The TL087, TL088, and TL287 are obsolete and are no longer supplied.

- **Low Input Offset Voltage . . . 0.5 mV Max**
- **Low Power Consumption**
- **Wide Common-Mode and Differential Voltage Ranges**
- **Low Input Bias and Offset Currents**
- **High Input Impedance . . . JFET-Input Stage**
- **Internal Frequency Compensation**
- **Latch-Up-Free Operation**
- **High Slew Rate . . . 18 V/μs Typ**
- **Low Total Harmonic Distortion 0.003% Typ**

TL087, TL088
D, JG, OR P PACKAGE
(TOP VIEW)

OFFSET N1	1	8	NC
IN –	2	7	V_{CC+}
IN+	3	6	OUT
V_{CC-}	4	5	OFFSET N2

TL088M
U PACKAGE
(TOP VIEW)

NC	1	10	NC
OFFSET N1	2	9	NC
IN –	3	8	V_{CC+}
IN+	4	7	OUT
V_{CC-}	5	6	OFFSET N2

TL287, TL288
JG OR P PACKAGE
(TOP VIEW)

1OUT	1	8	V_{CC+}
1IN –	2	7	2OUT
1IN+	3	6	2IN –
V_{CC-}	4	5	2IN+

NC – No internal connection

TL288M
U PACKAGE
(TOP VIEW)

NC	1	10	NC
1OUT	2	9	V_{CC+}
1IN –	3	8	2OUT
1IN+	4	7	2IN –
V_{CC-}	5	6	2IN+
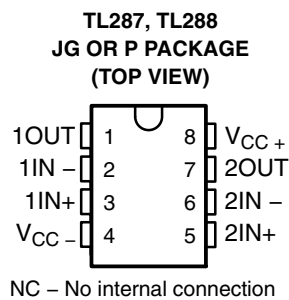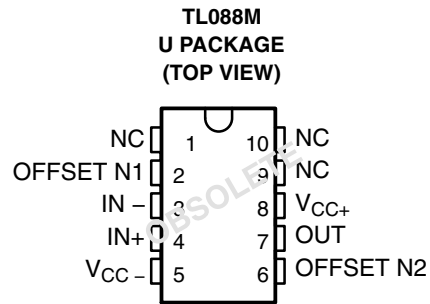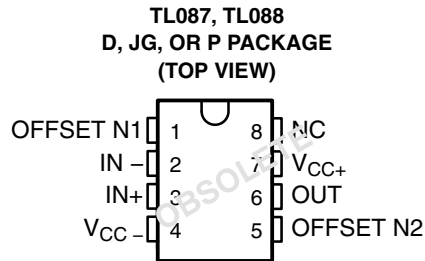
description/ordering information

These JFET-input operational amplifiers incorporate well-matched high-voltage JFET and bipolar transistors in a monolithic integrated circuit. They feature low input offset voltage, high slew rate, low input bias and offset currents, and low temperature coefficient of input offset voltage. Offset-voltage adjustment is provided for the TL087 and TL088.

The C-suffix devices are characterized for operation from 0°C to 70°C, and the I-suffix devices are characterized for operation from –40°C to 85°C. The M-suffix devices are characterized for operation over the full military temperature range of –55°C to 125°C.

ORDERING INFORMATION

T_A	TYPE	V_{IO} MAX AT 25°C	PACKAGE†		ORDERABLE PART NUMBER	TOP-SIDE MARKING
0°C to 70°C	Dual	1 mV	PDIP (P)	Tube of 50	TL288CP	TL288CP

† Package drawings, standard packing quantities, thermal data, symbolization, and PCB design guidelines are available at www.ti.com/sc/package.

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.
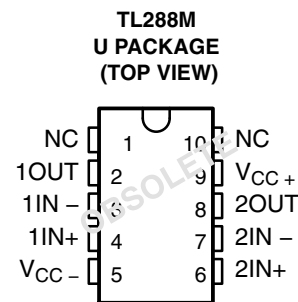
TEXAS INSTRUMENTS

TL087, TL088, TL287, TL288
JFET-INPUT OPERATIONAL AMPLIFIERS

SLOS082B – MARCH 1979 REVISED – JULY 2004

The TL087, TL088, and TL287 are
obsolete and are no longer supplied.

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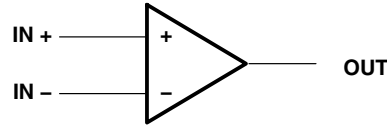
absolute maximum ratings over operating free-air temperature range (unless otherwise noted)

		TL088M TL288M	TL087I TL088I TL287I TL288I	TL087C TL088C TL287C TL288C	UNIT
Supply voltage, VCC+ (see Note 1)		18	18	18	V
Supply voltage, $V_{CC}-$ (see Note 1)		−18	−18	−18	V
Differential input voltage (see Note 2)		±30	±30	±30	V
Input voltage (see Notes 1 and 3)		±15	±15	±15	V
Input current, I_I (each Input)		±1	±1	±1	mA
Output current, I_O (each output)		±80	±80	±80	mA
Total $V_{CC}+$ terminal current		160	160	160	mA
Total $V_{CC}-$ terminal current		−160	−160	−160	mA
Duration of output short circuit (see Note 4)		Unlimited	Unlimited	Unlimited	
Continuous total dissipation		See Dissipation Rating Table			
Maximum junction temperature, T_J			150	150	°C
Package thermal impedance, θ_{JA} (see Notes 5 and 6)	P package		85	85	°C/W
Lead temperature 1,6 mm (1/16 inch) from case for 60 seconds	JG or U package	300	300	300	°C
Storage temperature range, T_{stg}		−65 to 150	−65 to 150	−65 to 150	°C

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 terminal with respect to the inverting input terminal.
    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. 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 PD = $(T_J$(max) − $T_A)/\theta_{JA}$. Operating at the absolute maximum T_J of 150°C can affect reliability.
    6. The package thermal impedance is calculated in accordance with JESD 51-7.
    7. 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.
    8. 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 PD = $(T_J$(max) − $T_A)/\theta_{JA}$. Operating at the absolute maximum T_J of 150°C can affect reliability.
    9. The package thermal impedance is calculated in accordance with JESD 51-7.

DISSIPATION RATING TABLE

PACKAGE	$T_A \leq 25°C$ POWER RATING	DERATING FACTOR ABOVE $T_{A\,=}$ 25°C	T_A = 70°C POWER RATING	T_A = 85°C POWER RATING	T_A = 125°C POWER RATING
JG	1050 mW	8.4 mW/°C	672 mW	546 mW	210 mW
U	675 mW	5.4 mW/°C	432 mW	351 mW	135 mW

The TL087, TL088, and TL287 are obsolete and are no longer supplied.

recommended operating conditions

			C-SUFFIX		I-SUFFIX		M-SUFFIX		UNIT
			MIN	MAX	MIN	MAX	MIN	MAX	
V_{CC}	Supply voltage		±5	±5	±5	±5	±5	±15	V
V_{IC}	Common-mode input voltage	$V_{CC\pm} = \pm5$ V	−1	4	−1	4	−1	4	V
		$V_{CC\pm} = \pm15$ V	−11	11	−11	11	−11	11	
V_I	Input voltage	$V_{CC\pm} = \pm5$ V	−1	4	−1	4	−1	4	V
		$V_{CC\pm} = \pm15$ V	−11	11	−11	11	−11	11	
T_A	Operating free-air temperature		0	70	−40	85	−55	125	°C

operating characteristics $V_{CC} = \pm15$ V, $T_A = 25°C$

PARAMETER		TEST CONDITIONS		TL088M, TL288M			TL087I, TL087C TL088I, TL088C			UNIT
				MIN	TYP	MAX	MIN	TYP	MAX	
SR	Slew rate at unity gain	$V_I = 10$ V, $C_L = 100$ pF,	$R_L = 2$ kΩ, $A_{VD} = 1$		18		8	18		V/μs
t_r	Rise time	$V_I = 20$ mV,	$R_L = 2$ kΩ,		55			55		ns
	Overshoot factor	$C_L = 100$ pF,	$A_{VD} = 1$		25			25		%
V_n	Equivalent input noise voltage	$R_S = 100$ Ω,	f = 1 kHz		19			19		nV/√Hz

TEXAS INSTRUMENTS

TL087, TL088, TL287, TL288
JFET-INPUT OPERATIONAL AMPLIFIERS

electrical characteristics, $V_{CC\pm} = \pm 15$ V

PARAMETER		TEST CONDITIONS†		TL088M TL288M MIN	TYP	MAX	TL087I TL088I TL287I TL288I MIN	TYP	MAX	TL087C TL088C TL287C TL288C MIN	TYP	MAX	UNIT
V_{IO}	Input offset voltage	$R_S = 50\ \Omega$, $V_O = 0$ $T_A = 25°C$	TL087, TL287					0.1	0.5		0.1	0.5	mV
			TL088, TL288		0.1	3		0.1	1		0.1	1	
		$R_S = 50\ \Omega$, $V_O = 0$, $T_A = $ full range	TL087, TL287						2			1.5	
			TL088, TL288			6			3			2.5	
α_{VIO}	Temperature coefficient of input offset voltage	$R_S = 50\ \Omega$,	$T_A = 25°C$ to MAX		10			8			8		µV/°C
I_{IO}	Input offset current	$T_A = 25°C$			5			5	100		5	100	pA
		$T_A = $ full range				25			3			2	nA
I_{IB}	Input bias current‡	$T_A = 25°C$			30			30	200		30	200	pA
		$T_A = $ full range				100			20			7	nA
V_{ICR}	Common-mode input voltage range	$T_A = 25°C$		$(V_{CC-})+4$ to $(V_{CC+})-4$			$(V_{CC-})+4$ to $(V_{CC+})-4$			$(V_{CC-})+4$ to $(V_{CC+})-4$			V
$V_{O(PP)}$	Maximum-peak-to-peak output voltage swing	$T_A = 25°C$,	$R_L = 10\ k\Omega$	24	27		24	27		24	27		V
		$T_A = $ full range	$R_L \geq 10\ k\Omega$	24			24			24			
			$R_L \geq 2\ k\Omega$	20			20			20			
A_{VD}	Large-signal differential voltage amplification	$R_L \geq 2\ k\Omega$, $V_O = \pm 10$ V, $T_A = 25°C$		50	105		50	105		50	105		V/mV
		$R_L \geq 2\ k\Omega$, $V_O = \pm 10$ V, $T_A = $ full range		25			25			25			
B_1	Unity-gain bandwidth	$T_A = 25°C$			3			3			3		MHz
r_i	Input resistance	$T_A = 25°C$			10^{12}			10^{12}			10^{12}		Ω
CMRR	Common–mode rejection ratio	$R_S = 50\ \Omega$, $V_O = 0$ V, $V_{IC} = V_{ICR}$ min, $T_A = 25°C$		80	93		80	93		80	93		dB
k_{SVR}	Supply voltage rejection ratio ($\Delta V_{CC\pm}/\Delta V_{IO}$)	$R_S = 50\ \Omega$, $V_O = 0$ V, $V_{CC\pm} = \pm 9$ V to ± 15 V, $T_A = 25°C$		80	99		80	99		80	99		dB
I_{CC}	Supply current (per amplifier)	No load, $V_O = 0$ V, $T_A = 25°C$			26	2.8		2.6	2.8		2.6	2.8	mA

† All characteristics are measured under open–loop conditions with zero common-mode input voltage, unless otherwise specified. Full range for T_A is −55°C to 125°C for TL_88M; −40°C to 85°C for TL_8_I; and 0°C to 70°C for TL_8_C.

