1 Features

- Qualified for Automotive Applications
- AEC-Q100 Qualified With the Following Results:
  - Device Temperature Grade 1: –40°C to +125°C Ambient Operating Temperature Range
  - Device HBM Classification Level 2
  - Device CDM Classification Level C4B
- High Speed: 4.5 ns
- Rail-To-Rail I/O
- Supply Voltage: 2.7 V to 5.5 V
- Push-Pull CMOS Output Stage
- Shutdown
- Micro Package: SOT23-6
- Low Supply Current: 3.2 mA
- Z-Suffix Offers Improved Delamination

2 Applications

- HEV/EV and Powertrain Applications
- DC-DC Converter
- Inverter
- Fuel Sensing
- Hybrid Power Control Unit
- Automatic Test Equipment
- Threshold Detector
- Zero-Crossing Detector
- Window Comparator

3 Description

The TLV3501A-Q1 push-pull output comparator features a fast 4.5-ns propagation delay and operation from 2.7 V to 5.5 V. The input voltage supports a common-mode range that goes beyond the rails which makes the device an ideal choice for low-voltage applications. The rail-to-rail output directly drives either CMOS or TTL logic. The fast delay and wide common-mode range also makes TLV3501A-Q1 device ideal for EMI reduction through frequency dithering by lowering the EMI peaks. These parameters allow the device to be ideal for both DC-DC converter and inverter applications in HEV/EV and powertrain.

The SOT23-6 microsized package provides options for portable and space-restricted applications. The Z-suffix offers reduced delamination compared to the standard device.

Device Information

<table>
<thead>
<tr>
<th>PART NUMBER</th>
<th>PACKAGE</th>
<th>BODY SIZE (NOM)</th>
</tr>
</thead>
<tbody>
<tr>
<td>TLV3501A-Q1</td>
<td>SOT-23 (6)</td>
<td>2.90 mm × 1.60 mm</td>
</tr>
</tbody>
</table>

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

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

Changes from Revision A (September 2010) to Revision B

Page

• Added z-suffix for improved delamination ............................................................... 1
• Added Pin Configuration and Functions section, ESD Ratings table, Feature Description section, Device Functional Modes, Application and Implementation section, Power Supply Recommendations section, Layout section, Device and Documentation Support section, and Mechanical, Packaging, and Orderable Information section ........................................ 1
• Deleted the Ordering Information table ....................................................................... 3

Changes from Original (September, 2010) to Revision A

Page

• Added new feature bullet regarding automotive application qualification........................ 1
5 Related Products

<table>
<thead>
<tr>
<th>PART NUMBER</th>
<th>FEATURES</th>
</tr>
</thead>
<tbody>
<tr>
<td>TLV3701-Q1</td>
<td>Automotive Nanopower, 560-nA $I_{CC}$, push-pull comparators</td>
</tr>
<tr>
<td>TLV3702-Q1</td>
<td>Automotive micropower, 100-µW, LinCMOS™ voltage, push-pull comparators</td>
</tr>
<tr>
<td>TLV3012-Q1</td>
<td>Automotive nanopower, 1.8-V, SOT23 push-pull comparator with voltage reference</td>
</tr>
<tr>
<td>TLC393-Q1</td>
<td>Automotive dual-micropower LinCMOS voltage comparator</td>
</tr>
</tbody>
</table>

6 Pin Configuration and Functions

Pin 1 is determined by orienting the package marking as indicated on the diagram.

