

Mono class D audio power amplifier with dedicated analog switch

Features

- Wide operating voltage range from V_{CC} = 2.4 V to 4.3 V
- Audio amplifier standby mode active low
- Output power: 1.6 W at 4.2 V or 0.75 W at 3.0 V into 4 Ω with 1% THD+N maximum
- Output power: 0.95 W at 4.2 V or 0.45 W at 3.0 V into 8 Ω with 1% THD+N maximum
- Adjustable gain via external resistors
- Low current consumption 2 mA at 3 V
- Efficiency: 88% typical
- Signal-to-noise ratio: 85 dB typical
- PSRR: 63 dB typical at 217 Hz with 6 dB gain
- PWM base frequency: 250 kHz
- Low pop and click noise
- Dual Power SPST with separated control
- Ultra-high off-isolation on analog switch: -80 dB typical from 20 Hz to 20 kHz

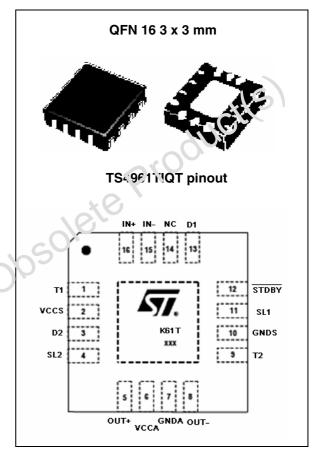
Applications

- Cellular telephones
- PDAs
- Notabook PCs

Description

The TS4961T is a smart combination of one mono class D audio power amplifier and a high-speed CMOS low-voltage dual power analog SPST.

One of the key functions of this device is the switch mode of the various audio signals coming from the codec or baseband through the loudspeaker. It can drive up to 1.6 W into a 4 Ω load and 0.95 W into an 8 Ω load. It achieves an outstanding efficiency of up to 88% typical.



The audio amplifying gain of the device can be controlled via two external gain-setting resistors. It is designed to operate from 2.4 to 4.3 V, making this device ideal for portable applications.

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1 Absolute maximum ratings and operating conditions

Table 1. Absolute maximum ratings

| Symbol | Parameter | Value | Unit |
|-------------------------------------|---|----------------------------------|------|
| V _{CCA} & V _{CCS} | Supply voltage ⁽¹⁾ ⁽²⁾ | GND to 5.5 | V |
| V _{in} | Input voltage | GND-0.3V / V _{CC} +0.3V | 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 (3) | 39 | N.Co |
| R _{thjc} | Thermal resistance junction to case | 5 | °C/W |
| P _d | Power dissipation | Internally limited (4) | |
| ESD | Human body model ⁽⁵⁾ | 2 | kV |
| ESD | Machine model ⁽⁶⁾ | 200 | V |
| Latch-up | Latch-up immunity of the Class D Amplifier (All Pins) Latch-up immunity of the Analog Switch (Supply Pinc) Latch-up immunity of the Analog Switch Supply (VC, Pins) | 200 100 200 | mA |
| V _{STBY} | Standby pin voltage maximum voltage | GND-0.3V / V _{CC} +0.3V | V |
| | Lead temperature (soldering, 10 sec) | 260 | °C |

- Caution: this device is not protected in the every of abnormal operating conditions, such as 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. When mounted on a 4-layers PC:
- 4. Exceeding the power derating `umes during a long period provokes abnormal operating conditions.
- 5. Human body model a 10 oF capacitor is charged to the specified voltage, then discharged through a 1.5 kΩ resistor between two pins of the device. This is done for all couples of connected pin combinations while the other pins are floating.
- Machine mc de la 200 pF capacitor is charged to the specified voltage, then discharged directly between two pins of the
 device with ne external series resistor (internal resistor < 5 Ω). This is done for all couples of connected pin combinations
 while the other pins are floating.

Table 2. Operating conditions for audio amplifier section

| Symbol | Parameter | Value | Unit |
|-------------------|---|--|------|
| V_{CCA} | Supply voltage ⁽¹⁾ | 2.4 to 4.3 | V |
| V _{IC} | Common mode input voltage range ⁽²⁾ | 0.5 to V _{CC} -0.8 | V |
| V _{STBY} | Standby voltage input: ⁽³⁾ Class D amplifier ON Class D amplifier OFF ⁽⁴⁾ | $1.4 \le V_{STBY} \le V_{CC}$ $GND \le V_{STBY} \le 0.4$ | V |
| R_{L} | Load resistor | ≥ 4 | Ω |

- 1. For V_{CC} from 2.4 V to 2.5 V, the operating temperature range is reduced to 0° C≤T_{amb} ≤70° 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 $V_{STBY} = GND$.



Table 3. Operating conditions for analog switch section

| Symbol | Parameter | Value | Unit | |
|-----------------|--|--|----------------------|-------|
| V _{CC} | Supply voltage | 2.4 to 4.3 | V | |
| V _{in} | Input voltage | 0 to V _{CC} | V | |
| V _{IC} | Control input voltage | 0 to 4.3 | V | |
| V _O | Output voltage | | 0 to V _{CC} | V |
| dt/dv | Input rise and fall time control input | V _{CC} = 2.5 V | 0 to 20 | ns/V |
| ui/uv | imput rise and iaii time control imput | $V_{CC} = 3.0 \text{ V to } 4.3 \text{ V}$ | 0 to 10 | 115/V |

Audio amplifier standby mode settings Table 4.

| | /STDBY | Functional description |
|----------|---------------|---------------------------------|
| | Low | OFF Device is in shut-down mode |
| | High | ON Device is in operating rode |
| Table 5. | Analog switch | settings truth table |

Analog switch settings truth table Table 5.

| High | ON D1 is connected to T1 | ON |
|-----------|----------------------------------|----------------------------------|
| | I DI IS CONNECTED TO LI | D2 is connected to T2 |
| Low | OFF High impedarce from D1 to T1 | OFF High impedance from D2 to T2 |
| Pro | 90. | |
| osolete ' | | |

Table 6. Pin description

| Name | Pin number | Function |
|--------|------------|---|
| VCCA | 6 | Class D audio amplifier power supply voltage input pin |
| VCCS | 2 | Analog switch power supply voltage input pin |
| /STDBY | 12 | Standby input pin (active low) to disable the audio amplifier |
| T1 | 1 | Independent output audio channel 1 |
| D2 | 3 | Common input audio channel 2 |
| SL2 | 4 | Select input pin for D2 to T2 (active high) |
| OUT+ | 5 | Positive differential audio output |
| GNDA | 7 | Audio amplifier input ground |
| OUT- | 8 | Negative differential audio output |
| T2 | 9 | Independent output audio channel 2 |
| GNDS | 10 | Analog switch input ground |
| SL1 | 11 | Select input pin for D1 to T1 (active !iigh) |
| D1 | 13 | Common input audio chancel : |
| NC | 14 | No internal connection |
| IN- | 15 | Audio negative ciffcrential input |
| IN+ | 16 | Audio p sitive differential input |
| E-Pad | - | Exposed pad (should be connected to GND) |
| .0 | oducil | |

2 Electrical characteristics

2.1 Audio amplifier section

Table 7. Electrical characteristics at V_{CC} = +4.3 V with GND = 0 V, V_{icm} = 2.1 V and T_{amb} = 25° C (unless otherwise specified)⁽¹⁾

| | Symbol | Parameter | Min. | Тур. | Max. | Unit |
|--------|-------------------|---|--------------------------|---------------------------|---------------------------------|------|
| | I _{CC} | Supply current No input signal, no load | | 2.1 | 3 | mA |
| | I _{STBY} | Standby current ⁽²⁾ No input signal, V _{STBY} = GND | | 10 | 1000 | rΑ |
| | V _{oo} | Output offset voltage No input signal, $R_L = 8\Omega$ | | 3 | 25 | mV |
| | P _{out} | Output power, G=6dB THD = 1% Max, f = 1kHz, $R_L = 4\Omega$ THD = 10% Max, f = 1kHz, $R_L = 4\Omega$ THD = 1% Max, f = 1kHz, $R_L = 8\Omega$ THD = 10% Max, f = 1kHz, $R_L = 8\Omega$ | P | 1.5 1.95 0.9 1.1 | | W |
| | THD + N | Total harmonic distortion + noise $P_{out} = 600 \text{ mW}_{RMS}, G = 60\%, 20\% \text{Hz} < f < 20\text{kHz}$ $R_L = 8\Omega + 15\mu\text{H}, BW < 30\text{kHz}$ $P_{out} = 700\text{mW}_{RMS}, G = 3\text{dB}, f = 1\text{kHz}$ $R_L = 8\Omega + 15\mu\text{H}, BW < 30\text{kHz}$ | | 2 0.35 | | % |
| | Efficiency | Efficiency $P_{out} = 1.45 \text{ W}_{RMS}, R_L = 4\Omega + \geq 15 \mu H$ $P_{NL} = 0.9 \text{ W}_{RMS}, R_L = 8\Omega + \geq 15 \mu H$ | | 78 88 | | % |
| | PSR.? | Power supply rejection ratio with inputs grounded $^{(3)}$ f = 217Hz, R _L = 8 Ω , G=6dB, V_{ripple} = 200m V_{pp} | | 63 | | dB |
| Obsole | CMRR | Common mode rejection ratio $f = 217Hz$, $R_L = 8\Omega$, $G = 6dB$, $\Delta Vic = 200mV_{pp}$ | | 57 | | dB |
| Opso | Gain | Gain value (R _{in} in kΩ) | 273kΩ R _{in} | 300kΩ R _{in} | <u>327kΩ</u> R _{in} | V/V |
| | R _{STBY} | Internal resistance from standby to GND | 273 | 300 | 327 | kΩ |
| | F _{PWM} | Pulse width modulator base frequency | | 280 | | kHz |
| | SNR | Signal to noise ratio (A-weighting) $P_{out} = 0.8W, R_L = 8\Omega$ | | 85 | | dB |
| | t _{WU} | Wake-up time | | 5 | 10 | ms |
| | t _{STBY} | Standby time | | 5 | 10 | ms |

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Table 7. Electrical characteristics at V_{CC} = +4.3 V with GND = 0 V, V_{icm} = 2.1 V and T_{amb} = 25° C (unless otherwise specified)⁽¹⁾ (continued)

| Symbol | Parameter | Min. | Тур. | Max. | Unit |
|----------------|---|------|----------------|------|--------------------|
| | Output voltage noise f = 20Hz to 20kHz, G = 6dB | | | | |
| | Unweighted $R_L = 4\Omega$ A-weighted $R_L = 4\Omega$ | | 85 60 | | |
| | Unweighted $R_L = 8\Omega$ A-weighted $R_L = 8\Omega$ | | 86 62 | | |
| | Unweighted $R_L = 4\Omega + 15\mu H$ A-weighted $R_L = 4\Omega + 15\mu H$ | | 83 60 | | |
| V _N | Unweighted R _L = 4Ω + 30μ H A-weighted R _L = 4Ω + 30μ H | | 88 64 | 1/2 | μν' _{RMS} |
| | Unweighted $R_L = 8\Omega + 30\mu H$ A-weighted $R_L = 8\Omega + 30\mu H$ | | 78 57 | 700 | |
| | Unweighted $R_L = 4\Omega + Filter$ A-weighted $R_L = 4\Omega + Filter$ Unweighted $R_L = 4\Omega + Filter$ | Pr | 37 65 82 | | |
| | A-weighted $R_L = 4\Omega + \text{Filter}$ | | 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*log(rms(V_{out}, 'rms V_{ripple})). V_{ripple} is the superimposed sinusoidal signal to V_{CC} at f = 217 Hz.

