

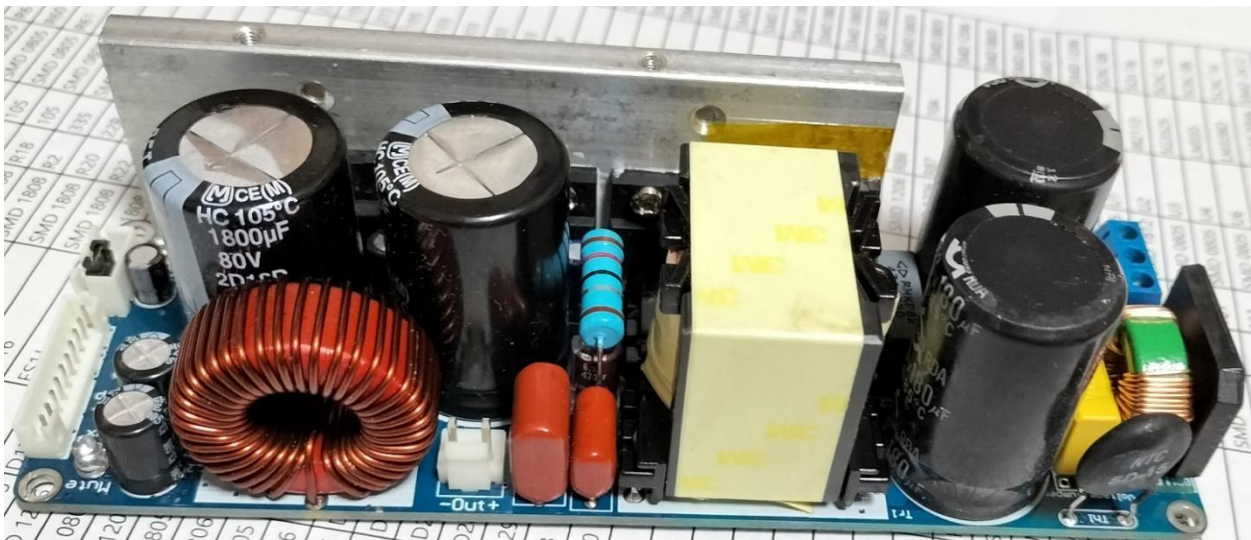
# IRS500SMPS Powered Audio Amplifier Module

The IRS500SMPS Audio Amplifier Module is a complete assembled Class D Full-Range Single-Channel Audio Amplifier with integrated Mains Power Supply. The amplifier has small footprint of just 150mm long, 55mm wide and approx. 38mm tall, making it easy to install within speaker enclosures, bass head amplifiers or it can be used to build multi-channel amplifier systems, allowing up to 8 IRS500SMPS Amplifier Modules to be installed in a standard 1 RU case in a single row layout, or up to 16 modules on two rows.

The core of the IRS500SMPS Audio Amplifier Module is the very popular audio power amplifier driver IC IRS2092S made by Infineon®, powered from a Low-noise, High Efficiency LLC Resonant Converter. The amplifier output power exceeds 500W on 4Ω load impedance or 300W on 8Ω load impedance with THD+N below 0.1%

## Amplifier Features:

- Output Power: 542W at 4Ω, or 306W at 8Ω, with max. 0.1% THD+N, @230V supply voltage.
- Output Power: 525W at 4Ω, or 302W at 8Ω, with max. 0.1% THD+N, @120V supply voltage.
- Output Power on 2R load: 468W @ 1% THD+N, current limited, supplied at 230V or 120V mains voltage.
- Audiophile sound Quality: 0.01% THD+N at 378W at 4Ω or 198W at 8Ω @230V or @120V mains voltage.
- Maximum Output Power: 637W at 4Ω, or 357W at 8Ω, with max. 10% THD+N, @230V supply voltage.
- High efficiency: Up to 87.4% @500W on 4Ω, or up to 89.6% 300W at 8Ω with 230V mains supply voltage.
- Idle Power consumption: Muted: 2.5-3W; Un-Muted without Input Signal: ~8W.
- Full Protection set included: Short-circuit, over-current, over-temperature.
- Sensitivity: 1.5V for 500W on 4Ω or 1.64V for 300W on 8Ω rated output power. Amplifier gain is 29.81.
- Can be feed either with Balanced or Unbalanced Input signal, and a simple 3 pins Volume Potentiometer can be connected directly to the IRS500SMPS Audio Amplifier Module dedicated pins.
- Mute control, Status and Temperature feedback pins for controlling the amplifier status within the system.
- Compact size 150x50mm, and 37mm tall. Heatslug height 35mm, with M4 threaded holes on the side and M3 holes on the top side for easier Heatsink installation.

