

## FAMILY OF NANOPOWER PUSH-PULL OUTPUT COMPARATORS

### FEATURES

- Qualification in Accordance With AEC-Q100†
- Qualified for Automotive Applications
- Customer-Specific Configuration Control Can Be Supported Along With Major-Change Approval
- ESD Protection Exceeds 2000 V Per MIL-STD-883, Method 3015; Exceeds 200 V Using Machine Model (C = 200 pF, R = 0)
- Low Supply Current . . . 560 nA/Per Channel
- Input Common-Mode Range Exceeds the Rails . . . -0.1 V to V<sub>CC</sub> + 5 V
- Supply Voltage Range . . . 2.7 V to 16 V
- Reverse Battery Protection Up to 18 V
- Push-Pull CMOS Output Stage
- Specified Temperature Range
  - -40°C to 125°C – Automotive Grade
- Ultrasmall Packaging
  - 5-Pin SOT-23 (TLV3701)
- Universal Op-Amp EVM (Reference SLOU060 for more information)

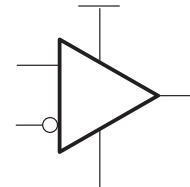
† Contact factory for details. Q100 qualification data available on request.

### APPLICATIONS

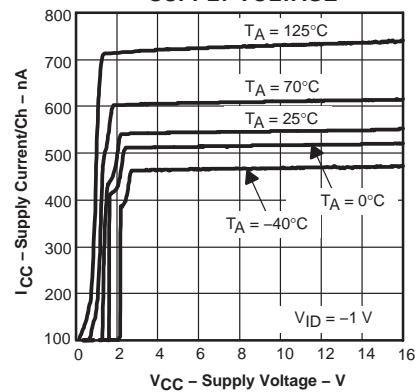
- Low Power Automotive Electronics
- Security Detection Systems

### DESCRIPTION

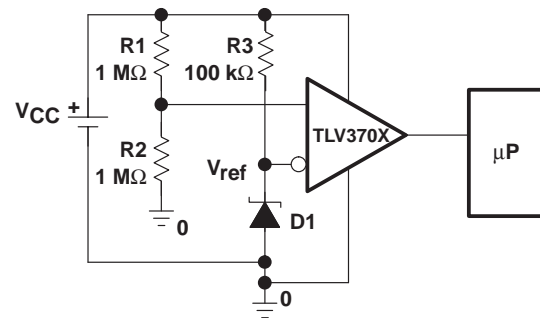
The TLV370x is Texas Instruments' first family of nanopower comparators with only 560 nA per channel supply current, which make this device ideal for low power applications.



**SUPPLY CURRENT  
vs  
SUPPLY VOLTAGE**



### high side voltage sense circuit



Please be aware that an important notice concerning availability, standard warranty, and use in critical applications of Texas Instruments semiconductor products and disclaimers thereto appears at the end of this data sheet.

**TLV3701-Q1**  
**TLV3702-Q1**  
**TLV3704-Q1**

SGLS154C – NOVEMBER 2000 – REVISED NOVEMBER 2003

**DESCRIPTION (continued)**

The TLV370x has a minimum operating supply voltage of 2.7 V over the extended automotive temperature range ( $T_A = -40^{\circ}\text{C}$  to  $125^{\circ}\text{C}$ ), 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 low power 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.

Devices are available in SOIC with the singles in the small SOT-23 package. Other package options may be made available upon request.

**A SELECTION OF OUTPUT COMPARATORST**

DEVICE	V <sub>CC</sub> (V)	V <sub>IO</sub> (μV)	I <sub>CC/Ch</sub> (μA)	I <sub>B</sub> (pA)	t <sub>PLH</sub> (μs)	t <sub>PHL</sub> (μs)	t <sub>f</sub> (μs)	t <sub>r</sub> (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.

**TLV3701 AVAILABLE OPTIONS**

T <sub>A</sub>	V <sub>IOmax</sub> AT 25°C	PACKAGED DEVICES		
		SMALL OUTLINE (D)	SOT-23 (DBV)‡	SYMBOL
-40°C to 125°C	5000 μV	TLV3701QDRQ1†	TLV3701QDBVRQ1	VBCQ

† Product Preview

‡ This package is only available taped and reeled with standard quantities of 3000 pieces per reel.

