# LM2903

## Low power dual voltage comparator
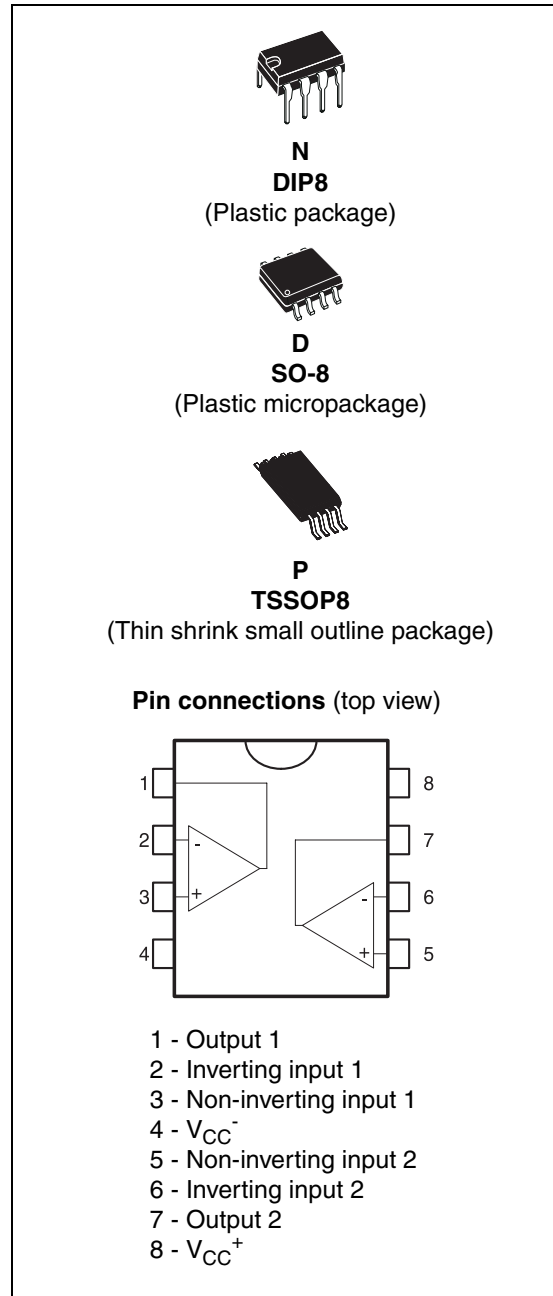
## Features

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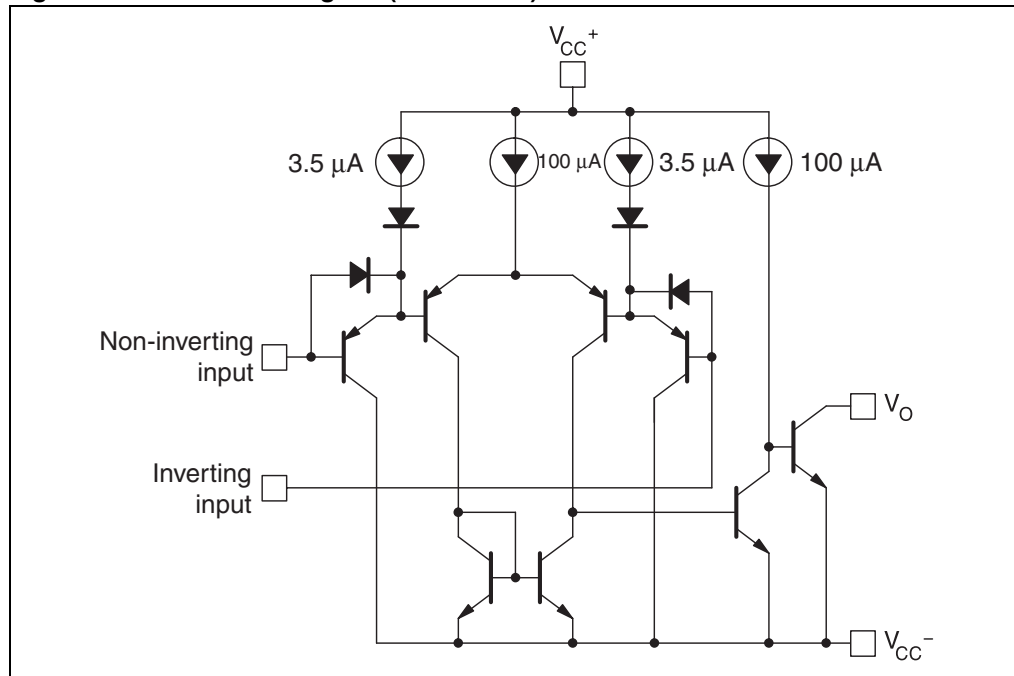- TTL, DTL, ECL, MOS, CMOS compatible outputs

## Description

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

This comparator also has a unique characteristic: the input common-mode voltage range includes the negative rail even though operated from a single power supply voltage.

