



TS4990

1.2W Audio Power Amplifier with Active-Low Standby Mode

- Operating from $V_{CC} = 2.2V$ to $5.5V$
- 1.2W Output power @ $V_{CC}=5V$, THD=1%, $f=1kHz$, with 8Ω Load
- Ultra-low consumption in standby mode (10nA)
- 62dB PSRR @ 217Hz in grounded mode
- Near-zero POP & CLICK
- Ultra-low distortion (0.1%)
- Unity gain stable
- Available in a 9-bump Flip-Chip, MiniSO8 and DFN8 packages

DESCRIPTION

The TS4990 has been designed for demanding audio applications such as mobile phones and to minimize the number of external components.

This Audio Power Amplifier is capable of delivering 1.2W of continuous RMS Output Power into an 8Ω load @ 5V.

An externally-controlled standby mode reduces the supply current to less than 10nA. It also includes internal thermal shutdown protection.

The unity-gain stable amplifier can be configured by external gain setting resistors.

APPLICATIONS

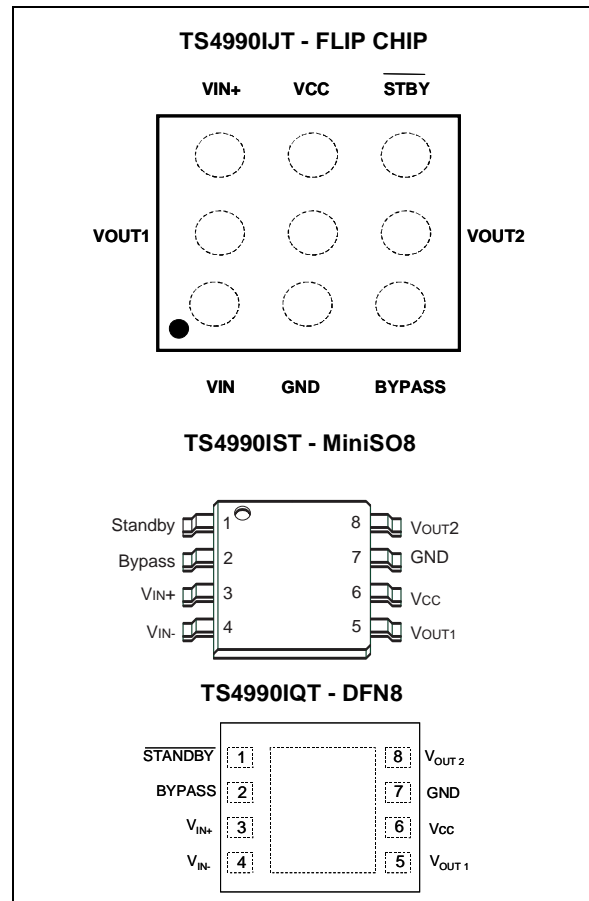
- Mobile phones (cellular / cordless)
- Laptop / notebook computers
- PDAs
- Portable audio devices

ORDER CODE

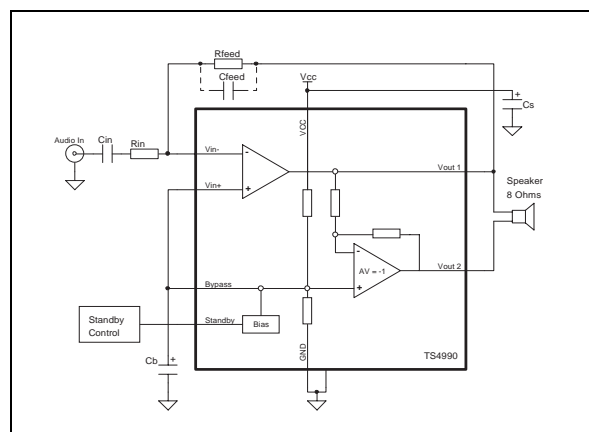
Part Number	Temperature Range: I	Package			Marking
		J	S	Q	
TS4990IJT	-40, +85°C	•			A90
TS4990IST			•		K990
TS4990IQT				•	K990

All packages available only in Tape & Reel (T)

PIN CONNECTIONS (Top View)



Typical application schematic



1 ABSOLUTE MAXIMUM RATINGS

Symbol	Parameter	Value	Unit
V_{CC}	Supply voltage ¹	6	V
V_i	Input Voltage ²	G_{ND} to V_{CC}	V
T_{oper}	Operating Free Air Temperature Range	-40 to + 85	°C
T_{stg}	Storage Temperature	-65 to +150	°C
T_j	Maximum Junction Temperature	150	°C
R_{thja}	Thermal Resistance Junction to Ambient Flip-Chip ³ MiniSO8 DFN8	250 215 120	°C/W
P_d	Power Dissipation	Internally Limited	
ESD	Human Body Model	2	kV
ESD	Machine Model	200	V
	Latch-up Immunity	200mA	
	Lead Temperature (soldering, 10sec)	250	°C

1) All voltage values are measured with respect to the ground pin.

2) The magnitude of input signal must never exceed $V_{CC} + 0.3V / G_{ND} - 0.3V$

3) Device is protected in case of over temperature by a thermal shutdown active @ 150°C.

2 OPERATING CONDITIONS

Symbol	Parameter	Value	Unit
V_{CC}	Supply Voltage	2.2 to 5.5	V
V_{ICM}	Common Mode Input Voltage Range	1.2V to V_{CC}	V
V_{STB}	Standby Voltage Input: Device ON Device OFF	$1.35 \leq V_{STB} \leq V_{CC}$ $G_{ND} \leq V_{STB} \leq 0.4$	V
R_L	Load Resistor	≥ 4	Ω
R_{OUTGND}	Resistor Output to GND ($V_{STB} = G_{ND}$)	≥ 1	M Ω
T_{SD}	Thermal Shutdown Temperature	150	°C
R_{THJA}	Thermal Resistance Junction to Ambient Flip-Chip ¹ MiniSO8 DFN8 ²	100 190 40	°C/W

1) This thermal resistance is reached with a 100mm² copper heatsink surface.

2) When mounted on a 4-layer PCB.

3 ELECTRICAL CHARACTERISTICS

Table 1: Electrical characteristics when $V_{CC} = +5V$, $GND = 0V$, $T_{amb} = 25^{\circ}C$ (unless otherwise specified)

Symbol	Parameter	Min.	Typ.	Max.	Unit
I_{CC}	Supply Current No input signal, no load		3.7	6	mA
$I_{STANDBY}$	Standby Current ¹ No input signal, $V_{stdby} = G_{ND}$, $R_L = 8\Omega$		10	1000	nA
V_{OO}	Output Offset Voltage No input signal, $R_L = 8\Omega$		1	10	mV
P_O	Output Power THD = 1% Max, $F = 1kHz$, $R_L = 8\Omega$	0.9	1.2		W
THD + N	Total Harmonic Distortion + Noise $P_O = 1W_{rms}$, $A_v = 2$, $20Hz \leq F \leq 20kHz$, $R_L = 8\Omega$		0.2		%
PSRR	Power Supply Rejection Ratio ² $R_L = 8\Omega$, $A_v = 2$, $V_{ripple} = 200mV_{pp}$, Input Grounded $F = 217Hz$ $F = 1kHz$	55 55	62 64		dB
T_{WU}	Wake-Up Time ($C_b = 1\mu F$)		90	130	ms
T_{STDB}	Standby Time ($C_b = 1\mu F$)		10		μs
V_{STDBH}	Standby Voltage Level High			1.3	V
V_{STDBL}	Standby Voltage Level Low			0.4	V
Φ_M	Phase Margin at Unity Gain $R_L = 8\Omega$, $C_L = 500pF$		65		Degrees
GM	Gain Margin $R_L = 8\Omega$, $C_L = 500pF$		15		dB
GBP	Gain Bandwidth Product $R_L = 8\Omega$		1.5		MHz

1) Standby mode is activated when V_{stdby} is tied to Gnd

2) All PSRR data limits are guaranteed by production sampling tests
Dynamic measurements - $20 \cdot \log(\text{rms}(V_{out})/\text{rms}(V_{ripple}))$. V_{ripple} is the sinusoidal signal superimposed upon V_{CC} .

Table 2:Electrical Characteristics when $V_{CC} = +3.3V$, $GND = 0V$, $T_{amb} = 25^{\circ}C$ (unless otherwise specified)

Symbol	Parameter	Min.	Typ.	Max.	Unit
I_{CC}	Supply Current No input signal, no load		3.3	6	mA
$I_{STANDBY}$	Standby Current ¹ No input signal, $V_{stdby} = G_{ND}$, $R_L = 8\Omega$		10	1000	nA
V_{OO}	Output Offset Voltage No input signal, $R_L = 8\Omega$		1	10	mV
P_o	Output Power THD = 1% Max, $F = 1kHz$, $R_L = 8\Omega$	375	500		mW
THD + N	Total Harmonic Distortion + Noise $P_o = 400mWrms$, $A_v = 2$, $20Hz \leq F \leq 20kHz$, $R_L = 8\Omega$		0.1		%
PSRR	Power Supply Rejection Ratio ² $R_L = 8\Omega$, $A_v = 2$, $V_{ripple} = 200mVpp$, Input Grounded $F = 217Hz$ $F = 1kHz$	55 55	61 63		dB
T_{WU}	Wake-Up Time ($C_b = 1\mu F$)		110	140	ms
T_{STDB}	Standby Time ($C_b = 1\mu F$)		10		μs
V_{STDBH}	Standby Voltage Level High			1.2	V
V_{STDBL}	Standby Voltage Level Low			0.4	V
Φ_M	Phase Margin at Unity Gain $R_L = 8\Omega$, $C_L = 500pF$		65		Degrees
GM	Gain Margin $R_L = 8\Omega$, $C_L = 500pF$		15		dB
GBP	Gain Bandwidth Product $R_L = 8\Omega$		1.5		MHz

1) Standby mode is activated when V_{stdby} is tied to Gnd

2) All PSRR data limits are guaranteed by production sampling tests
Dynamic measurements - $20 \cdot \log(\text{rms}(V_{out})/\text{rms}(V_{ripple}))$. V_{ripple} is the sinusoidal signal superimposed upon V_{CC} .

Table 3:Electrical characteristics when $V_{CC} = 2.6V$, $GND = 0V$, $T_{amb} = 25^{\circ}C$ (unless otherwise specified)

Symbol	Parameter	Min.	Typ.	Max.	Unit
I_{CC}	Supply Current No input signal, no load		3.1	6	mA
$I_{STANDBY}$	Standby Current ¹ No input signal, $V_{stdby} = G_{ND}$, $R_L = 8\Omega$		10	1000	nA
V_{OO}	Output Offset Voltage No input signal, $R_L = 8\Omega$		1	10	mV
P_o	Output Power THD = 1% Max, $F = 1kHz$, $R_L = 8\Omega$	220	300		mW
THD + N	Total Harmonic Distortion + Noise $P_o = 200mWrms$, $A_v = 2$, $20Hz \leq F \leq 20kHz$, $R_L = 8\Omega$		0.1		%
PSRR	Power Supply Rejection Ratio ² $R_L = 8\Omega$, $A_v = 2$, $V_{ripple} = 200mVpp$, Input Grounded $F = 217Hz$ $F = 1kHz$	55 55	60 62		dB
T_{WU}	Wake-Up Time ($C_b = 1\mu F$)		125	150	ms
T_{STDB}	Standby Time ($C_b = 1\mu F$)		10		μs
V_{STDBH}	Standby Voltage Level High			1.2	V
V_{STDBL}	Standby Voltage Level Low			0.4	V
Φ_M	Phase Margin at Unity Gain $R_L = 8\Omega$, $C_L = 500pF$		65		Degrees
GM	Gain Margin $R_L = 8\Omega$, $C_L = 500pF$		15		dB
GBP	Gain Bandwidth Product $R_L = 8\Omega$		1.5		MHz

1) Standby mode is activated when V_{stdby} is tied to Gnd

2) All PSRR data limits are guaranteed by production sampling tests
Dynamic measurements - $20 \cdot \log(rms(V_{out})/rms(V_{ripple}))$. V_{ripple} is the sinusoidal signal superimposed upon V_{cc} .

