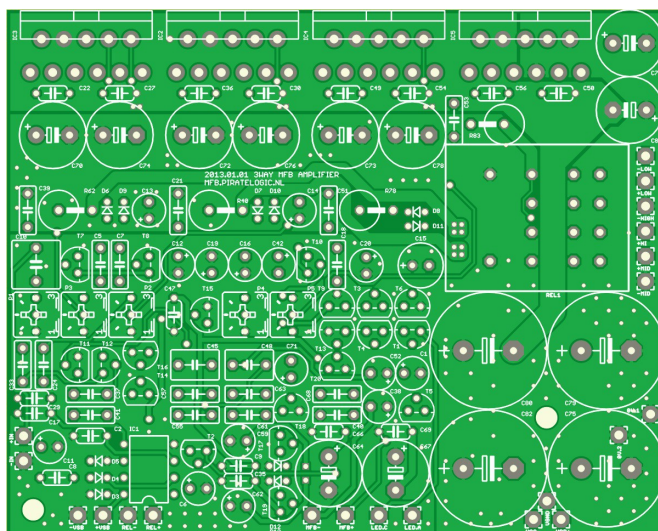# Usermanual
Module 2013.01

integrated 3 way motional feedback amplifier

piratelogic audio

amsterdam – holland

Contents

Introduction.

Thank you for purchasing the 2013.01 amplifier module. Using it in conjunction with modern drivers will allow you to build a first class motional feedback system.

Revisions

Prior to starting work please check if the datestamp at the footer of this page corresponds with the one in the online version at http://mfb.piratelogic.nl/data/docs/2013.01.usermanual.en.pdf

02/09/13	Initial version by CC
04/09/13	Added info on powerratings.
05/09/13	Added images & Design wizard chapter
19/09/13	Updated schematic
25/09/13	Updated schematic
29/09/13	Edited introduction , added BOM.
09/10/13	Added wizard info, removed BOM.
10/10/13	Updated wizard info describing BOM button.
27/11/13	Added measurement info.

Erratum

Any bug fixes will be announced here.

History

The original Philips MFB enclosures were produced by Philips Gloeilampen Fabriek NV in Leuven - Belgium between 1970 and 1989. At the time the concept was highly revolutionary and caused quite a stir with local hifi aficionados.

Future

With the introduction of the portable music players the home-stereo experience shifted away from separate hifi components to the smartphone and a pair of in-ear headphones. Because it took a long time for the hifi industry to pick up this change (they only recently started to include docking stations in their mini sets) a new breed of active speakers market segment was born.

Boom boxes

Most active speaker setups are direct descendants of cheap plastic PC speakers which suffice in teenager setups where they are being used in conjunction with low quality MP3 audio. Most of them have been sized down to the small and sexy smart phone form factor and don't excel in bass reproduction. There are of course some exceptions to the rule, but most just sound awfully boomy.

Piratelogic

We believe the time for MFB is **now,** the technology behind motional feedback allows small form factors to be combined with astonishing bass reproduction. Our business goal is to bring mfb production back to life starting with providing hifi diy enthusiasts with a high quality 2013 version of the original Philips 22AH587 MFB electronics. The first step was taken earlier this year with the 2012.01/02 modules, this document describes its successor : the integrated 2013.01 3 way motional feedback module.

Discussion Forum

All Piratelogic modules are discussed in the Piratlogic discussion forum, to visit this forum please navigate to:

http://forum.piratelogic.nl

Please note that in order for you to become a member of this forum you MUST send an email to register@piratelogic.nl with a small introduction who you are and why you like to become a member. This is only to avoid spammers from polluting our forum. If you are for real access will be granted within 2 business days.

Usage

The 2013.01 module contains all electronics needed to make an active 3 way motional feedback loudspeaker enclosure. It consist of a the following building blocks:

- Double layer 35uM fr4 PCB measuring 80 by 100mm.

- A three way 12db/Octave subtractive x-over. Please note that contrary to most subtractive designs this one does not suffer from 6db phase shift induced slopes limitations, is highly configurable and completely discrete in setup thus minimizing the number of gain stages to a bare minimum.

- A VCA based limiter to safeguard the drivers from being fed clipped material.

- Discrete pre-amp/filter regulators.

- MFB correction logic supporting both the original Philips MFB drivers as well as drivers equipped with the Measurements Specialities ACH01 acceleration sensor. Ready to use prepared woofers are available upon request.

- APUS (automatic power on upon signal) circuitry using a small 5V phone adapter as standby supply in conjunction with a 5V off-board mains relay .

- Three LM3886 based amplifiers with the option to extend the low note amplifier to a bridged design using a fourth LM3886 to accommodate 8 ohm drivers.

- Up to 28960 uF on-board buffer capacity using 6800 electrolytes.

- DC protection and power on sequencer to safeguard the drivers from DC in case of power amplifier failure and power-on irregularities.

The 2013.01 is the successor to the 2012.01/02 which was based on the same schematics but used through hole components and as such needed double the real estate of the 2012 pcb's.

Kit versions

The 2013.01 comes in 4 flavours depending on your budget and skill set:

- Bare PCB without any components. DO NOT ATTEMPT TO BUILD THIS MODULE UNLESS YOU ARE SEASONED AMPLIFIER BUILDER WITH 0805 SMD SOLDERING EXPERIENCE. SEE *BEFORE YOU START* AT THE END OF THIS DOCUMENT !!!

- PCB with pre-mounted 0805 / 1206 smd capacitors and resistors to the copper side.

- PCB module completely build and tested

- PCB module completely build and tested and mounted as a plate amp complete with toroid, heat sink and XLR inputs.
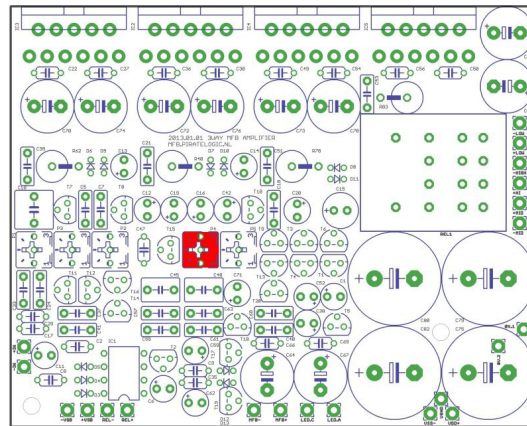
Pricing

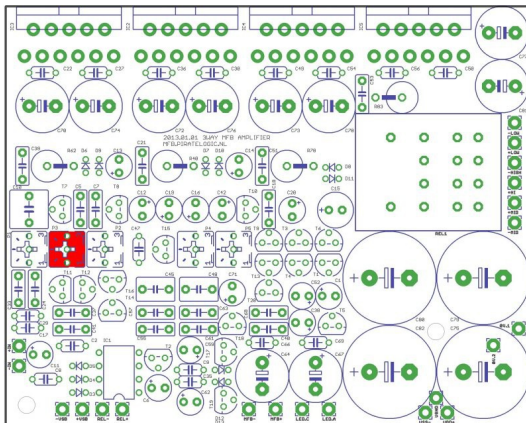2013.01 pricing details are available online, please visit our forum at http://forum.piratelogic.nl for more info.

