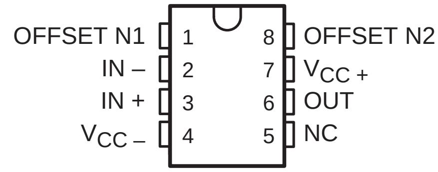
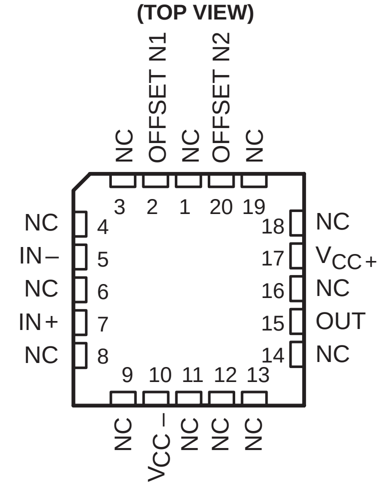
- **Outstanding Combination of dc Precision and AC Performance:**
  Unity-Gain Bandwidth . . . 15 MHz Typ
  V_n . . . . 3.3 nV/√Hz at f = 10 Hz Typ,
  2.5 nV/√Hz at f = 1 kHz Typ
  V_{IO} . . . . 25 μV Max
  A_{VD} . . . 45 V/μV Typ With R_L = 2 kΩ,
  19 V/μV Typ With R_L = 600 Ω
- **Available in Standard-Pinout Small-Outline Package**
- **Output Features Saturation Recovery Circuitry**
- **Macromodels and Statistical information**

D, JG, OR P PACKAGE
(TOP VIEW)



FK 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).

AVAILABLE OPTIONS

T_A	V_{IO}max AT 25°C	PACKAGED DEVICES				CHIP FORM‡ (Y)
		SMALL OUTLINE† (D)	CHIP CARRIER (FK)	CERAMIC DIP (JG)	PLASTIC DIP (P)	
0°C to 70°C	25 μV	TLE2027ACD TLE2037ACD	— —	— —	TLE2027ACP TLE2037ACP	TLE2027Y TLE2037Y
	100 μV	TLE2027CD TLE2037CD	— —	— —	TLE2027CP TLE2037CP	TLE2027Y TLE2037Y
−40°C to 105°C	25 μV	TLE2027AID TLE2037AID	— —	— —	TLE2027AIP TLE2037AIP	—
	100 μV	TLE2027ID TLE2037ID	— —	— —	TLE2027IP TLE2037IP	—
−55°C to 125°C	25 μV	TLE2027AMD TLE2037AMD	TLE2027AMFK TLE2037AMFK	TLE2027AMJG TLE2037AMJG	TLE2027AMP TLE2037AMP	—
	100 μV	TLE2027MD TLE2037MD	TLE2027MFK TLE2037MFK	TLE2027MJG TLE2037MJG	TLE2027MP TLE2037MP	—

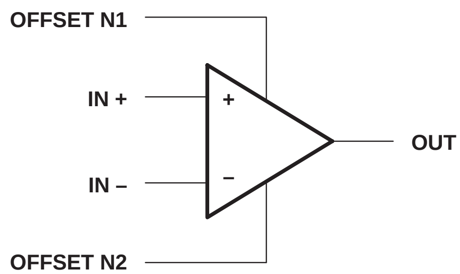
† The D packages are available taped and reeled. Add R suffix to device type (e.g., TLE2027ACDR).
‡ Chip forms are tested at 25°C only.

description (continued)

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/$\sqrt{Hz}$ and 2.5 nV/$\sqrt{Hz}$ 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.

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 C-suffix devices are characterized for operation from 0°C to 70°C. The I-suffix devices are characterized for operation from –40°C to 105°C. The M-suffix devices are characterized for operation over the full military temperature range of –55°C to 125°C.

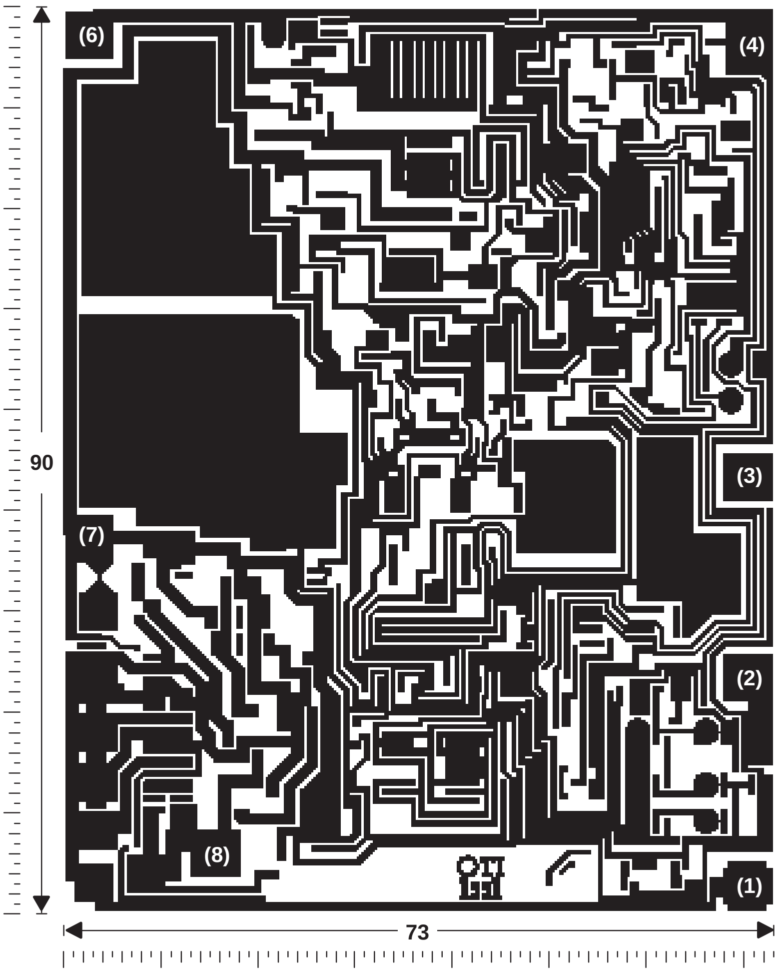
symbol

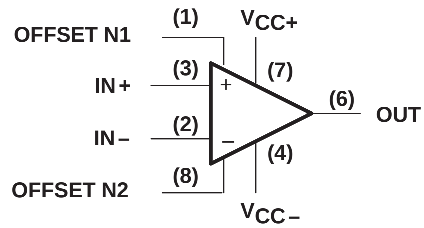


TLE202xY chip information

This chip, when properly assembled, displays characteristics similar to the TLE202xC. 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

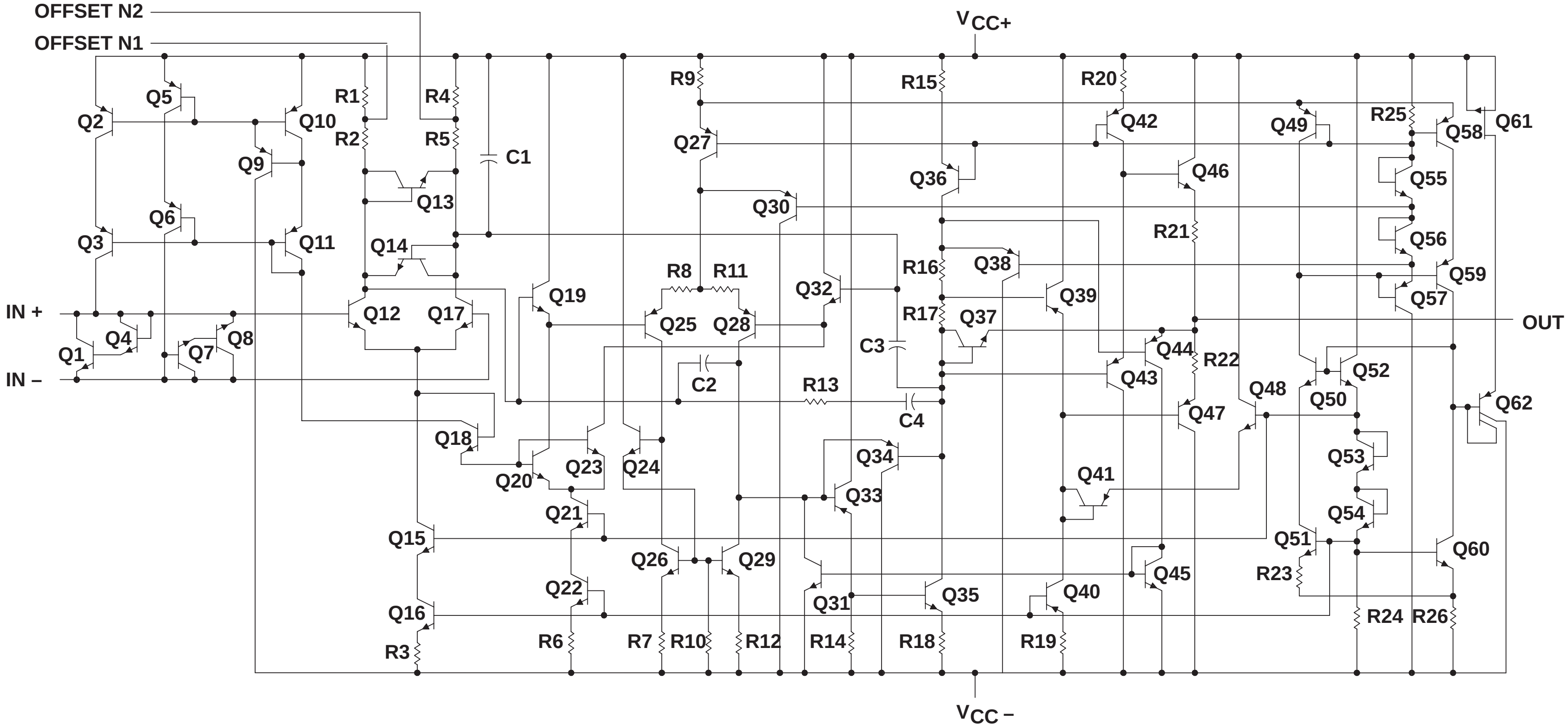
$T_J$max = 150°C

TOLERANCES ARE ±10%.

ALL DIMENSIONS ARE IN MILS.

PIN (4) IS INTERNALLY CONNECTED TO BACKSIDE OF CHIP.

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
Continuous total power dissipation . . . . . See Dissipation Rating Table
Operating free-air temperature range, T_A: C suffix . . . . . 0°C to 70°C
I suffix . . . . . – 40°C to 105°C
M suffix . . . . . – 55°C to 125°C
Storage temperature range, T_{stg} . . . . . – 65°C to 150°C
Case temperature for 60 seconds, T_C: FK package . . . . . 260°C
Lead temperature 1,6 mm (1/16 inch) from case for 10 seconds: D or P package . . . . . 260°C
Lead temperature 1,6 mm (1/16 inch) from case for 60 seconds: JG package . . . . . 300°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.

