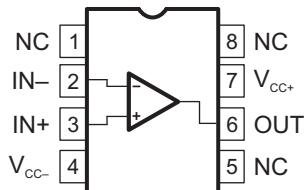


## LOW-POWER SINGLE OPERATIONAL AMPLIFIER

### FEATURES

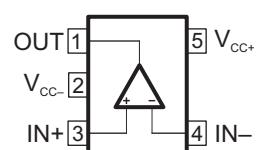
- **Wide Power-Supply Range**
  - Single Supply...3 V to 30 V
  - Dual Supply... $\pm 1.5$  V to  $\pm 15$  V
- **Large Output Voltage Swing...**  
0 V to 3.5 V (Min) ( $V_{CC} = 5$  V)
- **Low Supply Current...**500  $\mu$ A (Typ)
- **Low Input Bias Current...**20 nA (Typ)
- **Stable With High Capacitive Loads**

**D (SOIC) PACKAGE  
(TOP VIEW)**



NC – No internal connection

**DBV (SOT-23-5) PACKAGE  
(TOP VIEW)**



### DESCRIPTION/ORDERING INFORMATION

The TS321 is a bipolar operational amplifier for cost-sensitive applications in which space savings are important.

#### ORDERING INFORMATION

<b>T<sub>A</sub></b>	<b>PACKAGE<sup>(1)</sup></b>		<b>ORDERABLE PART NUMBER</b>	<b>TOP-SIDE MARKING<sup>(2)</sup></b>
–40°C to 125°C	SOIC – D	Tube of 75	TS321ID	SR321I
		Reel of 2500	TS321IDR	
	SOT-23-5 – DBV	Reel of 3000	TS321IDBVR	9C1_
		Reel of 250	TS321IDBVT	

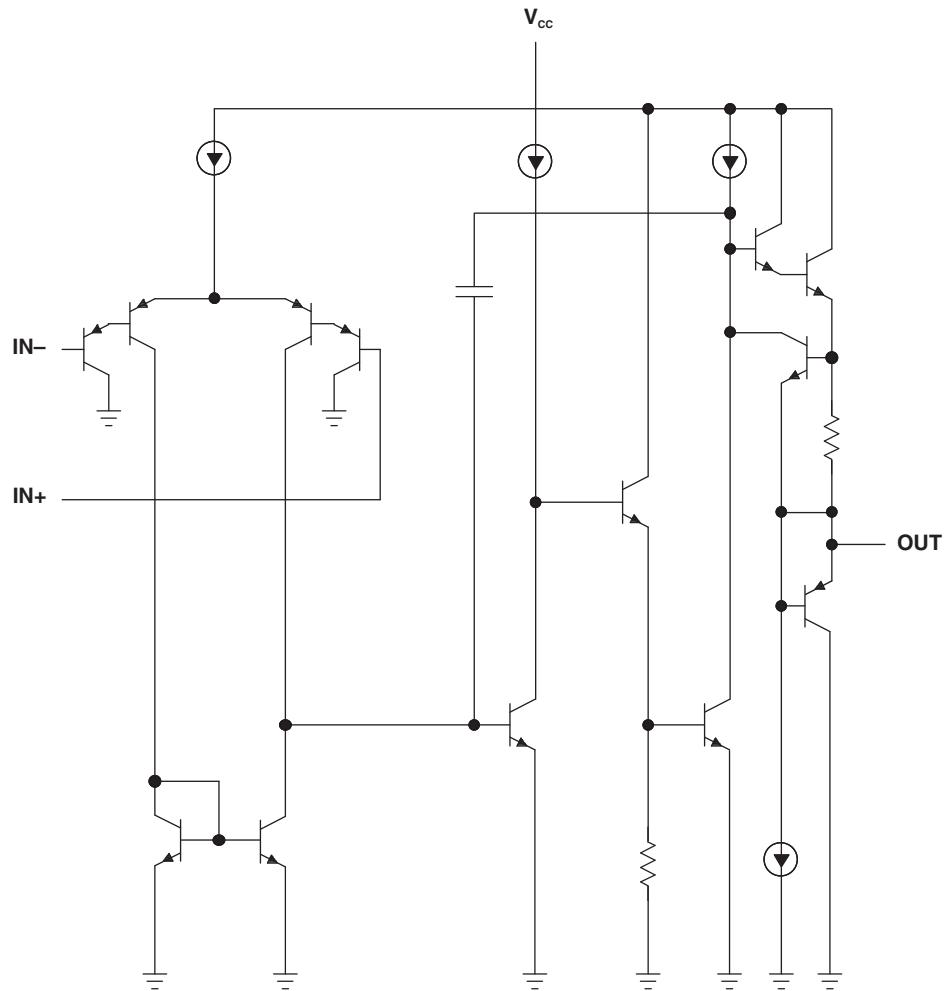
(1) For the most current package and ordering information, see the Package Option Addendum at the end of this document, or see the TI website at [www.ti.com](http://www.ti.com).

