SMPS240QR

The **SMPS240QR** Switched Mode Power Supply (SMPS) is specially designed to be used for Audio Amplifiers, both Class AB Linear Amplifiers with output power up to 120W and Class D Switched Amplifiers with output power up to 200W and have a crest factor of at least 2.5. **SMPS240QR** use state of the art, highly efficient Series Resonant Converter Topology. Due to the soft-switched topology used, the **SMPS240QR** has very low EMI noise, lower losses and is much more compact than any similar power rating Switched Mode Power Supply, which most of them use classic hard-switched topology. Several output voltage version are available for stock **SMPS240QR**, plus custom output voltages, on request for larger quantities. The suitable output voltage range both readily available as well as "available on request" can cover the entire voltage range from ±17V to ±80V. The output voltage of **SMPS240QR** is not tightly regulated, and is proportional with Mains Input voltage within 2-5% limits from no load to maximum load, making the **SMPS240QR** suitable to be used with several Audio Amplifiers available on the market, not just with the Connexelectronic ones.

SMPS240QR Features:

- Half-Bridge Series Resonant Converter Topology for lowest EMI and high efficiency, up to 94%.
- 230V AC Mains voltage version stock available and 120V AC Mains voltage version available on request.
- 240W Nominal Power, 300W Peak Power, 335W Short-Time Peak Power with crest factor 2.5
- Ready available output voltage versions in stock: **SMPS240QR** differential output: ±27V ±32V and ±40V
- 12V 300mA nominal and 500mA peak current, Regulated Auxiliary Voltage.7
- Complete protection set, Under-voltage, Over-voltage, Over-current, and Over-temperature Protection.
- Small size Integrated heatsinks for power devices, due to high efficiency.
- Compact size, 100x50x30mm, weight less than 200 grams, best size and weight to power and price ratio.

Fig.1 SMPS240QR picture

SMPS240QR Description: The current for the audio amplifiers producers, both in HI-FI or Pro-Audio field, is to use a hard-switching unregulated SMPS's 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 SMPS's are not yet widely accepted, mainly from subjective reasons such as "sound quality degradation" which was a direct effect of the previously mentioned early SMPS's, 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 **SMPS240QR** 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 **SMPS240QR** 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 94% 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 MOS-FET's or IGBT's 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.

Although the **output voltage** of **SMPS240QR** is unregulated and it follows the mains input voltage up to +5% and down to -10%, the overall performance compared with a linear power supply solution is much better from all points of view. Overall efficiency is higher, voltage drop is much lower and the weight and size are simply incomparable, about 10-15 times lighter and taking 5-10 times less space than a conventional linear power supply. For example, the **SMPS240QR** ±40V version, the output voltage when is powered from 230V mains voltage will be about ±41.3V-42.2V at no load, ±40V at 10-20% load and will drop down to ±37.5V-38.5V at full load. 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 **SMPS240QR**. For comparison, using a classic power supply comprised of a 240W mains power transformer, rectifier bridge and same capacitance value for electrolytic capacitors as **SMPS240QR** use on secondary side, if we take the output voltage value at no-load as reference, being equal with the output voltage of **SMPS240QR** at no load ±41.3V-42.2V, the output voltage at 10% load would be slightly lower, around ±38.5V-39V but under full load will drop down to ±33V-35V, due to several factors such as transformer windings DC and AC resistance, and the lack of large primary side storage capacitance which **SMPS240QR** have but the classic power supply doesn't have. The equivalent of total secondary side capacitance of **SMPS240QR** is about 3-4 times higher than the value of the actual secondary side capacitors due to the fact that the main storage capacitor is placed on the primary side and 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 **SMPS240QR** using compared to a classic power supply. And all this at a fraction of the weight, size and cost.

SMPS240QR have a regulated auxiliary output voltage of 12V capable to deliver 300mA continuous output current and up to 500mA peak current. The maximum current should not exceed 500mA to prevent overheating the mains side power devices which are attached on the same heatsink. The GND of the auxiliary output is isolated from main output GND, allowing the auxiliary supply GND node to be connected to any of the main output rails, especially –Vcc commonly used for class D amplifiers as power stage driver supply voltage.