**N
DIP8**
(Plastic package)

**D
SO-8**
(Plastic micropackage)

**P
TSSOP8**
(Thin shrink small outline package)

**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 - $V_{CC}^+$

# 1 Schematic diagram

**Figure 1.    Schematic diagram (1/2 LM2903)**

# 2 Absolute maximum ratings and operating conditions

**Table 1.    Absolute maximum ratings**

| Symbol | Parameter | Value | Unit |
|---|---|---|---|
| $V_{CC}$ | Supply voltage | ±18 to 36 | V |
| $V_{id}$ | Differential input voltage | ±36 | V |
| $V_{in}$ | Input voltage | -0.3 to +36 | V |
| | Output short-circuit to ground [1] | Infinite | |
| $R_{thja}$ | Thermal resistance junction to ambient[2]<br>DIP8<br>SO-8<br>TSSOP8 | 85<br>125<br>120 | °C/W |
| $R_{thjc}$ | Thermal resistance junction to case[2]<br>DIP8<br>SO-8<br>TSSOP8 | 41<br>40<br>37 | °C/W |
| $T_j$ | Maximum junction temperature | +150 | °C |
| $T_{stg}$ | Storage temperature range | -65 to +150 | °C |
| ESD | Human body model (HBM)[3] | 800 | V |
| | Machine model (MM)[4] | 200 | V |
| | CDM: charged device model[5] | 1.5 | kV |

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

2. Short-circuits can cause excessive heating and destructive dissipation. Values are typical.

3. Human body model: a 100 pF capacitor is charged to the specified voltage, then discharged through a 1.5 kΩ resistor between two pins of the device. This is done for all couples of connected pin combinations while the other pins are floating.

4. Machine model: a 200 pF capacitor is charged to the specified voltage, then discharged directly between two pins of the device with no external series resistor (internal resistor < 5 Ω). This is done for all couples of connected pin combinations while the other pins are floating.

5. Charged device model: all pins and the package are charged together to the specified voltage and then discharged directly to the ground through only one pin. This is done for all pins.

**Table 2.    Operating conditions**

| Symbol | Parameter | Value | Unit |
|---|---|---|---|
| $V_{icm}$ | Common mode input voltage range<br>$T_{min} \leq T_{amb} \leq T_{max}$ | 0 to $V_{CC}^+$ -1.5<br>0 to $V_{CC}^+$ -2 | V |
| $T_{oper}$ | Operating free-air temperature range | -40 to +125 | °C |

# 3 Electrical characteristics

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

| Symbol | Parameter | Min. | Typ. | Max. | Unit |
|---|---|---|---|---|---|
| $V_{io}$ | Input offset voltage [1]<br>$T_{min} \leq T_{amb} \leq T_{max}$ | | 1 | 7<br>15 | mV |
| $I_{io}$ | Input offset current<br>$T_{min} \leq T_{amb} \leq T_{max}$ | | 5 | 50<br>150 | nA |
| $I_{ib}$ | Input bias current [2]<br>$T_{min} \leq T_{amb} \leq T_{max}$ | | 25 | 250<br>400 | nA |
| $A_{vd}$ | Large signal voltage gain<br>$V_{CC}$ = 15V, $R_L$=15kΩ, $V_o$=1 to 11V | 25 | 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 |
| $V_{id}$ | Differential input voltage [3] | | | $V_{CC}^+$ | V |
| $V_{OL}$ | Low level output voltage ($V_{id}$ = -1V, $I_{sink}$ = 4mA)<br>$T_{min} \leq T_{amb} \leq T_{max}$ | | 250 | 400<br>700 | mV |
| $I_{OH}$ | High level output current ($V_{CC}$ =$V_o$ =30V, $V_{id}$ = 1V)<br>$T_{min} \leq T_{amb} \leq T_{max}$ | | 0.1 | <br>1 | nA<br>µA |
| $I_{sink}$ | Output sink current ($V_{id}$ = -1V, $V_o$ = 1.5V) | 6 | 16 | | mA |
| $t_{res}$ | Small signal response time [4] ($R_L$ = 5.1kΩ to $V_{CC}^+$) | | 1.3 | | µs |
| $t_{rel}$ | Large signal response time [5]<br>TTL input ($V_{ref}$ = +1.4 V, $R_L$=5.1kΩ to $V_{CC}^+$)<br>    Output signal at 50% of final value<br>    Output signal at 95% of final value | | | <br><br>500<br>1 | <br><br>ns<br>µs |

1. At output switch point, $V_O \approx$ 1.4 V, $R_S$ = 0 Ω with $V_{CC}^+$ from 5 V to 30 V, and over the full input common-mode range (0 V to $V_{CC}^+$ −1.5 V).