‡ Input bias currents of an FET-input operational amplifier are normal junction reverse currents, which are temperature sensitive. Pulse techniques must be used that will maintain the junction temperature as close to the ambient temperature as possible.

PARAMETER MEASUREMENT INFORMATION
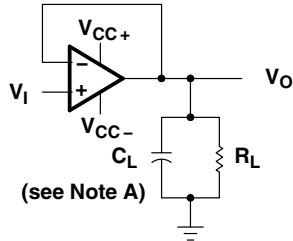
NOTE A: C_L includes fixture capacitance.

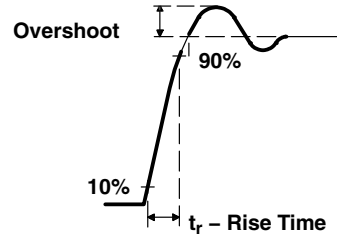**Figure 1. Slew Rate, Rise/Fall Time, and Overshoot Test Circuit**

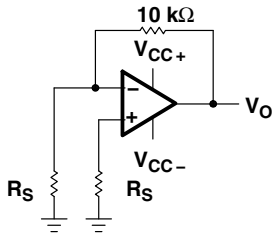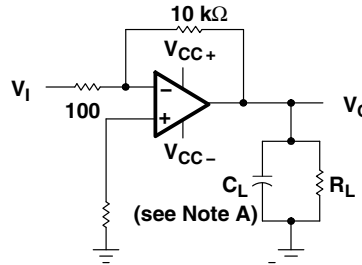**Figure 2. Rise Time and Overshoot Waveform**

Figure 3. Noise Voltage Test Circuit

NOTE A: C_L includes fixture capacitance.

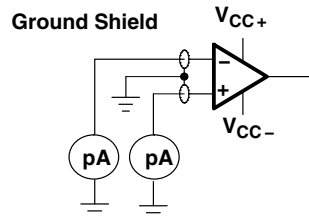**Figure 4. Unity-Gain Brandwidth and Phase Margin Test Circuit**

Figure 5. Input Bias and Offset Current Test Circuit

typical values

Typical values as presented in this data sheet represent the median (50% point) of device parametric performance.

input bias and offset current

At the picoamp bias current level typical of these JFET operational amplifiers, accurate measurement of the bias current becomes difficult. Not only does this measurement require a picoammeter, but test socket leakages can easily exceed the actual device bias currents. To accurately measure these small currents, Texas Instruments uses a two-step process. The socket leakage is measured using picoammeters with bias voltages applied, but with no device in the socket. The device then is inserted in the socket and a second test that measures both the socket leakage and the device input bias current is performed. The two measurements then are subtracted algebraically to determine the bias current of the device.

TYPICAL CHARACTERISTICS

table of graphs

			FIGURE
α_{VIO}	Temperature coefficient of input offset voltage	Distribution	6, 7
I_{IO}	Input offset current	vs Temperature	8
I_{IB}	Input bias current	vs V_{IC} vs Temperature	9 8
V_I	Common-mode input voltage range limits	vs V_{CC} vs Temperature	10 11
V_{ID}	Differential input voltage	vs Output voltage	12
V_{OM}	Maximum peak output voltage swing	vs V_{CC} vs Output current vs Frequency vs Temperature	13 17 14, 15, 16 18
A_{VD}	Differential voltage amplification	vs R_L vs Frequency vs Temperature	19 20 21
z_o	Output impedance	vs Frequency	24
CMRR	Common-mode rejection ratio	vs Frequency vs Temperature	22 23
k_{SVR}	Supply-voltage rejection ratio	vs Temperature	25
I_{OS}	Short-circuit output current	vs V_{CC} vs Time vs Temperature	26 27 28
I_{CC}	Supply current	vs V_{CC} vs Temperature	29 30
SR	Slew rate	vs R_L vs Temperature	31 32
	Overshoot factor	vs C_L	33
V_n	Equivalent input noise voltage	vs Frequency	34
THD	Total harmonic distortion	vs Frequency	35
B_1	Unity-gain bandwidth	vs V_{CC} vs Temperature	36 37
ϕ_m	Phase margin	vs V_{CC} vs C_L vs Temperature	38 39 40
	Phase shift	vs Frequency	20
	Pulse response	Small-signal Large-signal	41 42

TL087, TL088, TL287, TL288
JFET-INPUT OPERATIONAL AMPLIFIERS

TYPICAL CHARACTERISTICS†

DISTRIBUTION OF TL088
INPUT OFFSET VOLTAGE
TEMPERATURE COEFFICIENT

120 Units Tested From 2 Wafer Lots
$V_{CC\pm} = \pm15$ V
$T_A = 25°C$ to $125°C$
P Package

Percentage of Units – %

α_{VIO} – Temperature Coefficient – μV/°C
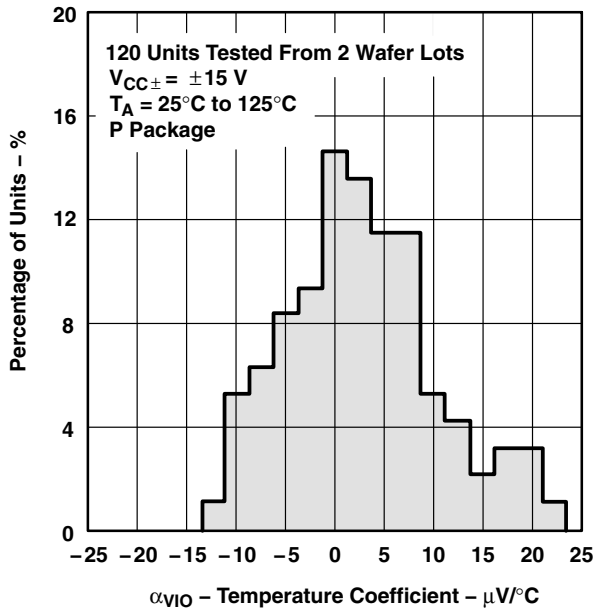
Figure 6

DISTRIBUTION OF TL288
INPUT OFFSET VOLTAGE
TEMPERATURE COEFFICIENT

172 Amplifiers Tested From 2 Wafer Lots
$V_{CC\pm} = \pm15$ V
$T_A = 25°C$ to $125°C$
P Package
One unit at -34.6 μV/°C

Percentage of Amplifiers – %

α_{VIO} – Temperature Coefficient – μV/°C
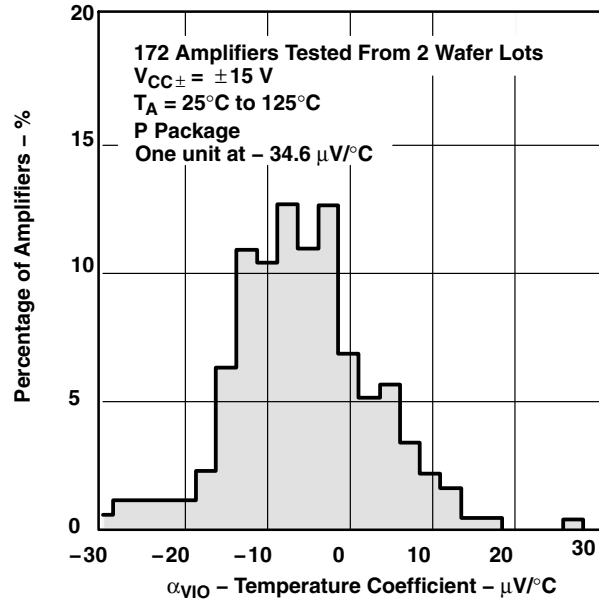
Figure 7

INPUT BIAS CURRENT AND
INPUT OFFSET CURRENT
vs
FREE-AIR TEMPERATURE

$V_{CC\pm} = \pm15$ V
$V_O = 0$
$V_{IC} = 0$

I_{IB}

I_{IO}

I_{IB} and I_{IO} – Bias and Offset Currents – nA

T_A – Free-Air Temperature – °C
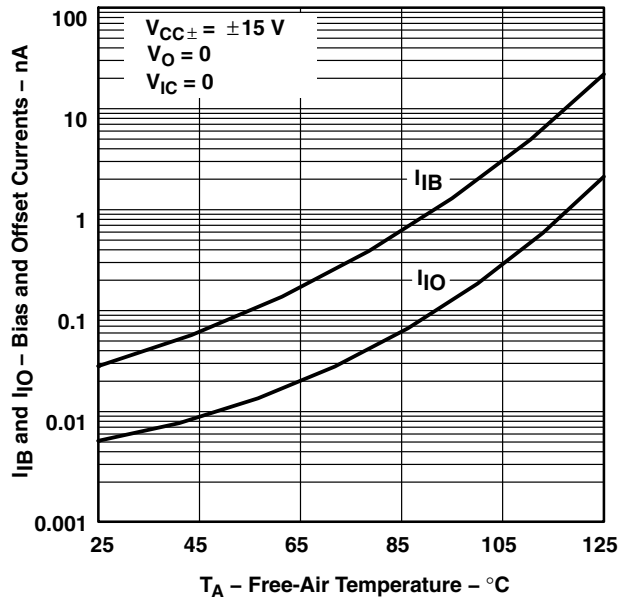
Figure 8