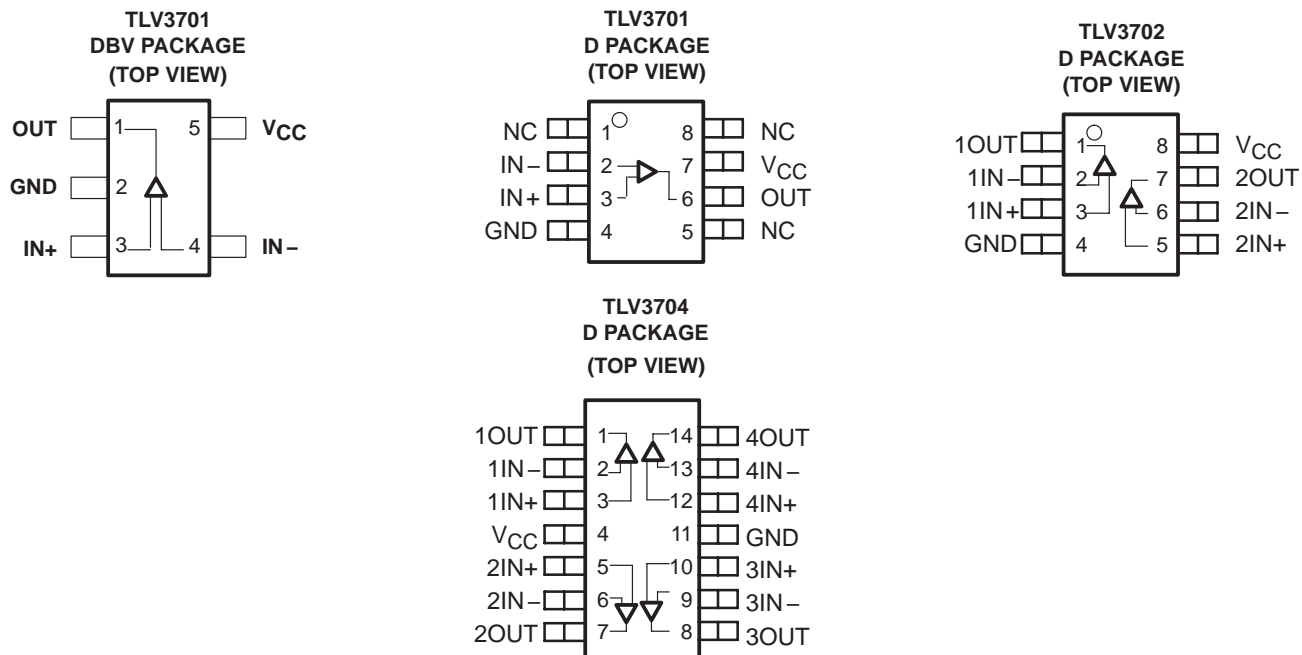
**TLV3702 AVAILABLE OPTIONS**

T <sub>A</sub>	V <sub>IOmax</sub> AT 25°C	PACKAGED DEVICES	
		SMALL OUTLINE (D)	SYMBOL
-40°C to 125°C	5000 μV	TLV3702QDRQ1	3702Q1

**TLV3704 AVAILABLE OPTIONS**

T <sub>A</sub>	V <sub>IOmax</sub> AT 25°C	PACKAGED DEVICES
		SMALL OUTLINE (D)
-40°C to 125°C	5000 μV	TLV3704QDRQ1†

† Product Preview



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

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

† 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	$\theta_{JC}$ ( $^\circ\text{C}/\text{W}$ )	$\theta_{JA}$ ( $^\circ\text{C}/\text{W}$ )	$T_A \leq 25^\circ\text{C}$ POWER RATING	$T_A = 125^\circ\text{C}$ POWER RATING
D (8)	38.3	176	710 mW	142 mW
D (14)	26.9	122.6	1022 mW	204.4 mW
DBV (5)	55	324.1	385 mW	77.1 mW

**TLV3701-Q1**  
**TLV3702-Q1**  
**TLV3704-Q1**

SGLS154C – NOVEMBER 2000 – REVISED NOVEMBER 2003

**recommended operating conditions**

		MIN	MAX	UNIT
Supply voltage, $V_{CC}$	Single supply	2.7	16	V
	Split supply	$\pm 1.35$	$\pm 8$	
Common-mode input voltage range, $V_{ICR}$		-0.1	$V_{CC}+5$	V
Operating free-air temperature, $T_A$	Q-suffix	-40	125	$^{\circ}\text{C}$

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

**dc performance**

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

$\dagger$  Full range is -40 $^{\circ}\text{C}$  to 125 $^{\circ}\text{C}$  for Q suffix.

**input/output characteristics**

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

$\dagger$  Full range is -40 $^{\circ}\text{C}$  to 125 $^{\circ}\text{C}$  for Q suffix.