2. The direction of the input current is out of the IC due to the PNP input stage. This current is essentially constant, independent of the state of the output, so no loading charge exists on the reference of input lines.

3. 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 V (or 0.3 V below the negative power supply, if used).

4. The response time specified is for a 100 mV input step with 5 mV overdrive.

5. Maximum values are guaranteed by design and evaluation.
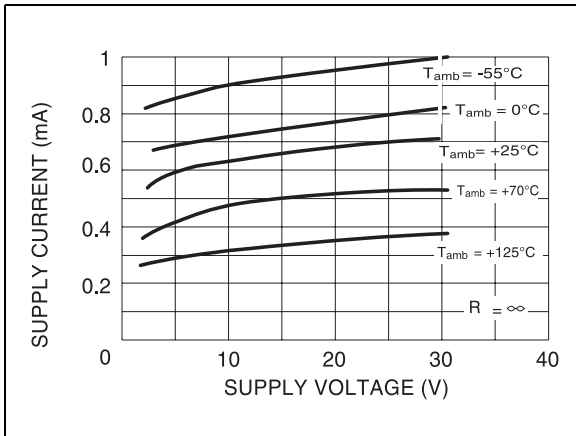
**Figure 2.** Supply current vs. supply voltage



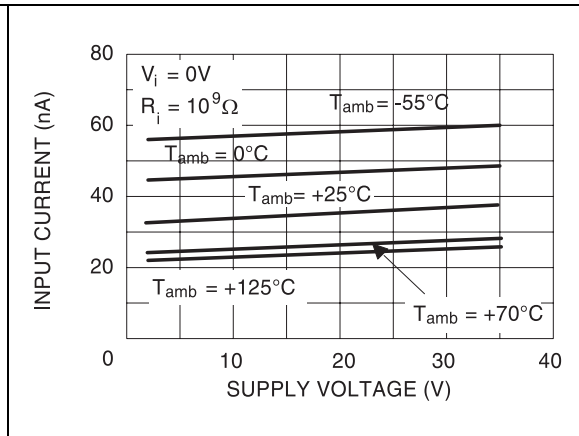**Figure 3.** Input current vs. supply voltage



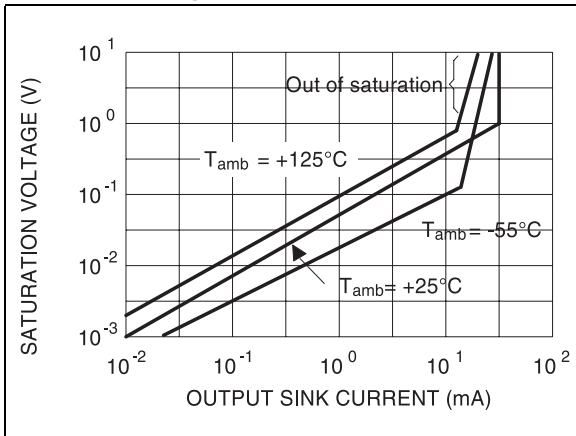**Figure 4.** Output saturation voltage vs. output current



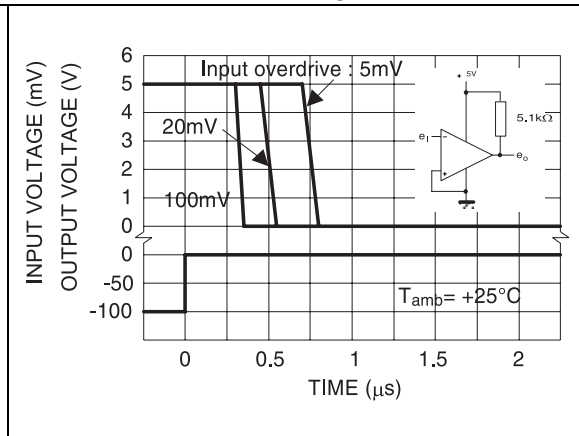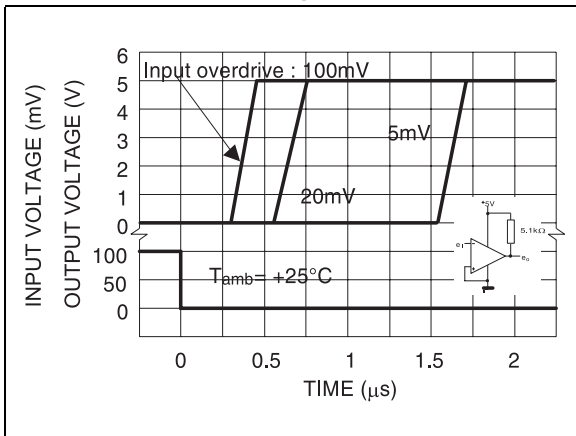**Figure 5.** Response time for various input overdrives - negative transition



