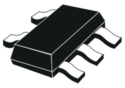
# TS3021

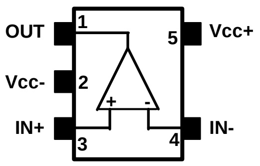
## Rail-to-rail 1.8 V high-speed comparator

Datasheet - production data

SOT23-5/SC70-5



Pin connections (top view)




## Features

- Propagation delay: 38 ns
- Low current consumption: 73 µA
- Rail-to-rail inputs
- Push-pull outputs
- Supply operation from 1.8 to 5 V
- Wide temperature range: -40 °C to 125 °C
- High ESD tolerance: 5 kV HBM, 300 V MM
- Latch-up immunity: 200 mA
- SMD packages
- Automotive qualification

## Related products

- TS3022 for a dual comparator with similar performances
- TS3011 for a high-speed comparator

## Applications

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

## Description

The TS3021 single comparator features high-speed response time with rail-to-rail inputs. With a supply voltage specified from 2 to 5 V, this comparator can operate over a wide temperature range: -40 °C to 125 °C.

The TS3021 comparator offers micropower consumption as low as a few tens of microamperes thus providing an excellent ratio of power consumption current versus response time.

The TS3021 includes push-pull outputs and is available in small packages (SOT23-5 and SC70-5).



This is information on a product in full production. www.st.com

# Contents

# 1 Absolute maximum ratings and operating conditions

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

| Symbol | Parameter | | Value | Unit |
|---|---|---|---|---|
| $V_{CC}$ | Supply voltage, $V_{CC} = (V_{CC+}) - (V_{CC-})$ (1) | | 5.5 | V |
| $V_{ID}$ | Differential input voltage (2) | | ±5 | |
| $V_{IN}$ | Input voltage range | | $(V_{CC-})$ - 0.3 to $(V_{CC+})$ + 0.3 | |
| $R_{thja}$ | Thermal resistance junction-to-ambient (3) | SOT23-5 | 250 | °C/W |
| | | SC70-5 | 205 | |
| $R_{thjc}$ | Thermal resistance junction-to-case (3) | SOT23-5 | 81 | |
| | | SC70-5 | 172 | |
| $T_{stg}$ | Storage temperature | | -65 to 150 | °C |
| $T_j$ | Junction temperature | | 150 | |
| $T_{LEAD}$ | Lead temperature (soldering 10 s) | | 260 | |
| ESD | HBM: human body model (4) | | 5000 | V |
| | MM: machine model (5) | | 300 | |
| | CDM: charged device model (6) | | 1500 | |
| | Latch-up immunity | | 200 | mA |

**Notes:**

(1) All voltage values, except the differential voltage are referenced to $(V_{CC-})$

(2) The magnitude of the 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 the package are charged together to the specified voltage and then discharged directly to the ground through only one pin. This is done for all pins.

**Table 2: Operating conditions**

| Symbol | Parameter | | Value | Unit |
|---|---|---|---|---|
| $V_{CC}$ | Supply voltage | 0 °C < Tamb < 125 °C | 1.8 to 5 | V |
| | | -40 °C < Tamb < 125°C | 2 to 5 | |
| $V_{icm}$ | Common mode input voltage range | -40 °C < Tamb < 85 °C | $(V_{CC-})$ - 0.2 to $(V_{CC+})$ + 0.2 | |
| | | 85 °C < Tamb < 125 °C | $(V_{CC-})$ to $(V_{CC+})$ | |
| $T_{oper}$ | Operating temperature range | | -40 to 125 | °C |

# 2 Electrical characteristics

**Table 3: Electrical characteristics at VCC = 2 V, Tamb = 25 ° C, and full Vicm range (unless otherwise specified)**

| Symbol | Parameter | Test conditions [(1)] | Min. | Typ. | Max. | Unit |
|---|---|---|---|---|---|---|
| $V_{IO}$ | Input offset voltage | Tamb (TS3021ILT, TS3021IYLT, TS3021ICT) | | 0.5 | 6 | mV |
| | | -40 °C < Tamb < 125 °C (TS3021ILT, TS3021IYLT, TS3021ICT) | | 0.5 | 7 | |
| | | Tamb (TS3021AILT) | | 0.5 | 2 | |
| $\Delta V_{io}/\Delta T$ | Input offset voltage drift | -40 °C < Tamb < 125 °C | | 3 | 20 | µV/°C |
| $I_{IO}$ | Input offset current [(2)] | Tamb | | 1 | 20 | nA |
| | | -40 °C < Tamb < 125 °C | | | 100 | |
| $I_{IB}$ | Input bias current [(2)] | Tamb | | 86 | 160 | |
| | | -40 °C < Tamb < 125 °C | | | 300 | |
| $I_{CC}$ | Supply current | No load, output high, Vicm = 0 V | | 73 | 90 | µA |
| | | No load, output high, Vicm = 0 V, -40 °C < Tamb < 125 °C | | | 115 | |
| | | No load, output low, Vicm = 0 V | | 84 | 105 | |
| | | No load, output low, Vicm = 0 V, -40 °C < Tamb < 125 °C | | | 125 | |
| $I_{SC}$ | Short-circuit current | Source | | 9 | | mA |
| | | Sink | | 10 | | |
| $V_{OH}$ | Output voltage high | Isource = 1 mA | 1.88 | 1.92 | | V |
| | | -40 °C < Tamb < 125 °C | 1.80 | | | |
| $V_{OL}$ | Output voltage low | Isink = 1 mA | | 60 | 100 | mV |
| | | -40 °C < Tamb < 125 °C | | | 150 | |
| CMRR | Common mode rejection ratio | 0 < Vicm < 2 V | | 67 | | dB |
| SVR | Supply voltage rejection | ΔVcc = 2 to 5 V | 58 | 73 | | |
| $TP_{LH}$ | Propagation delay, low to high output level [(3)] | Vicm = 0 V, f = 10 kHz, CL = 50 pF, overdrive = 100 mV | | 38 | 60 | ns |
| | | Vicm = 0 V, f = 10 kHz, CL = 50 pF, overdrive = 20 mV | | 48 | 75 | |
| $TP_{HL}$ | Propagation delay, high to low output level [(4)] | Vicm = 0 V, f = 10 kHz, CL = 50 pF, overdrive = 100 mV | | 40 | 60 | |
| | | Vicm = 0 V, f = 10 kHz, CL = 50 pF, overdrive = 20 mV | | 49 | 75 | |
| $T_F$ | Fall time | f = 10 kHz, CL = 50 pF, RL = 10 kΩ, overdrive = 100 mV | | 8 | | |
| $T_R$ | Rise time | f = 10 kHz, CL = 50 pF, RL = 10 kΩ, overdrive = 100 mV | | 9 | | |

