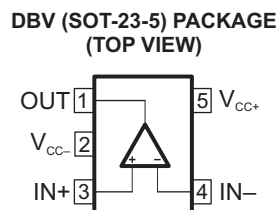
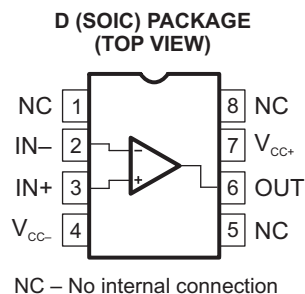


## FEATURES

- **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)
- **Low Input Offset Voltage...**2 mV (Max)
- **Stable With High Capacitive Loads**



## DESCRIPTION/ORDERING INFORMATION

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

### ORDERING INFORMATION

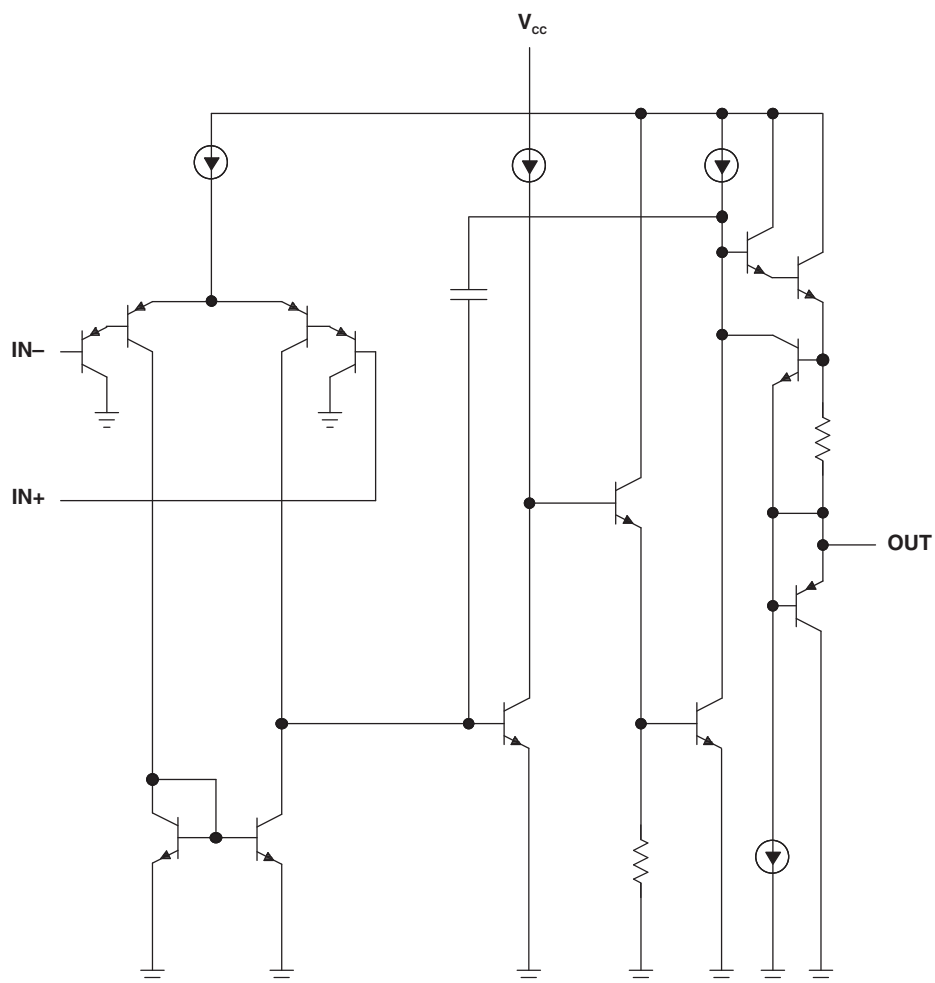
$T_A$	PACKAGE <sup>(1)</sup>		ORDERABLE PART NUMBER	TOP-SIDE MARKING <sup>(2)</sup>
–40°C to 125°C	SOIC – D	Tube of 75	TS321ID	SR321I
		Reel of 2500	TS321IDR	
	SOT-23-5 – DBV	Reel of 3000	TS321IDBVR	9C1_
		Reel of 250	TS321IDBVT	

(1) Package drawings, standard packing quantities, thermal data, symbolization, and PCB design guidelines are available at [www.ti.com/sc/package](http://www.ti.com/sc/package).

(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.