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

**power supply**

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

† Full range is  $-40^\circ\text{C}$  to  $125^\circ\text{C}$  for Q suffix.

**switching characteristics at recommended operating conditions,  $V_{CC} = 2.7\text{ V}, 5\text{ V}, 15\text{ V}$ ,  $T_A = 25^\circ\text{C}$  (unless otherwise noted)**

PARAMETER		TEST CONDITIONS		MIN	TYP	MAX	UNIT
$t_{(PLH)}$	Propagation response time, low-to-high-level output (see Note 3)	$f = 1\text{ kHz}$ , $V_{STEP} = 100\text{ mV}$ , $C_L = 10\text{ pF}$ , $V_{CC} = 2.7\text{ V}$ , $V_{IC} = V_{CC}/2$		Overdrive = 2 mV	240		$\mu\text{s}$
				Overdrive = 10 mV	64	150†	
				Overdrive = 50 mV	36		
$t_{(PHL)}$	Propagation response time, high-to-low-level output (see Note 3)	$f = 1\text{ kHz}$ , $V_{STEP} = 100\text{ mV}$ , $C_L = 10\text{ pF}$ , $V_{CC} = 2.7\text{ V}$ , $V_{IC} = V_{CC}/2$		Overdrive = 2 mV	167		$\mu\text{s}$
				Overdrive = 10 mV	67	150†	
				Overdrive = 50 mV	37		
$t_r$	Rise time	$C_L = 10\text{ pF}$ , $V_{CC} = 2.7\text{ V}$			7		$\mu\text{s}$
$t_f$	Fall time	$C_L = 10\text{ pF}$ , $V_{CC} = 2.7\text{ V}$			9		$\mu\text{s}$

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.

† This limit applies to the TLV3701-Q1 only.