**Notes:**

(1)All values over the temperature range are guaranteed through correlation and simulation. No production test is performed at the temperature range limits.

(2)Maximum values include unavoidable inaccuracies of the industrial tests

(3)Response time is measured 10%/90% of the final output value with the following conditions: inverting input voltage (IN-) = Vicm and non-inverting input voltage (IN+) moving from Vicm - 100 mV to Vicm + overdrive.

(4)Response time is measured 10%/90% of the final output value 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: Electrical characteristics at VCC = 3.3 V, Tamb = 25 ° C, and full Vicm range (unless otherwise specified)

| Symbol | Parameter | Test conditions [(1)] | Min. | Typ. | Max. | Unit |
|---|---|---|---|---|---|---|
| $V_{IO}$ | Input offset voltage | Tamb (TS3021ILT, TS3021IYLT, TS3021ICT) | | 0.2 | 6 | mV |
| | | -40 °C < Tamb < 125 °C (TS3021ILT, TS3021IYLT, TS3021ICT) | | 0.2 | 7 | |
| | | Tamb (TS3021AILT) | | 0.2 | 2 | |
| $\Delta V_{io}/\Delta T$ | Input offset voltage drift | -40 °C < Tamb < 125 °C | | 3 | 20 | µV/°C |
| $I_{IO}$ | Input offset current [(2)] | Tamb | | 1 | 20 | nA |
| | | -40 °C < Tamb < 125 °C | | | 100 | |
| $I_{IB}$ | Input bias current [(2)] | Tamb | | 86 | 160 | |
| | | -40 °C < Tamb < 125 °C | | | 300 | |
| $I_{CC}$ | Supply current | No load, output high, Vicm = 0 V | | 75 | 90 | µA |
| | | No load, output high, Vicm = 0 V, -40 °C < Tamb < 125 °C | | | 120 | |
| | | No load, output low, Vicm = 0 V | | 86 | 110 | |
| | | No load, output low, Vicm = 0 V, -40 °C < Tamb < 125 °C | | | 125 | |
| $I_{SC}$ | Short-circuit current | Source | | 26 | | mA |
| | | Sink | | 24 | | |
| $V_{OH}$ | Output voltage high | Isource = 1 mA | 3.20 | 3.25 | | V |
| | | -40 °C < Tamb < 125 °C | 3.10 | | | |
| $V_{OL}$ | Output voltage low | Isink = 1 mA | | 40 | 80 | mV |
| | | -40 °C < Tamb < 125 °C | | | 150 | |
| CMRR | Common mode rejection ratio | 0 < Vicm < 3.3 V | | 75 | | dB |
| SVR | Supply voltage rejection | ΔVcc = 2 to 5 V | 58 | 73 | | |
| $TP_{LH}$ | Propagation delay, low to high output level [(3)] | Vicm = 0 V, f = 10 kHz, CL = 50 pF, overdrive = 100 mV | | 39 | 65 | ns |
| | | Vicm = 0 V, f = 10 kHz, CL = 50 pF, overdrive = 20 mV | | 50 | 85 | |
| $TP_{HL}$ | Propagation delay, high to low output level [(4)] | Vicm = 0 V, f = 10 kHz, CL = 50 pF, overdrive = 100 mV | | 41 | 65 | |
| | | Vicm = 0 V, f = 10 kHz, CL = 50 pF, overdrive = 20 mV | | 51 | 80 | |
| $T_F$ | Fall time | f = 10 kHz, CL = 50 pF, RL = 10 kΩ, overdrive = 100 mV | | 5 | | |
| $T_R$ | Rise time | f = 10 kHz, CL = 50 pF, RL = 10 kΩ, overdrive = 100 mV | | 7 | | |

**Notes:**

(1)All values over the temperature range are guaranteed through correlation and simulation. No production test is performed at the temperature range limits.

(2)Maximum values include unavoidable inaccuracies of the industrial tests

(3)Response time is measured 10%/90% of the final output value with the following conditions: inverting input voltage (IN-) = Vicm and non-inverting input voltage (IN+) moving from Vicm - 100 mV to Vicm + overdrive.

