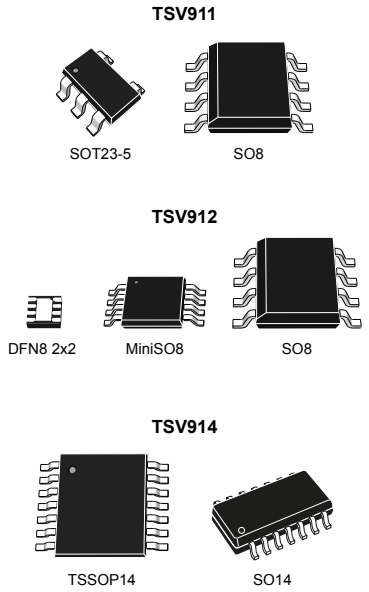
# TSV91x, TSV91xA

Datasheet

## Single, dual, and quad rail-to-rail input/output 8 MHz operational amplifiers




## Features

- Rail-to-rail input and output
- Wide bandwidth
- Low power consumption: 820 µA typ.
- Unity gain stability
- High output current: 35 mA
- Operating from 2.5 V to 5.5 V
- Low input bias current, 1 pA typ.
- Low input offset voltage: 1.5 mV max. (A grade)
- ESD internal protection ≥ 5 kV
- Latch-up immunity

## Applications

- Battery-powered applications
- Portable devices
- Signal conditioning
- Active filtering
- Medical instrumentation
- Automotive applications

| Product status link |
|---|
| TSV911, TSV911A, TSV912, TSV912A, TSV914, TSV914A |

| Related products | |
|---|---|
| See TSV991, TSV992, TSV994 and TSV991A, TSV992A, TSV994A | for higher speed |

## Description

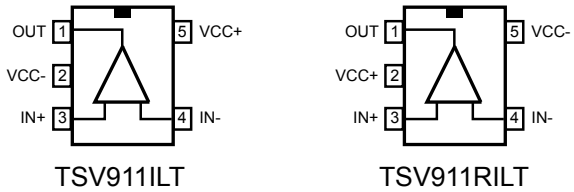
The TSV91x and TSV91xA operational amplifiers (op amps) offer low voltage operation and rail-to-rail input and output, as well as an excellent speed/power consumption ratio, providing an 8 MHz gain-bandwidth product while consuming only 1.1 mA maximum at 5 V. The op amps are unity gain stable and feature an ultra-low input bias current.

The devices are ideal for sensor interfaces, battery-supplied and portable applications, as well as active filtering.

# 1 Package pin connections

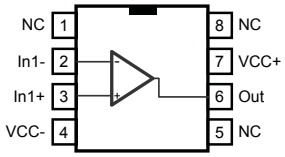
**Figure 1. Pin connections for each package (top view)**

SOT23-5

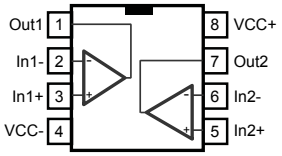



TSV911ILT TSV911RILT

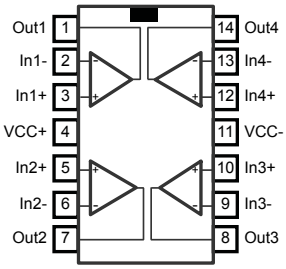
SO8 (single)




MiniSO8, SO8, DFN8 2x2 (dual)




SO14, TSSOP14




1. *The exposed pad of the DFN8 2x2 package is not internally connected and can be set 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] | | 6 | V |
| $V_{id}$ | Differential input voltage [2] | | $\pm V_{CC}$ | |
| $V_{in}$ | Input voltage [3] | | $(V_{CC-}) - 0.2$ to $(V_{CC+}) + 0.2$ | |
| $I_{in}$ | Input current [4] | | 10 | mA |
| $T_{stg}$ | Storage temperature | | -65 to 150 | °C |
| $T_j$ | Maximum junction temperature | | 150 | |
| $R_{thja}$ | Thermal resistance junction to ambient [5] [6] | SOT23-5 | 250 | °C/W |
| | | DFN8 2x2 | 57 | |
| | | SO8 | 125 | |
| | | MiniSO8 | 190 | |
| | | SO14 | 103 | |
| | | TSSOP14 | 100 | |
| $R_{thjc}$ | Thermal resistance junction to case [5] [6] | SOT23-5 | 81 | |
| | | SO8 | 40 | |
| | | MiniSO8 | 39 | |
| | | SO14 | 31 | |
| | | TSSOP14 | 32 | |
| ESD | HBM: human body model [7] | | 5 | kV |
| | MM: machine model [8] | | 400 | V |
| | CDM: charged device model [9] | SOT23-5, SO8, MiniSO8 | 1500 | |
| | | TSSOP14 | 750 | |
| | | SO14 | 500 | |
| | Latch-up immunity | | 200 | mA |

1. *All voltage values, except the 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*
3. *$V_{CC}$ - $V_{IN}$ must not exceed 6 V*
4. *Input current must be limited by a resistor in series with the inputs*
5. *Short-circuits can cause excessive heating and destructive dissipation.*
6. *$R_{th}$ are typical values*
7. *Human body model: 100 pF discharged through a 1.5 kΩ resistor between two pins of the device, done for all couples of pin combinations with other pins floating.*
8. *Machine model: 200 pF charged to the specified voltage, then discharged directly between two pins of the device with no external series resistor (internal resistor < 5 Ω), done for all couples of pin combinations with other pins floating*
9. *Charged device model: all pins plus packages are charged together to the specified voltage and then discharged directly to the ground.*

**Table 2. Operating conditions**

| Symbol | Parameter | | Value | Unit |
|---|---|---|---|---|
| $V_{CC}$ | Supply voltage | -40 °C < $T_{op}$ < 125 °C | 2.5 to 5.5 | V |
| | | 0 °C < $T_{op}$ < 125 °C | 2.3 to 5.5 | |
| $V_{icm}$ | Common mode input voltage range | | ($V_{CC-}$) - 0.1 to ($V_{CC+}$) + 0.1 | |
| $T_{op}$ | Operating free air temperature range | | -40 to 125 | °C |

# 3 Electrical characteristics

**Table 3. Electrical characteristics at $V_{CC+}$ = 2.5 V, $V_{CC-}$ = 0 V, $V_{icm}$ = $V_{CC}$/2, with $R_L$ connected to $V_{CC}$/2, T = 25 °C (unless otherwise specified)**

