# LM193, LM293, LM393

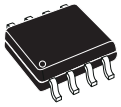
## Low power dual voltage comparators

**Datasheet – production data**

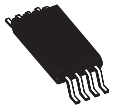
## Features

- Wide single-supply voltage range or dual supplies: +2 V to +36 V or ±1 V to ±18 V
- Very low supply current (0.45 mA) independent of supply voltage (1 mW/comparator at +5 V)
- Low input bias current: 20 nA typ.
- Low input offset current: ±3 nA typ.
- Low input offset voltage: ±1 mV typ.
- Input common-mode voltage range includes ground
- Low output saturation voltage: 80 mV typ. ($I_{sink}$ = 4 mA)
- Differential input voltage range equal to the supply voltage
- TTL, DTL, ECL, MOS, CMOS compatible outputs
- Available in DIP8, SO-8, TSSOP8, MiniSO-8, and DFN8 2 x 2 mm packages

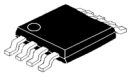
**DIP8**
(plastic package)



**SO-8**
(plastic micropackage)



**TSSOP8**
(thin shrink small outline package)



**MiniSO-8**
(plastic micropackage)

**DFN8 2 x 2 mm**
(plastic micropackage)

## Description

The LM193, LM293, and LM393 devices consist of two independent low voltage comparators designed specifically to operate from a single supply over a wide range of voltages. Operation from split power supplies is also possible.

These comparators also have a unique characteristic in that the input common-mode voltage range includes ground even though operated from a single power supply voltage.



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

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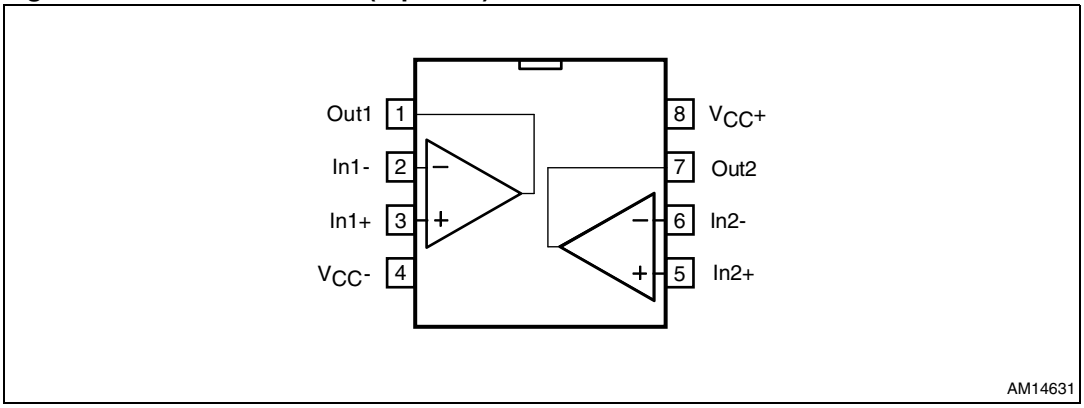
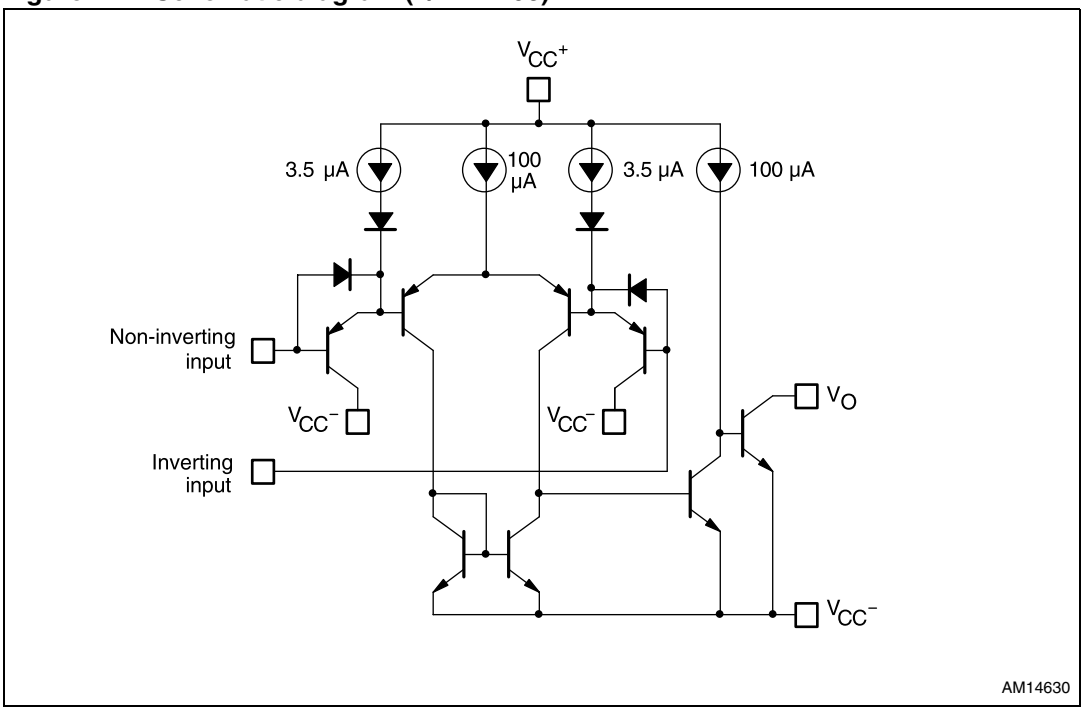
# 1 Pin connections

**Figure 1. Pin connections (top view)**



# 2 Schematic diagram

**Figure 2. Schematic diagram (1/2 LM193)**



# 3 Absolute maximum ratings and operating conditions

**Table 1. Absolute maximum ratings**

| Symbol | Parameter | Value | Unit |
|---|---|---|---|
| $V_{CC}$ | Supply voltage | ±18 or 36 | V |
| $V_{id}$ | Differential input voltage | ±36 | V |
| $V_{in}$ | Input voltage | -0.3 to +36 | V |
| | Output short-circuit to ground(1) | Infinite | |
| $R_{thja}$ | Thermal resistance junction to ambient(2)<br>SO-8<br>TSSOP8<br>DIP8<br>MiniSO-8<br>DFN8 2 x 2 mm | <br>125<br>120<br>85<br>190<br>57 | °C/W |
| $R_{thjc}$ | Thermal resistance junction to case(2)<br>SO-8<br>TSSOP8<br>DIP8<br>MiniSO-8<br>DFN8 2 x 2 mm | <br>40<br>37<br>41<br>39 | °C/W |
| $T_j$ | Maximum junction temperature | 150 | °C |
| $T_{stg}$ | Storage temperature range | -65 to +150 | °C |
| ESD Class(3) | HBM: human body model | H1B | |
| | MM: machine model | M2 | |
| | CDM: charged device model | C5 | |

1. Short-circuits from the output to $V_{CC}$+ can cause excessive heating and potential destruction. The maximum output current is approximately 20 mA independent of the magnitude of $V_{CC}$+.
2. Short-circuits can cause excessive heating and destructive dissipation. Values are typical.
3. ESD class definition from AEC-Q100:
HBM class H1B: ESD voltage level from 500 V to 1000 V
MM class M2: ESD voltage level from 100 V to 200 V
CDM class C5: ESD voltage level greater than 1500 V.

