ZinAmp

Beautiful sound, for people who love music

Datasheet & Build Guide 3-Way Plate Amp

Application & Purpose:

Fully featured Plate amp for installation on the rear of a 3-way loudspeaker cabinet. All analogue crossover with Class A/B amplification

Bass, mid and treble drivers are powered by one of three power amp modules and controlled by a Linkwitz Reilly 4th Order Active Cross-over (48dB/Oct). The crossover has infinitely variable slope frequencies using trimmers, as well as phase-shift control for mid and treble drivers

Power Amps are Class A/B LateralFET amps based on a 'blameless' topology, using Exicon Lateral MosFETs. Power output is approximately 150W.

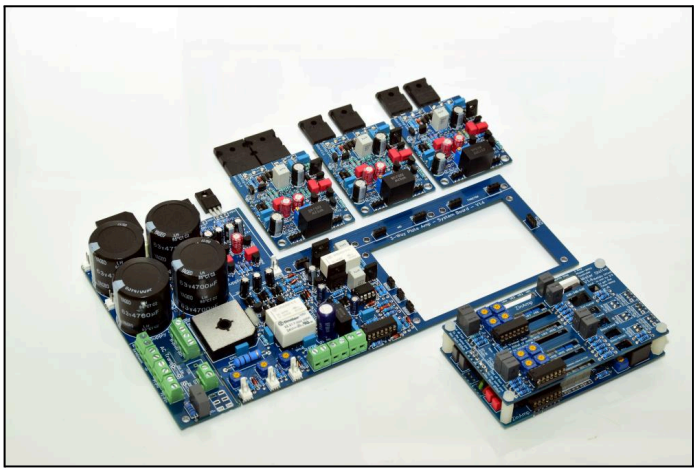
Other features include:

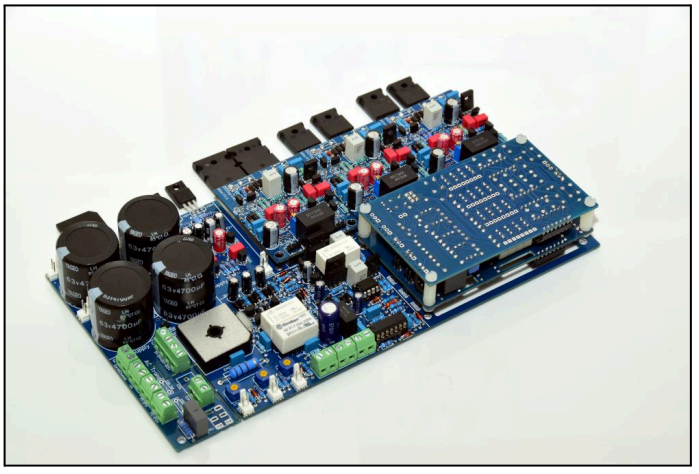
- Speaker Protection
- Auto Power-Off/On
- XLR and RCA inputs
- Support for 120 or 240v AC

Construction is modular, based around a system board. Power amps and Crossover can be swapped out in case of damage or module damage. Highly serviceable and maintainable.

Enclosure is anodised aluminium, laser-etched. The plate can be attached flush with the cabinet and the components housed in a 40mm-deep recess in the cab. Or, an optional back plate with screw lugs negates the need for a recess in the cabinet. Lugs are visible in the picture above-right.

Available ready-built or as a kit of parts, either with or without the plate-enclosure.





Specification:

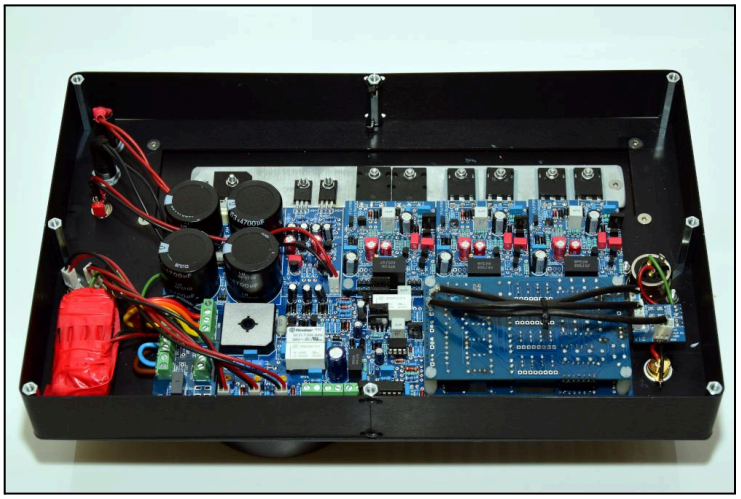
Enclosure Dimensions	348mm x 216mm x 45mm
Weight	4.5KGs
Channels	One (mono)
Power	150W (music power) - 100w RMS continuous
Transformer	Toroidal 2x40vAC 120VA min
Power Amps x 3	Class A/B Lateral Mosfet 'blameless' Exicon Lateral MosFETs. Double-die type on Bass-amp
Crossover	3 Way Linkwitz Reilly 4th Order with Phase shift & Bass-boost Slope positions are infinitely variable with trimmers Crossover can be preset and covered or exposed to the user
Damping Factor	≈ 100
Supply Voltage	240vAC or 120vAC Main board has provision for a selector switch if required
THD	0.009% (mostly lower 2nd order)
Earth Nets	Power and Audio
Speaker Protection	All three drivers. DC Relay controlled.
Soft Start	Optional, where using a larger toroidal i.e. > 250VA
Auto Power Off	After approx 15mins. Auto power-on with audio signal Overridable with switch to be always-on

A Fully Analogue alternative to DSP

Typically, a Digital Signal Processor (DSP) is used to control the EQ and crossover points of the drivers in a 3-way loudspeaker. These tend to be coupled with class D amplifiers.

The sound of Class D amplification is not to everyone's taste; especially with analogue sources like vinyl records which require analogue-to-digital conversion for the DSP, then back to analogue for amplification. To address this, we have created a fully-featured analogue plate amplifier with class A/B power amplification, making true analogue sound-shaping a practical proposition.

Phase-delay, bass-boost, baffle-step and infinitely variable crossover slopes are all featured here. I.e. true analogue sound-shaping and flexible enough for a wide variety of speaker driver combinations



Lid Off

Contents

Build and Construction

Kit options include ready-made boards, or blank PCBs. If you are purchasing ready-made boards, you can skip the steps for constructors of blank PCBs.

Please locate and read the following datasheets for the class A/B power amp and the 3 way crossover. You will need these modules complete and ready for building the plate amp.

Class A/B LateralFET Power Amp:
https://zinamp.co.uk/projects/PlateAmps.html#ClassABPowerAmpSmall

Crossover:
http://www.zinamp.co.uk/modules/crossovers.html

Assembly Stages - Overview

Stage 1 - System board. Solder-in components for the power supplies and AC transformer connections. Test for correct voltages and discharge safely

Stage 2 - Auto Power-Off/On. Solder-in components for Auto Power-Off/On system, rail fuses, test for correct voltages and and discharge safely

Stage 3 - Speaker Protection. Solder-in components for Speaker Protection, test that relays are closing on start-up and and discharge safely

Stage 4 - Crossover Connection. Perform a power-test on the crossover, install and test the crossover for DC offset at its input and outputs.

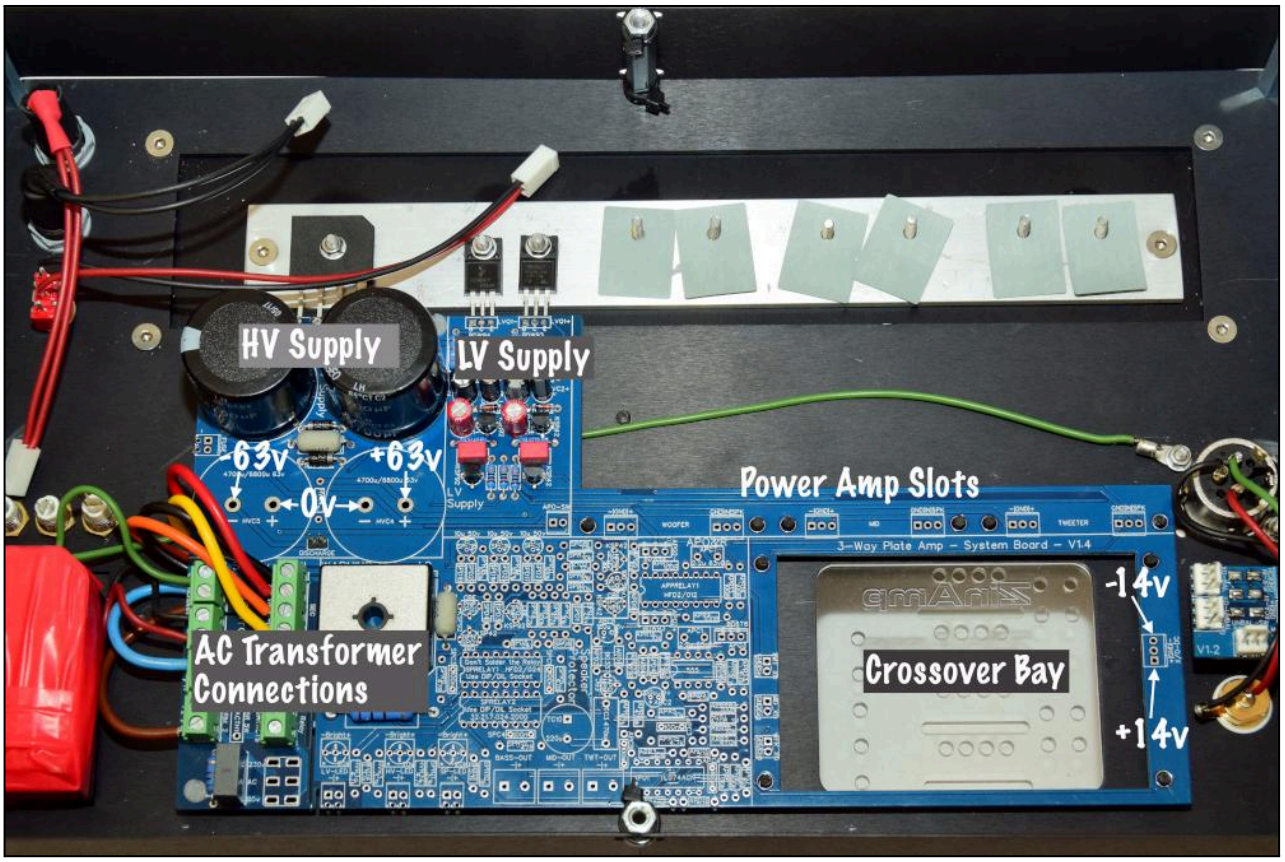
Stage 5 - Power Amp Installation. Test each Power Amp Module and set the DC offset to each speaker to zero.

