

LM2903-Q1 Dual Differential Comparators

1 Features

- Qualified for Automotive Applications
- AEC-Q100 Qualified with the Following Results:
 - Device Temperature Grade 1: –40°C to 125°C Ambient Operating Temperature Range
 - 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 & Power Train
 - Infotainment & 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.

Device Information⁽¹⁾

PART NUMBER	PACKAGE	BODY SIZE (NOM)
LM2903-Q1	VSSOP(8)	3.00 mm x 3.00 mm
	SOIC (8)	4.90 mm x 3.91 mm
	TSSOP (8)	3.00 mm x 4.40 mm

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

4 Simplified Schematic



Table of Contents

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5 Revision History

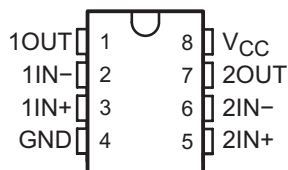
Changes from Revision D (April 2008) to Revision E

Page

<ul style="list-style-type: none"> • Added AEC-Q100 info to Features. 1 • Added Applications. 1 • Added Device Information table. 1 • Added Pin Functions table. 3 • Added Handling Ratings table. 3 • Added T_J and ESD ratings to Abs Max table. 3 • Updated Recommended Operating Conditions table. 4 • Added Thermal Information table. 4 • Updated Electrical Characteristics table. 4 	1 1 1 3 3 3 4 4 4
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6 Pin Configuration and Functions

**D, DGK OR PW PACKAGE
Top View**



Pin Functions

PIN		I/O	DESCRIPTION
NAME	NO.		
1OUT	1	Output	Comparator 1's output pin
1IN-	2	Input	Comparator 1's negative input pin
1IN+	3	Input	Comparator 1's positive input pin
GND	4	Input	Ground
2IN+	5	Input	Comparator 2's positive input pin
2IN-	6	Input	Comparator 2's negative input pin
2OUT	7	Output	Comparator 2's output pin
V _{CC}	8	Input	Supply Pin

7 Specifications

7.1 Absolute Maximum Ratings⁽¹⁾

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

		MIN	MAX	UNIT
V _{CC}	Supply voltage ⁽²⁾		36	V
V _{ID}	Differential input voltage ⁽³⁾	-36	36	V
V _I	Input voltage range (either input)	-0.3	36	V
V _O	Output voltage		36	V
I _O	Output current		20	mA
	Duration of output short-circuit to ground		Unlimited	
θ _{JA}	Package thermal impedance ⁽⁴⁾	D package	97	°C/W
		PW package	149	°C/W
		DGK package	199.4	°C/W

- (1) 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.
- (2) All voltage values, except differential voltages, are with respect to GND.
- (3) Differential voltages are at IN+ with respect to IN-.
- (4) The package thermal impedance is calculated in accordance with JESD 51-7.

7.2 Handling Ratings

		MIN	MAX	UNIT
T _{stg}	Storage temperature range	-65	150	°C
V _(ESD)	Electrostatic discharge	Human body model (HBM), per AEC Q100-002 ⁽¹⁾	0	1000
		Charged device model (CDM), per AEC Q100-011	0	750

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

7.3 Recommended Operating Conditions

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

	MIN	NOM	MAX	UNIT
V_{CC} (non-V devices)	2		30	V
V_{CC} (V devices)	2		32	V
T_J	Junction Temperature		125	°C

7.4 Thermal Information

THERMAL METRIC ⁽¹⁾		LM2903-Q1		UNIT
		DGK		
		8 PINS		
$R_{\theta JA}$	Junction-to-ambient thermal resistance	199.4		°C/W
$R_{\theta Jctop}$	Junction-to-case (top) thermal resistance	120.8		
$R_{\theta JB}$	Junction-to-board thermal resistance	90.2		
Ψ_{JT}	Junction-to-top characterization parameter	21.5		
Ψ_{JB}	Junction-to-board characterization parameter	119.1		

 (1) For more information about traditional and new thermal metrics, see the *IC Package Thermal Metrics* application report, [SPRA953](#).

