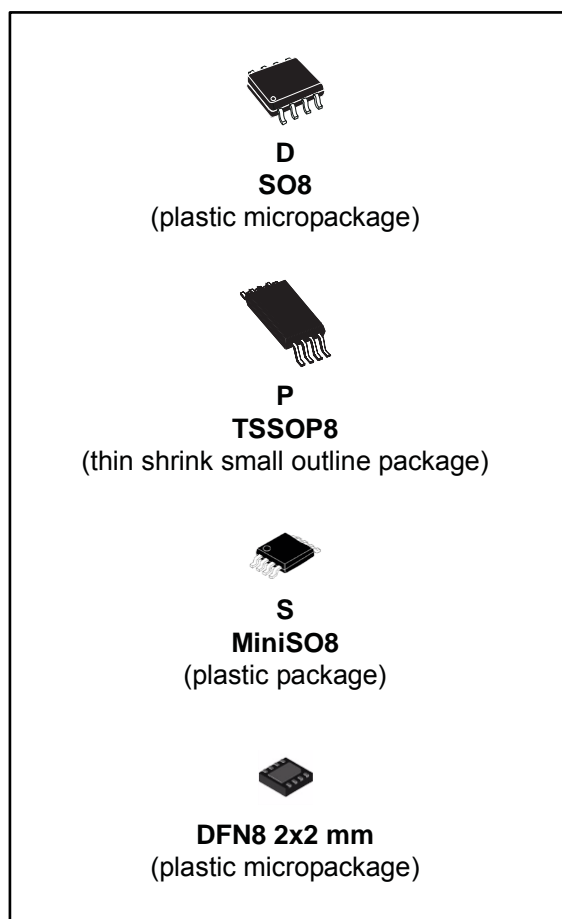


Micropower dual CMOS voltage comparators

Datasheet - production data



Features

- Low supply current: 5 μ A typ. per comparator
- Wide single supply range 2.7 V to 16 V or dual supplies (± 1.35 V to ± 8 V)
- Extremely low input bias current: 1 pA typ.

- Input common-mode voltage range includes ground
- Open drain output
- High input impedance: 10^{12} Ω typ
- Fast response time: 2 μ s typ. for 5 mV overdrive
- ESD tolerance: 4 kV HBM, 200 V MM

Related products

- Pin-to-pin and functionally compatible with the dual CMOS TS393 comparators
- See the TSX3702 for push-pull output

Applications

- Automotive
- Industrial

Description

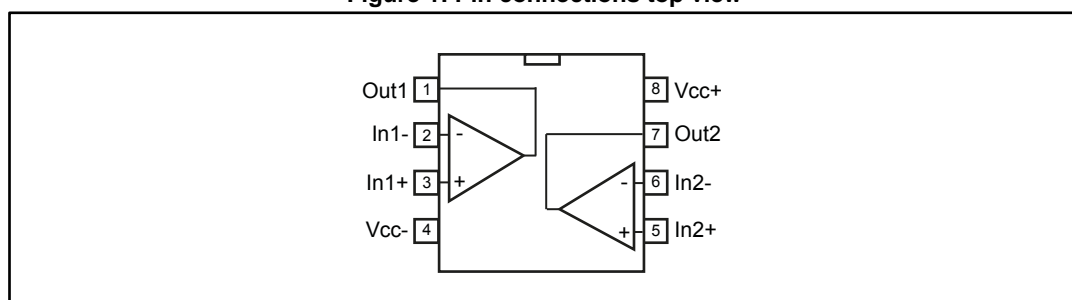
The TSX393 is a micropower CMOS dual voltage comparator which exhibits a very low current consumption of 5 μ A typical per comparator. This device was designed as the improvement of the TS393: it shows a lower current consumption, a better input offset voltage, and an enhanced ESD tolerance. The TSX393 is fully specified over a wide temperature range and is proposed in automotive grade for the SO8 package. It is fully compatible with the TS393 CMOS comparator and is available with similar packages. New tiny packages (MiniSO8 and DFN8 2x2 mm) are also proposed for the TSX393 thus allowing even more integration on applications.

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1 Package pin connections

Figure 1: Pin connections top view



2 Absolute maximum ratings

Table 1: Absolute maximum ratings (AMR)

| Symbol | Parameter | Value | Unit | |
|-------------------|---|------------|------|------|
| V _{CC+} | Supply voltage ⁽¹⁾ | 18 | V | |
| V _{id} | Differential input voltage ⁽²⁾ | ±18 | | |
| V _{in} | Input voltage ⁽³⁾ | -0.3 to 18 | | |
| V _o | Output voltage | 18 | | |
| I _o | Output current | 20 | mA | |
| I _F | Forward current in ESD protection diodes on inputs ⁽⁴⁾ | 50 | | |
| T _j | Maximum junction temperature | 150 | °C | |
| R _{thja} | Thermal resistance junction to ambient ⁽⁵⁾ | SO8 | 125 | °C/W |
| | | TSSOP8 | 120 | |
| | | MiniSO8 | 190 | |
| | | DFN8 2x2 | 115 | |
| T _{stg} | Storage temperature range | -65 to 150 | °C | |
| ESD | HBM: human body model ⁽⁶⁾ | 4000 | V | |
| | MM: machine model ⁽⁷⁾ | 200 | | |
| | CDM: charged device model ⁽⁸⁾ | 1500 | | |
| | Latch-up immunity | 200 | mA | |

Notes:

- (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) Excursions of input voltages may exceed the power supply level. As long as the common mode voltage (V_{icm} = (V_{in+}) + (V_{in-})/2) remains within the specified range, the comparator provides a stable output state. However, the maximum current of the input stage, through the ESD diodes (I_F), must be strictly observed.
- (4) Guaranteed by design
- (5) Short-circuits can cause excessive heating and destructive dissipation. Values are typical.
- (6) According to JEDEC standard JESD22-A114F
- (7) According to JEDEC standard JESD22-A115A
- (8) According to ANSI/ESD STM5.3.1

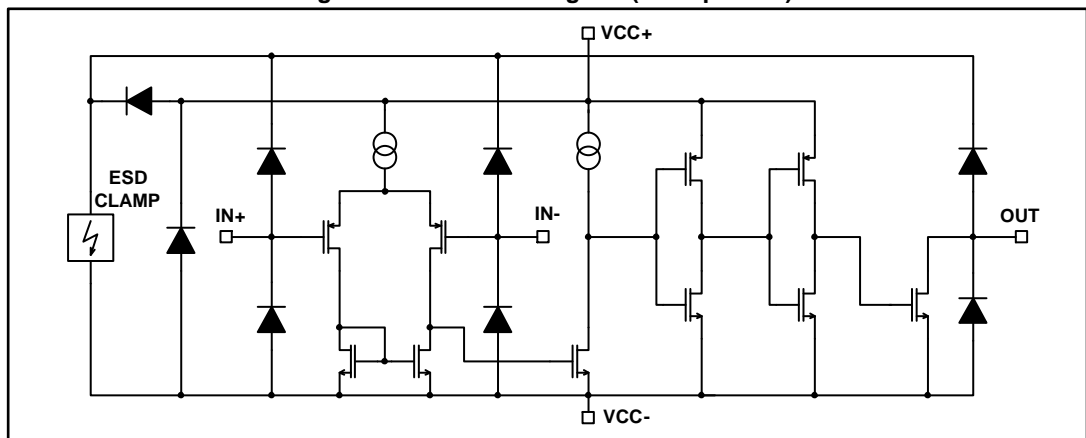
3 Operating conditions

Table 2: Operating conditions

| Symbol | Parameter | Value | Unit |
|------------|--------------------------------------|-------------------------|------|
| V_{CC^+} | Supply voltage | 2.7 to 16 | V |
| V_{icm} | Common mode input voltage range | 0 to $(V_{CC^+}) - 1.5$ | |
| | $T_{min} \leq T_{amb} \leq T_{max}$ | 0 to $(V_{CC^+}) - 2$ | |
| T_{oper} | Operating free-air temperature range | -40 to 125 | °C |

4 Schematic diagram

Figure 2: Schematic diagram (one operator)



5 Electrical characteristics

Table 3: $V_{CC+} = 3\text{ V}$, $V_{CC-} = 0\text{ V}$, $T_{amb} = 25\text{ °C}$ (unless otherwise specified)

| Symbol | Parameter | Condition | Min. | Typ. | Max. | Unit |
|-----------|-------------------------------------|---|------|------|------|---------------|
| V_{io} | Input offset voltage ⁽¹⁾ | $V_{icm} = 0\text{ V}$ | -5 | 0.1 | 5 | mV |
| | | $T_{min} \leq T_{amb} \leq T_{max}$ | -6 | | 6 | |
| I_{io} | Input offset current ⁽²⁾ | $V_{icm} = V_{CC}/2$ | | 1 | 10 | pA |
| | | $T_{min} \leq T_{amb} \leq T_{max}$ | | | 600 | |
| I_{ib} | Input bias current ⁽²⁾ | $V_{icm} = V_{CC}/2$ | | 1 | 10 | pA |
| | | $T_{min} \leq T_{amb} \leq T_{max}$ | | | 1200 | |
| CMR | Common-mode rejection ratio | $V_{icm} = 0\text{ to } (V_{CC+}) - 1.5\text{ V}$ | 58 | 73 | | dB |
| | | $V_{icm} = 0\text{ to } (V_{CC+}) - 2\text{ V}$, $T_{min} \leq T_{amb} \leq T_{max}$ | 55 | | | |
| SVR | Supply voltage rejection ratio | $V_{CC+} = 3\text{ V to } 5\text{ V}$, $V_{icm} = V_{CC}/2$ | 69 | 88 | | dB |
| | | $T_{min} \leq T_{amb} \leq T_{max}$ | 69 | | | |
| I_{OH} | High-level output voltage | $V_{id} = 1\text{ V}$, $V_{OH} = 3\text{ V}$ | | 1 | 40 | nA |
| | | $T_{min} \leq T_{amb} \leq T_{max}$ | | | 1000 | |
| V_{OL} | Low-level output voltage | $V_{id} = -1\text{ V}$, $I_{OL} = 4\text{ mA}$ | | 300 | 400 | mV |
| | | $T_{min} \leq T_{amb} \leq T_{max}$ | | | 600 | |
| I_{CC} | Supply current per comparator | No load, outputs low | | 5 | 6 | μA |
| | | $T_{min} \leq T_{amb} \leq T_{max}$ | | | 7 | |
| | | No load, outputs high | | 8 | 9 | |
| | | $T_{min} \leq T_{amb} \leq T_{max}$ | | | 11 | |
| t_{PLH} | Response time low to high | $V_{icm} = 0\text{ V}$, $f = 10\text{ kHz}$, $R_L = 5.1\text{ k}\Omega$, $C_L = 50\text{ pF}$, overdrive = 5 mV | | 2.5 | | μs |
| | | Overdrive = 100 mV | | 0.53 | 0.65 | |
| | | $T_{min} \leq T_{amb} \leq T_{max}$ | | | 0.7 | |
| t_{PHL} | Response time high to low | $V_{icm} = 0\text{ V}$, $f = 10\text{ kHz}$, $R_L = 5.1\text{ k}\Omega$, $C_L = 50\text{ pF}$, overdrive = 5 mV | | 2.0 | | μs |
| | | Overdrive = 100 mV | | 0.4 | 0.6 | |
| | | $T_{min} \leq T_{amb} \leq T_{max}$ | | | 0.65 | |
| t_f | Fall time | $f = 10\text{ kHz}$, $C_L = 50\text{ pF}$, $R_L = 5.1\text{ k}\Omega$, overdrive 50 mV | | 39 | | ns |

