

# TLE2227, TLE2227Y, TLE2237, TLE2237Y EXCALIBUR LOW-NOISE HIGH-SPEED PRECISION DUAL OPERATIONAL AMPLIFIERS

SLOS184 – FEBRUARY 1997

- Outstanding Combination of DC Precision and AC Performance:

Unity-Gain Bandwidth . . . 15 MHz Typ

$V_n$  . . . 3.3 nV/ $\sqrt{\text{Hz}}$  at  $f = 10$  Hz Typ,

2.5 nV/ $\sqrt{\text{Hz}}$  at  $f = 1$  kHz Typ

$V_{IO}$  . . . 100  $\mu\text{V}$  Typ

$A_{VD}$  . . . 45 V/ $\mu\text{V}$  Typ With  $R_L = 2$  k $\Omega$

38 V/ $\mu\text{V}$  Typ With  $R_L = 1$  k $\Omega$

- Available in 16-Pin Small-Outline Wide-Body Package
- Macromodels and Statistical Information Included
- Output Features Saturation Recovery Circuitry

## description

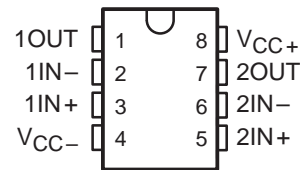
The TLE22x7C combines innovative circuit design expertise and high-quality process control techniques to produce a level of ac performance and dc precision previously unavailable in dual operational amplifiers. This device allows upgrades to systems that use lower-precision devices and is manufactured using Texas Instruments state-of-the-art Excalibur process.

In the area of dc precision, the TLE22x7C offers a typical offset voltage of 100  $\mu\text{V}$ , a common-mode rejection ratio of 115 dB (typ), a supply voltage rejection ratio of 120 dB (typ), and a dc gain of 45 V/ $\mu\text{V}$  (typ).

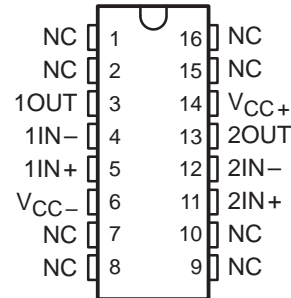
The ac performance is highlighted by a typical unity-gain bandwidth specification of 15 MHz, 55° of phase margin, and noise voltage specifications of 3.3 nV/ $\sqrt{\text{Hz}}$  and 2.5 nV/ $\sqrt{\text{Hz}}$  at frequencies of 10 Hz and 1 kHz, respectively.

The TLE22x7C is available in a wide variety of packages, including the industry standard 16-pin small-outline wide-body version for high-density system applications. This device is characterized for operation from 0°C to 70°C.

P PACKAGE  
(TOP VIEW)



DW PACKAGE  
(TOP VIEW)



NC – No internal connection

## AVAILABLE OPTIONS

$T_A$	$V_{IO}$ typ AT 25°C	PACKAGED DEVICES		CHIP FORM $\ddagger$ (Y)
		SMALL OUTLINE $\dagger$ (DW)	PLASTIC DIP (P)	
0°C to 70°C	100 $\mu\text{V}$	TLE2227CDW	TLE2227CP	TLE2227Y
	100 $\mu\text{V}$	TLE2237CDW	TLE2237CP	TLE2237Y

$\dagger$  The DW package is available taped and reeled. Add R suffix to device type (e.g., TLE2227CDWR).

$\ddagger$  Chip forms are tested at 25°C only.



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.

PRODUCTION DATA information is current as of publication date. Products conform to specifications per the terms of Texas Instruments standard warranty. Production processing does not necessarily include testing of all parameters.

 **TEXAS  
INSTRUMENTS**

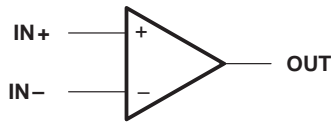
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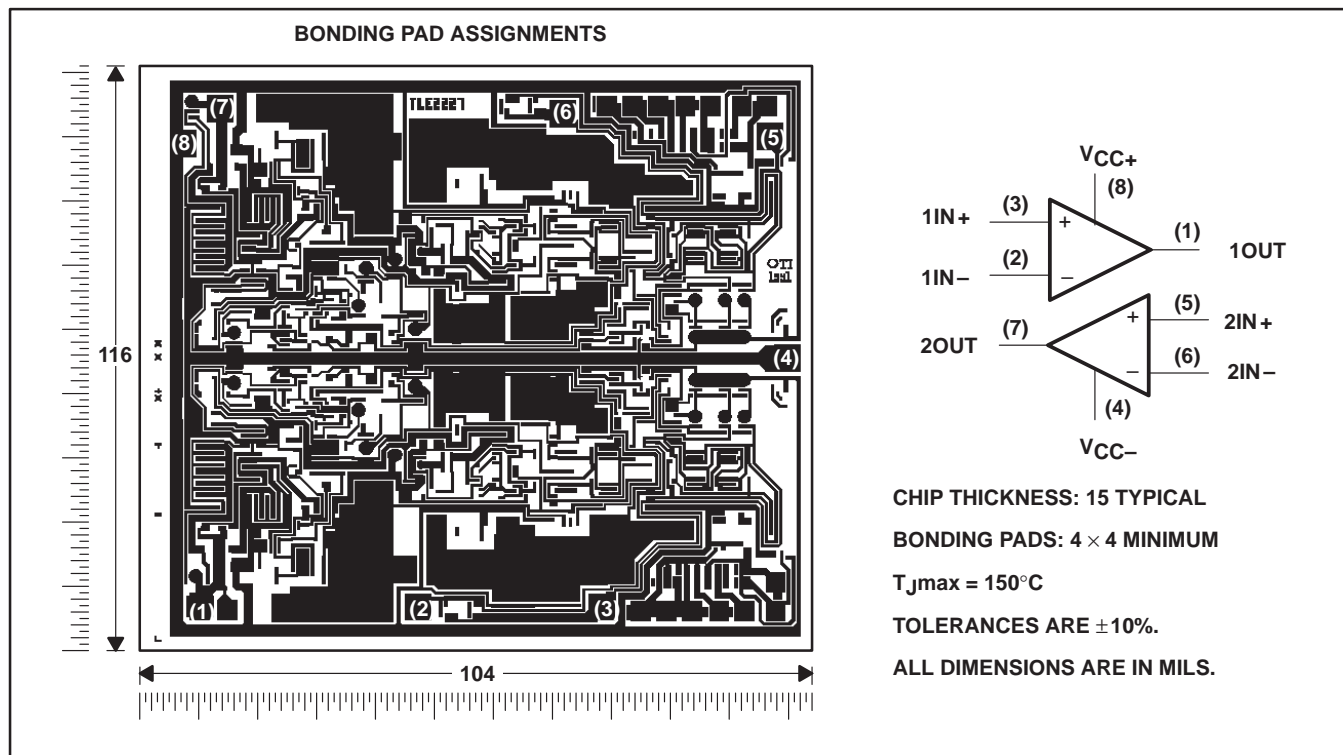
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## symbol (each amplifier)



## TLE2227Y chip information

This chip, properly assembled, displays characteristics similar to the TLE2227C. Thermal compression or ultrasonic bonding may be used on the doped-aluminum bonding pads. Chips may be mounted with conductive epoxy or a gold-silicon preform.

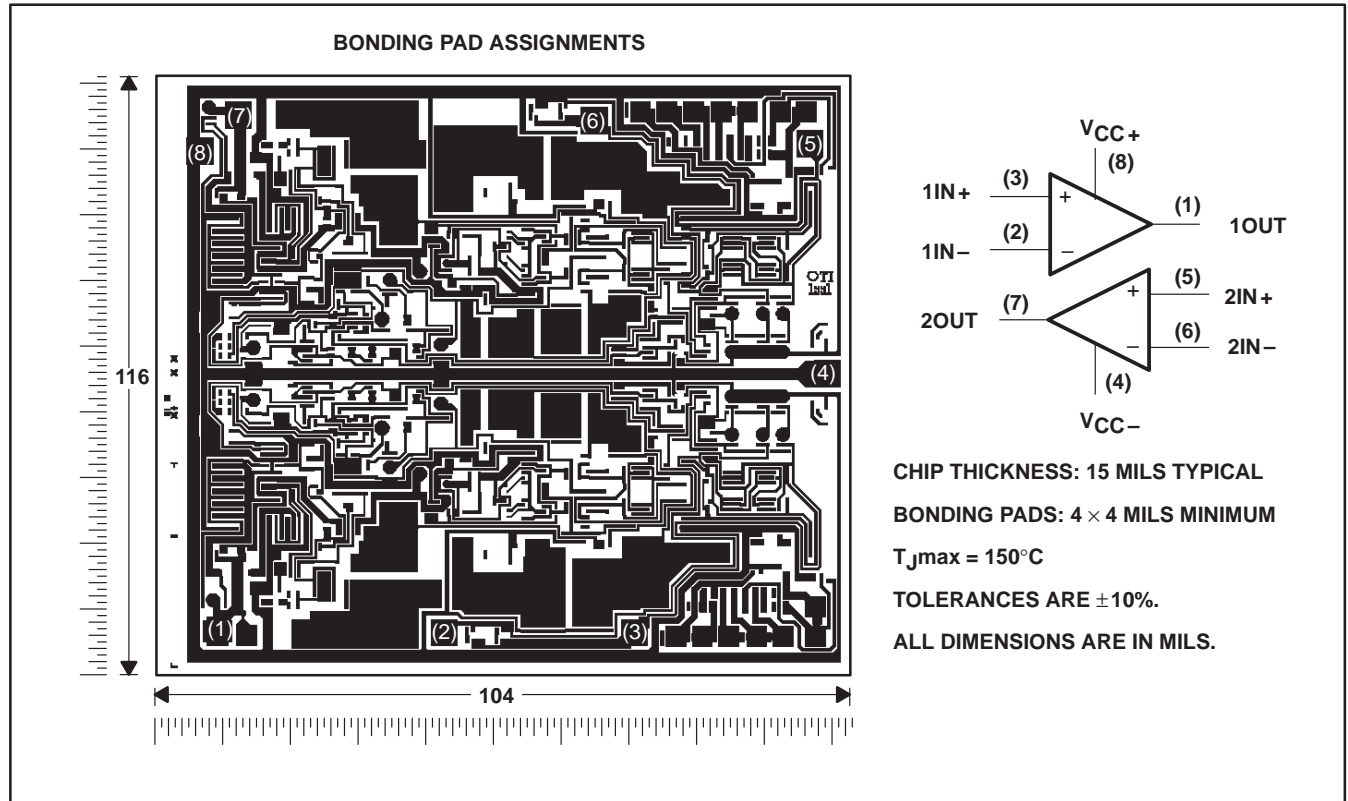


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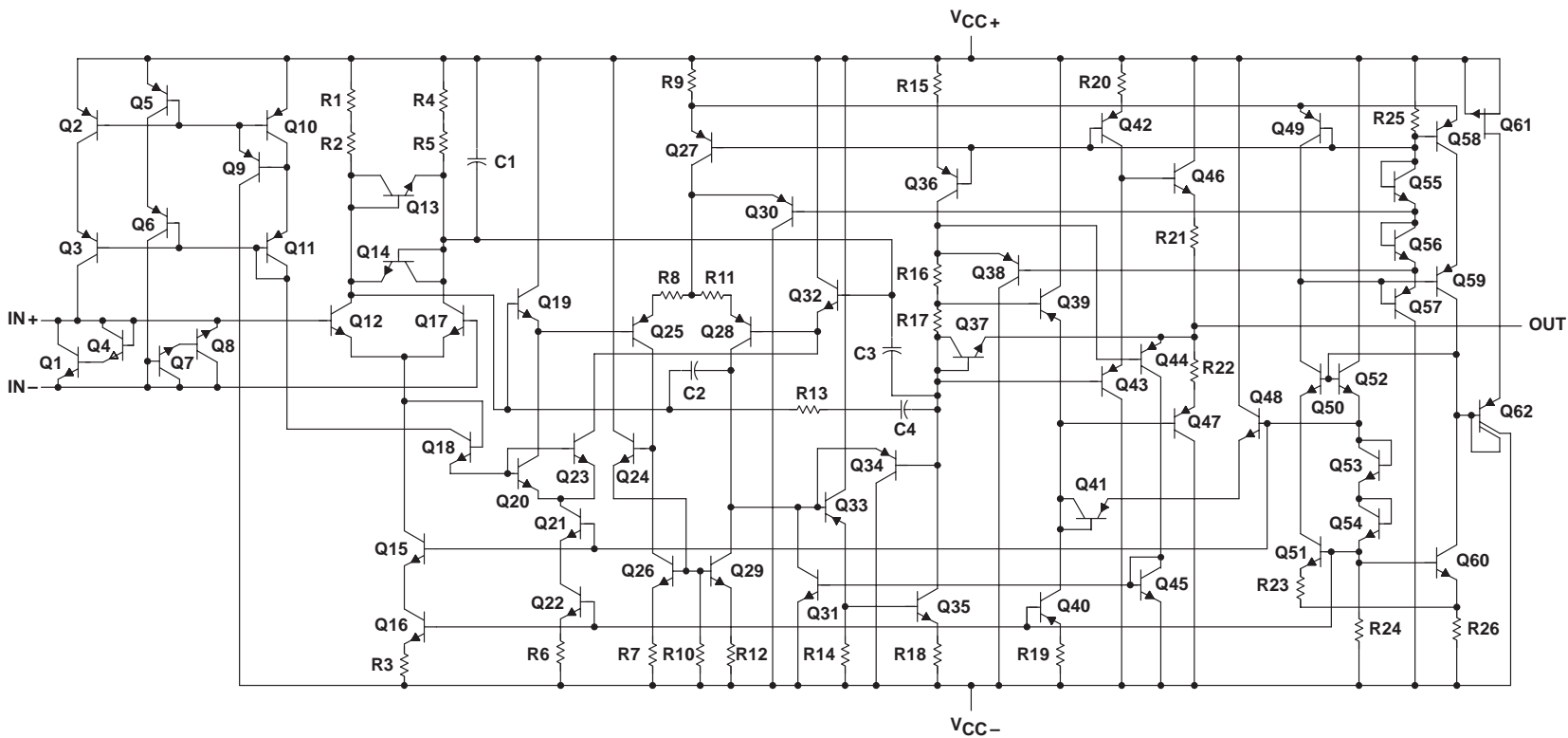
**TLE2237Y chip information**

This chip, when properly assembled, displays characteristics similar to TLE2237. Thermal compression or ultrasonic bonding may be used on the doped-aluminum bonding pads. The chip may be mounted with conductive epoxy or a gold-silicon preform.



