

## TLV320x-Q1 40-ns, Micropower, Push-Pull Output Automotive Comparators

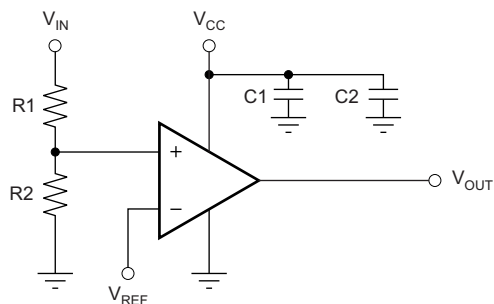
### 1 Features

- Qualified for Automotive Applications
- AEC Q100-Qualified With the Following Results
  - Device Temperature Grade 1:  $-40^{\circ}\text{C}$  to  $+125^{\circ}\text{C}$  Ambient Operating Temperature
  - Device HBM ESD Classification Level 2 (TLV3201-Q1)
  - Device HBM ESD Classification Level 3A (TLV3202-Q1)
  - Device CDM ESD Classification Level C5
- Low Propagation Delay: 40 ns
- Low Quiescent Current: 40  $\mu\text{A}$  per Channel
- Input Common-Mode Range Extends 200 mV Beyond Either Rail
- Low Input Offset Voltage: 1 mV
- Push-Pull Outputs
- Supply Range: 2.7 V to 5.5 V
- Small Packages: 5-Pin SC70 and 8-Pin VSSOP

### 2 Applications

- Engine Control Units (ECU)
- Body Control Modules (BCM)
- Battery Management Systems (BMS)
- HEV/EV Inverter and Motor Control
- Ultrasonic Ranging and LIDAR
- Steering and Traction Controllers
- Occupant Detection
- Infotainment Systems

#### Threshold Detector



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### 3 Description

The TLV3201-Q1 and TLV3202-Q1 are single and dual-channel comparators that offer the ultimate combination of high speed (40 ns) and low-power consumption (40  $\mu\text{A}$ ), both in extremely small packages with features such as rail-to-rail input, low offset voltage (1 mV), and large output drive current. The devices are also very easy to implement in a wide variety of applications where response time is critical.

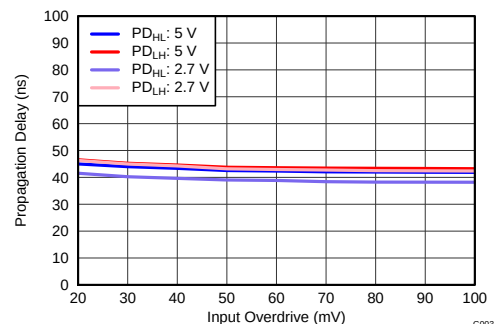
The TLV320x-Q1 family is available in single (TLV3201-Q1) and dual (TLV3202-Q1) channel versions, both with push-pull outputs. The TLV3201-Q1 is available in the 5-pin SC70 package. The TLV3202-Q1 is available in the 8-pin VSSOP package. All devices are specified for operation across the expanded industrial temperature range of  $-40^{\circ}\text{C}$  to  $+125^{\circ}\text{C}$ .

#### Device Information<sup>(1)</sup>

| PART NUMBER | PACKAGE   | BODY SIZE (NOM)   |
|-------------|-----------|-------------------|
| TLV3201-Q1  | SC70 (5)  | 2.00 mm × 1.25 mm |
| TLV3202-Q1  | VSSOP (8) | 3.00 mm × 3.00 mm |

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

#### Propagation Delay vs. Overdrive



G003



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## 4 Revision History

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

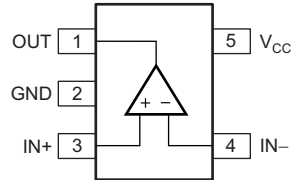
| Changes from Original (February 2017) to Revision A | Page      |
|-----------------------------------------------------|-----------|
| • Changed figure 29 .....                           | <b>15</b> |

## 5 Device Comparison Table

| DEVICE                     | DESCRIPTION                                                                                                                            |
|----------------------------|----------------------------------------------------------------------------------------------------------------------------------------|
| <a href="#">TLV3011</a>    | 5- $\mu\text{A}$ (maximum) open-drain, 1.8-V to 5.5-V with integrated voltage reference in 1.5-mm $\times$ 1.5-mm micro-sized packages |
| <a href="#">TLV3012</a>    | 5- $\mu\text{A}$ (maximum) push-pull, 1.8-V to 5.5-V with integrated voltage reference in micro-sized packages                         |
| <a href="#">TLV3501</a>    | 4.5-ns, rail-to-rail, push-pull comparator in micro-sized packages                                                                     |
| <a href="#">LMV7235</a>    | 75-ns, 65- $\mu\text{A}$ , 2.7-V to 5.5-V, rail-to-rail input comparator with open-drain output                                        |
| <a href="#">LMV7239</a>    | 75-ns, 65- $\mu\text{A}$ , 2.7-V to 5.5-V, rail-to-rail input comparator with push-pull output                                         |
| <a href="#">LMV7239-Q1</a> | Automotive 75-ns, 65- $\mu\text{A}$ , 2.7-V to 5.5-V, rail-to-rail input comparator with push-pull output                              |
| <a href="#">REF3333</a>    | 30-ppm/ $^{\circ}\text{C}$ drift, 3.9- $\mu\text{A}$ , SOT23-3, SC70-3 voltage reference                                               |

## 6 Pin Configuration and Functions

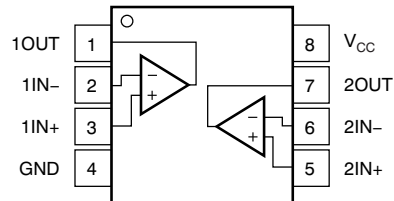
**TLV3201-Q1 DCK Package  
5-Pin SC70-5  
Top View**



**Pin Functions: TLV3201-Q1**

| PIN             |     | I/O | DESCRIPTION             |
|-----------------|-----|-----|-------------------------|
| NAME            | NO. |     |                         |
| GND             | 2   | —   | Negative supply, ground |
| IN–             | 4   | I   | Negative input          |
| IN+             | 3   | I   | Positive input          |
| OUT             | 1   | O   | Output                  |
| V <sub>CC</sub> | 5   | —   | Positive supply         |

**TLV3202-Q1 DGK Package  
8-Pin VSSOP  
Top View**



**Pin Functions: TLV3202-Q1**

| PIN             |     | I/O | DESCRIPTION                  |
|-----------------|-----|-----|------------------------------|
| NAME            | NO. |     |                              |
| 1IN–            | 2   | I   | Negative input, comparator 1 |
| 1IN+            | 3   | I   | Positive input, comparator 1 |
| 1OUT            | 1   | O   | Output, comparator 1         |
| 2IN–            | 6   | I   | Negative input, comparator 2 |
| 2IN+            | 5   | I   | Positive input, comparator 2 |
| 2OUT            | 7   | O   | Output, comparator 2         |
| GND             | 4   | —   | Negative supply, ground      |
| V <sub>CC</sub> | 8   | —   | Positive supply              |

## 7 Specifications

### 7.1 Absolute Maximum Ratings

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

|             |                                     | MIN  | MAX                      | UNIT |
|-------------|-------------------------------------|------|--------------------------|------|
| Voltage     | Supply voltage                      |      | 7                        | V    |
|             | Signal input pins <sup>(2)</sup>    | –0.5 | (V <sub>CC</sub> ) + 0.5 |      |
| Current     | Signal input pins <sup>(2)</sup>    | –10  | 10                       | mA   |
|             | Output short circuit <sup>(3)</sup> |      | 100                      |      |
| Temperature | Operating                           | –55  | 125                      | °C   |
|             | Junction, T <sub>J</sub>            |      | 150                      |      |
|             | Storage, T <sub>stg</sub>           | –65  | 150                      |      |

- (1) Stresses beyond those listed under *Absolute Maximum Ratings* may 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 may affect device reliability.
- (2) Input pins are diode-clamped to the power-supply rails. Input signals that can swing more than 0.5 V beyond the supply rails must be current limited to 10 mA or less.
- (3) Short-circuit to ground.

### 7.2 ESD Ratings

|                    |                         |                                                         | VALUE | UNIT |
|--------------------|-------------------------|---------------------------------------------------------|-------|------|
| TLV3201-Q1         |                         |                                                         |       |      |
| V <sub>(ESD)</sub> | Electrostatic discharge | Human-body model (HBM), per AEC Q100-002 <sup>(1)</sup> | ±3000 | V    |
|                    |                         | Charged-device model (CDM), per AEC Q100-011            | ±750  |      |
| TLV3202-Q1         |                         |                                                         |       |      |
| V <sub>(ESD)</sub> | Electrostatic discharge | Human-body model (HBM), per AEC Q100-002 <sup>(1)</sup> | ±4000 | V    |
|                    |                         | Charged-device model (CDM), per AEC Q100-011            | ±750  |      |

- (1) AEC Q100-002 indicates that HBM stressing shall be 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         | MAX         | UNIT |
|----------------|--------------------------------------------------------------------------|-------------|-------------|------|
| V <sub>S</sub> | Supply voltage, V <sub>S</sub> = (V <sub>S+</sub> ) – (V <sub>S–</sub> ) | 2.7 (±1.35) | 5.5 (±2.75) | V    |
| T <sub>A</sub> | Specified temperature                                                    | –40         | 125         | °C   |

### 7.4 Thermal Information

| THERMAL METRIC <sup>(1)</sup> |                                              | TLV3201-Q1  | TLV3202-Q1  | UNIT |
|-------------------------------|----------------------------------------------|-------------|-------------|------|
|                               |                                              | DCK (SC-70) | DGK (VSSOP) |      |
|                               |                                              | 5 PINS      | 8 PINS      |      |
| R <sub>θJA</sub>              | Junction-to-ambient thermal resistance       | 281.9       | 201.9       | °C/W |
| R <sub>θJC(top)</sub>         | Junction-to-case (top) thermal resistance    | 97.6        | 92.5        | °C/W |
| R <sub>θJB</sub>              | Junction-to-board thermal resistance         | 68.3        | 123.3       | °C/W |
| Ψ <sub>JT</sub>               | Junction-to-top characterization parameter   | 2.6         | 23          | °C/W |
| Ψ <sub>JB</sub>               | Junction-to-board characterization parameter | 67.3        | 212.6       | °C/W |

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

## 7.5 Electrical Characteristics: $V_{CC} = 5\text{ V}$

at  $T_A = 25^\circ\text{C}$  and  $V_{CC} = 5\text{ V}$  (unless otherwise noted)

