



RB-TK2350-1 RB-TK2350-2

CLASS-T DIGITAL AUDIO AMPLIFIER REFERENCE BOARD USING DIGITAL POWER PROCESSING (DPP™) TECHNOLOGY

Technical Information

Revision 1.5 June 2002

GENERAL DESCRIPTION

The RB-TK2350 reference board is based on the TK2350 digital audio power amplifier chipset from Tripath Technology. This board is designed to provide a simple and straightforward environment for the evaluation of the Tripath stereo TK2350 amplifier. This board can also be used in a bridged configuration for high power mono output.

Note: There are two versions of the RB-TK2350, depending on nominal supply voltage.

RB-TK2350-1 – Nominal supply voltage +/-21V to +/-39V

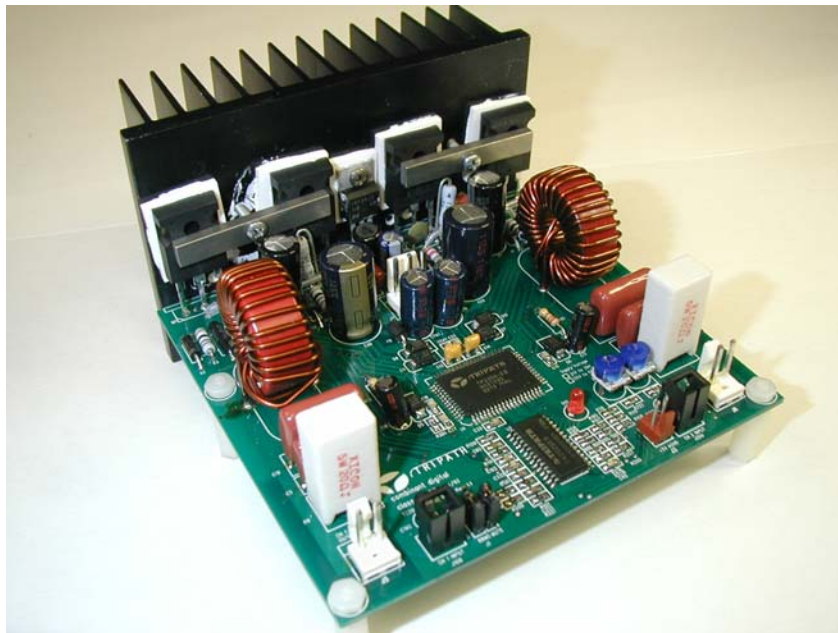
RB-TK2350-2 – Nominal supply voltage +/-35V to +/-60V

FEATURES

- RB-TK2350-1: 2 x 70W continuous output power @ 0.1% THD+N, 4Ω, ±28V
- RB-TK2350-1: 250W continuous output power @ 0.1% THD+N, bridged 4Ω, ±28V
- RB-TK2350-2: 2 x 175W continuous output power @ 0.1% THD+N, 4Ω, ±45V
- RB-TK2350-2: 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-TK2350-1 shown

OPERATING INSTRUCTIONS

Power Supply Description

There are three external power supplies required to operate this board: VPP, VNN, 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 TK2350 amplifier also requires a supply, VN10, that is 10V more positive than VNN and tracks VNN. This VN10 power supply is generated from the TP2350 through a P channel MOSFET (IRF9510). All output and power supply connections are supplied using tinned wire (not shown).

Though not required, the following powering-up sequence is usually adhered to during bench evaluations: 1st) V5 2nd) VNN and 3rd) VPP. 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-TK2350.

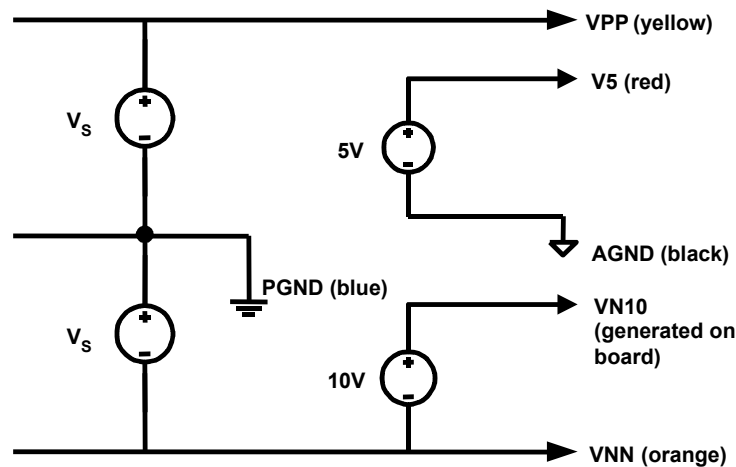


Figure 1

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-TK2350.

Connector	Power Supply
J4 (Yellow)	VPP
J4 (Blue)	PGND
J4 (Orange)	VNN
J3 (Red)	V5
J3 (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 J5. Channel 2 output and associated Power Ground 2 is located at J6. A two-wire harness for each output is provided. See Table 2 for the output connector wire colors. The TK2350 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
J5	White	Blue
J6	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 TK2350 chipset 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, D12, which will illuminate if a fault condition is reported. HMUTE, pin 8 on the TC2001, will illuminate D12 via R30, 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 J2), the LED will also be illuminated.

An over/under voltage fault will automatically reset (and D12 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 J2 and then replacing it). Assuming all supplies are still within specification, the HMUTE LED will be off and the TK2350 reference board will again amplify input signals.

