

# DATA SHEET

**LM193A/293/A/393/A/2903**

Low power dual voltage comparator

Product data  
Supersedes data of 2001 Aug 03  
File under Integrated Circuits, IC11 Handbook

2002 Jan 22

# Low power dual voltage comparator

## LM193A/293/A/393/A/2903

### 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.

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.

### FEATURES

- Wide single supply voltage range 2.0  $V_{DC}$  to 36  $V_{DC}$ , or dual supplies  $\pm 1.0 V_{DC}$ , to  $\pm 18 V_{DC}$
- Very low supply current drain (0.8 mA) independent of supply voltage (2.0 mW/comparator at 5.0  $V_{DC}$ )
- Low input biasing current 25 nA
- Low input offset current  $\pm 5$  nA and offset voltage  $\pm 2$  mV
- Input common-mode voltage range includes ground
- Differential input voltage range equal to the power supply voltage
- Low output 250 mV at 4 mA saturation voltage
- Output voltage compatible with TTL, DTL, ECL, MOS and CMOS logic systems

### APPLICATIONS

- A/D converters
- Wide range VCO
- MOS clock generator
- High voltage logic gate
- Multivibrators

### PIN CONFIGURATION

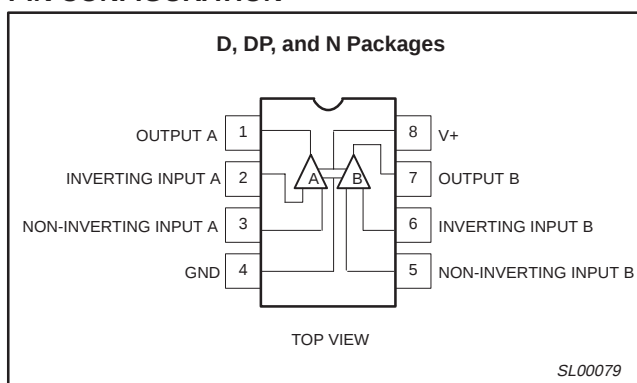


Figure 1. Pin configuration.

### EQUIVALENT CIRCUIT

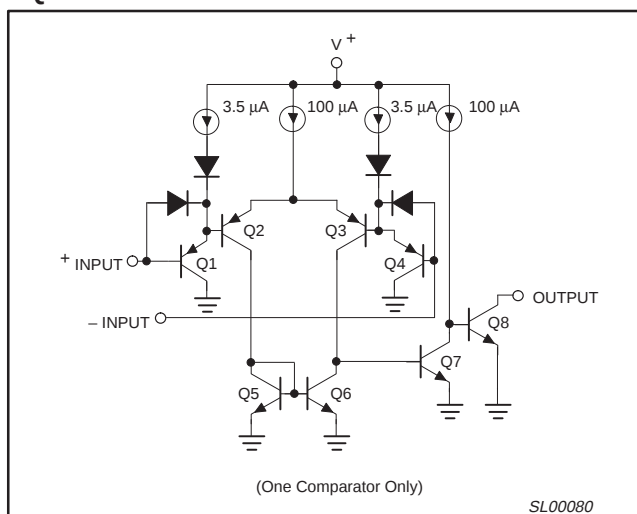


Figure 2. Equivalent circuit.

### ORDERING INFORMATION

| DESCRIPTION                                             | TEMPERATURE RANGE | ORDER CODE | DWG #    |
|---------------------------------------------------------|-------------------|------------|----------|
| 8-Pin Plastic Dual In-Line Package (DIP)                | -55 °C to +125 °C | LM193AN    | SOT97-1  |
| 8-Pin Plastic Small Outline (SO) Package                | -25 °C to +85 °C  | LM293D     | SOT96-1  |
| 8-Pin Plastic Dual In-Line Package (DIP)                | -25 °C to +85 °C  | LM293N     | SOT97-1  |
| 8-Pin Plastic Small Outline (SO) Package                | -25 °C to +85 °C  | LM293AD    | SOT96-1  |
| 8-Pin Plastic Dual In-Line Package (DIP)                | -25 °C to +85 °C  | LM293AN    | SOT97-1  |
| 8-Pin Plastic Small Outline (SO) Package                | 0 °C to +70 °C    | LM393D     | SOT96-1  |
| 8-Pin Plastic Thin Shrink Small Outline Package (TSSOP) | 0 °C to +70 °C    | LM393DP    | SOT505-1 |
| 8-Pin Plastic Dual In-Line Package (DIP)                | 0 °C to +70 °C    | LM393N     | SOT97-1  |
| 8-Pin Plastic Small Outline (SO) Package                | 0 °C to +70 °C    | LM393AD    | SOT96-1  |
| 8-Pin Plastic Dual In-Line Package (DIP)                | 0 °C to +70 °C    | LM393AN    | SOT97-1  |
| 8-Pin Plastic Small Outline (SO) Package                | -40 °C to +125 °C | LM2903D    | SOT96-1  |
| 8-Pin Plastic Dual In-Line Package (DIP)                | -40 °C to +125 °C | LM2903N    | SOT97-1  |

