TDA8920/8924 Audio Amplifier Module v1.0

The TDA8920/8924 Audio Amplifier Module is a Class D Stereo Audio Amplifier based on TDA8920/8924 Class D Audio Power Amplifier made by NXP (Philips) Company. This amplifier is a complete solution for middle and above middle power levels, it only requires a power transformer, wires, signal and speaker connectors and housing. The design of this board is in accordance with the manufacturer datasheet and recommendations, as well as the reference designs. Furthermore, some improvements has been made to make the board more compact and suitable to use both in new designs, in which the user will adopt the preferred housing, input stages and power supply, and can be used also as a drop-in replacement for existing audio amplifiers, which already have housing, transformer, and input stage.

Amplifier Features:

- TDA8920: Output Power: 2x70W at 4Ω, or 35W at 8Ω, with max. 0.1% THD+N, at +/- 27V Supply Voltage.
- TDA8924: Output Power: 2x70W at 4Ω, or 35W at 8Ω, with max. 0.1% THD+N, at +/-27V Supply Voltage.
- Output Power in Bridge mode: 160W at 4Ω, +/-24V or 135W at 8Ω, +/-27V Supply Voltage.
- Audiophile sound Quality: 0.02% THD+N at 36W at 4Ω or 20W at 8Ω.
- Very good efficiency: Up to 90% at 2x35W at 8Ω or up to 87% at 2x70W at 4Ω.
- Requires only an AC symmetrical supply of 2x20V AC at minimum 4A for stereo or min. 5A for BTL Mode
- Output over-current and short-circuit to GND or Powers supply rails protected, thermal protection.
- Zero dead time switching and very low quiescent current.
- Fixed gain of 30 dB in Single-Ended (SE) and 36 dB in Bridge-Tied Load (BTL)
- Can be used in both in stereo or BTL mode without any kind of modifications.
- Compact size, 70x70x40mm, assembled board, with flat base for direct mounting on heat sink.
- Mute control stand-by pins for controlling the amplifier status within the system
- Rectifier Bridge and big electrolytic caps integrated on board.
- Screw type terminals for output and Power Supply.
- Double layer, 1.6mm thick PCB with 2 oz copper traces, minimizes stray inductances and parasitic.
- Mostly SMD components used, mounted very close to the Power Amplifier IC to increase performances.

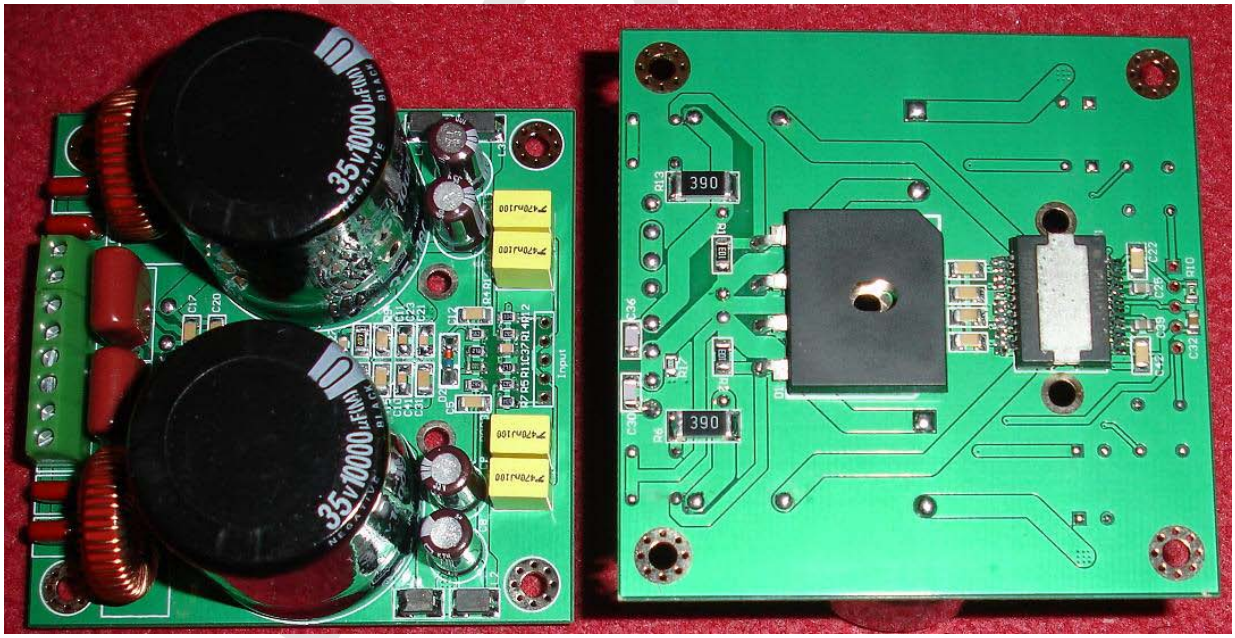

Figure 1: TDA8920 and TDA8924 Audio Amplifier Module without the heat sink, top and bottom view

