

# TLE2161, TLE2161A, TLE2161B EXCALIBUR JFET-INPUT HIGH-OUTPUT-DRIVE $\mu$ POWER OPERATIONAL AMPLIFIERS

SLOS049D – NOVEMBER 1989 – REVISED MAY 1996

- **Excellent Output Drive Capability**  
 $V_O = \pm 2.5 \text{ V Min at } R_L = 100 \ \Omega,$   
 $V_{CC\pm} = \pm 5 \text{ V}$   
 $V_O = \pm 12.5 \text{ V Min at } R_L = 600 \ \Omega,$   
 $V_{CC\pm} = \pm 15 \text{ V}$
- **Low Supply Current . . . 280  $\mu\text{A Typ}$**
- **Decompensated for High Slew Rate and Gain-Bandwidth Product**  
 $A_{VD} = 0.5 \text{ Min}$   
**Slew Rate = 10 V/ $\mu\text{s Typ}$**   
**Gain-Bandwidth Product = 6.5 MHz Typ**

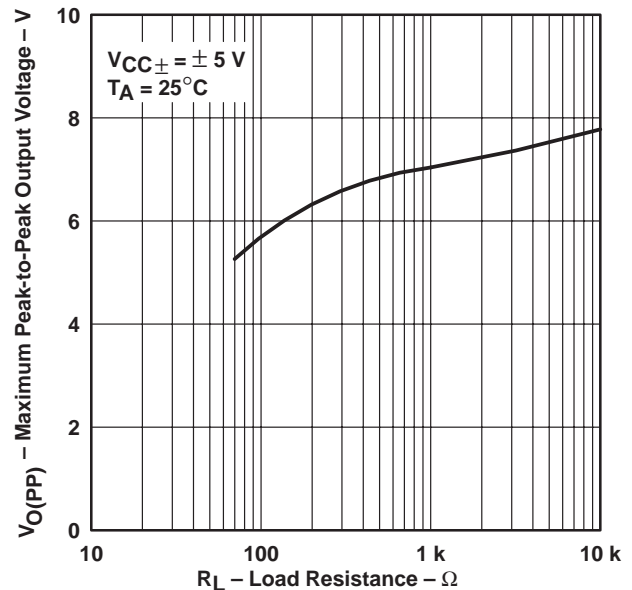
- **Wide Operating Supply Voltage Range**  
 $V_{CC\pm} = \pm 3.5 \text{ V to } \pm 18 \text{ V}$
- **High Open-Loop Gain . . . 280 V/mV Typ**
- **Low Offset Voltage . . . 500  $\mu\text{V Max}$**
- **Low Offset Voltage Drift With Time**  
**0.04  $\mu\text{V/Month Typ}$**
- **Low Input Bias Current . . . 5 pA Typ**

## description

The TLE2161, TLE2161A, and TLE2161B are JFET-input, low-power, precision operational amplifiers manufactured using the Texas Instruments Excalibur process. Decompensated for stability with a minimum closed-loop gain of 5, these devices combine outstanding output drive capability with low power consumption, excellent dc precision, and high gain-bandwidth product.

In addition to maintaining the traditional JFET advantages of fast slew rates and low input bias and offset currents, the Excalibur process offers outstanding parametric stability over time and temperature. This results in a device that remains precise even with changes in temperature and over years of use.

**MAXIMUM PEAK-TO-PEAK OUTPUT VOLTAGE  
vs  
LOAD RESISTANCE**



## AVAILABLE OPTIONS

$T_A$	$V_{IOmax}$ AT 25°C	PACKAGE			
		SMALL OUTLINE (D)	CHIP CARRIER (FK)	CERAMIC DIP (JG)	PLASTIC DIP (P)
0°C to 70°C	500 $\mu\text{V}$ 1.5 mV 3 mV	— TLE2161ACD TLE2161CD	— —	— —	TLE2161BCP TLE2161ACP TLE2161CP
-40°C to 85°C	500 $\mu\text{V}$ 1.5 mV 3 mV	— TLE2161AID TLE2161ID	— —	— —	TLE2161BIP TLE2161AIP TLE2161IP
-55°C to 125°C	500 $\mu\text{V}$ 1.5 mV 3 mV	— TLE2161AMD TLE2161MD	— TLE2161AMFK TLE2161MFK	TLE2161BMJG TLE2161AMJG TLE2161MJG	TLE2161BMP TLE2161AMP TLE2161MP

The D packages are available taped and reeled. Add R suffix to device type (e.g., TLE2161ACDR).



Please be aware that an important notice concerning availability, standard warranty, and use in critical applications of Texas Instruments semiconductor products and disclaimers thereto appears at the end of this data sheet.

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

**TEXAS  
INSTRUMENTS**

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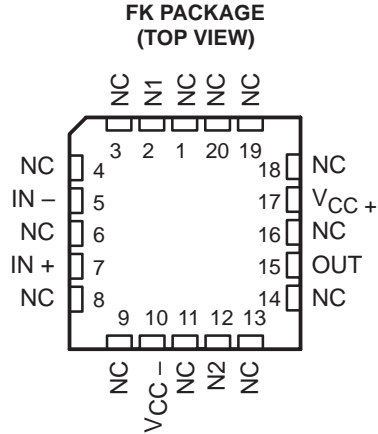
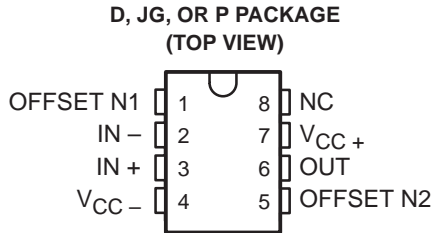
# TLE2161, TLE2161A, TLE2161B EXCALIBUR JFET-INPUT HIGH-OUTPUT-DRIVE μPOWER OPERATIONAL AMPLIFIERS

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## description (continued)

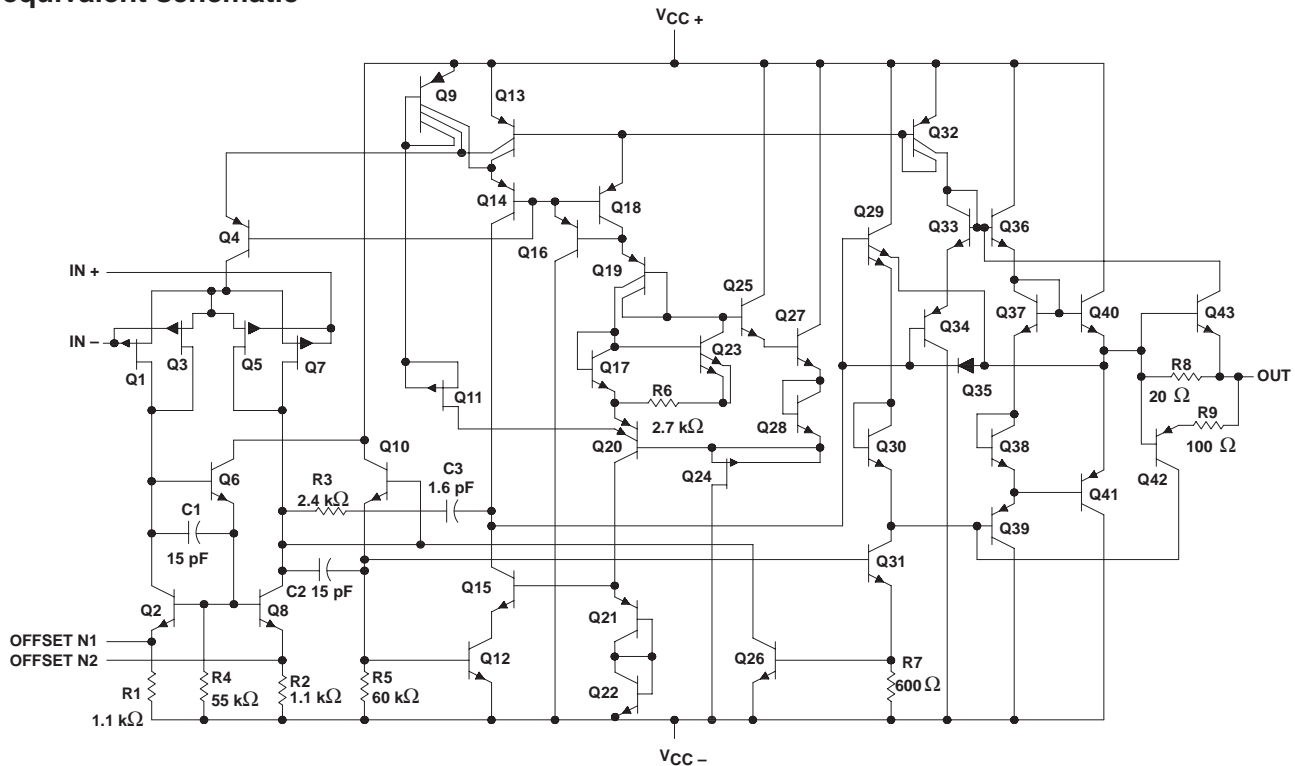
A variety of available options includes small-outline packages and chip-carrier versions for high-density system applications.

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 85°C. The M-suffix devices are characterized for operation over the full military temperature range of – 55°C to 125°C.



NC – No internal connection

## equivalent schematic



All component values are nominal.

**absolute maximum ratings over operating free-air temperature range (unless otherwise noted)†**

Supply voltage, $V_{CC+}$ (see Note 1)	19 V
Supply voltage, $V_{CC-}$	-19 V
Differential input voltage, $V_{ID}$ (see Note 2)	$\pm 38$ V
Input voltage range, $V_I$ (any input)	$V_{CC\pm}$
Input current, $I_I$ (each input)	$\pm 1$ mA
Output current, $I_O$	$\pm 80$ mA
Total current into $V_{CC+}$	80 mA
Total current out of $V_{CC-}$	80 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 85°C
M suffix	-55°C to 125°C
Storage temperature range, $T_{stg}$	-65°C to 150°C
Case temperature for 60 seconds: 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 60seconds: 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  $IN-$ .  
 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	$T_A \leq 25^\circ\text{C}$ POWER RATING	DERATING FACTOR ABOVE $T_A = 25^\circ\text{C}$	$T_A = 70^\circ\text{C}$ POWER RATING	$T_A = 85^\circ\text{C}$ POWER RATING	$T_A = 125^\circ\text{C}$ POWER RATING
D	725 mW	5.8 mW/°C	464 mW	377 mW	145 mW
FK	1375 mW	11.0 mW/°C	880 mW	715 mW	275 mW
JG	1050 mW	8.4 mW/°C	672 mW	546 mW	210 mW
P	1000 mW	8.0 mW/°C	640 mW	520 mW	200 mW

**recommended operating conditions**

	C SUFFIX		I SUFFIX		M SUFFIX		UNIT
	MIN	MAX	MIN	MAX	MIN	MAX	
Supply voltage, $V_{CC\pm}$	$\pm 3.5$	$\pm 18$	$\pm 3.5$	$\pm 18$	+3.5	$\pm 18$	V
Common-mode input voltage, $V_{IC}$	$V_{CC\pm} = \pm 5$ V		-1.6	4	-1.6	4	V
	$V_{CC\pm} = \pm 15$ V		-11	13	-11	13	
Operating free-air temperature, $T_A$	0	70	-40	85	-55	125	°C

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## EXCALIBUR JFET-INPUT HIGH-OUTPUT-DRIVE

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electrical characteristics at specified free-air temperature,  $V_{CC} \pm \pm 5\text{ V}$  (unless otherwise noted)

PARAMETER		TEST CONDITIONS	$T_A$ †	TLE2161C, TLE2161AC TLE2161BC			UNIT	
				MIN	TYP	MAX		
$V_{IO}$ Input offset voltage	TLE2161C	$V_{IC} = 0, R_S = 50\ \Omega$	25°C	0.8	3.1	mV		
			Full range	4				
			25°C	0.6	2.6			
	TLE2161AC		Full range	3.5				
			25°C	0.5	1.9			
			Full range	2.4				
	$\alpha_{V_{IO}}$ Temperature coefficient of input offset voltage		Input offset voltage long-term drift (see Note 4)	Full range	6		$\mu\text{V}/^\circ\text{C}$	
				25°C	0.04		$\mu\text{V}/\text{mo}$	
	$I_{IO}$ Input offset current			25°C	1		pA	
Full range		0.8		nA				
$I_{IB}$ Input bias current		25°C	3		pA			
		Full range	2		nA			
$V_{ICR}$ Common-mode input voltage range		25°C	-1.6 to 4	-2 to 6	V			
		Full range	-1.6 to 4		V			
$V_{OM+}$ Maximum positive peak output voltage swing	$R_L = 10\ \text{k}\Omega$	25°C	3.5	3.7	V			
		Full range	3.3					
	$R_L = 100\ \Omega$	25°C	2.5	3.1				
		Full range	2					
$V_{OM-}$ Maximum negative peak output voltage swing	$R_L = 10\ \text{k}\Omega$	25°C	-3.7	-3.9	V			
		Full range	-3.3					
	$R_L = 100\ \Omega$	25°C	-2.5	-2.7				
		Full range	-2					
$A_{VD}$ Large-signal differential voltage amplification	$V_O = \pm 2.8\ \text{V}, R_L = 10\ \text{k}\Omega$	25°C	15	80	V/mV			
		Full range	2					
	$V_O = 0\ \text{to}\ 2\ \text{V}, R_L = 100\ \Omega$	25°C	0.75	45				
		Full range	0.5					
	$V_O = 0\ \text{to}\ -2\ \text{V}, R_L = 100\ \Omega$	25°C	0.5	3				
		Full range	0.25					
$r_i$ Input resistance		25°C	$10^{12}$		$\Omega$			
$c_i$ Input capacitance		25°C	4		pF			
$z_o$ Open-loop output impedance	$I_O = 0$	25°C	280		$\Omega$			
CMRR Common-mode rejection ratio	$V_{IC} = V_{ICRmin}, R_S = 50\ \Omega$	25°C	65	82	dB			
		Full range	65					
kSVR Supply-voltage rejection ratio ( $\Delta V_{CC\pm} / \Delta V_{IO}$ )	$V_{CC\pm} = \pm 5\ \text{V to } \pm 15\ \text{V}, R_S = 50\ \Omega$	25°C	75	93	dB			
		Full range	75					
$I_{CC}$ Supply current	$V_O = 0, \text{ No load}$	25°C	280	325	$\mu\text{A}$			
		Full range	350					
$\Delta I_{CC}$ Supply-current change over operating temperature range		Full range	29		$\mu\text{A}$			

† Full range is 0°C to 70°C.

