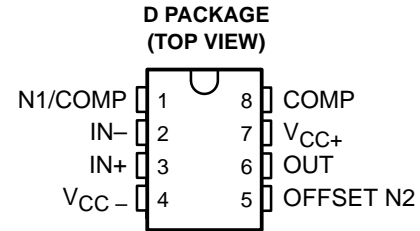


- Low Power Consumption
- Wide Common-Mode and Differential Voltage Ranges
- Low Input-Bias and Offset Currents
- Output Short-Circuit Protection
- Low Total Harmonic Distortion . . . 0.003% Typ
- Low Noise . . .  $V_n = 18 \text{ nV}/\sqrt{\text{Hz}}$  Typ at  $f = 1 \text{ kHz}$
- High Input Impedance . . . JFET Input Stage
- Common-Mode Input Voltage Range Includes  $V_{CC+}$
- Latch-Up-Free Operation
- High Slew Rate . . .  $13 \text{ V}/\mu\text{s}$  Typ



## description

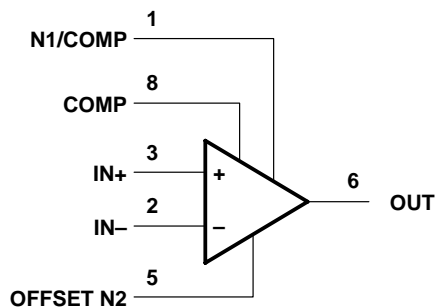
The JFET-input TL070 operational amplifier is designed as the lower-noise version of the TL080 amplifier with low input-bias and offset currents and fast slew rate. The low harmonic distortion and low noise make the TL070 ideally suited for high-fidelity and audio-preamplifier applications. This amplifier features JFET inputs (for high input impedance) coupled with bipolar output stages integrated on a single monolithic chip.

The TL070I device is characterized for operation from  $-40^{\circ}\text{C}$  to  $85^{\circ}\text{C}$ .

## AVAILABLE OPTIONS

$T_A$	$V_{IOmax}$ AT $25^{\circ}\text{C}$	PACKAGE
		SMALL OUTLINE (D)
$-40^{\circ}\text{C}$ to $85^{\circ}\text{C}$	10 mV	TL070ID

## logic symbol†



† This symbol is in accordance with ANSI/IEEE Std 91-1984 and IEC Publication 617-12.



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**TEXAS  
INSTRUMENTS**

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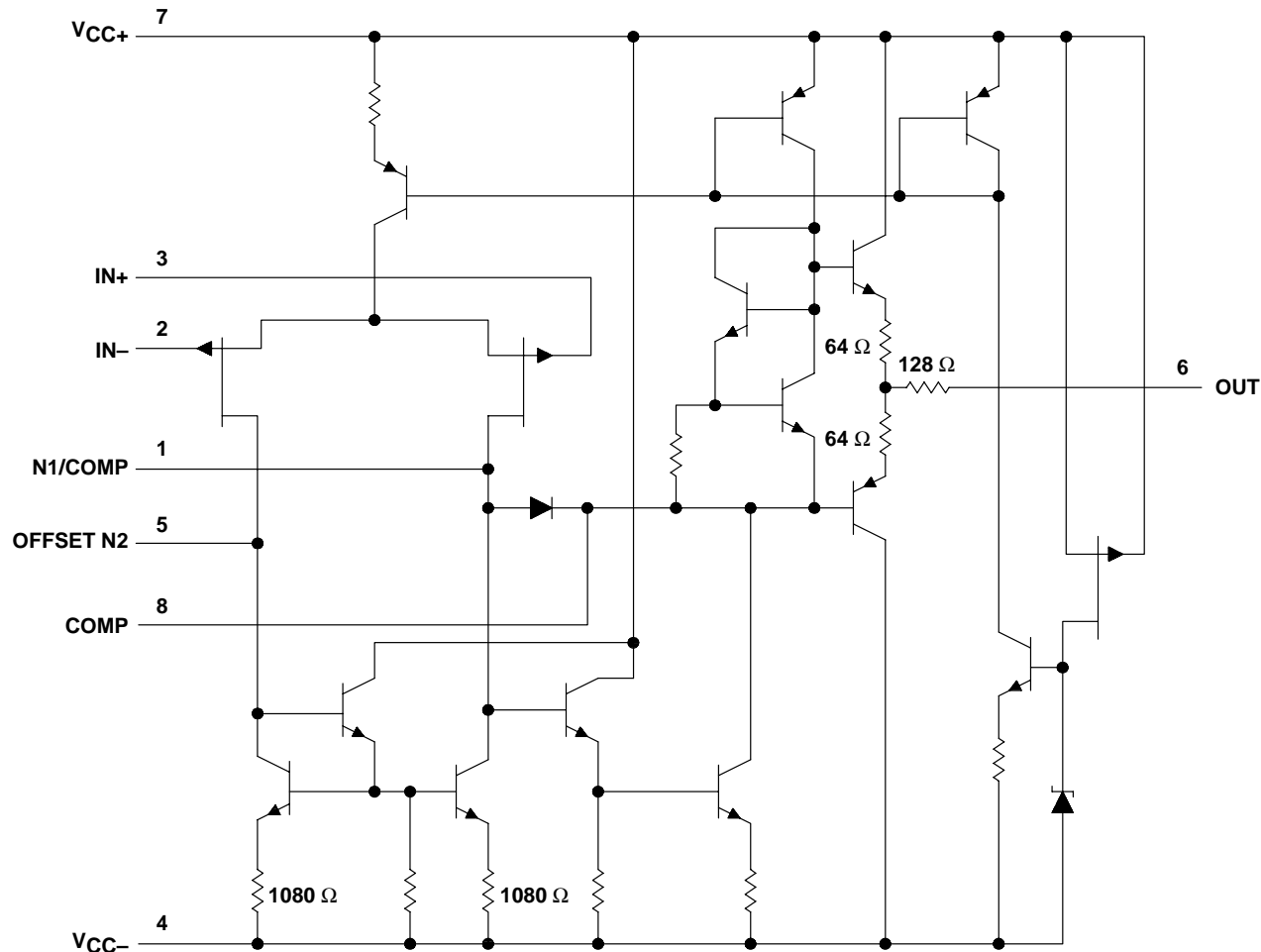
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# TL070

## JFET-INPUT OPERATIONAL AMPLIFIER

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### schematic



All component values shown are nominal.

COMPONENT COUNT†	
Transistors	13
Diodes	2
Resistors	10
epi-FET	1
JFET	2

† Includes all bias and trim circuitry

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

Supply voltage, $V_{CC+}$ (see Note 1)	18 V
Supply voltage, $V_{CC-}$	–18 V
Differential input voltage, $V_{ID}$ (see Note 2)	$\pm 30$ V
Input voltage, $V_I$ (see Notes 1 and 3)	$\pm 15$ V
Duration of short-circuit current (see Note 4)	Unlimited
Package thermal impedance, $\theta_{JA}$ (see Note 5): D package	97°C/W
PW package	149°C/W
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

† 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  $IN+$  with respect to  $IN-$ .
  3. The magnitude of the input voltage must never exceed the magnitude of the supply voltage or 15 V, whichever is less.
  4. The output may be shorted to ground or to either supply. Temperature and/or supply voltages must be limited to ensure that the dissipation rating is not exceeded.
  5. The package thermal impedance is calculated in accordance with JESD 51-7.

