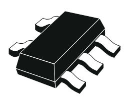
# TS331

## Micropower low-voltage rail-to-rail comparator

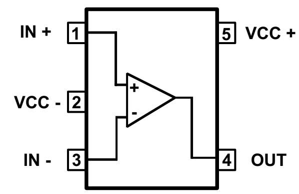
## Features

- Supply operation from 1.6 to 5 V
- Low current consumption: 20 µA
- Rail-to-rail inputs
- Wide temperature range: -40°C to +125°C
- Low output saturation voltage
- Low propagation delay: 210 ns
- Open-drain output
- ESD tolerance: 2 kV HBM/200 V MM
- SMD packages: SC70-5 and SOT23-5

**TS331**
**SOT23-5/SC70-5**



**Pin connections (top view)**




## Applications

- Mobile phones
- Notebooks and PDAs
- Battery supplied electronics
- General-purpose portable devices
- General-purpose low voltage applications

## Description

The TS331 is a single micropower and low-voltage comparator. It can operate with a supply voltage ranging from 1.6 to 5 V with only 20 µA current consumption. In addition, rail-to-rail inputs make it a perfect choice for low-voltage applications.

SOT23-5 and SC70-5 package availability is a real advantage for space saving constraints. The SC70-5 is approximately half the size of the SOT23-5.

The TS331 is specified for a wide temperature range of -40°C to +125°C, making it ideal for a wide range of applications.

# 1 Absolute maximum ratings and operating conditions

**Table 1. Absolute maximum ratings**

| Symbol | Parameter | Value | Unit |
|---|---|---|---|
| $V_{CC}$ | Supply voltage(1) | 5.5 | V |
| $V_{ID}$ | Differential input voltage(2) | ± 5.5 | V |
| $V_{IN}$ | Input voltage range | ($V_{CC}$-) -0.3 to ($V_{CC}$+) + 0.3 | V |
| $R_{thja}$ | Thermal resistance junction to ambient(3)<br>SC70-5<br>SOT23-5 | <br>205<br>250 | °C/W |
| $R_{thjc}$ | Thermal resistance junction to case (3)<br>SC70-5<br>SOT23-5 | <br>172<br>81 | °C/W |
| $T_{stg}$ | Storage temperature | -65 to +150 | °C |
| $T_j$ | Junction temperature | 150 | °C |
| $T_{LEAD}$ | Lead temperature (soldering 10 seconds) | 260 | °C |
| ESD | Human body model (HBM)(4) | 2000 | V |
| | Machine model (MM)(5) | 200 | |
| | Charged device model (CDM)(6) | 1500 | |
| | Latch-up immunity | 200 | mA |

1. All voltage values, except differential voltage, are referenced to $V_{cc}$-.
2. The magnitude of input and output voltages must never exceed the supply rail ±0.3 V.
3. Short-circuits can cause excessive heating. These values are typical.
4. 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.
5. 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.
6. Charged device model: all pins and 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 |
|---|---|---|---|
| $T_{oper}$ | Operating temperature range | -40 to +125 | °C |
| $V_{CC}$ | Supply voltage ($V_{CC}$+) - ($V_{CC}$-)<br>-40°C < $T_{amb}$ < +125°C | <br>1.6 to 5.0 | V |
| $V_{ICM}$ | Common mode input voltage range<br>$T_{amb}$ = +25°C<br>-40°C < $T_{amb}$ < +125°C | <br>($V_{CC}$-) -0.2 to ($V_{CC}$+)+0.2<br>($V_{CC}$-) to ($V_{CC}$+) | V |

# 2 Electrical characteristics

Table 3. $V_{CC}+ = +1.8$ V, $V_{CC}- = 0$ V, $T_{amb} = +25°C$ (unless otherwise specified)(1)

