CLASS-T DIGITAL AUDIO AMPLIFIER EVALUATION BOARD USING DIGITAL POWER PROCESSING™ TECHNOLOGY EB-TA0103

January 2001, For Rev. 3.3 Board

General Description

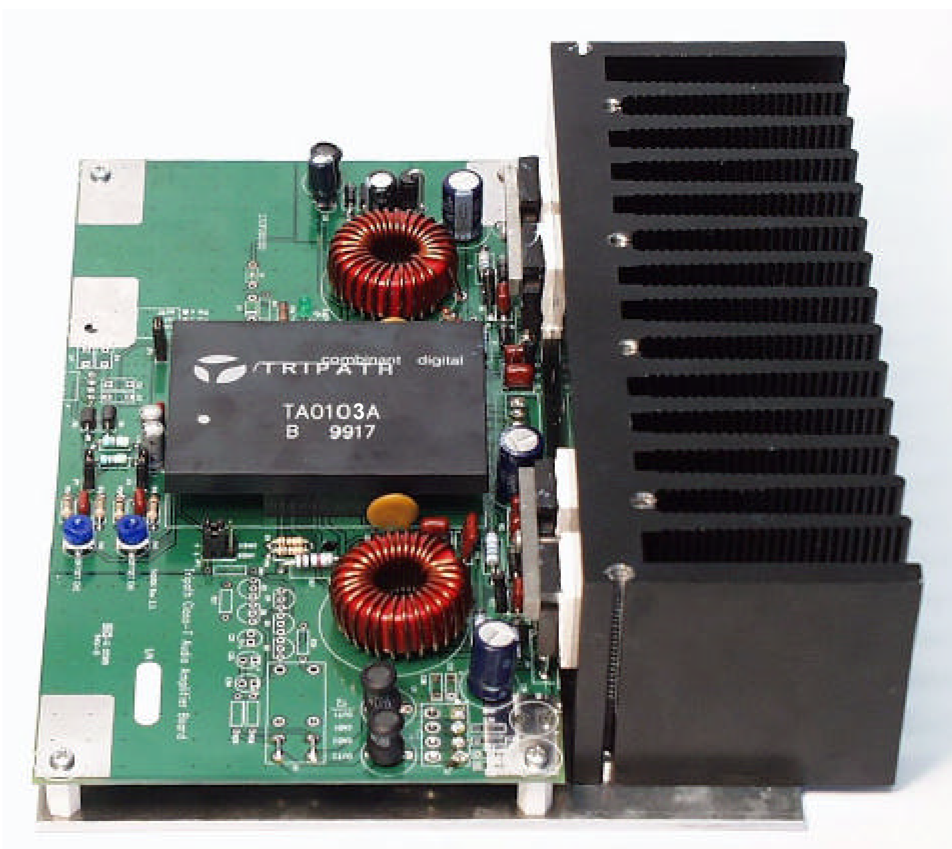
The EB-TA0103 evaluation board is based on the TA0103A digital audio power amplifier from Tripath Technology. This board is designed to provide a simple and straightforward environment for the evaluation of the Tripath stereo TA0103A amplifier. This board can also be used in a bridged configuration for high power mono output.

Features

- 2 x 250W rms @ 0.1% THD+N, 4Ω
- 500W rms bridgeable subwoofer output, @ 0.1% THD+N, 4Ω
- Four N-Channel power MOSFETs
- Outputs short circuit protected

Benefits

- Quick, easy evaluation and testing of the TA0103A 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 TA0103A amplifier also requires a supply, VN12, that is 12V more positive than Vsneg 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).

Though not required, the following powering-up sequence is usually adhered to during bench evaluations: 1^{st}) +5V, 2^{nd}) Vsneg and 3^{rd}) Vspos (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 Vsneg as it becomes more negative with respect to ground.

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 Vspos and Vsneg 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.

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). The TA0103A 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 board damage, the Analog Ground and Power Grounds should be kept separate. They are internally connected in the TA0103A amplifier.

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 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 Vspos and Vsneg. This is acceptable and will not cause any damage to the TA0103A.

