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

June 1999

General Description

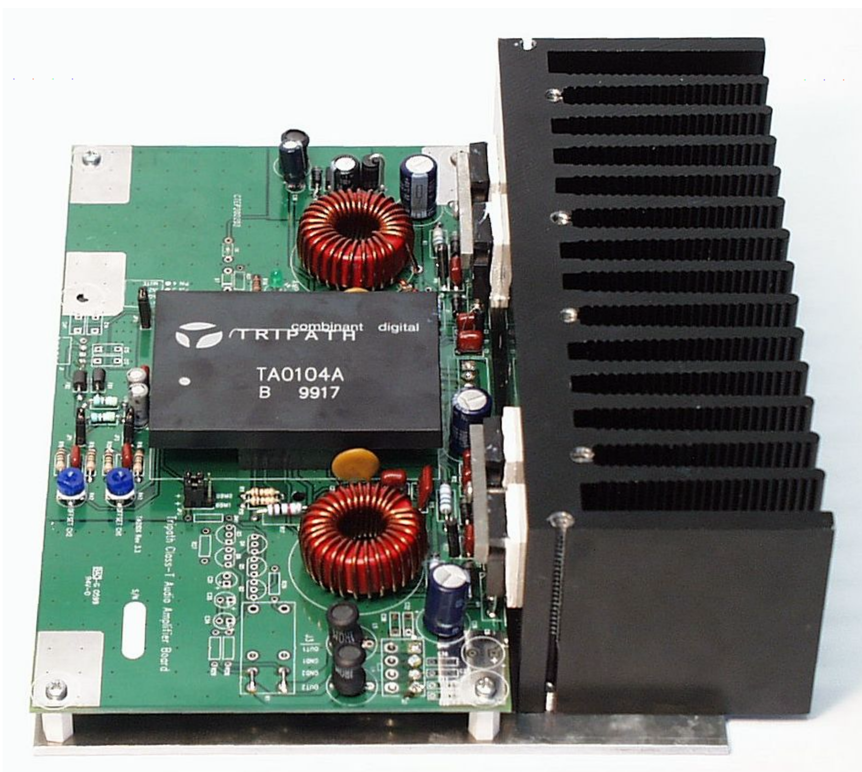
The EB-TA0104 evaluation board is based on the TA0104A digital audio power amplifier from Tripath Technology. This board is designed to provide a simple and straightforward environment for the evaluation of the Tripath stereo TA0104A amplifier. This board can also be used in a bridged configuration for high power mono output. Note that even though the maximum supply voltage limit for the TA0104A is ±100V, the supply voltage limit for this board is ±70V because of other component limitations.

Features

- 2 x 400W rms @ 0.1% THD+N, 4Ω
- 800W rms bridgeable subwoofer output, 4Ω
- 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: Vspos, Vsneg and +5V (see Figure 1). Vspos and Vsneg 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 Vsneg plus 12V and tracks Vneg. 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).

To begin evaluation, the following powering-up sequence is recommended: 1[st]) +5V, 2[nd]) Vsneg and 3[rd]) Vspos. 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.

NOTE: TO AVOID PERMANENT DAMAGE, DO NOT EXCEED $\pm$70V ON THE VOLTAGE SUPPLY RAILS, V_{SPOS} AND V_{SNEG}.

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. We recommend powering-down in the reverse order from power-up.

Input Connectors

Audio input to the board is located at IN1 and IN2 (see Figure 1). The input can be a test signal or music source. Connections are made using tinned wired to IN1, IN2 and Analog Ground, AGND.

Output Connectors

There are four female banana connectors on the evaluation board for speaker outputs OUT1, OUT2, GND1 and GND2 (see Figures 1). 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).

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

Turn-on/off Pop

To avoid turn-on and turn-off pops, MUTE the amplifier by pulling up the MUTE pin to +12V through a 1MΩ resistor before turning on or off the power supplies. Refer to the MUTE description in the TA0104A Control Circuitry section on page 5.

