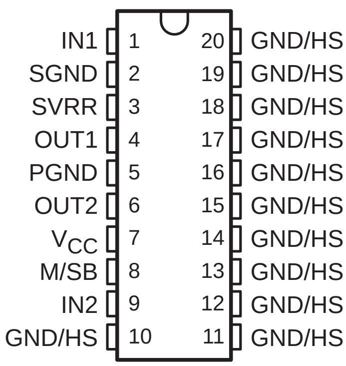
- **TDA1517P Compatible**
- **High Power Outputs (6 W/Channel)**
- **Surface Mount Availability**
  20-Pin Thermal SOIC PowerPAD™
- **Thermal Protection**
- **Fixed Gain . . . 20 dB**
- **Mute and Standby Operation**
- **Supply Range . . . 9.5 V – 18 V**

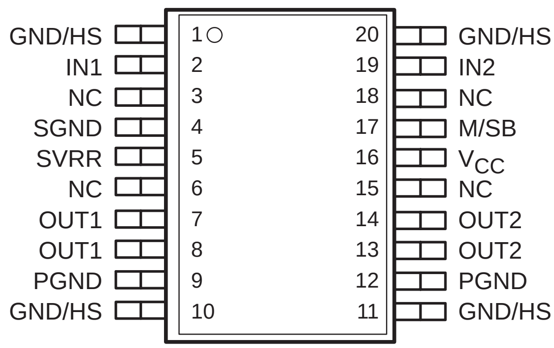
description

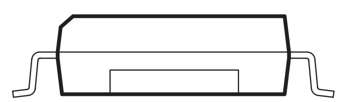
The TPA1517 is a stereo audio power amplifier that contains two identical amplifiers capable of delivering 6 W per channel of continuous average power into a 4-Ω load at 10% THD+N or 5 W per channel at 1% THD+N. The gain of each channel is fixed at 20 dB. The amplifier features a mute/standby function for power-sensitive applications. The amplifier is available in Texas Instruments patented PowerPAD 20-pin surface-mount thermally-enhanced package (DWP) that reduces board space and facilitates automated assembly while maintaining exceptional thermal characteristics.

NE PACKAGE
(TOP VIEW)



DWP PACKAGE
(TOP VIEW)





Cross Section View Showing PowerPAD

NC – No internal connection

AVAILABLE OPTIONS

T_A	PACKAGED DEVICES	
	THERMALLY ENHANCED PLASTIC DIP	THERMALLY ENHANCED SURFACE MOUNT
–20°C to 85°C	TPA1517NE	TPA1517DWP

Terminal Functions

TERMINAL NAME	DWP NO.	NE NO.	I/O	DESCRIPTION
IN1	2	1	I	IN1 is the audio input for channel 1.
SGND	4	2	I	SGNG is the input signal ground reference.
SVRR	5	3		SVRR is the midrail bypass mode enable.
OUT1	7, 8	4	O	OUT1 is the audio output for channel 1.
PGND	9, 12	5		PGND is the power ground reference.
OUT2	13, 14	6	O	OUT2 is the audio output for channel 2.
V_{CC}	16	7	I	V_{CC} is the supply voltage input.
M/SB	17	8	I	M/SB is the mute/standby mode enable. When held at less than 2 V, this signal enables the TPA1517 for standby operation. When held between 3.4 V and 8.8 V, this signal enables the TPA1517 for mute operation. When held above 9.2 V, the TPA1517 operates normally.
IN2	19	9	I	IN2 in the audio input for channel 2.
GND/HS	1, 10, 11, 20	10– 20		GND/HS are the ground and heatsink connections. All GND/HS terminals are connected directly to the mount pad for thermal-enhanced operation.

absolute maximum ratings over operating free-air temperature range (unless otherwise noted)†

Supply voltage, V_{CC} . . . . 22 V
Input voltage, V_I (IN1, IN2) . . . . 22 V
Continuous total power dissipation . . . . Internally limited (See Dissipation Rating Table)
Operating free-air temperature range, T_A . . . . –20°C to 85°C
Storage temperature range, T_{stg} . . . . –65°C to 150°C
Lead temperature 1,6 mm (1/16 inch) from case for 10 seconds: DWP or NE package . . . . 260°C

† Stresses beyond those listed under “absolute maximum ratings” may cause permanent damage to the device. These are stress ratings only, and functional operation of the device at these or any other conditions beyond those indicated under “recommended operating conditions” is not implied. Exposure to absolute-maximum-rated conditions for extended periods may affect device reliability.

NOTE 1: These devices have been classified as Class 1 ESD sensitive products per MIL-PRF-38535 Method 3015.7. Appropriate precautions should be taken to prevent serious damage to the device.

DISSIPATION RATING TABLE

PACKAGE	AIR FLOW (CFM)	$T_A \le 25°C$	DERATING FACTOR	$T_A = 70°C$	$T_A = 85°C$
DWP‡	0	2.94 W	23.5 mW/°C	1.88 W	1.53 W
	300	6.95 W	55.6 mW/°C	4.45 W	3.61 W
NE§	0	2.85 W	22.8 mW/°C	1.82 W	1.48 W
	300	4.85 W	38.8 mW/°C	3.1 W	2.52 W

‡ This parameter is measured with the recommended copper heat sink pattern on a 8-layer PCB, 6.9 in^2 1.5-in × 2-in PCB, 1 oz. copper with layers 1, 2, 4, 5, 7, and 8 at 5% coverage (0.9 in^2) and layers 3 and 6 at 100% coverage (6 in^2).
§ This parameter is measured with the recommended copper heat sink pattern on a 1-layer PCB, 4 in^2 5-in × 5-in PCB, 1 oz. copper, 2-in × 2-in coverage.

recommended operating conditions

	MIN	NOM	MAX	UNIT
Supply voltage, V_{CC}	9.5		18	V
Operating free-air temperature, T_A	–20		85	°C

electrical characteristics, V_{CC} = 14.5 V, T_A = 25°C (unless otherwise noted)

PARAMETER		TEST CONDITIONS	MIN	TYP	MAX	UNIT
I_{CC}	Quiescent current			40	80	mA
$V_{O(DC)}$	DC output voltage	See Note 2		5		V
$V_{(M/SB)}$	M/SB on voltage			9.5		V
$V_{O(M)}$	Mute output voltage	V_I = 1 V (max)		2		mV
$I_{CC(SB)}$	Quiescent current in standby mode			7	100	µA

NOTE 2: At 6 V < V_{CC} < 18 V the DC output voltage is approximately $V_{CC}/2$.

electrical characteristics, V_{CC} = 12 V, T_A = 25°C (unless otherwise noted)

PARAMETER		TEST CONDITIONS	MIN	TYP	MAX	UNIT
I_{CC}	Quiescent current			30	70	mA
$V_{O(DC)}$	DC output voltage	See Note 2		4		V
$V_{(M/SB)}$	M/SB on voltage			9.5		V
$V_{O(M)}$	Mute output voltage	V_I = 1 V (max)		2		mV
$I_{CC(SB)}$	Quiescent current in standby mode			7	100	µA

NOTE 2: At 6 V < V_{CC} < 18 V the DC output voltage is approximately $V_{CC}/2$.

operating characteristic, V_{CC} = 12 V, R_L = 4 Ω, f = 1 kHz, T_A = 25°C

PARAMETER		TEST CONDITIONS		MIN	TYP	MAX	UNIT
P_O	Output power (see Note 3)	THD = 0.2%			3		W
		THD = 10%			6		
SNR	Signal-to-noise ratio				84		dB
THD	Total harmonic distortion	P_O = 1 W	f = 1 kHz		0.1%		
$I_{O(SM)}$	Non-repetitive peak output current				4		A
$I_{O(RM)}$	Repetitive peak output current				2.5		A
	Low-frequency roll-off	–3 dB			45		Hz
	High-frequency roll-off	–1 dB		20			kHz
	Supply voltage rejection	M/SB = On			65		dB
z_I	Input impedance				60		kΩ
V_n	Noise output voltage (see Note 4)	R_S = 0,	M/SB = On		50		μV(rms)
		R_S = 10 kΩ,	M/SB = On		70		μV(rms)
		M/SB = Mute			50		μV(rms)
	Channel separation	R_S = 10 kΩ			60		dB
	Gain			18.5	20	21	
	Channel balance				0.1	1	dB

NOTES: 3. Output power is measured at the output terminals of the IC.
4. Noise voltage is measured in a bandwidth of 20 Hz to 20 kHz.

operating characteristic, V_{CC} = 14.5 V, R_L = 4 Ω, f = 1 kHz, T_A = 25°C

PARAMETER		TEST CONDITIONS		MIN	TYP	MAX	UNIT
P_O	Output power (see Note 3)	THD = 0.2%			4.5		W
		THD < 10%			6		W
SNR	Signal-to-noise ratio				84		dB
THD	Total harmonic distortion	P_O = 1 W			0.1%		
$I_{O(SM)}$	Non-repetitive peak output current				4		A
$I_{O(RM)}$	Repetitive peak output current				2.5		A
	Low-frequency roll-off	–3 dB			45		Hz
	High-frequency roll-off	–1 dB		20			kHz
	Supply voltage rejection	M/SB = On			65		dB
z_I	Input impedance				60		kΩ
V_n	Noise output voltage (see Note 4)	R_S = 0,	M/SB = On		50		μV(rms)
		R_S = 10 kΩ,	M/SB = On		70		μV(rms)
		M/SB = Mute			50		μV(rms)
	Channel separation	R_S = 10 kΩ			60		dB
	Gain			18.5	20	21	dB
	Channel balance				0.1	1	dB

NOTES: 3. Output power is measured at the output terminals of the IC.
4. Noise voltage is measured in a bandwidth of 22 Hz to 22 kHz.