Amplifier Description:

TDA8920/8924 Class D Stereo Audio Amplifier is built around TDA8920 or TDA8924, dedicated Audio Power amplifier Integrated Circuit. This circuit has the role to convert the audio input signal into a digital Pulse Width Modulator (PWM) signal using an analog input stage and the PWM modulator. To enable the output power transistors to be driven, this digital PWM signal is applied to a control and handshake block and driver circuits for both the high side and low side. In this way a level shift is performed from the low power digital PWM signal (at logic levels) to a high power PWM signal which switches between the main supply lines. A 2nd-order low-pass filter converts the PWM signal to an analog audio signal across the loudspeakers. The TDA8920B one-chip class-D amplifier contains high power D-MOS switches, drivers, timing and handshaking between the power switches and some control logic. For protection a temperature sensor and a maximum current detector are built-in. The two audio channels of the TDA8920B contain two PWM modulators, two analog feedback loops and two differential input stages. It also contains circuits common to both channels such as the oscillator, all reference sources, the mode functionality and a digital timing manager. The TDA8920B contains two independent amplifier channels with high output power, high efficiency, low distortion and a low quiescent current. The amplifier channels can be connected in the following configurations:

- Stereo Single-Ended (SE) amplifiers
- Mono Bridge-Tied Load (BTL) amplifier

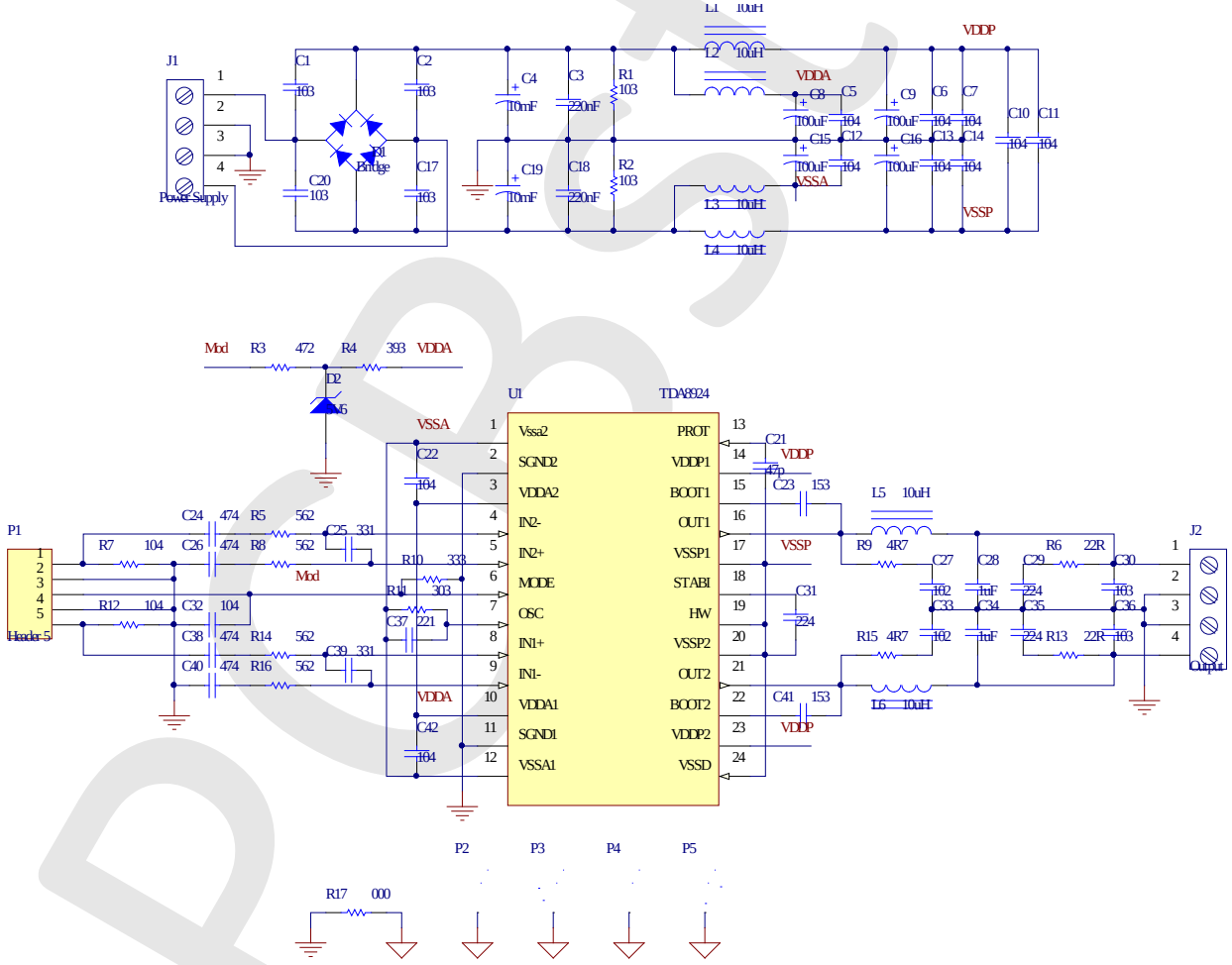

Figure 2: TDA8920/8924 Audio Amplifier Module Schematic Diagram

The audio input signal is provided to the TDA8920/8924 IC thru the small Input connector placed on the edge of the board, between the two pairs of input capacitors. The pins signification is as follows:

Pin1: Input Left Inverted
Pin2: Signal GND
Pin3: Mode Pin, toggle between Mute and operating mode
Pin4: Signal GND
Pin5: Input Right Non-Inverted

Notice that channels left and right are driven with 180° Shifted audio signal, and output is also shifted with 180°, so the left loudspeaker should be connected with – pin to output and + pin to GND. In this way, using the amplifier in BTL mode is easy, by simply connecting the both inputs together and the load between the outputs, without GND connection. In this case the system operates as a mono BTL amplifier and with the same loudspeaker impedance an approximately four times higher output power can be obtained. Another important advantage is that the pumping effect is attenuated due to the opposite signal phase from the Left and Right Channels, and the current handling of the power supply at low frequencies audio signal is improved.