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



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operating characteristics at specified free-air temperature,  $V_{CC} \pm = \pm 5$  V (unless otherwise noted)

PARAMETER	TEST CONDITIONS	$T_A$ †	TLE2161C, TLE2161AC TLE2161BC			UNIT
			MIN	TYP	MAX	
SR Slew rate (see Figure 1)	$A_{VD} = 5, R_L = 10 \text{ k}\Omega, C_L = 100 \text{ pF}$	25°C	7	10		V/ $\mu$ s
		Full range	5			
$V_n$ Equivalent input noise voltage (see Figure 2)	$R_S = 20 \Omega, f = 10 \text{ Hz}$	25°C		59	100	nV/ $\sqrt{\text{Hz}}$
	$R_S = 20 \Omega, f = 1 \text{ kHz}$			43	60	
$V_n(\text{PP})$ Peak-to-peak equivalent input noise voltage	$f = 0.1 \text{ Hz to } 10 \text{ Hz}$	25°C		1.1		$\mu$ V
$I_n$ Equivalent input noise current	$f = 1 \text{ kHz}$	25°C		1		fA/ $\sqrt{\text{Hz}}$
THD Total harmonic distortion	$V_{O(\text{PP})} = 2 \text{ V}, A_{VD} = 5, f = 10 \text{ kHz}, R_L = 10 \text{ k}\Omega$	25°C		0.025%		
Gain-bandwidth product (see Figure 3)	$f = 100 \text{ kHz}, R_L = 10 \text{ k}\Omega, C_L = 100 \text{ pF}$	25°C		5.8		MHz
	$f = 100 \text{ kHz}, R_L = 100 \text{ k}\Omega, C_L = 100 \text{ pF}$			4.3		
$t_s$ Settling time	$\epsilon = 0.1\%$	25°C		5		$\mu$ s
	$\epsilon = 0.01\%$			10		
$B_{OM}$ Maximum output-swing bandwidth	$A_{VD} = 5, R_L = 10 \text{ k}\Omega$	25°C		420		kHz
$\phi_m$ Phase margin (see Figure 3)	$A_{VD} = 5, R_L = 10 \text{ k}\Omega, C_L = 100 \text{ pF}$	25°C		70°		
	$A_{VD} = 5, R_L = 100 \Omega, C_L = 100 \text{ pF}$			84°		

† Full range is 0°C to 70°C.

# TLE2161, TLE2161A, TLE2161B

## EXCALIBUR JFET-INPUT HIGH-OUTPUT-DRIVE

### μPOWER OPERATIONAL AMPLIFIERS

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

PARAMETER		TEST CONDITIONS	$T_A$ †	TLE2161C, TLE2161AC TLE2161BC			UNIT
				MIN	TYP	MAX	
$V_{IO}$	Input offset voltage	$V_{IC} = 0,$ $R_S = 50\ \Omega$	25°C	0.6	3	mV	
			Full range	3.9			
			25°C	0.5	1.5		
			Full range	2.5			
			25°C	0.3	0.5		
			Full range	1			
$\alpha_{VIO}$	Temperature coefficient of input offset voltage	$V_{IC} = 0,$ $R_S = 50\ \Omega$	Full range	6		$\mu\text{V}/^\circ\text{C}$	
	Input offset voltage long-term drift (see Note 4)		25°C	0.04		$\mu\text{V}/\text{mo}$	
$I_{IO}$	Input offset current		25°C	2		pA	
			Full range	1		nA	
$I_{IB}$	Input bias current		25°C	4		pA	
			Full range	3		nA	
$V_{ICR}$	Common-mode input voltage range		25°C	-11 to 13	-12 to 16	V	
			Full range	-11 to 13		V	
$V_{OM+}$	Maximum positive peak output voltage swing	$R_L = 10\ \text{k}\Omega$	25°C	13.2	13.7	V	
			Full range	13			
		$R_L = 600\ \Omega$	25°C	12.5	13.2		
			Full range	12			
$V_{OM-}$	Maximum negative peak output voltage swing	$R_L = 10\ \text{k}\Omega$	25°C	-13.2	-13.7	V	
			Full range	-13			
		$R_L = 600\ \Omega$	25°C	-12.5	-13		
			Full range	-12			
$A_{VD}$	Large-signal differential voltage amplification	$V_O = \pm 10\ \text{V},$ $R_L = 10\ \text{k}\Omega$	25°C	30	230	V/mV	
			Full range	20			
		$V_O = 0\ \text{to}\ 8\ \text{V},$ $R_L = 600\ \Omega$	25°C	25	100		
			Full range	10			
		$V_O = 0\ \text{to}\ -8\ \text{V},$ $R_L = 600\ \Omega$	25°C	3	25		
			Full range	1			
$r_i$	Input resistance		25°C	$10^{12}$		$\Omega$	
$c_i$	Input capacitance		25°C	4		pF	
$z_o$	Open-loop output impedance	$I_O = 0$	25°C	280		$\Omega$	
CMRR	Common-mode rejection ratio	$V_{IC} = V_{ICRmin},$ $R_S = 50\ \Omega$	25°C	72	90	dB	
			Full range	70			
$k_{SVR}$	Supply-voltage rejection ratio ( $\Delta V_{CC\pm} / \Delta V_{IO}$ )	$V_{CC\pm} = \pm 5\ \text{V}\ \text{to}\ \pm 15\ \text{V},$ $R_S = 50\ \Omega$	25°C	75	93	dB	
			Full range	75			
$I_{CC}$	Supply current	$V_O = 0,$ No load	25°C	290	350	$\mu\text{A}$	
			Full range	375			
$\Delta I_{CC}$	Supply-current change over operating temperature range		Full range	34		$\mu\text{A}$	

† Full range is 0°C to 70°C.

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



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

PARAMETER	TEST CONDITIONS	$T_A$ †	TLE2161C, TLE2161AC TLE2161BC			UNIT
			MIN	TYP	MAX	
SR Slew rate (see Figure 1)	$A_{VD} = 5$ , $R_L = 10$ k $\Omega$ , $C_L = 100$ pF	25°C	7	10		V/ $\mu$ s
		Full range	5			
$V_n$ Equivalent input noise voltage (see Figure 2)	$R_S = 20$ $\Omega$ , $f = 10$ Hz	25°C		70	100	nV/ $\sqrt{\text{Hz}}$
	$R_S = 20$ $\Omega$ , $f = 1$ kHz			40	60	
$V_{n(PP)}$ Peak-to-peak equivalent input noise voltage	$f = 0.1$ Hz to 10 Hz	25°C		1.1		$\mu$ V
$I_n$ Equivalent input noise current	$f = 1$ kHz	25°C		1.1		fA/ $\sqrt{\text{Hz}}$
THD Total harmonic distortion	$V_{O(PP)} = 2$ V, $A_{VD} = 5$ , $f = 10$ kHz, $R_L = 10$ k $\Omega$	25°C		0.025%		
Gain-bandwidth product (see Figure 3)	$f = 100$ kHz, $R_L = 10$ k $\Omega$ , $C_L = 100$ pF	25°C		6.4		MHz
	$f = 100$ kHz, $R_L = 600$ $\Omega$ , $C_L = 100$ pF			5.6		
$t_s$ Settling time	$\epsilon = 0.1\%$	25°C		5		$\mu$ s
	$\epsilon = 0.01\%$			10		
BOM Maximum output-swing bandwidth	$A_{VD} = 5$ , $R_L = 10$ k $\Omega$	25°C		116		kHz
$\phi_m$ Phase margin (see Figure 3)	$A_{VD} = 5$ , $R_L = 10$ k $\Omega$ , $C_L = 100$ pF	25°C		72°		
	$A_{VD} = 5$ , $R_L = 600$ $\Omega$ , $C_L = 100$ pF			78°		

† Full range is 0°C to 70°C.

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electrical characteristics at specified free-air temperature,  $V_{CC} \pm \pm 5\text{ V}$  (unless otherwise noted)

PARAMETER		TEST CONDITIONS	$T_A^\dagger$	TLE2161I, TLE2161AI TLE2161BI			UNIT
				MIN	TYP	MAX	
$V_{IO}$	Input offset voltage	$V_{IC} = 0, R_S = 50\ \Omega$	25°C	0.8	3.1	mV	
			Full range	4.4			
			25°C	0.6	2.6		
			Full range	3.9			
			25°C	0.5	1.9		
			Full range	2.7			
$\alpha_{VIO}$	Temperature coefficient of input offset voltage	$V_{IC} = 0, R_S = 50\ \Omega$	Full range	6		$\mu\text{V}/^\circ\text{C}$	
	Input offset voltage long-term drift (see Note 4)		25°C	0.04		$\mu\text{V}/\text{mo}$	
$I_{IO}$	Input offset current		25°C	1		pA	
			Full range	2		nA	
$I_{IB}$	Input bias current		25°C	3		pA	
			Full range	4		nA	
$V_{ICR}$	Common-mode input voltage range		25°C	-1.6 to 4	-2 to 6	V	
			Full range	-1.6 to 4			
$V_{OM+}$	Maximum positive peak output voltage	$R_L = 10\ \text{k}\Omega$	25°C	3.5	3.7	V	
			Full range	3.1			
			25°C	2.5	3.1		
			Full range	2			
$V_{OM-}$	Maximum negative peak output voltage swing	$R_L = 10\ \text{k}\Omega$	25°C	-3.7	-3.9	V	
			Full range	-3.1			
			25°C	-2.5	-2.7		
			Full range	-2			
$A_{VD}$	Large-signal differential voltage amplification	$V_O = \pm 2.8\ \text{V}, R_L = 10\ \text{k}\Omega$	25°C	15	80	V/mV	
			Full range	2			
		$V_O = 0\ \text{to}\ 2\ \text{V}, R_L = 100\ \Omega$	25°C	0.75	45		
			Full range	0.5			
		$V_O = 0\ \text{to}\ -2\ \text{V}, R_L = 100\ \Omega$	25°C	0.5	3		
			Full range	0.25			
$r_i$	Input resistance		25°C	10 <sup>12</sup>		$\Omega$	
$c_i$	Input capacitance		25°C	4		pF	
$z_o$	Open-loop output impedance	$I_O = 0$	25°C	280		$\Omega$	
CMRR	Common-mode rejection ratio	$V_{IC} = V_{ICRmin}, R_S = 50\ \Omega$	25°C	65	82	dB	
			Full range	65			
kSVR	Supply-voltage rejection ratio ( $\Delta V_{CC\pm} / \Delta V_{IO}$ )	$V_{CC\pm} = \pm 5\ \text{V to } \pm 15\ \text{V}, R_S = 50\ \Omega$	25°C	75	93	dB	
			Full range	65			
$I_{CC}$	Supply current	$V_O = 0, \text{ No load}$	25°C	280	325	$\mu\text{A}$	
			Full range	350			
$\Delta I_{CC}$	Supply-current change over operating temperature range		Full range	29		$\mu\text{A}$	

$^\dagger$  Full range is  $-40^\circ\text{C}$  to  $85^\circ\text{C}$ .