Level adjustments
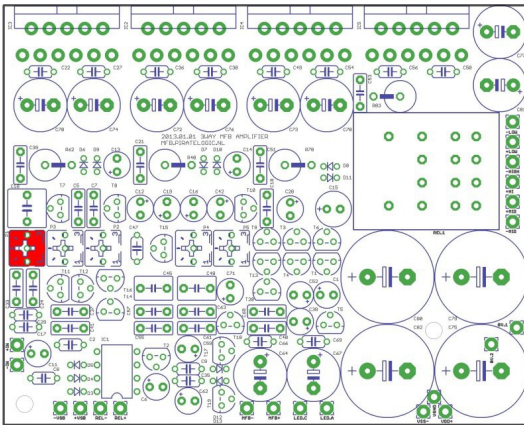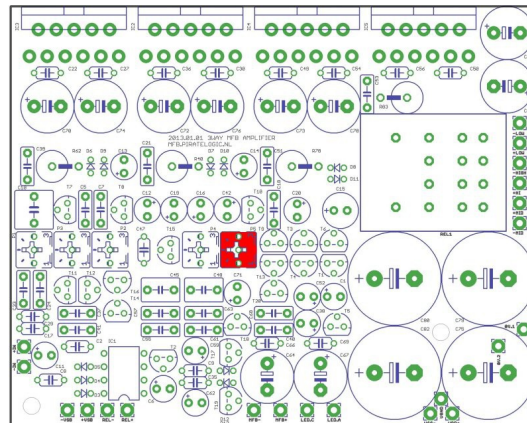
P1 : general input level
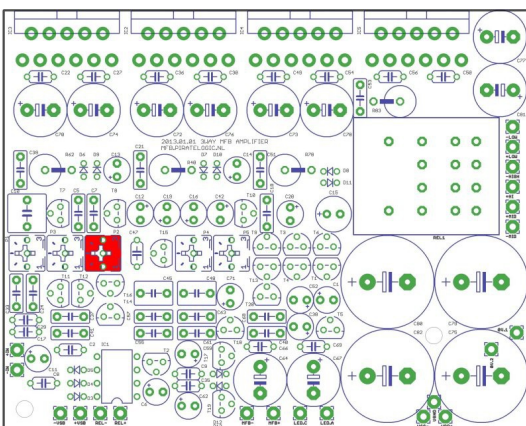
P4: MFB correction level

P3: high note amplifier level

P5: low note amplifier level

Fig 9. The 2013.01 potentiometers.

Depending on the need to allow adjustment s to happen from outside the enclosure the potentiometers may be moved from the components to the copper side of the board.

P2: mid note amplifier level

Accelerometer equipped woofers

The 2013.01 has been developed for use with stock Philips MFB woofers and has been confirmed to work properly in

conjunction with all existing models, i.e. the AD7067, AD8067, AD10100 and AD12100 mfb woofers.
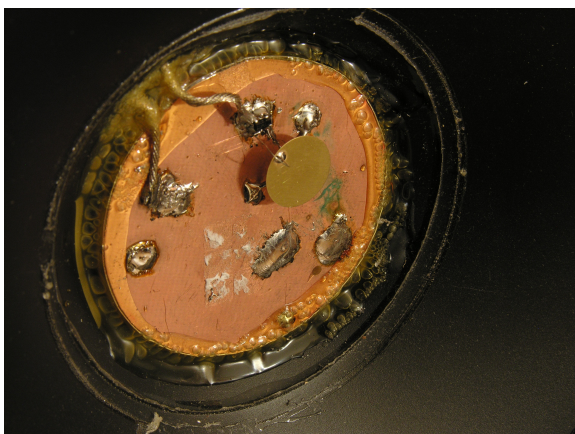
Because MFB woofers are no longer manufactured by Philips or any other manufacturer we have been forced to do some research of our own. Might you while reading this be aware of any existing mfb woofer manufactures then please let us know.

We have successfully paired an ACH01/02 accelerometer from Measurement Specialities http://mfb.piratelogic.nl/data/docs/ach01.pdf *with the Skytronic 902.208 PP woofer, a typical China made low cost polypropylene woofer.*
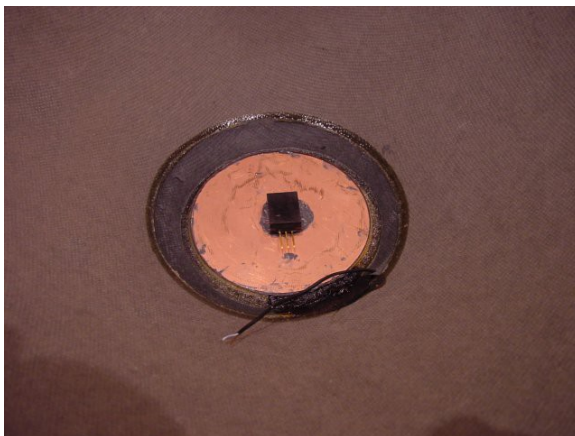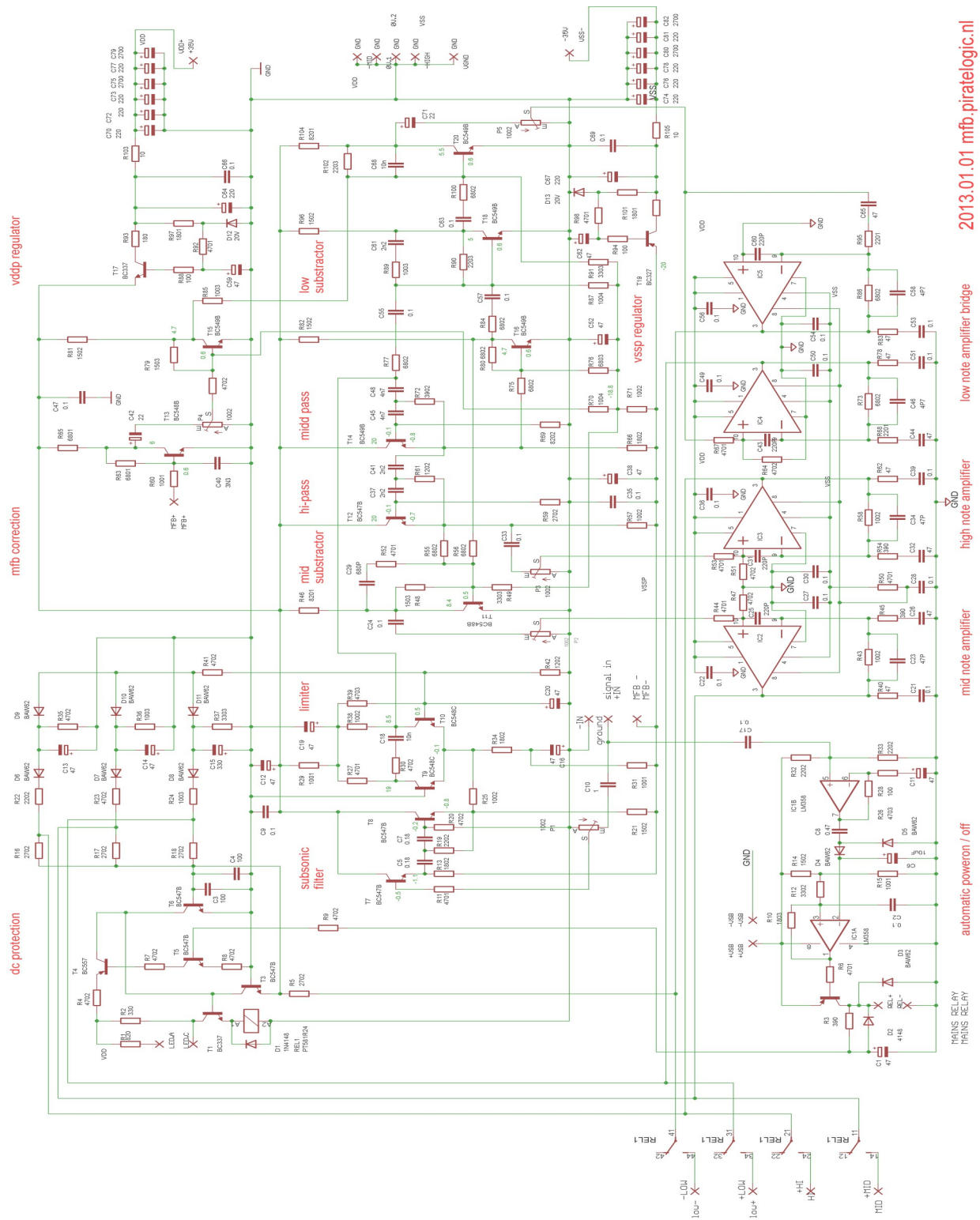