TYPICAL CHARACTERISTICS

Table of Graphs

				FIGURE
I_{CC}	Supply current		vs Supply voltage	1
PSRR	Power supply rejection ratio		vs Frequency	2, 3
THD + N	Total harmonic distortion plus noise	V_{CC} = 12 V	vs Frequency vs Power output	4, 5, 6 10, 11
		V_{CC} = 14.5 V	vs Frequency vs Power output	7, 8, 9 12, 13
	Crosstalk		vs Frequency	14, 15
	Gain margin		vs Frequency	16
	Phase shift		vs Frequency	16
V_n	Noise voltage		vs Frequency	17, 18
P_O	Output power		vs Supply voltage vs Load resistance	19 20
P_D	Power dissipation		vs Output power	21, 22

TYPICAL CHARACTERISTICS

SUPPLY CURRENT vs SUPPLY VOLTAGE

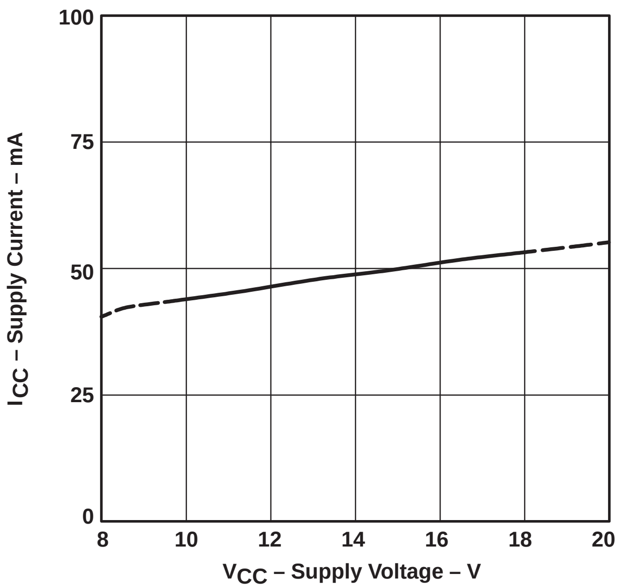


Figure 1

POWER SUPPLY REJECTION RATIO vs FREQUENCY

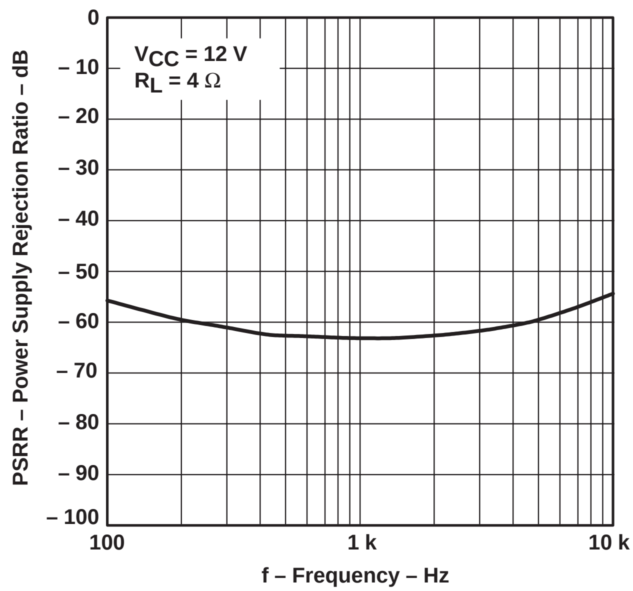


Figure 2

POWER SUPPLY REJECTION RATIO vs FREQUENCY