# TL070

## JFET-INPUT OPERATIONAL AMPLIFIER

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### electrical characteristics, $V_{CC\pm} = \pm 15\text{ V}$ (unless otherwise noted)

PARAMETER	TEST CONDITIONS	$T_A^\dagger$	MIN	TYP	MAX	UNIT
$V_{IO}$ Input offset voltage	$V_O = 0, R_S = 50\ \Omega$	25°C		3	10	mV
		Full range			13	
$\alpha_{V_{IO}}$ Temperature coefficient of input offset voltage	$V_O = 0, R_S = 50\ \Omega$	Full range		18		$\mu\text{V}/^\circ\text{C}$
$I_{IO}$ Input offset current	$V_O = 0$	25°C		5	100	pA
		Full range			10	nA
$I_{IB}$ Input bias current $^\ddagger$	$V_O = 0$	25°C		65	200	pA
		Full range			20	nA
$V_{ICR}$ Common-mode input voltage range		25°C	$\pm 11$	-12 to 15		V
$V_{OM}$ Maximum peak output voltage swing	$R_L = 10\ \text{k}\Omega$	25°C	$\pm 12$	$\pm 13.5$		V
	$R_L \geq 10\ \text{k}\Omega$	Full range	$\pm 12$			
	$R_L \geq 2\ \text{k}\Omega$		$\pm 10$			
$A_{VD}$ Large-signal differential voltage amplification	$V_O = \pm 10\text{ V}, R_L \geq 2\ \text{k}\Omega$	25°C	25	200		V/mV
		Full range	15			
$B_1$ Unity-gain bandwidth		25°C		3		MHz
$r_i$ Input resistance		25°C		$10^{12}$		$\Omega$
CMRR Common-mode rejection ratio	$V_{IC} = V_{ICRmin}, V_O = 0, R_S = 50\ \Omega$	25°C	70	100		dB
$k_{SVR}$ Supply-voltage rejection ratio ( $\Delta V_{CC\pm}/\Delta V_{IO}$ )	$V_{CC} = \pm 9\text{ V to } \pm 15\text{ V}, V_O = 0, R_S = 50\ \Omega$	25°C	70	100		dB
$I_{CC}$ Supply current	$V_O = 0, \text{ No load}$	25°C		1.4	2.5	mA
$V_{O1}/V_{O2}$ Crosstalk attenuation	$A_{VD} = 100$	25°C		120		dB

$^\dagger$  All characteristics are measured under open-loop conditions with zero common-mode voltage unless otherwise specified. Full range for  $T_A$  is  $-40^\circ\text{C}$  to  $85^\circ\text{C}$ .

$^\ddagger$  Input bias currents of a FET-input operational amplifier are normal junction reverse currents, which are temperature sensitive as shown in Figure 5. Pulse techniques must be used that will maintain the junction temperature as close to the ambient temperature as possible.

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

PARAMETER	TEST CONDITIONS	MIN	TYP	MAX	UNIT
SR Slew rate at unity gain	$V_I = 10\text{ V}, R_L = 2\ \text{k}\Omega, C_L = 100\ \text{pF}, \text{ See Figure 1}$	8	13		V/ $\mu\text{s}$
$t_r$ Rise-time overshoot factor	$V_I = 20\text{ mV}, R_L = 2\ \text{k}\Omega, C_L = 100\ \text{pF}, \text{ See Figure 1}$		0.1		$\mu\text{s}$
			20		%
$V_n$ Equivalent input noise voltage	$R_S = 20\ \Omega$	$f = 1\ \text{kHz}$		18	$\text{nV}/\sqrt{\text{Hz}}$
		$f = 10\ \text{Hz to } 10\ \text{kHz}$		4	$\mu\text{V}$
$I_n$ Equivalent input noise current	$R_S = 20\ \Omega, f = 1\ \text{kHz}$		0.01		$\text{pA}/\sqrt{\text{Hz}}$
THD Total harmonic distortion	$V_{O(rms)} = 10\text{ V}, R_S \leq 1\ \text{k}\Omega, R_L \geq 2\ \text{k}\Omega, f = 1\ \text{kHz}$		0.003		%



