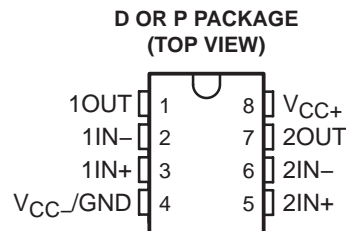


# TL3472

## HIGH-SLEW-RATE, SINGLE-SUPPLY OPERATIONAL AMPLIFIER

SLOS200G – OCTOBER 1997 – REVISED JULY 2003

- **Wide Gain-Bandwidth Product . . . 4 MHz**
- **High Slew Rate . . . 13 V/ $\mu$ s**
- **Fast Settling Time . . . 1.1  $\mu$ s to 0.1%**
- **Wide-Range Single-Supply Operation . . . 4 V to 36 V**
- **Wide Input Common-Mode Range Includes Ground ( $V_{CC-}$ )**
- **Low Total Harmonic Distortion . . . 0.02%**
- **Large-Capacitance Drive Capability . . . 10,000 pF**
- **Output Short-Circuit Protection**



### description/ordering information

Quality, low-cost, bipolar fabrication with innovative design concepts is employed for the TL3472 operational amplifier. This device offers 4 MHz of gain-bandwidth product, 13-V/ $\mu$ s slew rate, and fast settling time, without the use of JFET device technology. Although the TL3472 can be operated from split supplies, it is particularly suited for single-supply operation because the common-mode input voltage range includes ground potential ( $V_{CC-}$ ). With a Darlington transistor input stage, this device exhibits high input resistance, low input offset voltage, and high gain. The all-npn output stage, characterized by no dead-band crossover distortion and large output voltage swing, provides high-capacitance drive capability, excellent phase and gain margins, low open-loop high-frequency output impedance, and symmetrical source/sink ac frequency response. This low-cost amplifier is an alternative to the MC33072 and the MC34072 operational amplifiers.

### ORDERING INFORMATION

$T_A$	PACKAGE†		ORDERABLE PART NUMBER	TOP-SIDE MARKING
0°C to 70°C	PDIP (P)	Tube of 25	TL3472CP	TL3472CP
	SOIC (D)	Tube of 50	TL3472CD	3472C
		Reel of 2500	TL3472CDR	
-40°C to 105°C	PDIP (P)	Tube of 25	TL3472IP	TL3472IP
	SOIC (D)	Tube of 50	TL3472ID	Z3472
		Reel of 2500	TL3472IDR	

† 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).



