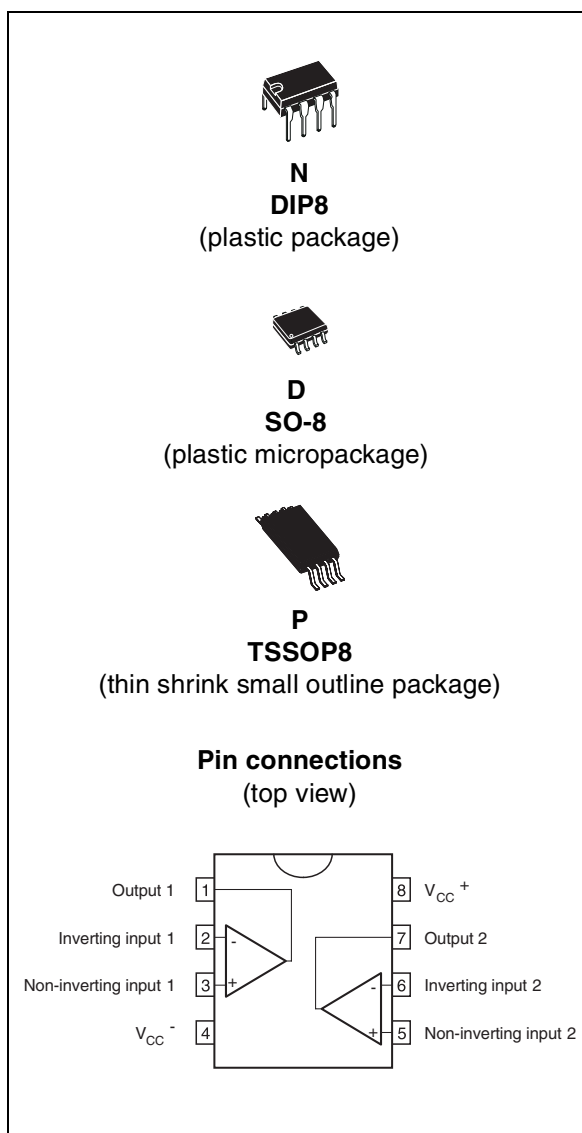# TS393

## Micropower dual CMOS voltage comparators

## Features

- Extremely low supply current: typically 9 µA 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 typical
- Extremely low input offset current: 1 pA typical
- Input common-mode voltage range includes ground
- High input impedance: $10^{12}$ Ω typ.
- Fast response time: 2.5 µs 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 µA 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)

| | | |
|---|---|---|
| Output 1 | 1 | 8 $V_{CC}$ + |
| Inverting input 1 | 2 − | 7 Output 2 |
| Non-inverting input 1 | 3 + | 6 Inverting input 2 |
| $V_{CC}$ - | 4 | 5 Non-inverting input 2 |

