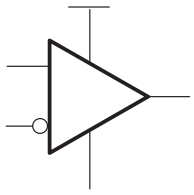
SGLS170 − JUNE 2003

# NANOPOWER PUSH-PULL OUTPUT COMPARATOR

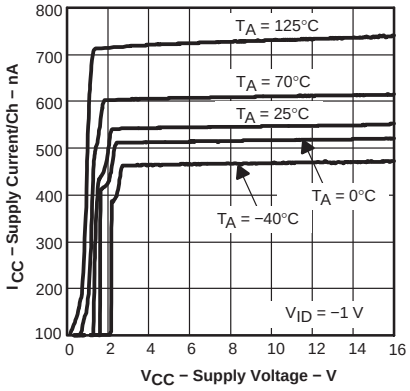
## FEATURES

- **Controlled Baseline**
  - **One Assembly/Test Site, One Fabrication Site**
- **Extended Temperature Performance of −40°C to 125°C**
- **Enhanced Diminishing Manufacturing Sources (DMS) Support**
- **Enhanced Product-Change Notification**
- **Qualification Pedigree†**
- **Low Supply Current . . . 560 nA**
- **Input Common-Mode Range Exceeds the Rails . . . −0.1 V to $V_{CC}$ + 5 V**
- **Supply Voltage Range . . . 2.7 V to 16 V**
- **Reverse Battery Protection Up to 18 V**
- **Push-Pull CMOS Output Stage**
- **Ultrasmall Packaging**
  - **5-Pin SOT-23**
- **Universal Op-Amp EVM (Reference SLOU060 for more information)**

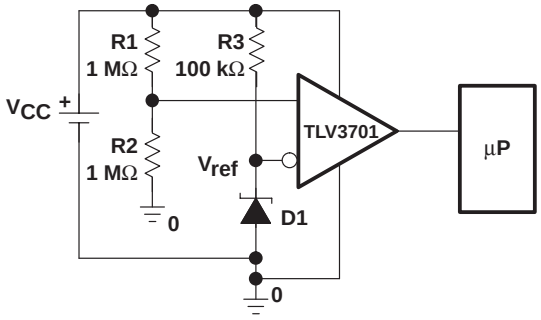
† Component qualification in accordance with JEDEC and industry standards to ensure reliable operation over an extended temperature range. This includes, but is not limited to, Highly Accelerated Stress Test (HAST) or biased 85/85, temperature cycle, autoclave or unbiased HAST, electromigration, bond intermetallic life, and mold compound life. Such qualification testing should not be viewed as justifying use of this component beyond specified performance and environmental limits.



**SUPPLY CURRENT vs SUPPLY VOLTAGE**




**high side voltage sense circuit**




## APPLICATIONS

- **Portable Battery Monitoring**
- **Security Detection Systems**

## DESCRIPTION

The TLV3701 is part of Texas Instruments' first family of nanopower comparator with only 560 nA supply current, which make this device ideal for low power applications.

## DESCRIPTION (continued)

The TLV3701 has a minimum operating supply voltage of 2.7 V over the extended temperature range $T_A$ = −40°C to 125°C, while having an input common-mode range of −0.1 to $V_{CC}$ + 5 V. The low supply current makes it an ideal choice for battery powered portable applications where quiescent current is the primary concern. Reverse battery protection guards the amplifier from an over-current condition due to improper battery installation. For harsh environments, the inputs can be taken 5 V above the positive supply rail without damage to the device.

This device is available in the small SOT-23 package. Other package options may be made available upon request.