Components	Functional Description
R_{in}	Inverting input resistor which sets the closed loop gain in conjunction with R_{feed} . This resistor also forms a high pass filter with C_{in} ($f_c = 1 / (2 \times \pi \times R_{in} \times C_{in})$)
C_{in}	Input coupling capacitor which blocks the DC voltage at the amplifier input terminal.
R_{feed}	Feed back resistor which sets the closed loop gain in conjunction with R_{in} .
C_s	Supply Bypass capacitor which provides power supply filtering.
C_b	Bypass pin capacitor which provides half supply filtering.
C_{feed}	Low pass filter capacitor allowing to cut the high frequency (low pass filter cut-off frequency $1 / (2 \times \pi \times R_{feed} \times C_{feed})$)
A_v	Closed loop gain in BTL configuration = $2 \times (R_{feed} / R_{in})$

Fig. 1: Open Loop Frequency Response

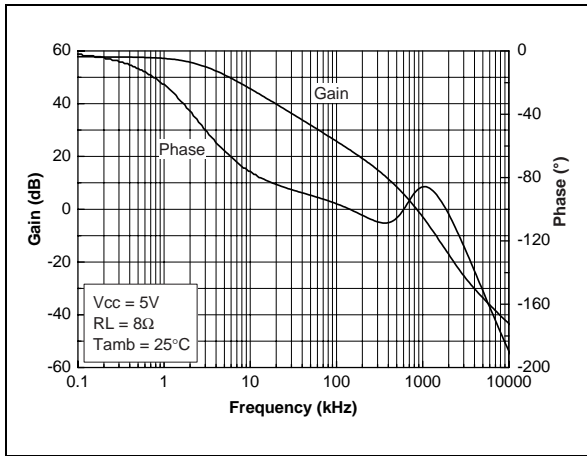


Fig. 4: Open Loop Frequency Response

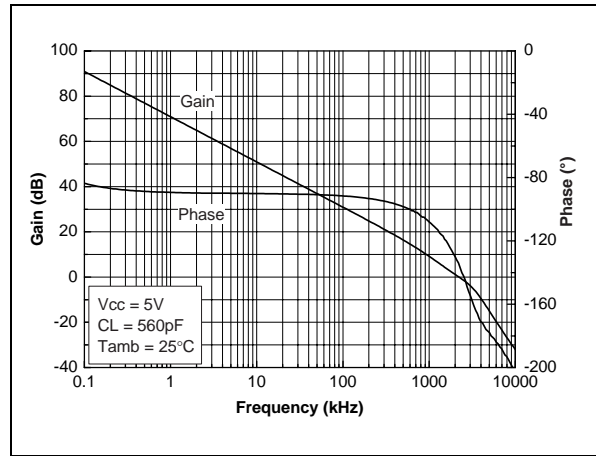


Fig. 2: Open Loop Frequency Response

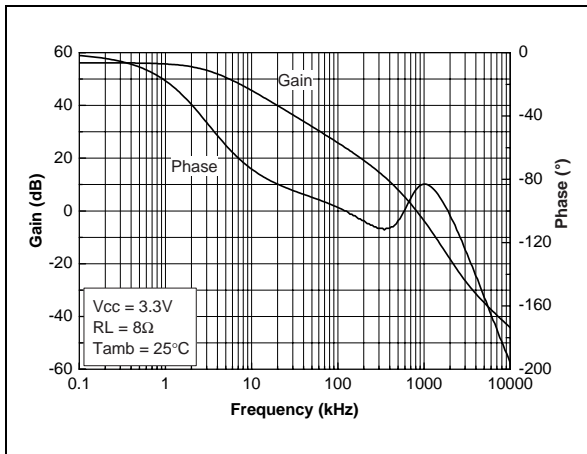


Fig. 5: Open Loop Frequency Response

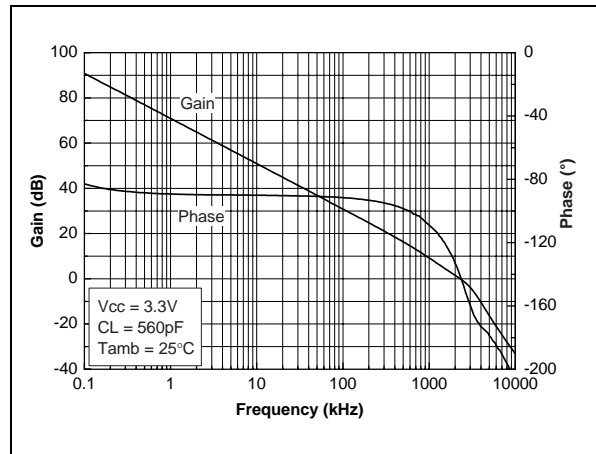


Fig. 3: Open Loop Frequency Response

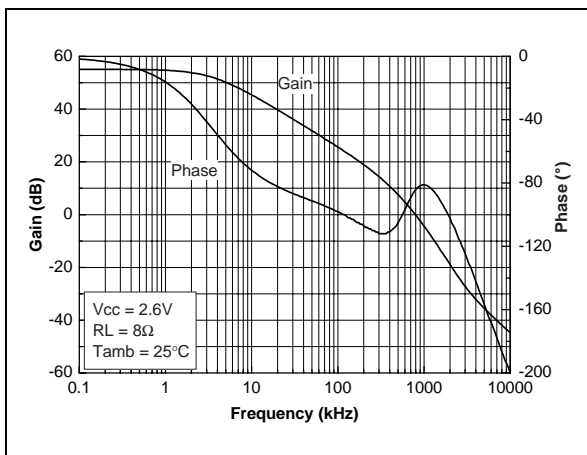


Fig. 6: Open Loop Frequency Response

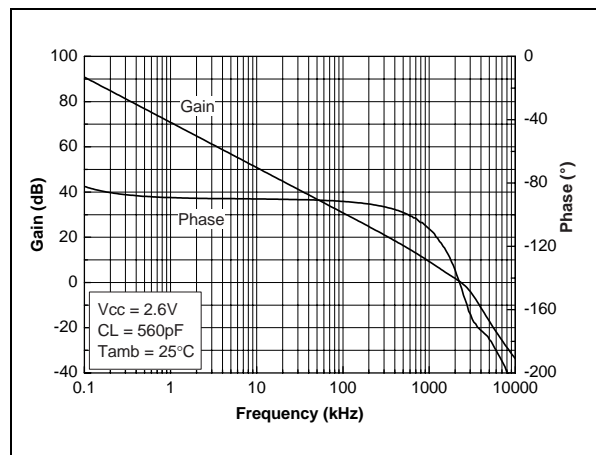


Fig. 7: Power Supply Rejection Ratio (PSRR) vs Power supply

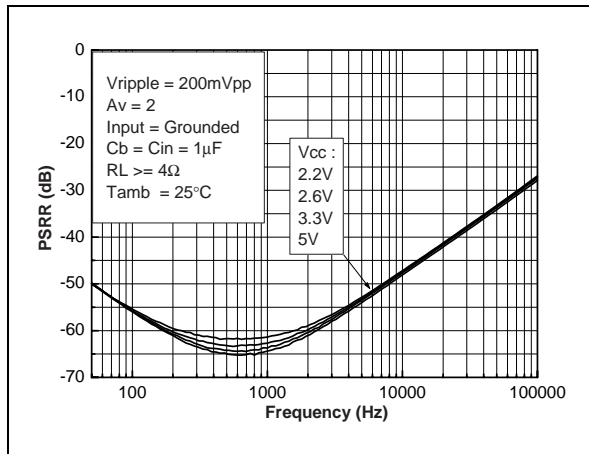


Fig. 8: Power Supply Rejection Ratio (PSRR) vs Power supply

