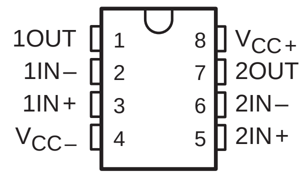
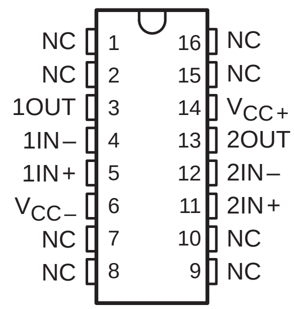
- **Outstanding Combination of DC Precision and AC Performance:**
  - **Unity-Gain Bandwidth . . . 15 MHz Typ**
  - **V_n . . . 3.3 nV/$\sqrt{Hz}$ at f = 10 Hz Typ, 2.5 nV/$\sqrt{Hz}$ at f = 1 kHz Typ**
  - **V_{IO} . . . 100 μV Typ**
  - **A_{VD} . . . 45 V/μV Typ With R_L = 2 kΩ, 38 V/μV Typ With R_L = 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/$\sqrt{Hz}$ and 2.5 nV/$\sqrt{Hz}$ at frequencies of 10 Hz and 1 kHz, respectively.

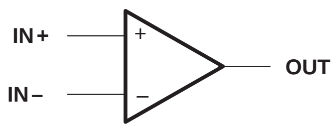
The TLE22x7C is available in a wide variety of packages, including the industry standard 16-pin small-outline wide-body version for high-density system applications. This device is characterized for operation from 0°C to 70°C.

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.

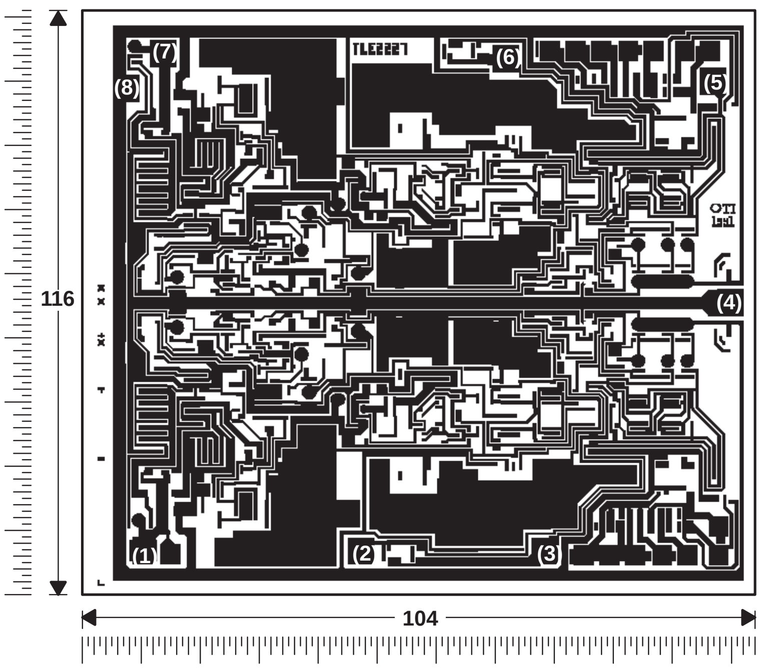
symbol (each amplifier)

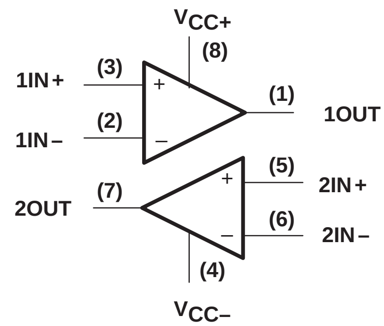


TLE2227Y chip information

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

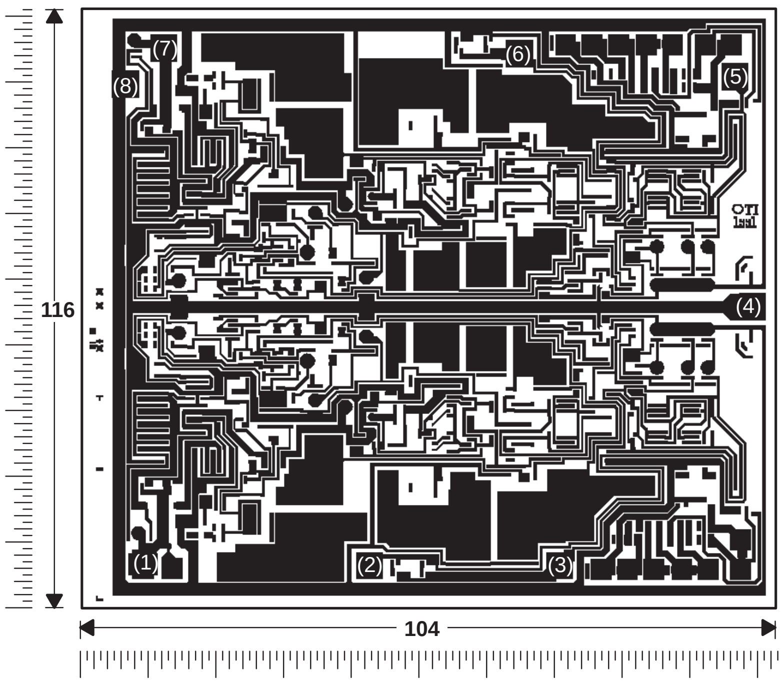
TOLERANCES ARE ±10%.

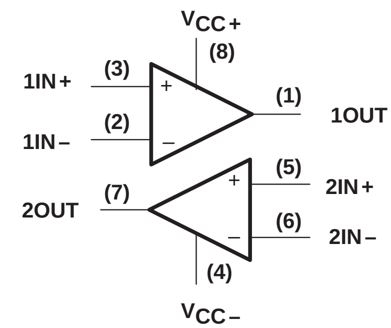
ALL DIMENSIONS ARE IN MILS.

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

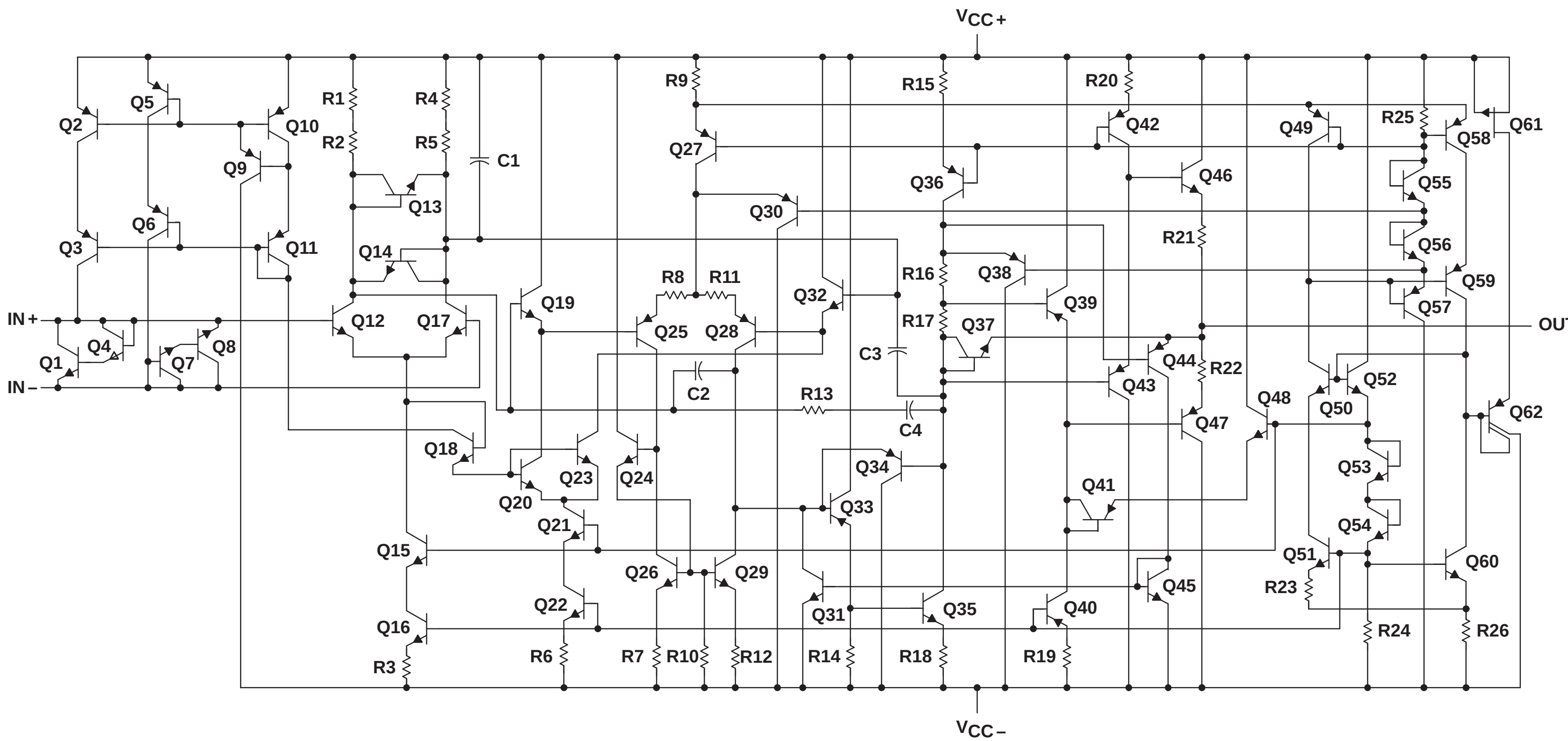
BONDING PADS: 4 × 4 MILS MINIMUM

$T_J$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, $V_{CC\pm} = \pm 15$ V (unless otherwise noted)

PARAMETER		TEST CONDITIONS		T_A†	TLE2227C MIN	TLE2227C TYP	TLE2227C MAX	UNIT
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	$V_O = \pm 11$ V,	$R_L = 2\ k\Omega$	25°C	2.5	45		V/µV
		$V_O = \pm 10$ V,	$R_L = 2\ k\Omega$	Full range	2			
		$V_O = \pm 10$ 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 ($\Delta V_{CC\pm}/\Delta V_{IO}$)	$V_{CC\pm} = \pm 4$ V to ± 18 V,	$R_S = 50\ \Omega$	25°C	94	120		dB
		$V_{CC\pm} = \pm 4$ 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, $V_{CC\pm} = \pm 15$ 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/√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/√HZ
		f = 1 kHz				0.4	0.6	
THD	Total harmonic distortion	$V_O = \pm 10$ 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 MIN	TLE2237C TYP	TLE2237C MAX	UNIT
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, $V_{CC\pm} = \pm 15$ 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	$R_S = 20\ \Omega$, f = 10 Hz	25°C		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	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	$V_O = \pm 10$ 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, $V_{CC\pm} = \pm15$ V, $T_A = 25°C$ (unless otherwise noted)