DISSIPATION RATING TABLE

PACKAGE	$T_A \le 25°C$ POWER RATING	DERATING FACTOR ABOVE $T_A = 25°C$	$T_A = 70°C$ POWER RATING	$T_A = 105°C$ POWER RATING	$T_A = 125°C$ POWER RATING
D	725 mW	5.8 mW/°C	464 mW	261 mW	145 mW
FK	1375 mW	11.0 mW/°C	880 mW	495 mW	275 mW
JG	1050 mW	8.4 mW/°C	672 mW	378 mW	210 mW
P	1000 mW	8.0 mW/°C	640 mW	360 mW	200 mW

recommended operating conditions

		C SUFFIX		I SUFFIX		M SUFFIX		UNIT
		MIN	MAX	MIN	MAX	MIN	MAX	
Supply voltage, $V_{CC\pm}$		±4	± 19	±4	±19	±4	±19	V
Common-mode input voltage, V_{IC}	$T_A = 25°C$	–11	11	–11	11	–11	11	V
	T_A = Full range‡	–10.5	10.5	–10.4	10.4	–10.2	10.2	
Operating free-air temperature, T_A		0	70	–40	105	–55	125	°C

‡ Full range is 0°C to 70°C for C-suffix devices, –40°C to 105°C for I-suffix devices, and –55°C to 125°C for M-suffix devices.

TLE20x7C electrical characteristics at specified free-air temperature, $V_{CC\pm}$ = ±15 V (unless otherwise noted)

PARAMETER		TEST CONDITIONS	T_A†	TLE20x7C MIN	TLE20x7C TYP	TLE20x7C MAX	TLE20x7AC MIN	TLE20x7AC TYP	TLE20x7AC MAX	UNIT
V_{IO}	Input offset voltage	V_{IC} = 0, R_S = 50 Ω	25°C		20	100		10	25	µV
			Full range			145			70	
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	–10.5 to 10.5			–10.5 to 10.5			
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			4			
		V_O = ±10 V, R_L = 1 kΩ	25°C	3.5	38		8	38		
			Full range	1			2.5			
		V_O = ±10 V, R_L = 600 Ω	25°C	2	19		5	19		
			Full range	0.5			2			
C_i	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	98			114			
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	92			106			
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 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.

TLE20x7C operating characteristics at specified free-air temperature, $V_{CC\pm} = \pm 15$ V, $T_A = 25°C$ (unless otherwise specified)

PARAMETER		TEST CONDITIONS		TLE20x7C			TLE20x7AC			UNIT
				MIN	TYP	MAX	MIN	TYP	MAX	
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, $T_A = 0°C$ to 70°C, See Figure 1	TLE2027	1.2			1.2			
			TLE2037	5			5			
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			1.5	4		1.5	4	pA/√Hz
		f = 1 kHz			0.4	0.6		0.4	0.6	
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%.

TLE20x7I electrical characteristics at specified free-air temperature, $V_{CC\pm}$ = ±15 V (unless otherwise noted)

PARAMETER		TEST CONDITIONS	T_A†	TLE20x7I			TLE20x7AI			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			180			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	–10.4 to 10.4			–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			3.5			
		V_O = ±10 V, R_L = 1 kΩ	25°C	3.5	38		8	38		
			Full range	1			2.2			
		V_O = ±10 V, R_L = 600 Ω	25°C	2	19		5	19		
			Full range	0.5			1.1			
C_i	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 105°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.

TLE20x7I operating characteristics at specified free-air temperature, $V_{CC\pm} = \pm 15$ V, $T_A = 25°C$ (unless otherwise specified)

PARAMETER		TEST CONDITIONS		TLE20x7I MIN	TLE20x7I TYP	TLE20x7I MAX	TLE20x7AI MIN	TLE20x7AI TYP	TLE20x7AI 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 = –40°C to 85°C, See Figure 1	TLE2027	1.1			1.1			
			TLE2037	4.7			4.7			
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			1.5	4		1.5	4	pA/√Hz
		f = 1 kHz			0.4	0.6		0.4	0.6	
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%.

TLE20x7M electrical characteristics at specified free-air temperature, $V_{CC\pm}$ = ±15 V (unless otherwise noted)

PARAMETER		TEST CONDITIONS	T_A†	TLE20x7M			TLE20x7AM			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	

* On products compliant to MIL-PRF-38535, this parameter is not production tested.
† Full range is – 55°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.

TLE20x7M operating characteristics at specified free-air temperature, $V_{CC\pm} = \pm15$ V, $T_A = 25°C$ (unless otherwise specified)

PARAMETER		TEST CONDITIONS		TLE20x7M MIN	TLE20x7M TYP	TLE20x7M MAX	TLE20x7AM MIN	TLE20x7AM TYP	TLE20x7AM 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			1.5	4*		1.5	4*	pA/√Hz
		f = 1 kHz			0.4	0.6*		0.4	0.6*	
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°		

* On products compliant to MIL-PRF-38535, this parameter is not production tested.
NOTE 5: Measured distortion of the source used in the analysis was 0.002%.

TLE20x7Y electrical characteristics, $V_{CC\pm}$ = ±15 V, T_A = 25°C (unless otherwise noted)

PARAMETER		TEST CONDITIONS	TLE20x7Y MIN	TLE20x7Y TYP	TLE20x7Y MAX	UNIT
V_{IO}	Input offset voltage	V_{IC} = 0, R_S = 50 Ω		20		µV
	Input offset voltage long-term drift (see Note 4)	V_{IC} = 0, R_S = 50 Ω		0.006		µV/mo
I_{IO}	Input offset current	V_{IC} = 0, R_S = 50 Ω		6		nA
I_{IB}	Input bias current	V_{IC} = 0, R_S = 50 Ω		15		nA
V_{ICR}	Common-mode input voltage range	R_S = 50 Ω		–13 to 13		V
V_{OM+}	Maximum positive peak output voltage swing	R_L = 600 Ω		12.9		V
		R_L = 2 kΩ		13.2		
V_{OM-}	Maximum negative peak output voltage swing	R_L = 600 Ω		–13		V
		R_L = 2 kΩ		–13.5		
A_{VD}	Large-signal differential voltage amplification	V_O = ±11 V, R_L = 2 kΩ		45		V/µV
		V_O = ±10 V, R_L = 1 kΩ		38		
		V_O = ±10 V, R_L = 600 Ω		19		
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 Ω		131		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		144		dB
I_{CC}	Supply current	V_O = 0, No load		3.8		mA

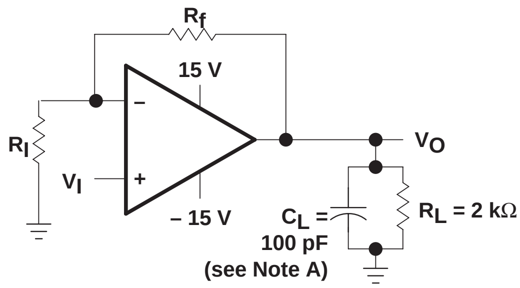
NOTE 4: Typical values are based on the input offset voltage shift observed through 168 hours of operating life test at T_A = 150°C extrapolated to T_A = 25°C using the Arrhenius equation and assuming an activation energy of 0.96 eV.

TLE20x7Y operating characteristics at specified free-air temperature, $V_{CC\pm} = \pm 15$ V

PARAMETER		TEST CONDITIONS		TLE20x7Y MIN	TLE20x7Y TYP	TLE20x7Y MAX	UNIT
SR	Slew rate at unity gain	$R_L = 2\ k\Omega$, $C_L = 100$ pF, See Figure 1	TLE2027		2.8		V/μs
			TLE2037		7.5		
V_n	Equivalent input noise voltage (see Figure 2)	$R_S = 20\ \Omega$, f = 10 Hz			3.3		$nV/\sqrt{Hz}$
		$R_S = 20\ \Omega$, f = 1 kHz			2.5		
$V_{N(PP)}$	Peak-to-peak equivalent input noise voltage	f = 0.1 Hz to 10 Hz			50		nV
I_n	Equivalent input noise current	f = 10 Hz			1.5		$pA/\sqrt{Hz}$
		f = 1 kHz			0.4		
THD	Total harmonic distortion	$V_O = +10$ V, $A_{VD} = 1$, See Note 5	TLE2027		< 0.002%		
		$V_O = +10$ V, $A_{VD} = 5$, See Note 5	TLE2037		< 0.002%		
B_1	Unity-gain bandwidth (see Figure 3)	$R_L = 2\ k\Omega$, $C_L = 100$ pF	TLE2027		13		MHz
			TLE2037		50		
B_{OM}	Maximum output-swing bandwidth	$R_L = 2\ k\Omega$	TLE2027		30		kHz
			TLE2037		80		
ϕ_m	Phase margin at unity gain (see Figure 3)	$R_L = 2\ k\Omega$, $C_L = 100$ pF	TLE2027		55°		
			TLE2037		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

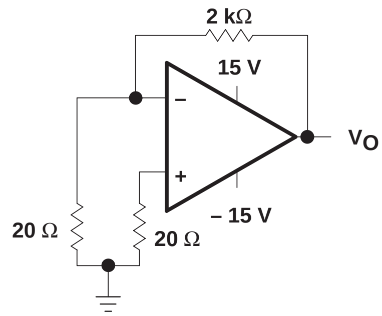
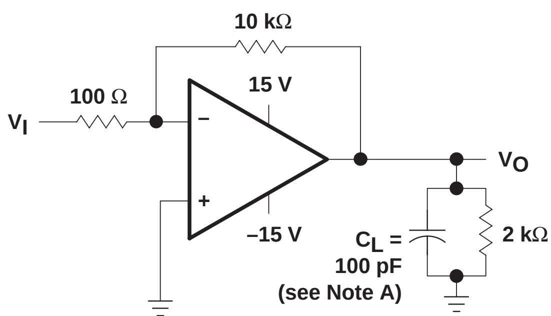
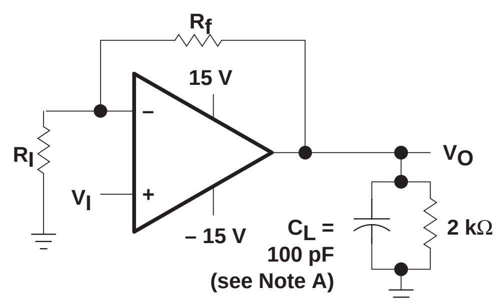


Figure 2. Noise-Voltage Test Circuit



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.

