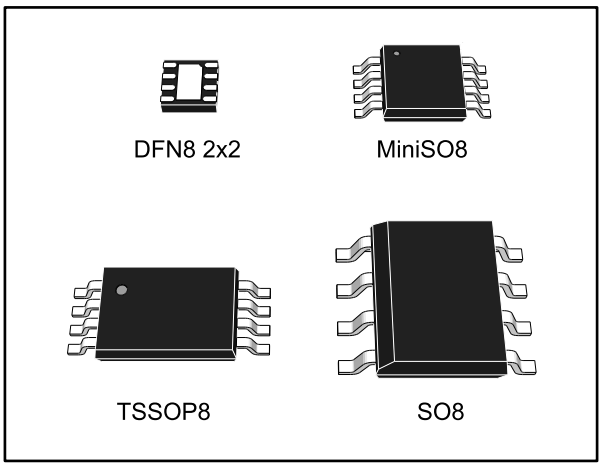
# LM193, LM293, LM393

## 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 DFN8 2x2, MiniSO8, TSSOP8, and SO8 packages

## Description

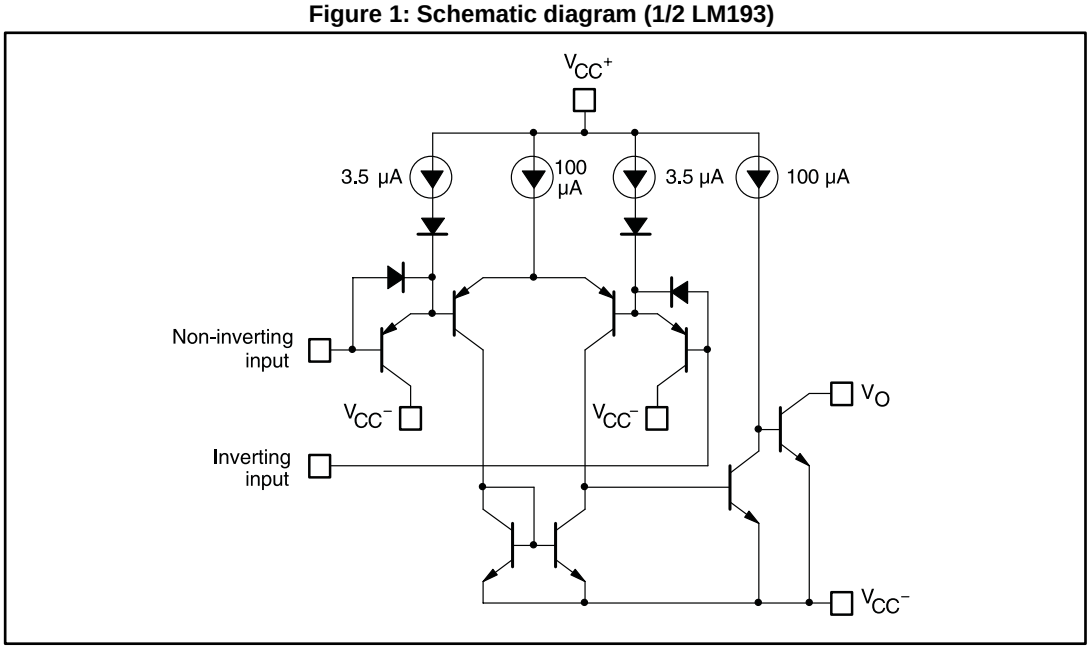
The LM193, LM293, and LM393 devices consist of two independent low voltage comparators designed specifically to operate from a single supply over a wide range of voltages. Operation from split power supplies is also possible.

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.

