

CLASS-T DIGITAL AUDIO AMPLIFIER EVALUATION BOARD USING DIGITAL POWER PROCESSING™ TECHNOLOGY EB-TA0104

June 2000, For Rev. 3.3 Board

General Description

The EB-TA0104 evaluation board is based on the TA0104A digital audio power amplifier from Tripath Technology. This board is designed to provide a simple and straightforward environment for the evaluation of the Tripath stereo TA0104A amplifier. This board can also be used in a bridged configuration for high power mono output.

Note: Although the maximum supply voltage limit for the TA0104A is $\pm 100V$, the supply voltage for this board is limited because of other component limitations. Do not exceed the following:

$\pm 90V$ for 4W Single Ended Applications

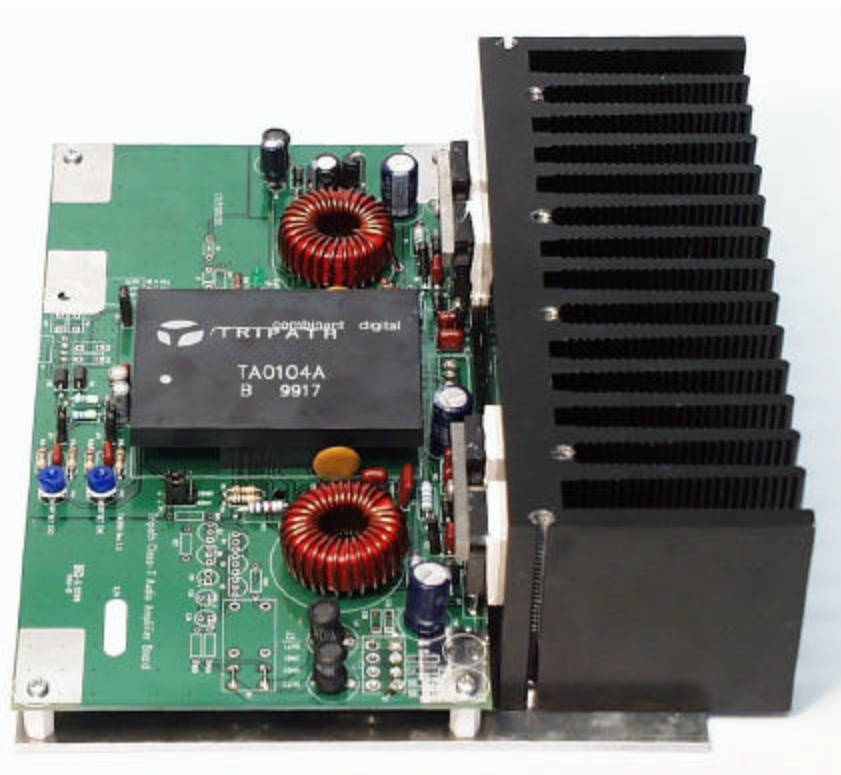
$\pm 75V$ for 4W Bridged or 2W Single Ended Applications

Features

- 2 x 400W @ 0.1% THD+N, 4 Ω
- 1000W bridgeable subwoofer output, 4 Ω @ 0.1% THD+N
- Four N-Channel power MOSFETs
- Outputs short circuit protected

Benefits

- Quick, easy evaluation and testing of the TA0104A amplifier
- Ready to use in many applications:
 - 2 channel stereo systems
 - Powered 2.1 speaker systems
 - Powered Subwoofers



OPERATING INSTRUCTIONS

Power Supply Description

There are three external power supplies required to operate this board: V_{spos} , V_{sneg} and +5V (see Figures 1 and 2). V_{spos} and V_{sneg} power the load and so must each be able to provide half of the desired output power, plus about 20% for overhead and margin. The TA0104A amplifier also requires a supply, VN12, that is 12V more positive than V_{sneg} and tracks V_{neg} . This evaluation board generates this VN12 voltage on-board. All input, output and power supply connections are made using tinned wire or female banana connectors (not shown).

Though not required, the following powering-up sequence is usually adhered to during bench evaluations: 1st) +5V, 2nd) V_{sneg} and 3rd) V_{spos} (refer to the Turn-on/off Pop section). The positive and negative supply voltages do not have to match or track each other, but distortion or clipping levels will be determined by the lowest (absolute) supply voltage. For applications where VN12 is supplied separately, make sure this supply tracks the V_{sneg} as it becomes more negative with respect to ground.

NOTE: TO AVOID PERMANENT DAMAGE, DO NOT EXCEED THE FOLLOWING:

$\pm 90V$ FOR 4Ω SINGLE ENDED APPLICATIONS

$\pm 75V$ FOR 4Ω BRIDGED OR 2Ω SINGLE ENDED APPLICATIONS

Once power is applied to the evaluation board, the green power light, LED 1, will illuminate. If it does not, power the unit down and recheck all connections and supplies. If the MUTE jumper is missing, the LED will not illuminate. To un-mute, short pins 2 and 3 of JP5. Please note that until the V_{spos} and V_{sneg} have powered up and are within the undervoltage and overvoltage limits, the LED will be illuminated (assuming everything else is properly connected). Once the amplifier is switching, if the undervoltage or overvoltage limit is violated, LED 1 will turn off until supply voltages are within specification.

