

Rail-to-rail micropower BiCMOS comparators

Features

- Ultra low current consumption (6 $\mu\text{A}/\text{comp}$ at $V_{\text{CC}} = 2.7\text{ V}$)
- Rail to rail CMOS inputs
- Push pull outputs
- Supply operation from 2.7 to 10 V
- Low propagation delay
- ESD protection (2 kV)
- Latch-up immunity (class A)
- Available in SOT23-5 micropackage

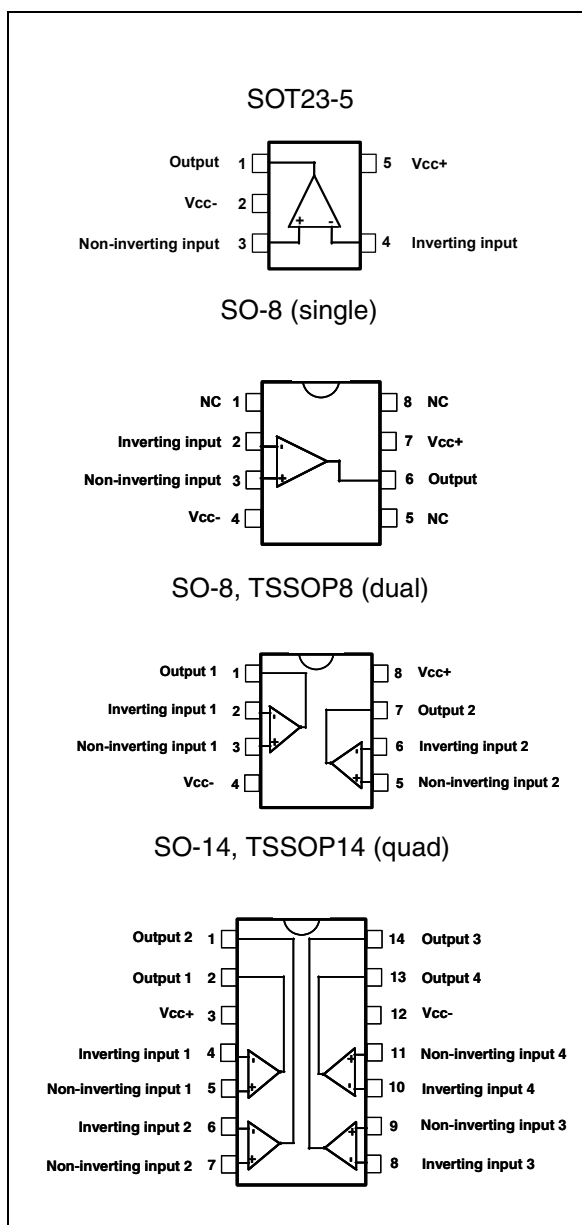
Applications

- Battery-powered systems such as alarms
- Portable communication systems
- Smoke/gas/fire detectors
- Portable computers

Description

The TS86x (single, dual and quad) is a rail-to-rail comparator characterized for 2.7 to 10 V operation over -40° C to $+85^{\circ}\text{ C}$ temperature ranges. It exhibits an excellent speed-to-power ratio, featuring a current consumption of 6 μA per comparator and a response time of 500 ns at 2.7 V for a 100 mV overdrive.

Due to its ultra-low power consumption and its availability in a tiny package, the TS86x comparator family is perfectly suited to battery-powered systems. The output stage is designed with a push-pull structure allowing a direct connection to the microcontroller without additional pull-up resistors.



1 Absolute maximum ratings and operating conditions

Table 1. Absolute maximum ratings

| Symbol | Parameter | Value | Unit |
|-------------------|---|--------------|------|
| V _{CC} | Supply voltage ⁽¹⁾ | 12 | V |
| V _{ID} | Differential Input Voltage ⁽²⁾ | ±12 | V |
| V _{IN} | Input Voltage Range ⁽³⁾ | -0.3 to 12.3 | V |
| R _{THJA} | Thermal resistance junction to ambient ⁽⁴⁾ | | |
| | SOT23-5 | 250 | °C/W |
| | SO8 | 125 | |
| | SO14 | 105 | |
| | TSSOP8 | 120 | |
| TSSOP14 | 100 | | |
| R _{THJC} | Thermal resistance junction to case ⁽⁴⁾ | | |
| | SOT23-5 | 81 | °C/W |
| | SO8 | 40 | |
| | SO14 | 31 | |
| | TSSOP8 | 37 | |
| TSSOP14 | 32 | | |
| T _{STG} | Storage temperature range | -65 to +150 | °C |
| T _J | Maximum junction temperature | 150 | °C |
| T _{LEAD} | Lead temperature (soldering, 10 sec) | 260 | °C |
| ESD | Human body model (HBM) ⁽⁵⁾ | 2 | kV |
| | Machine model (MM) ⁽⁶⁾ | 200 | V |
| | Latch-up immunity | Class A | |

1. All voltages values, except differential voltage are with respect to network terminal.
2. Differential voltages are non-inverting input terminal with respect to the inverting input terminal.
3. The magnitude of input and output voltages must never exceed V_{CC} +0.3V.
4. Short-circuits can cause excessive heating. These values are typical.
5. 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.
6. 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.

Table 2. Operating conditions

| Symbol | Parameter | Value | Unit |
|-------------------|--------------------------------------|--|------|
| V _{CC} | Supply voltage | 2.7 to 10 | V |
| V _{ICM} | Common mode input voltage range | V _{CC} ⁻ - 0.3 to V _{CC} ⁺ + 0.3 | V |
| T _{Oper} | Operating free air temperature range | -40 to + 85 | °C |

2 Electrical characteristics

**Table 3. Electrical characteristics at $V_{CC} = 2.7\text{ V}$, $T_{amb} = 25^\circ\text{ C}$
(unless otherwise specified)**