# 1 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 |
| $V_{in}$ | Input voltage[3] | 18 | V |
| $V_o$ | Output voltage | 18 | V |
| $I_o$ | Output current | 20 | mA |
| $I_F$ | Forward current in ESD protection diodes on inputs[4] | 50 | mA |
| $T_j$ | Maximum junction temperature | 150 | °C |
| $R_{thja}$ | Thermal resistance junction-to-ambient[5]<br>  DIP8<br>  SO-8<br>  TSSOP8 | 85<br>125<br>120 | °C/W |
| $R_{thjc}$ | Thermal resistance junction-to-case[5]<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[6] | 500 | V |
| | MM: machine model[7] | 200 | V |
| | CDM: charged device model[8] | 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 (IF) 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 kΩ 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 Ω). 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.
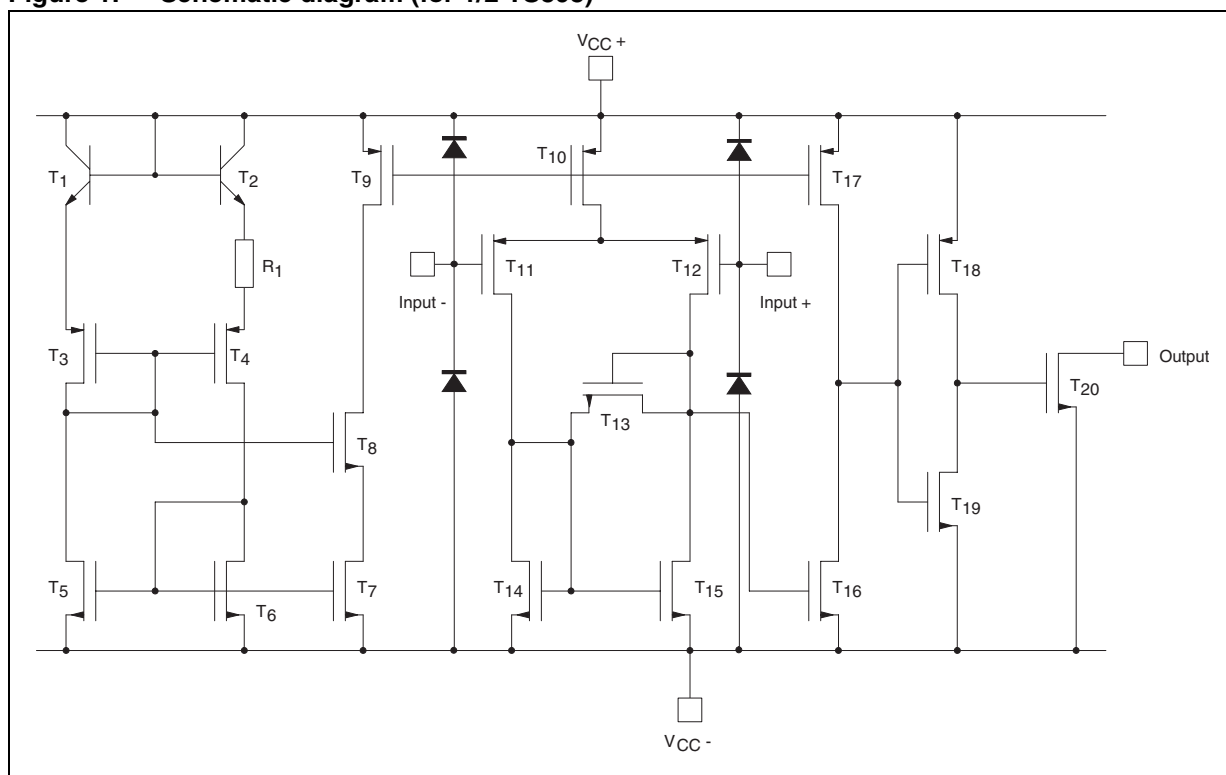
**Table 2.      Operating conditions**

| 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 V, $V_{CC}^-$ = 0 V, $T_{amb}$ = 25 °C (unless otherwise specified)

| Symbol | Parameter | Min. | Typ. | Max. | Unit |
|--------|-----------|------|------|------|------|
| $V_{io}$ | Input offset voltage[1] <br> $V_{ic}$ = 1.5 V <br> $T_{min} \leq T_{amb} \leq T_{max}$ | | | 5 <br> 6.5 | mV |
| $I_{io}$ | Input offset current[2] <br> $V_{ic}$ = 1.5 V <br> $T_{min} \leq T_{amb} \leq T_{max}$ | | 1 | <br> 300 | pA |
| $I_{ib}$ | Input bias current [2] <br> $V_{ic}$ = 1.5 V <br> $T_{min} \leq T_{amb} \leq T_{max}$ | | 1 | <br> 600 | pA |
| CMR | Common-mode rejection ratio <br> $V_{ic}$ = $V_{icm-min}$ | | 70 | | dB |
| SVR | Supply voltage rejection ratio <br> $V_{CC}^+$ = 3 V to 5 V | | 70 | | dB |
| $I_{OH}$ | High level output current <br> $V_{id}$ = +1 V, $V_{OH}$ = 3 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 V, $I_{OL}$ = +6 mA <br> $T_{min} \leq T_{amb} \leq T_{max}$ | | 400 | 550 <br> 800 | mV |
| $I_{CC}$ | Supply current (each comparator) <br> No load - outputs low <br> $T_{min} \leq T_{amb} \leq T_{max}$ | | 9 | 20 <br> 25 | µA |
| $t_{PLH}$ | Response time low to high <br> $V_{ic}$ = 0 V, f = 10 kHz, $R_L$ = 5.1 kΩ, $C_L$ = 50 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 V, f = 10 kHz, $R_L$ = 5.1 kΩ, $C_L$ = 50 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.** $V_{CC}^+ = 5$ V, $V_{CC}^- = 0$ V, $T_{amb} = 25$ °C (unless otherwise specified)

