

## Micropower dual CMOS voltage comparators

Datasheet —production data

### Features

- Extremely low supply current: typically 9  $\mu\text{A}$  per comparator
- Wide single supply range 2.7 V to 16 V or dual supplies ( $\pm 1.35$  V to  $\pm 8$  V)
- Extremely low input bias current: 1 pA typical
- Extremely low input offset current: 1 pA typical
- Input common-mode voltage range includes ground
- High input impedance:  $10^{12} \Omega$  typ.
- Fast response time: 2.5  $\mu\text{s}$  typ. for 5 mV overdrive
- Pin-to-pin and functionally compatible with dual bipolar LM393

### Description

The TS393 device is a micropower CMOS dual voltage comparator with extremely low consumption of 9  $\mu\text{A}$  typically per comparator (20 times less than the dual bipolar LM393 device). Similar performance is offered by the dual micropower comparator TS3702 with a push-pull CMOS output.

Thus response times remain similar to the LM393 device.



**N**  
**DIP8**  
(plastic package)

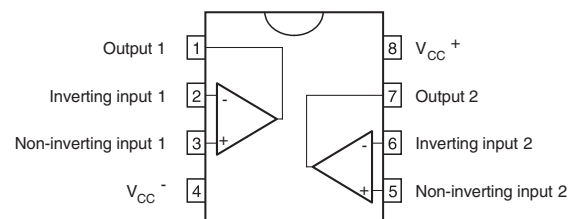


**D**  
**SO-8**  
(plastic micropackage)



**P**  
**TSSOP8**  
(thin shrink small outline package)

### Pin connections (top view)



# 1 Absolute maximum ratings

**Table 1. Absolute maximum ratings (AMR)**

| Symbol       | Parameter                                                                       | Value            | Unit |
|--------------|---------------------------------------------------------------------------------|------------------|------|
| $V_{CC}^{+}$ | Supply voltage <sup>(1)</sup>                                                   | 18               | V    |
| $V_{id}$     | Differential input voltage <sup>(2)</sup>                                       | $\pm 18$         | V    |
| $V_{in}$     | Input voltage <sup>(3)</sup>                                                    | 18               | V    |
| $V_o$        | Output voltage                                                                  | 18               | V    |
| $I_o$        | Output current                                                                  | 20               | mA   |
| $I_F$        | Forward current in ESD protection diodes on inputs <sup>(4)</sup>               | 50               | mA   |
| $T_j$        | Maximum junction temperature                                                    | 150              | °C   |
| $R_{thja}$   | Thermal resistance junction-to-ambient <sup>(5)</sup><br>DIP8<br>SO-8<br>TSSOP8 | 85<br>125<br>120 | °C/W |
| $R_{thjc}$   | Thermal resistance junction-to-case <sup>(5)</sup><br>DIP8<br>SO-8<br>TSSOP8    | 41<br>40<br>37   | °C/W |
| $T_{stg}$    | Storage temperature range                                                       | -65 to +150      | °C   |
| ESD          | HBM: human body model <sup>(6)</sup>                                            | 500              | V    |
|              | MM: machine model <sup>(7)</sup>                                                | 200              | V    |
|              | CDM: charged device model <sup>(8)</sup>                                        | 1                | kV   |