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## APPLICATION INFORMATION

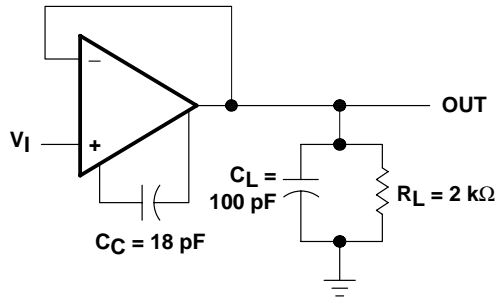


Figure 1. Unity-Gain Amplifier

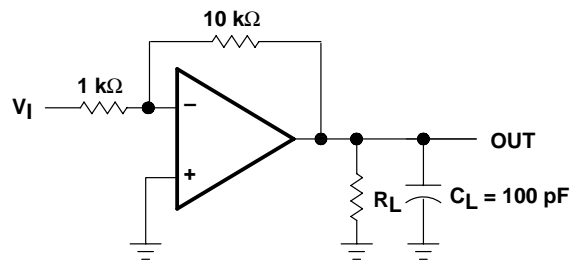


Figure 2. Gain-of-10 Inverting Amplifier

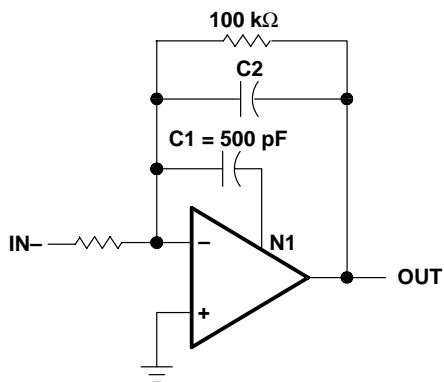


Figure 3. Feed-Forward Compensation

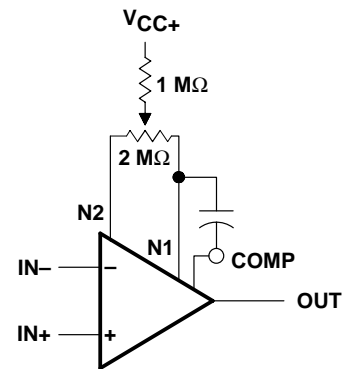


Figure 4. Input Offset Voltage Null Circuit

# TL070

## JFET-INPUT OPERATIONAL AMPLIFIER

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### TYPICAL CHARACTERISTICS

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TYPICAL CHARACTERISTICS†

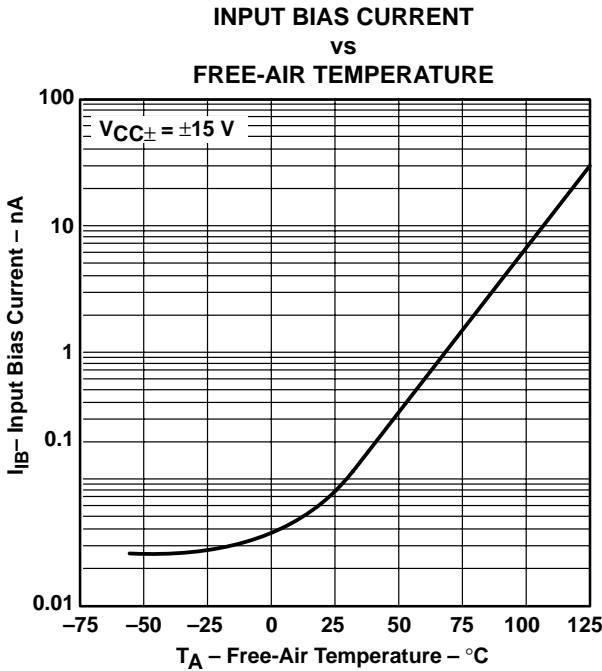


Figure 5

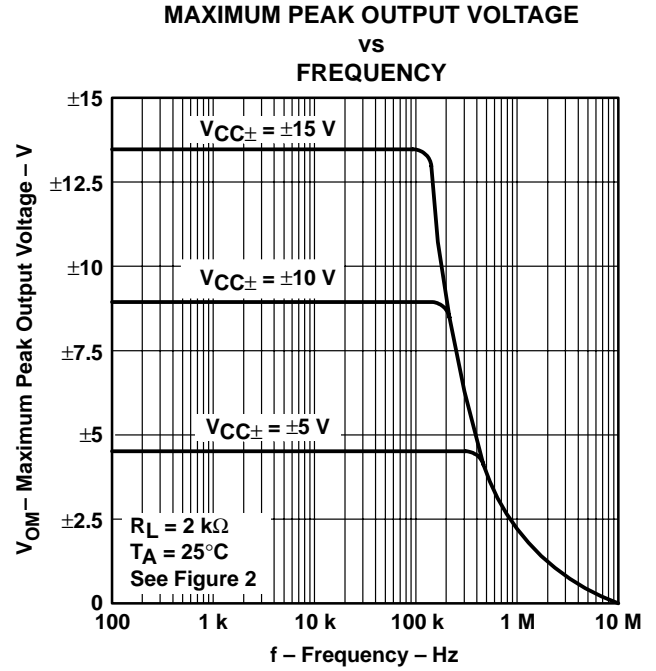


Figure 6

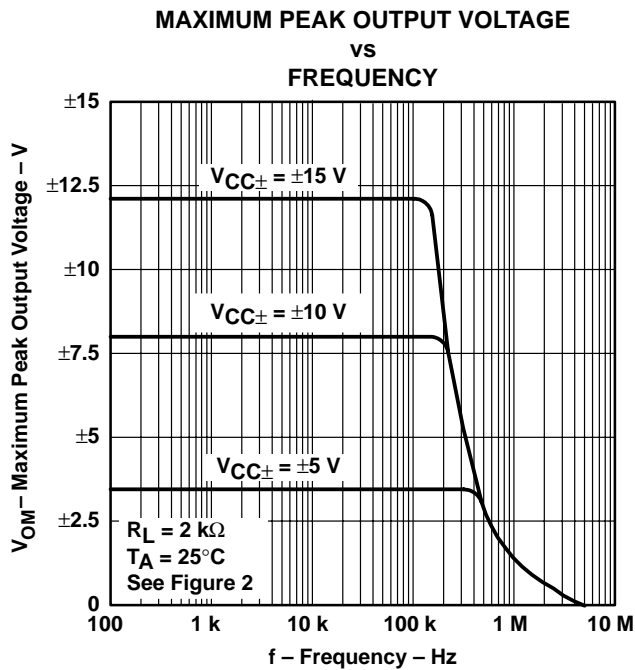


Figure 7

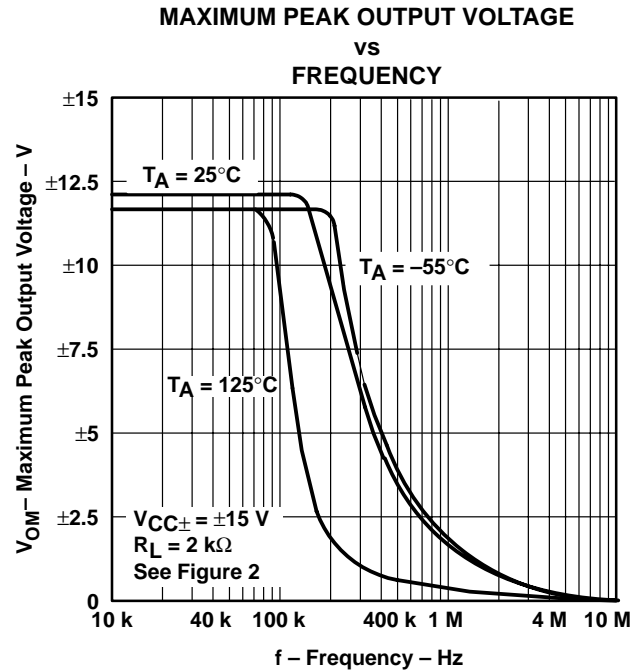


Figure 8

† Data at high and low temperatures are applicable only within the rated operating free-air temperature ranges of the various devices. An 18-pF compensation capacitor is used.