| Symbol | Parameter | Min. | Typ. | Max. | Unit |
|---|---|---|---|---|---|
| $V_{io}$ | Input offset voltage[1] <br> $V_{ic} = 2.5$ V, $V_{CC}^+ = 5$ V to 10 V <br> $T_{min} \leq T_{amb} \leq T_{max}$ | | 1.4 | 5 <br> 6.5 | mV |
| $I_{io}$ | Input offset current[2] <br> $V_{ic} = 2.5$ V <br> $T_{min} \leq T_{amb} \leq T_{max}$ | | 1 | <br> 300 | pA |
| $I_{ib}$ | Input bias current[2] <br> $V_{ic} = 2.5$ V <br> $T_{min} \leq T_{amb} \leq T_{max}$ | | 1 | <br> 600 | pA |
| CMR | Common-mode rejection ratio <br> $V_{ic} = 0$ V | | 71 | | dB |
| SVR | Supply voltage rejection ratio <br> $V_{CC}^+ = +5$ V to +10 V | | 80 | | dB |
| $I_{OH}$ | High level output voltage <br> $V_{id} = 1$ V, $V_{OH} = +5$ V <br> $T_{min} \leq T_{amb} \leq T_{max}$ | | 2 | 40 <br> 1000 | nA |
| $V_{OL}$ | Low level output voltage <br> $V_{id} = -1$ V, $I_{OL} = 6$ 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 | µA |
| $t_{PLH}$ | Response time low to high <br> $V_{ic} = 0$ V, $f = 10$ kHz, $R_L = 5.1$ kΩ, $C_L = 50$ 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 | | µs |
| $t_{PHL}$ | Response time high to low <br> $V_{ic} = 0$ V, $f = 10$ kHz, $R_L = 5.1$ kΩ, $C_L = 50$ 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 | | µs |
| $t_f$ | Fall time <br> $f = 10$ kHz, $C_L = 50$ pF, $R_L = 5.1$ kΩ, 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*. ECOPACK is an ST trademark.