# Contents

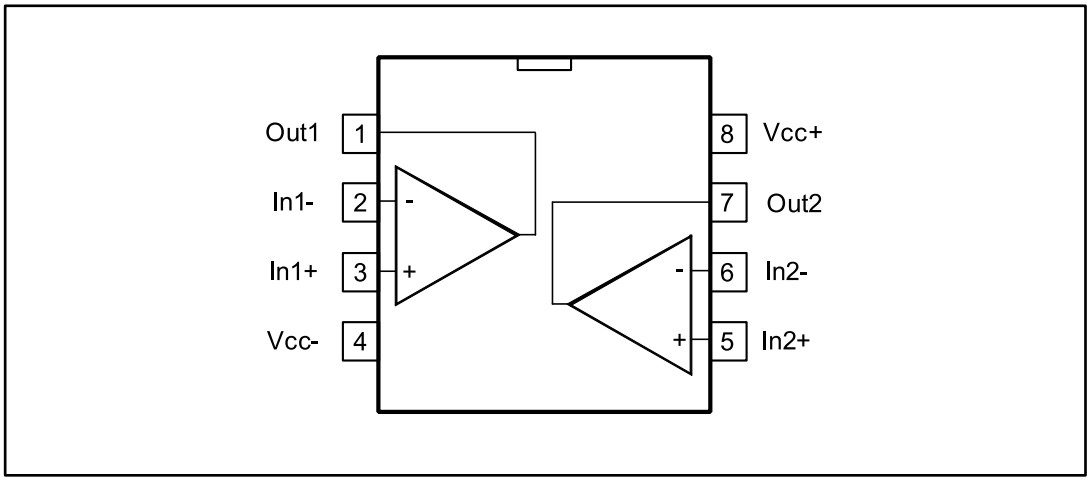
# 1 Schematic diagram

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



# 2 Package pin connections

**Figure 2: Pin connections (top view)**




1. The exposed pad of the DFN8 2x2 can be left floating or connected to ground

# 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 | |
| $V_{in}$ | Input voltage | | -0.3 to 36 | |
| | Output short-circuit to ground (1) | | Infinite | |
| $R_{thja}$ | Thermal resistance junction to ambient (2) | DFN8 2x2 | 57 | °C/W |
| | | MiniSO8 | 190 | |
| | | TSSOP8 | 120 | |
| | | SO8 | 125 | |
| $R_{thjc}$ | Thermal resistance junction to case (2) | DFN8 2x2 | — | |
| | | MiniSO8 | 39 | |
| | | TSSOP8 | 37 | |
| | | SO8 | 40 | |
| $T_j$ | Maximum junction temperature | | 150 | °C |
| $T_{stg}$ | Storage temperature range | | -65 to 150 | |
| ESD class (3) | HBM: human body model (4) | | H1B | |
| | MM: machine model (5) | | M2 | |
| | CDM: charged device model (6) | | C5 | |

**Notes:**

(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:

(4)HBM class H1B: ESD voltage level from 500 V to 1000 V

(5)MM class M2: ESD voltage level from 100 V to 200 V

(6)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) | $T_{amb}$ = 25 °C | 0 to ($V_{CC}^+$) - 1.5 | |
| | | $T_{min} \leq T_{amb} \leq T_{max}$ | 0 to ($V_{CC}^+$) - 2 | |
| $T_{oper}$ | Operating free-air temperature range | LM193, LM193A | -55 to 125 | °C |
| | | LM293, LM293A | -40 to 105 | |
| | | LM393, LM393A | 0 to 70 | |

**Notes:**

(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: VCC+ = 5 V, VCC- = 0 V, Tamb = 25 °C (unless otherwise specified)**

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

**Notes:**

(1)At output switch point, $V_o$ = 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.