| Symbol | Parameter | Test conditions | Min. | Typ. | Max. | Unit |
|---|---|---|---|---|---|---|
| $V_{IO}$ | Input offset voltage | $V_{ICM} = 0$ V<br>-40°C < $T_{amb}$ < +125°C | | 0.5 | 5<br>6 | mV |
| $\Delta V_{IO}$ | Input offset voltage drift | -40°C < $T_{amb}$ < +125°C | | 4.5 | | µV/°C |
| $I_{IB}$ | Input bias current(2) | <br>-40°C < $T_{amb}$ < +125°C | | 25 | 40<br>100 | nA |
| $I_{IO}$ | Input offset current(2) | <br>-40°C < $T_{amb}$ < +125°C | | 1 | 10<br>100 | nA |
| $I_{CC}$ | Supply current | No load, output low, $V_{ICM} = 0$ V<br>-40°C < $T_{amb}$ < +125°C<br>No load, output high, $V_{ICM} = 0$ V<br>-40°C < $T_{amb}$ < +125°C | | 20<br><br>22 | 26<br>30<br>29<br>33 | µA |
| $I_{OH}$ | Output current leakage | $V_{OUT} = V_{CC}+$<br>-40°C < $T_{amb}$ < +125°C | | 1 | 10<br>500 | nA |
| $V_{OL}$ | Output voltage low | $I_{SINK} = 1$ mA<br>-40°C < $T_{amb}$ < +125°C | | 24 | 30<br>50 | mV |
| $I_{SINK}$ | Output sink current | $V_{OUT} = 1.5$ V<br>-40°C < $T_{amb}$ < +125°C | 20<br>15 | 22 | | mA |
| CMRR | Common mode rejection ratio | 0 < $V_{ICM}$ < 1.8 V | 50 | 68 | | dB |
| $TP_{HL}$ | Propagation delay(3)<br>High to low output level | $V_{ICM} = 0$ V, $R_L = 5.1$ kΩ, $C_L = 50$ pF<br>Overdrive = 10 mV<br>Overdrive = 100 mV | | <br>300<br>210 | <br><br>310 | ns |
| $TP_{LH}$ | Propagation delay(4)<br>Low to high output level | $V_{ICM} = 0$ V, $R_L = 5.1$ kΩ, $C_L = 50$ pF<br>Overdrive = 10 mV<br>Overdrive = 100 mV | | <br>540<br>420 | <br><br>620 | ns |

1. All values over the temperature range are guaranteed through correlation and simulation. No production tests have been performed at the temperature range limits.
2. Maximum values include unavoidable inaccuracies of the industrial tests.
3. $TP_{HL}$ is measured when the output signal crosses a voltage level at 50% of Vcc with the following conditions: inverting input voltage (IN-) = VICM and non-inverting input voltage (IN+) moving from VICM + 100 mV to VICM - overdrive.
4. $TP_{LH}$ is measured when the output signal crosses a voltage level at 50% of Vcc with the following conditions: inverting input voltage (IN-) = VICM and non-inverting input voltage (IN+) moving from VICM - 100 mV to VICM + overdrive.

**Table 4.** $V_{CC}+ = +2.7$ V, $V_{CC}- = 0$ V, $T_{amb} = +25°C$ (unless otherwise specified)(1)

| Symbol | Parameter | Test conditions | Min. | Typ. | Max. | Unit |
|---|---|---|---|---|---|---|
| $V_{IO}$ | Input offset voltage | $V_{ICM} = 0$ V<br>$-40°C < T_{amb} < +125°C$ | | 0.5 | 5<br>6 | mV |
| $\Delta V_{IO}$ | Input offset voltage drift | $-40°C < T_{amb} < +125°C$ | | 3.3 | | µV/°C |
| $I_{IB}$ | Input bias current(2) | <br>$-40°C < T_{amb} < +125°C$ | | 25 | 40<br>100 | nA |
| $I_{IO}$ | Input offset current(2) | <br>$-40°C < T_{amb} < +125°C$ | | 1 | 10<br>100 | nA |
| $I_{CC}$ | Supply current | No load, output low, $V_{ICM} = 0$ V<br>$-40°C < T_{amb} < +125°C$<br><br>No load, output high, $V_{ICM} = 0$ V<br>$-40°C < T_{amb} < +125°C$ | | 21<br><br><br>23 | 27<br>31<br><br>30<br>34 | µA |
| $I_{OH}$ | Output current leakage | $V_{OUT} = V_{CC}+$<br>$-40°C < T_{amb} < +125°C$ | | 1 | 10<br>500 | nA |
| $V_{OL}$ | Output voltage low | $I_{SINK} = 1$ mA<br>$-40°C < T_{amb} < +125°C$ | | 17 | 30<br>50 | mV |
| $I_{SINK}$ | Output sink current | $V_{OUT} = 1.5$ V<br>$-40°C < T_{amb} < +125°C$ | 40<br>30 | 47 | | mA |
| CMRR | Common mode rejection ratio | $0 < V_{ICM} < 2.7$ V<br>$-40°C < T_{amb} < +125°C$ | 54<br>53 | 74 | | dB |
| $TP_{HL}$ | Propagation delay(3)<br>High to low output level | $V_{ICM} = 0$ V, $R_L = 5.1$ kΩ, $C_L = 50$ pF<br>Overdrive = 10 mV<br>Overdrive = 100 mV | | <br>320<br>220 | <br><br>320 | ns |
| $TP_{LH}$ | Propagation delay(4)<br>Low to high output level | $V_{ICM} = 0$ V, $R_L = 5.1$ kΩ, $C_L = 50$ pF<br>Overdrive = 10 mV<br>Overdrive = 100 mV | | <br>550<br>420 | <br><br>640 | ns |

1. All values over the temperature range are guaranteed through correlation and simulation. No production tests have been performed at the temperature range limits.
2. Maximum values include unavoidable inaccuracies of the industrial tests.
3. $TP_{HL}$ is measured when the output signal crosses a voltage level at 50% of Vcc with the following conditions: Inverting input voltage (IN-) = VICM and Non-inverting input voltage (IN+) moving from VICM + 100 mV to VICM - overdrive.
4. $TP_{LH}$ is measured when the output signal crosses a voltage level at 50% of Vcc with the following conditions: Inverting input voltage (IN-) = VICM and Non-inverting input voltage (IN+) moving from VICM - 100 mV to VICM + overdrive.