**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

TYPICAL CHARACTERISTICS

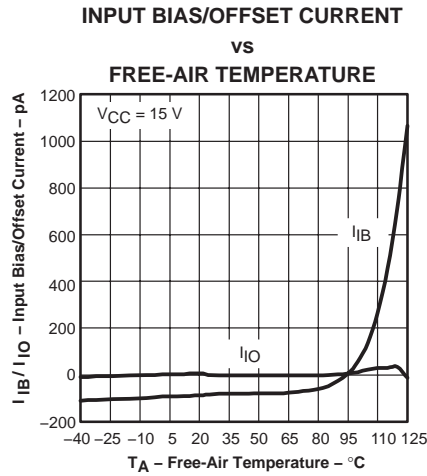


Figure 1

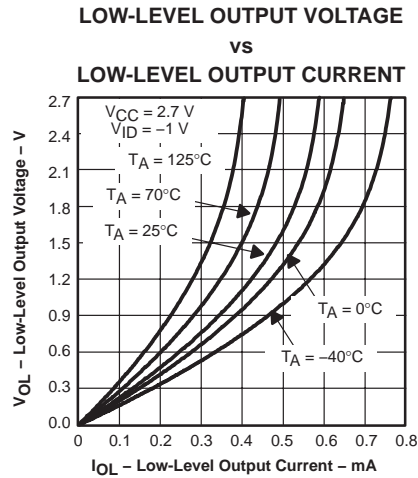


Figure 2

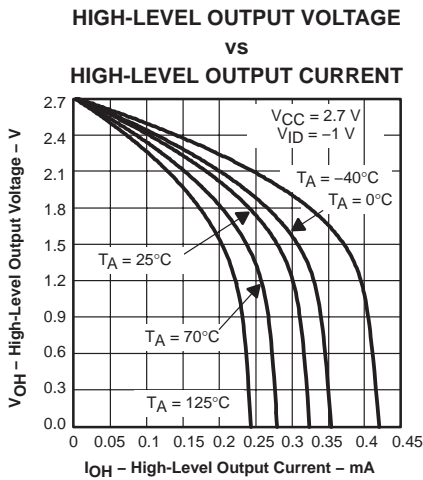


Figure 3

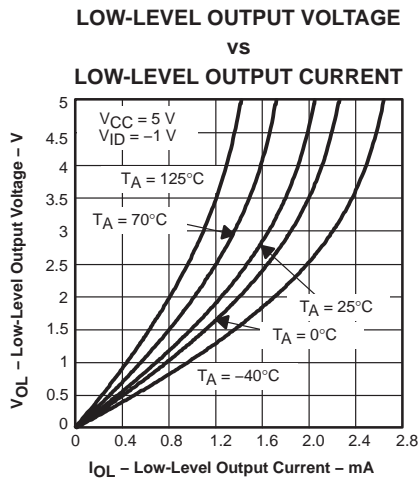


Figure 4

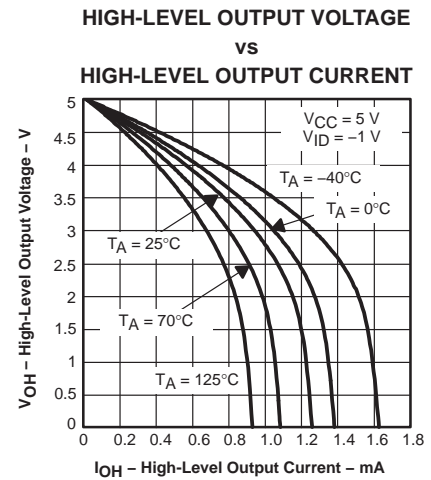


Figure 5

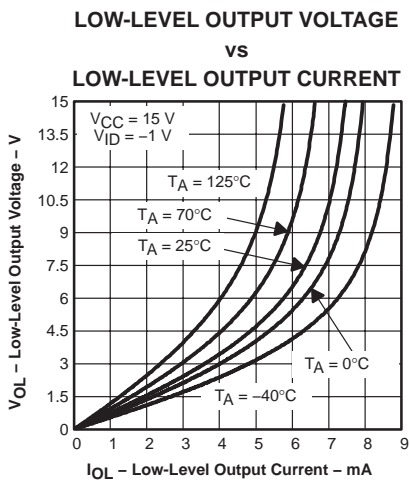


Figure 6

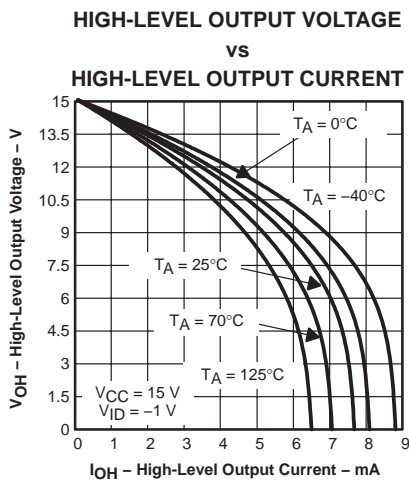


Figure 7

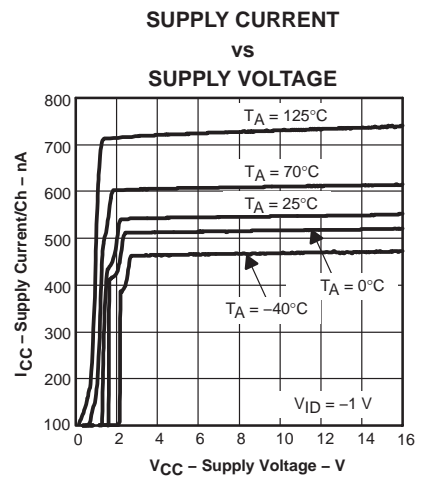


Figure 8

TYPICAL CHARACTERISTICS

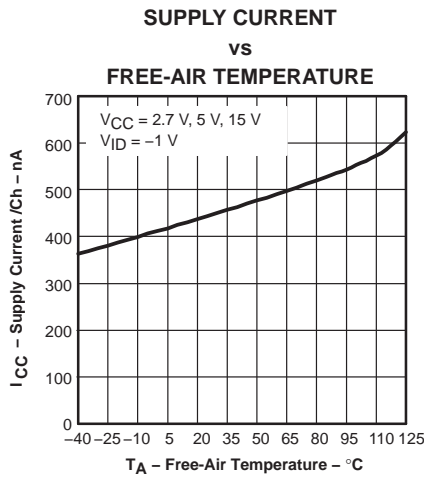


Figure 9

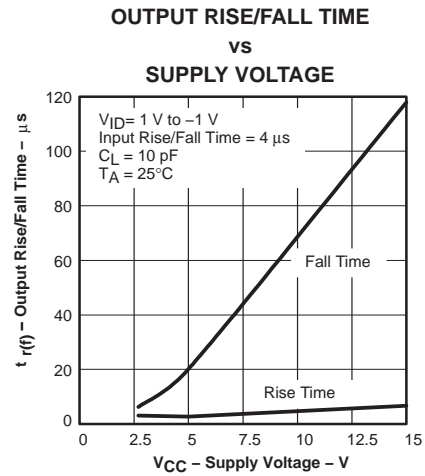


Figure 10

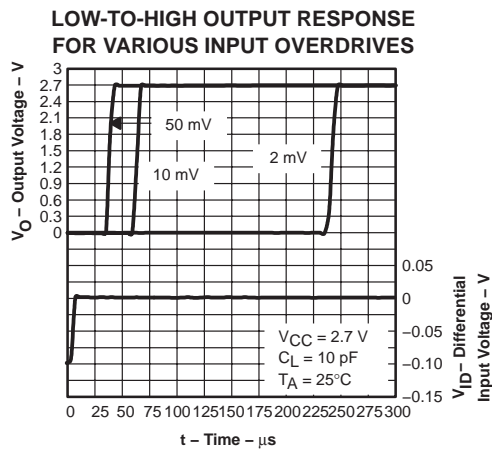


Figure 11

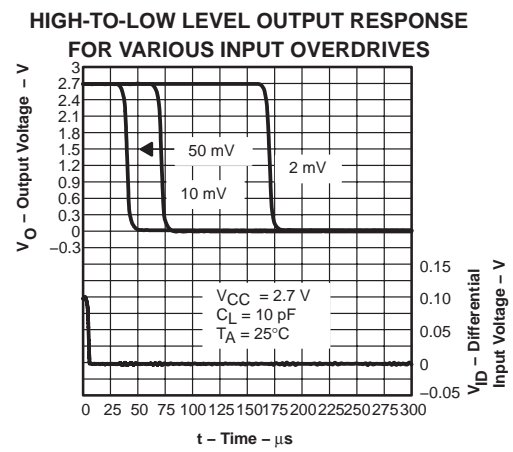


Figure 12

