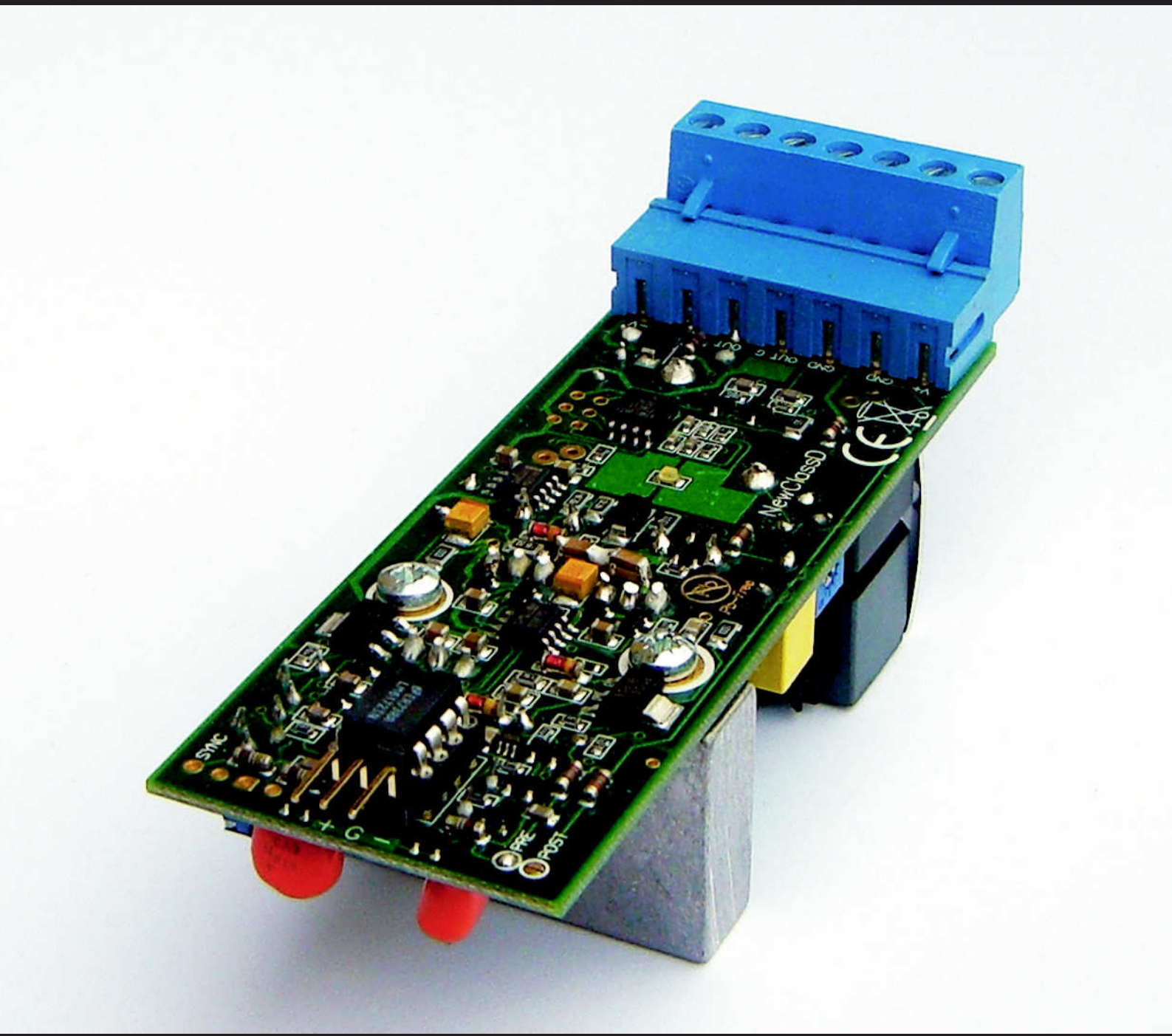
NewClassD



Cook Book

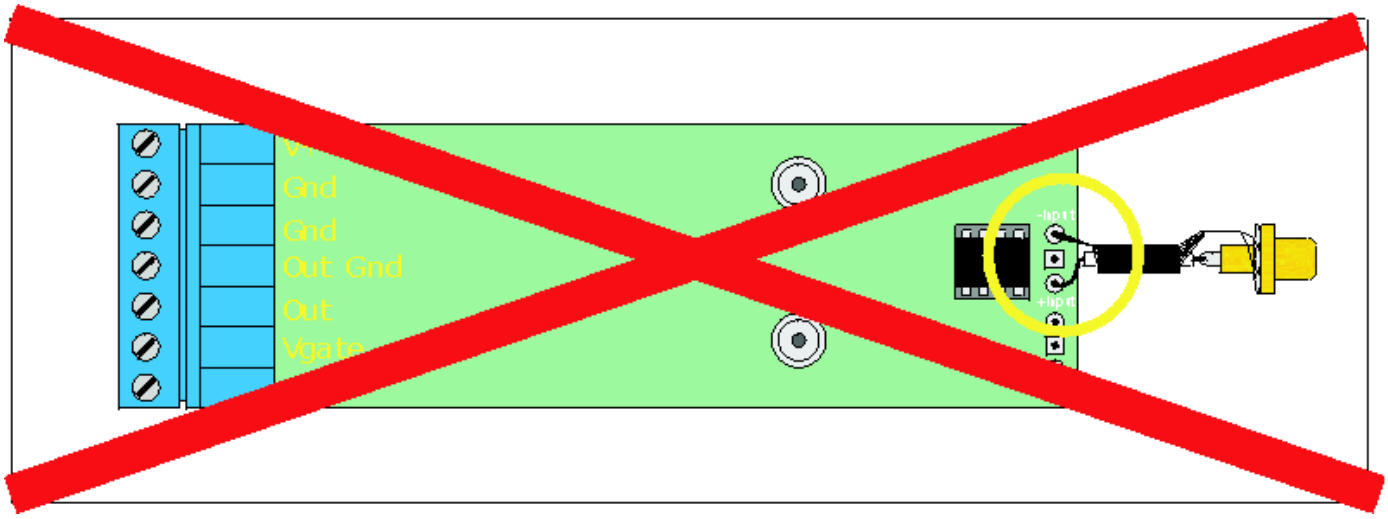
ver 1.06 - 2008

Advanced Class D Amplifier for DIY Construction

Before you begin.
We provide first some 'Dont's. These are provided to give you a short and sweet of things you should avoid doing to your NewClassD modules during the construction of your new amplifier. We have placed these in the beginning of the cookbook only to make sure you see them, in case you should decide not to read the entire cookbook.

Legal Notice.
NewClassD modules are covered by a limited warranty. In case a module malfunctions, your warranty will cover replacement of the module and other parts delivered by NewClassD, providing the instructions are regarded. No parts which are not delivered by NewClassd are covered by warranty, insurance or other in other way can become liability to NewClass, it's holding company Dexa Technologies Ltd, or it's insurance companies.

Dont's.



Never use the minus input terminal as GND for your input wire. If you are running un-balanced, short the minus input directly to the square GND terminal right next to it. Nothing else.
Never re-adjust the trimmers on the module, as this may damage the module in case of shoot-through.
Never use the module without proper heat sink attached.
Never change feedback mode while the amplifier is plugged into the power supply module. Not even when mains is not connected, as a substancial charge on the capacitors may destroy the module.
Never charge the power supply before inserting the plugs for the amplifier modules. You can accidently do this by connecting the powersupply with transformer to Mains Voltage, without any amplifier modules attached.
A charged power supply can hold power for months, and therefore MUST be discharged (All 3 voltages - through a 50 - 100 Ohms resistor) before connection to the modules. (Check with Voltmeter for < 5V). Once the modules are connected, charging and discharging is of course allowed at random.
Never connect the In-Circuit programming plug for the microprocessor to anything. This may disable the protection, or even damage the computer chip.
Never use both 'pre' and 'post' mode, when power is applied to the amplifer.
Never let metallic parts or liquids of any kind come in contact with the module's circuits, other than the connectors. Even when power is turned off.

Checklist.
Here is what you need to build a complete stereo amplifier:

2 NewClassD modules.
1 Power Supply Module.
1 Power transformer (up to 2 x 42 V AC) with mounting hardware.
1 Enclosure.
4 Speaker Binding Posts.
2 RCA Phono plugs.
1 IEC mains socket with fuse holder (and fuse 5-6.3 AT).
3 x 1 m 12 gauge (2.5 mm2) single wire.
~0.5m Speaker cable.
~0.5m Signal cable (preferably screened).

