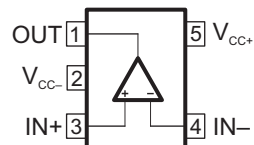


LOW-POWER SINGLE OPERATIONAL AMPLIFIER

FEATURES

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

**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⁽¹⁾

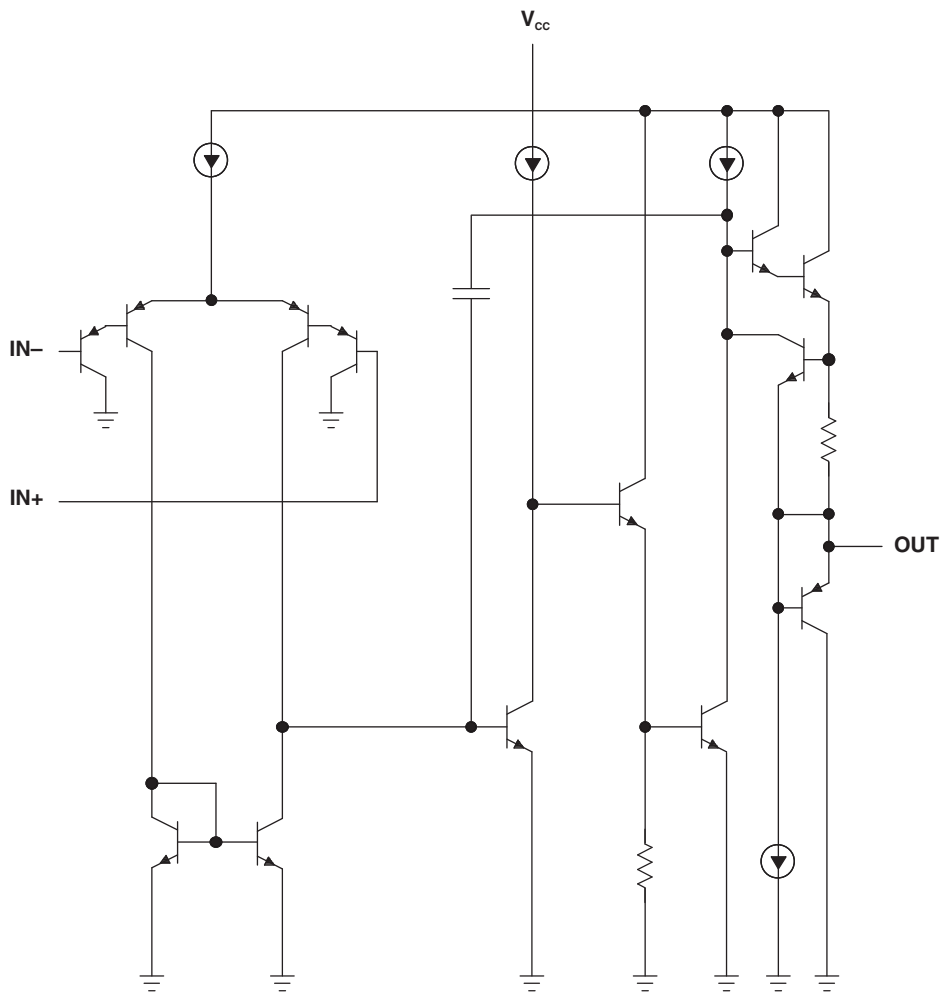
| T_A | PACKAGE ⁽²⁾ | | ORDERABLE PART NUMBER | TOP-SIDE MARKING |
|----------------|------------------------|--------------|-----------------------|------------------|
| –40°C to 125°C | SOT-23-5 – DBV | Reel of 3000 | TS321QDBVRQ1 | 9CNS |

- (1) For the most current package and ordering information, see the Package Option Addendum at the end of this document, or see the TI web site at www.ti.com.
- (2) Package drawings, thermal data, and symbolization are available at www.ti.com/packaging.