INPUT BIAS CURRENT
vs
COMMON-MODE INPUT VOLTAGE

$V_{CC\pm} = \pm15$ V
$T_A = 25°C$

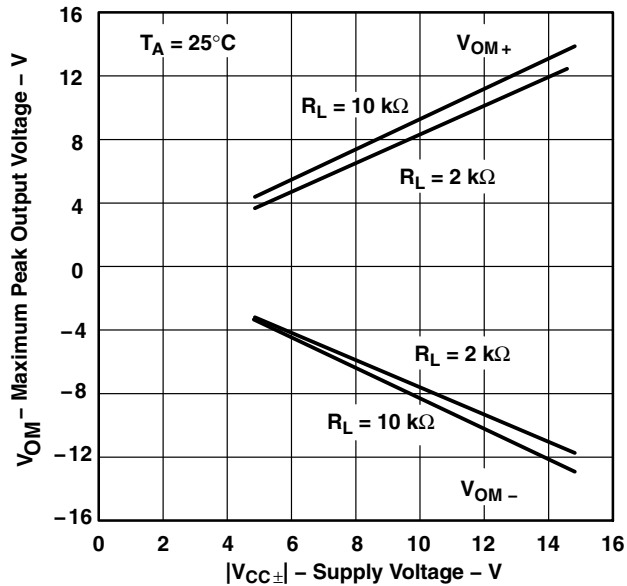I_{IB} – Input Bias Current – nA

V_{IC} – Common-Mode Input Voltage – V
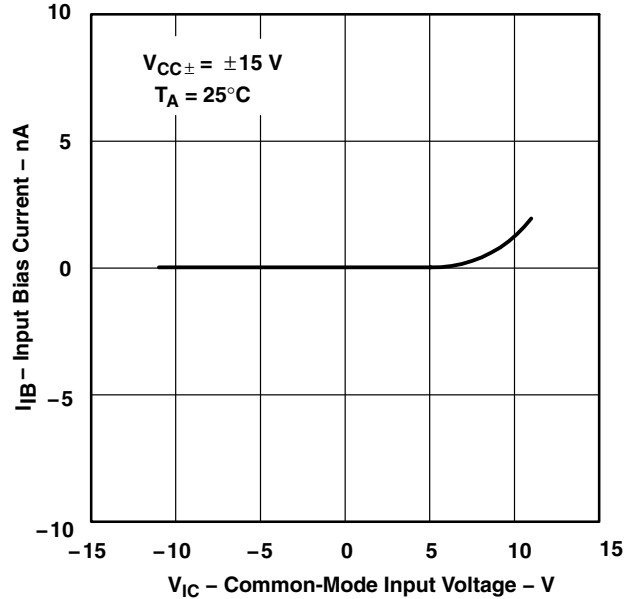
Figure 9

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

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TL087, TL088, TL287, TL288
JFET-INPUT OPERATIONAL AMPLIFIERS

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TYPICAL CHARACTERISTICS†

**COMMON-MODE
INPUT VOLTAGE RANGE LIMITS
vs
SUPPLY VOLTAGE**
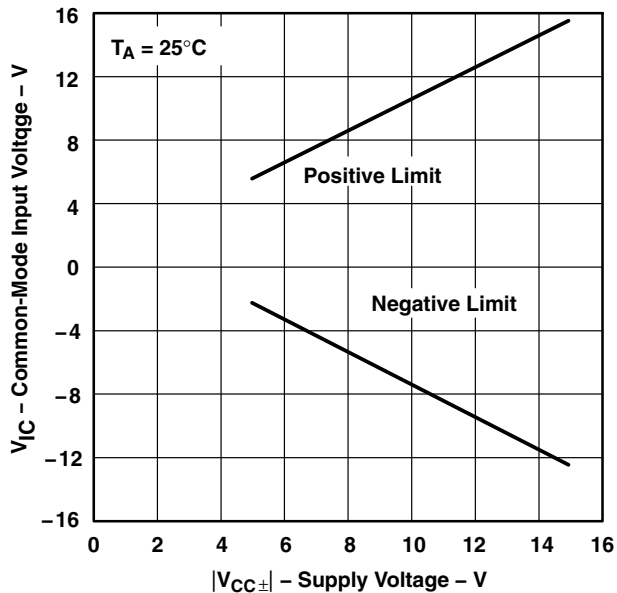
Figure 10

**COMMON-MODE
INPUT VOLTAGE RANGE LIMITS
vs
FREE-AIR TEMPERATURE**
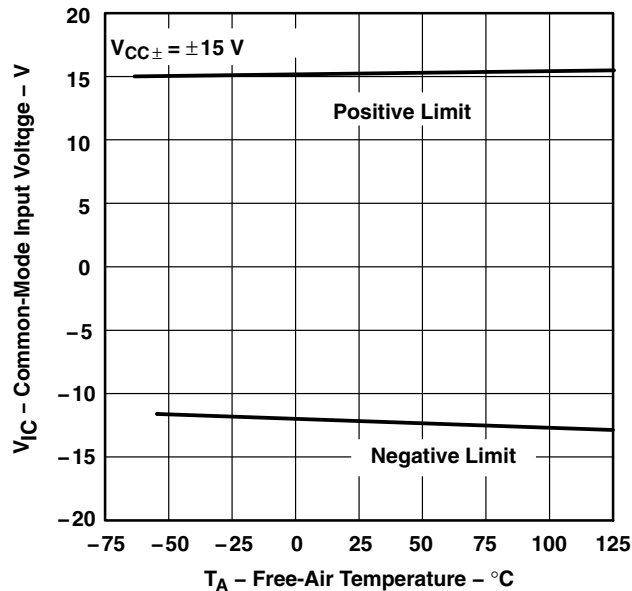
Figure 11

**OUTPUT VOLTAGE
vs
DIFFERENTIAL INPUT VOLTAGE**
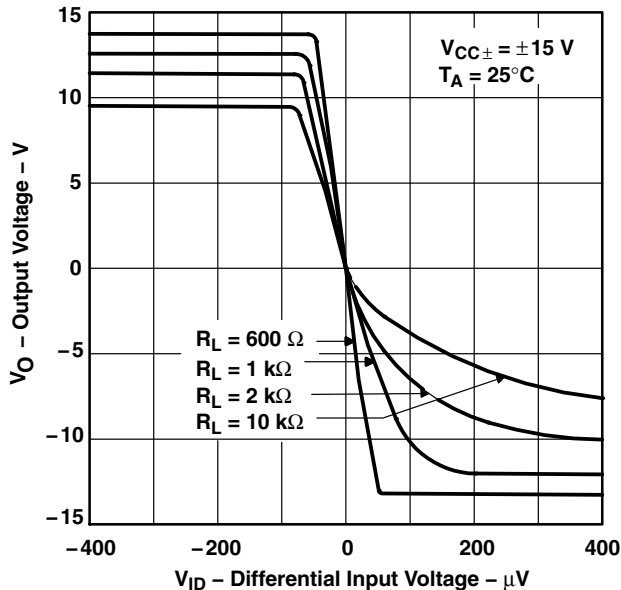
Figure 12

**MAXIMUM PEAK OUTPUT VOLTAGE
vs
SUPPLY VOLTAGE**

Figure 13

† Data at high and low temperatures are applicable within the rated operating free-air temperature ranges of the various devices.
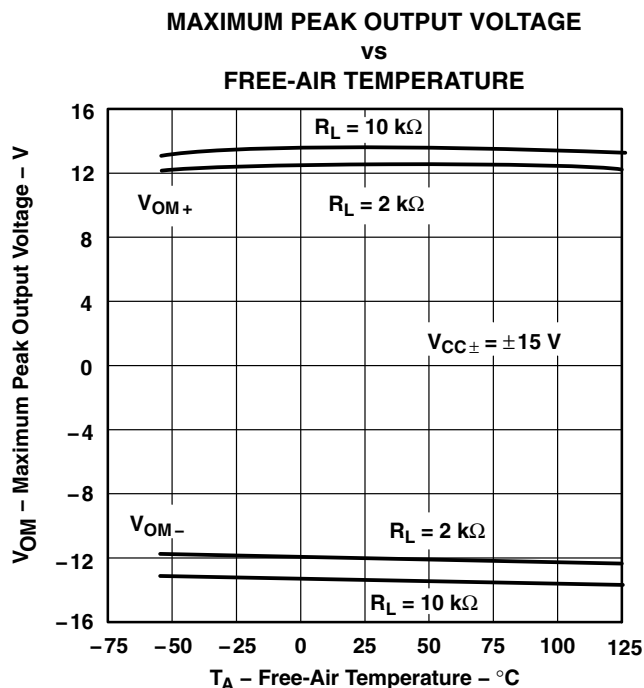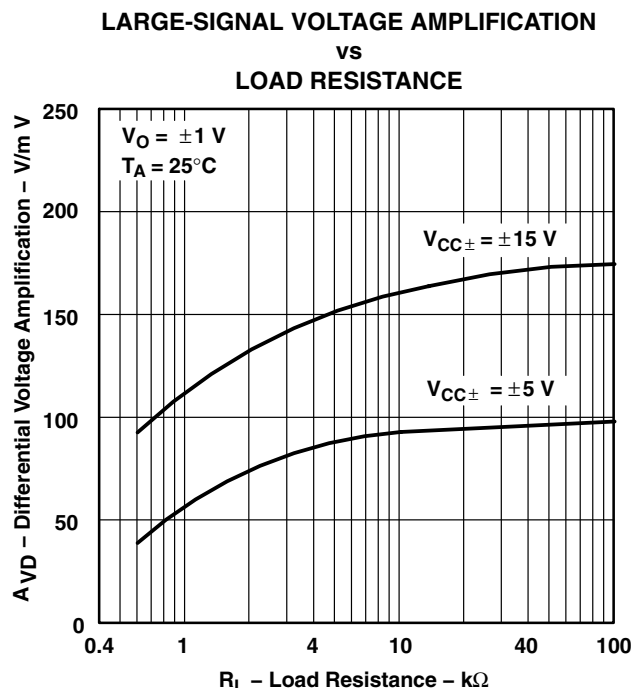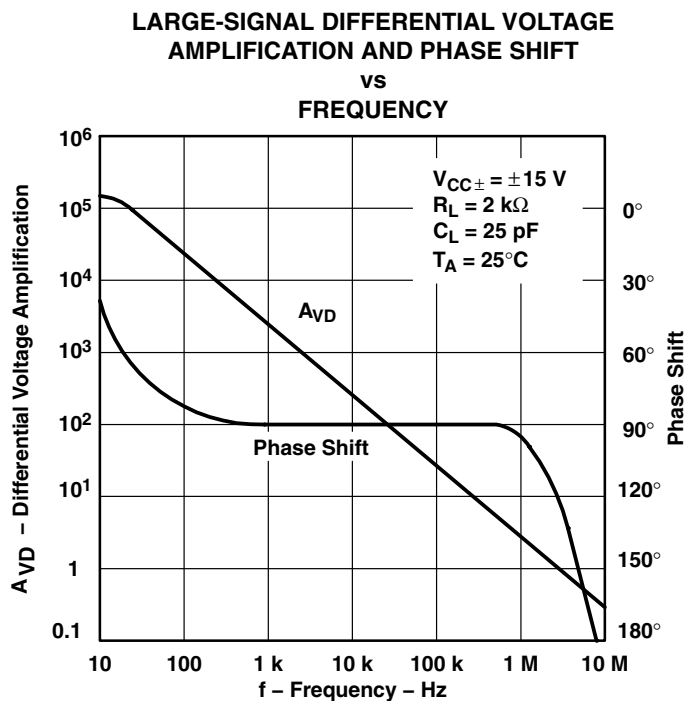
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9

