

Class-T Digital Audio Amplifier Reference Board using Digital Power Processing (DPP™) Technology

February 2001, For Rev. 3.0 Board

RB-TA3020-1
RB-TA3020-2

General Description

The RB-TA3020 reference board is based on the TA3020 digital audio power amplifier from Tripath Technology. This board is designed to provide a simple and straightforward environment for the reference of the Tripath stereo TA3020 amplifier. This board can also be used in a bridged configuration for high power mono output.

Note: There are two versions of the RB-TA3020, depending on nominal supply voltage.

RB-TA3020-1 – Nominal supply voltage +/-21V to +/-39V

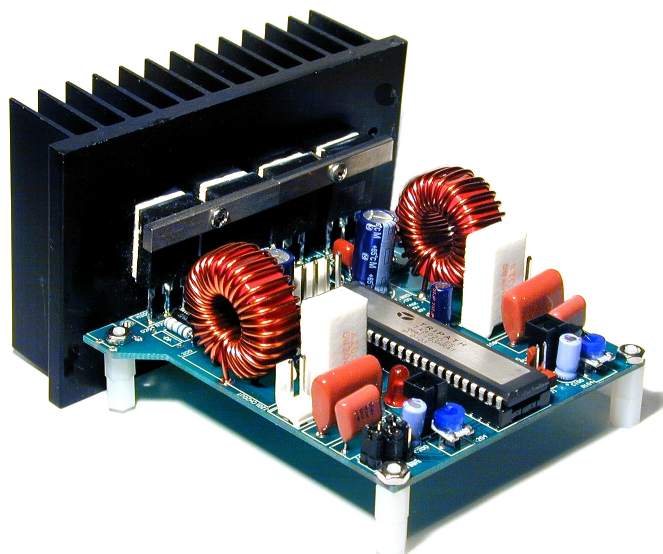
RB-TA3020-2 – Nominal supply voltage +/-35V to +/-60V

Features

- RB-TA3020-1: 2 x 70W continuous output power @ 0.1% THD+N, 4Ω, ±28V
- RB-TA3020-1: 250W continuous output power @ 0.1% THD+N, bridged 4Ω, ±28V
- RB-TA3020-2: 2 x 175W continuous output power @ 0.1% THD+N, 4Ω, ±45V
- RB-TA3020-2: 525W continuous output power @ 0.1% THD+N, bridged 4Ω, ±45V
- Outputs short circuit protected

Benefits

- Uses only N-channel power MOSFETs
- Ready to use in many applications:
 - 2 channel stereo systems
 - Powered 2.1 speaker systems
 - Powered Subwoofers



Note: RB-TA3020-1 shown

OPERATING INSTRUCTIONS

Power Supply Description

There are four external power supplies required to operate this board: VPP, VNN, VN10, and V5 (see Figures 1 and 2). VPP and VNN 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 TA3020 amplifier also requires a supply, VN10, that is 10V more positive than VNN and tracks VNN. All output and power supply connections are made using tinned wire (not shown).

Though not required, the following powering-up sequence is usually adhered to during bench evaluations: 1st) V5 and VN10, 2nd) VNN and 3rd) VPP (refer to the Turn-on/off Pop section). Please 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. Figure 1 shows the proper supply configuration for the RB-TA3020.

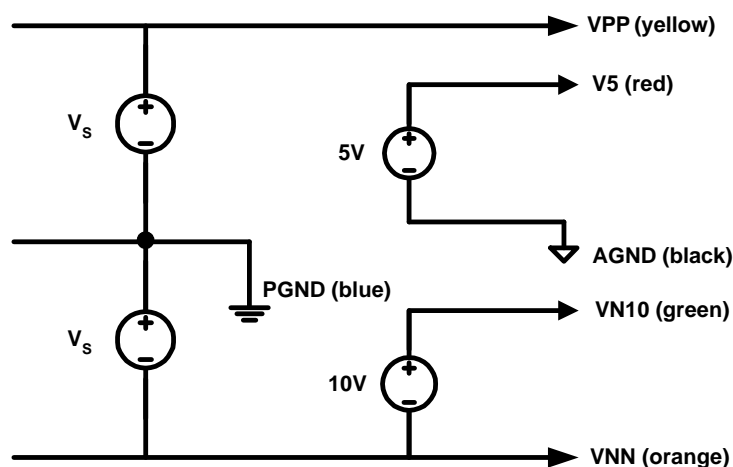


Figure 1

Note: To avoid signal degradation, the Analog Ground and Power Ground should be kept separate at the power supply. They are connected locally on the RB-TA3020.

Connector	Power Supply
J5 (Yellow)	VPP
J5 (Blue)	PGND
J5 (Orange)	VNN
J5 (Green)	VN10
J1 (Red)	V5
J1 (Black)	AGND

Table 1

Input Connections

Audio input to the board is located at CH1 INPUT (J100) and CH2 INPUT (J200) (see Figures 2 and 3). The input can be a test signal or music source. A dual RCA cable is provided with female 100mil connectors that mate with J100 and J200.

Output Connections

There are two output connectors on the reference board for the speaker outputs. Channel 1 output and associated Power Ground 1 is located at J101. Channel 2 output and associated Power Ground 2 is located at J201. A two-wire harness for each output is provided. See Table 2 for the output connector wire colors. The TA3020 can be operated as a two-channel single-ended amplifier, bridged mono output amplifier (see Figure 9) 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 with resistive load (see Application Note 4 for more information on bench testing).

Connector Name	Output	Ground
J101	White	Blue
J201	Red	Black

Table 2

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 V5 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 acceptable. In practice, the V5 will usually collapse before VPP and VNN. The same discussion holds true for the VN10 supply. It can collapse before VPP or VNN though this may cause a larger turn-off pop than if the mute had been activated before either the VN10 or V5 supply have collapsed. No damage will occur to the TA3020 if either the V5 or VN10 collapse before VPP or VNN, assuming the mute is asserted before the supplies start to discharge.

HMUTE

There is an LED, D1, that will illuminate if a fault condition is reported. HMUTE, pin 15, will illuminate D1 via R2, if the processor detects an over or under voltage fault, as well as an over current fault. In addition, if MUTE is high (by removing jumper on J4), the LED will also be illuminated.

An over/under voltage fault will automatically reset (and D1 will turn off) once the supply voltage is brought back into specification. If an over current condition occurs, cycle the MUTE pin (by removing the jumper on J4 and then replacing it). Assuming all supplies are still within specification, the HMUTE LED will be off and the TA3020 reference board will again amplify input signals.

