SMPS500QRv3

The **SMPS500QRv3** Switched Mode Power Supply (SMPS) is **Custom Built upon order** to satisfy the Power needs for both Linear Amplifiers such as class AB Amplifiers or Switched Amplifiers such as Class D or Class T. SMPS500QRv3 output voltage is not regulated and it follows the mains input voltage within +5% to -10% variation. SMPS500QRv3 use state of the art, highly efficient Zero-Voltage-Switching Topology. The soft-switched topology used allows SMPS500QRv3 to have very low EMI noise, lower losses and smaller size compared to an equivalent power rating classic hard-switched SMPS. Five output voltage values are commonly requested plus special voltage version in range of±30V to ±170V. SMPS500QRv3 is suitable to be used with most of the Audio Amplifiers from the market as long as the output voltage and current match the amplifier requirements, not just with the Connexelectronic ones.

SMPS500QRv3 Features:

- Zero-Voltage-Switching Topology for high efficiency, up to 96.3% and lowest EMI.
- 230V AC and 120V AC models available, jumper selectable.
- 500W Total Output Power, 700W Peak Output Power when used for audio amplifiers with crest ratio of 3.
- SMPS500QRv3 allows a high degree of customization, several differential output voltages are possible: ±32V ±40V ±45V ±55V ±60V and special voltages in range of±30V to ±170V.
- Differential Auxiliary Voltage available, with voltage value in range of ±12V to ±20V at 300mA max.
- Complete protection set, Under-voltage, Over-current, and Short-Circuit Protection.
- On-board Soft Start for smooth turns ON without current peaks or breaker tripping.
- Compact size, 100x100mm and 36mm tall from the PCB base, can fit into 1RU unit, lightweight, 400 grams.
- Screw type terminals for Mains Input Fast-On connectors for Voltage Output

Fig.1 SMPS500QRv3 appearance

SMPS500QRv3 Description: The current for the audio amplifiers producers, both in HI-FI or Pro-Audio field, is to use a hard-switching unregulated SMPSs which proved to be an EMI inferno, requiring extra additional filtering and shielding to achieve decent EMI performances and to not disturb all the sensitive circuits near-by. The main reason behind this is the cost, which is lower for such power supplies than for a ZVS one; another reason is the lack of knowledge and fully understanding of ZVS SMPS operation. Since the Audio-amplifiers SMPSs are not yet widely accepted, mainly from subjective reasons such as "sound quality degradation" which was a direct effect of the previously mentioned early SMPSs, and the lower cost of classic, old type transformers when purchased in mass-production quantities beats the cost of developing and producing a good performance SMPS for audio applications, many companies which produce audio equipment, both for consumer and pro-audio are still using old type mains transformers and some, still use the old, hard-switched type SMPS mainly because most of the SMPS designers came from consumer products field where product cost stays ahead performance.

Being soft commutated, the SMPS500QRv3 intermodulation noise which might occur has very low value, below the S/N ration threshold, thus inaudible. Switching frequency during normal operation is constant, around 80KHz, and is completely rejected by the mains EMI filters, so it doesn't interfere with near-by equipment through power lines. The ZVS topology used for the SMPS500QRv3 was chosen due to its many advantages compared with all other topologies. Among the advantages, we consider that the most important are superior efficiency, up to 96.3% lower EMI and noise, compact size and reasonable complexity. The operation principle of this converter was described in many papers, application notes, and reference designs. Although is not a new technology, being discovered more than 15-20 years ago, until recently, the lack of knowledge, documentation and availability of good characteristic electronic components such as high-speed MOSFETs or IGBTs prohibited this topology to spread like other hard switched topologies did. Only after the LCD and Plasma TV's came-up and initiatives to increase efficiency of the consumer products such as 80+, 90+ were imposed, engineers had to look towards other solution than the current, mature hard-switched topologies, which can't break the 90% efficiency barrier without significant cost and complexity increase. For a ZVS resonant converter, efficiencies greater than 92% are common and even 95-96% can be achieved. In some cases the DC-DC converter is supplied from the output of a PFC pre-regulator capable to supply a constant 400V DC. In our case, the PFC stage is not required, due to the purpose of the application and because similar or better efficiencies can be achieved without using a complicated PFC circuitry which would increase the size of the SMPS board, EMI, and decrease the performance due to the fact that the available space is limited and the PFC inductor might interfere with other circuits operation.