| PARAMETER            |                                        | TEST CONDITIONS                                                         | MIN                      | TYP                           | MAX                      | UNIT    |
|----------------------|----------------------------------------|-------------------------------------------------------------------------|--------------------------|-------------------------------|--------------------------|---------|
| OFFSET VOLTAGE       |                                        |                                                                         |                          |                               |                          |         |
| V <sub>IO</sub>      | Input offset voltage                   | V <sub>CM</sub> = V <sub>CC</sub> / 2                                   |                          | 1                             | 5                        | mV      |
|                      |                                        | T <sub>A</sub> = −40°C to 125°C                                         |                          |                               | 6                        |         |
| dV <sub>OS</sub> /dT | Input offset voltage drift             | T <sub>A</sub> = −40°C to 125°C                                         |                          | 1                             | 10                       | μV/°C   |
| PSRR                 | Power-supply rejection ratio           | V <sub>CM</sub> = V <sub>CC</sub> / 2, V <sub>CC</sub> = 2.5 V to 5.5 V | 65                       | 85                            |                          | dB      |
|                      | Input hysteresis                       |                                                                         |                          | 1.2                           |                          | mV      |
| INPUT BIAS CURRENT   |                                        |                                                                         |                          |                               |                          |         |
| I <sub>IB</sub>      | Input bias current                     | V <sub>CM</sub> = V <sub>CC</sub> / 2                                   |                          | 1                             | 50                       | pA      |
|                      |                                        | T <sub>A</sub> = −40°C to 125°C                                         |                          |                               | 5                        | nA      |
| I <sub>IO</sub>      | Input offset current                   | V <sub>CM</sub> = V <sub>CC</sub> / 2                                   |                          | 1                             | 50                       | pA      |
|                      |                                        | T <sub>A</sub> = −40°C to 125°C                                         |                          |                               | 2.5                      | nA      |
| INPUT VOLTAGE RANGE  |                                        |                                                                         |                          |                               |                          |         |
| V <sub>CM</sub>      | Common-mode voltage                    | T <sub>A</sub> = −40°C to 125°C                                         | (V <sub>EE</sub> ) − 0.2 |                               | (V <sub>CC</sub> ) + 0.2 | V       |
| CMRR                 | Common-mode rejection ratio            | −0.2 V < V <sub>CM</sub> < 5.2 V                                        | 60                       | 70                            |                          | dB      |
| INPUT IMPEDANCE      |                                        |                                                                         |                          |                               |                          |         |
|                      | Common mode                            |                                                                         |                          | 10 <sup>13</sup>    2         |                          | Ω    pF |
|                      | Differential                           |                                                                         |                          | 10 <sup>13</sup>    4         |                          | Ω    pF |
| OUTPUT               |                                        |                                                                         |                          |                               |                          |         |
| V <sub>OL</sub>      | Voltage output swing from lower rail   | I <sub>SINK</sub> = 4 mA                                                |                          | 175                           | 190                      | mV      |
|                      |                                        | T <sub>A</sub> = −40°C to 125°C                                         |                          |                               | 225                      |         |
| V <sub>OH</sub>      | Voltage output swing from upper rail   | I <sub>SOURCE</sub> = 4 mA                                              |                          | 120                           | 140                      | mV      |
|                      |                                        | T <sub>A</sub> = −40°C to 125°C                                         |                          |                               | 170                      |         |
| I <sub>SC</sub>      | Short-circuit current (per comparator) | I <sub>SC</sub> sinking                                                 | 40                       | 48                            |                          | mA      |
|                      |                                        | T <sub>A</sub> = −40°C to 125°C                                         |                          | See <a href="#">Figure 14</a> |                          |         |
|                      |                                        | I <sub>SC</sub> sourcing                                                | 52                       | 60                            |                          |         |
|                      |                                        | T <sub>A</sub> = −40°C to 125°C                                         |                          | See <a href="#">Figure 14</a> |                          |         |
| POWER SUPPLY         |                                        |                                                                         |                          |                               |                          |         |
| V <sub>CC</sub>      | Specified voltage                      |                                                                         | 2.7                      |                               | 5.5                      | V       |
| I <sub>Q</sub>       | Quiescent current                      | T <sub>A</sub> = 25°C                                                   |                          | 40                            | 50                       | μA      |
|                      |                                        | T <sub>A</sub> = −40°C to 125°C                                         |                          |                               | 65                       |         |

## 7.6 Electrical Characteristics: $V_{CC} = 2.7\text{ V}$

at  $T_A = 25^\circ\text{C}$  and  $V_{CC} = 2.7\text{ V}$  (unless otherwise noted)

| PARAMETER            |                              | TEST CONDITIONS                                                         | MIN                      | TYP | MAX                      | UNIT  |
|----------------------|------------------------------|-------------------------------------------------------------------------|--------------------------|-----|--------------------------|-------|
| OFFSET VOLTAGE       |                              |                                                                         |                          |     |                          |       |
| V <sub>IO</sub>      | Input offset voltage         | V <sub>CM</sub> = V <sub>CC</sub> / 2                                   |                          | 1   | 5                        | mV    |
|                      |                              | T <sub>A</sub> = −40°C to 125°C                                         |                          |     | 6                        |       |
| dV <sub>OS</sub> /dT | Input offset voltage drift   | T <sub>A</sub> = −40°C to 125°C                                         |                          | 1   | 10                       | μV/°C |
| PSRR                 | Power-supply rejection ratio | V <sub>CM</sub> = V <sub>CC</sub> / 2, V <sub>CC</sub> = 2.5 V to 5.5 V | 65                       | 85  |                          | dB    |
|                      | Input hysteresis             |                                                                         |                          | 1.2 |                          | mV    |
| INPUT BIAS CURRENT   |                              |                                                                         |                          |     |                          |       |
| I <sub>IB</sub>      | Input bias current           | V <sub>CM</sub> = V <sub>CC</sub> / 2                                   |                          | 1   | 50                       | pA    |
|                      |                              | T <sub>A</sub> = −40°C to 125°C                                         |                          |     | 5                        | nA    |
| I <sub>IO</sub>      | Input offset current         | V <sub>CM</sub> = V <sub>CC</sub> / 2                                   |                          | 1   | 50                       | pA    |
|                      |                              | T <sub>A</sub> = −40°C to 125°C                                         |                          |     | 2.5                      | nA    |
| INPUT VOLTAGE RANGE  |                              |                                                                         |                          |     |                          |       |
| V <sub>CM</sub>      | Common-mode voltage          | T <sub>A</sub> = −40°C to 125°C                                         | (V <sub>EE</sub> ) − 0.2 |     | (V <sub>CC</sub> ) + 0.2 | V     |
| CMRR                 | Common-mode rejection ratio  | −0.2 V < V <sub>CM</sub> < 2.9 V                                        | 56                       | 68  |                          | dB    |

## Electrical Characteristics: $V_{CC} = 2.7\text{ V}$ (continued)

at  $T_A = 25^\circ\text{C}$  and  $V_{CC} = 2.7\text{ V}$  (unless otherwise noted)

| PARAMETER       |                                        | TEST CONDITIONS                 | MIN                           | TYP | MAX | UNIT    |
|-----------------|----------------------------------------|---------------------------------|-------------------------------|-----|-----|---------|
| INPUT IMPEDANCE |                                        |                                 |                               |     |     |         |
| Common mode     |                                        |                                 | 10 <sup>13</sup>    2         |     |     | Ω    pF |
| Differential    |                                        |                                 | 10 <sup>13</sup>    4         |     |     | Ω    pF |
| OUTPUT          |                                        |                                 |                               |     |     |         |
| V <sub>OL</sub> | Voltage output swing from lower rail   | I <sub>SINK</sub> = 4 mA        | 230                           |     | 260 | mV      |
|                 |                                        | T <sub>A</sub> = −40°C to 125°C |                               |     | 325 |         |
| V <sub>OH</sub> | Voltage output swing from upper rail   | I <sub>SOURCE</sub> = 4 mA      | 210                           |     | 250 | mV      |
|                 |                                        | T <sub>A</sub> = −40°C to 125°C |                               |     | 350 |         |
| I <sub>SC</sub> | Short-circuit current (per comparator) | I <sub>SC</sub> sinking         | 13                            | 19  |     | mA      |
|                 |                                        | T <sub>A</sub> = −40°C to 125°C | See <a href="#">Figure 14</a> |     |     |         |
|                 |                                        | I <sub>SC</sub> sourcing        | 15                            | 21  |     |         |
|                 |                                        | T <sub>A</sub> = −40°C to 125°C | See <a href="#">Figure 14</a> |     |     |         |
| POWER SUPPLY    |                                        |                                 |                               |     |     |         |
| V <sub>CC</sub> | Specified voltage                      |                                 | 2.7                           |     | 5.5 | V       |
| I <sub>Q</sub>  | Quiescent current                      | T <sub>A</sub> = 25°C           | 36                            |     | 46  | μA      |
|                 |                                        | T <sub>A</sub> = −40°C to 125°C |                               |     | 60  |         |

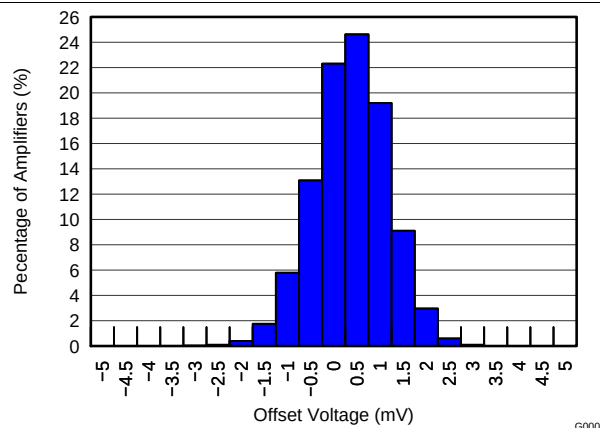
## 7.7 Switching Characteristics

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

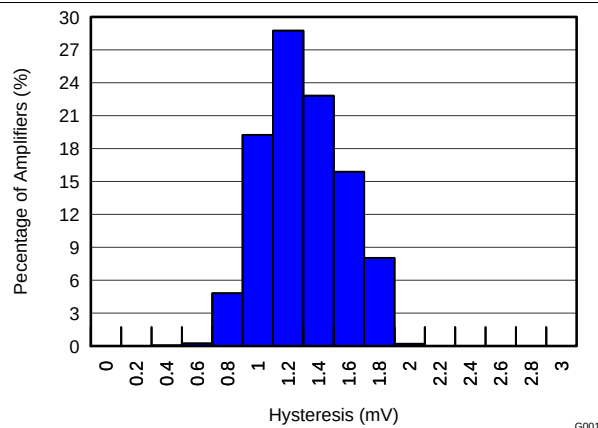
| PARAMETER                               |                        | TEST CONDITIONS                                                             |                                                  | MIN | TYP | MAX | UNIT |
|-----------------------------------------|------------------------|-----------------------------------------------------------------------------|--------------------------------------------------|-----|-----|-----|------|
| t <sub>PD</sub>                         | Propagation delay time | Low to high                                                                 | Input overdrive = 20 mV, C <sub>L</sub> = 15 pF  |     | 47  | 50  | ns   |
|                                         |                        |                                                                             | Input overdrive = 100 mV, C <sub>L</sub> = 15 pF |     | 42  | 50  |      |
|                                         |                        |                                                                             | T <sub>A</sub> = −40°C to 125°C                  |     |     | 55  |      |
|                                         | High to low            | Input overdrive = 20 mV, C <sub>L</sub> = 15 pF                             |                                                  | 40  | 50  |     |      |
|                                         |                        | Input overdrive = 100 mV, C <sub>L</sub> = 15 pF                            |                                                  | 38  | 50  |     |      |
|                                         |                        | T <sub>A</sub> = −40°C to 125°C                                             |                                                  |     | 55  |     |      |
| Propagation delay skew                  |                        | Input overdrive = 20 mV, C <sub>L</sub> = 15 pF                             |                                                  | 2   |     | ns  |      |
| Propagation delay matching (TLV3202-Q1) |                        | High to low or low to high, input overdrive = 20 mV, C <sub>L</sub> = 15 pF |                                                  | 5   |     | ns  |      |
| t <sub>R</sub>                          | Rise time              | 10% to 90%                                                                  |                                                  | 2.9 |     | ns  |      |
| t <sub>F</sub>                          | Fall time              | 10% to 90%                                                                  |                                                  | 3.7 |     | ns  |      |

## 7.8 Typical Characteristics

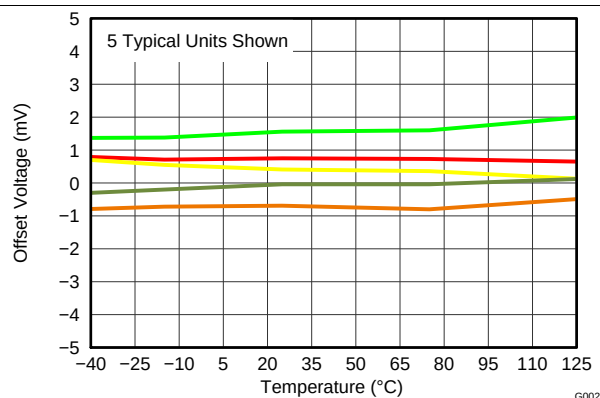
at  $T_A = 25^\circ\text{C}$ ,  $V_{CC} = 5\text{ V}$ , and input overdrive ( $V_{OD}$ ) = 20 mV (unless otherwise noted)



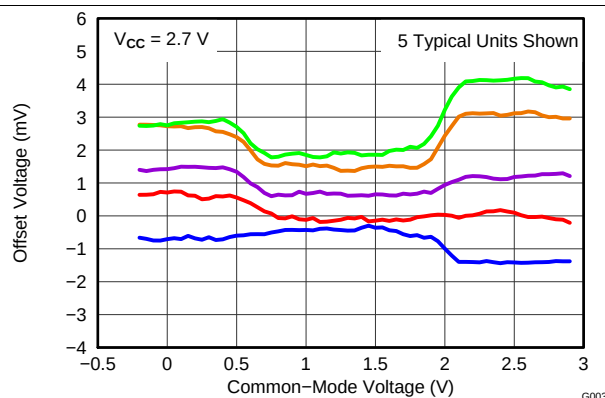
**Figure 1. Offset Voltage Distribution**