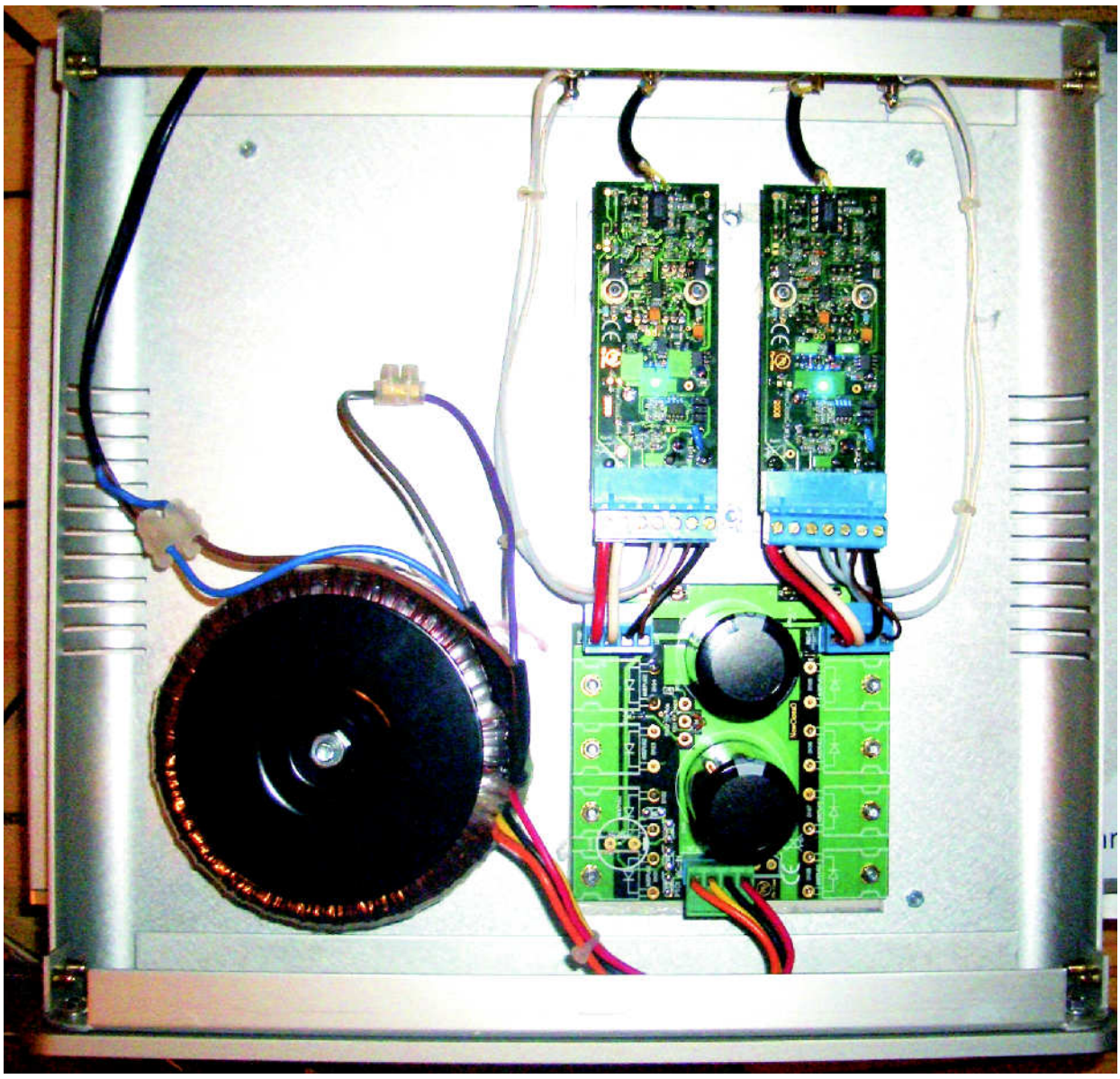
Tools required.
Wire Cutter.
Small Blade Screwdriver.
Medium Pozidrive Screwdriver.
TX20 Screwdriver or bit.
Autocrimper (Can get from any gas station).
Solder Iron and solder.
Drill machine, and drills.

Building Step by Step.
On the next pages you can find a simple step by step building instruction for a complete amplifier.

Mechanical outline.
First lay down the components of your amplifier in your enclosure, to see how everything can be best fitted inside.

Take the following into consideration, in prioritized order: (If you don't follow these rules, you will not get an optimal result of your amplifier).

1..The base plate of the amplifiers, must have good cooling from the enclosure. A thin steel bottom plate is not enough cooling. In this case you must add a 4 by 6 inch (10 x15 cm) aluminium plate to distribute heat. (Reliability issue!)
2..Wire distance between PSU and amplifiers must be SHORT! 4-6 inch (10-15cm) is no good!
3..Distance between Amplifier's / input wiring and mains transformer (and it's wires) must be as big as possible.
4..Wire distance of input signal and speake cables must be as short as possible.
5..Wire distance between mains transformer and PSU must be short.

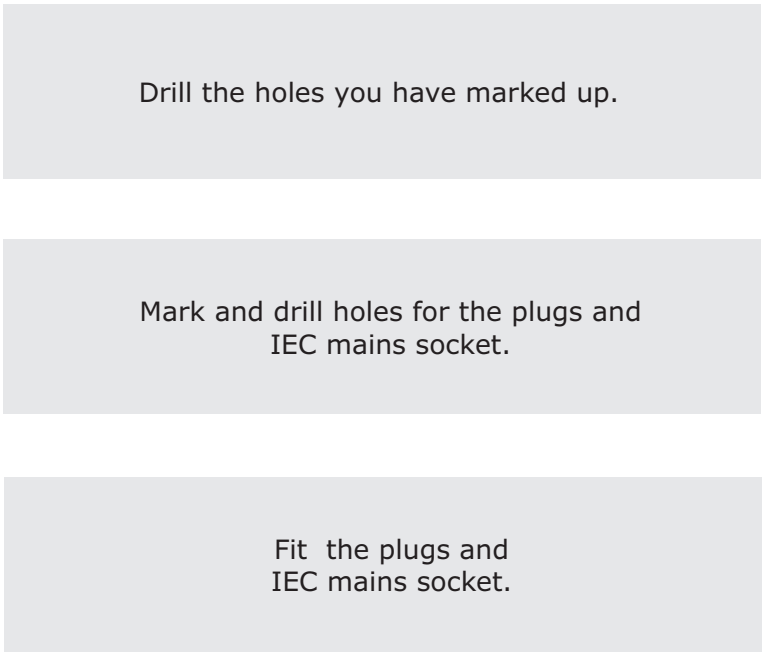


Here is an example of a good layout. Note the wires from PSU to amplifiers are very short (2 inch / 5 cm). The transformer wires are slightly longer, but that was the tradeoff. It is further down on the priority list.
This enclosure is aluminium, (ATI Research 738-AU) which is very good, both because of good thermal conductivity, but also because the aluminium will not cause any magnetic disturbance of the amplifiers output coils. (Steel casing can derate the audio performance).

Mark up the holes for the modules and transformer.

Fastening.
Use good solid screws to fasten the modules in the case. M4 size is adequate, while M3 is too weak. The modules should be tightly fastened to the substrate, and there should be no debree or dirt underneath them.

Cooling.
NewClassD modules operate with controlled slope switching (nano alignment) to get rid of most audio distortion. The back side of this is that the idle power consumption is about twice that of normal Class D modules. Therefore adequate

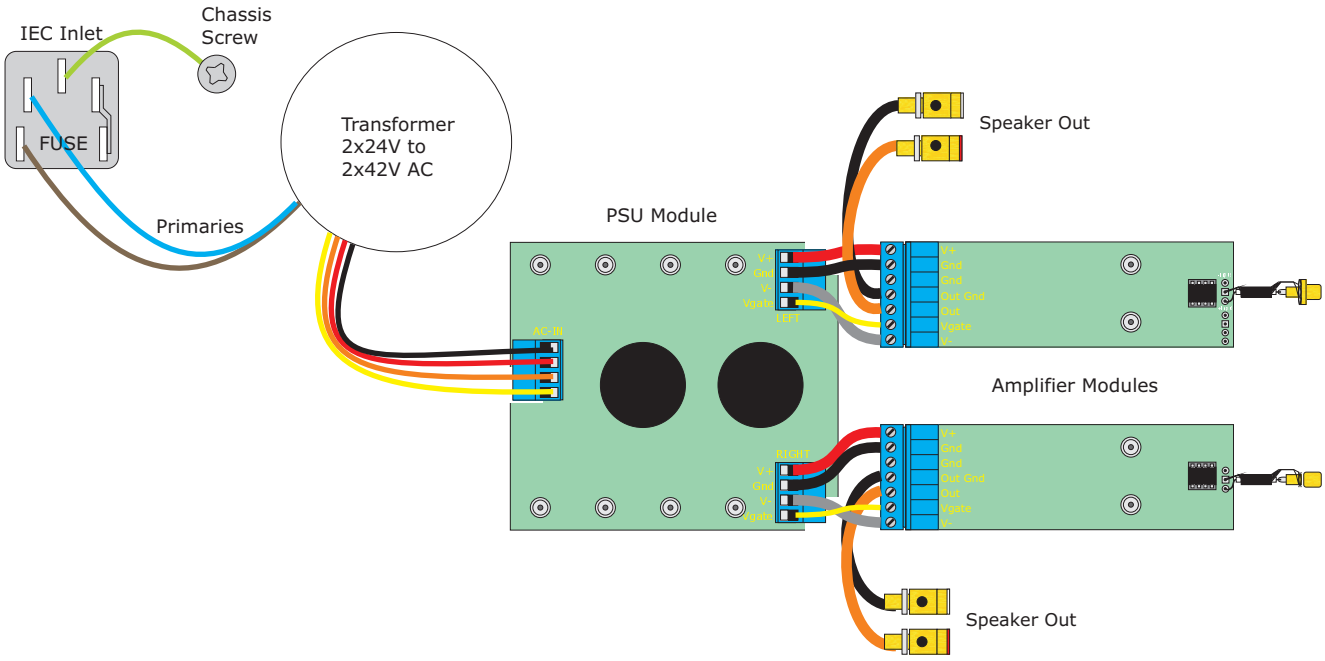


cooling should be provided by the enclosure. The bottom plate of an all aluminium case is fully adequate, and no heat sink is required. If you use a steel or wooden case, you should mount the module baseplate on a 4mm aluminium sheet of no less than 4 by 6 inches (10 x 15 cm). This can cool both modules, but they still get hot. Twice this size (about the size of this page) is recommended.

Electrical Safety.
Mainly an issue for the mains side of the transformer. Use only double insulated wiring, or single insulated wire with heatshrink. Crimp terminals should be isolated, and also have heatshrink on top of that, after crimping them on the wire. Ensure all wires are securely fastened (by pulling ALL of them). Make sure you have AT ALL TIMES a mains fuse connected, when the amplifier is on.
If you use a smaller AUX transformer it MUST HAVE it's own fuse with ~0.5 A rating. This fuse should be connected on the amplifier side of the main fuse, so in case the mains fuse blows, no power will pass through the smaller AUX fuse.

Fasten the modules in the casing.

Wiring Diagram.