EB-TA0103 Board

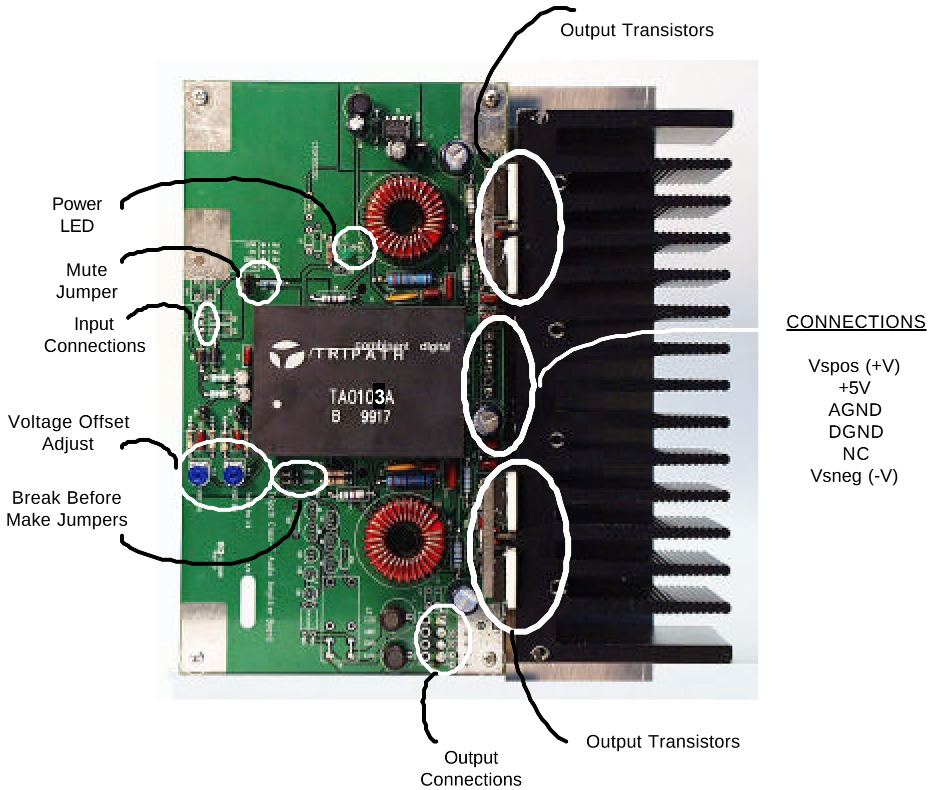


Figure 1

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

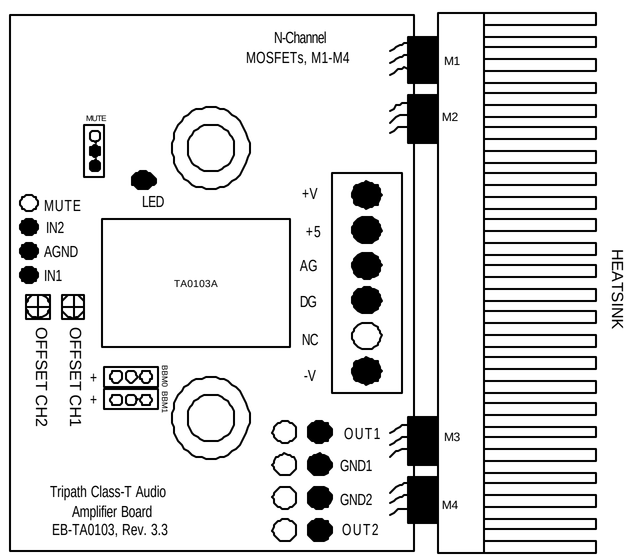


Figure 2

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.

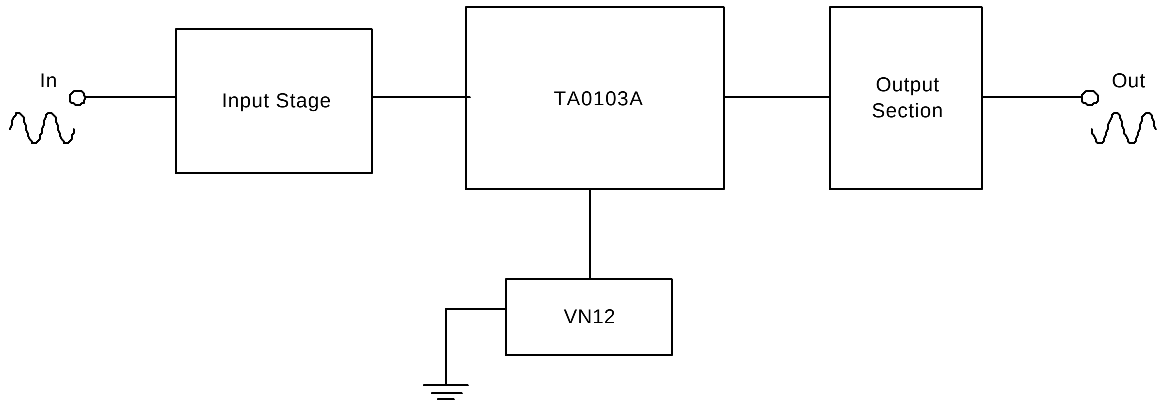


Figure 3

Input Stage

Figure 4 shows one channel of the Input Stage. The TA0103A amplifier is designed to accept unbalanced inputs and provide an overall gain of 9.8, or approximately 20 dB. Please note that the input stage of the TA0103A 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.

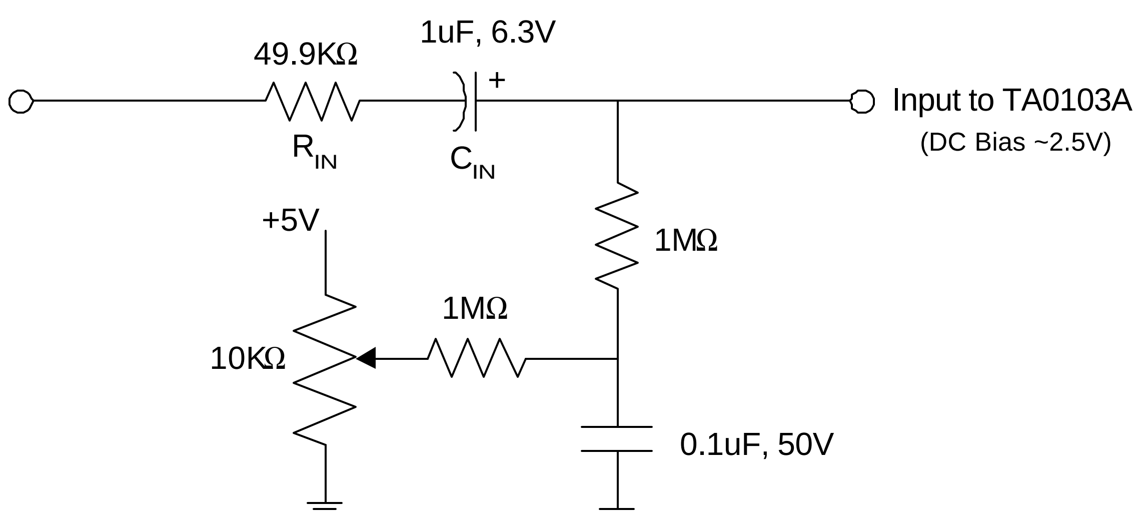


Figure 4

The gain of each channel of the TA0103A 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:

$Av = 538 \times 10^3 / (R_{IN} + 5000)$
where R_{IN} is in Ohms

In this design, R_{IN} is 49.9KΩ, which yields an Av of 9.8 (20 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 TA0103A by ~1 dB.

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 can be nulled by adjusting the 10KΩ 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 TA0103A is placed in the EB-TA0103 evaluation board, the offset of each channel would need to be re-trimmed.

TA0103A 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 TA0103A (±35V to ±60V). Once the supply is within these limits, the amplifier will automatically reset and LED 1 will illuminate. As stated previously, until the supplies Vspos and Vsneg are within the specified range, LED 1 will be illuminated. It would be impossible for the TA0103A 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 3-pin 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.

