LM2903-Q1 Automotive Dual Differential Comparators

1 Features

• Qualified for Automotive Applications
• AEC-Q100 Qualified with the Following Results:
  – Device Temperature Grade 0: -40°C to 150°C Ambient Operating Temperature Range (LM2903E-Q1)
  – Device Temperature Grade 1: -40°C to 125°C Ambient Operating Temperature Range (LM2903-Q1)
  – Device HBM ESD Classification Level H1C
  – Device CDM ESD Classification Level C4B
• ESD Protection Exceeds 1000 V Per MIL-STD-883, Method 3015; Exceeds 100 V Using Machine Model (C = 200 pF, R = 0 Ω)
• Single Supply or Dual Supplies
• Low Supply-Current Drain Independent of Supply Voltage 0.4 mA Typ Per Comparator
• Low Input Bias Current 25 nA Typ
• Low Input Offset Current 5 nA Typ
• Low Input Offset Voltage 2 mV Typ
• Common-Mode Input Voltage Range Includes Ground
• Differential Input Voltage Range Equal to Maximum-Rated Supply Voltage ±36 V
• Low Output Saturation Voltage
• Output Compatible With TTL, MOS, and CMOS

2 Applications

• Automotive
  – HEV/EV and Power Train
  – Infotainment and Cluster
  – Body Control Module
• Industrial
  – Power supervision
  – Oscillator
  – Peak Detector
  – Logic Voltage Translation

3 Description

This device consists of two independent voltage comparators that are designed to operate from a single power supply over a wide range of voltages. Operation from dual supplies is possible, as long as the difference between the two supplies is 2 V to 36 V, and VCC is at least 1.5 V more positive than the input common-mode voltage. Current drain is independent of the supply voltage. The outputs can be connected to other open-collector outputs to achieve wired-AND relationships.

The LM2903-Q1 is Qualified for the AEC-Q100 Grade 1 temperature range of -40°C to +125°C. The LM2903E-Q1 is Qualified for the AEC-Q100 Grade 0 temperature range of -40°C to +150°C.

Device Information

<table>
<thead>
<tr>
<th>PART NUMBER</th>
<th>PACKAGE</th>
<th>BODY SIZE (NOM)</th>
</tr>
</thead>
<tbody>
<tr>
<td>LM2903-Q1</td>
<td>VSSOP(8)</td>
<td>3.00 mm x 3.00 mm</td>
</tr>
<tr>
<td></td>
<td>SOIC (8)</td>
<td>4.90 mm x 3.91 mm</td>
</tr>
<tr>
<td></td>
<td>TSSOP (8)</td>
<td>3.00 mm x 4.40 mm</td>
</tr>
<tr>
<td>LM2903E-Q1</td>
<td>TSSOP (8)</td>
<td>3.00 mm x 4.40 mm</td>
</tr>
</tbody>
</table>

(1) For all available packages, see the orderable addendum at the end of the datasheet.
Table of Contents

1 Features .............................................................. 1
2 Applications ........................................................ 1
3 Description .......................................................... 1
4 Revision History ..................................................... 2
5 Pin Configuration and Functions ................................. 3
6 Specifications ....................................................... 3
   6.1 Absolute Maximum Ratings ................................. 3
   6.2 Handling Ratings .............................................. 4
   6.3 Recommended Operating Conditions, LM2903-Q1 .. 4
   6.4 Recommended Operating Conditions, LM2903E-Q1 .... 4
   6.5 Thermal Information ......................................... 4
   6.6 Electrical Characteristics .................................... 5
   6.7 Switching Characteristics ................................... 5
   6.8 Typical Characteristics ...................................... 6
7 Detailed Description .............................................. 7
   7.1 Overview ....................................................... 7
   7.2 Functional Block Diagram ................................... 7
7.3 Feature Description ............................................. 7
7.4 Device Functional Modes ...................................... 7
8 Application and Implementation ................................. 8
   8.1 Application Information ...................................... 8
   8.2 Typical Application .......................................... 8
9 Power Supply Recommendations ............................... 10
10 Layout .............................................................. 10
    10.1 Layout Guidelines ......................................... 10
    10.2 Layout Example ............................................. 10
11 Device and Documentation Support ............................ 11
    11.1 Related Links ................................................. 11
    11.2 Receiving Notification of Documentation Updates .. 11
    11.3 Community Resources ..................................... 11
    11.4 Trademarks .................................................. 11
    11.5 Electrostatic Discharge Caution ......................... 11
    11.6 Glossary ..................................................... 11
12 Mechanical, Packaging, and Orderable Information .......... 11

4 Revision History

Changes from Revision F (May 2018) to Revision G

- Changed previous Q1 graphs to match new format ................................................................. 6
- Added LM2903E-Q1 specific graphs ......................................................................................... 6

Changes from Revision E (June 2014) to Revision F

- Added LM2903E-Q1 to datasheet ............................................................................................ 1
- Added Pin Functions table .............................................. 3
- Changed Thermal Information Table ......................................................................................... 4

Changes from Revision D (April 2008) to Revision E

- Added AEC-Q100 info to Features ....................................................................................... 1
- Added Applications .......................................................... 1
- Added Device Information table ........................................................................................... 1
- Added Handling Ratings table .............................................................................................. 4
- Added $T_J$ and ESD ratings to Abs Max table ......................................................................... 4
- Updated Recommended Operating Conditions table ............................................................. 4
- Added Thermal Information table .......................................................................................... 4
- Updated Electrical Characteristics table .................................................................................. 5
5 Pin Configuration and Functions