| Symbol | Parameter | Conditions | Min. | Typ. | Max. | Unit |
|---|---|---|---|---|---|---|
| **DC performance** | | | | | | |
| $V_{io}$ | Offset voltage, TSV91x | $T_{op}$ = 25 °C | | 0.1 | 4.5 | mV |
| | | $T_{min} < T_{op} < T_{max}$ | | | 7.5 | |
| | Offset voltage, TSV91xA | $T_{op}$ = 25 °C | | | 1.5 | |
| | | $T_{min} < T_{op} < T_{max}$ | | | 3 | |
| $\Delta V_{io}/\Delta T$ | Input offset voltage drift | | | 5 | | µV/°C |
| $I_{io}$ | Input offset current (1) | $T_{op}$ = 25 °C | | 1 | 10 | pA |
| | | $T_{min} < T_{op} < T_{max}$ | | | 100 | |
| $I_{ib}$ | Input bias current (1) | $T_{op}$ = 25 °C | | 1 | 10 | |
| | | $T_{min} < T_{op} < T_{max}$ | | | 100 | |
| CMR | Common mode rejection ratio,20 log ($\Delta V_{ic}/\Delta V_{io}$) | 0 V to 2.5 V, $V_{out}$ = 1.25 V, $T_{op}$ = 25 °C | 58 | 75 | | dB |
| | | $T_{min} < T_{op} < T_{max}$ | 53 | | | |
| $A_{vd}$ | Large signal voltage gain | $R_L$ = 10 kΩ, $V_{out}$ = 0.5 V to 2 V, $T_{op}$ = 25 °C | 80 | 89 | | |
| | | $T_{min} < T_{op} < T_{max}$ | 75 | | | |
| $V_{CC}$ - $V_{OH}$ | High-level output voltage | $R_L$ = 10 kΩ | | 15 | 40 | mV |
| | | $T_{min} < T_{op} < T_{max}$ | | | 40 | |
| | | $R_L$ = 600 Ω | | 45 | 150 | |
| | | $T_{min} < T_{op} < T_{max}$ | | | 150 | |
| $V_{OL}$ | Low-level output voltage | $R_L$ = 10 kΩ | | 15 | 40 | |
| | | $T_{min} < T_{op} < T_{max}$ | | | 40 | |
| | | $R_L$ = 600 Ω | | 45 | 150 | |
| | | $T_{min} < T_{op} < T_{max}$ | | | 150 | |
| $I_{out}$ | $I_{sink}$ | $V_o$ = 2.5 V, $T_{op}$ = 25 °C | 18 | 32 | | mA |
| | | $T_{min} < T_{op} < T_{max}$ | 16 | | | |
| | $I_{source}$ | $V_o$ = 0 V, $T_{op}$ = 25 °C | 18 | 35 | | |
| | | $T_{min} < T_{op} < T_{max}$ | 16 | | | |
| $I_{CC}$ | Supply current (per channel) | No load, $V_{out}$ = $V_{CC}$/2 | | 0.78 | 1.1 | |
| | | $T_{min} < T_{op} < T_{max}$ | | | 1.1 | |
| **AC performance** | | | | | | |
| GBP | Gain bandwidth product | $R_L$ = 2 kΩ, $C_L$ = 100 pF, f = 100 kHz, $T_{op}$ = 25 °C | | 8 | | MHz |
| $F_u$ | Unity gain frequency | $R_L$ = 2 kΩ, $C_L$ = 100 pF, $T_{op}$ = 25 °C | | 7.2 | | |
| ϕm | Phase margin | $R_L$ = 2 kΩ, $C_L$ = 100 pF, $T_{op}$ = 25 °C | | 45 | | Degrees |
| $G_m$ | Gain margin | $R_L$ = 2 kΩ, $C_L$ = 100 pF, $T_{op}$ = 25 °C | | 8 | | dB |
| SR | Slew rate | $R_L$ = 2 kΩ, $C_L$ = 100 pF, $A_v$ = 1, $T_{op}$ = 25 °C | | 4.5 | | V/µs |

| Symbol | Parameter | Conditions | Min. | Typ. | Max. | Unit |
|---|---|---|---|---|---|---|
| $e_n$ | Equivalent input noise voltage | f = 10 kHz, $T_{op}$ = 25 °C | | 21 | | nV/√Hz |
| THD+$e_n$ | Total harmonic distortion | G = 1, f = 1 kHz, $R_L$ = 2 kΩ, BW = 22 kHz, $T_{op}$ = 25 °C, $V_{icm}$ = ($V_{CC}$ + 1)/2, $V_{out}$ = 1.1 $V_{pp}$ | | 0.001 | | % |

*1. Guaranteed by design*

**Table 4. Electrical characteristics at $V_{CC+}$ = 3.3 V, $V_{CC-}$ = 0 V, $V_{icm}$ = $V_{CC}$/2, with $R_L$ connected to $V_{CC}$/2, T = 25 °C (unless otherwise specified)**

| Symbol | Parameter | Conditions | Min. | Typ. | Max. | Unit |
|---|---|---|---|---|---|---|
| **DC performance** | | | | | | |
| $V_{io}$ | Offset voltage, TSV91x | $T_{op}$ = 25 °C | | 0.1 | 4.5 | mV |
| | | $T_{min} < T_{op} < T_{max}$ | | | 7.5 | |
| | Offset voltage, TSV91xA | $T_{op}$ = 25 °C | | | 1.5 | |
| | | $T_{min} < T_{op} < T_{max}$ | | | 3 | |
| $\Delta V_{io}/\Delta T$ | Input offset voltage drift | | | 5 | | µV/°C |
| $I_{io}$ | Input offset current (1) | $T_{op}$ = 25 °C | | 1 | 10 | pA |
| | | $T_{min} < T_{op} < T_{max}$ | | | 100 | |
| $I_{ib}$ | Input bias current (1) | $T_{op}$ = 25 °C | | 1 | 10 | |
| | | $T_{min} < T_{op} < T_{max}$ | | | 100 | |
| CMR | Common mode rejection ratio, 20 log ($\Delta V_{ic}/\Delta V_{io}$) | 0 V to 3.3 V, $V_{out}$ = 1.65 V, $T_{op}$ = 25 °C | 60 | 78 | | dB |
| | | $T_{min} < T_{op} < T_{max}$ | 55 | | | |
| $A_{vd}$ | Large signal voltage gain | $R_L$ = 10 kΩ, $V_{out}$ = 0.5 V to 2.8 V, $T_{op}$ = 25 °C | 80 | 89 | | |
| | | $T_{min} < T_{op} < T_{max}$ | 75 | | | |
| $V_{CC}$ - $V_{OH}$ | High-level output voltage | $R_L$ = 10 kΩ | | 15 | 40 | mV |
| | | $T_{min} < T_{op} < T_{max}$ | | | 40 | |
| | | $R_L$ = 600 Ω | | 45 | 150 | |
| | | $T_{min} < T_{op} < T_{max}$ | | | 150 | |
| $V_{OL}$ | Low-level output voltage | $R_L$ = 10 kΩ | | 15 | 40 | |
| | | $T_{min} < T_{op} < T_{max}$ | | | 40 | |
| | | $R_L$ = 600 Ω | | 45 | 150 | |
| | | $T_{min} < T_{op} < T_{max}$ | | | 150 | |
| $I_{out}$ | $I_{sink}$ | $V_o$ = 3.3 V, $T_{op}$ = 25 °C | 18 | 32 | | mA |
| | | $T_{min} < T_{op} < T_{max}$ | 16 | | | |
| | $I_{source}$ | $V_o$ = 0 V, $T_{op}$ = 25 °C | 18 | 35 | | |
| | | $T_{min} < T_{op} < T_{max}$ | 16 | | | |
| $I_{CC}$ | Supply current (per channel) | No load, $V_{out}$ = $V_{CC}$/2 | | 0.8 | 1.1 | |
| | | $T_{min} < T_{op} < T_{max}$ | | | 1.1 | |
| **AC performance** | | | | | | |
| GBP | Gain bandwidth product | $R_L$ = 2 kΩ, $C_L$ = 100 pF, f = 100 kHz, $T_{op}$ = 25 °C | | 8 | | MHz |
| $F_u$ | Unity gain frequency | $R_L$ = 2 kΩ, $C_L$ = 100 pF, $T_{op}$ = 25 °C | | 7.2 | | |
| ϕm | Phase margin | $R_L$ = 2 kΩ, $C_L$ = 100 pF, $T_{op}$ = 25 °C | | 45 | | Degrees |
| $G_m$ | Gain margin | $R_L$ = 2 kΩ, $C_L$ = 100 pF, $T_{op}$ = 25 °C | | 8 | | dB |
| SR | Slew rate | $R_L$ = 2 kΩ, $C_L$ = 100 pF, $A_v$ = 1, $T_{op}$ = 25 °C | | 4.5 | | V/µs |

| Symbol | Parameter | Conditions | Min. | Typ. | Max. | Unit |
|---|---|---|---|---|---|---|
| $e_n$ | Equivalent input noise voltage | f = 10 kHz, $T_{op}$ = 25 °C | | 21 | | nV/√Hz |
| THD+$e_n$ | Total harmonic distortion | G = 1, f = 1 kHz, $R_L$ = 2 kΩ, BW = 22 kHz, $T_{op}$ = 25 °C, $V_{icm}$ = ($V_{CC}$ + 1)/2, $V_{out}$ = 1.9 $V_{pp}$ | | 0.0007 | | % |

