

# TLE207x-Q1, TLE207xA-Q1 EXCALIBUR LOW-NOISE HIGH-SPEED JFET-INPUT OPERATIONAL AMPLIFIERS

SGLS226B – DECEMBER 2003 – REVISED MAY 2008

- Qualified for Automotive Applications
- Direct Upgrades to TL05x, TL07x, and TL08x BiFET Operational Amplifiers
- Greater Than 2× Bandwidth (10 MHz) and 3× Slew Rate (45 V/μs) Than TL07x
- Ensured Maximum Noise Floor 17 nV/√Hz
- On-Chip Offset Voltage Trimming for Improved DC Performance
- Wider Supply Rails Increase Dynamic Signal Range to ±19 V

## description/ordering information

The TLE207x series of JFET-input operational amplifiers more than double the bandwidth and triple the slew rate of the TL07x and TL08x families of BiFET operational amplifiers. Texas Instruments Excalibur process yields a typical noise floor of 11.6 nV/√Hz, 17-nV/√Hz ensured maximum, offering immediate improvement in noise-sensitive circuits designed using the TL07x. The TLE207x also has wider supply voltage rails, increasing the dynamic signal range for BiFET circuits to ±19 V. On-chip zener trimming of offset voltage yields precision grades for greater accuracy in dc-coupled applications. The TLE207x are pin-compatible with lower performance BiFET operational amplifiers for ease in improving performance in existing designs.

BiFET operational amplifiers offer the inherently higher input impedance of the JFET-input transistors, without sacrificing the output drive associated with bipolar amplifiers. This makes them better suited for interfacing with high-impedance sensors or very low-level ac signals. They also feature inherently better ac response than bipolar or CMOS devices having comparable power consumption.

The TLE207x family of BiFET amplifiers are Texas Instruments highest performance BiFETs, with tighter input offset voltage and ensured maximum noise specifications. Designers requiring less stringent specifications but seeking the improved ac characteristics of the TLE207x should consider the TLE208x operational amplifier family.

Because BiFET operational amplifiers are designed for use with dual power supplies, care must be taken to observe common-mode input voltage limits and output swing when operating from a single supply. DC biasing of the input signal is required and loads should be terminated to a virtual ground node at mid-supply. Texas Instruments TLE2426 integrated virtual ground generator is useful when operating BiFET amplifiers from single supplies.

## ORDERING INFORMATION†

T <sub>A</sub>	V <sub>IO</sub> max AT 25°C	PACKAGE‡		ORDERABLE PART NUMBER	TOP-SIDE MARKING
-40°C to 125°C	2 mV	SOIC – D	Tape and reel	TLE2071AQDRQ1	2071AQ
	4 mV	SOIC – D	Tape and reel	TLE2071QDRQ1	2071Q1
	3.5 mV	SOIC – D	Tape and reel	TLE2072AQDRQ1	2072AQ
	6 mV	SOIC – D	Tape and reel	TLE2072QDRQ1	2072Q1
	4 mV	SOP – DW	Tape and reel	TLE2074AQDWRQ1§	TLE2074AQ1
	7 mV	SOP – DW	Tape and reel	TLE2074QDWRQ1§	TLE2074Q1

† For the most current package and ordering information, see the Package Option Addendum at the end of this document, or see the TI web site at <http://www.ti.com>.

‡ Package drawings, thermal data, and symbolization are available at <http://www.ti.com/packaging>.

§ Product Preview



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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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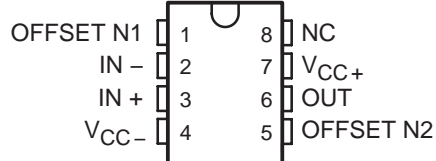
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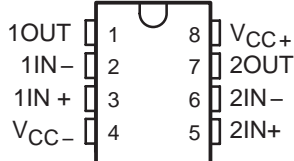
## description/ordering information (continued)

The TLE207x are fully specified at  $\pm 15$  V and  $\pm 5$  V. For operation in low-voltage and/or single-supply systems, Texas Instruments LinCMOS families of operational amplifiers (TLC- and TLV-prefix) are recommended. When moving from BiFET to CMOS amplifiers, particular attention should be paid to slew rate and bandwidth requirements and output loading.

