

## Low power dual voltage comparators

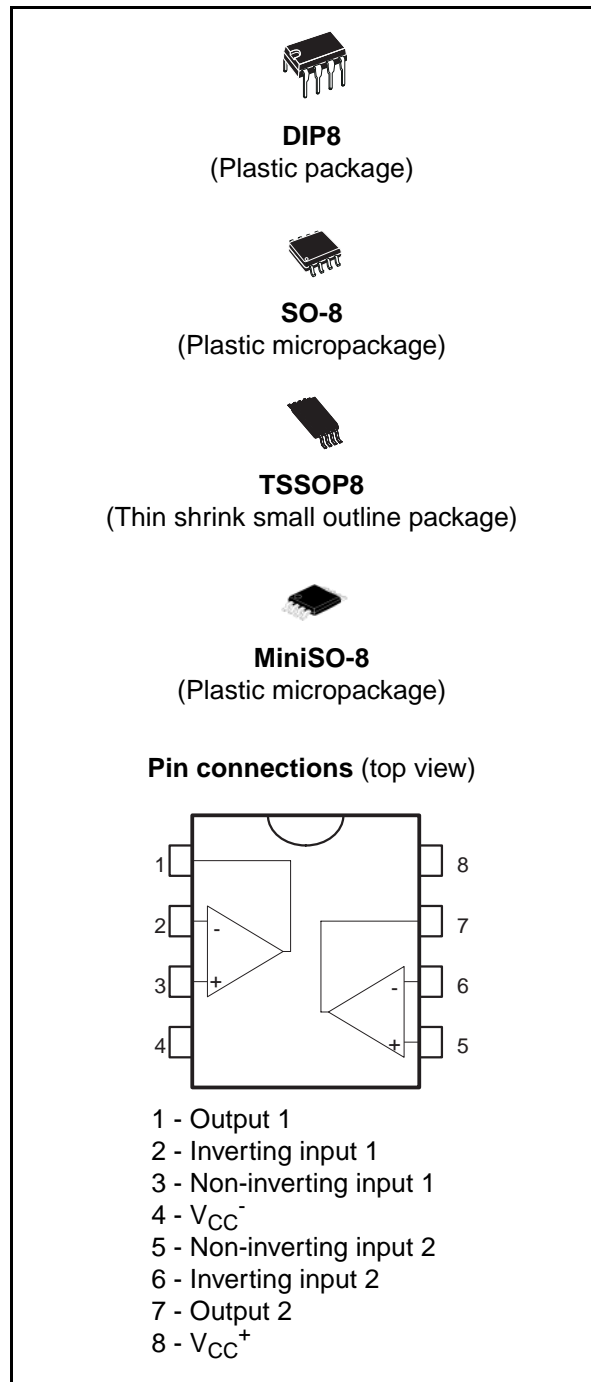
### Features

- Wide single-supply voltage range or dual supplies: +2 V to +36 V or  $\pm 1$  V to  $\pm 18$  V
- Very low supply current (0.4 mA) independent of supply voltage (1 mW/comparator at +5 V)
- Low input bias current: 25 nA typ.
- Low input offset current:  $\pm 5$  nA typ.
- Low input offset voltage:  $\pm 1$  mV typ.
- Input common-mode voltage range includes ground
- Low output saturation voltage: 250 mV typ. ( $I_{\text{sink}} = 4$  mA)
- Differential input voltage range equal to the supply voltage
- TTL, DTL, ECL, MOS, CMOS compatible outputs

### Description

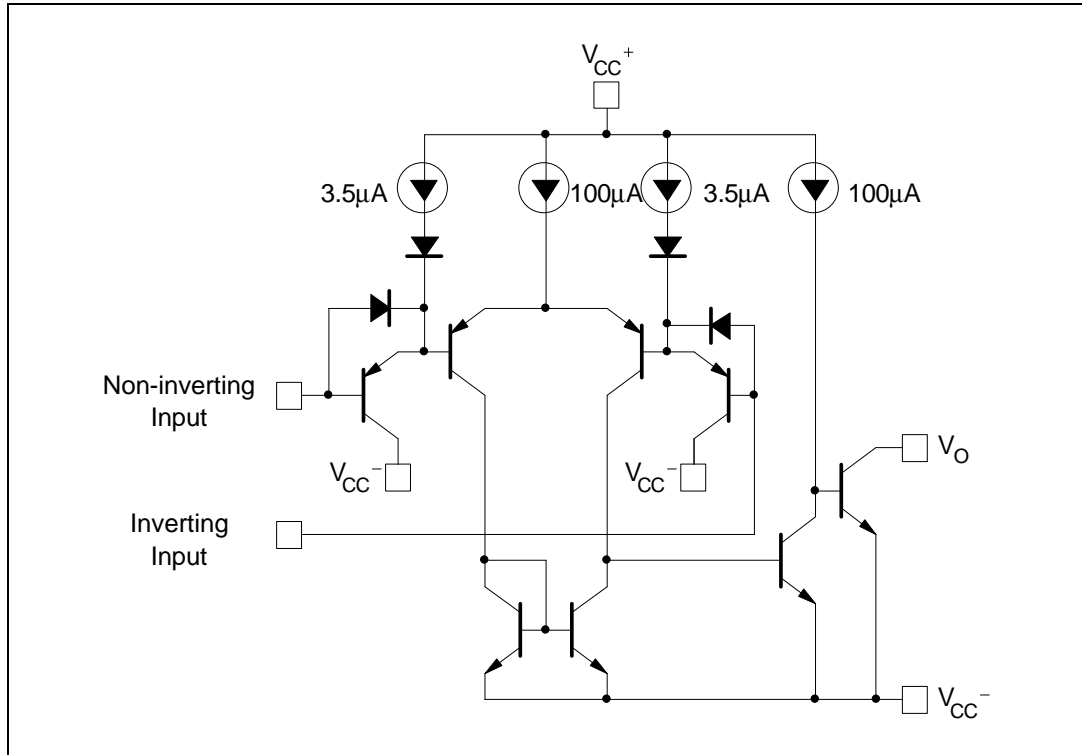
These devices consist of two independent low voltage comparators designed specifically to operate from a single supply over a wide range of voltages. Operation from split power supplies is also possible.

