

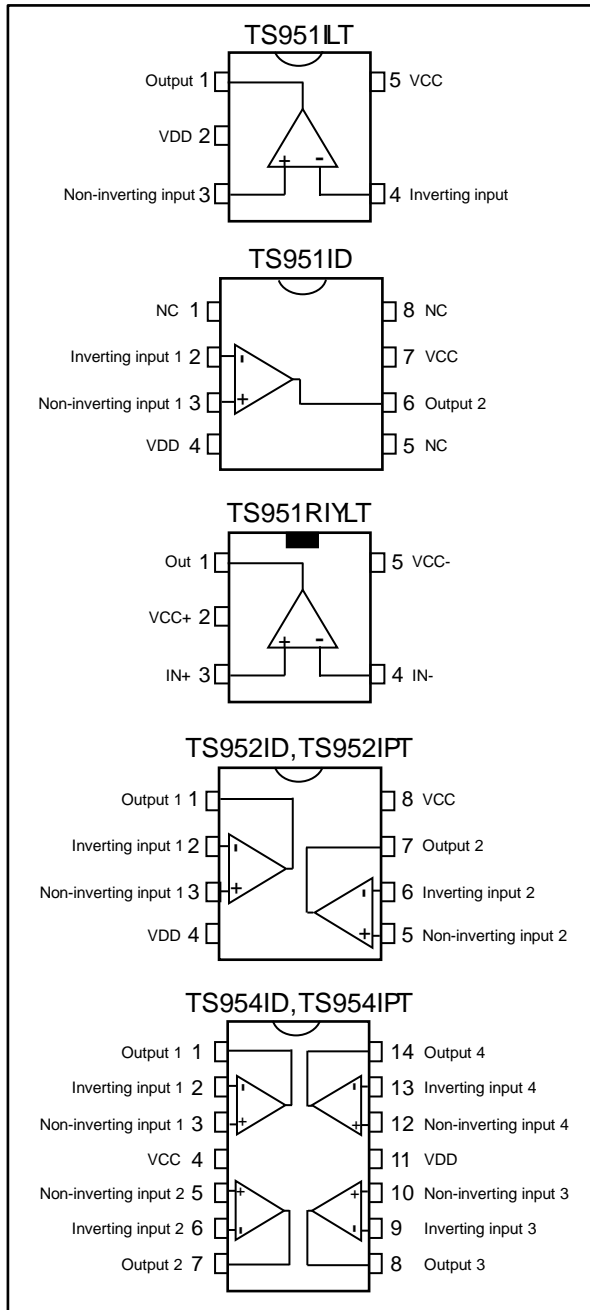


THE DATASHEET OF TS952IN



Input/output rail-to-rail low-power operational amplifiers

Datasheet - production data



Features

- Rail-to-rail input common mode voltage range
- Rail-to-rail output voltage swing
- Operates from 2.7 V to 12 V
- High-speed (3 MHz, 1 V/ μ s)
- Low consumption (0.9 mA at 3 V)
- Supply voltage rejection ratio: 80 dB
- Latch-up immunity
- Available in SOT23-5 micropackage, SO8, TSSOP8, SO14, and TSSOP14 packages

Applications

- Set-top boxes
- Laptop/notebook computers
- Transformer/line drivers
- Personal entertainment (CD players)
- Portable communications (cell phones, pagers)
- Instrumentation and sensors
- Digital-to-analog converter buffers
- Portable headphone speaker drivers

Description

The TS951, TS952, and TS954 family of devices are rail-to-rail BiCMOS operational amplifiers optimized and fully specified for 3 V and 5 V operation.

The TS951 device is housed in the space-saving 5-pin SOT23 package that makes it well suited for battery powered systems. This micropackage simplifies the PC board design because of its ability to be placed in tight spaces (outside dimensions are: 2.8 mm x 2.9 mm).

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1 Absolute maximum ratings and operating conditions

Table 1: Absolute maximum ratings

| Symbol | Parameter | Value | Unit | |
|------------|---|----------------------------------|------|------|
| V_{CC} | Supply voltage ⁽¹⁾ | 14 | 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 | |
| | | SO14 | 103 | |
| | | TSSOP14 | 100 | |
| R_{thjc} | Thermal resistance junction-to-case ⁽⁴⁾ | SOT23-5 | 81 | |
| | | SO8 | 40 | |
| | | TSSOP8 | 37 | |
| | | SO14 | 31 | |
| | | TSSOP14 | 32 | |
| ESD | HBM: human body model ⁽⁵⁾ | TS951 | 1 | kV |
| | | TS952 | 2 | |
| | | TS954 | 3 | |
| | MM: machine model ⁽⁶⁾ | | 120 | V |
| | CDM: charged device model ⁽⁷⁾ | TS951 | 1.5 | kV |
| | | TS952 | 1.5 | |
| TS954 | | 1 | | |
| | Latch-up immunity | 200 | mA | |
| | Lead temperature (soldering, 10 s) | 260 | °C | |

Notes:

⁽¹⁾All voltage values, except differential voltage are with respect to network ground terminal.

