

## LM2903-Q1 and LM2903B-Q1 Automotive Dual Comparators

### 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
  - Device HBM ESD classification level H1C
  - Device CDM ESD classification level C4B
- Improved 2kV HBM ESD for "B" device
- Tri-Temp testing available for "B" device
- Single supply or dual supplies
- Low supply-current independent of supply voltage 200uA typical per comparator ("B" Versions)
- Low input bias current 3.5nA typical ("B" device)
- Low input offset current 0.5nA typical ("B" device)
- Low input offset voltage  $\pm 0.37\text{mV}$  typical ("B" device)
- Common-mode input voltage range includes ground
- Differential input voltage range equal to maximum-rated supply voltage  $\pm 36\text{ V}$
- Output compatible with TTL, MOS, and CMOS
- **Functional Safety-Capable**
  - [Documentation available to aid functional safety system design](#)

### Applications

- **Automotive**
  - [HEV/EV and power train](#)
  - [Infotainment and cluster](#)
  - [Body control module](#)
- **Industrial**
- **Appliances**

### Description

The LM2903B-Q1 device is the next generation version of the industry-standard LM2903-Q1 comparator family. This next generation family provides outstanding value for cost-sensitive applications, with features including lower offset voltage, higher supply voltage capability, lower supply current, lower input bias current, lower propagation delay, and improved 2kV ESD performance with drop-in replacement convenience.

All devices consist of two independent voltage comparators that are designed to operate over a wide range of voltages. Operation from dual supplies also is possible as long as the difference between the two supplies is within 2V to 36V, and VCC is at least 1.5V more positive than the input common-mode voltage. The outputs can be connected to other open-collector outputs.

The LM2903-Q1 and LM2903B-Q1 are qualified for the AEC-Q100 Grade 1 temperature range of –40°C to +125°C. The LM2903E-Q1 is Qualified for the Grade 0 extended temperature range of –40°C to +150°C.

#### Device Information

| PART NUMBER | PACKAGE <sup>(1)</sup> | BODY SIZE (NOM) |
|-------------|------------------------|-----------------|
| LM2903B-Q1  | SOIC (8)               | 4.90mm × 3.91mm |
|             | TSSOP (8)              | 3.00mm × 4.40mm |
|             | VSSOP(8)               | 3.00mm × 3.00mm |
|             | WSON (8)               | 2.00mm × 2.00mm |
|             | SOT-23 (8)             | 1.60mm × 2.90mm |
| LM2903-Q1   | SOIC (8)               | 4.90mm × 3.91mm |
|             | TSSOP (8)              | 3.00mm × 4.40mm |
|             | VSSOP(8)               | 3.00mm × 3.00mm |
| LM2903E-Q1  | TSSOP (8)              | 3.00mm × 4.40mm |

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

#### Family Comparison Table

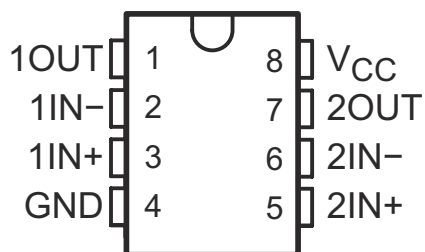
| Specification                                   | LM2903B-Q1 | LM2903-Q1  | LM2903-Q1 "A" Devices | LM2903-Q1 "AV" Devices | LM2903E-Q1 | Units |
|-------------------------------------------------|------------|------------|-----------------------|------------------------|------------|-------|
| Specified Supply Voltage                        | 2 to 36    | 2 to 30    | 2 to 30               | 2 to 32                | 2 to 30    | V     |
| Total Supply Current (5V to V <sub>S</sub> max) | 0.6 to 0.8 | 1 to 2.5   | 1 to 2.5              | 1 to 2.5               | 1 to 2.5   | mA    |
| Temperature Range                               | –40 to 125 | –40 to 125 | –40 to 125            | –40 to 125             | –40 to 150 | °C    |
| ESD (HBM / CDM)                                 | 2k / 1k    | 1k / 750   | 1k / 750              | 1k / 750               | 1k / 750   | V     |
| Offset Voltage (max over temp)                  | $\pm 4$    | $\pm 15$   | $\pm 4$               | $\pm 4$                | $\pm 15$   | mV    |
| Input Bias Current (typ / max)                  | 3.5 / 25   | 25 / 250   | 25 / 250              | 25 / 250               | 25 / 250   | nA    |
| Response Time (typ)                             | 1          | 1.3        | 1.3                   | 1.3                    | 1.3        | μsec  |



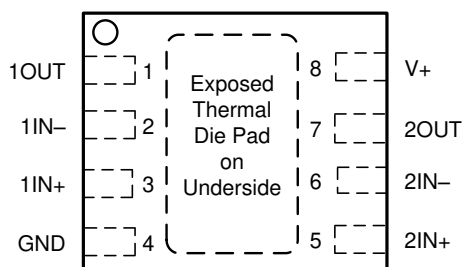
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## 1 Pin Configuration and Functions



**Figure 1-1. D, DGK, DDF OR PW PACKAGE**  
Top View



Connect thermal pad directly to GND pin.

**Figure 1-2. DSG Package**  
**8-Pin WSON With Exposed Pad**  
Top View

### 1.1 Pin Functions

| NAME            | PIN                                  |     | I/O    | DESCRIPTION                        |
|-----------------|--------------------------------------|-----|--------|------------------------------------|
|                 | SOIC, VSSOP, PDIP, SO, DDF and TSSOP | DSG |        |                                    |
| 1OUT            | 1                                    | 1   | Output | Output pin of comparator 1         |
| 1IN-            | 2                                    | 2   | Input  | Negative input pin of comparator 1 |
| 1IN+            | 3                                    | 3   | Input  | Positive input pin of comparator 1 |
| GND             | 4                                    | 4   | —      | Ground                             |
| 2IN+            | 5                                    | 5   | Input  | Positive input pin of comparator 2 |
| 2IN-            | 6                                    | 6   | Input  | Negative input pin of comparator 2 |
| 2OUT            | 7                                    | 7   | Output | Output pin of comparator 2         |
| V <sub>CC</sub> | 8                                    | 8   | —      | Positive Supply                    |
| Thermal Pad     | —                                    | PAD | —      | Connect directly to GND pin        |

## 2 Specifications

### 2.1 Absolute Maximum Ratings, LM2903-Q1 and LM2903E-Q1

over operating free-air temperature range (unless otherwise noted) <sup>(1)</sup>

|                  |                                                | MIN  | MAX       | UNIT |
|------------------|------------------------------------------------|------|-----------|------|
| V <sub>CC</sub>  | Supply voltage <sup>(2)</sup>                  |      | 36        | V    |
| V <sub>CC</sub>  | Supply voltage, LM2903E-Q1 Only <sup>(2)</sup> |      | 32        | V    |
| V <sub>ID</sub>  | Differential input voltage <sup>(3)</sup>      | –36  | 36        | V    |
| V <sub>I</sub>   | Input voltage range (either input)             | –0.3 | 36        | V    |
| V <sub>O</sub>   | Output voltage                                 |      | 36        | V    |
| I <sub>O</sub>   | Output current                                 |      | 20        | mA   |
| T <sub>J</sub>   | Operating virtual-junction temperature         |      | 150       | °C   |
| T <sub>SCG</sub> | Duration of output short-circuit to ground     |      | Unlimited | s    |

- (1) Stresses beyond those listed under *Absolute Maximum Ratings* can 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 can 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–.

### 2.2 Absolute Maximum Ratings, LM2903B-Q1

over operating free-air temperature range (unless otherwise noted) <sup>(1)</sup>

|                                                             |  | MIN  | MAX       | UNIT |
|-------------------------------------------------------------|--|------|-----------|------|
| Supply voltage: V <sub>S</sub> = (V+) – (V–)                |  | –0.3 | 38        | V    |
| Differential input voltage : V <sub>ID</sub> <sup>(2)</sup> |  |      | ±38       | V    |
| Input pins (IN+, IN–)                                       |  | –0.3 | 38        | V    |
| Current into input pins (IN+, IN–)                          |  |      | –50       | mA   |
| Output pin (OUT)                                            |  | –0.3 | 38        | V    |
| Output sink current                                         |  |      | 25        | mA   |
| Operating virtual-junction temperature                      |  |      | 150       | °C   |
| Output short-circuit duration <sup>(3)</sup>                |  |      | Unlimited | s    |

- (1) Stresses beyond those listed under *Absolute Maximum Ratings* can cause permanent damage to the device. These are stress ratings only, which do not imply functional operation of the device at these or any other conditions beyond those indicated under *Recommended Operating Conditions*. Exposure to absolute-maximum-rated conditions for extended periods can affect device reliability.
- (2) Differential voltages are at IN+ with respect to IN–.
- (3) Short circuits from outputs to V+ can cause excessive heating and eventual destruction.

### 2.3 ESD Ratings, LM2903-Q1 and LM2903E-Q1

|                    |                           |                                                         |                | MIN   | MAX  | UNIT |
|--------------------|---------------------------|---------------------------------------------------------|----------------|-------|------|------|
| T <sub>stg</sub>   | Storage temperature range |                                                         | LM2903-Q1 Only | –65   | 150  | °C   |
| V <sub>(ESD)</sub> | Electrostatic discharge   | Human body model (HBM), per AEC Q100-002 <sup>(1)</sup> |                | –1000 | 1000 | V    |
|                    |                           | Charged device model (CDM), per AEC Q100-011            | All pins       | –750  | 750  |      |

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

### 2.4 ESD Ratings, LM2903B-Q1

|                    |                           |                                                         |          | MIN   | MAX  | UNIT |
|--------------------|---------------------------|---------------------------------------------------------|----------|-------|------|------|
| T <sub>stg</sub>   | Storage temperature range |                                                         |          | –65   | 150  | °C   |
| V <sub>(ESD)</sub> | Electrostatic discharge   | Human body model (HBM), per AEC Q100-002 <sup>(1)</sup> |          | -2000 | 2000 | V    |
|                    |                           | Charged device model (CDM), per AEC Q100-011            | All pins | -1000 | 1000 |      |

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

## 2.5 Recommended Operating Conditions, LM2903B-Q1

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

|                                      | MIN  | MAX        | UNIT |
|--------------------------------------|------|------------|------|
| Supply voltage: $V_S = (V+) - (V-)$  | 2    | 36         | V    |
| Ambient temperature, $T_A$ , LM2903B | -40  | 125        | °C   |
| Input voltage range, $V_{IVR}$       | -0.1 | $(V+) - 2$ | V    |

## 2.6 Recommended Operating Conditions, LM2903-Q1

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

|                            | MIN | MAX | UNIT |
|----------------------------|-----|-----|------|
| $V_{CC}$ (non-V devices)   | 2   | 30  | V    |
| $V_{CC}$ (V devices)       | 2   | 32  | V    |
| $T_J$ Junction Temperature | -40 | 125 | °C   |

## 2.7 Recommended Operating Conditions, LM2903E-Q1

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

|                            | MIN | MAX | UNIT |
|----------------------------|-----|-----|------|
| $V_{CC}$                   | 2   | 30  | V    |
| $T_J$ Junction Temperature | -40 | 150 | °C   |

## 2.8 Thermal Information

| THERMAL METRIC <sup>(1)</sup>                                     | LM2903x-Q1  |                |               |               |                 | UNIT |
|-------------------------------------------------------------------|-------------|----------------|---------------|---------------|-----------------|------|
|                                                                   | D<br>(SOIC) | DGK<br>(VSSOP) | PW<br>(TSSOP) | DSG<br>(WSOP) | DDF<br>(SOT-23) |      |
|                                                                   | 8 PINS      | 8 PINS         | 8 PINS        | 8 PINS        | 8 PINS          |      |
| $R_{\theta JA}$ Junction-to-ambient thermal resistance            | 154.1       | 176.5          | 182.9         | 102.1         | 197.9           | °C/W |
| $R_{\theta JC(top)}$ Junction-to-case (top) thermal resistance    | 96.5        | 85.5           | 87.1          | 126.0         | 119.2           |      |
| $R_{\theta JB}$ Junction-to-board thermal resistance              | 97.7        | 112.4          | 123.2         | 68.6          | 115.4           |      |
| $\Psi_{JT}$ Junction-to-top characterization parameter            | 45.7        | 17.3           | 16.7          | 15.9          | 19.4            |      |
| $\Psi_{JB}$ Junction-to-board characterization parameter          | 96.9        | 110.1          | 120.4         | 68.4          | 113.7           |      |
| $R_{\theta JC(bot)}$ Junction-to-case (bottom) thermal resistance | -           | -              | -             | 43.9          | -               |      |

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

## 2.9 Electrical Characteristics LM2903B - Q1

$V_S = 5V$ ,  $V_{CM} = (V-)$ ;  $T_A = 25^\circ C$  (unless otherwise noted).

| PARAMETER    |                                                                                    |                                        | TEST CONDITIONS                                                   | MIN  | TYP        | MAX        | UNIT    |
|--------------|------------------------------------------------------------------------------------|----------------------------------------|-------------------------------------------------------------------|------|------------|------------|---------|
| $V_{IO}$     | Input offset voltage, DGK package only                                             | Input offset voltage, DGK package only | $V_S = 5$ to 36V                                                  | -3.5 | $\pm 0.37$ | 3.5        | mV      |
| $V_{IO}$     | Input offset voltage, DGK package only                                             | Input offset voltage, DGK package only | $V_S = 5$ to 36V, $T_A = -40^\circ C$ to $+125^\circ C$           | -5   |            | 5          | mV      |
| $V_{IO}$     | Input offset voltage                                                               |                                        | $V_S = 5$ to 36V                                                  | -2.5 | $\pm 0.37$ | 2.5        | mV      |
|              |                                                                                    |                                        | $V_S = 5$ to 36V, $T_A = -40^\circ C$ to $+125^\circ C$           | -4   |            | 4          | mV      |
| $I_B$        | Input bias current                                                                 |                                        |                                                                   | -25  | -3.5       |            | nA      |
|              |                                                                                    |                                        | $T_A = -40^\circ C$ to $+125^\circ C$                             | -50  |            |            | nA      |
| $I_{OS}$     | Input offset current                                                               |                                        |                                                                   | -10  | $\pm 0.5$  | 10         | nA      |
|              |                                                                                    |                                        | $T_A = -40^\circ C$ to $+125^\circ C$                             | -25  |            | 25         | nA      |
| $V_{CM}$     | Common mode range <sup>(1)</sup>                                                   |                                        | $V_S = 3$ to 36V                                                  | (V-) |            | (V+) - 1.5 | V       |
|              |                                                                                    |                                        | $V_S = 3$ to 36V, $T_A = -40^\circ C$ to $+125^\circ C$           | (V-) |            | (V+) - 2.0 | V       |
| $A_{VD}$     | Large signal differential voltage amplification                                    |                                        | $V_S = 15V$ , $V_O = 1.4V$ to $11.4V$ ;<br>$R_L \geq 15k$ to (V+) | 50   | 200        |            | V/mV    |
| $V_{OL}$     | Low level output Voltage {swing from (V-)}<br>$I_{SINK} \leq 4mA$ , $V_{ID} = -1V$ |                                        |                                                                   |      | 110        | 400        | mV      |
|              |                                                                                    |                                        | $T_A = -40^\circ C$ to $+125^\circ C$                             |      |            | 550        | mV      |
| $I_{OH-LKG}$ | High-level output leakage current                                                  |                                        | (V+) = $V_O = 5V$ ; $V_{ID} = 1V$                                 |      | 0.1        | 20         | nA      |
|              |                                                                                    |                                        | (V+) = $V_O = 36V$ ; $V_{ID} = 1V$                                |      | 0.3        | 50         | nA      |
| $I_{OL}$     | Low level output current                                                           |                                        | $V_{OL} = 1.5V$ ; $V_{ID} = -1V$ ; $V_S = 5V$                     | 6    | 21         |            | mA      |
| $I_Q$        | Quiescent current (all comparators)                                                |                                        | $V_S = 5V$ , no load                                              |      | 400        | 600        | $\mu A$ |
|              |                                                                                    |                                        | $V_S = 36V$ , no load, $T_A = -40^\circ C$ to $+125^\circ C$      |      | 550        | 800        | $\mu A$ |

(1) The voltage at any input should not be allowed to go negative by more than 0.3V. The upper end of the input voltage range is  $V_{CC} - 1.5V$  for one input, and the other input can exceed the  $V_{CC}$  level; the comparator provides a proper output state. Either or both inputs can go to 36V without damage.