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





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operating characteristics at specified free-air temperature,  $V_{CC} \pm = \pm 5\text{ V}$  (unless otherwise noted)

PARAMETER		TEST CONDITIONS	$T_A$ †	TLE2161, TLE2161A TLE2161BI			UNIT
				MIN	TYP	MAX	
SR	Slew rate (see Figure 1)	$A_{VD} = 5$ , $R_L = 10\text{ k}\Omega$ , $C_L = 100\text{ pF}$	25°C	7	10		V/μs
			Full range	5			
$V_n$	Equivalent input noise voltage (see Figure 2)	$R_S = 20\ \Omega$ , $f = 10\text{ Hz}$	25°C		59	100	nV/√Hz
		$R_S = 20\ \Omega$ , $f = 1\text{ kHz}$			43	60	
$V_{n(PP)}$	Peak-to-peak equivalent input noise voltage	$f = 0.1\text{ Hz to }10\text{ Hz}$	25°C		1.1		μV
$I_n$	Equivalent input noise current	$f = 1\text{ kHz}$	25°C		1		fA/√Hz
THD	Total harmonic distortion	$V_{O(PP)} = 2\text{ V}$ , $R_L = 10\text{ k}\Omega$ , $A_{VD} = 5$ , $f = 10\text{ kHz}$	25°C		0.025%		
	Gain-bandwidth product (see Figure 3)	$f = 100\text{ kHz}$ , $R_L = 10\text{ k}\Omega$ , $C_L = 100\text{ pF}$	25°C		5.8		MHz
		$f = 100\text{ kHz}$ , $R_L = 100\ \Omega$ , $C_L = 100\text{ pF}$			4.3		
$t_s$	Settling time	$\epsilon = 0.1\%$	25°C		5		μs
		$\epsilon = 0.01\%$			10		
$B_{OM}$	Maximum output-swing bandwidth	$A_{VD} = 5$ , $R_L = 10\text{ k}\Omega$	25°C		420		kHz
$\phi_m$	Phase margin (see Figure 3)	$A_{VD} = 5$ , $R_L = 10\text{ k}\Omega$ , $C_L = 100\text{ pF}$	25°C		70°		
		$A_{VD} = 5$ , $R_L = 100\ \Omega$ , $C_L = 100\text{ pF}$			84°		

† Full range is – 40°C to 85°C.

**TLE2161, TLE2161A, TLE2161B**  
**EXCALIBUR JFET-INPUT HIGH-OUTPUT-DRIVE**  
**μPOWER OPERATIONAL AMPLIFIERS**

SLOS049D – NOVEMBER 1989 – REVISED MAY 1996

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

PARAMETER		TEST CONDITIONS	$T_A^\dagger$	TLE2161, TLE2161A TLE2161B			UNIT
				MIN	TYP	MAX	
$V_{IO}$	Input offset voltage	$V_{IC} = 0, R_S = 50\ \Omega$	25°C	0.6	3	mV	
			Full range	4.3			
			25°C	0.5	1.5		
			Full range	2.9			
			25°C	0.3	0.5		
			Full range	1.3			
$\alpha_{VIO}$	Temperature coefficient of input offset voltage	$V_{IC} = 0, R_S = 50\ \Omega$	Full range	6		$\mu\text{V}/^\circ\text{C}$	
	Input offset voltage long-term drift (see Note 4)		25°C	0.04		$\mu\text{V}/\text{mo}$	
$I_{IO}$	Input offset current		25°C	2		pA	
			Full range	3		nA	
$I_{IB}$	Input bias current		25°C	4		pA	
			Full range	5		nA	
$V_{ICR}$	Common-mode input voltage range		25°C	-11 to 13	-12 to 16	V	
			Full range	-11 to 13		V	
$V_{OM+}$	Maximum positive peak output voltage swing	$R_L = 10\ \text{k}\Omega$	25°C	13.2	13.7	V	
			Full range	13			
			25°C	12.5	13.2		
			Full range	12			
$V_{OM-}$	Maximum negative peak output voltage swing	$R_L = 10\ \text{k}\Omega$	25°C	-13.2	-13.7	V	
			Full range	-13			
			25°C	-12.5	-13		
			Full range	-12			
$A_{VD}$	Large-signal differential voltage amplification	$V_0 = \pm 10\ \text{V}, R_L = 10\ \text{k}\Omega$	25°C	30	230	V/mV	
			Full range	20			
		$V_0 = 0\ \text{to}\ 8\ \text{V}, R_L = 600\ \Omega$	25°C	25	100		
			Full range	10			
		$V_0 = 0\ \text{to}\ -8\ \text{V}, R_L = 600\ \Omega$	25°C	3	25		
			Full range	1			
$r_i$	Input resistance		25°C	10 <sup>12</sup>		$\Omega$	
$c_i$	Input capacitance		25°C	4		pF	
$z_o$	Open-loop output impedance	$I_O = 0$	25°C	280		$\Omega$	
CMRR	Common-mode rejection ratio	$V_{IC} = V_{ICRmin}, R_S = 50\ \Omega$	25°C	72	90	dB	
			Full range	65			
$k_{SVR}$	Supply-voltage rejection ratio ( $\Delta V_{CC\pm} / \Delta V_{IO}$ )	$V_{CC\pm} = \pm 5\ \text{V to } \pm 15\ \text{V}, R_S = 50\ \Omega$	25°C	75	93	dB	
			Full range	65			
$I_{CC}$	Supply current	$V_0 = 0, \text{ No load}$	25°C	290	350	$\mu\text{A}$	
			Full range	375			
$\Delta I_{CC}$	Supply-current change over operating temperature range		Full range	34		$\mu\text{A}$	

$^\dagger$  Full range is -40°C to 85°C.

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



TLE2161, TLE2161A, TLE2161B  
EXCALIBUR JFET-INPUT HIGH-OUTPUT-DRIVE  
 $\mu$ POWER OPERATIONAL AMPLIFIERS  
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operating characteristics at specified free-air temperature,  $V_{CC} \pm = \pm 15$  V (unless otherwise noted)

PARAMETER	TEST CONDITIONS	$T_A$ †	TLE2161, TLE2161A TLE2161B			UNIT
			MIN	TYP	MAX	
SR Slew rate (see Figure 1)	$A_{VD} = 5$ , $R_L = 10$ k $\Omega$ , $C_L = 100$ pF	25°C	7	10		V/ $\mu$ s
		Full range	5			
$V_n$ Equivalent input noise voltage (see Figure 2)	$R_S = 20$ $\Omega$ , $f = 10$ Hz	25°C		70	100	nV/ $\sqrt{\text{Hz}}$
	$R_S = 20$ $\Omega$ , $f = 1$ kHz			40	60	
$V_{n(PP)}$ Peak-to-peak equivalent input noise voltage	$f = 0.1$ Hz to 10 Hz	25°C		1.1		$\mu$ V
$I_n$ Equivalent input noise current	$f = 1$ kHz	25°C		1.1		fA/ $\sqrt{\text{Hz}}$
THD Total harmonic distortion	$V_{O(PP)} = 2$ V, $A_{VD} = 5$ , $f = 10$ kHz, $R_L = 10$ k $\Omega$	25°C		0.025%		
Gain-bandwidth product (see Figure 3)	$f = 100$ kHz, $R_L = 10$ k $\Omega$ , $C_L = 100$ pF	25°C		6.4		MHz
	$f = 100$ kHz, $R_L = 600$ $\Omega$ , $C_L = 100$ pF			5.6		
$t_s$ Settling time	$\epsilon = 0.1\%$	25°C		5		$\mu$ s
	$\epsilon = 0.01\%$			10		
$B_{OM}$ Maximum output-swing bandwidth	$A_{VD} = 5$ , $R_L = 10$ k $\Omega$	25°C		116		kHz
$\phi_m$ Phase margin (see Figure 3)	$A_{VD} = 5$ , $R_L = 10$ k $\Omega$ , $C_L = 100$ pF	25°C		72°		
	$A_{VD} = 5$ , $R_L = 600$ $\Omega$ , $C_L = 100$ pF			78°		

† Full range is – 40°C to 85°C.

# TLE2161, TLE2161A, TLE2161B

## EXCALIBUR JFET-INPUT HIGH-OUTPUT-DRIVE

### μPOWER OPERATIONAL AMPLIFIERS

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electrical characteristics at specified free-air temperature,  $V_{CC} \pm \pm 5\text{ V}$  (unless otherwise noted)

PARAMETER		TEST CONDITIONS	$T_A$ †	TLE2161M TLE2161AM TLE2161BM			UNIT
				MIN	TYP	MAX	
$V_{IO}$	Input offset voltage	$V_{IC} = 0,$ $R_S = 50\ \Omega$	25°C	0.8	3.1	mV	
			Full range	6			
			25°C	0.6	2.6		
			Full range	4.6			
			25°C	0.5	1.9		
			Full range	3.1			
$\alpha_{VIO}$	Temperature coefficient of input offset voltage	$V_{IC} = 0,$ $R_S = 50\ \Omega$	Full range	6		$\mu\text{V}/^\circ\text{C}$	
	Input offset voltage long-term drift (see Note 4)		25°C	0.04		$\mu\text{V}/\text{mo}$	
$I_{IO}$	Input offset current		25°C	1		pA	
			Full range	15		nA	
$I_{IB}$	Input bias current	25°C	3		pA		
		Full range	30		nA		
$V_{ICR}$	Common-mode input voltage range	25°C	-1.6 to 4	-2 to 6	V		
		Full range	-1.6 to 4		V		
$V_{OM+}$	Maximum positive peak output voltage swing	All packages $R_L = 10\ \text{k}\Omega$	25°C	3.5	3.7	V	
			Full range	3			
		FK and JG packages $R_L = 600\ \Omega$	25°C	2.5	3.6	V	
			Full range	2			
		D and P packages $R_L = 100\ \Omega$	25°C	2.5	3.1	V	
			Full range	2			
$V_{OM-}$	Maximum negative peak output voltage swing	All packages $R_L = 10\ \text{k}\Omega$	25°C	-3.7	-3.9	V	
			Full range	-3			
		FK and JG packages $R_L = 600\ \Omega$	25°C	-2.5	-3.5	V	
			Full range	-2			
		D and P packages $R_L = 100\ \Omega$	25°C	-2.5	-2.7	V	
			Full range	-2			
AVD	Large-signal differential voltage amplification	All packages $V_0 = \pm 2.8\ \text{V},$ $R_L = 10\ \text{k}\Omega$	25°C	15	80	V/mV	
			Full range	2			
		FK and JG packages $V_0 = 0\ \text{to}\ 2.5\ \text{V},$ $R_L = 600\ \Omega$	25°C	1	65		
			Full range	0.5			
		FK and JG packages $V_0 = 0\ \text{to}\ -2.5\ \text{V},$ $R_L = 600\ \Omega$	25°C	1	16		
			Full range	0.5			
		D and P packages $V_0 = 0\ \text{to}\ 2\ \text{V},$ $R_L = 100\ \Omega$	25°C	0.75	45		
			Full range	0.5			
			D and P packages $V_0 = 0\ \text{to}\ -2\ \text{V},$ $R_L = 100\ \Omega$	25°C	0.5		3
				Full range	0.25		

† Full range is  $-55^\circ\text{C}$  to  $125^\circ\text{C}$ .

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



**TLE2161, TLE2161A, TLE2161B**  
**EXCALIBUR JFET-INPUT HIGH-OUTPUT-DRIVE**  
**μPOWER OPERATIONAL AMPLIFIERS**  
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**electrical characteristics at specified free-air temperature,  $V_{CC} \pm = \pm 5$  V (unless otherwise noted continued)**

PARAMETER	TEST CONDITIONS	$T_A$ †	TLE2161M TLE2161AM TLE2161BM			UNIT
			MIN	TYP	MAX	
$r_i$ Input resistance		25°C	10 <sup>12</sup>			Ω
$c_i$ Input capacitance		25°C	4			pF
$z_o$ Open-loop output impedance	$I_O = 0$	25°C	280			Ω
CMRR Common-mode rejection ratio	$V_{IC} = V_{ICRmin}, R_S = 50 \Omega$	25°C	65	82		dB
		Full range	60			
$k_{SVR}$ Supply-voltage rejection ratio ( $\Delta V_{CC\pm}/\Delta V_{IO}$ )	$V_{CC\pm} = \pm 5$ V to $\pm 15$ V, $R_S = 50 \Omega$	25°C	75	93		dB
		Full range	65			
$I_{CC}$ Supply current	$V_O = 0,$ No load	25°C	280	325		μA
		Full range	350			
$\Delta I_{CC}$ Supply-current change over operating temperature range		Full range	39		μA	

† Full range is –55°C to 125°C.