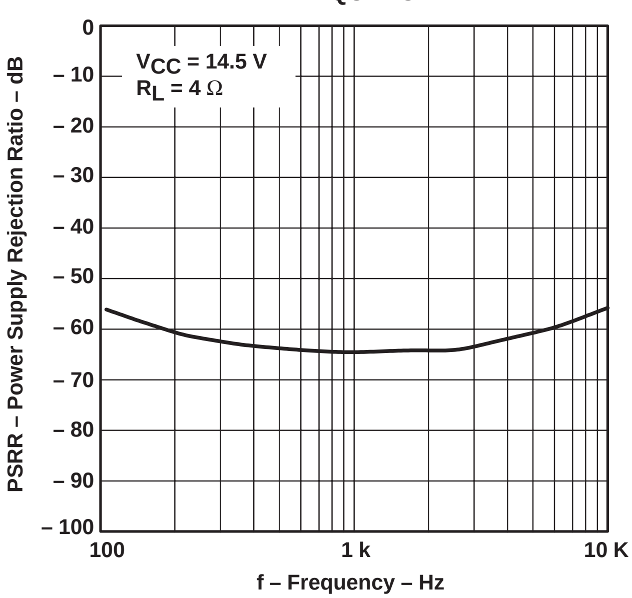


Figure 3

TOTAL HARMONIC DISTORTION PLUS NOISE vs FREQUENCY

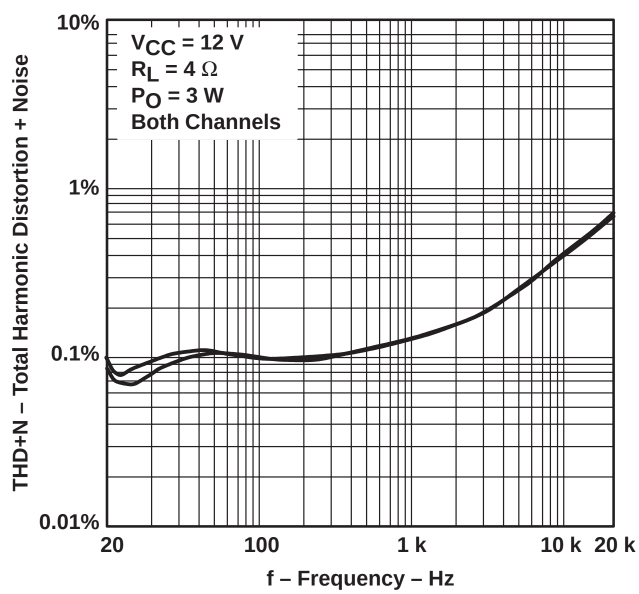


Figure 4

TYPICAL CHARACTERISTICS

TOTAL HARMONIC DISTORTION PLUS NOISE vs FREQUENCY

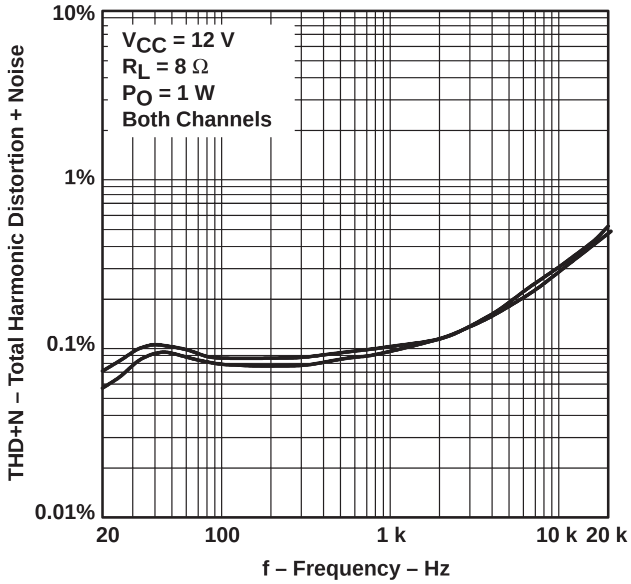


Figure 5

TOTAL HARMONIC DISTORTION PLUS NOISE vs FREQUENCY

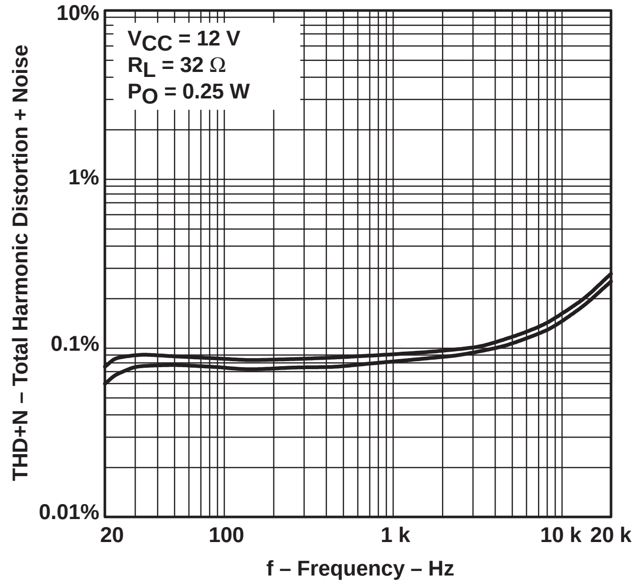


Figure 6

TOTAL HARMONIC DISTORTION PLUS NOISE vs FREQUENCY

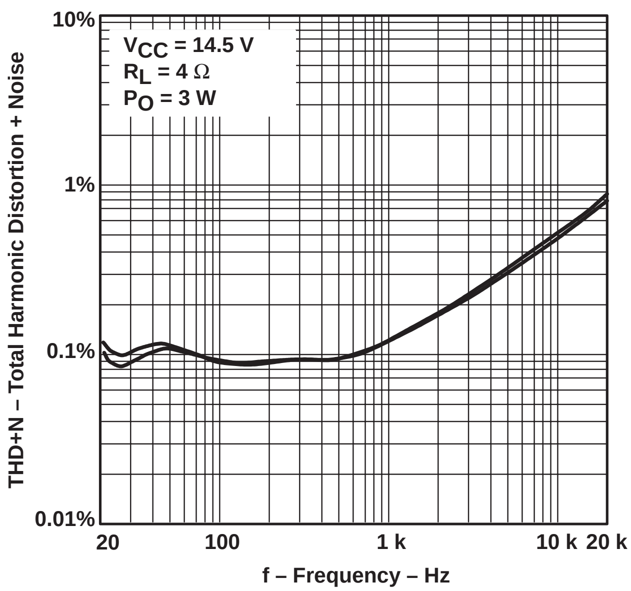


Figure 7

TOTAL HARMONIC DISTORTION PLUS NOISE vs FREQUENCY

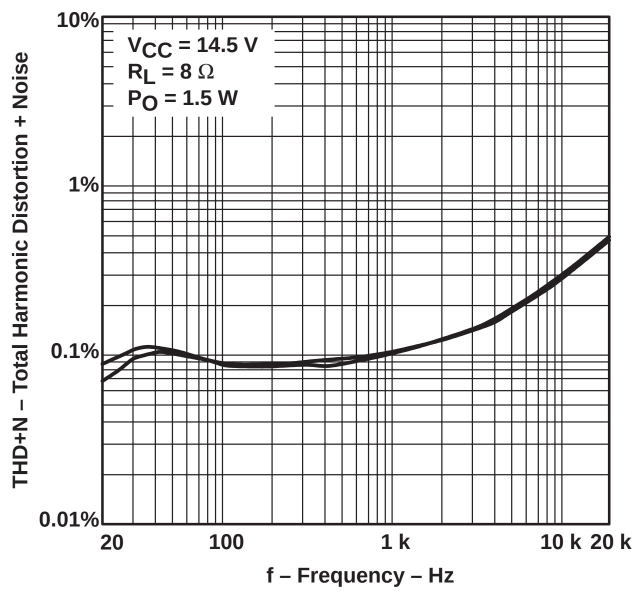


Figure 8

TYPICAL CHARACTERISTICS

TOTAL HARMONIC DISTORTION PLUS NOISE vs FREQUENCY

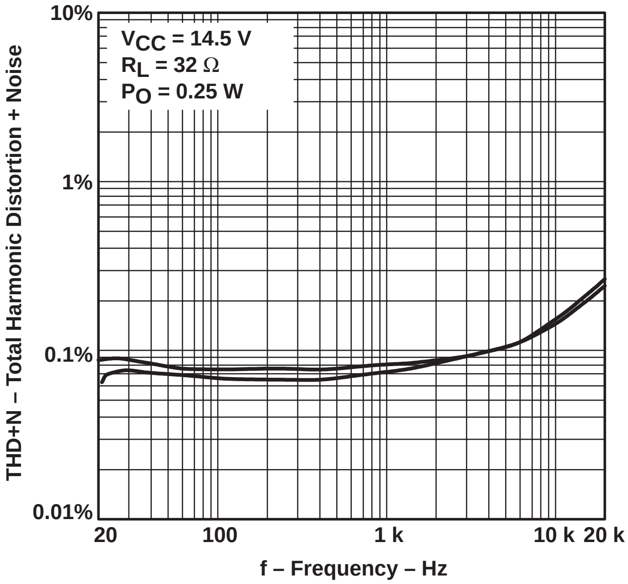


Figure 9

TOTAL HARMONIC DISTORTION PLUS NOISE vs POWER OUTPUT