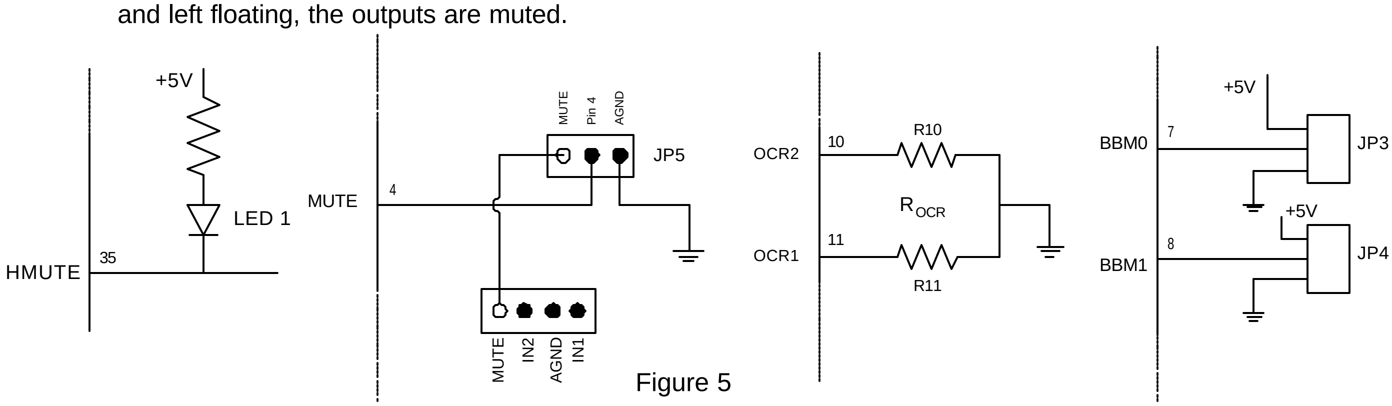


Figure 5

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 10KΩ 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 TA0103A 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).

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

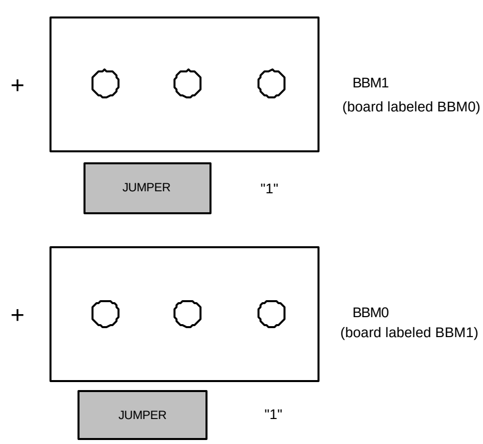


Figure 6

Output Section

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

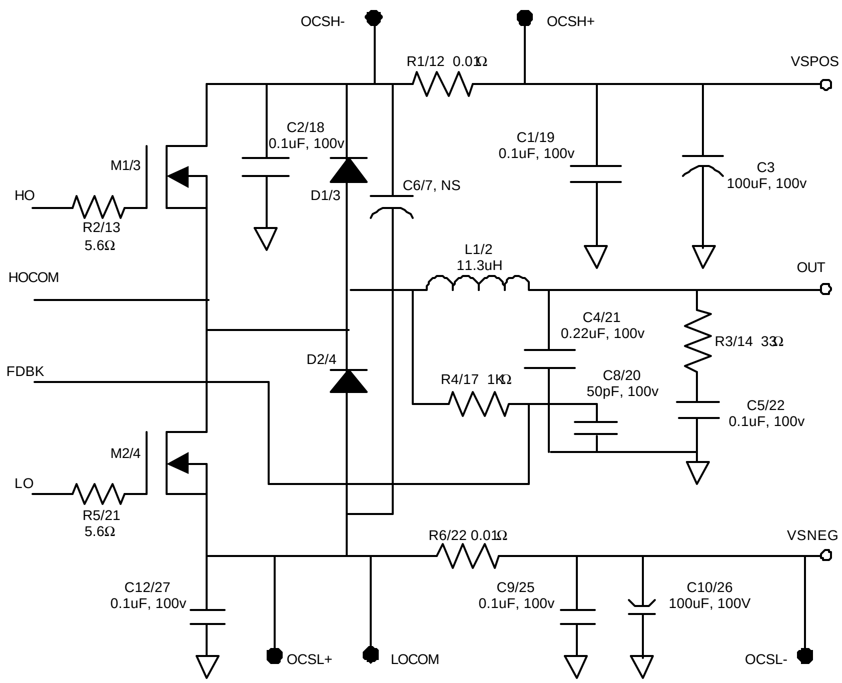


Figure 7

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 (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 TA0103A through the gate resistors. The devices used on the evaluation board are ST STW38NB20 MOSFETs. The TA0103A 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 saturate 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 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 TA0103A is an inverting amplifier.

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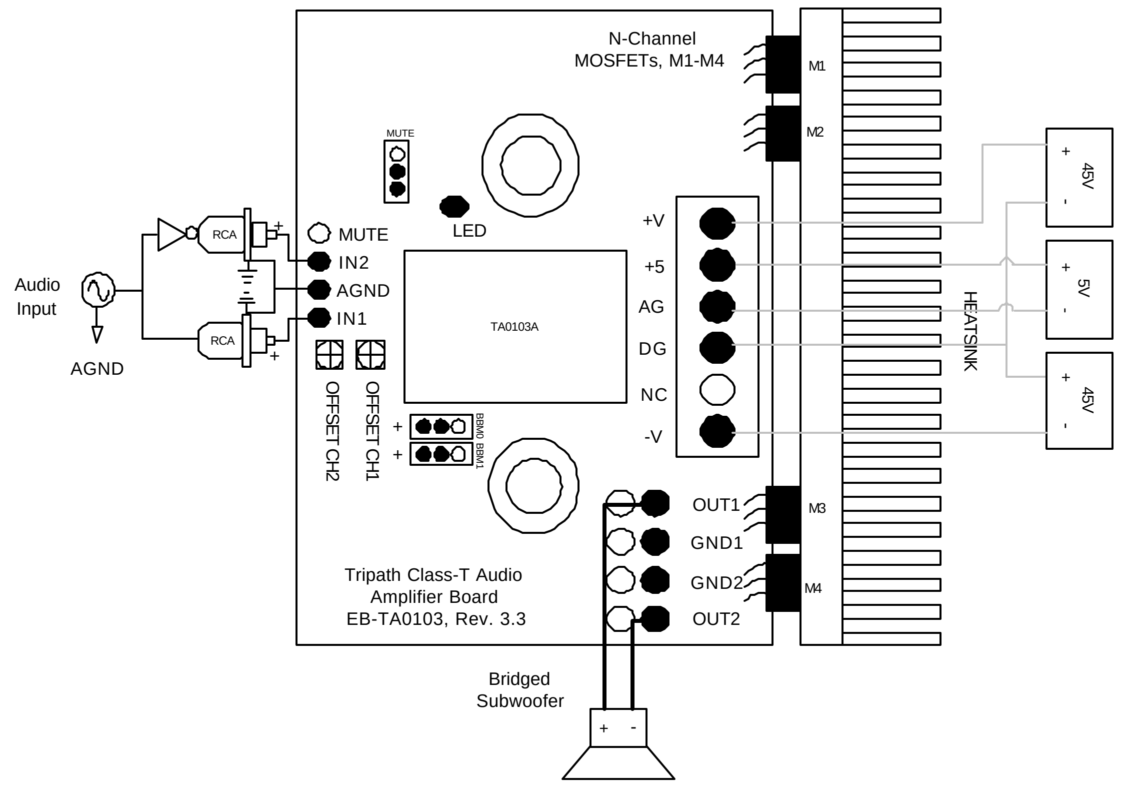

Figure 8

VN12 Bias Requirement
The VN12 circuit (Figure 9) is used to provide the voltage rail for the low side FET drivers on the TA0103A. 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 TA0103A amplifier and so is not shown). 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.

