

## 3 W filter-free class D audio power amplifier

Datasheet - production data



### Related products

- See TS2007 for further gain settings e.g. 6 or 12 dB
- See TS2012 for stereo settings

### Applications

- Portable gaming consoles
- VR headsets
- Smart phones
- Tablets

### Description

The TS4962M is a differential Class-D BTL power amplifier. It is able to drive up to 2.3 W into a 4  $\Omega$  load and 1.4 W into a 8  $\Omega$  load at 5 V. It achieves outstanding efficiency (88% typ.) compared to classical Class-AB audio amps.

The gain of the device can be controlled via two external gain-setting resistors. Pop and click reduction circuitry provides low on/off switch noise while allowing the device to start within 5 ms. A standby function (active low) allows the reduction of current consumption to 10 nA typ.

### Features

- Operating from  $V_{CC} = 2.4$  V to 5.5 V
- Standby mode active low
- Output power: 3 W into 4  $\Omega$  and 1.75 W into 8  $\Omega$  with 10% THD+N max. and 5 V power supply
- Output power: 2.3 W @5 V or 0.75 W @ 3.0 V into 4  $\Omega$  with 1% THD+N max.
- Output power: 1.4 W @5 V or 0.45 W @ 3.0 V into 8  $\Omega$  with 1% THD+N max.
- Adjustable gain via external resistors
- Low current consumption 2 mA @ 3 V
- Efficiency: 88% typ.
- Signal to noise ratio: 85 dB typ.
- PSRR: 63 dB typ. @217 Hz with 6 dB gain
- PWM base frequency: 250 kHz
- Low pop and click noise
- Available in Flip Chip 9 x 300  $\mu$ m (Pb-free)

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# 1 Block diagram and pinout

Figure 1. Block diagram

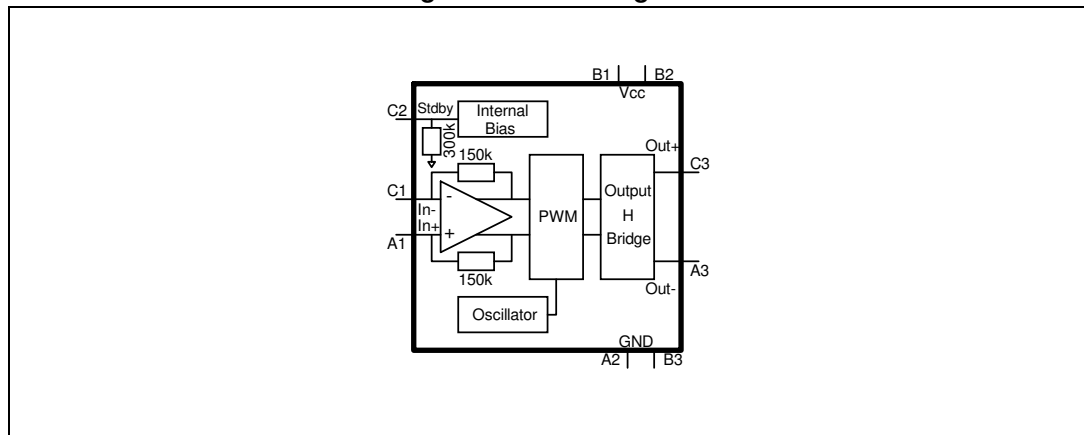
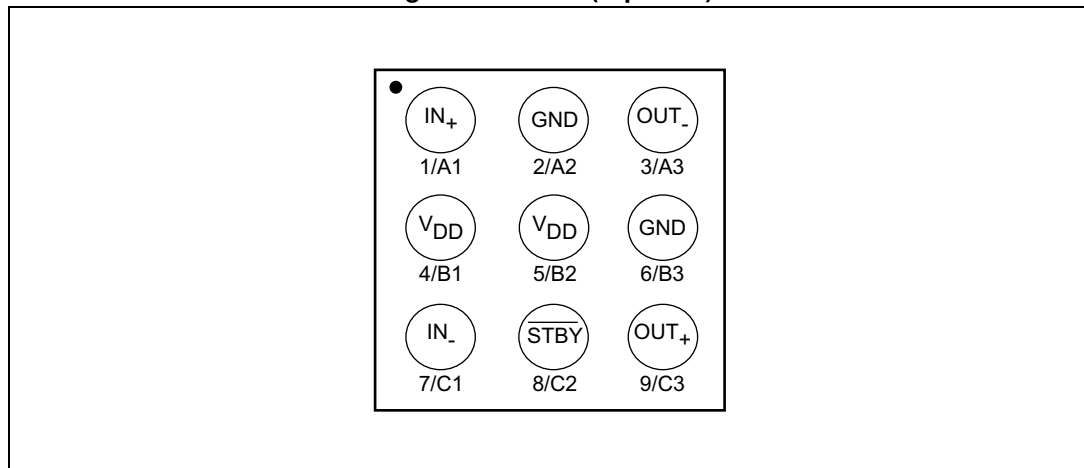


Figure 2. Pinout (top view)



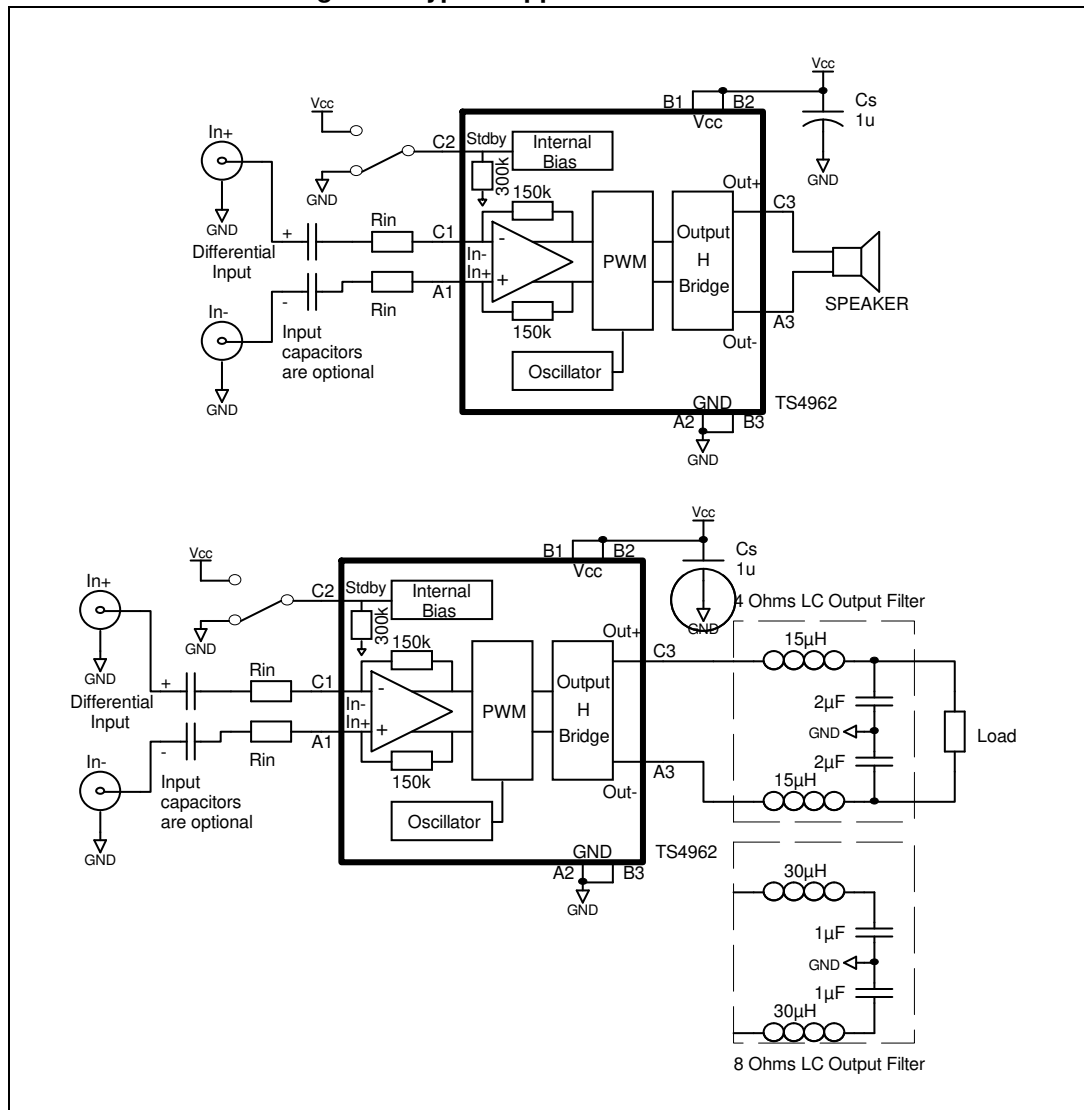
- Legend:
  - IN+ = positive differential input
  - IN- = negative differential input
  - VDD = analog power supply
  - GND = power supply ground
  - STBY = standby pin (active low)
  - OUT+ = positive differential output
  - OUT- = negative differential output
- Bumps are underneath, bump diameter = 300 μm

## 2 Application component information

Table 1. Component information

| Component       | Functional description   |
|-----------------|--|
| $C_s$           | Bypass supply capacitor. Install as close as possible to the TS4962M to minimize high-frequency ripple. A 100 nF ceramic capacitor should be added to enhance the power supply filtering at high frequency.            |
| $R_{in}$        | Input resistor to program the TS4962M differential gain (gain = $300\text{ k}\Omega/R_{in}$ with $R_{in}$ in $\text{k}\Omega$ ).   |
| Input capacitor | Due to common-mode feedback, these input capacitors are optional. However, they can be added to form with $R_{in}$ a 1 <sup>st</sup> order high-pass filter with -3 dB cut-off frequency = $1/(2*\pi*R_{in}*C_{in})$ . |

Figure 3. Typical application schematics



### 3 Absolute maximum ratings

**Table 2. Absolute maximum ratings**

| Symbol     | Parameter  | Value                             | Unit |
|------------|--|-----------------------------------|------|
| $V_{CC}$   | Supply voltage <sup>(1)</sup> <sup>(2)</sup>       | 6                                 | V    |
| $V_{in}$   | Input voltage <sup>(3)</sup>                       | GND to $V_{CC}$                   |      |
| $T_{oper}$ | Operating free-air temperature range               | -40 to + 85                       | °C   |
| $T_{stg}$  | Storage temperature                                | -65 to +150                       |      |
| $T_j$      | Maximum junction temperature                       | 150                               |      |
| $R_{thja}$ | Thermal resistance junction to ambient             | 200                               | °C/W |
| $P_{diss}$ | Power dissipation                                  | Internally limited <sup>(4)</sup> |      |
| ESD        | Human body model                                   | 2                                 | kV   |
| ESD        | Machine model                                      | 200                               | V    |
| Latch-up   | Latch-up immunity                                  | 200                               | mA   |
| $V_{STBY}$ | Standby pin voltage maximum voltage <sup>(5)</sup> | GND to $V_{CC}$                   | V    |
|            | Lead temperature (soldering, 10 s)                 | 260                               | °C   |

1. Caution: this device is not protected in the event of abnormal operating conditions, such as for example, short-circuiting between any one output pin and ground, between any one output pin and  $V_{CC}$ , and between individual output pins.
2. All voltage values are measured with respect to the ground pin.
3. The magnitude of the input signal must never exceed  $V_{CC} + 0.3\text{ V}$  / GND - 0.3 V.
4. Exceeding the power derating curves during a long period causes abnormal operation.
5. The magnitude of the standby signal must never exceed  $V_{CC} + 0.3\text{ V}$  / GND - 0.3 V.

**Table 3. Operating conditions**

| Symbol     | Parameter  | Value  | Unit     |
|------------|--|--|----------|
| $V_{CC}$   | Supply voltage <sup>(1)</sup>                                    | 2.4 to 5.5   | V        |
| $V_{IC}$   | Common-mode input voltage range <sup>(2)</sup>                   | 0.5 to $V_{CC} - 0.8$  |          |
| $V_{STBY}$ | Standby voltage input: <sup>(3)</sup><br>Device ON<br>Device OFF | $1.4 \leq V_{STBY} \leq V_{CC}$<br>$GND \leq V_{STBY} \leq 0.4$ <sup>(4)</sup> |          |
| $R_L$      | Load resistor  | $\geq 4$   | $\Omega$ |
| $R_{thja}$ | Thermal resistance junction to ambient <sup>(5)</sup>            | 90   | °C/W     |

1. For  $V_{CC}$  from 2.4 V to 2.5 V, the operating temperature range is reduced to  $0\text{ °C} \leq T_{amb} \leq 70\text{ °C}$ .
2. For  $V_{CC}$  from 2.4 V to 2.5 V, the common-mode input range must be set at  $V_{CC}/2$ .
3. Without any signal on  $V_{STBY}$ , the device is in standby.
4. Minimum current consumption is obtained when  $V_{STBY} = GND$ .
5. With heat sink surface = 125 mm<sup>2</sup>.

## 4 Electrical characteristics

Table 4.  $V_{CC} = 5\text{ V}$ ,  $GND = 0\text{ V}$ ,  $V_{IC} = 2.5\text{ V}$ ,  $t_{amb} = 25\text{ }^{\circ}\text{C}$  (unless otherwise specified)

| Symbol     | Parameter  | Conditions   | Min.                                | Typ.                                | Max.                                | Unit       |
|------------|--|--|-------------------------------------|-------------------------------------|-------------------------------------|------------|
| $I_{CC}$   | Supply current   | No input signal, no load   |                                     | 2.3                                 | 3.3                                 | mA         |
| $I_{STBY}$ | Standby current <sup>(1)</sup>                                   | No input signal, $V_{STBY} = GND$  |                                     | 10                                  | 1000                                | nA         |
| $V_{OO}$   | Output offset voltage  | No input signal, $R_L = 8\ \Omega$   |                                     | 3                                   | 25                                  | mV         |
| $P_{out}$  | Output power   | G=6 dB<br>THD = 1% max., F = 1 kHz, $R_L = 4\ \Omega$<br>THD = 10% max., F = 1 kHz, $R_L = 4\ \Omega$<br>THD = 1% max., F = 1 kHz, $R_L = 8\ \Omega$<br>THD = 10% max., F = 1 kHz, $R_L = 8\ \Omega$                               |                                     | 2.3<br>3<br>1.4<br>1.75             |                                     | W          |
| THD + N    | Total harmonic distortion + noise                                | $P_{out} = 900\text{ mW}_{RMS}$ ,<br>G = 6 dB, 20 Hz < F < 20 kHz<br>$R_L = 8\ \Omega + 15\ \mu\text{H}$ , BW < 30 kHz<br>$P_{out} = 1\text{ W}_{RMS}$ , G = 6 dB, F = 1 kHz,<br>$R_L = 8\ \Omega + 15\ \mu\text{H}$ , BW < 30 kHz |                                     | 1<br>0.4                            |                                     | %          |
| Efficiency | Efficiency   | $P_{out} = 2\text{ W}_{RMS}$ , $R_L = 4\ \Omega + \geq 15\ \mu\text{H}$<br>$P_{out} = 1.2\text{ W}_{RMS}$ , $R_L = 8\ \Omega + \geq 15\ \mu\text{H}$   |                                     | 78<br>88                            |                                     | %          |
| PSRR       | Power supply rejection ratio with inputs grounded <sup>(2)</sup> | F = 21 Hz, $R_L = 8\ \Omega$ , G=6 dB,<br>$V_{ripple} = 200\text{ mV}_{pp}$  |                                     | 63                                  |                                     | dB         |
| CMRR       | Common-mode rejection ratio                                      | F = 217 Hz, $R_L = 8\ \Omega$ , G = 6 dB,<br>$\Delta V_{icm} = 200\text{ mV}_{pp}$   |                                     | 57                                  |                                     | dB         |
| Gain       | Gain value   | $R_{in}$ in k $\Omega$   | $\frac{273\text{ k}\Omega}{R_{in}}$ | $\frac{300\text{ k}\Omega}{R_{in}}$ | $\frac{327\text{ k}\Omega}{R_{in}}$ | V/V        |
| $R_{STBY}$ | Internal resistance from Standby to GND                          |  | 273                                 | 300                                 | 327                                 | k $\Omega$ |
| $F_{PWM}$  | Pulse width modulator base frequency                             |  | 180                                 | 250                                 | 320                                 | kHz        |
| SNR        | Signal to noise ratio  | A-weighting, $P_{out} = 1.2\text{ W}$ , $R_L = 8\ \Omega$  |                                     | 85                                  |                                     | dB         |
| $t_{WU}$   | Wake-up time   |  |                                     | 5                                   | 10                                  | ms         |
| $t_{STBY}$ | Standby time   |  |                                     | 5                                   | 10                                  | ms         |

Table 4.  $V_{CC} = 5\text{ V}$ ,  $GND = 0\text{ V}$ ,  $V_{IC} = 2.5\text{ V}$ ,  $t_{amb} = 25\text{ °C}$  (unless otherwise specified) (continued)

| Symbol | Parameter            | Conditions   | Min. | Typ.     | Max. | Unit                       |
|--------|----------------------|--|------|----------|------|----------------------------|
| $V_N$  | Output voltage noise | F = 20 Hz to 20 kHz, G = 6 dB<br>Unweighted $R_L = 4\ \Omega$<br>A-weighted $R_L = 4\ \Omega$    |      | 85<br>60 |      | $\mu\text{V}_{\text{RMS}}$ |
|        |                      | Unweighted $R_L = 8\ \Omega$<br>A-weighted $R_L = 8\ \Omega$                                     |      | 86<br>62 |      |                            |
|        |                      | Unweighted $R_L = 4\ \Omega + 15\ \mu\text{H}$<br>A-weighted $R_L = 4\ \Omega + 15\ \mu\text{H}$ |      | 83<br>60 |      |                            |
|        |                      | Unweighted $R_L = 4\ \Omega + 30\ \mu\text{H}$<br>A-weighted $R_L = 4\ \Omega + 30\ \mu\text{H}$ |      | 88<br>64 |      |                            |
|        |                      | Unweighted $R_L = 8\ \Omega + 30\ \mu\text{H}$<br>A-weighted $R_L = 8\ \Omega + 30\ \mu\text{H}$ |      | 78<br>57 |      |                            |
|        |                      | Unweighted $R_L = 4\ \Omega + \text{filter}$<br>A-weighted $R_L = 4\ \Omega + \text{filter}$     |      | 87<br>65 |      |                            |
|        |                      | Unweighted $R_L = 4\ \Omega + \text{filter}$<br>A-weighted $R_L = 4\ \Omega + \text{filter}$     |      | 82<br>59 |      |                            |

- Standby mode is active when  $V_{\text{STBY}}$  is tied to GND.
- Dynamic measurements -  $20 \cdot \log(\text{rms}(V_{\text{out}})/\text{rms}(V_{\text{ripple}}))$ .  $V_{\text{ripple}}$  is the superimposed sinusoidal signal to  $V_{CC}$  @  $F = 217\text{ Hz}$ .

