CxD2160 Audio Amplifier Module

CxD2160 Audio Amplifier Module is a Stereo Class D Audio Amplifier plug&play amplifier module based on IRS2092S dedicated audio power amplifier driver made by International Rectifier. The amplifier is optimized for 8Ω speakers and is capable to deliver 160W on each channel with less than 0.1% THD at rated power and as low as 0.024% THD at 10-80W power range, when is supplied from any of our RxE series power supply with +-55V regulated voltage plus corresponding aux. voltages and control signals required for proper operation.

CxD2160 Audio Amplifier Module is a very compact Audio Amplifier module, with just 100mm long, 50mm wide and 32mm tall. When is supplied from the smallest dedicated power supply, SMPS320RxE which has the same size as CxD2160 Amplifier module, a very compact class D power amplifier can be built. CxD2160+SMPS320RxE offers a complete solution for a compact, medium power audio amplifier system used for DIY built amplifiers or even OEM production amplifiers.

Amplifier Features:

- Output Power: 166W at 8Ω, with max. 0.1% THD+N, @ ±55V regulated voltage + required Aux. voltages.
- Output Power: 4Ω capable with extended heatsink: 214W 4Ω, with max. 0.1% THD+N, supplied by SMPS500RxE or SMPS600RxE with output voltage configured for ±55V + required Aux. voltages.
- Up to 400W on 12Ω impedance in BTL mode supplied from a single SMPS500RxE ±55V + Aux. voltages.
- Audiophile sound Quality: 0.024% THD+N at 68W on 8Ω impedance on all audio frequency range.
- High efficiency: Up to 92.4% at 2x186W, 8Ω with max. 1% THD or 93.2% at 2x204W, 8Ω with 10% THD.
- Full Protection set included: Short-circuit, over-current, over-temperature, over-voltage, under-voltage, active DC speaker protection with instant SMPS latched shut-down, clock/pop free turn ON/Off.
- Quick and easy BTL operation without any additional signal phase shifter interface. Recommended BTL load impedance is 12-16Ω.
- Dedicated auxiliary supply and power sequence control to maximize performance and increase efficiency.
- Mute control and DC fast disconnect pins for interfacing the amplifier with the dedicated RxE series SMPS.
- Very compact size 100x50mm, and 32mm tall including PCB board thickness and SMD components under.
- Multi-channel setup possible using from two CxD2160 Amplifier Modules powered from a single SMPS600RxE up to 6 CxD2160 Amplifier Modules powered from a single SMPS2000RxE ±55V + Aux. voltages.
- Dedicated connectors for power, Aux supply, Signal and Outputs for quick and easy installation, no soldering required on the CxD2160 Amplifier board.
- Fully balanced input with 1.5V rms for ver.2 or 0.775V rms for ver.3 input sensitivity for rated output power allows easy and straightforward interconnection with standardized commercial audio sources.
- User accessible, easy to use Mute pin and Mute On-board LED to indicate the status of the amplifier.

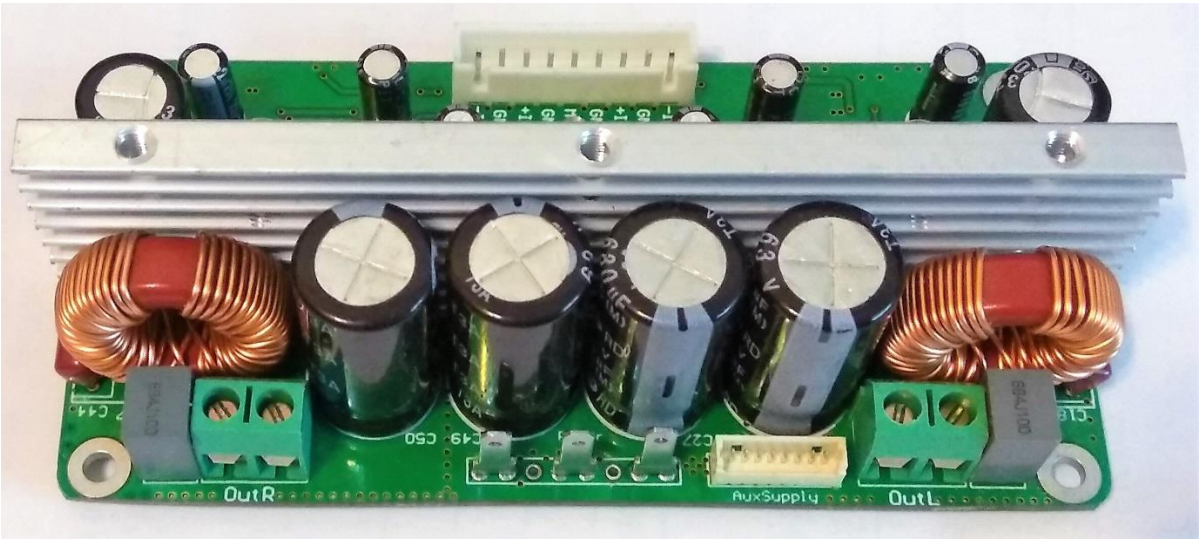


Figure 1: CxD2160 Amplifier Module appearance

Amplifier Description:

The cores of the CxD2160 Audio Amplifier are two IRS2092S IC's, dedicated Class D Audio Power Amplifier driver, one for each channel as well as several other components to allow system integration.

The main blocks of this amplifier are:

- Input stage, which contains one low-noise high performance Operational Amplifier for impedance matching and to allow both balanced and unbalanced input connections;
- Amplifier Power Stage, built around IRS2092S dedicated Class D amplifier controller, one for each channel plus the Class D dedicated dual-transistor MOS-FET;
- House-keeping power supply, control and protections circuits and dedicated SMPS interface circuits.

Input Stage: The audio input signal is provided to CxD2160 through the Signal connector passes through a preamplifier stage which has the role of impedance adapter and balanced/unbalanced input adapter. The CxD2160 Amplifier gain is a product of input stage gain and power stage gain. The default gain of the input stage is 1 for ver.2 and 2.2 for ver.3. The gain of Left Channel is: (R1+R5)/R10 and for Right Channel: (R30+R35)/R40. The default value is 36.6 for ver.2 and 21 for ver.3. Changing these values will change the gain and changing R10 & R40 will influence the switching frequency, and values out of range will result in poor audio performance, or malfunction.

It also remove some of the very high, above the audio frequency range components, and allow only signals below 24KHz to pass to prevent beating or other class-D amplifiers associated issues. Having both the inverted and non-inverted inputs routed to the Signal Input connector, a quick and easy installation is possible. One inherent advantage of fully balanced input is that the amplifier can be used with one channel 180° out of phase and the corresponding speaker output also inverted to avoid bus pumping phenomenon. Changing the modes from balanced to unbalanced as well as Stereo to BTL is very easy and does not require any additional preamplifier or adapter just proper wiring.