⁽²⁾Differential voltages are the non-inverting input terminal with respect to the inverting input terminal. If $V_{id} > \pm 1$ V, the maximum input current must not exceed ± 1 mA. In this case ($V_{id} > \pm 1$ V), an input series resistor must be added to limit input current.

⁽³⁾Do not exceed 14 V.

⁽⁴⁾Short-circuits can cause excessive heating and destructive dissipation. R_{th} are typical values.

⁽⁵⁾Human body model: a 100 pF capacitor is charged to the specified voltage, then discharged through a 1.5 k Ω 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⁾Charged device model: all pins and the 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 12 | V |
| V_{icm} | Common mode input voltage range | $V_{DD} - 0.2$ to $V_{CC} + 0.2$ | |
| T_{oper} | Operating free air temperature range | -40 to 125 | °C |

2 Electrical characteristics

Table 3: Electrical characteristics at $V_{CC} = 3\text{ V}$, $V_{DD} = 0\text{ V}$, R_L connected to $V_{CC}/2$, $T_{amb} = 25\text{ }^\circ\text{C}$ (unless otherwise specified)

| Symbol | Parameter | Min. | Typ. | Max. | Unit |
|--------------------------|--|-------------------------------------|------|------|------------------------------|
| V_{io} | Input offset voltage | | | 6 | mV |
| | $T_{min} \leq T_{amb} \leq T_{max}$ | | | 8 | |
| $\Delta V_{io}/\Delta T$ | Input offset voltage drift | | 2 | | $\mu\text{V}/^\circ\text{C}$ |
| I_{io} | Input offset current | | 1 | 30 | nA |
| | | $T_{min} \leq T_{amb} \leq T_{max}$ | | 80 | |
| I_{ib} | Input bias current | $V_{icm} = V_{CC}/2$ | 35 | 100 | |
| | | $T_{min} \leq T_{amb} \leq T_{max}$ | | 200 | |
| CMR | Common mode rejection ratio | 50 | 80 | | dB |
| SVR | Supply voltage rejection ratio, $V_{CC} = 2.7\text{ V}$ to 3.3 V | 60 | 80 | | |
| A_{vd} | Large signal voltage gain, $V_o = 2 V_{pk-pk}$, $R_L = 600\ \Omega$ | | 80 | | |
| V_{OH} | High level output voltage, $R_L = 600\ \Omega$ | 2.8 | 2.9 | | V |
| V_{OL} | Low level output voltage, $R_L = 600\ \Omega$ | | 80 | 250 | mV |
| I_{sc} | Output short-circuit current | 10 | | | mA |
| I_{CC} | Supply current (per amplifier), no load, $V_{icm} = V_{CC}/2$ | | 0.9 | 1.3 | |
| GBP | Gain bandwidth product, $R_L = 2\text{ k}\Omega$ | | 3 | | MHz |
| SR | Slew rate | | 1 | | V/ μs |
| ϕ_m | Phase margin at unit gain, $R_L = 600\ \Omega$, $C_L = 100\text{ pF}$ | | 60 | | Degrees |
| Gm | Gain margin, $R_L = 600\ \Omega$, $C_L = 100\text{ pF}$ | | 10 | | dB |
| e_n | Equivalent input noise voltage, $f = 1\text{ kHz}$ | | 25 | | $\text{nV}/\sqrt{\text{Hz}}$ |
| THD | Total harmonic distortion, $V_{out} = 4 V_{pk-pk}$, $F = 10\text{ kHz}$, $A_v = 2$, $R_L = 10\text{ k}\Omega$ | | 0.01 | | % |

Table 4: Electrical characteristics at $V_{CC} = 5\text{ V}$, $V_{DD} = 0\text{ V}$, R_L connected to $V_{CC}/2$, $T_{amb} = 25\text{ }^{\circ}\text{C}$ (unless otherwise specified)

