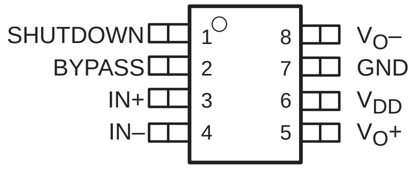
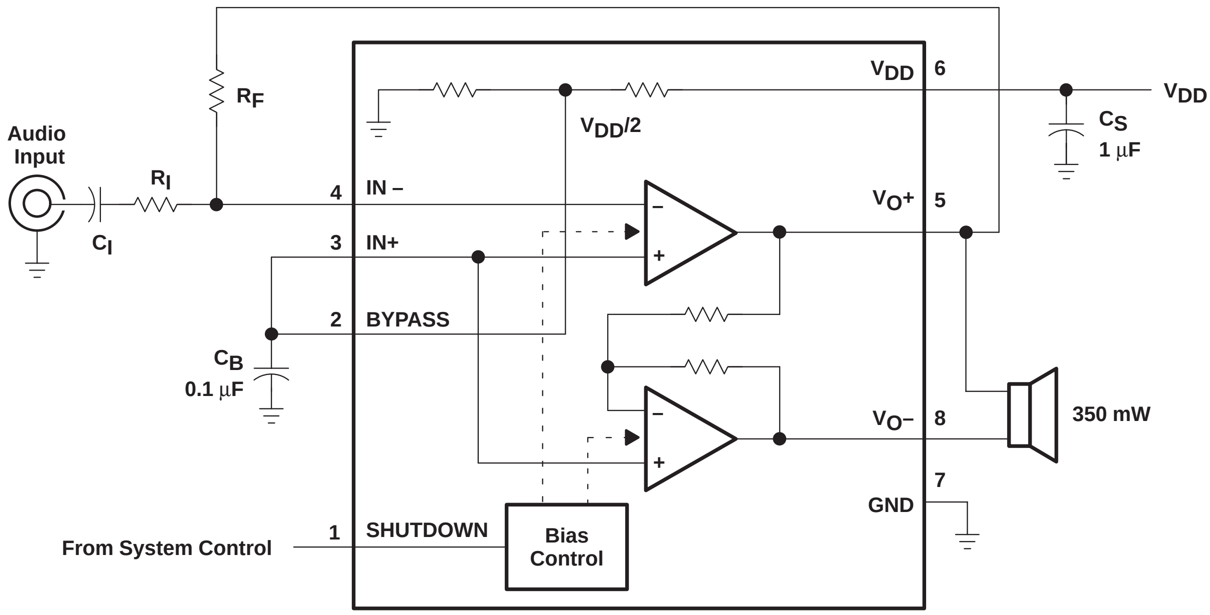
- **Fully Specified for 3.3-V and 5-V Operation**
- **Wide Power Supply Compatibility 2.5 V – 5.5 V**
- **Output Power for R_L = 8 Ω**
  - **350 mW at V_{DD} = 5 V, BTL**
  - **250 mW at V_{DD} = 3.3 V, BTL**
- **Ultra-Low Quiescent Current in Shutdown Mode . . . 0.15 μA**
- **Thermal and Short-Circuit Protection**
- **Surface-Mount Packaging**
  - **SOIC**
  - **PowerPAD™ MSOP**

D OR DGN PACKAGE
(TOP VIEW)



description

The TPA301 is a bridge-tied load (BTL) audio power amplifier developed especially for low-voltage applications where internal speakers are required. Operating with a 3.3-V supply, the TPA301 can deliver 250-mW of continuous power into a BTL 8-Ω load at less than 1% THD+N throughout voice band frequencies. Although this device is characterized out to 20 kHz, its operation was optimized for narrower band applications such as cellular communications. The BTL configuration eliminates the need for external coupling capacitors on the output in most applications, which is particularly important for small battery-powered equipment. This device features a shutdown mode for power-sensitive applications with a quiescent current of 0.15 μA during shutdown. The TPA301 is available in an 8-pin SOIC surface-mount package and the surface-mount PowerPAD MSOP, which reduces board space by 50% and height by 40%.



AVAILABLE OPTIONS

T_A	PACKAGED DEVICES		MSOP Symbolization
	SMALL OUTLINE† (D)	MSOP† (DGN)	
–40°C to 85°C	TPA301D	TPA301DGN	AAA

† The D and DGN packages are available taped and reeled. To order a taped and reeled part, add the suffix R to the part number (e.g., TPA301DR).

Terminal Functions

TERMINAL NAME	NO.	I/O	DESCRIPTION
BYPASS	2	I	BYPASS is the tap to the voltage divider for internal mid-supply bias. This terminal should be connected to a 0.1-μF to 1-μF capacitor when used as an audio amplifier.
GND	7		GND is the ground connection.
IN–	4	I	IN– is the inverting input. IN– is typically used as the audio input terminal.
IN+	3	I	IN+ is the noninverting input. IN+ is typically tied to the BYPASS terminal.
SHUTDOWN	1	I	SHUTDOWN places the entire device in shutdown mode when held high (I_{DD} < 1 μA).
V_{DD}	6		V_{DD} is the supply voltage terminal.
V_O+	5	O	V_O+ is the positive BTL output.
V_O–	8	O	V_O– is the negative BTL output.

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

Supply voltage, V_{DD} . . . . 6 V
Input voltage, V_I . . . . –0.3 V to V_{DD} +0.3 V
Continuous total power dissipation . . . . internally limited (see Dissipation Rating Table)
Operating free-air temperature range, T_A . . . . –40°C to 85°C
Operating junction temperature range, T_J . . . . –40°C to 150°C
Storage temperature range, T_{stg} . . . . –65°C to 150°C
Lead temperature 1,6 mm (1/16 inch) from case for 10 seconds . . . . 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.

DISSIPATION RATING TABLE

PACKAGE	$T_A \leq 25°C$	DERATING FACTOR	$T_A = 70°C$	$T_A = 85°C$
D	725 mW	5.8 mW/°C	464 mW	377 mW
DGN	2.14 W§	17.1 mW/°C	1.37 W	1.11 W

§ Please see the Texas Instruments document, *PowerPAD Thermally Enhanced Package Application Report* (literature number SLMA002), for more information on the PowerPAD package. The thermal data was measured on a PCB layout based on the information in the section entitled *Texas Instruments Recommended Board for PowerPAD* on page 33 of the before mentioned document.

recommended operating conditions

	MIN	MAX	UNIT
Supply voltage, V_{DD}	2.5	5.5	V
Operating free-air temperature, T_A	–40	85	°C

electrical characteristics at specified free-air temperature, V_{DD} = 3.3 V, T_A = 25°C (unless otherwise noted)

PARAMETER		TEST CONDITIONS	MIN	TYP	MAX	UNIT
V_{OD}	Differential output voltage	See Note 1		5	20	mV
PSRR	Power supply rejection ratio	V_{DD} = 3.2 V to 3.4 V		85		dB
$I_{DD(q)}$	Supply current (see Figure 3)	BTL mode		0.7	1.5	mA
$I_{DD(sd)}$	Supply current, shutdown mode (see Figure 4)			0.15	5	µA

NOTE 1: At 3 V < V_{DD} < 5 V the dc output voltage is approximately V_{DD}/2.

operating characteristics, V_{DD} = 3.3 V, T_A = 25°C, R_L = 8 Ω

PARAMETER		TEST CONDITIONS		MIN	TYP	MAX	UNIT
P_O	Output power, see Note 2	THD = 0.5%,	See Figure 9		250		mW
THD + N	Total harmonic distortion plus noise	P_O = 250 mW, Gain = 2,	f = 20 Hz to 4 kHz, See Figure 7		1.3%		
	Maximum output power bandwidth	Gain = 2, See Figure 7	THD = 3%,		10		kHz
B_1	Unity-gain bandwidth	Open Loop,	See Figure 15		1.4		MHz
	Supply ripple rejection ratio	f = 1 kHz, See Figure 2	C_B = 1 µF,		71		dB
V_n	Noise output voltage	Gain = 1, R_L = 32 Ω,	C_B = 0.1 µF, See Figure 19		15		µV(rms)

NOTE 2: Output power is measured at the output terminals of the device at f = 1 kHz.

electrical characteristics at specified free-air temperature, V_{DD} = 5 V, T_A = 25°C (unless otherwise noted)