The ACH01/02 mounted in a 15" PA chassis.

An expiremental acceleration sensor using an ordinary piezo buzzer element.

Schematic

Description

The input signal arrives at C10 (1uF MKP) from where its level may be adjusted using P1. From P1 its fed to a 12dB high pass subsonic filter based around T7, T8 and C5 and C7.

Subsonic filter

Fig 2 : the subsonic filter capacitors C5 & C7.

Please take into consideration that reproducing (sub) low frequencies requires considerably amounts of energy to be send to the low-note driver. When determining the lower -3dB pole please observe the LM3886 SOAR ratings.

Please refer to the Design Wizards chapter for further information on how to fine tune this filter.

Limiter

Leaving the subsonic filter the signal enters a VCA based around T9 & T10 which is controlled by the DC level at C20 which is controlled using rectified portions of the amplifier outputs via R22, 23 and 24.

Fig 3 : the Limiter resistors R22, 23 and 24. Adjust these in value to avoid your 2013 from processing clipped material. The limiter is configurable using a calculator, refer to the Design Wizards chapter for further information.

First High Pass

Leaving the VCA the signal enters a two way path, the first one - going left in the schematic – enters a second high pass LR filter based around T14, C45 and C48. The second one is through C55 to T18 where the signal is summed with the inverted version first path signal arriving via T16.
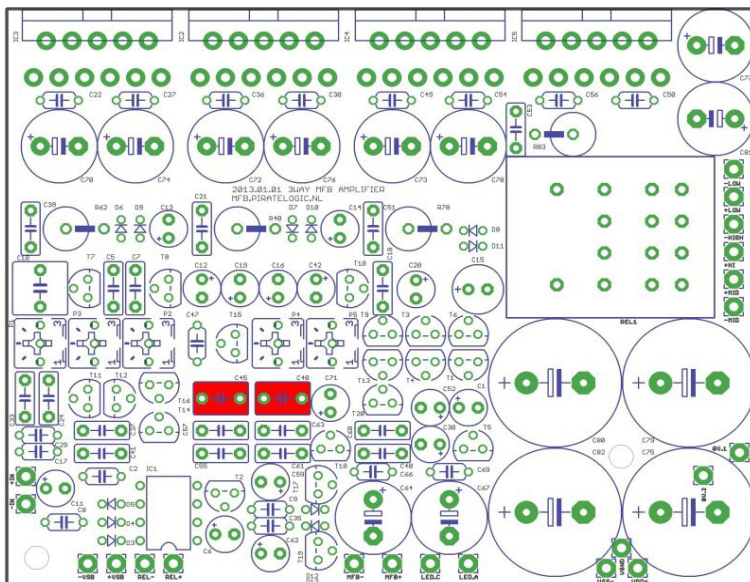
Fig 4 : the C45 and C48 capacitors that form the first Linkwits Riley high pass filter. This filter determines both the low cut off pole aswell as the midrange start pole. It does so by substraction.

The result at the base of T18 is a low pass version of the signal. Next the signal is summed with the MFB correction signal which enters the module at the base of T13. The RC combination R89 C61 in the nfb loop of T18 compensates for the 2nd order phase response allowing for a true 12dB/oct low pass slope to be used.
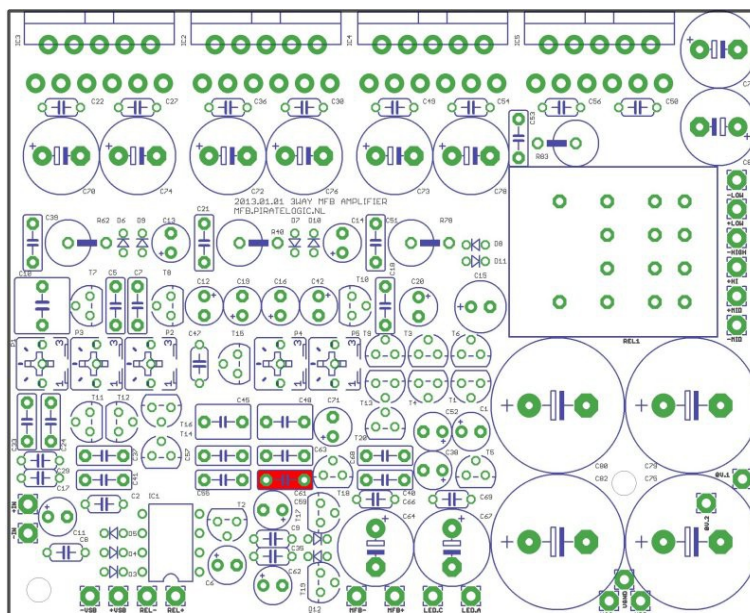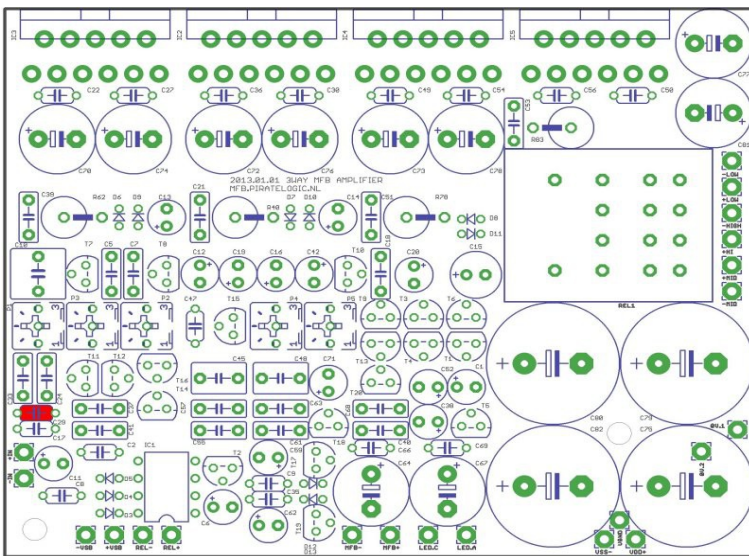

Fig 4 : C61 and R89 2nd order slope correction (R89 is not visible here as it is situated at the bottom). Using the stock xover frequencies these don't need to be finetuned. However in those rare cases where extreme xover frequencies are used please refer to the Design Wizard chapter for finetuning information.