| Symbol | Parameter | Min. | Typ. | Max. | Unit |
|-----------------|---|--------------|------------|--------------|------------------------------|
| V_{IO} | Input offset voltage TS861/2/4 $T_{min} < T < T_{max}$ | | 3 | 15 18 | mV |
| | TS861/2/4A $T_{min} < T < T_{max}$ | | 3 | 7 10 | |
| ΔV_{IO} | Input offset voltage drift | | 6 | | $\mu\text{V}/^\circ\text{C}$ |
| I_{IO} | Input offset current ⁽¹⁾ $T_{min} < T < T_{max}$ | | 1 | 150 300 | pA |
| I_{IB} | Input bias current ⁽¹⁾ $T_{min} < T < T_{max}$ | | 1 | 300 600 | pA |
| V_{OH} | High level output voltage $I_{SOURCE} = 2.5\text{ mA}$ $T_{min} < T < T_{max}$ | 2.35 2.15 | 2.45 | | V |
| V_{OL} | Low level output voltage $I_{SINK} = 2.5\text{ mA}$ $T_{min} < T < T_{max}$ | | 0.2 | 0.35 0.45 | V |
| A_{VD} | Large signal voltage gain ⁽²⁾ | | 240 | | dB |
| CMR | Common mode rejection ratio $0 < V_{ICM} < 2.7\text{ V}$ | | 65 | | dB |
| SVR | Supply voltage rejection ratio $0 < V_{CC} < 10\text{ V}$ | | 80 | | dB |
| I_{CC} | Supply current per comparator no load, output low no load, output high | | 6 8 | 12 14 | μA |
| T_{PLH} | Propagation delay from output low to output high $V_{ICM} = 1.35\text{ V}$, $f = 10\text{ kHz}$, $C_L = 50\text{ pF}$ overdrive = 10 mV overdrive = 100 mV | | 1.5 0.6 | | μs |
| T_{PHL} | Propagation delay from output high to output low $V_{ICM} = 1.35\text{ V}$, $f = 10\text{ kHz}$, $C_L = 50\text{ pF}$ overdrive = 10 mV overdrive = 100 mV | | 1.5 0.5 | | μs |

Table 3. Electrical characteristics at $V_{CC} = 2.7\text{ V}$, $T_{amb} = 25^\circ\text{ C}$ (unless otherwise specified) (continued)

| Symbol | Parameter | Min. | Typ. | Max. | Unit |
|--------|--|------|------|------|------|
| T_F | Fall time f = 10 kHz, $C_L = 50\text{ pF}$, overdrive = 100 mV | | 20 | | ns |
| T_R | Rise time f = 10 kHz, $C_L = 50\text{ pF}$, overdrive = 100 mV | | 20 | | ns |

1. Maximum values including unavoidable inaccuracies of the industrial tests.
2. Design evaluation.

Note: Limits are 100% production tested at 25° C. Limits over temperature are guaranteed through correlation and by design.

Table 4. Electrical characteristics at $V_{CC} = 5\text{ V}$, $T_{amb} = 25^\circ\text{ C}$ (unless otherwise specified)

| Symbol | Parameter | Min. | Typ. | Max. | Unit |
|-----------------|--|-------------|------|-------------|------------------------------|
| V_{IO} | Input offset voltage TS861/2/4 $T_{min} < T < T_{max}$ | | 3 | 15 18 | mV |
| | TS861/2/4A $T_{min} < T < T_{max}$ | | 3 | 7 10 | |
| ΔV_{IO} | Input offset voltage drift | | 6 | | $\mu\text{V}/^\circ\text{C}$ |
| I_{IO} | Input offset current ⁽¹⁾ $T_{min} < T < T_{max}$ | | 1 | 150 300 | pA |
| | Input bias current ⁽¹⁾ $T_{min} < T < T_{max}$ | | 1 | 300 600 | |
| V_{OH} | High level output voltage $I_{SOURCE} = 5\text{ mA}$ $T_{min} < T < T_{max}$ | 4.6 4.45 | 4.8 | | V |
| | Low level output voltage $I_{SINK} = 5\text{ mA}$ $T_{min} < T < T_{max}$ | | 0.2 | 0.4 0.55 | |
| A_{VD} | Large signal voltage gain ⁽²⁾ | | 240 | | dB |
| CMR | Common mode rejection ratio $0 < V_{ICM} < 5\text{ V}$ | | 70 | | dB |
| SVR | Supply voltage rejection ratio $2.7 < V_{CC} < 10\text{ V}$ | | 80 | | dB |
| I_{CC} | Supply current per comparator no load, output low | | 6 | 12 | μA |
| | no load, output high | | 8 | 14 | |
| T_{PLH} | Propagation delay from output low to output high $V_{ICM} = 2.5\text{ V}$, $f = 10\text{ kHz}$, $C_L = 50\text{ pF}$ overdrive = 10 mV | | 2 | | μs |
| | overdrive = 100 mV | | 0.5 | | |
| T_{PHL} | Propagation delay from output high to output low $V_{ICM} = 2.5\text{ V}$, $f = 10\text{ kHz}$, $C_L = 50\text{ pF}$ overdrive = 10 mV | | 2 | | μs |
| | overdrive = 100 mV | | 0.4 | | |
| T_F | Fall time $f = 10\text{ kHz}$, $C_L = 50\text{ pF}$, overdrive = 100 mV | | 20 | | ns |
| T_R | Rise time $f = 10\text{ kHz}$, $C_L = 50\text{ pF}$, overdrive = 100 mV | | 20 | | ns |

1. Maximum values including unavoidable inaccuracies of the industrial test.

2. Design evaluation.

Note: Limits are 100% production tested at 25°C. Limits over temperature are guaranteed through correlation and by design.

Table 5. Electrical characteristics at $V_{CC} = +10\text{ V}$, $T_{amb} = 25^\circ\text{ C}$ (unless otherwise specified)

| Symbol | Parameter | Min. | Typ. | Max. | Unit |
|-----------------|--|-------------|------------|-------------|------------------------------|
| V_{IO} | Input offset voltage ($V_{ICM} = V_{CC} / 2$) TS861/2/4 $T_{min} < T < T_{max}$ | | 3 | 15 18 | mV |
| ΔV_{IO} | Input offset voltage drift | | 6 | | $\mu\text{V}/^\circ\text{C}$ |
| I_{IO} | Input offset current ⁽¹⁾ $T_{min} < T < T_{max}$ | | 1 | 150 300 | pA |
| I_{IB} | Input bias current ⁽¹⁾ $T_{min} < T < T_{max}$ | | 1 | 300 600 | pA |
| V_{OH} | High level output voltage $I_{SOURCE} = 5\text{ mA}$ $T_{min} < T < T_{max}$ | 9.6 9.45 | 9.8 | | V |
| V_{OL} | Low level output voltage $I_{SINK} = 5\text{ mA}$ $T_{min} < T < T_{max}$ | | 0.2 | 0.4 0.55 | V |
| A_{VD} | Large signal voltage gain ⁽²⁾ | | 240 | | dB |
| CMR | Common mode rejection ratio $0 < V_{ICM} < 10\text{ V}$ | | 75 | | dB |
| SVR | Supply voltage rejection ratio $2.7 < V_{CC} < 10\text{ V}$ | | 80 | | dB |
| I_{CC} | Supply current per comparator no load, output low no load, output high | | 7 10 | 14 16 | μA |
| T_{PLH} | Propagation delay from output low to output high $V_{ICM} = 5\text{ V}$, $f = 10\text{ kHz}$, $C_L = 50\text{ pF}$ overdrive = 10 mV overdrive = 100 mV | | 3 0.5 | | μs |
| T_{PHL} | Propagation delay from output high to output low $V_{ICM} = 5\text{ V}$, $f = 10\text{ kHz}$, $C_L = 50\text{ pF}$ overdrive = 10 mV overdrive = 100 mV | | 2.6 0.4 | | μs |
| T_F | Fall time $f = 10\text{ kHz}$, $C_L = 50\text{ pF}$, overdrive = 100 mV | | 20 | | ns |
| T_R | Rise time $f = 10\text{ kHz}$, $C_L = 50\text{ pF}$, overdrive = 100 mV | | 20 | | ns |

1. Maximum values including unavoidable inaccuracies of the industrial test.

2. Design evaluation.

Note: Limits are 100% production tested at 25° C . Limits over temperature are guaranteed through correlation and by design.

