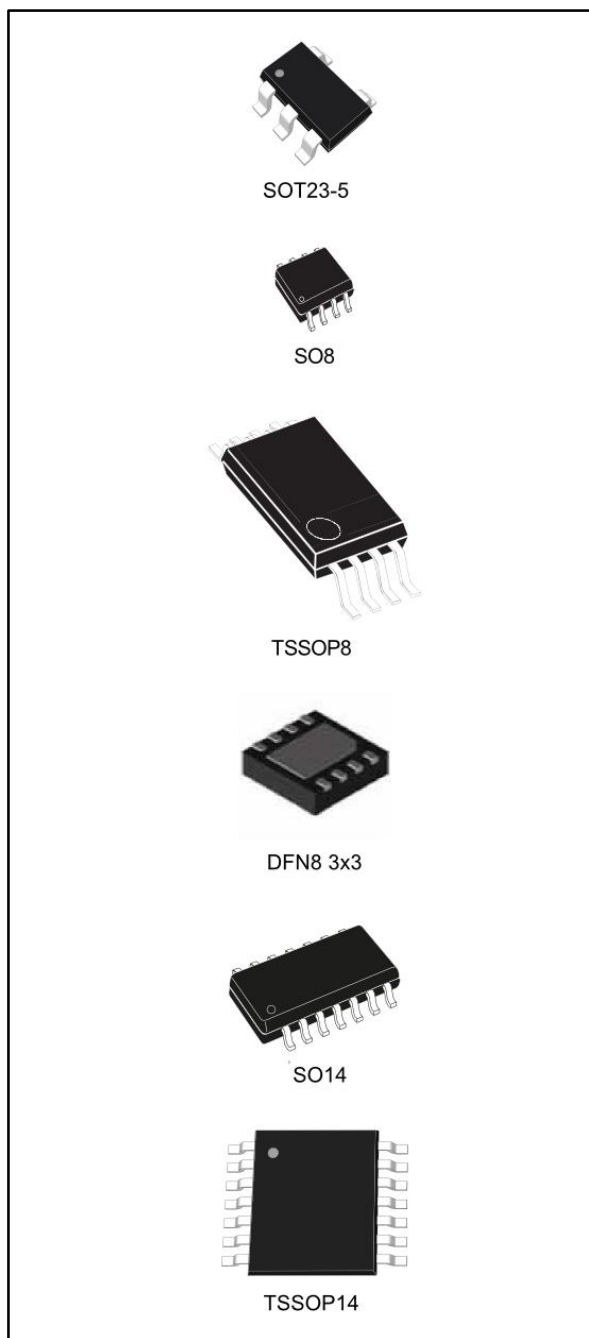


Output rail-to-rail very low noise operational amplifier

Datasheet - production data

**Features**

- Rail-to-rail output voltage swing ± 2.4 V at $V_{CC} = \pm 2.5$ V
- Very low noise level: 4 nV/ $\sqrt{\text{Hz}}$
- Ultra low distortion: 0.003 %
- High dynamic features: 12 MHz, 4 V/ μs
- Operating range: 2.7 to 10 V
- ESD protection (2 kV)
- Latch-up immunity (class A)

Applications

- Portable devices (CD players, PDAs)
- Portable communication (cell phones, pagers)
- Instrumentation and sensing technology
- Professional audio circuits

Description

The TS97x family of operational amplifiers operate with voltages as low as ± 1.35 V and feature output rail-to-rail signal swing. The TS97x devices are particularly well suited for portable and battery-supplied equipment. Very low noise and low distortion characteristics make them ideal for audio pre-amplification.

The TS97x devices are available in a variety of packages to suit all types of applications. For applications where space saving is critical, the SOT23-5 package (2.8 x 2.9 mm) or the DFN8 package (3 x 3 mm) simplify the board design because they can be placed anywhere on it.