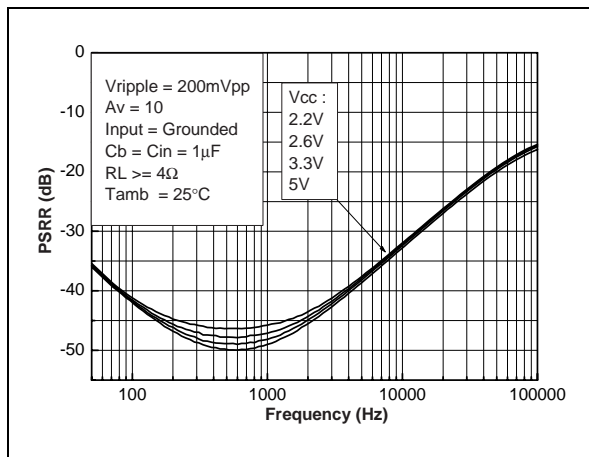


Fig. 9: Power Supply Rejection Ratio (PSRR) vs Power supply

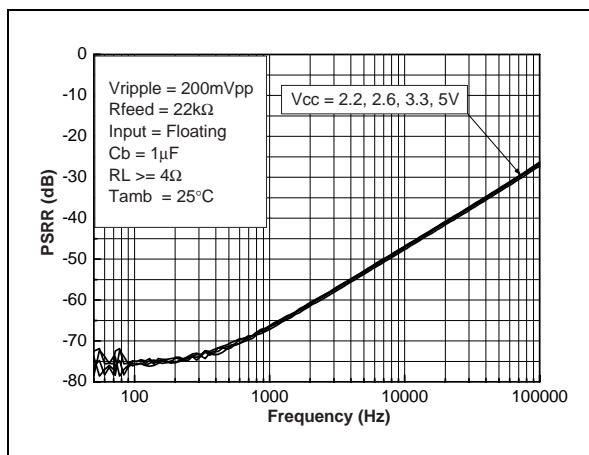


Fig. 10: Power Supply Rejection Ratio (PSRR) vs Power supply

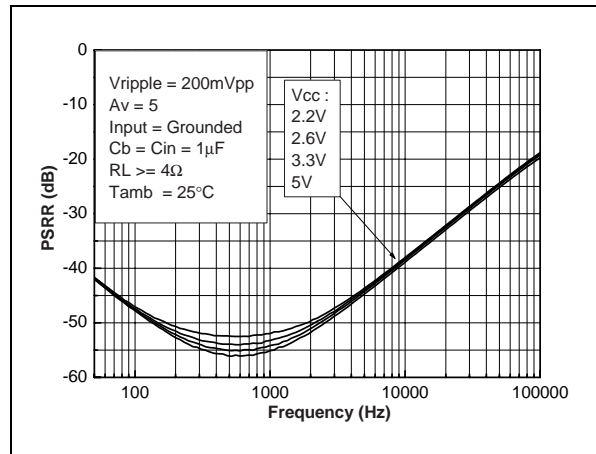


Fig. 11: Power Supply Rejection Ratio (PSRR) vs Power supply

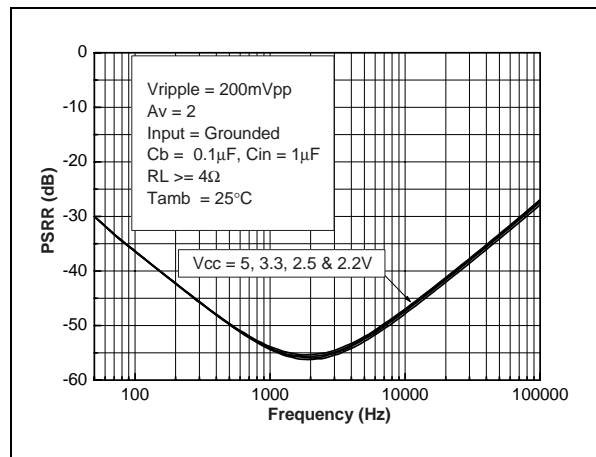


Fig. 12: Power Supply Rejection Ratio (PSRR) vs Power supply

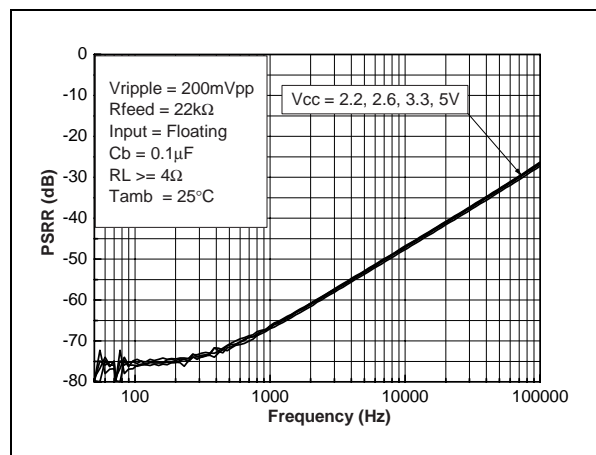


Fig. 13: Power Supply Rejection Ratio (PSRR) vs DC Output Voltage

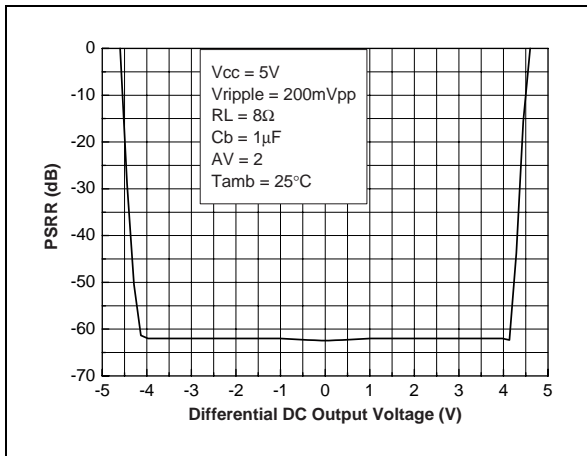


Fig. 14: Power Supply Rejection Ratio (PSRR) vs DC Output Voltage

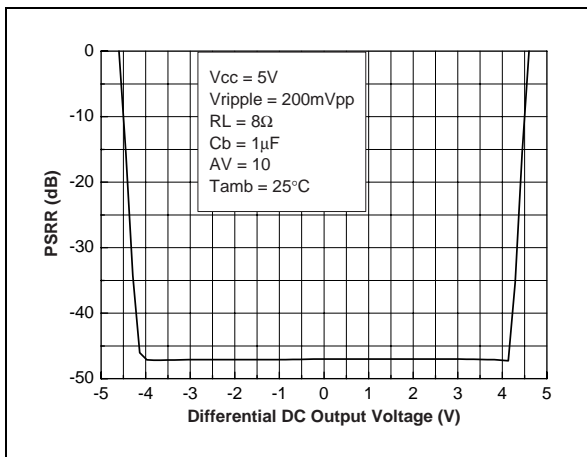


Fig. 15: Power Supply Rejection Ratio (PSRR) vs DC Output Voltage

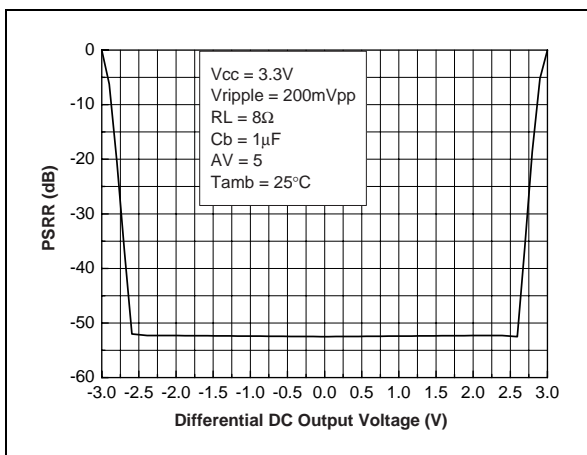


Fig. 16: Power Supply Rejection Ratio (PSRR) vs DC Output Voltage

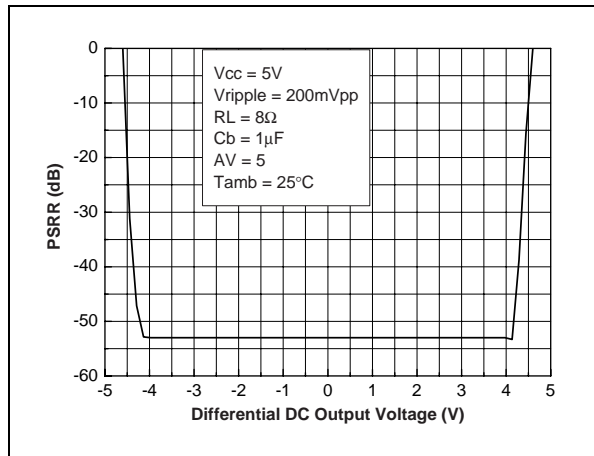


Fig. 17: Power Supply Rejection Ratio (PSRR) vs DC Output Voltage

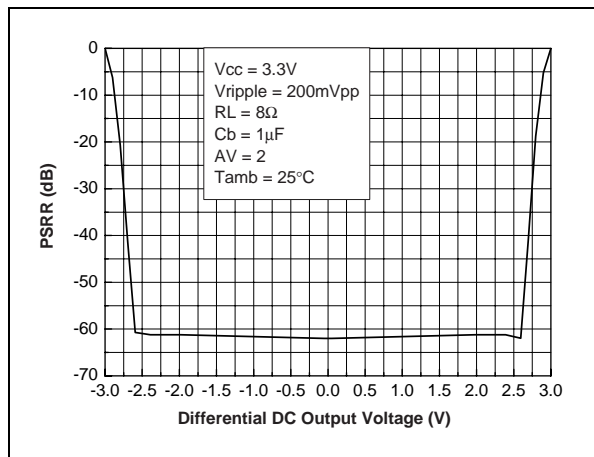


Fig. 18: Power Supply Rejection Ratio (PSRR) vs DC Output Voltage

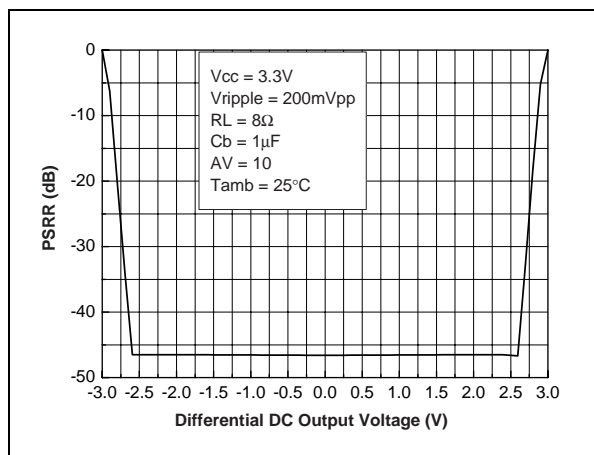


Fig. 19: Power Supply Rejection Ratio (PSRR) vs DC Output Voltage

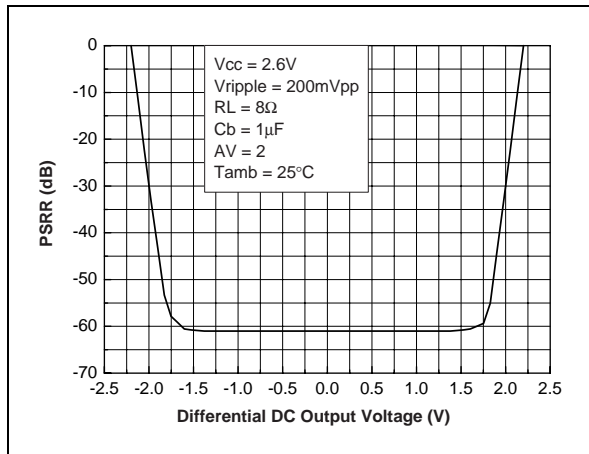


Fig. 20: Power Supply Rejection Ratio (PSRR) vs DC Output Voltage

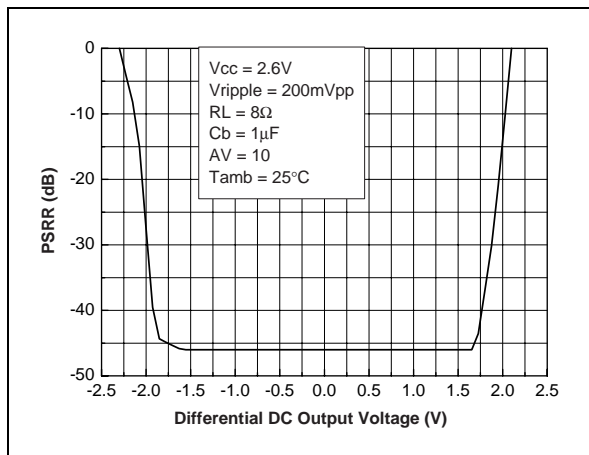


Fig. 21: Output Power vs Power Supply Voltage