*1. Guaranteed by design*

**Table 5. Electrical characteristics at $V_{CC+}$ = 5 V, $V_{CC-}$ = 0 V, $V_{icm}$ = $V_{CC}$/2, with $R_L$ connected to $V_{CC}$/2, T = 25 °C (unless otherwise specified)**

| Symbol | Parameter | Conditions | Min. | Typ. | Max. | Unit |
|---|---|---|---|---|---|---|
| **DC performance** | | | | | | |
| $V_{io}$ | Offset voltage, TSV91x | $T_{op}$ = 25 °C | | 0.1 | 4.5 | mV |
| | | $T_{min} < T_{op} < T_{max}$ | | | 7.5 | |
| | Offset voltage, TSV91xA | $T_{op}$ = 25 °C | | | 1.5 | |
| | | $T_{min} < T_{op} < T_{max}$ | | | 3 | |
| $\Delta V_{io}/\Delta T$ | Input offset voltage drift | | | 5 | | µV/°C |
| $I_{io}$ | Input offset current (1) | $T_{op}$ = 25 °C | | 1 | 10 | pA |
| | | $T_{min} < T_{op} < T_{max}$ | | | 100 | |
| $I_{ib}$ | Input bias current (1) | $T_{op}$ = 25 °C | | 1 | 10 | |
| | | $T_{min} < T_{op} < T_{max}$ | | | 100 | |
| CMR | Common mode rejection ratio, 20 log ($\Delta V_{ic}/\Delta V_{io}$) | 0 V to 5 V, $V_{out}$ = 2.5 V, $T_{op}$ = 25 °C | 62 | 82 | | dB |
| | | $T_{min} < T_{op} < T_{max}$ | 58 | | | |
| SVR | Supply voltage rejection ratio, 20 log ($\Delta V_{CC}/\Delta V_{io}$) | $V_{CC}$ = 2.5 to 5 V | 70 | 86 | | |
| $A_{vd}$ | Large signal voltage gain | $R_L$ = 10 kΩ, $V_{out}$ = 0.5 V to 4.5 V, $T_{op}$ = 25 °C | 80 | 91 | | |
| | | $T_{min} < T_{op} < T_{max}$ | 75 | | | |
| $V_{CC}$ - $V_{OH}$ | High-level output voltage | $R_L$ = 10 kΩ | | 15 | 40 | mV |
| | | $T_{min} < T_{op} < T_{max}$ | | | 40 | |
| | | $R_L$ = 600 Ω | | 45 | 150 | |
| | | $T_{min} < T_{op} < T_{max}$ | | | 150 | |
| $V_{OL}$ | Low-level output voltage | $R_L$ = 10 kΩ | | 15 | 40 | |
| | | $T_{min} < T_{op} < T_{max}$ | | | 40 | |
| | | $R_L$ = 600 Ω | | 45 | 150 | |
| | | $T_{min} < T_{op} < T_{max}$ | | | 150 | |
| $I_{out}$ | $I_{sink}$ | $V_o$ = 5 V, $T_{op}$ = 25 °C | 18 | 32 | | mA |
| | | $T_{min} < T_{op} < T_{max}$ | 16 | | | |
| | $I_{source}$ | $V_o$ = 0 V, $T_{op}$ = 25 °C | 18 | 35 | | |
| | | $T_{min} < T_{op} < T_{max}$ | 16 | | | |
| $I_{CC}$ | Supply current (per channel) | No load, $V_{out}$ = 2.5 V | | 0.78 | 1.1 | |
| | | $T_{min} < T_{op} < T_{max}$ | | | 1.1 | |
| **AC performance** | | | | | | |
| GBP | Gain bandwidth product | $R_L$ = 2 kΩ, $C_L$ = 100 pF, f = 100 kHz, $T_{op}$ = 25 °C | | 8 | | MHz |
| $F_u$ | Unity gain frequency | $R_L$ = 2 kΩ, $C_L$ = 100 pF, $T_{op}$ = 25 °C | | 7.5 | | |
| ϕm | Phase margin | $R_L$ = 2 kΩ, $C_L$ = 100 pF, $T_{op}$ = 25 °C | | 45 | | Degrees |
| $G_m$ | Gain margin | $R_L$ = 2 kΩ, $C_L$ = 100 pF, $T_{op}$ = 25 °C | | 8 | | dB |

| Symbol | Parameter | Conditions | Min. | Typ. | Max. | Unit |
|---|---|---|---|---|---|---|
| SR | Slew rate | $R_L$ = 2 kΩ, $C_L$ = 100 pF, $A_v$ = 1, $T_{op}$ = 25 °C | | 4.5 | | V/µs |
| $e_n$ | Equivalent input noise voltage | f = 1 kHz, $T_{op}$ = 25 °C | | 27 | | nV/√Hz |
| | | f = 10 kHz, $T_{op}$ = 25 °C | | 21 | | |
| THD+$e_n$ | Total harmonic distortion | G = 1, f = 1 kHz, $R_L$ = 2 kΩ, BW = 22 kHz, $T_{op}$ = 25 °C, $V_{icm}$ = ($V_{CC}$ + 1)/2, $V_{out}$ = 3.6 $V_{pp}$ | | 0.0004 | | % |