| Symbol | Parameter | Min. | Typ. | Max. | Unit |
|--------------------------|--|-------------------------------------|------|------|--------------------------------|
| V_{io} | Input offset voltage | | | 6 | mV |
| | $T_{min} \leq T_{amb} \leq T_{max}$ | | | 8 | |
| $\Delta V_{io}/\Delta T$ | Input offset voltage drift | | 2 | | $\mu\text{V}/^{\circ}\text{C}$ |
| I_{io} | Input offset current | $V_{icm} = V_{CC}/2$ | 1 | 30 | nA |
| | | $T_{min} \leq T_{amb} \leq T_{max}$ | | 80 | |
| I_{ib} | Input bias current | $V_{icm} = V_{CC}/2$ | 35 | 100 | |
| | | $T_{min} \leq T_{amb} \leq T_{max}$ | | 200 | |
| CMR | Common mode rejection ratio | 50 | 80 | | dB |
| SVR | Supply voltage rejection ratio, $V_{CC} = 2.7\text{ V}$ to 3.3 V | 60 | 80 | | |
| A_{vd} | Large signal voltage gain, $V_o = 2 V_{pk-pk}$, $R_L = 600\ \Omega$ | | 86 | | |
| V_{OH} | High level output voltage, $R_L = 600\ \Omega$ | 4.7 | 4.8 | | V |
| V_{OL} | Low level output voltage, $R_L = 600\ \Omega$ | | 80 | 300 | mV |
| I_{sc} | Output short-circuit current | 10 | | | mA |
| I_{CC} | Supply current (per amplifier), no load, $V_{icm} = V_{CC}/2$ | | 0.95 | 1.4 | |
| GBP | Gain bandwidth product, $R_L = 2\text{ k}\Omega$ | | 3 | | MHz |
| SR | Slew rate | | 1 | | $\text{V}/\mu\text{s}$ |
| ϕ_m | Phase margin at unit gain, $R_L = 600\ \Omega$, $C_L = 100\text{ pF}$ | | 60 | | Degrees |
| Gm | Gain margin, $R_L = 600\ \Omega$, $C_L = 100\text{ pF}$ | | 10 | | dB |
| e_n | Equivalent input noise voltage, $f = 1\text{ kHz}$ | | 25 | | $\text{nV}/\sqrt{\text{Hz}}$ |
| THD | Total harmonic distortion, $V_{out} = 4 V_{pk-pk}$, $F = 10\text{ kHz}$, $A_v = 2$, $R_L = 10\text{ k}\Omega$ | | 0.01 | | % |