TYPICAL CHARACTERISTICS†

MAXIMUM PEAK-TO-PEAK OUTPUT VOLTAGE
vs
FREQUENCY
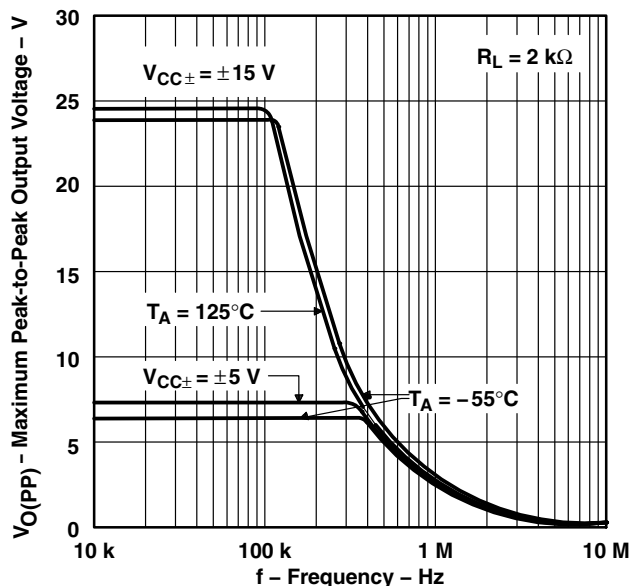
Figure 14

MAXIMUM PEAK-TO-PEAK OUTPUT VOLTAGE
vs
FREQUENCY
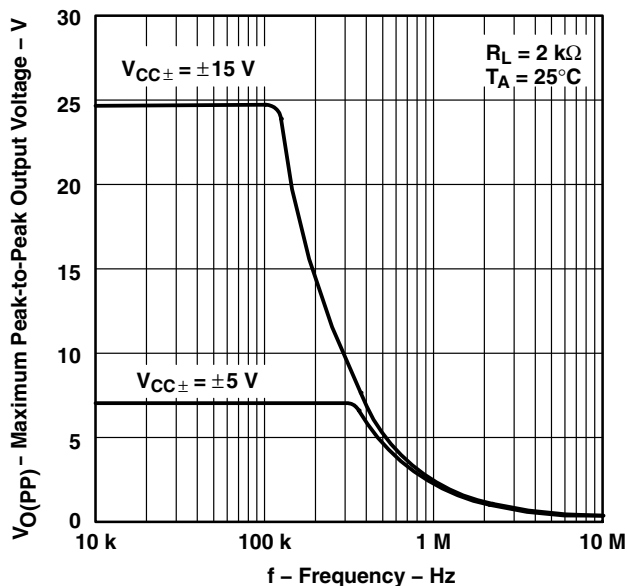
Figure 15

MAXIMUM PEAK-TO-PEAK OUTPUT VOLTAGE
vs
FREQUENCY
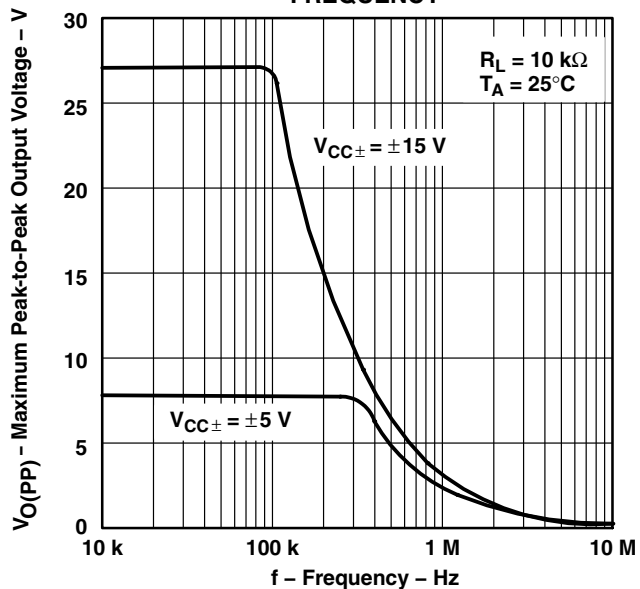
Figure 16
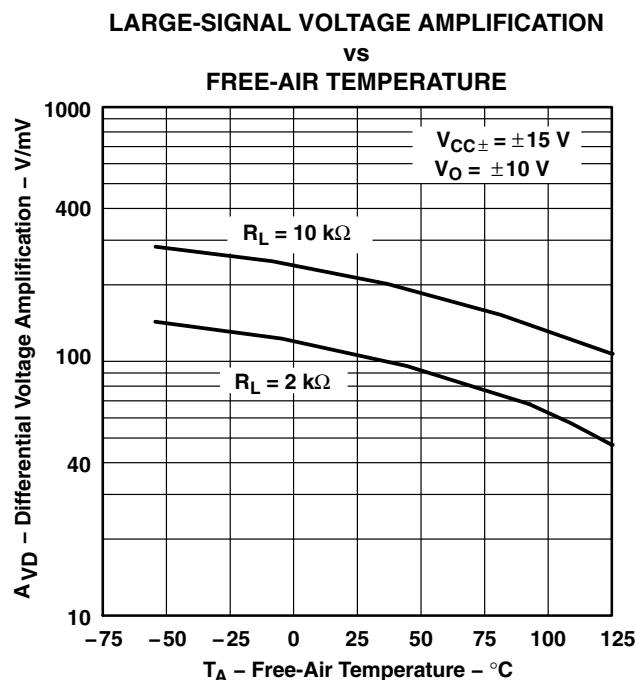
MAXIMUM PEAK OUTPUT VOLTAGE
vs
OUTPUT CURRENT
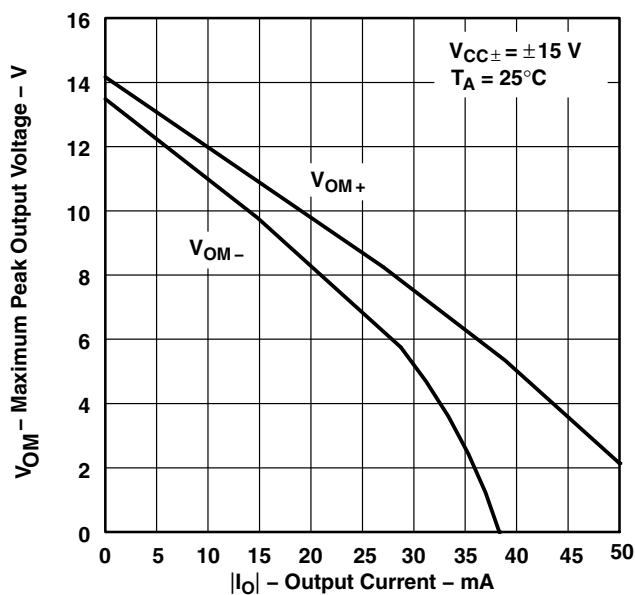
Figure 17