PARAMETER		TEST CONDITIONS		TLE2227Y			UNIT
				MIN	TYP	MAX	
V_{IO}	Input offset voltage	$V_{IC} = 0$,	$R_S = 50\ \Omega$		100	350	μV
	Input offset voltage long-term drift (see Note 4)	$V_{IC} = 0$,	$R_S = 50\ \Omega$		0.006	1	μV/mo
I_{IO}	Input offset current	$V_{IC} = 0$,	$R_S = 50\ \Omega$		7.5	90	nA
I_{IB}	Input bias current	$V_{IC} = 0$,	$R_S = 50\ \Omega$		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	$V_O = \pm11$ V,	$R_L = 2\ k\Omega$	2.5	45		V/μV
		$V_O = \pm10$ V,	$R_L = 1\ k\Omega$	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,	$R_S = 50\ \Omega$	98	115		dB
k_{SVR}	Supply-voltage rejection ratio ($\Delta V_{CC\pm}/\Delta V_{IO}$)	$V_{CC\pm} = \pm4$ V to ±18 V,	$R_S = 50\ \Omega$	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, $V_{CC\pm} = \pm15$ V, $T_A = 25°C$

PARAMETER		TEST CONDITIONS		TLE2227Y			UNIT
				MIN	TYP	MAX	
SR	Slew rate	$R_L = 2\ k\Omega$,	$C_L = 100$ pF	1.7	2.5		V/μs
V_n	Equivalent input noise voltage	$R_S = 20\ \Omega$,	f = 10 Hz		3.3	8	nV/√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/√HZ
		f = 1 kHz			0.4	0.6	
THD	Total harmonic distortion	$V_O = \pm10$ V, See Note 5	$A_{VD} = 1$,		<0.002%		
B_1	Unity-gain bandwidth	$R_L = 2\ k\Omega$,	$C_L = 100$ pF	7	13		MHz
B_{OM}	Maximum output-swing bandwidth	$R_L = 2\ k\Omega$			30		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%.

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)	$V_{IC} = 0$,	$R_S = 50\ \Omega$		0.006	1	µV/mo
I_{IO}	Input offset current	$V_{IC} = 0$,	$R_S = 50\ \Omega$		7.5	90	nA
I_{IB}	Input bias current	$V_{IC} = 0$,	$R_S = 50\ \Omega$		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

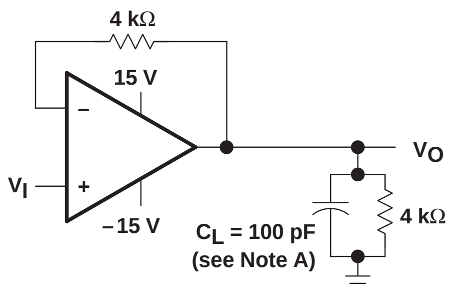
NOTE 4. Typical values are based on the input offset voltage shift observed through 168 hours of operating life test at $T_A = 150°C$ extrapolated to $T_A = 25°C$ using the Arrhenius equation and assuming an activation energy of 0.96 eV.

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/√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/√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

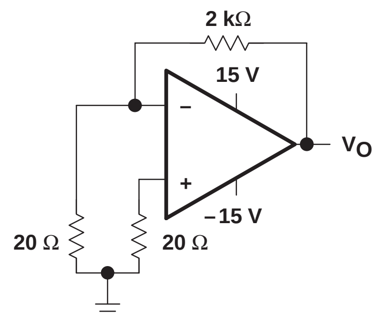
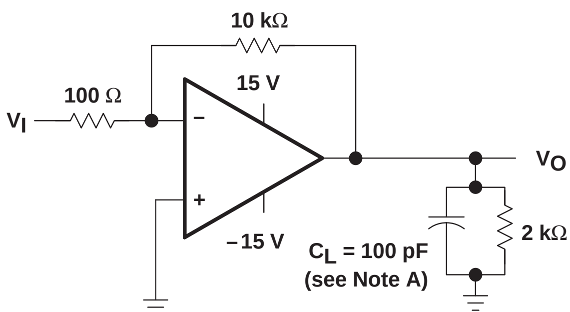
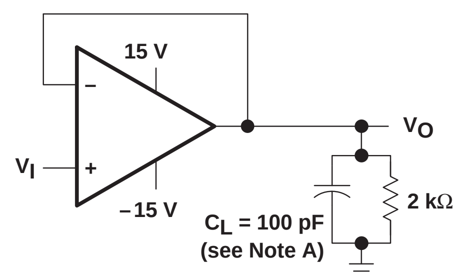


Figure 2. Noise-Voltage Test Circuit



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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ΔV_{IO}	Input offset voltage change	vs Time after power on	6, 7
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
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