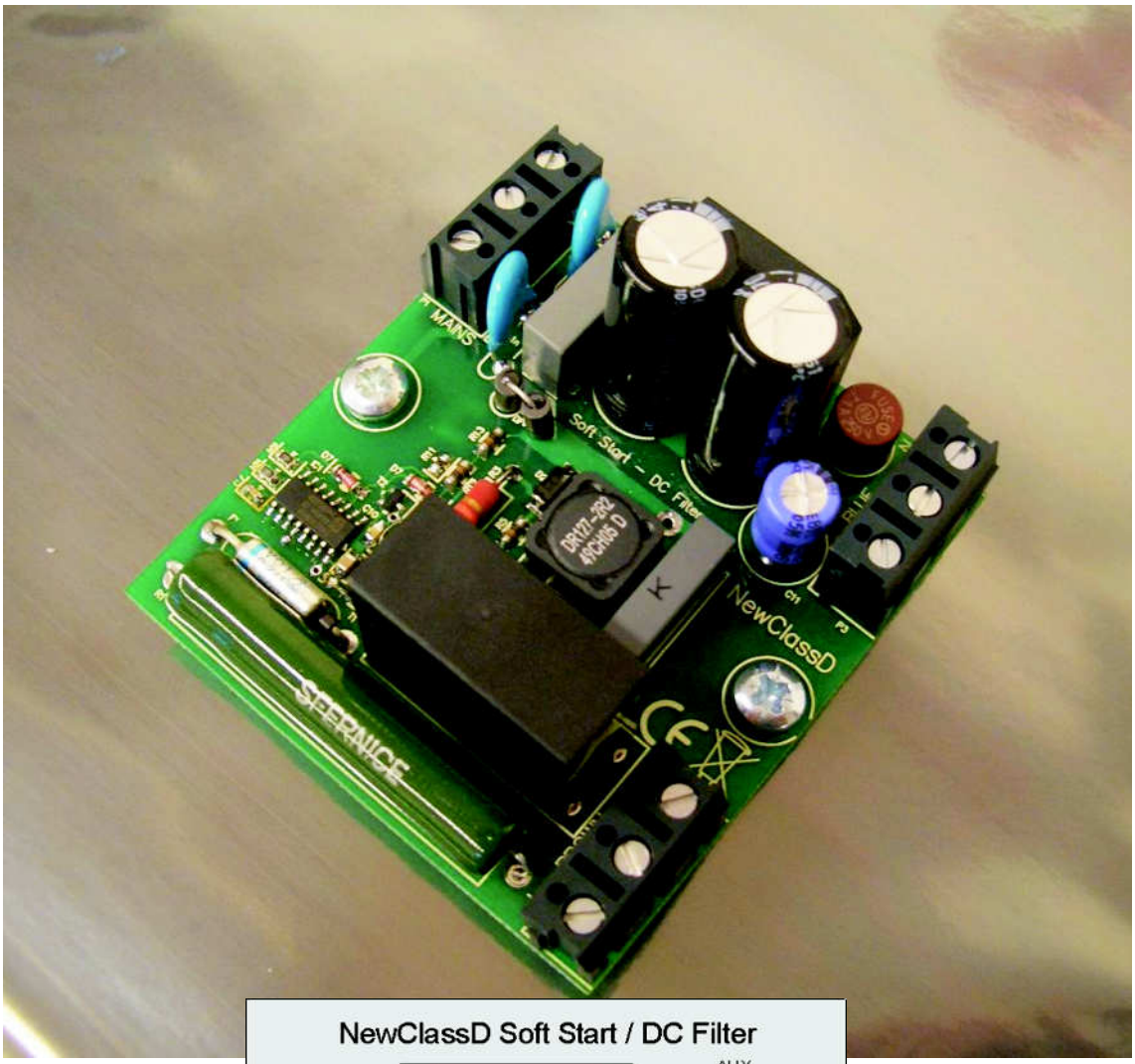
Connection on Mains side.

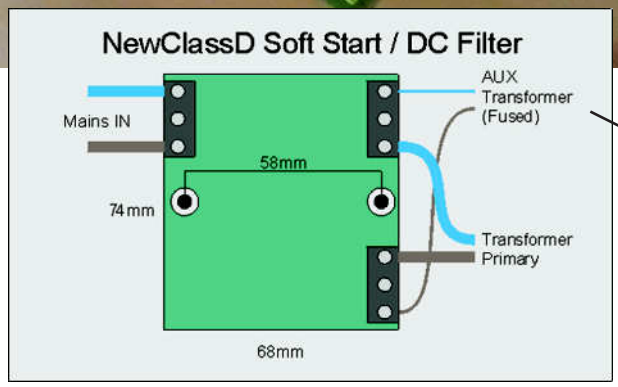
In most cases you can simply connect the transformer wires directly to the fused IEC inlet terminals with use of insulated crimp terminals.
In case you have a mains transformer bigger than 500 VA you need a soft start circuit to protect the fuses and switches in the system from overloading at startup.

Soft Start consideratons.

A soft start slowly charges the mains capacitors and magnetizes the mains transformer slowly, to preserve the fuses and switches. The full mains power is switched in after 2-3 seconds. In relation to NewClassD there is a problem to be considered. At startup the NCD module waits 3 seconds, before the microcontroller switches the amplifier on. At this time the processor takes a snapshot of the voltages, as reference for ongoing power monitoring. If the softstart is not fully switched in at this time, the reference in the NCD will be too low, and give cause for shut-down, when the soft start eventually comes on. This is seen as, the modules coming on fine at first, but once the soft start kicks in, the module shuts down, and the blue LED is blinking constantly.
Solve this by speeding up the softstart a little, or connect the Gate Driver supply only after the soft start is finished.

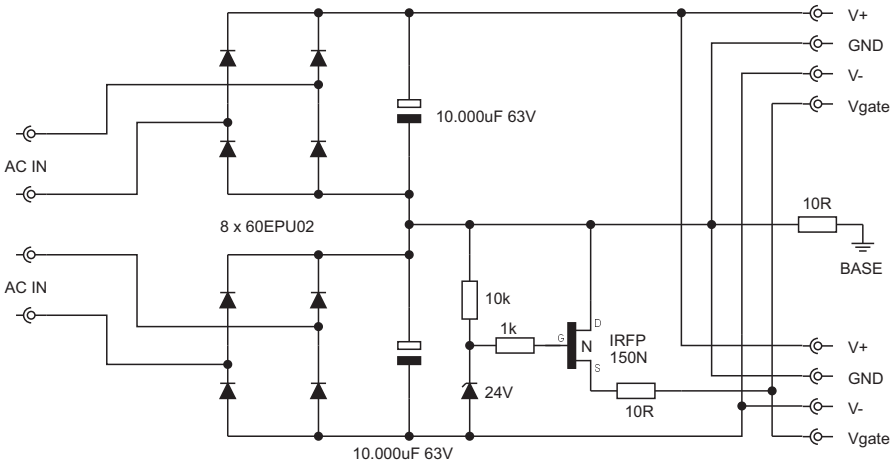
Soft Start Circuit.
We offer a soft start circuit particularly suitable for NewClassD. The special feature of this soft start is the short charge time, of only 1 second. This allows for the supply rails to be at full level before the NCD's microprocessor diagnostic system starts meauring the system voltages. This 'All-in-one' audio net interface also has a DC blocker (10000uF) and a HF frequency blocker, that prevents RF noise on the mains grid, while not affecting the sound of the amplifier.



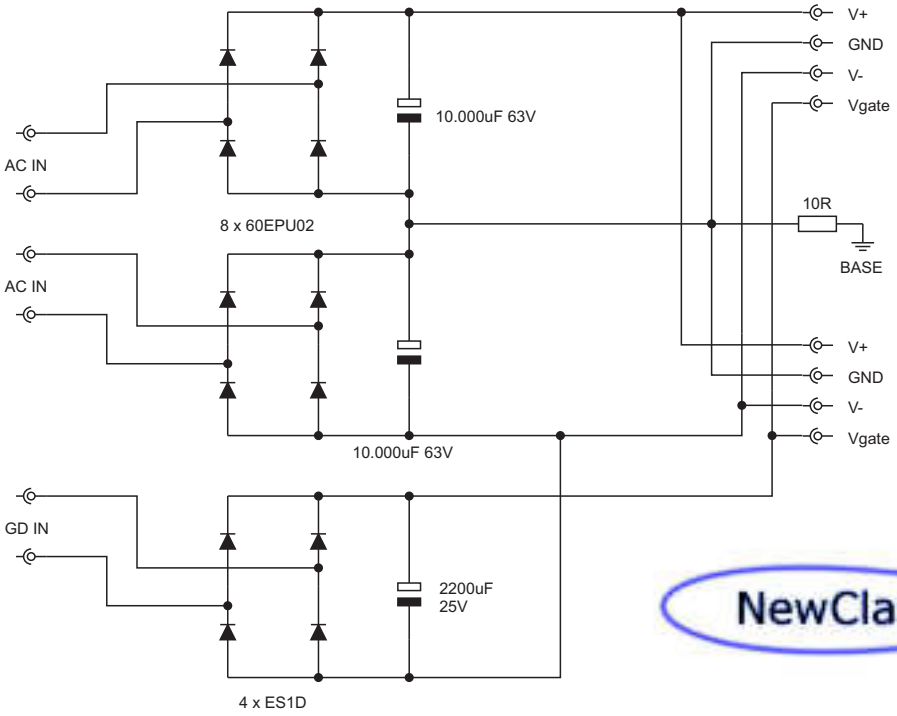


Connection scheme.

There is also a separate fused outlet for an AUX transformer which allows you to use a separate gate drive or preamplifier transformer with easy connection to the common mains.

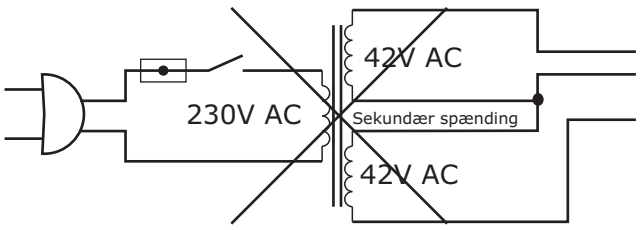


4 wire Power Supply Schematic
(This 4 wire version is suitable for standard transformers)



6 wire Power Supply Schematic
(This 6 wire version is suitable for special transformers with separate gate drive winding of 15V AC).