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**TEXAS  
INSTRUMENTS**

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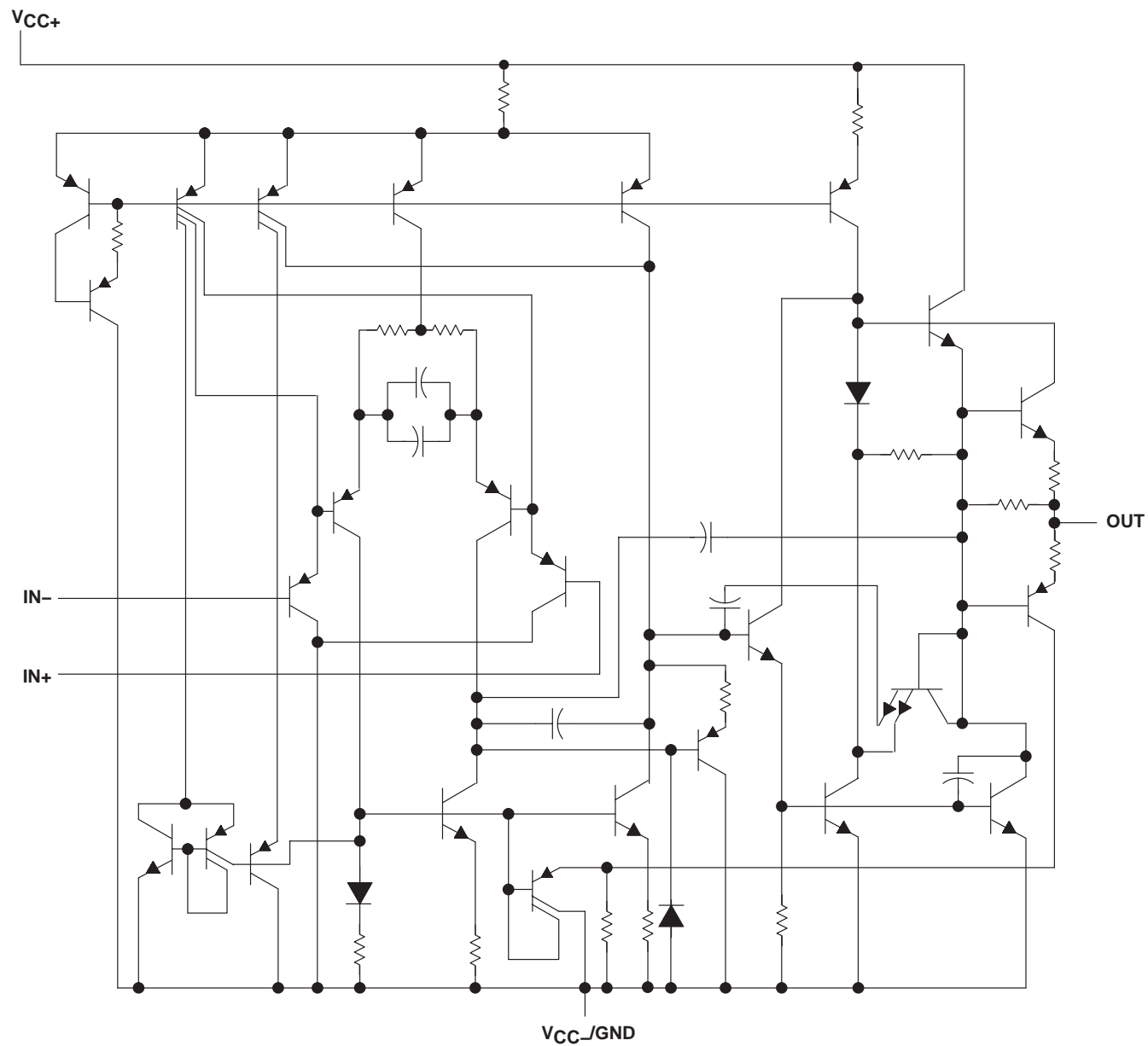
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# TL3472

## HIGH-SLEW-RATE, SINGLE-SUPPLY OPERATIONAL AMPLIFIER

SLOS200G – OCTOBER 1997 – REVISED JULY 2003

### schematic (each amplifier)



# TL3472

## HIGH-SLEW-RATE, SINGLE-SUPPLY OPERATIONAL AMPLIFIER

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

Supply voltage (see Note 1): $V_{CC+}$	18 V
$V_{CC-}$	–18 V
Differential input voltage, $V_{ID}$ (see Note 2)	±36 V
Input voltage, $V_I$ (any input)	$V_{CC\pm}$
Input current, $I_I$ (each input)	±1 mA
Output current, $I_O$	±80 mA
Total current into $V_{CC+}$	80 mA
Total current out of $V_{CC-}$	80 mA
Duration of short-circuit current at (or below) 25°C (see Note 3)	Unlimited
Package thermal impedance, $\theta_{JA}$ (see Notes 4 and 5): D package	97°C/W
P package	85°C/W
Operating virtual junction temperature, $T_J$	150°C
Lead temperature 1.6 mm (1/16 inch) from case for 10 seconds	260°C
Storage temperature range, $T_{stg}$	–65°C to 150°C