## 2.10 Switching Characteristics LM2903B - Q1

$V_S = 5V$ ,  $V_O$  PULLUP = 5V,  $V_{CM} = V_S/2$ ,  $C_L = 15pF$ ,  $R_L = 5.1k\Omega$ ,  $T_A = 25^\circ C$  (unless otherwise noted).

| PARAMETER      |                                                                              |  | TEST CONDITIONS                           | MIN | TYP  | MAX | UNIT |
|----------------|------------------------------------------------------------------------------|--|-------------------------------------------|-----|------|-----|------|
| $t_{response}$ | Propagation delay time, high-to-low; TTL input signal <sup>(1)</sup>         |  | TTL input with $V_{ref} = 1.4V$           |     | 300  |     | ns   |
| $t_{response}$ | Propagation delay time, high-to-low; Small scale input signal <sup>(1)</sup> |  | Input overdrive = 5mV, Input step = 100mV |     | 1000 |     | ns   |

(1) High-to-low and low-to-high refers to the transition at the input.

## 2.11 LM2903B-Q1 "T", "R" and "H" Temperature Test Options

The following table describes the production temperature testing for the LM2903B-Q1 "H", "R" and "T" options. Specifications are the same as the LM2903B-Q1 above.

| Test             | LM2903B-Q1 | LM2903BR-Q1 | LM2903BH-Q1 | LM2903BT-Q1     |
|------------------|------------|-------------|-------------|-----------------|
| Probe (Wafer)    | -          | 25°C        | 125°C       | -40°C and 125°C |
| Final (Packaged) | 25°C       | 25°C        | 25°C        | 25°C            |

## 2.12 Electrical Characteristics, LM2903-Q1 and LM2903E-Q1

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

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

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

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

(3) The voltage at either input or common-mode can not be allowed to go negative by more than 0.3V. The upper end of the common-mode voltage range is  $V_{CC} + 1.5V$  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 30V (32V for V-suffix devices) without damage.

## 2.13 Switching Characteristics, LM2903-Q1 and LM2903E-Q1

$V_{CC} = 5V$ ,  $T_A = 25^\circ C$

| PARAMETER     | TEST CONDITIONS                               |                                    | TYP | UNIT    |
|---------------|-----------------------------------------------|------------------------------------|-----|---------|
| Response time | $R_L$ connected to 5V through 5.1k $\Omega$ , | 100m input step with 5mV overdrive | 1.3 | $\mu s$ |
|               | $C_L = 15pF$ <sup>(1)</sup> <sup>(2)</sup>    | 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 1.4V.

## 2.14 Typical Characteristics

$T_A = 25^\circ\text{C}$ ,  $V_S = 5\text{V}$ ,  $R_{\text{PULLUP}} = 5.1\text{k}$ ,  $C_L = 15\text{pF}$ ,  $V_{\text{CM}} = 0\text{V}$ ,  $V_{\text{UNDERDRIVE}} = 100\text{mV}$ ,  $V_{\text{OVERDRIVE}} = 100\text{mV}$  unless otherwise noted.

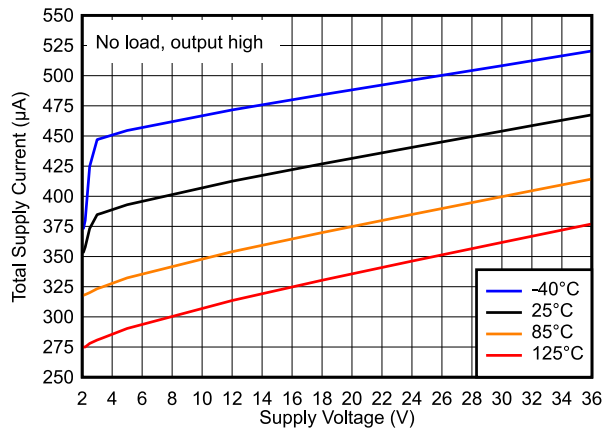


Figure 2-1. Total Supply Current vs. Supply Voltage

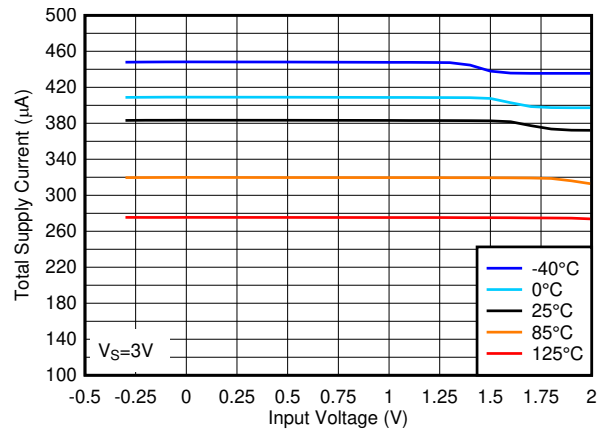


Figure 2-2. Total Supply Current vs. Input Voltage at 3V

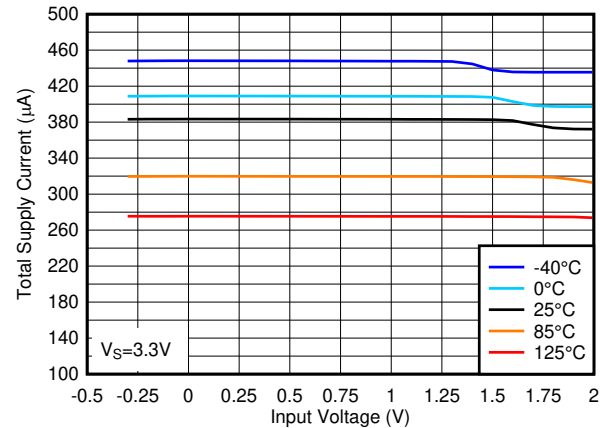


Figure 2-3. Total Supply Current vs. Input Voltage at 3.3V

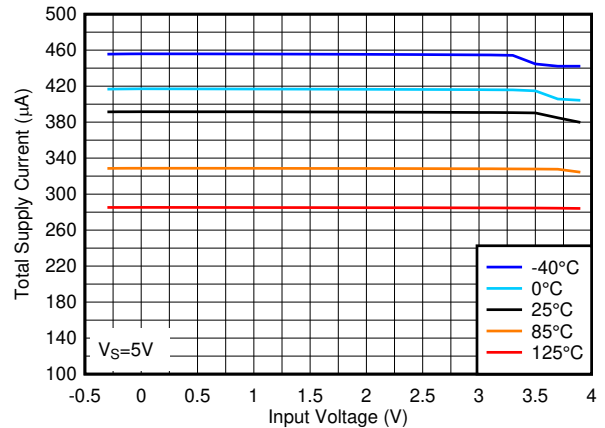


Figure 2-4. Total Supply Current vs. Input Voltage at 5V

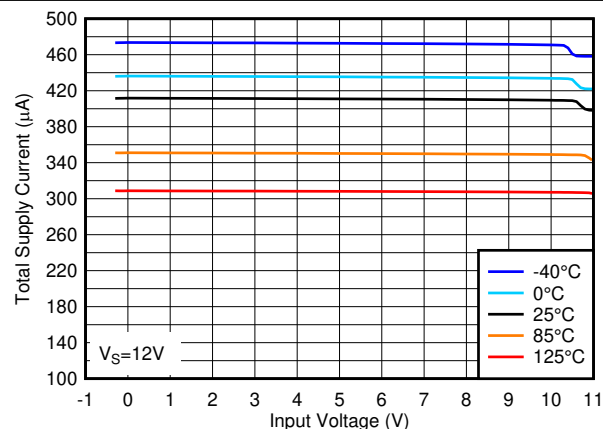


Figure 2-5. Total Supply Current vs. Input Voltage at 12V

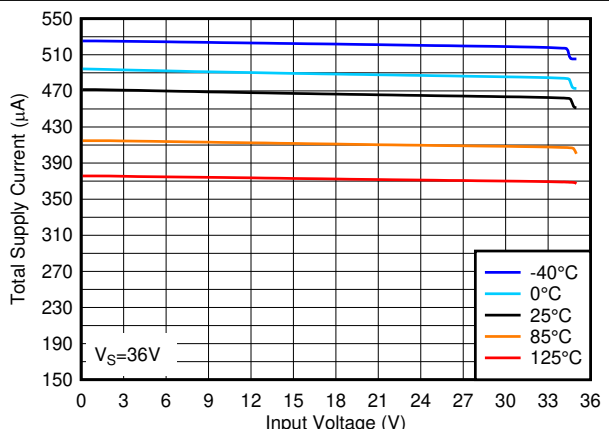


Figure 2-6. Total Supply Current vs. Input Voltage at 36V

## 2.14 Typical Characteristics (continued)

$T_A = 25^\circ\text{C}$ ,  $V_S = 5\text{V}$ ,  $R_{\text{PULLUP}} = 5.1\text{k}$ ,  $C_L = 15\text{pF}$ ,  $V_{\text{CM}} = 0\text{V}$ ,  $V_{\text{UNDERDRIVE}} = 100\text{mV}$ ,  $V_{\text{OVERDRIVE}} = 100\text{mV}$  unless otherwise noted.

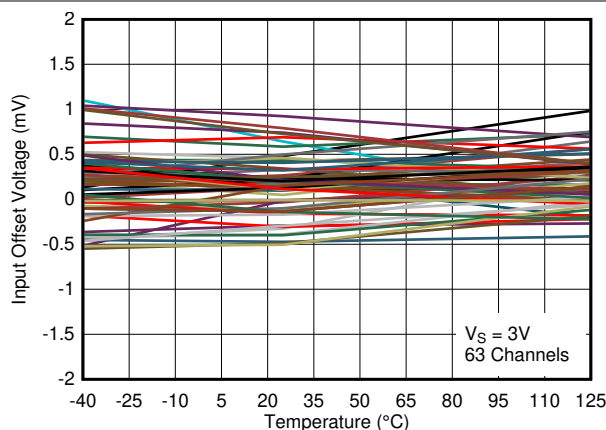


Figure 2-7. Input Offset Voltage vs. Temperature at 3V

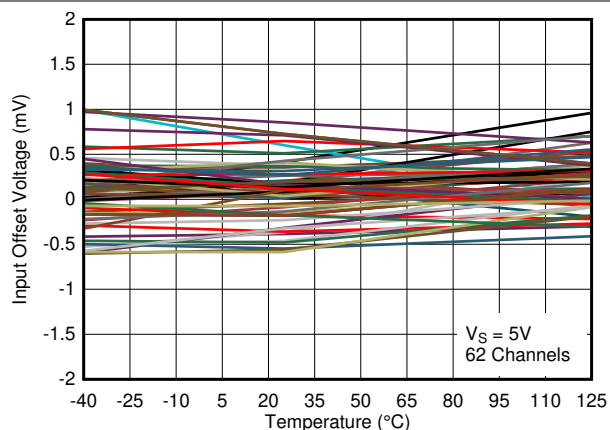


Figure 2-8. Input Offset Voltage vs. Temperature at 5V

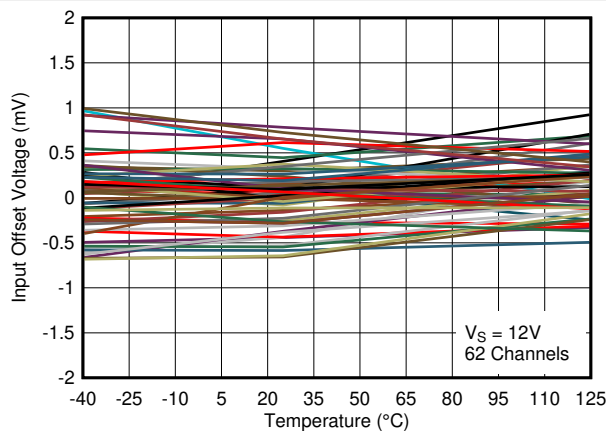


Figure 2-9. Input Offset Voltage vs. Temperature at 12V

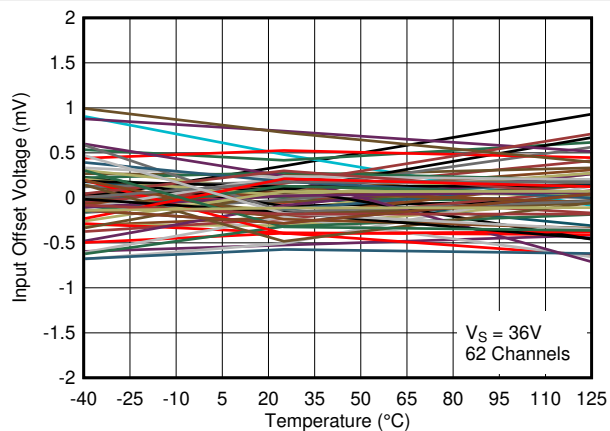


Figure 2-10. Input Offset Voltage vs. Temperature at 36V

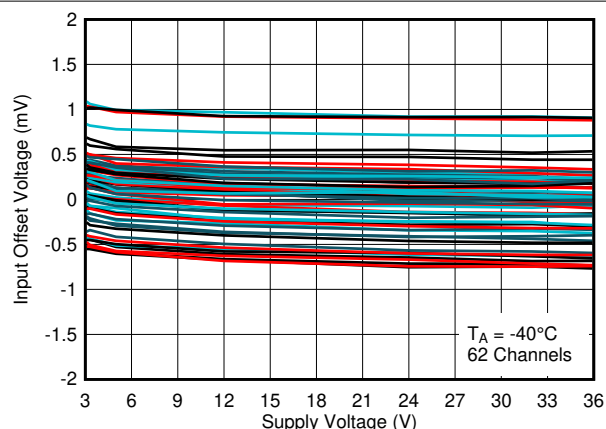


Figure 2-11. Input Offset Voltage vs. Supply Voltage at  $-40^\circ\text{C}$

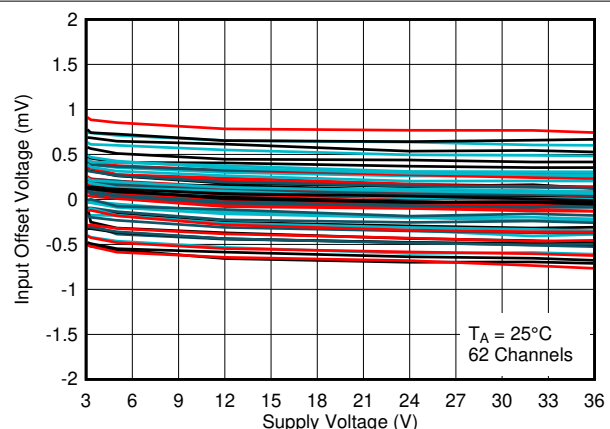


Figure 2-12. Input Offset Voltage vs. Supply Voltage at  $25^\circ\text{C}$

## 2.14 Typical Characteristics (continued)

$T_A = 25^\circ\text{C}$ ,  $V_S = 5\text{V}$ ,  $R_{\text{PULLUP}} = 5.1\text{k}$ ,  $C_L = 15\text{pF}$ ,  $V_{\text{CM}} = 0\text{V}$ ,  $V_{\text{UNDERDRIVE}} = 100\text{mV}$ ,  $V_{\text{OVERDRIVE}} = 100\text{mV}$  unless otherwise noted.

