



# TS4982

## 2 W stereo audio power amplifier with ground-referenced headphone driver

### Features

- 2 W output power into 4  $\Omega$  load per channel
- 125 mW into 16  $\Omega$  load ground-referenced stereo headphone driver
- Four-step gain settings on speaker path
- 3 levels of 3D effect on speaker path
- PC-beep input system detection
- $\pm 8$  kV HBM ESD-protected headphone outputs
- Pop and click reduction circuitry
- 32-pin 5 x 5 mm QFN package
- Thermal shutdown and output short-circuit protection<sup>(a)</sup>

### Applications

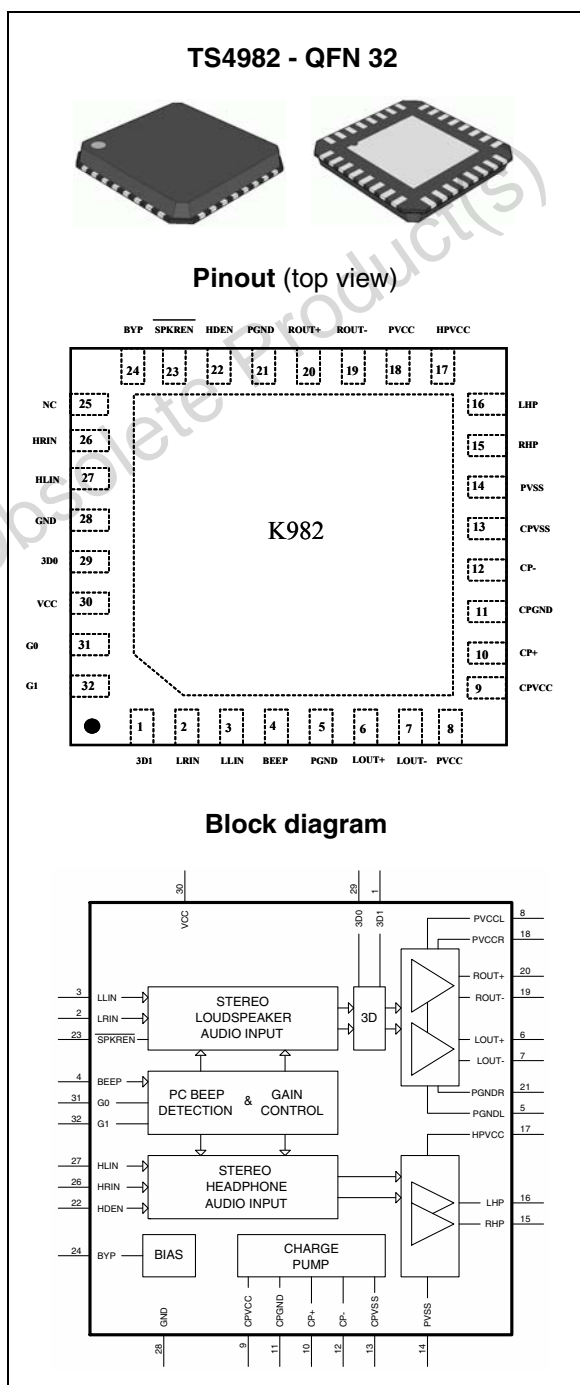
- Laptop/notebook computers
- Portable audio devices

### Description

The TS4982 features a stereo loudspeaker driver and a ground-referenced stereo headphone driver. An independent standby mode pin allows the TS4982 to simultaneously drive both output drivers. Operating on a single 5 V supply, the TS4982 delivers 2 W (typ.) output power into a 4  $\Omega$  load at 1% THD+N.

The TS4982 features a PC beep input, three levels of 3D stereo enhancement and 4-step gain control using two digital input pins. Minimum external components make the TS4982 well-suited for notebook and other hand-held sound equipment. It also has an internal thermal shutdown (150° C) and output short circuit protection mechanism.

a. Patented US#: 2009/0102561, EP#: 1978636



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# 1 Absolute maximum ratings and operating conditions

**Table 1. Absolute maximum ratings**

Symbol	Parameter	Value	Unit
V <sub>CC</sub> PV <sub>CCL</sub> PV <sub>CCR</sub> HPV <sub>CC</sub> CPV <sub>CC</sub>	Supply voltage <sup>(1)</sup>	6	V
V <sub>in</sub>	Input voltage Loudspeaker inputs Headphone inputs V <sub>H DEN</sub> = V <sub>IH</sub> V <sub>H DEN</sub> = V <sub>IL</sub>	-0.3 to V <sub>CC</sub> + 0.3  -3 to 3 -0.3 to V <sub>CC</sub> + 0.3	V
T <sub>oper</sub>	Operating free-air temperature range	-40 to + 85	°C
T <sub>stg</sub>	Storage temperature	-65 to +150	°C
T <sub>j</sub>	Maximum junction temperature	150	°C
R <sub>thja</sub>	Thermal resistance junction to ambient <sup>(2)</sup>	80	°C/W
P <sub>d</sub>	Power dissipation	Internally limited <sup>(3)</sup>	
ESD	HBM: human body model All pins except headphone outputs <sup>(4)</sup> Headphone output pins (LHP, RHP) <sup>(5)</sup>	2 8	kV
	MM: machine model <sup>(6)</sup>	200	V
	CDM: charged device model <sup>(7)</sup>	1500	V
Latch-up	Latch-up immunity	200	mA
	Lead temperature (soldering, 10 sec)	260	°C

- All voltage values are measured with respect to the ground pin.
- Device is protected in case of over-temperature by a thermal shutdown active at 150° C.
- Exceeding the power derating curves during a long period can cause abnormal operation.
- Human body model: a 100 pF capacitor is charged to the specified voltage, then discharged through a 1.5 kΩ resistor between two pins of the device. This is done for all couples of connected pin combinations while the other pins are floating.
- Human body model: a 100 pF capacitor is charged to the specified voltage, then discharged through a 1.5 kΩ resistor between two pins of the device. This is done between headphone output pins, between headphone output pins and V<sub>CC</sub>, GND. The other pins are floating.
- Machine model: a 200 pF capacitor is charged to the specified voltage, then discharged directly between two pins of the device with no external series resistor (internal resistor < 5 Ω). This is done for all couples of connected pin combinations while the other pins are floating.
- Charged device model: all pins and package are charged together to the specified voltage and then discharged directly to ground through only one pin.

**Table 2. Operating conditions**

Symbol	Parameter	Value	Unit
V <sub>CC</sub> PV <sub>CCL</sub> PV <sub>CCR</sub>	Common power supply voltage <sup>(1)</sup> Left channel loudspeaker amplifier power supply Right channel loudspeaker amplifier power supply	4.5 to 5.5	V
HPV <sub>CC</sub> CPV <sub>CC</sub>	Headphone supply voltage <sup>(2)</sup> Negative charge pump supply voltage	3 to V <sub>CC</sub>	V
R <sub>L</sub>	Load resistor Speaker output Headphone output	≥ 4 ≥ 16	Ω
T <sub>oper</sub>	Operating free-air temperature range	-40 to +85	°C
V <sub>IH</sub>	High-level input voltage 3D0, 3D1, G0, G1, HDEN, SPKREN pin <sup>(3)</sup>	2.0 ≤ V <sub>IH</sub> ≤ V <sub>CC</sub>	V
V <sub>IL</sub>	Low-level input voltage 3D0, 3D1, G0, G1, HDEN, SPKREN pin <sup>(3)</sup>	GND ≤ V <sub>IL</sub> ≤ 0.8	V
R <sub>thja</sub>	Thermal resistance junction to ambient <sup>(4)</sup>	25	°C/W

1. V<sub>CC</sub>, PV<sub>CCL</sub> and PV<sub>CCR</sub> must be shorted or at the same voltage.
2. HPV<sub>CC</sub> and CPV<sub>CC</sub> must be shorted or at the same voltage.
3. Any digital pins (3D0, 3D1, G0, G1, SPKREN, HDEN) must not be left floating.
4. With 4-layer PCB.

**Table 3. Operating modes**

SPKREN	HDEN	V <sub>SPKREN</sub>	V <sub>HDEN</sub>	Speaker amplifier	Headphone amplifier
0	0	V <sub>IL</sub>	V <sub>IL</sub>	ENABLED	DISABLED (standby)
0	1	V <sub>IL</sub>	V <sub>IH</sub>	ENABLED	ENABLED
1	0	V <sub>IH</sub>	V <sub>IL</sub>	DISABLED (standby)	DISABLED (standby)
1	1	V <sub>IH</sub>	V <sub>IH</sub>	DISABLED (standby)	ENABLED

## 2 Typical application

Figure 1. Typical application schematics

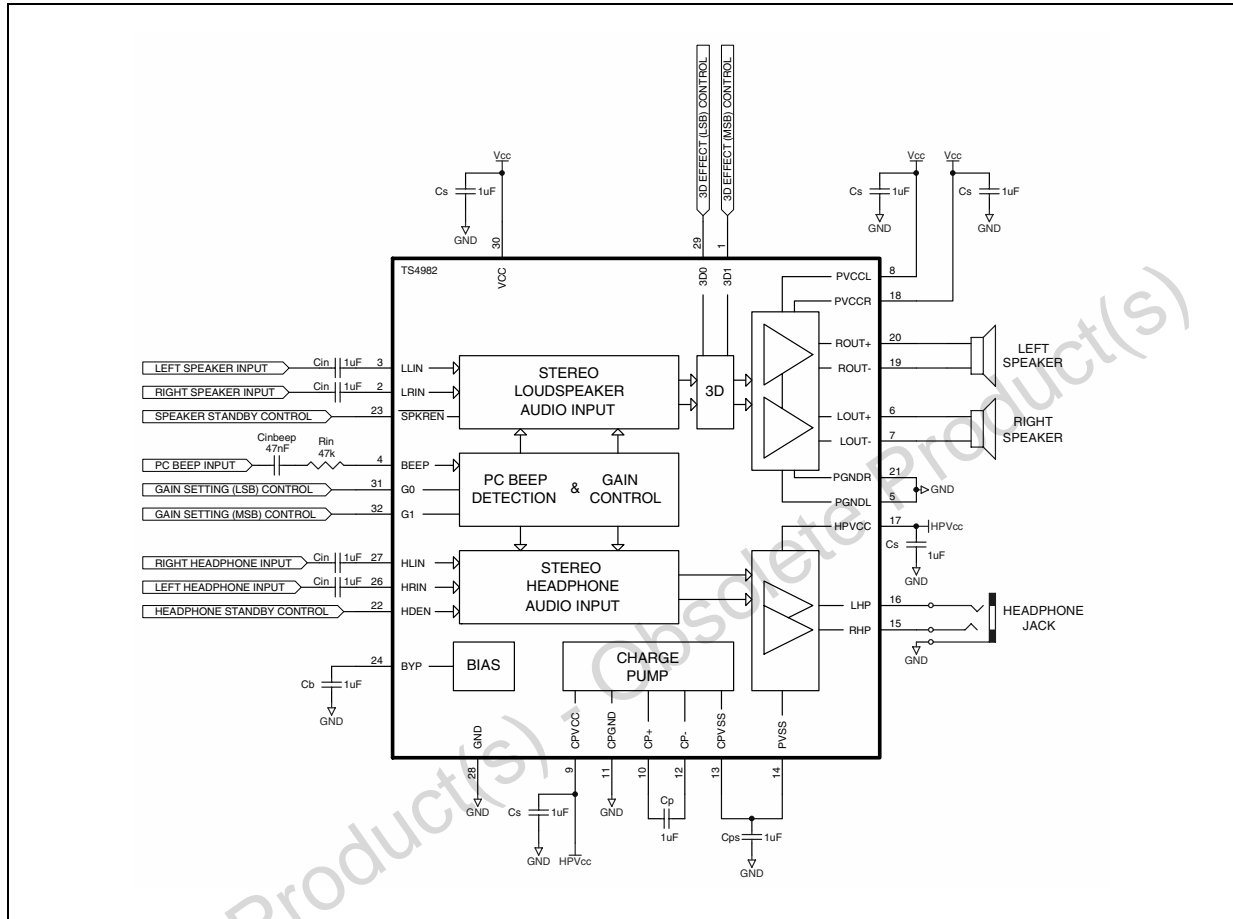


Table 4. External component description

Components	Value	Functional description
Cs, Cps	1μF	Supply decoupling capacitor that provides power supply filtering.
Cb	1μF	Bypass decoupling capacitor that provides half-supply filtering.
Cin	1μF	Input coupling capacitors that block the DC voltage at the amplifier input terminal. The capacitors also form a high-pass filter with Zin.
Cinbeep	47nF	Input coupling capacitors that block the DC voltage at the PCBEEP input terminal. The capacitors also form a high-pass filter with Rin.
Rin	47kΩ	Inverting input resistor for PCBEEP input. Together with the internal 47 kΩ feedback resistor the PC beep input gain can be adjusted to change a voltage detection level.
Cp	1μF	Flying capacitor for the negative charge pump.