Figure 1. V_{IO} versus V_{ICM} at $V_{CC} = 2.7\text{ V}$

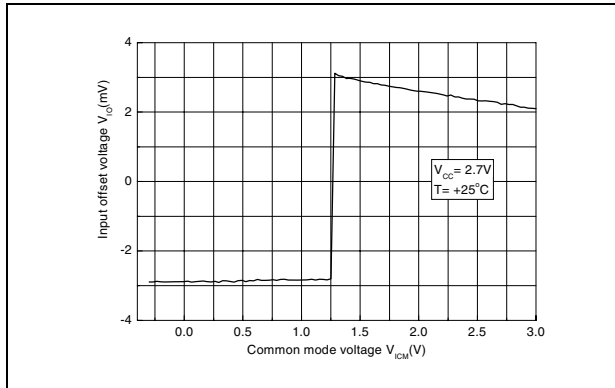


Figure 2. V_{IO} versus V_{ICM} and temperature at $V_{CC} = 2.7\text{ V}$

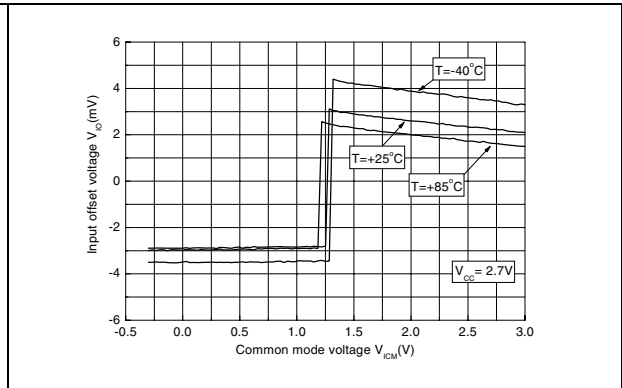


Figure 3. V_{IO} versus V_{ICM} at $V_{CC} = 5\text{ V}$

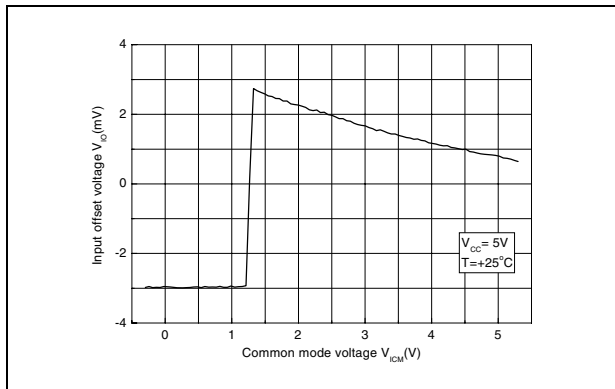


Figure 4. V_{IO} versus V_{ICM} and temperature at $V_{CC} = 5\text{ V}$

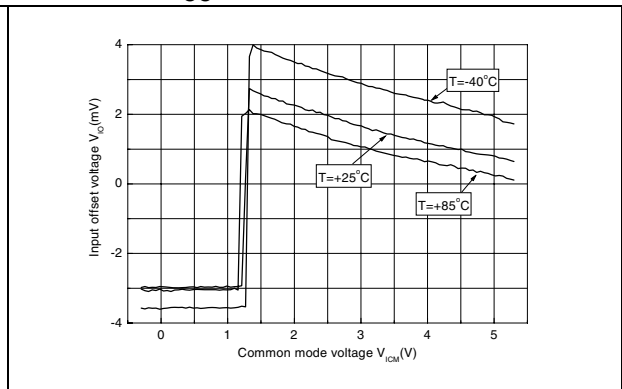


Figure 5. V_{IO} versus V_{ICM} at $V_{CC} = 10\text{ V}$

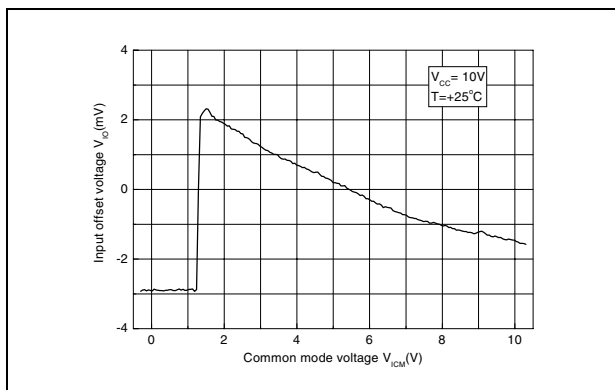


Figure 6. V_{IO} versus V_{ICM} and temperature at $V_{CC} = 10\text{ V}$

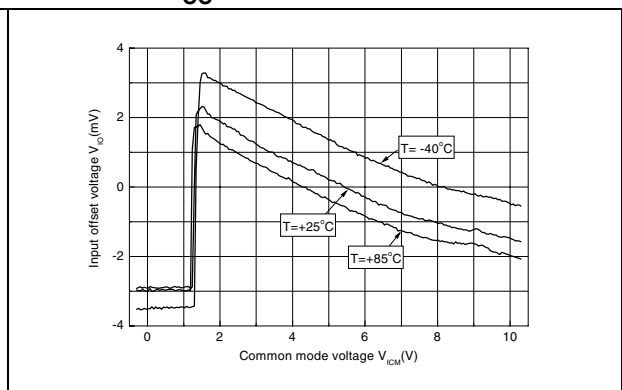


Figure 7. V_{IO} versus V_{CC} at $V_{ICM} = V_{CC}/2$

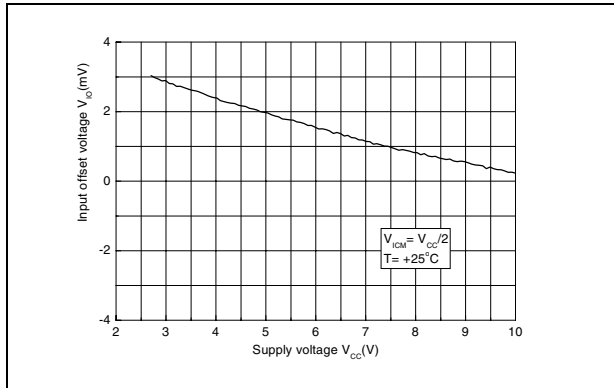


Figure 8. V_{IO} versus temperature at $V_{CC} = 5\text{ V}$

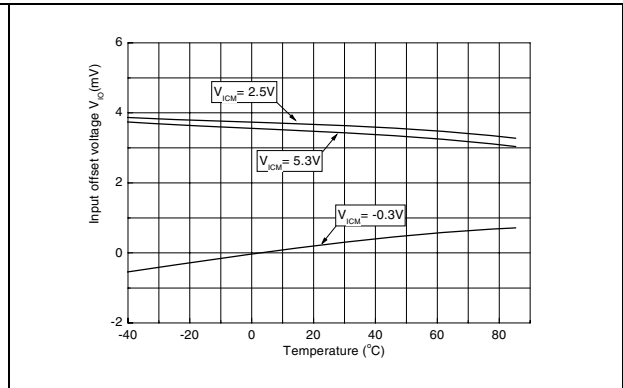


Figure 9. Supply current (I_{CC}) versus supply voltage (V_{CC})

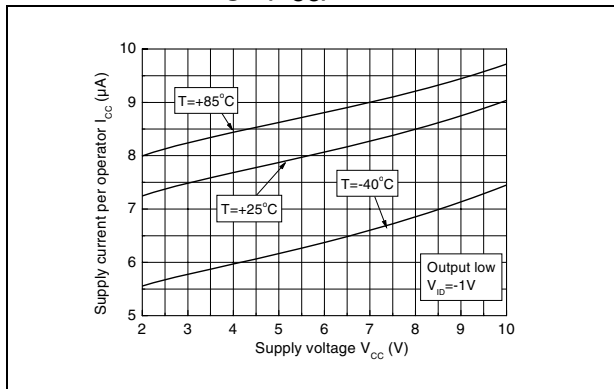


Figure 10. Supply current (I_{CC}) versus supply voltage (V_{CC})