**Table 2. Operating conditions**

| Symbol | Parameter | Value | Unit |
|---|---|---|---|
| $V_{CC}$ | Supply voltage ($V_{CC}^+$ - $V_{CC}^-$) | 2 to 36 | V |
| $V_{icm}$ | Common mode input voltage range ($V_{CC}^+$= 30 V)(1)<br>$T_{amb}$ = +25 °C<br>$T_{min} \leq T_{amb} \leq T_{max}$ | <br>0 to $V_{CC}^+$ -1.5<br>0 to $V_{CC}^+$ -2 | V |
| $T_{oper}$ | Operating free-air temperature range<br>LM193, LM193A<br>LM293, LM293A<br>LM393, LM393A | <br>-55 to +125<br>-40 to +105<br>0 to +70 | °C |

1. The input common-mode voltage of either input signal voltage should not be allowed to go negative by more than 0.3 V. The high end of the common-mode voltage range is $V_{CC}^+$ -1.5 V, but either or both inputs can go to +30 V without damage.

# 4 Electrical characteristics

**Table 3. $V_{CC}^+$ = +5V, $V_{CC}^-$= 0V, $T_{amb}$ = +25 °C (unless otherwise specified)**

| Symbol | Parameter | LM193A - LM293A LM393A | | | LM193- LM293 LM393 | | | Unit |
|---|---|---|---|---|---|---|---|---|
| | | Min. | Typ. | Max. | Min | Typ. | Max. | |
| $V_{io}$ | Input offset voltage(1)<br>$T_{min} \le T_{amb} \le T_{max}$ | | 1 | 2<br>4 | | 1 | 5<br>9 | mV |
| $I_{io}$ | Input offset current<br>$T_{min} \le T_{amb} \le T_{max}$ | | 3 | 25<br>100 | | 3 | 50<br>150 | nA |
| $I_{ib}$ | Input bias current ($I^+$ or $I^-$)(2)<br>$T_{min} \le T_{amb} \le T_{max}$ | | 20 | 100<br>300 | | 20 | 250<br>400 | nA |
| $A_{vd}$ | Large signal voltage gain<br>$V_{CC}$ = 15 V, $R_L$ = 15 kΩ, $V_o$ = 1 V to 11 V | 50 | 200 | | 50 | 200 | | V/mV |
| $I_{CC}$ | Supply current (all comparators)<br>$V_{CC}$ = +5 V, no load<br>$V_{CC}$ = +30 V, no load | | <br>0.45<br>0.6 | <br>1<br>2.5 | | <br>0.45<br>0.6 | <br>1<br>2.5 | mA |
| $V_{id}$ | Differential input voltage(3) | | | $V_{CC}^+$ | | | $V_{CC}^+$ | |
| $V_{OL}$ | Low level output voltage<br>$V_{id}$ = -1 V, $I_{sink}$ = 4 mA<br>$T_{min} \le T_{amb} \le T_{max}$ | | 80 | 400<br>700 | | 80 | 400<br>700 | mV |
| $I_{OH}$ | High level output current<br>$V_{CC}$ = $V_o$ = 30 V, $V_{id}$ = 1 V<br>$T_{min} \le T_{amb} \le T_{max}$ | | 0.1 | <br>1 | | 0.1 | <br>1 | nA<br>µA |
| $I_{sink}$ | Output sink current $V_{id}$= 1 V, $V_o$ = 1.5 V | 6 | 18 | | 6 | 18 | | mA |
| $t_{re}$ | Response time (4)<br>$R_L$= 5.1 kΩ connected to $V_{CC}^+$ | | 1.3 | | | 1.3 | | µs |
| $t_{rel}$ | Large signal response time<br>$R_L$= 5.1 kΩ connected to $V_{CC}^+$<br>$e_I$ = TTL,$V_{(ref)}$ = +1.4 V | | 300 | | | 300 | | ns |

1. At output switch point, $V_o \approx$ 1.4 V, $R_s$ = 0 with $V_{CC}^+$ from 5 V to 30 V, and over the full common-mode range (0 V to $V_{CC}^+$ -1.5 V).
2. The direction of the input current is out of the IC due to the PNP input stage. This current is essentially constant, independent of the state of the output, so no loading charge exists on the reference of input lines.
3. Positive excursions of input voltage may exceed the power supply level. As long as the other voltage remains within the common-mode range, the comparator will provide a proper output state. The low input voltage state must not be less than -0.3 V (or 0.3 V below the negative power supply, if used).
4. The response time specified is for a 100 mV input step with 5 mV overdrive. For larger overdrive signals 300 ns can be obtained.