1. *Guaranteed by design*

# 4 Electrical characteristic curves

**Figure 2. Input offset voltage distribution at T = 25 °C**

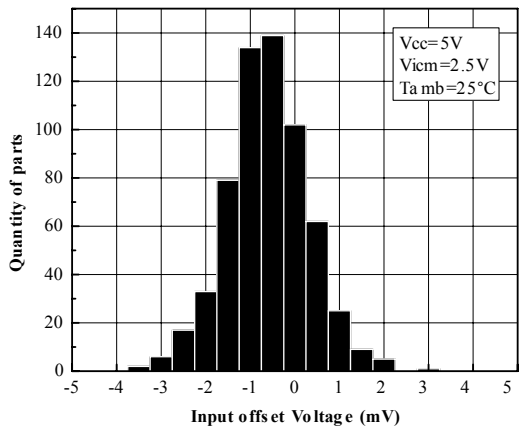



**Figure 3. Input offset voltage distribution at T = 125 °C**

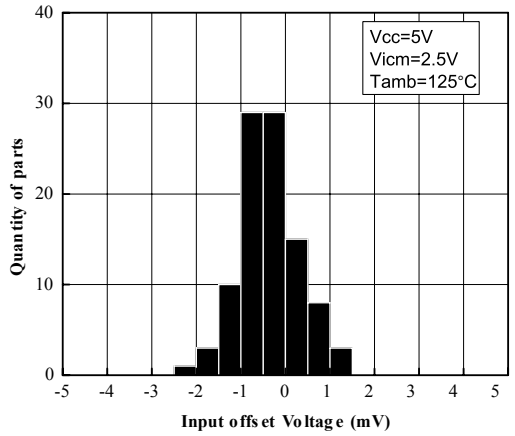



**Figure 4. Supply current vs. input common-mode voltage at $V_{CC}$ = 2.5 V**

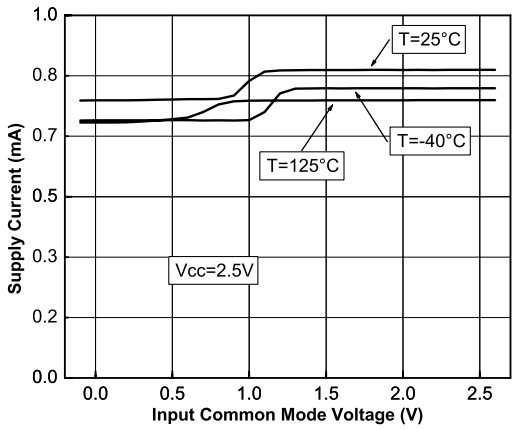



**Figure 5. Supply current vs. input common-mode voltage at $V_{CC}$ = 5 V**

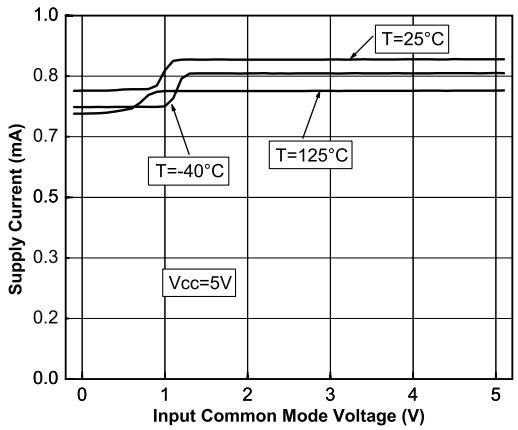



**Figure 6. Output current vs. output voltage at $V_{CC}$ = 2.5 V**

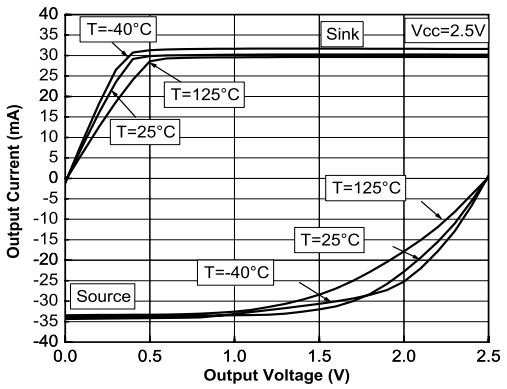



**Figure 7. Output current vs. output voltage at $V_{CC}$ = 5 V**

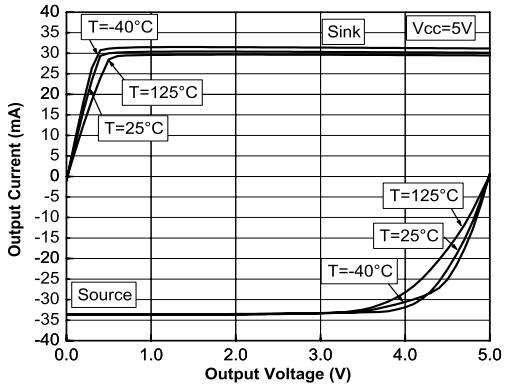


**Figure 8. Voltage gain and phase vs. frequency at $V_{CC}$ = 2.5 V and $V_{icm}$ = 0.5 V**

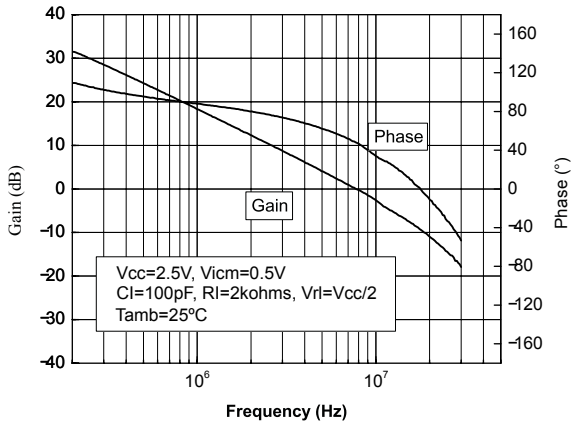



**Figure 9. Voltage gain and phase vs. frequency at $V_{CC}$ = 5.5 V and $V_{icm}$ = 0.5 V**

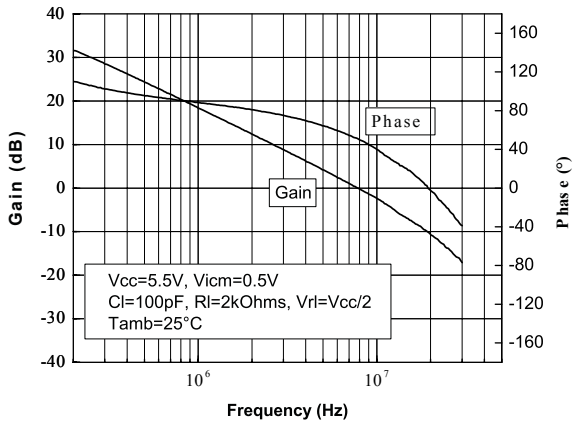



**Figure 10. Phase margin vs. capacitive load**

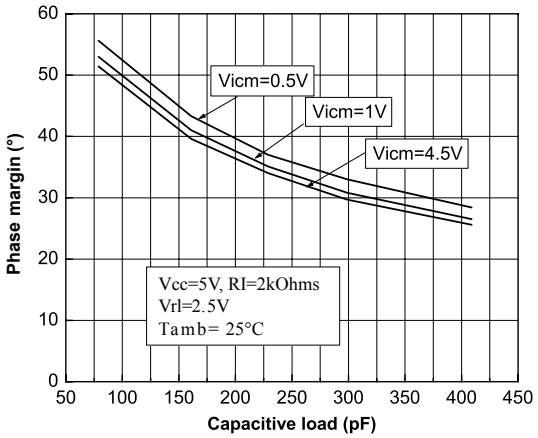



**Figure 11. Phase margin vs. output current**

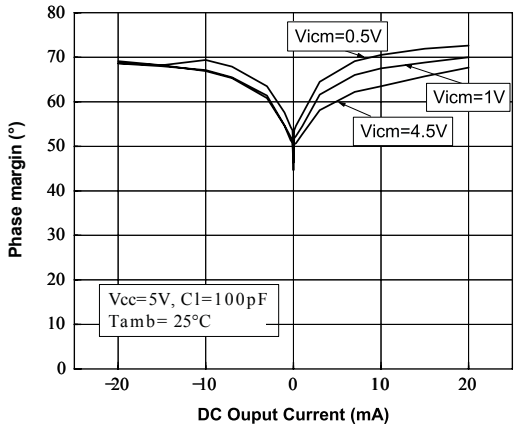



**Figure 12. Positive slew rate**

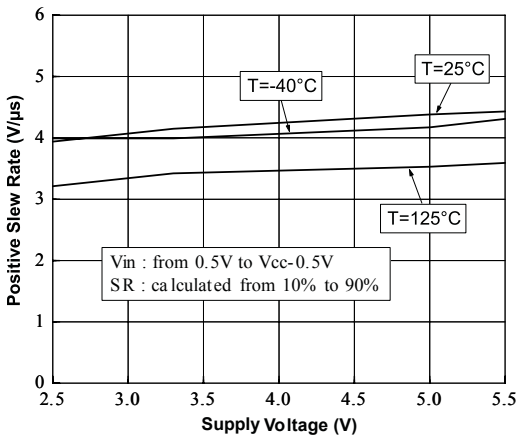



**Figure 13. Negative slew rate**

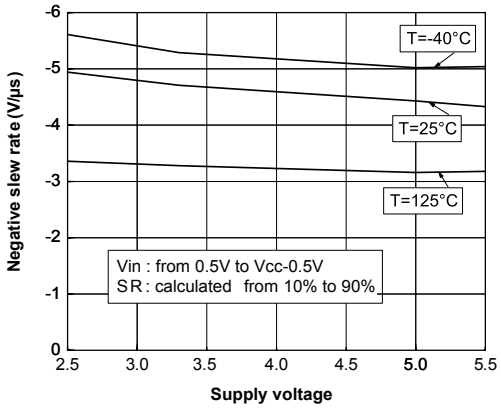


**Figure 14. Distortion + noise vs. frequency**

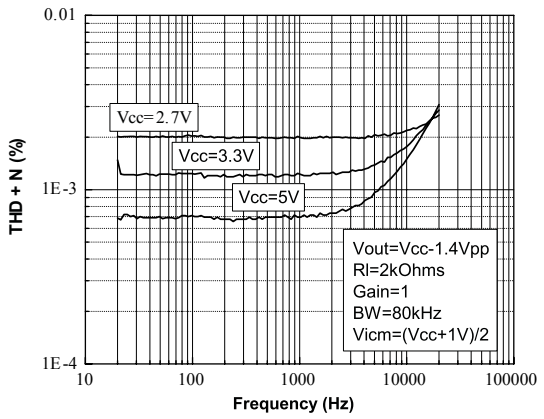



**Figure 15. Distortion + noise vs. output voltage**

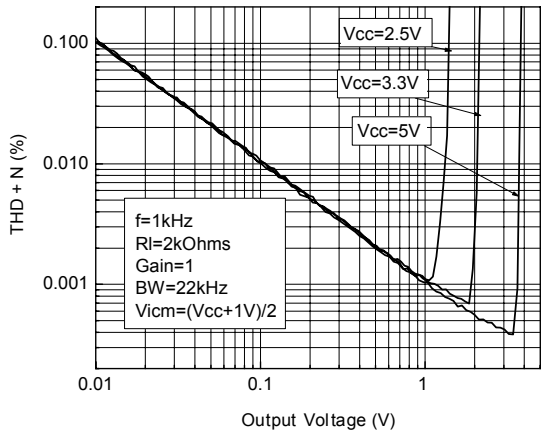



**Figure 16. Noise vs. frequency**

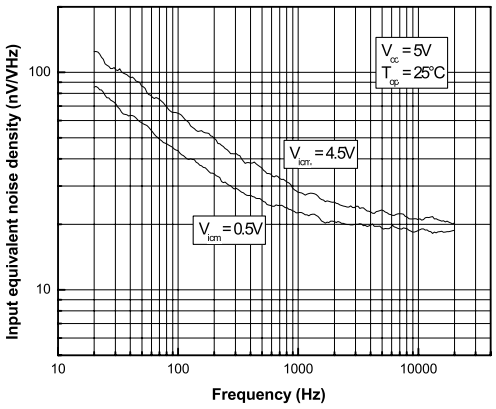



