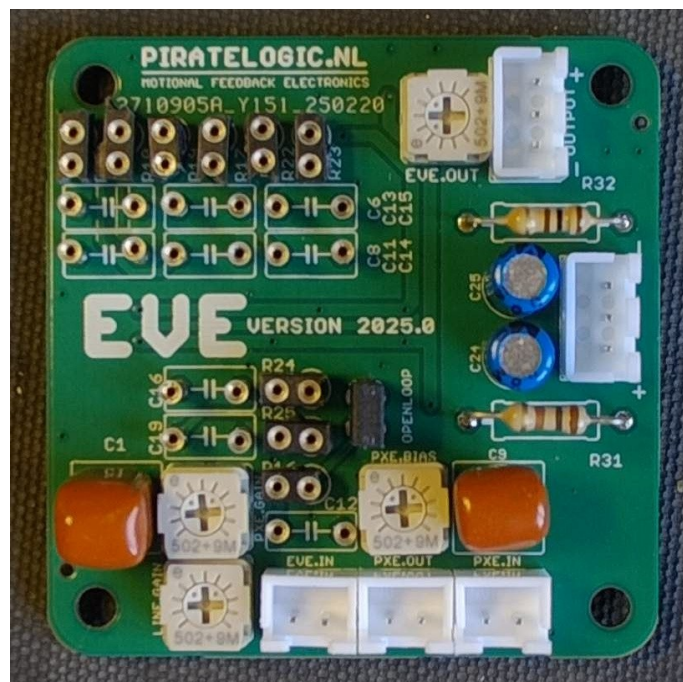


EVE

servo evaluation pcb

VERSION 2025.0



SUBJECT TO PERMANENT DEVELOPMENT

Contents

Before you start	3
Prerequisites.....	3
Warranty / Disclaimer / Copyright.....	3
Pricing & Availability.....	3
Bill of materials.....	4
Design considerations.....	5
Main design steps.....	5
Driver choice.....	5
Accelerometer Selection.....	6
The original Philips MFB sensor.....	6
Measurement specialities ACH-01.....	6
Piratelogic Starbass Sensors.....	7
Starbass ClingOn.....	7
Starbass 54.....	7
ClingOn variants C1, C2, C3.....	8
Loop design.....	9
Loop shaping.....	9
Loop gain.....	9
Enclosure design.....	10
Low Pass Filter.....	10
Crossover points.....	10
Rumble High Pass Filter.....	11
Disabling buildin filters.....	11
Accelerometer settings.....	12
Bias.....	12
Gain.....	12
Highpass filter.....	12
Lowpass filter.....	12
Module technical information.....	13
Schematics.....	13
Line buffer.....	14
4 th order high pass.....	14
PXE input buffer.....	14
Loop Mixer.....	14
EVE.out level control.....	14
Powering EVE.....	14
Power requirements.....	14
Choosing Components.....	15
Module layout.....	15
Module Photo.....	15
PCB top layer – part names.....	16
PCB bottom layer – part names.....	16
PCB bottom layer – part values.....	17
PCB dimensions.....	17
Tips & tricks.....	18
Buildup tips.....	18
Component build order.....	18
Component sockets.....	18
Start Cheap !.....	18
DIYaudio test case.....	19
Basics.....	19
Example ScanSpeak.....	20
Free air response.....	20
Closed box response.....	20
Loop phase.....	21
Loop bandwidth.....	21
Amplifier bandwidth.....	21
Addendum.....	22
Errata.....	22
Document history.....	22
External links.....	22
About the author.....	23

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 2025.0 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 trimmers 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** are non included through-hole setup dependent components.