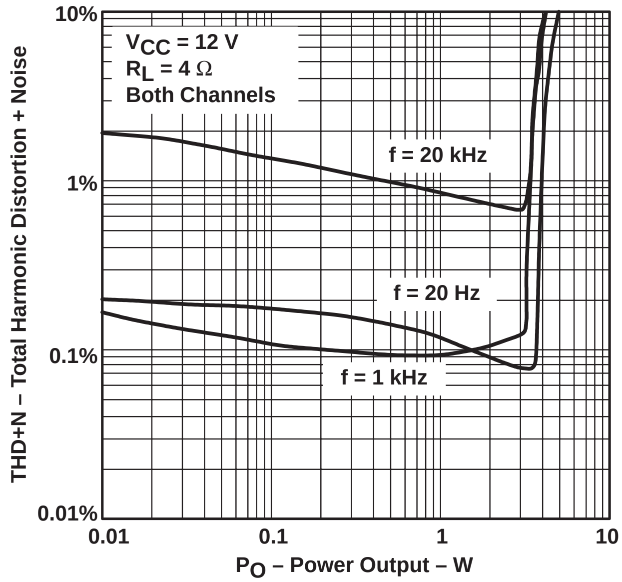


Figure 10

TOTAL HARMONIC DISTORTION PLUS NOISE vs POWER OUTPUT

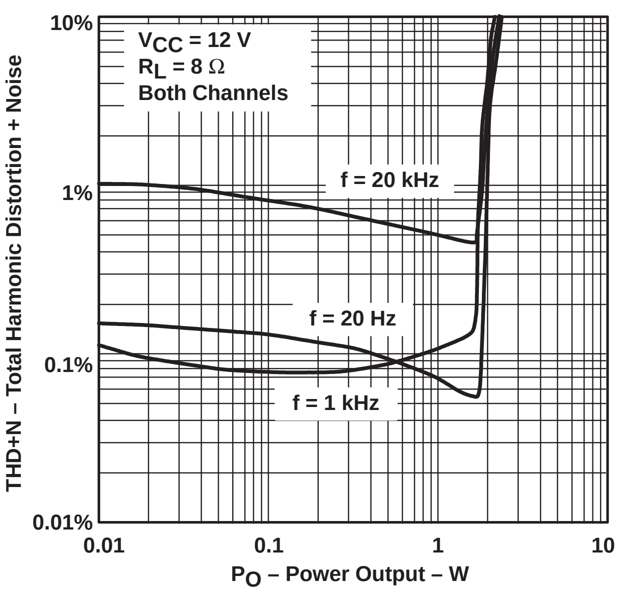


Figure 11

TOTAL HARMONIC DISTORTION PLUS NOISE vs POWER OUTPUT

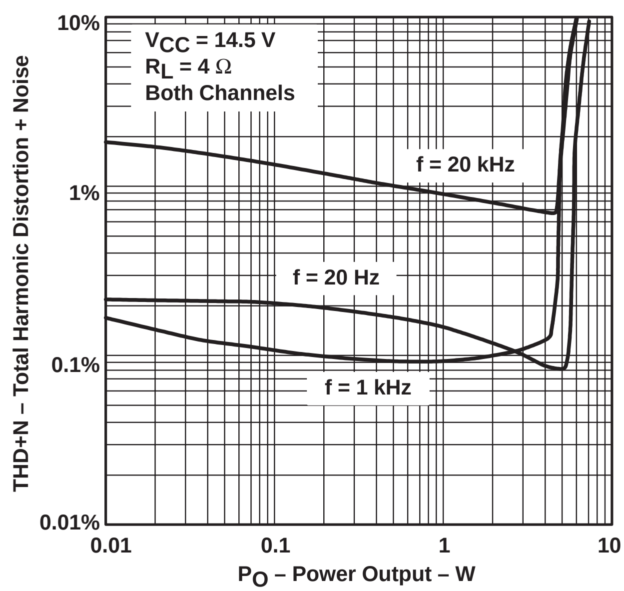


Figure 12

TYPICAL CHARACTERISTICS

TOTAL HARMONIC DISTORTION PLUS NOISE vs POWER OUTPUT

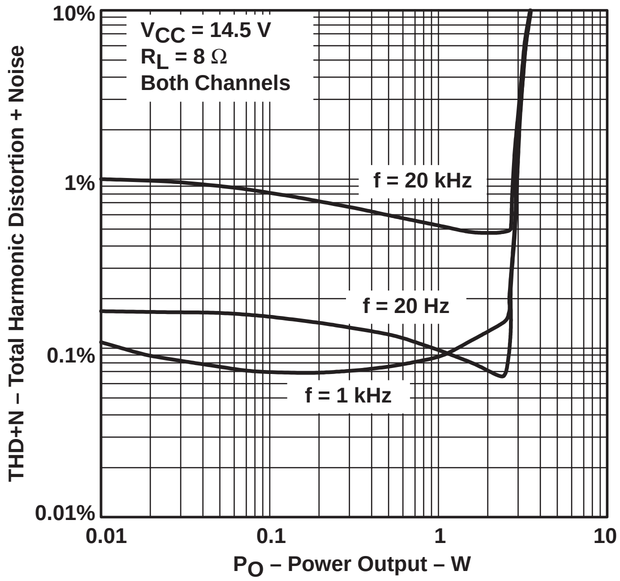


Figure 13

CROSSTALK vs FREQUENCY

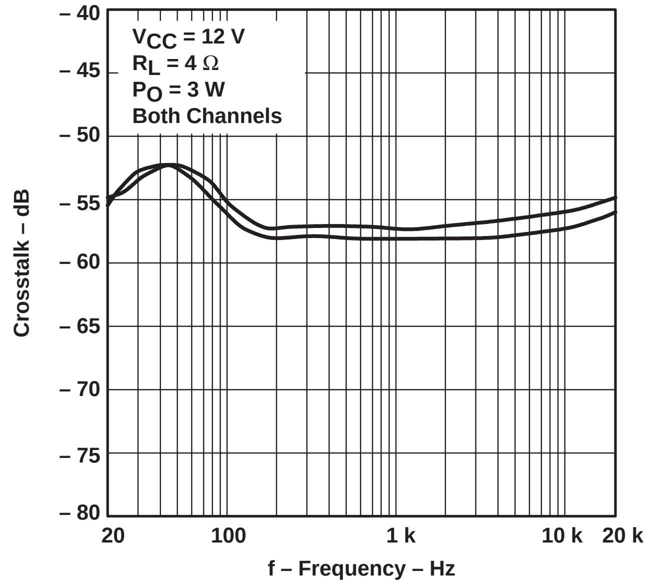


Figure 14

CROSSTALK vs FREQUENCY

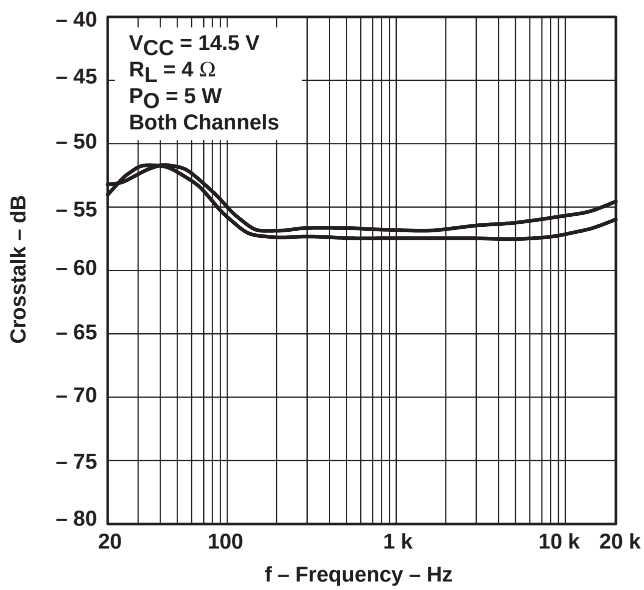


Figure 15

TYPICAL CHARACTERISTICS

GAIN AND PHASE SHIFT
vs
FREQUENCY

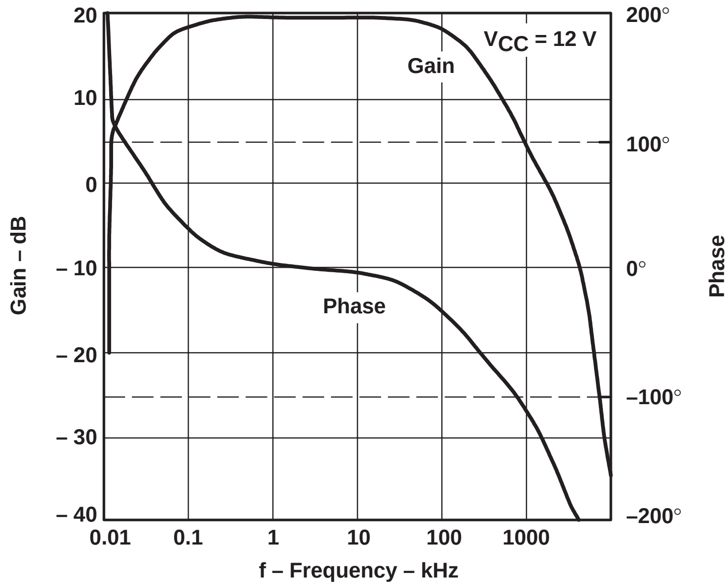


Figure 16

NOISE VOLTAGE
vs
FREQUENCY

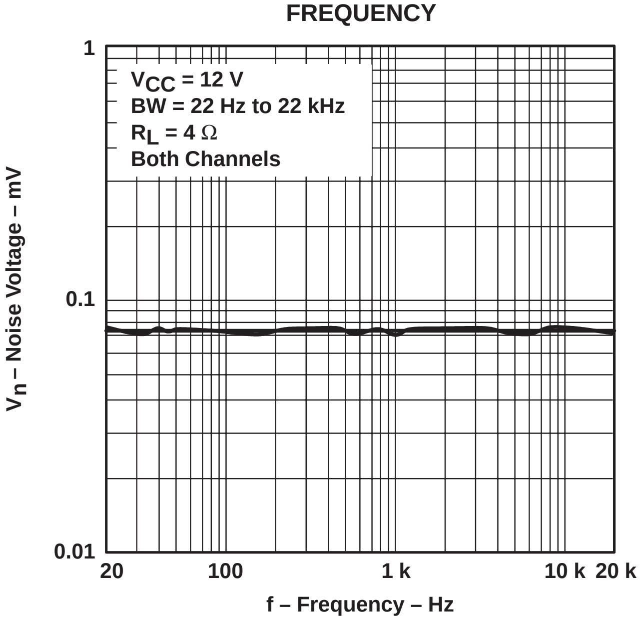


Figure 17

NOISE VOLTAGE