DISTRIBUTION OF
INPUT OFFSET VOLTAGE

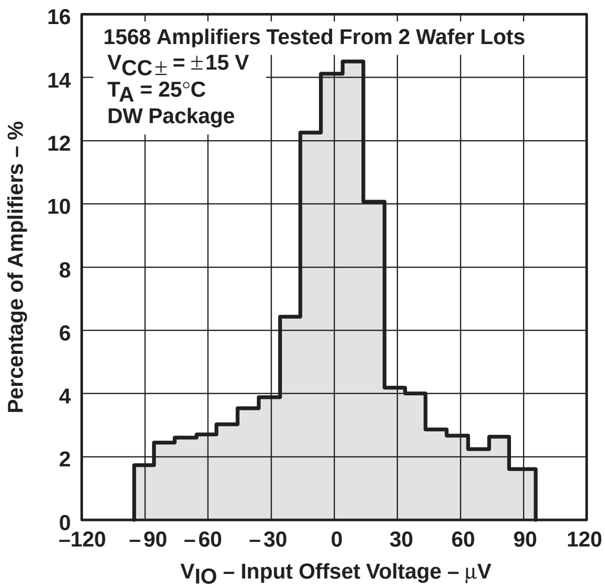

Figure 5

INPUT OFFSET VOLTAGE CHANGE
vs
TIME AFTER POWER ON

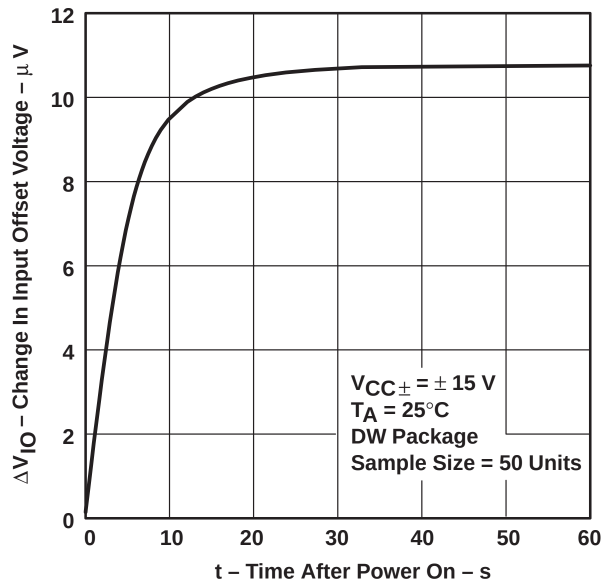

Figure 6

INPUT OFFSET VOLTAGE CHANGE
vs
TIME AFTER POWER ON

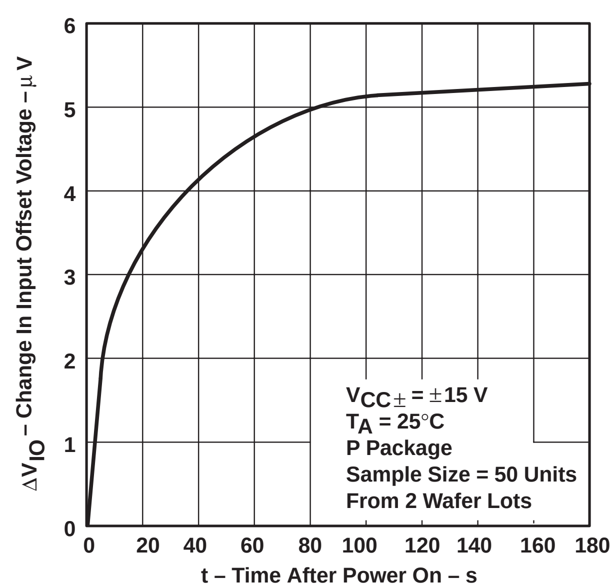

Figure 7

INPUT OFFSET CURRENT
vs
FREE-AIR TEMPERATURE

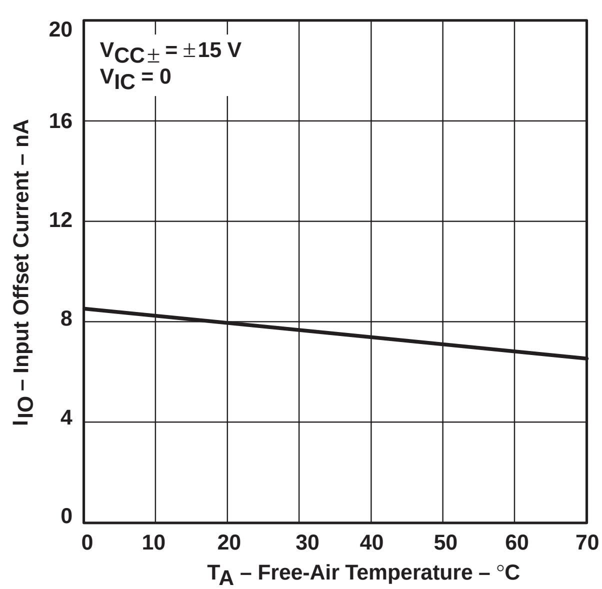

Figure 8

TYPICAL CHARACTERISTICS

INPUT BIAS CURRENT vs COMMON-MODE INPUT VOLTAGE

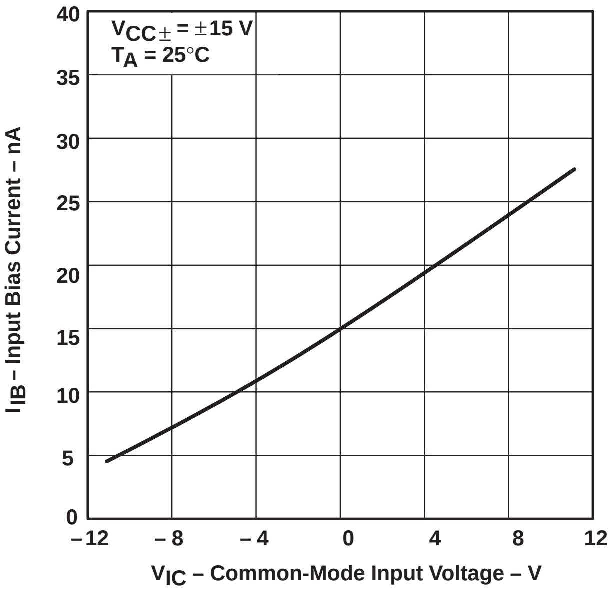

Figure 9

INPUT BIAS CURRENT vs FREE-AIR TEMPERATURE

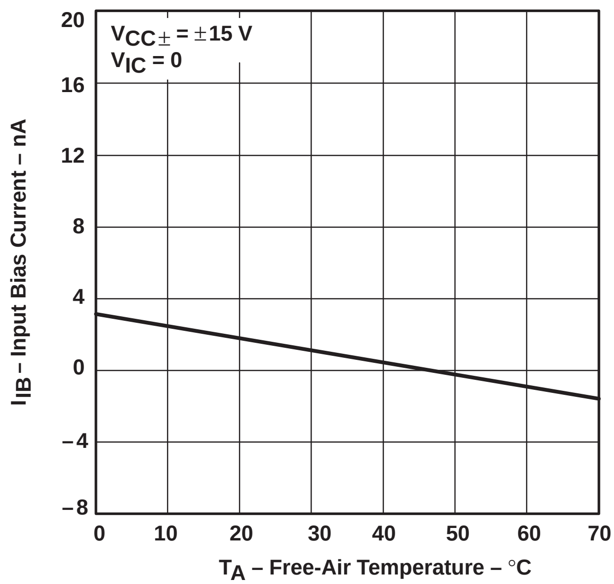

Figure 10

INPUT CURRENT vs DIFFERENTIAL INPUT VOLTAGE

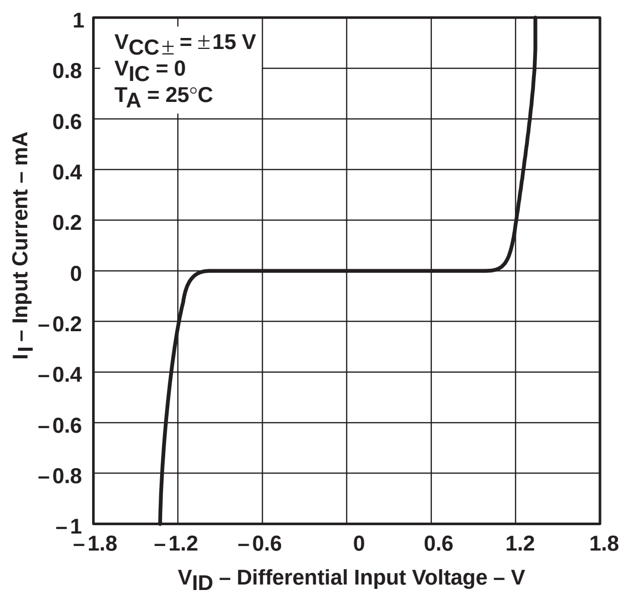

Figure 11

MAXIMUM PEAK-TO-PEAK OUTPUT VOLTAGE vs FREQUENCY

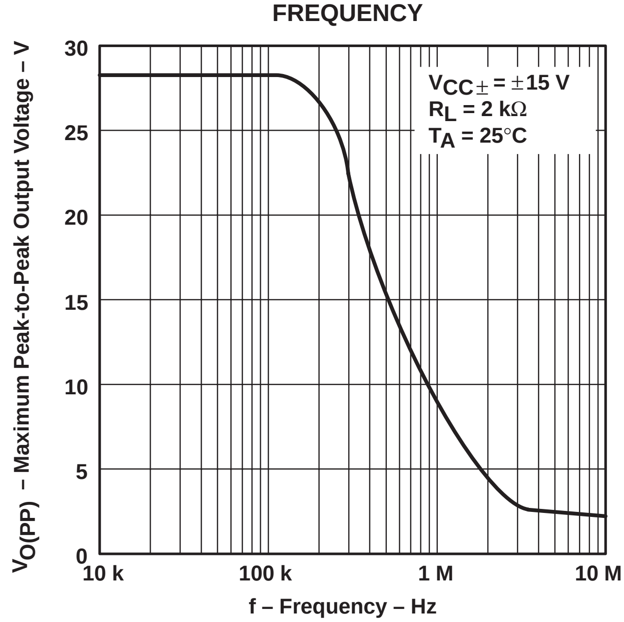

Figure 12

TYPICAL CHARACTERISTICS

MAXIMUM POSITIVE PEAK OUTPUT VOLTAGE vs LOAD RESISTANCE

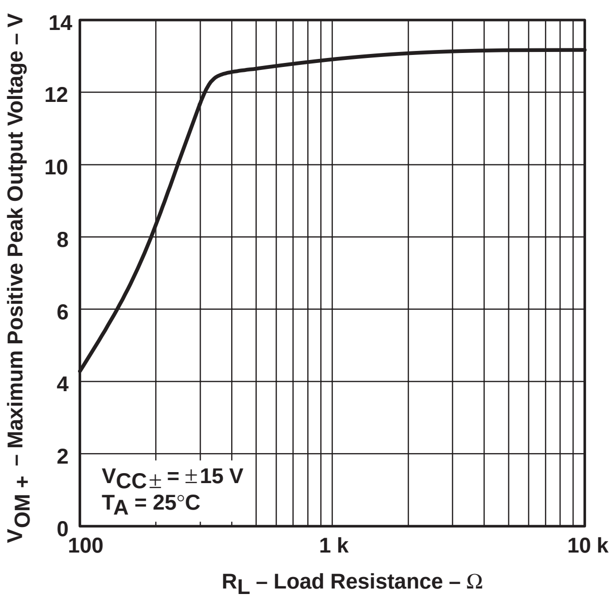

Figure 13

MAXIMUM NEGATIVE PEAK OUTPUT VOLTAGE vs LOAD RESISTANCE