Center Tab Transformers



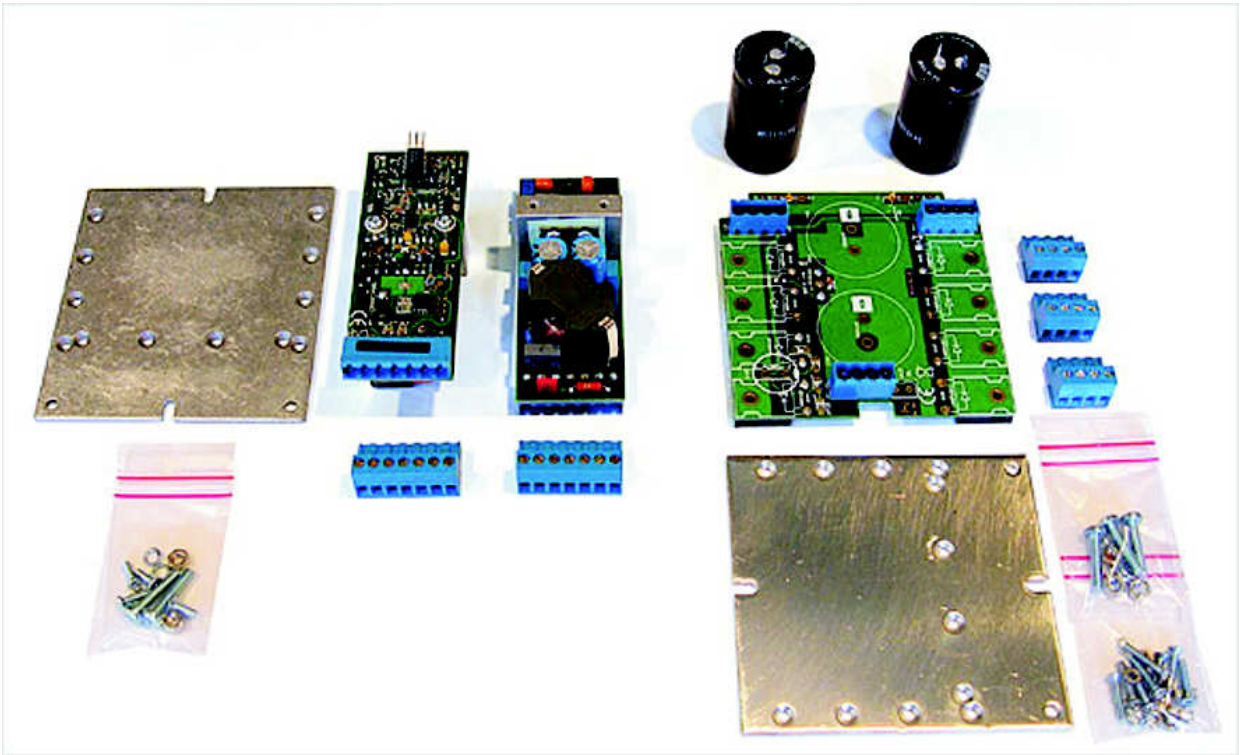
Can NOT be used with the PSU module!

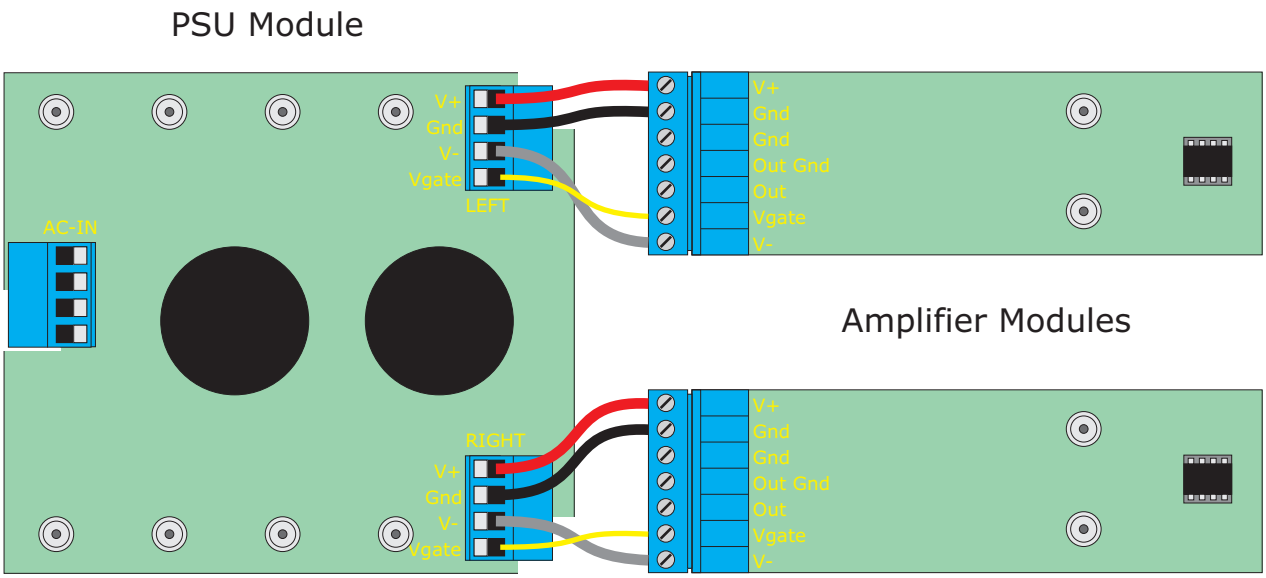
Connection of Transformers to Power Supply.
There is not much to be said about these connections. If the colors coming out of the transformer differs from the drawing (yellow, orange, red, black) take a look on the label on the transformer to get the right colors for your transformer.

Note! You can NOT use a transformer with common center tab, like 42-0-42V, with our power supply modules. If you have a transformer like t hat, you must build a simple 'traditional' power supply with bridge rectifier and two caps.

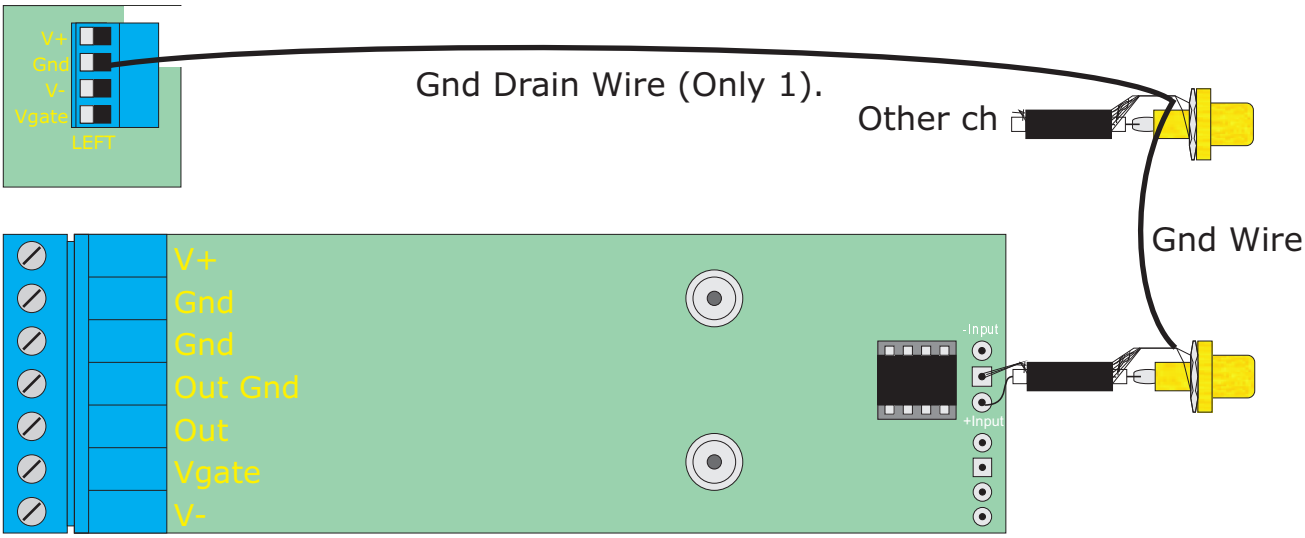
Connection of Power Supply to Amplifiers.
For +, - and GND use 12 gauge (2.5mm2) single wire, and keep it SHORT!
If you have 4-6 inches, the sound quality will suffer. To ensure easy access we have provided plugs for these connections. To optimize the sound you can consider soldering these wires directly onto the circuit board underneath the plug. (On the other side of the PCB). Be careful to get + and - right. Check one more time just to be sure.

Connect the Transformer wires to the IEC plug.





Connect the PSU module with the Amplifier Modules.

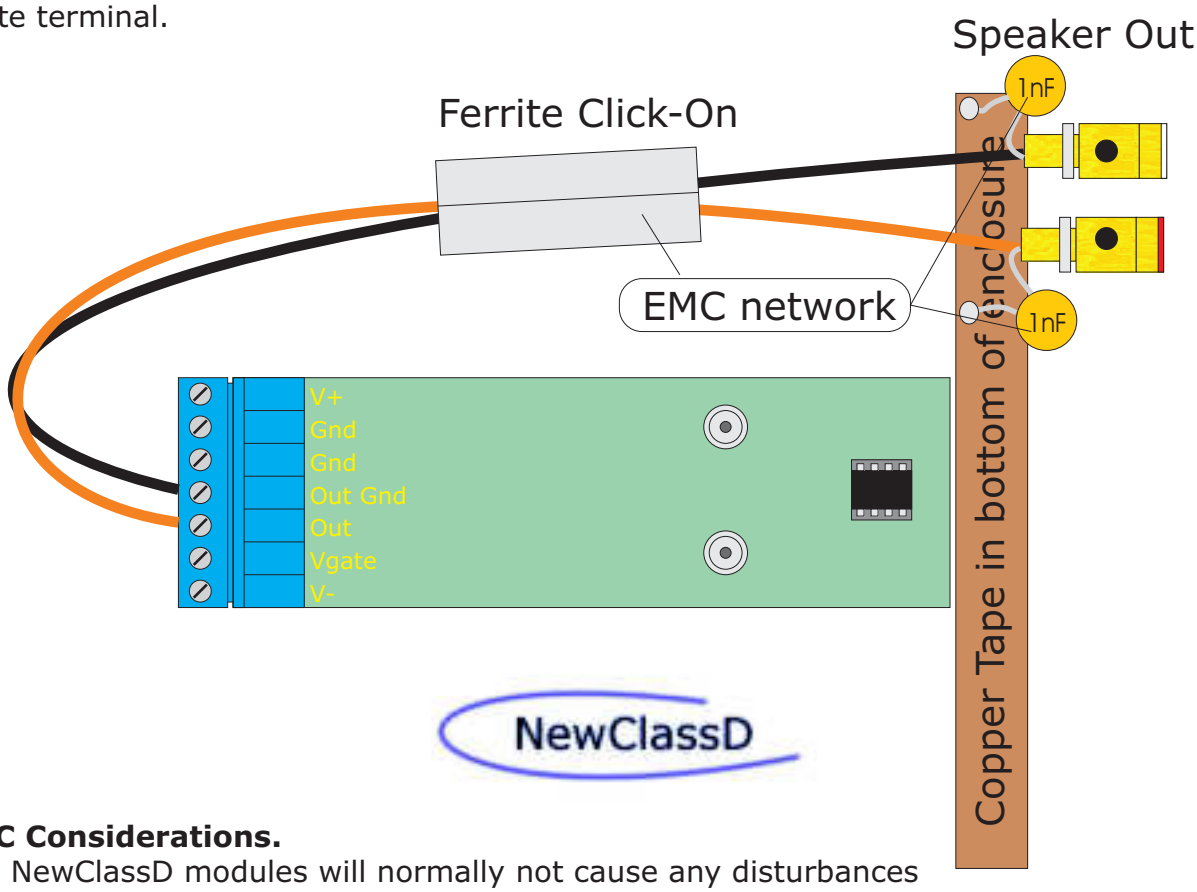


This is proper connection of unbalanced input to the amplifier. You can also connect the minus input to the square GND terminal right next to it. If you want phase reversal, you can connect the 'hot' center wire of the signal cable to the minus input. In any other case, don't connect the minus terminal to anything.
Do not use the minus input as GND for your input wire!
You don't have to strictly use schielded cable, unshielded will do nicely. But shielded makes some noise considerations much easier.