Notes:

(1)The specified offset voltage is the maximum value required to drive the output up to 2.5 V or down to 0.3 V

(2)Guaranteed by design

Table 4: VCC+ = 5 V, VCC- = 0 V, Tamb = 25 °C (unless otherwise specified)

| Symbol | Parameter | Condition | Min. | Typ. | Max. | Unit |
|------------------|-------------------------------------|---|------|------|------|------|
| V _{io} | Input offset voltage ⁽¹⁾ | V _{icm} = V _{CC} /2 | -5 | 0.1 | 5 | mV |
| | | T _{min} ≤ T _{amb} ≤ T _{max} | -6 | | 6 | |
| I _{io} | Input offset current ⁽²⁾ | V _{icm} = V _{CC} /2 | | 1 | 10 | pA |
| | | T _{min} ≤ T _{amb} ≤ T _{max} | | | 600 | |
| I _{ib} | Input bias current ⁽²⁾ | V _{icm} = V _{CC} /2 | | 1 | 10 | pA |
| | | T _{min} ≤ T _{amb} ≤ T _{max} | | | 1200 | |
| CMR | Common-mode rejection ratio | V _{icm} = 0 to (V _{CC} ⁺) - 1.5 V | 66 | 85 | | dB |
| | | V _{icm} = 0 to (V _{CC} ⁺) - 2 V, T _{min} ≤ T _{amb} ≤ T _{max} | 65 | | | |
| SVR | Supply voltage rejection ratio | V _{CC} ⁺ = 5 V to 10 V, V _{icm} = V _{CC} /2 | 71 | 89 | | dB |
| | | T _{min} ≤ T _{amb} ≤ T _{max} | 70 | | | |
| I _{OH} | High-level output voltage | V _{id} = 1 V, V _{OH} = 5 V | | 1 | 40 | nA |
| | | T _{min} ≤ T _{amb} ≤ T _{max} | | | 1000 | |
| V _{OL} | Low-level output voltage | V _{id} = -1 V, I _{OL} = 4 mA | | 180 | 250 | mV |
| | | T _{min} ≤ T _{amb} ≤ T _{max} | | | 400 | |
| I _{CC} | Supply current per comparator | No load, outputs low | | 5 | 8 | μA |
| | | T _{min} ≤ T _{amb} ≤ T _{max} | | | 9 | |
| | | No load, outputs high | | 9 | 10 | |
| | | T _{min} ≤ T _{amb} ≤ T _{max} | | | 11 | |
| t _{PLH} | Response time low to high | V _{icm} = 0 V, f = 10 kHz, R _L = 5.1 kΩ, C _L = 50 pF, overdrive = 5 mV | | 2.5 | | μs |
| | | Overdrive = 10 mV | | 1.6 | | |
| | | Overdrive = 20 mV | | 1.0 | | |
| | | Overdrive = 40 mV | | 0.7 | | |
| | | Overdrive = 100 mV | | 0.52 | 0.6 | |
| | | T _{min} ≤ T _{amb} ≤ T _{max} | | | 0.7 | |
| | | TTL input ⁽³⁾ | | 0.55 | 0.7 | |
| | | T _{min} ≤ T _{amb} ≤ T _{max} | | | 0.75 | |
| t _{PHL} | Response time high to low | V _{icm} = 0 V, f = 10 kHz, R _L = 5.1 kΩ, C _L = 50 pF, overdrive = 5 mV | | 2.8 | | μs |
| | | Overdrive = 10 mV | | 1.8 | | |
| | | Overdrive = 20 mV | | 1.0 | | |
| | | Overdrive = 40 mV | | 0.7 | | |
| | | Overdrive = 100 mV | | 0.46 | 0.6 | |
| | | T _{min} ≤ T _{amb} ≤ T _{max} | | | 0.7 | |
| | | TTL input ⁽³⁾ | | 0.30 | 0.40 | |
| | | T _{min} ≤ T _{amb} ≤ T _{max} | | | 0.50 | |

| Symbol | Parameter | Condition | Min. | Typ. | Max. | Unit |
|--------|-----------|---|------|------|------|------|
| t_f | Fall time | $f = 10 \text{ kHz}$, $C_L = 50 \text{ pF}$, $R_L = 5.1 \text{ k}\Omega$, overdrive 50 mV | | 30 | | ns |

Notes:

(1)The specified offset voltage is the maximum value required to drive the output up to 4.5 V or down to 0.3 V

(2)Guaranteed by design

(3)A step from 0 V to 3 V is applied on one input while the other is fixed at 1.4 V. Response time is the time interval between the application of the input voltage step and the moment the output voltage reaches 50 % of its final value.