RB-TK2350 Board

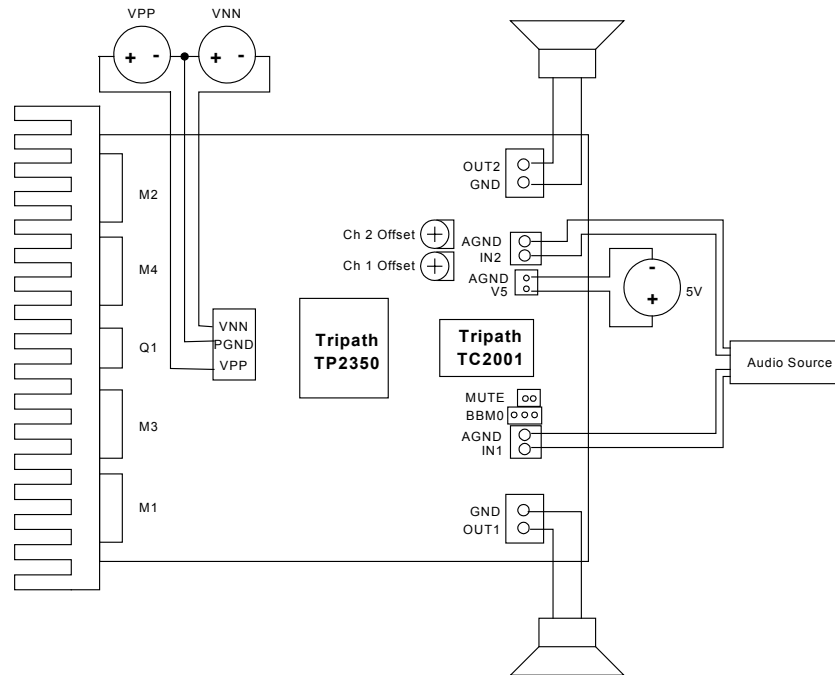


Figure 3

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.

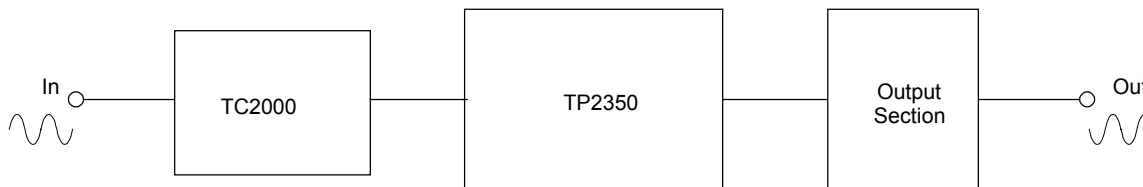


Figure 4

Note: The TK2350 is an inverting amplifier.

TK2350 Amplifier Gain

The TK2350 amplifier gain is the product of the input stage gain and the modulator gain.

$$A_{VTA2350} = A_{VINPSTAGE} * A_{VMODULATOR}$$

$$A_{VTA2350} \approx -\frac{R_F}{R_I} \times \left(\frac{R_{FBC} * (R_{FBA} + R_{FBB})}{R_{FBA} * R_{FBB}} + 1 \right)$$

For the RB-TA2350-2 board;

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

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

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

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

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

$$A_{VTA2350} \approx -\frac{20k\Omega}{49.9k\Omega} \times \left(\frac{13.3k\Omega * (1k\Omega + 1.07k\Omega)}{1k\Omega * 1.07k\Omega} + 1 \right) = 10.71V/V$$

Input Stage

Figure 5 shows one channel of the Input Stage. The TK2350 amplifier is designed to accept unbalanced inputs. For the RB-TK2350-1, the gain is 6.4, or approximately 16 dB. For the RB-TK2350-2, the gain is 10.8, or approximately 20.7 dB. Please note that the input stage of the TC2001 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.

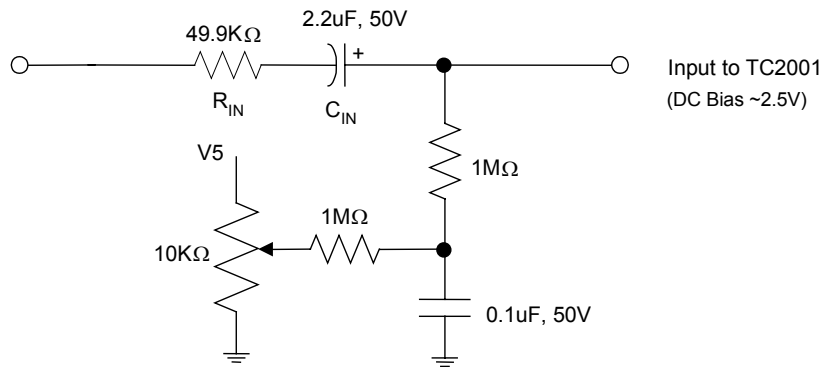


Figure 5

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 -3 dB point of the input high-pass filter. The frequency of the input high pass pole, F_P , -3 dB 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 10KΩ 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 ± 25 mV. R104 is used to adjust the offset of CH1, and R204 is used to adjust the offset of CH2. If a different TC2001 or TP2350 is placed in the RB-TK2350 reference board, the offset of each channel will need to be re-trimmed.

RB-TK2350 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.

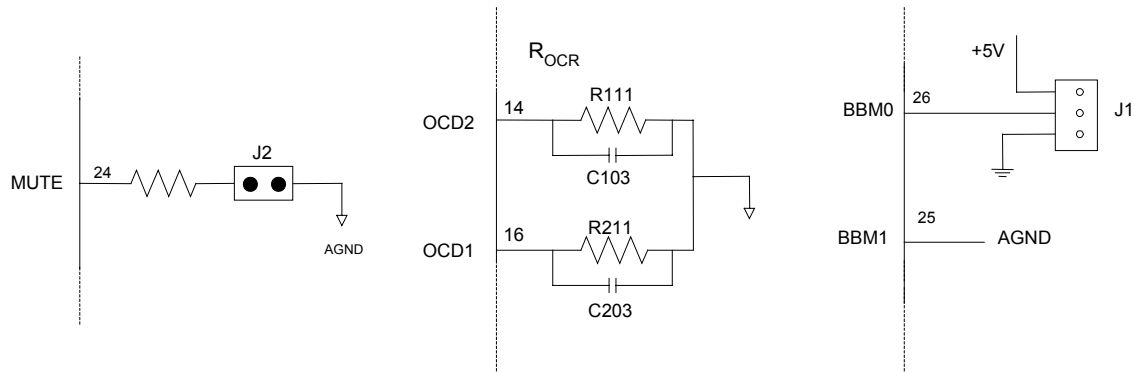


Figure 6

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 single-ended 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-TK2350 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 TK2350 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).

	BBM 1	BBM 0	Delay
1)	0	0	120nS
2)	0	1	80nS

Note: The default delay jumper setting is 80nS.