(4)Response time is measured 10%/90% of the final output value 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: Electrical characteristics at VCC = 5 V, Tamb = 25 ° C, and full Vicm range (unless otherwise specified)

| Symbol | Parameter | Test conditions [(1)] | Min. | Typ. | Max. | Unit |
|---|---|---|---|---|---|---|
| $V_{IO}$ | Input offset voltage | Tamb (TS3021ILT, TS3021IYLT, TS3021ICT) | | 0.2 | 6 | mV |
| | | -40 °C < Tamb < 125 °C (TS3021ILT, TS3021IYLT, TS3021ICT) | | 0.2 | 7 | |
| | | Tamb (TS3021AILT) | | 0.2 | 2 | |
| $\Delta V_{io}/\Delta T$ | Input offset voltage drift | -40 °C < Tamb < 125 °C | | 3 | 20 | µV/°C |
| $I_{IO}$ | Input offset current [(2)] | Tamb | | 1 | 20 | nA |
| | | -40 °C < Tamb < 125 °C | | | 100 | |
| $I_{IB}$ | Input bias current [(2)] | Tamb | | 86 | 160 | |
| | | -40 °C < Tamb < 125 °C | | | 300 | |
| $I_{CC}$ | Supply current | No load, output high, Vicm = 0 V | | 77 | 95 | µA |
| | | No load, output high, Vicm = 0 V, -40 °C < Tamb < 125 °C | | | 125 | |
| | | No load, output low, Vicm = 0 V | | 89 | 115 | |
| | | No load, output low, Vicm = 0 V, -40 °C < Tamb < 125 °C | | | 135 | |
| $I_{SC}$ | Short-circuit current | Source | | 51 | | mA |
| | | Sink | | 40 | | |
| $V_{OH}$ | Output voltage high | Isource = 4 mA | 4.80 | 4.84 | | V |
| | | -40 °C < Tamb < 125 °C | 4.70 | | | |
| $V_{OL}$ | Output voltage low | Isink = 4 mA | | 130 | 180 | mV |
| | | -40 °C < Tamb < 125 °C | | | 250 | |
| CMRR | Common mode rejection ratio | 0 < Vicm < 5 V | | 79 | | dB |
| SVR | Supply voltage rejection | ∆Vcc = 2 to 5 V | 58 | 73 | | |
| $TP_{LH}$ | Propagation delay, low to high output level [(3)] | Vicm = 0 V, f = 10 kHz, CL = 50 pF, overdrive = 100 mV | | 42 | 75 | ns |
| | | Vicm = 0 V, f = 10 kHz, CL = 50 pF, overdrive = 20 mV | | 54 | 105 | |
| $TP_{HL}$ | Propagation delay, high to low output level [(4)] | Vicm = 0 V, f = 10 kHz, CL = 50 pF, overdrive = 100 mV | | 45 | 75 | |
| | | Vicm = 0 V, f = 10 kHz, CL = 50 pF, overdrive = 20 mV | | 55 | 95 | |
| $T_F$ | Fall time | f = 10 kHz, CL = 50 pF, RL = 10 kΩ, overdrive = 100 mV | | 4 | | |
| $T_R$ | Rise time | f = 10 kHz, CL = 50 pF, RL = 10 kΩ, overdrive = 100 mV | | 4 | | |

**Notes:**

(1)All values over the temperature range are guaranteed through correlation and simulation. No production test is performed at the temperature range limits.

(2)Maximum values include unavoidable inaccuracies of the industrial tests

(3)Response time is measured 10%/90% of the final output value with the following conditions: inverting input voltage (IN-) = Vicm and non-inverting input voltage (IN+) moving from Vicm - 100 mV to Vicm + overdrive.

(4)Response time is measured 10%/90% of the final output value 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: Current consumption vs. supply voltage (Vicm = 0 V, output high)

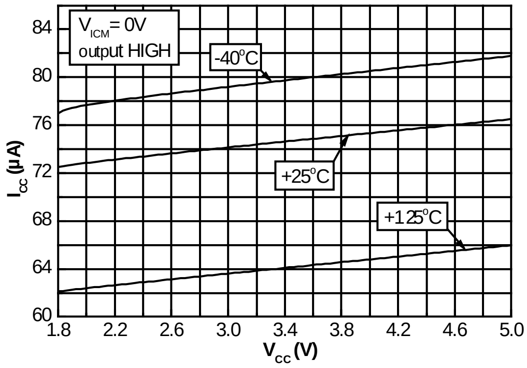



Figure 2: Current consumption vs. supply voltage (Vicm = Vcc output high)

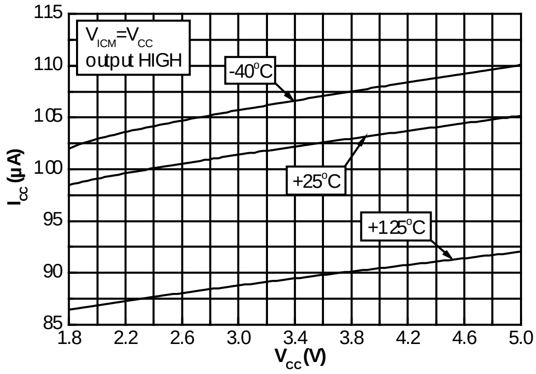



Figure 3: Current consumption vs. supply voltage (Vicm = 0 V, output low)