# 5 Electrical characteristic curves

Figure 3: Supply current vs. supply voltage

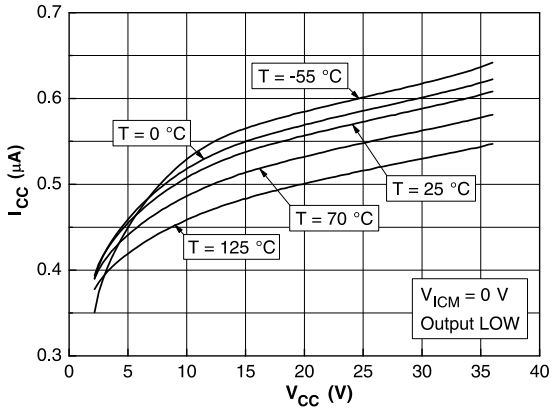



Figure 4: Input current vs. supply voltage

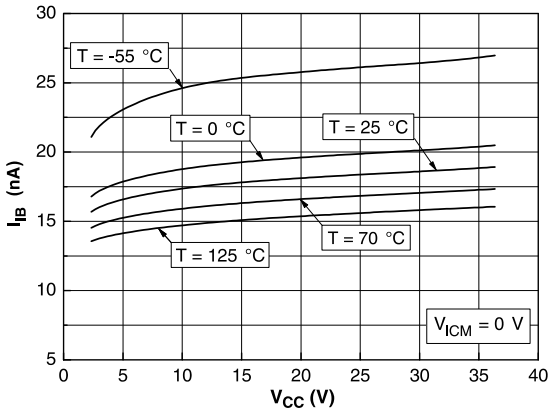



Figure 5: Output saturation voltage vs. output current

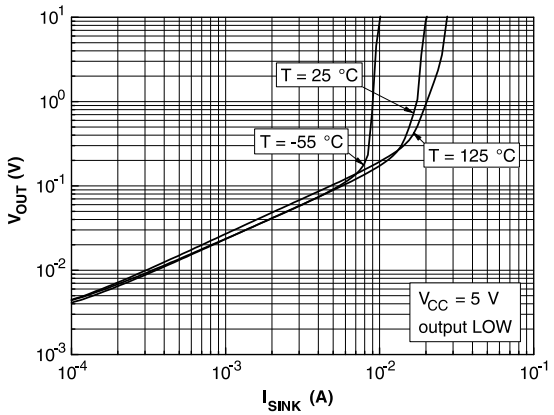



Figure 6: Response time for various input overdrives - negative transition

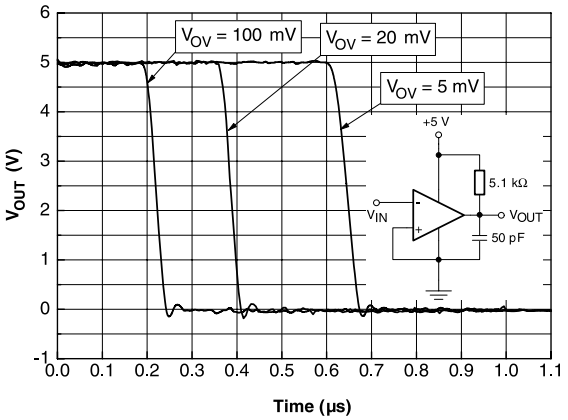
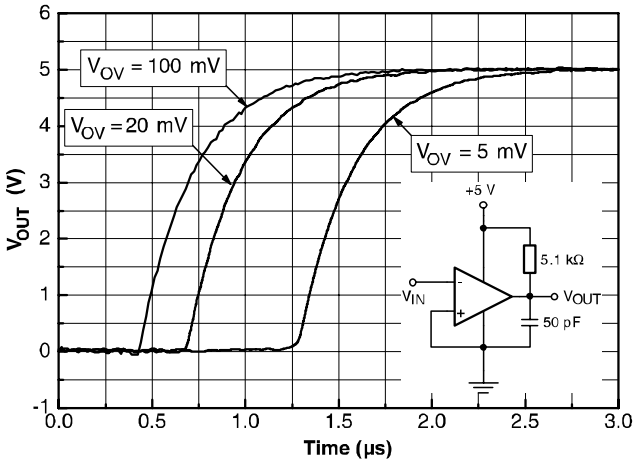



Figure 7: Response time for various input overdrives - positive transition



# 6 Typical applications

Figure 8: Basic comparator

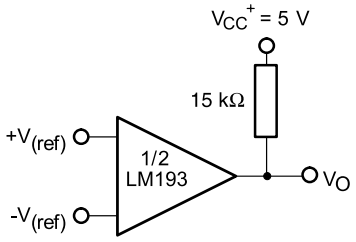



Figure 9: Driving TTL

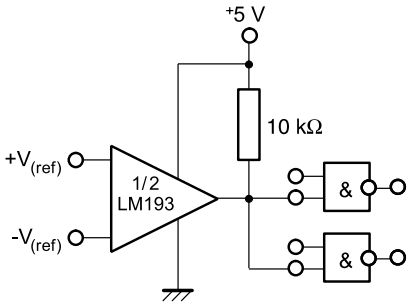



Figure 10: Low-frequency op amp (1)

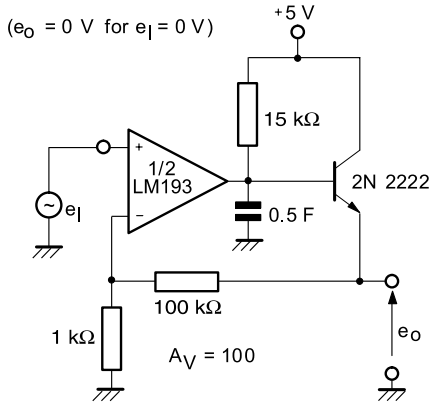



Figure 11: Driving CMOS

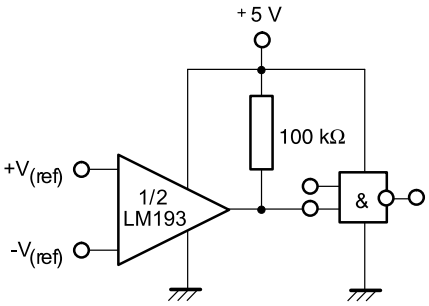



Figure 12: Low-frequency op amp (2)