Stage 6 - Sound Test. Test that each power amp is conveying the correct frequency range, as set on the crossover

Stage 7 - Driver Connection. Connect the Bass, Mid and Treble drivers and close the lid!

Stage 1 - System board

The system board hosts the power supplies, auto-off/on and speaker protection modules. It also provides connections for the AC transformer. Slots are provided for power amps and crossover, minimising the wiring required to complete the construction. The picture below shows where each of these sections are located on the system board:



To complete the first stage, install components for the AC Transformer connections, HV Supply and LV Supply. HV supplies the power amps -/+60v and LV supplies the crossover and Auto Off/On module within -/+14v

The picture above shows a ZinAmp enclosure with the following fittings:

- Top Left - DC Rail fuses (+ve and -ve)
- Centre Left - system LEDs
- Bottom Left - Fused AC Isolation Switch
- Bottom Right - RCA connector
- Centre Right - RCA / XLR selector switch
- Top Right - XLR connector

Safety Note: Mains AC and HV DC wiring can be hazardous during construction. The AC switch and DC Rail fuses should be covered with insulation material to make them safe, as shown above.

AC Connections:

These are clearly marked in the left-edge of the PCB and must be connected as follows

- AC -ve and +ve. I.e. neutral and live from the Mains AC Switch
- Earth. From the AC Mains Switch.
- Chassis. To the metal plate (note green wire in the centre of the picture above)
- Transformer Primaries. For a 240vAC installation, use terminals P1- and P2+ as shown above. If your transformer has dual primaries, solder the two 0v taps together and insulate. For a 120vAC installation, connect both primaries in parallel in terminals P1- and P2+. Only use terminals P2+ and P2- if you have a multi-voltage selector switch.
- Transformer Secondaries. Note the colour order above which is fairly typical of toroidal secondaries i.e. Black, Red, Orange, Yellow. Check your make and model of transformer to be certain, as some manufacturers' schemes vary.

Applying Power for the First Time:

This is best done with a Variac. If you don't have a variac (and if you do), ensure the following checks are made and accept that there may be smoke or damage if any components have been incorrectly installed.

Check that:

- your AC isolation switch has a 3A slow blow fuse.
- the components are soldered in as shown in the picture and described above
- the two darlington transistors for the LV supply are on the heatsink
- your multimeter is set to DC voltage, ready to test the voltages on the board

Measuring DC Voltages:

The picture on the previous page indicates the DC voltages you should see at each point. Place your black meter terminal on the pad marked 0v. Take a reading with the red terminal at the points marked +63v, -63v, +14v and -14v. These voltages should be within 10% of the values stated.

Note: you are testing the transformer in an unloaded state. You can expect the DC voltage to be between 58 and 65v for a 40-0-40v AC transformer; this is due to the transformers regulation allowance. With crossover and power amps installed, this voltage may well drop to around 55-57vDC. If the HV voltage is lower than 55v on a 40v transformer, you may have a fault somewhere.

Discharge Safely

With this first test complete, switch off the AC power, remove the IEC plug from the AC isolation switch and place a metal screwdriver across the two discharge terminals in the HT power supply - for about 10 seconds. Check the HT voltages are now less than 5v - in which case they should be safe to handle.

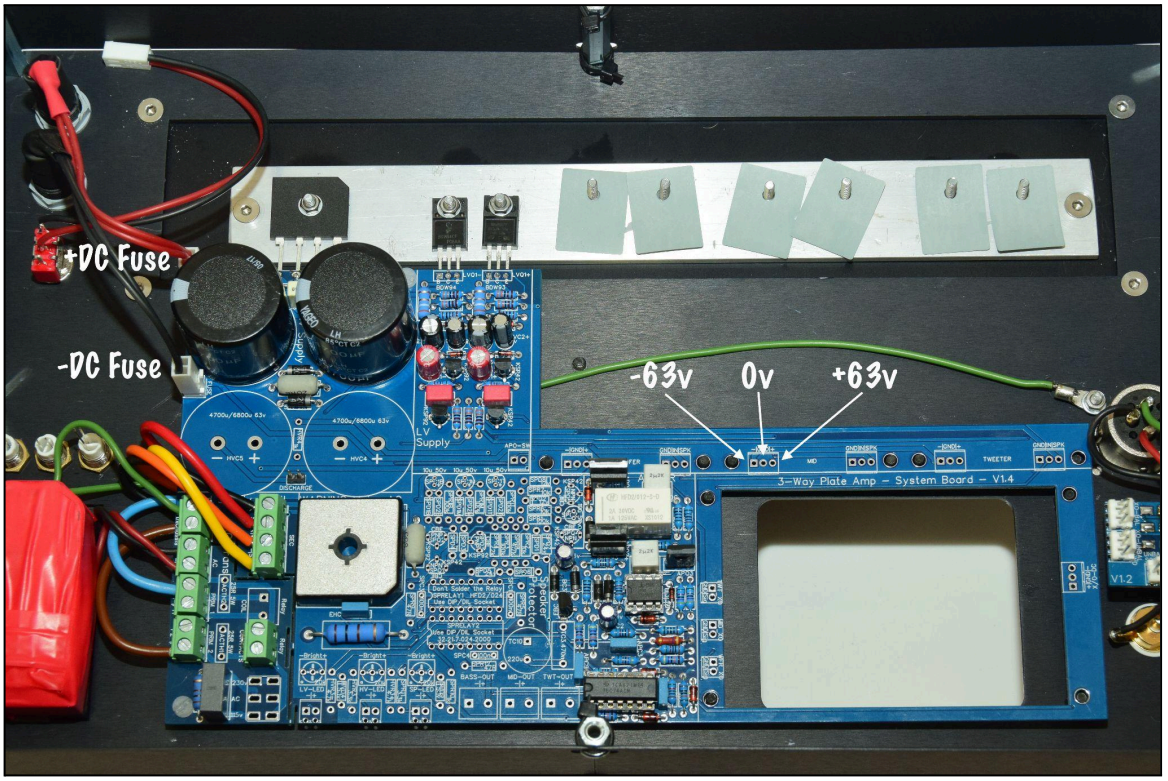
Never bridge the discharge terminals with the power on!

Stage 2 - Auto Power Off/On

Install the components marked with the prefix of ‘APO’ on the board, as shown below. Testing this module is done in two stages. First, with the DC fuses disconnected and second, with the DC fuses connected. The APO system features two darlington transistors used to switch on/off the HV DC supply to the power amps. Supply is switched on and off by a relay. The relay is connected to the bases of the darlingtons, which minimises the switching current and maximises the life of the relay.

An opamp listens for an input signal and charges a capacitor. When the capacitor discharges, it triggers a 555 timer and opens the relay, switching off the power amps.

We recommend you use an 8-pin DIP/DIL socket for the relay, a 7-pin socket for the opamp and an 8-pin socket for the time. Soldering relays or other legged components into PCBs is asking for problems. These do fail and very occasionally arrive faulty and are notoriously difficult to unsolder. You will want to be able to swap these components out quickly and easily. A DIP/DIL socket is always indicated.



Applying Power

Again, use a variac if you have one. At this stage, the LV supply is under a small load from the APO module. However, any incorrectly installed components may result in a very large load placed on the LV supply. The supply has current limiting to about 150mA, at which point the voltage will begin to drop.

Test 1 - DC Fuses disconnected: with the DC fuses disconnected, switch on. You should hear the relay click. Check the DC terminals on the right of the crossover bay. These should be at -/+14v. If these have dropped below 12v, it indicates that the LV supply is being overloaded and the overload protection is activating.

The power amp supply terminals above are marked at -/+63v. With the fuses disconnected, these should be at 0v.

Switch off for about 10 secs and listen to the APO relay click open. If you don't hear this, the relay may not have closed after power-on. Switch on and off again to recheck this. If there is no relay sound, there is likely to be a problem somewhere in the APO module.

