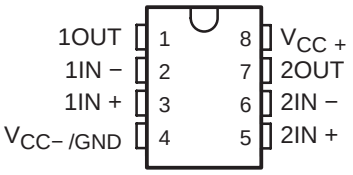
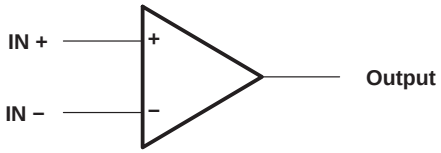
SLOS086 − D2567, OCTOBER 1979 − REVISED OCTOBER 1990

- **Wide Range of Supply Voltages**
  Single Supply . . . 5 V to 30 V
  Dual Supplies . . . ± 2.5 V to ± 15 V
- **Class AB Output Stage**
- **True Differential Input Stage**
- **Low Input Bias Current**
- **Internal Frequency Compensation**
- **Short-Circuit Protection**

D OR P PACKAGE
(TOP VIEW)



symbol (each amplifier)



description

The TL322C and the TL322I are dual operational amplifiers similar in performance to the uA741 but with several distinct advantages. They are designed to operate from a single supply over a range of voltages from 5 V to 30 V. Operation from split supplies is also possible provided the difference between the two supplies is 5 V to 30 V. The common-mode input range includes the negative supply. Output range is from the negative supply to V_{CC} −1.5 V. Quiescent supply currents per amplifier are typically less than one-half those of the uA741.

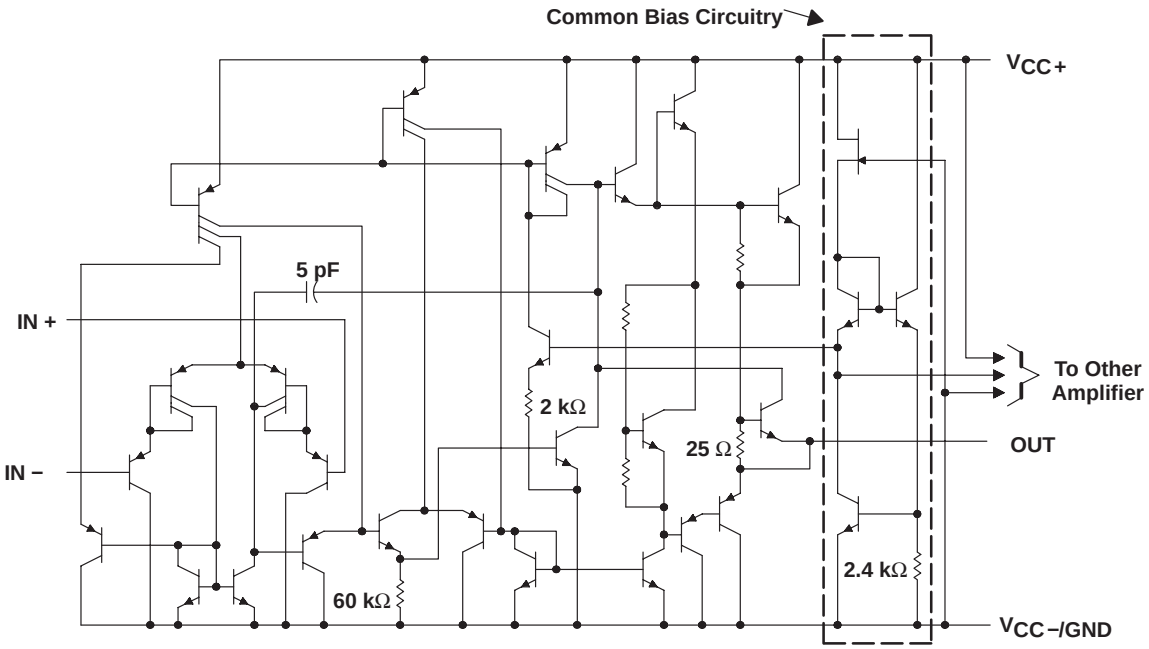
The TL322C is characterized for operation from 0°C to 70°C. The TL322I is characterized for operation from −40°C to 85°C.