**Figure 3. Supply current vs. supply voltage**

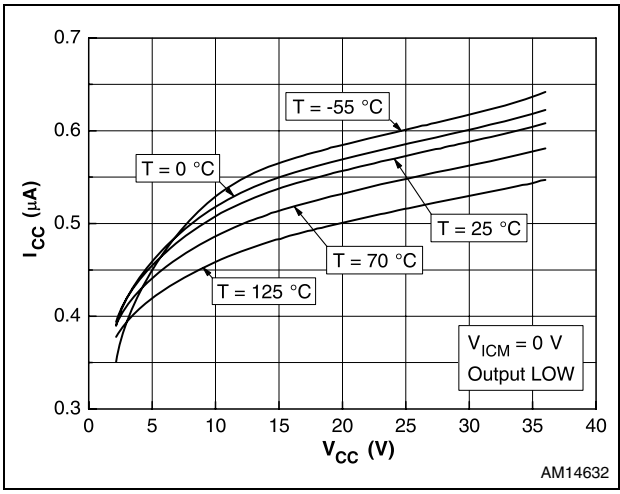



**Figure 4. Input current vs. supply voltage**

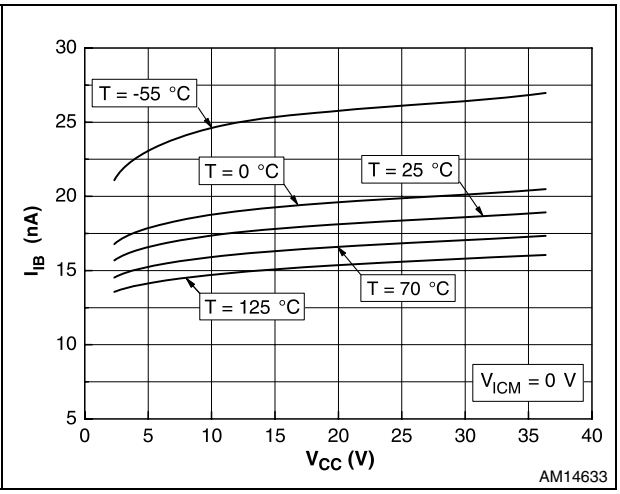



**Figure 5. Output saturation voltage vs. output current**

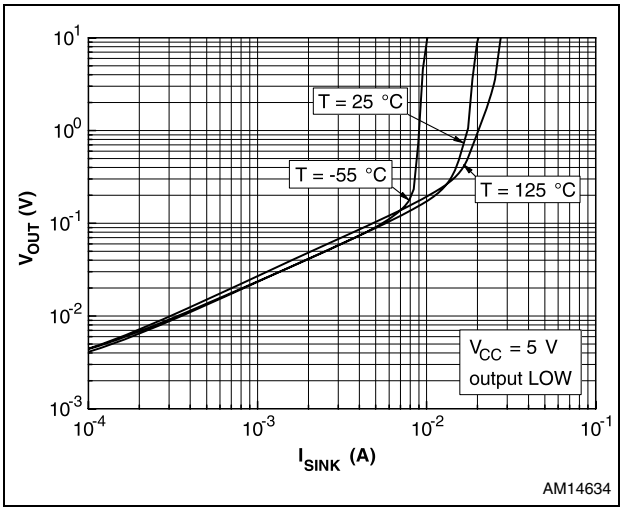



**Figure 6. Response time for various input overdrives - negative transition**

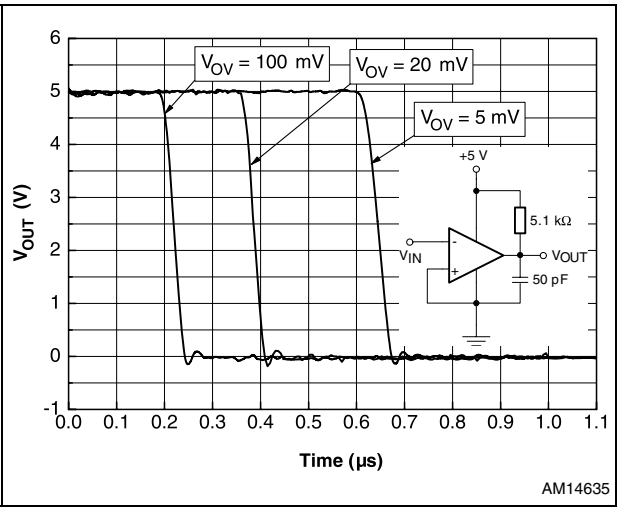
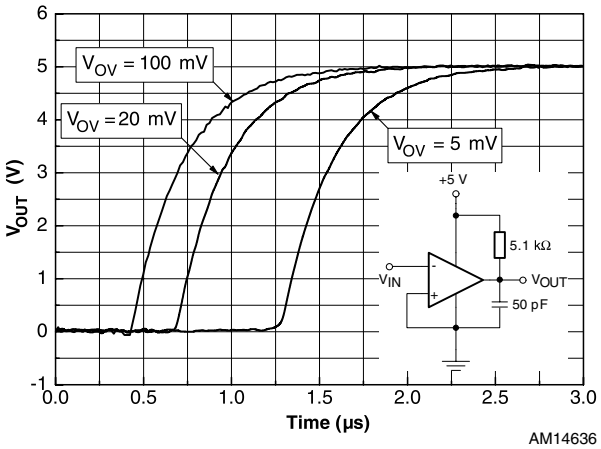