**Table 5. $V_{CC}+ = +5$ V, $V_{CC}- = 0$ V, $T_{amb} = +25°C$ (unless otherwise specified)(1)**

| Symbol | Parameter | Test conditions | Min. | Typ. | Max. | Unit |
|---|---|---|---|---|---|---|
| $V_{IO}$ | Input offset voltage | $V_{ICM} = 0$ V<br>$-40°C < T_{amb} < +125°C$ | | 0.5 | 5<br>6 | mV |
| $\Delta V_{IO}$ | Input offset voltage drift | $-40°C < T_{amb} < +125°C$ | | 1.3 | | µV/°C |
| $I_{IB}$ | Input bias current(2) | <br>$-40°C < T_{amb} < +125°C$ | | 30 | 40<br>100 | nA |
| $I_{IO}$ | Input offset current(2) | <br>$-40°C < T_{amb} < +125°C$ | | 1 | 10<br>100 | nA |
| $I_{CC}$ | Supply current | No load, output low, $V_{ICM} = 0$ V<br>$-40°C < T_{amb} < +125°C$<br><br>No load, output high, $V_{ICM} = 0$ V<br>$-40°C < T_{amb} < +125°C$ | | 23<br><br><br>26 | 30<br>34<br><br>34<br>38 | µA |
| $I_{OH}$ | Output current leakage | $V_{OUT} = V_{CC}+$<br>$-40°C < T_{amb} < +125°C$ | | 1 | 10<br>600 | nA |
| $V_{OL}$ | Output voltage low | $I_{SINK} = 4$ mA<br>$-40°C < T_{amb} < +125°C$ | | 48 | 60<br>80 | mV |
| $I_{SINK}$ | Output sink current | $V_{OUT} = 1.5$ V<br>$-40°C < T_{amb} < +125°C$ | 82<br>68 | 93 | | mA |
| $A_V$ | Voltage gain | | 40 | 100 | | V/mV |
| CMRR | Common mode rejection ratio | $0 < V_{ICM} < 5$ V<br>$-40°C < T_{amb} < +125°C$ | 60<br>58 | 79 | | dB |
| SVR | Supply voltage rejection | $\Delta V_{CC} = 1.8$ to 5 V<br>$-40°C < T_{amb} < +125°C$ | 56<br>56 | 75 | | dB |
| $TP_{HL}$ | Propagation delay(3)<br>High to low output level | $V_{ICM} = 0$ V, $R_L = 5.1$ kΩ, $C_L = 50$ pF<br>Overdrive = 10 mV<br>Overdrive = 100 mV | | <br>380<br>270 | <br><br>430 | ns |
| $TP_{LH}$ | Propagation delay(4)<br>Low to high output level | $V_{ICM} = 0$ V, $R_L = 5.1$ kΩ, $C_L = 50$ pF<br>Overdrive = 10 mV<br>Overdrive = 100 mV | | <br>570<br>450 | <br><br>720 | ns |

1. All values over the temperature range are guaranteed through correlation and simulation. No production tests have been performed at the temperature range limits.
2. Maximum values include unavoidable inaccuracies of the industrial tests.
3. $TP_{HL}$ is measured when the output signal crosses a voltage level at 50% of Vcc with the following conditions: Inverting input voltage (IN-) = VICM and Non-inverting input voltage (IN+) moving from VICM + 100 mV to VICM - overdrive.
4. $TP_{LH}$ is measured when the output signal crosses a voltage level at 50% of Vcc with the following conditions: Inverting input voltage (IN-) = VICM and Non-inverting input voltage (IN+) moving from VICM - 100 mV to VICM + overdrive.