## Low power dual voltage comparator

## LM193A/293/A/393/A/2903

## ABSOLUTE MAXIMUM RATINGS

| SYMBOL    | PARAMETER                                                                                  | RATING          | UNIT               |
|-----------|--------------------------------------------------------------------------------------------|-----------------|--------------------|
| $V_{CC}$  | Supply voltage                                                                             | 36 or $\pm 18$  | $V_{DC}$           |
|           | Differential input voltage                                                                 | 36              | $V_{DC}$           |
| $V_{IN}$  | Input voltage                                                                              | $-0.3$ to $+36$ | $V_{DC}$           |
| $P_D$     | Maximum power dissipation, $T_{amb} = 25\text{ }^{\circ}\text{C}$ (still-air) <sup>1</sup> |                 |                    |
|           | N package                                                                                  | 1160            | mW                 |
|           | D package                                                                                  | 780             | mW                 |
|           | LM393DP package                                                                            | 714             | mW                 |
|           | Output short-circuit to ground <sup>2</sup>                                                | Continuous      |                    |
| $I_{IN}$  | Input current ( $V_{IN} < -0.3 V_{DC}$ ) <sup>3</sup>                                      | 50              | mA                 |
| $T_{amb}$ | Operating temperature range                                                                |                 |                    |
|           | LM193A                                                                                     | $-55$ to $+125$ | $^{\circ}\text{C}$ |
|           | LM293/293A                                                                                 | $-25$ to $+85$  | $^{\circ}\text{C}$ |
|           | LM393/393A                                                                                 | $0$ to $+70$    | $^{\circ}\text{C}$ |
|           | LM2903                                                                                     | $-40$ to $+125$ | $^{\circ}\text{C}$ |
| $T_{stg}$ | Storage temperature range                                                                  | $-65$ to $+150$ | $^{\circ}\text{C}$ |
| $T_{sld}$ | Lead soldering temperature (10 sec max)                                                    | 230             | $^{\circ}\text{C}$ |

## NOTES:

- Derate above  $25\text{ }^{\circ}\text{C}$ , at the following rates:  
N package at  $9.3\text{ mW}/^{\circ}\text{C}$   
D package at  $6.2\text{ mW}/^{\circ}\text{C}$   
DP package at  $5.72\text{ mW}/^{\circ}\text{C}$
- Short circuits from the output to  $V_{+}$  can cause excessive heating and eventual destruction. The maximum output current is approximately  $20\text{ mA}$  independent of the magnitude of  $V_{+}$ .
- 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  $-0.3 V_{DC}$ .

## Low power dual voltage comparator

## LM193A/293/A/393/A/2903

## DC AND AC ELECTRICAL CHARACTERISTICS

$V_+ = 5 V_{DC}$ , LM193A:  $-55\text{ }^{\circ}\text{C}$   $T_{amb} \leq +125\text{ }^{\circ}\text{C}$ , unless otherwise specified. LM293/293A:  $-25\text{ }^{\circ}\text{C}$   $T_{amb} \leq +85\text{ }^{\circ}\text{C}$ , unless otherwise specified.

LM393/393A:  $0\text{ }^{\circ}\text{C}$   $T_{amb} \leq +70\text{ }^{\circ}\text{C}$ , unless otherwise specified. LM2903:  $-40\text{ }^{\circ}\text{C}$   $T_{amb} \leq +125\text{ }^{\circ}\text{C}$ , unless otherwise specified.