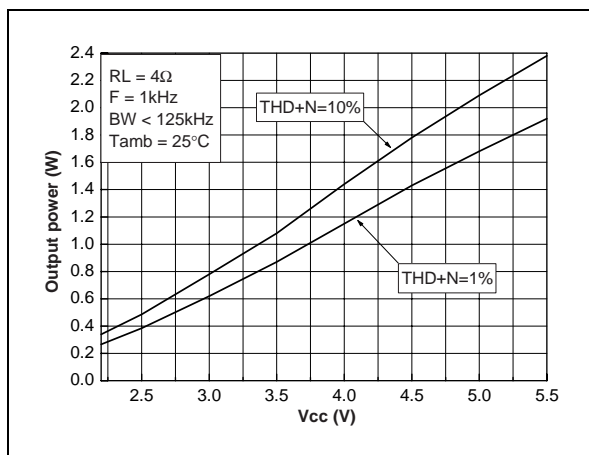


Fig. 22: Power Supply Rejection Ratio (PSRR) vs DC Output Voltage

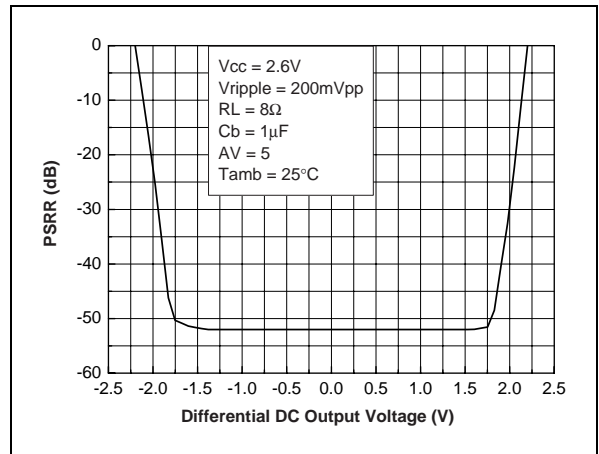


Fig. 23: Power Supply Rejection Ratio (PSRR) at F=217Hz vs Bypass Capacitor

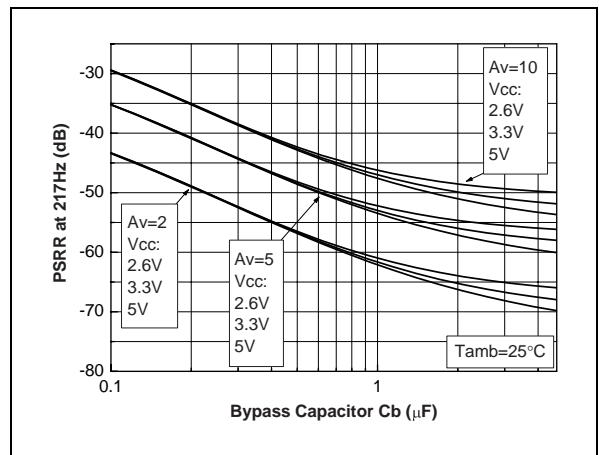


Fig. 24: Output Power vs Power Supply Voltage

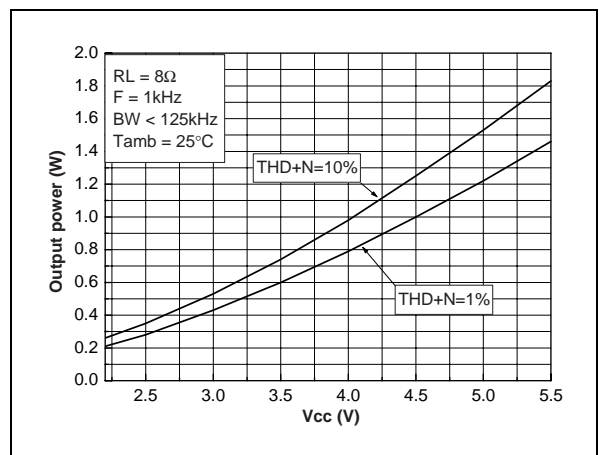


Fig. 25: Output Power vs Power Supply Voltage

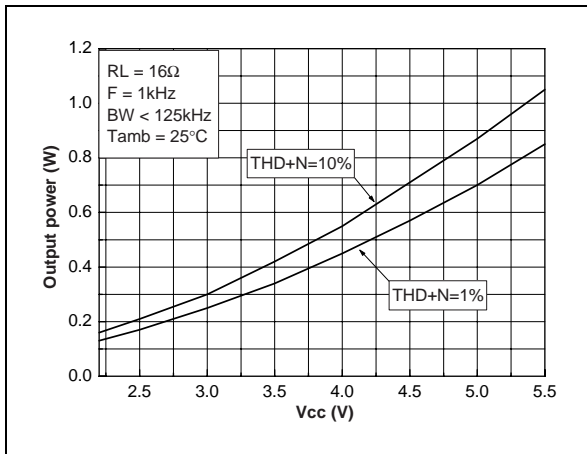


Fig. 28: Output Power vs Power Supply Voltage

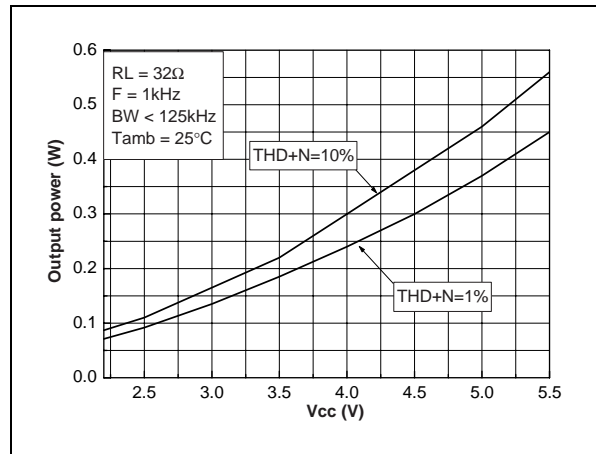


Fig. 26: Output Power vs Load Resistor

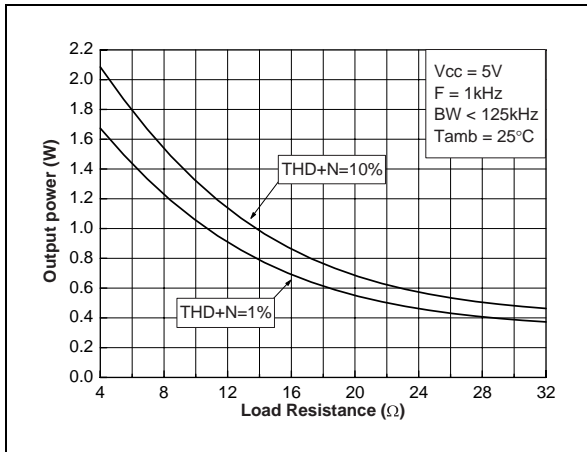


Fig. 29: Output Power vs Load Resistor

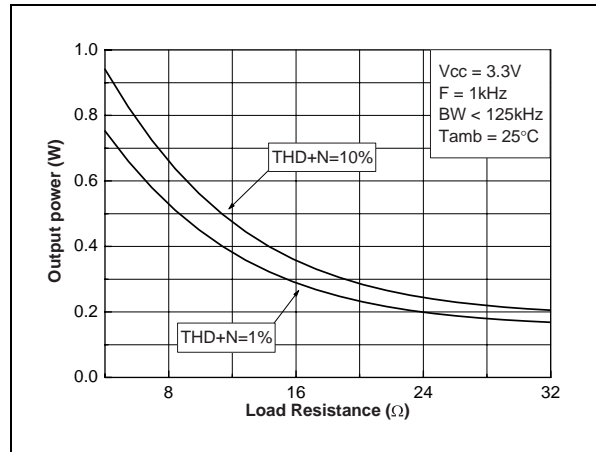


Fig. 27: Output Power vs Load Resistor

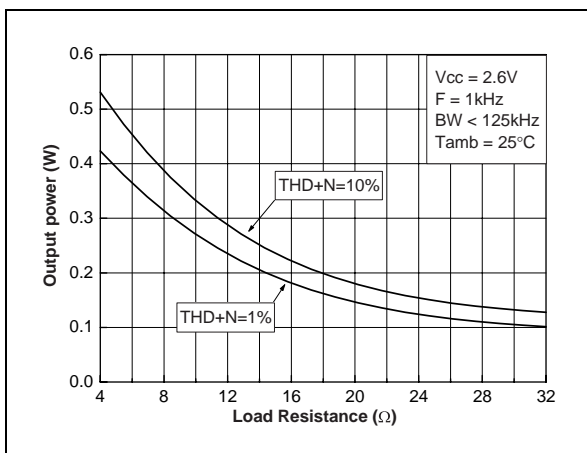


Fig. 30: Power Dissipation vs Pout

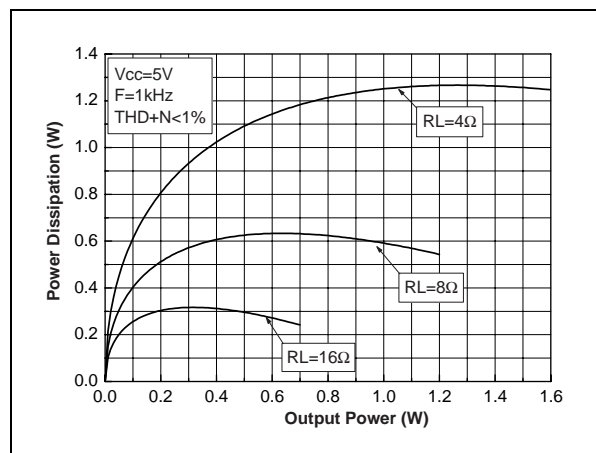


Fig. 31: Power Dissipation vs Pout

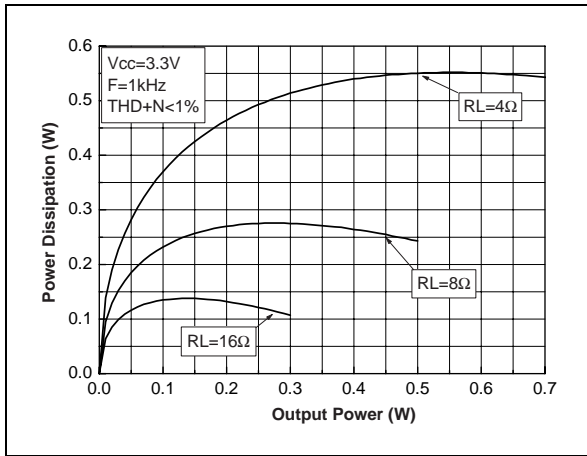


Fig. 34: Power Dissipation vs Pout

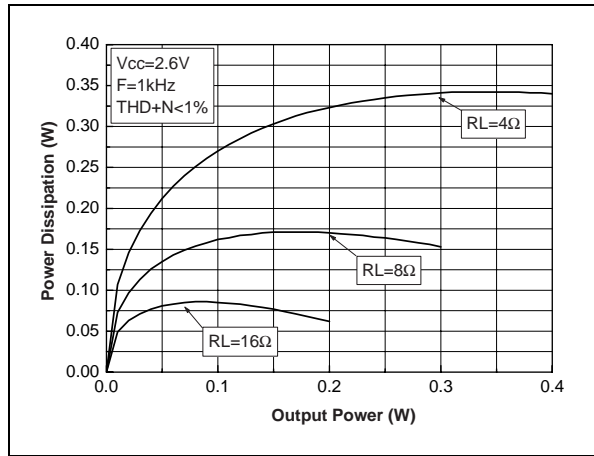


Fig. 32: Power Derating Curves

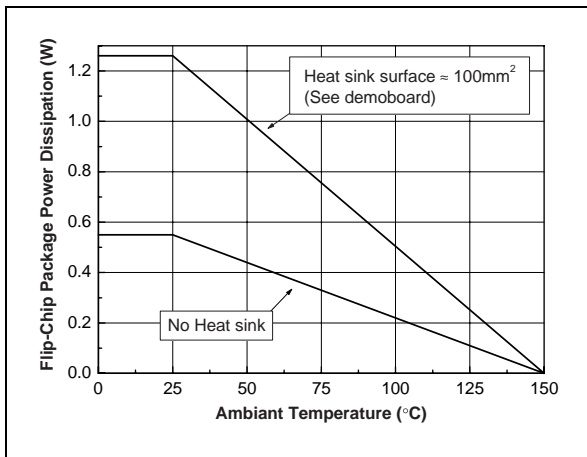


Fig. 35: Clipping Voltage vs Power Supply Voltage and Load Resistor

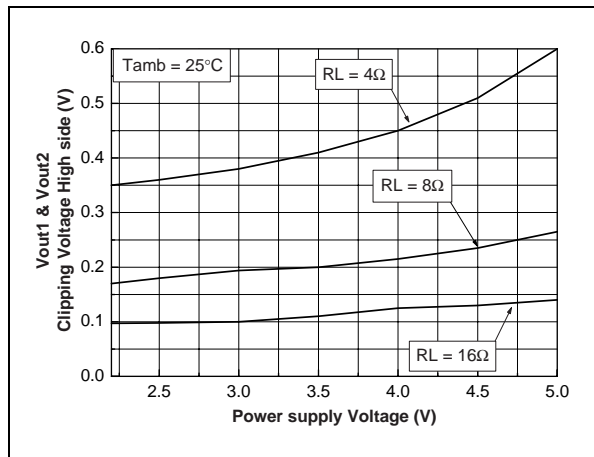


Fig. 33: Clipping Voltage vs Power Supply Voltage and Load Resistor

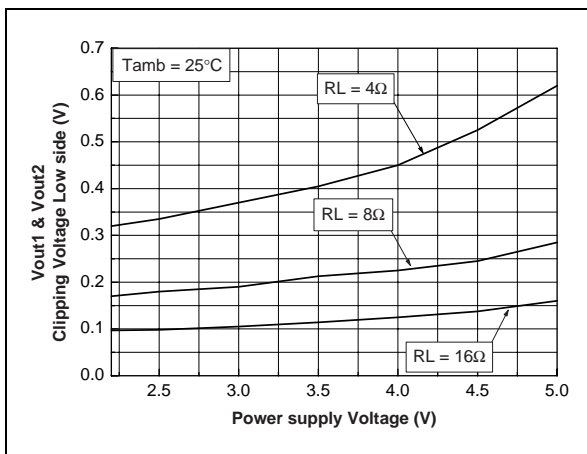


Fig. 36: Current Consumption vs Power Supply Voltage

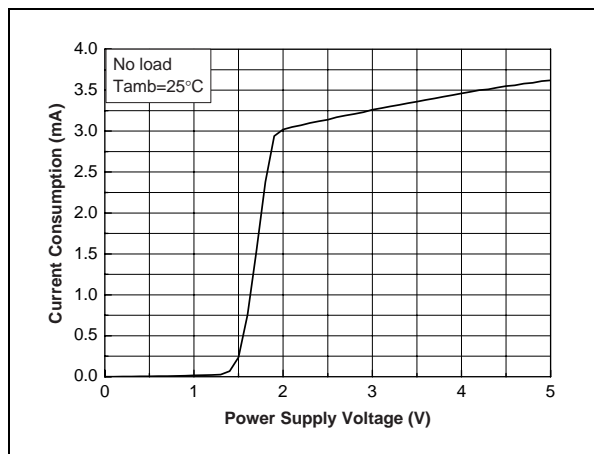