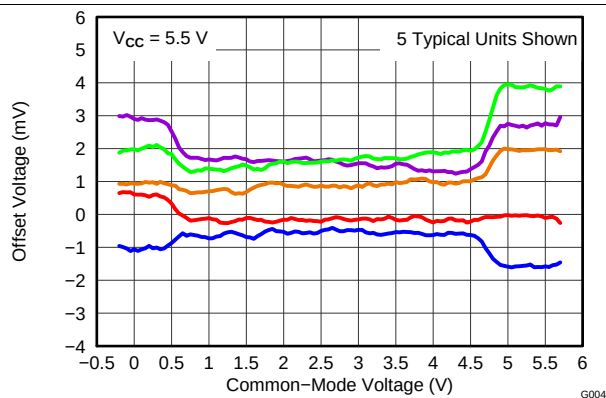
**Figure 2. Hysteresis Distribution**



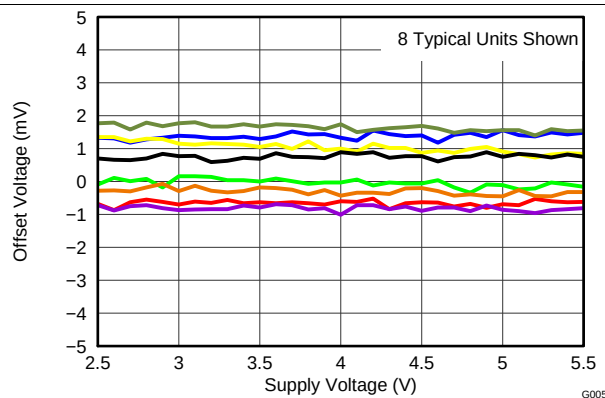
**Figure 3. Offset Voltage vs Temperature**



**Figure 4. Offset Voltage vs Common-Mode Voltage**



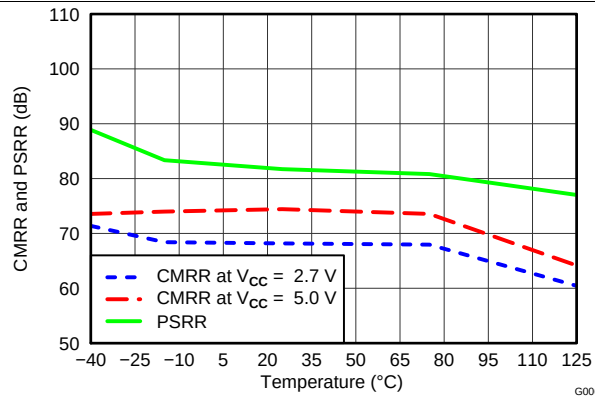
**Figure 5. Offset Voltage vs Common-Mode Voltage**



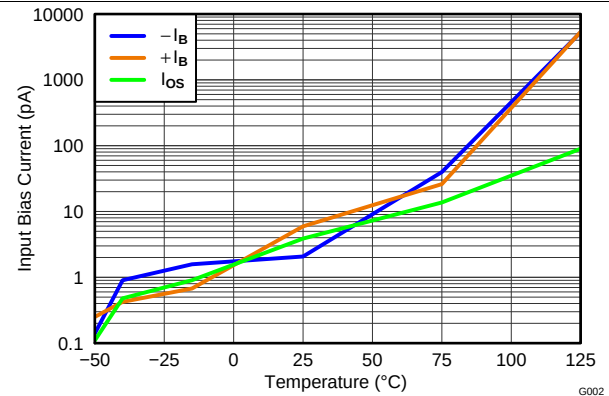
**Figure 6. Offset Voltage vs Power Supply**

## Typical Characteristics (continued)

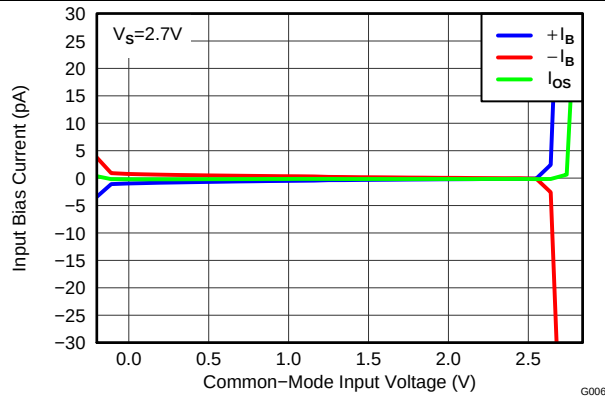
at  $T_A = 25^\circ\text{C}$ ,  $V_{CC} = 5\text{ V}$ , and input overdrive ( $V_{OD}$ ) = 20 mV (unless otherwise noted)



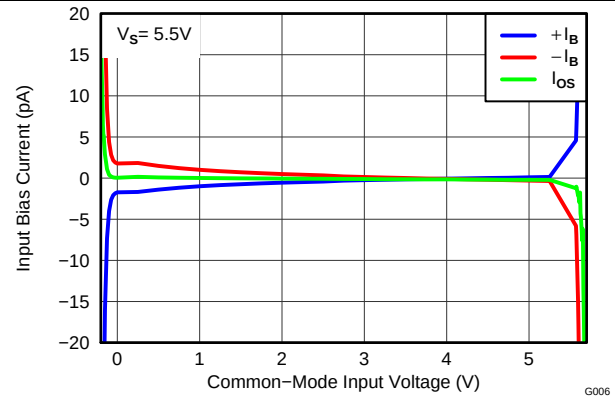
**Figure 7. Common-Mode Rejection Ratio and Power-Supply Rejection Ratio vs Temperature**



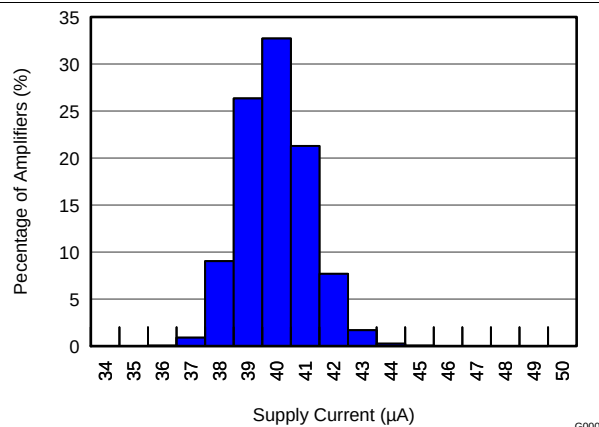
**Figure 8. Input Bias Current and Input Offset Current vs Temperature**



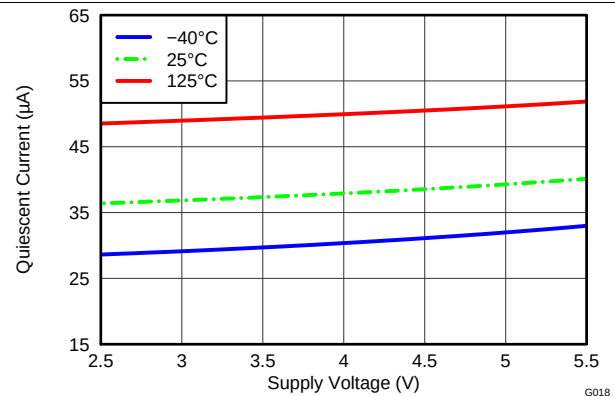
**Figure 9. Input Bias Current and Input Offset Current vs Common-Mode Input Voltage**



**Figure 10. Input Bias Current and Input Offset Current vs Common-Mode Input Voltage**



**Figure 11. Quiescent Current Distribution**



**Figure 12. Quiescent Current vs Supply Voltage**



## Typical Characteristics (continued)

at  $T_A = 25^\circ\text{C}$ ,  $V_{CC} = 5\text{ V}$ , and input overdrive ( $V_{OD}$ ) = 20 mV (unless otherwise noted)

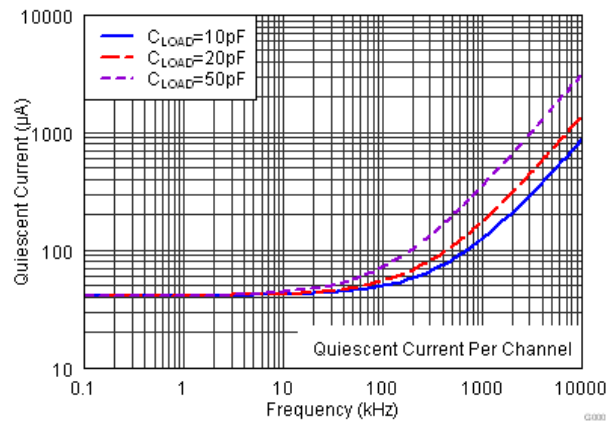


Figure 13. Quiescent Current vs Switching Frequency

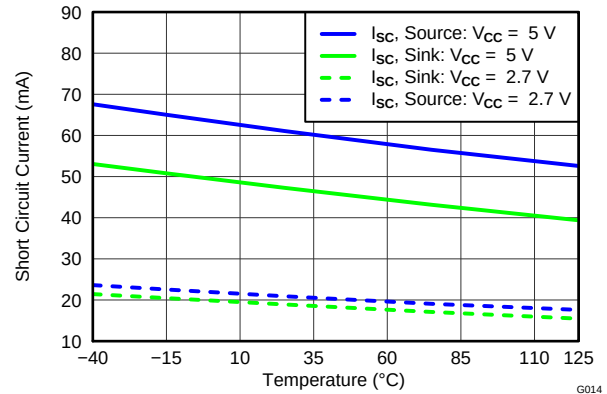


Figure 14. Short-Circuit Current vs Temperature

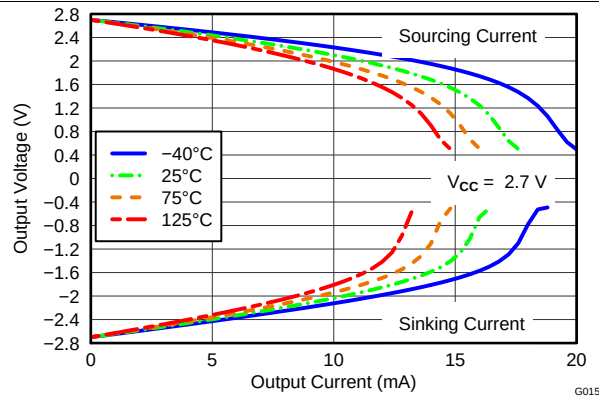


Figure 15. Output Voltage vs Output Current

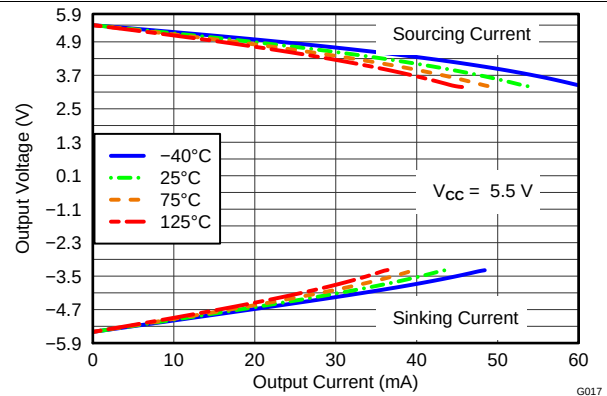


Figure 16. Output Voltage vs Output Current

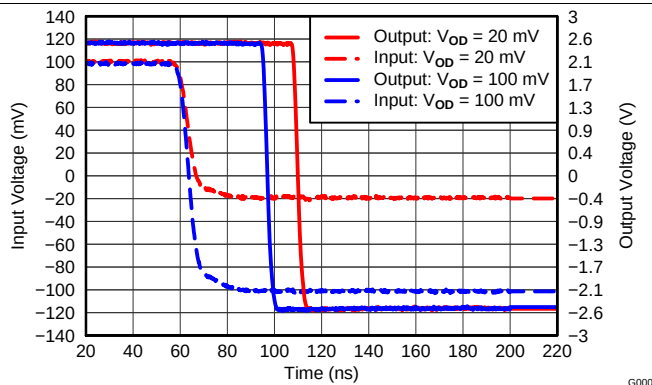


Figure 17. Propagation Delay Falling Edge

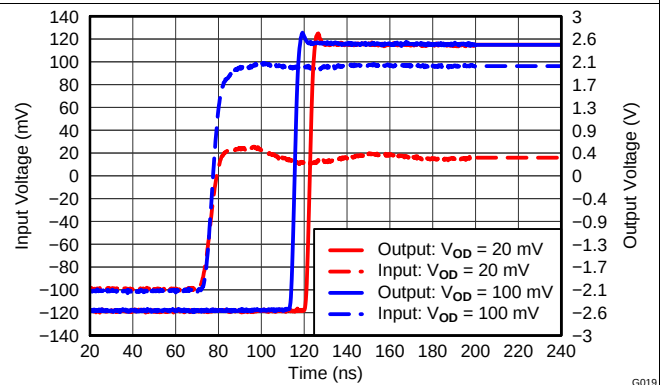
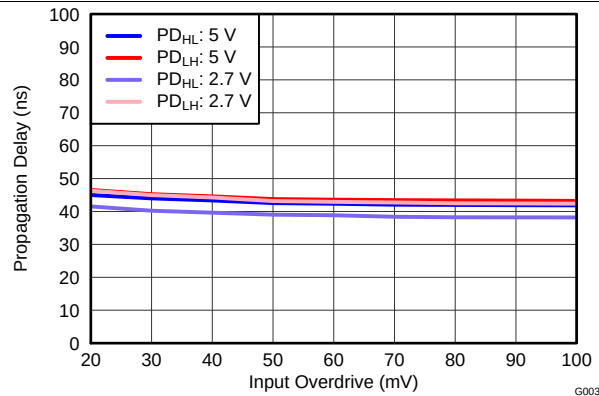