The **Signal** input connector pinout is as follows:

- Pin 1: **-In1**: Inverting Input for Left Channel
- Pin 2: **GND**: GND Signal
- Pin 3: **+In1**: Non-Inverting Input for Left Channel
- Pin 4: **GND**: GND Signal
- Pin 5: **Mut**: Mute Control
- Pin 6: **GND**: GND Signal
- Pin 7: **+In2**: Non-Inverting Input for Right Channel
- Pin 8: **GND**: GND Signal
- Pin 9: **-In2**: Inverting Input for Right Channel

Amplifier Power Stage: The amplifier power stage comprises of one IRS2092S dedicated driver IC plus two dedicated dual MOS-FET transistors for Class D Audio amplifier applications. The topology used represents an analog version of a second-order sigma-delta modulation having a Class D switching stage inside the loop. The benefit of the sigma-delta modulation, in comparison to the carrier-signal based modulation, is that all the error in the audible frequency range is shifted to the inaudible upper-frequency range by nature of its operation. Also, sigma-delta modulation allows a designer to apply a sufficient amount of error correction. This self-oscillating topology consists of the following functional blocks: Integrator, Comparator, Level-shifter, Gate drivers, Power MOS-FET's and Output Low-pass Filter. More details are available on the IC manufacturer website.

Since the IRS2092S dedicated driver contains all the necessary blocks for a high performance class D amplifier, the implementation is simple and reliable. However, some parameters must be defined to allow operation in a wide range of conditions. These parameters are: amplifier gain, switching frequency, dead-time and several other parameters related to protection, such as Over-Current threshold, Over-temperature, and supply voltage limits, Under-voltage and over-voltage. Since all these parameters are optimally configured and tested during manufacturing for each board and each batch separately, there is no reason for end-user to change any of these parameters because it can worsen the operation conditions or even lead to malfunctions. In this manual, only a brief explanation regarding gain choice will be written.

Each amplifier batch and version is particularly configured for optimal performance in terms of sound quality, electrical efficiency, and EMI radiation. We continuously try to improve the performance and parameters of the CxD2160 amplifiers, by continuously testing and listening from minor changes to important Schematic and PCB layout changes. Some critical components such as dual MOS-FET's and output filter components (power inductor, low-pass filter capacitors, Zobel Network resistors and capacitors) as well as several smaller components, might have different values from one version to another. We succeeded to improve the sound quality, efficiency and reliability as well as reducing the noise floor and EMI from the first batch released in 2014 till today by more than two fold, rising the CxD2160 Amplifier sound quality and performance well above competitors.

The output filter of CxD2160 uses Micrometals®–2 material high-quality power inductors, made of special selected powder cores for high power and high frequency applications. Notable characteristics are high resistivity, low hysteresis and low eddy current losses and excellent inductance stability under both DC and AC conditions, no thermal aging, making them the most suitable choice for Output power inductor of a class D amplifier. Among these, Magnetics® Kool-Mu, MPP and HF can used, if carefully selected with excellent RF properties for some higher power versions. Although the current tendency on the market for similar IRS2092 amplifiers is to use a smaller and cheaper ferrite core inductor (more or less genuine) usually Sagami® replicas, easy to identify by the lack or genuine marking, and several other no-name brands, these are only suitable for a narrow power range applications, often up to 100-150W or even less due to their sharp saturation characteristics. Once the saturation current is reached, inductance sharply drops leading to high distortion and possible amplifier failure if the over-current protection isn't properly designed.

The amplifier has built-in Mute circuit, which allows silent turn ON/OFF without any click/pop noise and if is supplied from RxE type SMPS it can be operated without an external speaker protection circuit because the CxD2160+SMPS_RxE combination offers Active DC speaker protection with instant latched turn-off in case that DC component is detected at the output of any channels of the CxD160 Amplifier. The Fast-disconnect signal is a logic signal, open collector, active on low, with 1k series resistor, so it must be biased and monitored for proper operation. This is done on every RxE series SMPS. Once the Fast-disconnect signal is pulled low, for at least 200uS to prevent false triggering, the power supply will shut-down immediately to prevent any possible damage to the speakers or the rest of the components from the amplifier. To resume operation, the SMPS must be disconnected from mains for at least 5-10 min allowing all the electrolytic capacitors to discharge and then can try again to restart. If the cause of DC component on output was not eliminated, the SMPS will shut down again immediately after power-on avoiding damage to the speaker. Note that this kind of fault is an abnormal situation never encountered in normal operation and should be avoided as much as possible because in some extreme cases can damage the amplifier due to bus-pumping. Possible causes are: excessive DC bias on the signal input, due to a damaged signal source or wrongly configured DC servo preamp which puts out DC voltage, case which forces the amplifier power stage to deliver a biased output voltage proportional with input DC bias and sign.

In extreme situation when an additional level of safety or reliability is required or if the CxD2160 Amplifier Module is used with some expensive speakers, a speaker protection circuit can be considered as an extra level of protection. The latest amplifier versions include DC protection and quick-disconnect signals for SMPS in the unlikely event of DC signal present at the output of the amplifier.

House-keeping power supply and protections circuits: Both the amplifier stage and input stage requires several supply voltages for operation. In general, with low-cost or simplest amplifier implementation these voltages are derived from the main differential supply, using some ballast resistors and Zenner diodes or at most linear regulators using NPN/PNP transistors and Zenner diodes. The main advantage of this simple implementation is that no additional supply voltages are required, while the main reason of this implementation is manufacturing cost, simplicity and spare effort to design a better, decent power supply. This simplicity comes with a higher price in the long term, reflected in the electricity bill as well as reliability. With an average wasted power of 4-7W for a dual channel amplifier supplied at ±50V to ±60V, in some cases exceeding the power stage idle power losses, the whole concept of Efficient class D amplifier is compromised. If the amplifier is operated between 10-12 hours daily in one year, it can waste as much as 25-30kWh of electricity more than an amplifier which has efficient aux. supply in the same operating conditions. This translates in an extra $5-6 per year wasted as unwanted heat. Moreover, the idle wasted power increase the operating temperature and reduce the operating lifetime of the amplifier and possibly the whole system, if the rest of components are installed near the heat source. In extreme cases, it can pose risk of fire.

CxD2160 uses an additional Auxiliary supply connector for optimizing the efficiency and reducing the temperature build-up due to power dissipation of the linear regulators which are the main source of idle power losses for most Class D amplifiers on the market. Through the small 8 pin AuxSupply connector three voltages are supplied, one voltage for driver stage, in range of 16V to 25V at 60mA typical and 100mA max., one differential voltage in range of ±16 to ±26V at 30-50mA max. for the Input stage, housekeeping circuits and IRS2092 IC's.