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## JFET-INPUT OPERATIONAL AMPLIFIER

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### TYPICAL CHARACTERISTICS†

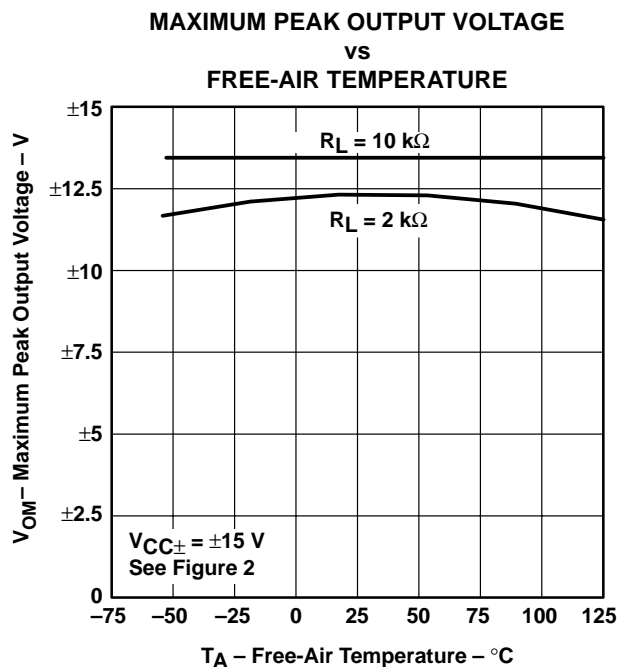


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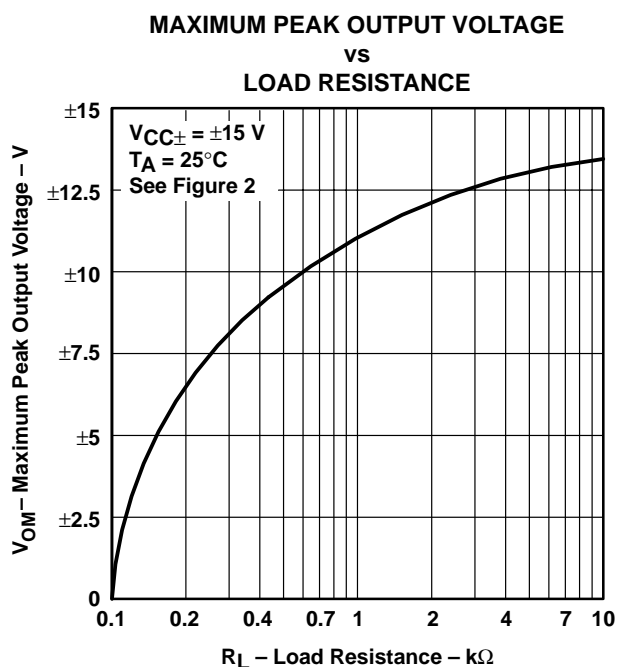


Figure 10

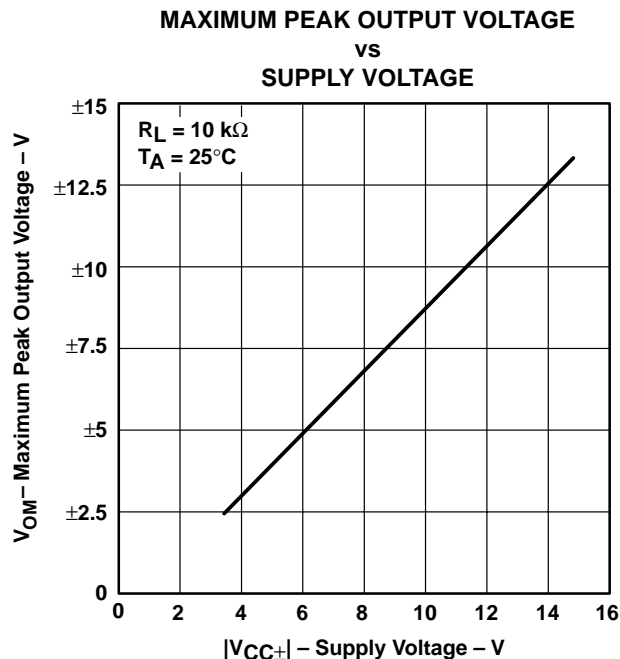


Figure 11

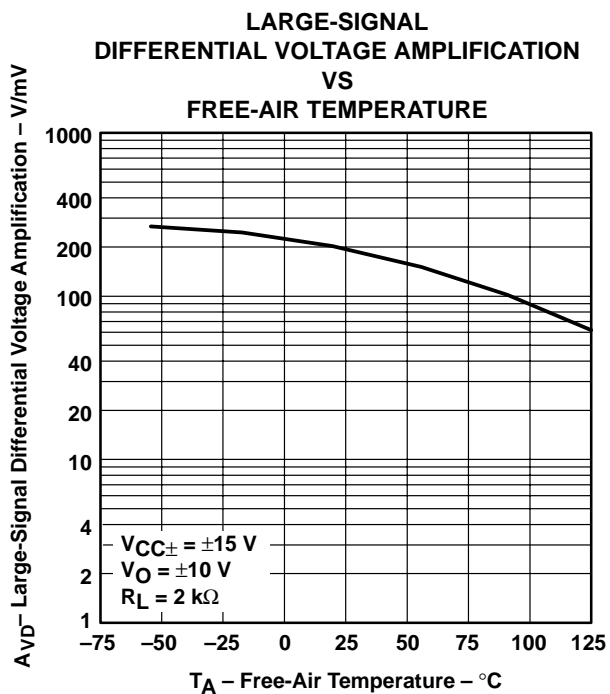


Figure 12

† Data at high and low temperatures are applicable only within the rated operating free-air temperature ranges of the various devices. An 18-pF compensation capacitor is used.