PARAMETER		TEST CONDITIONS	MIN	TYP	MAX	UNIT
V_{OD}	Differential output voltage			5	20	mV
PSRR	Power supply rejection ratio	V_{DD} = 4.9 V to 5.1 V		78		dB
$I_{DD(q)}$	Quiescent current (see Figure 3)			0.7	1.5	mA
$I_{DD(sd)}$	Quiescent current, shutdown mode (see Figure 4)			0.15	5	µA

operating characteristics, V_{DD} = 5 V, T_A = 25°C, R_L = 8 Ω

PARAMETER		TEST CONDITIONS		MIN	TYP	MAX	UNIT
P_O	Output power	THD = 0.5%,	See Figure 13		700		mW
THD + N	Total harmonic distortion plus noise	P_O = 250 mW, Gain = 2,	f = 20 Hz to 4 kHz, See Figure 11		1%		
	Maximum output power bandwidth	Gain = 2, See Figure 11	THD = 2%,		10		kHz
B_1	Unity-gain bandwidth	Open Loop,	See Figure 16		1.4		MHz
	Supply ripple rejection ratio	f = 1 kHz, See Figure 2	C_B = 1 µF,		65		dB
V_n	Noise output voltage	Gain = 1, R_L = 32 Ω,	C_B = 0.1 µF, See Figure 20		15		µV(rms)

PARAMETER MEASUREMENT INFORMATION

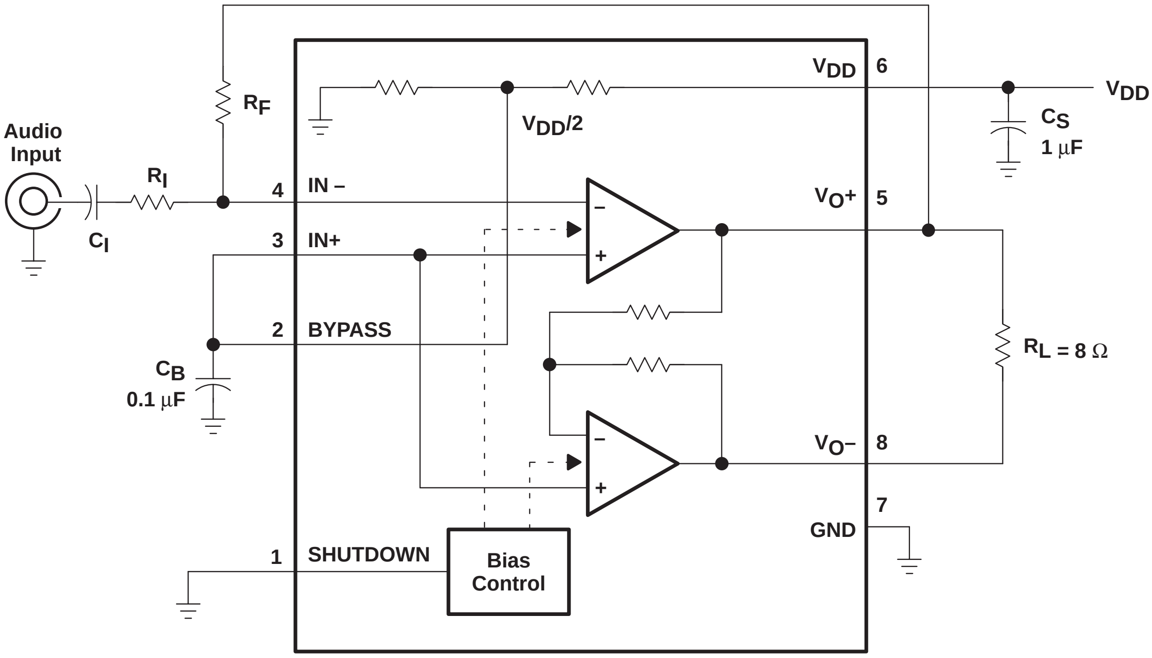


Figure 1. Test Circuit

TYPICAL CHARACTERISTICS

Table of Graphs

			FIGURE
k_{SVR}	Supply voltage rejection ratio	vs Frequency	2
I_{DD}	Supply current	vs Supply voltage	3, 4
P_O	Output power	vs Supply voltage	5
		vs Load resistance	6
THD + N	Total harmonic distortion plus noise	vs Frequency	7, 8, 11, 12
		vs Output power	9, 10, 13, 14
	Open loop gain and phase	vs Frequency	15, 16
	Closed loop gain and phase	vs Frequency	17, 18
V_n	Output noise voltage	vs Frequency	19, 20
P_D	Power dissipation	vs Output power	21, 22