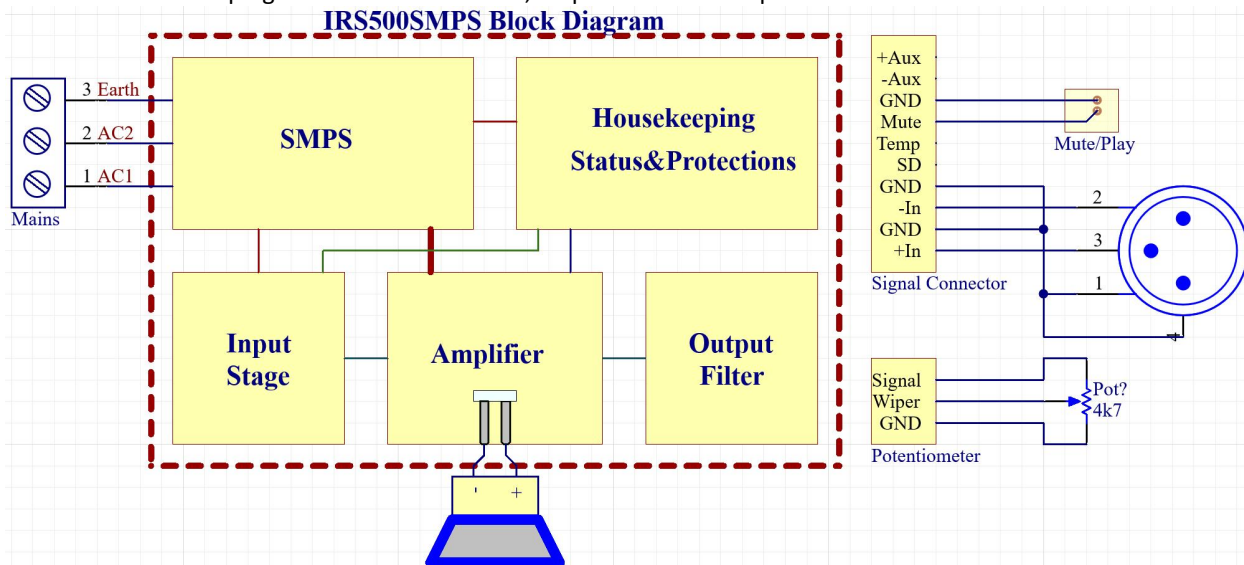


**Figure 1: IRS500SMPS Audio Amplifier Module**

## Amplifier Description:

The IRS500SMPS Audio Amplifier Module is based on the very popular audio power amplifier driver IC IRS2092S made by Infineon® powered from a Low-noise High Efficiency Regulated Voltage LLC Resonant Converter. The main blocks of this amplifier are:

- Input stage, which contains a low-noise Operational Amplifier for impedance match and to allow either balanced or unbalanced input signal to be feed to the amplifier.
- Amplifier Power Stage, built around IRS2092S dedicated Class D amplifier controller, and two High-speed switching MOSFETs.
- Output Low-Pass Filter which is used to filter the High-Frequency component of the Output Signal.
- Mains Power Supply, made of a Low-Noise High-Efficiency Regulated LLC Resonant Converter.
- House-keeping Status and Protections, amplifier status and protections circuits.