(2) DBV: The actual top-side marking has one additional character that designates the assembly/test site.



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.

## SCHEMATIC DIAGRAM



## Absolute Maximum Ratings<sup>(1)</sup>

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

		MIN	MAX	UNIT	
V <sub>CC</sub>	Supply voltage <sup>(2)</sup>	Single	32	V	
		Dual	±16		
V <sub>ID</sub>	Differential input voltage <sup>(3)</sup>		32	V	
V <sub>I</sub>	Input voltage range <sup>(2)(4)</sup>		-0.3	32	V
I <sub>I</sub>	Input current <sup>(4)</sup>		50	mA	
t <sub>short</sub>	Duration of output short circuit to ground		Unlimited		
θ <sub>JA</sub>	Package thermal impedance, junction to free air <sup>(5)(6)</sup>	D package	97	°C/W	
		DBV package	206		
T <sub>J</sub>	Operating virtual junction temperature		150	°C	
T <sub>stg</sub>	Storage temperature range	-65	150	°C	

- (1) 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.
- (2) These voltage values are with respect to the midpoint between V<sub>CC+</sub> and V<sub>CC-</sub>.
- (3) Differential voltages are at IN+ with respect to IN-.
- (4) Neither input must ever be more positive than V<sub>CC+</sub> or more negative than V<sub>CC-</sub>.
- (5) Maximum power dissipation is a function of T<sub>J(max)</sub>, θ<sub>JA</sub>, and T<sub>A</sub>. The maximum allowable power dissipation at any allowable ambient temperature is P<sub>D</sub> = (T<sub>J(max)</sub> - T<sub>A</sub>)/θ<sub>JA</sub>. Selecting the maximum of 150°C can affect reliability.
- (6) The package thermal impedance is calculated in accordance with JESD 51-7.

## Recommended Operating Conditions

		MIN	MAX	UNIT
V <sub>CC</sub>	Supply voltage	Single supply	3	V
		Dual supply	±1.5	
T <sub>A</sub>	Operating free-air temperature	-40	125	°C

## Electrical Characteristics

$V_{CC+} = 5 \text{ V}$ ,  $V_{CC-} = \text{GND}$ ,  $V_O = 1.4 \text{ V}$  (unless otherwise noted)