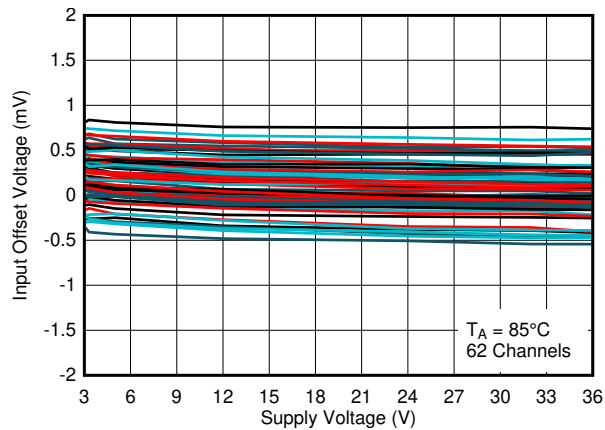


Figure 2-13. Input Offset Voltage vs. Supply Voltage at 85°C

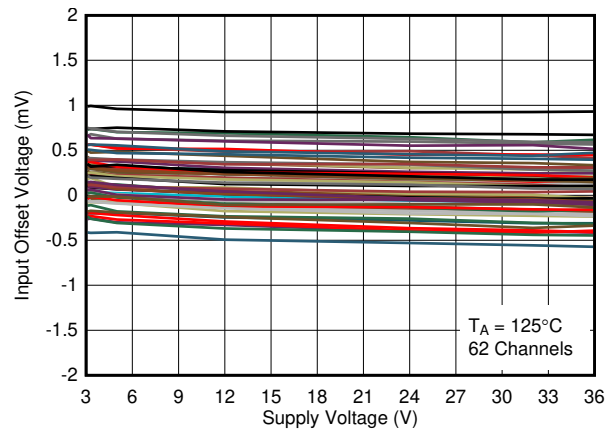


Figure 2-14. Input Offset Voltage vs. Supply Voltage at 125°C

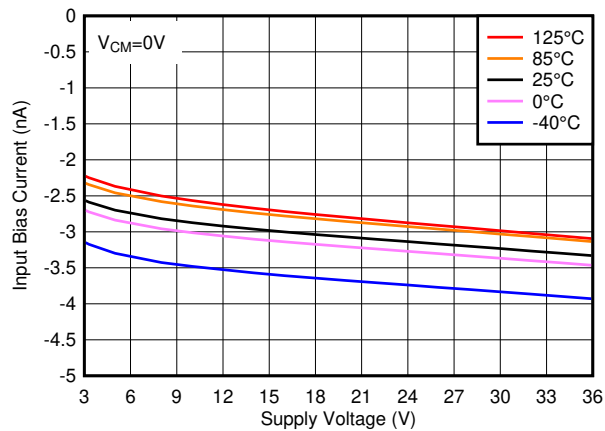


Figure 2-15. Input Bias Current vs. Supply Voltage

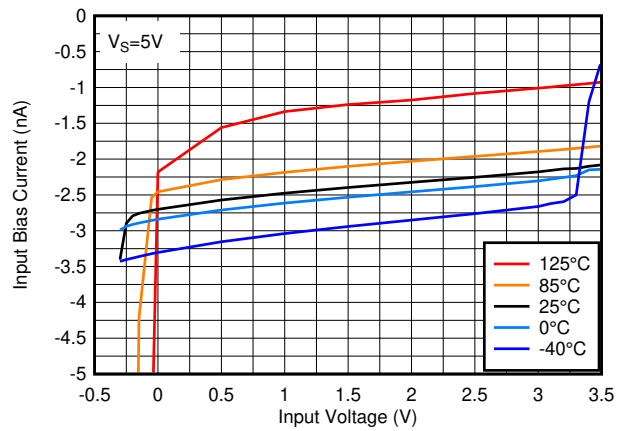


Figure 2-16. Input Bias Current vs. Input Voltage at 5V

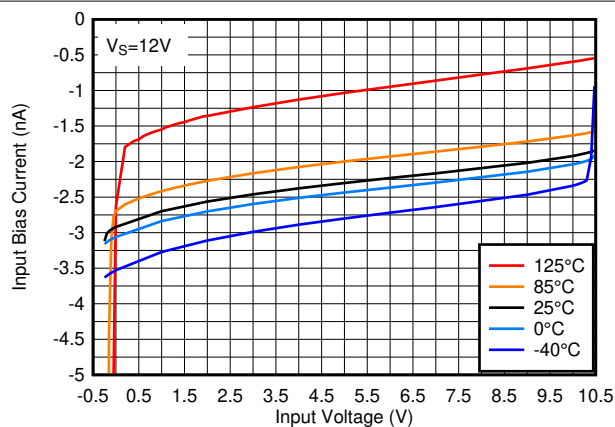


Figure 2-17. Input Bias Current vs. Input Voltage at 12V

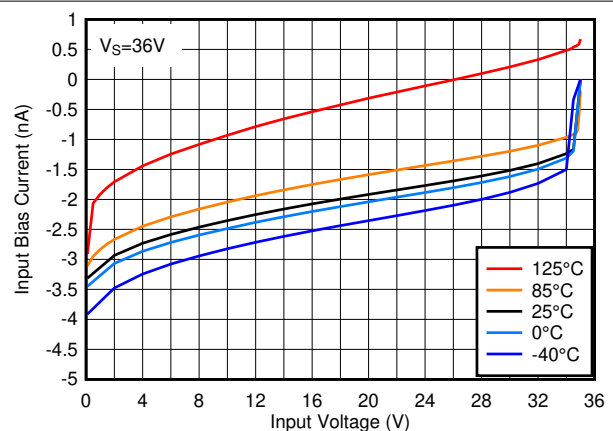
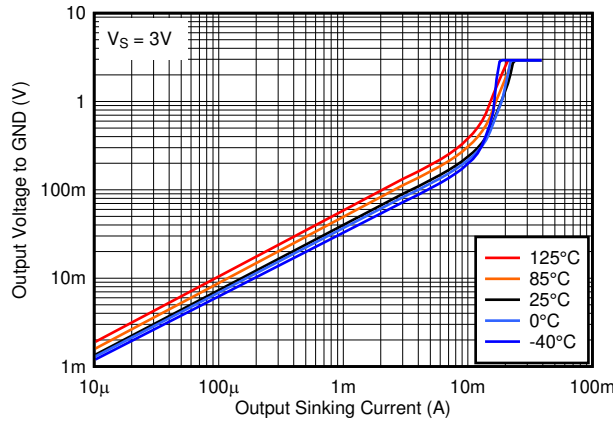


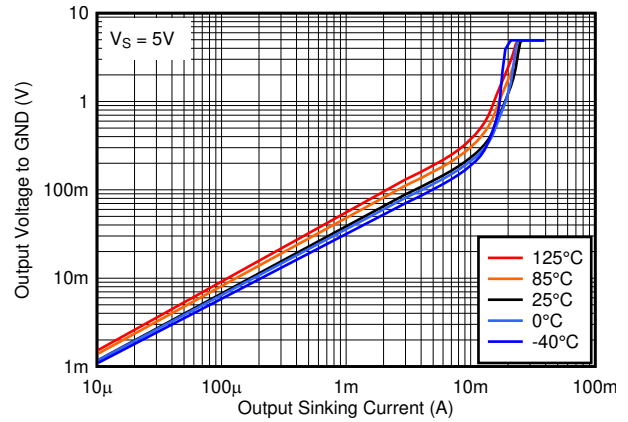
Figure 2-18. Input Bias Current vs. Input Voltage at 36V

## 2.14 Typical Characteristics (continued)

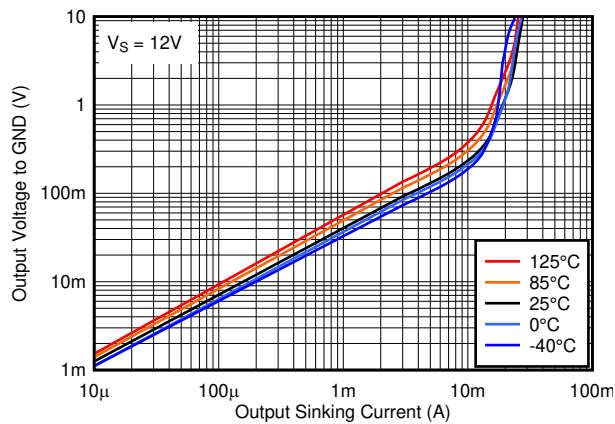
$T_A = 25^\circ\text{C}$ ,  $V_S = 5\text{V}$ ,  $R_{\text{PULLUP}} = 5.1\text{k}$ ,  $C_L = 15\text{pF}$ ,  $V_{\text{CM}} = 0\text{V}$ ,  $V_{\text{UNDERDRIVE}} = 100\text{mV}$ ,  $V_{\text{OVERDRIVE}} = 100\text{mV}$  unless otherwise noted.



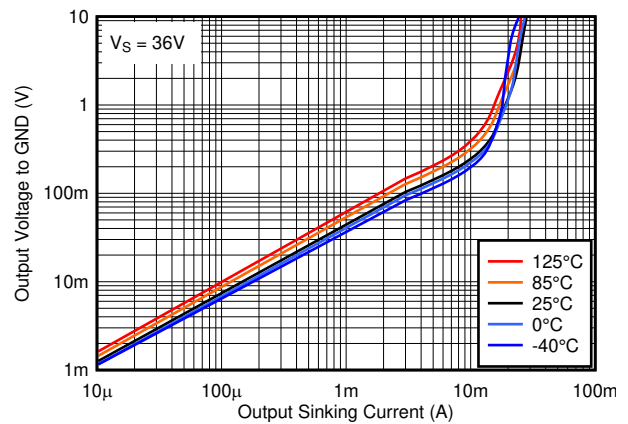
**Figure 2-19. Output Low Voltage vs. Output Sinking Current at 3V**



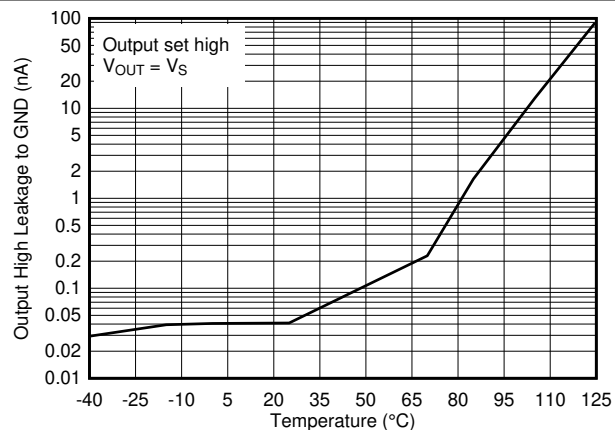
**Figure 2-20. Output Low Voltage vs. Output Sinking Current at 5V**



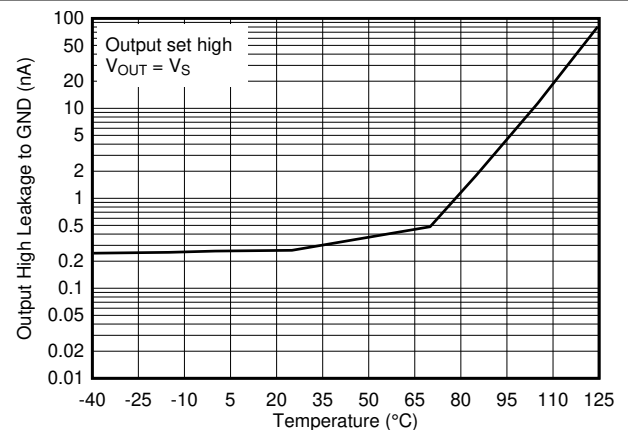
**Figure 2-21. Output Low Voltage vs. Output Sinking Current at 12V**



**Figure 2-22. Output Low Voltage vs. Output Sinking Current at 36V**



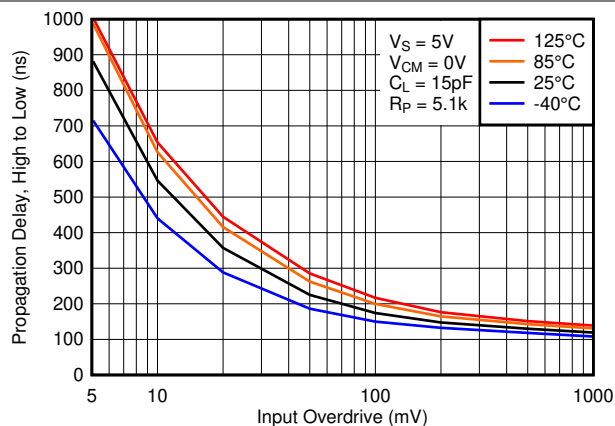
**Figure 2-23. Output High Leakage Current vs. Temperature at 5V**



