

## LM193A/LM193QML Low Power Low Offset Voltage Dual Comparators

Check for Samples: [LM193A](#), [LM193QML](#)

### FEATURES

- Available with Radiation Guarantee
  - Total Ionizing Dose 100 krad(Si)
  - ELDRS Free 100 krad(Si)
- Wide Supply
  - Voltage Range:  $2.0V_{DC}$  to  $36V_{DC}$
  - Single or Dual Supplies:  $\pm 1.0V$  to  $\pm 18V$
- Very Low Supply Current Drain (0.4 mA) — Independent of Supply Voltage
- Low Input Biasing Current: 25 nA typ
- Low Input Offset Current:  $\pm 5$  nA typ
- Input Common-Mode Voltage Range Includes Ground
- Differential Input Voltage Range Equal to the Power Supply Voltage
- Low Output Saturation Voltage,  $\pm 250$  mV at 4 mA typ
- Output Voltage Compatible with TTL, DTL, ECL, MOS and CMOS Logic Systems

### ADVANTAGES

- High Precision Comparators
- Reduced  $V_{OS}$  Drift Over Temperature
- Eliminates Need for Dual Supplies
- Allows Sensing Near Ground
- Compatible with All Forms of Logic
- Power Drain Suitable for Battery Operation

### DESCRIPTION

The LM193 series consists of two independent precision voltage comparators with an offset voltage specification as low as 2.0 mV max for two comparators which were designed specifically to operate from a single power supply over a wide range of voltages. Operation from split power supplies is also possible and the low power supply current drain is independent of the magnitude of the power supply voltage. 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.

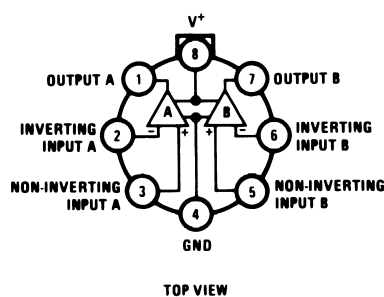
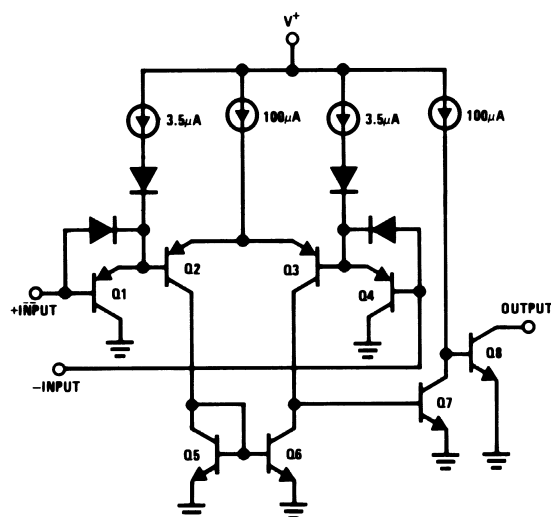
Application areas include limit comparators, simple analog to digital converters; pulse, squarewave and time delay generators; wide range VCO; MOS clock timers; multivibrators and high voltage digital logic gates. The LM193 series was designed to directly interface with TTL and CMOS. When operated from both plus and minus power supplies, the LM193 series will directly interface with MOS logic where their low power drain is a distinct advantage over standard comparators.



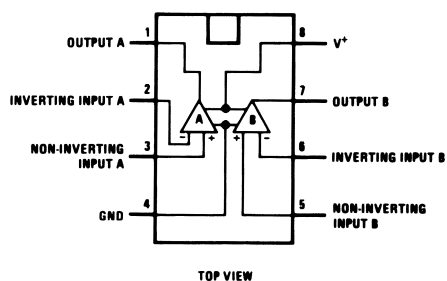
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## Schematic and Connection Diagrams



**Figure 1. TO-99 Package**  
See Package Number LMC



**Figure 2. CDIP Package**  
See Package Number NAB0008A



These devices have limited built-in ESD protection. The leads should be shorted together or the device placed in conductive foam during storage or handling to prevent electrostatic damage to the MOS gates.

## Absolute Maximum Ratings<sup>(1)</sup>

|                                                                       |                 |                                           |         |
|-----------------------------------------------------------------------|-----------------|-------------------------------------------|---------|
| Supply Voltage, V <sup>+</sup>                                        |                 | 36V <sub>DC</sub> or ±18V <sub>DC</sub>   |         |
| Differential Input Voltage <sup>(2)</sup>                             |                 | 36V                                       |         |
| Input Voltage                                                         |                 | −0.3V <sub>DC</sub> to +36V <sub>DC</sub> |         |
| Input Current (V <sub>IN</sub> < −0.3V <sub>DC</sub> ) <sup>(3)</sup> |                 | 50 mA                                     |         |
| Maximum Junction Temperature                                          |                 | 150°C                                     |         |
| Power Dissipation <sup>(4)(5)</sup>                                   | TO-99           | 660 mW                                    |         |
|                                                                       | CDIP            | 780 mW                                    |         |
| Output Short-Circuit to Ground <sup>(6)</sup>                         |                 | Continuous                                |         |
| Operating Temperature Range                                           |                 | −55°C ≤ T <sub>A</sub> ≤ +125°C           |         |
| Storage Temperature Range                                             |                 | −65°C ≤ T <sub>A</sub> ≤ +150°C           |         |
| Thermal Resistance                                                    | θ <sub>JA</sub> | TO-99 (Still Air)                         | 174°C/W |
|                                                                       |                 | TO-99 (500LF/Min Air flow)                | 99°C/W  |
|                                                                       |                 | CDIP (Still Air)                          | 146°C/W |
|                                                                       |                 | CDIP (500LF/Min Air flow)                 | 85°C/W  |
|                                                                       | θ <sub>JC</sub> | TO-99                                     | 44°C/W  |
|                                                                       |                 | CDIP                                      | 33°C/W  |
| Lead Temperature (Soldering, 10 seconds)                              |                 | 260°C                                     |         |
| ESD Tolerance <sup>(7)</sup>                                          |                 | 500V                                      |         |

- (1) Absolute Maximum Ratings indicate limits beyond which damage to the device may occur. Operating Ratings indicate conditions for which the device is functional, but do not ensure specific performance limits. For ensured specifications and test conditions, see the Electrical Characteristics. The ensured specifications apply only for the test conditions listed. Some performance characteristics may degrade when the device is not operated under the listed test conditions.
- (2) 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 magnitude of the negative power supply, if used).
- (3) This input current will only exist when the voltage at any of the input leads is driven negative. It is due to the collector-base junction of the input PNP transistors becoming forward biased and thereby acting as input diode clamps. In addition to this diode action, there is also lateral NPN parasitic transistor action on the IC chip. This transistor action can cause the output voltages of the comparators to go to the  $V^+$  voltage level (or to ground for a large overdrive) for the time duration that an input is driven negative. This is not destructive and normal output states will re-establish when the input voltage, which was negative, again returns to a value greater than -0.3V<sub>DC</sub>.
- (4) The maximum power dissipation must be derated at elevated temperatures and is dictated by T<sub>Jmax</sub> (maximum junction temperature),  $\theta_{JA}$  (package junction to ambient thermal resistance), and T<sub>A</sub> (ambient temperature). The maximum allowable power dissipation at any temperature is  $P_{Dmax} = (T_{Jmax} - T_A)/\theta_{JA}$  or the number given in the Absolute Maximum Ratings, whichever is lower.
- (5) The LM193A must be derated based on a 150°C, T<sub>Jmax</sub>. The low bias dissipation and the ON-OFF characteristic of the outputs keep the chip dissipation very small ( $P_D \leq 100mW$ ), provided the output transistors are allowed to saturate.
- (6) Short circuits from the output to  $V^+$  can cause excessive heating and eventual destruction. When considering short circuits to ground, the maximum output current is approximately 20 mA independent of the magnitude of  $V^+$ .
- (7) Human body model, 1.5K $\Omega$  in series with 100pF.

## Quality Conformance Inspection

Mil-Std-883, Method 5005 - Group A

| Subgroup | Description         | Temp°C |
|----------|---------------------|--------|
| 1        | Static tests at     | 25     |
| 2        | Static tests at     | 125    |
| 3        | Static tests at     | -55    |
| 4        | Dynamic tests at    | 25     |
| 5        | Dynamic tests at    | 125    |
| 6        | Dynamic tests at    | -55    |
| 7        | Functional tests at | 25     |
| 8A       | Functional tests at | 125    |
| 8B       | Functional tests at | -55    |

## Quality Conformance Inspection (continued)

Mil-Std-883, Method 5005 - Group A

| Subgroup | Description        | Temp°C |
|----------|--------------------|--------|
| 9        | Switching tests at | 25     |
| 10       | Switching tests at | 125    |
| 11       | Switching tests at | -55    |
| 12       | Settling time at   | 25     |
| 13       | Settling time at   | 125    |
| 14       | Settling time at   | -55    |