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

# 4 Typical application schematics
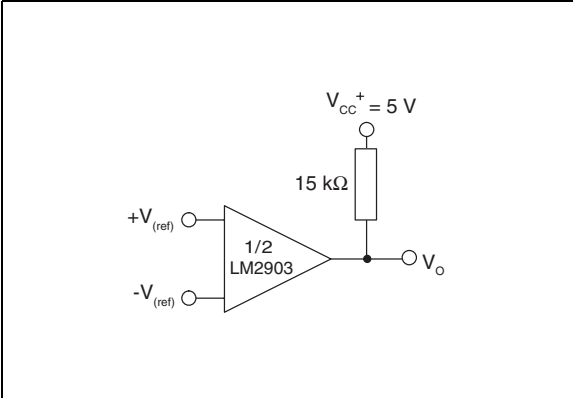
Figure 7. Basic comparator
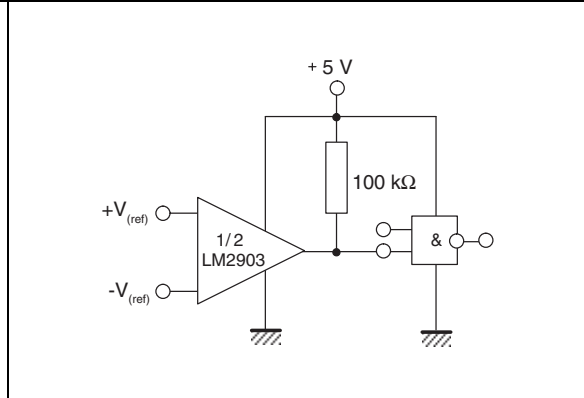


Figure 8. Driving CMOS


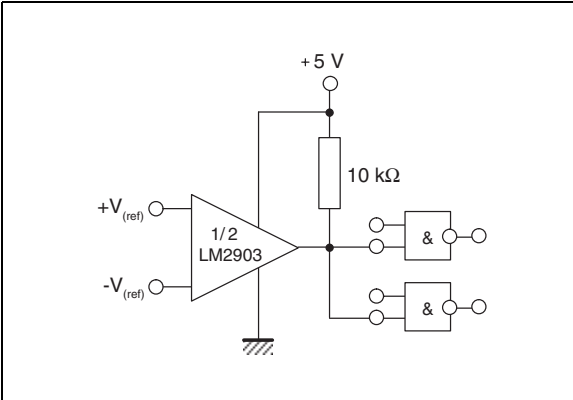
Figure 9. Driving TTL



Figure 10. Low frequency op-amp



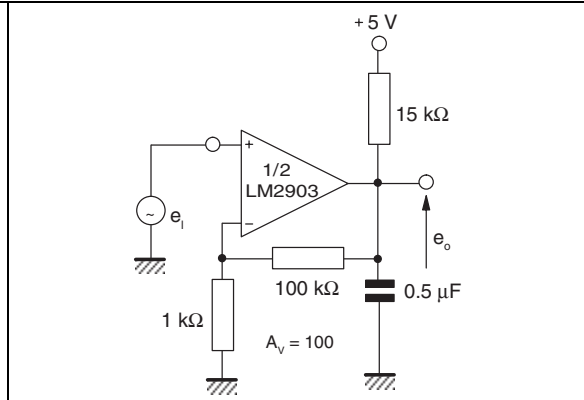Figure 11. Low frequency op-amp
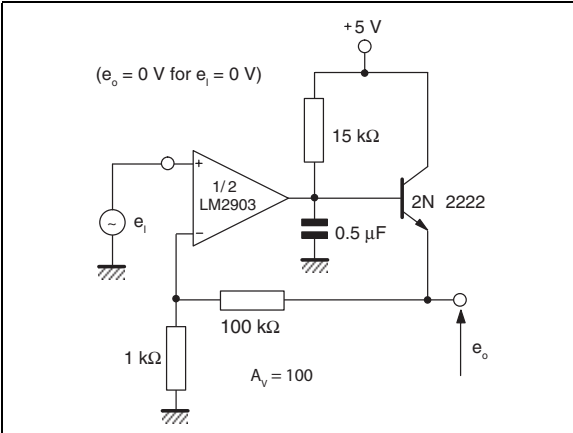