Table 5.  $V_{CC} = 4.2V$ ,  $GND = 0V$ ,  $V_{IC} = 2.5V$ ,  $T_{amb} = 25^{\circ}C$  (unless otherwise specified) <sup>(1)</sup>

| Symbol     | Parameter  | Conditions  | Min.                        | Typ.                        | Max.                        | Unit       |
|------------|--|---|-----------------------------|-----------------------------|-----------------------------|------------|
| $I_{CC}$   | Supply current   | No input signal, no load  |                             | 2.1                         | 3                           | mA         |
| $I_{STBY}$ | Standby current <sup>(2)</sup>                                   | No input signal, $V_{STBY} = GND$   |                             | 10                          | 1000                        | nA         |
| $V_{OO}$   | Output offset voltage  | No input signal, $R_L = 8 \Omega$   |                             | 3                           | 25                          | mV         |
| $P_{out}$  | Output power   | G=6dB<br>THD = 1% max, F = 1 kHz,<br>$R_L = 4 \Omega$<br>THD = 10% max, F = 1 kHz,<br>$R_L = 4 \Omega$<br>THD = 1% max, F = 1 kHz,<br>$R_L = 8 \Omega$<br>THD = 10% max, F = 1 kHz,<br>$R_L = 8 \Omega$   |                             | 1.6<br>2<br>0.95<br>1.2     |                             | W          |
| THD + N    | Total harmonic distortion + noise                                | $P_{out} = 600mW_{RMS}$ , G = 6 dB,<br>20 Hz < F < 20k Hz<br>$R_L = 8 \Omega + 15 \mu H$ , BW < 30 kHz<br>$P_{out} = 700 mW_{RMS}$ , G = 6 dB,<br>F = 1 kHz,<br>$R_L = 8 \Omega + 15 \mu H$ , BW < 30 kHz |                             | 1<br>0.35                   |                             | %          |
| Efficiency | Efficiency   | $P_{out} = 1.45 W_{RMS}$ , $R_L = 4 \Omega + \geq 15 \mu H$<br>$P_{out} = 0.9 W_{RMS}$ , $R_L = 8 \Omega + \geq 15 \mu H$   |                             | 78<br>88                    |                             | %          |
| PSRR       | Power supply rejection ratio with inputs grounded <sup>(3)</sup> | F = 217 Hz, $R_L = 8 \Omega$ , G=6 dB,<br>$V_{ripple} = 200 mV_{pp}$  |                             | 63                          |                             | dB         |
| CMRR       | Common-mode rejection ratio                                      | F = 217 Hz, $R_L = 8 \Omega$ , G = 6 dB,<br>$\Delta V_{icm} = 200 mV_{pp}$  |                             | 57                          |                             | dB         |
| Gain       | Gain value   | $R_{in}$ in k $\Omega$  | $\frac{273k\Omega}{R_{in}}$ | $\frac{300k\Omega}{R_{in}}$ | $\frac{327k\Omega}{R_{in}}$ | V/V        |
| $R_{STBY}$ | Internal resistance from Standby to GND                          |   | 273                         | 300                         | 327                         | k $\Omega$ |
| $F_{PWM}$  | Pulse width modulator base frequency                             |   | 180                         | 250                         | 320                         | kHz        |
| SNR        | Signal to noise ratio  | A-weighting, $P_{out} = 0.9 W$ ,<br>$R_L = 8 \Omega$  |                             | 85                          |                             | dB         |
| $t_{WU}$   | Wake-up time   |   |                             | 5                           | 10                          | ms         |
| $t_{STBY}$ | Standby time   |   |                             | 5                           | 10                          | ms         |



Table 5.  $V_{CC} = 4.2V$ ,  $GND = 0V$ ,  $V_{IC} = 2.5V$ ,  $T_{amb} = 25^{\circ}C$  (unless otherwise specified) <sup>(1)</sup>

| Symbol | Parameter            | Conditions   | Min. | Typ.     | Max. | Unit          |
|--------|----------------------|--|------|----------|------|---------------|
| $V_N$  | Output voltage noise | F = 20Hz to 20 kHz, G = 6 dB<br>Unweighted $R_L = 4 \Omega$<br>A-weighted $R_L = 4 \Omega$ |      | 85<br>60 |      | $\mu V_{RMS}$ |
|        |                      | Unweighted $R_L = 8 \Omega$<br>A-weighted $R_L = 8 \Omega$                                 |      | 86<br>62 |      |               |
|        |                      | Unweighted $R_L = 4 \Omega + 15 \mu H$<br>A-weighted $R_L = 4 \Omega + 15 \mu H$           |      | 83<br>60 |      |               |
|        |                      | Unweighted $R_L = 4 \Omega + 30 \mu H$<br>A-weighted $R_L = 4 \Omega + 30 \mu H$           |      | 88<br>64 |      |               |
|        |                      | Unweighted $R_L = 8 \Omega + 30 \mu H$<br>A-weighted $R_L = 8 \Omega + 30 \mu H$           |      | 78<br>57 |      |               |
|        |                      | Unweighted $R_L = 4 \Omega + \text{filter}$<br>A-weighted $R_L = 4 \Omega + \text{filter}$ |      | 87<br>65 |      |               |
|        |                      | Unweighted $R_L = 4 \Omega + \text{filter}$<br>A-weighted $R_L = 4 \Omega + \text{filter}$ |      | 82<br>59 |      |               |

1. All electrical values are guaranteed with correlation measurements at 2.5 V and 5 V.
2. Standby mode is active when  $V_{STBY}$  is tied to GND.
3. Dynamic measurements -  $20 \cdot \log(\text{rms}(V_{out})/\text{rms}(V_{ripple}))$ .  $V_{ripple}$  is the superimposed sinusoidal signal to  $V_{CC}$  @  $F = 217$  Hz.

Table 6.  $V_{CC} = 3.6\text{ V}$ ,  $GND = 0\text{ V}$ ,  $V_{IC} = 2.5\text{ V}$ ,  $T_{amb} = 25\text{ }^\circ\text{C}$  (unless otherwise specified) <sup>(1)</sup>

| Symbol     | Parameter  | Conditions  | Min.                               | Typ.                               | Max.                               | Unit       |
|------------|--|---|------------------------------------|------------------------------------|------------------------------------|------------|
| $I_{CC}$   | Supply current   | No input signal, no load  |                                    | 2                                  | 2.8                                | mA         |
| $I_{STBY}$ | Standby current <sup>(2)</sup>                                   | No input signal, $V_{STBY} = GND$   |                                    | 10                                 | 1000                               | nA         |
| $V_{OO}$   | Output offset voltage  | No input signal, $R_L = 8\ \Omega$  |                                    | 3                                  | 25                                 | mV         |
| $P_{out}$  | Output power   | G=6dB<br>THD = 1% max., F = 1 kHz, $R_L = 4\ \Omega$<br>THD = 10% max., F = 1 kHz, $R_L = 4\ \Omega$<br>THD = 1% max., F = 1 kHz, $R_L = 8\ \Omega$<br>THD = 10% max., F = 1 kHz, $R_L = 8\ \Omega$                                   |                                    | 1.15<br>1.51<br>0.7<br>0.9         |                                    | W          |
| THD + N    | Total harmonic distortion + noise                                | $P_{out} = 500\text{ mW}_{RMS}$ ,<br>G = 6 dB, 20 Hz < F < 20 kHz<br>$R_L = 8\ \Omega + 15\ \mu\text{H}$ , BW < 30 kHz<br>$P_{out} = 500\text{ mW}_{RMS}$ , G = 6 dB, F = 1 kHz,<br>$R_L = 8\ \Omega + 15\ \mu\text{H}$ , BW < 30 kHz |                                    | 1<br>0.27                          |                                    | %          |
| Efficiency | Efficiency   | $P_{out} = 1\text{ W}_{RMS}$ , $R_L = 4\ \Omega + \geq 15\ \mu\text{H}$<br>$P_{out} = 0.65\text{ W}_{RMS}$ , $R_L = 8\ \Omega + \geq 15\ \mu\text{H}$   |                                    | 78<br>88                           |                                    | %          |
| PSRR       | Power supply rejection ratio with inputs grounded <sup>(3)</sup> | F = 217 Hz, $R_L = 8\ \Omega$ , G=6 dB,<br>$V_{ripple} = 200\text{ mV}_{pp}$  |                                    | 62                                 |                                    | dB         |
| CMRR       | Common-mode rejection ratio                                      | F = 217 Hz, $R_L = 8\ \Omega$ , G = 6 dB,<br>$\Delta V_{icm} = 200\text{ mV}_{pp}$  |                                    | 56                                 |                                    | dB         |
| Gain       | Gain value   | $R_{in}$ in k $\Omega$  | $\frac{273\text{k}\Omega}{R_{in}}$ | $\frac{300\text{k}\Omega}{R_{in}}$ | $\frac{327\text{k}\Omega}{R_{in}}$ | V/V        |
| $R_{STBY}$ | Internal resistance from Standby to GND                          |   | 273                                | 300                                | 327                                | k $\Omega$ |
| $F_{PWM}$  | Pulse width modulator base frequency                             |   | 180                                | 250                                | 320                                | kHz        |
| SNR        | Signal to noise ratio  | A-weighting, $P_{out} = 0.6\text{ W}$ , $R_L = 8\ \Omega$   |                                    | 83                                 |                                    | dB         |
| $t_{WU}$   | Wake-up time   |   |                                    | 5                                  | 10                                 | ms         |
| $t_{STBY}$ | Standby time   |   |                                    | 5                                  | 10                                 | ms         |

Table 6.  $V_{CC} = 3.6\text{ V}$ ,  $GND = 0\text{ V}$ ,  $V_{IC} = 2.5\text{ V}$ ,  $T_{amb} = 25\text{ }^\circ\text{C}$  (unless otherwise specified) <sup>(1)</sup>

| Symbol | Parameter            | Conditions   | Min. | Typ.     | Max. | Unit                       |
|--------|----------------------|--|------|----------|------|----------------------------|
| $V_N$  | Output voltage noise | F = 20 Hz to 20 kHz, G = 6 dB<br>Unweighted $R_L = 4\ \Omega$<br>A-weighted $R_L = 4\ \Omega$    |      | 83<br>57 |      | $\mu\text{V}_{\text{RMS}}$ |
|        |                      | Unweighted $R_L = 8\ \Omega$<br>A-weighted $R_L = 8\ \Omega$                                     |      | 83<br>61 |      |                            |
|        |                      | Unweighted $R_L = 4\ \Omega + 15\ \mu\text{H}$<br>A-weighted $R_L = 4\ \Omega + 15\ \mu\text{H}$ |      | 81<br>58 |      |                            |
|        |                      | Unweighted $R_L = 4\ \Omega + 30\ \mu\text{H}$<br>A-weighted $R_L = 4\ \Omega + 30\ \mu\text{H}$ |      | 87<br>62 |      |                            |
|        |                      | Unweighted $R_L = 8\ \Omega + 30\ \mu\text{H}$<br>A-weighted $R_L = 8\ \Omega + 30\ \mu\text{H}$ |      | 77<br>56 |      |                            |
|        |                      | Unweighted $R_L = 4\ \Omega + \text{filter}$<br>A-weighted $R_L = 4\ \Omega + \text{filter}$     |      | 85<br>63 |      |                            |
|        |                      | Unweighted $R_L = 4\ \Omega + \text{filter}$<br>A-weighted $R_L = 4\ \Omega + \text{filter}$     |      | 80<br>57 |      |                            |

1. All electrical values are guaranteed with correlation measurements at 2.5 V and 5 V.
2. Standby mode is active when  $V_{\text{STBY}}$  is tied to GND.
3. Dynamic measurements -  $20 \cdot \log(\text{rms}(V_{\text{out}})/\text{rms}(V_{\text{ripple}}))$ .  $V_{\text{ripple}}$  is the superimposed sinusoidal signal to  $V_{CC}$  @  $F = 217\text{ Hz}$ .

Table 7.  $V_{CC} = 3\text{ V}$ ,  $GND = 0\text{ V}$ ,  $V_{IC} = 2.5\text{ V}$ ,  $T_{amb} = 25\text{ }^\circ\text{C}$  (unless otherwise specified) <sup>(1)</sup>

| Symbol     | Parameter  | Conditions  | Min.                               | Typ.                               | Max.                               | Unit       |
|------------|--|---|------------------------------------|------------------------------------|------------------------------------|------------|
| $I_{CC}$   | Supply current   | No input signal, no load  |                                    | 1.9                                | 2.7                                | mA         |
| $I_{STBY}$ | Standby current <sup>(2)</sup>                                   | No input signal, $V_{STBY} = GND$   |                                    | 10                                 | 1000                               | nA         |
| $V_{OO}$   | Output offset voltage  | No input signal, $R_L = 8\ \Omega$  |                                    | 3                                  | 25                                 | mV         |
| $P_{out}$  | Output power   | G=6dB<br>THD = 1% max., F = 1 kHz, $R_L = 4\ \Omega$<br>THD = 10% max., F = 1 kHz, $R_L = 4\ \Omega$<br>THD = 1% max., F = 1 kHz, $R_L = 8\ \Omega$<br>THD = 10% max., F = 1 kHz, $R_L = 8\ \Omega$                                   |                                    | 0.75<br>1<br>0.5<br>0.6            |                                    | W          |
| THD + N    | Total harmonic distortion + noise                                | $P_{out} = 350\text{ mW}_{RMS}$ , G = 6 dB,<br>20 Hz < F < 20 kHz<br>$R_L = 8\ \Omega + 15\ \mu\text{H}$ , BW < 30 kHz<br>$P_{out} = 350\text{ mW}_{RMS}$ , G = 6 dB, F = 1 kHz,<br>$R_L = 8\ \Omega + 15\ \mu\text{H}$ , BW < 30 kHz |                                    | 1<br>0.21                          |                                    | %          |
| Efficiency | Efficiency   | $P_{out} = 0.7\text{ W}_{RMS}$ , $R_L = 4\ \Omega + \geq 15\ \mu\text{H}$<br>$P_{out} = 0.45\text{ W}_{RMS}$ , $R_L = 8\ \Omega + \geq 15\ \mu\text{H}$   |                                    | 78<br>88                           |                                    | %          |
| PSRR       | Power supply rejection ratio with inputs grounded <sup>(3)</sup> | F = 217 Hz, $R_L = 8\ \Omega$ , G=6 dB,<br>$V_{ripple} = 200\text{ mV}_{pp}$  |                                    | 60                                 |                                    | dB         |
| CMRR       | Common-mode rejection ratio                                      | F = 217Hz, $R_L = 8\ \Omega$ , G = 6 dB,<br>$\Delta V_{icm} = 200\text{ mV}_{pp}$   |                                    | 54                                 |                                    | dB         |
| Gain       | Gain value   | $R_{in}$ in k $\Omega$  | $\frac{273\text{k}\Omega}{R_{in}}$ | $\frac{300\text{k}\Omega}{R_{in}}$ | $\frac{327\text{k}\Omega}{R_{in}}$ | V/V        |
| $R_{STBY}$ | Internal resistance from Standby to GND                          |   | 273                                | 300                                | 327                                | k $\Omega$ |
| $F_{PWM}$  | Pulse width modulator base frequency                             |   | 180                                | 250                                | 320                                | kHz        |
| SNR        | Signal to noise ratio  | A-weighting, $P_{out} = 0.4\text{ W}$ , $R_L = 8\ \Omega$   |                                    | 82                                 |                                    | dB         |
| $t_{WU}$   | Wake-up time   |   |                                    | 5                                  | 10                                 | ms         |
| $t_{STBY}$ | Standby time   |   |                                    | 5                                  | 10                                 | ms         |

Table 7.  $V_{CC} = 3\text{ V}$ ,  $GND = 0\text{ V}$ ,  $V_{IC} = 2.5\text{ V}$ ,  $T_{amb} = 25\text{ }^{\circ}\text{C}$  (unless otherwise specified) <sup>(1)</sup> (continued)

| Symbol | Parameter            | Conditions   | Min. | Typ.     | Max. | Unit                       |
|--------|----------------------|--|------|----------|------|----------------------------|
| $V_N$  | Output Voltage Noise | f = 20 Hz to 20 kHz, G = 6 dB<br>Unweighted $R_L = 4\ \Omega$<br>A-weighted $R_L = 4\ \Omega$    |      | 83<br>57 |      | $\mu\text{V}_{\text{RMS}}$ |
|        |                      | Unweighted $R_L = 8\ \Omega$<br>A-weighted $R_L = 8\ \Omega$                                     |      | 83<br>61 |      |                            |
|        |                      | Unweighted $R_L = 4\ \Omega + 15\ \mu\text{H}$<br>A-weighted $R_L = 4\ \Omega + 15\ \mu\text{H}$ |      | 81<br>58 |      |                            |
|        |                      | Unweighted $R_L = 4\ \Omega + 30\ \mu\text{H}$<br>A-weighted $R_L = 4\ \Omega + 30\ \mu\text{H}$ |      | 87<br>62 |      |                            |
|        |                      | Unweighted $R_L = 8\ \Omega + 30\ \mu\text{H}$<br>A-weighted $R_L = 8\ \Omega + 30\ \mu\text{H}$ |      | 77<br>56 |      |                            |
|        |                      | Unweighted $R_L = 4\ \Omega + \text{filter}$<br>A-weighted $R_L = 4\ \Omega + \text{filter}$     |      | 85<br>63 |      |                            |
|        |                      | Unweighted $R_L = 4\ \Omega + \text{filter}$<br>A-weighted $R_L = 4\ \Omega + \text{filter}$     |      | 80<br>57 |      |                            |

1. All electrical values are guaranteed with correlation measurements at 2.5 V and 5 V.
2. Standby mode is active when  $V_{\text{STBY}}$  is tied to GND.
3. Dynamic measurements -  $20 \cdot \log(\text{rms}(V_{\text{out}})/\text{rms}(V_{\text{ripple}}))$ .  $V_{\text{ripple}}$  is the superimposed sinusoidal signal to  $V_{CC}$  @  $F = 217\text{ Hz}$ .