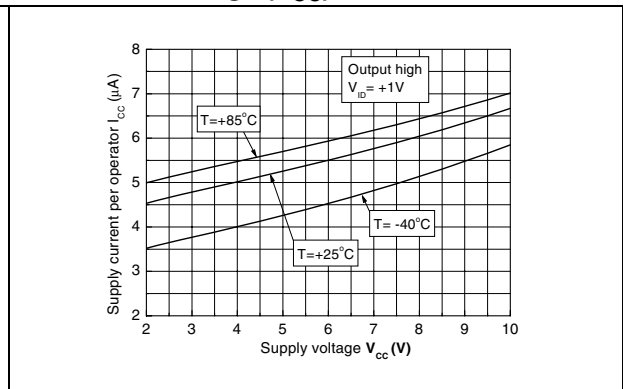


Figure 11. Supply current (I_{CC}) versus temperature

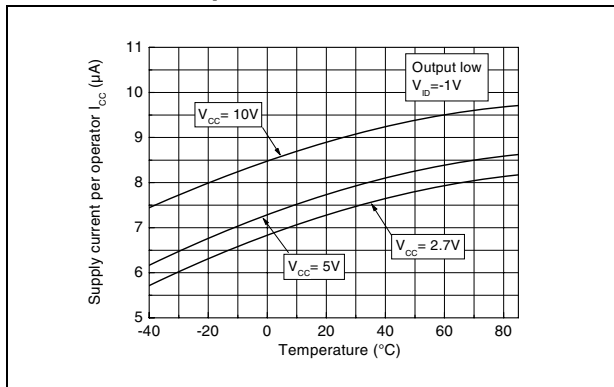


Figure 12. Supply current (I_{CC}) versus temperature

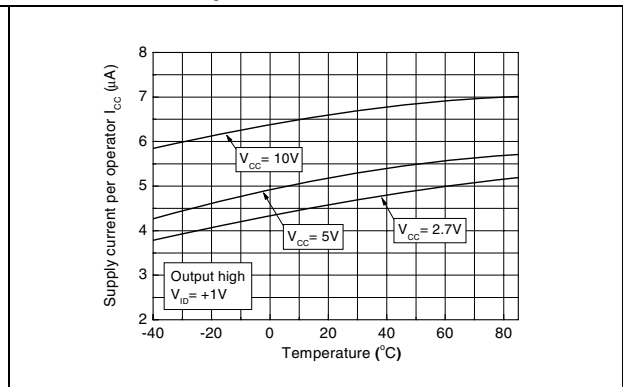


Figure 13. V_{OL} versus I_{SINK} and temperature at $V_{CC} = 5V$

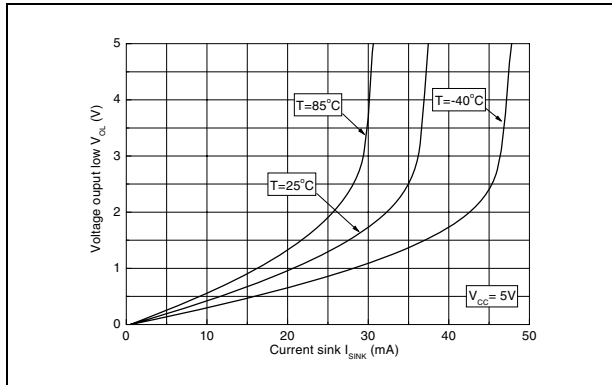


Figure 14. V_{OH} versus I_{SOURCE} and temperature at $V_{CC} = 5V$

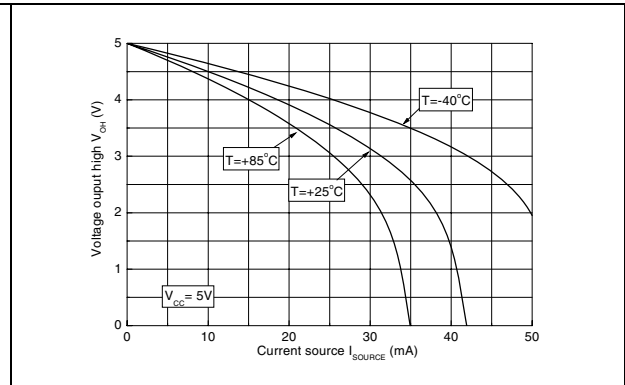


Figure 15. Propagation delay T_{PLH} versus V_{ICM} with $V_{OVD} = 100mV$

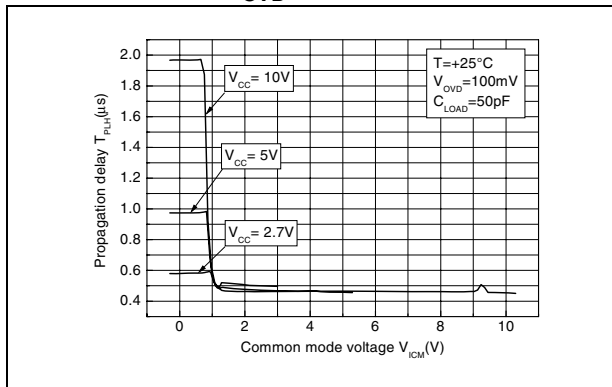


Figure 16. Propagation delay T_{PHL} versus V_{ICM} with $V_{OVD} = 100mV$

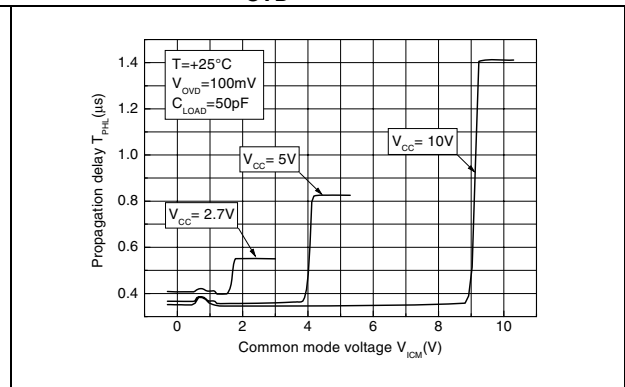


Figure 17. Propagation delay T_{PLH} versus V_{ICM} with $V_{OVD} = 10mV$

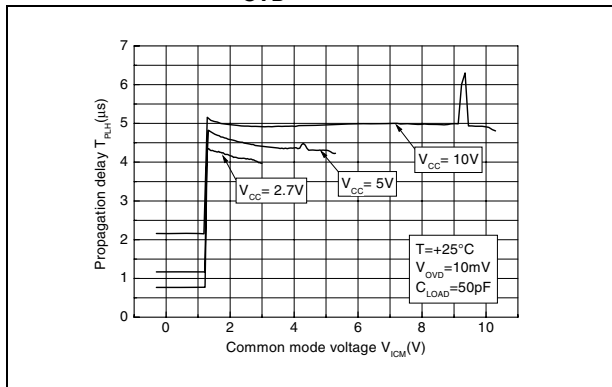