| SYMBOL     | PARAMETER                                       | TEST CONDITIONS                                                                                                                                                    | LM193A |           |                        | LM293A/393A |           |                        | LM2903 |                      |                       | UNIT          |
|------------|-------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------|-----------|------------------------|-------------|-----------|------------------------|--------|----------------------|-----------------------|---------------|
|            |                                                 |                                                                                                                                                                    | Min    | Typ       | Max                    | Min         | Typ       | Max                    | Min    | Typ                  | Max                   |               |
| $V_{OS}$   | Input offset voltage <sup>2</sup>               | $T_{amb} = 25\text{ }^{\circ}\text{C}$<br>Over temp.                                                                                                               |        | $\pm 1.0$ | $\pm 2.0$<br>$\pm 4.0$ |             | $\pm 1.0$ | $\pm 2.0$<br>$\pm 4.0$ |        | $\pm 2.0$<br>$\pm 9$ | $\pm 7.0$<br>$\pm 15$ | mV<br>mV      |
|            |                                                 |                                                                                                                                                                    |        |           |                        |             |           |                        |        |                      |                       |               |
| $V_{CM}$   | Input common-mode voltage range <sup>3, 6</sup> | $T_{amb} = 25\text{ }^{\circ}\text{C}$<br>Over temp.                                                                                                               | 0      |           | $V_+ - 1.5$            | 0           |           | $V_+ - 1.5$            | 0      |                      | $V_+ - 1.5$           | V             |
|            |                                                 |                                                                                                                                                                    | 0      |           | $V_+ - 2.0$            | 0           |           | $V_+ - 2.0$            | 0      |                      | $V_+ - 2.0$           | V             |
| $V_{IDR}$  | Differential input voltage <sup>1</sup>         | Keep all $V_{IN} \geq 0 V_{DC}$<br>(or $V_-$ if needed)                                                                                                            |        |           | $V_+$                  |             |           | $V_+$                  |        |                      | $V_+$                 | V             |
| $I_{BIAS}$ | Input bias current <sup>4</sup>                 | $I_{IN(+)}$ or $I_{IN(-)}$ with output<br>in linear range<br>$T_{amb} = 25\text{ }^{\circ}\text{C}$<br>Over temp.                                                  |        | 25        | 100<br>300             |             | 25        | 250<br>400             |        | 25<br>200            | 250<br>500            | nA<br>nA      |
|            |                                                 |                                                                                                                                                                    |        |           |                        |             |           |                        |        |                      |                       |               |
| $I_{OS}$   | Input offset current                            | $I_{IN(+)} - I_{IN(-)}$<br>$T_{amb} = 25\text{ }^{\circ}\text{C}$<br>Over temp.                                                                                    |        | $\pm 3.0$ | $\pm 25$<br>$\pm 100$  |             | $\pm 5.0$ | $\pm 50$<br>$\pm 150$  |        | $\pm 5$<br>$\pm 50$  | $\pm 50$<br>$\pm 200$ | nA<br>nA      |
|            |                                                 |                                                                                                                                                                    |        |           |                        |             |           |                        |        |                      |                       |               |
| $I_{OL}$   | Output sink current                             | $V_{IN(-)} \geq 1 V_{DC}$ ; $V_{IN(+)} = 0$ ;<br>$V_O \leq 1.5 V_{DC}$<br>$T_{amb} = 25\text{ }^{\circ}\text{C}$                                                   | 6.0    | 16        |                        | 6.0         | 16        |                        | 6.0    | 16                   |                       | mA            |
|            | Output leakage current                          | $V_O = 5 V_{DC}$ ; $T_{amb} = 25\text{ }^{\circ}\text{C}$<br>$V_{IN(+)} \geq 1 V_{DC}$ ; $V_{IN(-)} = 0$ ;<br>$V_O = 30 V_{DC}$ ;<br>Over temp.                    |        | 0.1       |                        |             | 0.1       |                        |        | 0.1                  |                       | nA            |
|            |                                                 |                                                                                                                                                                    |        |           | 1.0                    |             |           | 1.0                    |        |                      | 1.0                   | $\mu\text{A}$ |
| $I_{CC}$   | Supply current                                  | $R_L = \infty$ on both comparators;<br>$T_{amb} = 25\text{ }^{\circ}\text{C}$                                                                                      |        | 0.8       | 1                      |             | 0.8       | 1                      |        | 0.8                  | 1                     | mA            |
|            |                                                 | $R_L = \infty$ on both comparators; $V_+ = 30\text{ V}$                                                                                                            |        | 1         | 2.5                    |             | 1         | 2.5                    |        | 1                    | 2.5                   | mA            |
| $A_V$      | Voltage gain                                    | $R_L \geq 15\text{ k}\Omega$ ;<br>$V_+ = 15 V_{DC}$ ;<br>$T_{amb} = 25\text{ }^{\circ}\text{C}$                                                                    | 50     | 200       |                        | 50          | 200       |                        | 25     | 100                  |                       | V/mV          |
| $V_{OL}$   | Saturation voltage                              | $V_{IN(-)} \geq 1 V_{DC}$ ;<br>$V_{IN(+)} = 0$ ; $I_{SINK} \leq 4\text{ mA}$<br>$T_{amb} = 25\text{ }^{\circ}\text{C}$<br>Over temp.                               |        | 250       | 400<br>700             |             | 250       | 400<br>700             |        | 400                  | 400<br>700            | mV<br>mV      |
|            |                                                 |                                                                                                                                                                    |        |           |                        |             |           |                        |        |                      |                       |               |
| $t_{LSR}$  | Large-signal response time                      | $V_{IN} = \text{TTL logic swing}$ ,<br>$V_{REF} = 1.4 V_{DC}$ ;<br>$V_{RL} = 5 V_{DC}$ ;<br>$R_L = 5.1\text{ k}\Omega$ ;<br>$T_{amb} = 25\text{ }^{\circ}\text{C}$ |        | 300       |                        |             | 300       |                        |        | 300                  |                       | ns            |
| $t_R$      | Response time <sup>5</sup>                      | $V_{RL} = 5 V_{DC}$ ;<br>$R_L = 5.1\text{ k}\Omega$ ;<br>$T_{amb} = 25\text{ }^{\circ}\text{C}$                                                                    |        | 1.3       |                        |             | 1.3       |                        |        | 1.3                  |                       | $\mu\text{s}$ |

## Low power dual voltage comparator

## LM193A/293/A/393/A/2903

**DC ELECTRICAL CHARACTERISTICS** (Continued)

$V_+ = 5 V_{DC}$ , LM193A:  $-55\text{ }^{\circ}\text{C}$   $T_{amb} \leq +125\text{ }^{\circ}\text{C}$ , unless otherwise specified. LM293/293A:  $-25\text{ }^{\circ}\text{C}$   $T_{amb} \leq +85\text{ }^{\circ}\text{C}$ , unless otherwise specified. LM393/393A:  $0\text{ }^{\circ}\text{C}$   $T_{amb} \leq +70\text{ }^{\circ}\text{C}$ , unless otherwise specified. LM2903:  $-40\text{ }^{\circ}\text{C}$   $T_{amb} \leq +125\text{ }^{\circ}\text{C}$ , unless otherwise specified.

