

## LOW POWER DUAL VOLTAGE COMPARATORS

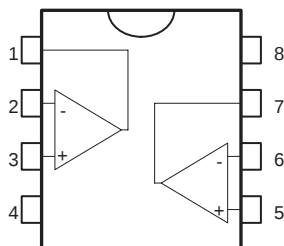
- WIDE SINGLE SUPPLY VOLTAGE RANGE OR DUAL SUPPLIES : +2V TO +36V OR  $\pm 1V$  TO  $\pm 18V$
- VERY LOW SUPPLY CURRENT (0.4mA) INDEPENDENT OF SUPPLY VOLTAGE (1mW/comparator at +5V)
- LOW INPUT BIAS CURRENT : 25nA TYP
- LOW INPUT OFFSET CURRENT :  $\pm 5nA$  TYP
- LOW INPUT OFFSET VOLTAGE :  $\pm 1mV$  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

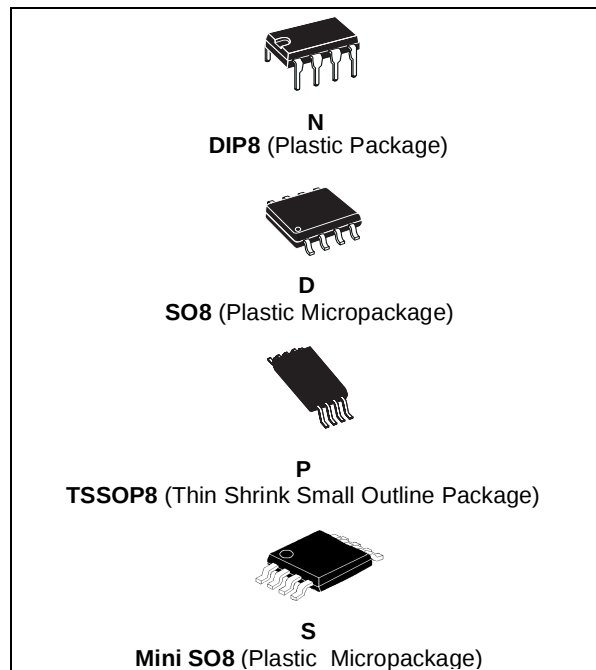
These devices consist of two independent low voltage comparators designed specifically to operate from a single supply over a wide range of voltages. Operation from split power supplies is also possible.

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.

### PIN CONNECTIONS (top view)



- 1 - Output 1
- 2 - Inverting input 1
- 3 - Non-inverting input 1
- 4 -  $V_{CC}^-$
- 5 - Non-inverting input 2
- 6 - Inverting input 2
- 7 - Output 2
- 8 -  $V_{CC}^+$