3 Electrical characteristic curves

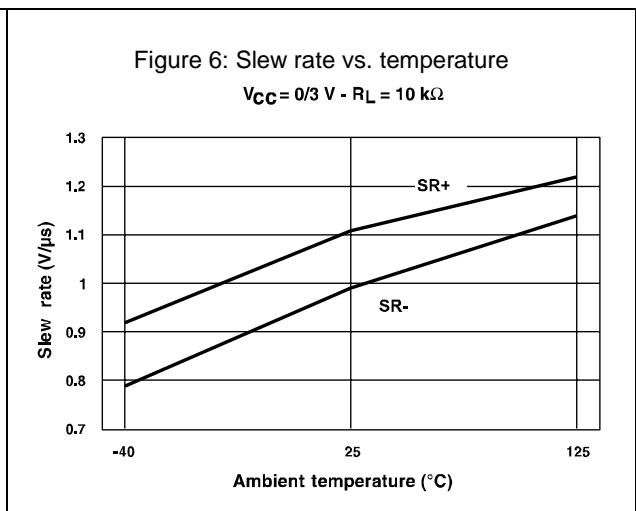
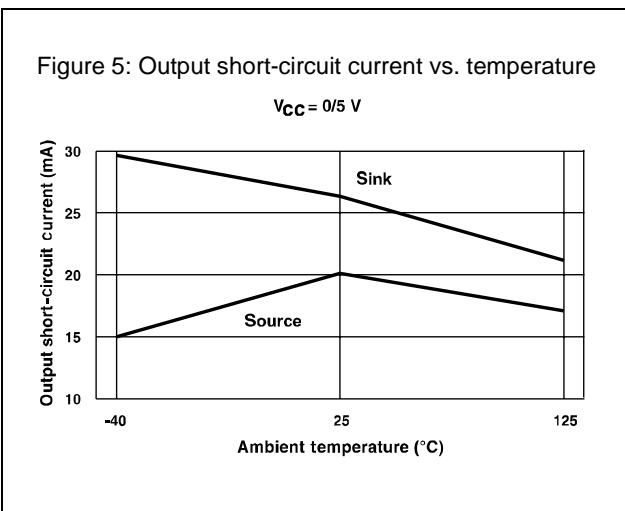
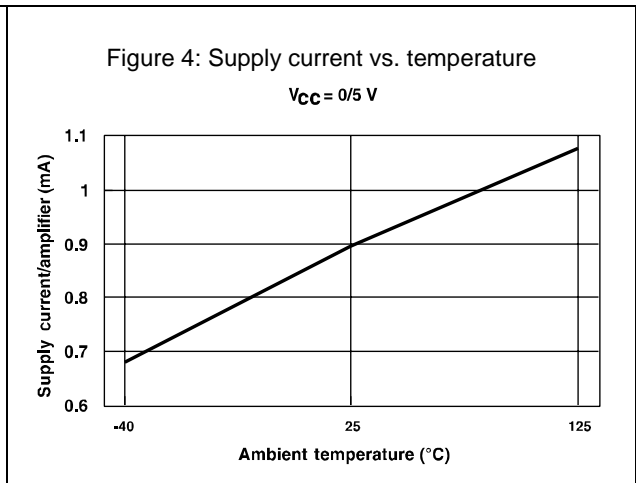
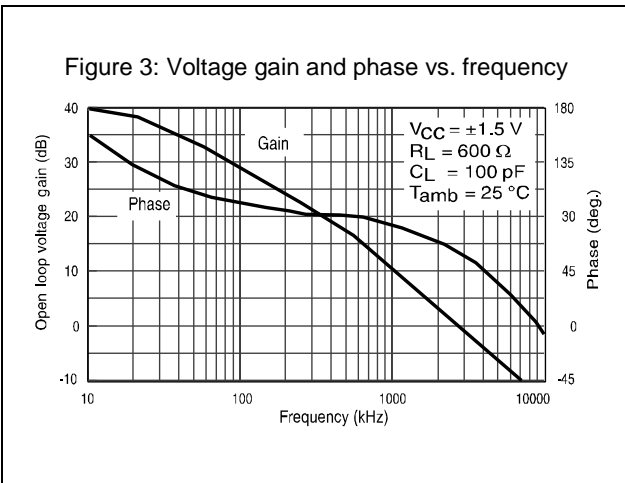
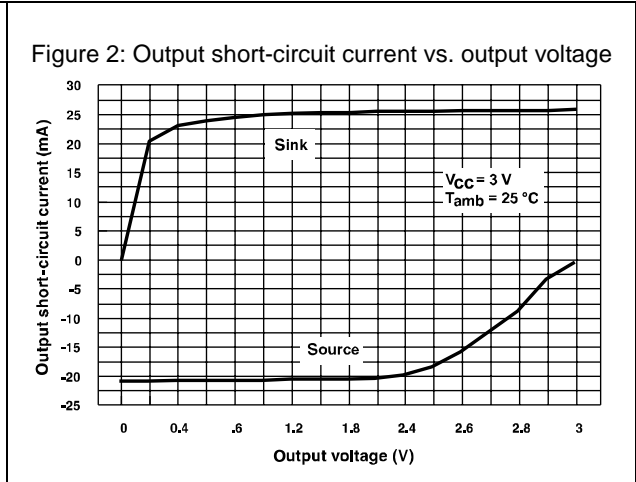
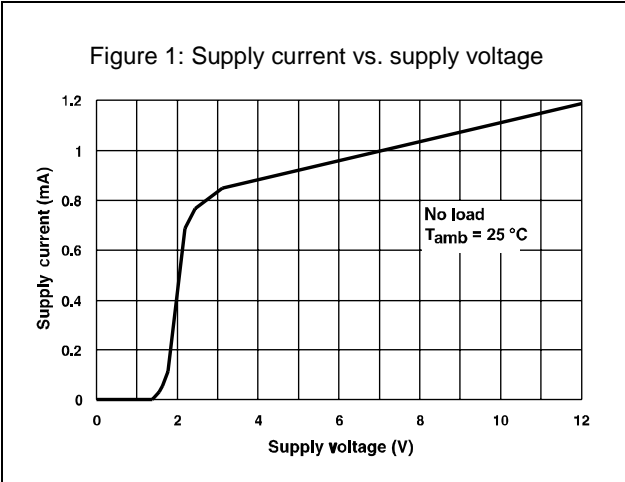


Figure 7: THD + noise vs. Vout (VCC = ± 1.5 V, RL = 600 Ω, f = 1 kHz, G = -1)