<sup>†</sup> 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 the midpoint between  $V_{CC+}$  and  $V_{CC-}$ .
  2. Differential voltages are at the noninverting input with respect to the inverting input. Excessive input current can flow when the input is less than  $V_{CC-} - 0.3$  V.
  3. The output can be shorted to either supply. Temperature and/or supply voltages must be limited to ensure that the maximum dissipation rating is not exceeded.
  4. Maximum power dissipation is a function of  $T_J(\text{max})$ ,  $\theta_{JA}$ , and  $T_A$ . The maximum allowable power dissipation at any allowable ambient temperature is  $P_D = (T_J(\text{max}) - T_A)/\theta_{JA}$ . Operating at the absolute maximum  $T_J$  of 150°C can impact reliability.
  5. The package thermal impedance is calculated in accordance with JESD 51-7.

### recommended operating conditions

			MIN	MAX	UNIT
V <sub>CC±</sub>	Supply voltage		4	36	V
V <sub>IC</sub>	Common-mode input voltage	V <sub>CC</sub> = 5 V	0	2.8	V
		V <sub>CC±</sub> = ±15 V	−15	12.8	
T <sub>A</sub>	Operating free-air temperature	TL3472C	0	70	°C
		TL3472I	−40	105	



# TL3472

## HIGH-SLEW-RATE, SINGLE-SUPPLY OPERATIONAL AMPLIFIER

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

PARAMETER		TEST CONDITIONS		T <sub>A</sub>	MIN	TYP†	MAX	UNIT
V <sub>IO</sub>	Input offset voltage	V <sub>IC</sub> = 0, V <sub>O</sub> = 0, R <sub>S</sub> = 50 Ω	V <sub>CC</sub> = 5 V	25°C	1.5		10	mV
			V <sub>CC</sub> = ±15 V	25°C	1.0		10	
Full range‡				12				
	α <sub>V<sub>IO</sub></sub>		Temperature coefficient of input offset voltage	V <sub>CC</sub> = ±15 V	Full range‡	10		
I <sub>IO</sub>	Input offset current		V <sub>CC</sub> = ±15 V	25°C	6		75	nA
				Full range‡	300			
I <sub>IB</sub>	Input bias current	V <sub>CC</sub> = ±15 V	25°C	100		500	nA	
			Full range‡	700				
V <sub>ICR</sub>	Common-mode input voltage range	R <sub>S</sub> = 50 Ω	25°C	-15 to 12.8		V		
			Full range‡	-15 to 12.8				
V <sub>OH</sub>	High-level output voltage	V <sub>CC+</sub> = 5 V, V <sub>CC-</sub> = 0, R <sub>L</sub> = 2 kΩ	25°C	3.7	4		V	
		R <sub>L</sub> = 10 kΩ	25°C	13.6	14			
		R <sub>L</sub> = 2 kΩ	Full range‡	13.4				
V <sub>OL</sub>	Low-level output voltage	V <sub>CC+</sub> = 5 V, V <sub>CC-</sub> = 0, R <sub>L</sub> = 2 kΩ	25°C	0.1		0.3	V	
		R <sub>L</sub> = 10 kΩ	25°C	-14.7		-14.3		
		R <sub>L</sub> = 2 kΩ	Full range‡	-13.5				
A <sub>VD</sub>	Large-signal differential voltage amplification	V <sub>O</sub> = ±10 V, R <sub>L</sub> = 2 kΩ	25°C	25	100		V/mV	
			Full range‡	20				
I <sub>OS</sub>	Short-circuit output current	Source: V <sub>ID</sub> = 1 V, V <sub>O</sub> = 0	25°C	-10	-34		mA	
		Sink: V <sub>ID</sub> = -1 V, V <sub>O</sub> = 0		20	27			
CMRR	Common-mode rejection ratio	V <sub>IC</sub> = V <sub>ICR</sub> (min), R <sub>S</sub> = 50 Ω	25°C	65	97		dB	
k <sub>SVR</sub>	Supply-voltage rejection ratio (ΔV <sub>CC±</sub> /ΔV <sub>IO</sub> )	V <sub>CC±</sub> = ±13.5 V to ±16.5 V, R <sub>S</sub> = 100 Ω	25°C	70	97		dB	
I <sub>CC</sub>	Supply current (per channel)	V <sub>O</sub> = 0, No load	25°C	3.5		4.5	mA	
			Full range‡	4.5		5.5		
		V <sub>CC+</sub> = 5 V, V <sub>O</sub> = 2.5 V, V <sub>CC-</sub> = 0, No load	25°C	3.5		4.5		