EB-TA0104 Board

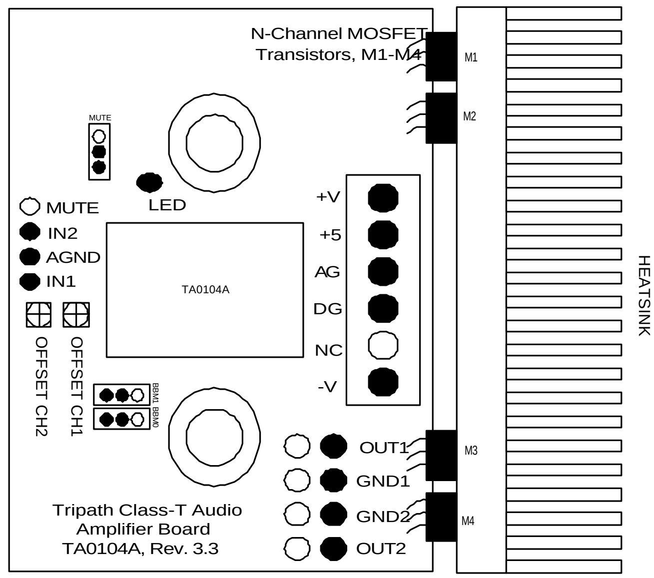


Figure 1

ARCHITECTURE

A block diagram of one channel of the evaluation board is shown in Figure 2. The major functional blocks of the amplifier are described below.

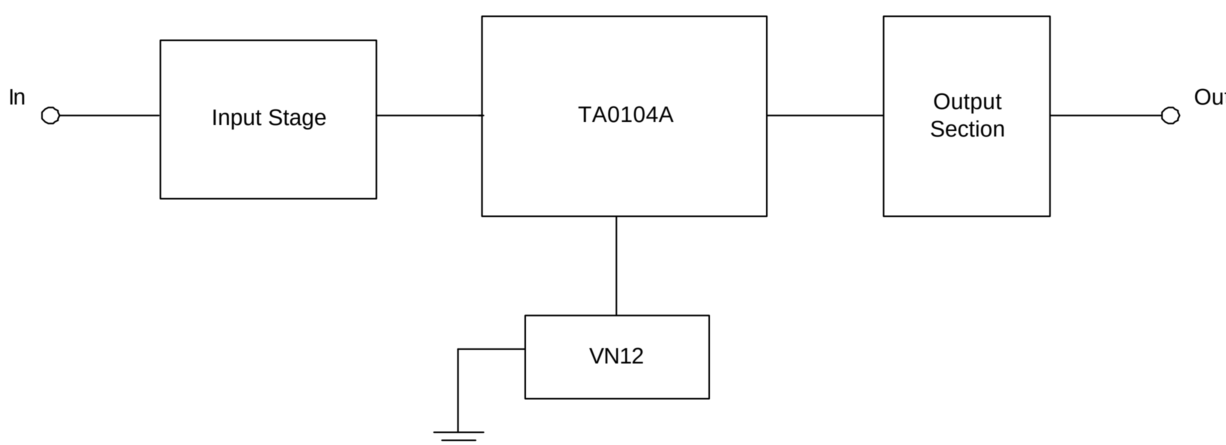


Figure 2

Input Stage

Figure 3 shows one channel of the Input Stage. The TA0104A amplifier is designed to accept unbalanced inputs and provide an overall gain of 14, or approximately 23 dB.