Table 8.  $V_{CC} = 2.5\text{ V}$ ,  $GND = 0\text{ V}$ ,  $V_{IC} = 2.5\text{ V}$ ,  $T_{amb} = 25\text{ }^\circ\text{C}$  (unless otherwise specified)

| Symbol     | Parameter  | Conditions  | Min.                               | Typ.                               | Max.                               | Unit       |
|------------|--|---|------------------------------------|------------------------------------|------------------------------------|------------|
| $I_{CC}$   | Supply current   | No input signal, no load  |                                    | 1.7                                | 2.4                                | mA         |
| $I_{STBY}$ | Standby current <sup>(1)</sup>                                   | No input signal, $V_{STBY} = GND$   |                                    | 10                                 | 1000                               | nA         |
| $V_{OO}$   | Output offset voltage  | No input signal, $R_L = 8\ \Omega$  |                                    | 3                                  | 25                                 | mV         |
| $P_{out}$  | Output power   | G=6dB<br>THD = 1% max., F = 1 kHz, $R_L = 4\ \Omega$<br>THD = 10% max., F = 1 kHz, $R_L = 4\ \Omega$<br>THD = 1% max., F = 1 kHz, $R_L = 8\ \Omega$<br>THD = 10% max., F = 1 kHz, $R_L = 8\ \Omega$                               |                                    | 0.52<br>0.71<br>0.33<br>0.42       |                                    | W          |
| THD + N    | Total harmonic distortion + noise                                | $P_{out} = 200\text{ mW}_{RMS}$ , G = 6 dB, 20 Hz < F < 20 kHz<br>$R_L = 8\ \Omega + 15\ \mu\text{H}$ , BW < 30 kHz<br>$P_{out} = 200\text{ W}_{RMS}$ , G = 6 dB, F = 1 kHz,<br>$R_L = 8\ \Omega + 15\ \mu\text{H}$ , BW < 30 kHz |                                    | 1<br>0.19                          |                                    | %          |
| Efficiency | Efficiency   | $P_{out} = 0.47\text{ W}_{RMS}$ , $R_L = 4\ \Omega + \geq 15\ \mu\text{H}$<br>$P_{out} = 0.3\text{ W}_{RMS}$ , $R_L = 8\ \Omega + \geq 15\ \mu\text{H}$   |                                    | 78<br>88                           |                                    | %          |
| PSRR       | Power supply rejection ratio with inputs grounded <sup>(2)</sup> | F = 217 Hz, $R_L = 8\ \Omega$ , G=6 dB,<br>$V_{ripple} = 200\text{ mV}_{pp}$  |                                    | 60                                 |                                    | dB         |
| CMRR       | Common-mode rejection ratio                                      | F = 217 Hz, $R_L = 8\ \Omega$ , G = 6 dB,<br>$\Delta V_{icm} = 200\text{ mV}_{pp}$  |                                    | 54                                 |                                    | dB         |
| Gain       | Gain value   | $R_{in}$ in k $\Omega$  | $\frac{273\text{k}\Omega}{R_{in}}$ | $\frac{300\text{k}\Omega}{R_{in}}$ | $\frac{327\text{k}\Omega}{R_{in}}$ | V/V        |
| $R_{STBY}$ | Internal resistance from Standby to GND                          |   | 273                                | 300                                | 327                                | k $\Omega$ |
| $F_{PWM}$  | Pulse width modulator base frequency                             |   | 180                                | 250                                | 320                                | kHz        |
| SNR        | Signal to noise ratio  | A-weighting, $P_{out} = 1.2\text{ W}$ , $R_L = 8\ \Omega$   |                                    | 80                                 |                                    | dB         |
| $t_{WU}$   | Wake-up time   |   |                                    | 5                                  | 10                                 | ms         |
| $t_{STBY}$ | Standby time   |   |                                    | 5                                  | 10                                 | ms         |

Table 8.  $V_{CC} = 2.5\text{ V}$ ,  $GND = 0\text{ V}$ ,  $V_{IC} = 2.5\text{ V}$ ,  $T_{amb} = 25\text{ }^{\circ}\text{C}$  (unless otherwise specified) (continued)

| Symbol | Parameter            | Conditions   | Min. | Typ.     | Max. | Unit                       |
|--------|----------------------|--|------|----------|------|----------------------------|
| $V_N$  | Output voltage noise | F = 20Hz to 20kHz, G = 6 dB<br>Unweighted $R_L = 4\ \Omega$<br>A-weighted $R_L = 4\ \Omega$      |      | 85<br>60 |      | $\mu\text{V}_{\text{RMS}}$ |
|        |                      | Unweighted $R_L = 8\ \Omega$<br>A-weighted $R_L = 8\ \Omega$                                     |      | 86<br>62 |      |                            |
|        |                      | Unweighted $R_L = 4\ \Omega + 15\ \mu\text{H}$<br>A-weighted $R_L = 4\ \Omega + 15\ \mu\text{H}$ |      | 76<br>56 |      |                            |
|        |                      | Unweighted $R_L = 4\ \Omega + 30\ \mu\text{H}$<br>A-weighted $R_L = 4\ \Omega + 30\ \mu\text{H}$ |      | 82<br>60 |      |                            |
|        |                      | Unweighted $R_L = 8\ \Omega + 30\ \mu\text{H}$<br>A-weighted $R_L = 8\ \Omega + 30\ \mu\text{H}$ |      | 67<br>53 |      |                            |
|        |                      | Unweighted $R_L = 4\ \Omega + \text{filter}$<br>A-weighted $R_L = 4\ \Omega + \text{filter}$     |      | 78<br>57 |      |                            |
|        |                      | Unweighted $R_L = 4\ \Omega + \text{filter}$<br>A-weighted $R_L = 4\ \Omega + \text{filter}$     |      | 74<br>54 |      |                            |

- Standby mode is active when  $V_{\text{STBY}}$  is tied to GND.
- Dynamic measurements -  $20 \cdot \log(\text{rms}(V_{\text{out}})/\text{rms}(V_{\text{ripple}}))$ .  $V_{\text{ripple}}$  is the superimposed sinusoidal signal to  $V_{CC}$  @  $F = 217\text{ Hz}$ .

Table 9.  $V_{CC} = 2.4\text{ V}$ ,  $GND = 0\text{ V}$ ,  $V_{IC} = 2.5\text{ V}$ ,  $T_{amb} = 25\text{ }^\circ\text{C}$  (unless otherwise specified)

| Symbol     | Parameter                               | Conditions  | Min.                               | Typ.                               | Max.                               | Unit                |
|------------|---|---|------------------------------------|------------------------------------|------------------------------------|---------------------|
| $I_{CC}$   | Supply current                          | No input signal, no load  |                                    | 1.7                                |                                    | mA                  |
| $I_{STBY}$ | Standby current <sup>(1)</sup>          | No input signal, $V_{STBY} = GND$   |                                    | 10                                 |                                    | nA                  |
| $V_{OO}$   | Output offset voltage                   | No input signal, $R_L = 8\ \Omega$  |                                    | 3                                  |                                    | mV                  |
| $P_{out}$  | Output power                            | G=6dB<br>THD = 1% max., F = 1 kHz, $R_L = 4\ \Omega$<br>THD = 10% max., F = 1 kHz, $R_L = 4\ \Omega$<br>THD = 1% max., F = 1 kHz, $R_L = 8\ \Omega$<br>THD = 10% max., F = 1 kHz, $R_L = 8\ \Omega$ |                                    | 0.48<br>0.65<br>0.3<br>0.38        |                                    | W                   |
| THD + N    | Total harmonic distortion + noise       | $P_{out} = 200\text{ mW}_{RMS}$ , G = 6 dB, 20 Hz < F < 20 kHz<br>$R_L = 8\ \Omega + 15\ \mu\text{H}$ , BW < 30 kHz   |                                    | 1                                  |                                    | %                   |
| Efficiency | Efficiency                              | $P_{out} = 0.38\text{ W}_{RMS}$ , $R_L = 4\ \Omega + \geq 15\ \mu\text{H}$<br>$P_{out} = 0.25\text{ W}_{RMS}$ , $R_L = 8\ \Omega + \geq 15\ \mu\text{H}$  |                                    | 77<br>86                           |                                    | %                   |
| CMRR       | Common-mode rejection ratio             | F = 217 Hz, $R_L = 8\ \Omega$ , G = 6 dB,<br>$\Delta V_{icm} = 200\text{ mV}_{pp}$  |                                    | 54                                 |                                    | dB                  |
| Gain       | Gain value                              | $R_{in}$ in k $\Omega$  | $\frac{273\text{k}\Omega}{R_{in}}$ | $\frac{300\text{k}\Omega}{R_{in}}$ | $\frac{327\text{k}\Omega}{R_{in}}$ | V/V                 |
| $R_{STBY}$ | Internal resistance from Standby to GND |   | 273                                | 300                                | 327                                | k $\Omega$          |
| $F_{PWM}$  | Pulse width modulator base frequency    |   |                                    | 250                                |                                    | kHz                 |
| SNR        | Signal to noise ratio                   | A Weighting, $P_{out} = 1.2\text{ W}$ , $R_L = 8\ \Omega$   |                                    | 80                                 |                                    | dB                  |
| $t_{WU}$   | Wake-up time                            |   |                                    | 5                                  |                                    | ms                  |
| $t_{STBY}$ | Standby time                            |   |                                    | 5                                  |                                    | ms                  |
| $V_N$      | Output voltage noise                    | F = 20 Hz to 20 kHz, G = 6 dB<br>Unweighted $R_L = 4\ \Omega$<br>A-weighted $R_L = 4\ \Omega$   |                                    | 85<br>60                           |                                    | $\mu\text{V}_{RMS}$ |
|            |   | Unweighted $R_L = 8\ \Omega$<br>A-weighted $R_L = 8\ \Omega$  |                                    | 86<br>62                           |                                    |                     |
|            |   | Unweighted $R_L = 4\ \Omega + 15\ \mu\text{H}$<br>A-weighted $R_L = 4\ \Omega + 15\ \mu\text{H}$  |                                    | 76<br>56                           |                                    |                     |
|            |   | Unweighted $R_L = 4\ \Omega + 30\ \mu\text{H}$<br>A-weighted $R_L = 4\ \Omega + 30\ \mu\text{H}$  |                                    | 82<br>60                           |                                    |                     |
|            |   | Unweighted $R_L = 8\ \Omega + 30\ \mu\text{H}$<br>A-weighted $R_L = 8\ \Omega + 30\ \mu\text{H}$  |                                    | 67<br>53                           |                                    |                     |
|            |   | Unweighted $R_L = 4\ \Omega + \text{Filter}$<br>A-weighted $R_L = 4\ \Omega + \text{Filter}$  |                                    | 78<br>57                           |                                    |                     |
|            |   | Unweighted $R_L = 4\ \Omega + \text{Filter}$<br>A-weighted $R_L = 4\ \Omega + \text{Filter}$  |                                    | 74<br>54                           |                                    |                     |

1. Standby mode is active when  $V_{STBY}$  is tied to GND.

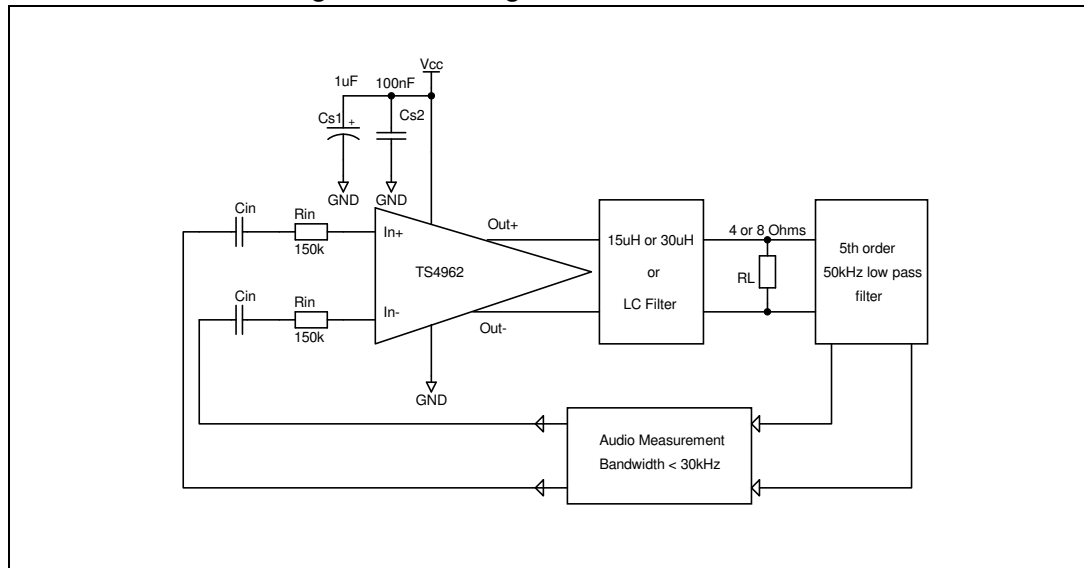


## 5 Electrical characteristic curves

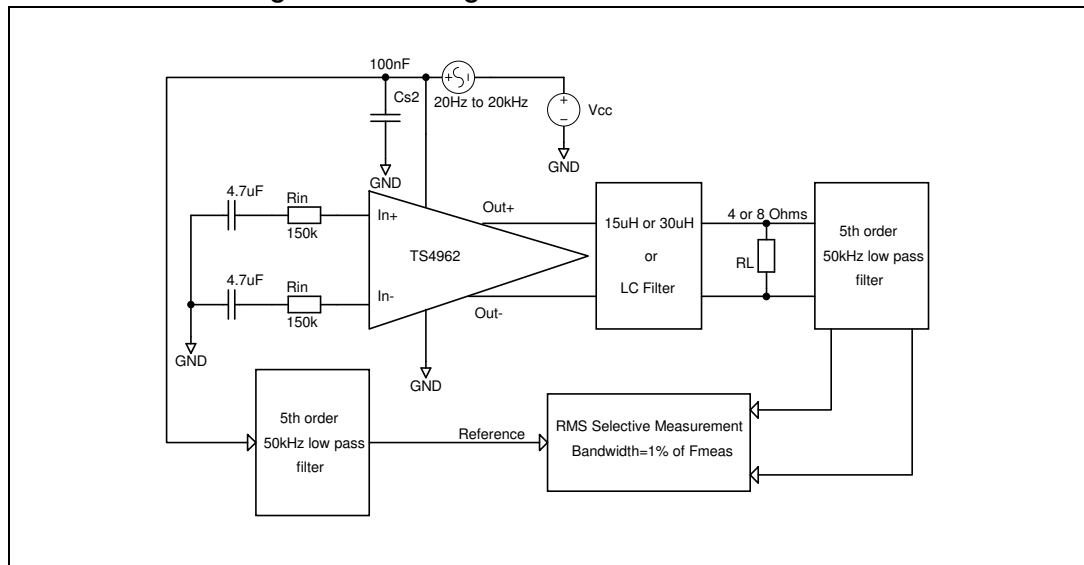
The graphs included in this section use the following abbreviations:

- $R_L + 15 \mu\text{H}$  or  $30 \mu\text{H}$  = pure resistor + very low series resistance inductor
- Filter = LC output filter ( $1 \mu\text{F} + 30 \mu\text{H}$  for  $4 \Omega$  and  $0.5 \mu\text{F} + 60 \mu\text{H}$  for  $8 \Omega$ )
- All measurements made with  $C_{s1} = 1 \mu\text{F}$  and  $C_{s2} = 100 \text{nF}$  except for PSRR where  $C_{s1}$  is removed.