**Figure 7. Response time for various input overdrives - positive transition**



# 5 Typical applications

**Figure 8. Basic comparator**

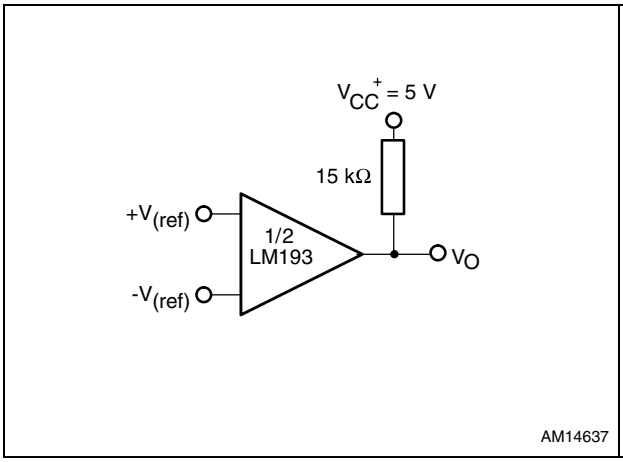



**Figure 9. Driving TTL**

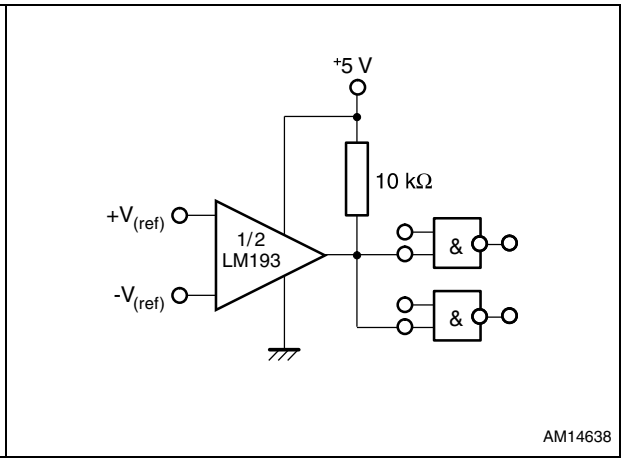



**Figure 10. Low frequency op amp**

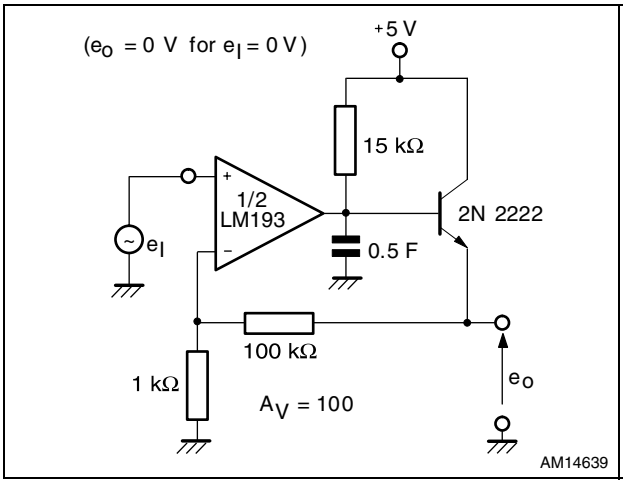



**Figure 11. Driving CMOS**

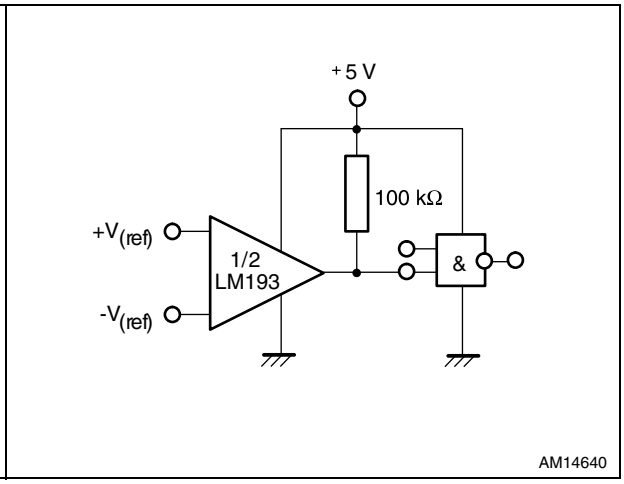



**Figure 12. Low frequency op amp**

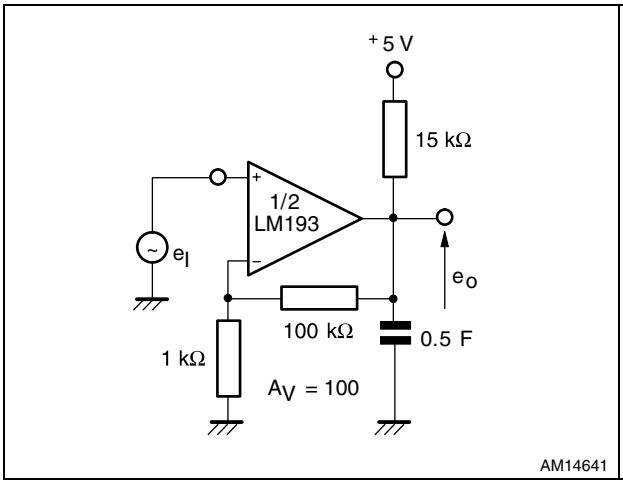



**Figure 13. Transducer amplifier**

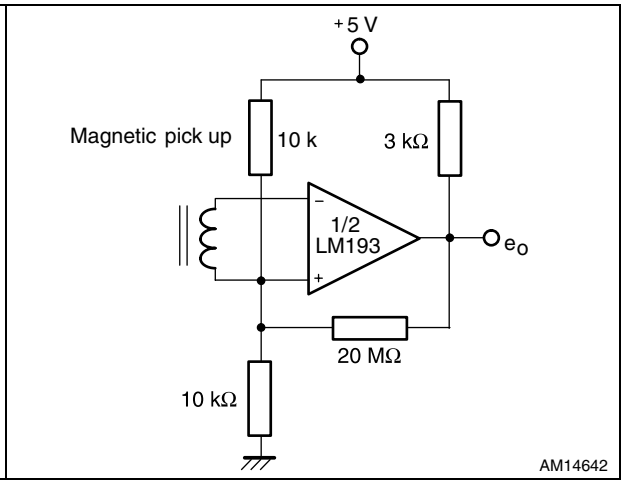