**Table 5. Pin descriptions**

Pin number	Pin name	I/O/P <sup>(1)</sup>	Pin description
1	3D1	I	3D effect MSB input pin
2	LRIN	I	Right channel loudspeaker amplifier input
3	LLIN	I	Left channel loudspeaker amplifier input
4	BEEP	I	PC BEEP input
5	PGND	P	Loudspeaker amplifier power ground
6	LOUT+	O	Left channel loudspeaker positive output
7	LOUT-	O	Left channel loudspeaker negative output
8	PVCC	P	Loudspeaker amplifier power supply
9	CPVCC	P	Charge pump power supply
10	CP+	I/O	Charge pump flying capacitor positive pin
11	CPGND	P	Charge pump ground
12	CP-	I/O	Charge pump flying capacitor negative pin
13	CPVSS	P	Charge pump output, must be shorted to PVSS
14	PVSS	P	Headphone amplifier negative power supply, must be shorted to CPVSS, no external supply allowed
15	RHP	O	Right channel headphone output
16	LHP	O	Left channel headphone output
17	HPVCC	P	Headphone amplifier positive power supply
18	PVCC	P	Loudspeaker amplifier power supply
19	ROUT-	O	Right channel loudspeaker negative output
20	ROUT+	O	Left channel loudspeaker positive output
21	PGND	P	Loudspeaker amplifier power ground
22	HDEN	I	Headphone standby input pin
23	SPKREN	I	Loudspeaker standby input pin,
24	BYP	I	Common mode bias voltage
25	NC		Not internally connected
26	HRIN	I	Right channel headphone amplifier input
27	HLIN	I	Left channel headphone amplifier input
28 <sup>(2)</sup>	GND	P	Device ground
29	3D0	I	3D effect LSB input pin
30	VCC	P	Common power supply
31	G0	I	Gain control LSB input pin
32	G1	I	Gain control MSB input pin
EXPAD		P	Thermal pad to be soldered to the ground plane of the PCB

1. I - input, O - output, P - passive or power.
2. All GNDs are internally-connected together.

### 3 Electrical characteristics

#### 3.1 Electrical characteristics tables

**Table 6. General electrical characteristics,  $V_{CC} = PV_{CC} = HPV_{CC} = CPV_{CC} = 5V$ ,  $T_{amb} = 25^{\circ}C$  (unless otherwise specified)**

Symbol	Parameter	Min.	Typ.	Max.	Unit
$I_{CC}$	Current consumption, no load Speaker mode, $V_{SPKREN} = V_{HDEN} = GND$ Headphone mode, $V_{SPKREN} = V_{HDEN} = V_{CC}$		8 6	12 10	mA
$I_{STBY}$	Standby current consumption, no input signal $V_{HDEN} = GND$ , $V_{SPKREN} = V_{CC}$ ,		1	5	$\mu A$
$I_{in}$	Level input current G0, G1, 3D0, 3D1, SPKREN, HDEN pins			1	$\mu A$
$Z_{in}$	Input impedance	24	30	36	k $\Omega$

**Table 7. Loudspeaker amplifier,  $V_{CC} = PV_{CCL,R} = 5V$ ,  $V_{HDEN} = V_{SPKREN} = GND$ ,  $C_b = C_{in} = C_s = 1 \mu F$ ,  $V_{3D0} = V_{3D1} = GND$ , gain = 9 dB,  $T_{amb} = 25^{\circ}C$  (unless otherwise specified)**

Symbol	Parameter	Min.	Typ.	Max.	Unit
$P_O$	Output power THD+N = 1%, $R_L = 4 \Omega$ , $f = 1 kHz$		2		W
THD + N	Total harmonic distortion plus noise, $P_O = 1.5 W$ , $R_L = 4 \Omega$ , $20 Hz \leq f \leq 20 kHz$ , BW = 22 Hz to 22 kHz		0.08 -62		% dB
$V_{oo}$	Differential output offset voltage, no load, inputs AC grounded, gain = 13.5 dB, $V_{3D0} = V_{3D1} = V_{CC}$	-35		35	mV
Gain	Gain $G0 = G1 = V_{IL}$ $G0 = V_{IH}$ , $G1 = V_{IL}$ $G0 = V_{IL}$ , $G1 = V_{IH}$ $G0 = G1 = V_{IH}$		9 10.5 12 13.5		dB
$G_{err}$	Gain error		0.5		dB
PSRR	Speaker power supply rejection ratio <sup>(1)</sup> $R_L = 4 \Omega$ , $V_{ripple} = 200 mV_{pp}$ , $F = 1 kHz$		-75		dB
$X_T$	Channel crosstalk $P_O = 1.5 W$ , $R_L = 4 \Omega$ , $20 Hz \leq f \leq 20 kHz$		-85		dB
$V_n$	Output noise voltage, A-weighted filter, $R_L = 4 \Omega$ Gain = 9 dB, $V_{3D0} = V_{3D1} = GND$ Gain = 13.5 dB, $V_{3D0} = V_{3D1} = V_{CC}$		17 87		$\mu V_{rms}$
SNR	Signal to noise ratio, A-weighted filter, $R_L = 4 \Omega$ $P_O = 2 W$ , THD+N = 1%, $F = 1 kHz$		103		dB

**Table 7. Loudspeaker amplifier,  $V_{CC} = PV_{CCL,R} = 5\text{ V}$ ,  $V_{HDEN} = V_{SPKREN} = \text{GND}$ ,  $C_b = C_{in} = C_s = 1\ \mu\text{F}$ ,  $V_{3D0} = V_{3D1} = \text{GND}$ , gain = 9 dB,  $T_{amb} = 25^\circ\text{C}$  (unless otherwise specified) (continued)**

Symbol	Parameter	Min.	Typ.	Max.	Unit
$C_L$	Capacitive load $R_L = 4\ \Omega$ to $100\ \Omega$ $R_L > 100\ \Omega$			400 100	pF
$t_{WU}$	Wake up time		6	10	ms
$t_{STBY}$	Standby time			200	$\mu\text{s}$

1. Dynamic selective measurements -  $20 \cdot \log(\text{rms}(V_{out})/\text{rms}(V_{ripple}))$ .  $V_{ripple}$  is an added sinus signal to  $V_{CC}$  and  $PV_{CCL,R}$ .

**Table 8. Headphone amplifier,  $V_{CC} = PV_{CCL,R} = HPV_{CC} = CPV_{CC} = 5\text{ V}$ ,  $V_{HDEN} = V_{SPKREN} = V_{CC}$ ,  $C_b = C_{in} = C_s = C_p = C_{ps} = 1\ \mu\text{F}$ ,  $V_{3D0} = V_{3D1} = \text{GND}$ ,  $A_V = 3.5\text{ dB}$ ,  $T_{amb} = 25^\circ\text{C}$  (unless otherwise specified)**

Symbol	Parameter	Min.	Typ.	Max.	Unit
$P_O$	Output power, THD+N = 1%, $R_L = 16\ \Omega$ , $F = 1\text{ kHz}$ , $HPV_{CC} = CPV_{CC} = 5\text{ V}$ $HPV_{CC} = CPV_{CC} = 3\text{ V}$	100 35	125 65		mW
THD+N	Total harmonic distortion plus noise $P_O = 100\text{ mW}$ , $R_L = 16\ \Omega$ , $20\text{ Hz} \leq F \leq 20\text{ kHz}$ , $BW = 22\text{ Hz}$ to $22\text{ kHz}$		0.05 -66		% dB
$V_{oo}$	Output offset voltage, inputs AC grounded, no load	-10	0	10	mV
Gain	Gain		3.5		dB
$G_{ERR}$	Gain error		0.5		dB
PSRR	Power supply rejection ratio <sup>(1)</sup> $R_L = 16\ \Omega$ , $V_{ripple} = 200\text{ mV}_{pp}$ , $F = 1\text{ kHz}$		-75		dB
$X_T$	Channel crosstalk $P_O = 100\text{ mW}$ , $R_L = 16\ \Omega$ , $20\text{ Hz} \leq F \leq 20\text{ kHz}$		-75		dB
$V_n$	Output noise voltage, A-weighted filter, $R_L = 16\ \Omega$ $HPV_{CC} = CPV_{CC} = 5\text{ V}$ $HPV_{CC} = CPV_{CC} = 3\text{ V}$		10 10		$\mu\text{V}_{rms}$
SNR	Signal-to-noise ratio $P_O = 125\text{ mW}$ , $R_L = 16\ \Omega$ , A-weighted filter		102		dB
$C_L$	Capacitive load $R_L = 16\ \Omega$ to $100\ \Omega$ $R_L > 100\ \Omega$			400 100	pF
$t_{WU}$	Wake-up time		6	10	ms
$t_{STBY}$	Standby time			200	$\mu\text{s}$

1. Dynamic selective measurements -  $20 \cdot \log(\text{rms}(V_{out})/\text{rms}(V_{ripple}))$ .  $V_{ripple}$  is an added sinus signal to  $HPV_{CC}$  and  $CPV_{CC}$ .