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

TYPICAL CHARACTERISTICS†

MAXIMUM PEAK OUTPUT VOLTAGE
vs
FREE-AIR TEMPERATURE

Figure 18

LARGE-SIGNAL VOLTAGE AMPLIFICATION
vs
LOAD RESISTANCE

Figure 19

LARGE-SIGNAL DIFFERENTIAL VOLTAGE
AMPLIFICATION AND PHASE SHIFT
vs
FREQUENCY

Figure 20

LARGE-SIGNAL VOLTAGE AMPLIFICATION
vs
FREE-AIR TEMPERATURE
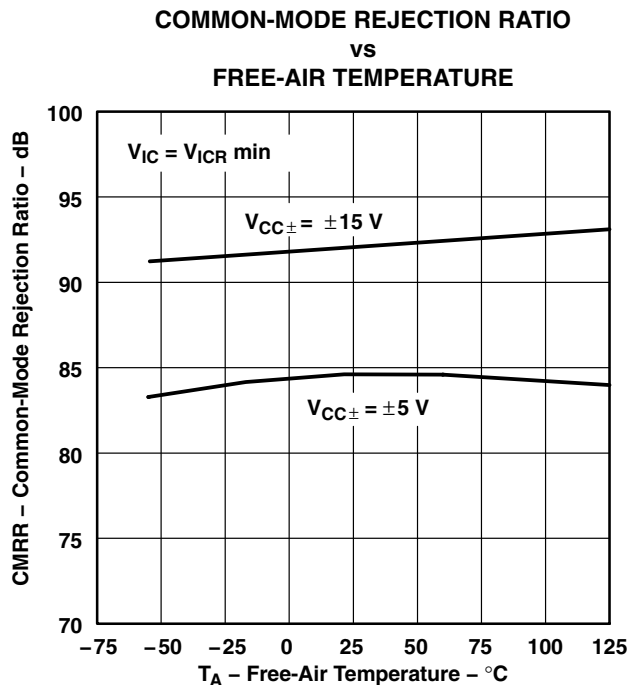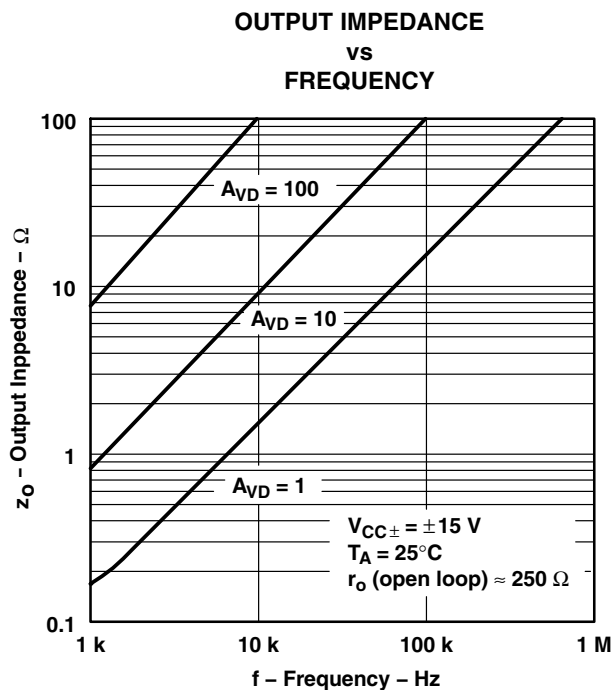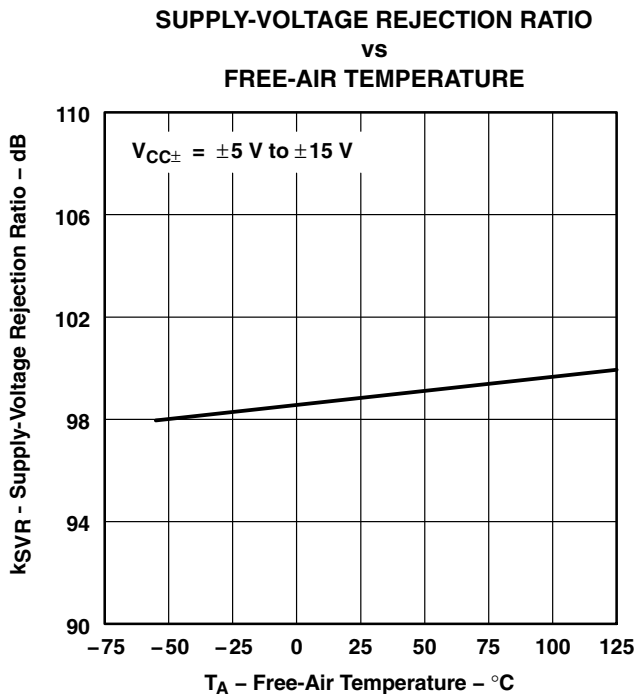

Figure 21

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

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TYPICAL CHARACTERISTICS†

COMMON-MODE REJECTION RATIO
vs
FREQUENCY

$V_{CC\pm} = \pm15$ V
$T_A = 25°C$

Figure 22

COMMON-MODE REJECTION RATIO
vs
FREE-AIR TEMPERATURE

$V_{IC} = V_{ICR}$ min

$V_{CC\pm} = \pm15$ V

$V_{CC\pm} = \pm5$ V

Figure 23

OUTPUT IMPEDANCE
vs
FREQUENCY

$A_{VD} = 100$

$A_{VD} = 10$

$A_{VD} = 1$

$V_{CC\pm} = \pm15$ V
$T_A = 25°C$
r_o (open loop) ≈ 250 Ω

Figure 24

SUPPLY-VOLTAGE REJECTION RATIO
vs
FREE-AIR TEMPERATURE

$V_{CC\pm} = \pm5$ V to ±15 V
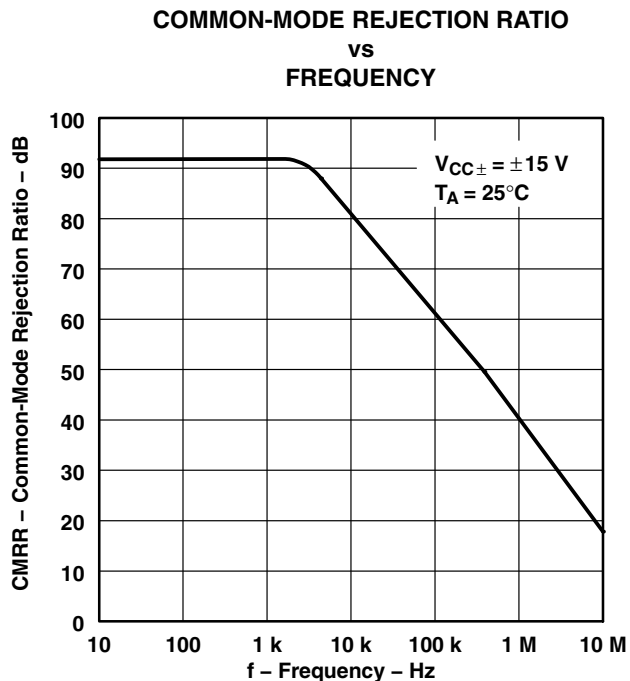
Figure 25

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

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TYPICAL CHARACTERISTICS†

SHORT-CIRCUIT OUTPUT CURRENT
vs
SUPPLY VOLTAGE

Figure 26

SHORT-CIRCUIT OUTPUT CURRENT
vs
TIME

Figure 27

SHORT-CIRCUIT OUTPUT CURRENT
vs
FREE-AIR TEMPERATURE

Figure 28

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

TL087, TL088, TL287, TL288
JFET-INPUT OPERATIONAL AMPLIFIERS

SLOS082B – MARCH 1979 – REVISED – JULY 2004

TYPICAL CHARACTERISTICS†

SUPPLY CURRENT
vs
SUPPLY VOLTAGE
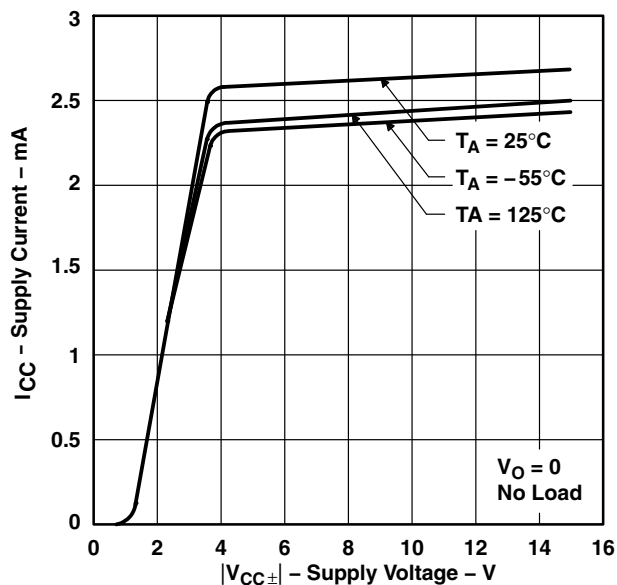
Figure 29

SUPPLY CURRENT
vs
FREE-AIR TEMPERATURE
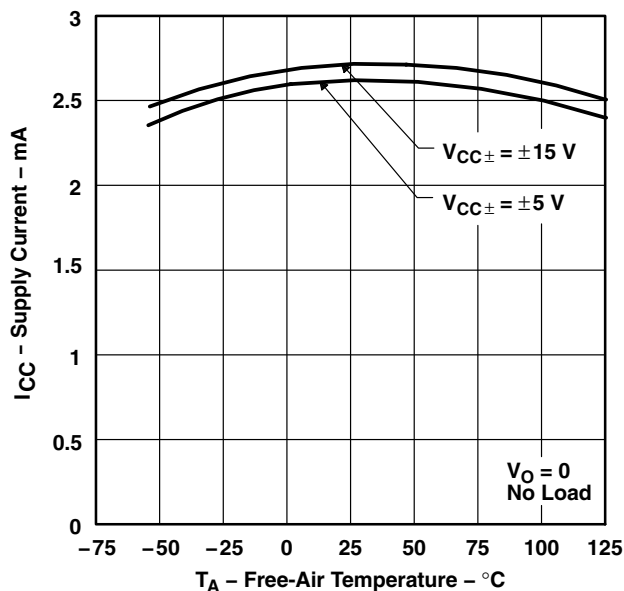
Figure 30