**Figure 2: IRS500SMPS Audio Amplifier Module Block Diagram**

**Input Stage:** The balanced Audio Input signal is feed to the IRS500SMPS Amplifier through the Input Signal connector and it passes through a preamplifier stage which has the role of impedance adapter and gain amplifier. The default gain of this input stage is 1. It also remove some of the very high, above the audio frequency range components, and allow only signals below 22KHz 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, changing the modes from Balanced to Unbalanced Mode easily by means of wiring. There is only one electrolytic capacitor in the entire signal chain, and in is strongly recommended to be kept as it is and to NOT be changed with any so-called audiophile capacitor because the performances won't change in better but often worse. The choice of this capacitor was done after evaluating and listening to several candidates. Correct wiring of input signal and output is more important in this case.

A 3 wire Potentiometer with the value in range of 3-10kΩ can be directly connected to the IRS500SMPS Amplifier board to allow Volume Control. For this purpose, a small 3 pin connector was installed on the edge of the PCB near the heatslug. The Connector with 3 wires, approx. 20cm long is provided but NOT the potentiometer.

**Amplifier Input Stage:** The amplifier Input Stage comprises of one Low-Noise Operational Amplifier which serves as Impedance adapter and allows both Balanced and Unbalanced Input Signal to be supplied to the IRS500SMPS Amplifier Module. The Input Impedance of the Balanced Input Stage is 2x10kΩ. The IRS500SMPS Amplifier Module Amplifier gain is 29.81. The Input Signal Amplitude for rated output power of 500W on 4Ω Impedance is 1.5V or 1.64V for 300W on 8Ω. Between the Input Stage and the Amplifier Power Stage a Volume Potentiometer can be connected to adjust the Volume. If the Potentiometer is not used, just connect together the Signal and Wiper within the Potentiometer Connector using a 2.54mm Jumper.

**Amplifier Power Stage:** The amplifier Power Stage comprises of one IRS2092S dedicated driver IC plus two dedicated MOSFETs suitable for medium-high power 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, the 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 MOSFETs 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 were defined to allow operation in a wide range of conditions, from low power, to highest power. 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 already optimally configured and tested during manufacturing for each board individually, there is no reason for end-user to change any of these parameters because it can worsen the operation conditions or even lead to malfunction.

The amplifier power stage is particularly configured for optimal performance in terms of sound quality, electrical efficiency, and EMI radiation. Some critical components such as Power MOSFETs and output filter components (power inductor, low-pass filter capacitors, Zobel Network resistors and capacitors). The supply voltage was carefully chosen to deliver the require power and offer high performance and to prevent malfunction or damage of the amplifier. All the power devices are installed onto a small, aluminum heatslug which serve as heat transfer interface from the IRS500SMPS Amplifier to an external heatsink with a thermal resistance of not more than 0.8°C/W for proper operation even with the lowest impedance loads. A thermal sensor installed inside the heatslug will monitor the temperature and Mute the power stage if the temperature reaches approx. 85°C to protect the power transistors and will Un-Mute when the temperature drops below 80°C.

**Output Low-Pass Filter:** The output filter of the IRS500SMPS Amplifier Module uses high-quality power inductors, made of special selected powder cores for power applications. Notable characteristics are high resistivity, low hysteresis and eddy current losses and excellent inductance stability under both DC and AC conditions and no thermal aging, make them most suitable choice for Output Power Inductor of the class D amplifier. The Powder core used for the Output filter have a soft-saturation characteristic, avoiding sudden drop in inductance during peak current demand and protecting the power stage in case of overload or short-circuit. The Output Low-Pass Filter is a Second Order Low-Pass Filter with the Cutoff Frequency of 41.2kHz, which is more than double the maximum audible frequency. This allows a linear reproduction of all frequencies within the audio spectrum without peaks and drops caused by the Output Filter Characteristic changes. A Zobel Network comprised of a film capacitor and a power resistor is used to avoid high frequency oscillation (peaking) if the amplifier operates without load. The Output Filter is optimized for 6Ω loads, so it can be used for 4Ω and 8Ω loads as well.