| SYMBOL     | PARAMETER                                       | TEST CONDITIONS                                                                                                                                              | LM293/393 |           |                            | UNIT                |
|------------|-------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------|-----------|----------------------------|---------------------|
|            |                                                 |                                                                                                                                                              | Min       | Typ       | Max                        |                     |
| $V_{OS}$   | Input offset voltage <sup>2</sup>               | $T_{amb} = 25\text{ }^{\circ}\text{C}$<br>Over temp.                                                                                                         |           | $\pm 2.0$ | $\pm 5.0$<br>$\pm 9.0$     | mV<br>mV            |
| $V_{CM}$   | Input common-mode voltage range <sup>3, 6</sup> | $T_{amb} = 25\text{ }^{\circ}\text{C}$<br>Over temp.                                                                                                         | 0<br>0    |           | $V_+ - 1.5$<br>$V_+ - 2.0$ | V<br>V              |
| $V_{IDR}$  | Differential input voltage <sup>1</sup>         | Keep all $V_{IN} \geq 0 V_{DC}$<br>(or $V_-$ if needed)                                                                                                      |           |           | $V_+$                      | V                   |
| $I_{BIAS}$ | Input bias current <sup>4</sup>                 | $I_{IN(+)}$ or $I_{IN(-)}$ with output in linear range<br>$T_{amb} = 25\text{ }^{\circ}\text{C}$<br>Over temp.                                               |           | 25        | 250<br>400                 | nA<br>nA            |
| $I_{OS}$   | Input offset current                            | $I_{IN(+)} - I_{IN(-)}$<br>$T_{amb} = 25\text{ }^{\circ}\text{C}$<br>Over temp.                                                                              |           | $\pm 5.0$ | $\pm 50$<br>$\pm 150$      | nA<br>nA            |
| $I_{OL}$   | Output sink current                             | $V_{IN(-)} \geq 1 V_{DC}$ ; $V_{IN(+)} = 0$ ; $V_O \leq 1.5 V_{DC}$<br>$T_{amb} = 25\text{ }^{\circ}\text{C}$                                                | 6.0       | 16        |                            | mA                  |
|            | Output leakage current                          | $V_{IN(+)} \geq 1 V_{DC}$ ; $V_{IN(-)} = 0$ ,<br>$V_O = 5 V_{DC}$ ; $T_{amb} = 25\text{ }^{\circ}\text{C}$<br>$V_O = 30 V_{DC}$ ; over temp.                 |           | 0.1       | 1.0                        | nA<br>$\mu\text{A}$ |
| $I_{CC}$   | Supply current                                  | $R_L = \infty$ on both comparators,<br>$T_{amb} = 25\text{ }^{\circ}\text{C}$                                                                                |           | 0.8       | 1                          | mA                  |
|            |                                                 | $R_L = \infty$ on both comparators;<br>$V_+ = 30\text{ V}$                                                                                                   |           |           | 2.5                        | mA                  |
| $A_V$      | Voltage gain                                    | $R_L \geq 15\text{ k}\Omega$ ; $V_+ = 15 V_{DC}$                                                                                                             | 50        | 200       |                            | V/mV                |
| $V_{OL}$   | Saturation voltage                              | $V_{IN(-)} \geq 1 V_{DC}$ ; $V_{IN(+)} = 0$ ; $I_{SINK} \leq 4\text{ mA}$<br>$T_{amb} = 25\text{ }^{\circ}\text{C}$<br>Over temp.                            |           | 250       | 400<br>700                 | mV<br>mV            |
| $t_{LSR}$  | Large signal response time                      | $V_{IN} = \text{TTL logic swing}$ ,<br>$V_{REF} = 1.4 V_{DC}$ ; $V_{RL} = 5 V_{DC}$ ;<br>$R_L = 5.1\text{ k}\Omega$ ; $T_{amb} = 25\text{ }^{\circ}\text{C}$ |           | 300       |                            | ns                  |
| $t_R$      | Response time <sup>5</sup>                      | $V_{RL} = 5 V_{DC}$ ; $R_L = 5.1\text{ k}\Omega$<br>$T_{amb} = 25\text{ }^{\circ}\text{C}$                                                                   |           | 1.3       |                            | $\mu\text{s}$       |