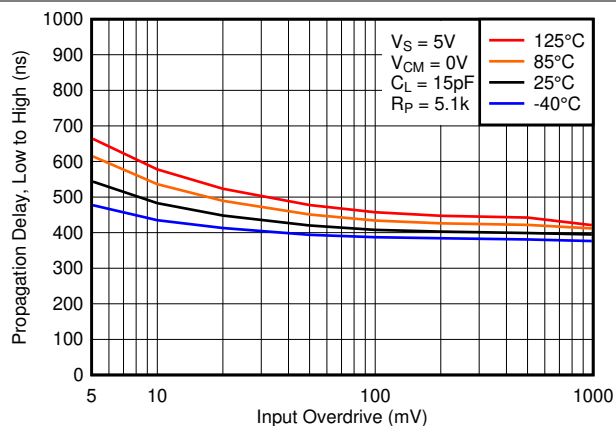
**Figure 2-24. Output High Leakage Current vs. Temperature at 36V**

## 2.14 Typical Characteristics (continued)

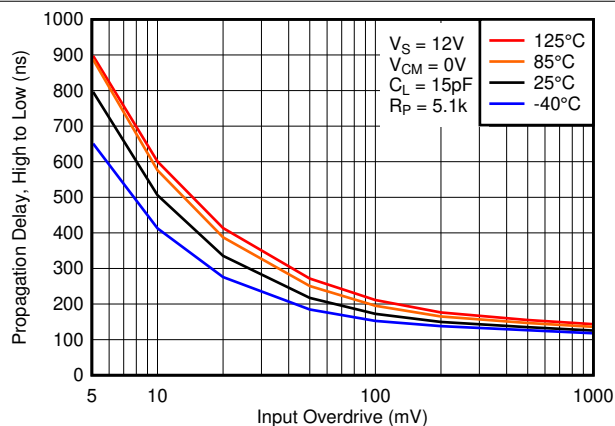
$T_A = 25^\circ\text{C}$ ,  $V_S = 5\text{V}$ ,  $R_{\text{PULLUP}} = 5.1\text{k}$ ,  $C_L = 15\text{pF}$ ,  $V_{\text{CM}} = 0\text{V}$ ,  $V_{\text{UNDERDRIVE}} = 100\text{mV}$ ,  $V_{\text{OVERDRIVE}} = 100\text{mV}$  unless otherwise noted.



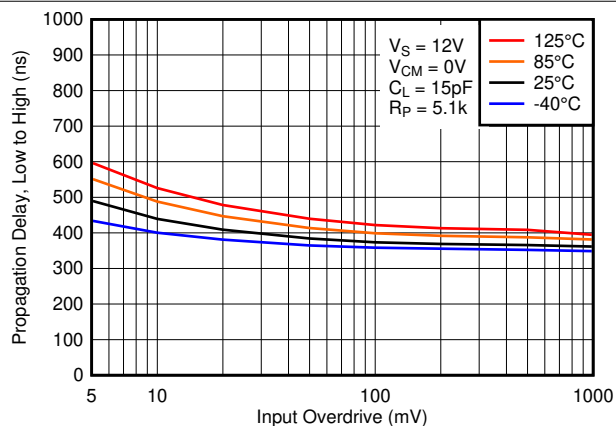
**Figure 2-25. High to Low Propagation Delay vs. Input Overdrive Voltage, 5V**



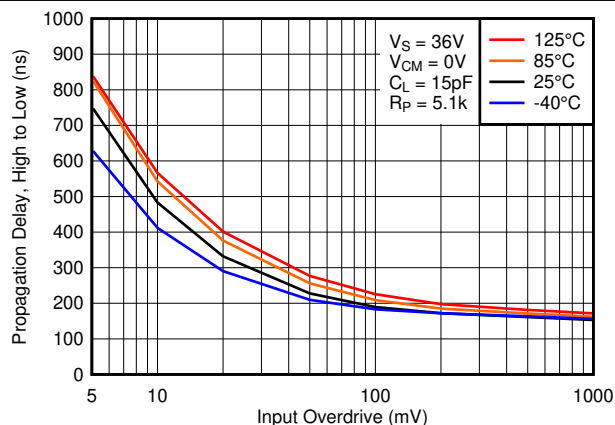
**Figure 2-26. Low to High Propagation Delay vs. Input Overdrive Voltage, 5V**



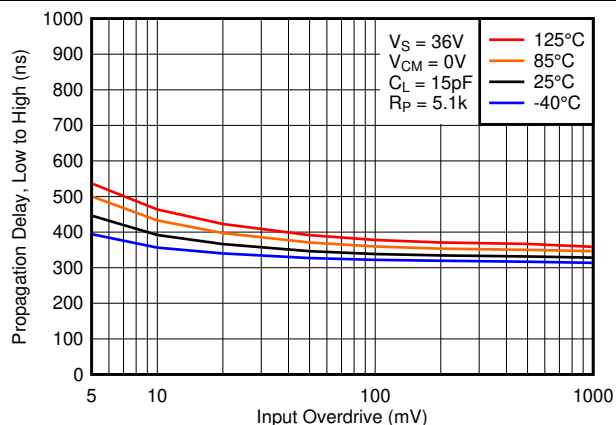
**Figure 2-27. High to Low Propagation Delay vs. Input Overdrive Voltage, 12V**



**Figure 2-28. Low to High Propagation Delay vs. Input Overdrive Voltage, 12V**



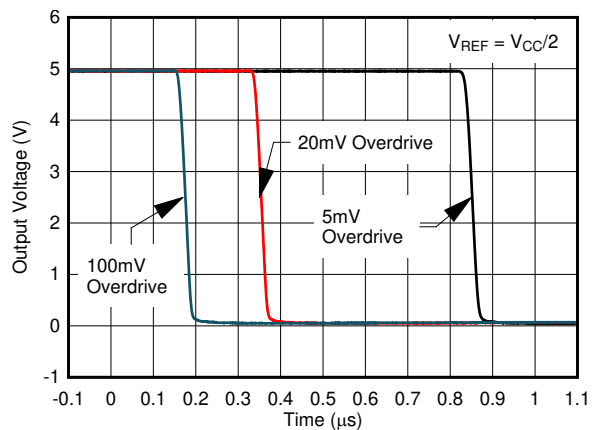
**Figure 2-29. High to Low Propagation Delay vs. Input Overdrive Voltage, 36V**



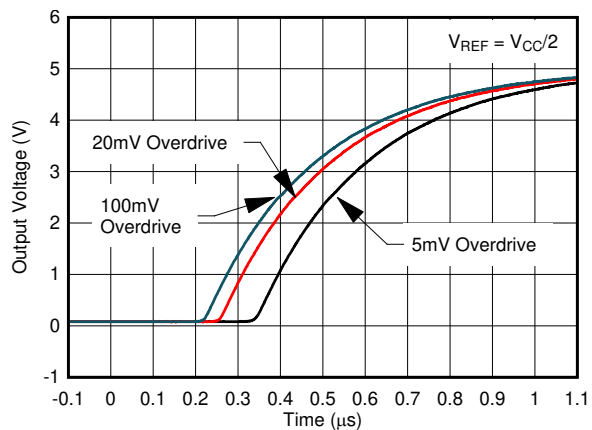
**Figure 2-30. Low to High Propagation Delay vs. Input Overdrive Voltage, 36V**

## 2.14 Typical Characteristics (continued)

$T_A = 25^\circ\text{C}$ ,  $V_S = 5\text{V}$ ,  $R_{\text{PULLUP}} = 5.1\text{k}$ ,  $C_L = 15\text{pF}$ ,  $V_{\text{CM}} = 0\text{V}$ ,  $V_{\text{UNDERDRIVE}} = 100\text{mV}$ ,  $V_{\text{OVERDRIVE}} = 100\text{mV}$  unless otherwise noted.



**Figure 2-31. Response Time for Various Overdrives, High-to-Low Transition**



**Figure 2-32. Response Time for Various Overdrives, Low-to-High Transition**

## 3 Detailed Description

### 3.1 Overview

The LM2903-Q1 family is a dual comparator with the ability to operate up to 36V 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 (2V to 36V), low  $I_q$  and fast response.

This device is AEC-Q100 qualified and can operate over a wide temperature range of  $-40^{\circ}\text{C}$  to  $125^{\circ}\text{C}$  (LM2903-Q1 and LM2903B-Q1) or  $-40^{\circ}\text{C}$  to  $150^{\circ}\text{C}$  (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.

The "B" versions add dedicated ESD protections on all the pins for improved ESD performance as well as improved negative input voltage handling. Please see Application Note [SNOAA35](#) for more information

### 3.2 Functional Block Diagram

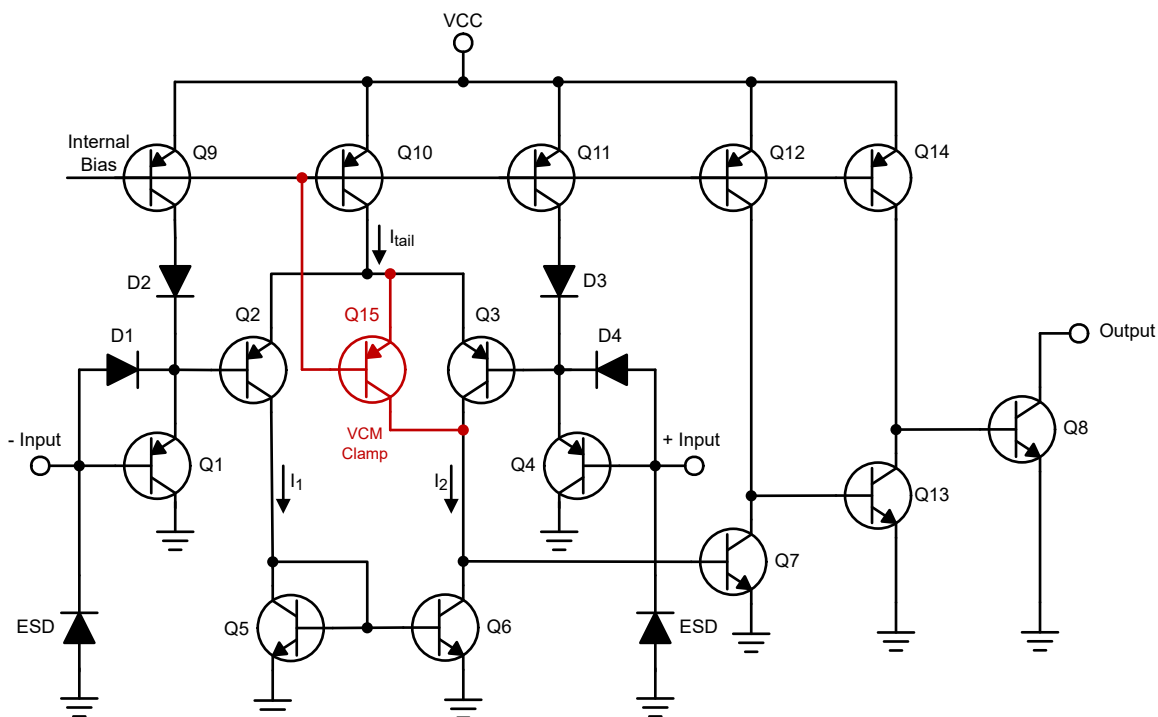


Figure 3-1. Schematic (Each Comparator)

### 3.3 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  $V_{CC}-1.5\text{V}$  differential input. This enables much head room for modern day supplies of 3.3V and 5.0V. A clamp (Q15) was added around Q3 to force the output low when both inputs are taken above the VCM range.

The output consists of an open drain NPN (pull-down or low side) transistor. The output NPN sinks current when the negative input voltage is higher than the positive input voltage and the offset voltage. The  $V_{OL}$  is resistive and scales with the output current. Please see [Output Low Voltage vs. Output Sinking Current at 5V](#) in the [Typical Characteristics](#) section for  $V_{OL}$  values with respect to the output current.

## 3.4 Device Functional Modes

### 3.4.1 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.

## 4 Application and Implementation

### Note

Information in the following applications sections is not part of the TI component specification, and TI does not warrant its accuracy or completeness. TI's customers are responsible for determining suitability of components for their purposes, as well as validating and testing their design implementation to confirm system functionality.

### 4.1 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.

### 4.2 Typical Application

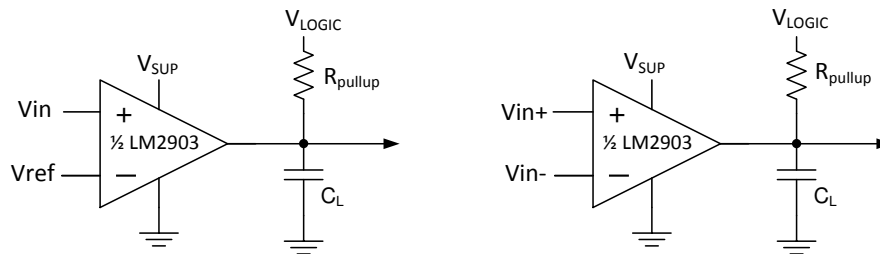


Figure 4-1. Single-ended and Differential Comparator Configurations

#### 4.2.1 Design Requirements

For this design example, use the parameters listed in [Table 4-1](#) as the input parameters.

Table 4-1. Design Parameters

| DESIGN PARAMETER                      | EXAMPLE VALUE   |
|---------------------------------------|-----------------|
| Input Voltage Range                   | 0V to Vsup-1.5V |
| Supply Voltage                        | 2V to 36V       |
| Logic Supply Voltage                  | 2V to 36V       |
| Output Current (R <sub>PULLUP</sub> ) | 1μA to 20mA     |
| Input Overdrive Voltage               | 100mV           |
| Reference Voltage                     | 2.5V            |
| Load Capacitance (C <sub>L</sub> )    | 15pF            |

#### 4.2.2 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

##### 4.2.2.1 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 0V to  $V_{CC} - 2V$ . This limits the input voltage range to as high as  $V_{CC} - 2.0V$  and as low as 0V. Operation outside of this range can yield incorrect comparisons.

Below is a list of input voltage situation and the outcomes:

- When both IN- and IN+ are both within the common mode range:
  - If IN- is higher than IN+ and the offset voltage, the output is low and the output transistor is sinking current
  - If IN- is lower than IN+ and the offset voltage, the output is high impedance and the output transistor is not conducting
- When IN- is higher than common mode and IN+ is within common mode, the output is low and the output transistor is sinking current
- 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
- When IN- and IN+ are both higher than common mode, see Section 2 of [Application Design Guidelines for LM339, LM393, TL331 Family Comparators Including the New B-versions](#)

#### 4.2.2.2 Minimum Overdrive Voltage

Overdrive Voltage is the differential voltage produced between the positive and negative inputs of the comparator over the offset voltage ( $V_{IO}$ ). To make an accurate comparison the Overdrive Voltage ( $V_{OD}$ ) must 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 4-2](#) and [Figure 4-3](#) show positive and negative response times with respect to overdrive voltage.