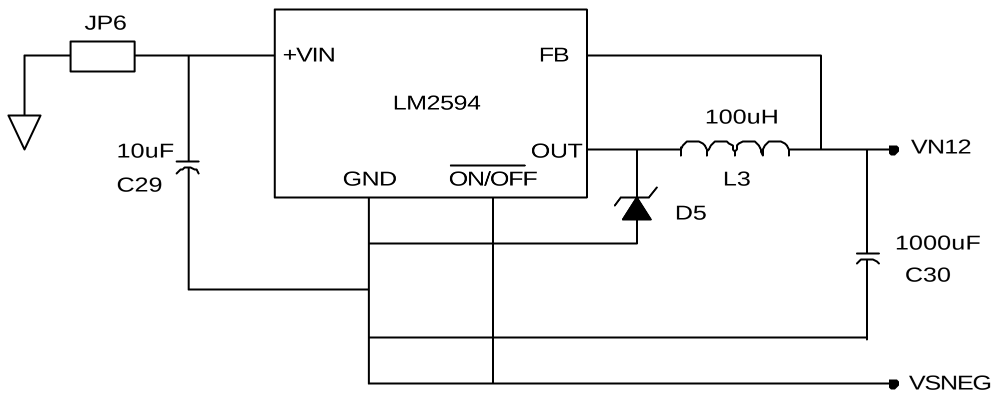

Figure 9

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**

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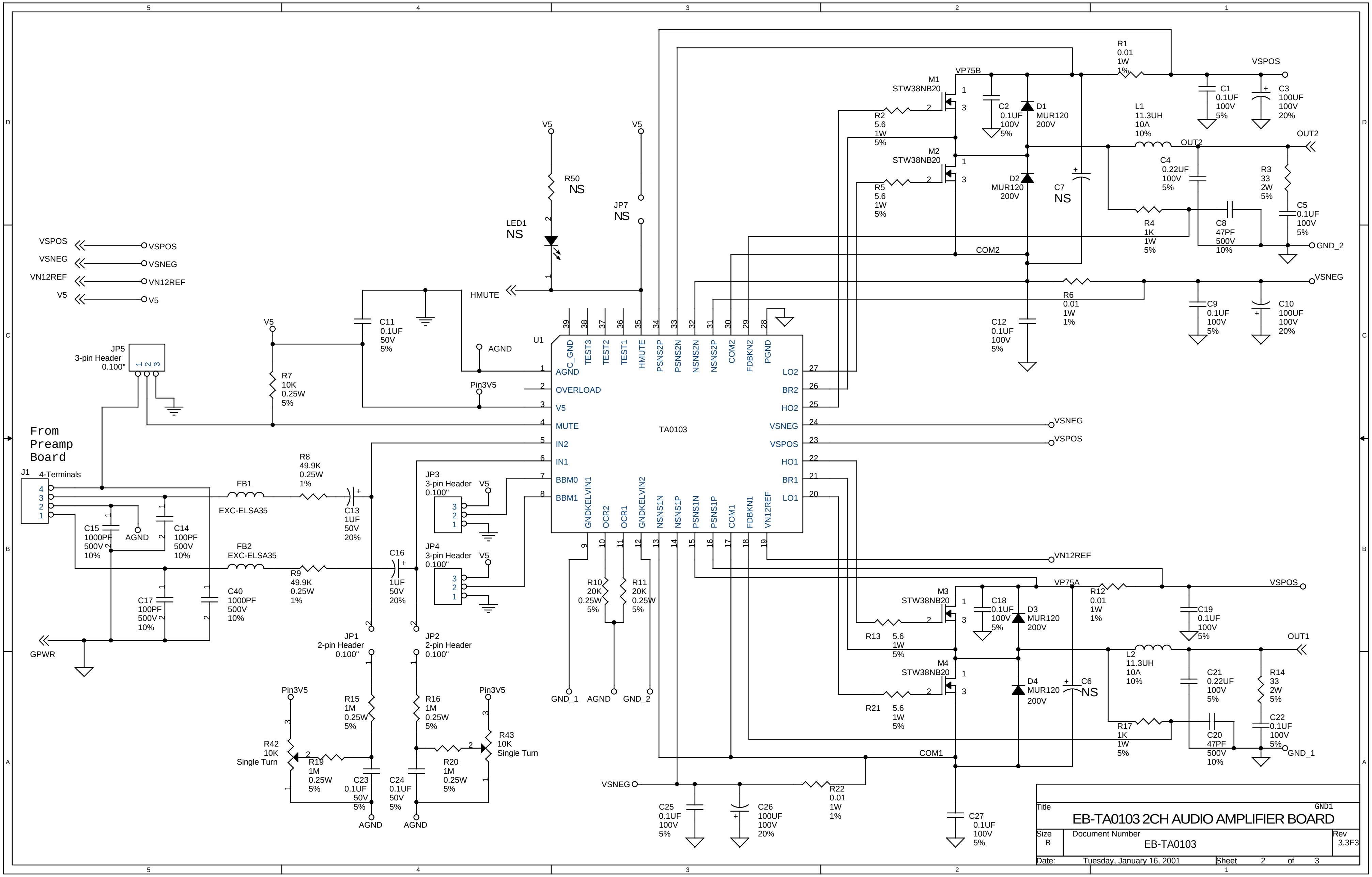