**operating characteristics,  $V_{CC} \pm = \pm 5$  V,  $T_A = 25^\circ\text{C}$**

PARAMETER	TEST CONDITIONS	TLE2161M TLE2161AM TLE2161BM			UNIT
		MIN	TYP	MAX	
SR Slew rate (see Figure 1)	$A_{VD} = 5,$ $R_L = 10$ kΩ, $C_L = 100$ pF	10			V/μs
$V_n$ Equivalent input noise voltage (see Figure 2)	$R_S = 20 \Omega,$ $f = 10$ Hz	59			nV/√Hz
	$R_S = 20 \Omega,$ $f = 1$ kHz	43			
$V_n(PP)$ Peak-to-peak equivalent input noise voltage	$f = 0.1$ Hz to 10 Hz	1.1			μV
$I_n$ Equivalent input noise current	$f = 1$ kHz	1			fA/√Hz
THD Total harmonic distortion	$A_{VD} = 5,$ $R_L = 10$ kΩ, $V_O(PP) = 2$ V, $f = 10$ kHz,	0.025%			
Gain-bandwidth product (see Figure 3)	$f = 100$ kHz, $R_L = 10$ kΩ, $C_L = 100$ pF	5.8			MHz
	$f = 100$ kHz, $R_L = 600$ kΩ, $C_L = 100$ pF	4.3			
$t_s$ Settling time	$\epsilon = 0.1\%$	5			μs
	$\epsilon = 0.01\%$	10			
$B_{OM}$ Maximum output-swing bandwidth	$A_{VD} = 5,$ $R_L = 10$ kΩ	420			kHz
$\phi_m$ Phase margin (see Figure 3)	$A_{VD} = 5,$ $R_L = 10$ kΩ, $C_L = 100$ pF	70°			
	$A_{VD} = 5,$ $R_L = 600 \Omega,$ $C_L = 100$ pF	84°			

**TLE2161, TLE2161A, TLE2161B**  
**EXCALIBUR JFET-INPUT HIGH-OUTPUT-DRIVE**  
**μPOWER OPERATIONAL AMPLIFIERS**

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

PARAMETER		TEST CONDITIONS	$T_A$ †	TLE2161M TLE2161AM TLE2161BM			UNIT
				MIN	TYP	MAX	
$V_{IO}$	Input offset voltage	$V_{IC} = 0, R_S = 50\ \Omega$	25°C	0.6	3	mV	
			Full range	6			
			25°C	0.5	1.5		
			Full range	3.6			
			25°C	0.3	0.5		
			Full range	1.7			
$\alpha V_{IO}$	Temperature coefficient of input offset voltage	$V_{IC} = 0, R_S = 50\ \Omega$	Full range	6		$\mu\text{V}/^\circ\text{C}$	
Input offset voltage long-term drift (see Note 4)			25°C	0.04		$\mu\text{V}/\text{mo}$	
$I_{IO}$	Input offset current		25°C	2		pA	
			Full range	20		nA	
$I_{IB}$	Input bias current	25°C	4		pA		
		Full range	40		nA		
$V_{ICR}$	Common-mode input voltage range	25°C	-11 to 13	-12 to 16	V		
		Full range	-11 to 13		V		
$V_{OM+}$	Maximum positive peak output voltage swing	$R_L = 10\ \text{k}\Omega$	25°C	13.2	13.7	V	
			Full range	12.5			
		$R_L = 600\ \Omega$	25°C	12.5	13.2		
			Full range	12			
$V_{OM-}$	Maximum negative peak output voltage swing	$R_L = 10\ \text{k}\Omega$	25°C	-13.2	-13.7	V	
			Full range	-12.5			
		$R_L = 600\ \Omega$	25°C	-12.5	-13		
			Full range	-12			
$A_{VD}$	Large-signal differential voltage amplification	$V_O = \pm 10\ \text{V}, R_L = 10\ \text{k}\Omega$	25°C	30	230	V/mV	
			Full range	20			
		$V_O = 0\ \text{to}\ 8\ \text{V}, R_L = 600\ \Omega$	25°C	25	100		
			Full range	7			
		$V_O = 0\ \text{to}\ -8\ \text{V}, R_L = 600\ \Omega$	25°C	3	25		
			Full range	1			
$r_i$	Input resistance		25°C	10 <sup>12</sup>		$\Omega$	
$c_i$	Input capacitance		25°C	4		pF	
$z_o$	Open-loop output impedance	$I_O = 0$	25°C	280		$\Omega$	
CMRR	Common-mode rejection ratio	$V_{IC} = V_{ICR\text{min}}, R_S = 50\ \Omega$	25°C	72	90	dB	
			Full range	65			
$k_{SVR}$	Supply-voltage rejection ratio ( $\Delta V_{CC\pm} / \Delta V_{IO}$ )	$V_{CC\pm} = \pm 5\ \text{V to } \pm 15\ \text{V}, R_S = 50\ \Omega$	25°C	75	93	dB	
			Full range	65			
$I_{CC}$	Supply current	$V_O = 0, \text{ No load}$	25°C	290	350	$\mu\text{A}$	
			Full range	375			
$\Delta I_{CC}$	Supply-current change over operating temperature range		Full range	46		$\mu\text{A}$	

† 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  $T_A = 150^\circ\text{C}$  extrapolated to  $T_A = 25^\circ\text{C}$  using the Arrhenius equation and assuming an activation energy of 0.96 eV.



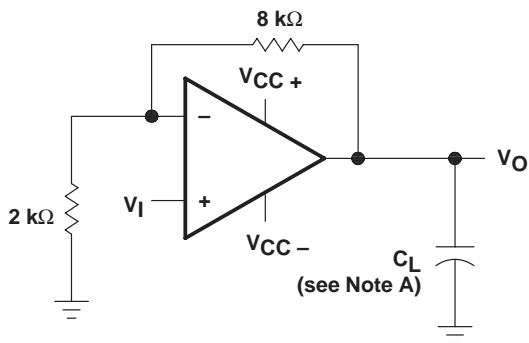
TLE2161, TLE2161A, TLE2161B  
EXCALIBUR JFET-INPUT HIGH-OUTPUT-DRIVE  
μPOWER OPERATIONAL AMPLIFIERS  
SLOS049D – NOVEMBER 1989 – REVISED MAY 1996

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

PARAMETER	TEST CONDITIONS	$T_A$ †	TLE2161M TLE2161AM TLE2161BM			UNIT
			MIN	TYP	MAX	
SR Slew rate (see Figure 1)	$A_{VD} = 5, R_L = 10 \text{ k}\Omega, C_L = 100 \text{ pF}$	25°C	7	10		V/μs
		Full range	5			
$V_n$ Equivalent input noise voltage (see Figure 2)	$R_S = 20 \Omega, f = 10 \text{ Hz}$	25°C	70			nV/√Hz
	$R_S = 20 \Omega, f = 1 \text{ kHz}$		40			
$V_{N(PP)}$ Peak-to-peak equivalent input noise voltage	$f = 0.1 \text{ Hz to } 10 \text{ Hz}$	25°C	1.1			μV
$I_n$ Equivalent input noise current	$f = 1 \text{ Hz}$	25°C	1.1			fA/√Hz
THD Total harmonic distortion	$V_{O(PP)} = 2 \text{ V}, A_{VD} = 5, f = 10 \text{ kHz}, R_L = 10 \text{ k}\Omega$	25°C	0.025%			
Gain-bandwidth product (see Figure 3)	$f = 100 \text{ kHz}, R_L = 10 \text{ k}\Omega, C_L = 100 \text{ pF}$	25°C	6.4			MHz
	$f = 100 \text{ kHz}, R_L = 600 \Omega, C_L = 100 \text{ pF}$		5.6			
$t_s$ Settling time	$\epsilon = 0.1\%$	25°C	5			μs
	$\epsilon = 0.01\%$		10			
$B_{OM}$ Maximum output-swing bandwidth	$A_{VD} = 5, R_L = 10 \text{ k}\Omega$	25°C	116			kHz
$\phi_m$ Phase margin (see Figure 3)	$A_{VD} = 5, R_L = 10 \text{ k}\Omega, C_L = 100 \text{ pF}$	25°C	72°			
	$A_{VD} = 5, R_L = 600 \Omega, C_L = 100 \text{ pF}$		78°			

† Full range is – 55°C to 125°C.

PARAMETER MEASUREMENT INFORMATION



NOTE A: C<sub>L</sub> includes fixture capacitance.

Figure 1. Slew-Rate Test Circuit

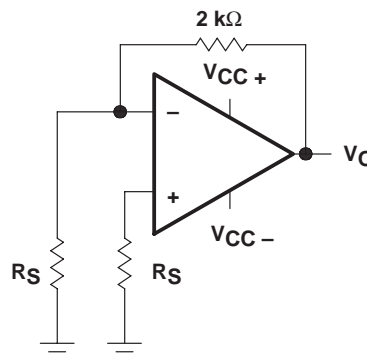
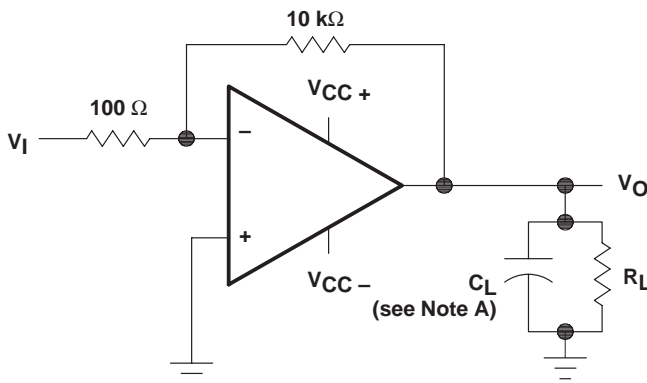


Figure 2. Noise-Voltage Test Circuit



NOTE A: C<sub>L</sub> includes fixture capacitance.

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

typical values

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

Input bias and offset current

At the picoampere bias-current level typical of the TLE2161, TLE2161A, and TLE2161B, accurate measurement of the bias current becomes difficult. Not only does this measurement require a picoammeter, but test socket leakages can easily exceed the actual device bias currents. To accurately measure these small currents, Texas Instruments uses a two-step process. The socket leakage is measured using picoammeters with bias voltages applied but with no device in the socket. The device is then inserted into the socket, and a second test that measures both the socket leakage and the device input bias current is performed. The two measurements are then subtracted algebraically to determine the bias current of the device.



## TYPICAL CHARACTERISTICS

**Table of Graphs**

			FIGURE
$V_{IO}$	Input offset voltage	Distribution	4
$I_{IB}$	Input bias current	vs Common-mode input voltage	5
		vs Free-air temperature	6
$I_{IO}$	Input offset current	vs Free-air temperature	6
$V_{ICR}$	Common-mode input voltage range limits	vs Free-air temperature	7
$V_{OM}$	Maximum positive peak output voltage	vs Output current	8
$V_{OM}$	Maximum negative peak output voltage	vs Output current	9
$V_{OM}$	Maximum peak output voltage	vs Supply voltage	10, 11, 12
$V_{O(PP)}$	Maximum peak-to-peak output voltage	vs Frequency	13, 14, 15
$A_{VD}$	Large-signal differential voltage amplification	vs Frequency	16
		vs Free-air temperature	17
$I_{OS}$	Short-circuit output current	vs Elapsed time	18
		Large-signal voltage amplification	19
$z_o$	Output impedance	vs Frequency	20
CMRR	Common-mode rejection ratio	vs Frequency	21
$I_{CC}$	Supply current	vs Supply voltage	22
		vs Free-air temperature	23
	Pulse response	Small signal	24, 25
		Large signal	26, 27
	Noise voltage (referred to input)	0.1 to 10 Hz	28
$V_n$	Equivalent input noise voltage	vs Frequency	29
THD	Total harmonic distortion	vs Frequency	30, 31
		Gain-bandwidth product	32
		vs Supply voltage	33
		vs Free-air temperature	33
$\phi_m$	Phase margin	vs Supply voltage	34
		vs Free-air temperature	35
	Phase shift	vs Frequency	16