Table 8. Electrical characteristics at V_{CC} = +3.6 V with GND = 0 V, V_{icm} = 1.8 V, T_{amb} = 25° C (unless otherwise specified)⁽¹⁾

| Parameter | Min. | Тур. | Max. | Unit |
|--|---|---|---|---|
| Supply current No input signal, no load | | 2 | 2.8 | mA |
| Standby current ⁽²⁾ No input signal, V _{STBY} = GND | | 10 | 1000 | nA |
| Output offset voltage No input signal, $R_L = 8\Omega$ | | 3 | 25 | mV |
| Output power, G=6dB THD = 1% Max, f = 1kHz, $R_L = 4\Omega$ THD = 10% Max, f = 1kHz, $R_L = 4\Omega$ THD = 1% Max, f = 1kHz, $R_L = 8\Omega$ THD = 10% Max, f = 1kHz, $R_L = 8\Omega$ | | 1.1 1.4 0.7 0.85 | cil | Sw |
| Total harmonic distortion + noise $P_{out} = 450 \text{ mW}_{RMS}, G = 6\text{dB}, 20\text{Hz} < f < 20\text{kHz}$ $R_L = 8\Omega + 15\mu\text{H}, BW < 30\text{kHz}$ $P_{out} = 500\text{mW}_{RMS}, G = 6\text{dB}, f = 1\text{kHz}$ $R_L = 8\Omega + 15\mu\text{H}, BW < 30\text{kHz}$ | P | 2 0.1 | | % |
| Efficiency $P_{out} = 1 \text{ W}_{RMS}, R_L = 4\Omega + \geq 15\mu \text{ h}$ $P_{out} = 0.65 \text{ W}_{RMS}, R_L = 8\Omega + \geq 15\mu \text{H}$ | | 78 88 | | % |
| Power supply rejection ratio with inputs grounded $^{(3)}$ f = 217Hz, R _L = Ω G =6dB, V_{ripple} = 200m V_{pp} | | 62 | | dB |
| Common racde rejection ratio $f = 217 r^{1}z, \; f_{1}L = 8\Omega, \;\; G = 6dB, \; \Delta Vic = 200 mV_{pp}$ | | 56 | | dB |
| Gaırı value (R _{in} in kΩ) | 273kΩ R _{in} | <u>300kΩ</u> R _{in} | <u>327kΩ</u> R _{in} | V/V |
| Internal resistance from standby to GND | 273 | 300 | 327 | kΩ |
| Pulse width modulator base frequency | | 280 | | kHz |
| Signal to noise ratio (A-weighting) $P_{out} = 0.6W, R_L = 8\Omega$ | | 83 | | dB |
| Wake-up time | | 5 | 10 | ms |
| Standby time | | 5 | 10 | ms |
| 1 | Supply current No input signal, no load Standby current (2) No input signal, $V_{STBY} = GND$ Output offset voltage No input signal, $R_L = 8\Omega$ Output power, $G=6dB$ THD = 1% Max, $f=1kHz$, $R_L = 4\Omega$ THD = 10% Max, $f=1kHz$, $R_L = 4\Omega$ THD = 1% Max, $f=1kHz$, $R_L = 8\Omega$ THD = 10% Max, $f=1kHz$, $R_L = 8\Omega$ THD = 10% Max, $f=1kHz$, $R_L = 8\Omega$ THD = 10% Max, $f=1kHz$, $R_L = 8\Omega$ Total harmonic distortion + noise $P_{out} = 450 \text{ mW}_{RMS}$, $G=6dB$, $20Hz < f < 20kHz$ $R_L = 8\Omega + 15\mu H$, $BW < 30kHz$ $P_{out} = 500mW_{RMS}$, $G=6dB$, $f=1kHz$ $R_L = 8\Omega + 15\mu H$, $BW < 30kHz$ Efficiency $P_{out} = 1 \text{ W}_{RMS}$, $R_L = 4\Omega + \geq 15\mu H$ Power supply rejection ratio with inputs grounded (3) $f=217Hz$, $R_L = \Omega$ $G=6dB$, $V_{ripple} = 200mV_{pp}$ Common rac de rejection ratio $f=217Hz$, $f=212Hz$, $f=312Hz$ $f=$ | Supply current No input signal, no load $Standby \ current \ ^{(2)} \ No \ input \ signal, \ V_{STBY} = GND$ Output offset voltage No input signal, $R_L = 8\Omega$ Output power, $G=6dB$ $THD = 1\% \ Max, \ f = 1kHz, \ R_L = 4\Omega$ $THD = 10\% \ Max, \ f = 1kHz, \ R_L = 8\Omega$ $THD = 10\% \ Max, \ f = 1kHz, \ R_L = 8\Omega$ $THD = 10\% \ Max, \ f = 1kHz, \ R_L = 8\Omega$ $THD = 10\% \ Max, \ f = 1kHz, \ R_L = 8\Omega$ $Total \ harmonic \ distortion + noise$ $P_{out} = 450 \ mW_{RMS}, \ G = 6dB, \ 20Hz < f < 20kHz$ $R_L = 8\Omega + 15\mu H, \ BW < 30kHz$ $P_{out} = 500mW_{RMS}, \ G = 6dB, \ f = 1kHz$ $R_L = 8\Omega + 15\mu H, \ BW < 30kHz$ $P_{out} = 10.65 \ W_{RMS}, \ R_L = 8\Omega + 2.15\mu H$ $Power \ supply \ rejection \ ratio \ with inputs \ grounded \ ^{(3)}$ $f = 217Hz, \ R_L = 8\Omega \ G = 6dB, \ V_{ripple} = 200mV_{pp}$ Common \text{race } \text{de } \text{rejection ratio} \text{ f } \text{ common race } \text{de } \text{ rejection ratio} \text{ f } \text{ common race } \text{ de } \text{ rejection ratio} \text{ f } \text{ common race } \text{ Re } \text{ common race } \text{ Re } \text{ common race } \text{ rejection ratio} \text{ f } \text{ common race } \text{ Re } \text{ common race } \text{ rejection ratio} \text{ f } \text{ common race } \text{ Re } \text{ common race } \text{ rejection ratio} \text{ f } \text{ common race } \text{ rejection ratio} \text{ f } \text{ common race } \text{ Re } \text{ rejection ratio} \text{ rejection ratio} \text{ f } \text{ common race } \text{ rejection ratio} rejection | Supply current No input signal, no load | $\begin{array}{c ccccccccccccccccccccccccccccccccccc$ |

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Table 8. Electrical characteristics at $V_{CC} = +3.6 \text{ V}$ with GND = 0 V, $V_{icm} = 1.8 \text{ V}$, $T_{amb} = 25^{\circ} \text{ C}$ (unless otherwise specified)⁽¹⁾ (continued)

| Symbol | Parameter | Min. | Тур. | Max. | Unit |
|----------------|--|------|----------------|------|--------------------|
| | Output voltage noise f = 20Hz to 20kHz, G = 6dB | | | | |
| | Unweighted R $_{L}$ = 4Ω A-weighted R $_{L}$ = 4Ω | | 83 57 | | |
| | Unweighted $R_L = 8\Omega$ A-weighted $R_L = 8\Omega$ | | 83 61 | | |
| | Unweighted R _L = 4Ω + 15μ H A-weighted R _L = 4Ω + 15μ H | | 81 58 | | |
| V _N | Unweighted R _L = 4Ω + 30μ H A-weighted R _L = 4Ω + 30μ H | | 87 62 | 1/3 | μν' _{RMS} |
| | Unweighted R _L = 8Ω + 30μ H A-weighted R _L = 8Ω + 30μ H | | 77 56 | Cer | |
| | Unweighted $R_L=4\Omega+$ Filter A-weighted $R_L=4\Omega+$ Filter Unweighted $R_L=4\Omega+$ Filter | PI | პ5 63 80 | | |
| | A-weighted $R_L = 4\Omega + \text{Filter}$ | | 57 | | |

- 1. All electrical values are guaranteed with correlation measurements at 2.5 V and 5 V.
- 2. Standby mode is activated when V_{STBY} is tied to Gi 'D.
- 3. Dynamic measurements 20*log(rms(V_{out}, 'rms V_{ripple})). V_{ripple} is the superimposed sinusoidal signal to V_{CC} at f = 217 Hz.

Table 9. Electrical characteristics at V_{CC} = +3.0 V with GND = 0 V, V_{icm} = 1.5 V, T_{amb} = 25° C (unless otherwise specified)⁽¹⁾

| S | Symbol | Parameter | Min. | Тур. | Max. | Unit |
|------|-------------------|--|-----------------------------|--------------------------|---------------------------------|------|
| | I _{CC} | Supply current No input signal, no load | | 1.9 | 2.7 | mA |
| | I _{STBY} | Standby current ⁽²⁾ 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 THD = 1% Max, f = 1kHz, $R_L = 4\Omega$ THD = 10% Max, f = 1kHz, $R_L = 4\Omega$ THD = 1% Max, f = 1kHz, $R_L = 8\Omega$ THD = 10% Max, f = 1kHz, $R_L = 8\Omega$ | | 0.7 1 0.5 0.3 | cil | Sw |
| Т | ⁻HD + N | Total harmonic distortion + noise $P_{out} = 300 \text{ mW}_{RMS}, G = 6\text{dB}, 20\text{Hz} < f < 20\text{kHz}$ $R_L = 8\Omega + 15\mu\text{H}, \text{BW} < 30\text{kHz}$ $P_{out} = 350\text{mW}_{RMS}, G = 6\text{dB}, f = 1\text{kHz}$ $R_L = 8\Omega + 15\mu\text{H}, \text{BW} < 30\text{kHz}$ | Pr | 2 0.1 | | % |
| E | fficiency | Efficiency $P_{out} = 0.7 \text{ W}_{RMS}, R_L = 4\Omega + \geq 15\mu \text{ h}$ $P_{out} = 0.45 \text{ W}_{RMS}, R_L = 8\Omega + \geq 15\mu \text{ H}$ | | 78 88 | | % |
| | PSRR | Power supply rejection ratio with inputs grounded $^{(3)}$ f = 217Hz, R _L = 1 1 1 2 2 3 4 4 5 5 5 6 5 6 6 6 7 | | 60 | | dB |
| | CMRR | Common incide rejection ratio $f = 2^{17} \cdot ^{12} \cdot ^{1} $ | | 54 | | dB |
| | Gai | Gaın value (R _{in} in kΩ) | $\frac{273k\Omega}{R_{in}}$ | 300kΩ R _{in} | <u>327kΩ</u> R _{in} | V/V |
| K | S'BY | Internal resistance from standby to GND | 273 | 300 | 327 | kΩ |
| 76 | F _{PWM} | Pulse width modulator base frequency | | 280 | | kHz |
|)SO. | SNR | Signal to noise ratio (A-weighting) $P_{out} = 0.4W, \ R_L = 8\Omega$ | | 82 | | dB |
| | t _{WU} | Wake-up time | | 5 | 10 | ms |
| | t _{STBY} | Standby time | | 5 | 10 | ms |

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Table 9. Electrical characteristics at V_{CC} = +3.0 V with GND = 0 V, V_{icm} = 1.5 V, T_{amb} = 25° C (unless otherwise specified)⁽¹⁾ (continued)

| Symbol | Parameter | Min. | Тур. | Max. | Unit |
|----------------|---|------|----------------|------|--------------------|
| | Output voltage noise f = 20Hz to 20kHz, G = 6dB | | | | |
| | Unweighted R $_{\rm L}$ = 4Ω A-weighted R $_{\rm L}$ = 4Ω | | 83 57 | | |
| | Unweighted $R_L=8\Omega$ A-weighted $R_L=8\Omega$ | | 83 61 | | |
| | Unweighted R _L = 4Ω + 15μ H A-weighted R _L = 4Ω + 15μ H | | 81 58 | | |
| V _N | Unweighted R _L = 4Ω + 30μ H A-weighted R _L = 4Ω + 30μ H | | 87 62 | | μ./ _{RMS} |
| | Unweighted R _L = 8Ω + 30μ H A-weighted R _L = 8Ω + 30μ H | | 77 56 | YO. | |
| | Unweighted $R_L = 4\Omega + Filter$ A-weighted $R_L = 4\Omega + Filter$ Unweighted $R_L = 4\Omega + Filter$ | PI | 85 63 80 | | |
| | A-weighted $R_L = 4\Omega + Filter$ | | 57 | | |

- 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*log(rms(V_{out}, 'rms V_{ripple})). V_{ripple} is the superimposed sinusoidal signal to V_{CC} at f = 217 Hz.