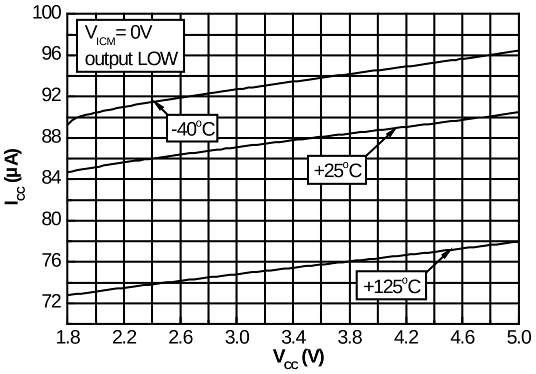



Figure 4: Current consumption vs. supply voltage (Vicm = Vcc output low)

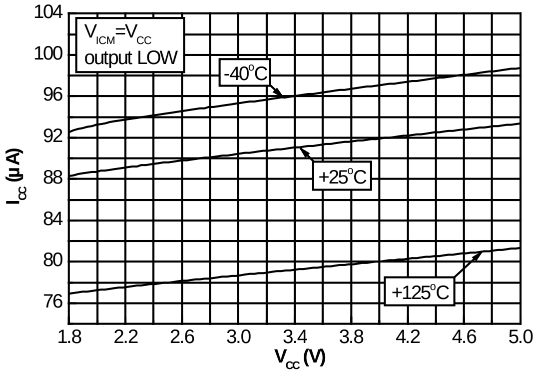



Figure 5: Output voltage vs. source current, Vcc = 2 V

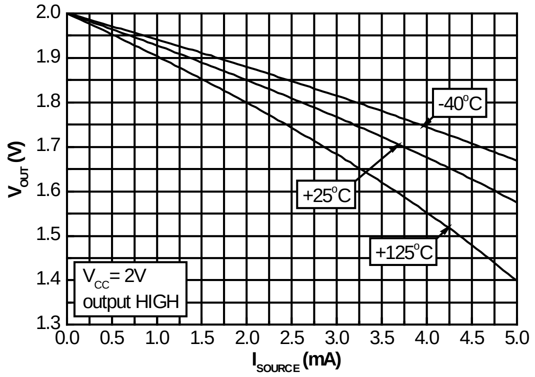



Figure 6: Output voltage vs. sink current, Vcc = 2 V

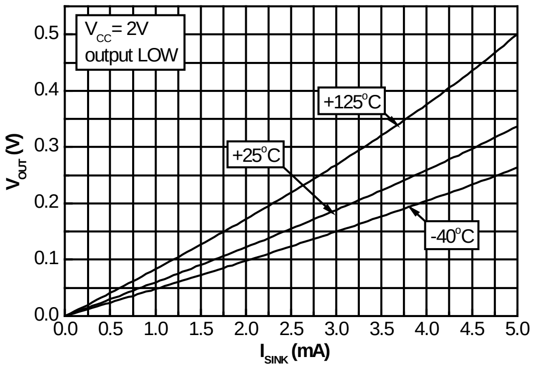


Figure 7: Output voltage vs. source current, Vcc = 3.3 V

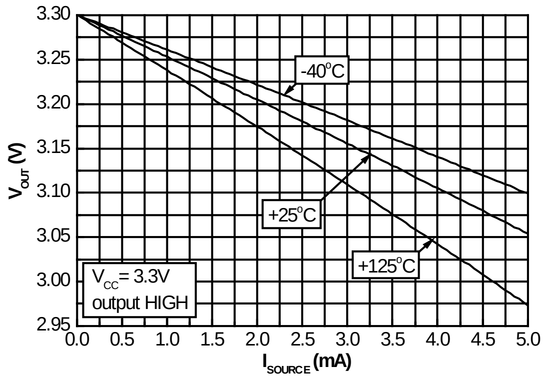



Figure 8: Output voltage vs. sink current, Vcc = 3.3 V

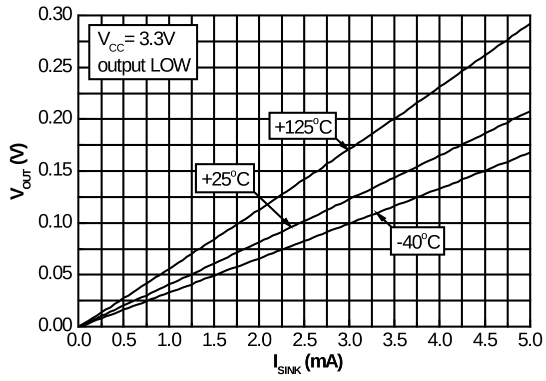



Figure 9: Output voltage vs. source current, Vcc = 5 V

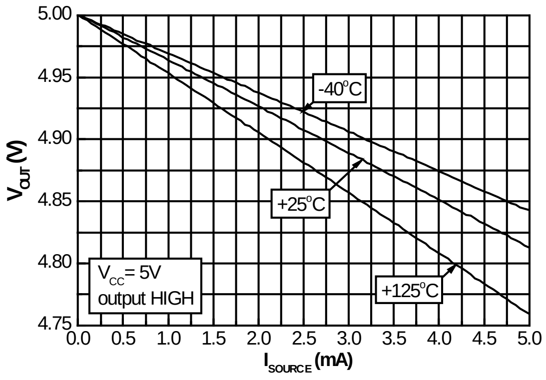