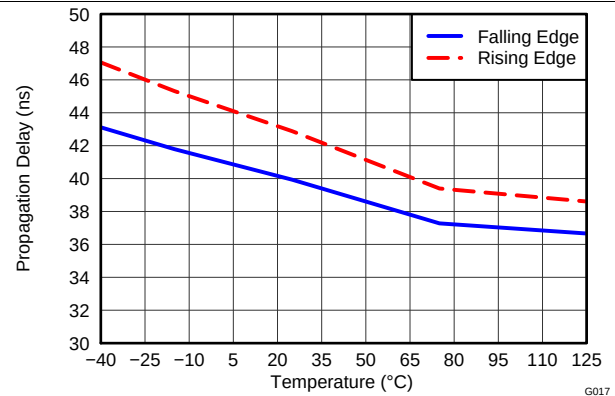
Figure 18. Propagation Delay Rising Edge

## Typical Characteristics (continued)

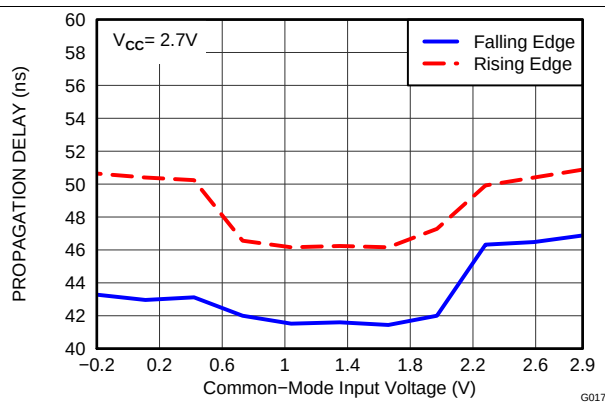
at  $T_A = 25^\circ\text{C}$ ,  $V_{CC} = 5\text{ V}$ , and input overdrive ( $V_{OD}$ ) = 20 mV (unless otherwise noted)



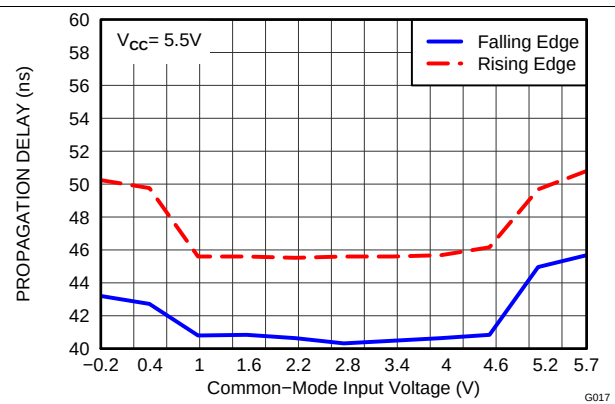
**Figure 19. Propagation Delay vs Input Overdrive**



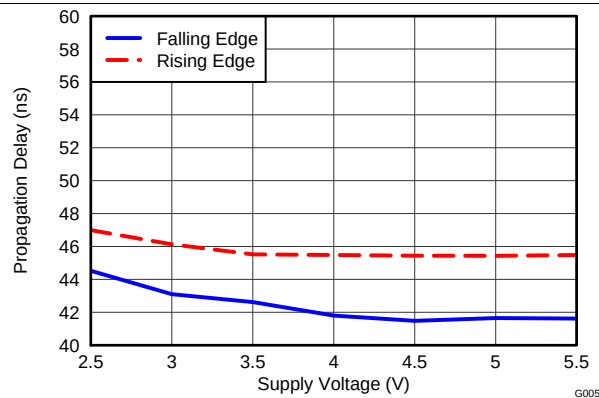
**Figure 20. Propagation Delay vs Temperature**



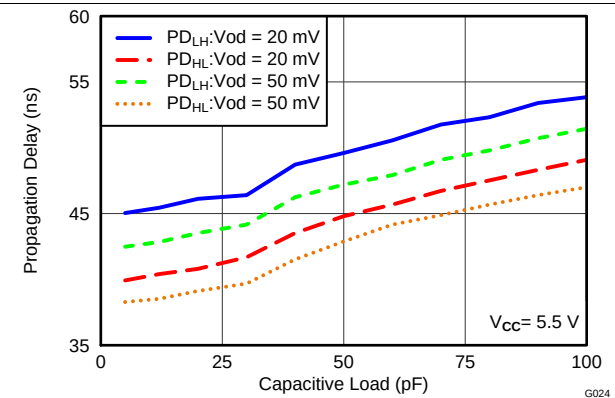
**Figure 21. Propagation Delay vs Common-Mode Voltage**



**Figure 22. Propagation Delay vs Common-Mode Voltage**



**Figure 23. Propagation Delay vs Supply Voltage**



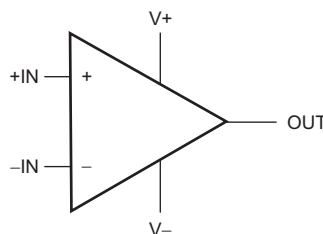
**Figure 24. Propagation Delay vs Capacitive Load**

## 8 Detailed Description

### 8.1 Overview

The TLV3201-Q1 and TLV3202-Q1 devices feature 40-ns response time and include 1.2 mV of internal hysteresis for improved noise immunity with an input common-mode range that extends 0.2 V beyond the power-supply rails.

### 8.2 Functional Block Diagram



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### 8.3 Feature Description

#### 8.3.1 Operating Voltage

The TLV3201-Q1 and TLV3202-Q1 comparators are specified for use on a single supply from 2.7 V to 5.5 V (or a dual supply from  $\pm 1.35$  V to  $\pm 2.75$  V) over a temperature range of  $-40^{\circ}\text{C}$  to  $+125^{\circ}\text{C}$ . The device continues to function below this range, but performance is not specified.

#### 8.3.2 Input Overvoltage Protection

The device inputs are protected by electrostatic discharge (ESD) diodes that conduct if the input voltages exceed the power supplies by more than approximately 300 mV. Momentary voltages greater than 300 mV beyond the power supply can be tolerated if the input current is limited to 10 mA. This limiting is easily accomplished with a small input resistor in series with the input to the comparator.

### 8.4 Device Functional Modes

The device is fully functional when powered by rail-to-rail supply voltage greater than 2.7 V.

## 9 Application and Implementation

### NOTE

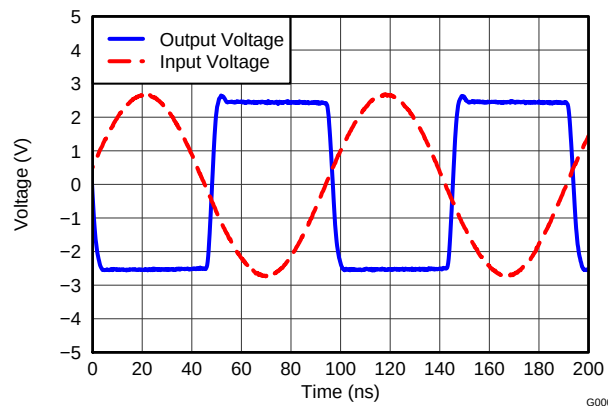
Information in the following applications sections is not part of the TI component specification, and TI does not warrant its accuracy or completeness. TI's customers are responsible for determining suitability of components for their purposes. Customers should validate and test their design implementation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

### 9.1 Application Information

The TLV3201-Q1 and TLV3202-Q1 are single- and dual-supply (respectively), push-pull comparators featuring 40 ns of propagation delay on only 40  $\mu$ A of supply current. This combination of fast response time and minimal power consumption make the TLV3201-Q1 and TLV3202-Q1 excellent comparators for portable, battery-powered applications as well as fast-switching threshold detection such as pulse-width modulation (PWM) output monitors and zero-cross detection.

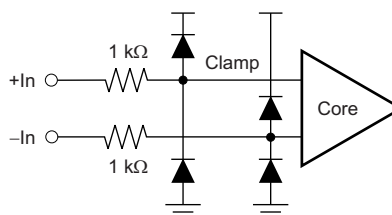
#### 9.1.1 Comparator Inputs

The TLV3201-Q1 and TLV3202-Q1 are rail-to-rail input comparators, with an input common-mode range that exceeds the supply rails by 200 mV for both positive and negative supplies. The devices are specified from 2.7 V to 5.5 V, with room temperature operation from 2.5 V to 5.5 V. The TLV3201-Q1 and TLV3202-Q1 are designed to prevent phase inversion when the input pins exceed the supply voltage. Figure 25 shows the TLV320x-Q1 response when input voltages exceed the supply, resulting in no phase inversion.



**Figure 25. No Phase Inversion: Comparator Response to Input Voltage (Propagation Delay Included)**

The ESD protection input structure of two back-to-back diodes and 1-k $\Omega$  series resistors are used to limit the differential input voltage applied to the precision input of the comparator by clamping input voltages that exceed  $V_{CC}$  beyond the specified operating conditions. If potential overvoltage conditions that exceed absolute maximum ratings are present, the addition of external bypass diodes and resistors is recommended, as shown in Figure 26. Large differential voltages greater than the supply voltage must be avoided to prevent damage to the input stage.



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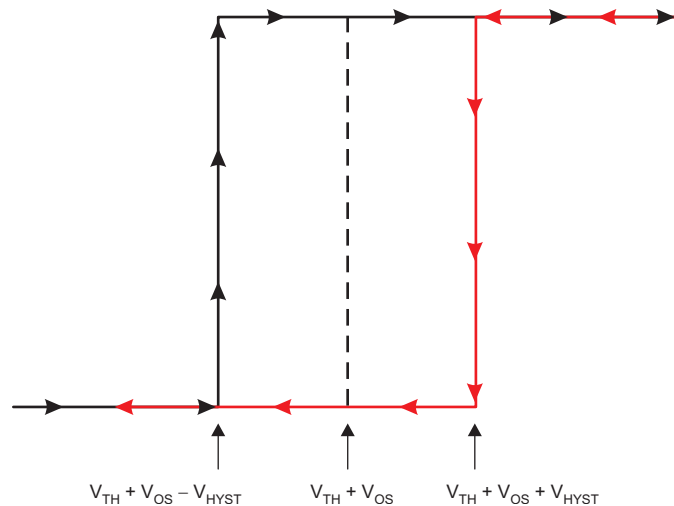
**Figure 26. TLV3201-Q1 Equivalent Input structure**

## Application Information (continued)

### 9.1.2 External Hysteresis

The TLV3201-Q1 and TLV3202-Q1 have a hysteresis transfer curve (shown in [Figure 27](#)) that is a function of three components:  $V_{TH}$ ,  $V_{OS}$ , and  $V_{HYST}$ .