AVAILABLE OPTIONS

T_A	V_{IO} MAX AT 25°C	PACKAGE	
		SMALL OUTLINE (D)	PLASTIC DIP (P)
0°C to 70°c	10 mV	TL322CD	TL322CP
0°C to 70°c	8 mV	TL322ID	TL322IP

D packages are available taped and reeled. Add R suffix to device type, (e.g., TL322CDR).

schematic (each amplifier)



All component values shown are nominal.

TEXAS INSTRUMENTS
POST OFFICE BOX 655303 • DALLAS, TEXAS 75265
POST OFFICE BOX 1443 • HOUSTON, TEXAS 77001

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

	TL322C	TL322I	UNIT
Supply voltage V_{CC+} (see Note 1)	18	18	V
Supply voltage V_{CC-} (see Note 1)	−18	−18	V
Supply voltage V_{CC+} (with respect to V_{CC-})	36	36	V
Differential input voltage (see Note 2)	±36	±36	V
Input voltage (see Notes 1 and 3)	±18	±18	V
Continuous total power disspation	See Dissipation Rating Table		
Operating free-air temperature range	0 to 70	−40 to 85	°C
Storage temperature range	−65 to 150	−65 to 150	°C
Lead temperature 1,6 mm (1/16 inch) from case for 10 seconds	260	260	°C

NOTES: 1. These voltage values are with respect to the midpoint between V_{CC+} and V_{CC-}.
2. Differential voltages are at the noninverting input terminal with respect to the inverting input terminal.
3. Neither input must ever be more positive than V_{CC+} or more negative than V_{CC-}.

DISSIPATION RATING TABLE

PACKAGE	$T_A \le 25°C$ POWER RATING	DERATING FACTOR	DERATE ABOVE T_A	$T_A = 70°C$ POWER RATING	$T_A = 85°C$ POWER RATING
D	680 mW	5.8 mW/°C	33°C	464 mW	377 mW
P	680 mW	8.0 mW/°C	65°C	640 mW	520 mW

recommended operating conditions

	MIN	NOM	MAX	UNIT
Single supply voltage, V_{CC}	5		30	V
Dual supply voltage, V_{CC+}	2.5		15	V
Dual supply voltage, V_{CC-}	− 2.5		− 15	V

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

PARAMETER		TEST CONDITIONS†		TL322C			TL322I			UNIT
				MIN	TYP	MAX	MIN	TYP	MAX	
V_{IO}	Input offset voltage	V_O = 0, R_S = 50 Ω	25°C		2	10		2	8	mV
			Full range			12			10	
α_{VIO}	Temperature coefficient of input offset voltage	V_O = 0, R_S = 50 Ω	25°C		10			10		µV/°C
I_{IO}	Input offset current	V_O = 0	25°C		30	50		30	75	nA
			Full range			200			250	
α_{IIO}	Temperature coefficient of input offset current	V_O = 0	25°C		50			50		pA/°C
I_{IB}	Input bias current	V_O = 0	25°C		−0.2	−0.5		−0.2	−0.5	µA
			Full range			−0.8			−1	
V_{ICR}	Common-mode input voltage range‡		25°C	V_{CC-} to 13	V_{CC-} to 13.5		V_{CC-} to 13	V_{CC-} to 13.5		V
V_{OM}	Peak output voltage swing	R_L = 10 kΩ	25°C	±12	±13.5		±12	±12.5		V
		R_L = 2 kΩ	25°C	±10	±13		±10	±12		
			Full range	±10			±10			
A_{VD}	Large-signal differential voltage amplification	V_O = ±10 V, R_L = 2 kΩ	25°C	20	200		20	200		V/mV
			Full range	15			15			
B_{OM}	Maximum-output-swing bandwidth	$V_{O(PP)}$ = 20 V, A_{VD} = 1, THD ≤ 5%, R_L = 2 kΩ	25°C		9			9		kHz
B_1	Unity-gain bandwidth	V_O = 50 mV, R_L = 10 kΩ	25°C		1			1		MHz
ϕ_m	Phase margin	R_L = 2 kΩ, C_L = 200 pF	25°C		60°			60°		
r_i	Input resistance	f = 20 Hz	25°C	0.3	1		0.3	1		MΩ
r_o	Output resistance	f = 20 Hz	25°C		75			75		Ω
CMRR	Common-mode rejection ratio	V_{IC} = V_{ICR} min, R_S = 50 Ω	25°C	70	90		70	90		dB
k_{SVS}	Supply voltage sensitivity ($\Delta V_{IO}/\Delta V_{CC}$)	V_{CC} = ±2.5 V to ±15 V, R_S = 50 Ω	25°C		30	150		30	150	µV/V
I_{OS}	Short-circuit output current§	V_O = 0	25°C	±10	±30	±45	±10	±30	±45	mA
I_{CC}	Total supply current	V_O = 0, No load	25°C		1.4	4		1.4	4	mA

