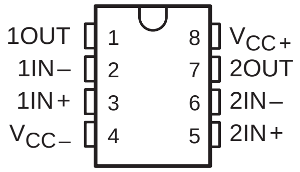
TLE2227, TLE2227Y, TLE2237, TLE2237Y
EXCALIBUR LOW-NOISE HIGH-SPEED PRECISION DUAL OPERATIONAL AMPLIFIERS

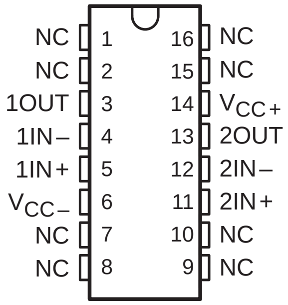
SLOS184 – FEBRUARY 1997

- **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 μV Typ**
  - **A_{VD} . . . 45 V/μV Typ With R_L = 2 kΩ**
    38 V/μV Typ With R_L = 1 kΩ
- **Available in 16-Pin Small-Outline Wide-Body Package**
- **Macromodels and Statistical Information Included**
- **Output Features Saturation Recovery Circuitry**

P PACKAGE
(TOP VIEW)



DW PACKAGE
(TOP VIEW)



NC – No internal connection

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 μV, 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/μV (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.

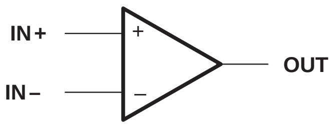
The TLE22x7C is available in a wide variety of packages, including the industry standard 16-pin small-outline wide-body version for high-density system applications. This device is characterized for operation from 0°C to 70°C.

AVAILABLE OPTIONS

T_A	V_{IO}typ AT 25°C	PACKAGED DEVICES		CHIP FORM[‡] (Y)
		SMALL OUTLINE[†] (DW)	PLASTIC DIP (P)	
0°C to 70°C	100 μV	TLE2227CDW	TLE2227CP	TLE2227Y
	100 μV	TLE2237CDW	TLE2237CP	TLE2237Y

[†] The DW package is available taped and reeled. Add R suffix to device type (e.g., TLE2227CDWR).
[‡] Chip forms are tested at 25°C only.

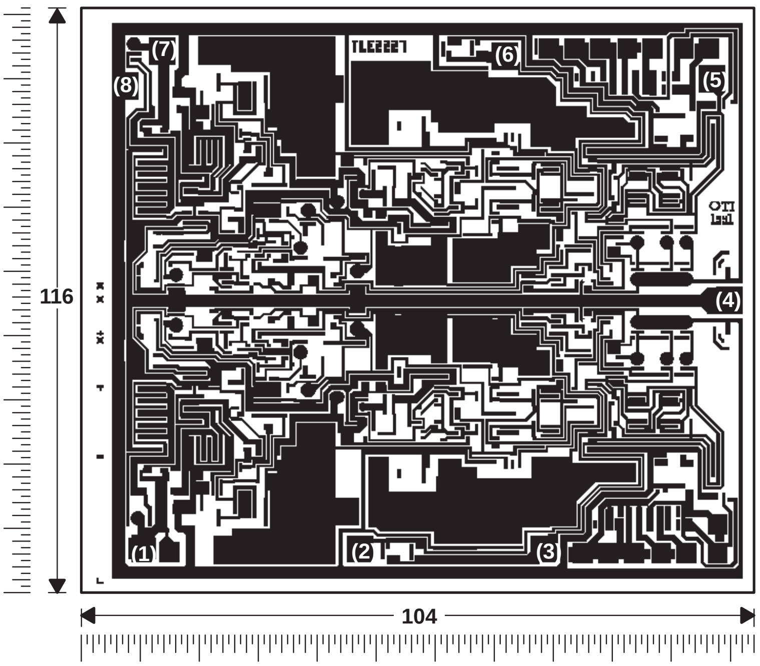
symbol (each amplifier)

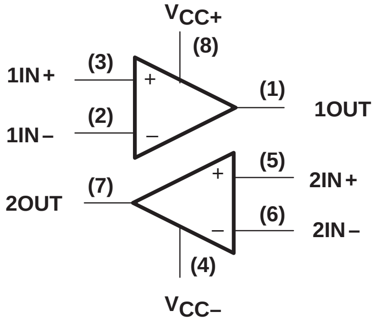


TLE2227Y chip information

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 my be mounted with conductive epoxy or a gold-silicon preform.

BONDING PAD ASSIGNMENTS





CHIP THICKNESS: 15 TYPICAL

BONDING PADS: 4 × 4 MINIMUM

$T_J$max = 150°C

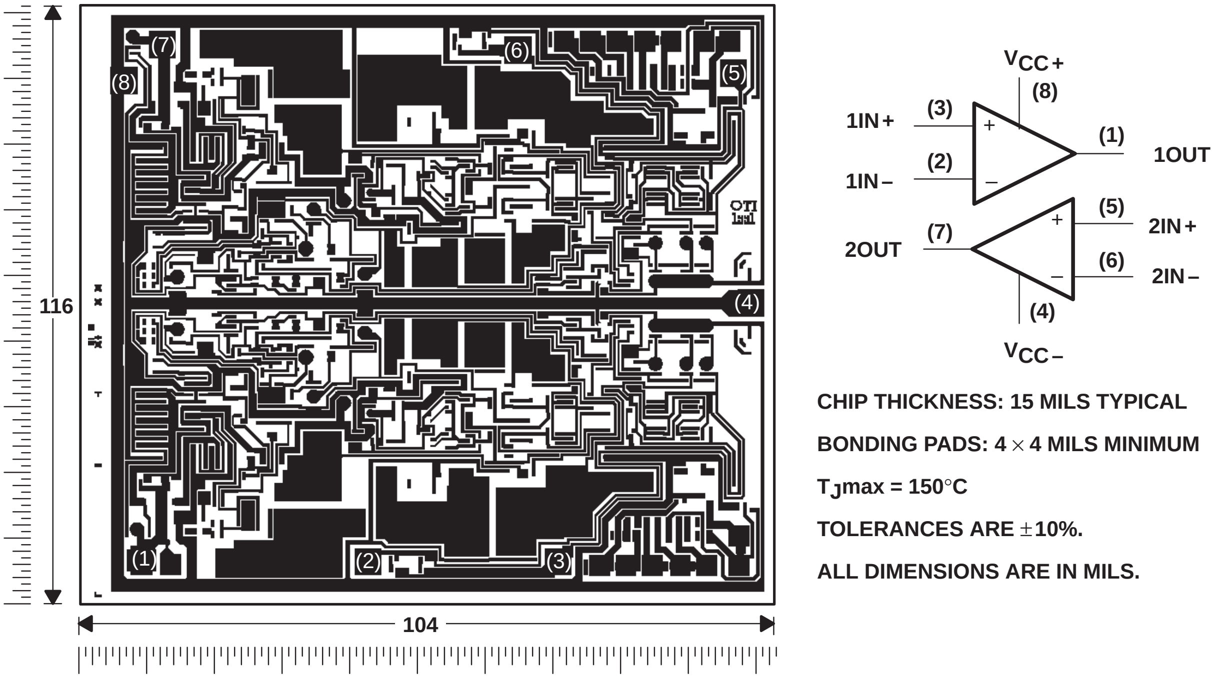
TOLERANCES ARE ±10%.

ALL DIMENSIONS ARE IN MILS.

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.

BONDING PAD ASSIGNMENTS



CHIP THICKNESS: 15 MILS TYPICAL

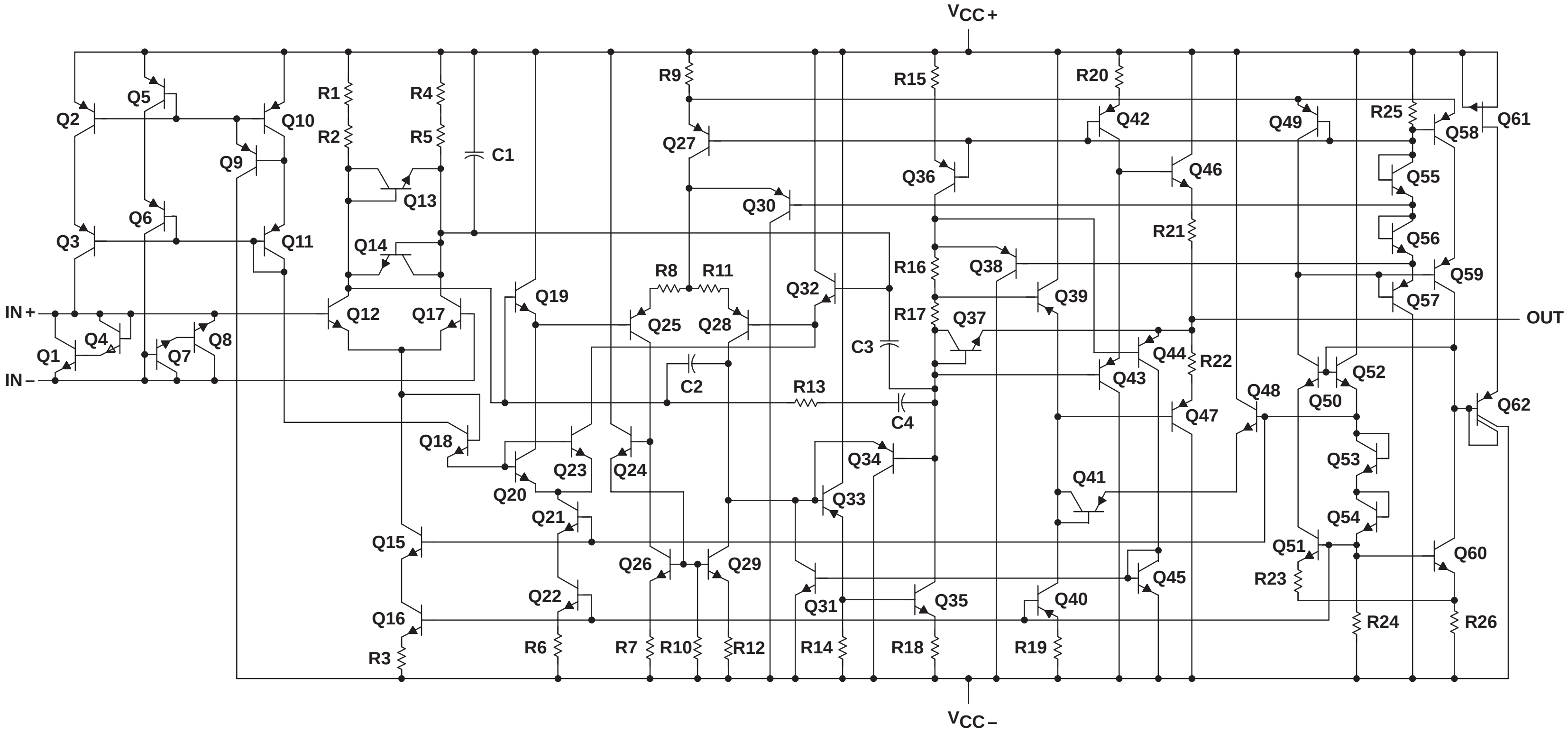
BONDING PADS: 4 × 4 MILS MINIMUM

$T_J$max = 150°C

TOLERANCES ARE ±10%.