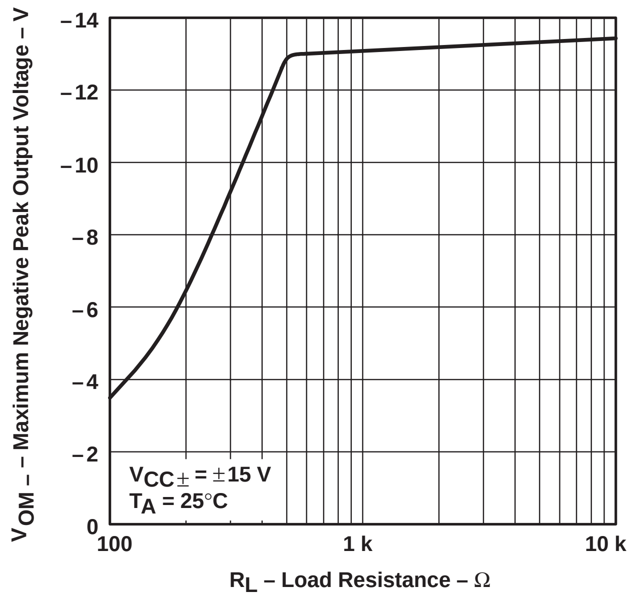

Figure 14

MAXIMUM POSITIVE PEAK OUTPUT VOLTAGE vs FREE-AIR TEMPERATURE

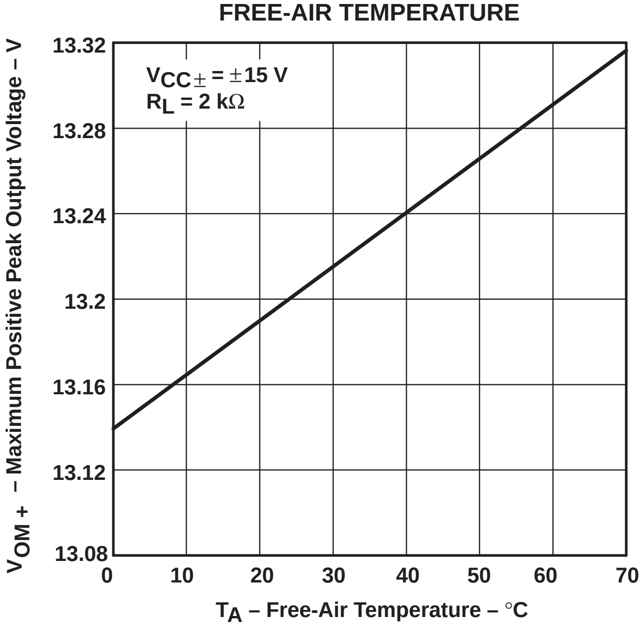

Figure 15

MAXIMUM NEGATIVE PEAK OUTPUT VOLTAGE vs FREE-AIR TEMPERATURE

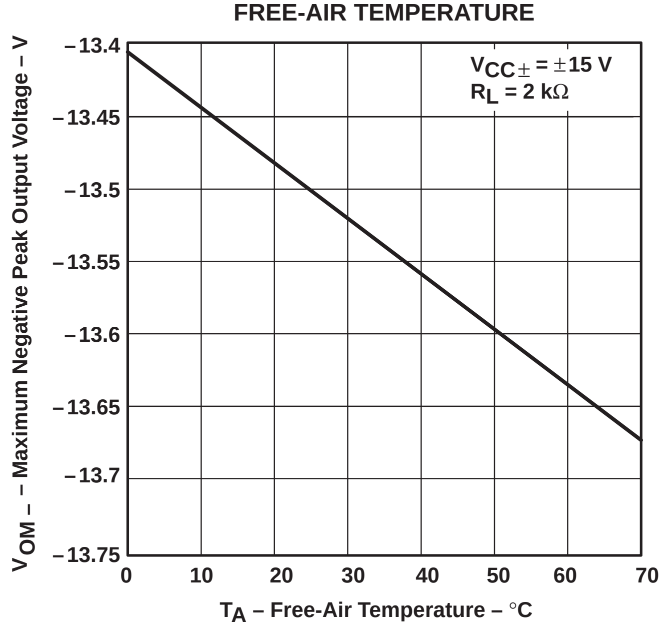

Figure 16

TYPICAL CHARACTERISTICS

LARGE-SIGNAL DIFFERENTIAL VOLTAGE AMPLIFICATION vs SUPPLY VOLTAGE

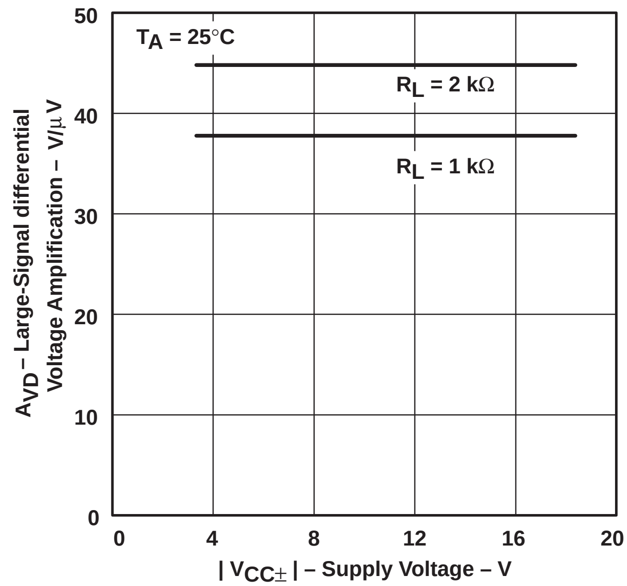

Figure 17

LARGE-SIGNAL DIFFERENTIAL VOLTAGE AMPLIFICATION AND PHASE SHIFT vs FREQUENCY

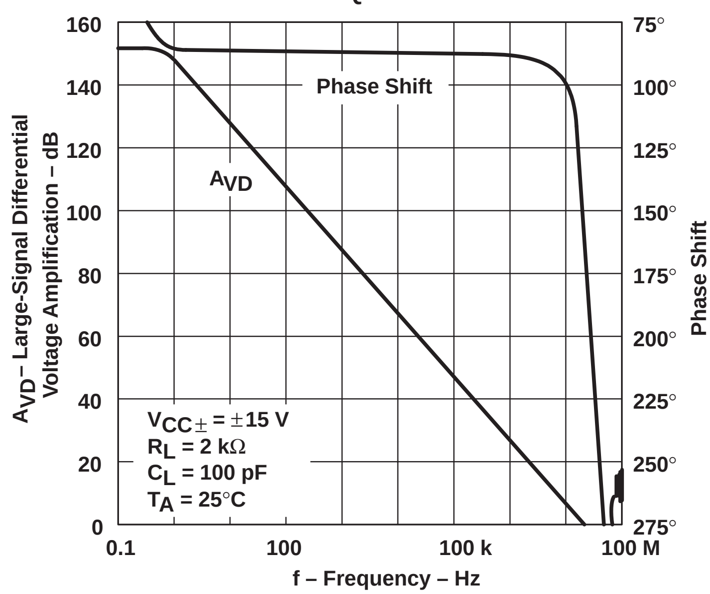

Figure 18

TYPICAL CHARACTERISTICS

LARGE-SIGNAL DIFFERENTIAL VOLTAGE AMPLIFICATION vs LOAD RESISTANCE

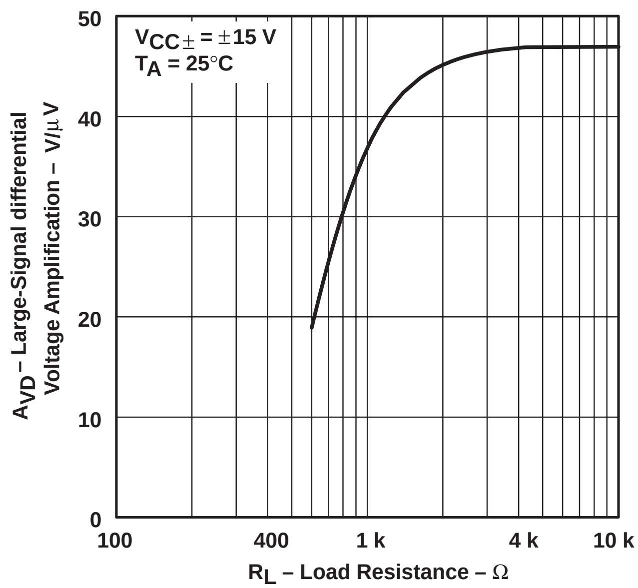

Figure 19

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

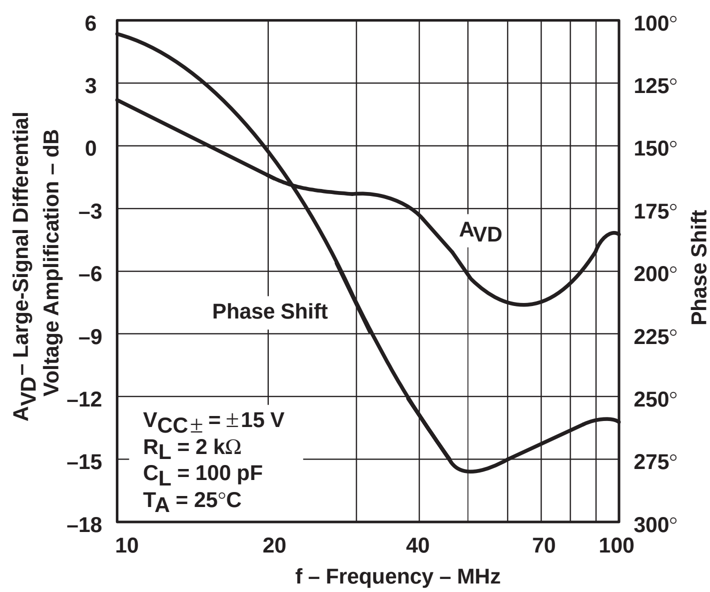

Figure 20

TYPICAL CHARACTERISTICS

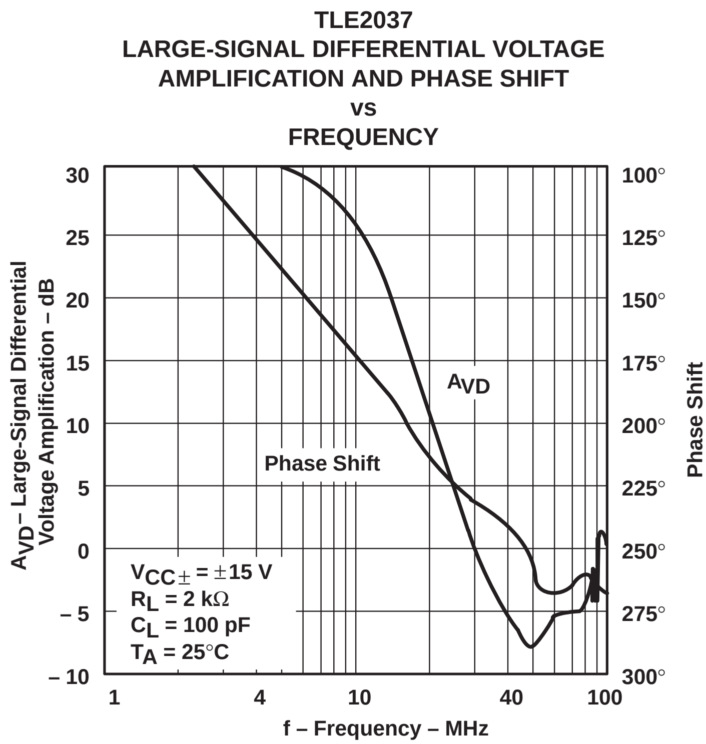

Figure 21

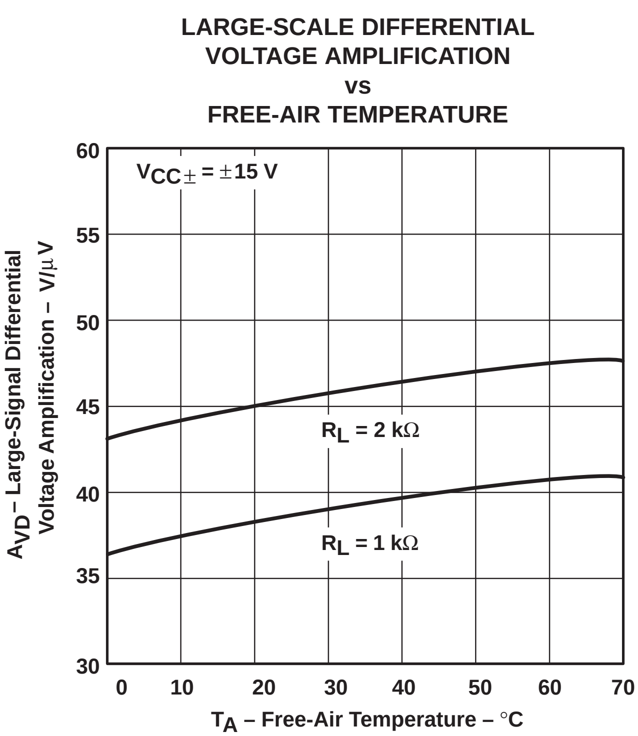

Figure 22

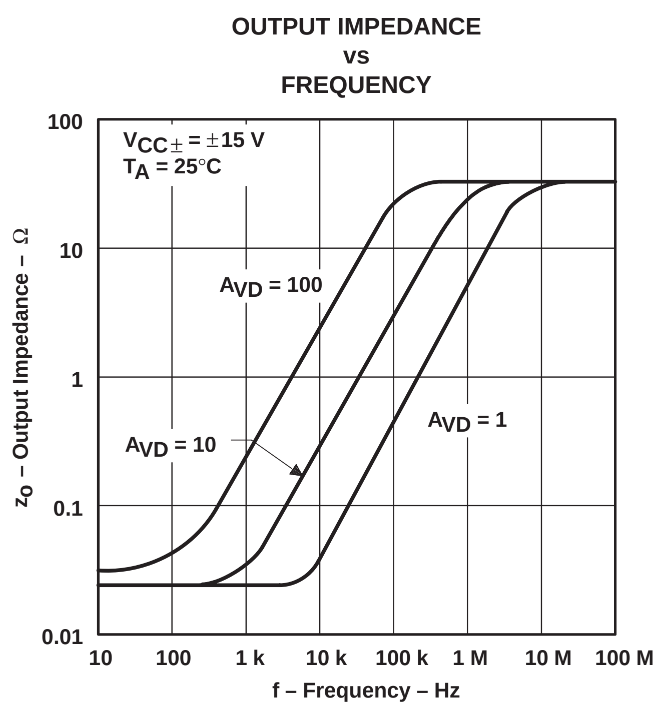

Figure 23

TYPICAL CHARACTERISTICS

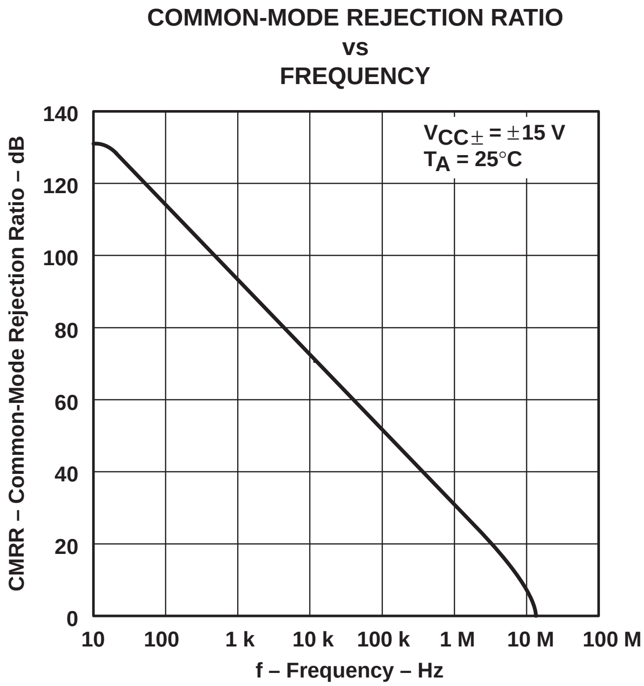