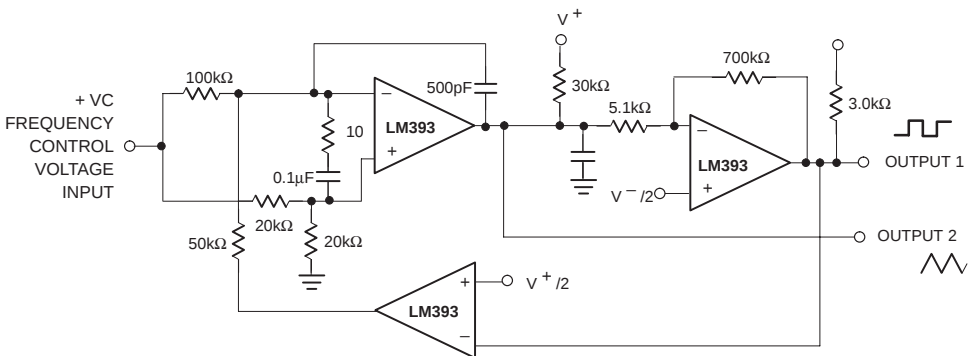
**NOTES:**

- Positive excursions of input voltage may exceed the power supply level by 17 V. As long as the other voltage remains within the common-mode range, the comparator will provide a proper output state. The low input voltage state must not be less than  $-0.3 V_{DC}$  ( $V_{DC}$  below the magnitude of the negative power supply, if used).
- At output switch point,  $V_O \approx 1.4 V_{DC}$ ,  $R_S = 0\text{ }\Omega$  with  $V_+$  from  $5 V_{DC}$  to  $30 V_{DC}$  and over the full input common-mode range ( $0 V_{DC}$  to  $V_+ - 1.5 V_{DC}$ ).
- The input common-mode voltage or either input signal voltage should not be allowed to go negative by more than 0.3 V. The upper end of the common-mode voltage range is  $V_+ - 1.5\text{ V}$ , but either or both inputs can go to  $30 V_{DC}$  without damage.
- 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 change exists on the reference or input lines.
- The response time specified is for a 100 mV input step with a 5 mV overdrive.
- For input signals that exceed  $V_{CC}$ , only the over-driven comparator is affected. With a 5 V supply,  $V_{IN}$  should be limited to 25 V maximum, and a limiting resistor should be used on all inputs that might exceed the positive supply.

# Low power dual voltage comparator

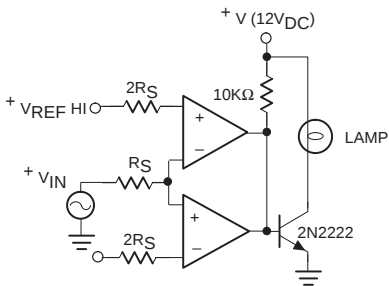
LM193A/293/A/393/A/2903

## EQUIVALENT CIRCUIT

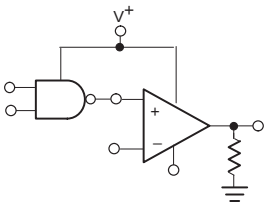


**NOTES:**  
 $V+ = 30V_{DC}$   
 $+ 250mV_{DC} \leq V_C = 50V_{DC}$   
 $700H \leq f_O = 100kHz$

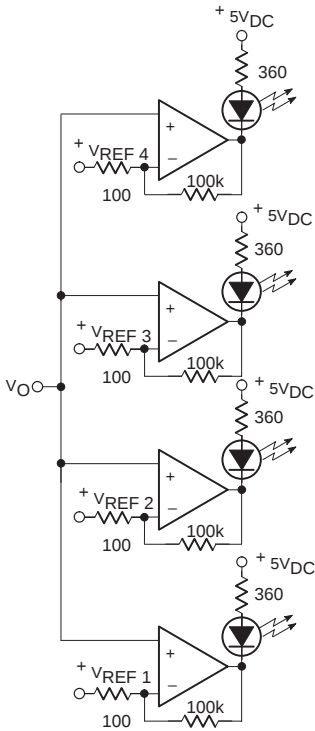
Two-Decade High-Frequency VCO



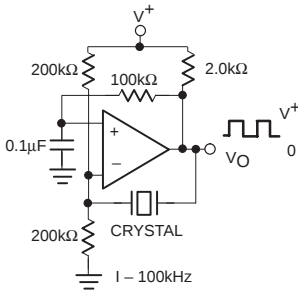
Limit Comparator



TTL-to-MOS Logic Converter



Visible Voltage Indicator



Crystal-Controlled Oscillator

**NOTE:**  
 Input of unused comparators should be grounded.

SL00081

Figure 3. Equivalent circuit.