![Pin Configuration Diagram]

<table>
<thead>
<tr>
<th>PIN</th>
<th>I/O</th>
<th>DESCRIPTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>1OUT</td>
<td>1</td>
<td>Output</td>
</tr>
<tr>
<td>1IN-</td>
<td>2</td>
<td>Input</td>
</tr>
<tr>
<td>1IN+</td>
<td>3</td>
<td>Input</td>
</tr>
<tr>
<td>GND</td>
<td>4</td>
<td>Input</td>
</tr>
<tr>
<td>2IN-</td>
<td>5</td>
<td>Input</td>
</tr>
<tr>
<td>2IN+</td>
<td>6</td>
<td>Input</td>
</tr>
<tr>
<td>2OUT</td>
<td>7</td>
<td>Output</td>
</tr>
<tr>
<td>VCC</td>
<td>8</td>
<td>Input</td>
</tr>
</tbody>
</table>

6 Specifications

6.1 Absolute Maximum Ratings

<table>
<thead>
<tr>
<th>PARAMETER</th>
<th>MIN</th>
<th>MAX</th>
<th>UNIT</th>
</tr>
</thead>
<tbody>
<tr>
<td>VCC</td>
<td>–36</td>
<td>36</td>
<td>V</td>
</tr>
<tr>
<td>VCC</td>
<td>–32</td>
<td>32</td>
<td>V</td>
</tr>
<tr>
<td>VD</td>
<td>–36</td>
<td>36</td>
<td>V</td>
</tr>
<tr>
<td>VI</td>
<td>–0.3</td>
<td>36</td>
<td>V</td>
</tr>
<tr>
<td>VO</td>
<td>36</td>
<td></td>
<td>V</td>
</tr>
<tr>
<td>IO</td>
<td>20</td>
<td></td>
<td>mA</td>
</tr>
</tbody>
</table>

Stresses beyond those listed under Absolute Maximum Ratings may cause permanent damage to the device. These are stress ratings only, and functional operation of the device at these or any other conditions beyond those indicated under Recommended Operating Conditions is not implied. Exposure to absolute-maximum-rated conditions for extended periods may affect device reliability.

(1) All voltage values, except differential voltages, are with respect to GND.
(2) Differential voltages are at IN+ with respect to IN-.
### 6.2 Handling Ratings

<table>
<thead>
<tr>
<th></th>
<th>MIN</th>
<th>MAX</th>
<th>UNIT</th>
</tr>
</thead>
<tbody>
<tr>
<td>$T_{stg}$</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Storage temperature range</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>LM2903-Q1 Only</td>
<td>–65</td>
<td>150</td>
<td>°C</td>
</tr>
<tr>
<td>$V_{(ESD)}$</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Electrostatic discharge</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Human body model (HBM), per AEC Q100-002(^{(1)})</td>
<td>0</td>
<td>1000</td>
<td>V</td>
</tr>
<tr>
<td>Charged device model (CDM), per AEC Q100-011</td>
<td>All pins</td>
<td>0</td>
<td>750</td>
</tr>
</tbody>
</table>

\(^{(1)}\) AEC Q100-002 indicates HBM stressing is done in accordance with the ANSI/ESDA/JEDEC JS-001 specification.

### 6.3 Recommended Operating Conditions, LM2903-Q1

over operating free-air temperature range (unless otherwise noted)

<table>
<thead>
<tr>
<th></th>
<th>MIN</th>
<th>NOM</th>
<th>MAX</th>
<th>UNIT</th>
</tr>
</thead>
<tbody>
<tr>
<td>$V_{CC}$ (non-V devices)</td>
<td>2</td>
<td>30</td>
<td>V</td>
<td></td>
</tr>
<tr>
<td>$V_{CC}$ (V devices)</td>
<td>2</td>
<td>32</td>
<td>V</td>
<td></td>
</tr>
<tr>
<td>$T_J$</td>
<td></td>
<td></td>
<td></td>
<td>°C</td>
</tr>
<tr>
<td>Junction Temperature</td>
<td>-40</td>
<td>125</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### 6.4 Recommended Operating Conditions, LM2903E-Q1

over operating free-air temperature range (unless otherwise noted)

<table>
<thead>
<tr>
<th></th>
<th>MIN</th>
<th>NOM</th>
<th>MAX</th>
<th>UNIT</th>
</tr>
</thead>
<tbody>
<tr>
<td>$V_{CC}$</td>
<td>2</td>
<td>30</td>
<td>V</td>
<td></td>
</tr>
<tr>
<td>$T_J$</td>
<td></td>
<td></td>
<td></td>
<td>°C</td>
</tr>
<tr>
<td>Junction Temperature</td>
<td>-40</td>
<td>150</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### 6.5 Thermal Information