TYPICAL CHARACTERISTICS

SUPPLY VOLTAGE REJECTION RATIO
vs
FREQUENCY

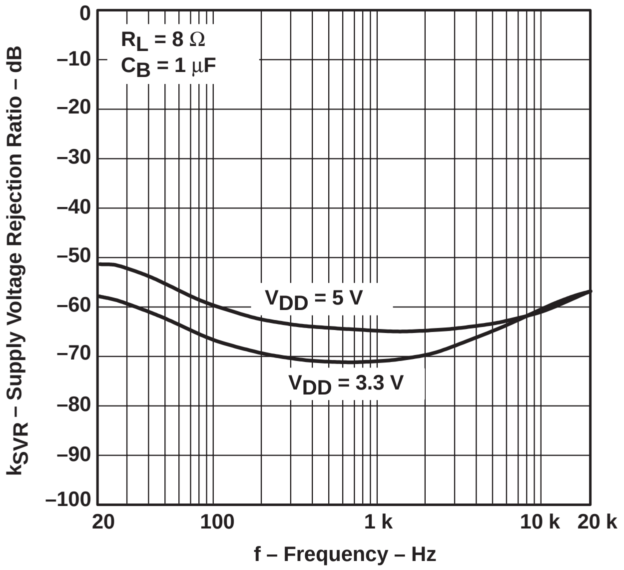


Figure 2

SUPPLY CURRENT
vs
SUPPLY VOLTAGE

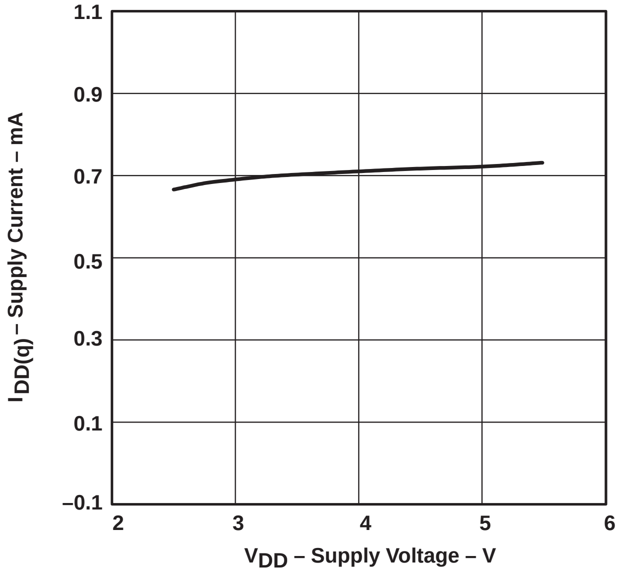


Figure 3

SUPPLY CURRENT (SHUTDOWN)
vs
SUPPLY VOLTAGE

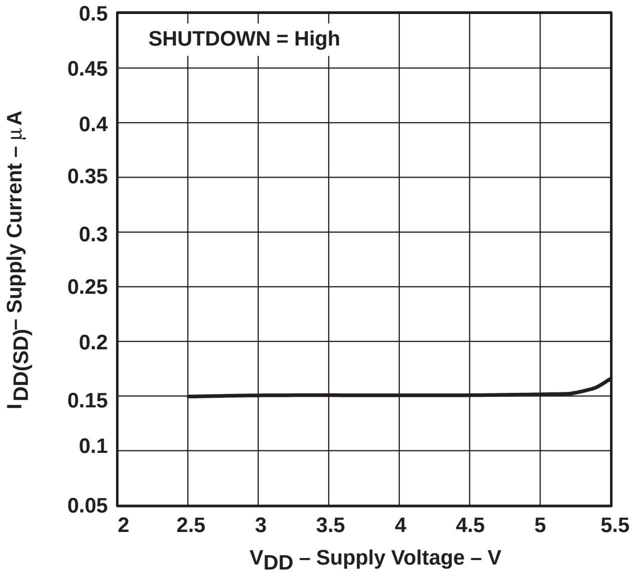


Figure 4

TYPICAL CHARACTERISTICS

**OUTPUT POWER
vs
SUPPLY VOLTAGE**

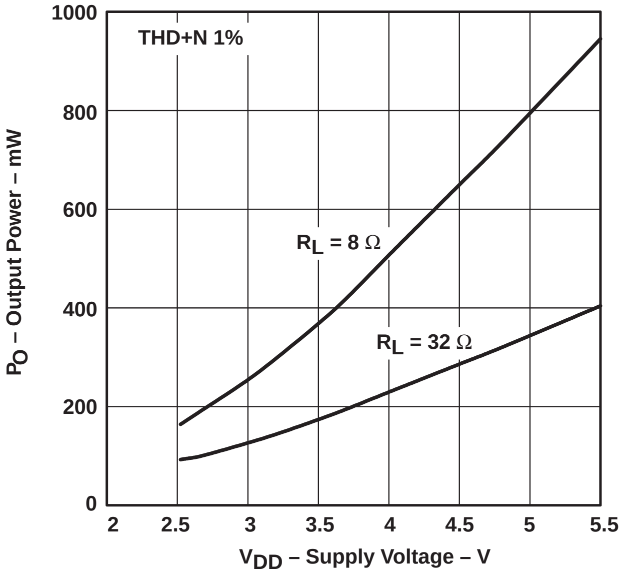


Figure 5

**OUTPUT POWER
vs
LOAD RESISTANCE**

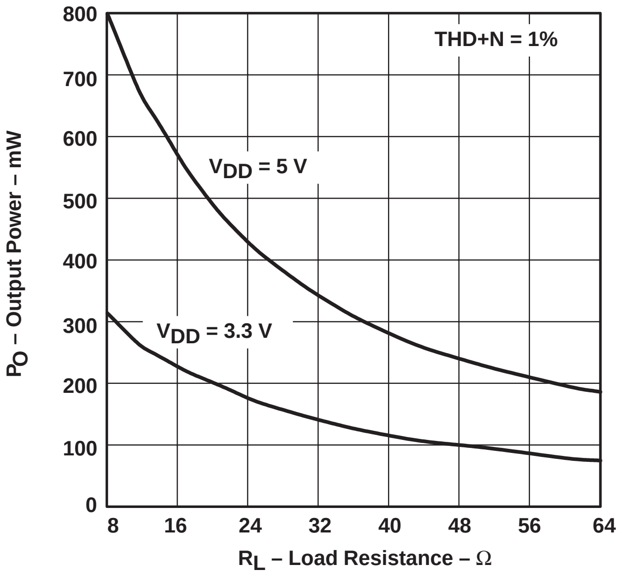


Figure 6

TYPICAL CHARACTERISTICS

TOTAL HARMONIC DISTORTION PLUS NOISE vs FREQUENCY

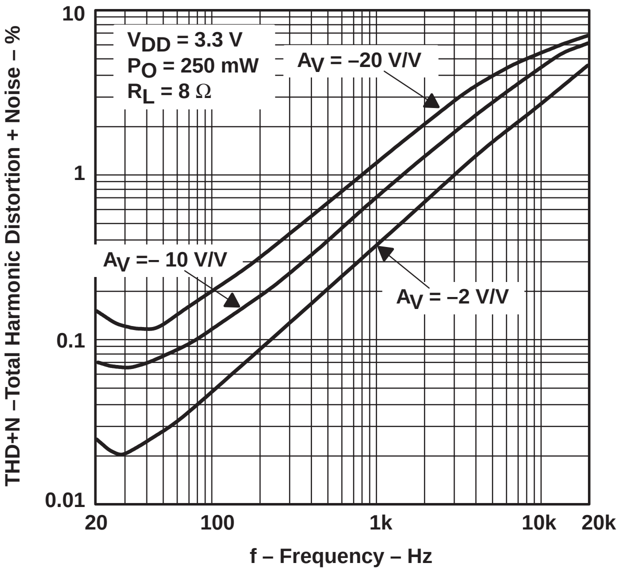


Figure 7

TOTAL HARMONIC DISTORTION PLUS NOISE vs FREQUENCY

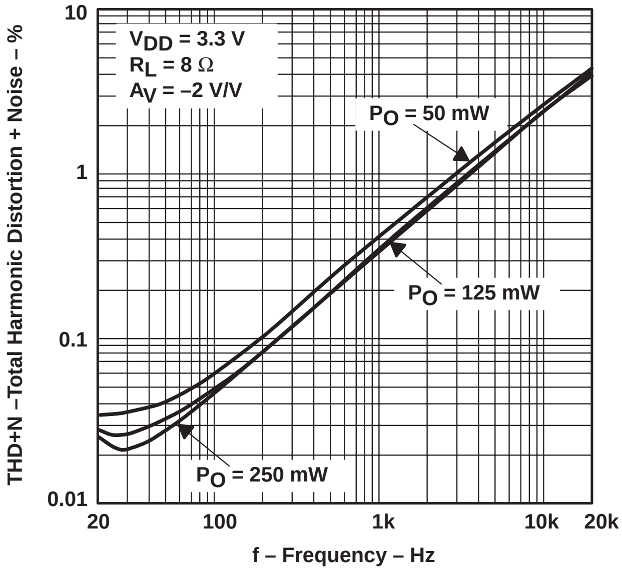


Figure 8

TOTAL HARMONIC DISTORTION PLUS NOISE vs OUTPUT POWER

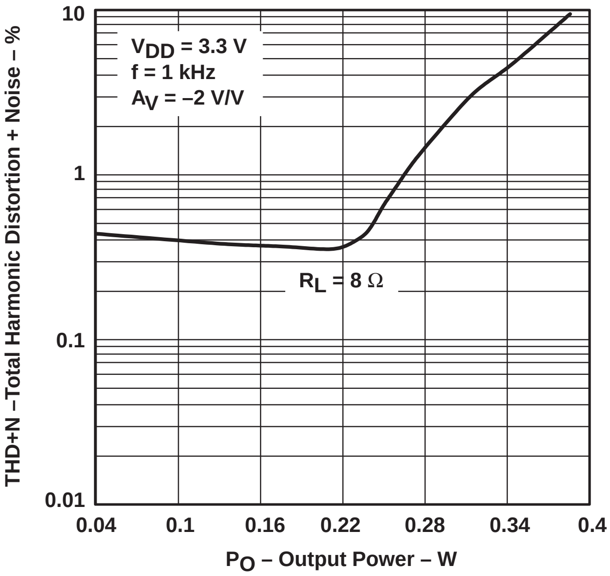


Figure 9

TOTAL HARMONIC DISTORTION PLUS NOISE vs OUTPUT POWER

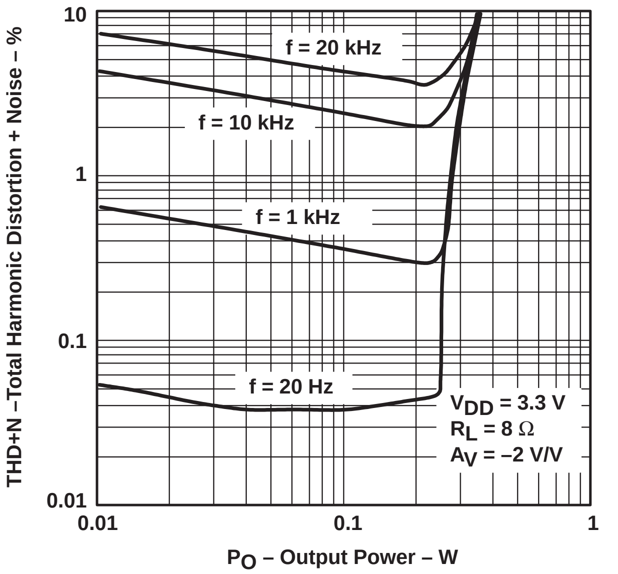


Figure 10

TYPICAL CHARACTERISTICS

TOTAL HARMONIC DISTORTION PLUS NOISE vs FREQUENCY

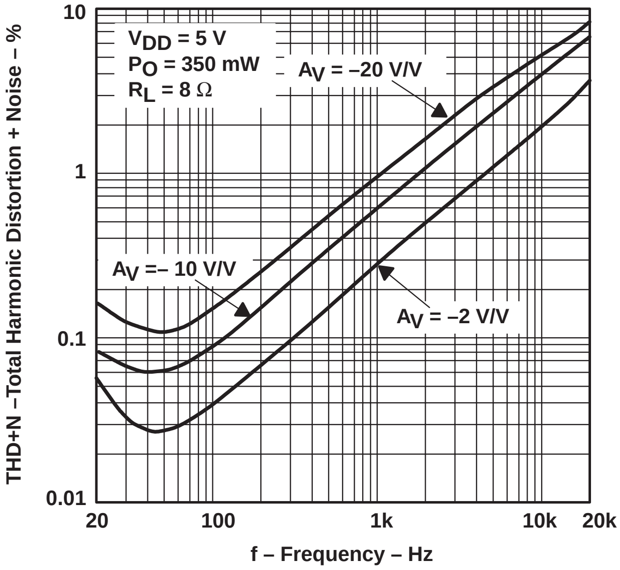


Figure 11

TOTAL HARMONIC DISTORTION PLUS NOISE vs FREQUENCY

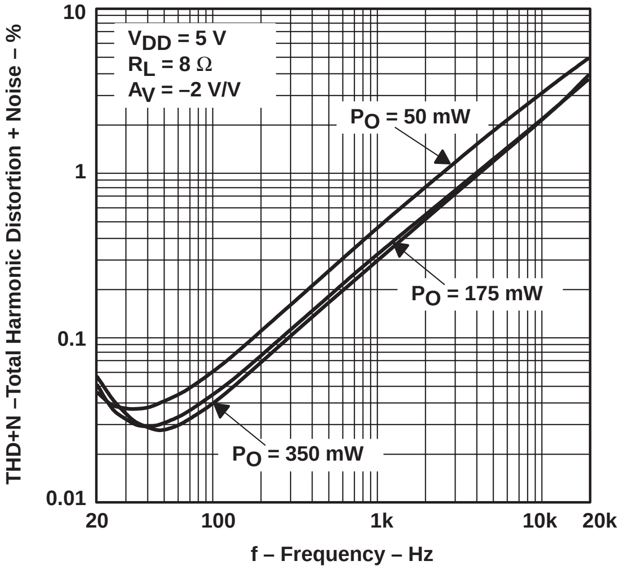


Figure 12

TOTAL HARMONIC DISTORTION PLUS NOISE vs OUTPUT POWER

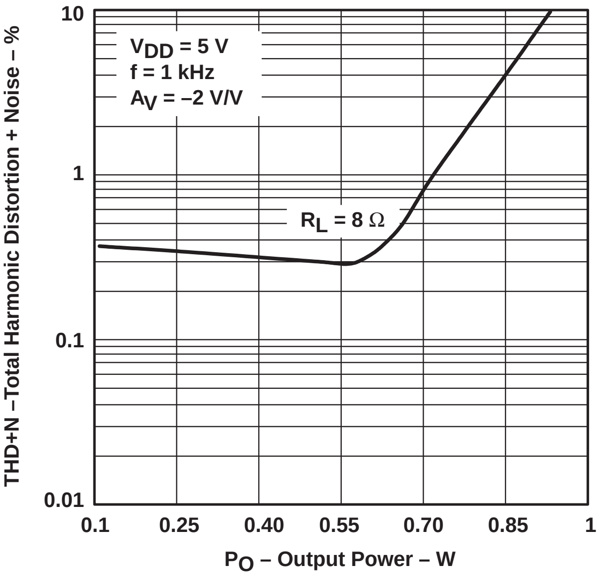


Figure 13

TOTAL HARMONIC DISTORTION PLUS NOISE vs OUTPUT POWER