Table 5: $V_{CC+} = 16 \text{ V}$, $V_{CC-} = 0 \text{ V}$, $T_{amb} = 25 \text{ }^\circ\text{C}$ (unless otherwise specified)

| Symbol | Parameter | Condition | Min. | Typ. | Max. | Unit |
|-----------|-------------------------------------|--|------|------|------|---------------|
| V_{io} | Input offset voltage ⁽¹⁾ | $V_{icm} = V_{CC}/2$ | -5 | 0.1 | 5 | mV |
| | | $T_{min} \leq T_{amb} \leq T_{max}$ | -6 | | 6 | |
| I_{io} | Input offset current ⁽²⁾ | $V_{icm} = V_{CC}/2$ | | 1 | 10 | pA |
| | | $T_{min} \leq T_{amb} \leq T_{max}$ | | | 600 | |
| I_{ib} | Input bias current ⁽²⁾ | $V_{icm} = V_{CC}/2$ | | 1 | 10 | pA |
| | | $T_{min} \leq T_{amb} \leq T_{max}$ | | | 1200 | |
| CMR | Common-mode rejection ratio | $V_{icm} = 0$ to $(V_{CC+}) - 1.5 \text{ V}$ | 72 | 90 | | dB |
| | | $V_{icm} = 0$ to $(V_{CC+}) - 2 \text{ V}$, $T_{min} \leq T_{amb} \leq T_{max}$ | 70 | | | |
| SVR | Supply voltage rejection ratio | $V_{CC+} = 5 \text{ V}$ to 16 V , $V_{icm} = V_{CC}/2$ | 73 | 90 | | dB |
| | | $T_{min} \leq T_{amb} \leq T_{max}$ | 72 | | | |
| I_{OH} | High-level output voltage | $V_{id} = 1 \text{ V}$, $V_{OH} = 16 \text{ V}$ | | 1 | 40 | nA |
| | | $T_{min} \leq T_{amb} \leq T_{max}$ | | | 1000 | |
| V_{OL} | Low-level output voltage | $V_{id} = -1 \text{ V}$, $I_{OL} = 4 \text{ mA}$ | | 90 | 150 | mV |
| | | $T_{min} \leq T_{amb} \leq T_{max}$ | | | 250 | |
| I_{CC} | Supply current per comparator | No load, outputs low | | 7 | 9 | μA |
| | | $T_{min} \leq T_{amb} \leq T_{max}$ | | | 10 | |
| | | No load, outputs high | | 11 | 13 | |
| | | $T_{min} \leq T_{amb} \leq T_{max}$ | | | 14 | |
| t_{PLH} | Response time low to high | $V_{icm} = 0 \text{ V}$, $f = 10 \text{ kHz}$, $R_L = 5.1 \text{ k}\Omega$, $C_L = 50 \text{ pF}$, overdrive = 5 mV | | 2.3 | | μs |
| | | Overdrive = 10 mV | | 1.5 | | |
| | | Overdrive = 20 mV | | 1.0 | | |
| | | Overdrive = 40 mV | | 0.7 | | |
| | | Overdrive = 100 mV | | 0.55 | 0.65 | |
| | | $T_{min} \leq T_{amb} \leq T_{max}$ | | | 0.70 | |
| t_{PHL} | Response time high to low | $V_{icm} = 0 \text{ V}$, $f = 10 \text{ kHz}$, $R_L = 5.1 \text{ k}\Omega$, $C_L = 50 \text{ pF}$, overdrive = 5 mV | | 2.4 | | μs |
| | | Overdrive = 10 mV | | 1.6 | | |

| Symbol | Parameter | Condition | Min. | Typ. | Max. | Unit |
|--------|-----------|--|------|------|------|------|
| | | Overdrive = 20 mV | | 1.0 | | |
| | | Overdrive = 40 mV | | 0.7 | | |
| | | Overdrive = 100 mV | | 0.55 | 0.70 | |
| | | $T_{min} \leq T_{amb} \leq T_{max}$ | | | 0.75 | |
| t_f | Fall time | f = 10 kHz, $C_L = 50$ pF, $R_L = 5.1$ k Ω , overdrive 50 mV | | 11 | | ns |

Notes:

⁽¹⁾The specified offset voltage is the maximum value required to drive the output up to 4.5 V or down to 0.3 V