<table>
<thead>
<tr>
<th>PIN NO.</th>
<th>NAME</th>
<th>I/O(1)</th>
<th>DESCRIPTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>–IN</td>
<td>I</td>
<td>Inverting input</td>
</tr>
<tr>
<td>2</td>
<td>V–</td>
<td>I</td>
<td>Negative (lowest) power supply</td>
</tr>
<tr>
<td>3</td>
<td>+IN</td>
<td>I</td>
<td>Noninverting input</td>
</tr>
<tr>
<td>4</td>
<td>V+</td>
<td>I</td>
<td>Positive (highest) power supply</td>
</tr>
<tr>
<td>5</td>
<td>OUT</td>
<td>O</td>
<td>Output</td>
</tr>
<tr>
<td>6</td>
<td>SHDN</td>
<td>—</td>
<td>Shutdown (the device is idle when this pin is not in use)</td>
</tr>
</tbody>
</table>

(1) I = input, O = output
7 Specifications

7.1 Absolute Maximum Ratings
over operating free-air temperature range (unless otherwise noted)\(^{(1)}\)

<table>
<thead>
<tr>
<th>MIN</th>
<th>MAX</th>
<th>UNIT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Supply voltage</td>
<td>5.5</td>
<td>V</td>
</tr>
<tr>
<td>Signal input terminal voltage(^{(2)}) ((V−) − 0.3) ((V+) + 0.3)</td>
<td>V</td>
<td></td>
</tr>
<tr>
<td>Signal input terminal current(^{(2)})</td>
<td>10</td>
<td>mA</td>
</tr>
<tr>
<td>Output short-circuit current(^{(3)})</td>
<td>74</td>
<td>mA</td>
</tr>
<tr>
<td>Thermal impedance, junction to free air</td>
<td>200</td>
<td>°C/W</td>
</tr>
<tr>
<td>Operating temperature</td>
<td>−40</td>
<td>125</td>
</tr>
<tr>
<td>Junction temperature</td>
<td>150</td>
<td>°C</td>
</tr>
<tr>
<td>Storage temperature</td>
<td>−65</td>
<td>150</td>
</tr>
</tbody>
</table>

\(^{(1)}\) 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 terminals are diode-clamped to the power-supply rails. Input signals that can swing more than 0.3 V beyond the supply rails should be current limited to 10 mA or less.

\(^{(3)}\) Short circuit to ground, one comparator per package.

7.2 ESD Ratings

<table>
<thead>
<tr>
<th>VALUE</th>
<th>UNIT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Human-body model (HBM), per AEC Q100-002(^{(1)})</td>
<td>±2000</td>
</tr>
<tr>
<td>Charged-device model (CDM), per AEC Q100-011</td>
<td>±500</td>
</tr>
<tr>
<td>Corner pins (1, 3, 4, and 6)</td>
<td>±750</td>
</tr>
</tbody>
</table>

\(^{(1)}\) 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)

<table>
<thead>
<tr>
<th>MIN</th>
<th>NOM</th>
<th>MAX</th>
<th>UNIT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Supply voltage (V_S)</td>
<td>2.2</td>
<td>2.7</td>
<td>5.5</td>
</tr>
<tr>
<td>Low-level input voltage, SHDN (comparator is enabled) (V_{IL})</td>
<td>((V+) − 1.7)</td>
<td></td>
<td>V</td>
</tr>
<tr>
<td>High-level input voltage, SHDN (comparator is disabled) (V_{IH}) ((V+) − 0.9)</td>
<td></td>
<td></td>
<td>V</td>
</tr>
<tr>
<td>Operating temperature (T_A)</td>
<td>−40</td>
<td>125</td>
<td>°C</td>
</tr>
</tbody>
</table>

\(^{(1)}\) When the SHDN pin is within 0.9 V of the most positive supply, the part is disabled. When it is more than 1.7 V below the most positive supply, the part is enabled.

7.4 Thermal Information

<table>
<thead>
<tr>
<th>THERMAL METRIC(^{(1)})</th>
<th>TLY3501A-Q1 DBV (SOT-23)</th>
<th>UNIT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Junction-to-ambient thermal resistance (R_{JA})</td>
<td>192.2</td>
<td>°C/W</td>
</tr>
<tr>
<td>Junction-to-case (top) thermal resistance (R_{JJC(top)})</td>
<td>134.8</td>
<td>°C/W</td>
</tr>
<tr>
<td>Junction-to-board thermal resistance (R_{JJB})</td>
<td>37.1</td>
<td>°C/W</td>
</tr>
<tr>
<td>Junction-to-top characterization parameter (\psi_{JT})</td>
<td>28.3</td>
<td>°C/W</td>
</tr>
<tr>
<td>Junction-to-board characterization parameter (\psi_{JJB})</td>
<td>36.7</td>
<td>°C/W</td>
</tr>
<tr>
<td>Junction-to-case (bottom) thermal resistance (R_{JJC(bot)})</td>
<td>—</td>
<td>°C/W</td>
</tr>
</tbody>
</table>

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

$T_A = 25^\circ C$ and $V_S = 2.7$ V to 5.5 V (unless otherwise noted).