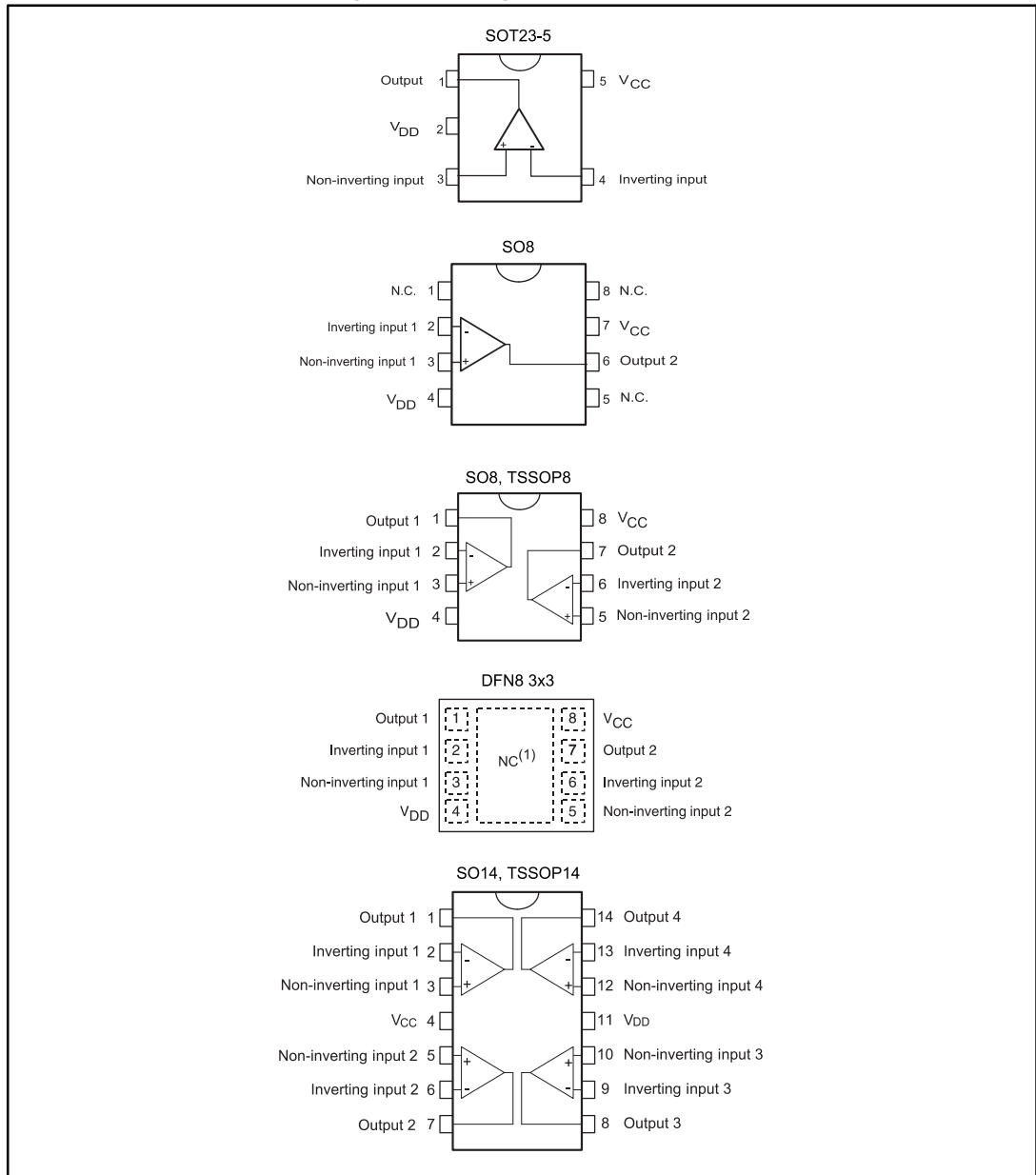
Contents

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1 Package pin connections

Figure 1: Package pin connections



1. The exposed pad of the DFN8 3x3 can be connected to V_{CC} or left floating

2 Absolute maximum ratings and operating conditions

Table 1: Absolute maximum ratings (AMR)

| Symbol | Parameter | Value | Unit | |
|-------------------|---|--|------|------|
| V _{CC} | Supply voltage ⁽¹⁾ | 12 | V | |
| V _{id} | Differential input voltage ⁽²⁾ | ±1 | | |
| V _{in} | Input voltage ⁽³⁾ | V _{DD} - 0.3 to V _{CC} + 0.3 | | |
| T _{stg} | Storage temperature range | -65 to 150 | °C | |
| T _j | Maximum junction temperature | 150 | | |
| R _{thja} | Thermal resistance junction-to-ambient ⁽⁴⁾ | SOT23-5 | 250 | °C/W |
| | | SO8 | 125 | |
| | | TSSOP8 | 120 | |
| | | DFN8 3x3 | 40 | |
| | | SO14 | 105 | |
| | | TSSOP14 | 100 | |
| R _{thjc} | Thermal resistance junction-to-case ⁽⁴⁾ | SOT23-5 | 81 | |
| | | SO8 | 40 | |
| | | TSSOP8 | 37 | |
| | | DFN8 3x3 | 5.2 | |
| | | SO14 | 31 | |
| | | TSSOP14 | 32 | |
| ESD | HBM: human body model ⁽⁵⁾ | 2 | kV | |
| | MM: machine model ⁽⁶⁾ | 200 | V | |
| | CDM: charged device model ^{(7) (8)} | 1.5 | kV | |
| | Lead temperature (soldering, 10 sec.) | 260 | °C | |

Notes:

- ⁽¹⁾All voltage values, except the differential voltage are with respect to the network ground terminal.
- ⁽²⁾The differential voltage is the non-inverting input terminal with respect to the inverting input terminal.
- ⁽³⁾The magnitude of input and output voltages must never exceed V_{CC} + 0.3 V.
- ⁽⁴⁾Short-circuits can cause excessive heating and destructive dissipation. Values are typical.
- ⁽⁵⁾Human body model: a 100 pF capacitor is charged to the specified voltage, then discharged through a 1.5kΩ resistor between two pins of the device. This is done for all couples of connected pin combinations while the other pins are floating.
- ⁽⁶⁾Machine model: a 200 pF capacitor is charged to the specified voltage, then discharged directly between two pins of the device with no external series resistor (internal resistor < 5 Ω). This is done for all couples of connected pin combinations while the other pins are floating.
- ⁽⁷⁾ No value specified for CDM on SOT23-5 package.
- ⁽⁸⁾Charged device model: all pins and package are charged together to the specified voltage and then discharged directly to ground through only one pin. This is done for all pins.



