

FEATURES

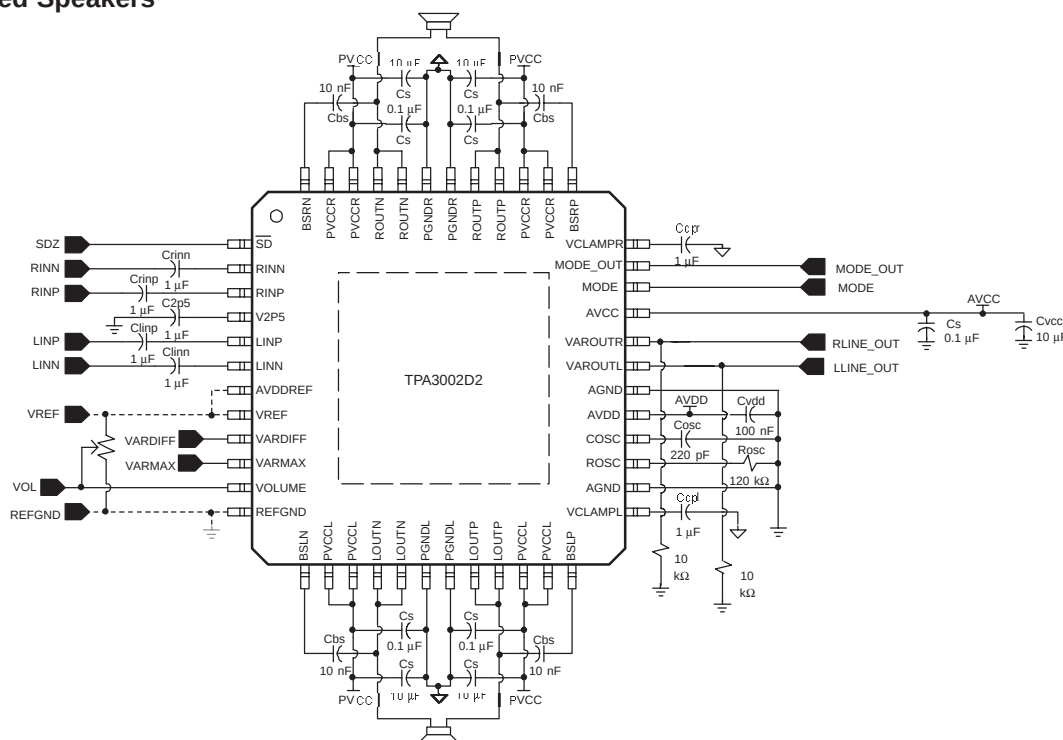
- 9-W/Ch Into an 8- Ω Load From 12-V Supply
- Efficient, Class-D Operation Eliminates Heatsinks and Reduces Power Supply Requirements
- 32-Step DC Volume Control From -40 dB to 36 dB
- Line Outputs For External Headphone Amplifier With Volume Control
- Regulated 5-V Supply Output for Powering TPA6110A2
- Space-Saving, Thermally-Enhanced PowerPAD™ Packaging
- Thermal and Short-Circuit Protection

The TPA3002D2 is a 9-W (per channel) efficient, Class-D audio amplifier for driving bridged-tied stereo speakers. The TPA3002D2 can drive stereo speakers as low as 8 Ω . The high efficiency of the TPA3002D2 eliminates the need for external heatsinks when playing music.

Stereo speaker volume is controlled with a dc voltage applied to the volume control terminal offering a range of gain from -40 dB to 36 dB. Line outputs, for driving external headphone amplifier inputs, are also dc voltage controlled with a range of gain from -56 dB to 20 dB.

An integrated 5-V regulated supply is provided for powering an external headphone amplifier.