Figure 7

Output Section

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

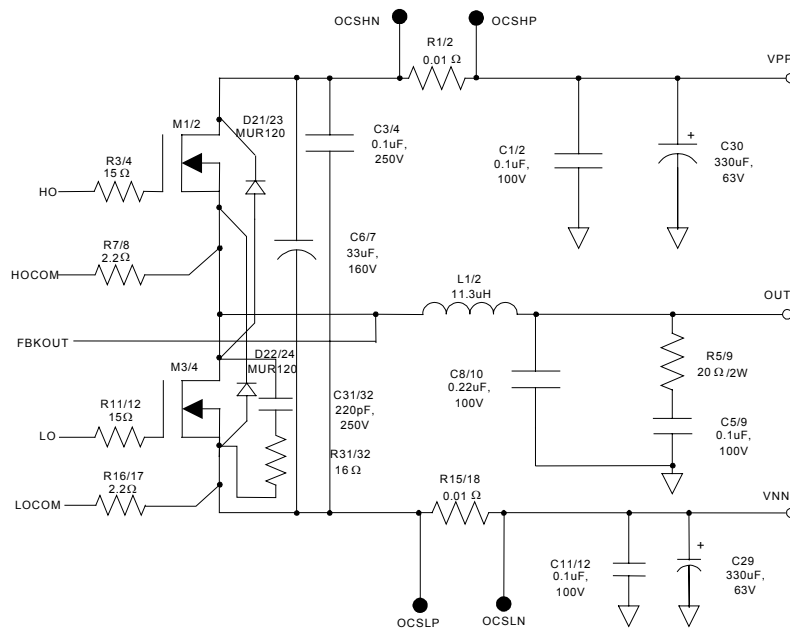


Figure 8

The gate resistors (labeled R3, R4, R11, and R12 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 15Ω when the Q_g is greater than 70nC and R_G of 22Ω when the gate charge (Q_g) of the output FET is less than 70nC.

The output MOSFETs (M1, M2, M3, and M4) provide the switching function required of a Class-T design. They are driven directly by the TP2350 through the gate resistors. The devices used on the reference board are ST STW34NB20 MOSFETs. The TK2350 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 bypass capacitors C105/C205 and C113/C213 are critical to the reduction of ringing on the output MOSFETs. These parts are placed as closely as possible to the leads of the MOSFETs, and the leads of the capacitors themselves are as short as practical. Their values will not change with different output MOSFETs.

The output diodes D106/D107/D206/D207 are also critical to the reduction of ringing on the outputs of the FETs. They shunt the inductive energy if the output exceeds V_{PP} or goes below V_{NN} . The proper connection of these diodes are “drain to drain” and “source to source” as shown in the schematic diagrams.

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-TK2350 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, J100 pin 1) and the “+” terminal to the output of the non-inverted channel with respect to the input signal (Channel 2 output, J200 pin 1).

The connection shown in Figure 9 is the easiest way to use the RB-TK2350 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-TK2350 to be modified.

Change R200 to 20KΩ from 49.9KΩ. Connect Pin 22 (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 22 and IN2 on J200 should be removed.

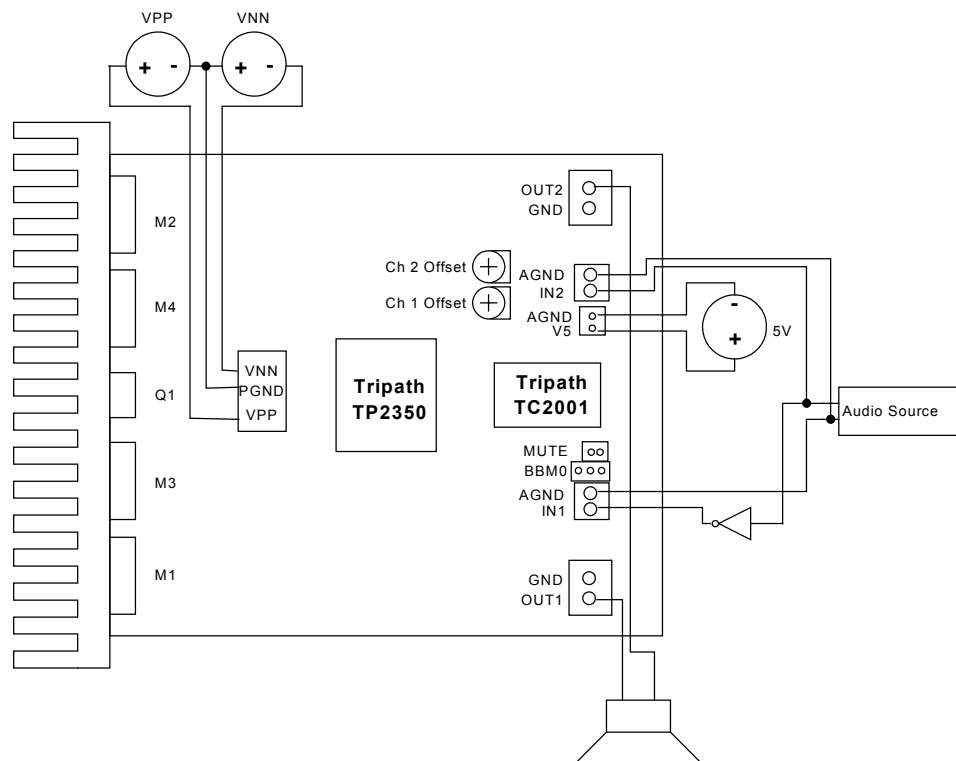


Figure 9

Circuit Board Layout

The TK2350 is a power (high current) amplifier that operates at relatively high switching frequencies. The output of the amplifier switches between V_{PP} and V_{NN} at high speeds while driving large currents. This high-frequency digital signal is passed through an LC low-pass filter to recover the amplified audio signal. Since the amplifier must drive the inductive LC output filter and speaker loads, the amplifier outputs can be pulled above the supply voltage and below ground by the energy in the output inductance. To avoid subjecting the TK2350 to potentially damaging voltage stress, it is critical to have a good printed circuit board layout. It is recommended that Tripath's layout and application circuit be used for all applications and only be deviated from after careful analysis of the effects of any changes.