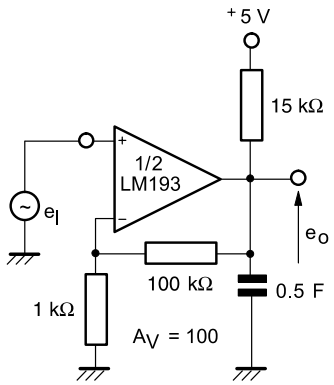



Figure 13: Transducer amplifier

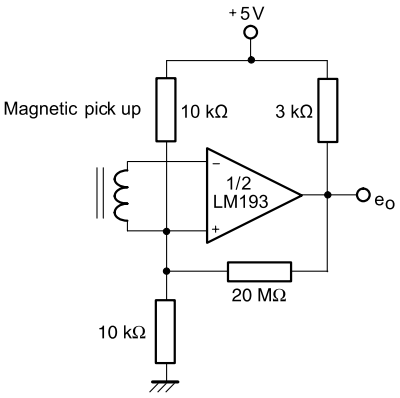


Figure 14: Low-frequency op amp with offset adjust

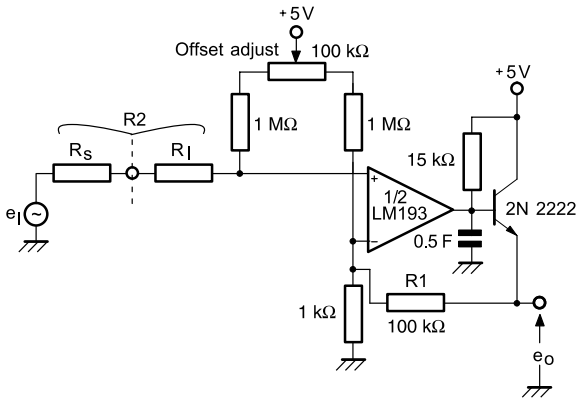



Figure 15: Zero crossing detector (single power supply)

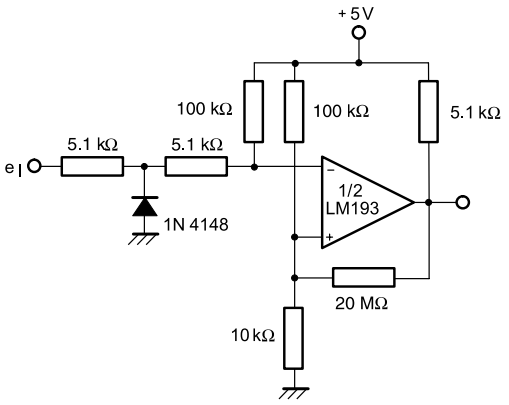



Figure 16: Limit comparator

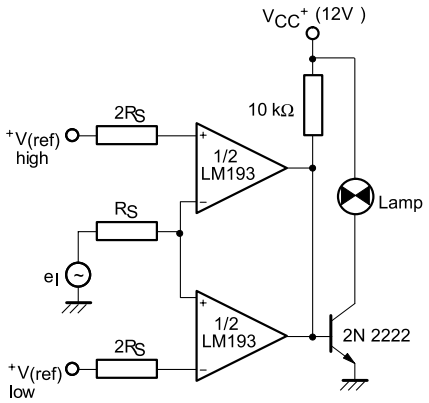



Figure 17: Crystal controlled comparator

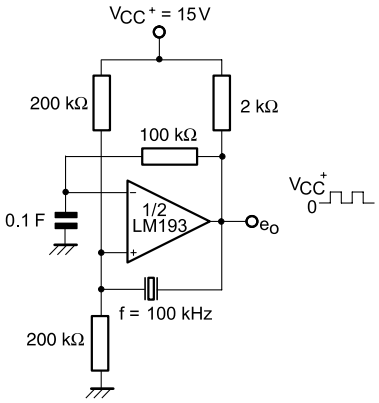



Figure 18: Split supply applications (zero crossing detector)