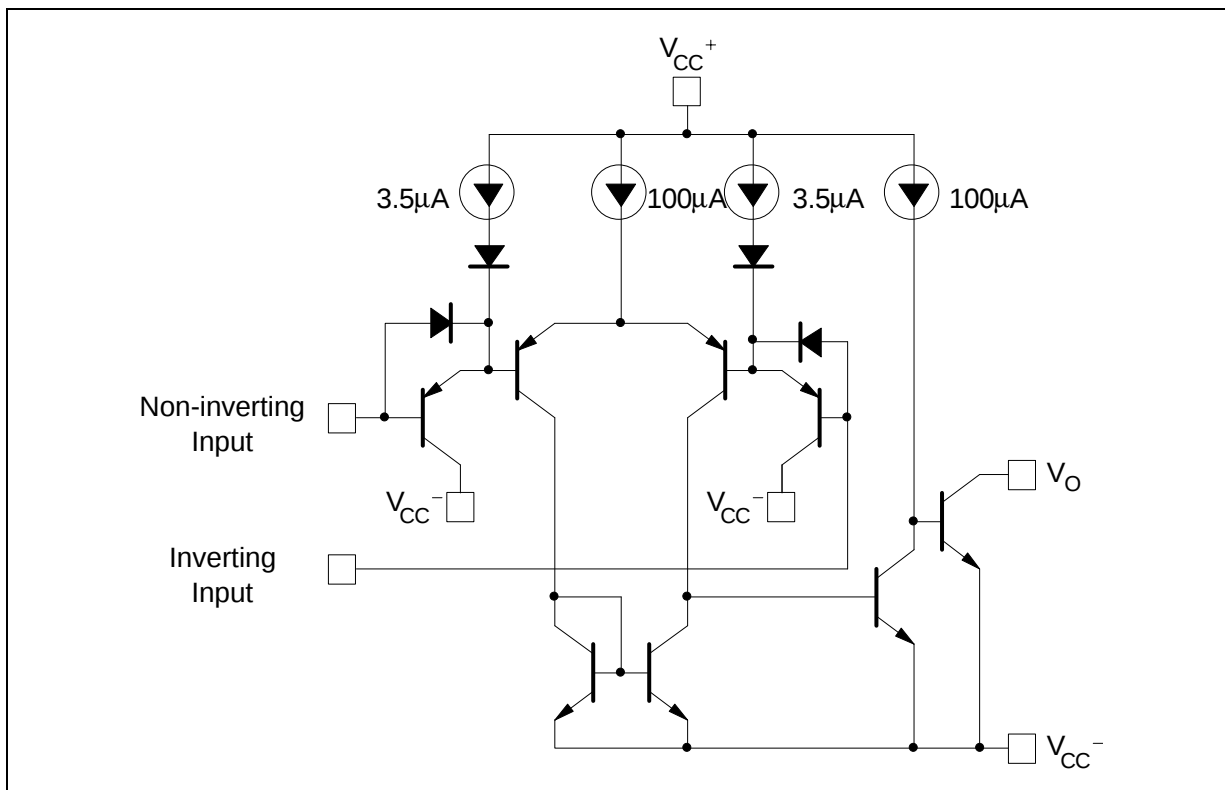


### ORDER CODE

| Part Number      | Temperature Range | Package |   |   |   |
|------------------|-------------------|---------|---|---|---|
|                  |                   | N       | D | P | S |
| LM193            | -55°C, +125°C     | •       | • | • | • |
| LM293            | -40°C, +105°C     | •       | • | • | • |
| LM393            | 0°C, +70°C        | •       | • | • | • |
| Example : LM393D |                   |         |   |   |   |

N = Dual in Line Package (DIP)  
D = Small Outline Package (SO) - also available in Tape & Reel (DT)  
P = Thin Shrink Small Outline Package (TSSOP) - only available in Tape & Reel (PT)  
S = MiniSO Package (MiniSO) only available in Tape & Reel (ST)

## SCHEMATIC DIAGRAM (1/2 LM193)



## ABSOLUTE MAXIMUM RATINGS

| Symbol    | Parameter                                                            | Value                     | Unit |
|-----------|----------------------------------------------------------------------|---------------------------|------|
| $V_{CC}$  | Supply voltage                                                       | $\pm 18$ or 36            | V    |
| $V_{id}$  | Differential Input Voltage                                           | $\pm 36$                  | V    |
| $V_i$     | Input Voltage                                                        | -0.3 to +36               | V    |
|           | Output Short-circuit to Ground - note <sup>1)</sup>                  | Infinite                  |      |
| $P_d$     | Power Dissipation <sup>2)</sup><br>DIP8<br>SO8<br>TSSOP8<br>Mini SO8 | 1250<br>710<br>625<br>580 | mW   |
| $T_{stg}$ | Storage Temperature Range                                            | -65 to +150               | °C   |

1. Short-circuits from the output to  $V_{CC}^+$  can cause excessive heating and eventual destruction. The maximum output current is approximately 20mA independent of the magnitude of  $V_{CC}^+$ .

2.  $P_d$  is calculated with  $T_{amb} = +25^\circ\text{C}$ ,  $T_j = +150^\circ\text{C}$  and  $R_{thja} = 100^\circ\text{C/W}$  for DIP8 package  
 $= 175^\circ\text{C/W}$  for SO8 package  
 $= 200^\circ\text{C/W}$  for TSSOP8 package  
 $= 215^\circ\text{C/W}$  for Mini SO8 package

## OPERATING CONDITIONS

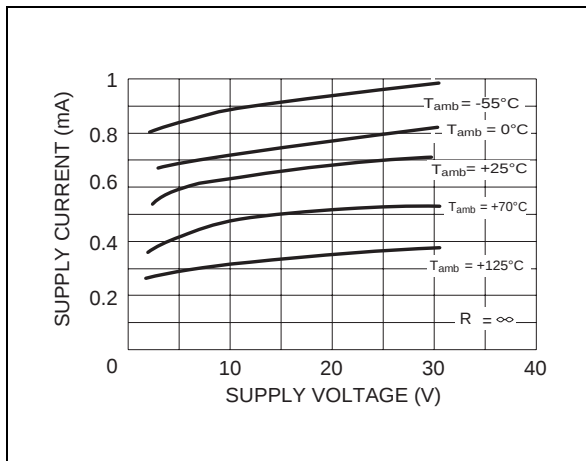
| Symbol     | Parameter                                                       | Value                                  | Unit |
|------------|-----------------------------------------------------------------|----------------------------------------|------|
| $V_{icm}$  | Common Mode Input Voltage Range                                 | 0 to $V_{CC}^+ - 1.5$                  | V    |
| $T_{oper}$ | Operating Free-Air Temperature range<br>LM193<br>LM293<br>LM393 | -55 to +125<br>-40 to +125<br>0 to +70 | °C   |