Table 10. Electrical characteristics at V_{CC} = +2.5 V with GND = 0 V, V_{icm} = 1.25 V, T_{amb} = 25° C (unless otherwise specified)

| Parameter | Min. | Тур. | Max. | Unit |
|--|--|---|--|---|
| Supply current No input signal, no load | | 1.7 | 2.4 | mA |
| Standby current ⁽¹⁾ No input signal, V _{STBY} = GND | | 10 | 1000 | nA |
| Output offset voltage No input signal, $R_L = 8\Omega$ | | 3 | 25 | mV |
| Output power, G=6dB THD = 1% Max, f = 1kHz, $R_L = 4\Omega$ THD = 10% Max, f = 1kHz, $R_L = 4\Omega$ THD = 1% Max, f = 1kHz, $R_L = 8\Omega$ THD = 10% Max, f = 1kHz, $R_L = 8\Omega$ | | 0.5 0.65 0.33 0.4 |)Cil | Sw |
| Total harmonic distortion + noise $P_{out} = 180 \text{ mW}_{RMS}, G = 6\text{dB}, 20\text{Hz} < f < 20\text{kHz}$ $R_L = 8\Omega + 15\mu\text{H}, BW < 30\text{kHz}$ $P_{out} = 200\text{mW}_{RMS}, G = 6\text{dB}, f = 1\text{kHz}$ $R_L = 8\Omega + 15\mu\text{H}, BW < 30\text{kHz}$ | P | 1 0.05 | | % |
| Efficiency $P_{out} = 0.47 \text{ W}_{RMS}, R_L = 4\Omega + \ge 15 \mu H$ $P_{out} = 0.3 \text{ W}_{RMS}, R_L = 8\Omega + \ge 15 \mu H$ | | 78 88 | | % |
| Power supply rejection ratio with inputs grounded $^{(2)}$ f = 217Hz, R _L = Ω G =6dB, V_{ripple} = 200m V_{pp} | | 60 | | dB |
| Common race rejection ratio $f = 2171^{12}, \text{ fi}_{L} = 8\Omega, G = 6\text{dB}, \ \Delta V_{ic} = 200\text{mV}_{pp}$ | | 54 | | dB |
| Gaιπ value (R _{in} in kΩ) | 273kΩ R _{in} | <u>300kΩ</u> R _{in} | <u>327kΩ</u> R _{in} | V/V |
| Internal resistance from standby to GND | 273 | 300 | 327 | kΩ |
| Pulse width modulator base frequency | | 280 | | kHz |
| Signal to noise ratio (A-weighting) $P_{out} = 0.3W, R_L = 8\Omega$ | | 80 | | dB |
| Wake-up time | | 5 | 10 | ms |
| Standby time | | 5 | 10 | ms |
| | No input signal, no load Standby current (1) No input signal, $V_{STBY} = GND$ Output offset voltage No input signal, $R_L = 8\Omega$ Output power, $G=6dB$ $THD = 1\%$ Max, $f = 1kHz$, $R_L = 4\Omega$ $THD = 10\%$ Max, $f = 1kHz$, $R_L = 4\Omega$ $THD = 10\%$ Max, $f = 1kHz$, $R_L = 8\Omega$ $THD = 10\%$ Max, $f = 1kHz$, $R_L = 8\Omega$ $THD = 10\%$ Max, $f = 1kHz$, $R_L = 8\Omega$ Total harmonic distortion + noise $P_{out} = 180 \text{ mW}_{RMS}$, $G = 6dB$, $20Hz < f < 20kHz$ $R_L = 8\Omega + 15\mu H$, $BW < 30kHz$ $P_{out} = 200mW_{RMS}$, $G = 6dB$, $f = 1kHz$ $R_L = 8\Omega + 15\mu H$, $BW < 30kHz$ Efficiency $P_{out} = 0.47 \text{ W}_{RMS}$, $R_L = 4\Omega + 2 + 5\mu H$ Power supply rejection ratio with inputs grounded (2) $f = 217Hz$, $R_L = 8\Omega$, $G = 6dB$, $V_{ripple} = 200mV_{pp}$ Common red de rejection ratio $f = 217 + 2 + 3 + 3 + 3 + 3 + 3 + 3 + 3 + 3 + 3$ | No input signal, no load Standby current (1) No input signal, $V_{STBY} = GND$ Output offset voltage No input signal, $R_L = 8\Omega$ Output power, $G=6dB$ $THD = 1\%$ Max, $f = 1kHz$, $R_L = 4\Omega$ $THD = 10\%$ Max, $f = 1kHz$, $R_L = 4\Omega$ $THD = 1\%$ Max, $f = 1kHz$, $R_L = 8\Omega$ Thus $R_L = 8\Omega$ Total harmonic distortion + noise $R_L = 8\Omega + 15\mu H$, $R_L = 8\Omega + 15\mu H$ Power supply rejection ratio with inputs grounded (2) $R_L = 217Hz$, $R_L = 2\Omega + 2\Omega + 215\mu H$ Power supply rejection ratio with inputs grounded (2) $R_L = 217Hz$, $R_L = 8\Omega + 2\Omega + 215\mu H$ Power supply rejection ratio $R_L = R_L + R_L +$ | No input signal, no load $ \begin{array}{c} 1.7 \\ \text{Standby current} \ ^{(1)} \\ \text{No input signal, V}_{\text{STBY}} = \text{GND} \\ \\ \text{Output offset voltage} \\ \text{No input signal, R}_{L} = 8\Omega \\ \\ \\ \text{Output power, G=6dB} \\ \text{THD} = 1\% \text{ Max, f} = 1\text{kHz, R}_{L} = 4\Omega \\ \text{THD} = 1\% \text{ Max, f} = 1\text{kHz, R}_{L} = 8\Omega \\ \\ \text{THD} = 1\% \text{ Max, f} = 1\text{kHz, R}_{L} = 8\Omega \\ \text{THD} = 1\% \text{ Max, f} = 1\text{kHz, R}_{L} = 8\Omega \\ \\ \text{THD} = 10\% \text{ Max, f} = 1\text{kHz, R}_{L} = 8\Omega \\ \\ \text{THD} = 10\% \text{ Max, f} = 1\text{kHz, R}_{L} = 8\Omega \\ \\ \text{Total harmonic distortion + noise} \\ \text{Pout} = 180 \text{ mW}_{\text{RMS}}, \text{G} = 6\text{dB, 20Hz} < \text{f} < 20\text{kHz} \\ \\ \text{R}_{L} = 8\Omega + 15\mu\text{H, BW} < 30\text{kHz} \\ \\ \text{Pout} = 200\text{mW}_{\text{RMS}}, \text{G} = 6\text{dB, f} = 1\text{kHz} \\ \\ \text{R}_{L} = 8\Omega + 15\mu\text{H, BW} < 30\text{kHz} \\ \\ \text{Pout} = 0.3 \text{ W}_{\text{RMS}}, \text{R}_{L} = 4\Omega + 2 + 2 + 5\mu\text{H} \\ \\ \text{Power supply rejection ratio with inputs grounded} \ ^{(2)} \\ \\ \text{f} = 217\text{Hz, R}_{L} = 8\Omega \text{ G} = 6\text{dB, } \text{V}_{\text{ripple}} = 200\text{mV}_{\text{pp}} \\ \\ \text{Common racede rejection ratio} \\ \\ \text{f} = 217\text{Hz, R}_{L} = 8\Omega \text{ G} = 6\text{dB, } \Delta\text{V}_{\text{ic}} = 200\text{mV}_{\text{pp}} \\ \\ \text{Gain value} \ (\text{R}_{\text{in}} \text{ in k}\Omega) \\ \\ \text{Pulse width modulator base frequency} \\ \\ \text{Signal to noise ratio (A-weighting)} \\ \\ \\ \text{Pout} = 0.3\text{W, R}_{L} = 8\Omega \\ \\ \text{Wake-up time} \\ \\ \\ \text{5} \\ \\ \text{Signal to noise ratio (A-weighting)} \\ \\ \text{Pout} = 0.3\text{W, R}_{L} = 8\Omega \\ \\ \text{Wake-up time} \\ \\ \\ \text{5} \\ \\ \text{10} \\ \\ $ | No input signal, no load $ \begin{array}{c} 1.7 & 2.4 \\ \text{Standby current } (1) \\ \text{No input signal, V}_{STBY} = \text{GND} \\ \\ \text{Output offset voltage} \\ \text{No input signal, R}_L = 8\Omega \\ \\ \text{Output power, G=6dB} \\ \text{THD} = 10\% \text{ Max, f} = 1\text{kHz, R}_L = 4\Omega \\ \text{THD} = 10\% \text{ Max, f} = 1\text{kHz, R}_L = 8\Omega \\ \text{THD} = 10\% \text{ Max, f} = 1\text{kHz, R}_L = 8\Omega \\ \text{THD} = 10\% \text{ Max, f} = 1\text{kHz, R}_L = 8\Omega \\ \text{THD} = 10\% \text{ Max, f} = 1\text{kHz, R}_L = 8\Omega \\ \text{THD} = 10\% \text{ Max, f} = 1\text{kHz, R}_L = 8\Omega \\ \text{THD} = 10\% \text{ Max, f} = 1\text{kHz, R}_L = 8\Omega \\ \text{THD} = 10\% \text{ Max, f} = 1\text{kHz, R}_L = 8\Omega \\ \text{THD} = 10\% \text{ Max, f} = 1\text{kHz, R}_L = 8\Omega \\ \text{THD} = 10\% \text{ Max, f} = 1\text{kHz, R}_L = 8\Omega \\ \text{THD} = 10\% \text{ Max, f} = 1\text{kHz, R}_L = 8\Omega \\ \text{THD} = 10\% \text{ Max, f} = 1\text{kHz, R}_L = 8\Omega \\ \text{THD} = 10\% \text{ Max, f} = 1\text{kHz, R}_L = 8\Omega \\ \text{THD} = 10\% \text{ Max, f} = 1\text{kHz, R}_L = 8\Omega \\ \text{THD} = 10\% \text{ Max, f} = 1\text{kHz, R}_L = 8\Omega \\ \text{THD} = 10\% \text{ Max, f} = 1\text{kHz, R}_L = 8\Omega \\ \text{THD} = 10\% \text{ Max, f} = 1\text{kHz, R}_L = 8\Omega \\ \text{THD} = 10\% \text{ Max, f} = 1\text{kHz, R}_L = 8\Omega \\ \text{THD} = 10\% \text{ Max, f} = 1\text{kHz, R}_L = 8\Omega \\ \text{THD} = 10\% \text{ Max, f} = 1\text{kHz, R}_L = 8\Omega \\ \text{THD} = 10\% \text{ Max, f} = 1\text{kHz, R}_L = 8\Omega \\ \text{THD} = 10\% \text{ Max, f} = 1\text{kHz, R}_L = 8\Omega \\ \text{THD} = 10\% \text{ Max, f} = 1\text{kHz, R}_L = 8\Omega \\ \text{THD} = 10\% \text{ Max, f} = 1\text{kHz, R}_L = 8\Omega \\ \text{THD} = 10\% \text{ Max, f} = 1\text{kHz, R}_L = 8\Omega \\ \text{THD} = 10\% \text{ Max, f} = 1\text{kHz, R}_L = 8\Omega \\ \text{THD} = 10\% \text{ Max, f} = 1\text{kHz, R}_L = 8\Omega \\ \text{THD} = 10\% \text{ Max, f} = 1\text{kHz, R}_L = 8\Omega \\ \text{THD} = 10\% \text{ Max, f} = 1\text{kHz, R}_L = 8\Omega \\ \text{THD} = 10\% \text{ Max, f} = 1\text{kHz, R}_L = 8\Omega \\ \text{THD} = 10\% \text{ Max, f} = 1\text{kHz, R}_L = 8\Omega \\ \text{THD} = 10\% \text{ Max, f} = 1\text{kHz, R}_L = 8\Omega \\ \text{THD} = 10\% \text{ Max, f} = 1\text{kHz, R}_L = 8\Omega \\ \text{THD} = 10\% \text{ Max, f} = 1\text{kHz, R}_L = 8\Omega \\ \text{THD} = 10\% \text{ Max, f} = 1\text{kHz, R}_L = 8\Omega \\ \text{THD} = 10\% \text{ Max, f} = 1\text{kHz, R}_L = 8\Omega \\ \text{THD} = 10\% \text{ Max, f} = 1\text{kHz, R}_L = 10\% \\ \text{THD} = 10\% \text{ Max, f} = 1\text{kHz, R}_L = 10\% \\ \text{THD} = 10\% \text{ Max, f} = 1\text{kHz, R}_L = 10\% \\ \text{THD} = 10\% \text{ Max, f} = 1\text{kHz, R}_L = 10\% \\ TH$ |