<table>
<thead>
<tr>
<th>THERMAL METRIC(^{(1)})</th>
<th>LM2903E-Q1</th>
<th>LM2903-Q1</th>
<th>LM2903-Q1</th>
<th>LM2903-Q1</th>
<th>UNIT</th>
</tr>
</thead>
<tbody>
<tr>
<td>$R_{UA}$</td>
<td>178.9</td>
<td>199.4</td>
<td>186.6</td>
<td>126.0</td>
<td>°C/W</td>
</tr>
<tr>
<td>$R_{UC}$</td>
<td>70.7</td>
<td>120.8</td>
<td>79.6</td>
<td>74.2</td>
<td></td>
</tr>
<tr>
<td>$R_{UB}$</td>
<td>108.9</td>
<td>90.2</td>
<td>116.5</td>
<td>66.4</td>
<td></td>
</tr>
<tr>
<td>$\psi_JT$</td>
<td>11.9</td>
<td>21.5</td>
<td>17.7</td>
<td>25.4</td>
<td></td>
</tr>
<tr>
<td>$\psi_{JB}$</td>
<td>107.3</td>
<td>119.1</td>
<td>114.9</td>
<td>65.9</td>
<td></td>
</tr>
</tbody>
</table>

\(^{(1)}\) For more information about traditional and new thermal metrics, see the *Semiconductor and IC Package Thermal Metrics* application report (SPRA953).
6.6 Electrical Characteristics

at specified free-air temperature, \( V_{CC} = 5 \) V (unless otherwise noted)

<table>
<thead>
<tr>
<th>PARAMETER</th>
<th>TEST CONDITIONS</th>
<th>( T_A^{(1)} )</th>
<th>MIN</th>
<th>TYP</th>
<th>MAX</th>
<th>UNIT</th>
</tr>
</thead>
<tbody>
<tr>
<td>( V_{IO} ) Input offset voltage</td>
<td>( V_O = 1.4 ) V, ( V_C = V_{CC} ), ( V_{CC} = 5 ) V to MAX(^{(2)} )</td>
<td>Non-A devices</td>
<td>25°C</td>
<td>2</td>
<td>7</td>
<td>( mV )</td>
</tr>
<tr>
<td></td>
<td></td>
<td>A-suffix devices</td>
<td>25°C</td>
<td>1</td>
<td>2</td>
<td>( mV )</td>
</tr>
<tr>
<td>( I_{IO} ) Input offset current</td>
<td>( V_O = 1.4 ) V</td>
<td>25°C</td>
<td>5</td>
<td>50</td>
<td></td>
<td>( nA )</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Full range</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>( I_B ) Input bias current</td>
<td>( V_O = 1.4 ) V</td>
<td>25°C</td>
<td>25</td>
<td>250</td>
<td></td>
<td>( nA )</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Full range</td>
<td></td>
<td>500</td>
<td></td>
<td></td>
</tr>
<tr>
<td>( V_{CR} ) Common-mode input voltage range(^{(3)} )</td>
<td>( V_CC = 15 ) V, ( V_O = 1.4 ) V to 11.4 V, ( R_L \geq 15 ) k( \Omega ) to ( V_{CC} )</td>
<td>25°C</td>
<td>25</td>
<td>100</td>
<td></td>
<td>( V/mV )</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Full range</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>( A_{VD} ) Large-signal differential-voltage amplification</td>
<td>( V_{CC} = 15 ) V, ( V_O = 1.4 ) V to 11.4 V, ( R_L \geq 15 ) k( \Omega ) to ( V_{CC} )</td>
<td>25°C</td>
<td>0.1</td>
<td>50</td>
<td></td>
<td>( nA )</td>
</tr>
<tr>
<td>( I_{OH} ) High-level output current</td>
<td>( V_{OH} = 5 ) V</td>
<td>25°C</td>
<td>1</td>
<td></td>
<td></td>
<td>( \mu A )</td>
</tr>
<tr>
<td></td>
<td>( V_{OH} = V_{CC} ) MAX(^{(2)} )</td>
<td>Full range</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>( V_{OL} ) Low-level output voltage</td>
<td>( I_L = 4 ) mA, ( V_{OL} = -1 ) V</td>
<td>25°C</td>
<td>150</td>
<td>400</td>
<td></td>
<td>( mV )</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Full range</td>
<td></td>
<td>700</td>
<td></td>
<td></td>
</tr>
<tr>
<td>( I_{CL} ) Low-level output current</td>
<td>( V_{CL} = 1.5 ) V, ( V_{CL} = -1 ) V</td>
<td>25°C</td>
<td>6</td>
<td></td>
<td></td>
<td>( mA )</td>
</tr>
<tr>
<td>( I_{CC} ) Supply current</td>
<td>( R_L ) connected to 5 V through 5.1 k( \Omega ), ( C_L = 15 ) pF(^{(1)})(^{(2)} )</td>
<td>( V_{CC} = 5 ) V</td>
<td>25°C</td>
<td>0.8</td>
<td>1</td>
<td>( mA )</td>
</tr>
</tbody>
</table>

(1) Full range (MIN or MAX) for LM2903-Q1 is \( -40\degree \)C to 125\degree \)C and \( -40\degree \)C to 150\degree \)C for the LM2903E-Q1. All characteristics are measured with zero common-mode input voltage, unless otherwise specified.

(2) \( V_{CC} \) MAX = 30 V for non-V devices and 32 V for V-suffix devices.

(3) The voltage at either input or common-mode should not be allowed to go negative by more than 0.3 V. The upper end of the common-mode voltage range is \( VCC+ - 1.5 \) V for the inverting input (\( - \)), and the non-inverting input (\( + \)) can exceed the \( VCC \) level; the comparator provides a proper output state. Either or both inputs can go to 30 V (32V for V-suffix devices) without damage.