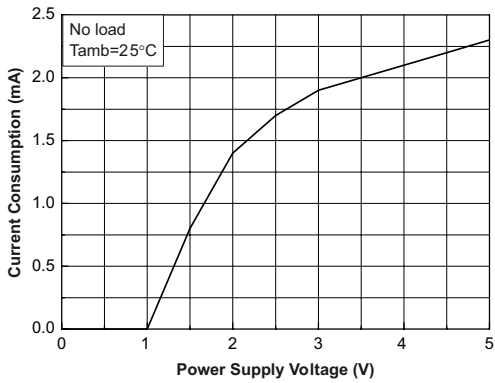
**Figure 4. Test diagram for measurements**



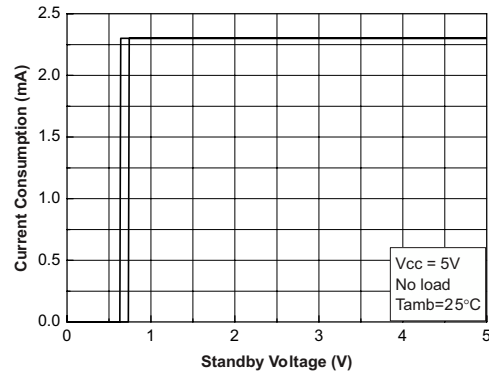
**Figure 5. Test diagram for PSRR measurements**



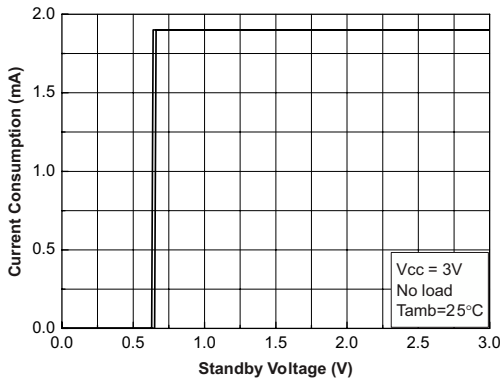
**Figure 6. Current consumption vs. power supply voltage**



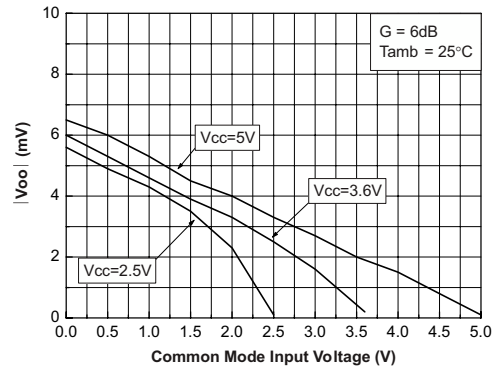
**Figure 7. Current consumption vs. standby voltage at  $V_{CC} = 5\text{ V}$**



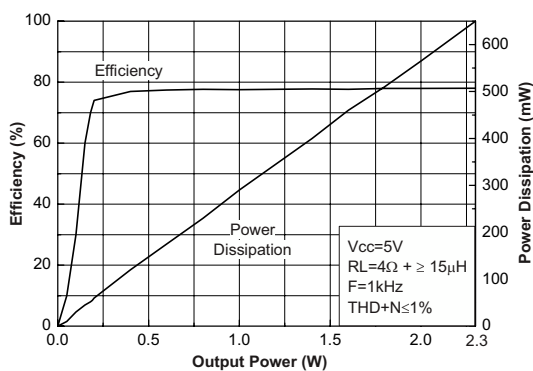
**Figure 8. Current consumption vs. standby voltage at  $V_{CC} = 3\text{ V}$**



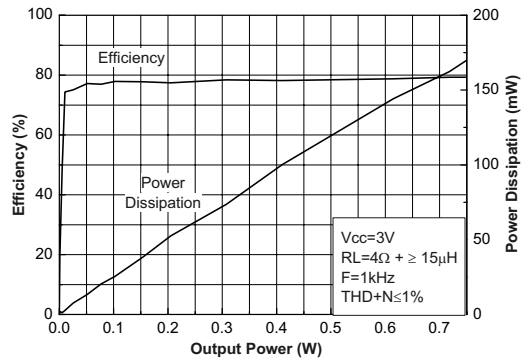
**Figure 9. Output offset voltage vs. common-mode input voltage**



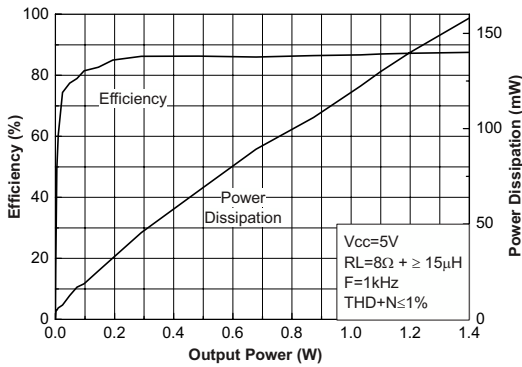
**Figure 10. Efficiency vs. output power at  $V_{CC} = 5\text{ V}$  and  $R_L = 4\ \Omega$**



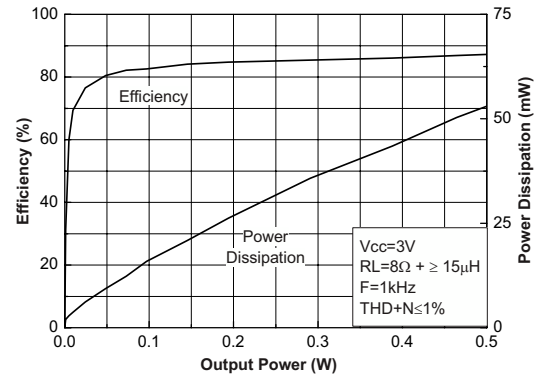
**Figure 11. Efficiency vs. output power at  $V_{CC} = 3\text{ V}$  and  $R_L = 4\ \Omega$**



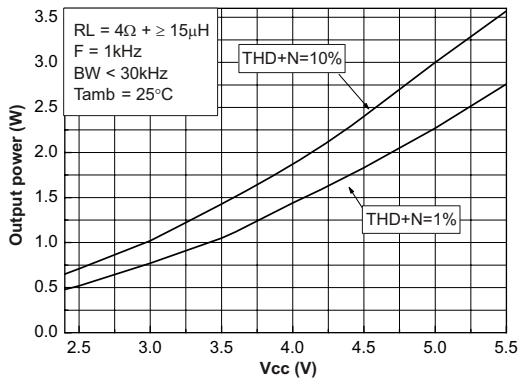
**Figure 12. Efficiency vs. output power at  $V_{CC} = 5\text{ V}$  and  $R_L = 8\ \Omega$**



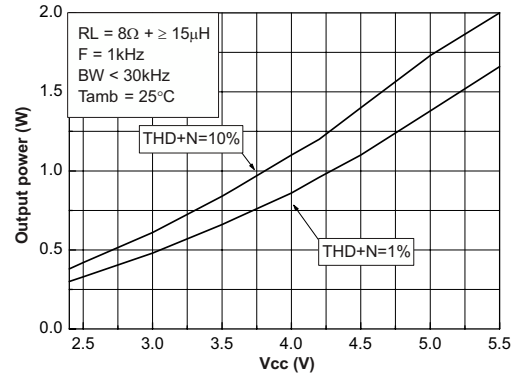
**Figure 13. Efficiency vs. output power at  $V_{CC} = 3\text{ V}$  and  $R_L = 8\ \Omega$**



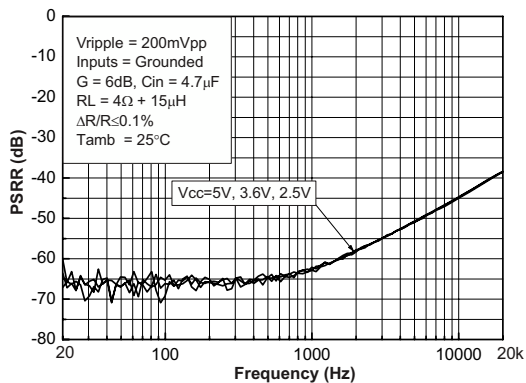
**Figure 14. Output power vs. power supply voltage at  $R_L = 4\ \Omega$**



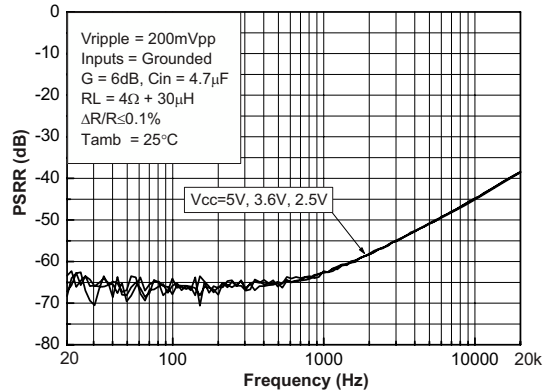
**Figure 15. Output power vs. power supply voltage at  $R_L = 8\ \Omega$**



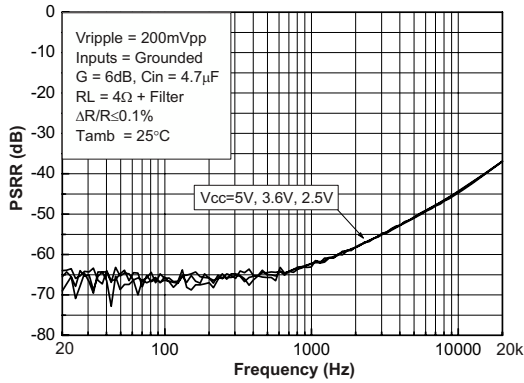
**Figure 16. PSRR vs. frequency at  $R_L = 4\ \Omega + 15\ \mu\text{H}$**



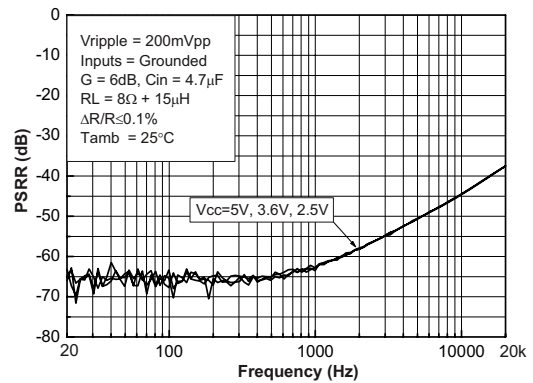
**Figure 17. PSRR vs. frequency at  $R_L = 4\ \Omega + 30\ \mu\text{H}$**



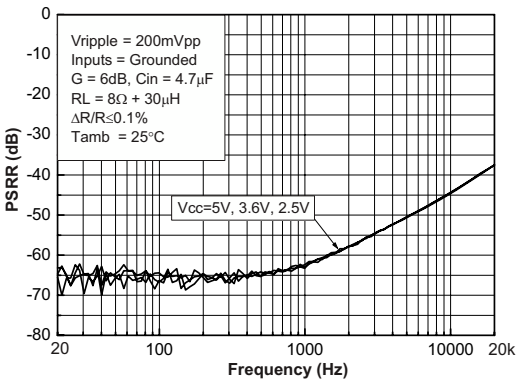
**Figure 18. PSRR vs. frequency at  $R_L = 4\ \Omega + \text{filter}$**



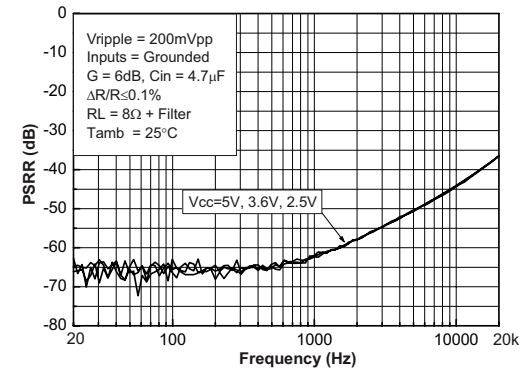
**Figure 19. PSRR vs. frequency at  $R_L = 8\ \Omega + 15\ \mu\text{H}$**



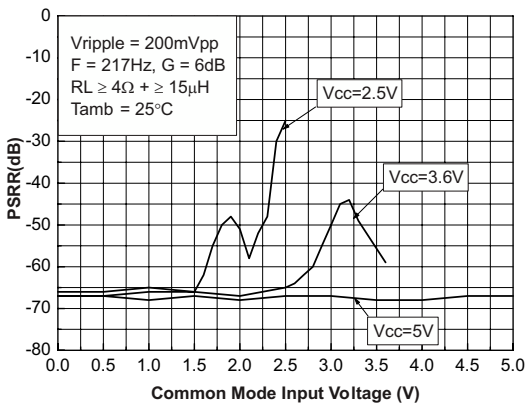
**Figure 20. PSRR vs. frequency at  $R_L = 8\ \Omega + 30\ \mu\text{H}$**



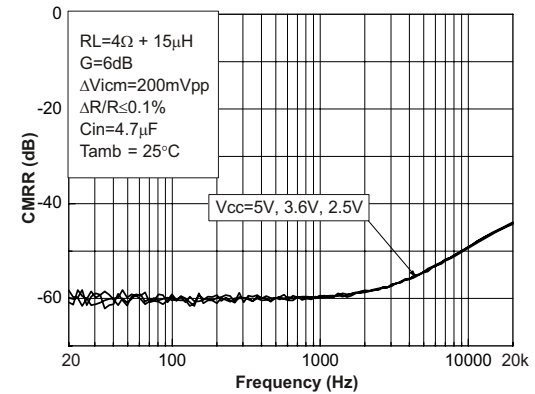
**Figure 21. PSRR vs. frequency at  $R_L = 8\ \Omega + \text{filter}$**

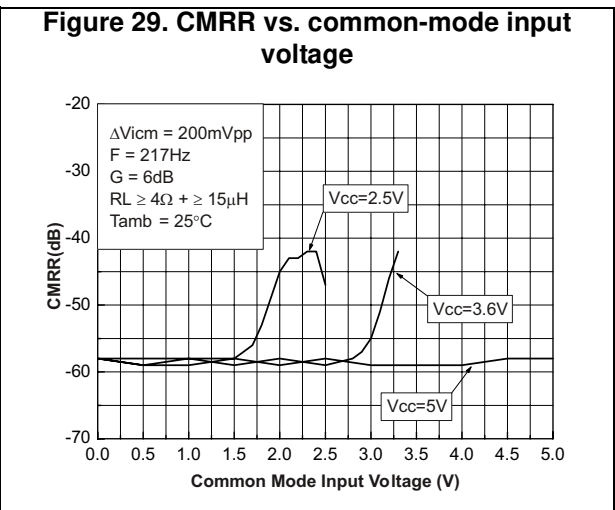
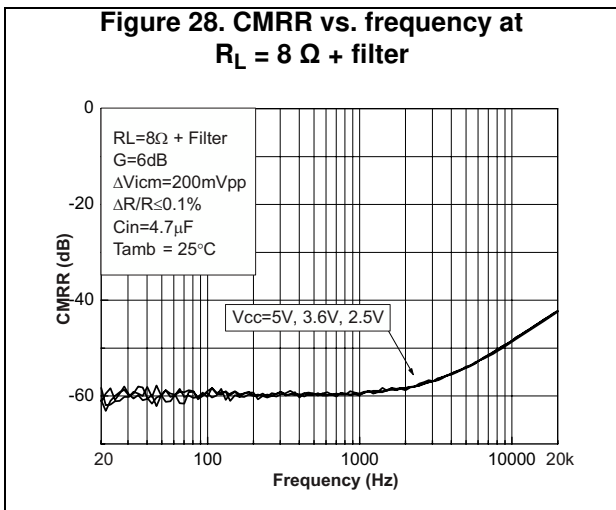
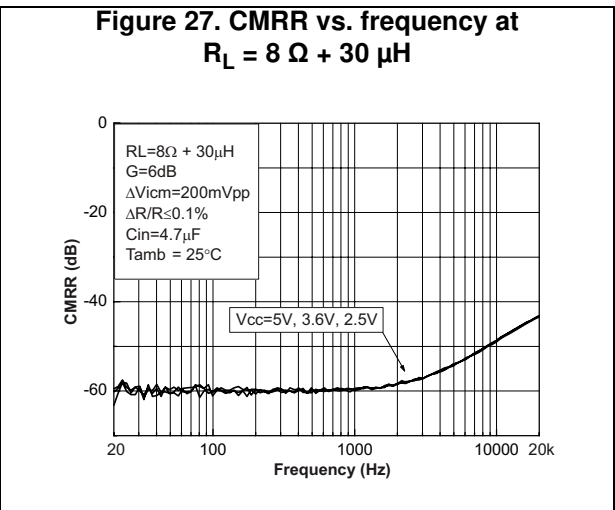
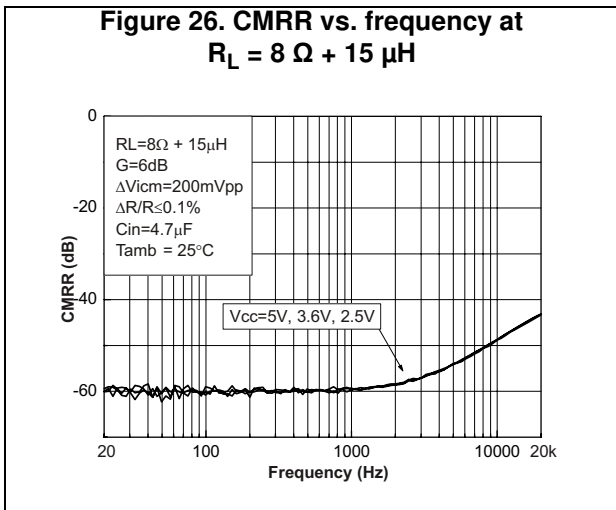
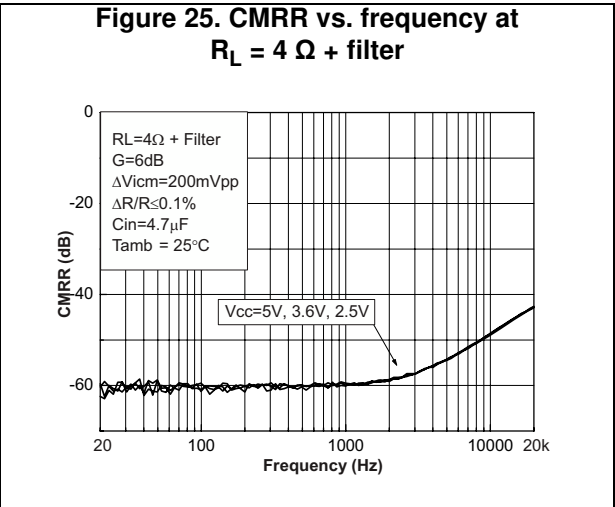
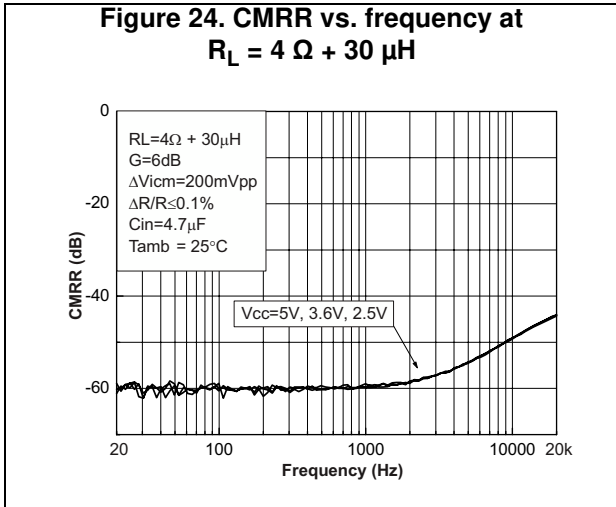