SLEW RATE
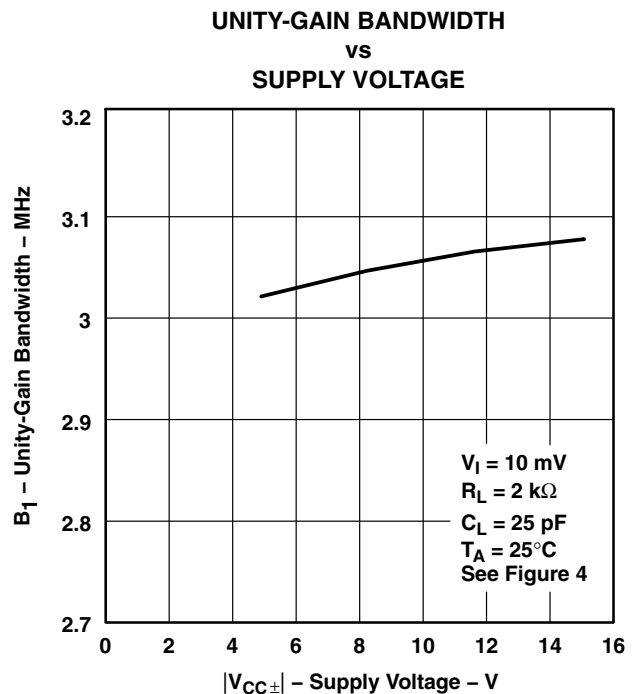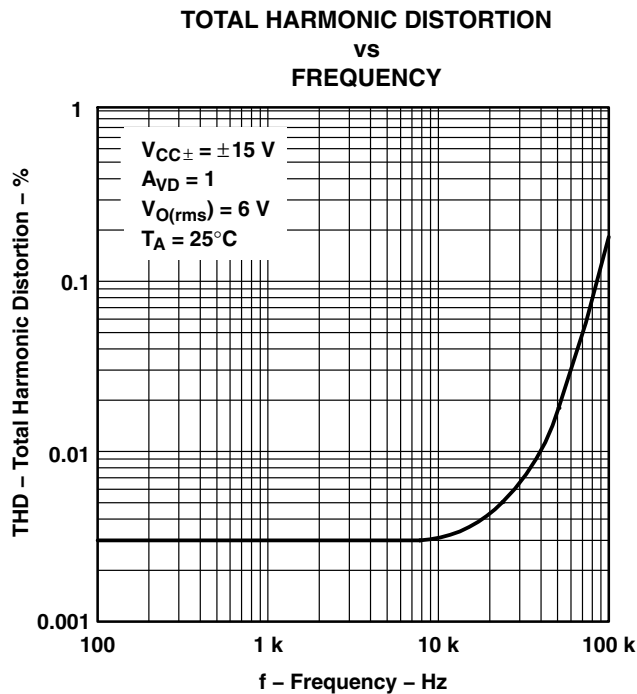**vs**
LOAD RESISTANCE
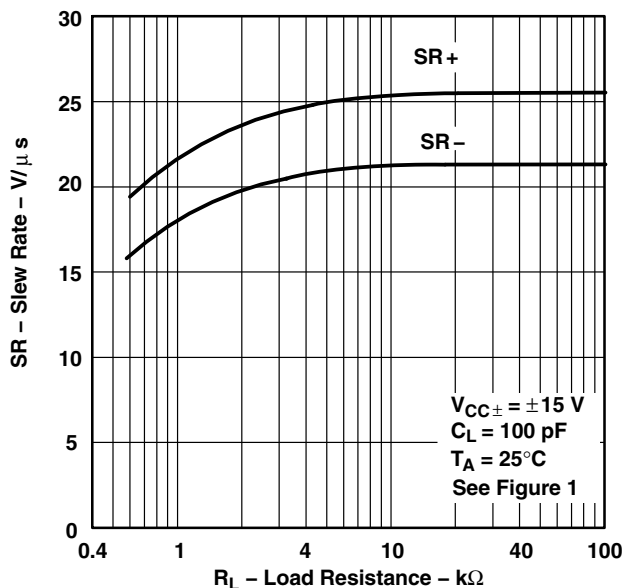
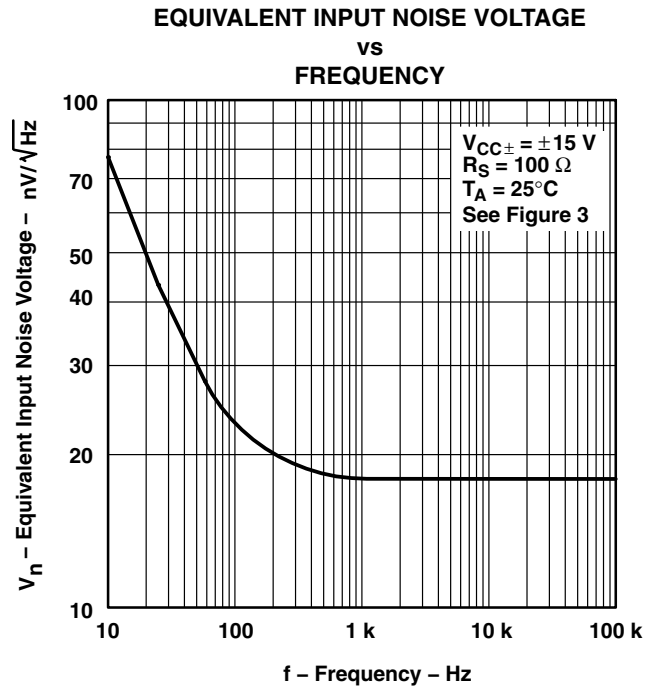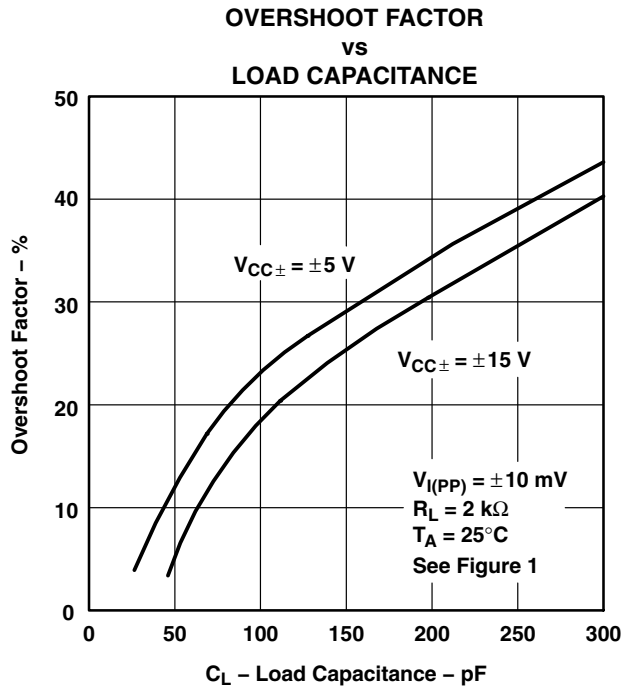**Figure 31**

SLEW RATE
vs
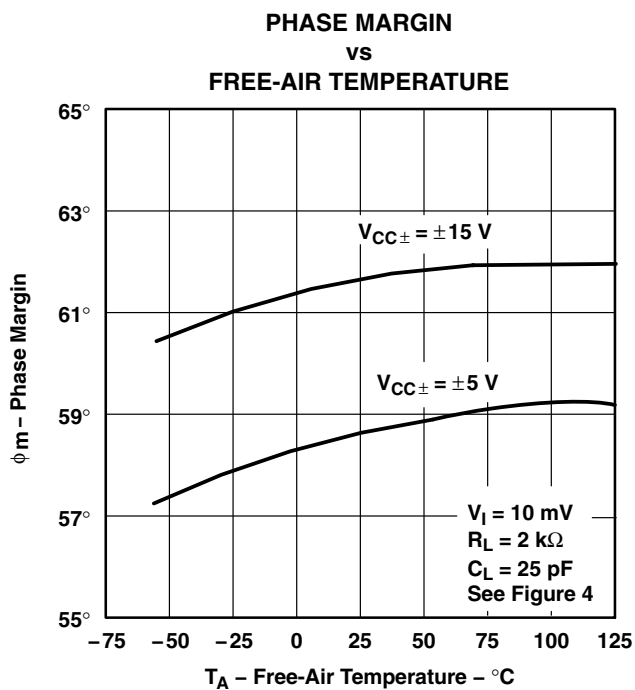**FREE-AIR TEMPERATURE**
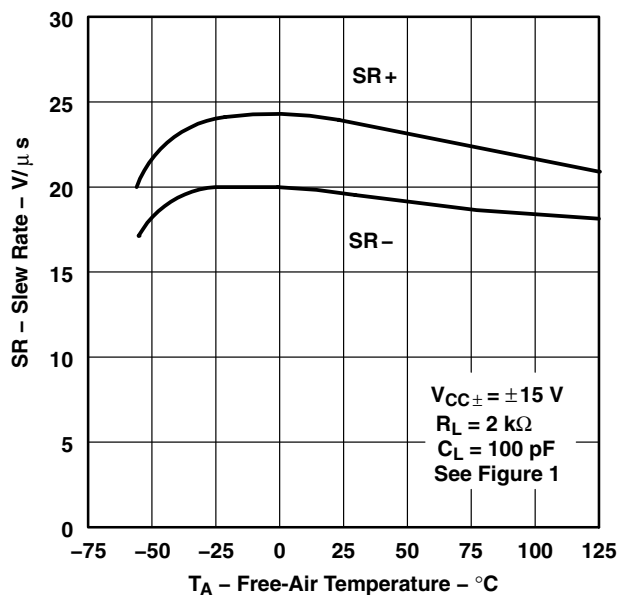
Figure 32