Input Connections

Audio input to the board is located at IN1 and IN2 (see Figures 1 and 2). The input can be a test signal or music source. Connections are made using tinned wired to IN1, IN2 and Analog Ground, AGND. These connections are made on the evaluation board using a cable harness with female banana connectors (not shown).

Output Connections

There are four female banana connectors on the evaluation board for speaker outputs OUT1, OUT2, and Power Grounds, GND1 and GND2 (see Figures 1 and 2; cable harness connections are not shown). The TA0104A can be operated as a two channel single-ended amplifier, bridged mono output amplifier (see Figure 8) or with a passive crossover for a 2.1 channel application (refer to Application Note 13). Outputs can be any passive speaker(s) or test measurement equipment (see Application Note 4 "Parametric Measurements" for more information on bench testing).

Note: To avoid performance degradation, the Analog Ground and Power Grounds should be kept separate. They are internally connected in the TA0104A amplifier.

Connector Name	Channel
IN1	Channel 1 Input
IN2	Channel 2 Input
OUT1	Channel 1 Output
OUT2	Channel 2 Output

Board Operating Conditions

SYMBOL	PARAMETER	MIN.	TYP.	MAX.	UNITS
V _s	Supply Voltage (V _{spos} & V _{sneg}) 4Ω Single Ended 4Ω Bridged or 2Ω Single Ended	+/-55 +/-55	+/-75	+/-90 +/-75	V
V5	Positive 5V Bias Supply	4.5	5	5.5	V

See TA0104A data sheet for additional information on Absolute Maximum Ratings, Operating Conditions, Electrical Characteristics and Performance Characteristics.

Turn-on/off Pop

To avoid turn-on pops, bring the mute from a high to a low state after all power supplies have settled. To avoid turn-off pops, bring the mute from a low to a high state before turning off the supplies. The only issue with bringing up the 5V last or turning it off first is clicks/pops. If the mute line is properly toggled (slow turn-on, quick turn-off), then any power up sequence is fine. In practice, the 5V will usually collapse before V_{spos} and V_{sneg}. This is acceptable and will not cause any damage to the TA0104A.

ARCHITECTURE

A block diagram of one channel of the evaluation board is shown in Figure 3. The major functional blocks of the amplifier are described below.

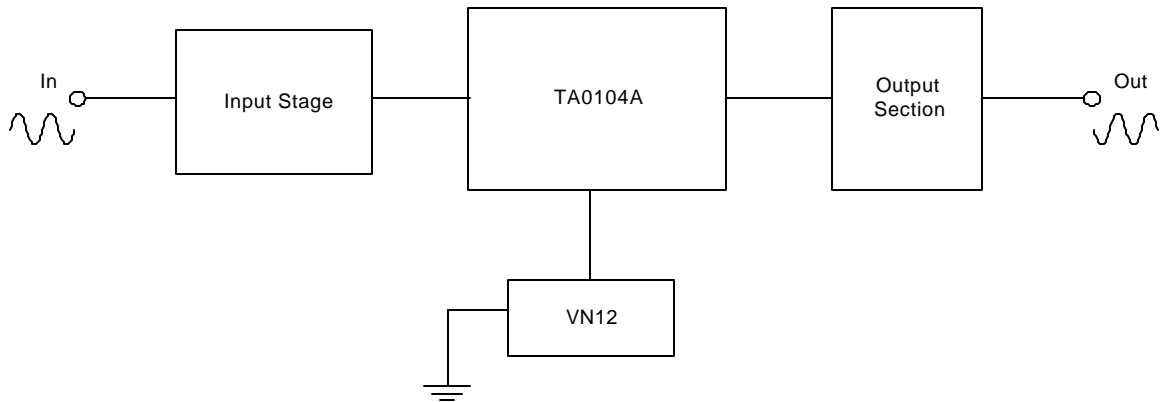


Figure 3

Note: The TA0104A is an inverting amplifier.

Input Stage

Figure 4 shows one channel of the Input Stage. The TA0104A amplifier is designed to accept unbalanced inputs and provide an overall gain of 14.5, or approximately 23 dB. Please note that the input stage of the TA0104A is biased at approximately 2.5VDC. Therefore, for an input signal centered around ground (0VDC), the polarity of the coupling capacitor, C_{IN} , shown in Figure 4 is correct.