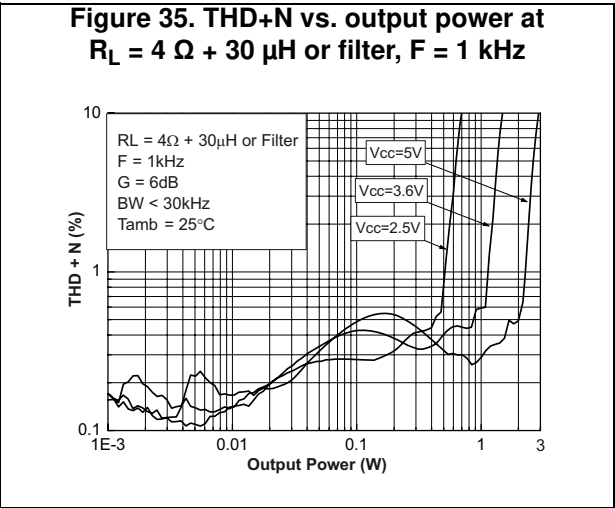
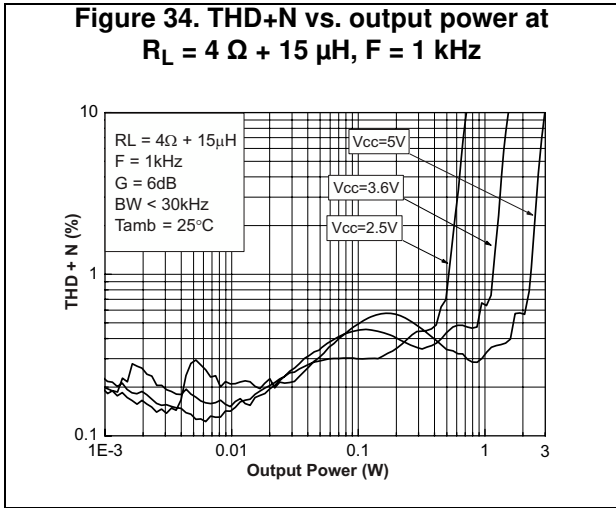
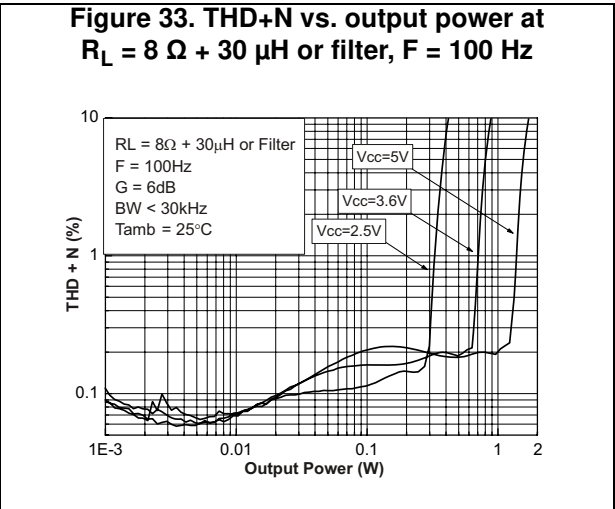
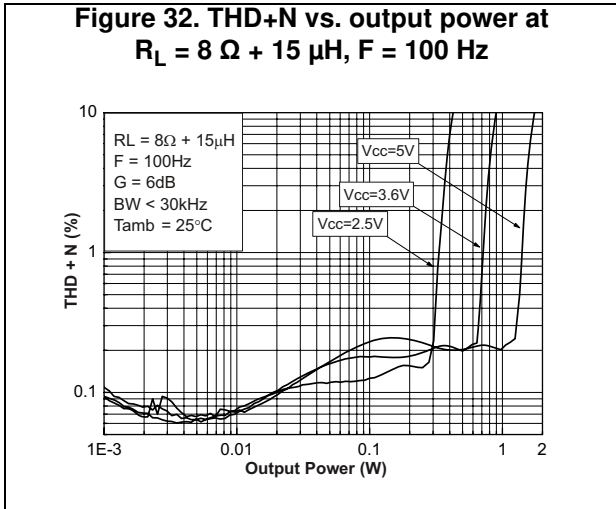
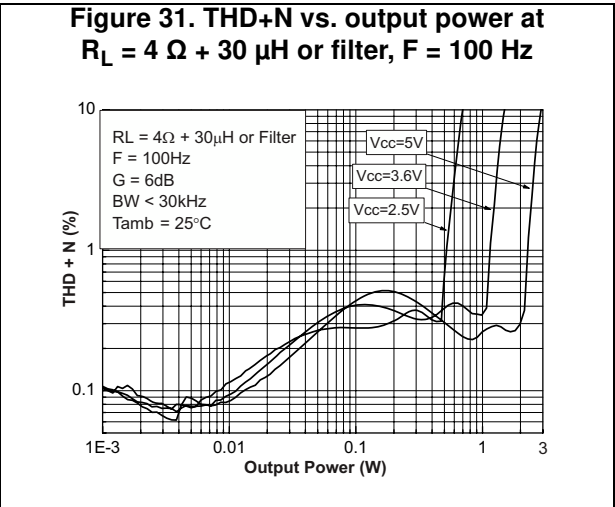
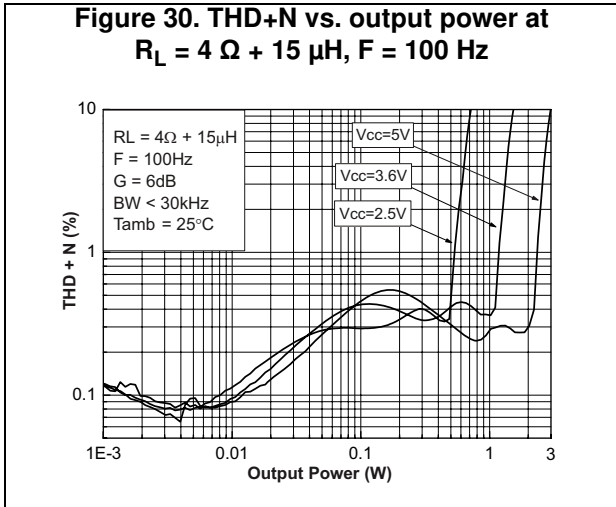
**Figure 22. PSRR vs. common-mode input voltage**



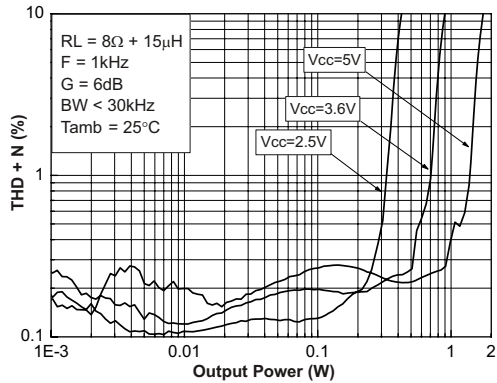
**Figure 23. CMRR vs. frequency at  $R_L = 4\ \Omega + 15\ \mu\text{H}$**



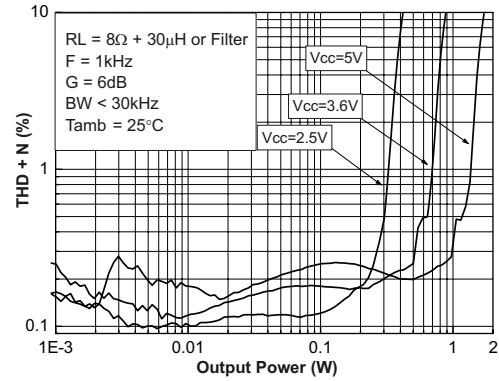




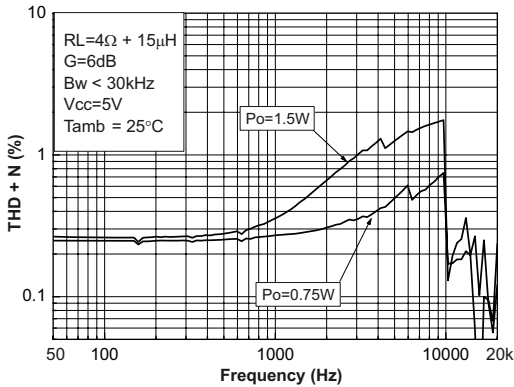
**Figure 36. THD+N vs. output power at  $R_L = 8 \Omega + 15 \mu\text{H}$ ,  $F = 1 \text{ kHz}$**



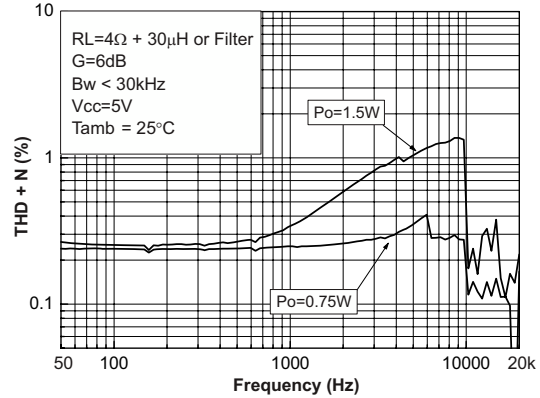
**Figure 37. THD+N vs. output power at  $R_L = 8 \Omega + 30 \mu\text{H}$  or filter,  $F = 1 \text{ kHz}$**



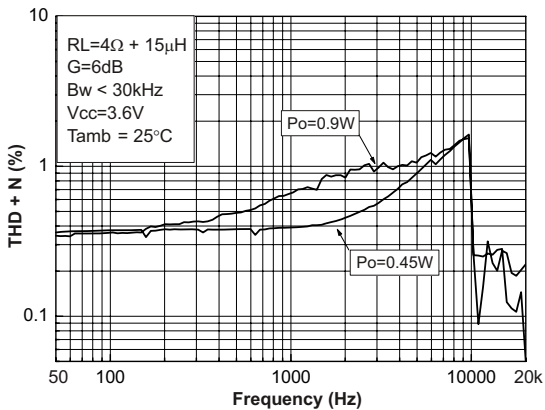
**Figure 38. THD+N vs. frequency at  $R_L = 4 \Omega + 15 \mu\text{H}$ ,  $V_{CC} = 5 \text{ V}$**



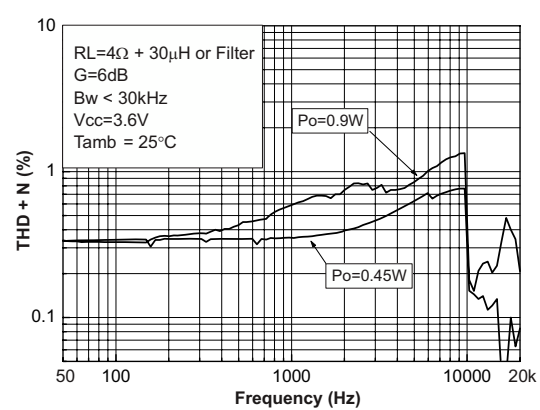
**Figure 39. THD+N vs. frequency at  $R_L = 4 \Omega + 30 \mu\text{H}$  or filter,  $V_{CC} = 5 \text{ V}$**



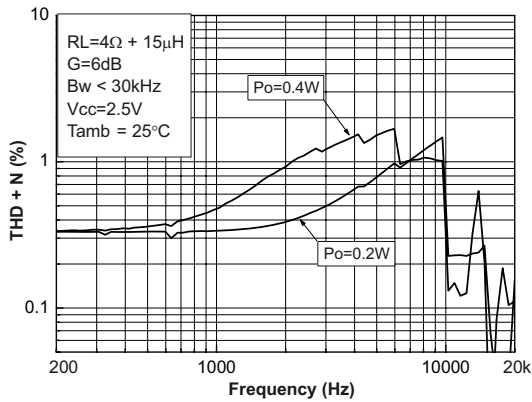
**Figure 40. THD+N vs. frequency at  $R_L = 4 \Omega + 15 \mu\text{H}$ ,  $V_{CC} = 3.6 \text{ V}$**



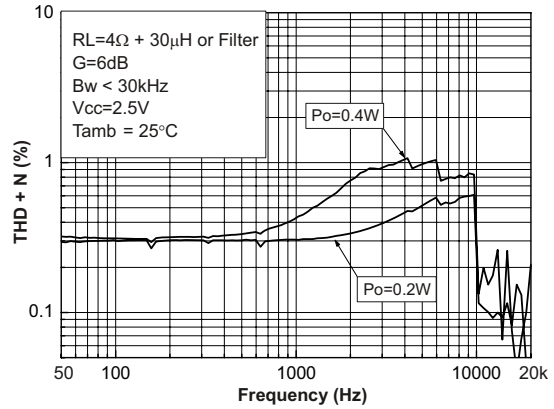
**Figure 41. THD+N vs. frequency at  $R_L = 4 \Omega + 30 \mu\text{H}$  or filter,  $V_{CC} = 3.6 \text{ V}$**



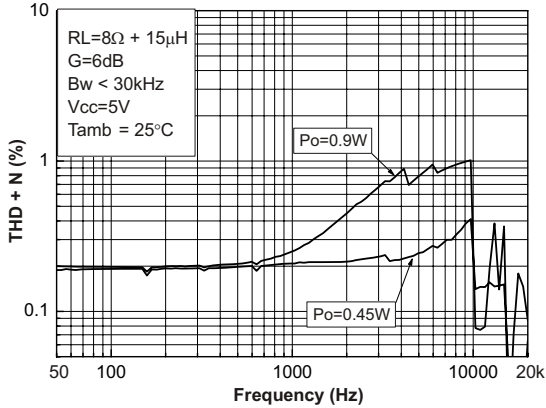
**Figure 42. THD+N vs. frequency at  $R_L = 4 \Omega + 15 \mu H$ ,  $V_{CC} = 2.5 V$**



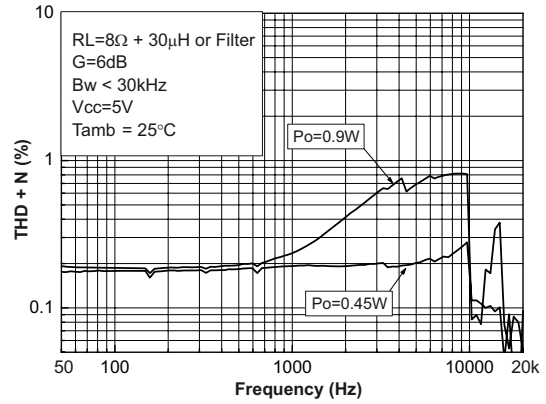
**Figure 43. THD+N vs. frequency at  $R_L = 4 \Omega + 30 \mu H$  or filter,  $V_{CC} = 2.5 V$**



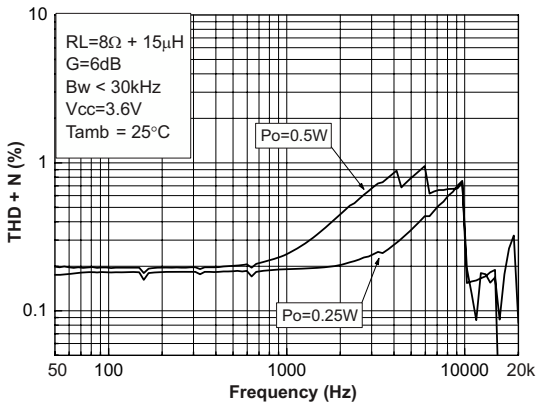
**Figure 44. THD+N vs. frequency at  $R_L = 8 \Omega + 15 \mu H$ ,  $V_{CC} = 5 V$**