Table 2: Operating conditions

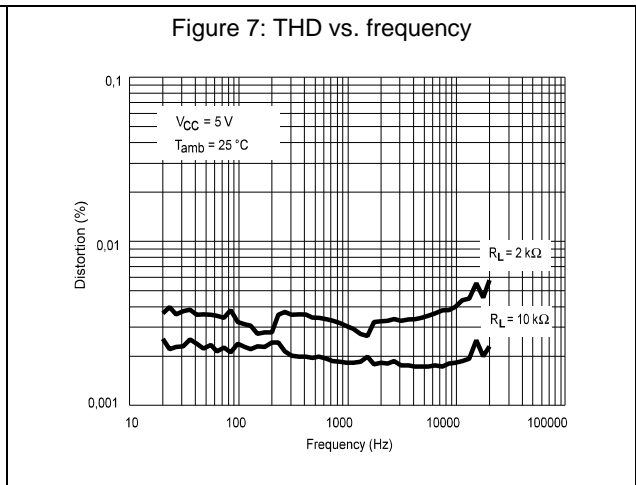
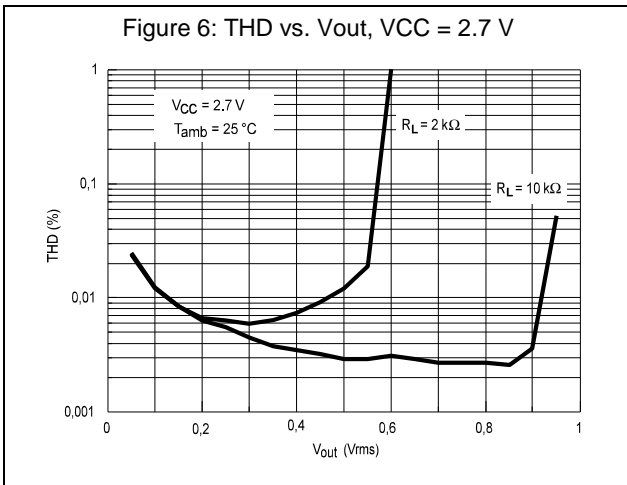
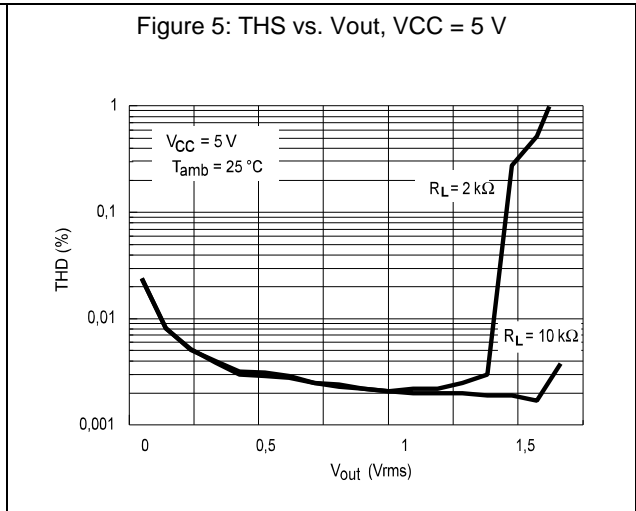
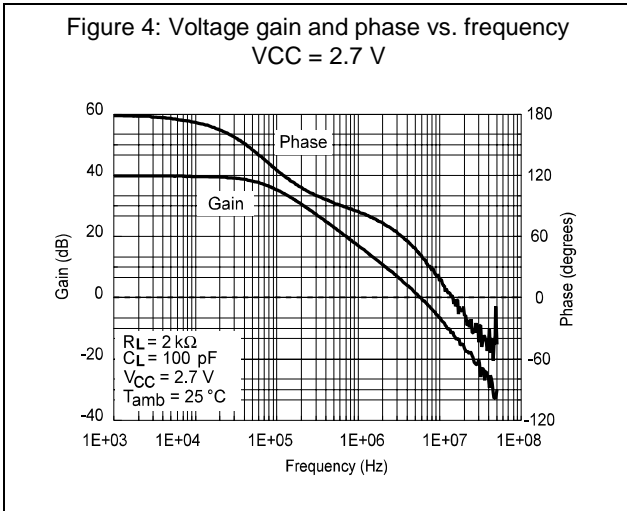
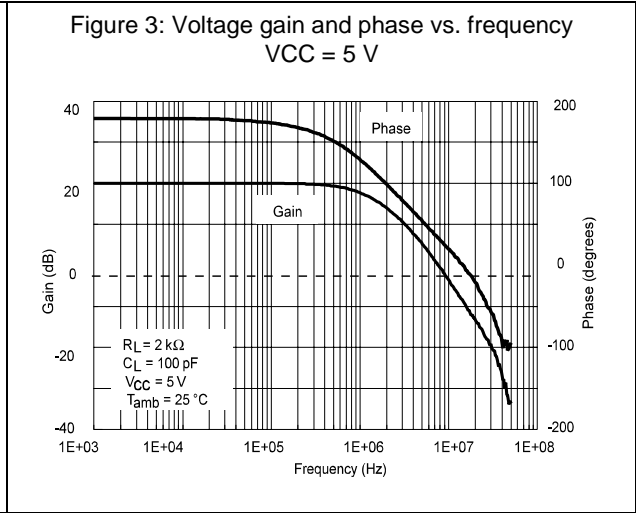
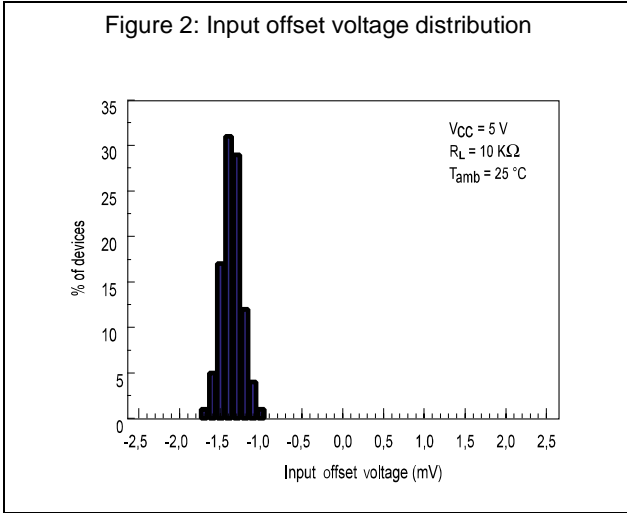
| Symbol | Parameter | Value | Unit |
|------------|--------------------------------------|------------------------------------|------|
| V_{CC} | Supply voltage | 2.7 to 10 | V |
| V_{icm} | Common mode input voltage range | $V_{DD} + 1.15$ to $V_{CC} - 1.15$ | |
| T_{oper} | Operating free air temperature range | -40 to 125 | °C |