vs
FREQUENCY

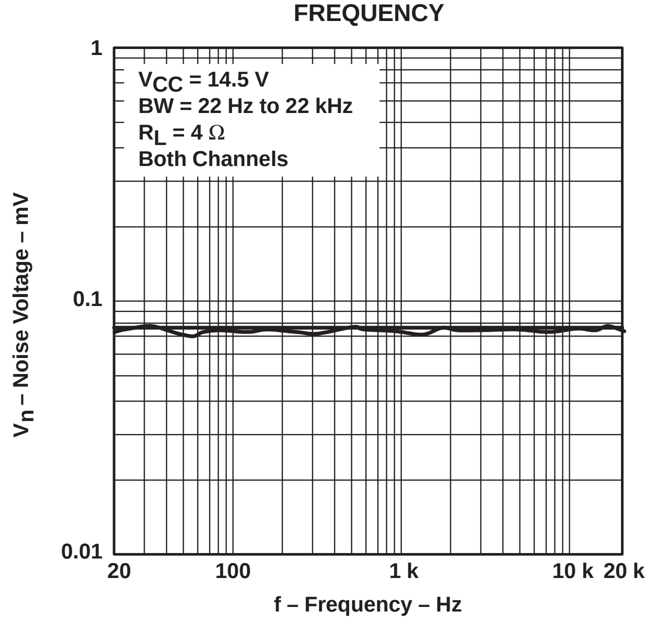


Figure 18

TYPICAL CHARACTERISTICS

OUTPUT POWER vs SUPPLY VOLTAGE

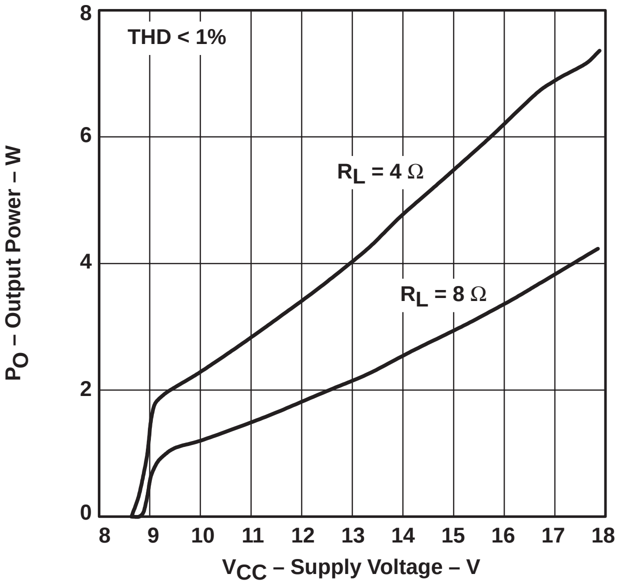


Figure 19

OUTPUT POWER vs LOAD RESISTANCE

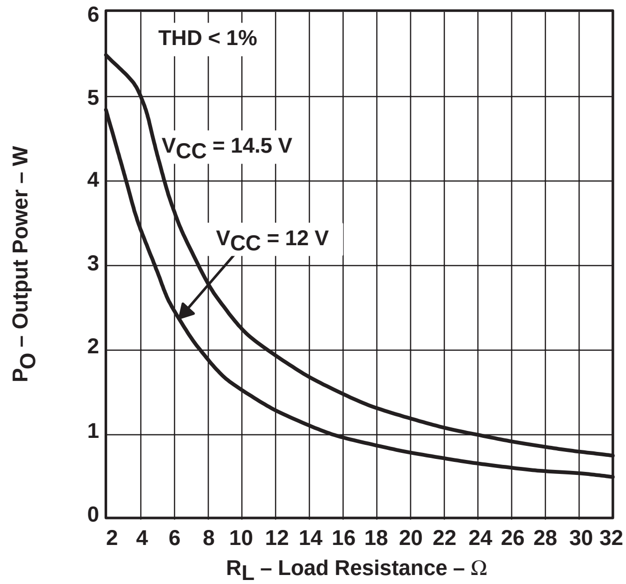


Figure 20

POWER DISSIPATION vs OUTPUT POWER

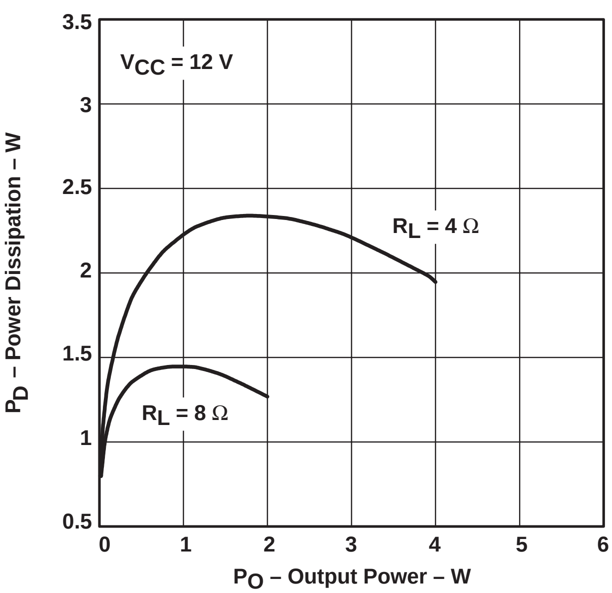


Figure 21

POWER DISSIPATION vs OUTPUT POWER

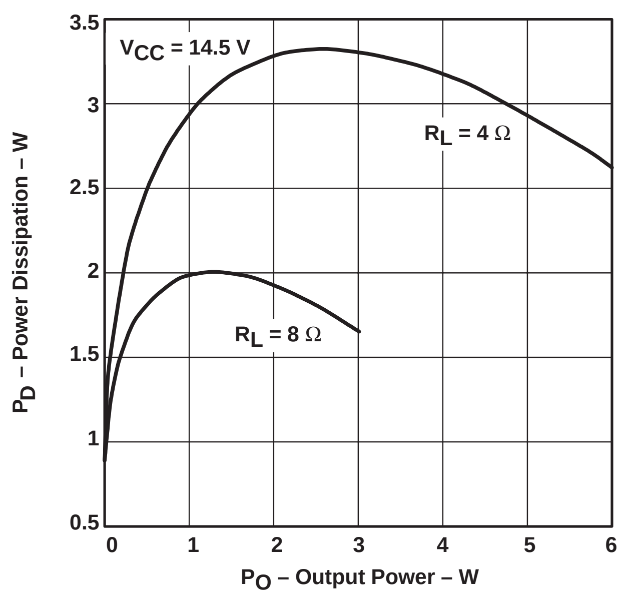
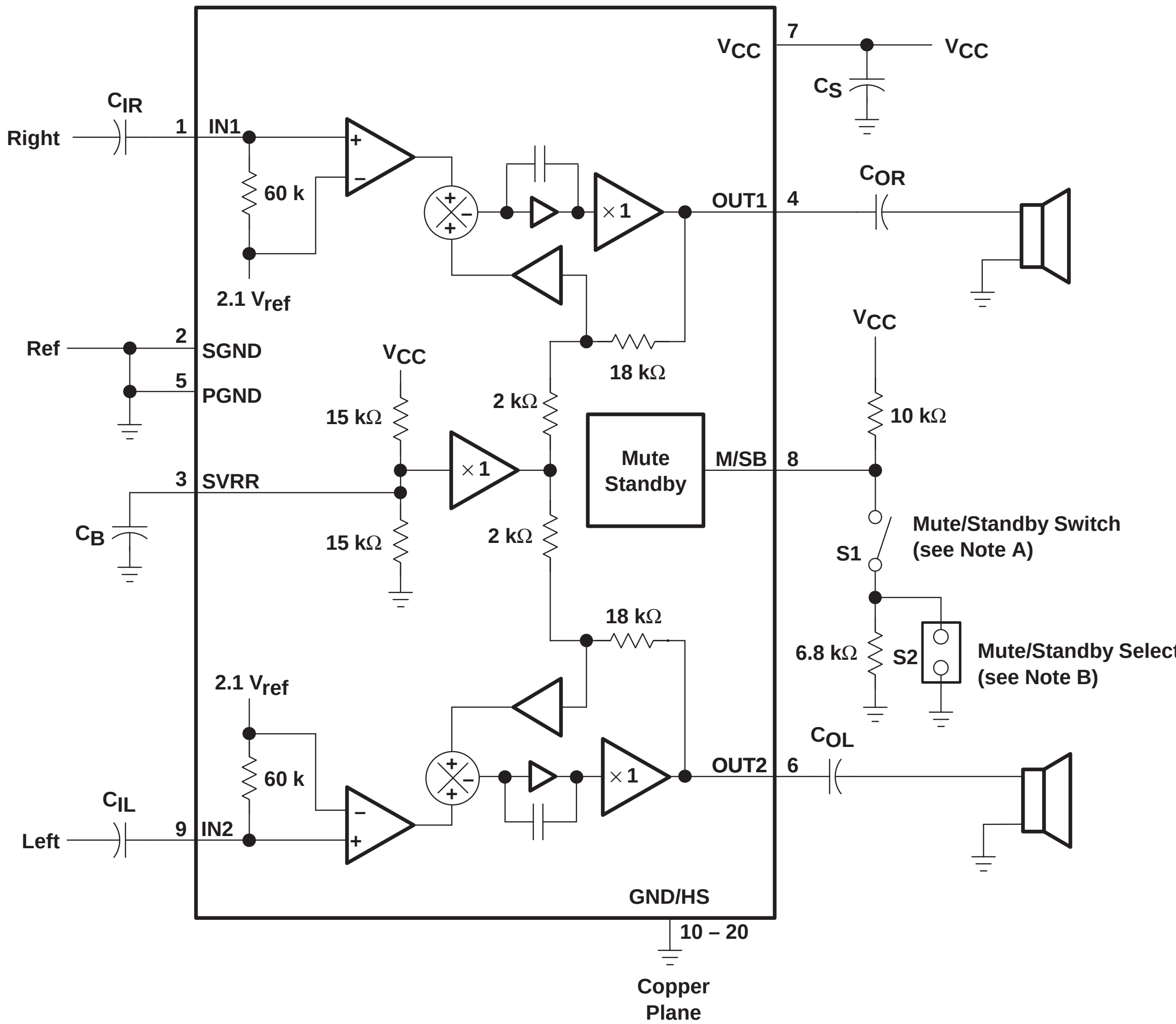


Figure 22

APPLICATION INFORMATION

amplifier operation

The TPA1517 is a stereo audio power amplifier designed to drive 4-Ω speakers at up to 6 W per channel. Figure 23 is a schematic diagram of the minimum recommended configuration of the amplifier. Gain is internally fixed at 20 db (gain of 10).