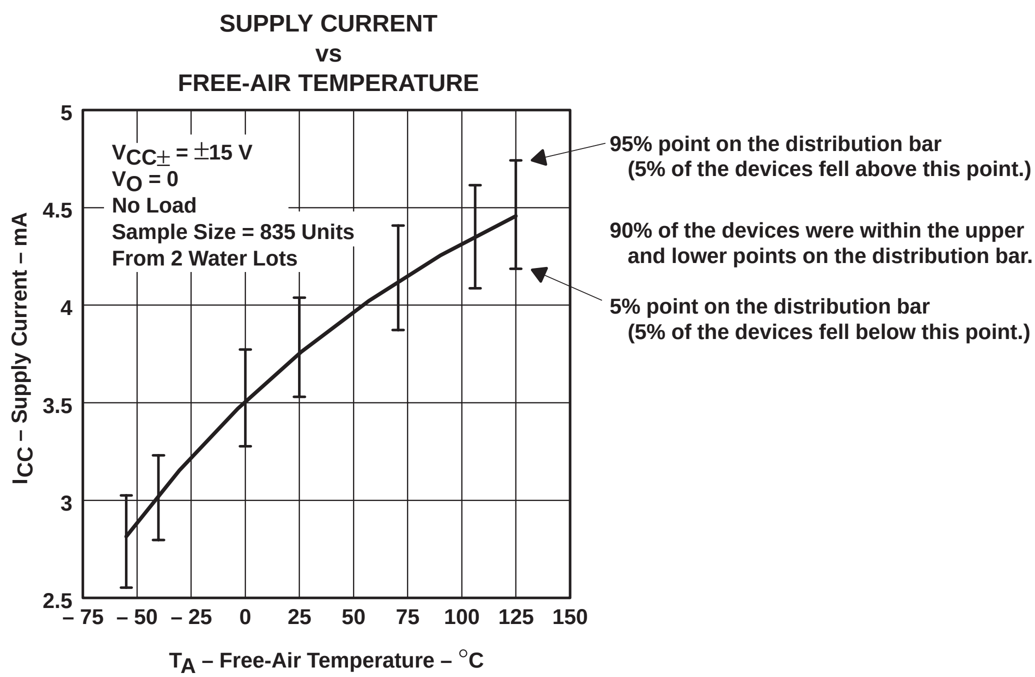


Figure 5. Sample Graph With Distribution Bars

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-circut 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