#### 4.2.2.3 Output and Drive Current

Output current is determined by the load/pull-up resistance and logic/pull-up voltage. The output current produces a output low voltage ( $V_{OL}$ ) from the comparator. In which  $V_{OL}$  is proportional to the output current. Use [Figure 2-21](#) to determine  $V_{OL}$  based on the output current.

The output current can also effect the transient response. More explanation is in the next section.

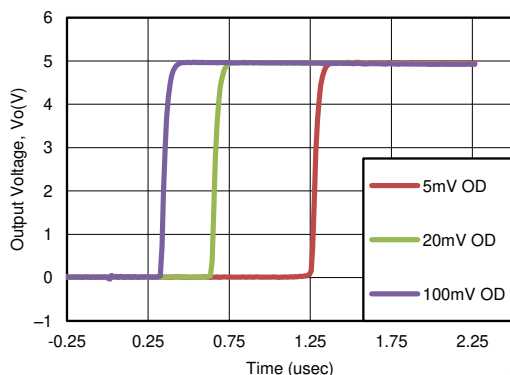
#### 4.2.2.4 Response Time

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

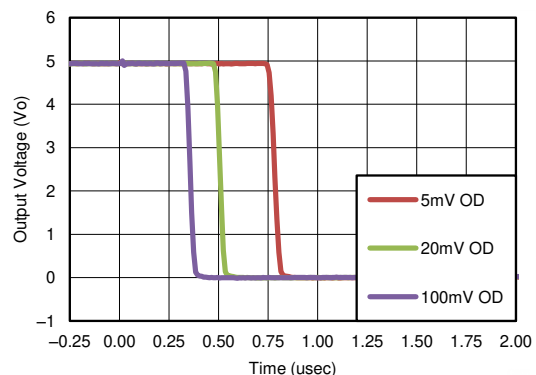
- The positive response time ( $T_P$ ) is approximately  $T_P = R_{PULLUP} \times C_L$
- The negative response time ( $T_N$ ) is approximately  $T_N = R_{CE} \times C_L$ 
  - $R_{CE}$  can be determine by taking the slope of [Figure 2-21](#) in it's linear region at the desired temperature, or by dividing the  $V_{OL}$  by  $I_{out}$

#### 4.2.3 Application Curves

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



**Figure 4-2. Response Time for Various Overdrives (Positive Transition)**



**Figure 4-3. Response Time for Various Overdrives (Negative Transition)**

### 4.3 Power Supply Recommendations

A bypass capacitor is recommended 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.

### 4.4 Layout

#### 4.4.1 Layout Guidelines

For accurate comparator applications without hysteresis, a stable power supply with minimal noise must be maintained. To achieve this, the best practice is to add a bypass capacitor between the supply voltage and ground. This can 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.

#### 4.4.2 Layout Example

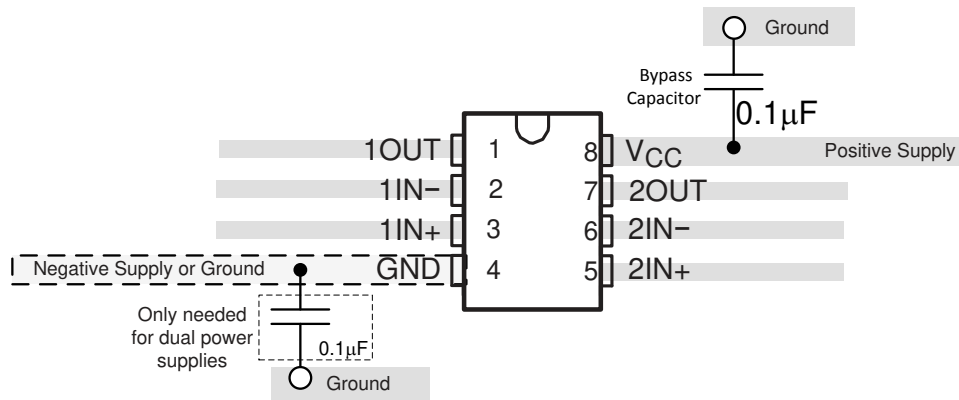


Figure 4-4. LM2903Q1 Layout Example

## 5 Device and Documentation Support

### 5.1 Documentation Support

#### 5.1.1 Related Documentation

[LM2903B-Q1 Functional Safety FIT Rate, FMD and Pin FMA](#) - SLCA005

[Application Design Guidelines for LM339, LM393, TL331 Family Comparators](#) - SNOAA35

[Analog Engineers Circuit Cookbook: Amplifiers \(See Comparators section\)](#) - SLYY137

### 5.2 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.

### 5.3 Support Resources

[TI E2E™ support forums](#) are an engineer's go-to source for fast, verified answers and design help — straight from the experts. Search existing answers or ask your own question to get the quick design help you need.

Linked content is 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](#).

### 5.4 Trademarks

TI E2E™ is a trademark of Texas Instruments.

All trademarks are the property of their respective owners.

## 5.5 Electrostatic Discharge Caution



This integrated circuit can be damaged by ESD. Texas Instruments recommends that all integrated circuits be handled with appropriate precautions. Failure to observe proper handling and installation procedures can cause damage.

ESD damage can range from subtle performance degradation to complete device failure. Precision integrated circuits may be more susceptible to damage because very small parametric changes could cause the device not to meet its published specifications.

## 5.6 Glossary

### TI Glossary

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

## 6 Revision History

NOTE: Page numbers for previous revisions may differ from page numbers in the current version.

| <b>Changes from Revision L (August 2023) to Revision M (December 2024)</b> | <b>Page</b>        |
|----------------------------------------------------------------------------|--------------------|
| • Updated thermal table .....                                              | <a href="#">5</a>  |
| • Updated Typical Characteristics.....                                     | <a href="#">8</a>  |
| • Updated Functional Block Diagram.....                                    | <a href="#">14</a> |

| <b>Changes from Revision K (August 2022) to Revision L (August 2023)</b> | <b>Page</b>        |
|--------------------------------------------------------------------------|--------------------|
| • Added reference to Application Note.....                               | <a href="#">16</a> |

| <b>Changes from Revision J (November 2020) to Revision K (August 2022)</b> | <b>Page</b>       |
|----------------------------------------------------------------------------|-------------------|
| • Added T, R and H Temp Test Options table.....                            | <a href="#">6</a> |

| <b>Changes from Revision I (June 2020) to Revision J (November 2020)</b>                     | <b>Page</b>       |
|----------------------------------------------------------------------------------------------|-------------------|
| • Changed LM2903B-Q1 Minimum Recommended Supply Voltage to 2V throughout the data sheet..... | <a href="#">1</a> |
| • Added Operating Virtual Temp to Abs Max Table for both versions.....                       | <a href="#">4</a> |
| • Updated Supply Voltage vs Supply Current graph for 2V.....                                 | <a href="#">4</a> |

| <b>Changes from Revision G (November 2018) to Revision H (January 2020)</b> | <b>Page</b>        |
|-----------------------------------------------------------------------------|--------------------|
| • Added LM2903B-Q1 to data sheet.....                                       | <a href="#">1</a>  |
| • Added Device Information table. ....                                      | <a href="#">1</a>  |
| • Added "B" device graphs .....                                             | <a href="#">8</a>  |
| • Changed incorrect input text in Feature Description in Apps Section.....  | <a href="#">14</a> |

| <b>Changes from Revision F (May 2018) to Revision G (November 2018)</b> | <b>Page</b> |
|-------------------------------------------------------------------------|-------------|
|-------------------------------------------------------------------------|-------------|

| <b>Changes from Revision H (January 2020) to Revision I (June 2020)</b> | <b>Page</b>        |
|-------------------------------------------------------------------------|--------------------|
| • Added Functional Safety text and links.....                           | <a href="#">1</a>  |
| • Added VSSOP package to Device Info list for "B".....                  | <a href="#">1</a>  |
| • Added DGK to "B" Thermal Table.....                                   | <a href="#">5</a>  |
| • Added text to Apps Overview section for ESD.....                      | <a href="#">14</a> |

## 7 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<br>(1) | Package Type | Package Drawing | Pins | Package Qty | Eco Plan<br>(2) | Lead finish/<br>Ball material<br>(6) | MSL Peak Temp<br>(3) | Op Temp (°C) | Device Marking<br>(4/5) | Samples                 |
|------------------|---------------|--------------|-----------------|------|-------------|-----------------|--------------------------------------|----------------------|--------------|-------------------------|-------------------------|
| LM2903AVQDRG4Q1  | ACTIVE        | SOIC         | D               | 8    | 2500        | RoHS & Green    | NIPDAU                               | Level-1-260C-UNLIM   | -40 to 125   | 2903AVQ                 | <a href="#">Samples</a> |
| LM2903AVQDRQ1    | ACTIVE        | SOIC         | D               | 8    | 2500        | RoHS & Green    | NIPDAU                               | Level-1-260C-UNLIM   | -40 to 125   | 2903AVQ                 | <a href="#">Samples</a> |
| LM2903AVQPWRG4Q1 | ACTIVE        | TSSOP        | PW              | 8    | 2000        | RoHS & Green    | NIPDAU                               | Level-1-260C-UNLIM   | -40 to 125   | 2903AVQ                 | <a href="#">Samples</a> |
| LM2903AVQPWRQ1   | ACTIVE        | TSSOP        | PW              | 8    | 2000        | RoHS & Green    | NIPDAU                               | Level-1-260C-UNLIM   | -40 to 125   | 2903AVQ                 | <a href="#">Samples</a> |
| LM2903BHQDGKRQ1  | ACTIVE        | VSSOP        | DGK             | 8    | 2500        | RoHS & Green    | NIPDAU                               | Level-1-260C-UNLIM   | -40 to 125   | 3BHQ                    | <a href="#">Samples</a> |
| LM2903BHQDRQ1    | ACTIVE        | SOIC         | D               | 8    | 3000        | RoHS & Green    | NIPDAU                               | Level-1-260C-UNLIM   | -40 to 125   | 903BHQ                  | <a href="#">Samples</a> |
| LM2903BHQPWRQ1   | ACTIVE        | TSSOP        | PW              | 8    | 3000        | RoHS & Green    | NIPDAU                               | Level-1-260C-UNLIM   | -40 to 125   | 2903BH                  | <a href="#">Samples</a> |
| LM2903BQDDFRQ1   | ACTIVE        | SOT-23-THIN  | DDF             | 8    | 3000        | RoHS & Green    | NIPDAU                               | Level-1-260C-UNLIM   | -40 to 125   | 903BQ                   | <a href="#">Samples</a> |
| LM2903BQDGKRQ1   | ACTIVE        | VSSOP        | DGK             | 8    | 2500        | RoHS & Green    | NIPDAU                               | Level-1-260C-UNLIM   | -40 to 125   | 03BQ                    | <a href="#">Samples</a> |
| LM2903BQDRQ1     | ACTIVE        | SOIC         | D               | 8    | 2500        | RoHS & Green    | NIPDAU                               | Level-1-260C-UNLIM   | -40 to 125   | 2903BQ                  | <a href="#">Samples</a> |
| LM2903BQPWRQ1    | ACTIVE        | TSSOP        | PW              | 8    | 2000        | RoHS & Green    | NIPDAU                               | Level-1-260C-UNLIM   | -40 to 125   | 2903BQ                  | <a href="#">Samples</a> |
| LM2903BRQDGKRQ1  | ACTIVE        | VSSOP        | DGK             | 8    | 2500        | RoHS & Green    | NIPDAU                               | Level-1-260C-UNLIM   | -40 to 125   | 3BRQ                    | <a href="#">Samples</a> |
| LM2903BRQDRQ1    | ACTIVE        | SOIC         | D               | 8    | 3000        | RoHS & Green    | NIPDAU                               | Level-1-260C-UNLIM   | -40 to 125   | 903BRQ                  | <a href="#">Samples</a> |
| LM2903BRQPWRQ1   | ACTIVE        | TSSOP        | PW              | 8    | 3000        | RoHS & Green    | NIPDAU                               | Level-1-260C-UNLIM   | -40 to 125   | 2903BR                  | <a href="#">Samples</a> |
| LM2903BTQDGKRQ1  | ACTIVE        | VSSOP        | DGK             | 8    | 2500        | RoHS & Green    | NIPDAU                               | Level-1-260C-UNLIM   | -40 to 125   | 3BTQ                    | <a href="#">Samples</a> |
| LM2903BTQDRQ1    | ACTIVE        | SOIC         | D               | 8    | 3000        | RoHS & Green    | NIPDAU                               | Level-1-260C-UNLIM   | -40 to 125   | 903BTQ                  | <a href="#">Samples</a> |
| LM2903BTQPWRQ1   | ACTIVE        | TSSOP        | PW              | 8    | 3000        | RoHS & Green    | NIPDAU                               | Level-1-260C-UNLIM   | -40 to 125   | 2903BT                  | <a href="#">Samples</a> |
| LM2903BWDSGRQ1   | ACTIVE        | WSO          | DSG             | 8    | 3000        | RoHS & Green    | Call TI   SN                         | Level-2-260C-1 YEAR  | -40 to 125   | 3BWQ                    | <a href="#">Samples</a> |
| LM2903EPWRQ1     | ACTIVE        | TSSOP        | PW              | 8    | 2000        | RoHS & Green    | NIPDAU                               | Level-2-260C-1 YEAR  | -40 to 150   | 2903Q0                  | <a href="#">Samples</a> |
| LM2903QDGKRQ1    | ACTIVE        | VSSOP        | DGK             | 8    | 2500        | RoHS & Green    | NIPDAUAG                             | Level-2-260C-1 YEAR  | -40 to 125   | KACQ                    | <a href="#">Samples</a> |

| Orderable Device | Status<br>(1) | Package Type | Package<br>Drawing | Pins | Package<br>Qty | Eco Plan<br>(2) | Lead finish/<br>Ball material<br>(6) | MSL Peak Temp<br>(3) | Op Temp (°C) | Device Marking<br>(4/5) | Samples                 |
|------------------|---------------|--------------|--------------------|------|----------------|-----------------|--------------------------------------|----------------------|--------------|-------------------------|-------------------------|
| LM2903QDRG4Q1    | ACTIVE        | SOIC         | D                  | 8    | 2500           | RoHS & Green    | NIPDAU                               | Level-1-260C-UNLIM   | -40 to 125   | 2903Q1                  | <a href="#">Samples</a> |
| LM2903QDRQ1      | ACTIVE        | SOIC         | D                  | 8    | 2500           | RoHS & Green    | NIPDAU                               | Level-1-260C-UNLIM   | -40 to 125   | 2903Q1                  | <a href="#">Samples</a> |
| LM2903QPWRG4Q1   | ACTIVE        | TSSOP        | PW                 | 8    | 2000           | RoHS & Green    | NIPDAU                               | Level-1-260C-UNLIM   | -40 to 125   | 2903Q1                  | <a href="#">Samples</a> |
| LM2903QPWRQ1     | ACTIVE        | TSSOP        | PW                 | 8    | 2000           | RoHS & Green    | NIPDAU                               | Level-1-260C-UNLIM   | -40 to 125   | 2903Q1                  | <a href="#">Samples</a> |
| LM2903VQDRG4Q1   | OBSOLETE      | SOIC         | D                  | 8    |                | TBD             | Call TI                              | Call TI              | -40 to 125   | 2903VQ1                 |                         |
| LM2903VQDRQ1     | ACTIVE        | SOIC         | D                  | 8    | 2500           | RoHS & Green    | NIPDAU                               | Level-1-260C-UNLIM   | -40 to 125   | 2903VQ1                 | <a href="#">Samples</a> |
| LM2903VQPWRG4Q1  | ACTIVE        | TSSOP        | PW                 | 8    | 2000           | RoHS & Green    | NIPDAU                               | Level-1-260C-UNLIM   | -40 to 125   | 2903VQ                  | <a href="#">Samples</a> |
| LM2903VQPWRQ1    | ACTIVE        | TSSOP        | PW                 | 8    | 2000           | RoHS & Green    | NIPDAU                               | Level-1-260C-UNLIM   | -40 to 125   | 2903VQ                  | <a href="#">Samples</a> |

(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) **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.