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

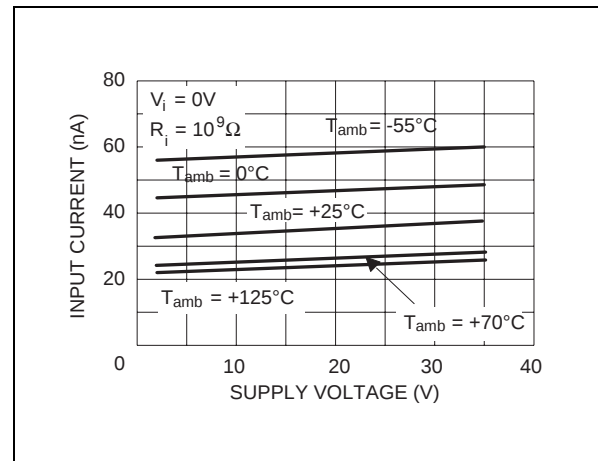
| Symbol     | Parameter                                                                                                                                             | Min    | Typ.     | Max.                               | Unit          |
|------------|-------------------------------------------------------------------------------------------------------------------------------------------------------|--------|----------|------------------------------------|---------------|
| $V_{io}$   | Input Offset Voltage - note <sup>1)</sup><br>$T_{amb} = +25^\circ C$<br>$T_{min} \leq T_{amb} \leq T_{max}$                                           |        | 1        | 5<br>9                             | mV            |
| $I_{ib}$   | Input Bias Current - note <sup>2)</sup><br>$T_{amb} = +25^\circ C$<br>$T_{min} \leq T_{amb} \leq T_{max}$                                             |        | 25       | 250<br>400                         | nA            |
| $I_{io}$   | Input Offset Current<br>$T_{amb} = +25^\circ C$<br>$T_{min} \leq T_{amb} \leq T_{max}$                                                                |        | 5        | 50<br>150                          | nA            |
| $A_{vd}$   | Large Signal Voltage Gain<br>$V_{CC} = 15V$ , $R_L = 15k\Omega$ , $V_O = 1V$ to $11V$                                                                 | 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                           | mA            |
| $V_{icm}$  | Input Common Mode Voltage Range - note <sup>3)</sup><br>$T_{amb} = +25^\circ C$<br>$T_{min} \leq T_{amb} \leq T_{max}$                                | 0<br>0 |          | $V_{CC}^+ - 1.5$<br>$V_{CC}^+ - 2$ | V             |
| $V_{id}$   | Differential Input Voltage -note <sup>4)</sup>                                                                                                        |        |          | $V_{CC}^+$                         | V             |
| $I_{sink}$ | Output Sink Current<br>$V_{id} = 1V$ , $V_O = 1.5V$                                                                                                   | 6      | 16       |                                    | mA            |
| $V_{OL}$   | 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                         | mV            |
| $I_{OH}$   | High Level Output Current ( $V_{id} = 1V$ )<br>$V_{id} = 1V$ , $V_{CC} = V_O = 30V$<br>$T_{amb} = +25^\circ C$<br>$T_{min} \leq T_{amb} \leq T_{max}$ |        | 0.1      | 1                                  | nA<br>$\mu A$ |
| $t_{re}$   | Response Time - note <sup>5)</sup><br>$R_L = 5.1k\Omega$ to $V_{CC}^+$                                                                                |        | 1.3      |                                    | $\mu s$       |
| $t_{rel}$  | Large Signal Response Time<br>$V_i = TTL$ , $V_{(ref)} = +1.4V$ , $R_L = 5.1k\Omega$ to $V_{CC}^+$                                                    |        | 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 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.
- 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).
- The response time specified is for a  $100mV$  input step with  $5mV$  overdrive. For larger overdrive signals  $300ns$  can be obtained.

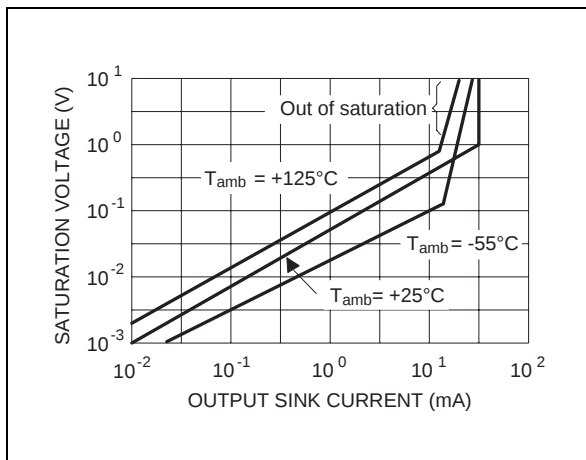
### SUPPLY CURRENT versus SUPPLY VOLTAGE



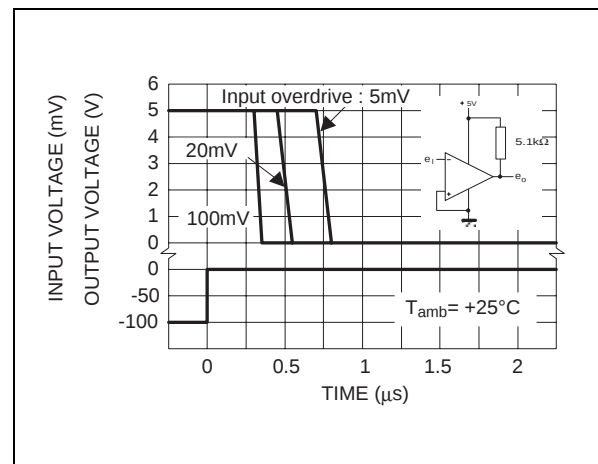
### INPUT CURRENT versus SUPPLY VOLTAGE



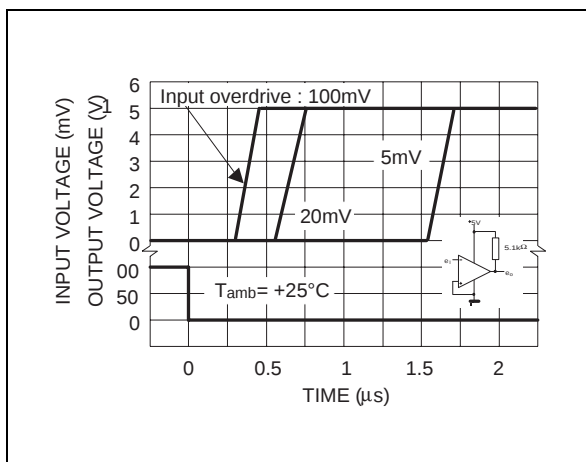
### OUTPUT SATURATION VOLTAGE versus OUTPUT CURRENT



