



# LM193, A LM293, A - LM393, A

## Low Power Dual Voltage Comparators

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

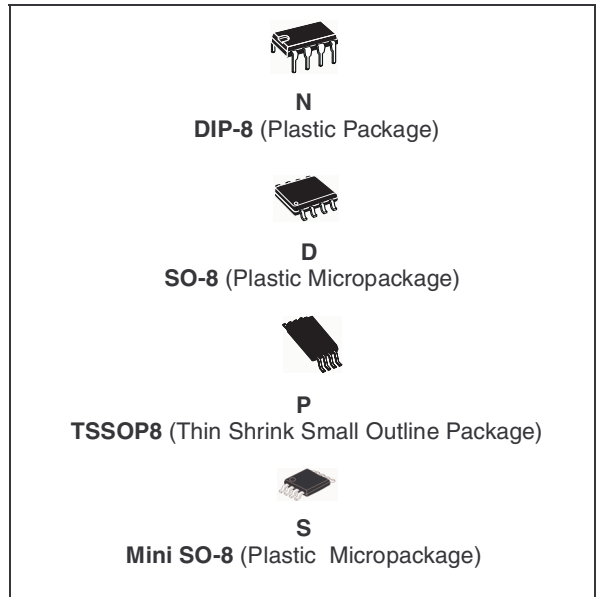
### Description

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.

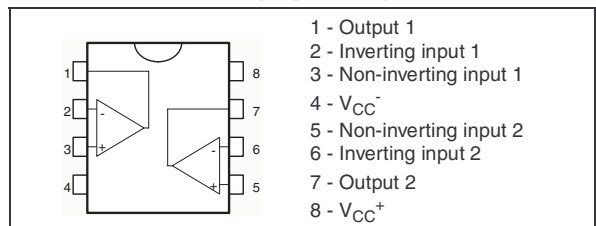
These comparators also have a unique characteristic in that the input common-mode voltage range includes ground even though operated from a single power supply voltage.

### Order Codes

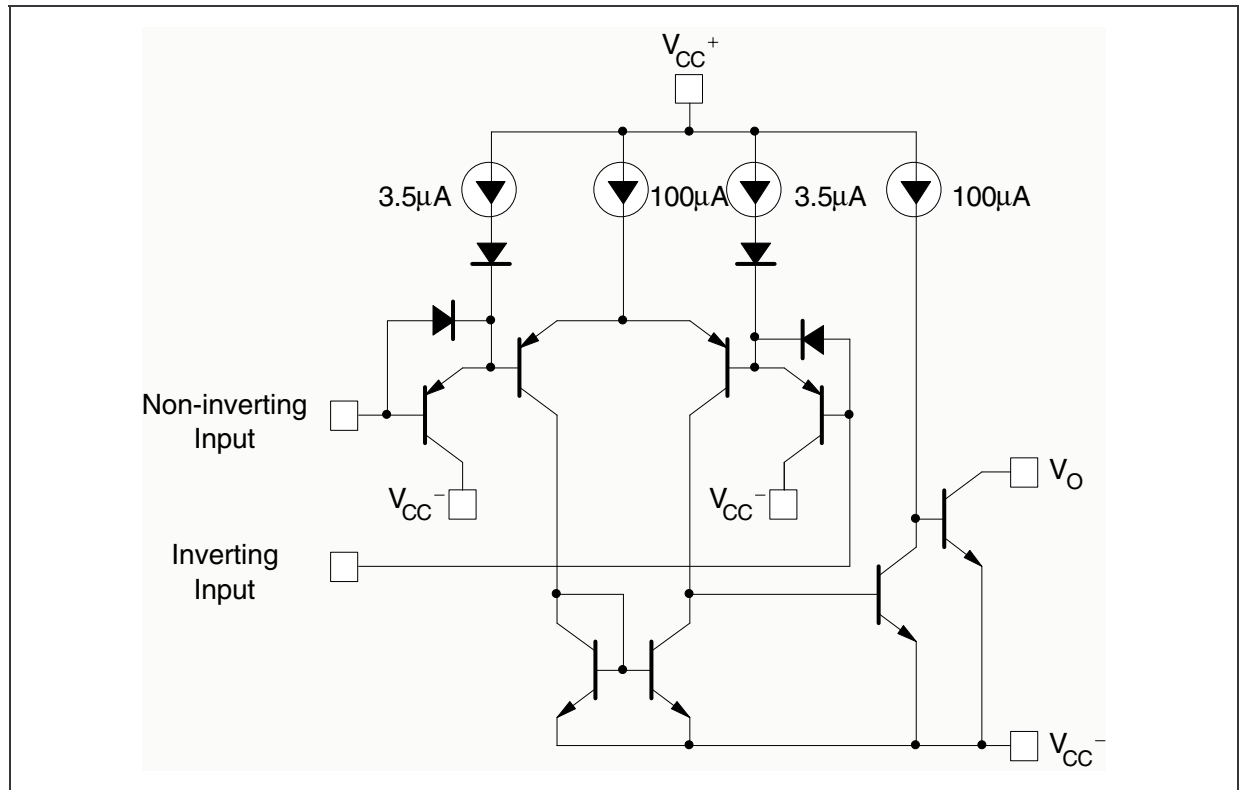
| Part Number      | Temperature Range | Package                                | Packing                     |
|------------------|-------------------|--|-----------------------------|
| LM193AD/LM193ADT | -55°C, +125°C     | SO                                     | Tube or Tape & Reel         |
| LM193AN          |                   | DIP                                    | Tube                        |
| LM193D/LM193DT   |                   | SO                                     | Tube or Tape & Reel         |
| LM193N           |                   | DIP                                    | Tube                        |
| LM293AD/LM293ADT | -40°C, +105°C     | SO                                     | Tube or Tape & Reel         |
| LM293AN          |                   | DIP                                    | Tube                        |
| LM293D/LM293DT   |                   | SO                                     | Tube or Tape & Reel         |
| LM293N           |                   | DIP                                    | Tube                        |
| LM293PT          |                   | TSSOP<br>(Thin Shrink Outline Package) | Tape & Reel                 |
| LM293ST          |                   | Mini SO                                | Tape & Reel                 |
| LM393AD/LM393ADT | 0°C, +70°C        | SO                                     | Tube or Tape & Reel         |
| LM393D/LM393DT   |                   | SO                                     | Tube or Tape & Reel         |
| LM393N           |                   | DIP                                    | Tube                        |
| LM393PT          |                   | TSSOP<br>(Thin Shrink Outline Package) | Tape & Reel                 |
| LM393ST          |                   | Mini SO                                | Tape & Reel                 |
| LM393YDT/YD      |                   | -40°C, +125°C                          | SO (automotive grade level) |