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	1n	805	NPO!	PXE.OUT	JST.XH.2	JST.XH.2	JST-XH 2.54 mm Pitch Connector
C3	1n	805	NPO!	R1	1001	603	
C4	10u 16V	SMC_A		R2	2203	603	
C5	1n	805	NPO!	R3	1001	603	
C6	CX	C050-035X075	WIMA 5MM MKT/MKP	R4	1001	603	
C7	1n	805	NPO!	R5	1002	603	
C8	CX	C050-035X075	WIMA 5MM MKT/MKP	R6	1001	603	
C9	3u3	C050-075X075	WIMA 5MM MKT/MKP	R7	1001	603	
C10	10u 16V	SMC_A		R8	1001	603	
C11	CX	C050-035X075	WIMA 5MM MKT/MKP	R9	RX	0309V	0.25w 1% METAL FILM THROUGHOLE
C12	CX	C050-030X075	WIMA 5MM MKT/MKP	R10	RX	0309V	0.25w 1% METAL FILM THROUGHOLE
C13	CX	C050-035X075	WIMA 5MM MKT/MKP	R11	1001	603	
C14	CX	C050-035X075	WIMA 5MM MKT/MKP	R12	1002	603	
C15	CX	C050-035X075	WIMA 5MM MKT/MKP	R13	2203	603	
C16	CX	C050-035X075	WIMA 5MM MKT/MKP	R14	1001	603	
C17	100n	805	XR7	R15	1001	603	
C18	100n	805	XR7	R16	RX	0309V	0.25w 1% METAL FILM THROUGHOLE
C19	100n	805	XR7	R17	RX	0309V	0.25w 1% METAL FILM THROUGHOLE
C20	100n	805	XR7	R18	1001	603	
C21	100n	805	XR7	R19	RX	0309V	0.25w 1% METAL FILM THROUGHOLE
C22	100n	805	XR7	R20	1002	603	
C23	100n	805	XR7	R21	1002	603	
C24	10-63	E2,5-5	ELCO grid 2.54 mm, diameter 5 mm	R22	RX	0309V	0.25w 1% METAL FILM THROUGHOLE
C25	10-63	E2,5-5	ELCO 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	1201	603	
EVE.OUT	5K	B25P	BOURNS 3386	R27	2201	603	
IC1	tl72	S008	TL072	R28	2201	603	
IC2	tl74	S014	TL074	R29	1001	603	
IC3	5532	S008	NE5532	R30	1001	603	
LINE.GAIN	5K	B25P	BOURNS 3386	R31	RX	0414/15	2W 5% METAL FILM THROUGHOLE
OPENLOOP	JUMPER	JUMPER	THROUGHOLE	R32	RX	0414/15	2W 5% METAL FILM THROUGHOLE
OUTPUT	JST.XH.3	JST.XH.3	JST-XH 2.54 mm Pitch Connector	T1	849	SOT23	
POWER	JST.XH.3	JST.XH.3	JST-XH 2.54 mm Pitch Connector	T2	BCV62	SOT143B	

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:

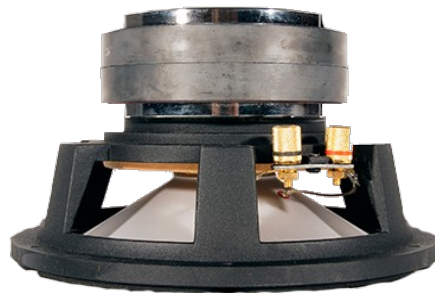
- **Driver choice:** as the feedback loop will put extra electrical and mechanical stress on your driver carefully selecting an appropriate driver should be your first step. Failure to do so will almost always result in sub optimal system performance and in worst case scenario defective drivers.
- **Accelerometer 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 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 piston motion in the area mfb will be active in. The larger the driver the harder it will be for it to maintain piston operation. *For high SPL designs daisy chaining multiple smaller diameter drivers might yield better results than 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. The folks over at <https://purifi-audio.com/ushindi> have done a great writeup on the subject, look it up and scroll down to *Surround Radiation Distortion (SRD)* for further details.
- **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 than carbon / non metallic models.
- **High temp voicecoil former :** usage of vintage – paper – voicecoil formers severely restrict the powerhandling.

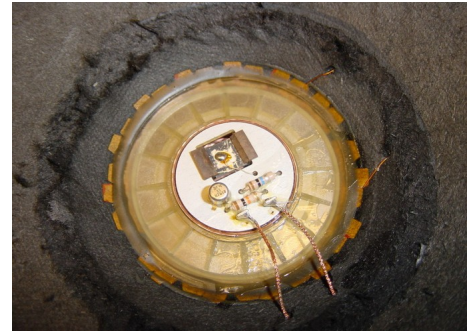


Accelerometer Selection

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 specialties ACH-01

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.

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

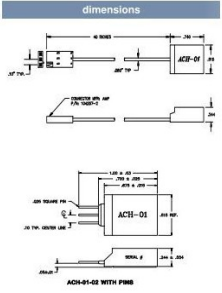
- Wide Frequency Response
- Excellent Phase Response
- Small Temperature Dependence
- Wide Supply Voltage Range
- Excellent Linearity
- Very High Resonant Frequency
- Wide Dynamic Range
- Low Transverse Sensibility
- Wide Temperature Range
- Low Impedance Output
- Ultra Low Power

APPLICATIONS

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



dimensions



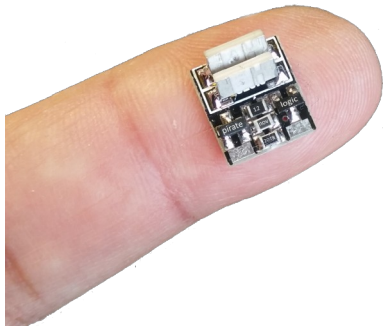
ACH-01 Rev 1
www.measurement-specialties.com
10070000

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

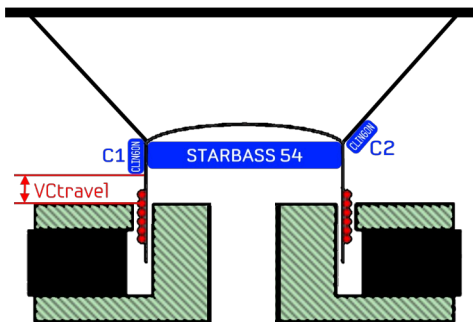


Starbass 54

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.