- $V_{TH}$ : the actual set voltage or threshold trip voltage
- $V_{OS}$ : the internal offset voltage between  $V_{IN+}$  and  $V_{IN-}$ . This voltage is added to  $V_{TH}$  to form the actual trip point at which the comparator must respond to change output states.
- $V_{HYST}$ : internal hysteresis (or trip window) that is designed to reduce comparator sensitivity to noise.



**Figure 27. TLV320x-Q1 Hysteresis Transfer Curve**

#### 9.1.2.1 Inverting Comparator with Hysteresis

The inverting comparator with hysteresis requires a three-resistor network that is referenced to the comparator supply voltage ( $V_{CC}$ ), as shown in [Figure 28](#). When  $V_{IN}$  at the inverting input is less than  $V_A$ , the output voltage is high (for simplicity, assume  $V_O$  switches as high as  $V_{CC}$ ). The three network resistors can be represented as  $R1 \parallel R3$  in series with  $R2$ . The lower input trip voltage ( $V_{A1}$ ) is defined by [Equation 1](#).

$$V_{A1} = V_{CC} \times \frac{R2}{(R1 \parallel R3) + R2} \quad (1)$$

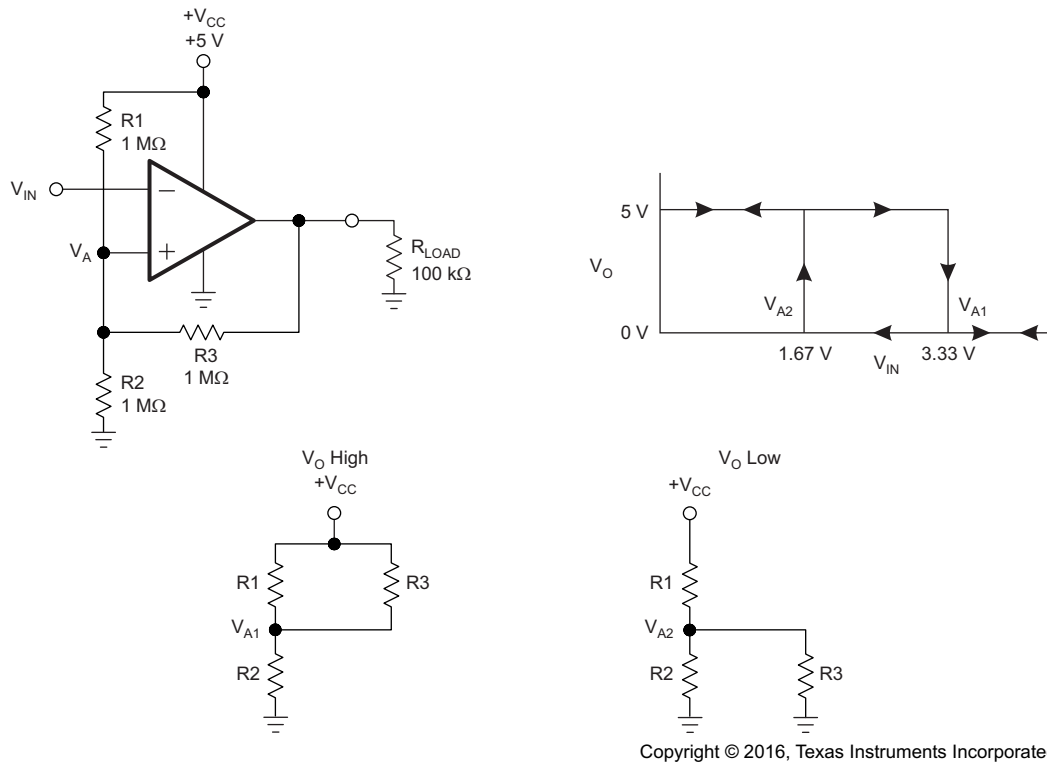
When  $V_{IN}$  is greater than  $[V_A \times (V_{IN} > V_A)]$ , the output voltage is low, very close to ground. In this case, the three network resistors can be presented as  $R2 \parallel R3$  in series with  $R1$ . The upper trip voltage ( $V_{A2}$ ) is defined by [Equation 2](#).

$$V_{A2} = V_{CC} \times \frac{R2 \parallel R3}{R1 + (R2 \parallel R3)} \quad (2)$$

The total hysteresis provided by the network is defined by [Equation 3](#).

$$\Delta V_A = V_{A1} - V_{A2} \quad (3)$$

## Application Information (continued)



**Figure 28. TLV3201-Q1 in Inverting Configuration With Hysteresis**

### 9.1.2.2 Noninverting Comparator With Hysteresis

A noninverting comparator with hysteresis requires a two-resistor network, as shown in [Figure 29](#) and a voltage reference (V<sub>REF</sub>) at the inverting input. When V<sub>IN</sub> is low, the output is also low. For the output to switch from low to high, V<sub>IN</sub> must rise up to V<sub>IN1</sub>. V<sub>IN1</sub> is calculated by [Equation 4](#).

$$V_{IN1} = R1 \times \frac{V_{REF}}{R2} \times V_{REF} \quad (4)$$

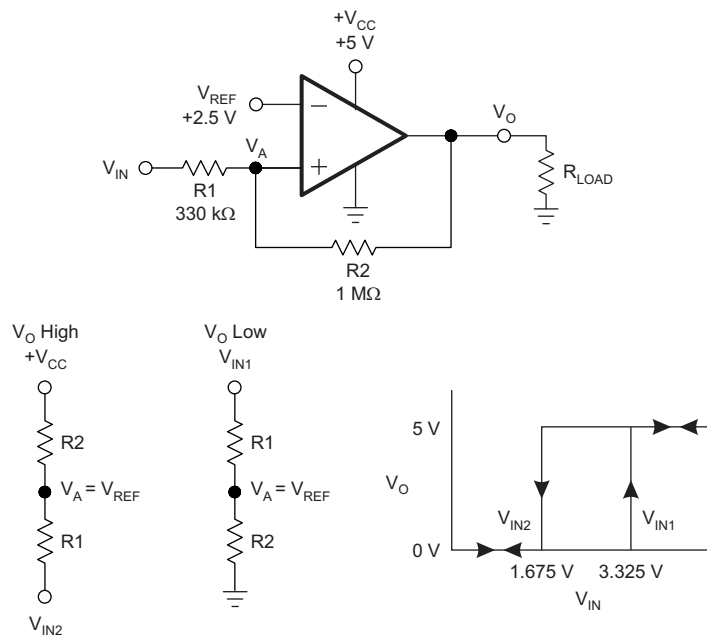
When V<sub>IN</sub> is high, the output is also high. In order for the comparator to switch back to a low state, V<sub>IN</sub> must equal V<sub>REF</sub> before V<sub>A</sub> is again equal to V<sub>REF</sub>. V<sub>IN</sub> can be calculated by [Equation 5](#).

$$V_{IN2} = \frac{V_{REF} (R1 + R2) - V_{CC} \times R1}{R2} \quad (5)$$

The hysteresis of this circuit is the difference between V<sub>IN1</sub> and V<sub>IN2</sub>, as defined by [Equation 6](#).

$$\Delta V_{IN} = V_{CC} \times \frac{R1}{R2} \quad (6)$$

## Application Information (continued)



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**Figure 29. TLV3201-Q1 in Noninverting Configuration With Hysteresis**

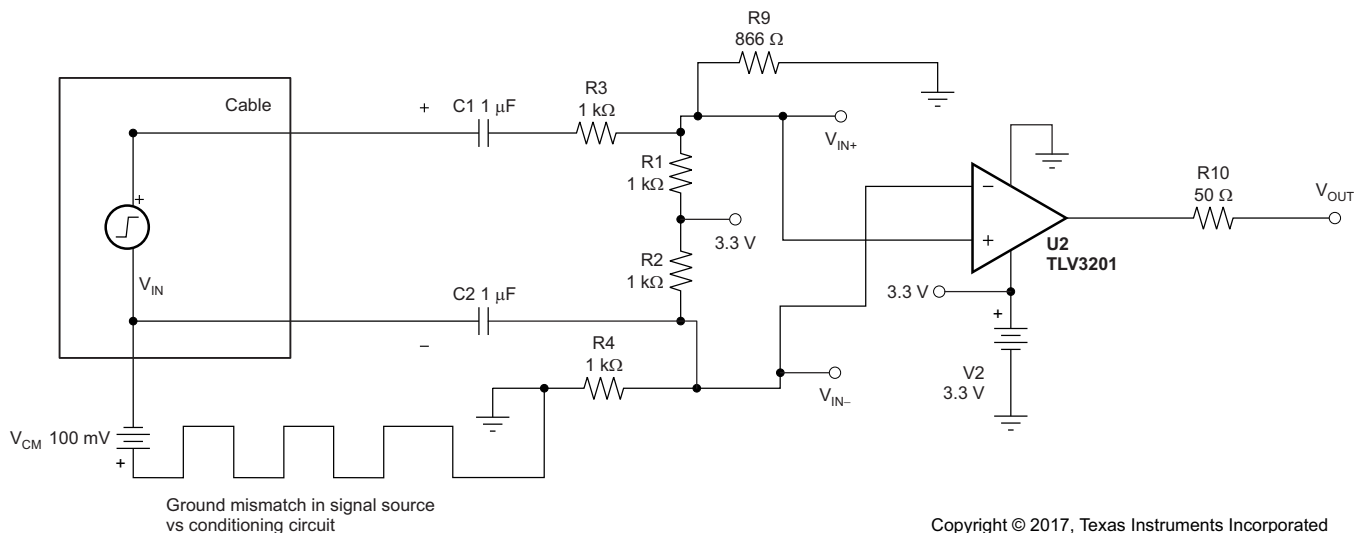
### 9.1.3 Capacitive Loads

The TLV3201-Q1 and TLV3202-Q1 feature a push-pull output. When the output switches, there is a direct path between  $V_{CC}$  and ground, causing increased output sinking or sourcing current during the transition. Following the transition the output current decreases and supply current returns to 40  $\mu$ A, thus maintaining low power consumption. Under reasonable capacitive loads, the TLV3201-Q1 and TLV3202-Q1 maintain specified propagation delay (see [Typical Characteristics](#)), but excessive capacitive loading under high switching frequencies may increase supply current, propagation delay, or induce decreased slew rate.

## 9.2 Typical Applications

### 9.2.1 TLV3201-Q1 Configured as an AC-Coupled Comparator

One of the benefits of ac coupling a single-supply comparator circuit is that it can block dc offsets induced by ground-loop offsets that could potentially produce either a false trip or a common-mode input violation. Figure 30 shows the TLV3201-Q1 configured as an ac-coupled comparator.



**Figure 30. TLV3201-Q1 Configured as an AC-Coupled Comparator (Schematic)**

#### 9.2.1.1 Design Requirements

Design requirements include:

- Ability to tolerate up to  $\pm 100$  mV of common-mode signal.
- Trigger only on ac signals (such as zero-cross detection).

#### 9.2.1.2 Detailed Design Procedure

Design analysis:

- AC-coupled, high-pass frequency
- Large capacitors require longer start-up time from device power on
- Use 1- $\mu$ F capacitor to achieve high-pass frequency of approximately 159 Hz
- For high-pass equivalent, use  $C_{IN} = 0.5 \mu\text{F}$ ,  $R_{IN} = 2 \text{ k}\Omega$ 
  1. Set up input dividers initially for one-half supply (to be in center of acceptable common-mode range).
  2. Adjust either divider slightly upwards or downwards as desired to establish quiescent output condition.
  3. Select coupling capacitors based on lowest expected frequency.