Second High Pass

The signal leaving the first path then enters a second LR high pass filter based around T12, C37 and C41 which similar as the low section is split into a two way path. The first path is routed directly to the high note amplifier via C33. The second path is summed with a phase inverted output signal of the first LR high pass via R55 and R54 resulting in a bandpass -mid- signal at the base of T11.
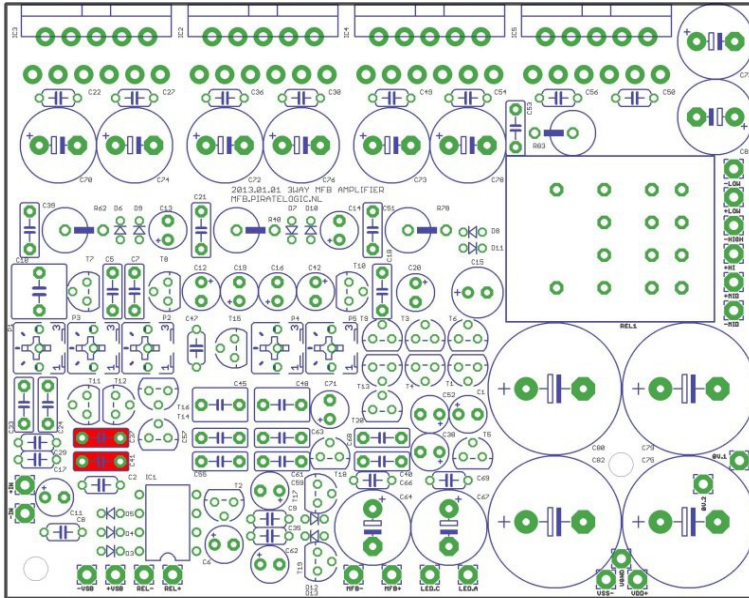
Fig 5 : C37 and C41 forming the second Linkwitz Riley high pass filter. This filter determines both the mid cut off pole aswell as the high start pole. And like with the first LR filter it does so by substraction.

Fig 5 : C29 and R52 2nd order slope correction - R52 is not visible here as it is situated at the bottom of the PCB. Using the stock xover frequencies these don't need to be finetuned. However in those rare cases where extreme xover frequencies are used please refer to the Design Wizard chapter for finetuning information.

The entire filter, limiter and correction logic receives power from a discrete build stabilizer providing stabilized +/- 20V rails by means of T17 and T19. The choice was made not to use integrated 3 pin regulators because of their disability to handle higher VDD and VSS rails.

Next to entering the filter itself the input signal is also routed to the input of IC1b where it is amplified, rectified and fed to the as a Schmidt trigger configured IC1a driving T2 which allows the main supply to be switched via a mains AC

power relay.

[todo additional APUS info]

The logic around T3,4 and 5 acts as a watchdog to keep the drivers from being fed with DC incase one of the 3886 amplifier chips malfunction. IC2 and 3 form the respectively mid and hi note amplifier, the low note amplifier IC4 can be optionally turned into a bridge amp using IC5 by populating the corresponding parts.

[todo 2013 filter calc]. [todo 2013 limiter calc].

Buffer Capacitors.

Depending on the type of powersupply used with the 2013 module you may decide to increase or decrease the size of the onboard buffer capacitors. Most switchmode powersupplies come with onboard low-esr buffers and don't need the extra buffers, in some cases you are even not allowed to use them because they cause the SMPS to trip while charging the 0.1 Ohm low esr elco's. If you decide to go conventional by using for instance a toroid you may increase these capacitors upto 6800 uF or even bigger if physical size allows.
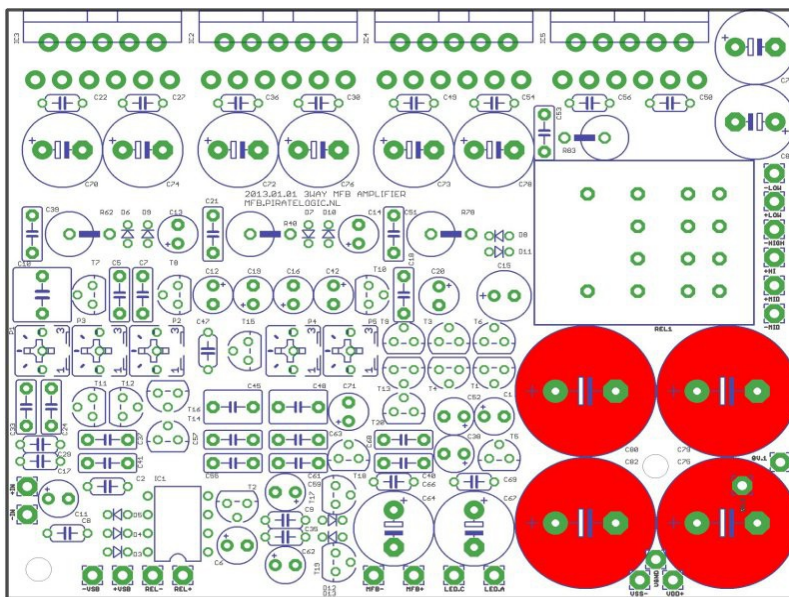

Fig 6: The onboard buffer capacitors , C76 & C79 for the positive VDD rail and C80 & C82 for the negative VSS rail. The maximum diameter is 18mm with a pin grid of 7.5 mm.

By default the 2013.01 kit is shipped with 4 pieces of 2700uF 35V Nippon Chemicon SXE low-esr capacitors

Low note Bridge / Single ended amplifier operation.