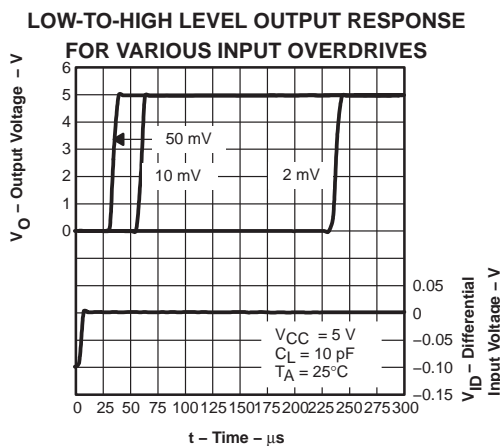


Figure 13

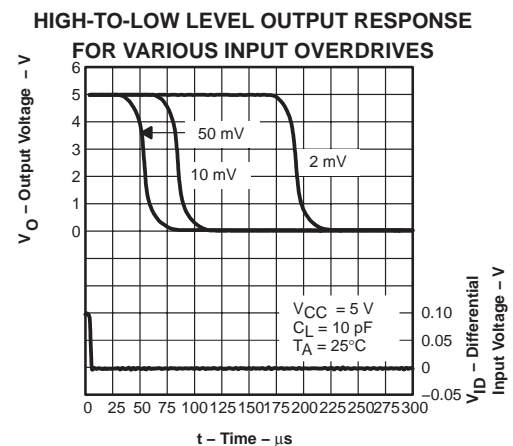


Figure 14

TYPICAL CHARACTERISTICS

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

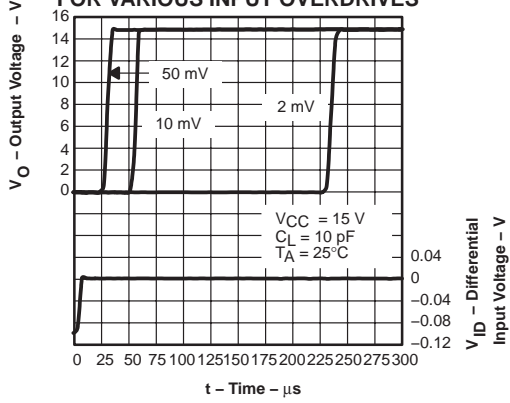


Figure 15

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

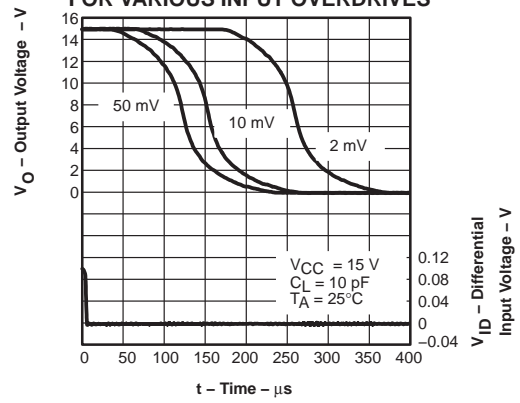


Figure 16



**PACKAGING INFORMATION**

Orderable Device	Status <sup>(1)</sup>	Package Type	Package Drawing	Pins	Package Qty	Eco Plan <sup>(2)</sup>	Lead/Ball Finish	MSL Peak Temp <sup>(3)</sup>
TLV3701QDBVRQ1	ACTIVE	SOT-23	DBV	5	3000	None	Call TI	Level-1-220C-UNLIM
TLV3702QDRQ1	ACTIVE	SOIC	D	8	2500	Pb-Free (RoHS)	CU NIPDAU	Level-2-250C-1 YEAR/ Level-1-235C-UNLIM

<sup>(1)</sup> 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.