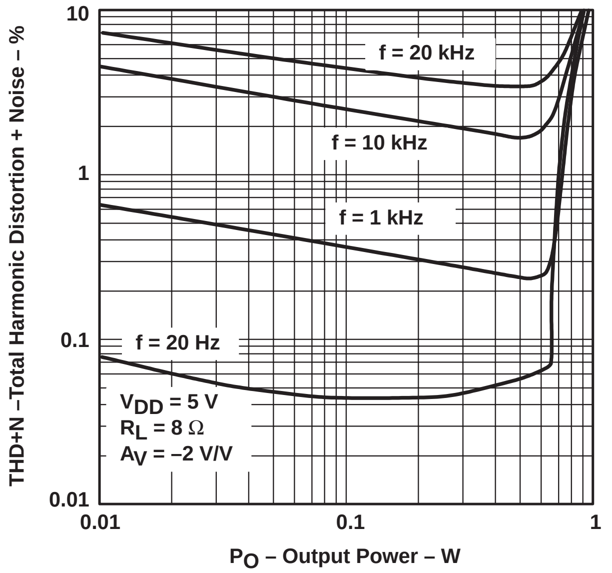


Figure 14

TYPICAL CHARACTERISTICS

OPEN-LOOP GAIN AND PHASE
vs
FREQUENCY

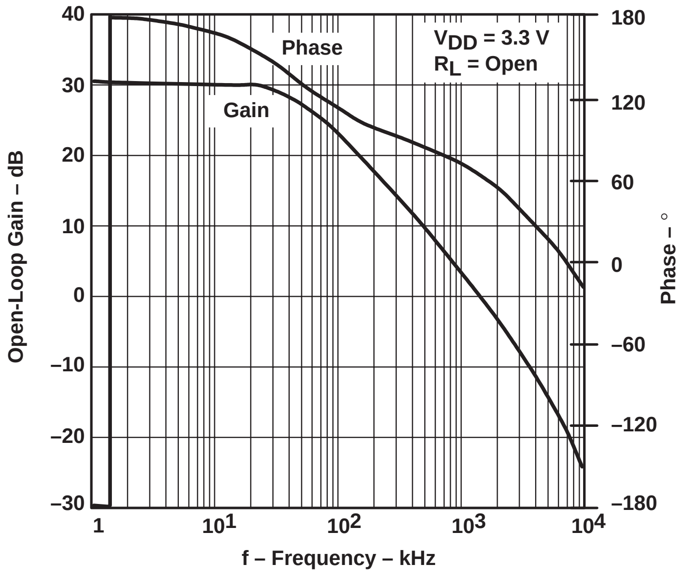


Figure 15

OPEN-LOOP GAIN AND PHASE
vs
FREQUENCY

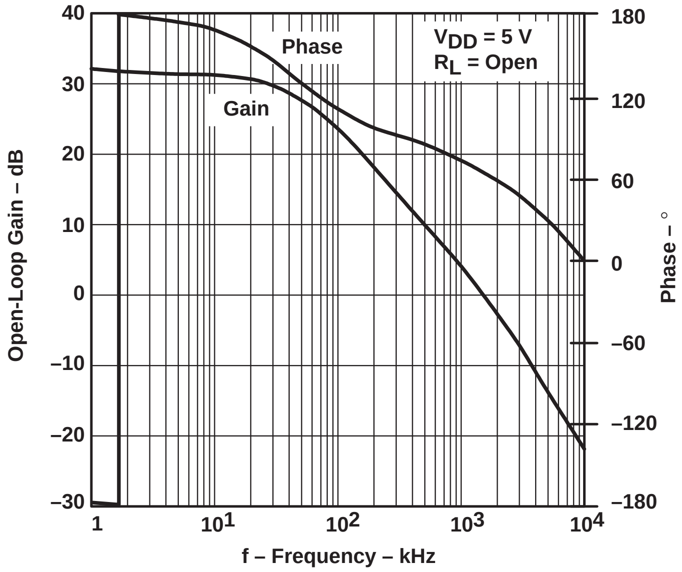


Figure 16

TYPICAL CHARACTERISTICS

**CLOSED-LOOP GAIN AND PHASE
vs
FREQUENCY**

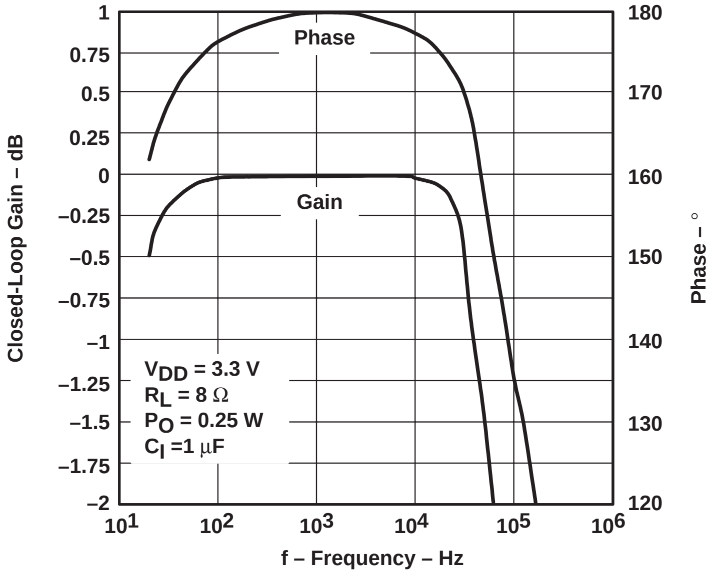


Figure 17

**CLOSED-LOOP GAIN AND PHASE
vs
FREQUENCY**

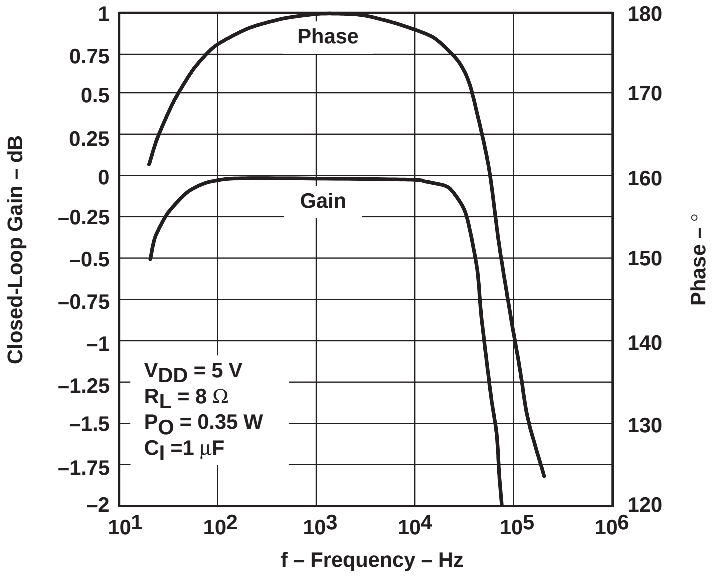


Figure 18

TYPICAL CHARACTERISTICS

OUTPUT NOISE VOLTAGE vs FREQUENCY

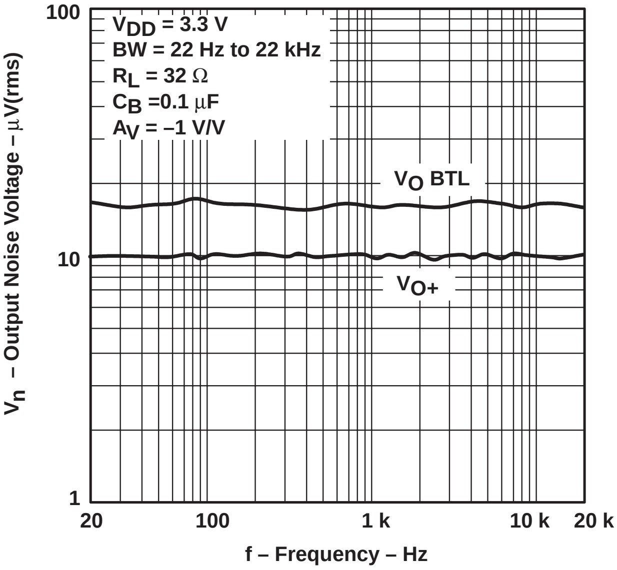


Figure 19

OUTPUT NOISE VOLTAGE vs FREQUENCY

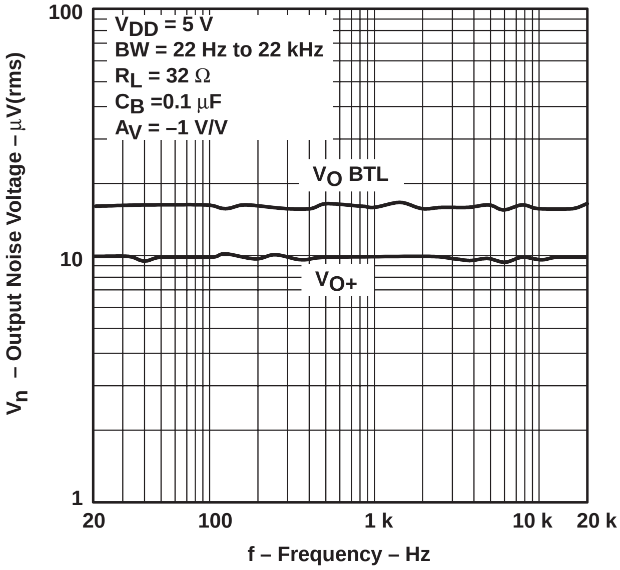


Figure 20

POWER DISSIPATION vs OUTPUT POWER

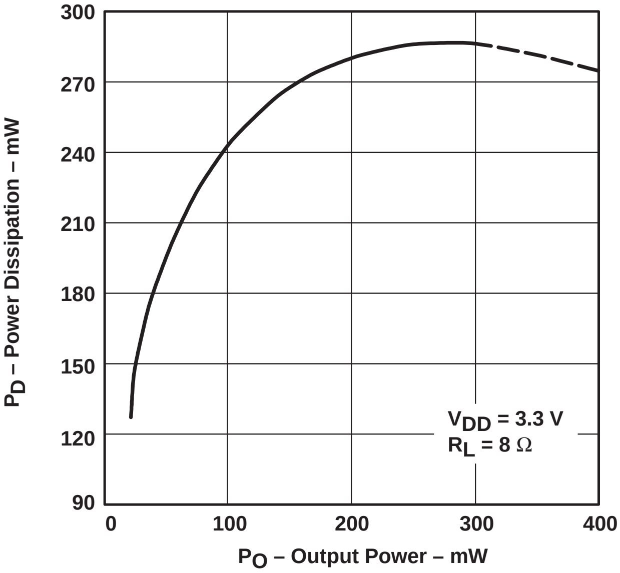


Figure 21

POWER DISSIPATION vs OUTPUT POWER

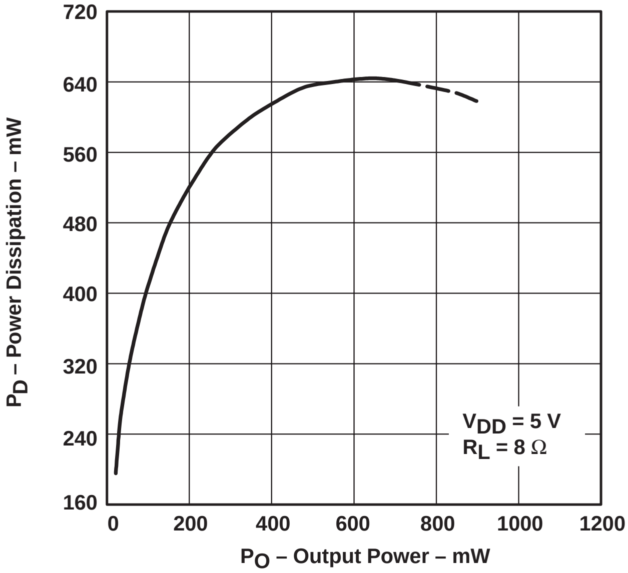


Figure 22

APPLICATION INFORMATION

bridge-tied load

Figure 23 shows a linear audio power amplifier (APA) in a BTL configuration. The TPA301 BTL amplifier consists of two linear amplifiers driving both ends of the load. There are several potential benefits to this differential drive configuration but power to the load should be initially considered. The differential drive to the speaker means that as one side is slewing up, the other side is slewing down, and vice