<table>
<thead>
<tr>
<th>PARAMETER</th>
<th>TEST CONDITIONS</th>
<th>MIN</th>
<th>TYP</th>
<th>MAX</th>
<th>UNIT</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>OFFSET VOLTAGE</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$V_{OS}$</td>
<td>Input offset voltage $^{(1)}$</td>
<td>$V_{CM} = 0$ V, $I_Q = 0$ mA</td>
<td>±1</td>
<td>±6.5</td>
<td>mV</td>
</tr>
<tr>
<td>$dV_{OS}/dT$</td>
<td>Input offset voltage $^{(1)}$ vs temperature</td>
<td>$T_A = -40^\circ C$ to $+125^\circ C$</td>
<td>±5</td>
<td></td>
<td>μV/°C</td>
</tr>
<tr>
<td>PSRR</td>
<td>Input offset voltage $^{(1)}$ vs power supply</td>
<td></td>
<td>100</td>
<td>400</td>
<td>μV/V</td>
</tr>
<tr>
<td></td>
<td>Input hysteresis</td>
<td></td>
<td>6</td>
<td></td>
<td>mV</td>
</tr>
<tr>
<td><strong>INPUT BIAS CURRENT</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$I_B$</td>
<td>Input bias current $^{(2)}$</td>
<td>$V_{CM} = V_{CC}/2$, $\Delta V_{IN} = \pm 5.5$ V</td>
<td>±2</td>
<td>±10</td>
<td>pA</td>
</tr>
<tr>
<td>$I_{OS}$</td>
<td>Input offset current $^{(2),(3)}$</td>
<td>$V_{CM} = V_{CC}/2\Delta V_{IN} = \pm 5.5$ V</td>
<td>±2</td>
<td>±10</td>
<td>pA</td>
</tr>
<tr>
<td><strong>INPUT VOLTAGE RANGE</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$V_{CM}$</td>
<td>Common-mode voltage range</td>
<td></td>
<td>$V_{CM} = (V_+) - 0.2$ V</td>
<td>$V_{CM} = (V_+) + 0.2$ V</td>
<td>V</td>
</tr>
<tr>
<td>CMRR</td>
<td>Common-mode rejection</td>
<td></td>
<td>$T_A = 25^\circ C$</td>
<td>$T_A = -40^\circ C$ to $+125^\circ C$</td>
<td>dB</td>
</tr>
<tr>
<td><strong>INPUT IMPEDANCE</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Common-mode</td>
<td></td>
<td>$10^{13}$</td>
<td>$\Omega</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Differential</td>
<td></td>
<td>$10^{13}$</td>
<td>$\Omega</td>
<td></td>
</tr>
<tr>
<td><strong>OUTPUT</strong></td>
<td>$V_{OH}$, $V_{OL}$</td>
<td>Voltage output swing from rail</td>
<td>$I_{OUT} = \pm 1$ mA</td>
<td>30</td>
<td>50</td>
</tr>
<tr>
<td><strong>SHUTDOWN</strong></td>
<td>$I_{OFF}$</td>
<td>Shutdown turnoff time</td>
<td></td>
<td>30</td>
<td></td>
</tr>
<tr>
<td></td>
<td>$I_{ON}$</td>
<td>Shutdown turnon time</td>
<td></td>
<td>100</td>
<td></td>
</tr>
<tr>
<td>$V_H$</td>
<td>SHDN high threshold</td>
<td>Comparator is enabled $^{(4)}$</td>
<td>$V_{IN} = (V_+) - 1.7$ V</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$V_L$</td>
<td>SHDN low threshold</td>
<td>Comparator is disabled $^{(4)}$</td>
<td>$V_{IN} = 0.9$ V</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$I_{OSD}$</td>
<td>Quiescent current in shutdown</td>
<td></td>
<td>2</td>
<td></td>
<td>μA</td>
</tr>
<tr>
<td><strong>POWER SUPPLY</strong></td>
<td>$V_S$</td>
<td>Specified voltage</td>
<td></td>
<td>2.7</td>
<td>5.5</td>
</tr>
<tr>
<td></td>
<td>Operating voltage range</td>
<td></td>
<td>2.2 to 5.5</td>
<td></td>
<td>V</td>
</tr>
<tr>
<td>$I_Q$</td>
<td>Quiescent current</td>
<td>$V_S = 5$ V, $V_O = High$</td>
<td>3.2</td>
<td>5</td>
<td>mA</td>
</tr>
<tr>
<td><strong>TEMPERATURE RANGE</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Specified temperature</td>
<td></td>
<td>$-40$</td>
<td>125</td>
<td>°C</td>
</tr>
<tr>
<td></td>
<td>Operating temperature</td>
<td></td>
<td>$-40$</td>
<td>125</td>
<td>°C</td>
</tr>
<tr>
<td></td>
<td>Storage temperature</td>
<td></td>
<td>$-65$</td>
<td>150</td>
<td>°C</td>
</tr>
<tr>
<td>$R_{JJA}$</td>
<td>Thermal resistance, SOT23-6 package</td>
<td></td>
<td>200</td>
<td></td>
<td>°C/W</td>
</tr>
</tbody>
</table>