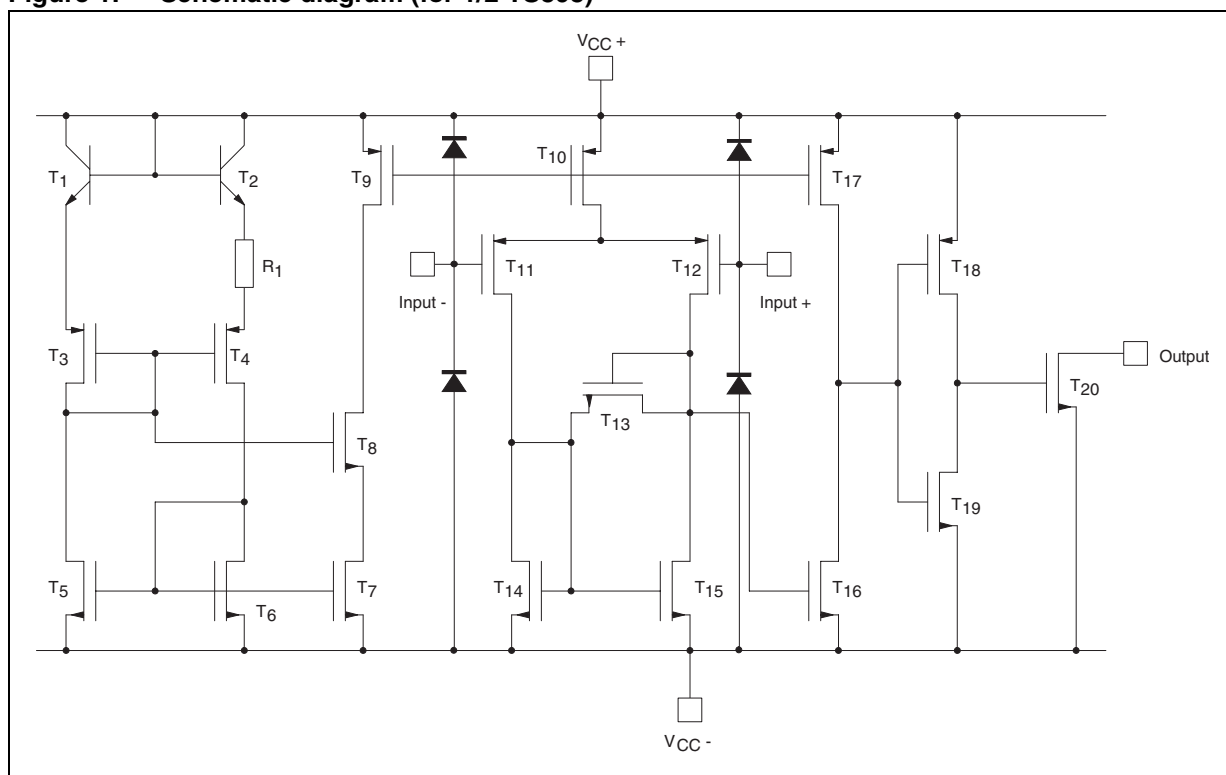
1. All voltage values, except differential voltage, are with respect to network ground terminal.
2. Differential voltages are the non-inverting input terminal with respect to the inverting input terminal.
3. Excursions of input voltages may exceed the power supply level. As long as the common mode voltage  $[V_{icm} = (V_{in}^{+} + V_{in}^{-})/2]$  remains within the specified range, the comparator will provide a stable output state. However, the maximum current through the ESD diodes ( $I_F$ ) of the input stage must strictly be observed.
4. Guaranteed by design.
5. Short-circuits can cause excessive heating and destructive dissipation. Values are typical.
6. Human body model: A 100 pF capacitor is charged to the specified voltage, then discharged through a 1.5 k $\Omega$  resistor between two pins of the device. This is done for all couples of connected pin combinations while the other pins are floating.
7. 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  $\Omega$ ). This is done for all couples of connected pin combinations while the other pins are floating.
8. 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<br>TS393C, TS393I                                       | 2.7 to 16                                        | V    |
| $V_{icm}$    | Common mode input voltage range<br>$T_{min} \leq T_{amb} \leq T_{max}$ | 0 to $V_{CC}^{+} - 1.5$<br>0 to $V_{CC}^{+} - 2$ | V    |
| $T_{oper}$   | Operating free air temperature range<br>TS393C<br>TS393I               | 0 to +70<br>-40 to +125                          | °C   |

## 2 Schematic diagram

Figure 1. Schematic diagram (for 1/2 TS393)



