

## Rail-to-rail high-speed comparator

### Features

- Propagation delay: 8 ns
- Low current consumption: 470  $\mu$ A typ at 5 V
- Rail-to-rail inputs
- Push-pull outputs
- Supply operation from 2.2 to 5 V
- Wide temperature range: -40°C to +125°C
- ESD tolerance: 2 kV HBM/200 V MM
- Latch-up immunity: 200 mA
- SMD packages

### Applications

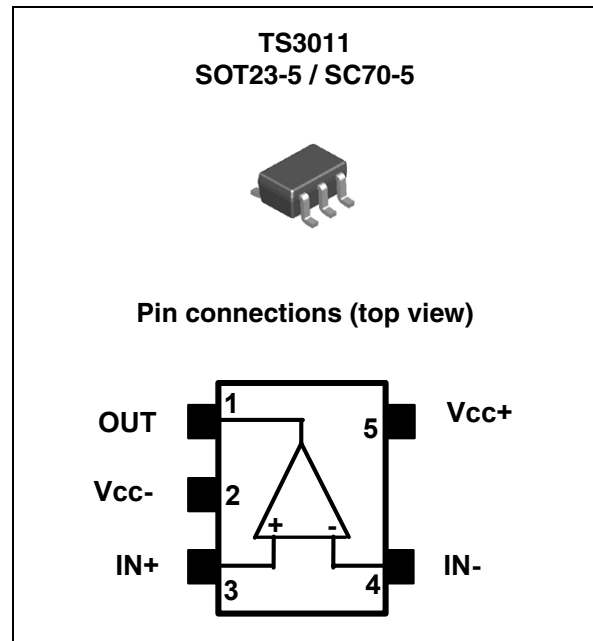
- Telecoms
- Instrumentation
- Signal conditioning
- High-speed sampling systems
- Portable communication systems

### Description

The TS3011 single comparator features a high-speed response time with rail-to-rail inputs. Specified for a supply voltage of 2.2 to 5 V, this comparator can operate over a wide temperature range of -40°C to +125°C.

The TS3011 offers micropower consumption as low as a few hundred microamperes, thus providing an excellent ratio of power consumption current versus response time.

The TS3011 includes push-pull outputs and is available in small packages (SMD): SOT23-5 and SC70-5.



# 1 Absolute maximum ratings and operating conditions

**Table 1. Absolute maximum ratings**

| Symbol            | Parameter  | Value  | Unit |
|-------------------|--|--|------|
| V <sub>CC</sub>   | Supply voltage <sup>(1)</sup>  | 5.5  | V    |
| V <sub>ID</sub>   | Differential input voltage <sup>(2)</sup>                                  | ±5   | V    |
| V <sub>IN</sub>   | Input voltage range  | (V <sub>CC-</sub> ) - 0.3 to (V <sub>CC+</sub> ) + 0.3 | V    |
| R <sub>THJA</sub> | Thermal resistance junction to ambient <sup>(3)</sup><br>SC70-5<br>SOT23-5 | 205<br>250   | °C/W |
| R <sub>THJC</sub> | Thermal resistance junction to case <sup>(3)</sup><br>SC70-5<br>SOT23-5    | 172<br>81  | °C/W |
| T <sub>STG</sub>  | Storage temperature  | -65 to +150  | °C   |
| T <sub>J</sub>    | Junction temperature   | 150  | °C   |
| T <sub>LEAD</sub> | Lead temperature (soldering 10 seconds)                                    | 260  | °C   |
| ESD               | Human body model (HBM) <sup>(4)</sup>                                      | 2000   | V    |
|                   | Machine model (MM) <sup>(5)</sup>  | 200  |      |
|                   | Charged device model (CDM) <sup>(6)</sup><br>SOT23-5<br>SC70-5             | 1500<br>1300   |      |
|                   | Latch-up immunity  | 200  | mA   |

1. All voltage values, except the differential voltage, are referenced to V<sub>CC-</sub>.
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.

**Table 2. Operating conditions**

| Symbol            | Parameter  | Value  | Unit |
|-------------------|--|--|------|
| T <sub>Oper</sub> | Operating temperature range  | -40 to +125  | °C   |
| V <sub>CC</sub>   | Supply voltage (V <sub>CC+</sub> - V <sub>CC-</sub> )<br>-40°C < T <sub>amb</sub> < +125°C | 2.2 to 5   | V    |
| V <sub>ICM</sub>  | Common mode input voltage range<br>-40°C < T <sub>amb</sub> < +125°C                       | (V <sub>CC-</sub> ) - 0.2 to (V <sub>CC+</sub> ) + 0.2 | V    |