ALL DIMENSIONS ARE IN MILS.

equivalent schematic (each amplifier)



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

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)	±1.2 V
Input voltage range, V_I (any input)	$V_{CC\pm}$
Input current, I_I (each input)	±1 mA
Output current, I_O	±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 ±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	$T_A \le 25°C$ POWER RATING	DERATING FACTOR ABOVE $T_A = 25°C$	$T_A = 70°C$ 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, $V_{CC\pm}$		±4	±19	V
Common-mode input voltage, V_{IC}	$T_A = 25°C$		±11	V
	T_A = Full range†		±10.5	
Operating free-air temperature, T_A		0	70	°C

† Full range is 0°C to 70°C.

electrical characteristics at specified free-air temperature, $V_{CC\pm} = \pm15$ 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	µV
			Full range			500	
α_{VIO}	Temperature coefficient of input offset voltage		Full range		0.4	1	µV/°C
	Input offset voltage long-term drift (see Note 4)		25°C		0.006	1	µV/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	$R_L = 1\ k\Omega$	25°C	10.5			V
			Full range	10			
		$R_L = 2\ k\Omega$	25°C	12			
			Full range	11			
V_{OM-}	Maximum negative peak output voltage swing	$R_L = 1\ k\Omega$	25°C	−10.5	−13		V
			Full range	−10			
		$R_L = 2\ k\Omega$	25°C	−12	−13.5		
			Full range	−11			
A_{VD}	Large-signal differential voltage amplification	$V_O = \pm11$ V, $R_L = 2\ k\Omega$	25°C	2.5	45		V/µV
		$V_O = \pm10$ V, $R_L = 2\ k\Omega$	Full range	2			
		$V_O = \pm10$ V, $R_L = 1\ k\Omega$	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		Ω
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 ($\Delta V_{CC\pm}/\Delta V_{IO}$)	$V_{CC\pm} = \pm4$ V to ±18 V, $R_S = 50\ \Omega$	25°C	94	120		dB
		$V_{CC\pm} = \pm4$ V to ±18 V, $R_S = 50\ \Omega$	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 $T_A = 150°C$ extrapolated to $T_A = 25°C$ using the Arrhenius equation and assuming an activation energy of 0.96 eV.

operating characteristics at specified free-air temperature, $V_{CC\pm} = \pm15$ V

PARAMETER		TEST CONDITIONS		T_A†	TLE2227C			UNIT
					MIN	TYP	MAX	
SR	Slew rate	$R_L = 2$ kΩ,	$C_L = 100$ pF	25°C	1.7	2.5		V/μs
				Full range	1.2			
V_n	Equivalent input noise voltage	$R_S = 20$ Ω,	f = 10 Hz	25°C		3.3	8	nV/$\sqrt{HZ}$
		$R_S = 20$ Ω,	f = 1 kHz			2.5	4.5	
$V_{N(PP)}$	Peak-to-peak equivalent input noise voltage	f = 0.1 Hz to 10 Hz		25°C		50	250	nV
I_n	Equivalent input noise current	f = 10 Hz		25°C		1.5	4	pA/$\sqrt{HZ}$
		f = 1 kHz				0.4	0.6	
THD	Total harmonic distortion	$V_O = \pm10$ V, See Note 5	$A_{VD} = 1$,	25°C		< 0.002%		
B_1	Unity-gain bandwidth	$R_L = 2$ kΩ,	$C_L = 100$ pF	25°C	7	13		MHz
B_{OM}	Maximum output-swing bandwidth	$R_L = 2$ kΩ		25°C		30		kHz
ϕ_m	Phase margin	$R_L = 2$ kΩ	$C_L = 100$ 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%.

electrical characteristics at specified free-air temperature, $V_{CC\pm} = \pm15$ V (unless otherwise noted)

PARAMETER		TEST CONDITIONS	T_A†	TLE2237C			UNIT
				MIN	TYP	MAX	
V_{IO}	Input offset voltage	$V_{IC} = 0$, $R_S = 50\ \Omega$	25°C		100	350	µV
			Full range			500	µV/°C
α_{VIO}	Temperature coefficient of input offset voltage		Full range		0.4	1	
	Input offset voltage long-term drift (see Note 4)		25°C		0.006	1	µV/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	$R_L = 1\ k\Omega$	25°C	10.5			V
			Full range	10			
		$R_L = 2\ k\Omega$	25°C	12			
			Full range	11			
V_{OM-}	Maximum negative peak output voltage swing	$R_L = 1\ k\Omega$	25°C	–10.5	–13		V
			Full range	–10			
		$R_L = 2\ k\Omega$	25°C	–12	–13.5		
			Full range	–11			
A_{VD}	Large-signal differential voltage amplification	$V_O = \pm11$V, $R_L = 2\ k\Omega$	25°C	2.5	45		V/µV
		$V_O = \pm10$ V, $R_L = 2\ k\Omega$	Full range	2			
		$V_O = \pm10$ V, $R_L = 1\ k\Omega$	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		Ω
CMRR	Common-mode rejection ratio	$V_{IC} = V_{ICR}$min, $R_S = 50\ \Omega$	25°C	98	115		dB
			Full range	95			
k_{SVR}	Supply-voltage rejection ratio ($\Delta V_{CC\pm}/\Delta V_{IO}$)	$V_{CC\pm} = \pm4$ V to ±18 V, $R_S = 50\ \Omega$	25°C	94	120		dB
		$V_{CC\pm} = \pm4$ V to ±18 V, $R_S = 50\ \Omega$	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 $T_A = 150°C$ extrapolated to $T_A = 25°C$ using the Arrhenius equation and assuming an activation energy of 0.96 eV.

operating characteristics at specified free-air temperature, $V_{CC\pm} = \pm15$ V

PARAMETER		TEST CONDITIONS	T_A†	TLE2237C			UNIT
				MIN	TYP	MAX	
SR	Slew rate	A_{VD} = 5, RL = 2 kΩ, C_L = 100 pF	25°C	4	5		V/µs
			Full range	3			
V_n	Equivalent input noise voltage	R_S = 20 Ω, f = 10 Hz	25°C		3.3	8	nV/$\sqrt{Hz}$
		R_S = 20 Ω, f = 1 kHz			2.5	4.5	
$V_{n(PP)}$	Peak-to-peak equivalent input noise voltage	f = 0.1 Hz to 10 Hz	25°C		50	250	nV
I_n	Equivalent input noise current	f = 10 Hz	25°C		1.5	4	pA/$\sqrt{Hz}$
		f = 1 kHz			0.4	0.6	
THD	Total harmonic distortion	V_O = ±10 V, A_{VD} = 5 V, See Note 5	25°C		<0.002%		
GBP	Gain-bandwidth product	f = 100 kHz, R_L = 2 kΩ, C_L = 100 pF	25°C	35	50		MHz
B_{OM}	Maximum output-swing bandwidth	R_L = 2 kΩ	25°C		80		kHz
ϕ_m	Phase margin	R_L = 2 kΩ, C_L = 100 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%.

electrical characteristics, $V_{CC\pm}$ = ±15 V, T_A = 25°C (unless otherwise noted)

PARAMETER		TEST CONDITIONS	TLE2227Y			UNIT
			MIN	TYP	MAX	
V_{IO}	Input offset voltage	V_{IC} = 0, R_S = 50 Ω		100	350	μV
	Input offset voltage long-term drift (see Note 4)			0.006	1	μV/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 Ω	–11 to 11	–13 to 13		V
V_{OM+}	Maximum positive peak output voltage swing	R_L = 1 kΩ	10.5			V
		R_L = 2 kΩ	12			
V_{OM-}	Maximum negative peak output voltage swing	R_L = 1 kΩ	–10.5	–13		V
		R_L = 2 kΩ	–12	–13.5		
A_{VD}	Large-signal differential voltage amplification	V_O = ±11 V, R_L = 2 kΩ	2.5	45		V/μV
		V_O = ±10 V, R_L = 1 kΩ	3.5	38		
ci	Input capacitance			8		pF
z_o	Open-loop output impedance	I_O = 0		50		Ω
CMRR	Common-mode rejection ratio	V_{IC} = V_{ICR}min, R_S = 50 Ω	98	115		dB
k_{SVR}	Supply-voltage rejection ratio ($\Delta V_{CC\pm}/\Delta V_{IO}$)	$V_{CC\pm}$ = ±4 V to ±18 V, R_S = 50 Ω	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°C extrapolated to T_A = 25°C using the Arrhenius equation and assuming an activation energy of 0.96 eV.

operating characteristics, $V_{CC\pm}$ = ±15 V, T_A = 25°C

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

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

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	$V_{IC} = 0$, $R_S = 50\ \Omega$		100	350	µV
	Input offset voltage long-term drift (see Note 4)			0.006	1	µV/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	$R_L = 1\ k\Omega$	10.5			V
		$R_L = 2\ k\Omega$	12			
V_{OM-}	Maximum negative peak output voltage swing	$R_L = 1\ k\Omega$	–10.5	–13		V
		$R_L = 2\ k\Omega$	–12	–13.5		
A_{VD}	Large-signal differential voltage amplification	$V_O = \pm 11$ V, $R_L = 2\ k\Omega$	2.5	45		V/µV
		$V_O = \pm 10$ V, $R_L = 1\ k\Omega$	3.5	38		
C_i	Input capacitance			8		pF
z_O	Open-loop output impedance	$I_O = 0$		50		Ω
CMRR	Common-mode rejection ratio	$V_{IC} = V_{ICR}$min, $R_S = 50\ \Omega$	98	115		dB
k_{SVR}	Supply-voltage rejection ratio ($\Delta V_{CC\pm}/\Delta V_{IO}$)	$V_{CC\pm} = \pm 4$ V to ± 18 V, $R_S = 50\ \Omega$	94	120		dB
I_{CC}	Supply current	$V_O = 0$, No load		7.3	10.6	mA

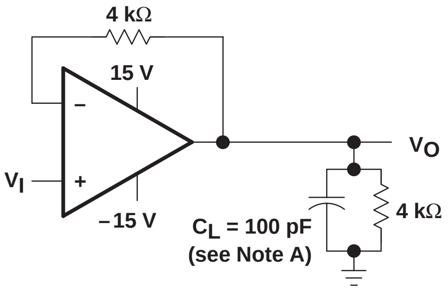
NOTE 4. Typical values are based on the input offset voltage shift observed through 168 hours of operating life test at $T_A = 150°C$ extrapolated to $T_A = 25°C$ using the Arrhenius equation and assuming an activation energy of 0.96 eV.