Figure 24

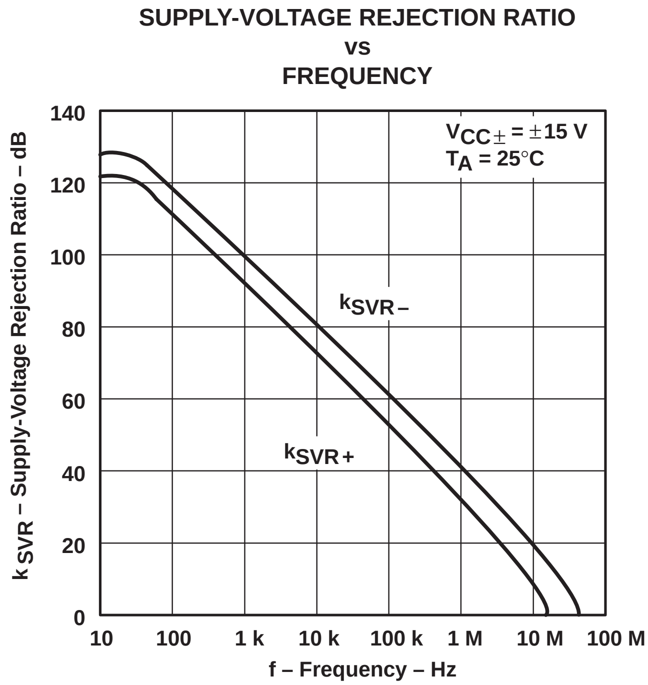

Figure 25

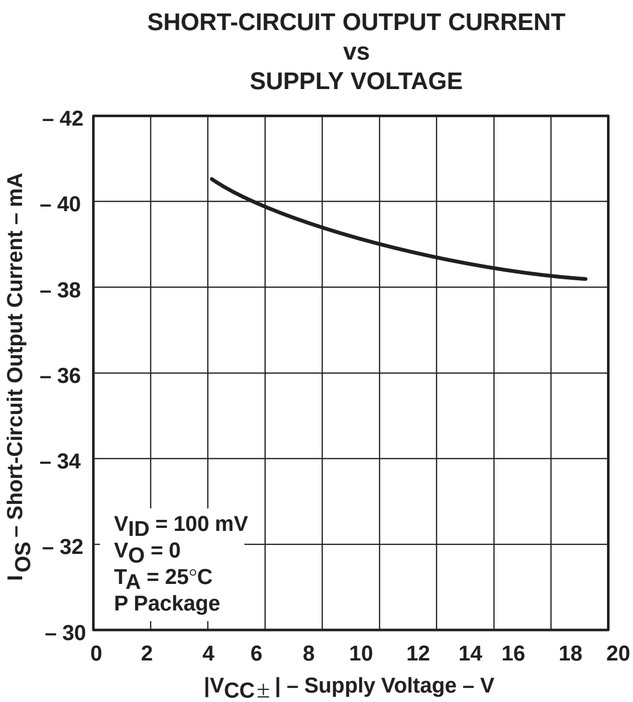

Figure 26

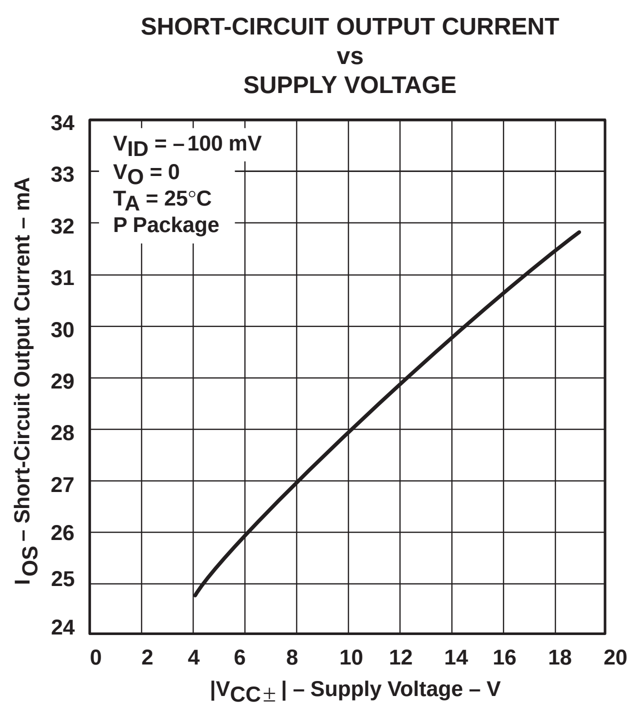

Figure 27

TYPICAL CHARACTERISTICS

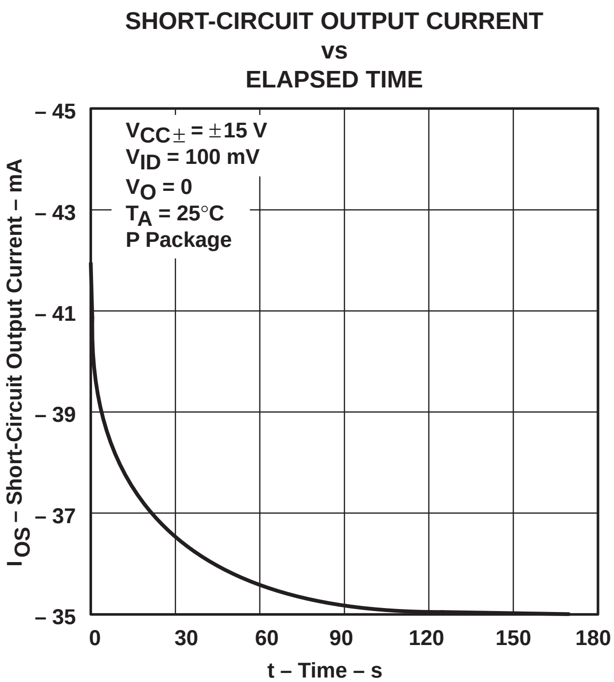

Figure 28

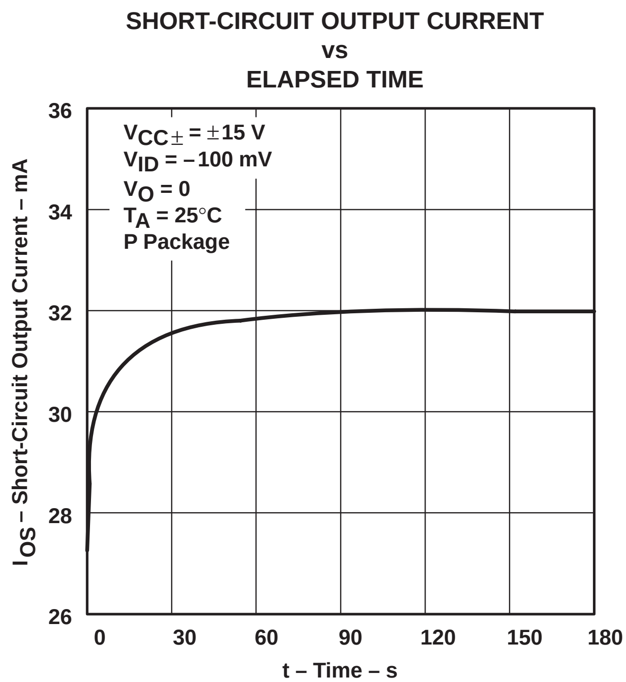

Figure 29

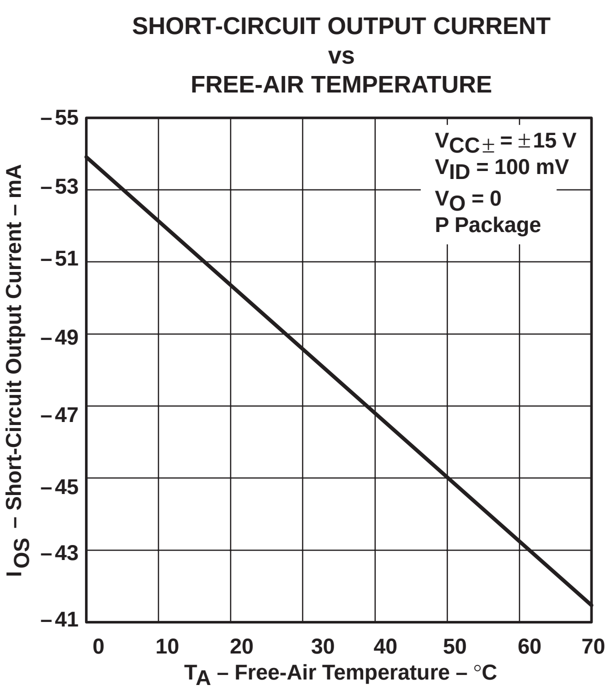

Figure 30

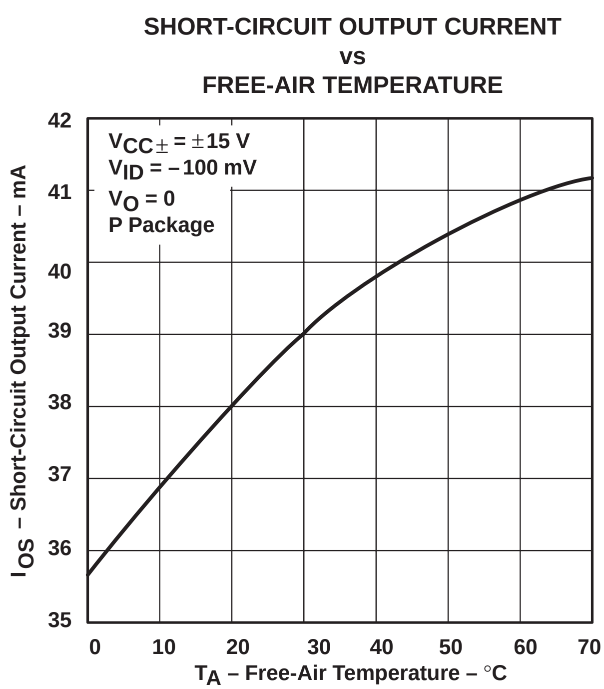

Figure 31

TYPICAL CHARACTERISTICS

SUPPLY CURRENT
vs
SUPPLY VOLTAGE

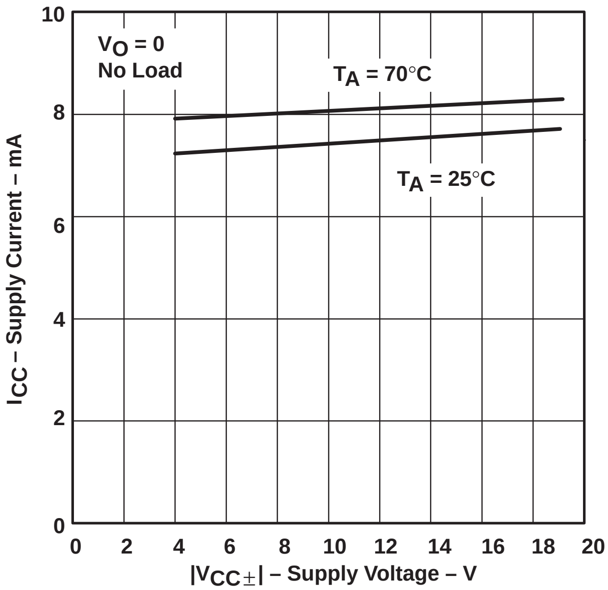

Figure 32

SUPPLY CURRENT
vs
FREE-AIR TEMPERATURE

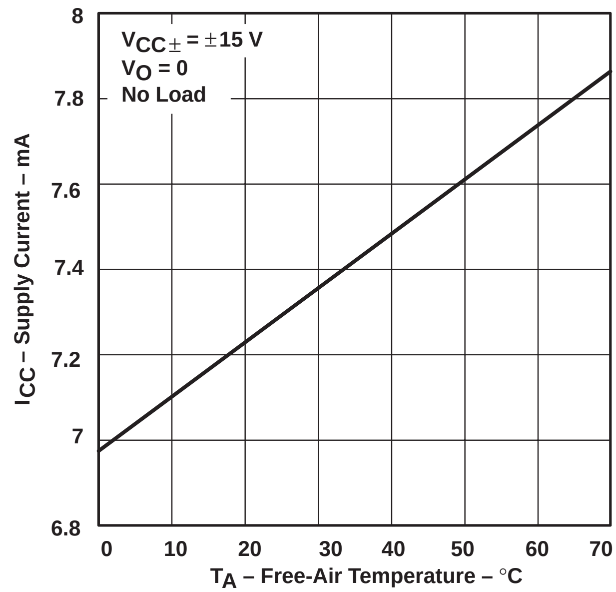

Figure 33

TLE2227
VOLTAGE-FOLLOWER
SMALL-SIGNAL
PULSE RESPONSE

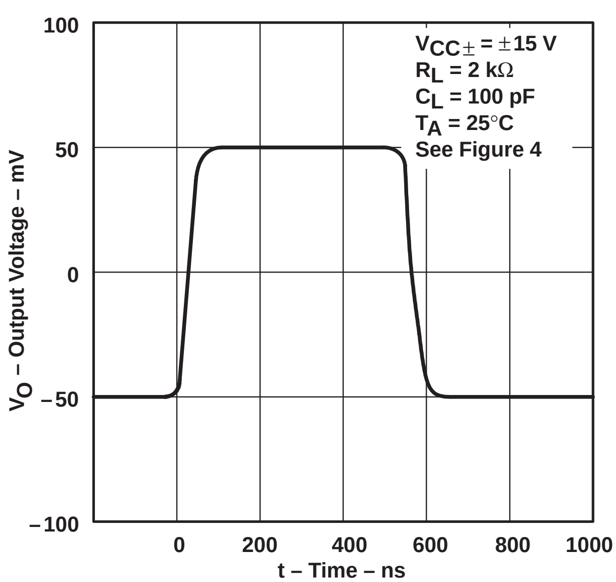

Figure 34

TLE2237
VOLTAGE-FOLLOWER
SMALL-SIGNAL
PULSE RESPONSE

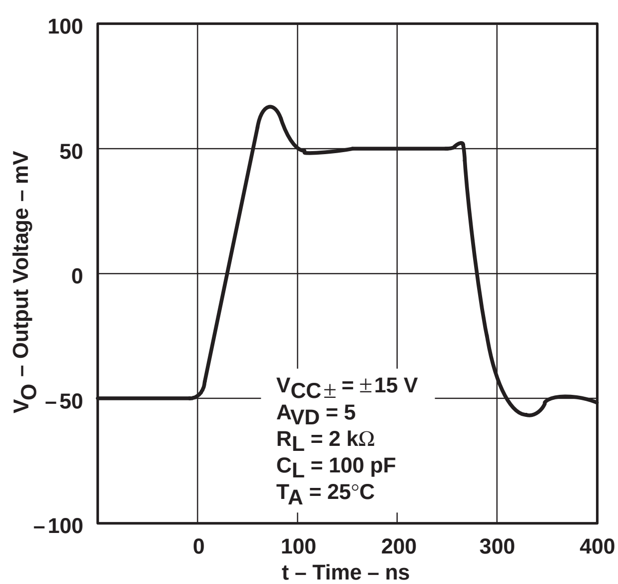

Figure 35

TYPICAL CHARACTERISTICS

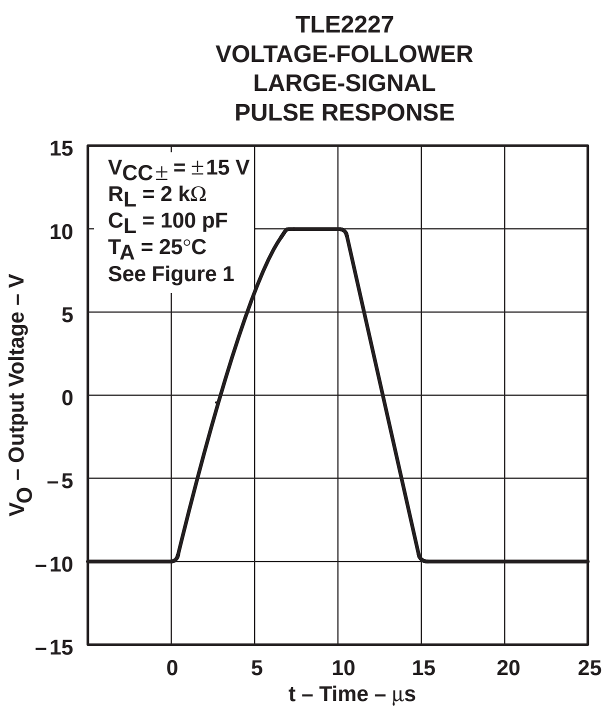

Figure 36

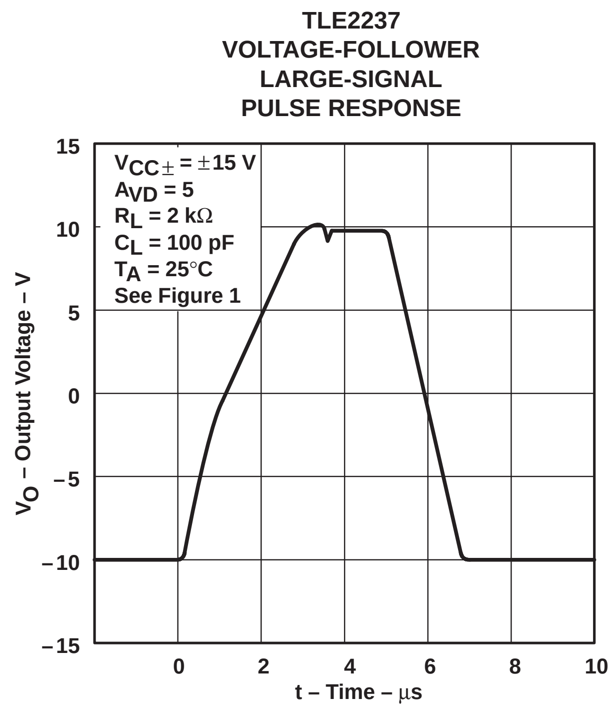

Figure 37

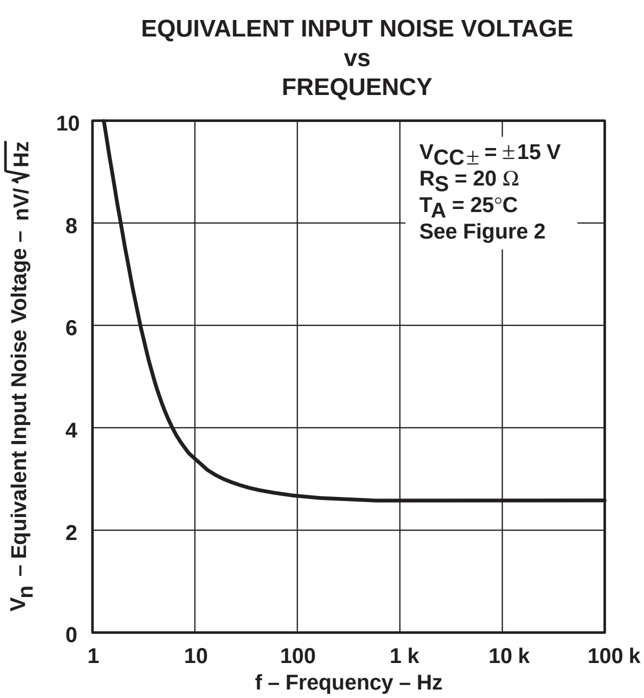

Figure 38