Fig. 37: Current Consumption vs Standby Voltage @ Vcc = 5V

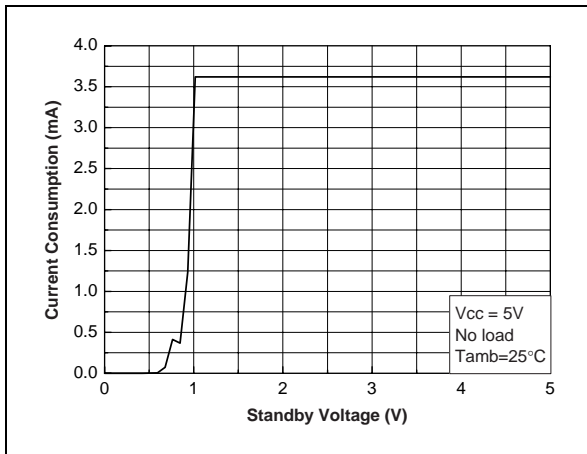


Fig. 40: Current Consumption vs Standby Voltage @ Vcc = 3.3V

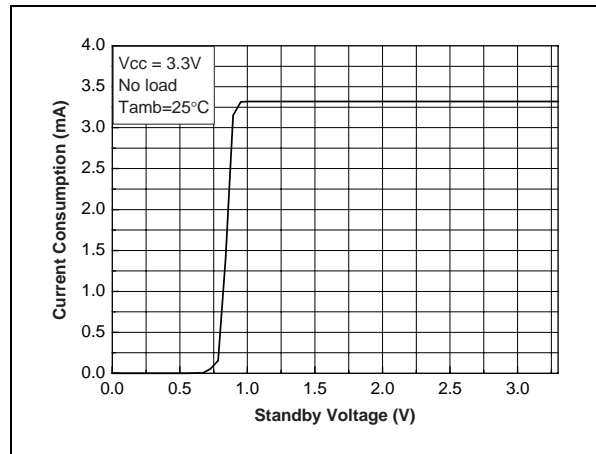


Fig. 38: Current Consumption vs Standby Voltage @ Vcc = 2.6V

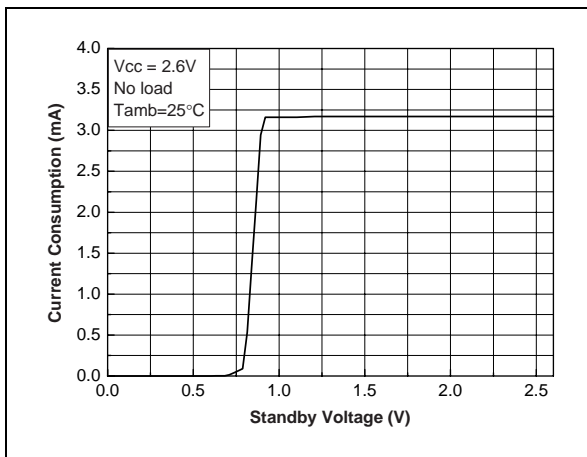


Fig. 41: Current Consumption vs Standby Voltage @ Vcc = 2.2V

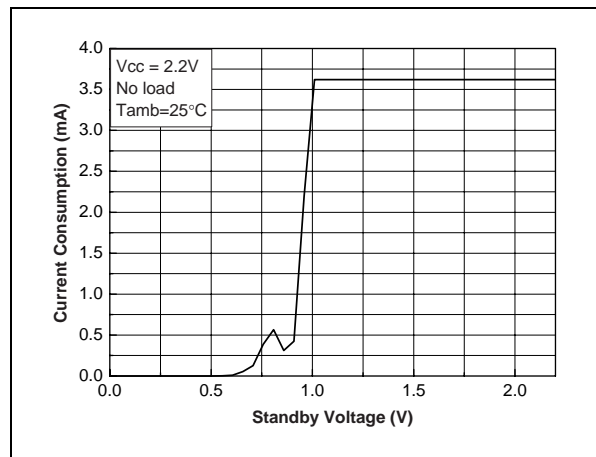


Fig. 39: THD + N vs Output Power

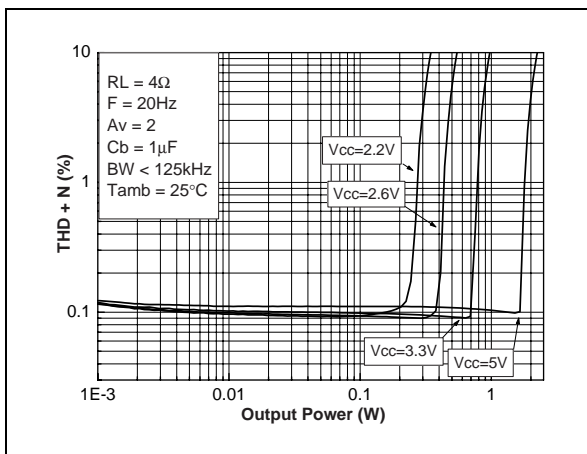


Fig. 42: THD + N vs Output Power

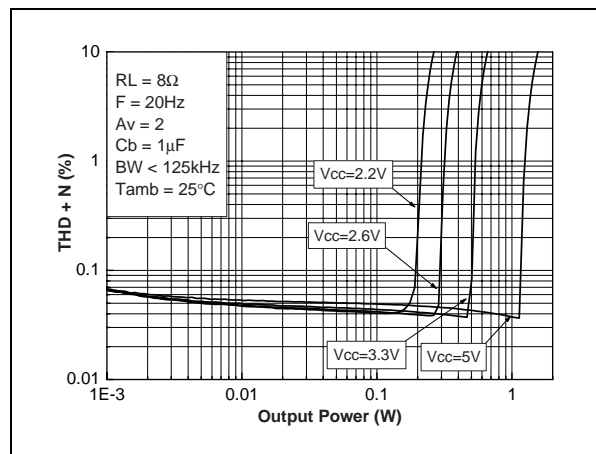


Fig. 43: THD + N vs Output Power

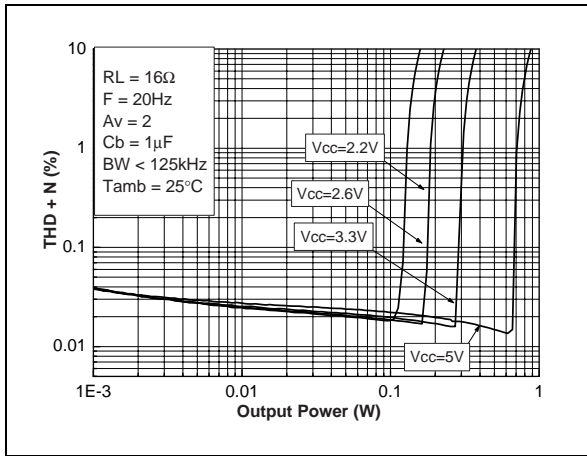


Fig. 46: THD + N vs Output Power

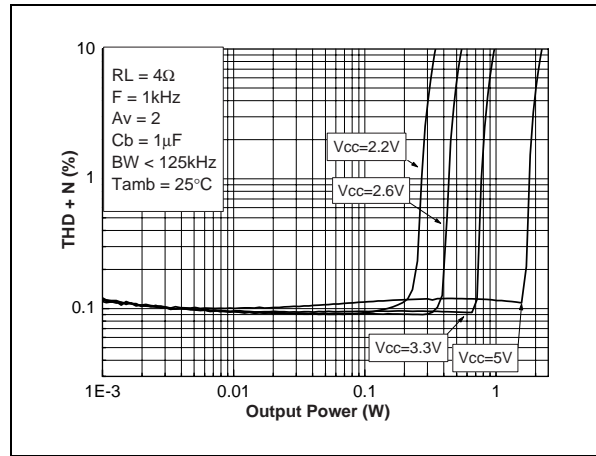


Fig. 44: THD + N vs Output Power

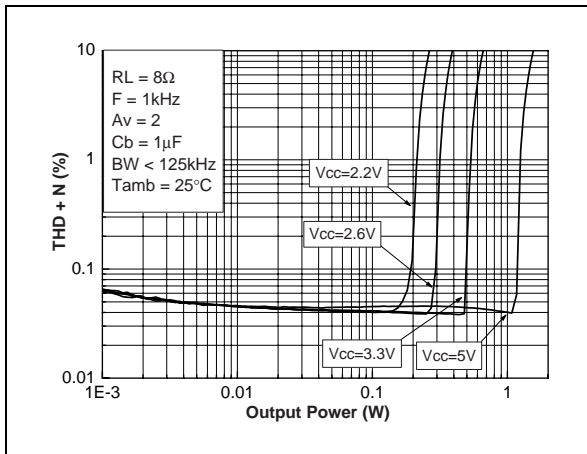


Fig. 47: THD + N vs Output Power

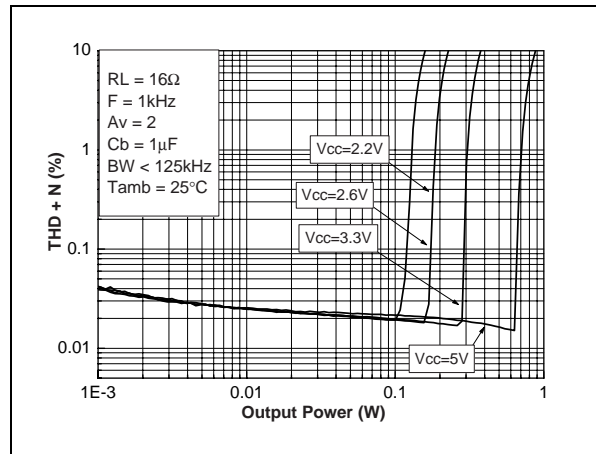


Fig. 45: THD + N vs Output Power

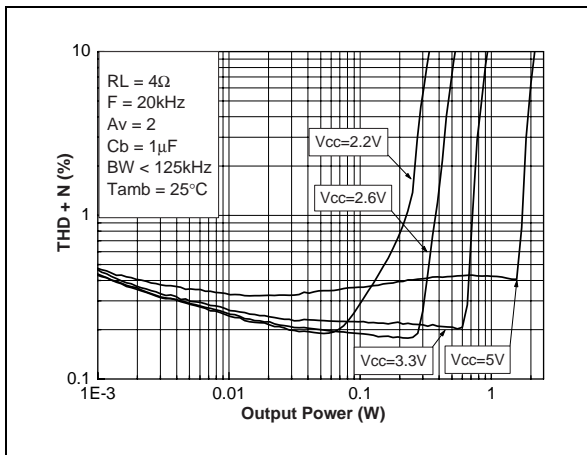


Fig. 48: THD + N vs Output Power

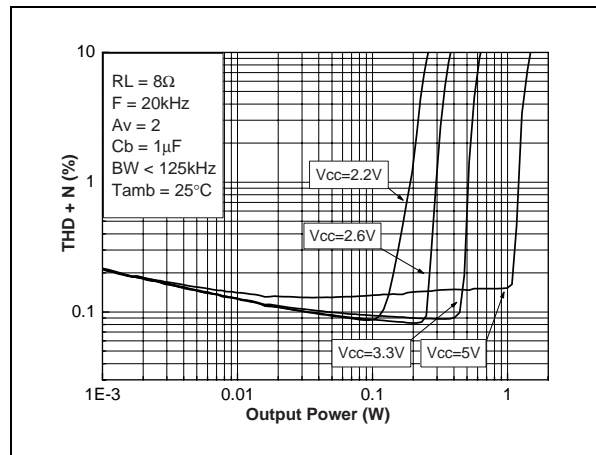


Fig. 49: THD + N vs Output Power

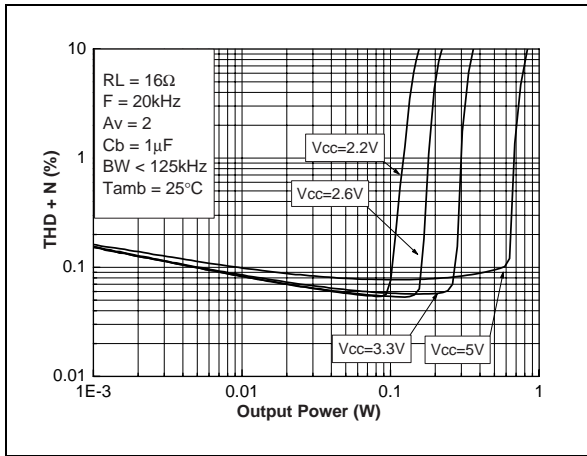


Fig. 52: THD + N vs Frequency

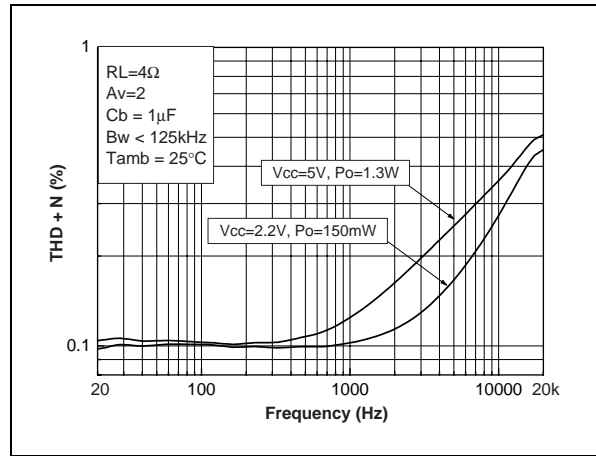


Fig. 50: THD + N vs Frequency

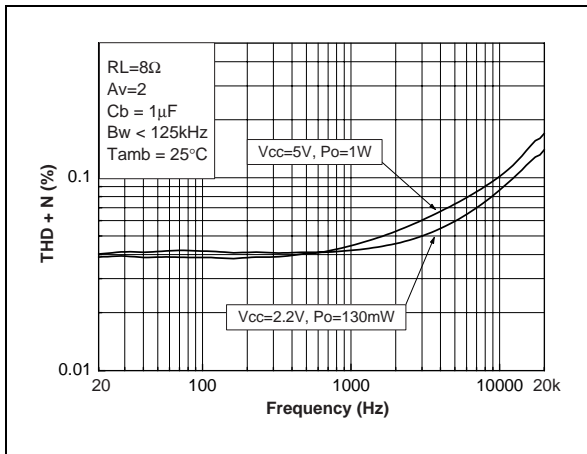


Fig. 53: THD + N vs Frequency

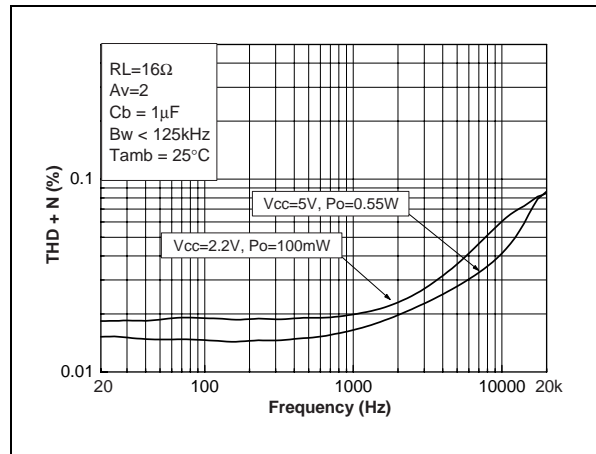


Fig. 51: Signal to Noise Ratio vs Power Supply with Unweighted Filter (20Hz to 20kHz)