7.5 Electrical Characteristics

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

PARAMETER	TEST CONDITIONS	T_A ⁽¹⁾	MIN	TYP	MAX	UNIT
V_{IO} Input offset voltage	$V_O = 1.4$ V, $V_{IC} = V_{IC(min)}$, $V_{CC} = 5$ V to MAX ⁽²⁾	Non-A devices	25°C	2	7	mV
			Full range	15		
		A-suffix devices	25°C	1	2	
			Full range	4		
I_{IO} Input offset current	$V_O = 1.4$ V	25°C	5	50	nA	
		Full range	200			
I_{IB} Input bias current	$V_O = 1.4$ V	25°C	-25	-250	nA	
		Full range	-500			
V_{ICR} Common-mode input voltage range ⁽³⁾		25°C	0 to $V_{CC}-1.5$		V	
		Full range	0 to $V_{CC}-2$			
A_{VD} Large-signal differential-voltage amplification	$V_{CC} = 15$ V, $V_O = 1.4$ V to 11.4 V, $R_L \geq 15$ k Ω to V_{CC}	25°C	25	100	V/mV	
I_{OH} High-level output current	$V_{OH} = 5$ V $V_{OH} = V_{CC}$ MAX ⁽²⁾	$V_{ID} = 1$ V	25°C	0.1	50	nA
			Full range	1		μ A
V_{OL} Low-level output voltage	$I_{OL} = 4$ mA,	$V_{ID} = -1$ V	25°C	150	400	mV
			Full range	700		
I_{OL} Low-level output current	$V_{OL} = 1.5$ V,	$V_{ID} = -1$ V	25°C	6		mA
I_{CC} Supply current	$R_L = \infty$	$V_{CC} = 5$ V	25°C	0.8	1	mA
		$V_{CC} = MAX$ ⁽²⁾	Full range	2.5		

- (1) Full range (MIN or MAX) for LM2903Q is -40°C to 125°C. 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 $V_{CC} + 1.5$ V for the inverting input (-), and the non-inverting input (+) can exceed the V_{CC} level; the comparator provides a proper output state. Either or both inputs can go to 30 V (32V for V-suffix devices) without damage.