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

![Texas Instruments logo] **TEXAS INSTRUMENTS**

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TYPICAL CHARACTERISTICS†

OVERSHOOT FACTOR
vs
LOAD CAPACITANCE

$V_{CC\pm} = \pm 5$ V

$V_{CC\pm} = \pm 15$ V

$V_{I(PP)} = \pm 10$ mV
$R_L = 2$ kΩ
$T_A = 25°C$
See Figure 1

Figure 33

EQUIVALENT INPUT NOISE VOLTAGE
vs
FREQUENCY

$V_{CC\pm} = \pm 15$ V
$R_S = 100$ Ω
$T_A = 25°C$
See Figure 3

Figure 34

TOTAL HARMONIC DISTORTION
vs
FREQUENCY

$V_{CC\pm} = \pm 15$ V
$A_{VD} = 1$
$V_{O(rms)} = 6$ V
$T_A = 25°C$

Figure 35

UNITY-GAIN BANDWIDTH
vs
SUPPLY VOLTAGE

$V_I = 10$ mV
$R_L = 2$ kΩ
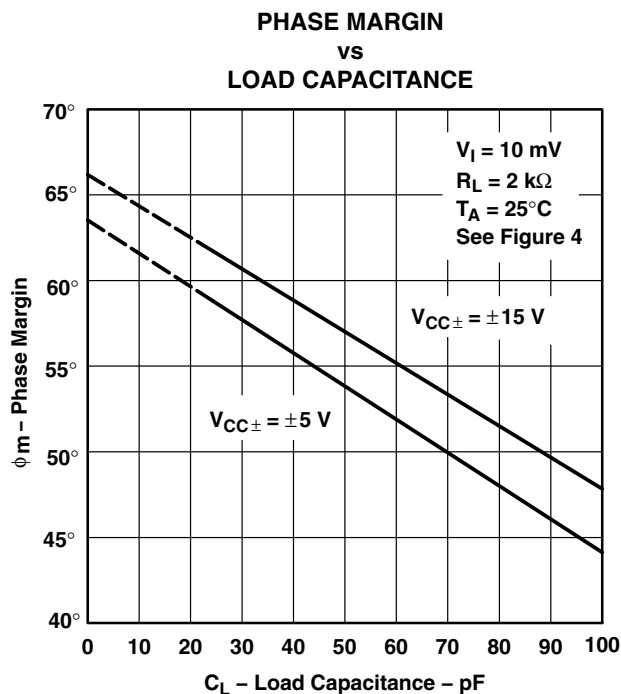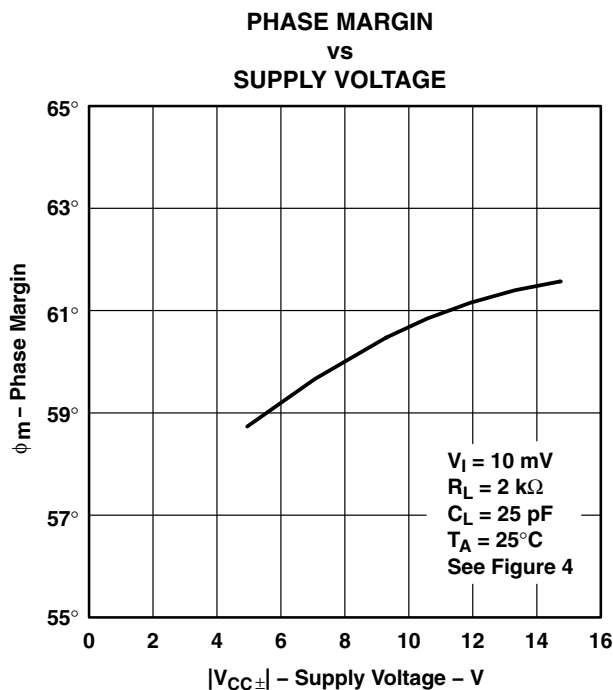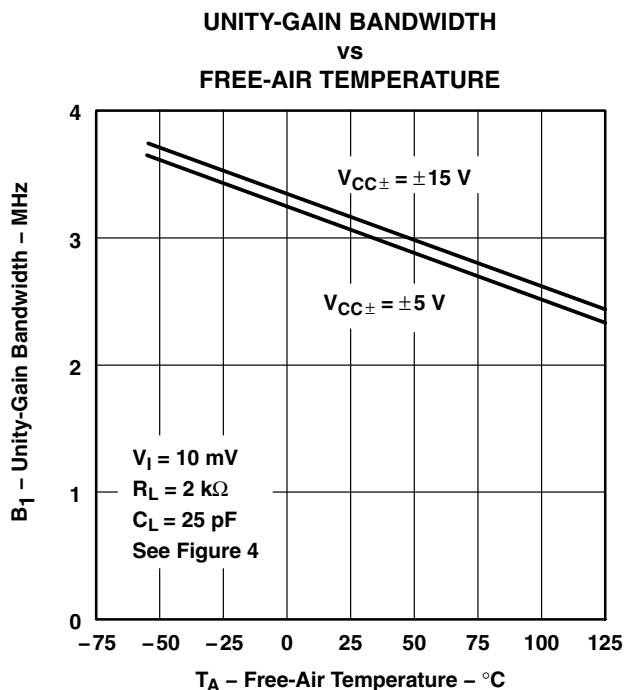$C_L = 25$ pF
$T_A = 25°C$
See Figure 4

Figure 36

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

TL087, TL088, TL287, TL288
JFET-INPUT OPERATIONAL AMPLIFIERS

TYPICAL CHARACTERISTICS†

UNITY-GAIN BANDWIDTH
vs
FREE-AIR TEMPERATURE

Figure 37

PHASE MARGIN
vs
SUPPLY VOLTAGE

Figure 38

PHASE MARGIN
vs
LOAD CAPACITANCE

Figure 39

PHASE MARGIN
vs
FREE-AIR TEMPERATURE

Figure 40

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

![TEXAS INSTRUMENTS logo]

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TYPICAL CHARACTERISTICS

VOLTAGE-FOLLOWER
SMALL-SIGNAL
PULSE RESPONSE

$V_{CC\pm} = \pm15$ V
$R_L = 2$ kΩ
$C_L = 100$ pF
$T_A = 25°C$
See Figure 1

t – Time – µs
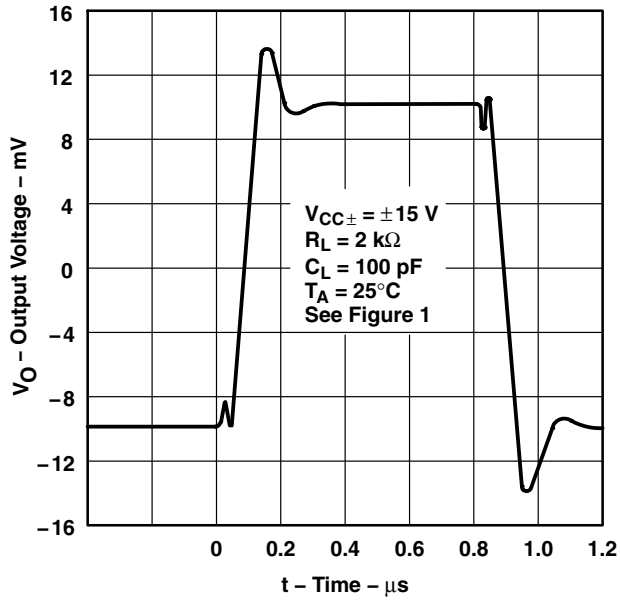
Figure 41

VOLTAGE-FOLLOWER
LARGE-SIGNAL
PULSE RESPONSE
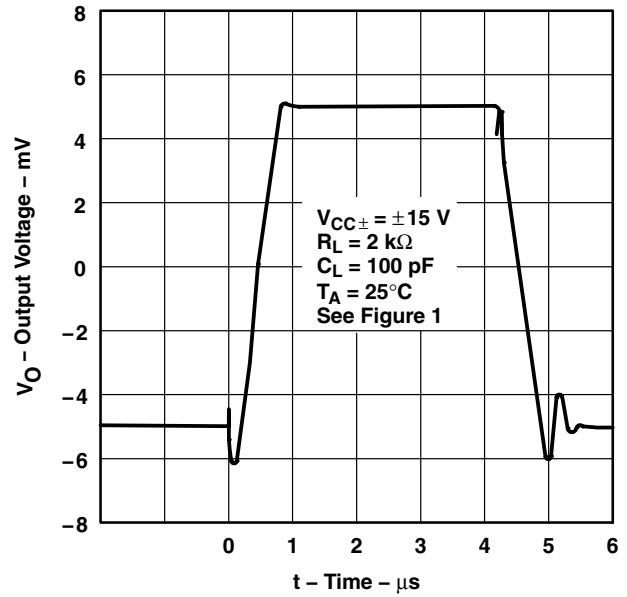
$V_{CC\pm} = \pm15$ V
$R_L = 2$ kΩ
$C_L = 100$ pF
$T_A = 25°C$
See Figure 1

t – Time – µs

Figure 42

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INSTRUMENTS

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TYPICAL APPLICATION DATA

output characteristics

All operating characteristics are specified with 100-pF load capacitance. These amplifiers will drive higher capacitive loads; however, as the load capacitance increases, the resulting response pole occurs at lower frequencies, causing ringing, peaking, or even oscillation. The value of the load capacitance at which oscillation occurs varies with production lots. If an application appears to be sensitive to oscillation due to load capacitance, adding a small resistance in series with the load should alleviate the problem. Capacitive loads of 1000 pF, and larger, may be driven if enough resistance is added in series with the output (see Figure 43).
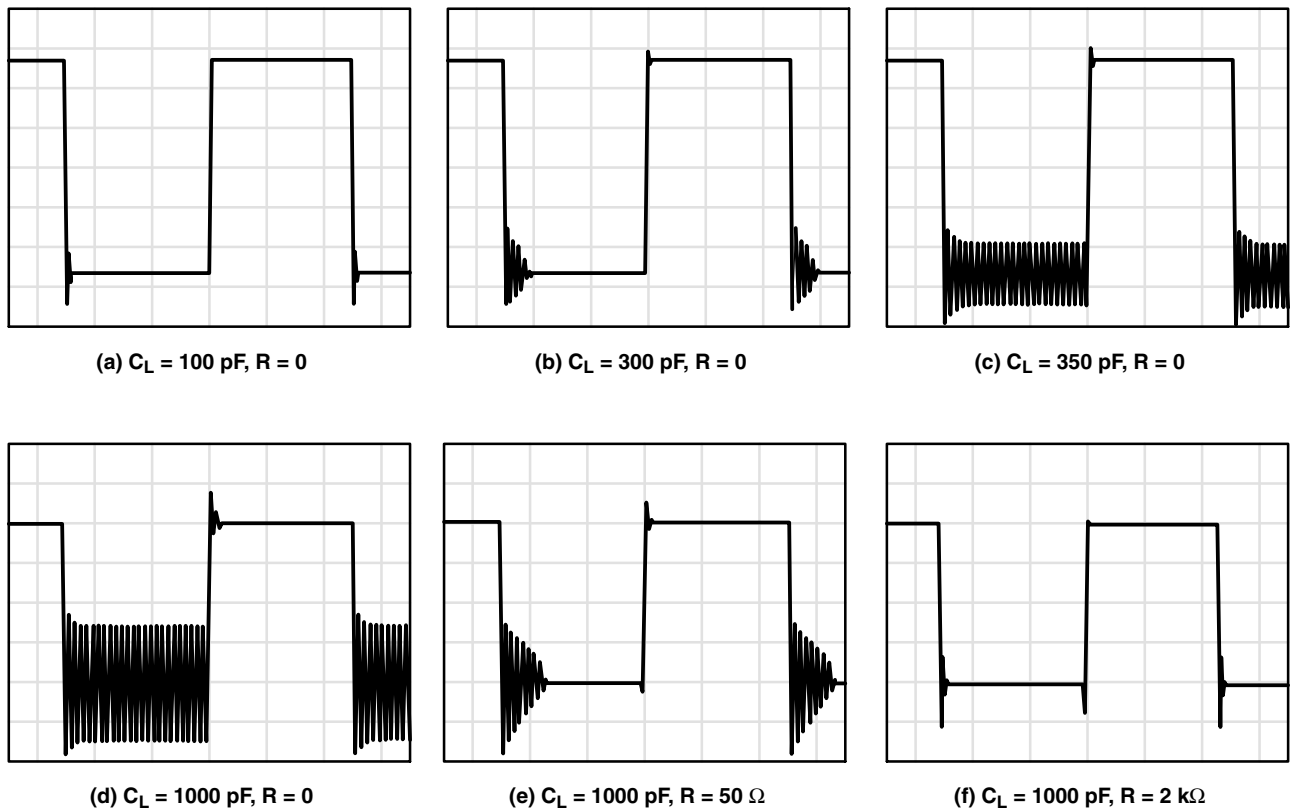