**Figure 1. Supply current versus supply voltage with output high, $V_{ICM} = 0$ V**

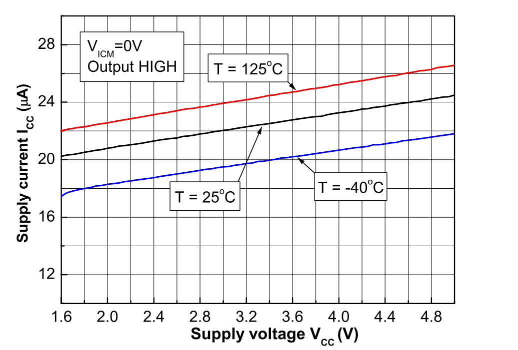



**Figure 2. Supply current versus supply voltage with output high, $V_{ICM} = V_{CC}$**

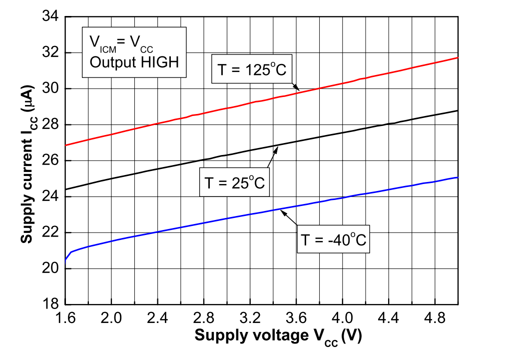



**Figure 3. Supply current versus supply voltage with output low, $V_{ICM} = 0$ V**

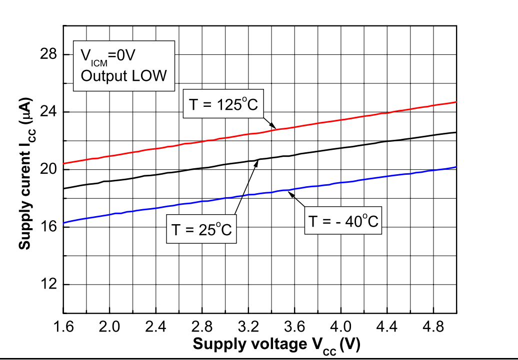



**Figure 4. Supply current versus supply voltage with output low, $V_{ICM} = V_{CC}$**

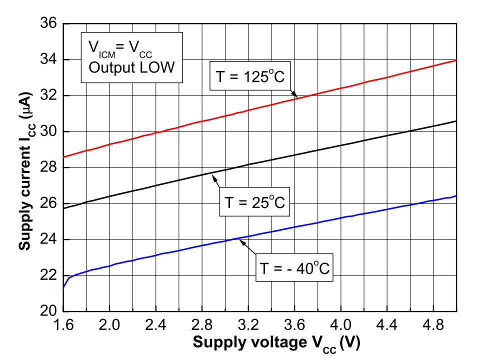



**Figure 5. Supply current versus temperature**

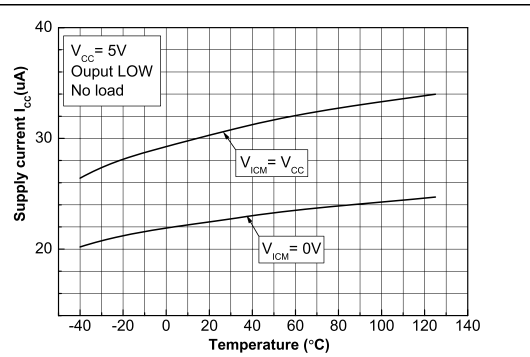



**Figure 6. Input bias current versus input common-mode voltage**

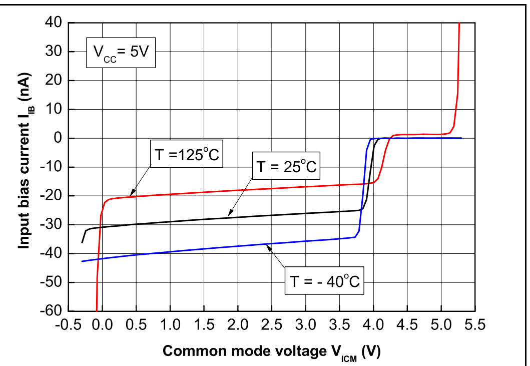


