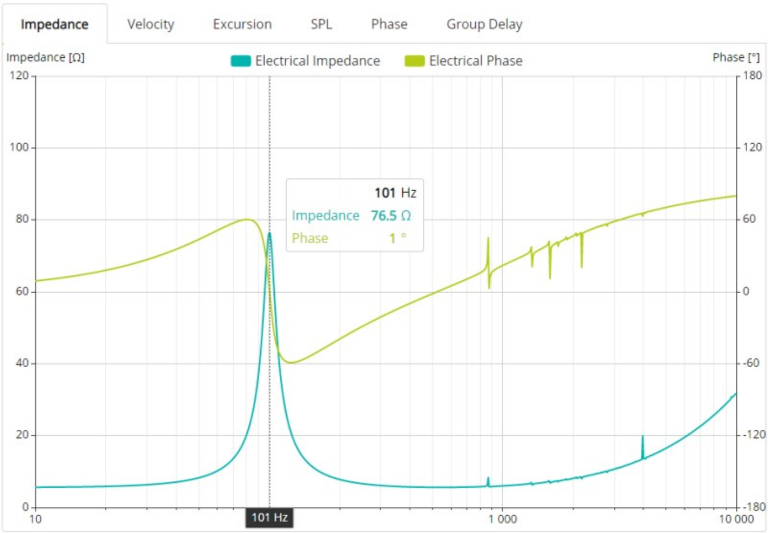
Shown on the right is the drivers free air impedance/phase curve. Note the 120 degree phase shift at 45hz, the drivers free air resonance frequency F3driver. Using this driver TS parameters as a reference the choosen F3mfb frequency would equal 45hz or higher.



Closed box response

The graph on the right shows the impedance/phase plot for the driver mounted into a 3.7 Little/One closed box, both F3box and it's accompaning phase shift have shifted towards 101 hz .

To assure stable operation the F3box phase shift should be compensated by the stepfilter R27 and C15.



Loop phase

Please note EVE introduces a 180 degree phase shift between it's EVE.IN and EVE.OUT 3 signal due to the inverting nature of the summation opamp IC1A. EVE2024 is fitted with a symmetric input, to invert output phase swap the 1 and 3 output pins to your amplifier. When your amp is equipped with a single async input connect it to either pin 1 or 3 of the OUTPUT.

Loop bandwidth

C14 limits the upper bandwidth of the mfb loop, refer to *2nd order Lowpass filter IC1C* table on page 8 for suggested values.

Amplifier bandwidth

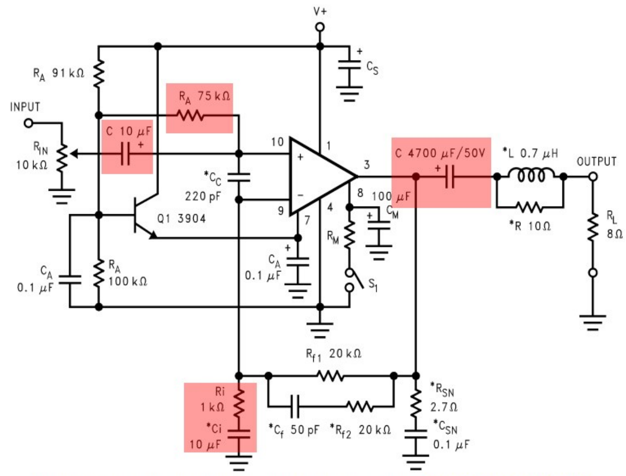
When using EVE with third party power amplifiers make sure their lower bandwidth pole starts sufficiently low, a too high value may negatively effect loop stability due to the introduction of LF phaseshifts. As a rule of thumb make sure your amplifier lower F3 pole is at least 1 tenth of your desired F3mfb.

As an example please find the following points of attention in the LM3886 based setup on the right:

LM3886 — Texas Instruments

SNAS091C – MAY 1999 – REVISED MARCH 2013 — www.ti.com

Single Supply Application Circuit



*Optional components dependent upon specific design requirements. Refer to the External Components Description for a component functional description.

Figure 3. Typical Single Supply Audio Amplifier Application Circuit

- The amp input RC 10uF/75K, F corner for this combination is 0,21 hz allowing for a F3mfb of 2,1 hz and above.
- The amp feedback loop RC 10uF/1K , F corner for this combination is 16 hz allowing for a F3mfb of 160 hz and above. For a F3mfb of 20hz up the capacitor to at least 100uF.
- Some older designs use an dc blocking output capacitor in series with the driver, for a F3mfb of 20hz in combination with a 4 ohm driver use an output capacitor of at least 20.000uF.

Addendum

Errata

< none at this time >

Document history

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 by clicking the Piratelogic EVE 2024.0 Manual link in the footer of this document.

27FEB2024	Initial version by CC		
14APR2024	Draft #1		
12JUN2024	Added buildup tips		
13JUN2024	Updated BOM		
08JUL2024	Start Cheap !		

External links

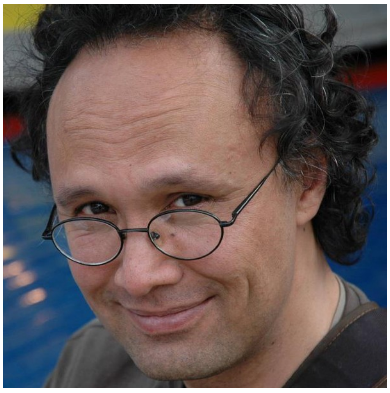
mfbfreaks.com

mfblabs.nl

www.repairyourspeakers.com

www.lautsprecher-manufaktur.de

About the author



Ever since I first was subjected to the Motional Feedback bass reproduction at age eleven I'm amongst the evangelists for this truly revolutionary loudspeaker technology. It's sheer impact on low note sonics, it's power and control will remain with anyone fortunate enough to have witnessed it.

During research into electro & mechatronics, the science behind motional feedback, it quickly became obvious that all starts with obtaining a high resolution and error free control signal, as such focus was shifted towards development of the Piratelogic StarBass accelerometers. A turning point was the discovery of an industrial shock sensor paving the way for a new breed of high quality servo designs. Being a hands-on guy I prefer building things using an educated trial and error approach , simulations and formula's are great but witnessing things react the way they do is gold. Building well performing MFB systems isn't an easy thing to do but using EVE with an StarBass equipped driver allows you to skip the hardest parts.

Created from an affordable budget the Little/One 2 way system is my proof of concept that MFB is still very much alive and kicking and it's successor, the Grown/Up 3 way is on its way to create even more fuzz. The EVE 2020 design incorporates lessons learned so far, its open-source design is my gift to you, ready to be pirated world wide. Hence the *logic* in Piratelogic .... now **GO!** use EVE to learn about MFB, use it to create your own servo drive low note system and put motional feedback back where it belongs : into the spotlights among the top low frequency enclosures out there.

Stay safe & clear from audiophile cabling & fuse discussions,

Greetings from Amsterdam,

Mail	chris@piratelogic.nl
Twitter	/@motoindo
MFBlabs.nl	/motoindo
facebook	/sonny soerabaja
	/piratelogic

Youtube channel : https://www.youtube.com/user/motorindo

Chris Camphuisen