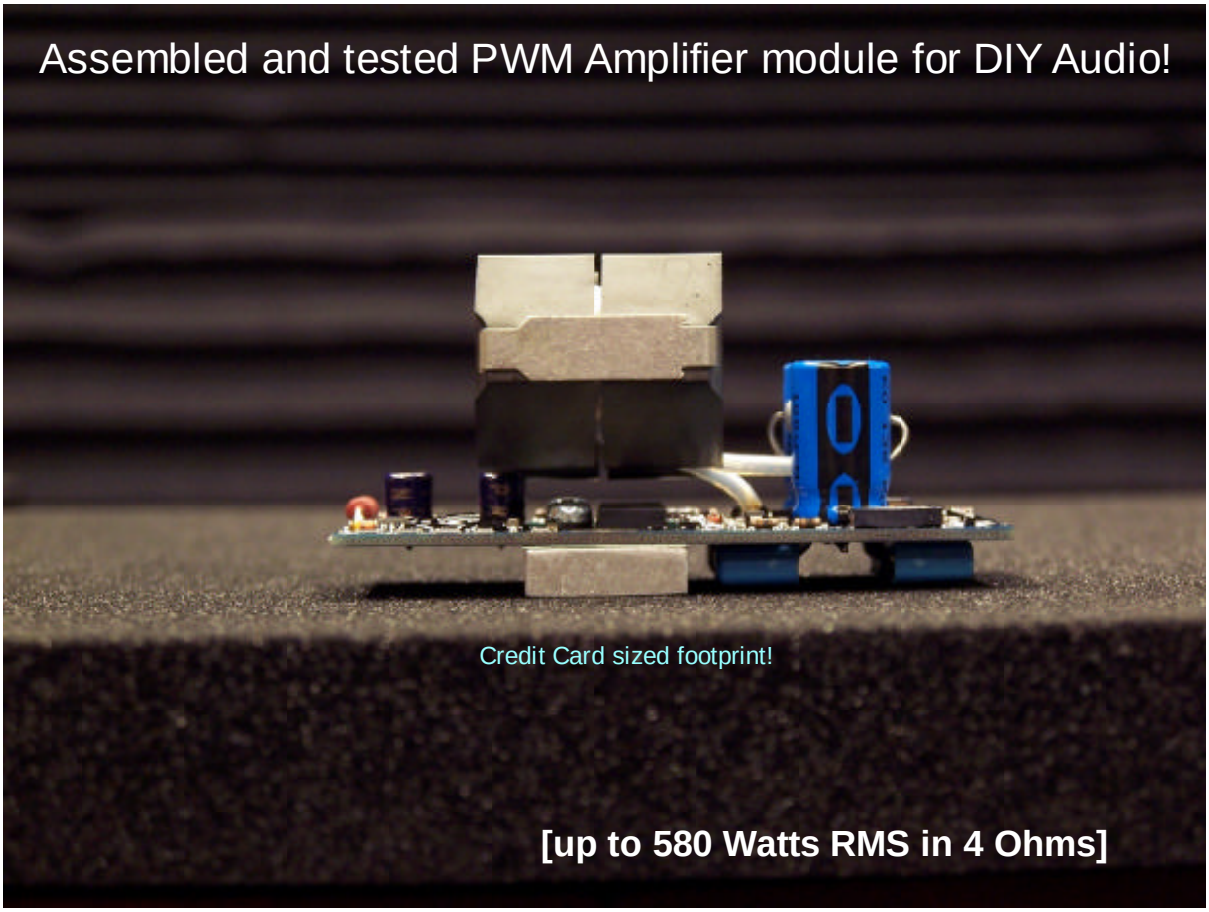
# ZAPpulse 2.2 Special Edition

And ZAPpulse 2.2 Standard

**COOKBOOK**

PulseField Technology

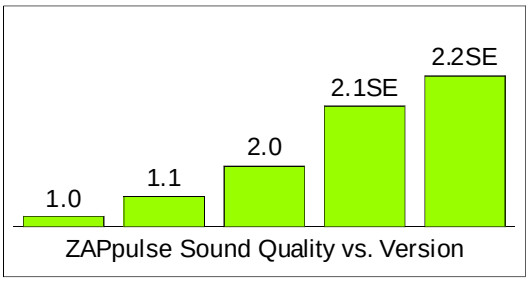


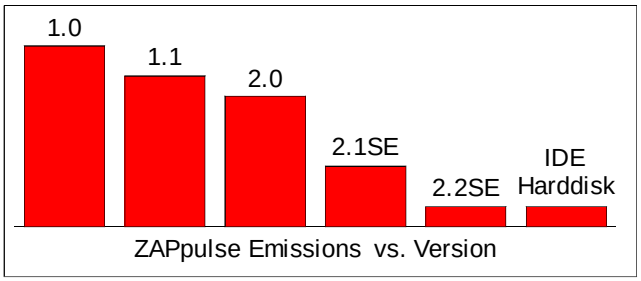

*ZAPpulse amplifiers represent the best in PWM (Pulse Width Modulation) amplifiers. Based on a single integrating modulator stage, the ZAPpulse has the shortest feedback delay of any PWM amplifier available on the market, allowing for best possible sound quality. These modules are ultra efficient at some 96% of the applied power is usable audio power! This means almost no heatsinking is necessary. Despite the small size these modules are incredibly rugged and will drive 2 Ohms and even lower impedances with no hazzle! Power exceeding 1 kW per module is fully supported! The input stage is fully balanced, without conversion circuits, so both balanced and unbalanced signals are equally usable. Sound quality is on level with market leading Class A amps!*

L C Audio Technology Inc.

## Content.



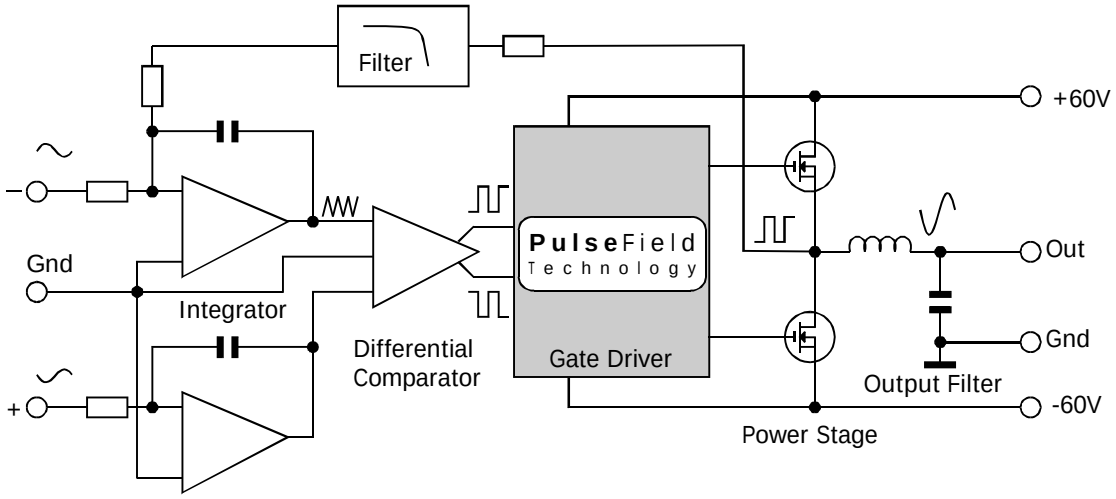



**More Informations: www.lcaudio.com**

## Principle of Operation.

*In a conventional amplifier the input signal is amplified through various analog stages to a progressively higher amplitude. In the final stages of the amplifier, the output stage, high current capability is added to enable the amplifier to drive loudspeaker loads. When current is drawn out of the output stage to the load, heat is dissipated in the output stages, since the load current multiplied with the voltage drop over the output device gives a power value (of average 60% of the max. output power) that needs to dissipate in heat sinks. 60% is not the power loss at maximum output power, but the average heat dissipated at various output power levels (except very small levels below 1W). So a 100 Watt amplifier will as average need to dissipate 60 Watts power into heat sinks. The ZAPpulse operates in a different way, the output devices are either off or on with no significant voltage drop. So even when the load draw large amounts of current, there is only minimal power to be dissipated. To control the signal amplitude, the pulse width of the output square wave is controlled very accurately.*




*After the output devices the square wave need to be filtered with a choke and capacitor. This filter regenerates an analog signal that can be fed to the loudspeakers. The choke and capacitor's quality is paramount in order to get a good sound quality, so we use an oversized (1.5 kW) ultra high speed ferrite core with silver conductor and TEFLON insulator. This choke has a very low impedance (only 5 milli Ohms), and allows for a good damping factor in any speaker load. To get an output signal of say 30V, the output devices are made to switch high 75% of time, and 25% of time low. In this case the Pulse Width is 75%. SinceV+ to V- voltage is 120V, the output voltage seen from V- is 75% of 120V = 90V as seen from the minus rail. Translating to 30V, above GND. (As wanted in our example. Operating from +60V to -60V allows for any output voltage in this range, including 0V. Thus a total DC coupled system for highest possible sound performance. Pulse Width Modulation is often shortened to PWM. A very important stage in a PWM amplifier is the modulator. It can be made i various ways, with different properties. We have selected and optimized the balanced integrating type.*