**Figure 7. Input current versus differential input voltage**

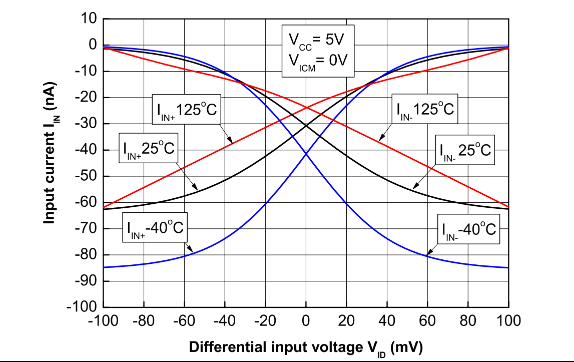



**Figure 8. Input offset voltage versus temperature**

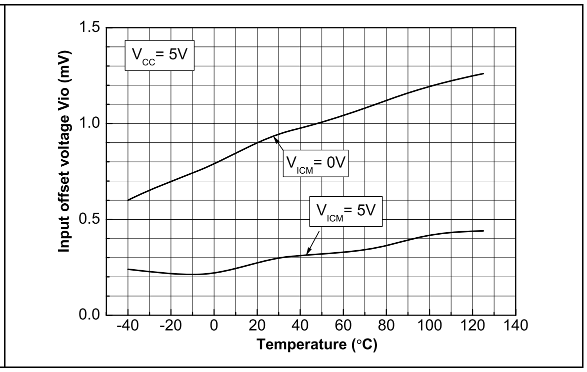



**Figure 9. Output voltage versus output sink current, $V_{CC}$ = 1.8 V**

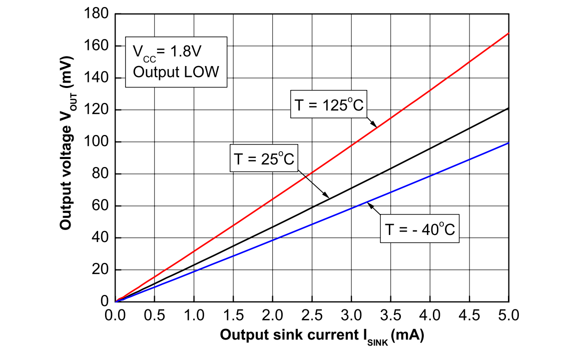



**Figure 10. Output voltage versus output sink current, $V_{CC}$ = 2.7 V**

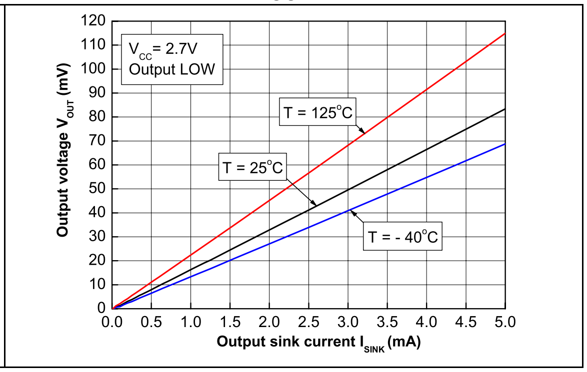



**Figure 11. Output voltage versus output sink current, $V_{CC}$ = 5 V**

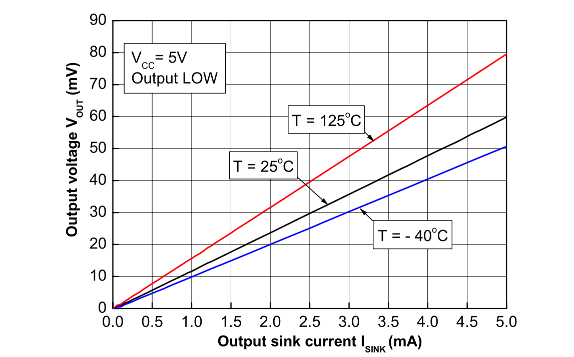



**Figure 12. Output sink current versus output voltage**

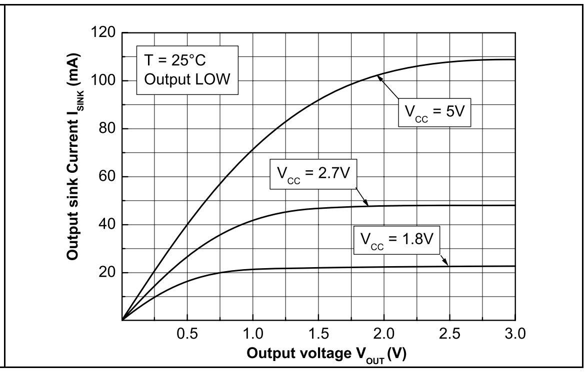