Figure 12. Transducer amplifier
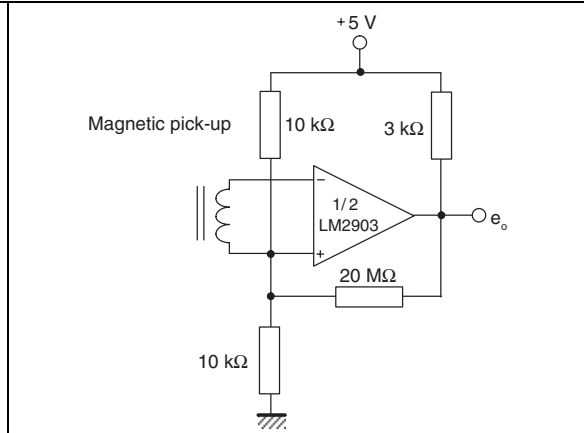
**Figure 13.   Low frequency op- amp with offset adjust**
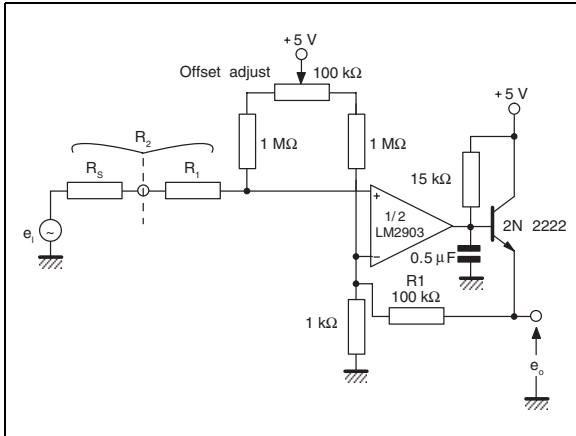