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.



# 1 Schematic diagram

Figure 1. Schematic diagram (1/2 LM193)



## 2 Absolute maximum ratings and operating conditions

**Table 1. Absolute maximum ratings**

| Symbol     | Parameter   | Value          | Unit |
|------------|---|----------------|------|
| $V_{CC}$   | Supply voltage  | $\pm 18$ or 36 | V    |
| $V_{id}$   | Differential input voltage                            | $\pm 36$       | V    |
| $V_{in}$   | Input voltage   | -0.3 to +36    | V    |
|            | Output short-circuit to ground <sup>(1)</sup>         | Infinite       |      |
| $R_{thja}$ | Thermal resistance junction to ambient <sup>(2)</sup> |                | °C/W |
|            | SO-8  | 125            |      |
|            | TSSOP8  | 120            |      |
|            | DIP8  | 85             |      |
| $R_{thjc}$ | Thermal resistance junction to case <sup>(2)</sup>    |                | °C/W |
|            | SO-8  | 40             |      |
|            | TSSOP8  | 37             |      |
|            | DIP8  | 41             |      |
|            | MiniSO-8  | 39             |      |
| $T_j$      | Maximum junction temperature                          | 150            | °C   |
| $T_{stg}$  | Storage temperature range                             | -65 to +150    | °C   |
| ESD        | HBM: human body model <sup>(3)</sup>                  | 800            | V    |
|            | MM: machine model <sup>(4)</sup>                      | 200            |      |
|            | CDM: charged device model <sup>(5)</sup>              | 1500           |      |

- 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  $V_{CC}^+$ .
- Short-circuits can cause excessive heating and destructive dissipation. Values are typical.
- Human body model: A 100 pF capacitor is charged to the specified voltage, then discharged through a 1.5 k $\Omega$  resistor between two pins of the device. This is done for all couples of connected pin combinations while the other pins are floating.
- 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  $\Omega$ ). This is done for all couples of connected pin combinations while the other pins are floating.
- 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  | 2 to 36                                      | V    |
| $V_{icm}$  | Common mode input voltage range ( $V_{CC}^+ = 30V$ ) <sup>(1)</sup><br>$T_{amb} = +25^\circ C$<br>$T_{min} \leq T_{amb} \leq T_{max}$ | 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   | -55 to +125<br>-40 to +105<br>0 to +70       | °C   |

- 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.

### 3 Electrical characteristics

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

| Symbol     | Parameter   | LM193A - LM293A<br>LM393A |          |            | LM193- LM293<br>LM393 |          |            | Unit          |
|------------|---|---------------------------|----------|------------|-----------------------|----------|------------|---------------|
|            |   | Min.                      | Typ.     | Max.       | Min.                  | Typ.     | Max.       |               |
| $V_{io}$   | Input offset voltage <sup>(1)</sup><br>$T_{min} \leq T_{amb} \leq T_{max}$                                      |                           | 1        | 2<br>4     |                       | 1        | 5<br>9     | mV            |
| $I_{io}$   | Input offset current<br>$T_{min} \leq T_{amb} \leq T_{max}$   |                           | 3        | 25<br>100  |                       | 5        | 50<br>150  | nA            |
| $I_{ib}$   | Input bias current ( $I^+$ or $I^-$ ) <sup>(2)</sup><br>$T_{min} \leq T_{amb} \leq T_{max}$                     |                           | 25       | 100<br>300 |                       | 25       | 250<br>400 | nA            |
| $A_{vd}$   | Large signal voltage gain<br>$V_{CC} = 15V$ , $R_L = 15k\Omega$ , $V_o = 1V$ to $11V$                           | 50                        | 200      |            | 50                    | 200      |            | V/mV          |
| $I_{CC}$   | Supply current (all comparators)<br>$V_{CC} = +5V$ , no load<br>$V_{CC} = +30V$ , no load                       |                           | 0.4<br>1 | 1<br>2.5   |                       | 0.4<br>1 | 1<br>2.5   | mA            |
| $V_{id}$   | Differential input voltage <sup>(3)</sup>   |                           |          | $V_{CC}^+$ |                       |          | $V_{CC}^+$ |               |
| $V_{OL}$   | Low level output voltage<br>$V_{id} = -1V$ , $I_{sink} = 4mA$<br>$T_{min} \leq T_{amb} \leq T_{max}$            |                           | 250      | 400<br>700 |                       | 250      | 400<br>700 | mV            |
| $I_{OH}$   | High level output current<br>$V_{CC} = V_o = 30V$ , $V_{id} = 1V$<br>$T_{min} \leq T_{amb} \leq T_{max}$        |                           | 0.1      | 1          |                       | 0.1      | 1          | nA<br>$\mu A$ |
| $I_{sink}$ | Output sink current $V_{id} = 1V$ , $V_o = 1.5V$  | 6                         | 16       |            | 6                     | 16       |            | mA            |
| $t_{re}$   | Response time <sup>(4)</sup><br>$R_L = 5.1k\Omega$ connected to $V_{CC}^+$                                      |                           | 1.3      |            |                       | 1.3      |            | $\mu s$       |
| $t_{rel}$  | Large signal response time<br>$R_L = 5.1k\Omega$ connected to $V_{CC}^+$ , $e_1 = TTL$ ,<br>$V_{(ref)} = +1.4V$ |                           | 300      |            |                       | 300      |            | ns            |

- At output switch point,  $V_o \approx 1.4V$ ,  $R_s = 0$  with  $V_{CC}^+$  from 5V to 30V, and over the full common-mode range (0V to  $V_{CC}^+ - 1.5V$ ).
- 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.
- The response time specified is for a 100 mV input step with 5 mV overdrive. For larger overdrive signals 300 ns can be obtained.
- 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 -0.3V (or 0.3V below the negative power supply, if used).