RB-TA3020 Board

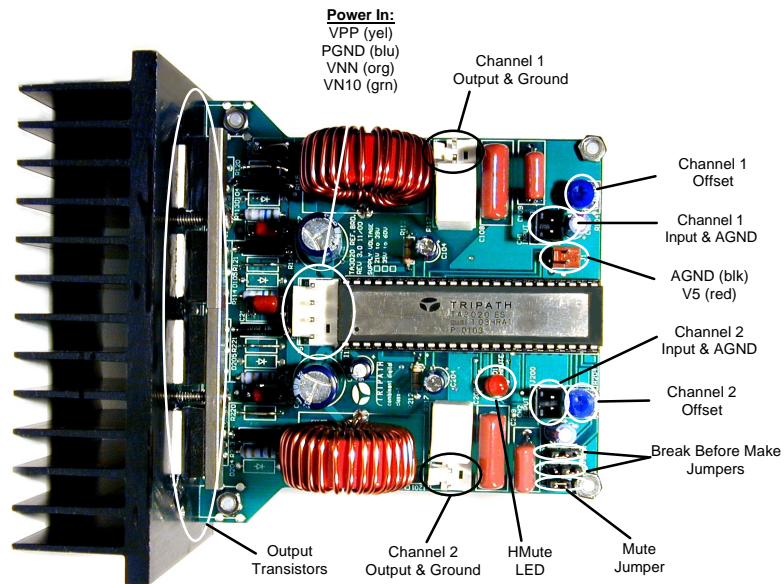


Figure 2

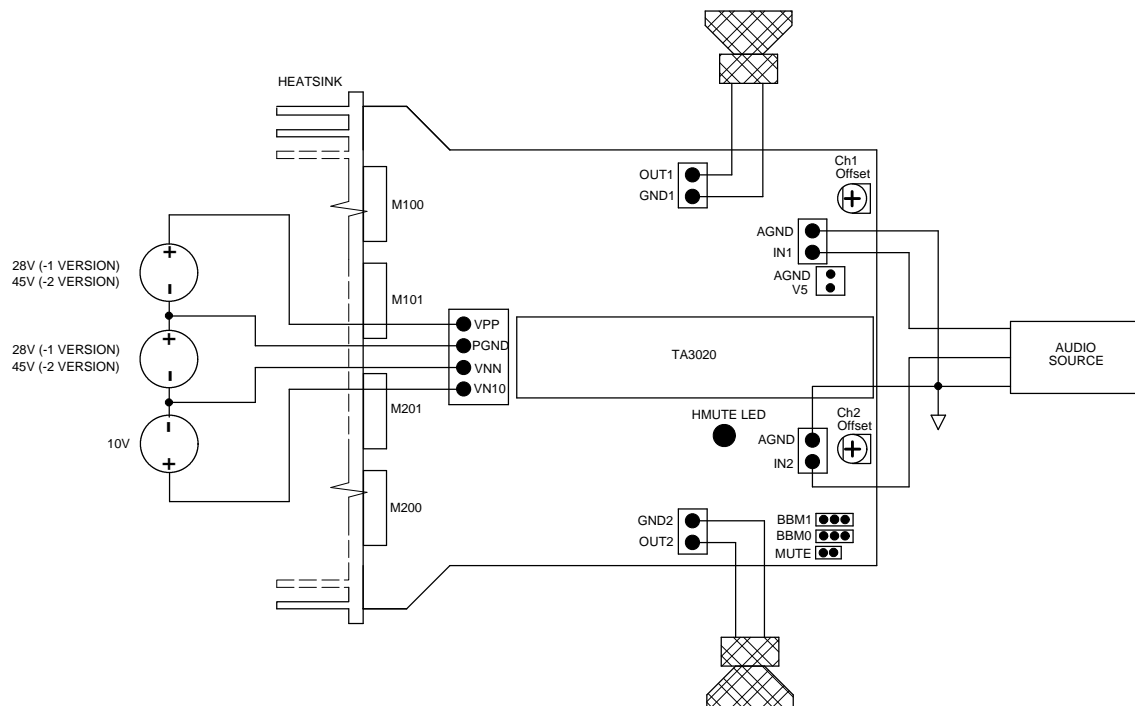


Figure 3

ARCHITECTURE

A block diagram of one channel of the reference board is shown in Figure 4. The major functional blocks of the amplifier are described below.

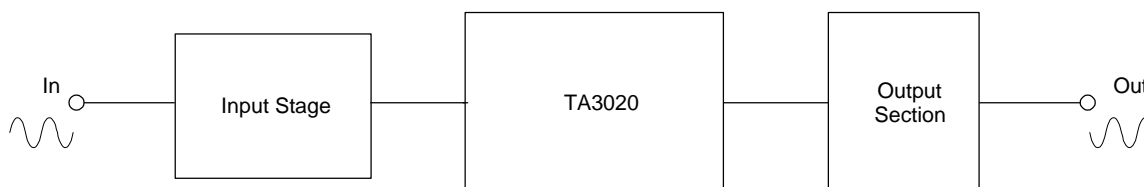


Figure 4

Note: The TA3020 is an inverting amplifier.

TA3020 Amplifier Gain

The TA3020 amplifier gain is the product of the input stage gain and the modulator gain.

$$AV_{TA3020} = A_{INPUTSTAGE} * A_{MODULATOR}$$

$$AV_{TA3020} \approx -\frac{R_F}{R_I} \times \left(\frac{R_{FBC} * (R_{FBA} + R_{FBB})}{R_{FBA} * R_{FBB}} + 1 \right)$$

For the RB-TA3020-2 board;

$$R_I (R100, R200) = 49.9k\Omega$$

$$R_F (R101, R201) = 20k\Omega$$

$$R_{FBA} (R105, R205) = 1k\Omega$$

$$R_{FBB} (R110, R210) = 1.07k\Omega$$

$$R_{FBC} (R106, R206) = 13.3k\Omega$$

$$AV_{TA3020} \approx -\frac{20k\Omega}{49.9k\Omega} \times \left(\frac{13.3k\Omega * (1k\Omega + 1.07k\Omega)}{1k\Omega * 1.07k\Omega} + 1 \right) = 10.71V/V$$

Input Stage

Figure 5 shows one channel of the Input Stage. The TA3020 amplifier is designed to accept unbalanced inputs. For the RB-TA3020-1, the gain is 6.4, or approximately 16 dB. For the RB-TA3020-2, the gain is 10.8, or approximately 20.7 dB. Please note that the input stage of the TA3020 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 5 is correct.