### 3 Electrical characteristics

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

| Symbol    | Parameter                                                                                                                                                     | Min. | Typ.        | Max.       | Unit |
|-----------|---------------------------------------------------------------------------------------------------------------------------------------------------------------|------|-------------|------------|------|
| $V_{io}$  | Input offset voltage <sup>(1)</sup><br>$V_{ic} = 1.5\text{ V}$<br>$T_{\text{min}} \leq T_{\text{amb}} \leq T_{\text{max}}$                                    |      |             | 5<br>6.5   | mV   |
| $I_{io}$  | Input offset current <sup>(2)</sup><br>$V_{ic} = 1.5\text{ V}$<br>$T_{\text{min}} \leq T_{\text{amb}} \leq T_{\text{max}}$                                    |      | 1           | 300        | pA   |
| $I_{ib}$  | Input bias current <sup>(2)</sup><br>$V_{ic} = 1.5\text{ V}$<br>$T_{\text{min}} \leq T_{\text{amb}} \leq T_{\text{max}}$                                      |      | 1           | 600        | pA   |
| CMR       | Common-mode rejection ratio<br>$V_{ic} = V_{icm\text{-min}}$                                                                                                  |      | 70          |            | dB   |
| SVR       | Supply voltage rejection ratio<br>$V_{CC}^+ = 3\text{ V to }5\text{ V}$                                                                                       |      | 70          |            | dB   |
| $I_{OH}$  | High level output current<br>$V_{id} = +1\text{ V}$ , $V_{OH} = 3\text{ V}$<br>$T_{\text{min}} \leq T_{\text{amb}} \leq T_{\text{max}}$                       |      | 2           | 40<br>1000 | nA   |
| $V_{OL}$  | Low level output voltage<br>$V_{id} = -1\text{ V}$ , $I_{OL} = +6\text{ mA}$<br>$T_{\text{min}} \leq T_{\text{amb}} \leq T_{\text{max}}$                      |      | 400         | 550<br>800 | mV   |
| $I_{CC}$  | Supply current (each comparator)<br>No load - outputs low<br>$T_{\text{min}} \leq T_{\text{amb}} \leq T_{\text{max}}$                                         |      | 9           | 20<br>25   | μA   |
| $t_{PLH}$ | Response time low to high<br>$V_{ic} = 0\text{ V}$ , $f = 10\text{ kHz}$ , $R_L = 5.1\text{ k}\Omega$ , $C_L = 50\text{ pF}$<br>Overdrive = 5 mV<br>TTL input |      | 1.5<br>0.7  |            | μs   |
| $t_{PHL}$ | Response time high to low<br>$V_{ic} = 0\text{ V}$ , $f = 10\text{ kHz}$ , $R_L = 5.1\text{ k}\Omega$ , $C_L = 50\text{ pF}$<br>Overdrive = 5 mV<br>TTL input |      | 2.5<br>0.08 |            | μs   |

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. Maximum values include unavoidable inaccuracies of the industrial tests.

Table 4.  $V_{CC}^+ = 5\text{ V}$ ,  $V_{CC}^- = 0\text{ V}$ ,  $T_{amb} = 25\text{ }^{\circ}\text{C}$  (unless otherwise specified)

| Symbol    | Parameter                                                                                                                                                                                                                      | Min. | Typ.                             | Max.       | Unit          |
|-----------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------|----------------------------------|------------|---------------|
| $V_{io}$  | Input offset voltage <sup>(1)</sup><br>$V_{ic} = 2.5\text{ V}$ , $V_{CC}^+ = 5\text{ V}$ to $10\text{ V}$<br>$T_{min} \leq T_{amb} \leq T_{max}$                                                                               |      | 1.4                              | 5<br>6.5   | mV            |
| $I_{io}$  | Input offset current <sup>(2)</sup><br>$V_{ic} = 2.5\text{ V}$<br>$T_{min} \leq T_{amb} \leq T_{max}$                                                                                                                          |      | 1                                | 300        | pA            |
| $I_{ib}$  | Input bias current <sup>(2)</sup><br>$V_{ic} = 2.5\text{ V}$<br>$T_{min} \leq T_{amb} \leq T_{max}$                                                                                                                            |      | 1                                | 600        | pA            |
| CMR       | Common-mode rejection ratio<br>$V_{ic} = 0\text{ V}$                                                                                                                                                                           |      | 71                               |            | dB            |
| SVR       | Supply voltage rejection ratio<br>$V_{CC}^+ = +5\text{ V}$ to $+10\text{ V}$                                                                                                                                                   |      | 80                               |            | dB            |
| $I_{OH}$  | High level output voltage<br>$V_{id} = 1\text{ V}$ , $V_{OH} = +5\text{ V}$<br>$T_{min} \leq T_{amb} \leq T_{max}$                                                                                                             |      | 2                                | 40<br>1000 | nA            |
| $V_{OL}$  | Low level output voltage<br>$V_{id} = -1\text{ V}$ , $I_{OL} = 6\text{ mA}$<br>$T_{min} \leq T_{amb} \leq T_{max}$                                                                                                             |      | 260                              | 400<br>650 | mV            |
| $I_{CC}$  | Supply current (each comparator)<br>No load - outputs low<br>$T_{min} \leq T_{amb} \leq T_{max}$                                                                                                                               |      | 10                               | 20<br>25   | $\mu\text{A}$ |
| $t_{PLH}$ | Response time low to high<br>$V_{ic} = 0\text{ V}$ , $f = 10\text{ kHz}$ , $R_L = 5.1\text{ k}\Omega$ , $C_L = 50\text{ pF}$ ,<br>Overdrive = 5 mV<br>Overdrive = 10 mV<br>Overdrive = 20 mV<br>Overdrive = 40 mV<br>TTL input |      | 1.5<br>1.2<br>1.0<br>0.8<br>0.7  |            | $\mu\text{s}$ |
| $t_{PHL}$ | Response time high to low<br>$V_{ic} = 0\text{ V}$ , $f = 10\text{ kHz}$ , $R_L = 5.1\text{ k}\Omega$ , $C_L = 50\text{ pF}$ ,<br>Overdrive = 5 mV<br>Overdrive = 10 mV<br>Overdrive = 20 mV<br>Overdrive = 40 mV<br>TTL input |      | 2.5<br>1.9<br>1.2<br>0.8<br>0.08 |            | $\mu\text{s}$ |
| $t_f$     | Fall time<br>$f = 10\text{ kHz}$ , $C_L = 50\text{ pF}$ , $R_L = 5.1\text{ k}\Omega$ overdrive 50 mV                                                                                                                           |      | 25                               |            | ns            |