TYPICAL CHARACTERISTICS†

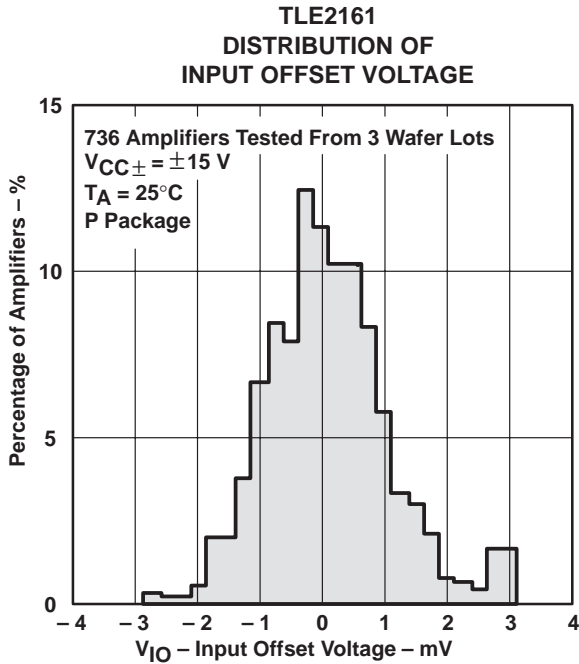


Figure 4

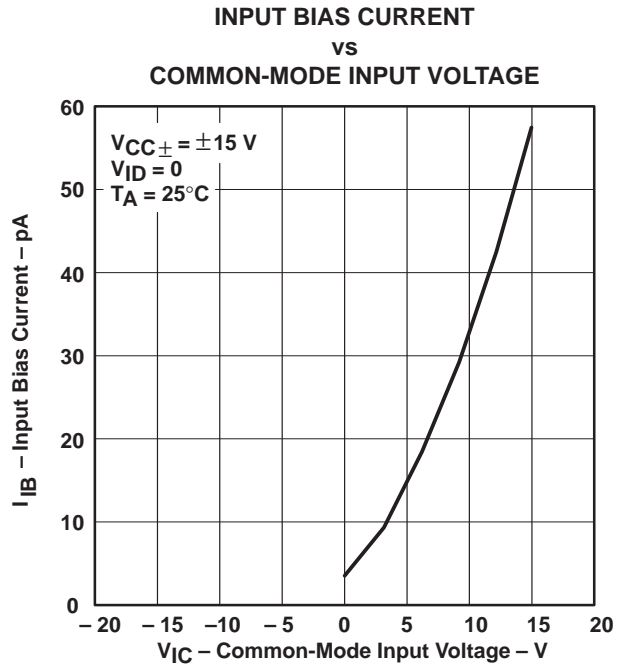


Figure 5

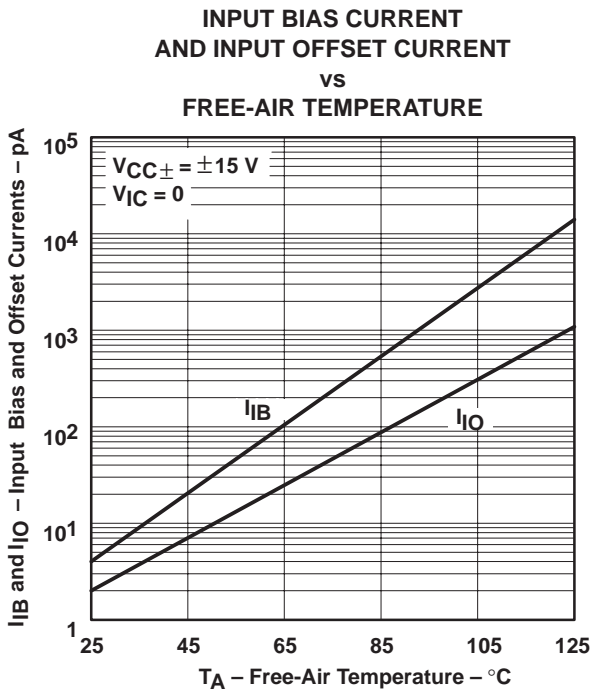


Figure 6

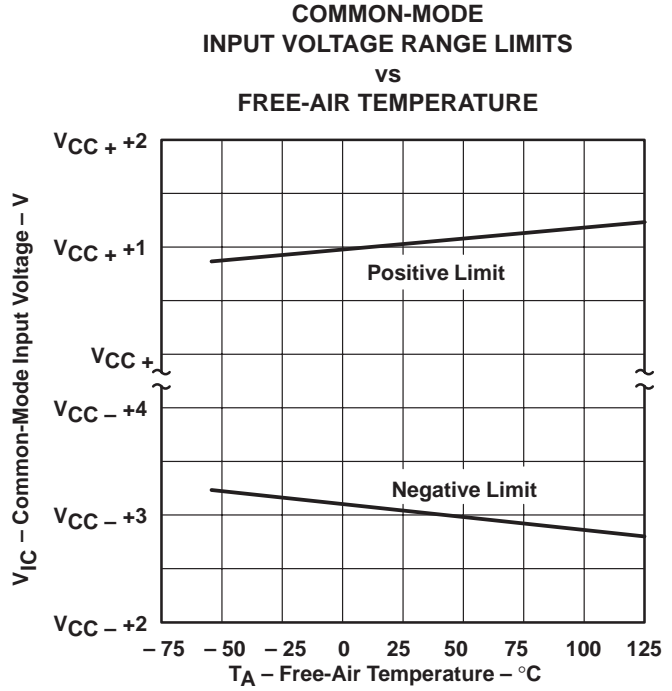


Figure 7

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

TYPICAL CHARACTERISTICS

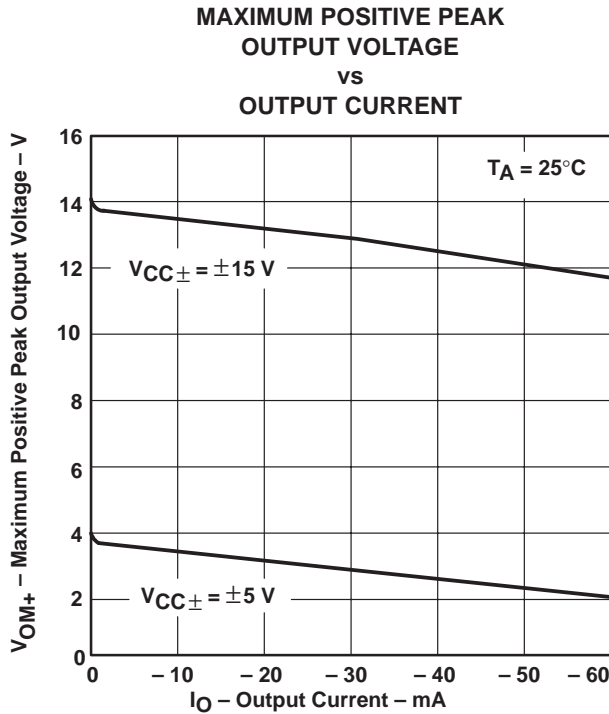


Figure 8

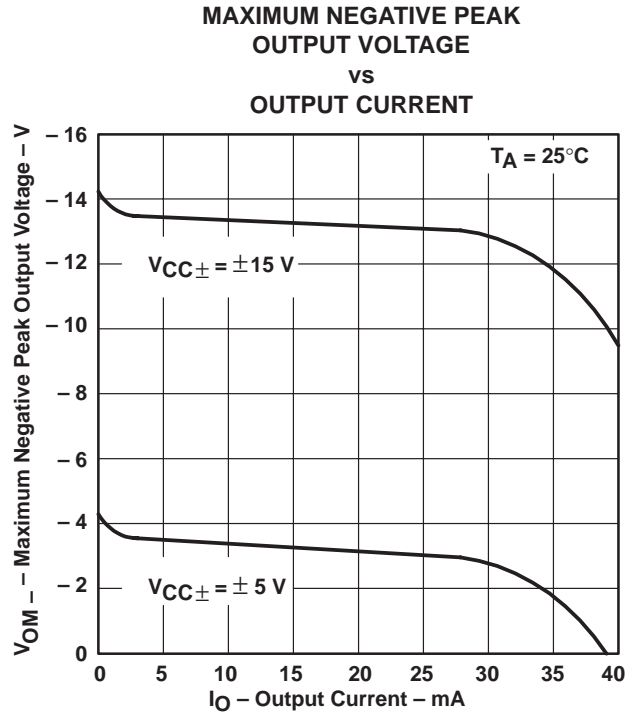


Figure 9

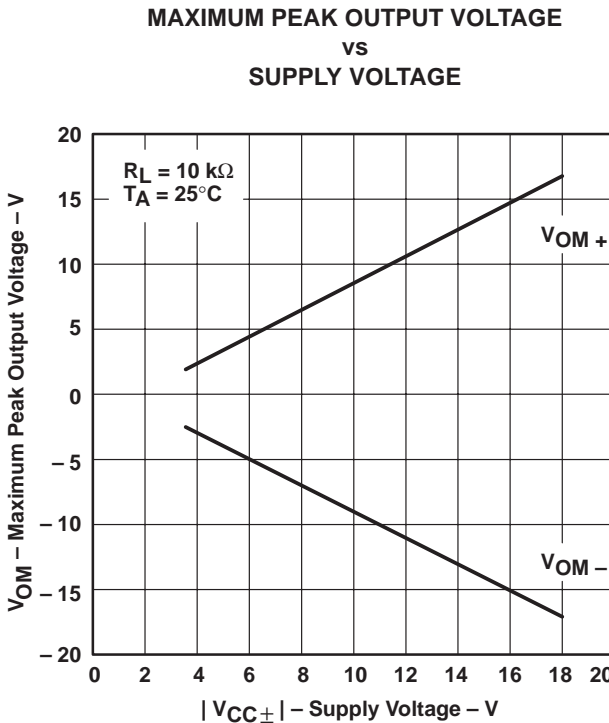


Figure 10

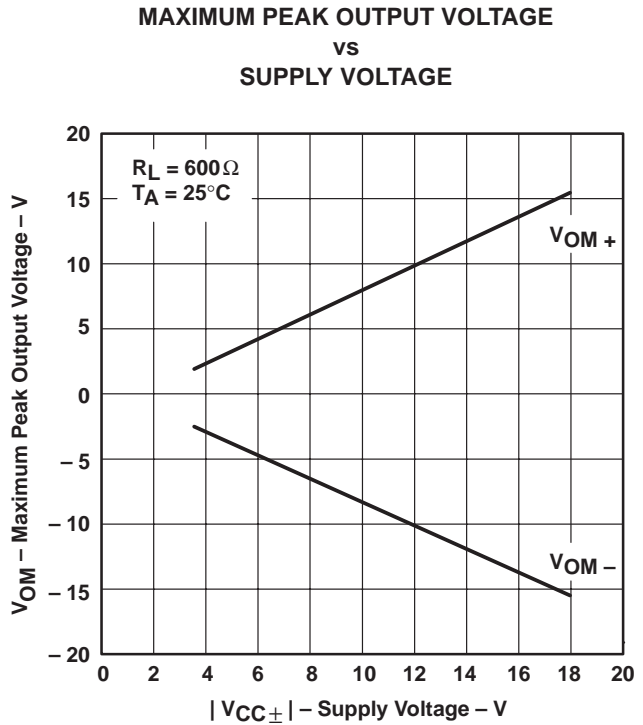


Figure 11

TYPICAL CHARACTERISTICS

MAXIMUM PEAK OUTPUT VOLTAGE  
 vs  
 SUPPLY VOLTAGE

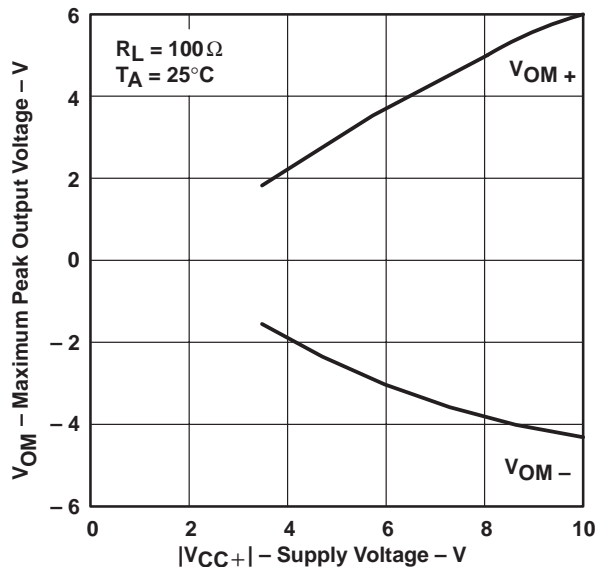


Figure 12

MAXIMUM PEAK-TO-PEAK  
 OUTPUT VOLTAGE  
 vs  
 FREQUENCY

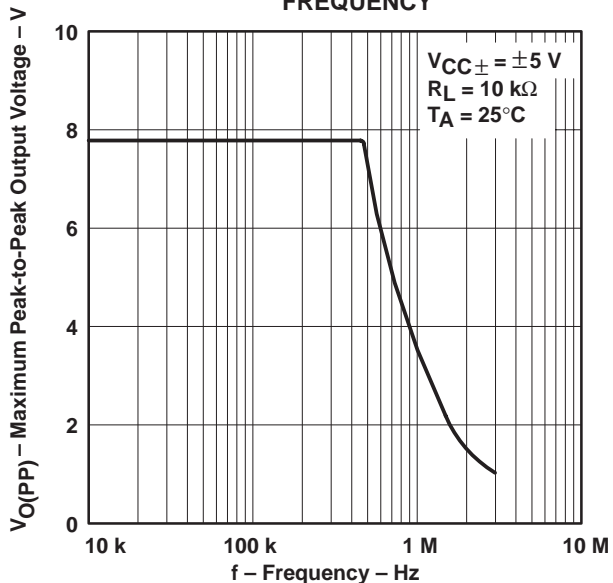


Figure 13

MAXIMUM PEAK-TO-PEAK  
 OUTPUT VOLTAGE  
 vs  
 FREQUENCY

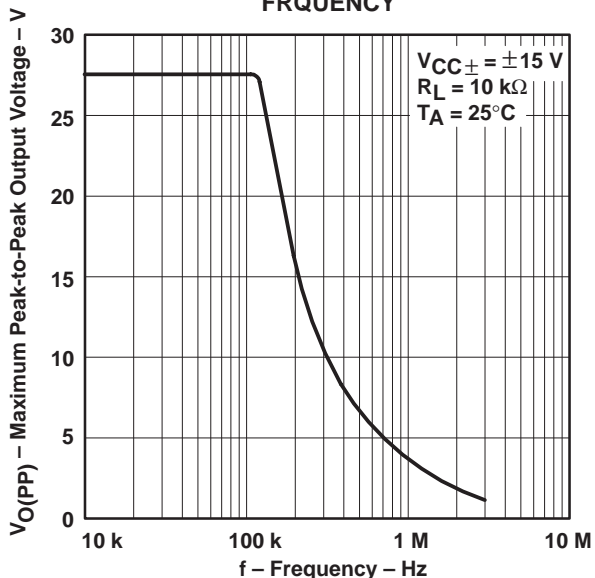


Figure 14

MAXIMUM PEAK-TO-PEAK  
 OUTPUT VOLTAGE  
 vs  
 FREQUENCY

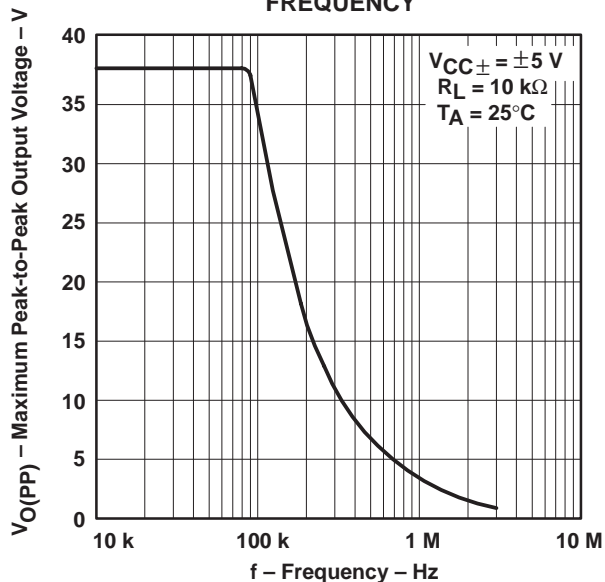


Figure 15

TYPICAL CHARACTERISTICS†

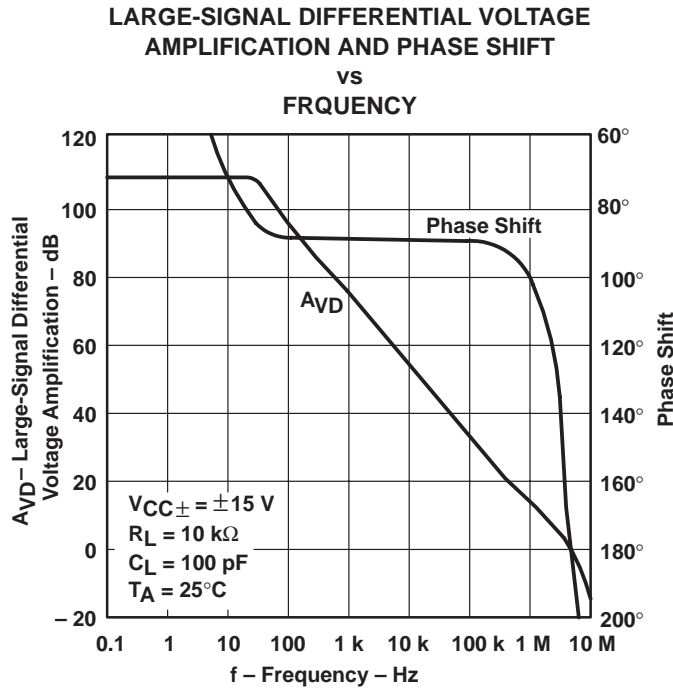


Figure 16

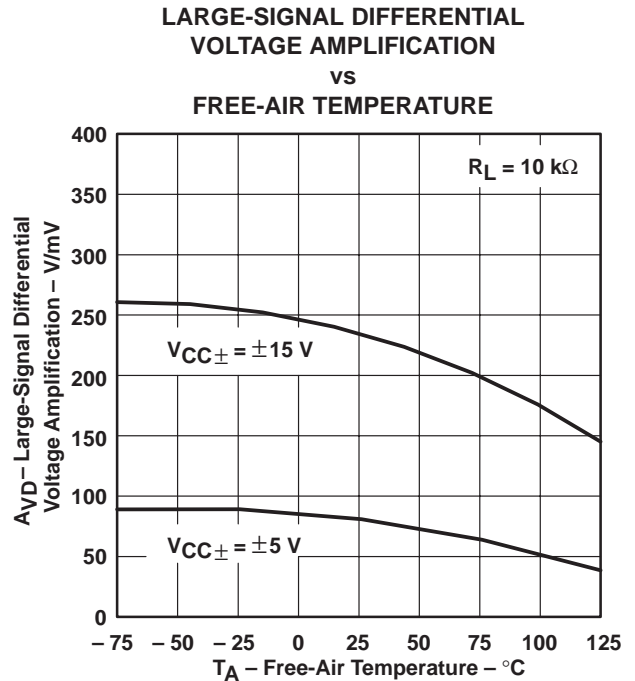


Figure 17

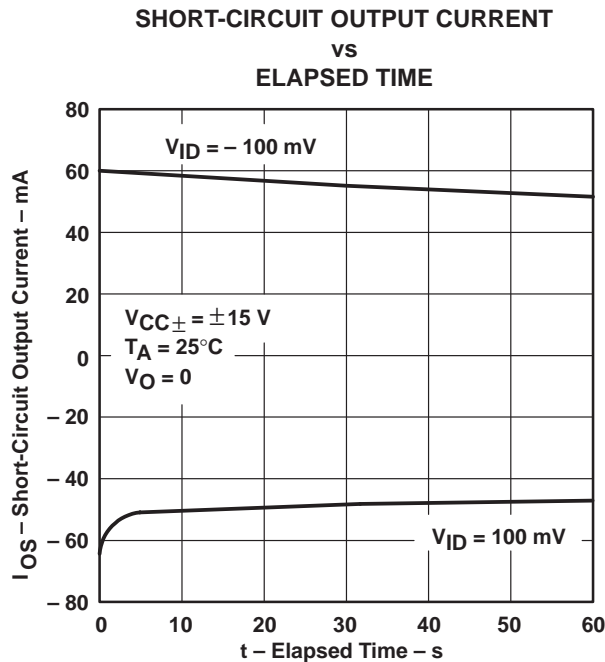


Figure 18

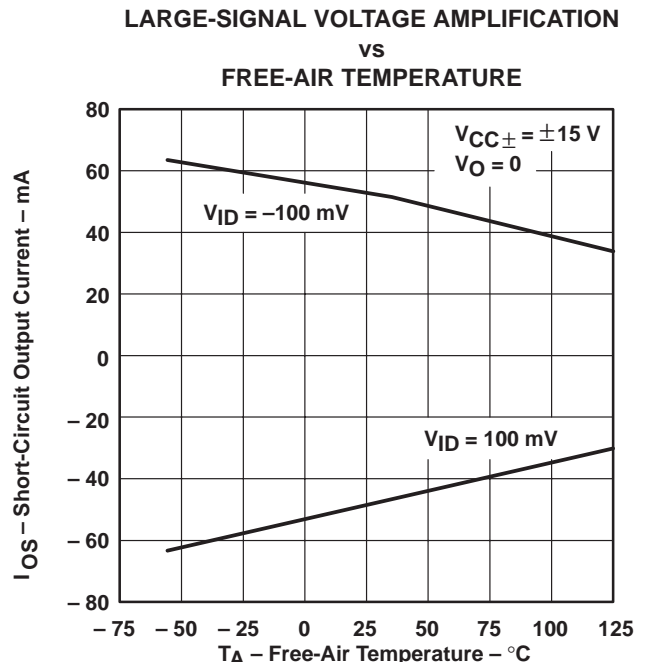


Figure 19

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

TYPICAL CHARACTERISTICS†

OUTPUT IMPEDANCE  
 VS  
 FREQUENCY

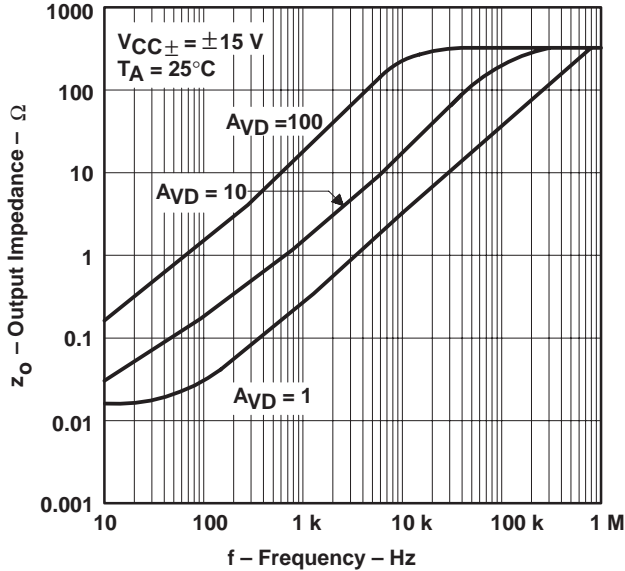


Figure 20

COMMON-MODE REJECTION RATIO  
 VS  
 FREQUENCY

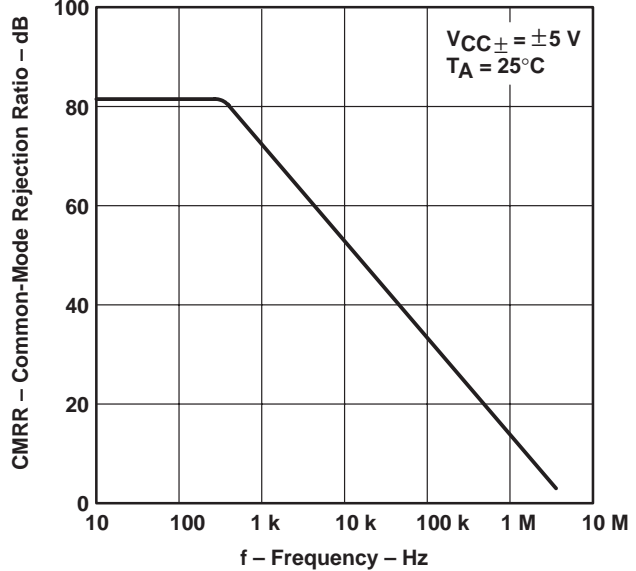


Figure 21

SUPPLY CURRENT  
 VS  
 SUPPLY VOLTAGE

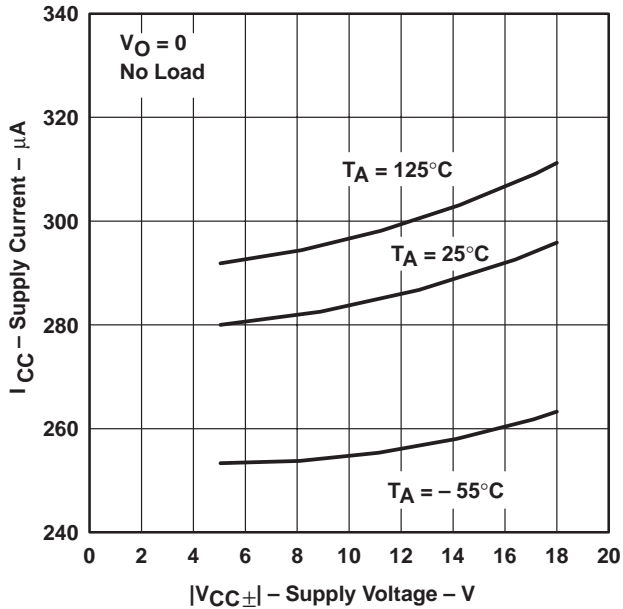


Figure 22

SUPPLY CURRENT  
 VS  
 FREE-AIR TEMPERATURE

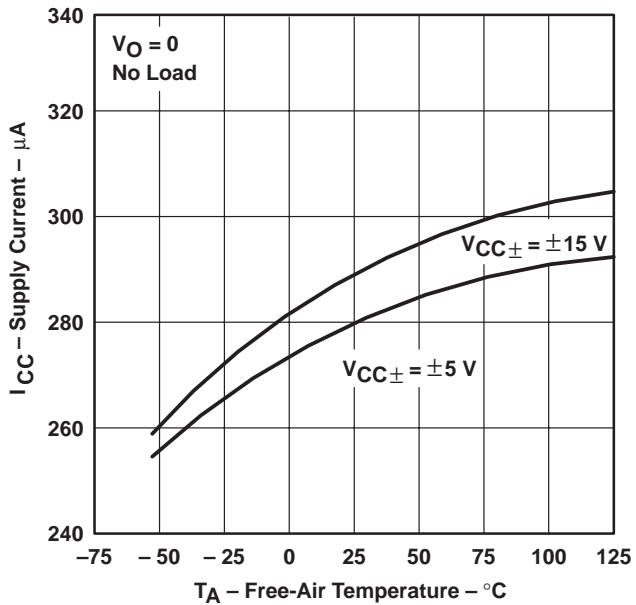


Figure 23

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

TYPICAL CHARACTERISTICS

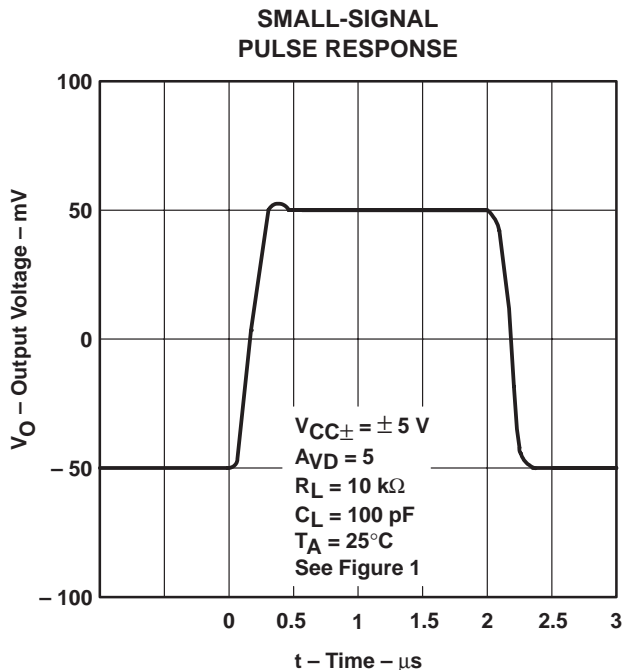


Figure 24

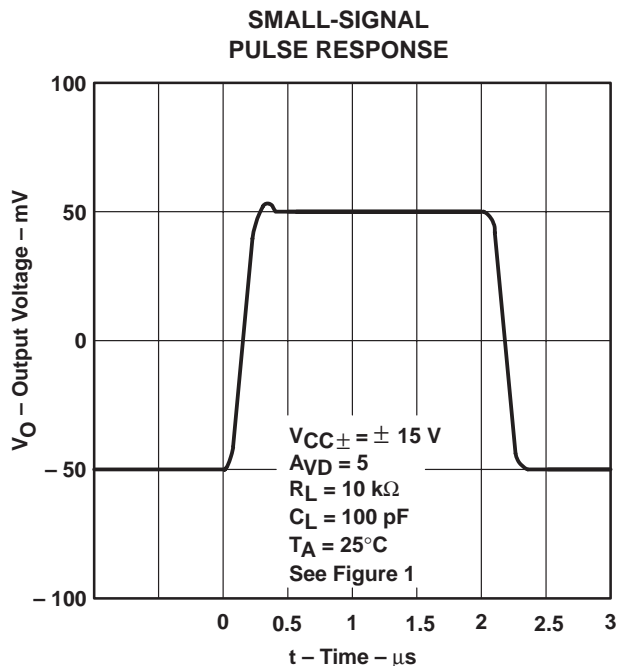


Figure 25

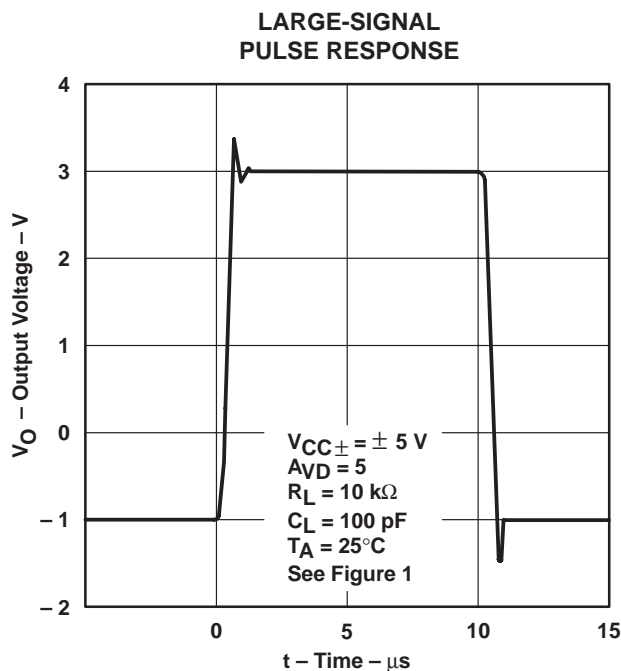


Figure 26

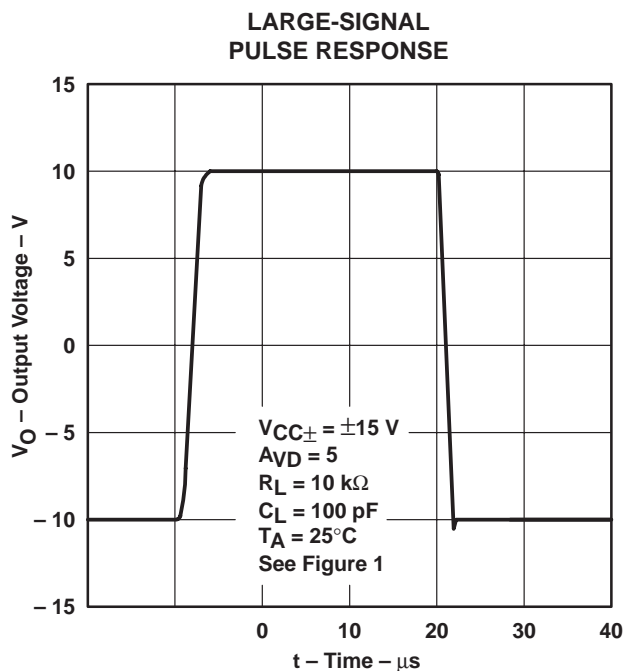


Figure 27

TYPICAL CHARACTERISTICS

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