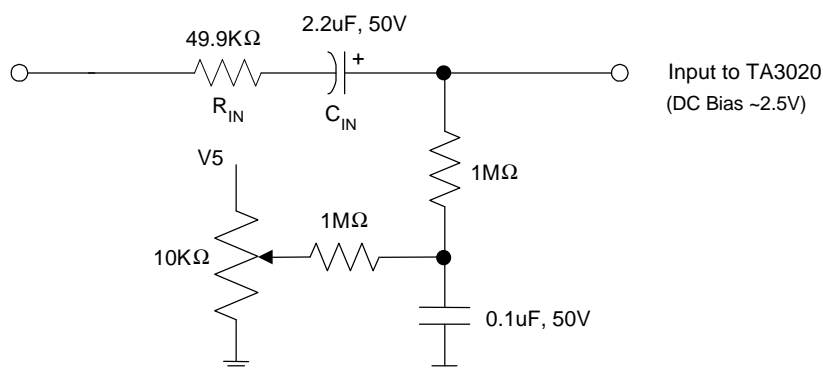


Figure 5

The value of the input capacitor, C_{IN} , in Figure 5 (labeled C100 and C200 on the schematic), and the input resistor, R_{IN} (labeled R100 and R200), 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:

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

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

R_{IN} = input resistor value in Ohms

Output offset voltages can be nulled by adjusting the $10\text{K}\Omega$ potentiometer shown in Figure 5. Once set, the offset does not typically drift with temperature, so no tracking circuitry is required. Offsets can typically be set to $\pm 25\text{ mV}$. R104 is used to adjust the offset of CH1, and R204 is used to adjust the offset of CH2. If a different TA3020 is placed in the RB-TA3020 reference board, the offset of each channel would need to be re-trimmed.

RB-TA3020 Control Circuitry

The MUTE pin is brought out to an external 2-pin header, J4 (Figure 6). When a jumper is installed from Pin 1 to 2 of J4, 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, and the amplifier is muted.

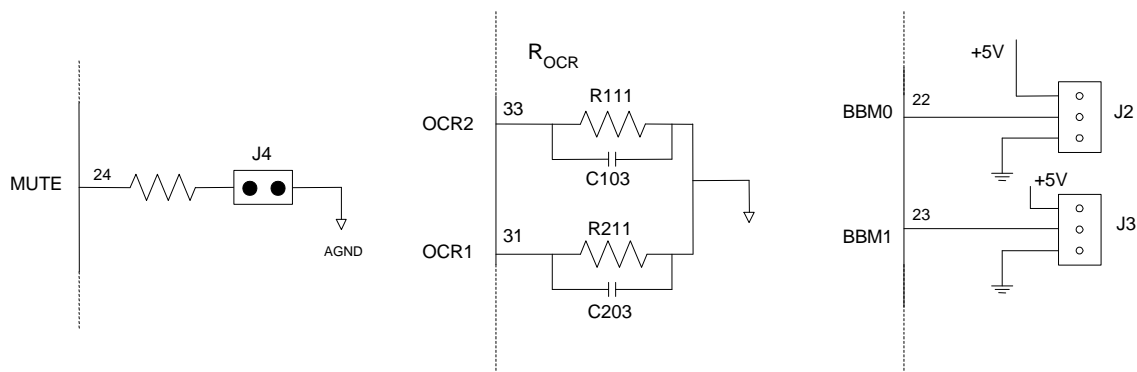


Figure 6

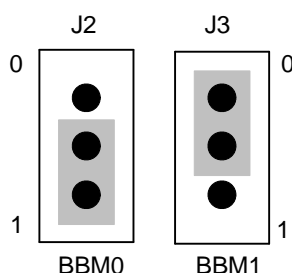
The resistors, R_{OCR} in Figure 6 (labeled R111 and R211 in the schematic), set the overcurrent threshold for the output devices. Note that these are NOT the sense resistors (the overcurrent sense resistors, R_S , are in the output stage). By adjusting the R_{OCR} resistor values, the threshold at which 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 reference board is pre-set to 20K Ω for a 4 Ω application. For lower impedance applications (i.e. 4 Ω bridged), this board’s overcurrent may trip prematurely. This is indicated by the amplifier going into mute; 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, though if set too low of a value, 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 BBM0 setting, via jumper J2, on the 3-pin header (see Figure 6). Please note that BBM1 is hardwired to “0” on the RB-TA3020 since operating the reference board with BBM delays of 40nS or less will result in significant shoot through current and possible MOSFET destruction.

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 TA3020 does not impact the performance of the amplifier. This amplifier board is set to 80nS, and the table below shows the BBM values for various settings of the jumpers (Figure 7).

	<u>BBM1</u>	<u>BBM0</u>	<u>Delay</u>
1)	0	0	120nS
2)	0	1	80nS
3)	1	0	40nS
4)	1	1	0nS



Note: The default delay jumper setting is 80nS.

Figure 7

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.

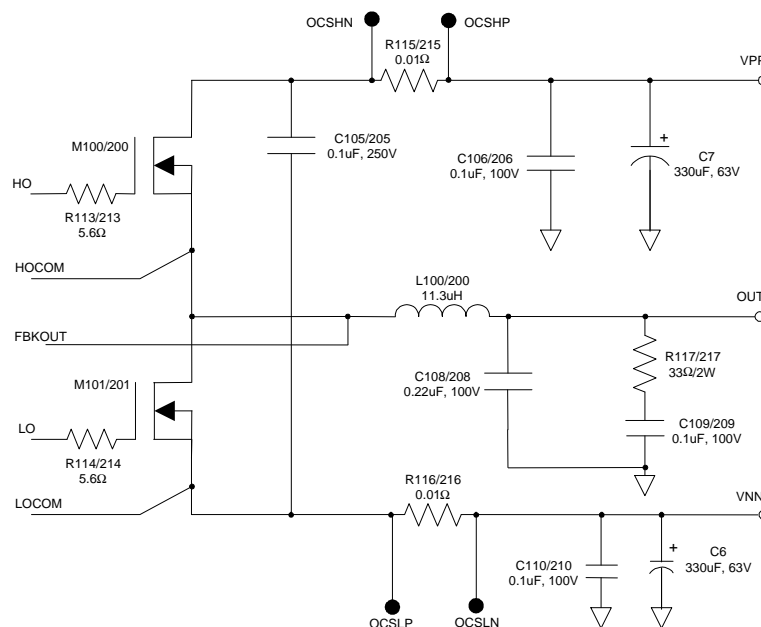


Figure 8

The gate resistors (labeled R113, R213, R114, and R214 in Figure 8 and the attached schematic) 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 5.6Ω when the Q_g is greater than 70nC and R_G of 10Ω when the gate charge (Q_g) of the output FET is less than 70nC.