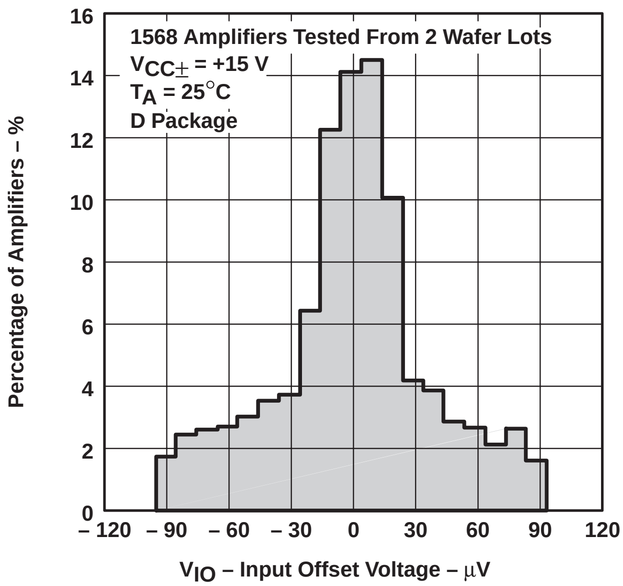


Figure 6

INPUT OFFSET VOLTAGE CHANGE
vs
TIME AFTER POWER ON

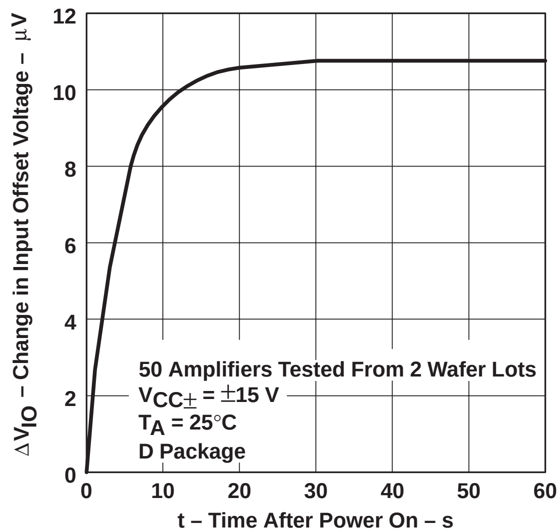


Figure 7

INPUT OFFSET VOLTAGE CHANGE
vs
TIME AFTER POWER ON

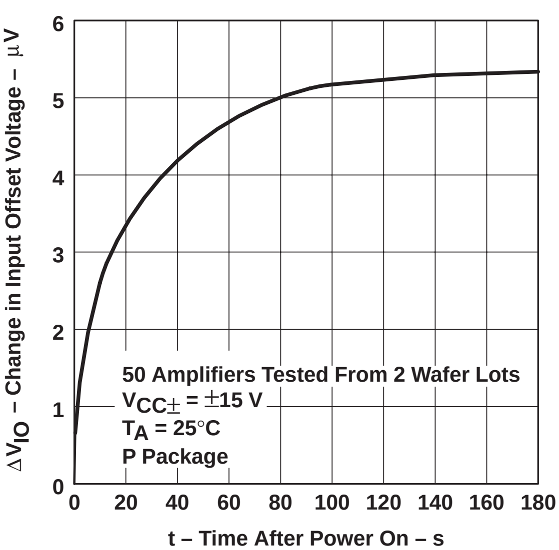


Figure 8

INPUT OFFSET CURRENT†
vs
FREE-AIR TEMPERATURE

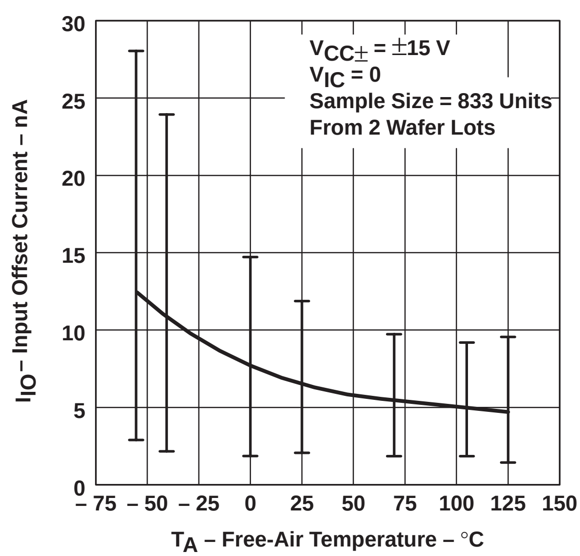


Figure 9

† 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

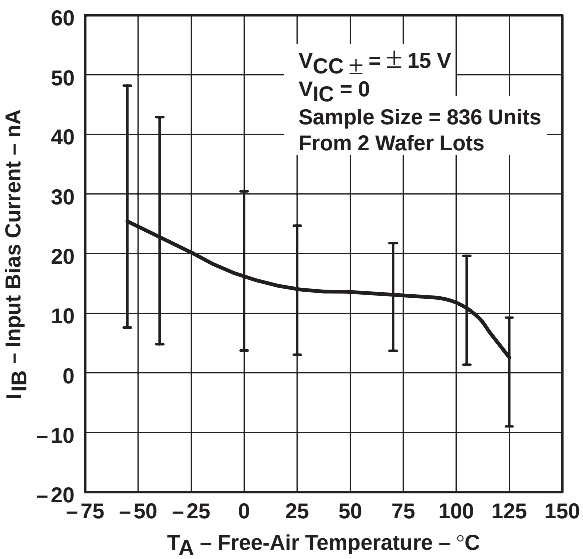


Figure 10

INPUT BIAS CURRENT vs COMMON-MODE INPUT VOLTAGE

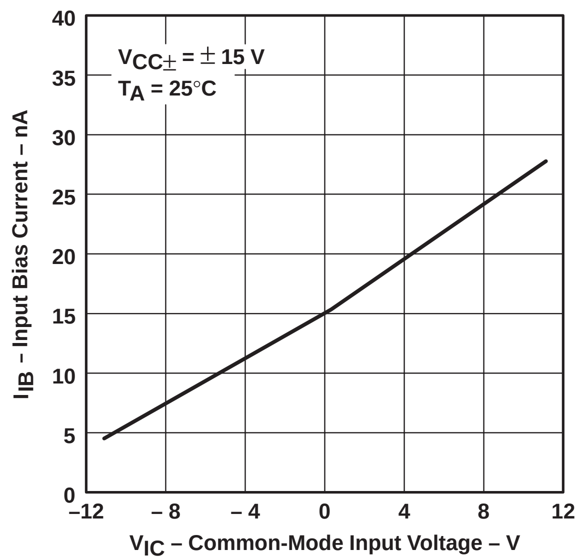


Figure 11

INPUT CURRENT vs DIFFERENTIAL INPUT VOLTAGE

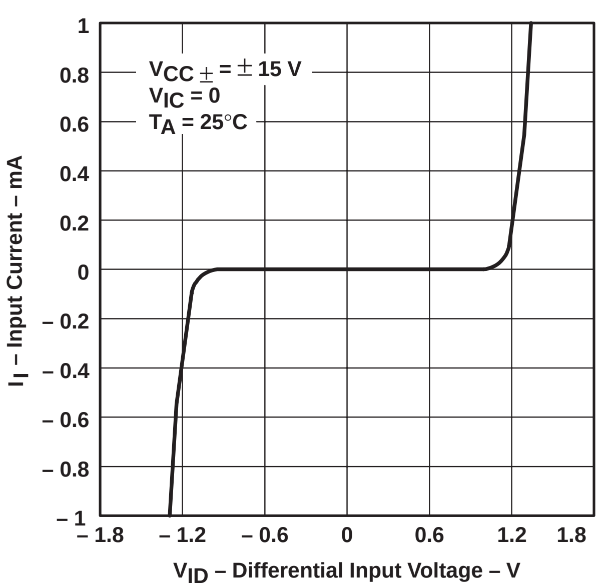


Figure 12

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

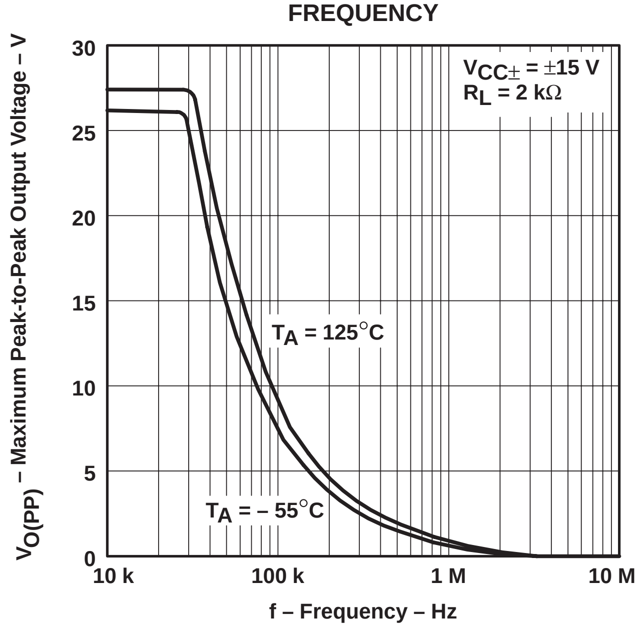


Figure 13

† 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**

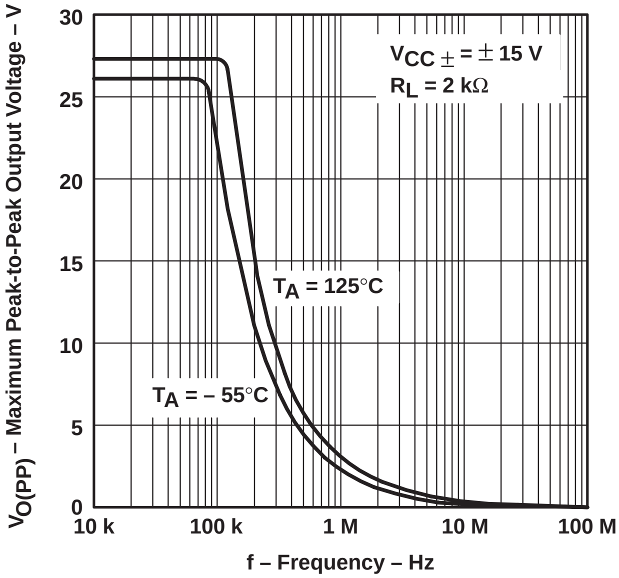


Figure 14

**MAXIMUM POSITIVE PEAK
OUTPUT VOLTAGE
vs
LOAD RESISTANCE**

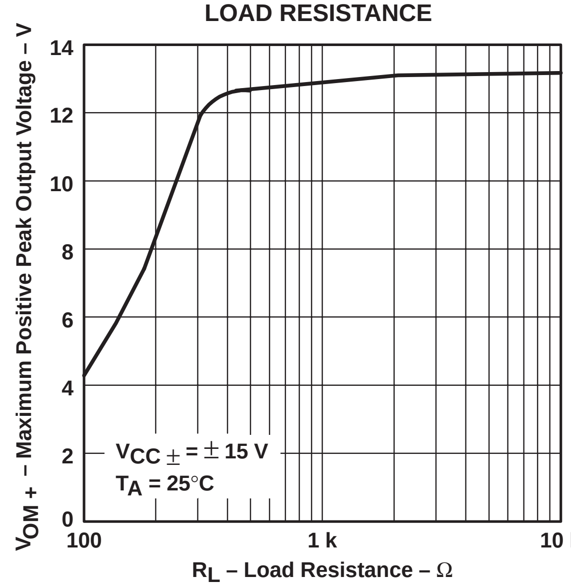


Figure 15

**MAXIMUM NEGATIVE PEAK
OUTPUT VOLTAGE
vs