Over-current Protection: The IRS2092 Stereo Audio Amplifier Module has built-in over-current protection circuitry to protect itself and the output transistors from over-current and short-circuit conditions. The over-current protection will Mute the corresponding amplifier channel when the current exceeds 18A and resume operation after approx. two seconds if the over-current condition was removed. The low-side current sensing feature protects the low side MOSFET from an overload condition in negative load current by measuring drain-to-source voltage across RDS(ON) during its on state. OCP shuts down the switching operation if the drain-to-source voltage exceeds a preset trip level. The voltage setting on the OCSET pin programs the threshold for low-side over-current sensing. When the VS voltage during low-side conduction gets higher than the OCSET voltage, the IRS2092 turns off outputs and pulls CSD down to -VSS. At this values, the over-current threshold is set at 36 A. The high-side current sensing protects the high side MOSFET from an overload condition in positive load current by measuring drain-to-source voltage across RDS(ON) during its on state. OCP shuts down the switching operation if the drain-to-source voltage exceeds a preset trip level. High-side over-current sensing monitors drain-to-source voltage of the high-side MOSFET while it is in the on state through the CSH and VS pins. The CSH pin detects the drain voltage with reference to the VS pin, which is the source of the high-side MOSFET. In contrast to the low-side current sensing, the threshold of CSH pin to trigger OC protection is internally fixed at 1.2V. An external resistive divider is used to program a threshold an external reverse blocking diode is required to block high voltage feeding into the CSH pin during low-side conduction.

Under-voltage and Overvoltage Protection: CxD2160 Module senses the power rails through a dedicated detection circuit. The under-voltage and over-voltage thresholds are determined by the values of the resistors in the networks, and are power version dependent. If the supply voltage falls outside the upper and lower limits determined by the detection circuit, CxD2160 module shuts enters in Mute condition. The removal of the over-voltage or under-voltage condition returns CxD2160 module to normal operation. Please note that trip points specified in the Electrical Characteristics table are at 25°C and may change over temperature. The nominal operating voltage will typically be chosen as the supply "center point." This allows the supply voltage to fluctuate, both above and below, the nominal supply voltage. Once the supply comes back into the supply voltage operating range (as defined by the supply sense resistors), CxD2160 module will automatically be un-muted and will begin to amplify. There is a small hysteresis range on both the under-voltage and over-voltage thresholds. If the amplifier is powered up in the hysteresis band CxD2160 module might misbehave and this supply voltage values must be avoided. Thus, the usable supply range is the difference between the over-voltage turn-off and under-voltage turn-off for both the V+ and V- supplies. It should be noted that there is a timer of approximately 300mS with respect to the over and under voltage sensing circuit. Thus, the supply voltage must be outside of the user defined supply range for greater than 200-300mS for CxD2160 module to be muted.

Bus Pumping: An unwanted and potentially troublesome phenomenon present in all single-ended Class D amplifiers is the power supply pumping effect. It is caused by the flowing of the current from the output filter inductor into the power supply filter capacitors in opposite direction as the DC load sink current. The phenomenon is more evident at low-frequency and high amplitude signals, and if is not prevented it will trip the Overvoltage protection circuit, causing the amplifier to enter in Mute state until the supply voltage drop below the lower overvoltage protection threshold. Another cause of the Bus pumping is the DC offset which, if is larger than 100-200mV, opposite voltage rail will start increasing the voltage until the Overvoltage protection circuit will trip, and Mute the amplifier. CxD2160 module does not need any kind of DC offset adjustment it has a very low DC offset, below 10mV. However, if the user is tempted to play with the input capacitor, and change it with some kind of audiophile capacitor with the size of a potato, or use no capacitor at all, relying on some sort of DC servo circuits, or not even such circuits, the smallest DC component present at the input of the amplifier will lead to DC offset at output and consequently lead to bus-pumping. For this reason we strongly suggest to NOT change the input capacitor or at most, if there's no way to convince of uselessness of this action, use a similar value and size.

There is one single electrolytic capacitor in the entire signal chain for each channel, C11 for Left Channel and C35 for Right Channel, and in is strongly recommended to be kept as it is and NOT changed with any so called audiophile capacitor because the performances won't change in better, but for sure in worse including the risk of damaging the amplifier by shorting or breaking PCB tracks. The current used electrolytic capacitor was selected for best parameters and all the amplifier tests and measurements were made using these capacitors.

There are few solutions to reduce the Bus-pumping. If the pumping effect is too high, this will lead to amplifier oscillations between ON/OFF states, since the under-voltage and over-voltage protection is not latched shutdown. The first solution is to use large Electrolytic capacitors on each power supply voltage rail to absorb the pumped supply current and to use-it in the next switching cycle. This method is less efficient when the output amplitude increase and the frequency decrease, being ineffective with DC signal. The best solution to avoid Bus-Pumping is to drive one amplifier channel 180° out of phase with respect to the other. This setup will reduce the Bus-pumping because each channel is pumping out of phase with the other, and the net effect is a cancellation of pumping currents in the power supply. The phase of the audio signals needs to be corrected by connecting one of the speakers in the opposite polarity as the other channel. To achieve the phase shift, the input signal must be connected as shown in Figure 4-7, and taking advantage of using the amplifier with differential audio signal input when is available.

EMI Reduction: Each power MOS-FET has a fast recovery diode connected in parallel for reduction of ringing on the outputs of the MOS-FET's. They shunt the inductive energy generated in the parasitic inductance of the components leads and PCB tracks. The fast-recovery type SMD diodes are connected close to MOS-FET transistors to minimize the ringing. For some amplifier version, the diodes are redundant since the MOS-FET's body diodes are hyper-fast type and external diodes are not absolutely required.

Furthermore, for reducing the ringing, few bypass capacitors are placed close to output power MOS-FET's. There are 2 types of capacitors: one type is X7R material, ceramic capacitors, SMD1206 footprint placed on the bottom side of the PCB, very close to the output MOS-FET's and the other type are electrolytic capacitors, for energy storage during peaks. The ceramic capacitors are connected between V+ and GND, V- and GND and V+ to V-. They provide extremely low stray inductance and ESR, which is helpful for reducing ringing. The electrolytic capacitors acts as energy storage tank during peak power consumption, as well as minimizing the pumping effect which switching amplifiers experience at high power outputs and low frequencies.

Thermal Management: The CxD2160 Amplifier Module, require a heatsink to keep the temperature within normal operation limits. The temperature increase is only caused by the Power MOS-FET's, the linear regulators for +-12V and housekeeping supply dissipate a negligible amount of power and they are SMD type installed on the backside of the PCB board. The mechanical design of the CxD2160 Amplifier Module was made in such way that quick and easier installation is possible, and the existing on-board heatsink can be mounted on a larger, flat metallic surface which will provide additional cooling. The simplest way to install the CxD2160 Amplifier Module in the enclosure is to fix the PCB board with 4 M3 screws, one in each mounting hole from the corners and then a 100x50mm or larger flat aluminum heatsink to be mounted on top of the existing heatsink using the 3 M3 mounting holes on the top of the heatsink. The optimal installation require using 4 28m long M3 stand-offs and install the CxD2160 Amplifier Module top side down with the on-board heatsink in thermal contact with enclosure bottom or side area, whichever offers lowest thermal resistance. In some cases, if the system size is limited or is difficult to provide an additional cooling area, the existing on-board heatsink can be used if a small cooling fan is used, at least 40mm type with 3-4 cf/m airflow blowing the air through the heatsink fins outside of the enclosure.