TS4961T Electrical characteristics

Table 10. Electrical characteristics at V_{CC} = +2.5 V with GND = 0 V, V_{icm} = 1.25 V, T_{amb} = 25° C (unless otherwise specified) (continued)

| 0 | | | Max. | Unit |
|---|--|---|--|--|
| Output voltage noise f = 20Hz to 20kHz, G = 6dB | | | | |
| Unweighted $R_L=4\Omega$ A-weighted $R_L=4\Omega$ | | 85 60 | | |
| Unweighted $R_L=8\Omega$ A-weighted $R_L=8\Omega$ | | 86 62 | | |
| Unweighted R _L = 4Ω + 15μ H A-weighted R _L = 4Ω + 15μ H | | 76 56 | | |
| Unweighted R _L = 4Ω + 30μ H A-weighted R _L = 4Ω + 30μ H | | 82 60 | 1/2 | μν' _{RMS} |
| Unweighted R _L = 8Ω + 30μ H A-weighted R _L = 8Ω + 30μ H | | 67 53 | 7.Cr | |
| Unweighted $R_L = 4\Omega + Filter$ A-weighted $R_L = 4\Omega + Filter$ Unweighted $R_L = 4\Omega + Filter$ | PI | 78 57 74 | | |
| | Unweighted $R_L=4\Omega$ A-weighted $R_L=8\Omega$ Unweighted $R_L=8\Omega$ A-weighted $R_L=8\Omega$ Unweighted $R_L=4\Omega+15\mu H$ A-weighted $R_L=4\Omega+15\mu H$ Unweighted $R_L=4\Omega+30\mu H$ Unweighted $R_L=4\Omega+30\mu H$ Unweighted $R_L=8\Omega+30\mu H$ Unweighted $R_L=4\Omega+Filter$ A-weighted $R_L=4\Omega+Filter$ | Unweighted $R_L=4\Omega$ A-weighted $R_L=8\Omega$ Unweighted $R_L=8\Omega$ A-weighted $R_L=8\Omega$ Unweighted $R_L=8\Omega$ Unweighted $R_L=4\Omega+15\mu H$ A-weighted $R_L=4\Omega+30\mu H$ Unweighted $R_L=4\Omega+30\mu H$ Unweighted $R_L=8\Omega+30\mu H$ Unweighted $R_L=8\Omega+30\mu H$ Unweighted $R_L=8\Omega+30\mu H$ Unweighted $R_L=8\Omega+30\mu H$ Unweighted $R_L=4\Omega+Filter$ A-weighted $R_L=4\Omega+Filter$ Unweighted $R_L=4\Omega+Filter$ Unweighted $R_L=4\Omega+Filter$ Unweighted $R_L=4\Omega+Filter$ | Unweighted $R_L = 4\Omega$ 85 A-weighted $R_L = 4\Omega$ 86 Unweighted $R_L = 8\Omega$ 86 A-weighted $R_L = 8\Omega$ 62 Unweighted $R_L = 4\Omega + 15\mu H$ 76 A-weighted $R_L = 4\Omega + 15\mu H$ 56 Unweighted $R_L = 4\Omega + 30\mu H$ 82 A-weighted $R_L = 4\Omega + 30\mu H$ 60 Unweighted $R_L = 4\Omega + 30\mu H$ 67 Unweighted $R_L = 8\Omega + 30\mu H$ 67 A-weighted $R_L = 8\Omega + 30\mu H$ 53 Unweighted $R_L = 4\Omega + Filter$ 78 A-weighted $R_L = 4\Omega + Filter$ 57 Unweighted $R_L = 4\Omega + Filter$ 57 | $\begin{array}{llllllllllllllllllllllllllllllllllll$ |

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

^{2.} Dynamic measurements - 20*log(rms(V_{out})/rms('r_{fip le'})). V_{ripple} is the superimposed sinusoidal signal to V_{CC} at f = 217 Hz.

Table 11. Electrical characteristics at V_{CC} +2.4 V with GND = 0 V, V_{icm} = 1.2 V, T_{amb} = 25° C (unless otherwise specified)

| Symbol | Parameter | Min. | Тур. | Max. | Unit |
|-------------------|---|---------------------------------|-----------------------------|---------------------------------|------|
| I _{CC} | Supply current No input signal, no load | | 1.7 | | mA |
| I _{STBY} | Standby current ⁽¹⁾ 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 THD = 1% Max, f = 1kHz, $R_L = 4\Omega$ THD = 10% Max, f = 1kHz, $R_L = 4\Omega$ THD = 1% Max, f = 1kHz, $R_L = 8\Omega$ THD = 10% Max, f = 1kHz, $R_L = 8\Omega$ | | 0.42 0.61 0.3 0.33 | octl | Sw' |
| THD + N | Total harmonic distortion + noise $P_{out} = 150 \text{ mW}_{RMS}, G = 6\text{dB}, 20\text{Hz} < f < 20\text{kHz}$ $R_L = 8\Omega + 15\mu\text{H}, BW < 30\text{kHz}$ | P | 0 | | % |
| Efficiency | Efficiency $P_{out} = 0.38 \; W_{RMS}, \; R_L = 4\Omega + \geq 15 \mu H$ $P_{out} = 0.25 \; W_{RMS}, \; R_L = 8\Omega + \geq 15 \mu' 1$ | | 77 86 | | % |
| CMRR | Common mode rejection ratio $f = 217Hz$, $R_L = 8\Omega$, $G = 6dE$, $\Delta V_{ic} = 200mV_{pp}$ | | 54 | | dB |
| Gain | Gain value (R _{in} ir κO) | <u>273kΩ</u> R _{in} | 300kΩ R _{in} | <u>327kΩ</u> R _{in} | V/V |
| R _{STBY} | Internal recistance from standby to GND | 273 | 300 | 327 | kΩ |
| F _{PWM} | Pulce vidth modulator base frequency | | 280 | | kHz |
| SNR | Signal to noise ratio (A-weighting) $P_{out} = 0.25W, R_L = 8\Omega$ | | 80 | | dB |
| † _{WU} | Wake-up time | | 5 | | ms |
| t _{STBY} | Standby time | | 5 | | ms |

TS4961T **Electrical characteristics**

Electrical characteristics at V_{CC} +2.4 V with GND = 0 V, V_{icm} = 1.2 V, T_{amb} = 25° C (unless otherwise specified) (continued) Table 11.

| | Parameter | Min. | Тур. | Max. | Unit |
|----------------|--|------|----------|------------------|----------|
| | Output voltage noise f = 20Hz to 20kHz, G = 6dB | | | | |
| | Unweighted $R_L = 4\Omega$ | | 85 | | |
| | A-weighted $R_L = 4\Omega$ Unweighted $R_L = 8\Omega$ | | 60 86 | | |
| | A-weighted $H_L = 8\Omega$ | | 62 | | |
| | Unweighted R _L = 4Ω + 15 μ H A-weighted R _L = 4Ω + 15 μ H | | 76 56 | | |
| V _N | Unweighted R _L = 4Ω + 30μ H A-weighted R _L = 4Ω + 30μ H | | 82 60 | * | ans, and |
| | Unweighted $R_L = 8\Omega + 30\mu H$ | | 67 | $^{\prime}C_{r}$ | |
| | A-weighted $R_L = 8\Omega + 30\mu H$ Unweighted $R_L = 4\Omega + Filter$ | 0 1 | 53 78 | | |
| | A-weighted $H_L = 4\Omega + \text{Filter}$ | (8) | 57 | | |
| | Unweighted $R_L = 4\Omega + Filter$ A-weighted $R_L = 4\Omega + Filter$ | 3 | 74 54 | | |
| ate P' | oducile | | | | |

2.2 Analog switch section

Table 12. DC specifications

| | | | | Value | | | | - | | |
|---------------------|---|---------------------|---|-----------------|--------------------------|-------|------|-------|-------|--|
| Symbol | Parameter | V _{CC} (V) | Test conditions | T _{an} | T _{amb} = 25 °C | | Unit | | | |
| | | | | Min | Тур | Max | Min | Max | | |
| | | 2.5 | | 1.2 | | | 1.2 | | | |
| V | High level input voltage | 2.7 –3.0 | | 1.3 | | | 1.3 | | V | |
| V _{IH} | Trigit level iriput voltage | 3.3 –3.6 | | 1.4 | | | 1.4 | | V | |
| | | 4.3 | | 1.5 | | | 1.5 | 10 | | |
| | | 2.5 | | | | 0.25 | | ી.∠ે5 | , | |
| V _{IL} | Low level input voltage | 2.7 –3.0 | | | | 0.25 | | 0.25 | V | |
| V IL | Zow ioto: input tollage | 3.3 –3.6 | | | | 0.30 |). | 0.30 | V | |
| | | 4.3 | | | | 0.40 | | 0.40 | | |
| | S _{PEAK} , Switch T _n ON resistance | 4.3 | | X | 1.10 | 1.3 | | 1.5 | | |
| R _{PEAK} , | | 3.6 | $V_S = 0 V \text{ to } V_{CC}$ | | 1.15 | 1.4 | | 1.6 | Ω | |
| Tn | | 3.0 | I _S = 100 mA | | 1.25 | 1.5 | | 1.8 | 22 | |
| | | 2.7 | Oh, | | 1.35 | 1.6 | | 1.9 | | |
| | | 4.3 | | | 10 | | | | | |
| ΔR _{ON,} | ON resistance match | 3.6 | ν _S at R _{PEAK} | | 14 | | | | mΩ | |
| Tn | between Tn channels ⁽¹⁾ | 3.1 | I _S = 100 mA | | 14 | | | | 11122 | |
| | <u> </u> | 2.7 | | | 15 | | | | | |
| | 2100 | 4.3 | | | 0.45 | 0.50 | | 0.55 | | |
| R _{FLAT,} | ON resistar ce flatness | 3.6 | $V_S = 0$ to V_{CC} | | 0.45 | 0.50 | | 0.55 | δ | |
| Tn | for [™] ก channels ⁽²⁾ | 3.0 | I _S = 100 mA | | 0.50 | 0.55 | | 0.60 | 22 | |
| | | 2.7 | | | 0.55 | 0.60 | | 0.70 | | |
| OFF | OFF state leakage current (Tn), (Dn) | 4.3 | V _S = 0.3 or 4 V | | | ±0.1 | | ±1 | μΑ | |
| I _{SEL} | SEL leakage current | 0 -4.3 | V _{SEL} = 0 to 4.3 V | | | ±0.05 | | ±1 | μΑ | |
| I _{CC} | Quiescent supply current | 2.4 –4.3 | V _{SEL} = V _{CC} or GND | | | ±0.05 | | ±0.2 | μΑ | |
| | Quiescent supply | | V _{SEL} = 1.65 V | | ±37 | ±50 | | ±100 | | |
| I _{CCLV} | current low voltage | 4.3 | V _{SEL} = 1.80 V | | ±33 | ±40 | | ±50 | μΑ | |
| | driving | | V _{SEL} = 2.60 V | | ±12 | ±20 | | ±30 | | |
| | | | | | | | | | | |

^{1.} $\Delta R_{ON} = R_{ON(max)} - R_{ON(min)}$.