Connect the input plugs to the Amplifier modules.

Sound Properties of Cables.
The sound properties of the input cables, however short, is of great importance to the overall result of your amplifier. Use the best cables you can find, meaning those with the sound that suits you best. Don't use standard mounting wire here!

Connection of Amplifiers to Output Terminals.
Before connecting the speaker cable, it's a good idea to check the speaker terminal for continuity to the gase. If there is any connection, you MUST take the terminal out, and remove the debree that is shorting the terminal to the case. Use good quality loudspeaker cable, and do not fasten them together with input wires or transformer wires. Be careful to get the polarity of the output and GND right. Output goes to the RED speaker terminal, while GND goes to the black or white terminal.



EMC Considerations.
The NewClassD modules will normally not cause any disturbances to your radio or TV reception. However since this is a DIY module, the implementation can in some cases lead to disturbance, in the form of increased background noise on FM receivers standing right next to the amplifier. For example the speaker wires may pick up on some RF signal inside the enclosure, and transmit it out to the speaker wire outside, that will then work as an aerial.
Therefore we recommend using the above EMC network, which will block any RF emittance from exiting your amplifier. A kit is available from NewClassD free of charge for all who have NewClassD modules.

Connect the Speaker Terminals to the Amplifier outputs.

Double check if the modules are fastened.

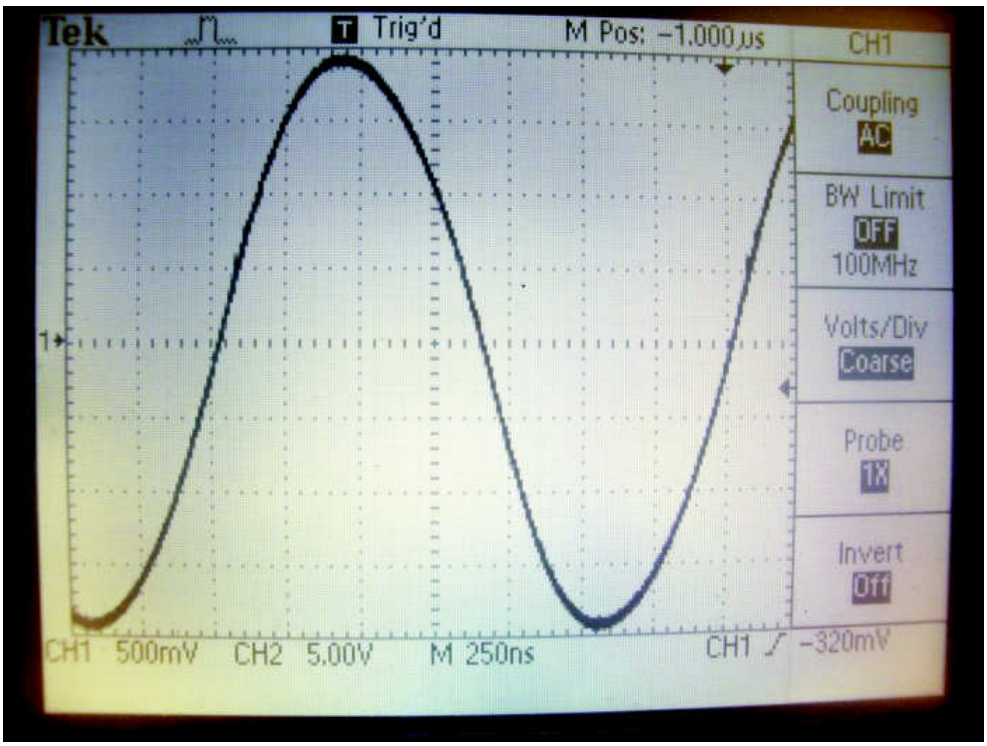
Double check if the cables are secured.

Connect your loudspeakers, and source..

Turn the power on...

The blue LED's will now flash for a few seconds, and then come on constantly. A small click should be heard in the speakers, if you hear any loud or suspicious noises, turn off immediately!
Wait a few minutes to see if everything turns out fine, and then start listening. Note the brand new modules might sound a bit hard at first, but it goes away after a few hours of playing.
Check for excessive temperature or anything smelling for the first few hours of operation.

Residuals.
Residuals come from the internal switching of the NewClassD amplifier (120Vpp square wave of 500 kHz) filtered by the second order output filter of about 160 kHz corner frequency.
With 500kHz / 160kHz you have around 2.5 octaves of 12dB damping.
Around 30 dB under the 120 Vpp. This results in around 4 Vpp residuals left on the output terminals. This is in no way harmful for your loudspeaker, and is quite normal. The residual could arguably be reduced by using a 80 kHz or 30kHz filter instead (like some other brands of Class D modules), but then that also severely limits the output bandwidth.



Actual residuals from the NCD 1.

NewClassD

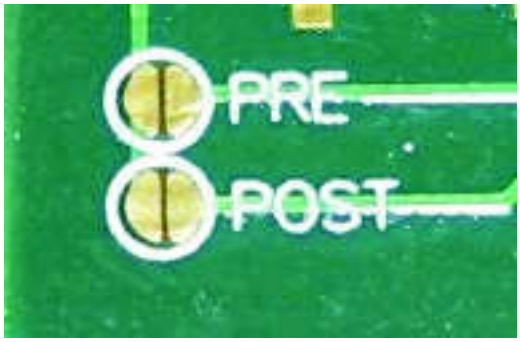
Options.
By this time your amplifier should be fully operational, and you should play on it for a few days before trying out the various options. It will take some time for the Power Supply caps to break in, and give a good sound, so don't be scared if the sound is not good in the first hour or so.

Feedback.
You can change feedback topology on NewClassD amplifiers. This is following countless discussions on world forums about whether post or pre filter feedback is better.

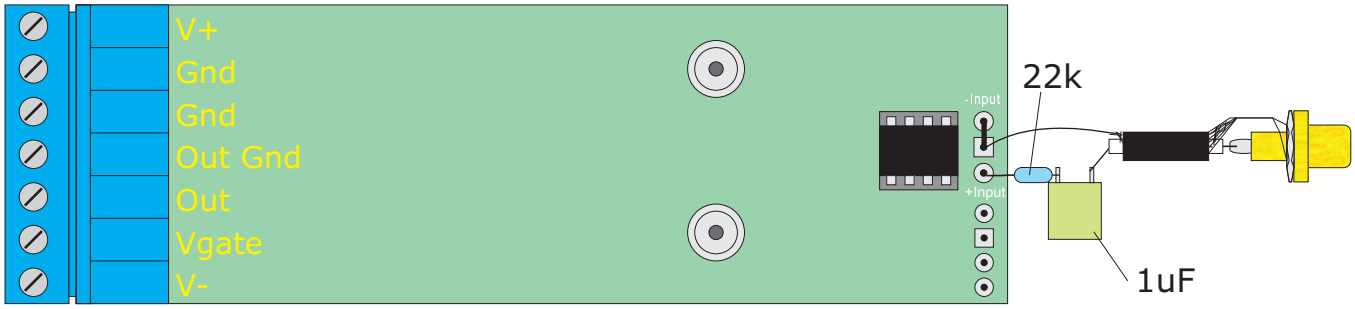
In Post filter feedback mode the audio feedback signal is taken after the output filter, effectively including the output coil in the feedback loop. The good news is that you get a frequency response that is virtually independent of the load impedance. At least in theory. The bad news is, that the speaker's back EMF will now inject a signal into the feedback loop. This results in less dynamics, and less openness in the soundstage. How big the problem is, depends on your loudspeakers.

In Pre filter feedback mode the feedback signal is taken before the output coil. This effectively isolates the speaker's back EMF, from the feedback loop, and so you get better dynamics, and more openness. The bad news is that your frequency response is now load dependent. But for one thing the response is already in the area of 160 kHz -3dB, so it will take a lot of load, to get to 20 kHz. Another ting is, that an actual loudspeaker is not resistive, but mostly inductive load. This negates the effect of load dependent frequency response.
All in all we recommend the 'pre' filter mode as the best sounding, and most stable.

To select 'pre' filter mode, [default] place a solder bubble on the 'pre' pad.
To select 'post' filter mode, remove the solder from the 'pre' pad and place some solder on the 'post' pad instead. You will find these pads near the audio input.



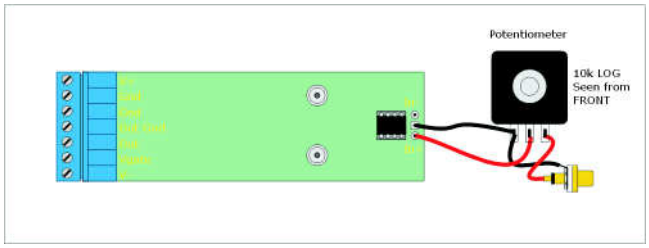
Using a Tube Preamplifier



To connect your NewClassD to a Tube preamplifier, reduce the sensitivity by adding a series resistor to the input (good quality), and also connect a small MKT 1uF in series with the input, to make the amplifier immune to the tube preamplifier's DC bump during power-up. DO NOT use a big sized speaker capacitor in this position!

To determine which capacitor is good quality for this position, place all selected types you have in mind on your workbench. Take a big magnet, and place it on top of the capacitors. Lift the magnet away. The types that are still on your workbench are good for Audio. The others are not. In other words, use a non-magnetic MKT type.