(a) C_L = 100 pF, R = 0

(b) C_L = 300 pF, R = 0

(c) C_L = 350 pF, R = 0

(d) C_L = 1000 pF, R = 0

(e) C_L = 1000 pF, R = 50 Ω

(f) C_L = 1000 pF, R = 2 kΩ

Figure 43. Effect of Capacitive Loads

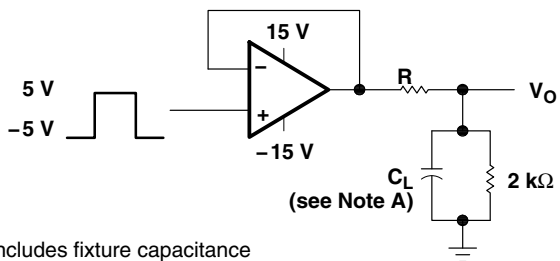NOTE A: C_L includes fixture capacitance

Figure 44. Test Circuit for Output Characteristics

TYPICAL APPLICATION DATA

input characteristics

These amplifiers are specified with a minimum and a maximum input voltage that, if exceeded at either input, could cause the device to malfunction.

Because of the extremely high input impedance and resulting low bias current requirements, these amplifiers are well suited for low-level signal processing; however, leakage currents on printed circuit boards and sockets easily can exceed bias current requirements and cause degradation in system performance. It is good practice to include guard rings around inputs (see Figure 45). These guards should be driven from a low-impedance source at the same voltage level as the common-mode input.
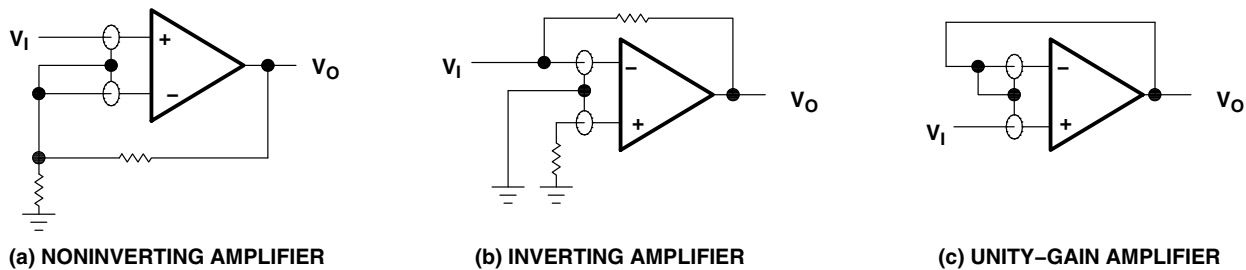

(a) NONINVERTING AMPLIFIER   (b) INVERTING AMPLIFIER   (c) UNITY–GAIN AMPLIFIER

Figure 45. Use of Guard Rings

noise performance

The noise specifications in operational amplifier circuits are greatly dependent on the current in the first-stage diflferential amplifier. The low input bias current requirements of these amplifiers result in a very low current noise. This feature makes the devices especially favorable over bipolar devices when using values of circuit impedance greater than 50 kΩ.

PACKAGING INFORMATION

Orderable Device	Status (1)	Package Type	Package Drawing	Pins	Package Qty	Eco Plan (2)	Lead finish/ Ball material (6)	MSL Peak Temp (3)	Op Temp (°C)	Device Marking (4/5)	Samples
TL288CP	ACTIVE	PDIP	P	8	50	RoHS & Green	NIPDAU	N / A for Pkg Type	0 to 70	TL288CP	Samples
TL288CPE4	LIFEBUY	PDIP	P	8	50	RoHS & Green	NIPDAU	N / A for Pkg Type	0 to 70	TL288CP	

(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) **RoHS:** TI defines "RoHS" to mean semiconductor products that are compliant with the current EU RoHS requirements for all 10 RoHS substances, including the requirement that RoHS substance do not exceed 0.1% by weight in homogeneous materials. Where designed to be soldered at high temperatures, "RoHS" products are suitable for use in specified lead-free processes. TI may reference these types of products as "Pb-Free".
RoHS Exempt: TI defines "RoHS Exempt" to mean products that contain lead but are compliant with EU RoHS pursuant to a specific EU RoHS exemption.
Green: TI defines "Green" to mean the content of Chlorine (Cl) and Bromine (Br) based flame retardants meet JS709B low halogen requirements of <=1000ppm threshold. Antimony trioxide based flame retardants must also meet the <=1000ppm threshold requirement.

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

(4) There may be additional marking, which relates to the logo, the lot trace code information, or the environmental category on the device.

(5) Multiple Device Markings will be inside parentheses. Only one Device 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 Device Marking for that device.

(6) Lead finish/Ball material - Orderable Devices may have multiple material finish options. Finish options are separated by a vertical ruled line. Lead finish/Ball material values may wrap to two lines if the finish value exceeds the maximum column width.

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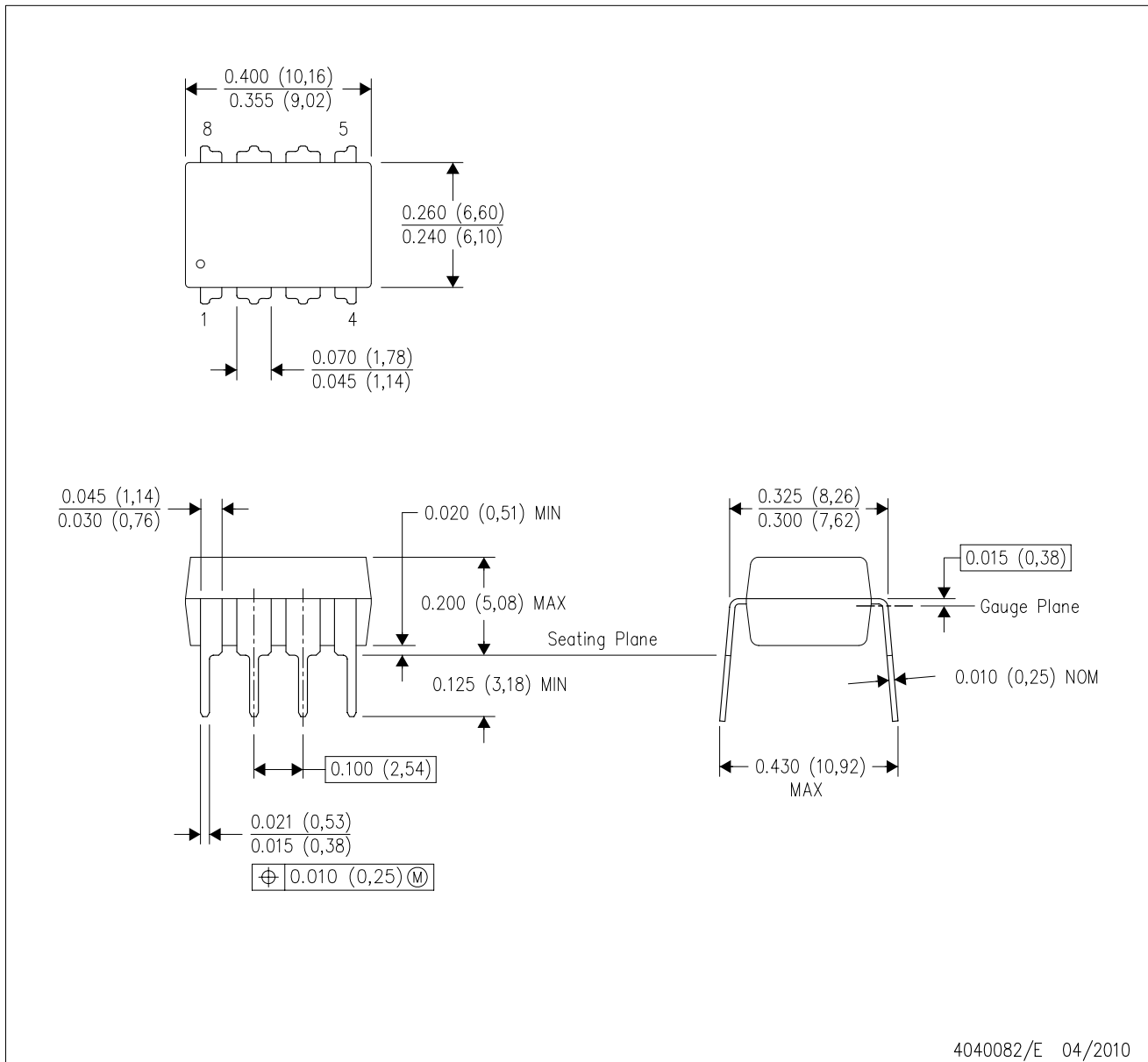
PACKAGE MATERIALS INFORMATION

TUBE

*All dimensions are nominal

Device	Package Name	Package Type	Pins	SPQ	L (mm)	W (mm)	T (µm)	B (mm)
TL288CP	P	PDIP	8	50	506	13.97	11230	4.32
TL288CPE4	P	PDIP	8	50	506	13.97	11230	4.32

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

0.400 (10,16)
0.355 (9,02)

8   5

0.260 (6,60)
0.240 (6,10)

1   4

0.070 (1,78)
0.045 (1,14)

0.045 (1,14)
0.030 (0,76)

0.020 (0,51) MIN

0.200 (5,08) MAX

Seating Plane

0.125 (3,18) MIN

0.100 (2,54)

0.021 (0,53)
0.015 (0,38)

⊕ 0.010 (0,25) Ⓜ

0.325 (8,26)
0.300 (7,62)

0.015 (0,38)

Gauge Plane

0.010 (0,25) NOM

0.430 (10,92)
MAX

4040082/E   04/2010

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.

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