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. Maximum values including unavoidable inaccuracies of the industrial tests.

## 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](http://www.st.com). ECOPACK is an ST trademark.

## 4.1 DIP8 package

Figure 2. DIP8 package outline

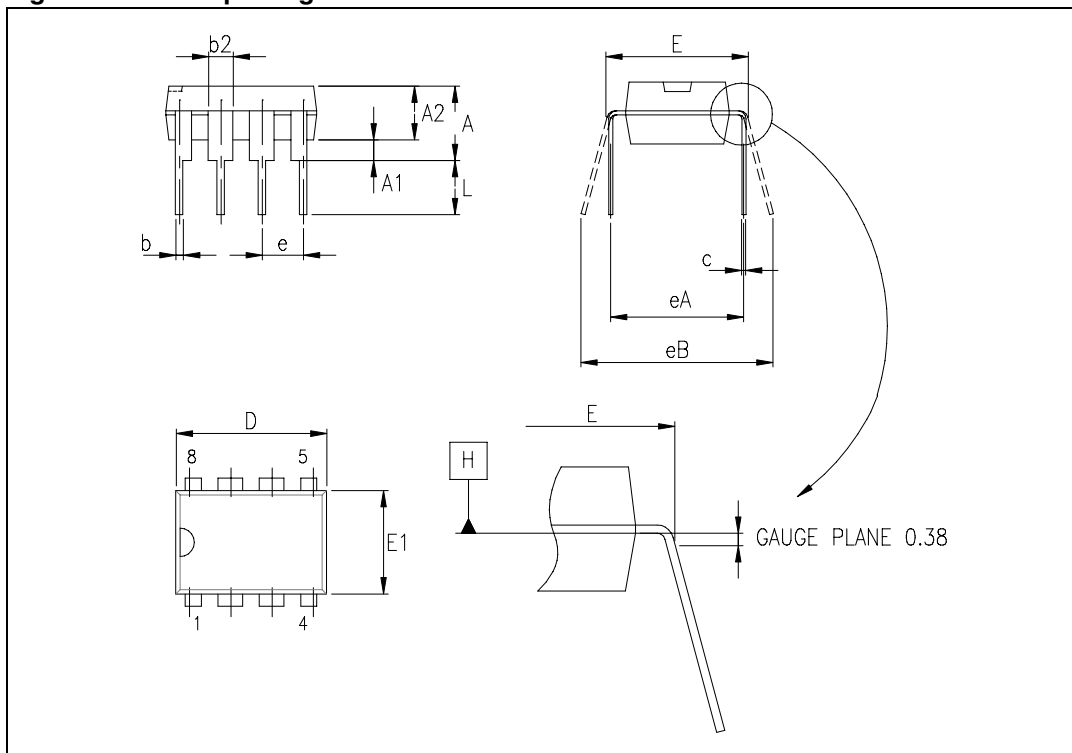


Table 5. DIP8 package mechanical data

| Symbol | Dimensions  |      |       |        |       |       |
|--------|-------------|------|-------|--------|-------|-------|
|        | Millimeters |      |       | Inches |       |       |
|        | Min.        | Typ. | Max.  | Min.   | Typ.  | Max.  |
| A      |             |      | 5.33  |        |       | 0.210 |
| A1     | 0.38        |      |       | 0.015  |       |       |
| A2     | 2.92        | 3.30 | 4.95  | 0.115  | 0.130 | 0.195 |
| b      | 0.36        | 0.46 | 0.56  | 0.014  | 0.018 | 0.022 |