- LCD Monitors and TVs
- Powered Speakers



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TPA3002D2

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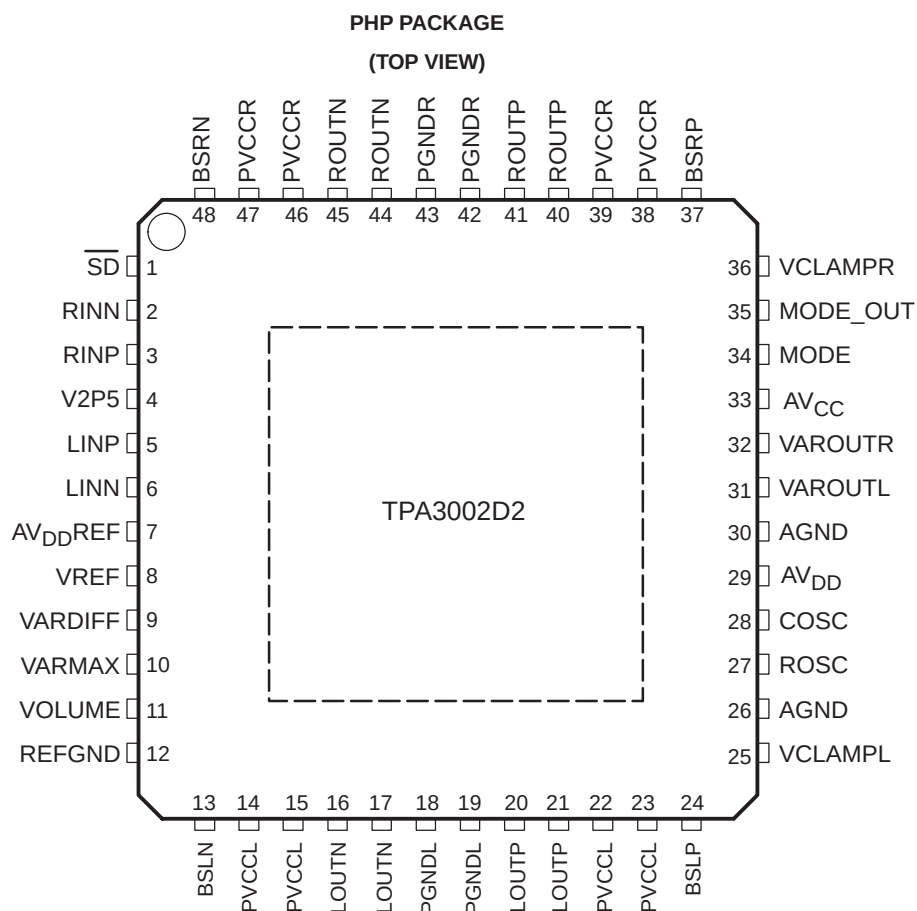
These devices have limited built-in ESD protection. The leads should be shorted together or the device placed in conductive foam during storage or handling to prevent electrostatic damage to the MOS gates.

AVAILABLE OPTIONS

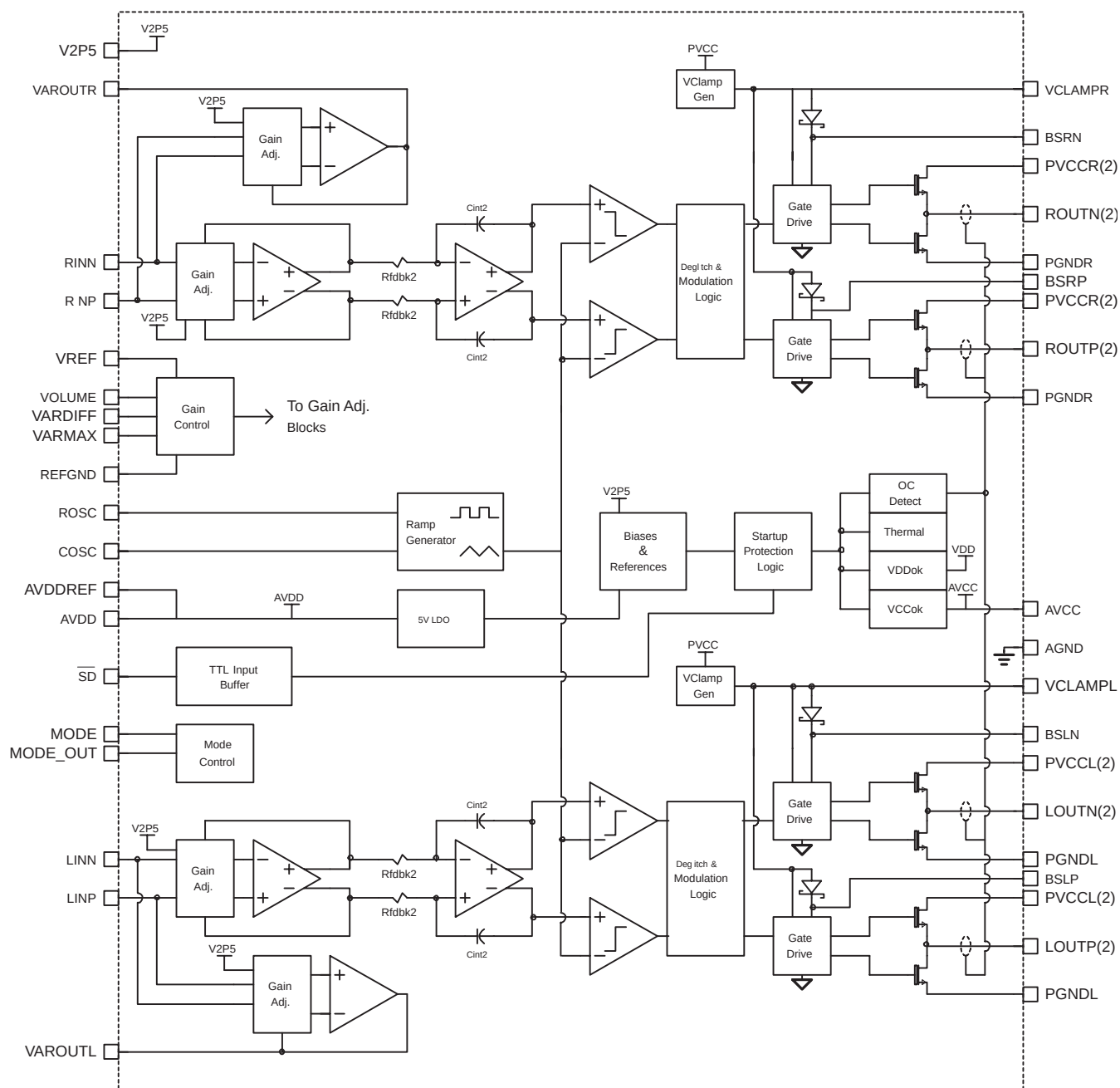
T _A	PACKAGED DEVICE
	48-PIN HTQFP (PHP) ⁽¹⁾
–40°C to 85°C	TPA3002D2PHP