Figure 2. Supply current vs. supply voltage

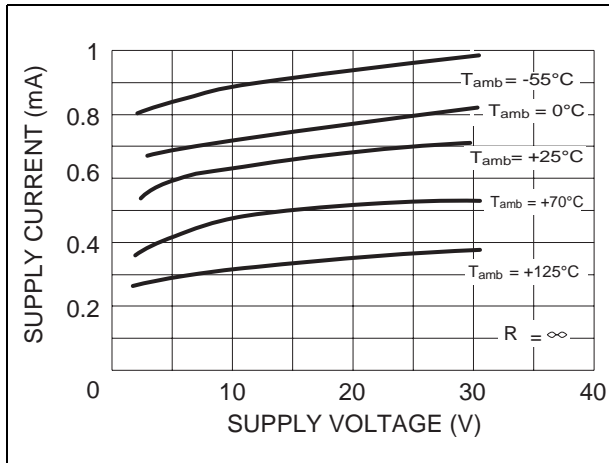


Figure 3. Input current vs. supply voltage

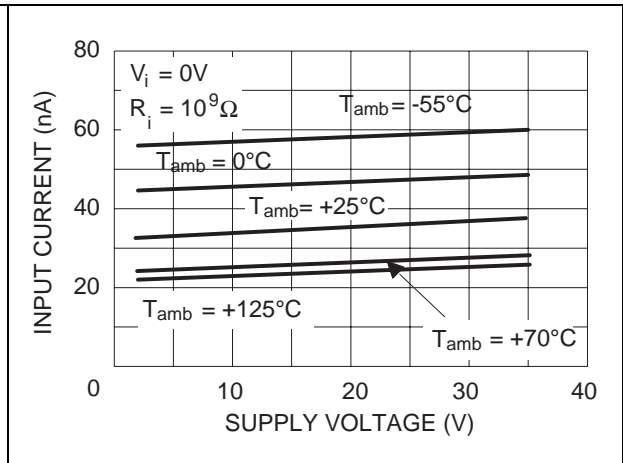


Figure 4. Output saturation voltage vs. frequency

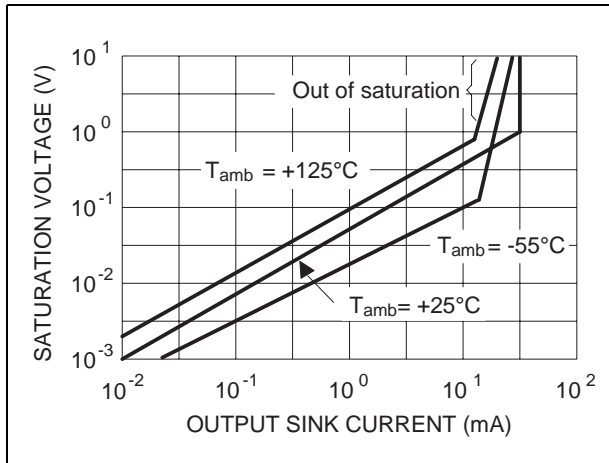


Figure 5. Response time for various input overdrives - negative transition

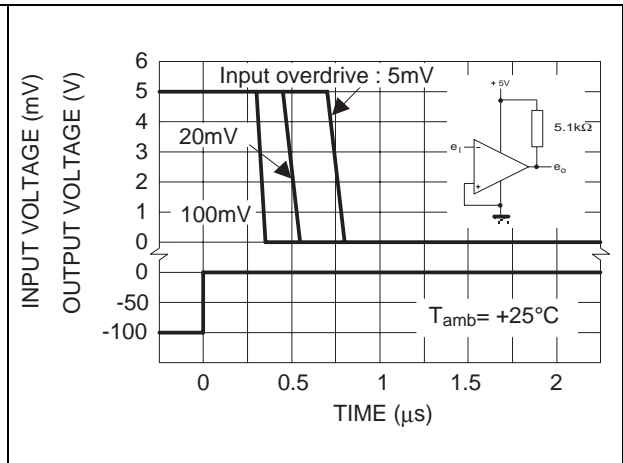
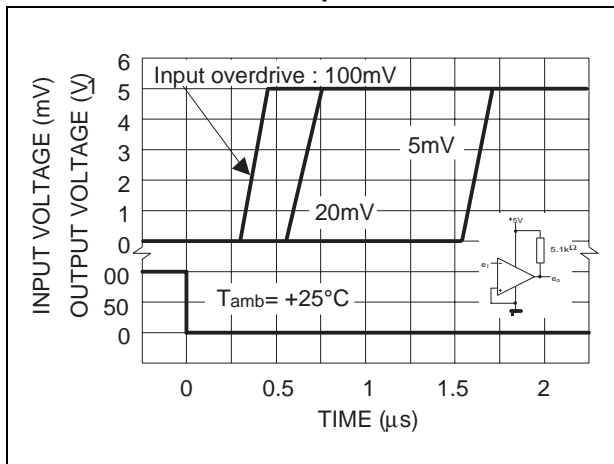