### RESPONSE TIME FOR VARIOUS INPUT OVERDRIVES - NEGATIVE TRANSITION

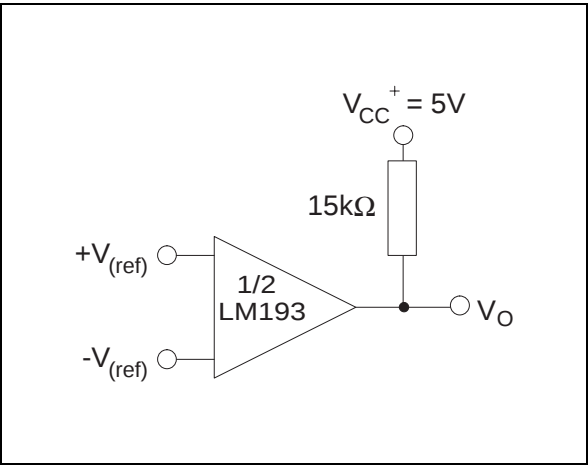


### RESPONSE TIME FOR VARIOUS INPUT OVERDRIVES - POSITIVE TRANSITION

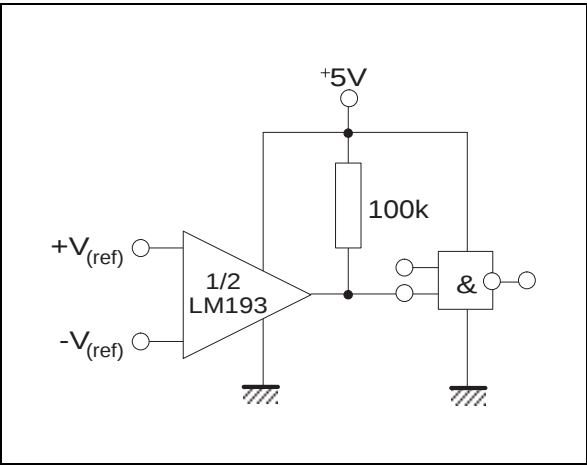


TYPICAL APPLICATIONS

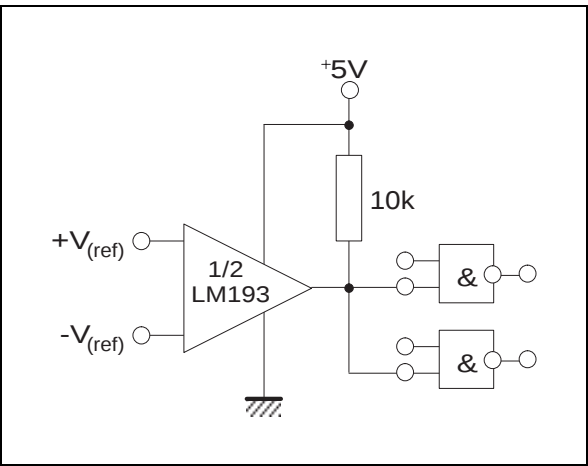
BASIC COMPARATOR



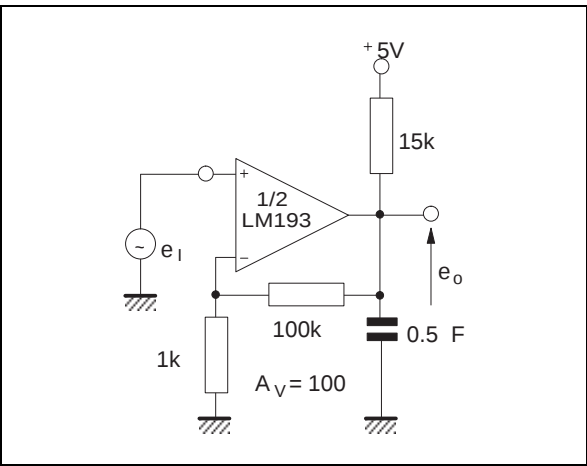
DRIVING CMOS