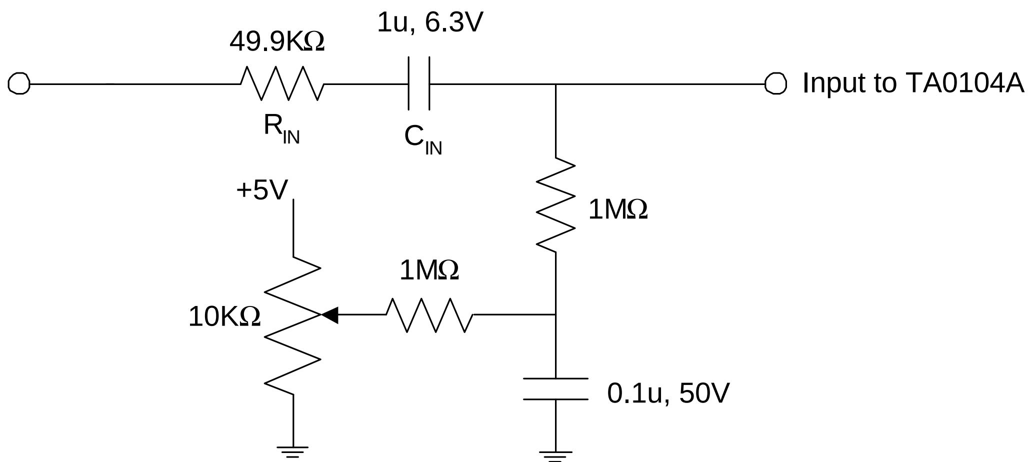


Figure 3

The gain of each channel of the TA0104A amplifier is set by the value of resistor R_{IN} in Figure 3 (labeled R8 and R9 on the schematic), according to the following equation:

$Av = 800 \times 10^3 / (R_{IN} + 5000)$
where R_{IN} is in Ohms

In this design, R_{IN} is 49.9KΩ, which yields an Av of 14 (23 dB). This value is a good compromise between gain and noise, as decreasing the gain further results in a negligible increase in noise margin.

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

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

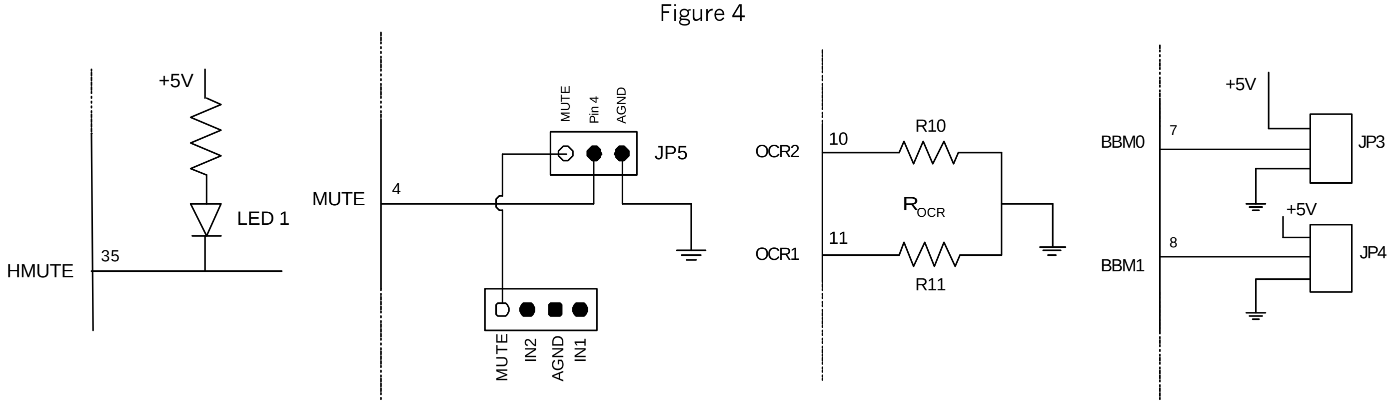
where: C_{IN} = input capacitor value in Farads
R_{IN} = input resistor value in Ohms

Output offset voltages are nulled in the input stage potentiometers provided here for this purpose. Once set, the offset does not typically drift with temperature, so no tracking circuitry is required. Offsets can typically be set to +/-25 mV.

TA0104A Control Circuitry
Voltage +5V 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 4). If this is caused by a fault condition (i.e. over-current, over or under voltage), the cause of the fault must be cleared and the AC power must be cycled before normal operation can resume.

The MUTE pin is brought out to an external 3-pin header, JP5 (Figure 4). When a jumper is installed from Pin 4 to ground, the MUTE line is pulled to ground and the outputs are enabled. If the MUTE jumper is connected from the external MUTE connection to Pin 4 and pulled high to +12V through 1MΩ, the outputs are muted. Note that if the MUTE jumper is removed, then 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.