**Table 9. Internal charge pump stage**

Symbol	Parameter	Min.	Typ.	Max.	Unit
$f_{osc}$	Internal frequency of charge pump across temperature range	400	550	800	kHz

**Table 10. PC beep input stage,  $R_{IN} = 47\text{ k}\Omega$ ,  $C_{IN} = 47\text{ nF}$** 

Symbol	Parameter	Min.	Typ.	Max.	Unit
$V_{beep}$	Beep signal minimum amplitude	0.8			$V_{pp}$
$f_{beep}$	Beep signal minimum frequency	400			Hz

## 3.2 Electrical characteristic curves

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Figure 2. Current consumption vs. power supply voltage

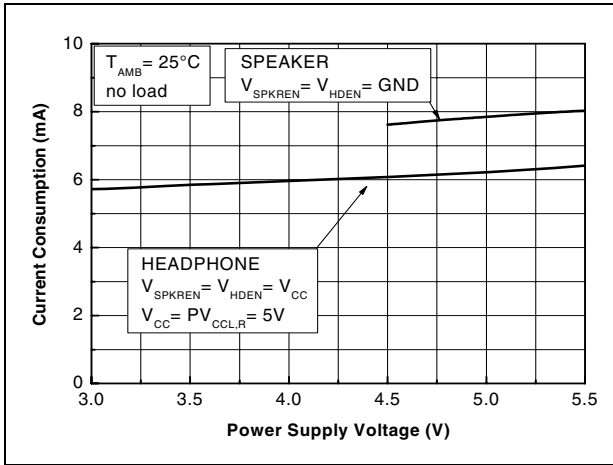


Figure 3. Current consumption vs. standby voltage

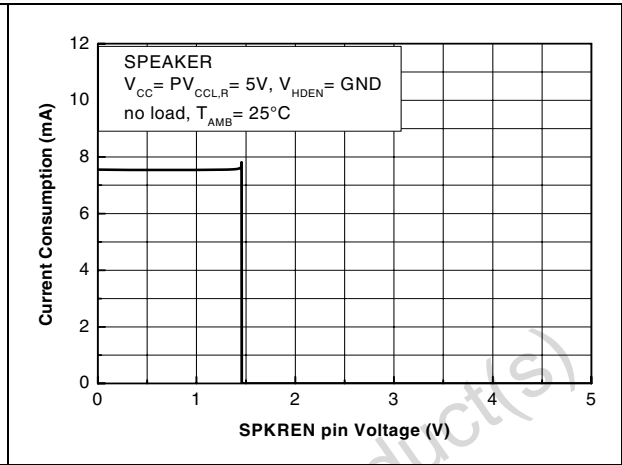


Figure 4. Current consumption vs. standby voltage

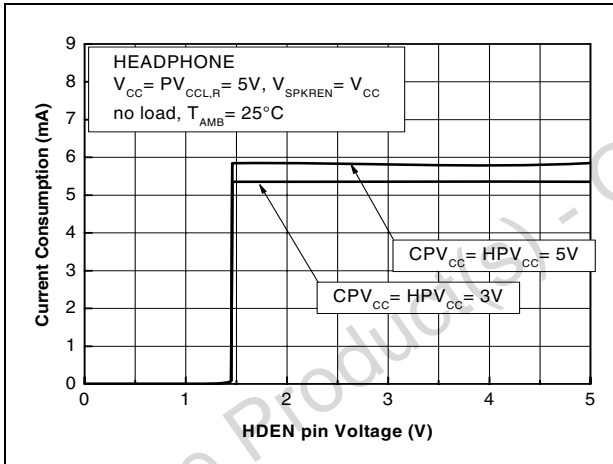


Figure 5. Power derating curves

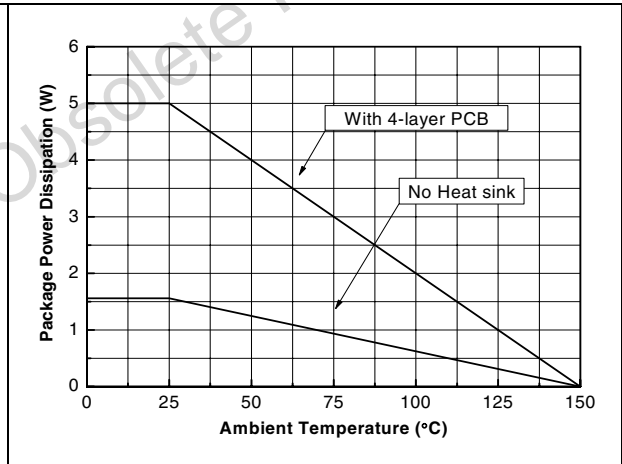


Figure 6. Output power vs. power supply

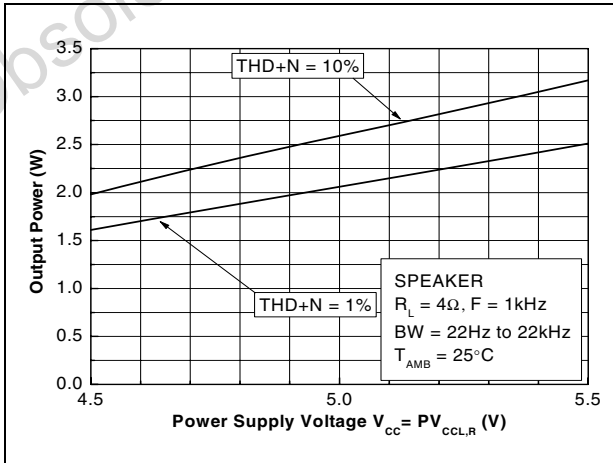


Figure 7. Output power vs. power supply

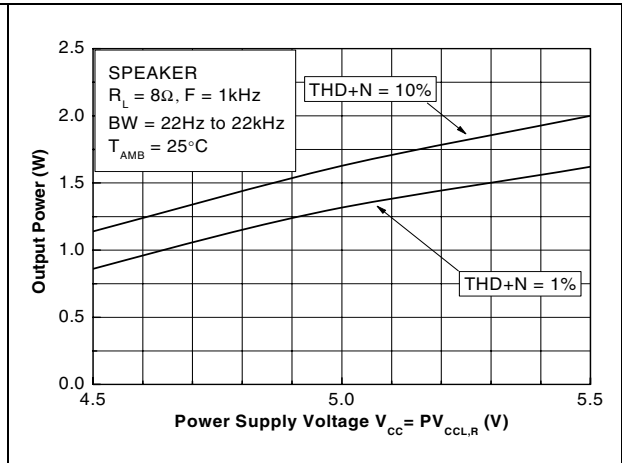


Figure 8. Output power vs. power supply

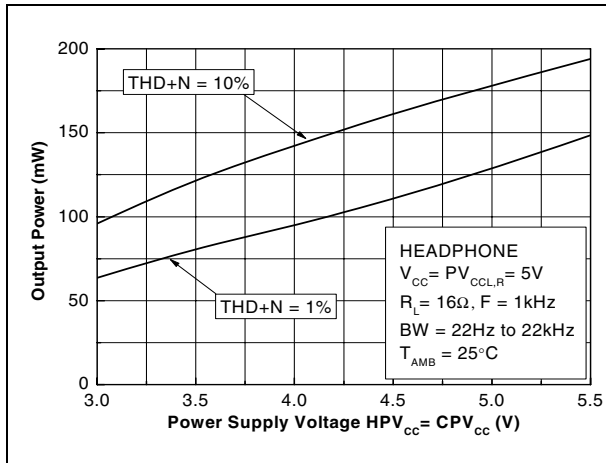


Figure 9. Output power vs. power supply

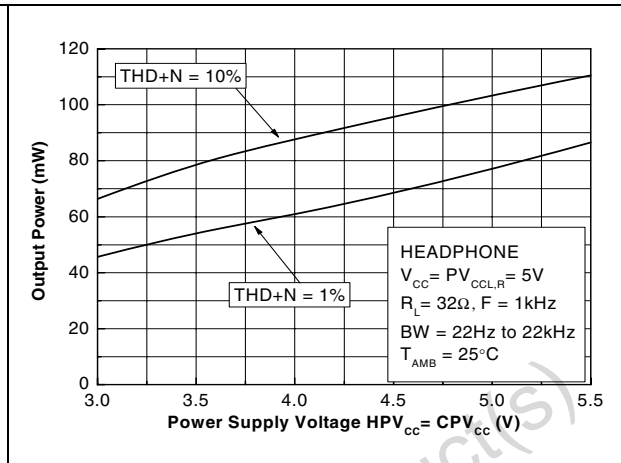


Figure 10. Output power vs. load resistance