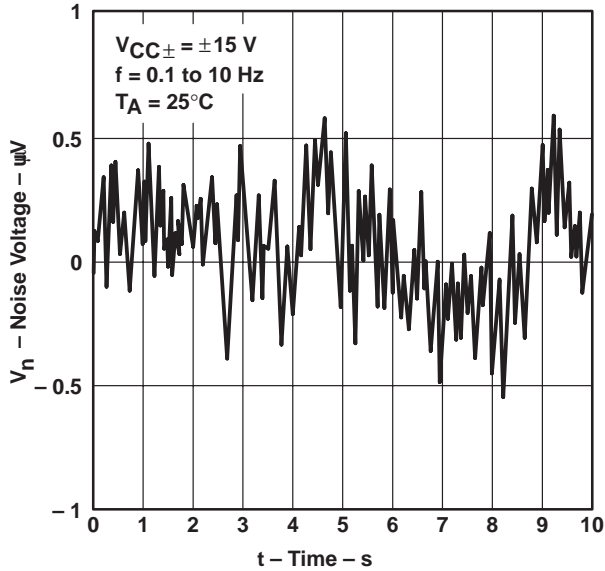


Figure 28

EQUIVALENT INPUT NOISE VOLTAGE  
 VS  
 FREQUENCY

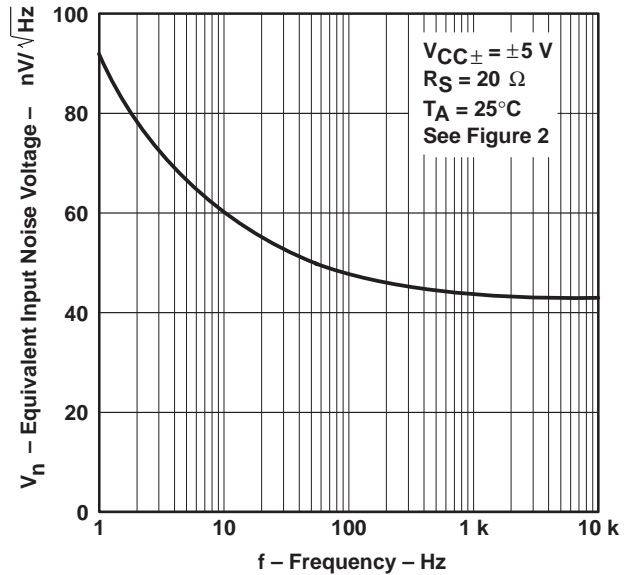


Figure 29

TOTAL HARMONIC DISTORTION  
 VS  
 FREQUENCY

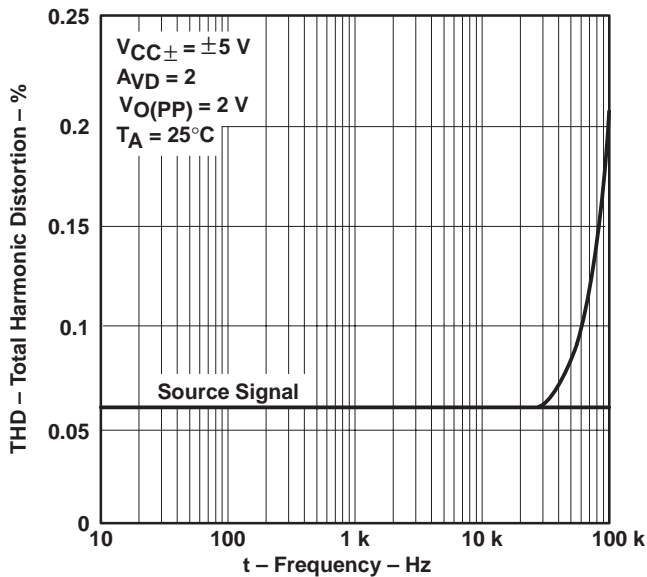


Figure 30

TOTAL HARMONIC DISTORTION  
 VS  
 FREQUENCY

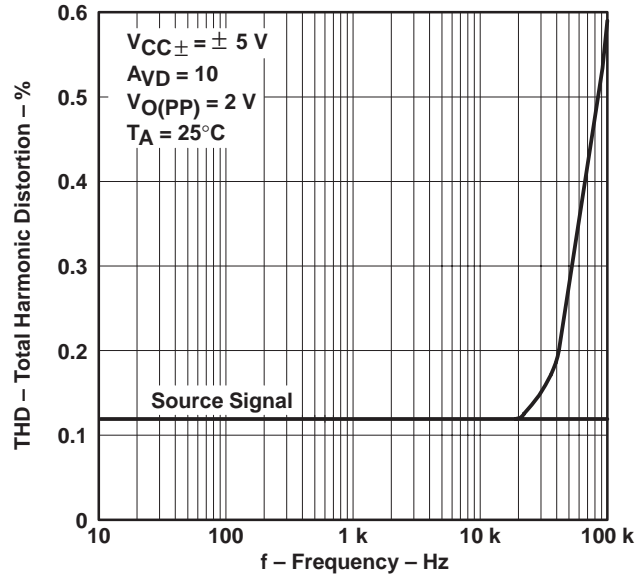


Figure 31



TYPICAL CHARACTERISTICS

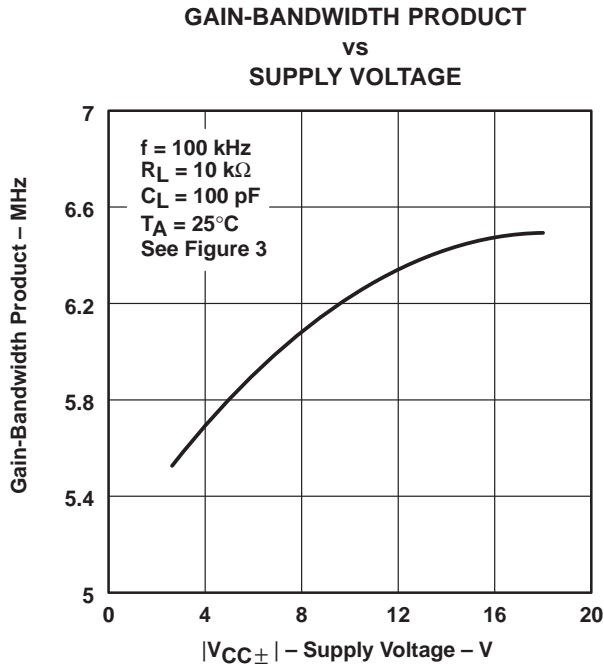


Figure 32

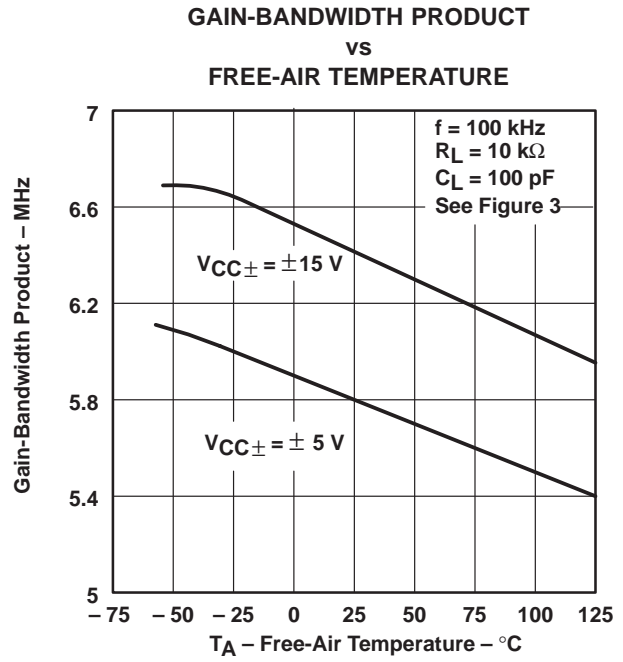


Figure 33

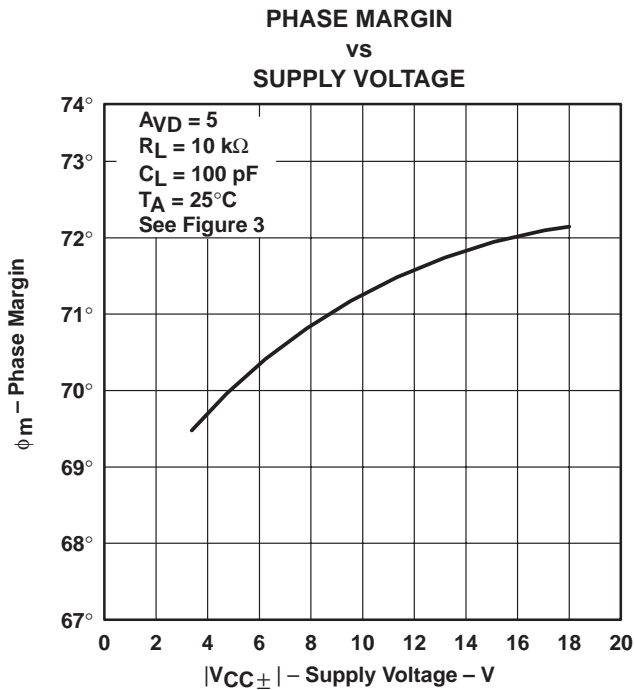


Figure 34

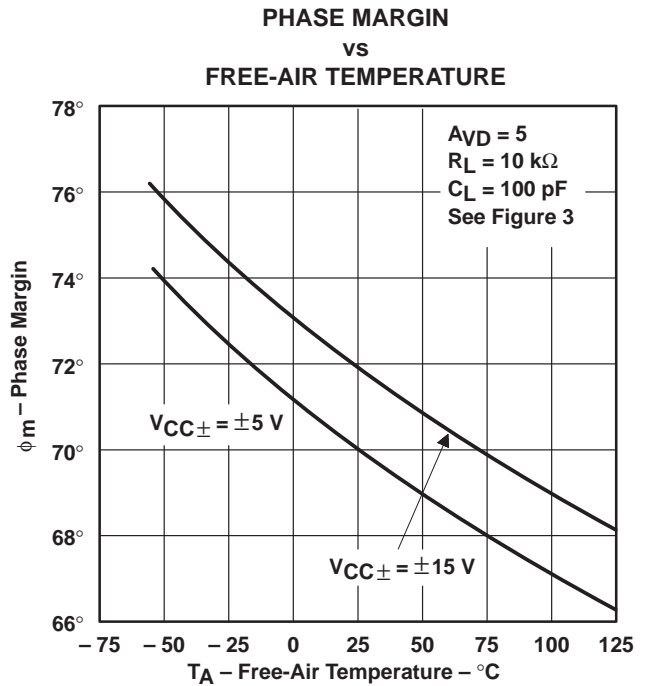


Figure 35

APPLICATION INFORMATION

macromodel information

Macromodel information provided was derived using Microsim *Parts*<sup>™</sup>, the model generation software used with Microsim *PSpice*<sup>™</sup>. The Boyle macromodel (see Note 5) and subcircuit in Figure 36 and Figure 37 were generated using the TLE2161 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

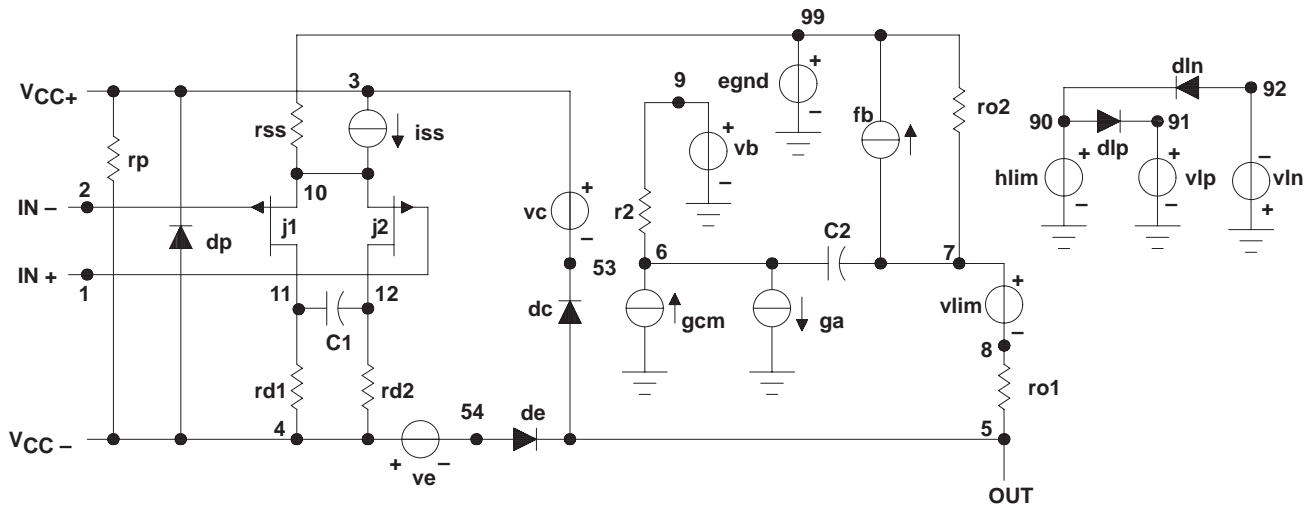


Figure 36. Boyle Macromodel

NOTE 5: 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).

PSpice and Parts are trademark of MicroSim Corporation.

APPLICATION INFORMATION

macromodel information (continued)

```
.subckt TLE2161 1 2 3 4 5
c1 11 12 125.4E-14
c2 6 7 5.000E-12
dc 5 53 dx
de 54 5d x
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 4.085E6 -4E6 4E6 4E6 -4E6
ga 6 0 11 12 201.1E-6
gcm 0 6 10 99 3.576E-9
iss 3 10 dc 45.00E-6
hlim 90 0 vlim 1K
j1 11 2 10 jx
j2 12 1 10 jx
r2 6 9 100.0E3
rd1 4 11 4.973E3
rd2 4 12 4.973E3
ro1 8 5 280
ro2 7 99 280
rp 3 4 113.2E3
rss 10 99 4.444E6
vb 9 0 dc 0
vc 3 53 dc 2
ve 54 4 dc 2
vlim 7 8 dc 0
vlp 91 0 dc 50
vln 0 92 dc 50
.model dx D (Is=800.0E-18)
.model jx Pjf (Is=1.000E-12 Beta=480E-6 Vto=-1)
.ends
```

Figure 37. Macromodel Subcircuit

APPLICATION INFORMATION

input characteristics

The TLE2161, TLE2161A and TLE2161B are specified with a minimum and a maximum input voltage that if exceeded at either input could cause the device to malfunction.