6.7 Switching Characteristics

\( V_{CC} = 5 \) V, \( T_A = 25\degree \)C

<table>
<thead>
<tr>
<th>PARAMETER</th>
<th>TEST CONDITIONS</th>
<th>TYP</th>
<th>UNIT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Response time</td>
<td>( R_L ) connected to 5 V through 5.1 k( \Omega ), ( C_L = 15 ) pF(^{(1)})(^{(2)} )</td>
<td>1.3</td>
<td>( \mu s )</td>
</tr>
<tr>
<td></td>
<td>100-mV input step with 5-mV overdrive</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>TTL-level input step</td>
<td>0.3</td>
<td></td>
</tr>
</tbody>
</table>

(1) \( C_L \) includes probe and jig capacitance.

(2) The response time specified is the interval between the input step function and the instant when the output crosses 1.4 V.
6.8 Typical Characteristics

Figure 1. Supply Current vs. Supply Voltage

Figure 2. Supply Current vs. Supply Voltage

Figure 3. Input Bias Current vs. Supply Voltage

Figure 4. Input Bias Current vs. Supply Voltage

Figure 5. Output Low Voltage vs. Output Current

Figure 6. Output Low Voltage vs. Output Current
7 Detailed Description

7.1 Overview
The LM2903-Q1 family is a dual comparator with the ability to operate up to 36 V on the supply pin. This standard device has proven ubiquity and versatility across a wide range of applications. This is due to its very wide supply voltages range (2 V to 36 V), low Iq and fast response.

This device is AEC-Q100 qualified and can operate over a wide temperature range of –40°C to 125°C (LM2903-Q1) or –40°C to 150°C (LM2903E-Q1).

The open-drain output allows the user to configure the output's logic low voltage ($V_{OL}$) and can be utilized to enable the comparator to be used in AND functionality.

7.2 Functional Block Diagram

![Functional Block Diagram](image)

Figure 7. Schematic (Each Comparator)

7.3 Feature Description

LM2903-Q1 family consists of a PNP darlington pair input, allowing the device to operate with very high gain and fast response with minimal input bias current. The input Darlington pair creates a limit on the input common mode voltage capability, allowing LM2903-Q1 to accurately function from ground to $V_{CC}–1.5V$ differential input. This is enables much head room for modern day supplies of 3.3 V and 5.0 V.

The output consists of an open drain NPN (pull-down or low side) transistor. The output NPN will sink current when the positive input voltage is higher than the negative input voltage and the offset voltage. The $V_{OL}$ is resistive and will scale with the output current. Please see Figure 3 in the Typical Characteristics section for $V_{OL}$ values with respect to the output current.

7.4 Device Functional Modes

7.4.1 Voltage Comparison
The LM2903-Q1 family operates solely as a voltage comparator, comparing the differential voltage between the positive and negative pins and outputting a logic low or high impedance (logic high with pull-up) based on the input differential polarity.
8 Application and Implementation

8.1 Application Information
LM2903-Q1 will typically be used to compare a single signal to a reference or two signals against each other. Many users take advantage of the open drain output to drive the comparison logic output to a logic voltage level to an MCU or logic device. The wide supply range and high voltage capability makes LM2903Q1 optimal for level shifting to a higher or lower voltage.

8.2 Typical Application

![ Comparator Configurations Diagram ]

**Figure 8. Single-ended and Differential Comparator Configurations**

8.2.1 Design Requirements
For this design example, use the parameters listed in Table 1 as the input parameters.

<table>
<thead>
<tr>
<th>DESIGN PARAMETER</th>
<th>EXAMPLE VALUE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Input Voltage Range</td>
<td>0 V to Vsup-1.5 V</td>
</tr>
<tr>
<td>Supply Voltage</td>
<td>2 V to 36 V</td>
</tr>
<tr>
<td>Logic Supply Voltage</td>
<td>2 V to 36 V</td>
</tr>
<tr>
<td>Output Current (R_{PULLUP})</td>
<td>1 µA to 20 mA</td>
</tr>
<tr>
<td>Input Overdrive Voltage</td>
<td>100 mV</td>
</tr>
<tr>
<td>Reference Voltage</td>
<td>2.5 V</td>
</tr>
<tr>
<td>Load Capacitance (C_L)</td>
<td>15 pF</td>
</tr>
</tbody>
</table>

8.2.2 Detailed Design Procedure
When using LM2903-Q1 family in a general comparator application, determine the following:
• Input Voltage Range
• Minimum Overdrive Voltage
• Output and Drive Current
• Response Time

8.2.2.1 Input Voltage Range
When choosing the input voltage range, the input common mode voltage range (V_{ICR}) must be taken into account. If temperature operation is above or below 25°C the V_{ICR} can range from 0 V to V_{CC}− 2.0 V. This limits the input voltage range to as high as V_{CC}− 2.0 V and as low as 0 V. Operation outside of this range can yield incorrect comparisons.

Below is a list of input voltage situation and their outcomes:
1. When both IN- and IN+ are both within the common mode range:
   a. If IN- is higher than IN+ and the offset voltage, the output is low and the output transistor is sinking current
   b. If IN- is lower than IN+ and the offset voltage, the output is high impedance and the output transistor is not conducting
2. When IN- is higher than common mode and IN+ is within common mode, the output is low and the output transistor is sinking current.