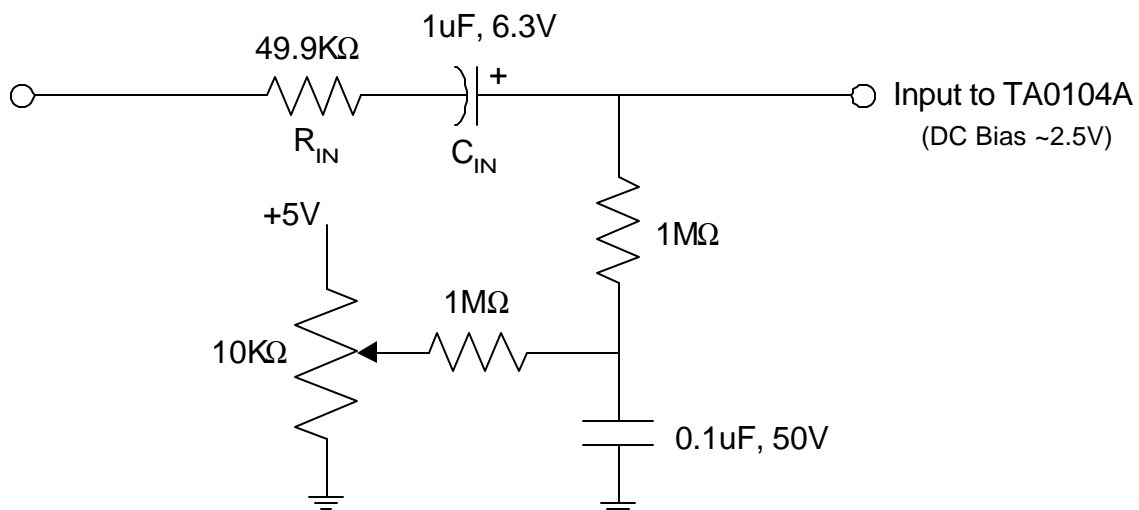


Figure 4

The gain of each channel of the TA0104A amplifier is set by the value of resistor R_{IN} in Figure 4 (labeled R8 and R9 on the schematic), according to the following equation:

$$A_v = 800 \times 10^3 / (R_{IN} + 5000)$$

where R_{IN} is in Ohms

In this design, R_{IN} is 49.9K Ω , which yields an A_v of 14.5 (23 dB). This value is a good compromise between gain and noise, though reducing R_{IN} by a factor of two will only increase the noise generated inside the TA0104A by ~1 dB.

The value of the input capacitor, C_{IN} , in Figure 4 (labeled C13 and C16 on the schematic), and the input resistor, R_{IN} (labeled R8 and R9), set the -3dB point of the input high-pass filter. The frequency of the input high pass pole, F_P , -3dB point can be calculated as follows:

$$F_P = 1 / ((2\pi \times C_{IN})(R_{IN} + 5000))$$

where: C_{IN} = input capacitor value in Farads
 R_{IN} = input resistor value in Ohms

Output offset voltages can be nulled by adjusting the 10K Ω potentiometer shown in Figure 4. Once set, the offset does not typically drift with temperature, so no tracking circuitry is required. Offsets can typically be set to +/- 25 mV. R43 is used to adjust the offset of CH1, and R42 is used to adjust the offset of CH2. If a different TA0104A is placed in the EB-TA0104 evaluation board, the offset of each channel would need to be re-trimmed.

TA0104A Control Circuitry

The 5V supply drives the power light, LED 1, directly to indicate a “good” status. If the LED 1 is off, the amplifier is in HMUTE (see Figure 5). HMUTE goes high (i.e. LED1 is off), when a fault condition occurs. If this is caused by an overcurrent condition, the mute pin must be cycled (i.e. low to high to low) to clear the fault. If the fault was caused by an over- or undervoltage, simply bring the supply rails to within the OV and UV specifications for the TA0104A ($\pm 55V$ to $\pm 92V$). Once the supply is within these limits, the amplifier will automatically reset and LED 1 will illuminate. As stated previously, until the supplies V_{pos} and V_{neg} are within the specified range, LED 1 will be illuminated. It would be impossible for the TA0104A to report a supply voltage fault during power up without requiring a specified supply voltage power sequence that is clearly undesirable.

The MUTE pin is brought out to an external 3pin header, JP5 (Figure 5). When a jumper is installed from Pin 4 to ground (by shorting pins 2 and 3 on JP5), the MUTE line is pulled to ground and the outputs are enabled. Note that if the MUTE jumper is removed, the MUTE pin floats high, the amplifier is muted and the power LED will not be lit. This is done to remind the user of a possible “jumper off” condition if there is no output. If the MUTE jumper is driven from the external MUTE connection to Pin 4 and left floating, the outputs are muted.