⁽²⁾Guaranteed by design

Figure 3: Current consumption vs. supply voltage, output high

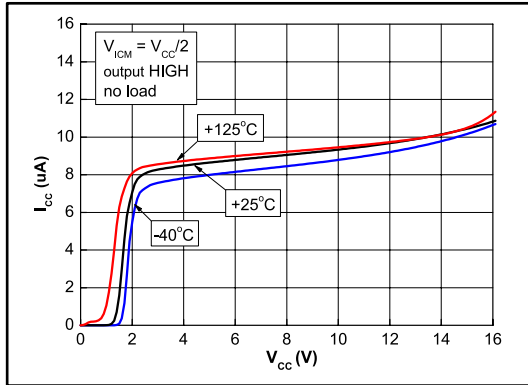


Figure 4: Current consumption vs. supply voltage, output low

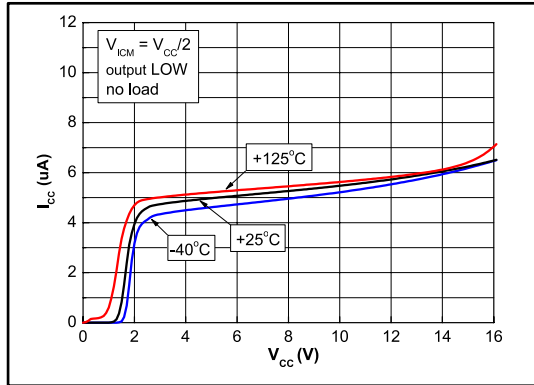


Figure 5: Current consumption vs. input common-mode voltage, output high

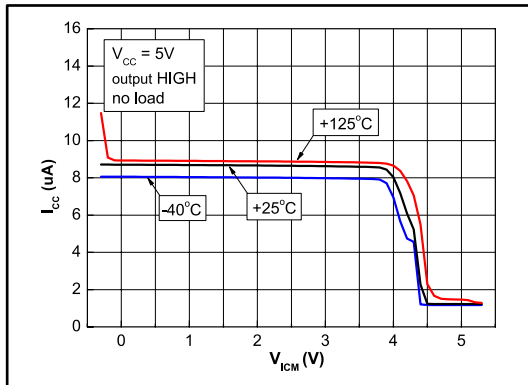


Figure 6: Current consumption vs. common-mode voltage, output low

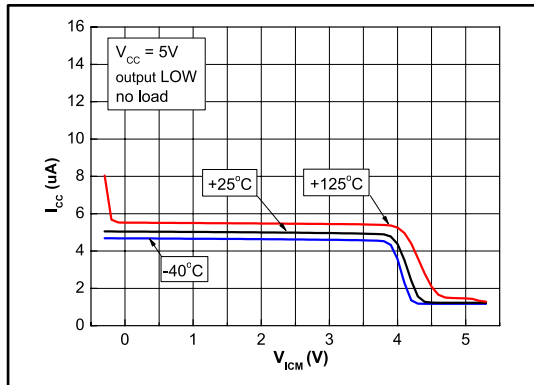


Figure 7: Output leakage current vs. output voltage, VCC = 5 V

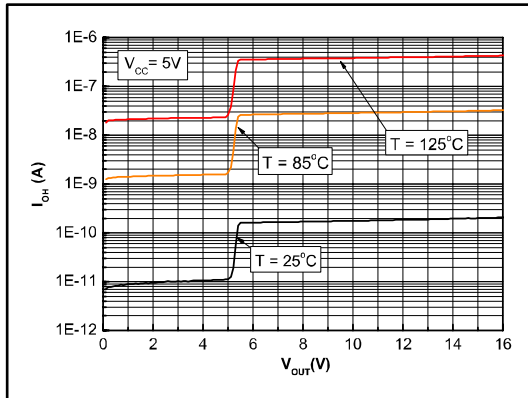


Figure 8: Output leakage current vs. supply voltage, VCC = 5 V

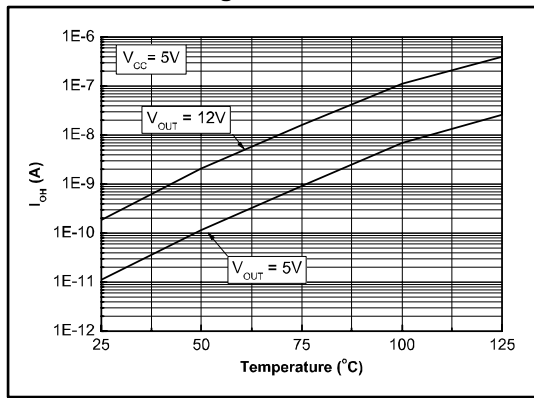


Figure 9: Output voltage drop vs. output sink current, VCC = 5 V



Figure 10: Output voltage drop vs. output sink current, VCC = 12 V



Figure 11: Input offset voltage distribution, VCC = 5 V



Figure 12: Input current vs input voltage, VCC = 5 V

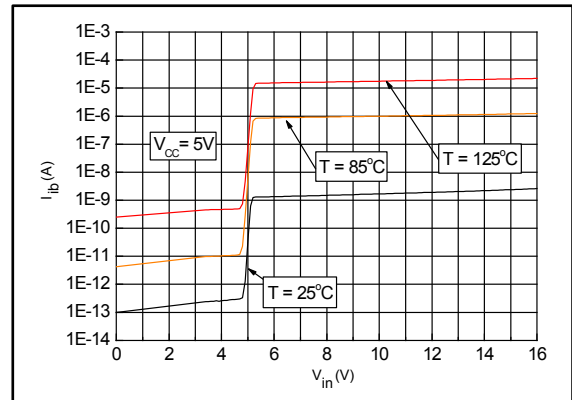