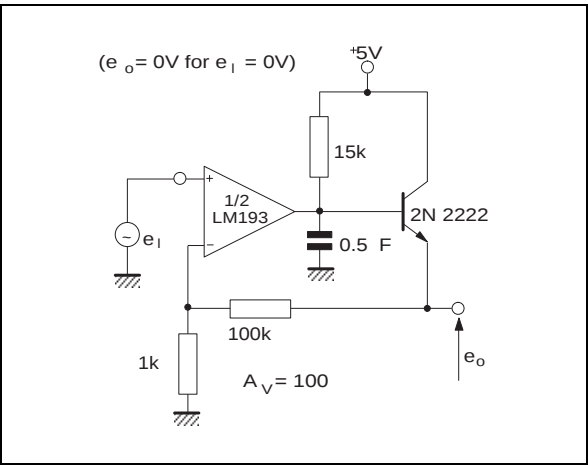
DRIVING TTL



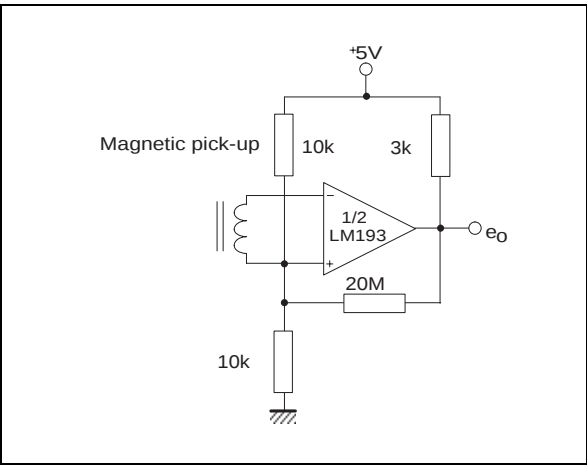
LOW FREQUENCY OP AMP



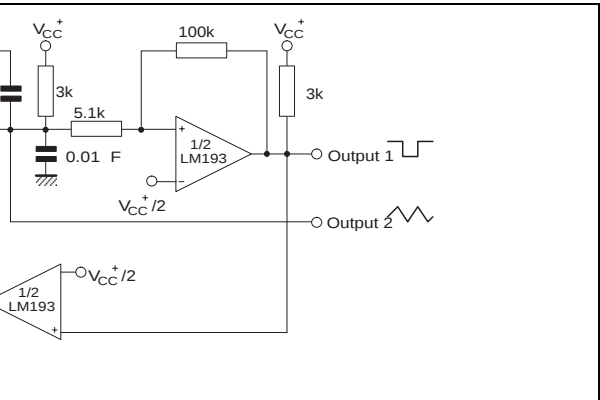
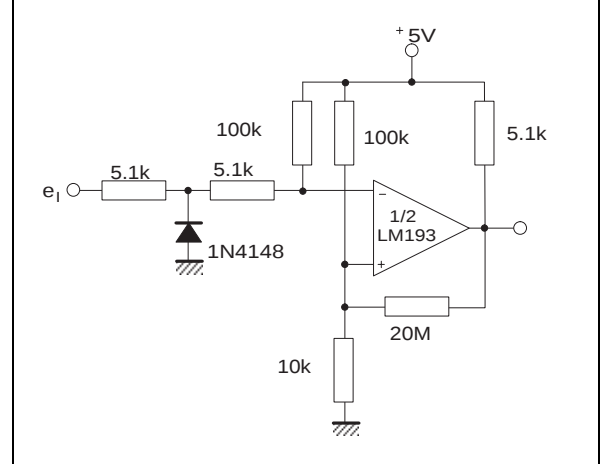
LOW FREQUENCY OP AMP



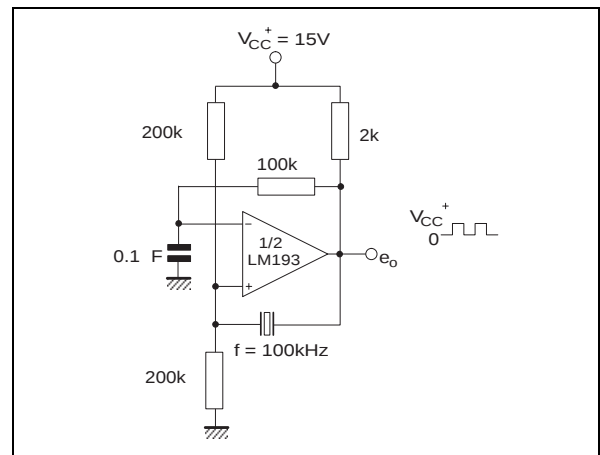
TRANSDUCER AMPLIFIER

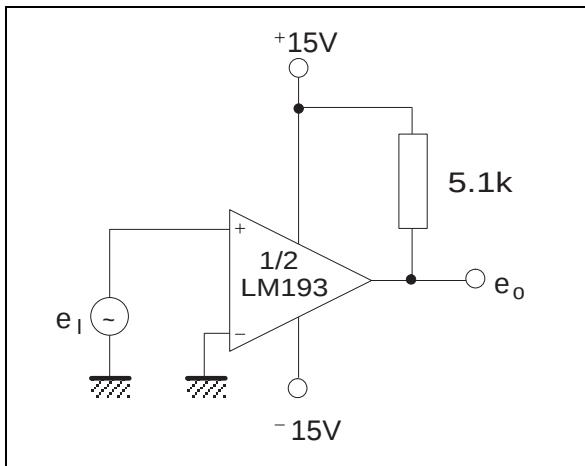
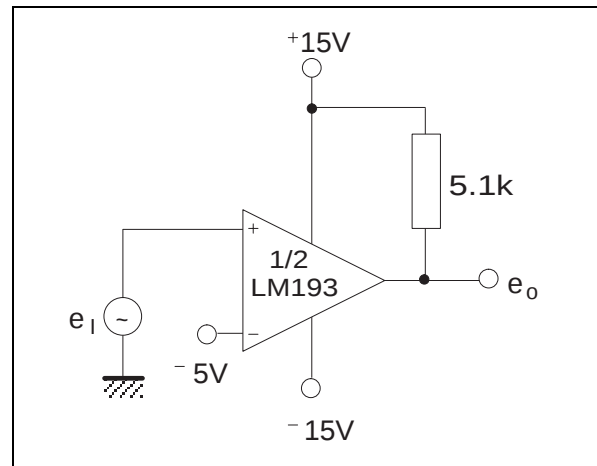