NOTES: A. When S1 is open, the TPA1517 operates normally. When this switch is closed, the device is in mute/standby mode.
B. When S2 is open, activating S1 places the TPA1517 in mute mode. When S2 is closed, activating S1 places the TPA1517 in standby mode.
C. The terminal numbers are for the 20-pin NE package.

Figure 23. TPA1517 Minimum Configuration

The following equation is used to relate gain in V/V to dB:

$$G_{dB} = 20\ LOG\left(G_{V/V}\right)$$

APPLICATION INFORMATION

The audio outputs are biased to a midrail voltage which is shown by the following equation:

$$V_{MID} = \frac{V_{CC}}{2}$$

The audio inputs are always biased to 2.1 V when in mute or normal mode. Any dc offset between the input signal source and the input terminal is amplified and can seriously degrade the performance of the amplifier. For this reason, it is recommended that the inputs always be connected through a series capacitor (ac coupled). The power outputs, also having a dc bias, must be connected to the speakers via series capacitors.

mute/standby operation

The TPA1517 has three modes of operation; normal, mute, and standby. They are controlled by the voltage on the M/SB terminal as described in Figure 24. In normal mode, the TPA1517 amplifies the signal applied to the two input terminals providing low impedance drive to speakers connected to the output terminals. In mute mode, the amplifier retains all bias voltages and quiescent supply current levels but does not pass the input signal to the output. In standby mode, the internal bias generators and power-drive stages are turned off, thereby reducing the quiescent current levels.

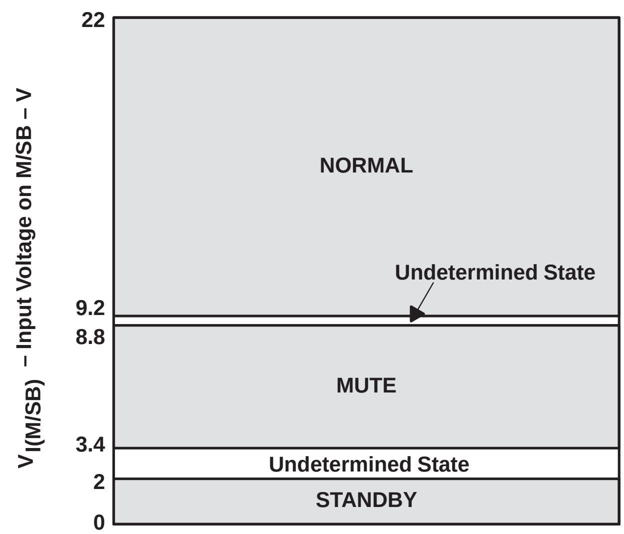
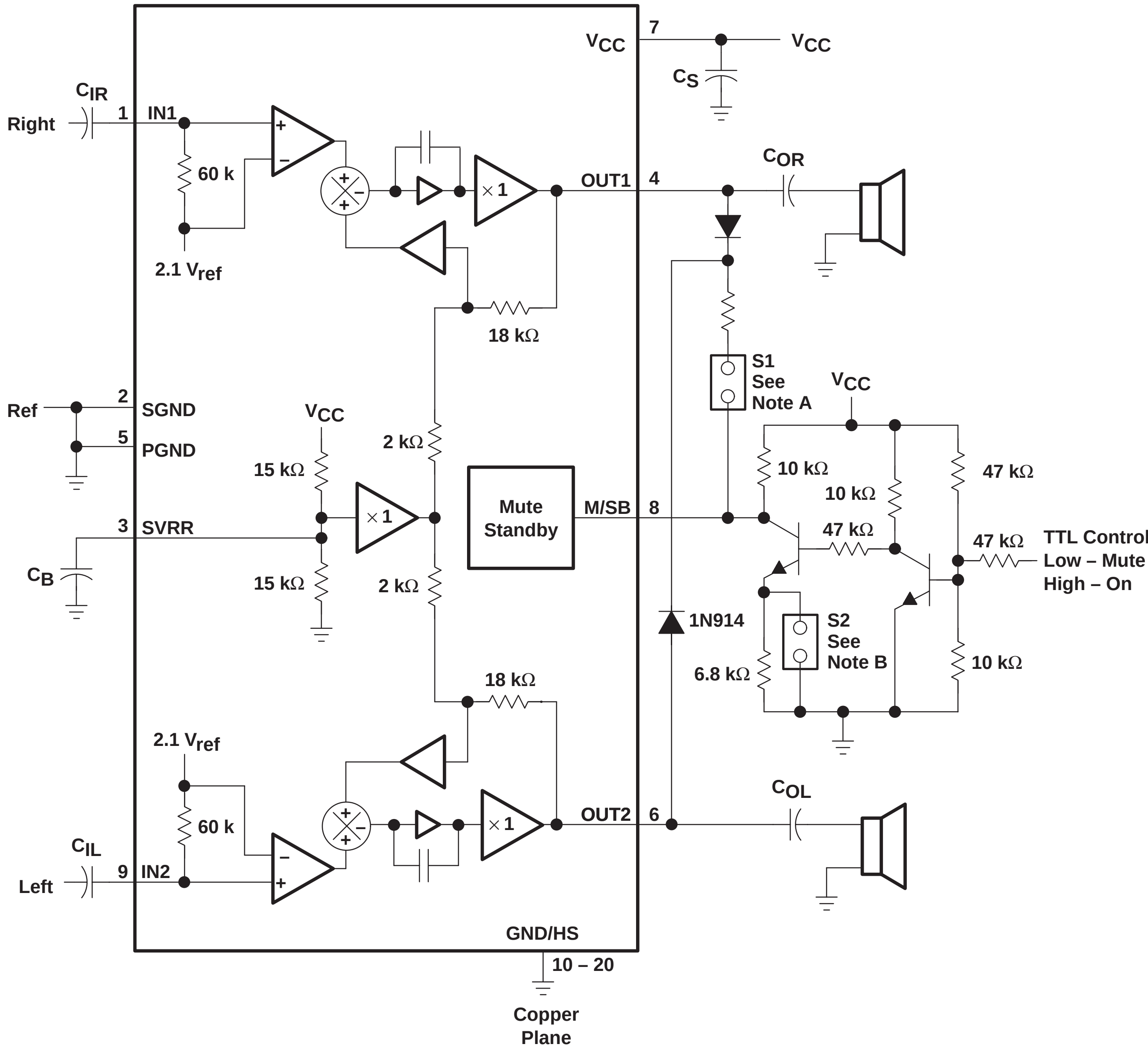


Figure 24. Standby, Mute, and Normal (On) Operating Conditions

The designer must take care to place the control voltages within the defined ranges for each desired mode, whenever an external circuit is used to control the input voltage at the M/SB terminal. The undefined area can cause unpredictable performance and should be avoided. As the control voltage moves through the undefined areas pop or click sounds may be heard in the speaker. Moving from mute to normal causes a very small click sound. Whereas moving from standby to mute can cause a much larger pop sound. Figure 25 shows external circuitry designed to help reduce transition pops when moving from standby mode to normal mode.

APPLICATION INFORMATION

Figure 25 is a reference schematic that provides TTL-level control of the M/SB terminal. A diode network is also included which helps reduce turn-on pop noises. The diodes serve to drain the charge out of the output coupling capacitors while the amplifier is in shutdown mode. When the M/SB voltage is in the normal operating range, the diodes have no effect on the ac performance of the system.