## LM193 Electrical Characteristics DC Parameters

The following conditions apply, unless otherwise specified. +V = 5V, V<sub>CM</sub> = 0V

| Symbol            | Parameter                    | Conditions                                                                    | Notes              | Min   | Max  | Unit | Sub-groups |
|-------------------|------------------------------|-------------------------------------------------------------------------------|--------------------|-------|------|------|------------|
| I <sub>CC</sub>   | Supply Current               |                                                                               |                    |       | 1.0  | mA   | 1, 2, 3    |
|                   |                              | +V = 36V                                                                      |                    |       | 2.5  | mA   | 1, 2, 3    |
| I <sub>CEX</sub>  | Output Leakage Current       | +V = 30V, +V <sub>I</sub> = 1V,<br>V <sub>O</sub> = 30V, -V <sub>I</sub> = 0V |                    | -0.65 | 0.65 | μA   | 1          |
|                   |                              |                                                                               |                    | -1.0  | 1.0  | μA   | 2, 3       |
| I <sub>Sink</sub> | Output Sink Current          | V <sub>O</sub> = 1.5V, -V <sub>I</sub> = 1V,<br>+V <sub>I</sub> = 0V          |                    | 6.0   |      | mA   | 1          |
| V <sub>Sat</sub>  | Output Saturation Voltage    | I <sub>Sink</sub> = 4mA, -V <sub>I</sub> = 1V,<br>+V <sub>I</sub> = 0V        |                    |       | 0.4  | V    | 1          |
|                   |                              |                                                                               |                    |       | 0.7  | V    | 2, 3       |
| V <sub>IO</sub>   | Input Offset Voltage         |                                                                               |                    | -5.0  | 5.0  | mV   | 1          |
|                   |                              |                                                                               |                    | -9.0  | 9.0  | mV   | 2, 3       |
|                   |                              | +V = 30V                                                                      |                    | -5.0  | 5.0  | mV   | 1          |
|                   |                              |                                                                               |                    | -9.0  | 9.0  | mV   | 2, 3       |
|                   |                              | +V = 30V, V <sub>CM</sub> = 28.5V                                             |                    | -5.0  | 5.0  | mV   | 1          |
|                   |                              | +V = 30V, V <sub>CM</sub> = 28.0V                                             |                    | -9.0  | 9.0  | mV   | 2, 3       |
| ±I <sub>IB</sub>  | Input Bias Current           |                                                                               |                    | -100  | -1.0 | nA   | 1          |
|                   |                              |                                                                               |                    | -300  | -1.0 | nA   | 2, 3       |
| I <sub>IO</sub>   | Input offset Current         | R <sub>S</sub> = 50Ω                                                          |                    | -25   | 25   | nA   | 1          |
|                   |                              |                                                                               |                    | -100  | 100  | nA   | 2, 3       |
| V <sub>CM</sub>   | Common Mode Voltage          | +V = 30V                                                                      | See <sup>(1)</sup> |       | 28.5 | V    | 1          |
|                   |                              |                                                                               | See <sup>(1)</sup> |       | 28   | V    | 2, 3       |
| PSRR              | Power Supply Rejection Ratio | +V = 5V to 30V,<br>R <sub>S</sub> = 50Ω                                       |                    | 60    |      | dB   | 1          |
| CMRR              | Common Mode Rejection Ratio  | +V = 30V, R <sub>S</sub> = 50Ω<br>V <sub>CM</sub> = 0V to 28.5V,              |                    | 60    |      | dB   | 1          |
| V <sub>Diff</sub> | Differential Input Voltage   | +V = 30V, +V <sub>I</sub> = 36V,<br>-V <sub>I</sub> = 0V                      | See <sup>(2)</sup> |       | 500  | nA   | 1, 2, 3    |
|                   |                              | +V = 30V, +V <sub>I</sub> = 0V,<br>-V <sub>I</sub> = +36V                     | See <sup>(2)</sup> |       | 500  | nA   | 1, 2, 3    |
| A <sub>VS</sub>   | Voltage Gain                 | +V = 15V, R <sub>PULLUP</sub> = 15KΩ<br>1V ≤ V <sub>O</sub> ≤ 11V,            | See <sup>(3)</sup> | 50    |      | V/mV | 4          |

(1) Parameter specified by the V<sub>IO</sub> tests.

(2) The value for V<sub>Diff</sub> is not datalogged during Read and Record.

(3) Datalog reading in K = V/mV.

## LM193 Electrical Characteristics AC Parameters

The following conditions apply, unless otherwise specified. +V = 5V

| Symbol    | Parameter     | Conditions      | Notes | Min | Max | Unit    | Sub-groups |
|-----------|---------------|-----------------|-------|-----|-----|---------|------------|
| $t_{RLH}$ | Response Time | $V_{OD} = 5mV$  |       |     | 5.0 | $\mu S$ | 9          |
|           |               | $V_{OD} = 50mV$ |       |     | 0.8 | $\mu S$ | 9          |
| $t_{RHL}$ | Response Time | $V_{OD} = 5mV$  |       |     | 2.5 | $\mu S$ | 9          |
|           |               | $V_{OD} = 50mV$ |       |     | 0.8 | $\mu S$ | 9          |

## LM193A Electrical Characteristics DC Parameters

The following conditions apply, unless otherwise specified. +V = 5V,  $V_{CM} = 0V$

| Symbol       | Parameter                    | Conditions                                                     | Notes              | Min   | Max  | Unit    | Sub-groups |
|--------------|------------------------------|----------------------------------------------------------------|--------------------|-------|------|---------|------------|
| $I_{CC}$     | Supply Current               | $R_L = \text{Infinity}$                                        |                    |       | 1.0  | mA      | 1, 2, 3    |
|              |                              | +V = 36V, $R_L = \text{Infinity}$                              |                    |       | 2.5  | mA      | 1, 2, 3    |
| $I_{CEX}$    | Output Leakage Current       | +V = 30V, $V_I = 1V$ ,<br>$V_O = 30$ , $-V_I = 0$              |                    | -0.65 | 0.65 | $\mu A$ | 1          |
|              |                              |                                                                |                    | -1.0  | 1.0  | $\mu A$ | 2, 3       |
| $I_{Sink}$   | Output Sink Current          | $V_O = 1.5V$ , $-V_I = 1V$ ,<br>$+V_I = 0V$                    |                    | 6.0   |      | mA      | 1          |
|              |                              |                                                                |                    | 4.0   |      | mA      | 2, 3       |
| $V_{Sat}$    | Output Saturation Voltage    | $I_{Sink} = 4mA$ ,<br>$-V_I = 1V$ , $+V_I = 0V$                |                    |       | 0.4  | V       | 1          |
|              |                              |                                                                |                    |       | 0.7  | V       | 2, 3       |
| $V_{IO}$     | Input Offset Voltage         |                                                                |                    | -2.0  | 2.0  | mV      | 1          |
|              |                              |                                                                |                    | -4.0  | 4.0  | mV      | 2, 3       |
|              |                              | +V = 30V                                                       |                    | -2.0  | 2.0  | mV      | 1          |
|              |                              |                                                                |                    | -4.0  | 4.0  | mV      | 2, 3       |
|              |                              | +V = 30V, $V_{CM} = 28.5V$                                     |                    | -2.0  | 2.0  | mV      | 1          |
|              |                              | +V = 30V, $V_{CM} = 28.0V$                                     |                    | -4.0  | 4.0  | mV      | 2, 3       |
| $\pm I_{IB}$ | Input Bias Current           | $V_O = 1.5V$                                                   |                    | -100  | -1.0 | nA      | 1          |
|              |                              |                                                                |                    | -300  | -1.0 | nA      | 2, 3       |
| $I_{IO}$     | Input offset Current         | $R_S = 50\Omega$ , $V_O = 1.5V$                                |                    | -25   | 25   | nA      | 1          |
|              |                              |                                                                |                    | -100  | 100  | nA      | 2, 3       |
| $V_{CM}$     | Common Mode Voltage          | +V = 30V                                                       | See <sup>(1)</sup> |       | 28.5 | V       | 1          |
|              |                              |                                                                | See <sup>(1)</sup> |       | 28   | V       | 2, 3       |
| PSRR         | Power Supply Rejection Ratio | +V = 5V to 30V,<br>$R_S = 50\Omega$                            |                    | 60    |      | dB      | 1          |
| CMRR         | Common Mode Rejection Ratio  | +V = 30V, $R_S = 50\Omega$<br>$V_{CM} = 0V$ to 28.5V,          |                    | 60    |      | dB      | 1          |
| $V_{Diff}$   | Differential Input Voltage   | +V = 30V, $+V_I = 36V$ , $-V_I = 0V$                           | See <sup>(2)</sup> |       | 500  | nA      | 1, 2, 3    |
|              |                              | +V = 30V, $+V_I = 0V$ , $-V_I = +36V$                          | See <sup>(2)</sup> |       | 500  | nA      | 1, 2, 3    |
| $A_{VS}$     | Voltage Gain                 | +V = 15V, $R_{pullup} = 15K\Omega$<br>$1V \leq V_O \leq 11V$ , | See <sup>(3)</sup> | 50    |      | V/mV    | 4          |
|              |                              |                                                                | See <sup>(3)</sup> | 25    |      | V/mV    | 5, 6       |

(1) Parameter specified by the  $V_{IO}$  tests.

(2) The value for  $V_{Diff}$  is not datalogged during Read and Record.

(3) Datalog reading in K = V/mV.