**Figure 14.   Zero crossing detector (single power supply)**
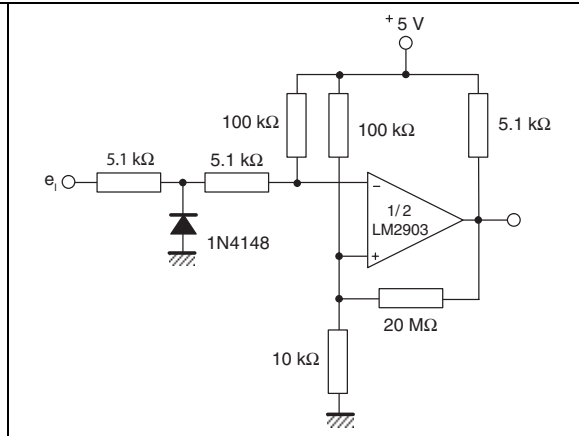


**Figure 15.   Limit comparator**
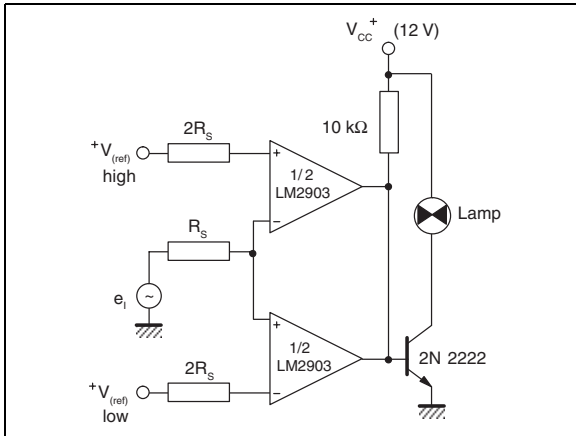


**Figure 16.   Split-supply applications - zero crossing detector**
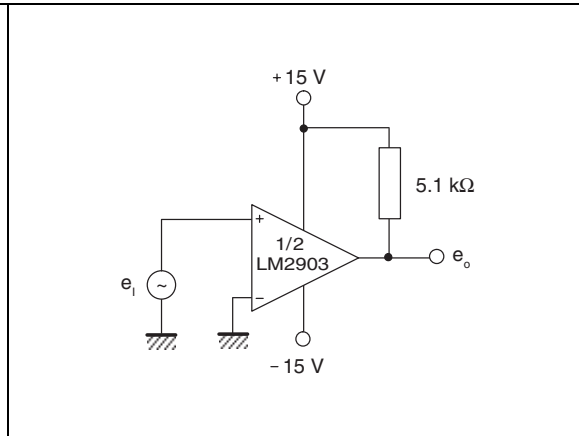


**Figure 17.   Crystal controlled oscillator**
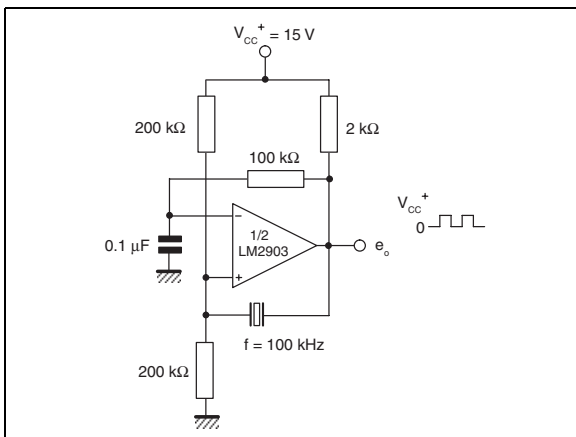


**Figure 18.   Comparator with a negative reference**

### Figure 19. Time delay generator



### Figure 20. Two-decade high-frequency VCO
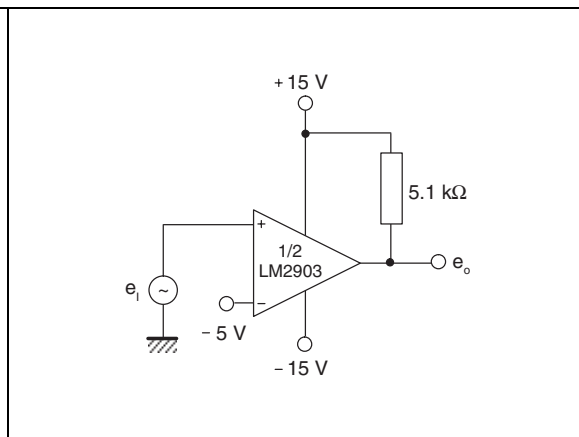
# 5 Package information

In order to meet environmental requirements, ST offers these devices in different grades of ECOPACK® packages, depending on their level of environmental compliance. ECOPACK® specifications, grade definitions and product status are available at: *www.st.com*. ECOPACK® is an ST trademark.

## 5.1 DIP8 package information

**Figure 21. DIP8 package mechanical drawing**
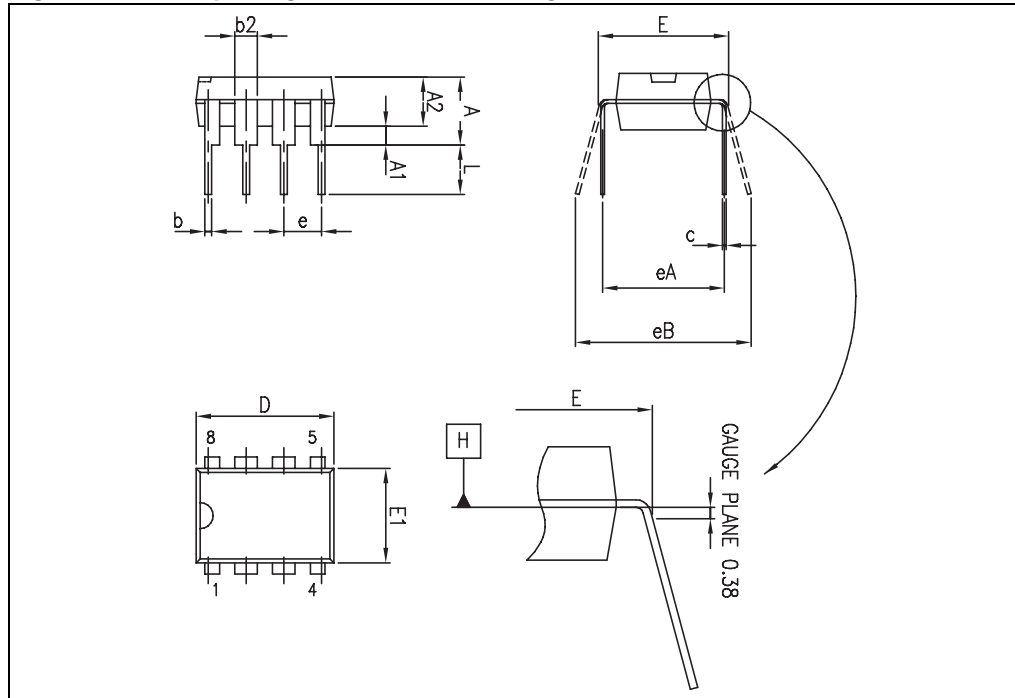


**Table 4. DIP8 package mechanical data**

| Ref. | Dimensions | | | | | |
|------|------------|---|---|---|---|---|
|      | Millimeters | | | Inches | | |
|      | Min. | Typ. | Max. | Min. | Typ. | Max. |
| A    |      |      | 5.33 |      |      | 0.210 |
| A1   | 0.38 |      |      | 0.015 |      |      |
| A2   | 2.92 | 3.30 | 4.95 | 0.115 | 0.130 | 0.195 |
| b    | 0.36 | 0.46 | 0.56 | 0.014 | 0.018 | 0.022 |
| b2   | 1.14 | 1.52 | 1.78 | 0.045 | 0.060 | 0.070 |
| c    | 0.20 | 0.25 | 0.36 | 0.008 | 0.010 | 0.014 |
| D    | 9.02 | 9.27 | 10.16 | 0.355 | 0.365 | 0.400 |
| E    | 7.62 | 7.87 | 8.26 | 0.300 | 0.310 | 0.325 |
| E1   | 6.10 | 6.35 | 7.11 | 0.240 | 0.250 | 0.280 |
| e    |      | 2.54 |      |      | 0.100 |      |
| eA   |      | 7.62 |      |      | 0.300 |      |
| eB   |      |      | 10.92 |      |      | 0.430 |
| L    | 2.92 | 3.30 | 3.81 | 0.115 | 0.130 | 0.150 |