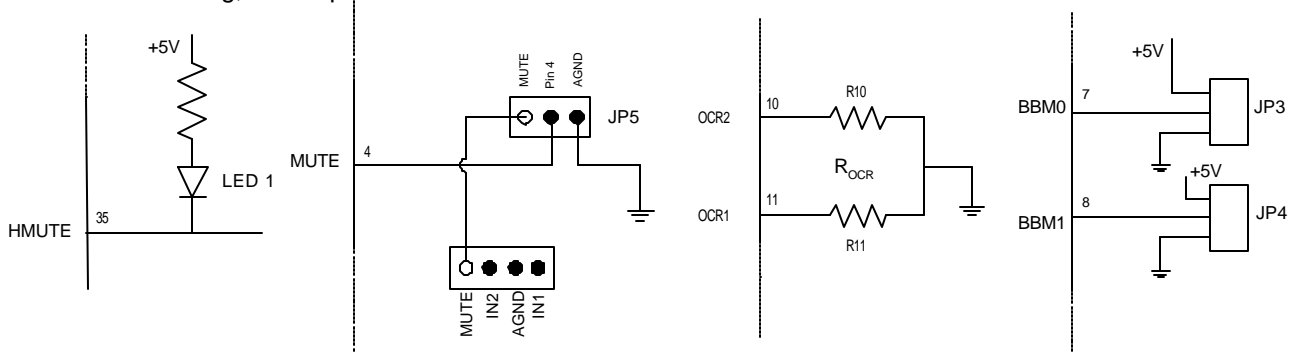


Figure 5

The resistors, R_{OCR} in Figure 5 (labeled R10 and R11 in the schematic), set the overcurrent threshold for the output devices. Note that these are NOT the sense resistors (the overcurrent sense resistors, R_S , are in the output stage). By adjusting the R_{OCR} resistor values, the threshold at which the amplifier “trips” can be changed. The range that the overcurrent trip point can be adjusted (by changing R_{OCR}) is determined by the value of the sense resistors.

R_{OCR} on this evaluation board is pre-set to $10K\Omega$ for a 4Ω application. For lower impedance applications (i.e. 4Ω bridged), this board’s overcurrent may trip prematurely. This is indicated by HMUTE going high; to clear, toggle the mute or cycle the power. To reduce overcurrent sensitivity, decrease the value of R_{OCR} until the sensitivity meets the desired level. R_{OCR} can be reduced to 0Ω though this may result in an overcurrent threshold that is so high the amplifier will try to drive a short circuit, possibly damaging the output FETs.

Finally, the Break-Before-Make (or “BBM”) lines are used to control the “dead time” of the output FETs. The “dead time” is the period of time between the turn-off of one device and the turn-on of the opposite device on the same channel. If the two devices are both on at the same time, current “shoots through” from one supply to the other, bypassing the load altogether. Obviously, this will have a great impact on the overall efficiency of the amplifier. However, if the dead time is too long, linearity suffers. The optimum BBM setting will change with different output FETs, different operating voltages, different layouts and different performance requirements. For this reason, Tripath has provided a means to adjust the BBM setting among four preset levels by moving jumpers JP3 and JP4 on their 3-pin headers (see Figure 5).

These settings should be verified over the full temperature and load range of the application to ensure that any thermal rise of the output FETs and TA0104A does not impact the performance of the amplifier. This amplifier board is set to 65nS, and the table below shows the BBM values for various settings of the jumpers (Figure 6).

	<u>BBM1</u>	<u>BBM0</u>	<u>Delay</u>
1)	0	0	145nS
2)	0	1	105nS
3)	1	0	65nS
4)	1	1	25nS

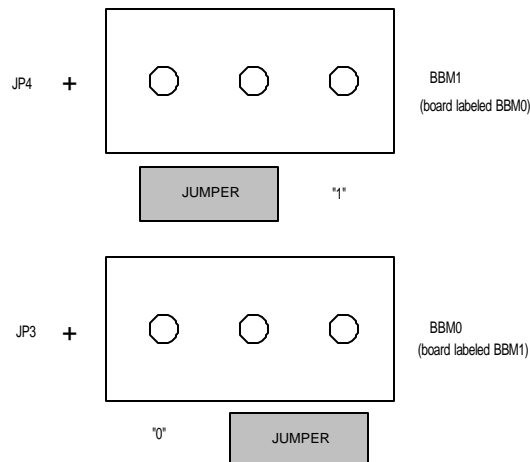


Figure 6

Output Section

The output section includes the gate resistors, FETs, output filters, the previously mentioned OVERCURRENT sense resistors, clamping diodes, a Zobel Network, and various bypass capacitors.