## More ZAPpulse Techtalk!

*The heart of the ZAPpulse amplifier is a balanced integrating PWM modulator. It basicly integrates the DC level of one switching cycle of the output stage, including any switching noises, slope differences etc. Then this value is compared, and corrected in the next switching cycle to create an output signal of exactly 0 Volt. This correction is performed every switching cycle, which is about 500.000 times per second.*

*The input signal is injected directly into the integrator to keep signal paths ultra short. No signal conditioning, such as DC blocking, HF blocking or other limiting factors are present on the ZAPpulse module. So if this is required by your application, you have to add these functions outside the module. When signal is applied to the input, the integrator no longer corrects the output signal level to 0 Volts, but to the audio signal.*
*The feedback group delay is kept very low, only around 1 uS, to allow for TIM free operation. The analog integrating feedback loop has a lower group delay of any completely digital (DSP based) feedback loop. And since output switching noise products are the same no matter the modulator type, the analog feedback loop gives a much better rejection of noise products than a true digital approach. It's all about speed, and how fast the noise can be cancelled.*

*The output square wave has a base frequency of typ. 460 kHz, and rise times of some 10.000 V/uS. The slopes are minimised to around 80nS to keep switching losses low at heavy speaker loads. However at low signal amplitudes the main power loss comes from capacities in the MOSFET's, so transitions are slowed to reduce EMI, noise and idle loss. This is controlled by the PulseField circuit in the Gate driver.*

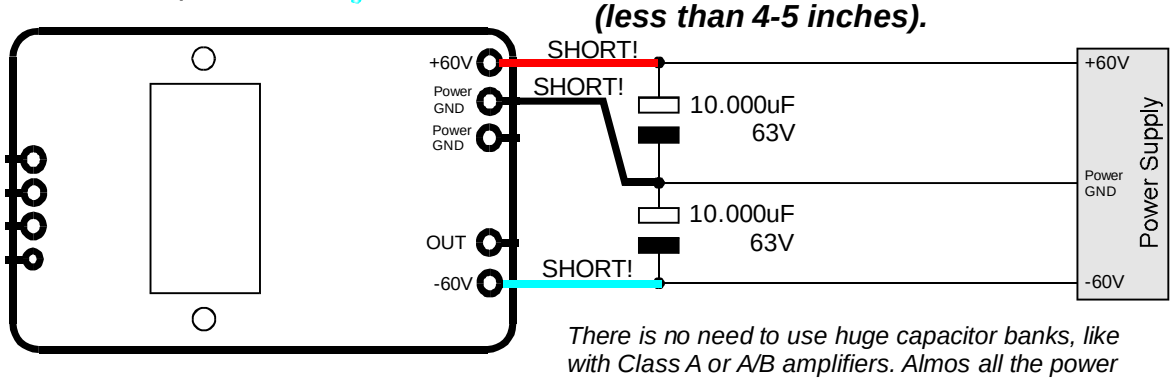
*A simple rule says that at no signal, a ZAPpulse loses some 9.5 Watts power to capacities in the MOSFET's, and at full power it loses another 9.5 Watts to serial resistance. So at 500 W out you only have to dissipate around 19 Watts to the heat sinks.*

*One great advantage PWM amplifiers have over conventional analog amplifiers is, that PWM amplifiers have exceptional ability to expand the sound stage with added sound level. An analog amplifier would typically collapse the soundstage at higher levels, depending on the size of the power supply (why we have huge power supply banks in all our analog amplifiers). The PWM will play with wide and deep sound stage at any listening level, even with a very (almost too) small power supply. We have made tests with a 2 x 250 W RMS ZAPpulse amp, running with only two 2200 uF 100V main caps. And it still has plenty of bass control, definition, width and depth. Opportunities for interesting experiments in this field are obvious.*

## Connection of a Power Supply

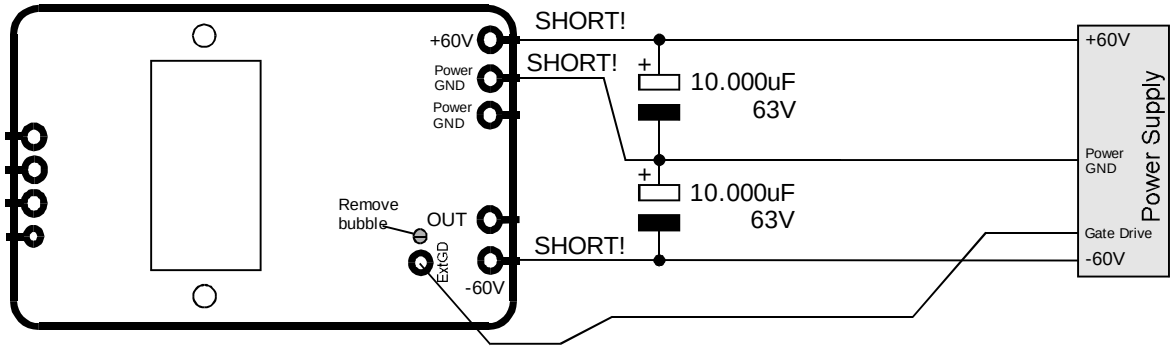
*To make ZAPpulse 2.2SE work, simply connect a typical Audio Power Supply of +/-35V to +/- 72V. (max. 60 V for the standard version). The output power depends on the voltage of the power supply. The 2.2 standard version uses 63V capacitors, on the board, while the 2.2SE uses 100 V caps. This is why the SE can be made to deliver much higher powers than the standard modules. In the standard version, the sound quality of the main caps must be considered.*

*The midrange and treble sonic properties of these caps, will interact with the overall sound performance of the amplifier, so we recommend using very high quality caps with standard modules. With the SE modules the mid and high frequency performance is fixed at the highest level by the BC Vishay series RLI136 (100uF 100V). So PSU caps only need to have good bass props.* ***Always use short and heavy wire between PSU caps and modules (less than 4-5 inches).***




*There is no need to use huge capacitor banks, like with Class A or A/B amplifiers. Almos all the power of the PSU will be translated to audio power, so smaller caps will work just as well. 10.000 uF is adequate for driving 2 channels at full power.*

## External Gate Drive.




The ZAPpulse 2.2SE module has an on-board Gate Drive regulator. It derives it's voltage from the negative -60V rail (why the negative rail has a higher consumption than the positive rail). By feeding a separate gate drive voltage from the power supply (15-20 V DC 200 mA) you can reduce the idle loss of a ZAPpulse module from 9.5W to 5W. This will make your amplifier even cooler! IMPORTANT! The Gate drive voltage (minus) must be tied to the -60V rail NOT to GND!

## Output Power vs. Power Supply Voltage.

*The Output power can be calculated as a function of the max. signal amplitude, which depends on the supply voltage. At +/- 60V Supply Voltage the amp can ideally deliver 120 Vpp. To calculate the output power we need the RMS value, which is simply 120 / 2pi = 120 / 2,82 = 42,6 Vrms (in this example).*
*Output power is then calculated using Ohms Law:*

$$P = \frac{U^2}{R}$$

*P = Output Power RMS*
*U = RMS Voltage (42,6)*
*R = Speaker Impedance (8)*

*In this example 223 watts RMS.*

*This was ideal values, in ZAPpulse the practical values are corrected with a serial loss of 1 - 3 VDC depending on load impedance (1 V @ 8 Ohms).*

*At +/- 60 VDC you will get a practical output power of: some 210 Watts RMS.*

*See below for output powers at other transformer voltages, and load impedances.*

*Bottom table shows bridge mode ZAPpulse modules operating at very high power!*

| Transformer AC V | DC Voltage | 8 Ohms Power | 4 Ohms Power |
|---|---|---|---|
| 2 x 24 V AC | +/- 32 V DC | 60 W | 106 W |
| 2 x 27 V AC | +/- 36 V DC | 78 W | 137 W |
| 2 x 33 V AC | +/- 45 V DC | 119 W | 222 W |
| 2 x 36 V AC | +/- 49 V DC | 144 W | 266 W |
| 2 x 40 V AC | +/- 55 V DC | 180 W | 340 W |
| 2 x 42 V AC | +/- 58 V DC | 200 W | 380 W |
| 2 x 45 V AC | +/- 62 V DC | 230 W | 438 W |
| 2 x 50 V AC | +/- 69 V DC | 286 W | 548 W |

*You can also Bridge-tie your speaker loads to get higher output power. For this you need 2 ZAPpulse modules per audio channel.*