LOAD RESISTANCE**

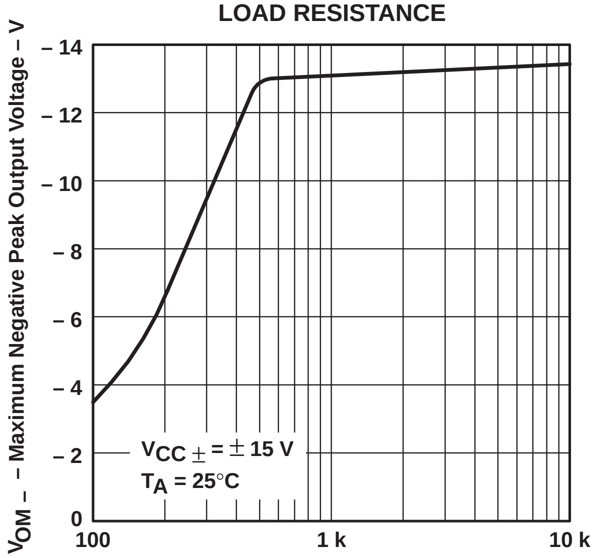


Figure 16

**MAXIMUM POSITIVE PEAK
OUTPUT VOLTAGE†
vs
FREE-AIR TEMPERATURE**

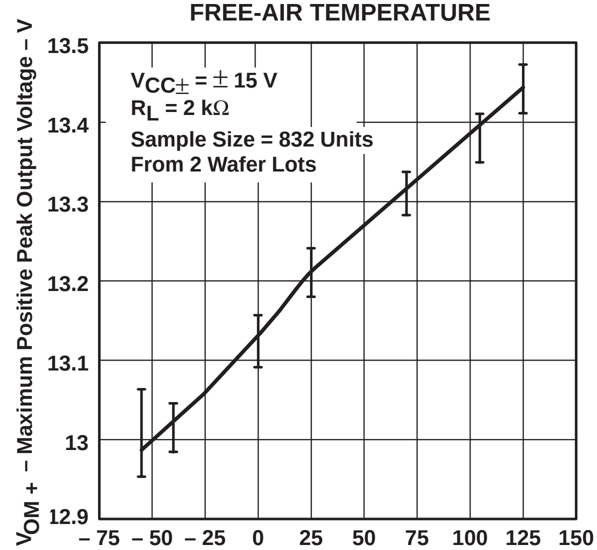


Figure 17

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

TYPICAL CHARACTERISTICS

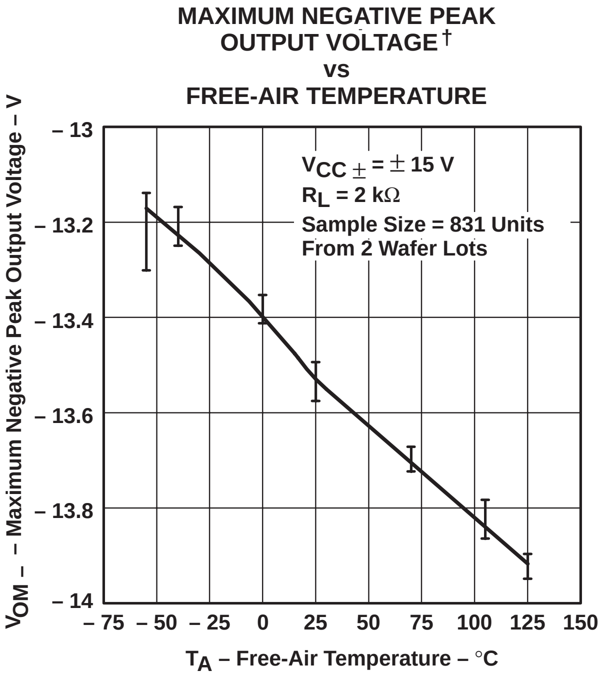


Figure 18

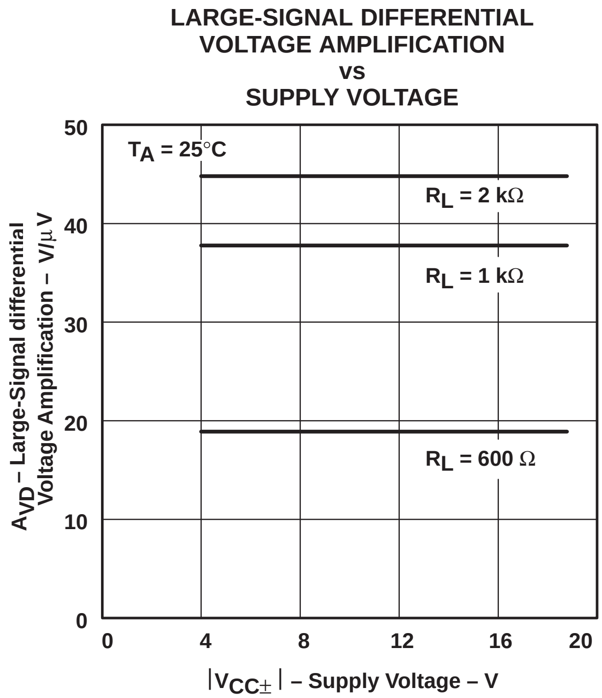


Figure 19

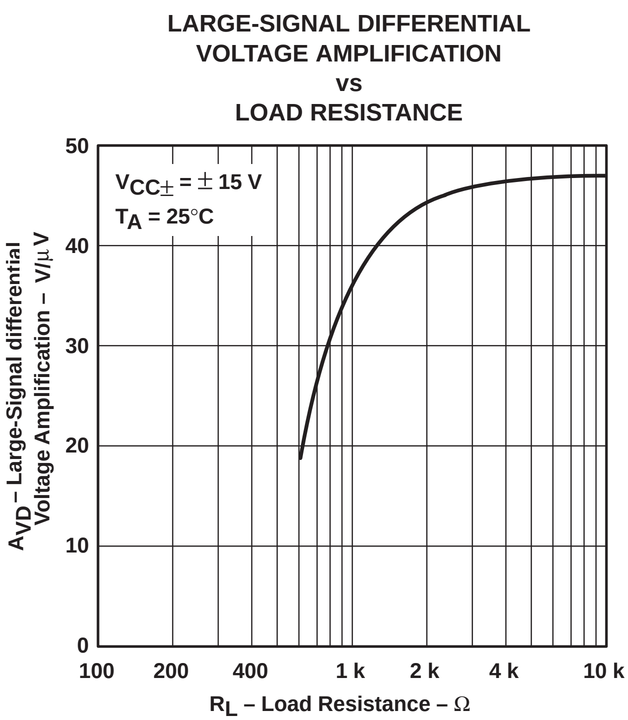


Figure 20

† 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

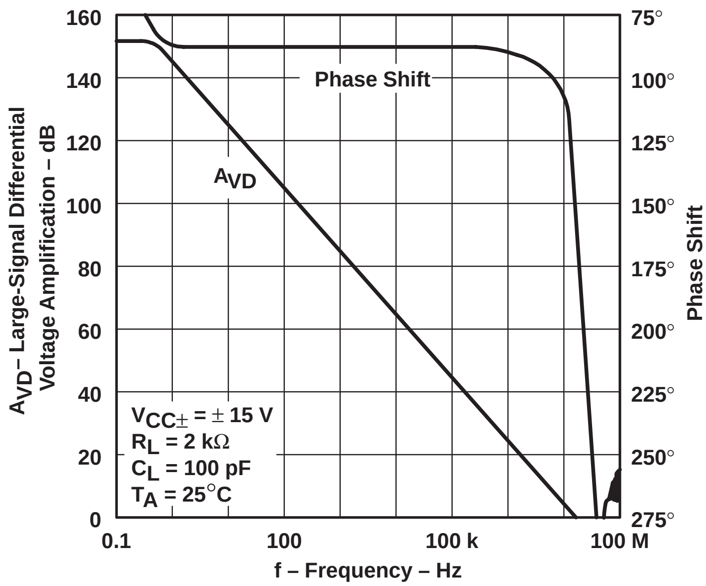


Figure 21

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

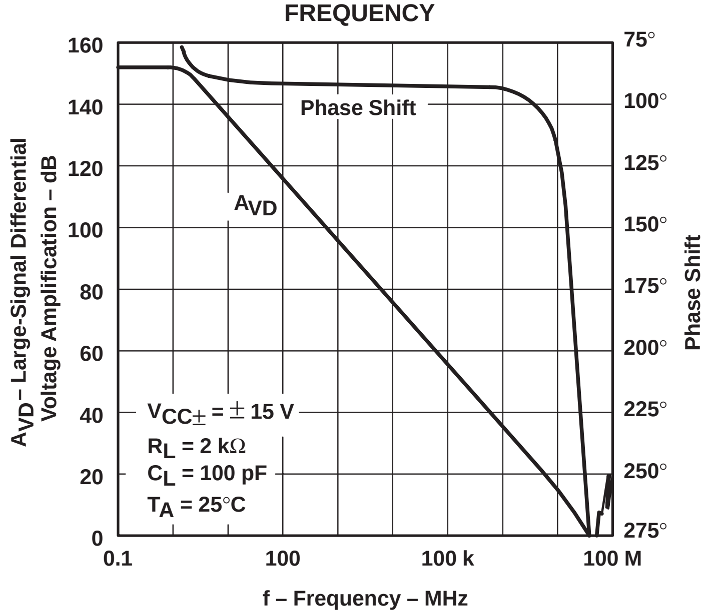


Figure 22

TYPICAL CHARACTERISTICS

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

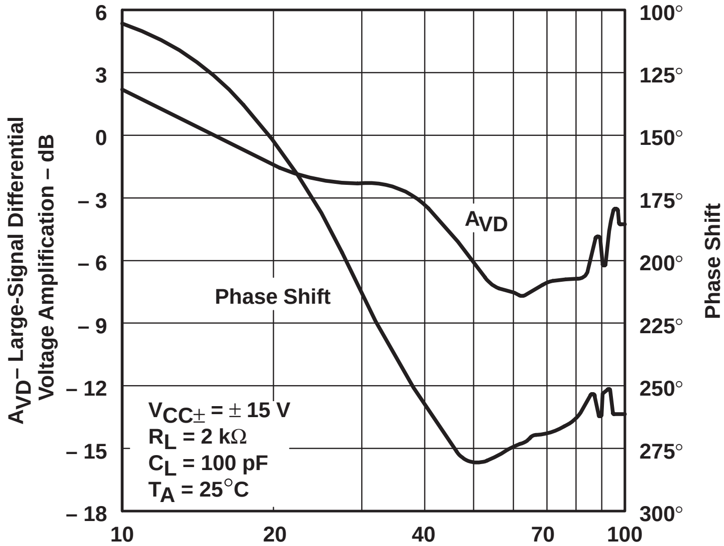


Figure 23

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

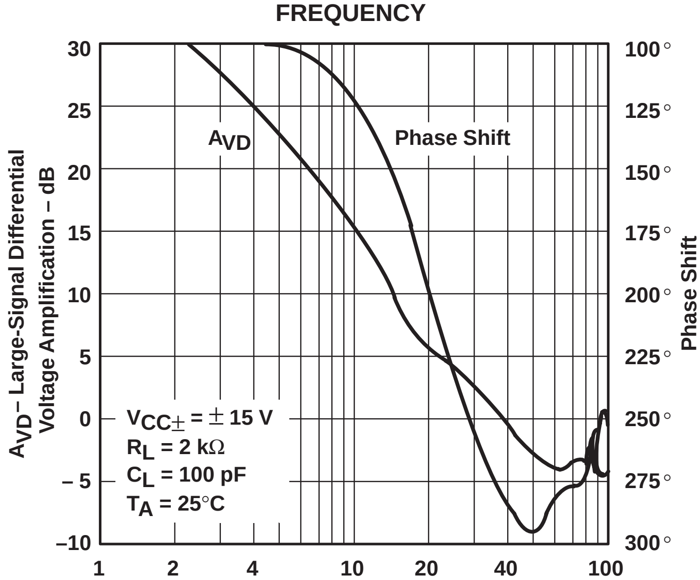


Figure 24

TYPICAL CHARACTERISTICS

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

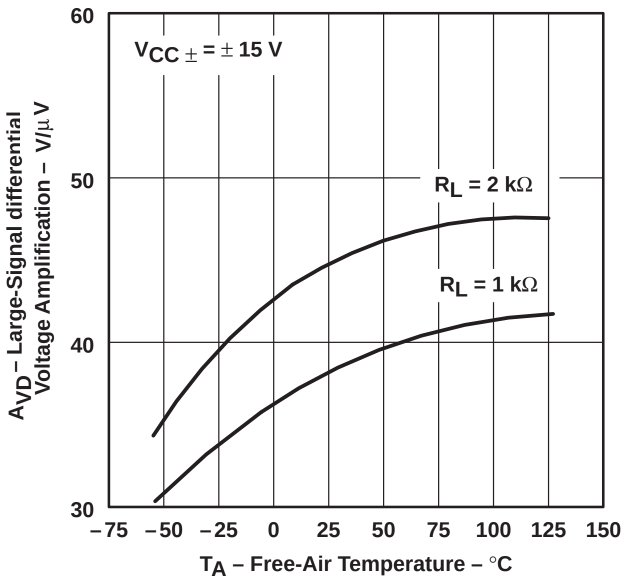
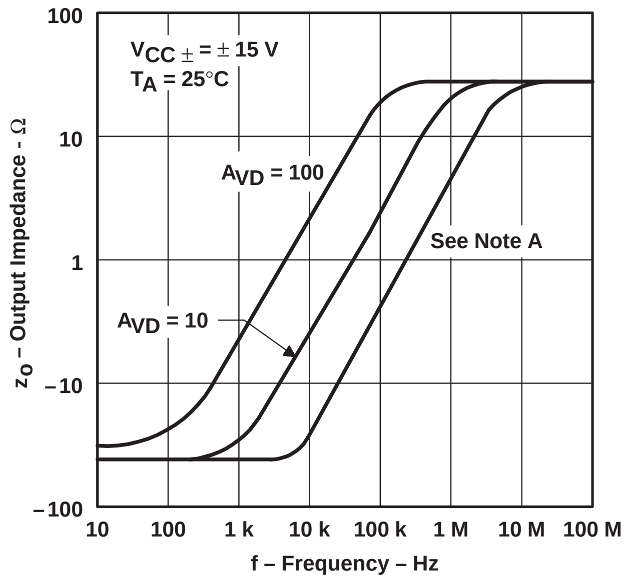