Because of the extremely high input impedance and resulting low bias-current requirements, the TLE2161, TLE2161A, and TLE2161B are well suited for low-level signal processing; however, leakage currents on printed circuit boards and sockets can easily exceed bias-current requirements and cause degradation in system performance. It is a good practice to include guard rings around inputs (see Figure 38). These guards should be driven from a low-impedance source at the same voltage level as the common-mode input.

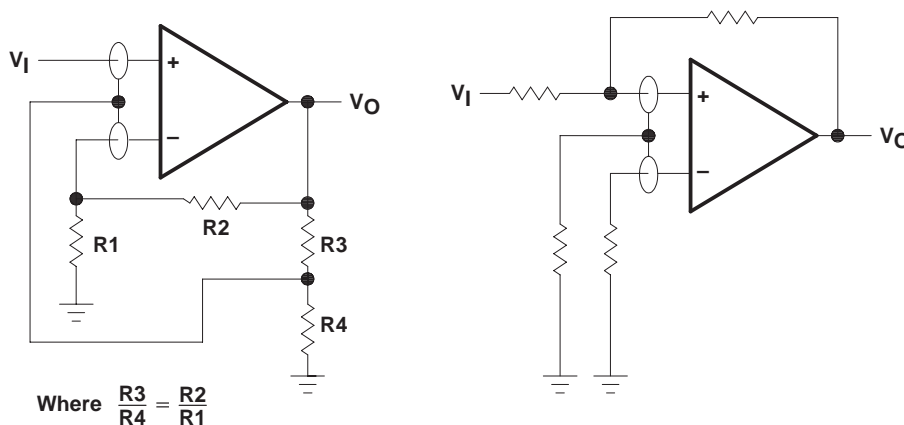


Figure 38. Use of Guard Rings

input offset voltage nulling

The TLE2161 series offers external null pins that can further reduce the input offset voltage. The circuit in Figure 39 can be connected as shown if the feature is desired. When external nulling is not needed, the null pins may be left disconnected.

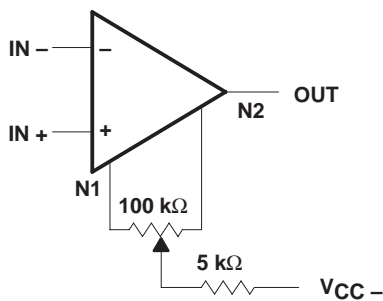


Figure 39. Input Offset Voltage Nulling

**PACKAGING INFORMATION**

Orderable Device	Status (1)	Package Type	Package Drawing	Pins	Package Qty	Eco Plan (2)	Lead finish/ Ball material (6)	MSL Peak Temp (3)	Op Temp (°C)	Device Marking (4/5)	Samples
5962-9095801QPA	ACTIVE	CDIP	JG	8	50	Non-RoHS & Green	SNPB	N / A for Pkg Type	-55 to 125	9095801QPA TLE2161M	<a href="#">Samples</a>
5962-9095802QPA	ACTIVE	CDIP	JG	8	50	Non-RoHS & Green	SNPB	N / A for Pkg Type	-55 to 125	9095802QPA TLE2161AM	<a href="#">Samples</a>
5962-9095803QPA	ACTIVE	CDIP	JG	8	50	Non-RoHS & Green	SNPB	N / A for Pkg Type	-55 to 125	9095803QPA TLE2161BM	<a href="#">Samples</a>
TLE2161ACD	OBSOLETE	SOIC	D	8		TBD	Call TI	Call TI	0 to 70	2161AC	
TLE2161AIDR	ACTIVE	SOIC	D	8	2500	RoHS & Green	NIPDAU	Level-1-260C-UNLIM		2161AI	<a href="#">Samples</a>
TLE2161AMJGB	ACTIVE	CDIP	JG	8	50	Non-RoHS & Green	SNPB	N / A for Pkg Type	-55 to 125	9095802QPA TLE2161AM	<a href="#">Samples</a>
TLE2161BMJGB	ACTIVE	CDIP	JG	8	50	Non-RoHS & Green	SNPB	N / A for Pkg Type	-55 to 125	9095803QPA TLE2161BM	<a href="#">Samples</a>
TLE2161ID	OBSOLETE	SOIC	D	8		TBD	Call TI	Call TI		2161I	
TLE2161IDR	ACTIVE	SOIC	D	8	2500	RoHS & Green	NIPDAU	Level-1-260C-UNLIM		2161I	<a href="#">Samples</a>