## Typical Applications (continued)

### 9.2.1.3 Application Curve

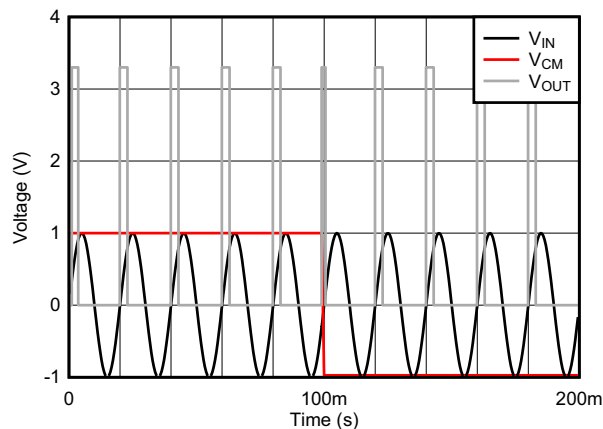
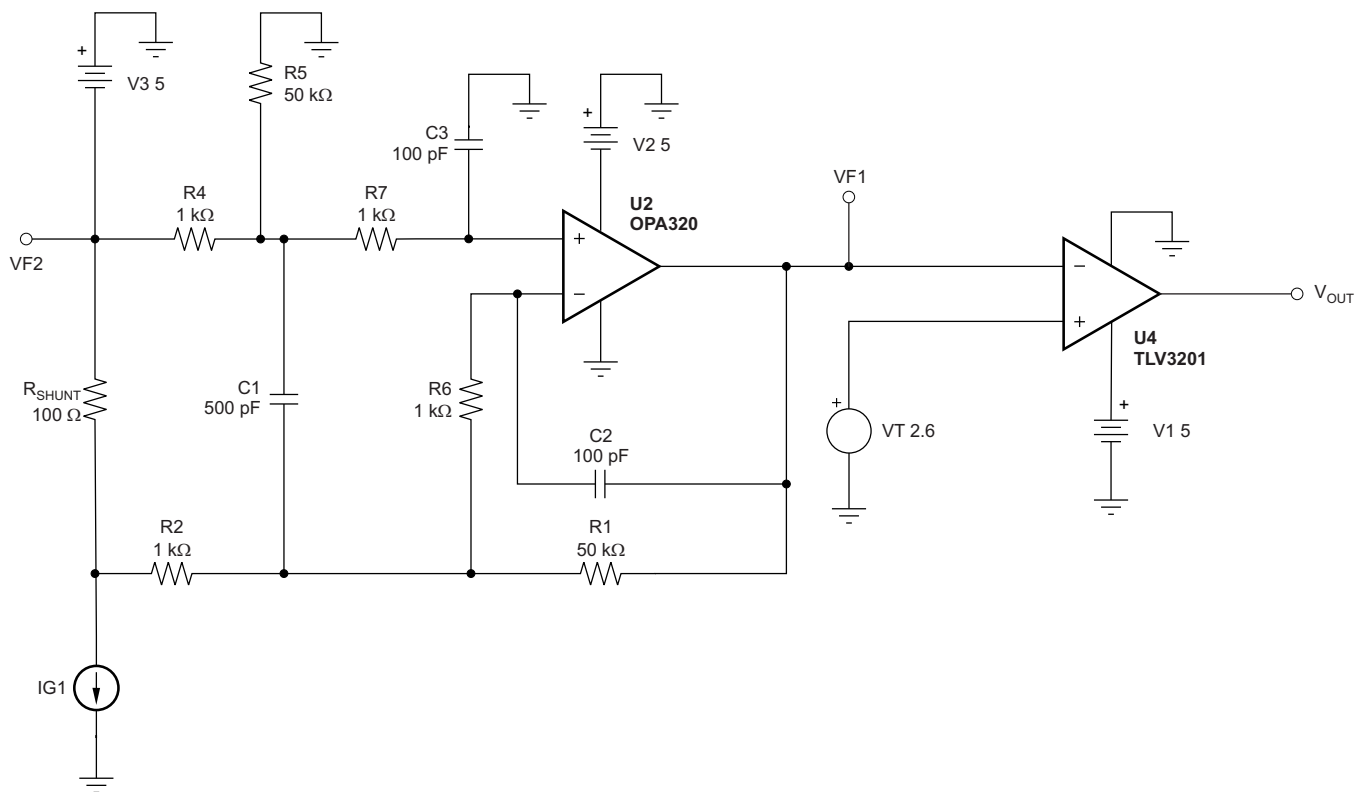


Figure 31. AC-Coupled Comparator Results

### 9.2.2 TLV3201-Q1 and OPA320 Configured as a Fast-Response Output Current Monitor

Figure 32 shows a single-supply current monitor configured as a difference amplifier with a gain of 50 to trip at 500 $\mu$ A. The OPA320 was chosen for this circuit because of its gain bandwidth (20 MHz), which allows higher speed triggering and monitoring of the current across the shunt resistor followed by the fast response of the TLV3201-Q1.



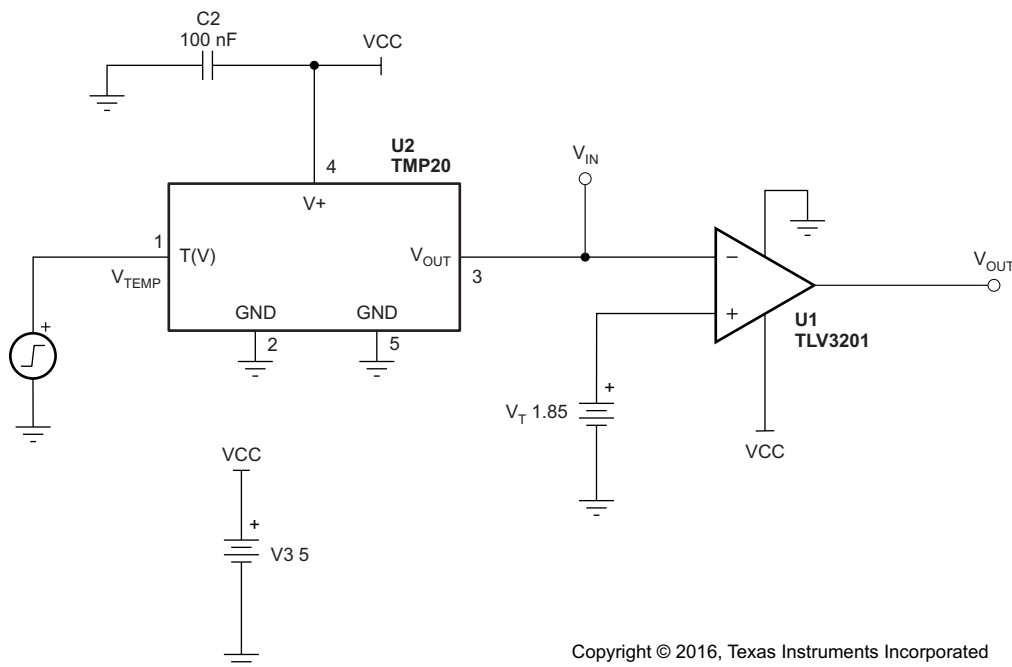
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Figure 32. TLV3201-Q1 and OPA320 Configured as a Fast-Response Output Current Monitor

## Typical Applications (continued)

### 9.2.3 TLV3201-Q1 and TMP20 Configured as a Precision Analog Temperature Switch

Figure 33 shows the TMP20 and TLV3201-Q1 designed as a high-speed temperature switch. The TMP20 is an analog output temperature sensor where output voltage decreases with temperature. The comparator output is tripped when the output reaches a critical trip threshold.



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**Figure 33. TLV3201-Q1 and TMP20 Configured as a Precision Analog Temperature Switch**

## 10 Power Supply Recommendations

The TLV3201-Q1 and TLV3202-Q1 comparators are specified for use on a single supply from 2.7 V to 5.5 V (or a dual supply from  $\pm 1.35$  V to  $\pm 2.75$  V) over a temperature range of  $-40^{\circ}\text{C}$  to  $+125^{\circ}\text{C}$ . The device continues to function below this range, but performance is not specified. Place bypass capacitors close to the power-supply pins to reduce noise coupling in from noisy or high-impedance power supplies. For more detailed information on bypass capacitor placement, see [Layout Guidelines](#).

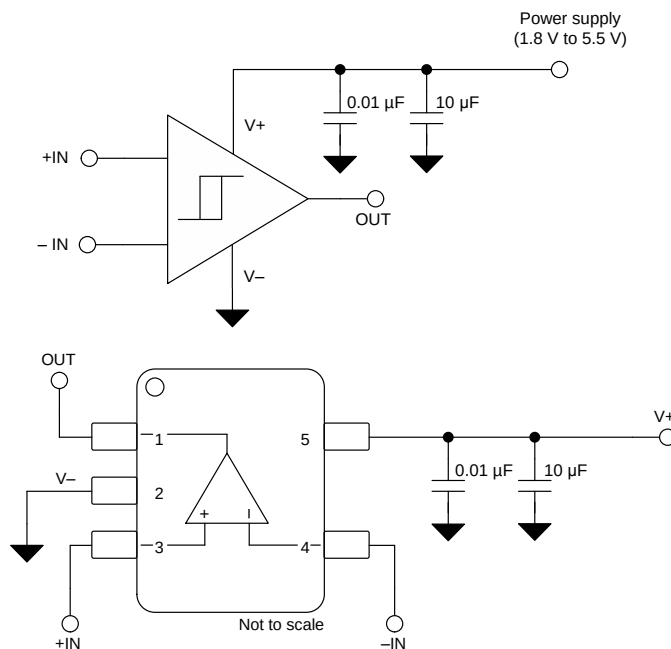
## 11 Layout

### 11.1 Layout Guidelines

The TLV3201-Q1 and TLV3202-Q1 are fast-switching, high-speed comparators and require high-speed layout considerations. For best results, maintain the following layout guidelines:

- Use a printed-circuit board (PCB) with a good, unbroken low-inductance ground plane.
- Place a decoupling capacitor (0.1- $\mu$ F ceramic, surface-mount capacitor) as close as possible to  $V_{CC}$ .
- On the inputs and the output, keep lead lengths as short as possible to avoid unwanted parasitic feedback around the comparator. Keep inputs away from the output.
- Solder the device directly to the PCB rather than using a socket.
- For slow-moving input signals, take care to prevent parasitic feedback. A small capacitor (1000 pF or less) placed between the inputs can help eliminate oscillations in the transition region. This capacitor causes some degradation to propagation delay when the impedance is low. The topside ground plane runs between the output and inputs.
- The ground pin ground trace runs under the device up to the bypass capacitor, shielding the inputs from the outputs.

### 11.2 Layout Example



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**Figure 34. TLV3201-Q1 SOT-23 Board Layout Example**

## 12 Device and Documentation Support

### 12.1 Device Support

#### 12.1.1 Development Support

##### 12.1.1.1 TINA-TI™ Simulation Software (Free Download)

TINA-TI™ software, based on a SPICE engine, is a simple, powerful, and easy-to-use circuit simulation program. The TINA-TI software is a free, fully-functional version of the TINA software, preloaded with a library of macro models in addition to a range of both passive and active models. TINA-TI software provides all the conventional DC, transient, and frequency domain analysis of SPICE, as well as additional design capabilities.

Available as a [free download](#) from the Analog eLab Design Center, TINA-TI software offers extensive post-processing capability that allows users to format results in a variety of ways. Virtual instruments offer the ability to select input waveforms and probe circuit nodes, voltages, and waveforms, creating a dynamic quick-start tool.

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#### NOTE

These files require that either the TINA software (from DesignSoft™) or TINA-TI software be installed. Download the free TINA-TI software from the [TINA-TI folder](#).

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##### 12.1.1.2 Universal Operational Amplifier EVM

The [Universal Op Amp EVM](#) is a series of general-purpose, blank circuit boards that simplify prototyping circuits for a variety of IC package types. While primarily for Operational Amplifiers, the pinouts are the same as the TLV320x-Q1 comparators and can be used for prototyping comparator circuits easily and quickly. Five models are offered, with each model intended for a specific package type. PDIP, SOIC, MSOP, TSSOP and SOT23 packages are all supported.

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#### NOTE

These boards are unpopulated, so users must provide their own ICs. TI recommends requesting several operational amplifier device samples when ordering the Universal Op Amp EVM.

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##### 12.1.1.3 TI Precision Designs

TI Precision Designs are analog solutions created by TI's precision analog applications experts and offer the theory of operation, component selection, simulation, complete PCB schematic and layout, bill of materials, and measured performance of many useful circuits. TI Precision Designs are available online at <http://www.ti.com/www/en/analog/precision-designs/>.

##### 12.1.1.4 WEBENCH® Filter Designer

[WEBENCH® Filter Designer](#) is a simple, powerful, and easy-to-use active filter design program. The WEBENCH Filter Designer lets you create optimized filter designs using a selection of TI operational amplifiers and passive components from TI's vendor partners. Placing filters before the comparator can greatly improve noise rejection and false triggers. Available as a web-based tool from the WEBENCH® Design Center, [WEBENCH® Filter Designer](#) allows you to design, optimize, and simulate complete multistage active filter solutions within minutes.

## 12.2 Documentation Support

### 12.2.1 Related Documentation

The following documents are relevant to using the TLV320x-Q1, and recommended for reference. All are available for download at [www.ti.com](http://www.ti.com) unless otherwise noted.