PARAMETER	TEST CONDITIONS	$T_A$	MIN	TYP	MAX	UNIT
$V_{IO}$ Input offset voltage	$R_S = 0, 5 \text{ V} < V_{CC+} < 30 \text{ V}$ , $0 < V_{IC} < (V_{CC+} - 1.5 \text{ V})$	25°C		0.5	4	mV
		Full range			5	
$I_{IO}$ Input offset current		25°C		2	30	nA
		Full range			50	
$I_{IB}$ Input bias current <sup>(1)</sup>		25°C		20	150	nA
		Full range			200	
$A_{VD}$ Large-signal differential voltage amplification	$V_{CC} = 15 \text{ V}$ , $R_L = 2 \text{ k}\Omega$ , $V_O = 1.4 \text{ V}$ to $11.4 \text{ V}$	25°C	50	100		V/mV
		Full range	25			
$V_{ICR}$ Common-mode input voltage <sup>(2)</sup>	$V_{CC} = 30 \text{ V}$	25°C	0		$V_{CC+} - 1.5$	V
		Full range	0		$V_{CC+} - 2$	
$V_{OH}$ High-level output voltage	$V_{CC} = 30 \text{ V}$	$R_L = 2 \text{ k}\Omega$	25°C	26	27	V
			Full range	25.5		
		$R_L = 10 \text{ k}\Omega$	25°C	27	28	
			Full range	26.5		
	$V_{CC} = 5 \text{ V}$	$R_L = 2 \text{ k}\Omega$	25°C	3.5		
			Full range	3		
$V_{OL}$ Low-level output voltage	$R_L = 10 \text{ k}\Omega$	25°C		5	15	V
		Full range			20	
GBP	Gain bandwidth product	$V_{CC} = 30 \text{ V}$ , $V_I = 10 \text{ mV}$ , $R_L = 2 \text{ k}\Omega$ , $f = 100 \text{ kHz}$ , $C_L = 100 \text{ pF}$	25°C		0.8	MHz
SR	Slew rate	$V_{CC} = 15 \text{ V}$ , $V_I = 0.5 \text{ V}$ to $3 \text{ V}$ , $R_L = 2 \text{ k}\Omega$ , $C_L = 100 \text{ pF}$ , unity gain	25°C		0.4	V/μs
$\phi_m$	Phase margin		25°C		60	°
CMRR	Common-mode rejection ratio	$R_S \leq 10 \text{ k}\Omega$	25°C	65	85	dB
$I_{SOURCE}$	Output source current	$V_{CC} = 15 \text{ V}$ , $V_O = 2 \text{ V}$ , $V_{ID} = 1 \text{ V}$	25°C	20	40	mA
$I_{SINK}$ Output sink current		$V_{CC} = 15 \text{ V}$ , $V_{ID} = 1 \text{ V}$	25°C	10	20	mA
		$V_O = 0.2 \text{ V}$	25°C	12	50	μA
$I_O$	Short-circuit to GND	$V_{CC} = 15 \text{ V}$	25°C		40	mA
SVR	Supply-voltage rejection ratio	$V_{CC} = 5 \text{ V}$ to $30 \text{ V}$	25°C	65	110	dB
$I_{CC}$ Total supply current	No load	$V_{CC} = 5 \text{ V}$	25°C		500	800
		$V_{CC} = 30 \text{ V}$			600	900
		$V_{CC} = 5 \text{ V}$	Full range		600	900
		$V_{CC} = 30 \text{ V}$				1000
THD	Total harmonic distortion	$V_{CC} = 30 \text{ V}$ , $V_O = 2 \text{ V}_{pp}$ , $A_V = 20 \text{ dB}$ , $R_L = 2 \text{ k}\Omega$ , $f = 1 \text{ kHz}$ , $C_L = 100 \text{ pF}$	25°C		0.015	%
$e_N$	Equivalent input noise voltage	$V_{CC} = 30 \text{ V}$ , $f = 1 \text{ kHz}$ , $R_S = 100 \Omega$	25°C		50	nV/√Hz

- (1) The direction of the input current is out of the device. This current essentially is constant, independent of the state of the output, so no loading change exists on the input lines.
- (2) The input common-mode voltage of either input signal should not be allowed to go negative by more than 0.3 V. The upper end of the common-mode voltage range is  $V_{CC+} - 1.5 \text{ V}$ , but either or both inputs can go to 32 V without damage.

**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>
TS321ID	ACTIVE	SOIC	D	8	75	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
TS321IDBVR	ACTIVE	SOT-23	DBV	5	3000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
TS321IDBVRE4	ACTIVE	SOT-23	DBV	5	3000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
TS321IDBVRG4	ACTIVE	SOT-23	DBV	5	3000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
TS321IDBVVT	ACTIVE	SOT-23	DBV	5	250	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
TS321IDBVTE4	ACTIVE	SOT-23	DBV	5	250	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
TS321IDBVTG4	ACTIVE	SOT-23	DBV	5	250	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
TS321IDE4	ACTIVE	SOIC	D	8	75	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
TS321IDG4	ACTIVE	SOIC	D	8	75	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
TS321IDR	ACTIVE	SOIC	D	8	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
TS321IDRE4	ACTIVE	SOIC	D	8	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
TS321IDRG4	ACTIVE	SOIC	D	8	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-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.