### Pin Connections (top view)



## 1 Schematic Diagram (1/2 LM193)



## 2 Absolute Maximum Ratings

**Table 1. Key parameters and their absolute maximum ratings**

| Symbol           | Parameter  | Value                     | Unit |
|------------------|--|---------------------------|------|
| V <sub>cc</sub>  | Supply voltage   | ±18 or 36                 | V    |
| V <sub>id</sub>  | Differential Input Voltage   | ±36                       | V    |
| V <sub>i</sub>   | Input Voltage  | -0.3 to +36               | V    |
|                  | Output Short-circuit to Ground - note <sup>1</sup>                     | Infinite                  |      |
| P <sub>d</sub>   | Power Dissipation <sup>2</sup><br>DIP-8<br>SO-8<br>TSSOP8<br>Mini SO-8 | 1250<br>710<br>625<br>580 | mW   |
| T <sub>stg</sub> | Storage Temperature Range  | -65 to +150               | °C   |

1) Short-circuits from the output to V<sub>CC</sub><sup>+</sup> can cause excessive heating and eventual destruction. The maximum output current is approximately 20mA independent of the magnitude of V<sub>CC</sub><sup>+</sup>.

2) P<sub>d</sub> is calculated with T<sub>amb</sub> = +25°C, T<sub>j</sub> = +150°C and R<sub>thja</sub> = 100°C/W for DIP8 package  
 = 175°C/W for SO8 package  
 = 200°C/W for TSSOP8 package  
 = 215°C/W for Mini SO8 package

**Table 2. Operating Conditions**

| Symbol            | Parameter  | Value                                  | Unit |
|-------------------|--|--|------|
| V <sub>icm</sub>  | Common Mode Input Voltage Range  | 0 to V <sub>CC</sub> <sup>+</sup> -1.5 | V    |
| T <sub>oper</sub> | Operating Free-Air Temperature range<br>LM193, A<br>LM293, A<br>LM393, A | -55 to +125<br>-40 to +105<br>0 to +70 | °C   |

## 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 - note <sup>1</sup><br>$T_{amb} = +25^\circ C$<br>$T_{min} \leq T_{amb} \leq T_{max}$                              |                           | 1        | 2<br>4                             |                       | 1        | 5<br>9                             | mV            |
| $I_{io}$   | Input Offset Current<br>$T_{amb} = +25^\circ C$<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 $I^-$ ) - note <sup>2</sup><br>$T_{amb} = +25^\circ C$<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            |
| $V_{icm}$  | Input Common Mode Voltage Range - note <sup>3</sup><br>$V_{CC} = 30V$<br>$T_{amb} = +25^\circ C$<br>$T_{min} \leq T_{amb} \leq T_{max}$ | 0<br>0                    |          | $V_{CC}^+ - 1.5$<br>$V_{CC}^+ - 2$ | 0<br>0                |          | $V_{CC}^+ - 1.5$<br>$V_{CC}^+ - 2$ | V             |
| $V_{id}$   | Differential Input Voltage -note <sup>4</sup>   |                           |          | $V_{CC}^+$                         |                       |          | $V_{CC}^+$                         |               |
| $V_{OL}$   | Low Level Output Voltage<br>$V_{id} = -1V$ , $I_{sink} = 4mA$<br>$T_{amb} = +25^\circ C$<br>$T_{min} \leq T_{amb} \leq T_{max}$         |                           | 250      | 400<br>700                         |                       | 250      | 400<br>700                         | V             |
| $I_{OH}$   | High Level Output Current ( $V_{id} = 1V$ )<br>$V_{CC} = V_o = 30V$<br>$T_{amb} = +25^\circ C$<br>$T_{min} \leq T_{amb} \leq T_{max}$   |                           | 0.1      | 1                                  |                       | 0.1      | 1                                  | nA<br>$\mu A$ |
| $I_{SINK}$ | Output Sink Current<br>$V_{id} = 1V$ , $V_o = 1.5V$   | 6                         | 16       |                                    | 6                     | 16       |                                    | mA            |
| tre        | Response Time - note <sup>5</sup><br>$R_L = 5.1k\Omega$ connected to $V_{CC}^+$   |                           | 1.3      |                                    |                       | 1.3      |                                    | $\mu s$       |
| trel       | Large Signal Response Time<br>$R_L = 5.1k\Omega$ connected to $V_{CC}^+$ , $e_i = TTL$ ,<br>$V_{(ref)} = +1.4v$                         |                           | 300      |                                    |                       | 300      |                                    | ns            |