The following components are important to place near either their associated TC2001, TP2350, or output MOSFET pins. The recommendations are ranked in order of layout importance, either for proper device operation or performance considerations. The component designators, referred to, are for channel 1 of the RB-TK2350.

- The capacitors, C_{HBR} (C3/C6), provide high frequency bypassing of the amplifier power supplies and will serve to reduce spikes across the supply rails. Please note that both mosfet half-bridges must be decoupled separately. In addition, the voltage rating for C_{HBR} should be at least 150V as this capacitor is exposed to the full supply range, V_{PP} - V_{NN} .
- D_O (D21/D22) are also critical to the reduction of ringing on the outputs of the FETs. They shunt the inductive energy if the output exceeds V_{PP} or goes below V_{NN} . The proper connection of these diodes are "drain to drain" and "source to source" as shown in the schematic diagrams. These diodes have a 200V rating.
- C_{FB} (C107) removes very high frequency components from the amplifier feedback signals and lowers the output switching frequency by delaying the feedback signals. In addition, the value of C_{FB} is different for channel 1 and channel 2 to keep the average switching frequency difference greater than 40kHz. This minimizes in-band audio noise. Locate these capacitors as close to their respective TC2001 pin as possible.
- To minimize noise pickup and minimize THD+N, R_{FBC} (R106/R109) should be located as close to the TC2001 as possible. Make sure that the routing of the high voltage feedback lines is kept far away from the input op amps or significant noise coupling may occur. It is best to shield the high voltage feedback lines by using a ground plane around these traces as well as the input section.
- C_B (C7A1/C19), C_{SW} (C5A1/C20) provides high frequency bypassing for the VN10 and bootstrap supplies. Very high currents are present on these supplies.

In general, to enable placement as close to the TP2350, and minimize PCB parasitics, the capacitors C_{FB} , C_B and C_{SW} should be surface mount types, located on the "solder" side of the board.

Some components are not sensitive to location but are very sensitive to layout and trace routing.

- To maximize the damping factor and reduce distortion and noise, the modulator feedback connections should be routed directly to the pins of the output inductors. L_O (L100).
- The output filter capacitor, C_O (C10), and zobel capacitor, R_Z (R9), should be star connected with the load return. The output ground feedback signal should be taken from this star point.
- The modulator feedback resistors, R_{FBA} (R105/R108) and R_{FBB} (R107/R110), should all be grounded and attached to 5V together. These connections will serve to minimize common mode noise via the differential feedback.
- The feedback signals that come directly from the output inductors are high voltage and high frequency in nature. If they are routed close to the input nodes, INV1 and INV2, the high impedance inverting opamp pins will pick up noise. This coupling will result in significant

background noise, especially when the input is AC coupled to ground, or an external source such as a CD player or signal generator is connected. Thus, care should be taken such that the feedback lines are not routed near any of the input section.

- To minimize the possibility of any noise pickup, the trace lengths of INV1 and INV2 should be kept as short as possible. This is most easily accomplished by locating the input resistors, R_i (R100), and the input stage feedback resistors, R_F (R101), as close to the TC2001 as possible. In addition, the offset trim resistor, R_{OFF} (R122), which connects to either FDBKP1, or FDBKP2, should be located close to the TC2001 input section.

Performing Measurements on the EB-K2350

The TK2350 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 TK2350 amplifier switching pattern will degrade the measurement.

One feature of the TK2350 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-TK2350 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 (available in Pads PowerPCB format). Gerber files are also available.