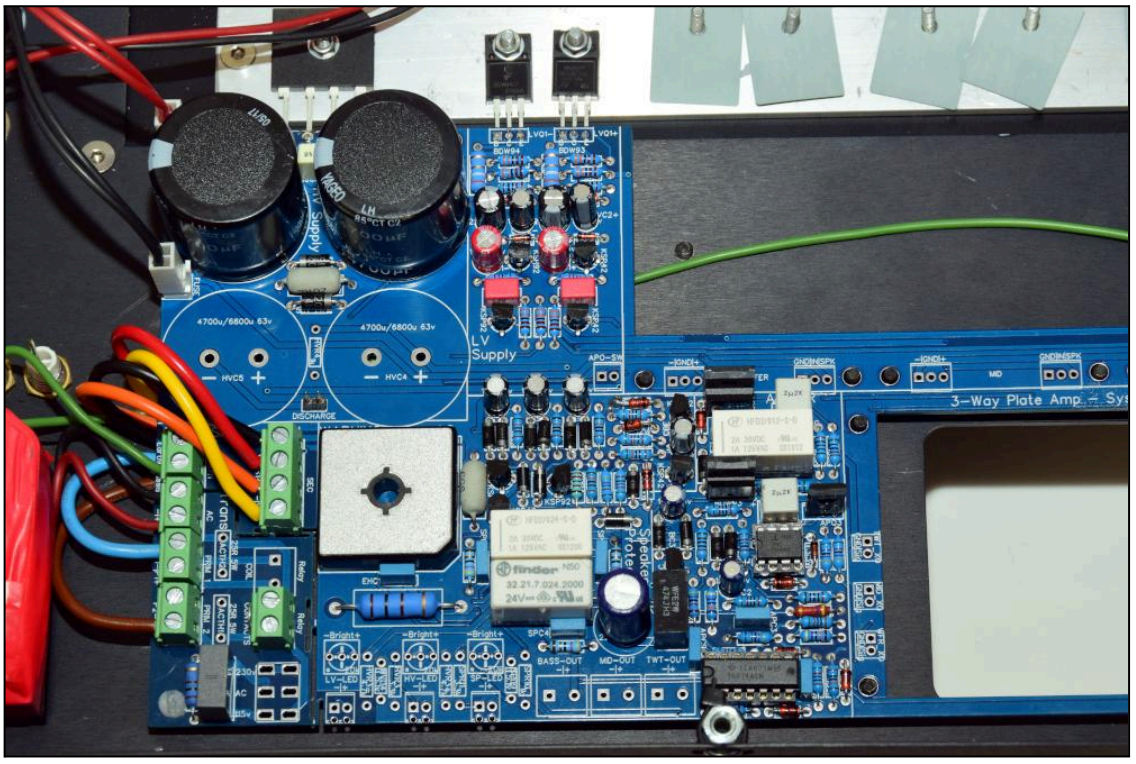
Test 2 - DC Fuses connected: with the DC fuses connected, switch on. You should hear the relay click. Check the DC terminals on the right of the crossover bay. These should still be at -/+14v.

The power amp supply terminals above are marked at -/+63v. With the fuses connected, these should be at -/+63v.

Switch off for about 10 secs and check for the APO relay clicking open.

Stage 3 - Speaker Protection

Install the components marked with the prefix of 'SP' on the board. The speaker protection module has two relays for cutting each speaker from its power amp. These relays are different. The lower relay is single-pole and rated at a higher current. It's used for the bass amp. The other relay is double-pole and carries the signal for the mid and treble amps.



There is a 2 second delay at startup before the relays are closed. This prevents any start-up thump or snap entering the speakers and protects them from unnecessary cone excursion.

Power On

Using a Variac for this test will delay the closing of the relays, but is still advisable.

Expect a 2 second delay under normal operation. Switching off, the relays will close after 3-4 seconds. When you install the power amps i.e. load up the power supply, this interval will be about 0.5 seconds

Repeat this test 3 or 4 times and ensure you can hear the speaker protection relays closing after power-on and opening again after power-off.

Stage 4 - Crossover Connection

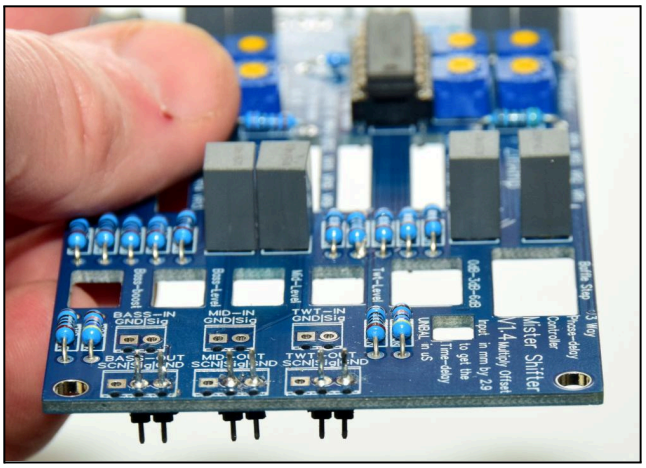
You will need a ready assembled and tested crossover and phase-shifter. Refer to the datasheet for the crossover module if you are building these yourself from a blank board. It is also a good idea to set the crossover points you require at this point. The datasheet contains a full explanation of how to do this:

http://www.zinamp.co.uk/modules/crossovers.html

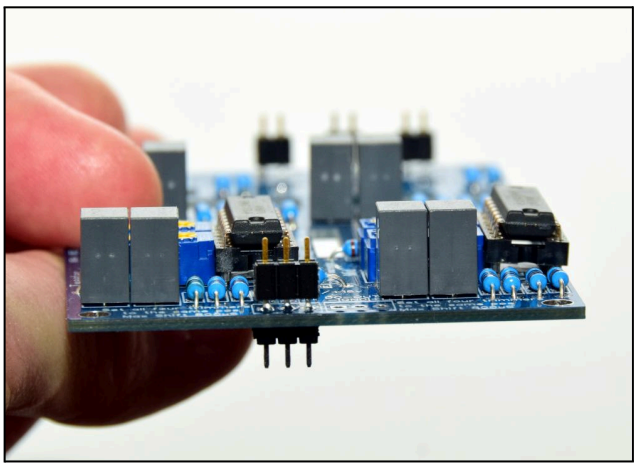
The phase shift and crossover modules need connecting and testing for any errant shorts before installing. This test can be performed with a 9v battery and is described further on.

Solder In the Shifter Audio Connector Pins

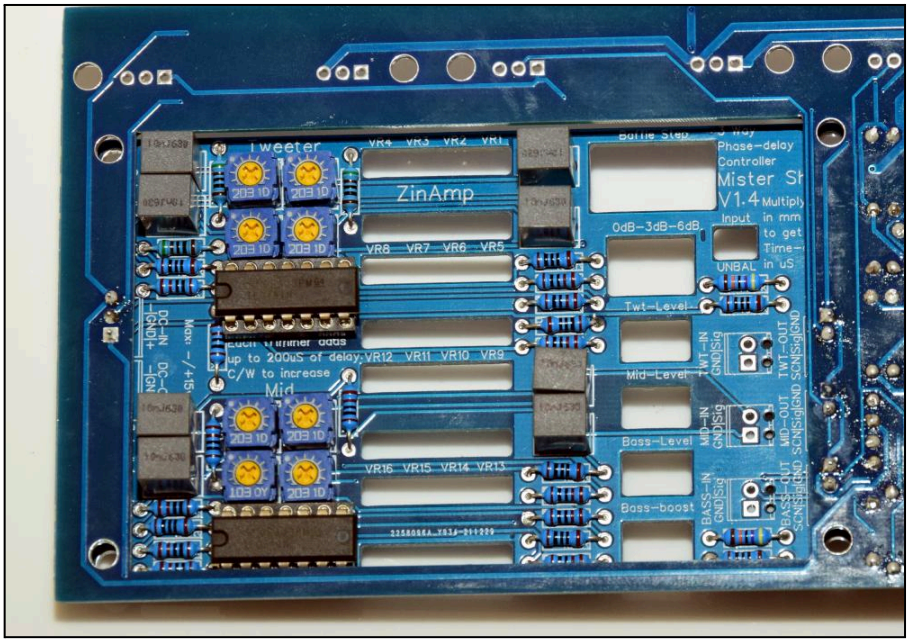
The picture below shows the 2-pin audio connectors for the shifter module. These must be soldered as shown. There is also a three pin power connector on the opposite end of the shifter board. Solder a 3-pin connector into this in the same orientation.



Audio Pins


Power Pins

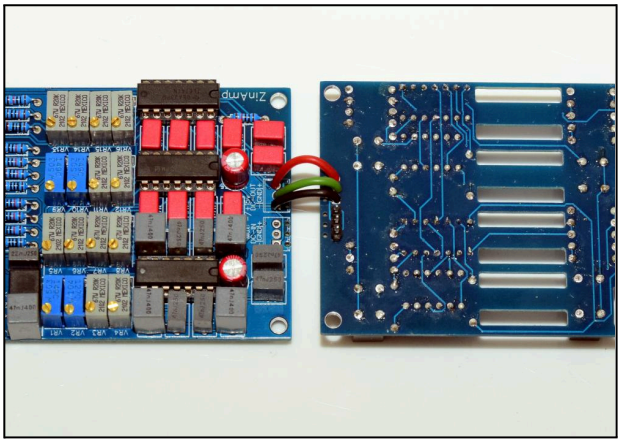
The picture on the right shows the sockets placed over the pins. These solder into the main board of the plate amp. Line these up with the holes in the main board and solder as shown in the next picture. This ensures the pins and sockets are perfectly aligned.