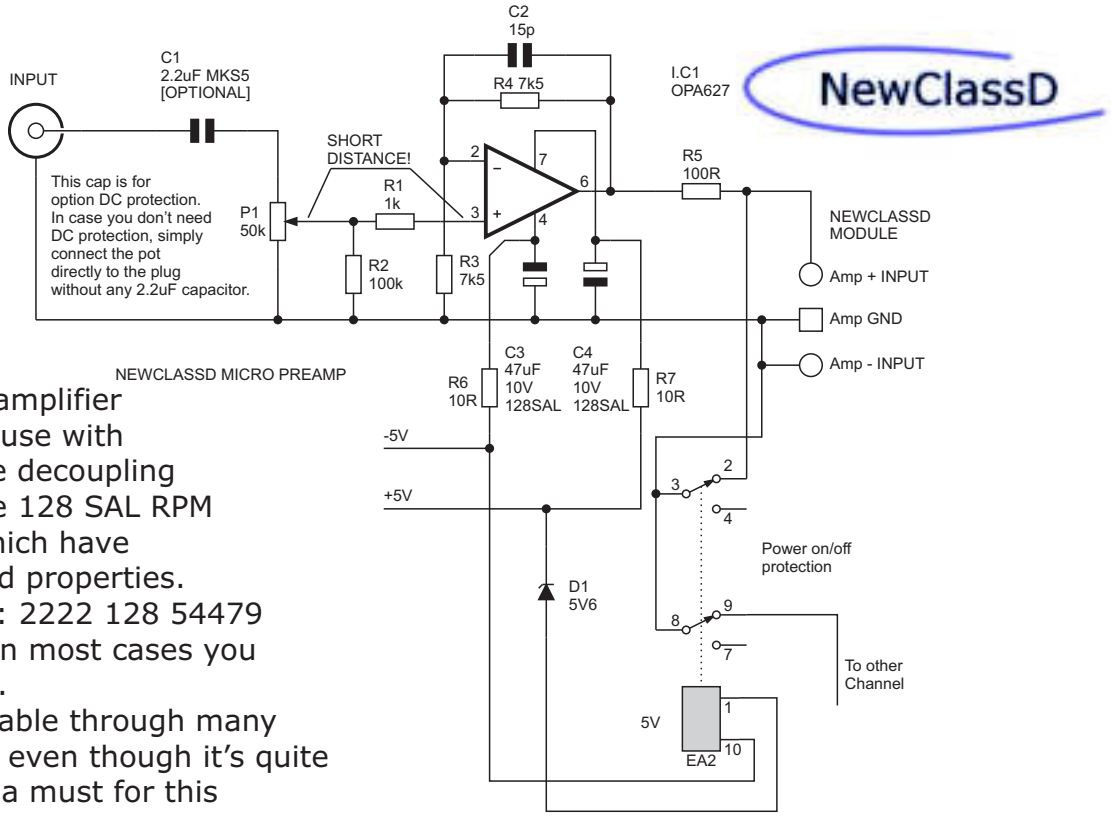
Volume Control.
You can add a volume control to your NewClassD amplfier quite easily. This way you strictly don't need a preamplifier, so you can save the money, and also shorten your signal path. On the other hand you only have the one input, so it's only a practical solution in case you mostly use one signal source (i.e. CD player).



The simplest way to do this is by adding a 10k potentiometer in the signal path, effectively forming an internal passive volume control.

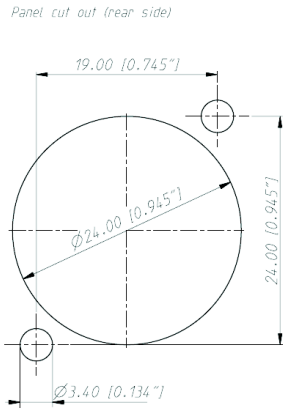
This works nicely, but the passive volume control is often criticised for having less microdynamics, and a flat 'background' of the soundstage. To get past this, you can build a simple 'micropreamp' that performs as well as any high-end preamplifier. It takes a bit of circuitry, and also a good power supply, but on the other hand, the sound result is definitely worth the effort and cost.

Micro Preamplifier

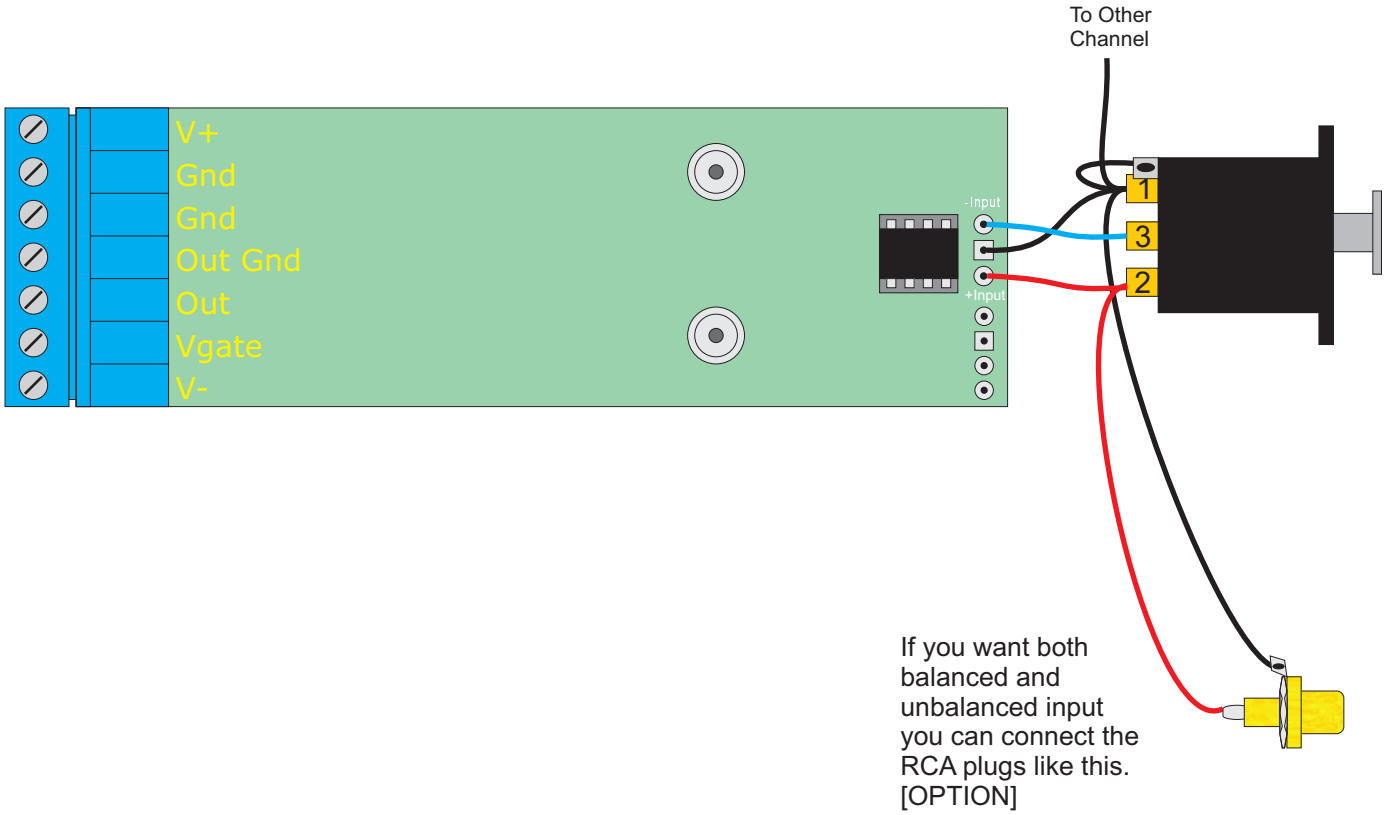


This is the pre-amplifier we propose for use with NewClassD. The decoupling caps are of type 128 SAL RPM from Vishay, which have very good sound properties.
Their part no is: 2222 128 54479
C1 is optional, in most cases you can leave it out.
OPA627 is available through many parts suppliers, even though it's quite expensive, it is a must for this construction.

Balanced Input. [OPTION]
Your NCD module will directly interface to abalanced inout signal.
Connect a female XLR receptable (for example Neutrik Nc3-FD-H-B) to the amplifier's three inpuit terminals.



Connect pin 1 of the XLR plug to the center pin of the amplifier.
Connect pin 2 of the XLR plug to the + input pin of the amplifier.
Connect pin 3 of the XLR plug to the - input of the amplifier.
Connect the GND vane to pin 1, and also connect the 2 channel's pin 1's together with a short and solid pieace of wire. This way you avoid and external hum loops.

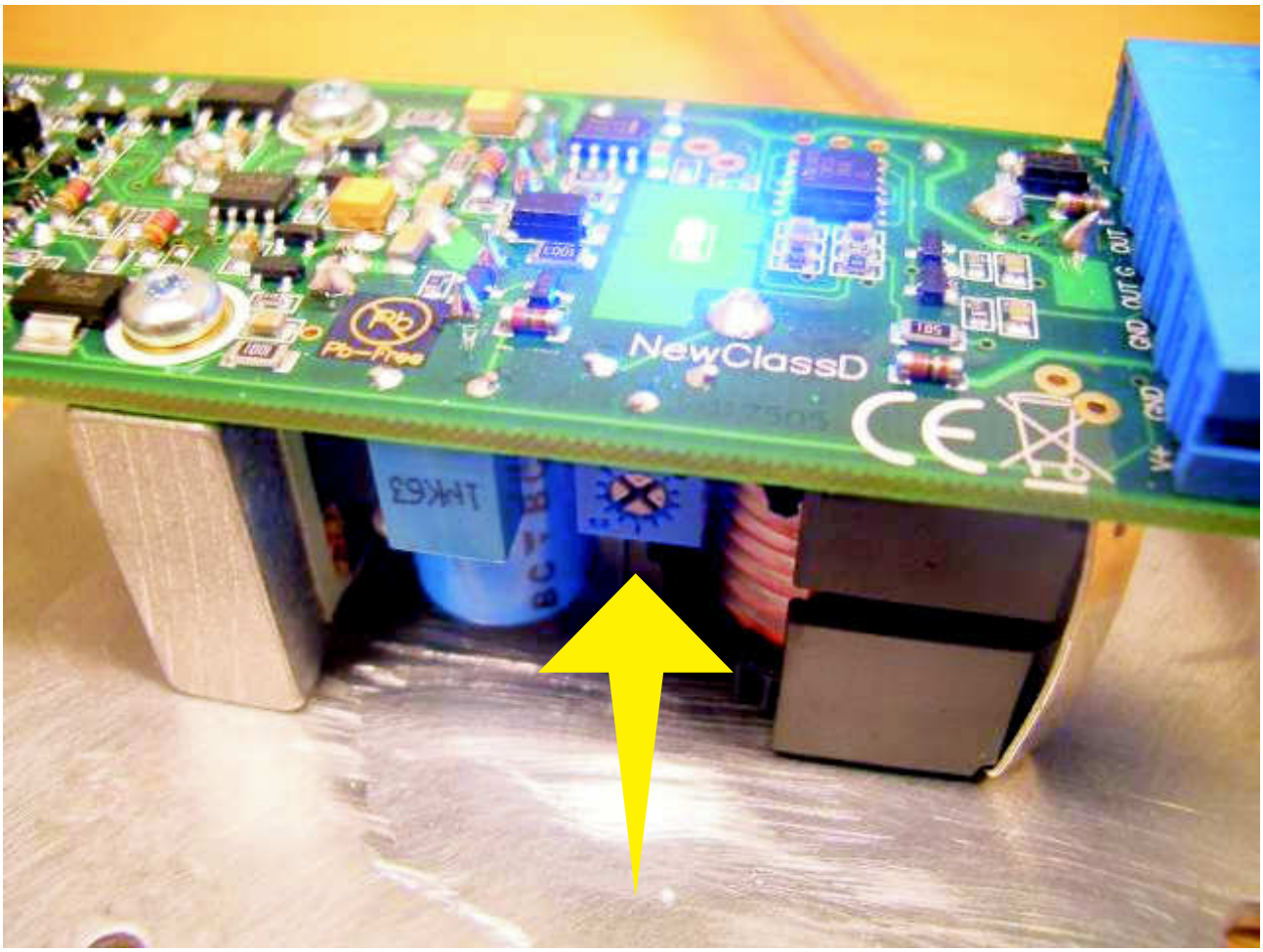


If you want both balanced and unbalanced input you can connect the RCA plugs like this. [OPTION]

Frequency Adjustment
From factory we have adjusted the frequency of your amplifier module, to give the optimal performance. Therefore to maintain the best performance, we recommend you don't re-adjust the switching frequency. If you want to do it anyway, this is how to do it:

Under the module is placed a small trimmer. The frequency trimmer is standing alone on the pcb, there are also a pair of trimmers standing together, but these are for the nano-alignment adjustment. Don't re-adjust these under any circumstances.