Figure 6. Response time for various input overdrives - positive transition



# 4 Typical applications

Figure 7. Basic comparator

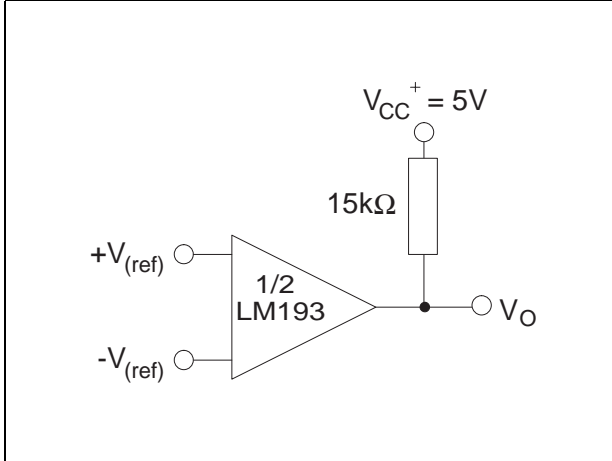


Figure 8. Driving TTL

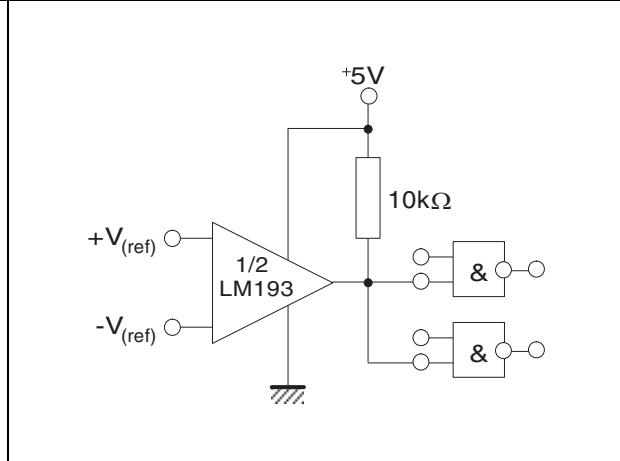


Figure 9. Low frequency op-amp

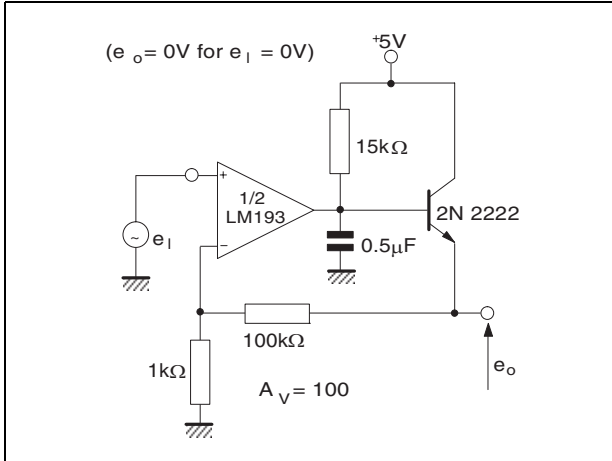


Figure 10. Driving CMOS

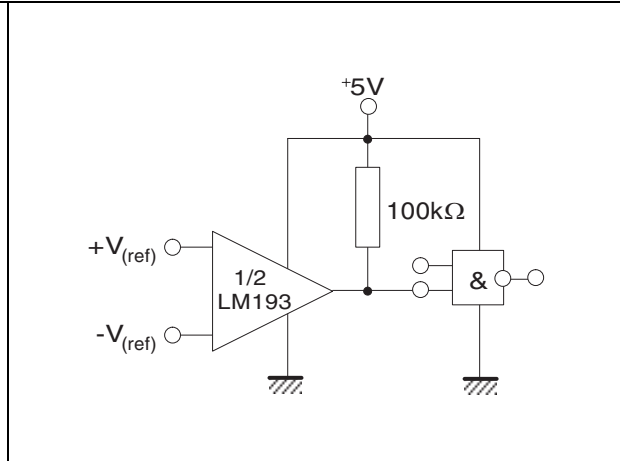


Figure 11. Low frequency op-amp

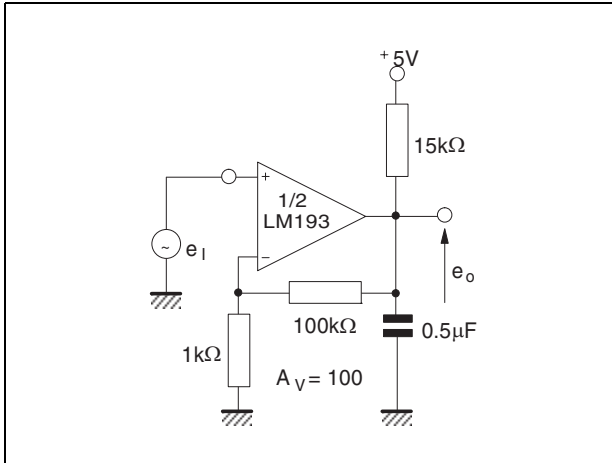


Figure 12. Transducer amplifier

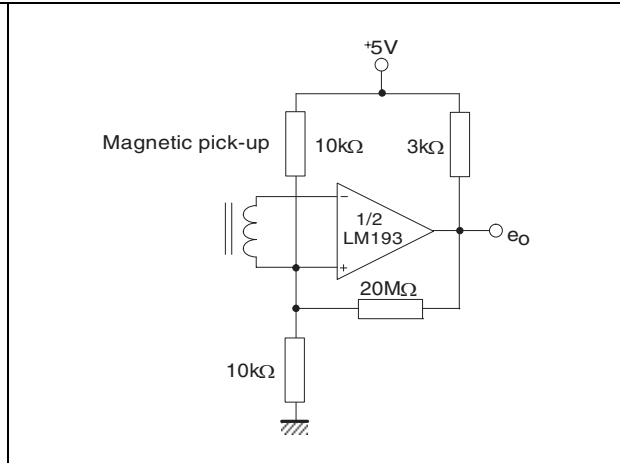


Figure 13. Low frequency op-amp with offset adjust

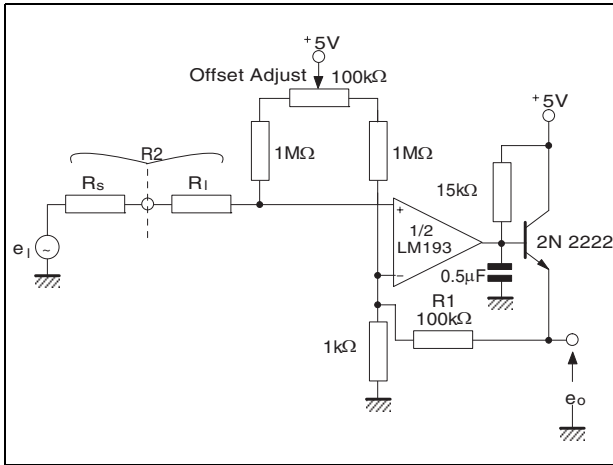


Figure 14. Zero crossing detector (single power supply)