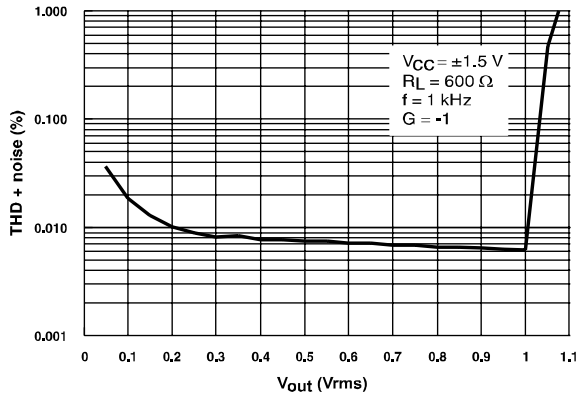


Figure 8: THD + noise vs. frequency

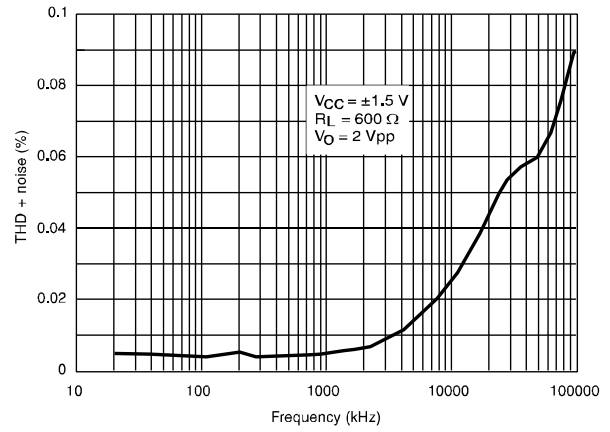


Figure 9: THD + noise vs. Vout (VCC = ± 1.5 V, RL = 2 kΩ, f = 1 kHz, G = -1)

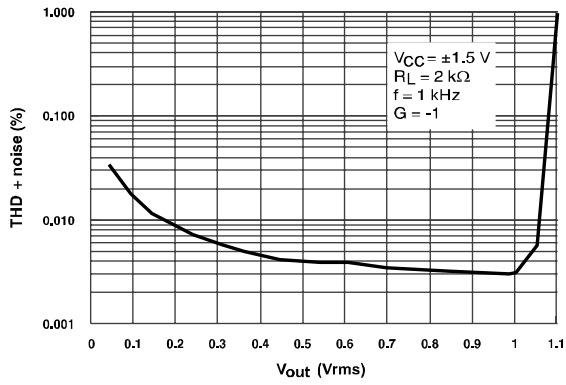
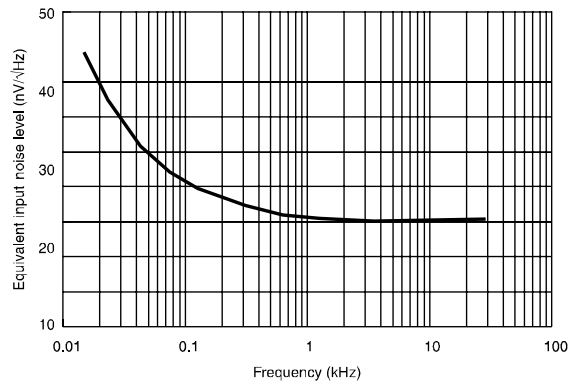


Figure 10: Equivalent input noise level vs. frequency



4 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.