**A SELECTION OF OUTPUT COMPARATORS†**

| DEVICE | $V_{CC}$ (V) | $V_{IO}$ (μV) | $I_{CC}$/Ch (μA) | $I_{IB}$ (pA) | $t_{PLH}$ (μs) | $t_{PHL}$ (μs) | $t_f$ (μs) | $t_r$ (μs) | RAIL-TO-RAIL | OUTPUT STAGE |
|---|---|---|---|---|---|---|---|---|---|---|
| TLV370x | 2.5 − 16 | 250 | 0.56 | 80 | 56 | 83 | 22 | 8 | I | PP |
| TLV340x | 2.5 − 16 | 250 | 0.47 | 80 | 55 | 30 | 5 | − | I | OD |
| TLC3702/4 | 3 − 16 | 1200 | 9 | 5 | 1.1 | 0.65 | 0.5 | 0.125 | − | PP |
| TLC393/339 | 3 − 16 | 1400 | 11 | 5 | 1.1 | 0.55 | 0.22 | − | − | OD |
| TLC372/4 | 3 − 16 | 1000 | 75 | 5 | 0.65 | 0.65 | − | − | − | OD |

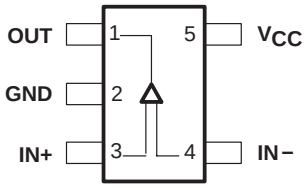
† All specifications are typical values measured at 5 V.

**AVAILABLE OPTIONS†**

| $T_A$ | $V_{IO}$ max AT 25°C | PACKAGED DEVICES | |
|---|---|---|---|
| | | SOT-23 (DBV)‡ | SYMBOL |
| −40°C to 125°C | 5000 μV | TLV3701QDBVREP | VBCE |

† Contact the local TI sales office for availability of other package options.
‡ This package is only available taped and reeled with standard quantities of 3000 pieces per reel.

**DBV PACKAGE**
**(TOP VIEW)**



## absolute maximum ratings over operating free-air temperature range (unless otherwise noted)†

Supply voltage, $V_{CC}$ (see Note 1) . . . . . 17 V
Differential input voltage, $V_{ID}$ . . . . . ±20 V
Input voltage range, $V_I$ (see Notes 1 and 2) . . . . . 0 to $V_{CC}$ + 5 V
Input current range, $I_I$ . . . . . ±10 mA
Output current range, $I_O$ . . . . . ±10 mA
Continuous total power dissipation . . . . . See Dissipation Rating Table
Operating free-air temperature range, $T_A$ . . . . . −40°C to 125°C
Maximum junction temperature, $T_J$ . . . . . 150°C
Storage temperature range, $T_{stg}$ . . . . . −65°C to 150°C
Lead temperature 1,6 mm (1/16 inch) from case for 10 seconds . . . . . 260°C

† Stresses beyond those listed under “absolute maximum ratings” may cause permanent damage to the device. These are stress ratings only, and functional operation of the device at these or any other conditions beyond those indicated under “recommended operating conditions” is not implied. Exposure to absolute-maximum-rated conditions for extended periods may affect device reliability.

NOTES: 1. All voltage values, except differential voltages, are with respect to GND.
2. Input voltage range is limited to 20 V max or $V_{CC}$ + 5 V, whichever is smaller.

**DISSIPATION RATING TABLE**

| PACKAGE | $\theta_{JC}$ (°C/W) | $\theta_{JA}$ (°C/W) | $T_A \le 25°C$ POWER RATING | $T_A = 125°C$ POWER RATING |
|---|---|---|---|---|
| DBV | 55 | 324.1 | 385 mW | 77.1 mW |

## recommended operating conditions

| | | MIN | MAX | UNIT |
|---|---|---|---|---|
| Supply voltage, $V_{CC}$ | Single supply | 2.7 | 16 | V |
| | Split supply | ±1.35 | ±8 | |
| Common-mode input voltage range, $V_{ICR}$ | | −0.1 | $V_{CC}$+5 | V |
| Operating free-air temperature, $T_A$ | | −40 | 125 | °C |

## electrical characteristics at specified operating free-air temperature, $V_{CC}$ = 2.7 V, 5 V, 15 V (unless otherwise noted)