## 2 Electrical characteristics

**Table 3.**  $V_{CC} = +2.2\text{ V}$ ,  $V_{ICM} = V_{CC}/2$ ,  $T_{amb} = +25^\circ\text{C}$  (unless otherwise specified)<sup>(1)</sup>

| Symbol          | Parameter  | Test conditions   | Min.         | Typ.             | Max.                           | Unit                         |
|-----------------|--|---|--------------|------------------|--------------------------------|------------------------------|
| $V_{IO}$        | Input offset voltage <sup>(2)</sup>                          | $-40^\circ\text{C} < T_{amb} < +125^\circ\text{C}$  | -7<br>-8     | -0.2             | 7<br>8                         | mV                           |
| $\Delta V_{IO}$ | Input offset voltage drift                                   | $-40^\circ\text{C} < T_{amb} < +125^\circ\text{C}$  |              | 5                | 20                             | $\mu\text{V}/^\circ\text{C}$ |
| $V_{HYST}$      | Input hysteresis voltage <sup>(3)</sup>                      |   |              | 2                |                                | mV                           |
| $I_{IO}$        | Input offset current <sup>(4)</sup>                          | $-40^\circ\text{C} < T_{amb} < +125^\circ\text{C}$  |              | 1                | 20<br>100                      | pA                           |
| $I_{IB}$        | Input bias current   | $-40^\circ\text{C} < T_{amb} < +125^\circ\text{C}$  |              | 1                | 20<br>100                      | pA                           |
| $I_{CC}$        | Supply current   | No load, output high<br>$-40^\circ\text{C} < T_{amb} < +125^\circ\text{C}$<br><br>No load, output low<br>$-40^\circ\text{C} < T_{amb} < +125^\circ\text{C}$ |              | 0.52<br><br>0.65 | 0.64<br>0.9<br><br>0.88<br>1.1 | mA                           |
| $I_{SC}$        | Short circuit current  | Source<br>Sink  | 14<br>11     | 18<br>14         |                                | mA                           |
| $V_{OH}$        | Output voltage high  | $I_{source} = 4\text{ mA}$<br>$-40^\circ\text{C} < T_{amb} < +125^\circ\text{C}$  | 1.94<br>1.85 | 1.97             |                                | V                            |
| $V_{OL}$        | Output voltage low   | $I_{sink} = 4\text{ mA}$<br>$-40^\circ\text{C} < T_{amb} < +125^\circ\text{C}$  |              | 150              | 190<br>250                     | mV                           |
| CMRR            | Common mode rejection ratio                                  | $0 < V_{ICM} < 2.7\text{ V}$  | 50           | 68               |                                | dB                           |
| $T_{PLH}$       | Propagation delay <sup>(5)</sup><br>low to high output level | $C_L = 12\text{ pF}$ , $R_L = 1\text{ M}\Omega$<br>Overdrive = 5 mV<br>Overdrive = 15 mV<br>Overdrive = 50 mV   |              | 16<br>12<br>10   | 15                             | ns                           |
| $T_{PHL}$       | Propagation delay <sup>(6)</sup><br>high to low output level | $C_L = 12\text{ pF}$ , $R_L = 1\text{ M}\Omega$<br>Overdrive = 5 mV<br>Overdrive = 15 mV<br>Overdrive = 50 mV   |              | 16<br>12<br>10   | 15                             | ns                           |
| $T_R$           | Rise time (10% to 90%)                                       | $C_L = 12\text{ pF}$ , $R_L = 1\text{ M}\Omega$<br>Overdrive = 100 mV   |              | 3.0              |                                | ns                           |
| $T_F$           | Fall time (90% to 10%)                                       | $C_L = 12\text{ pF}$ , $R_L = 1\text{ M}\Omega$<br>Overdrive = 100 mV   |              | 2.5              |                                | ns                           |

1. All values over the temperature range are guaranteed through correlation and simulation. No production tests are performed at the temperature range limits.
2. The offset is defined as the average value of positive ( $V_{TRIP+}$ ) and negative ( $V_{TRIP-}$ ) trip points (input voltage differences requested to change the output state in each direction).
3. Hysteresis is a built-in feature of the TS3011. It is defined as the voltage difference between the trip points.
4. Maximum values include unavoidable inaccuracies of the industrial tests.
5. Overdrive is measured with reference to the  $V_{TRIP+}$  point.
6. Overdrive is measured with reference to the  $V_{TRIP-}$  point.

Table 4.  $V_{CC} = +2.7\text{ V}$ ,  $V_{ICM} = V_{CC}/2$ ,  $T_{amb} = +25^\circ\text{C}$  (unless otherwise specified)<sup>(1)</sup>

