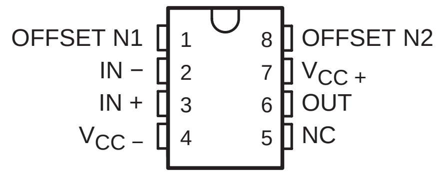
- **Qualified for Automotive Applications**
- **ESD Protection Exceeds 2000 V Per MIL-STD-883, Method 3015; Exceeds 200 V Using Machine Model (C = 200 pF, R = 0)**
- **Outstanding Combination of DC Precision and AC Performance:**
  Unity-Gain Bandwidth . . . 15 MHz Typ
  V_n . . . . 3.3 nV/√Hz at f = 10 Hz Typ,
  2.5 nV/√Hz at f = 1 kHz Typ
  V_{IO} . . . . 25 μV Max
  A_{VD} . . . 45 V/μV Typ With R_L = 2 kΩ,
  19 V/μV Typ With R_L = 600 Ω
- **Available in Standard-Pinout Small-Outline Package**
- **Output Features Saturation Recovery Circuitry**
- **Macromodels and Statistical information**

D PACKAGE
(TOP VIEW)



description

The TLE20x7 and TLE20x7A contain innovative circuit design expertise and high-quality process control techniques to produce a level of ac performance and dc precision previously unavailable in single operational amplifiers. Manufactured using Texas Instruments state-of-the-art Excalibur process, these devices allow upgrades to systems that use lower-precision devices.

In the area of dc precision, the TLE20x7 and TLE20x7A offer maximum offset voltages of 100 μV and 25 μV, respectively, common-mode rejection ratio of 131 dB (typ), supply voltage rejection ratio of 144 dB (typ), and dc gain of 45 V/μV (typ).

The ac performance of the TLE2027 and TLE2037 is highlighted by a typical unity-gain bandwidth specification of 15 MHz, 55° of phase margin, and noise voltage specifications of 3.3 nV/√Hz and 2.5 nV/√Hz at frequencies of 10 Hz and 1 kHz, respectively. The TLE2037 and TLE2037A have been decompensated for faster slew rate (−7.5 V/μs, typical) and wider bandwidth (50 MHz). To ensure stability, the TLE2037 and TLE2037A should be operated with a closed-loop gain of 5 or greater.

ORDERING INFORMATION†

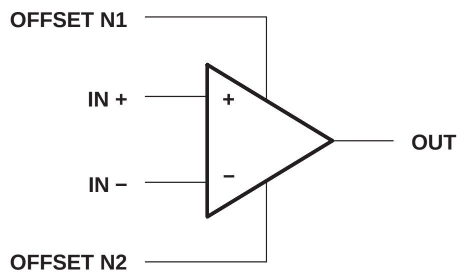
T_A	V_{IO}max AT 25°C	PACKAGE‡		ORDERABLE PART NUMBER	TOP-SIDE MARKING
−40°C to 125°C	25 μV	SOIC (D)	Tape and reel	TLE2027AQDRQ1	2027AQ
				TLE2037AQDRQ1	2037AQ
	100 μV	SOIC (D)	Tape and reel	TLE2027QDRQ1	2027Q1
				TLE2037QDRQ1	2037Q1

† For the most current package and ordering information, see the Package Option Addendum at the end of this document, or see the TI web site at http://www.ti.com.
‡ Package drawings, thermal data, and symbolization are available at http://www.ti.com/packaging.

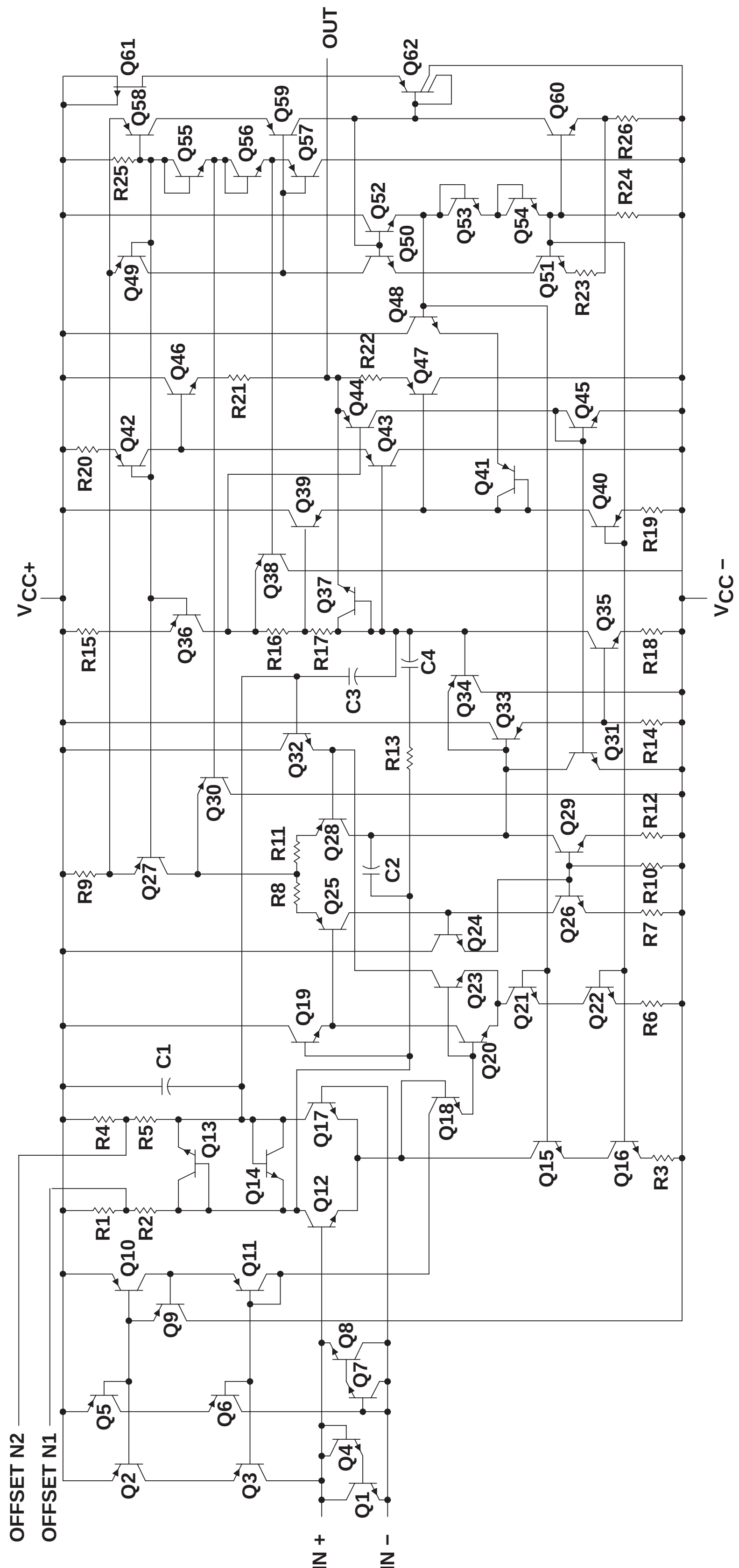
description (continued)

Both the TLE20x7 and TLE20x7A are available in a wide variety of packages, including the industry-standard 8-pin small-outline version for high-density system applications. The Q-suffix devices are characterized for operation from −40°C to 125°C.

symbol



equivalent schematic



ACTUAL DEVICE COMPONENT COUNT		
COMPONENT	**TLE2027**	**TLE2037**
Transistors	61	61
Resistors	26	26
epiFET	1	1
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
Junction temperature, T_J	142°C
Operating free-air temperature range, T_A: Q suffix	−40°C to 125°C
Storage temperature range, T_{stg}	− 65°C to 150°C
Package thermal impedance, θ_{JA} (D Package) (0 LFPM) (see Note 4)	101°C/W
Lead temperature 1,6 mm (1/16 inch) from case for 10 seconds: D package	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 may be shorted to either supply. Temperature and/or supply voltages must be limited to ensure that the maximum dissipation rating is not exceeded.
4. The thermal impedance is calculated in accordance with JESD 51−7.

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	11	V
	T_A = Full range‡	−10.2	10.2	
Operating free-air temperature, T_A		−40	125	°C

‡ Full range is −40°C to 125°C for Q-suffix devices.

TLE20x7-Q1 electrical characteristics at specified free-air temperature, $V_{CC\pm}$ = ±15 V (unless otherwise noted)

PARAMETER		TEST CONDITIONS	T_A†	TLE20x7-Q1			TLE20x7A-Q1			UNIT
				MIN	TYP	MAX	MIN	TYP	MAX	
V_{IO}	Input offset voltage	V_{IC} = 0, R_S = 50 Ω	25°C		20	100		10	25	μV
			Full range			200			105	
α_{VIO}	Temperature coefficient of input offset voltage		Full range		0.4	1		0.2	1	μV/°C
	Input offset voltage long-term drift (see Note 4)		25°C		0.006	1		0.006	1	μV/mo
I_{IO}	Input offset current		25°C		6	90		6	90	nA
			Full range			150			150	
I_{IB}	Input bias current		25°C		15	90		15	90	nA
			Full range			150			150	
V_{ICR}	Common-mode input voltage range	R_S = 50 Ω	25°C	−11 to 11	−13 to 13		−11 to 11	−13 to 13		V
			Full range	−10.3 to 10.3			−10.4 to 10.4			
V_{OM+}	Maximum positive peak output voltage swing	R_L = 600 Ω	25°C	10.5	12.9		10.5	12.9		V
			Full range	10			10			
		R_L = 2 kΩ	25°C	12	13.2		12	13.2		
			Full range	11			11			
V_{OM-}	Maximum negative peak output voltage swing	R_L = 600 Ω	25°C	−10.5	−13		−10.5	−13		V
			Full range	−10			−10			
		R_L = 2 kΩ	25°C	−12	−13.5		−12	−13.5		
			Full range	−11			−11			
A_{VD}	Large-signal differential voltage amplification	V_O = ±11 V, R_L = 2 kΩ	25°C	5	45		10	45		V/μV
		V_O = ±10 V, R_L = 2 kΩ	Full range	2.5			3.5			
		V_O = ±10 V, R_L = 1 kΩ	25°C	3.5	38		8	38		
			Full range	1.8			2.2			
		V_O = ±10 V, R_L = 600 Ω	25°C	2	19		5	19		
Ci	Input capacitance		25°C		8			8		pF
z_o	Open-loop output impedance	I_O = 0	25°C		50			50		Ω
CMRR	Common-mode rejection ratio	$V_{IC} = V_{ICR}$min, R_S = 50 Ω	25°C	100	131		117	131		dB
			Full range	96			113			
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	25°C	94	144		110	144		dB
		$V_{CC\pm}$ = ±4 V to ±18 V, R_S = 50 Ω	Full range	90			105			
I_{CC}	Supply current	V_O = 0, No load	25°C		3.8	5.3		3.8	5.3	mA
			Full range			5.6			5.6	

† Full range is −40°C to 125°C.

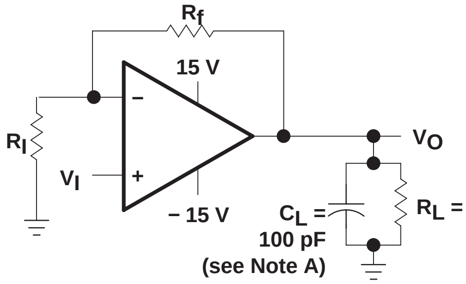
NOTE 4: Typical values are based on the input offset voltage shift observed through 168 hours of operating life test at T_A = 150°C extrapolated to T_A = 25°C using the Arrhenius equation and assuming an activation energy of 0.96 eV.