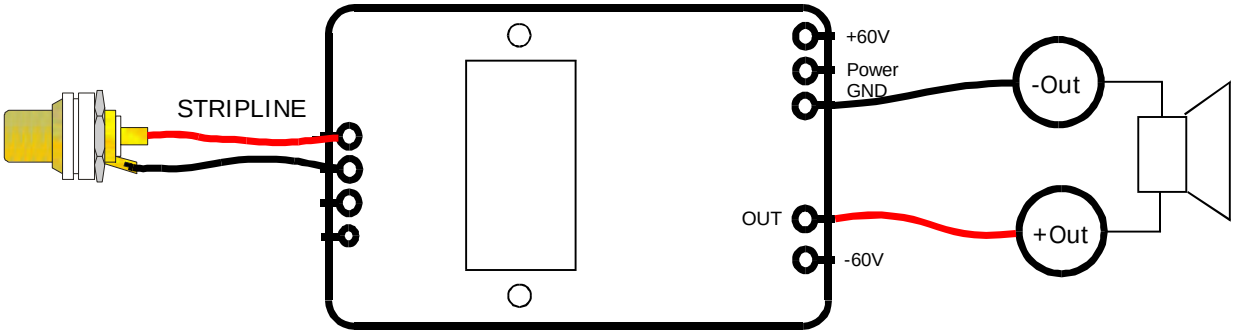
| Transformer AC V | DC Voltage | 8 Ohms Power | 4 Ohms Power |
|---|---|---|---|
| 2 x 24 V AC | +/- 32 V DC | 219 W | 397 W |
| 2 x 27 V AC | +/- 36 V DC | 286 W | 526 W |
| 2 x 33 V AC | +/- 45 V DC | 448 W | 837 W |
| 2 x 36 V AC | +/- 49 V DC | 542 W | 1019 W |
| 2 x 40 V AC | +/- 55 V DC | 682 W | 1291 W |
| 2 x 42 V AC | +/- 58 V DC | 758 W | 1439 W |
| 2 x 45 V AC | +/- 62 V DC | 879 W | **note** |
| 2 x 50 V AC | +/- 69 V DC | 1100 W | **note** |

**note**: Not recommended for safe operation of modules.

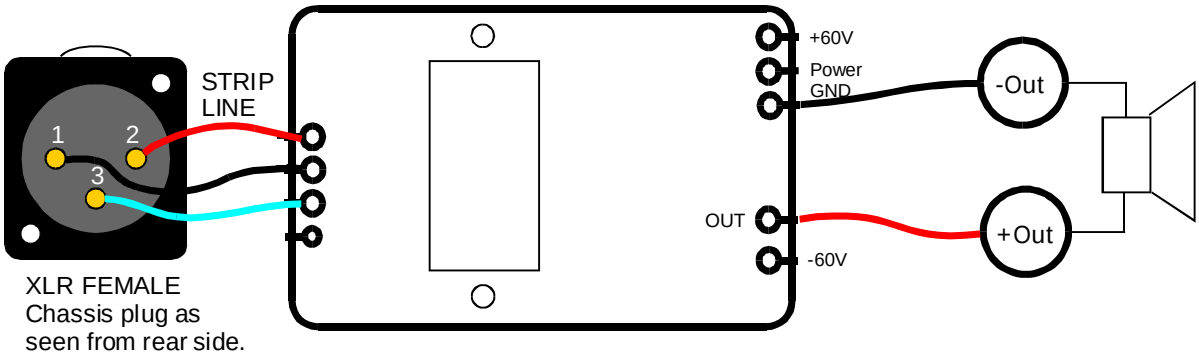
## Connection of In- and Outputs.

*Here you can see how inputs and outputs are connected to the ZAPpulse module .*

## Unbalanced Input.



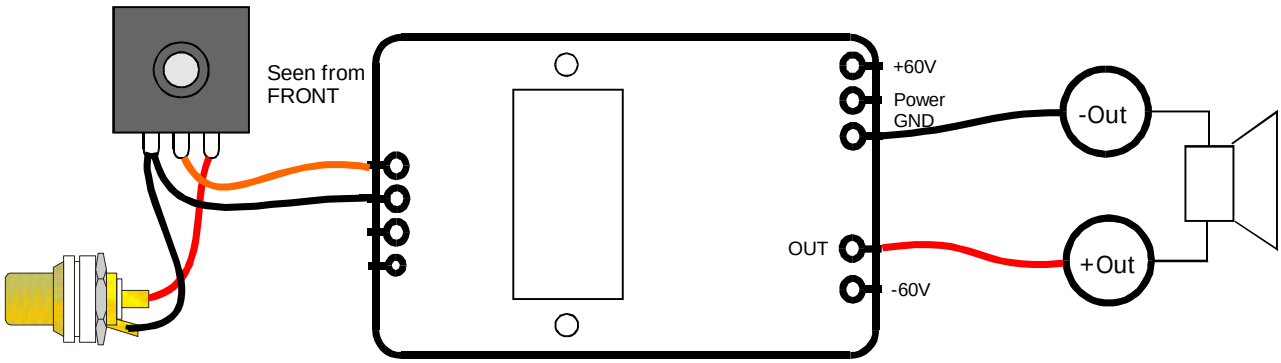

## Balanced Input




*If you want to ensure safe operation of your ZAPpulse module, dont let the input wires close to loudspeaker cable,power line cable, power transformers or the Ferrite coil. Dont leave long input wires unconnected.*

## Passive Volume control

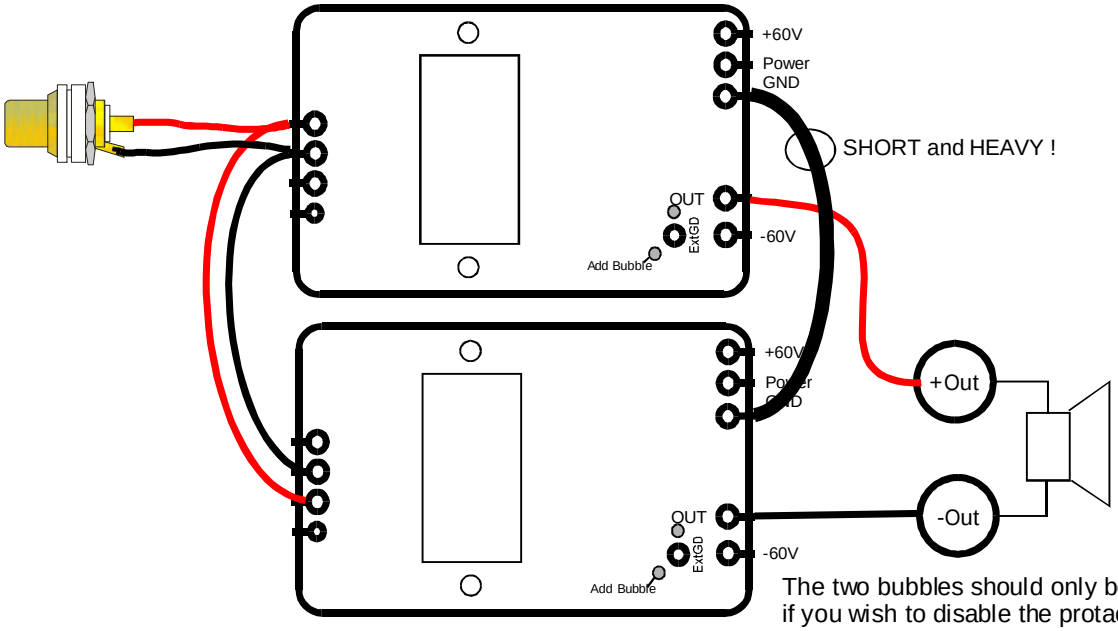
Potentiometer 22k log.



## Bridge Tied Load and disabling of Protection system.

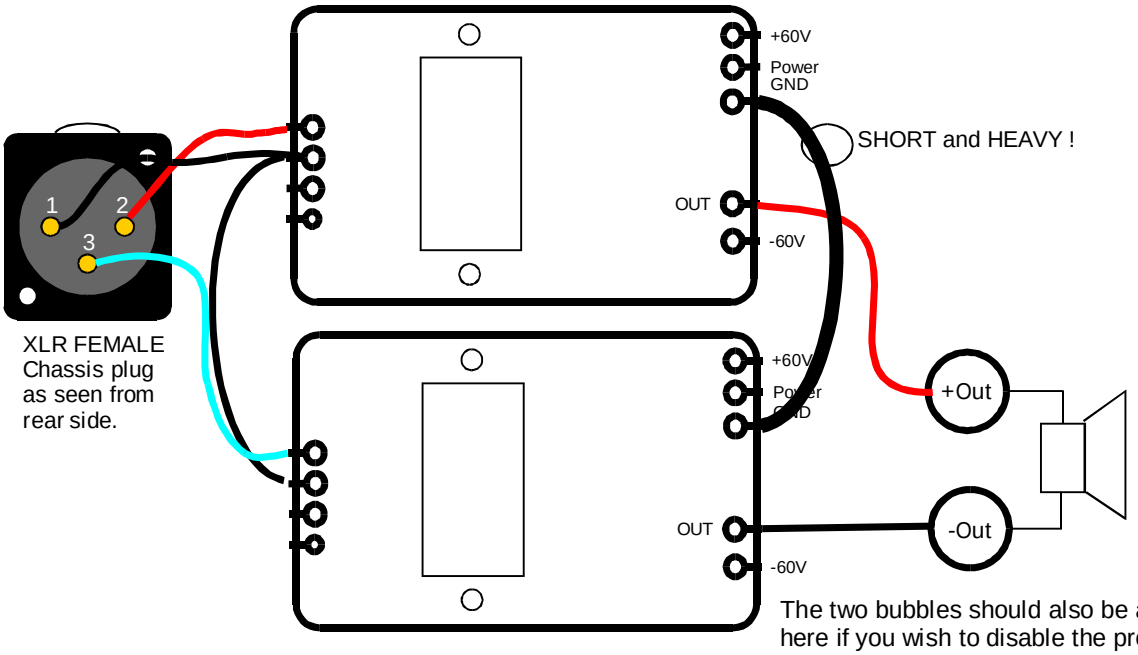
*Thanks to ZAPpulse's true balanced modulator it is very easy to BLT the modules. Due to the increased load on each module, you may experience pumping or fallout in the signal, this comes from the protection circuit. To avoid pumping simply disable the protection system as shown below.*

## Unbalanced Input




The two bubbles should only be added if you wish to disable the protaction system.