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

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

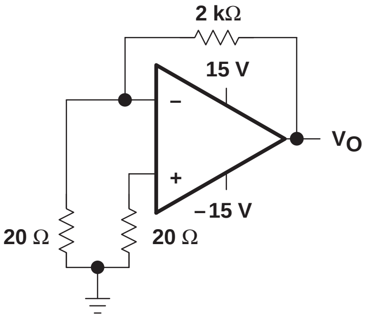
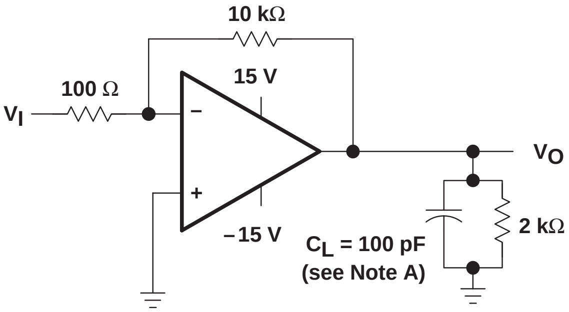
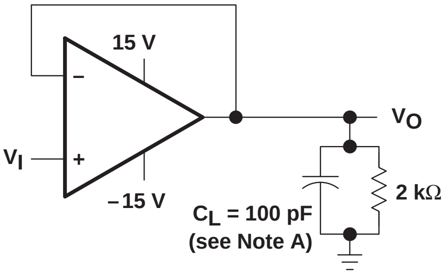


Figure 2. Noise-Voltage Test Circuit



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_{IB}	Input bias current	vs Common-mode input voltage vs Free-air temperature	9 10
I_I	Input current	vs Differential input voltage	11
$V_{O(PP)}$	Maximum peak-to-peak output voltage	vs Frequency	12
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
k_{SVR}	Supply-voltage rejection ratio	vs Frequency	25
I_{OS}	Short-circuit output current	vs Supply voltage vs Elasped time vs Free-air temperature	26, 27 28, 29 30, 31
I_{CC}	Supply current	vs Supply voltage vs Free-air temperature	32 33
	Voltage-follower small-signal pulse response	vs Time	34, 35
	Voltage-follower large-signal pulse response	vs Time	36, 37
V_n	Equivalent input noise voltage	vs Frequency	38
	Noise voltage (referred to input)	Over 10-second interval	39
B_1	Unity-gain bandwidth	vs Supply voltage vs Load capacitance	40, 41 42, 43
SR	Slew rate	vs Free-air temperature	44, 45
ϕ_m	Phase margin	vs Supply voltage vs Load capacitance	46 47, 48
	Phase shift	vs Frequency	18, 20, 21