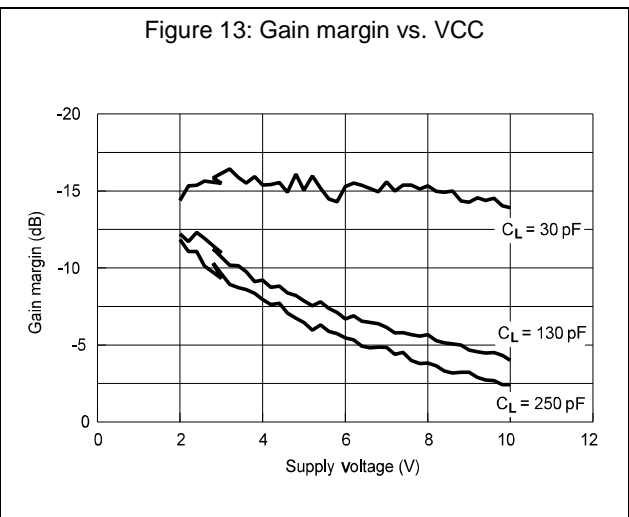
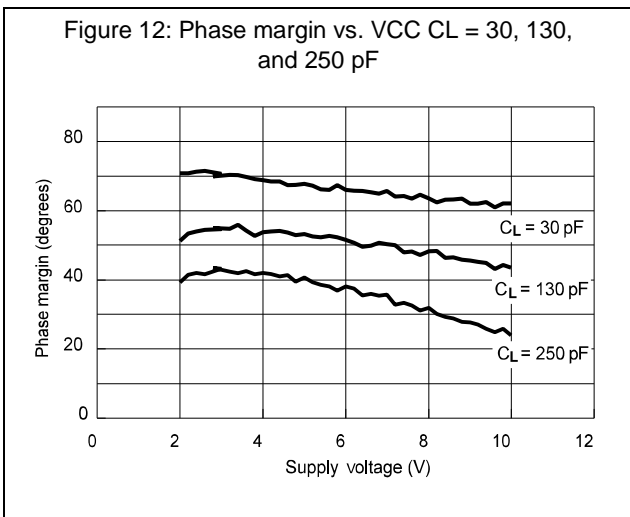
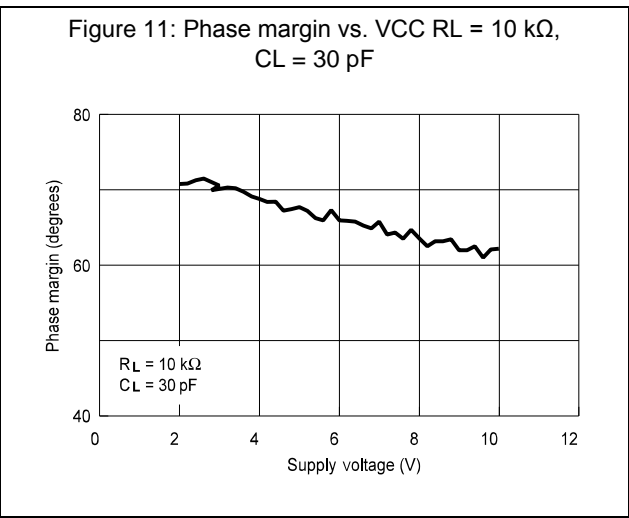
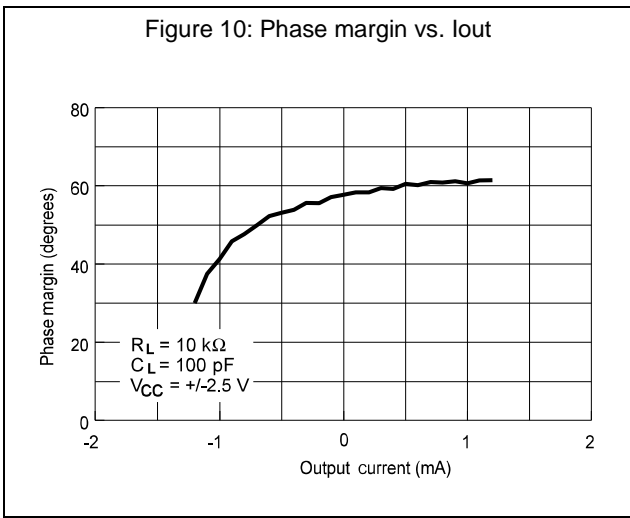
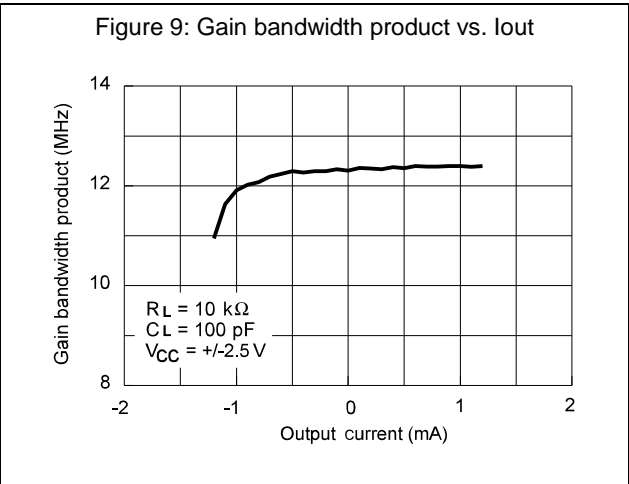
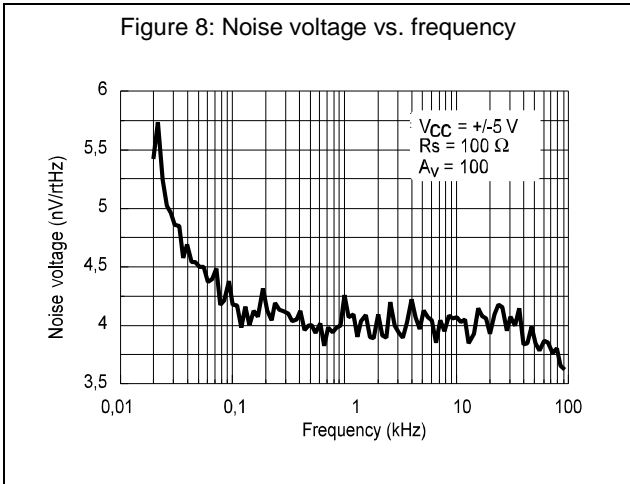
3 Electrical characteristics

Table 3: Electrical characteristics at VCC = 2.5 V, VDD = -2.5 V, Tamb = 25 °C
(unless otherwise specified)

| Symbol | Parameter | Conditions | Min. | Typ. | Max. | Unit |
|----------------------|---------------------------------|---|-------|-------|------|---------|
| V _{io} | Input offset voltage | | | 1 | 5 | mV |
| | | T _{min} ≤ T _{amb} ≤ T _{max} | | | 7 | |
| ΔV _{io} /ΔT | Input offset voltage drift | V _{icm} = 0 V, V _o = 0 V | | 5 | | μV/°C |
| I _{io} | Input offset current | V _{icm} = 0 V, V _o = 0 V | | 10 | 150 | nA |
| I _{ib} | Input bias current | V _{icm} = 0 V, V _o = 0 V | | 200 | 750 | |
| | | T _{min} ≤ T _{amb} ≤ T _{max} | | 200 | 1000 | |
| V _{icm} | Common mode input voltage range | | -1.35 | | 1.35 | V |
| CMR | Common mode rejection ratio | V _{icm} = ±1.35 V | 60 | 85 | | dB |
| SVR | Supply voltage rejection ratio | V _{CC} = ±2 V to ±3 V | 60 | 70 | | |
| A _{vd} | Large signal voltage gain | R _L = 2 kΩ | 70 | 80 | | V |
| V _{OH} | High-level output voltage | | 2 | 2.4 | | |
| V _{OL} | Low-level output voltage | | | -2.4 | -2 | |
| I _{source} | Output source current | | | 1.5 | | mA |
| I _{sink} | Output sink current | | | 100 | | |
| I _{CC} | Supply current per amplifier | Unity gain, no load | | 2 | 2.8 | |
| GBP | Gain bandwidth product | f = 100 kHz, R _L = 2 kΩ, C _L = 100 pF | 8.5 | 12 | | MHz |
| SR | Slew rate | A _v = 1, V _{in} = ±1 V | 2.8 | 4 | | V/μs |
| ∅ _m | Phase margin at unit gain | R _L = 2 kΩ, C _L = 100 pF | | 60 | | Degrees |
| G _m | Gain margin | | | | 10 | |
| e _n | Equivalent input noise voltage | f = 100 kHz | | 4 | | nV/√Hz |
| i _n | Equivalent input noise current | f = 1 kHz | | 250 | | fA/√Hz |
| THD | Total harmonic distortion | f = 1 kHz, A _v = -1, R _L = 10 kΩ | | 0.003 | | % |

4 Electrical characteristic curves





5 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. ECOPACK® is an ST trademark.

