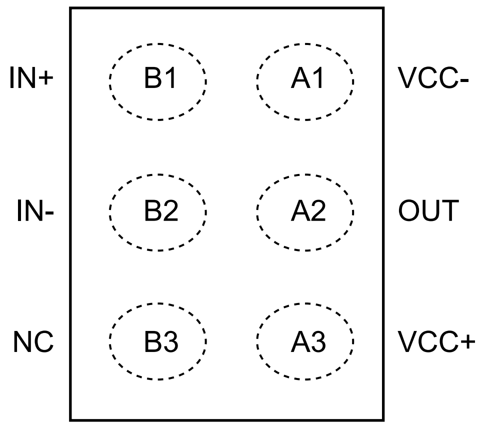
TS985

# Micropower low-voltage, 1.2 x 0.8 mm CSP comparator

Datasheet - production data



CSP 6-bump

## Features

- Supply operation from 1.8 to 5 V
- Low current consumption: 14 µA
- Rail to rail inputs, push-pull outputs
- Low propagation delay: 300 ns
- 60 µA supply current at 1 MHz switching frequency
- Low output saturation voltage
- Internal hysteresis
- Wide temperature range: -40 ° to 85 °C
- ESD tolerance: 2 kV HBM
- 6-bump CSP, 1.2 x 0.8 mm, 400 µm pitch

## Applications

- Mobiles phones
- Battery supplied electronics
- General purpose portable devices
- General purpose low voltage applications

## Description

The TS985 is a single micropower and low voltage comparator. It can operate with a supply voltage ranging from 1.8 V to 5 V with a typical current consumption as low as 14 µA while achieving a 300 ns propagation delay. In addition, rail-to-rail inputs make it a perfect choice for low voltage applications.

The 6-bump chip scale package (CSP) is a real advantage for overcoming space constraints.

TS985 is specified for temperature between -40 °C to 85 °C, making it ideal for a wide range of applications.

# Contents

# 1 Absolute maximum ratings

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

| Symbol | Parameter | Value | Unit |
|---|---|---|---|
| $V_{CC}$ | Supply voltage (1) | 5.5 | V |
| $V_{id}$ | Differential input voltage (2) | ±5.5 | |
| $V_{in}$ | Input voltage (3) | $(V_{CC}^-)$ - 0.3 to $(V_{CC}^+)$ + 0.3 | |
| $V_{out}$ | Output voltage | 5.5 | |
| $I_F$ | Forward current in ESD protection diodes on inputs (4) | 10 | mA |
| $T_j$ | Maximum junction temperature | 150 | °C |
| $T_{stg}$ | Storage temperature range | -65 to 150 | |
| $R_{thja}$ | Thermal resistance junction to ambient (5) | TBA | °C/W |
| ESD | HBM: human body model (6) | 2000 | V |
| | CDM: charged device model (7) | 1500 | |
| | Latch-up immunity | 200 | mA |

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. According to JEDEC standard JESD22-A114F.
7. According to ANSI/ESD STM5.3.1.

**Table 2. Operating conditions**

| Symbol | Parameter | Value | Unit |
|---|---|---|---|
| $V_{CC}^+$ | Supply voltage | 1.8 to 5.0 | V |
| $V_{icm}$ | Common mode input voltage range, $T_{amb}$ = 25 °C | $(V_{CC}^-)$ - 0.25 to $(V_{CC}^+)$ + 0.25 | |
| | Common mode input voltage range, $T_{min} \leq T_{amb} \leq T_{max}$ | $(V_{CC}^-)$ to $(V_{CC}^+)$ | |
| $T_{oper}$ | Operating free-air temperature range | -40 to 85 | °C |

# 2 Electrical characteristics

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

| Symbol | Parameter | Min. | Typ. | Max. | Unit |
|---|---|---|---|---|---|
| $V_{io}$ | Input offset voltage, full $V_{icm}$ range | | 0.5 | 8 | mV |
| | Input offset voltage, $T_{min} \leq T_{amb} \leq T_{max}$ | | | 9 | |
| $\Delta V_{io}/\Delta T$ | Input offset voltage drift vs. temperature | | 4.5 | | uV/°C |
| $V_{Hyst}$ | Input hysteresis voltage | | 3 | | mV |
| $I_{ib}$ | Input bias current (1), full $V_{icm}$ range | | 14 | 40 | nA |
| | Input bias current (1), $T_{min} \leq T_{amb} \leq T_{max}$ | | | 100 | |
| $I_{io}$ | Input offset current, full $V_{icm}$ range | | 1 | 10 | |
| | Input offset current, $T_{min} \leq T_{amb} \leq T_{max}$ | | | 100 | |
| CMR | Common-mode rejection ratio, $V_{icm}$ = 0 to 1.8 V | 43 | | | dB |
| $I_{CC}$ | Supply current per comparator, no load - $V_{icm}$ = 0 V | | 13 | 19 | µA |
| | Supply current per comparator, $T_{min} \leq T_{amb} \leq T_{max}$ | | | 20 | |
| $V_{OH}$ | High-level output voltage, $I_{Source}$ = 1 mA | 1.69 | 1.71 | | V |
| | High-level output voltage, $T_{min} \leq T_{amb} \leq T_{max}$ | 1.67 | | | |
| $V_{OL}$ | Low-level output voltage, $I_{Sink}$ = 1 mA | | 65 | 80 | mV |
| | Low-level output voltage, $T_{min} \leq T_{amb} \leq T_{max}$ | | | 95 | |
| $I_{Sink}$ | $V_{OUT}$ = 0 V | 6 | 8 | | mA |
| | $T_{min} \leq T_{amb} \leq T_{max}$ | 5 | | | |
| $I_{Source}$ | $V_{OUT} = V_{CC}$ | 4.5 | 7.3 | | |
| | $T_{min} \leq T_{amb} \leq T_{max}$ | 3.5 | | | |
| $t_{PHL}$ | Response time high to low (2), $V_{icm}$ = 0 V, $C_L$ = 15 pF, overdrive = 10 mV | | 730 | | ns |
| | Response time high to low (2), $V_{icm}$ = 0 V, $C_L$ = 15 pF, overdrive = 100 mV | | 300 | | |
| $t_{PLH}$ | Response time low to high (3), $V_{icm}$ = 0 V, $C_L$ = 15 pF, overdrive = 10 mV | | 730 | | |
| | Response time low to high (3), $V_{icm}$ = 0 V, $C_L$ = 15 pF, overdrive = 100 mV | | 300 | | |