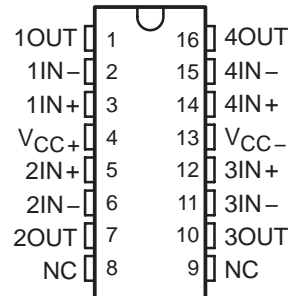
**TLE2071 AND TLE2071A  
D PACKAGE  
(TOP VIEW)**



**TLE2072 AND TLE2072A  
D PACKAGE  
(TOP VIEW)**

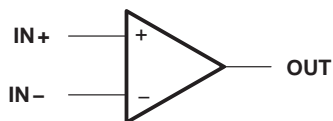


**TLE2074 AND TLE2074A  
DW PACKAGE  
(TOP VIEW)**



NC – No internal connection

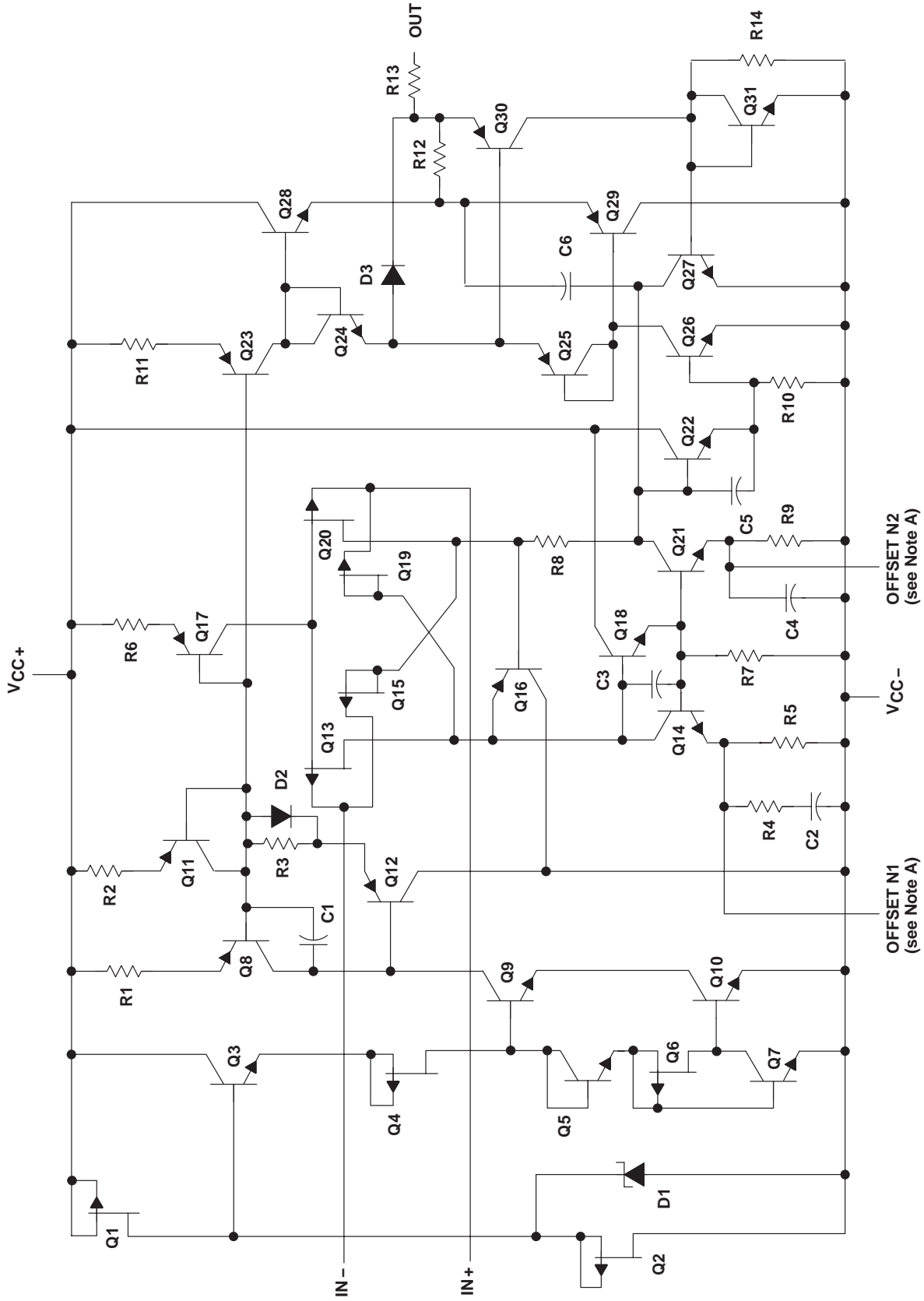
## symbol



# TLE207x-Q1, TLE207xA-Q1 EXCALIBUR LOW-NOISE HIGH-SPEED JFET-INPUT OPERATIONAL AMPLIFIERS

SLOS181A – FEBRUARY 1997 – REVISED MARCH 2000 (sourced from

equivalent schematic



NOTES: A. OFFSET N1 AND OFFSET N2 are only available on the TLE2071x devices.

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**JFET-INPUT OPERATIONAL AMPLIFIERS**  
 SLOS181A – FEBRUARY 1997 – REVISED MARCH 2000 (sourced from)

equivalent schematic (continued)

COMPONENT	ACTUAL DEVICE COMPONENT COUNT			
	TLE2071	TLE2072	TLE2074	TLE2074
Transistors	33	57	114	114
Resistors	25	37	74	74
Diodes	8	5	10	10
Capacitors	6	11	22	22



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

Supply voltage, $V_{CC+}$ (see Note 1)	19 V
Supply voltage, $V_{CC-}$ (see Note 1)	–19 V
Differential input voltage range, $V_{ID}$ (see Note 2)	$V_{CC+}$ to $V_{CC-}$
Input voltage range, $V_I$ (any input)	$V_{CC+}$ to $V_{CC-}$
Input current, $I_I$ (each input)	$\pm 1$ mA