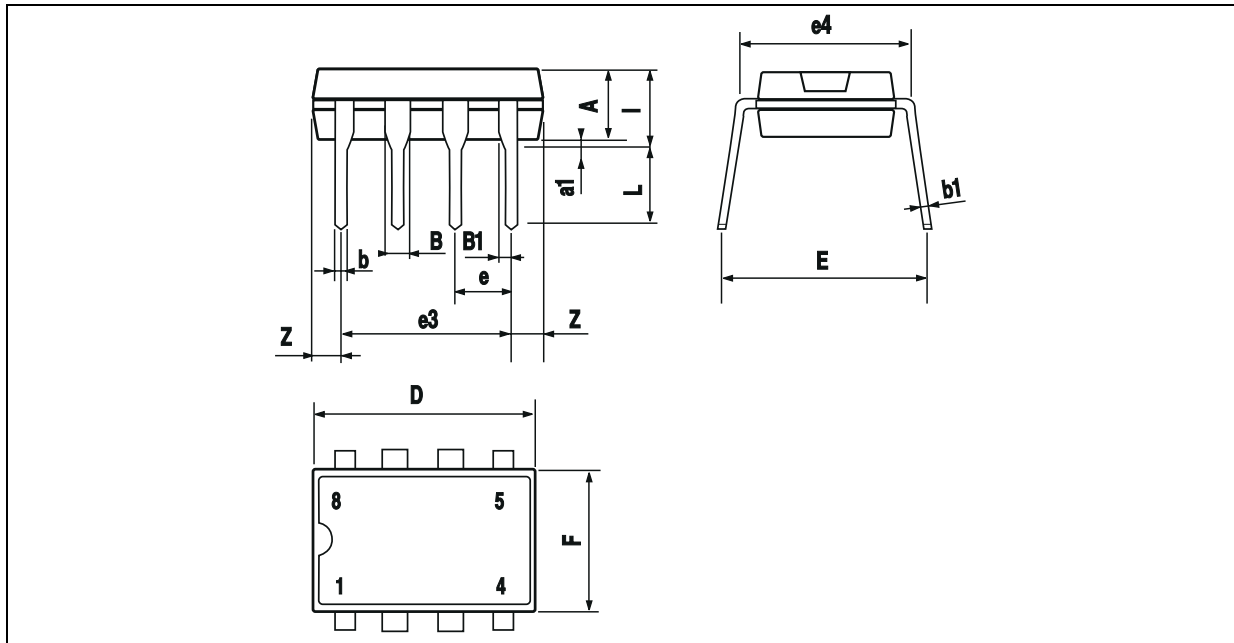
### ZERO CROSSING DETECTOR (single power supply)