The **output voltage** of SMPS500QRv3 is unregulated and it follows the mains input voltage up to +5% and down to -10%. For example, the SMPS500QRv3 ±60V version, the output voltage when is powered from 230V mains voltage will be about ±61.5-62V at no load, ±60V at 10% load and will drop down to ±54-55V at 100% load, or 500W. All these values are guaranteed with a stable mains voltage which does not drop more than 1V from zero to full load at the input of SMPS500QRv3. For comparison, using a classic power supply comprised of a 500W mains transformer, rectifier bridge and same capacitance value for electrolytic capacitors as SMPS500QRv3 use on secondary side, if we take the output voltage value at no-load as reference, being equal with the output voltage of SMPS500QRv3 at no load ±61.5-62V, the output voltage at 10% load would be equal or at most slightly higher, around ±60-60.5V but under full load will drop down to ±50-52V, due to several factors such as transformer windings DC and AC resistance, and the lack of large primary side storage capacitance which SMPS500QRv3 have and the classic power supply doesn't have. The equivalent of total secondary side capacitance of SMPS500QRv3 is about 3-4 times higher than the value of the actual secondary side capacitors due to the fact that the main storage capacitors placed on the primary side can store more energy per volume being high-voltage type. This leads to another inherent advantage over the classic power supply, the amplifier headroom is increased, and was proven during audition sessions that the punch and bass are deeper when SMPS500QRv3 using compared to a classic power supply. And all this at a fraction of the weight, size and cost.

An important aspect which must be considered when the SMPS500QRv3 is powered ON, the initial current drawn from the mains is few times higher than the average operating current. This is called surge current and all electronic equipment show the same behavior, especially SMPSs. The reason for this is that the filter capacitors are completely discharged, and act as a short circuit for a brief period. The current is higher as the capacitors capacity and voltage is higher, and is proportional with the capacitor stored energy ($CU^2/2$). To prevent harmful effects which this high value inrush current might have to the Power Supply components, a thermistor is used to limit the inrush current to a lower value than the mains fuse will trip or might damage any components from the Amplifier Power Supply. The thermistor is a passive component which has the property to decrease its

resistance when the temperature increases. It has higher electrical resistance at low temperature, thus reducing the inrush current, and when the current which passes through, will heat-up the thermistor, the resistance will decrease, and the dissipated power will be reduces. One drawback might be the increased operating temperature, especially when the SMPS500QRv3 is supplied at low mains voltage and delivers high output power. The thermistor is placed on the edge of the board close to the Mains input connector, this avoiding heating-up other temperature sensitive components. Note that there is no need to use any other external power soft-start circuit when the SMPS500QRv3 is powered from standard mains supply voltage of 120 or 230V AC.

The SMPS500QRv3 features a soft-start characteristic, which allows progressive charge of the output filter capacitors, with a controlled charging current, without tripping over-current protection. This protection works very well with the existing capacitors values and if the extra-capacitors added does not exceed the value of the existing capacitors. Also, during turn-On sequence the output current is limited to prevent damage to the amplifier if for some reason the current consumption exceeds about 20% of the rated current. Note that any normal amplifier (except class A amplifiers) does not require more than 2-10% of the rated current as quiescent current, and preventing the SMPS to start while a massive current consumption is detected can prevent damage for the amplifier. The value and the working voltage of the output capacitors depend on the type of the SMPS, single or dual voltage, and the value of the output voltage. The optimal values are chosen for each particular version. On the mains side, 400V type capacitors are used if the SMPS500QRv3 is used at 230V mains only and 180-200V type capacitors are used if SMPS500QRv3 is used on 120V. Although the soft-switching characteristic allows the SMPS500QRv3 to run a lot cooler than similar power hard-switched SMPSs, over-temperature protection was added to prevent damage if the SMPS500QRv3 is abused or used for continuous operation at high power. This consists of a circuit which monitors the temperature of the primary MOS-FET's and disables the power supply when the operating temperature reach 90-95˚C. To resume operation, the mains power must be disconnected for at least 10 minutes allowing the temperature to drop and all capacitors to discharge before power on again.