Output current, $I_O$ (each output)	$\pm 80$ mA
Total current into $V_{CC+}$	160 mA
Total current out of $V_{CC-}$	160 mA
Duration of short-circuit current at (or below) 25°C (see Note 3)	unlimited
Maximum Junction Temperature, $T_J$	150°C
Package thermal impedance, $\theta_{JA}$ (see Note 4): D package	126°C/W
DW package	75°C/W
Operating free-air temperature range, $T_A$ : Q suffix	–40°C to 125°C
Storage temperature range	–65°C to 150°C
Lead temperature 1,6 mm (1/16 inch) from case for 3 seconds	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 the noninverting input with respect to the inverting input.
  3. The output may be shorted to either supply. Temperatures and/or supply voltages must be limited to ensure that the maximum dissipation rate is not exceeded.
  4. The package thermal impedance is calculated in accordance with JESD 51-7.

**recommended operating conditions**

		MIN	MAX	UNIT
Supply voltage, $V_{CC\pm}$		$\pm 2.25$	$\pm 19$	V
Common-mode input voltage, $V_{IC}$	$V_{CC\pm} = \pm 5$ V	–0.8	5	V
	$V_{CC\pm} = \pm 15$ V	–10.8	15	
Operating free-air temperature, $T_A$		–40	125	°C



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TLE2071-Q1 electrical characteristics at specified free-air temperature,  $V_{CC\pm} = \pm 5\text{ V}$  (unless otherwise noted)