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equivalent schematic (each amplifier)



ACTUAL DEVICE COMPONENT COUNT		
COMPONENT	TLE2227	TLE2237
Transistors	62	62
Resistors	24	24
Diodes	0	0
Capacitors	4	4

**TLE2227, TLE2227Y, TLE2237, TLE2237Y**  
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**absolute maximum ratings over operating free-air temperature range (unless otherwise noted)†**

Supply voltage, $V_{CC+}$ (see Note 1)	19 V
Supply voltage, $V_{CC-}$	-19 V
Differential input voltage, $V_{ID}$ (see Note 2)	$\pm 1.2$ V
Input voltage range, $V_I$ (any input)	$V_{CC\pm}$
Input current, $I_I$ (each input)	$\pm 1$ mA
Output current, $I_O$	$\pm 50$ mA
Total current into $V_{CC+}$	50 mA
Total current out of $V_{CC-}$	50 mA
Duration of short-circuit current at (or below) 25°C (see Note 3)	unlimited
Continuous total dissipation	See Dissipation Rating Table
Operating free-air temperature range, $T_A$	0°C to 70°C
Lead temperature 1,6 mm (1/16 inch) from case for 10 seconds	260°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  $IN-$ . Excessive current flows if a differential input voltage in excess of approximately  $\pm 1.2$  V is applied between the inputs unless some limiting resistance is used.
  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.

**DISSIPATION RATING TABLE**

PACKAGE	$T_A \leq 25^\circ\text{C}$ POWER RATING	DERATING FACTOR ABOVE $T_A = 25^\circ\text{C}$	$T_A = 70^\circ\text{C}$ POWER RATING
DW	1025 mW	8.2 mW/°C	656 mW
P	1000 mW	8.0 mW/°C	640 mW

**recommended operating conditions**

	MIN	MAX	UNIT
Supply voltage, $V_{CC\pm}$	$\pm 4$	$\pm 19$	V
Common-mode input voltage, $V_{IC}$	$T_A = 25^\circ\text{C}$		V
	$T_A = \text{Full range}^\dagger$		
Operating free-air temperature, $T_A$	0	70	°C

† Full range is 0°C to 70°C.



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

PARAMETER	TEST CONDITIONS	$T_A$ †	TLE2227C			UNIT
			MIN	TYP	MAX	
$V_{IO}$ Input offset voltage	$V_{IC} = 0,$ $R_S = 50\ \Omega$	25°C	100	350	$\mu\text{V}$	
		Full range	500			
$\alpha_{VIO}$ Temperature coefficient of input offset voltage		Full range	0.4	1	$\mu\text{V}/^\circ\text{C}$	
Input offset voltage long-term drift (see Note 4)		25°C	0.006	1	$\mu\text{V}/\text{mo}$	
$I_{IO}$ Input offset current		25°C	7.5	90	nA	
		Full range	150			
$I_{IB}$ Input bias current	25°C	15	90	nA		
	Full range	150				
$V_{ICR}$ Common-mode input voltage range	$R_S = 50\ \Omega$	25°C	-11 to 11	-13 to 13	V	
		Full range	-10.5 to 10.5			
$V_{OM+}$ Maximum positive peak output voltage swing	$R_L = 1\ \text{k}\Omega$	25°C	10.5		V	
		Full range	10			
	$R_L = 2\ \text{k}\Omega$	25°C	12			
		Full range	11			
$V_{OM-}$ Maximum negative peak output voltage swing	$R_L = 1\ \text{k}\Omega$	25°C	-10.5	-13	V	
		Full range	-10			
	$R_L = 2\ \text{k}\Omega$	25°C	-12	-13.5		
		Full range	-11			
$A_{VD}$ Large-signal differential voltage amplification	$V_O = \pm 11\ \text{V},$ $R_L = 2\ \text{k}\Omega$	25°C	2.5	45	$\text{V}/\mu\text{V}$	
		Full range	2			
	$V_O = \pm 10\ \text{V},$ $R_L = 1\ \text{k}\Omega$	25°C	3.5	38		
		Full range	1			
$c_i$ Input capacitance		25°C	8		pF	
$z_o$ Open-loop output impedance	$I_O = 0$	25°C	50		$\Omega$	
CMRR Common-mode rejection ratio	$V_{IC} = V_{ICR\text{min}},$ $R_S = 50\ \Omega$	25°C	98	115	dB	
		Full range	95			
$k_{SVR}$ Supply-voltage rejection ratio ( $\Delta V_{CC\pm}/\Delta V_{IO}$ )	$V_{CC\pm} = \pm 4\ \text{V to } \pm 18\ \text{V},$ $R_S = 50\ \Omega$	25°C	94	120	dB	
		Full range	92			
$I_{CC}$ Supply current	$V_O = 0,$ No load	25°C	7.3	10.6	mA	
		Full range	11.2			

† Full range is 0°C to 70°C.

NOTE 4: Typical values are based on the input offset voltage shift observed through 168 hours of operating life test at  $T_A = 150^\circ\text{C}$  extrapolated to  $T_A = 25^\circ\text{C}$  using the Arrhenius equation and assuming an activation energy of 0.96 eV.



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**operating characteristics at specified free-air temperature,  $V_{CC\pm} = \pm 15\text{ V}$**

PARAMETER		TEST CONDITIONS	$T_A$ †	TLE2227C			UNIT
				MIN	TYP	MAX	
SR	Slew rate	$R_L = 2\text{ k}\Omega$ , $C_L = 100\text{ pF}$	25°C	1.7	2.5		V/ $\mu$ s
			Full range	1.2			
$V_n$	Equivalent input noise voltage	$R_S = 20\ \Omega$ , $f = 10\text{ Hz}$	25°C	3.3		8	nV/ $\sqrt{\text{Hz}}$
		$R_S = 20\ \Omega$ , $f = 1\text{ kHz}$		2.5			
$V_{N(PP)}$	Peak-to-peak equivalent input noise voltage	$f = 0.1\text{ Hz to }10\text{ Hz}$	25°C	50	250		nV
$I_n$	Equivalent input noise current	$f = 10\text{ Hz}$	25°C	1.5		4	pA/ $\sqrt{\text{Hz}}$
		$f = 1\text{ kHz}$		0.4			
THD	Total harmonic distortion	$V_O = \pm 10\text{ V}$ , $A_{VD} = 1$ , See Note 5	25°C	<0.002%			
$B_1$	Unity-gain bandwidth	$R_L = 2\text{ k}\Omega$ , $C_L = 100\text{ pF}$	25°C	7	13		MHz
$B_{OM}$	Maximum output-swing bandwidth	$R_L = 2\text{ k}\Omega$	25°C	30			kHz
$\phi_m$	Phase margin	$R_L = 2\text{ k}\Omega$ , $C_L = 100\text{ pF}$	25°C	40°			

† Full range is 0°C to 70°C.

NOTE 5: Measured distortion of the source used in the analysis is 0.002%.

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

PARAMETER	TEST CONDITIONS	$T_A^\dagger$	TLE2237C			UNIT
			MIN	TYP	MAX	
$V_{IO}$ Input offset voltage	$V_{IC} = 0, R_S = 50\ \Omega$	25°C	100	350		$\mu\text{V}$
		Full range		500		$\mu\text{V}/^\circ\text{C}$
$\alpha_{VIO}$ Temperature coefficient of input offset voltage		Full range	0.4	1		$\mu\text{V}/\text{mo}$
Input offset voltage long-term drift (see Note 4)		25°C	0.006	1		$\mu\text{V}/\text{mo}$
$I_{IO}$ Input offset current		25°C	7.5	90		nA
		Full range		150		nA
$I_{IB}$ Input bias current	25°C	15	90		nA	
	Full range		150		nA	
$V_{ICR}$ Common-mode input voltage range	$R_S = 50\ \Omega$	25°C	-11 to 11	-13 to 13		V
		Full range	-10.5 to 10.5			V
$V_{OM+}$ Maximum positive peak output voltage swing	$R_L = 1\ \text{k}\Omega$	25°C	10.5			V
		Full range	10			V
	$R_L = 2\ \text{k}\Omega$	25°C	12			V
		Full range	11			V
$V_{OM-}$ Maximum negative peak output voltage swing	$R_L = 1\ \text{k}\Omega$	25°C	-10.5	-13		V
		Full range	-10			V
	$R_L = 2\ \text{k}\Omega$	25°C	-12	-13.5		V
		Full range	-11			V
$A_{VD}$ Large-signal differential voltage amplification	$V_O = \pm 11\text{ V}, R_L = 2\ \text{k}\Omega$	25°C	2.5	45		$\text{V}/\mu\text{V}$
		Full range	2			$\text{V}/\mu\text{V}$
	$V_O = \pm 10\ \text{V}, R_L = 1\ \text{k}\Omega$	25°C	3.5	38		$\text{V}/\mu\text{V}$
		Full range	1			$\text{V}/\mu\text{V}$
$C_i$ Input capacitance		25°C	8		pF	
$z_O$ Open-loop output impedance	$I_O = 0$	25°C	50		$\Omega$	
CMRR Common-mode rejection ratio	$V_{IC} = V_{ICRmin}, R_S = 50\ \Omega$	25°C	98	115		dB
		Full range	95			dB
$k_{SVR}$ Supply-voltage rejection ratio ( $\Delta V_{CC\pm}/\Delta V_{IO}$ )	$V_{CC\pm} = \pm 4\ \text{V to } \pm 18\ \text{V}, R_S = 50\ \Omega$	25°C	94	120		dB
		Full range	92			dB
$I_{CC}$ Supply current	$V_O = 0, \text{ No load}$	25°C	7.3	10.6		mA
		Full range		11.2		mA

$^\dagger$  Full range is 0°C to 70°C.

NOTE 4. Typical values are based on the input offset voltage shift observed through 168 hours of operating life test at  $T_A = 150^\circ\text{C}$  extrapolated to  $T_A = 25^\circ\text{C}$  using the Arrhenius equation and assuming an activation energy of 0.96 eV.





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**operating characteristics at specified free-air temperature,  $V_{CC\pm} = \pm 15\text{ V}$**

PARAMETER		TEST CONDITIONS	$T_A$ †	TLE2237C			UNIT
				MIN	TYP	MAX	
SR	Slew rate	$A_{VD} = 5$ , $R_L = 2\text{ k}\Omega$ , $C_L = 100\text{ pF}$	25°C	4	5		V/ $\mu$ s
			Full range	3			
$V_n$	Equivalent input noise voltage	$R_S = 20\ \Omega$ , $f = 10\text{ Hz}$	25°C		3.3	8	nV/ $\sqrt{\text{Hz}}$
					2.5	4.5	
$V_{n(PP)}$	Peak-to-peak equivalent input noise voltage	$f = 0.1\text{ Hz to }10\text{ Hz}$	25°C		50	250	nV
$I_n$	Equivalent input noise current	$f = 10\text{ Hz}$	25°C		1.5	4	pA/ $\sqrt{\text{Hz}}$
					0.4	0.6	
THD	Total harmonic distortion	$V_O = \pm 10\text{ V}$ , $A_{VD} = 5\text{ V}$ , See Note 5	25°C	<0.002%			
GBP	Gain-bandwidth product	$f = 100\text{ kHz}$ , $R_L = 2\text{ k}\Omega$ , $C_L = 100\text{ pF}$	25°C	35	50		MHz
B <sub>OM</sub>	Maximum output-swing bandwidth	$R_L = 2\text{ k}\Omega$	25°C	80			kHz
$\phi_m$	Phase margin	$R_L = 2\text{ k}\Omega$ , $C_L = 100\text{ pF}$	25°C	40°			

† Full range is 0°C to 70°C.

NOTE 5. Measured distortion of the source used in the analysis was 0.002%.

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**electrical characteristics,  $V_{CC\pm} = \pm 15\text{ V}$ ,  $T_A = 25^\circ\text{C}$  (unless otherwise noted)**

PARAMETER	TEST CONDITIONS	TLE2227Y			UNIT
		MIN	TYP	MAX	
$V_{IO}$ Input offset voltage	$V_{IC} = 0$ , $R_S = 50\ \Omega$		100	350	$\mu\text{V}$
Input offset voltage long-term drift (see Note 4)			0.006	1	$\mu\text{V}/\text{mo}$
$I_{IO}$ Input offset current			7.5	90	nA
$I_{IB}$ Input bias current			15	90	nA
$V_{ICR}$ Common-mode input voltage range	$R_S = 50\ \Omega$	-11 to 11	-13 to 13		V
$V_{OM+}$ Maximum positive peak output voltage swing	$R_L = 1\ \text{k}\Omega$ $R_L = 2\ \text{k}\Omega$		10.5 12		V
$V_{OM-}$ Maximum negative peak output voltage swing	$R_L = 1\ \text{k}\Omega$ $R_L = 2\ \text{k}\Omega$	-10.5 -12	-13 -13.5		V
$A_{VD}$ Large-signal differential voltage amplification	$V_O = \pm 11\ \text{V}$ , $R_L = 2\ \text{k}\Omega$ $V_O = \pm 10\ \text{V}$ , $R_L = 1\ \text{k}\Omega$	2.5 3.5	45 38		$\text{V}/\mu\text{V}$
$c_i$ Input capacitance			8		pF
$z_o$ Open-loop output impedance	$I_O = 0$		50		$\Omega$
CMRR Common-mode rejection ratio	$V_{IC} = V_{ICR\text{min}}$ , $R_S = 50\ \Omega$	98	115		dB
$k_{SVR}$ Supply-voltage rejection ratio ( $\Delta V_{CC\pm}/\Delta V_{IO}$ )	$V_{CC\pm} = \pm 4\ \text{V}$ to $\pm 18\ \text{V}$ , $R_S = 50\ \Omega$	94	120		dB
$I_{CC}$ Supply current	$V_O = 0$ , No load	7.3	10.6		mA

NOTE 4. Typical values are based on the input offset voltage shift observed through 168 hours of operating life test at  $T_A = 150^\circ\text{C}$  extrapolated to  $T_A = 25^\circ\text{C}$  using the Arrhenius equation and assuming an activation energy of 0.96 eV.