Auxilliary output voltage:
SMPS500QRv3 has a dual output auxiliary output voltage which can be used to supply other stages of the amplifier. The aux. output voltage is unregulated and the average value is around ±15V to ±20V at 300mA Maximum available current for short period is 500mA. The auxiliary outputs are protected against overload and short-circuit using two resettable PTC fuses which will disconnect the aux output once the maximum current of ~800mA is exceeded and will reconnect after the overload or short-circuit condition was cleared. Although the output is protected, for long time reliable operation is do not use the SMPS500QRv3 with aux. outputs shorted or overloaded. We recommended using linear voltage regulators such as 78xx and 79xx series after the auxiliary output to supply regulated voltage to other circuits such as preamplifiers.

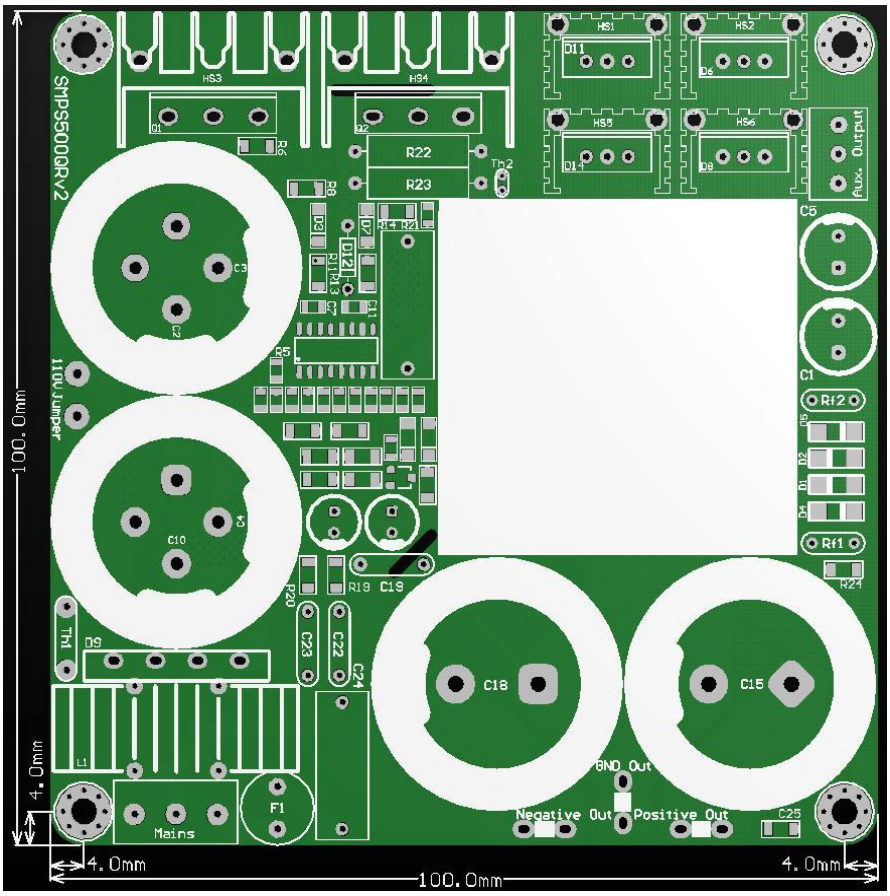
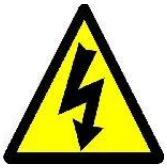


Fig.2 SMPS500QRv3 board layout and size



Warning:

Before you proceed with installation, make sure you have read this warning SMPS500QRV3: The SMPS500QRV3 is powered from the mains voltage and the primary side of the SMPS has hazardous voltages up to 340V DC and up to 500V 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 SMPS while it is connected to the mains and at least 10 minutes after complete disconnect from mains. If any changes or reconnection needs to be done, disconnect the unit from the mains and allow all capacitors to discharge for at least 10 minutes before handling it. The secondary side capacitors have no bleeding resistors which would waste power and decrease efficiency, and they must be discharged using a 10-100R 3-5W power resistor before handling the SMPS500QRv3. 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 and the on-board mains fuse has just protection purpose. In case of blown fuse, do not attempt to replace the fuse, contact us first, because other components might be affected if a wrong fuse value is used. Do not attempt to change any other component from the SMPS500QRV3. A safety clearance of at least 6mm must be kept between the board and the case, or any conductive part of the amplifier. The heat transfer between the heatsinks and ambient must not be obstructed for proper operation.