TYPICAL CHARACTERISTICS†

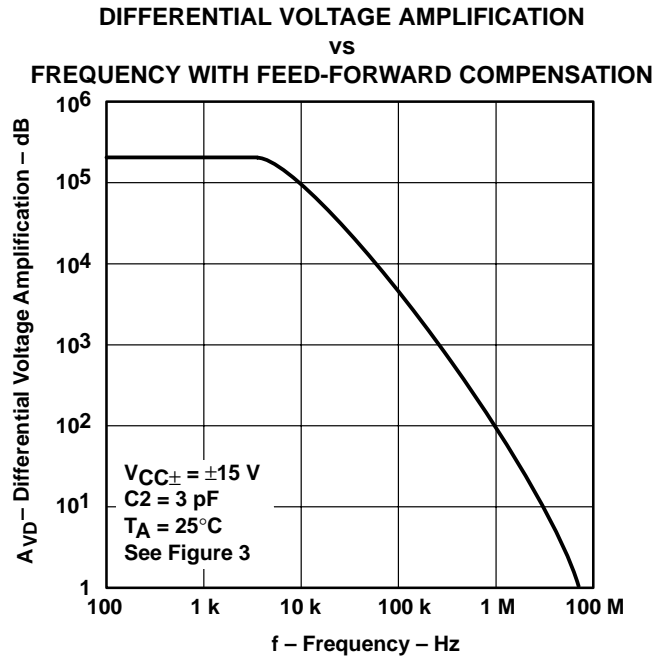


Figure 13

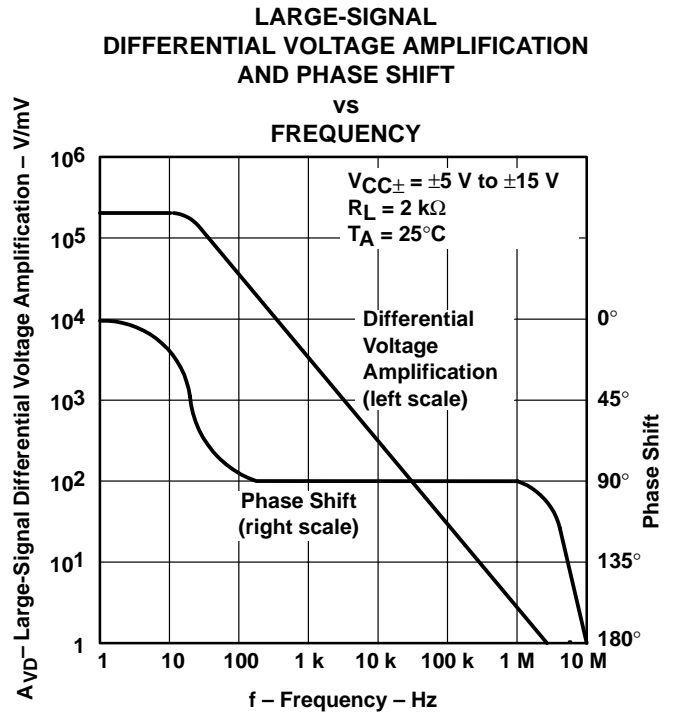


Figure 14

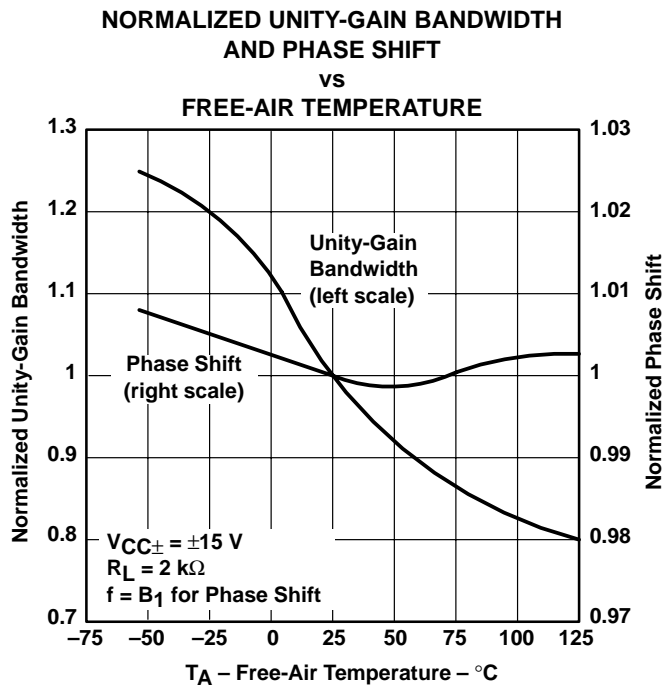


Figure 15

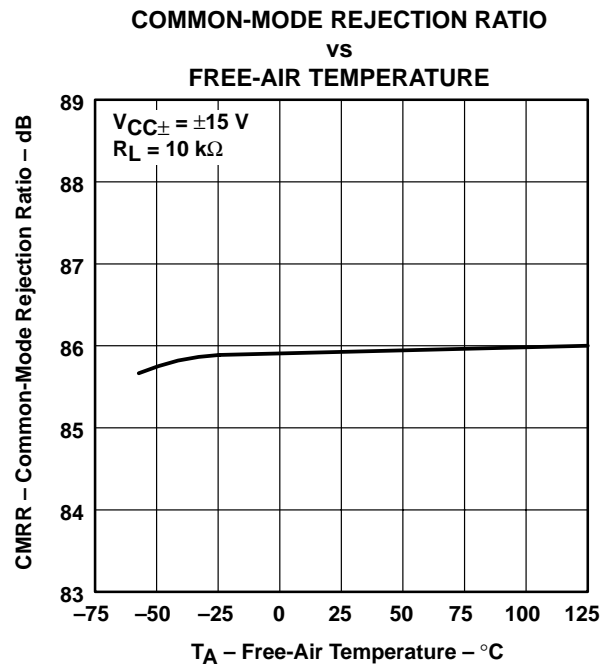


Figure 16

† Data at high and low temperatures are applicable only within the rated operating free-air temperature ranges of the various devices. An 18-pF compensation capacitor is used.

# TL070

## JFET-INPUT OPERATIONAL AMPLIFIER

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### TYPICAL CHARACTERISTICS†