- 1) 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  $V_{CC}^+ - 1.5V$ ).
- 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) The input common-mode voltage of either input signal voltage should not be allowed to go negative by more than 0.3V. The upper end of the common-mode voltage range is  $V_{CC}^+ - 1.5V$ , but either or both inputs can go to +30V without damage.
- 4) The response time specified is for a 100mV input step with 5mV overdrive. For larger overdrive signals 300ns can be obtained.
- 5) 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 1. Supply current vs. supply voltage

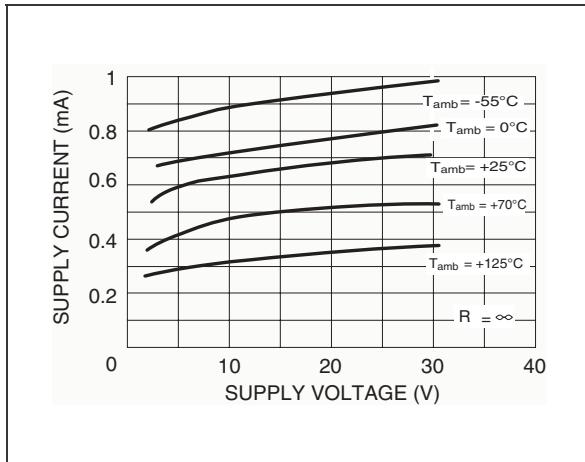


Figure 2. Output saturation voltage vs. output current

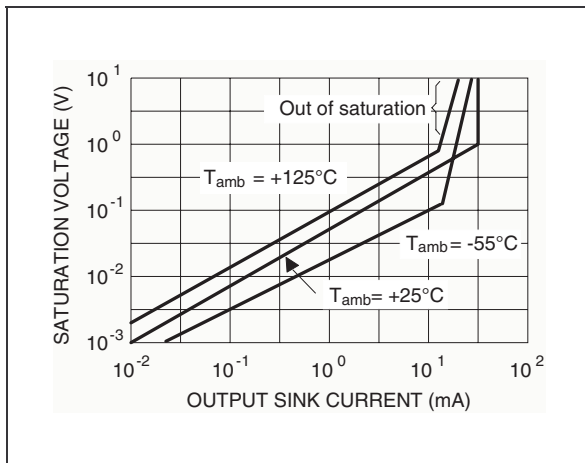


Figure 3. Response time for various input overdrives - positive transition

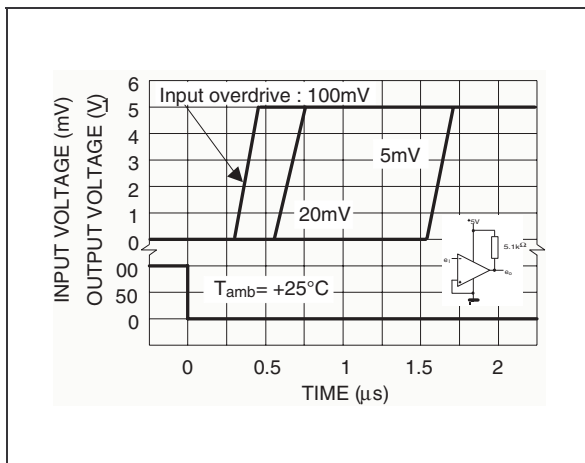


Figure 4. Input current vs. supply voltage

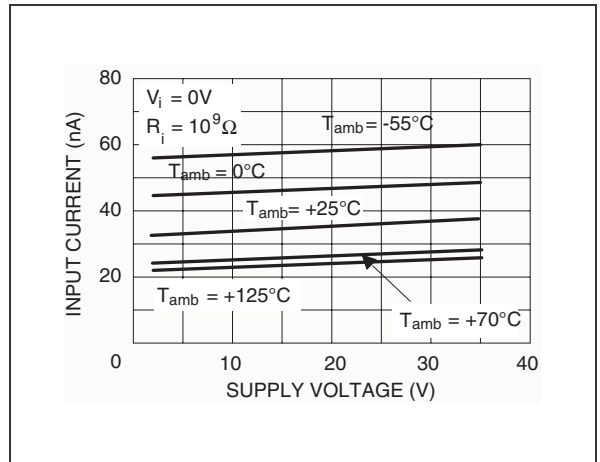
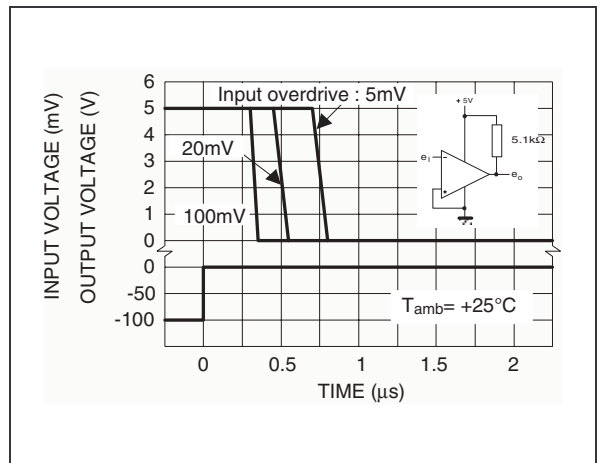