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

PARAMETER	TEST CONDITIONS	TLE2227Y			UNIT
		MIN	TYP	MAX	
SR Slew rate	$R_L = 2\ \text{k}\Omega$ , $C_L = 100\ \text{pF}$	1.7	2.5		$\text{V}/\mu\text{s}$
$V_n$ Equivalent input noise voltage	$R_S = 20\ \Omega$ , $f = 10\ \text{Hz}$ $R_S = 20\ \Omega$ , $f = 1\ \text{kHz}$		3.3 2.5	8 4.5	$\text{nV}/\sqrt{\text{Hz}}$
$V_{N(PP)}$ Peak-to-peak equivalent input noise voltage	$f = 0.1\ \text{Hz}$ to $10\ \text{Hz}$		50	250	nV
$I_n$ Equivalent input noise current	$f = 10\ \text{Hz}$ $f = 1\ \text{kHz}$		1.5 0.4	4 0.6	$\text{pA}/\sqrt{\text{Hz}}$
THD Total harmonic distortion	$V_O = \pm 10\ \text{V}$ , $A_{VD} = 1$ , See Note 5		<0.002%		
$B_1$ Unity-gain bandwidth	$R_L = 2\ \text{k}\Omega$ , $C_L = 100\ \text{pF}$	7	13		MHz
$B_{OM}$ Maximum output-swing bandwidth	$R_L = 2\ \text{k}\Omega$		30		kHz
$\phi_m$ Phase margin	$R_L = 2\ \text{k}\Omega$ , $C_L = 100\ \text{pF}$		40°		

NOTE 5 Measured distortion of the source used in the analysis is 0.002%.



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

PARAMETER	TEST CONDITIONS	TLE2237Y			UNIT
		MIN	TYP	MAX	
$V_{IO}$ Input offset voltage	$V_{IC} = 0, \quad R_S = 50 \Omega$		100	350	$\mu$ V
Input offset voltage long-term drift (see Note 4)			0.006	1	$\mu$ V/mo
$I_{IO}$ Input offset current			7.5	90	nA
$I_{IB}$ Input bias current			15	90	nA
$V_{ICR}$ Common-mode input voltage range	$R_S = 50 \Omega$	-11 to 11	-13 to 13		V
$V_{OM+}$ Maximum positive peak output voltage swing	$R_L = 1 \text{ k}\Omega$	10.5			V
	$R_L = 2 \text{ k}\Omega$	12			
$V_{OM-}$ Maximum negative peak output voltage swing	$R_L = 1 \text{ k}\Omega$	-10.5	-13		V
	$R_L = 2 \text{ k}\Omega$	-12	-13.5		
$A_{VD}$ Large-signal differential voltage amplification	$V_O = \pm 11 \text{ V}, \quad R_L = 2 \text{ k}\Omega$	2.5	45		V/ $\mu$ V
	$V_O = \pm 10 \text{ V}, \quad R_L = 1 \text{ k}\Omega$	3.5	38		
$C_i$ Input capacitance		8			pF
$z_O$ Open-loop output impedance	$I_O = 0$	50			$\Omega$
CMRR Common-mode rejection ratio	$V_{IC} = V_{ICRmin}, \quad R_S = 50 \Omega$	98	115		dB
$k_{SVR}$ Supply-voltage rejection ratio ( $\Delta V_{CC\pm}/\Delta V_{IO}$ )	$V_{CC\pm} = \pm 4 \text{ V to } \pm 18 \text{ V}, \quad R_S = 50 \Omega$	94	120		dB
$I_{CC}$ Supply current	$V_O = 0, \quad \text{No load}$	7.3	10.6		mA

NOTE 4. Typical values are based on the input offset voltage shift observed through 168 hours of operating life test at  $T_A = 150^\circ\text{C}$  extrapolated to  $T_A = 25^\circ\text{C}$  using the Arrhenius equation and assuming an activation energy of 0.96 eV.

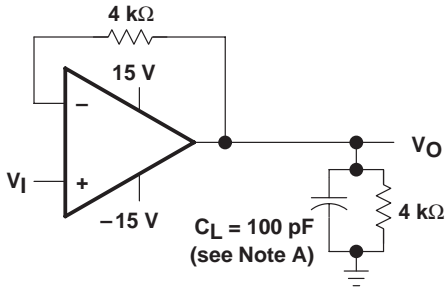
**operating characteristics at specified free-air temperature  $V_{CC\pm} = \pm 15$  V**

PARAMETER	TEST CONDITIONS	TLE2237Y			UNIT
		MIN	TYP	MAX	
SR Slew rate	$R_L = 2 \text{ k}\Omega, \quad C_L = 100 \text{ pF}$	4	5		V/ $\mu$ s
$V_n$ Equivalent input noise voltage	$R_S = 20 \Omega, \quad f = 10 \text{ Hz}$		3.3	8	nV/ $\sqrt{\text{Hz}}$
	$R_S = 20 \Omega, \quad f = 1 \text{ kHz}$		2.5	4.5	
$V_{n(PP)}$ Peak-to-peak equivalent input noise voltage	$f = 0.1 \text{ Hz to } 10 \text{ Hz}$		50	250	nV
$I_n$ Equivalent input noise current	$f = 10 \text{ Hz}$		1.5	4	pA/ $\sqrt{\text{Hz}}$
	$f = 1 \text{ kHz}$		0.4	0.6	
THD Total harmonic distortion	$V_O = \pm 10 \text{ V}, \quad A_{VD} = 1, \quad \text{See Note 5}$	<0.002%			
$B_1$ Unity-gain bandwidth	$R_L = 2 \text{ k}\Omega, \quad C_L = 100 \text{ pF}$	35	50		MHz
$B_{OM}$ Maximum output-swing bandwidth	$R_L = 2 \text{ k}\Omega$	80			kHz
$\phi_m$ Phase margin	$R_L = 2 \text{ k}\Omega, \quad C_L = 100 \text{ pF}$	40°			

NOTE 5. Measured distortion of the source used in the analysis is 0.002%.



PARAMETER MEASUREMENT INFORMATION



NOTE A:  $C_L$  includes fixture capacitance.

Figure 1. Slew-Rate Test Circuit

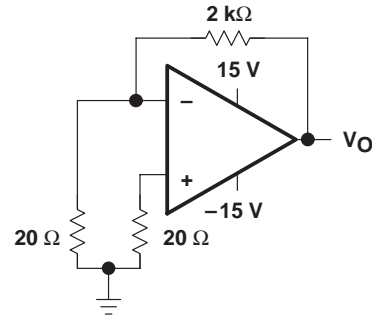
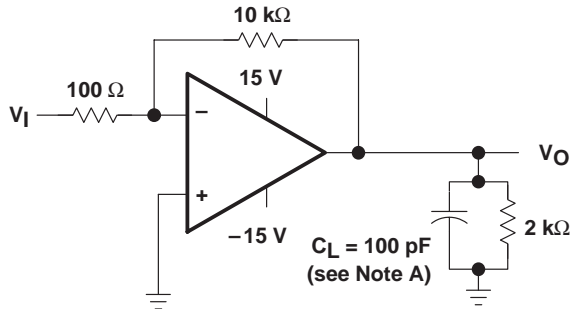
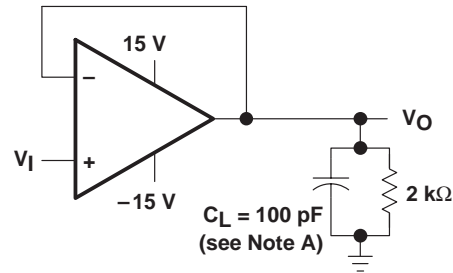


Figure 2. Noise-Voltage Test Circuit



NOTE A:  $C_L$  includes fixture capacitance.

Figure 3. Unity-Gain Bandwidth and Phase-Margin Test Circuit



NOTE A:  $C_L$  includes fixture capacitance.

Figure 4. Small-Signal Pulse-Response Test Circuit

## TYPICAL CHARACTERISTICS

**Table of Graphs**

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$I_{IO}$	Input offset current	vs Free-air temperature	8
$I_{IB}$	Input bias current	vs Common-mode input voltage vs Free-air temperature	9 10
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$V_{OM}$	Maximum peak positive output voltage	vs Load resistance vs Free-air temperature	13 15
$V_{OM}$	Maximum peak negative output voltage	vs Load resistance vs Free-air temperature	14 16
$A_{VD}$	Large-signal differential voltage amplification	vs Supply voltage vs Load resistance vs Frequency vs Free-air temperature	17 19 18, 20, 21 22
$z_o$	Output impedance	vs Frequency	23
CMRR	Common-mode rejection ratio	vs Frequency	24
kSVR	Supply-voltage rejection ratio	vs Frequency	25
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TYPICAL CHARACTERISTICS