## Low power dual voltage comparator

## LM193A/293/A/393/A/2903

## TYPICAL PERFORMANCE CHARACTERISTICS

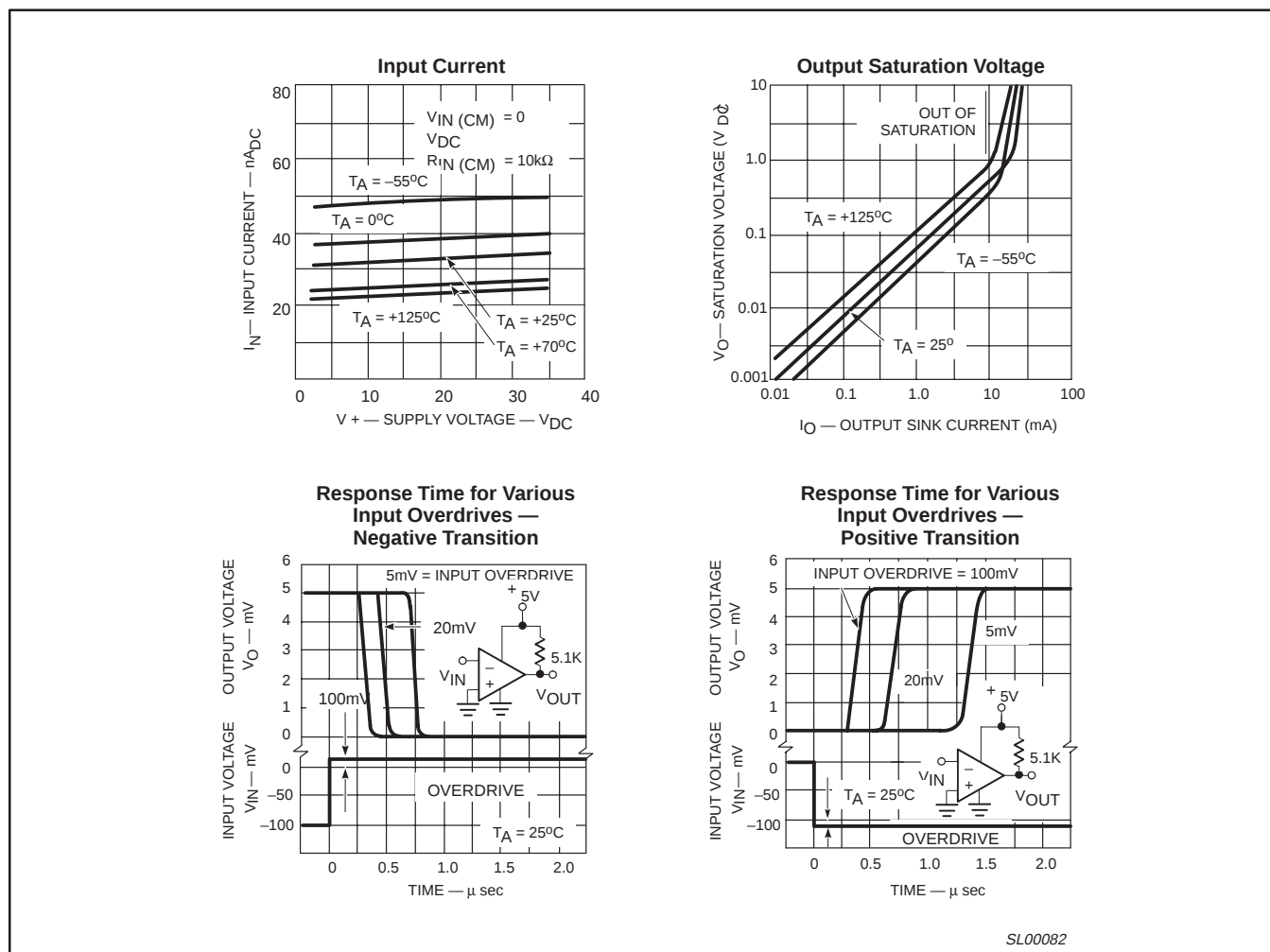


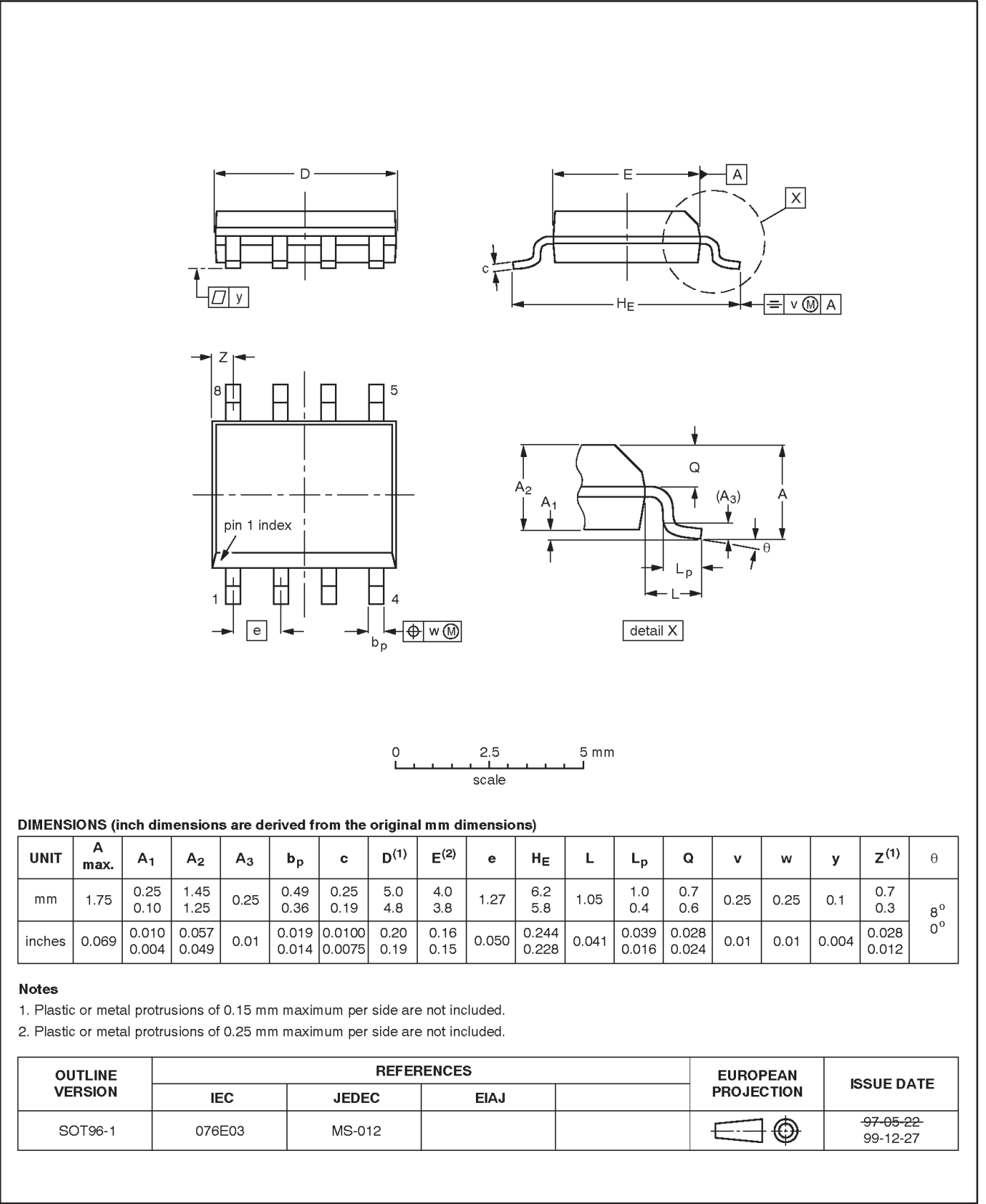
Figure 4. Typical performance characteristics.