3. When IN+ is higher than common mode and IN- is within common mode, the output is high impedance and the output transistor is not conducting.

4. When IN- and IN+ are both higher than common mode, the output is low and the output transistor is sinking current.

8.2.2.2 Minimum Overdrive Voltage

Overdrive Voltage is the differential voltage produced between the positive and negative inputs of the comparator over the offset voltage (\(V_{IC}\)). In order to make an accurate comparison the Overdrive Voltage (\(V_{OD}\)) should be higher than the input offset voltage (\(V_{IO}\)). Overdrive voltage can also determine the response time of the comparator, with the response time decreasing with increasing overdrive. Figure 9 and Figure 10 show positive and negative response times with respect to overdrive voltage.

8.2.2.3 Output and Drive Current

Output current is determined by the load/pull-up resistance and logic/pull-up voltage. The output current will produce a output low voltage (\(V_{OL}\)) from the comparator. In which \(V_{OL}\) is proportional to the output current. Use Figure 5 to determine \(V_{OL}\) based on the output current.

The output current can also effect the transient response. More will be explained in the next section.

8.2.2.4 Response Time

The transient response can be determined by the load capacitance (\(C_L\)), load/pull-up resistance (\(R_{PULLUP}\)) and equivalent collector-emitter resistance (\(R_{CE}\)).

- The positive response time (\(\tau_p\)) is approximately \(\tau_p \sim R_{PULLUP} \times C_L\)
- The negative response time (\(\tau_N\)) is approximately \(\tau_N \sim R_{CE} \times C_L\)

\(R_{CE}\) can be determine by taking the slope of Figure 5 in it's linear region at the desired temperature, or by dividing the \(V_{OL}\) by \(I_{out}\).

8.2.3 Application Curves

The following curves were generated with 5 V on \(V_{CC}\) and \(V_{Logic}\), \(R_{PULLUP} = 5.1 \text{ k}\Omega\), and 50 pF scope probe.
9 Power Supply Recommendations

For fast response and comparison applications with noisy or AC inputs, it is recommended to use a bypass capacitor on the supply pin to reject any variation on the supply voltage. This variation can eat into the comparator's input common mode range and create an inaccurate comparison.

10 Layout

10.1 Layout Guidelines

For accurate comparator applications without hysteresis it is important maintain a stable power supply with minimized noise and glitches, which can affect the high level input common mode voltage range. In order to achieve this, it is best to add a bypass capacitor between the supply voltage and ground. This should be implemented on the positive power supply and negative supply (if available). If a negative supply is not being used, do not put a capacitor between the IC's GND pin and system ground.

10.2 Layout Example

![Figure 11. LM2903Q1 Layout Example](image-url)
11 Device and Documentation Support

11.1 Related Links
The table below lists quick access links. Categories include technical documents, support and community resources, tools and software, and quick access to sample or buy.

<table>
<thead>
<tr>
<th>PARTS</th>
<th>PRODUCT FOLDER</th>
<th>SAMPLE &amp; BUY</th>
<th>TECHNICAL DOCUMENTS</th>
<th>TOOLS &amp; SOFTWARE</th>
<th>SUPPORT &amp; COMMUNITY</th>
</tr>
</thead>
<tbody>
<tr>
<td>LM2903-Q1</td>
<td>Click here</td>
<td>Click here</td>
<td>Click here</td>
<td>Click here</td>
<td>Click here</td>
</tr>
<tr>
<td>LM2903E-Q1</td>
<td>Click here</td>
<td>Click here</td>
<td>Click here</td>
<td>Click here</td>
<td>Click here</td>
</tr>
</tbody>
</table>

11.2 Receiving Notification of Documentation Updates
To receive notification of documentation updates, navigate to the device product folder on ti.com. In the upper right corner, click on Alert me to register and receive a weekly digest of any product information that has changed. For change details, review the revision history included in any revised document.

11.3 Community Resources
The following links connect to TI community resources. Linked contents are provided "AS IS" by the respective contributors. They do not constitute TI specifications and do not necessarily reflect TI's views; see TI's Terms of Use.

**TI E2E™ Online Community**  **TI's Engineer-to-Engineer (E2E) Community.** Created to foster collaboration among engineers. At e2e.ti.com, you can ask questions, share knowledge, explore ideas and help solve problems with fellow engineers.

**Design Support**  **TI's Design Support** Quickly find helpful E2E forums along with design support tools and contact information for technical support.

11.4 Trademarks
E2E is a trademark of Texas Instruments.
All other trademarks are the property of their respective owners.