⁽¹⁾ The PHP package is available taped and reeled. To order a taped and reeled part, add the suffix R to the part number (e.g., TPA3002D2PHPR).

PIN ASSIGNMENTS



FUNCTIONAL BLOCK DIAGRAM



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Terminal Functions

TERMINAL NO.	NAME	I/O	DESCRIPTION
AGND	26, 30	–	Analog ground for digital/analog cells in core
AV _{CC}	33	–	High-voltage analog power supply (8.5 V to 14 V)
AV _{DD}	29	O	5-V Regulated output capable of 100-mA output
AV _{DD} REF	7	O	5-V Reference output—provided for connection to adjacent VREF terminal.
BSLN	13	I/O	Bootstrap I/O for left channel, negative high-side FET
BSLP	24	I/O	Bootstrap I/O for left channel, positive high-side FET
BSRN	48	I/O	Bootstrap I/O for right channel, negative high-side FET
BSRP	37	I/O	Bootstrap I/O for right channel, positive high-side FET
COSC	28	I/O	I/O for charge/discharging currents onto capacitor for ramp generator triangle wave biased at V2P5
LINN	6	I	Negative differential audio input for left channel
LINP	5	I	Positive differential audio input for left channel
LOUTN	16, 17	O	Class-D 1/2-H-bridge negative output for left channel
LOUTP	20, 21	O	Class-D 1/2-H-bridge positive output for left channel
MODE	34	I	Input for MODE control. A logic high on this pin places the amplifier in the variable output mode and the Class-D outputs are disabled. A logic low on this pin places the amplifier in the Class-D mode and Class-D stereo outputs are enabled. Variable outputs (VAROUTL and VAROUTR) are still enabled in Class-D mode to be used as line-level outputs for external amplifiers.
MODE_OUT	35	O	Output for control of the variable output amplifiers. When the MODE pin (34) is a logic high, the MODE_OUT pin is driven low. When the MODE pin (34) is a logic low, the MODE_OUT pin is driven high. This pin is intended for MUTE control of an external headphone amplifier. Leave unconnected when not used for headphone amplifier control.
PGNDL	18, 19	–	Power ground for left channel H-bridge
PGNDR	42, 43	–	Power ground for right channel H-bridge
PVCCL	14, 15	–	Power supply for left channel H-bridge (tied to pins 22 and 23 internally), not connected to PVCCR or AV _{CC} .
PVCCL	22, 23	–	Power supply for left channel H-bridge (tied to pins 14 and 15 internally), not connected to PVCCR or AV _{CC} .
PVCCR	38, 39	–	Power supply for right channel H-bridge (tied to pins 46 and 47 internally), not connected to PVCCL or AV _{CC} .
PVCCR	46, 47	–	Power supply for right channel H-bridge (tied to pins 38 and 39 internally), not connected to PVCCL or AV _{CC} .
REFGND	12	–	Ground for gain control circuitry. Connect to AGND. If using a DAC to control the volume, connect the DAC ground to this terminal.
RINP	3	I	Positive differential audio input for right channel
RINN	2	I	Negative differential audio input for right channel
ROSC	27	I/O	Current setting resistor for ramp generator. Nominally equal to 1/8*V _{CC}
ROUTN	44, 45	O	Class-D 1/2-H-bridge negative output for right channel
ROUTP	40, 41	O	Class-D 1/2-H-bridge positive output for right channel
SD	1	I	Shutdown signal for IC (low = shutdown, high = operational). TTL logic levels with compliance to V _{CC} .
VARDIFF	9	I	DC voltage to set the difference in gain between the Class-D and VAROUT outputs. Connect to GND or AV _{DD} REF if VAROUT outputs are unconnected.
VARMAX	10	I	DC voltage that sets the maximum gain for the VAROUT outputs. Connect to GND or AV _{DD} REF if VAROUT outputs are unconnected.
VAROUTL	31	O	Variable output for left channel audio. Line level output for driving external HP amplifier.
VAROUTR	32	O	Variable output for right channel audio. Line level output for driving external HP amplifier.
VCLAMPL	25	–	Internally generated voltage supply for left channel bootstrap capacitors.
VCLAMPR	36	–	Internally generated voltage supply for right channel bootstrap capacitors.
VOLUME	11	I	DC voltage that sets the gain of the Class-D and VAROUT outputs.
VREF	8	I	Analog reference for gain control section.
V2P5	4	O	2.5-V Reference for analog cells, as well as reference for unused audio input when using single-ended inputs.
—	Thermal Pad	–	Connect to AGND and PGND—should be center point for both grounds.