4.1 SOT23-5 package information

Figure 11: SOT23-5 package outline

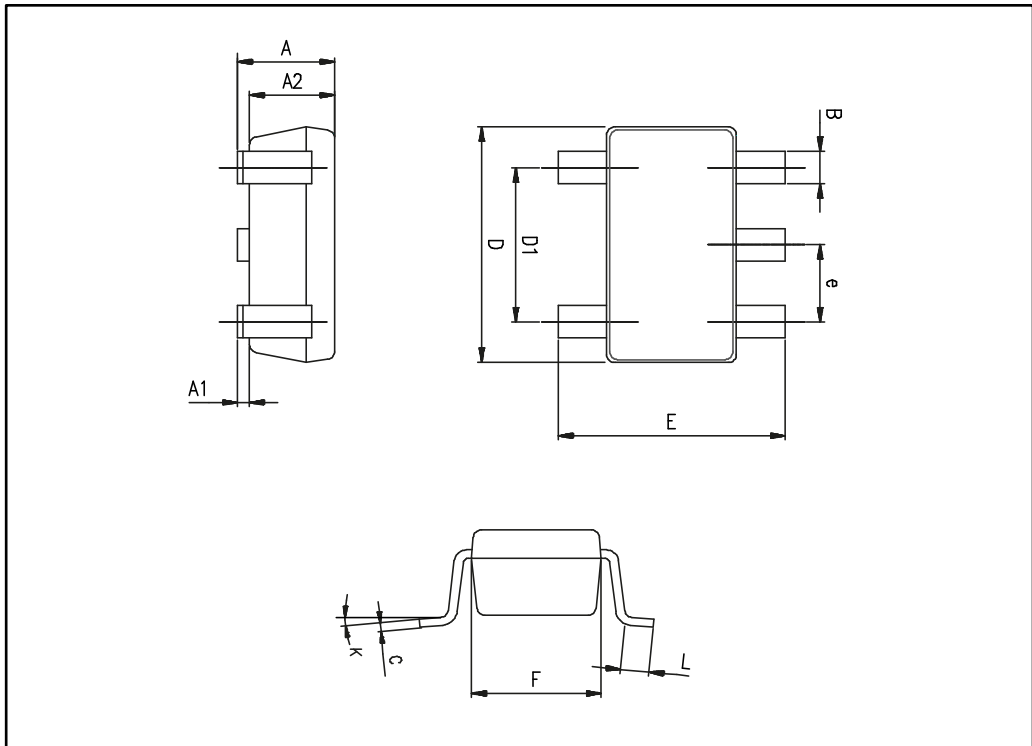


Table 5: SOT23-5 package mechanical data

| 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 |

4.2 SO8 package information

Figure 12: SO8 package outline

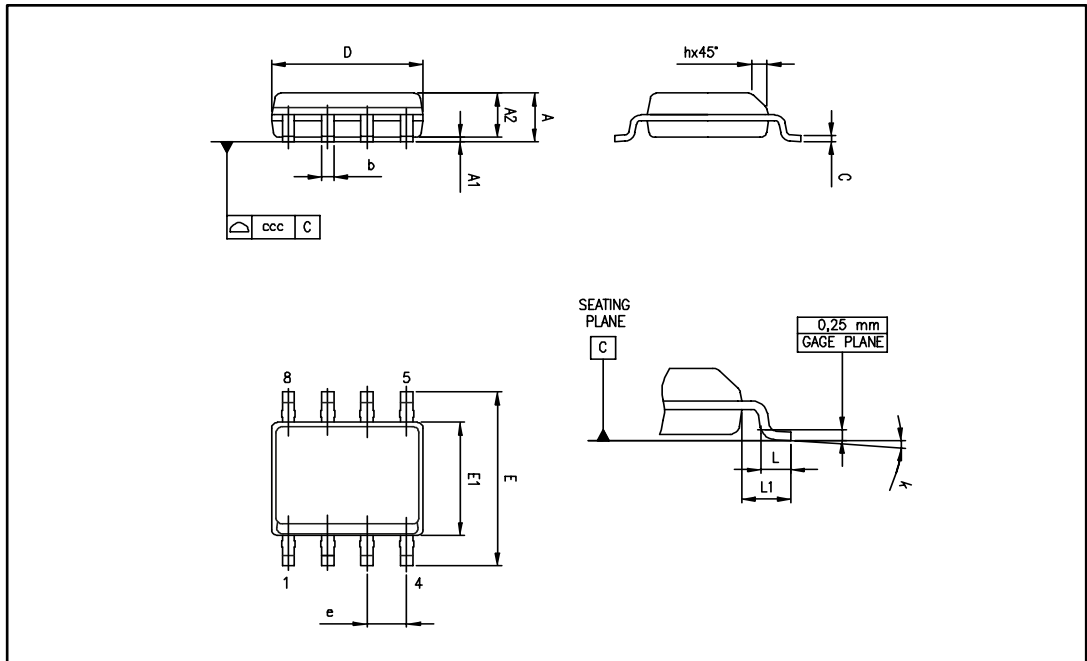


Table 6: SO8 package mechanical data

| 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 |

4.3 TSSOP8 package information

Figure 13: TSSOP8 package outline

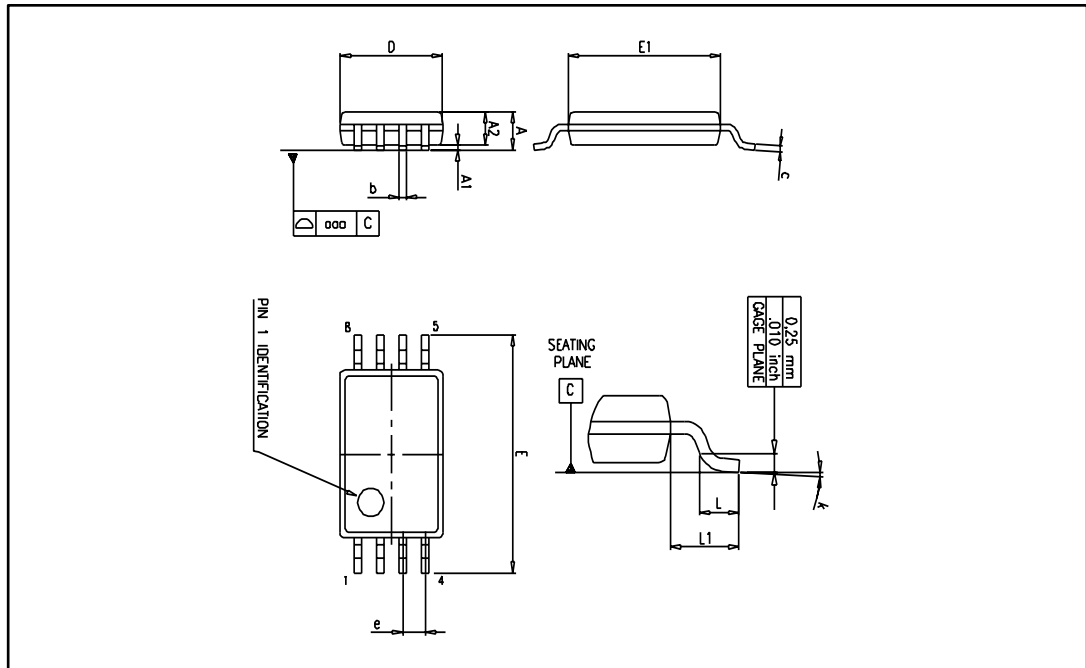


Table 7: TSSOP8 package mechanical data

| 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 | |

4.4 SO14 package information

Figure 14: SO14 package outline

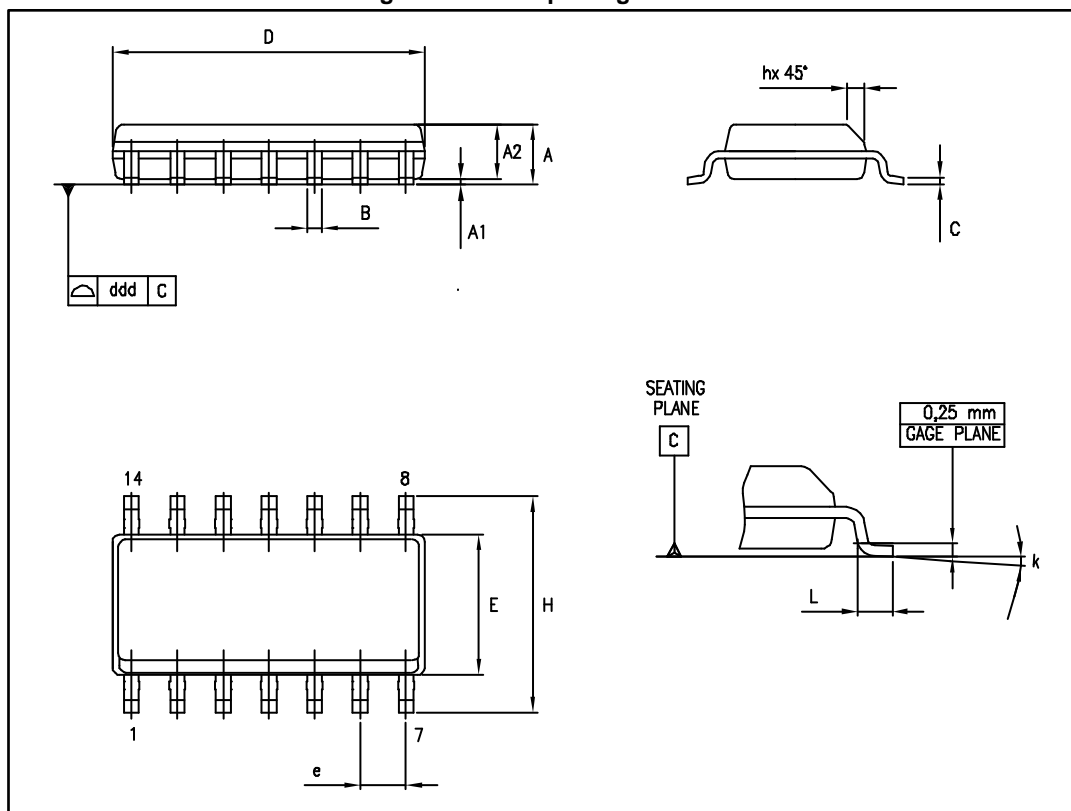


Table 8: SO14 package mechanical data

| 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 |

4.5 TSSOP14 package information

Figure 15: TSSOP14 package outline

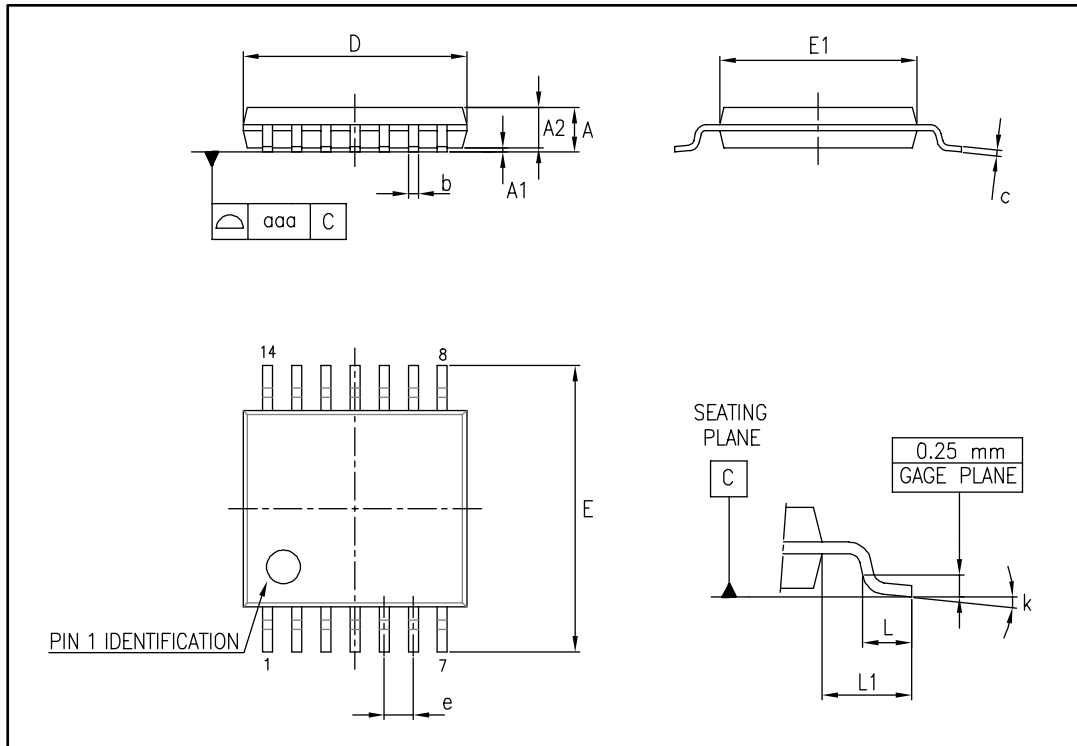


Table 9: TSSOP14 package mechanical data

| 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 |

5 Ordering information

Table 10: Order codes

| Order code | Temperature range | Package | Packaging | Marking |
|--------------------------|-------------------|-------------------------------|---------------|---------|