TLE20x7-Q1 operating characteristics at specified free-air temperature, $V_{CC\pm} = \pm15$ V, $T_A = 25°C$ (unless otherwise specified)

PARAMETER		TEST CONDITIONS		TLE20x7-Q1 MIN	TLE20x7-Q1 TYP	TLE20x7-Q1 MAX	TLE20x7A-Q1 MIN	TLE20x7A-Q1 TYP	TLE20x7A-Q1 MAX	UNIT
SR	Slew rate at unity gain	$R_L = 2$ kΩ, $C_L = 100$ pF, See Figure 1	TLE2027	1.7	2.8		1.7	2.8		V/μs
			TLE2037	6	7.5		6	7.5		
		$R_L = 2$ kΩ, $C_L = 100$ pF, $T_A = -55°C$ to 125°C, See Figure 1	TLE2027	1			1			
			TLE2037	4.4			4.4			
V_n	Equivalent input noise voltage (see Figure 2)	$R_S = 20$ Ω,	f = 10 Hz		3.3	8		3.3	4.5	nV/√Hz
		$R_S = 20$ Ω,	f = 1 kHz		2.5	4.5		2.5	3.8	
$V_{N(PP)}$	Peak-to-peak equivalent input noise voltage	f = 0.1 Hz to 10 Hz			50	250		50	130	nV
I_n	Equivalent input noise current	f = 10 Hz			10			10		pA/√Hz
		f = 1 kHz			0.8			0.8		
THD	Total harmonic distortion	$V_O = +10$ V, $A_{VD} = 1$, See Note 5	TLE2027		<0.002			<0.002		%
		$V_O = +10$ V, $A_{VD} = 5$, See Note 5	TLE2037		<0.002			<0.002		
B_1	Unity-gain bandwidth (see Figure 3)	$R_L = 2$ kΩ, $C_L = 100$ pF	TLE2027	7	13		9	13		MHz
			TLE2037	35	50		35	50		
B_{OM}	Maximum output-swing bandwidth	$R_L = 2$ kΩ	TLE2027		30			30		kHz
			TLE2037		80			80		
ϕ_m	Phase margin at unity gain (see Figure 3)	$R_L = 2$ kΩ, $C_L = 100$ pF	TLE2027		55			55		°
			TLE2037		50			50		

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

PARAMETER MEASUREMENT INFORMATION



NOTE A: C_L includes fixture capacitance.

Figure 1. Slew-Rate Test Circuit

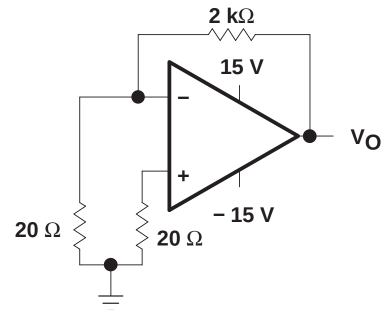
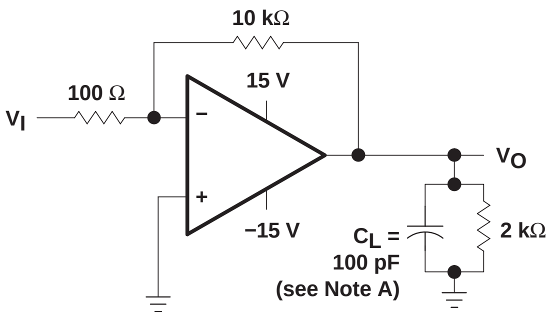
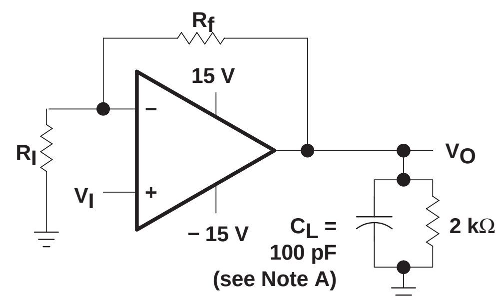


Figure 2. Noise-Voltage Test Circuit



NOTE A: C_L includes fixture capacitance.

Figure 3. Unity-Gain Bandwidth and Phase-Margin Test Circuit (TLE2027 Only)



NOTES: A. C_L includes fixture capacitance.
B. For the TLE2037 and TLE2037A, A_{VD} must be ≥ 5.

Figure 4. Small-Signal Pulse-Response Test Circuit

typical values

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

initial estimates of parameter distributions

In the ongoing program of improving data sheets and supplying more information to our customers, Texas Instruments has added an estimate of not only the typical values, but also the spread around these values. These are in the form of distribution bars that show the 95% (upper) points and the 5% (lower) points from the characterization of the initial wafer lots of this new device type (see Figure 5). The distribution bars are shown at the points where data was actually collected. The 95% and 5% points are used instead of ±3 sigma, since some of the distributions are not true Gaussian distributions.

The number of units tested and the number of different wafer lots used are on all of the graphs where distribution bars are shown. As noted in Figure 5, there were a total of 835 units from two wafer lots. In this case, there is a good estimate for the within-lot variability and a possibly poor estimate of the lot-to-lot variability. This is always the case on newly released products, since there can only be data available from a few wafer lots.

The distribution bars are not intended to replace the minimum and maximum limits in the electrical tables. Each distribution bar represents 90% of the total units tested at a specific temperature. While 10% of the units tested fell outside any given distribution bar, this should not be interpreted to mean that the same individual devices fell outside every distribution bar.

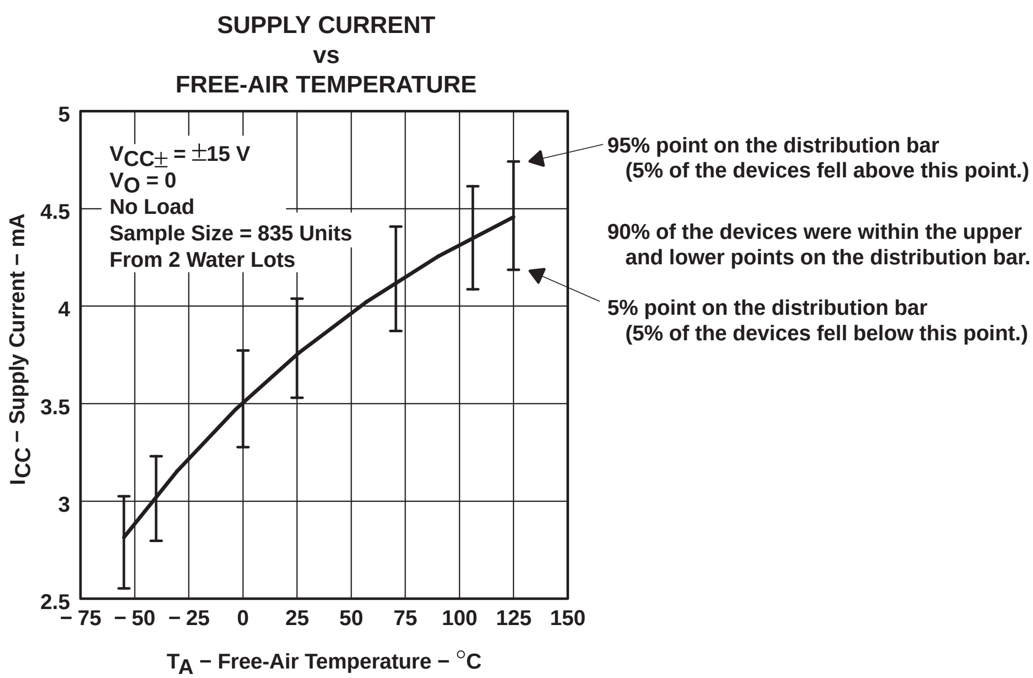


Figure 5. Sample Graph With Distribution Bars

TYPICAL CHARACTERISTICS

Table of Graphs

			FIGURE
V_{IO}	Input offset voltage	Distribution	6, 7
ΔV_{IO}	Input offset voltage change	vs Time after power on	8, 9
I_{IO}	Input offset current	vs Free-air temperature	10
I_{IB}	Input bias current	vs Free-air temperature vs Common-mode input voltage	11 12
I_I	Input current	vs Differential input voltage	13
$V_{O(PP)}$	Maximum peak-to-peak output voltage	vs Frequency	14, 15
V_{OM}	Maximum (positive/negative) peak output voltage	vs Load resistance vs Free-air temperature	16, 17 18, 19
A_{VD}	Large-signal differential voltage amplification	vs Supply voltage vs Load resistance vs Frequency vs Free-air temperature	20 21 22 − 25 26
z_o	Output impedance	vs Frequency	27
CMRR	Common-mode rejection ratio	vs Frequency	28
k_{SVR}	Supply-voltage rejection ratio	vs Frequency	29
I_{OS}	Short-circuit output current	vs Supply voltage vs Elapsed time vs Free-air temperature	30, 31 32, 33 34, 35
I_{CC}	Supply current	vs Supply voltage vs Free-air temperature	36 37
	Voltage-follower pulse response	Small signal Large signal	38, 40 39, 41
V_n	Equivalent input noise voltage	vs Frequency	42
	Noise voltage (referred to input)	Over 10-second interval	43
B_1	Unity-gain bandwidth	vs Supply voltage vs Load capacitance	44 45
	Gain bandwidth product	vs Supply voltage vs Load capacitance	46 47
SR	Slew rate	vs Free-air temperature	48, 49
ϕ_m	Phase margin	vs Supply voltage vs Load capacitance vs Free-air temperature	50, 51 52, 53 54, 55
	Phase shift	vs Frequency	22 − 25