ADVANCED INFORMATION

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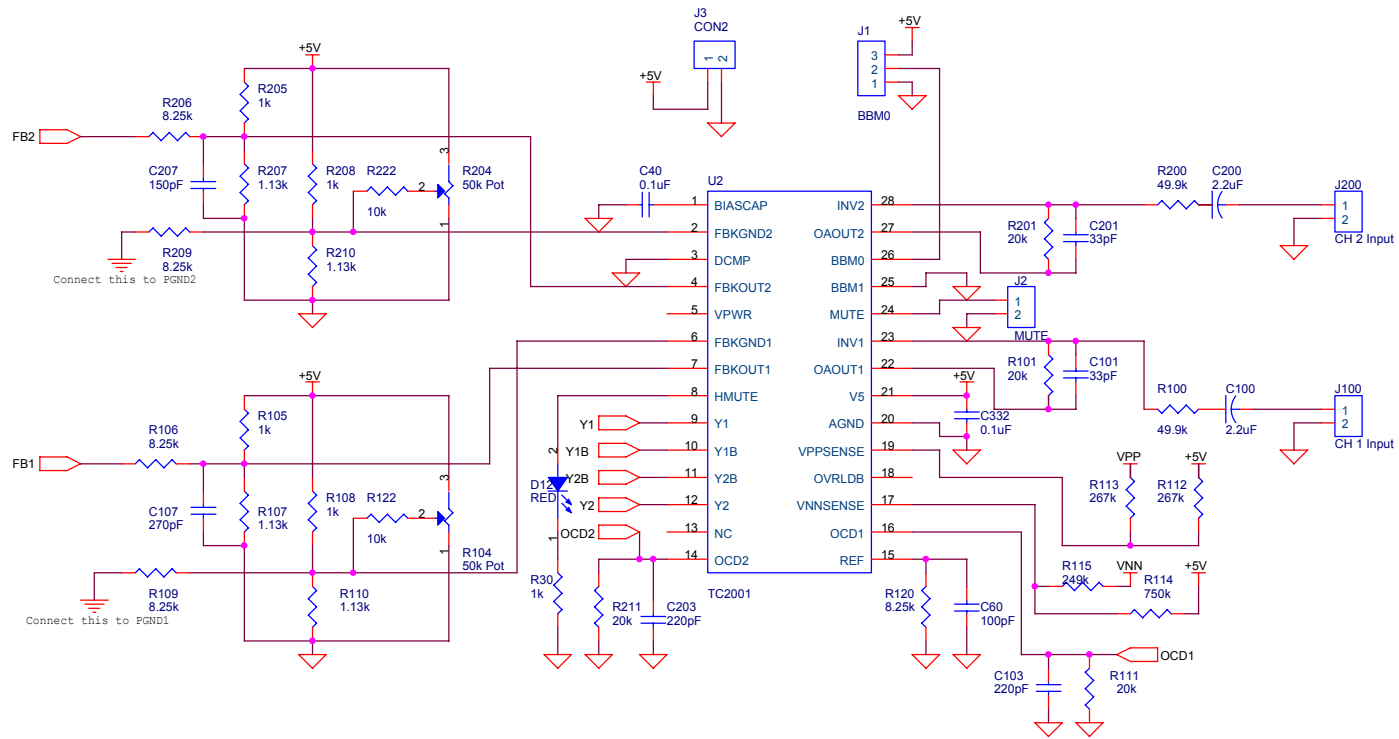
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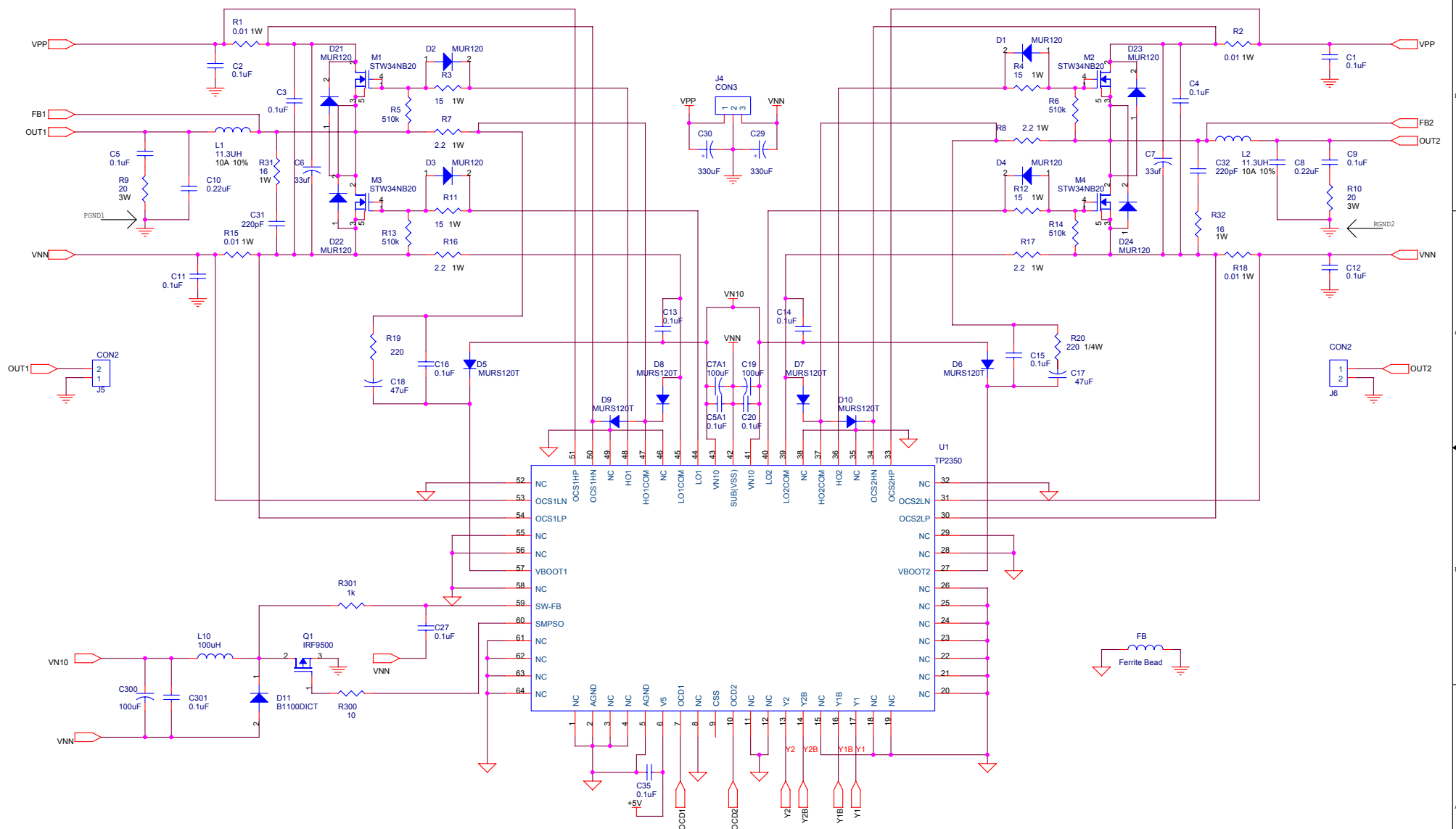


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Title		
RB-TK2350-1 Board +/-21V to +/- 39V		
Size	Document Number	Rev
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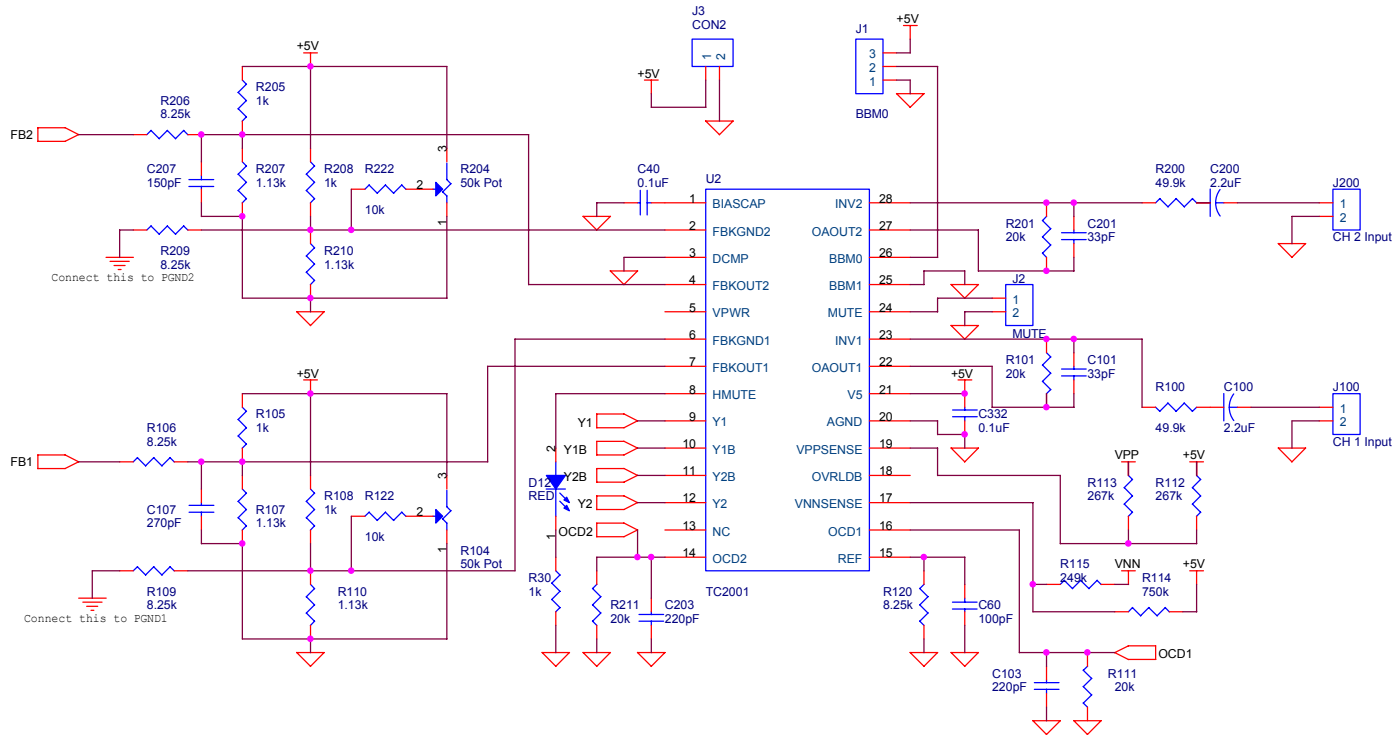