ABSOLUTE MAXIMUM RATINGS

over operating free-air temperature range unless otherwise noted⁽¹⁾

		UNIT
Supply voltage range:	AV _{CC} , PV _{CC}	–0.3 V to 15 V
Input voltage range, V _I	MODE, VREF, VARDIFF, VARMAX, VOLUME	0 V to 5.5 V
	SD	–0.3 V to V _{CC} + 0.3 V
	RINN, RINP, LINN, LINP	–0.3 V to 7 V
Supply current	AV _{DD}	120 mA
	AV _{DD} REF	10 mA
Output current, VAROUTL, VAROUTR		20 mA
Continuous total power dissipation		See Dissipation Rating Table
Operating free-air temperature range, T _A		–40°C to 85°C
Operating junction temperature range, T		–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

⁽¹⁾ 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.

PACKAGE DISSIPATION RATINGS

PACKAGE	T _A ≤ 25°C	DERATING FACTOR	T _A = 70°C	T _A = 85°C
PHP	4.3 W	34.7 mW/°C ⁽¹⁾	2.7 W	2.2 W

⁽¹⁾ The PowerPAD must be soldered to a thermal land on the printed circuit board. Please refer to the *PowerPAD Thermally Enhanced Package* application note (SLMA002).

RECOMMENDED OPERATING CONDITIONS

		MIN	MAX	UNIT
Supply voltage, V _{CC}	PV _{CC} , AV _{CC}	8.5	14	V
Volume reference voltage	VREF	3.0	5.5	V
Volume control pins, input voltage	VARDIFF, VARMAX, VOLUME		5.5	V
High-level input voltage, V _{IH}	SD	2		V
	MODE	3.5		
Low-level input voltage, V _{IL}	SD		0.8	V
	MODE		2	
High-level output voltage, V _{OH}	MODE_OUT, I _{OH} = 1 mA	AV _{DD} –100mV		V
Low-level output voltage, V _{OL}	MODE_OUT, I _{OL} = –1 mA	AGND+100mV		V
High-level input current, I _{IH}	MODE, V _I = 5 V, V _{CC} = 14 V		1	μA
	SD, V _I = 14 V, V _{CC} = 14 V		30	μA
Low-level input current, I _{IL}	MODE, V _I = 0 V, V _{CC} = 14 V		1	μA
	SD, V _I = 0 V, V _{CC} = 14 V		1	μA
Oscillator frequency, f _{OSC}		225	275	kHz
Operating free-air temperature, T _A		–40	85	°C

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DC ELECTRICAL CHARACTERISTICS

$T_A = 25^\circ\text{C}$, $V_{CC} = 12\text{ V}$, $R_L = 8\ \Omega$ (unless otherwise noted)

PARAMETER		TEST CONDITIONS	MIN	TYP	MAX	UNIT
$ V_{OS} $	Class-D Output offset voltage (measured differentially)	INN and INP connected together, Gain = 36 dB		10	65	mV
V2P5 (terminal 4)	2.5-V Bias voltage	No load	0.45x AV_{DD}	0.5x AV_{DD}	0.55x AV_{DD}	V
AV_{DD}	5-V Regulated output	$I_O = 0$ to 100 mA, $\overline{SD} = 2\text{ V}$, $V_{CC} = 8\text{ V}$ to 14 V	4.5	5.0	5.5	V
PSRR	Class-D power supply rejection ratio	$V_{CC} = 11.5\text{ V}$ to 12.5 V		-80		dB
$I_{CC}(\text{class-D})$	Class-D mode quiescent current	MODE = 2 V, $\overline{SD} = 2\text{ V}$		16	28.5	mA
$I_{CC}(\text{varout})$	Variable output mode quiescent current	MODE = 3.5 V, $\overline{SD} = 2\text{ V}$		7	9	mA
$I_{CC}(\text{class-D} - \text{max power})$	Class-D mode RMS current at max power	$R_L = 8\ \Omega$, $P_O = 9\text{ W}$		2		A
$I_{CC}(\overline{SD})$	Supply current in shutdown mode	$\overline{SD} = 0.8\text{ V}$		1	10	μA
$r_{ds(on)}$	Drain-source on-state resistance	$V_{CC} = 12\text{ V}$, $I_O = 1\text{ A}$, $T_J = 25^\circ\text{C}$ High side		300		m Ω
		Low side		250		
		Total		550	590	

AC ELECTRICAL CHARACTERISTICS FOR CLASS-D OUTPUTS

$T_A = 25^\circ\text{C}$, $V_{CC} = 12\text{ V}$, $R_L = 8\ \Omega$ (unless otherwise noted)