TYPICAL CHARACTERISTICS

DISTRIBUTION
INPUT OFFSET VOLTAGE

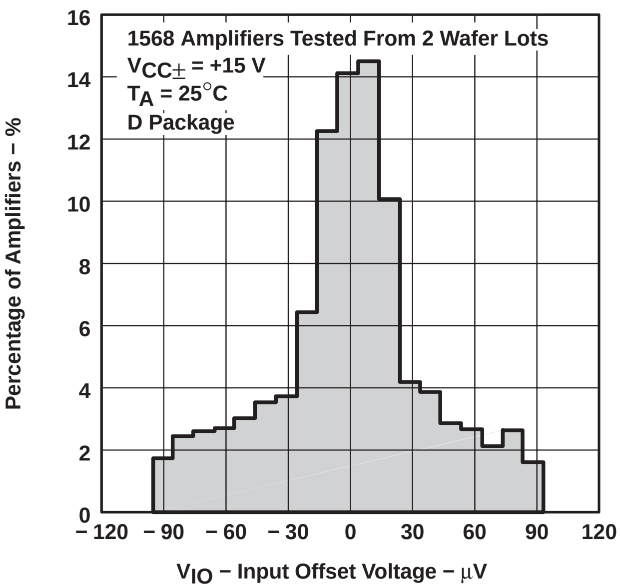


Figure 6

INPUT OFFSET VOLTAGE CHANGE
vs
TIME AFTER POWER ON

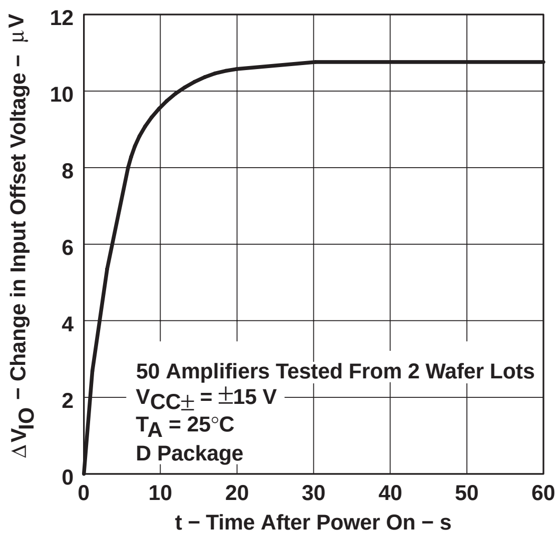


Figure 7

INPUT OFFSET VOLTAGE CHANGE
vs
TIME AFTER POWER ON

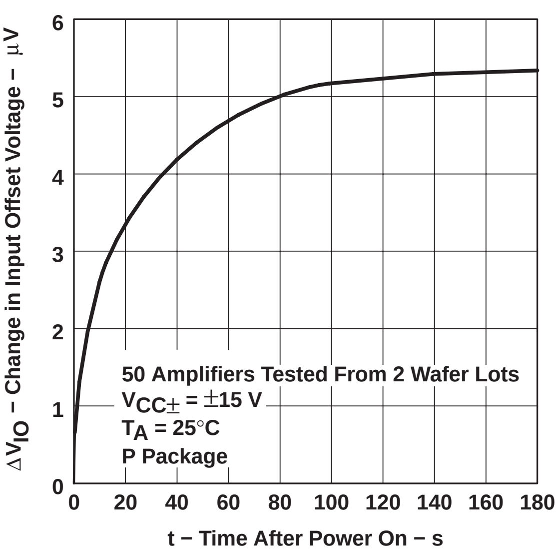


Figure 8

INPUT OFFSET CURRENT†
vs
FREE-AIR TEMPERATURE

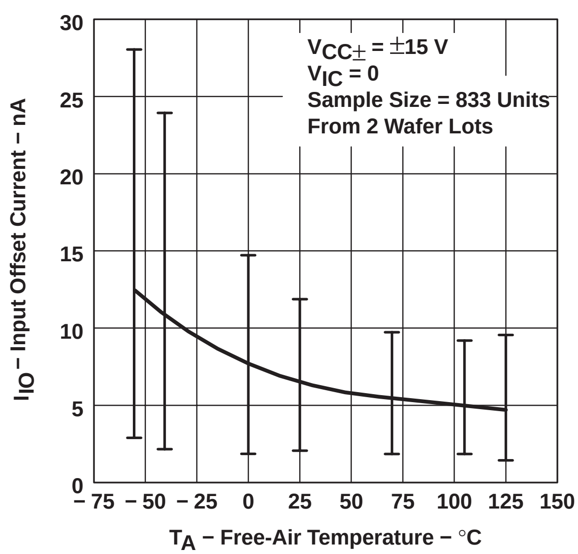


Figure 9

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

TYPICAL CHARACTERISTICS

**INPUT BIAS CURRENT †
vs
FREE-AIR TEMPERATURE**

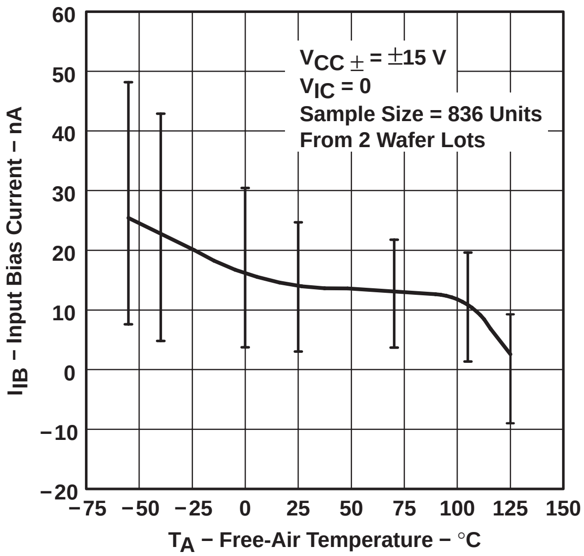


Figure 10

**INPUT BIAS CURRENT
vs
COMMON-MODE INPUT VOLTAGE**

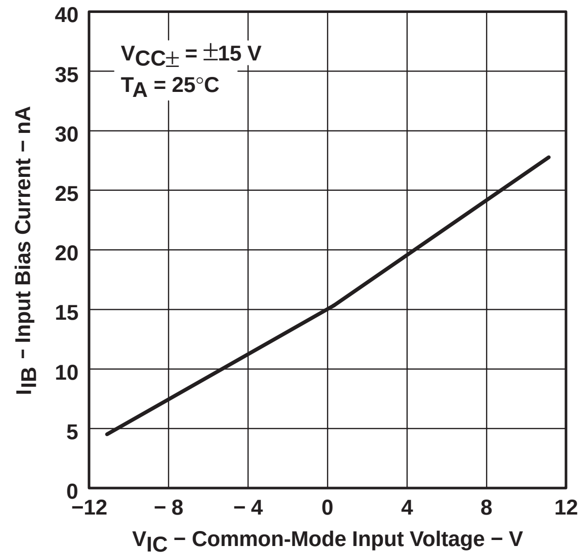


Figure 11

**INPUT CURRENT
vs
DIFFERENTIAL INPUT VOLTAGE**

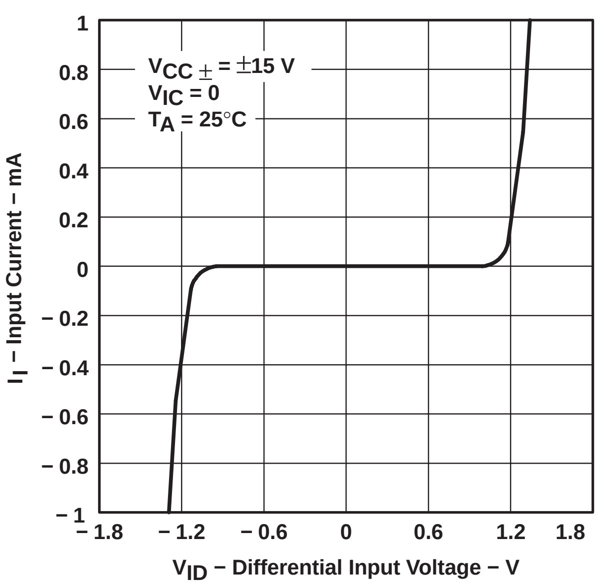


Figure 12

**TLE2027
MAXIMUM PEAK-TO-PEAK
OUTPUT VOLTAGE †
vs
FREQUENCY**

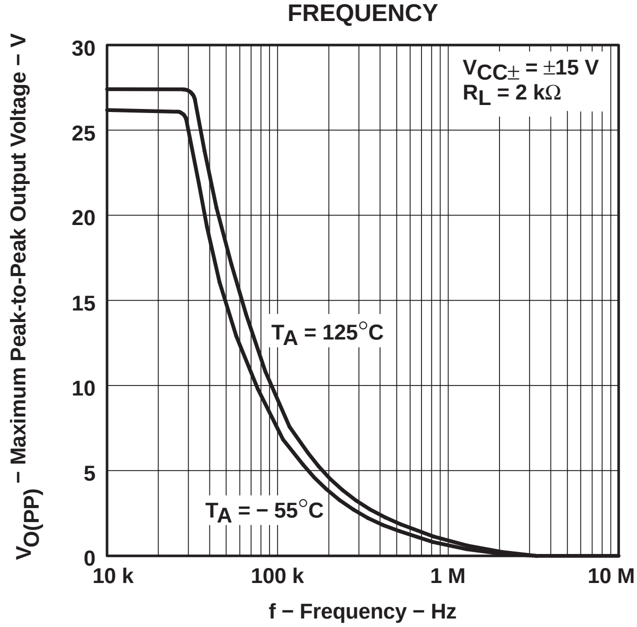


Figure 13

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

TYPICAL CHARACTERISTICS

TLE2037
MAXIMUM PEAK-TO-PEAK
OUTPUT VOLTAGE†
vs
FREQUENCY

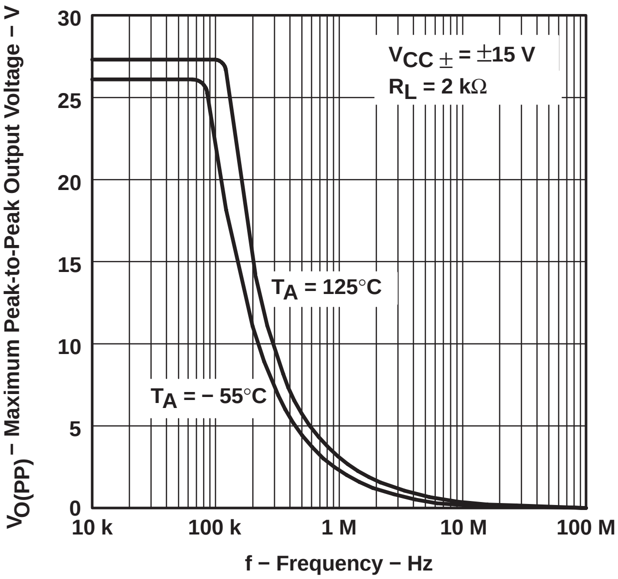


Figure 14

MAXIMUM POSITIVE PEAK
OUTPUT VOLTAGE
vs
LOAD RESISTANCE

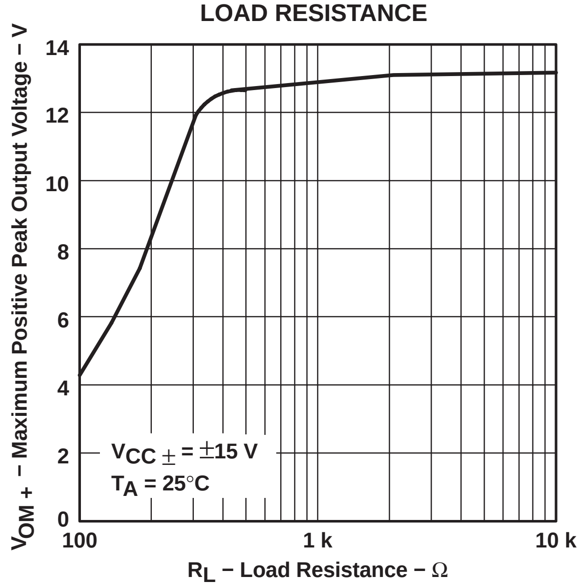


Figure 15

MAXIMUM NEGATIVE PEAK
OUTPUT VOLTAGE
vs
LOAD RESISTANCE

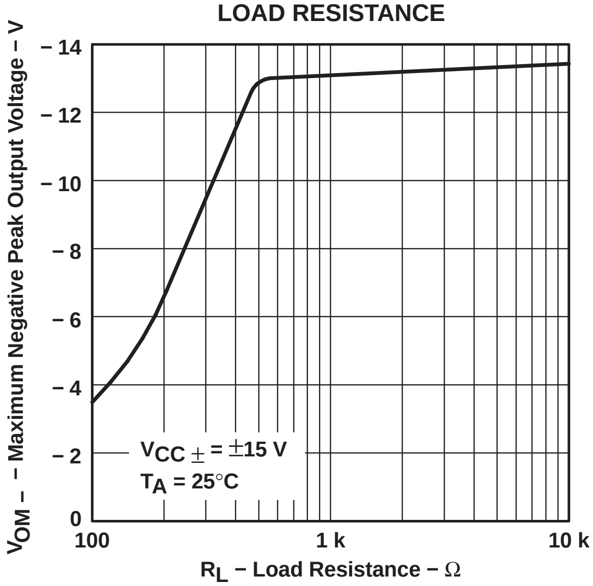


Figure 16

MAXIMUM POSITIVE PEAK
OUTPUT VOLTAGE†
vs
FREE-AIR TEMPERATURE