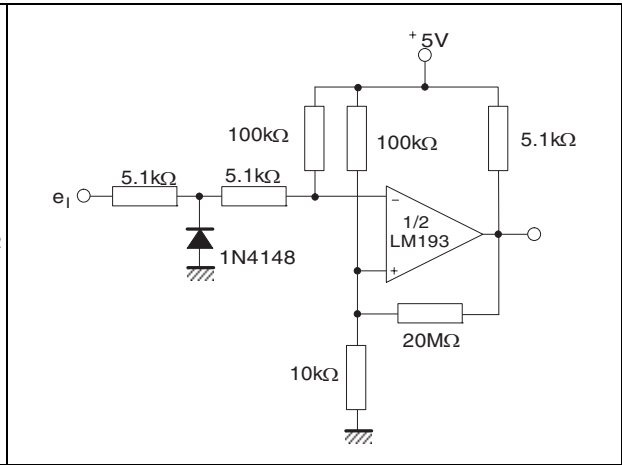


Figure 15. Limit comparator

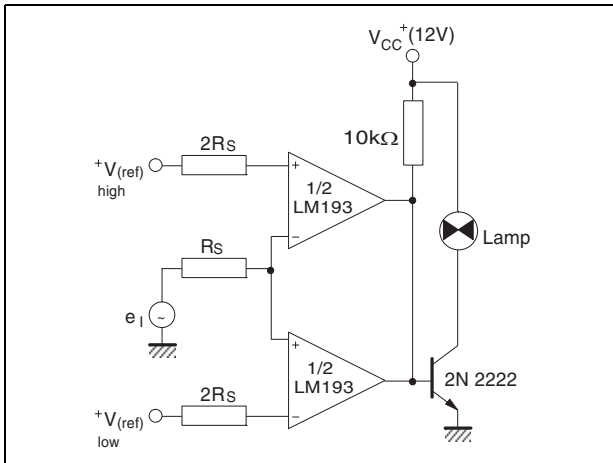


Figure 16. Crystal controlled oscillator

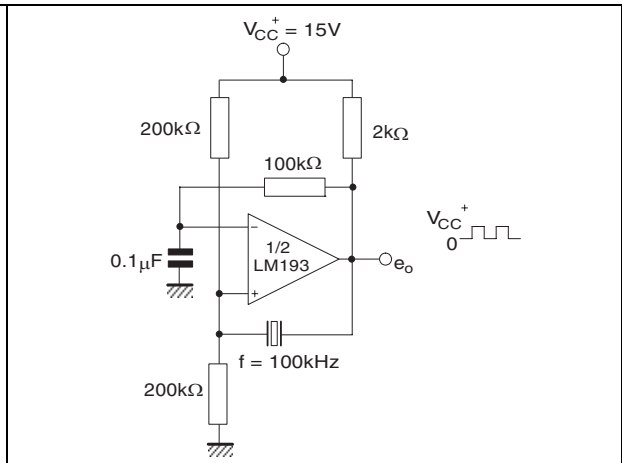


Figure 17. Split-supply applications - zero crossing detector

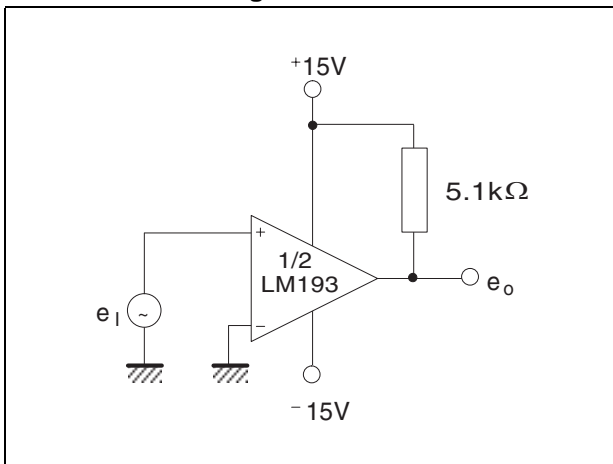


Figure 18. Comparator with a negative reference

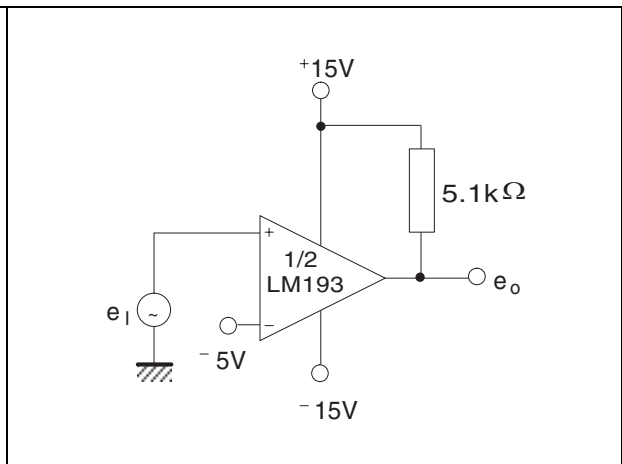
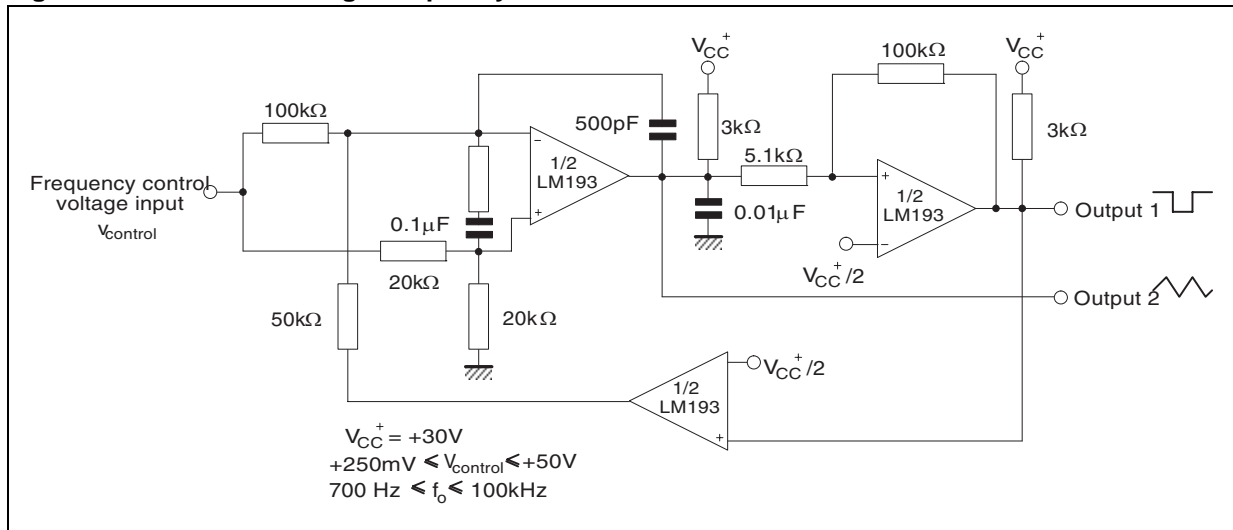


Figure 19. Two-decade high-frequency VCO



## 5 Package information

In order to meet environmental requirements, ST offers these devices in ECOPACK<sup>®</sup> packages. These packages have a lead-free second level interconnect. The category of second level interconnect is marked on the package and on the inner box label, in compliance with JEDEC Standard JESD97. The maximum ratings related to soldering conditions are also marked on the inner box label. ECOPACK is an ST trademark. ECOPACK specifications are available at: [www.st.com](http://www.st.com).