5.1 SOT23-5 package information

Figure 14: SOT23-5 package outline

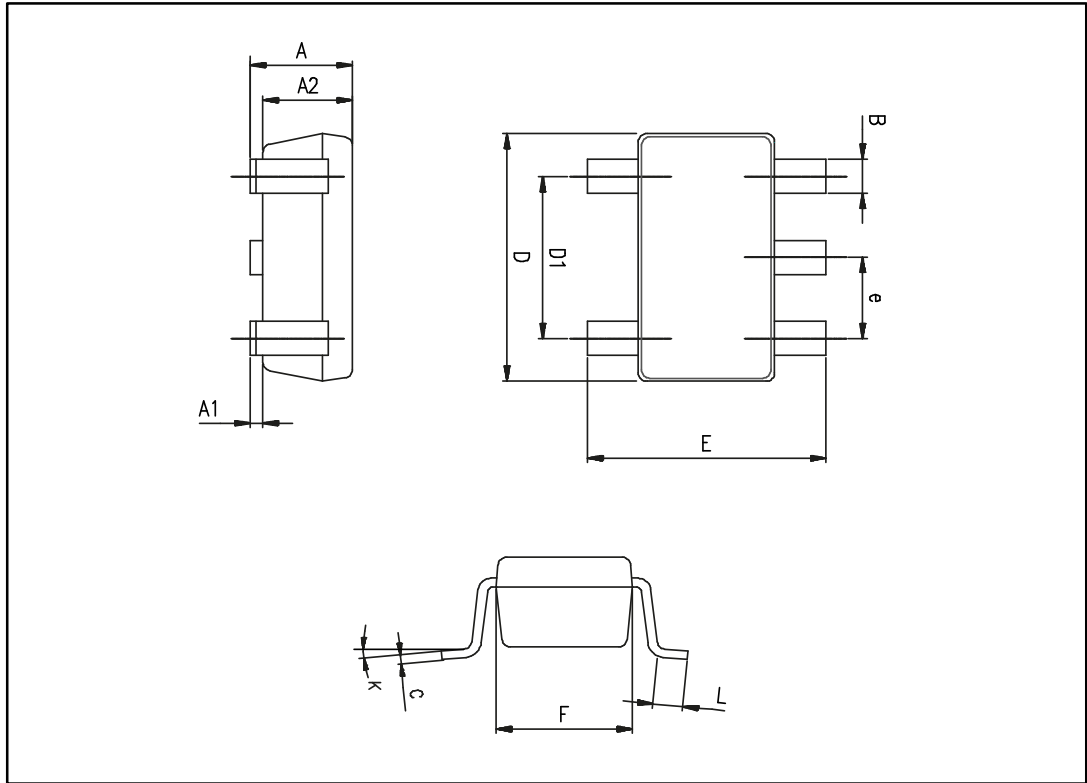


Table 4: SOT23-5 mechanical data

| Ref. | Dimensions | | | | | |
|------|-------------|------|------------|-----------|-------|------------|
| | Millimeters | | | Inches | | |
| | Min. | Typ. | Max. | Min. | Typ. | Max. |
| A | 0.90 | 1.20 | 1.45 | 0.035 | 0.047 | 0.057 |
| A1 | | | 0.15 | | | 0.006 |
| A2 | 0.90 | 1.05 | 1.30 | 0.035 | 0.041 | 0.051 |
| B | 0.35 | 0.40 | 0.50 | 0.014 | 0.016 | 0.020 |
| C | 0.09 | 0.15 | 0.20 | 0.004 | 0.006 | 0.008 |
| D | 2.80 | 2.90 | 3.00 | 0.110 | 0.114 | 0.118 |
| D1 | | 1.90 | | | 0.075 | |
| e | | 0.95 | | | 0.037 | |
| E | 2.60 | 2.80 | 3.00 | 0.102 | 0.110 | 0.118 |
| F | 1.50 | 1.60 | 1.75 | 0.059 | 0.063 | 0.069 |
| L | 0.10 | 0.35 | 0.60 | 0.004 | 0.014 | 0.024 |
| K | 0 degrees | | 10 degrees | 0 degrees | | 10 degrees |

5.2 SO8 package information

Figure 15: SO8 package outline

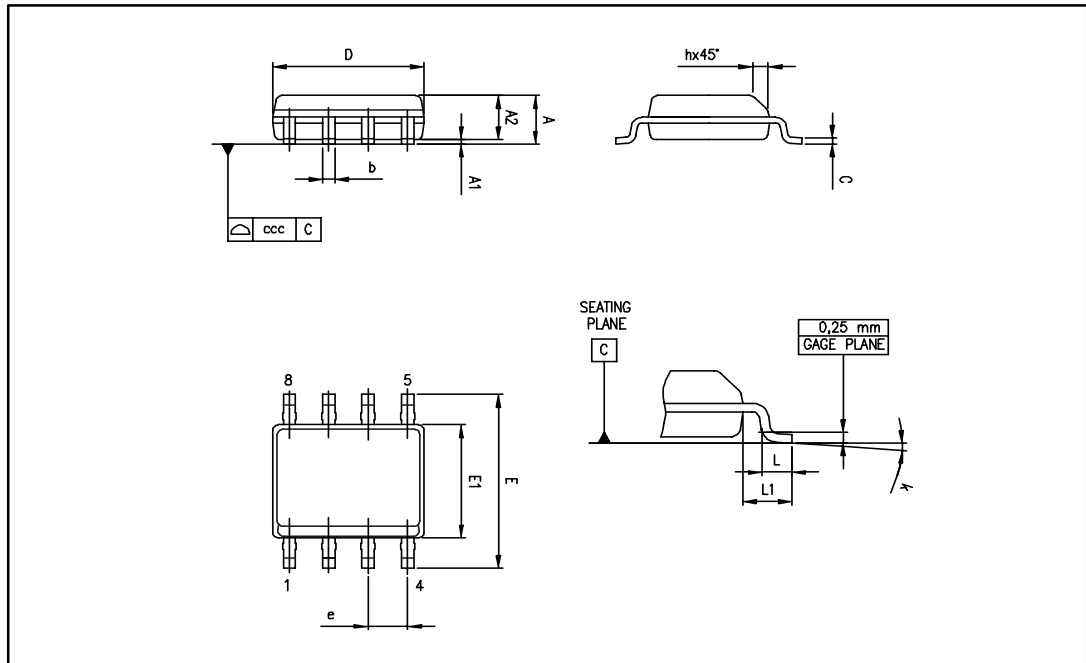


Table 5: SO8 mechanical data

| Ref. | Dimensions | | | | | |
|------|-------------|------|------|--------|-------|-------|
| | Millimeters | | | Inches | | |
| | Min. | Typ. | Max. | Min. | Typ. | Max |
| A | | | 1.75 | | | 0.069 |
| A1 | 0.10 | | 0.25 | 0.004 | | 0.010 |
| A2 | 1.25 | | | 0.049 | | |
| b | 0.28 | | 0.48 | 0.011 | | 0.019 |
| c | 0.17 | | 0.23 | 0.007 | | 0.010 |
| D | 4.80 | 4.90 | 5.00 | 0.189 | 0.193 | 0.197 |
| E | 5.80 | 6.00 | 6.20 | 0.228 | 0.236 | 0.244 |
| E1 | 3.80 | 3.90 | 4.00 | 0.150 | 0.154 | 0.157 |
| e | | 1.27 | | | 0.050 | |
| h | 0.25 | | 0.50 | 0.010 | | 0.020 |
| L | 0.40 | | 1.27 | 0.016 | | 0.050 |
| L1 | | 1.04 | | | 0.040 | |
| k | 1° | | 8° | 1° | | 8° |
| ccc | | | 0.10 | | | 0.004 |