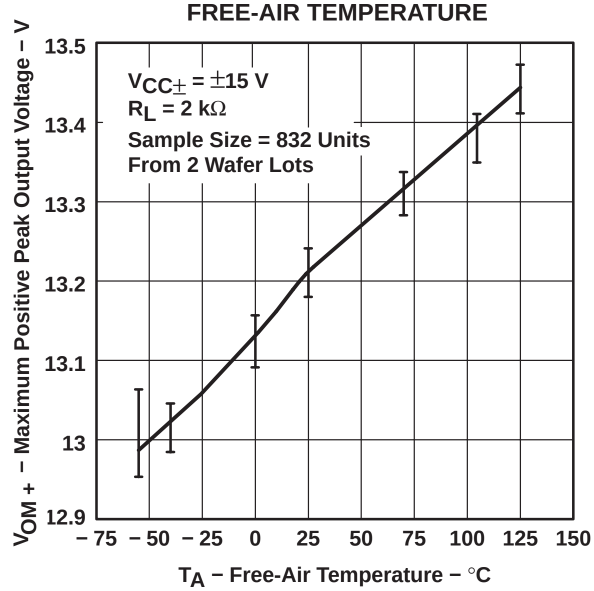


Figure 17

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

TYPICAL CHARACTERISTICS

MAXIMUM NEGATIVE PEAK OUTPUT VOLTAGE† vs FREE-AIR TEMPERATURE

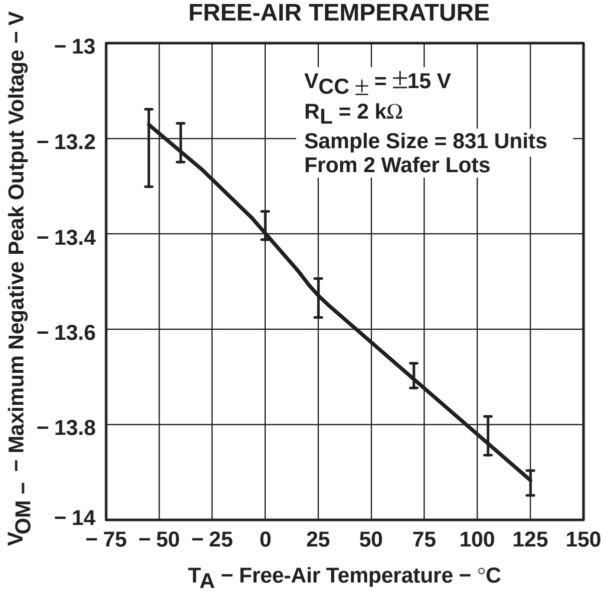


Figure 18

LARGE-SIGNAL DIFFERENTIAL VOLTAGE AMPLIFICATION vs SUPPLY VOLTAGE

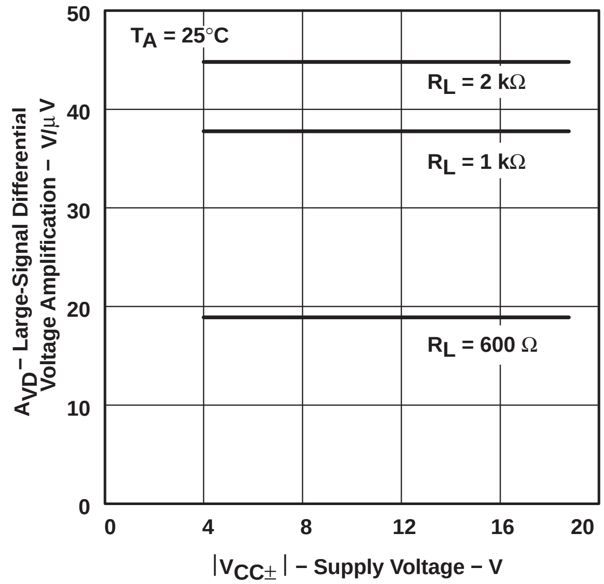


Figure 19

LARGE-SIGNAL DIFFERENTIAL VOLTAGE AMPLIFICATION vs LOAD RESISTANCE

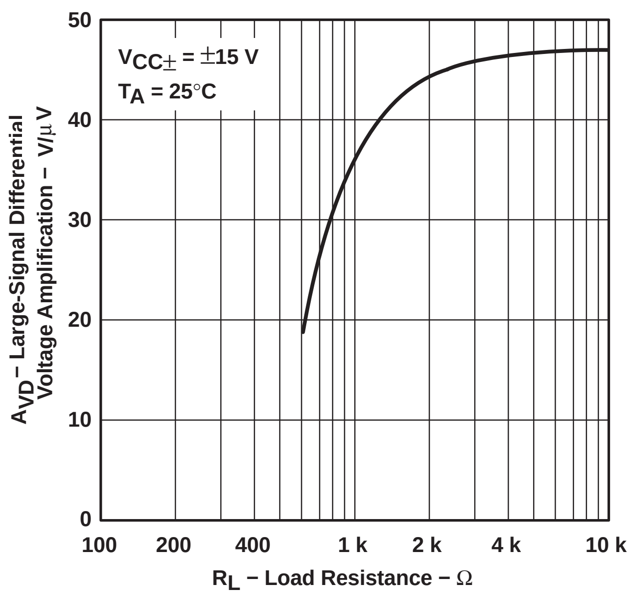


Figure 20

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

TYPICAL CHARACTERISTICS

TLE2027
LARGE-SIGNAL DIFFERENTIAL VOLTAGE AMPLIFICATION AND PHASE SHIFT
vs
FREQUENCY

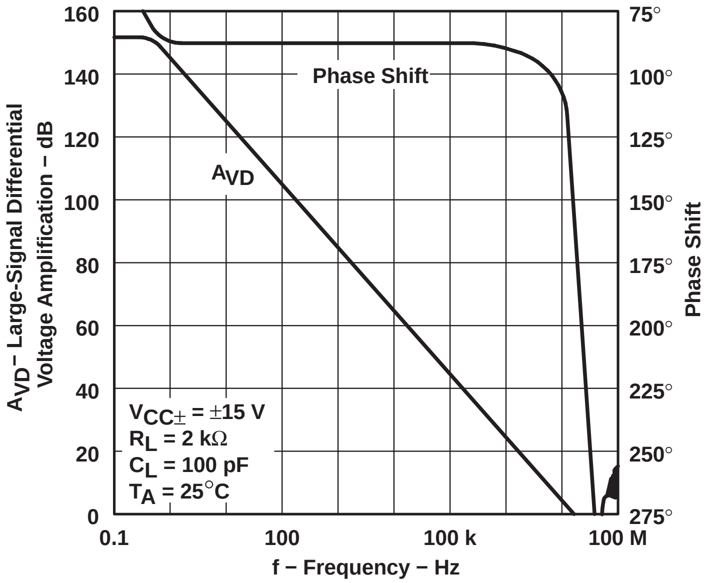


Figure 21

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

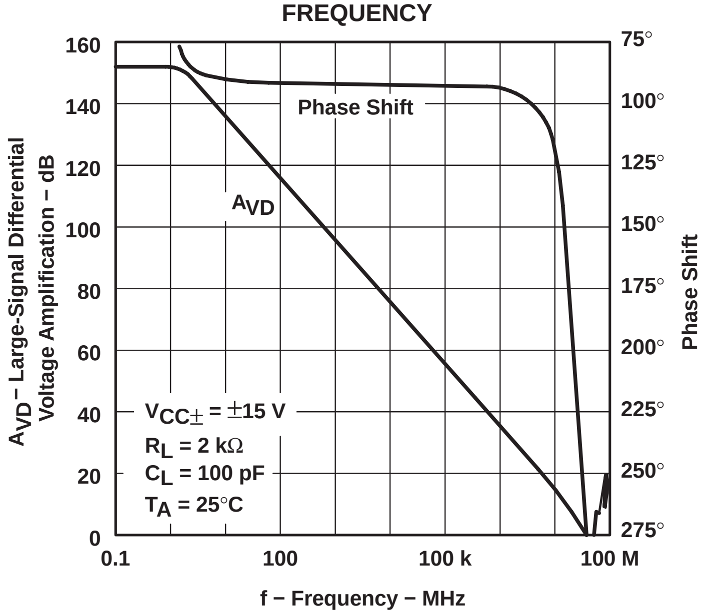


Figure 22

TYPICAL CHARACTERISTICS

TLE2027
LARGE-SIGNAL DIFFERENTIAL VOLTAGE AMPLIFICATION AND PHASE SHIFT
vs
FREQUENCY

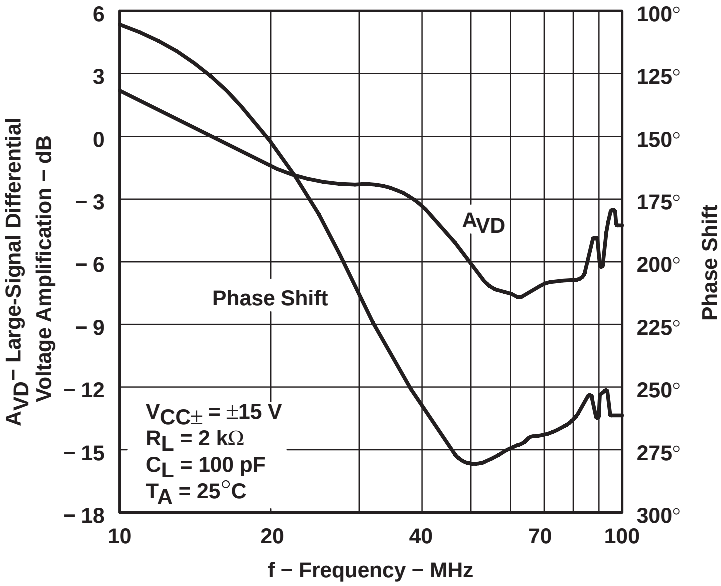


Figure 23

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

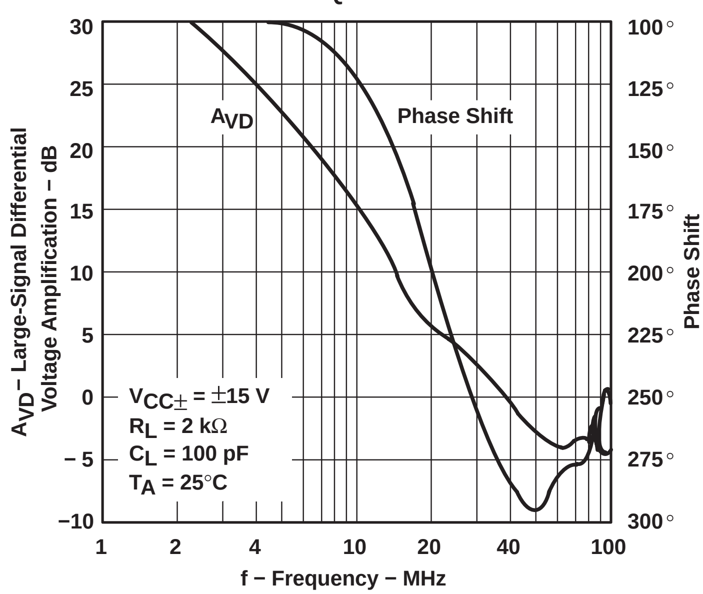


Figure 24

TYPICAL CHARACTERISTICS

LARGE-SIGNAL DIFFERENTIAL VOLTAGE AMPLIFICATION† vs FREE-AIR TEMPERATURE

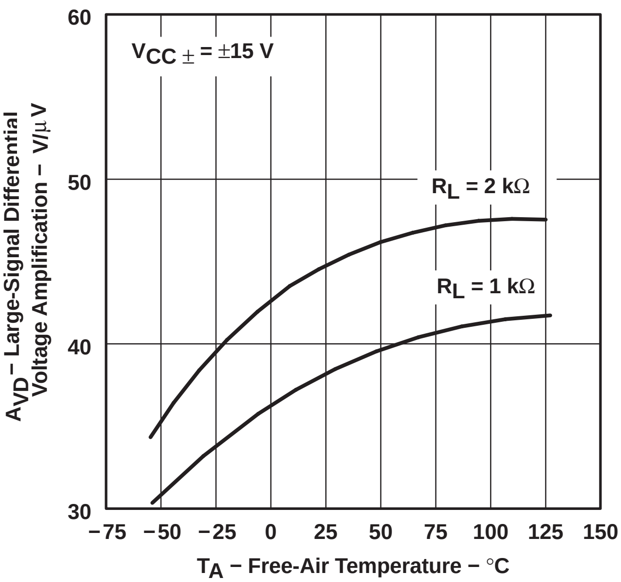
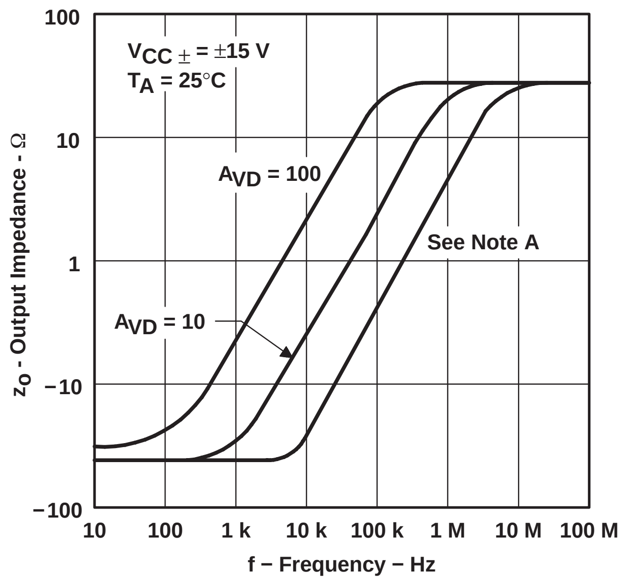


Figure 25

OUTPUT IMPEDANCE vs FREQUENCY



NOTE A: For this curve, the TLE2027 is A_{VD} = 1 and the TLE2037 is A_{VD} = 5.