Figure 18. Propagation delay T_{PHL} versus V_{ICM} with $V_{OVD} = 10mV$

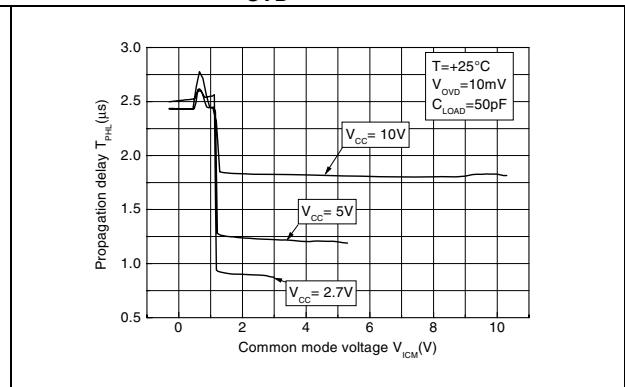


Figure 19. Propagation delay versus V_{CC} with $V_{OVD} = 10\text{ mV}$

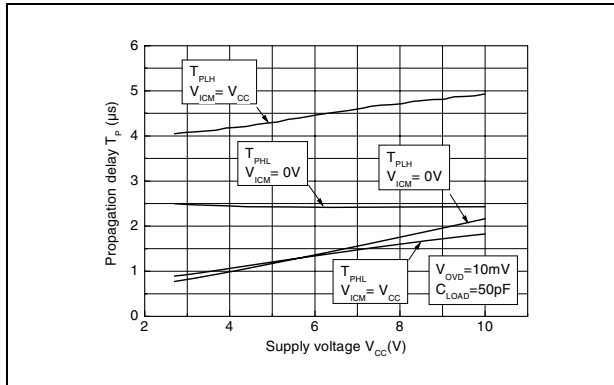


Figure 20. Propagation delay versus V_{CC} with $V_{OVD} = 100\text{ mV}$

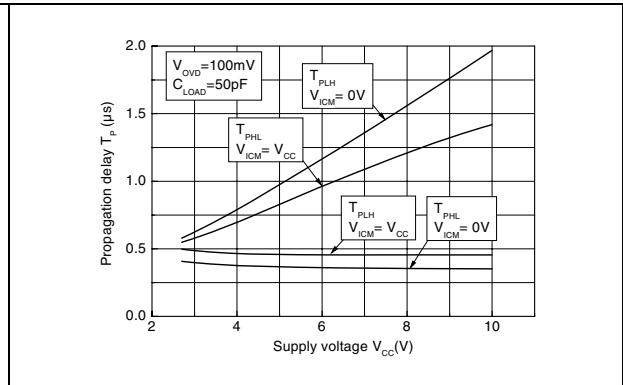


Figure 21. Propagation delay versus overdrive voltage at $V_{CC} = 2.7\text{ V}$

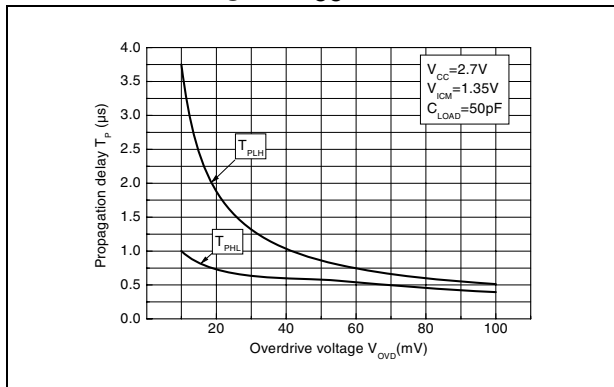


Figure 22. Propagation delay versus overdrive voltage at $V_{CC} = 5\text{ V}$

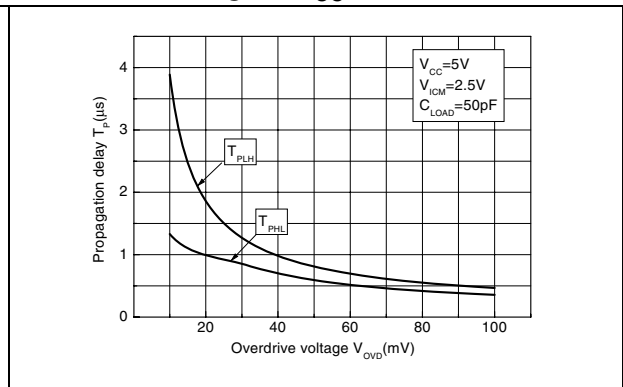
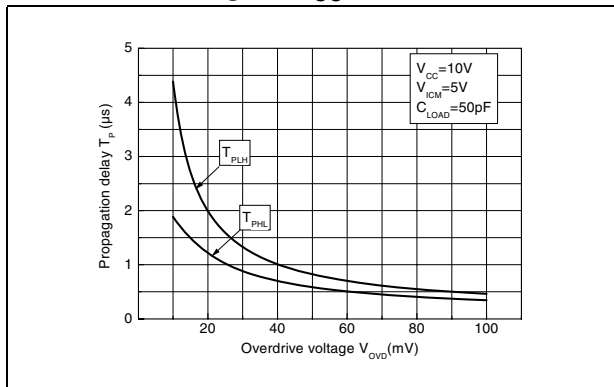


Figure 23. Propagation delay versus overdrive voltage at $V_{CC} = 10\text{ V}$



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 SO-8 package information