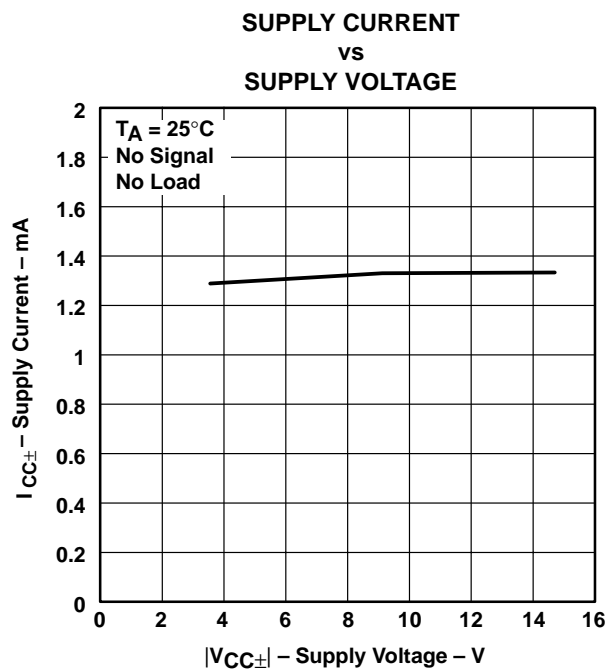


Figure 17

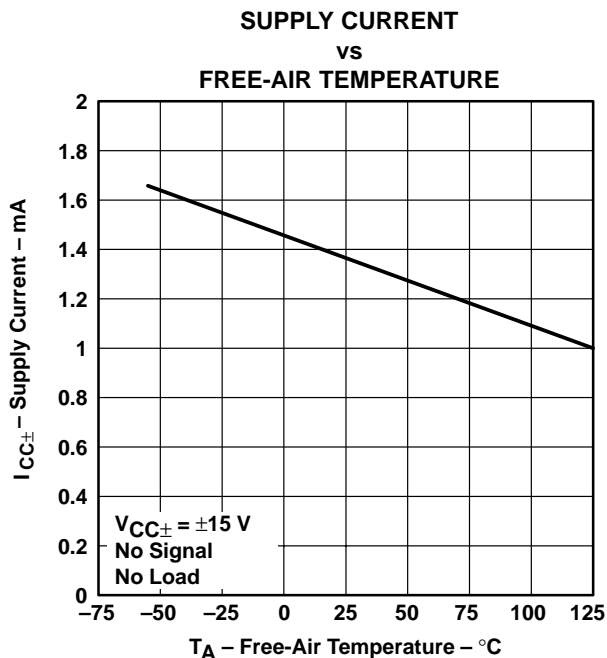


Figure 18

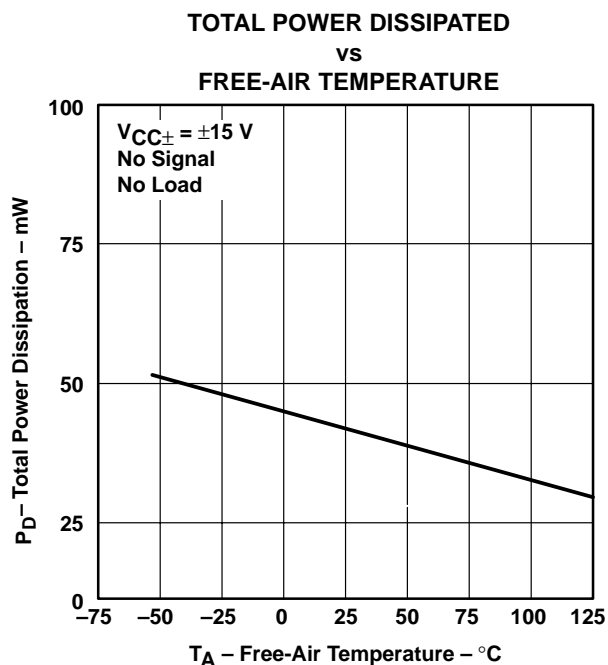


Figure 19

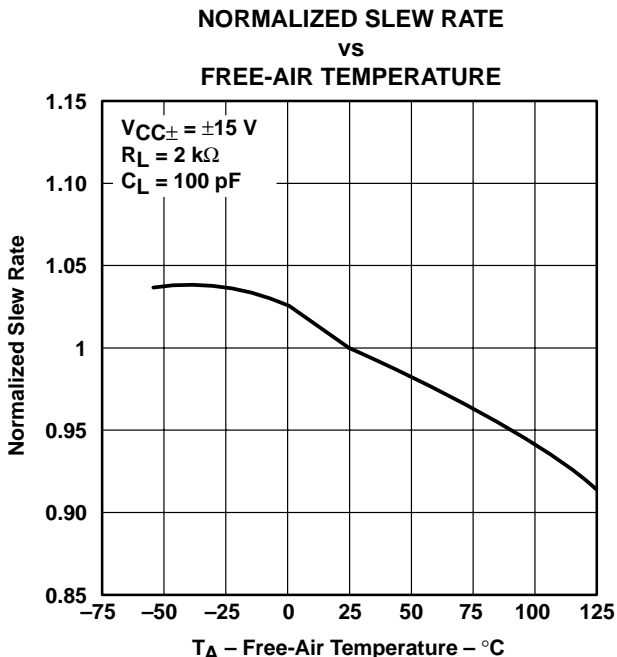


Figure 20

† Data at high and low temperatures are applicable only within the rated operating free-air temperature ranges of the various devices. An 18-pF compensation capacitor is used.