DISTRIBUTION OF  
 INPUT OFFSET VOLTAGE

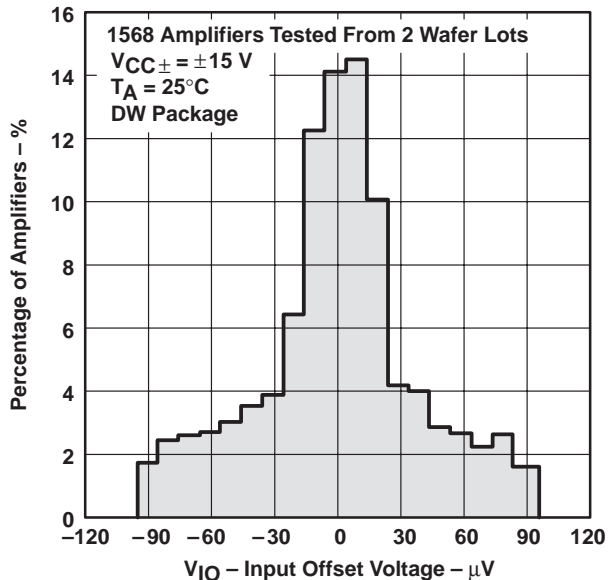


Figure 5

INPUT OFFSET VOLTAGE CHANGE  
 vs  
 TIME AFTER POWER ON

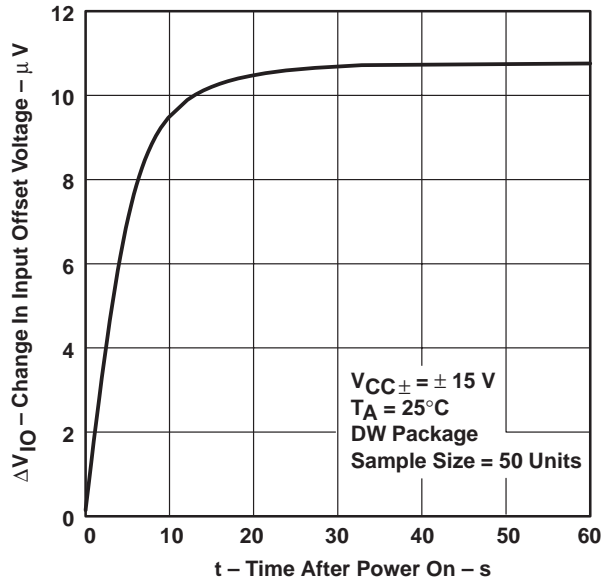


Figure 6

INPUT OFFSET VOLTAGE CHANGE  
 vs  
 TIME AFTER POWER ON

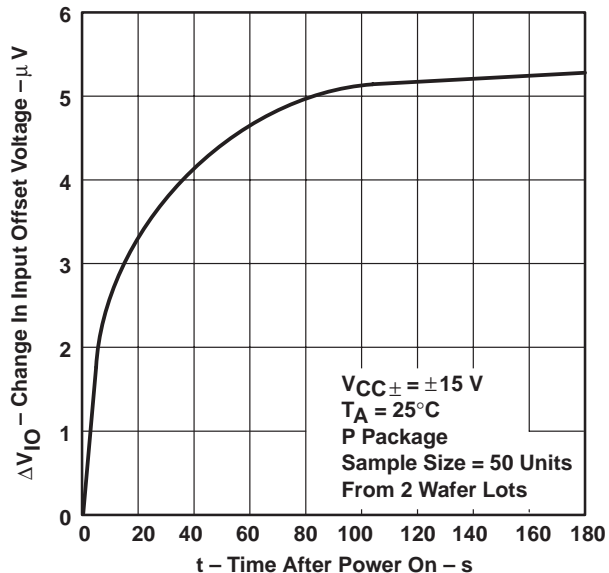


Figure 7

INPUT OFFSET CURRENT  
 vs  
 FREE-AIR TEMPERATURE

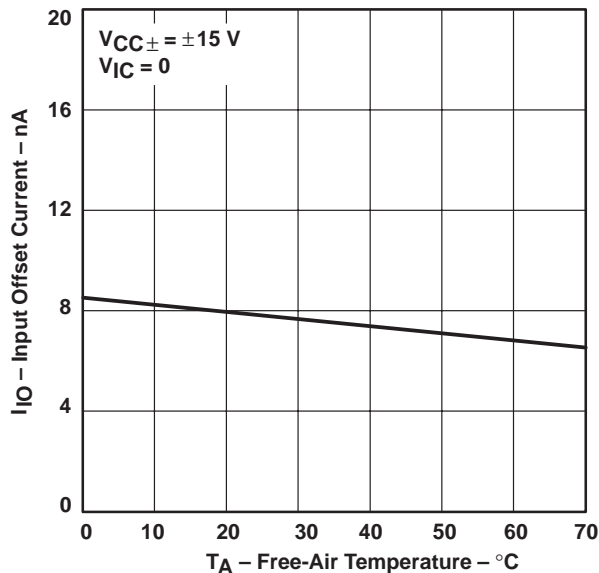


Figure 8

TYPICAL CHARACTERISTICS

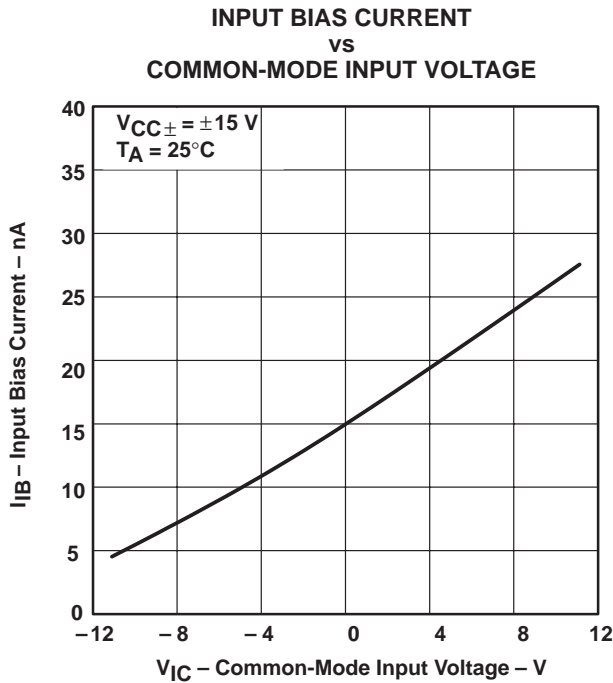


Figure 9

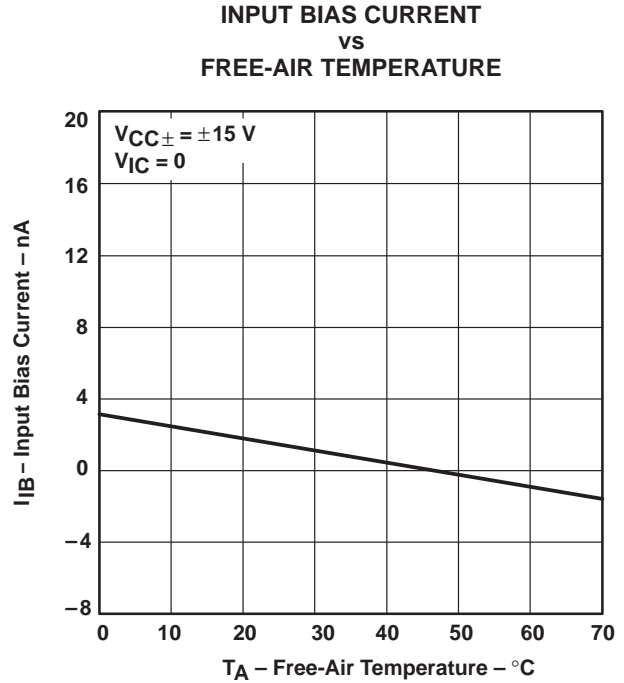


Figure 10

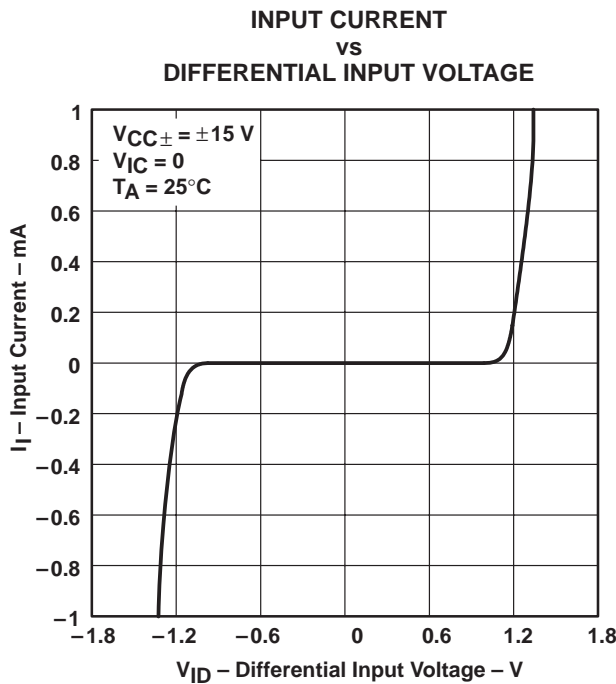


Figure 11

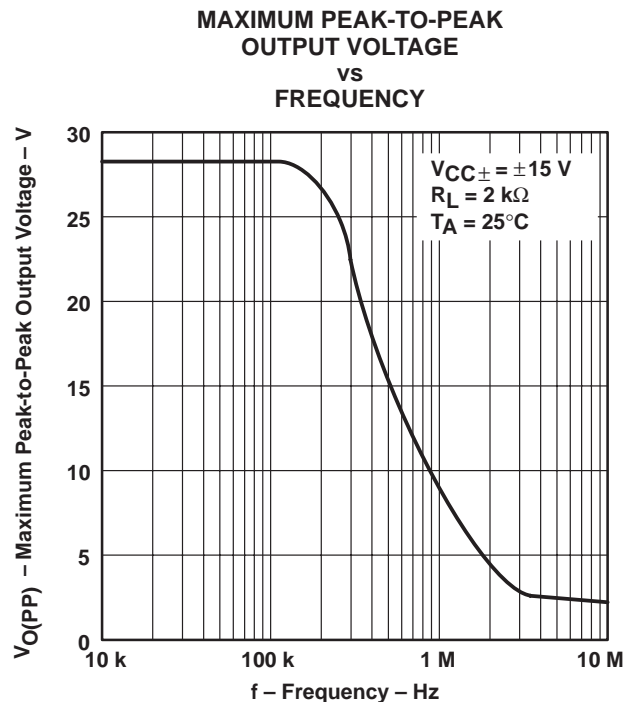


Figure 12

TYPICAL CHARACTERISTICS

MAXIMUM POSITIVE PEAK  
 OUTPUT VOLTAGE  
 VS  
 LOAD RESISTANCE

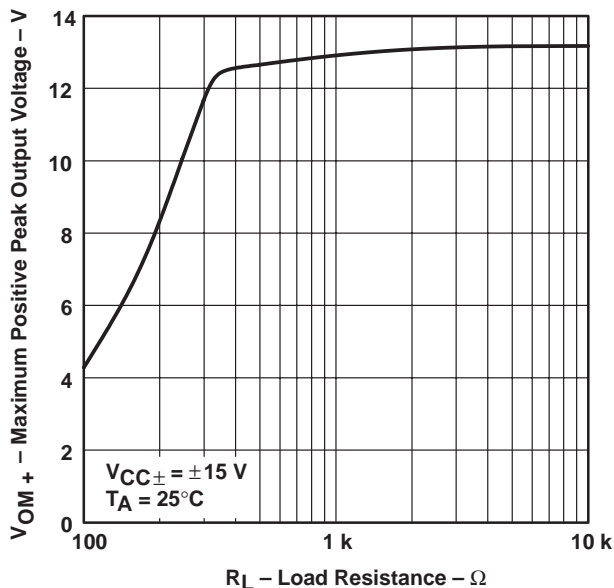


Figure 13

MAXIMUM NEGATIVE PEAK  
 OUTPUT VOLTAGE  
 VS  
 LOAD RESISTANCE

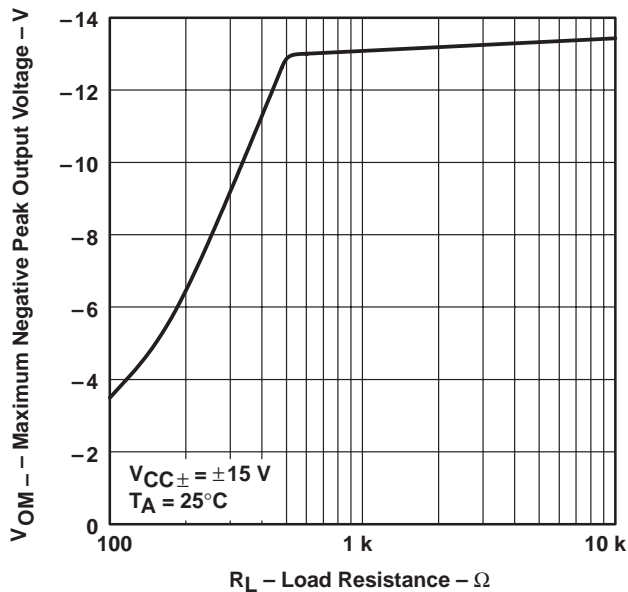


Figure 14

MAXIMUM POSITIVE PEAK  
 OUTPUT VOLTAGE  
 VS  
 FREE-AIR TEMPERATURE

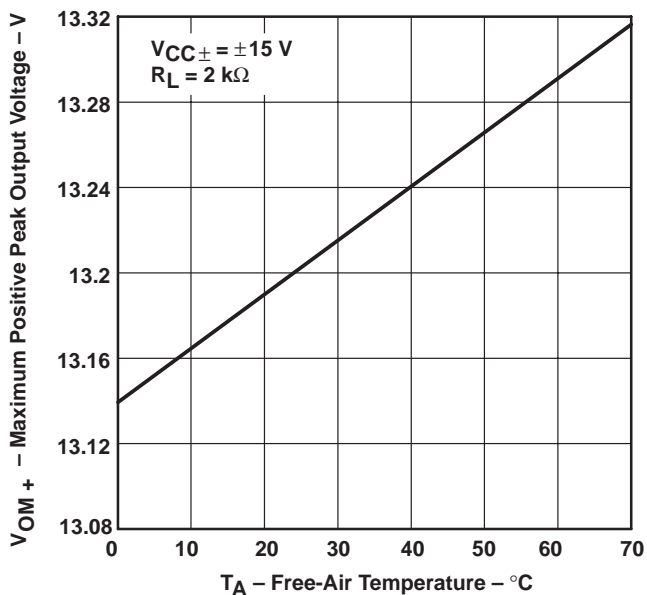


Figure 15

MAXIMUM NEGATIVE PEAK  
 OUTPUT VOLTAGE  
 VS  
 FREE-AIR TEMPERATURE

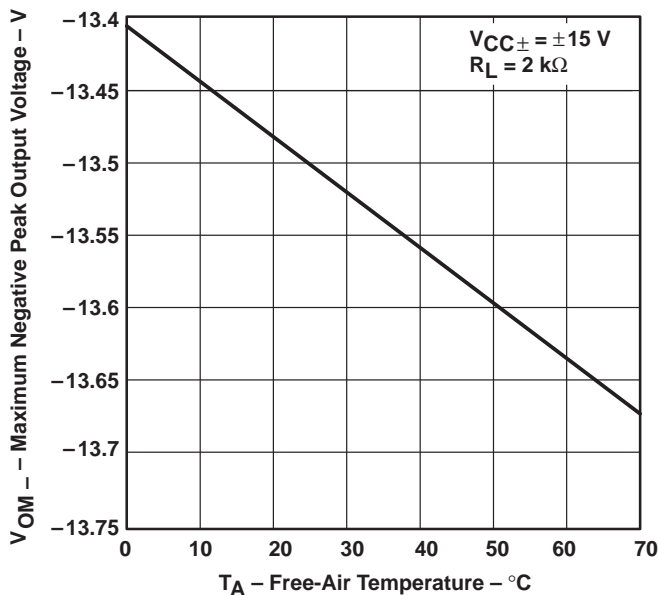


Figure 16



TYPICAL CHARACTERISTICS

LARGE-SIGNAL DIFFERENTIAL  
 VOLTAGE AMPLIFICATION

vs  
 SUPPLY VOLTAGE

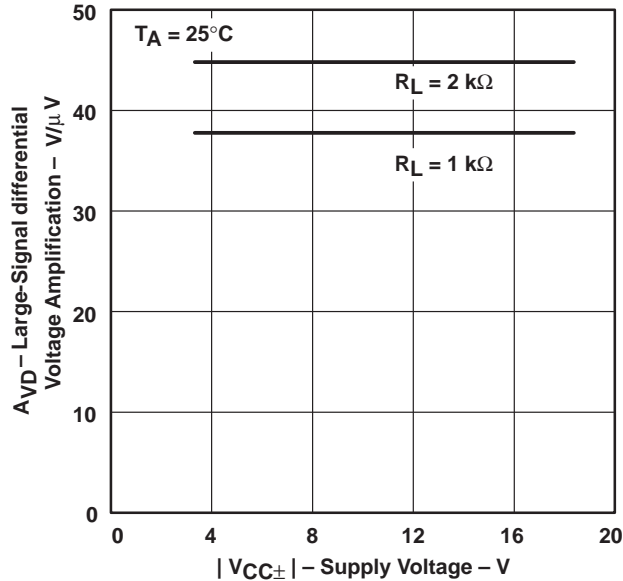


Figure 17

LARGE-SIGNAL DIFFERENTIAL VOLTAGE  
 AMPLIFICATION AND PHASE SHIFT

vs  
 FREQUENCY

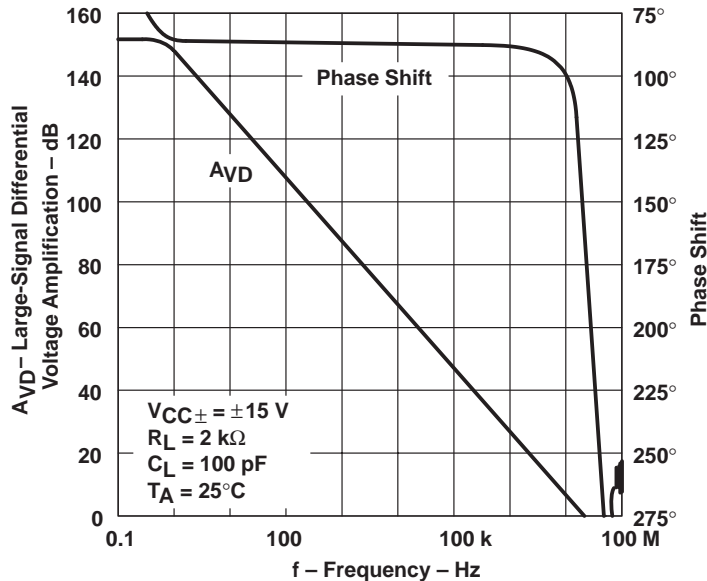


Figure 18

TYPICAL CHARACTERISTICS

LARGE-SIGNAL DIFFERENTIAL  
 VOLTAGE AMPLIFICATION  
 vs  
 LOAD RESISTANCE

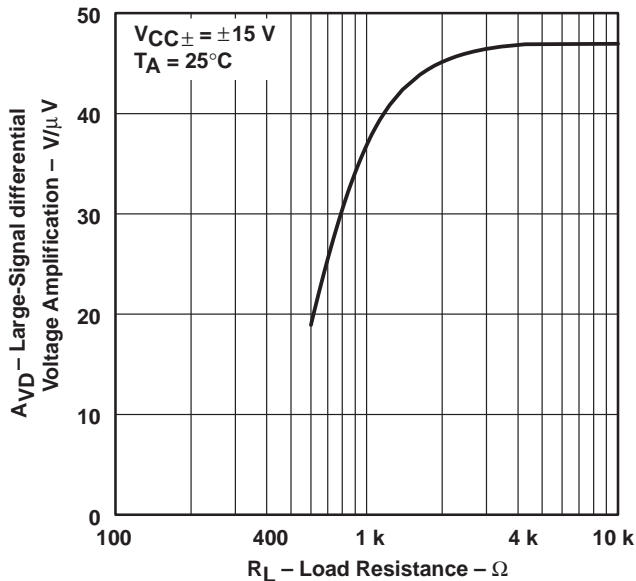


Figure 19

TLE2227  
 LARGE-SIGNAL DIFFERENTIAL VOLTAGE  
 AMPLIFICATION AND PHASE SHIFT  
 vs  
 FREQUENCY

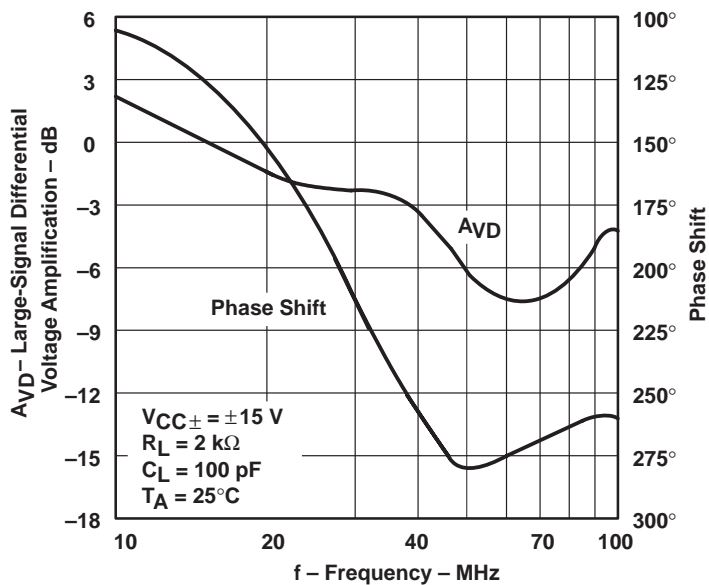


Figure 20

TYPICAL CHARACTERISTICS

TLE2037  