## LM193A Electrical Characteristics AC Parameters

The following conditions apply, unless otherwise specified.  $+V = 5V$ ,  $V_{CM} = 0V$

| Symbol    | Parameter     | Conditions      | Notes | Min | Max | Unit    | Sub-groups |
|-----------|---------------|-----------------|-------|-----|-----|---------|------------|
| $t_{RLH}$ | Response Time | $V_{OD} = 5mV$  |       |     | 5.0 | $\mu S$ | 9          |
|           |               | $V_{OD} = 50mV$ |       |     | 0.8 | $\mu S$ | 9          |
| $t_{RHL}$ | Response Time | $V_{OD} = 5mV$  |       |     | 2.5 | $\mu S$ | 9          |
|           |               | $V_{OD} = 50mV$ |       |     | 0.8 | $\mu S$ | 9          |

## LM193A Electrical Characteristics DC Drift Parameters

The following conditions apply, unless otherwise specified.  $+V = 5V$ ,  $V_{CM} = 0V$

Delta calculations performed on QMLV devices at Group B, Subgroup 5 only

| Symbol       | Parameter            | Conditions | Notes | Min  | Max | Unit | Sub-groups |
|--------------|----------------------|------------|-------|------|-----|------|------------|
| $V_{IO}$     | Input Offset Voltage | $+V = 30V$ |       | -1.0 | 1.0 | mV   | 1          |
| $\pm I_{IB}$ | Input Bias Current   |            |       | -15  | 15  | nA   | 1          |

## LM193A - 100K Radiation Electrical Characteristics DC Parameters<sup>(1)(2)</sup>

The following conditions apply, unless otherwise specified.  $+V = 5V$ ,  $V_{CM} = 0V$

| Symbol       | Parameter                    | Conditions                                                  | Notes              | Min   | Max  | Unit    | Sub-groups |
|--------------|------------------------------|-------------------------------------------------------------|--------------------|-------|------|---------|------------|
| $I_{CC}$     | Supply Current               | $R_L = \text{Infinity}$                                     |                    |       | 1.0  | mA      | 1, 2, 3    |
|              |                              | $+V = 36V$ , $R_L = \text{Infinity}$                        |                    |       | 2.5  | mA      | 1, 2, 3    |
| $I_{CEX}$    | Output Leakage Current       | $+V = 30V$ , $+V_I = 1V$ ,<br>$V_O = 30$ , $-V_I = 0$       |                    | -0.65 | 0.65 | $\mu A$ | 1          |
|              |                              |                                                             |                    | -1.0  | 1.0  | $\mu A$ | 2, 3       |
| $I_{Sink}$   | Output Sink Current          | $V_O = 1.5V$ , $-V_I = 1V$ ,<br>$+V_I = 0V$                 |                    | 6.0   |      | mA      | 1          |
|              |                              |                                                             |                    | 4.0   |      | mA      | 2, 3       |
| $V_{Sat}$    | Output Saturation Voltage    | $I_{Sink} = 4mA$ ,<br>$-V_I = 1V$ , $+V_I = 0V$             |                    |       | 0.4  | V       | 1          |
|              |                              |                                                             |                    |       | 0.7  | V       | 2, 3       |
| $V_{IO}$     | Input Offset Voltage         |                                                             |                    | -2.0  | 2.0  | mV      | 1          |
|              |                              |                                                             |                    | -4.0  | 4.0  | mV      | 2, 3       |
|              |                              | $+V = 30V$                                                  |                    | -2.0  | 2.0  | mV      | 1          |
|              |                              |                                                             |                    | -4.0  | 4.0  | mV      | 2, 3       |
|              |                              | $+V = 30V$ , $V_{CM} = 28.5V$                               |                    | -2.0  | 2.0  | mV      | 1          |
|              |                              | $+V = 30V$ , $V_{CM} = 28.0V$                               |                    | -4.0  | 4.0  | mV      | 2, 3       |
| $\pm I_{IB}$ | Input Bias Current           | $V_O = 1.5V$                                                |                    | -100  | -1.0 | nA      | 1          |
|              |                              |                                                             |                    | -300  | -1.0 | nA      | 2, 3       |
| $I_{IO}$     | Input offset Current         | $R_S = 50\Omega$ , $V_O = 1.5V$                             |                    | -25   | 25   | nA      | 1          |
|              |                              |                                                             |                    | -100  | 100  | nA      | 2, 3       |
| $V_{CM}$     | Common Mode Voltage          | $+V = 30V$                                                  | See <sup>(3)</sup> |       | 28.5 | V       | 1          |
|              |                              |                                                             | See <sup>(3)</sup> |       | 28   | V       | 2, 3       |
| PSRR         | Power Supply Rejection Ratio | $+V = 5V$ to $30V$ ,<br>$R_S = 50\Omega$                    |                    | 60    |      | dB      | 1          |
| CMRR         | Common Mode Rejection Ratio  | $+V = 30V$ , $R_S = 50\Omega$<br>$V_{CM} = 0V$ to $28.5V$ , |                    | 60    |      | dB      | 1          |

- (1) Pre and post irradiation limits are identical to those listed under AC and DC electrical characteristics except as listed in the Post Radiation Limits Table. These parts may be dose rate sensitive in a space environment and demonstrate enhanced low dose rate effect. Radiation end point limits for the noted parameters are specified only for the conditions as specified in MIL-STD-883, Method 1019
- (2) Low dose rate testing has been performed on a wafer-by-wafer basis, per test method 1019 condition D of MIL-STD-883, with no enhanced low dose rate sensitivity (ELDRS) effect.
- (3) Parameter specified by the  $V_{IO}$  tests.

## LM193A - 100K Radiation Electrical Characteristics DC Parameters<sup>(1)(2)</sup> (continued)

The following conditions apply, unless otherwise specified. +V = 5V, V<sub>CM</sub> = 0V

| Symbol            | Parameter                  | Conditions                                             | Notes              | Min | Max | Unit | Sub-groups |
|-------------------|----------------------------|--------------------------------------------------------|--------------------|-----|-----|------|------------|
| V <sub>Diff</sub> | Differential Input Voltage | +V = 30V, +V <sub>I</sub> = 36V, -V <sub>I</sub> = 0V  | See <sup>(4)</sup> |     | 500 | nA   | 1, 2, 3    |
|                   |                            | +V = 30V, +V <sub>I</sub> = 0V, -V <sub>I</sub> = +36V | See <sup>(4)</sup> |     | 500 | nA   | 1, 2, 3    |
| A <sub>VS</sub>   | Voltage Gain               | +V = 15V, R <sub>PULLUP</sub> = 15KΩ                   | See <sup>(3)</sup> | 50  |     | V/mV | 4          |
|                   |                            | 1V ≤ V <sub>O</sub> ≤ 11V,                             | See <sup>(5)</sup> | 25  |     | V/mV | 5, 6       |

(4) The value for V<sub>Diff</sub> is not datalogged during Read and Record.

(5) Datalog reading in K = V/mV.

## LM193A - 100K Radiation Electrical Characteristics AC Parameters<sup>(1)(2)</sup>

The following conditions apply, unless otherwise specified. +V = 5V, V<sub>CM</sub> = 0V

| Symbol           | Parameter     | Conditions             | Notes | Min | Max | Unit | Sub-groups |
|------------------|---------------|------------------------|-------|-----|-----|------|------------|
| t <sub>RLH</sub> | Response Time | V <sub>OD</sub> = 5mV  |       |     | 5.0 | μS   | 9          |
|                  |               | V <sub>OD</sub> = 50mV |       |     | 0.8 | μS   | 9          |
| t <sub>RHL</sub> | Response Time | V <sub>OD</sub> = 5mV  |       |     | 2.5 | μS   | 9          |
|                  |               | V <sub>OD</sub> = 50mV |       |     | 0.8 | μS   | 9          |

(1) Pre and post irradiation limits are identical to those listed under AC and DC electrical characteristics except as listed in the Post Radiation Limits Table. These parts may be dose rate sensitive in a space environment and demonstrate enhanced low dose rate effect. Radiation end point limits for the noted parameters are specified only for the conditions as specified in MIL-STD-883, Method 1019

(2) Low dose rate testing has been performed on a wafer-by-wafer basis, per test method 1019 condition D of MIL-STD-883, with no enhanced low dose rate sensitivity (ELDRS) effect.

## LM193A - 100K Radiation Electrical Characteristics (Continued) DC Drift Parameters<sup>(1)(2)</sup>

The following conditions apply, unless otherwise specified. +V = 5V, V<sub>CM</sub> = 0V

Delta calculations performed on QMLV devices at Group B, Subgroup 5 only

| Symbol          | Parameter            | Conditions | Notes | Min  | Max | Unit | Sub-groups |
|-----------------|----------------------|------------|-------|------|-----|------|------------|
| V <sub>IO</sub> | Input Offset Voltage | +V = 30V   |       | -1.0 | 1.0 | mV   | 1          |
| ±I <sub>B</sub> | Input Bias Current   |            |       | -15  | 15  | nA   | 1          |

(1) Low dose rate testing has been performed on a wafer-by-wafer basis, per test method 1019 condition D of MIL-STD-883, with no enhanced low dose rate sensitivity (ELDRS) effect.

(2) Pre and post irradiation limits are identical to those listed under AC and DC electrical characteristics except as listed in the Post Radiation Limits Table. These parts may be dose rate sensitive in a space environment and demonstrate enhanced low dose rate effect. Radiation end point limits for the noted parameters are specified only for the conditions as specified in MIL-STD-883, Method 1019

## LM193A - 100K Radiation Electrical Characteristics (Continued) AC Parameters - Post Radiation Limits @ +25°C<sup>(1)(2)</sup>

The following conditions apply, unless otherwise specified. +V = 5V, V<sub>CM</sub> = 0V

| Symbol           | Parameter     | Conditions             | Notes | Min | Max | Unit | Sub-groups |
|------------------|---------------|------------------------|-------|-----|-----|------|------------|
| t <sub>RLH</sub> | Response Time | V <sub>OD</sub> = 50mV |       |     | 1.0 | μS   | 9          |

(1) Pre and post irradiation limits are identical to those listed under AC and DC electrical characteristics except as listed in the Post Radiation Limits Table. These parts may be dose rate sensitive in a space environment and demonstrate enhanced low dose rate effect. Radiation end point limits for the noted parameters are specified only for the conditions as specified in MIL-STD-883, Method 1019

(2) Low dose rate testing has been performed on a wafer-by-wafer basis, per test method 1019 condition D of MIL-STD-883, with no enhanced low dose rate sensitivity (ELDRS) effect.