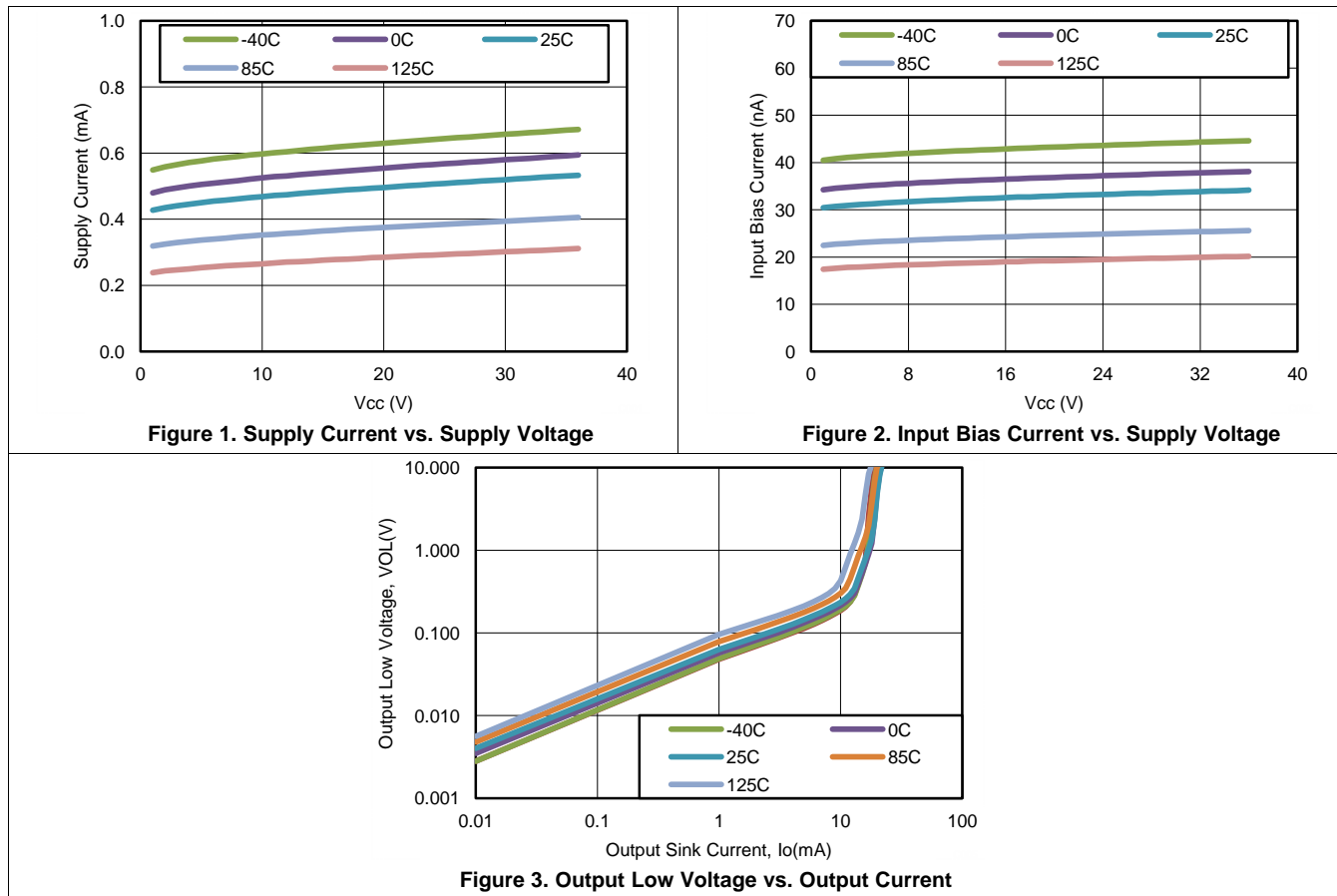
7.6 Switching Characteristics

V_{CC} = 5 V, T_A = 25°C

PARAMETER	TEST CONDITIONS		TYP	UNIT
Response time	R _L connected to 5 V through 5.1 kΩ,	100-mV input step with 5-mV overdrive	1.3	μs
	C _L = 15 pF ⁽¹⁾⁽²⁾	TTL-level input step	0.3	

- (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.

7.7 Typical Characteristics



8 Detailed Description

8.1 Overview

The LM2903 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 I_q and fast response.

This device is Q100 qualified and can operate over a wide temperature range (-40°C to 125°C).

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.

8.2 Functional Block Diagram

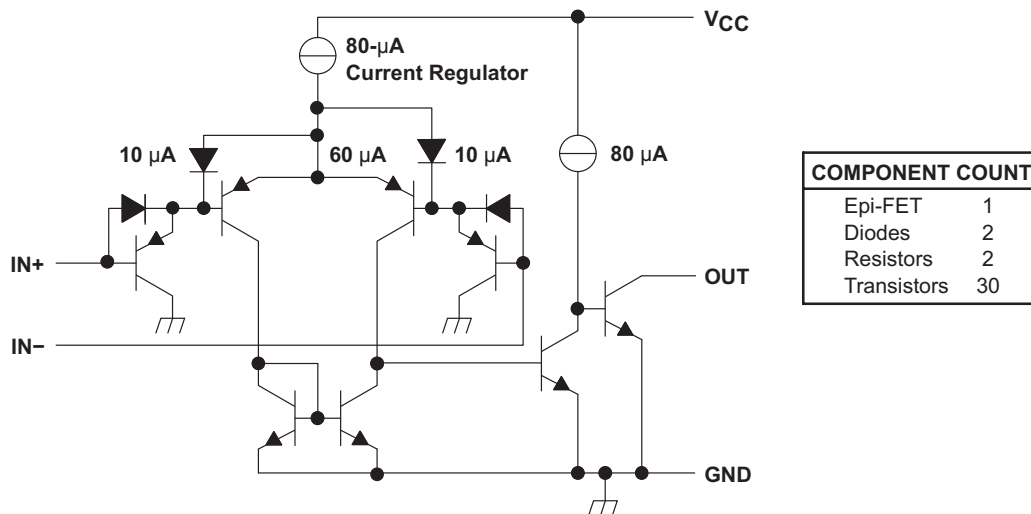


Figure 4. Schematic (Each Comparator)

8.3 Feature Description

LM2903 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 to accurately function from ground to $V_{CC}-1.5\text{V}$ differential input. This enables much head room for modern day supplies of 3.3 V & 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 2](#) in the [Typical Characteristics](#) section for V_{OL} values with respect to the output current.