 LARGE-SIGNAL DIFFERENTIAL VOLTAGE  
 AMPLIFICATION AND PHASE SHIFT  
 VS  
 FREQUENCY

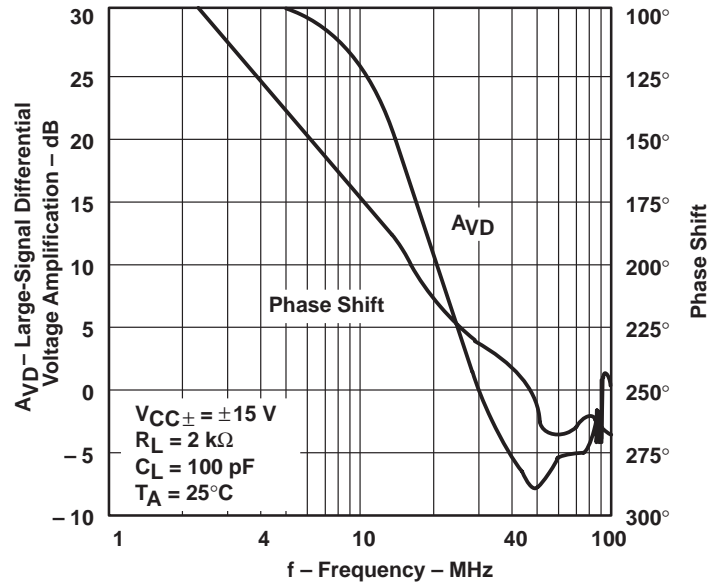


Figure 21

LARGE-SCALE DIFFERENTIAL  
 VOLTAGE AMPLIFICATION  
 VS  
 FREE-AIR TEMPERATURE

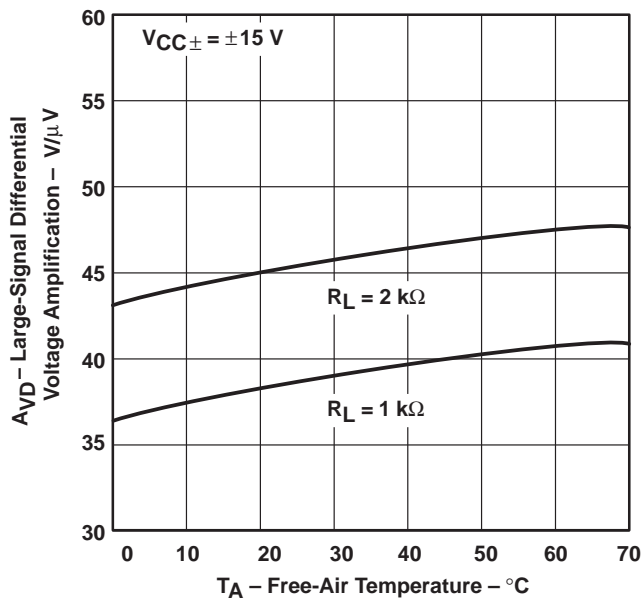


Figure 22

OUTPUT IMPEDANCE  
 VS  
 FREQUENCY

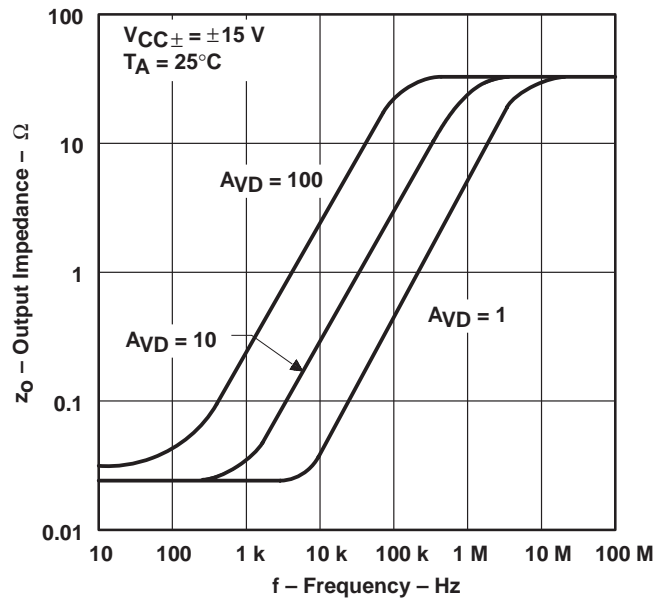


Figure 23

TYPICAL CHARACTERISTICS

COMMON-MODE REJECTION RATIO  
 VS  
 FREQUENCY

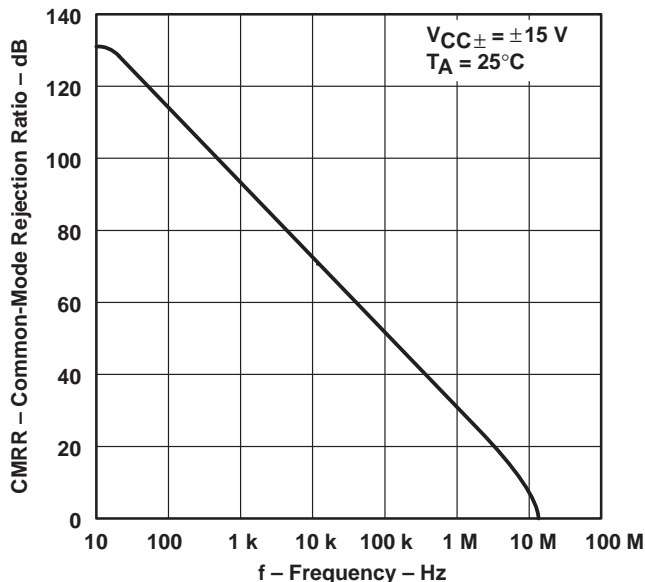


Figure 24

SUPPLY-VOLTAGE REJECTION RATIO  
 VS  
 FREQUENCY

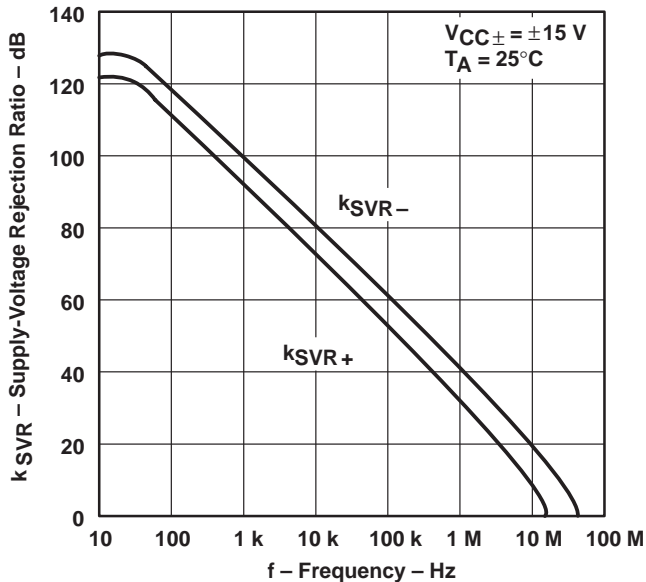


Figure 25

SHORT-CIRCUIT OUTPUT CURRENT  
 VS  
 SUPPLY VOLTAGE

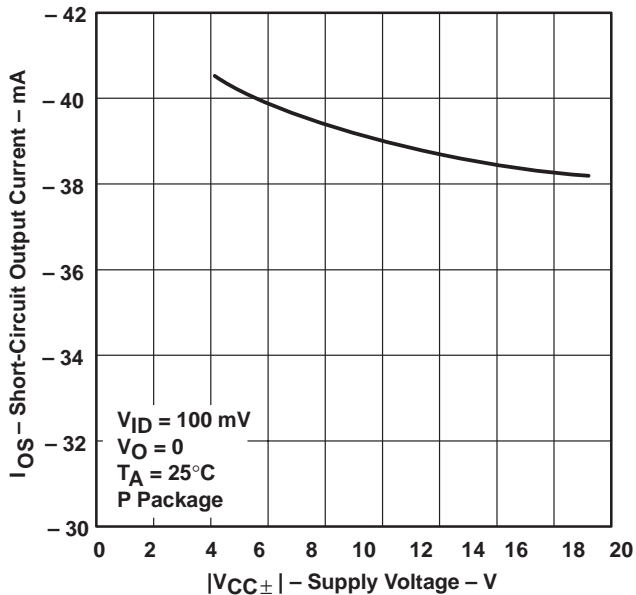


Figure 26

SHORT-CIRCUIT OUTPUT CURRENT  
 VS  
 SUPPLY VOLTAGE

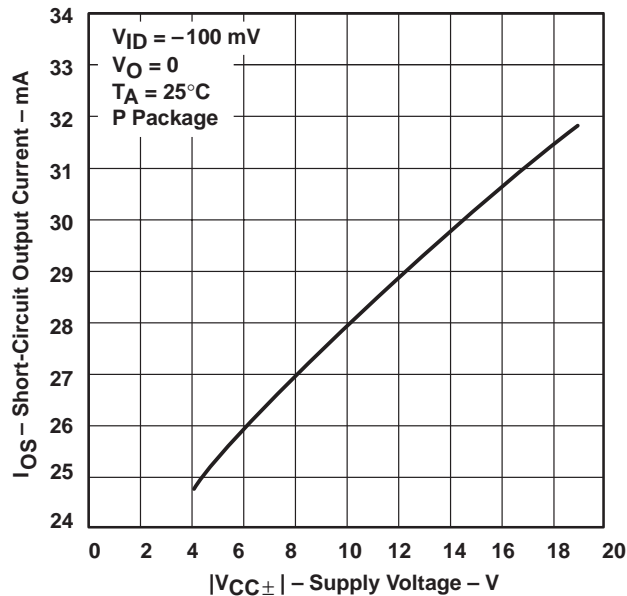


Figure 27

TYPICAL CHARACTERISTICS

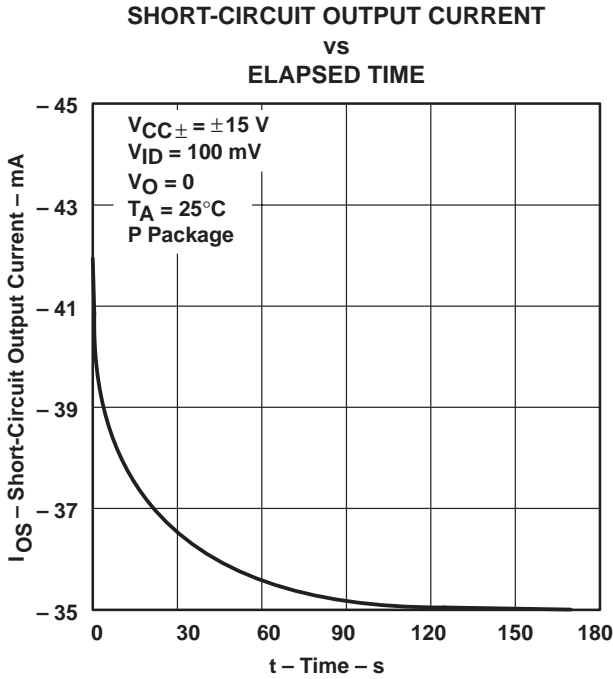


Figure 28

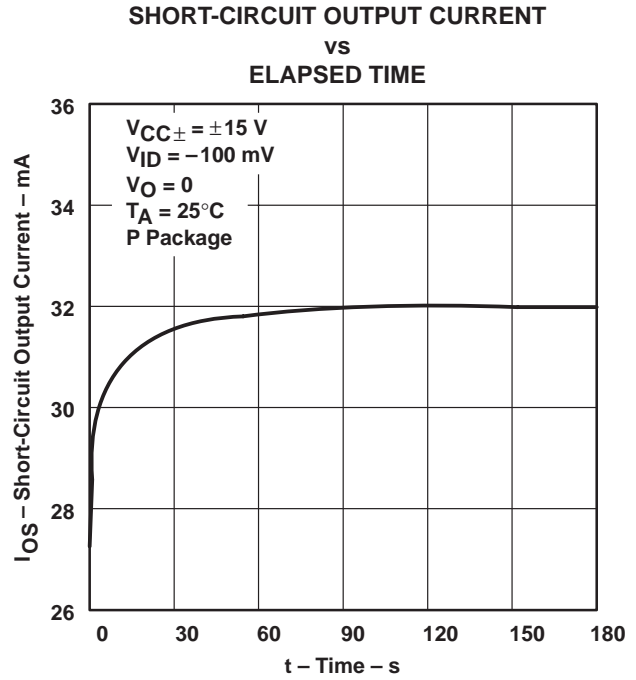


Figure 29

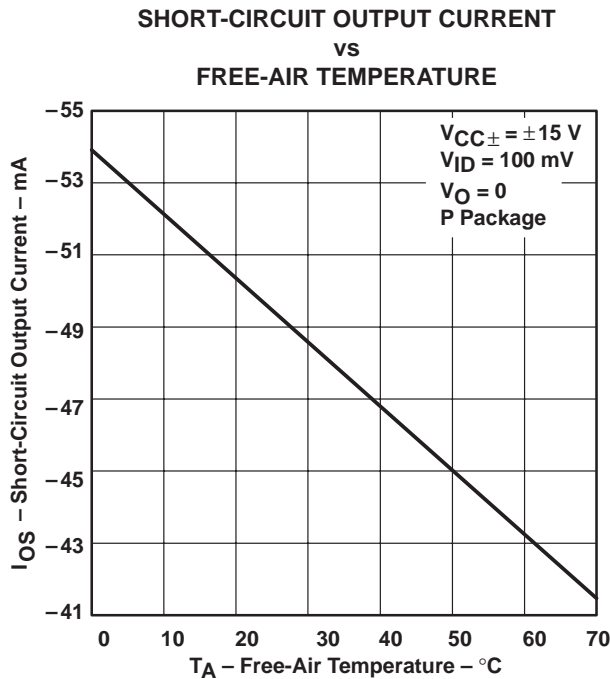


Figure 30

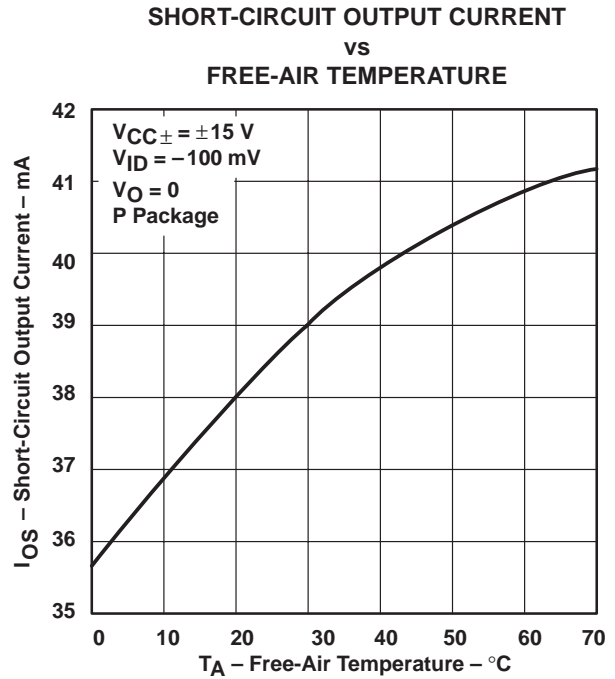


Figure 31

TYPICAL CHARACTERISTICS

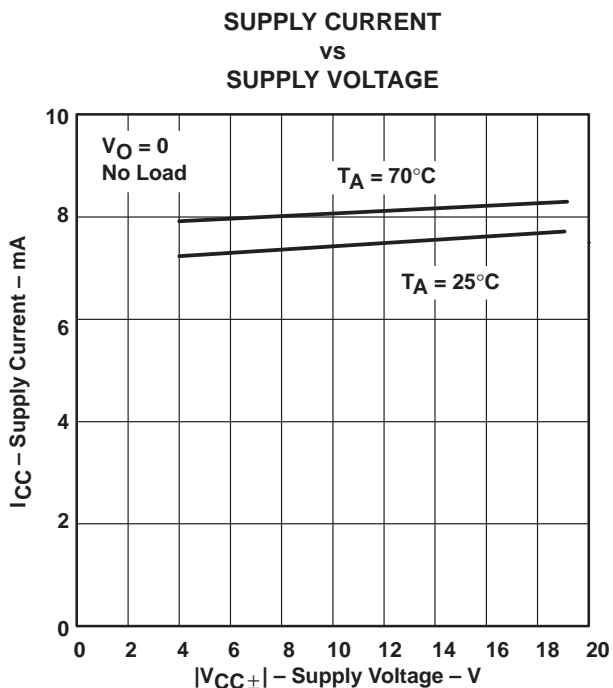


Figure 32

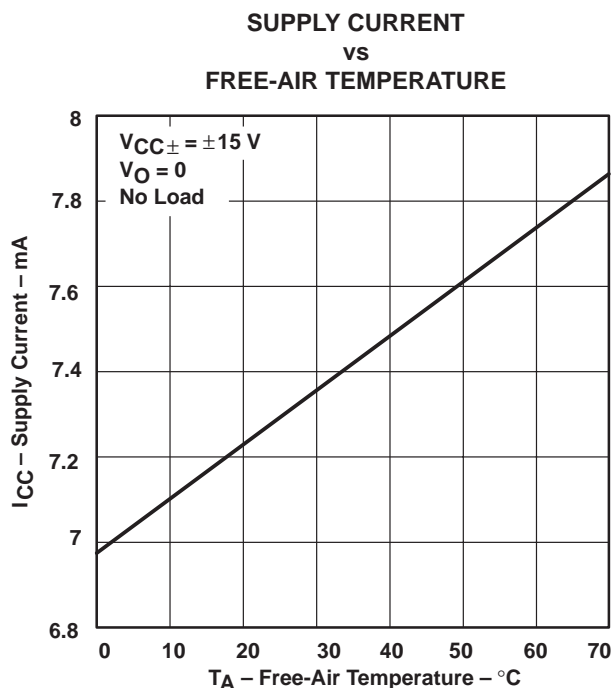


Figure 33

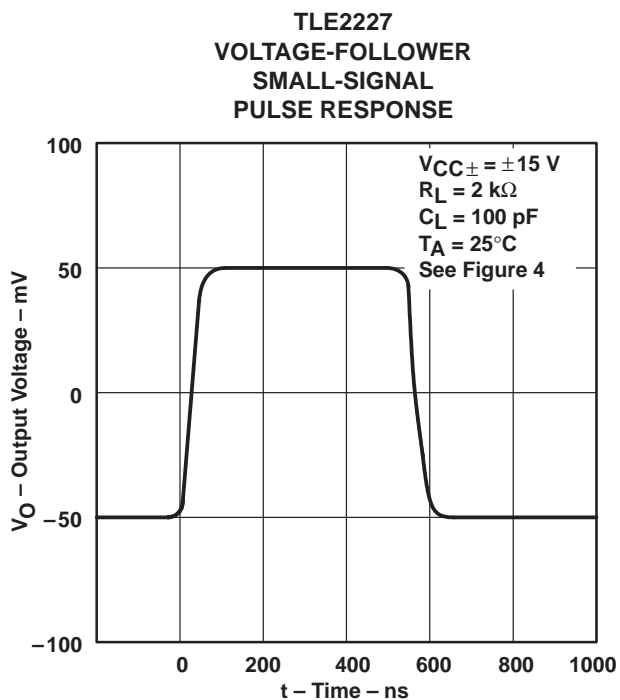


Figure 34

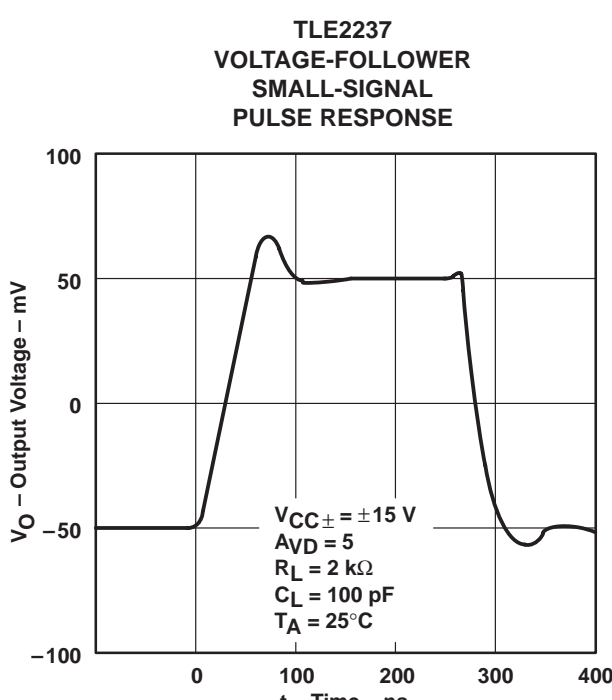


Figure 35

TYPICAL CHARACTERISTICS

TLE2227  
 VOLTAGE-FOLLOWER  
 LARGE-SIGNAL  
 PULSE RESPONSE

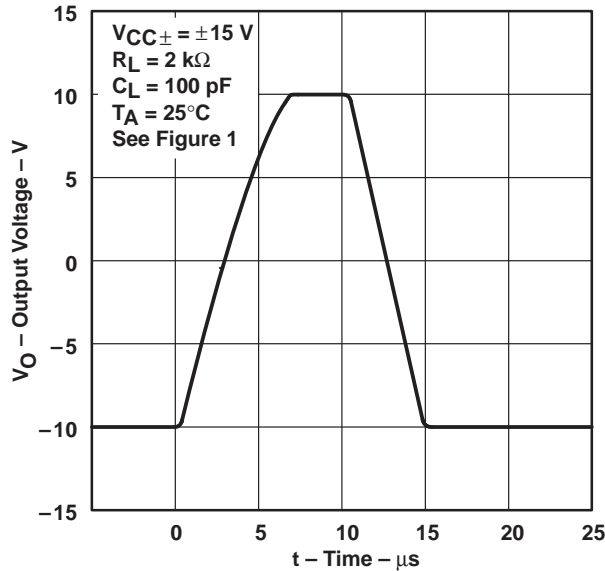


Figure 36

TLE2237  
 VOLTAGE-FOLLOWER  
 LARGE-SIGNAL  
 PULSE RESPONSE

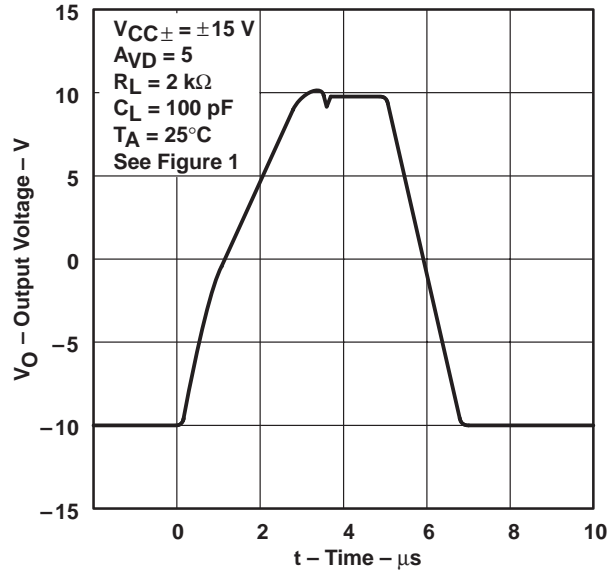


Figure 37

EQUIVALENT INPUT NOISE VOLTAGE  
 vs  
 FREQUENCY

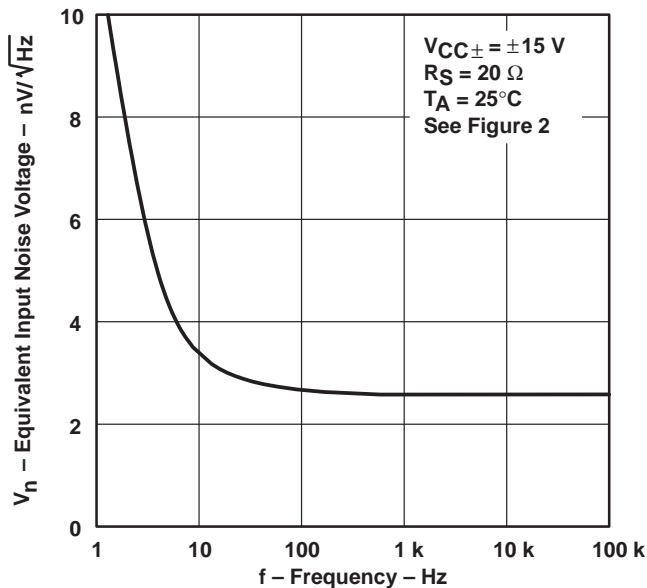


Figure 38

NOISE VOLTAGE  
 (REFERRED TO INPUT)  
 OVER A 10-SECOND INTERVAL

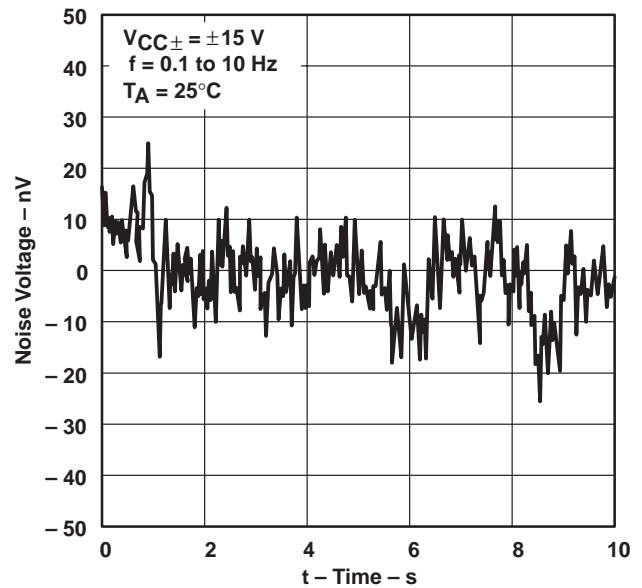


Figure 39

TYPICAL CHARACTERISTICS