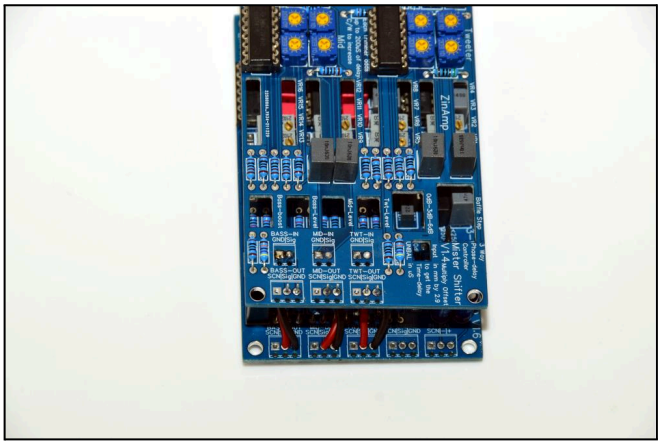
Remove the shifter module from the main board, leaving the sockets behind in the main board.

Connect the shifter to the main crossover board

This is done in two steps - power and audio - as shown below. Wire lengths should be approx 20-25mm



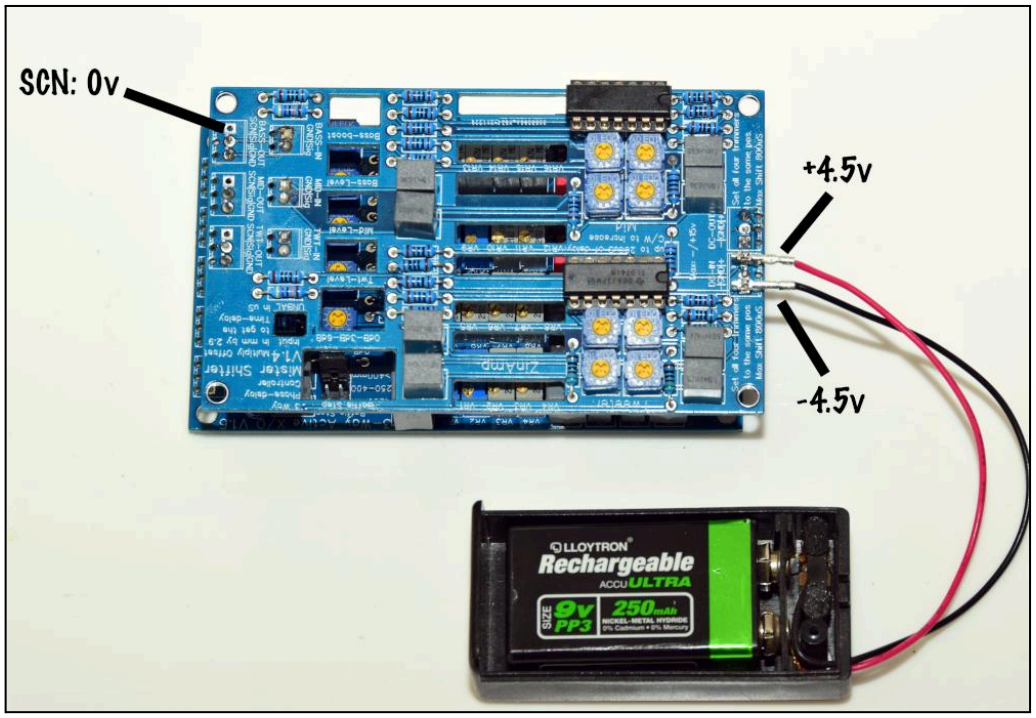
Power Connections



Audio Connections

Test for Short Circuits

A simple power test is required to ensure there are no shorts in the crossover module. A short at this stage may easily damage the LV supply on the main board - in spite of it having overload protection. It is not worth the risk at this stage and a test with a 9v battery is simple to do. See picture below.



Check for the voltages shown above. The SCN pin top-left is connected to the power ground and should float at 0v in relation to the +ve and -ve battery terminals. Note, the battery is connected to the shifter module and has been rotated 180 degrees in the picture.

Assuming this test passes as shown above, the crossover can be installed into the main board and the power applied

Installing and testing the crossover

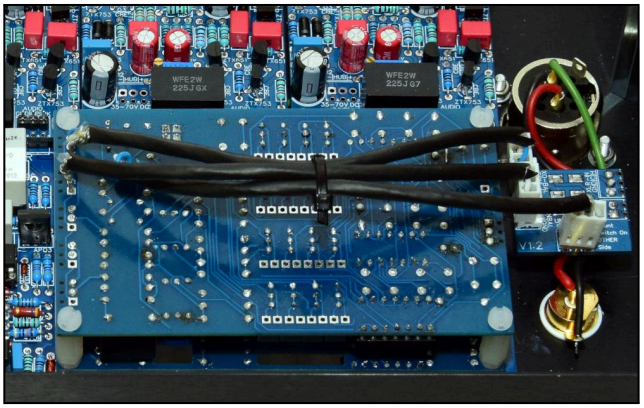
Locate the power and audio pins with their corresponding sockets on the main board. Press gently until home. This action should be smooth. Any asymmetric resistance to pushing home should be investigated; do not “force”!

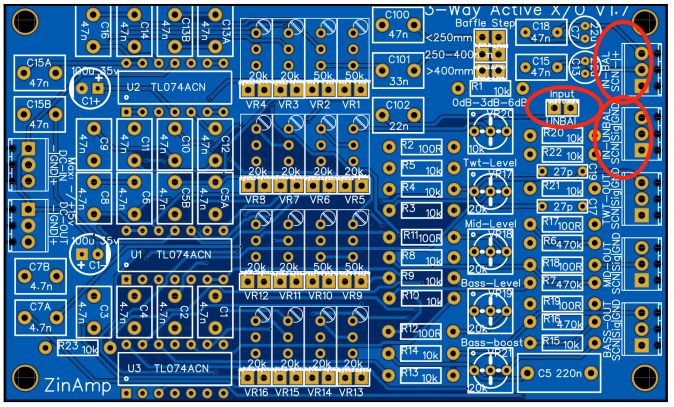
Power On

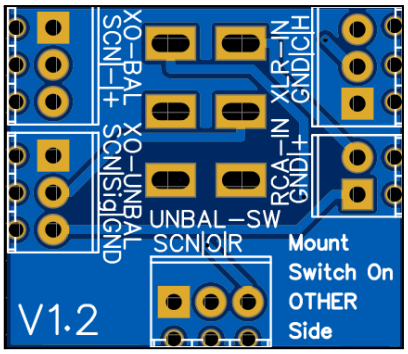
Again, use a Variac if you have one. With power up, the voltages at the power terminals of the crossover should read -/+14v. Check these. Any significant voltage drop suggests the LV power supply overload protection is being activated - suggesting an incorrectly installed component in the crossover or shifter.

Selector Switch Wiring

The picture below shows the wiring from the crossover to the selector switch and the input sockets to the selector switch. The input source can be switched between XLR balanced and RCA; either, but not both.







The three cables shown are:

- Top - Balanced In
- Middle - Unbalancing Switch - closed when RCA is selected, open for XLR
- Bottom - Unbalanced In

Note the pin-outs on the pcb shown above-right. These correspond with identical pinouts on the sector switch (bottom). SCN means cable screen. Use 2 core screened cable.

Note: for the Unbalancing switch (UNBAL-SW) the screen is only connected at the selector switch end.

Crossover Final Fitting

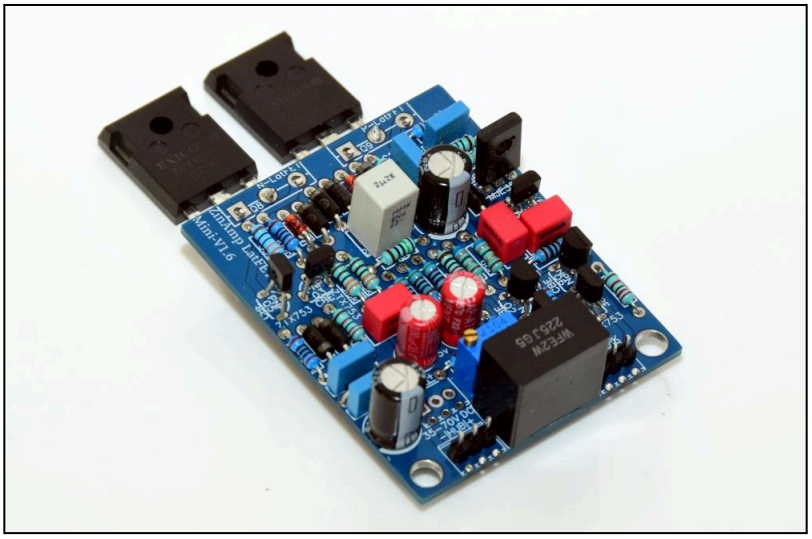
The image above-left shows 18mm nylon standoffs between the crossover and shifter module. We recommend non-metallic standoffs and screws for this purpose. Metal will almost certainly cause a short and must not be used.