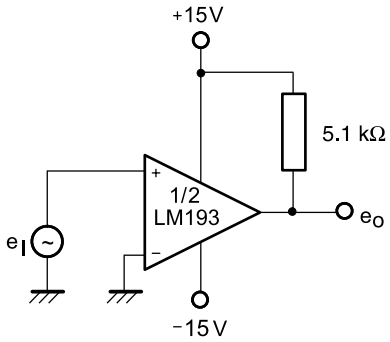



Figure 19: Comparator with a negative reference

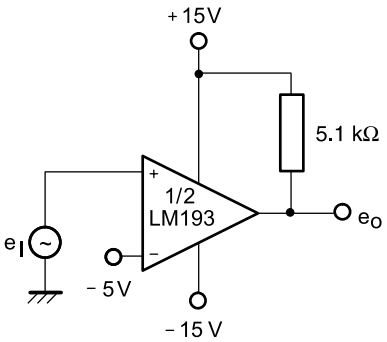
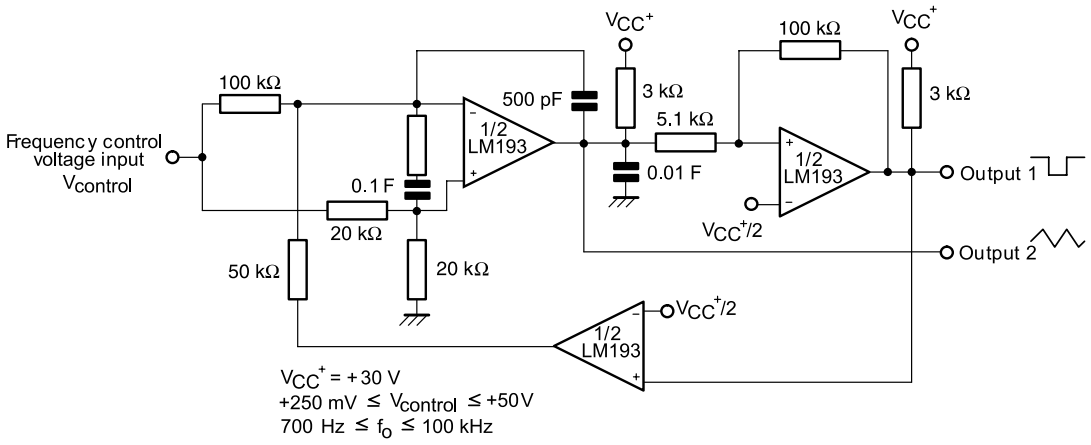