TYPICAL CHARACTERISTICS

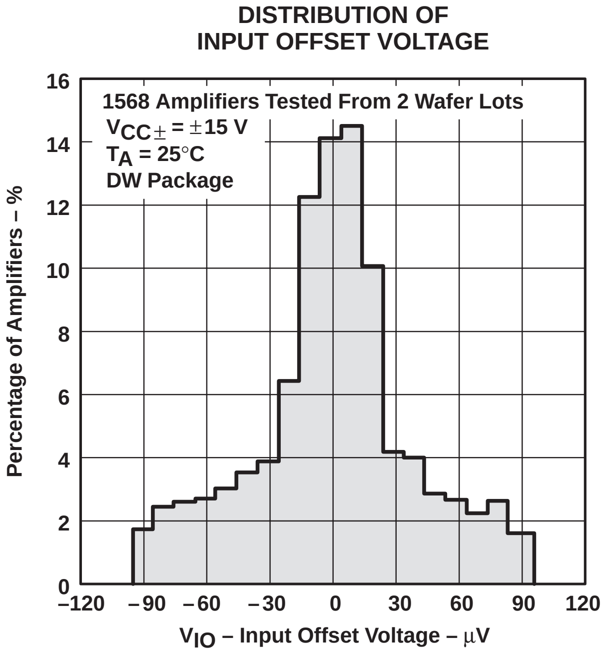

Figure 5

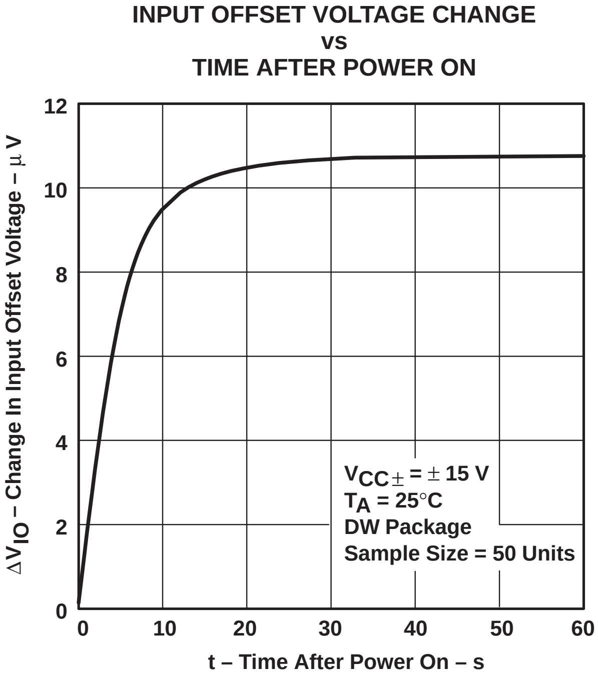

Figure 6

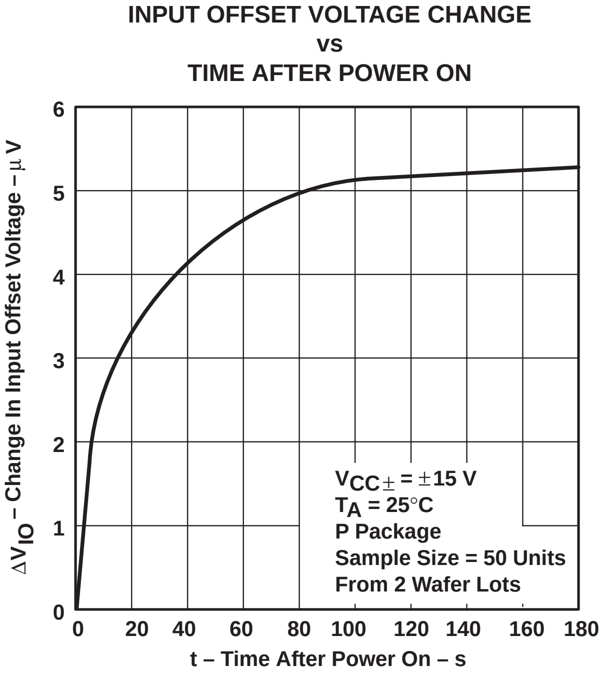

Figure 7

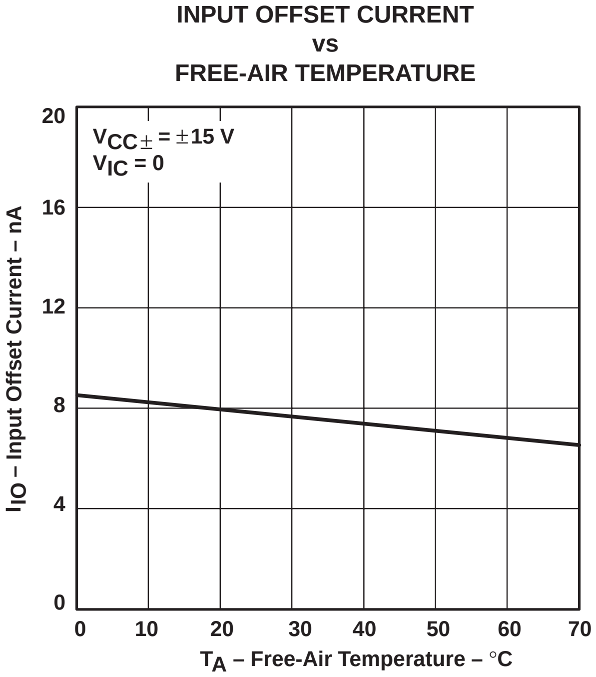

Figure 8

TYPICAL CHARACTERISTICS

INPUT BIAS CURRENT
vs
COMMON-MODE INPUT VOLTAGE

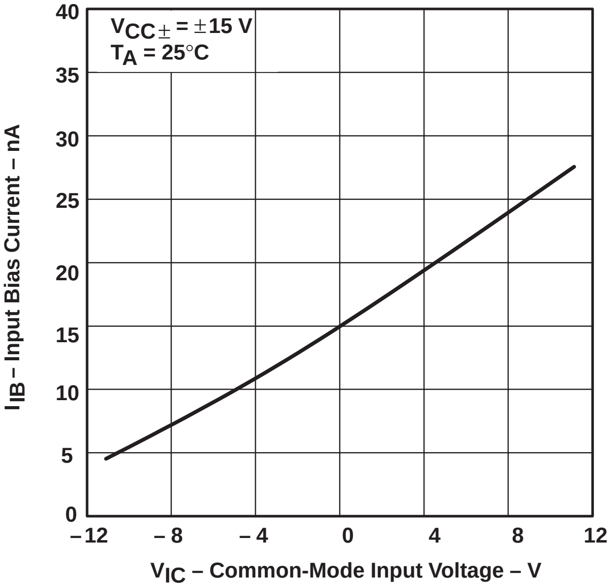

Figure 9

INPUT BIAS CURRENT
vs
FREE-AIR TEMPERATURE

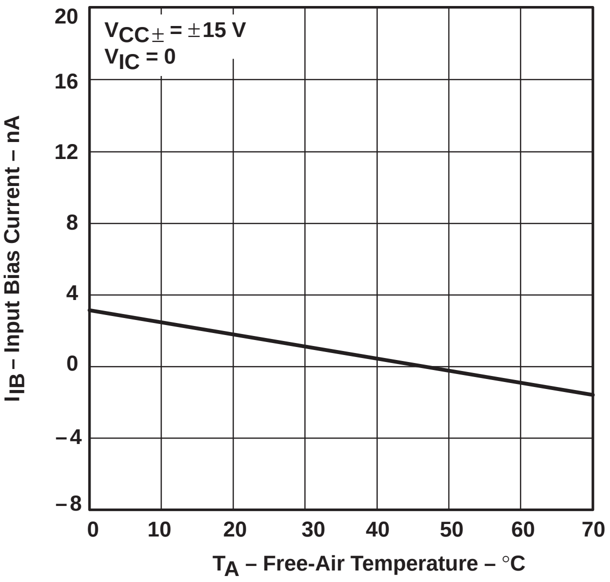

Figure 10

INPUT CURRENT
vs
DIFFERENTIAL INPUT VOLTAGE

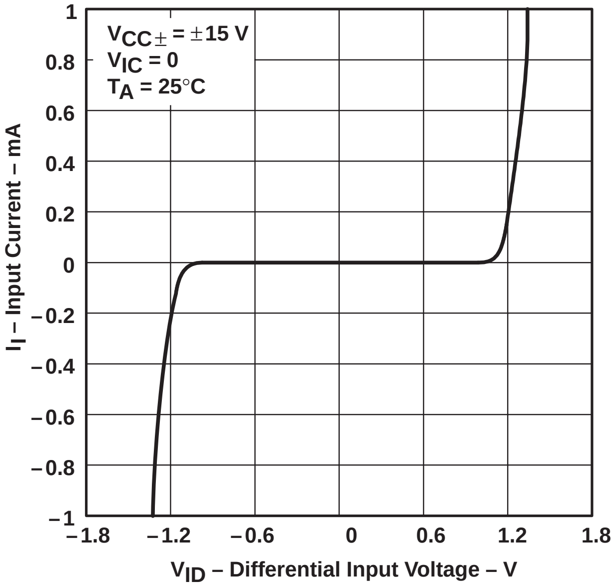

Figure 11

MAXIMUM PEAK-TO-PEAK
OUTPUT VOLTAGE
vs
FREQUENCY

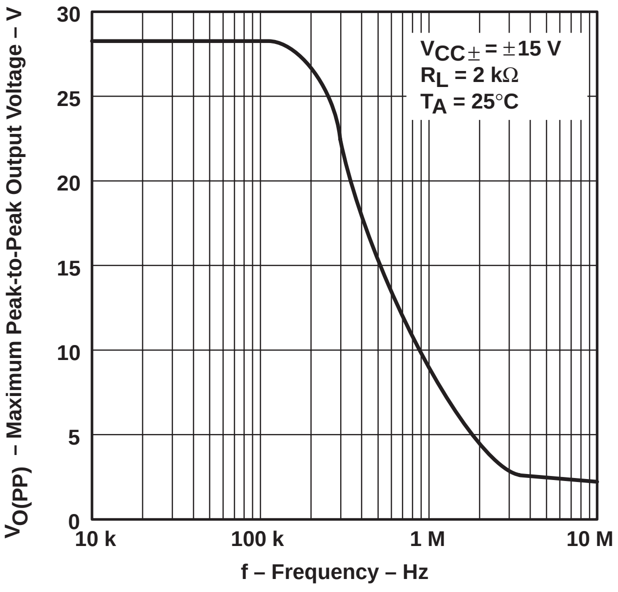

Figure 12

TYPICAL CHARACTERISTICS

MAXIMUM POSITIVE PEAK OUTPUT VOLTAGE vs LOAD RESISTANCE

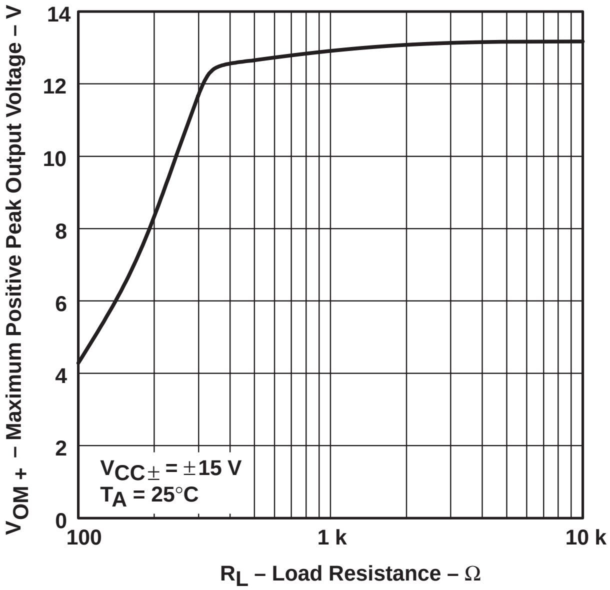

Figure 13

MAXIMUM NEGATIVE PEAK OUTPUT VOLTAGE vs LOAD RESISTANCE

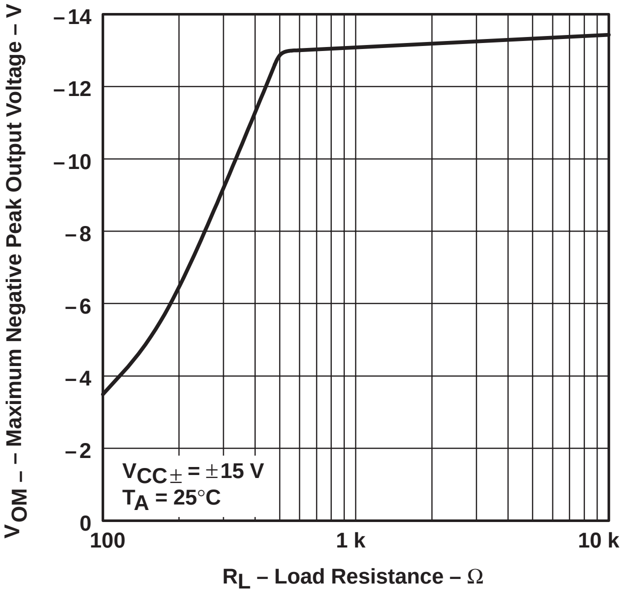

Figure 14

MAXIMUM POSITIVE PEAK OUTPUT VOLTAGE vs FREE-AIR TEMPERATURE