**OBSELETE:** TI has discontinued the production of the device.

<sup>(2)</sup> Eco Plan - May not be currently available - please check <http://www.ti.com/productcontent> for the latest availability information and additional product content details.

**None:** Not yet available Lead (Pb-Free).

**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.

**Green (RoHS & no Sb/Br):** TI defines "Green" to mean "Pb-Free" and in addition, uses package materials that do not contain halogens, including bromine (Br) or antimony (Sb) above 0.1% of total product weight.

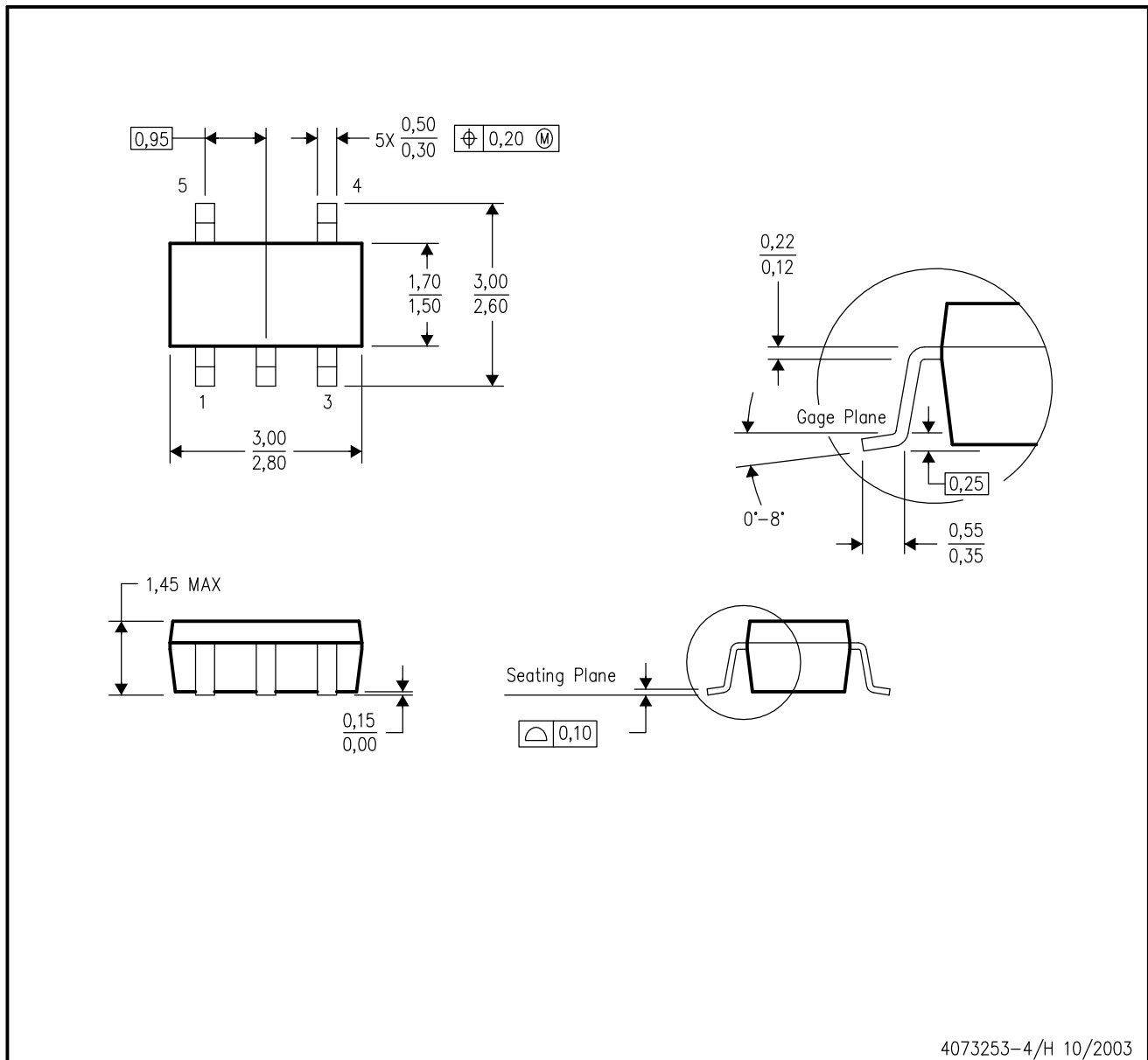
<sup>(3)</sup> MSL, Peak Temp. -- The Moisture Sensitivity Level rating according to the JEDEC industry standard classifications, and peak solder temperature.