† All typical values are at  $T_A = 25^\circ\text{C}$ .

‡ Full range is  $0^\circ\text{C}$  to  $70^\circ\text{C}$  for the TL3472C device and  $-40^\circ\text{C}$  to  $105^\circ\text{C}$  for the TL3472I device.

# TL3472

## HIGH-SLEW-RATE, SINGLE-SUPPLY OPERATIONAL AMPLIFIER

SLOS200G – OCTOBER 1997 – REVISED JULY 2003

operating characteristics,  $V_{CC\pm} = \pm 15\text{ V}$ ,  $T_A = 25^\circ\text{C}$

PARAMETER		TEST CONDITIONS		MIN	TYP	MAX	UNIT
SR+	Positive slew rate	$V_I = -10\text{ V to } 10\text{ V}$ , $R_L = 2\text{ k}\Omega$ , $C_L = 300\text{ pF}$	$A_V = 1$	8	10		$\text{V}/\mu\text{s}$
SR–	Negative slew rate		$A_V = -1$		13		$\text{V}/\mu\text{s}$
$t_s$	Settling time	$A_{VD} = -1$ , 10-V step	To 0.1%		1.1		$\mu\text{s}$
			To 0.01%		2.2		
$V_n$	Equivalent input noise voltage	$f = 1\text{ kHz}$ , $R_S = 100\text{ }\Omega$			49		$\text{nV}/\sqrt{\text{Hz}}$
$I_n$	Equivalent input noise current	$f = 1\text{ kHz}$			0.22		$\text{pA}/\sqrt{\text{Hz}}$
THD	Total harmonic distortion	$V_{O(PP)} = 2\text{ V to } 20\text{ V}$ , $R_L = 2\text{ k}\Omega$ , $A_{VD} = 10$ , $f = 10\text{ kHz}$			0.02		%
GBW	Gain-bandwidth product	$f = 100\text{ kHz}$		3	4		MHz
BW	Power bandwidth	$V_{O(PP)} = 20\text{ V}$ , $R_L = 2\text{ k}\Omega$ , $A_{VD} = 1$ , THD = 5.0%			160		kHz
$\phi_m$	Phase margin	$R_L = 2\text{ k}\Omega$	$C_L = 0$		70		deg
			$C_L = 300\text{ pF}$		50		
	Gain margin	$R_L = 2\text{ k}\Omega$	$C_L = 0$		12		dB
			$C_L = 300\text{ pF}$		4		
$r_i$	Differential input resistance	$V_{IC} = 0$			150		$\text{M}\Omega$
$C_i$	Input capacitance	$V_{IC} = 0$			2.5		pF
	Channel separation	$f = 10\text{ kHz}$			101		dB
$z_o$	Open-loop output impedance	$f = 1\text{ MHz}$ , $A_V = 1$			20		$\Omega$