Figure 25

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

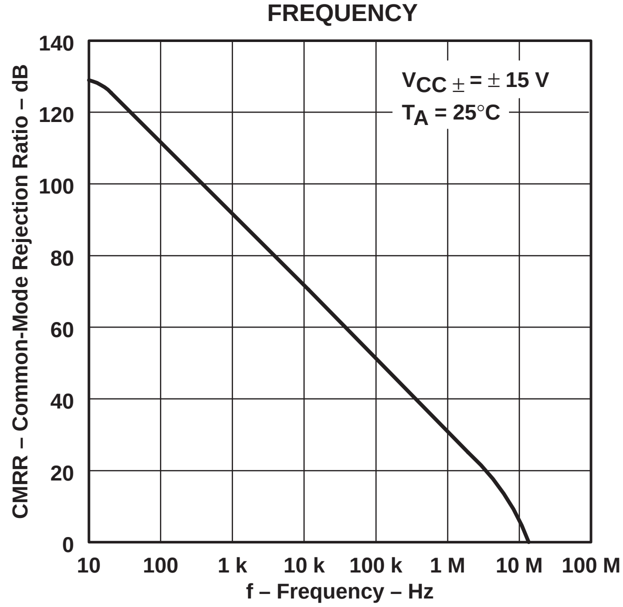


Figure 27

SUPPLY-VOLTAGE REJECTION RATIO vs FREQUENCY

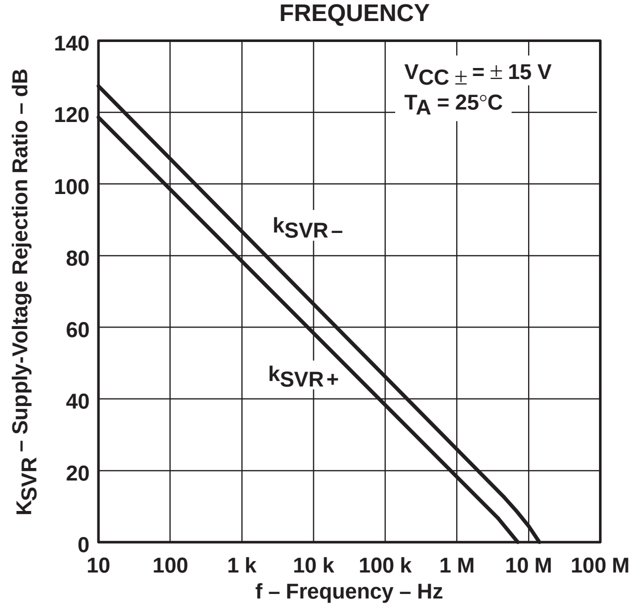


Figure 28

† 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

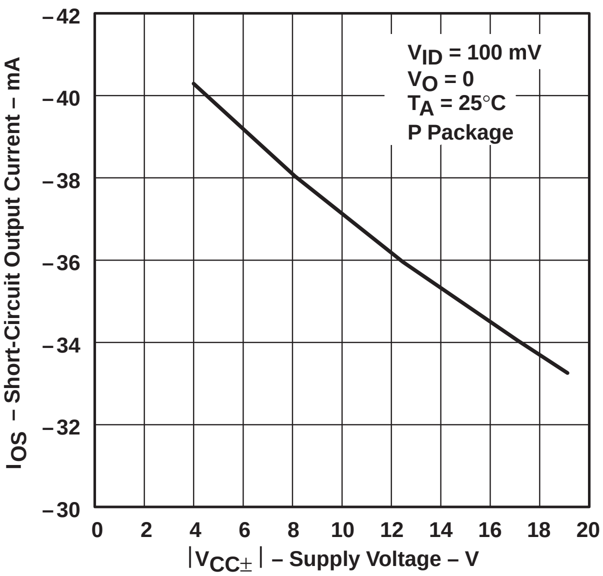


Figure 29

SHORT-CIRCUIT OUTPUT CURRENT vs SUPPLY VOLTAGE

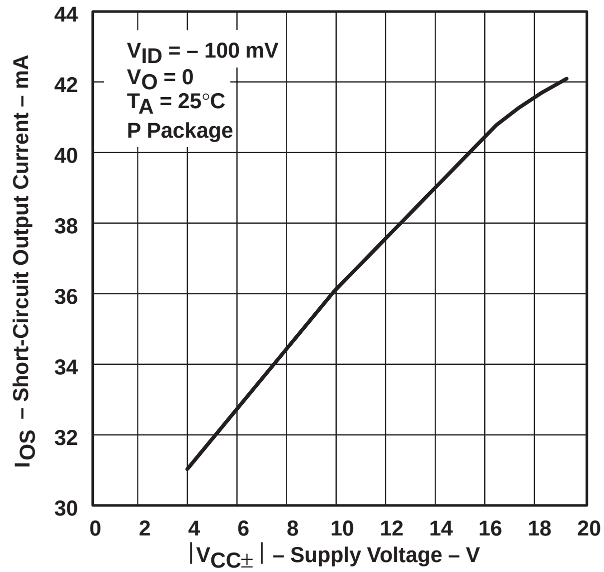


Figure 30

SHORT-CIRCUIT OUTPUT CURRENT vs ELAPSED TIME

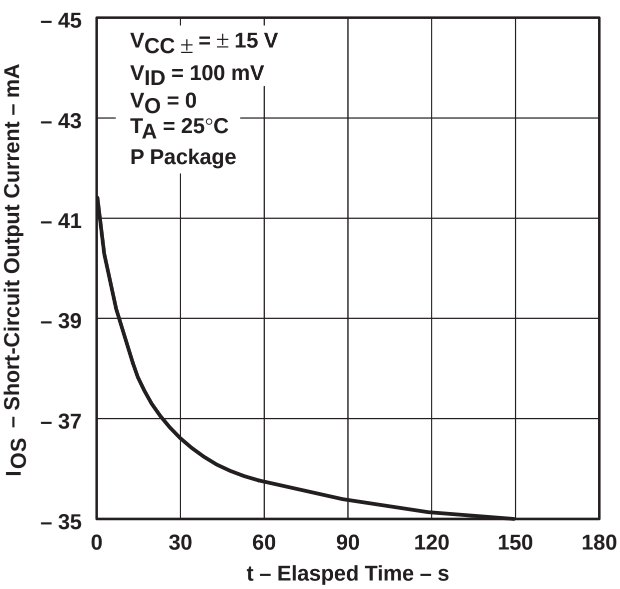


Figure 31

SHORT-CIRCUIT OUTPUT CURRENT vs ELAPSED TIME

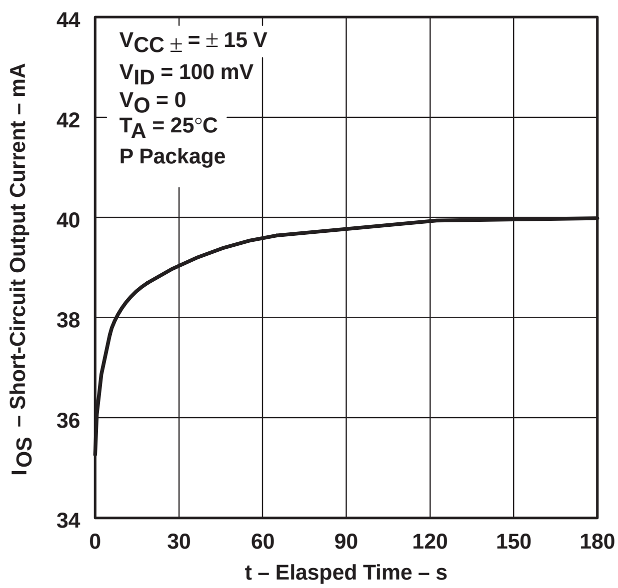


Figure 32

TYPICAL CHARACTERISTICS

SHORT-CIRCUIT OUTPUT CURRENT† vs FREE-AIR TEMPERATURE

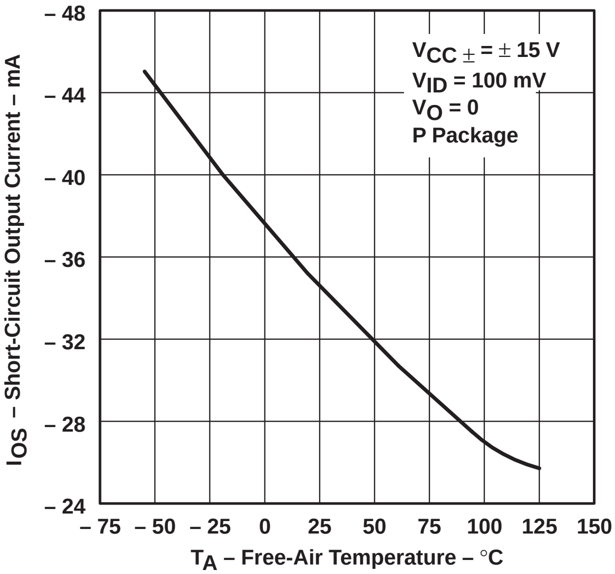


Figure 33

SHORT-CIRCUIT OUTPUT CURRENT† vs FREE-AIR TEMPERATURE

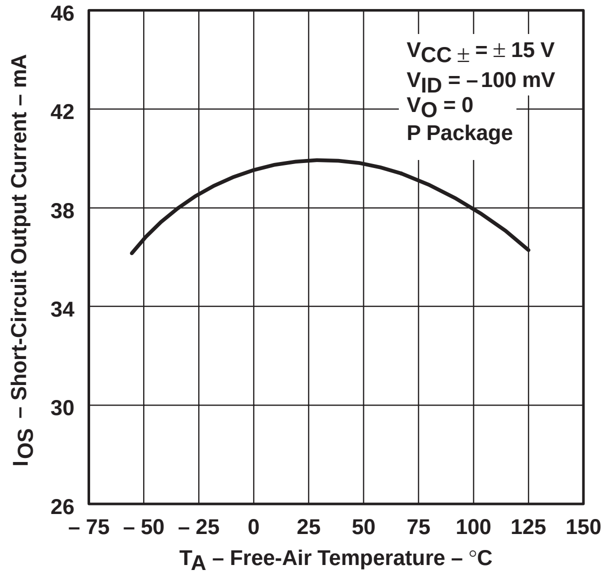


Figure 34

SUPPLY CURRENT† vs SUPPLY VOLTAGE

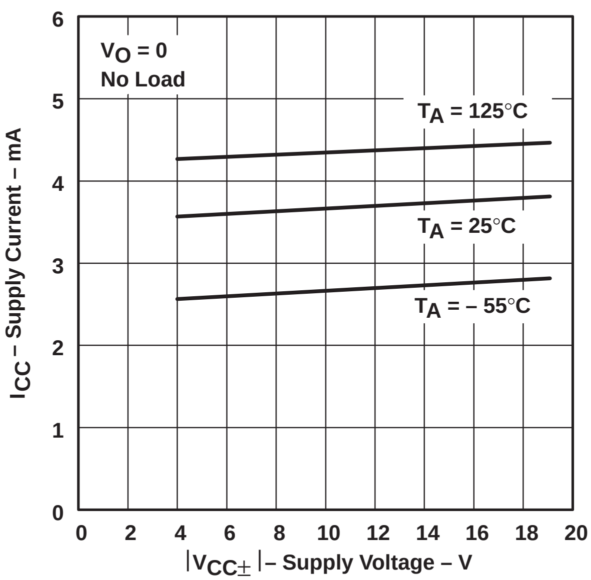


Figure 35

SUPPLY CURRENT† vs FREE-AIR TEMPERATURE

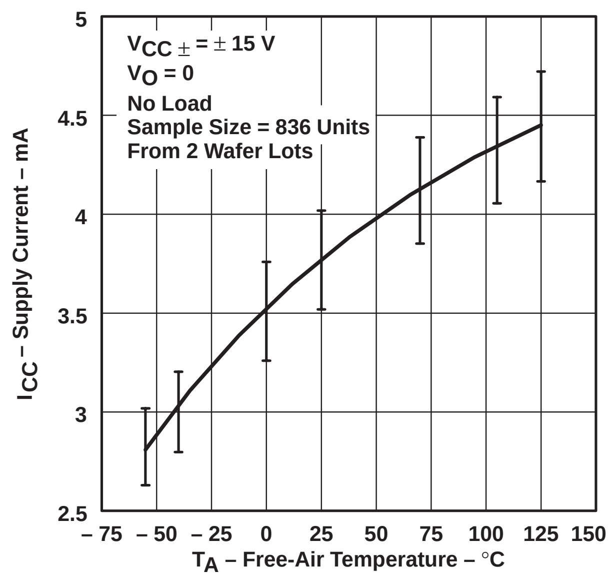


Figure 36

† 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**

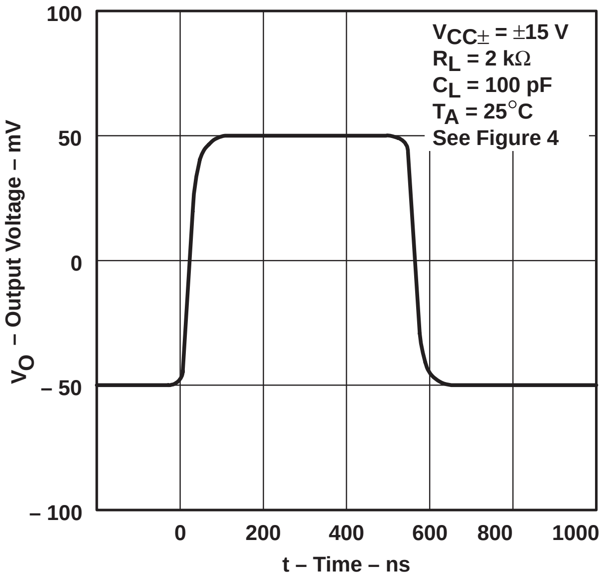