| Symbol          | Parameter  | Test conditions  | Min.         | Typ. | Max.        | Unit                         |
|-----------------|--|--|--------------|------|-------------|------------------------------|
| $V_{IO}$        | Input offset voltage <sup>(2)</sup>                          | $-40^\circ\text{C} < T_{amb} < +125^\circ\text{C}$                               | -7<br>-9     | -0.1 | 7<br>9      | mV                           |
| $\Delta V_{IO}$ | Input offset voltage drift                                   | $-40^\circ\text{C} < T_{amb} < +125^\circ\text{C}$                               |              | 5    | 20          | $\mu\text{V}/^\circ\text{C}$ |
| $V_{HYST}$      | Input hysteresis voltage <sup>(3)</sup>                      |  |              | 2    |             | mV                           |
| $I_{IO}$        | Input offset current <sup>(4)</sup>                          | $-40^\circ\text{C} < T_{amb} < +125^\circ\text{C}$                               |              | 1    | 20<br>100   | pA                           |
| $I_{IB}$        | Input bias current   | $-40^\circ\text{C} < T_{amb} < +125^\circ\text{C}$                               |              | 1    | 20<br>100   | pA                           |
| $I_{CC}$        | Supply current   | No load, output high<br>$-40^\circ\text{C} < T_{amb} < +125^\circ\text{C}$       |              | 0.52 | 0.65<br>0.9 | mA                           |
|                 |  | No load, output low<br>$-40^\circ\text{C} < T_{amb} < +125^\circ\text{C}$        |              | 0.66 | 0.89<br>1.1 |                              |
| $I_{SC}$        | Short circuit current  | Source   | 24           | 27   |             | mA                           |
|                 |  | Sink   | 19           | 22   |             |                              |
| $V_{OH}$        | Output voltage high  | $I_{source} = 4\text{ mA}$<br>$-40^\circ\text{C} < T_{amb} < +125^\circ\text{C}$ | 2.48<br>2.40 | 2.52 |             | V                            |
| $V_{OL}$        | Output voltage low   | $I_{sink} = 4\text{ mA}$<br>$-40^\circ\text{C} < T_{amb} < +125^\circ\text{C}$   |              | 130  | 170<br>220  | mV                           |
| CMRR            | Common mode rejection ratio                                  | $0 < V_{ICM} < 2.7\text{ V}$   | 52           | 70   |             | dB                           |
| $T_{PLH}$       | Propagation delay <sup>(5)</sup><br>low to high output level | $C_L = 12\text{ pF}$ , $R_L = 1\text{ M}\Omega$<br>Overdrive = 5 mV              |              | 16   |             | ns                           |
|                 |  | Overdrive = 15 mV  |              | 11   |             |                              |
|                 |  | Overdrive = 50 mV  |              | 9    | 13          |                              |
| $T_{PHL}$       | Propagation delay <sup>(6)</sup><br>high to low output level | $C_L = 12\text{ pF}$ , $R_L = 1\text{ M}\Omega$<br>Overdrive = 5 mV              |              | 16   |             | ns                           |
|                 |  | Overdrive = 15 mV  |              | 11   |             |                              |
|                 |  | Overdrive = 50 mV  |              | 9    | 13          |                              |
| $T_R$           | Rise time (10% to 90%)                                       | $C_L = 12\text{ pF}$ , $R_L = 1\text{ M}\Omega$<br>Overdrive = 100 mV            |              | 2.3  |             | ns                           |
| $T_F$           | Fall time (90% to 10%)                                       | $C_L = 12\text{ pF}$ , $R_L = 1\text{ M}\Omega$<br>Overdrive = 100 mV            |              | 1.8  |             | ns                           |

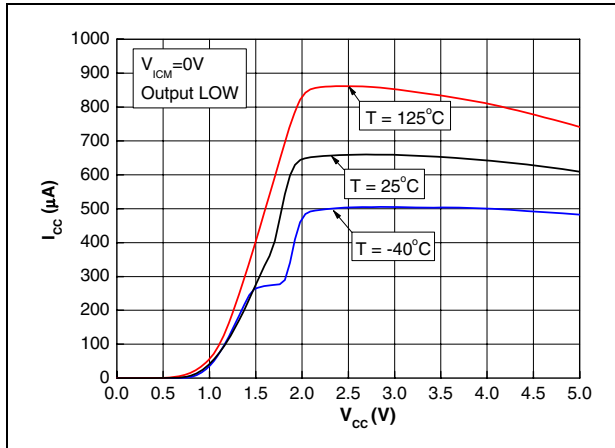
1. All values over the temperature range are guaranteed through correlation and simulation. No production tests are performed at the temperature range limits.
2. The offset is defined as the average value of positive ( $V_{TRIP+}$ ) and negative ( $V_{TRIP-}$ ) trip points (input voltage differences requested to change the output state in each direction).
3. Hysteresis is a built-in feature of the TS3011. It is defined as the voltage difference between the trip points.
4. Maximum values include unavoidable inaccuracies of the industrial tests.
5. Overdrive is measured with reference to the  $V_{TRIP+}$  point.
6. Overdrive is measured with reference to the  $V_{TRIP-}$  point.

Table 5.  $V_{CC} = +5\text{ V}$ ,  $V_{ICM} = V_{CC}/2$ ,  $T_{amb} = +25^\circ\text{C}$  (unless otherwise specified)<sup>(1)</sup>