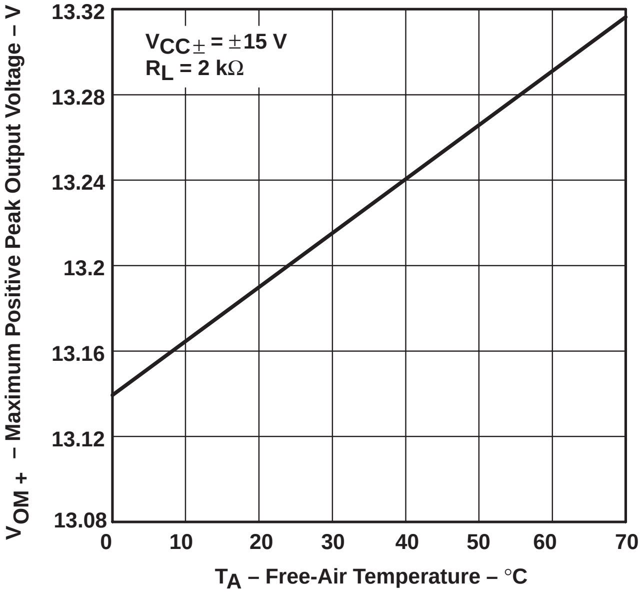

Figure 15

MAXIMUM NEGATIVE PEAK OUTPUT VOLTAGE vs FREE-AIR TEMPERATURE

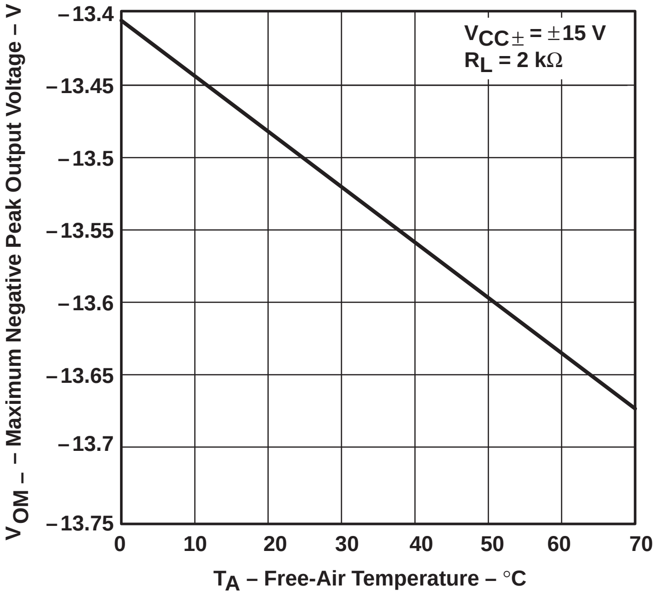

Figure 16

TYPICAL CHARACTERISTICS

LARGE-SIGNAL DIFFERENTIAL VOLTAGE AMPLIFICATION vs SUPPLY VOLTAGE

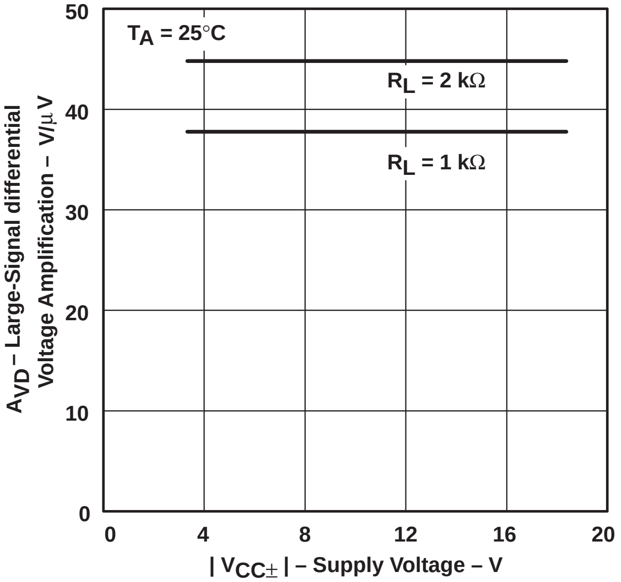

Figure 17

LARGE-SIGNAL DIFFERENTIAL VOLTAGE AMPLIFICATION AND PHASE SHIFT vs FREQUENCY

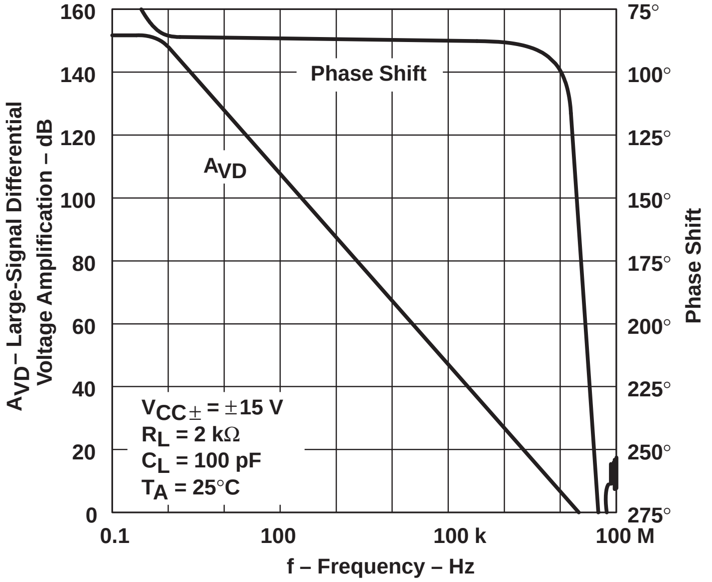

Figure 18

TYPICAL CHARACTERISTICS

LARGE-SIGNAL DIFFERENTIAL VOLTAGE AMPLIFICATION vs LOAD RESISTANCE

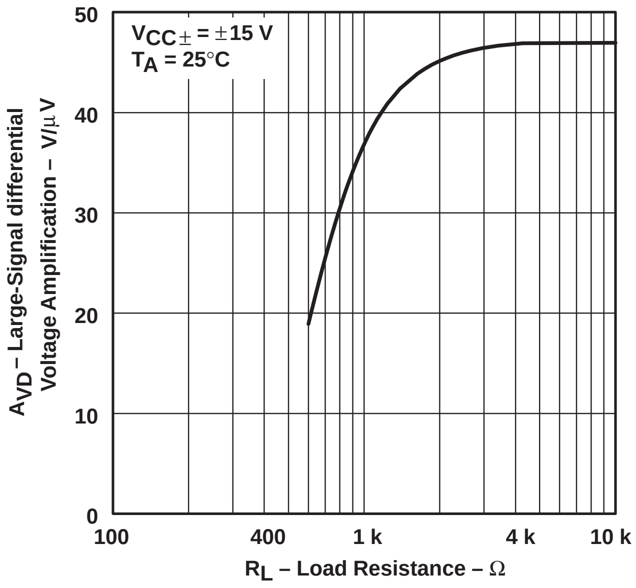

Figure 19

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

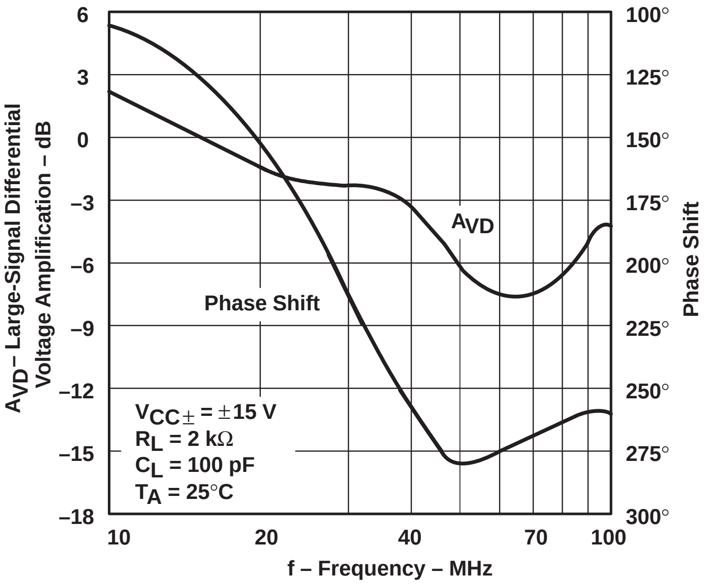

Figure 20

TYPICAL CHARACTERISTICS

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

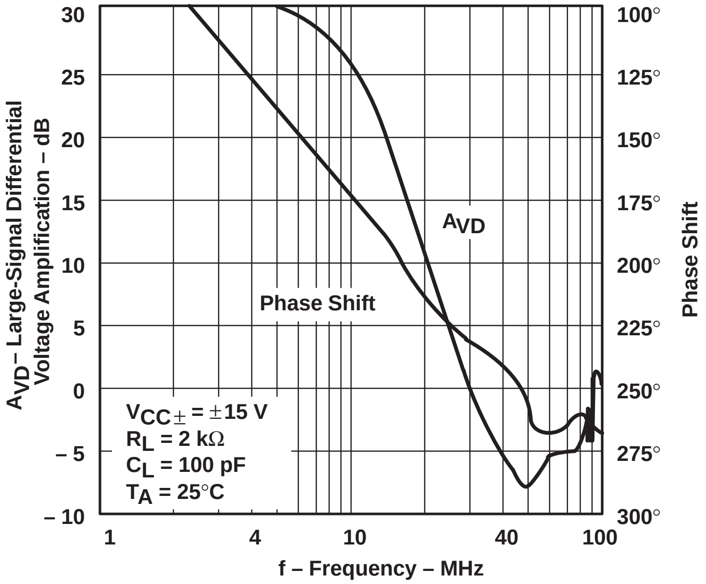

Figure 21

LARGE-SCALE DIFFERENTIAL VOLTAGE AMPLIFICATION vs FREE-AIR TEMPERATURE