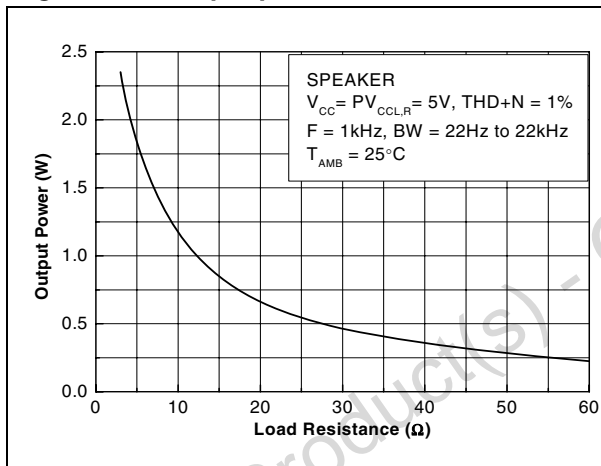


Figure 11. Output power vs. load resistance

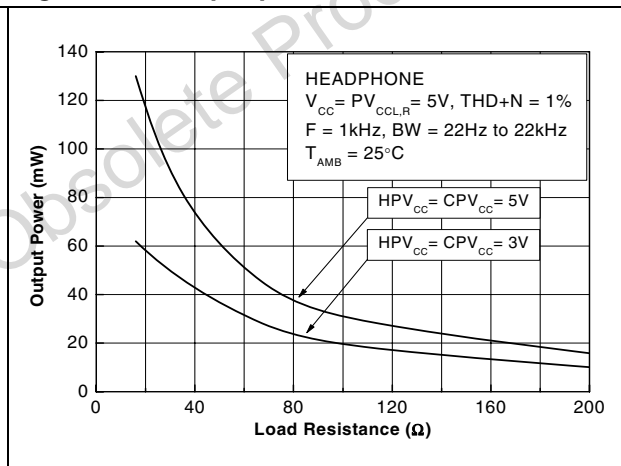


Figure 12. THD+N vs. output power

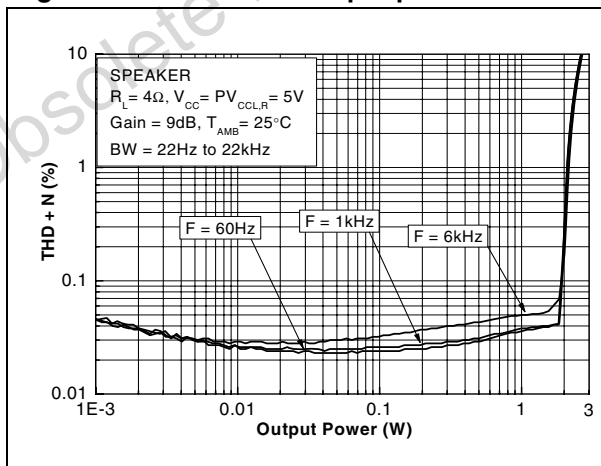


Figure 13. THD+N vs. output power

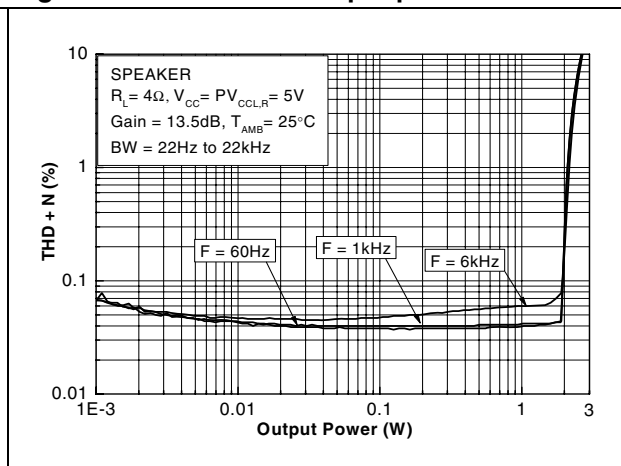


Figure 14. THD+N vs. output power

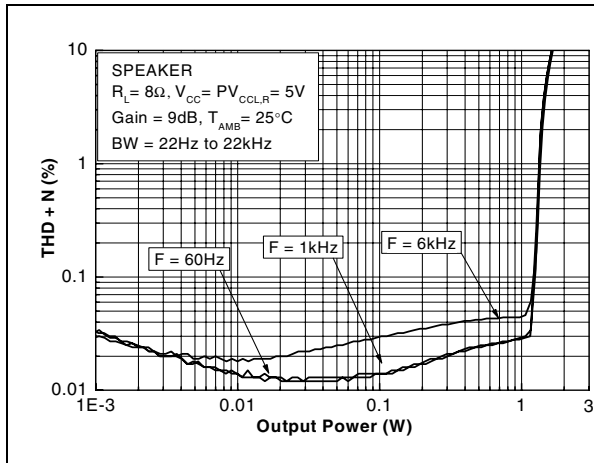


Figure 15. THD+N vs. output power

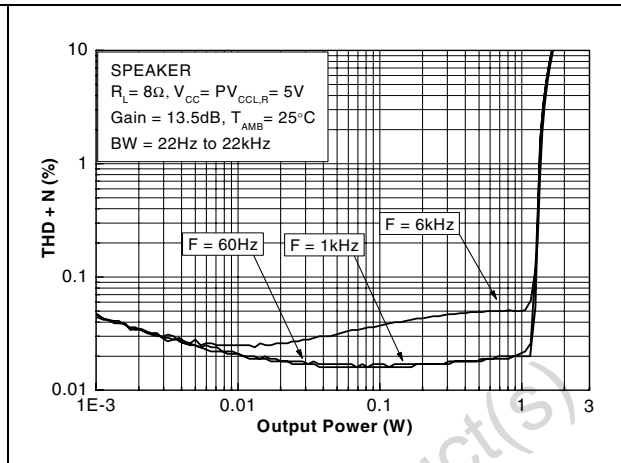


Figure 16. THD+N vs. output power

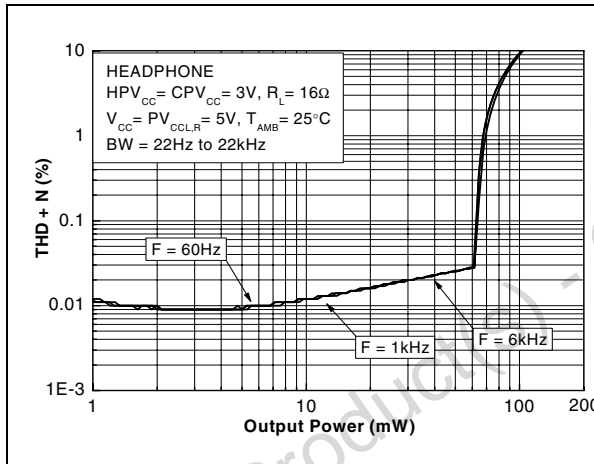


Figure 17. THD+N vs. output power

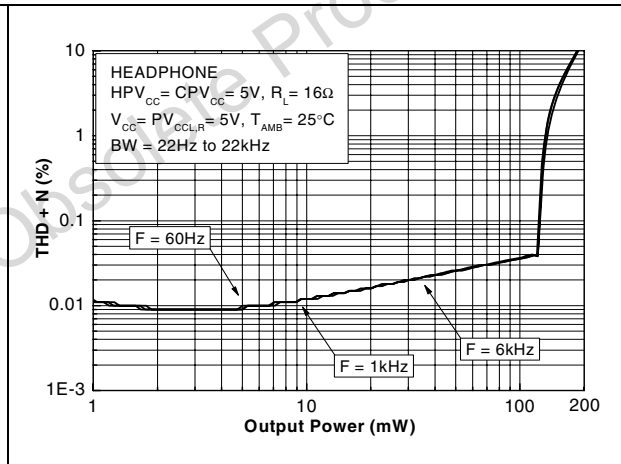


Figure 18. THD+N vs. output power

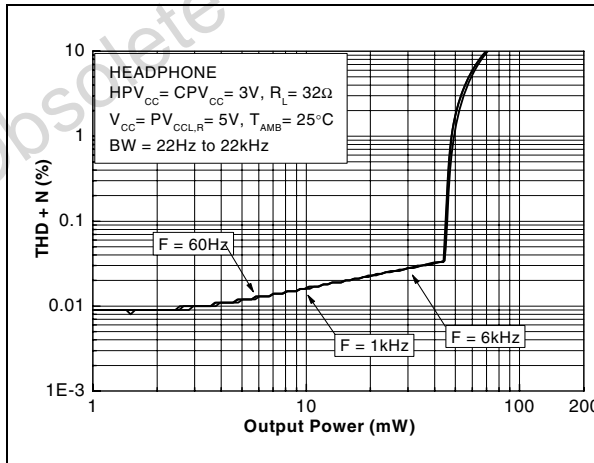


Figure 19. THD+N vs. output power

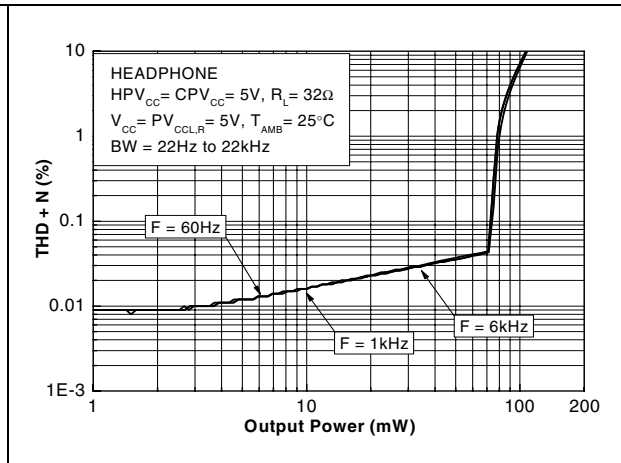


Figure 20. THD+N vs. frequency

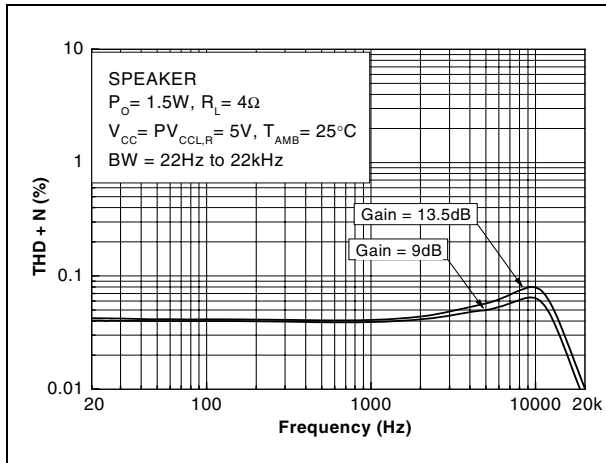


Figure 21. THD+N vs. frequency

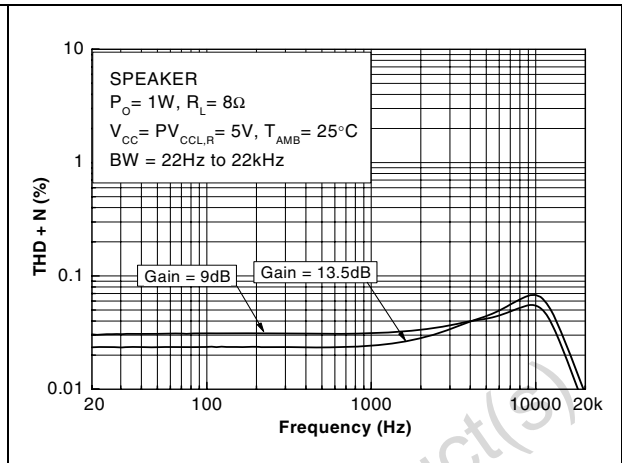


Figure 22. THD+N vs. frequency

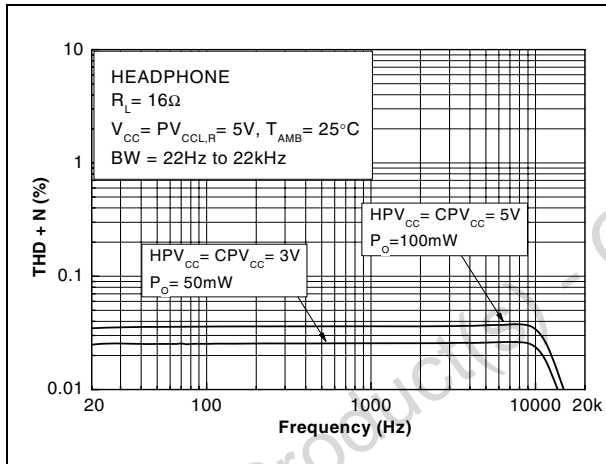


Figure 23. THD+N vs. frequency

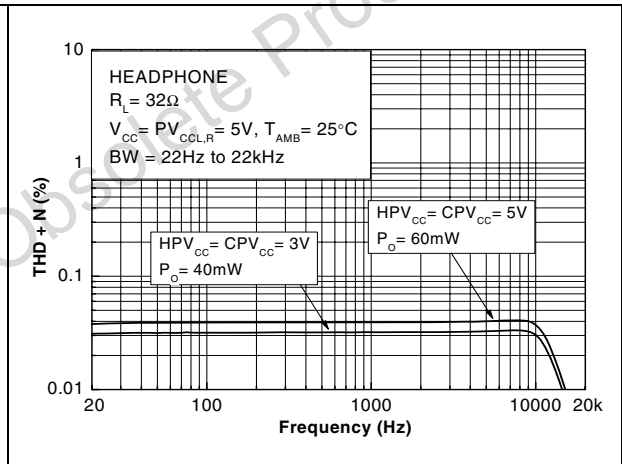


Figure 24. Power supply rejection ratio vs. frequency

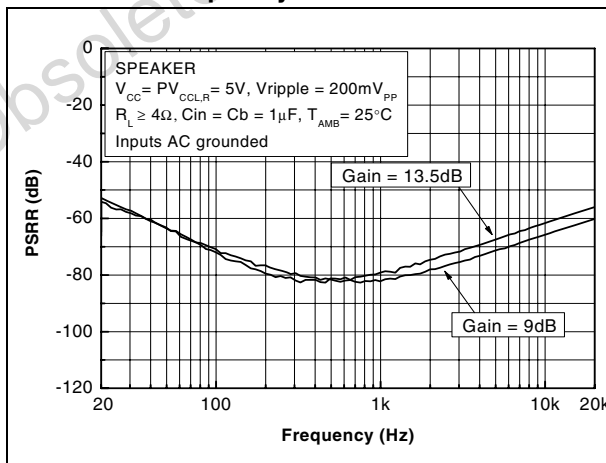
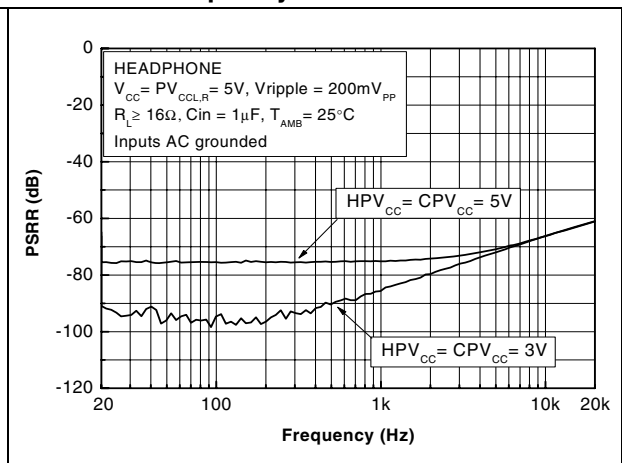
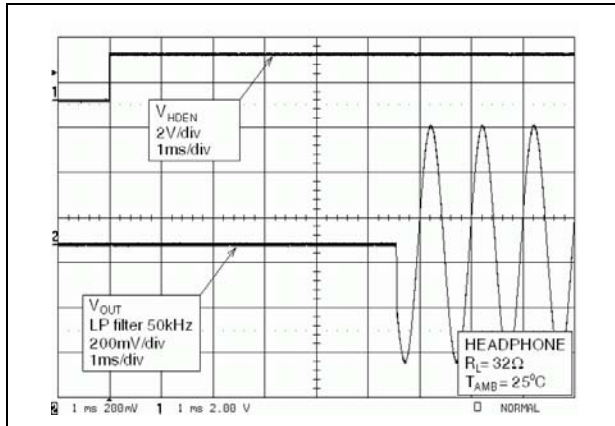