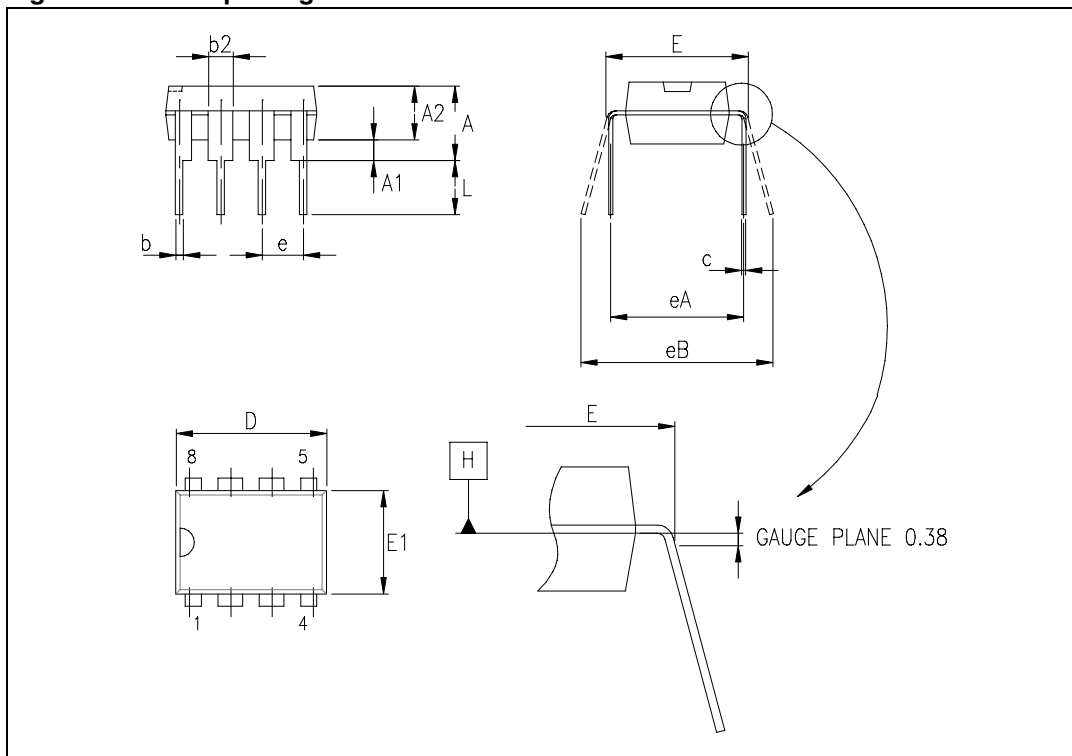# 4.1 DIP8 package

**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**
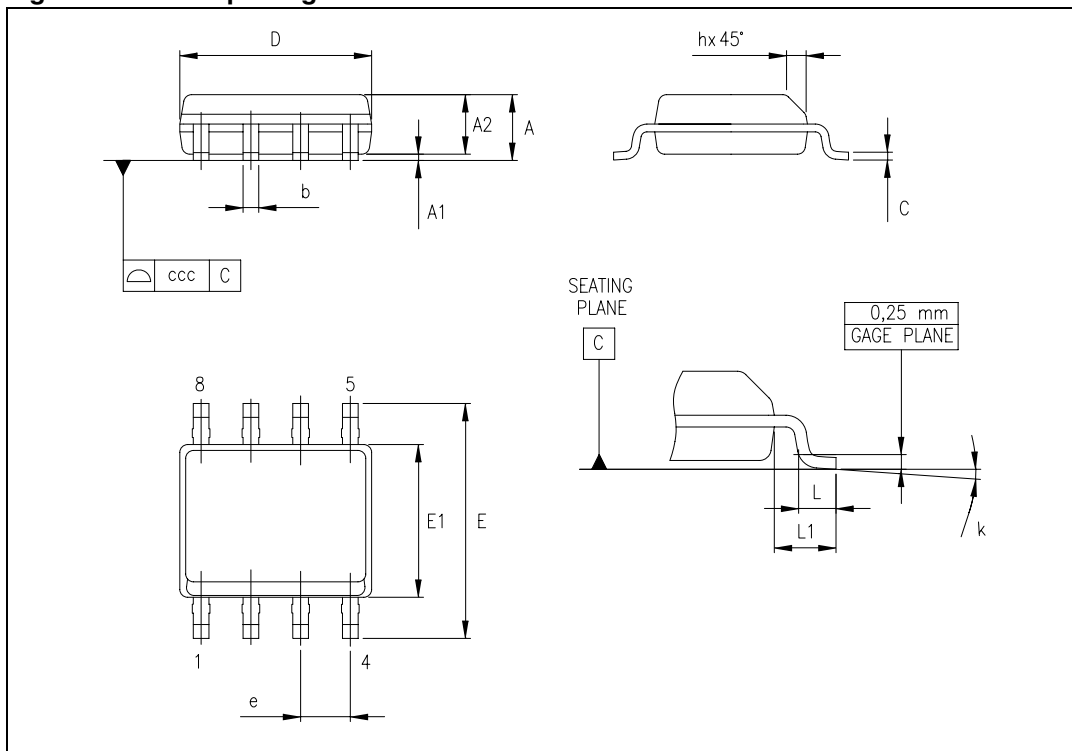


**Table 6.** **SO-8 package mechanical data**

| 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**
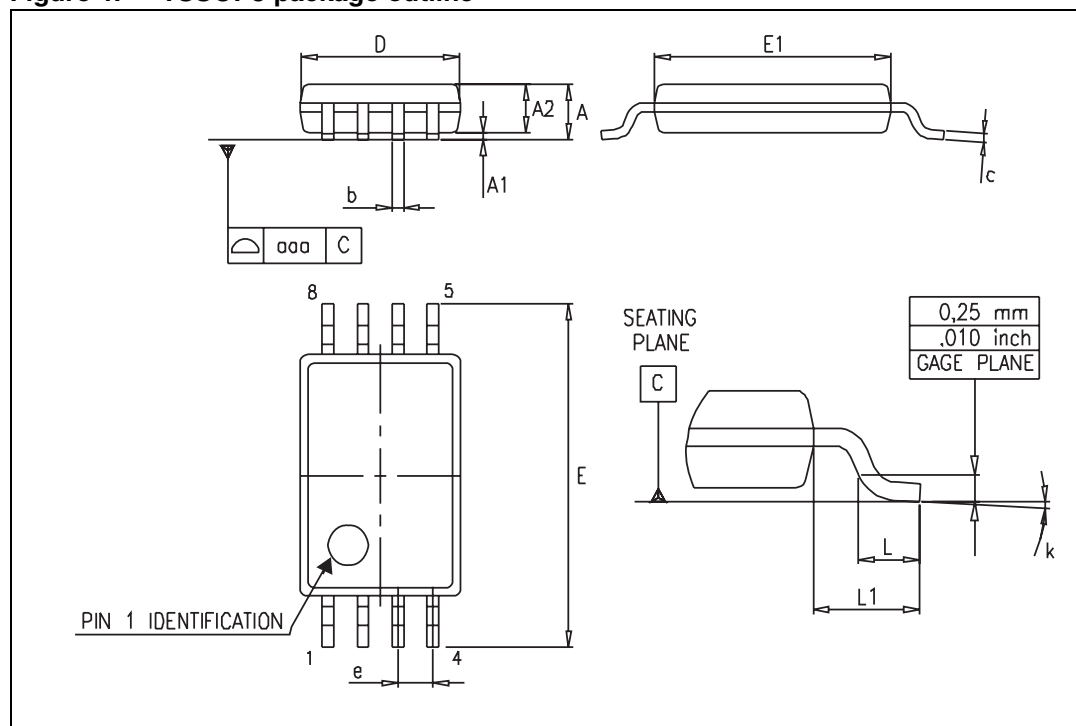