8.4 Device Functional Modes

8.4.1 Voltage Comparison

The LM2903-Q1 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.

9 Application and Implementation

9.1 Application Information

LM2903Q1 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.

9.2 Typical Application

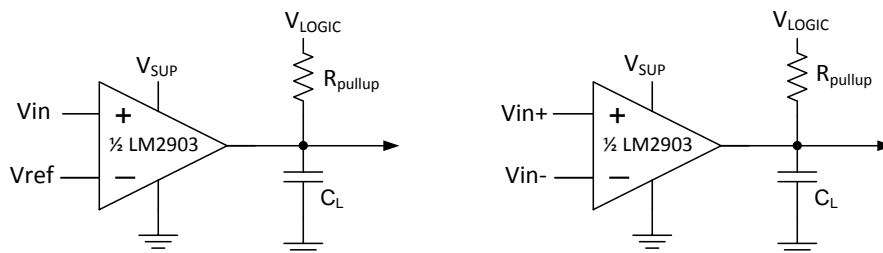


Figure 5. Single-ended and Differential Comparator Configurations

9.2.1 Design Requirements

For this design example, use the parameters listed in [Table 1](#) as the input parameters.

Table 1. Design Parameters

DESIGN PARAMETER	EXAMPLE VALUE
Input Voltage Range	0 V to $V_{sup}-1.5$ V
Supply Voltage	2 V to 36 V
Logic Supply Voltage	2 V to 36 V
Output Current (R_{PULLUP})	1 μ A to 20 mA
Input Overdrive Voltage	100 mV
Reference Voltage	2.5 V
Load Capacitance (C_L)	15 pF

9.2.2 Detailed Design Procedure

When using LM2903-Q1 in a general comparator application, determine the following:

- Input Voltage Range
- Minimum Overdrive Voltage
- Output & Drive Current
- Response Time

9.2.2.1 Input Voltage Range

When choosing the input voltage range, the input common mode voltage range (V_{ICR}) must be taken in to 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- & 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

9.2.2.2 Minimum Overdrive Voltage

Overdrive Voltage is the differential voltage produced between the positive and negative inputs of the comparator over the offset voltage (V_{IO}). 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 6](#) & [Figure 7](#) show positive and negative response times with respect to overdrive voltage.

9.2.2.3 Output & 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 3](#) 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.