Figure 13: Propagation delay tPLH vs. input signal overdrive, VCC = 5 V

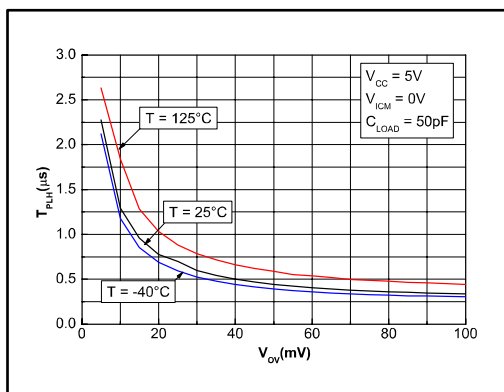


Figure 14: Propagation delay tPHL vs. input signal overdrive, VCC = 5 V

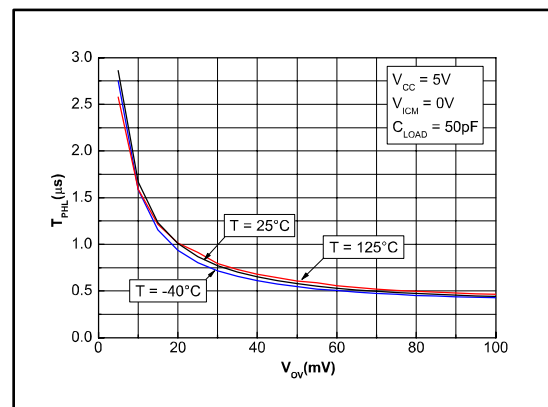


Figure 15: Propagation delay t_{PHL} vs. input signal overdrive, V_{CC} = 5 V

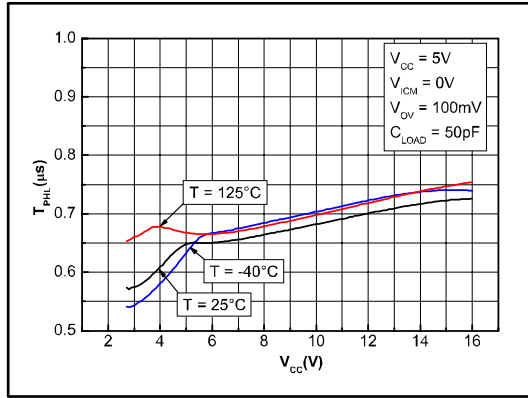
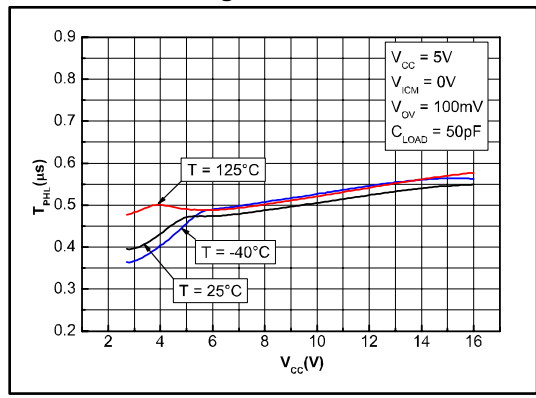


Figure 16: Propagation delay t_{PHL} vs. supply voltage, V_{CC} = 5 V



6 Application information (input voltages)

The ESD strategy used in the TSX393 (and shown in [Figure 2](#) allows input voltages from -0.3 V up to 16 V to be applied regardless of the V_{CC+} voltage. When $V_{IN} > V_{CC+}$ a leakage current goes from the input through the protection diode to the ESD clamp. This current is about 0.2 nA at 25 °C and about 250 nA at 125 °C. For a detailed input characteristic see [Figure 12](#). The device is designed to prevent phase reversal.

7 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.