### dc performance

| PARAMETER | | TEST CONDITIONS | $T_A$† | MIN | TYP | MAX | UNIT |
|---|---|---|---|---|---|---|---|
| $V_{IO}$ | Input offset voltage | $V_{IC} = V_{CC}/2$, $R_S = 50\ \Omega$ | 25°C | | 250 | 5000 | μV |
| | | | Full range | | | 7000 | |
| $\alpha_{VIO}$ | Offset voltage drift | | 25°C | | 3 | | μV/°C |
| CMRR | Common-mode rejection ratio | $V_{IC}$ = 0 to 2.7 V, $R_S = 50\ \Omega$ | 25°C | 55 | 72 | | dB |
| | | | Full range | 50 | | | |
| | | $V_{IC}$ = 0 to 5 V, $R_S = 50\ \Omega$ | 25°C | 60 | 76 | | |
| | | | Full range | 55 | | | |
| | | $V_{IC}$ = 0 to 15 V, $R_S = 50\ \Omega$ | 25°C | 65 | 88 | | |
| | | | Full range | 60 | | | |
| $A_{VD}$ | Large-signal differential voltage amplification | | 25°C | | 1000 | | V/mV |

† Full range is −40°C to 125°C for Q suffix.

## electrical characteristics at specified operating free-air temperature, $V_{CC}$ = 2.7 V, 5 V, 15 V (unless otherwise noted) (continued)

### input/output characteristics

| PARAMETER | | TEST CONDITIONS | $T_A$† | MIN | TYP | MAX | UNIT |
|---|---|---|---|---|---|---|---|
| $I_{IO}$ | Input offset current | $V_{IC} = V_{CC}/2$, $R_S = 50\ \Omega$ | 25°C | | 20 | 100 | pA |
| | | | Full range | | | 1000 | |
| $I_{IB}$ | Input bias current | | 25°C | | 80 | 250 | pA |
| | | | Full range | | | 2000 | |
| $r_{i(d)}$ | Differential input resistance | | 25°C | | 300 | | MΩ |
| $V_{OH}$ | High-level output voltage | $V_{IC} = V_{CC}/2$, $I_{OH} = 2\ \mu A$, $V_{ID} = 1$ V | 25°C | | $V_{CC}-$ 0.08 | | mV |
| | | $V_{IC} = V_{CC}/2$, $I_{OH} = -50\ \mu A$, $V_{ID} = 1$ V | 25°C | $V_{CC}-$ 320 | | | |
| | | | Full range | $V_{CC}-$ 450 | | | |
| $V_{OL}$ | Low-level output voltage | $V_{IC} = V_{CC}/2$, $I_{OH} = 2\ \mu A$, $V_{ID} = -1$ V | 25°C | | 8 | | mV |
| | | $V_{IC} = V_{CC}/2$, $I_{OH} = 50\ \mu A$, $V_{ID} = -1$ V | 25°C | | 80 | 200 | |
| | | | Full range | | | 300 | |

† Full range is −40°C to 125°C for Q suffix.

### power supply

| PARAMETER | | TEST CONDITIONS | | $T_A$† | MIN | TYP | MAX | UNIT |
|---|---|---|---|---|---|---|---|---|
| $I_{CC}$ | Supply current | Output state high | | 25°C | | 560 | 800 | nA |
| | | | | Full range | | | 1200 | |
| PSRR | Power supply rejection ratio | $V_{IC} = V_{CC}/2$ V, No load | $V_{CC}$ = 2.7 V to 5 V | 25°C | 75 | 100 | | dB |
| | | | | Full range | 70 | | | |
| | | | $V_{CC}$ = 5 V to 15 V | 25°C | 85 | 105 | | |
| | | | | Full range | 80 | | | |

† Full range is −40°C to 125°C for Q suffix.

## switching characteristics at recommended operating conditions (unless otherwise noted)

| PARAMETER | | TEST CONDITIONS | | MIN | TYP | MAX | UNIT |
|---|---|---|---|---|---|---|---|
| $t_{(PLH)}$ | Propagation response time, low-to-high-level output (see Note 3) | f = 1 kHz, $V_{STEP}$ = 100 mV, $C_L$ = 10 pF, $V_{CC}$ = 2.7 V | Overdrive = 2 mV | | 240 | | µs |
| | | | Overdrive = 10 mV | | 64 | | |
| | | | Overdrive = 50 mV | | 36 | | |
| $t_{(PHL)}$ | Propagation response time, high-to-low-level output (see Note 3) | | Overdrive = 2 mV | | 167 | | |
| | | | Overdrive = 10 mV | | 67 | | |
| | | | Overdrive = 50 mV | | 37 | | |
| $t_r$ | Rise time | $C_L$ = 10 pF, $V_{CC}$ = 2.7 V | | | 7 | | µs |
| $t_f$ | Fall time | $C_L$ = 10 pF, $V_{CC}$ = 2.7 V | | | 9 | | µs |