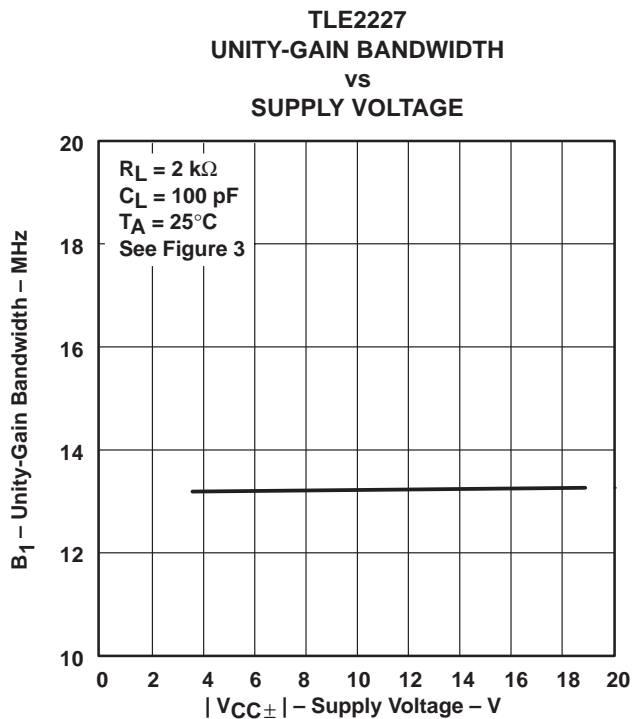


Figure 40

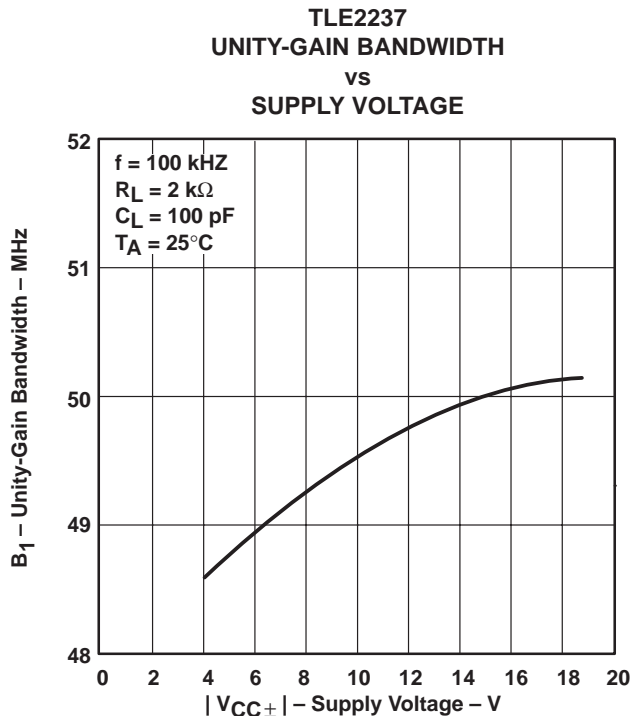


Figure 41

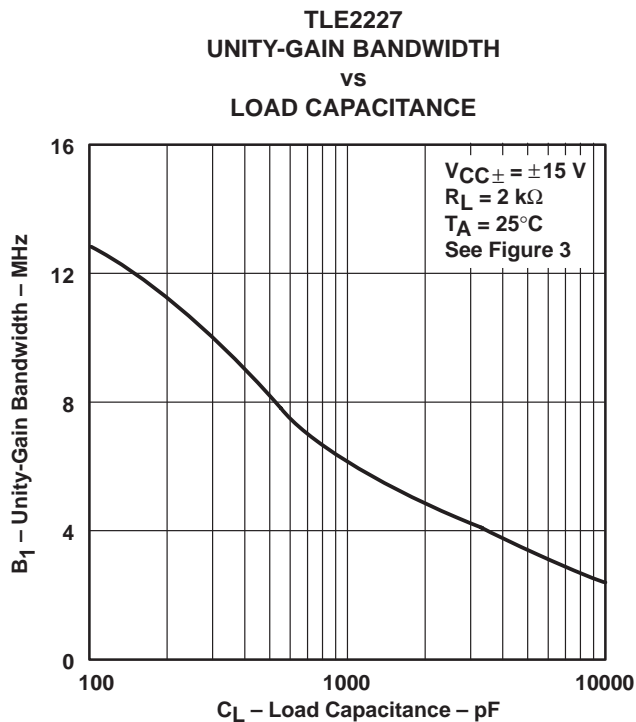


Figure 42

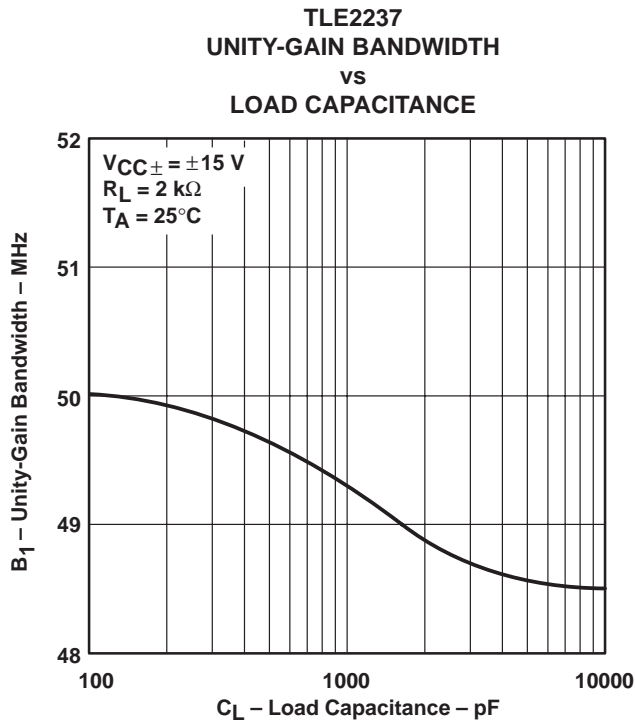


Figure 43



TYPICAL CHARACTERISTICS

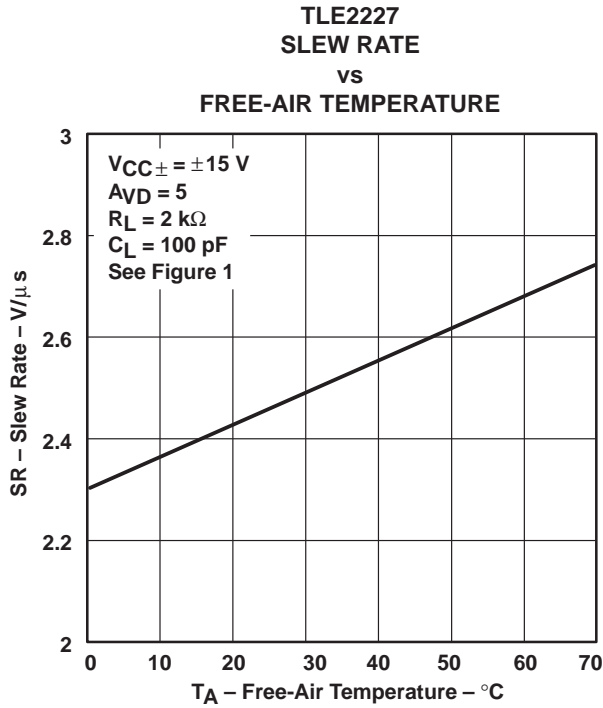


Figure 44

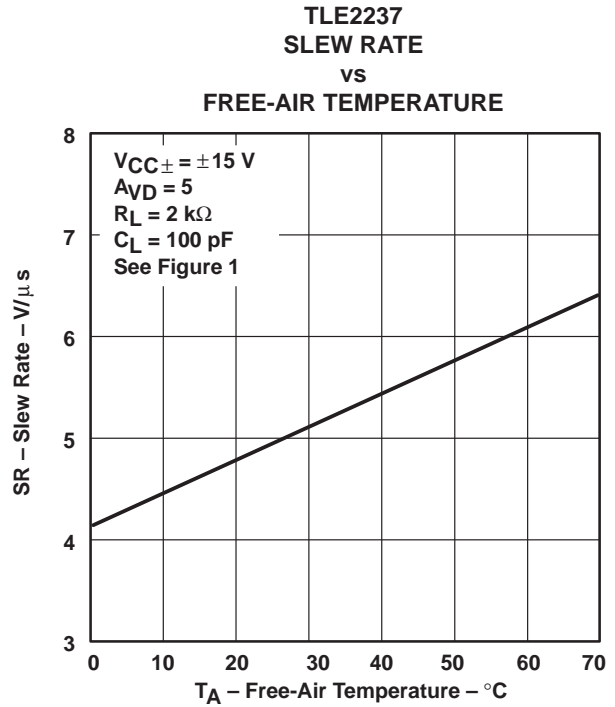


Figure 45

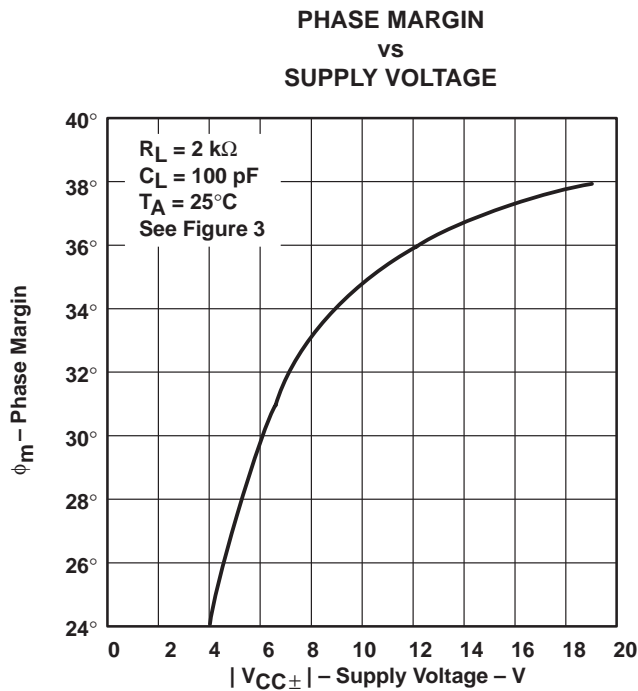


Figure 46

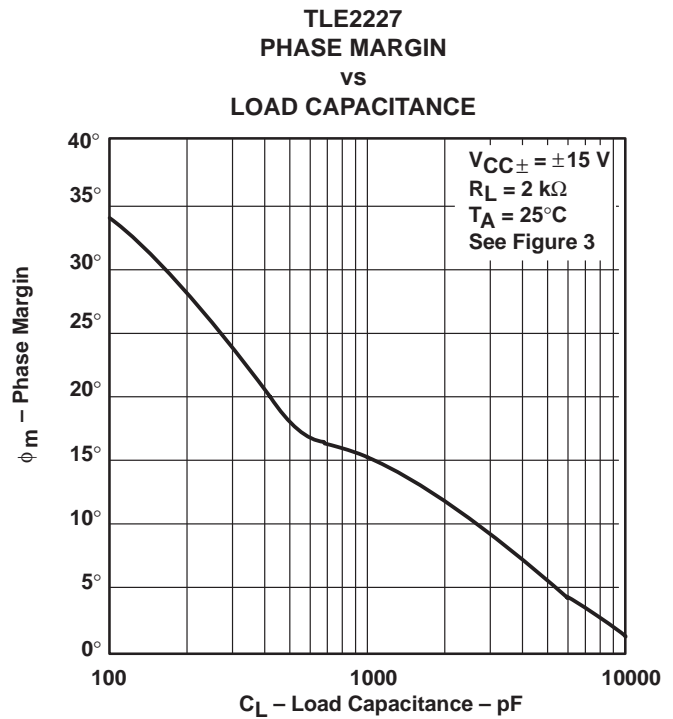


Figure 47

# TLE2227, TLE2227Y, TLE2237, TLE2237Y EXCALIBUR LOW-NOISE HIGH-SPEED PRECISION DUAL OPERATIONAL AMPLIFIERS

SLOS184 – FEBRUARY 1997

## TYPICAL CHARACTERISTICS

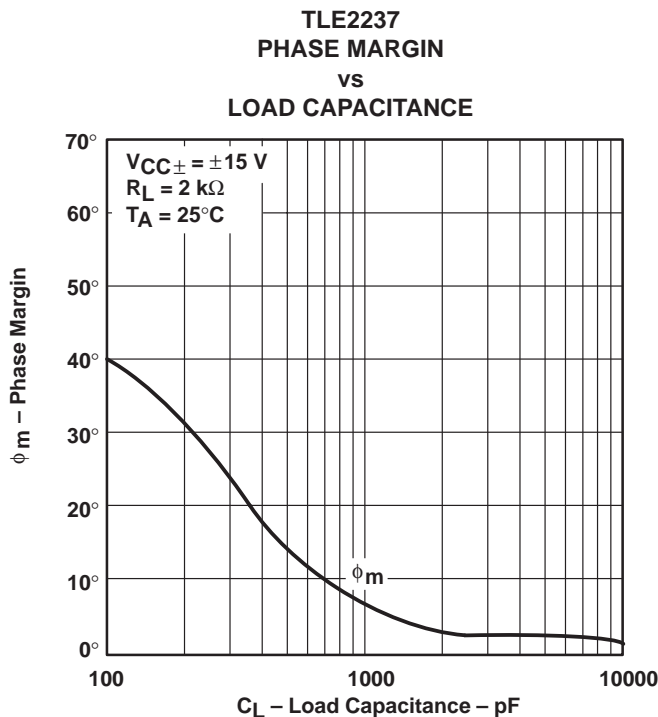


Figure 48

## APPLICATION INFORMATION

### TLE2227 macromodel information

Macromodel information provided was derived using Microsim *Parts*<sup>™</sup>, the model generation software used with Microsim *PSPice*<sup>™</sup>. The Boyle macromodel (see Note 6) and subcircuit in Figure 49 and Figure 50 are generated using the TLE2227C typical electrical and operating characteristics at 25°C. Using this information, output simulations of the following key parameters can be generated to a tolerance of 20% (in most cases):

- Maximum positive output voltage swing
- Maximum negative output voltage swing
- Slew rate
- Quiescent power dissipation
- Input bias current
- Open-loop voltage amplification
- Unity-gain bandwidth
- Common-mode rejection ratio
- Phase margin
- DC output resistance
- AC output resistance
- Short-circuit output current limit

NOTE 6: G. R. Boyle, B. M. Cohn, D. O. Pederson, and J. E. Solomon, "Macromodeling of Integrated Circuit Operational Amplifiers", *IEEE Journal of Solid-State Circuits*, SC-9, 353 (1974).

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APPLICATION INFORMATION

TLE2227 macromodel information (continued)