Title		
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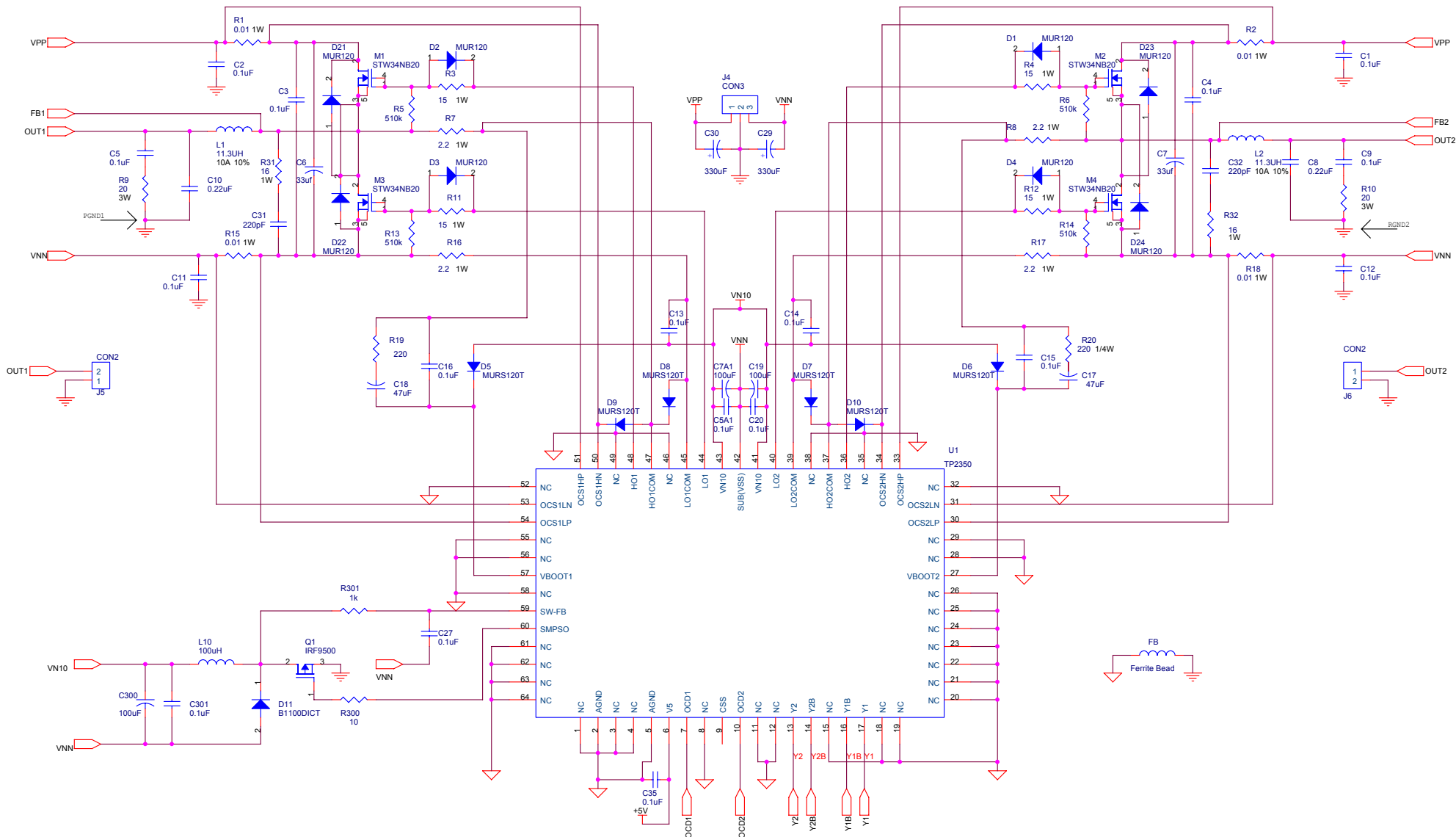
RB-TK2350-1, TK2350 Reference design **Revised: June 12, 2002**
Bill of Materials **Revision: 1.5**