PARAMETER	TEST CONDITIONS	$T_A$ †	TLE2071-Q1			TLE2071A-Q1			UNIT	
			MIN	TYP	MAX	MIN	TYP	MAX		
$V_{IO}$ Input offset voltage	$V_{IC} = 0, V_O = 0,$ $R_S = 50\ \Omega,$	25°C	0.34	4		0.3	2	mV		
		Full range			9		7			
$\alpha_{VIO}$ Temperature coefficient of input offset voltage		Full range	3.2			3.2	20	$\mu\text{V}/^\circ\text{C}$		
$I_{IO}$ Input offset current	$V_{IC} = 0, V_O = 0,$ See Figure 4	25°C	5	100		5	100	pA		
		Full range			20		20	nA		
$I_{IB}$ Input bias current		25°C	15	175		15	175	pA		
		Full range			60		60	nA		
$V_{ICR}$ Common-mode input voltage range	$R_S = 50\ \Omega$	25°C	5 to -1	5 to -1.9		5 to -1	5 to -1.9	V		
		Full range	5 to -0.8			5 to -0.8				
$V_{OM+}$ Maximum positive peak output voltage swing	$I_O = -200\ \mu\text{A}$	25°C	3.8	4.1		3.8	4.1	V		
		Full range	3.6			3.6				
	$I_O = -2\ \text{mA}$	25°C	3.5	3.9		3.5	3.9			
		Full range	3.3			3.3				
	$I_O = -20\ \text{mA}$	25°C	1.5	2.3		1.5	2.3			
		Full range	1.4			1.4				
$V_{OM-}$ Maximum negative peak output voltage swing	$I_O = 200\ \mu\text{A}$	25°C	-3.8	-4.2		-3.8	-4.2	V		
		Full range	-3.6			-3.6				
	$I_O = 2\ \text{mA}$	25°C	-3.5	-4.1		-3.5	-4.1			
		Full range	-3.3			-3.3				
	$I_O = 20\ \text{mA}$	25°C	-1.5	-2.4		-1.5	-2.4			
		Full range	-1.4			-1.4				
$A_{VD}$ Large-signal differential voltage amplification	$V_O = \pm 2.3\ \text{V}$	$R_L = 600\ \Omega$	25°C	80	91		80	91	dB	
			Full range	78			78			
		$R_L = 2\ \text{k}\Omega$	25°C	90	100		90	100		
			Full range	88			88			
		$R_L = 10\ \text{k}\Omega$	25°C	95	106		95	106		
			Full range	93			93			
$r_i$ Input resistance	$V_{IC} = 0$	25°C	$10^{12}$			$10^{12}$			$\Omega$	
$c_i$ Input capacitance	$V_{IC} = 0,$ See Figure 5	Common mode	25°C	11			11			pF
		Differential	25°C	2.5			2.5			
$z_o$ Open-loop output impedance	$f = 1\ \text{MHz}$	25°C	80			80			$\Omega$	
CMRR Common-mode rejection ratio	$V_{IC} = V_{ICRmin}, V_O = 0,$ $R_S = 50\ \Omega$	25°C	70	89		70	89	dB		
		Full range	68			68				
$k_{SVR}$ Supply-voltage rejection ratio ( $\Delta V_{CC\pm} / \Delta V_{IO}$ )	$V_{CC\pm} = \pm 5\ \text{V}$ to $\pm 15\ \text{V},$ $V_O = 0,$ $R_S = 50\ \Omega$	25°C	82	99		82	99	dB		
		Full range	80			80				

† Full range is  $-40^\circ\text{C}$  to  $125^\circ\text{C}$ .



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**TLE2071-Q1 electrical characteristics at specified free-air temperature,  $V_{CC\pm} = \pm 5\text{ V}$  (unless otherwise noted) (continued)**

PARAMETER	TEST CONDITIONS	$T_A$ †	TLE2071-Q1			TLE2071A-Q1			UNIT
			MIN	TYP	MAX	MIN	TYP	MAX	
$I_{CC}$ Supply current	$V_O = 0$ , No load	25°C	1.35	1.6	2.2	1.35	1.6	2.2	mA
		Full range	2.2			2.2			
$I_{OS}$ Short-circuit output current	$V_O = 0$	25°C	$V_{ID} = 1\text{ V}$			-35			mA
			$V_{ID} = -1\text{ V}$			45			

† Full range is  $-40^\circ\text{C}$  to  $125^\circ\text{C}$ .