7.1 SO8 package information

Figure 17: SO8 package outline

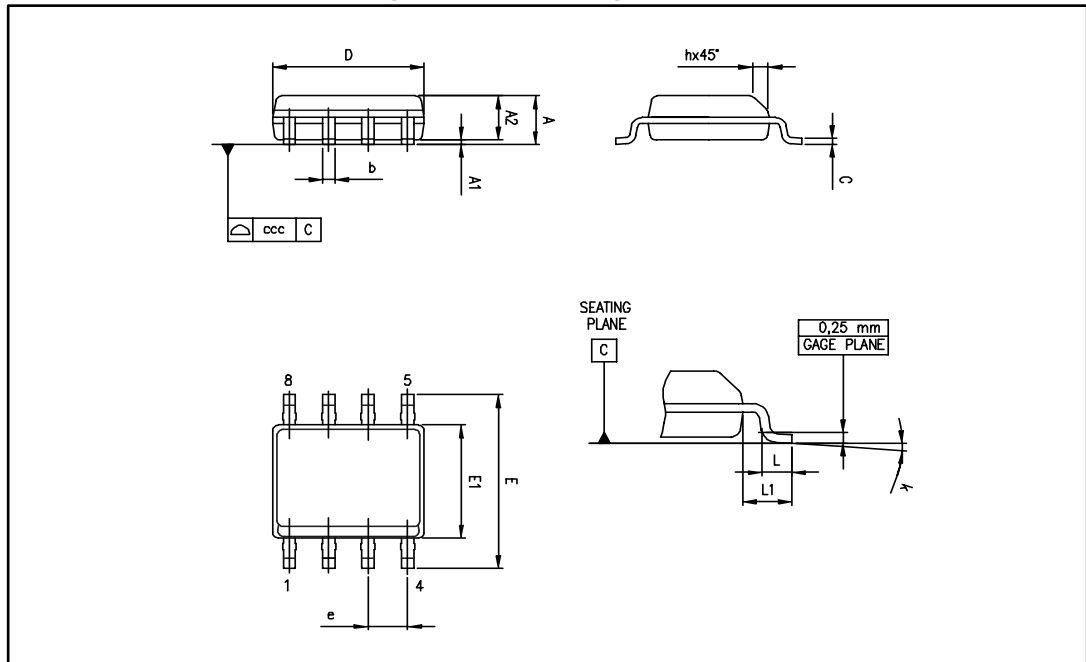


Table 6: SO8 mechanical data

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

7.2 TSSOP8 package information

Figure 18: TSSOP8 package outline

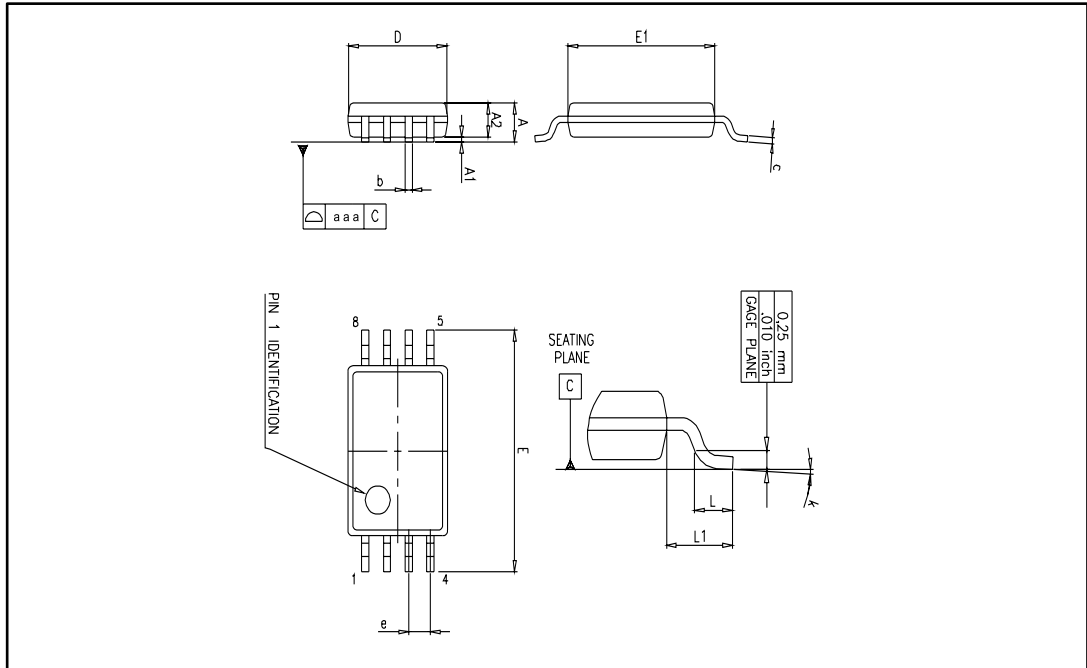


Table 7: TSSOP8 mechanical data

| 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 | |

7.3 DFN8 2x2 package information

Figure 19: DFN8 2x2 package outline

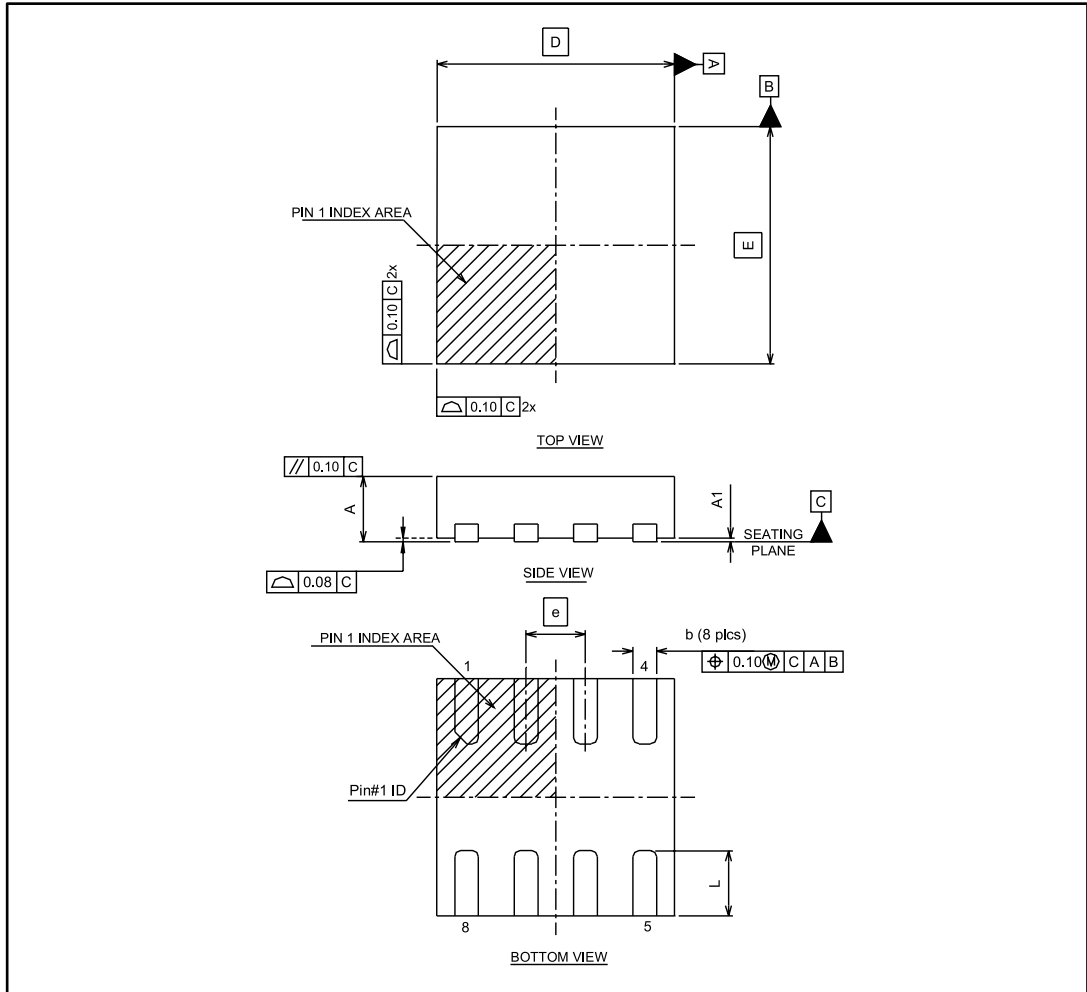


Table 8: DFN8 2x2 mechanical data

| Ref. | Dimensions | | | | | |
|------|-------------|------|------|--------|-------|-------|
| | Millimeters | | | Inches | | |
| | Min. | Typ. | Max. | Min. | Typ. | Max. |
| A | 0.70 | 0.75 | 0.80 | 0.028 | 0.030 | 0.031 |
| A1 | 0.00 | 0.02 | 0.05 | 0.000 | 0.001 | 0.002 |
| b | 0.15 | 0.20 | 0.25 | 0.006 | 0.008 | 0.010 |
| D | | 2.00 | | | 0.079 | |
| E | | 2.00 | | | 0.079 | |
| e | | 0.50 | | | 0.020 | |
| L | 0.045 | 0.55 | 0.65 | 0.018 | 0.022 | 0.026 |
| N | 8 | | | | | |

Figure 20: DFN8 2x2 recommended footprint



7.4 MiniSO8 package information

Figure 21: MiniSO8 package outline

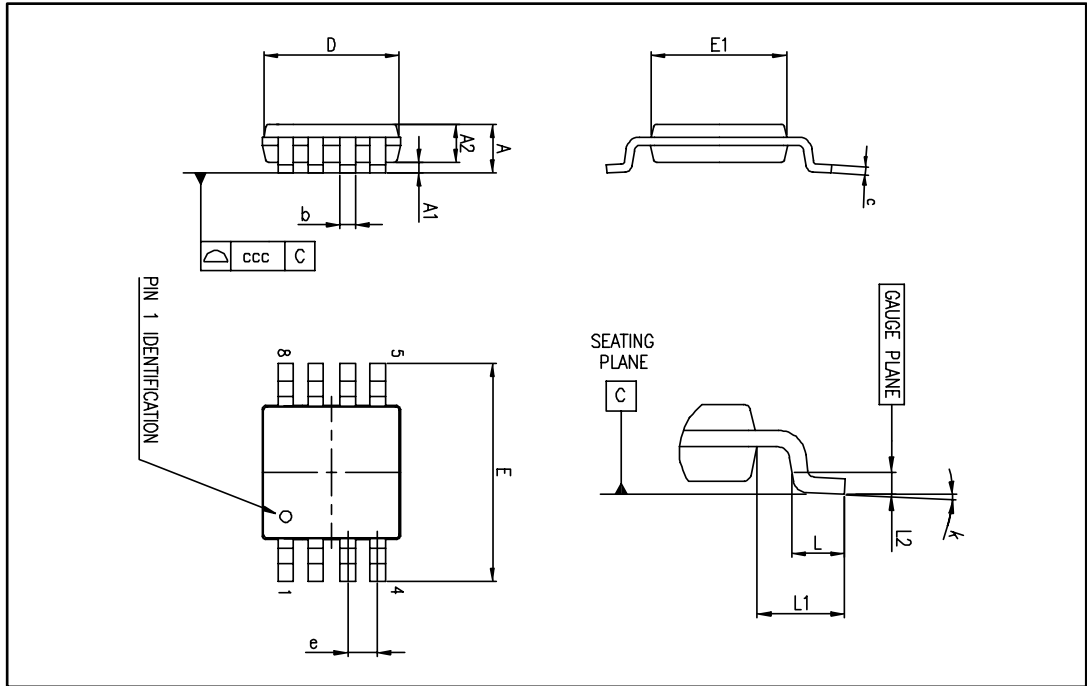


Table 9: MiniSO8 mechanical data

| Ref. | Dimensions | | | | | |
|------|-------------|------|------|--------|-------|-------|
| | Millimeters | | | Inches | | |
| | Min. | Typ. | Max. | Min. | Typ. | Max. |