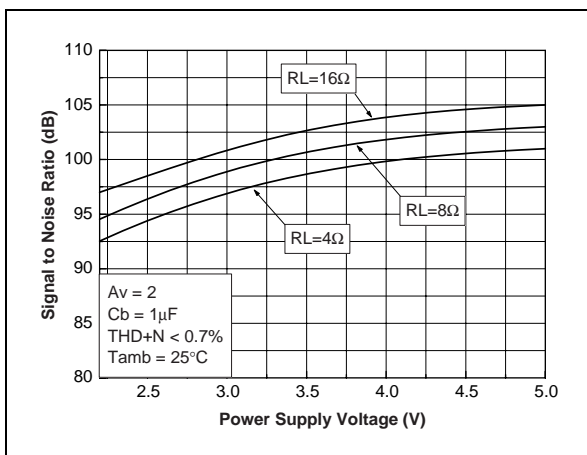


Fig. 54: Signal to Noise Ratio vs Power Supply with Unweighted Filter (20Hz to 20kHz)

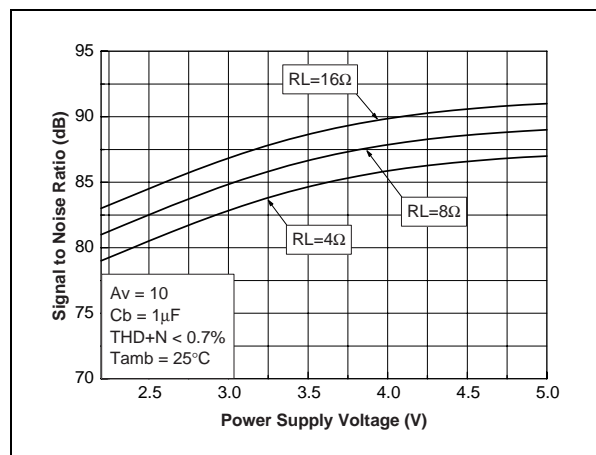


Fig. 55: Signal to Noise Ratio vs Power Supply with A Weighted Filter

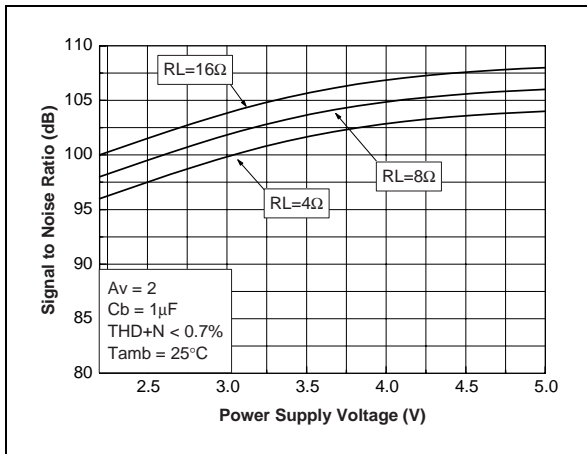


Fig. 56: Output Noise Voltage device ON

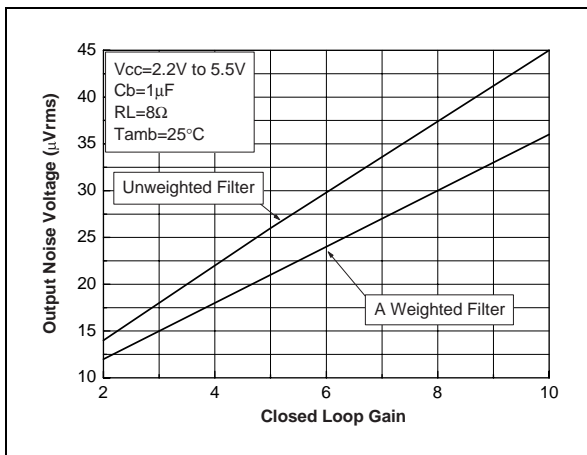


Fig. 57: Signal to Noise Ratio vs Power Supply with A Weighted Filter

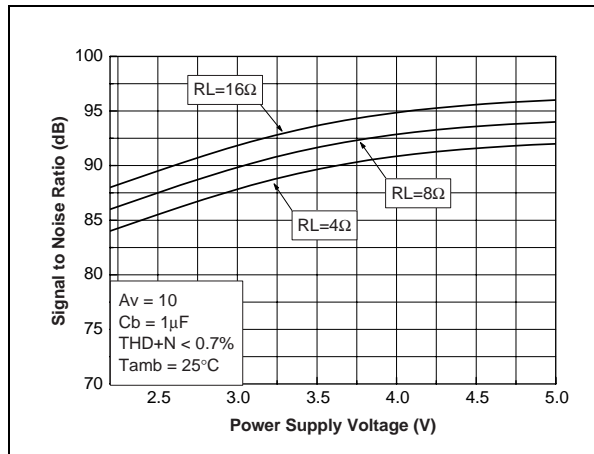
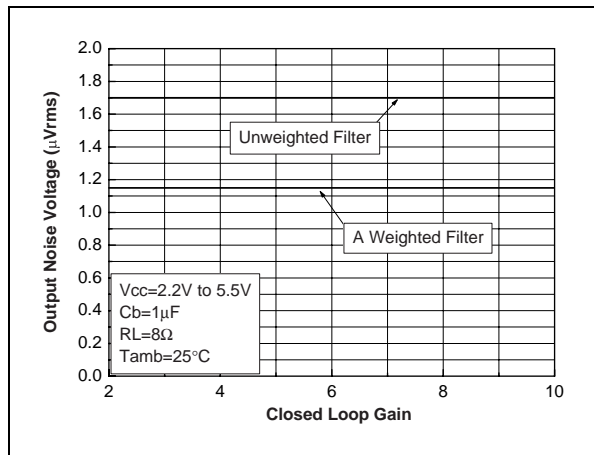


Fig. 58: Output Noise Voltage device in Standby



4 APPLICATION INFORMATION

4.1 BTL Configuration Principle

The TS4990 is a monolithic power amplifier with a BTL output type. BTL (Bridge Tied Load) means that each end of the load is connected to two single-ended output amplifiers. Thus, we have:

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

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

$$\text{and } V_{\text{out1}} - V_{\text{out2}} = 2V_{\text{out}} \text{ (V)}$$

The output power is:

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

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

4.2 Gain In Typical Application Schematic

The typical application schematic is shown in [Figure](#) on page 1.

In the flat region (no C_{in} effect), the output voltage of the first stage is (in Volts):

$$V_{\text{out1}} = (-V_{\text{in}}) \frac{R_{\text{feed}}}{R_{\text{in}}}$$

For the second stage: $V_{\text{out2}} = -V_{\text{out1}}$ (V)

The differential output voltage is (in Volts):

$$V_{\text{out2}} - V_{\text{out1}} = 2V_{\text{in}} \frac{R_{\text{feed}}}{R_{\text{in}}}$$

The differential gain named gain (G_v) for more convenient usage is:

$$G_v = \frac{V_{\text{out2}} - V_{\text{out1}}}{V_{\text{in}}} = 2 \frac{R_{\text{feed}}}{R_{\text{in}}}$$

V_{out2} is in phase with V_{in} and V_{out1} is phased 180° with V_{in} . This means that the positive terminal of the loudspeaker should be connected to V_{out2} and the negative to V_{out1} .

4.3 Low and high frequency response

In the low frequency region, C_{in} starts to have an effect. C_{in} forms with R_{in} a high-pass filter with a -3dB cut-off frequency. F_{CL} is in Hz.

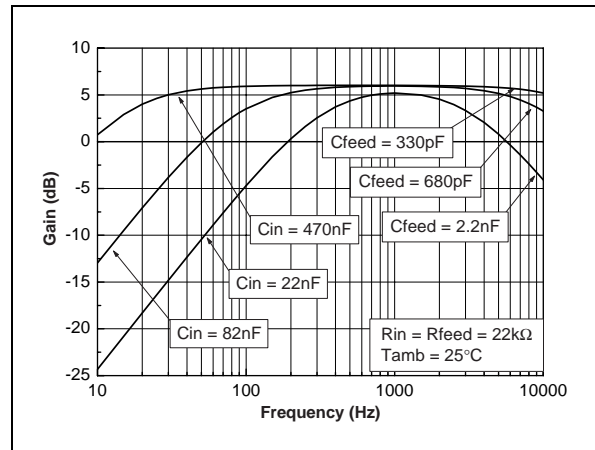
$$F_{\text{CL}} = \frac{1}{2\pi R_{\text{in}} C_{\text{in}}}$$

In the high frequency region, you can limit the bandwidth by adding a capacitor (C_{feed}) in parallel with R_{feed} . It forms a low-pass filter with a -3dB cut-off frequency. F_{CH} is in Hz.

$$F_{\text{CH}} = \frac{1}{2\pi R_{\text{feed}} C_{\text{feed}}}$$

The following graph shows an example of C_{in} and C_{feed} influence.

Fig. 59: Frequency Response Gain vs C_{in} , & C_{feed}



4.4 Power dissipation and efficiency

Hypotheses:

- Load voltage and current are sinusoidal (V_{out} and I_{out})
- Supply voltage is a pure DC source (V_{CC})

Regarding the load we have:

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

and

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

and

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

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

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

The power delivered by the supply voltage is:

$$P_{\text{supply}} = V_{\text{CC}} I_{\text{CC AVG}} \text{ (W)}$$

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

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

$$P_{\text{diss}} = \frac{2\sqrt{2}V_{\text{CC}}}{\pi\sqrt{R_L}} \sqrt{P_{\text{out}}} - P_{\text{out}}$$

and the maximum value is obtained when:

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

and its value is:

$$P_{\text{diss max}} = \frac{2V_{\text{CC}}^2}{\pi^2 R_L} \text{ (W)}$$

Note: This maximum value is only dependent on power supply voltage and load values.

The **efficiency** is the ratio between the output power and the power supply

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

The maximum theoretical value is reached when $V_{\text{peak}} = V_{\text{CC}}$, so

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

4.5 Decoupling of the circuit

Two capacitors are needed to correctly bypass the TS4990. A power supply bypass capacitor C_S and a bias voltage bypass capacitor C_B .

C_S has particular influence on the THD+N in the high frequency region (above 7kHz) and an indirect influence on power supply disturbances. With a value for C_S of 1 μ F, you can expect similar THD+N performances to those shown in the datasheet.

In the high frequency region, if C_S is lower than 1 μ 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 μ F, those disturbances on the power supply rail are more filtered.

C_B has an influence on THD+N at lower frequencies, but its function is critical to the final result of PSRR (with input grounded and in the lower frequency region).

If C_B is lower than 1 μ F, THD+N increases at lower frequencies and PSRR worsens.

If C_B is higher than 1 μ F, the benefit on THD+N at lower frequencies is small, but the benefit to PSRR is substantial.