After final fitting, perform another power-on test, listening for the APO and speaker protection relays. Check the voltages to the crossover are still -/+14v

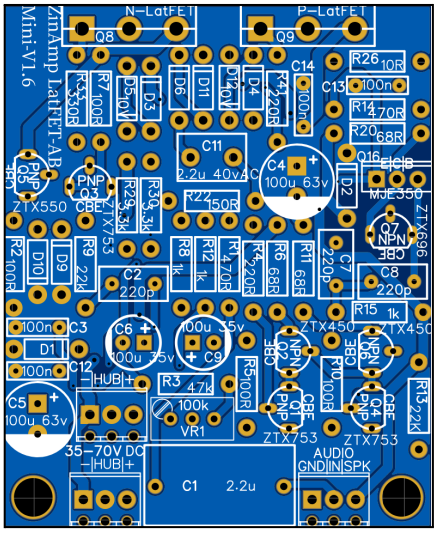
Stage 5 - Power Amp Installation

You will need three ready-assembled power amp modules. Refer to the datasheet for the power amp module if you are building these yourself from a blank board. You will need to test them in two stages; once with the main output drivers uninstalled and again with the main drivers soldered in

http://www.zinamp.co.uk/modules/index.html#LateralFETClassABPowerAmplifier



LatFET - mini Power Amp



PCB

The ZinAmp LatFET mini Power Amp is a fully featured class A/B power amp, based on a proven stable ‘blameless’ topology. THD is low at around 0.009% and gain is approx x22 with a damping factor of around 100. In spite of its small size, there is no compromise!

The same pin and socket arrangement used for the crossover is used to retain the power amps on the main board. Refer to the previous stage in this guide where you will see how these pins and sockets are used to retain and seat the crossover. Follow the same steps to fit the power amp pins & sockets

These modules will need installing and testing individually in their respective slots. Mark them as left, middle and right (or bass, mid, treble) as their pins & sockets may be in slightly different positions after fitting; this will avoid pin or socket damage during testing.

Test 1 - main devices not installed

The first test is to ensure that each module has been built correctly. The test is a simple DC offset test at the speaker output. Turning the trimer pot, it should be possible to centre or zero the speaker terminal to -/+ 25mV. A large DC offset at the speaker output i.e. more than 2V, suggests a problem with the amplifier module.

Seat the module aligning its pins with the sockets on the main board. Switch on and check the voltage at the SPK pin relative to GND. Adjust the trimmer on the board to ‘zero’ the voltage at the SPK pin.

Test 2 - main devices installed

A word of warning - make sure you install the devices the right way around. I.e. the N-FET device on the left and the P-FET device on the right in the PCB. Your DC fuses will blow if you get these the wrong way around. You may also do other damage!

The bass module requires double-die Laterl FETs. The mid and treble modules require single-die Lateral FETs. Do not use HexFETs (IRFP types). These will not work and will cause damage. Only use Lateral FETs. We only recommend Exicon LateralFETs from Profusion as these are the only source of new stock in the world and are guaranteed as authentic.

The power-on test must be done with the devices attached to the heatsink. At idle, they will warm quite quickly and if not bolted onto the heatsink, may overheat within 2 or 3 mins.

Check the DC voltage at the SPK pin is still close to zero. It may have moved slightly now that the devices are installed.

Finally check the DC voltage across R22 (see above right). This is the DC bias voltage of the output devices and should be close to 1vDC (-/+ 5%). If this is more than 1.5v, switch off immediately as your output devices are over-biased and will soon overheat!

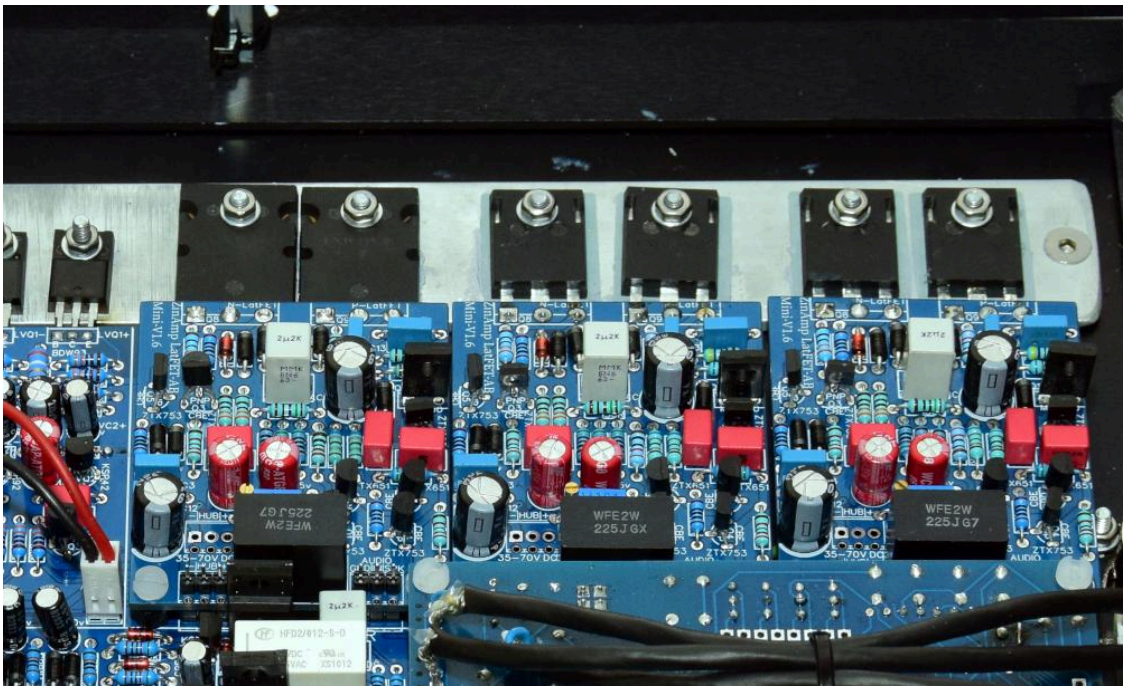
Repeat for each individual Amplifier Module

Repeat tests 1 and 2 for each individual module in its respective slot - before installing them all. Do not install them one, then both, then all three. Any problem with one module, may cause damage to others.

Only install all three modules, when you know each one has passed tests 1 and 2 alone in its individual slot.

Final Fitting

Use nylon screws and non-metallic standoffs to retain the power amps against the main board. The power amp will sit 5-6mm above the main board on their pins and sockets



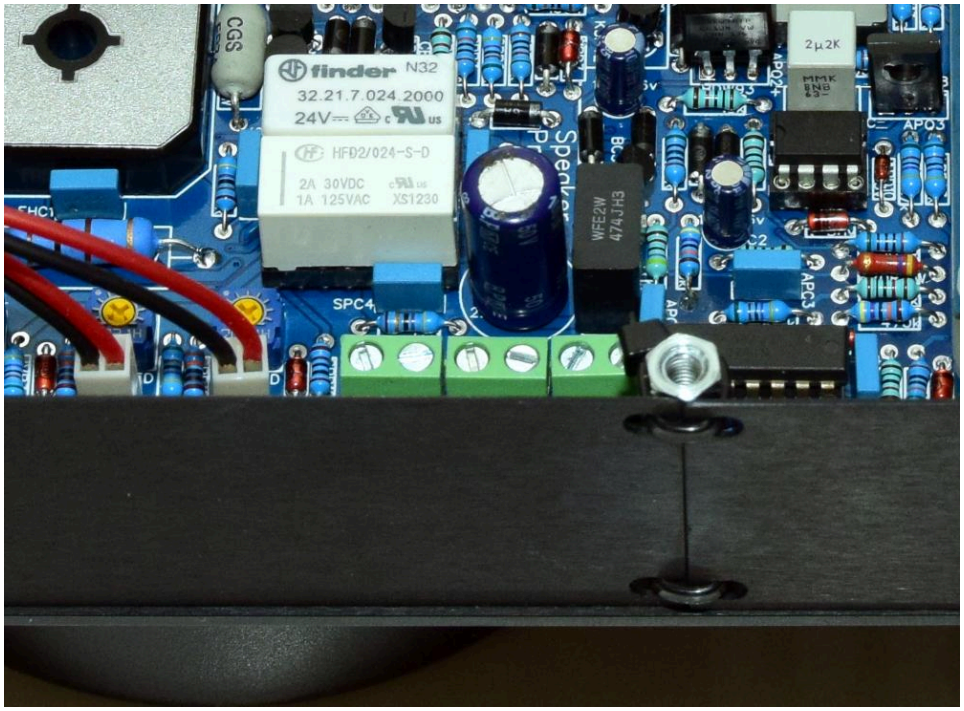
Stage 6 - Sound Test

If you have already set the crossover points on the crossover module, this test will be quite simple. Otherwise, these will need to be set before proceeding, otherwise unpredictable results will be observed! Refer to the datasheet for the crossover for full instructions of how to do this:

http://www.zinamp.co.uk/modules/crossovers.html

Test with a conventional 2 way speaker

The most practical way to test the plate amp is with a simple 2 way speaker that has a passive crossover inside. Using individual drivers makes this more difficult.



The three pairs of speaker terminals are shown above as green screw-terminal blocks.

- Left - Bass
- Centre - Mid
- Right - Tweeter

The plate amp has no volume attenuator. Do not connect a line level device like a CD player straight into it. You will cause untold damage this way! If using a phone, take extra care to ensure the phone's audio volume is actually right down. Better still use a preamp with a volume control and turn it to zero before switching on your plate amp!

With a small test signal into the RCA socket, touch the speaker wires onto the Bass terminals, then the Mid, then the Tweeter. You should hear sounds in the corresponding frequency range for each set of terminals.