Low power dual voltage comparator

LM193A/293/A/393/A/2903

SO8: plastic small outline package; 8 leads; body width 3.9 mm

SOT96-1



Low power dual voltage comparator

LM193A/293/A/393/A/2903

DIP8: plastic dual in-line package; 8 leads (300 mil)

SOT97-1

Technical drawing of the SOT97-1 package showing top, side, and end views with dimensions A, A1, A2, b, b1, b2, c, D, E, e, e1, L, ME, MH, w, Z, and pin 1 index.

0 5 10 mm

scale

**DIMENSIONS (inch dimensions are derived from the original mm dimensions)**

| UNIT   | A<br>max. | A <sub>1</sub><br>min. | A <sub>2</sub><br>max. | b              | b <sub>1</sub> | b <sub>2</sub> | c              | D <sup>(1)</sup> | E <sup>(1)</sup> | e    | e <sub>1</sub> | L            | M <sub>E</sub> | M <sub>H</sub> | w     | Z <sup>(1)</sup><br>max. |
|--------|-----------|------------------------|------------------------|----------------|----------------|----------------|----------------|------------------|------------------|------|----------------|--------------|----------------|----------------|-------|--------------------------|
| mm     | 4.2       | 0.51                   | 3.2                    | 1.73<br>1.14   | 0.53<br>0.38   | 1.07<br>0.89   | 0.36<br>0.23   | 9.8<br>9.2       | 6.48<br>6.20     | 2.54 | 7.62           | 3.60<br>3.05 | 8.25<br>7.80   | 10.0<br>8.3    | 0.254 | 1.15                     |
| inches | 0.17      | 0.020                  | 0.13                   | 0.068<br>0.045 | 0.021<br>0.015 | 0.042<br>0.035 | 0.014<br>0.009 | 0.39<br>0.36     | 0.26<br>0.24     | 0.10 | 0.30           | 0.14<br>0.12 | 0.32<br>0.31   | 0.39<br>0.33   | 0.01  | 0.045                    |