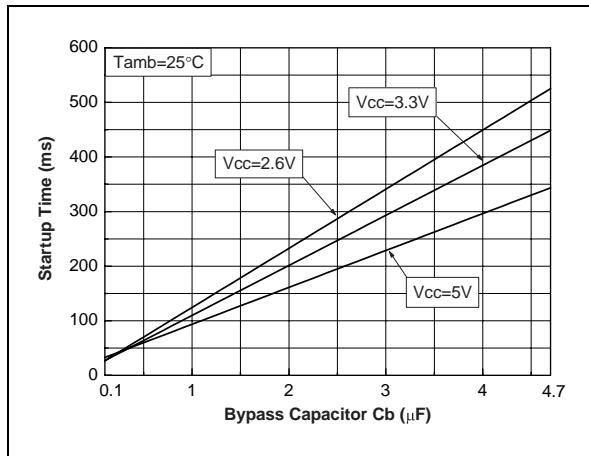
Note that C_{in} has a non-negligible effect on PSRR at lower frequencies. The lower the value of C_{in} , the higher the PSRR.

4.6 Wake-up Time: T_{WU}

When the standby is released to put the device ON, the bypass capacitor C_B will not be charged immediately. As C_B is directly linked to the bias of the amplifier, the bias will not work properly until the C_B voltage is correct. The time to reach this voltage is called wake-up time or T_{WU} and specified in electrical characteristics table with $C_B=1\mu$ F.

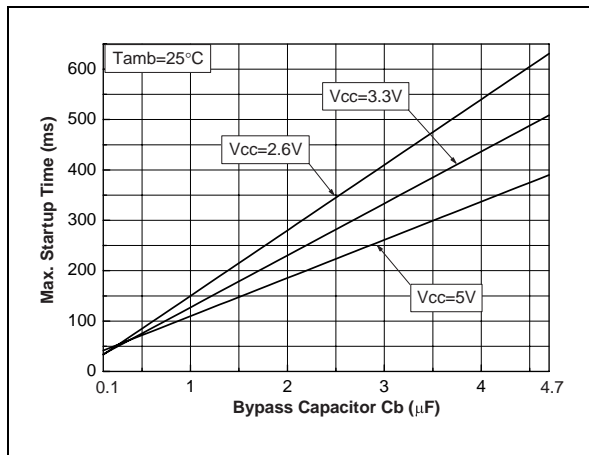
If C_B has a value other than 1 μ F, please refer to the graph in [Figure 60](#) to establish the wake-up time value.

Fig. 60: Typical Wake-up Time vs. C_b



Due to process tolerances, the maximum value of wake-up time could be established by the graph in [Figure 61](#):

Fig. 61: Maximum Wake-up Time vs. C_b



Note: Bypass capacitor C_b as also a tolerance of typically +/-20%. To calculate the wake-up time with this tolerance, refer to the previous graph (considering for example for $C_b=1\mu\text{F}$ in the range of $0.8\mu\text{F}\leq C_b\leq 1.2\mu\text{F}$).

4.7 Shutdown time

When the standby command is set, the time required to put the two output stages in high impedance and the internal circuitry in shutdown mode is a few microseconds.

Note: In shutdown mode, Bypass pin and V_{in} - pin are short-circuited to ground by internal switches. This allows a quick discharge of C_b and C_{in} capacitors.

4.8 Pop performance

Pop performance is intimately linked with the size of the input capacitor C_{in} and the bias voltage bypass capacitor C_b .

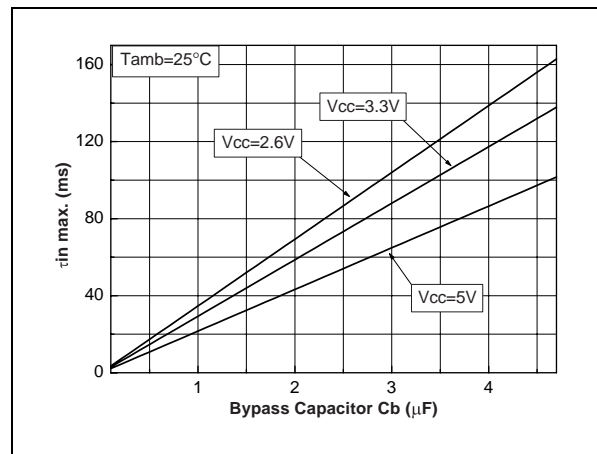
The size of C_{in} is dependent on the lower cut-off frequency and PSRR values requested. The size of C_b is dependent on THD+N and PSRR values requested at lower frequencies.

Moreover, C_b determines the speed with which the amplifier turns ON. In order to reach near zero pop and click, the equivalent input constant time,

$$\tau_{in} = (R_{in} + 2k\Omega) \times C_{in} \text{ (s) with } R_{in} \geq 5k\Omega$$

must not reach the τ_{in} maximum value as indicated in the graph below.

Fig. 62: τ_{in} max. versus Bypass Capacitor



By following previous rules, the TS4990 can reach near zero pop and click even with high gains such as 20 dB.

Example:

With $R_{in} = 22 \text{ k}\Omega$ and a 20 Hz, -3 db low cut-off frequency, $C_{in}=361 \text{ nF}$. So, $C_{in}=390 \text{ nF}$ with standard value which gives a lower cut-off frequency equal to 18.5 Hz. In this case, $(R_{in} + 2 \text{ k}\Omega) \times C_{in} = 9.36 \text{ ms}$. When referring to the previous graph, if $C_b = 1 \mu\text{F}$ and $V_{cc} = 5 \text{ V}$, we read 20 ms max. This value is twice as high as our current value, thus we can state that pop and click will be reduced to its lowest value.

Minimizing both C_{in} and the gain benefits both the pop phenomena, and the cost and size of the application.

4.9 Application: Differential inputs BTL power amplifier.

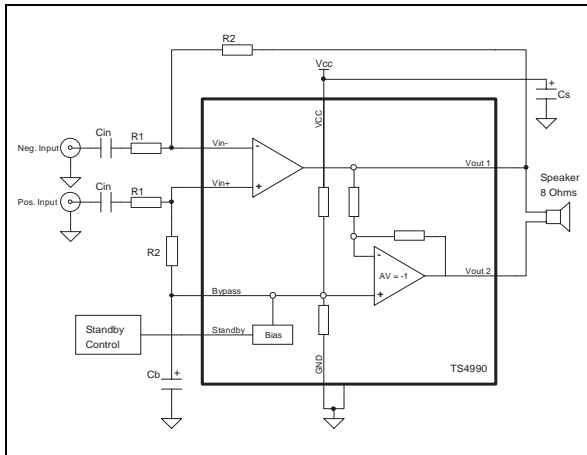
The schematic in *Figure 63* shows how to design the TS4990 to work in a differential input mode.

The gain of the amplifier is:

$$G_{VDIFF} = 2 \frac{R_2}{R_1}$$

In order to reach the optimal performance of the differential function, R_1 and R_2 should be matched at 1% max.

Fig. 63: Differential Input Amplifier Configuration



The input capacitor C_{IN} could be calculated by the following formula using the -3dB lower frequency required. (F_L is the lower frequency required)

$$C_{IN} \approx \frac{1}{2 \pi R_1 F_L} (F)$$

Note: This formula is true only if:

$$F_{CB} = \frac{1}{2 \pi (R_1 + R_2) C_B} (Hz)$$

is 5 times lower than F_L .

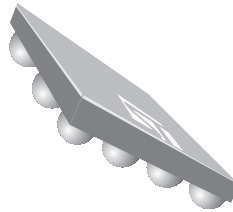
The following bill of material is an example of a differential amplifier with a gain of 2 and a -3dB lower cut-off frequency of about 80Hz.

Components:

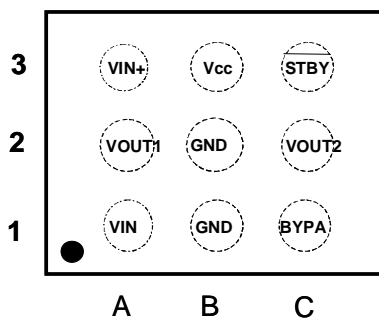
Designator	Part Type
R1	20k / 1%
R2	20k / 1%
C_{in}	100nF
$C_b=C_s$	1 μ F
U1	TS4990

5 PACKAGE MECHANICAL DATA

5.1 TS4990IJT Pinout and Package Mechanical Data



5.1.1 Pinout (Top View)



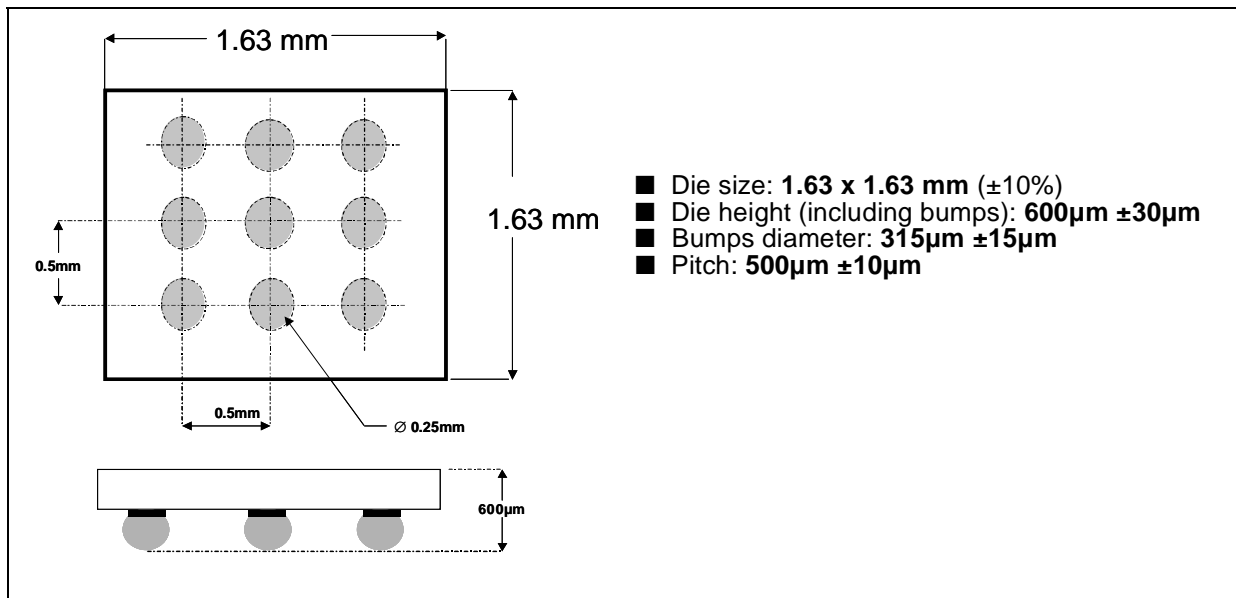
■ Balls are underneath

5.1.2 Marking (Top View)

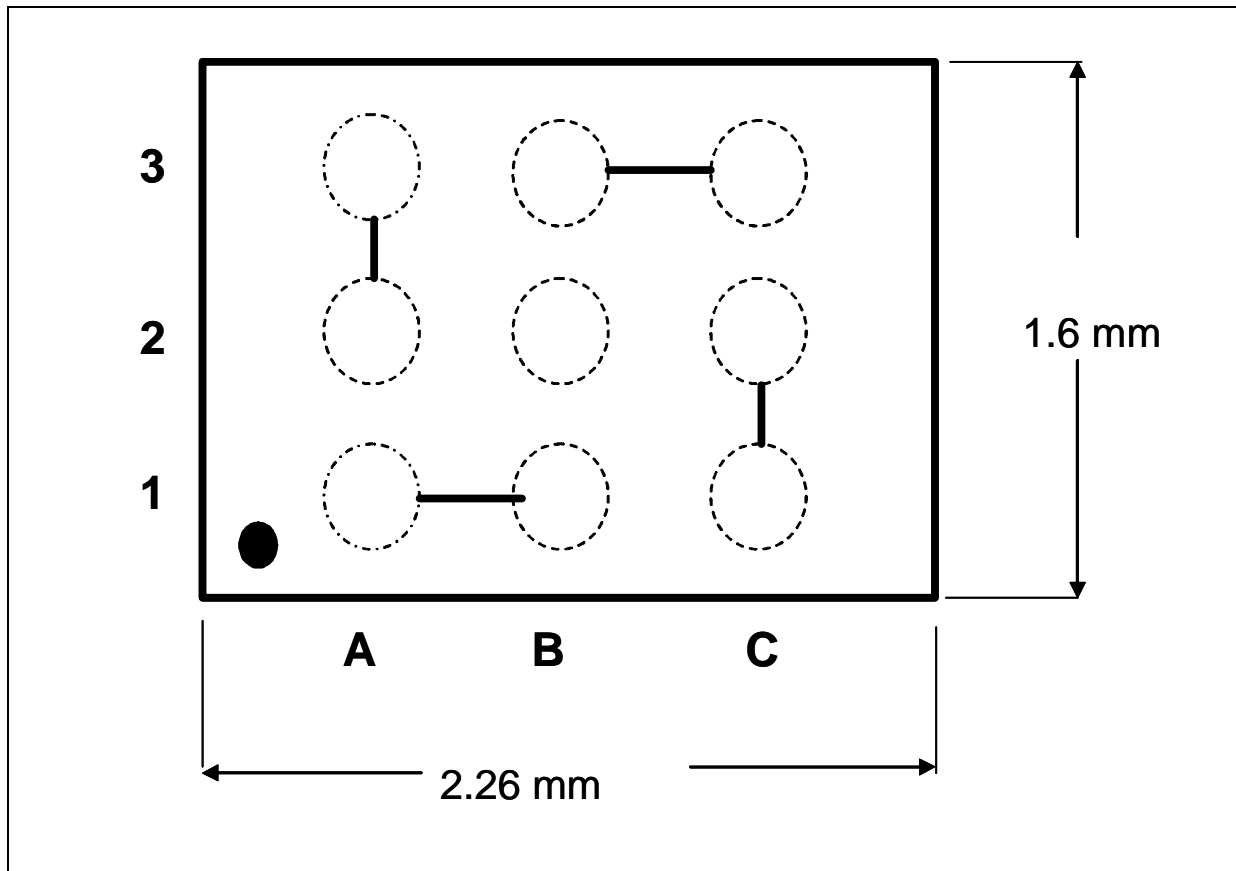


- ST Logo
- Part number: A90
- Three digits Datecode: YWW
- The dot is for marking pin A1