5.3 TSSOP8 package information

Figure 16: TSSOP8 package outline

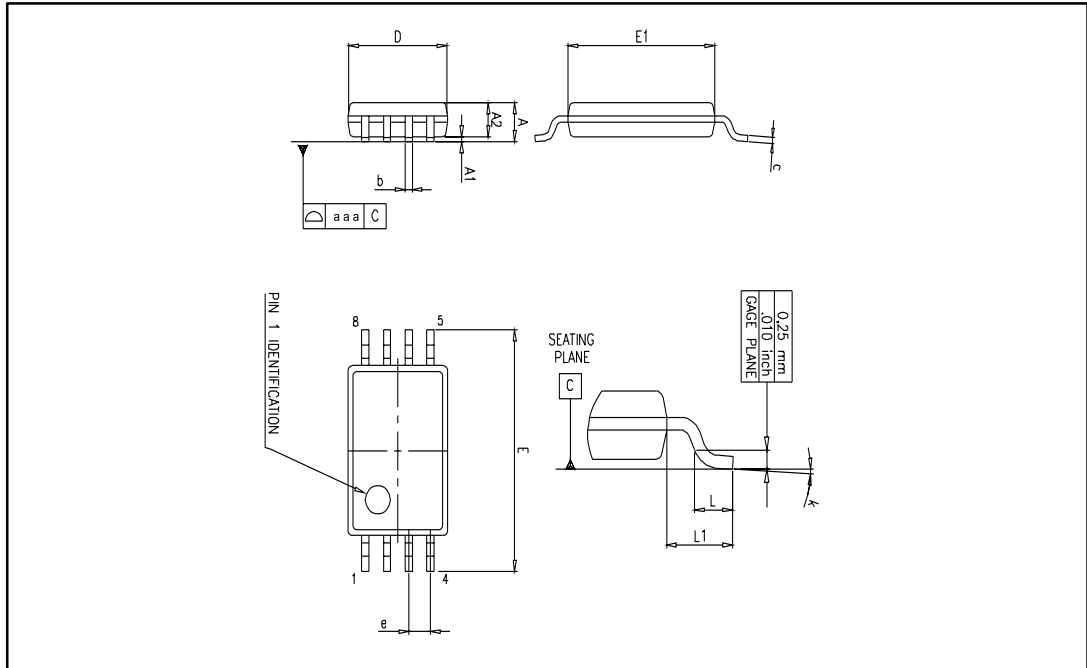


Table 6: TSSOP8 mechanical data

| Ref. | Dimensions | | | | | |
|------|-------------|------|------|--------|--------|-------|
| | Millimeters | | | Inches | | |
| | Min. | Typ. | Max. | Min. | Typ. | Max. |
| A | | | 1.2 | | | 0.047 |
| A1 | 0.05 | | 0.15 | 0.002 | | 0.006 |
| A2 | 0.80 | 1.00 | 1.05 | 0.031 | 0.039 | 0.041 |
| b | 0.19 | | 0.30 | 0.007 | | 0.012 |
| c | 0.09 | | 0.20 | 0.004 | | 0.008 |
| D | 2.90 | 3.00 | 3.10 | 0.114 | 0.118 | 0.122 |
| E | 6.20 | 6.40 | 6.60 | 0.244 | 0.252 | 0.260 |
| E1 | 4.30 | 4.40 | 4.50 | 0.169 | 0.173 | 0.177 |
| e | | 0.65 | | | 0.0256 | |
| k | 0° | | 8° | 0° | | 8° |
| L | 0.45 | 0.60 | 0.75 | 0.018 | 0.024 | 0.030 |
| L1 | | 1 | | | 0.039 | |
| aaa | | 0.1 | | | 0.004 | |