## Balanced Input



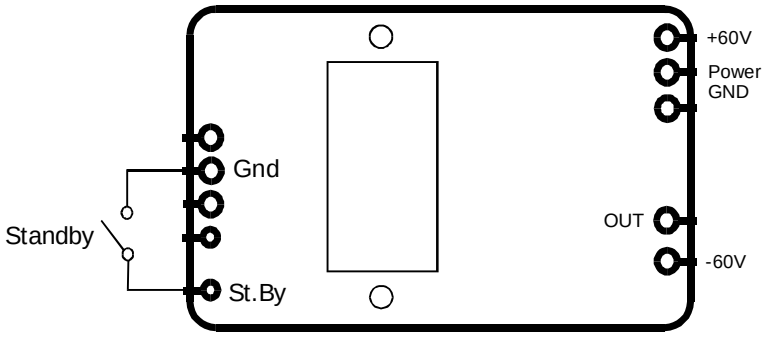

The two bubbles should also be added here if you wish to disable the protection system.

## Effects of the Switching Frequency.

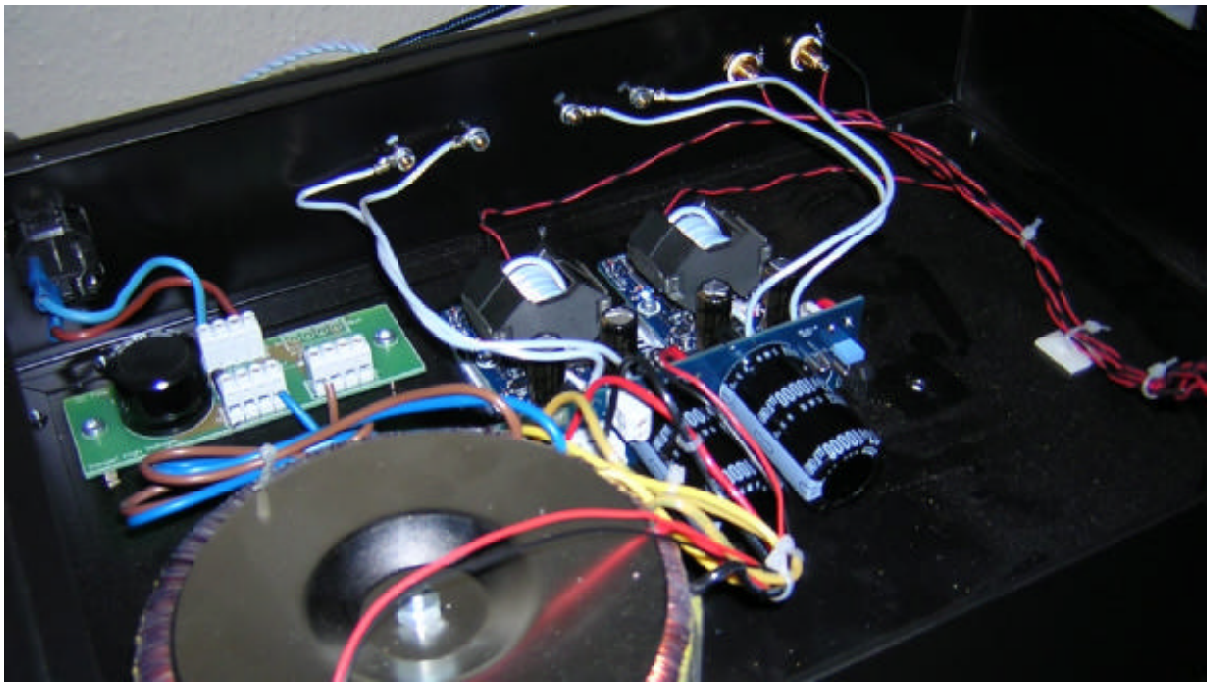
*The Switching Frequency is the number of switching cycles per second. It is NOT the same as the bandwidth of the amplifier! Higher switching frequencies may theoretically lead to higher resolution in the treble regions, but may also add switching noise and extra distortions. The free running frequency of a ZAPpulse 2.2SE is 460 kHz +/- 20 kHz. We recommend leaving the module in the free running mode unless there are special factors speaking for an external frequency control. This may be to have the module run syncronously with a D/A converter, or if you have several channels in the same enclosure.*

*In this case on or more of the modules may interact with the others to create a background noise. In this case you can syncronize the modules with a common clock, to eliminate the high pitch noise. More about this later.*
*In our experience there is really no incentive to run the modules at higher frequencies, as it will most probably not add to your sound quality.*

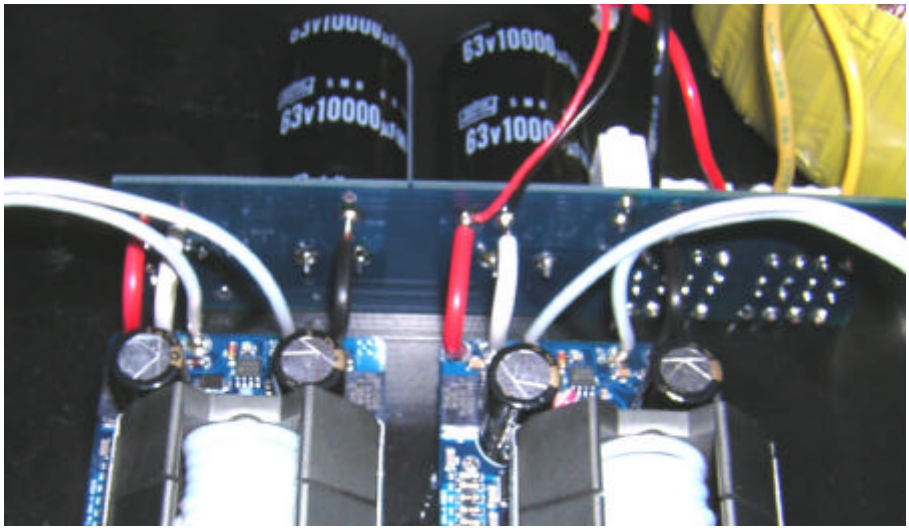
## Remote Shutdown.




ZAPpulse 2.2SE (og ZAPpulse 2.2) can be remotely turned on or off to a standby mode. In standby the module is halted, so the modulator stops, but the analog circuits are still active. The consumption in standby mode is roughly 4 Watts per module.
To let the module run, do nothing. To turn it off, connect St.By. terminal to GND with a switch, relay or collector of an NPN transistor (1mA). Several St.By. terminals may be connected directly to each other.



*This is how simple a complete 2x200 Watt amplifier with Volume Control can be built! The circuit in the upper left corner is a DC filter to avoid DC voltage on the powergrid to make the toroid transformer produce a mechanical hum. After the transformer there is a Predator power supply with rectifiers and 2 x 10.000 uF capacitors. Then the 2 modules, a potentiometer (for Volume Control) and input plugs.*
*For cooling is used the bottom of the enclosure, here in 1 mm. Steel plate with powder paint. This shows just how little cooling is required for high power operation.*




The Predator Power unit makes it really simple to connect modules to the powersupply. A Predator power supply also has on board external Gate Drive voltage, should you wish to use that option.

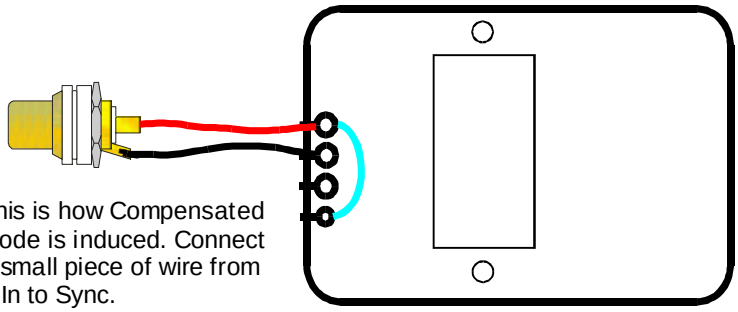
## Compensated Mode

*The output filter of ZAPpulse 2.2 is made with a choke and a capacitor. This means it is not only a 12dB / Octave filter, but at the critical frequency, it is also a suction network. This frequency is around 150 kHz, and will cause a signal peak of around 12-14 dB @ 8 Ohms load. (6 dB @ 4 Ohms). Completely out of audible range, but enough to cause some tweeters to sound sharp, even if ZAPpulse has a ruler straight frequency response to 70 kHz.*

*It is impossible to remove the resonance completely, but you can compensate for the peak, as shown below. With this small compensation, the frequency response will be straight from DC to around 180 KHz within 3-4 dB. (See frequency curves on page 13.)*

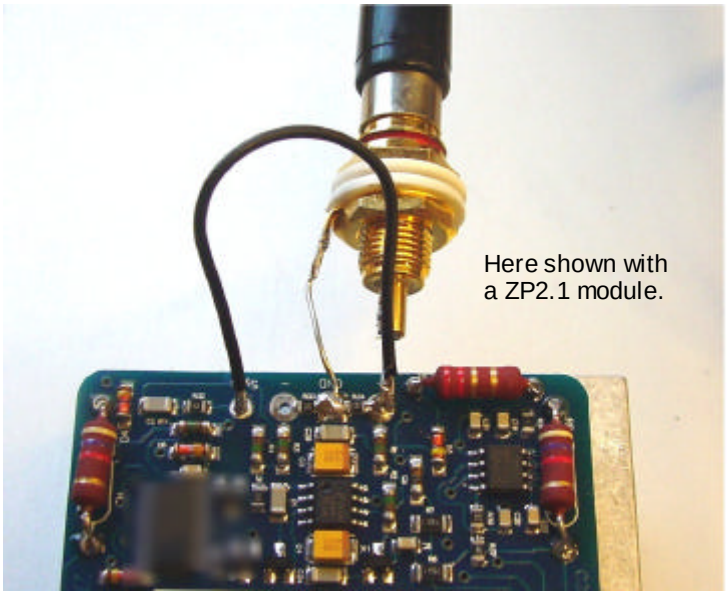
*So in case you experience a little sharpness in the treble, this simple compensation may be the solution.*

*You can alter the compensation or even make 1st order low pass filters by connecting a capacitor from + input to - input. (Resistor is 17k0).*



This is how Compensated mode is induced. Connect a small piece of wire from +In to Sync.