Figure 10: Output voltage vs. sink current, Vcc = 5 V

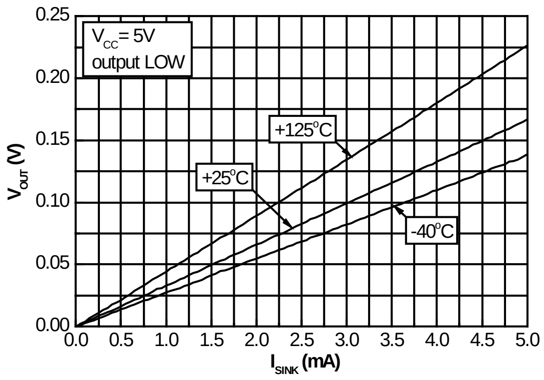



Figure 11: Input offset voltage vs. temperature and common mode voltage

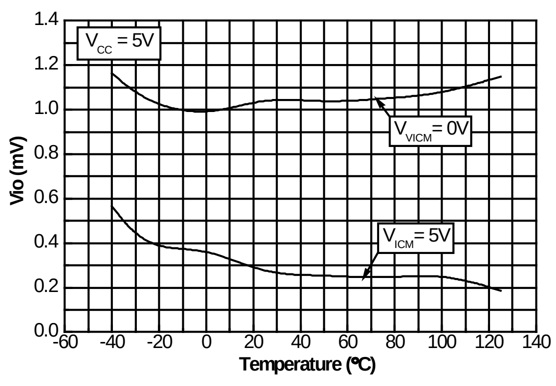



Figure 12: Input bias current vs. temperature and input voltage

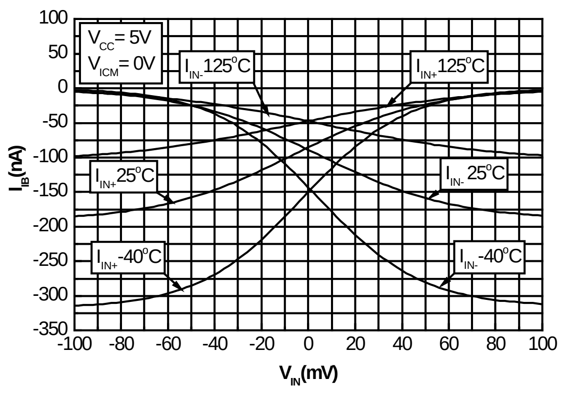


Figure 13: Current consumption vs. commutation frequency

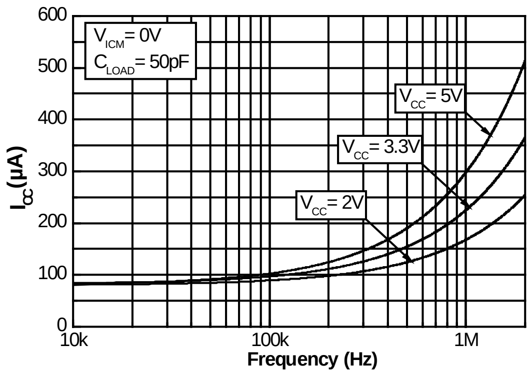



Figure 14: Propagation delay (HL) vs. overdrive at Vcc = 2 V, Vicm = 0 V

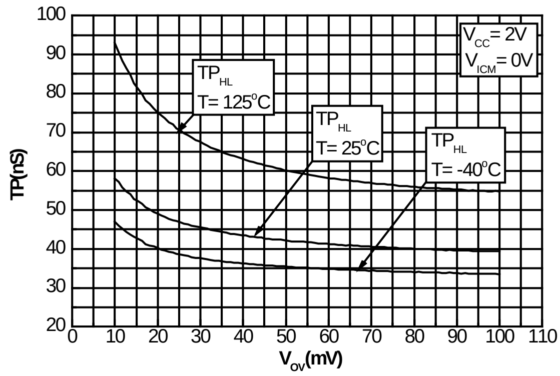



Figure 15: Propagation delay (HL) vs. overdrive at Vcc = 2 V, Vicm = Vcc

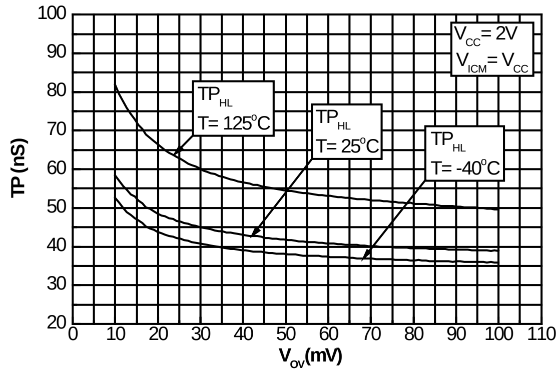