Figure 37

**TLE2027
VOLTAGE-FOLLOWER
LARGE-SIGNAL
PULSE RESPONSE**

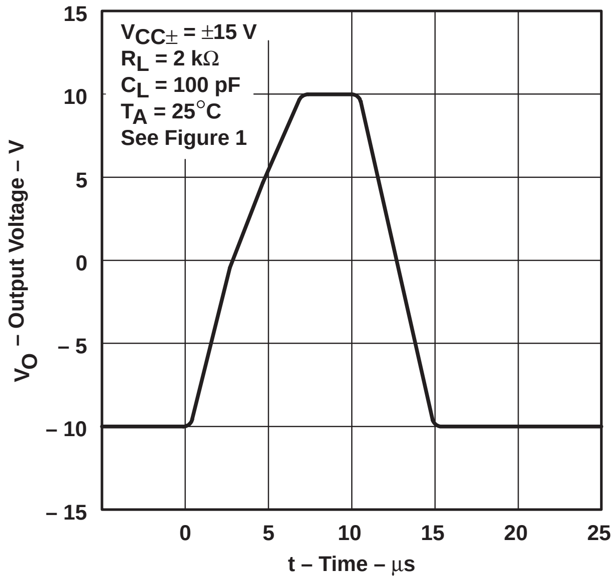


Figure 38

**TLE2037
VOLTAGE-FOLLOWER
SMALL-SIGNAL
PULSE RESPONSE**

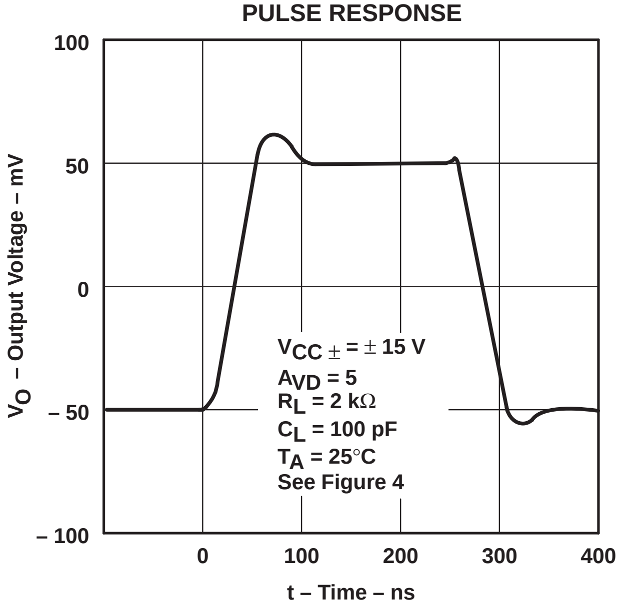


Figure 39

**TLE2037
VOLTAGE-FOLLOWER
LARGE-SIGNAL
PULSE RESPONSE**

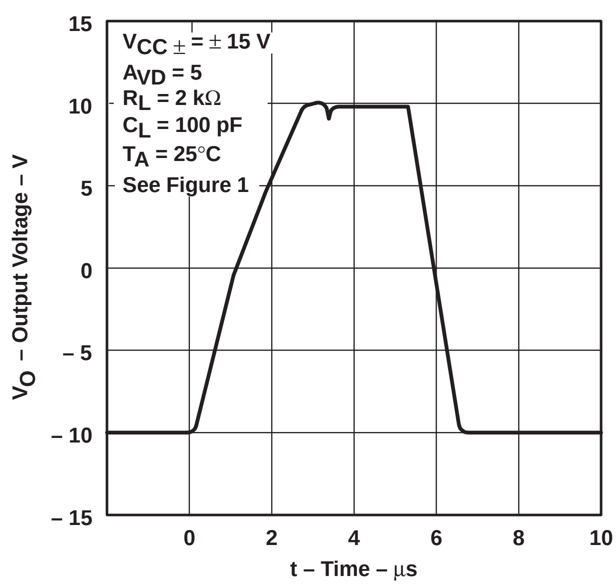


Figure 40

TYPICAL CHARACTERISTICS

EQUIVALENT INPUT NOISE VOLTAGE
vs
FREQUENCY

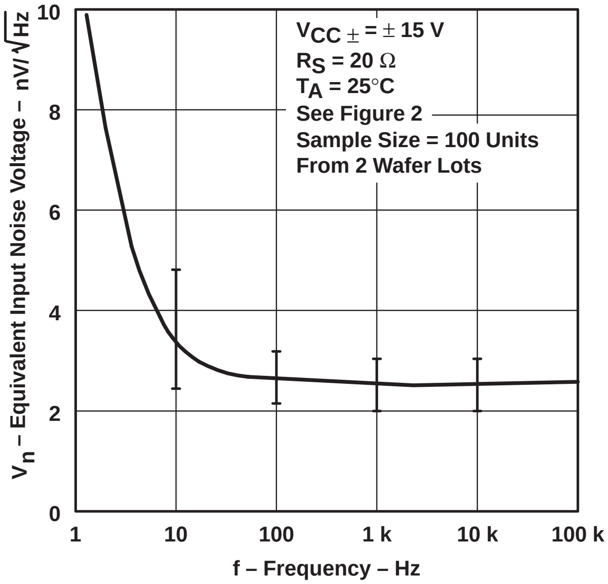


Figure 41

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

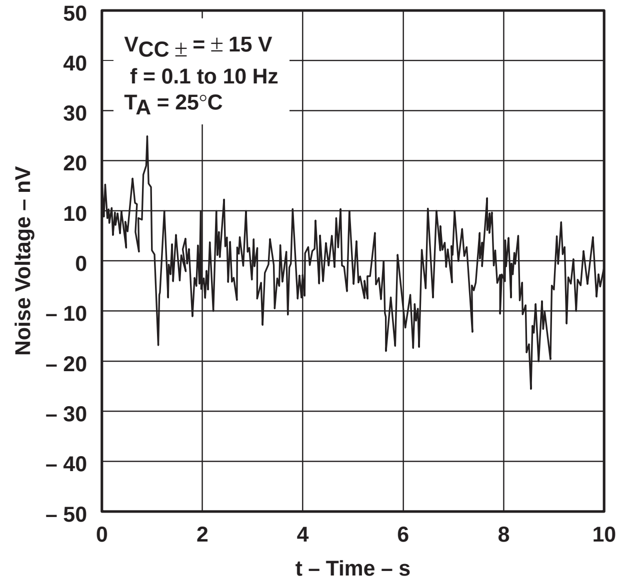


Figure 42

TLE2027
UNITY-GAIN BANDWIDTH
vs
SUPPLY VOLTAGE

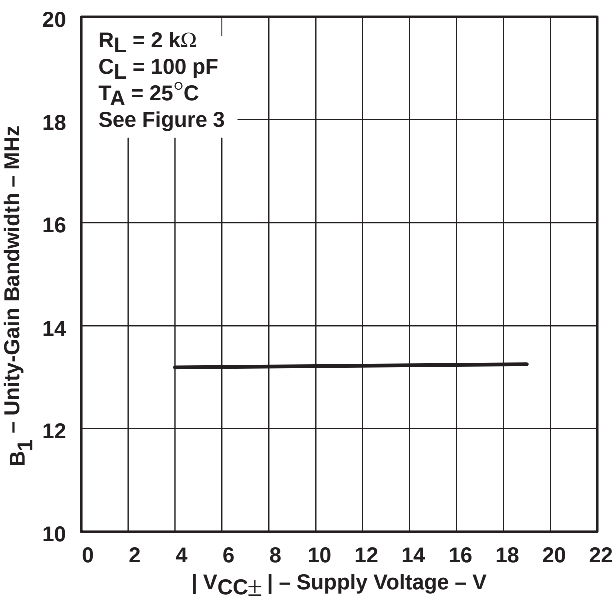


Figure 43

TLE2037
GAIN-BANDWIDTH PRODUCT
vs
SUPPLY VOLTAGE

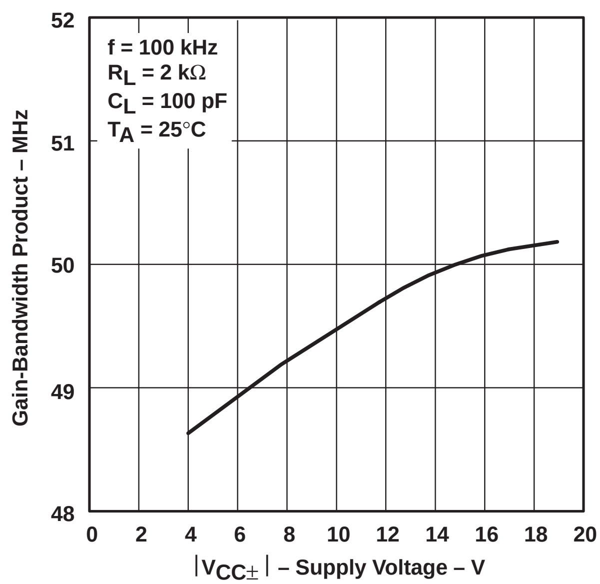


Figure 44

TYPICAL CHARACTERISTICS

TLE2027
UNITY-GAIN BANDWIDTH
vs
LOAD CAPACITANCE

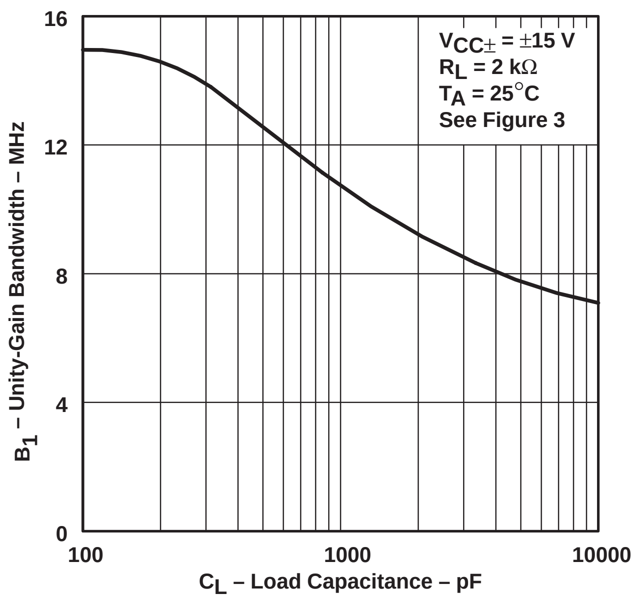


Figure 45

TLE2037
GAIN-BANDWIDTH PRODUCT
vs
LOAD CAPACITANCE

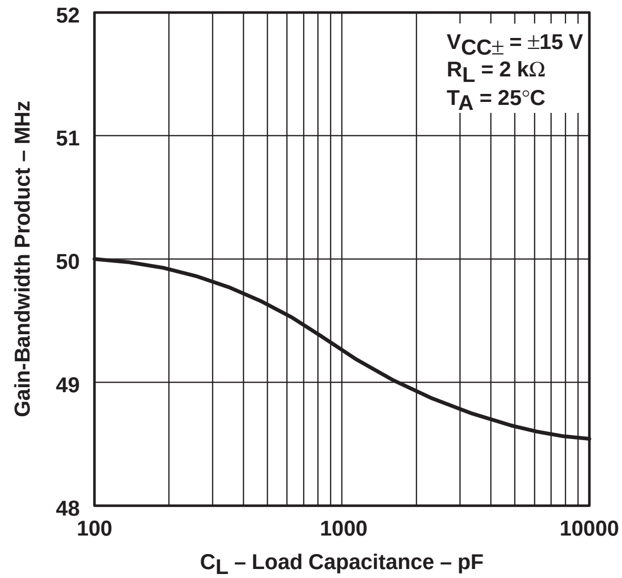


Figure 46

TLE2027
SLEW RATE†
vs
FREE-AIR TEMPERATURE

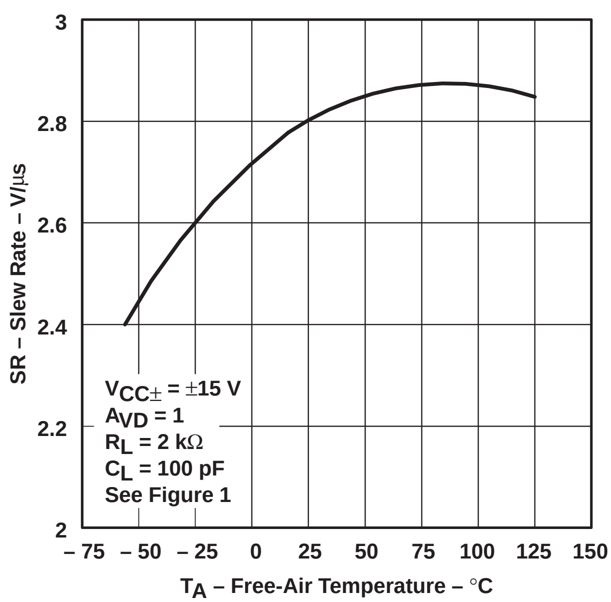


Figure 47

TLE2037
SLEW RATE†
vs
FREE-AIR TEMPERATURE