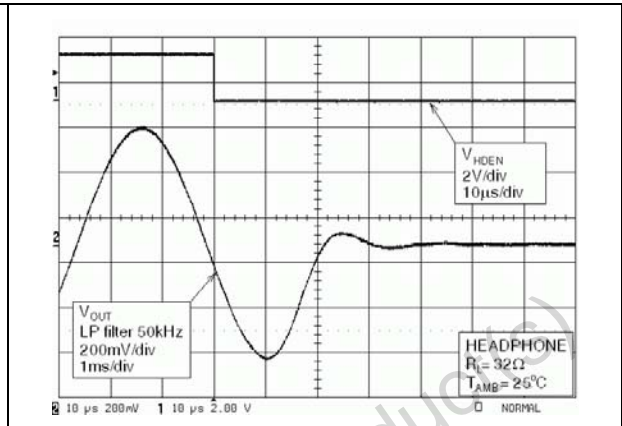
Figure 25. Power supply rejection ratio vs. frequency



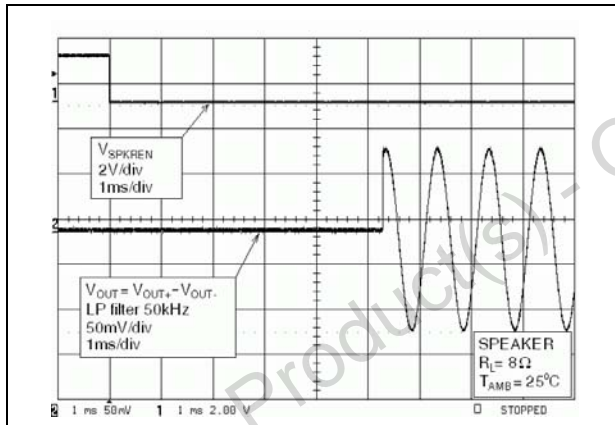
**Figure 26. Wake-up time,**  
 $V_{CC}=PV_{CCL,R}=CPV_{CC}=HPV_{CC}=5V,$   
 $V_{SPKREN}=V_{IH}$



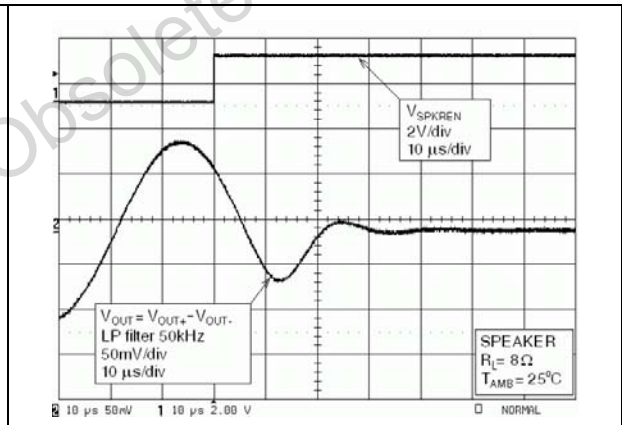
**Figure 27. Standby time,**  
 $V_{CC}=PV_{CCL,R}=CPV_{CC}=HPV_{CC}=5V,$   
 $V_{SPKREN}=V_{IH}$



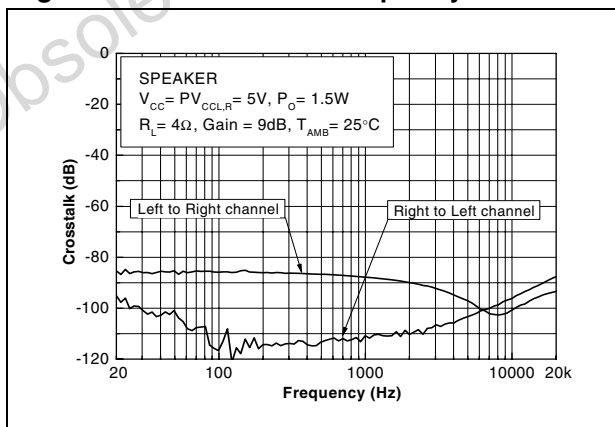
**Figure 28. Wake-up time,**  
 $V_{CC}=PV_{CCL,R}=CPV_{CC}=HPV_{CC}=5V,$   
 $V_{HDEN}=V_{IL}$



**Figure 29. Standby time,**  
 $V_{CC}=PV_{CCL,R}=CPV_{CC}=HPV_{CC}=5V,$   
 $V_{HDEN}=V_{IL}$



**Figure 30. Crosstalk vs. frequency**



**Figure 31. Crosstalk vs. frequency**

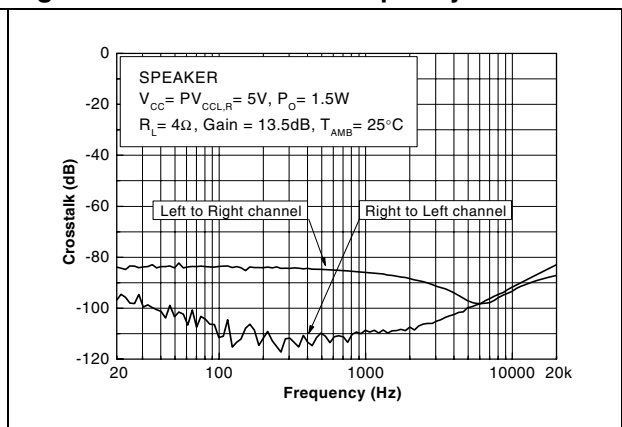


Figure 32. Crosstalk vs. frequency

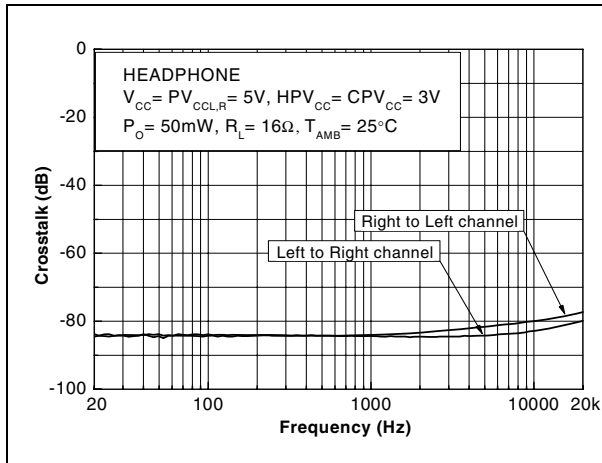


Figure 33. Crosstalk vs. frequency

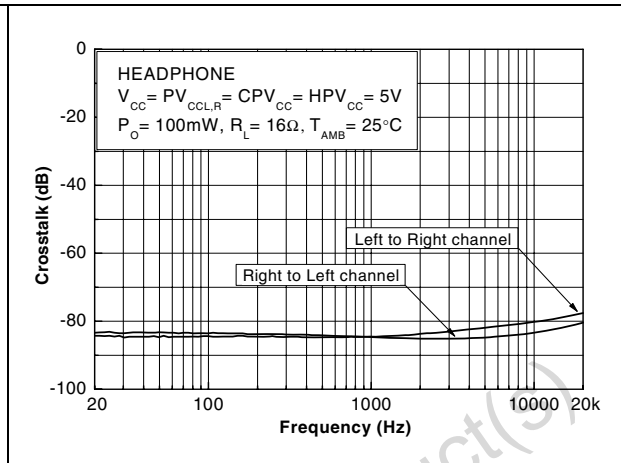


Figure 34. Inter-channel isolation vs. frequency

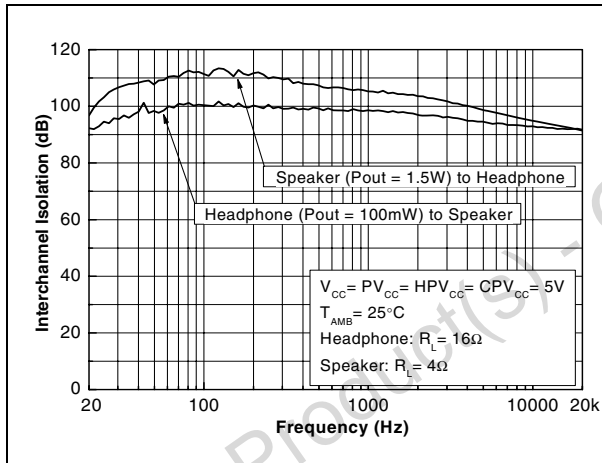


Figure 35. Power dissipation vs. output power per one channel

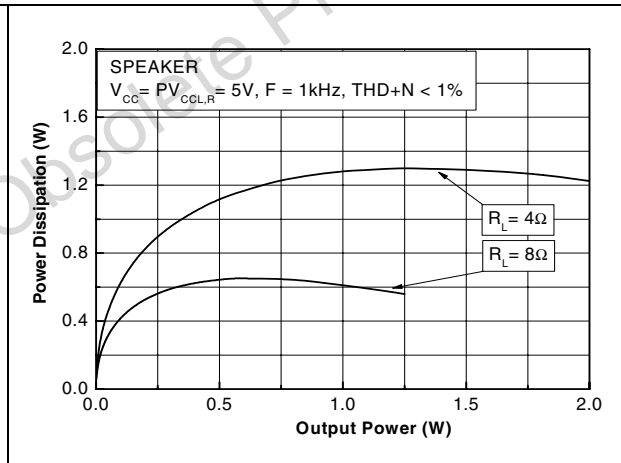


Figure 36. Power dissipation vs. output power per one channel

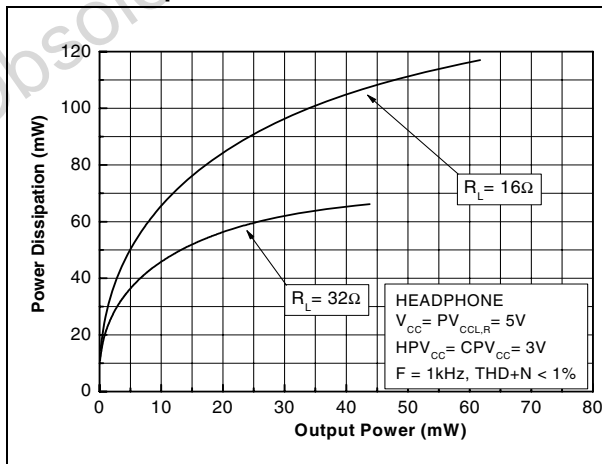
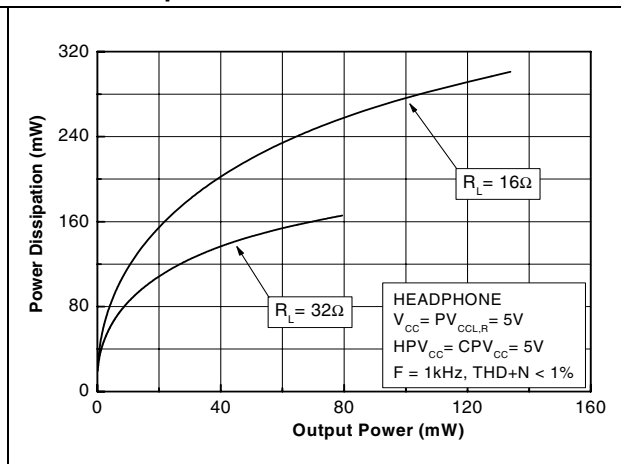


Figure 37. Power dissipation vs. output power per one channel



## 4 Application information

### 4.1 General description

The TS4982 is a stereo loudspeaker power amplifier and ground-referenced headphone driver with dedicated separated single-ended inputs in a QFN32 package, which is the best solution in space-saving applications. Each of the audio paths, loudspeaker or headphone, can be independently set to standby mode to save battery life.