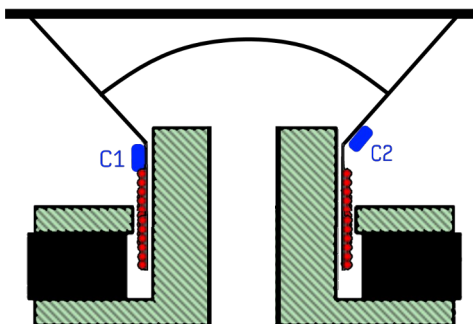
Current status: production version 6, in stock.

ClingOn variants C1, C2, C3



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

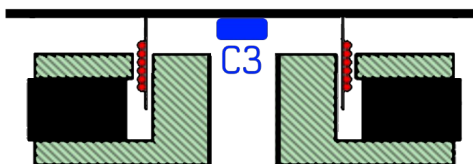
1. StarBass 54 requires disassembly of the dustcap, best quality feedback signal for VC diameters between 1.5 and 2 inch. Balanced loading, between 3 and 4 grams addition to MMS.
2. ClingOn C1 with 90° primary axis, no dustcap disassembly required, usability depends on VCtravel, risk of unbalanced loading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

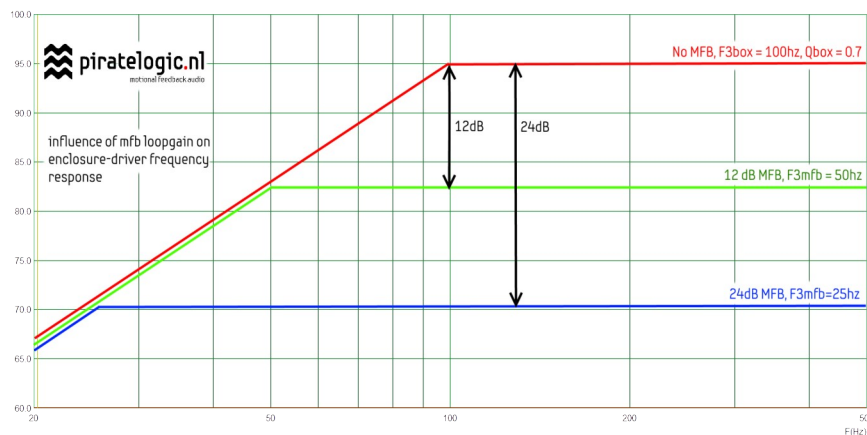
A well designed motional feedback loop will minimize an enclosure's influence on driver performance by keeping its voice coil under tight loop control. As long as both amplifier and driver operate within their *safe operating area* and *minimal phase margin between the voicecoil input and accelerometer 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.

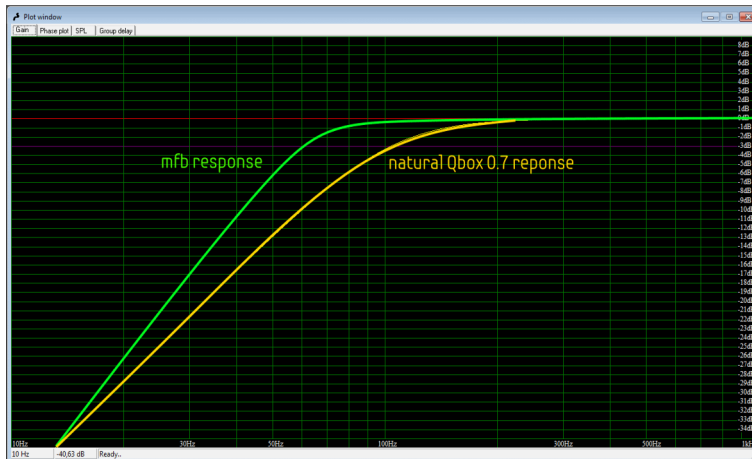
To illustrate the relation between loopgain and enclosure tuning the following graph is provided, please note this graph is for informational purposes only and does not reflect actual forward gain levels as these remain equal above **F3mfb**.