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

<sup>(2)</sup> 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> 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.

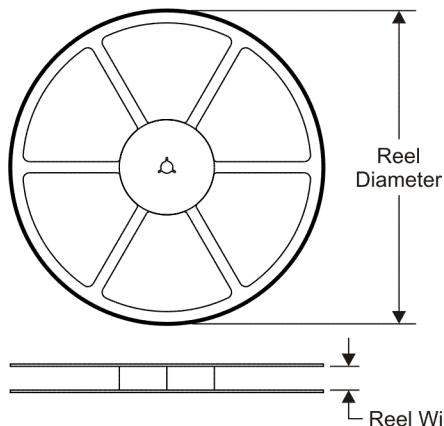
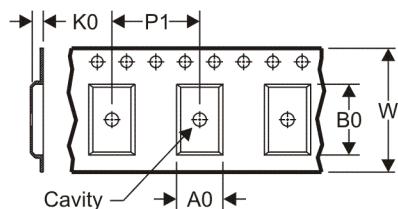
**Green (RoHS & no Sb/Br):** TI defines "Green" to mean Pb-Free (RoHS compatible), and free of Bromine (Br) and Antimony (Sb) based flame retardants (Br or Sb do not exceed 0.1% by weight in homogeneous material)

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

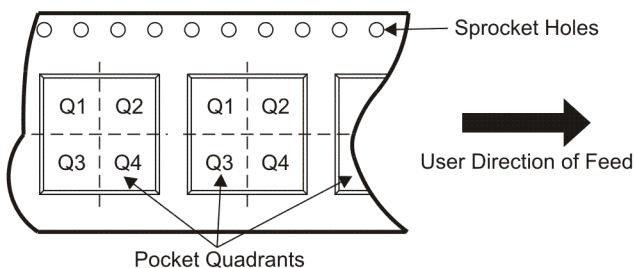
**Important Information and Disclaimer:** The information provided on this page represents TI's knowledge and belief as of the date that it is provided. TI bases its knowledge and belief on information provided by third parties, and makes no representation or warranty as to the accuracy of such information. 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.

**TAPE AND REEL INFORMATION**
**REEL DIMENSIONS**

**TAPE DIMENSIONS**


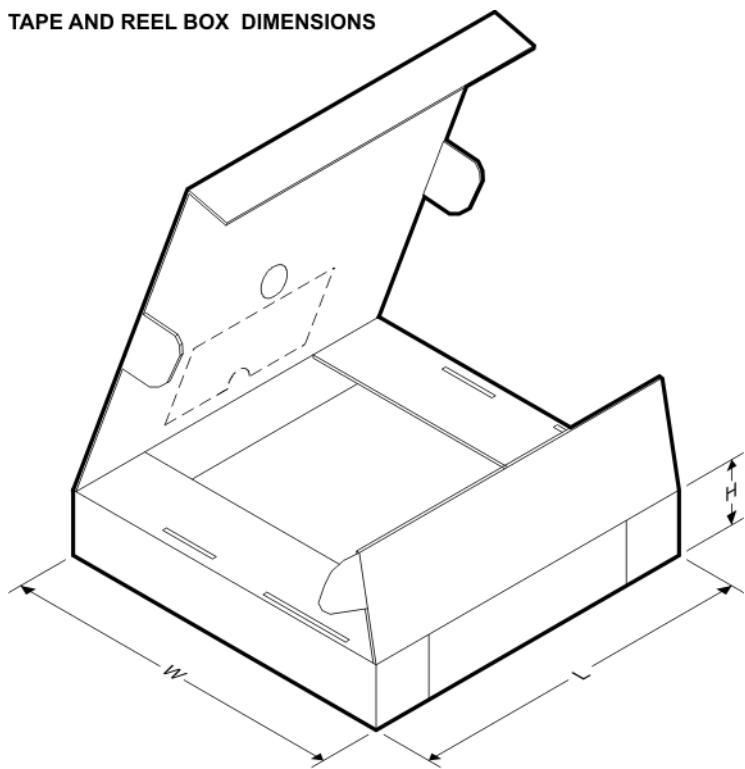
A0	Dimension designed to accommodate the component width
B0	Dimension designed to accommodate the component length
K0	Dimension designed to accommodate the component thickness
W	Overall width of the carrier tape
P1	Pitch between successive cavity centers