## Typical Performance Characteristics

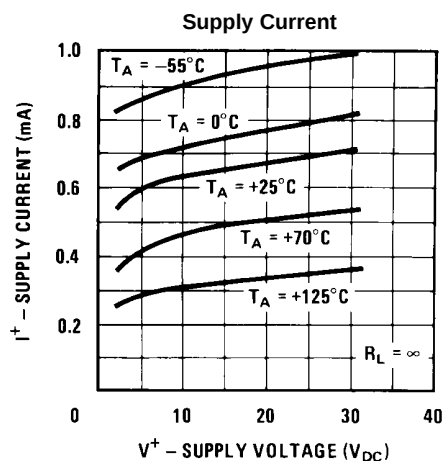


Figure 3.

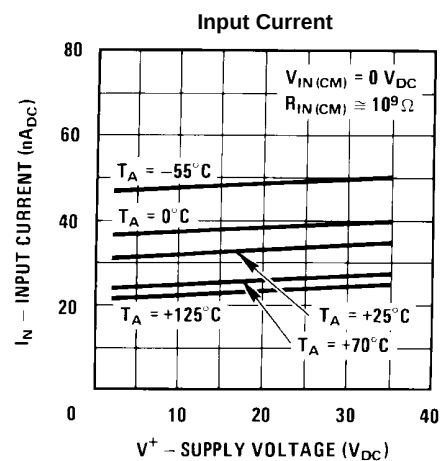


Figure 4.

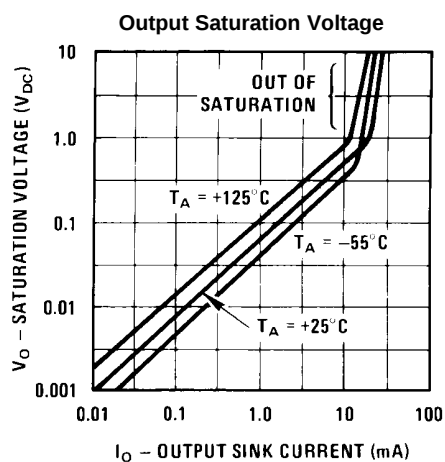


Figure 5.

### Response Time for Various Input Overdrives—Negative Transition

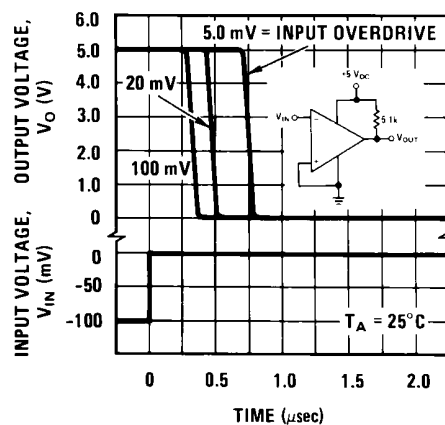


Figure 6.

### Response Time for Various Input Overdrives—Positive Transition

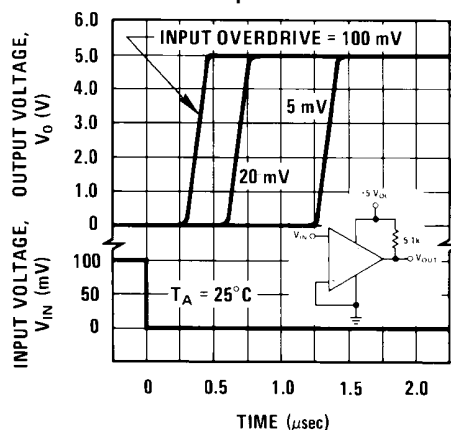


Figure 7.

## APPLICATION HINTS

The LM193 series are high gain, wide bandwidth devices which, like most comparators, can easily oscillate if the output lead is inadvertently allowed to capacitively couple to the inputs via stray capacitance. This shows up only during the output voltage transition intervals as the comparator change states. Power supply bypassing is not required to solve this problem. Standard PC board layout is helpful as it reduces stray input-output coupling. Reducing the input resistors to  $< 10\text{ k}\Omega$  reduces the feedback signal levels and finally, adding even a small amount (1.0 to 10 mV) of positive feedback (hysteresis) causes such a rapid transition that oscillations due to stray feedback are not possible. Simply socketing the IC and attaching resistors to the pins will cause input-output oscillations during the small transition intervals unless hysteresis is used. If the input signal is a pulse waveform, with relatively fast rise and fall times, hysteresis is not required.

All input pins of any unused comparators should be tied to the negative supply.

The bias network of the LM193 series establishes a drain current which is independent of the magnitude of the power supply voltage over the range of from  $2.0\text{ V}_{\text{DC}}$  to  $30\text{ V}_{\text{DC}}$ .

It is usually unnecessary to use a bypass capacitor across the power supply line.

The differential input voltage may be larger than  $V^+$  without damaging the device (see following note).

### NOTE

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  $-0.3\text{V}$  (or  $0.3\text{V}$  below the magnitude of the negative power supply, if used).

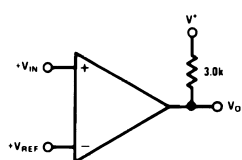
Protection should be provided to prevent the input voltages from going negative more than  $-0.3\text{ V}_{\text{DC}}$  (at  $25^\circ\text{C}$ ). An input clamp diode can be used as shown in the [applications section](#).

The output of the LM193 series is the uncommitted collector of a grounded-emitter NPN output transistor. Many collectors can be tied together to provide an output OR'ing function. An output pull-up resistor can be connected to any available power supply voltage within the permitted supply voltage range and there is no restriction on this voltage due to the magnitude of the voltage which is applied to the  $V^+$  terminal of the LM193 package. The output can also be used as a simple SPST switch to ground (when a pull-up resistor is not used). The amount of current which the output device can sink is limited by the drive available (which is independent of  $V^+$ ) and the  $\beta$  of this device. When the maximum current limit is reached (approximately 16mA), the output transistor will come out of saturation and the output voltage will rise very rapidly. The output saturation voltage is limited by the approximately  $60\Omega\text{ }r_{\text{SAT}}$  of the output transistor. The low offset voltage of the output transistor (1.0mV) allows the output to clamp essentially to ground level for small load currents.

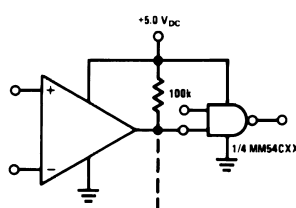
## Typical Applications

 $(V^+ = 5.0 \text{ V}_{\text{DC}})$ 

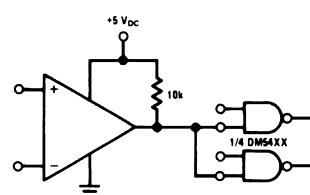
## Basic Comparator



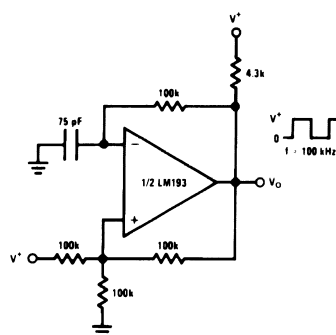
## Driving CMOS



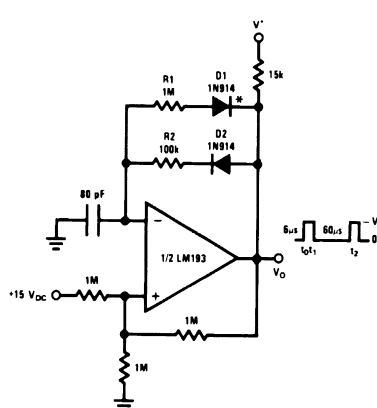
## Driving TTL



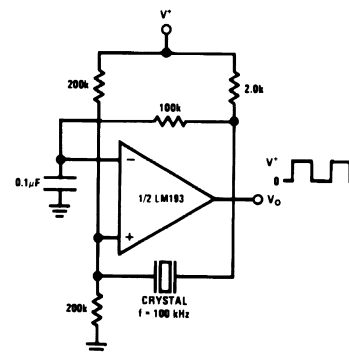
## Squarewave Oscillator



## Pulse Generator

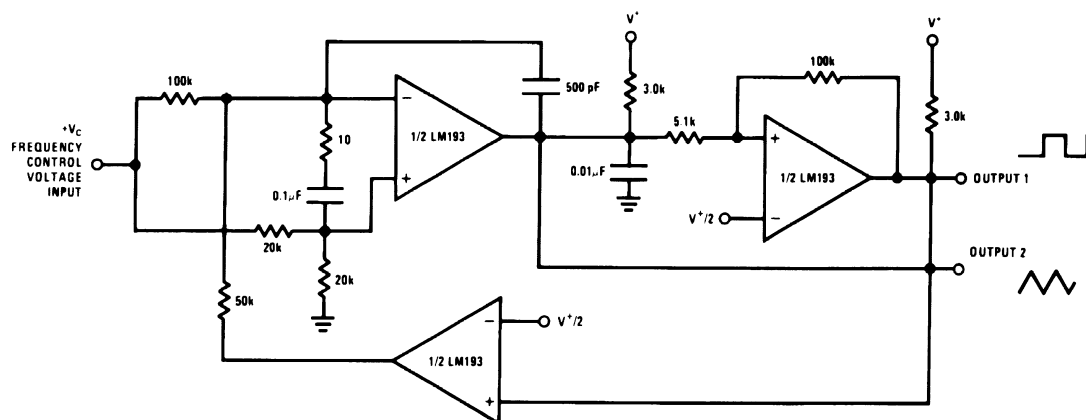


### Crystal Controlled Oscillator

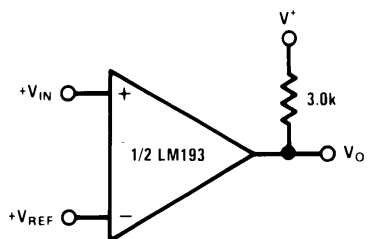


\* For large ratios of  $R1/R2$ ,  $D1$  can be omitted.