EVE maximum loopgain is determined by IC1A and default set to $R23/R20$ i.e. $100/10 = 10x$ or 20dB. R22 & C15 are used to compensate for the natural 2nd order rolloff below F3box.

Enclosure design

- First step is set the low frequency pole for your mfb box F_{3mfb} equal to the driver physical resonance frequency $F_{3driver}$ or higher, choosing values below $F_{3driver}$ will severely limit driver efficiency due to usage outside it's physical limits.
- Second step using the driver TS parameters calculate V_{box} '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 F_{3box} in half so if the desired lower frequency pole of your finished box F_{3mfb} is 60hz the chosen F_{3box} should be 120hz or lower.

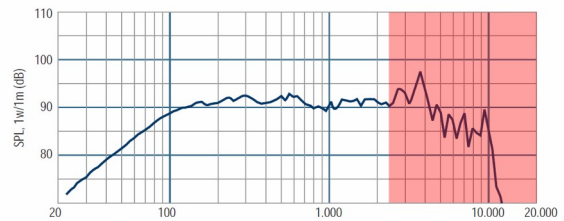


Example WINISD response plot for a driver with a F_c of 60hz mounted in a sealed $Q=0.7$ enclosure with a natural F_{box} of 120hz which is moved down to F_{mfb} of 60hz.

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 limit system efficiency and SPL.

Low Pass Filter

The 3rd step is to decide on a low pass filter frequency - F_{lpf} - 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 F_{lpf} 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 F_{lpf}

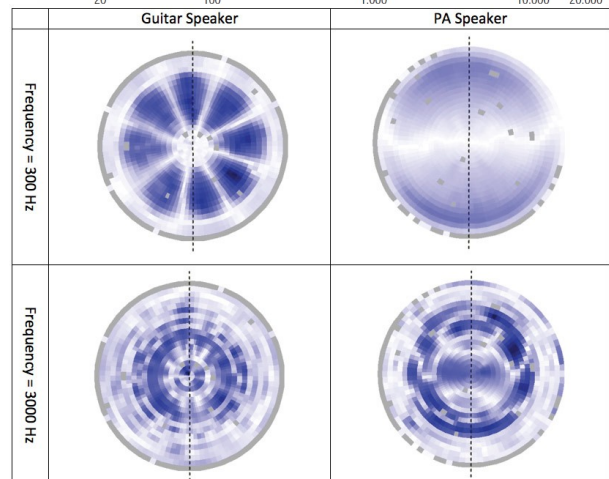


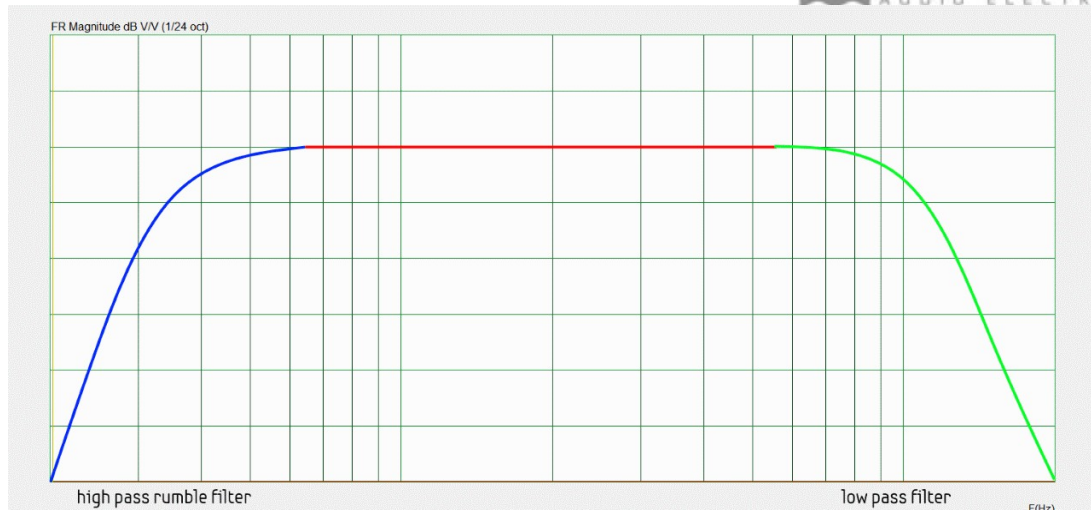
For mfb to work correctly driver cone motion requires to be *pistonc* in the area your loop is active in – voicecoil movement must mimic the cone without any partial vibrations like shown for the guitar speaker image (courtesy <https://www.premierguitar.com>) on the right.

None pistonc 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 F_{3mfb} and F_{lpf} and F_{3box} the component values for the desired crossover points can be calculated. The blue curve represents F_{3mfb} and the green curve F_{lpf} . 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.