Figure 4



The resistors, R_{OCR} in Figure 4 (labeled R10 and R11 in the schematic) set the overcurrent threshold for the output devices. Note that these are NOT the sense lines (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 set INDEPENDENT of the value chosen for the overcurrent sense resistors. The formula for determining the value for these threshold resistors follows:

$$I_{SC} \times R_S = (V_{TOC} \times 9100) / (9100 + R_{OCR})$$

where:

R_S and R_{OCR} are in Ω
$I_{SC} = 3 \times I_{RMS} = 3 \times (P_{OUT}/R_L)^{0.5}$ (Over-current is typically set for 3 x RMS current)
V_{TOC} = Over-current sense threshold voltage (in the range of .67 - .82V)
= 0.75V typically

when $R_{OCR} = 0\Omega$, $R_S = (0.75)/I_{SC}$

Here's an example that shows the value of being able to select the OVERCURRENT threshold independently of R_S. First, note that R_S will dissipate approximately $(I_{RMS})^2 \times R_S$ of power. So, setting an I_{SC} of 30A with $R_{OCR} = 0\Omega$ means that $R_S = 25m\Omega$ and R_S must dissipate 2.5W on average. If, in this example, $R_{OCR} = 9.1K\Omega$ and $I_{SC} = 30A$, R_S will be 12mΩ and only have to dissipate 1.2W on average. Since high-wattage resistors are usually only available in a few low-resistance values (10mΩ, 25mΩ and 50mΩ), R_{OCR} can be used to adjust for a particular OVERCURRENT threshold using one of these standard values for R_S. Also, overall amplifier efficiency is improved.

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 4).

These settings should be verified over the full temperature and load range of the application to ensure that any thermal drift of this timing does not impact the performance of the amplifier. This amplifier board is set to 25nS, and the table below shows the BBM values for various settings of the jumpers (Figure 5).