Double check the DC offsets of each power amp on its SPK terminal one more time and adjust to within -/+25mV of zero.

Once this test is complete, you can connect your main speaker drivers.

Stage 7 - Driver Connection

Connect each driver in your installation using stout copper cable. We recommend 16-18 AWG. 16 is thicker than 18. Using very thick cable inside a speaker is not recommended as the cable runs are relatively short and very thick cable is very difficult to solder securely without damaging your drivers. If possible, connect your drivers to their respective cables using crimp or ring terminals. Avoid applying excessive heat to the driver terminals. This will damage the insulation on driver coils - permanently!

Golden Rules

DO - ensure the -ve and +ve terminals on your plate amp outputs correspond with your drivers' -ve and +ve terminals, so that phase alignment is preserved.

DON'T - short or cross any of your output terminals with the power on. This will blow the DC rail fuses, but may damage the power amps.

– NEXT SECTION: General Operation –

General Operation

This section serves as an owners manual for your 3-way Plate Amp.

Features Described:

- RCAInput
- XLR Input
- Auto Power-Off/On
- Fuses and Safety
- Heat and Proximity to Walls
- Crossover Adjustment

RCA Input

Both RCA and XLR inputs are non-attenuated. This means a full line level signal will go straight through your power amps and into your speakers. Damage will occur if you do this. Do not attach a CD player, tape-deck, tuner, TV, DAC or any other non-attenuated line source to either of these inputs. Do not connect the line-out from another amplifier, as this will also be full line-level.

Only connect an attenuated source to the RCA input. A pre-amp is ideal. The 2-position selector switch must be toggled to point to the RCA input in order to receive a signal through it.

XLR Input

Both XLR and RCA inputs are non-attenuated. This means a full line level signal will go straight through your power amps and into your speakers. Damage will occur if you do this.

Only connect an attenuated source to the XLR input. A pre-amp is ideal. The 2-position selector switch must be toggled to point to the XLR input in order to receive a signal through it.

DON'T MIX RCA AND XLR SOURCES. There are cables available with an XLR plug on one end and an RCA plug on the other. DO NOT USE THESE. These cables do not convert an unbalanced RCA signal to a balanced XLR signal. This requires special circuitry, normally found in studio mixing desks and microphone preamps. If you are not connecting equipment like this (i.e. home use), use the RCA input. Contrary to myth, XLR is not superior to RCA over short cable runs. XLR only starts to outperform RCA in terms of noise-cancelling with very long cable runs (i.e. greater than 10 metres).

Auto Power-Off/On

These plate amps will switch off after approx 10-20mins with no incoming audio signal. They will switch on again if they play a signal.

This feature may be overridden with a switch on the rear. I.e. Always On

We do not recommend you leave these amplifiers in the auto-off state for long periods of time (e.g. overnight) and that you switch off at the main-switch when not using them.

Auto-power off shuts down the power amps only. The power amps are the biggest heat source inside and shutting these down when not in use saves energy. However, the power system is still charged up and on standby.

Leaving these amplifiers on standby for long periods simply shortens the life of components like filter capacitors. These typically have a lifespan of 2000-4000hrs (166 days!) and any opportunity should be taken to conserve this.

Switch off when not in use!

Fuses and Safety

There are fuse holders on the back of the plate amp for the DC rails of the power amps. These are clearly marked as **2A fast**. A fast fuse blows quickly and only fast fuses must be used here, otherwise damage to your power amps is almost inevitable. Do not use regular domestic fuses in these ports. Domestic fuses are typically slow-blow.

The mains switch is fused with a 3A slow-blow fuse. Only replace this with a 3A slow-blow; nothing larger. A fast blow fuse here will fail when mains power is switched on.

Use a fused IEC cable with a maximum 5A slow-blow fuse. IEC cables often come with 13A fuses in the plug. This should be changed for a 3A or 5A slow blow fuse. 13A is a lot of current and increases the risk of fire or other hazards.

Heat and Proximity to Walls

The heatsink on the back of these amplifiers gets warm - to about 25 degrees celsius above room temperature. We recommend you do not place the back of these plate amps up against walls, furniture, nor box them in to hide them.

Allow at least 8cms between the heatsink and wall and ensure air is flowing freely around them. Do not place clothes, towels, blankets, boxes or other items over your speakers that would prevent air from flowing freely around the heatsink.

Crossover Adjustment

ZinAmp's active crossover is relatively straightforward to set up, but you must make the necessary adjustments in the right order. This order is always as follows:

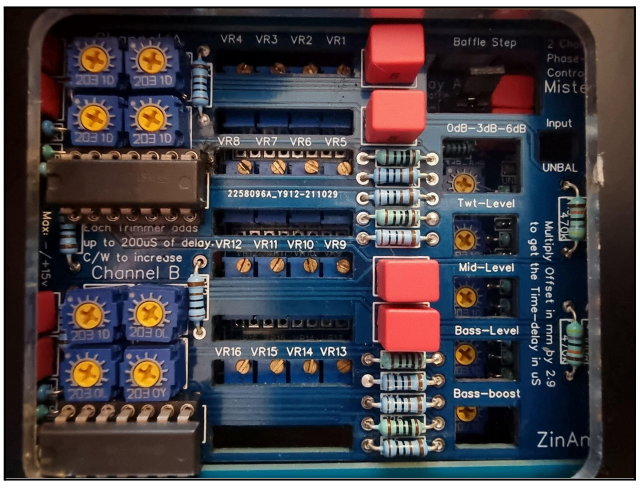
1. Set the crossover frequencies for Low-Mid and Mid-High
2. Set the output levels of each driver
3. Adjust the Baffle Step
4. Add Bass-boost if required
5. Set the phase offset of the mid and high drivers

1. Set the crossover frequencies for Low-Mid and Mid-High

These are typically set prior to delivery but can be adjusted. The datasheet for ZinAmps crossover explains how to do this using a multi-meter and an excel spreadsheet downloadable from ZinAmp's website: http://www.zinamp.co.uk/modules/crossovers.html

2. Set the output levels of each driver

Adjusting the output levels of your crossover to suit your taste is simple to do. However, with repeated plays of different music, you may have to make further adjustments until you are happy. Always apply the same adjustment to the left and right amps of a stereo pair and take your time. The image below shows these adjusters on the right of the crossover.



These general tips will help you achieve a satisfactory adjustment quite quickly:

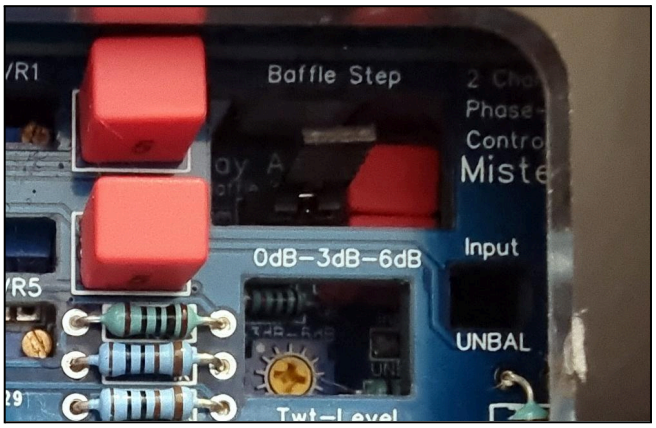
- Adjust the Bass to full
- Mid to approx 80%
- Treble to approx 80% - then adjust for harshness/softness

Most listeners prefer a small cut to the mid frequencies. This is due to the nature of human hearing which is more sensitive to mid range sound-waves.

Treble is very personal and one's ability to hear it will depend on age and other factors.

3. Adjust the Baffle Step

Baffle step adjustment simply applies a roll-off to the overall signal to compensate for the diffraction of low-frequency waves that are often lost 'around the sides' of your speaker cabinet. Some of them bounce back from the walls, but you may find the a small amount of baffle step restores low frequency depth to the sound:



In the picture above there is a jumper shunt that can be moved up and down to select one of three positions. These correspond to the baffle-width (front width) of your speaker cabinet:

- Top Position - less than 250mm
- Middle Position - 250mm-400mm
- Bottom Position - greater than 400mm

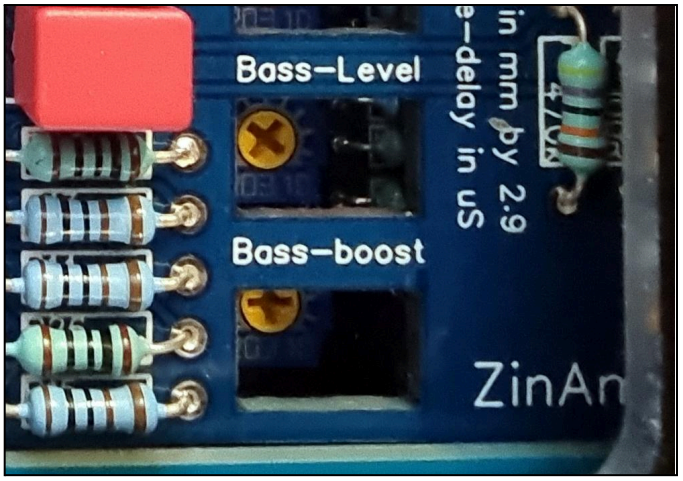
Most speaker baffles are in the 250mm to 400mm range, so this middle position is the most typical.