**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>
TL3472CD	ACTIVE	SOIC	D	8	75	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
TL3472CDE4	ACTIVE	SOIC	D	8	75	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
TL3472CDG4	ACTIVE	SOIC	D	8	75	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
TL3472CDR	ACTIVE	SOIC	D	8	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
TL3472CDRE4	ACTIVE	SOIC	D	8	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
TL3472CDRG4	ACTIVE	SOIC	D	8	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
TL3472CP	ACTIVE	PDIP	P	8	50	Pb-Free (RoHS)	CU NIPDAU	N / A for Pkg Type
TL3472CPE4	ACTIVE	PDIP	P	8	50	Pb-Free (RoHS)	CU NIPDAU	N / A for Pkg Type
TL3472ID	ACTIVE	SOIC	D	8	75	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
TL3472IDE4	ACTIVE	SOIC	D	8	75	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
TL3472IDG4	ACTIVE	SOIC	D	8	75	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
TL3472IDR	ACTIVE	SOIC	D	8	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
TL3472IDRE4	ACTIVE	SOIC	D	8	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
TL3472IDRG4	ACTIVE	SOIC	D	8	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
TL3472IP	ACTIVE	PDIP	P	8	50	Pb-Free (RoHS)	CU NIPDAU	N / A for Pkg Type
TL3472IPE4	ACTIVE	PDIP	P	8	50	Pb-Free (RoHS)	CU NIPDAU	N / A for Pkg Type

<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.

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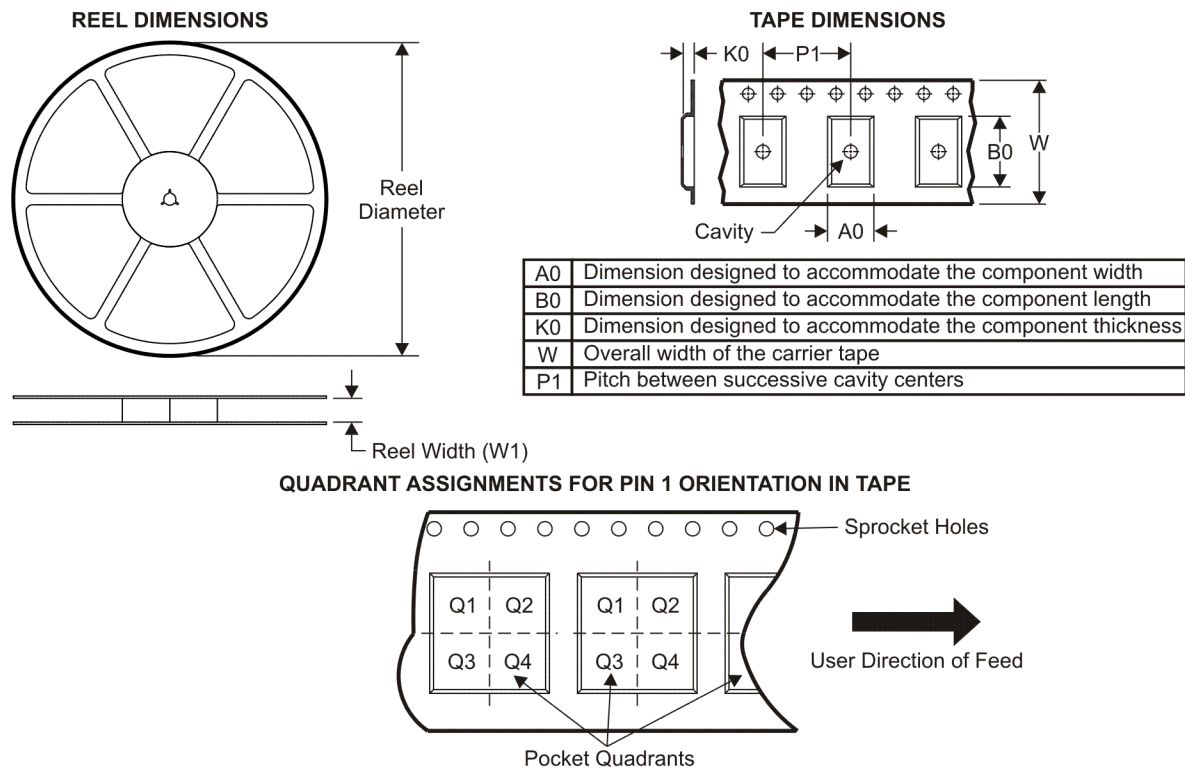
**OTHER QUALIFIED VERSIONS OF TL3472 :**