11.5 Electrostatic Discharge Caution
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.

11.6 Glossary
SLYZ022 — **TI Glossary.**
This glossary lists and explains terms, acronyms, and definitions.

12 Mechanical, Packaging, and Orderable Information
The following pages include mechanical, packaging, and orderable information. This information is the most current data available for the designated devices. This data is subject to change without notice and revision of this document. For browser-based versions of this data sheet, refer to the left-hand navigation.
<table>
<thead>
<tr>
<th>Orderable Device</th>
<th>Status</th>
<th>Package Type</th>
<th>Package Drawing</th>
<th>Pins</th>
<th>Package Qty</th>
<th>Eco Plan</th>
<th>Lead/Ball Finish</th>
<th>MSL Peak Temp</th>
<th>Op Temp (°C)</th>
<th>Device Marking</th>
<th>Samples</th>
</tr>
</thead>
<tbody>
<tr>
<td>LM2903AVDRG4Q1</td>
<td>ACTIVE</td>
<td>SOIC</td>
<td>D</td>
<td>8</td>
<td>2500</td>
<td>Green (RoHS &amp; no Sb/Br)</td>
<td>CU NIPDAU</td>
<td>Level-1-260C-UNLIM</td>
<td>-40 to 125</td>
<td>2903AVQ</td>
<td></td>
</tr>
<tr>
<td>LM2903AVQDRG1</td>
<td>ACTIVE</td>
<td>SOIC</td>
<td>D</td>
<td>8</td>
<td>2500</td>
<td>Green (RoHS &amp; no Sb/Br)</td>
<td>CU NIPDAU</td>
<td>Level-1-260C-UNLIM</td>
<td>-40 to 125</td>
<td>2903AVQ</td>
<td></td>
</tr>
<tr>
<td>LM2903AVPWRG4Q1</td>
<td>ACTIVE</td>
<td>TSSOP</td>
<td>PW</td>
<td>8</td>
<td>2000</td>
<td>Green (RoHS &amp; no Sb/Br)</td>
<td>CU NIPDAU</td>
<td>Level-1-260C-UNLIM</td>
<td>-40 to 125</td>
<td>2903AVQ</td>
<td></td>
</tr>
<tr>
<td>LM2903AVPWRQ1</td>
<td>ACTIVE</td>
<td>TSSOP</td>
<td>PW</td>
<td>8</td>
<td>2000</td>
<td>Green (RoHS &amp; no Sb/Br)</td>
<td>CU NIPDAU</td>
<td>Level-1-260C-UNLIM</td>
<td>-40 to 125</td>
<td>2903AVQ</td>
<td></td>
</tr>
<tr>
<td>LM2903QDGKRQ1</td>
<td>ACTIVE</td>
<td>VSSOP</td>
<td>DGK</td>
<td>8</td>
<td>2500</td>
<td>Green (RoHS &amp; no Sb/Br)</td>
<td>CU NIPDAUAG</td>
<td>Level-2-260C-1 YEAR</td>
<td>-40 to 125</td>
<td>KACQ</td>
<td>Samples</td>
</tr>
<tr>
<td>LM2903QDRG4Q1</td>
<td>ACTIVE</td>
<td>SOIC</td>
<td>D</td>
<td>8</td>
<td>2500</td>
<td>Green (RoHS &amp; no Sb/Br)</td>
<td>CU NIPDAU</td>
<td>Level-1-260C-UNLIM</td>
<td>-40 to 125</td>
<td>2903Q1</td>
<td></td>
</tr>
<tr>
<td>LM2903QDRQ1</td>
<td>ACTIVE</td>
<td>SOIC</td>
<td>D</td>
<td>8</td>
<td>2500</td>
<td>Green (RoHS &amp; no Sb/Br)</td>
<td>CU NIPDAU</td>
<td>Level-1-260C-UNLIM</td>
<td>-40 to 125</td>
<td>2903Q1</td>
<td></td>
</tr>
<tr>
<td>LM2903QPWRG4Q1</td>
<td>ACTIVE</td>
<td>TSSOP</td>
<td>PW</td>
<td>8</td>
<td>2000</td>
<td>Green (RoHS &amp; no Sb/Br)</td>
<td>CU NIPDAU</td>
<td>Level-1-260C-UNLIM</td>
<td>-40 to 125</td>
<td>2903Q1</td>
<td></td>
</tr>
<tr>
<td>LM2903QPWRQ1</td>
<td>ACTIVE</td>
<td>TSSOP</td>
<td>PW</td>
<td>8</td>
<td>2000</td>
<td>Green (RoHS &amp; no Sb/Br)</td>
<td>CU NIPDAU</td>
<td>Level-1-260C-UNLIM</td>
<td>-40 to 125</td>
<td>2903Q1</td>
<td></td>
</tr>
<tr>
<td>LM2903QVDRG4Q1</td>
<td>ACTIVE</td>
<td>SOIC</td>
<td>D</td>
<td>8</td>
<td>2500</td>
<td>Green (RoHS &amp; no Sb/Br)</td>
<td>CU NIPDAU</td>
<td>Level-1-260C-UNLIM</td>
<td>-40 to 125</td>
<td>2903VQ1</td>
<td></td>
</tr>
<tr>
<td>LM2903QVDRQ1</td>
<td>ACTIVE</td>
<td>SOIC</td>
<td>D</td>
<td>8</td>
<td>2500</td>
<td>Green (RoHS &amp; no Sb/Br)</td>
<td>CU NIPDAU</td>
<td>Level-1-260C-UNLIM</td>
<td>-40 to 125</td>
<td>2903VQ1</td>
<td></td>
</tr>
<tr>
<td>LM2903VQPWRG4Q1</td>
<td>ACTIVE</td>
<td>TSSOP</td>
<td>PW</td>
<td>8</td>
<td>2000</td>
<td>Green (RoHS &amp; no Sb/Br)</td>
<td>CU NIPDAU</td>
<td>Level-1-260C-UNLIM</td>
<td>-40 to 125</td>
<td>2903VQ</td>
<td></td>
</tr>
<tr>
<td>LM2903VQPWRQ1</td>
<td>ACTIVE</td>
<td>TSSOP</td>
<td>PW</td>
<td>8</td>
<td>2000</td>
<td>Green (RoHS &amp; no Sb/Br)</td>
<td>CU NIPDAU</td>
<td>Level-1-260C-UNLIM</td>
<td>-40 to 125</td>
<td>2903VQ</td>
<td></td>
</tr>
</tbody>
</table>

(1) 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.
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.