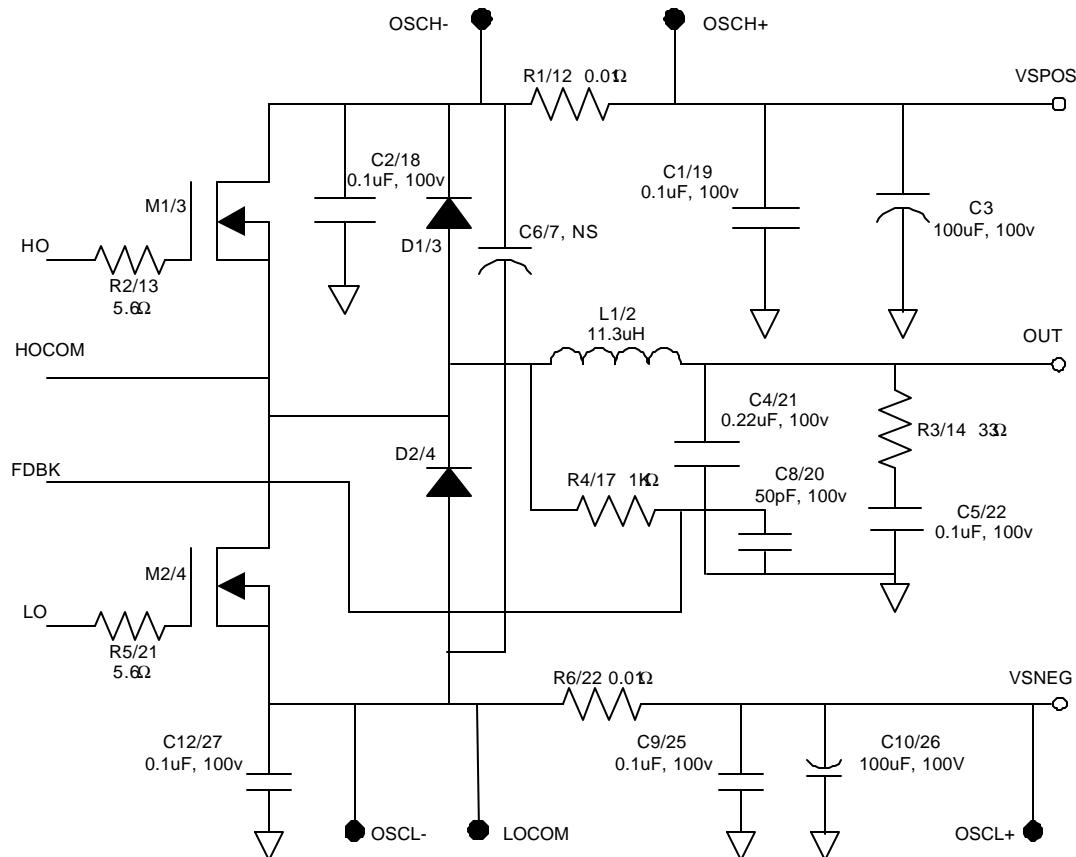


Figure 7

The gate resistors (labeled R2, R5, R13, and R21 in the schematic and Figure 7) are used to control MOSFET switching rise/fall times and thereby minimize voltage overshoots. They also dissipate a portion of the power resulting from moving the gate charge each time the MOSFET is switched. If R_G is too small, excessive heat can be generated in the driver. Large gate resistors lead to slower gate transitions resulting in longer rise/fall times and thus requiring a larger BBM setting. Tripath recommends using an R_G of 10Ω when the gate charge (Q_g) of the output FET is less than $70nC$ and 5.6Ω when the Q_g is greater than $70nC$.

The output FETs, M1-M4, provide the switching function required of a Class-T design. They are driven directly by the TA0104A through the gate resistors. The devices used on the evaluation board are ST STW38NB20 MOSFETs. The TA0104A data sheet contains information on output FET selection as well as Tripath application notes "FETs – Selection and Efficiency" and "Designing with Switching Amplifiers for Performance and Reliability".

The output filters L1/C4 and L2/C21 are the low-pass filters that recover the analog audio signal. One of the benefits of the Class-T design is the ability to use output filters with relatively high cutoff frequencies. This greatly reduces the speaker interactions that can occur with the use of lower-frequency filters common in Class-D designs. Also, the higher-frequency operation means that the filter can be of a lower order (simpler and less costly).

The OEM may benefit from some experimentation in the filter design, but the values provided in the reference design, 11.3uH and 0.22uF, provide excellent results for most loads between 4Ω and 8Ω.

As important as the values themselves, the material used in the core is important to the performance of the filter. Core materials that saturates too easily will not provide acceptable distortion or efficiency figures. Tripath recommends a low-mu (permeability of 10) type 2 iron powder core.

The clamping diodes D1-D4 are required to limit the reverse voltages seen by the output FETs as a result of normal operation. The diodes should be mounted as close as possible to the FET. Depending on the application, these may or may not be necessary.

The Zobel circuits R3/C5 and R14/C22 are there in case an amplifier is powered up with no load attached. The Q of the LC output filter, with no load attached, rises quickly out to 80kHz. Resonant currents in the filter and ringing on the output could reduce the reliability of the amplifier. The Zobel eliminates these problems by reducing the Q of the network significantly above 50kHz. Modifying the LC output filter should not require a recalculation of the Zobel value.

The bypass capacitors C12/C27 are critical to the reduction of ringing on the outputs of the FETs. These parts are placed as closely as possible to the leads of the FETs, and the leads of the capacitors themselves are as short as practical. Their values will not change with different output FETs.

Connection Diagram for Bridge Mode Operation

The amplifier is connected to the power supplies and load as shown in Figure 8. Note that an inverter has been added in front of one of the channel inputs (i.e. channel 2). The main reason for processing the channels out of phase is to avoid potential problems with switching power supplies, but it also simplifies the connections for bridged-mode operation. For bridged operation, simply connect the “-” terminal to the output of the inverted channel (i.e. channel 1) and the “+” terminal to the output of the non-inverted channel with respect to the input signal (i.e. channel 2). As stated before, the TA0104A is an inverting amplifier.

*Please note the Break-Before-Make labels on the PC Board are incorrect and are reversed.