	BBM0	BBM1	Delay
1)	0	0	145nS
2)	1	0	105nS
3)	0	1	65nS
4)	1	1	25nS

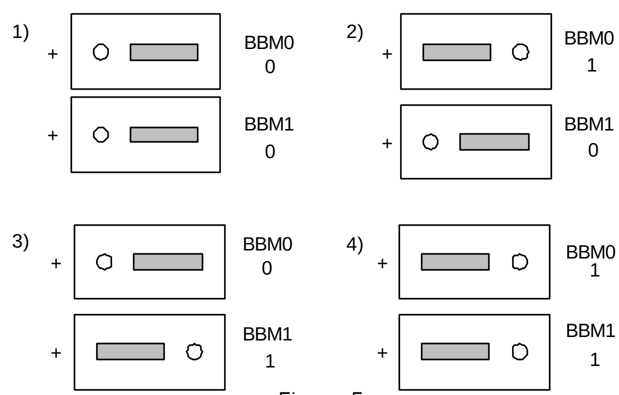


Figure 5

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

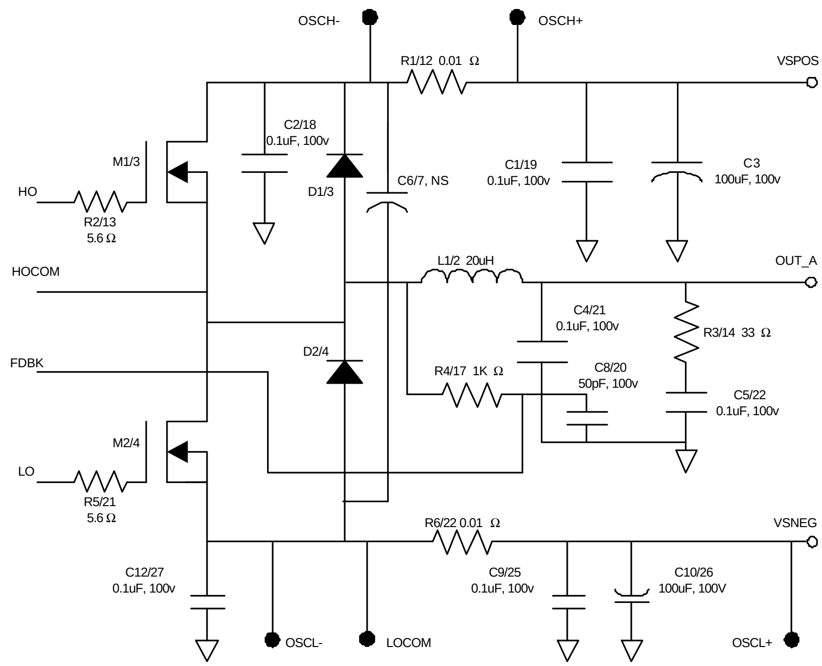


Figure 6

The gate resistors (labeled R2, R5, R13, and R21 in the schematic and Figure 6) 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 (Qg) of the output FET is less than 70nC and 5.6Ω when the Qg 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 which saturates too easily will not provide acceptable distortion or efficiency figures. Tripath recommends a low-mu (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 with short leads, as close as possible to the FET. Only Schottky diodes should be used here due to their very low forward voltage drop and fast switching. The diodes should have a forward current rating of at least one Ampere.

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 values.

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 and Bridge Mode Operation
The amplifier is connected to the power supplies and load(s) as shown in Figure 7. Note that the stereo speakers appear to be connected out of phase. Actually, connecting the speakers in this way restores in-phase operation, as the channels move through the TA0104A out of phase. 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. Note that for bridged operation, there are no external inverter circuits or switches required; simply connect the load between the "+" output terminal of the left channel and the "-" output of the right channel.