versa. This in effect doubles the voltage swing on the load as compared to a ground referenced load. Plugging $2 \times V_{O(PP)}$ into the power equation, where voltage is squared, yields 4× the output power from the same supply rail and load impedance (see equation 1).

$$V_{(rms)} = \frac{V_{O(PP)}}{2\sqrt{2}}$$

$$\text{Power} = \frac{V_{(rms)}^{2}}{R_L} \qquad (1)$$

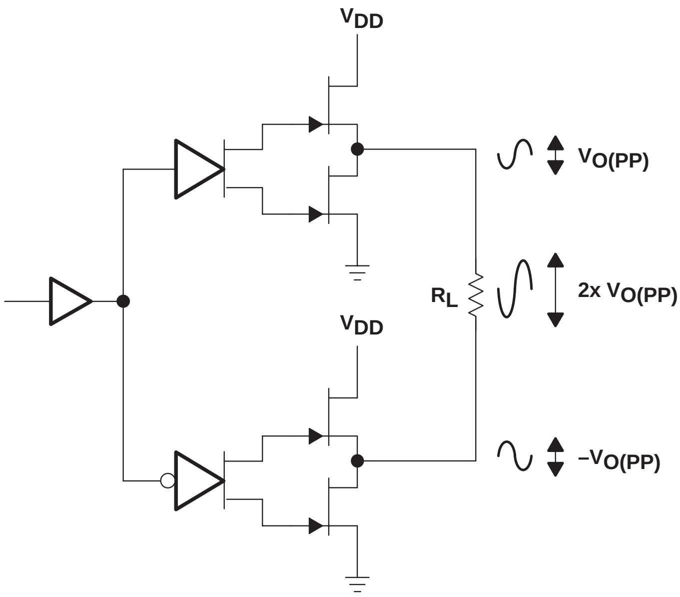


Figure 23. Bridge-Tied Load Configuration

In a typical portable handheld equipment sound channel operating at 3.3 V, bridging raises the power into an 8-Ω speaker from a single-ended (SE, ground reference) limit of 62.5 mW to 250 mW. In sound power that is a 6-dB improvement — which is loudness that can be heard. In addition to increased power, there are frequency response concerns. Consider the single-supply SE configuration shown in Figure 24. A coupling capacitor is required to block the dc offset voltage from reaching the load. These capacitors can be quite large (approximately 33 µF to 1000 µF) so they tend to be expensive, heavy, occupy valuable PCB area, and have the additional drawback of limiting low-frequency performance of the system. This frequency limiting effect is due to the high pass filter network created with the speaker impedance and the coupling capacitance and is calculated with equation 2.