1. Maximum values include unavoidable inaccuracies of the industrial tests.
2. $TP_{HL}$ is measured when the output signal crosses a voltage level at 50% of $V_{CC}$ with the following conditions: inverting input voltage (IN-) = $V_{ICM}$ and non-inverting input (IN+), moving from $V_{ICM}$ + 100mV to $V_{ICM}$ - overdrive.
3. $TP_{LH}$ is measured when the output signal crosses a voltage level at 50 % of $V_{CC}$ with the following conditions: inverting input voltage (IN-) = $V_{ICM}$ and non-inverting input (IN+), moving from $V_{ICM}$ - 100 mV to $V_{ICM}$ + overdrive.

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

| Symbol | Parameter | Min. | Typ. | Max. | Unit |
|---|---|---|---|---|---|
| $V_{io}$ | Input offset voltage, full $V_{icm}$ range | | 0.5 | 8 | mV |
| | Input offset voltage, $T_{min} \leq T_{amb} \leq T_{max}$ | | | 9 | |
| $\Delta V_{io}/\Delta T$ | Input offset voltage drift vs. temperature | | 4.5 | | uV/°C |
| $V_{Hyst}$ | Input hysteresis voltage | | 3 | | mV |
| $I_{ib}$ | Input bias current (1), full $V_{icm}$ range | | 15 | 40 | nA |
| | Input bias current (1), $T_{min} \leq T_{amb} \leq T_{max}$ | | | 100 | |
| $I_{io}$ | Input offset current, full $V_{icm}$ range | | 1 | 10 | |
| | Input offset current, $T_{min} \leq T_{amb} \leq T_{max}$ | | | 100 | |
| CMR | Common-mode rejection ratio, $V_{icm}$ = 0 to 2.7 V | 48 | | | dB |
| $I_{CC}$ | Supply current per comparator, no load - $V_{icm}$ = 0 V | | 14 | 20 | µA |
| | Supply current per comparator, $T_{min} \leq T_{amb} \leq T_{max}$ | | | 22 | |
| $V_{OH}$ | High-level output voltage, $I_{Source}$ = 1 mA | 2.6 | 2.64 | | V |
| | High-level output voltage, $T_{min} \leq T_{amb} \leq T_{max}$ | 2.5 | | | |
| $V_{OL}$ | Low-level output voltage, $I_{Sink}$ = 1 mA | | 43 | 55 | mV |
| | Low-level output voltage, $T_{min} \leq T_{amb} \leq T_{max}$ | | | 65 | |
| $I_{Sink}$ | $V_{OUT}$ = 0 V | 14 | 18 | | mA |
| | $T_{min} \leq T_{amb} \leq T_{max}$ | 12 | | | |
| $I_{Source}$ | $V_{OUT}$ = $V_{CC}$ | 14 | 18 | | |
| | $T_{min} \leq T_{amb} \leq T_{max}$ | 12 | | | |
| $t_{PHL}$ | Response time high to low (2), $V_{icm}$ = 0 V, $C_L$ = 15 pF, overdrive = 10 mV | | 860 | | ns |
| | Response time high to low (2), $V_{icm}$ = 0 V, $C_L$ = 15 pF, overdrive = 100 mV | | 330 | | |
| $t_{PLH}$ | Response time low to high (3), $V_{icm}$ = 0 V, $C_L$ = 15 pF, overdrive = 10 mV | | 860 | | |
| | Response time low to high (3), $V_{icm}$ = 0 V, $C_L$ = 15 pF, overdrive = 100 mV | | 330 | | |

1. Maximum values include unavoidable inaccuracies of the industrial tests.
2. $TP_{HL}$ is measured when the output signal crosses a voltage level at 50% of $V_{CC}$ with the following conditions: inverting input voltage (IN-) = $V_{ICM}$ and non-inverting input (IN+), moving from $V_{ICM}$ + 100mV to $V_{ICM}$ - overdrive.
3. $TP_{LH}$ is measured when the output signal crosses a voltage level at 50 % of $V_{CC}$ with the following conditions: inverting input voltage (IN-) = $V_{ICM}$ and non-inverting input (IN+), moving from $V_{ICM}$ - 100 mV to $V_{ICM}$ + overdrive.