Figure 5. Response time for various input overdrives - negative transition



### 4 Typical Applications

Figure 6. Basic comparator

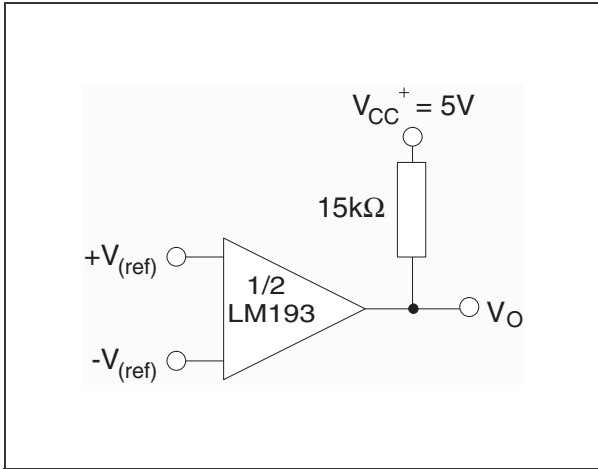


Figure 7. driving TTL

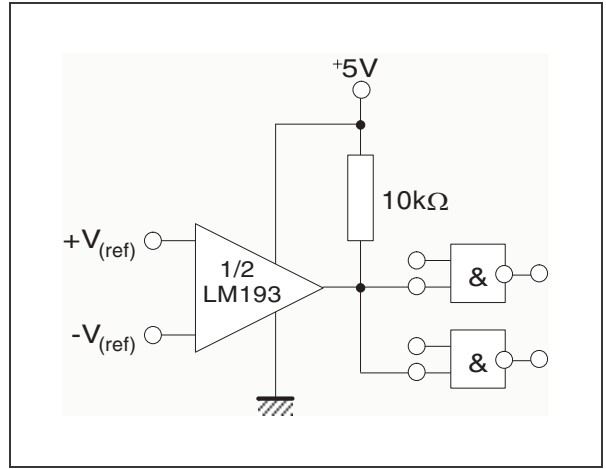


Figure 8. Low frequency op-amp

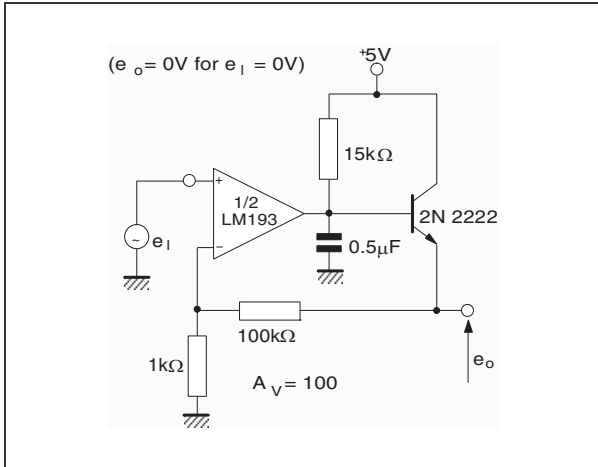


Figure 9. Driving CMOS

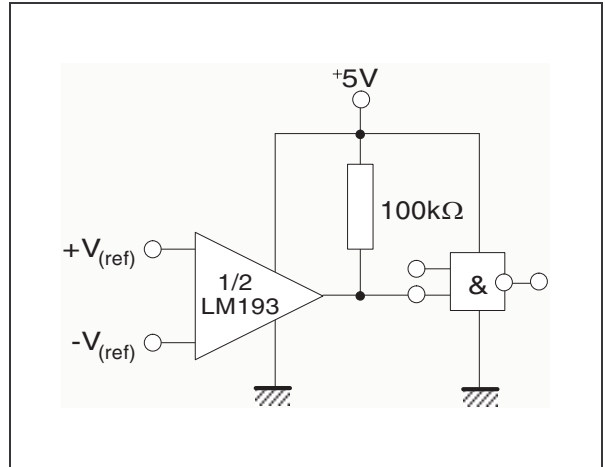


Figure 10. Low frequency op-amp

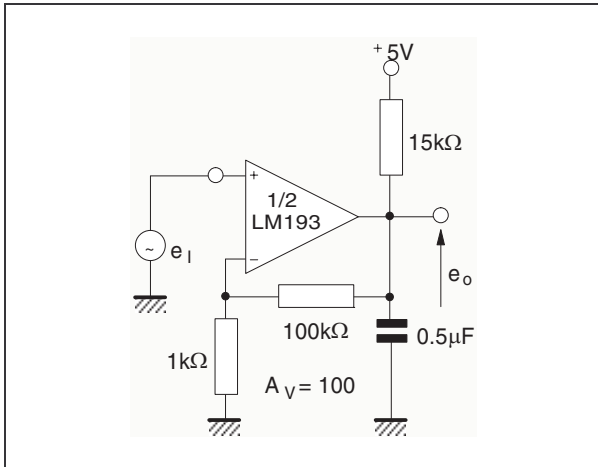


Figure 11. Transducer amplifier

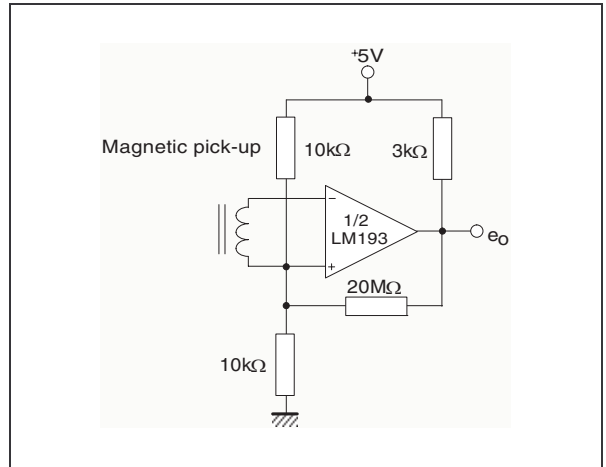


Figure 12. Low frequency op-amp with offset adjust

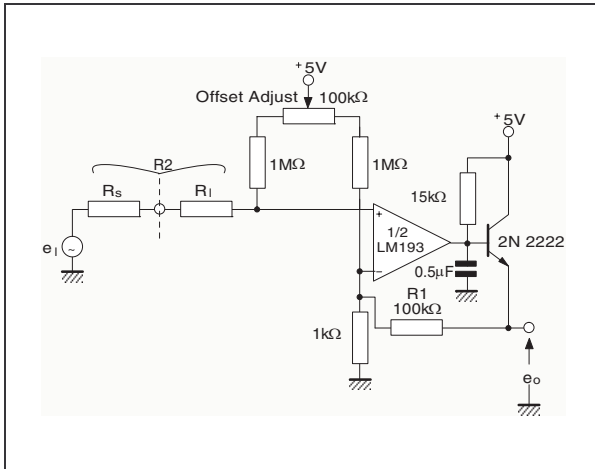


Figure 13. Zero crossing detector (single power supply)