- [Frequency Dithering With the UCC28950 and TLV3201](#)
- [Frequency Dithering with the UCC28180 and TLV3201](#)
- [Comparator with Hysteresis Reference Design](#)

## 12.3 Related Links

[Table 1](#) lists quick access links. Categories include technical documents, support and community resources, tools and software, and quick access to order now.

**Table 1. Related Links**

| PARTS      | PRODUCT FOLDER             | ORDER NOW                  | TECHNICAL DOCUMENTS        | TOOLS & SOFTWARE           | SUPPORT & COMMUNITY        |
|------------|----------------------------|----------------------------|----------------------------|----------------------------|----------------------------|
| TLV3201-Q1 | <a href="#">Click here</a> | <a href="#">Click here</a> | <a href="#">Click here</a> | <a href="#">Click here</a> | <a href="#">Click here</a> |
| TLV3202-Q1 | <a href="#">Click here</a> | <a href="#">Click here</a> | <a href="#">Click here</a> | <a href="#">Click here</a> | <a href="#">Click here</a> |

## 12.4 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.

## 12.5 Community Resource

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

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

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

## 12.6 Trademarks

E2E is a trademark of Texas Instruments.  
WEBENCH is a registered trademark of Texas Instruments.  
DesignSoft is a trademark of DesignSoft, Inc.  
TINA-TI is a trademark of Texas Instruments and DesignSoft, Inc..  
All other trademarks are the property of their respective owners.

## 12.7 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.

## 12.8 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<br>(1) | Package Type | Package<br>Drawing | Pins | Package<br>Qty | Eco Plan<br>(2)            | Lead/Ball Finish<br>(6) | MSL Peak Temp<br>(3) | Op Temp (°C) | Device Marking<br>(4/5) | Samples                 |
|------------------|---------------|--------------|--------------------|------|----------------|----------------------------|-------------------------|----------------------|--------------|-------------------------|-------------------------|
| TLV3201AQDCKRQ1  | ACTIVE        | SC70         | DCK                | 5    | 3000           | Green (RoHS<br>& no Sb/Br) | NIPDAU                  | Level-2-260C-1 YEAR  | -40 to 125   | 5HF                     | <a href="#">Samples</a> |
| TLV3202AQDGKRQ1  | ACTIVE        | VSSOP        | DGK                | 8    | 2500           | Green (RoHS<br>& no Sb/Br) | NIPDAUAG                | Level-2-260C-1 YEAR  | -40 to 125   | 1C8Q                    | <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.

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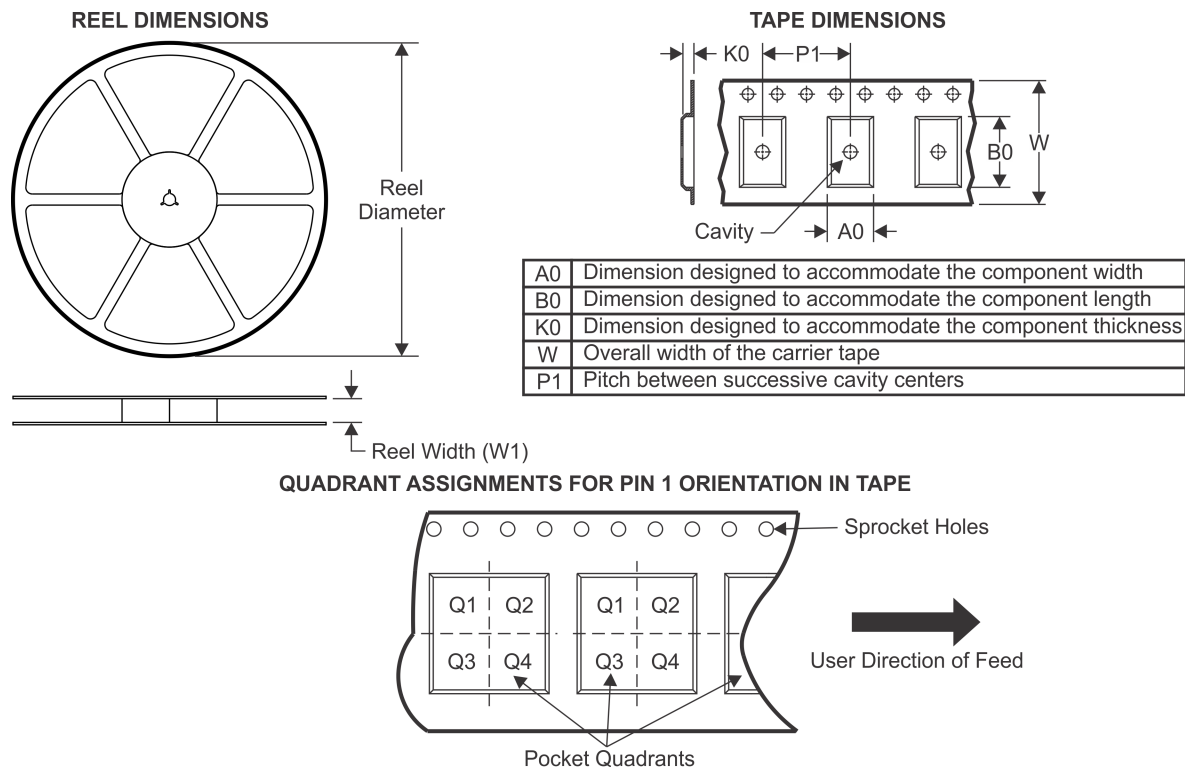
In no event shall TI's liability arising out of such information exceed the total purchase price of the TI part(s) at issue in this document sold by TI to Customer on an annual basis.

**OTHER QUALIFIED VERSIONS OF TLV3201-Q1, TLV3202-Q1 :**

- Catalog: [TLV3201](#), [TLV3202](#)

**NOTE: Qualified Version Definitions:**

- Catalog - TI's standard catalog product

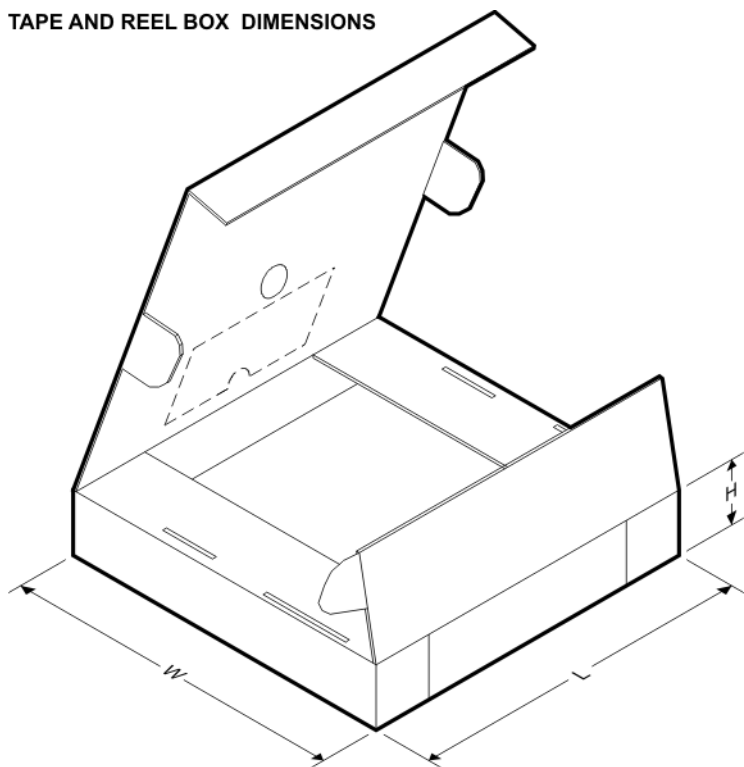
**TAPE AND REEL INFORMATION**


\*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 |
|-----------------|--------------|-----------------|------|------|--------------------|--------------------|---------|---------|---------|---------|--------|---------------|
| TLV3201AQDCKRQ1 | SC70         | DCK             | 5    | 3000 | 178.0              | 9.0                | 2.4     | 2.5     | 1.2     | 4.0     | 8.0    | Q3            |
| TLV3202AQDGKRQ1 | VSSOP        | DGK             | 8    | 2500 | 330.0              | 12.4               | 5.3     | 3.4     | 1.4     | 8.0     | 12.0   | Q1            |



## TAPE AND REEL BOX DIMENSIONS

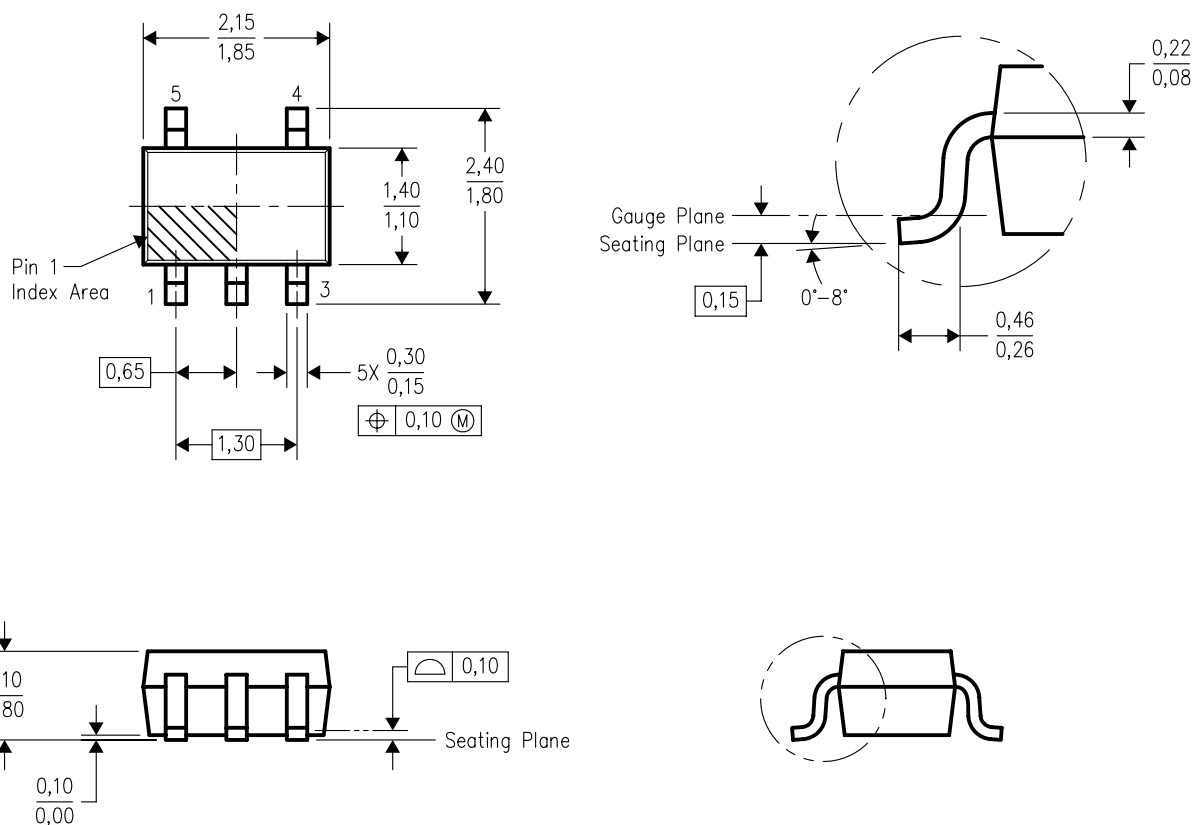


\*All dimensions are nominal

| Device          | Package Type | Package Drawing | Pins | SPQ  | Length (mm) | Width (mm) | Height (mm) |
|-----------------|--------------|-----------------|------|------|-------------|------------|-------------|
| TLV3201AQDCKRQ1 | SC70         | DCK             | 5    | 3000 | 190.0       | 190.0      | 30.0        |
| TLV3202AQDGKRQ1 | VSSOP        | DGK             | 8    | 2500 | 366.0       | 364.0      | 50.0        |