## 5.1 DIP8 package information

Figure 20. DIP8 package mechanical drawing

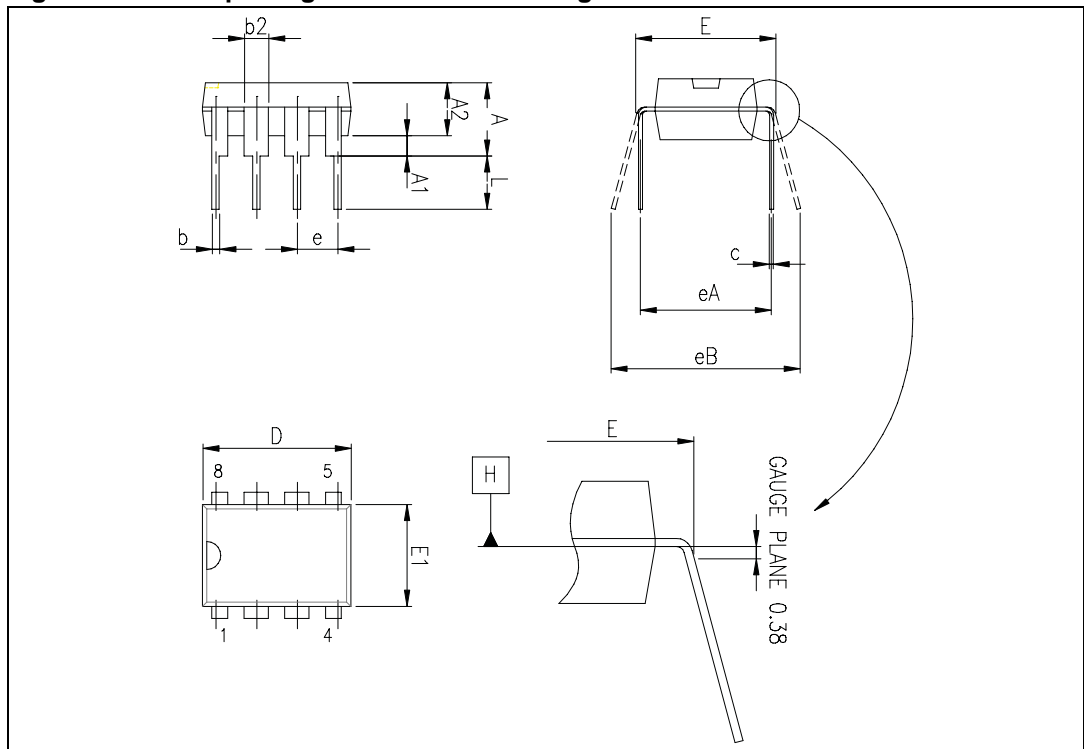


Table 4. DIP8 package mechanical data

| Ref. | 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 |

## 5.2 SO-8 package information

Figure 21. SO-8 package mechanical drawing

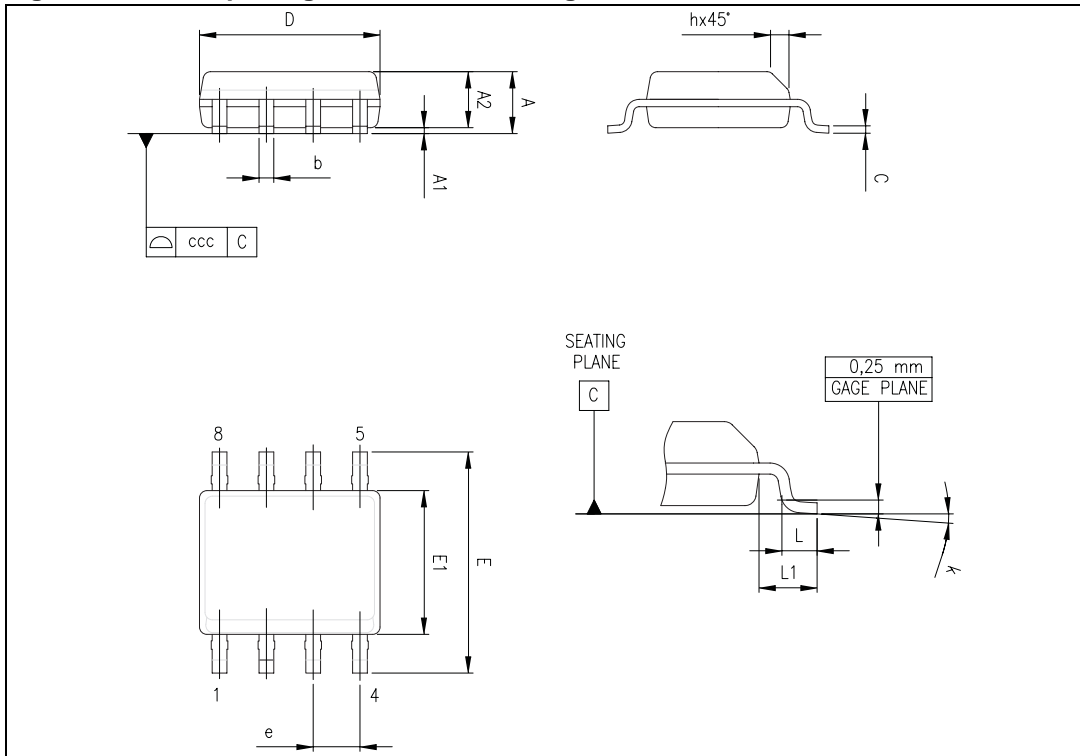


Table 5. SO-8 package mechanical data

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

### 5.3 TSSOP8 package information

Figure 22. TSSOP8 package mechanical drawing

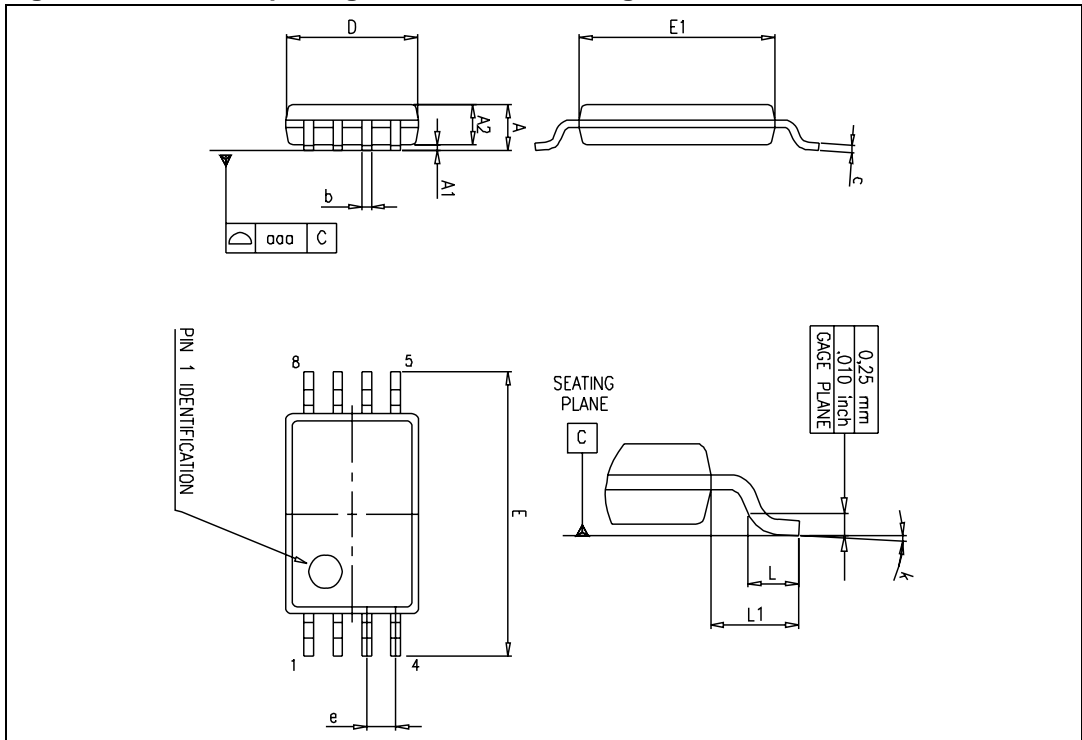


Table 6. TSSOP8 package mechanical data

| 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  |       |

### 5.4 MiniSO-8 package information

Figure 23. MiniSO-8 package mechanical drawing

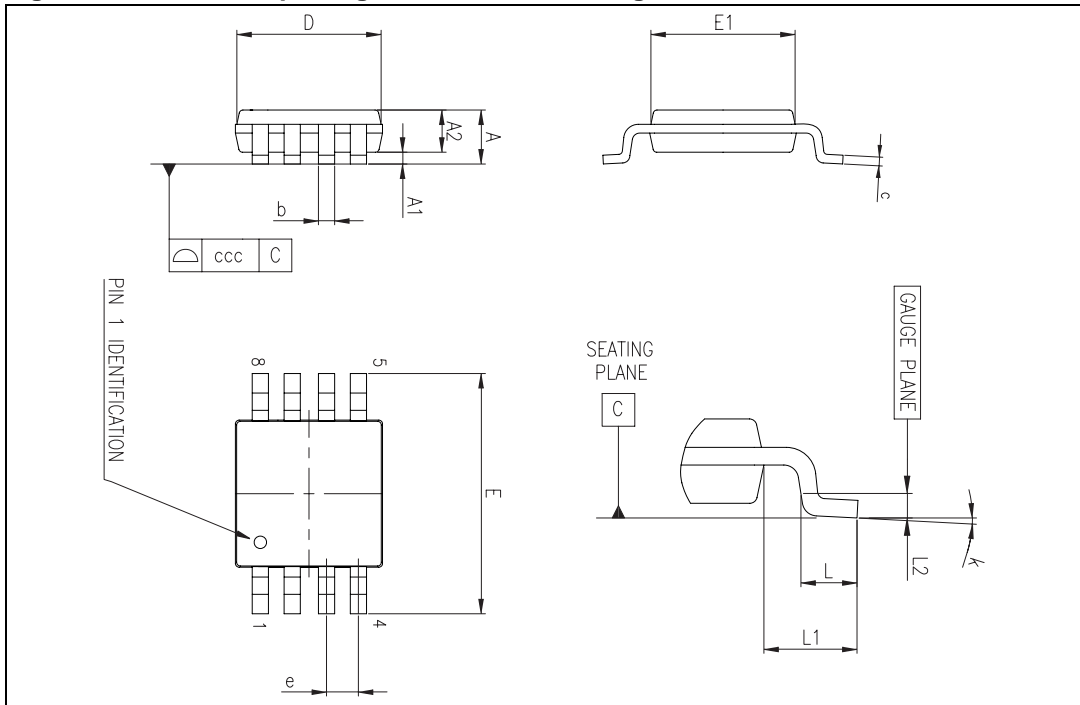


Table 7. MiniSO-8 package mechanical data

| 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 |

## 6 Ordering information

**Table 8. Order codes**

| Order code  | Temperature range | Package                    | Packing                | Marking |
|---|-------------------|----------------------------|------------------------|---------|
| LM193AD<br>LM193ADT                                 | -55°C, +125°C     | SO-8                       | Tube or<br>Tape & reel | 193A    |
| LM193D<br>LM193DT                                   |                   |                            |                        | 193     |
| LM193AYD <sup>(1)</sup><br>LM193AYDT                |                   | SO-8<br>(Automotive grade) | Tube or<br>Tape & reel | 193AY   |