## 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	30	V
		Dual supply	±1.5	±15	
T <sub>A</sub>	Operating free-air temperature		–40	125	°C

# TS321

## LOW-POWER SINGLE OPERATIONAL AMPLIFIER

SLOS489A–DECEMBER 2005–REVISED MARCH 2007

### 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/ $\mu\text{s}$
$\phi_m$ 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	$V_{CC} = 15\text{ V}$ , $V_{ID} = 1\text{ V}$	$V_O = 2\text{ V}$	25°C	10	20	mA
		$V_O = 0.2\text{ V}$	25°C	12	50	$\mu\text{A}$
$I_O$ Short-circuit to GND	$V_{CC} = 15\text{ V}$	25°C		40	60	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	25°C	$V_{CC} = 5\text{ V}$		500	$\mu\text{A}$
			$V_{CC} = 30\text{ V}$		600	
		Full range	$V_{CC} = 5\text{ V}$		600	
			$V_{CC} = 30\text{ V}$		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	$V_{CC} = 30\text{ V}$ , $f = 1\text{ kHz}$ , $R_S = 100\text{ }\Omega$	25°C		50		nV/ $\sqrt{\text{Hz}}$

- (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
TS321IDBPRE4	ACTIVE	SOT-23	DBV	5	3000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
TS321IDBVT	ACTIVE	SOT-23	DBV	5	250	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
TS321IDBPTE4	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
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

<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 - 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)

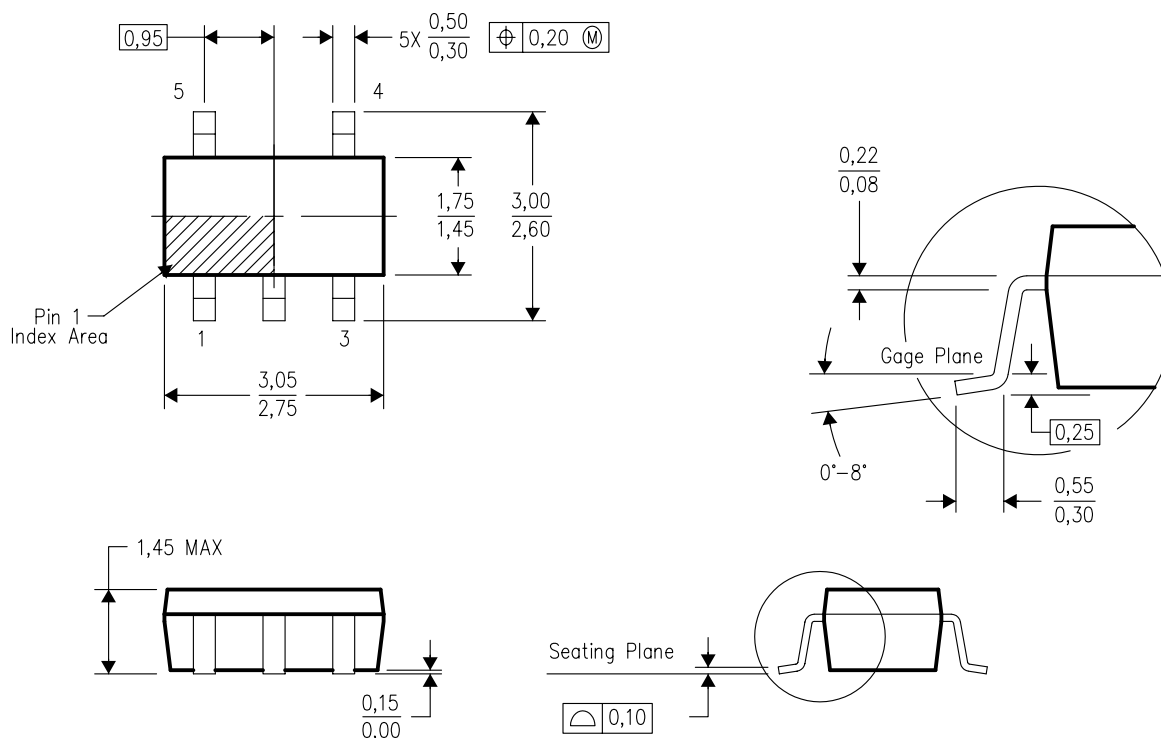
<sup>(3)</sup> MSL, Peak Temp. -- The Moisture Sensitivity Level rating according to the JEDEC industry standard classifications, and peak solder temperature.