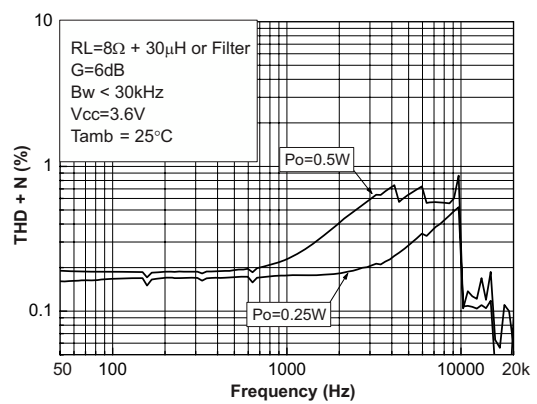
**Figure 45. THD+N vs. frequency at  $R_L = 8 \Omega + 30 \mu H$  or filter,  $V_{CC} = 5 V$**



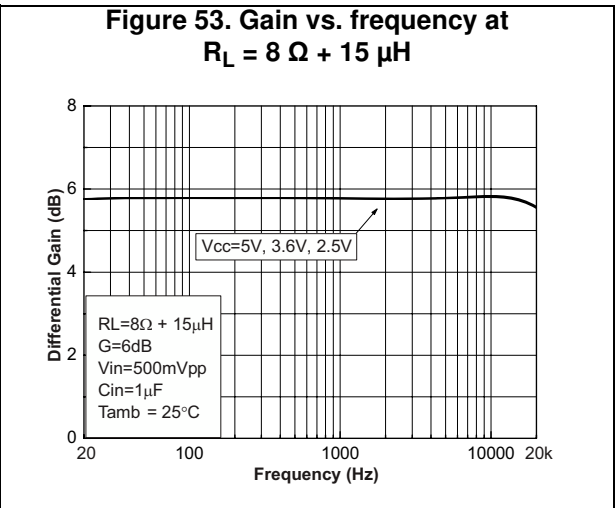
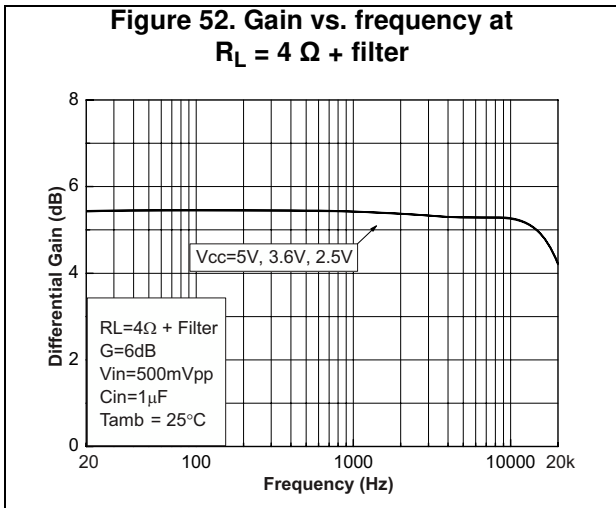
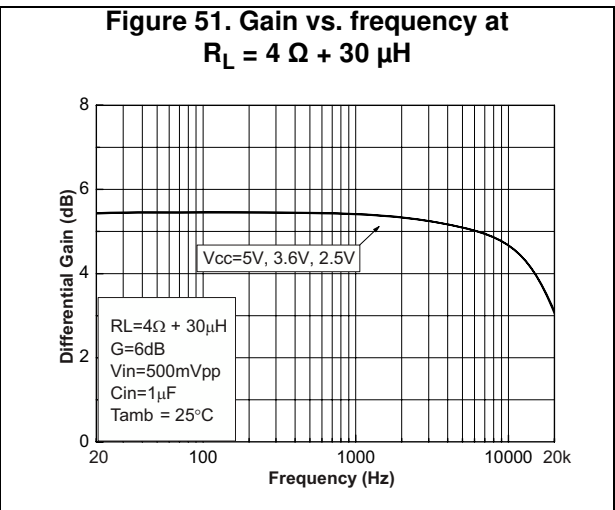
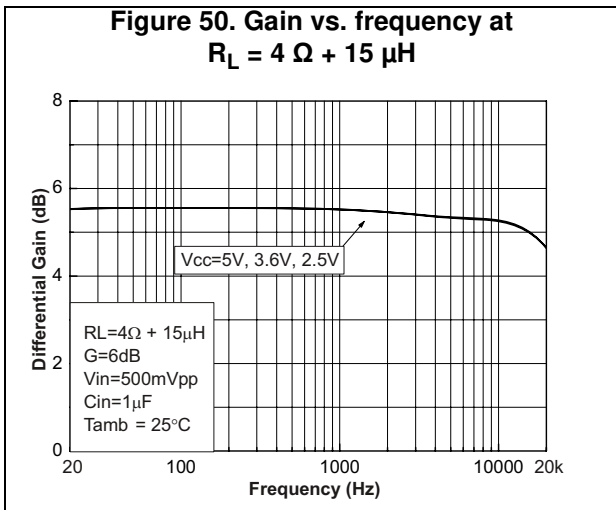
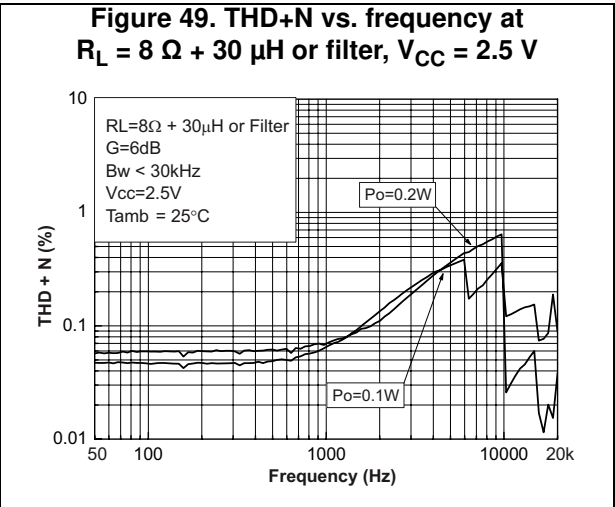
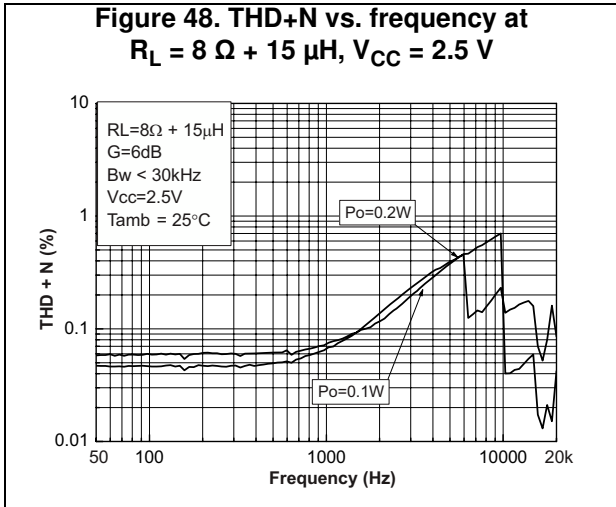
**Figure 46. THD+N vs. frequency at  $R_L = 8 \Omega + 15 \mu H$ ,  $V_{CC} = 3.6 V$**

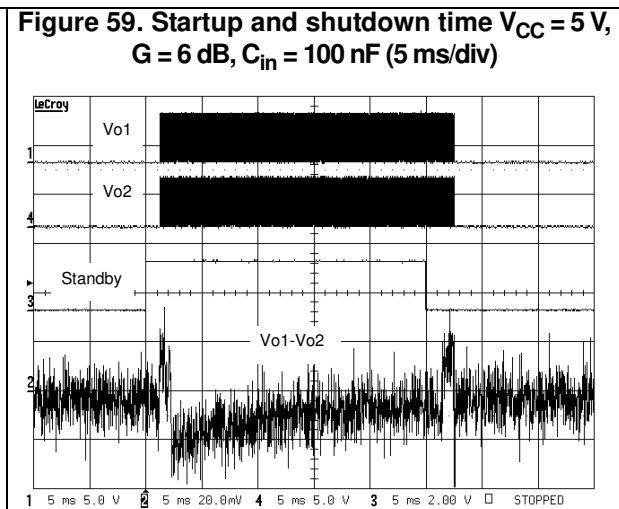
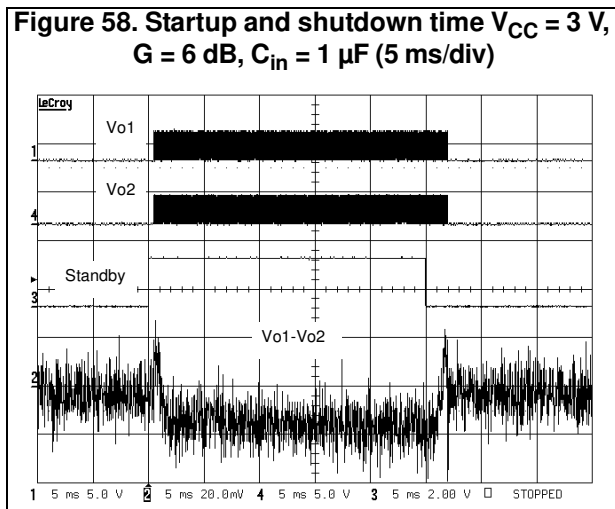
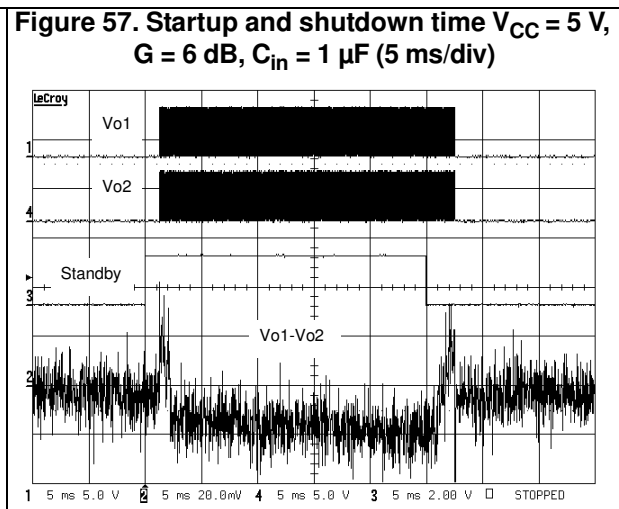
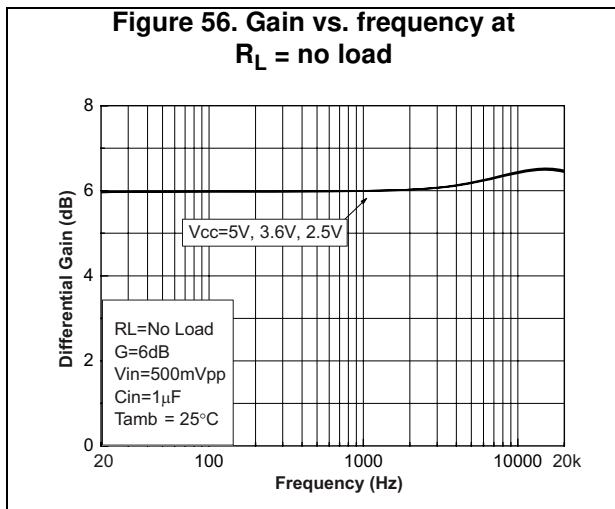
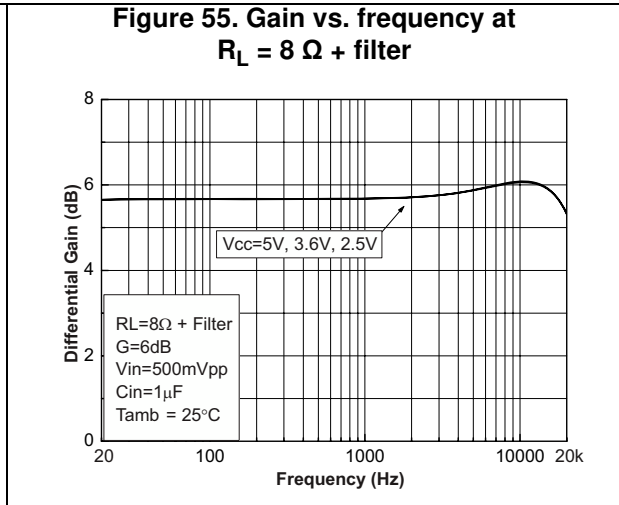
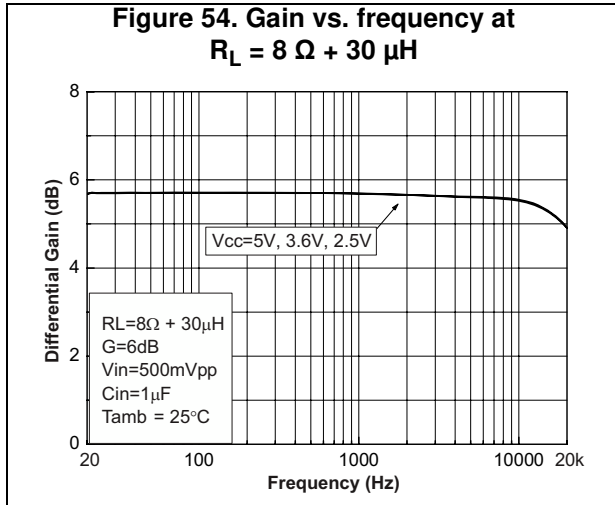


**Figure 47. THD+N vs. frequency at  $R_L = 8 \Omega + 30 \mu H$  or filter,  $V_{CC} = 3.6 V$**

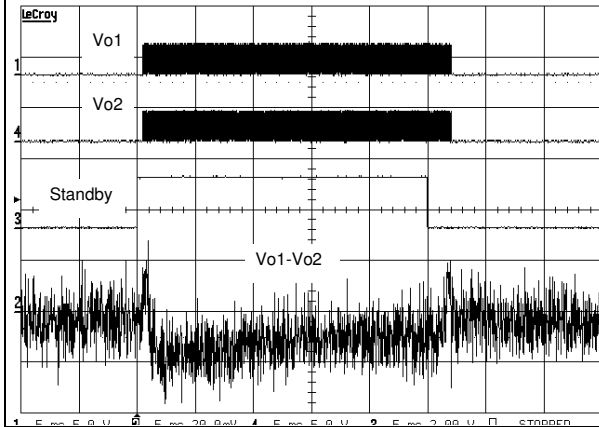




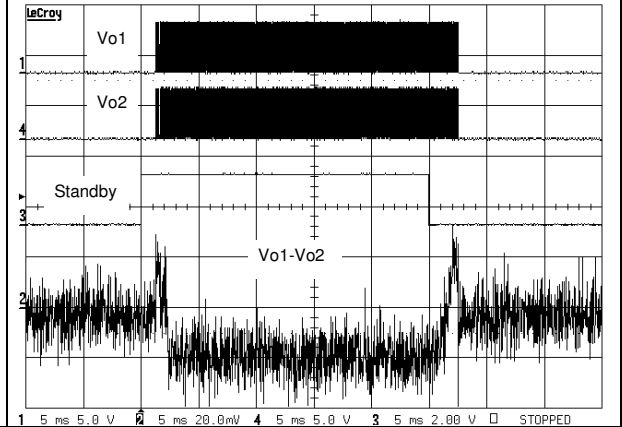




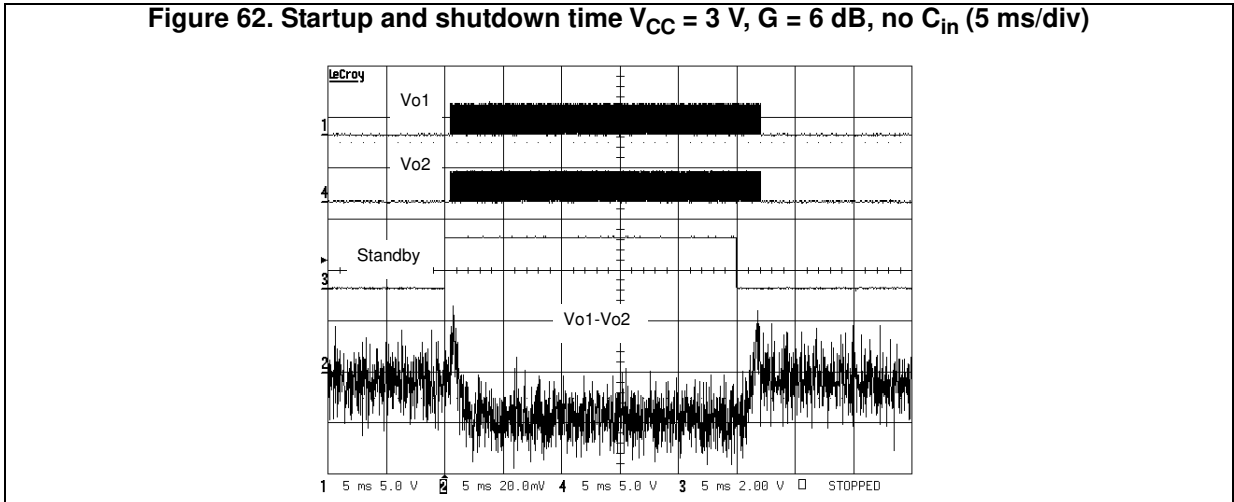
**Figure 60. Startup and shutdown time  $V_{CC} = 3\text{ V}$ ,  $G = 6\text{ dB}$ ,  $C_{in} = 100\text{ nF}$  (5 ms/div)**



**Figure 61. Startup and shutdown time  $V_{CC} = 5\text{ V}$ ,  $G = 6\text{ dB}$ , No  $C_{in}$  (5 ms/div)**



**Figure 62. Startup and shutdown time  $V_{CC} = 3\text{ V}$ ,  $G = 6\text{ dB}$ , no  $C_{in}$  (5 ms/div)**



## 6 Application information

### 6.1 Differential configuration principle

The TS4962M is a monolithic fully-differential input/output class D power amplifier. The TS4962M also includes a common-mode feedback loop that controls the output bias value to average it at  $V_{CC}/2$  for any DC common-mode input voltage. This allows the device to always have a maximum output voltage swing, and by consequence, maximizes the output power. Moreover, as the load is connected differentially compared to a single-ended topology, the output is four times higher for the same power supply voltage.