If the CxD2160 Amplifier Module is supplied from a SMPS320RxE, which has the same footprint size and height as the CxD2160 Amplifier Module, they can be installed side by side, leaving at least 6-8mm clearance between boards and enclosure walls. The recommended internal height of the amplifier enclosure is 35mm, which will allow at tight fit of both the CxD2160 Amplifier Module and SMPS32RxE power supply and direct contact between on-board heatsinks and enclosure top cover, which will be used as extended cooling area for both the CxD2160 Amplifier Module and SMPS320RxE. With such implementation, if the enclosure is made of aluminum, and has a total thermal resistance below 2.4°C/W the cooling fan can be omitted.

The CxD2160 Amplifier Module has an over-temperature sensor which will Mute the amplifier if the heatsink temperature rise above 85-90°C to protect the power stage from failure and will resume operation once the temperature dropped to about 75-80°C. If the amplifier is overloaded or poorly ventilated, leading to overheating, it will toggle between Mute and Operation around the over-temperature tripping point.

Mute control: When the Mute pin 5 of the **Signal** connector is connected to GND the both amplifier channels are muted (both high and low-side transistors are turned off). There is a delay of approximately 800 milliseconds between the de-assertion of MUTE and the un-muting of CxD2160 Amplifier Module which prevents false activation due to possible noise induced in the Mute wires from nearby noise sources. When the CxD2160 Amplifier Module is Muted, either from an external Mute control signal, or due to an over-current, overvoltage or under-voltage condition, Mute LED's will lit. During Power-On sequence, the Mute will be automatically controlled by the SMPS, the amplifier will be kept in Mute state for about two seconds till all the supply voltages reach the nominal value and the amplifier reach a stable operation state. This will lead to a noiseless Turn-ON without click or pop noises which is extremely important especially when the amplifier is used at very low initial sound volume. At Power-Off, the CxD2160 Amplifier Module will be Muted as soon as the mains voltage drops for at least 50-60ms, while the SMPS still operates and the output voltages are still stable, for the same reason, to prevent any click or pop noise which might occur if any of the supply voltage falls earlier than the other ones.

Although the CxD2160 Amplifier Module has noiseless Turn-ON and Turn-Off, in some cases click and pop noise can be perceived if the signal source is powered On after the CxD2160 Amplifier Module reach the operating mode, or the signal source is powered off before the CxD2160 Amplifier Module is powered Off due to the fact that the signal source transients will be amplified by the CxD2160 Amplifier Module if the correct power sequencing was not set. If this issue is encountered is strongly recommended to configure the setup in such way that the CxD2160 Amplifier Module will last Turn-On and first Turn-Off to avoid the transients being amplified.

User can implement a simple and easy Mute control for the CxD2160 Amplifier Module using a toggle switch mounted on the front panel of the enclosure. The switch will connect together the Mute pin and any of the adjacent GND pins from the signal connector. No other component is required. Once the Mute switch is activated the amplifier will enter in Mute state and will resume operation less than a second after Mute button is released.

BTL mode operation: If the output power delivered by the amplifier in Single-Ended operation mode is not enough for a given application, CxD2160 Amplifier Module can be used in BTL mode without any modification to the board, by just wiring the input signals accordingly, one channel 180° out of phase with respect to another. The theoretical output power in BTL mode is 4 times the power of a single channel on the same load, but practical output power which can be achieved with THD within low limits are between 3.2 to 3.7 times the output power of a single channel. Operating the amplifier in BTL mode will cancel the Bus-Pumping phenomenon due to the fact that each channel is driven with 180˚ out of phase Audio Signal, and at any time power will be drawn from both supply rails, by each channel power stage alternatively. Although the amplifier is capable to drive loads with impedances as low as 8Ω, the minimum load impedance for BTL operation is 12Ω because in BTL mode both channels are operating simultaneously with the same amount of output power and the total dissipated power will be significant. The recommended BTL operation load impedance is 16Ω, and the rated output power will be the sum of each channel's output power on 8Ω load impedance. When operating in BTL mode, the input signal amplitude for both channels must be identical, any difference in amplitude will lead to distortion and overloading. The easiest way to make sure the signal amplitude is identical for both channels is to wire the corresponding inputs in parallel and feed them from the same signal source.

Layout: The PCB Layout design has an important contribution to the overall performance of the CxD2160 Amplifier Module. That's why double layer, FR-4 material with 1.6mm thickness and copper tracks thickness of 70um or 2 oz was chosen. The tracks width, were calculated to withstand the currents which they have to carry, and also the distance between adjacent tracks which carries higher voltages than 50V is big enough to satisfy the clearance conditions imposed by the safety standards. The size of the PCB is 100 x 50 mm or less than 4 x 2 inch, and has 4 isolated mounting holes, on each corner of the PCB. The mounting holes are 3.2mm diameter or 0.12 inch, copper plated and soldered, for better mechanical strength. The distance from the edge of the board to the mounting holes is 4mm for each hole, thus the mounting holes are arranged in a 92x42mm perimeter. The layout is symmetrical for Left and Right channel with respect to center axis, for better performances and aesthetical reasons. The heat sink is mounted directly onto the PCB and does not require additional support. The heatsink height is 28mm and for easier installation, 4 brass standoffs with the same height can be installed from each mounting hole to the baseplate or heatsink on which the on-board heatsink will stand as well. The standoffs are isolated from GND or any other potential, only the heatsink will be connected to Power GND, avoiding GND loops.

Wiring: the amplifier to connectors, potentiometers, transformers, auxiliary boards, must be done with proper size wires and the cables must be laid carefully to avoid parasitic couplings, both capacitive and inductive, which will degrade the S/N ratio and amplifier performances. It is recommended to use heavy gauge wires for Power Supply and Loudspeaker Output and short shielded cables for Audio Input. The input cables can be wired with shielded cables as short as possible, far from the amplifier output section or **SMPS**. The power connections, to the loudspeakers and SMPS must be wired with wires which are able to carry currents in excess of 10A. **Attention** must be paid to insulation, especially for the mains powered wires, where double insulation wires must be used.

Recommended power supply: The CxD2160 Amplifier Module was designed to use separate supply rails for power stage, input stage and housekeeping circuits to maximize performance and efficiency. The best performance can be achieved when is paired with a dedicated RxE series SMPS which can supply all the required voltages and control signals required for proper operation. For best performance and efficiency the supply voltage for the power stage was chosen a regulated ±55V optimal supply voltage, chosen after many calculation as the best compromise between the desired output power, sound quality and lowest power dissipation while keeping superior reliability and simple installation. Although most of the class D amplifiers can run on unregulated voltage supply rails, will slightly lower PSRR values, we chose to use regulated voltage supply rails for best performance and to optimize efficiency. With unregulated voltage supply rails, to achieve the rated power, the idle voltage must be at least 10-15% higher than the voltage require to deliver the actual rated power. This increased supply voltage would lead to approx. 25-30% more power loss, both as idle loss and dynamic loss, knowing that the overall switching loss is proportional with the square of the supply voltage. Also, using regulated voltage supply rails will minimize the bus pumping, because the supply voltage will swing much less when the power supply delivers regulated voltage, and allow us to use smaller footprint capacitors and reduce the overall size of the amplifier.