4 th order Rumble filter IC2C, IC2D Q=0.5			2 nd order Lowpass filter IC2A Q=0.74			
C6,C8,C11,C13	R9,R10,R17,R19 (K)	Frequency (hz)	R24,R25 (K)	C19 (nF)	C16(nF)	Frequency (hz)
100	15	106	2.2	47	100	1055
100	18	88	3.3	47	100	703
220	10	72	3.9	47	100	595
220	12	60	4.7	47	100	493
220	15	48	2.7	100	220	397
220	18	40	3.3	100	220	325
220	22	32	3.9	100	220	275
220	27	27	4.7	100	220	228
220	33	21	5.6	100	220	191

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.*

Disabling buildin filters

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 C16, C19 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 V_{GS} to 0Vdc and placing a resistor over the pxe element which itself behaves like a capacitor :

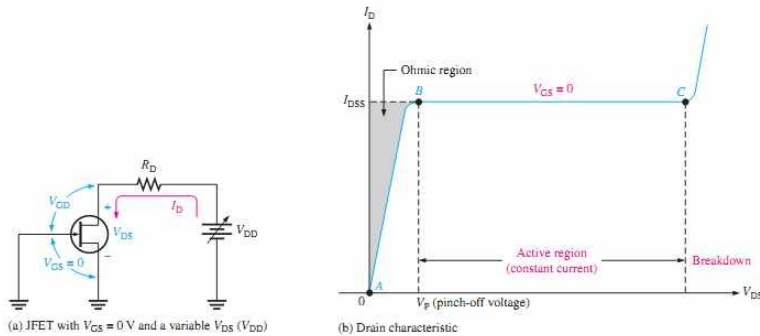


image courtesy of https://www.industrial-electronics.com/electrnc-dvcs-9e_8.html

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 I_{DSS} . 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 will due to their larger excursion exhibit higher signal output then standard drivers. To accommodate for this adjust **PXE.GAIN** which sets the gain for the incoming accelerometer signal.

Highpass filter

C9 provides an AC coupling between the T2 mirror output and IC1b input and determines the lower pole for the accelerometer signal **Fpxe.low.**, To ensure low end loop stability C9 and R13 are 3u3 and 220K setting **Fpxe.low** at 2hz. .Too high values in respect to F3mfb will cause phase shift induced LF oscillations. See also the topic *Amplifier bandwidth* in the chapter *Configuring the Servo Feedback Loop*.