**Figure 17. Phase margin vs. capacitive load and serial resistor**

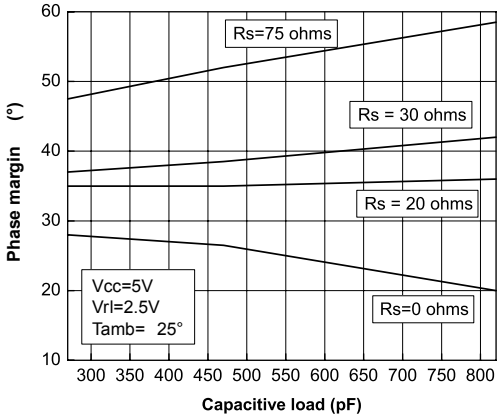
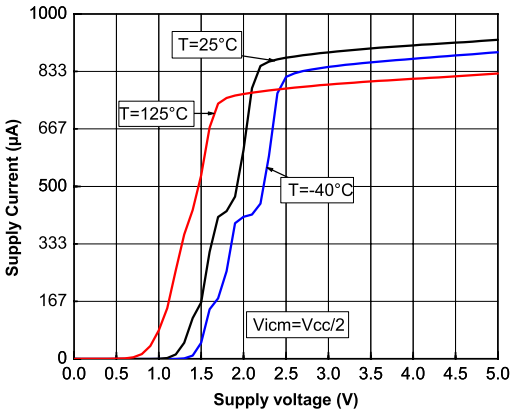



**Figure 18. Supply current vs. supply voltage**



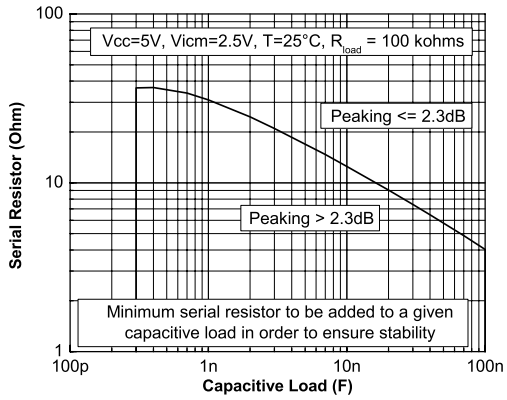
# 5 Application information

## 5.1 Driving resistive and capacitive loads

These products are low-voltage, low-power operational amplifiers optimized to drive rather large resistive loads above 2 kΩ.

In a *follower* configuration, these operational amplifiers can drive capacitive loads up to 100 pF with no oscillations. When driving larger capacitive loads, adding a small in-series resistor at the output can improve the stability of the device (figure below shows the recommended in-series resistor values). Once the in-series resistor value has been selected, the stability of the circuit should be tested on bench and simulated with the simulation model.

**Figure 19. In-series resistor vs. capacitive load**




## 5.2 PCB layouts

For correct operation, it is advised to add 10 nF decoupling capacitors as close as possible to the power supply pins.

## 5.3 Macromodel

An accurate macromodel of the TSV91x is available on STMicroelectronics' web site at: ***www.st.com*** . This model is a trade-off between accuracy and complexity (that is, time simulation) of the TSV91x operational amplifiers. It emulates the nominal performances of a typical device within the specified operating conditions mentioned in the datasheet. It helps to validate a design approach and to select the right operational amplifier, *but it does not* replace on-board measurements.

# 6 Package information

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.