Besides the power stage supply voltage of ±55V, three additional auxiliary voltages in range of 16 to 25V are required for input stage, small-signal stage, driver stage, control and protection stage. All these voltages are supplied by any of our RxE series SMPS, from the smallest one, SMPS320RxE to the largest currently available SMPS2000RxE, all using the same 8 pin 0.05" connector with the same pinout making an easy choice based only on the output voltages and required power rating.

Note that although each board has Under-voltage and over-voltage protections, these protections are intended to protect the amplifier from power supply voltage swing due to bus pumping if a poor power supply is used instead of dedicated RxE series SMPS (low current capability, small electrolytic capacitors) with CxD2160 Amplifier Module, and protecting the module in case of excessively higher voltages than was designed for is not guaranteed in any form. Again, end-user should never intervene and/or change any of these components in any situation. Supply voltages out of range will automatically mute the amplifier, and if the supply voltage is significantly higher than maximum allowed (25-30% more) can damage the amplifier. The rule of thumb is that the power supply must be able to provide at least the short-term peak power required by the amplifier in any conditions (considering the efficiency figures as well). With audio signal the peak to average ratio is currently 8 but both the power supplies and the amplifiers are designed for a more realistic value of 2.5-3.

The average power consumed by the CxD2160 Amplifier Module supplied from a SMPS320RxE 230V mains voltage version measured during audition tests with combined musical program at levels near clipping was 128W average, 374W peak power consumption while the amplifier delivered at least 165W per channel on 8Ω load impedance. The idle power loss of the CxD2160 Amplifier Module is up to 5W when operate and the SMPS320RxE power loss is about 3W or below, the total idle power consumption for the same setup is around 8W with the amplifier active and no input signal, and below 3W with the amplifier in Mute state, ready to operate once the Mute condition is removed. This idle power consumption is lower than any other similar power rating amplifiers on the market, is comparable or below the power loss of a single channel 150-200W Class D amplifier stage alone, without power supply. An average setup of two channels 150-200W Class D amplifiers plus a linear power supply would consume at least 25-30W at idle and in some cases if a poorly designed power supply is used even more than 40W, losing the main purpose of an efficient Class D amplifier. As already explained in this manual few pages before, only this idle power loss cost difference can add up to significant cost. 30W idle power loss vs. 8W power loss means 80-100kw in one year of use, or about $20 difference cost in electricity bill for each year of use only reflected from idle power loss alone, without considering the corresponding losses at medium-high power which can easily make up $50-60 difference in one year period.

Amplifier Connection and Operation:

For proper operation, CxD2160 Amplifier Module must be used according with the instructions provided in this manual. CxD2160 Amplifier Module can be used in several configurations, depending on the system requirements. To build a complete amplifier based on the configuration described, two RCA type Signal Input connectors for unbalanced input signal or two XRL connectors for balanced input signal and two Speaker connectors are needed. They must be installed on the enclosure backside and wired according to the schematics below, for each shown configuration.

The most common and simple configuration use one SMPS320RxE as power supply, unbalanced input signal and a dual potentiometer for adjusting the volume. CxD2160 Amplifier Module can be supplied with either balanced or unbalanced audio signal with the maximum amplitude of 1.5V rms for ver.2 and 0.775V for ver.3. The audio signal must be applied at the input of the CxD2160 Amplifier Module, on the Signal connector as can be seen in the following schematics. In the first schematic represented in **Figure2**, the signal phase is inverted for left channel input and the left speaker is also connected in antiphase to reduce bus pumping phenomenon. To be able to conveniently adjust the listening volume it is strongly recommended to use a potentiometer, logarithmic type with 50KΩ value or maximum 100KΩ.

The power supply used in the first example is SMPS320RxE, but any other RxE series SMPS can be used in the same way, respecting the polarity of the main supply wires and using the cable provided for Aux. supply interconnection. The installation and interconnection between CxD2160 Amplifier Module and SMPS320RxE board is shown in the figure below:

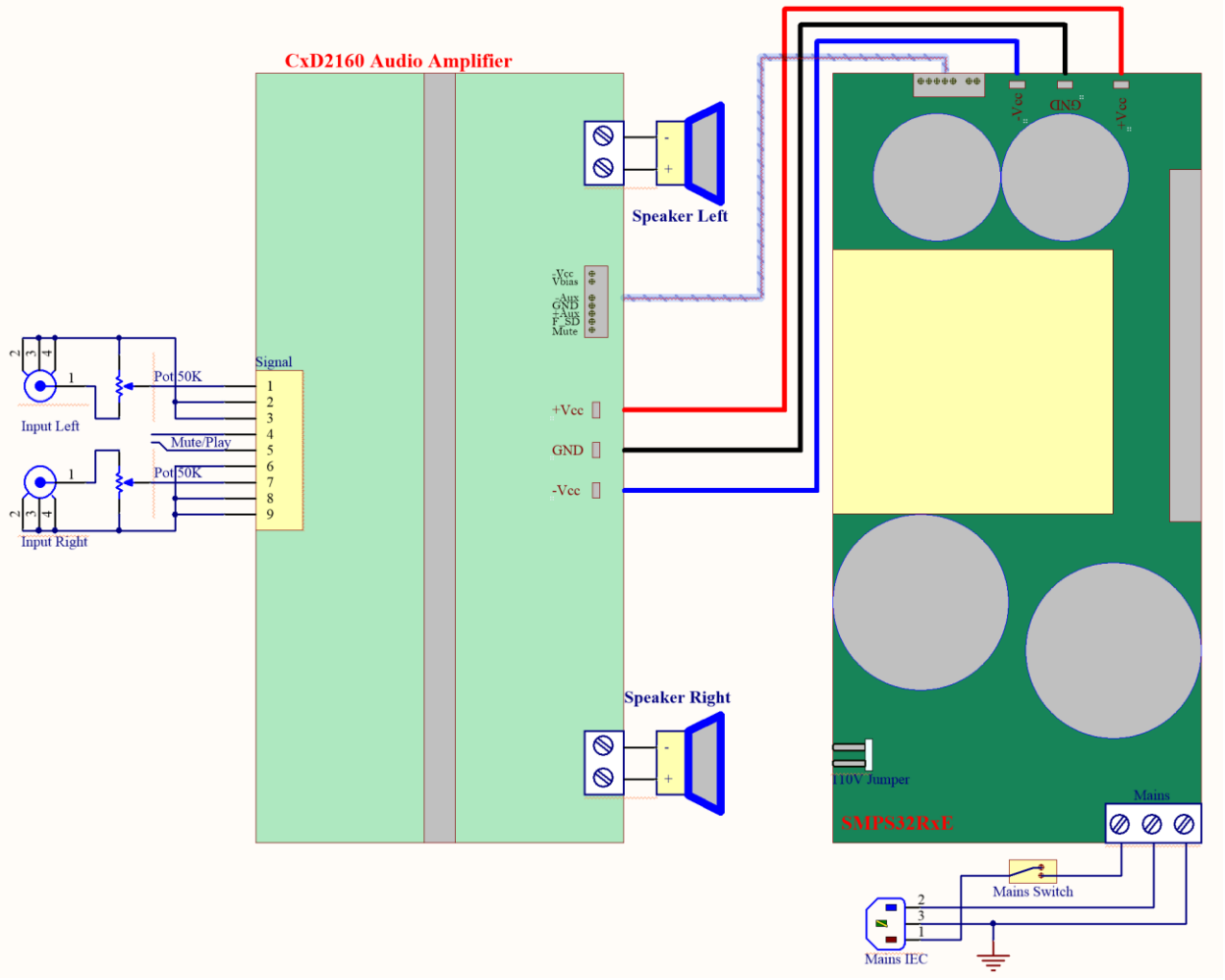


Figure2: CxD2160 Amplifier Module & SMPS320RxE Interconnection using unbalanced RCA connectors and potentiometer