- Automotive: [TL3472-Q1](#)

NOTE: Qualified Version Definitions:

- Automotive - Q100 devices qualified for high-reliability automotive applications targeting zero defects

**TAPE AND REEL INFORMATION**

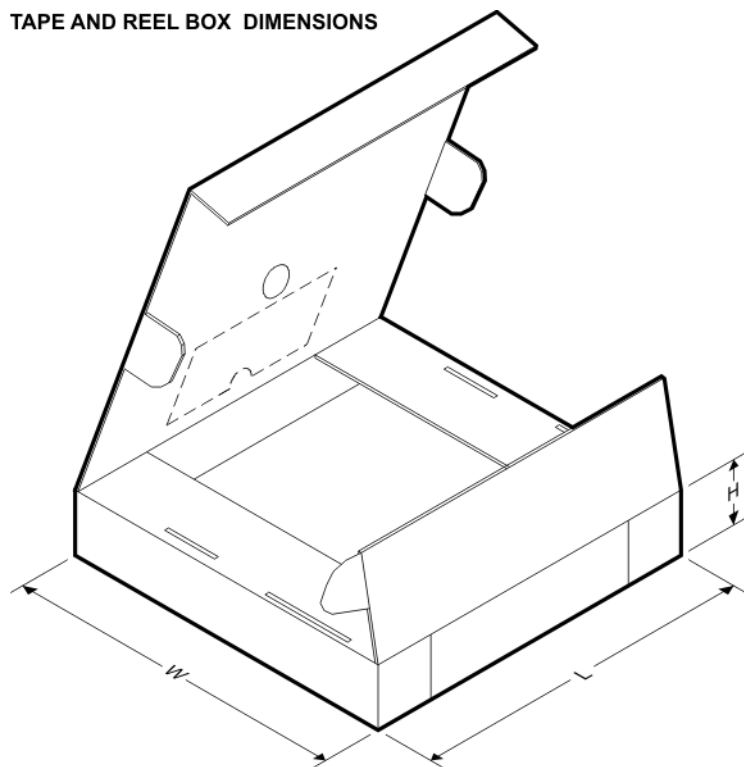


\*All dimensions are nominal

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
TL3472CDR	SOIC	D	8	2500	330.0	12.4	6.4	5.2	2.1	8.0	12.0	Q1
TL3472CDR	SOIC	D	8	2500	330.0	12.4	6.4	5.2	2.1	8.0	12.0	Q1
TL3472IDR	SOIC	D	8	2500	330.0	12.4	6.4	5.2	2.1	8.0	12.0	Q1
TL3472IDR	SOIC	D	8	2500	330.0	12.4	6.4	5.2	2.1	8.0	12.0	Q1