^{2.} Flatness is defined as the difference between the maximum and minimum value of on-resistance as measured over the specified analog signal ranges.

Table 13. AC electrical characteristics (C_L = 35 pF, R_L = 50 Ω , $t_r = t_f \le 5$ ns)

| | | | | | | Value | ! | | | |
|------------------------------------|-------------------|---------------------|--------------------------------------|-----|--------------------------|-------|---------------------------------------|-----|--------------|--|
| Symbol | Parameter | V _{CC} (V) | Test conditions | Tai | T _{amb} = 25 °C | | T _{amb} = 25 °C -40 to 85 °C | | -40 to 85 °C | |
| | | | | Min | Тур | Max | Min | Max | | |
| | | 2.5 —2.7 | | | 0.45 | | | | | |
| t _{PLH,} t _{PHL} | Propagation delay | 3.0 —3.3 | | | 0.30 | | | | ns | |
| | | 3.6 -4.3 | | | 0.30 | | | | | |
| | | 2.5 —2.7 | | | 65 | 85 | | 90 | | |
| t_{ON} | Turn-ON time | 3.0 -3.3 | V _S = 1.5 V | | 42 | 55 | | 65 | ns | |
| | | 3.6 -4.3 | | | 40 | 55 | | 65 | 51 | |
| | | 2.5 —2.7 | | | 18 | 30 | | 4) | | |
| t_{OFF} | Turn-OFF time | 3.0 —3.3 | V _S = 1.5 V | | 16 | 30 | 70, | 40 | ns | |
| | | 3.6 -4.3 | | | 15 | 3L | | 40 | | |
| | | 2.5 —2.7 | C _L = 100 pF | | 51 | | | | | |
| Q | Charge injection | 3.0 —3.3 | $R_L = 1 M\Omega$ $V_{GEN} = 0 V$ | 10 | 51 | | | | р(| |
| | | 3.6 -4.3 | $R_{GEN} = 0 \Omega$ | | 49 | | | | | |
| | lete Pro | (| 3) | | | | | | | |

Table 14. Analog switch characteristics (C_L = 5 pF, R_L = 50 Ω , T_{amb} = 25 °C)

| OIRH _{Tn} swift | Parameter isolation for tch T1,T2 | V _{CC} (V) | Test conditions $V_S{=}1\ V_{rms},$ $F{=}1\ MHz,$ $R_L = 50\ \Omega$ | T _{an} Min | Typ -80 | °C Max | -40 to Min | 85 °C Max | Ur |
|--------------------------|---|---------------------|--|------------------------|---------|-----------|---------------|--------------|-----|
| VtalkTn Cro | | 2.5 -4.3 | F=1 MHz, | Min | | Max | Min | Max | |
| VtalkTn Cro | | 2.5 —4.3 | F=1 MHz, | | -80 | | | | |
| VtalkTp Cro | tch T1,T2 | 2.5 —4.3 | | 1 | | | | | d |
| | | | $V_S=1 V_{rms}$, F = 10 MHz, $R_L = 50 \Omega$ | | -60 | | | | u |
| Λιαικ I I T1 : | esstalk between | 2.5 — 4.3 | V _S =1 V _{rms} , F = 1 MHz | | -85 | | | | o d |
| | and T2 | 2.5 — 4.5 | V _S =1 V _{rms} , F = 10 MHz | | -74 | | 9/ | | |
| | dB bandwidth for tch T1, T2 | 2.5 —4.3 | $R_L = 50 \Omega$ Signal = 0 dBm | | 58 | 5// | | | M |
| | ntrol pin input pacitance | | V _{CC} = 0 V | 16 | 9 | | | | р |
| C _{ON.Tn} whe | port capacitance en the switch is abled | 3.3 | F = 1 MH.2 | | 113 | | | | р |
| C _{OFF,Tn} whe | port capacitance en the switch is abled | | F:: 1 MHz | | 85 | | | | þ |

3 Electrical characteristics curves

3.1 Audio amplifier section

The graphs included in this section use the following abbreviations:

- $R_L + 15 \mu H$ or 30 μH = pure resistor + very low series resistance inductor.
- Filter = LC output filter (1 μ F+30 μ H for 4 Ω and 0.5 μ F+6 0 μ H for 8 Ω).
- All measurements done with $C_{s1} = 1 \mu F$ and $C_{s2} = 100 nF$ except for PSRR where C_{s1} is removed

Figure 1. Test diagram for audio amplifier measurements

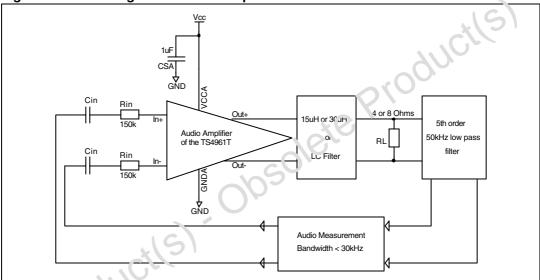


Figure 2. Test diagram for audio amplifier PSRR measurements

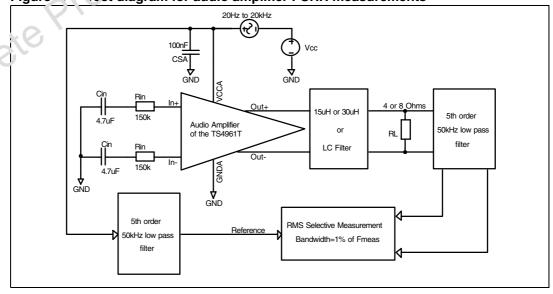


Figure 3. Current consumption vs. power supply voltage

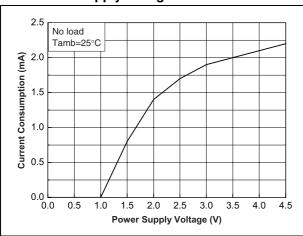


Figure 4. Current consumption vs. standby voltage

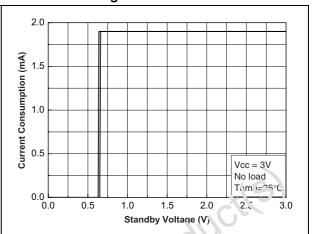


Figure 5. Output offset voltage vs. common mode input voltage

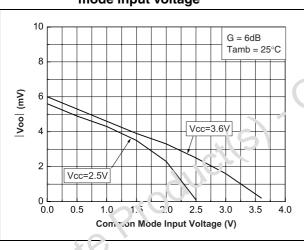


Figure 6. Efficiency vs. output power

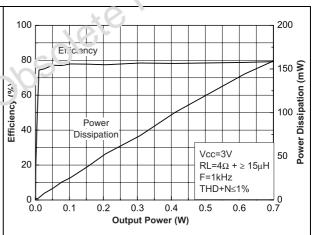
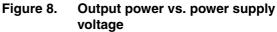
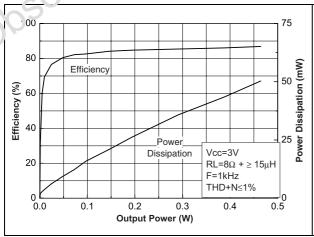


Figure 7. Efficiency vs. output power





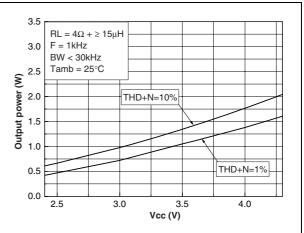
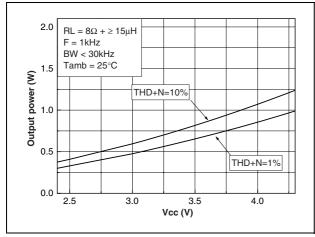


Figure 9. Output power vs. power supply voltage

Figure 10. PSSR vs. frequency



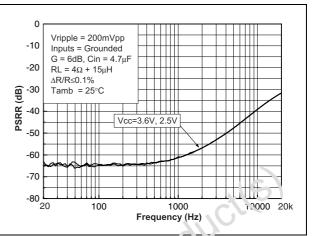
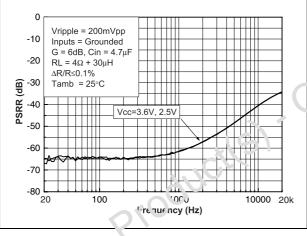


Figure 11. PSSR vs. frequency

Figure 12. PSSR vs. frequency



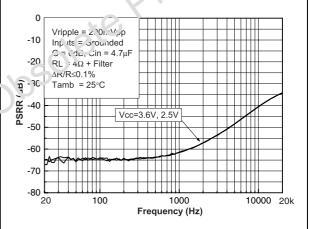
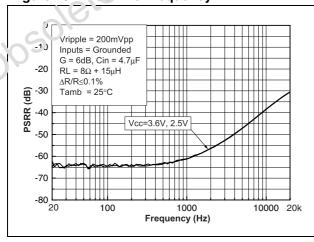


Figure 13. POSR vs. frequency

Figure 14. PSSR vs. frequency



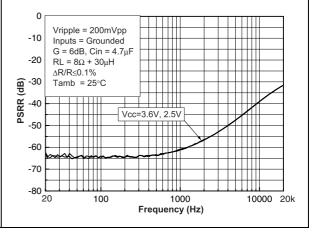
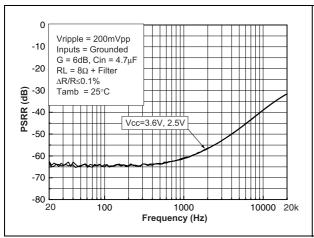


Figure 15. PSSR vs. frequency

Figure 16. PSSR vs. common mode input voltage



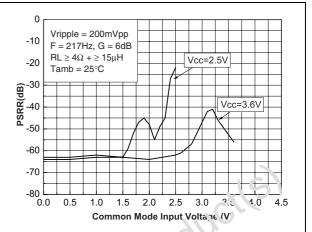
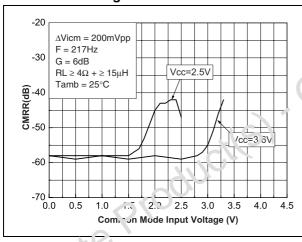


Figure 17. CMRR vs. common mode input voltage

Figure 18. CMRR vs. f.equancy



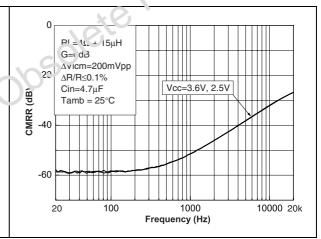
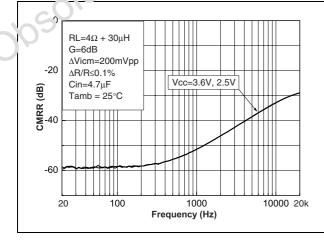