## 6.1 SOT23-5 package information

**Figure 20. SOT23-5 package outline**

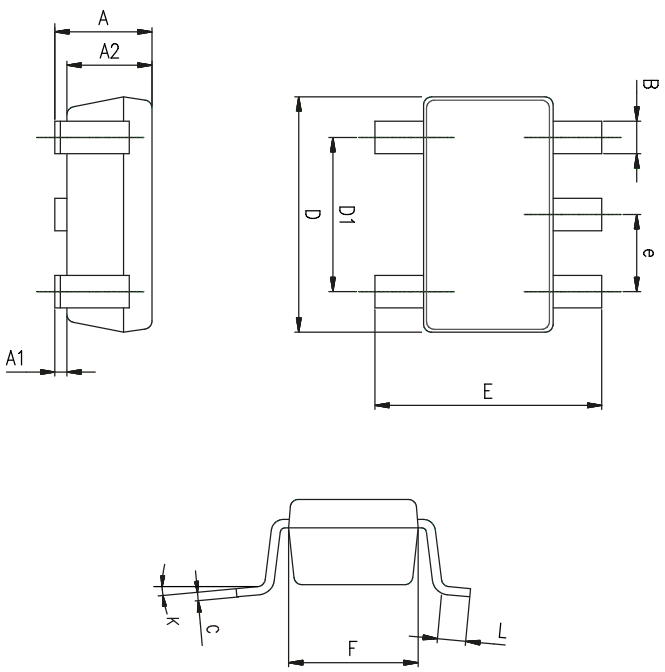



**Table 6. SOT23-5 mechanical data**

| 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 |

## 6.2 DFN8 2 x 2 package information

Figure 21. DFN8 2 x 2 package outline

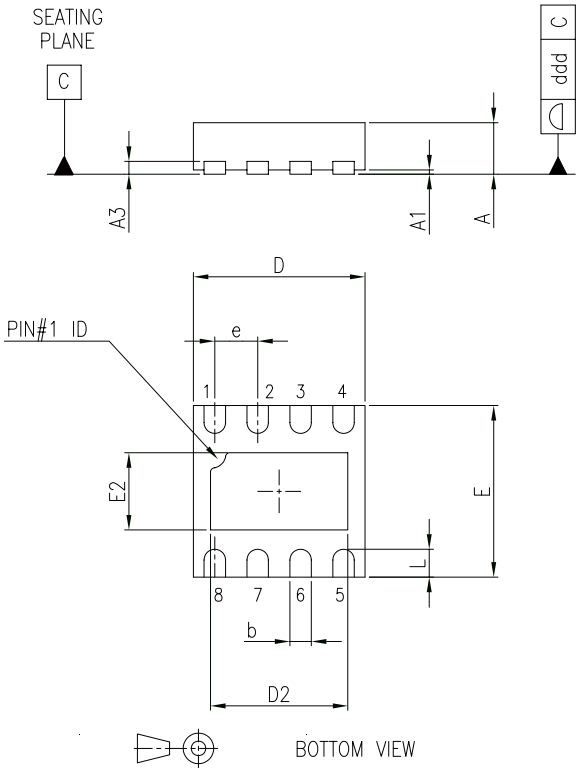
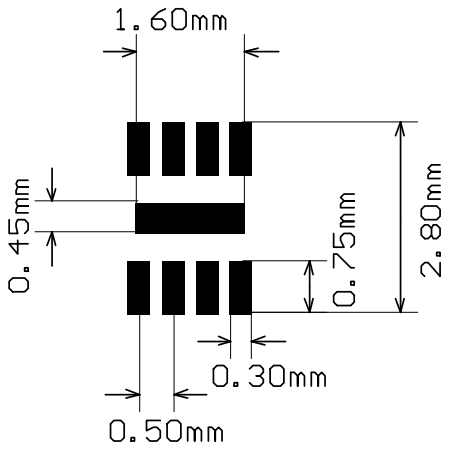



Table 7. DFN8 2 x 2 mechanical data

| Ref. | Dimensions | | | | | |
|---|---|---|---|---|---|---|
| | Millimeters | | | Inches | | |
| | Min. | Typ. | Max. | Min. | Typ. | Max. |
| A | 0.51 | 0.55 | 0.60 | 0.020 | 0.022 | 0.024 |
| A1 | | | 0.05 | | | 0.002 |
| A3 | | 0.15 | | | 0.006 | |
| b | 0.18 | 0.25 | 0.30 | 0.007 | 0.010 | 0.012 |
| D | 1.85 | 2.00 | 2.15 | 0.073 | 0.079 | 0.085 |
| D2 | 1.45 | 1.60 | 1.70 | 0.057 | 0.063 | 0.067 |
| E | 1.85 | 2.00 | 2.15 | 0.073 | 0.079 | 0.085 |
| E2 | 0.75 | 0.90 | 1.00 | 0.030 | 0.035 | 0.039 |
| e | | 0.50 | | | 0.020 | |
| L | | | 0.425 | | | 0.017 |
| ddd | | | 0.08 | | | 0.003 |

Figure 22. **DFN8 2 x 2 recommended footprint**




*Note:* *The exposed pad of the DFN8 2x2 package is not internally connected. It can be set to $V_{CC}^-$ or left floating.*

## 6.3 MiniSO8 package information

Figure 23. MiniSO8 package outline

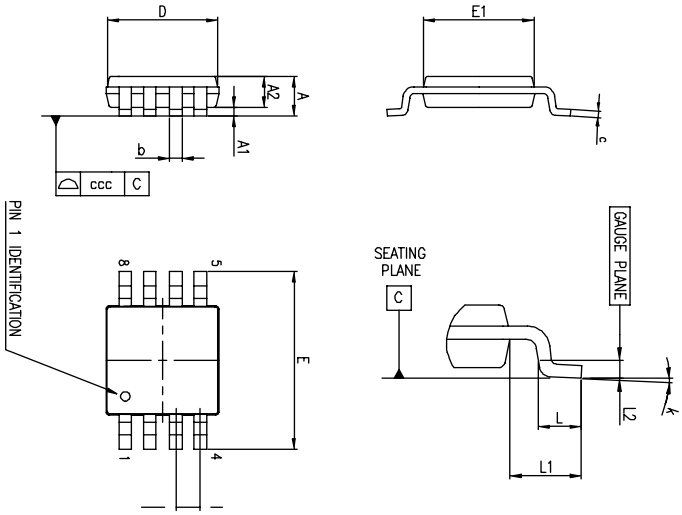



Table 8. MiniSO8 package mechanical data

| Ref. | Dimensions | | | | | |
|---|---|---|---|---|---|---|
| | Millimeters | | | Inches | | |
| | Min. | Typ. | Max. | Min. | Typ. | Max. |
| A | | | 1.1 | | | 0.043 |
| A1 | 0 | | 0.15 | 0 | | 0.0006 |
| A2 | 0.75 | 0.85 | 0.95 | 0.030 | 0.033 | 0.037 |
| b | 0.22 | | 0.40 | 0.009 | | 0.016 |
| c | 0.08 | | 0.23 | 0.003 | | 0.009 |
| D | 2.80 | 3.00 | 3.20 | 0.11 | 0.118 | 0.126 |
| E | 4.65 | 4.90 | 5.15 | 0.183 | 0.193 | 0.203 |
| E1 | 2.80 | 3.00 | 3.10 | 0.11 | 0.118 | 0.122 |
| e | | 0.65 | | | 0.026 | |
| L | 0.40 | 0.60 | 0.80 | 0.016 | 0.024 | 0.031 |
| L1 | | 0.95 | | | 0.037 | |
| L2 | | 0.25 | | | 0.010 | |
| k | 0° | | 8° | 0° | | 8° |
| ccc | | | 0.10 | | | 0.004 |

## 6.4 SO8 package information

Figure 24. SO8 package outline

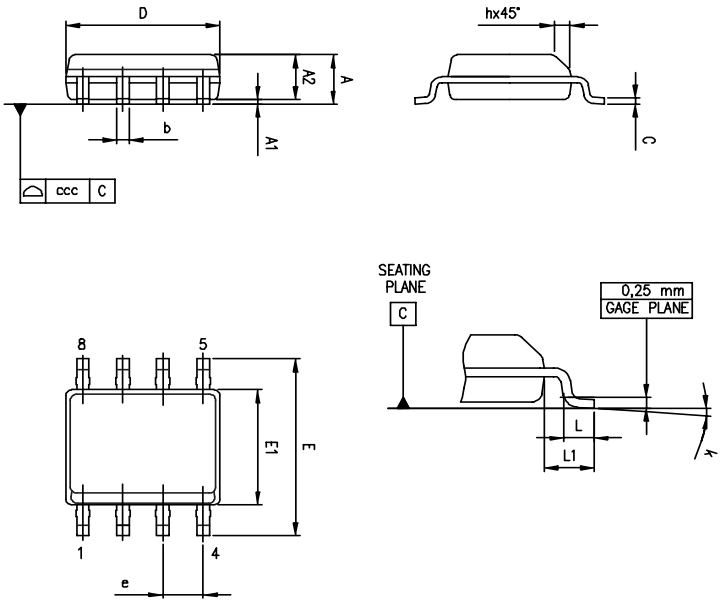



Table 9. SO8 package mechanical data

| 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 | 0° | | 8° | 0° | | 8° |
| ccc | | | 0.10 | | | 0.004 |