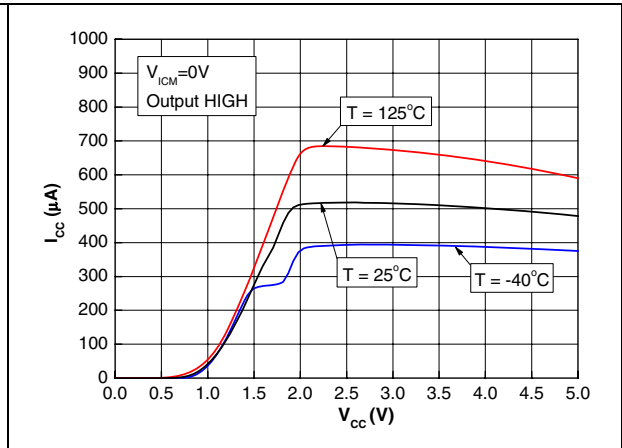
| Symbol          | Parameter  | Test conditions  | Min.         | Typ. | Max.        | Unit                         |
|-----------------|--|--|--------------|------|-------------|------------------------------|
| $V_{IO}$        | Input offset voltage <sup>(2)</sup>                          | $-40^\circ\text{C} < T_{amb} < +125^\circ\text{C}$                               | -7<br>-9     | -0.4 | 7<br>9      | mV                           |
| $\Delta V_{IO}$ | Input offset voltage drift                                   | $-40^\circ\text{C} < T_{amb} < +125^\circ\text{C}$                               |              | 10   | 30          | $\mu\text{V}/^\circ\text{C}$ |
| $V_{HYST}$      | Input hysteresis voltage <sup>(3)</sup>                      |  |              | 2    |             | mV                           |
| $I_{IO}$        | Input offset current <sup>(4)</sup>                          | $-40^\circ\text{C} < T_{amb} < +125^\circ\text{C}$                               |              | 1    | 20<br>100   | pA                           |
| $I_{IB}$        | Input bias current   | $-40^\circ\text{C} < T_{amb} < +125^\circ\text{C}$                               |              | 1    | 20<br>100   | pA                           |
| $I_{CC}$        | Supply current   | No load, output high<br>$-40^\circ\text{C} < T_{amb} < +125^\circ\text{C}$       |              | 0.47 | 0.69<br>0.9 | mA                           |
|                 |  | No load, output low<br>$-40^\circ\text{C} < T_{amb} < +125^\circ\text{C}$        |              | 0.60 | 0.91<br>1.1 |                              |
| $I_{SC}$        | Short circuit current  | Source   | 58           | 62   |             | mA                           |
|                 |  | Sink   | 58           | 64   |             |                              |
| $V_{OH}$        | Output voltage high  | $I_{source} = 4\text{ mA}$<br>$-40^\circ\text{C} < T_{amb} < +125^\circ\text{C}$ | 4.84<br>4.80 | 4.89 |             | V                            |
| $V_{OL}$        | Output voltage low   | $I_{sink} = 4\text{ mA}$<br>$-40^\circ\text{C} < T_{amb} < +125^\circ\text{C}$   |              | 90   | 120<br>180  | mV                           |
| CMRR            | Common mode rejection ratio                                  | $0 < V_{ICM} < 5\text{ V}$   | 57           | 74   |             | dB                           |
| SVR             | Supply voltage rejection                                     | $\Delta V_{CC} = 2.2\text{ V to } 5\text{ V}$                                    |              | 79   |             |                              |
| $T_{PLH}$       | Propagation delay <sup>(5)</sup><br>low to high output level | $C_L = 12\text{ pF}$ , $R_L = 1\text{ M}\Omega$<br>Overdrive = 5 mV              |              | 14   |             | ns                           |
|                 |  | Overdrive = 15 mV  |              | 10   |             |                              |
|                 |  | Overdrive = 50 mV  |              | 8    | 11          |                              |
| $T_{PHL}$       | Propagation delay <sup>(6)</sup><br>high to low output level | $C_L = 12\text{ pF}$ , $R_L = 1\text{ M}\Omega$<br>Overdrive = 5 mV              |              | 16   |             | ns                           |
|                 |  | Overdrive = 15 mV  |              | 11   |             |                              |
|                 |  | Overdrive = 50 mV  |              | 9    | 12          |                              |
| $T_R$           | Rise time (10% to 90%)                                       | $C_L = 12\text{ pF}$ , $R_L = 1\text{ M}\Omega$<br>Overdrive = 100 mV            |              | 1.1  |             | ns                           |
| $T_F$           | Fall time (10% to 90%)                                       | $C_L = 12\text{ pF}$ , $R_L = 1\text{ M}\Omega$<br>Overdrive = 100 mV            |              | 1.0  |             | ns                           |

1. All values over the temperature range are guaranteed through correlation and simulation. No production tests are performed at the temperature range limits.
2. The offset is defined as the average value of positive ( $V_{TRIP+}$ ) and negative ( $V_{TRIP-}$ ) trip points (input voltage differences requested to change the output state in each direction).
3. Hysteresis is a built-in feature of the TS3011. It is defined as the voltage difference between the trip points.
4. Maximum values include unavoidable inaccuracies of the industrial tests.
5. Overdrive is measured with reference to the  $V_{TRIP+}$  point.
6. Overdrive is measured with reference to the  $V_{TRIP-}$  point.

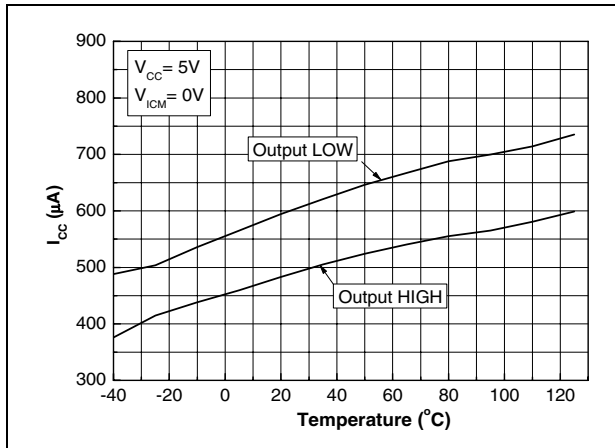
**Figure 1. Current consumption vs. power supply voltage - output low**