NOTES: A. When S1 is closed, the depop circuitry is active during standby mode.
B. When S2 is open, activating S1 places the TPA1517 in mute mode. When S2 is closed, activating S1 places the TPA1517 in standby mode.
C. The terminal numbers are for the 20-pin NE package.

Figure 25. TTL Control with POP Reduction

APPLICATION INFORMATION

component selection

Some of the general concerns for selection of capacitors are:

- Leakage currents on aluminum electrolytic capacitors
- ESR (equivalent series resistance)
- Temperature ratings

leakage currents

Leakage currents on most ceramic, polystyrene, and paper capacitors are negligible for this application. Leakage currents for aluminum electrolytic and tantalum tend to be higher. This is especially important on the input terminals and the SVRR capacitor. These nodes encounter from 3 V to 7 V, and need to have leakage currents less than 1 µA to keep from affecting the output power and noise performance.

equivalent series resistance

ESR is mainly important on the output coupling capacitor, where even 1 Ω of ESR in C_O with an 8-Ω speaker can reduce the output drive power by 12.5 %. ESR should be considered across the frequency range of interest, (i.e., 20 Hz to 20 kHz). The following equation calculates the amount of power lost in the coupling capacitor:

$$\% \text{ Power in } C_O = \frac{ESR}{R_L}$$

In general, the power supply decoupling requires a very low ESR as well to take advantage of the full output drive current.

temperature range

The temperature range of the capacitors may or may not seem like an obvious thing to specify, but it is very important. Many of the high-density capacitors perform very differently at different temperatures. When consistent high performance is required from the system over temperature in terms of low THD, maximum output power, and turn-on/off popping, then interactions of the coupling capacitors and the SVRR capacitors need to be considered, as well as the change in ESR on the output capacitor with temperature.

turn-on pop consideration

To select the proper input coupling capacitor, the designer should select a capacitor large enough to allow the lowest desired frequency pass and small enough that the time constant is shorter than the output RC time constant to minimize turn-on popping. The input time constant for the TPA1517 is determined by the input 60-kΩ resistance of the amplifier, and the input coupling capacitor according to the following generic equation:

$$T_C = \frac{1}{2\pi RC}$$

For example, 8-Ω speakers and 220-µF output coupling capacitors would yield a 90-Hz cut-off point for the output RC network. The input network should be the same speed or faster (> 90 Hz T_C). A good choice would be 180 Hz. As the input resistance is 60 kΩ, a 14-nF input coupling capacitor would do.

The bypass-capacitor time constant should be much larger (×5) than either the input coupling capacitor time constant or the output coupling capacitor time constants. In the previous example with the 220-µF output coupling capacitor, the designer should want the bypass capacitor, T_C, to be in the order of 18 Hz or lower. To get an 18-Hz time constant, C_B is required to be 1 µF or larger because the resistance this capacitor sees is 7.5 kΩ.

APPLICATION INFORMATION

In summary, follow one of the three simple relations presented below, depending on the tradeoffs between low frequency response and turn-on pop. If depop performance is the top priority, then follow:

$$7500\ C_B > 5R_LC_O > 300000\ C_I$$

If low frequency ac response is more important but depop is still a consideration then follow:

$$\frac{1}{2\pi 60000\ C_I} < 10\ \text{Hz}$$

Finally, if low frequency response is most important and depop is not a consideration then follow:

$$\frac{1}{2\pi 60000\ C_I} \leq \frac{1}{2\pi R_L\ C_I} \leq F\ \text{low}$$

thermal applications

Linear power amplifiers dissipate a significant amount of heat in the package under normal operating conditions. A typical music CD requires 12 dB to 15 dB of dynamic headroom to pass the loudest portions without distortion as compared with the average power output. Figure 19 shows that when the TPA1517 is operating from a 12-V supply into a 4-Ω speaker that approximately 3.5 W peaks are possible. Converting watts to dB suing the following equation:

$$P_{dB} = 10\,\text{Log}\,P_W$$
$$= 10\,\text{Log}\,3.5$$
$$= 5.44\ \text{dB}$$

Subtracting dB for the headroom restriction to obtain the average listening level without distortion yields the following:

$$5.44\ \text{dB} - 15\ \text{dB} = -9.56\ \text{dB}\ (15\ \text{dB headroom})$$
$$5.44\ \text{dB} - 12\ \text{dB} = -6.56\ \text{dB}\ (12\ \text{dB headroom})$$

Converting dB back into watts:

$$P_W = 10^{PdB/10}$$
$$= 111\ \text{mW}\ (15\ \text{dB headroom})$$
$$= 221\ \text{mW}\ (12\ \text{dB headroom})$$

This is valuable information to consider when attempting to estimate the heat dissipation requirements for the amplifier system. Comparing the absolute worst cast, which is 3.5 W of continuous power output with 0 dB of headroom, against 12-dB and 15-dB applications drastically affects maximum ambient temperature ratings for the system. Using the power dissipation curves for a 12-V, 4-Ω system, internal dissipation in the TPA1517 and maximum ambient temperatures are shown in Table 1.

APPLICATION INFORMATION

Table 1. TPA1517 Power Rating

PEAK OUTPUT POWER (W)	AVERAGE OUTPUT POWER	POWER DISSIPATION (W/Channel)	MAXIMUM AMBIENT TEMPERATURE	
			0 CFM	300 CFM
3.5	3.5 W	2.1	–34°C	42°C
3.5	1.77 W (3 dB)	2.4	–61°C	26°C
3.5	884 mW (6 dB)	2.25	–48°C	34°C
3.5	442 mW (9 dB)	1.75	–4°C	60°C
3.5	221 mW (12 dB)	1.5	18°C	73°C
3.5	111 mW (15 dB)	1.25	40°C	85°C

The maximum ambient temperature depends on the heatsinking ability of the PCB system. Using the 0-CFM and 300-CFM data from the dissipation rating table, the derating factor for the NE package with 4 square inches of copper area is 22.8 mW/°C and 38.8 mW/°C respectively. Converting this to θ_{JA}:

$$\theta_{JA} = \frac{1}{\text{Derating}}$$

$$\text{For 0 CFM}: \; = \frac{1}{0.0228} = 43.9°C/W$$

$$\text{For 300 CFM}: \; = \frac{1}{0.0388} = 25.8°C/W$$

To calculate maximum ambient temperatures, first consider that the numbers from the dissipation graphs are per channel so the dissipated heat needs to be doubled for two channel operation. Given θ_{JA}, the maximum allowable junction temperature and the total internal dissipation, the maximum ambient temperature can be calculated with the following equation. The maximum recommended junction temperature for the TPA1517 is 150 °C.

$$T_A\,\text{Max} = T_J\,\text{Max} - \Theta JA\; P_D$$

$$= 150 - 43.9(1.25 \times 2) = 40°C \text{ (15 dB headroom, 0 CFM)}$$

$$= 150 - 25.8(1.25 \times 2) = 85°C \text{ (15 dB headroom, 300 CFM)}$$

Table 1 clearly shows that for most applications some airflow is required to keep junction temperatures in the specified range. The TPA1517 is designed with thermal protection that turns the device off when the junction temperature surpasses 150 °C to prevent damage to the IC. Using the DWP package on a multilayer PCB with internal ground planes can achieve better thermal performance. Table 1 was calculated for a maximum volume system; when the output level is reduced, the numbers in the table change significantly. Also using 8-Ω speakers dramatically increases the thermal performance by increasing amplifier efficiency.