**TLE2071-Q1 operating characteristics at specified free-air temperature,  $V_{CC\pm} = \pm 5\text{ V}$**

PARAMETER	TEST CONDITIONS	$T_A$ †	TLE2071-Q1			TLE2071A-Q1			UNIT
			MIN	TYP	MAX	MIN	TYP	MAX	
$SR+$ Positive slew rate	$V_{O(PP)} = \pm 2.3\text{ V}$ , $A_{VD} = -1$ , $R_L = 2\text{ k}\Omega$ , $C_L = 100\text{ pF}$ , See Figure 1	25°C	35			35			$\text{V}/\mu\text{s}$
		Full range	20			20			
$SR-$ Negative slew rate	$V_{O(PP)} = \pm 2.3\text{ V}$ , $A_{VD} = -1$ , $R_L = 2\text{ k}\Omega$ , $C_L = 100\text{ pF}$ , See Figure 1	25°C	38			38			$\text{V}/\mu\text{s}$
		Full range	20			20			
$t_s$ Settling time	$A_{VD} = -1$ , 2-V step, $R_L = 1\text{ k}\Omega$ , $C_L = 100\text{ pF}$	25°C	To 10 mV			0.25			$\mu\text{s}$
			To 1 mV			0.4			
$V_n$ Equivalent input noise voltage	$R_S = 20\ \Omega$ , See Figure 3	25°C	f = 10 Hz		28	55	28 55		$\text{nV}/\sqrt{\text{Hz}}$
			f = 10 kHz		11.6	17	11.6 17		
$V_{N(PP)}$ Peak-to-peak equivalent input noise voltage	$R_S = 20\ \Omega$ , See Figure 3	25°C	f = 10 Hz to 10 kHz		6			$\mu\text{V}$	
			f = 0.1 Hz to 10 Hz		0.6				
$I_n$ Equivalent input noise current	$V_{IC} = 0$ , f = 10 kHz	25°C	2.8			2.8			$\text{fA}/\sqrt{\text{Hz}}$
THD + N Total harmonic distortion plus noise	$V_{O(PP)} = 5\text{ V}$ , f = 1 kHz, $R_S = 25\ \Omega$	$A_{VD} = 10$ , $R_L = 2\text{ k}\Omega$	25°C			0.013%			0.013%
$B_1$ Unity-gain bandwidth	$V_I = 10\text{ mV}$ , $C_L = 25\text{ pF}$ , $R_L = 2\text{ k}\Omega$ , See Figure 2	25°C	9.4			9.4			MHz
$B_{OM}$ Maximum output-swing bandwidth	$V_{O(PP)} = 4\text{ V}$ , $R_L = 2\text{ k}\Omega$ , $C_L = 25\text{ pF}$	$A_{VD} = -1$ , $C_L = 25\text{ pF}$	25°C			2.8			2.8
$\phi_m$ Phase margin at unity gain	$V_I = 10\text{ mV}$ , $C_L = 25\text{ pF}$ , $R_L = 2\text{ k}\Omega$ , See Figure 2	25°C	56			56			

† Full range is  $-40^\circ\text{C}$  to  $125^\circ\text{C}$ .



# TLE207x-Q1, TLE207xA-Q1 EXCALIBUR LOW-NOISE HIGH-SPEED JFET-INPUT OPERATIONAL AMPLIFIERS

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TLE2071-Q1 electrical characteristics at specified free-air temperature,  $V_{CC\pm} = \pm 15\text{ V}$  (unless otherwise noted)

PARAMETER	TEST CONDITIONS	$T_A$ †	TLE2071-Q1			TLE2071A-Q1			UNIT	
			MIN	TYP	MAX	MIN	TYP	MAX		
$V_{IO}$ Input offset voltage	$V_{IC} = 0,$ $R_S = 50\ \Omega$ $V_O = 0,$	25°C	0.49	4		0.47	2	mV		
		Full range			9		7			
$\alpha_{VIO}$ Temperature coefficient of input offset voltage		Full range	3.2			3.2	20	$\mu\text{V}/^\circ\text{C}$		
$I_{IO}$ Input offset current	$V_{IC} = 0,$ $V_O = 0,$ See Figure 4	25°C	6	100		6	100	pA		
		Full range		20			20	nA		
$I_{IB}$ Input bias current		25°C	20	175		20	175	pA		
		Full range		60			60	nA		
$V_{ICR}$ Common-mode input voltage range	$R_S = 50\ \Omega$	25°C	15 to -11	15 to -11.9		15 to -11	15 to -11.9	V		
		Full range	15 to -10.9			15 to -10.9				
$V_{OM+}$ Maximum positive peak output voltage swing	$I_O = -200\ \mu\text{A}$	25°C	13.8	14.1		13.8	14.1	V		
		Full range	13.6			13.6				
	$I_O = -2\ \text{mA}$	25°C	13.5	13.9		13.5	13.9			
		Full range	13.3			13.3				
	$I_O = -20\ \text{mA}$	25°C	11.5	12.3		11.5	12.3			
		Full range	11.4			11.4				
$V_{OM-}$ Maximum negative peak output voltage swing	$I_O = 200\ \mu\text{A}$	25°C	-13.8	-14.2		-13.8	-14.2	V		
		Full range	-13.6			-13.6				
	$I_O = 2\ \text{mA}$	25°C	-13.5	-14		-13.5	-14			
		Full range	-13.3			-13.3				
	$I_O = 20\ \text{mA}$	25°C	-11.5	-12.4		-11.5	-12.4			
		Full range	-11.4			-11.4				
$A_{VD}$ Large-signal differential voltage amplification	$V_O = \pm 10\ \text{V}$	$R_L = 600\ \Omega$	25°C	80	96		80	96	dB	
			Full range	78			78			
		$R_L = 2\ \text{k}\Omega$	25°C	90	109		90	109		
			Full range	88			88			
		$R_L = 10\ \text{k}\Omega$	25°C	95	118		95	118		
			Full range	93			93			
$r_i$ Input resistance	$V_{IC} = 0$	25°C	$10^{12}$			$10^{12}$			$\Omega$	
$c_i$ Input capacitance	$V_{IC} = 0,$ See Figure 5	Common mode	25°C	7.5			7.5			pF
		Differential	25°C	2.5			2.5			
$z_o$ Open-loop output impedance	$f = 1\ \text{MHz}$	25°C	80			80			$\Omega$	
CMRR Common-mode rejection ratio	$V_{IC} = V_{ICRmin},$ $V_O = 0,$ $R_S = 50\ \Omega$	25°C	80	98		80	98	dB		
		Full range	78			78				
$k_{SVR}$ Supply-voltage rejection ratio ( $\Delta V_{CC\pm}/\Delta V_{IO}$ )	$V_{CC\pm} = \pm 5\ \text{V to } \pm 15\ \text{V},$ $V_O = 0,$ $R_S = 50\ \Omega$	25°C	82	99		82	99	dB		
		Full range	80			80				