**Figure 13. Output voltage versus temperature**

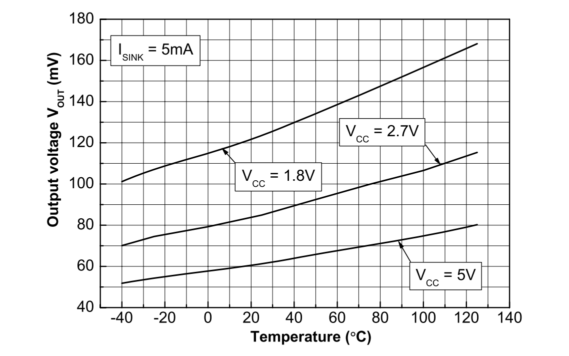



**Figure 14. Propagation delay versus overdrive with negative transition, $V_{CC}$ = 1.8 V**

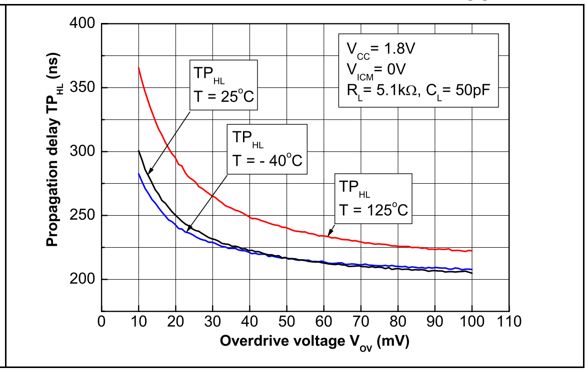



**Figure 15. Propagation delay versus overdrive with positive transition, $V_{CC}$ = 1.8 V**

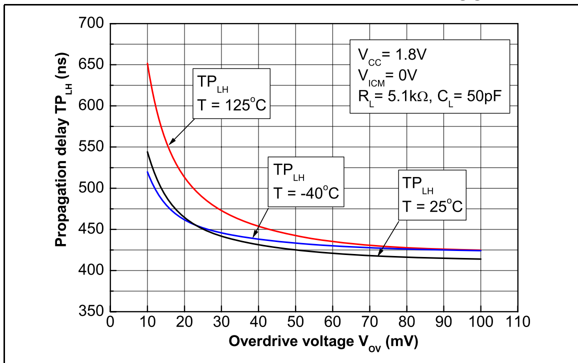



**Figure 16. Propagation delay versus common mode voltage, $V_{CC}$ = 1.8 V**

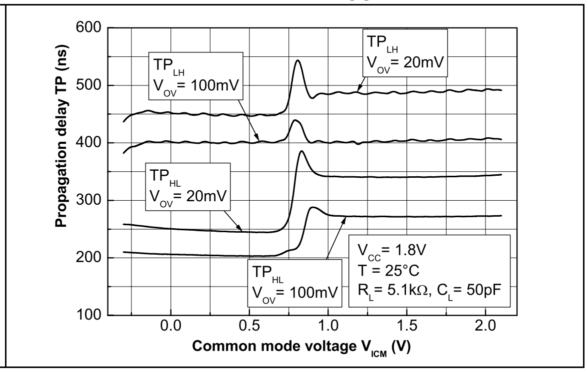



**Figure 17. Propagation delay versus overdrive with negative transition, $V_{CC}$ = 2.7 V**

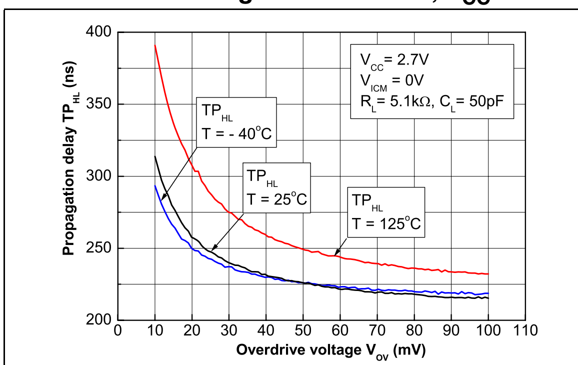



**Figure 18. Propagation delay versus overdrive with positive transition, $V_{CC}$ = 2.7 V**

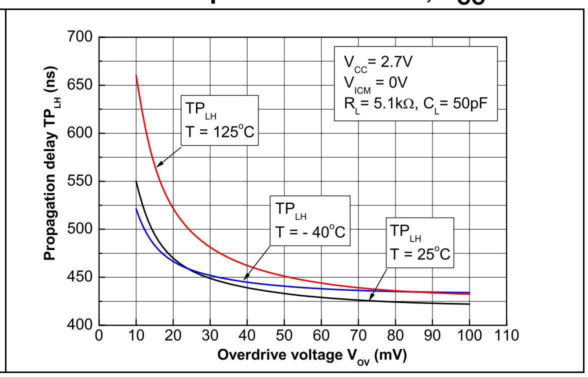