You can also connect a 100 pF capacitor from + input to - input (only in case of unbalanced input signal).



Here shown with a ZP2.1 module.

# Tekniske Data

## Absolute Maximum Ratings

Operating Temperature .....0 - 70°C

Storage Temperature .....-10 - 70°C

Supply Voltage Power .....+ and - 63 V

Supply Voltage Power (2.1 SE) .....+ and - 75 V

Input Voltage .....+/- 15 V

Output Current DC .....+/- 22 A

Repetitive Output Current <100mS ..... +/- 44 A

**LEGAL and WARRANTY NOTICE**
Use of this product is at own risk and liability. No legal liability is assumed by producer, distributor, wholesaler or any other staff or associate of L C Audio Technology. Warranties cover any failure, occuring when product is used within maximum ratings bounds, and as shown on application notes.
If product is stressed beyond these limits, the warranty is void.
We direct your attention to high EMC levels of this product may affect other electronic systems, such as pacemakers, life support systems in vicinity, TV and radio reception equipment, computers, and other electronic equipment.
In such cases where any disturbances occur, the risk and damages are fully assumed by the user of the product.
Warranties do not cover any other item than the product itself, even in cases where failure can be traced to the producer.

## DC Characteristics

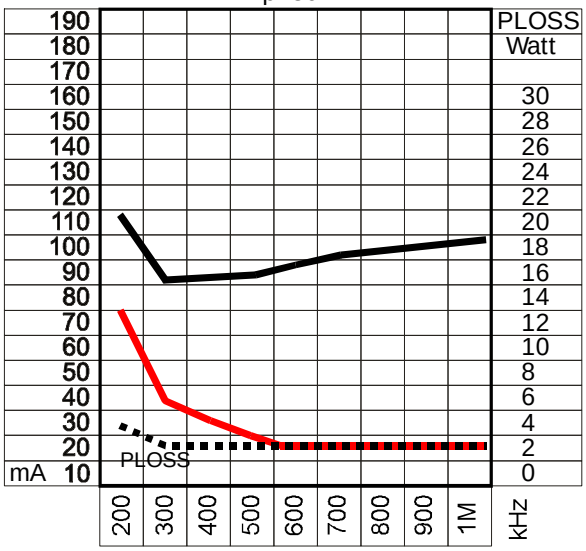
| Symbol | Parameter | Condition | Min | Typ | Max | Units |
|---|---|---|---|---|---|---|
| Vp | Main Supply Voltage | | 35 | | 60 | Volts |
| Vp | Main Supply Voltage | 2.2 SE | 35 | | 75 | Volts |
| Ip0 | Main Supply Idle Current | Fsw=500kHz 45V | - | 38 | 60 | mA |
| Ip0 | Main Supply Idle Current | Fsw=500kHz 45V | - | -110 | -142 | mA |
| Ip0 | Main Supply Idle Current | Fsw=500kHz 60V | - | 50 | 74 | mA |
| Ip0 | Main Supply Idle Current | Fsw=500kHz 60V | - | -120 | -160 | mA |
| Zin | Signal Input Load | | 14,8 | 17,0 | 47 | kOhm |
| Zout | Output ESR | Vp- << Vo << Vp+ | | 6 | 10 | mOhm |

## AC Characteristics

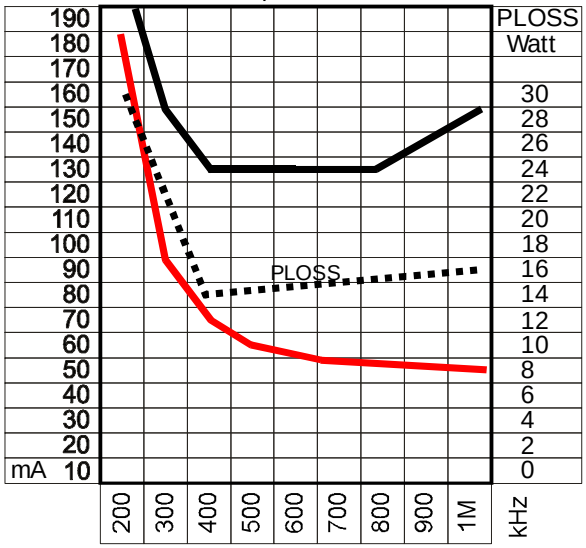
| Symbol | Parameter | Condition | Min | Typ | Max | Units |
|---|---|---|---|---|---|---|
| G | Voltage Gain | | 40 | 41,2 | 43 | |
| GdB | Gain dB | | 32 | 32,3 | 32,7 | dB |
| IN | Equivalent input noise | BWL 20-20.000 Hz | | 200 | | uV |
| Fmax | Signal Bandwidth | 8 Ohms +/-3dB | 80 | 91 | 100 | kHz |
| Fmax | Signal Bandwidth | 8 Ohms +0-1dB | 60 | 62 | 70 | kHz |
| Fmax | Signal Bandwidth, Comp. | 8 Ohms +/-4dB | 160 | 180 | 200 | kHz |
| LD | Load Impedance | 20 - 20.000 Hz | 2 | 8 | 32 | Ohms |
| LDD | Load Impedance | 5 - 100.000 Hz | 2 | 8 | 16 | Ohms |
| THD | Total Harmonic Distorsion | BWL 20-20.000 Hz | | 0,03 | tbd | % |
| OD | Output Damping Factor | 8 Ohms | 200 | 250 | 320 | |