The output FETs (M100, M101, M200 and M201) provide the switching function required of a Class-T design. They are driven directly by the TA3020 through the gate resistors. The devices used on the reference board are ST STW34NB20 MOSFETs. The TA3020 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 L100/C108 and L200/C208 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 (nominal resonant frequency of 101kHz), 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- μ core, like type 2, iron powder cores. Micrometals, (www.micrometals.com), is a main supplier of iron powder cores. The core part number used on the RB-TA3020 is T106-2 and is wound with 29 turns of 16AWG wire.

The Zobel circuits R117/C109 and R217/C209 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, though depending on application, the power capability of R117 and R217 may need to be increased to 5W from 2W. The components used on the reference board should be quite adequate for almost all applications.

The bypass capacitors C105/C205 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 9. 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* (Channel 1 output, J101 pin 1) and the “+” terminal to the output of the non-inverted channel with respect to the input signal (Channel 2 output, J201 pin 2).

The connection shown in Figure 9 is the easiest way to use the RB-TA3020 to test bridged mode operation. If the evaluation setup does not provide two out of phase signals, there is another way to evaluate bridge mode operation. This requires the RB-TA3020 to be modified.

Change R201 to 20KΩ from 49.9KΩ. Connect Pin 26 (OAOUT1) to IN2 on J200. The input signal is still applied to (J100) and is inverted on chip thus providing the input signal for Channel 2 via J200. If the gain of the system needs to be modified, R101 can be adjusted. R201 should be left at 20KΩ. If stereo operation is again desired, then the value of R101 and R201 must be made the same to ensure nominal gain for both channels. Additionally, the connection between Pin 26 and IN2 on J200 should be removed.

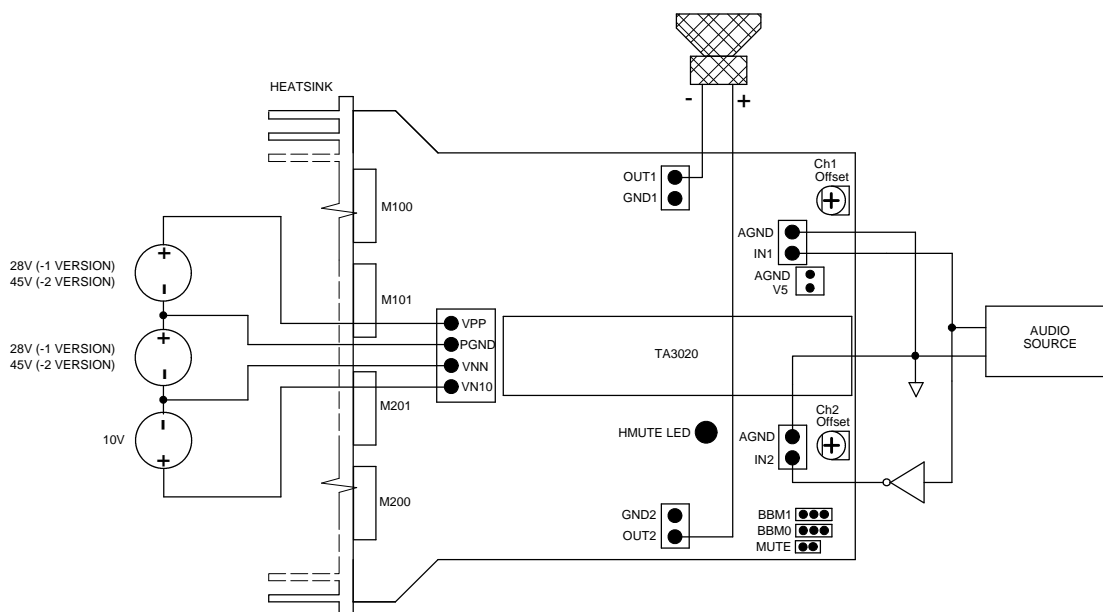


Figure 9

Performing Measurements on the EB-TA3020

The TA3020 operates by generating a high frequency switching signal based on the audio input. This signal is sent through a low-pass filter that recovers an amplified version of the audio input. The frequency of the switching pattern is spread spectrum in nature and typically varies between 100kHz and 1MHz, which is well above the 20Hz – 20kHz audio band. The pattern itself does not alter or distort the audio input signal, but it does introduce some inaudible components.

The measurements of certain performance parameters, particularly noise related specifications such as THD+N, are significantly affected by the design of the low-pass filter used on the output as well as the bandwidth setting of the measurement instrument used. Unless the filter has a very sharp roll-off just beyond the audio band or the bandwidth of the measurement instrument is limited, some of the inaudible noise components introduced by the TA3020 amplifier switching pattern will degrade the measurement.

One feature of the TA3020 is that it does not require large multi-pole filters to achieve excellent performance in listening tests, usually a more critical factor than performance measurements. Though using a multi-pole filter may remove high-frequency noise and improve THD+N type measurements (when they are made with wide-bandwidth measuring equipment), these same filters degrade frequency

response. The RB-TA3020 Reference Board has a simple two-pole output filter with excellent performance in listening tests.

(See Application Note 4 for more information on bench testing)