**Figure 14. Low frequency op amp with offset adjust**

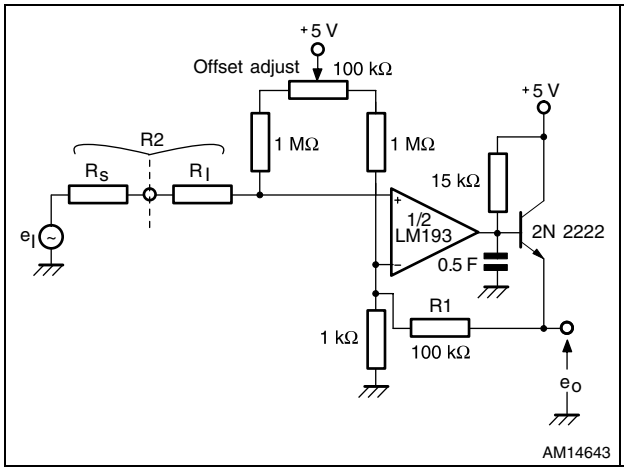



**Figure 15. Zero crossing detector (single power supply)**

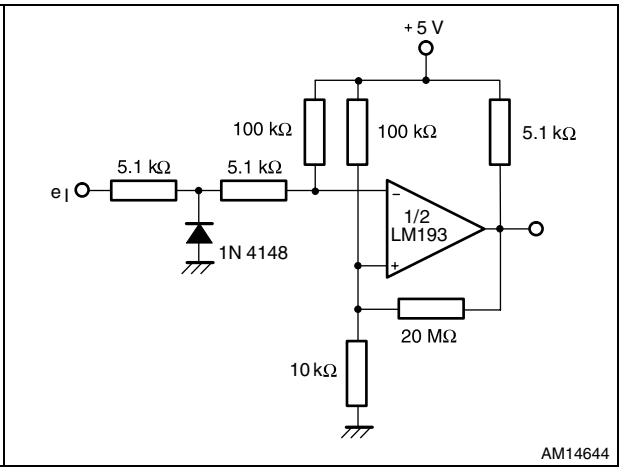



**Figure 16. Limit comparator**

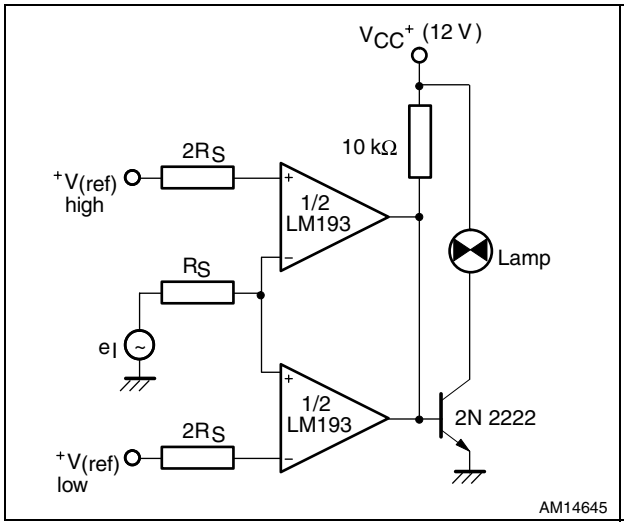



**Figure 17. Crystal controlled oscillator**

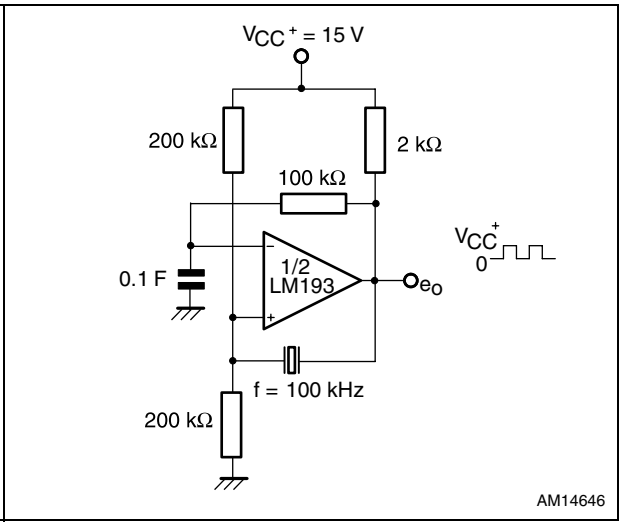



**Figure 18. Split-supply applications - zero crossing detector**

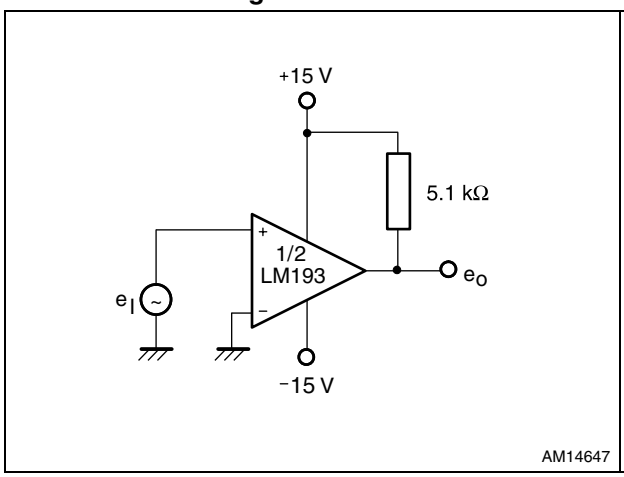



**Figure 19. Comparator with a negative reference**

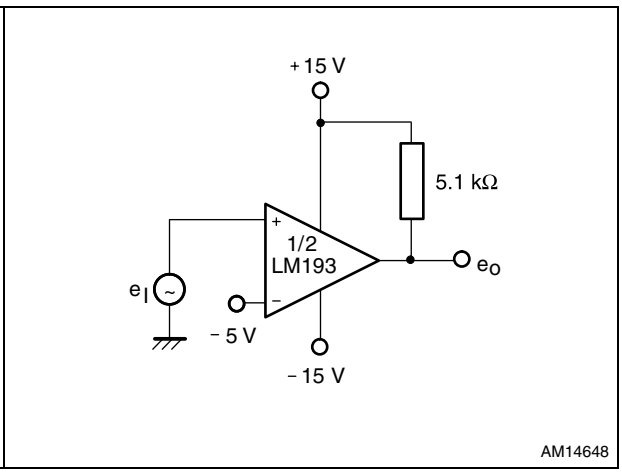
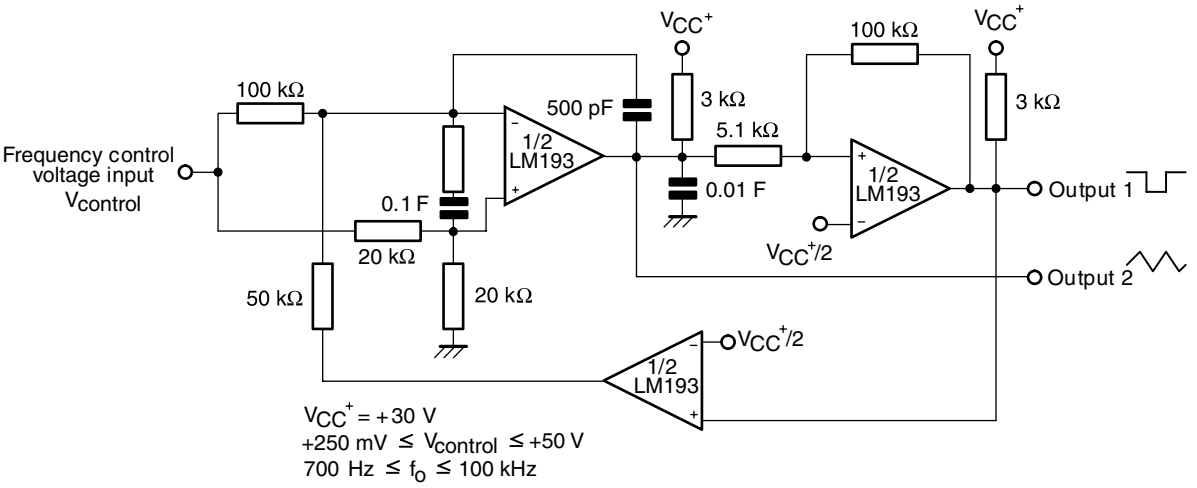