<u>Item</u>	<u>Qty</u>	<u>Reference</u>	<u>Part</u>	<u>Footprint</u>	<u>Rating</u>	<u>Manufacturer</u>	<u>Manufacturer P/N</u>	<u>Distributor P/N</u>
1	4	C1,C2,C11,C12	0.1uF	cap200	100V	PANASONIC	ECQ-E1104KF	DK EF1104-ND
2	2	C4,C3	0.1uF	cap300	250V	PANASONIC	ECQ-E2104KF	DK EF2104-ND
3	1	C5, C9	0.1uF	cap500	100V	PANASONIC	ECH-S1104JZ	DK PS1104J
4	2	C6,C7	33uf	CAPE\200\400	160V	PANASONIC	EEU-EB2C330	DK 5901-ND
5	2	C10,C8	0.22uF	cap400	100V	PANASONIC	ECH-S1224JZ	DK PS1224J-ND
6	2	C13,C14	0.1uF	sip-2p-a	50V	KEMET	C320C104K1R5CA	DK 399-2048-ND
7	5	C15,C16,C27,C40, C301,C332	0.1uF	cap0805	50V	PANASONIC	ECJ-2VF1H104Z	DK PCC1864CT-ND
8	2	C18,C17	47uF	CAPE\100\200	25V	PANASONIC	ECA-1EHG470	DK P5539-ND
9	3	C19,C7A1,C300	100uF	cape\150\330	35V	PANASONIC	EEU-FC1V101	DK P10294-ND
10	3	C20,C35,C5A1	0.1uF	cap0805	100V	PANASONIC	ECJ-2VF1H104Z	DK PCC1864CT-ND
11	2	C29,C30	330uF	cape\200\500	63V	PANASONIC	EEU-FC1J331	DK P10349-ND
12	2	C31,C32	220pF	cap104	200V	PANASONIC	ECK-D2H221KB5	DK P4104A-ND
13	1	C60	100pF	cap0805	50V	PANASONIC	ECJ-2VC1H101J	DK PCC101CGCT-ND
14	2	C200,C100	2.2uF	CAPE\100\200	10V	PANASONIC	ECA-1HHG2R2	DK P5564-ND
15	2	C101,C201	33pF	cap0805	50V	PANASONIC	ECJ-2VC1H330J	DK PCC330CGCT-ND
16	2	C103,C203	220pF	cap0805	50V	PANASONIC	ECJV1C1H221J	DK PCC221CGCT-ND
17	1	C107	270pF	cap0805	50V	PANASONIC	ECU-V1H271KBN	DK PCC271BNCT-ND
18	1	C207	150pF	cap0805	50V	PANASONIC	ECJ-2VC1H151J	DK PCC151CGCT-ND
19	4	D1,D2,D3,D4	MUR120	diode		MOTOROLA	MUR120	
20	6	D5,D6,D7,D8,D9,D10	MURS120T	smb		MOTOROLA	MURS120T	NWK 08F2006
21	1	D11	B1100DICT	SMA		DIODES INCORPORATED	B1100DICT	DK B1100DICT-ND
22	1	D12	RED LED	LED		OPEN	OPEN	OPEN
23	4	D21,D22,D23,D24	MUR120	longdiode		MOTOROLA	MUR120	
24	1	FB	Ferrite Bead	res-1/8w-short		PANASONIC	EXC-ELSA352	DK P9820BK-ND
25	1	J1	BBM0	sip-3p		OPEN	OPEN	OPEN
26	1	J2	MUTE	sip-2p		OPEN	OPEN	OPEN
27	1	J3	CON2	hdr2p100-75c32d		WALDOM	22-23-2021	DK WM4200-ND
28	1	J4	CON3	header3-156		WALDOM	26-48-1031	DK WM4401-ND
29	2	J5,J6	CON2	hdr2p156-125c75c		WALDOM	26-60-4020	DK WM4620-ND
30	1	J100	CH 1 Input	BLKHEADER		WALDOM	705-43-0001	DK WM4800-ND
31	1	J200	CH 2 Input	BLKHEADER		WALDOM	705-43-0001	DK WM4800-ND
32	2	L2,L1	11.3UH	ind10_v	10A	COIL WINDING SPECIALISTS	T106-2 Core	29 turns / 16AWG

33	1 L10	100uH	ind\200\400		JW MILLER	6000-101K	DK TK4300-ND
34	4 M1,M2,M3,M4	STW34NB20	to220-up-a	200V/34A	ST MICROELECTRONICS	STW34NB20	
35	1 Q1	IRF9510	TO220V		INTERNATIONAL RECTIFIER	IRF9510	
36	4 R1,R2,R15,R18	0.01	res\500	1W	OHMITE	12FR010	DK 12FR010-ND
37	4 R3,R4,R11,R12	15	res\400	1W	PANASONIC	ERG-1SJ150	DK P15W-1BK-ND
38	4 R5,R6,R13,R14	510k	res0805	1/8W	OPEN		
39	4 R7,R8,R16,R17	2.2	res\400	1W	PANASONIC	ERX-1SJ2R2	DK P2.2W-1BK-ND
40	2 R9,R10	20	res3w-vert	3W	XICON		MSR 280-PRM5-20
41	2 R19,R20	220	res-1/4w	1/4W	OPEN		
	R30,R105,R108,						
42	6 R205,R208,R301	1k	res0805	1/8W	OPEN		
43	2 R32,R31	16	res-0.1-stand	1W	OPEN		
44	2 R200,R100	49.9k	res0805	1/8W	OPEN		
45	4 R101,R111,R201, R211	20k	res0805	1/8W	OPEN		
46	2 R104,R204	50k Pot	POT3306P		BOURNS	3306P-1-503	DK 3306P-503-ND
	R106,R109,R120,						
47	5 R206,R209	8.25k	res0805	1/8W	OPEN		
48	4 R107,R110,R207, R210	1.13k	res0805	1/8W	OPEN		
49	2 R113,R112	267k	res0805	1/8W	OPEN		
50	1 R114	750k	res0805	1/8W	OPEN		
51	1 R115	249k	res0805	1/8W	OPEN		
52	1 R120	8.25k	res0805	1/8W	OPEN		
53	2 R222,R122	10k	res0805	1/8W	OPEN		
54	1 R300	10	805		OPEN		
56	1 U1	TP2350	QFP64-2		TRIPATH	TP2350	
57	1 U2	TC2001	SO28		TRIPATH	TC2001	
	Transistor Mounting						
58	2 Bars				OPEN		
59	2 Wire Jumper	16 AWG			OPEN		
60	1 Heatsink for MOSFETs				OPEN		



Title		RB-TK2350-1 Board +/-21V to +/- 39V
Size	Document Number	Rev 1.5
Date:	Wednesday, June 12, 2002	Sheet 1 of 2