| b2     | 1.14        | 1.52 | 1.78  | 0.045  | 0.060 | 0.070 |
| c      | 0.20        | 0.25 | 0.36  | 0.008  | 0.010 | 0.014 |
| D      | 9.02        | 9.27 | 10.16 | 0.355  | 0.365 | 0.400 |
| E      | 7.62        | 7.87 | 8.26  | 0.300  | 0.310 | 0.325 |
| E1     | 6.10        | 6.35 | 7.11  | 0.240  | 0.250 | 0.280 |
| e      |             | 2.54 |       |        | 0.100 |       |
| eA     |             | 7.62 |       |        | 0.300 |       |
| eB     |             |      | 10.92 |        |       | 0.430 |
| L      | 2.92        | 3.30 | 3.81  | 0.115  | 0.130 | 0.150 |



## 4.2 SO-8 package

Figure 3. SO-8 package outline

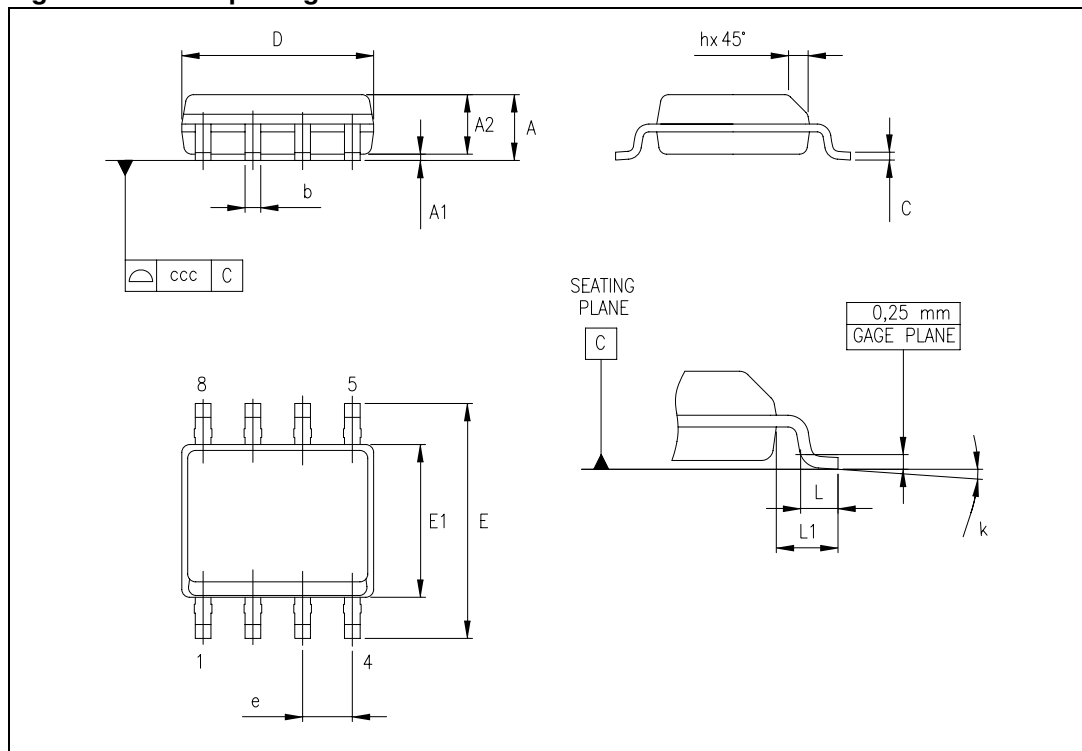


Table 6. SO-8 package mechanical data

| Symbol | 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 |
| k      | 1°          |      | 8°   | 1°     |       | 8°    |
| ccc    |             |      | 0.10 |        |       | 0.004 |