TYPICAL CHARACTERISTICS

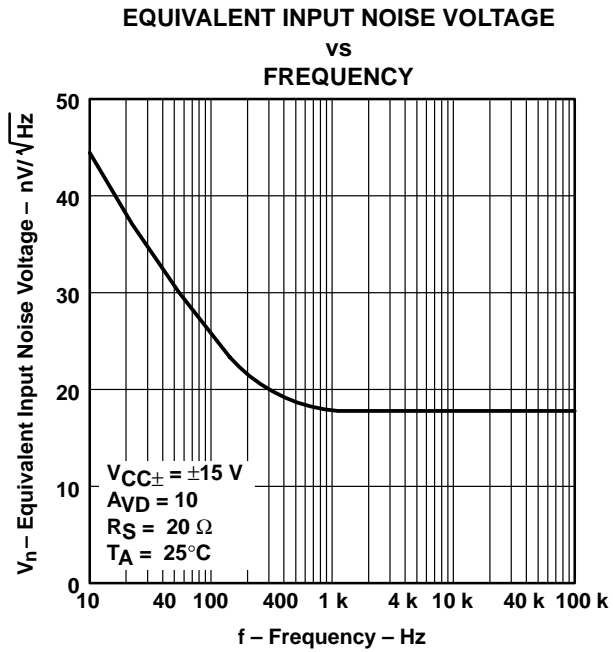


Figure 21

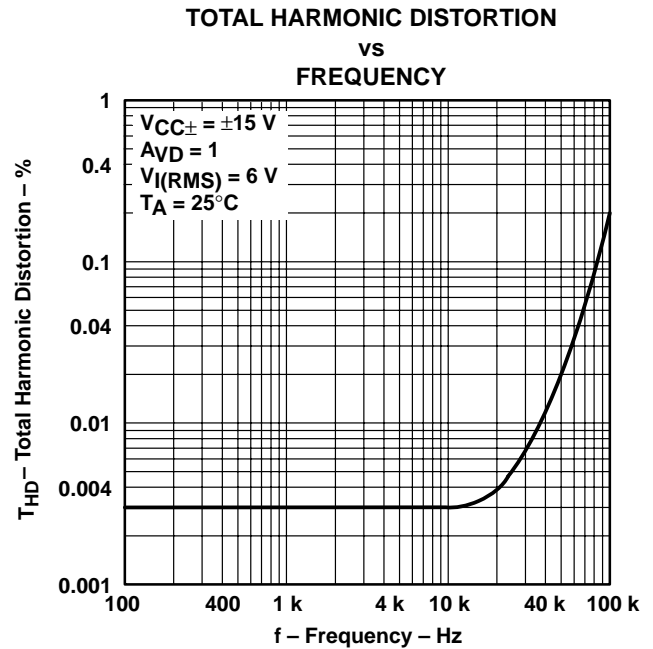


Figure 22

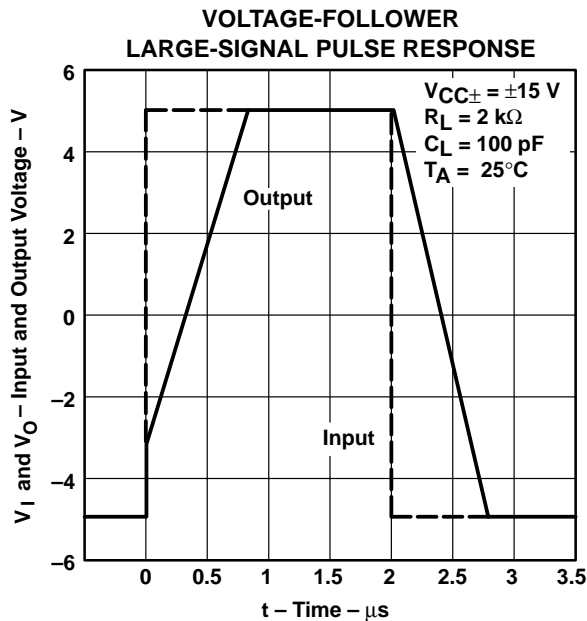


Figure 23

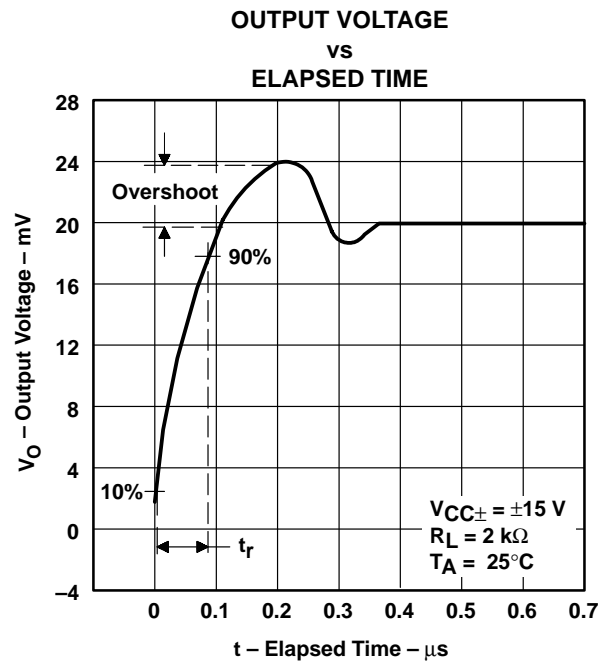


Figure 24

# TL070

## JFET-INPUT OPERATIONAL AMPLIFIER

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### APPLICATION INFORMATION

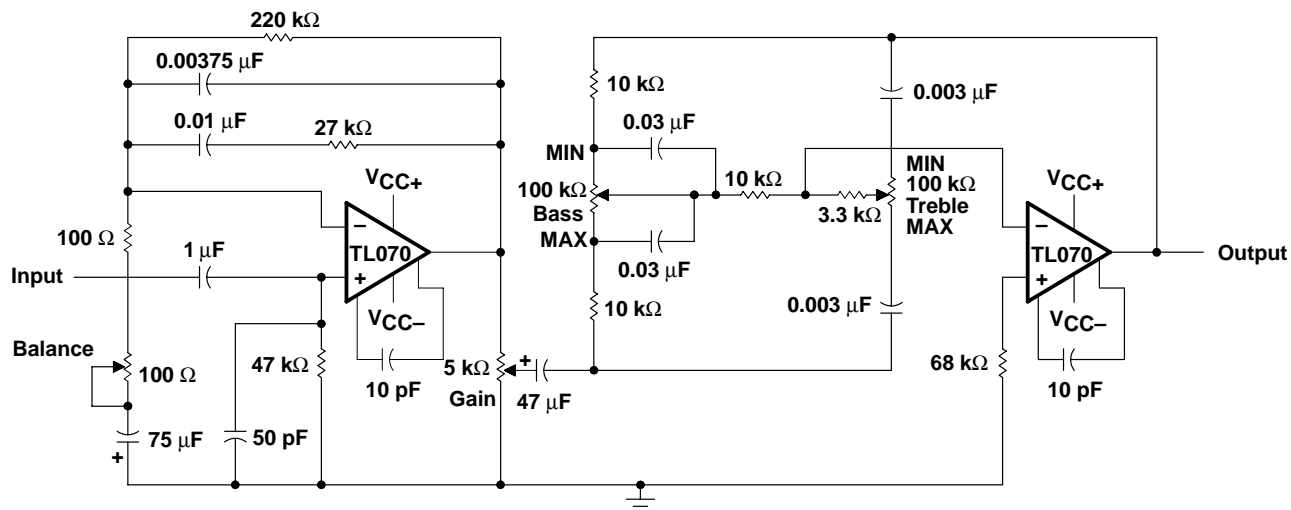


Figure 25. IC Preamplifier

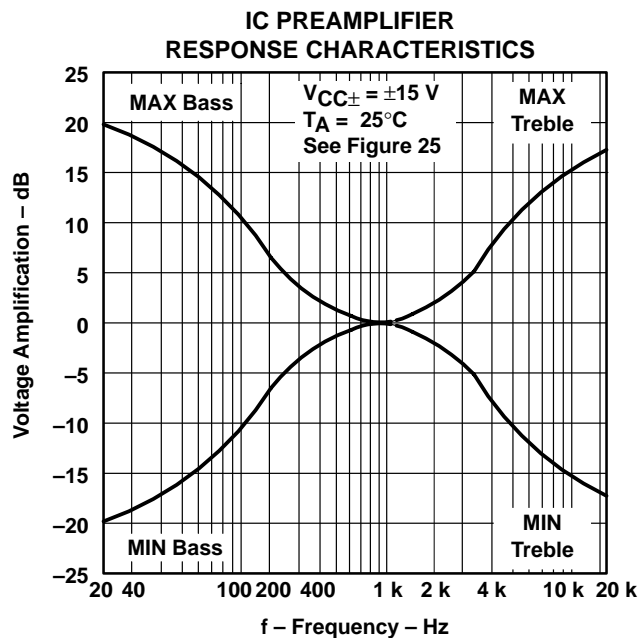


Figure 26

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**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>
TL070CD	OBSOLETE	SOIC	D	8		TBD	Call TI	Call TI
TL070CP	OBSOLETE	PDIP	P	8		TBD	Call TI	Call TI
TL070IDR	ACTIVE	SOIC	D	8		TBD	Call TI	Call TI
TL070IDRE4	ACTIVE	SOIC	D	8		TBD	Call TI	Call TI
TL070IDRG4	ACTIVE	SOIC	D	8		TBD	Call TI	Call TI
TL070IP	OBSOLETE	PDIP	P	8		TBD	Call TI	Call TI

<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.

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**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)