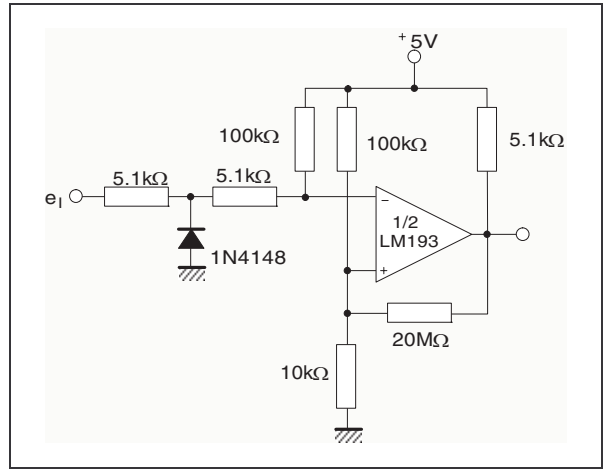


Figure 14. Two-decade high-frequency VCO

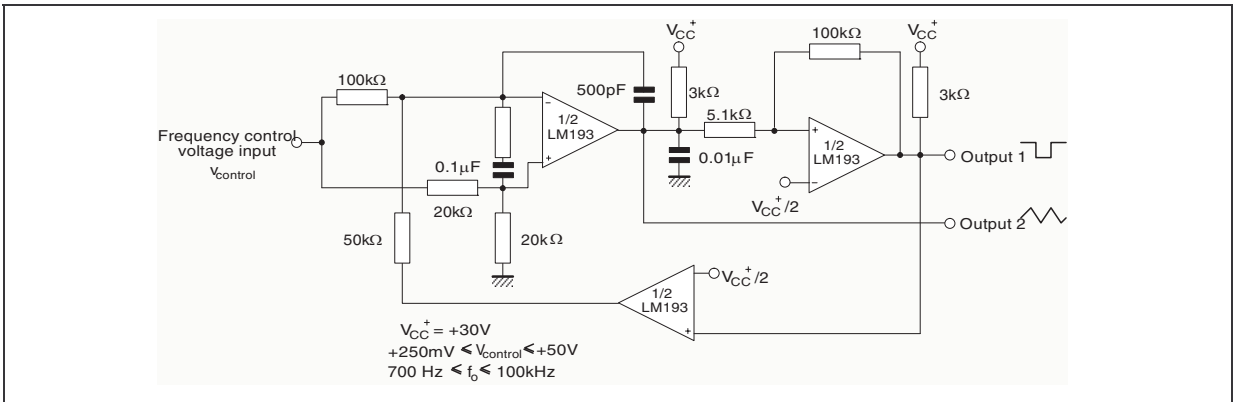


Figure 15. Limit comparator

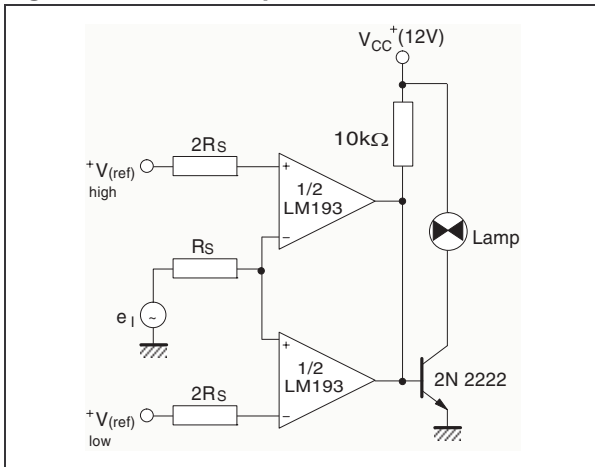


Figure 16. Crystal controlled oscillator

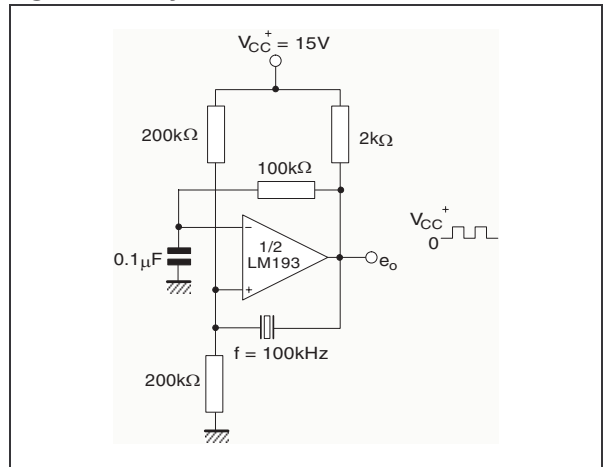


Figure 17. Split-supply applications - zero crossing detector

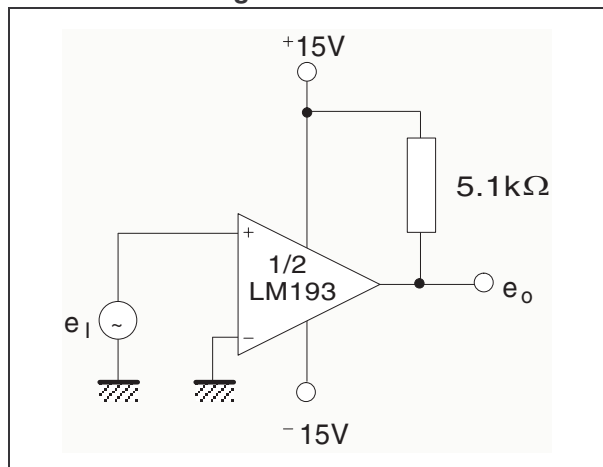
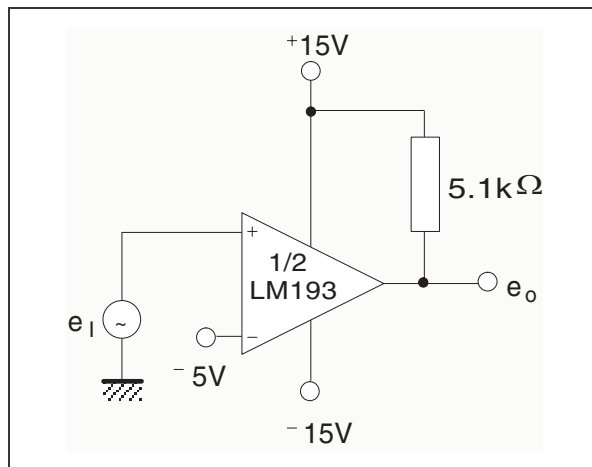


Figure 18. Comparator with a negative reference



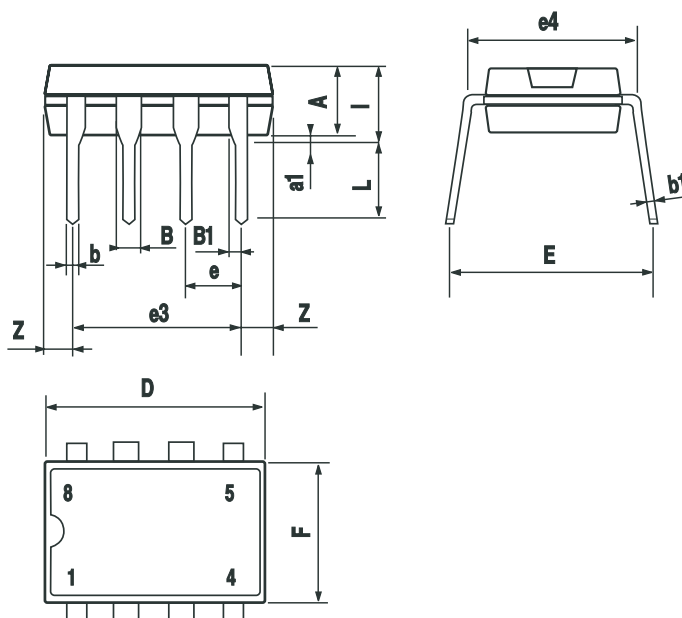


## 5 Package Mechanical Data

## 5.1 DIP8 package

Plastic DIP-8 MECHANICAL DATA

| DIM. | mm.  |      |      | inch  |       |       |
|------|------|------|------|-------|-------|-------|
|      | MIN. | TYP  | MAX. | MIN.  | TYP.  | MAX.  |
| A    |      | 3.3  |      |       | 0.130 |       |
| a1   | 0.7  |      |      | 0.028 |       |       |
| B    | 1.39 |      | 1.65 | 0.055 |       | 0.065 |
| B1   | 0.91 |      | 1.04 | 0.036 |       | 0.041 |
| b    |      | 0.5  |      |       | 0.020 |       |
| b1   | 0.38 |      | 0.5  | 0.015 |       | 0.020 |
| D    |      |      | 9.8  |       |       | 0.386 |
| E    |      | 8.8  |      |       | 0.346 |       |
| e    |      | 2.54 |      |       | 0.100 |       |
| e3   |      | 7.62 |      |       | 0.300 |       |
| e4   |      | 7.62 |      |       | 0.300 |       |
| F    |      |      | 7.1  |       |       | 0.280 |
| l    |      |      | 4.8  |       |       | 0.189 |
| L    |      | 3.3  |      |       | 0.130 |       |
| Z    | 0.44 |      | 1.6  | 0.017 |       | 0.063 |