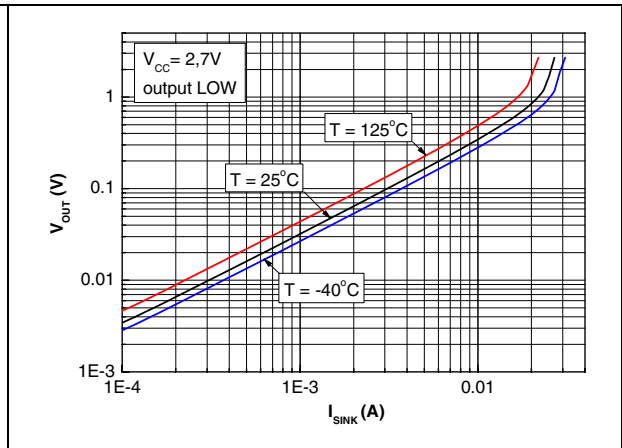
**Figure 2. Current consumption vs. power supply voltage - output high**



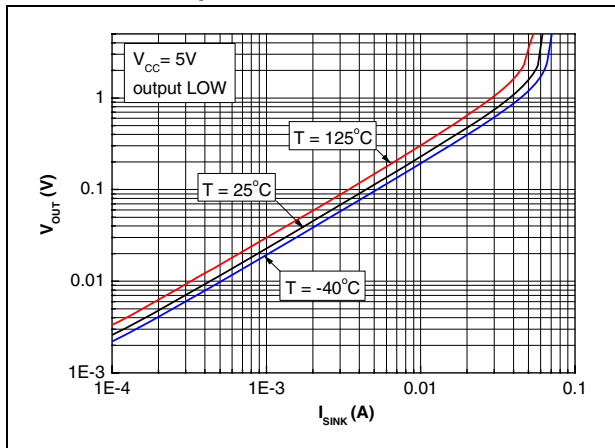
**Figure 3. Current consumption vs. temperature**



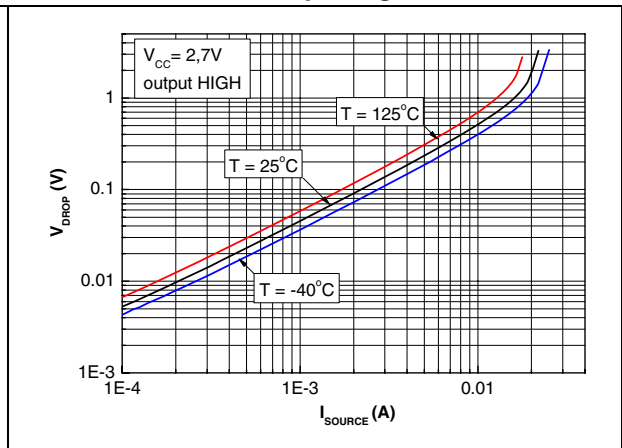
**Figure 4. Output voltage vs. sinking current, output low, VCC = 2.7 V**



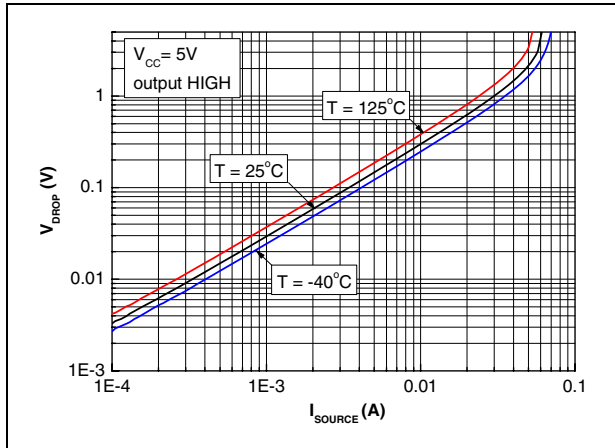
**Figure 5. Output voltage vs. sinking current, output low, VCC = 5 V**



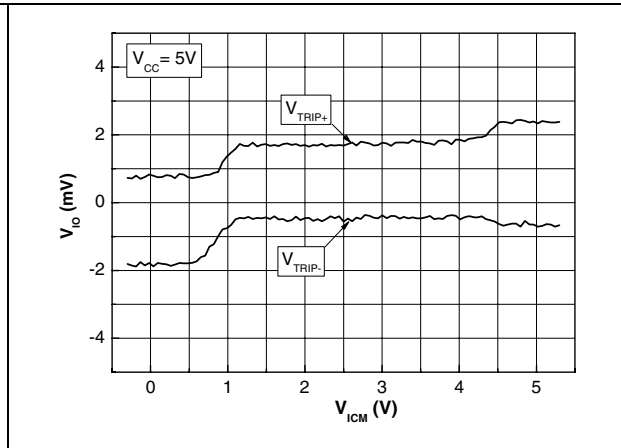
**Figure 6. Output voltage drop vs. sourcing current, output high, VCC = 2.7 V**



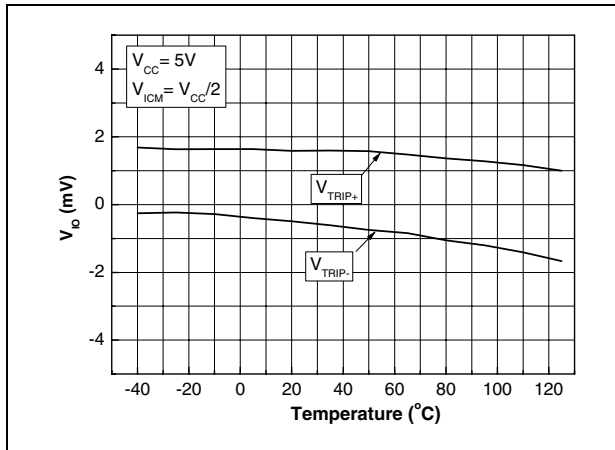
**Figure 7. Output voltage drop vs. sourcing current, output high, VCC = 5 V**