This is the right trimmer for frequency adjustment:



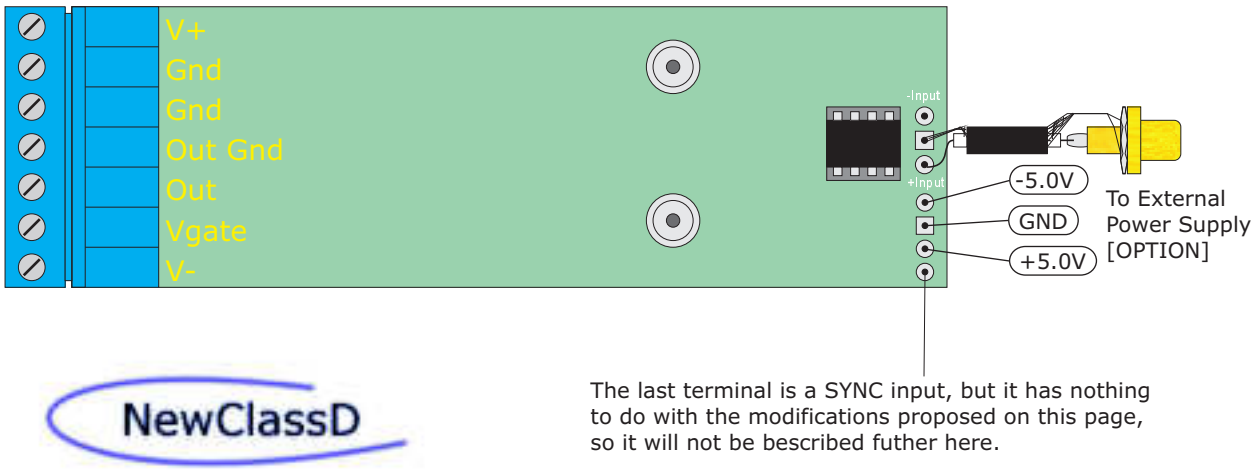
In case you experience heterodyning. (A faint high pitch whistle tone in your speakers), you can readjust the frequency control trimmer in small portions. (Max +- 1mm). Adjust it slightly back and forth until the tone disappears.
If you want to experiment with full frequency range adjustments, we recommend you have a scope and secure power supply attached during adjustment, and a resistor load of 8 Ohms instead of your loudspeakers.
Caution: The trimmer is not limited for the general user to play safely with, so under some conditions the amplifier may become unstable during extremes of the frequency adjustment. This can damage the loudspeakers, and module, if the above precautions are not observed.
The frequency range is 400 - 950 kHz, and the adjustment works equally well with pre- and post filter feedback selected.

External power supply for the input stage. [OPTIONAL]
This is a modification for the more advanced Audio DIY'er. Whether it has any positive effect on the sound quality can not be determined technically, since the module already has onboard precision power supply regulators for the input stage. Never the less we are aware that some DIY'ers want to try it out as a modification.

First you need a stable low noise power supply source of +/- 5.0 Volts.

DO NOT attempt to change the power supply voltage beyond the below limits, to see if the sound changes. The amplifier may become unstable or even be damaged.

Voltage Limits:
Lower: At 4.7 Volts the internal power regulator will start to kick in, and take over the supply.
Upper: At 6.3 Volts you meet the maximum voltage limit of the bypassing capacitors. Even if you change these to a higher voltage, other circuits may overload at higher voltages than 6.3V.



Voltage on the input stage is allowed regardless of main power or Gate Drive power. So you don't need to switch this supply on and off with the other supplies in the amplifier. Just leave it on.

On the other hand it is NOT recommended to have main and gate power on the amplifier, if the input stage is not supplied. This can lead to serious malfunctions, and damage your loudspeakers. So in other words don't use the input power supply as a stand-by function for the amplifier.

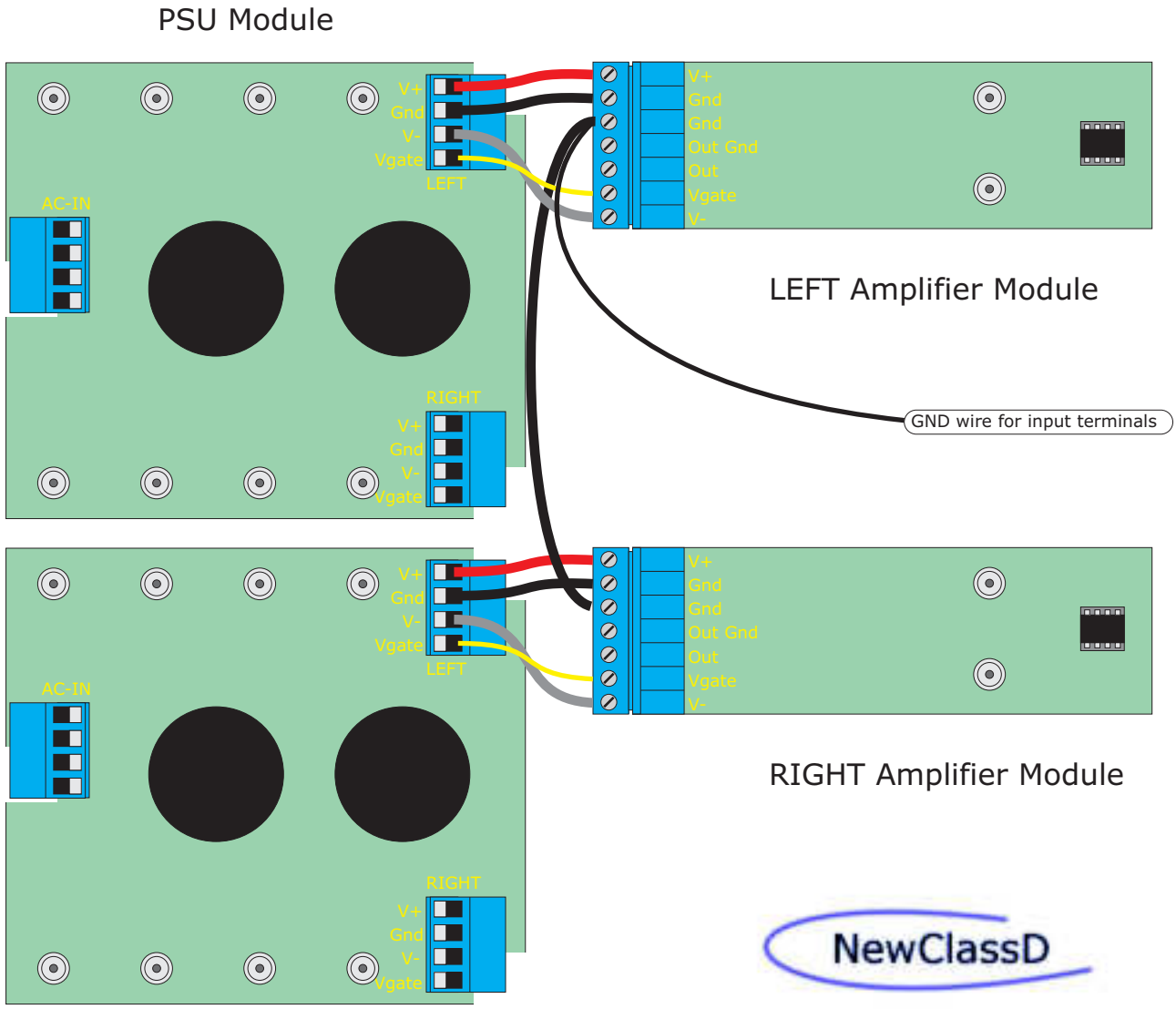
You can in principle disable the internal regulator by removing the two SOT223 transistors from the PCB. This however can be an irreversable process. When you apply a voltage higher than 4.7V, the power for the input stage will automatically be derived from your external supply, so disabling the on-board regulators is not mandatory.

All in all this modification should be carried out only by experienced audio DIY'ers, and with great caution.

Not for the beginner!

DUAL MONO setup. [OPTIONAL]
To optimise the sound quality, you can use a separate power supply and transformer for each amplifier channel. If you do that, and still place both channels in the same enclosure, you then have a DUAL MONO amplifier.

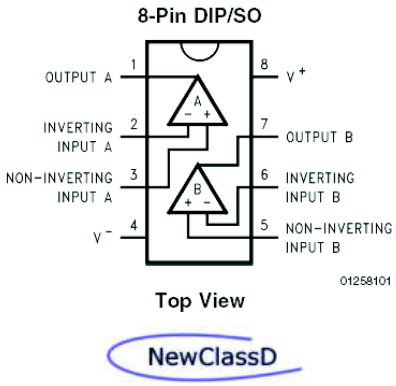
Here is how it's done:



As can be seen it's quite easy to do, all you need is a normal stereo set of NewClassD with PSU module, and an extra PSU module, and extra transformer. This is because each PSU module should be fed with it's own mains transformer.
On the other hand, the transformer now only has to run one channel, and thus can be smaller in size (we recommend > 200 VA per channel).
Note: the extra wire from L GND to R GND, this connection voids the noise that can otherwise come if the two channels are totally isolated, and then come together in the preamplifier's GND. **This GND wire should be short and heavy gauge.**
Input's and output's are connected as usual (see earlier in this CookBook).