The CxD2160 Amplifier Module can also be supplied from different power supply such as SMPS500RxE, SPS600RxE, SMPS1200RxE or even SMPS2000RxE in multi-channel, multi-module configuration. When using any other power supply than SMPS320RxE the voltage choice must be carefully chosen, ±55V. Any other supply voltage is not suitable, too low and the CxD2160 Amplifier Module will not operate properly, too high can lead to damage. We do not recommend to use any other power supply than RxE series. It is often believed that a bulky linear power supply will offer better performance than the existing highly optimized SMPS's which is just very false.

Figure3 shows the interconnection schematic between CxD2160 Amplifier Module and SMPS500RxE board. In the same way, any other RxE series SMPS can be used. **Figure3** also shows a different input signal wiring configuration, using unbalanced input RCA Connectors and no potentiometer. The configuration without potentiometer must be used only when a preamplifier with volume control and free pop/click noise precede the amplifier in the signal chain. It is not recommended to use a mobile device, phone or tablet or even a desktop computer or a laptop with the configuration without potentiometer because all of these devices suffer from transients bursts which exceed the maximum limit for the CxD2160 Amplifier Module amplitude of the input signal. It is very important to remember, to not connect or disconnect the Signal Input or the speaker output wiring or connectors while the amplifier is powered On. Any input or output wiring must be connected or disconnected only after the amplifier is powered off and the power cable is disconnected from mains wall plug. Failing to respect this simple rule might lead to damage of the amplifier or the signal source equipment.

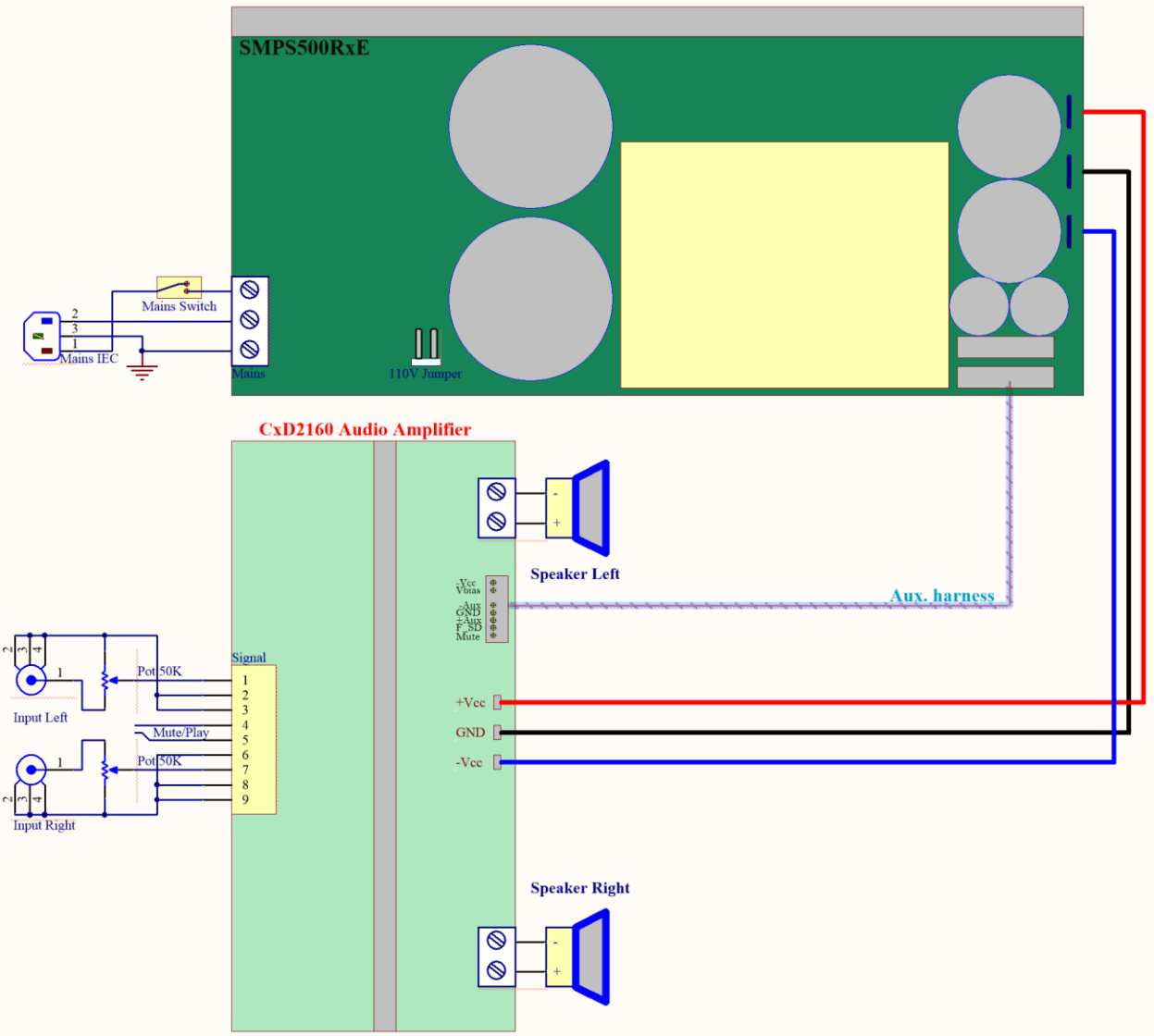


Figure3: CxD2160 Amplifier Module & SMPS500RxE Interconnection using unbalanced RCA connectors