## Typ. Idle Consumption.

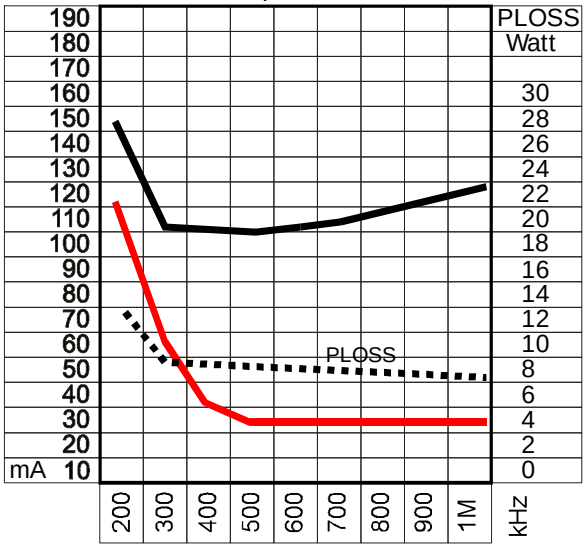
Vp=30V



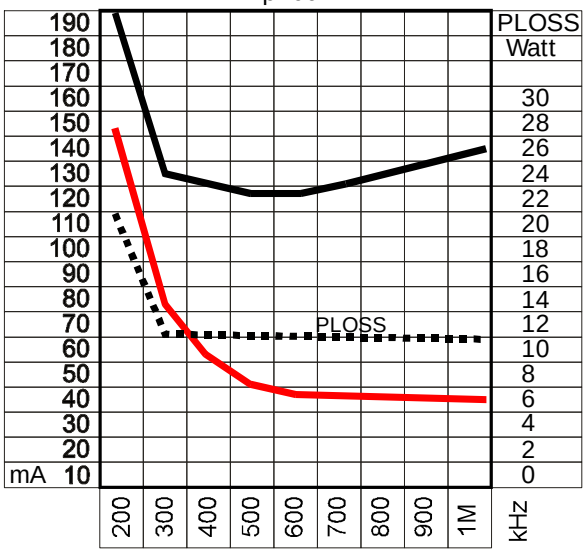

Vp=75V



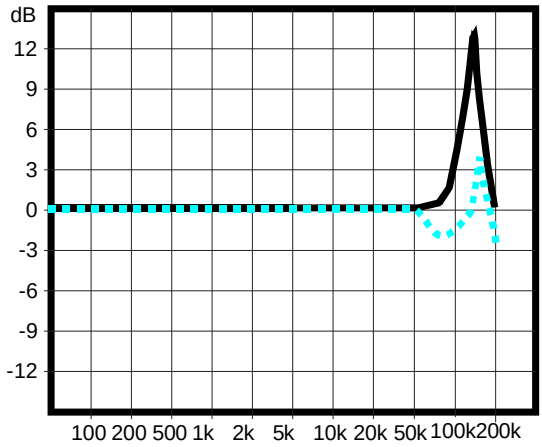

Vp=45V



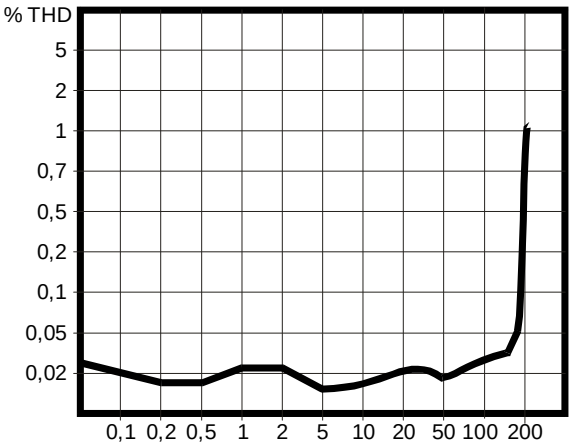

Vp=60V



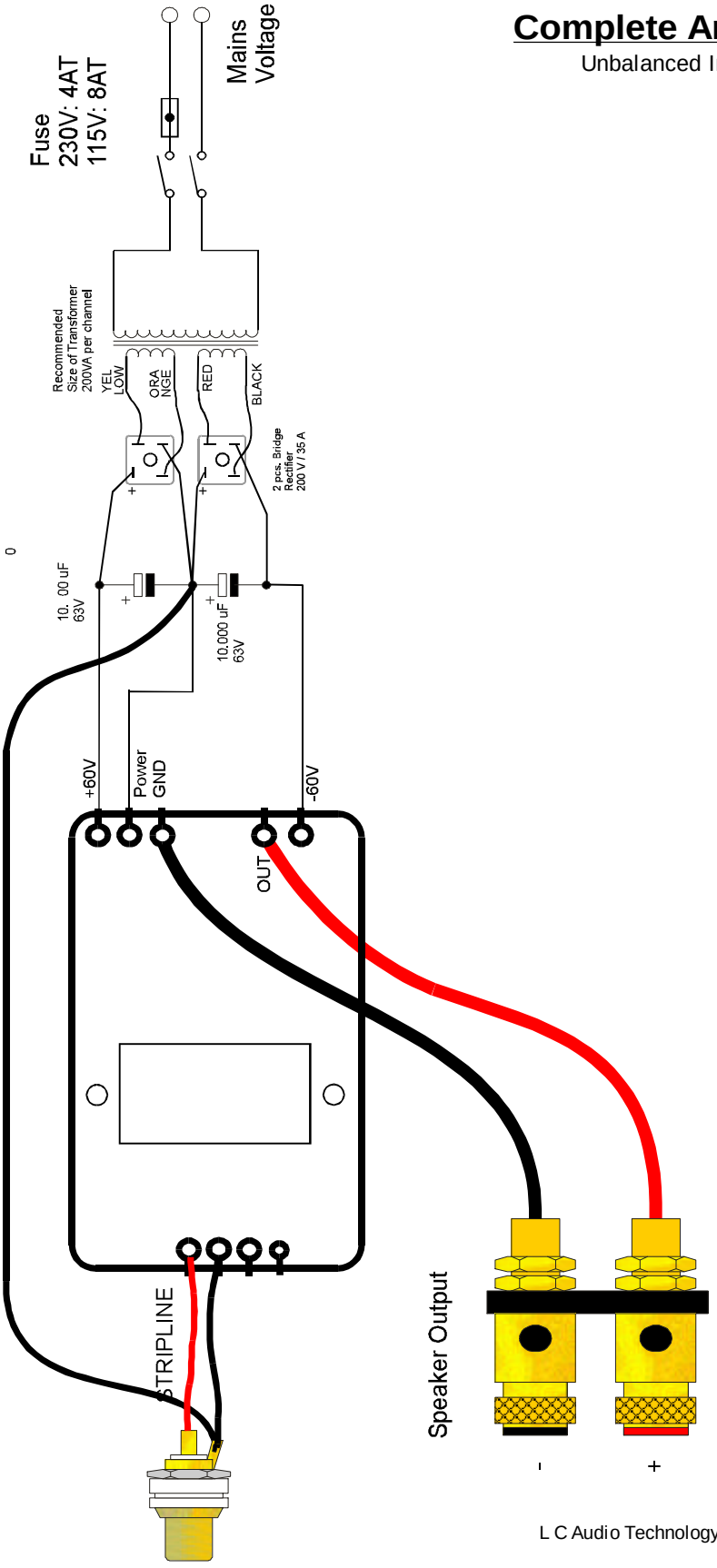

## Frequency Response and THD

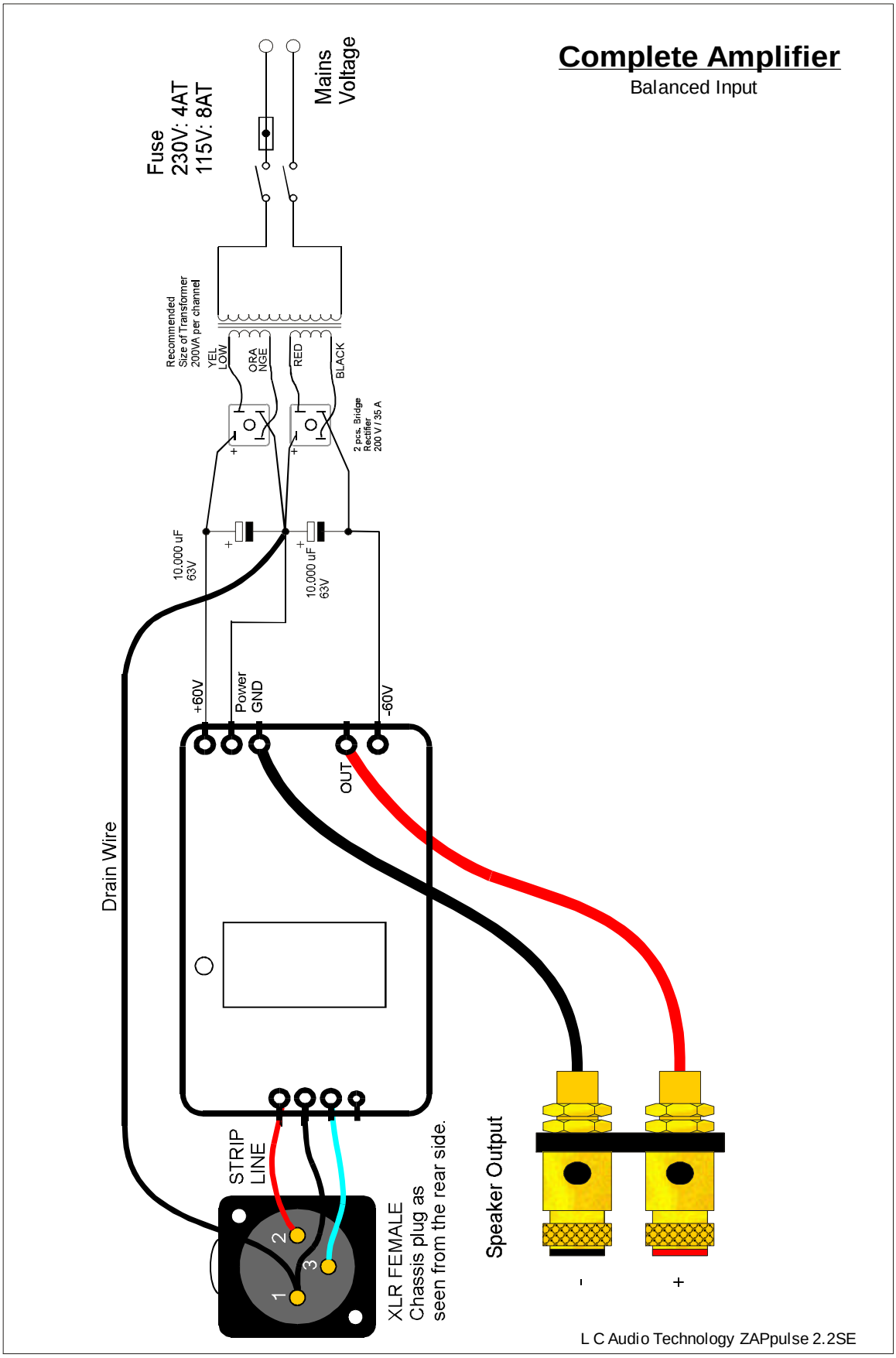



**Frequency Response**
**(dotted is Comp. Mode)**



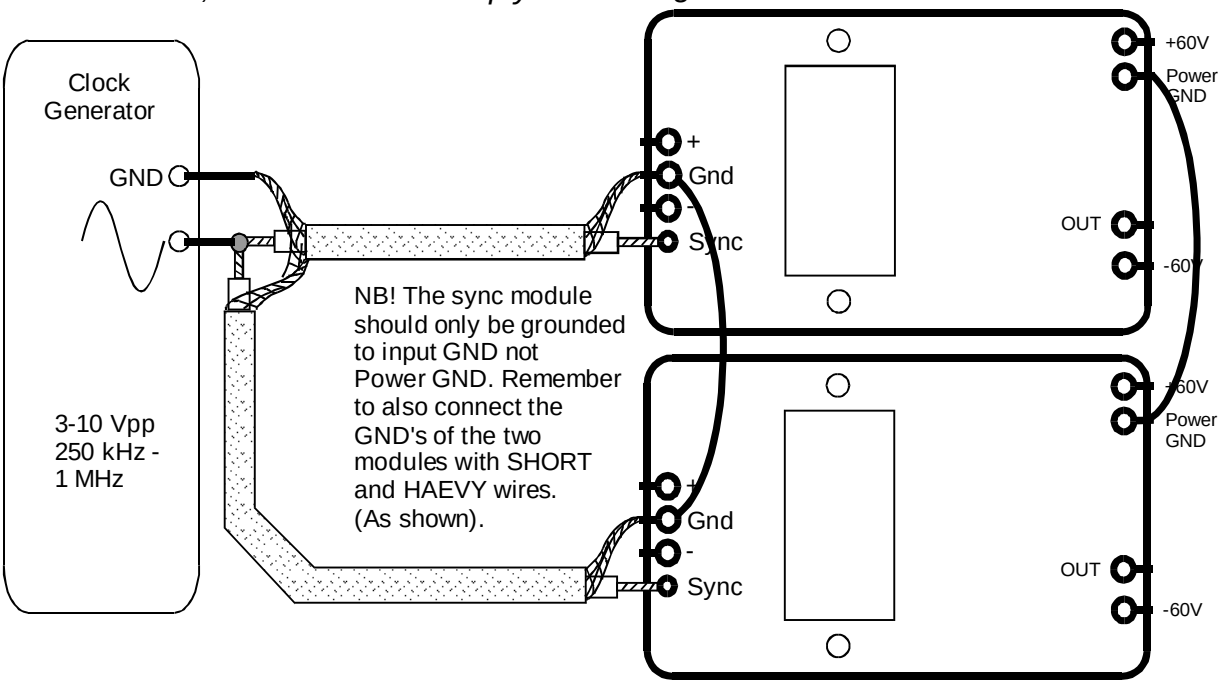

**THD + N vs. Output Power 1 kHz 8 Ohm**

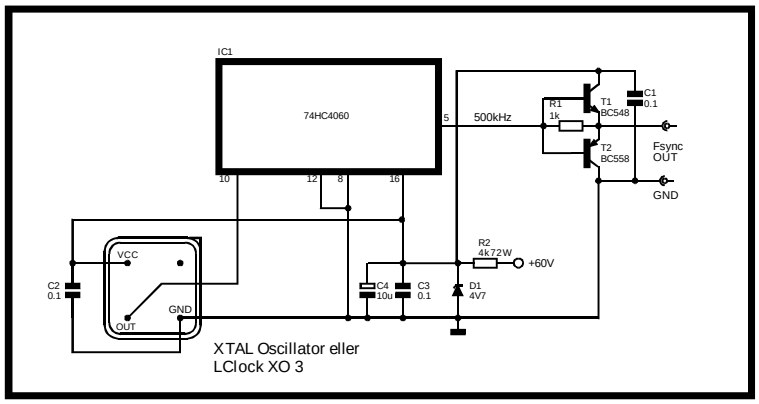




## Sync Mode.

*If you simply connect ZAPpulse modules to a power supply, they will run in the free running mode, at some 460 kHz. This works fine, but in some cases it is beneficial to alter or syncronize the switching frequency. Especially if you have several channels in one enclosure, the sync mode will reduce the total EMC noise, and eliminate background noises from magnetic interference inside the ensclosure.*
*We ONLY recommend sync'ing in cases where you have 3 or more channels in one enclosure, at 2 or less it is simply not necessary or beneficial.*
*To sync the module add a squarewave or sine wave of the sync. freq. to the sync. input. Each modules load is 22k. At 460 Khz the module will sync at a few hundred mV, but the further from this freq. the higher amplitude is required. At 1 MHz you may need as much as 10 Vpp to sync. To avoid mode jumping (sometimes heard as a crackling noise in the treble speakers, when playing at high volume), you must make sure the sync signal is removed at high volumes.*