Using alternative OP-AMP type for the input stage. [OPTIONAL]
The input OP-AMP has significant effect on the sound quality. We have chosen LM6172 as the standard type, based on it's good performance, and high stability. Some features of LM6172 is UGBW of 100 MHz, and a slew rate of 3000 V/uS.
Other types may have better performance, and therefore we have placed the LM6172 in a socket, so it's easy to experiment with other types.

The LM6172 has a standard pin-out for a DUAL op-amp in 8 pin DIP package. This is also the same pin-out as NE5532, TL072, OPA2134, AD712 etc. etc.
Some of these op-amps will actually work in a NewClassD amplifier, however of course with lower performance than LM6172.



To get a good result from another OP-AMP here are the features of that OP-AMP, you should look for:

High Unity Gain Bandwidth (> 50 MHz).
Low Group Delay / High slew rate. (> 100 V/uS).
Stable at +/- 4.5V to at least +/- 6V.
Low input noise (< 10 nV/Hz).
Low input current noise (< 3 pA/Hz).
Low input BIAS current (as this can otherwise lead to DC offset on the output).

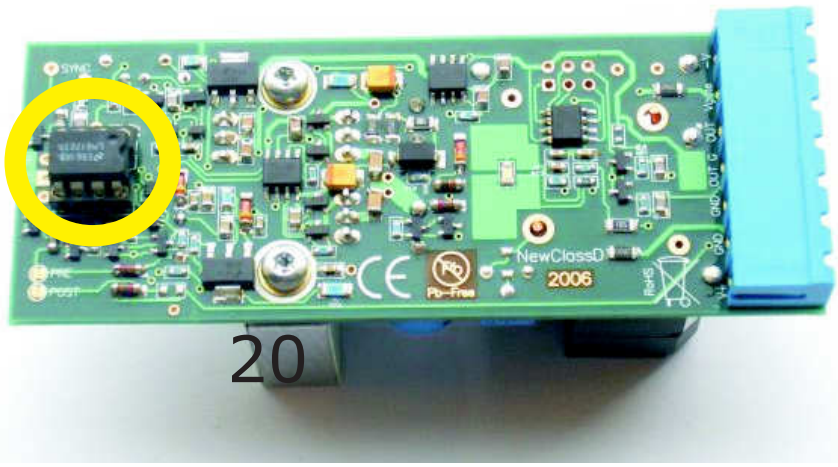
We have had good results from using LM4562 (also from National Semiconductor), even though it exhibits much higher THD than LM6172 in a NewClassD amplifier (because it's slower than LM6172), it has a warmer and more pleasant sound to it, but still with myriads of detail.

We have also heard people who had very good experience with a OPA627 DUAL module, and described it as sounding 'simply heavenly'.

To get one of these (rather expensive) modules, you will have to turn to a third party vendor, Google it, to find the various options.

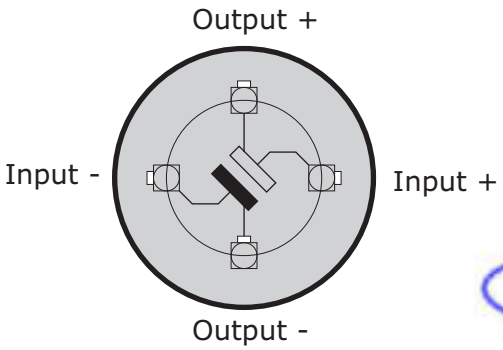
Be Careful...
When you experiment with alternative OP-AMPs we recommend you connect an old set of speakers the first time you start the amplifier up with a new OP-AMP. If it's not stable, you can get rather big bang's and DC on the output of your amplifier.
Remember to check the on and off noise with the new OP-AMP, as you can get a big bang at those times, with a partially unstable OP-AMP.
If no pop's are heard at on and off, and there is clean signal, the OP-AMP can be considered safe to use.

This is the OP-AMP, remove it by yanking it out carefully with a small screw driver. Check if all pins on the new OP-AMP are safely connected in the socket before connecting the power.



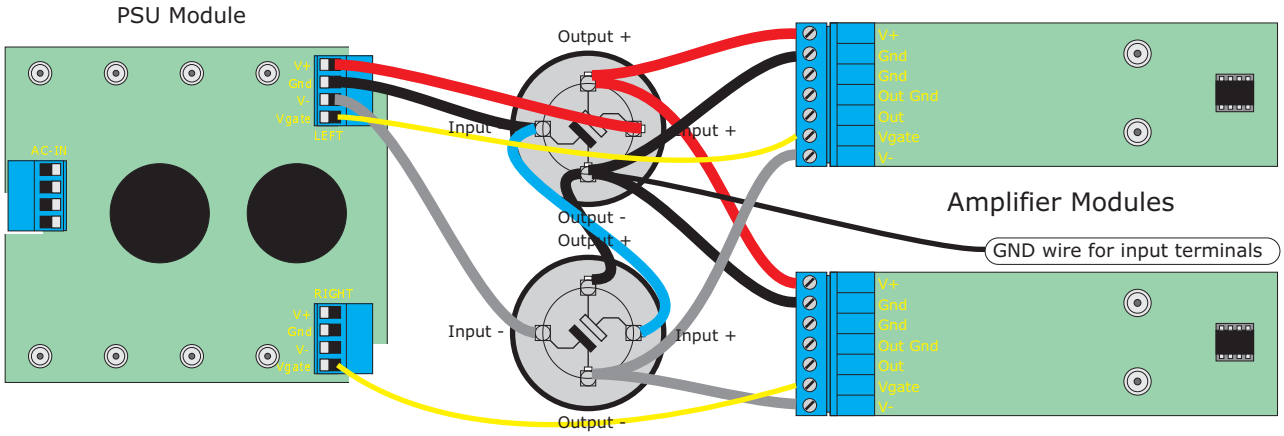
Using 4-pole capacitors. [OPTIONAL]
The use of special Audio Grade 4-Pole capacitors can enhance the sound quality of any amplifier, also the NewClassD. A 4-Pole capacitor effectively cuts off any high frequency noise from the power supply, making way for greater tranquility and microdetail in the listening experience.

The 4-Pole capacitors can not fit onto the NewClassD power supply PCB, but can fairly easy be mounted between the PSU and amplifier module. We then suggest to glue the 4-Pole capacitors in position, and connecting the terminals using a good quality solid core wire, of 12-14 AWG (1.5-2.5 mm2).



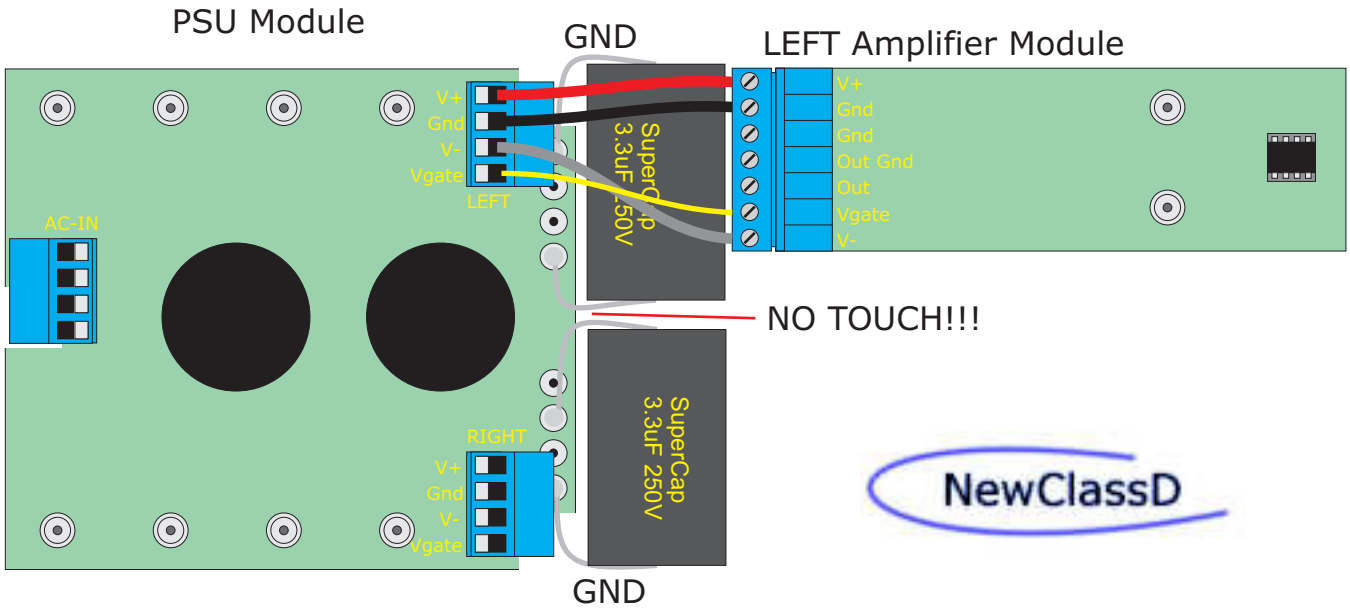
Pin Connections for the 4-Pole Capacitors

As can be seen, the 4-Pole capacitor has both input and output terminals. This should not confuse you, because it simply means, the power goes into the capacitor on one set of terminals, and out on another. The current then travels through the capacitor, to flow into the amplifier. The result is that seen from the amplifier, the capacitor effectively has no series inductance, but only capacitance. We recommend using DEXA capacitors.



Connections for NewClassD modules connected with 4-Pole Capacitors

Plastic Decoupling Capacitors. [OPTIONAL]
To optimize the sound quality, you can use plastic capacitors of good quality to decouple the power rails. This technique is well know in old-school audio amplifiers, and works just as well in Class D amplifiers. The NCD PSU module is prepared for installation of these plastic caps.



This modification will give your NCD amplifier a fantastic top, with softer and warmer voice reproduction. Use good quality capacitors. Many makes are available, in different qualities, and prices. MKP / Polypropylene types are usually regarded as the best and most expensive, but even MKT types have very good properties, and they are usually low in cost.
The exact type to use its a matter of taste, we recommend you use the types you prefer for your speaker crossover's treble section.

Use values from 3.3uF to 6.8uF for best result.

NOTE ! The power rails are facing each other on the PSU module, so the to wires in center between the two caps may NOT touch each other! Use a piece of wire tubing to insulate them both, and you will be fine. Keep the wires short for best sound result.