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⁽¹⁾

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

| | | MIN | MAX | UNIT |
|--------------------|---|-------------|-----------|------|
| V _{CC} | Supply voltage ⁽²⁾ | Single | 32 | V |
| | | Dual | ±16 | |
| V _{ID} | Differential input voltage ⁽³⁾ | | 32 | V |
| V _I | Input voltage range ⁽²⁾⁽⁴⁾ | –0.3 | 32 | V |
| I _I | Input current ⁽⁴⁾ | | 50 | mA |
| t _{short} | Duration of output short circuit to ground | | Unlimited | |
| θ _{JA} | Package thermal impedance, junction to free air ⁽⁵⁾⁽⁶⁾ | DBV package | 206 | °C/W |
| T _J | Operating virtual junction temperature | | 150 | °C |
| T _{stg} | 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_{CC+} and V_{CC–}.
- (3) Differential voltages are at IN+ with respect to IN–.
- (4) Neither input must ever be more positive than V_{CC+} or more negative than V_{CC–}.
- (5) Maximum power dissipation is a function of T_{J(max)}, θ_{JA}, and T_A. The maximum allowable power dissipation at any allowable ambient temperature is P_D = (T_{J(max)} – T_A)/θ_{JA}. 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 _{CC} | Supply voltage | Single supply | 3 | V |
| | | Dual supply | ±1.5 | |
| T _A | 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 ⁽¹⁾ | | | 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 V | | 25°C | 50 | 100 | | V/mV |
| | | | | Full range | 25 | | | |
| V_{ICR} | Common-mode input voltage ⁽²⁾ | $V_{CC} = 30\text{ V}$ | | 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 | mV |
| | | | | 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 V , $R_L = 2\text{ k}\Omega$, $C_L = 100\text{ pF}$, unity gain | | 25°C | | 0.4 | | V/ μs |
| ϕ_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 | μA |
| 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 V | | 25°C | 65 | 110 | | dB |
| I_{CC} | Total supply current | No load | | 25°C | $V_{CC} = 5\text{ V}$ | 500 | 800 | μA |
| | | | | | $V_{CC} = 30\text{ V}$ | 600 | 900 | |
| | | | | Full range | $V_{CC} = 5\text{ V}$ | 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/ $\sqrt{\text{Hz}}$ |

- (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 (1) | Package Type | Package Drawing | Pins | Package Qty | Eco Plan (2) | Lead/Ball Finish | MSL Peak Temp (3) | Op Temp (°C) | Top-Side Markings (4) | Samples |
|------------------|---------------|--------------|--------------------|------|----------------|----------------------------|------------------|----------------------|--------------|--------------------------|---------|
| TS321QDBVRQ1 | ACTIVE | SOT-23 | DBV | 5 | 3000 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-1-260C-UNLIM | -40 to 125 | 9CNS | Samples |

(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> 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) Multiple Top-Side Markings will be inside parentheses. Only one Top-Side 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 Top-Side Marking for that device.

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OTHER QUALIFIED VERSIONS OF TS321-Q1 :

- Catalog: [TS321](#)

NOTE: Qualified Version Definitions:

- Catalog - TI's standard catalog product

TAPE AND REEL INFORMATION



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 |
|--------------|--------------|-----------------|------|------|--------------------|--------------------|---------|---------|---------|---------|--------|---------------|
| TS321QDBVRQ1 | SOT-23 | DBV | 5 | 3000 | 180.0 | 8.4 | 3.23 | 3.17 | 1.37 | 4.0 | 8.0 | Q3 |

TAPE AND REEL BOX DIMENSIONS



*All dimensions are nominal

| Device | Package Type | Package Drawing | Pins | SPQ | Length (mm) | Width (mm) | Height (mm) |
|--------------|--------------|-----------------|------|------|-------------|------------|-------------|
| TS321QDBVRQ1 | SOT-23 | DBV | 5 | 3000 | 202.0 | 201.0 | 28.0 |

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. Mold flash and protrusion shall not exceed 0.15 per side.
 - D. Falls within JEDEC MO-178 Variation AA.

DBV (R-PDSO-G5)

PLASTIC SMALL OUTLINE



- NOTES:
- A. All linear dimensions are in millimeters.
 - B. This drawing is subject to change without notice.
 - C. Customers should place a note on the circuit board fabrication drawing not to alter the center solder mask defined pad.
 - D. Publication IPC-7351 is recommended for alternate designs.
 - E. Laser cutting apertures with trapezoidal walls and also rounding corners will offer better paste release. Customers should contact their board assembly site for stencil design recommendations. Example stencil design based on a 50% volumetric metal load solder paste. Refer to IPC-7525 for other stencil recommendations.

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