The advantages of a full-differential amplifier are:

- High PSRR (power supply rejection ratio)
- High common-mode noise rejection
- Virtually zero pop without additional circuitry, giving a faster start-up time compared to conventional single-ended input amplifiers.
- Easier interfacing with differential output audio DAC
- No input coupling capacitors required due to common-mode feedback loop

The main disadvantage is:

- As the differential function is directly linked to external resistor mismatching, particular attention to this mismatching is mandatory to obtain the best performance from the amplifier.

### 6.2 Gain in typical application schematic

Typical differential applications are shown in [Figure 3 on page 4](#).

In the flat region of the frequency-response curve (no input coupling capacitor effect), the differential gain is expressed by the relation:

$$A_{V_{diff}} = \frac{Out^+ - Out^-}{In^+ - In^-} = \frac{300}{R_{in}}$$

with  $R_{in}$  expressed in  $k\Omega$ .

Due to the tolerance of the internal  $150\text{ k}\Omega$  feedback resistor, the differential gain will be in the range (no tolerance on  $R_{in}$ ):

$$\frac{273}{R_{in}} \leq A_{V_{diff}} \leq \frac{327}{R_{in}}$$

## 6.3 Common-mode feedback loop limitations

The common-mode feedback loop allows the output DC bias voltage to be averaged at  $V_{CC}/2$  for any DC common-mode bias input voltage.

However, due to  $V_{icm}$  limitation in the input stage (see [Table 3: Operating conditions on page 5](#)), the common-mode feedback loop can ensure its role only within a defined range. This range depends upon the values of  $V_{CC}$  and  $R_{in}$  ( $A_{Vdiff}$ ). To have a good estimation of the  $V_{icm}$  value, we can apply this formula (no tolerance on  $R_{in}$ ):

$$V_{icm} = \frac{V_{CC} \times R_{in} + 2 \times V_{IC} \times 150k\Omega}{2 \times (R_{in} + 150k\Omega)} \quad (V)$$

with

$$V_{IC} = \frac{In^+ + In^-}{2} \quad (V)$$

and the result of the calculation must be in the range:

$$0.5V \leq V_{icm} \leq V_{CC} - 0.8V$$

Due to the  $\pm 9\%$  tolerance on the 150k $\Omega$  resistor, it is also important to check  $V_{icm}$  in these conditions:

$$\frac{V_{CC} \times R_{in} + 2 \times V_{IC} \times 136.5k\Omega}{2 \times (R_{in} + 136.5k\Omega)} \leq V_{icm} \leq \frac{V_{CC} \times R_{in} + 2 \times V_{IC} \times 163.5k\Omega}{2 \times (R_{in} + 163.5k\Omega)}$$

If the result of the  $V_{icm}$  calculation is not in the previous range, input coupling capacitors must be used (with  $V_{CC}$  from 2.4V to 2.5V, input coupling capacitors are mandatory).

### Example

With  $V_{CC} = 3V$ ,  $R_{in} = 150k$  and  $V_{IC} = 2.5V$ , we typically find  $V_{icm} = 2V$  and this is lower than  $3V - 0.8V = 2.2V$ . With 136.5k $\Omega$  we find 1.97V, and with 163.5k $\Omega$  we have 2.02V. So, no input coupling capacitors are required.

## 6.4 Low frequency response

If a low frequency bandwidth limitation is requested, it is possible to use input coupling capacitors.

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

$$F_{CL} = \frac{1}{2\pi \times R_{in} \times C_{in}} \quad (Hz)$$

So, for a desired cut-off frequency we can calculate  $C_{in}$ ,

$$C_{in} = \frac{1}{2\pi \times R_{in} \times F_{CL}} \quad (F)$$

with  $R_{in}$  in  $\Omega$  and  $F_{CL}$  in Hz.

## 6.5 Decoupling of the circuit

A power supply capacitor, referred to as  $C_S$ , is needed to correctly bypass the TS4962M.

The TS4962M has a typical switching frequency at 250 kHz and an output fall and rise time about 5ns. Due to these very fast transients, careful decoupling is mandatory.

A 1  $\mu$ F ceramic capacitor is enough, but it must be located very close to the TS4962M in order to avoid any extra parasitic inductance created by an overly long track wire. In relation with  $dI/dt$ , this parasitic inductance introduces an overvoltage that decreases the global efficiency and, if it is too high, may cause a breakdown of the device.

In addition, even if a ceramic capacitor has an adequate high-frequency ESR value, its current capability is also important. A 0603 size is a good compromise, particularly when a 4  $\Omega$  load is used.

Another important parameter is the rated voltage of the capacitor. A 1  $\mu$ F/6.3 V capacitor used at 5 V, loses about 50% of its value. In fact, with a 5V power supply voltage, the decoupling value is about 0.5  $\mu$ F instead of 1 $\mu$ F. As  $C_S$  has particular influence on the THD+N in the medium-high frequency region, this capacitor variation becomes decisive. In addition, less decoupling means higher overshoots, which can be problematic if they reach the power supply AMR value (6 V).

## 6.6 Wake-up time ( $t_{WU}$ )

When the standby is released to set the device ON, there is a wait of about 5ms. The TS4962M has an internal digital delay that mutes the outputs and releases them after this time in order to avoid any pop noise.

## 6.7 Shutdown time ( $t_{STBY}$ )

When the standby command is set, the time required to put the two output stages into high impedance and to put the internal circuitry in shutdown mode, is about 5 ms. This time is used to decrease the gain and avoid any pop noise during shutdown.

## 6.8 Consumption in shutdown mode

Between the shutdown pin and GND there is an internal 300 k $\Omega$  resistor. This resistor forces the TS4962M to be in standby mode when the standby input pin is left floating.

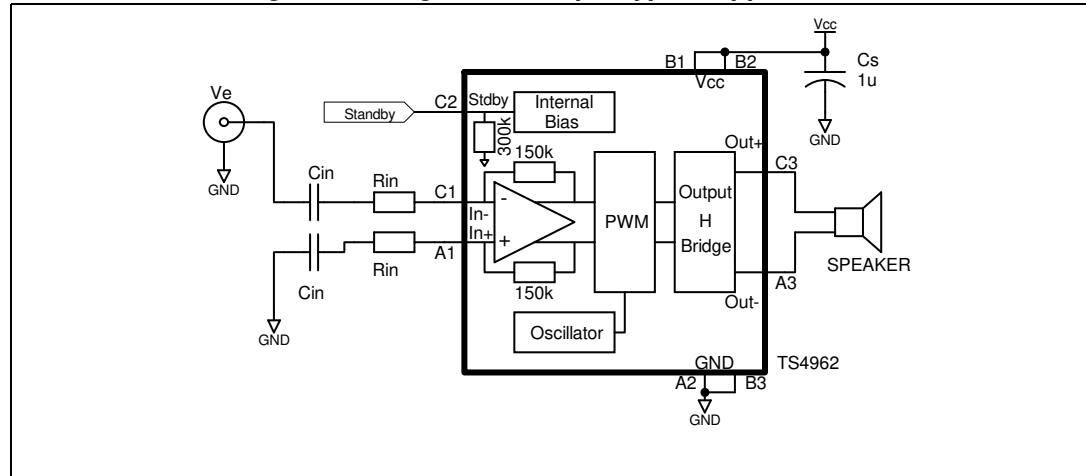
However, this resistor also introduces additional power consumption if the shutdown pin voltage is not 0 V.

For example, with a 0.4 V standby voltage pin, [Table 3: Operating conditions on page 5](#), shows that you must add  $0.4 \text{ V}/300 \text{ k}\Omega = 1.3 \mu\text{A}$  in typical ( $0.4 \text{ V}/273 \text{ k}\Omega = 1.46 \mu\text{A}$  in maximum) to the shutdown current specified in [Table 4 on page 6](#).

## 6.9 Single-ended input configuration

It is possible to use the TS4962M in a single-ended input configuration. However, input coupling capacitors are needed in this configuration. The schematic in *Figure 63* shows a single-ended input typical application.

**Figure 63. Single-ended input typical application**



All formulas are identical except for the gain (with  $R_{in}$  in  $k\Omega$ ):

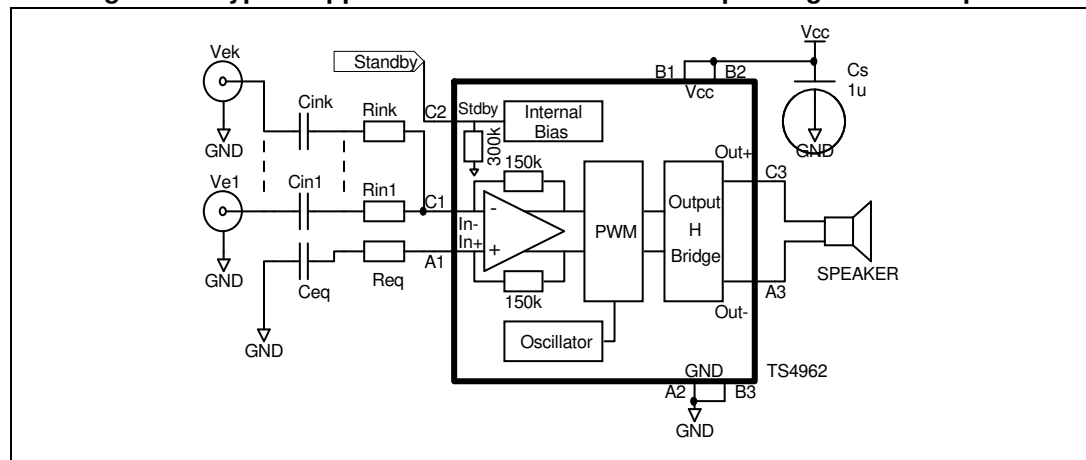
$$A_{V_{single}} = \frac{V_e}{Out^+ - Out^-} = \frac{300}{R_{in}}$$

And, due to the internal resistor tolerance we have:

$$\frac{273}{R_{in}} \leq A_{V_{single}} \leq \frac{327}{R_{in}}$$

In the event that multiple single-ended inputs are summed, it is important that the impedance on both TS4962M inputs ( $In^-$  and  $In^+$ ) are equal.

**Figure 64. Typical application schematic with multiple single-ended inputs**



We have the following equations:

$$\text{Out}^+ - \text{Out}^- = V_{e1} \times \frac{300}{R_{in1}} + \dots + V_{ek} \times \frac{300}{R_{ink}} \quad (V)$$

$$C_{eq} = \sum_{j=1}^k C_{inj}$$

$$C_{inj} = \frac{1}{2 \times \pi \times R_{inj} \times F_{CLj}} \quad (F)$$

$$R_{eq} = \frac{1}{\sum_{j=1}^k \frac{1}{R_{inj}}}$$

In general, for mixed situations (single-ended and differential inputs), it is best to use the same rule, that is, to equalize impedance on both TS4962M inputs.

## 6.10 Output filter considerations

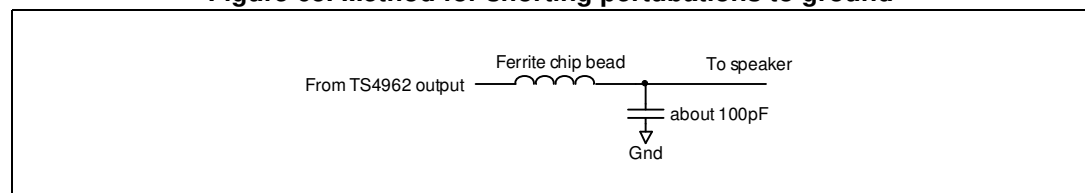
The TS4962M is designed to operate without an output filter. However, due to very sharp transients on the TS4962M output, EMI radiated emissions may cause some standard compliance issues.

These EMI standard compliance issues can appear if the distance between the TS4962M outputs and loudspeaker terminal is long (typically more than 50mm, or 100mm in both directions, to the speaker terminals). As the PCB layout and internal equipment device are different for each configuration, it is difficult to provide a one-size-fits-all solution.

However, to decrease the probability of EMI issues, there are several simple rules to follow:

- Reduce, as much as possible, the distance between the TS4962M output pins and the speaker terminals.
- Use ground planes for “shielding” sensitive wires
- Place, as close as possible to the TS4962M and in series with each output, a ferrite bead with a rated current at minimum 2A and impedance greater than 50Ω at frequencies above 30MHz. If, after testing, these ferrite beads are not necessary, replace them by a short-circuit. Murata BLM18EG221SN1 or BLM18EG121SN1 are possible examples of devices you can use.
- Allow enough of a footprint to place, if necessary, a capacitor to short perturbations to ground (see the schematics in [Figure 65](#)).

**Figure 65. Method for shorting perturbations to ground**



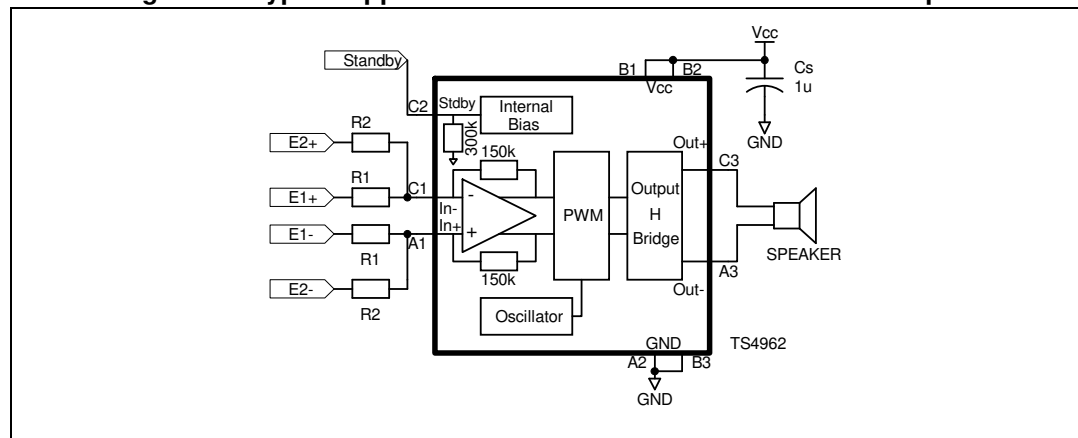


In the case where the distance between the TS4962M outputs and speaker terminals is high, it is possible to have low frequency EMI issues due to the fact that the typical operating frequency is 250kHz. In this configuration, we recommend using an output filter (as shown in [Figure 3: Typical application schematics on page 4](#)). It should be placed as close as possible to the device.