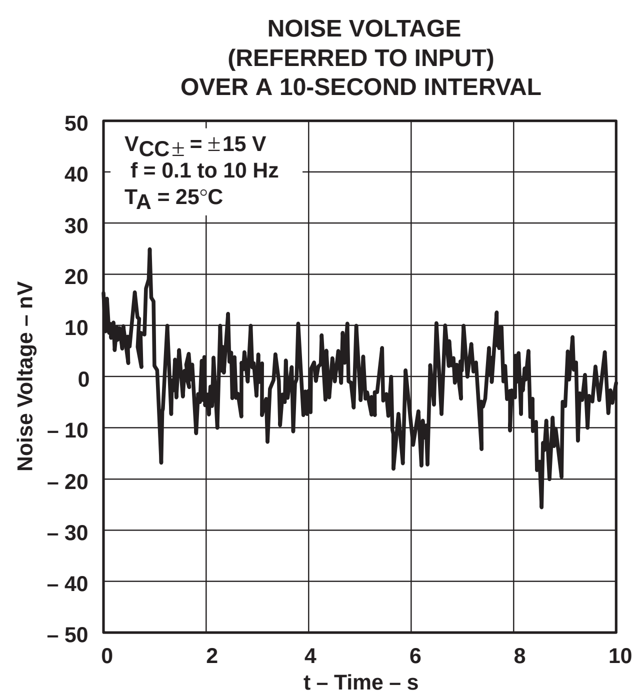

Figure 39

TYPICAL CHARACTERISTICS

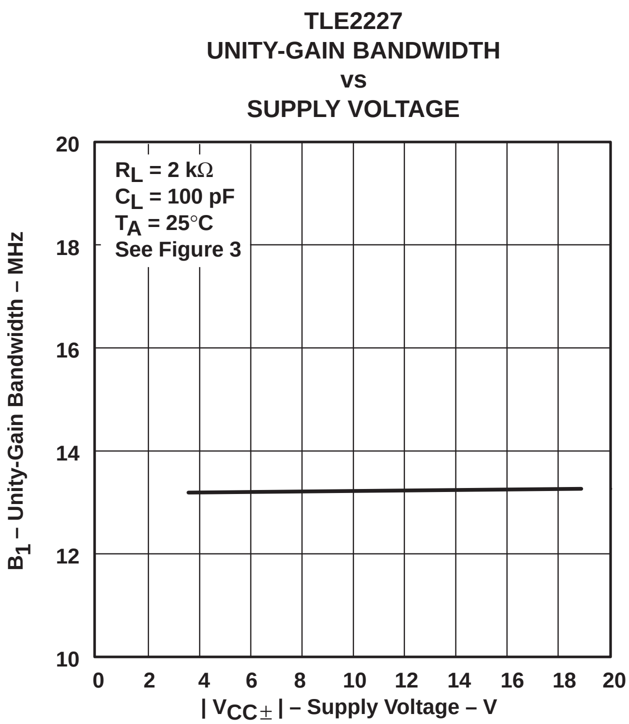

Figure 40

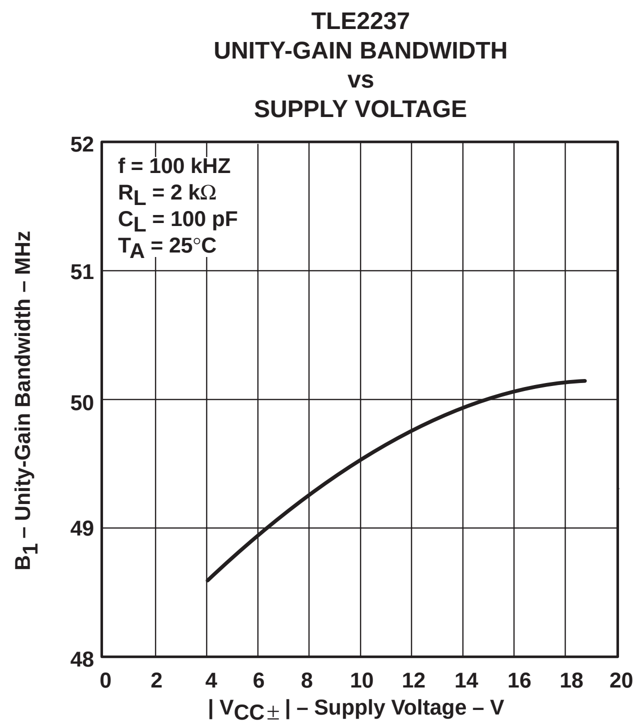

Figure 41

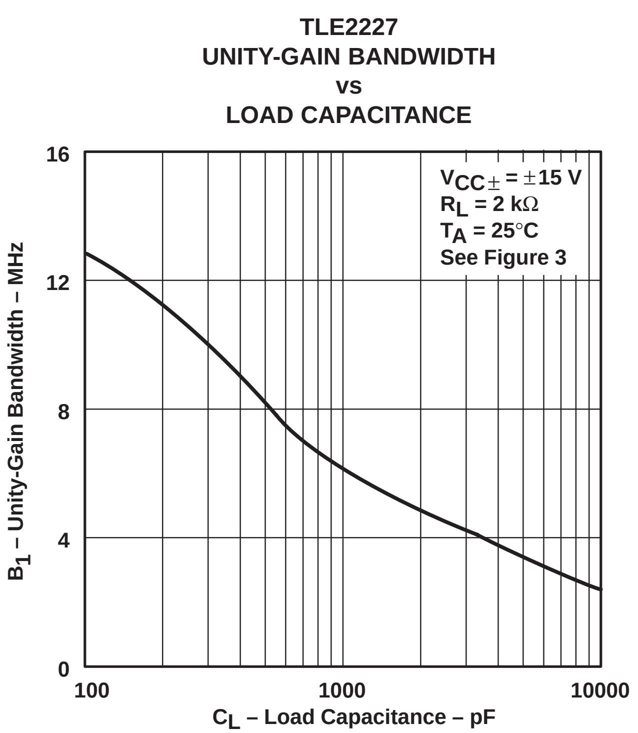

Figure 42

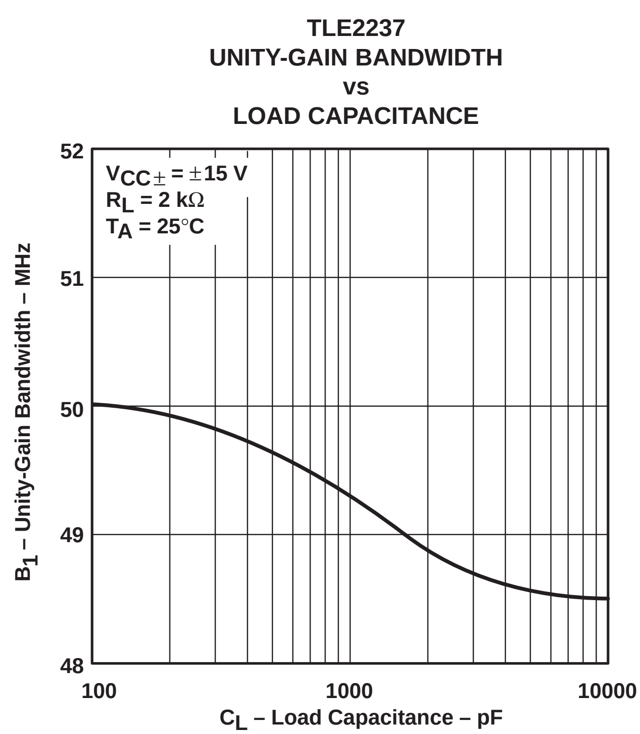

Figure 43

TYPICAL CHARACTERISTICS

TLE2227
SLEW RATE
vs
FREE-AIR TEMPERATURE

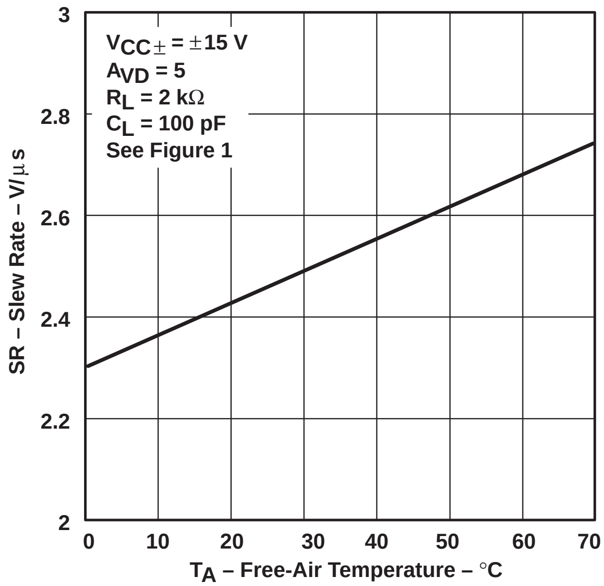

Figure 44

TLE2237
SLEW RATE
vs
FREE-AIR TEMPERATURE

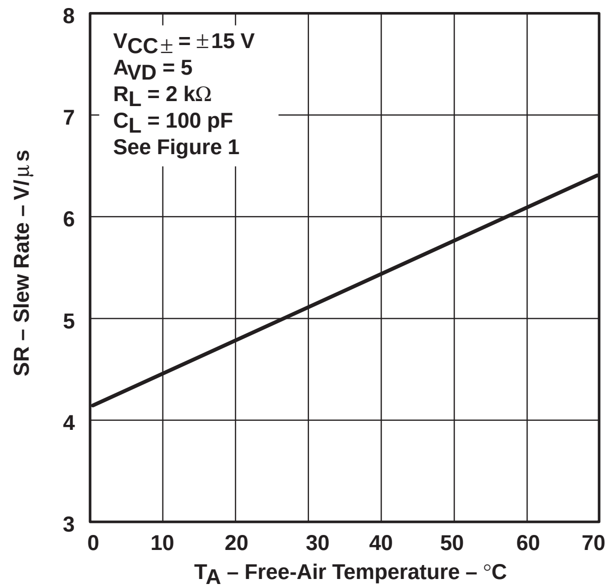

Figure 45

PHASE MARGIN
vs
SUPPLY VOLTAGE

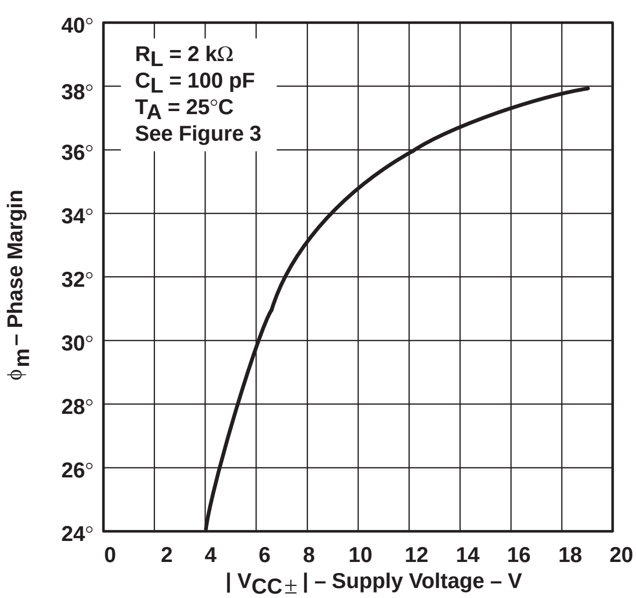

Figure 46

TLE2227
PHASE MARGIN
vs
LOAD CAPACITANCE

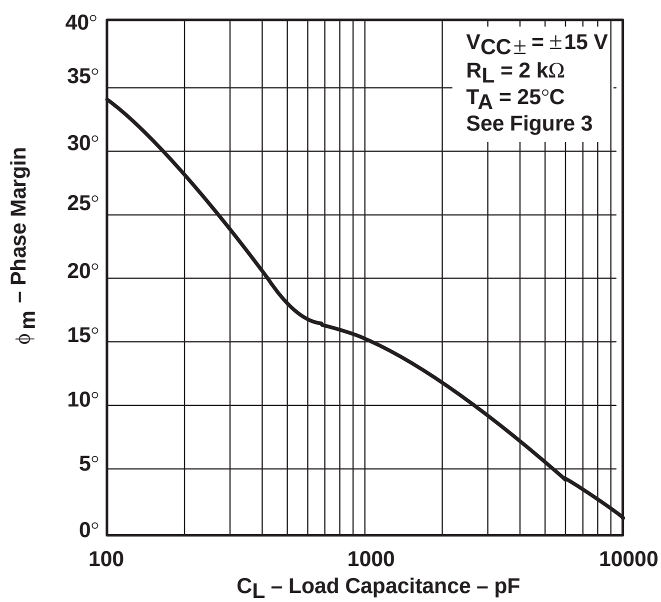

Figure 47

TYPICAL CHARACTERISTICS

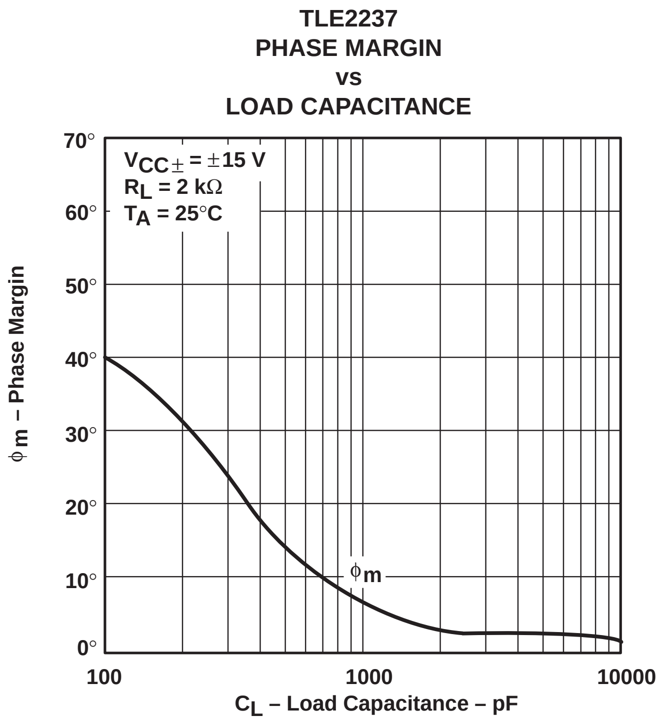

Figure 48

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)

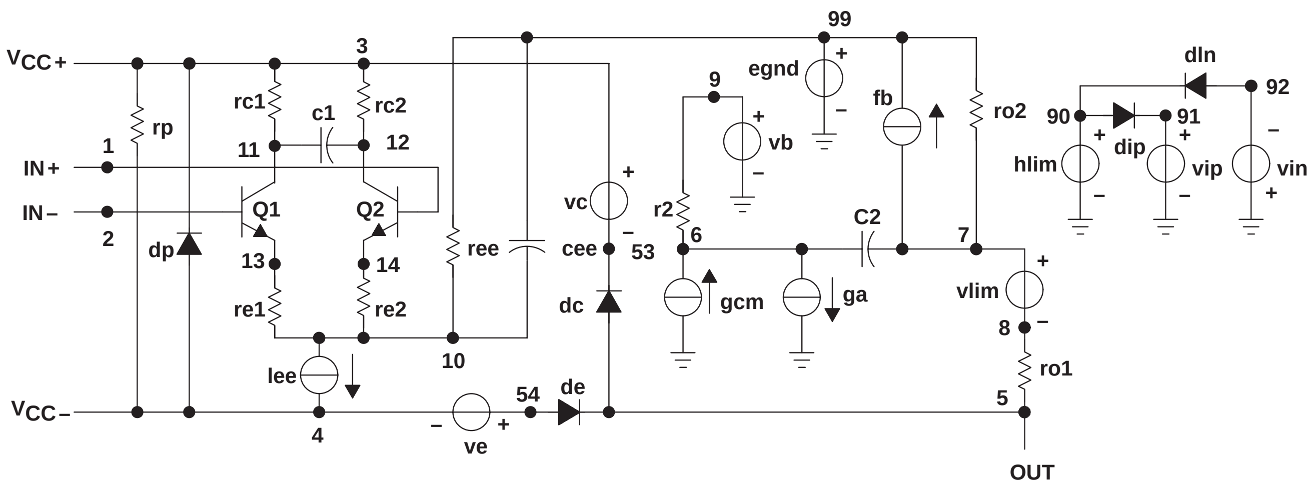

Figure 49. Boyle Macromodel

```
.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).

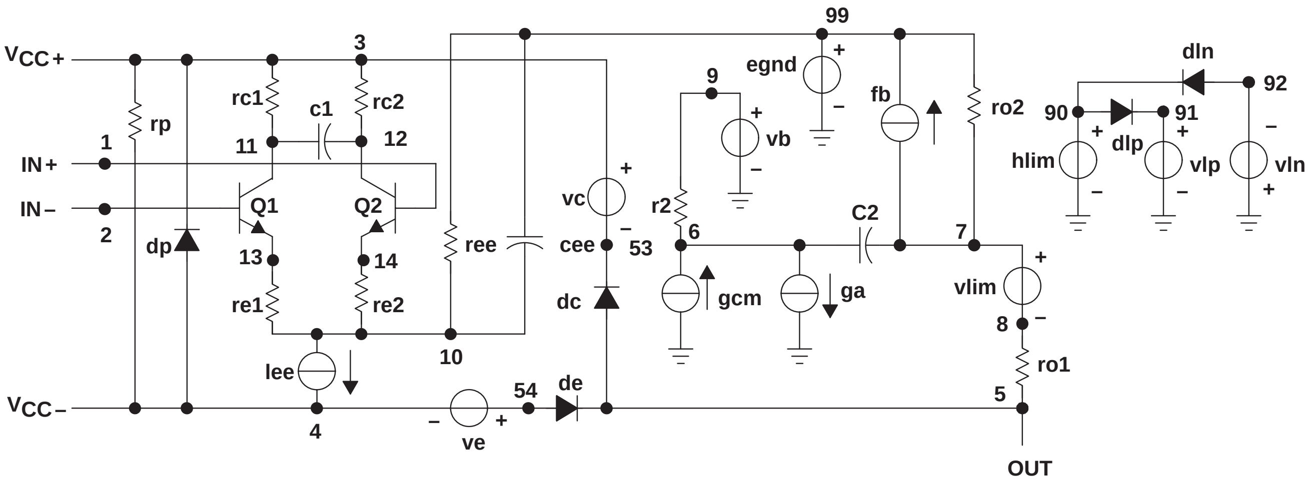

Figure 51. Boyle Macromodel