## DCK (R-PDSO-G5)

## PLASTIC SMALL-OUTLINE PACKAGE

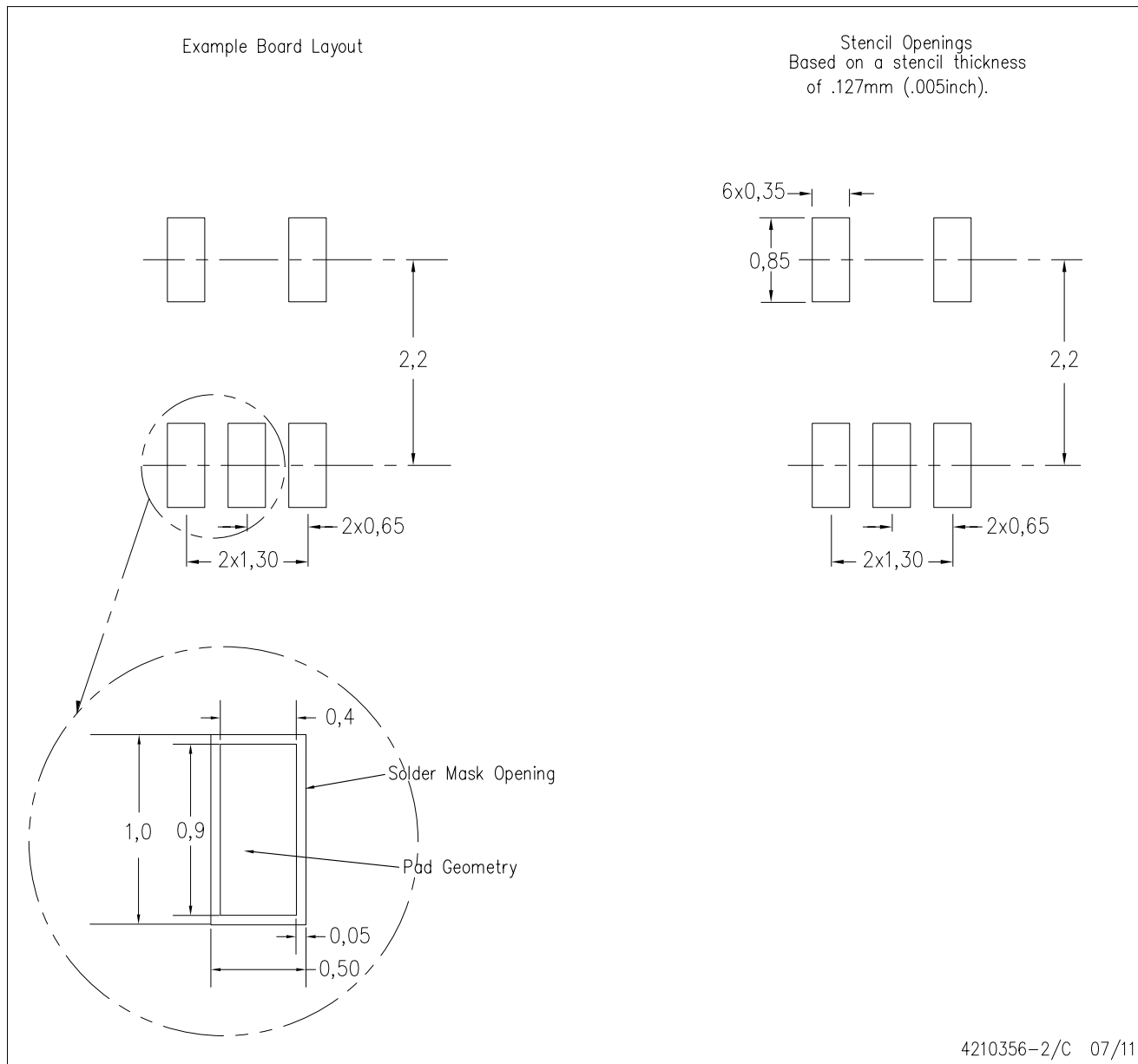


4093553-3/G 01/2007

- NOTES:
- All linear dimensions are in millimeters.
  - This drawing is subject to change without notice.
  - Body dimensions do not include mold flash or protrusion. Mold flash and protrusion shall not exceed 0.15 per side.
  - Falls within JEDEC MO-203 variation AA.

DCK (R-PDSO-G5)

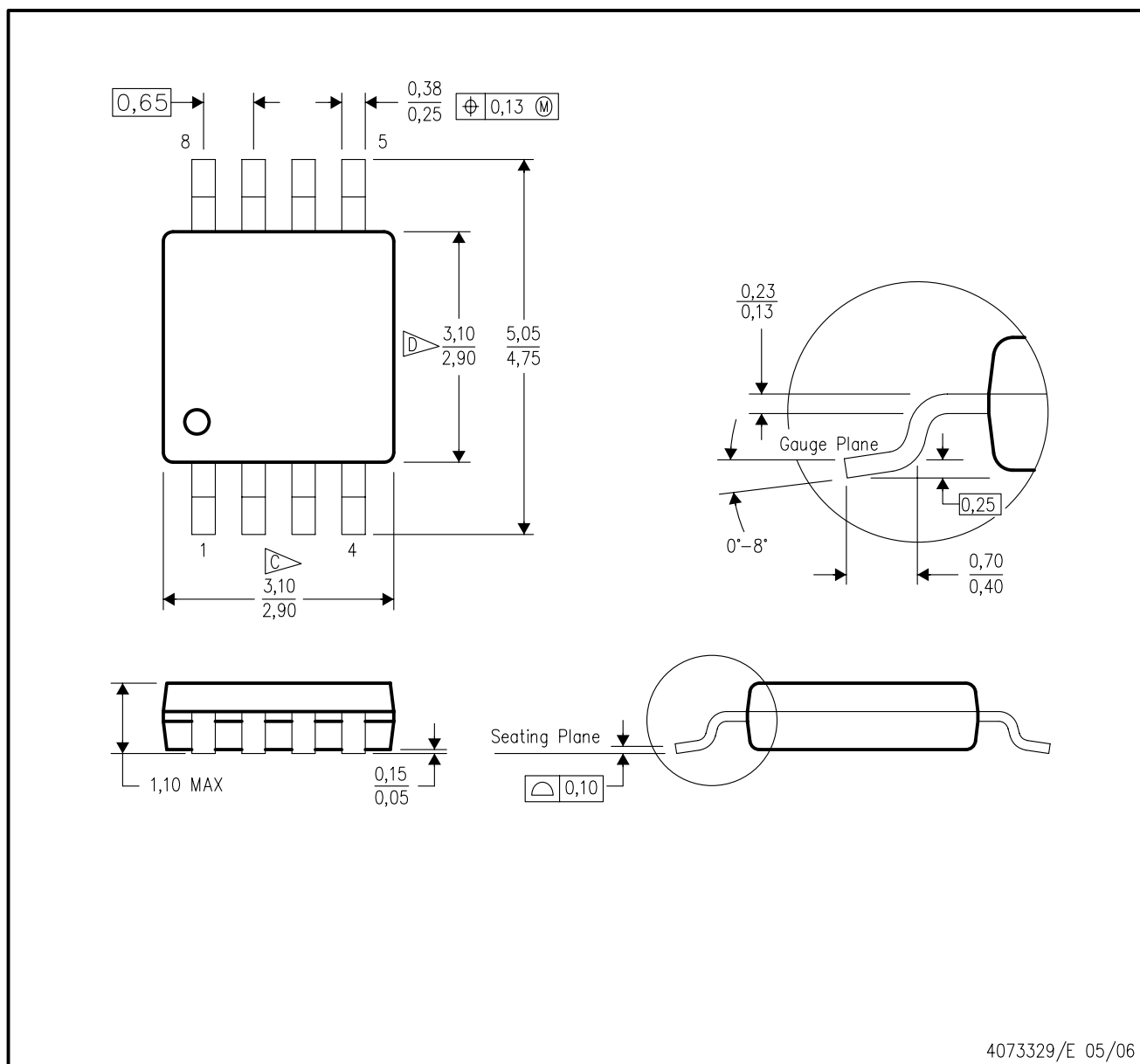
PLASTIC SMALL OUTLINE



- NOTES:
- A. All linear dimensions are in millimeters.
  - B. This drawing is subject to change without notice.
  - C. Customers should place a note on the circuit board fabrication drawing not to alter the center solder mask defined pad.
  - D. Publication IPC-7351 is recommended for alternate designs.
  - E. 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. Example stencil design based on a 50% volumetric metal load solder paste. Refer to IPC-7525 for other stencil recommendations.

DGK (S-PDSO-G8)

PLASTIC SMALL-OUTLINE PACKAGE

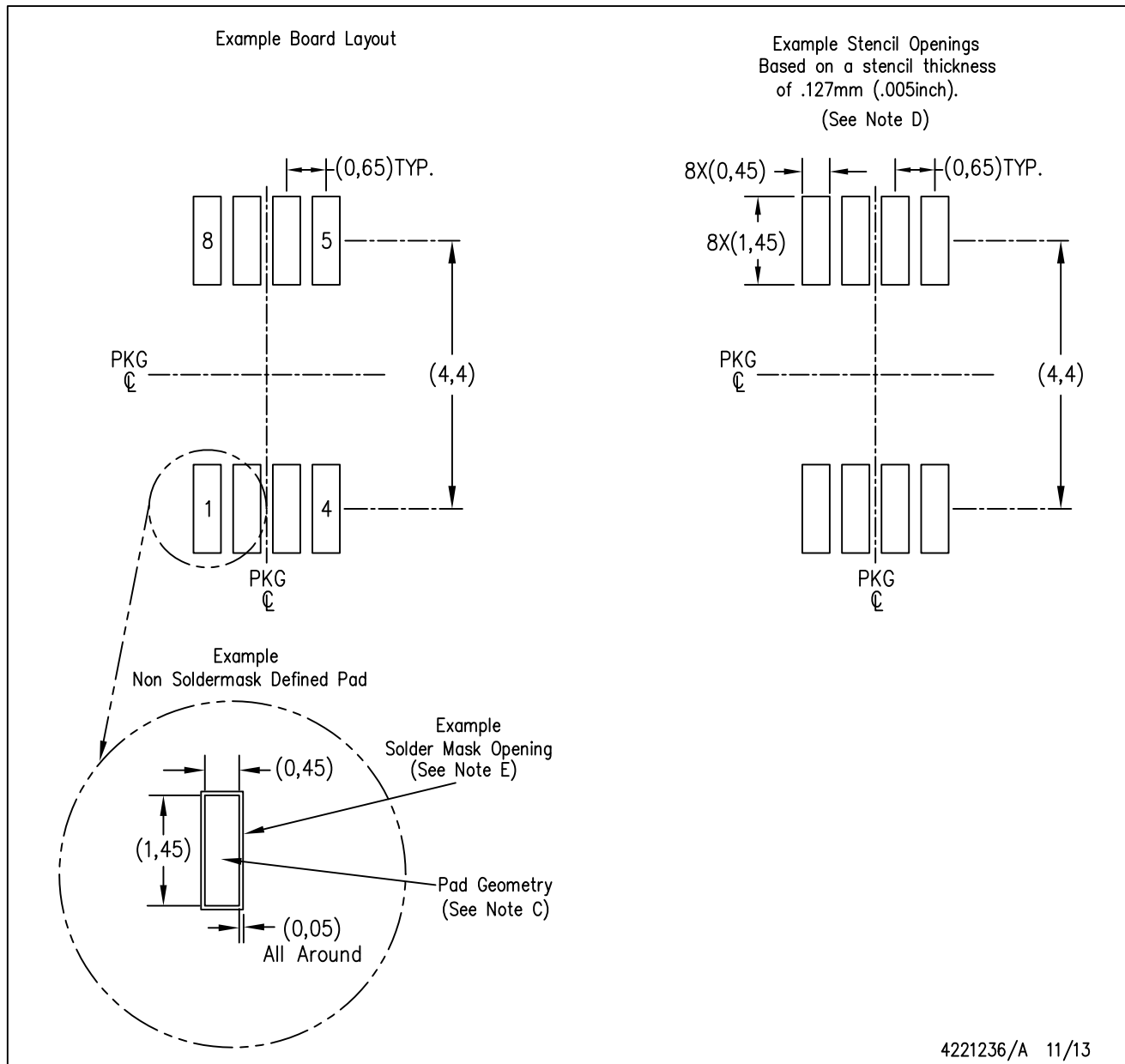


## NOTES:

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

DGK (S-PDSO-G8)

PLASTIC SMALL OUTLINE PACKAGE



- NOTES:
- All linear dimensions are in millimeters.
  - This drawing is subject to change without notice.
  - Publication IPC-7351 is recommended for alternate designs.
  - 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.
  - Customers should contact their board fabrication site for solder mask tolerances between and around signal pads.

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