APPLICATION INFORMATION

bridge-tied load versus single-ended mode (continued)

$$f_{(corner)} = \frac{1}{2\pi R_L C_C} \qquad (2)$$

For example, a 68-µF capacitor with an 8-Ω speaker would attenuate low frequencies below 293 Hz. The BTL configuration cancels the dc offsets, eliminating the need for the blocking capacitors. Low-frequency performance is then limited only by the input network and speaker response. Cost and PCB space are also minimized by eliminating the bulky coupling capacitor.

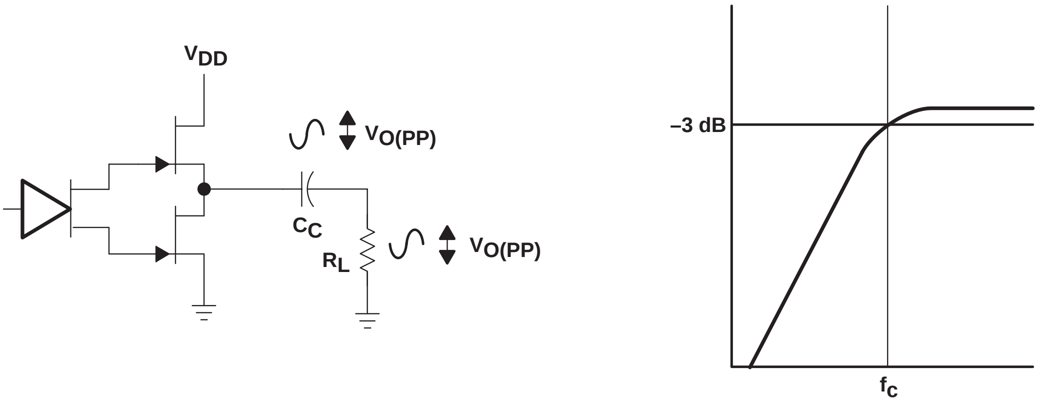


Figure 24. Single-Ended Configuration and Frequency Response

Increasing power to the load does carry a penalty of increased internal power dissipation. The increased dissipation is understandable considering that the BTL configuration produces 4× the output power of a SE configuration. Internal dissipation versus output power is discussed further in the *thermal considerations* section.

BTL amplifier efficiency

Linear amplifiers are notoriously inefficient. The primary cause of these inefficiencies is voltage drop across the output stage transistors. There are two components of the internal voltage drop. One is the headroom or dc voltage drop that varies inversely to output power. The second component is due to the sinewave nature of the output. The total voltage drop can be calculated by subtracting the RMS value of the output voltage from V_{DD}. The internal voltage drop multiplied by the RMS value of the supply current, I_{DD}rms, determines the internal power dissipation of the amplifier.

An easy-to-use equation to calculate efficiency starts out as being equal to the ratio of power from the power supply to the power delivered to the load. To accurately calculate the RMS values of power in the load and in the amplifier, the current and voltage waveform shapes must first be understood (see Figure 25).

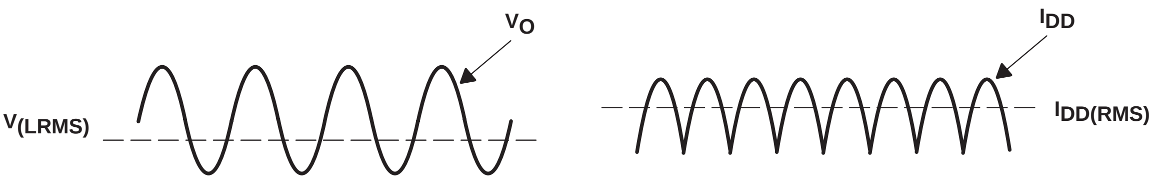


Figure 25. Voltage and Current Waveforms for BTL Amplifiers

APPLICATION INFORMATION

BTL amplifier efficiency (continued)

Although the voltages and currents for SE and BTL are sinusoidal in the load, currents from the supply are very different between SE and BTL configurations. In an SE application the current waveform is a half-wave rectified shape whereas in BTL it is a full-wave rectified waveform. This means RMS conversion factors are different. Keep in mind that for most of the waveform both the push and pull transistors are not on at the same time, which supports the fact that each amplifier in the BTL device only draws current from the supply for half the waveform. The following equations are the basis for calculating amplifier efficiency.

$$\text{Efficiency} = \frac{P_L}{P_{SUP}} \tag{3}$$

Where:

$$P_L = \frac{V_L rms^2}{R_L} = \frac{V_p{}^2}{2R_L}$$

$$V_L rms = \frac{V_P}{\sqrt{2}}$$

$$P_{SUP} = V_{DD}\, I_{DD} rms = \frac{V_{DD}\, 2V_P}{\pi\, R_L}$$

$$I_{DD} rms = \frac{2V_P}{\pi\, R_L}$$

$$\text{Efficiency of a BTL Configuration} = \frac{\pi\, V_P}{2V_{DD}} = \frac{\pi \left(\frac{P_L R_L}{2}\right)^{1/2}}{2V_{DD}} \tag{4}$$

Table 1 employs equation 4 to calculate efficiencies for three different output power levels. The efficiency of the amplifier is quite low for lower power levels and rises sharply as power to the load is increased resulting in a nearly flat internal power dissipation over the normal operating range. The internal dissipation at full output power is less than in the half power range. Calculating the efficiency for a specific system is the key to proper power supply design.

Table 1. Efficiency vs Output Power in 3.3-V 8-Ω BTL Systems

OUTPUT POWER (W)	EFFICIENCY (%)	PEAK-to-PEAK VOLTAGE (V)	INTERNAL DISSIPATION (W)
0.125	33.6	1.41	0.26
0.25	47.6	2.00	0.29
0.375	58.3	2.45†	0.28

† High-peak voltage values cause the THD to increase.

A final point to remember about linear amplifiers (either SE or BTL) is how to manipulate the terms in the efficiency equation to utmost advantage when possible. Note that in equation 4, V_{DD} is in the denominator. This indicates that as V_{DD} goes down, efficiency goes up.

APPLICATION INFORMATION

application schematic

Figure 26 is a schematic diagram of a typical handheld audio application circuit, configured for a gain of –10 V/V.

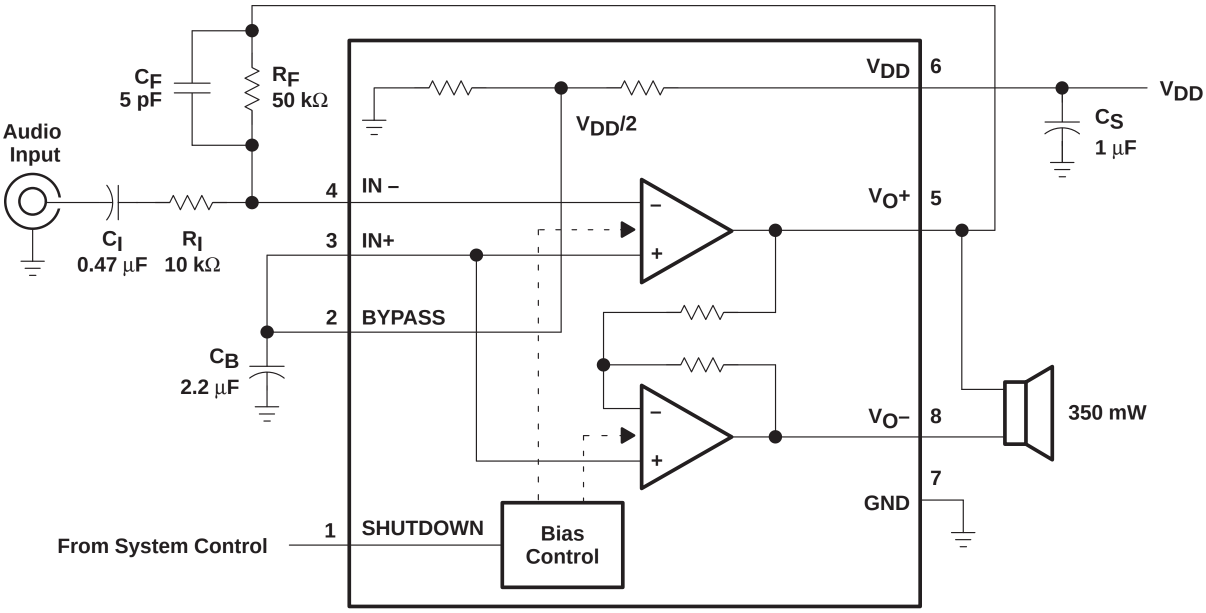


Figure 26. TPA301 Application Circuit

The following sections discuss the selection of the components used in Figure 26.