The 2013.01 has been designed for usage with 4 as well as 8 ohm woofers. The low note amplifier consists of a single LM3886 which is capable of delivering 68watts into a 4 ohm load. Especially for usage with 8ohm drivers the 2013.01 has been equipped with an optional LM3886 to allow the low note amplifier to be operated in bridge mode.
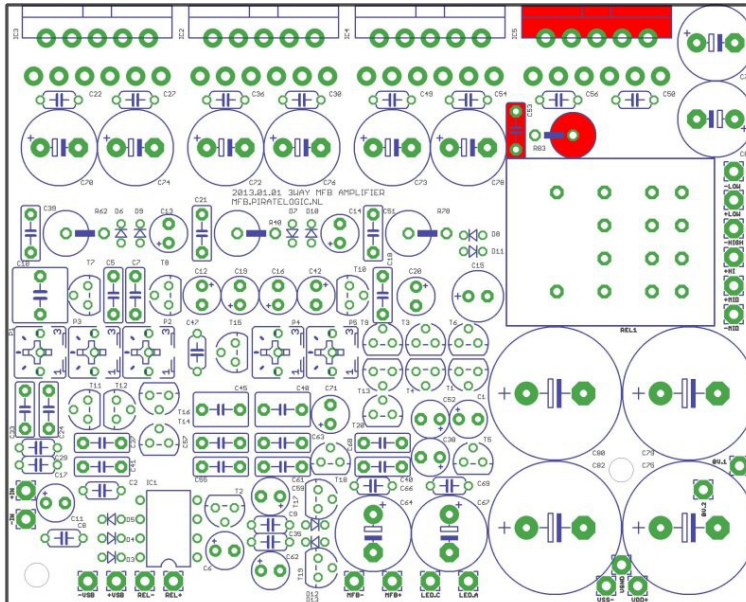
Incase the 2013.01 is used with a 8 ohm woofer the low note LM3886 amplifier can be set to bridged operation by adding an extra LM3886 at position IC5.
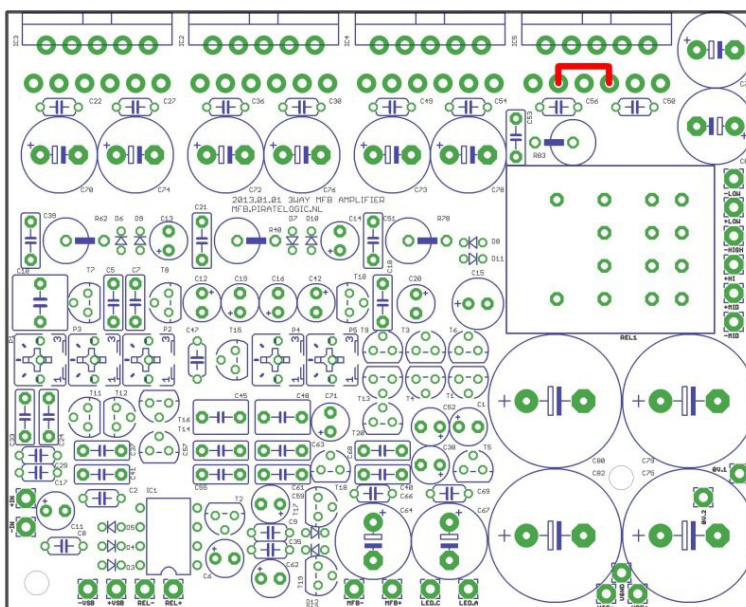
By default the 2013.01 board is set to single ended operation with position IC5 left unpopulated and pin 3 and 7 hardwired.

To modify the 2013.01 into bridged mode operation remove the wire between pin 3 and 7 and populate position IC5 with a LM3886.

Before changing from single ended to bridged mode please read *Power ratings* to ensure safe operation.

Power ratings

The 2013.01 is designed to drive impedances between 4 and 16 ohms and requires symmetrical rails between +/- 25V to 40V depending on the driver impedance. The ready build 2013.01 modules are equipped with 2700uF/35V capacitors and is designed to run with 4 ohm drivers on +/- 28V rails. To accommodate the usage of 8 Ohm bass drivers the low note amplifier may be switched to bridge mode.

[todo : elaborate on the different rail voltages]

Table 1. Maximum Power Supply Voltages

Woofer impedance	Maximum VDD/VSS rails voltage	Maximum Pout @ 0.1% thd
4 Ohm	+/- 28V	68 Watt
8 Ohm	+/- 35V	38 Watt
16 Ohm	+/- 40V	19 Watt
4 Ohm bridge	+/- 20V	100 Watt
8 Ohm bridge	+/- 28V	100 Watt
16 Ohm bridge	+/- 37V	100 Watt

Please consult the LM3886 data sheet http://www.ti.com/lit/ds/symlink/lm3886.pdf and the Application Report http://www.ti.com/lit/an/snaa021b/snaa021b.pdf for detailed information .
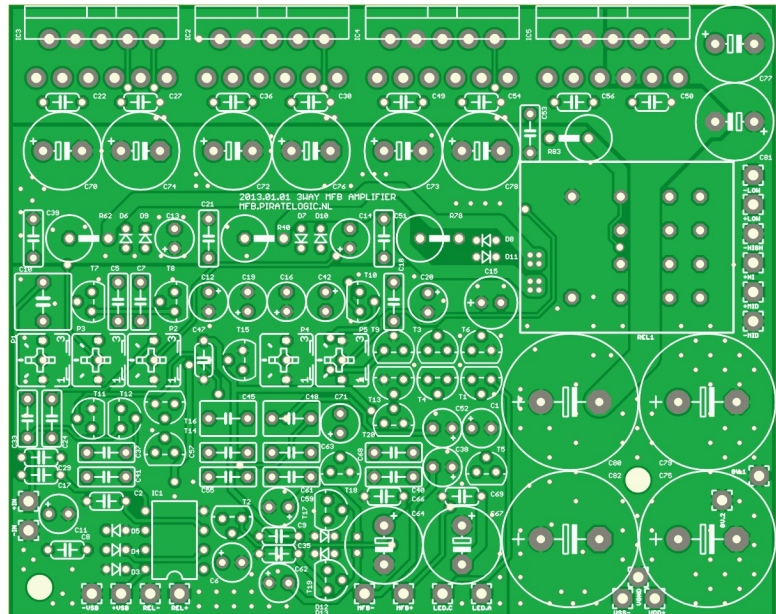
The printed circuit board.

For online -full screen- versions of these images please visit the following online locations :
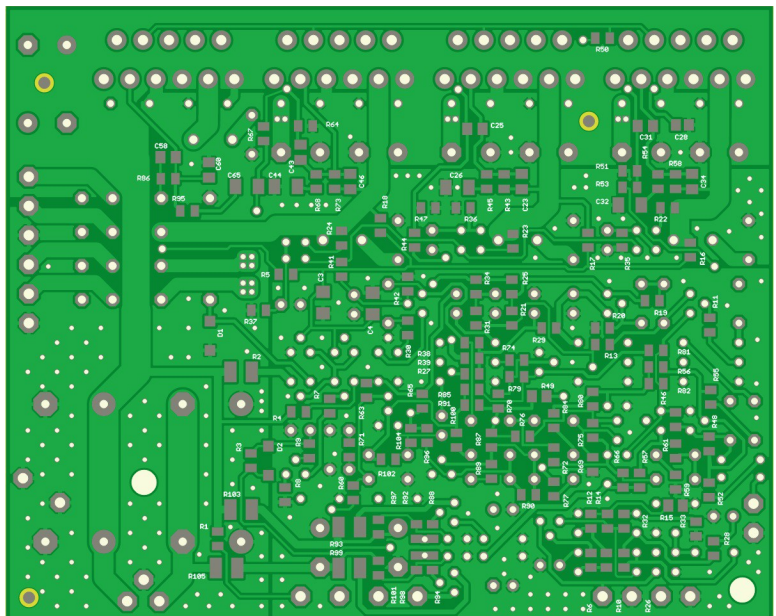
component side / top layer : http://mfb.piratelogic.nl/data/images/2013.01.01.pcbchecker.top.jpg