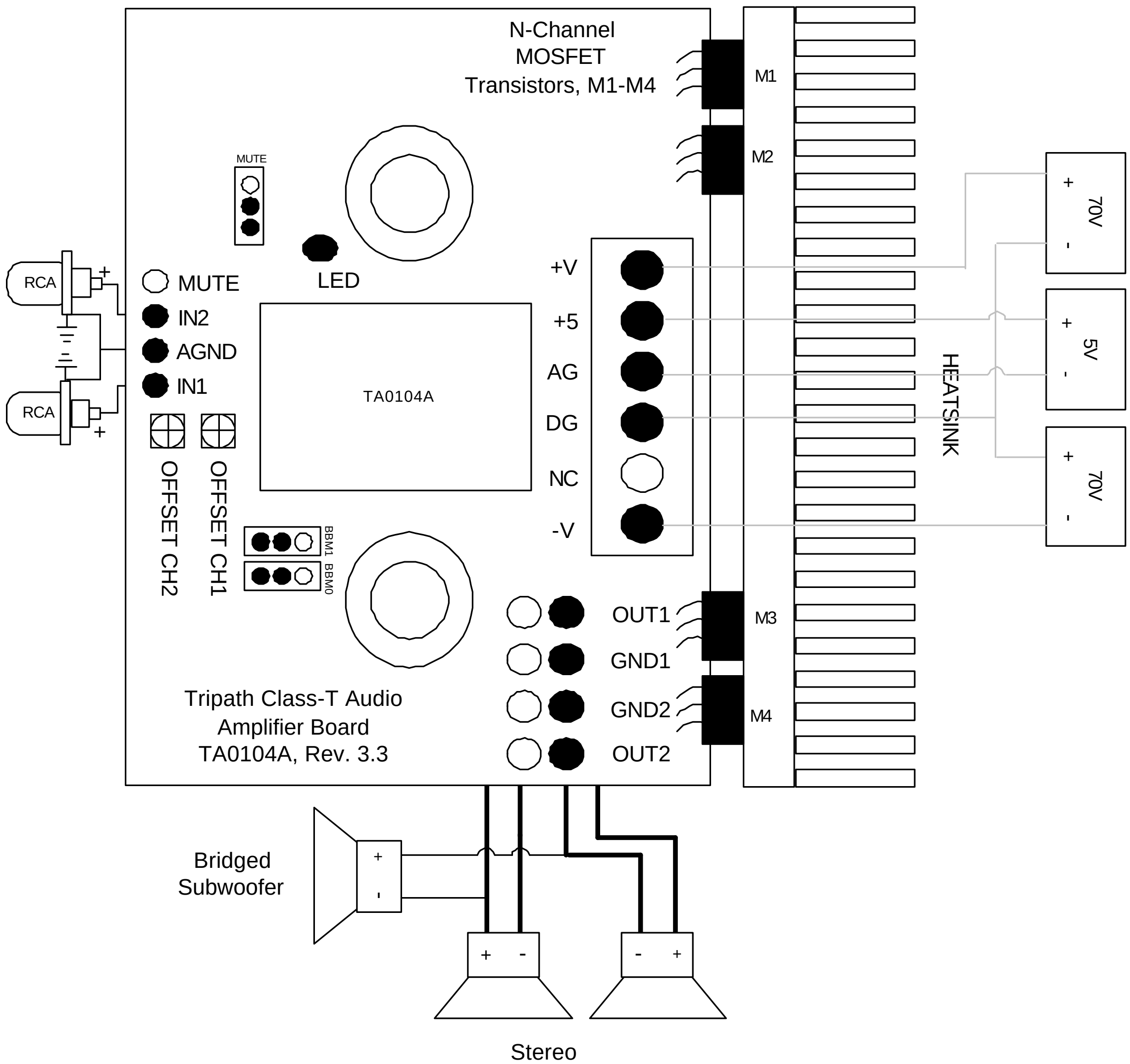


Figure 7

VN12 Bias Requirement
The VN12 circuit (Figure 8) 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 corresponding +12V "floating" supply is generated internal to the TA0104A amplifier and so is not shown). The VN12 circuit uses a National LM2594 "simple switcher" integrated circuit 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.

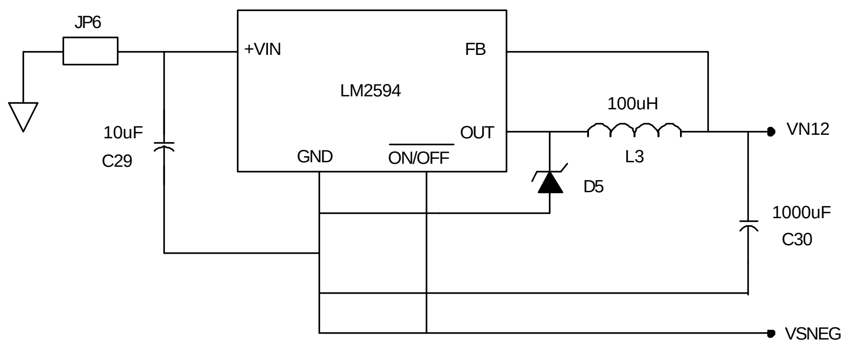


Figure 8

FAQ's

Q. The TA0104A supply voltage rails are rated at ±100V. Why is this evaluation board limited to +70V maximum?
A. IC's used in the 12V Bias supply circuitry limited this boards voltage supply to ±70V. Damage will occur to the board at higher voltages.

Q. Can I use the TA0104A reference design to drive 2 Ohm (or lower) loads?
A. The reference design can drive 2 Ohm 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 heatsink?
A. No, the TA0104A heat sink is sized assuming no significant airflow around it.