Figure 20: Two-decade, high-frequency VCO



# 7 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.

## 7.1 DFN8 2x2 package information

**Figure 21: DFN8 2x2 package outline**

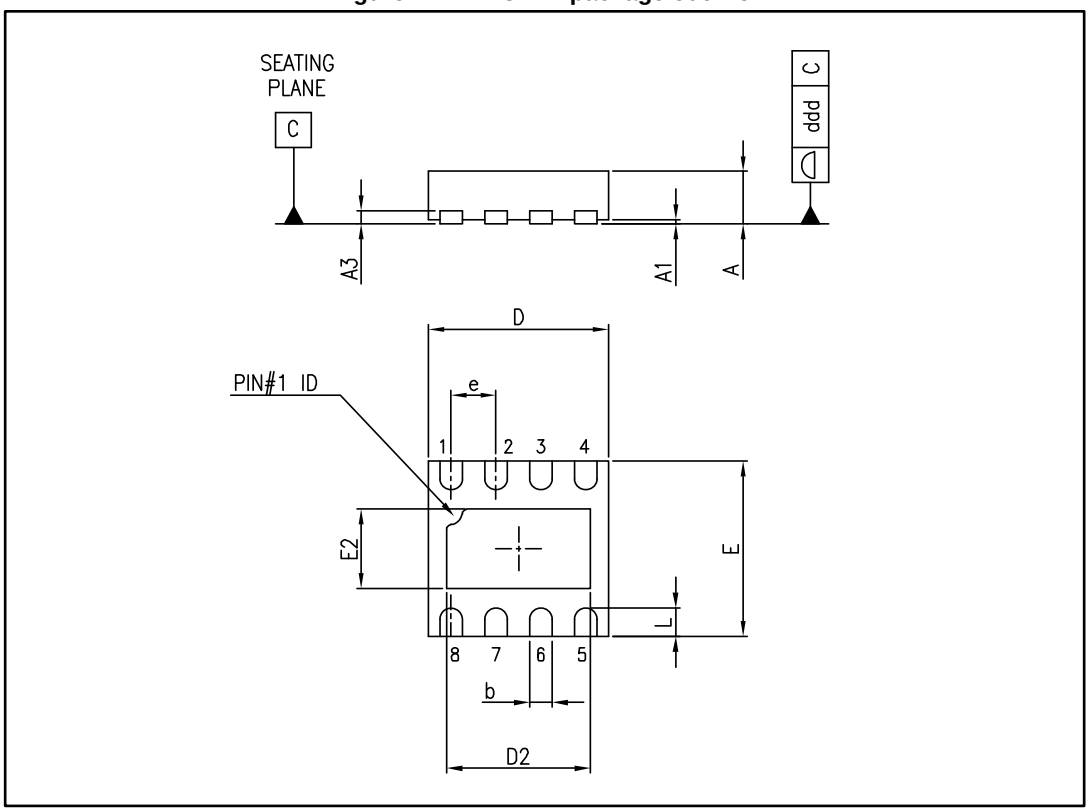
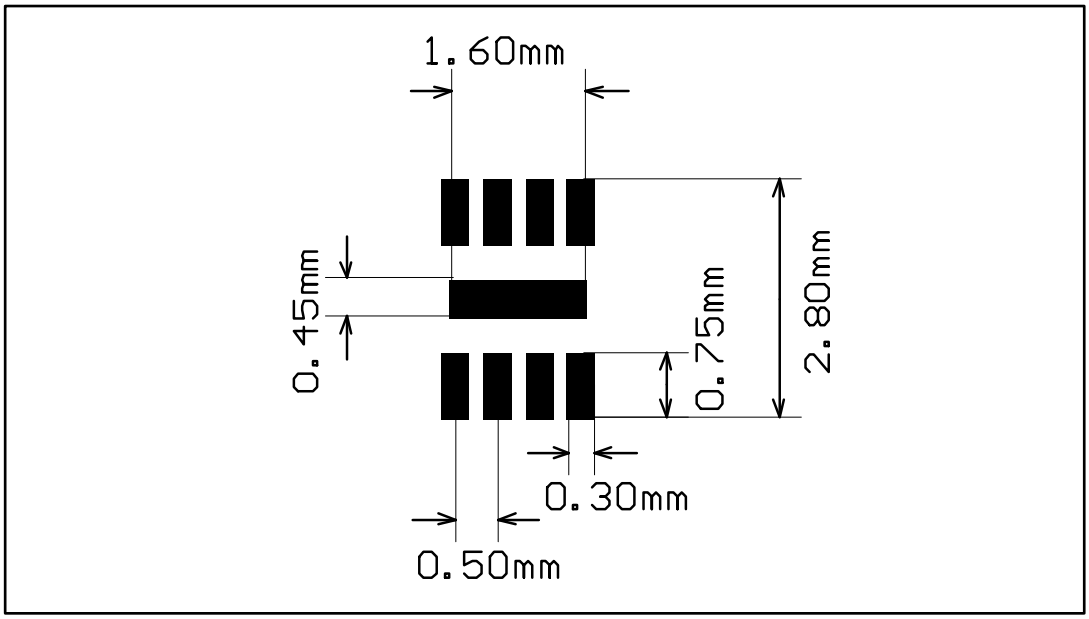



**Table 4: DFN8 2x2 mechanical data**

| Ref. | 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 | | | 0.425 | | | 0.017 |
| ddd | | | 0.08 | | | 0.003 |