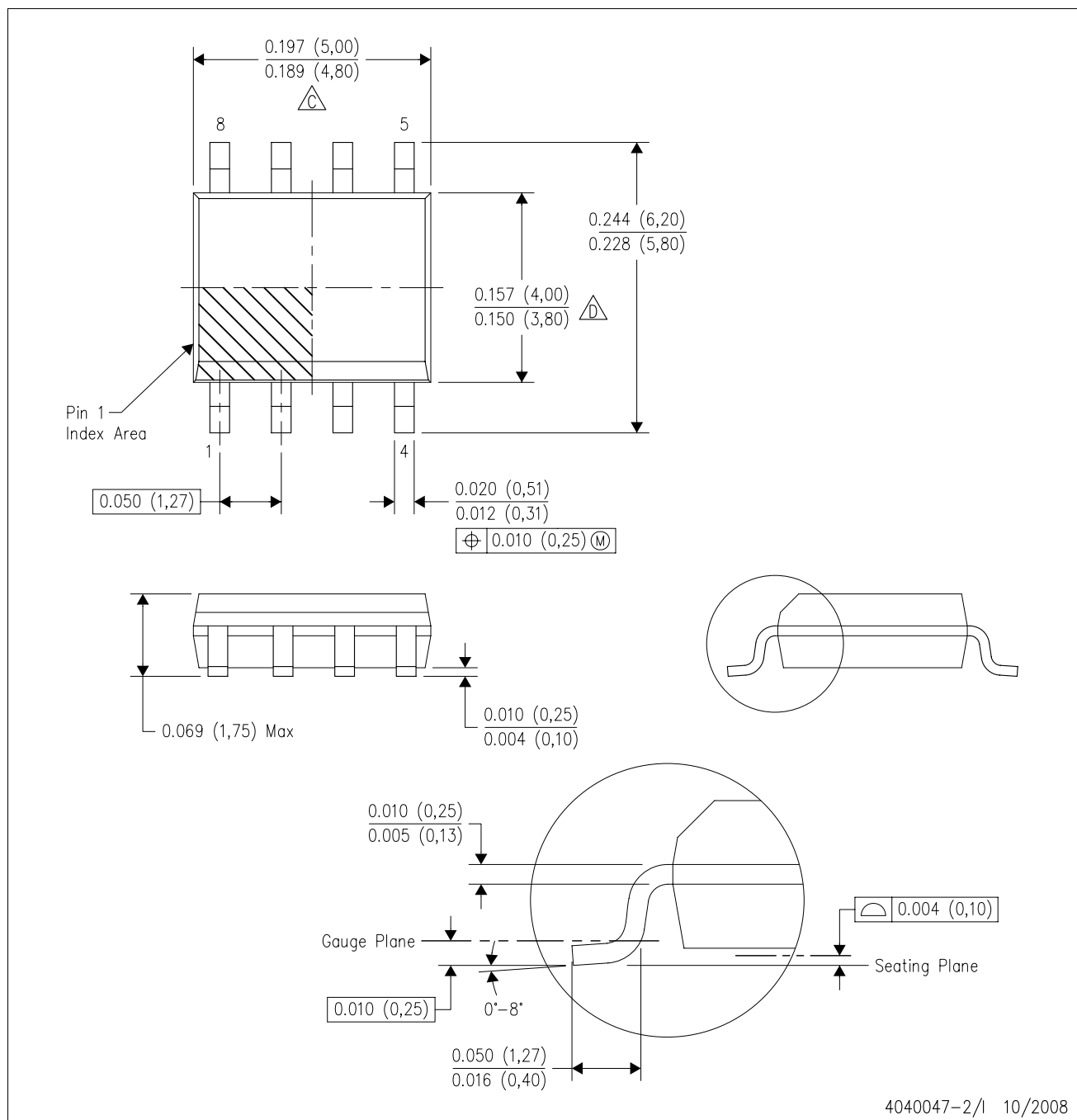
<sup>(3)</sup> MSL, Peak Temp. -- The Moisture Sensitivity Level rating according to the JEDEC industry standard classifications, and peak solder temperature.

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D (R-PDSO-G8)

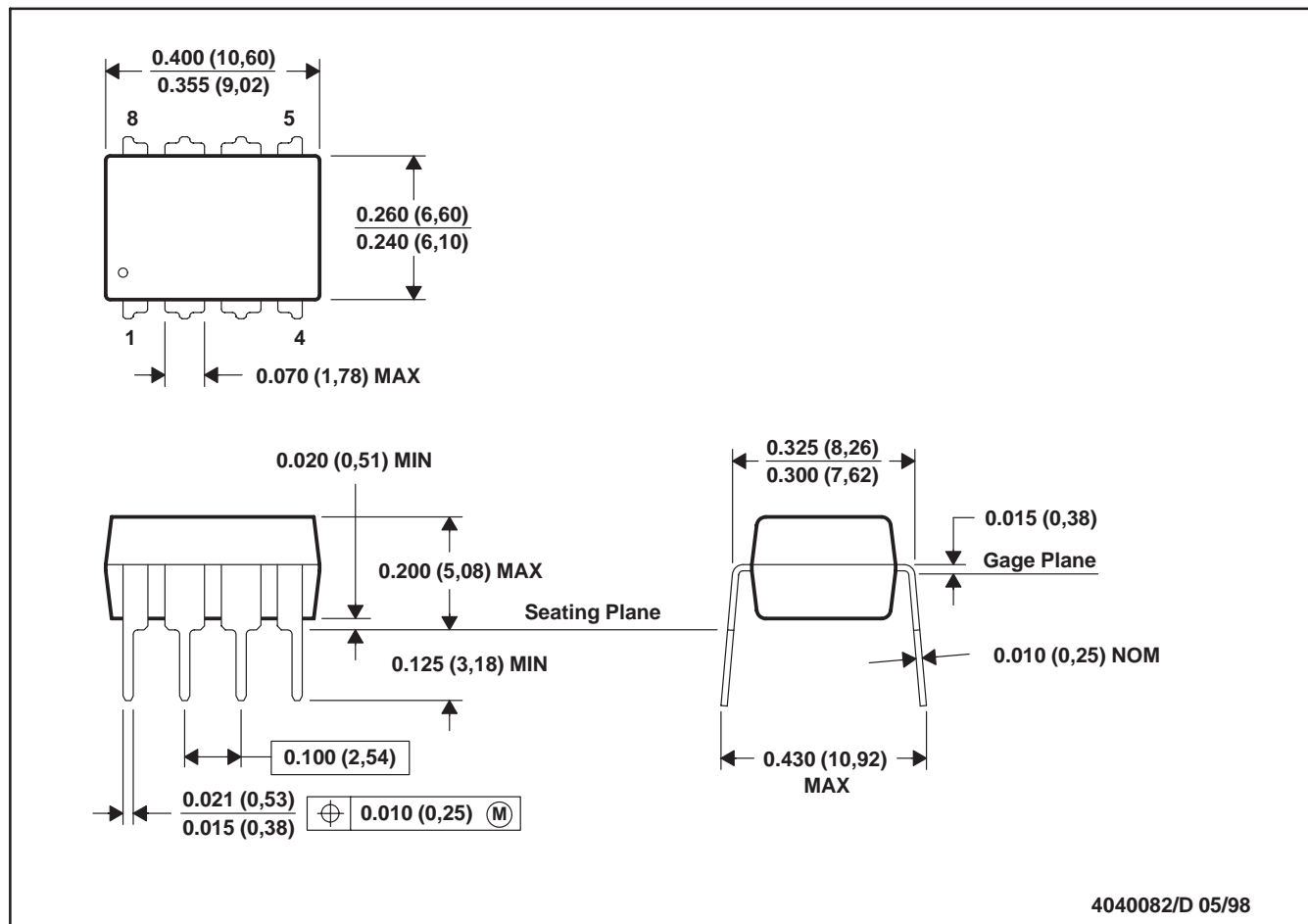
PLASTIC SMALL-OUTLINE PACKAGE



- NOTES:
- A. All linear dimensions are in inches (millimeters).
  - B. This drawing is subject to change without notice.
  - 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.

## P (R-PDIP-T8)

## PLASTIC DUAL-IN-LINE



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