† All characteristics are under open-loop conditions unless otherwise noted. Full range for T_A is 0°C to 70°C for TL322C and −40°C to 85°C for TL322I.

‡ The V_{ICR} limits are directly linked volt-for-volt to supply voltage; the positive limit is 2 V less than V_{CC+}.

§ Temperature and/or supply voltages must be limited to ensure that the dissipation rating is not exceeded.

electrical characteristics, V_{CC+} = 5 V, V_{CC-} = 0 V, T_A = 25°C (unless otherwise noted)

PARAMETER		TEST CONDITIONS†	TL322C			TL322I			UNIT
			MIN	TYP	MAX	MIN	TYP	MAX	
V_{IO}	Input offset voltage	V_O = 2.5 V, R_S = 50 Ω		2	10			8	mV
I_{IO}	Input offset current	V_O = 2.5 V		30	50			75	nA
I_{IB}	Input bias current			−0.2	−0.5			−0.5	pA
V_{OM}	Peak output voltage swing‡	R_L = 10 kΩ	3.3	3.5		3.3	3.5		V
		R_L = 10 kΩ, V_{CC+} = 5 V to 30 V	V_{CC+} −1.7			V_{CC+} −1.7			
A_{VD}	Large-signal differential voltage amplification	V_O = 1.7 V to 3.3 V, R_L = 2 kΩ	20	200		20	200		V/mV
k_{SVS}	Supply voltage sensitivity (ΔV_{IO}/ ΔV_{CC+})	V_{CC} = ±2.5 V to ±15 V			150			150	μV/V
I_{CC}	Supply current	V_O = 2.5 V, No load		1.2	4		1.2	4	mA
V_{o1} /V_{o2}	Crosstalk attenuation	A_{VD} = 100, f = 1 kHz to 20 kHz		120			120		dB

† All characteristics are specified under open-loop conditions.
‡ Output will swing essentially to ground.

switching characteristics, V_{CC+} = 15 V, V_{CC-} = − 15 V A_{VD} = 1, T_A = 25°C (unless otherwise noted)

PARAMETER		TEST CONDITIONS	MIN	TYP	MAX	UNIT
SR	Slew rate at unity gain	V_I = ±10 V, C_L = 100 pF, See Figure 1		0.6		V/μs
t_r	Rise time	ΔV_O = 50 mV, C_L = 100 pF, R_L = 10 kΩ, See Figure 1		0.35		μs
t_f	Fall time			0.35		μs
	Overshoot factor			20%		
	Crossover distortion	$V_{I(PP)}$ = 30 mV, $V_{O(PP)}$= 2 V, f = 10 kHz		1%		