component selection

gain setting resistors, R_F and R_I

The gain for each audio input of the TPA301 is set by resistors R_F and R_I according to equation 5 for BTL mode.

$$\text{BTL Gain} = A_V = -2\left(\frac{R_F}{R_I}\right) \qquad (5)$$

BTL mode operation brings about the factor 2 in the gain equation due to the inverting amplifier mirroring the voltage swing across the load. Given that the TPA301 is a MOS amplifier, the input impedance is very high, consequently input leakage currents are not generally a concern although noise in the circuit increases as the value of R_F increases. In addition, a certain range of R_F values are required for proper start-up operation of the amplifier. Taken together it is recommended that the effective impedance seen by the inverting node of the amplifier be set between 5 kΩ and 20 kΩ. The effective impedance is calculated in equation 6.

$$\text{Effective Impedance} = \frac{R_F R_I}{R_F + R_I} \qquad (6)$$

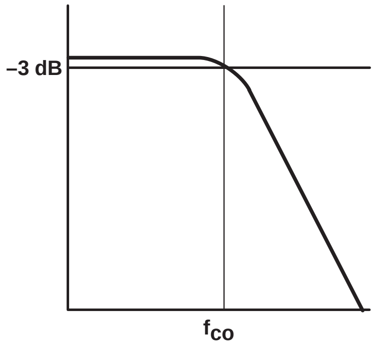
APPLICATION INFORMATION

component selection (continued)

As an example, consider an input resistance of 10 kΩ and a feedback resistor of 50 kΩ. The BTL gain of the amplifier would be –10 V/V, and the effective impedance at the inverting terminal would be 8.3 kΩ, which is well within the recommended range.

For high performance applications metal film resistors are recommended because they tend to have lower noise levels than carbon resistors. For values of R_F above 50 kΩ the amplifier tends to become unstable due to a pole formed from R_F and the inherent input capacitance of the MOS input structure. For this reason, a small compensation capacitor, C_F, of approximately 5 pF should be placed in parallel with R_F when R_F is greater than 50 kΩ. This, in effect, creates a low-pass filter network with the cutoff frequency defined in equation 7.

$$f_{co(lowpass)} = \frac{1}{2\pi R_F C_F} \qquad (7)$$

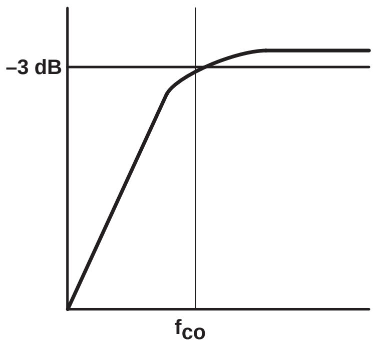


For example, if R_F is 100 kΩ and C_F is 5 pF then f_{co} is 318 kHz, which is well outside of the audio range.

input capacitor, C_I

In the typical application an input capacitor, C_I, is required to allow the amplifier to bias the input signal to the proper dc level for optimum operation. In this case, C_I and R_I form a high-pass filter with the corner frequency determined in equation 8.

$$f_{co(highpass)} = \frac{1}{2\pi R_I C_I} \qquad (8)$$



The value of C_I is important to consider as it directly affects the bass (low frequency) performance of the circuit. Consider the example where R_I is 10 kΩ and the specification calls for a flat bass response down to 40 Hz. Equation 8 is reconfigured as equation 9.

$$C_I = \frac{1}{2\pi R_I f_{co}} \qquad (9)$$

APPLICATION INFORMATION

component selection (continued)

In this example, C_I is 0.40 µF so one would likely choose a value in the range of 0.47 µF to 1 µF. A further consideration for this capacitor is the leakage path from the input source through the input network (R_I, C_I) and the feedback resistor (R_F) to the load. This leakage current creates a dc offset voltage at the input to the amplifier that reduces useful headroom, especially in high gain applications. For this reason a low-leakage tantalum or ceramic capacitor is the best choice. When polarized capacitors are used, the positive side of the capacitor should face the amplifier input in most applications, as the dc level there is held at $V_{DD}/2$, which is likely higher than the source dc level. It is important to confirm the capacitor polarity in the application.

power supply decoupling, C_S

The TPA301 is a high-performance CMOS audio amplifier that requires adequate power supply decoupling to ensure the output total harmonic distortion (THD) is as low as possible. Power supply decoupling also prevents oscillations for long lead lengths between the amplifier and the speaker. The optimum decoupling is achieved by using two capacitors of different types that target different types of noise on the power supply leads. For higher frequency transients, spikes, or digital hash on the line, a good low equivalent-series-resistance (ESR) ceramic capacitor, typically 0.1 µF, placed as close as possible to the device V_{DD} lead, works best. For filtering lower-frequency noise signals, a larger aluminum electrolytic capacitor of 10 µF or greater placed near the audio power amplifier is recommended.

midrail bypass capacitor, C_B

The midrail bypass capacitor, C_B, is the most critical capacitor and serves several important functions. During start-up or recovery from shutdown mode, C_B determines the rate at which the amplifier starts up. The second function is to reduce noise produced by the power supply caused by coupling into the output drive signal. This noise is from the midrail generation circuit internal to the amplifier, which appears as degraded PSRR and THD + N. The capacitor is fed from a 250-kΩ source inside the amplifier. To keep the start-up pop as low as possible, the relationship shown in equation 10 should be maintained, which insures the input capacitor is fully charged before the bypass capacitor is fully charged and the amplifier starts up.

$$\frac{10}{\left(C_B \times 250\ \text{k}\Omega\right)} \leq \frac{1}{\left(R_F + R_I\right)\ C_I} \qquad (10)$$

As an example, consider a circuit where C_B is 2.2 µF, C_I is 0.47 µF, R_F is 50 kΩ and R_I is 10 kΩ. Inserting these values into the equation 10 we get:

$$18.2 \leq 35.5$$

which satisfies the rule. Bypass capacitor, C_B, values of 2.2 µF to 1 µF ceramic or tantalum **low-ESR** capacitors are recommended for the best THD and noise performance.

using low-ESR capacitors

Low-ESR capacitors are recommended throughout this application. A real (as opposed to ideal) capacitor can be modeled simply as a resistor in series with an ideal capacitor. The voltage drop across this resistor minimizes the beneficial effects of the capacitor in the circuit. The lower the equivalent value of this resistance, the more the real capacitor behaves like an ideal capacitor.

APPLICATION INFORMATION

5-V versus 3.3-V operation

The TPA301 operates over a supply range of 2.5 V to 5.5 V. This data sheet provides full specifications for 5-V and 3.3-V operation, as these are considered to be the two most common standard voltages. There are no special considerations for 3.3-V versus 5-V operation with respect to supply bypassing, gain setting, or stability. The most important consideration is that of output power. Each amplifier in TPA301 can produce a maximum voltage swing of V_{DD} – 1 V. This means, for 3.3-V operation, clipping starts to occur when $V_{O(PP)}$ = 2.3 V as opposed to $V_{O(PP)}$ = 4 V at 5 V. The reduced voltage swing subsequently reduces maximum output power into an 8-Ω load before distortion becomes significant.

Operation from 3.3-V supplies, as can be shown from the efficiency formula in equation 4, consumes approximately two-thirds the supply power for a given output-power level than operation from 5-V supplies.

headroom and thermal considerations

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. From the TPA301 data sheet, one can see that when the TPA301 is operating from a 5-V supply into a 8-Ω speaker 350 mW peaks are available. Converting watts to dB:

$$P_{dB} = 10 \text{Log} P_W = 10 \text{Log}\ 3500\ \text{mW} = -4.6\ \text{dB}$$

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

$$-4.6\ \text{dB} - 15\ \text{dB} = -19.6\ \text{dB}\ (15\ \text{dB headroom})$$
$$-4.6\ \text{dB} - 12\ \text{dB} = -16.6\ \text{dB}\ (12\ \text{dB headroom})$$
$$-4.6\ \text{dB} - 9\ \text{dB} = -13.6\ \text{dB}\ (9\ \text{dB headroom})$$
$$-4.6\ \text{dB} - 6\ \text{dB} = -10.6\ \text{dB}\ (6\ \text{dB headroom})$$
$$-4.6\ \text{dB} - 3\ \text{dB} = -7.6\ \text{dB}\ (3\ \text{dB headroom})$$

Converting dB back into watts:

$$P_W = 10^{PdB/10}$$
$$= 11\ \text{mW}\ (15\ \text{dB headroom})$$
$$= 22\ \text{mW}\ (12\ \text{dB headroom})$$
$$= 44\ \text{mW}\ (9\ \text{dB headroom})$$
$$= 88\ \text{mW}\ (6\ \text{dB headroom})$$
$$= 175\ \text{mW}\ (3\ \text{dB headroom})$$

APPLICATION INFORMATION

headroom and thermal considerations (continued)

This is valuable information to consider when attempting to estimate the heat dissipation requirements for the amplifier system. Comparing the absolute worst case, which is 350 mW 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 5-V, 8-Ω system, the internal dissipation in the TPA301 and maximum ambient temperatures is shown in Table 2.