When **SMPS240QR** 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 SMPS's. 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 **SMPS240QR** 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. No need to use any other external power soft-start circuit if a single **SMPS240QR** is powered from standard mains supply voltage of 120 or 230V AC.

The **SMPS240QR** 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 output voltage version.

Thermal Management: **SMPS240QR** requires proper thermal management to keep the maximum temperature of all the components within their operating range. The efficiency of **SMPS240QR** from 15% to 100% load is over 90% with peak efficiency 94%. Efficiency and dissipated power depends on output voltage version, the highest voltage version has the highest the efficiency. If the **SMPS240QR** is installed in a tight enclosure next to other modules which generate heat, using a cooling fan is strongly recommended to keep the temperature within normal operation limits, without affecting the reliability or trigger the Over-Temperature protection too early. The fan must be installed on the back side of the enclosure and absorb the hot air through the board and blow the hot air outside the enclosure. While the hot air is removed from the enclosure instead of blowing air inside, the average temperature of PCB and temperature sensitive components such as electrolytic capacitors is kept 15-20°C lower than if the air would circulate in opposite direction as well as reducing dust quantity by stopping some of the dust on the air intake before reaches the power supply board. The cooling fan must be 12V 80-120mA rated, 50x50mm or 40x40mm type, ball bearing. It is not provided with **SMPS240QR** but can be supplied on request. The fan can be powered from **SMPS240QR** directly, from +Aux- connector. **SMPS240QR** has over-temperature protection to prevent damage if is used for continuous operation at high power. The thermal sensor monitors the temperature of the primary MOS-FET's and disables the power supply if 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.

Although the soft-switching characteristic allows **SMPS240QR** to run cooler than similarly rated hard-switched SMPS, the generated heat must be removed by the heatsink thermally connected to the primary side power devices and placed on a side of the board and thermal pads under the PCB which will transfer the heat from secondary side rectifiers to the bottom base plate of the enclosure in which the **SMPS240QR** will be installed. The rectifiers are installed on the bottom side of **SMPS240QR** as can be seen on the right side picture. All 4 diodes are packaged in SMC footprints and soldered on the top left corner. Their height from the PCB is ~2.5mm. For better thermal transfer, 2.5mm thick thermal conductive sheet must be used to remove the heat from the diodes and transfer to the metal enclosure below **SMPS240QR**. The spacers between PCB and bottom plate must be 5mm long.

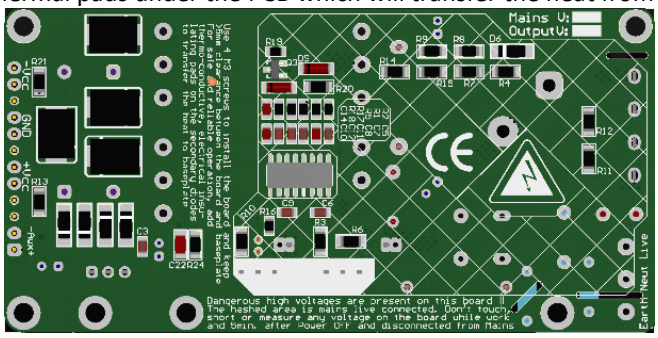

Fig.2 SMPS240QR bottom side components

For best performance and maximum efficiency, the current version of **SMPS240QR** is only available with 230V mains input voltage version. 120V mains voltage versions can be built on request if MOQ is meet. As alternative for 120V market, a slightly higher power version was developed, **SMPS300QR.** The **SMPS240QR** size is 100x50mm and 30mm tall with the default capacitors. It has 4 mounting holes at the corners of the board, the distance from each hole and PCB edge can be seen in Fig.3 along with Mains pinout and DC output pinout. The mains input connector is screw type terminal block. **For safe and reliable operation, the SMPS240QR board must be earth connected.** Noise or hum caused by unwanted GND loops is suppressed by using a GND loop breaker circuit made of R24 and C22. If noise persists, R24 value can be reduced. The signification of the pins starting from bottom left corner is:

- Pin1: Protective Earth connection
- Pin2: Neutral Mains connection
- Pin3: Live Mains connection

DC output voltage wires should be connected using 2.5mm Fast-On clips, on the Fast-On blade terminals placed on the right side of the PCB. Bare Fast-On plugs without wires are provided, on which properly sized wires must be attached and crimped. For mains supply, 1.5-2mm² wires are recommended and for output DC voltage 1.5-2.5mm² must be used, depending on the output current, allowing up to 5A/mm² current density. For auxiliary output, no PCB connector is used due to narrow space and wires can be soldered directly on the PCB. Make sure there is enough clearance between Fast-On clips while operates and isolate them with thermal contracting tube.

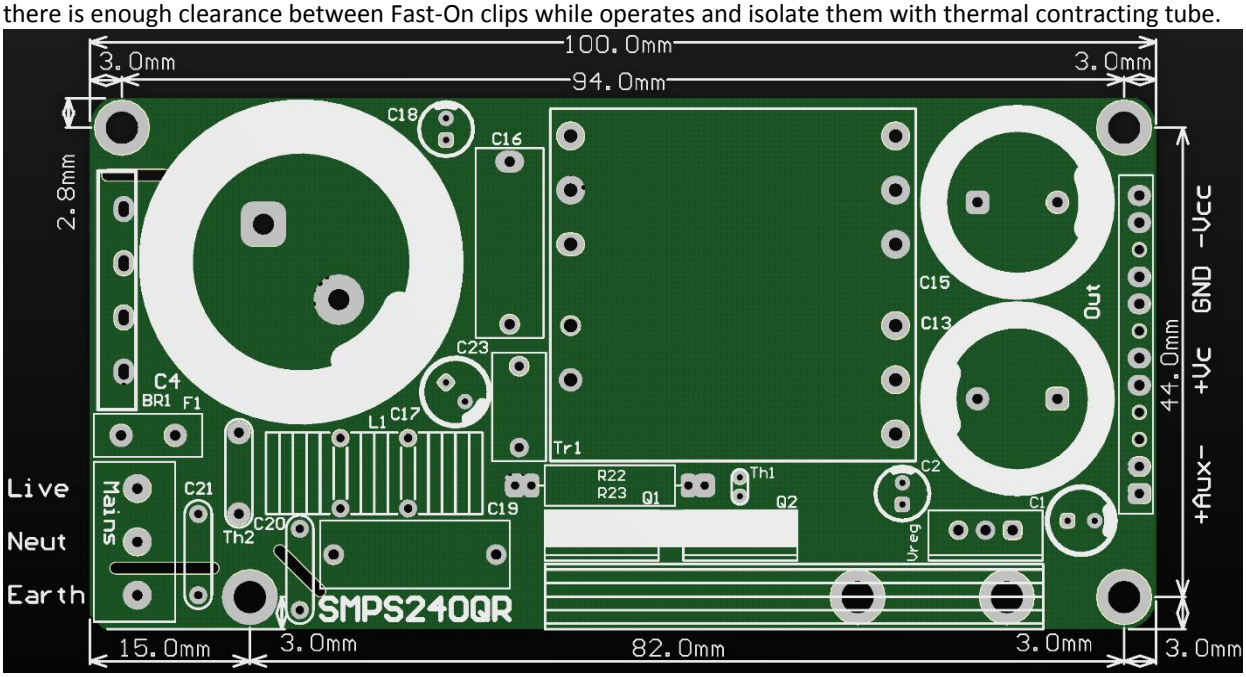

Fig.2 SMPS240QR Layout and size

Warning:

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

The SMPS240QR is powered from the mains voltage and the primary side of the SMPS has hazardous voltages up to 340V DC and up to 300V 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. 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 SMPS240QR. A safety clearance of at least 5mm must be kept between the board and the case, or any conductive part of the amplifier and an insulating sheet made of suitable material must be used between the power supply board and bottom of the enclosure. The heat transfer between the heatsinks and ambient must not be obstructed for proper operation.