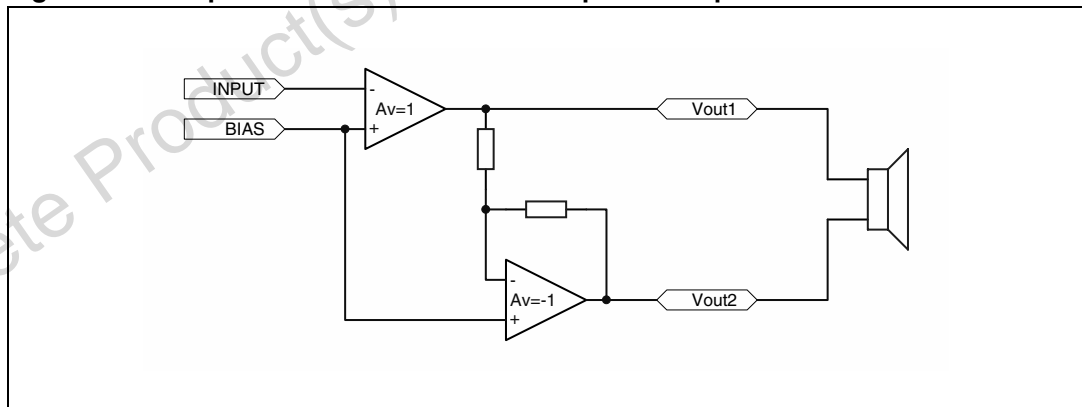
The loudspeaker amplifier with BTL output configuration (see [Section 4.2: Loudspeaker BTL configuration principle on page 16](#)) can deliver 2 W output power into a 4  $\Omega$  load with both channels enabled at 1% THD+N with a nominal power supply of 5 V. The gain (see [Section 4.2](#)) of the loudspeaker amplifier can be set to four discrete levels thanks to two digital inputs. The stereo sound perception which could seem poor in an application (notebook) can be enhanced by a 3D effect internal block in three levels (see [Section 4.3: Power dissipation and efficiency on page 17](#)).

In the audio path which is not in standby mode, a PC beep signal is mixed if it is detected (see [Section 4.7: PC beep on page 21](#)) on the PC beep input.

The outputs are protected against over-current consumption which can appear when the outputs are short-circuited between them or to GND or Vcc. There is also an internal thermal shutdown activated at 150° C (typical) and deactivated at 120° C (typical).

### 4.2 Loudspeaker BTL configuration principle

Figure 38. Simplified schematic of the loudspeaker amplifier





Bridge tied load (BTL) means that each end of the load is connected to two single-ended output amplifiers. Therefore, we have:

$$\text{Single-ended output 1} = V_{out1} = V_{out}$$

$$\text{Single-ended output 2} = V_{out2} = -V_{out}$$

$$\text{BTL output} = V_{out1} - V_{out2} = 2V_{out}$$

The output power is:

$$P_{out} = \frac{(2V_{outRMS})^2}{R_L}$$

For the same power supply voltage, the output power in a BTL configuration is four times higher than the output power in a single-ended configuration.

### 4.3 Power dissipation and efficiency

Hypotheses:

The voltage and current in the load are sinusoidal ( $V_{out}$  and  $I_{out}$ ).

The supply voltage is a pure DC source ( $V_{CC}$ ).

Regarding the load we have:

$$V_{out} = V_{PEAK} \sin \omega t \quad (V)$$

and

$$I_{out} = \frac{V_{out}}{R_L} \quad (A)$$

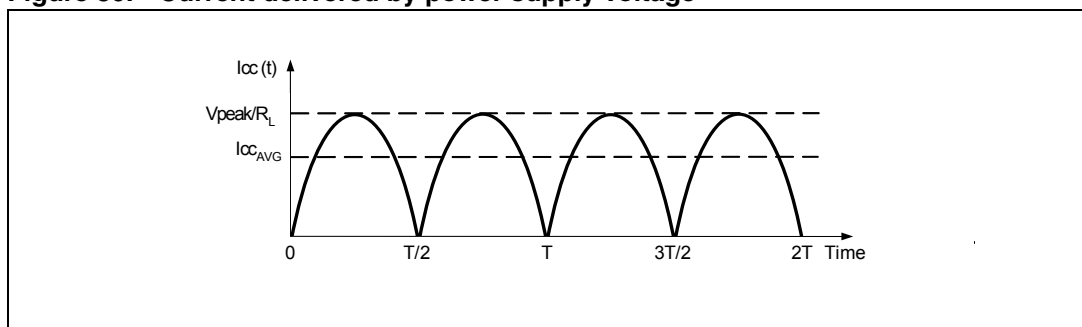
and

$$P_{out} = \frac{V_{PEAK}^2}{2R_L} \quad (W)$$

Therefore, the average current delivered by the supply voltage is:

$$I_{CC_{AVG}} = 2 \frac{V_{PEAK}}{\pi R_L} \quad (A)$$

**Figure 39. Current delivered by power supply voltage**



The power delivered by the supply voltage is:

$$P_{supply} = V_{CC} \cdot I_{CC_{AVG}} \quad (W)$$

Then, the **power dissipated by each amplifier** is:

$$P_{diss} = P_{supply} - P_{out} \quad (W)$$

$$P_{diss} = \frac{2\sqrt{2}V_{CC}}{\pi\sqrt{R_L}} \cdot \sqrt{P_{out}} - P_{out} \quad (W)$$

and the maximum value is obtained when:

$$\frac{\partial P_{diss}}{\partial P_{out}} = 0$$

and its value is:

$$P_{dissmax} = \frac{2V_{CC}^2}{\pi^2 R_L} \quad (W)$$

This maximum value only depends on the power supply voltage and load values.

The **efficiency**,  $\eta$  is the ratio between the output power and the power supply:

$$\eta = \frac{P_{out}}{P_{supply}} = \frac{\pi V_{PEAK}}{4V_{CC}}$$

The maximum theoretical value is reached when:

- $V_{PEAK} = V_{CC}$  for the loudspeaker part, so that:

$$\eta = \frac{\pi}{4} = 78.5\%$$

- $V_{PEAK} = V_{CC}/2$  for the headphone part, so that:

$$\eta = \frac{\pi}{8} = 39.3\%$$

### 4.4 Loudspeaker 3D effect enhancement

The TS4982 features a 3D audio effect which can be programmed at three discrete levels (LOW, MEDIUM, HIGH) through input pins 3D1 and 3D0 which provide a digital interface. The correspondence between the logic levels of this interface and 3D effect levels are shown in the [Table 12 on page 19](#).

The 3D audio effect applied to the stereo audio signals evokes perception of spatial hearing and improves this effect in cases where the stereo speakers are too close to each other, such as in small handheld devices or mobile equipment.

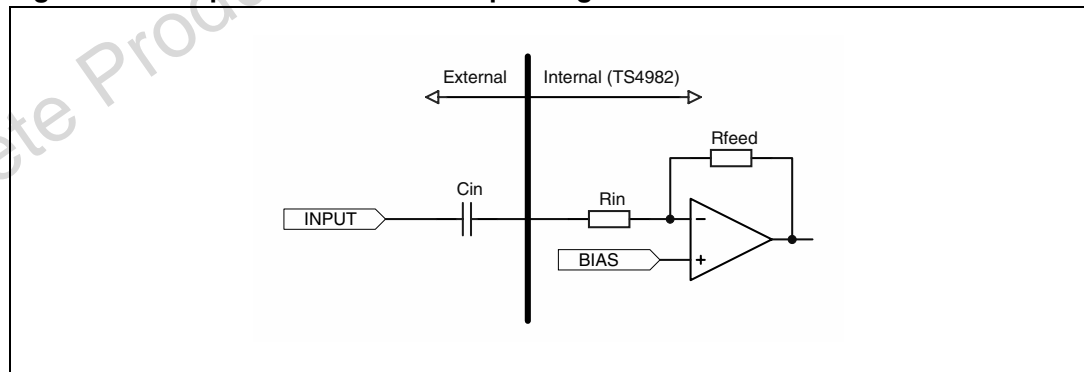
The perceived amount of 3D effect also depends on many factors such as speaker position, distance between speakers and listener, frequency spectrum of the audio signal, or the difference of signal between the left and right channels. In some cases, the volume can increase when the 3D effect is switched on. This factor depends on the composition of the stereo audio signal and its frequency spectrum.

**Table 12. 3D effect settings**

3D1	3D0	V <sub>3D1</sub>	V <sub>3D0</sub>	3D effect level
0	0	V <sub>IL</sub>	V <sub>IL</sub>	OFF
0	1	V <sub>IL</sub>	V <sub>IH</sub>	LOW
1	0	V <sub>IH</sub>	V <sub>IL</sub>	MEDIUM
1	1	V <sub>IH</sub>	V <sub>IH</sub>	HIGH

### 4.5 Low frequency response

**Figure 40. Simplified schematic of input stage**



In the low-frequency region, the input coupling capacitor  $C_{in}$  starts to have an effect.  $C_{in}$  forms, with the  $R_{in}$ , a first order high-pass filter with a -3 dB cut-off frequency:

$$F_{CL} = \frac{1}{2\pi \cdot R_{in} \cdot C_{in}}$$

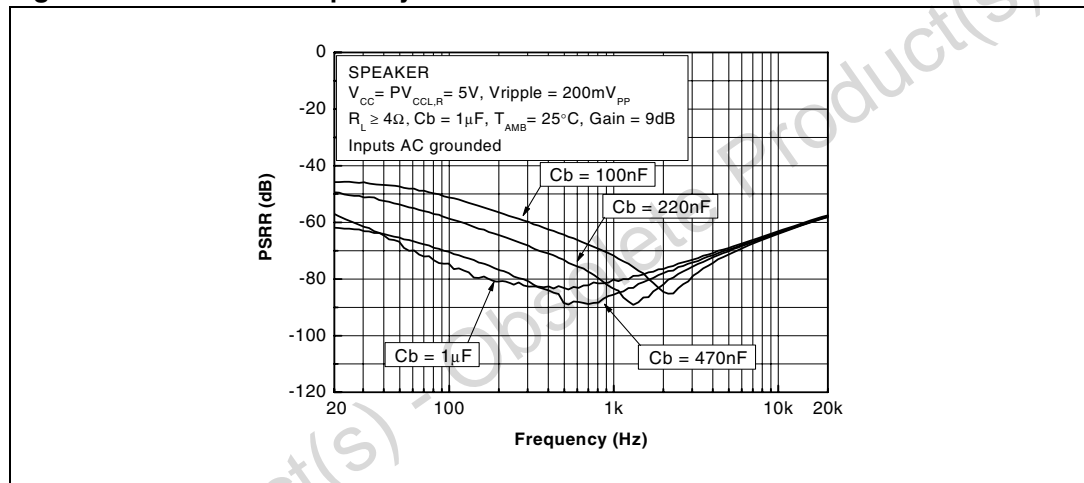
In this case we can consider that Rin equals Zin. So, for a desired cut-off frequency F<sub>CL</sub>, C<sub>in</sub> is calculated as follows:

$$C_{in} = \frac{1}{2\pi \cdot Z_{in} \cdot F_{CL}}$$

The input impedance Zin is for the whole power supply voltage range, typically 30 kΩ. There is also a tolerance around the typical value (see [Table 6 on page 7](#)) and it must be taken into account.