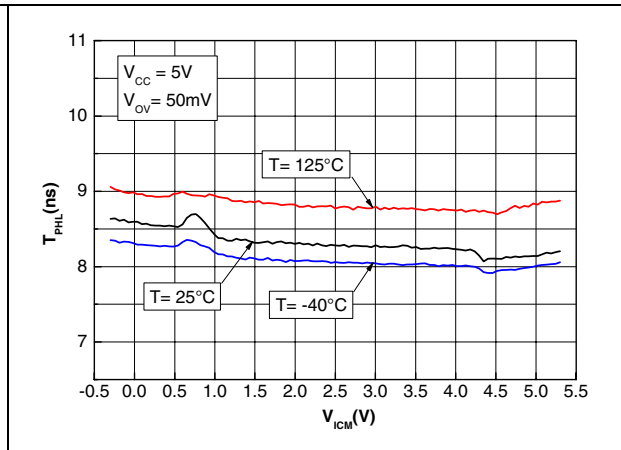
**Figure 8. Input offset voltage vs. common mode voltage**



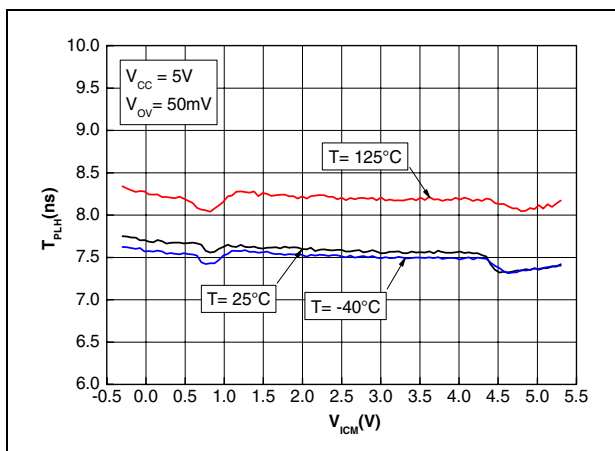
**Figure 9. Input offset voltage vs. temperature**



**Figure 10. Propagation delay vs. common mode voltage with negative transition**



**Figure 11. Propagation delay vs. common mode voltage with positive transition**



**Figure 12. Propagation delay vs. power supply voltage with negative transition**

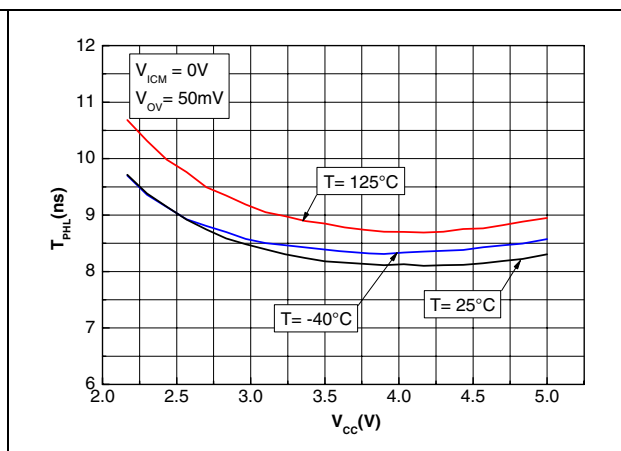


Figure 13. Propagation delay vs. power supply voltage with positive transition

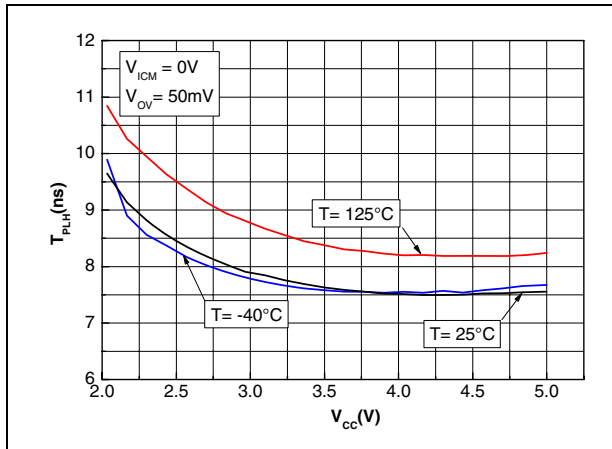


Figure 14. Propagation delay vs. overdrive with negative transition,  $V_{CC} = 2.7 V$