Figure 19 CMRR vs. frequency

Figure 20. CMRR vs. frequency



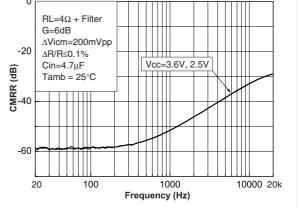


Figure 21. CMRR vs. frequency

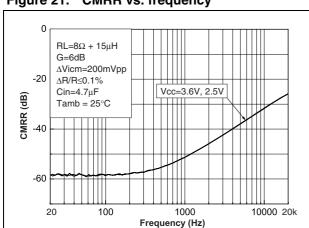


Figure 22. CMRR vs. frequency

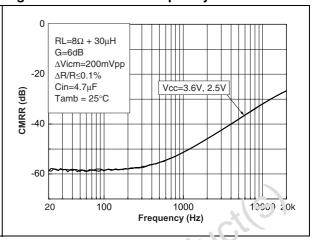


Figure 23. CMRR vs. frequency

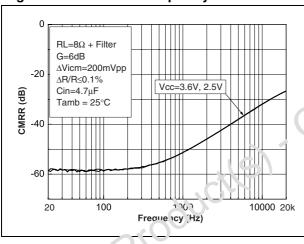


Figure 24. THD+N vs. output cower

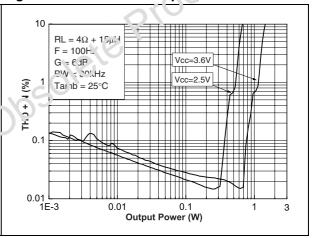


Figure 25. THD+N vs. output power

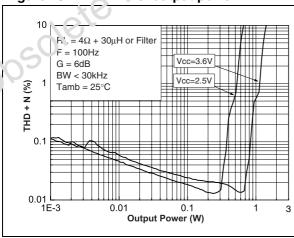


Figure 26. THD+N vs. output power

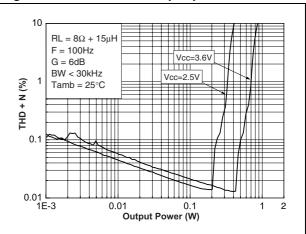


Figure 27. THD+N vs. output power

10 $RL = 8\Omega + 30 \mu H$ or Filter Vcc=3.6V F = 100Hz G = 6dBBW < 30kHzVcc=2.5V (%) N + QH1 Tamb = 25°C 0.1 0.01 L 1E-3

0.1

Output Power (W)

Figure 28. THD+N vs. output power

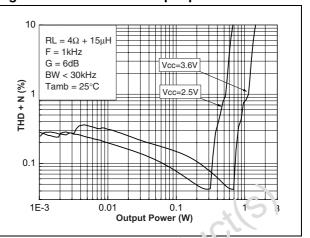


Figure 29. THD+N vs. output power

0.01

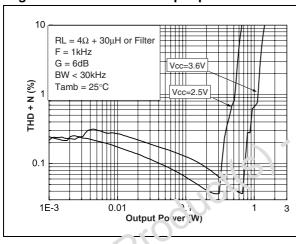


Figure 30. THD+N vs. output Dower

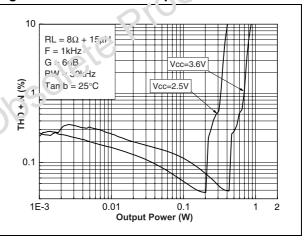


Figure 31. THD+N vs. output power

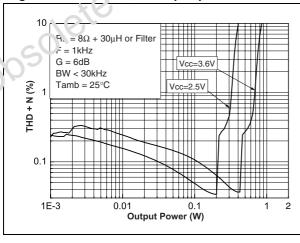


Figure 32. THD+N vs. frequency

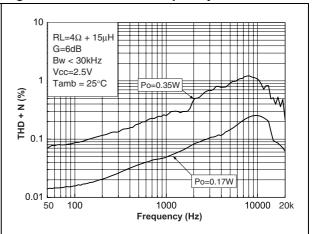


Figure 33. THD+N vs. frequency

10
RL=4Ω + 30μH or Filter
G=6dB
Bw < 30kHz
Vcc=2.5V
Tamb = 25°C

1
1
0.01
50
100
1000
10000
10000
20k
Frequency (Hz)

Figure 34. THD+N vs. frequency

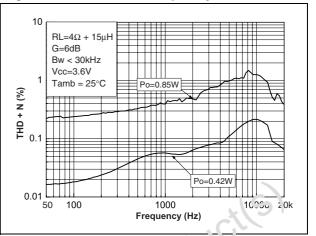


Figure 35. THD+N vs. frequency

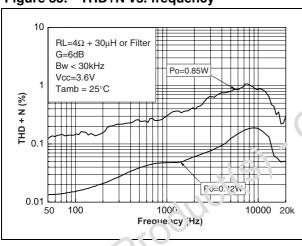


Figure 36. THD+N vs. frequency

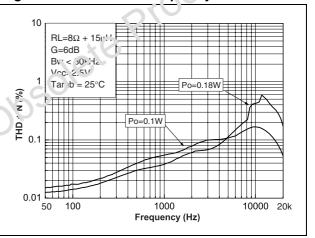


Figure 37. THD+N vs. frequency

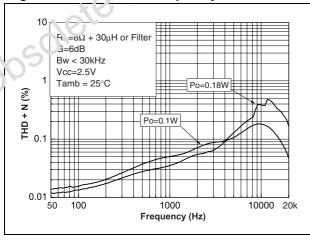


Figure 38. THD+N vs. frequency

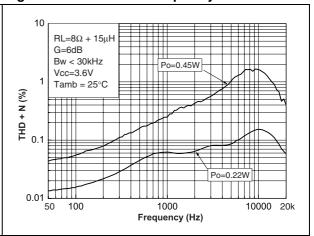


Figure 39. THD+N vs. frequency

Frequency (Hz)

Figure 40. Gain vs. frequency

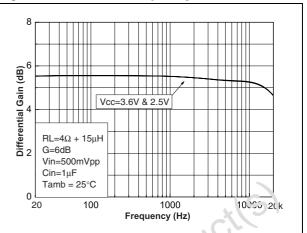


Figure 41. Gain vs. frequency

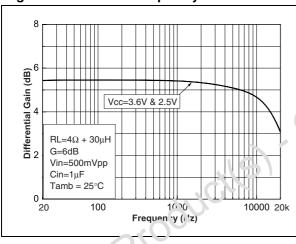


Figure 42. Gain vs. frequency

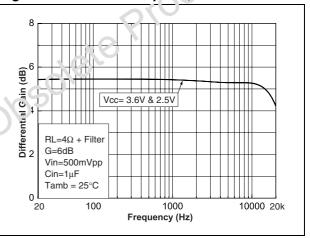


Figure 43. Gain vo. frequency

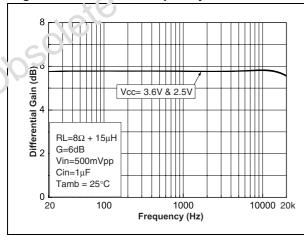


Figure 44. Gain vs. frequency

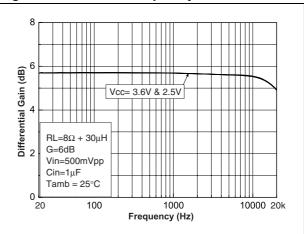


Figure 45. Gain vs. frequency

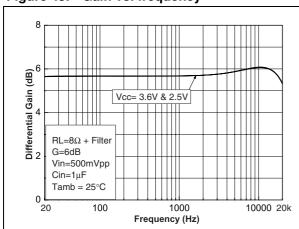


Figure 46. Gain vs. frequency

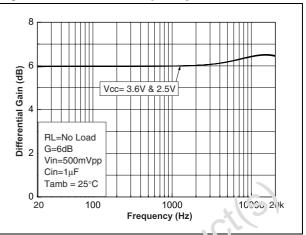
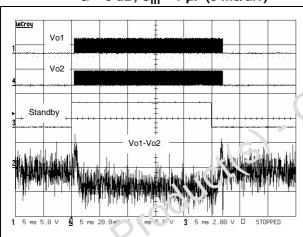


Figure 47. Startup & shutdown time $V_{CC}=3$ V, Figure 48. Startup & shutdown time $V_{CC}=3$ V, G=6 dB, $C_{in}=1$ μF (5 ms/div) G=6 dP, $C_{in}=1$ 00 nF (5 ms/div)



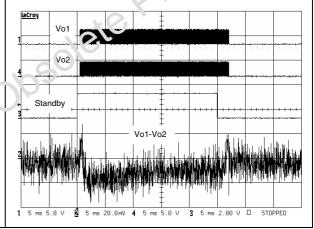
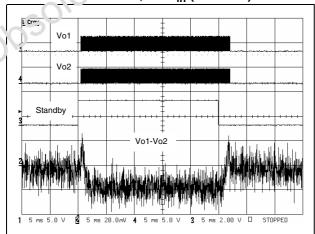


Figure 49. Startup & shutdown time $V_{CC} = 3 \text{ V}$, G = 6 dB, no C_{in} (5 ms/div)



3.2 Analog switch section

The graphs included in this section use the following abbreviations.

- $R_1 + 15 \mu H$ or 30 μH = pure resistor + very low series resistance inductor.
- Filter = LC output filter (1 μ F + 30 μ H for 4 Ω and 0.5 μ F + 6 0 μ H for 8 Ω).
- All measurements done with $C_{s1} = 1 \mu F$ and $C_{s2} = 100 nF$ except for PSRR where C_{s1} is removed.

Figure 50. Test diagram for switch measurements

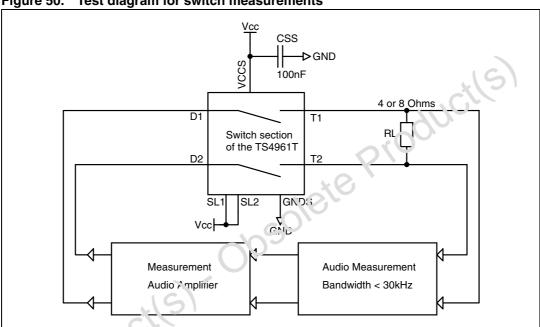
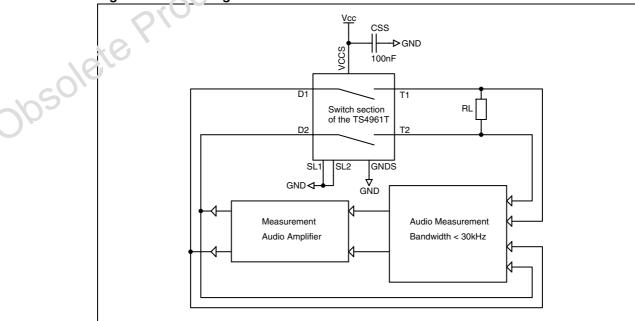


Figure 51. Test diagram for isolation switch measurements



5//

Figure 52. ON resistance

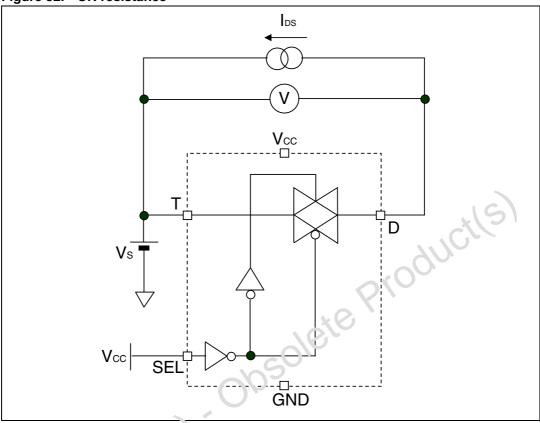


Figure 53. OFF leakage

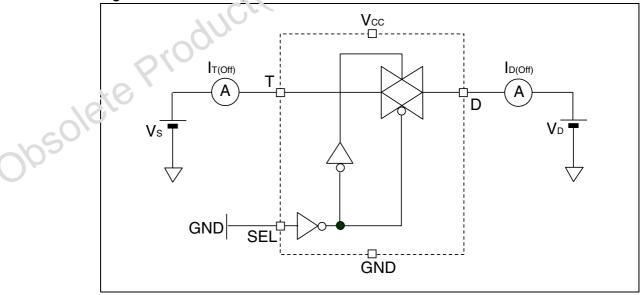


Figure 54. OFF isolation

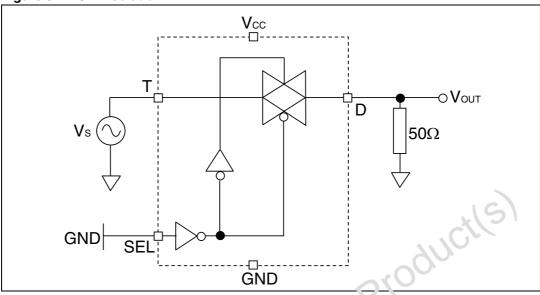
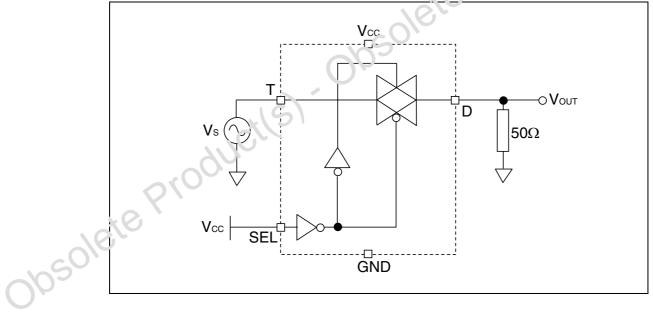