Title		RB-TK2350-1 Board +/-21V to +/-39V	
Size	Document Number	Rev 1.5	
Date:	Wednesday, June 12, 2002	Sheet	2 of 2

RB-TK2350-2, TK2350 Reference design

Revised: June 11, 2002

Bill of Materials

Revision: 1.5

<u>Item</u>	<u>Qty</u>	<u>Reference</u>	<u>Part</u>	<u>Footprint</u>	<u>Rating</u>	<u>Manufacturer</u>	<u>Manufacturer P/N</u>	<u>Distributor P/N</u>
1	4	C1,C2,C11,C12	0.1uF	cap200	100V	PANASONIC	ECQ-E1104KF	DK EF1104-ND
2	2	C4,C3	0.1uF	cap300	250V	PANASONIC	ECQ-E2104KF	DK EF2104-ND
3	1	C5, C9	0.1uF	cap500	100V	PANASONIC	ECH-S1104JZ	DK PS1104J
4	2	C6,C7	33uf	CAPE\200\400	160V	PANASONIC	EEU-EB2C330	DK 5901-ND
5	2	C10,C8	0.22uF	cap400	100V	PANASONIC	ECH-S1224JZ	DK PS1224J-ND
6	2	C13,C14	0.1uF	sip-2p-a	50V	KEMET	C320C104K1R5CA	DK 399-2048-ND
7	5	C15,C16,C27,C40, C301,C332	0.1uF	cap0805	50V	PANASONIC	ECJ-2VF1H104Z	DK PCC1864CT-ND
8	2	C18,C17	47uF	CAPE\100\200	25V	PANASONIC	ECA-1EHG470	DK P5539-ND
9	3	C19,C7A1,C300	100uF	cape\150\330	35V	PANASONIC	EEU-FC1V101	DK P10294-ND
10	3	C20,C35,C5A1	0.1uF	cap0805	100V	PANASONIC	ECJ-2VF1H104Z	DK PCC1864CT-ND
11	2	C29,C30	330uF	cape\200\500	63V	PANASONIC	EEU-FC1J331	DK P10349-ND
12	2	C31,C32	220pF	cap104	200V	PANASONIC	ECK-D2H221KB5	DK P4104A-ND
13	1	C60	100pF	cap0805	50V	PANASONIC	ECJ-2VC1H101J	DK PCC101CGCT-ND
14	2	C200,C100	2.2uF	CAPE\100\200	10V	PANASONIC	ECA-1HHG2R2	DK P5564-ND
15	2	C101,C201	33pF	cap0805	50V	PANASONIC	ECJ-2VC1H330J	DK PCC330CGCT-ND
16	2	C103,C203	220pF	cap0805	50V	PANASONIC	ECJV1C1H221J	DK PCC221CGCT-ND
17	1	C107	270pF	cap0805	50V	PANASONIC	ECU-V1H271KBN	DK PCC271BNCT-ND
18	1	C207	150pF	cap0805	50V	PANASONIC	ECJ-2VC1H151J	DK PCC151CGCT-ND
19	4	D1,D2,D3,D4	MUR120	diode		MOTOROLA	MUR120	
20	6	D5,D6,D7,D8,D9,D10	MURS120T	smb		MOTOROLA	MURS120T	NWK 08F2006
21	1	D11	B1100DICT	SMA		DIODES INCORPORATED	B1100DICT	DK B1100DICT-ND
22	1	D12	RED LED	LED		OPEN	OPEN	OPEN
23	4	D21,D22,D23,D24	MUR120	longdiode		MOTOROLA	MUR120	
24	1	FB	Ferrite Bead	res-1/8w-short		PANASONIC	EXC-ELSA352	DK P9820BK-ND
25	1	J1	BBM0	sip-3p		OPEN	OPEN	OPEN
26	1	J2	MUTE	sip-2p		OPEN	OPEN	OPEN
27	1	J3	CON2	hdr2p100-75c32d		WALDOM	22-23-2021	DK WM4200-ND
28	1	J4	CON3	header3-156		WALDOM	26-48-1031	DK WM4401-ND
29	2	J5,J6	CON2	hdr2p156-125c75c		WALDOM	26-60-4020	DK WM4620-ND
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35	1 Q1	IRF9510	TO220V		INTERNATIONAL RECTIFIER	IRF9510	
36	4 R1,R2,R15,R18	0.01	res\500	1W	OHMITE	12FR010	DK 12FR010-ND
37	4 R3,R4,R11,R12	15	res\400	1W	PANASONIC	ERG-1SJ150	DK P15W-1BK-ND
38	4 R5,R6,R13,R14	510k	res0805	1/8W	OPEN		
39	4 R7,R8,R16,R17	2.2	res\400	1W	PANASONIC	ERX-1SJ2R2	DK P2.2W-1BK-ND
40	2 R9,R10	20	res3w-vert	3W	XICON		MSR 280-PRM5-20
41	2 R19,R20	220	res-1/4w	1/4W	OPEN		
42	6 R208,R301	1k	res0805	1/8W	OPEN		
43	2 R32,R31	16	res-0.1-stand	1W	OPEN		
44	2 R200,R100	49.9k	res0805	1/8W	OPEN		
45	4 R101,R111,R201, R211	20k	res0805	1/8W	OPEN		
46	2 R104,R204	50k Pot	POT3306P		BOURNS	3306P-1-503	DK 3306P-503-ND
47	4 R106,R109,R206, R209	13.7k	res0805	1/8W	OPEN		
48	4 R107,R110,R207, R210	1.07k	res0805	1/8W	OPEN		
49	2 R113,R112	453k	res0805	1/8W	OPEN		
50	1 R114	1.2M	res0805	1/8W	OPEN		
51	1 R115	412k	res0805	1/8W	OPEN		
52	1 R120	8.25k	res0805	1/8W	OPEN		
53	2 R222,R122	10k	res0805	1/8W	OPEN		
54	1 R300	10	805		OPEN		
56	1 U1	TP2350	QFP64-2		TRIPATH	TP2350	
57	1 U2	TC2001	SO28		TRIPATH	TC2001	
	Transistor Mounting						
58	2 Bars				OPEN		
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