Figure 16: Propagation delay (LH) vs. overdrive at Vcc = 2 V, Vicm = 0 V

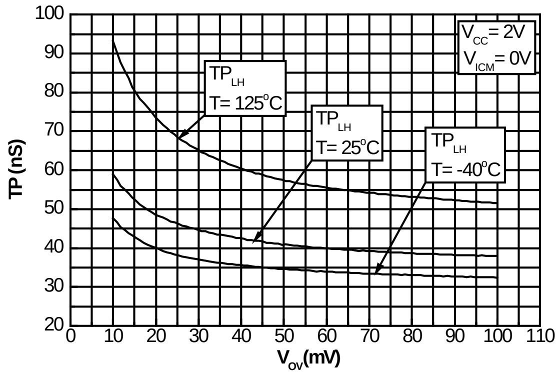



Figure 17: Propagation delay (LH) vs. overdrive at Vcc = 2 V, Vicm = Vcc

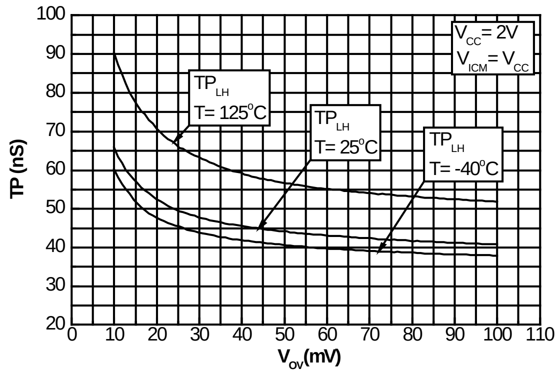



Figure 18: Propagation delay (HL) vs. overdrive at Vcc = 3.3 V, Vicm = 0 V

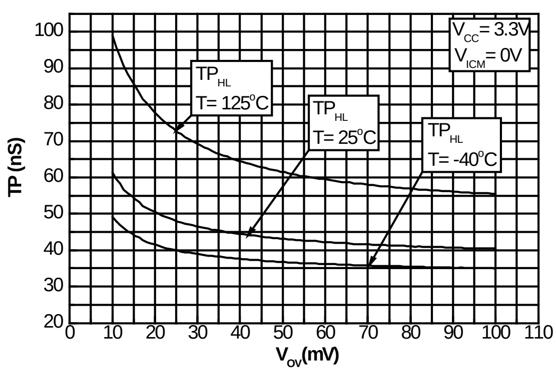


Figure 19: Propagation delay (HL) vs. overdrive at Vcc = 3.3 V, Vicm = Vcc

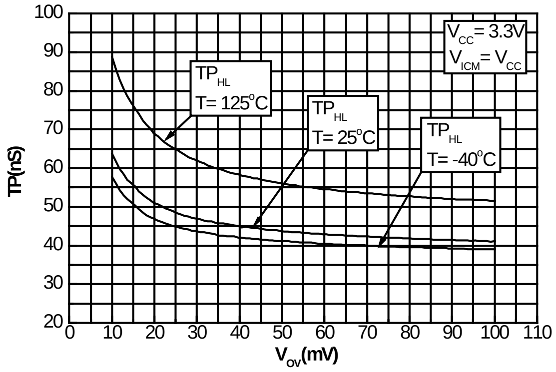



Figure 20: Propagation delay (LH) vs. overdrive at Vcc = 3.3 V, Vicm = 0 V

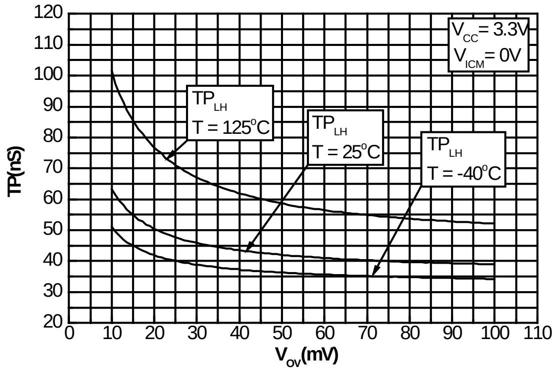



Figure 21: Propagation delay (LH) vs. overdrive at Vcc = 3.3 V, Vicm = Vcc