NOTE 3: The response time specified is the interval between the input step function and the instant when the output crosses 1.4 V. Propagation responses are longer at higher supply voltages, refer to Figures 11−16 for further details.

## TYPICAL CHARACTERISTICS

### Table of Graphs

| | | | FIGURE |
|---|---|---|---|
| | Input bias/offset current | vs Free-air temperature | 1 |
| $V_{OL}$ | Low-level output voltage | vs Low-level output current | 2, 4, 6 |
| $V_{OH}$ | High-level output voltage | vs High-level output current | 3, 5, 7 |
| $I_{CC}$ | Supply current | vs Supply voltage | 8 |
| | | vs Free-air temperature | 9 |
| | Output fall time/rise time | vs Supply voltage | 10 |
| | Low-to-high level output response for various input overdrives | | 11, 13, 15 |
| | High-to-low level output response for various input overdrives | | 12, 14, 16 |

**INPUT BIAS/OFFSET CURRENT vs FREE-AIR TEMPERATURE**

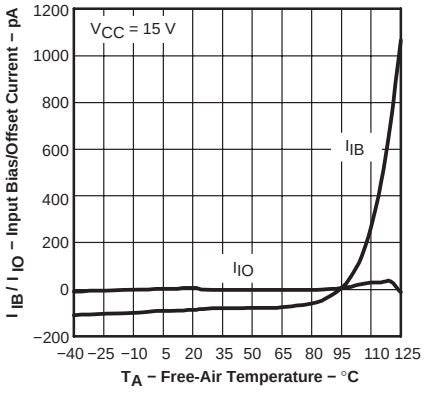



Figure 1

**LOW-LEVEL OUTPUT VOLTAGE vs LOW-LEVEL OUTPUT CURRENT**

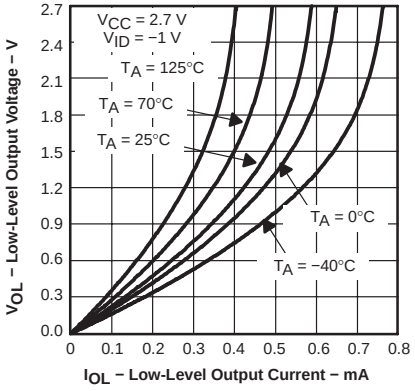



Figure 2

**HIGH-LEVEL OUTPUT VOLTAGE vs HIGH-LEVEL OUTPUT CURRENT**

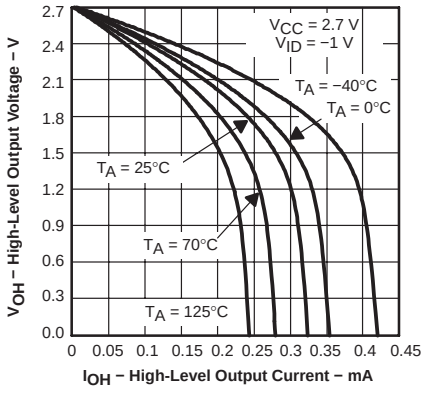



Figure 3

**LOW-LEVEL OUTPUT VOLTAGE vs LOW-LEVEL OUTPUT CURRENT**

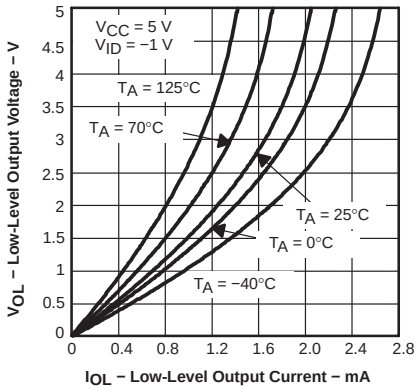



Figure 4