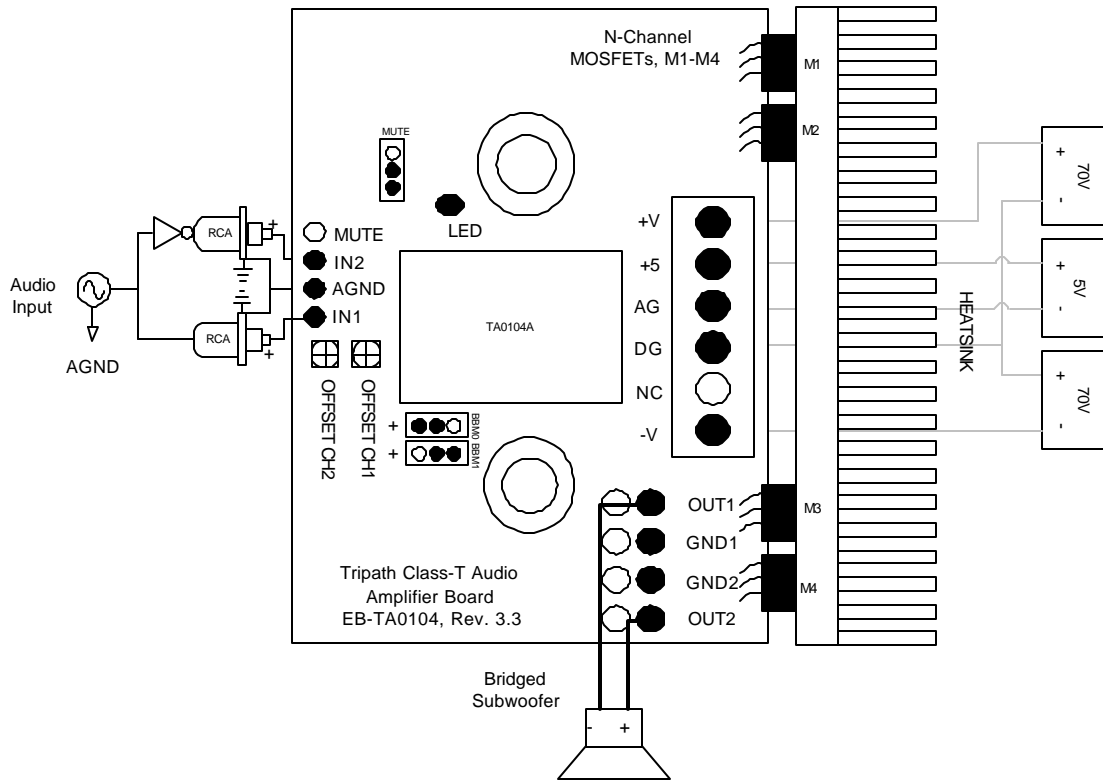


Figure 8

VN12 Bias Requirement

The VN12 circuit (Figure 9) is used to provide the voltage rail for the low side FET drivers on the TA0104A. This supply must track the Vsneg rail, and so, for simplicity, this supply is included on this amplifier board. The VN12 circuit uses a National LM2594HVN-12 “simple switcher” voltage regulator for all control. A few passive components complete the design. Tripath does not anticipate that there will be any reason to modify the operation of this circuit. Should the OEM wish to do so, however, reference data for the LM2594 is available at www.national.com/pf/LM/LM2594.

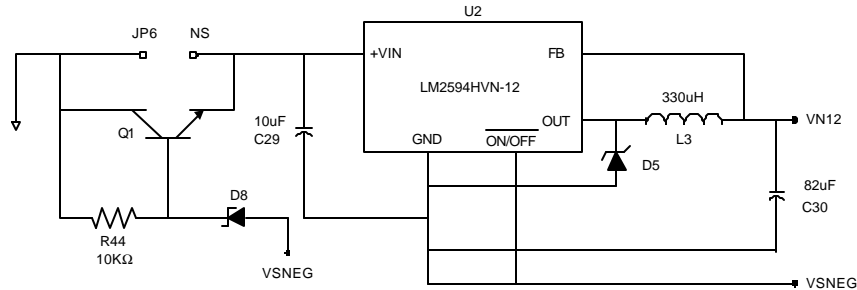


Figure 9

FAQ's

- Q. The TA0104A supply voltage rails are rated at $\pm 100V$. Why is this evaluation board limited to $\pm 90V$ maximum?
- A. IC's used in the 12V bias supply circuitry as well as the choice of STW38NB20 FETs limit this boards voltage supply to $\pm 90V$ into 4Ω single ended, $\pm 75V$ for 4Ω Bridged, or $\pm 75V$ for 2Ω single ended applications. Damage will occur to the board at higher voltages.
- Q. Can I use the TA0104A reference design to drive 2Ω (or lower) loads?
- A. The reference design can drive 2Ω single ended loads. For use with loads of lower nominal impedance, a new filter design may be required. Please contact the Tripath Applications group for support in this area.
- Q. Do I need to attach a fan to the heat sink?
- A. For normal operation, the heat sink is sized appropriately. Continuous operation at high levels (especially low impedance loads) may cause excessive power dissipation thus requiring a fan.

DIMENSIONS

The evaluation board dimensions with the heat sink are: 8" x 7.5" x 2.5".