**QUADRANT ASSIGNMENTS FOR PIN 1 ORIENTATION IN TAPE**


\*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
TS321IDBVR	SOT-23	DBV	5	3000	180.0	9.2	3.23	3.17	1.37	4.0	8.0	Q3
TS321IDBVT	SOT-23	DBV	5	250	180.0	9.2	3.23	3.17	1.37	4.0	8.0	Q3
TS321IDR	SOIC	D	8	2500	330.0	12.4	6.4	5.2	2.1	8.0	12.0	Q1

**TAPE AND REEL BOX DIMENSIONS**

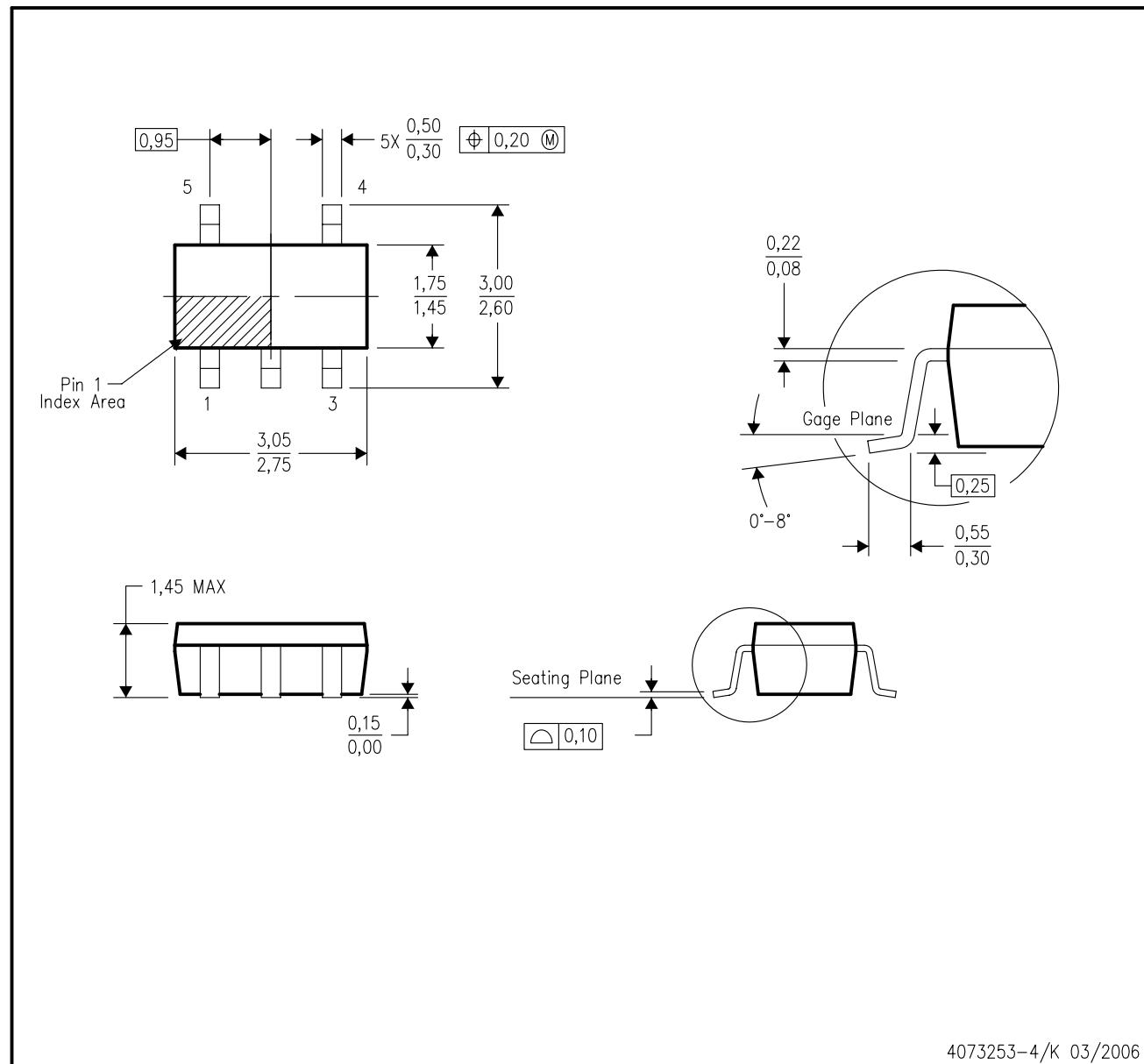


\*All dimensions are nominal

Device	Package Type	Package Drawing	Pins	SPQ	Length (mm)	Width (mm)	Height (mm)
TS321IDBVR	SOT-23	DBV	5	3000	202.0	201.0	28.0
TS321IDBVT	SOT-23	DBV	5	250	202.0	201.0	28.0
TS321IDR	SOIC	D	8	2500	340.5	338.1	20.6