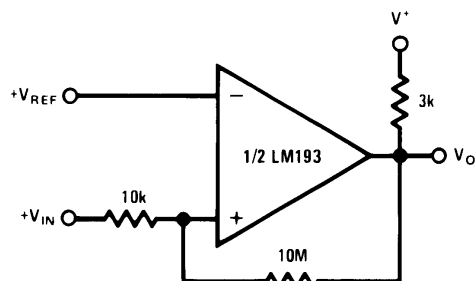
### Figure 8. Two-Decade High Frequency VCO


$$\begin{aligned} V^* &= +30 V_{DC} \\ +250 \text{ mV}_{DC} &\leq V_C \leq +50 V_{DC} \\ 700\text{Hz} &\leq f_0 \leq 100\text{kHz} \end{aligned}$$

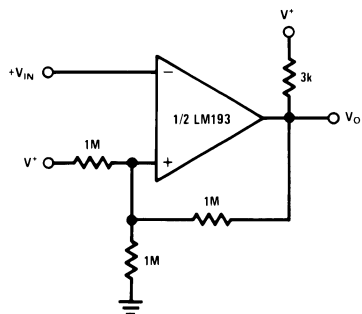
**Basic Comparator**



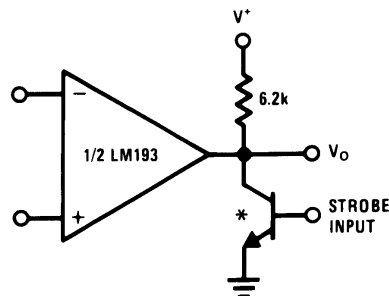
**Non-Inverting Comparator with Hysteresis**



**Inverting Comparator with Hysteresis**

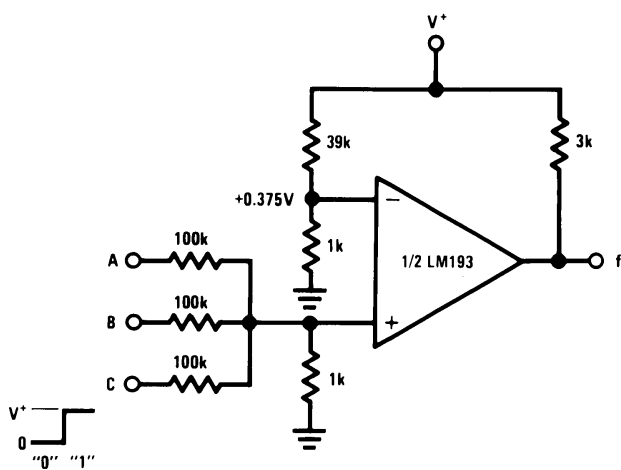


**Output Strobing**

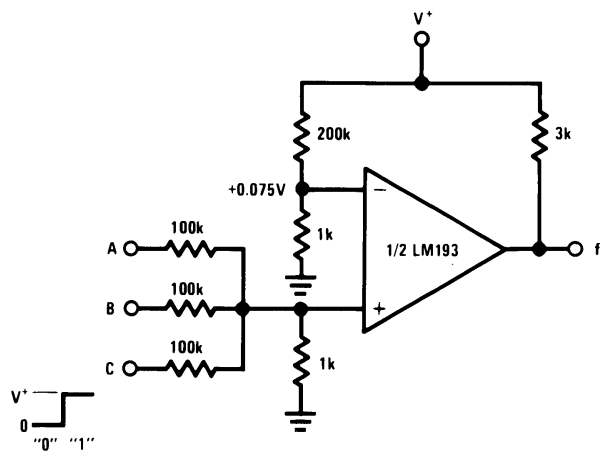


\* OR LOGIC GATE  
WITHOUT PULL-UP RESISTOR

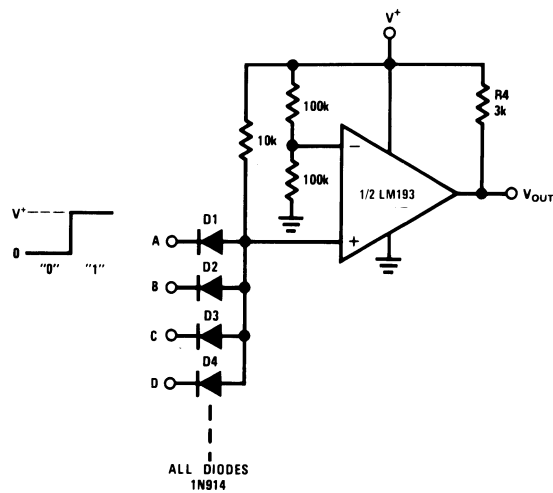
**AND Gate**



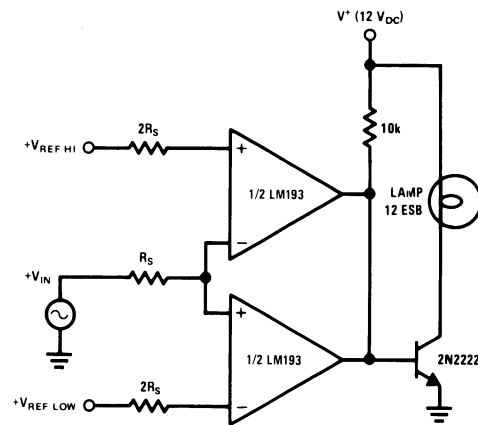
**OR Gate**



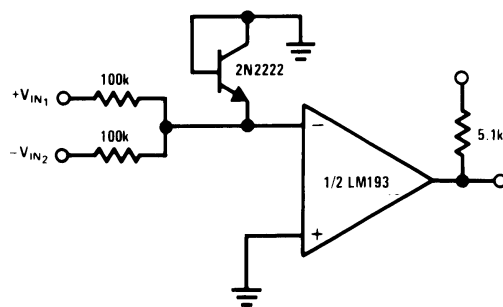
Large Fan-in AND Gate



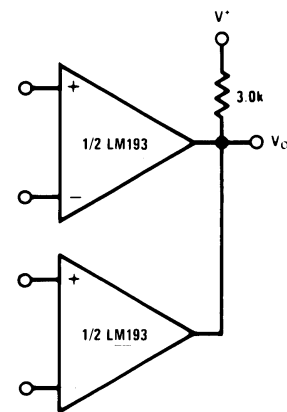
Limit Comparator



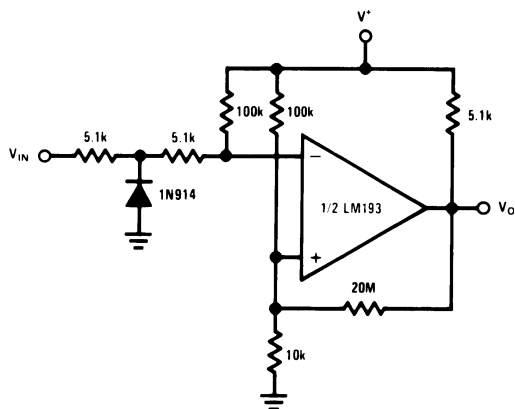
Comparing Input Voltages of Opposite Polarity



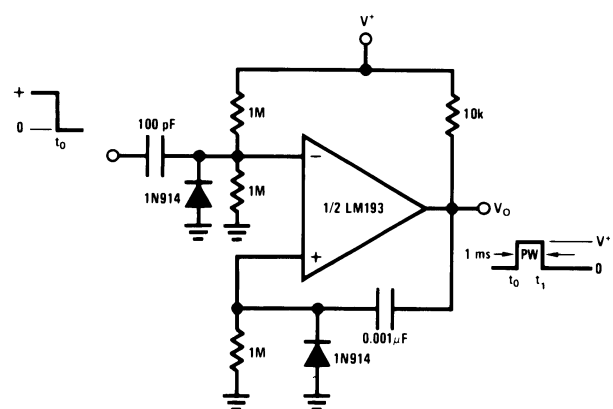
ORing the Outputs



Zero Crossing Detector (Single Power Supply)