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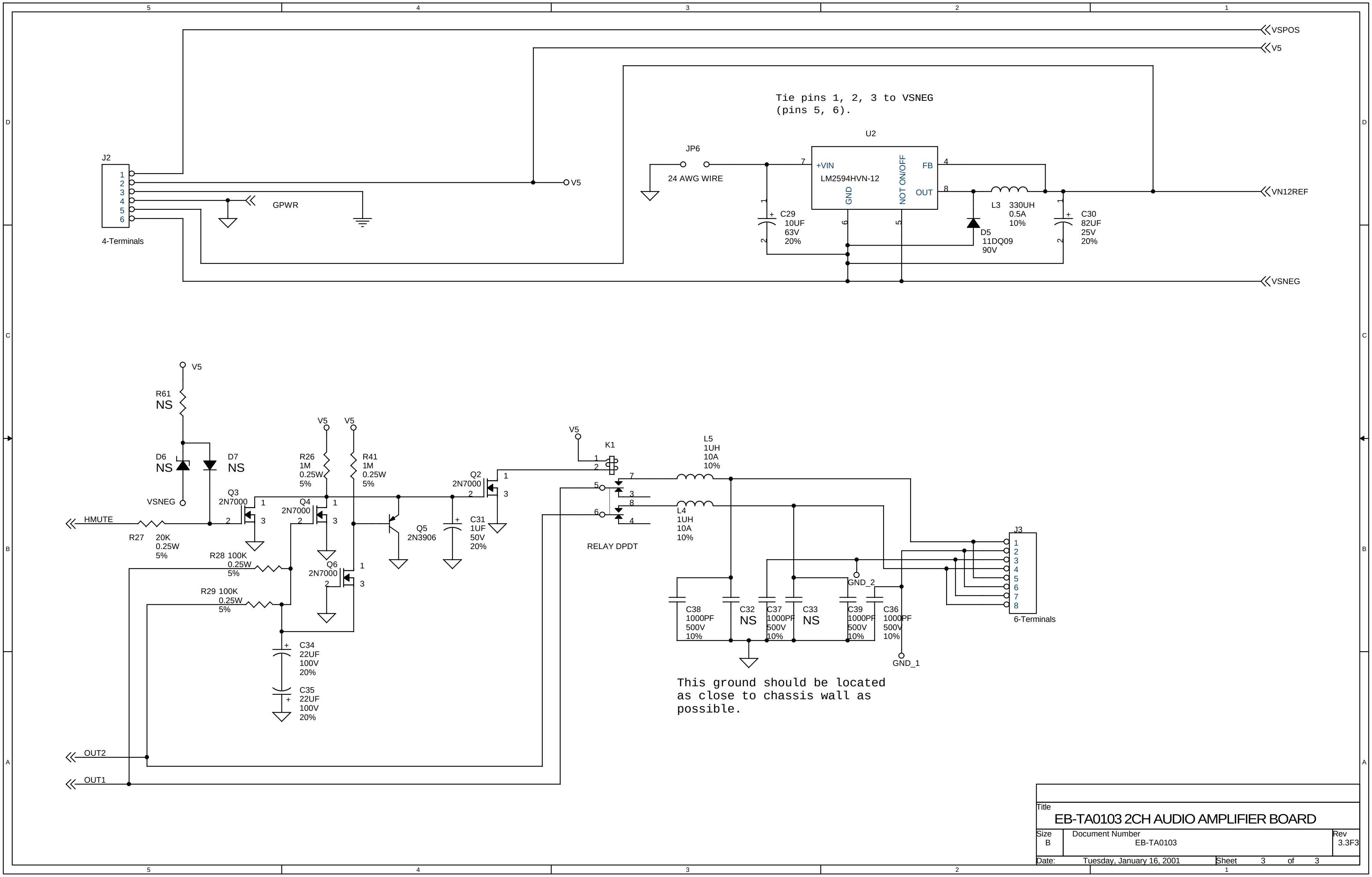
Size	Document Number	Rev
B	EB-TA0103	3.3F3

Date: Tuesday, January 16, 2001 Sheet 2 of 3



Title	EB-TA0103 2CH AUDIO AMPLIFIER BOARD	
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Bill Of Materials for EB-TA0103