## 5.2  SO-8 package information

**Figure 22.  SO-8 package mechanical drawing**
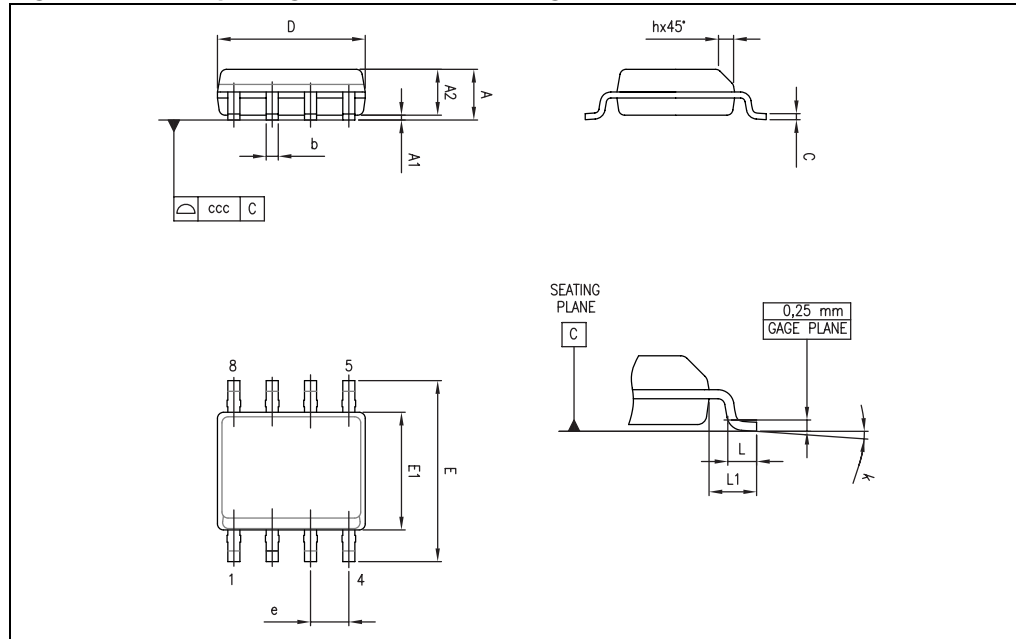


**Table 5.  SO-8 package mechanical data**

| Ref. | Dimensions | | | | | |
|---|---|---|---|---|---|---|
| | Millimeters | | | Inches | | |
| | Min. | Typ. | Max. | Min. | Typ. | Max. |
| A | | | 1.75 | | | 0.069 |
| A1 | 0.10 | | 0.25 | 0.004 | | 0.010 |
| A2 | 1.25 | | | 0.049 | | |
| b | 0.28 | | 0.48 | 0.011 | | 0.019 |
| c | 0.17 | | 0.23 | 0.007 | | 0.010 |
| D | 4.80 | 4.90 | 5.00 | 0.189 | 0.193 | 0.197 |
| E | 5.80 | 6.00 | 6.20 | 0.228 | 0.236 | 0.244 |
| E1 | 3.80 | 3.90 | 4.00 | 0.150 | 0.154 | 0.157 |
| e | | 1.27 | | | 0.050 | |
| h | 0.25 | | 0.50 | 0.010 | | 0.020 |
| L | 0.40 | | 1.27 | 0.016 | | 0.050 |
| L1 | | 1.04 | | | 0.040 | |
| k | 1° | | 8° | 1° | | 8° |
| ccc | | | 0.10 | | | 0.004 |