One-Shot Multivibrator



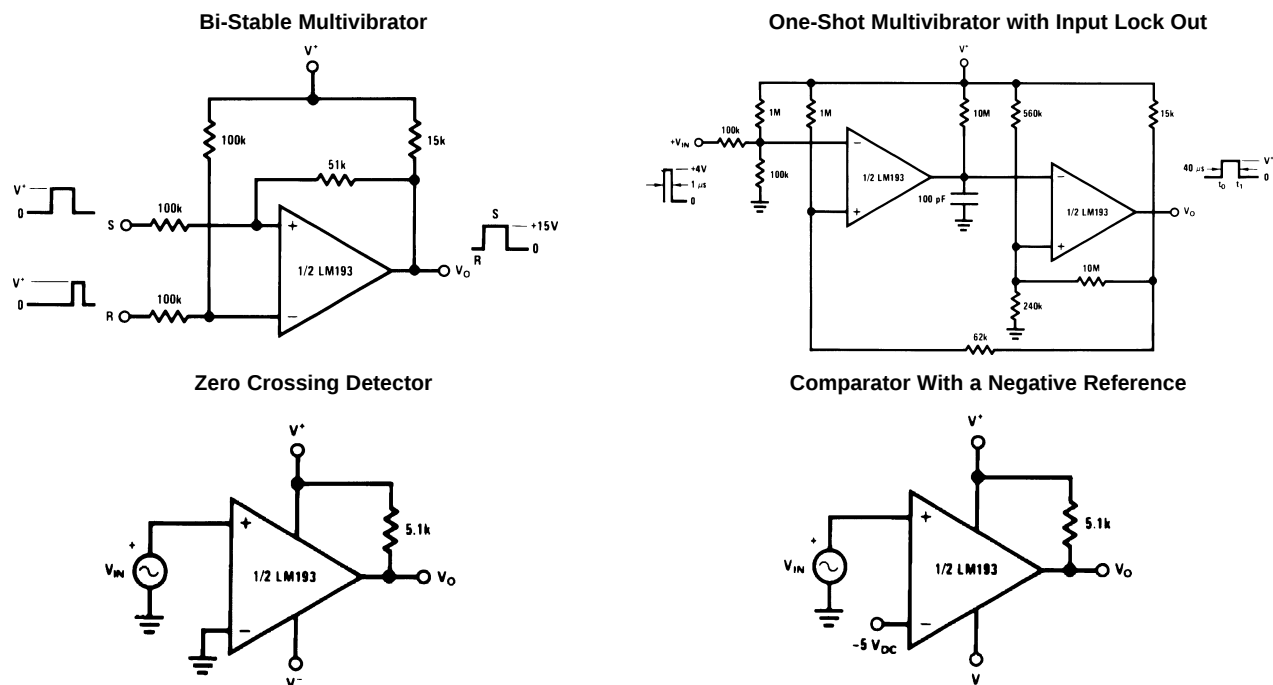
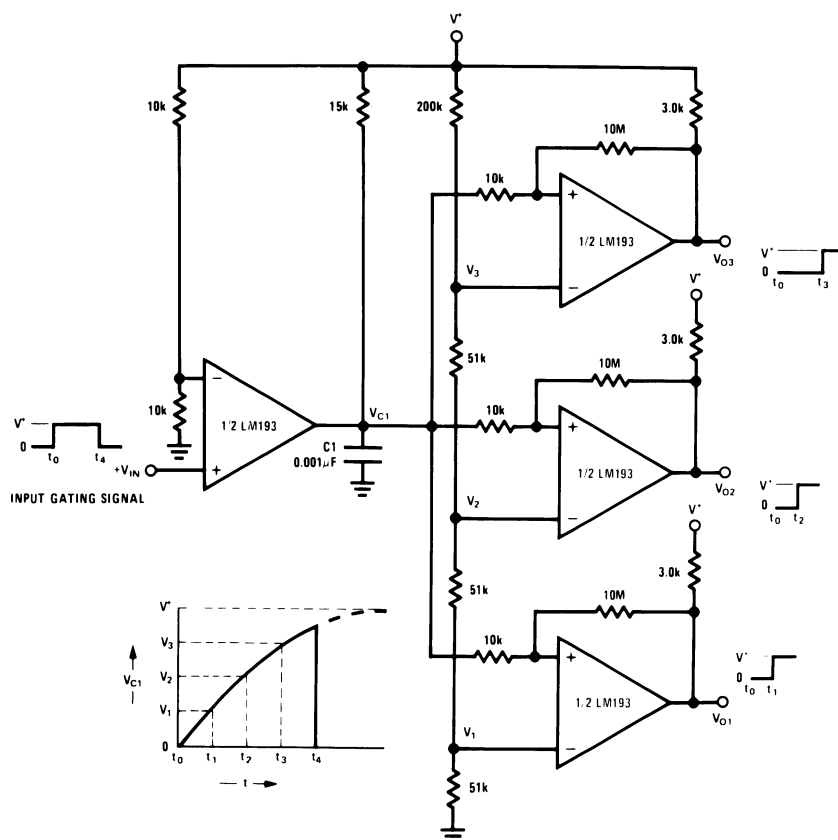


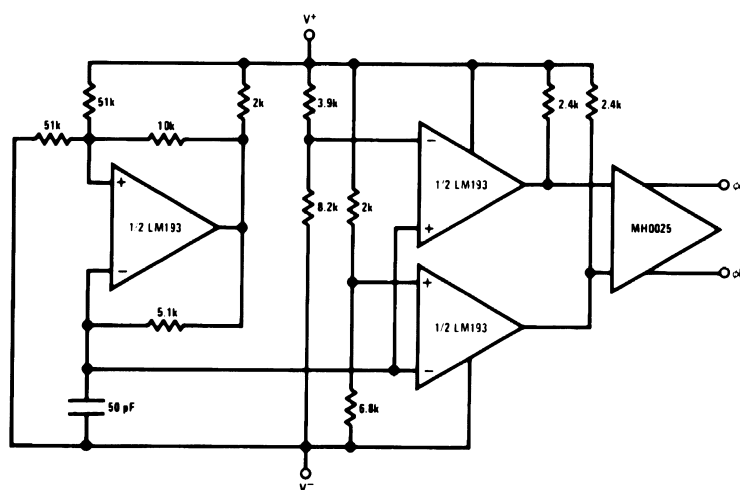
Figure 9. Time Delay Generator



## Split-Supply Applications

( $V^+ = +15\text{ V}_{\text{DC}}$  and  $V^- = -15\text{ V}_{\text{DC}}$ )

Figure 10. MOS Clock Driver



**Table 1. Revision History**

| Date Released | Revision | Section                                            | Originator  | Changes                                                                                                                                                                                                                                                                                                                                                          |
|---------------|----------|----------------------------------------------------|-------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 05/09/05      | A        | New Release. Corporate format                      | L. Lytle    | 2 MDS datasheets converted into one Corp. datasheet format. MNLM193A-X Rev 1B3 & MNLM193–X Rev 0E1. The Iout Vsat condition for LM193 was changed to Isink for consistency with the LM193A and JAN electrical conditions. Also, redundant parameters were removed from conditions that were defined at beginning of the table. MDS data sheets will be archived. |
| 05/07/07      | B        | Features, Ordering Information, LM193A Electricals | Larry McGee | Added Radiation Electrical information for LM193A Device. Revision A will be archived.                                                                                                                                                                                                                                                                           |
| 10/29/07      | C        | Features, Ordering Information, Notes              | Larry McGee | Added reference to New ELDS NSID and SMD Device 03, ELDRS Note 12. Revision B will be archived.                                                                                                                                                                                                                                                                  |
| 03/20/13      | C        | All                                                |             | Changed layout of National Data Sheet to TI format                                                                                                                                                                                                                                                                                                               |

## PACKAGING INFORMATION

| Orderable Device | Status<br>(1) | Package Type | Package<br>Drawing | Pins | Package<br>Qty | Eco Plan<br>(2)         | Lead finish/<br>Ball material<br>(6) | MSL Peak Temp<br>(3) | Op Temp (°C) | Device Marking<br>(4/5)                                             | Samples                 |
|------------------|---------------|--------------|--------------------|------|----------------|-------------------------|--------------------------------------|----------------------|--------------|---------------------------------------------------------------------|-------------------------|
| 5962-9452602MGA  | ACTIVE        | TO-99        | LMC                | 8    | 20             | RoHS & Green            | Call TI                              | Level-1-NA-UNLIM     | -55 to 125   | LM193AH/883<br>5962-9452602MGA Q<br>ACO<br>5962-9452602MGA Q<br>>T  | <a href="#">Samples</a> |
| 5962-9452602MPA  | ACTIVE        | CDIP         | NAB                | 8    | 40             | Non-RoHS<br>& Green     | Call TI                              | Level-1-NA-UNLIM     | -55 to 125   | LM193AJ/883<br>5962-94526<br>02MPA Q ACO<br>02MPA Q >T              | <a href="#">Samples</a> |
| 5962-9452602VPA  | ACTIVE        | CDIP         | NAB                | 8    | 40             | Non-RoHS<br>& Green     | Call TI                              | Level-1-NA-UNLIM     | -55 to 125   | LM193AJ-QMLV<br>5962-94526<br>02VPA Q ACO<br>02VPA Q >T             | <a href="#">Samples</a> |
| 5962R9452602V9A  | ACTIVE        | DIE SALE     | Y                  | 0    | 40             | RoHS & Green            | Call TI                              | Level-1-NA-UNLIM     | -55 to 125   |                                                                     | <a href="#">Samples</a> |
| 5962R9452602VGA  | ACTIVE        | TO-99        | LMC                | 8    | 20             | Non-RoHS &<br>Non-Green | Call TI                              | Call TI              | -55 to 125   | LM193AHRQMLV<br>5962R9452602VGA Q<br>ACO<br>5962R9452602VGA Q<br>>T | <a href="#">Samples</a> |
| 5962R9452602VPA  | ACTIVE        | CDIP         | NAB                | 8    | 40             | Non-RoHS<br>& Green     | Call TI                              | Level-1-NA-UNLIM     | -55 to 125   | LM193AJRQMLV<br>5962R94526<br>02VPA Q ACO<br>02VPA Q >T             | <a href="#">Samples</a> |
| 5962R9452603V9A  | ACTIVE        | DIE SALE     | Y                  | 0    | 40             | RoHS & Green            | Call TI                              | Level-1-NA-UNLIM     | -55 to 125   |                                                                     | <a href="#">Samples</a> |
| 5962R9452603VGA  | ACTIVE        | TO-99        | LMC                | 8    | 20             | Non-RoHS &<br>Non-Green | Call TI                              | Call TI              | -55 to 125   | LM193AHRQMLV<br>5962R9452603VGA Q<br>ACO<br>5962R9452603VGA Q<br>>T | <a href="#">Samples</a> |
| 5962R9452603VPA  | ACTIVE        | CDIP         | NAB                | 8    | 40             | Non-RoHS<br>& Green     | Call TI                              | Level-1-NA-UNLIM     | -55 to 125   | LM193AJRLV<br>5962R94526<br>03VPA Q ACO<br>03VPA Q >T               | <a href="#">Samples</a> |
| LM193 MD8        | ACTIVE        | DIE SALE     | Y                  | 0    | 400            | RoHS & Green            | Call TI                              | Level-1-NA-UNLIM     | -55 to 125   |                                                                     | <a href="#">Samples</a> |