## DBV (R-PDSO-G5)

## PLASTIC SMALL-OUTLINE PACKAGE



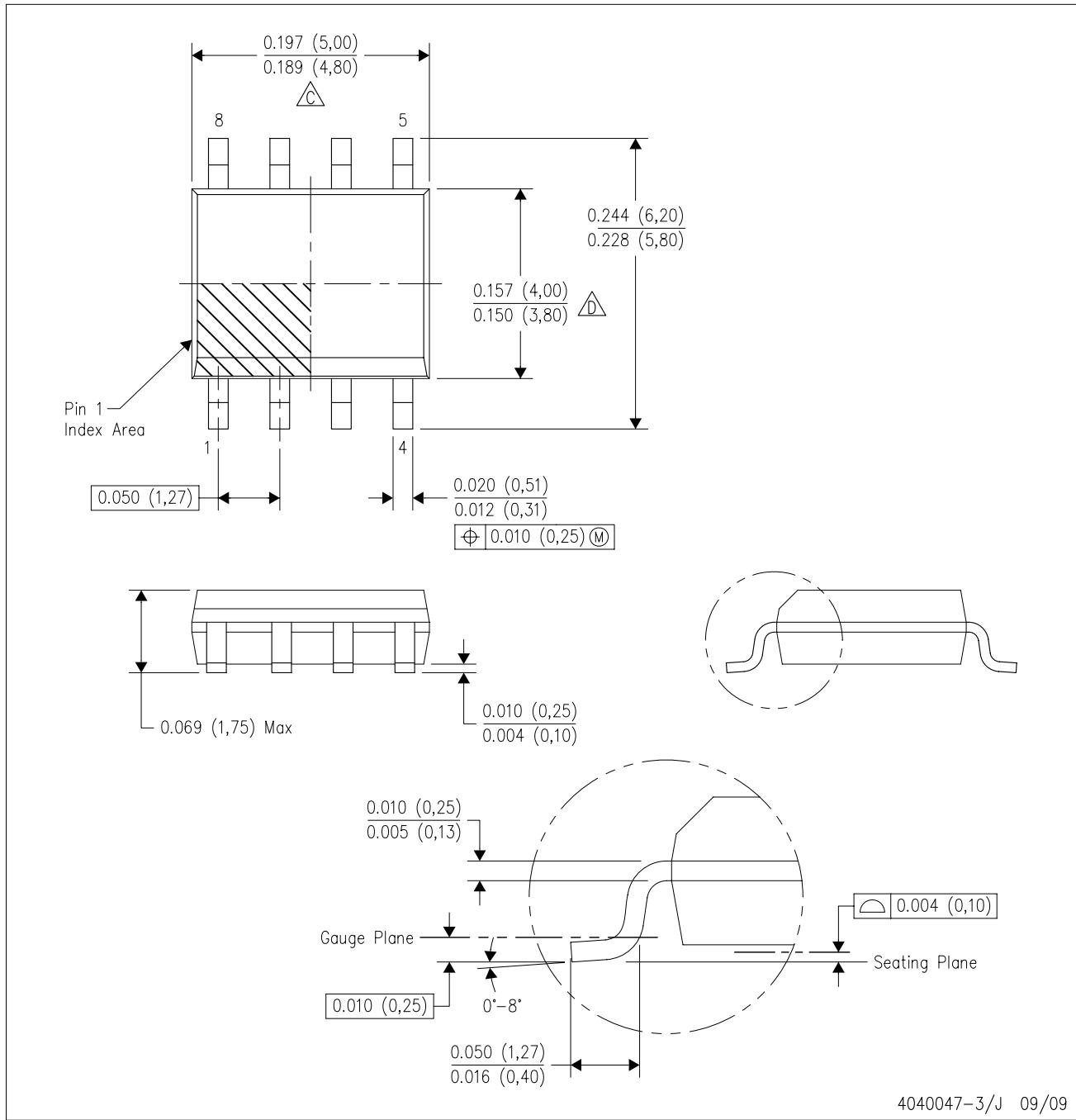
4073253-4/K 03/2006

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-178 Variation AA.

D (R-PDSO-G8)

PLASTIC SMALL-OUTLINE PACKAGE



4040047-3/J 09/09

NOTES: A. All linear dimensions are in inches (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 .006 (0,15) per end.

△D Body width does not include interlead flash. Interlead flash shall not exceed .017 (0,43) per side.

E. Reference 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 TI 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. Information of third parties may be subject to additional restrictions.

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.

TI products are not authorized for use in safety-critical applications (such as life support) where a failure of the TI product would reasonably be expected to cause severe personal injury or death, unless officers of the parties have executed an agreement specifically governing such use. Buyers represent that they have all necessary expertise in the safety and regulatory ramifications of their applications, and acknowledge and agree that they are solely responsible for all legal, regulatory and safety-related requirements concerning their products and any use of TI products in such safety-critical applications, notwithstanding any applications-related information or support that may be provided by TI. Further, Buyers must fully indemnify TI and its representatives against any damages arising out of the use of TI products in such safety-critical applications.

TI products are neither designed nor intended for use in military/aerospace applications or environments unless the TI products are specifically designated by TI as military-grade or "enhanced plastic." Only products designated by TI as military-grade meet military specifications. Buyers acknowledge and agree that any such use of TI products which TI has not designated as military-grade is solely at the Buyer's risk, and that they are solely responsible for compliance with all legal and regulatory requirements in connection with such use.