APPLICATION INFORMATION

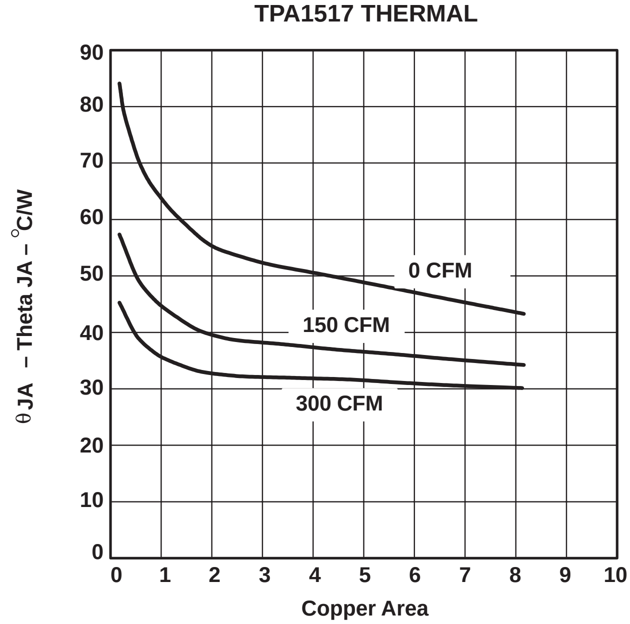
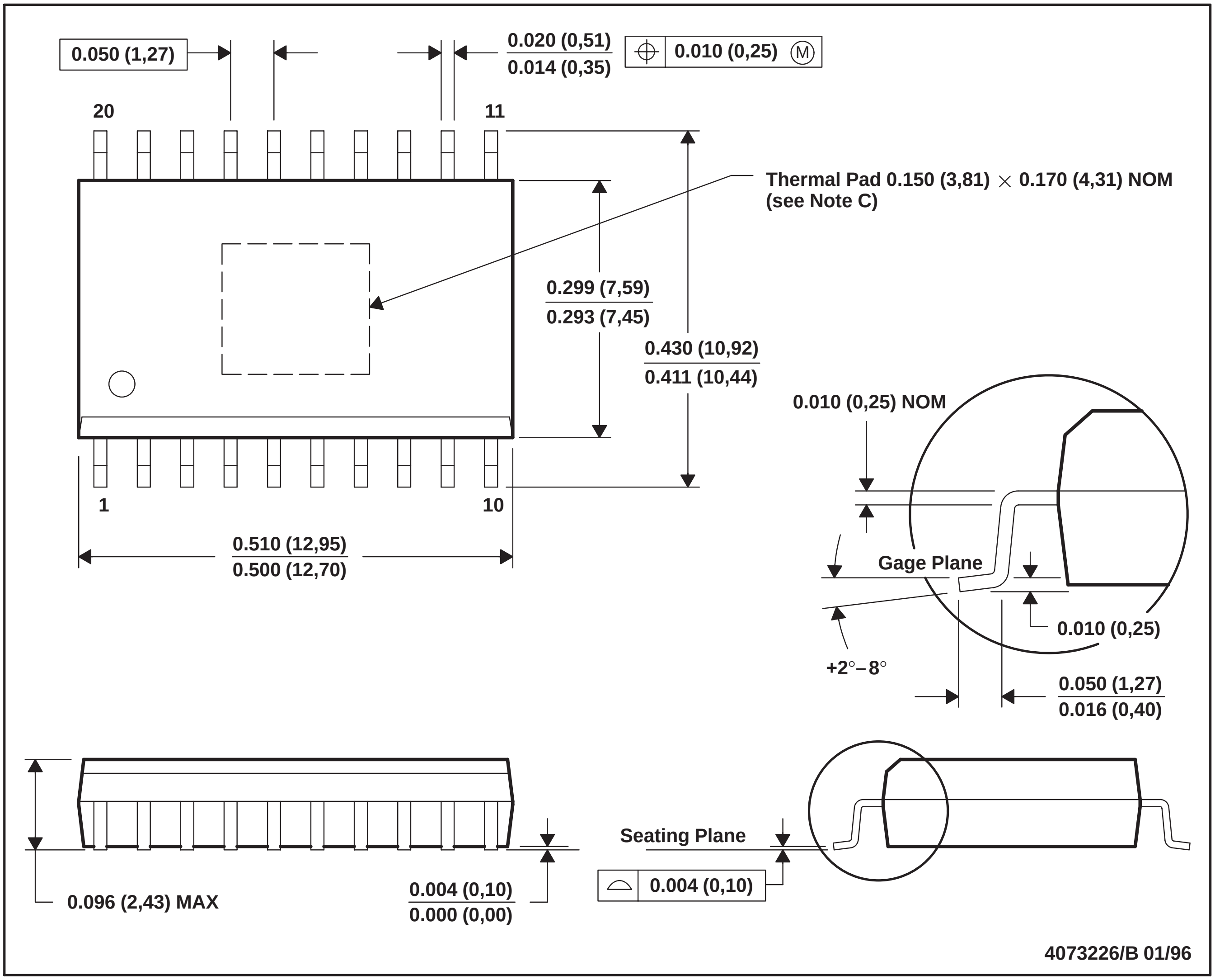


Figure 26

MECHANICAL INFORMATION

DWP (R-PDSO-G20) **PowerPAD™ PLASTIC SMALL-OUTLINE PACKAGE**



NOTES: A. All linear dimensions are in inches (millimeters).
B. This drawing is subject to change without notice.
C. The thermal performance may be enhanced by bonding the thermal pad to an external thermal plane. This solderable pad is electrically and thermally connected to the backside of the die and leads 1, 10, 11 and 20.

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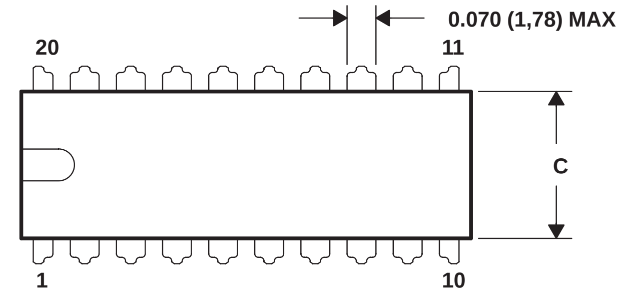
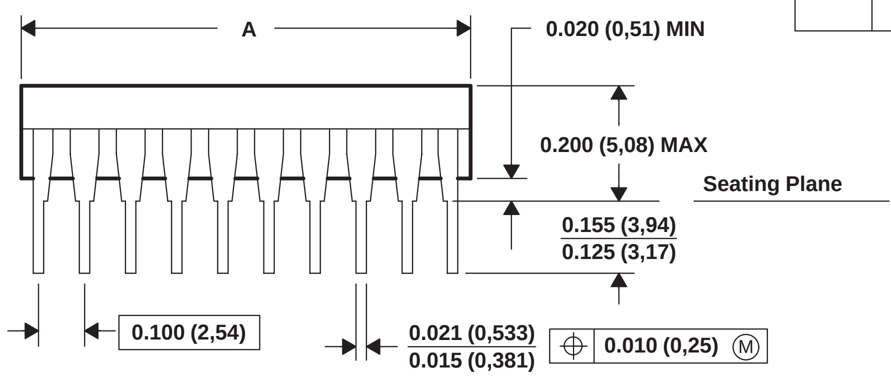
MECHANICAL INFORMATION

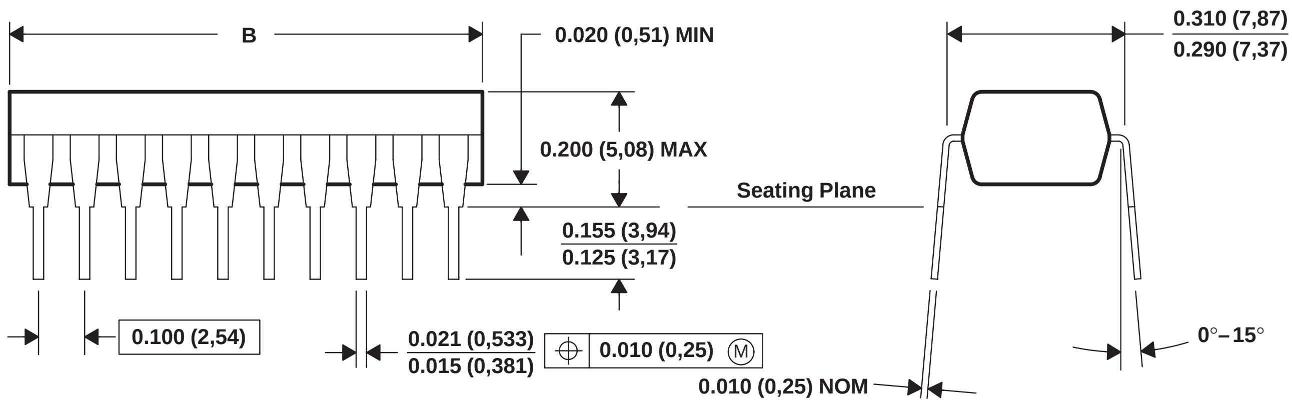
NE (R-PDIP-T)** **PLASTIC DUAL-IN-LINE PACKAGE**

20 PIN SHOWN



DIM	PINS **	16	20
A	MIN	——	0.914 (23,22)
	MAX	0.780 (19,80)	0.975 (24,77)
B	MIN	——	0.930 (23,62)
	MAX	——	1.000 (25,40)
C	MIN	0.240 (6,10)	0.260 (6,61)
	MAX	0.260 (6,60)	0.280 (7,11)





4040054 / B 04/95

NOTES: A. All linear dimensions are in inches (millimeters).
B. This drawing is subject to change without notice.
C. Falls within JEDEC MS-001 (16 pin only)

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