Revision 7

	P/N	Qty.	Reference	Description	Value	Rating	Tolerance	Manufacturer	Mfg. Part #	Vendor	Vendor Part #
1	050-00011-0AB	1	PCB Assembly, Tested	EB-TA0103							
2	040-00011-0AB	1	PCB Assembly, Untested	EB-TA0103							
3	302-00001-000	10	C1,C2,C5,C9,C12,C18,C19,C22,C25,C27	Stack Metallized Film Caps	0.1UF	100V	5%	Panasonic	ECQ-V1104JM	Digi-Key	P4725-ND
4	301-00005-000	3	C3,C10,C26	Radial Lead Aluminum Electrolytic Caps	100UF	100V	20%	Panasonic	ECA-2AHG101	Digi-Key	P5597-ND
5	302-00003-000	2	C21,C4	Stack Metallized Film Caps	0.22UF	100V	5%	Panasonic	ECQ-V1224JM	Digi-Key	P4729-ND
6	300-00008-000	2	C8,C20	Ceramic Disk Caps	47PF	500V	10%	Panasonic	E4008A-ND	Digi-Key	ECC-D2H470K5
7	302-00007-000	3	C11,C23,C24	Stack Metallized Film Caps	0.1UF	50V	5%	Panasonic	ECQ-V1H104JL	Digi-Key	P4525-ND
8	301-00017-000	3	C13,C16,C31	Radial Lead Aluminum Electrolytic Caps	1UF	50V	20%	Panasonic	ECA-1HM010	Digi-Key	P5174-ND
9	300-00019-000	2	C14,C17	Ceramic Disk Caps	100PF	500V	10%	Panasonic	ECK-D2H101KB5	Digi-Key	P4100A-ND
10	300-00020-000	6	C15,C36,C37,C38,C39,C40	Ceramic Disk Caps	1000PF	500V	10%	Panasonic	ECK-D2H102KB5	Digi-Key	P4112A-ND
11	301-00006-000	1	C29	Radial Lead Aluminum Electrolytic Caps	10UF	63V	20%	Panasonic	ECA-1JM100	Digi-Key	P5189-ND
12	301-00018-000	1	C30	Radial Lead Aluminum Electrolytic Caps	82UF	25V	20%	Panasonic	ECA-1EFQ820	Digi-Key	P5697-ND
13	301-00019-000	2	C34,C35	Radial Lead Aluminum Electrolytic Caps	22UF	100V	20%	Panasonic	ECA-2AHG220	Digi-Key	P5594-ND
14	400-00005-000	4	D1,D2,D3,D4	Fast Recovery Diode	MUR120	200V		Motorola	MUR120		
15	400-00013-000	1	D5	Schottky Diode	11DQ09	90V		IR	11DQ09	Digi-Key	11DQ09-ND
16	215-00001-000	2	FB1,FB2	Ferrite Beads	EXC-ELSA35				EXC-ELSA35		
17	800-00003-000	2	JP2,JP1	Header Strips	2-pin Header, 0.100"			Phyco	2100-1X2SF1		
18	800-00016-000	3	JP3,JP4,JP5	Header Strips	3-pin Header, 0.100"			Phyco	2100-1X3SF1		
19		1	JP6		24 AWG WIRE						
20	802-00001-000	1	K1	Potter & Brumfield	RELAY DPDT	8A/5V		Siemens	RTE24005		
21	700-00001-000	2	L2,L1	Iron Powder, 29 Turns of 16 AWG	11.3UH	10A	10%	Amidon	T-106-2	AMIDON AMI-10231	
22	700-00002-000	1	L3	Inductor	330UH	0.5A	10%	ISI	RL622-331K		
23	700-00003-000	2	L5,L4	Inductor	1UH	10A	10%	ISI	RL622-1R0M		
24	503-00004-000	4	M1,M2,M3,M4	N-Ch Mosfet	STW38NB20	200V/38A		SGS-Thomson	STW38NB20		
25	502-00001-000	4	Q2,Q3,Q4,Q6	N-Ch Mosfet	2N7000	0.5W		NSC	2N7000		
26	500-00001-000	1	Q5	P-Ch BJT	2N3906	0.5W		NSC	2N3906		
27	206-00001-000	4	R1,R6,R12,R22	Resistor	0.01	1W	1%	Well-Mag	MR0100805		
28	206-00003-000	4	R2,R5,R13,R21	Resistor	5.6	1W	5%	Panasonic		Digi-Key	P5.6W-1TR-ND
29	207-00002-000	2	R14,R3	Resistor	33	2W	5%	Panasonic		Digi-Key	P33W-2TR-ND
30	206-00004-000	2	R4,R17	Resistor	1K	1W	5%	Panasonic		Digi-Key	P1.0KW-1TR-ND
31	202-00006-000	2	R7	Resistor	10K	0.25W	5%	Yageo		Digi-Key	10KQTR-ND
32	202-00007-000	2	R8,R9	Resistor	49.9K	0.25W	1%	Yageo		Digi-Key	49.9XTR-ND
33	202-00008-000	6	R15,R16,R19,R20,R26,R41	Resistor	1M	0.25W	5%	Yageo		Digi-Key	1MQTR-ND
34	202-00002-000	1	R10,R11,R27	Resistor	20K	0.25W	5%	Yageo		Digi-Key	20KQTR-ND
35	202-00005-000	2	R28,R29	Resistor	100K	0.25W	5%	Yageo		Digi-Key	100KQTR-ND
36	204-00008-000	2	R43,R42	Resistor	10K-Single Turn			Bourns	3306P-1103	Digi-Key	3306P-103-ND
37	050-00005-3AB	1	U1	Audio Amplifier	TA0103			Tripath	TA0103		
38	601-00003-000	1	U2	12V Switcher	LM2594HVN-12			NSC	LM2594HVN-12		
39	800-00017-000	2	U1	1 X 11 female socket				Phyco	4150-1X11 SF1		
40	800-00018-000	2	U1	1 X 8 female socket				Phyco	4150-1X8 SF1		
41	850-00003-000	1		Cable Ties	8"			T&B	10400		
42	180-00003-000	1		Printed Circuit Board				Bay Area Ckt	TA010X_REV 3.3		
43	850-00004-000	4		Aluminum Stand-Offs	4-40 x 1/2"					Olander	4C50RF4U
44	850-00005-000	4		Screws for Stand-Offs	4-40 x 1/4"					Olander	4C25PPMS
45	850-00006-000	4		Alumina Oxide Spacers				Thermalloy	4170	Bisco Industries	
46	850-00007-000	1		Heatsink				ACK Tech/ CCI	CS8157-18070		
47	850-00008-000	2		Small, Clamp Bars				Abacus	100-3900-002		
48	850-00009-000	2		Screws for Clamp Bars	4-40 x 1/2					Olander	4C75PPMS
49	850-00010-000	1		Red Wire	6", 24 AWG Wire						
50	850-00013-000	1		Red Wire	6", 18 AWG Wire						
51	850-00013-000	1		Red Wire	12", 18 AWG Wire						
52	850-00011-000	1		Black Wire	6", 24 AWG Wire						
53	850-00014-000	1		Black Wire	6", 18 AWG Wire						
54	850-00014-000	1		Black Wire	12", 18 AWG Wire						

55	850-00012-000	1		White Wire	6", 24 AWG Wire						
56	850-00015-000	1		White Wire	6", 18 AWG Wire						
57	850-00016-000	1		Yellow Wire	12", 18 AWG Wire						
58	850-00017-000	1		Blue Wire	6", 18 AWG Wire						
59	850-00017-000	1		Blue Wire	12", 18 AWG Wire						
60	850-00018-000	1		Orange Wire	12", 18 AWG Wire						
61	800-00009-000	2		Female Banana Jack w/ screws	Red			Johnson Comp.	108-0901-001	Digi-Key	J151-ND
62	800-00010-000	2		Female Banana Jack w/ screws	Black			Johnson Comp.	108-0903-001	Digi-Key	J152-ND
63	800-00012-000	2		Female Banana Jack w/ screws	Blue			Johnson Comp.	108-0910-001	Digi-Key	J155-ND
64	800-00011-000	1		Female Banana Jack w/ screws	White			Johnson Comp.	108-0901-001	Digi-Key	J150-ND
65	800-00014-000	1		Female Banana Jack w/ screws	Yellow			Johnson Comp.	108-0907-001	Digi-Key	J154-ND
66	800-00013-000	1		Female Banana Jack w/ screws	Orange			Johnson Comp.	108-0906-001	Digi-Key	J356-ND
67		10	LED1,C6,JP7,C7,C32,C33,R50, R61 , D6, D7		No Stuff						
68	850-00019-000	3		8-32 x 3/8 Phil Flat, Baseplate screw, SS						Orlander	
69	850-00020-000	4		4-40 x 1/4 Phil Flat, Baseplate screw, SS						Orlander	
70	850-00021-000	1		Baseplate, Aluminum				Abacus Mfg.			
71	950-00003-000	1		Shipping box w/ foam							
72	950-00004-000	1		10 x 12 Anti-static bag							
73	800-00019-000	5	JP1, 2, 3, 4, 5	2 pin header, jumper	jumper						