Figure 24. SO-8 package mechanical drawing

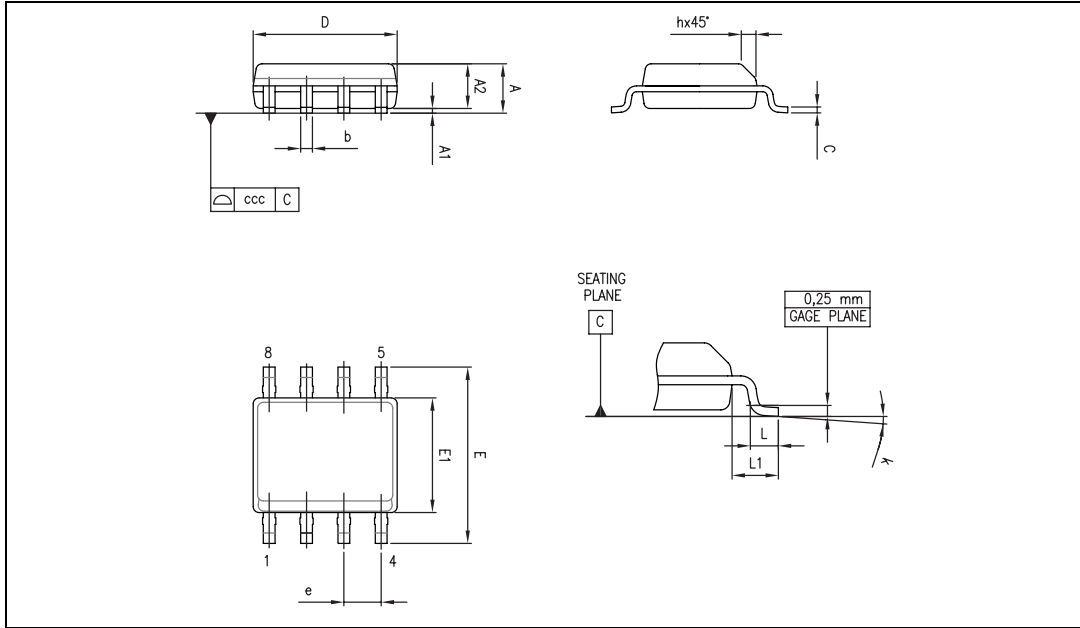


Table 6. SO-8 package mechanical data

| Ref. | Dimensions | | | | | |
|------|-------------|------|------|--------|-------|-------|
| | Millimeters | | | Inches | | |
| | Min. | Typ. | Max. | Min. | Typ. | Max. |
| A | | | 1.75 | | | 0.069 |
| A1 | 0.10 | | 0.25 | 0.004 | | 0.010 |
| A2 | 1.25 | | | 0.049 | | |
| b | 0.28 | | 0.48 | 0.011 | | 0.019 |
| c | 0.17 | | 0.23 | 0.007 | | 0.010 |
| D | 4.80 | 4.90 | 5.00 | 0.189 | 0.193 | 0.197 |
| E | 5.80 | 6.00 | 6.20 | 0.228 | 0.236 | 0.244 |
| E1 | 3.80 | 3.90 | 4.00 | 0.150 | 0.154 | 0.157 |
| e | | 1.27 | | | 0.050 | |
| h | 0.25 | | 0.50 | 0.010 | | 0.020 |
| L | 0.40 | | 1.27 | 0.016 | | 0.050 |
| L1 | | 1.04 | | | 0.040 | |
| k | 0 | | 8° | 1° | | 8° |
| ccc | | | 0.10 | | | 0.004 |