**HIGH-LEVEL OUTPUT VOLTAGE vs HIGH-LEVEL OUTPUT CURRENT**

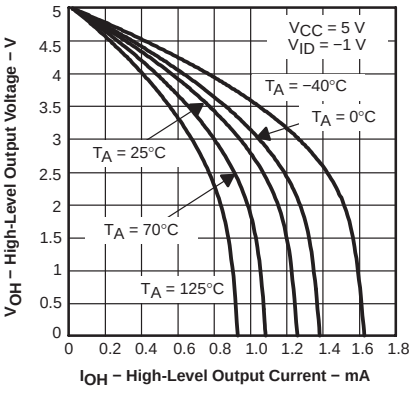



Figure 5

## TYPICAL CHARACTERISTICS

**LOW-LEVEL OUTPUT VOLTAGE vs LOW-LEVEL OUTPUT CURRENT**

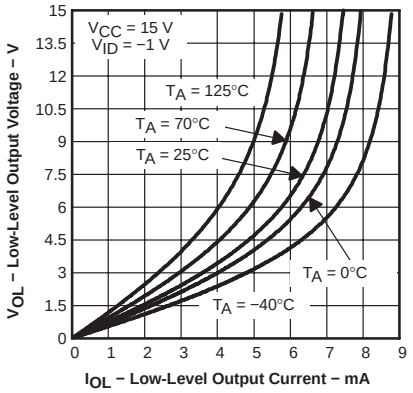



Figure 6

**HIGH-LEVEL OUTPUT VOLTAGE vs HIGH-LEVEL OUTPUT CURRENT**

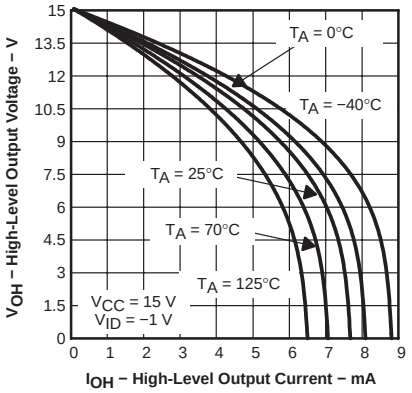



Figure 7

**SUPPLY CURRENT vs SUPPLY VOLTAGE**

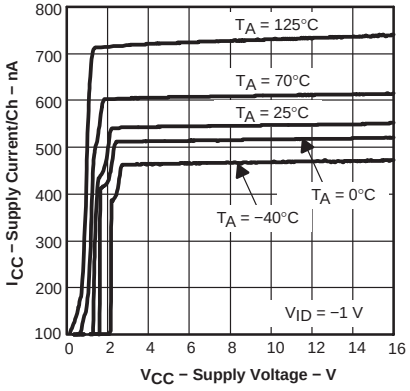



Figure 8

**SUPPLY CURRENT vs FREE-AIR TEMPERATURE**

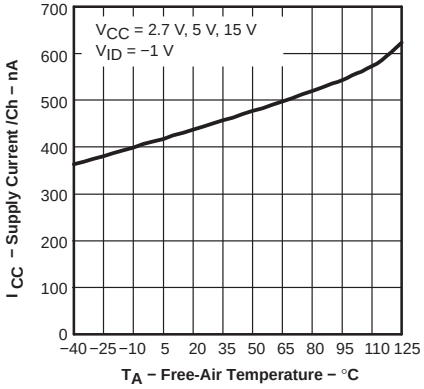



Figure 9

**OUTPUT RISE/FALL TIME vs SUPPLY VOLTAGE**

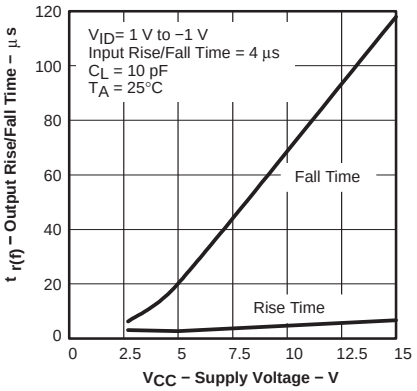



Figure 10

**LOW-TO-HIGH OUTPUT RESPONSE FOR VARIOUS INPUT OVERDRIVES**

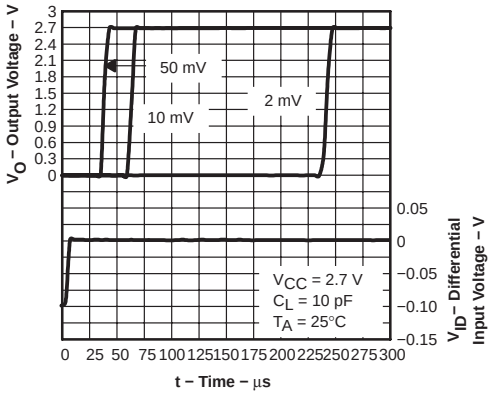



Figure 11

**HIGH-TO-LOW LEVEL OUTPUT RESPONSE FOR VARIOUS INPUT OVERDRIVES**

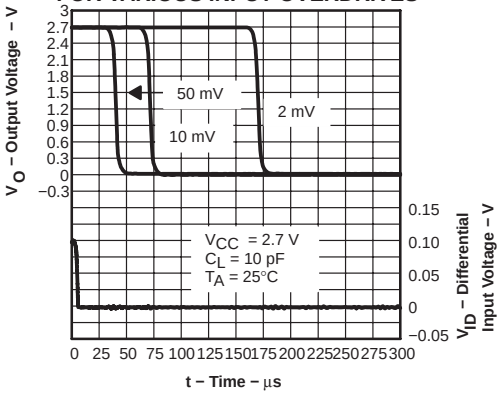



Figure 12

## TYPICAL CHARACTERISTICS

**LOW-TO-HIGH LEVEL OUTPUT RESPONSE FOR VARIOUS INPUT OVERDRIVES**

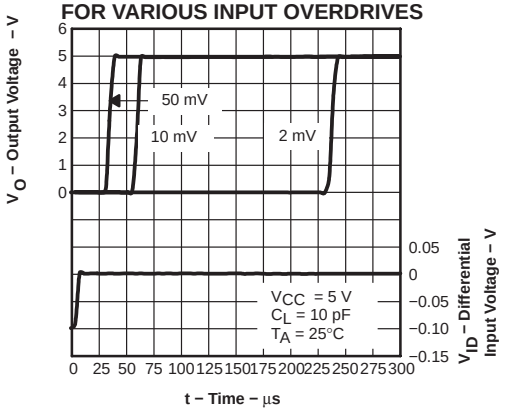



**Figure 13**

**HIGH-TO-LOW LEVEL OUTPUT RESPONSE FOR VARIOUS INPUT OVERDRIVES**

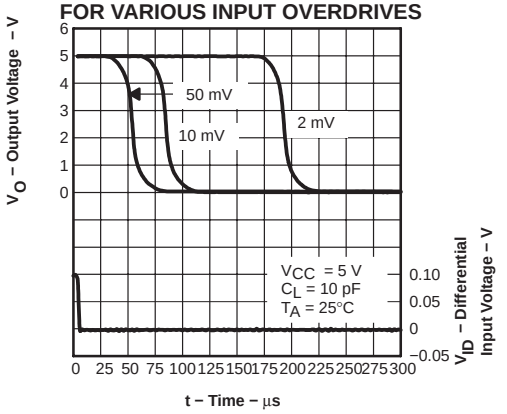



**Figure 14**

**LOW-TO-HIGH LEVEL OUTPUT RESPONSE FOR VARIOUS INPUT OVERDRIVES**

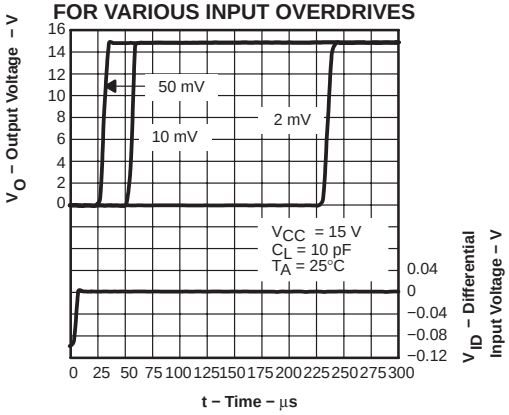



**Figure 15**

**HIGH-TO-LOW LEVEL OUTPUT RESPONSE FOR VARIOUS INPUT OVERDRIVES**

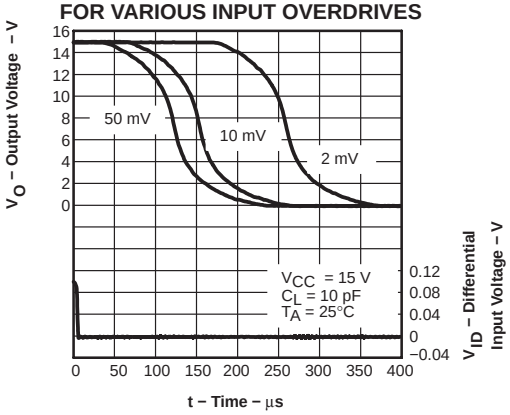