**Figure 22: DFN8 2x2 recommended footprint**



## 7.2 MiniSO8 package information

**Figure 23: MiniSO8 package outline**

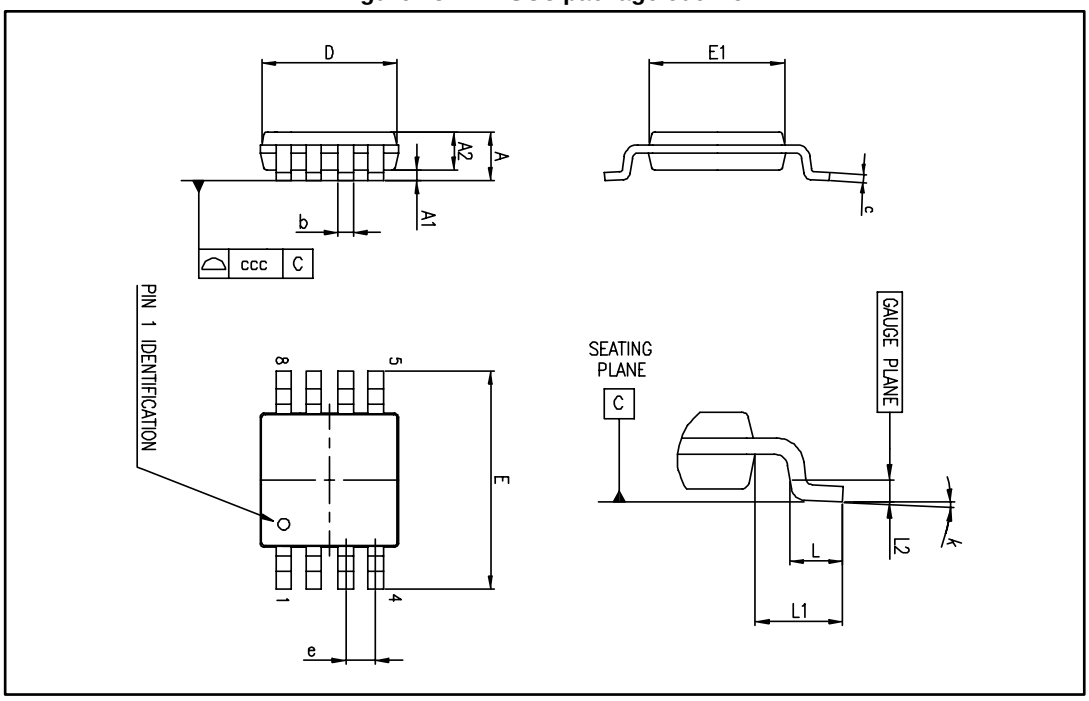



**Table 5: MiniSO8 mechanical data**

| Ref. | 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 |

## 7.3 TSSOP8 package information

**Figure 24: TSSOP8 package outline**

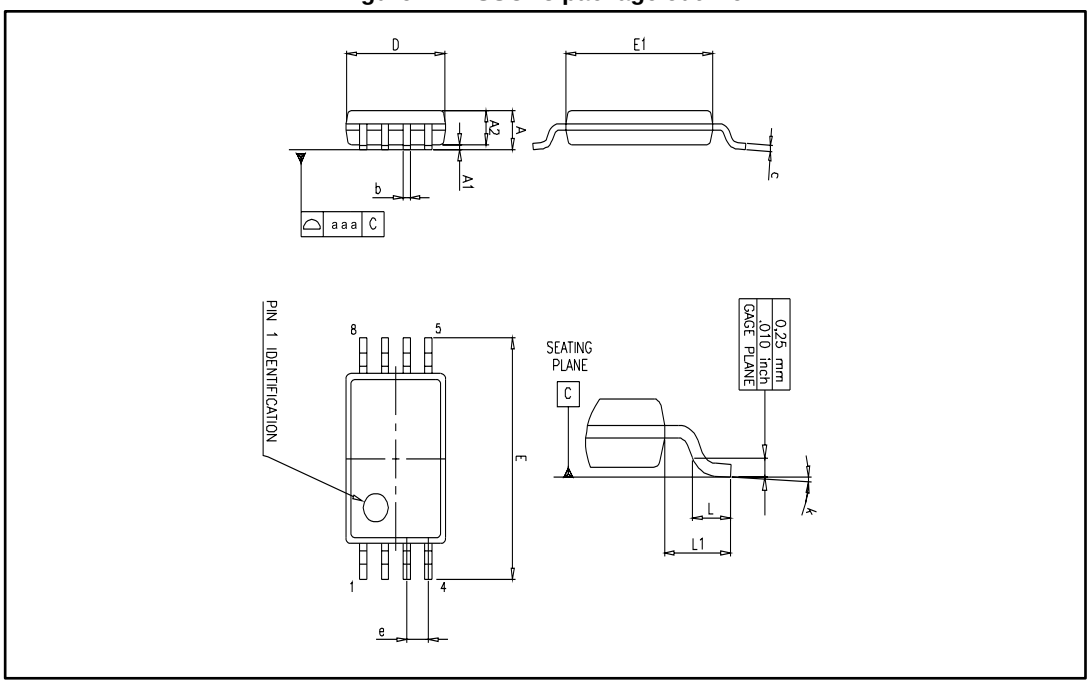



**Table 6: TSSOP8 mechanical data**

| Ref. | Dimensions | | | | | |
|---|---|---|---|---|---|---|
| | Millimeters | | | Inches | | |
| | Min. | Typ. | Max. | Min. | Typ. | Max. |
| A | | | 1.2 | | | 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 | | 0.1 | | | 0.004 | |