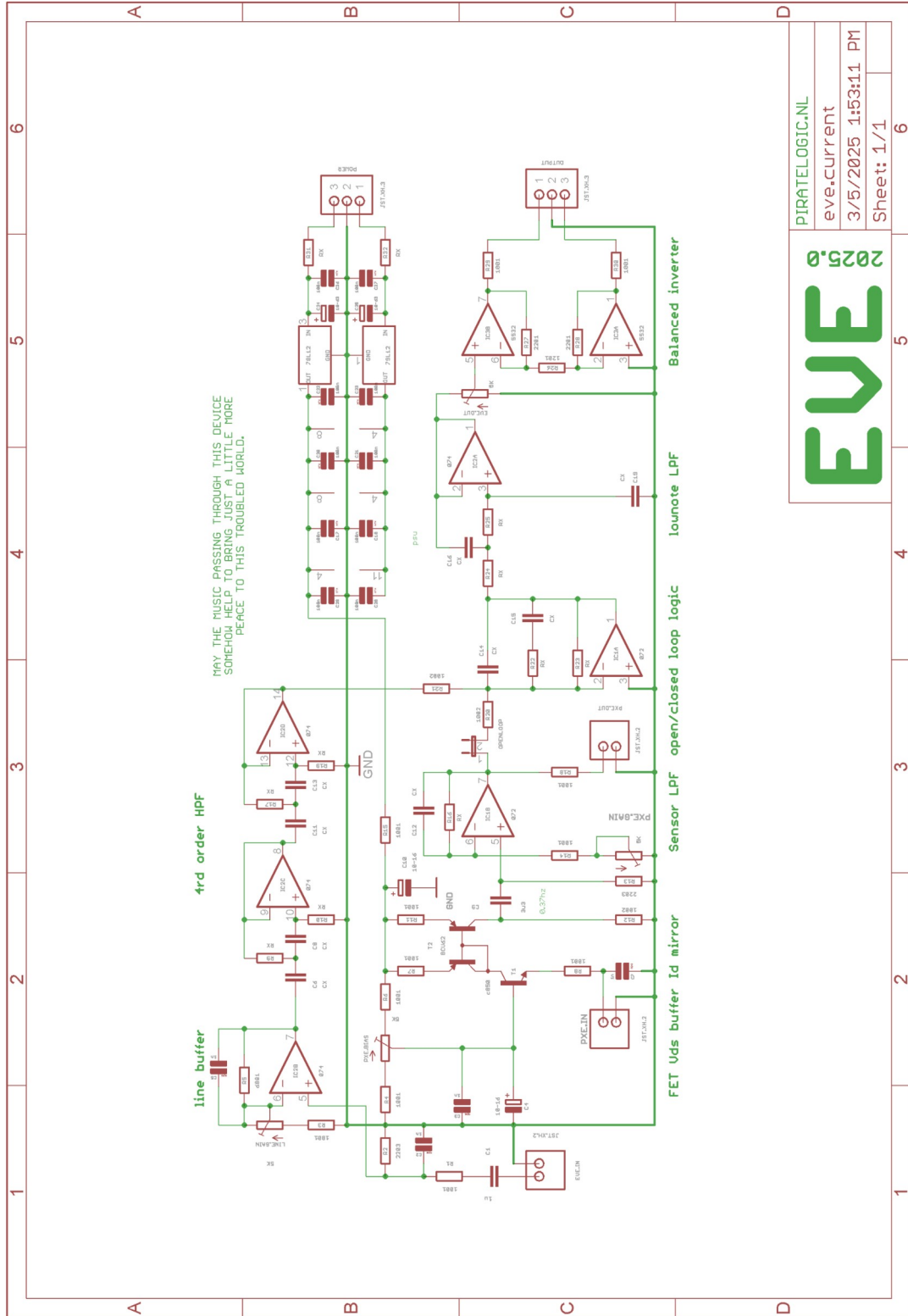
Lowpass filter

The high pole for the accelerometer signal – **Fpxe.high** – avoids driver breakup and sensor resonance from entering the summation signal at IC1a which loop bandwidth is determined by R16 // 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



PIRATELOGIC.NL
eve-current
3/5/2025 1:53:11 PM
Sheet: 1/1

2025.0
EVE

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

PXE input buffer

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

- The accelerometer current source 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 order 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 startup dc setpoints and/or 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.

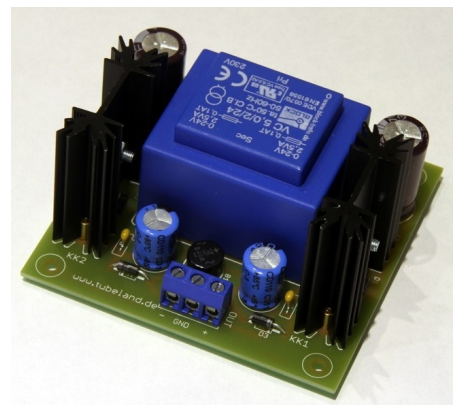
Powering EVE

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:

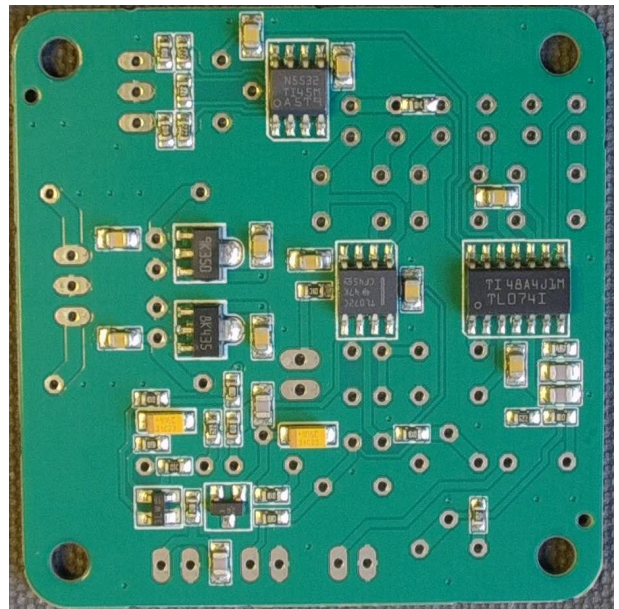
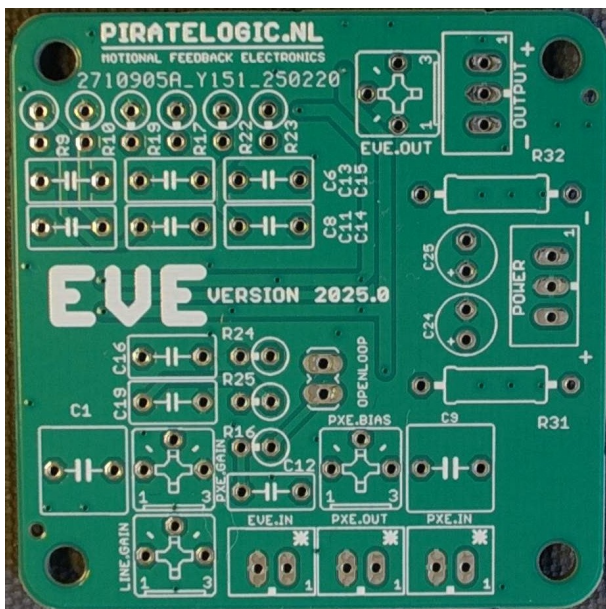
https://www.tubeland.de/product_info.php?products_id=13:

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

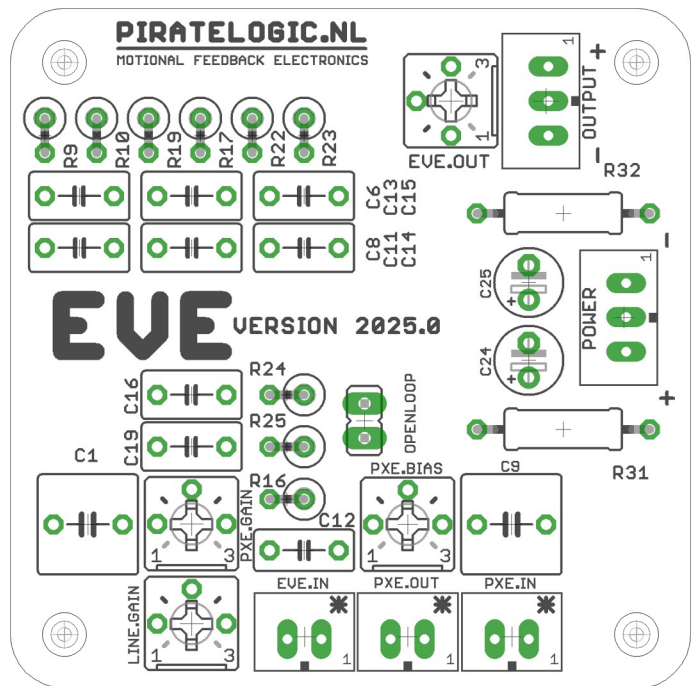


PCB top layer – part names

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

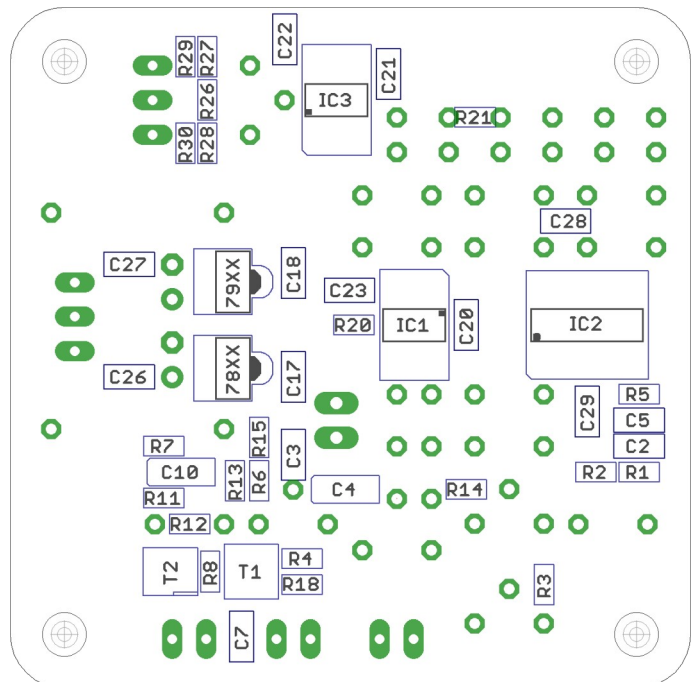
The user is free to choose capacities brands of their own liking, the 5mm footprints allow placement of both standard polyester and polypropylene types.

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 earlier versions EVE 2025.0 comes with all bottom SMD parts factory mounted.