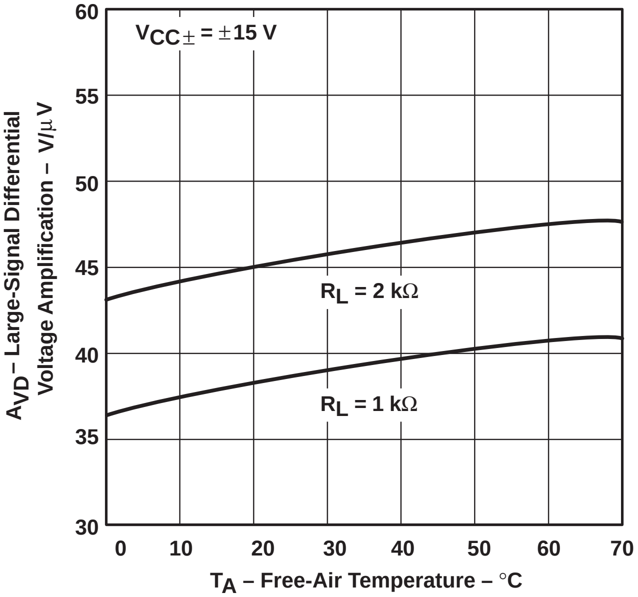

Figure 22

OUTPUT IMPEDANCE vs FREQUENCY

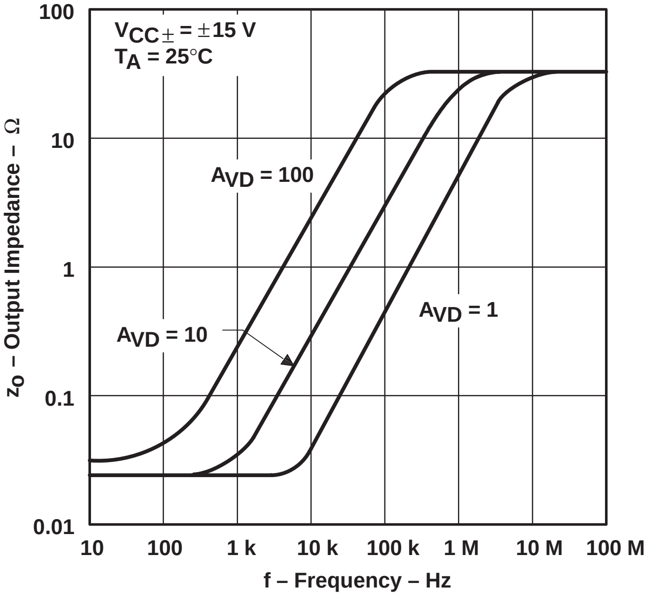

Figure 23

TYPICAL CHARACTERISTICS

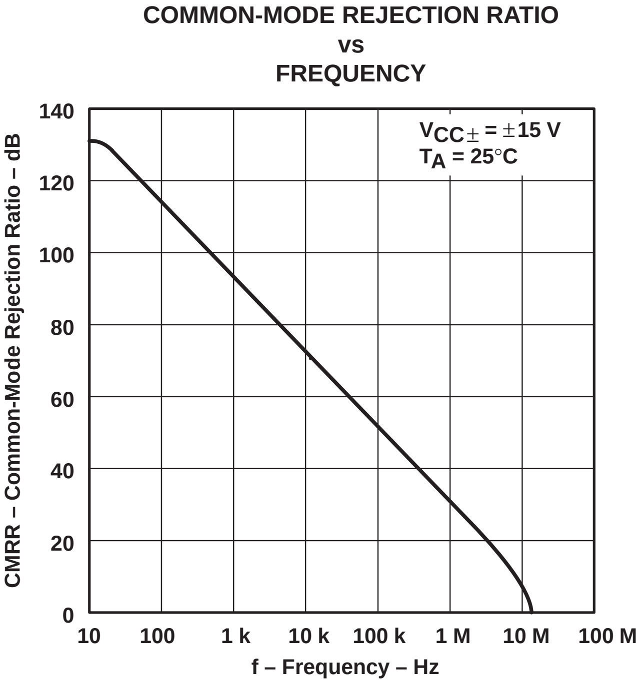

Figure 24

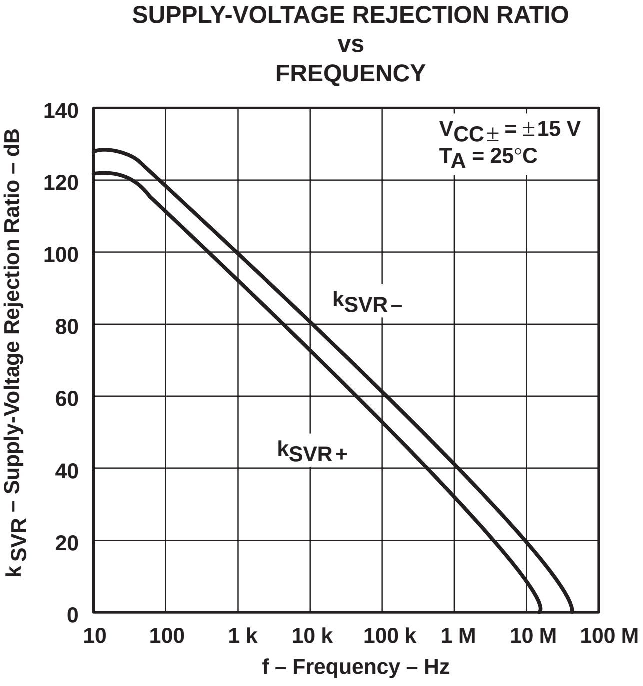

Figure 25

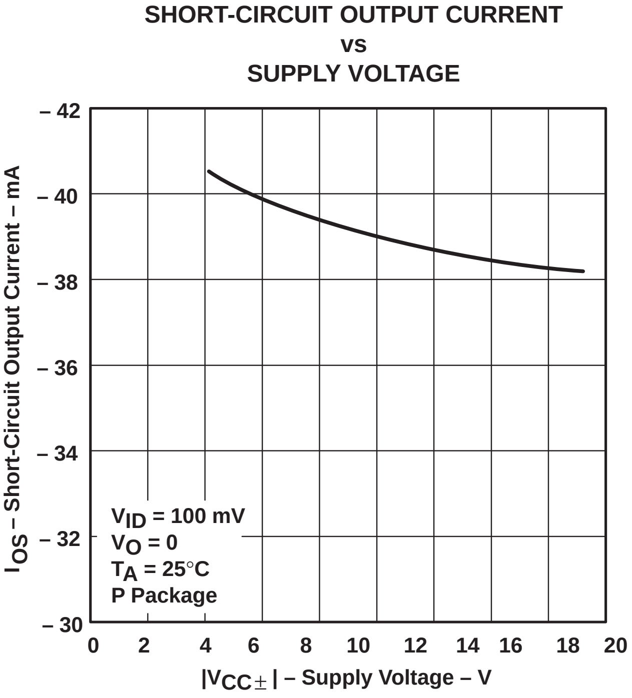

Figure 26

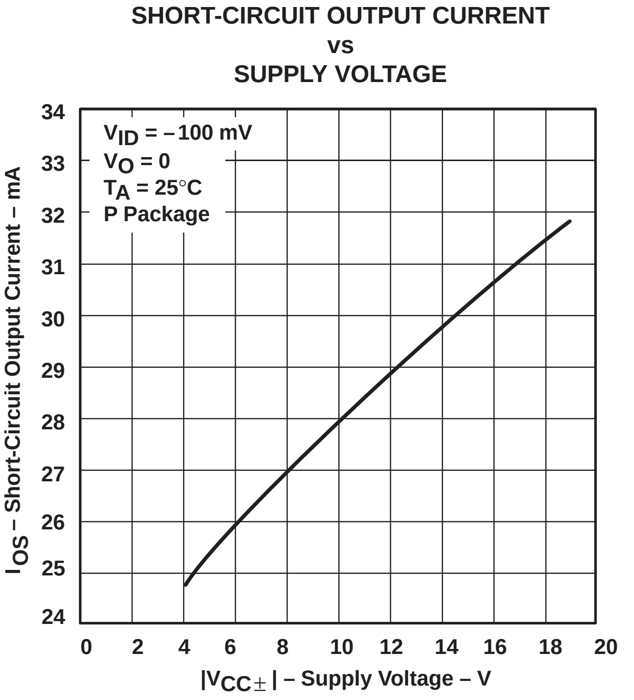

Figure 27

TYPICAL CHARACTERISTICS

SHORT-CIRCUIT OUTPUT CURRENT vs ELAPSED TIME

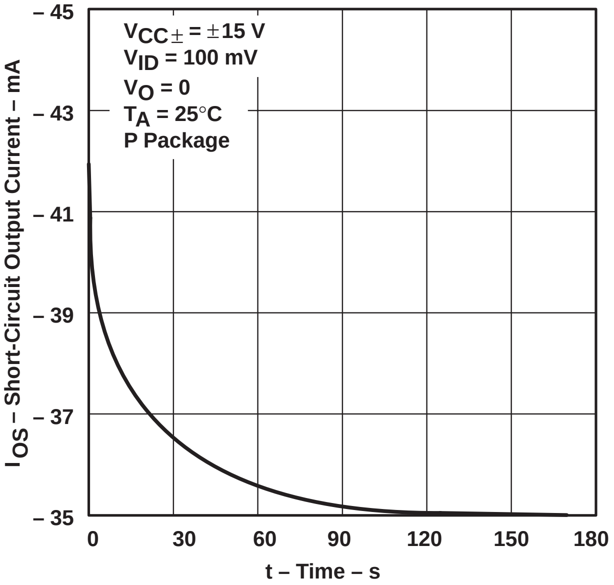

Figure 28

SHORT-CIRCUIT OUTPUT CURRENT vs ELAPSED TIME

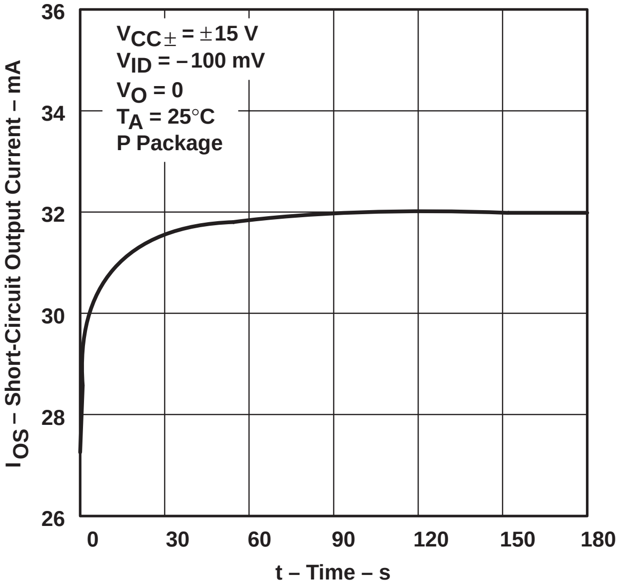

Figure 29

SHORT-CIRCUIT OUTPUT CURRENT vs FREE-AIR TEMPERATURE

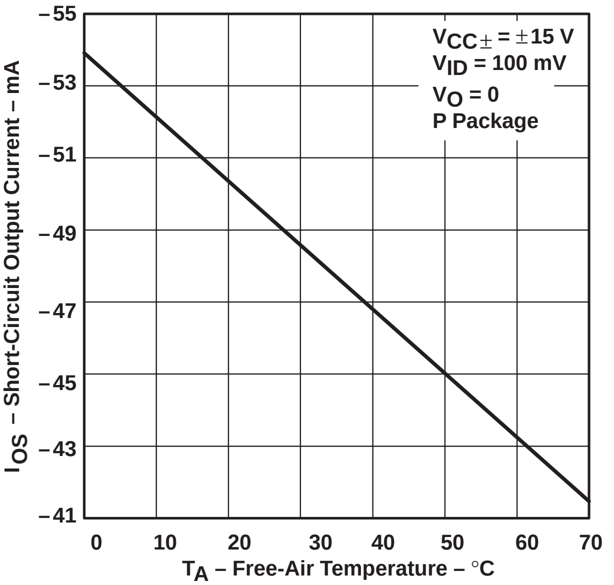

Figure 30

SHORT-CIRCUIT OUTPUT CURRENT vs FREE-AIR TEMPERATURE

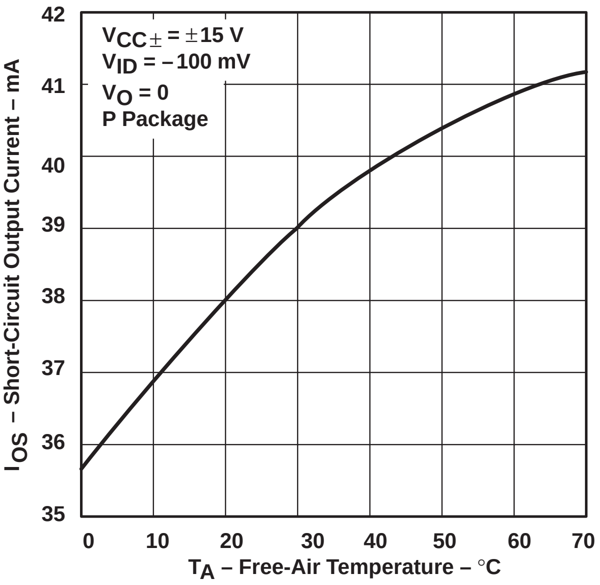

Figure 31

TYPICAL CHARACTERISTICS

SUPPLY CURRENT
vs
SUPPLY VOLTAGE

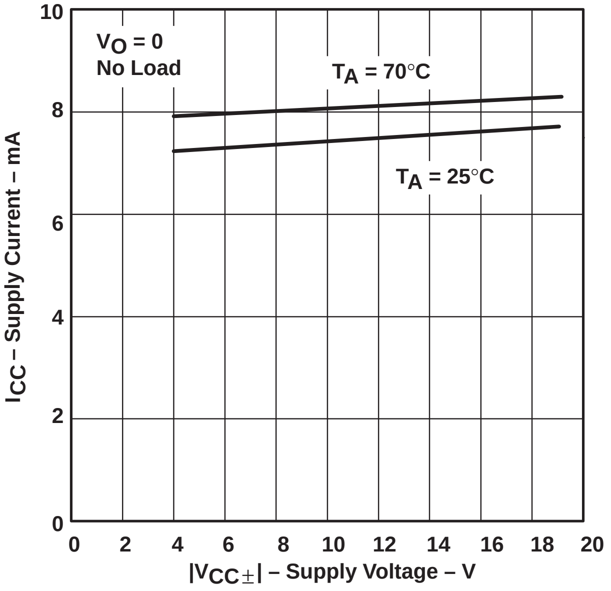

Figure 32

SUPPLY CURRENT