The amplifier Closed Loop Voltage Gain has the value of 30dB for TDA8920 in stereo mode, 36dB for TDA8920 in BTL mode, 28dB for TDA8924 in stereo mode and 34dB for TDA8924 in BTL mode. The gain is fixed and cannot be changed, unless is used an input attenuator for reducing the gain, or and input preamplifier for increasing the gain. For most application, this gain values are optimal and does not require changes.

For pop noise-free start-up an RC time-constant must be applied on the MODE pin. The bias-current setting of the VI-converter input is directly related to the voltage on the MODE pin. In turn the bias-current setting of the VI converters is directly related to the DC output offset voltage. In Mute mode the bias current setting of the VI converters is zero (VI converters disabled) and in Operating mode the bias current is at maximum. The time constant required to apply the DC output offset voltage gradually between Mute and Operating mode levels can be generated via an RC-network on the MODE pin. Thus a slow dV/dt on the MODE pin results in a slow dV/dt for the DC output offset voltage, resulting in pop noise-free start-up. A time-constant of 500 ms is sufficient to guarantee pop noise-free start-up. The amplifier system can be switched to one of three operating modes by pin MODE:

- **Standby mode**, with a very low supply current when on Mode Pin is applied a voltage less than 0.8V DC.
- **Mute mode**, the amplifiers are operational; but the audio signal at the output is suppressed by disabling the VI-converter input stages, when on Mode Pin is applied a voltage between 2.2V and 3V DC.
- **Operating mode**, the amplifiers are fully operational with output signal, when on Mode Pin is applied a voltage between 4.2V and 5.5V DC.

The PWM signals from amplifier's outputs need to be filtered using a low pass filter in order to remove the high frequency components and to extract the audio component. This can be achieved using LC networks, which consist of inductor L1 and capacitor C28 for Left channel and inductor L2 and capacitor C34 for Right channel. In addition to this, each channel has a Zobel Network, which is required in case that the amplifier is powered without load, to decrease the Q factor of the filter circuit above 50 KHz. The cut-off frequency of the low pass filter was chosen above the audio range, the higher-frequency operation means that the filter can be of a lower order, simpler and cheaper. The values chosen for the output filter are: Inductance of the filter coil = 10uH, made on Micrometals T68-2 core material, by wounding 41 turns of 0.65 mm copper wire. Capacitor has the value of 1uF, at a working voltage of at least 100V, for increased reliability.