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).

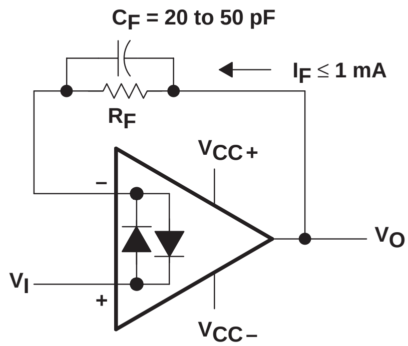

Figure 53. Voltage-Follower Circuit

PACKAGE OPTION ADDENDUM

PACKAGING INFORMATION

Orderable Device	Status [(1)]	Package Type	Package Drawing	Pins	Package Qty	Eco Plan [(2)]	Lead/Ball Finish	MSL Peak Temp [(3)]
TLE2227CDW	OBSOLETE	SOIC	DW	16		TBD	Call TI	Call TI
TLE2227CP	OBSOLETE	PDIP	P	8		TBD	Call TI	Call TI
TLE2237CDW	OBSOLETE	SOIC	DW	16		TBD	Call TI	Call TI
TLE2237CP	OBSOLETE	PDIP	P	8		TBD	Call TI	Call TI
TLE2237IDW	OBSOLETE	SOIC	DW	16		TBD	Call TI	Call TI

[(1)] The marketing status values are defined as follows:
ACTIVE: Product device recommended for new designs.
LIFEBUY: TI has announced that the device will be discontinued, and a lifetime-buy period is in effect.
NRND: Not recommended for new designs. Device is in production to support existing customers, but TI does not recommend using this part in a new design.
PREVIEW: Device has been announced but is not in production. Samples may or may not be available.
OBSOLETE: TI has discontinued the production of the device.

[(2)] Eco Plan - The planned eco-friendly classification: Pb-Free (RoHS) or Green (RoHS & no Sb/Br) - please check http://www.ti.com/productcontent for the latest availability information and additional product content details.
TBD: The Pb-Free/Green conversion plan has not been defined.
Pb-Free (RoHS): TI's terms "Lead-Free" or "Pb-Free" mean semiconductor products that are compatible with the current RoHS requirements for all 6 substances, including the requirement that lead not exceed 0.1% by weight in homogeneous materials. Where designed to be soldered at high temperatures, TI Pb-Free products are suitable for use in specified lead-free processes.
Green (RoHS & no Sb/Br): TI defines "Green" to mean Pb-Free (RoHS compatible), and free of Bromine (Br) and Antimony (Sb) based flame retardants (Br or Sb do not exceed 0.1% by weight in homogeneous material)

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

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