PARAMETER MEASUREMENT INFORMATION

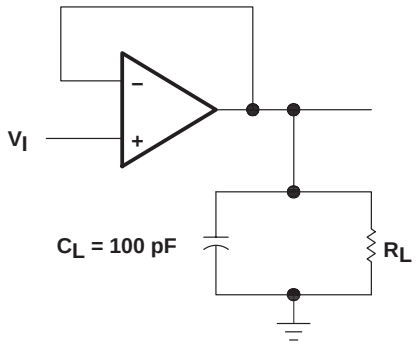


Figure 1. Unity-Gain Amplifier

TYPICAL CHARACTERISTICS†

INPUT BIAS CURRENT vs FREE-AIR TEMPERATURE

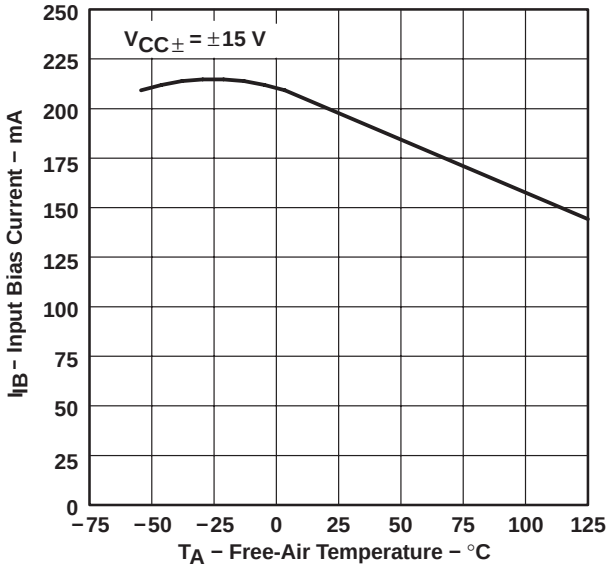


Figure 2

INPUT BIAS CURRENT vs SUPPLY VOLTAGE

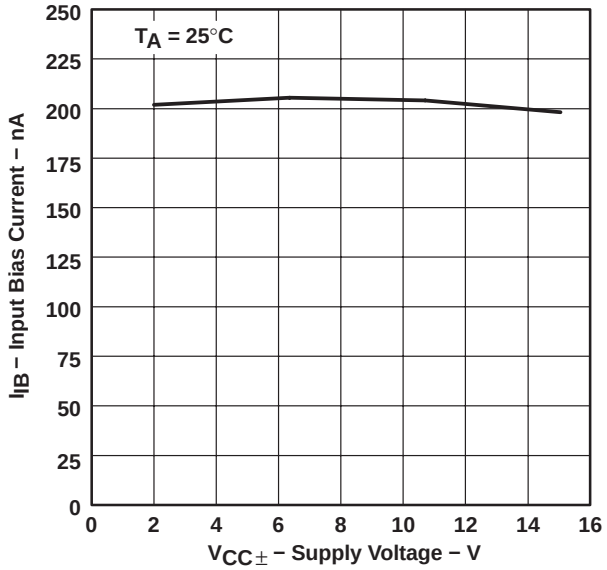


Figure 3

MAXIMUM PEAK-TO-PEAK OUTPUT VOLTAGE vs SUPPLY VOLTAGE

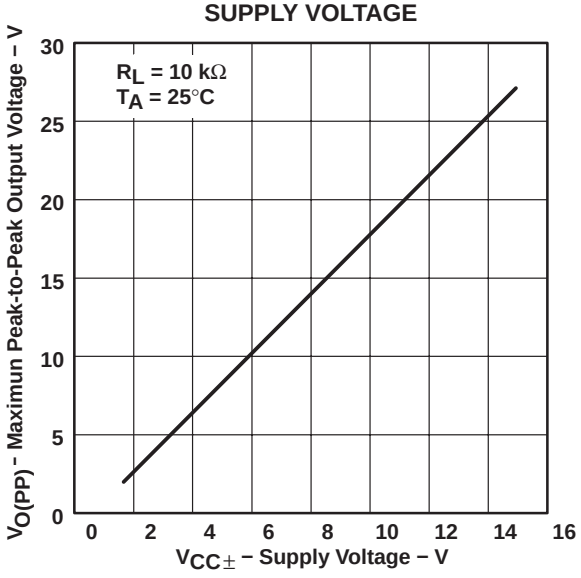


Figure 4

MAXIMUM PEAK-TO-PEAK OUTPUT VOLTAGE vs FREQUENCY

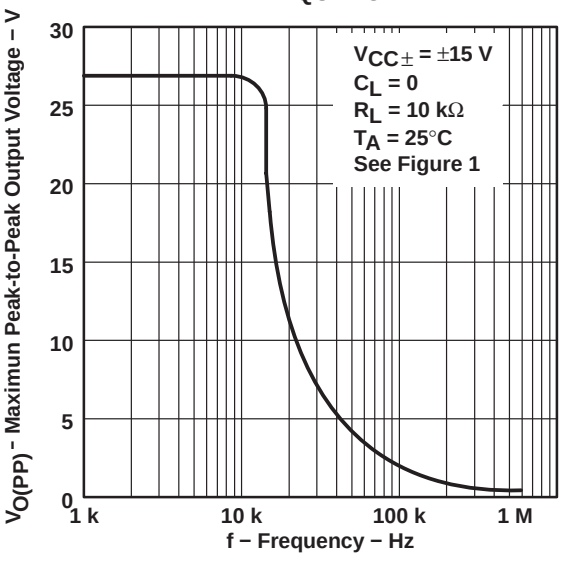


Figure 5

† Data at high and low temperatures are applicable only within the rated operating free-air temperature ranges of the various devices.