**Mains Power Supply:** The IRS500SMPS Amplifier Module require several supply voltages for operation: the main differential supply voltage for the Amplifier Power Stage,  $\pm 72$  to  $\pm 75$ V depending on the board version, 12V to Vnn and  $\pm 12$ V for the Amplifier Input Stage. Additionally, a differential voltage in range of  $\pm 16$ V to  $\pm 19$ V is available on the Signal Output Connector with a current capability of 100mA on each rail to supply other stages outside the IRS500SMPS Amplifier Module, within the Amplifier System. All these voltages are all generated from the onboard SMPS. The Mains Power Supply is a Soft-Switched type, LLC Resonant Converter, which can operate both at 230V and 120V Mains Voltage. The main advantage of this SMPS is the increased efficiency, very low switching noise, and Output Voltage regulation which guarantees the expected Output Power and THD values independent of the Mains Supply Voltage variations, as long as the Mains Voltage value is within recommended operating values. Having a high efficiency means low Power Losses and low Thermal Dissipation. The SMPS operates at variable Frequency, around 100kHz at low-load or High Mains Input Voltage and down to approx. 85kHz at full-load or low Mains Input Voltage. Due to High Switching Frequency the Power Transformer is very compact and contributes to the IRS500SMPS Amplifier Module small size.

The Mains Supply Voltage can be either 230V or 120V. The 230V Mains Voltage version, use 400V type, 150uF or 180uF Primary side Electrolytic Capacitors connected in parallel, while the 120V Mains Voltage version use 200V type, 560uF or 680uF Capacitors connected in series. A Voltage Selection Jumper must be placed on the 120V version only when the Mains Voltage is 120V. Do NOT supply a 120V fitted board with 230V because it can be damaged!!! For Safety reasons, the IRS500SMPS Amplifier Modules ordered with 230V Mains Voltage value are fitted with 400V Capacitors connected in parallel which will prevent damage if the Voltage Selection Jumper is placed by mistake. For 120V version boards, care should be taken to avoid damage by supplying it with 230V.

**House-keeping Status and Protection Circuits:** The IRS500SMPS Amplifier has built-in Mute circuit, which allows silent turn ON/OFF without any loud click/pop noise and can be operated without an external speaker protection circuit. The IRS500SMPS Amplifier board have built-in Over-current, Short-circuit, Mains Under-voltage and Over-voltage protections which allows reliable operation as long as it is uses within the recommended values. The IRS500SMPS Amplifier include DC protection and quick-disconnect of the SMPS in the unlikely event of a Power Stage failure and DC signal present at the output of the amplifier. Once the fault is asserted, the Fast-disconnect function latches the IRS500SMPS Amplifier into Shut-Down Mode and the IRS500SMPS Amplifier will not restart to avoid possible damage to the speakers or the rest of the components in the system. A turn-On attempt can be tried after disconnecting the IRS500SMPS Amplifier from Mains for at least 2-5 minutes to allow all the capacitors to discharge reset the latched fault condition. If the issue persists, do not try again, and contact us. Note that this kind of fault is an abnormal situation never encountered in normal operation.

There are two small LEDs on the IRS500SMPS Amplifier Module PCB which indicates the state of the amplifier: Mute LED, Red color which indicates that the module is Muted from various reasons. ON LED, Blue color which indicates that the module works normally. During normal operation only Blue LED lit, and when only Red LED lit it shows that the IRS500SMPS Amplifier module is either Muted or in protect mode, possibly due to Under-Voltage, Over-Voltage, Over-Current or Over-Temperature condition. If the Red LED is always ON no matter of the operation mode, it can indicate a malfunction or missing one of main or auxiliary supply voltage due to overload on the aux. output. During Turn-On and Turn-Off Sequence, as well as while transitioning from Mute to normal operation, the Red LED will be lit briefly while the Blue LED will be lit, indicating the operation mode transition. When the Red LED lit, the Pin 5 of the Signal Input Connector: Shut Down or Mute Out voltage value rise to approx. 5V, so this signal can be used to control and monitor the operation of the IRS500SMPS Amplifier within the system.