3.2 TSSOP8 package information

Figure 25. TSSOP8 package mechanical drawing

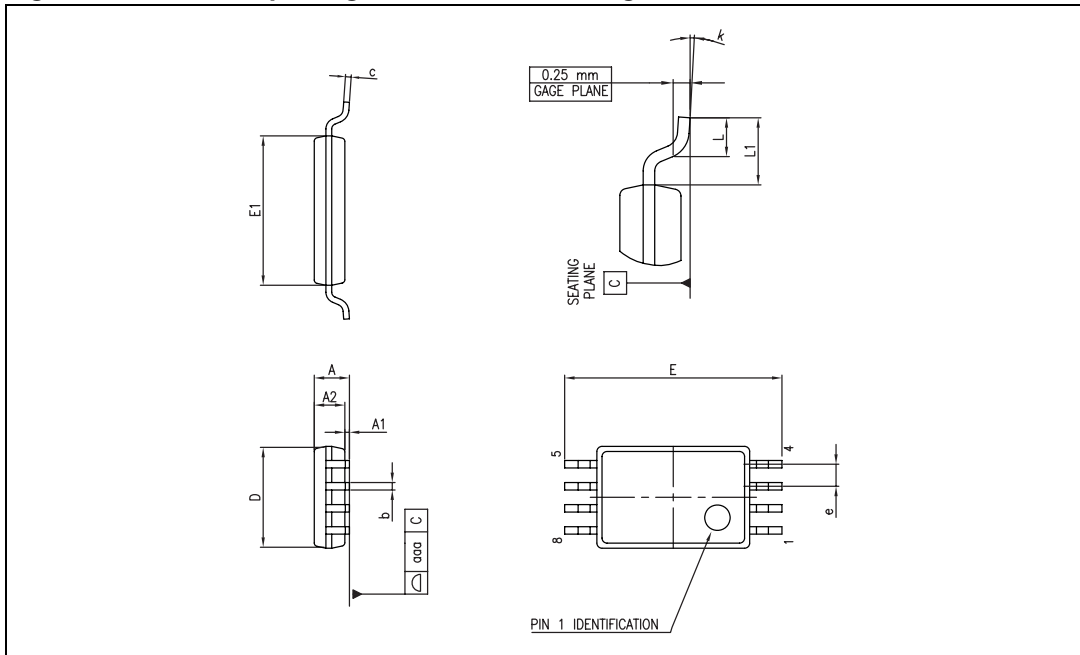


Table 7. TSSOP8 package mechanical data

| Ref. | Dimensions | | | | | |
|------|-------------|------|------|--------|--------|-------|
| | Millimeters | | | Inches | | |
| | Min. | Typ. | Max. | Min. | Typ. | Max. |
| A | | | 1.20 | | | 0.047 |
| A1 | 0.05 | | 0.15 | 0.002 | | 0.006 |
| A2 | 0.80 | 1.00 | 1.05 | 0.031 | 0.039 | 0.041 |
| b | 0.19 | | 0.30 | 0.007 | | 0.012 |
| c | 0.09 | | 0.20 | 0.004 | | 0.008 |
| D | 2.90 | 3.00 | 3.10 | 0.114 | 0.118 | 0.122 |
| E | 6.20 | 6.40 | 6.60 | 0.244 | 0.252 | 0.260 |
| E1 | 4.30 | 4.40 | 4.50 | 0.169 | 0.173 | 0.177 |
| e | | 0.65 | | | 0.0256 | |
| k | 0° | | 8° | 0° | | 8° |
| L | 0.45 | 0.60 | 0.75 | 0.018 | 0.024 | 0.030 |
| L1 | | 1 | | | 0.039 | |
| aaa | | | 0.10 | | | 0.004 |

3.3 SO-14 package information

Figure 26. SO-14 package mechanical drawing

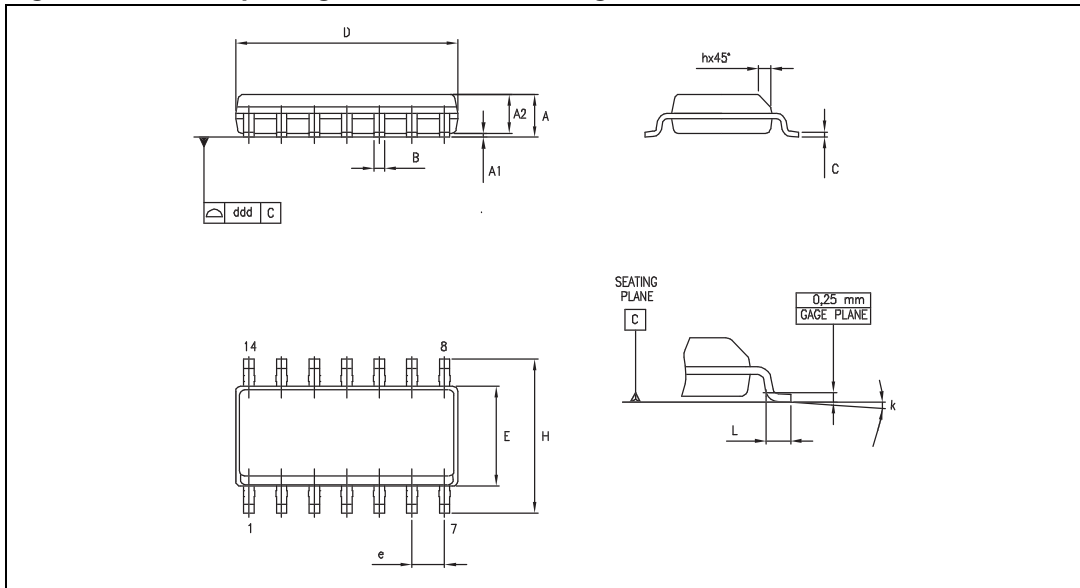


Table 8. SO-14 package mechanical data

| Dimensions | | | | | | |
|------------|-------------|------|------|--------|------|-------|
| Ref. | Millimeters | | | Inches | | |
| | Min. | Typ. | Max. | Min. | Typ. | Max. |
| A | 1.35 | | 1.75 | 0.05 | | 0.068 |
| A1 | 0.10 | | 0.25 | 0.004 | | 0.009 |
| A2 | 1.10 | | 1.65 | 0.04 | | 0.06 |
| B | 0.33 | | 0.51 | 0.01 | | 0.02 |
| C | 0.19 | | 0.25 | 0.007 | | 0.009 |
| D | 8.55 | | 8.75 | 0.33 | | 0.34 |
| E | 3.80 | | 4.0 | 0.15 | | 0.15 |
| e | | 1.27 | | | 0.05 | |
| H | 5.80 | | 6.20 | 0.22 | | 0.24 |
| h | 0.25 | | 0.50 | 0.009 | | 0.02 |
| L | 0.40 | | 1.27 | 0.015 | | 0.05 |
| k | 8° (max.) | | | | | |
| ddd | | | 0.10 | | | 0.004 |