## TAPE AND REEL BOX DIMENSIONS

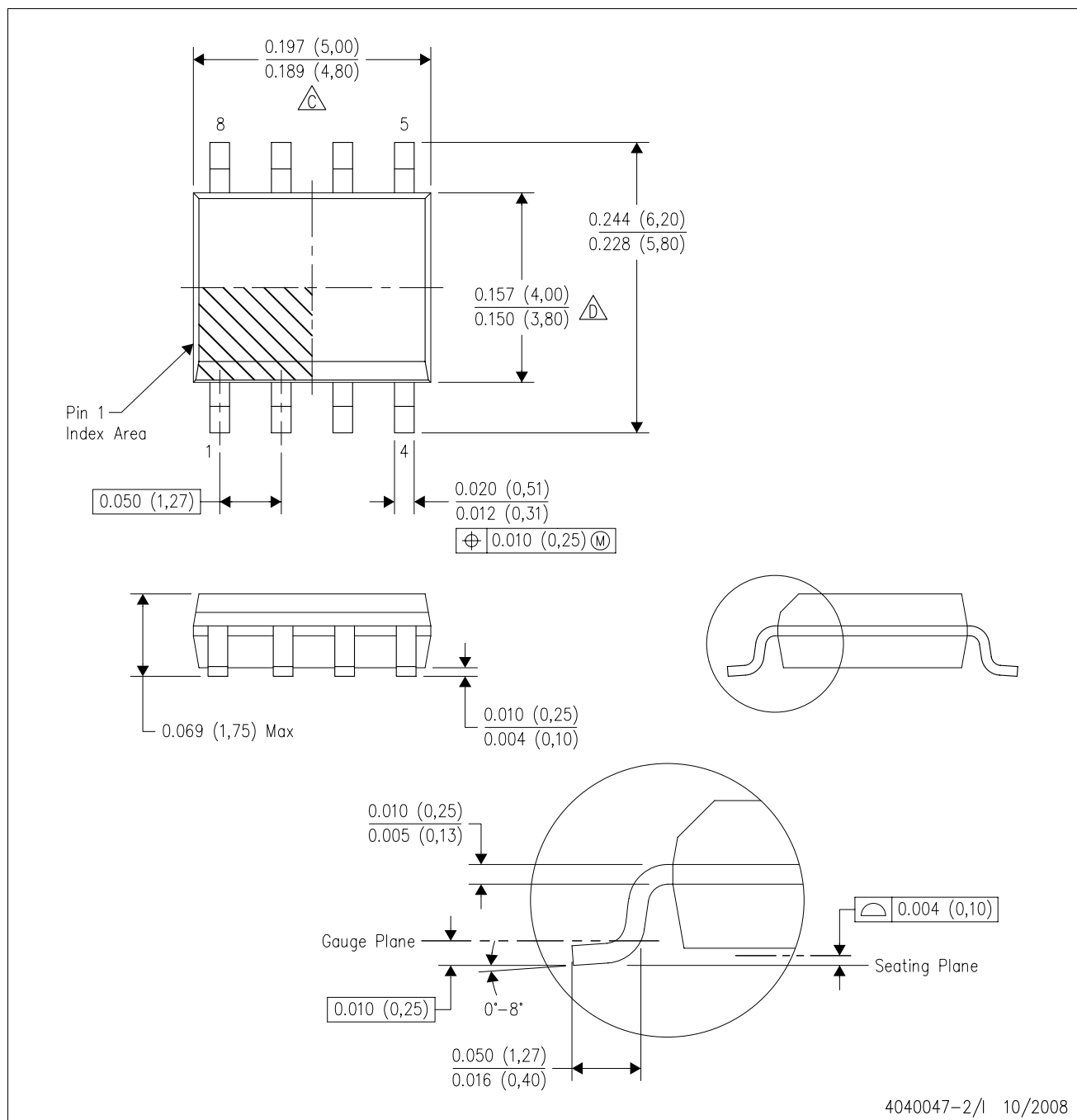


\*All dimensions are nominal

Device	Package Type	Package Drawing	Pins	SPQ	Length (mm)	Width (mm)	Height (mm)
TL3472CDR	SOIC	D	8	2500	340.5	338.1	20.6
TL3472CDR	SOIC	D	8	2500	346.0	346.0	29.0
TL3472IDR	SOIC	D	8	2500	346.0	346.0	29.0
TL3472IDR	SOIC	D	8	2500	340.5	338.1	20.6

D (R-PDSO-G8)