Figure 26

COMMON-MODE REJECTION RATIO vs FREQUENCY

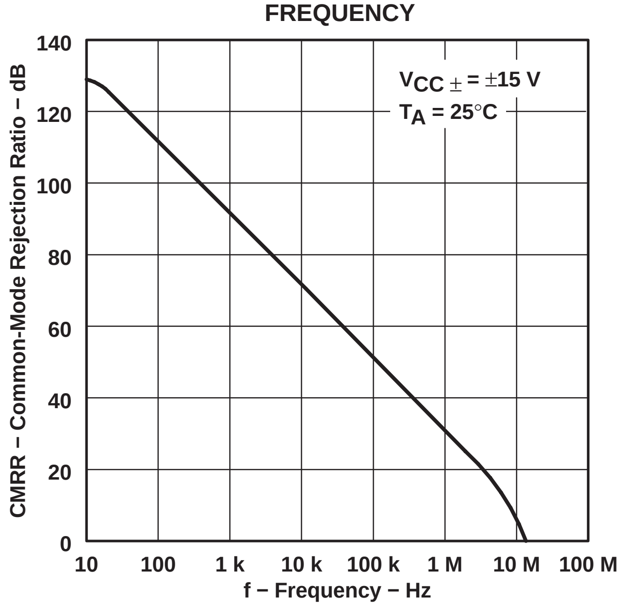


Figure 27

SUPPLY-VOLTAGE REJECTION RATIO vs FREQUENCY

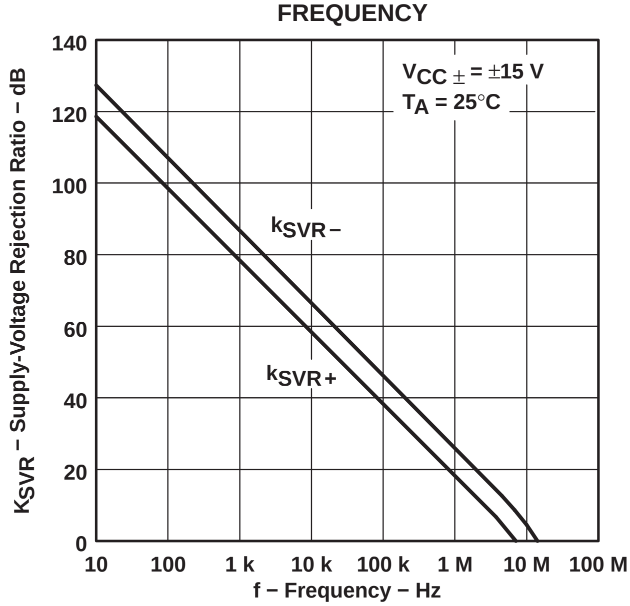


Figure 28

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

TYPICAL CHARACTERISTICS

SHORT-CIRCUIT OUTPUT CURRENT vs SUPPLY VOLTAGE

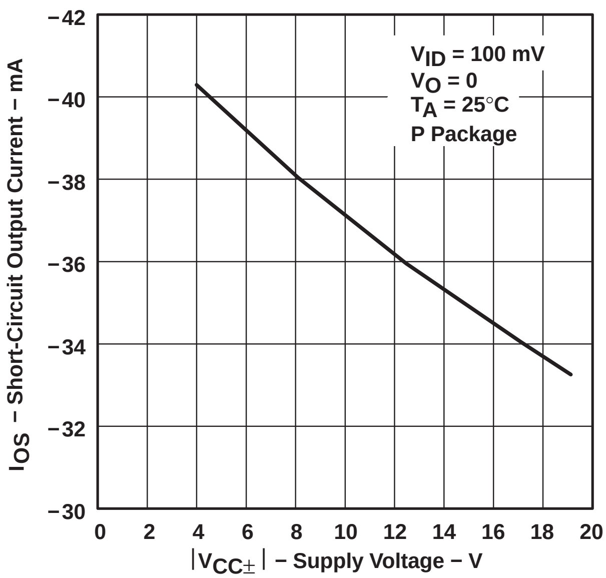


Figure 29

SHORT-CIRCUIT OUTPUT CURRENT vs SUPPLY VOLTAGE

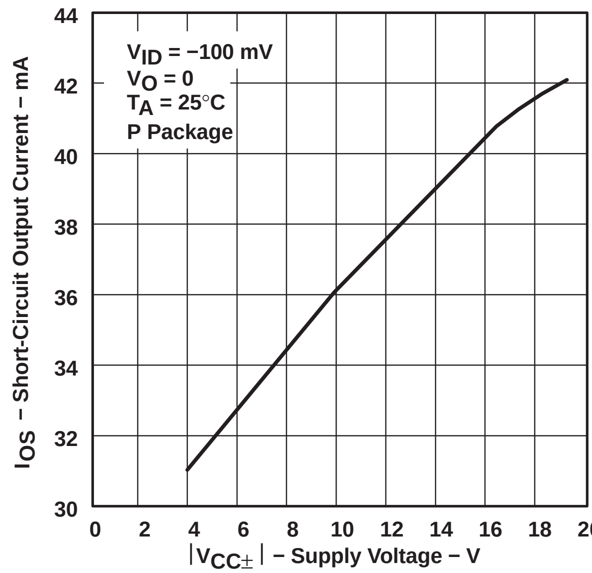


Figure 30

SHORT-CIRCUIT OUTPUT CURRENT vs ELAPSED TIME

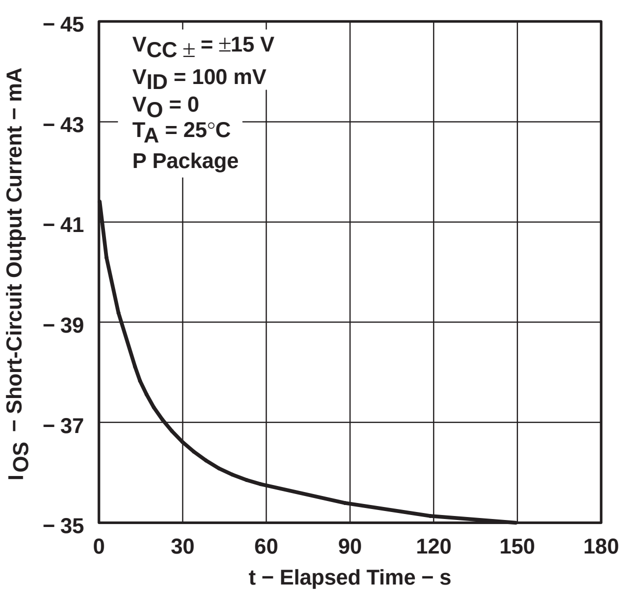


Figure 31

SHORT-CIRCUIT OUTPUT CURRENT vs ELAPSED TIME

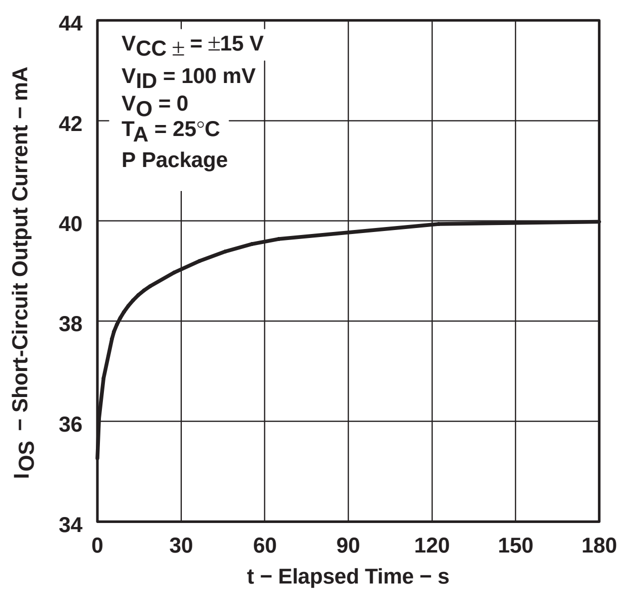


Figure 32

TYPICAL CHARACTERISTICS

SHORT-CIRCUIT OUTPUT CURRENT † vs FREE-AIR TEMPERATURE

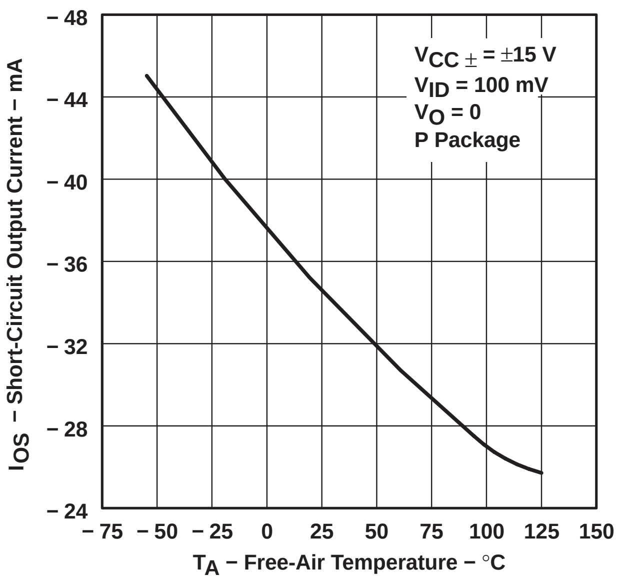


Figure 33

SHORT-CIRCUIT OUTPUT CURRENT † vs FREE-AIR TEMPERATURE

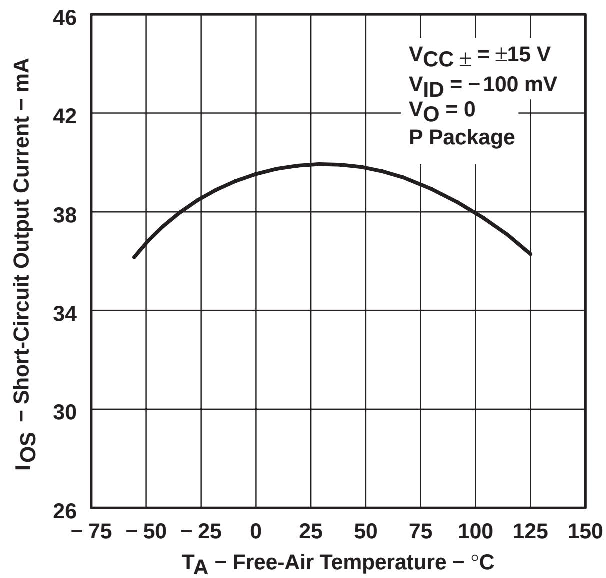


Figure 34

SUPPLY CURRENT † vs SUPPLY VOLTAGE

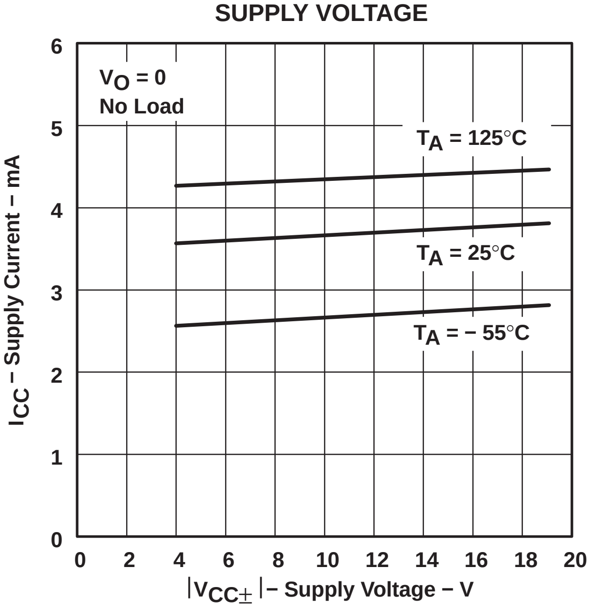


Figure 35

SUPPLY CURRENT † vs FREE-AIR TEMPERATURE

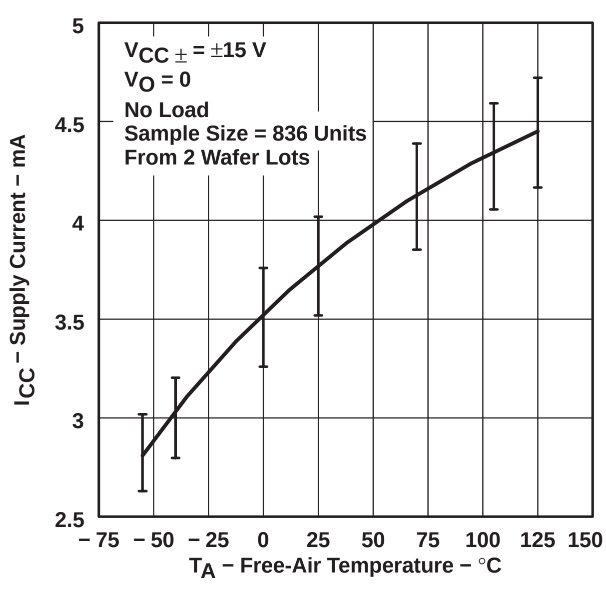


Figure 36

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

TYPICAL CHARACTERISTICS

TLE2027 VOLTAGE-FOLLOWER SMALL-SIGNAL PULSE RESPONSE

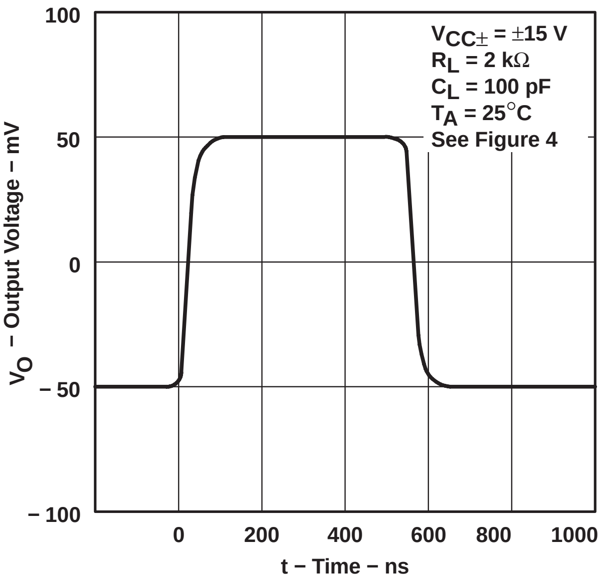


Figure 37

TLE2027 VOLTAGE-FOLLOWER LARGE-SIGNAL PULSE RESPONSE

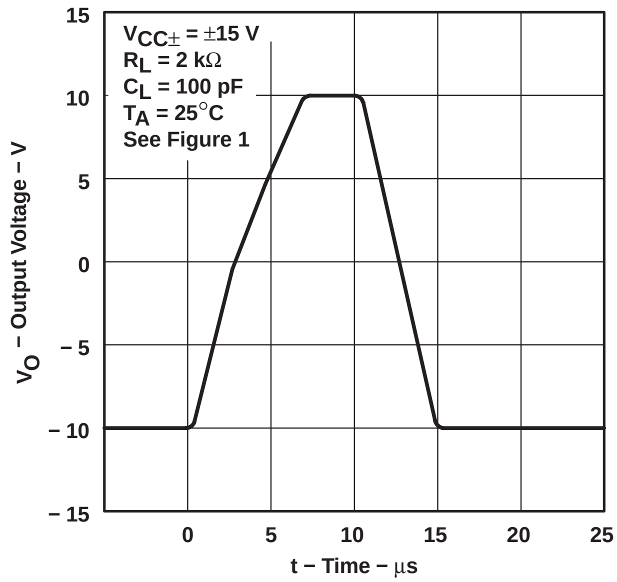


Figure 38