MSL, Peak Temp. - The Moisture Sensitivity Level rating according to the JEDEC industry standard classifications, and peak solder temperature.

There may be additional marking, which relates to the logo, the lot trace code information, or the environmental category on the device.

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.

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

Important Information and Disclaimer: The information provided on this page represents TI's knowledge and belief as of the date that it is provided. TI bases its knowledge and belief on information provided by third parties, and makes no representation or warranty as to the accuracy of such information. Efforts are underway to better integrate information from third parties. TI has taken and continues to take reasonable steps to provide representative and accurate information but may not have conducted destructive testing or chemical analysis on incoming materials and chemicals. TI and TI suppliers consider certain information to be proprietary, and thus CAS numbers and other limited information may not be available for release.

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 LM2903-Q1:

- Catalog: LM2903

NOTE: Qualified Version Definitions:

- Catalog - TI's standard catalog product
TAPE AND REEL INFORMATION

**Device** | **Package Type** | **Package Drawing** | **Pins** | **SPQ** | **Reel Diameter (mm)** | **Reel Width W1 (mm)** | **A0 (mm)** | **B0 (mm)** | **K0 (mm)** | **P1 (mm)** | **W (mm)** | **Pin1 Quadrant**
--- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | ---
LM2903AVQDRQ1 | SOIC | D | 8 | 2500 | 330.0 | 12.5 | 6.4 | 5.2 | 2.1 | 8.0 | 12.0 | Q1
LM2903AVQPWRG4Q1 | TSSOP | PW | 8 | 2000 | 330.0 | 12.4 | 7.0 | 3.6 | 1.6 | 8.0 | 12.0 | Q1
LM2903AVQPWRQ1 | TSSOP | PW | 8 | 2000 | 330.0 | 12.4 | 7.0 | 3.6 | 1.6 | 8.0 | 12.0 | Q1
LM2903EPWRQ1 | TSSOP | PW | 8 | 2000 | 330.0 | 12.4 | 7.0 | 3.6 | 1.6 | 8.0 | 12.0 | Q1
LM2903QDGKRQ1 | VSSOP | DGK | 8 | 2500 | 330.0 | 12.4 | 5.3 | 3.4 | 1.4 | 8.0 | 12.0 | Q1
LM2903QPWRG4Q1 | TSSOP | PW | 8 | 2000 | 330.0 | 12.4 | 7.0 | 3.6 | 1.6 | 8.0 | 12.0 | Q1
LM2903QPWRQ1 | TSSOP | PW | 8 | 2000 | 330.0 | 12.4 | 7.0 | 3.6 | 1.6 | 8.0 | 12.0 | Q1
LM2903VQPWRG4Q1 | TSSOP | PW | 8 | 2000 | 330.0 | 12.4 | 7.0 | 3.6 | 1.6 | 8.0 | 12.0 | Q1
LM2903VQPWRQ1 | TSSOP | PW | 8 | 2000 | 330.0 | 12.4 | 7.0 | 3.6 | 1.6 | 8.0 | 12.0 | Q1

*All dimensions are nominal.
**TAPE AND REEL BOX DIMENSIONS**

*All dimensions are nominal*

<table>
<thead>
<tr>
<th>Device</th>
<th>Package Type</th>
<th>Package Drawing</th>
<th>Pins</th>
<th>SPQ</th>
<th>Length (mm)</th>
<th>Width (mm)</th>
<th>Height (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>LM2903AVQDRQ1</td>
<td>SOIC</td>
<td>D</td>
<td>8</td>
<td>2500</td>
<td>340.5</td>
<td>338.1</td>
<td>20.6</td>
</tr>
<tr>
<td>LM2903AVQPWRG4Q1</td>
<td>TSSOP</td>
<td>PW</td>
<td>8</td>
<td>2000</td>
<td>367.0</td>
<td>367.0</td>
<td>35.0</td>
</tr>
<tr>
<td>LM2903AVQPWRQ1</td>
<td>TSSOP</td>
<td>PW</td>
<td>8</td>
<td>2000</td>
<td>367.0</td>
<td>367.0</td>
<td>35.0</td>
</tr>
<tr>
<td>LM2903EPWRQ1</td>
<td>TSSOP</td>
<td>PW</td>
<td>8</td>
<td>2000</td>
<td>367.0</td>
<td>367.0</td>
<td>35.0</td>
</tr>
<tr>
<td>LM2903QDGKRQ1</td>
<td>VSSOP</td>
<td>DGK</td>
<td>8</td>
<td>2500</td>
<td>366.0</td>
<td>364.0</td>
<td>50.0</td>
</tr>
<tr>
<td>LM2903QPWRG4Q1</td>
<td>TSSOP</td>
<td>PW</td>
<td>8</td>
<td>2000</td>
<td>367.0</td>
<td>367.0</td>
<td>35.0</td>
</tr>
<tr>
<td>LM2903QPWRQ1</td>
<td>TSSOP</td>
<td>PW</td>
<td>8</td>
<td>2000</td>
<td>367.0</td>
<td>367.0</td>
<td>35.0</td>
</tr>
<tr>
<td>LM2903VQPWRG4Q1</td>
<td>TSSOP</td>
<td>PW</td>
<td>8</td>
<td>2000</td>
<td>367.0</td>
<td>367.0</td>
<td>35.0</td>
</tr>
<tr>
<td>LM2903VQPWRQ1</td>
<td>TSSOP</td>
<td>PW</td>
<td>8</td>
<td>2000</td>
<td>367.0</td>
<td>367.0</td>
<td>35.0</td>
</tr>
</tbody>
</table>
NOTES:

1. Linear dimensions are in inches [millimeters]. Dimensions in parenthesis are for reference only. Controlling dimensions are in inches. Dimensioning and tolerancing per ASME Y14.5M.
2. This drawing is subject to change without notice.
3. This dimension does not include mold flash, protrusions, or gate burrs. Mold flash, protrusions, or gate burrs shall not exceed .006 [0.15] per side.
4. This dimension does not include interlead flash.
5. Reference JEDEC registration MS-012, variation AA.
NOTES: (continued)

6. Publication IPC-7351 may have alternate designs.
7. Solder mask tolerances between and around signal pads can vary based on board fabrication site.
NOTES: (continued)

8. Laser cutting apertures with trapezoidal walls and rounded corners may offer better paste release. IPC-7525 may have alternate design recommendations.
9. Board assembly site may have different recommendations for stencil design.
DGK (S–PDSO–G8)  PLASTIC SMALL–OUTLINE PACKAGE

NOTES:

A. All linear dimensions are in millimeters.
B. This drawing is subject to change without notice.
   ▶ Body length does not include mold flash, protrusions, or gate burrs. Mold flash, protrusions, or gate burrs shall not exceed 0.15 per end.
   ▶ Body width does not include interlead flash. Interlead flash shall not exceed 0.50 per side.
E. Falls within JEDEC MO–187 variation AA, except interlead flash.

4073329/E 05/06
NOTES:
A. All linear dimensions are in millimeters.
B. This drawing is subject to change without notice.
C. Publication IPC-7351 is recommended for alternate designs.
D. Laser cutting apertures with trapezoidal walls and also rounding corners will offer better paste release. Customers should contact their board assembly site for stencil design recommendations. Refer to IPC-7525 for other stencil recommendations.
E. Customers should contact their board fabrication site for solder mask tolerances between and around signal pads.
NOTES:

1. All linear dimensions are in millimeters. Any dimensions in parenthesis are for reference only. Dimensioning and tolerancing per ASME Y14.5M.
2. This drawing is subject to change without notice.
3. This dimension does not include mold flash, protrusions, or gate burrs. Mold flash, protrusions, or gate burrs shall not exceed 0.15 mm per side.
4. This dimension does not include interlead flash. Interlead flash shall not exceed 0.25 mm per side.
5. Reference JEDEC registration MO-153, variation AA.
NOTES: (continued)

6. Publication IPC-7351 may have alternate designs.
7. Solder mask tolerances between and around signal pads can vary based on board fabrication site.
8. Laser cutting apertures with trapezoidal walls and rounded corners may offer better paste release. IPC-7525 may have alternate design recommendations.
9. Board assembly site may have different recommendations for stencil design.
IMPORTANT NOTICE AND DISCLAIMER

TI PROVIDES TECHNICAL AND RELIABILITY DATA (INCLUDING DATASHEETS), DESIGN RESOURCES (INCLUDING REFERENCE DESIGNS), APPLICATION OR OTHER DESIGN ADVICE, WEB TOOLS, SAFETY INFORMATION, AND OTHER RESOURCES “AS IS” AND WITH ALL FAULTS, AND DISCLAIMS ALL WARRANTIES, EXPRESS AND IMPLIED, INCLUDING WITHOUT LIMITATION ANY IMPLIED WARRANTIES OF MERCHANTABILITY, FITNESS FOR A PARTICULAR PURPOSE OR NON-INFRINGEMENT OF THIRD PARTY INTELLECTUAL PROPERTY RIGHTS.

These resources are intended for skilled developers designing with TI products. You are solely responsible for (1) selecting the appropriate TI products for your application, (2) designing, validating and testing your application, and (3) ensuring your application meets applicable standards, and any other safety, security, or other requirements. These resources are subject to change without notice. TI grants you permission to use these resources only for development of an application that uses the TI products described in the resource. Other reproduction and display of these resources is prohibited. No license is granted to any other TI intellectual property right or to any third party intellectual property right. TI disclaims responsibility for, and you will fully indemnify TI and its representatives against, any claims, damages, costs, losses, and liabilities arising out of your use of these resources.

TI’s products are provided subject to TI’s Terms of Sale (www.ti.com/legal/termsofsale.html) or other applicable terms available either on ti.com or provided in conjunction with such TI products. TI’s provision of these resources does not expand or otherwise alter TI’s applicable warranties or warranty disclaimers for TI products.

Mailing Address: Texas Instruments, Post Office Box 655303, Dallas, Texas 75265
Copyright © 2019, Texas Instruments Incorporated