**Figure 20. Two-decade high frequency VCO**



# 6 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.

## 6.1 DIP8 package information

**Figure 21. DIP8 package outline**

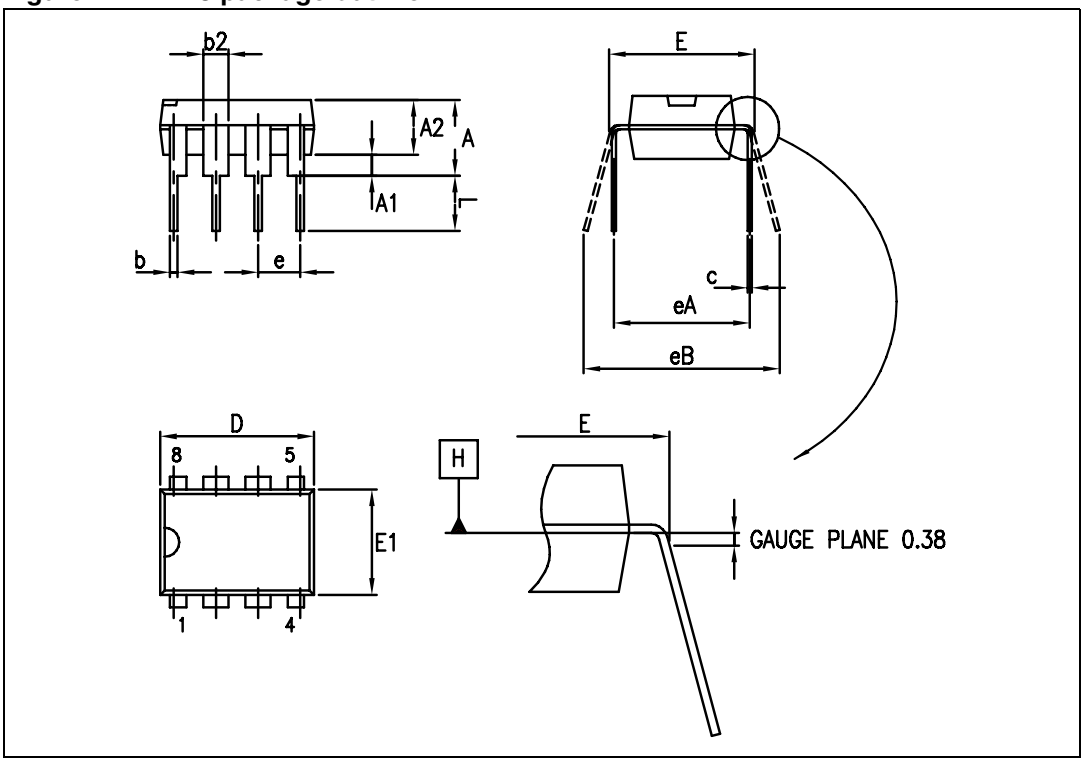



**Table 4. DIP8 package mechanical data**

| Symbol | Dimensions | | | | | |
|---|---|---|---|---|---|---|
| | Millimeters | | | Inches | | |
| | Min. | Typ. | Max. | Min. | Typ. | Max. |
| A | | | 5.33 | | | 0.210 |
| A1 | 0.38 | | | 0.015 | | |
| A2 | 2.92 | 3.30 | 4.95 | 0.115 | 0.130 | 0.195 |
| b | 0.36 | 0.46 | 0.56 | 0.014 | 0.018 | 0.022 |
| b2 | 1.14 | 1.52 | 1.78 | 0.045 | 0.060 | 0.070 |
| c | 0.20 | 0.25 | 0.36 | 0.008 | 0.010 | 0.014 |
| D | 9.02 | 9.27 | 10.16 | 0.355 | 0.365 | 0.400 |
| E | 7.62 | 7.87 | 8.26 | 0.300 | 0.310 | 0.325 |
| E1 | 6.10 | 6.35 | 7.11 | 0.240 | 0.250 | 0.280 |
| e | | 2.54 | | | 0.100 | |
| eA | | 7.62 | | | 0.300 | |
| eB | | | 10.92 | | | 0.430 |
| L | 2.92 | 3.30 | 3.81 | 0.115 | 0.130 | 0.150 |