**Figure 19. Propagation delay versus common mode voltage, $V_{CC}$ = 2.7 V**

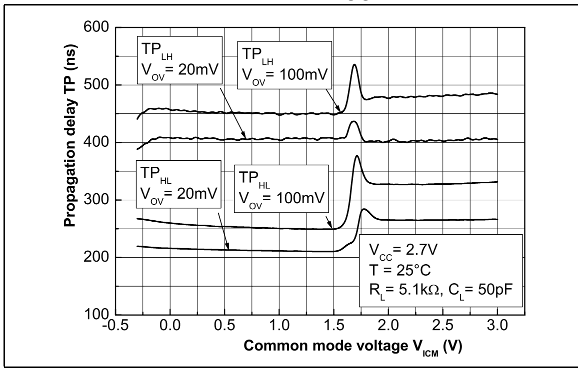



**Figure 20. Propagation delay versus overdrive with negative transition, $V_{CC}$ = 5 V**

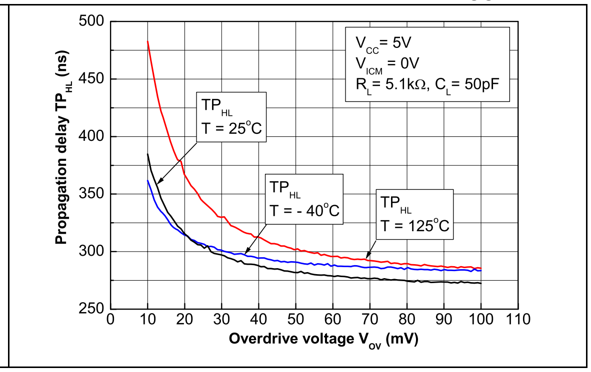



**Figure 21. Propagation delay versus overdrive with positive transition, $V_{CC}$ = 5 V**

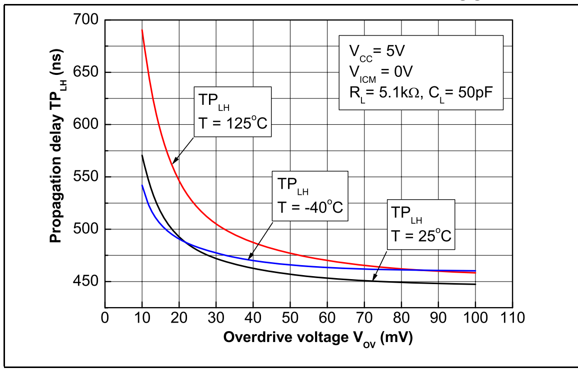



**Figure 22. Propagation delay versus common mode voltage, $V_{CC}$ = 5 V**

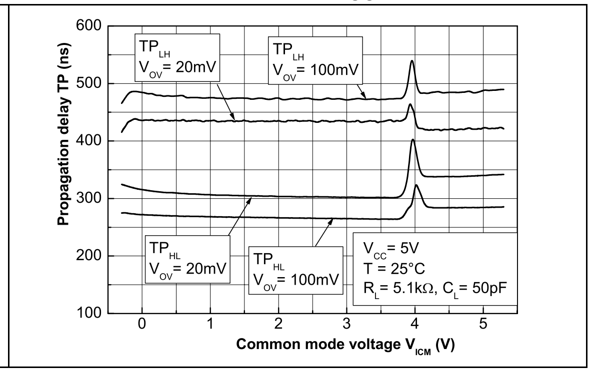



**Figure 23. Propagation delay versus time with negative transition**

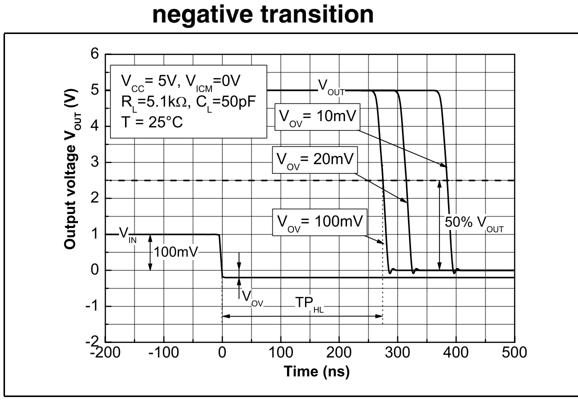
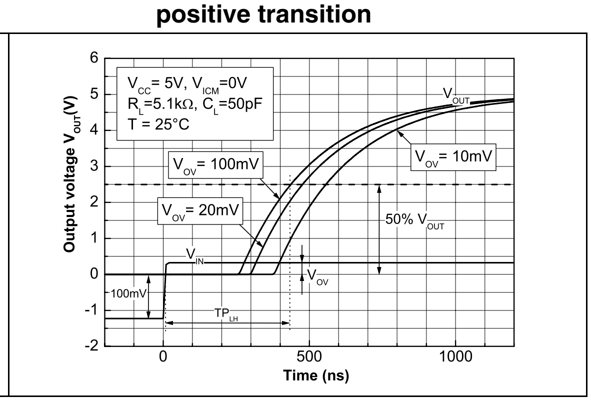