## CRYSTAL CONTROLLED OSCILLATOR

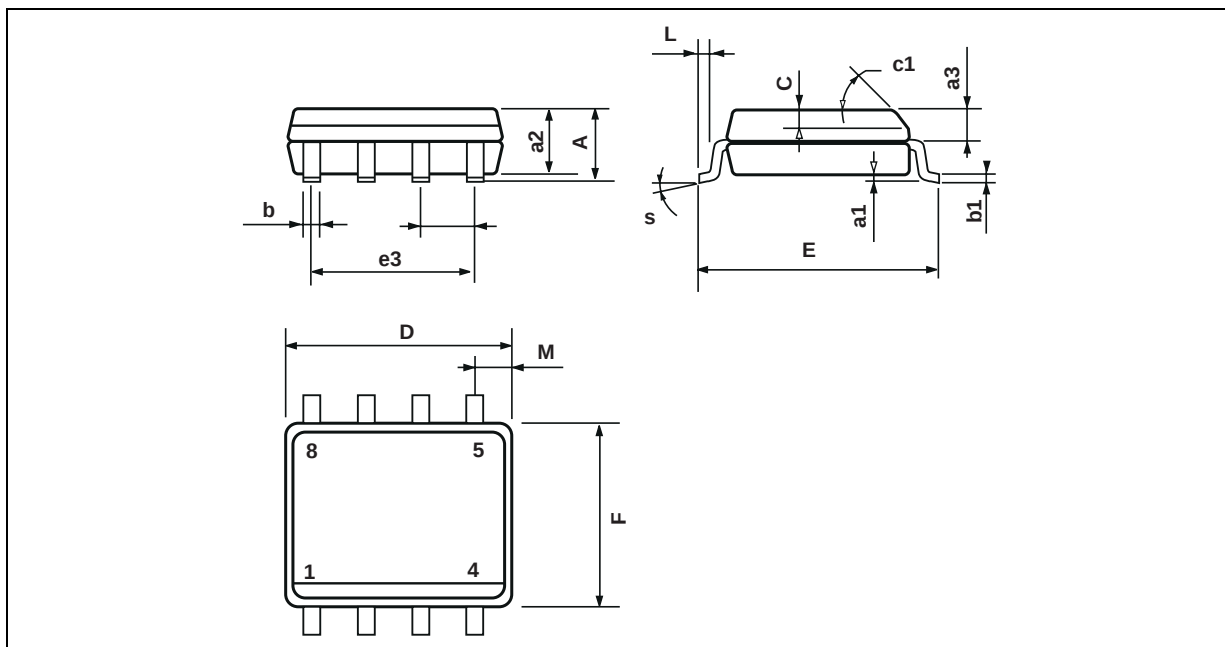


**SPLIT-SUPPLY APPLICATIONS****ZERO CROSSING DETECTOR****COMPARATOR WITH A NEGATIVE REFERENCE**

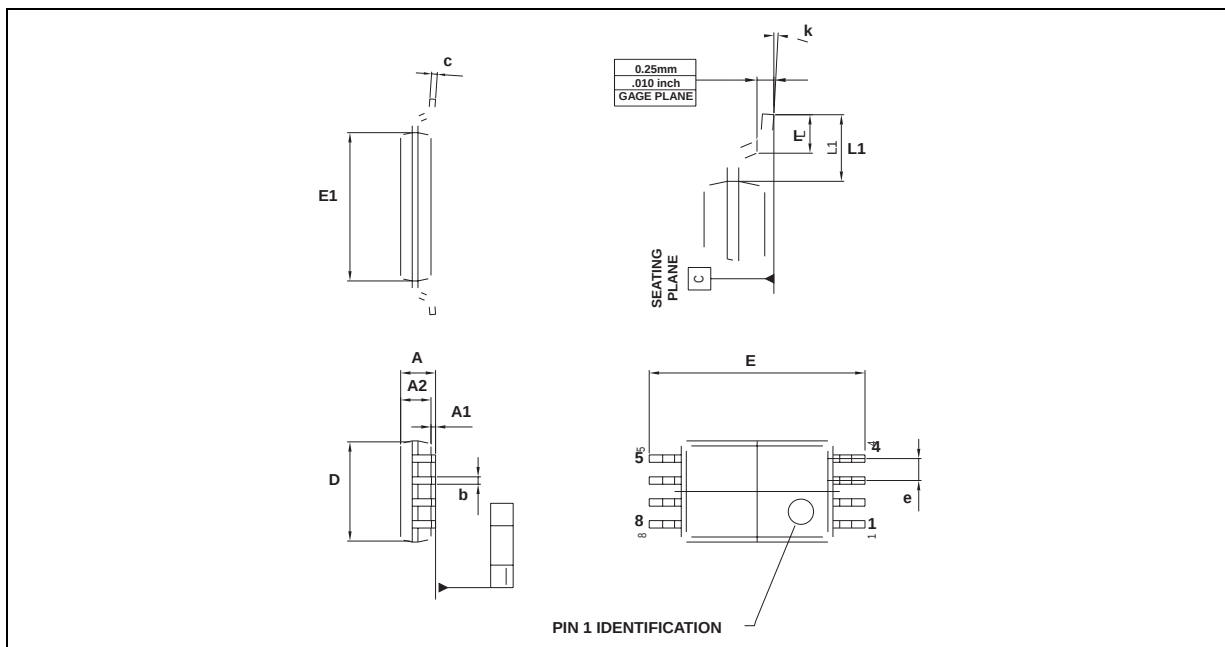
**PACKAGE MECHANICAL DATA**  
 8 PINS - PLASTIC DIP


| Dimensions | Millimeters |      |       | Inches |       |       |
|------------|-------------|------|-------|--------|-------|-------|
|            | Min.        | Typ. | Max.  | Min.   | Typ.  | Max.  |
| A          |             | 3.32 |       |        | 0.131 |       |
| a1         | 0.51        |      |       | 0.020  |       |       |
| B          | 1.15        |      | 1.65  | 0.045  |       | 0.065 |
| b          | 0.356       |      | 0.55  | 0.014  |       | 0.022 |
| b1         | 0.204       |      | 0.304 | 0.008  |       | 0.012 |
| D          |             |      | 10.92 |        |       | 0.430 |
| E          | 7.95        |      | 9.75  | 0.313  |       | 0.384 |
| e          |             | 2.54 |       |        | 0.100 |       |
| e3         |             | 7.62 |       |        | 0.300 |       |
| e4         |             | 7.62 |       |        | 0.300 |       |
| F          |             |      | 6.6   |        |       | 0.260 |
| i          |             |      | 5.08  |        |       | 0.200 |
| L          | 3.18        |      | 3.81  | 0.125  |       | 0.150 |
| Z          |             |      | 1.52  |        |       | 0.060 |