Figure 55. Bandwidth



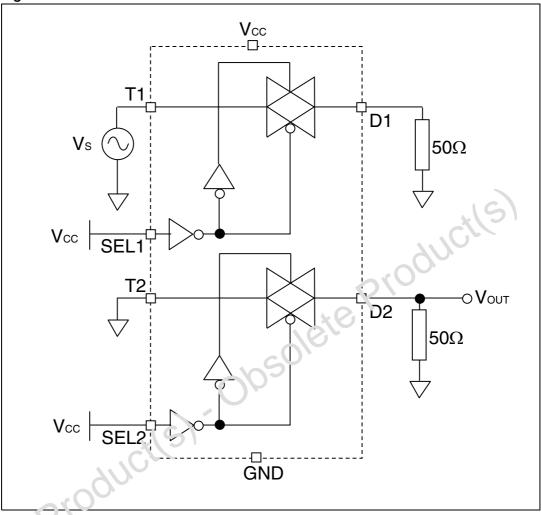
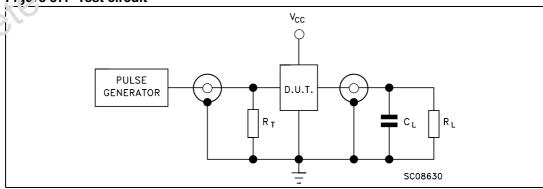


Figure 56. Switch-to-switch crosstalk





Note: 1 $C_L = 5/35 \text{ pF}$ or equivalent (includes jig and probe capacitance).

- 2 $R_L = 50 \Omega$ or equivalent.
- 3 $R_T = Z_{OUT}$ of pulse generator (typically 50 Ω).

5//

Figure 58. Switching time and charge injection Figure 59. Switching time and charge injection test circuit schematics

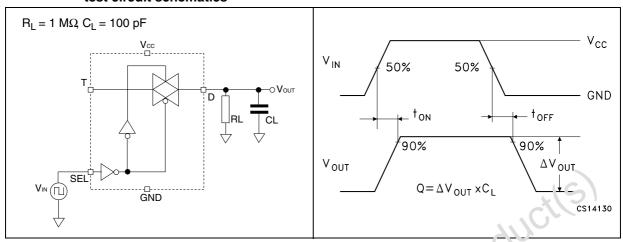


Figure 60. Turn on, turn off time test circuit schematics

Figure 61. Turn on turn of time

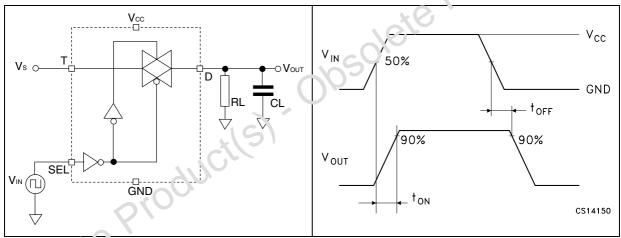


Figure \$2 THD+N vs. output power

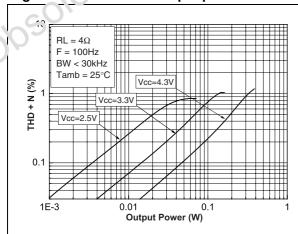


Figure 63. THD+N vs. output power

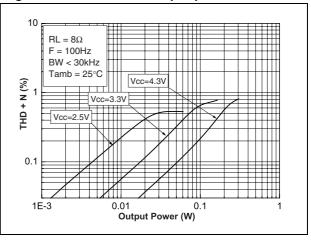


Figure 64. THD+N vs. output power

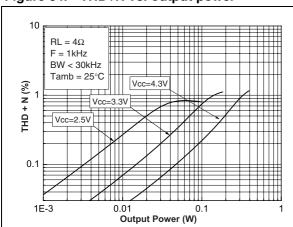


Figure 65. THD+N vs. output power

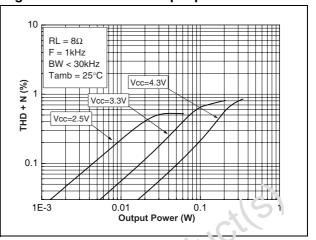


Figure 66. THD+N vs. output power

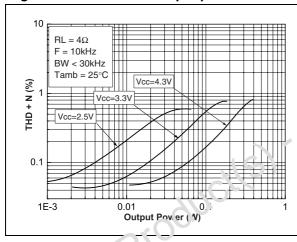


Figure 67. THD+N vs. output cower

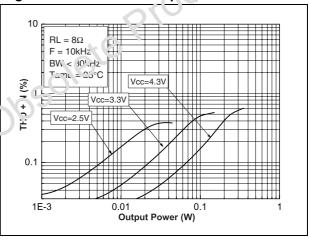


Figure 68. THD+N vs. frequency

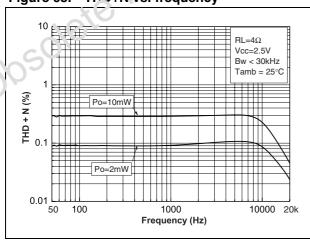


Figure 69. THD+N vs. frequency

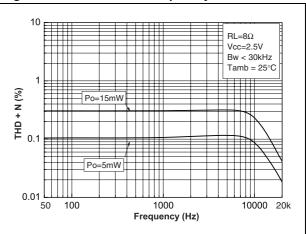


Figure 70. THD+N vs. frequency

RL=4Ω Vcc=3.3V $\mathsf{Bw} < 30 \mathsf{kHz}$ Tamb = 25°C (%) N + QHL Po=35mW

1000

Frequency (Hz)

10000 20k

Figure 71. THD+N vs. frequency

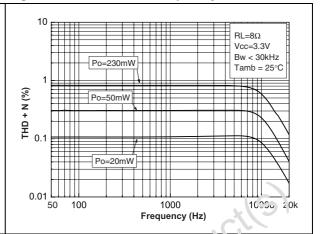


Figure 72. THD+N vs. frequency

Po=10mW

0.1

0.01

50 100

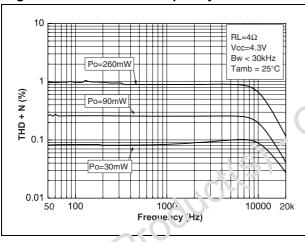


Figure 73. THD+N vs. frequency

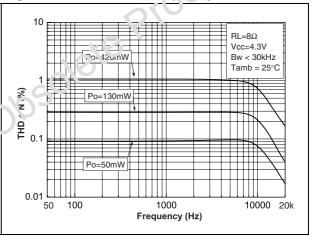
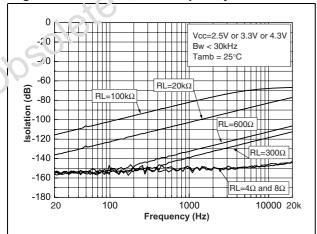


Figure 74. Isolation vs. frequency

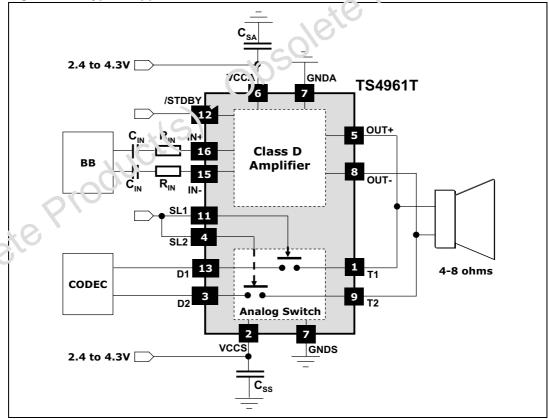


4 Application component information

Table 15. Component information

| Component | Functional description |
|-----------------|---|
| C _{SA} | Bypass supply capacitor. Install as close as possible to the VCCA pin of the TS4961T to minimize high-frequency ripple. A 1 uF ceramic capacitor should be added to enhance power supply filtering at high frequencies (see below). |
| C _{SS} | Bypass supply capacitor. Install as close as possible to the VCCS pin of the TS4961T to minimize high-frequency ripple. A 100 nF ceramic capacitor should be added to enhance power supply filtering at high frequencies. |
| R _{IN} | Input resistor to program the TS4961T differential gain (gain = 300 kΩ/ P_{IN} w.th P_{IN} in kΩ). |
| C _{IN} | Because common mode feedback is implemented, these input capacitors are optional. However, they can be added to form with R_{IN} a 15% order high pass filter with a -3 dB cut-off frequency = $1/(2^*\pi^*R_{IN}^*C_{IN})$. |

Figure 75. Typical application schematics



4.1 Common mode feedback loop limitations

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

However, because of the V_{icm} limitation in the input stage (see *Table 2: Operating conditions for audio amplifier section on page 3*), the common mode feedback loop can only fulfill its role within a defined range. This range depends upon the values of V_{CC} and R_{in} (Av). To obtain a good estimation of the V_{icm} value, the following formula can be used (no tolerance on R_{in}):

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

with

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

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

$$0.5V \le V_{icm} \le V_{CO} - 0.8V$$

Due to the +/-9% tolerance on the 150 k Ω resistor, it is also important to check V_{icm} in these conditions:

$$\frac{V_{CC} \times R_{in} + 2 \times V_{IC} < 133.5 \text{k}\Omega}{2 \times (R_{in} + 136.5 \text{k}\Omega)} \leq V_{icm} \leq \frac{V_{CC} \times R_{in} + 2 \times V_{IC} \times 163.5 \text{k}\Omega}{2 \times (R_{in} + 163.5 \text{k}\Omega)}$$

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

For example:

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

oducils

4.2 Low frequency response

If a low frequency bandwidth limitation is required, 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 -3 dB cut-off frequency:

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

Therefore, for a desired cut-off frequency F_{CL}, C_{in} is calculated as follows:

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

with R_{in} in Ω and F_{CI} in Hz.

4.3 Decoupling of the circuit

A power supply capacitor, referred to as C_S , is necessary to correctly bypass the class D part of the TS4961T.

The TS4961T has a typical switching frequency at 250 kHz and an output fall and rise time at approximately 5 ns. Because of these very test transients, careful decoupling is mandatory.

A 1 μ F ceramic capacitor is enough, but it must be located very close to the TS4961T in order to avoid any extra parasitic inductance created by a long track wire. In relation with dl/dt, this parasitic inductance in roduces 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 Ω load is used.

Another important parameter is the rated voltage of the capacitor. A 1 μ F/6.3 V capacitor Ls. d at 5 V, loses about 50% of its value. In fact, with a 5 V power supply voltage, the elecoupling value is about 0.5 μ F instead of 1 μ F. Since C_S has a 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).

4.4 Wake-up time (t_{WU})

There is a wait of approximately 5 ms when standby is released to set the device ON. The TS4961T has an internal digital delay that mutes the outputs and releases them after this time in order to avoid any pop noise.

4.5 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 standby mode, is about 5 ms. This time is used to decrease the gain and avoid any pop noise during shutdown.

4.6 Consumption in standby mode

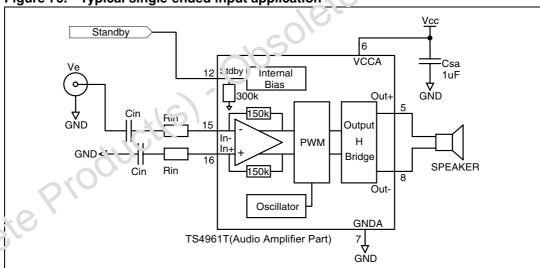
Between the shutdown pin and GND there is an internal 300 k Ω resistor. This resistor forces the TS4961T to switch to standby mode when the standby input is left floating.