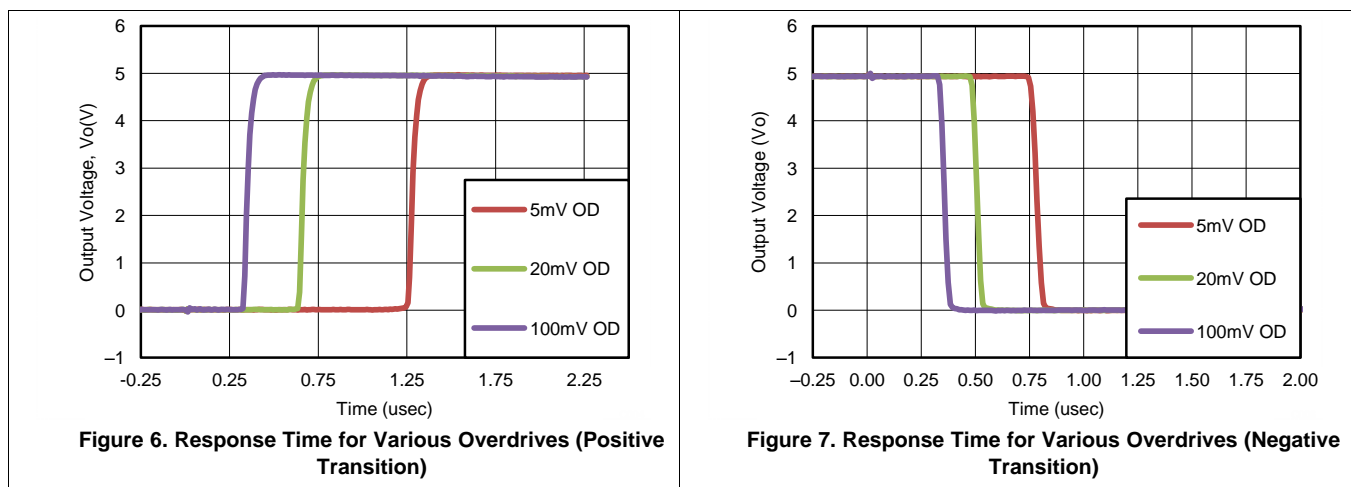
9.2.2.4 Response Time

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 (τ_P) is approximately $\tau_P \sim R_{PULLUP} \times C_L$
- The negative response time (τ_N) is approximately $\tau_N \sim R_{CE} \times C_L$
 - R_{CE} can be determine by taking the slope of [Figure 3](#) in it's linear region at the desired temperature, or by dividing the V_{OL} by I_{out}

9.2.3 Application Curves

The following curves were generated with 5 V on V_{CC} & V_{Logic} , $R_{PULLUP} = 5.1 \text{ k}\Omega$, and 50 pF scope probe.



10 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.

11 Layout

11.1 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.

11.2 Layout Example

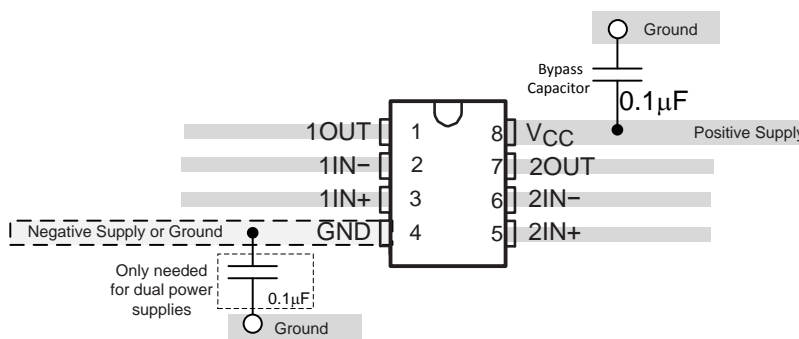


Figure 8. LM2903Q1 Layout Example

12 Device and Documentation Support

12.1 Trademarks

All trademarks are the property of their respective owners.

12.2 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.

12.3 Glossary

[SLYZ022](#) — *TI Glossary*.

This glossary lists and explains terms, acronyms, and definitions.

13 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.

PACKAGING INFORMATION

Orderable Device	Status (1)	Package Type	Package Drawing	Pins	Package Qty	Eco Plan (2)	Lead/Ball Finish (6)	MSL Peak Temp (3)	Op Temp (°C)	Device Marking (4/5)	Samples
LM2903AVQDRG4Q1	ACTIVE	SOIC	D	8	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	-40 to 125	2903AVQ	Samples
LM2903AVQDRQ1	ACTIVE	SOIC	D	8	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	-40 to 125	2903AVQ	Samples
LM2903AVQPWRG4Q1	ACTIVE	TSSOP	PW	8	2000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	-40 to 125	2903AVQ	Samples
LM2903AVQPWRQ1	ACTIVE	TSSOP	PW	8	2000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	-40 to 125	2903AVQ	Samples
LM2903QDGKRQ1	ACTIVE	VSSOP	DGK	8	2500	Green (RoHS & no Sb/Br)	CU NIPDAUAG	Level-2-260C-1 YEAR	-40 to 125	KACQ	Samples
LM2903QDRG4Q1	ACTIVE	SOIC	D	8	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	-40 to 125	2903Q1	Samples
LM2903QDRQ1	ACTIVE	SOIC	D	8	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	-40 to 125	2903Q1	Samples
LM2903QPWRG4Q1	ACTIVE	TSSOP	PW	8	2000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	-40 to 125	2903Q1	Samples
LM2903QPWRQ1	ACTIVE	TSSOP	PW	8	2000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	-40 to 125	2903Q1	Samples
LM2903VQDRG4Q1	ACTIVE	SOIC	D	8	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	-40 to 125	2903VQ1	Samples
LM2903VQDRQ1	ACTIVE	SOIC	D	8	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	-40 to 125	2903VQ1	Samples
LM2903VQPWRG4Q1	ACTIVE	TSSOP	PW	8	2000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	-40 to 125	2903VQ	Samples
LM2903VQPWRQ1	ACTIVE	TSSOP	PW	8	2000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	-40 to 125	2903VQ	Samples