Note that although the IRS500SMPS Amplifier board have Over-current, Short-circuit, Under-voltage and Over-voltage protections, these protections are intended to protect the amplifier from events occurring during normal operation, and protecting the module from excessively higher voltages than was designed for, caused by improper mains voltage selection or output voltage swing due to bus pumping if the Amplifier Module is used to amplify very low-frequencies with high amplitudes while driving very low impedance speakers, is not guaranteed. The IRS500SMPS Amplifier Module must be used properly, avoid abusing it and only rely on these protections.

**Thermal Management:** Although the IRS500SMPS Amplifier Module is highly efficient, for long term reliable operation requires cooling to keep the temperature within operating limits. The temperature rise is caused by the dissipated power in the Power Amplifier Stage and SMPS stage. During operation at high Output Power, the total losses can average around 27W with Audio Signal Crest Factor of 2.5 or more. The IRS500SMPS Amplifier Module is equipped with a heatslug, which is a solid block of aluminum on which the Power Semiconductors are installed. This serves as a thermal transfer piece or a bridge between Power Semiconductors and the larger heatsink which is usually located on the edge or outside the Amplifier enclosure or in a well-ventilated area. It also adds to the structural rigidity of the whole Amplifier assembly and the whole IRS500SMPS Amplifier Module can be installed on a larger heatsink by bolting the heatslug on it using suitable M4 screws as long as all the connecting wires are provided with suitable strain relief to avoid snapping them or damaging the board due to mechanical tension caused by tensed wires.

The choice of the heatsink must take into account few factors. If we allow a max. temperature rise of 40°C in an ambient temperature of 35°C, the heatsink temperature will reach 75°C and the heatsink must have Thermal Resistance  $R_{th}$  of 1.5°C/W or better to be able to dissipate the generated heat without overheating and triggering the over-temperature protection. The most suitable heatsink is made of aluminum, have vertical oriented fins and is placed so that free convection currents allow cooling. The size of the heatsink can be roughly 100mm to 150mm wide, 35mm to 50mm tall, and the depth of the fins must be at least 25mm. The total number of cooling fins for

efficient cooling must be at least 15, more are better. If the IRS500SMPS Amplifier Module operates in an environment where is not exposed to direct sunlight, a black anodized heatsink will be the best choice. However, if the IRS500SMPS Amplifier Module is installed in an enclosure or speaker cabinet which might be used in direct sunlight, do not use a black anodized heatsink as this will absorb more heat energy from Sun radiation than will dissipate, worsening the overall performances.

For Multi-Channel operation, where multiple IRS500SMPS Amplifier Modules are installed within the same enclosure side by side, a dedicated heatsink with horizontal fins is used instead of the heatslug, which will allow batch cooling of all the IRS500SMPS Amplifier Modules within the Multi-Channel enclosure. This particular version can also be used for single or dual channel installation where the overall size is an important factor or thermal demand is higher and forced air cooling is required. If this is the case, a small 40x40mm or 50x50mm cooling fan can be used to keep the IRS500SMPS Amplifier Module temperature within the operating limits.

Within the IRS500SMPS Amplifier Module heatslug or on the bottom of the heatsink, a temperature sensor is installed which continuously monitors the heatslug or heatsink temperature which is in direct correlation with the Power Semiconductors temperature. Because the finite thermal resistance of the transfer material as well as thermal inertia, a temperature difference 5°C to 15°C between the Junction temperature of the Power Semiconductors and the actual reading is expected. For this reason, the Thermal Protection will Mute the IRS00SMPS Amplifier Power Stage if the temperature of the sensor reaches approx. 85°C to protect the power transistors and will Un-Mute when the temperature drops below 80°C. Considering the temperature difference, it means that the protection will keep the Junction temperature of the Power Semiconductors below 100°C, less than the maximum specified temperature from their data-sheet, usually 125°C or even 150°C for some components.