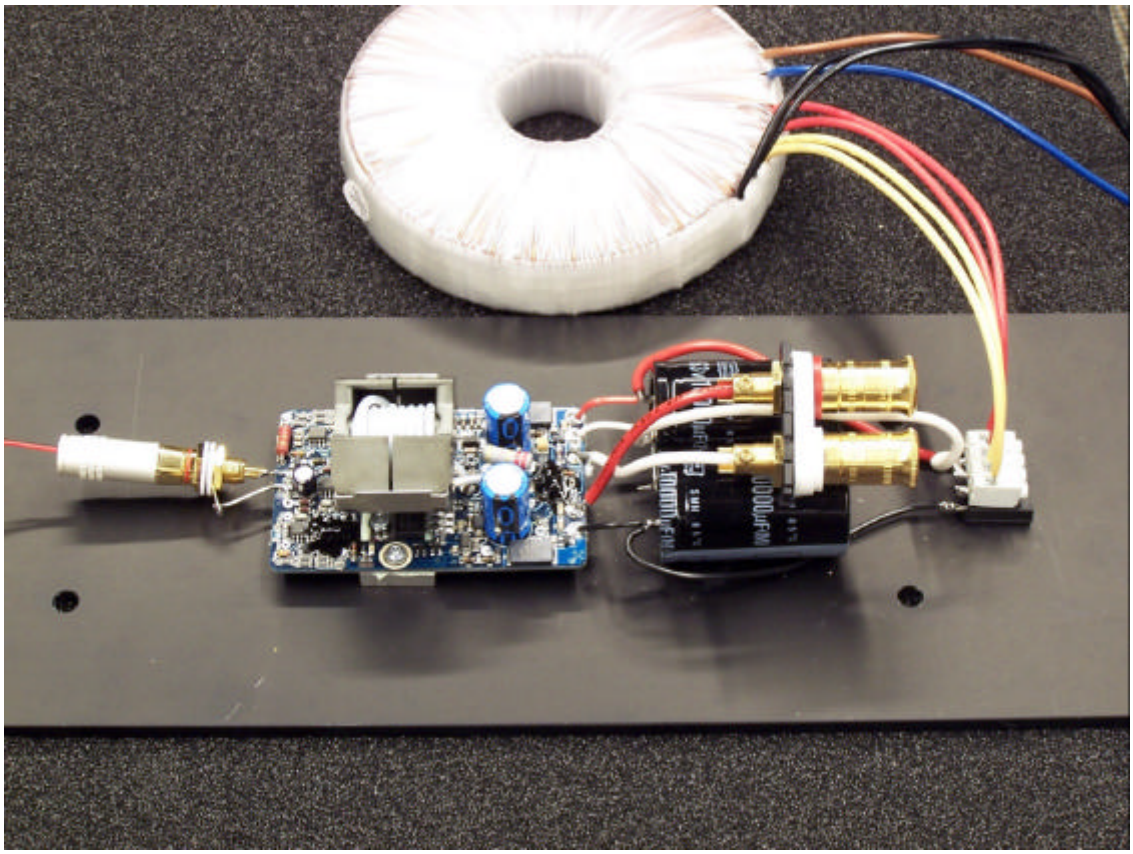




*This is a recipe for a good clock generator. The amplifier is not jitter sensitive, so you can use a normal metal can clock generator of 16.9344 MHz for input. If you also sync the amplifiers with your CD player, we recommend using a better clock, like LClock XO3.*
*The +60V can be connected directly with main power supply of the amplifier. (30 V - 75 V will work just fine).*

## Heat Sinking.

*Cooling requirements depends on the applied supply voltage, as most of the heat is generated in idle mode, with no load. If you want to be sure to have appropriate cooling, simply use a A5 size (½ Letter) size aluminum sheet per module. But less will most probably do. A 200 Watt stereo amplifier can be cooled just using the bottom of a thin steel sheet 19" Rack enclosure (42 x 30 cm). Even playing at full power for extended periods will not thermally overload the ZAPpulse amplifier.*
*So the obvious cooling solution would most often be to place the modules on the enclosure floor or side walls.*
*With smaller power supplies of +/- 35 - 40 V which gives powers of 50 - 80 Watts in 8 Ohms, no heat sinking or cabinet fastening is called for at all.*
*Not all power is dissipated in the heat sink, some 3 Watts are dissipated in the power resistors on the board, and 1-2 Watts in the filter choke all depending on signal load.*