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

4.7 Single-ended input configuration

The TS4961Tcan be used in a single-ended input configuration, but it coupling capacitors are necessary. *Figure 76* shows a typical single-ended input application.

Figure 76. Typical single-ended input application



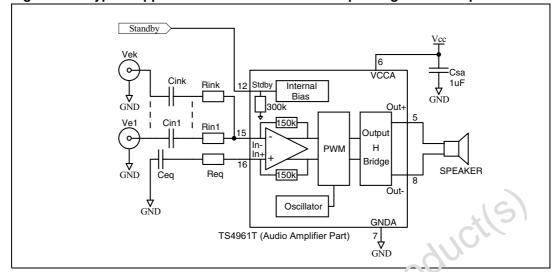
All formulas are identical except for the gain (with R_{in} in $k\Omega$):

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

Due to the internal resistor tolerance, A_{Vsingle} is in the range of:

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

In the event that multiple single-ended inputs are summed, it is important that the impedance on both TS4961 inputs (In⁻ and In⁺) be equal.



Typical application schematics with multiple single-ended inputs

We have the following equations.

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

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

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

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

Josolete Product(s) In general, for mixed situations (single-ended and differential inputs), the same rule must be used, that is, to equalize impedance on both TS4961T inputs.

4.8 Output filter considerations

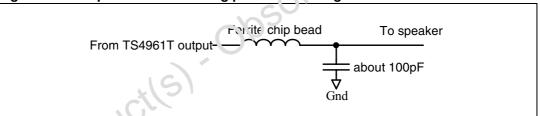
The TS4961T is designed to operate without an output filter. However, due to very sharp transients on the TS4961T output, EMI radiated emissions may cause some standard compliance issues.

These EMI standard compliance issues can appear if the distance between the TS4961T outputs and loudspeaker terminal are long (typically more than 50 mm, or 100 mm in both directions, to the speaker terminals). Since 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 TS4961T output pins and the speaker terminals.
- Use ground planes for shielding sensitive wires.
- Place, as close as possible to the TS4961T and in series with each output, a ferrite bead with a rated current of 2.5 A minimum, and impedance greater them 50 Ω at frequencies above 30 MHz. If, after testing, these ferrite beads are represented in the property of them by a short circuit.
- Allow enough footprint to place, if necessary, a capacitor 'o short perturbations to ground as shown in *Figure 78*.

Figure 78. Output filter for shorting pertubations to ground



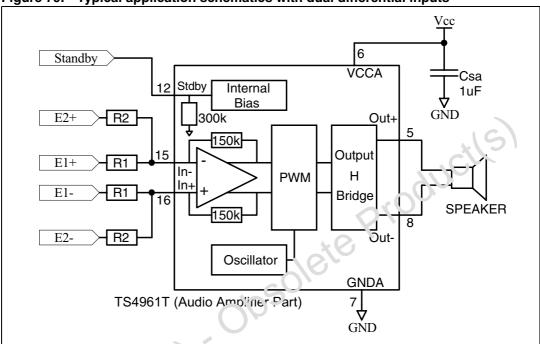
In the case where the distance between the TS4961T outputs and speaker terminals is high, it is possible to have low frequency EMI issues due to the fact that the typical operating frequency is 250 kHz.

In this configuration, it is recommended to use an output filter. It should be placed as close as possible to the TS4961T.

Examples with summed inputs 4.9

4.9.1 **Example 1: dual differential inputs**

Figure 79. Typical application schematics with dual differential inputs



With (Ri in kΩ):
$$A_{V_1} = \frac{Out^+ - Out^-}{E_1^+ - E_1^-} = \frac{300}{R_1}$$

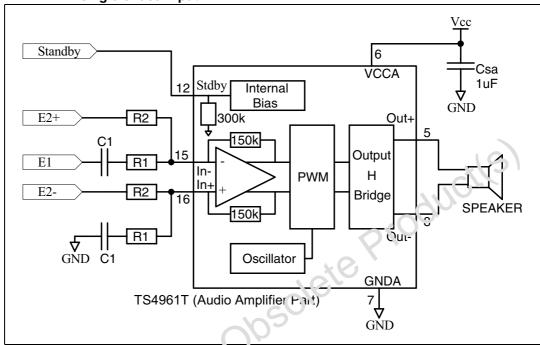
$$A_{V_2} = \frac{Out^+ - Out^-}{E_2^+ - E_2^-} = \frac{300}{R_2}$$

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

$$V_{IC_1} = \frac{E_1^+ + E_1^-}{2} \text{ and } V_{IC_2} = \frac{E_2^+ + E_2^-}{2}$$

4.9.2 Example 2: one differential input plus one single-ended input

Figure 80. Typical application schematics with one differential input plus one single-ended input



With (Ri in kΩ):

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

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

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

Using the audio amplifier and switch on the same speaker 4.10

The TS4961T can be used to supply a speaker with two different sources. The typical application is shown in Figure 81.

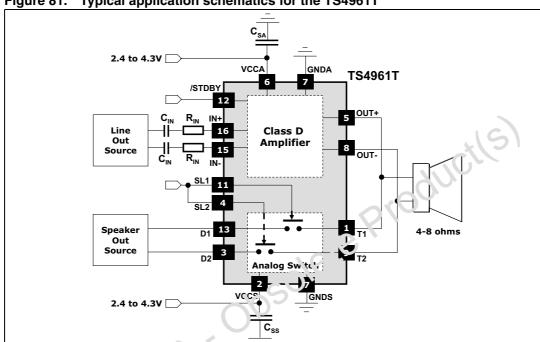


Figure 81. Typical application schematics for the TS4961T

The first source is a line-out signal provided by the baseband and the second is a speaker-out signal coming from the CODEC. Switching is done through the standby pin (/STDBY) of the audin amplifier and through the SLn pins of the switch.

Note that, as shown in Figure 82, all pins should not be switched at the same time because this carr ause damage to the TS4961T audio amplifier and to the external audio amplifier that provides the speaker-out signal. Jbsolet

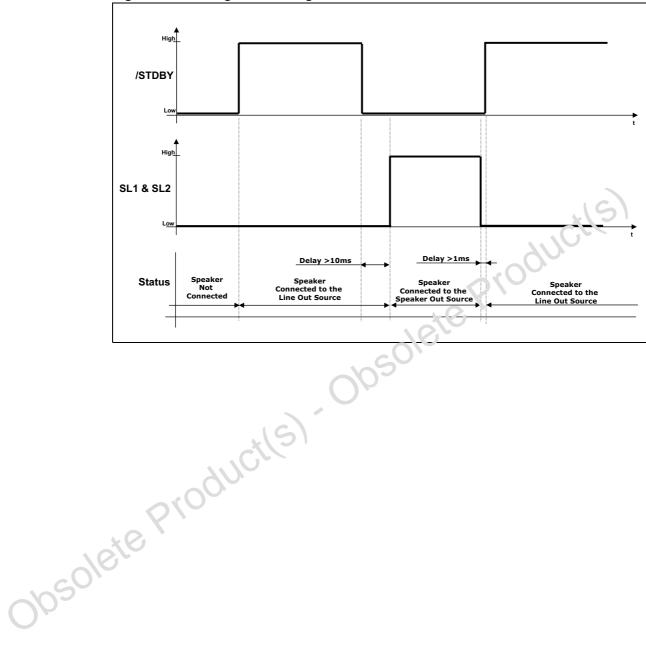


Figure 82. Timing of switching between two audio sources

TS4961T Package information

5 Package information

In order to meet environmental requirements, ST offers these devices in ECOPACK[®] packages. These packages have a lead-free second level interconnect. The category of second level interconnect is marked on the package and on the inner box label, in compliance with JEDEC Standard JESD97. The maximum ratings related to soldering conditions are also marked on the inner box label. ECOPACK is an ST trademark. ECOPACK specifications are available at: www.st.com.

Obsolete Product(s). Obsolete Product(s)

45/49

Package information TS4961T

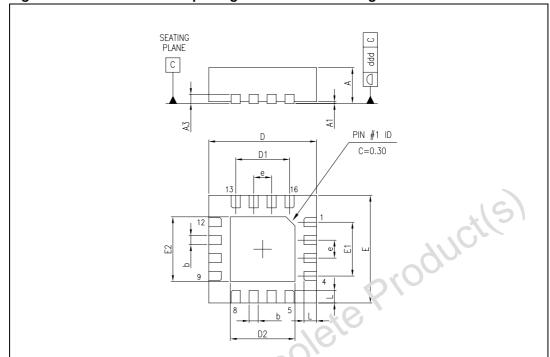


Figure 83. QFN16 3 x 3 mm package mechanical drawing

Note:

For enhanced thermal performance the expused pad must be soldered to a copper area on the PCB, acting as a heatsink. This capper area can be electrically connected to pins 7 and 10 or left floating.

Table 16. QFN16 3 x 3 n... package mechanical data

| | | Dimensions | | | | | |
|-------|------|------------|-------------|------|-------|--------|-------|
| | Ref. | 70,0 | Millimeters | | | Inches | |
| | 6// | Min. | Тур. | Max. | Min. | Тур. | Max. |
| | A | 0.80 | 0.90 | 1.00 | 0.031 | 0.035 | 0.039 |
| 7/6 | A1 | | 0.02 | 0.05 | | 0.001 | 0.002 |
| 1250. | A3 | | 0.20 | | | 0.008 | |
| Oh | b | 0.18 | 0.25 | 0.30 | 0.007 | 0.01 | 0.012 |
| | D | 2.85 | 3.00 | 3.15 | 0.112 | 0.118 | 0.124 |
| | D1 | | 1.50 | | | 0.059 | |
| | D2 | 1.70 | 1.80 | 1.90 | 0.067 | 0.071 | 0.075 |
| | Е | 2.85 | 3.00 | 3.15 | 0.112 | 0.118 | 0.124 |
| | E1 | | 1.50 | | | 0.059 | |
| | E2 | 1.70 | 1.80 | 1.90 | 0.067 | 0.071 | 0.075 |
| | е | 0.45 | 0.50 | 0.55 | 0.018 | 0.020 | 0.022 |
| | L | 0.30 | 0.40 | 0.50 | 0.012 | 0.016 | 0.020 |
| | ddd | | | 0.08 | | | 0.003 |

TS4961T **Package information**

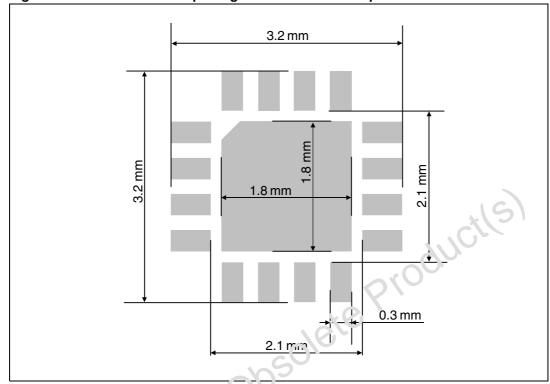


Figure 84. QFN16 3 x 3 mm package recommended footprint

Note:

The substrate pad should be tied to the FCB GND. Obsolete Productls

Ordering information TS4961T

Ordering information 6

Table 17. **Order codes**

| Order code | Temperature range | Package | Packing | Marking |
|------------|-------------------|---------|-------------|---------|
| TS4961TIQT | -40°C to +85°C | QFN16 | Tape & reel | K61T |

Revision history 7

Table 18. **Document revision history**

| DateRevisionChanges16-Sep-20081Initial release. | es | Changes | | |
|---|-----|------------------|----------|-------------|
| 0,40 | 100 | Changes | Revision | Date |
| | | Initial release. | 1 | 16-Sep-2008 |
| Obsolete Product(s) Obsolete \ | | Obsolete Pr | l | |

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