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

| Symbol | Parameter | Min. | Typ. | Max. | Unit |
|---|---|---|---|---|---|
| $V_{io}$ | Input offset voltage, full $V_{icm}$ range | | 0.5 | 8 | mV |
| | Input offset voltage, $T_{min} \leq T_{amb} \leq T_{max}$ | | | 9 | |
| $\Delta V_{io}/\Delta T$ | Input offset voltage drift vs. temperature | | 4.5 | | uV/°C |
| $V_{Hyst}$ | Input hysteresis voltage | | 3 | | mV |
| $I_{ib}$ | Input bias current (1), full $V_{icm}$ range | | 17 | 50 | nA |
| | Input bias current (1), $T_{min} \leq T_{amb} \leq T_{max}$ | | | 100 | |
| $I_{io}$ | Input offset current, full $V_{icm}$ range | | 1 | 10 | |
| | Input offset current, $T_{min} \leq T_{amb} \leq T_{max}$ | | | 100 | |
| CMR | Common-mode rejection ratio, $V_{icm}$ = 0 to 5 V | 56 | | | dB |
| $I_{CC}$ | Supply current per comparator, no load - $V_{icm}$ = 0 V | | 16 | 24 | µA |
| | Supply current per comparator, $T_{min} \leq T_{amb} \leq T_{max}$ | | | 25 | |
| $V_{OH}$ | High-level output voltage, $I_{Source}$ = 1 mA | 4.85 | 4.9 | | V |
| | High-level output voltage, $T_{min} \leq T_{amb} \leq T_{max}$ | 4.8 | | | |
| $V_{OL}$ | Low-level output voltage, $I_{Sink}$ = 1 mA | | 31 | 45 | mV |
| | Low-level output voltage, $T_{min} \leq T_{amb} \leq T_{max}$ | | | 55 | |
| $I_{Sink}$ | $V_{OUT}$ = 0 V | 35 | 42 | | mA |
| | $T_{min} \leq T_{amb} \leq T_{max}$ | 30 | | | |
| $I_{Source}$ | $V_{OUT} = V_{CC}$ | 45 | 52 | | |
| | $T_{min} \leq T_{amb} \leq T_{max}$ | 40 | | | |
| $t_{PHL}$ | Response time high to low (2), $V_{icm}$ = 0 V, $C_L$ = 15 pF, overdrive = 10 mV | | 1100 | | ns |
| | Response time high to low (2), $V_{icm}$ = 0 V, $C_L$ = 15 pF, overdrive = 100 mV | | 420 | | |
| $t_{PLH}$ | Response time low to high (3), $V_{icm}$ = 0 V, $C_L$ = 15 pF, overdrive = 10 mV | | 1100 | | |
| | Response time low to high (3), $V_{icm}$ = 0 V, $C_L$ = 15 pF, overdrive = 100 mV | | 420 | | |

1. Maximum values include unavoidable inaccuracies of the industrial tests.
2. $TP_{HL}$ is measured when the output signal crosses a voltage level at 50% of $V_{CC}$ with the following conditions: inverting input voltage (IN-) = $V_{ICM}$ and non-inverting input (IN+), moving from $V_{ICM}$ + 100mV to $V_{ICM}$ - overdrive.
3. $TP_{LH}$ is measured when the output signal crosses a voltage level at 50 % of $V_{CC}$ with the following conditions: inverting input voltage (IN-) = $V_{ICM}$ and non-inverting input (IN+), moving from $V_{ICM}$ - 100 mV to $V_{ICM}$ + overdrive.