TLE2037 VOLTAGE-FOLLOWER SMALL-SIGNAL PULSE RESPONSE

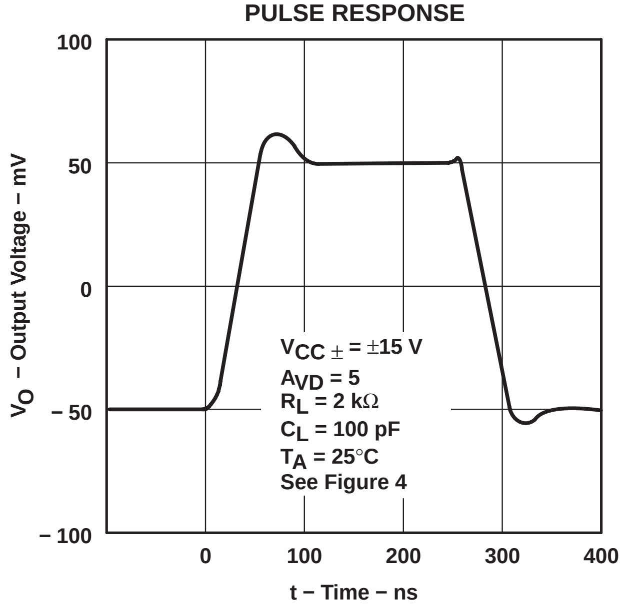


Figure 39

TLE2037 VOLTAGE-FOLLOWER LARGE-SIGNAL PULSE RESPONSE

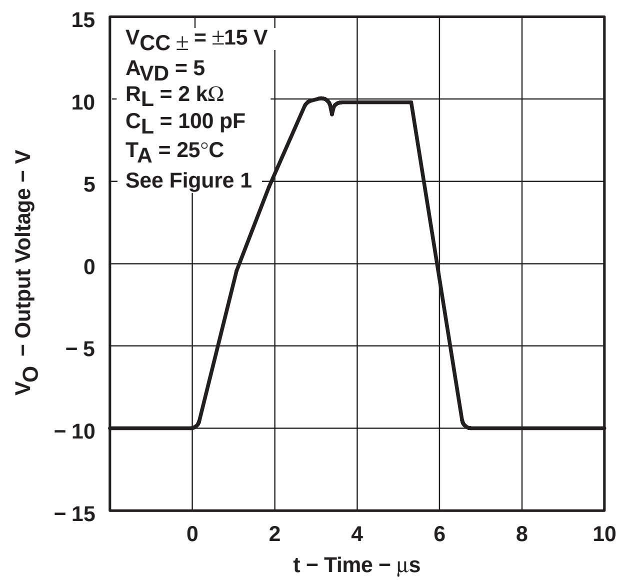


Figure 40

TYPICAL CHARACTERISTICS

EQUIVALENT INPUT NOISE VOLTAGE vs FREQUENCY

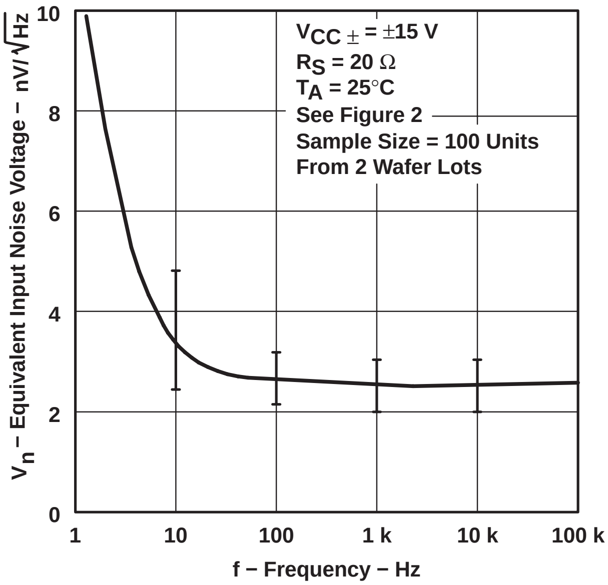


Figure 41

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

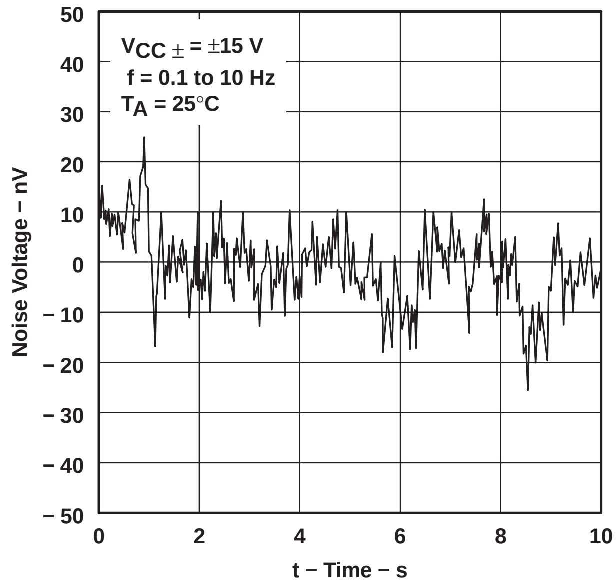


Figure 42

TLE2027 UNITY-GAIN BANDWIDTH vs SUPPLY VOLTAGE

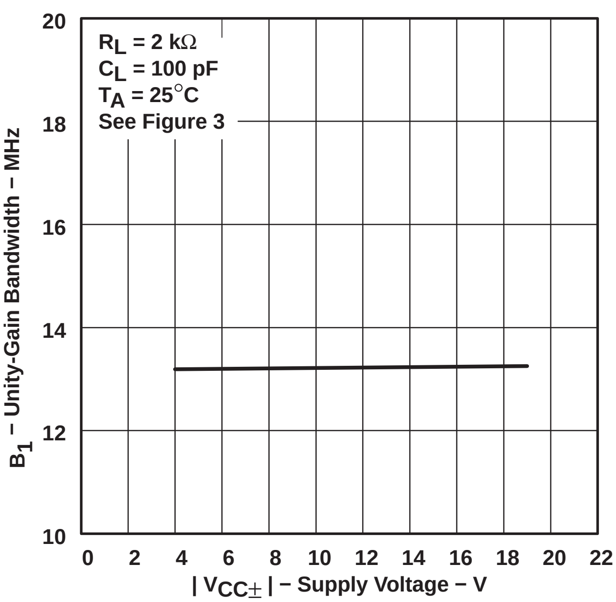


Figure 43

TLE2037 GAIN-BANDWIDTH PRODUCT vs SUPPLY VOLTAGE

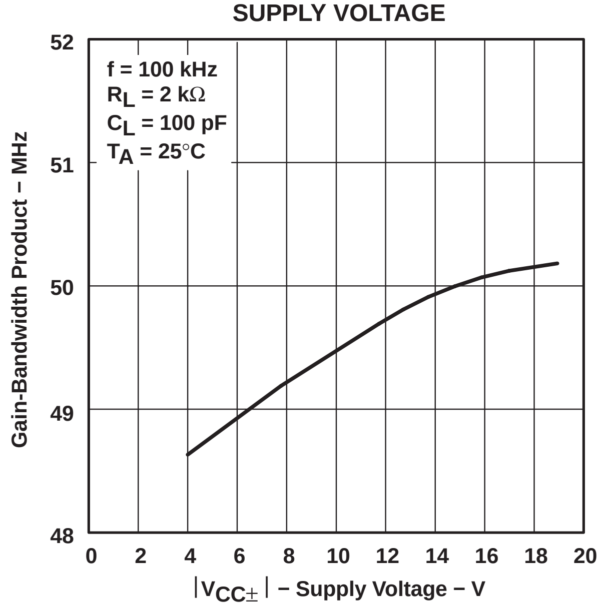


Figure 44

TYPICAL CHARACTERISTICS

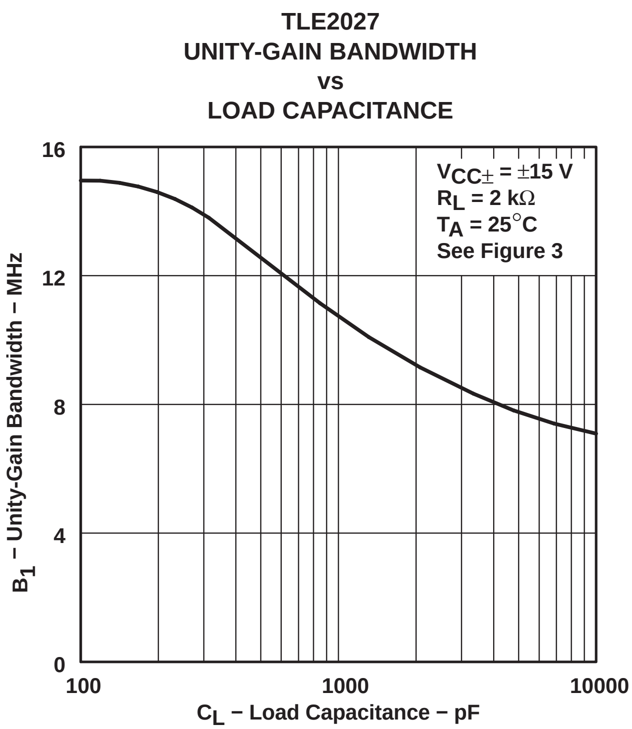


Figure 45

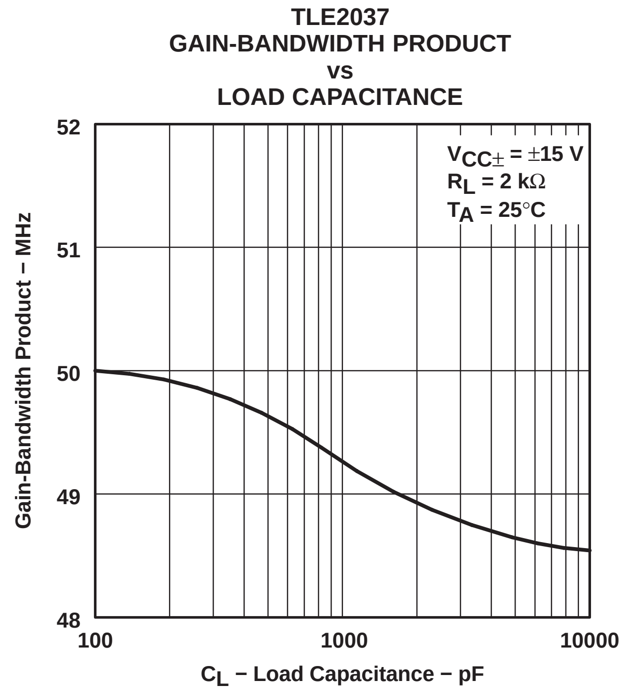


Figure 46

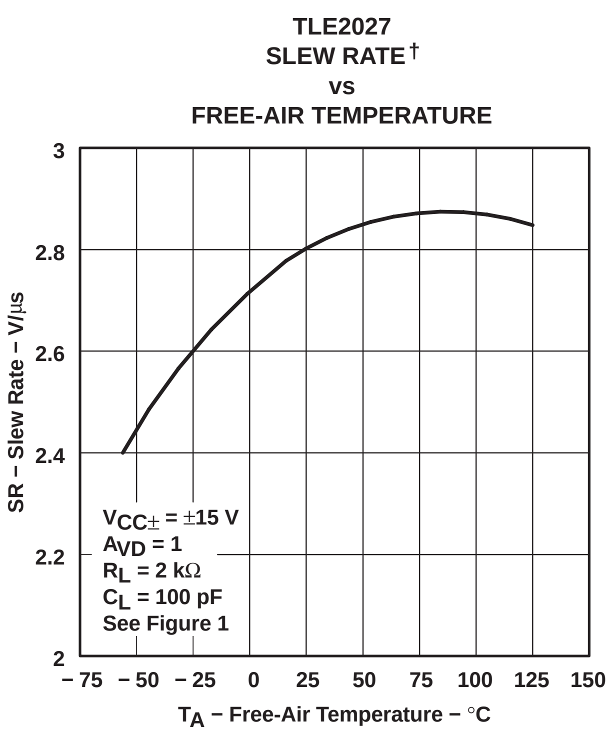


Figure 47

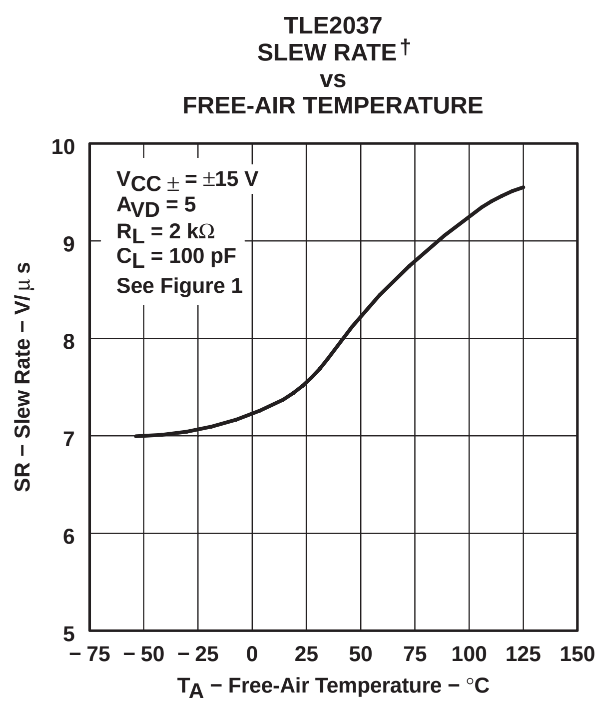


Figure 48

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

TYPICAL CHARACTERISTICS

TLE2027
PHASE MARGIN
vs
SUPPLY VOLTAGE

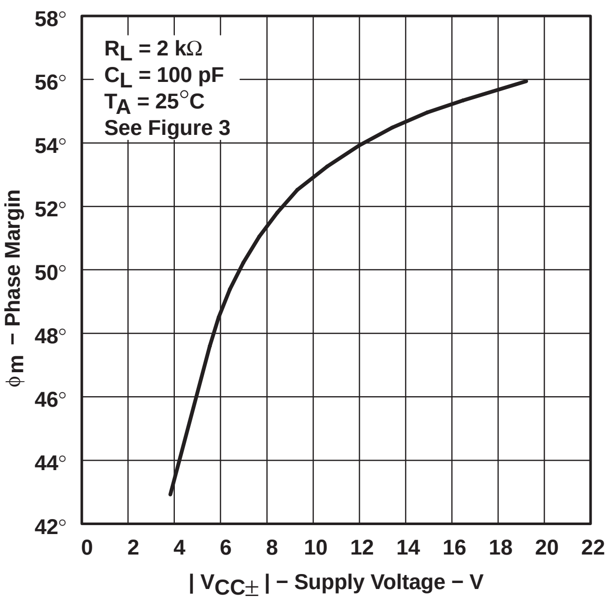


Figure 49

TLE2037
PHASE MARGIN
vs
SUPPLY VOLTAGE

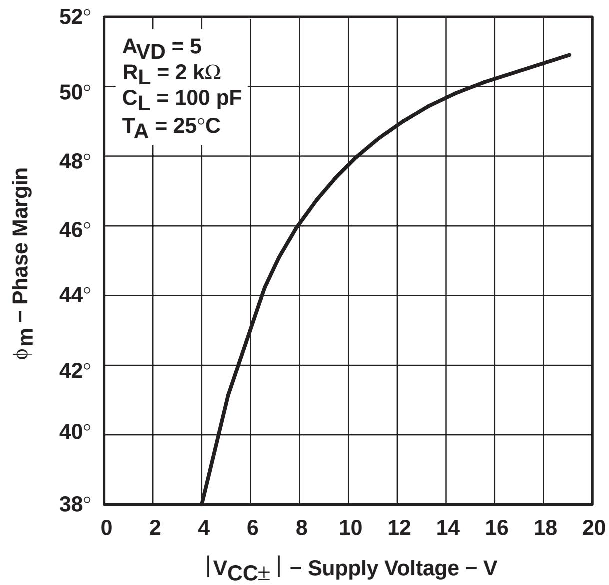


Figure 50

TLE2027
PHASE MARGIN
vs
LOAD CAPACITANCE

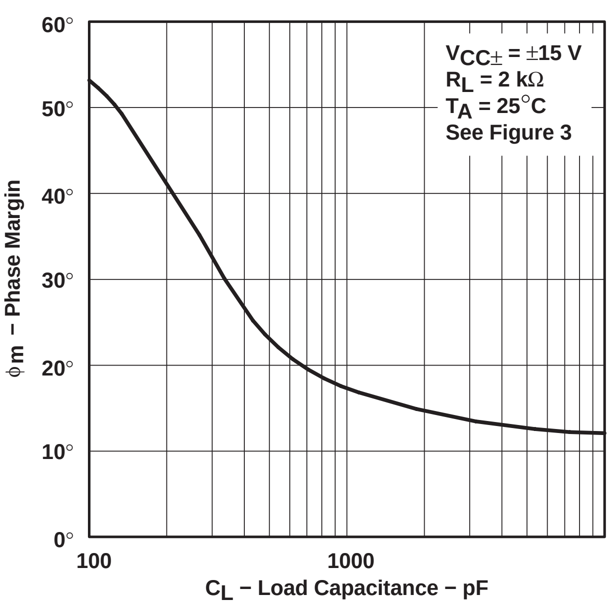


Figure 51

TLE2037
PHASE MARGIN
vs
LOAD CAPACITANCE

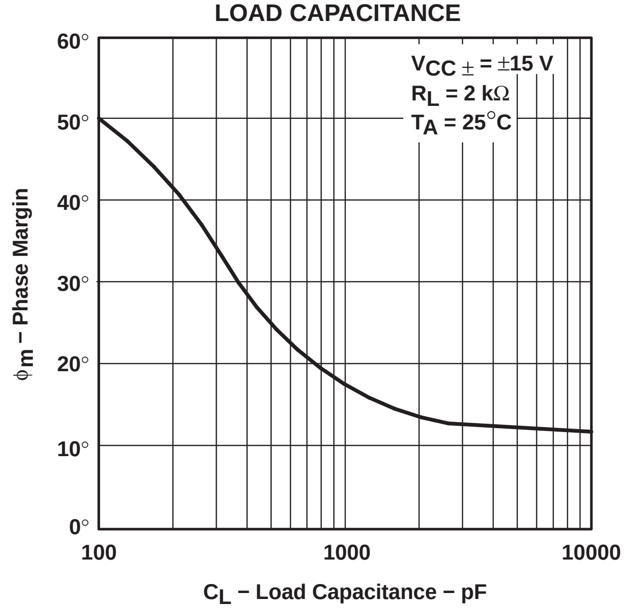


Figure 52

TYPICAL CHARACTERISTICS

TLE2027
PHASE MARGIN†
vs
FREE-AIR TEMPERATURE

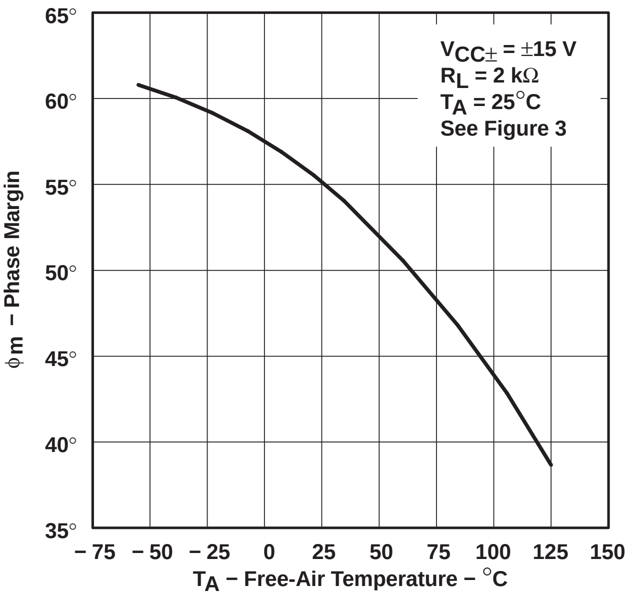