$^{(1)}$ $V_{OS}$ is defined as the average of the positive and the negative switching thresholds.

$^{(2)}$ Not production tested.

$^{(3)}$ The difference between $I_B^+$ and $I_B^-$. 

$^{(4)}$ When the shutdown pin is within 0.9 V of the most positive supply, the part is disabled. When it is more than 1.7 V below the most positive supply, the part is enabled.
7.6 Switching Characteristics

$T_A = 25^\circ C$ and $V_S = 2.7$ V to 5.5 V (unless otherwise noted).

<table>
<thead>
<tr>
<th>PARAMETER</th>
<th>TEST CONDITIONS</th>
<th>MIN</th>
<th>TYP</th>
<th>MAX</th>
<th>UNIT</th>
</tr>
</thead>
<tbody>
<tr>
<td>$T_{pd}$ <strong>Prop</strong></td>
<td>$\Delta V_{IH} = 100$ mV, Overdrive = 20 mV</td>
<td>4.5</td>
<td>6.4</td>
<td></td>
<td>ns</td>
</tr>
<tr>
<td></td>
<td>$T_A = 25^\circ C$</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>$T_A = -40^\circ C$ to $+125^\circ C$</td>
<td>7.0</td>
<td>10</td>
<td></td>
<td>ns</td>
</tr>
<tr>
<td></td>
<td>$\Delta V_{IH} = 100$ mV, Overdrive = 5 mV</td>
<td>7.5</td>
<td>10</td>
<td></td>
<td>ns</td>
</tr>
<tr>
<td></td>
<td>$T_A = 25^\circ C$</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>$T_A = -40^\circ C$ to $+125^\circ C$</td>
<td>12</td>
<td></td>
<td></td>
<td>ns</td>
</tr>
</tbody>
</table>

(1) Not production tested.
(2) Propagation delay cannot be accurately measured with low overdrive on automatic test equipment. This parameter is ensured by characterization at 100-mV overdrive.
(3) The difference between the propagation delay going high and the propagation delay going low.
(4) Measured between 10% of $V_S$ and 90% of $V_S$.

7.7 Typical Characteristics

At $T_A = 25^\circ C$, $V_S = 5$ V, and input overdrive = 100 mV (unless otherwise noted).