DOCUMENTATION

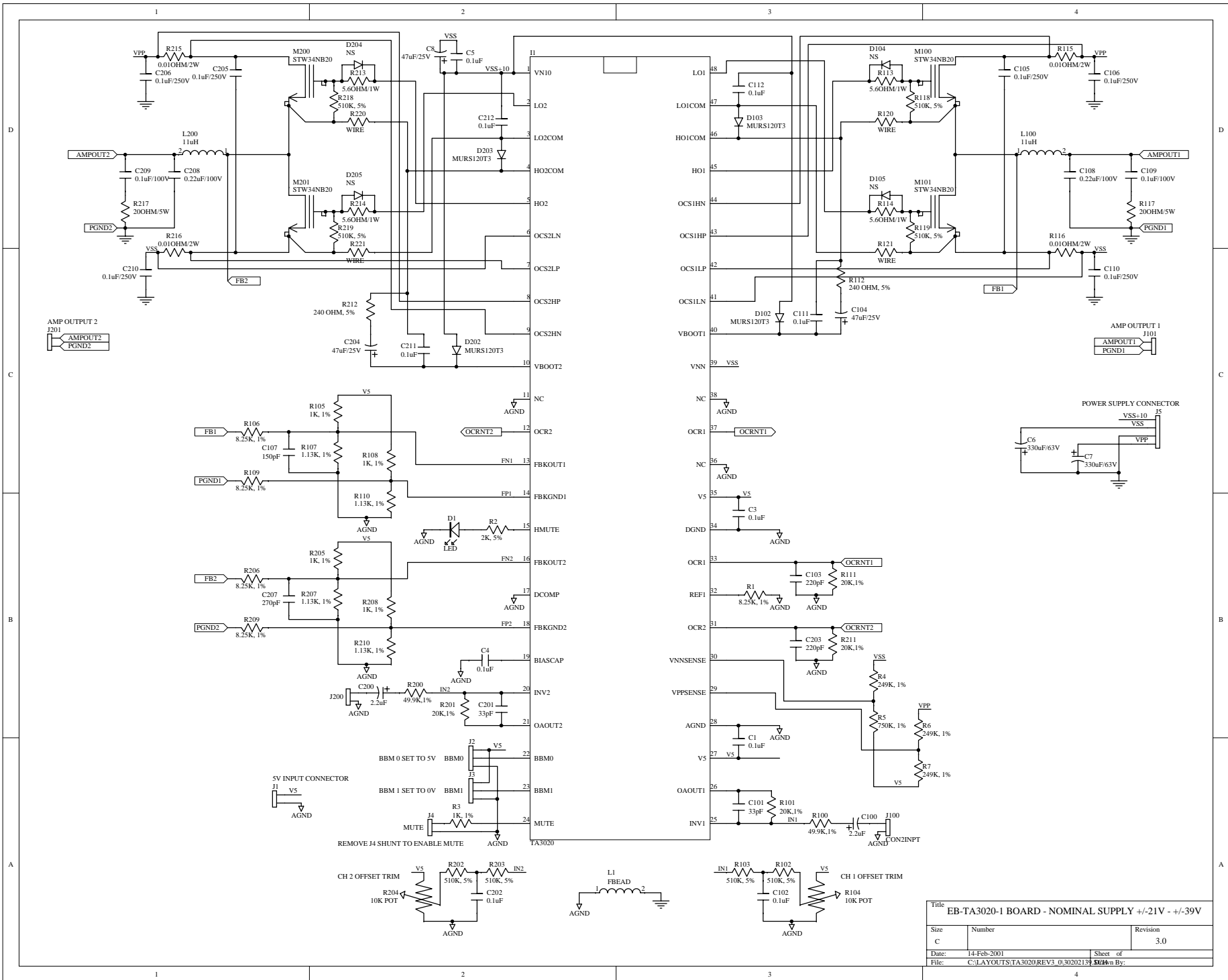
Soft copies of the schematics and layout can be provided upon request.

CONTACT INFORMATION

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

TRIPATH TECHNOLOGY, INC.

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Santa Clara, California 95054
408-567-3000



Bill of Material for RB-TA3020-1

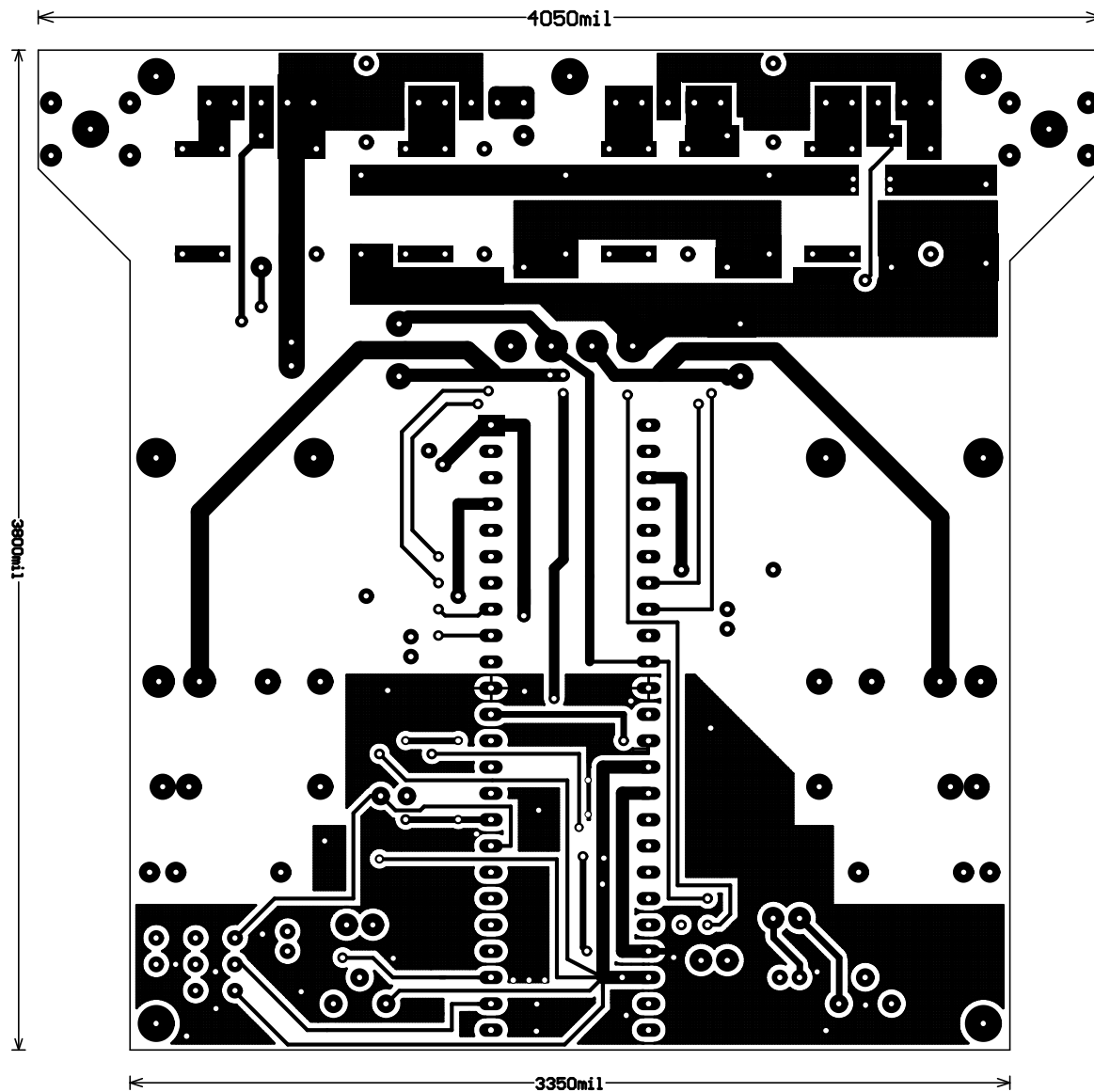
Used	Part Type	Designator	Footprint	Part Field 1	Part Field 2	Part Field 3
====	=====	=====	=====	=====	=====	=====
4	0.01OHM/2W	R115 R116 R215 R216	RLVR1RG2	OHMITE	12FR010	DK 12FR010-ND
10	0.1uF	C1 C102 C111 C112	0805	20% TOL.	*	*
		C202 C211 C212 C3 C4				
		C5				
2	0.1uF/100V	C109 C209	C0U1MF10	PANASONIC	ECH-S1104JZ	DK PS1104J-ND
6	0.1uF/250V	C105 C106 C110 C205	C0U1MF10	PANASONIC	ECQ-E2104KF	DK EF2104-ND
		C206 C210				
2	0.22uF/100V	C108 C208	C0U22MF10	PANASONIC	ECH-S1224JZ	DK PS1224J-ND
4	1.13K, 1%	R107 R110 R207 R210	0805	*	*	*
2	10K POT	R104 R204	POTSTURN	BOURNS	3306P-1-103	DK 3306P-103-ND
2	11uH	L100 L200	T106	COIL WINDING SPEC	T106-2 CORE	29TURNS / 16AWG
1	150pF	C107	0805	NPO 5%	*	*
5	1K, 1%	R105 R108 R205 R208	0805	*	*	*
		R3				
2	2.2uF	C100 C200	C10UEL05	PANASONIC	ECA-1HHG2R2	DK P5564-ND
4	20K,1%	R101 R111 R201 R211	0805	*	*	*
2	20OHM/5W	R117 R217	R33R3W	XICON	ERG-2SJ330	MSR 280-PRM5-20
2	220pF	C103 C203	0805	NPO 5%	*	*
2	240 OHM, 5%	R112 R212	0805	*	*	*
3	249K, 1%	R4 R6 R7	0805	*	*	*
1	270pF	C207	0805	NPO 5%	*	*
1	2K, 5%	R2	0805			
2	330uF/63V	C6 C7	C100UEL06	PANASONIC	EEU-FC1J331	DK P10349-ND
2	33pF	C101 C201	0805	NPO 5%	*	*
3	47uF/25V	C104 C204 C8	C10UEL05	PANASONIC	ECA-1EHG470	DK P5539-ND
2	49.9K,1%	R100 R200	0805	*	*	*
4	5.6OHM/1W	R113 R114 R213 R214	RES1WFLT	PANASONIC	ERG-1SJ5R6	P5.6W-1BK-ND
8	510K, 5%	R102 R103 R118 R119	0805	*	*	*
		R202 R203 R218 R219				
1	750K, 1%	R5	0805	*	*	*
5	8.25K, 1%	R1 R106 R109 R206	0805	*	*	*
		R209				
2	CON2	J101 J201	PWR2	WALDOM	26-60-4020	DK WM4620-ND
2	CON2INPT	J100 J200	CON2	WALDOM	705-43-0001	DK WM4800-ND
1	CON2LPWR	J1	CON2B	WALDOM	22-23-2021	DK WM4200-ND