## 7.4 SO8 package information

**Figure 25: SO8 package outline**

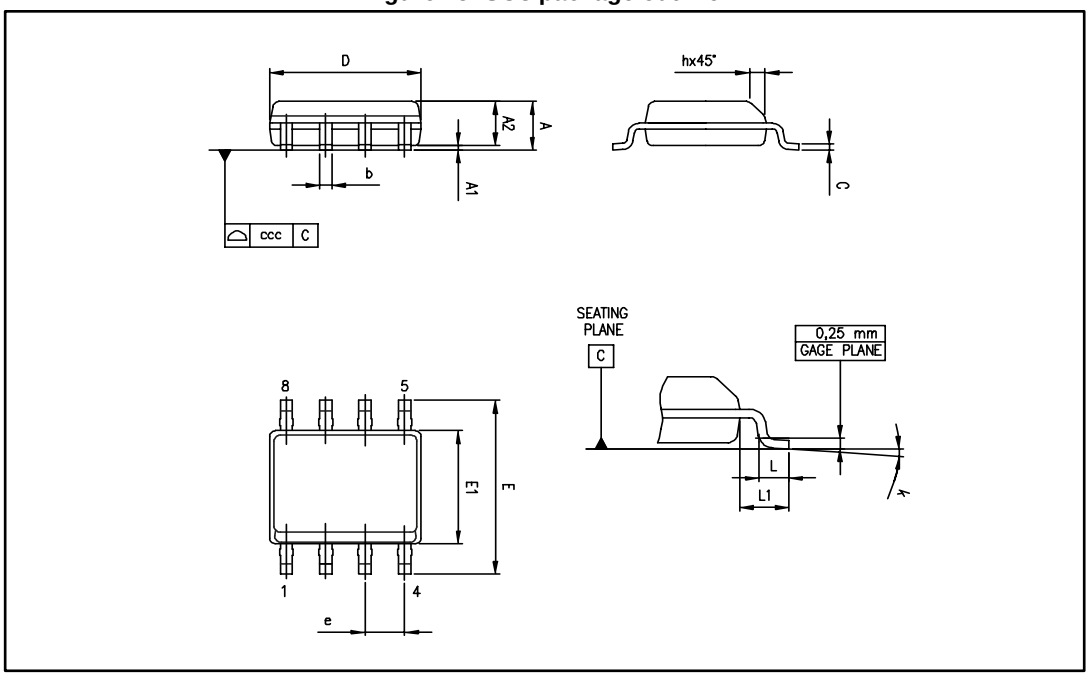



**Table 7: SO8 mechanical data**

| 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 | 1° | | 8° | 1° | | 8° |
| ccc | | | 0.10 | | | 0.004 |

# 8 Ordering information

**Table 8: Order codes**

| Order code | Temperature range | Package | Packing | Marking |
|---|---|---|---|---|
| LM193ADT (1) | -55 °C to 125 °C | SO8 | Tube or tape and reel | 193A |
| LM193DT | | | | 193 |
| LM293ADT | -40 °C to 105 °C | | | 293A |
| LM293D | | | | 293 |
| LM293DT | | | | |
| LM293PT | | TSSOP8 | Tape and reel | |
| LM293ST | | MiniSO8 | | K512 |
| LM293QT | | DFN8 2x2 | | K59 |
| LM393ADT | 0 °C to 70 °C | SO8 | Tube or tape and reel | 393A |
| LM393D | | | | 393 |
| LM393DT | | | | |
| LM393PT | | TSSOP8 | Tape and reel | |
| LM393ST | | MiniSO8 | | M393 |
| LM393QT | | DFN8 2x2 | | K5B |

**Notes:**

(1)Not recommended for new design (NRND)

# 9 Revision history

**Table 9: 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). |

| Date | Revision | Changes |
|---|---|---|
| 09-Feb-2016 | 15 | Updated document layout<br>Removed DIP8 package<br>*Features*: removed “plastic micropackage” from the DFN8 2x2, MiniSO8, and SO8 silhouettes; removed “thin shrink small outline package” from the TSSOP8 silhouette.<br>*Figure 2*: added footnote about the exposed pad of the DFN8 2x2<br>*Table 4*: updated “L” value<br>*Table 6*: “aaa” value is a typ. value not a max. value<br>*Table 7*: updated min. “k” millimeters value<br>*Table 8*: removed following obsolete order codes: LM193AD, LM193D, LM193AN, LM193N, LM293AD, LM293AN, LM293N, LM393AD, LM393AN, LM393N; added footnote (not recommended for new design) to order code LM193ADT; replaced marking of LM393QT with “K5B” instead of “K5C”. |

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