| A | | | 1.1 | | | 0.043 |
| A1 | 0 | | 0.15 | 0 | | 0.006 |
| 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 |

8 Ordering information

Table 10: Order codes

| Order code | Temperature range | Package | Packing | Marking |
|---------------------------|-------------------|------------------------|---------------|---------|
| TSX393IDT | -40 °C, 125 °C | SO8 | Tape and reel | SX393I |
| TSX393IPT | | TSSOP8 | | SX393 |
| TSX393IST | | MiniSO8 | | K530 |
| TSX393IQ2T | | DFN8 2x2 | | K5K |
| TSX393IYDT ⁽¹⁾ | | SO8 (automotive grade) | | SX393IY |

Notes:

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

9 Revision history

Table 11: Document revision history

| Date | Revision | Changes |
|-------------|----------|---|
| 30-Oct-2014 | 1 | Initial release. |
| 07-Sep-2015 | 2 | Table 1: "Absoluet maximum ratings (AMR)": updated R_{thja} value for the DFN8 2x2 package. Section 7.3 "DFN8 2x2 package information": replaced pacakge outline, mechanical data, and recommended footprint by "non-exposed" pad information. |
| 06-Jun-2016 | 3 | Table 3, Table 4, and Table 5: updated I_{IO} and I_{IB} temperature max values, updated VOL condition. In Table 3 only, updated tPHL max value. In Table 5 only, updated IOH condition. Table 10: updated automotive footnote. |
| 06-Jul-2017 | 4 | Table 10 : updated automotive footnote. |

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