## 5.3  TSSOP8 package information

**Figure 23.  TSSOP8 package mechanical drawing**
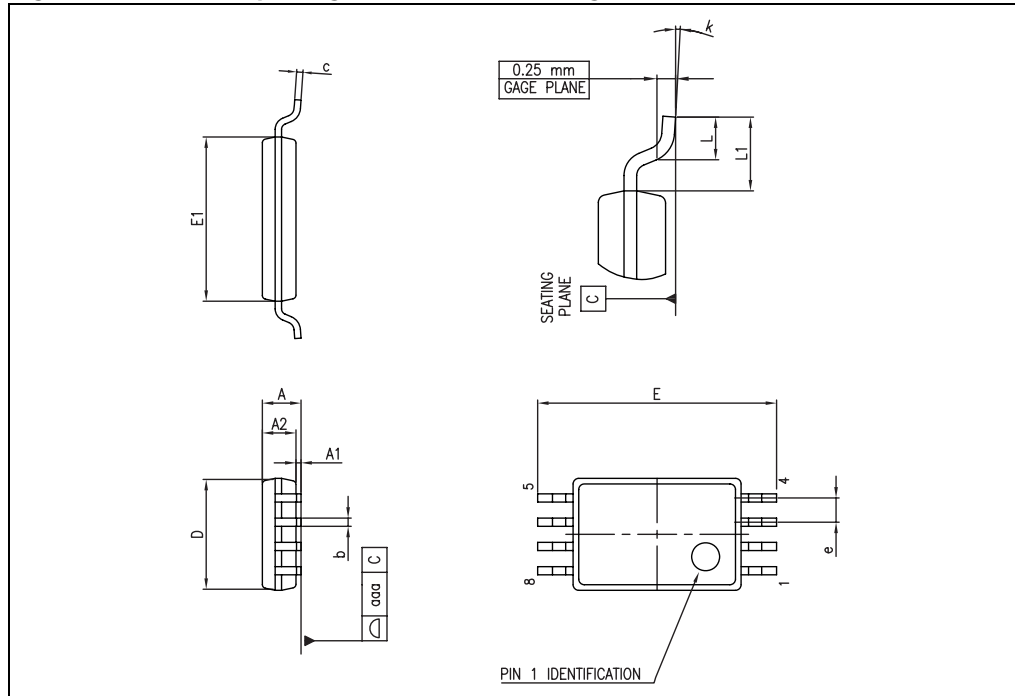


**Table 6.  TSSOP8 package mechanical data**

| Ref. | Dimensions | | | | | |
|------|------------|---|---|---|---|---|
|      | Millimeters | | | Inches | | |
|      | Min. | Typ. | Max. | Min. | Typ. | Max. |
| A    |      |      | 1.20 |      |      | 0.047 |
| A1   | 0.05 |      | 0.15 | 0.002 |      | 0.006 |
| A2   | 0.80 | 1.00 | 1.05 | 0.031 | 0.039 | 0.041 |
| b    | 0.19 |      | 0.30 | 0.007 |      | 0.012 |
| c    | 0.09 |      | 0.20 | 0.004 |      | 0.008 |
| D    | 2.90 | 3.00 | 3.10 | 0.114 | 0.118 | 0.122 |
| E    | 6.20 | 6.40 | 6.60 | 0.244 | 0.252 | 0.260 |
| E1   | 4.30 | 4.40 | 4.50 | 0.169 | 0.173 | 0.177 |
| e    |      | 0.65 |      |      | 0.0256 |      |
| k    | 0°   |      | 8°   | 0°   |      | 8°   |
| L    | 0.45 | 0.60 | 0.75 | 0.018 | 0.024 | 0.030 |
| L1   |      | 1    |      |      | 0.039 |      |
| aaa  |      |      | 0.10 |      |      | 0.004 |

# 6 Ordering information

**Table 7. Order codes**

| Order code | Temperature range | Package | Packing | Marking |
|---|---|---|---|---|
| LM2903N | -40°C to +125°C | DIP8 | Tube | LM2903N |
| LM2903D/DT | | SO-8 | Tube or tape & reel | 2903 |
| LM2903PT | | TSSOP8 | Tape & reel | |
| LM2903YD[1] LM2903YDT[1] | | SO-8 (Automotive grade) | Tube or tape & reel | 2903Y |
| LM2903YPT[2] | | TSSOP8 (Automotive grade) | Tape & reel | |

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

2. Qualification and characterization according to AEC Q100 and Q003 or equivalent, advanced screening according to AEC Q001 & Q 002 or equivalent are on-going.

# 7 Revision history

**Table 8.** **Document revision history**

| Date | Revision | Changes |
|------|----------|---------|
| 15-Jun-2003 | 1 | Initial release. |
| 2-May-2005 | 2 | PPAP references inserted in the datasheet see table order code p1. |
| 8-Aug-2005 | 3 | Electrical characteristics table corrected (see *Table 3 on page 4*).<br>Pin connections diagram moved to cover page.<br>Lead-free package information added. |
| 27-Oct-2005 | 4 | PPAP part number added in *Table 7: Order codes*. |
| 11-May-2007 | 5 | ESD tolerance added in *Table 1: Absolute maximum ratings on page 3*. |
| 17-Jan-2008 | 6 | Added $R_{thja}$ and $R_{thjc}$, and ESD CDM parameters in *Table 1: Absolute maximum ratings*.<br>Removed $V_{icm}$ from electrical characteristics in *Table 3*.<br>Reformatted package information in *Section 5*.<br>Added footnotes for automotive grade parts in *Table 7: Order codes*. |
| 21-Feb-2008 | 7 | Corrected SO-8 package mechanical data. Dimension E in drawing was marked H in table.<br>Corrected revision history (revision 6 is of January 2008, not January 2007). |
| 03-Dec-2009 | 8 | Added pin description on cover page. |

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