**Table 7. TSSOP8 package mechanical data**

| 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 TS393CDT | | SO-8 | Tube or tape and reel | S393C |
| TS393IN | -40 °C, +125 °C | DIP8 | Tube | TS393IN |
| TS393ID TS393IDT | | SO-8 | Tube or tape and reel | S393I |
| TS393IPT | | TSSOP8 | Tape and reel | S393I |
| TS393IYDT[1] | | SO-8 (automotive grade) | Tube or 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. ESD protection inserted in AMR table. |
| 28-Apr-2008 | 3 | Added footnotes for automotive grade order codes in order codes table. Updated ESD values for HBM and MM. Updated document format. |
| 21-Nov-2012 | 4 | Updated ECOPACK text in *Section 4: Package information*. Updated *Table 8* (qualified TS393IYDT and removed TS393IYD order code). Minor corrections throughout document. |

**Please Read Carefully:**

Information in this document is provided solely in connection with ST products. STMicroelectronics NV and its subsidiaries ("ST") reserve the right to make changes, corrections, modifications or improvements, to this document, and the products and services described herein at any time, without notice.

All ST products are sold pursuant to ST's terms and conditions of sale.

Purchasers are solely responsible for the choice, selection and use of the ST products and services described herein, and ST assumes no liability whatsoever relating to the choice, selection or use of the ST products and services described herein.

No license, express or implied, by estoppel or otherwise, to any intellectual property rights is granted under this document. If any part of this document refers to any third party products or services it shall not be deemed a license grant by ST for the use of such third party products or services, or any intellectual property contained therein or considered as a warranty covering the use in any manner whatsoever of such third party products or services or any intellectual property contained therein.

**UNLESS OTHERWISE SET FORTH IN ST'S TERMS AND CONDITIONS OF SALE ST DISCLAIMS ANY EXPRESS OR IMPLIED WARRANTY WITH RESPECT TO THE USE AND/OR SALE OF ST PRODUCTS INCLUDING WITHOUT LIMITATION IMPLIED WARRANTIES OF MERCHANTABILITY, FITNESS FOR A PARTICULAR PURPOSE (AND THEIR EQUIVALENTS UNDER THE LAWS OF ANY JURISDICTION), OR INFRINGEMENT OF ANY PATENT, COPYRIGHT OR OTHER INTELLECTUAL PROPERTY RIGHT.**

**UNLESS EXPRESSLY APPROVED IN WRITING BY TWO AUTHORIZED ST REPRESENTATIVES, ST PRODUCTS ARE NOT RECOMMENDED, AUTHORIZED OR WARRANTED FOR USE IN MILITARY, AIR CRAFT, SPACE, LIFE SAVING, OR LIFE SUSTAINING APPLICATIONS, NOR IN PRODUCTS OR SYSTEMS WHERE FAILURE OR MALFUNCTION MAY RESULT IN PERSONAL INJURY, DEATH, OR SEVERE PROPERTY OR ENVIRONMENTAL DAMAGE. ST PRODUCTS WHICH ARE NOT SPECIFIED AS "AUTOMOTIVE GRADE" MAY ONLY BE USED IN AUTOMOTIVE APPLICATIONS AT USER'S OWN RISK.**

Resale of ST products with provisions different from the statements and/or technical features set forth in this document shall immediately void any warranty granted by ST for the ST product or service described herein and shall not create or extend in any manner whatsoever, any liability of ST.

ST and the ST logo are trademarks or registered trademarks of ST in various countries.

Information in this document supersedes and replaces all information previously supplied.

The ST logo is a registered trademark of STMicroelectronics. All other names are the property of their respective owners.

STMicroelectronics group of companies

Australia - Belgium - Brazil - Canada - China - Czech Republic - Finland - France - Germany - Hong Kong - India - Israel - Italy - Japan - Malaysia - Malta - Morocco - Philippines - Singapore - Spain - Sweden - Switzerland - United Kingdom - United States of America

**www.st.com**