solder side / bottom layer : http://mfb.piratelogic.nl/data/images/2013.01.01.pcbchecker.bottom.jpg
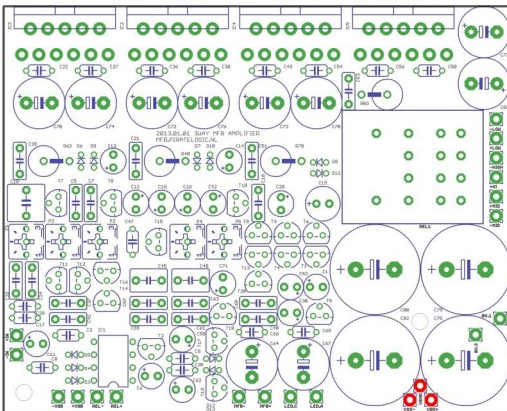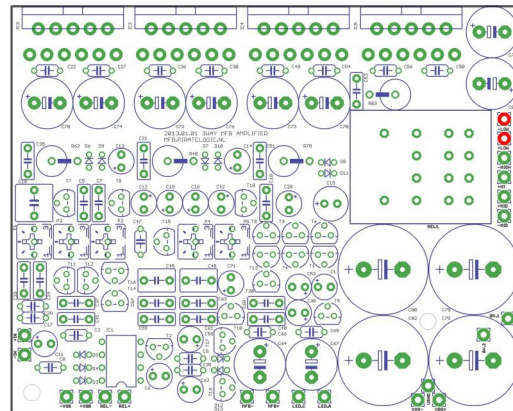
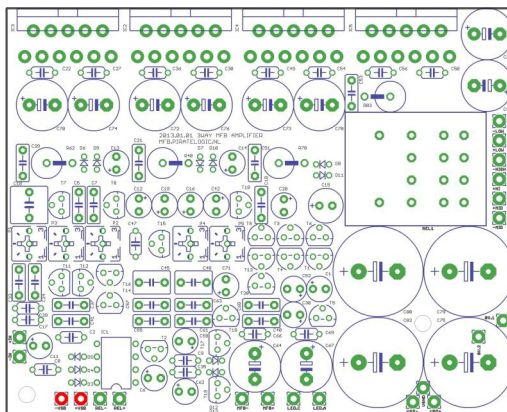*Fig 7 . 2013.01 component side*

Fig 8 . 2013.01 copper side
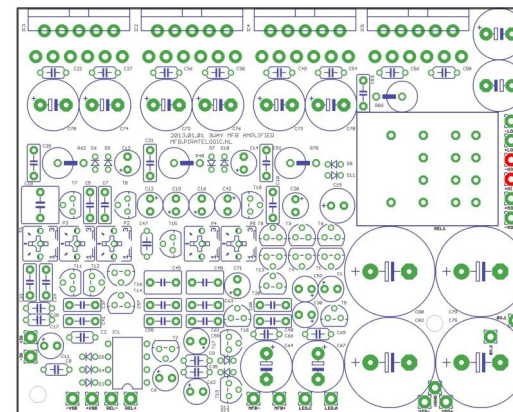
Off board connections
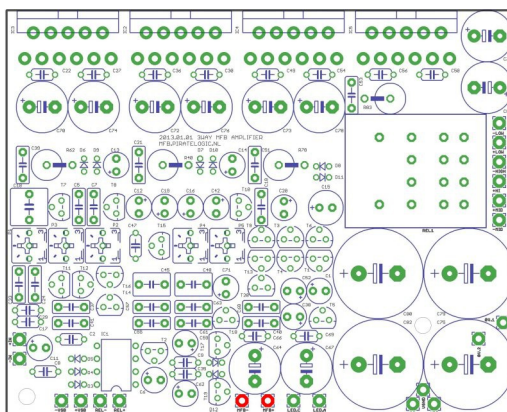

VSS (-) GND and VDD(+) connections
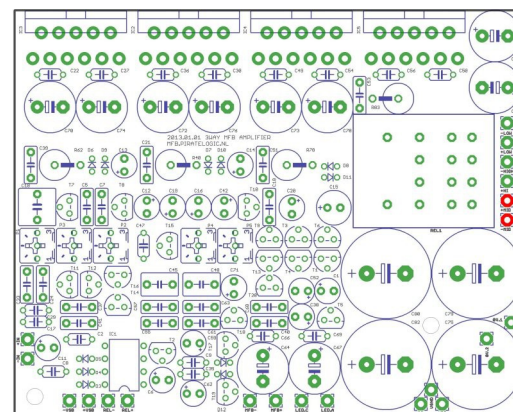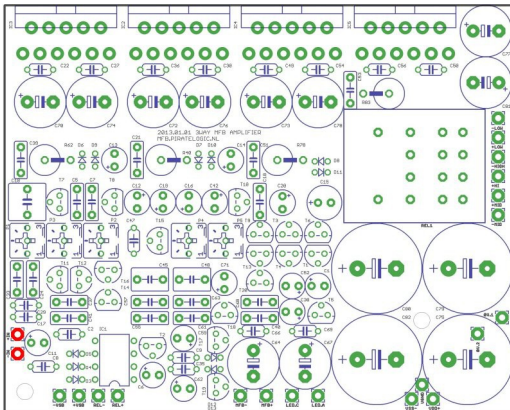

Woofer output
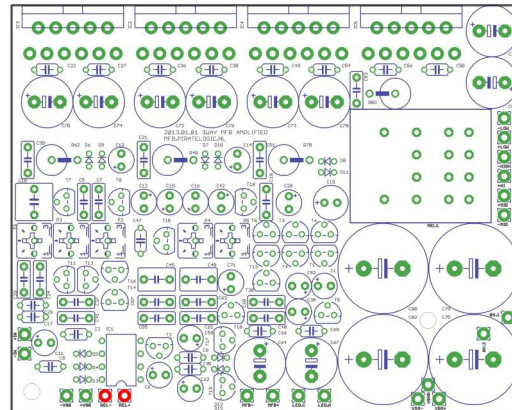

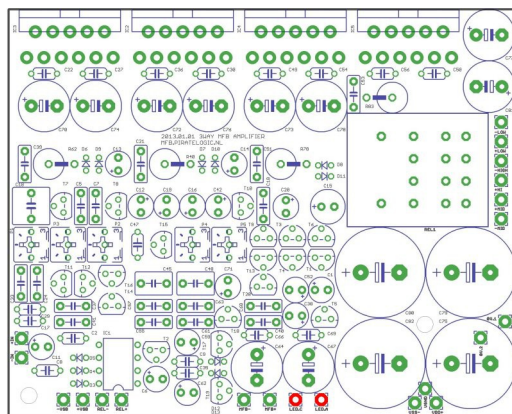5V Standby supply

Tweeter output

MFB input

Squaker output

Signal input

Mains relay

Control led connection

Fig 10. The 2013.01 connections..

As with all amplifiers make sure to use appropriate wiring to ensure safety and trouble free operation.

Please note the 2013.01 does not include onboard fuses, please make sure your powersupply has !

To avoid groundloops only connect the Supply rails GND with the common ground. Als on the need to allow adjustment s to happen from outside the enclosure one may choose to move the potentiometers from the components to the copper side of the board.