† Full range is  $-40^\circ\text{C}$  to  $125^\circ\text{C}$ .





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**TLE2071-Q1 electrical characteristics at specified free-air temperature,  $V_{CC\pm} = \pm 15\text{ V}$  (unless otherwise noted) (continued)**

PARAMETER	TEST CONDITIONS	$T_A$ †	TLE2071-Q1			TLE2071A-Q1			UNIT
			MIN	TYP	MAX	MIN	TYP	MAX	
$I_{CC}$ Supply current	$V_O = 0$ , No load	25°C	1.35	1.7	2.2	1.35	1.7	2.2	mA
		Full range	2.2			2.2			
$I_{OS}$ Short-circuit output current	$V_O = 0$	25°C	$V_{ID} = 1\text{ V}$	-30	-45	-30	-45	mA	
			$V_{ID} = -1\text{ V}$	30	48	30	48		

† Full range is  $-40^\circ\text{C}$  to  $125^\circ\text{C}$ .

**TLE2071-Q1 operating characteristics at specified free-air temperature,  $V_{CC\pm} = \pm 15\text{ V}$**

PARAMETER	TEST CONDITIONS	$T_A$ †	TLE2071-Q1			TLE2071A-Q1			UNIT
			MIN	TYP	MAX	MIN	TYP	MAX	
$SR+$ Positive slew rate	$V_{O(PP)} = 10\text{ V}$ , $A_{VD} = -1$ , $R_L = 2\text{ k}\Omega$ , $C_L = 100\text{ pF}$ , See Figure 1	25°C	30	40		30	40	$\text{V}/\mu\text{s}$	
		Full range	22			22			
$SR-$ Negative slew rate		25°C	30	45		30	45	$\text{V}/\mu\text{s}$	
		Full range	22			22			
$t_s$ Settling time	$A_{VD} = -1$ , 10-V step, $R_L = 1\text{ k}\Omega$ , $C_L = 100\text{ pF}$	25°C	To 10 mV	0.4		0.4		$\mu\text{s}$	
			To 1 mV	1.5		1.5			
$V_n$ Equivalent input noise voltage	$R_S = 20\ \Omega$ , See Figure 3	25°C	$f = 10\text{ Hz}$	28	55	28	55	$\text{nV}/\sqrt{\text{Hz}}$	
			$f = 10\text{ kHz}$	11.6	17	11.6	17		
$V_{N(PP)}$ Peak-to-peak equivalent input noise voltage		25°C	$f = 10\text{ Hz to }10\text{ kHz}$	6		6		$\mu\text{V}$	
			$f = 0.1\text{ Hz to }10\text{ Hz}$	0.6		0.6			
$I_n$ Equivalent input noise current	$V_{IC} = 0$ , $f = 10\text{ kHz}$	25°C	2.8		2.8		$\text{fA}/\sqrt{\text{Hz}}$		
THD + N Total harmonic distortion plus noise	$V_{O(PP)} = 20\text{ V}$ , $A_{VD} = 10$ , $f = 1\text{ kHz}$ , $R_L = 2\text{ k}\Omega$ , $R_S = 25\ \Omega$	25°C	0.008%		0.008%				
$B_1$ Unity-gain bandwidth	$V_I = 10\text{ mV}$ , $R_L = 2\text{ k}\Omega$ , $C_L = 25\text{ pF}$ , See Figure 2	25°C	8	10	8	10	MHz		
$B_{OM}$ Maximum output-swing bandwidth	$V_{O(PP)} = 20\text{ V}$ , $A_{VD} = -1$ , $R_L = 2\text{ k}\Omega$ , $C_L = 25\text{ pF}$	25°C	478	637	478	637	kHz		
$\phi_m$ Phase margin at unity gain	$V_I = 10\text{ mV}$ , $R_L = 2\text{ k}\Omega$ , $C_L = 25\text{ pF}$ , See Figure 2	25°C	57		57				