**Figure 1. Output Response for Various Overdrive Voltages (Rising)**

**Figure 2. Output Response For Various Overdrive Voltages (Falling)**
Typical Characteristics (continued)

At $T_A = 25^\circ C$, $V_S = 5$ V, and input overdrive = 100 mV (unless otherwise noted).

![Figure 3. Propagation Delay vs Temperature](image1)

![Figure 4. Propagation Delay vs Temperature](image2)

![Figure 5. Propagation Delay vs Capacitive Load](image3)

![Figure 6. Propagation Delay vs Capacitive Load](image4)

![Figure 7. Propagation Delay vs Supply Voltage](image5)

![Figure 8. Wake-Up Delay vs Temperature](image6)
Typical Characteristics (continued)

At $T_A = 25^\circ$C, $V_S = 5$ V, and input overdrive = 100 mV (unless otherwise noted).

$V_{DD} = 5$ V  $V_{IN} = 20$ mV$_{PP}$

**Figure 9. Response to 50-MHz Sine Wave**

**Figure 10. Response to 100-MHz Sine Wave**

**Figure 11. Quiescent Current vs Supply Voltage**

**Figure 12. Quiescent Current vs Temperature**

**Figure 13. Quiescent Current vs Shutdown Voltage**

**Figure 14. Quiescent Current vs Frequency**
8 Detailed Description

8.1 Overview
The TLV3501A-Q1 device features high-speed response and includes 6 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

8.3 Feature Description

8.3.1 Operating Voltage
The TLV3501A-Q1 comparators are specified for use on a single supply from 2.7 V to 5.5 V (or a dual supply from ±1.35 V to ±2.75 V) over a temperature range of −40°C to +125°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 comparator, as shown in Figure 15.

Figure 15. Input Current Protection for Voltages Exceeding the Supply Voltage
8.4 Device Functional Modes

8.4.1 Shutdown

A shutdown pin (SHDN) allows the device to go idle when the SHDN pin is not in use. When the SHDN pin is high, the device draws about 2 μA and the output goes to high impedance. When the shutdown pin is low, the TLV3501A-Q1 device is active. When the TLV3501A-Q1 shutdown feature is not used, connect the shutdown pin to the most negative supply, as shown in Figure 16. Exiting shutdown mode takes about 100 ns.

![Figure 16. Basic Connections for the TLV3501A-Q1](image-url)
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

9.1.1 Adding External Hysteresis

The TLV3501A-Q1 device has a robust performance when used with a good layout. However, the comparator inputs have little noise immunity within the range of specified offset voltage (±5 mV). For slow moving or noisy input signals, the comparator output can cause an undesirable switch state as input signals move through the switching threshold. In such applications, the 6 mV of internal hysteresis of the TLV3501A-Q1 device might not be sufficient. In cases where greater noise immunity is desired, external hysteresis can be added by connecting a small amount of feedback to the positive. Figure 17 shows a typical topology used to introduce 25 mV of additional hysteresis, for a total of 31-mV hysteresis when operating from a single 5-V supply. Use Equation 1 to calculate the approximate total hysteresis.

\[ V_{HYST} = \frac{(V+) \times R_1}{R_1 + R_2} + 6 \text{ mV} \]

The total hysteresis, \( V_{HYST} \), sets the value of the transition voltage required to switch the comparator output by enlarging the threshold region, thereby reducing sensitivity to noise.

Figure 17. Adding Hysteresis to the TLV3501A-Q1

9.2 Typical Application

9.2.1 Relaxation Oscillator

The TLV3501A-Q1 device can easily be configured as a simple and inexpensive relaxation oscillator. In Figure 18, the \( R_2 \) network sets the trip threshold at 1/3 and 2/3 of the supply. Because this circuit is a high-speed circuit, the resistor values are rather low to minimize the effect of parasitic capacitance. The positive input alternates between 1/3 of \( V^+ \) and 2/3 of \( V^+ \) depending on whether the output is low or high. The time to charge (or discharge) is \( 0.69 \times R_1 C \). Therefore, the period is \( 1.38 \times R_1 C \). For 62 pF and 1 kΩ as shown in Figure 18, the output is calculated to be 10.9 MHz. An implementation of this circuit oscillated at 9.6 MHz. Parasitic capacitance and component tolerances explain the difference between theory and actual performance.
Typical Application (continued)