# 3 Electrical characteristic curves

**Figure 1. Supply current vs temperature and supply voltage**

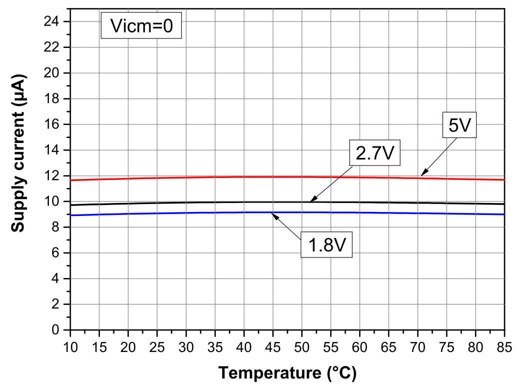



**Figure 2. Supply current vs supply voltage, $V_{icm}$ = 0 V, output low**

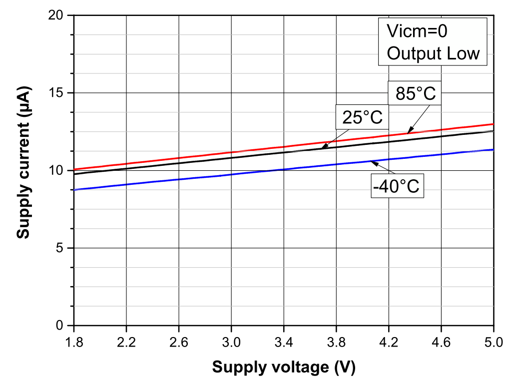



**Figure 3. Supply current vs supply voltage, $V_{icm}$ = 0 V, output high**

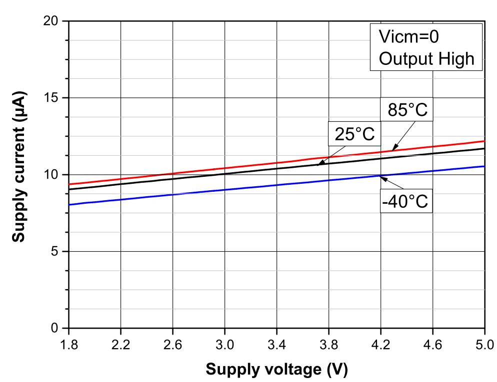



**Figure 4. Supply current vs supply voltage, $V_{icm}$ = $V_{CC}$, output low**

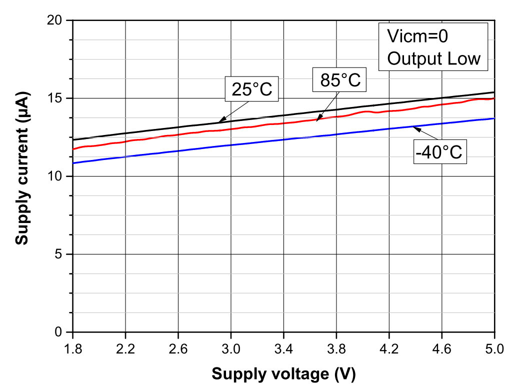



**Figure 5. Supply current vs supply voltage, $V_{icm}$ = $V_{CC}$, output high**

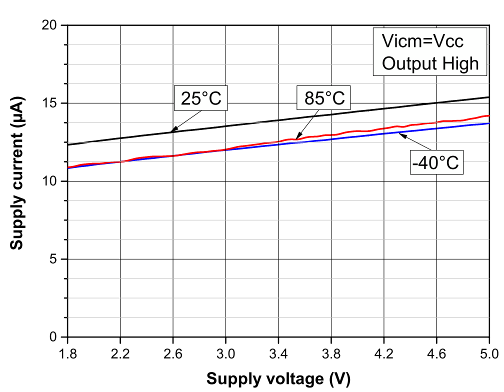



**Figure 6. Input bias current vs. input common mode voltage $V_{CC}$ = 1.8 V**

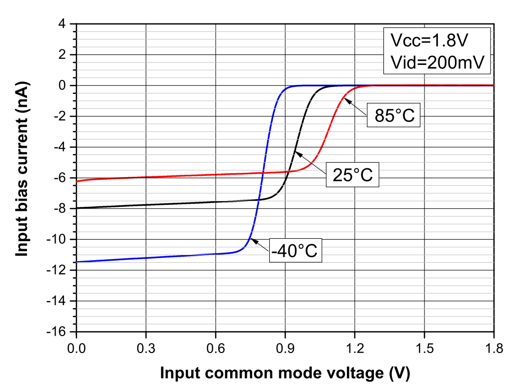


**Figure 7. Input bias current vs. input common mode voltage $V_{CC}$ = 2.7 V**

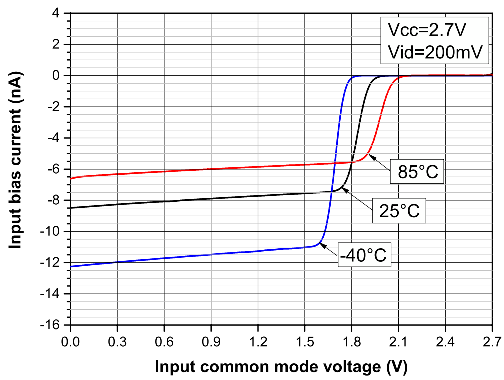



**Figure 8. Input bias current vs. input common mode voltage $V_{CC}$ = 5 V**

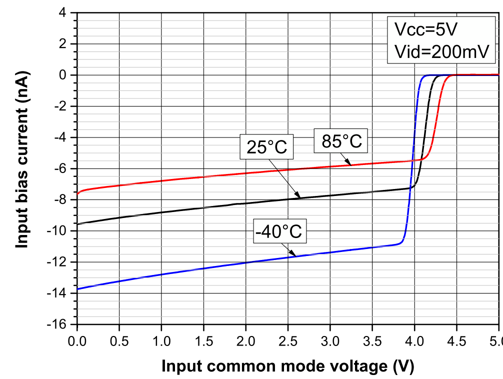



**Figure 9. Input offset voltage vs. input common mode voltage $V_{CC}$ = 1.8 V**

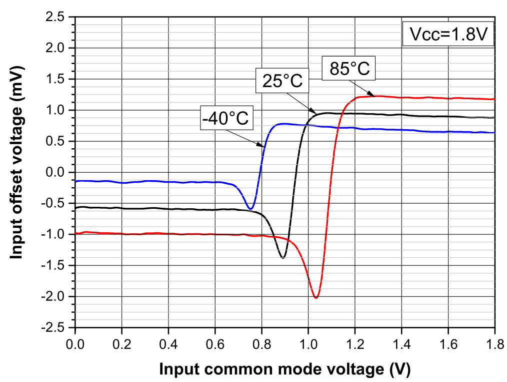