† Full range is  $-40^\circ\text{C}$  to  $125^\circ\text{C}$ .



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TLE2072-Q1 electrical characteristics at specified free-air temperature,  $V_{CC\pm} = \pm 5\text{ V}$  (unless otherwise noted)

PARAMETER	TEST CONDITIONS	$T_A$ †	TLE2072-Q1			TLE2072A-Q1			UNIT	
			MIN	TYP	MAX	MIN	TYP	MAX		
$V_{IO}$ Input offset voltage	$V_{IC} = 0, V_O = 0, R_S = 50\ \Omega$	25°C	0.9	6		0.65	3.5	mV		
		Full range			10		8			
$\alpha_{VIO}$ Temperature coefficient of input offset voltage		Full range	2.3			2.3	20	$\mu\text{V}/^\circ\text{C}$		
$I_{IO}$ Input offset current	$V_{IC} = 0, V_O = 0, \text{See Figure 4}$	25°C	5	100		5	100	pA		
		Full range			20		20	nA		
$I_{IB}$ Input bias current		25°C	15	175		15	175	pA		
		Full range			60		60	nA		
$V_{ICR}$ Common-mode input voltage range	$R_S = 50\ \Omega$	25°C	5 to -1	5 to -1.9		5 to -1	5 to -1.9	V		
		Full range	5 to -0.8			5 to -0.8				
$V_{OM+}$ Maximum positive peak output voltage swing	$I_O = -200\ \mu\text{A}$	25°C	3.8	4.1		3.8	4.1	V		
		Full range	3.6			3.6				
	$I_O = -2\ \text{mA}$	25°C	3.5	3.9		3.5	3.9			
		Full range	3.3			3.3				
$I_O = -20\ \text{mA}$	25°C	1.5	2.3		1.5	2.3				
	Full range	1.4			1.4					
$V_{OM-}$ Maximum negative peak output voltage swing	$I_O = 200\ \mu\text{A}$	25°C	-3.8	-4.2		-3.8	-4.2	V		
		Full range	-3.6			-3.6				
	$I_O = 2\ \text{mA}$	25°C	-3.5	-4.1		-3.5	-4.1			
		Full range	-3.3			-3.3				
$I_O = 20\ \text{mA}$	25°C	-1.5	-2.4		-1.5	-2.4				
	Full range	-1.4			-1.4					
$A_{VD}$ Large-signal differential voltage amplification	$V_O = \pm 2.3\ \text{V}$	$R_L = 600\ \Omega$	25°C	80	91		80	91	dB	
			Full range	78			78			
		$R_L = 2\ \text{k}\Omega$	25°C	90	100		90	100		
			Full range	88			88			
		$R_L = 10\ \text{k}\Omega$	25°C	95	106		95	106		
			Full range	93			93			
$r_i$ Input resistance	$V_{IC} = 0$	25°C	$10^{12}$			$10^{12}$			$\Omega$	
$c_i$ Input capacitance	$V_{IC} = 0, \text{See Figure 5}$	Common mode	25°C	11			11			pF
		Differential	25°C	2.5			2.5			
$z_o$ Open-loop output impedance	$f = 1\ \text{MHz}$	25°C	80			80			$\Omega$	
CMRR Common-mode rejection ratio	$V_{IC} = V_{ICRmin}, V_O = 0, R_S = 50\ \Omega$	25°C	70	89		70	89	dB		
		Full range	68			68				

† Full range is  $-40^\circ\text{C}$  to  $125^\circ\text{C}$ .