The amplifier power supply requirements depend on the required power level, operation mode (Stereo, or BTL) and the load impedance. The recommended operating voltage range is between ±15V to ±28V. If the supply voltage drops below ±12.5 V, the Under Voltage Protection (UVP) circuit is activated and the system will shut-down correctly. If the internal clock is used, this switch-off will be silent and without pop noise. When the supply voltage rises above the threshold level, the system is restarted again after 100 ms. If the supply voltage exceeds ±33 V the Over Voltage Protection (OVP) circuit is activated and the power stages will shut-down. It is re-enabled as soon as the supply voltage drops below the threshold level. So in this case no timer of 100 ms is started.

Note that although there is Over Voltage Protection Circuit, the Audio Amplifier can be damaged if the Power Supply Voltage values exceed the maximum Supply Voltage value of ±30V DC.

The TDA8920/8924 Audio Power Amplifier has on-board rectifier bridge and filter capacitors, and requires symmetric AC voltage to be provided. The symmetric AC voltage value should be between 2x14V AC for lower power levels to 2x20V AC for nominal power levels. The AC voltage should not be higher than 2x22V AC.

To guarantee the robustness of the class-D amplifier the maximum output current which can be delivered by the output stage is limited. An over-current protection is included for each output power switch. When the current flowing through any of the power switches exceeds a defined internal threshold (e.g. in case of a short-circuit to the supply lines or a short-circuit across the load), the amplifier will shut down immediately and an internal timer will be started. After a fixed time (e.g. 100 ms) the amplifier is switched on again. If the requested output current is still too high the amplifier will switch-off again. Thus the amplifier will try to switch to the operating mode every 100 ms. The average dissipation will be low in this situation because of this low duty cycle. If the over-current condition is removed the amplifier will remain operating. Because the duty cycle is low the amplifier will be switched off for a relatively long period of time, which will be noticed as a so-called audio-hole; an audible interruption in the output signal. To trigger the maximum current protection in the TDA8920/8924, the required output current must exceed the maximum current value of 8A for TDA8920 or 11.3A for TDA8924. This situation occurs in case of:

- Short-circuits from any output terminal to the supply lines (VDD or VSS)
- Short-circuit across the load or load impedance below the specified values of 2Ω and 4Ω.

Even if load impedances are connected to the amplifier outputs which have an impedance rating of 4Ω, this impedance can be lower due to the frequency characteristic of the loudspeaker; practical loudspeaker impedances can be modeled as an RLC network which will have a specific frequency characteristic: the impedance at the output of the amplifier will vary with the input frequency. A high supply voltage in combination with low impedance will result in large current requirements. Another factor which must be taken into account is the ripple current which will also flow through the output power switches. This ripple current depends on the inductor values which are used, supply voltage, oscillator frequency, duty factor and minimum pulse width. The maximum available output current to drive the load impedance can be calculated by subtracting the ripple current from the maximum repetitive peak current in the output pin, which is 8A for TDA8920 and 11.3 A for the TDA8924. Output current limiting goes with a signal on the protection pin (pin PROT). This pin is HIGH under normal operation. It goes LOW when current protection takes place. In order to filter the protection signal a capacitor can be connected between pin PROT and VSS (C21). However, this capacitor slows down the protective action as well as it filters the signal. Therefore, the value of the capacitor should be limited to a maximum value of 220 pF. For a more detailed description of the implications of output current limiting see also the application notes (tbf).

In a typical stereo half-bridge SE application the TDA8920/8924 class-D amplifier is supplied by a symmetrical voltage (e.g VDD = +27 V and VSS = -27 V). When the amplifier is used in a SE configuration, a so-called **pumping effect** can occur. During one switching interval, energy is taken from one supply (e.g. VDD), while a part of that energy is delivered back to the other supply line (e.g. VSS) and vice versa. When the voltage supply source cannot sink energy, the voltage across the output capacitors of that voltage supply source will increase: the supply voltage is pumped to higher levels. The voltage increase caused by the pumping effect depends on:

- Speaker impedance
- Supply voltage
- Audio signal frequency
- Value of decoupling capacitors on supply lines
- Source and sink currents of other channels

The pumping effect should not cause a malfunction of either the audio amplifier and/or the voltage supply source. For instance, this malfunction can be caused by triggering of the under-voltage or overvoltage protection or unbalance protection of the amplifier. Best remedy for pumping effects is to use the TDA8920/8924 in a mono full-bridge application or in case of stereo half-bridge application, to provide 180˚ shifted audio signal and connect one loudspeaker with + at GND and – at Output, or, adapt the power supply by using high capacity decoupling capacitors (at least 10000uF).