vs
FREE-AIR TEMPERATURE

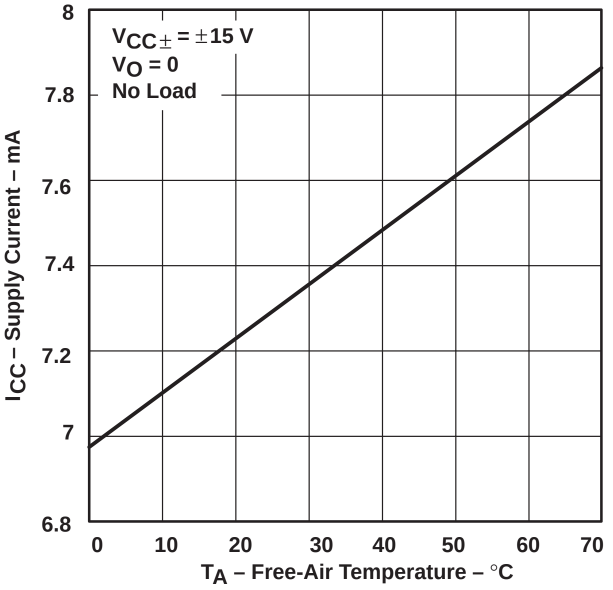

Figure 33

TLE2227
VOLTAGE-FOLLOWER
SMALL-SIGNAL
PULSE RESPONSE

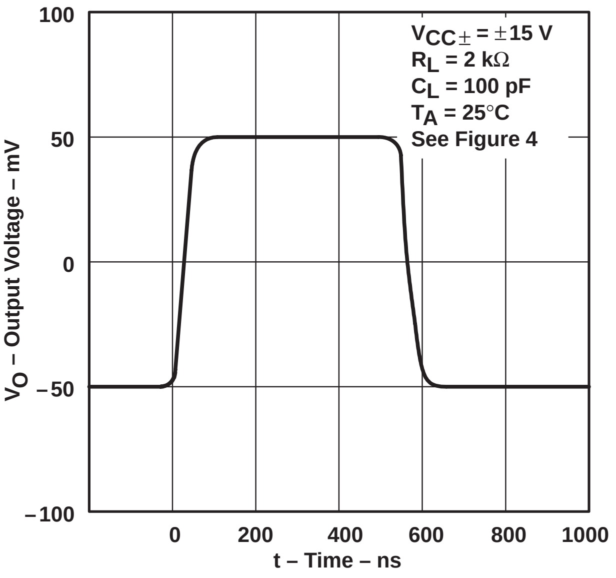

Figure 34

TLE2237
VOLTAGE-FOLLOWER
SMALL-SIGNAL
PULSE RESPONSE

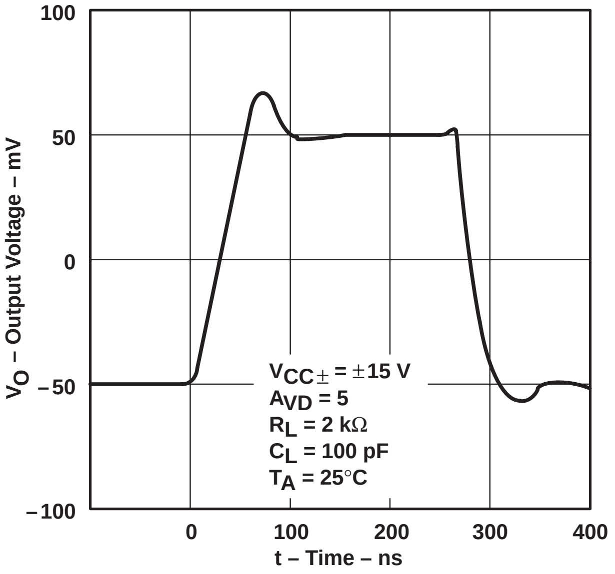

Figure 35

TYPICAL CHARACTERISTICS

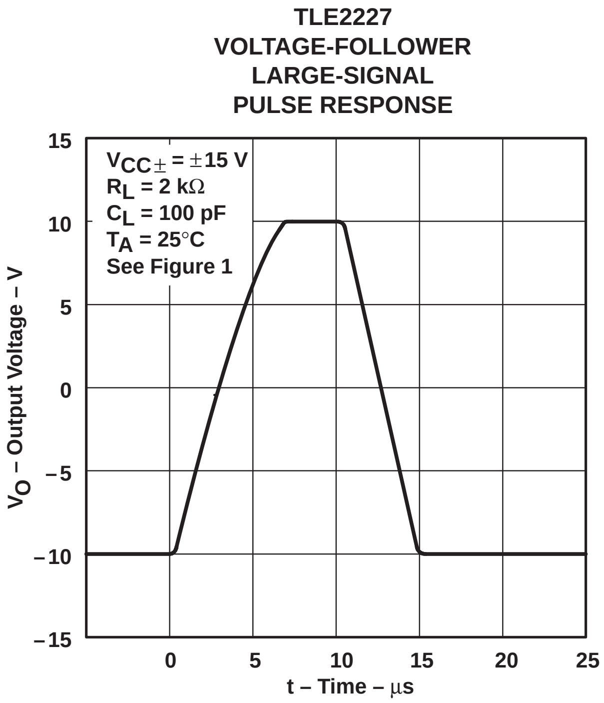

Figure 36

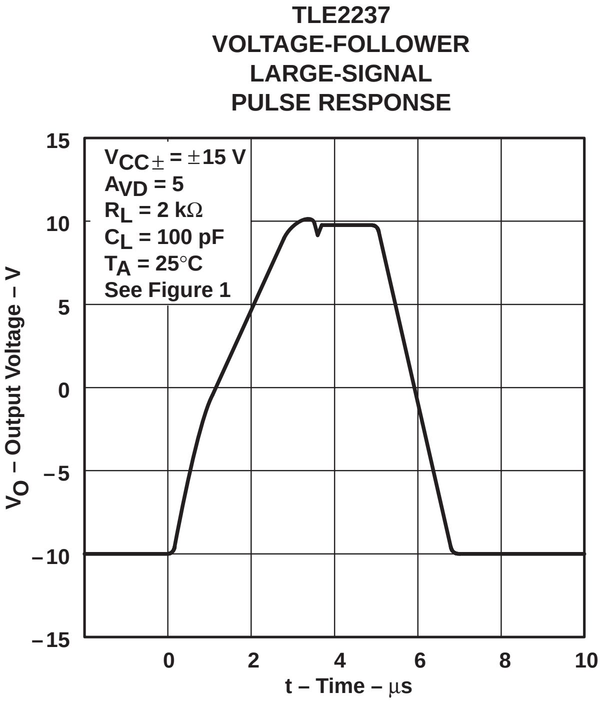

Figure 37

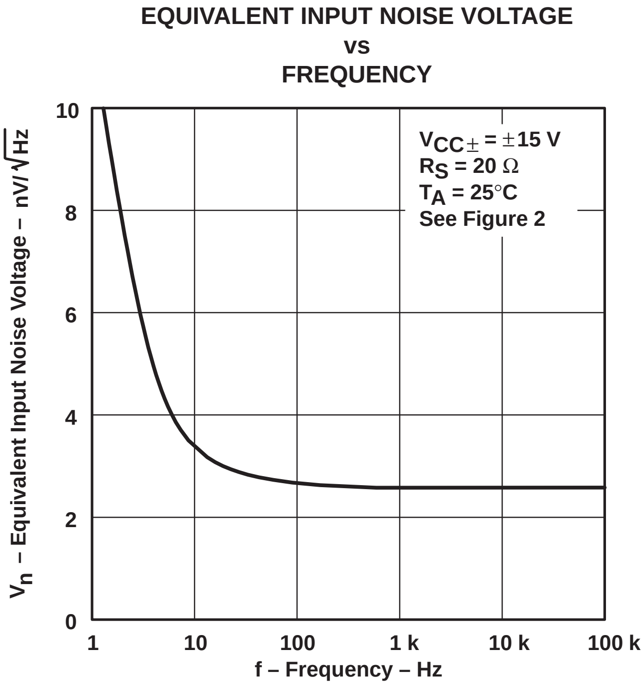

Figure 38

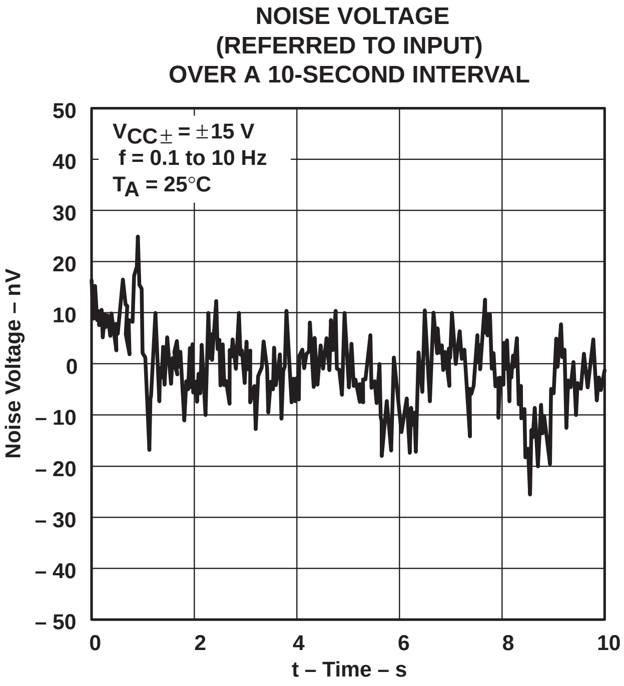

Figure 39

TYPICAL CHARACTERISTICS

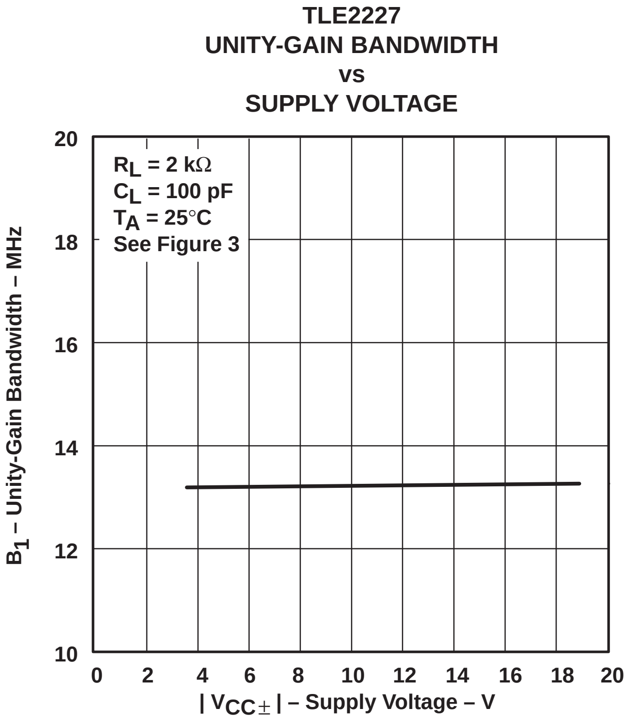

Figure 40

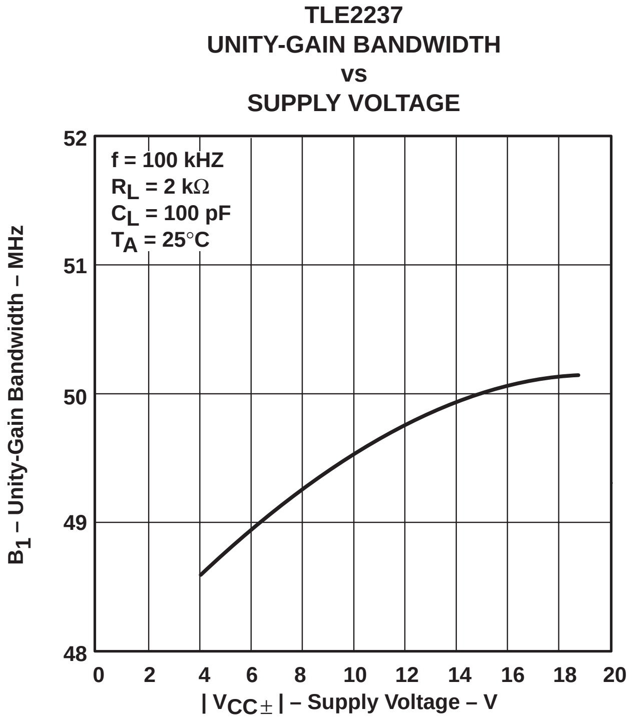

Figure 41

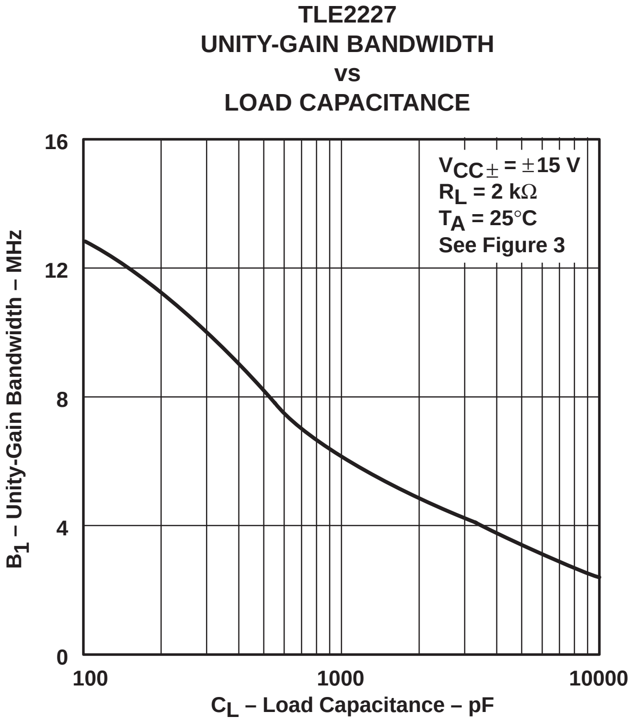

Figure 42

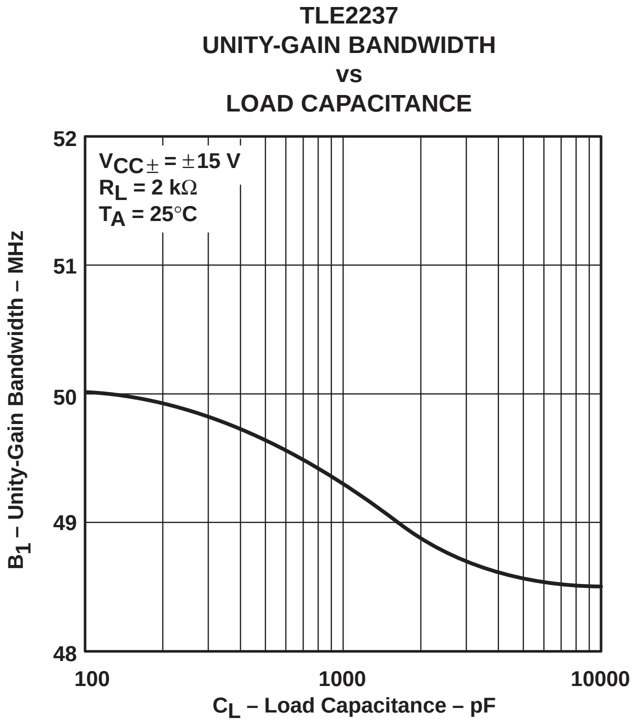

Figure 43

TYPICAL CHARACTERISTICS

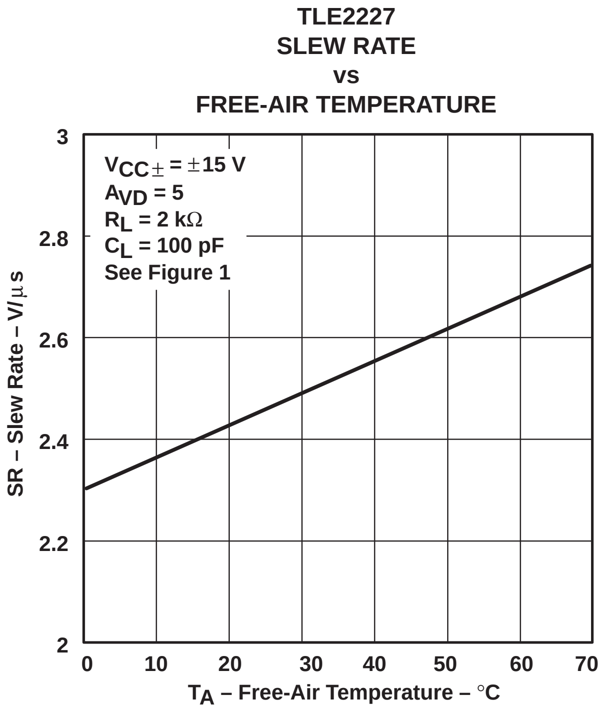

Figure 44

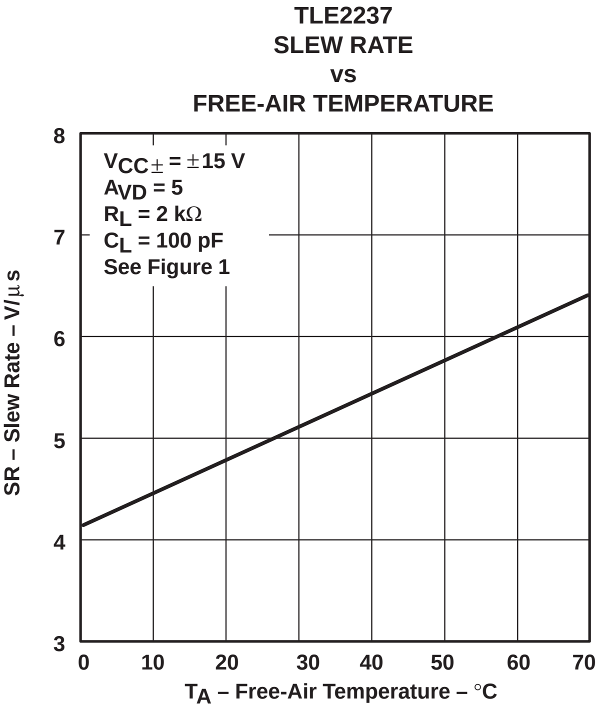

Figure 45

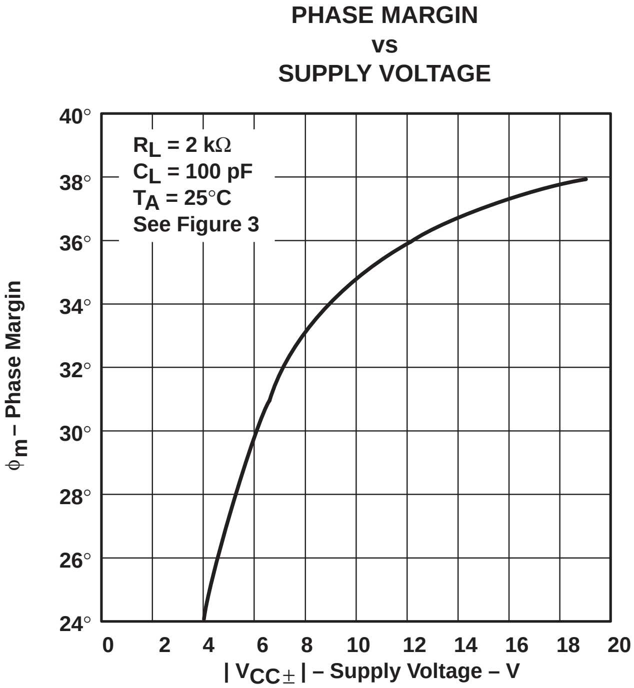