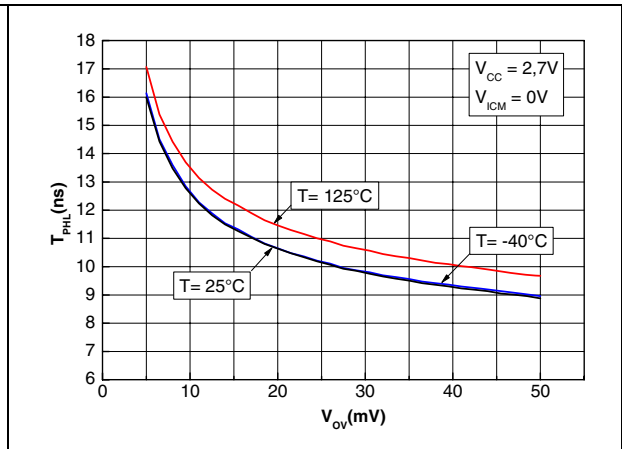


Figure 15. Propagation delay vs. overdrive with positive transition,  $V_{CC} = 2.7 V$

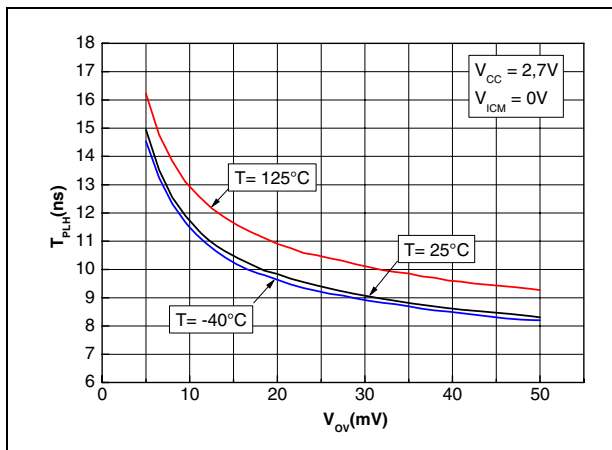


Figure 16. Propagation delay vs. overdrive with negative transition,  $V_{CC} = 5 V$

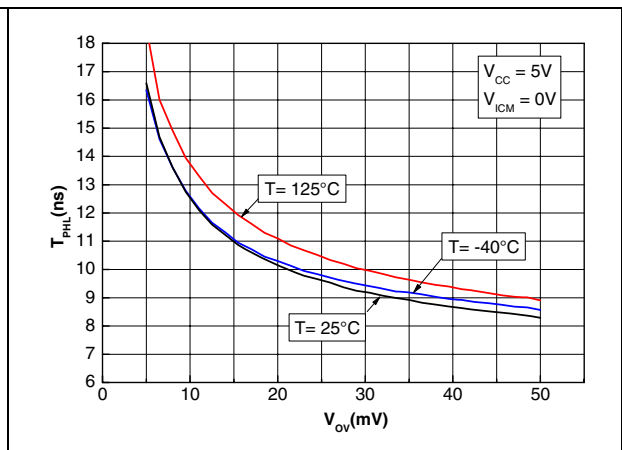


Figure 17. Propagation delay vs. overdrive with positive transition,  $V_{CC} = 5 V$

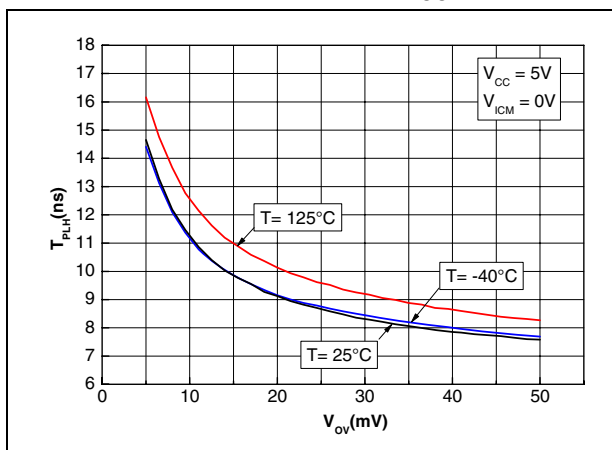
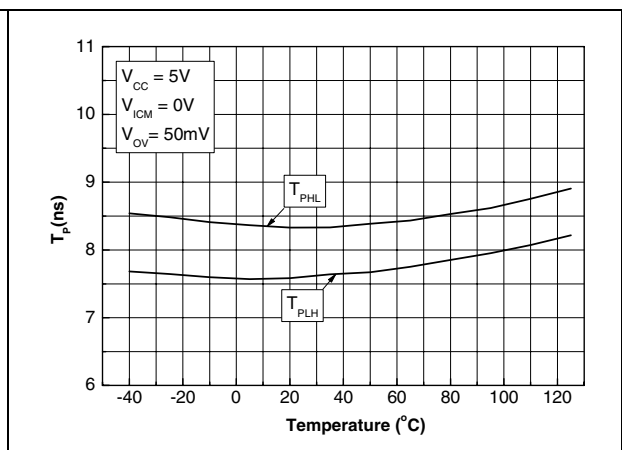


Figure 18. Propagation delay vs. temperature





### 3 Package information

In order to meet environmental requirements, ST offers these devices in different grades of ECOPACK<sup>®</sup> packages, depending on their level of environmental compliance. ECOPACK<sup>®</sup> specifications, grade definitions and product status are available at: [www.st.com](http://www.st.com). ECOPACK<sup>®</sup> is an ST trademark.