(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.

(2) Eco Plan - The planned eco-friendly classification: Pb-Free (RoHS), Pb-Free (RoHS Exempt), or Green (RoHS & no Sb/Br) - please check <http://www.ti.com/productcontent> for the latest availability information and additional product content details.

TBD: The Pb-Free/Green conversion plan has not been defined.

Pb-Free (RoHS): TI's terms "Lead-Free" or "Pb-Free" mean semiconductor products that are compatible with the current RoHS requirements for all 6 substances, including the requirement that lead not exceed 0.1% by weight in homogeneous materials. Where designed to be soldered at high temperatures, TI Pb-Free products are suitable for use in specified lead-free processes.

Pb-Free (RoHS Exempt): This component has a RoHS exemption for either 1) lead-based flip-chip solder bumps used between the die and package, or 2) lead-based die adhesive used between the die and leadframe. The component is otherwise considered Pb-Free (RoHS compatible) as defined above.

Green (RoHS & no Sb/Br): TI defines "Green" to mean Pb-Free (RoHS compatible), and free of Bromine (Br) and Antimony (Sb) based flame retardants (Br or Sb do not exceed 0.1% by weight in homogeneous material)

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

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

(5) 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.

(6) 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.

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OTHER QUALIFIED VERSIONS OF LM2903-Q1 :

- Catalog: [LM2903](#)

NOTE: Qualified Version Definitions:

- Catalog - TI's standard catalog product

TAPE AND REEL INFORMATION



QUADRANT ASSIGNMENTS FOR PIN 1 ORIENTATION IN TAPE



*All dimensions are nominal

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
LM2903AVQPWRG4Q1	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
LM2903VQPWRG4Q1	TSSOP	PW	8	2000	330.0	12.4	7.0	3.6	1.6	8.0	12.0	Q1

TAPE AND REEL BOX DIMENSIONS


*All dimensions are nominal

Device	Package Type	Package Drawing	Pins	SPQ	Length (mm)	Width (mm)	Height (mm)
LM2903AVQPWRG4Q1	TSSOP	PW	8	2000	367.0	367.0	35.0
LM2903QDGKRQ1	VSSOP	DGK	8	2500	366.0	364.0	50.0
LM2903VQPWRG4Q1	TSSOP	PW	8	2000	367.0	367.0	35.0



- 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.

EXAMPLE BOARD LAYOUT

PW0008A

TSSOP - 1.2 mm max height

SMALL OUTLINE PACKAGE



LAND PATTERN EXAMPLE
SCALE:10X



SOLDER MASK DETAILS
NOT TO SCALE

4221848/A 02/2015

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.

EXAMPLE STENCIL DESIGN

PW0008A

TSSOP - 1.2 mm max height

SMALL OUTLINE PACKAGE



SOLDER PASTE EXAMPLE
BASED ON 0.125 mm THICK STENCIL
SCALE:10X

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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.

D (R-PDSO-G8)

PLASTIC SMALL OUTLINE



- NOTES:
- A. All linear dimensions are in inches (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 0.006 (0,15) each side.
 - Body width does not include interlead flash. Interlead flash shall not exceed 0.017 (0,43) each side.
 - E. Reference JEDEC MS-012 variation AA.

D (R-PDSO-G8)

PLASTIC SMALL OUTLINE



4211283-2/E 08/12

- 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.
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