**Figure 24. Propagation delay versus time with positive transition**



# 3 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.

## 3.1 SOT23-5 package

**Figure 25. SOT23-5 package mechanical drawing**

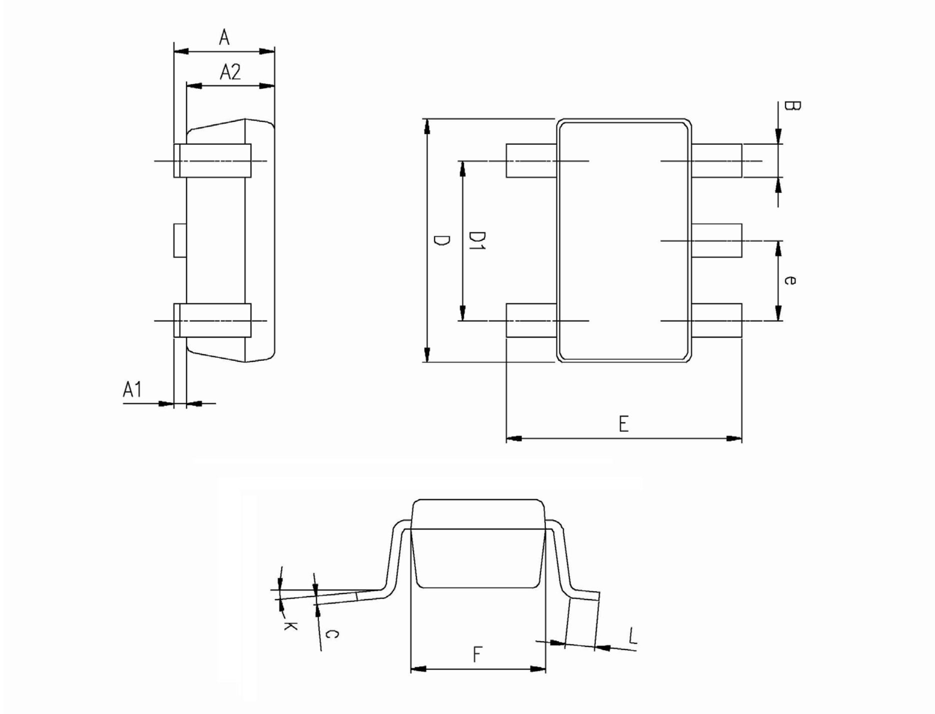



**Table 6. SOT23-5 package mechanical data**

| 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 | 0.013 | 0.015 | 0.019 |
| C | 0.09 | 0.15 | 0.20 | 0.003 | 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 | 0.013 | 0.023 |
| K | 0 degrees | | 10 degrees | | | |

## 3.2 SC70-5 (SOT323-5) package

**Figure 26. SC70-5 (SOT323-5) package mechanical drawing**

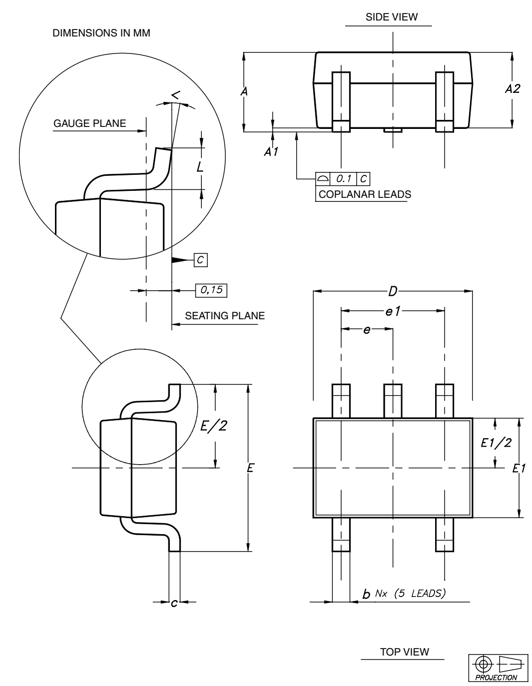



**Table 7. SC70-5 (or SOT323-5) package mechanical data**

| Ref | Dimensions | | | | | |
|---|---|---|---|---|---|---|
| | Millimeters | | | Inches | | |
| | Min | Typ | Max | Min | Typ | Max |
| A | 0.80 | | 1.10 | 0.315 | | 0.043 |
| A1 | | | 0.10 | | | 0.004 |
| A2 | 0.80 | 0.90 | 1.00 | 0.315 | 0.035 | 0.039 |
| b | 0.15 | | 0.30 | 0.006 | | 0.012 |
| c | 0.10 | | 0.22 | 0.004 | | 0.009 |
| D | 1.80 | 2.00 | 2.20 | 0.071 | 0.079 | 0.087 |
| E | 1.80 | 2.10 | 2.40 | 0.071 | 0.083 | 0.094 |
| E1 | 1.15 | 1.25 | 1.35 | 0.045 | 0.049 | 0.053 |
| e | | 0.65 | | | 0.025 | |
| e1 | | 1.30 | | | 0.051 | |
| L | 0.26 | 0.36 | 0.46 | 0.010 | 0.014 | 0.018 |
| < | 0° | | 8° | | | |

# 4 Ordering information

**Table 8. Order codes**

| Part number | Temperature range | Package | Packaging | Marking |
|---|---|---|---|---|
| TS331ILT | -40°C, +125°C | SOT23-5 | Tape & reel | K506 |
| TS331ICT | | SC70-5 | Tape & reel | K55 |

# 5 Revision history

**Table 9. Document revision history**

| Date | Revision | Changes |
|---|---|---|
| 29-Mar-2010 | 1 | Initial release. |

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**