PARAMETER		TEST CONDITIONS	MIN	TYP	MAX	UNITS
k_{SVR}	Supply ripple rejection ratio	$V_{CC} = 11.5\text{ V}$ to 12.5 V from 10 Hz to 1 kHz, Gain = 36 dB		-67		dB
P_O	Continuous output power	THD+N = 1%, $f = 1\text{ kHz}$, $R_L = 8\ \Omega$		7.5		W
		THD+N = 10%, $f = 1\text{ kHz}$, $R_L = 8\ \Omega$		9		W
V_n	Output integrated noise floor	20 Hz to 22 kHz, No filter, Gain = 0.5 dB		79		μV
				-82		dBV
		20 Hz to 22 kHz, A-weighted filter, Gain = 13.2 dB		100		μV
				-80		dBV
	Crosstalk, Class-D-Left $\rightarrow$ Class-D-Right	Gain = 13.2 dB, $P_O = 1\text{ W}$, $R_L = 8\ \Omega$		-77		dB
	Crosstalk, Class-D $\rightarrow$ VAROUT	Maximum output at THD < 0.5%, Gain = 36 dB		-63		dB
SNR	Signal-to-noise ratio	Maximum output at THD+N < 0.5%, $f = 1\text{ kHz}$, Gain = 36 dB		96		dB
	Thermal trip point			150		$^\circ\text{C}$
	Thermal hysteresis			20		$^\circ\text{C}$

CHARACTERISTICS FOR VAROUT OUTPUTS

PARAMETER		TEST CONDITIONS	MIN	TYP	MAX	UNITS
$ V_{OS} $	Output offset voltage	Measured between V2P5 and VAROUT, Gain = 20 dB, $R_L = 10\text{ k}\Omega$		10		mV
THD+N	Total harmonic distortion + noise	$A_V = 7.3\text{ dB}$, $f = 1\text{ kHz}$, $P_O = 6\text{ mW}$, $R_L = 32\ \Omega$		0.025%		
		$A_V = 7.3\text{ dB}$, $f = 1\text{ kHz}$, $R_L = 2\text{ k}\Omega$, $V_O = 1\text{ V}_{rms}$		0.002%		
PSRR	DC power supply rejection ratio	Gain = 20 dB		-74		dB
k_{SVR}	Supply ripple rejection ratio	Gain = 20 dB, $f = 1\text{ kHz}$		-95		dB
	Crosstalk, VAROUTL $\rightarrow$ VAROUTR	Maximum output at THD < 0.5%, Gain = 20 dB		-60		dB
	Crosstalk, VAROUT $\rightarrow$ Class-D	Maximum output at THD < 0.5%, Gain = 20 dB		-74		dB
V_n	Output integrated noise floor	20 Hz to 22 kHz, Gain = 20 dB		75		μV
		20 Hz to 22 kHz, Gain = -0.3 dB		15		

Table 1. DC Volume Control for Class-D Outputs

VOLTAGE ON THE VOLUME PIN AS A PERCENTAGE OF VREF (INCREASING VOLUME OR FIXED GAIN)	VOLTAGE ON THE VOLUME PIN AS A PERCENTAGE OF VREF (DECREASING VOLUME)	GAIN OF CLASS-D AMPLIFIER
%	%	dB
0 – 4.5	0 – 2.9	–75 ⁽¹⁾
4.5 – 6.7	2.9 – 5.1	–40.0
6.7 – 8.91	5.1 – 7.2	–37.5
8.9 – 11.1	7.2 – 9.4	–35.0
11.1 – 13.3	9.4 – 11.6	–32.4
13.3 – 15.5	11.6 – 13.8	–29.9
15.5 – 17.7	13.8 – 16.0	–27.4
17.7 – 19.9	16.0 – 18.2	–24.8
19.9 – 22.1	18.2 – 20.4	–22.3
22.1 – 24.3	20.4 – 22.6	–19.8
24.3 – 26.5	22.6 – 24.8	–17.2
26.5 – 28.7	24.8 – 27.0	–14.7
28.7 – 30.9	27.0 – 29.1	–12.2
30.9 – 33.1	29.1 – 31.3	–9.6
33.1 – 35.3	31.3 – 33.5	–7.1
35.3 – 37.5	33.5 – 35.7	–4.6
37.5 – 39.7	35.7 – 37.9	–2.0
39.7 – 41.9	37.9 – 40.1	0.5 [†]
41.9 – 44.1	40.1 – 42.3	3.1
44.1 – 46.4	42.3 – 44.5	5.6
46.4 – 48.6	44.5 – 46.7	8.1
48.6 – 50.8	46.7 – 48.9	10.7
50.8 – 53.0	48.9 – 51.0	13.2
53.0 – 55.2	51.0 – 53.2	15.7
55.2 – 57.4	53.2 – 55.4	18.3
57.4 – 59.6	55.4 – 57.6	20.8
59.6 – 61.8	57.6 – 59.8	23.3
61.8 – 64.0	59.8 – 62.0	25.9
64.0 – 66.2	62.0 – 64.2	28.4
66.2 – 68.4	64.2 – 66.4	30.9
68.4 – 70.6	66.4 – 68.6	33.5
> 70.6	>68.6	36.0 ⁽¹⁾

⁽¹⁾ Tested in production. Remaining steps are specified by design.