The adjuster marked 0-3dB-6dB is used to increase the baffle-step. 3dB i.e. half-way is normally plenty. You may find the sound is a little dull, even at 50% / 3dB. You can compensate for this by increasing the tweeter level.

TIP: if you apply 30% baffle step, you can increase the baffle step effect by reducing the mid-level slightly. This will result in a more open sound with clearer treble nuances.

4. Add Bass-boost if required

Whilst bass-boost may sound like a fix-all for small speakers or those without much bass response, it may not add much to the sound if your drivers don't have a particularly low frequency response in the first place.



You can rotate the bass-boost adjuster clockwise and if you hear an increase in bass response and you like it, keep it like that. Only rotate it to the point where it no longer makes a difference. Any further and you are wasting amplifier power, generating heat and potentially over-stressing the voice-coils in your bass-drivers.

Do not turn the bass-boost up full and hope for the best. If bass-boost makes no difference, leave it turned fully down. This will conserve the power of your amplifier and generate less heat.

Bass boost may work better for speakers with sealed cabs. Ported cabs (particularly T-line) may behave unpredictably with bass-boost added, resulting in bass 'boom' or 'raspberry' sounding notes emanating from your speakers!

We are yet to find a situation where more than 50% bass-boost made any desirable difference to the sound! In our demo sealed speakers, we generally set this to 25%

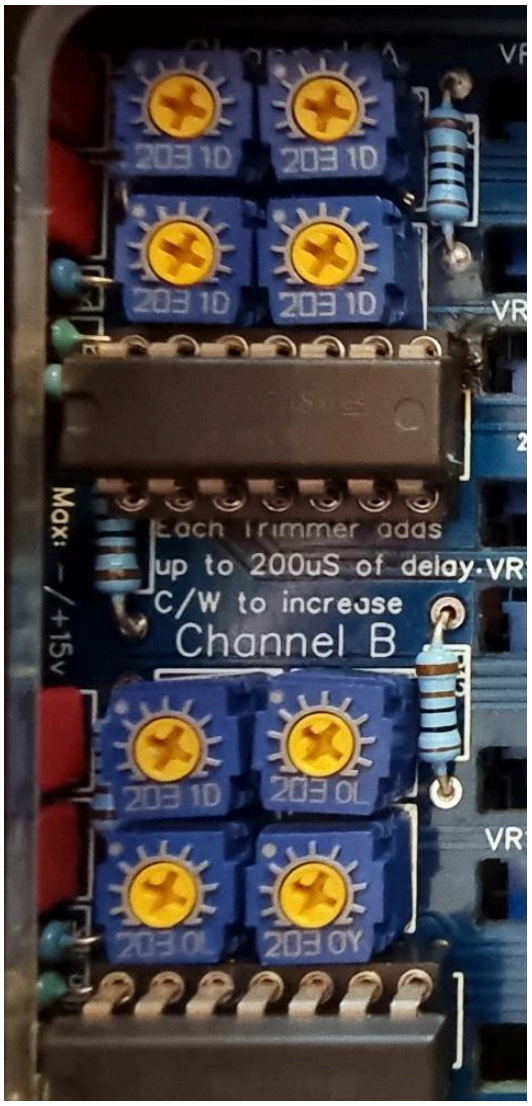
Remember, bass-boost is not a fix-all.

5. Set the phase offset of the mid and high drivers

In a typical 3-way speaker, the centre of pressure of the bass driver sits a few cm back from the centre of the mid driver and a few more from the centre of the tweeter.

Phase adjustment can be applied to the mid and treble drivers to delay the signal output and align the phase of the signal through both crossover regions.

This is a complex topic and phase adjustment may be mitigated by other room effects, such as the listener being off axis or wooden floors and high ceilings. The only way to adjust phase accurately is to use an SPL mic and software like Room EQ Wizard. This may take time, but the results are ultimately more accurate.



The upper 4 adjusters are for the tweeter and the lower 4 for the mid driver.

The amount of phase delay is calculated by multiplying the offset of the driver in mm by 2.9 (a time constant based on the speed of sound)

For a tweeter that is 50mm forward of the bass driver, multiply 50mm by 2.9 to give 145uS.

For a mid driver that is 25mm forward of the bass driver, multiply 25mm by 2.9 to give 72.5uS.

Each adjuster adds a max of 200uS of phase delay. To work out the position of all four adjusters:

Tweeter: 145uS ÷ 4 = 36.25uS.

(36.25 ÷ 200) x 100 = 18% rotation

Mid: 72.5uS ÷ 4 = 18.125uS.

(18.125 ÷ 200) x 100 = 9% rotation

It is easy to see that trying to set an adjuster to 9% or 18% accurately is a little tricky. This is why an SPL mic and software like Room EQ Wizard is more accurate. Each driver will also have its own inherent phase shift which is only detectable with a mic and software.

ALWAYS make sure each adjuster in a group of 4 is set to the same position.

Parts Lists

Three separate parts lists are shown below.

1. System (main) board
2. LateralFET Power Amp (mini)
3. 3-Way Crossover & Phase Shifter

System (main) board

Designator	Value/Spec	Qty	Sup	Manuf	Manuf. Part	Sup. Part
EHD1	GBPC3508	1	RS	HY	GBPC3506W	917-8821
APC8,APC3,APC4,SPC4,EHC1,SPC1,SPC3	100n	7	RS	Epcos	B32529C1104K000	896-1332
APR8,HVR4,LVR3+,LVR3-,SPR10	1k	5	RS	TE Connectivity	LR1F1K0	125-1159
APR9,APR2,APR7,APR10	220k	4	RS	TE Connectivity	LR1F220K	125-1159
APD11	6.2v	1	RS	Nexperia	BZX85C6V2	759-8891
APR4,APR12	470R	2	RS	TE Connectivity	LR1F470R	149-060
LVR5+,LVR5-	47R 1W	2	RS	Vishay	PR01000104709JA100	683-5515
APQ3	MJE350	1	RS	OnSemi	MJE350G	125-1158
APR3,APR5,APR6,APR11,APR13,APR14,APR16,APR19,SPR2,SPR6,SPR7	10k	11	RS	TE Connectivity	LR1F10K	125-1164
SPD2,APD5,APD7	10v	3	RS	Nexperia	BZX79-C10,113	544-4461
LVR6+,LVR6-	3.9R 1W	2	RS	TE Connectivity	ROX1SJ3R9	214-0813
SPD8,SPD7	24v	2	RS	OnSemi	1N4749A	186-9155
X/O-DC	+|GND|-	1	RS	Samtec	SLW-103-01-G-S	180-0848
PSD1	GBU2510	1	RS	HY	GBU2510	923-5472
HVC1	100n 63v	1	RS	Epcos	B32529C1104K000	896-1332
WFR_AMP,MID_AMP,TWT_AMP	GND|IN|SPK	3	RS	Samtec	SLW-103-01-G-S	180-0848
MID_XO,TWT_XO,WFR_XO	GND|Sig	3	RS	Samtec	SLW-102-01-T-S	923-5472
MID,TWT,WFR	-|GND|+	3	RS	Samtec	SLW-103-01-G-S	180-0848
DISCHARGE	Jumper	1	RS			
APSWITCH-TRIGGER	555	1	RS	Renesas	ICM7555IPAZ	921-5374

HV+DC,HV-DC	FUSE	2	RS			
HVC2,HVC3,HVC4,HVC5	4700u/6800u 63v	4	RS	Yaego	LH063M4700BPF-3030	440-6755
ACR2,HVR1	100R 1W	2	RS	TE Connectivity	ROX1SJ100R	125-1174
APR18,APR15,APR23,HVR3+,HVR3-	4.7k	5	RS	Vishay	MRS25000C4701FCT00	683-3799
LVR1+,LVR1-,LVR2+,LVR2-,LVR8+,LVR8-,HVR3,LVR2,SPR11	3.3k	9	RS	TE Connectivity	LR1F3K3	125-1162
APQ2+,LVQ1+	BDW93	2	RS	ST	BDW93CFP	793-1318
APQ2-,LVQ1-	BDW94	2	RS	OnSemi	BDW94CFTU	807-5178
APPRELAY1	HFD2/012	1	RS	Hongfa	HFD2/012-S-D	176-2938
BASS-OUT,MID-OUT,TWT-OUT,AC	-|+	4	RS	RS Pro	146-8347	146-8347
COIL,CONTACTS	Relay	2	RS	RS Pro	146-8347	146-8347
EARTH	Earth|Chassis	1	RS	RS Pro	146-8347	146-8347
PRIM_1	P1-|P1+	1	RS	RS Pro	146-8347	146-8347
PRIM_2	P2-|P2+	1	RS	RS Pro	146-8347	146-8347
SEC	S1-|S1+|S2-|S2+	1	RS	RS Pro	146-8347	146-8347
TC10	220u	1	RS	Panasonic	ECEA1EN221U	176-3786
LVQ3+,LVQ2+,SPQ1,SPQ5,SPQ4	KSP42	5	RS	OnSemi	KSP42TA	739-0505
LVQ3-,LVQ2-,SPQ2,SPQ3	KSP92	4	RS	OnSemi	KSP92TA	
APC1,APC7	2.2u 63vDC	2	RS	Kemet	MMK5225K63J06L4BULK	191-985
APO-SW	O|R	1	RS			
LVD1+,LVD1-,SPD9,HVD4,APD3	5.1v	5	RS	Nexperia	BZX79-C5V1,113	544-3597
LVC3+,LVC3-	220u 16v	2	RS	Wurth	NRSZ221M10V6.3X11F	839-6438
EHR2	0.1R 3W	1	RS	TE Connectivity	ER74R10KT	158-569
SPC1B,SPC1M,SPC1T,SPC2,LVC2+,LVC2-	10u 50v	6	RS	Nichicon	UPW1H100MDD	715-2819
APD9,SPD1,SPD1B,SPD1M,SPD1T,SPD2B,SPD2M,SPD2T,SPD3,SPD4,SPD6,APD2,APD4,APD6	1A 50v	14	RS	Vishay	UF4001-E3/54	628-9669
SPR1,SPR1B,SPR1M,SPR1T,SPR3	100k	4	RS	TE Connectivity	LR1F100K	125-1168
36982	470R 1W	1	RS	Vishay	PR01000104700JA100	683-5518