In the typical application, C<sub>in</sub> = 1 μF, then F<sub>CL</sub> = 5.3 Hz. If F<sub>CL</sub> is required higher to limit low frequencies, it must be taken account that the speaker's PSRR performance for the low frequency region is decreased. The headphone PSRR remains the same.

Figure 41. PSRR vs. frequency



## 4.6 Gain settings

In the flat region of the frequency-response curve (no input coupling capacitor or internal feedback loop + load effect) the gain of the loudspeaker amplifier can be set in four discrete levels thanks to the two digital inputs G1 and G0.

The headphone amplifier gain does not depend on the loudspeaker gain setting and is kept equal to 3.5 dB.

Table 13. Gain settings

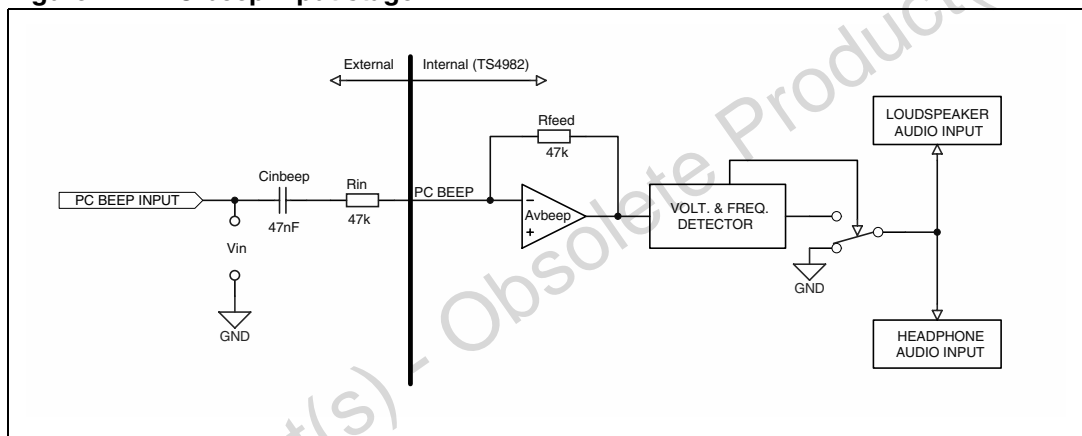
G1	G0	V <sub>G1</sub>	V <sub>G0</sub>	Loudspeaker amplifier gain (dB)	Headphone amplifier gain (dB)
0	0	V <sub>IL</sub>	V <sub>IL</sub>	9	3.5
0	1	V <sub>IL</sub>	V <sub>IH</sub>	10.5	3.5
1	0	V <sub>IH</sub>	V <sub>IL</sub>	12	3.5
1	1	V <sub>IH</sub>	V <sub>IH</sub>	13.5	3.5

## 4.7 PC beep

The PC beep input allows to send a system beep (for instance power-on self-test error code) through the amplifiers to the loudspeaker or (and) headphone output. In the typical application (see *Figure 1*) the input is passed through when eight sequential rising edges in the signal appear on the detector input with the minimum amplitude  $V_{in_{MIN}} = 0.8 V_{P-P}$  and minimum frequency  $F_{MIN} = 400$  Hz. The PC beep signal is mixed with gain = -1 V/V into a loudspeaker (SPKREN = 0) or headphone (HDEN = 1) path. The signal from the loudspeaker or headphone inputs are not muted. The beep signal pass-through is switched off when there is no signal with sufficient amplitude  $V_{in_{MIN}}$  present during a  $1/F_{MIN}$  (1/400 s) time period.

The overall gain in the typical application ( $R_{in} = R_{feed} = 47\text{ k}\Omega$ ) is equal to the loudspeaker or headphone gain setting.

**Figure 42. PC beep input stage**



The input capacitor  $C_{inbeep}$  with input resistor  $R_{in}$  forms a high-pass filter with a -3 dB low frequency cut-off  $F_{CL}$  which must be lower than  $F_{MIN}$ .

$$C_{inbeep} \geq \frac{1}{2\pi \cdot R_{in} \cdot F_{MIN}}$$

For a typical application ( $R_{in} = 47\text{ k}\Omega$ ,  $F_{MIN} = 400$  Hz) a good choice is  $C_{inbeep} = 47\text{ nF}$ .

If it is necessary to change the minimum amplitude  $V_{in_{MIN}} = 0.8 V_{P-P}$  the gain of the PC BEEP input amplifier has to be changed. For a typical application ( $R_{in} = R_{feed} = 47\text{ k}\Omega$ ) the gain is -1 V/V.

$$A_v = -\frac{R_{feed}}{R_{in}} = -\frac{47000}{47000} = -1$$

If  $V_{in_{MIN2}}$  is a new requested minimum amplitude then a new input resistor  $R_{in}$  is:

$$R_{in}[\Omega] = \frac{R_{feed} \cdot V_{in_{MIN2}}}{V_{in_{MIN}}} = 5875 \cdot V_{in_{MIN2}}[V_{PP}]$$

## 4.8 Decoupling and charge pump capacitors

Only a power supply decoupling capacitor  $C_s$  and a bias voltage decoupling capacitor  $C_b$  are needed to correctly decouple the TS4982.

### 4.8.1 Decoupling capacitors $C_s$ and $C_b$

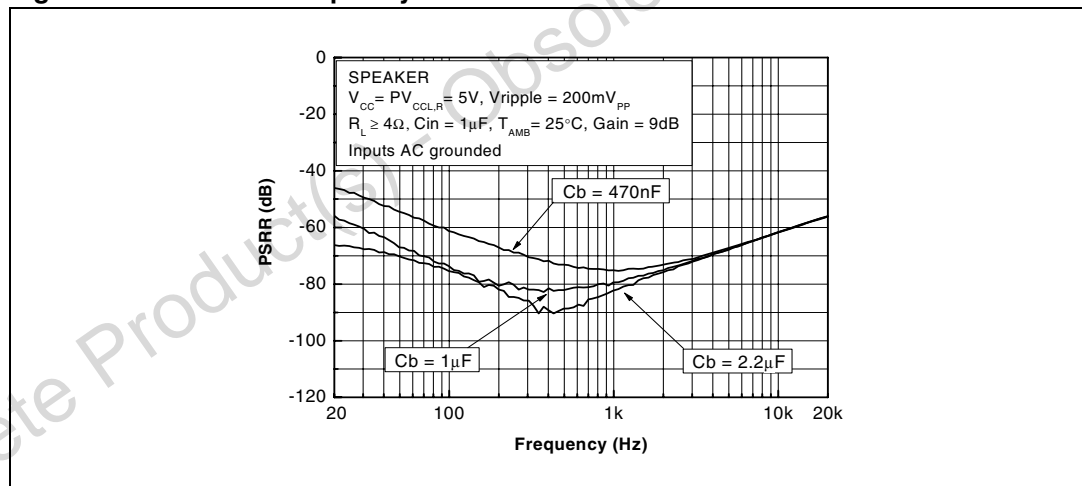
$C_s$  has a particular influence on the THD+N in the high frequency region (above 7 kHz) and an indirect influence on the power supply disturbances. With a value for  $C_s$  of 1  $\mu\text{F}$ , you can expect similar THD+N performances to those outlined in this document (see [Figure 12](#) to [Figure 23](#)). For example:

- In the high frequency region, if  $C_s$  is lower than 1  $\mu\text{F}$ , it increases THD+N and disturbances on the power supply rail are less filtered.
- On the other hand, if  $C_s$  is higher than 1  $\mu\text{F}$ , those disturbances on the power supply rail are more filtered.

$C_b$  has a critical influence on the final result of the PSRR with input grounded and in the lower frequency region in the following manner:

- If  $C_b$  is lower than 1  $\mu\text{F}$  the PSRR performance worsens at lower frequencies.
- If  $C_b$  is higher than 1  $\mu\text{F}$ , the benefit to PSRR is decreased significantly.

**Figure 43. PSRR vs. frequency**



## 4.8.2 Charge pump capacitors Cp and Cps

A proper selection of the charge pump capacitors Cp and Cps is necessary to generate an efficient negative voltage by the internal charge pump without a negative impact on the audio performance.

The following are some recommendations for the decoupling and charge pump capacitors.

- Low ESR capacitors are needed to minimize the output resistance of the charge pump.
- An X7R dielectric type for large temperature ranges should be used.
- Placement of the component as close to the package pins as possible. Small packages (for instance SMD 0603, 0402) make it easier.
- Use of a 10 V DC rating voltage for 5 V operation or 6.3 V DC rating operation for 3 V operation with regard to the  $\Delta C/\Delta V$  variation of this type of dielectric.
- For a typical application a 1  $\mu\text{F}$  ceramic capacitor is recommended (see [Figure 1 on page 5](#)).

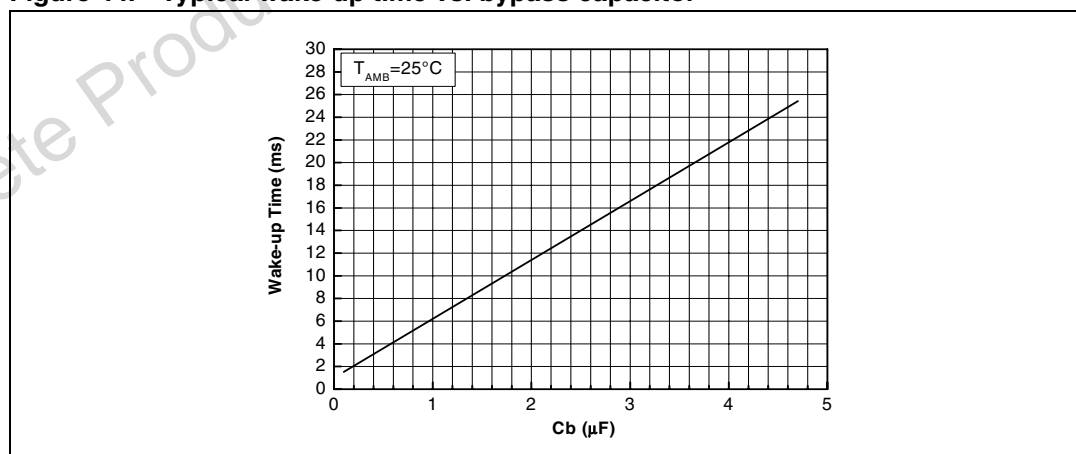
## 4.9 Wake-up time

When the standby is released to turn the device ON, the bypass capacitor Cb is charged immediately. As Cb is directly linked to the bias of the loudspeaker amplifier, the bias will not work properly until the Cb voltage is correct. The time to reach this voltage plus a time delay of 1 ms (pop precaution) is called **the wake-up time** or  $t_{\text{WU}}$ . It is specified in the electrical characteristics with Cb = 1  $\mu\text{F}$  in [Table 7 on page 7](#).