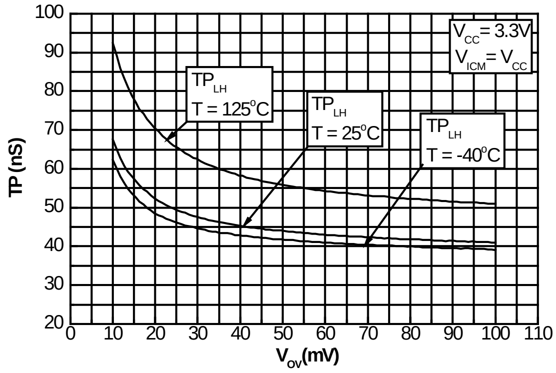



Figure 22: Propagation delay (HL) vs. overdrive at Vcc = 5 V, Vicm = 0 V

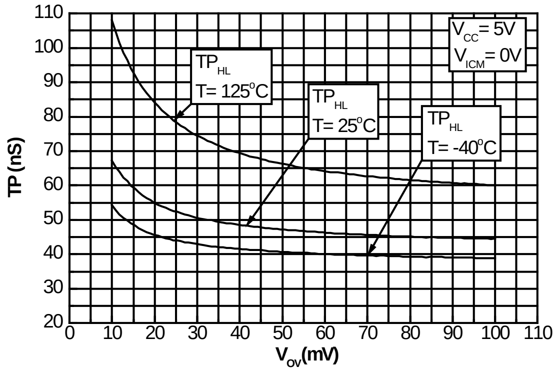



Figure 23: Propagation delay (HL) vs. overdrive at Vcc = 5 V, Vicm = Vcc

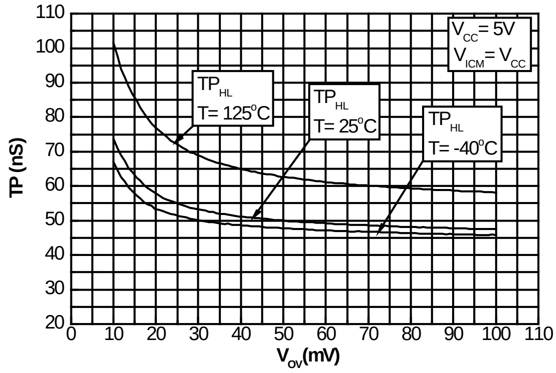



Figure 24: Propagation delay (LH) vs. overdrive at Vcc = 5 V, Vicm = 0 V

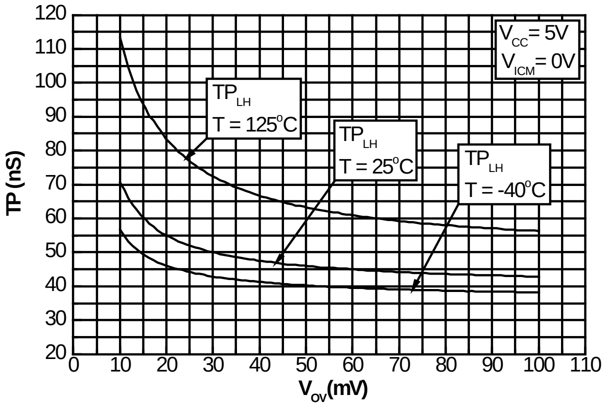


Figure 25: Propagation delay (LH) vs. overdrive at Vcc = 5 V, Vicm = Vcc

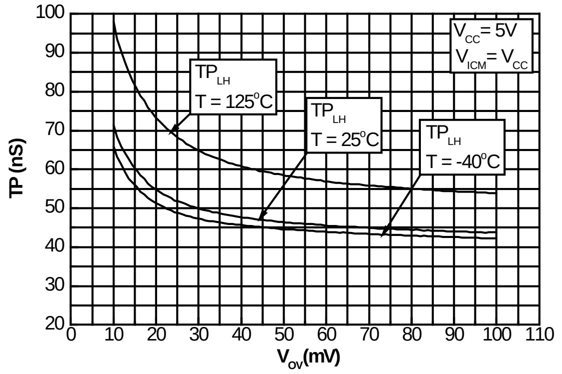



Figure 26: Propagation delay vs. temperature, Vcc = 5 V, overdrive = 100 mV

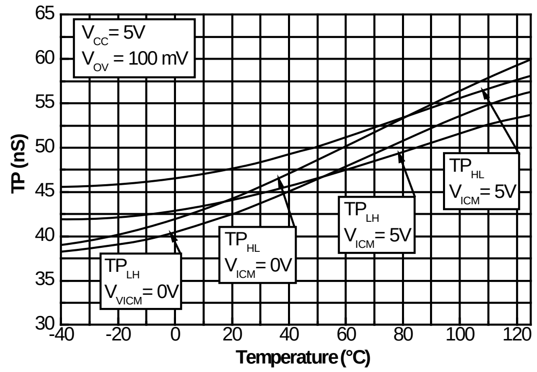
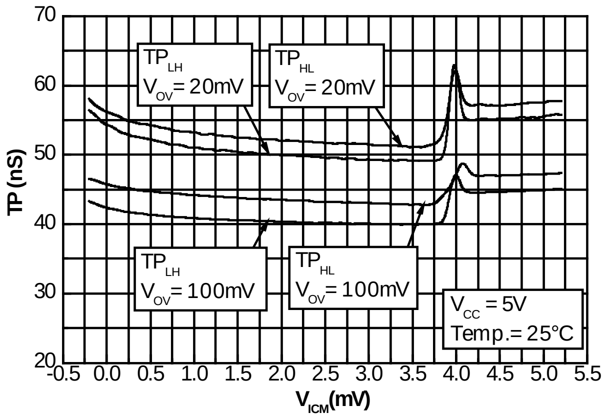