## 6.5 TSSOP-14 package information

Figure 25. **TSSOP-14 package outline**

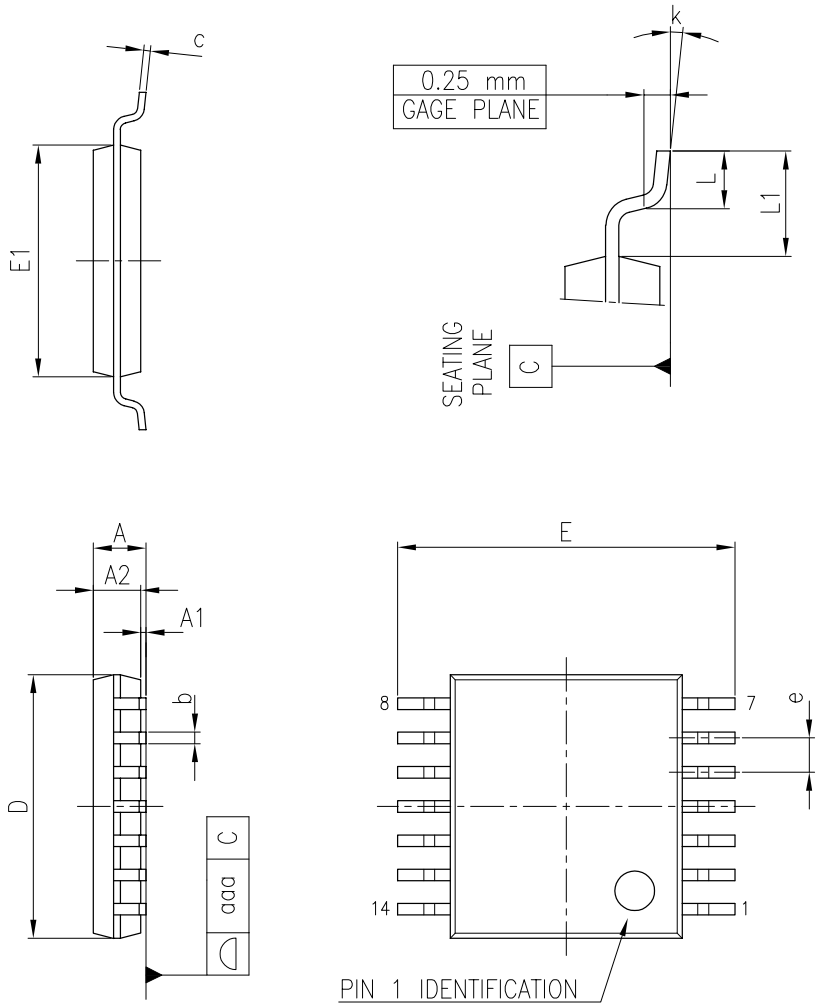
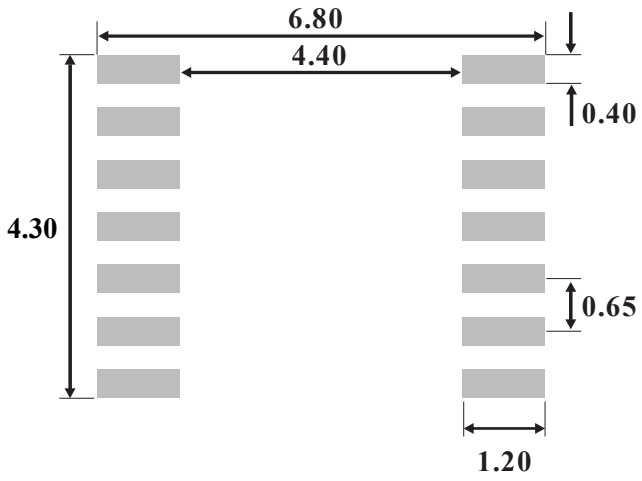


**Table 10. TSSOP-14 package mechanical data**

| Dim. | Dimension | | | | | |
|---|---|---|---|---|---|---|
| | Millimeters | | | Inches | | |
| | Min. | Typ. | Max. | Min. | Typ. | Max. |
| A | | | 1.20 | | | 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 | 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 | 0.177 |
| e | 0.65 BSC | | | 0.25 BSC | | |
| L | 0.45 | 0.60 | 0.75 | 0.018 | 0.024 | 0.030 |
| L1 | | 1.00 | | | 0.039 | |
| k | 8° (max) | | | | | |
| aaa | | | 0.10 | | | 0.004 |

**Figure 26. TSSOP-14 recommended footprint**



## 6.6 SO-14 package information

Figure 27. SO-14 package outline

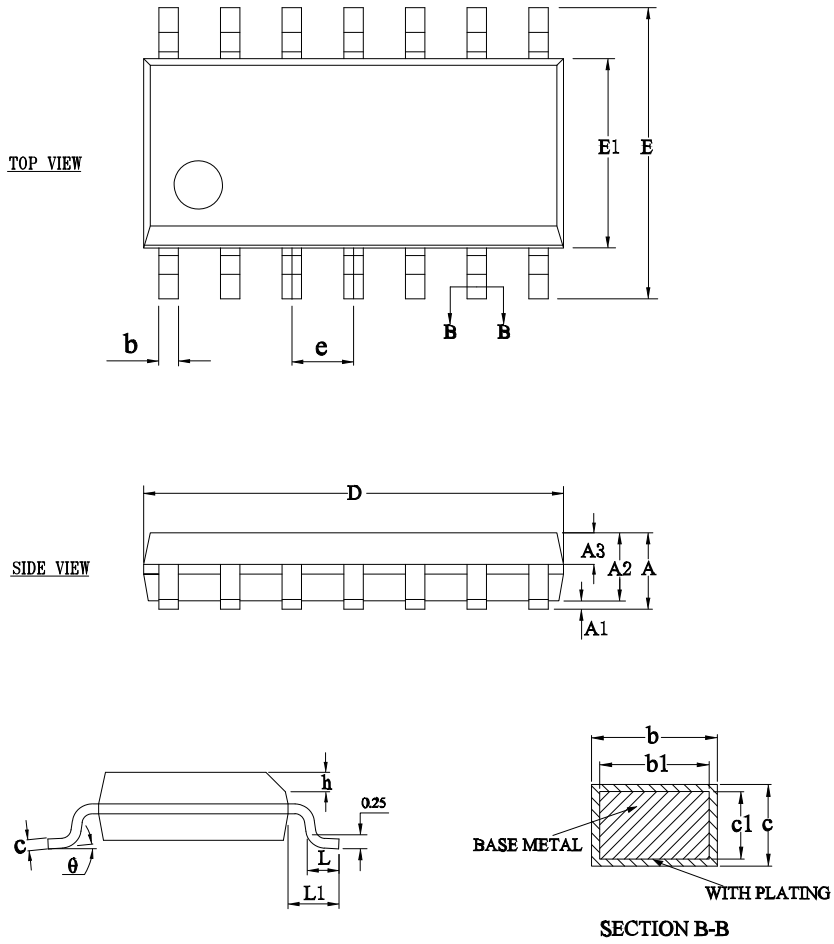
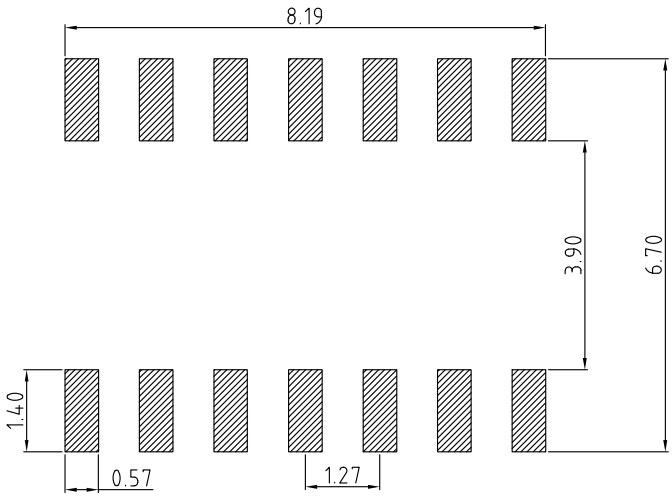