Note #1 (J1):

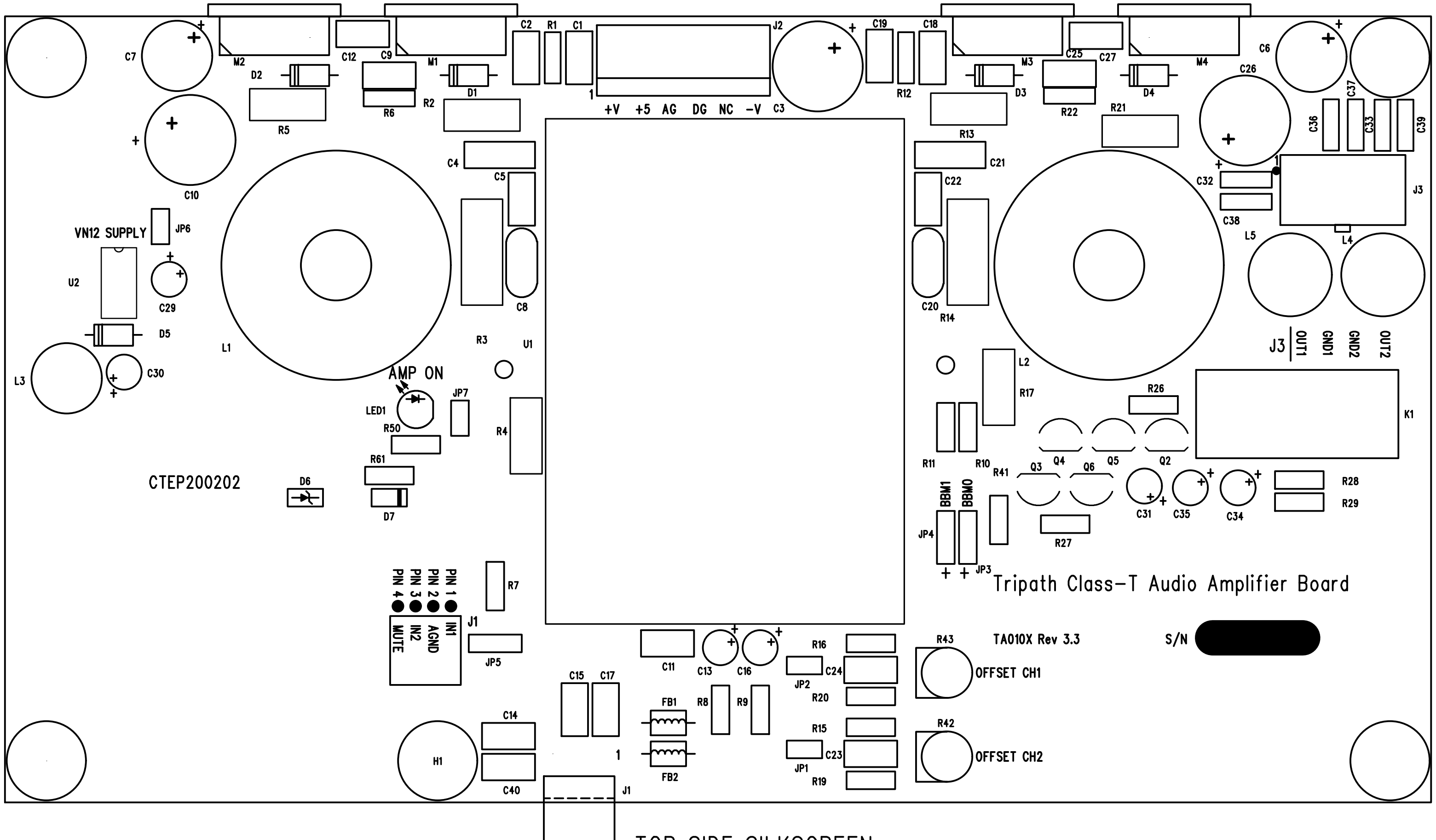
Use a 24AWG (6" long) stripped at end.
Terminal 1: Red Wire
Terminal 2: Black Wire
Terminal 3: White Wire
Terminal 4: No Wire

Note #2 (J2):

Use a 18AWG (12" long) with a female banana jack at the end.
Terminal 1: Yellow Wire
Terminal 2: Red Wire
Terminal 3: Black Wire
Terminal 4: Blue Wire
Terminal 5: No wire
Terminal 6: Orange Wire