5.4 DFN8 3x3 exposed pad package information

Figure 17: DFN8 3x3 package outline

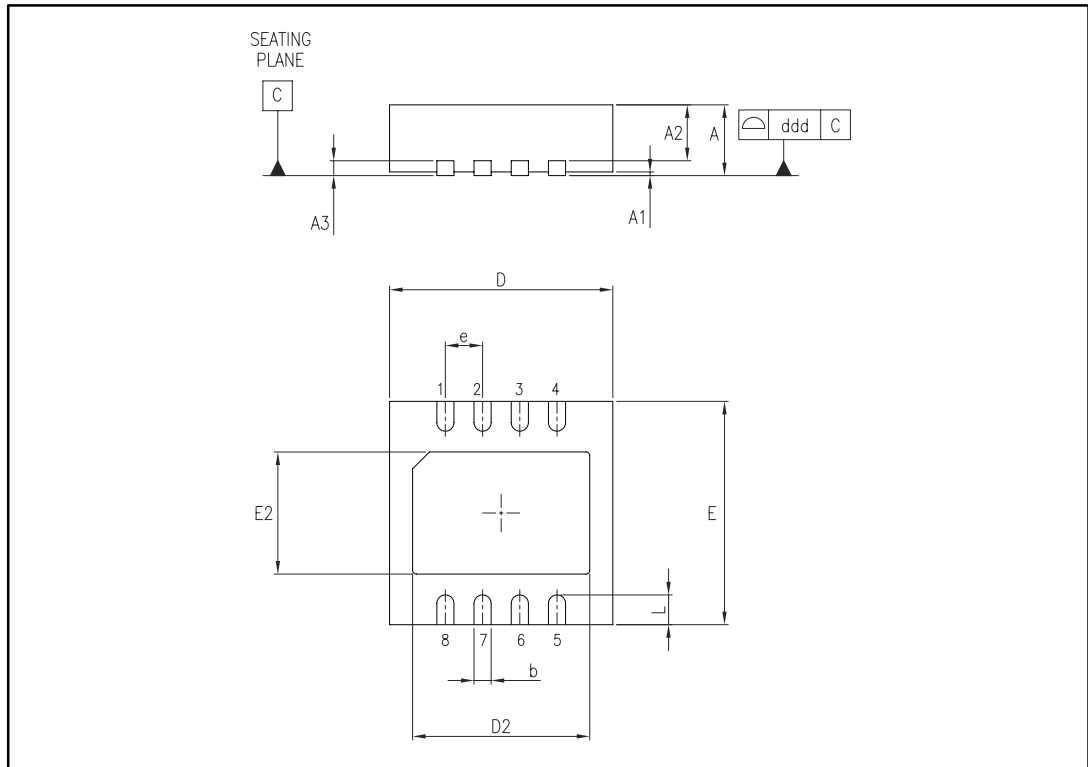


Table 7: DFN8 3x3 mechanical data

| Symbol | Dimensions | | | | | |
|--------|-------------|------|------|--------|--------|--------|
| | Millimeters | | | Inches | | |
| | Min. | Typ. | Max. | Min. | Typ. | Max. |
| A | 0.80 | 0.90 | 1.00 | 0.031 | 0.035 | 0.039 |
| A1 | | 0.02 | | | 0.0008 | 0.0019 |
| A2 | 0.55 | 0.65 | 0.80 | 0.021 | 0.025 | 0.031 |
| A3 | | 0.20 | | | 0.008 | |
| b | 0.18 | 0.25 | 0.30 | 0.007 | 0.010 | 0.012 |
| D | 2.85 | 3.00 | 3.15 | 0.112 | 0.118 | 0.124 |
| D2 | 2.20 | | 2.70 | 0.087 | | 0.106 |
| E | 2.85 | 3.00 | 3.15 | 0.112 | 0.118 | 0.124 |
| E2 | 1.40 | | 1.75 | 0.055 | | 0.069 |
| e | | 0.50 | | | 0.020 | |
| L | 0.30 | 0.40 | 0.50 | 0.012 | 0.016 | 0.020 |
| ddd | | | 0.08 | | | 0.003 |

5.5 SO14 package information

Figure 18: SO14 package outline

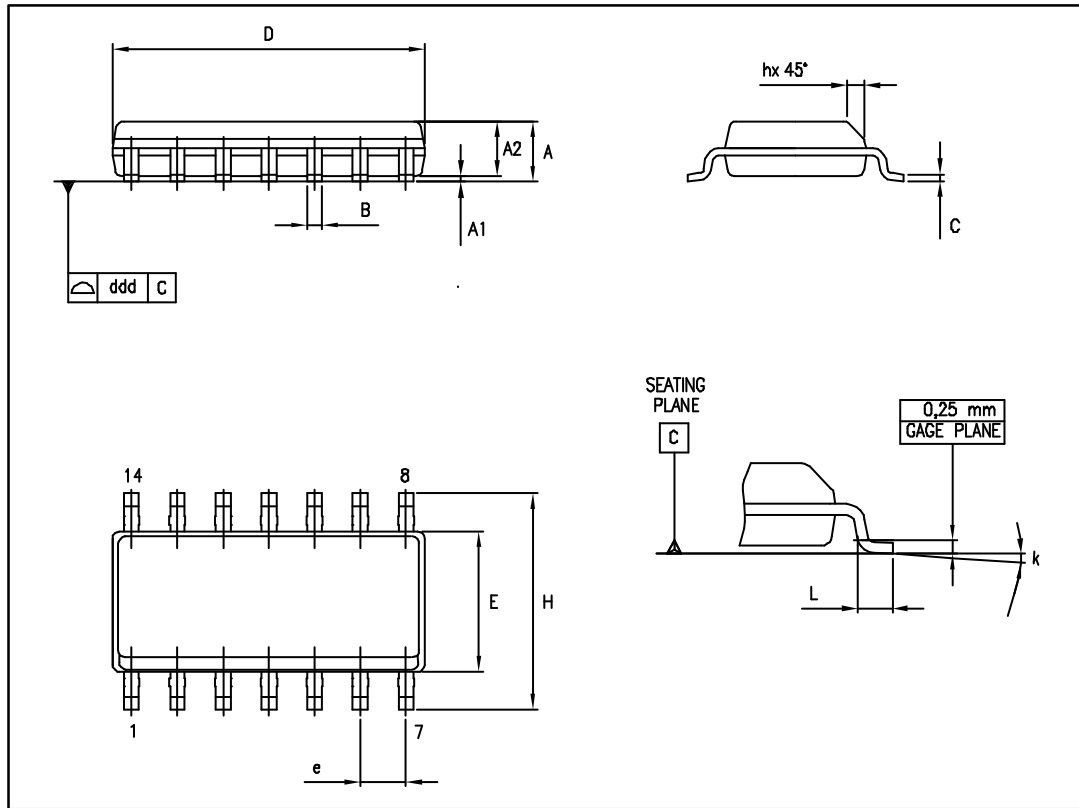


Table 8: SO14 mechanical data

| Ref. | Dimensions | | | | | |
|------|-------------|------|------|--------|------|-------|
| | Millimeters | | | Inches | | |
| | Min. | Typ. | Max. | Min. | Typ. | Max. |
| A | 1.35 | | 1.75 | 0.05 | | 0.068 |
| A1 | 0.10 | | 0.25 | 0.004 | | 0.009 |
| A2 | 1.10 | | 1.65 | 0.04 | | 0.06 |
| B | 0.33 | | 0.51 | 0.01 | | 0.02 |
| C | 0.19 | | 0.25 | 0.007 | | 0.009 |
| D | 8.55 | | 8.75 | 0.33 | | 0.34 |
| E | 3.80 | | 4.0 | 0.15 | | 0.15 |
| e | | 1.27 | | | 0.05 | |
| H | 5.80 | | 6.20 | 0.22 | | 0.24 |
| h | 0.25 | | 0.50 | 0.009 | | 0.02 |
| L | 0.40 | | 1.27 | 0.015 | | 0.05 |
| k | 8° (max) | | | | | |
| ddd | | | 0.10 | | | 0.004 |