*A thermal protection circuit will shut the module down at around 100 deg. C.*

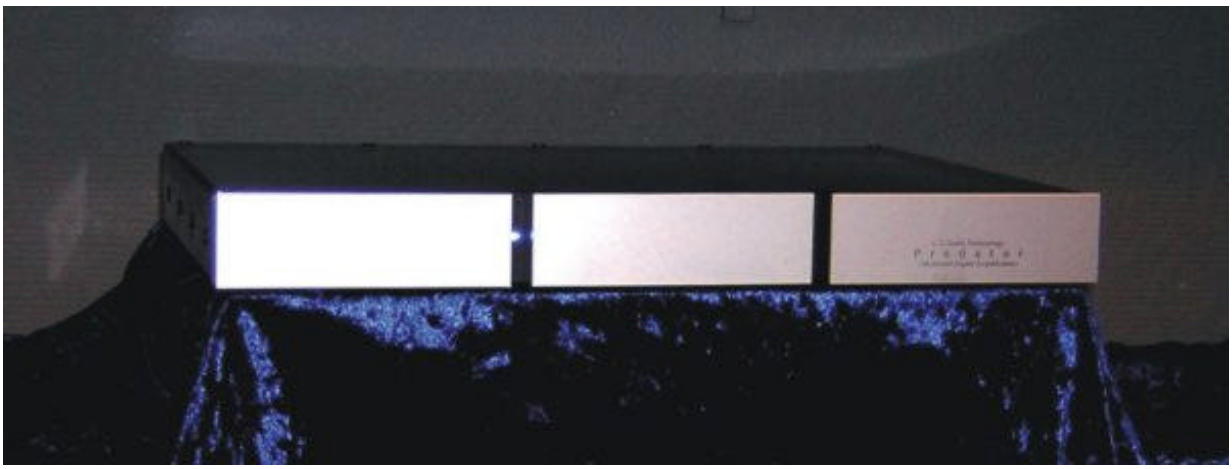


## Minimalist System...

*To run the ZAPpule 2.2SE module only require in/out plugs, a pair of capacitors, rectifier and a transformer.*

*Here shown above a 200 Watt mono block. The heat sink shown here is vastly oversized.*

Even the description is minimalistic :-)



Predator SE is based on ZAPpulse 2.2SE

## Shopping List.

Here is all you need to build a complete working amplifier (2x200 Watts in 8 Ohms and 2 x400 Watts in 4 Ohms:

2 pcs. ZAPpulse 2.2SE
1 pcs. Predator Power Supply Unit
2 pcs. Pancake Transformer 2x42V + 15V
2 set Speaker Terminal
2 pcs. RCA phono plug
1 pcs,. Mains fused inlet with fuses.
1 pcs. Enclosure (Metal).

Optionals:
2 pcs. XLR Female connectors
1 pcs. DC Filter for Mains
1 pcs. Sync. Module
1 pcs. Blue LED
1 pcs. Potentiometer 2x22k log for volume
1 pcs. Active X-over

## Surround Amplifier

*ZAPpulse 2.2SE is ideal to build multichannel amplifiers. The small size and lack of heat sink requirements allows for very compact applications of 5 - 7 or 8 channel amplifiers with high power. Enough power and performance to meet professional Cinema requirements.*
*Our V4P power Supply board is perfect for multichannel amplifiers, as it has connection for up to 8 channels. For normal use one 500 VA transformer is enough to drive 5 channels of 200 Watts RMS (total 1000 Watts Audio Power) because there is no thermal loss in the amplifiers, and even if the power at clipping level is 1000 Watts total, the average power cointent of a signal integrated over a period of ½ hour (thermal time constant of the transformer), is only less than 50%.*
*A complete 5 ch. 200 Watts can be built for around 1500 USD. A bigger professional Cinema amplifier with 6 ch. 200 Watts plus 1 ch. 800 Watts sub. and 1.5 kW transformers can be built for around 2500 USD.*

***Active Crossover.***
*Another obvious application for ZAPpulse 2.2SE is a system amplifier where the crossover is made with small signal parts, before the amplifier stage. The advantages of this are many. First the cross over parts cost close to nothing, so it is cheap to experiment. The damping factor is optimal in the entire freq. range, whereas in passive x-overs, the damping factor is very poor in the cross regions. Very high sound pressure levels can be achieved, with this method, as you can not hear if the bass amp. is clipping as long as the mid. amp. is not. This effect is used in Rock Concerts as it is much more efficient than bridging amplifiers to huge output powers. In this way there is no need for passive x-over networks in the speakers, the ZAPpulse amps are connected DIRECTLY to the speaker driver. (There is no significant pop noise at power up / down).*

*The filter board with 1 - 2 - 3 or 4th order high and low pass filters plus level control for each output and powersupply can be purchased from us at only the price of one good filter coil. (USD 160).*

*See*
*www.lcaudio.dk/com/index.php?page=13*

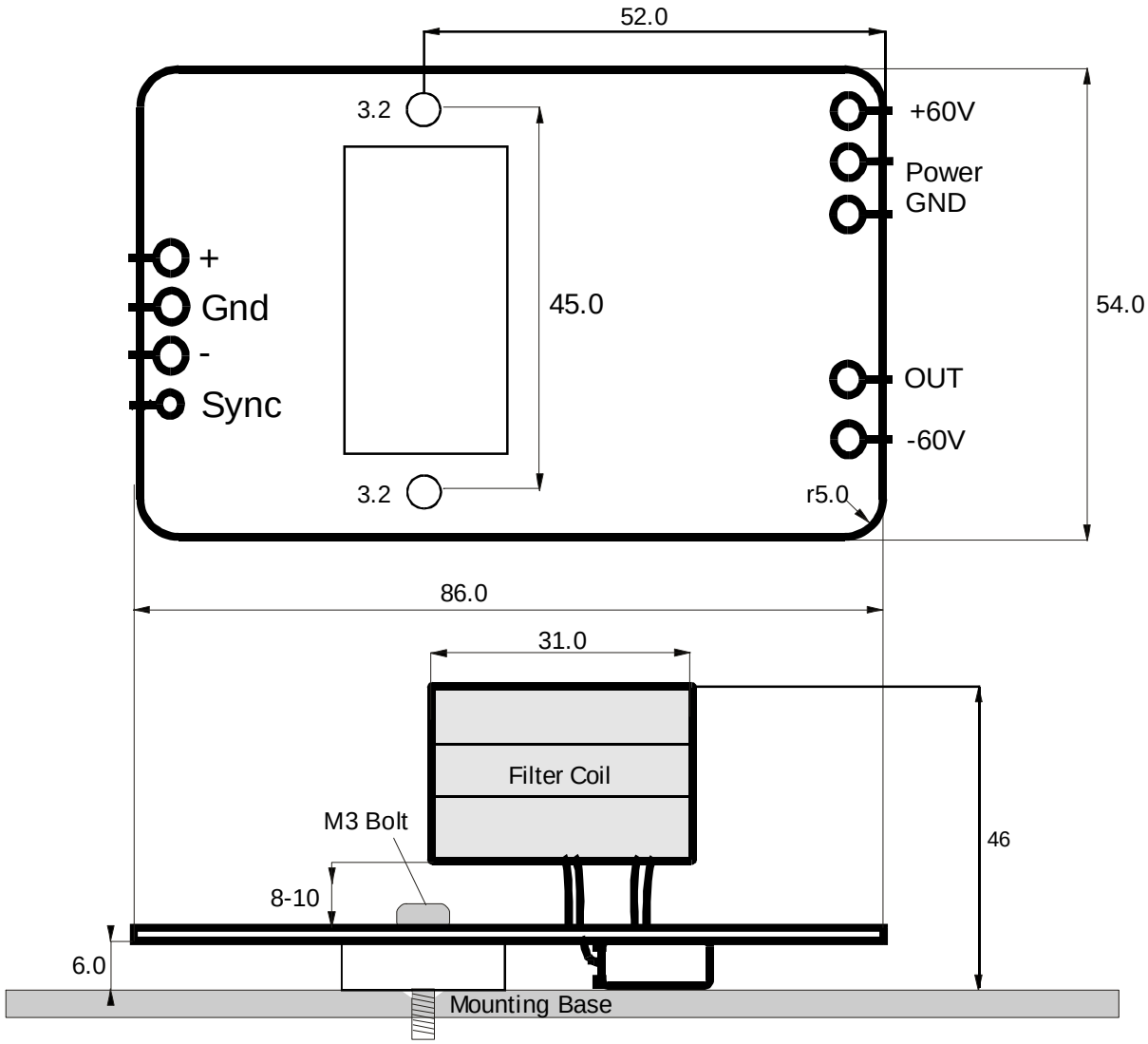
*A First order simple filter can even be made with only the ZAPpulse module and one capacitor. HP or LP.*

***Professional Use.***
*Despite the small size of these modules, they are extremely rugged. They can produce vast amounts of distortion free and clean Audio Power. The lack of heat dissipation means it's hard to overload a ZAPpulse module.*

*Balanced input and short circuit protection are standard professional features on every ZAPpulse module. To allow for trouble free field operation we recommend building in DC blocking and HF filtering on the input.*
*Simply connect a 470 nF and 1kOhms in series with each signal input, and 1n from each signal to gnd (after the 1k Ohms).*

*A ZAPpulse 2.2SE will sound much better than a normal PA Amplifier, and no cooler fans, heavy power supplies or huge heat sinks are needed at all!*

# Mekaniske Mål og  monteringsinformation.




L C Audio Technology Inc

**NOTES on mounting of ZP 2.2SE Modules..**

The mounting surface should preferably be of heat conducting metal such as Aluminium, Copper, Brass or other semi or high conducting metals.

Surface must be smooth, and free drilling particles, oil, liquids and dirt.

When mounting on rough or painted surface, use a standard heat conducting grease.

The M3 hole in the mounting base must be cleared with a 0.5 mm. recession to avoid metal splinters from tilting the modules.

The aluminum block on ZP0202 is electrically isolated, and conducts no voltage.

Fasten mounting screws tightly, and assure they have a tight grip in the mounting Base.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