## 6.11 Different examples with summed inputs

### Example 1: Dual differential inputs

Figure 66. Typical application schematic with dual differential inputs



With ( $R_i$  in  $k\Omega$ ):

$$A_{V_1} = \frac{Out^+ - Out^-}{E_1^+ - E_1^-} = \frac{300}{R_1}$$

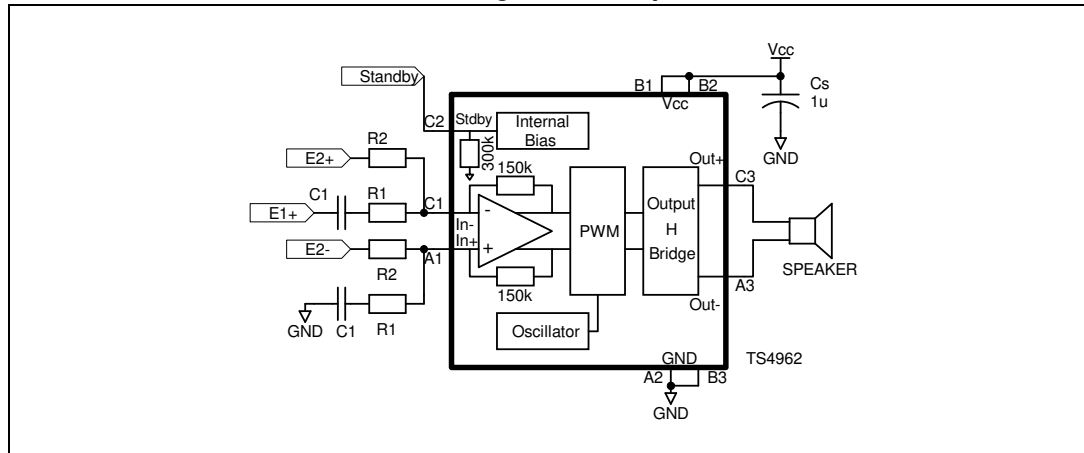
$$A_{V_2} = \frac{Out^+ - Out^-}{E_2^+ - E_2^-} = \frac{300}{R_2}$$

$$0.5V \leq \frac{V_{CC} \times R_1 \times R_2 + 300 \times (V_{IC1} \times R_2 + V_{IC2} \times R_1)}{300 \times (R_1 + R_2) + 2 \times R_1 \times R_2} \leq V_{CC} - 0.8V$$

$$V_{IC1} = \frac{E_1^+ + E_1^-}{2} \quad \text{and} \quad V_{IC2} = \frac{E_2^+ + E_2^-}{2}$$

**Example 2: One differential input plus one single-ended input**

**Figure 67. Typical application schematic with one differential input plus one single-ended input**



With (R<sub>i</sub> in kΩ):

$$A_{V_1} = \frac{Out^+ - Out^-}{E_1^+} = \frac{300}{R_1}$$

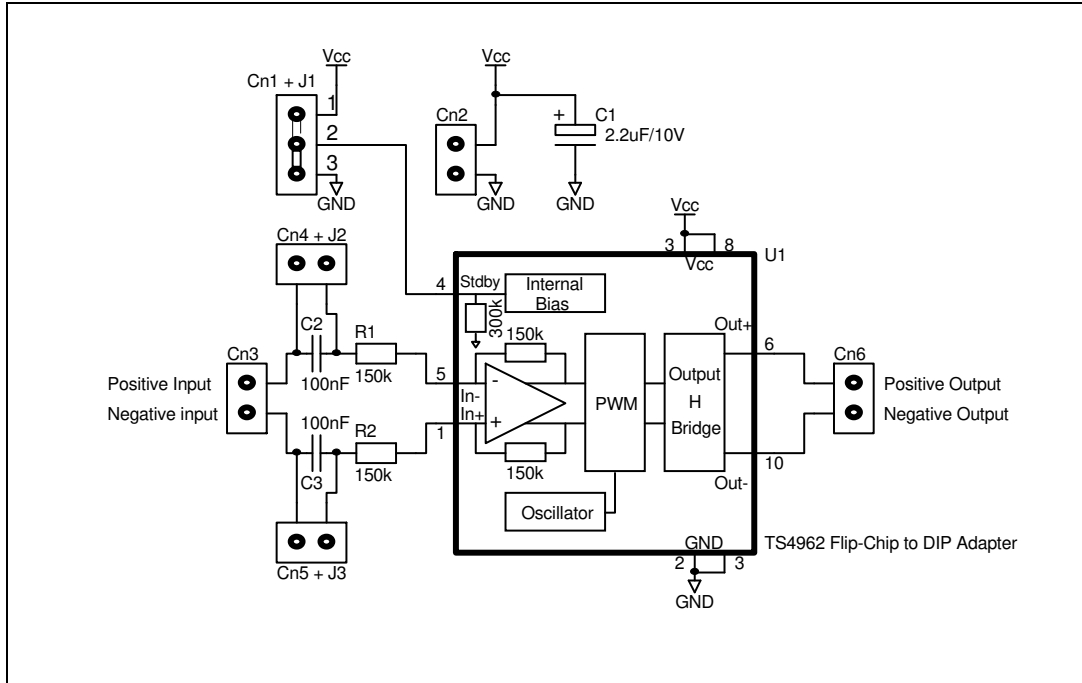
$$A_{V_2} = \frac{Out^+ - Out^-}{E_2^+ - E_2^-} = \frac{300}{R_2}$$

$$C_1 = \frac{1}{2\pi \times R_1 \times F_{CL}} \quad (F)$$

# 7 Evaluation board

An evaluation board for the TS4962M is available with a Flip Chip to DIP adapter. For more information about this board, refer to AN2134.

**Figure 68. Schematic diagram of mono class D evaluation board for TS4962M**



**Figure 69. Diagram for Flip Chip to DIP adapter**

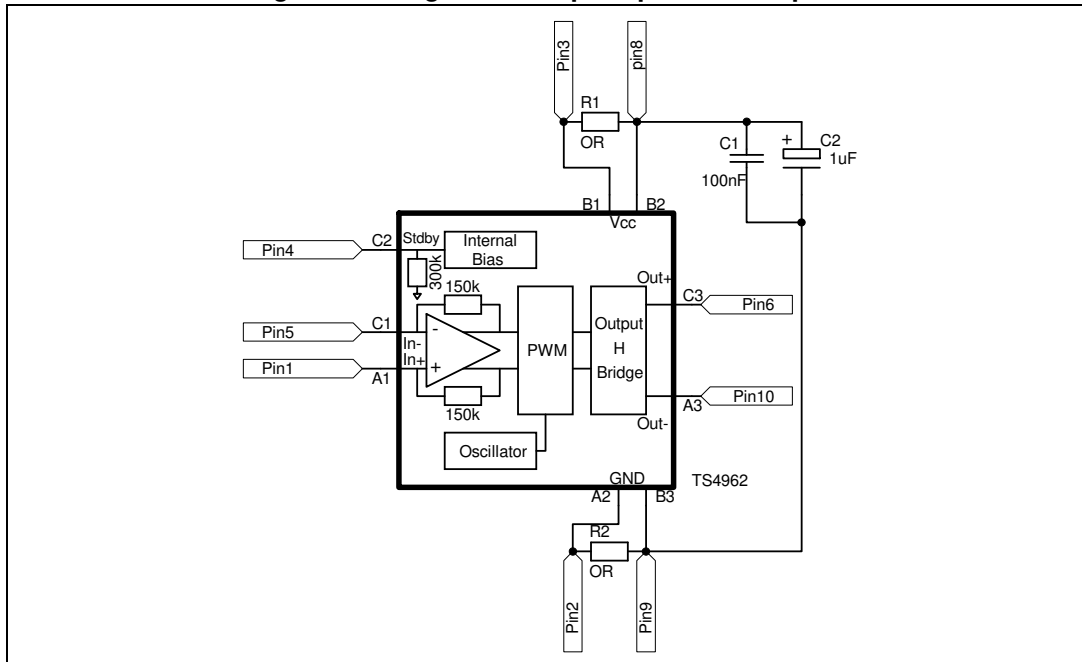


Figure 70. Top view

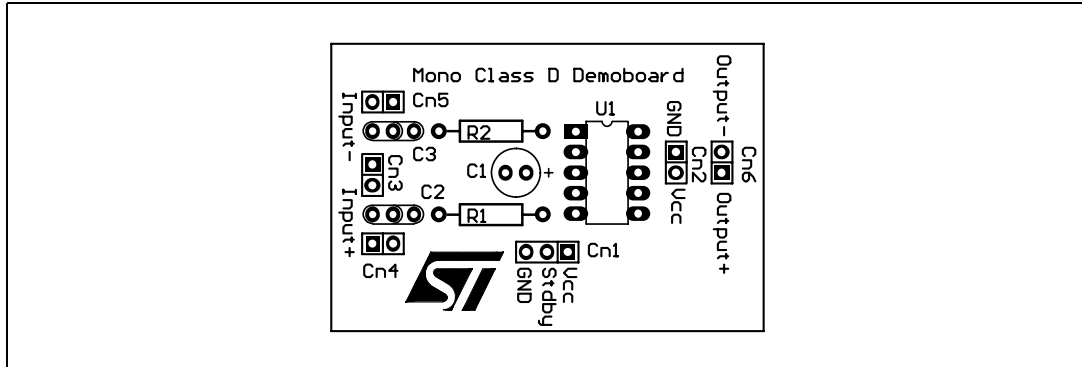


Figure 71. Bottom layer

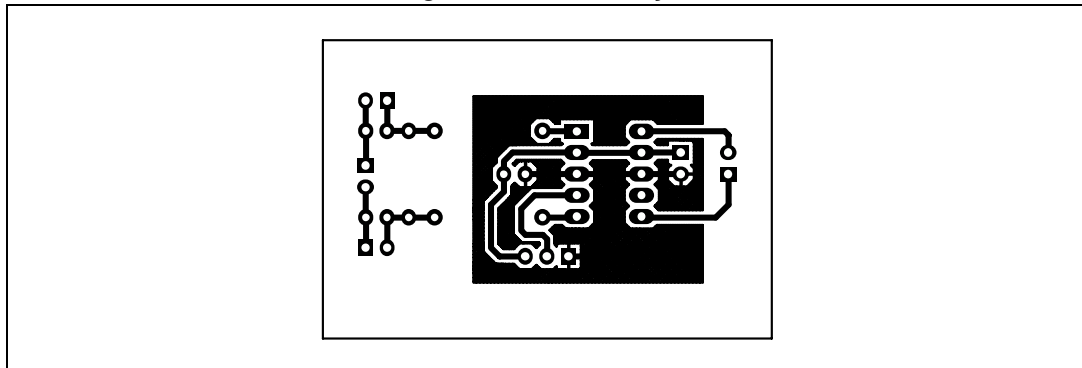
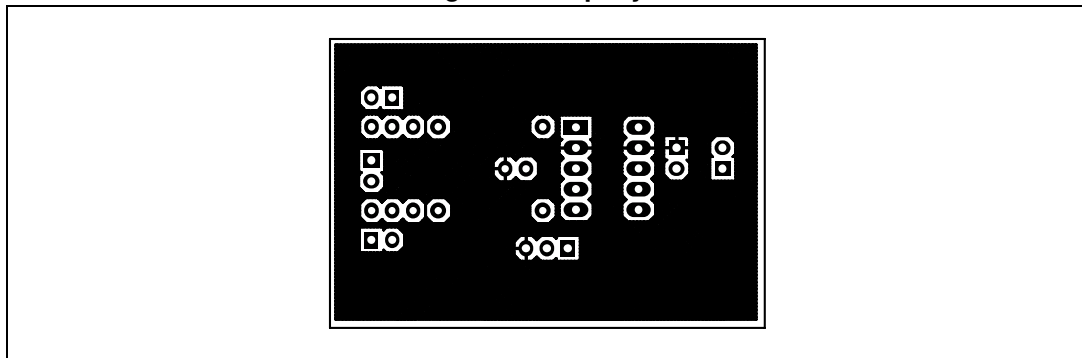


Figure 72. Top layer



## 8 Package information

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

### 8.1 9-bump Flip Chip package information

Figure 73. 9-bump Flip Chip package outline

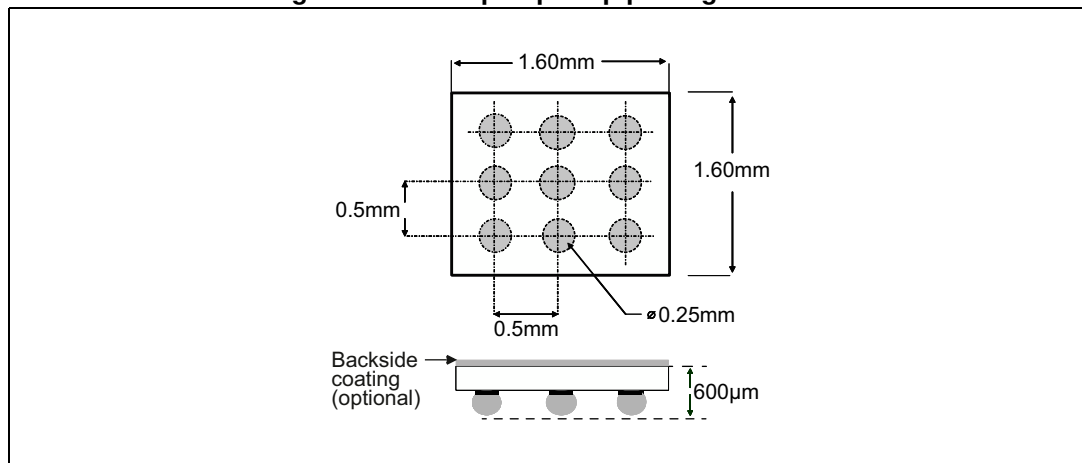
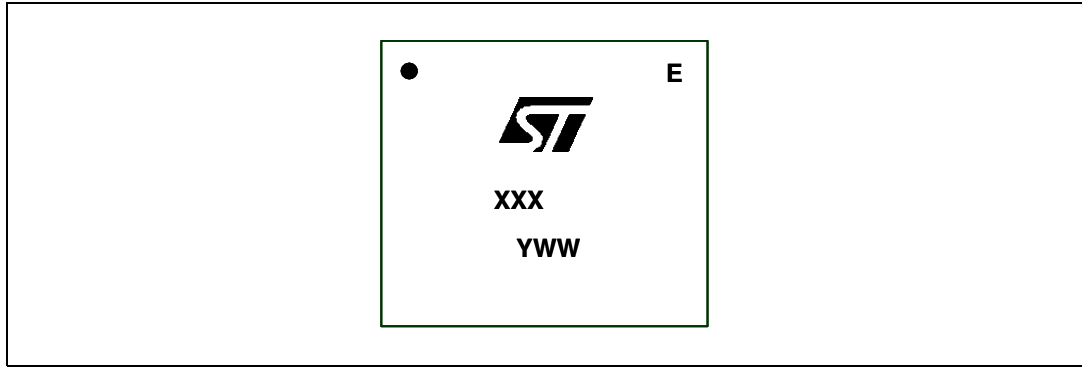


Table 10. 9-bump Flip Chip mechanical data

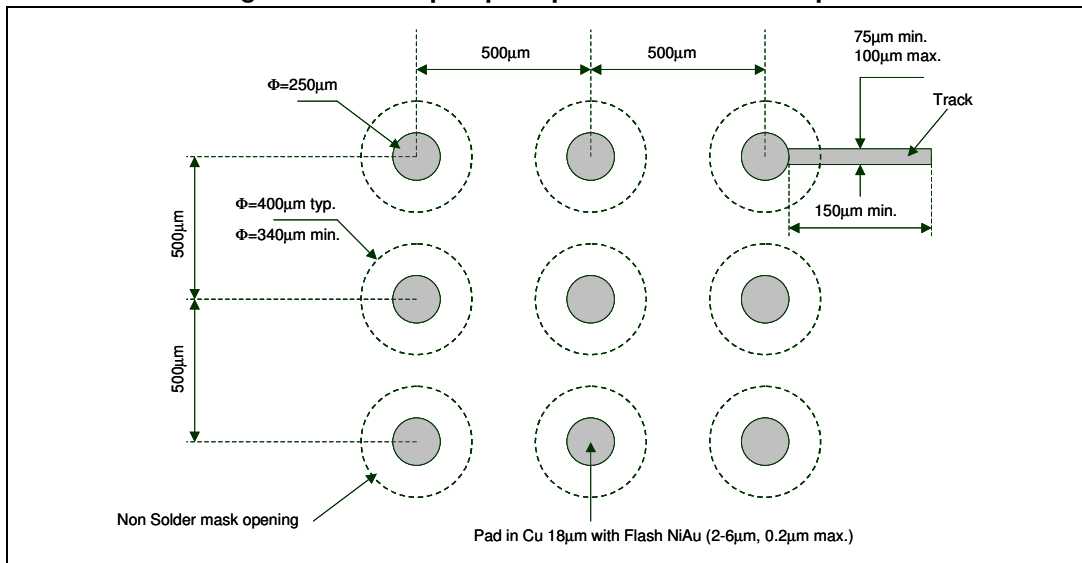
| Parameter   | Dimensions                           |
|---|--------------------------------------|
| Die size  | 1.6 mm x 1.6 mm $\pm 30 \mu\text{m}$ |
| Die height (including bumps)                              | 600 $\mu\text{m}$                    |
| Bump diameter   | 315 $\mu\text{m} \pm 50 \mu\text{m}$ |
| Bump diameter before re-flow                              | 300 $\mu\text{m} \pm 10 \mu\text{m}$ |
| Bump height   | 250 $\mu\text{m} \pm 40 \mu\text{m}$ |
| Die height  | 350 $\mu\text{m} \pm 20 \mu\text{m}$ |
| Pitch   | 500 $\mu\text{m} \pm 50 \mu\text{m}$ |
| Coplanarity   | 50 $\mu\text{m}$ max.                |
| Backside coating<br>(optional, only for the TS4962MEIKJT) | 25 $\mu\text{m} \pm 3 \mu\text{m}$   |

Figure 74. 9-bump Flip Chip marking (top view)



1. Legend:
  - ST logo
  - E = symbol for lead-free
  - First two "XX" = product code = 62
  - Third X = assembly code
  - Three-digit date code, Y = year, WW = week
  - Black dot is for marking pin A1

Figure 75. 9-bump Flip Chip recommended footprint



## 9 Ordering information

**Table 11. Order code table**

| Part number  | Temperature range | Package                                   | Packing       | Marking |
|--------------|-------------------|---|---------------|---------|
| TS4962MEIJT  | -40 °C to 85 °C   | Lead-free Flip Chip                       | Tape and reel | 62L     |
| TS4962MEIKJT |                   | Lead-free Flip Chip with backside coating |               |         |

## 10 Revision history

**Table 12. Document revision history**

| Date        | Revision | Changes   |
|-------------|----------|---|
| Oct. 2005   | 1        | First release corresponding to the product preview version.   |
| Nov. 2005   | 2        | Electrical data updated for output voltage noise, see Table 4, Table 5, Table 6, Table 7, Table 8 and Table 9<br>Formatting changes throughout.   |
| Dec. 2005   | 3        | Product in full production.   |
| 10-Jan-2007 | 4        | Template update, no technical changes.  |
| 10-Oct-2016 | 5        | Updated datasheet layout<br>Added package silhouettes<br>Added <i>Related products</i><br>Updated <i>Applications</i><br><i>Section 5: Electrical characteristic curves</i> : updated titles of graphs which had same titles.<br><i>Figure 73: 9-bump Flip Chip package outline</i> : updated diagram to display the optional backside coating for order code TS4962MEIKJT.<br>Added <i>Table 10</i> to display package mechanical data as a separate table (with information concerning the optional backside coating for order code TS4962MEIKJT).<br><i>Table 11: Order code table</i> : updated marking of order code TS4962MEIJT, added order code TS4962MEIKJT. |
| 15-Jan-2018 | 6        | Updated Table 10: 9-bump Flip Chip mechanical data.   |
| 17-Mar-2020 | 7        | Removed feature on the cover page and footnote $R_{thja}$ parameter in <a href="#">Table 2</a> .  |



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