**Figure 10. Input offset voltage vs. input common mode voltage $V_{CC}$ = 2.7 V**

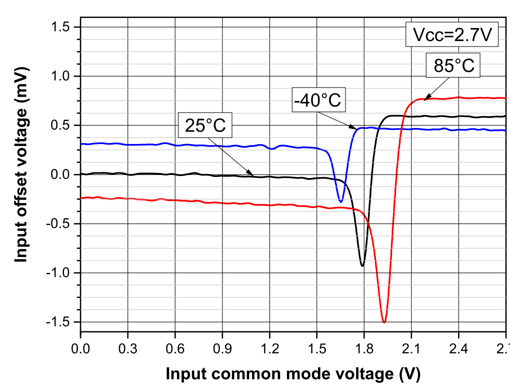



**Figure 11. Input offset voltage vs. input common mode voltage $V_{CC}$ = 5 V**

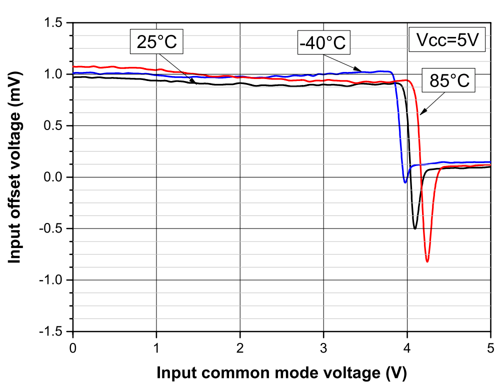



**Figure 12. Output voltage vs. output sink current $V_{CC}$ = 1.8 V**

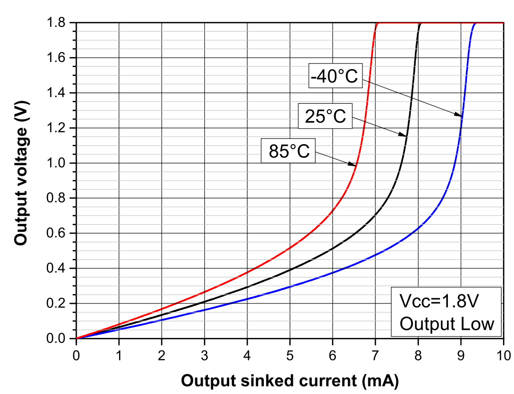


**Figure 13. Output voltage vs. output source current $V_{CC}$ = 1.8 V**

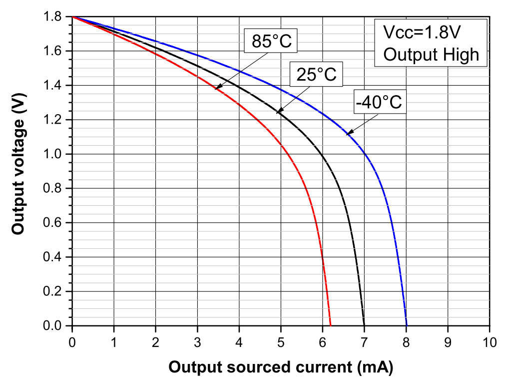



**Figure 14. Output voltage vs. output sink current $V_{CC}$ = 2.7 V**

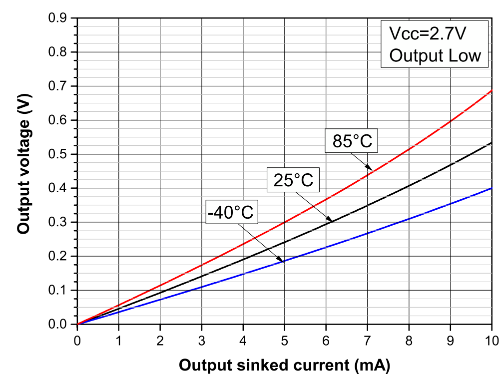



**Figure 15. Output voltage vs. output source current $V_{CC}$ = 2.7 V**

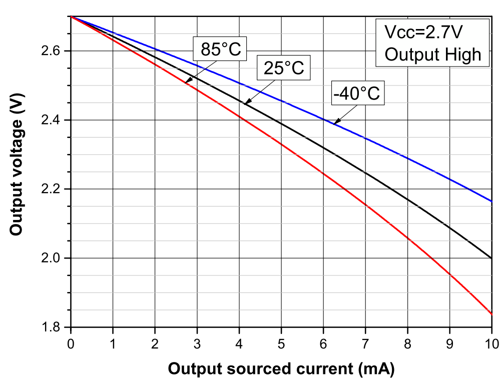



**Figure 16. Output voltage vs. output sink current $V_{CC}$ = 5 V**

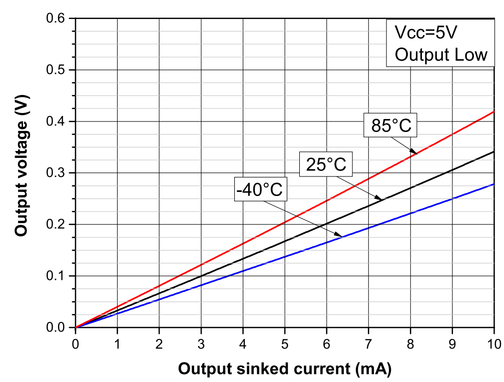



**Figure 17. Output voltage vs. output source current $V_{CC}$ = 5 V**

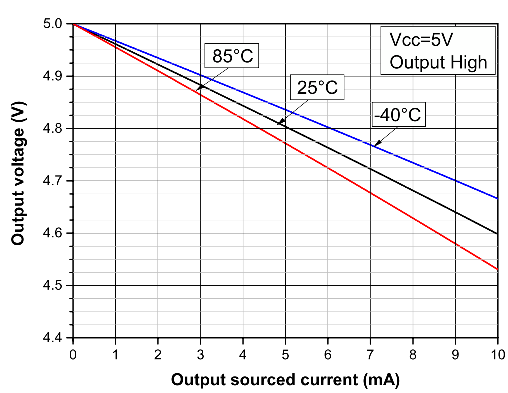



**Figure 18. Propagation delay low to high vs temperature with 50 mV input overdrive**

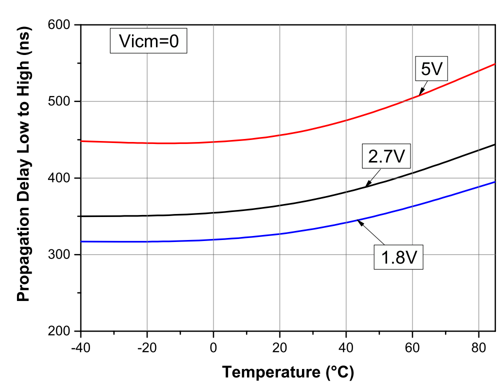


Figure 19. Propagation delay high to low vs temperature with 50 mV input overdrive