**Important Information and Disclaimer:**The information provided on this page represents TI's knowledge and belief as of the date that it is provided. TI bases its knowledge and belief on information provided by third parties, and makes no representation or warranty as to the accuracy of such information. Efforts are underway to better integrate information from third parties. TI has taken and continues to take reasonable steps to provide representative and accurate information but may not have conducted destructive testing or chemical analysis on incoming materials and chemicals. TI and TI suppliers consider certain information to be proprietary, and thus CAS numbers and other limited information may not be available for release.

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.

DBV (R-PDSO-G5)

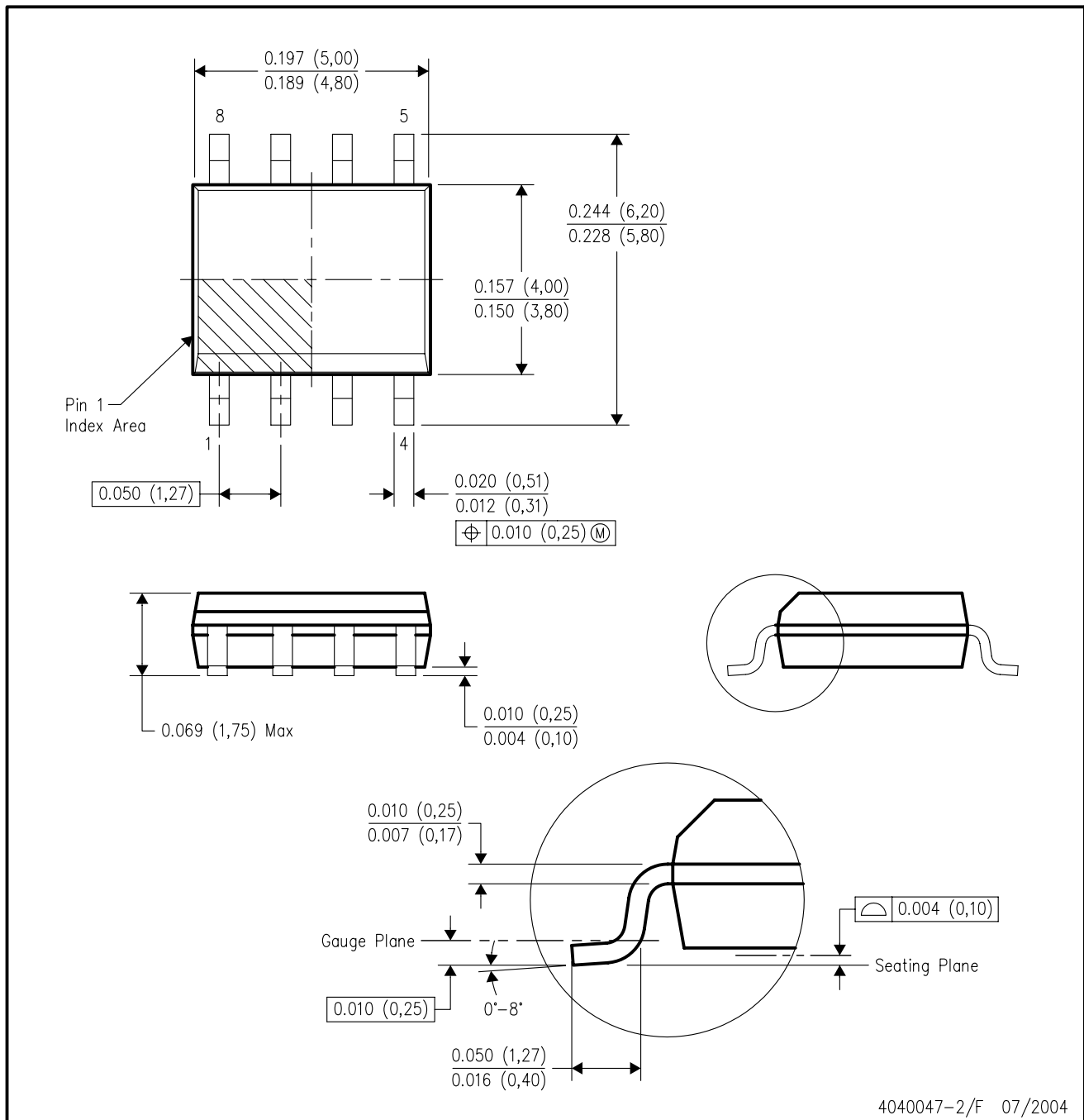
PLASTIC SMALL-OUTLINE PACKAGE



- NOTES:
- A. All linear dimensions are in millimeters.
  - B. This drawing is subject to change without notice.
  - C. Body dimensions do not include mold flash or protrusion.
  - D. Falls within JEDEC MO-178 Variation AA.

D (R-PDSO-G8)

PLASTIC SMALL-OUTLINE PACKAGE



- NOTES:
- A. All linear dimensions are in inches (millimeters).
  - B. This drawing is subject to change without notice.
  - C. Body dimensions do not include mold flash or protrusion not to exceed 0.006 (0,15).
  - D. Falls within JEDEC MS-012 variation AA.

## IMPORTANT NOTICE

Texas Instruments Incorporated and its subsidiaries (TI) reserve the right to make corrections, modifications, enhancements, improvements, and other changes to its products and services at any time and to discontinue any product or service without notice. Customers should obtain the latest relevant information before placing orders and should verify that such information is current and complete. All products are sold subject to TI's terms and conditions of sale supplied at the time of order acknowledgment.

TI warrants performance of its hardware products to the specifications applicable at the time of sale in accordance with TI's standard warranty. Testing and other quality control techniques are used to the extent TI deems necessary to support this warranty. Except where mandated by government requirements, testing of all parameters of each product is not necessarily performed.

TI assumes no liability for applications assistance or customer product design. Customers are responsible for their products and applications using TI components. To minimize the risks associated with customer products and applications, customers should provide adequate design and operating safeguards.