DOCUMENTATION

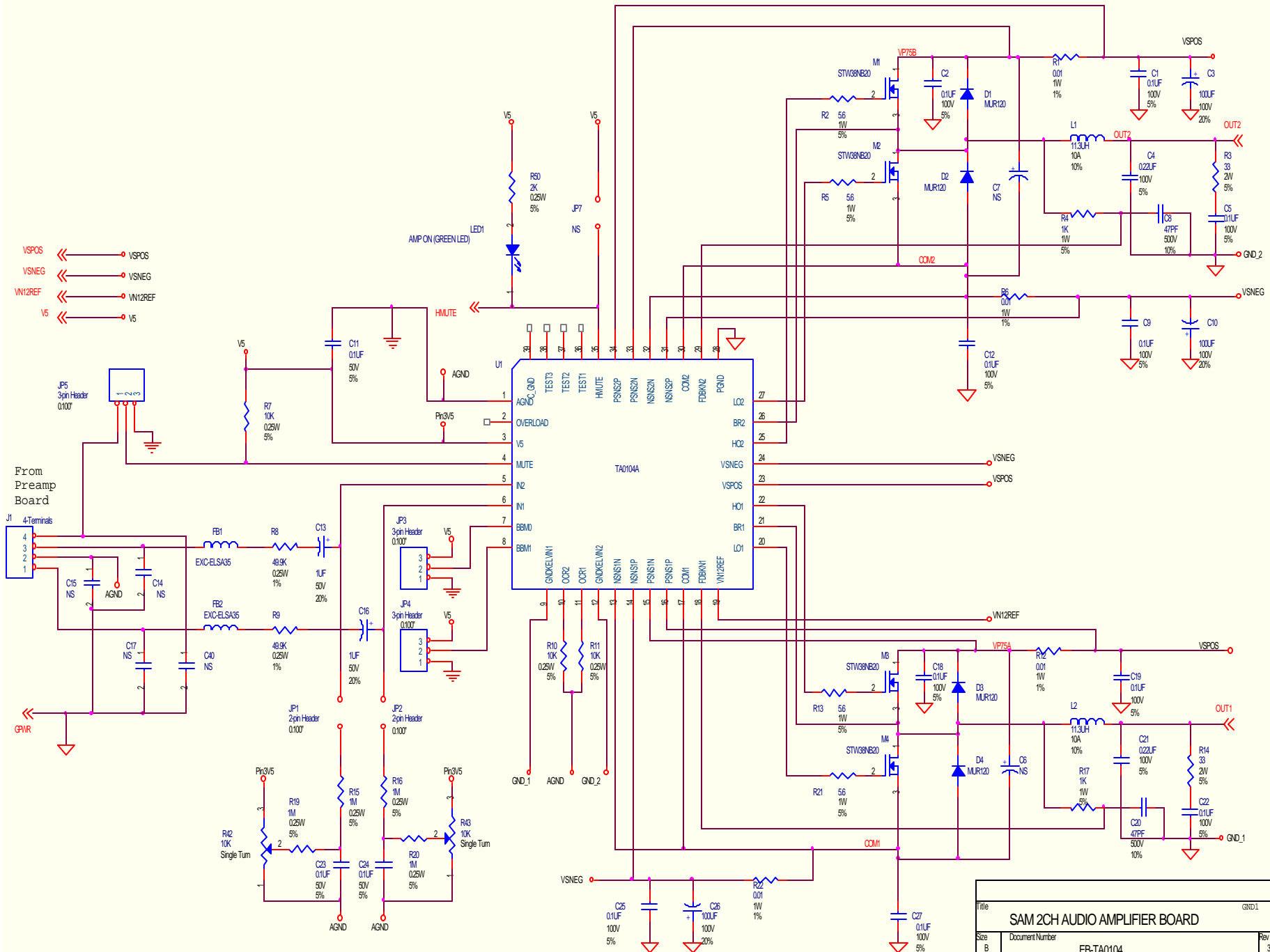
Schematics and layout in software or paper form can be provided upon request.

CONTACT INFORMATION

For more information on Tripath products, visit our web site at: www.tripath.com

TRIPATH TECHNOLOGY, INC.

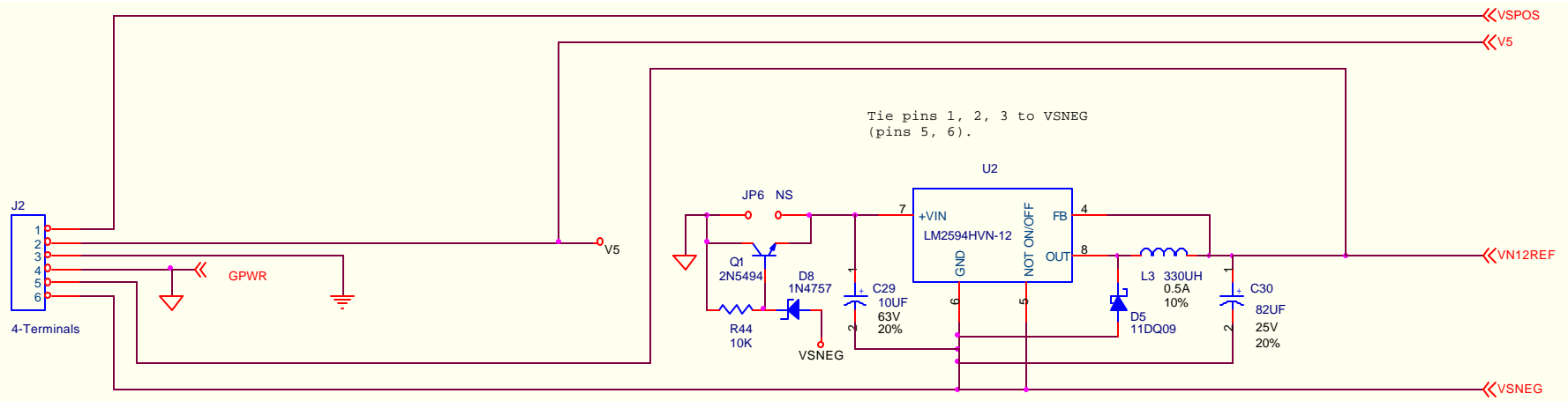
3900 Freedom Circle
 Santa Clara, California 95054
 408-567-3000