## 6.2 SO-8 package information

**Figure 22. SO-8 package outline**

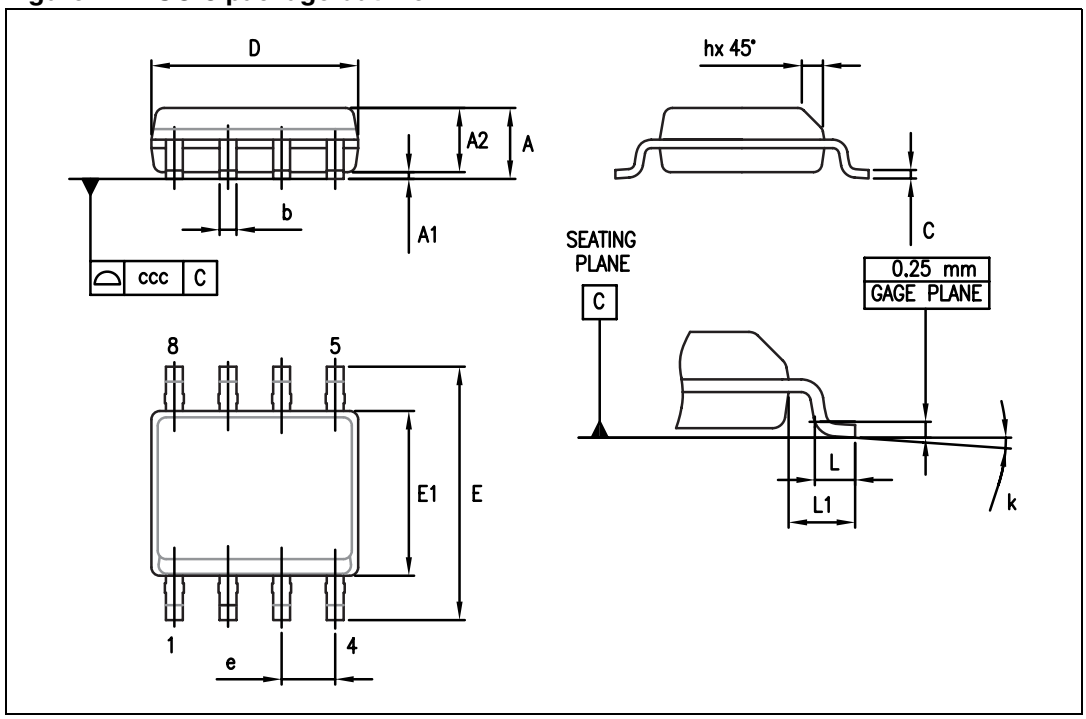



**Table 5. SO-8 package mechanical data**

| Symbol | 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 |

## 6.3 TSSOP8 package information

**Figure 23. TSSOP8 package outline**

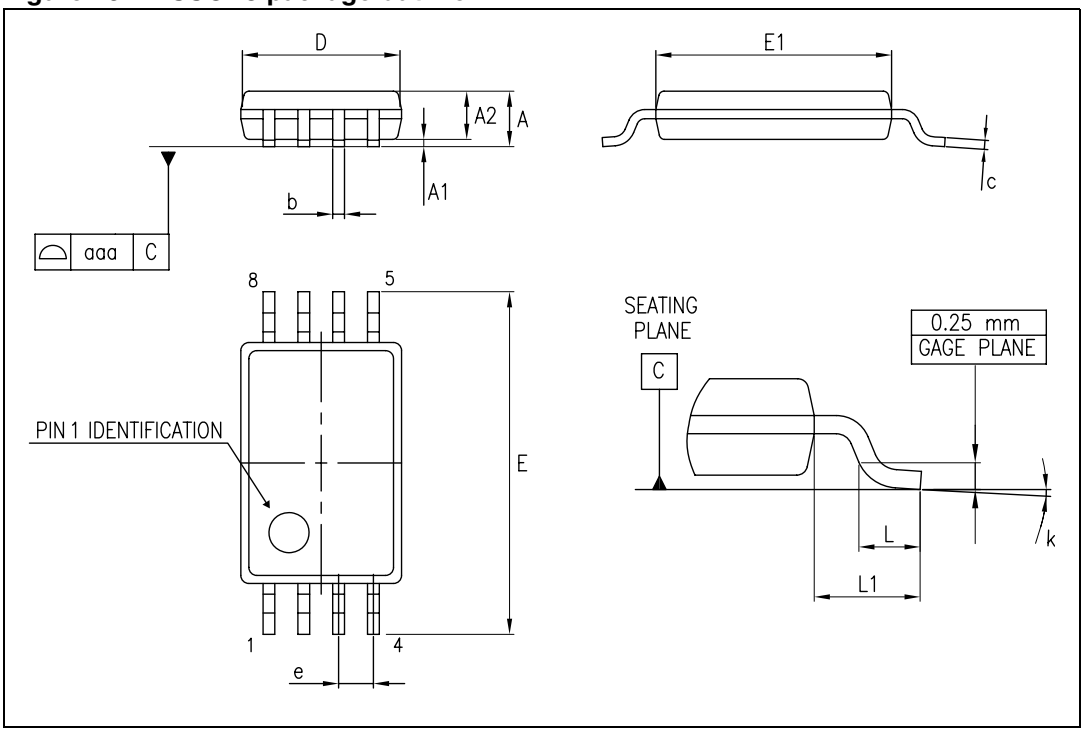



**Table 6. TSSOP8 package mechanical data**

| Symbol | 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 |

## 6.4 MiniSO-8 package information

**Figure 24. MiniSO-8 package outline**

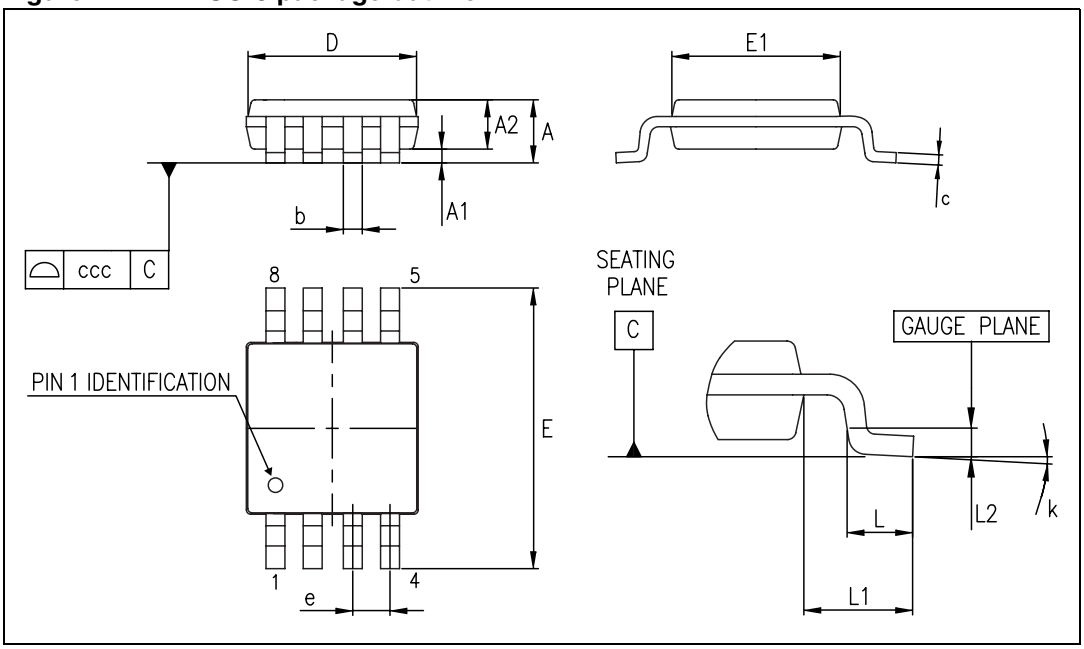



**Table 7. MiniSO-8 package mechanical data**

| Symbol | Dimensions | | | | | |
|---|---|---|---|---|---|---|
| | Millimeters | | | Inches | | |
| | Min. | Typ. | Max. | Min. | Typ. | Max. |
| A | | | 1.1 | | | 0.043 |
| A1 | 0 | | 0.15 | 0 | | 0.006 |
| A2 | 0.75 | 0.85 | 0.95 | 0.030 | 0.033 | 0.037 |
| b | 0.22 | | 0.40 | 0.009 | | 0.016 |
| c | 0.08 | | 0.23 | 0.003 | | 0.009 |
| D | 2.80 | 3.00 | 3.20 | 0.11 | 0.118 | 0.126 |
| E | 4.65 | 4.90 | 5.15 | 0.183 | 0.193 | 0.203 |
| E1 | 2.80 | 3.00 | 3.10 | 0.11 | 0.118 | 0.122 |
| e | | 0.65 | | | 0.026 | |
| L | 0.40 | 0.60 | 0.80 | 0.016 | 0.024 | 0.031 |
| L1 | | 0.95 | | | 0.037 | |
| L2 | | 0.25 | | | 0.010 | |
| k | 0° | | 8° | 0° | | 8° |
| ccc | | | 0.10 | | | 0.004 |

## 6.5 DFN8 package information

**Figure 25. DFN8 2 x 2 x 0.6 mm package outline (pitch 0.5 mm)**

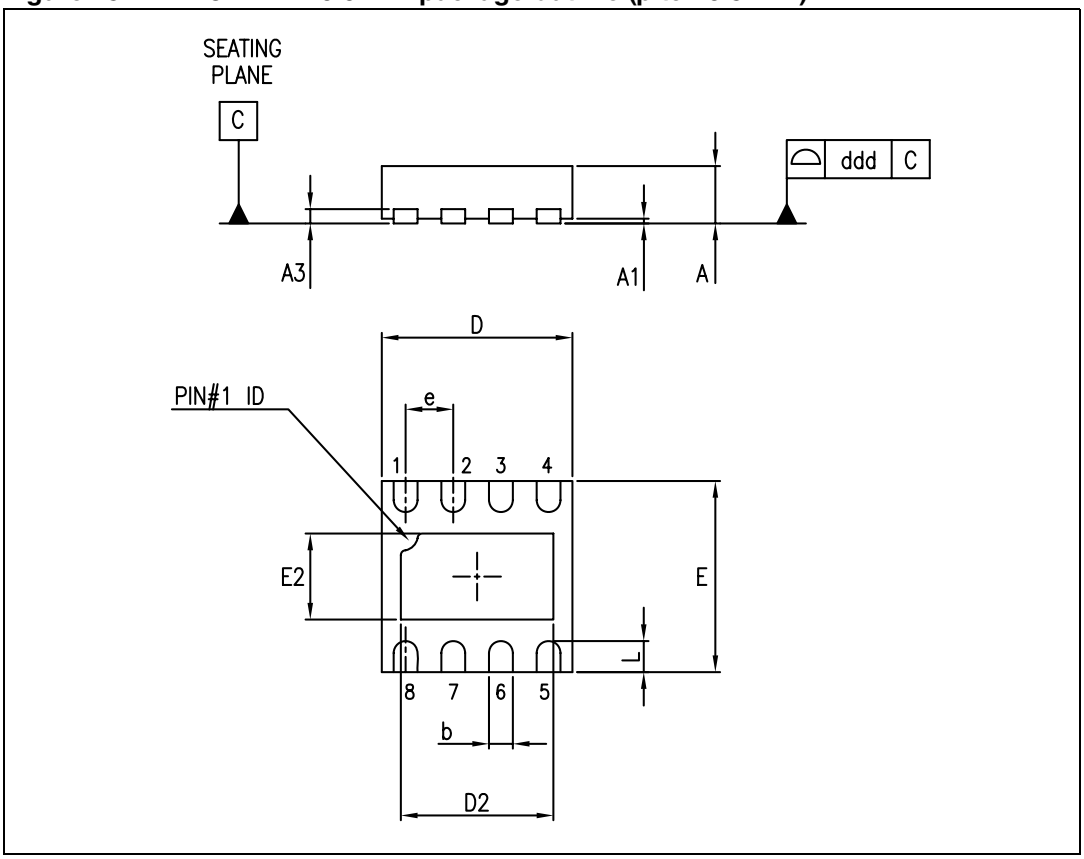
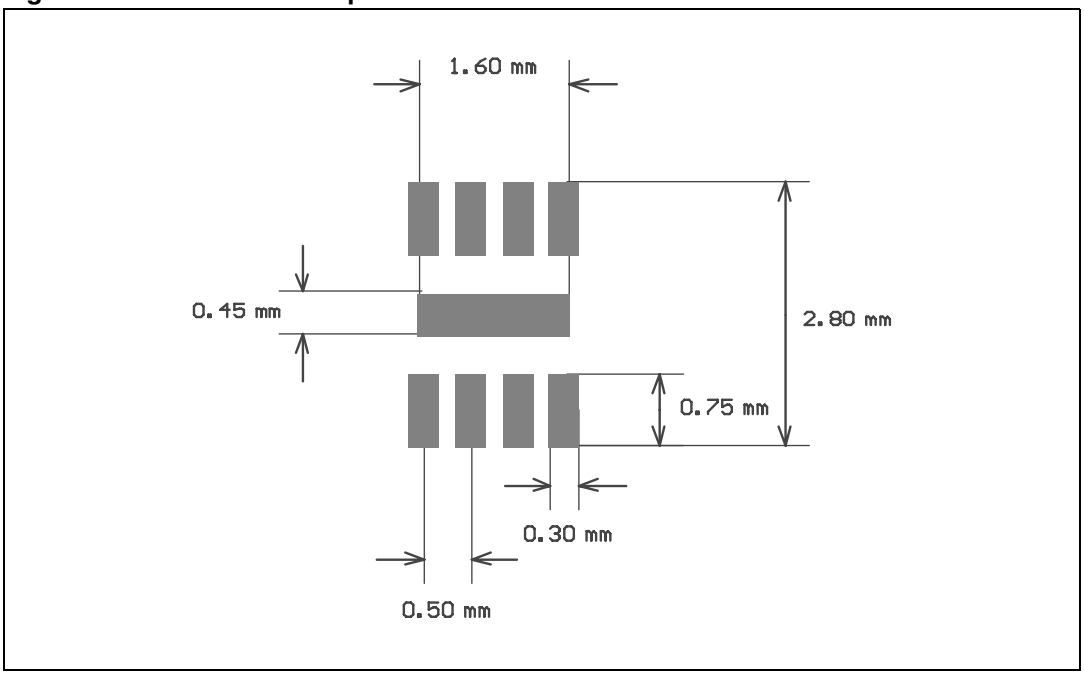