Application instructions:

The TDA8920/8924 Audio Amplifier Module is fully assembled and tested and can be used as Power Audio Amplifier in custom designed or DIY amplifiers or can be used as drop-in replacement for existing audio amplifiers, which already have housing, transformer, and input stage. The amplifier requires to be mounted onto an external heat sink which will be able to dissipate the heat generated by the TDA8920/8924 IC and the rectifier bridge. Limiting factor is the 150 °C maximum junction temperature Tj(max) which cannot be exceeded. Note that due to the finite thermal resistance between the chip junction and the heat sink, the heat sink maximum temperature will be much lower than the junction temperature, even when the junction has a temperature close to 150°C. to keep the chip temperature within the limits, a heat sink with maximum 3.5 K/W is required. Convection cooling is enough, no need forced air cooling unless the heat sink is very small and is fitted inside a tight and unventilated space, or in case of using few modules together in as small housing. The TDA8920/8924 IC heat sink pad must be electrical isolated from the heat sink with mica insulator or silicon glass fiber material which is very good thermal conductor and very good electrical insulator, since is connected to negative voltage supply, and not to GND. Also electrical insulator thermo conductive silicon can be used between the heat sink and rectifier bridge and the IC and insulating pad The mounting screws should be M3 size, and the tightening torque should be between 0.25 to 0.35 Nm, and the board must be fixed over the heat sink using spacers between, which will keep same distance, without bending the board. The size and position of the heat sink holes should be same as the board holes, which can be seen in the Figure 3. A tolerance of less than 0.3 mm is recommended.

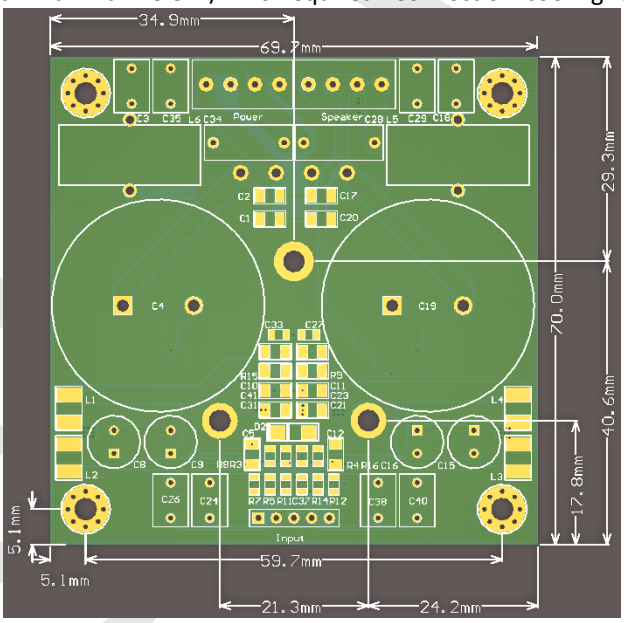

Figure 3. Board layout and mounting holes position.

The power supply is connected to the screw type connector placed on the top left of the board. The pin-out is as follows: Pin 1: AC1, Pin 2: GND, Pin 3: GND, Pin 4: AC2. A thoroidal transformer which can provide 2x20V AC at minimum 4A should be used. Also a 2.5 A fuse for 230V AC mains or 5 A for 110V AC mains should be used in the primary side between mains and transformer. In multi-channel systems it is recommended to use separate transformer windings for each amplifier module, or if is possible to use separate transformers.

The loudspeaker connector is placed on the top right of the board. The pin-out is as follows: Pin 1: Output Left, Pin 2: GND, Pin 3: GND, Pin 4: Output Right. For stereo applications, due to inverted input the left loudspeaker should be connected with – pin to output and + pin to GND. In this way, using the amplifier in BTL mode is easy, by simply connecting the both inputs together and the load between the outputs, without GND connection.

Disclaimer:

The TDA8920/8924 Audio Amplifier Module 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, **PCBstuff**, 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 medium level of voltages on this board, the user should take all the caution measures needed when working with high voltage levels, should not touch any unisolated part of the board or connectors, or short-circuit any part of the board or connectors. Any misusage will be made on user responsibility.

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