### Amplifier Connection and Operation:

For proper operation, the IRS500SMPS Amplifier Module must be used according with the instructions provided in this manual. The IRS500SMPS Audio Amplifier Module can be connected in several configurations, depending on the system requirements. The most common and simple configuration is shown in the schematic in Figure 3. Only the Input Signal connector and Speaker wires are needed. Below are few connection diagrams showing the inter-connection. For proper operation and best performances, the IRS500SMPS requires to be supplied with a balanced or unbalanced audio signal with the maximum amplitude in range of 1.5V for 500W on 4Ω or 1.64V for 300W on 8Ω rated output power with the current gain setting. The audio signal must be applied at the input of the Amplifier, on the Signal connector as can be seen in the following schematics. In the below schematics, the signal phase is inverted for left channel to prevent or reduce bus pumping phenomenon. To be able to conveniently adjust the listening volume it is strongly recommended to use a potentiometer, logarithmic type with value of 50KΩ or maximum 100KΩ. The potentiometer must be connected as in the Figure 6 example.

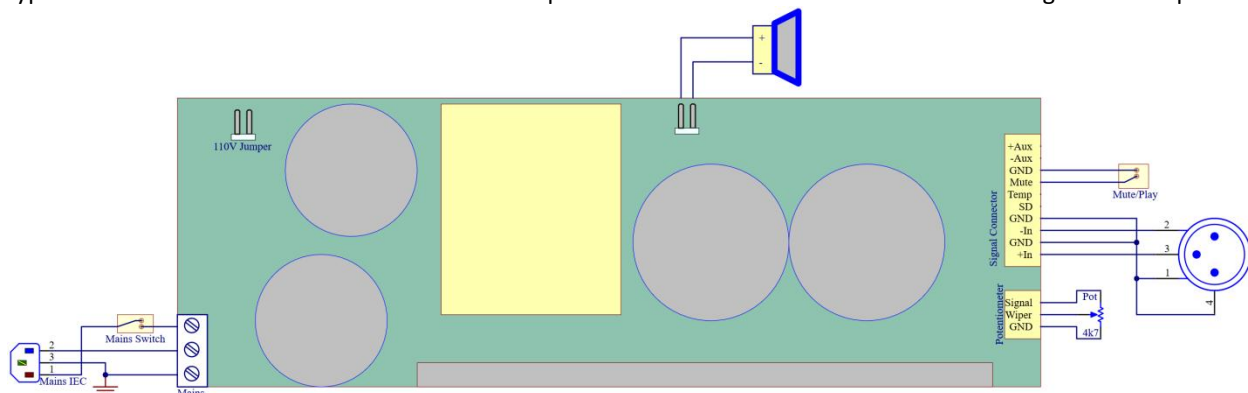


Figure 3: IRS500SMPS Audio Amplifier Module Interconnection using Balanced XLR connector

**Mute control:** When the Mute pin7 of the **Signal** connector is connected to GND the amplifier is muted (both high and low-side transistors are turned off). There is a delay of approximately 400-600 milliseconds between the de-assertion of MUTE and the un-muting of the IRS500SMPS Audio Amplifier Module which prevents false activation due to possible noise induced in the Mute wires from nearby noise sources. When the amplifier is Muted, either from an external Mute control signal, or due to an over-current, over-voltage or under-voltage condition, the Mute LED will lit and the ON LED will not lit. Also, when the ampler is in Mute state, the pin5 of the Aux connector will toggle from +5V to -5V to indicate the amplifier state to the power supply circuits which might



act accordingly. This is an I/O pin also used for delay turn ON of the amplifier when all the supply voltages are steady and amplifier ready to run. This function adds one more level of protection to the loudspeakers which are used with this amplifier.