**Table 8. DFN8 2 x 2 x 0.6 mm package mechanical data (pitch 0.5 mm)**

| Symbol | Dimensions | | | | | |
|---|---|---|---|---|---|---|
| | Millimeters | | | Inches | | |
| | Min. | Typ. | Max. | Min. | Typ. | Max. |
| A | 0.51 | 0.55 | 0.60 | 0.020 | 0.022 | 0.024 |
| A1 | | | 0.05 | | | 0.002 |
| A3 | | 0.15 | | | 0.006 | |
| b | 0.18 | 0.25 | 0.30 | 0.007 | 0.010 | 0.012 |
| D | 1.85 | 2.00 | 2.15 | 0.073 | 0.079 | 0.085 |
| D2 | 1.45 | 1.60 | 1.70 | 0.057 | 0.063 | 0.067 |
| E | 1.85 | 2.00 | 2.15 | 0.073 | 0.079 | 0.085 |
| E2 | 0.75 | 0.90 | 1.00 | 0.030 | 0.035 | 0.039 |
| e | | 0.50 | | | 0.020 | |
| L | | | 0.50 | | | 0.020 |
| ddd | | | 0.08 | | | 0.003 |

**Figure 26. DFN8 2 x 2 footprint recommendation**



# 7 Ordering information

**Table 9. Order codes**

| Order code | Temperature range | Package | Packing | Marking |
|---|---|---|---|---|
| LM193AD<br>LM193ADT | -55 °C, +125 °C | SO-8 | Tube or<br>tape and reel | 193A |
| LM193D<br>LM193DT | | | | 193 |
| LM193AN | | DIP8 | Tube | LM193AN |
| LM193N | | | | LM193N |
| LM293AD<br>LM293ADT | -40 °C, +105 °C | SO-8 | Tube or<br>tape and reel | 293A |
| LM293D<br>LM293DT | | | | 293 |
| LM293AN | | DIP8 | Tube | LM293AN |
| LM293N | | | | LM293N |
| LM293PT | | TSSOP8 | Tape and reel | 293 |
| LM293ST | | MiniSO-8 | Tape and reel | K512 |
| LM293QT | | DFN8 2 x 2 | Tape and reel | K59 |
| LM393AD<br>LM393ADT | 0 °C, +70 °C | SO-8 | Tube or<br>tape and reel | 393A |
| LM393D<br>LM393DT | | | | 393 |
| LM393AN | | DIP8 | Tube | LM393AN |
| LM393N | | | | LM393N |
| LM393PT | | TSSOP8 | Tape and reel | 393 |
| LM393ST | | MiniSO-8 | Tape and reel | M393 |
| LM393QT | | DFN8 2 x 2 | Tape and reel | K5C |

# 8 Revision history

**Table 10. Document revision history**

| Date | Revision | Changes |
|---|---|---|
| 02-Jul-2002 | 1 | First release. |
| 02-Jan-2005 | 2 | Class A of the product included in the datasheet. |
| 02-May-2005 | 3 | PPAP references inserted in the datasheet, see *Table 7: Ordering information on page 18*. |
| 02-Jul-2005 | 4 | Modification on PPAP references - Errors on part numbers, see *Table 7: Ordering information on page 18*. |
| 22-Nov-2005 | 5 | Modification on *Table 3 on page 6*. LM293,A must be -40/+105°C instead of -40/+125°C. |
| 16-Feb-2006 | 6 | Unit error for $V_{ol}$ parameter see *Table 3 on page 6*. |
| 23-Aug-2007 | 7 | Corrected error in DIP8 package information related to lead thickness, see *Figure 21 on page 12*.<br>Added values for $R_{thja}$ and $R_{thjc}$, and ESD parameters in *Table 1: Absolute maximum ratings*. |
| 08-Nov-2007 | 8 | Updated MiniSO-8 package information.<br>Reformatted package information.<br>Added automotive grade order codes. |
| 19-Feb-2008 | 9 | Corrected error in SO-8 package mechanical data: E dimension in drawing was marked with an F in table. |
| 15-Dec-2008 | 10 | Corrected heading in *Figure 5*. |
| 22-Feb-2010 | 11 | Deleted automotive grade order codes for LM293 and LM393. |
| 22-Jun-2011 | 12 | Updated typical performance curves.<br>Updated typical values on*Table 3 on page 6*.<br>Updated ESD parameters with ESD classes in *Table 1: Absolute maximum ratings*.<br>Added DFN8 2x2mm package mechanical drawing.<br>Added DFN8 2x2mm recommended footprint.<br>Added DFN8 2x2mm order codes in *Table 9*. |
| 27-Jun-2012 | 13 | Updated *Features* (added package information), *Description* (added RPNs), *Figure 1: Pin connections (top view)* moved to page 3, added *Contents*, updated marking of the LM293QT device in *Table 9*, minor text corrections throughout document. |
| 18-Jan-2013 | 14 | Updated *Table 8* (added dimensions in inches). |

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