3.4 TSSOP14 package information

Figure 27. TSSOP14 package mechanical drawing

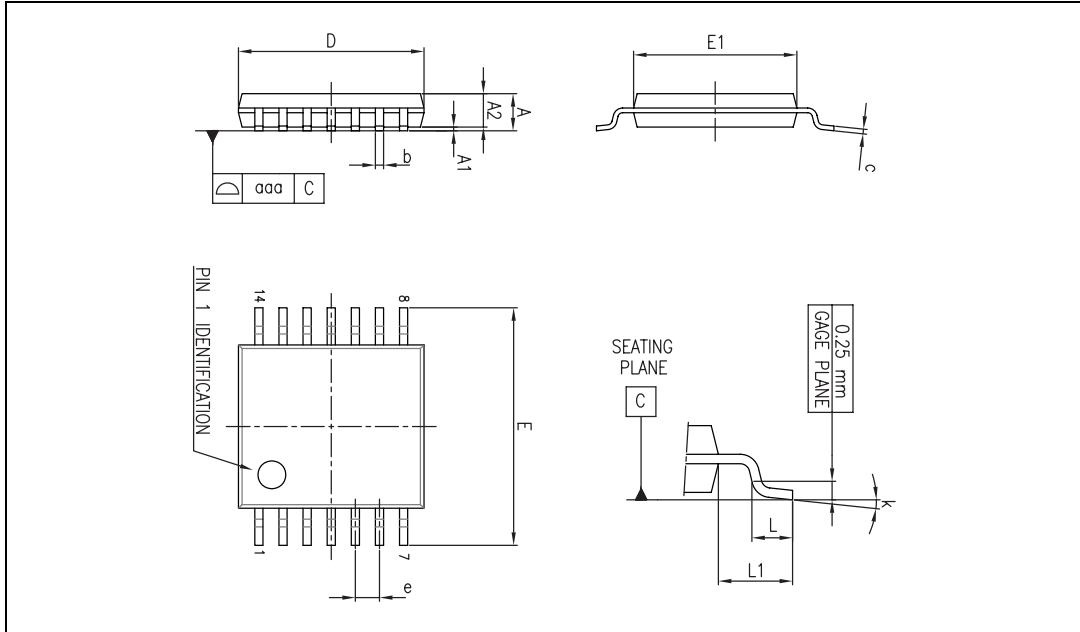


Table 9. TSSOP14 package mechanical data

| Ref. | Dimensions | | | | | |
|------|-------------|------|------|--------|--------|--------|
| | Millimeters | | | Inches | | |
| | Min. | Typ. | Max. | Min. | Typ. | Max. |
| A | | | 1.20 | | | 0.047 |
| A1 | 0.05 | | 0.15 | 0.002 | 0.004 | 0.006 |
| A2 | 0.80 | 1.00 | 1.05 | 0.031 | 0.039 | 0.041 |
| b | 0.19 | | 0.30 | 0.007 | | 0.012 |
| c | 0.09 | | 0.20 | 0.004 | | 0.0089 |
| D | 4.90 | 5.00 | 5.10 | 0.193 | 0.197 | 0.201 |
| E | 6.20 | 6.40 | 6.60 | 0.244 | 0.252 | 0.260 |
| E1 | 4.30 | 4.40 | 4.50 | 0.169 | 0.173 | 0.176 |
| e | | 0.65 | | | 0.0256 | |
| L | 0.45 | 0.60 | 0.75 | 0.018 | 0.024 | 0.030 |
| L1 | | 1.00 | | | 0.039 | |
| k | 0° | | 8° | 0° | | 8° |
| aaa | | | 0.10 | | | 0.004 |

3.5 SOT23-5 package information

Figure 28. SOT23-5L package mechanical drawing

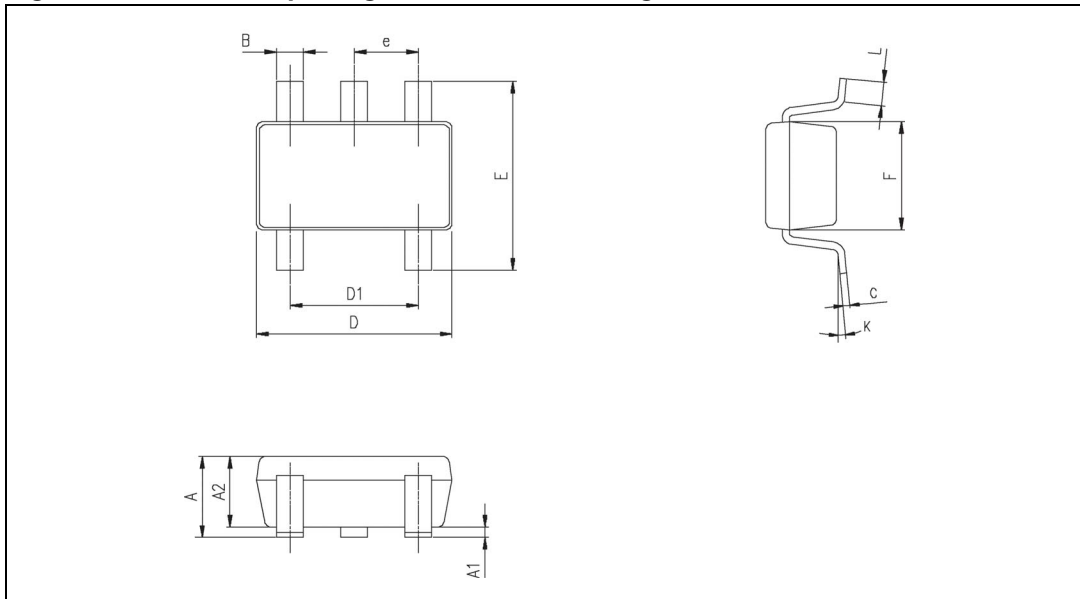


Table 10. SOT23-5L package mechanical data

| 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 | | | |

4 Ordering information

Table 11. Order codes

| Part number | Temperature range | Package | Packing | Marking |
|---|-------------------|------------------------------|---------------------|-----------------|
| TS861ILT TS861AILT | -40°C, +85°C | SOT-23 | Tape & reel | K501 K502 |
| TS861ID TS861IDT | | SO-8 | Tube Tape & reel | 861I |
| TS861AID TS861AIDT | | | Tube Tape & reel | 861AI |
| TS861IYLT ⁽¹⁾ TS861AIYLT ⁽¹⁾ | | SOT-23 (Automotive grade) | Tape & reel | K504 K505 |
| TS862ID TS862IDT | -40°C, +85°C | SO-8 | Tube Tape & reel | 862I |
| TS862AID TS862AIDT | | | Tube Tape & reel | 862AI |
| TS862IPT TS862AIPT | | TSSOP8 | Tape & reel | 862I 862AI |
| TS862IYDT ⁽¹⁾ TS862AIYDT ⁽¹⁾ | | SO-8 (Automotive grade) | Tape & reel | 862IY 862AIY |
| TS864ID TS864IDT | -40°C, +85°C | SO-14 | Tube Tape & reel | 864I |
| TS864AID TS864AIDT | | | Tube Tape & reel | 864AI |
| TS864IPT TS864AIPT | | TSSOP14 | Tape & reel | 864I 864AI |
| TS864IYDT ⁽¹⁾ TS864AIYDT ⁽¹⁾ | | SO-14 (Automotive grade) | Tape & reel | 864IY 864AIY |

1. Qualification and characterization according to AEC Q100 and Q003 or equivalent, advanced screening according to AEC Q001 & Q 002 or equivalent are on-going.

5 Revision history

Table 12. Document revision history

| Date | Revision | Changes |
|-------------|----------|---|
| 01-Feb-2002 | 1 | Initial release. |
| 28-Apr-2009 | 2 | Updated document format. Removed power dissipation from Table 1: Absolute maximum ratings . Added Rthja and Rthjc values and ESD notes in Table 1 . Updated curves in Figure 1 to Figure 14 . Changed Figure 15 , Figure 16 , Figure 17 and Figure 18 . Added Figure 19 , Figure 20 , Figure 21 , Figure 22 and Figure 23 . Removed DIP package information in Chapter 3 and Chapter 4 . Added ordering information in Table 11: Order codes . |

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