TYPICAL CHARACTERISTICS

LARGE-SIGNAL DIFFERENTIAL VOLTAGE AMPLIFICATION vs FREQUENCY

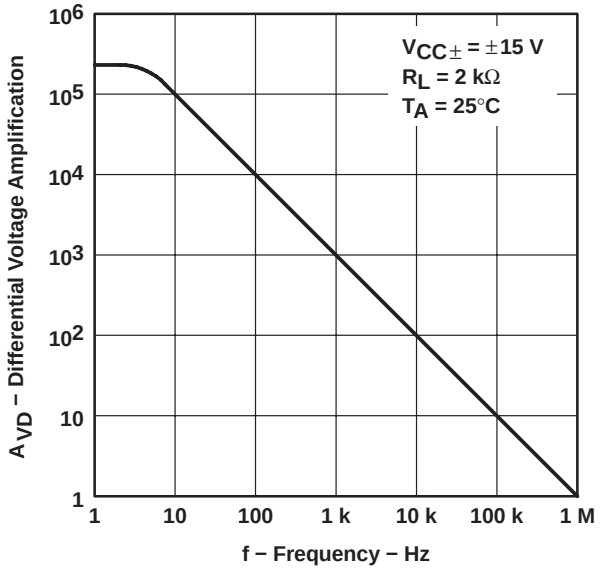


Figure 6

VOLTAGE-FOLLOWER LARGE-SIGNAL PULSE RESPONSE

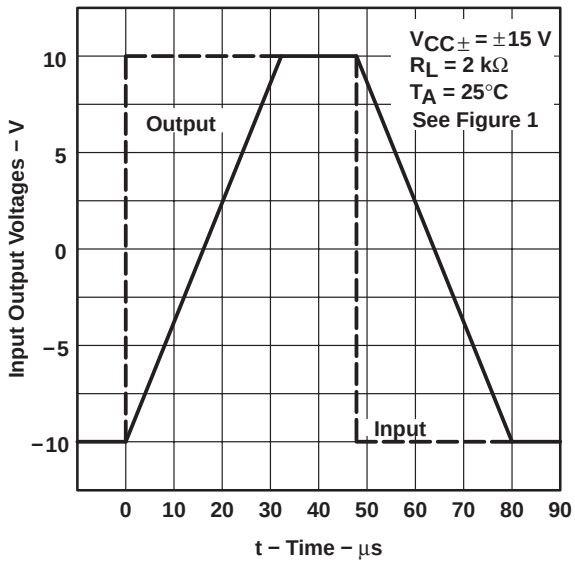


Figure 7

PACKAGING INFORMATION

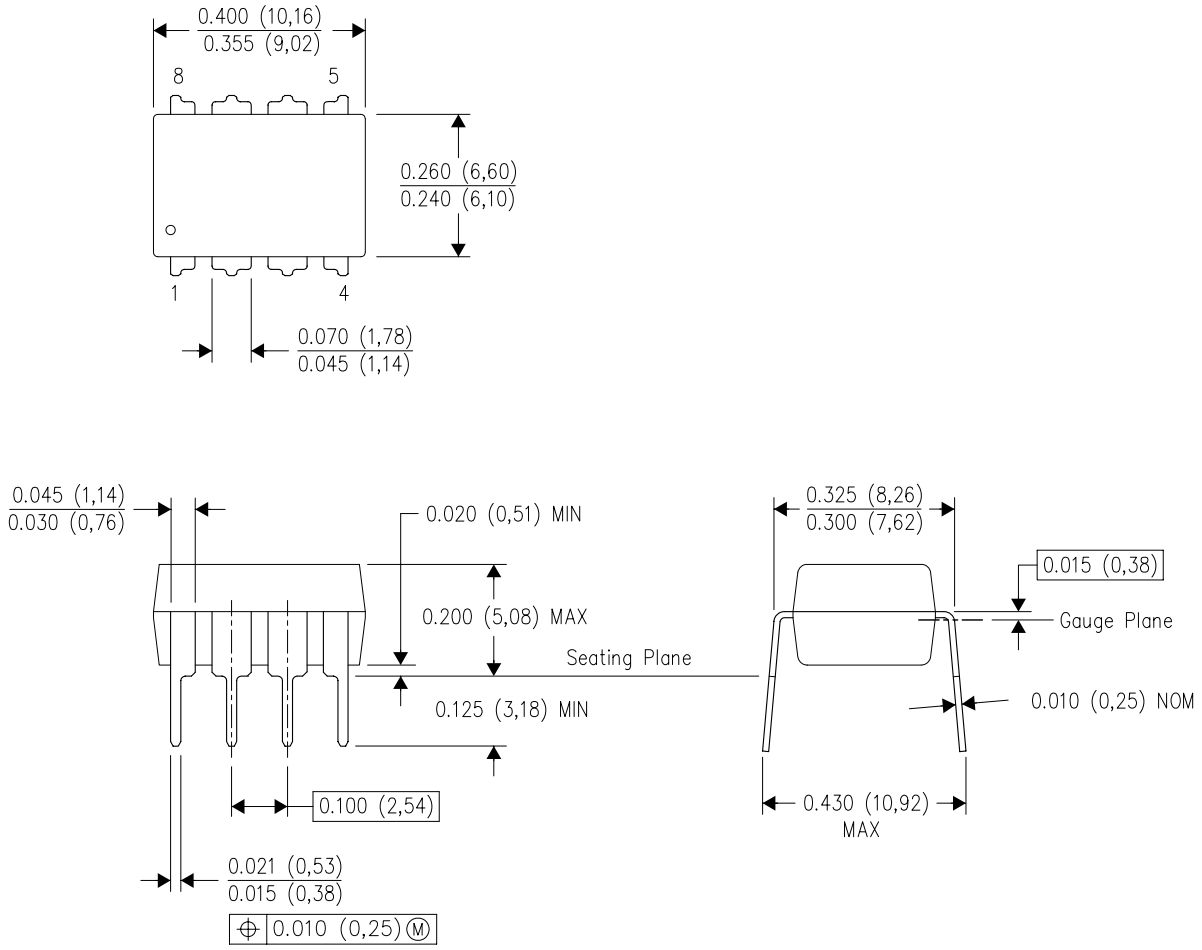
Orderable Device	Status (1)	Package Type	Package Drawing	Pins	Package Qty	Eco Plan (2)	Lead/ Ball Finish	MSL Peak Temp (3)	Samples (Requires Login)
TL322CP	OBSOLETE	PDIP	P	8		TBD	Call TI	Call TI	Samples Not Available
TL322ID	OBSOLETE	SOIC	D	8		TBD	Call TI	Call TI	Samples Not Available
TL322ID	OBSOLETE	SOIC	D	8		TBD	Call TI	Call TI	Samples Not Available
TL322IP	OBSOLETE	PDIP	P	8		TBD	Call TI	Call TI	Samples Not Available
TL322IP	OBSOLETE	PDIP	P	8		TBD	Call TI	Call TI	Samples Not Available

(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)