(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.

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

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

**OTHER QUALIFIED VERSIONS OF LM2903-Q1, LM2903B-Q1 :**

- Catalog : [LM2903](#), [LM2903B](#)

NOTE: Qualified Version Definitions:

- Catalog - TI's standard catalog product

## TAPE AND REEL INFORMATION



\*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 |
|------------------|--------------|-----------------|------|------|--------------------|--------------------|---------|---------|---------|---------|--------|---------------|
| LM2903AVQDRG4Q1  | SOIC         | D               | 8    | 2500 | 330.0              | 12.4               | 6.4     | 5.2     | 2.1     | 8.0     | 12.0   | Q1            |
| LM2903AVQDRG4Q1  | SOIC         | D               | 8    | 2500 | 330.0              | 12.4               | 6.4     | 5.2     | 2.1     | 8.0     | 12.0   | Q1            |
| LM2903AVQDRQ1    | SOIC         | D               | 8    | 2500 | 330.0              | 12.5               | 6.4     | 5.2     | 2.1     | 8.0     | 12.0   | Q1            |
| LM2903AVQDRQ1    | SOIC         | D               | 8    | 2500 | 330.0              | 12.4               | 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            |
| LM2903BHQDGKRQ1  | VSSOP        | DGK             | 8    | 2500 | 330.0              | 12.4               | 5.25    | 3.35    | 1.25    | 8.0     | 12.0   | Q1            |
| LM2903BHQDRQ1    | SOIC         | D               | 8    | 3000 | 330.0              | 12.4               | 6.4     | 5.2     | 2.1     | 8.0     | 12.0   | Q1            |
| LM2903BHPWRQ1    | TSSOP        | PW              | 8    | 3000 | 330.0              | 12.4               | 7.0     | 3.6     | 1.6     | 8.0     | 12.0   | Q1            |
| LM2903BQDDFRQ1   | SOT-23-THIN  | DDF             | 8    | 3000 | 180.0              | 8.4                | 3.2     | 3.2     | 1.4     | 4.0     | 8.0    | Q3            |
| LM2903BQDGKRQ1   | VSSOP        | DGK             | 8    | 2500 | 330.0              | 12.4               | 5.25    | 3.35    | 1.25    | 8.0     | 12.0   | Q1            |
| LM2903BQDRQ1     | SOIC         | D               | 8    | 2500 | 330.0              | 12.4               | 6.4     | 5.2     | 2.1     | 8.0     | 12.0   | Q1            |
| LM2903BQPWRQ1    | TSSOP        | PW              | 8    | 2000 | 330.0              | 12.4               | 7.0     | 3.6     | 1.6     | 8.0     | 12.0   | Q1            |
| LM2903BRQDGKRQ1  | VSSOP        | DGK             | 8    | 2500 | 330.0              | 12.4               | 5.25    | 3.35    | 1.25    | 8.0     | 12.0   | Q1            |
| LM2903BRQDRQ1    | SOIC         | D               | 8    | 3000 | 330.0              | 12.4               | 6.4     | 5.2     | 2.1     | 8.0     | 12.0   | Q1            |

| 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 |
|-----------------|--------------|-----------------|------|------|--------------------|--------------------|---------|---------|---------|---------|--------|---------------|
| LM2903BRQPWRQ1  | TSSOP        | PW              | 8    | 3000 | 330.0              | 12.4               | 7.0     | 3.6     | 1.6     | 8.0     | 12.0   | Q1            |
| LM2903BTQDGKRQ1 | VSSOP        | DGK             | 8    | 2500 | 330.0              | 12.4               | 5.25    | 3.35    | 1.25    | 8.0     | 12.0   | Q1            |
| LM2903BTQDRQ1   | SOIC         | D               | 8    | 3000 | 330.0              | 12.4               | 6.4     | 5.2     | 2.1     | 8.0     | 12.0   | Q1            |
| LM2903BTQPWRQ1  | TSSOP        | PW              | 8    | 3000 | 330.0              | 12.4               | 7.0     | 3.6     | 1.6     | 8.0     | 12.0   | Q1            |
| LM2903BWDSGRQ1  | WSO          | DSG             | 8    | 3000 | 180.0              | 8.4                | 2.2     | 2.2     | 1.2     | 4.0     | 8.0    | Q2            |
| 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            |
| LM2903QDRG4Q1   | SOIC         | D               | 8    | 2500 | 330.0              | 12.4               | 6.4     | 5.2     | 2.1     | 8.0     | 12.0   | Q1            |
| LM2903QDRQ1     | SOIC         | D               | 8    | 2500 | 330.0              | 12.4               | 6.4     | 5.2     | 2.1     | 8.0     | 12.0   | Q1            |
| LM2903QDRQ1     | SOIC         | D               | 8    | 2500 | 330.0              | 12.4               | 6.4     | 5.2     | 2.1     | 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            |
| LM2903VQPWRG4Q1 | 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            |
| LM2903VQPWRQ1   | 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            |

## TAPE AND REEL BOX DIMENSIONS



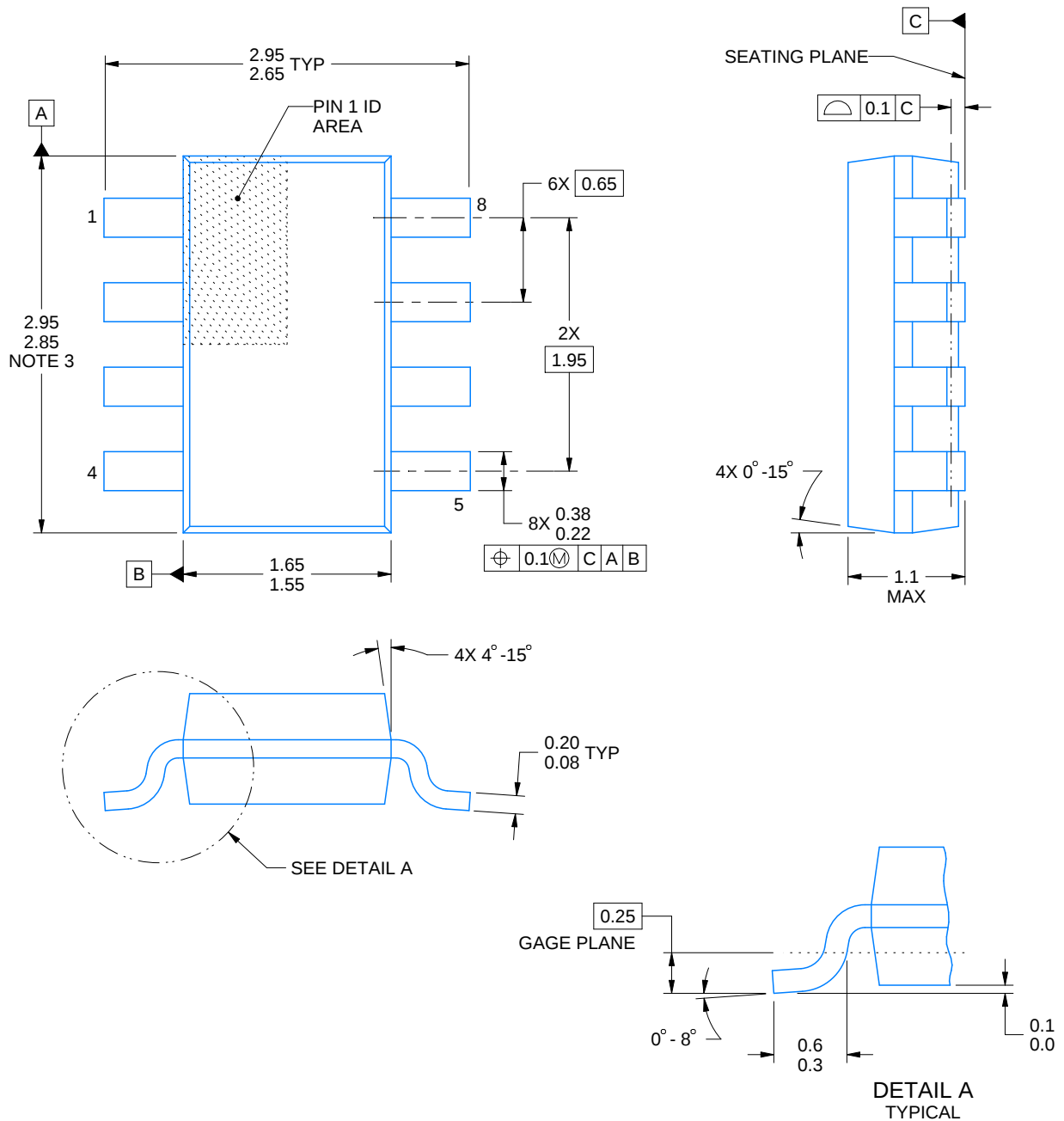
\*All dimensions are nominal

| Device           | Package Type | Package Drawing | Pins | SPQ  | Length (mm) | Width (mm) | Height (mm) |
|------------------|--------------|-----------------|------|------|-------------|------------|-------------|
| LM2903AVQDRG4Q1  | SOIC         | D               | 8    | 2500 | 340.5       | 338.1      | 20.6        |
| LM2903AVQDRG4Q1  | SOIC         | D               | 8    | 2500 | 353.0       | 353.0      | 32.0        |
| LM2903AVQDRQ1    | SOIC         | D               | 8    | 2500 | 353.0       | 353.0      | 32.0        |
| LM2903AVQDRQ1    | SOIC         | D               | 8    | 2500 | 340.5       | 338.1      | 20.6        |
| LM2903AVQPWRG4Q1 | TSSOP        | PW              | 8    | 2000 | 367.0       | 367.0      | 35.0        |
| LM2903AVQPWRQ1   | TSSOP        | PW              | 8    | 2000 | 356.0       | 356.0      | 35.0        |
| LM2903BHQDGKRQ1  | VSSOP        | DGK             | 8    | 2500 | 366.0       | 364.0      | 50.0        |
| LM2903BHQDRQ1    | SOIC         | D               | 8    | 3000 | 340.5       | 338.1      | 20.6        |
| LM2903BHQPWRQ1   | TSSOP        | PW              | 8    | 3000 | 356.0       | 356.0      | 35.0        |
| LM2903BQDDFRQ1   | SOT-23-THIN  | DDF             | 8    | 3000 | 210.0       | 185.0      | 35.0        |
| LM2903BQDGKRQ1   | VSSOP        | DGK             | 8    | 2500 | 366.0       | 364.0      | 50.0        |
| LM2903BQDRQ1     | SOIC         | D               | 8    | 2500 | 353.0       | 353.0      | 32.0        |
| LM2903BQPWRQ1    | TSSOP        | PW              | 8    | 2000 | 356.0       | 356.0      | 35.0        |
| LM2903BRQDGKRQ1  | VSSOP        | DGK             | 8    | 2500 | 366.0       | 364.0      | 50.0        |
| LM2903BRQDRQ1    | SOIC         | D               | 8    | 3000 | 340.5       | 338.1      | 20.6        |
| LM2903BRQPWRQ1   | TSSOP        | PW              | 8    | 3000 | 356.0       | 356.0      | 35.0        |
| LM2903BTQDGKRQ1  | VSSOP        | DGK             | 8    | 2500 | 366.0       | 364.0      | 50.0        |
| LM2903BTQDRQ1    | SOIC         | D               | 8    | 3000 | 340.5       | 338.1      | 20.6        |

| Device          | Package Type | Package Drawing | Pins | SPQ  | Length (mm) | Width (mm) | Height (mm) |
|-----------------|--------------|-----------------|------|------|-------------|------------|-------------|
| LM2903BTQPWRQ1  | TSSOP        | PW              | 8    | 3000 | 356.0       | 356.0      | 35.0        |
| LM2903BWDSGRQ1  | WSO8         | DSG             | 8    | 3000 | 213.0       | 191.0      | 35.0        |
| LM2903EPWRQ1    | TSSOP        | PW              | 8    | 2000 | 356.0       | 356.0      | 35.0        |
| LM2903QDGKRQ1   | VSSOP        | DGK             | 8    | 2500 | 366.0       | 364.0      | 50.0        |
| LM2903QDRG4Q1   | SOIC         | D               | 8    | 2500 | 340.5       | 338.1      | 20.6        |
| LM2903QDRQ1     | SOIC         | D               | 8    | 2500 | 353.0       | 353.0      | 32.0        |
| LM2903QDRQ1     | SOIC         | D               | 8    | 2500 | 340.5       | 338.1      | 20.6        |
| LM2903QPWRG4Q1  | TSSOP        | PW              | 8    | 2000 | 356.0       | 356.0      | 35.0        |
| LM2903QPWRQ1    | TSSOP        | PW              | 8    | 2000 | 356.0       | 356.0      | 35.0        |
| LM2903VQPWRG4Q1 | TSSOP        | PW              | 8    | 2000 | 353.0       | 353.0      | 32.0        |
| LM2903VQPWRG4Q1 | TSSOP        | PW              | 8    | 2000 | 356.0       | 356.0      | 35.0        |
| LM2903VQPWRG4Q1 | TSSOP        | PW              | 8    | 2000 | 367.0       | 367.0      | 35.0        |
| LM2903VQPWRQ1   | TSSOP        | PW              | 8    | 2000 | 356.0       | 356.0      | 35.0        |
| LM2903VQPWRQ1   | TSSOP        | PW              | 8    | 2000 | 353.0       | 353.0      | 32.0        |
| LM2903VQPWRQ1   | TSSOP        | PW              | 8    | 2000 | 356.0       | 356.0      | 35.0        |