Figure 53

TLE2037
PHASE MARGIN†
vs
FREE-AIR TEMPERATURE

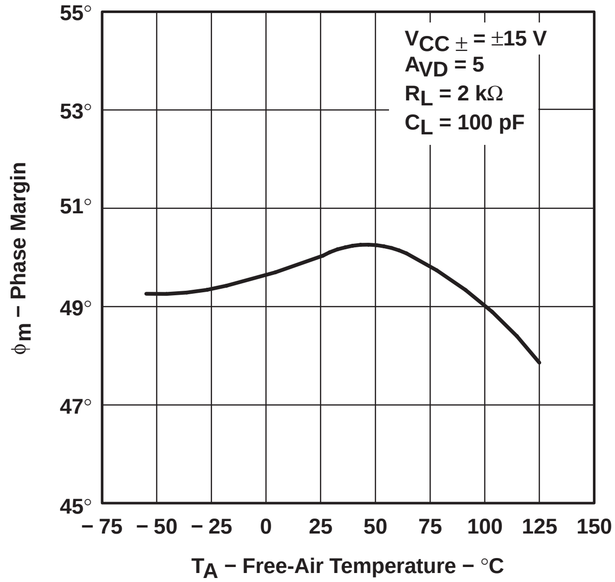


Figure 54

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

APPLICATION INFORMATION

input offset voltage nulling

The TLE2027 and TLE2037 series offers external null pins that can be used to further reduce the input offset voltage. The circuits of Figure 55 can be connected as shown if the feature is desired. If external nulling is not needed, the null pins may be left disconnected.

(a) STANDARD ADJUSTMENT (b) ADJUSTMENT WITH IMPROVED SENSITIVITY

Figure 55. Input Offset Voltage Nulling Circuits

voltage-follower applications

The TLE2027 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. It is recommended that a feedback resistor be used 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 phase margin. This problem can be alleviated by adding a capacitor (20 pF to 50 pF) in parallel with the feedback resistor (see Figure 56).

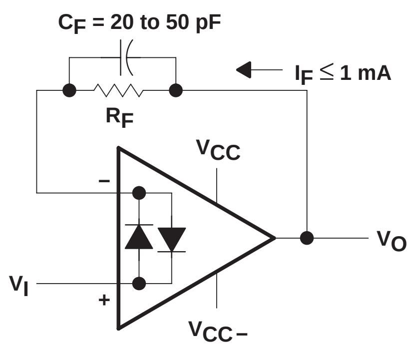


Figure 56. Voltage Follower

APPLICATION INFORMATION

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 57, Figure 58, and Figure 59 were generated using the TLE20x7 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
- Gain-bandwidth product
- 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).

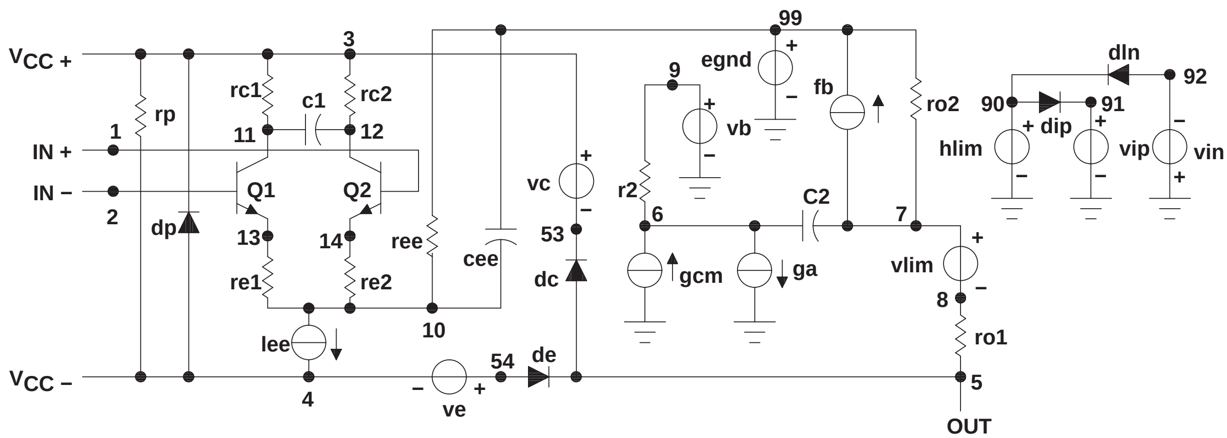


Figure 57. Boyle Macromodel

PSpice and *Parts* are trademarks of MicroSim Corporation.