### 4.3 TSSOP8 package

Figure 4. TSSOP8 package outline

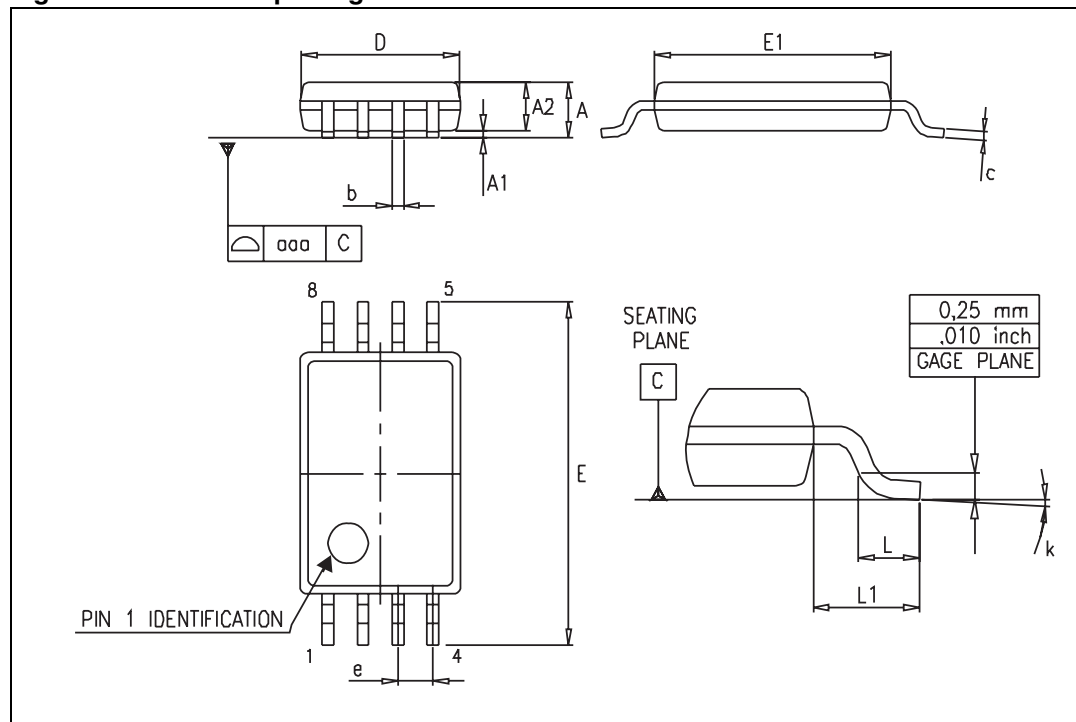


Table 7. TSSOP8 package mechanical data

| Symbol | 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 Ordering information

**Table 8. Order codes**

| Order code               | Temperature range | Package                    | Packing                  | Marking |
|--------------------------|-------------------|----------------------------|--------------------------|---------|
| TS393CN                  | 0 °C, +70 °C      | DIP8                       | Tube                     | TS393CN |
| TS393CD<br>TS393CDT      |                   | SO-8                       | Tube or<br>tape and reel | S393C   |
| TS393IN                  | -40 °C, +125 °C   | DIP8                       | Tube                     | TS393IN |
| TS393ID<br>TS393IDT      |                   | SO-8                       | Tube or<br>tape and reel | S393I   |
| TS393IPT                 |                   | TSSOP8                     | Tape and reel            | S393I   |
| TS393IYDT <sup>(1)</sup> |                   | SO-8<br>(automotive grade) | Tube or<br>tape and reel | S393IY  |

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

## 6 Revision history

**Table 9. Document revision history**

| Date        | Revision | Changes                                                                                                                                                                                                      |
|-------------|----------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 31-Jan-2003 | 1        | Initial release.                                                                                                                                                                                             |
| 31-Jul-2005 | 2        | PPAP references inserted in the datasheet, see order codes table.<br>ESD protection inserted in AMR table.                                                                                                   |
| 28-Apr-2008 | 3        | Added footnotes for automotive grade order codes in order codes table.<br>Updated ESD values for HBM and MM.<br>Updated document format.                                                                     |
| 21-Nov-2012 | 4        | Updated ECOPACK text in <a href="#">Section 4: Package information</a> .<br>Updated <a href="#">Table 8</a> (qualified TS393IYDT and removed TS393IYD order code).<br>Minor corrections throughout document. |

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