**DDF0008A****PACKAGE OUTLINE****SOT-23-THIN - 1.1 mm max height**

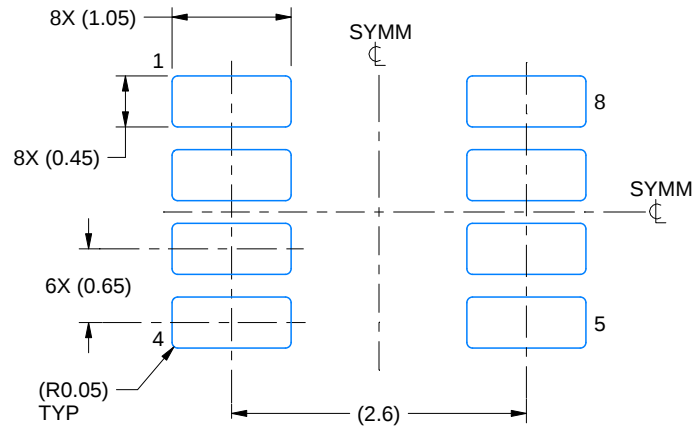
PLASTIC SMALL OUTLINE



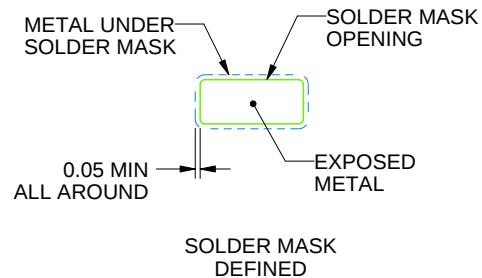
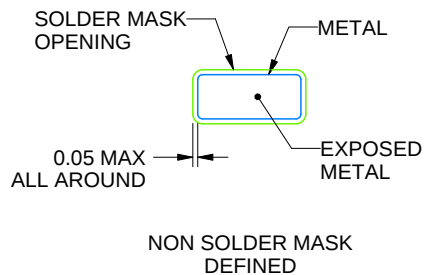
4222047/E 07/2024

**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.



LAND PATTERN EXAMPLE  
EXPOSED METAL SHOWN  
SCALE:15X



SOLDER MASK DETAILS

4222047/E 07/2024

NOTES: (continued)

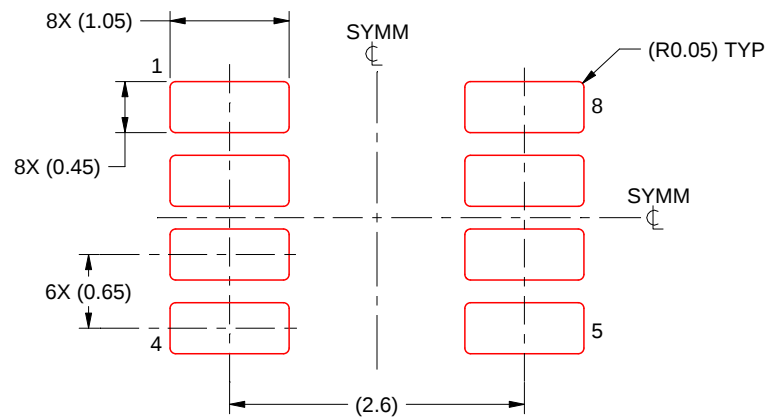
4. Publication IPC-7351 may have alternate designs.
5. Solder mask tolerances between and around signal pads can vary based on board fabrication site.

# EXAMPLE STENCIL DESIGN

DDF0008A

SOT-23-THIN - 1.1 mm max height

PLASTIC SMALL OUTLINE



SOLDER PASTE EXAMPLE  
BASED ON 0.125 mm THICK STENCIL  
SCALE:15X

4222047/E 07/2024

NOTES: (continued)

6. Laser cutting apertures with trapezoidal walls and rounded corners may offer better paste release. IPC-7525 may have alternate design recommendations.
7. Board assembly site may have different recommendations for stencil design.



## PACKAGE OUTLINE

**SOIC - 1.75 mm max height**

SMALL OUTLINE INTEGRATED CIRCUIT

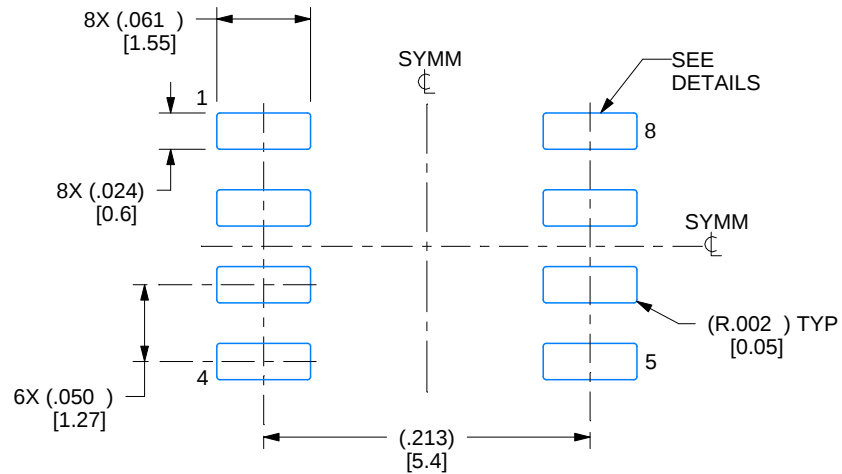


1. Linear dimensions are in inches [millimeters]. Dimensions in parenthesis are for reference only. Controlling dimensions are in inches. Dimensioning and tolerancing per ASME Y14.5M.
2. This drawing is subject to change without notice.
3. This dimension does not include mold flash, protrusions, or gate 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.

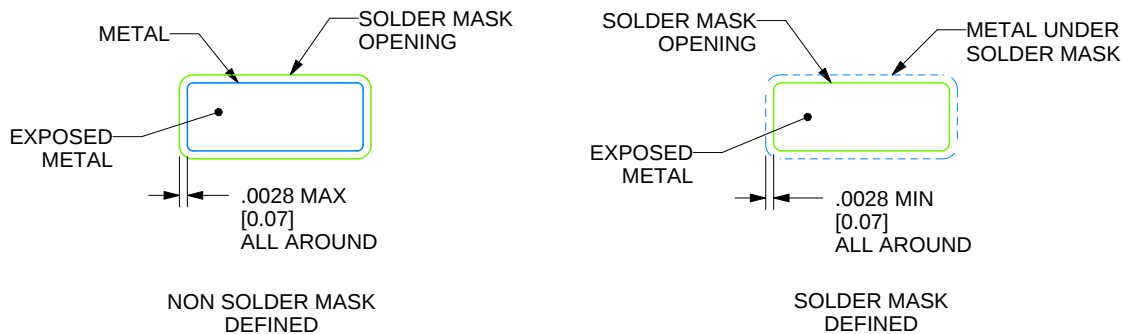
**D0008A**

**SOIC - 1.75 mm max height**

SMALL OUTLINE INTEGRATED CIRCUIT



LAND PATTERN EXAMPLE  
EXPOSED METAL SHOWN  
SCALE:8X



## SOLDER MASK DETAILS

4214825/C 02/2019

NOTES: (continued)

6. Publication IPC-7351 may have alternate designs.

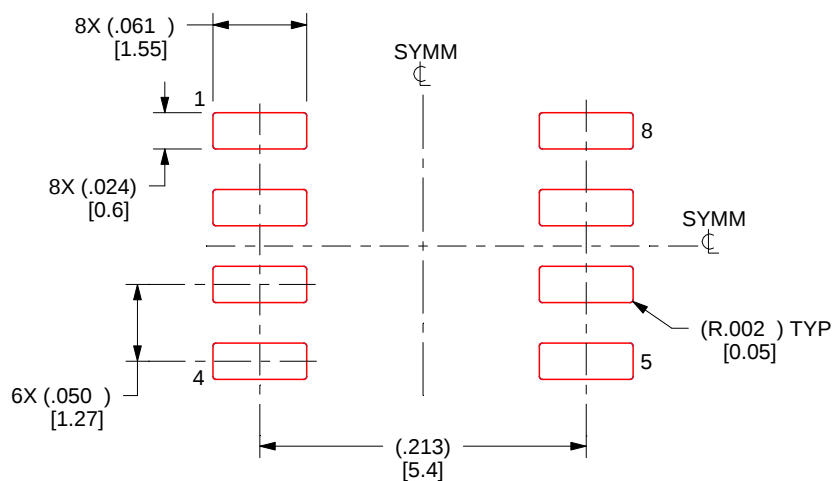
7. Solder mask tolerances between and around signal pads can vary based on board fabrication site.

## EXAMPLE STENCIL DESIGN

D0008A

SOIC - 1.75 mm max height

SMALL OUTLINE INTEGRATED CIRCUIT



SOLDER PASTE EXAMPLE  
BASED ON .005 INCH [0.125 MM] THICK STENCIL  
SCALE:8X

4214825/C 02/2019

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.

## GENERIC PACKAGE VIEW

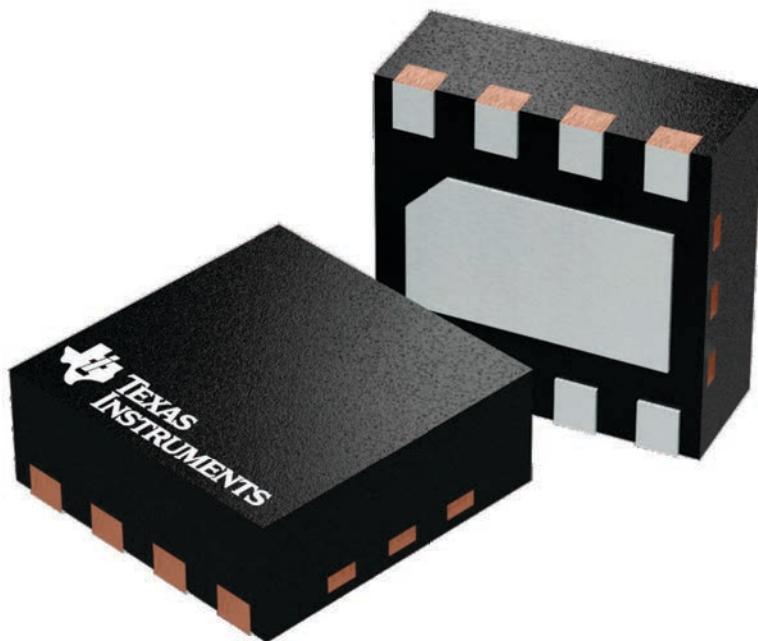
**DSG 8**

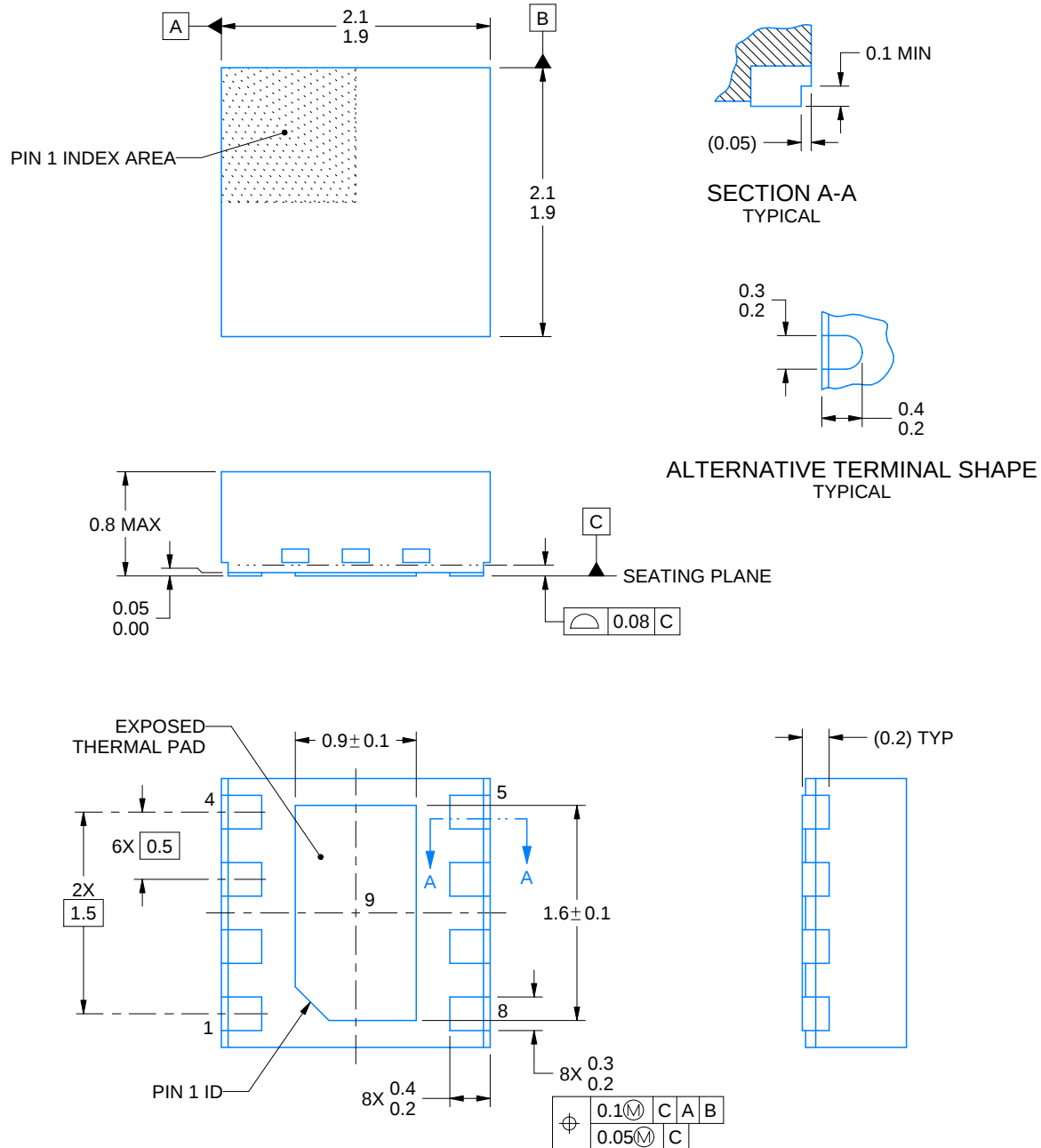
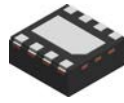
**WSON - 0.8 mm max height**

2 x 2, 0.5 mm pitch

PLASTIC SMALL OUTLINE - NO LEAD

This image is a representation of the package family, actual package may vary.  
Refer to the product data sheet for package details.