VSPOS <<< VSPOS
 VSNEG <<< VSNEG
 VN12REF <<< VN12REF
 V5 <<< V5

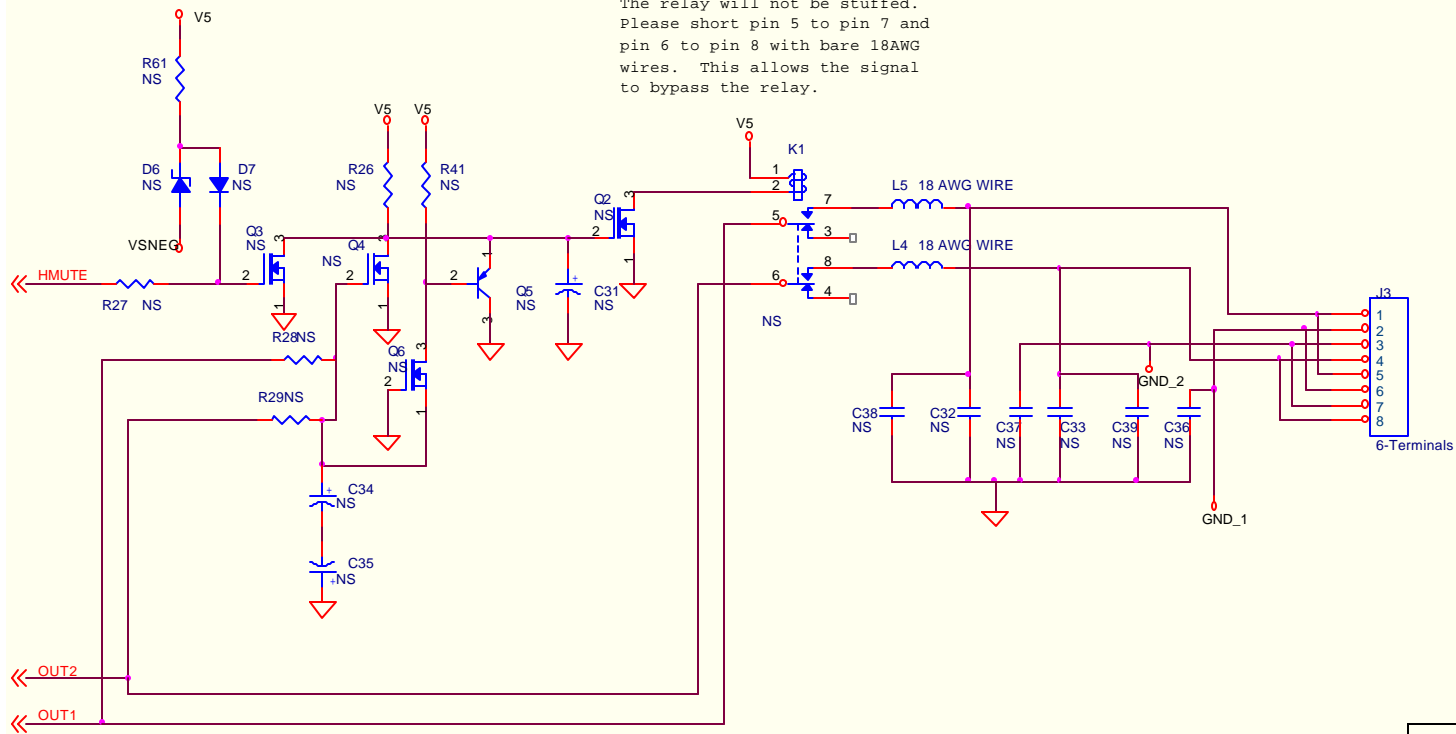
From Preamp Board

Title		GND1
SAM 2CH AUDIO AMPLIFIER BOARD		
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B	EB-TA0104	3/3
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Q1, R44, and D8 have been added to limit the input voltage for U2 to 50V.

The relay will not be stuffed. Please short pin 5 to pin 7 and pin 6 to pin 8 with bare 18AWG wires. This allows the signal to bypass the relay.



Title		
SAM 2CH AUDIO AMPLIFIER BOARD		
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