Figure 27: Propagation delay vs. common mode voltage, Vcc = 5 V



# 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 information

**Figure 28: SOT23-5 package outline**

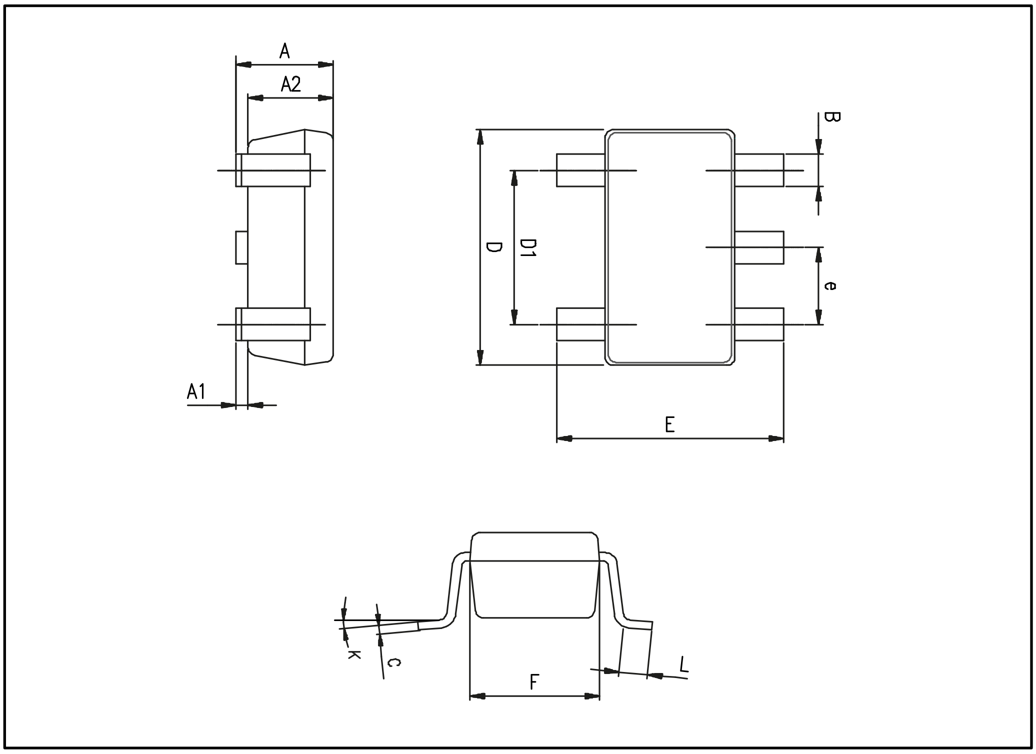



**Table 6: SOT23-5 mechanical data**

| 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 | 0.014 | 0.016 | 0.020 |
| C | 0.09 | 0.15 | 0.20 | 0.004 | 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 | 0.014 | 0.024 |
| K | 0 degrees | | 10 degrees | 0 degrees | | 10 degrees |

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

**Figure 29: SC70-5 (or SOT323-5) package outline**

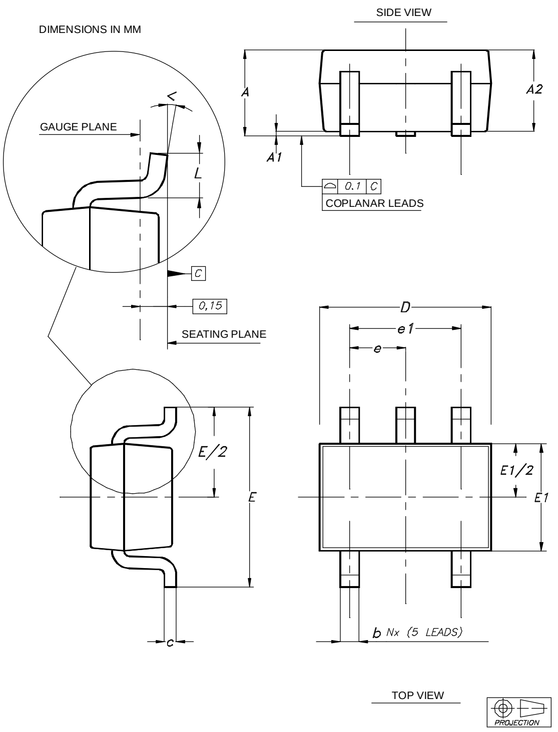



**Table 7: SC70-5 (or SOT323-5) mechanical data**

| 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° | 0° | | 8° |

# 4 Ordering information

**Table 8: Order codes**

| Order code | Temperature range | Package | Packaging | Marking |
|---|---|---|---|---|
| TS3021ILT | -40 to +125 °C | SOT23-5 | Tape and reel | K520 |
| TS3021IYLT [(1)] | | | | K529 |
| TS3021ICT | | SC70-5 | | K52 |
| TS3021AILT | | SOT23-5 | | K522 |

**Notes:**

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

# 5 Revision history

**Table 9: Document revision history**

| Date | Revision | Changes |
|---|---|---|
| 01-Jun-2006 | 1 | Initial release |
| 01-Sep-2006 | 2 | Dual version added<br>Pinout of single TS3021 corrected<br>Modified temperature range for input common mode voltage |
| 22-Feb-2007 | 3 | Addition of MiniSO-8 package for dual version |
| 17-Oct-2007 | 4 | Marking corrected for SO-8 package<br>Thermal resistance values corrected in AMR table<br>Notes on ESD added in AMR table |
| 04-Dec-2008 | 5 | Dual version (TS3022) removed<br>ESD tolerance modified in *Table 1: Absolute maximum ratings*<br>Made the following changes in *Table 3*:<br>– modified Vio typical value and maximum limits<br>– modified Iib typical value<br>– modified Icc typical values and corrected maximum limits<br>– modified Isc typical values<br>– modified Voh and Vol typical values<br>– modified CMRR and SVR typical values<br>– modified TPhl and TPlh typical values<br>All curves modified |
| 03-Jan-2013 | 6 | *Features*: added “automotive qualification”; added *Related products.*<br>*Table 1* and *Table 2*: Vdd and Vcc replaced by (Vcc-) and (Vcc+) respectively.<br>*Table 3*, *Table 4*, and *Table 5*: replaced ΔVio symbol with ΔVio/ΔT.<br>*Table 6* and *Table 7*: minor update (added angle dimensions to “inches” columns).<br>*Table 8*: added automotive order code |
| 02-Jun-2015 | 7 | *Table 3*, *Table 4*, and *Table 5*: updated Vio parameter<br>*Table 6*: small "rounding-off modifications to inches parameter<br>*Table 8*: added order code TS3021AILT |