PLASTIC SMALL-OUTLINE PACKAGE

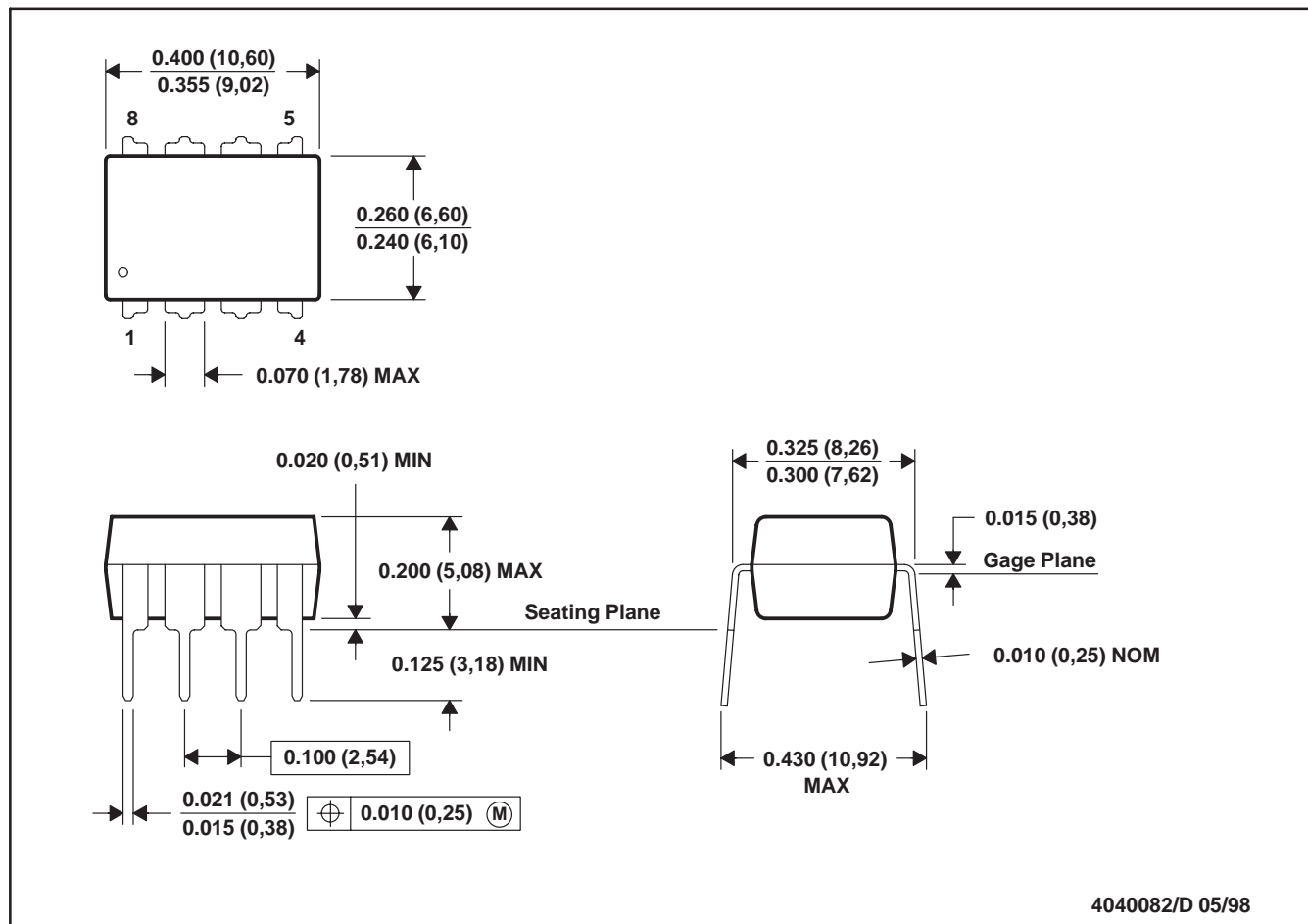


## NOTES:

- 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.

## P (R-PDIP-T8)

## PLASTIC DUAL-IN-LINE



NOTES: A. All linear dimensions are in inches (millimeters).  
 B. This drawing is subject to change without notice.  
 C. Falls within JEDEC MS-001

For the latest package information, go to [http://www.ti.com/sc/docs/package/pkg\\_info.htm](http://www.ti.com/sc/docs/package/pkg_info.htm)



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