**9.2.1.1 Design Requirements**

For hysteresis of 1/3 of \( V^+ \) and threshold levels between 1/3 of \( V^+ \) and 2/3 of \( V^+ \), the resistors connected to comparator positive input should be equal in value. The resistor value should be kept low enough so it does not create additional time constant because of the input capacitor and board parasitic capacitor. The value of the charging resistor, \( R_1 \), should be relatively low for high frequency switching without drawing high current and effecting the output high and low level. The value of the charging capacitor should be high enough to avoid errors cause by parasitic capacitance.

**9.2.1.2 Detailed Design Procedure**

For the positive input, \( +IN = 1/3 \ V_{OUT} + 1/3 \ V^+ = 1/3 \ V^+ \) if \( V_{OUT} \) is low and assuming \( V_{OL} \) is very close to GND. Or, \( +IN = 1/3 \ V_{OUT} + 1/3 \ V^+ = 1/3 \ V^+ = 2/3 \ V^+ \) if \( V_{OUT} \) is high and assuming \( V_{OH} \) is very close to \( V^+ \).

For the negative input, the capacitor charges to 2/3 \( V^+ \) and discharges to 1/3 \( V^+ \) exponentially at the same rate with a time constant of \( R_1 C \).

**9.2.1.3 Application Curve**

Figure 18. Relaxation Oscillator

Figure 19. TLV3501A-Q1 Device With Upper and Lower Threshold With 1-V Hysteresis
Typical Application (continued)

9.2.2 High-Speed Window Comparator

A window comparator circuit is used to determine when a signal is between two voltages. The TLV3501A-Q1 device can readily be used to create a high-speed window comparator. The $V_{HI}$ value is the upper voltage threshold, and the $V_{LO}$ value is the lower voltage threshold. When $V_{IN}$ is between these two thresholds, the output in Figure 20 is high. Figure 21 shows a simple means of obtaining an active low output. Note that the reference levels are connected differently between Figure 20 and Figure 21. The operating voltage range of either circuit is 2.7 V to 5.5 V.

![Figure 20. Window Comparator: Active High](image1)

![Figure 21. Window Comparator: Active Low](image2)

10 Power Supply Recommendations

The TLV3501A-Q1 comparator is specified for use on a single supply from 2.7 V to 5.5 V (or a dual supply from ±1.35 V to ±2.75 V) over a temperature range of -40°C to +125°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 the Layout Guidelines section.

11 Layout

11.1 Layout Guidelines

For any high-speed comparator or amplifier, proper design and printed circuit board (PCB) layout are necessary for optimal performance. Excess stray capacitance on the active input, or improper grounding, can limit the maximum performance of high-speed circuitry.
Layout Guidelines (continued)

Minimizing resistance from the signal source to the comparator input is necessary to minimize the propagation delay of the complete circuit. The source resistance along with input and stray capacitance creates an RC filter that delays voltage transitions at the input, and reduces the amplitude of high-frequency signals. The input capacitance of the TLV3501A-Q1 along with stray capacitance from an input pin to ground results in several picofarads of capacitance.

The location and type of capacitors used for power-supply bypassing are critical to high-speed comparators. The suggested 2.2-μF tantalum capacitor does not need to be as close to the device as the 0.1-μF capacitor, and can be shared with other devices. The 2.2-μF capacitor buffers the power-supply line against ripple, and the 0.1-μF capacitor provides a charge for the comparator during high-frequency switching.