TI products are neither designed nor intended for use in automotive applications or environments unless the specific TI products are designated by TI as compliant with ISO/TS 16949 requirements. Buyers acknowledge and agree that, if they use any non-designated products in automotive applications, TI will not be responsible for any failure to meet such requirements.

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

### Products

Amplifiers	<a href="http://amplifier.ti.com">amplifier.ti.com</a>
Data Converters	<a href="http://dataconverter.ti.com">dataconverter.ti.com</a>
DLP® Products	<a href="http://www.dlp.com">www.dlp.com</a>
DSP	<a href="http://dsp.ti.com">dsp.ti.com</a>
Clocks and Timers	<a href="http://www.ti.com/clocks">www.ti.com/clocks</a>
Interface	<a href="http://interface.ti.com">interface.ti.com</a>
Logic	<a href="http://logic.ti.com">logic.ti.com</a>
Power Mgmt	<a href="http://power.ti.com">power.ti.com</a>
Microcontrollers	<a href="http://microcontroller.ti.com">microcontroller.ti.com</a>
RFID	<a href="http://www.ti-rfid.com">www.ti-rfid.com</a>
RF/IF and ZigBee® Solutions	<a href="http://www.ti.com/lprf">www.ti.com/lprf</a>

### Applications

Audio	<a href="http://www.ti.com/audio">www.ti.com/audio</a>
Automotive	<a href="http://www.ti.com/automotive">www.ti.com/automotive</a>
Broadband	<a href="http://www.ti.com/broadband">www.ti.com/broadband</a>
Digital Control	<a href="http://www.ti.com/digitalcontrol">www.ti.com/digitalcontrol</a>
Medical	<a href="http://www.ti.com/medical">www.ti.com/medical</a>
Military	<a href="http://www.ti.com/military">www.ti.com/military</a>
Optical Networking	<a href="http://www.ti.com/opticalnetwork">www.ti.com/opticalnetwork</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

Copyright © 2009, Texas Instruments Incorporated