SMPS240QR specifications:

Output voltage version: **Parameters:**	**SMPS240QR ±32V**	**SMPS240QR ±36V**	**SMPS240QR ±40V**	**SMPS240QR ±45V**	**SMPS240QR Custom voltage**
No-load Output Voltage:	Minimum:±32V Maximum:±34V	Minimum:±36V Maximum:±38V	Minimum:±40V Maximum:±43V	Minimum:±45V Maximum:±48V	Minimum: ±17V Maximum: ±85V
Nominal Output Voltage measured at 10-20% load	Minimum:±31V Maximum:±33V	Minimum:±35.5V Maximum:±37.6V	Minimum:±39V Maximum:±42V	Minimum:±44V Maximum:±47V	Minimum:±17.5V Maximum:±84.5V
Full load Output Voltage measured at 100% load	Minimum:±29.2V Maximum:±30.6V	Minimum:±32.8V Maximum:±34V	Minimum:±37.5V Maximum:±38.3V	Minimum:±41.8V Maximum:±42.7V	Minimum:±16.2V Maximum:±74.5V
Maximum Output Voltage Ripple at 10% load:	100Hz: ±0.3Vpp 100KHz: ±24mVpp	100Hz: ±0.4Vpp 100KHz: ±27mVpp	100Hz: ±0.5Vpp 100KHz: ±29mVpp	100Hz: ±0.5Vpp 100KHz: ±33mVpp	100Hz: ±1.2Vpp 100KHz: ±75mVp
Maximum Output Voltage Ripple at 70% load:	100Hz: ±1.6Vpp 100KHz: ±73mVpp	100Hz: ±1.7Vpp 100KHz: ±78mVpp	100Hz: ±1.76Vpp 100KHz: ±83mVpp	100Hz: ±1.85Vpp 100KHz: ±88mVpp	100Hz: ±4.2Vpp 100KHz:±150mVp
Aux. Output Voltage:	Minimum: 11.8V Maximum: 12.3V	Minimum: 11.8V Maximum: 12.3V	Minimum: 11.8V Maximum: 12.3V	Minimum: 11.8V Maximum: 12.3V	Minimum: 5V Maximum: 24V
Mains input voltage:	Min: 192V Max: 258V	Min: 192V Max: 258V	Min: 192V Max: 258V	Min: 192V Max: 258V	Min: 192V Max: 258V
Main Output Current:	Nominal: 4A Peak: 5.5A	Nominal: 3.6A Peak: 5A	Nominal: 3.2A Peak: 4A	Nominal: 3A Peak: 3.6A	Nominal: 1.5-7.5A Peak: 1.8-9A
Aux. Output Current:	Nominal: 0.3 A Peak: 0.5A	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
No-Load power consumption :	Min: 1.6W Max: 2.1W	Min: 1.8 W Max: 2.7W	Min: 2W Max: 2.8W	Min: 2.2 Max: 2.9W	Min: 1.5W Max: 3.8W
Efficiency at 50% load	Min: 91.5% Max: 92.1 %	Min: 91.8% Max: 92.4%	Min: 92.7% Max: 93.2%	Min: 92.9% Max: 93.4%	Min: 90.1% Max: 94%

All the measurements from the table above except Mains Input Voltage range were made with steady mains voltage 230V AC 50Hz and 120V AC 60Hz as well as variable mains voltage according to table above using the following instruments: Fluke289 and HIOKI3238 Multimeters, HIOKI3332, Power Analyzer, LeCroy Wavesurfer LT374 and Tektronix TPS2024B Oscilloscopes, Rigol DSA815 Spectrum Analyzer and M9716B High Power Programmable DC load. For test results repeatability, must use the same values for mains voltage and load, and same measuring conditions and equipment.

Disclaimer:

The SMPS240QR 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.**