In a high-speed circuit, fast rising and falling switching transients create voltage differences across lines that would be at the same potential at DC. To reduce this effect, a ground plane is often used to reduce difference in voltage potential within the circuit board. A ground plane has the advantage of minimizing the effect of stray capacitances on the circuit board by providing a more desirable path for the current to flow. With a signal trace over a ground plane, at high-frequency the return current (in the ground plane) tends to flow directly under the signal trace. Breaks in the ground plane (as simple as through-hole leads and vias) increase the inductance of the plane, making it less effective at higher frequencies. Breaks in the ground plane for necessary vias should be spaced randomly.

Figure 22 shows a schematic of this circuit.

![Figure 22. Schematic for Figure 23](image)

Figure 22. Schematic for Figure 23

Figure 23 shows an evaluation layout for the TLV3501A-Q1 SOT23-6 package which is shown with SMA connectors bringing signals on and off the board. The RT1 and RT2 resistors are termination resistors for \(+V_{IN}\) and \(-V_{IN}\), respectively. The C1 and C2 capacitors are power-supply bypass capacitors. Place the 0.1-μF capacitor closest to the comparator. The ground plane is not shown, but the pads connected the resistors and capacitors are shown.

11.2 Layout Example

![Figure 23. TLV3501A-Q1 (SOT23) Sample Layout](image)
12 Device and Documentation Support

12.1 Documentation Support

12.1.1 Related Documentation
For related documentation see the following:
• TLV370x-Q1 Family of Nanopower Push-Pull Output Comparators, SGLS154
• TLC3702-Q1 Dual Micropower LinCMOS™ Voltage Comparators, SGLS156
• TLC3704-Q1 Quad Micropower LinCMOS™ Voltage Comparators, SGLS191
• TLV301x-Q1 Nanopower 1.8-V Comparator With Voltage Reference, SBOS551
• TLC393-Q1 Dual Micropower LinCMOS™ Voltage Comparator, SGLS198

12.2 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.

12.3 Trademarks
LinCMOS, E2E are trademarks of Texas Instruments. All other trademarks are the property of their respective owners.

12.4 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.

12.5 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

<table>
<thead>
<tr>
<th>Orderable Device</th>
<th>Status</th>
<th>Package Type</th>
<th>Package Drawing</th>
<th>Pins</th>
<th>Package Qty</th>
<th>Eco Plan</th>
<th>Lead/Ball Finish</th>
<th>MSL Peak Temp</th>
<th>Op Temp (°C)</th>
<th>Device Marking (4/5)</th>
<th>Samples</th>
</tr>
</thead>
<tbody>
<tr>
<td>TLV3501AQDBVRQ1</td>
<td>ACTIVE</td>
<td>SOT-23</td>
<td>DBV</td>
<td>6</td>
<td>3000</td>
<td>Green (RoHS &amp; no Sb/Br)</td>
<td>CU NIPDAU</td>
<td>Level-2-260C-1 YEAR</td>
<td>-40 to 125</td>
<td>VCBQ</td>
<td>Samples</td>
</tr>
<tr>
<td>TLV3501AZQDBVRQ1</td>
<td>ACTIVE</td>
<td>SOT-23</td>
<td>DBV</td>
<td>6</td>
<td>3000</td>
<td>Green (RoHS &amp; no Sb/Br)</td>
<td>CU SN</td>
<td>Level-3-260C-168 HR</td>
<td>-40 to 125</td>
<td>11Q2</td>
<td>Samples</td>
</tr>
</tbody>
</table>

(1) The marketing status values are defined as follows:
- **ACTIVE**: Product device recommended for new designs.
- **LIFEBUY**: TI has announced that the device will be discontinued, and a lifetime-buy period is in effect.
- **NRND**: Not recommended for new designs. Device is in production to support existing customers, but TI does not recommend using this part in a new design.
- **PREVIEW**: Device has been announced but is not in production. Samples may or may not be available.
- **OBSOLETE**: TI has discontinued the production of the device.