**Figure 16**

## PACKAGING INFORMATION

| Orderable part number | Status (1) | Material type (2) | Package \| Pins | Package qty \| Carrier | RoHS (3) | Lead finish/ Ball material (4) | MSL rating/ Peak reflow (5) | Op temp (°C) | Part marking (6) |
|---|---|---|---|---|---|---|---|---|---|
| TLV3701QDBVREP | Active | Production | SOT-23 (DBV) \| 5 | 3000 \| LARGE T&R | Yes | NIPDAU | Level-1-260C-UNLIM | -40 to 125 | VBCQ |
| TLV3701QDBVREP.A | Active | Production | SOT-23 (DBV) \| 5 | 3000 \| LARGE T&R | Yes | NIPDAU | Level-1-260C-UNLIM | -40 to 125 | VBCQ |
| V62/04726-01XE | Active | Production | SOT-23 (DBV) \| 5 | 3000 \| LARGE T&R | Yes | NIPDAU | Level-1-260C-UNLIM | -40 to 125 | VBCQ |

(1) **Status:** For more details on status, see our product life cycle.

(2) **Material type:** When designated, preproduction parts are prototypes/experimental devices, and are not yet approved or released for full production. Testing and final process, including without limitation quality assurance, reliability performance testing, and/or process qualification, may not yet be complete, and this item is subject to further changes or possible discontinuation. If available for ordering, purchases will be subject to an additional waiver at checkout, and are intended for early internal evaluation purposes only. These items are sold without warranties of any kind.

(3) **RoHS values:** Yes, No, RoHS Exempt. See the TI RoHS Statement for additional information and value definition.

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

(5) **MSL rating/Peak reflow:** The moisture sensitivity level ratings and peak solder (reflow) temperatures. In the event that a part has multiple moisture sensitivity ratings, only the lowest level per JEDEC standards is shown. Refer to the shipping label for the actual reflow temperature that will be used to mount the part to the printed circuit board.

(6) **Part marking:** There may be an additional marking, which relates to the logo, the lot trace code information, or the environmental category of the part.

Multiple part markings will be inside parentheses. Only one part marking contained in parentheses and separated by a "~" will appear on a part. If a line is indented then it is a continuation of the previous line and the two combined represent the entire part marking for that device.



**OTHER QUALIFIED VERSIONS OF TLV3701-EP :**

- Catalog : TLV3701

- Automotive : TLV3701-Q1

NOTE: Qualified Version Definitions:

- Catalog - TI's standard catalog product
- Automotive - Q100 devices qualified for high-reliability automotive applications targeting zero defects

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