APPLICATION INFORMATION

macromodel information (continued)

```
.subckt TLE2027 1 2 3 4 5
*
  c1      11   12   4.003E-12
  c2       6    7   20.00E-12
  dc       5   53   dz
  de      54    5   dz
  dlp     90   91   dz
  dln     92   90   dx
  dp       4    3   dz
  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
.modeldx D(Is=800.0E-18)
.modelqx NPN(Is=800.0E-18
Bf=7.000E3)
.ends
```

Figure 58. TLE2027 Macromodel Subcircuit

```
.subckt TLE2037 1 2 3 4 5
*
  c1      11   12   4.003E−12
  c2       6    7   7.500E−12
  dc       5   53   dz
  de      54    5   dz
  dlp     90   91   dz
  dln     92   90   dx
  dp       4    3   dz
  egnd    99    0   poly(2)  (3,0)
     (4,0)  0  .5  .5
  fb       7   99   poly(5)  vb vc
     ve vip vln 0 923.4E6 A800E6
     800E6 800E6 A800E6
  ga       6    0   11 12 2.121E−3
  gcm      0    6   10 99 597.7E−12
  iee     10    4   dc 56.26E−6
  hlim    90    0   vlim 1K
  q1      11    2   13 qx
  q2      12    1   14 qz
  r2       6    9   100.0E3
  rc1      3   11   471.5
  rc2      3   12   471.5
  re1     13   10   A448
  re2     14   10   A448
  ree     10   99   3.555E6
  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     dxD(Is=800.0E−18)
.model     qxNPN(Is=800.0E−18
   Bf=7.031E3)
.ends
```

Figure 59. TLE2037 Macromodel Subcircuit

PACKAGING INFORMATION

Orderable Device	Status (1)	Package Type	Package Drawing	Pins	Package Qty	Eco Plan (2)	Lead/Ball Finish (6)	MSL Peak Temp (3)	Op Temp (°C)	Device Marking (4/5)	Samples
TLE2037AQDRG4Q1	ACTIVE	SOIC	D	8	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	-40 to 125	2037AQ1	Samples
TLE2037AQDRQ1	ACTIVE	SOIC	D	8	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	-40 to 125	2037AQ1	Samples
TLE2037QDRQ1	OBSOLETE	SOIC	D	8		TBD	Call TI	Call TI	-40 to 125		

(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), Pb-Free (RoHS Exempt), or Green (RoHS & no Sb/Br) - please check http://www.ti.com/productcontent for the latest availability information and additional product content details.
TBD: The Pb-Free/Green conversion plan has not been defined.
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.
Pb-Free (RoHS Exempt): This component has a RoHS exemption for either 1) lead-based flip-chip solder bumps used between the die and package, or 2) lead-based die adhesive used between the die and leadframe. The component is otherwise considered Pb-Free (RoHS compatible) as defined above.
Green (RoHS & no Sb/Br): TI defines "Green" to mean Pb-Free (RoHS compatible), and free of Bromine (Br) and Antimony (Sb) based flame retardants (Br or Sb do not exceed 0.1% by weight in homogeneous material)

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

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

(5) Multiple Device Markings will be inside parentheses. Only one Device Marking contained in parentheses and separated by a "~" will appear on a device. If a line is indented then it is a continuation of the previous line and the two combined represent the entire Device Marking for that device.

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

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In no event shall TI's liability arising out of such information exceed the total purchase price of the TI part(s) at issue in this document sold by TI to Customer on an annual basis.

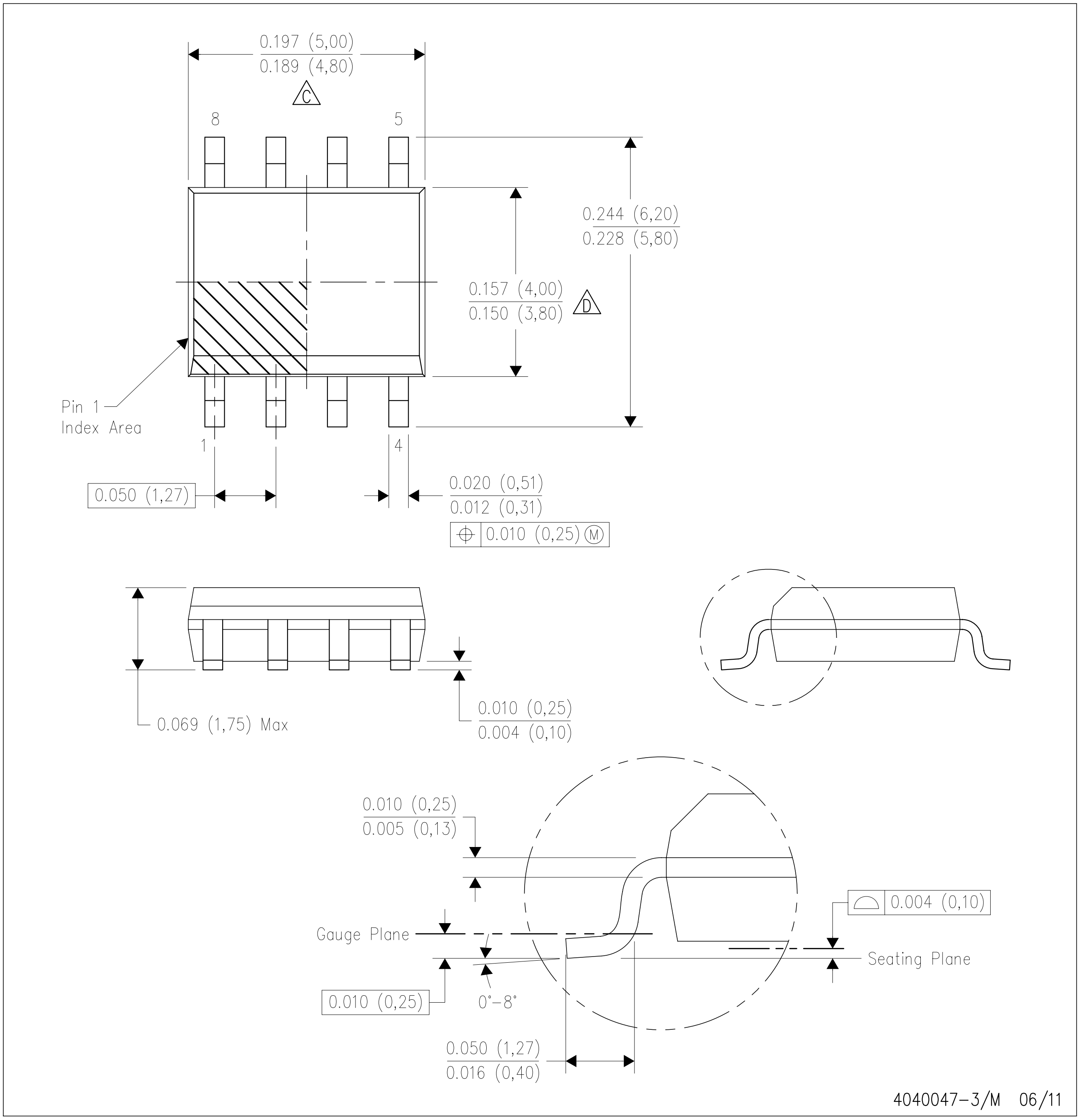
OTHER QUALIFIED VERSIONS OF TLE2037-Q1, TLE2037A-Q1 :

- Catalog: TLE2037, TLE2037A

NOTE: Qualified Version Definitions:

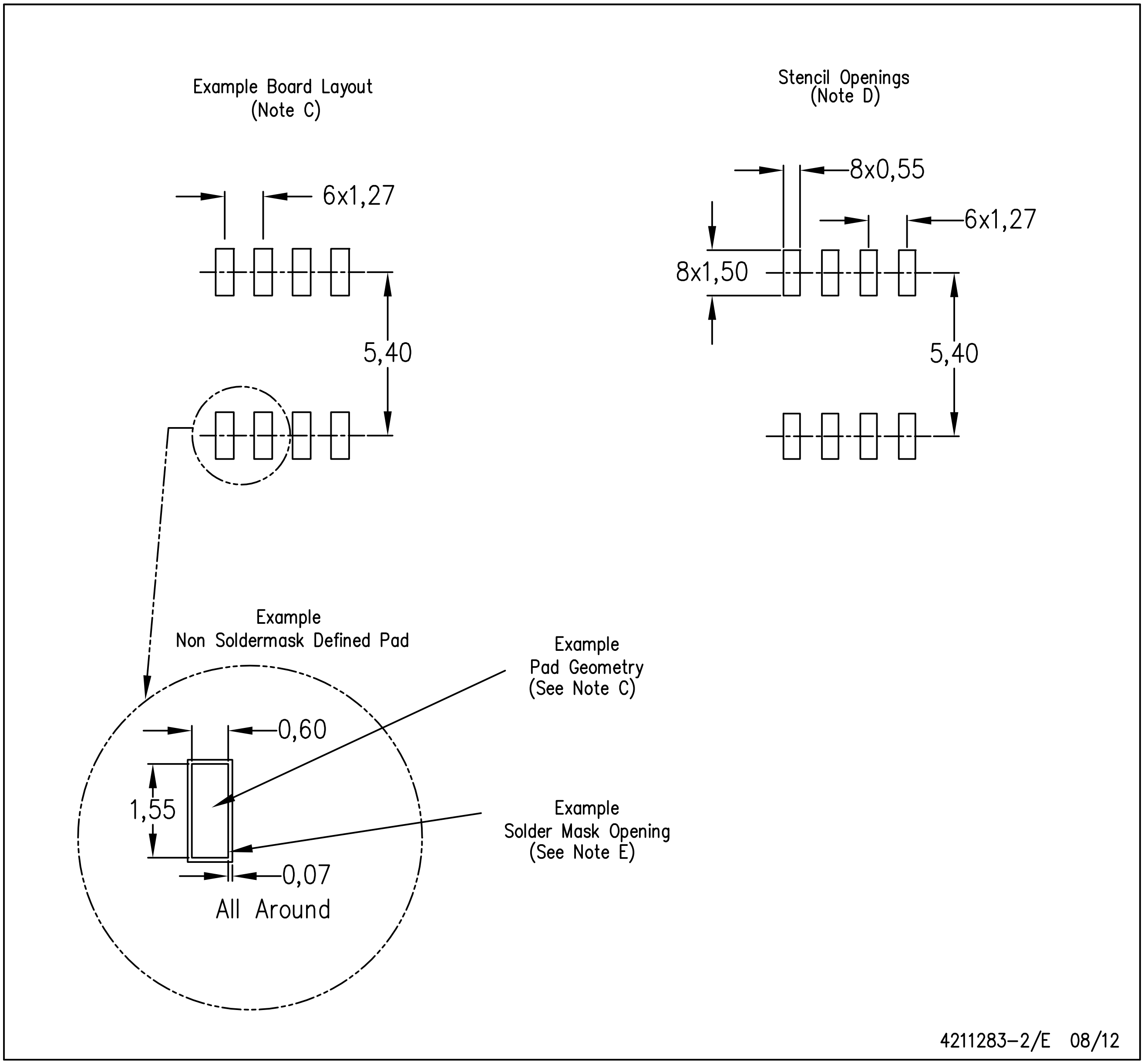
- Catalog - TI's standard catalog product

D (R–PDSO–G8) PLASTIC SMALL OUTLINE



NOTES:
- A. All linear dimensions are in inches (millimeters).
- B. This drawing is subject to change without notice.
- C. Body length does not include mold flash, protrusions, or gate burrs. Mold flash, protrusions, or gate burrs shall not exceed 0.006 (0,15) each side.
- D. Body width does not include interlead flash. Interlead flash shall not exceed 0.017 (0,43) each side.
- E. Reference JEDEC MS-012 variation AA.

D (R-PDSO-G8) PLASTIC SMALL OUTLINE



NOTES:
A. All linear dimensions are in millimeters.
B. This drawing is subject to change without notice.
C. Publication IPC-7351 is recommended for alternate designs.
D. Laser cutting apertures with trapezoidal walls and also rounding corners will offer better paste release. Customers should contact their board assembly site for stencil design recommendations. Refer to IPC-7525 for other stencil recommendations.
E. Customers should contact their board fabrication site for solder mask tolerances between and around signal pads.

IMPORTANT NOTICE

Products		**Applications**	
Audio	www.ti.com/audio	Automotive and Transportation	www.ti.com/automotive
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Interface	interface.ti.com	Medical	www.ti.com/medical
Logic	logic.ti.com	Security	www.ti.com/security
Power Mgmt	power.ti.com	Space, Avionics and Defense	www.ti.com/space-avionics-defense
Microcontrollers	microcontroller.ti.com	Video and Imaging	www.ti.com/video
RFID	www.ti-rfid.com		
OMAP Applications Processors	www.ti.com/omap	**TI E2E Community**	e2e.ti.com
Wireless Connectivity	www.ti.com/wirelessconnectivity		

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