TI does not warrant or represent that any license, either express or implied, is granted under any TI patent right, copyright, mask work right, or other TI intellectual property right relating to any combination, machine, or process in which TI products or services are used. Information published by TI regarding third-party products or services does not constitute a license from TI to use such products or services or a warranty or endorsement thereof. Use of such information may require a license from a third party under the patents or other intellectual property of the third party, or a license from TI under the patents or other intellectual property of TI.

Reproduction of information in TI data books or data sheets is permissible only if reproduction is without alteration and is accompanied by all associated warranties, conditions, limitations, and notices. Reproduction of this information with alteration is an unfair and deceptive business practice. TI is not responsible or liable for such altered documentation.

Resale of TI products or services with statements different from or beyond the parameters stated by TI for that product or service voids all express and any implied warranties for the associated TI product or service and is an unfair and deceptive business practice. TI is not responsible or liable for any such statements.

Following are URLs where you can obtain information on other Texas Instruments products and application solutions:

<b>Products</b>		<b>Applications</b>	
Amplifiers	<a href="http://amplifier.ti.com">amplifier.ti.com</a>	Audio	<a href="http://www.ti.com/audio">www.ti.com/audio</a>
Data Converters	<a href="http://dataconverter.ti.com">dataconverter.ti.com</a>	Automotive	<a href="http://www.ti.com/automotive">www.ti.com/automotive</a>
DSP	<a href="http://dsp.ti.com">dsp.ti.com</a>	Broadband	<a href="http://www.ti.com/broadband">www.ti.com/broadband</a>
Interface	<a href="http://interface.ti.com">interface.ti.com</a>	Digital Control	<a href="http://www.ti.com/digitalcontrol">www.ti.com/digitalcontrol</a>
Logic	<a href="http://logic.ti.com">logic.ti.com</a>	Military	<a href="http://www.ti.com/military">www.ti.com/military</a>
Power Mgmt	<a href="http://power.ti.com">power.ti.com</a>	Optical Networking	<a href="http://www.ti.com/opticalnetwork">www.ti.com/opticalnetwork</a>
Microcontrollers	<a href="http://microcontroller.ti.com">microcontroller.ti.com</a>	Security	<a href="http://www.ti.com/security">www.ti.com/security</a>
		Telephony	<a href="http://www.ti.com/telephony">www.ti.com/telephony</a>
		Video & Imaging	<a href="http://www.ti.com/video">www.ti.com/video</a>
		Wireless	<a href="http://www.ti.com/wireless">www.ti.com/wireless</a>

Mailing Address: Texas Instruments  
Post Office Box 655303 Dallas, Texas 75265