| TS951IDT | -40 °C to 125 °C | SO8 | Tape and reel | 951I |
| TS951ILT | | SOT23-5 | | K101 |
| TS951IYLT ⁽¹⁾ | | SOT23-5 (automotive grade) | | K102 |
| TS951RIYLT | | | | K103 |
| TS952IDT | | SO8 | | 952I |
| TS952IYDT ⁽¹⁾ | | SO8 (automotive grade) | | 952IY |
| TS952IPT | | TSSOP8 | | 952I |
| TS952IYPT ⁽¹⁾ | | TSSOP8 (automotive grade) | | 952Y |
| TS954IDT | | SO14 | | 954I |
| TS954IYDT ⁽¹⁾ | | SO14 (automotive grade) | | 954IY |
| TS954IPT | | TSSOP14 | | 954I |
| TS954IYPT ⁽¹⁾ | | TSSOP14 (automotive grade) | | 954Y |

Notes:

⁽¹⁾ Qualified and characterized according to AEC Q100 and Q003 or equivalent, advanced screening according to AEC Q001 and Q002 or equivalent.

6 Revision history

Table 11: Document revision history

| Date | Revision | Changes |
|-------------|----------|---|
| 01-May-2001 | 1 | Initial release. |
| 02-Jan-2005 | 2 | Modifications on AMR Table 1: "Absolute maximum ratings" (explanation of V_{id} and V_i limits, ESD MM and CDM values added, R_{thja} added). |
| 03-Jul-2005 | 3 | PPAP references inserted in the datasheet see Table 10: "Order codes" . |
| 04-Aug-2005 | 4 | Table data was badly formatted, see Table 4 . |
| 15-Dec-2005 | 5 | TS951IYLT PPAP reference added, see Table 10: "Order codes" . |