1	CON4	J5	PWR4	WALDOM	26-60-4040	DK WM4622-ND
1	FBEAD	L1	2512	*	*	*
1	HDR2	J4	GJMPR001	*	*	*
2	HDR3	J2 J3	GJMP3001	*	*	*
1	LED	D1	LED1	RED LED	*	*
4	MURS120T3	D102 D103 D202 D203	SMB	MOTOROLA	MURS120T3	*
4	NS	D104 D105 D204 D205	DIODE60	MOTOROLA	MUR120	*
4	STW34NB20	M100 M101 M200 M201	TO3P&220RGT	ST MICROELECTRONICS	*	*
1	TA3020	I1	DIP48	TRIPATH	*	*
4	WIRE	R120 R121 R220 R221	RES1WFLT	22AWG SOLID CORE WIRE		

Bill of Material for RB-TA3020-2

Used	Part Type	Designator	Footprint	Part Field 1	Part Field 2	Part Field 3
====	=====	=====	=====	=====	=====	=====
4	0.01OHM/2W	R115 R116 R215 R216	RLVR1RG2	OHMITE	12FR010	DK 12FR010-ND
10	0.1uF	C1 C102 C111 C112	0805	20% TOL.	*	*
		C202 C211 C212 C3 C4				
		C5				
2	0.1uF/100V	C109 C209	C0U1MF10	PANASONIC	ECH-S1104JZ	DK PS1104J-ND
6	0.1uF/250V	C105 C106 C110 C205	C0U1MF10	PANASONIC	ECQ-E2104KF	DK EF2104-ND
		C206 C210				
2	0.22uF/100V	C108 C208	C0U22MF10	PANASONIC	ECH-S1224JZ	DK PS1224J-ND
4	1.07K, 1%	R107 R110 R207 R210	0805	*	*	*
1	1.3M, 1%	R5	0805	*	*	*
2	10K POT	R104 R204	POTSTURN	BOURNS	3306P-1-103	DK 3306P-103-ND
2	11uH	L100 L200	T106	COIL WINDING SPEC	T106-2 CORE	29TURNS / 16AWG
4	13.3K, 1%	R106 R109 R206 R209	0805	*	*	*
1	150pF	C107	0805	NPO 5%	*	*
5	1K, 1%	R105 R108 R205 R208	0805	5%	*	*
		R3				
2	2.2uF	C100 C200	C10UEL05	PANASONIC	ECA-1HHG2R2	DK P5564-ND
4	20K,1%	R101 R111 R201 R211	0805	*	*	*
2	20OHM/5W	R117 R217	R33R3W	XICON	ERG-2SJ330	MSR 280-PRM5-20
2	220pF	C103 C203	0805	NPO 5%	*	*
2	240 OHM, 5%	R112 R212	0805	*	*	*
1	270pF	C207	0805	NPO 5%	*	*
1	2K, 5%	R2	0805			
2	330uF/63V	C6 C7	C100UEL06	PANASONIC	EEU-FC1J331	DK P10349-ND
2	33pF	C101 C201	0805	NPO 5%	*	*
3	453K, 1%	R4 R6 R7	0805	*	*	*
3	47uF/25V	C104 C204 C8	C10UEL05	PANASONIC	ECA-1EHG470	DK P5539-ND
2	49.9K,1%	R100 R200	0805	*	*	*
4	5.6OHM/1W	R113 R114 R213 R214	RES1WFLT	PANASONIC	ERG-1SJ5R6	P5.6W-1BK-ND
8	510K, 5%	R102 R103 R118 R119	0805	*	*	*
		R202 R203 R218 R219				
1	8.25K, 1%	R1	0805	*	*	*
2	CON2	J101 J201	PWR2	WALDOM	26-60-4020	DK WM4620-ND
2	CON2INPT	J100 J200	CON2	WALDOM	705-43-0001	DK WM4800-ND
1	CON2LPWR	J1	CON2B	WALDOM	22-23-2021	DK WM4200-ND