Design Wizards

The 2013.01 module is accompanied with an online assembly & calcuation wizard, to use this wizard you will need an internet connection. The wizard has been tested with Chrome, Safari and Firefox and may be found at the following adress: http://wizards.piratelogic.nl The wizard features 2 operation modes, assembly and calculation. On startup it defaults to assembly mode :

Assembly mode

By using your keyboard up & down arrow keys you may navigate through the bill of materials column on the right side of the screen.

Each step takes you thru a particular component whereby the wizard automatically switches to the corresponding layer showing you it's place on the pcb.

Because the BOM is maintained online it has been removed from this manual. The future version of the wizard will include a feature to download the BOM in CSV format. The main advantage of this online approach is that you are allways working with the latest & greatest most up to date version.
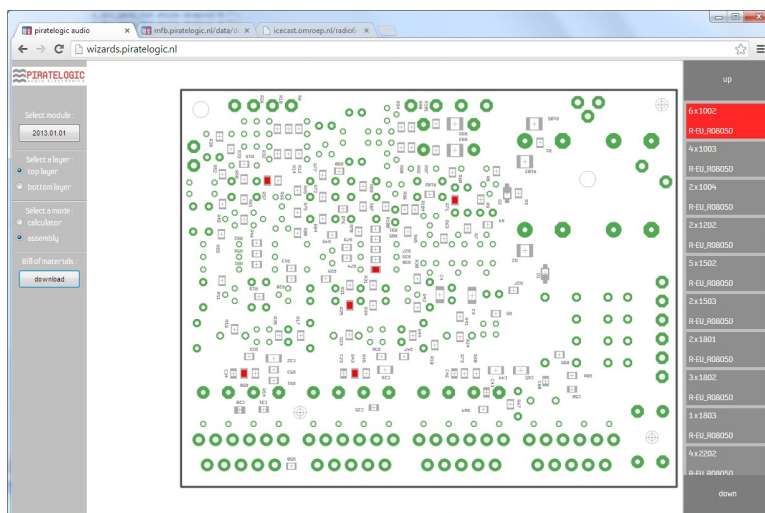

Calculation mode

The second operation mode offers a set of calculators to fine tune your 2013.01 module to specific driver specs by allowing you to choose custom values for
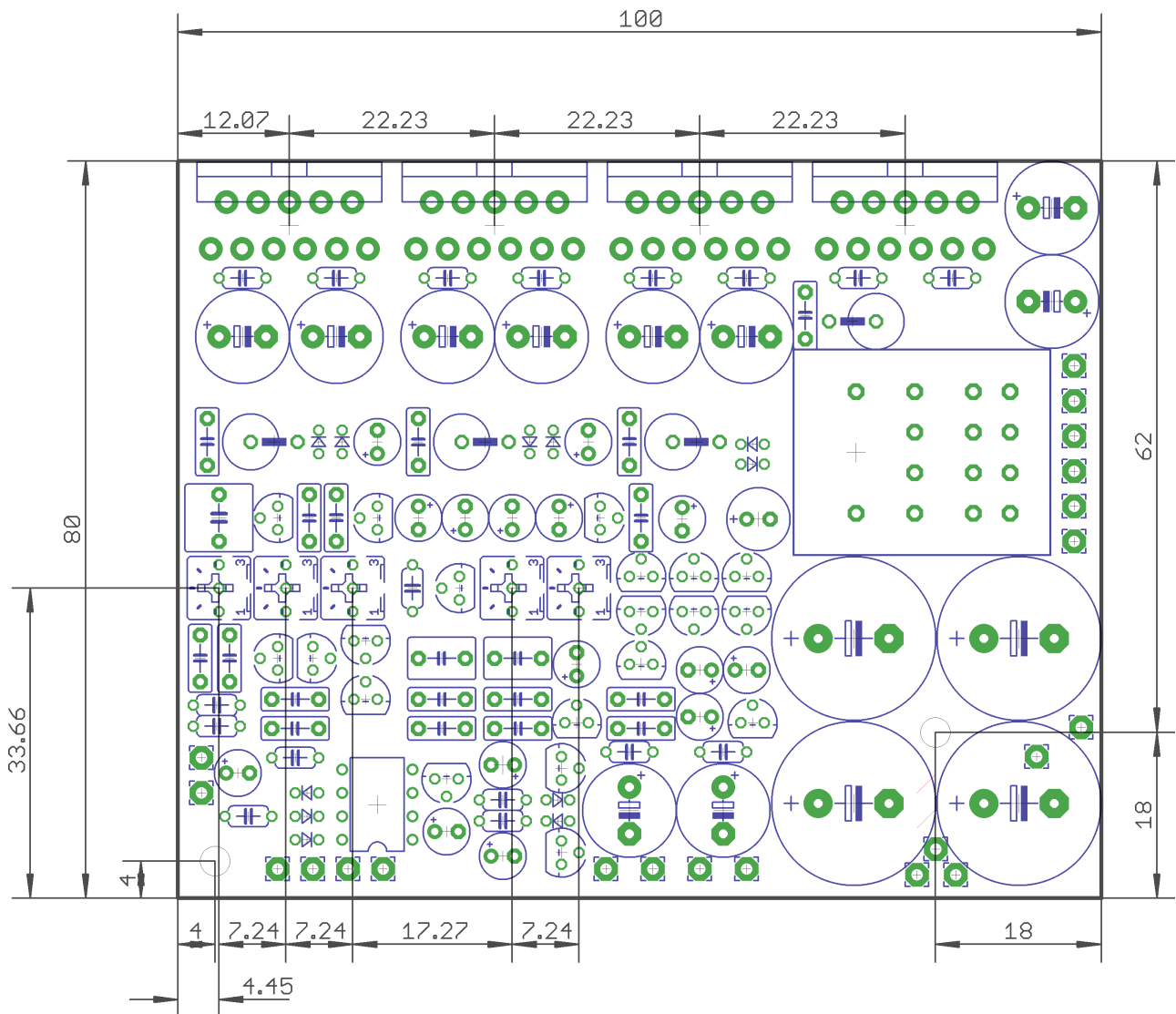
- low & high crossover frequencies
- limiter values
- amplifier gain settings.