Table 2. DC Volume Control for VAROUT Outputs

VAROUT_VOLUME (V) – FROM FIGURE 35 – AS A PERCENTAGE OF VREF (INCREASING VOLUME OR FIXED GAIN)	VAROUT_VOLUME (V) – FROM FIGURE 35 – AS A PERCENTAGE OF VREF (DECREASING VOLUME)	GAIN OF VAROUT AMPLIFIER
%	%	dB
0 – 4.5	0 – 2.9	–66 ⁽¹⁾
4.5 – 6.7	2.9 – 5.1	–56.0
6.7 – 8.91	5.1 – 7.2	–53.5
8.9 – 11.1	7.2 – 9.4	–50.9
11.1 – 13.3	9.4 – 11.6	–48.4
13.3 – 15.5	11.6 – 13.8	–45.9
15.5 – 17.7	13.8 – 16.0	–43.3
17.7 – 19.9	16.0 – 18.2	–40.8
19.9 – 22.1	18.2 – 20.4	–38.3
22.1 – 24.3	20.4 – 22.6	–35.7
24.3 – 26.5	22.6 – 24.8	–33.2
26.5 – 28.7	24.8 – 27.0	–30.7
28.7 – 30.9	27.0 – 29.1	–28.1
30.9 – 33.1	29.1 – 31.3	–25.6
33.1 – 35.3	31.3 – 33.5	–23.1
35.3 – 37.5	33.5 – 35.7	–20.5
37.5 – 39.7	35.7 – 37.9	–18.0
39.7 – 41.9	37.9 – 40.1	–15.5
41.9 – 44.1	40.1 – 42.3	–13.0 ⁽¹⁾
44.1 – 46.4	42.3 – 44.5	–10.4
46.4 – 48.6	44.5 – 46.7	–7.9
48.6 – 50.8	46.7 – 48.9	–5.3
50.8 – 53.0	48.9 – 51.0	–2.8
53.0 – 55.2	51.0 – 53.2	–0.3
55.2 – 57.4	53.2 – 55.4	2.3
57.4 – 59.6	55.4 – 57.6	4.8
59.6 – 61.8	57.6 – 59.8	7.3
61.8 – 64.0	59.8 – 62.0	9.9
64.0 – 66.2	62.0 – 64.2	12.4
66.2 – 68.4	64.2 – 66.4	14.9
68.4 – 70.6	66.4 – 68.6	17.5
> 70.6	>68.6	20.0 ⁽¹⁾

(1) Tested in production. Remaining steps are specified by design.

TYPICAL CHARACTERISTICS

TABLE OF GRAPHS

			FIGURE
	Class-D Efficiency	vs Output power	1
P _O	Class-D Output power	vs Load resistance	2
		vs Supply voltage	3
I _{CC}	Class-D Supply current	vs Supply voltage	4
		vs Output Power	5
I _{O(sd)}	Shutdown supply current	vs Supply voltage	6
	Class-D Input resistance	vs Gain	7
THD+N	Class-D Total harmonic distortion + noise	vs Frequency	8, 9
		vs Output power	10, 11
k _{SVR}	Class-D Supply ripple rejection ratio	vs Frequency	12
	Class-D Closed loop response		13
	Class-D Intermodulation performance		14
	Class-D Input offset voltage	vs Common-mode input voltage	15
	Class-D Crosstalk	vs Frequency	16
	Class-D Mute attenuation	vs Frequency	17
	Class-D Shutdown attenuation		18
	Class-D Common-mode rejection ratio	vs Frequency	19
	VAROUT Input resistance	vs Gain	20
	VAROUT Noise	vs Frequency	21
	VAROUT Closed Loop Response		22
	VAROUT Common-mode rejection ratio	vs Frequency	23
	VAROUT Crosstalk	vs Frequency	24
THD+N	VAROUT Total harmonic distortion + noise	vs Output power	25
		vs Output voltage	26
		vs Frequency	27
k _{SVR}	VAROUT Supply ripple rejection ratio	vs Frequency	28

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**EFFICIENCY
vs
OUTPUT POWER**