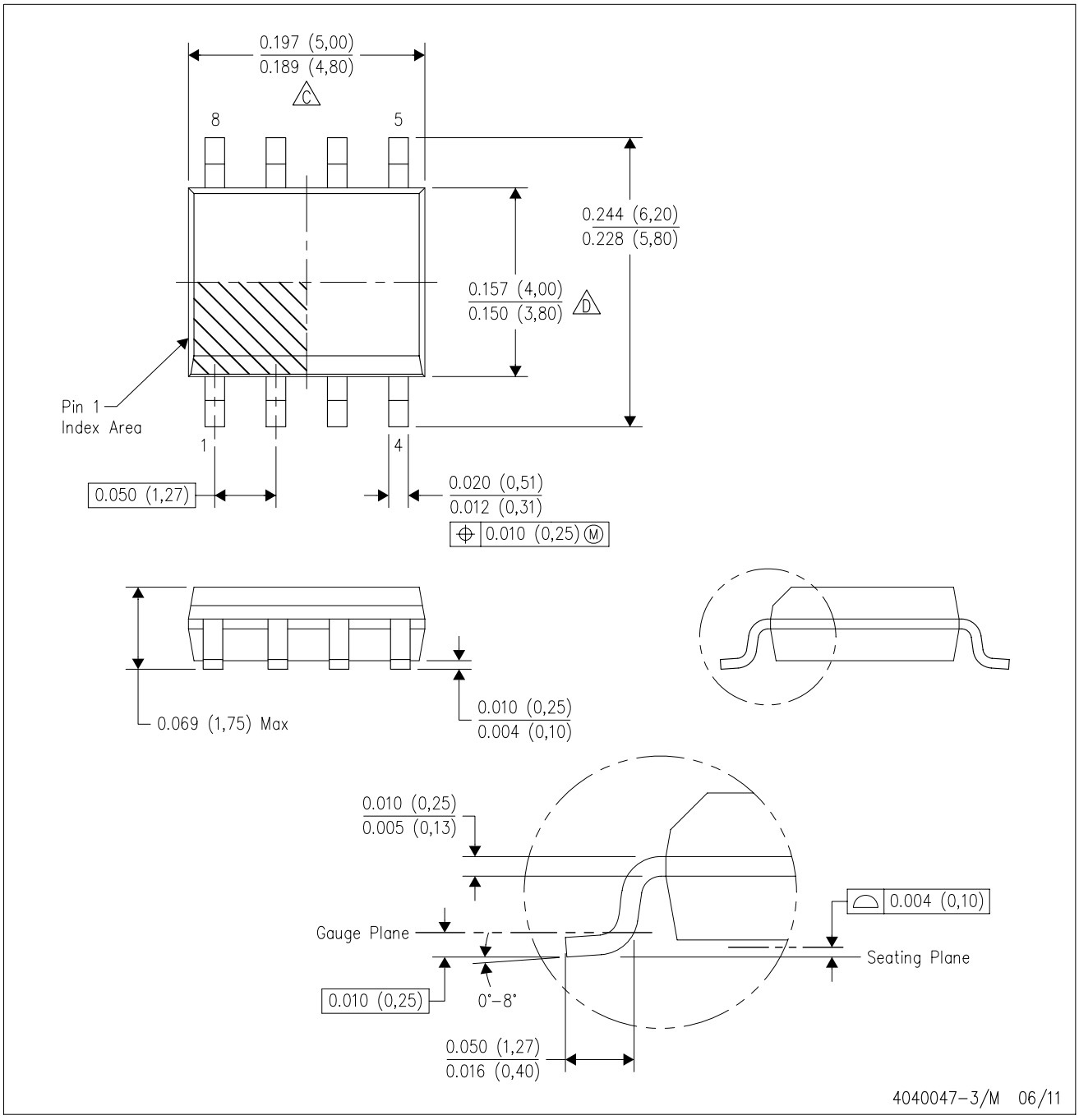
(3) MSL, Peak Temp. -- The Moisture Sensitivity Level rating according to the JEDEC industry standard classifications, and peak solder temperature.

P (R–PDIP–T8) PLASTIC DUAL–IN–LINE PACKAGE



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

D (R–PDSO–G8) PLASTIC SMALL OUTLINE



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 0.006 (0,15) each side.
D. Body width does not include interlead flash. Interlead flash shall not exceed 0.017 (0,43) each side.
E. Reference JEDEC MS–012 variation AA.

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