1	CON4	J5	PWR4	WALDOM	26-60-4040	DK WM4622-ND
1	FBEAD	L1	2512	*	*	*
1	HDR2	J4	GJMPR001	*	*	*
2	HDR3	J2 J3	GJMP3001	*	*	*
1	LED	D1	LED1	RED LED	*	*
4	MURS120T3	D102 D103 D202 D203	SMB	MOTOROLA	MURS120T3	*
4	NS	D104 D105 D204 D205	DIODE60	MOTOROLA	MUR120	*
4	STW34NB20	M100 M101 M200 M201	TO3P&220RGT	ST MICROELECTRONICS	*	*
1	TA3020	I1	DIP48	TRIPATH	*	*
4	WIRE	R120 R121 R220 R221	RES1WFLT	22AWG SOLID CORE WIRE		



FABRICATION NOTES

THIS IS A DOUBLE SIDED BOARD

MATERIAL: FR-4 OR EQUIVALENT

0.062 +/- 0.007 THICKNESS

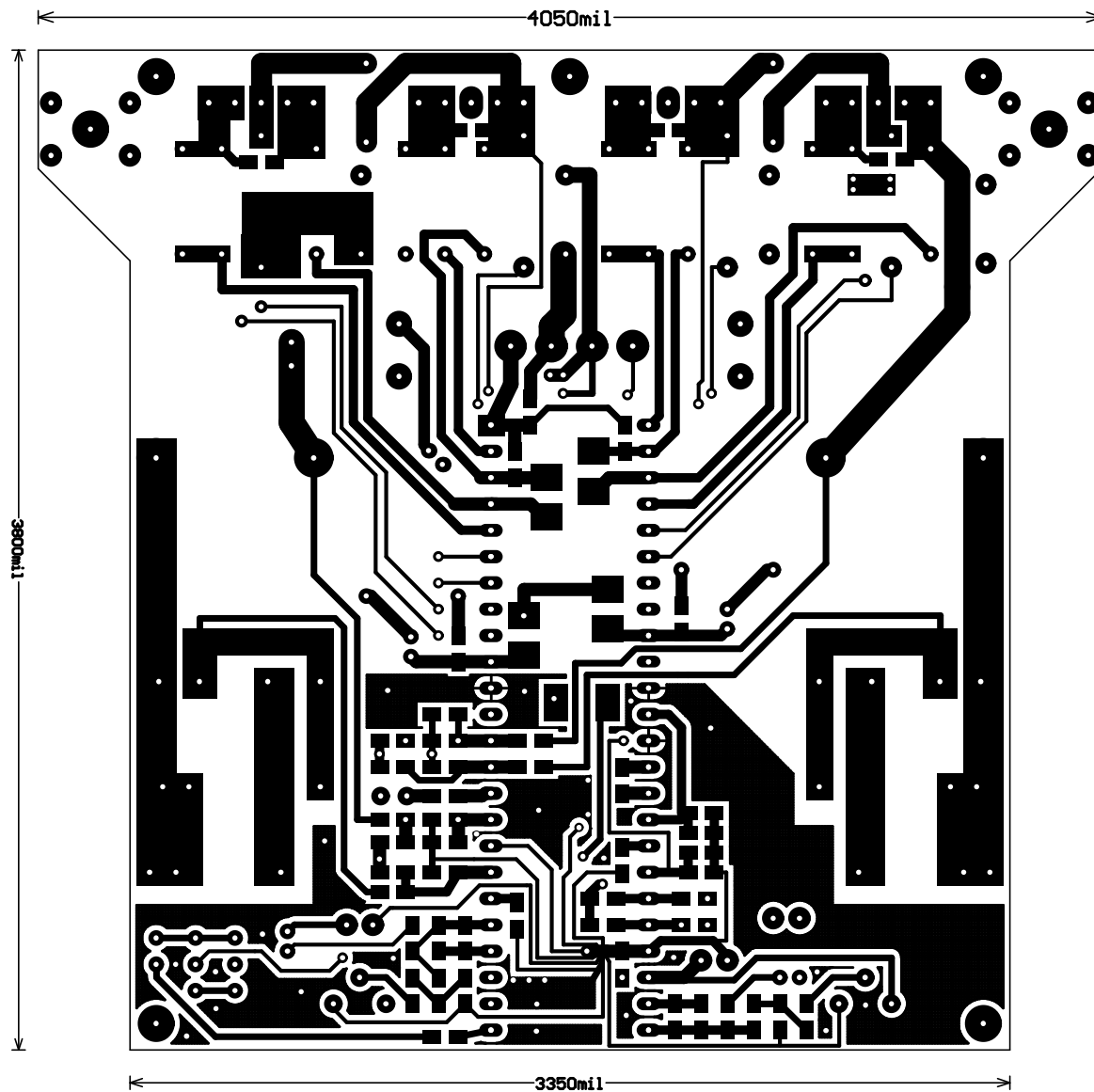
2 OZ COPPER, ALL LAYERS

SOLDERMASK OVER BARE COPPER, USE GREEN

SILKSCREEN TO BE WHITE

FABRICATE PER IPC STANDARDS

Board size is 4.05 x3.80



FABRICATION NOTES

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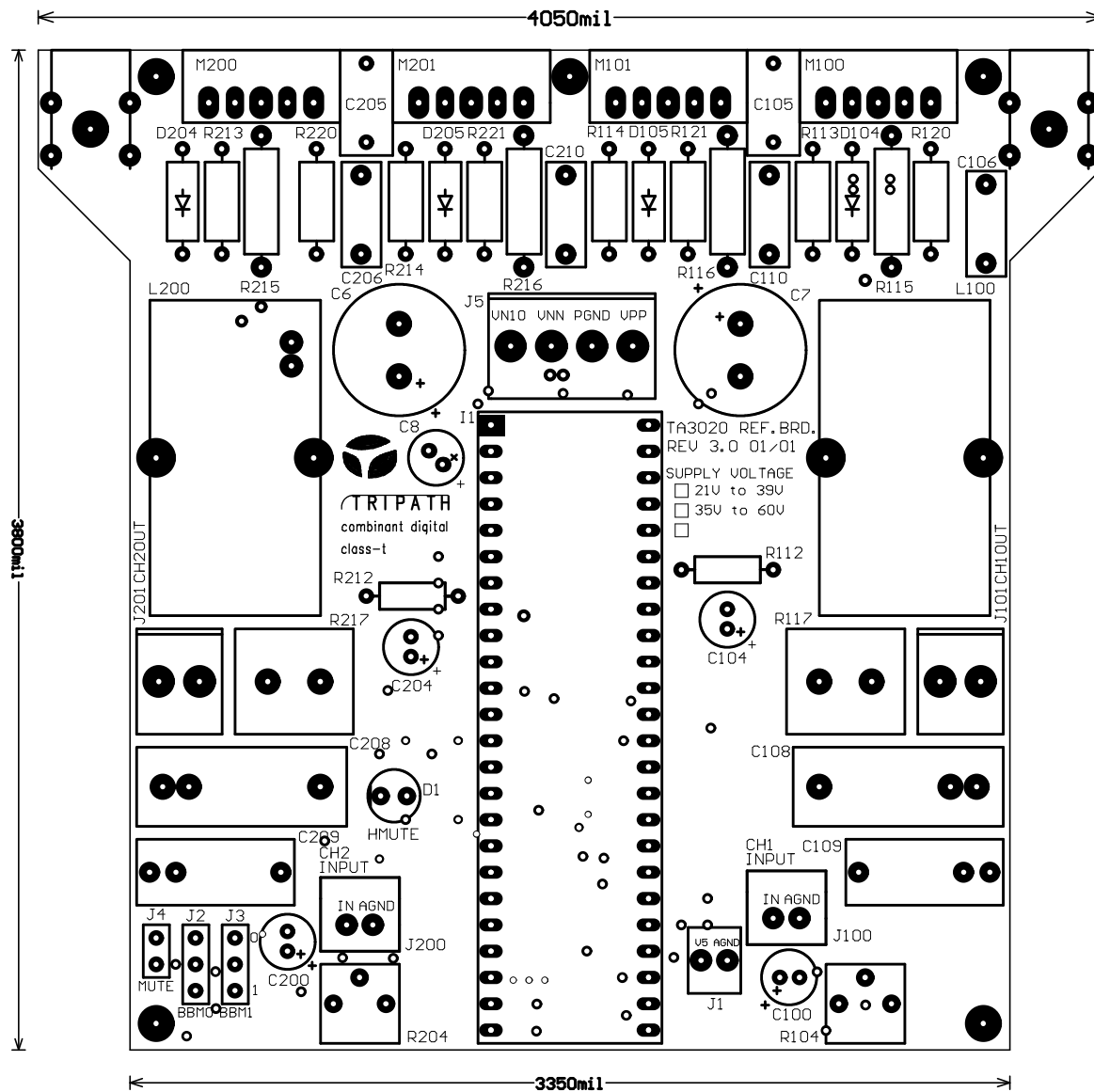
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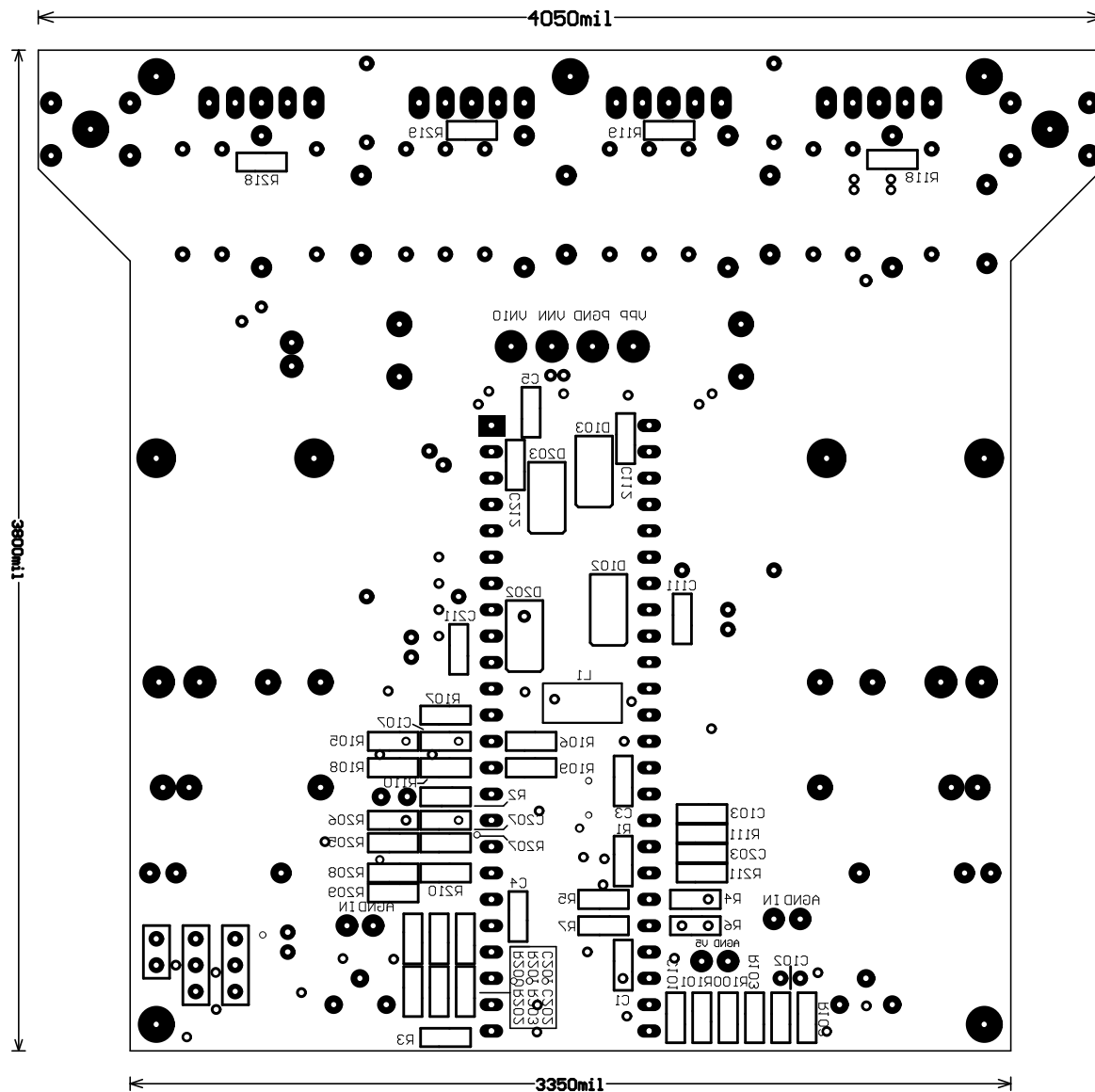
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