| Orderable Device | Status<br>(1) | Package Type | Package<br>Drawing | Pins | Package<br>Qty | Eco Plan<br>(2)     | Lead finish/<br>Ball material<br>(6) | MSL Peak Temp<br>(3) | Op Temp (°C) | Device Marking<br>(4/5)                                             | Samples                 |
|------------------|---------------|--------------|--------------------|------|----------------|---------------------|--------------------------------------|----------------------|--------------|---------------------------------------------------------------------|-------------------------|
| LM193 MDE        | ACTIVE        | DIESALE      | Y                  | 0    | 40             | RoHS & Green        | Call TI                              | Level-1-NA-UNLIM     | -55 to 125   |                                                                     | <a href="#">Samples</a> |
| LM193 MDR        | ACTIVE        | DIESALE      | Y                  | 0    | 40             | RoHS & Green        | Call TI                              | Level-1-NA-UNLIM     | -55 to 125   |                                                                     | <a href="#">Samples</a> |
| LM193AH/883      | ACTIVE        | TO-99        | LMC                | 8    | 20             | RoHS & Green        | Call TI                              | Level-1-NA-UNLIM     | -55 to 125   | LM193AH/883<br>5962-9452602MGA Q<br>ACO<br>5962-9452602MGA Q<br>>T  | <a href="#">Samples</a> |
| LM193AHLQMLV     | ACTIVE        | TO-99        | LMC                | 8    | 20             | Non-RoHS<br>& Green | Call TI                              | Level-1-NA-UNLIM     | -55 to 125   | LM193AHLQMLV<br>5962R9452603VGA Q<br>ACO<br>5962R9452603VGA Q<br>>T | <a href="#">Samples</a> |
| LM193AHRQMLV     | ACTIVE        | TO-99        | LMC                | 8    | 20             | Non-RoHS<br>& Green | Call TI                              | Level-1-NA-UNLIM     | -55 to 125   | LM193AHRQMLV<br>5962R9452602VGA Q<br>ACO<br>5962R9452602VGA Q<br>>T | <a href="#">Samples</a> |
| LM193AJ-QMLV     | ACTIVE        | CDIP         | NAB                | 8    | 40             | Non-RoHS<br>& Green | Call TI                              | Level-1-NA-UNLIM     | -55 to 125   | LM193AJ-QMLV<br>5962-94526<br>02VPA Q ACO<br>02VPA Q >T             | <a href="#">Samples</a> |
| LM193AJ/883      | ACTIVE        | CDIP         | NAB                | 8    | 40             | Non-RoHS<br>& Green | Call TI                              | Level-1-NA-UNLIM     | -55 to 125   | LM193AJ/883<br>5962-94526<br>02MPA Q ACO<br>02MPA Q >T              | <a href="#">Samples</a> |
| LM193AJRLQMLV    | ACTIVE        | CDIP         | NAB                | 8    | 40             | Non-RoHS<br>& Green | Call TI                              | Level-1-NA-UNLIM     | -55 to 125   | LM193AJRLV<br>5962R94526<br>03VPA Q ACO<br>03VPA Q >T               | <a href="#">Samples</a> |
| LM193AJRQMLV     | ACTIVE        | CDIP         | NAB                | 8    | 40             | Non-RoHS<br>& Green | Call TI                              | Level-1-NA-UNLIM     | -55 to 125   | LM193AJRQMLV<br>5962R94526<br>02VPA Q ACO<br>02VPA Q >T             | <a href="#">Samples</a> |
| LM193H/883       | ACTIVE        | TO-99        | LMC                | 8    | 20             | RoHS & Green        | Call TI                              | Level-1-NA-UNLIM     | -55 to 125   | LM193H/883 Q ACO<br>LM193H/883 Q >T                                 | <a href="#">Samples</a> |

| Orderable Device | Status<br>(1) | Package Type | Package<br>Drawing | Pins | Package<br>Qty | Eco Plan<br>(2)     | Lead finish/<br>Ball material<br>(6) | MSL Peak Temp<br>(3) | Op Temp (°C) | Device Marking<br>(4/5)           | Samples                 |
|------------------|---------------|--------------|--------------------|------|----------------|---------------------|--------------------------------------|----------------------|--------------|-----------------------------------|-------------------------|
| LM193J/883       | ACTIVE        | CDIP         | NAB                | 8    | 40             | Non-RoHS<br>& Green | Call TI                              | Level-1-NA-UNLIM     | -55 to 125   | LM193J<br>/883 Q ACO<br>/883 Q >T | <a href="#">Samples</a> |

<sup>(1)</sup> The marketing status values are defined as follows:

**ACTIVE:** Product device recommended for new designs.

**LIFEBUY:** TI has announced that the device will be discontinued, and a lifetime-buy period is in effect.

**NRND:** Not recommended for new designs. Device is in production to support existing customers, but TI does not recommend using this part in a new design.

**PREVIEW:** Device has been announced but is not in production. Samples may or may not be available.

**OBsolete:** TI has discontinued the production of the device.

<sup>(2)</sup> **RoHS:** TI defines "RoHS" to mean semiconductor products that are compliant with the current EU RoHS requirements for all 10 RoHS substances, including the requirement that RoHS substance do not exceed 0.1% by weight in homogeneous materials. Where designed to be soldered at high temperatures, "RoHS" products are suitable for use in specified lead-free processes. TI may reference these types of products as "Pb-Free".

**RoHS Exempt:** TI defines "RoHS Exempt" to mean products that contain lead but are compliant with EU RoHS pursuant to a specific EU RoHS exemption.

**Green:** TI defines "Green" to mean the content of Chlorine (Cl) and Bromine (Br) based flame retardants meet JS709B low halogen requirements of <=1000ppm threshold. Antimony trioxide based flame retardants must also meet the <=1000ppm threshold requirement.

<sup>(3)</sup> MSL, Peak Temp. - The Moisture Sensitivity Level rating according to the JEDEC industry standard classifications, and peak solder temperature.

<sup>(4)</sup> There may be additional marking, which relates to the logo, the lot trace code information, or the environmental category on the device.

<sup>(5)</sup> Multiple Device Markings will be inside parentheses. Only one Device Marking contained in parentheses and separated by a "~" will appear on a device. If a line is indented then it is a continuation of the previous line and the two combined represent the entire Device Marking for that device.

<sup>(6)</sup> Lead finish/Ball material - Orderable Devices may have multiple material finish options. Finish options are separated by a vertical ruled line. Lead finish/Ball material values may wrap to two lines if the finish value exceeds the maximum column width.

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In no event shall TI's liability arising out of such information exceed the total purchase price of the TI part(s) at issue in this document sold by TI to Customer on an annual basis.

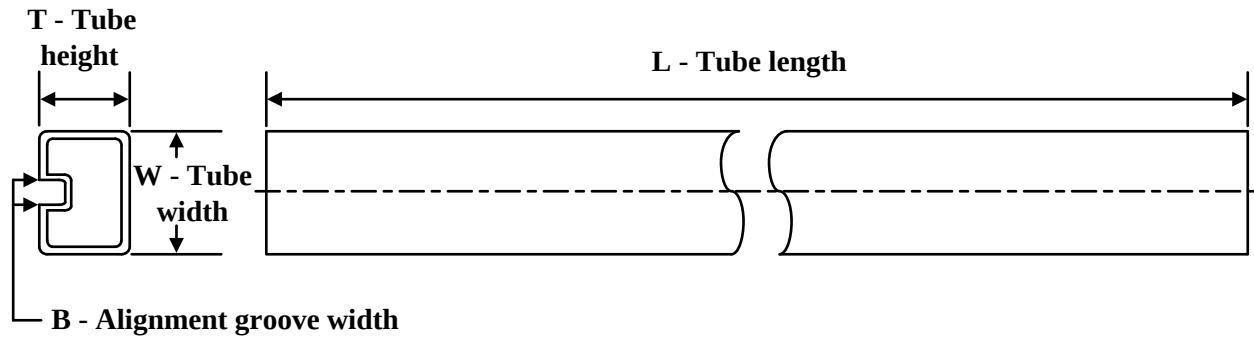
**OTHER QUALIFIED VERSIONS OF LM193QML, LM193QML-SP :**

- Military : [LM193QML](#)
- Space : [LM193QML-SP](#)

NOTE: Qualified Version Definitions:

- Military - QML certified for Military and Defense Applications
- Space - Radiation tolerant, ceramic packaging and qualified for use in Space-based application