Figure 46

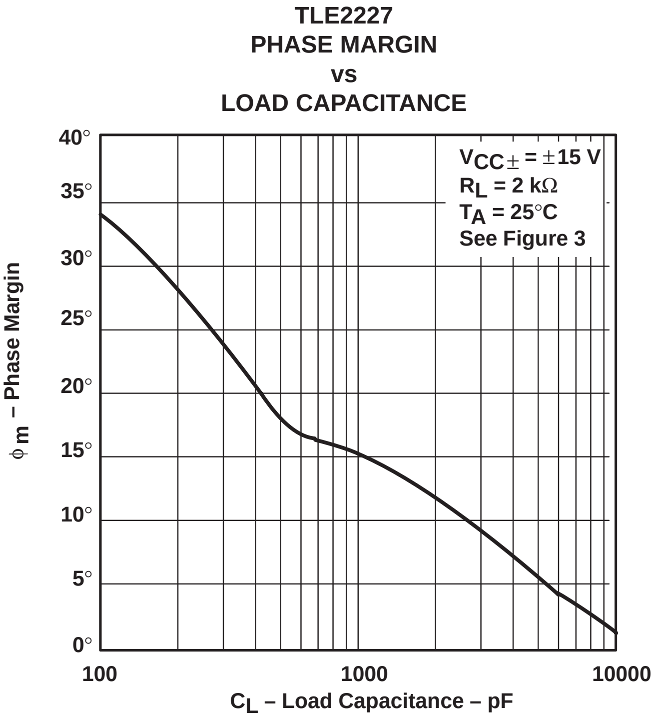

Figure 47

TYPICAL CHARACTERISTICS

TLE2237
PHASE MARGIN
vs
LOAD CAPACITANCE

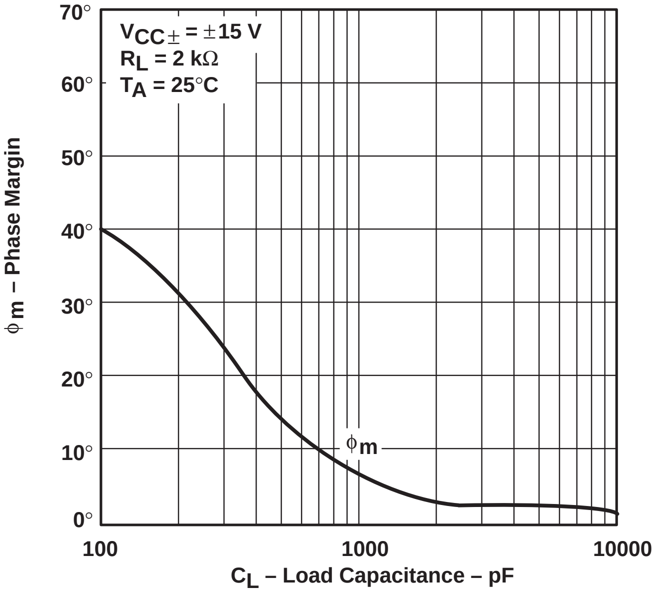

Figure 48

APPLICATION INFORMATION

TLE2227 macromodel information

Macromodel information provided was derived using Microsim *Parts*™, the model generation software used with Microsim *PSpice*™. 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)

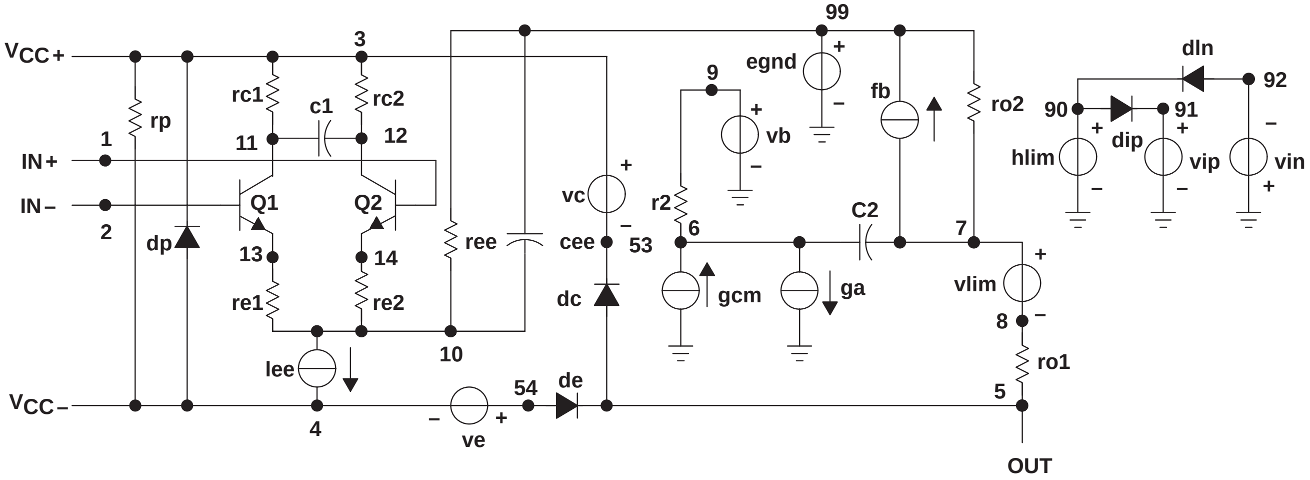

Figure 49. Boyle Macromodel

```
.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

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).

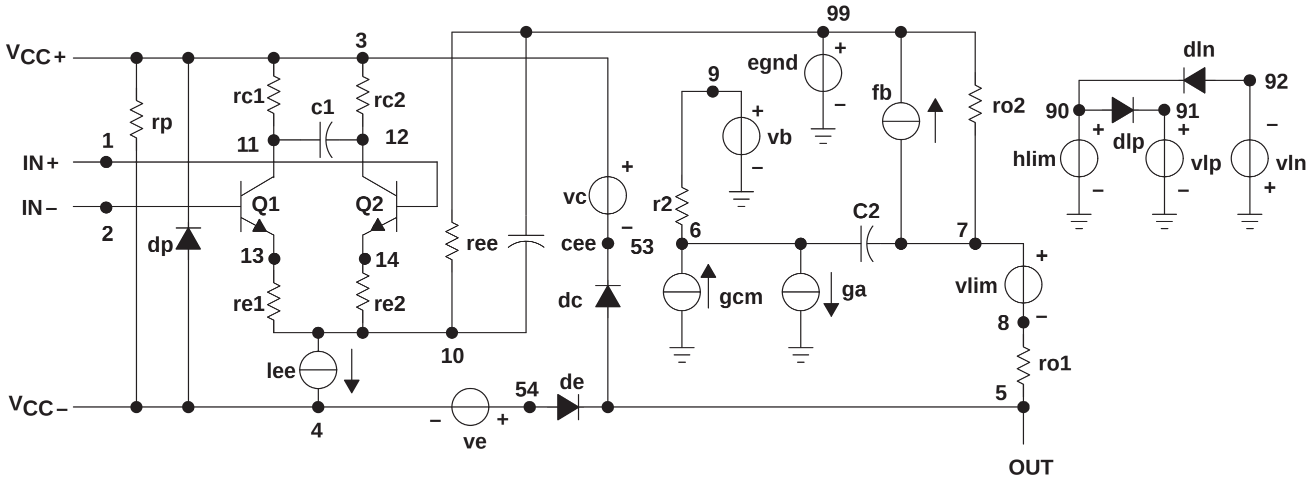

Figure 51. Boyle Macromodel

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 kΩ, 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).

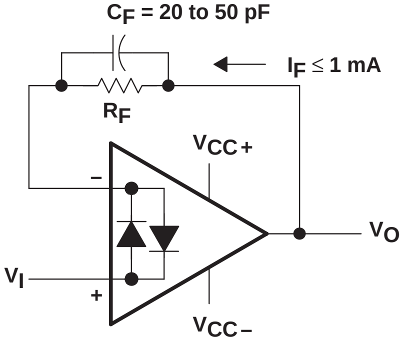

Figure 53. Voltage-Follower Circuit

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