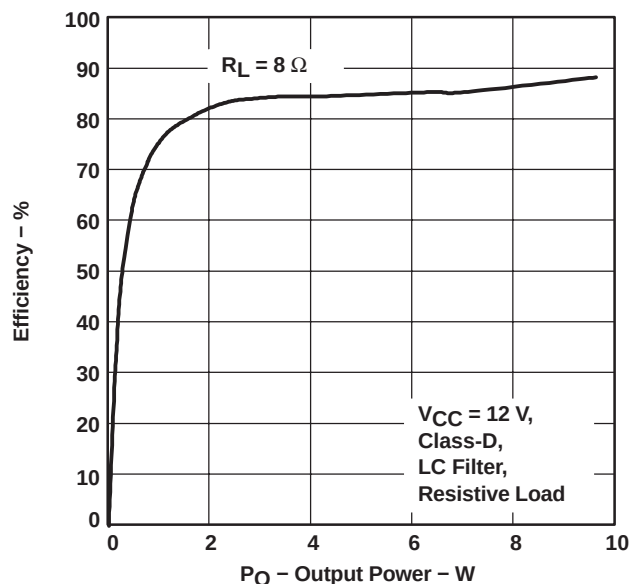


Figure 1

**OUTPUT POWER
vs
LOAD RESISTANCE**

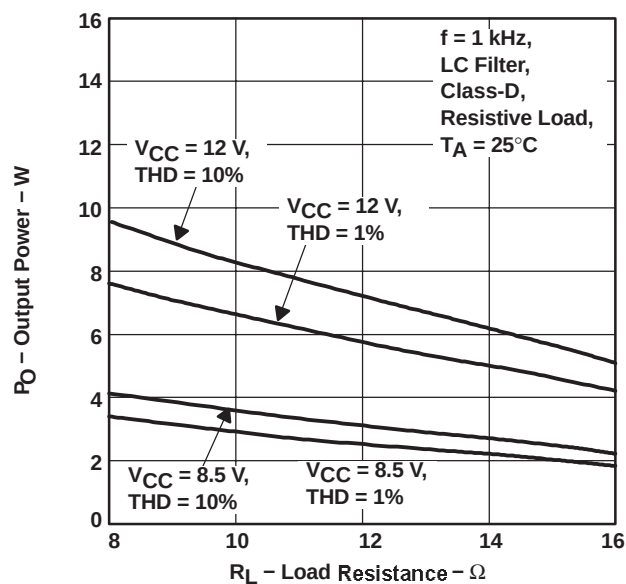


Figure 2

**OUTPUT POWER
vs
SUPPLY VOLTAGE**

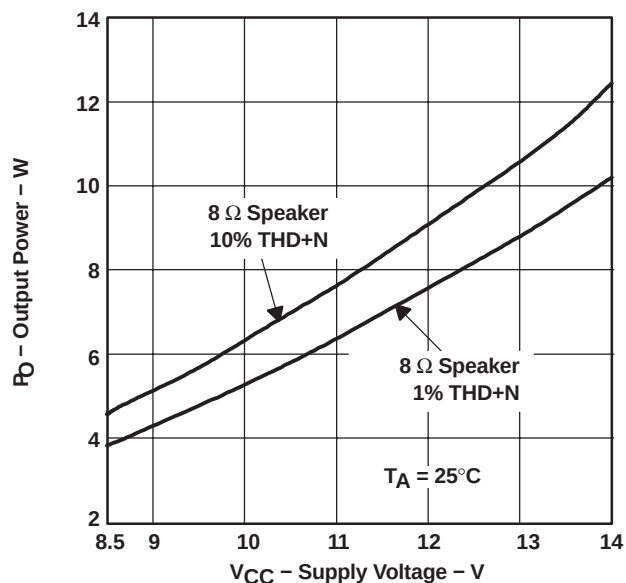


Figure 3

**SUPPLY CURRENT
vs
SUPPLY VOLTAGE**

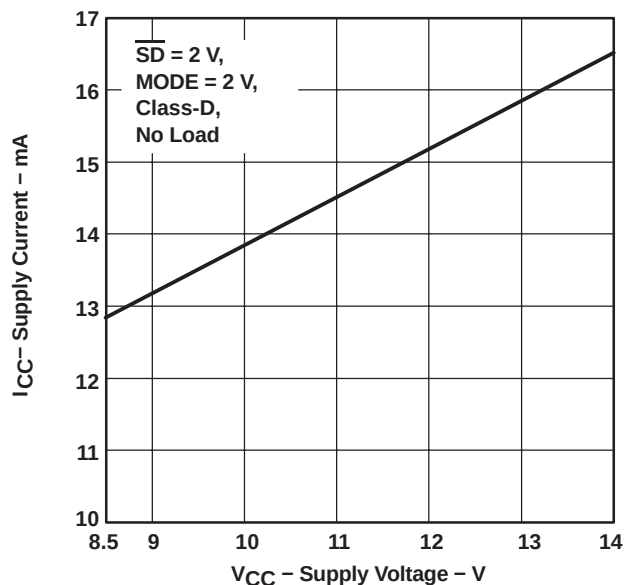