**Table 11. SO-14 package mechanical data**

| Dim. | Dimensions | | | | | |
|---|---|---|---|---|---|---|
| | Millimeters | | | Inches | | |
| | Min. | Typ. | Max. | Min. | Typ. | Max. |
| A | | | 1.75 | | | 0.069 |
| A1 | 0.10 | | 0.225 | 0.004 | | 0.009 |
| A2 | 1.30 | 1.40 | 1.50 | 0.051 | 0.055 | 0.059 |
| A3 | 0.60 | 0.65 | 0.70 | 0.024 | 0.026 | 0.028 |
| b | 0.39 | | 0.47 | 0.015 | | 0.019 |
| b1 | 0.38 | 0.41 | 0.44 | 0.015 | 0.016 | 0.017 |
| c | 0.20 | | 0.24 | 0.008 | | 0.009 |
| c1 | 0.19 | 0.20 | 0.21 | 0.0075 | 0.0079 | 0.0083 |
| D | 8.55 | 8.65 | 8.75 | 0.337 | 0.341 | 0.344 |
| 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 BSC | | | 0.050 BSC | | |
| h | 0.25 | | 0.50 | 0.010 | | 0.020 |
| L | 0.50 | | 0.80 | 0.020 | | 0.031 |
| L1 | 1.05 REF | | | 0.041 REF | | |
| θ | 8° (max) | | | | | |

**Figure 28. SO-14 recommended footprint**



# 7 Ordering information

**Table 12. Order codes**

| Order code | Temperature range | Package | Packing | Marking |
|---|---|---|---|---|
| TSV911IDT | -40 °C to 125 °C | SO8 | Tape and reel | V911I |
| TSV911AIDT | | | | V911AI |
| TSV911ILT | | SOT23-5 | | K127 |
| TSV911AILT | | | | K128 |
| TSV911RILT | | | | K125 |
| TSV912IST | | MiniSO8 | | K125 |
| TSV912AIST | | | | K126 |
| TSV912IDT | | SO8 | | V912I |
| TSV912AIDT | | | | V912AI |
| TSV912IQ2T | | DFN8 2x2 | | K1Q |
| TSV914IPT | | TSSOP14 | | V914I |
| TSV914AIPT | | | | V914AI |
| TSV914IDT | | SO14 | | V914I |
| TSV914AIDT | | | | V914AI |
| TSV911IYLT (1) | | SOT23-5, automotive grade | | K147 |
| TSV911AIYLT (1) | | | | K148 |
| TSV911IYDT (1) | | SO-8, automotive grade | | V911IY |
| TSV911AIYDT (1) | | | | V911AIY |
| TSV912IYDT (1) | | | | V912IY |
| TSV912AIYDT (1) | | | | V912AIY |
| TSV912IYST (1) | | MiniSO8, automotive grade | | K147 |
| TSV912AIYST (1) | | | | K148 |
| TSV914IYDT (1) | | SO14, automotive grade | | V914IY |
| TSV914AIYDT (1) | | | | V914AIY |
| TSV914IYPT (1) | | TSSOP14, automotive grade | | V914IY |
| TSV914AIYPT (1) | | | | V914AIY |

1. *Qualification and characterization according to AEC Q100 and Q003 or equivalent, advanced screening according to AEC Q001 & Q 002 or equivalent.*

## Revision history

**Table 13. Document revision history**

| Date | Revision | Changes |
|---|---|---|
| 28-Aug-2006 | 1 | First release. |
| 07-Jun-2007 | 2 | Modified ESD CDM parameter for SO-14 package in Table 2: Absolute maximum ratings.<br>Noise parameters updated in Section 2: Electrical characteristics.<br>Added limits in temperature in Section 2: Electrical characteristics.<br>Added automotive grade level description in Table 13: Order codes.<br>Added footnote about SO-14 package in Table 13: Order codes.<br>Added Figure 16: Phase margin vs. capacitive load and serial resistor. |
| 11-Feb-2008 | 3 | Updated footnotes for ESD parameters in Table 2: Absolute maximum ratings.<br>Corrected MiniSO-8 package information in Table 9: MiniSO-8 package mechanical data.<br>Added missing markings for order codes TSV911AILT and TSV912AILT in Table 13: Order codes. |
| 22-Jun-2009 | 4 | Added input current information in Table 2: Absolute maximum ratings.<br>Changed Figure 7 and Figure 8.<br>Added Chapter 3: Application information.<br>Updated package information in Chapter 4.<br>Added automotive order codes: TSV911IYLT, TSV911AIYLT, TSV912IYST, TSV912AIYST, TSV914IYPT and TSV914AIYPT in Table 13: Order codes. |
| 17-Sep-2009 | 5 | Added A versions of devices in title on cover page.<br>Modified ESD value for machine model in Table 2: Absolute maximum ratings.<br>Added Figure 17: Supply current vs. supply voltage on page 10. |
| 18-Mar-2010 | 6 | Added TSV911RILT in Table 13: Order codes, housed in a SOT23-5 package with a new pinout. |
| 24-Jun-2010 | 7 | Added pin connections for TSV911ILT and TSV91RILT on cover page.<br>Added Table 1: Device summary on cover page.<br>Modified supply voltage value in Table 3.<br>Corrected typical value of $DV_{io}$ in Table 4, Table 5 and Table 6.<br>Added TSV911RILT, TSV911IYDT and TSV911AIYDT order codes in Table 13.<br>Modified Note 2 under Table 13. |
| 06-Mar-2012 | 8 | Added DFN8 2x2 package and ordering information for TSV912 device to Chapter 4 and Chapter 5. |
| 27-Nov-2015 | 9 | Updated layout<br>Section 2: replaced $DV_{io}/DT$ by $\Delta V_{io}/\Delta T$.<br>Section 5.2: updated name of package and title of drawings and table; added note about exposed pad.<br>Table 13: "Order codes": removed obsolete order codes (TSV911ID, TSV911AID, TSV912ID, TSV912AID, TSV914ID, TSV914AID). |
| 29-Aug-2016 | 10 | Added silhouettes of packages to cover page<br>Placed pinout diagrams in Section 2: "Package pin connections"<br>Added Related products<br>Description: added footnote 1<br>Section 7.2: "DFN8 2 x 2 package information": modified note about the exposed pad.<br>Section 8: "Ordering information": removed note regarding "moisture<br>sensitivity level 1" |
| 10-Oct-2019 | 11 | Updated Table 12. Order codes. |
| 20-Nov-2019 | 12 | Updated cover page. |

| Date | Revision | Changes |
|---|---|---|
| 09-May-2025 | 13 | Updated Figure 15. |

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