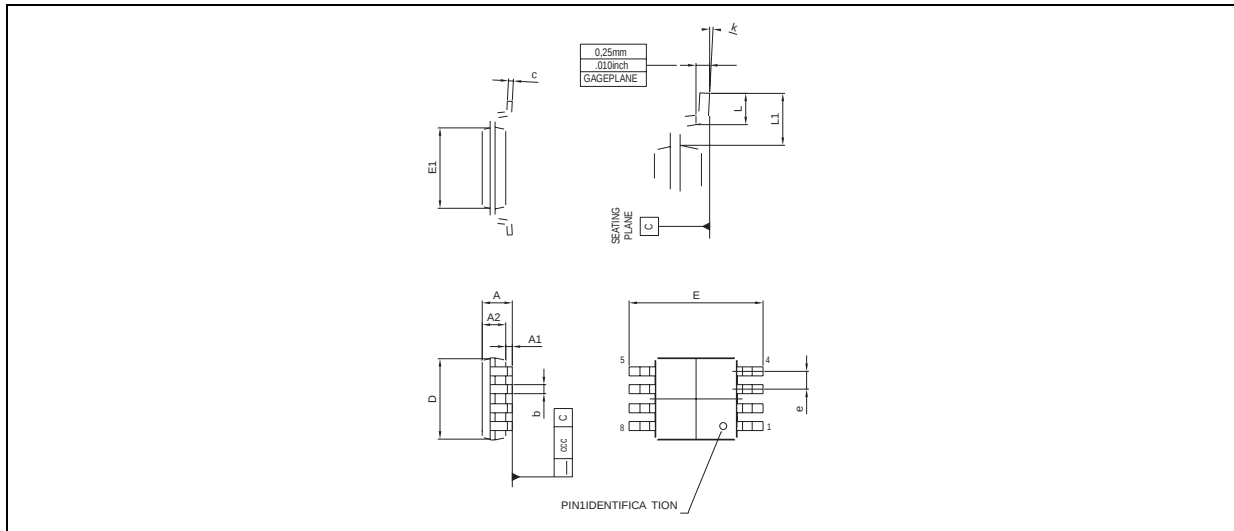
**PACKAGE MECHANICAL DATA**  
**8 PINS - PLASTIC MICROPACKAGE (SO)**



| Dimensions | Millimeters |      |      | Inches |       |       |
|------------|-------------|------|------|--------|-------|-------|
|            | Min.        | Typ. | Max. | Min.   | Typ.  | Max.  |
| A          |             |      | 1.75 |        |       | 0.069 |
| a1         | 0.1         |      | 0.25 | 0.004  |       | 0.010 |
| a2         |             |      | 1.65 |        |       | 0.065 |
| a3         | 0.65        |      | 0.85 | 0.026  |       | 0.033 |
| b          | 0.35        |      | 0.48 | 0.014  |       | 0.019 |
| b1         | 0.19        |      | 0.25 | 0.007  |       | 0.010 |
| C          | 0.25        |      | 0.5  | 0.010  |       | 0.020 |
| c1         | 45° (typ.)  |      |      |        |       |       |
| D          | 4.8         |      | 5.0  | 0.189  |       | 0.197 |
| E          | 5.8         |      | 6.2  | 0.228  |       | 0.244 |
| e          |             | 1.27 |      |        | 0.050 |       |
| e3         |             | 3.81 |      |        | 0.150 |       |
| F          | 3.8         |      | 4.0  | 0.150  |       | 0.157 |
| L          | 0.4         |      | 1.27 | 0.016  |       | 0.050 |
| M          |             |      | 0.6  |        |       | 0.024 |
| S          | 8° (max.)   |      |      |        |       |       |

**PACKAGE MECHANICAL DATA****8 PINS - THIN SHRINK SMALL OUTLINE PACKAGE**

| Dimensions | Millimeters |       |      | Inches |        |       |
|------------|-------------|-------|------|--------|--------|-------|
|            | Min.        | Typ.  | Max. | Min.   | Typ.   | Max.  |
| A          |             |       | 1.20 |        |        | 0.05  |
| A1         | 0.05        |       | 0.15 | 0.01   |        | 0.006 |
| A2         | 0.80        | 1.00  | 1.05 | 0.031  | 0.039  | 0.041 |
| b          | 0.19        |       | 0.30 | 0.007  |        | 0.15  |
| c          | 0.09        |       | 0.20 | 0.003  |        | 0.012 |
| D          | 2.90        | 3.00  | 3.10 | 0.114  | 0.118  | 0.122 |
| E          |             | 6.40  |      |        | 0.252  |       |
| E1         | 4.30        | 4.40  | 4.50 | 0.169  | 0.173  | 0.177 |
| e          |             | 0.65  |      |        | 0.025  |       |
| k          | 0°          |       | 8°   | 0°     |        | 8°    |
| l          | 0.50        | 0.60  | 0.75 | 0.09   | 0.0236 | 0.030 |
| L          | 0.45        | 0.600 | 0.75 | 0.018  | 0.024  | 0.030 |
| L1         |             | 1.000 |      |        | 0.039  |       |

**PACKAGE MECHANICAL DATA****8 PINS - PLASTIC MICROPACKAGE (miniSO)**

| Dimensions | Millimeters |       |       | Inches |       |       |
|------------|-------------|-------|-------|--------|-------|-------|
|            | Min.        | Typ.  | Max.  | Min.   | Typ.  | Max.  |
| A          |             |       | 1.100 |        |       | 0.043 |
| A1         | 0.050       | 0.100 | 0.150 | 0.002  | 0.004 | 0.006 |
| A2         | 0.780       | 0.860 | 0.940 | 0.031  | 0.034 | 0.037 |
| b          | 0.250       | 0.330 | 0.400 | 0.010  | 0.013 | 0.016 |
| c          | 0.130       | 0.180 | 0.230 | 0.005  | 0.007 | 0.009 |
| D          | 2.900       | 3.000 | 3.100 | 0.114  | 0.118 | 0.122 |
| E          | 4.750       | 4.900 | 5.050 | 0.187  | 0.193 | 0.199 |
| E1         | 2.900       | 3.000 | 3.100 | 0.114  | 0.118 | 0.122 |
| e          |             | 0.650 |       |        | 0.026 |       |
| L          | 0.400       | 0.550 | 0.700 | 0.016  | 0.022 | 0.028 |
| L1         |             | 0.950 |       |        | 0.037 |       |
| k          | 0d          | 3d    | 6d    | 0d     | 3d    | 6d    |
| aaa        |             |       | 0.100 |        |       | 0.004 |

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