**Layout:** The PCB Layout design has an important contribution to the overall performance of the IRS500SMPS Audio Amplifier Module. 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 70V is large enough to satisfy the clearance conditions imposed by the design standards. The size of the PCB is 150x 50 mm or just less than 6 x 2 inch, and has 5 mounting holes, 4 holes are on the corner of the PCB and one between the two large electrolytic capacitors. The mounting holes are 3.2mm diameter or 0.12 inch, copper plated 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 142x42mm perimeter, which we adopt as a standard for all our boards including amplifiers and power supplies. The main components layout and the Input and Output connectors pin out can be seen in the Figure 4. It is recommended to use heavy gauge wires for Power Supply and Loudspeaker Output and short shielded cables for Audio Input. The central mounting hole is connected to GND and should be considered if will be connected to chassis or not. The heatslug is mounted directly onto the PCB and does not require additional support. For high power application when the IRS500SMPS amplifier module is installed into a small poorly ventilated enclosure and with a smaller than necessary heatsink attached to the heatslug, a cooling fan is recommended to be used, and installed on the mains side of the board sucking air through it.

**Wiring** the amplifier to connectors, potentiometer, 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. The input cables should 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.

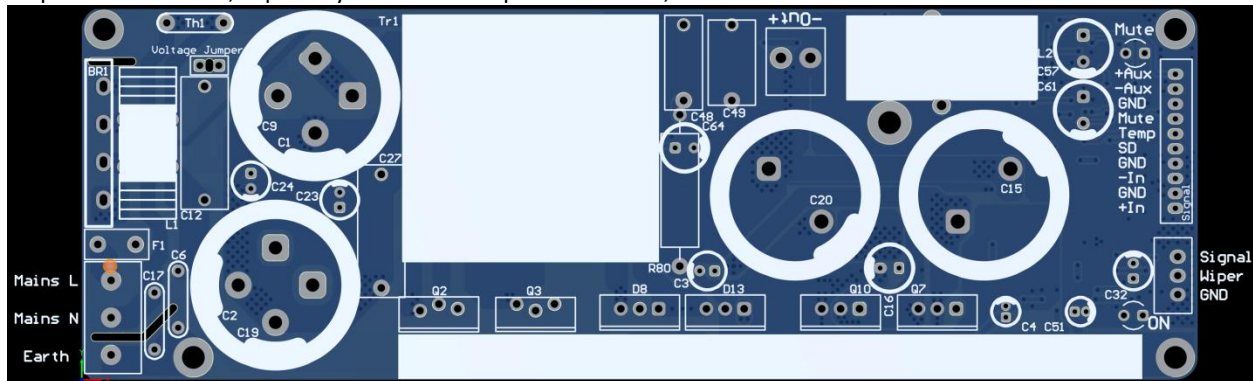
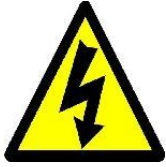


Figure 4: IRS500SMPS Module PCB Layout

## Connectors Pin-out:

The **Signal Input** connector pin-out (from bottom to top) is as follows:

- Pin 1: Non-Inverting Input
- Pin 2: GND Signal
- Pin 3: Inverting Input
- Pin 4: GND Signal
- Pin 5: Shut Down or Mute Out (Mute mode=5V Run mode=-5V)
- Pin 6: Temperature feedback (Heatslug temperature monitor 0-3V DC corresponding to 20°-75°C range)
- Pin 7: Mute (Pull-Down = Mute, left open or 5V Run)
- Pin 8: GND Aux
- Pin 9: -Aux Output: -16 to -19V @100mA, Aux Supply Output for other external Circuits
- Pin 10: +Aux Output: +16 to +19V @100mA Aux Supply Output for other external Circuits



## Warning:

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

The IRS500SMPS Amplifier Module contains potentially hazardous voltages up to 360V DC or 250V 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 other than the on-board mains fuse. In case of blown fuse, only replace the fuse with the same type and rating. Do not attempt to change any other component from the board. 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 the improvements". 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 coke can 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 IRS500SMPS 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 misuse 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**, and no support at all for the similar boards which aren't purchased directly from **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.