Figure 4

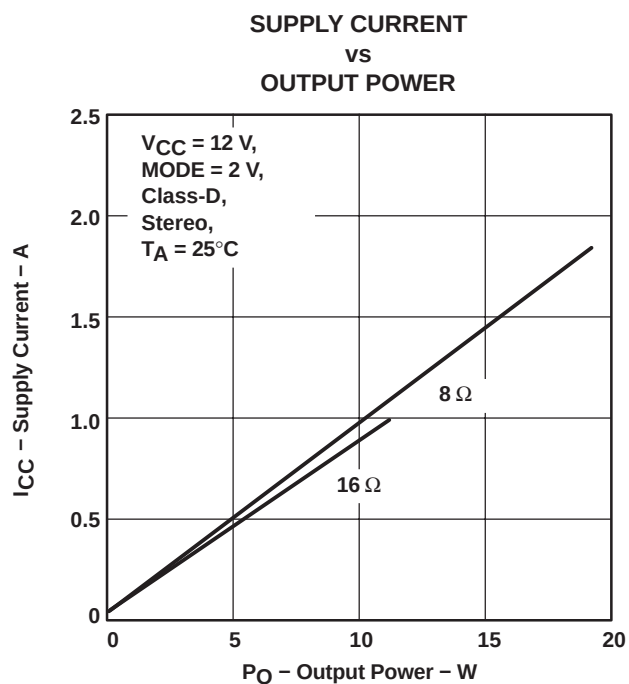


Figure 5

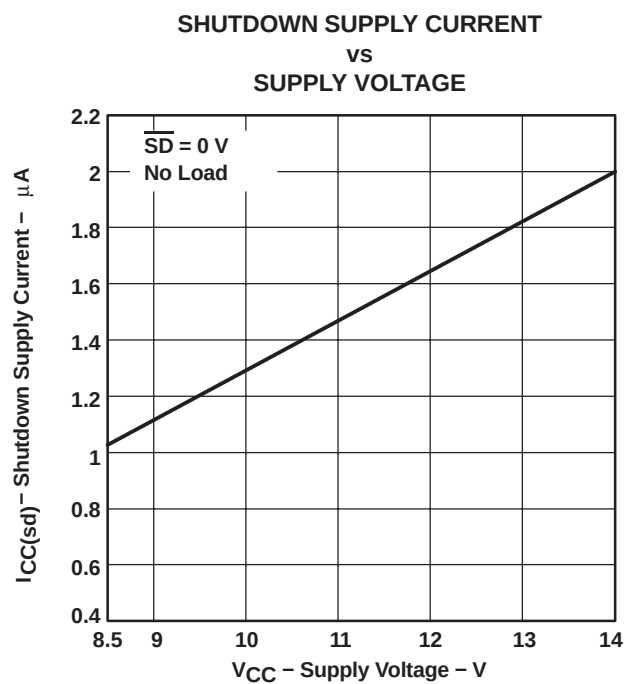


Figure 6

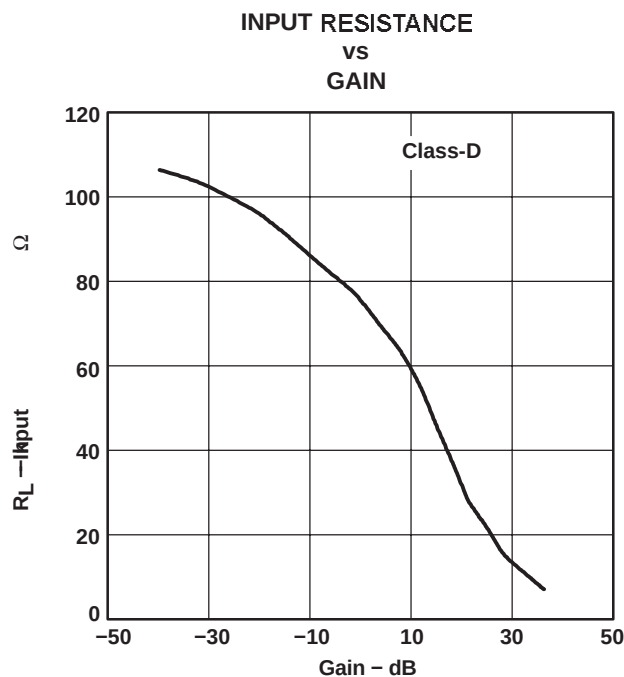


Figure 7

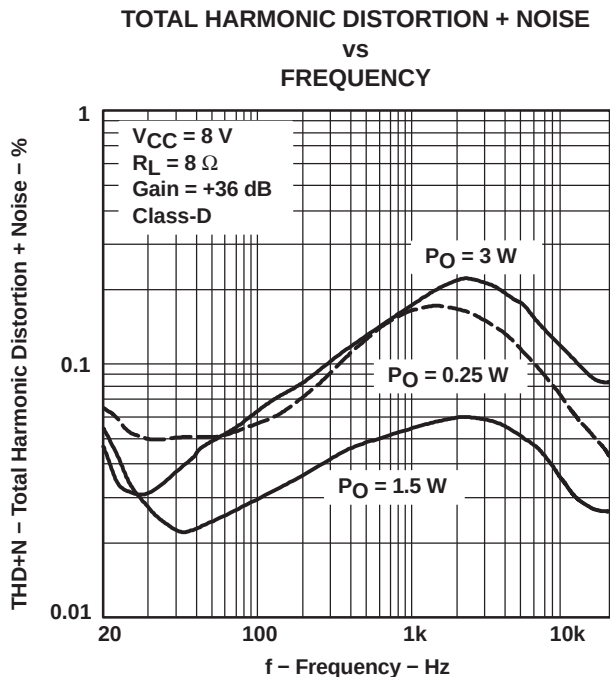


Figure 8

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