If Cb has a value other than 1  $\mu\text{F}$ , you can calculate the typical  $t_{\text{WU}}$  by using the following formula, or read it directly from the graph ([Figure 44](#)).

$$t_{\text{WU}}[\text{s}] = 5199 \cdot C_b + 0.001[\text{F}]$$

**Figure 44. Typical wake-up time vs. bypass capacitor**



If the headphone (speaker) is already out of the standby mode and the speaker (headphone) is enabled there is no need to charge Cb. Therefore, the wake-up time is only the pop precaution delay of 1 ms (typical).

## 4.10 Standby time

The time to disable the dedicated part into the standby mode since the level of the dedicated standby pins are changed (HDEN from "1" to "0", SPKREN from "0" to "1") is called the **standby time**. It is specified in the electrical characteristics in [Table 7 on page 7](#).

## 4.11 Pop & click

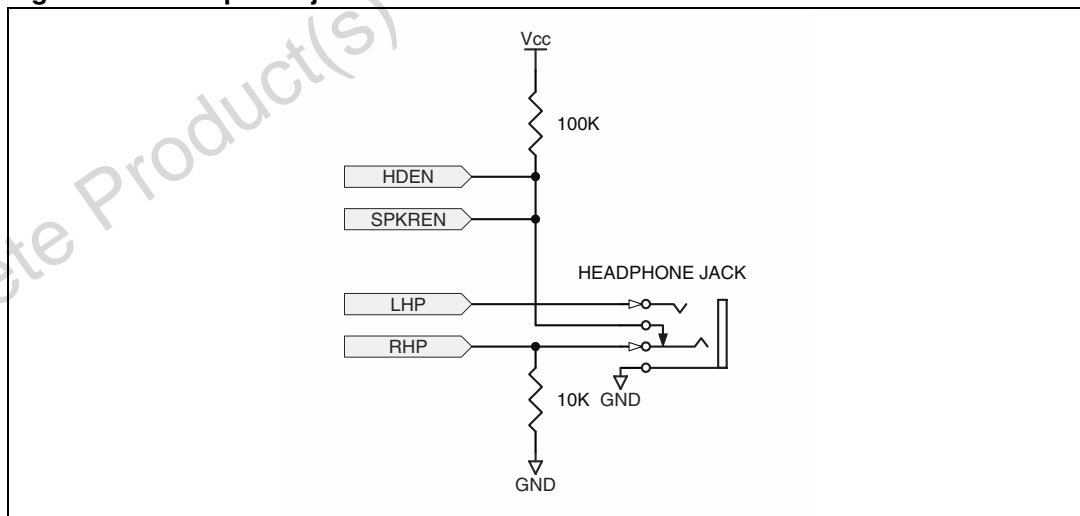
Older generations of headphone drivers with single-ended outputs have a load connected in series with a bulky capacitor (for instance 220  $\mu\text{F}$ ) to ground. With this type of configuration, when the amplifier is turned on by a standby control pin, a time transient phenomena on the load is present. This has been the main contribution to the unpleasant audible sound currently called "pop effect".

Thanks to the negative charge pump the headphone outputs are referred to ground without the need for bulky in-series capacitors. Therefore, the pop created by these bulky capacitors is internally eliminated. In addition, the TS4982 include a pop & click circuitry which suppresses any residual pop on the headphone and speaker outputs, thus enabling the outputs to be virtually pop & click-free.

## 4.12 Headphone jack detection

The device incorporates a simple circuitry that can be used to enable the headphone amplifier and disable the speaker amplifier by a headphone jack insertion.

**Figure 45. Headphone jack detection schematics**





### 4.13 PCB layout recommendations

The TS4982 can delivery 2 W into a 4  $\Omega$  load at 1% THD+N. To reach this output power value, you should follow these few recommendations during the design phase of the PCB.

- Use large and short traces for power supply ( $PV_{CCL,R}$ ) and outputs - load tracks to minimize losses due to track parasitic resistance.
- Connect all  $V_{CC}$  tracks ( $PV_{CCL,R}$ ,  $HPV_{CC}$ ,  $CPV_{CC}$ ,  $V_{CC}$ ) to one point on the board.
- Connect all grounding planes or tracks (GND, PGNDL, PGNDR, CPGND) to one point on the board.
- Keep the grounding of the charge pump CPGND away from other GNDs.
- Connect the exposed pad to the grounding plane or a large bottom copper area using vias for good heatsink.

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## 5 Package information

In order to meet environmental requirements, ST offers these devices in different grades of ECOPACK<sup>®</sup> packages, depending on their level of environmental compliance. ECOPACK<sup>®</sup> specifications, grade definitions and product status are available at: [www.st.com](http://www.st.com). ECOPACK<sup>®</sup> is an ST trademark.

Obsolete Product(s) - Obsolete Product(s)

### 5.1 QFN32 package information

Figure 46. QFN32 package mechanical drawing

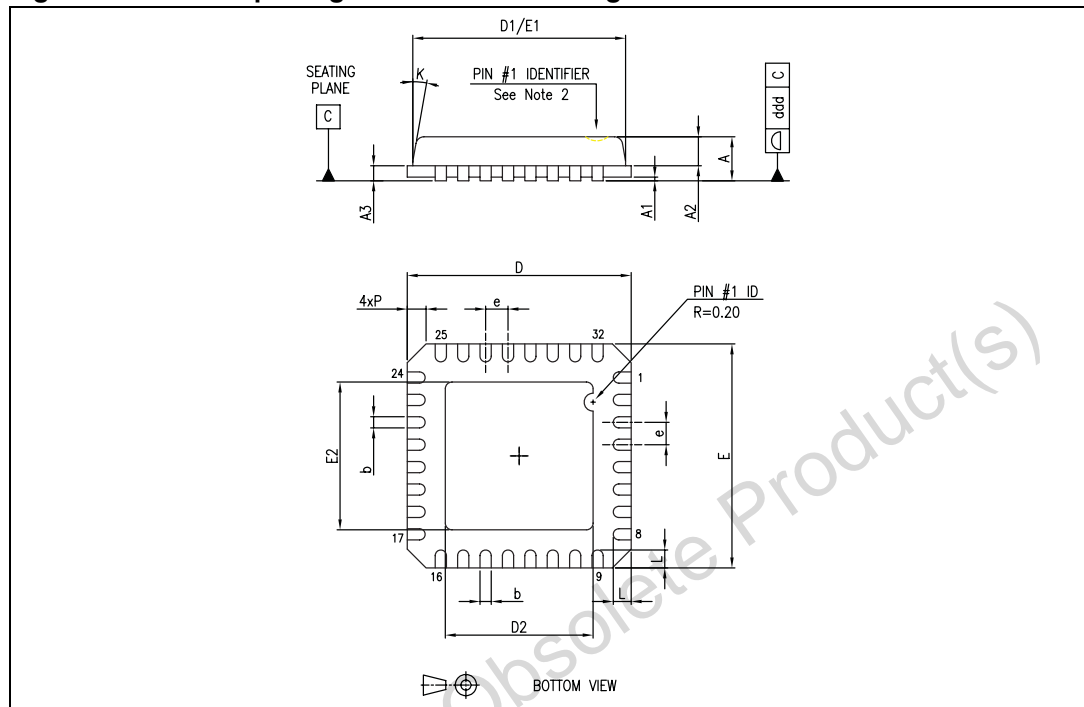
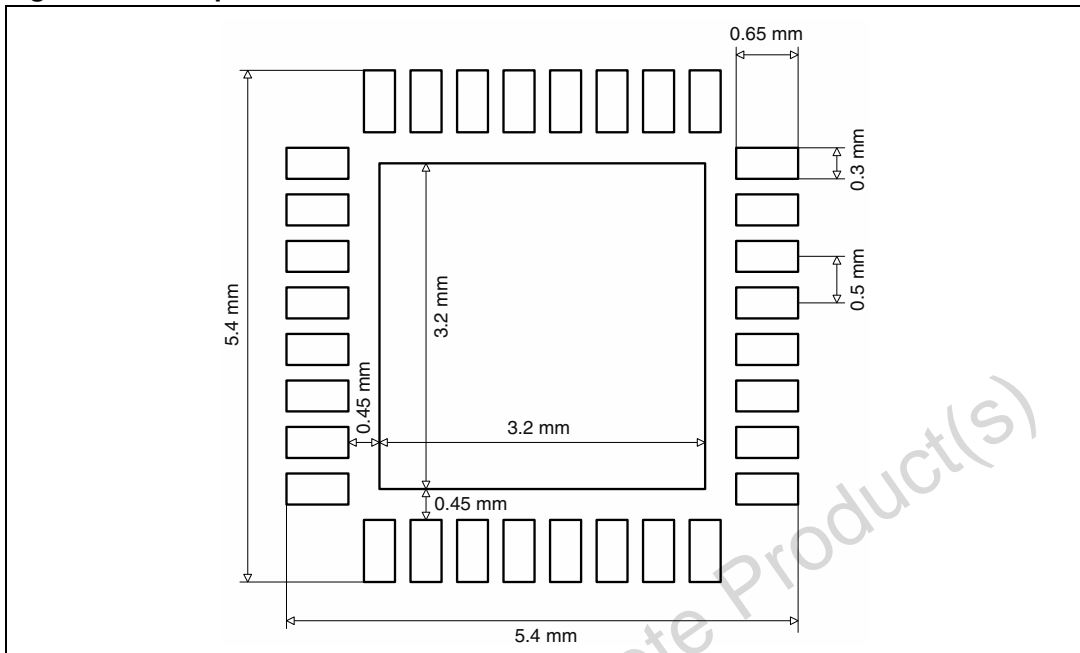


Table 14. QFN32 package mechanical data

Ref.	Dimensions					
	Millimeters			Inches		
	Min.	Typ.	Max.	Min.	Typ.	Max.
A	0.80	0.90	1.00	0.031	0.035	0.039
A1		0.02	0.05		0.0008	0.002
A2		0.65	1.00		0.026	0.039
A3		0.20			0.008	
b	0.18	0.25	0.30	0.007	0.010	0.012
D	4.85	5.00	5.15	0.191	0.20	0.203
D1		4.75			0.19	
D2	3.15	3.30	3.45	0.124	0.130	0.136
E	4.85	5.00	5.15	0.191	0.20	0.203
E1		4.75			0.19	
E2	3.15	3.30	3.45	0.124	0.130	0.136
e		0.50			0.020	
L	0.30	0.40	0.50	0.012	0.016	0.020
P			0.60			0.024
K			14			0.55
ddd			0.08			0.003

Figure 47. Footprint recommendation



## 6 Ordering information

Table 15. Order code

Order code	Temperature range	Package	Packaging	Marking
TS4982IQT	-40°C to +85°C	QFN32	Tape & reel	K982

Obsolete Product(s) - Obsolete Product(s)

## 7 Revision history

**Table 16. Document revision history**

Date	Revision	Changes
18-Mar-2008	1	Initial release.
16-Jun-2009	2	Document status promoted from target specification to full datasheet.

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