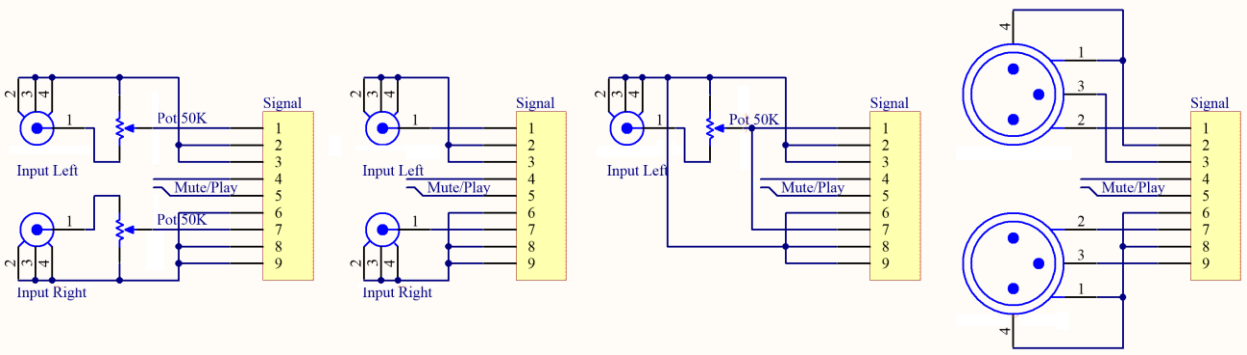


Figure4: Various Input Signal configuration for the CxD2160 Amplifier

Several input signal connection configurations are possible, four of them are shown in **Figure4** above. For simplification, only the input connector is shown with various input wiring configurations, from left to right:

1. Unbalanced input using RCA Connectors and potentiometer, explained in the description of **Figure2.**
2. Unbalanced input using RCA Connectors without potentiometer, explained in the description of **Figure3.**
3. Single channel BTL connection using one single RCA Connector and potentiometer. The speaker must be connected across + Out L which will be negative speaker terminal and + Out R which will be positive speaker terminal. No GND connection is required for speaker connection.
4. Fully balanced input using two XLR Connectors without potentiometer. The CxD2160 Amplifier Module can be connected straightforward to a line level signal source.

Connectors Pinout:

The Signal input connector pinout is as follows:

- Pin 1: **-In1**: Inverting Input for Left Channel
- Pin 2: **GND**: GND Signal
- Pin 3: **+In1**: Non-Inverting Input for Left Channel
- Pin 4: **GND**: GND Signal
- Pin 5: **Mut**: Mute Control
- Pin 6: **GND**: GND Signal
- Pin 7: **+In2**: Non-Inverting Input for Right Channel
- Pin 8: **GND**: GND Signal
- Pin 9: **-In2**: Inverting Input for Right Channel

The AuxSupply connector pinout is as follows:

- Pin 1: Shut-Down I/O
- Pin 2: Fast-Disconnect
- Pin 3: +V aux, 18-30V @ 40-50mA referenced to GND Signal pin 4
- Pin 4: GND Signal for Aux voltages
- Pin 5: +V aux, 18-30V @ 40-50mA referenced to GND Signal pin 4
- Pin 6: ---Not connected for clearance purpose---
- Pin 7: Vbias 18-25V @ 100mA referenced to –Vcc pin 8
- Pin 8: -Vcc

The power supply fast-on tabs polarity is marked on the backside of the PCB silkscreen. It is strongly recommended to observe the polarity marked on the PCB and match the polarity with the polarity of the power supply output tabs. Double check the correct connection before power ON first time. Working connection can lead to damage of the the CxD2160 Amplifier Module and power supply.

The speaker output screw terminal polarity is marked on the backside of the PCB silkscreen. It is recommended to observe the polarity marked on the PCB and phase the speakers with correct polarity. If the speakers are connected with wrong polarity the sound quality will be severely affected.

CxD2160 Amplifier Module measurements and performance: To characterize the CxD2160 Amplifier Module performances, some relevant measurements were done and displayed below:

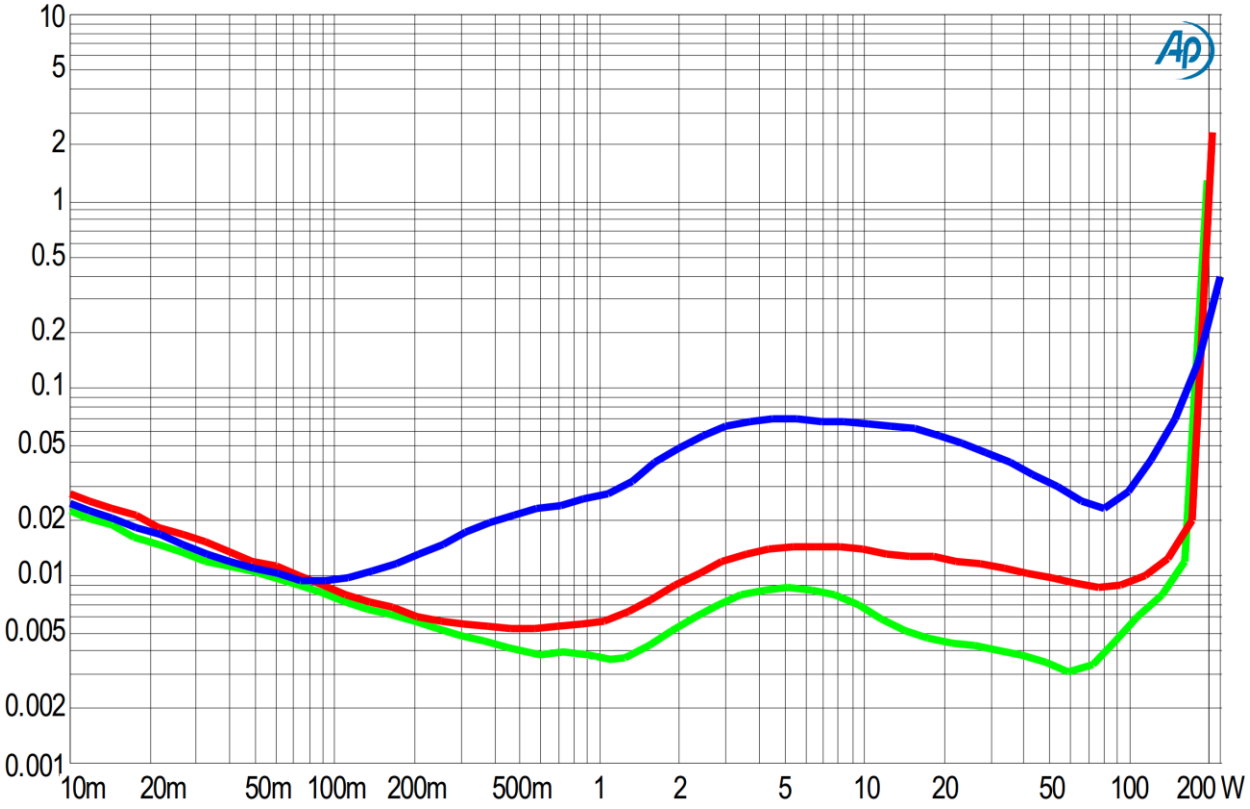


Figure5: THD vs Power for the CxD2160 Amplifier at 100Hz green, 1kHz red and 6.7kHz blue trace.