| 10-Dec-2007 | 6 | Added missing order codes, and automotive grade status in Table 10: "Order codes" . Updated footnotes for ESD parameters in Table 1: "Absolute maximum ratings" . Reformatted package information. |
| 10-Mar-2009 | 7 | Removed TS951IN and TS951IYD/DT from Table 10: "Order codes" . |
| 24-Feb-2011 | 8 | Changed TS951IYLT marking and updated automotive grade status in Table 10: "Order codes" . |
| 21-Nov-2012 | 9 | Updated Features (added DIP8, SO-8, TSSOP8, DIP14, SO-14, and TSSOP14 package). Updated Table 1: "Absolute maximum ratings" (added values of DIP8 and DIP14 packages for R_{thja} and R_{thjc} symbols). Updated title of Figure 7 and Figure 9 (added conditions). <i>Note that these figures were subsequently removed in revision 10 below.</i> Updated Table 10: "Order codes" (removed TS952IYD and TS954IYD order code, qualified status of TS954IYPT and TS952IYPT order code). Minor corrections throughout document. |
| 11-Sep-2013 | 10 | Removed DIP8 and DIP14 packages and all information pertaining to them. Table 10: "Order codes" ; updated marking of order code TS951IYLT from K1A2 to K102. |
| 27-Jun-2014 | 11 | Updated ESD(MM) in Table 1: "Absolute maximum ratings" Updated Table 10: "Order codes" |
| 13-Mar-2015 | 12 | Added order code TS951RIYLT throughout document |

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