4222124/E 05/2020

## NOTES:

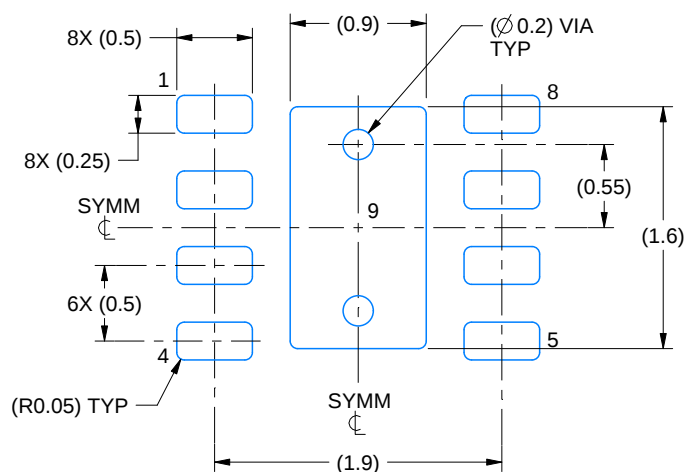
1. All linear dimensions are in millimeters. Any dimensions in parenthesis are for reference only. Dimensioning and tolerancing per ASME Y14.5M.
2. This drawing is subject to change without notice.
3. The package thermal pad must be soldered to the printed circuit board for thermal and mechanical performance.

# EXAMPLE BOARD LAYOUT

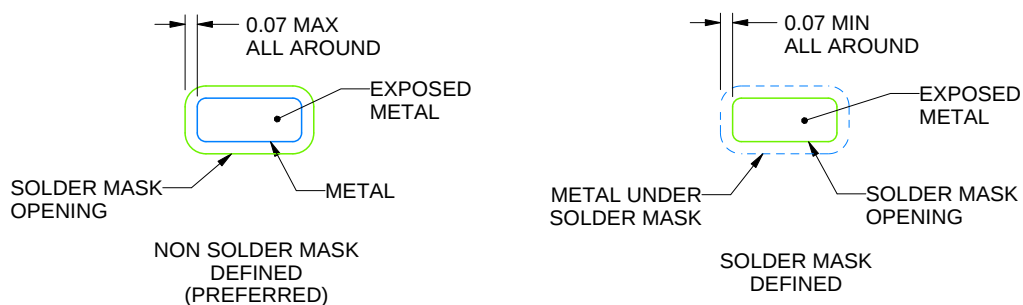
DSG0008B

WSN - 0.8 mm max height

PLASTIC SMALL OUTLINE - NO LEAD



**LAND PATTERN EXAMPLE**  
EXPOSED METAL SHOWN  
SCALE:20X



**SOLDER MASK DETAILS**

4222124/E 05/2020

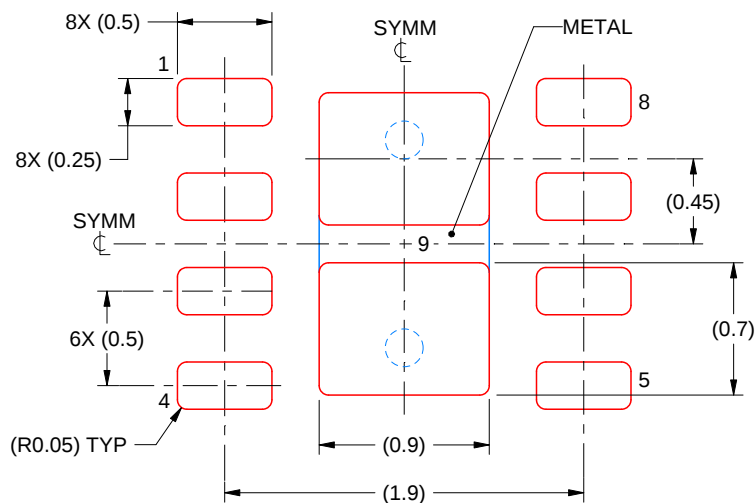
NOTES: (continued)

4. This package is designed to be soldered to a thermal pad on the board. For more information, see Texas Instruments literature number SLUA271 ([www.ti.com/lit/sluea271](http://www.ti.com/lit/sluea271)).
5. Vias are optional depending on application, refer to device data sheet. If any vias are implemented, refer to their locations shown on this view. It is recommended that vias under paste be filled, plugged or tented.

**DSG0008B**

**WSN - 0.8 mm max height**

PLASTIC SMALL OUTLINE - NO LEAD



## SOLDER PASTE EXAMPLE BASED ON 0.125 mm THICK STENCIL

EXPOSED PAD 9:  
87% PRINTED SOLDER COVERAGE BY AREA UNDER PACKAGE  
SCALE:25X

4222124/E 05/2020

NOTES: (continued)

6. Laser cutting apertures with trapezoidal walls and rounded corners may offer better paste release. IPC-7525 may have alternate design recommendations.

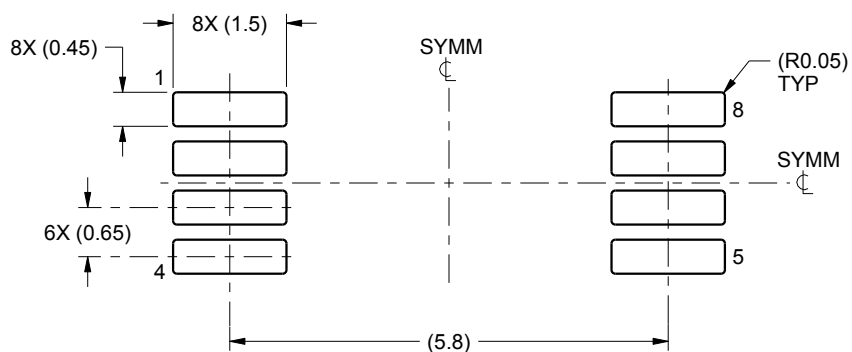


# EXAMPLE BOARD LAYOUT

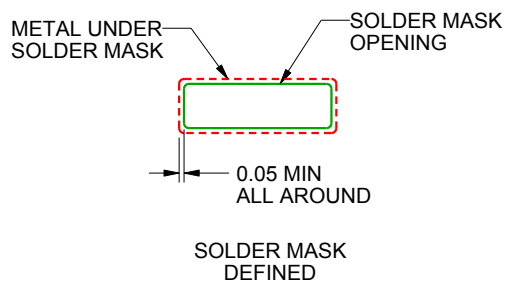
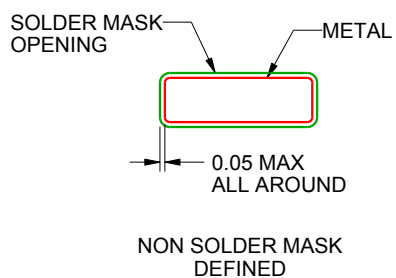
PW0008A

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.

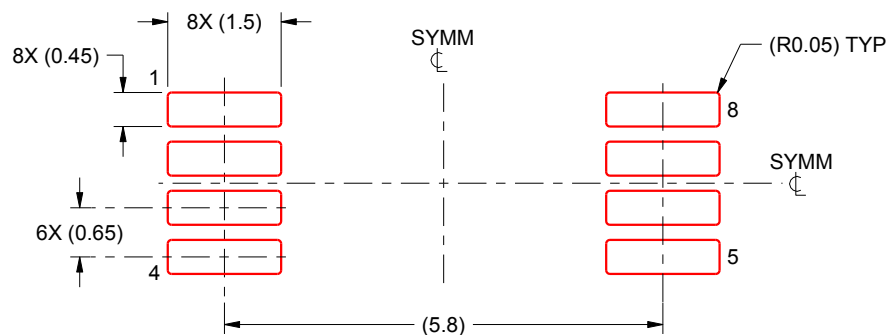
7. Solder mask tolerances between and around signal pads can vary based on board fabrication site.

## 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

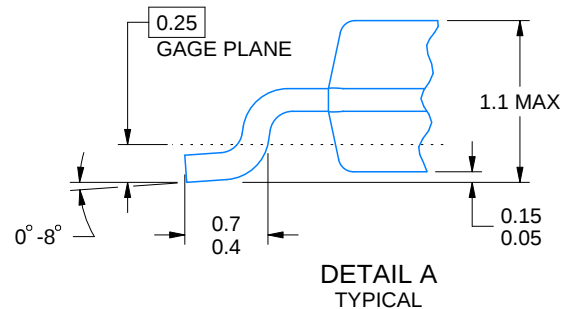
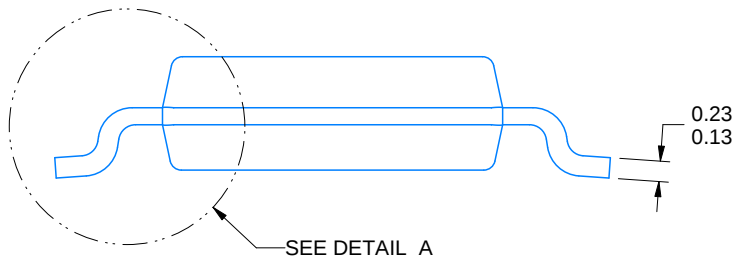
4221848/A 02/2015

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.



### VSSOP - 1.1 mm max height

[illegible]

PowerPAD is a trademark of Texas Instruments.

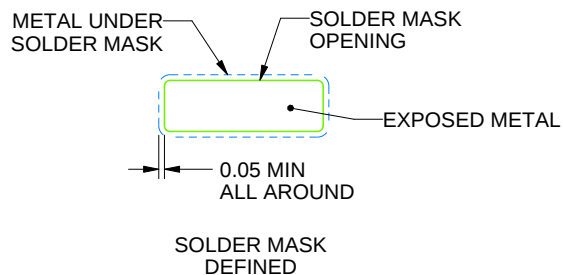
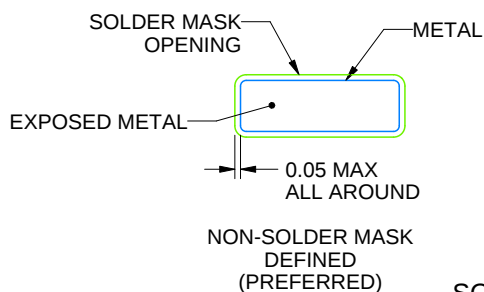
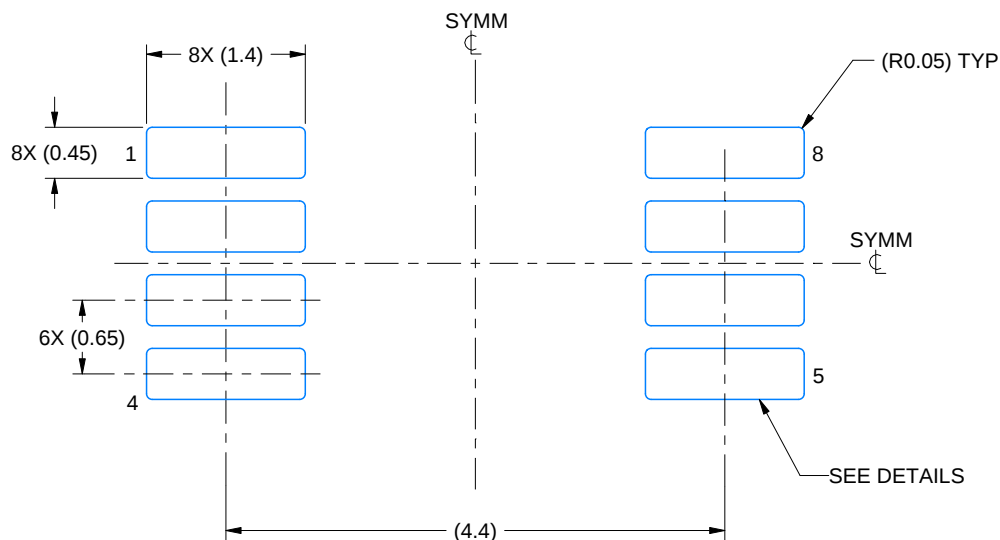
- 
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INSTRUMENTS  
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# EXAMPLE BOARD LAYOUT

DGK0008A

<sup>TM</sup> VSSOP - 1.1 mm max height

SMALL OUTLINE PACKAGE



SOLDER MASK DETAILS

4214862/A 04/2023

NOTES: (continued)

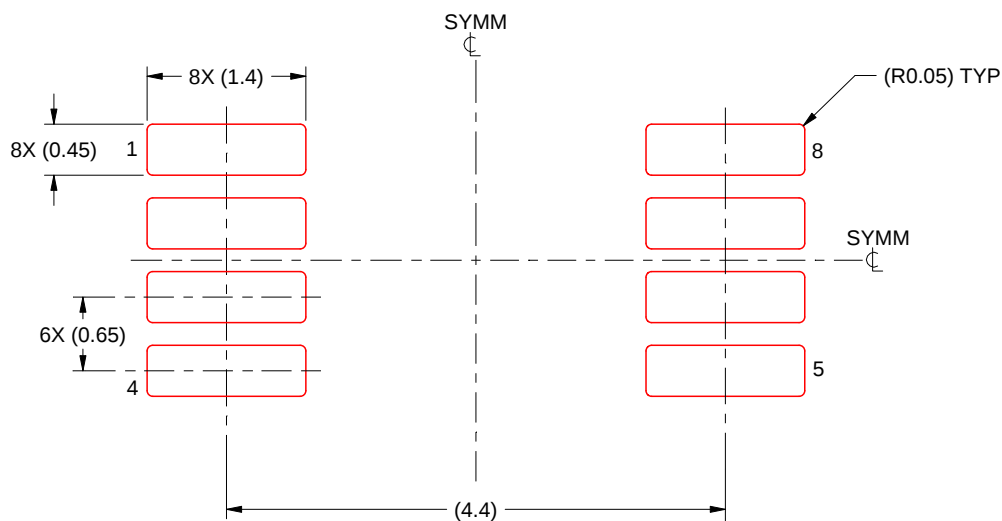
6. Publication IPC-7351 may have alternate designs.
7. Solder mask tolerances between and around signal pads can vary based on board fabrication site.
8. Vias are optional depending on application, refer to device data sheet. If any vias are implemented, refer to their locations shown on this view. It is recommended that vias under paste be filled, plugged or tented.
9. Size of metal pad may vary due to creepage requirement.

## EXAMPLE STENCIL DESIGN

DGK0008A

<sup>TM</sup> VSSOP - 1.1 mm max height

SMALL OUTLINE PACKAGE



SOLDER PASTE EXAMPLE  
SCALE: 15X

4214862/A 04/2023

NOTES: (continued)

11. Laser cutting apertures with trapezoidal walls and rounded corners may offer better paste release. IPC-7525 may have alternate design recommendations.
12. Board assembly site may have different recommendations for stencil design.

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