(2) Eco Plan - The planned eco-friendly classification: Pb-Free (RoHS), Pb-Free (RoHS Exempt), or Green (RoHS & no Sb/Br) - please check [http://www.ti.com/productcontent](http://www.ti.com/productcontent) for the latest availability information and additional product content details.
- **TBD**: The Pb-Free/Green conversion plan has not been defined.
- **Pb-Free (RoHS)**: TI's terms "Lead-Free" or "Pb-Free" mean semiconductor products that are compatible with the current RoHS requirements for all 6 substances, including the requirement that lead not exceed 0.1% by weight in homogeneous materials. Where designed to be soldered at high temperatures, TI Pb-Free products are suitable for use in specified lead-free processes.
- **Pb-Free (RoHS Exempt)**: This component has a RoHS exemption for either 1) lead-based flip-chip solder bumps used between the die and package, or 2) lead-based die adhesive used between the die and leadframe. The component is otherwise considered Pb-Free (RoHS compatible) as defined above.
- **Green (RoHS & no Sb/Br)**: TI defines "Green" to mean Pb-Free (RoHS compatible), and free of Bromine (Br) and Antimony (Sb) based flame retardants (Br or Sb do not exceed 0.1% by weight in homogeneous material).

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

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

(5) Multiple Device Markings will be inside parentheses. Only one Device Marking contained in parentheses and separated by a "," will appear on a device. If a line is indented then it is a continuation of the previous line and the two combined represent the entire Device Marking for that device.

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

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TAPE AND REEL INFORMATION

### TAPE DIMENSIONS

<table>
<thead>
<tr>
<th>Dimension</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>A0</td>
<td>Dimension designed to accommodate the component width</td>
</tr>
<tr>
<td>B0</td>
<td>Dimension designed to accommodate the component length</td>
</tr>
<tr>
<td>K0</td>
<td>Dimension designed to accommodate the component thickness</td>
</tr>
<tr>
<td>W</td>
<td>Overall width of the carrier tape</td>
</tr>
<tr>
<td>P1</td>
<td>Pitch between successive cavity centers</td>
</tr>
</tbody>
</table>

### REEL DIMENSIONS

- **Reel Diameter**: 178.0 mm
- **Reel Width (W1)**: 9.0 mm
- **Pocket Quadrants**: Q1, Q2, Q3, Q4
- **User Direction of Feed**: Right
- **Sprocket Holes**: Indicated

### PACKAGE MATERIALS INFORMATION

<table>
<thead>
<tr>
<th>Device</th>
<th>Package Type</th>
<th>Package Drawing</th>
<th>Pins SPQ</th>
<th>Reel Diameter (W1)</th>
<th>Reel Width (W1)</th>
<th>A0 (mm)</th>
<th>B0 (mm)</th>
<th>K0 (mm)</th>
<th>P1 (mm)</th>
<th>W (mm)</th>
<th>Pin1 Quadrant</th>
</tr>
</thead>
<tbody>
<tr>
<td>TLV3501AQDBVQ1</td>
<td>SOT-23</td>
<td>DBV</td>
<td>6</td>
<td>3000</td>
<td>178.0</td>
<td>9.0</td>
<td>3.23</td>
<td>3.17</td>
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<td>4.0</td>
<td>8.0</td>
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<td>DBV</td>
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<td>3000</td>
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<td>9.0</td>
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<td>3.17</td>
<td>1.37</td>
<td>4.0</td>
<td>8.0</td>
</tr>
</tbody>
</table>

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

*All dimensions are nominal*

<table>
<thead>
<tr>
<th>Device</th>
<th>Package Type</th>
<th>Package Drawing</th>
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<th>SPQ</th>
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<th>Width (mm)</th>
<th>Height (mm)</th>
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<tbody>
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<tr>
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<td>SOT-23</td>
<td>DBV</td>
<td>6</td>
<td>3000</td>
<td>180.0</td>
<td>180.0</td>
<td>18.0</td>
</tr>
</tbody>
</table>
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. Body dimensions do not include mold flash or protrusion. Mold flash and protrusion shall not exceed 0.15 per side.
4. Leads 1, 2, 3 may be wider than leads 4, 5, 6 for package orientation.
5. Reference JEDEC MO-178.
NOTES: (continued)

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