| LM193YD <sup>(1)</sup><br>LM193YDT                  |                   |                            |                        | 193Y    |
| LM193AN   |                   | DIP8                       | Tube                   | LM193AN |
| LM193N  |                   |                            |                        | LM193N  |
| LM293AD<br>LM293ADT                                 | -40°C, +105°C     | SO-8                       | Tube or<br>Tape & reel | 293A    |
| LM293D<br>LM293DT                                   |                   |                            |                        | 293     |
| LM293AYD <sup>(1)</sup><br>LM293AYDT <sup>(1)</sup> |                   | SO-8<br>(Automotive grade) | Tube or<br>Tape & reel | 293AY   |
| LM293YD <sup>(1)</sup><br>LM293YDT <sup>(1)</sup>   |                   |                            |                        | 293Y    |
| LM293AN   |                   | DIP8                       | Tube                   | LM293AN |
| LM293N  |                   |                            |                        | LM293N  |
| LM293PT   |                   | TSSOP8                     | Tape & reel            | 293     |
| LM293ST   |                   | MiniSO-8                   | Tape & reel            | K512    |
| LM393AD<br>LM393ADT                                 | 0°C, +70°C        | SO-8                       | Tube or<br>Tape & reel | 393A    |
| LM393D<br>LM393DT                                   |                   |                            |                        | 393     |
| LM393AYD <sup>(1)</sup><br>LM393AYDT <sup>(1)</sup> |                   | SO-8<br>(Automotive grade) | Tube or<br>Tape & reel | 393AY   |