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

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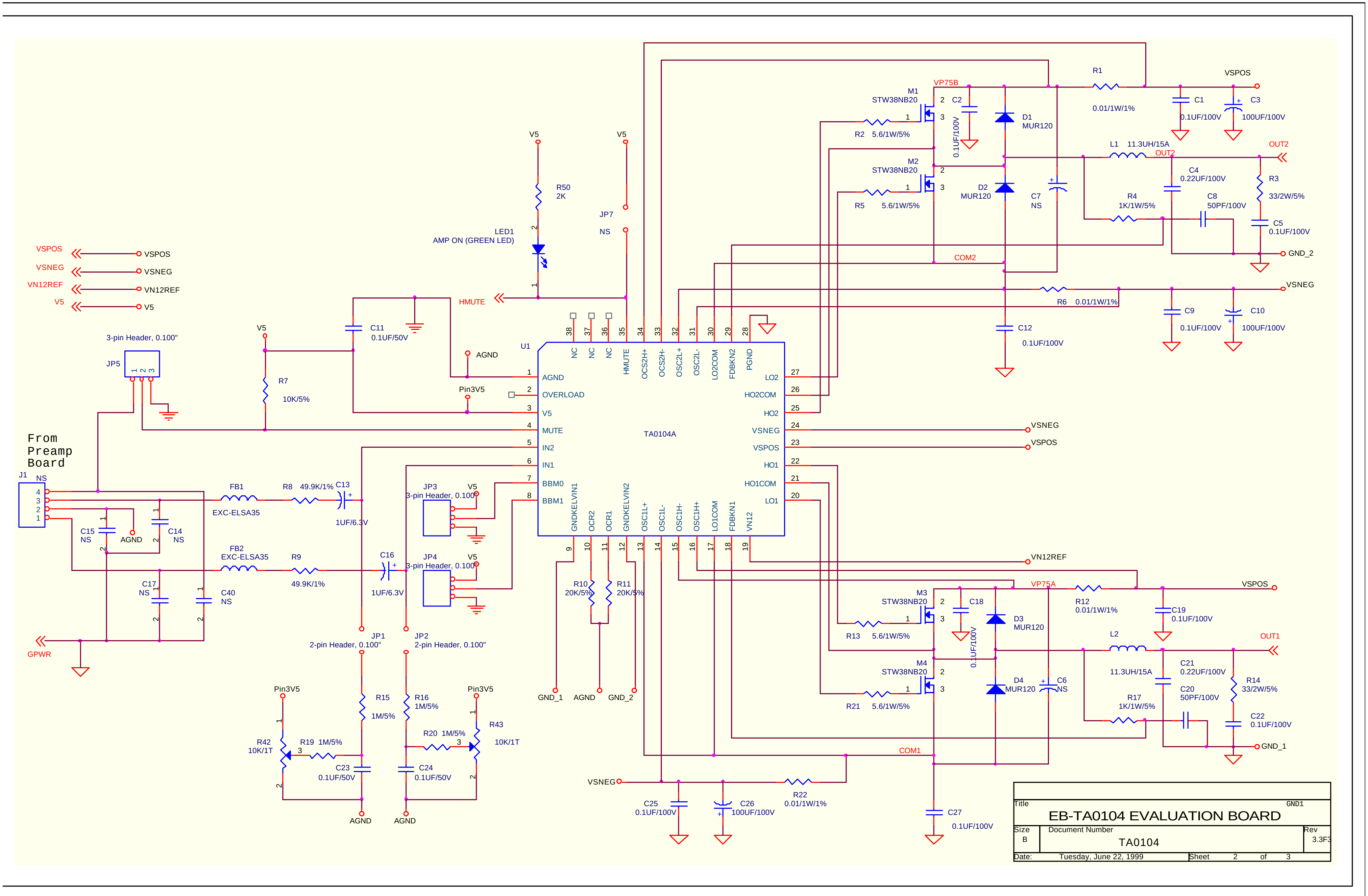
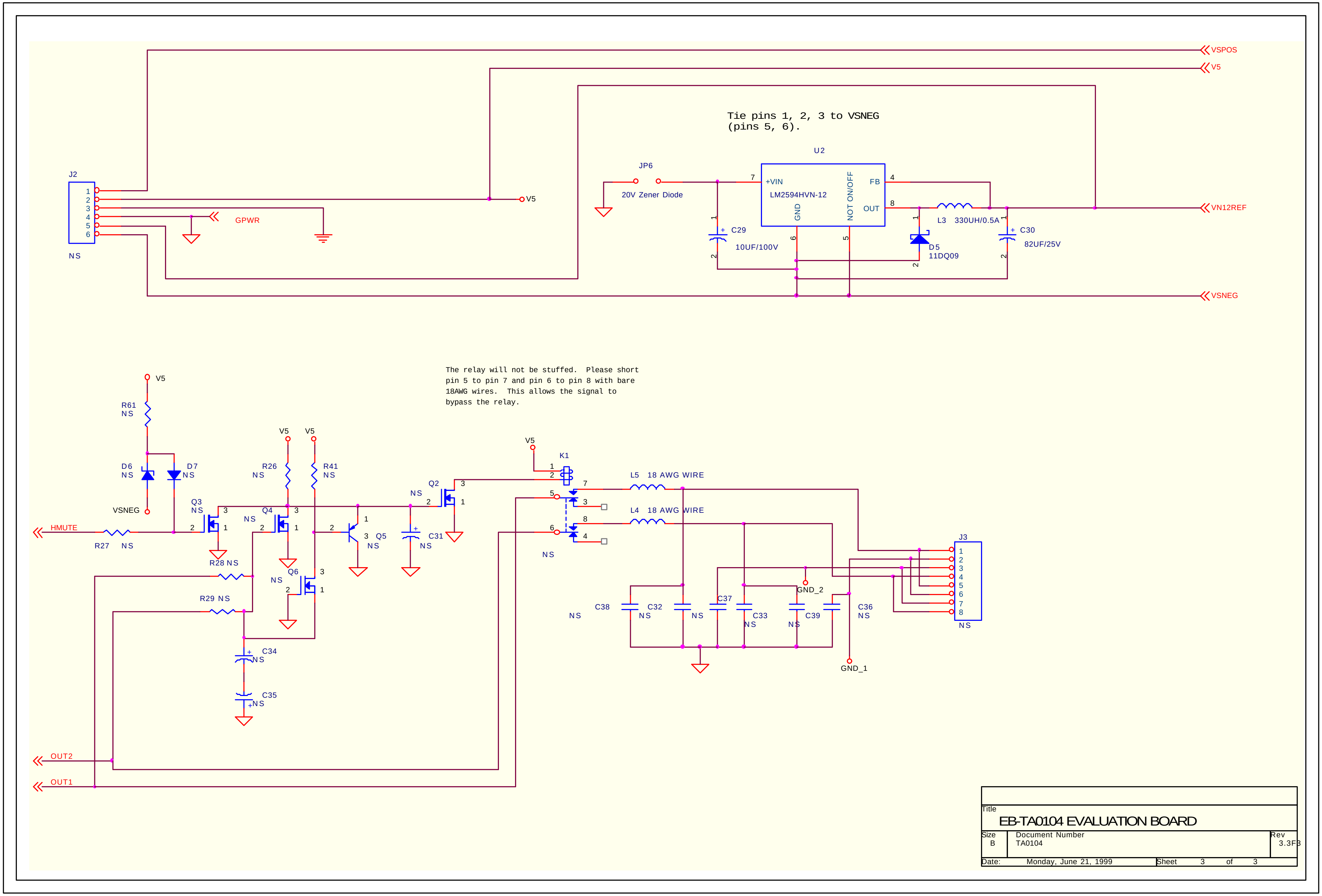


From Preamp Board
EB-TA0104 EVALUATION BOARD
Document Number
TA0104
Size B
Rev 3.3F3
Date: Tuesday, June 22, 1999
Sheet 2 of 3


Tie pins 1, 2, 3 to VSNEG (pins 5, 6).
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.
VSPOS
V5
VN12REF
VSNEG
GPWR
HMUTE
OUT2
OUT1
J2
J3
U2
LM2594HVN-12
JP6
20V Zener Diode
C29 10UF/100V
C30 82UF/25V
L3 330UH/0.5A
D5 11DQ09
L5 18 AWG WIRE
L4 18 AWG WIRE
K1
GND_1
GND_2
Title
EB-TA0104 EVALUATION BOARD
Size B
Document Number TA0104
Rev 3.3F3
Date: Monday, June 21, 1999
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