During calculation the wizard automatically displays the corresponding filter components for easy location & modification.
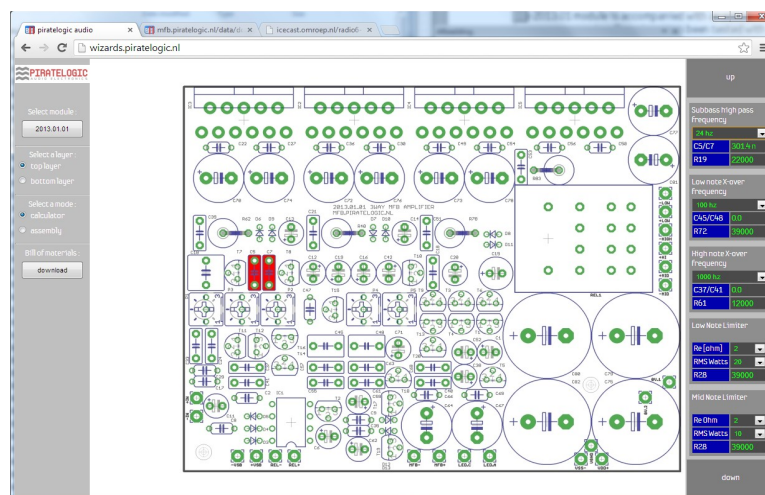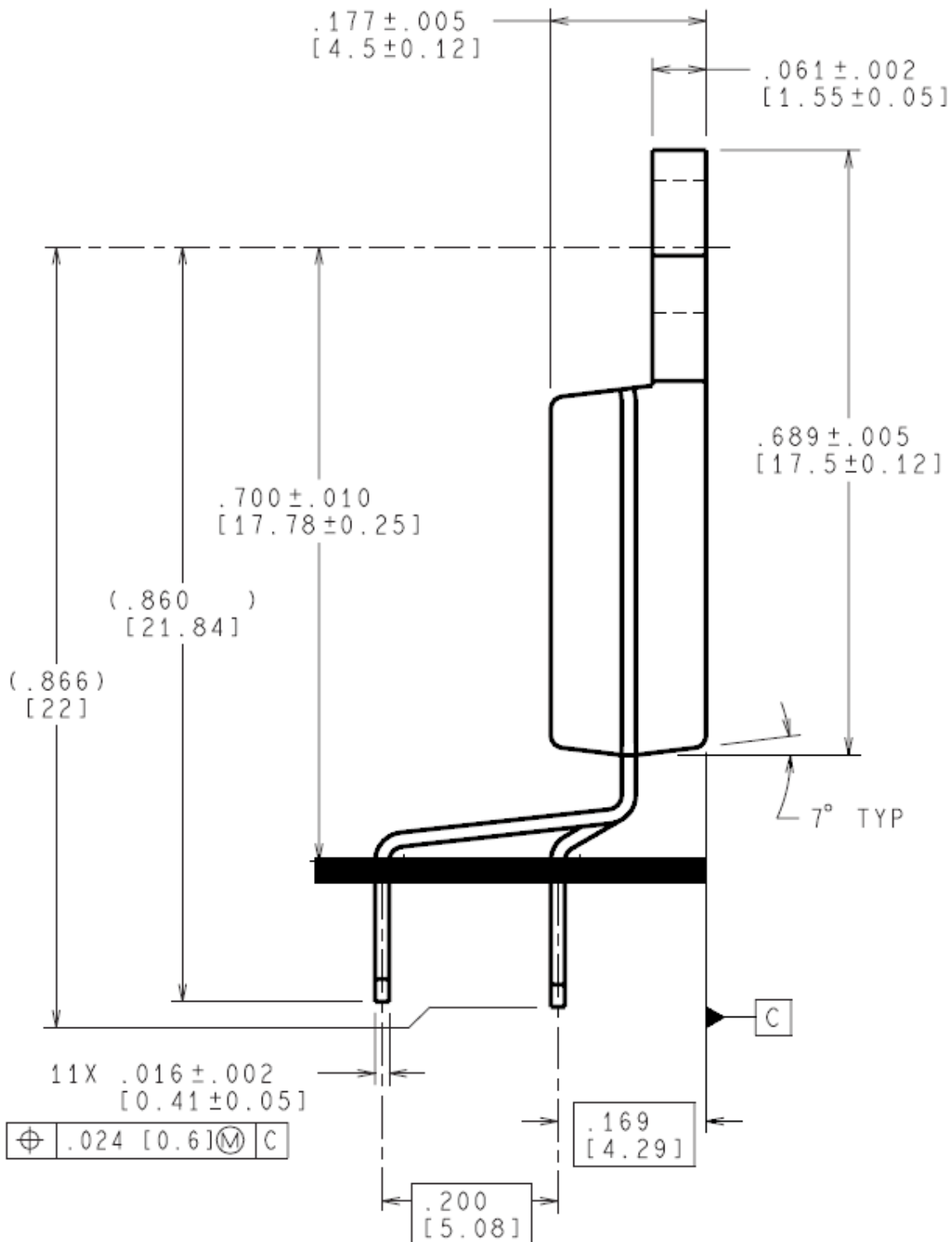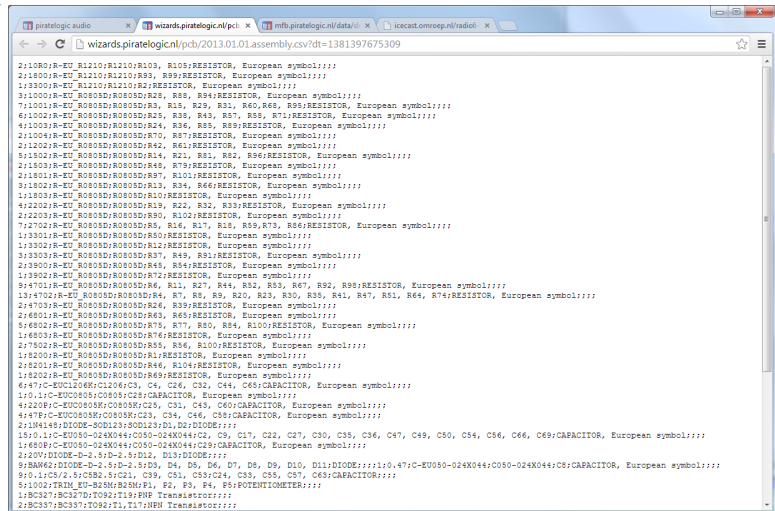
Board measurements

All measures in metric millimeters.

LM3886 measurements

Inches – [millimeters]

Bill of materials (bom)

Pressing the *download* button under the *bill of materials* section of the wizard will open a new browser tab containing the wizards database for the currently selected board.

The data displayed is an export from the eagle 6.5.0 bom.ulp user language program script, is semicolon delimited and uses the following field definitions:

2;10R0;R-EU_R1210;R1210;R103, R105;RESISTOR, European symbol;;;;							
count	value	family	package	part #	type	description	n.a.
2;	10R0	R-EU_R1210;	R1210;	R103, R105;	RESISTOR	European symbol;	;;;

Before you start...

Required skillset

The 2013.01 module like any mains connected apparatus will kill you if build / treated incorrectly, do **not** engage into using this kit (or any other DIY project for that matter) if you **a)** lack the necessary skill sets to safely build this thing **b)** see a, I'm not joking **c)** see b. Really.

Responsibility

We are not responsible for failures and or damages resulting from the use of this kit and will not replace any components once they have been used / soldered into the pcb.

Warranty

Although this kit has been developed with lots of love, tenderness and devotion we can only guarantee 100% operation for the ready & assembled versions. All kits are weighted & photographed before they leave our premises to make sure we don't forget anything. Might something be missing then contact us immediately within 1 week after receival.

The pre-assembled and tested kits come with a 1 year warranty, for INTL customers please note that this does not include transport costs.

Copyright

The schematics are a modern incarnation of the Philips 22AH587 motional feedback enclosure and as such a mixed property of Philips NV and Piratelogic. The PCB design and this manual are the property of Piratelogic. Please note that Philips NV is not in any way related to Piratelogic.

Support

For online support please visit our forum at forum.piratelogic.nl

Thanks

To Yvonne, my lovely lovely lovely wife, to the mfbfreaks community a whole, you rock ! And, off course, to the retired developers at Philips for giving us sooo much joy.

Chris Camphuisen

team lead

PIRATELOGIC
AUDIO ELECTRONICS