| LM393YD <sup>(1)</sup><br>LM393YDT <sup>(1)</sup>   |                   |                            |                        | 393Y    |
| LM393AN   |                   | DIP8                       | Tube                   | LM393AN |
| LM393N  |                   |                            |                        | LM393N  |
| LM393PT   |                   | TSSOP8                     | Tape & reel            | 393     |
| LM393ST   |                   | MiniSO-8                   | Tape & reel            | M393    |

1. Qualified and characterized according to AEC Q100 and Q003 or equivalent, advanced screening according to AEC Q001 & Q 002 or equivalent.

## 7 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 <a href="#">Table 6: Ordering information on page 13</a> .  |
| 02-Jul-2005 | 4        | Modification on PPAP references - Errors on part numbers, see <a href="#">Table 6: Ordering information on page 13</a> .   |
| 22-Nov-2005 | 5        | Modification on <a href="#">Table 3 on page 4</a> . LM293,A must be -40/+105°C instead of -40/+125°C.  |
| 16-Feb-2006 | 6        | Unit error for $V_{OI}$ parameter see <a href="#">Table 3 on page 4</a> .  |
| 23-Aug-2007 | 7        | Corrected error in DIP8 package information related to lead thickness, see <a href="#">Figure 20 on page 9</a> .<br>Added values for $R_{thja}$ and $R_{thjc}$ , and ESD parameters in <a href="#">Table 1: Absolute maximum ratings</a> . |
| 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.   |

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