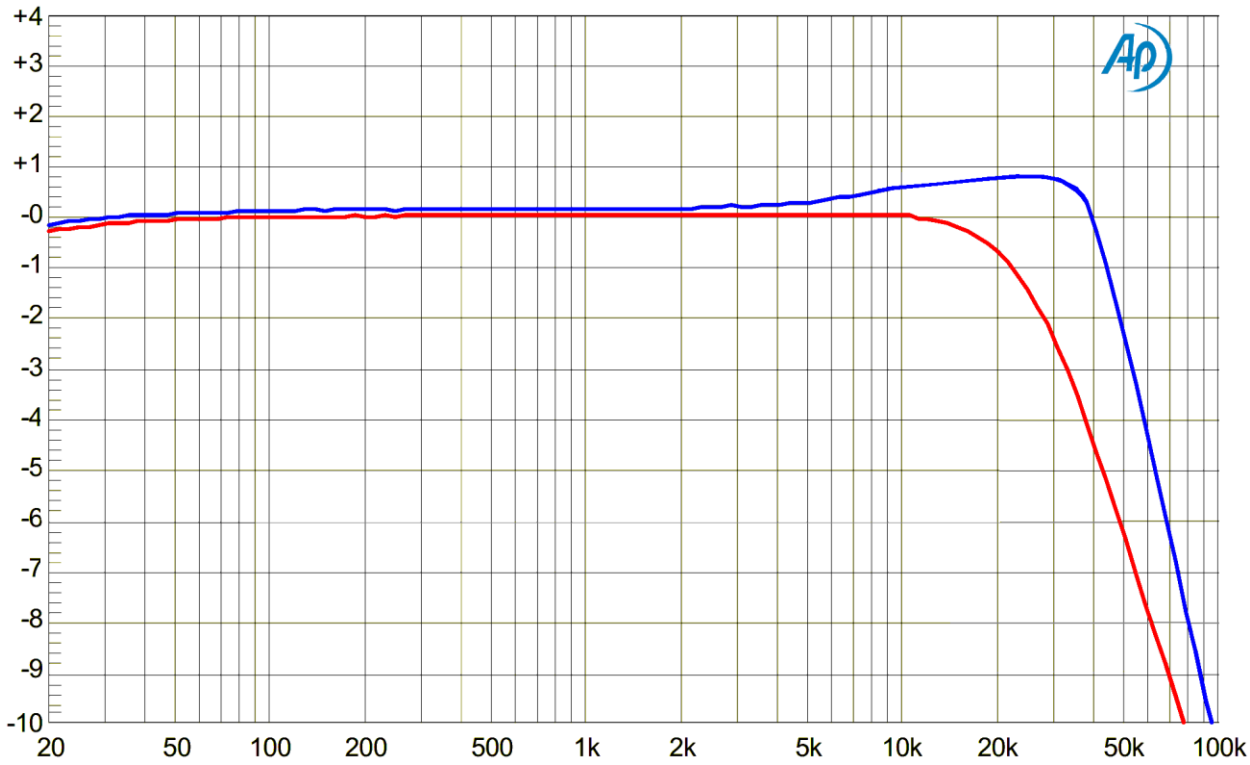
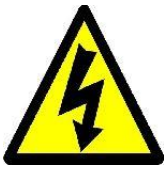


Figure6: Frequency response of the CxD2160 Amplifier: red trace: 4Ω load impedance blue trace: 8Ω load impedance.



Warning:

Before you proceed with installation, make sure you have read this warning:

The CxD2160 Amplifier Module contains potentially hazardous voltages up to 120V DC or 90V AC. This voltage levels are present on the top and bottom of the board, and during installation and operation should never touch any part of the board while it is connected to the mains and at least 5 minutes after complete disconnect from mains. If any adjustment or reconnection needs to be done, disconnect the unit from the mains and allow all capacitors to discharge for at least 5 minutes before handling it. Any ignorance of this warning will be made on user's responsibility, and can lead to serious injuries and possible death by electrocution if is handled improperly. This product has no serviceable parts only the SMPS used together with the CxD2160 Amplifier Module has an on-board mains fuse. In case of blown fuse, replace the fuse with the same type and rating only if no other visible damage occurred. Do not attempt to change any other component from the board, especially capacitors. A safety clearance of at least 6mm must be kept between the board and the case, or any conductive part of the amplifier.

For best performances and long term reliable operation read before proceed!!!

Peaking phenomenon will occur when the amplifier input is connected or disconnected while the amplifier is powered ON or the input is touched by hand to "~~*test*~~" if the amplifier is working. This is a very stupid mistake for any kind of amplifier, as the body static voltage corroborated with the voltage induced by the near electromagnetic field, less than ideal mains to amplifier ground isolation, will lead to high voltages build-up usually tens of volts which have 90% chances to damage any kind of amplifier with input impedance bigger than 10KΩ. Although the mains hum is dominant when "~~*testing*~~" the amplifier using this rude method, there is a full, rich spectrum of frequencies up to tens or hundreds of KHz, something which any normal amplifier should never expect. To prevent the amplifier failure, and making it ~~idiot-proof~~ , a more or less complex circuit can be employed but this will reduce its performances and sound quality, and due to this fact we strongly believe that the user know what he's doing and will avoid torturing the amplifier for its own good.

Although the amplifier comes with optimized components, yet some peoples still want to improve an optimized amplifier. The very common mistake found on Class D and T amplifier while tuning the amplifier, is to replace the input capacitors with bigger size, sometimes as big as a potato input capacitors. This is one of the biggest mistakes which can be possibly done on such amplifier. Not only that these placebo capacitors will not improve the sound, they will make it worse, and in some cases will damage the amplifier. Because as I wrote few rows above, the input should not be touched by hand or tools while is working, NEVER!!! (and this is often done during the tuning process) and these capacitors with their large volume and area will act like antennas which will pick-up the switching noise from the power stage, from the power supply, from environment, and also common mode noise from the amplifier housing if is made of metal and they are touching the case, even without electrical contact due to the stray capacitance between the capacitor and metal parts in close proximity.

Disclaimer:

The **CxD2160 Amplifier Module** Audio Amplifier shall be used according with the instructions provided in this document. The user should NOT attempt to modify or change any of the parameters of this product, which can lead to malfunction. The designer and manufacturer of the product, and the official distributor, **Connexelectronic**, will not be liable for any kind of loss or damage, including but not limited to incidental or consequential damages. Due to the mains voltages of this board, the user should take all the caution measures needed when working with mains voltages, should not touch any uninsulated part of the board or connectors, or short-circuit any part of the board or connectors. Any misusage will be made on user responsibility.

The designer and manufacturer reserve the right to make changes or modifications on both the product functions and performances without notice. The schematic and PCB design is **Connexelectronic** proprietary and shall not be distributed, copied or published without the **Connexelectronic** written agreement. **Connexelectronic** reserve the right to offer limited support for the boards purchased directly from **Connexelectronic**or **Connexelectronic**, and no support at all for the similar boards which aren't purchased directly from **Connexelectronic**and **Connexelectronic**, or future listed resellers, and from various reasons they look or pretend to be similar, exactly same, or improved version products. Purchasing the product means that you are aware and agree with all this conditions.