SMPS500QRV3 characteristics:

Output voltage: Parameters:	**SMPS500QRv3 ±32V**	**SMPS500QRv3 ±40V**	**SMPS500QRv3 ±45V**	**SMPS500QRv3 ±55V**	**SMPS500QRv3 ±60V**
No-load Output Voltage:	Minimum:±32V Maximum:±34V	Minimum:±40V Maximum:±43V	Minimum:±45V Maximum:±48V	Minimum:±55V Maximum:±58V	Minimum: 60V Maximum: 64V
Nominal Output Voltage measured at 10-20% load	Minimum:±31V Maximum:±33V	Minimum:±39V Maximum:±42V	Minimum:±44V Maximum:±47V	Minimum:±54V Maximum:±57V	Minimum:±58.5V Maximum:±62.5V
Full load Output Voltage measured at 100% load	Minimum:±29V Maximum:±30V	Minimum:±37V Maximum:±38V	Minimum:±41V Maximum:±42V	Minimum:±50V Maximum:±52V	Minimum:±53.5V Maximum:±56.5V
Aux. Output Voltage:	Minimum:±11V Maximum:±20V	Minimum:±11V Maximum:±20V	Minimum:±11V Maximum:±20V	Minimum:±11V Maximum:±20V	Minimum:±11V Maximum:±20V
Mains input voltage:	110V: 98-127V 230V: 196-254V	110V: 98-127V 230V: 196-254V	110V: 98-127V 230V: 196-254V	110V: 98-127V 230V: 196-254V	110V: 98-127V 230V: 196-254V
Main Output Current:	Nominal: 8A Peak: 11A	Nominal: 6.5A Peak: 8.5A	Nominal: 6A Peak: 8A	Nominal: 5A Peak: 7A	Nominal: 4.5A Peak: 6.5A
Aux. Output Current:	Nominal: 0.3 A Peak: 0.5A	Nominal: 0.3A Peak: 0.5A	Nominal: 0.3 A Peak: 0.5A	Nominal: 0.3 A Peak: 0.5A	Nominal: 0.3 A Peak: 0.5A
No-Load power cons.	Min: 1.8W Max: 2.5W	Min: 1.8W Max: 2.6W	Min: 1.9W Max: 2.6W	Min: 2 W Max: 2.7W	Min: 2.1W Max: 2.8W
Efficiency at 50% load	110V: 90.8 % 230V: 92.9%	110V: 92.0 % 230V: 94.2%	110V: 92.8 % 230V: 94.7%	110V: 93.9 % 230V: 95.5%	110V: 94.8 % 230V: 96.3%

All the output voltage values from the table above were measured with steady mains voltage 230V AC 50Hz and 120V AC 60Hz respectively. These values will differ if the mains voltage is lower or higher, accordingly.

Mains voltage is set by default to 230V to prevent any possible faults if wrong voltage version is ordered, for example 120V version for countries where 230V is also available. In this case the user must connect the 120V jumper IF and ONLY the mains voltage is within 100-127V interval otherwise damage might occur. A 230V configured power supply won't start at 120V and no damage can occur. But if it is configured for 120V and powered with 230V there are many chances to damage the power supply. The SMPS500QRv3 is designed to allow both 200V and 400V type capacitors to be installed on the primary side in series or parallel connection allowing the most suitable configuration and highest total capacitance to be achieved. The 230V version will use 400V capacitors only while 120V will use 180-200V capacitors. Capacitors are values are chosen for best fit on each power supply voltage version.

Disclaimer:

The SMPS500QRv3 is a fully customized product which tailor the needs of each particular application and it is strongly recommended to pay attention to the voltage choice during ordering process as each particular application might only work with its corresponding voltages, and wrong values can lead to malfunction and can damage the product.

The SMPS500QRv3 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, Connexelectronic, is not 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, only skilled users can install and use this product and the user should take all the measures needed when working with mains voltages, they should not touch any unisolated part of the board or connectors, or short-circuit any part of the board or connectors. Any misusage is the user's responsibility.

The designer and manufacturer reserve the right to make changes or modifications on both the product functions and the performance without notice. The design details and PCB design is **Connexelectronic** proprietary information and shall not be copied published or distributed without **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 listed resellers, and from various reasons they look or pretend to be similar, exactly the same, or improved version products. **Purchasing the product means that you are aware and agree with these conditions.**