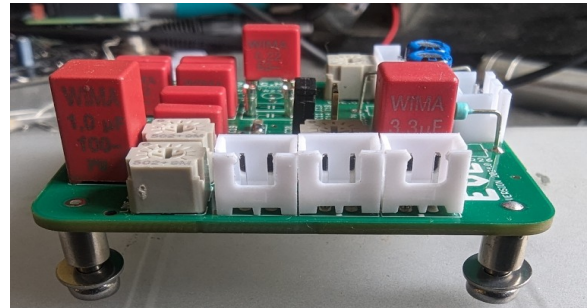


Tips & tricks

Buildup tips

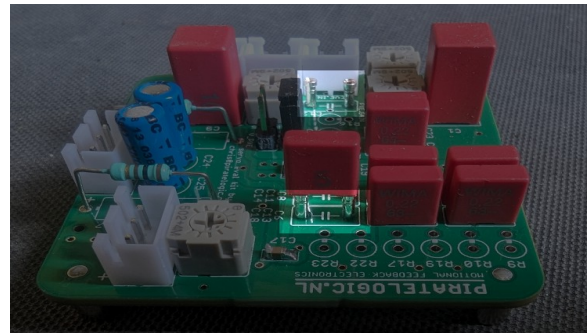
Component build order

When populating the EVE topside order your components height-wise, with the smaller components first. Shown component values are indicative 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 pin sockets rather than 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, **its advised 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 !

Prior to powering up your EVE test setup make sure to set LEVEL.OUT to minimum (turn c.c.w.) to avoid any startup dc setpoint artefacts from reaching your driver. Once all setpoints are reached – typically within a few seconds – it's safe to turn up LEVEL.OUT. When designing your system around EVE make sure to include a powerstage power-on delay !



DIYaudio test case

It is outside the scope of this document to fully cover the physical and electrical 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 F_{3box} as the turning point inbetween. From an electrical perspective it behaves similar to a standard second order high pass filter with the corresponding 12 dB/Oct slope and 180° phase shift at F_{3box} .

In order to do it's magic a well tuned MFB system will not only compensate for the -12dB slope below F_{3box} but also introduce a phase shift to compensate for the natural 180° phase shift at F_{3box} 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 F_{3box} . Depending on available power and F_{3box} this may result in very low – unhearable ! - frequency 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 and output but also keep them in phase.

Example ScanSpeak

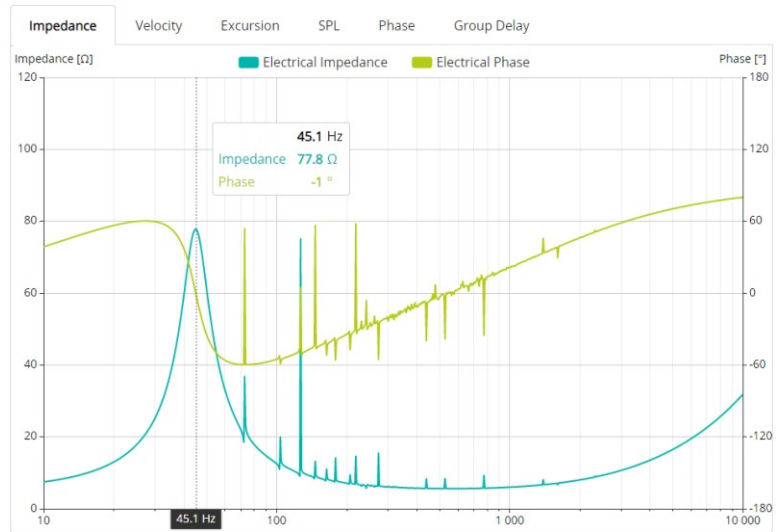
Free air response

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 chosen **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 accompanying 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. EVE2025 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 11 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:

- 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.

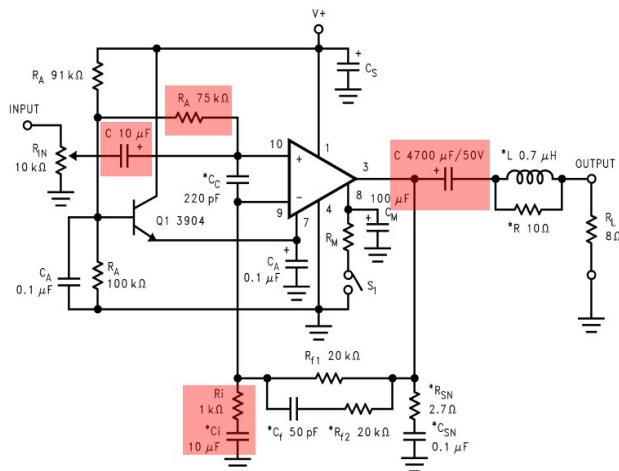
LM3886



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

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 matches the one in the online version by clicking the [PirateLogic EVE 2025.0 Manual](#) link in the footer of this document.

11 MAR 2025	Initial version by CC		
04 APR 2025	Start Cheap info added		

External links

piratelogic.nl

servolabs.nl

mfbfreaks.com

mfbblabs.nl

repairyourspeakers.com

zelfbouwaudio.nl/forum

youtube.com/user/motorindo

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.

While experimenting with accelerometer designs 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 clear from audiophile cabling & fuse discussions,

Greetings from Amsterdam,

Chris Camphuisen