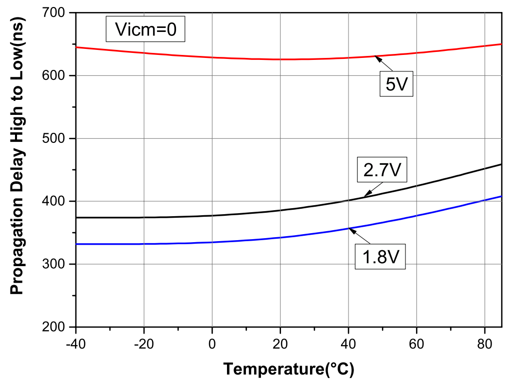



Figure 20. Propagation delay vs input common mode voltage $V_{CC}$ = 1.8 V negative transition

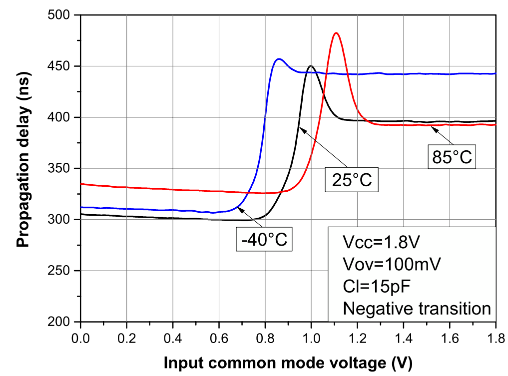



Figure 21. Propagation delay vs input common mode voltage $V_{CC}$ = 1.8 V positive transition

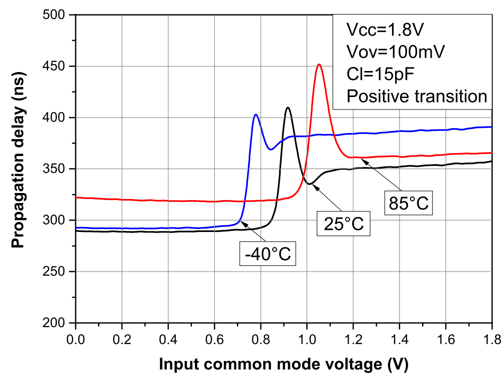



Figure 22. Propagation delay vs input common mode voltage $V_{CC}$ = 2.7 V negative transition

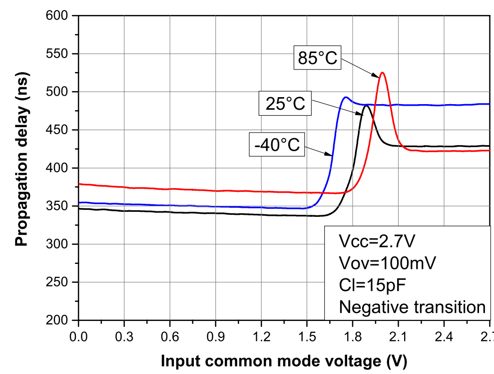



Figure 23. Propagation delay vs input common mode voltage $V_{CC}$ = 2.7 V positive transition

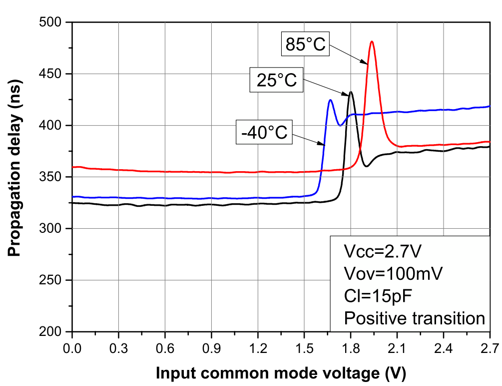



Figure 24. Propagation delay vs input common mode voltage $V_{CC}$ = 5 V negative transition