TLE2161MJGB	ACTIVE	CDIP	JG	8	50	Non-RoHS & Green	SNPB	N / A for Pkg Type	-55 to 125	9095801QPA TLE2161M	<a href="#">Samples</a>

(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) **RoHS:** TI defines "RoHS" to mean semiconductor products that are compliant with the current EU RoHS requirements for all 10 RoHS substances, including the requirement that RoHS substance do not exceed 0.1% by weight in homogeneous materials. Where designed to be soldered at high temperatures, "RoHS" products are suitable for use in specified lead-free processes. TI may reference these types of products as "Pb-Free".

**RoHS Exempt:** TI defines "RoHS Exempt" to mean products that contain lead but are compliant with EU RoHS pursuant to a specific EU RoHS exemption.

**Green:** TI defines "Green" to mean the content of Chlorine (Cl) and Bromine (Br) based flame retardants meet JS709B low halogen requirements of <=1000ppm threshold. Antimony trioxide based flame retardants must also meet the <=1000ppm threshold requirement.

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

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**OTHER QUALIFIED VERSIONS OF TLE2161, TLE2161A, TLE2161AM, TLE2161M :**

- Catalog : [TLE2161A](#), [TLE2161](#)
- Military : [TLE2161M](#), [TLE2161AM](#)

NOTE: Qualified Version Definitions:

- Catalog - TI's standard catalog product
- Military - QML certified for Military and Defense Applications

**TAPE AND REEL INFORMATION**

**QUADRANT ASSIGNMENTS FOR PIN 1 ORIENTATION IN TAPE**


\*All dimensions are nominal

Device	Package Type	Package Drawing	Pins	SPQ	Reel Diameter (mm)	Reel Width W1 (mm)	A0 (mm)	B0 (mm)	K0 (mm)	P1 (mm)	W (mm)	Pin1 Quadrant
TLE2161AIDR	SOIC	D	8	2500	330.0	12.4	6.4	5.2	2.1	8.0	12.0	Q1
TLE2161IDR	SOIC	D	8	2500	330.0	12.4	6.4	5.2	2.1	8.0	12.0	Q1

**TAPE AND REEL BOX DIMENSIONS**


\*All dimensions are nominal

Device	Package Type	Package Drawing	Pins	SPQ	Length (mm)	Width (mm)	Height (mm)
TLE2161AIDR	SOIC	D	8	2500	340.5	338.1	20.6
TLE2161IDR	SOIC	D	8	2500	353.0	353.0	32.0



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