5.6 TSSOP14 package information

Figure 19: TSSOP14 package outline

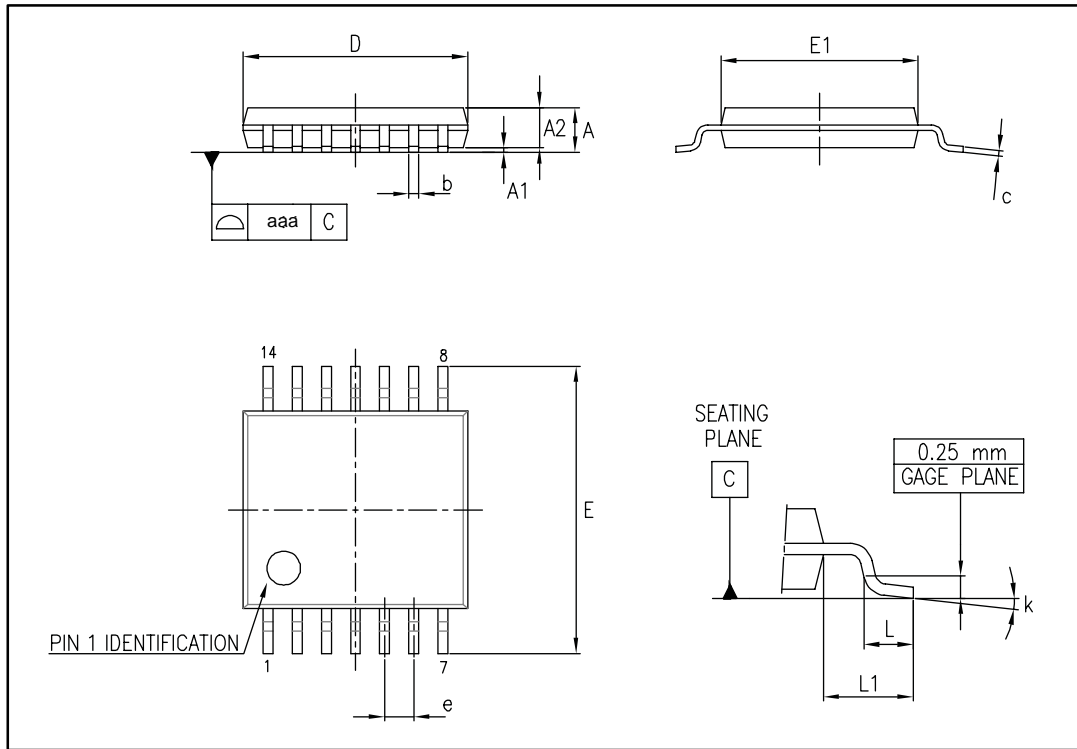


Table 9: TSSOP14 mechanical data

| Ref. | Dimensions | | | | | |
|------|-------------|------|------|--------|--------|--------|
| | Millimeters | | | Inches | | |
| | Min. | Typ. | Max. | Min. | Typ. | Max. |
| A | | | 1.20 | | | 0.047 |
| A1 | 0.05 | | 0.15 | 0.002 | 0.004 | 0.006 |
| A2 | 0.80 | 1.00 | 1.05 | 0.031 | 0.039 | 0.041 |
| b | 0.19 | | 0.30 | 0.007 | | 0.012 |
| c | 0.09 | | 0.20 | 0.004 | | 0.0089 |
| D | 4.90 | 5.00 | 5.10 | 0.193 | 0.197 | 0.201 |
| E | 6.20 | 6.40 | 6.60 | 0.244 | 0.252 | 0.260 |
| E1 | 4.30 | 4.40 | 4.50 | 0.169 | 0.173 | 0.176 |
| e | | 0.65 | | | 0.0256 | |
| L | 0.45 | 0.60 | 0.75 | 0.018 | 0.024 | 0.030 |
| L1 | | 1.00 | | | 0.039 | |
| k | 0° | | 8° | 0° | | 8° |
| aaa | | | 0.10 | | | 0.004 |

6 Ordering information

Table 10: Order codes

| Order code | Temperature range | Package | Packaging | Marking | |
|--------------------------|-------------------|-----------------------------------|---------------|---------|-------|
| TS971IDT | -40 °C, 125 °C | SO8 | Tape and reel | 971I | |
| TS971ILT | | SOT23-5 | | K120 | |
| TS971IYLT ⁽¹⁾ | | SOT23-5 (automotive grade level) | | K121 | |
| TS972IDT | | SO8 | | 972I | |
| TS972IPT | | TSSOP8 | | | |
| TS972IQT | | DFN8 3x3 | | | |
| TS972IYDT ⁽¹⁾ | | SO8 (automotive grade level) | | | 972IY |
| TS972IYPT ⁽¹⁾ | | TSSOP8 (automotive grade level) | | | 972IY |
| TS972IYQT ⁽¹⁾ | | DFN8 3x3 (automotive grade level) | | | 972IY |
| TS974IDT | | SO14 | | | 974I |
| TS974IPT | | TSSOP14 | | | |
| TS974IYPT ⁽¹⁾ | | TSSOP14 (automotive grade level) | | 974IY | |

Notes:

⁽¹⁾Qualified and characterized according to AEC Q100 and Q003 or equivalent, advanced screening according to AEC Q001 and Q 002 or equivalent.

7 Revision history

Table 11: Document revision history

| Date | Revision | Changes |
|--------------|----------|--|
| 15-Nov- 2002 | 1 | First release. |
| 9-May- 2005 | 2 | Modifications on AMR table (explanation of V_{id} and V_i limits) |
| 31-Aug-2005 | 3 | PPAP references inserted in the datasheet, see Table 1 on page 2. |
| 9-Dec-2005 | 4 | Thermal resistance junction to case data added in Table 1. on page 3 Missing PPAP references inserted in the datasheet, see Table 10: Order codes. |
| 3-Oct-2007 | 5 | Added R_{thja} and R_{thjc} values for DIP8 and DIP14 packages in Table 1. ESD footnotes updated in Table 1: Absolute maximum ratings (AMR). Description section updated on cover page. Markings for automotive grade parts corrected in Table 10: Order codes. |
| 20-Dec-2007 | 6 | Reformatted package information in Section 3: Package information. Footnotes for automotive grade parts corrected in Table 10: Order codes. |
| 06-May-2010 | 7 | Updated package information (drawings and data) in Chapter 3. Removed DIP package order codes from Chapter 4: Ordering information. |
| 19-Sep-2012 | 8 | Updated "Pin connection" figure on page 1 (removed part numbers). Removed TS971ID, TS971YD, TS972ID, TS972YD, TS974ID and TS974YD order code from Table 10. Qualified status of TS971IYLT and TS974IYPT order code in Table 10. Minor corrections throughout document. |
| 19-Jul-2013 | 9 | Added footnote regarding NC to the DFN8 3x3 pinout Table 10: Order codes: removed order code TS971IYDT; added automotive qualification to order code TS972IYPT. |
| 07-Mar-2014 | 10 | Table 3: Electrical characteristics at $V_{CC} = +2.5\text{ V}$, $V_{DD} = -2.5\text{ V}$, $T_{amb} = 25\text{ °C}$ (unless otherwise specified): added parameter "equivalent input noise current" |
| 24-Jun-2016 | 11 | Added package silhouettes to cover page Removed pinouts to Section 1: "Package pin connections" Updated document layout Table 5 : updated "k" parameter in Millimeters, Min. column. Table 6 : moved "aaa" parameter to Typ. column instead of Max. column. Table 7 : removed "0.5" from A1, Millimeters, Max column. Table 10: "Order codes" : removed obsolete order code TS974IYDT, added order code TS972IYQT, removed "tube" packaging. |

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