Table 2. TPA301 Power Rating, 5-V, 8-Ω, BTL

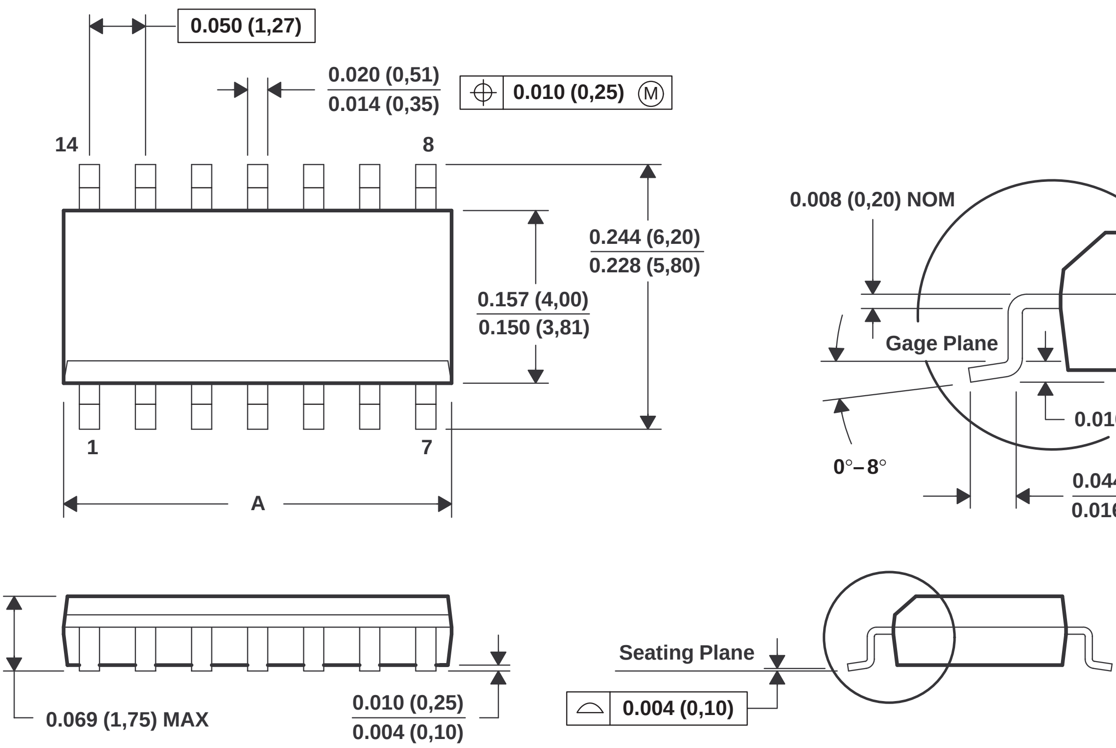
PEAK OUTPUT POWER (mW)	AVERAGE OUTPUT POWER	POWER DISSIPATION (mW)	MAXIMUM AMBIENT TEMPERATURE
			0 CFM
350	350 mW	600	46°C
350	175 mW (3 dB)	500	64°C
350	88 mW (6 dB)	380	85°C
350	44 mW (9 dB)	300	98°C
350	22 mW (12 dB)	200	115°C
350	11 mW (15 dB)	180	119°C

Table 2 shows that the TPA301 can be used to its full 350-mW rating without any heat sinking in still air up to 46°C.

MECHANICAL DATA

D (R-PDSO-G)** **PLASTIC SMALL-OUTLINE PACKAGE**

14 PINS SHOWN



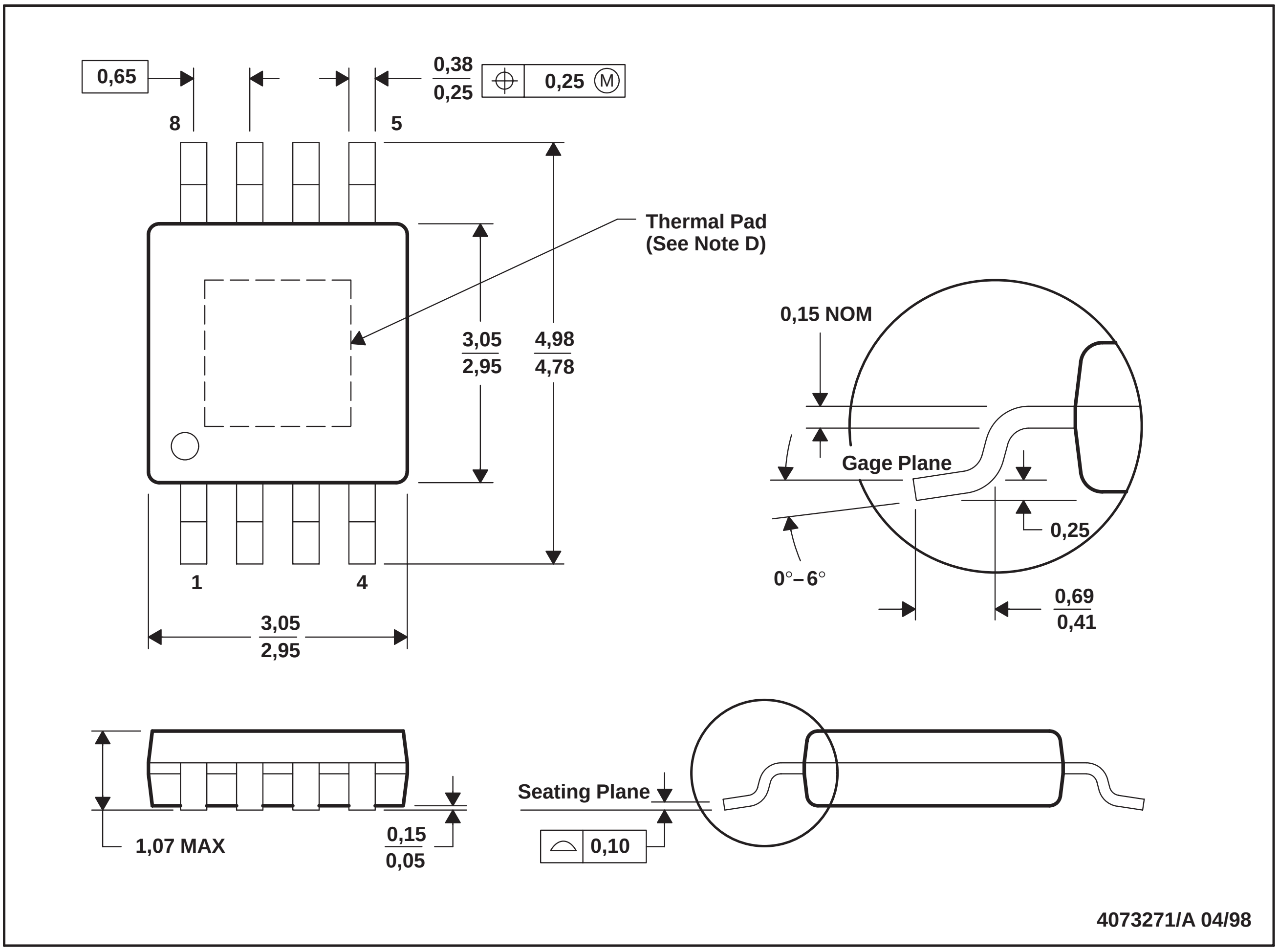
DIM \ PINS **	8	14	16
A MAX	0.197 (5,00)	0.344 (8,75)	0.394 (10,00)
A MIN	0.189 (4,80)	0.337 (8,55)	0.386 (9,80)

4040047/D 10/96

NOTES: A. All linear dimensions are in inches (millimeters).
B. This drawing is subject to change without notice.
C. Body dimensions do not include mold flash or protrusion, not to exceed 0.006 (0,15).
D. Falls within JEDEC MS-012

MECHANICAL DATA

DGN (S-PDSO-G8) **PowerPAD™ PLASTIC SMALL-OUTLINE PACKAGE**



NOTES: A. All linear dimensions are in millimeters.
B. This drawing is subject to change without notice.
C. Body dimensions include mold flash or protrusions.
D. The package thermal performance may be enhanced by attaching an external heat sink to the thermal pad. This pad is electrically and thermally connected to the backside of the die and possibly selected leads.
E. Falls within JEDEC MO-187

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