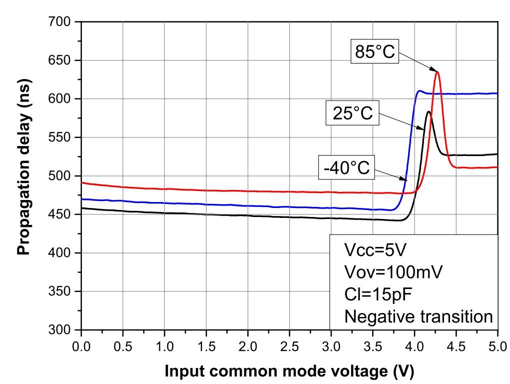


**Figure 25. Propagation delay vs input common mode voltage $V_{CC}$ = 5 V positive transition**

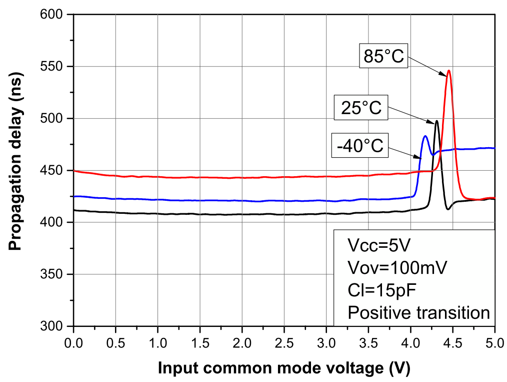



**Figure 26. Propagation delay vs input overdrive voltage $V_{CC}$ = 1.8 V negative transition**

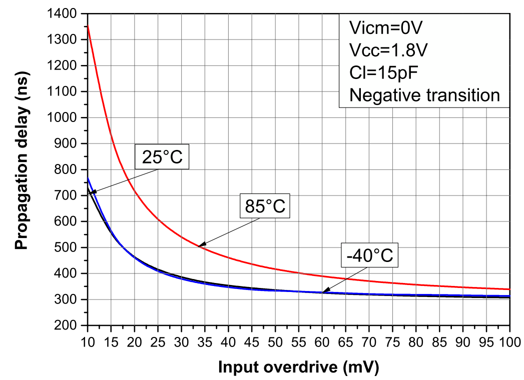



**Figure 27. Propagation delay vs input overdrive voltage $V_{CC}$ = 1.8 V positive transition**

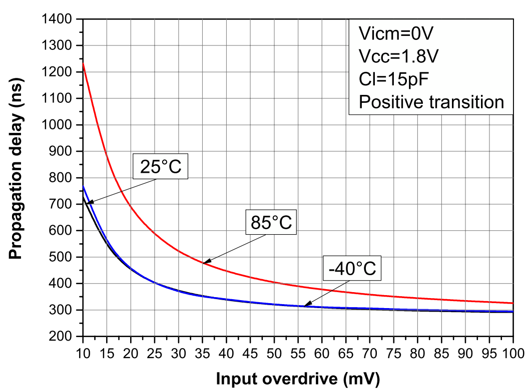



**Figure 28. Propagation delay vs input overdrive voltage $V_{CC}$ = 2.7 V negative transition**

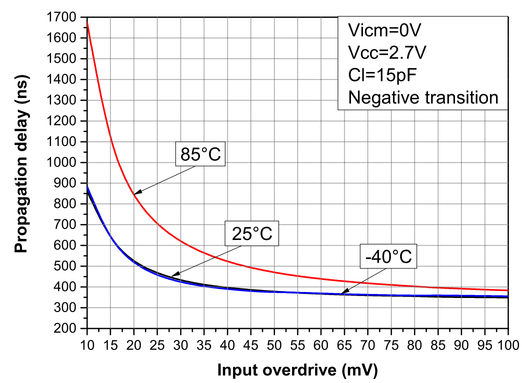



**Figure 29. Propagation delay vs input overdrive voltage $V_{CC}$ = 2.7 V positive transition**

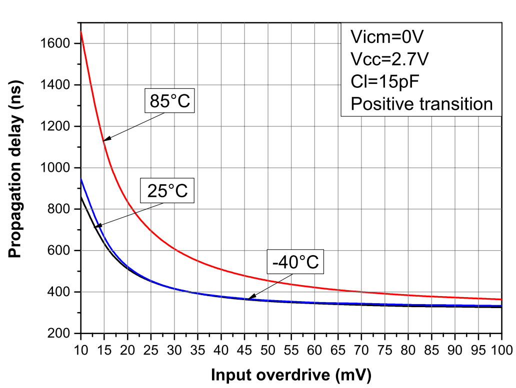



**Figure 30. Propagation delay vs input overdrive voltage $V_{CC}$ = 5 V negative transition**

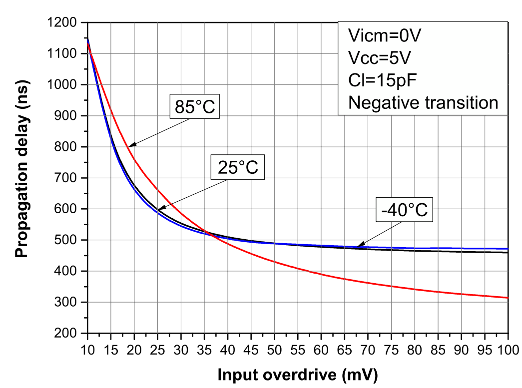


**Figure 31. Propagation delay vs input overdrive voltage $V_{CC}$ = 5 V positive transition**

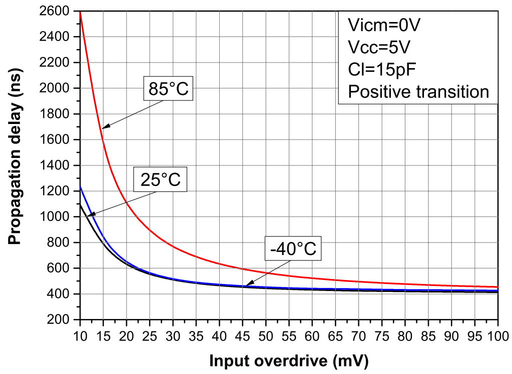
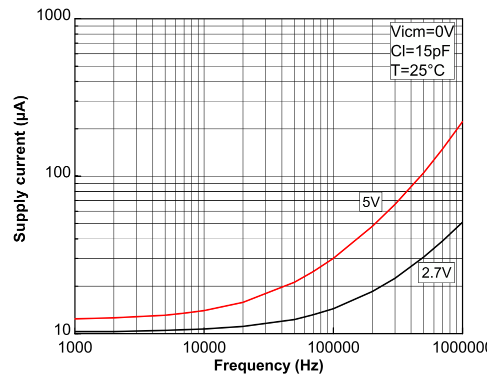