### 3.1 SOT23-5 package mechanical data

Figure 19. SOT23-5L package mechanical drawing

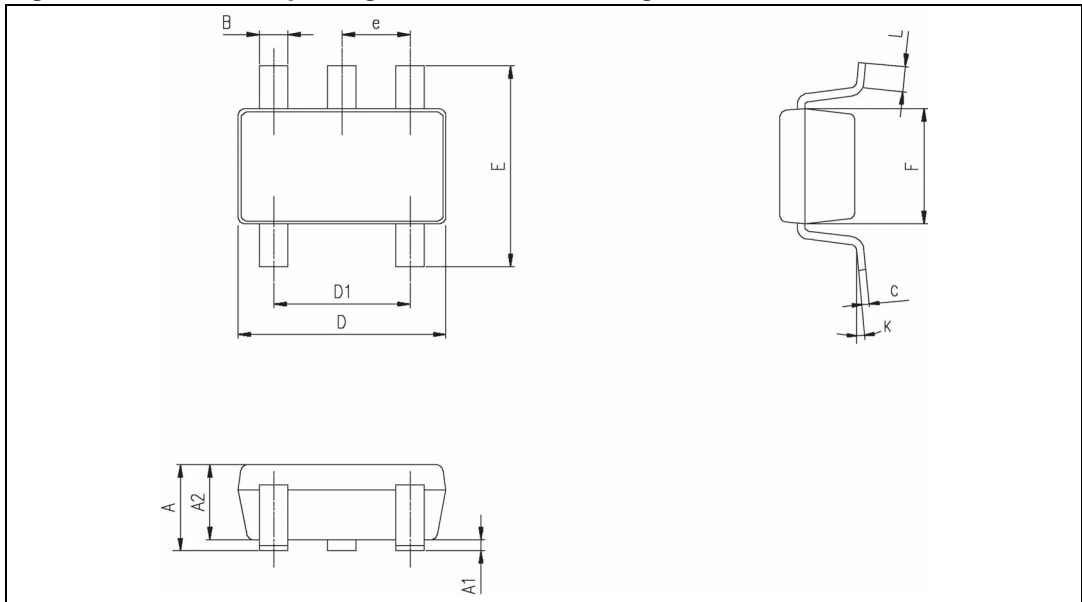


Table 6. SOT23-5L package mechanical data

| 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 mechanical data

Figure 20. SC70-5 (or SOT323-5) package mechanical drawing

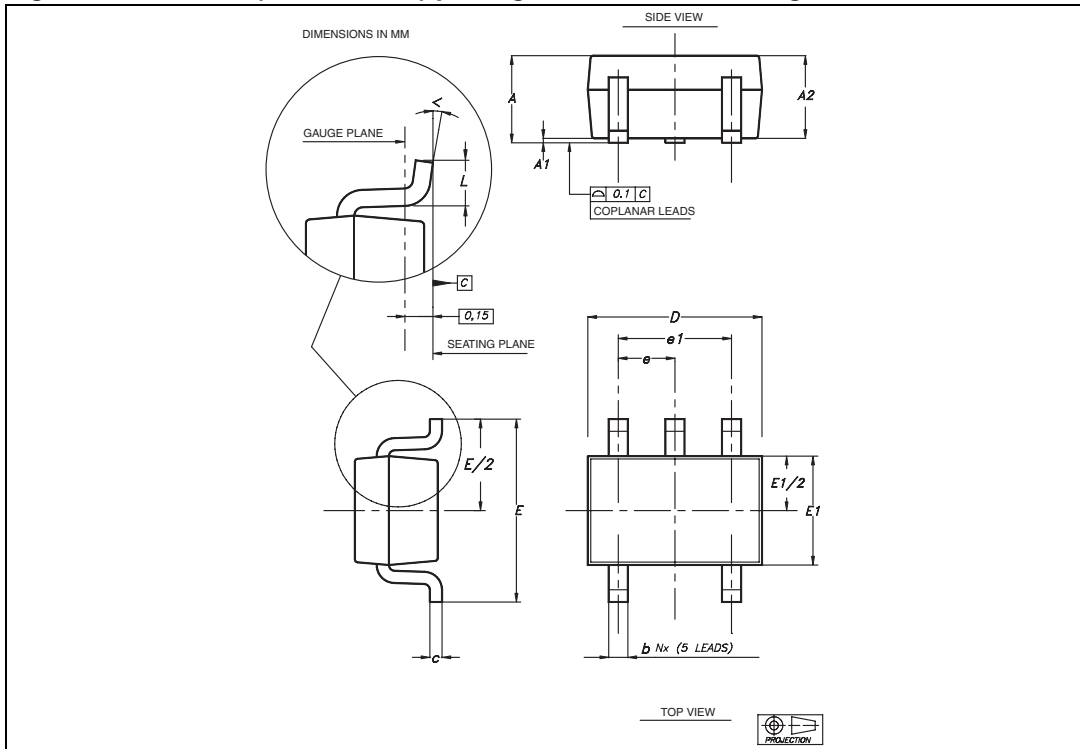


Table 7. SC70-5 (or SOT323-5) package mechanical data

| 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 |
|-------------|-------------------|---------|-------------|---------|
| TS3011ILT   | -40°C, +125°C     | SOT23-5 | Tape & reel | K540    |
| TS3011ICT   |                   | SC70-5  | Tape & reel | K54     |

## 5 Revision history

**Table 9. Document revision history**

| Date        | Revision | Changes          |
|-------------|----------|------------------|
| 03-Oct-2011 | 1        | Initial release. |

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