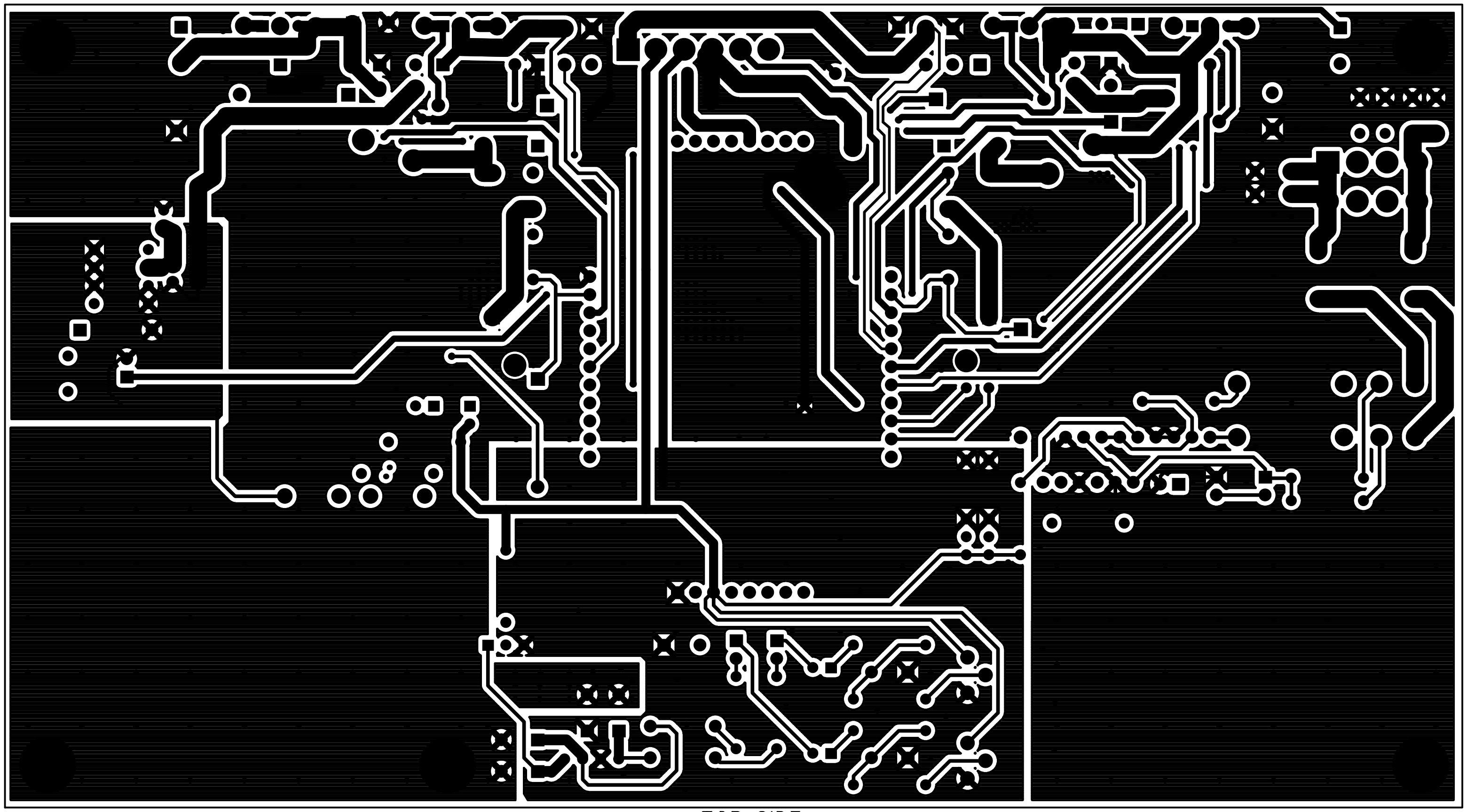
Note #3 (J3):

Use a 18AWG (6" long) with a female banana jack at the end.
Terminal 1: Red Wire
Terminal 2: Black Wire
Terminal 3: Blue Wire
Terminal 4: White Wire



TOP SIDE SILKSCREEN
P/N: CTEP200202
SH 3OF 6

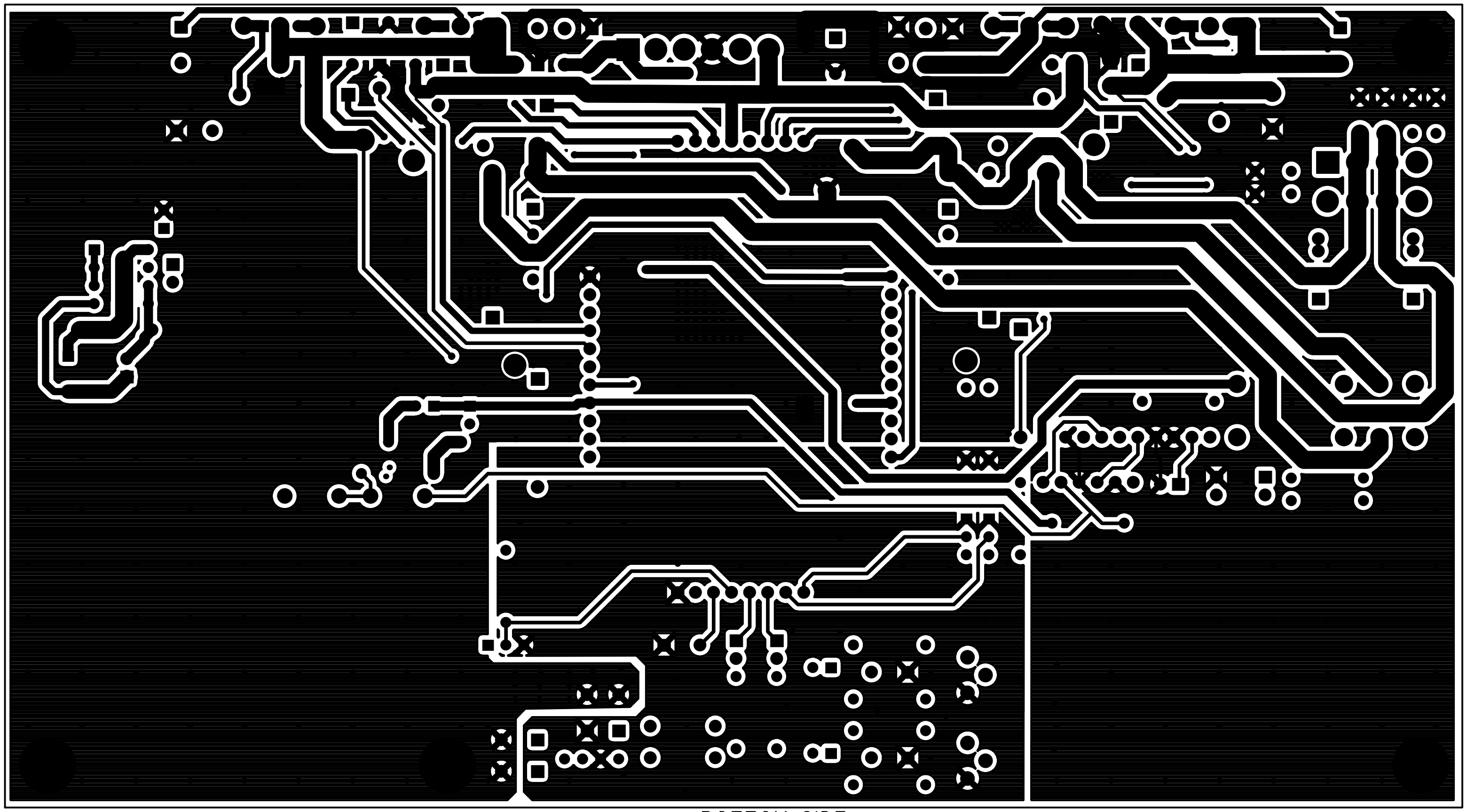
ta010x_rev3.3.pcb - Tue Aug 24 16:23:52 1999



TOP SIDE

P/N: CTEP200202
SH 1OF 6

ta010x_rev3.3.pcb - Tue Aug 24 16:23:30 1999



BOTTOM SIDE

P/N: CTEP200202
SH 2OF 6

ta010x_rev3.3.pcb - Tue Aug 24 16:22:53 1999