TC3	470n	1	RS	Panasonic	ECWFE2W474P1	105-1083
APC2,APC6	100u 16v	2	RS	Rubycon	16PK100MEFC5X11	763-9396
46113	100R	1	RS	TE Connectivity	LR1F100R	125-1155
APD10	3.3v	1	RS	Nexperia	BZX79-C3V3,113	544-3531
APQ1	BC337	1	RS	On	BC337-40TA	671-1119
APU1	TL074ACN	1	RS	Texas Instruments	TL074ACN	182-2441
SPR12,SPR5,SPR9	47R	3	RS	TE Connectivity	LR1F47R	148-175
SPRELAY2	32.21.7.024.2000	1	RS	Finder	32.21.7.024.2000	492-6647
MAINSACSELECTOR	115-230	1	RS	C & K	S202031MS02Q	175-9674
ACC2	100n	1	RS	Kemet	R75GF31004030J	171-9186
HVVR1,SPVR1,LVVR1	20k	3	RS	Copal	CT-6EV 20kR	896-7169
HV-LED,LV-LED,SP-LED	-|+	3	RS			
EHR1	100R 3W	1	RS	TE Connectivity	ROX3SJ100R	214-2623
ACTH1,ACTH2	25R 5W	2	RS			
LVC1+,LVC1-	100u 35v	2	RS	Vishay	MAL203850101E3	684-1973
LVR4-,LVR4+	2.2k	2	RS	Vishay	MRS25000C2201FCT00	683-3449
LVC4-,LVC4+	100p	2	RS	Wima	FKP2/100/100/5	484-1978
LVD2-,LVD2+	2.4v	2	RS	Nexperia	BZX79-C2V4,113	544-3503
SPR8	4.7k	1	RS	Vishay	MRS25000C4701FCT00	683-3799
SPD5	24v	1	RS	OnSemi	1N4749A	186-9155
SPRELAY1	HFD2/024	1	RS	Hongfa	HFD2/024-S-D	176-2943
SPR4	22k	1	RS	TE Connectivity	LR1F22K	125-1167

LateralFET Power Amp (mini)

Designator	Value/Spec	Qty	Sup	Manuf	Manuf. Part	Sup. Part
43-48V	-|HUB|+	1	RS	RS-PRO	790-1092	790-1092
OUT, IN	Bdg|Spk,IN	2	RS	RS-PRO	790-1098	790-1098
C2	100p	1	RS	Wima	FKP2/100/100/5	484-1978
C13,C14,C12,C3	100n	4	RS	Epcos	B32529C1104K000	896-1332
C10,C7	220p	2	RS	Wima	FKP2/220/100/5	484-1984
C11	2.2u 40vAC	1	RS	Kemet	MMK5225K63J06L4BULK	191-985
C1	2.2u 40v	1	RS	Kemet	MMK5225K63J06L4BULK	191-985
Q1,Q4,Q3,Q5,Q14	KSP92	5	RS	OnSemi	KSP92TA	806-4627
R5,R10	22R	2	RS	TE Connectivity	LR1F22R	148-095
R7,R2	100R	2	RS	TE Connectivity	LR1F100R	125-1155
R9	22k	1	RS	TE	LR1F22K	125-1167
R6,R11	68R	2	RS	TE Connectivity	LR1F68R	148-219
R4,R41	220R	2	RS	TE Connectivity	LR1F220R	148-348
R1,R12,R27,R8	1k	4	RS	Vishay	MRS25000C1001FCT00	683-3165
R3	47k	1	RS	TE Connectivity	LR1F47K	148-893
R13	22K	1	RS	TE	LR1F22K	125-1167
R26,R20,R37	10R	3	RS	Vishay	MBB02070C1009FCT00	125-1154
R33	330R	1	RS	Vishay	MRS25000C3300FCT00	683-3540

R29,R30	2.7k	2	RS	TE Connectivity	LR1F2K7	125-1161
R14	470R	1	RS	TE Connectivity	LR1F470R	125-1158
R17,R18	0.2R 3W	2	RS	TE	ER74R22KT	151-518
R22	150R	1	RS	Vishay	MRS25000C1500FCT00	683-3058
D5,D12	10V	2	RS	Nexperia	BZX79-C10,113	544-4461
C5,C4	220u 63v	2	RS	Nichicon	UVR1J221MPD1TD	862-3294
C6,C9	100u 35v	2	RS	Vishay	MAL203850101E3	684-1973
VR1	100k	1	RS	Bournes	PV36W104C01B00	769-2160
Q2,Q6	BC550/BC337	2	RS	OnSemi	BC33725TA	671-1116
Q7	KSP42	1	RS	OnSemi	KSP42BU	739-0372
Q12,Q8	N-LatFET	2	Profusion	Exicon	ECX10N20	ECX10N20
Q11,Q9	P-LatFET	2	Profusion	Exicon	ECX10P20	ECX10P20
D7,D8	50v 2A	2	RS	Vishay	SBYV27-50-E3/54	629-6746
D10,D9,D1,D2,D3,D4,D6,D11	50v 1A	8	RS	Vishay	1N4001-E3/54	628-8931
L1	3.9uH	1	RS	Panasonic	ELC11D3R9F	675-5343

3 Way Crossover

Designator	Value/Spec	Qty	Sup	Manuf	Manuf. Part	Sup. Part
C1+,C1-	100u 35v	4	RS	Vishay	MAL203850101E3	684-1973
C1,C2,C3,C4,C5A,C5B,C6,C7A,C7B,C8	4.7n	20	RS	Wima	FKP2/4700/63/5	115-736
C5	220n	2	RS	Panasonic	ECWFE2W224J	105-1074
C7,C13	22u	4	RS	Panasonic	ECEA1EN220X	176-3785
C17,C19	27p	4	RS	Murata	RDE5C2A270J0M1H03A	150-4025
C15,C18	47n	4	RS	Kemet	R79MC2470Z340J	171-9295
C9,C10,C11,C12,C13A,C13B,C14,C15A,C15B,C16,C100	47n	22	RS	Kemet	R79MC2470Z340J	171-9295
C101	33n	2	RS	Vishay	MKP1837333011	166-6459
C102	22n	2	RS	Kemet	R79IC2220Z345J	171-9259
R1,R3,R4,R9,R10,R13,R14,R20,R21,R22,R23	10k	22	RS	TE Connectivity	LR1F10K	125-1164
R2,R11,R12,R17,R18,R19	100R	12	RS	TE Connectivity	LR1F100R	125-1155
R5,R8,R15	4.7k	6	RS	Vishay	MRS25000C4701FCT00	683-3799
R6,R7,R16	470k	6	RS	TE Connectivity	LR1F470K	149-149
U1,U2,U3	TL074ACN	6	RS	Texas Instruments	TL074ACN	182-2441
VR1,VR2,VR9,VR10	50k	8	RS	Bournes	PV36W503C01B00	769-2195
VR3,VR4,VR5,VR6,VR7,VR8,VR11,VR12,VR13,VR14,VR15,VR16	20k	24	RS	Bournes	67YR20KLF	769-2170
VR17,VR18,VR19,VR21	20k	8	RS	Copal	CT-6EV 20kR	896-7169
VR20	10k	2	RS	Copal	CT-6EV 10kR	896-7140
3-pin Connectors	2.54mm pitch	14	RS	RS-PRO	790-1092	790-1092
Baffle Step Selector	2x3-pin 2.54mm pitch	2	RS	Harwin	M20-9980346	745-7046

Input Unbalanced Jumper	2-pin 2.54mm pitch	2	RS	RS-PRO	251-8086	251-8086
Shorting Link		2	RS	RS-PRO	251-8575	251-8575
Phase Shifter…..						
C1,C2,C3,C4,C5,C6,C7,C8	10n	8	RS	Wima	FKP2/0.01/63/5	115-758
CHAN-A-IN,CHAN-B-IN	GND|Sig	2	RS	RS-PRO	790-1098	790-1098
CHAN-A-OUT,CHAN-B-OUT	SCN|Sig|GND, -|GND|+	4	RS	RS-PRO	790-1092	790-1092
R1,R2,R3,R4,R5,R6,R7,R8,R9,R10,R11,R12,R13,R14,R15,R16	1k	16	RS	Vishay	MRS25000C1001FCT00	683-3165
R17,R18	100R	2	RS	TE Connectivity	LR1F100R	125-1155
U1,U2	TL074ACN	2	RS	Texas Instruments	TL074ACN	182-2441
VR1,VR2,VR3,VR4,VR5,VR6,VR7,VR8	20k	8	RS	Copal	CT-6EV 20kR	896-7169