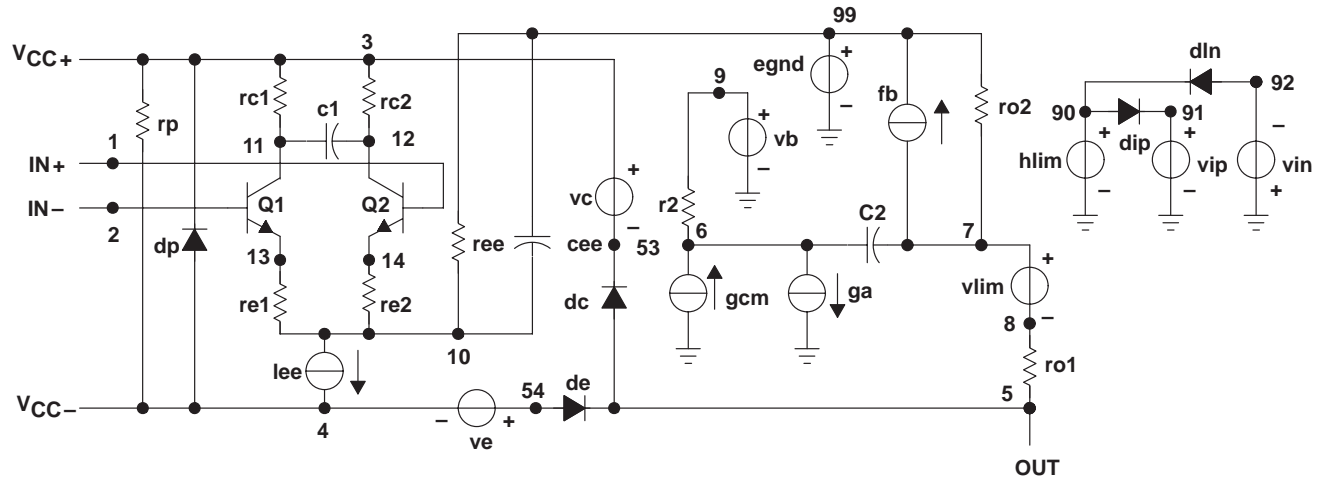


Figure 49. Boyle Macromodel

```
.subckt TLE2227 1 2 3 4 5
*
c1 11 12 4.003E-12
c2 6 7 20.00E-12
dc 5 53 dx
de 54 5 dx
dlp 90 91 dx
dln 92 90 dx
dp 4 3 dx
egnd 99 0 poly(2) (3,0) (4,0) 0 .5 .5
fb 7 99 poly(5) vb vc ve vlp vln 0 954.8E6 -1E9 1E9 1E9 -1E9
ga 6 0 11 12 2.062E-3
gcm 0 6 10 99 531.3E-12
iee 10 4 dc 56.01E-6
hlim 90 0 vlim 1K
q1 11 2 13 qx
q2 12 1 14 qx
r2 6 9 100.0E3
rc1 3 11 530.5
rc2 3 12 530.5
re1 13 10 -393.2
re2 14 10 -393.2
ree 10 99 3.571E6
ro1 8 5 25
ro2 7 99 25
rp 3 4 8.013E3
vb 9 0 dc 0
vc 3 53 dc 2.400
ve 54 4 dc 2.100
vlim 7 8 dc 0
vlp 91 0 dc 40
vln 0 92 dc 40
.model dx D(Is=800.0E-18)
.model qx NPN(Is=800.0E-18 Bf=7.000E3)
.ends
```

Figure 50. TLE2227 Macromodel Subcircuit

# TLE2227, TLE2227Y, TLE2237, TLE2237Y EXCALIBUR LOW-NOISE HIGH-SPEED PRECISION DUAL OPERATIONAL AMPLIFIERS

SLOS184 – FEBRUARY 1997

## TLE2037 macromodel information

Macromodel information provided is derived using *PSpice™ Parts™* model generation software. The Boyle macromodel (see Note 6) and subcircuit in Figure 51 and Figure 52 are generated using the TLE2237C typical electrical and operating characteristics at 25°C. Using this information, output simulations of the following key parameters can be generated to a tolerance of 20% (in most cases):

- Maximum positive output voltage swing
- Maximum negative output voltage swing
- Slew rate
- Quiescent power dissipation
- Input bias current
- Open-loop voltage amplification
- Unity-gain bandwidth
- Common-mode rejection ratio
- Phase margin
- DC output resistance
- AC output resistance
- Short-circuit output current limit

NOTE 6. G. R. Boyle, B. M. Cohn, D. O. Pederson, and J. E. Solomon, "Macromodeling of Integrated Circuit Operational Amplifiers," *IEEE Journal of Solid-State Circuits*, SC-9, 353 (1974).