**Figure 32. Supply current vs output transition frequency and supply voltage**



# 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 CSP 6-bump package information

**Figure 33. CSP 6-bump package outline**

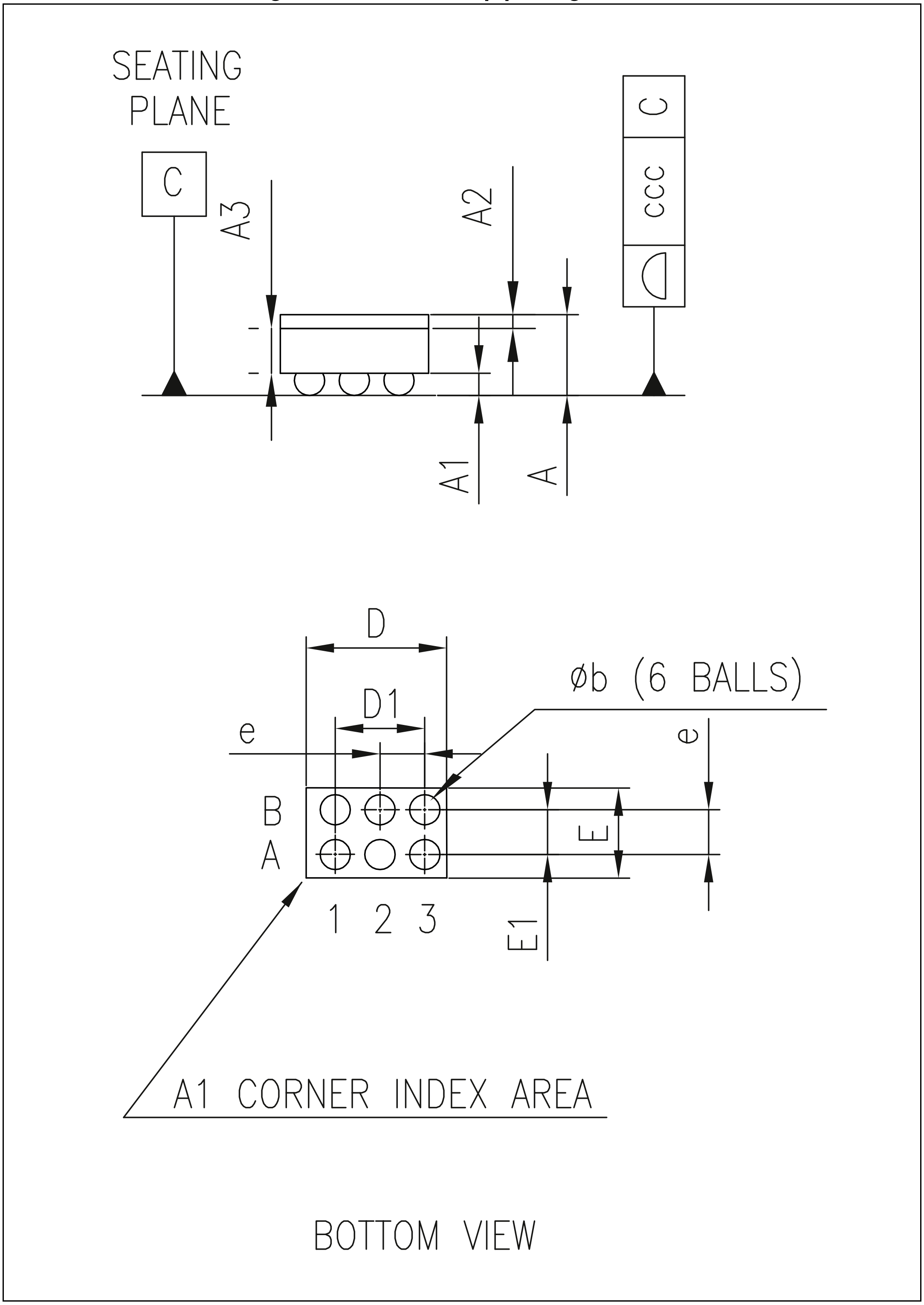


**Table 6. CSP 6-bump mechanical data**

| Ref. | Dimensions | | | | | |
|---|---|---|---|---|---|---|
| | Millimeters | | | Inches | | |
| | Min. | Typ. | Max. | Min. | Typ. | Max. |
| A | 0.485 | 0.525 | 0.57 | 0.019 | 0.021 | 0.022 |
| A1 | 0.17 | | 0.23 | 0.007 | | 0.009 |
| A2 | | 0.025 | 0.03 | | 0.001 | 0.001 |
| A3 | 0.275 | 0.3 | 0.325 | 0.011 | 0.012 | 0.013 |
| b | 0.23 | 0.26 | 0.29 | 0.009 | 0.01 | 0.011 |
| D | 1.18 | 1.2 | 1.22 | 0.046 | 0.047 | 0.048 |
| D1 | | 0.8 | | | 0.031 | |
| E | 0.78 | 0.8 | 0.82 | 0.031 | 0.031 | 0.032 |
| E1 | | 0.4 | | | 0.016 | |
| e | | 0.4 | | | 0.016 | |
| ccc | | | 0.075 | | | 0.003 |

# 5 Ordering information

**Table 7. Order codes**

| Order code | Temperature range | Package | Packing | Marking |
|---|---|---|---|---|
| TS985IJT | -40 °C to 85 °C | CSP 6-bump | Tape and reel | WA9 |

# 6 Revision history

**Table 8. Document revision history**

| Date | Revision | Changes |
|---|---|---|
| 23-Jun-2016 | 1 | Initial release |
| 04-Apr-2024 | 2 | Updated Marking in *Table 7* |