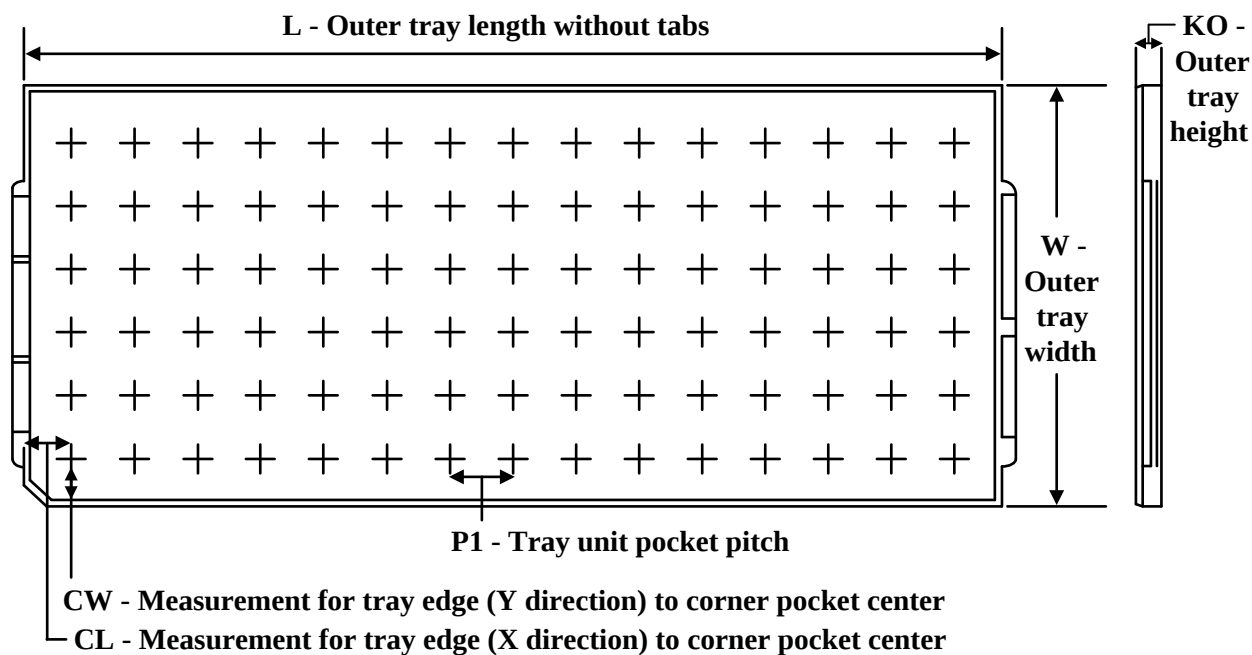
## TUBE



\*All dimensions are nominal

| Device          | Package Name | Package Type | Pins | SPQ | L (mm) | W (mm) | T (μm) | B (mm) |
|-----------------|--------------|--------------|------|-----|--------|--------|--------|--------|
| 5962-9452602MPA | NAB          | CDIP         | 8    | 40  | 506.98 | 15.24  | 13440  | NA     |
| 5962-9452602VPA | NAB          | CDIP         | 8    | 40  | 506.98 | 15.24  | 13440  | NA     |
| 5962R9452602VPA | NAB          | CDIP         | 8    | 40  | 506.98 | 15.24  | 13440  | NA     |
| 5962R9452603VPA | NAB          | CDIP         | 8    | 40  | 506.98 | 15.24  | 13440  | NA     |
| LM193AJ-QMLV    | NAB          | CDIP         | 8    | 40  | 506.98 | 15.24  | 13440  | NA     |
| LM193AJ/883     | NAB          | CDIP         | 8    | 40  | 506.98 | 15.24  | 13440  | NA     |
| LM193AJRLQMLV   | NAB          | CDIP         | 8    | 40  | 506.98 | 15.24  | 13440  | NA     |
| LM193AJRQMLV    | NAB          | CDIP         | 8    | 40  | 506.98 | 15.24  | 13440  | NA     |
| LM193J/883      | NAB          | CDIP         | 8    | 40  | 506.98 | 15.24  | 13440  | NA     |

## TRAY



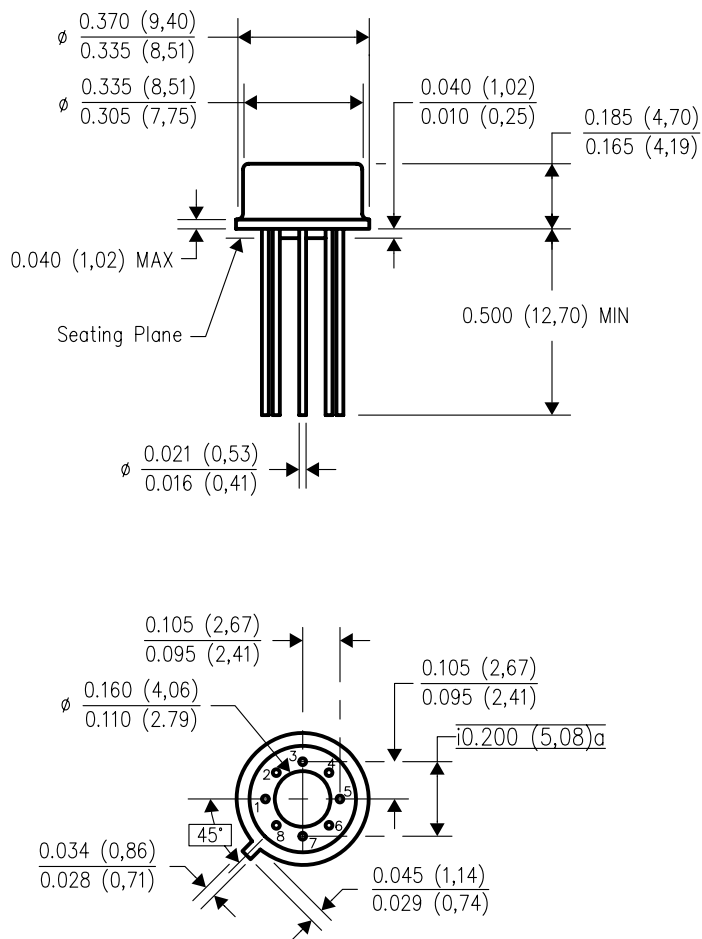
Chamfer on Tray corner indicates Pin 1 orientation of packed units.

\*All dimensions are nominal

| Device          | Package Name | Package Type | Pins | SPQ | Unit array matrix | Max temperature (°C) | L (mm) | W (mm) | K0 (μm) | P1 (mm) | CL (mm) | CW (mm) |
|-----------------|--------------|--------------|------|-----|-------------------|----------------------|--------|--------|---------|---------|---------|---------|
| 5962-9452602MGA | LMC          | TO-CAN       | 8    | 20  | 2 X 10            | 150                  | 126.49 | 61.98  | 8890    | 11.18   | 12.95   | 18.54   |
| 5962R9452602VGA | LMC          | TO-CAN       | 8    | 20  | 2 X 10            | 150                  | 126.49 | 61.98  | 8890    | 11.18   | 12.95   | 18.54   |
| 5962R9452603VGA | LMC          | TO-CAN       | 8    | 20  | 2 X 10            | 150                  | 126.49 | 61.98  | 8890    | 11.18   | 12.95   | 18.54   |
| LM193AH/883     | LMC          | TO-CAN       | 8    | 20  | 2 X 10            | 150                  | 126.49 | 61.98  | 8890    | 11.18   | 12.95   | 18.54   |
| LM193AHRQLV     | LMC          | TO-CAN       | 8    | 20  | 2 X 10            | 150                  | 126.49 | 61.98  | 8890    | 11.18   | 12.95   | 18.54   |
| LM193AHRQMLV    | LMC          | TO-CAN       | 8    | 20  | 2 X 10            | 150                  | 126.49 | 61.98  | 8890    | 11.18   | 12.95   | 18.54   |
| LM193H/883      | LMC          | TO-CAN       | 8    | 20  | 2 X 10            | 150                  | 126.49 | 61.98  | 8890    | 11.18   | 12.95   | 18.54   |

## LMC (O-MBCY-W8)

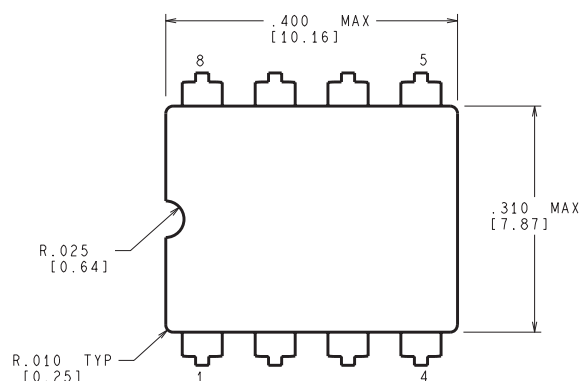
## METAL CYLINDRICAL PACKAGE



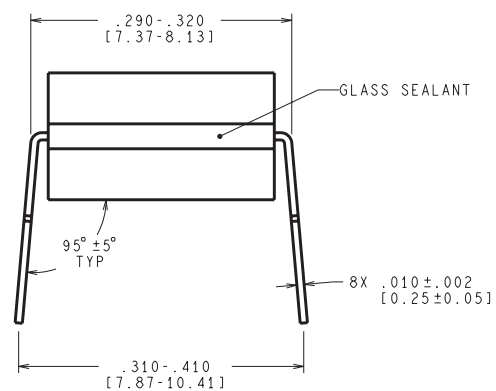
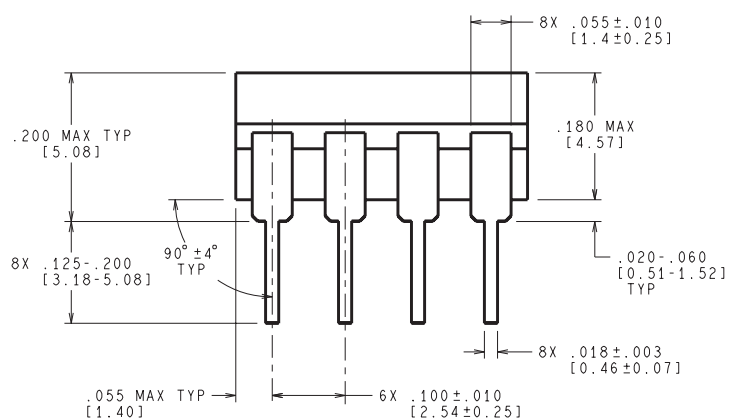
4202483/B 09/07

- NOTES:
- All linear dimensions are in inches (millimeters).
  - This drawing is subject to change without notice.
  - Leads in true position within 0.010 (0,25) R @ MMC at seating plane.
  - Pin numbers shown for reference only. Numbers may not be marked on package.
  - Falls within JEDEC MO-002/T0-99.

NAB0008A



CONTROLLING DIMENSION IS INCH  
VALUES IN [ ] ARE MILLIMETERS



J08A (Rev M)

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