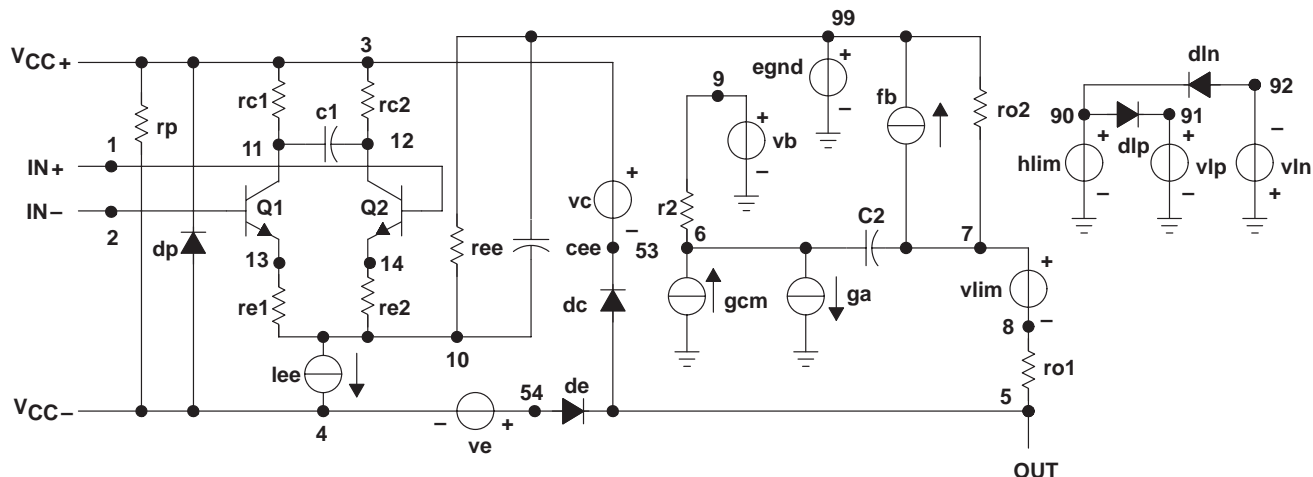


Figure 51. Boyle Macromodel

APPLICATION INFORMATION

TLE2037 macromodel information (continued)

```
.subckt TLE2227 1 2 3 4 5
*
c1 11 12 4.003E-12
c2 6 7 20.00E-12
dc 5 53 dx
de 54 5 dx
dlp 90 91 dx
dln 92 90 dx
dp 4 3 dx
egnd 99 0 poly(2) (3,0) (4,0) 0 .5 .5
fb 7 99 poly(5) vb vc ve vlp vln 0 954.8E6 -1E9 1E9 1E9 -1E9
ga 6 0 11 12 2.062E-3
gcm 0 6 10 99 531.3E-12
iee 10 4 dc 56.01E-6
hlim 90 0 vlim 1K
q1 11 2 13 qx
q2 12 1 14 qx
r2 6 9 100.0E3
rc1 3 11 530.5
rc2 3 12 530.5
re1 13 10 -393.2
re2 14 10 -393.2
ree 10 99 3.571E6
ro1 8 5 25
ro2 7 99 25
rp 3 4 8.013E3
vb 9 0 dc 0
vc 3 53 dc 2.400
ve 54 4 dc 2.100
vlim 7 8 dc 0
vlp 91 0 dc 40
vln 0 92 dc 40
.model dx D(Is=800.0E-18)
.model qx NPN(Is=800.0E-18 Bf=7.000E3)
.ends
```

Figure 52. TLE2237 Macromodel Subcircuit

## APPLICATION INFORMATION

### voltage-follower applications

The TLE22x7C circuitry includes input-protection diodes to limit the voltage across the input transistors; however, no provision is made in the circuit to limit the current if these diodes are forward biased. This condition can occur when the device is operated in the voltage-follower configuration and driven with a fast, large-signal pulse. A feedback resistor is recommended to limit the current to a maximum of 1 mA to prevent degradation of the device. Also, this feedback resistor forms a pole with the input capacitance of the device. For feedback resistor values greater than 10 k $\Omega$ , this pole degrades the amplifier's phase margin. This problem can be alleviated by adding a capacitor (20 pF to 50 pF) in parallel with the feedback resistor (see Figure 53).

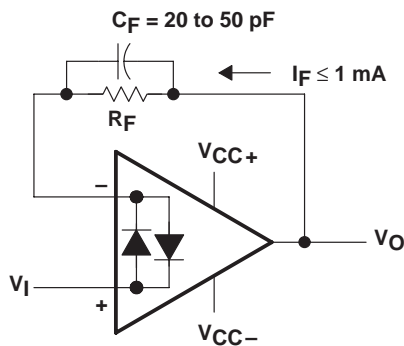


Figure 53. Voltage-Follower Circuit

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