5.1.3 Package mechanical data for 9-bump flip-chip



5.1.4 DAISY CHAIN MECHANICAL DATA



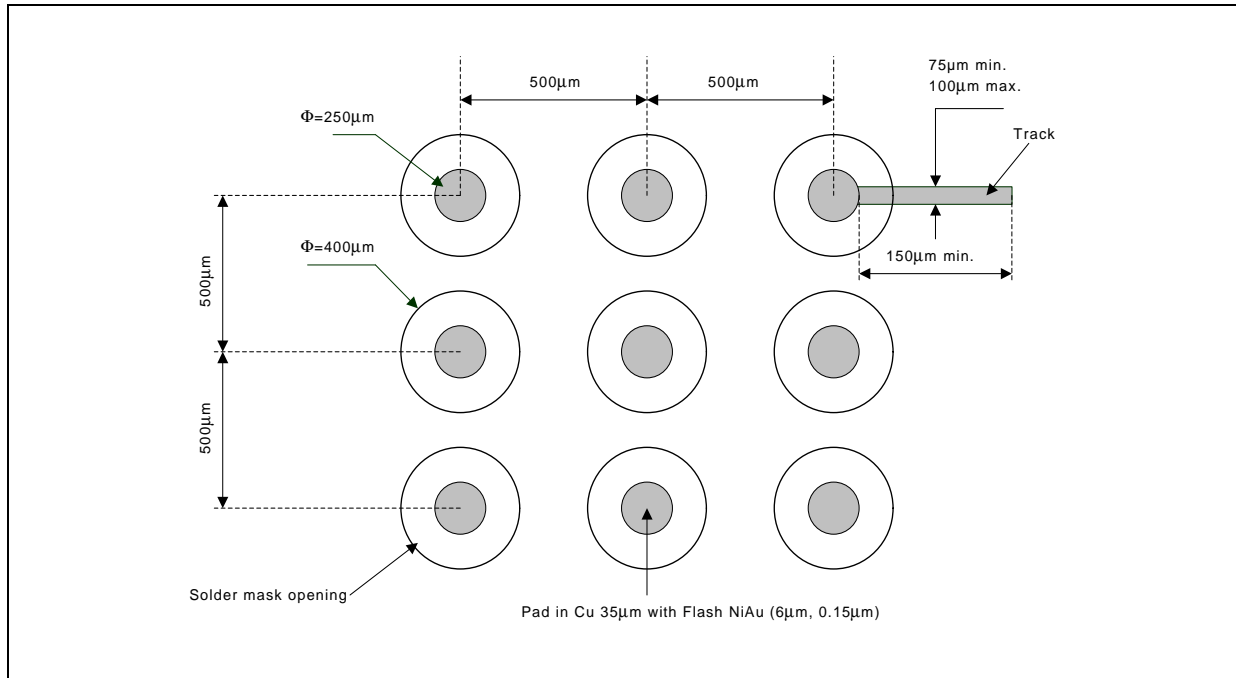
Remarks

The daisy chain sample features two by two pin connections. The schematic above illustrates the way pins connect to each other. This sample is used to test continuity on your board. Your PCB needs to be designed the opposite way, so that pins that are unconnected in the daisy chain sample, are connected on your PCB. If you do this, by simply connecting a Ohmmeter between pin A1 and pin A3, the soldering process continuity can be tested.

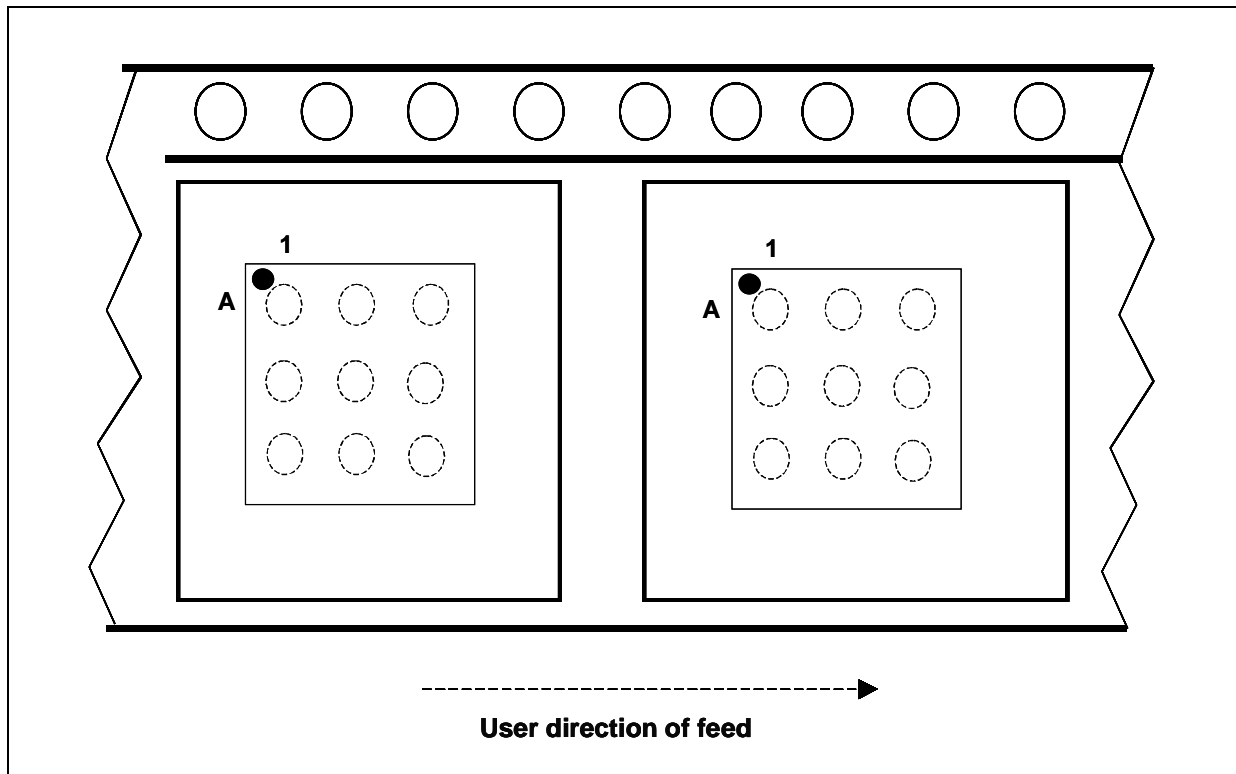
Order code

Part Number	Temperature Range	Package	Marking
		J	
TSDC05IJT	-40, +85°C	•	DC3

5.1.5 TS4990 Footprint recommendations



5.1.6 Tape & reel specification (top view)



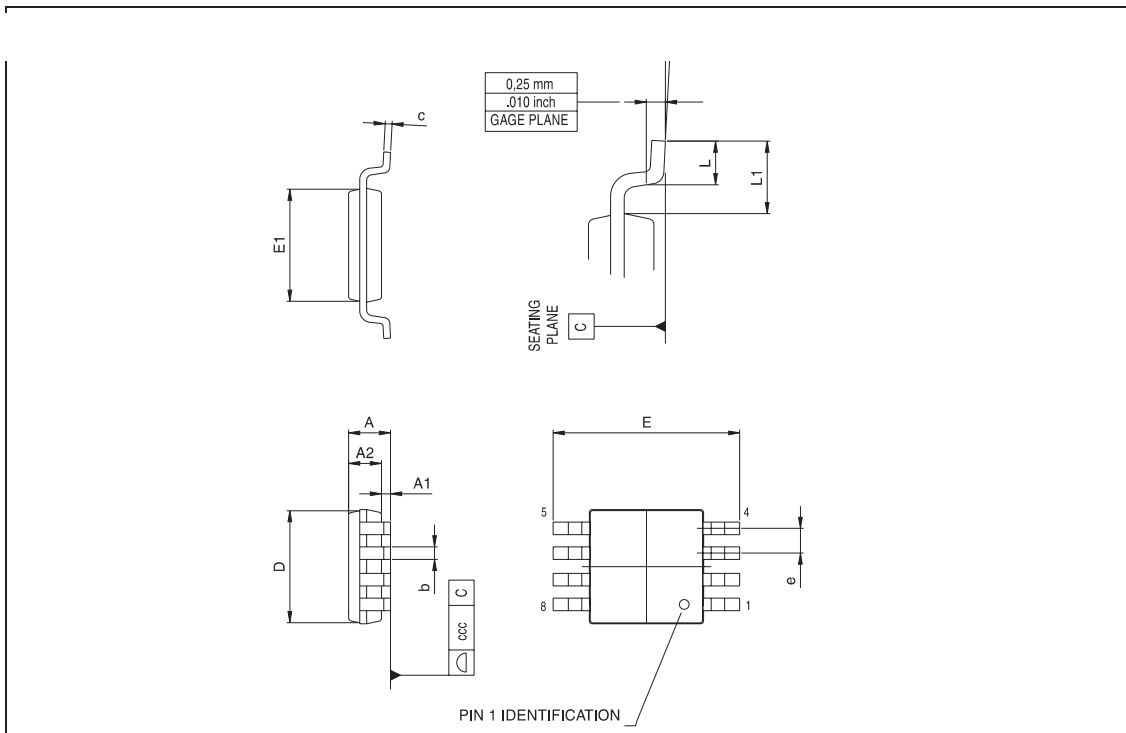
Device orientation

The devices are oriented in the carrier pocket with pin number A1 adjacent to the sprocket holes.

5.2 MINISO8 package mechanical data

miniSO-8 MECHANICAL DATA

DIM.	mm.			inch		
	MIN.	TYP.	MAX.	MIN.	TYP.	MAX.
A			1.1			0.043
A1	0.05	0.10	0.15	0.002	0.004	0.006
A2	0.78	0.86	0.94	0.031	0.031	0.037
b	0.25	0.33	0.40	0.010	0.13	0.013
c	0.13	0.18	0.23	0.005	0.007	0.009
D	2.90	3.00	3.10	0.114	0.118	0.122
E	4.75	4.90	5.05	0.187	0.193	0.199
E1	2.90	3.00	3.10	.0114	0.118	0.122
e		0.65			0.026	
K	0°		6°	0°		6°
L	0.40	0.55	0.70	0.016	0.022	0.028
L1			0.10			0.004



5.3 DFN8 package mechanical data

DFN8 (3x3) MECHANICAL DATA						
DIM.	mm.			inch		
	MIN.	TYP.	MAX.	MIN.	TYP.	MAX.
A	0.80	0.90	1.00	31.5	35.4	39.4
A1		0.02	0.05		0.8	2.0
A2		0.70			27.6	
A3		0.20			7.9	
b	0.18	0.23	0.30	7.1	9.1	11.8
D		3.00			118.1	
D2	2.23	2.38	2.48	87.8	93.7	97.7
E		3.00			118.1	
E2	1.49	1.64	1.74	58.7	64.6	68.5
e		0.50			19.7	
L	0.30	0.40	0.50	11.8	15.7	19.7

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