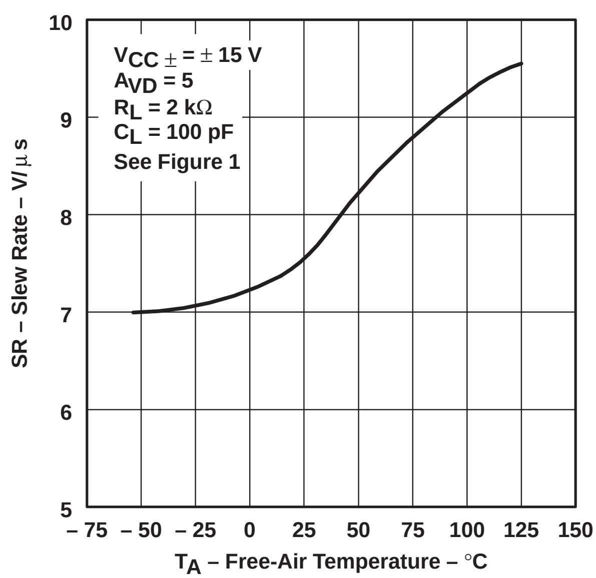


Figure 48

† 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**

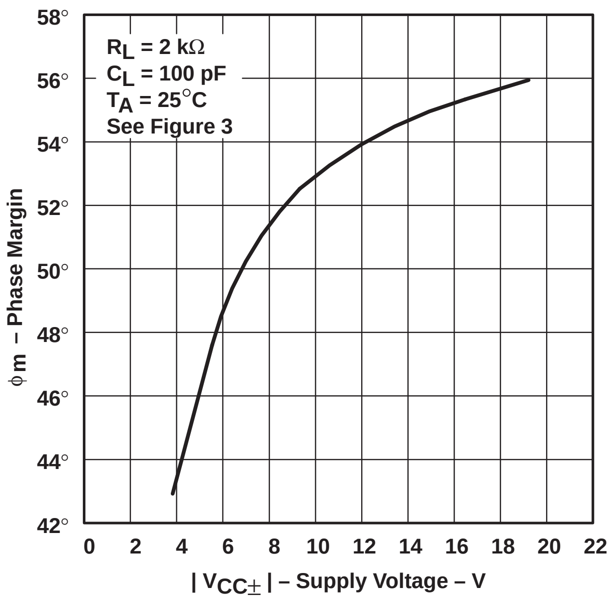


Figure 49

**TLE2037
PHASE MARGIN
vs
SUPPLY VOLTAGE**

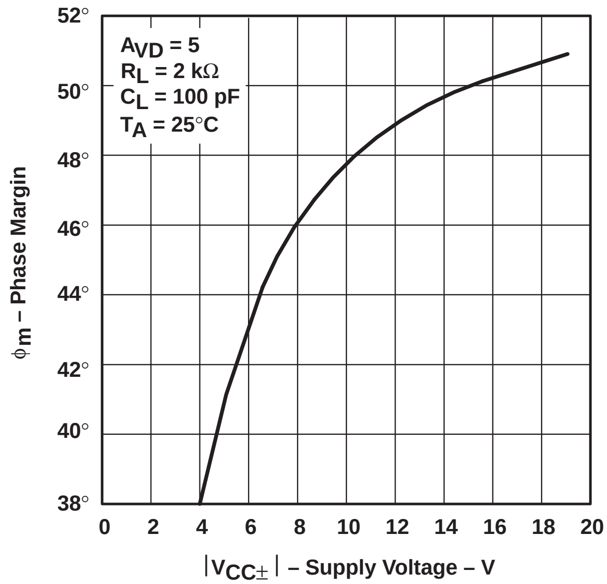


Figure 50

**TLE2027
PHASE MARGIN
vs
LOAD CAPACITANCE**

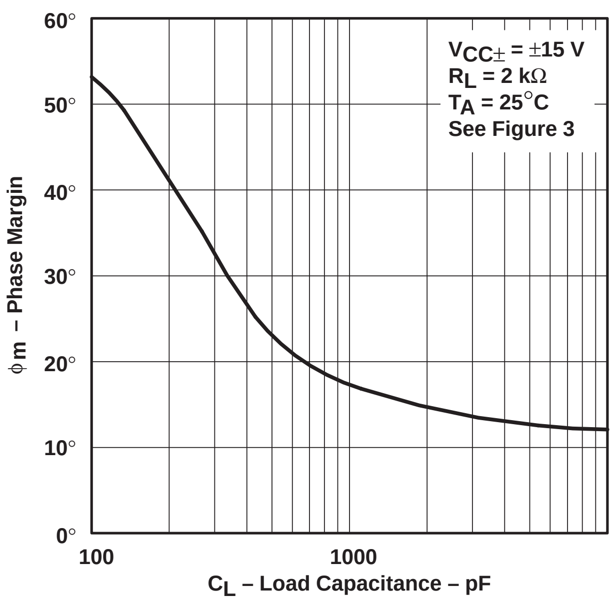


Figure 51

**TLE2037
PHASE MARGIN
vs
LOAD CAPACITANCE**

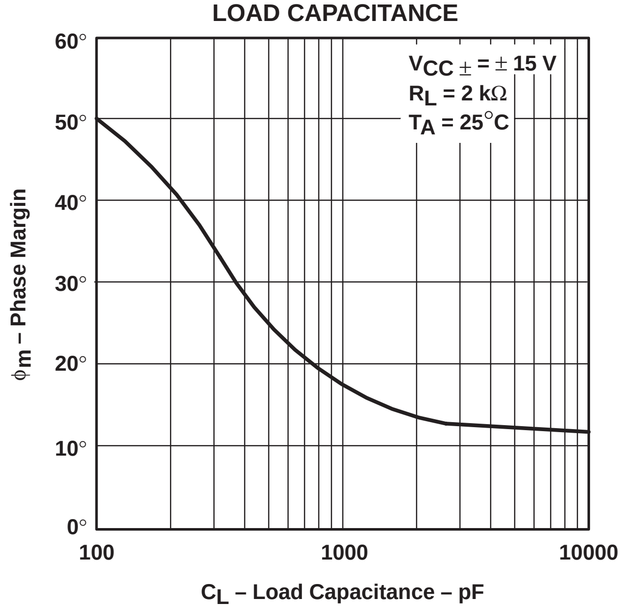


Figure 52

TYPICAL CHARACTERISTICS

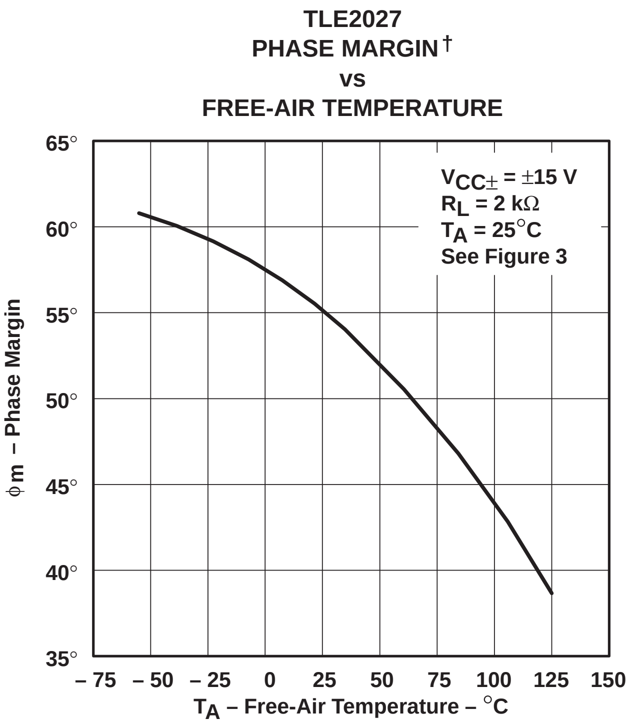


Figure 53

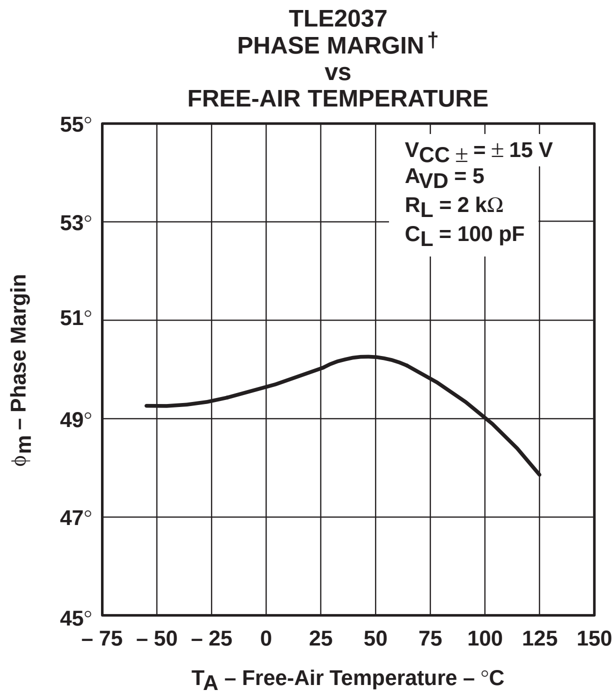


Figure 54

† 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.

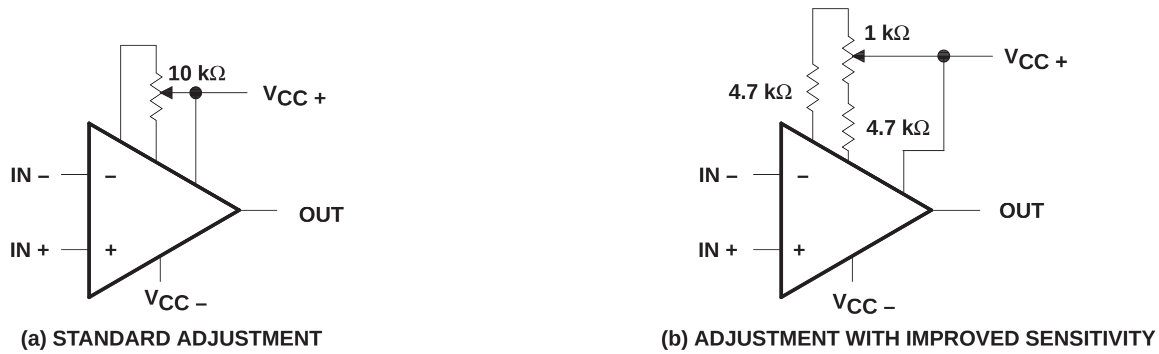


Figure 55. Input Offset Voltage Nulling Circuits

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).

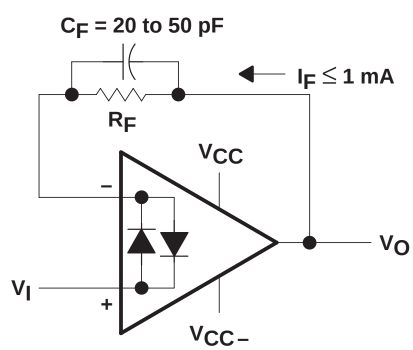


Figure 56. Voltage Follower

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).

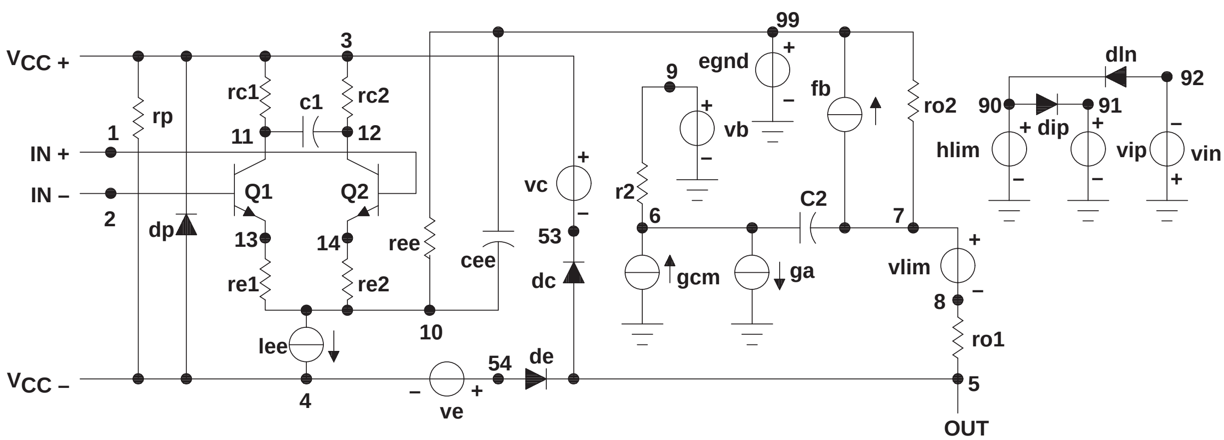


Figure 57. Boyle Macromodel

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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

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