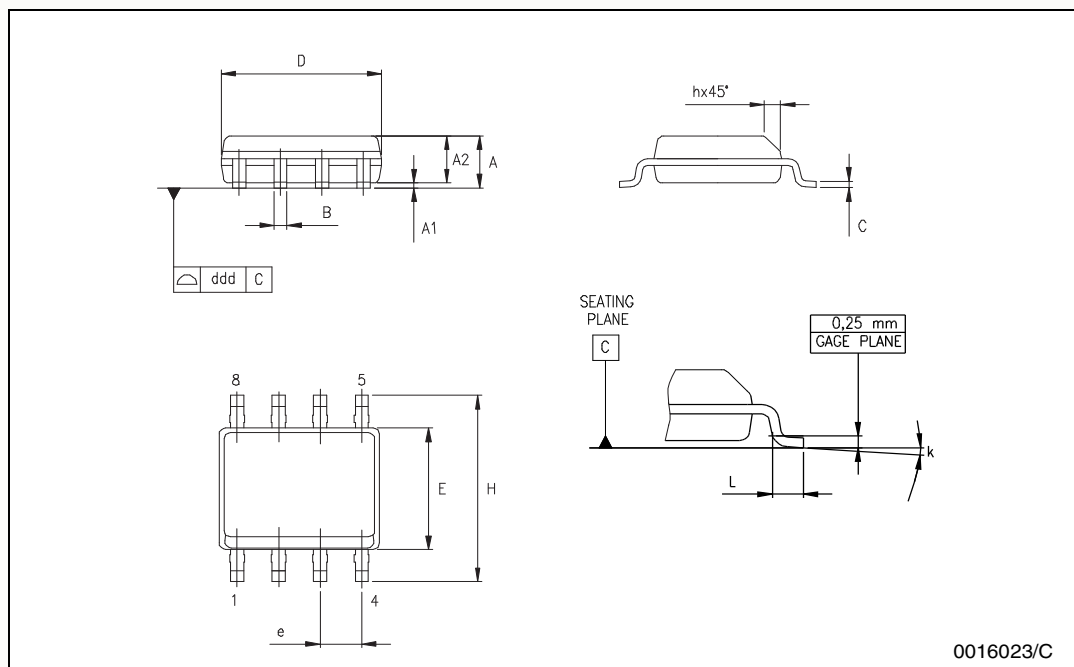


P001F

## 5.2 SO8 package

## SO-8 MECHANICAL DATA

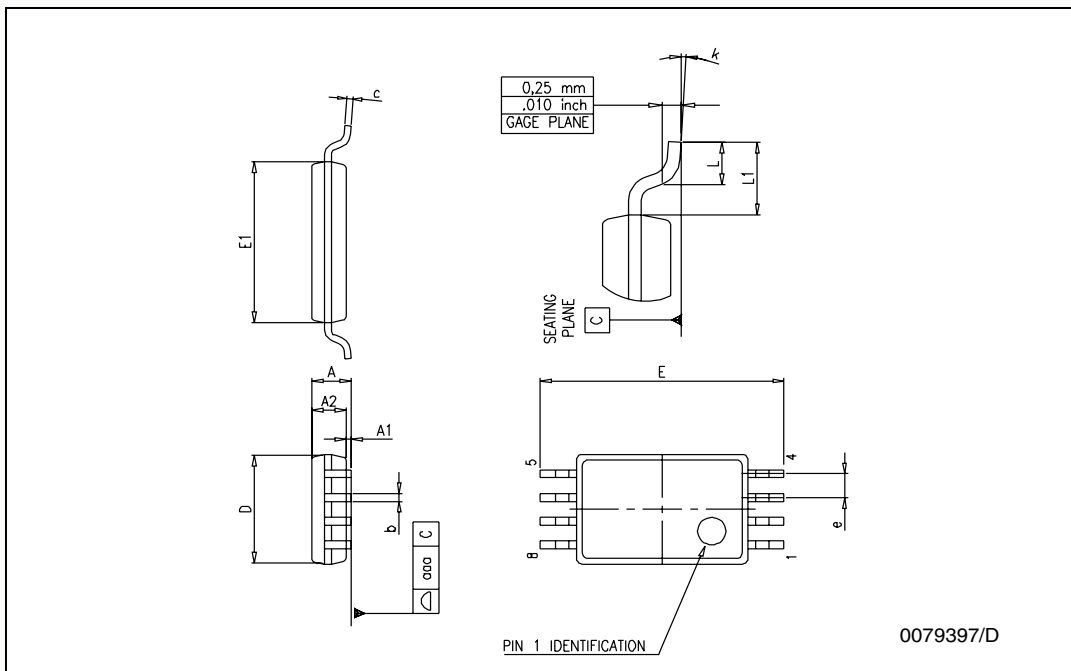
| DIM. | mm.       |      |      | inch  |       |       |
|------|-----------|------|------|-------|-------|-------|
|      | MIN.      | TYP  | MAX. | MIN.  | TYP.  | MAX.  |
| A    | 1.35      |      | 1.75 | 0.053 |       | 0.069 |
| A1   | 0.10      |      | 0.25 | 0.04  |       | 0.010 |
| A2   | 1.10      |      | 1.65 | 0.043 |       | 0.065 |
| B    | 0.33      |      | 0.51 | 0.013 |       | 0.020 |
| C    | 0.19      |      | 0.25 | 0.007 |       | 0.010 |
| D    | 4.80      |      | 5.00 | 0.189 |       | 0.197 |
| E    | 3.80      |      | 4.00 | 0.150 |       | 0.157 |
| e    |           | 1.27 |      |       | 0.050 |       |
| H    | 5.80      |      | 6.20 | 0.228 |       | 0.244 |
| h    | 0.25      |      | 0.50 | 0.010 |       | 0.020 |
| L    | 0.40      |      | 1.27 | 0.016 |       | 0.050 |
| k    | 8° (max.) |      |      |       |       |       |
| ddd  |           |      | 0.1  |       |       | 0.04  |