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## DBV (R-PDSO-G5)

## PLASTIC SMALL-OUTLINE PACKAGE

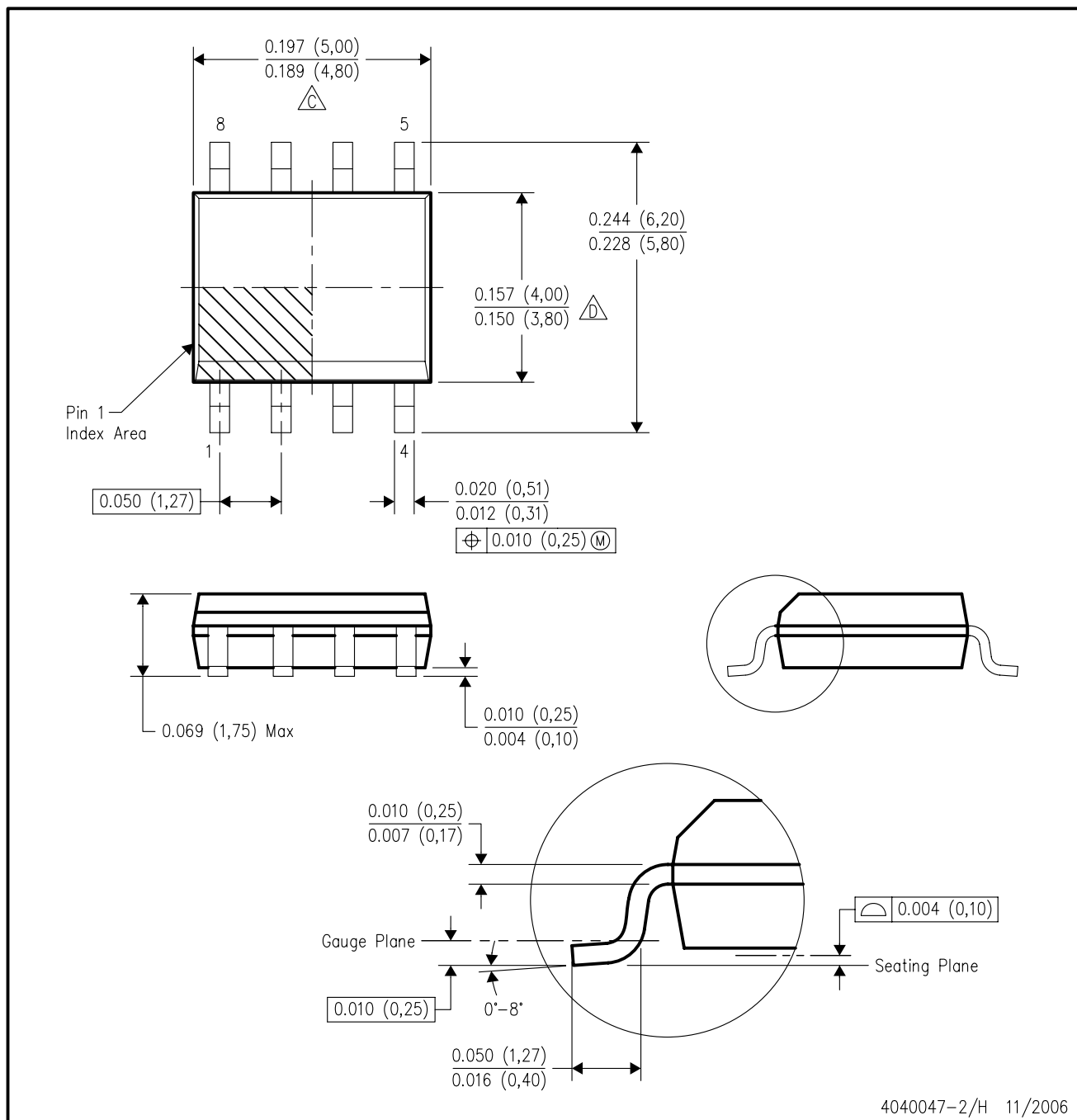


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- NOTES:
- All linear dimensions are in millimeters.
  - This drawing is subject to change without notice.
  - Body dimensions do not include mold flash or protrusion. Mold flash and protrusion shall not exceed 0.15 per side.
  - Falls within JEDEC MO-178 Variation AA.

## D (R-PDSO-G8)

## PLASTIC SMALL-OUTLINE PACKAGE



## NOTES:

- A. All linear dimensions are in inches (millimeters).
- B. This drawing is subject to change without notice.
- $\triangle C$  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.
- $\triangle D$  Body width does not include interlead flash. Interlead flash shall not exceed .017 (0,43) per side.
- E. Reference JEDEC MS-012 variation AA.

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