**Note**

1. Plastic or metal protrusions of 0.25 mm maximum per side are not included.

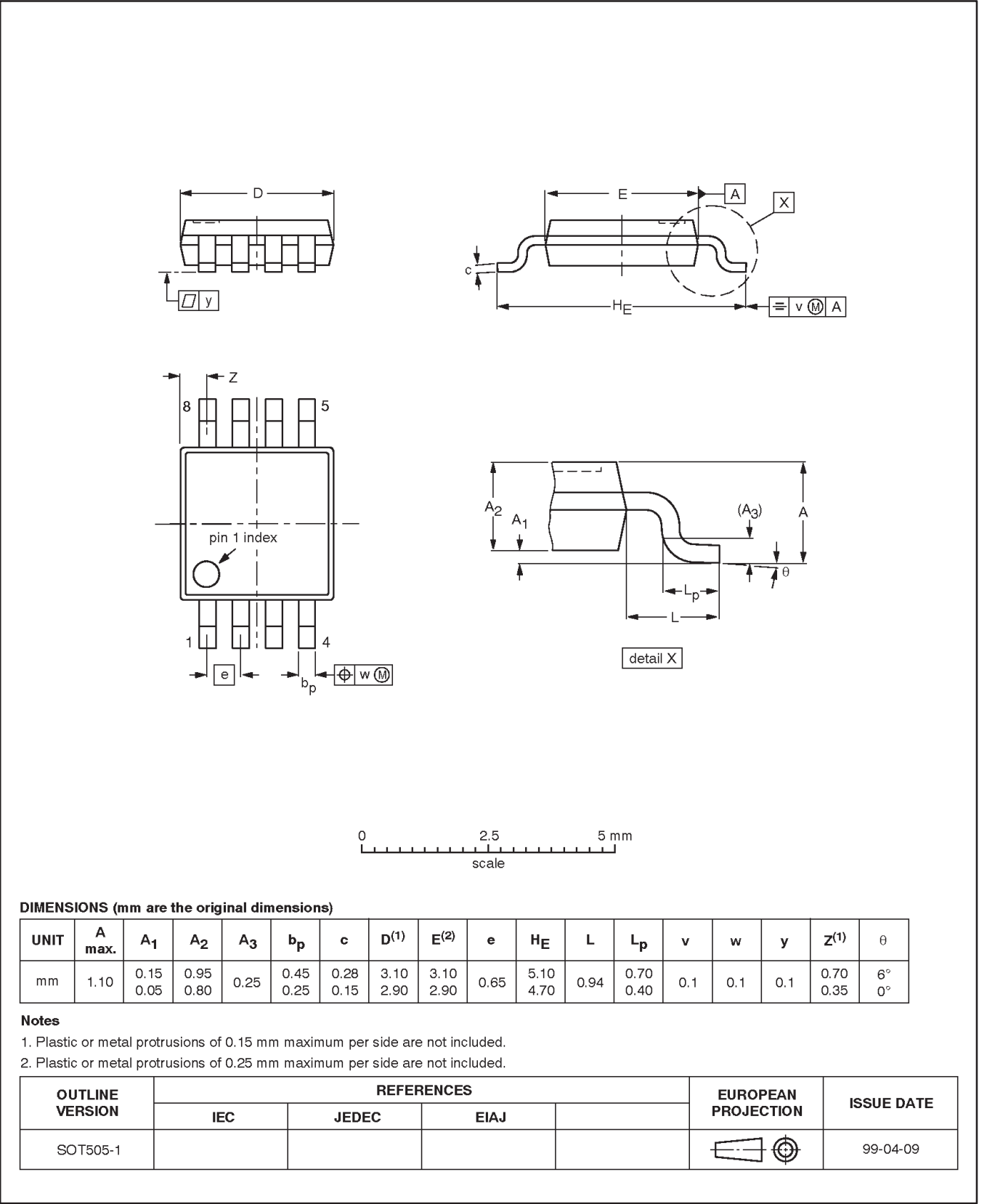
| OUTLINE<br>VERSION | REFERENCES |        |          |  | EUROPEAN<br>PROJECTION | ISSUE DATE           |
|--------------------|------------|--------|----------|--|------------------------|----------------------|
|                    | IEC        | JEDEC  | EIAJ     |  |                        |                      |
| SOT97-1            | 050G01     | MO-001 | SC-504-8 |  |                        | 95-02-04<br>99-12-27 |

Low power dual voltage comparator

LM193A/293/A/393/A/2903

TSSOP8: plastic thin shrink small outline package; 8 leads; body width 3 mm

SOT505-1



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Low power dual voltage comparator

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LM193A/293/A/393/A/2903

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**NOTES**

## Low power dual voltage comparator

LM193A/293/A/393/A/2903

## Data sheet status

| Data sheet status <sup>[1]</sup> | Product status <sup>[2]</sup> | Definitions                                                                                                                                                                                                                                                                                                            |
|----------------------------------|-------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Objective data                   | Development                   | This data sheet contains data from the objective specification for product development. Philips Semiconductors reserves the right to change the specification in any manner without notice.                                                                                                                            |
| Preliminary data                 | Qualification                 | This data sheet contains data from the preliminary specification. Supplementary data will be published at a later date. Philips Semiconductors reserves the right to change the specification without notice, in order to improve the design and supply the best possible product.                                     |
| Product data                     | Production                    | This data sheet contains data from the product specification. Philips Semiconductors reserves the right to make changes at any time in order to improve the design, manufacturing and supply. Changes will be communicated according to the Customer Product/Process Change Notification (CPCN) procedure SNW-SQ-650A. |

[1] Please consult the most recently issued data sheet before initiating or completing a design.

[2] The product status of the device(s) described in this data sheet may have changed since this data sheet was published. The latest information is available on the Internet at URL <http://www.semiconductors.philips.com>.

## Definitions

**Short-form specification** — The data in a short-form specification is extracted from a full data sheet with the same type number and title. For detailed information see the relevant data sheet or data handbook.

**Limiting values definition** — Limiting values given are in accordance with the Absolute Maximum Rating System (IEC 60134). Stress above one or more of the limiting values may cause permanent damage to the device. These are stress ratings only and operation of the device at these or at any other conditions above those given in the Characteristics sections of the specification is not implied. Exposure to limiting values for extended periods may affect device reliability.

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