5.3 TSSOP8 package

**TSSOP8 MECHANICAL DATA**

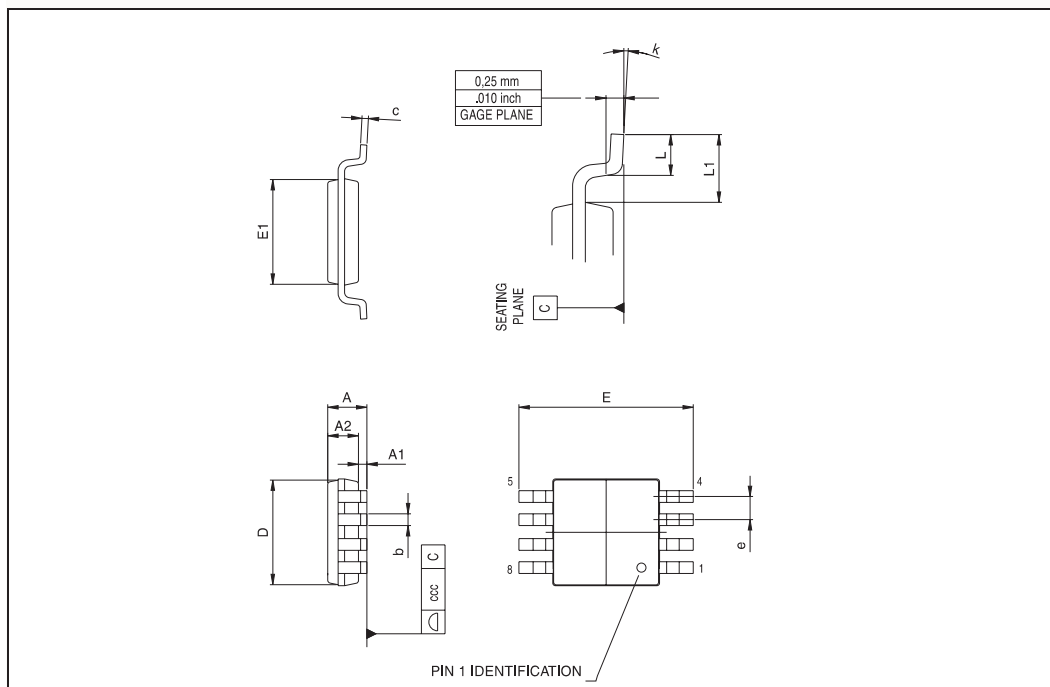
| DIM. | mm.  |      |      | inch  |        |       |
|------|------|------|------|-------|--------|-------|
|      | MIN. | TYP  | MAX. | MIN.  | TYP.   | MAX.  |
| A    |      |      | 1.2  |       |        | 0.047 |
| A1   | 0.05 |      | 0.15 | 0.002 |        | 0.006 |
| A2   | 0.80 | 1.00 | 1.05 | 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  |       |



## 5.4 Mini SO8 package

## miniSO-8 MECHANICAL DATA

| DIM. | mm.  |      |      | inch  |       |       |
|------|------|------|------|-------|-------|-------|
|      | MIN. | TYP  | MAX. | MIN.  | TYP.  | MAX.  |
| A    |      |      | 1.1  |       |       | 0.043 |
| A1   | 0.05 | 0.10 | 0.15 | 0.002 | 0.004 | 0.006 |
| A2   | 0.78 | 0.86 | 0.94 | 0.031 | 0.031 | 0.037 |
| b    | 0.25 | 0.33 | 0.40 | 0.010 | 0.13  | 0.013 |
| c    | 0.13 | 0.18 | 0.23 | 0.005 | 0.007 | 0.009 |
| D    | 2.90 | 3.00 | 3.10 | 0.114 | 0.118 | 0.122 |
| E    | 4.75 | 4.90 | 5.05 | 0.187 | 0.193 | 0.199 |
| E1   | 2.90 | 3.00 | 3.10 | .0114 | 0.118 | 0.122 |
| e    |      | 0.65 |      |       | 0.026 |       |
| K    | 0°   |      | 6°   | 0°    |       | 6°    |
| L    | 0.40 | 0.55 | 0.70 | 0.016 | 0.022 | 0.028 |
| L1   |      |      | 0.10 |       |       | 0.004 |



## 6 Revision History

| Date      | Revision | Description of Changes   |
|-----------|----------|--|
| July 2002 | 1        | First Release  |
| Jan. 2005 | 2        | Class A of the product included in the datasheet.  |
| May 2005  | 3        | PPAP references inserted in the datasheet see table order code p1                            |
| July 2005 | 4        | Modification on PPAP references - Errors on part numbers see table table order code p1.      |
| Nov. 2005 | 5        | Modification on <i>Table 3 on page 4</i> . LM293,A must be -40/+105°C instead of -40/+125°C. |

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