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**TLE2072-Q1 electrical characteristics at specified free-air temperature,  $V_{CC\pm} = \pm 5\text{ V}$  (unless otherwise noted) (continued)**

PARAMETER	TEST CONDITIONS	$T_A$ †	TLE2072-Q1			TLE2072A-Q1			UNIT	
			MIN	TYP	MAX	MIN	TYP	MAX		
$k_{SVR}$	Supply-voltage rejection ratio ( $\Delta V_{CC\pm} / \Delta V_{IO}$ )	$V_{CC\pm} = \pm 5\text{ V}$ to $\pm 15\text{ V}$ , $V_O = 0$ , $R_S = 50\ \Omega$	Full range	80			80		dB	
$I_{CC}$	Supply current (both channels)	$V_O = 0$ , No load	25°C	2.7	2.9	3.6	2.7	2.9	3.6	mA
			Full range			3.6			3.6	
$a_x$	Crosstalk attenuation	$V_{IC} = 0$ , $R_L = 2\text{ k}\Omega$	25°C		120		120		dB	
$I_{OS}$	Short-circuit output current	$V_O = 0$	25°C	$V_{ID} = 1\text{ V}$			–35			mA
				$V_{ID} = -1\text{ V}$			45			

† Full range is  $-40^\circ\text{C}$  to  $125^\circ\text{C}$ .

**TLE2072-Q1 operating characteristics at specified free-air temperature,  $V_{CC\pm} = \pm 5\text{ V}$**

PARAMETER	TEST CONDITIONS	$T_A$ †	TLE2072-Q1			TLE2072A-Q1			UNIT	
			MIN	TYP	MAX	MIN	TYP	MAX		
$SR+$	Positive slew rate	$V_{O(PP)} = \pm 2.3\text{ V}$ , $A_{VD} = -1$ , $C_L = 100\text{ pF}$ , $R_L = 2\text{ k}\Omega$ , See Figure 1	25°C	35			35			$\text{V}/\mu\text{s}$
			Full range	18			18			
$SR-$	Negative slew rate	$V_{O(PP)} = \pm 2.3\text{ V}$ , $A_{VD} = -1$ , $C_L = 100\text{ pF}$ , $R_L = 2\text{ k}\Omega$ , See Figure 1	25°C	38			38			$\text{V}/\mu\text{s}$
			Full range	18			18			
$t_s$	Settling time	$A_{VD} = -1$ , 2-V step, $R_L = 1\text{ k}\Omega$ , $C_L = 100\text{ pF}$	To 10 mV	0.25			0.25			$\mu\text{s}$
			To 1 mV	0.4			0.4			
$V_n$	Equivalent input noise voltage	$f = 10\text{ Hz}$	25°C	28	55		28	55	$\text{nV}/\sqrt{\text{Hz}}$	
			$f = 10\text{ kHz}$	11.6	17		11.6	17		
$V_{N(PP)}$	Peak-to-peak equivalent input noise voltage	$R_S = 20\ \Omega$ , See Figure 3	25°C	$f = 10\text{ Hz}$ to $10\text{ kHz}$			6			$\mu\text{V}$
				$f = 0.1\text{ Hz}$ to $10\text{ Hz}$			0.6			
$I_n$	Equivalent input noise current	$V_{IC} = 0$ , $f = 10\text{ kHz}$	25°C	2.8			2.8			$\text{fA}/\sqrt{\text{Hz}}$
THD + N	Total harmonic distortion plus noise	$V_{O(PP)} = 5\text{ V}$ , $f = 1\text{ kHz}$ , $R_S = 25\ \Omega$	25°C	0.013%			0.013%			
$B_1$	Unity-gain bandwidth	$V_I = 10\text{ mV}$ , $C_L = 25\text{ pF}$ , $R_L = 2\text{ k}\Omega$ , See Figure 2	25°C	9.4			9.4			MHz
$B_{OM}$	Maximum output-swing bandwidth	$V_{O(PP)} = 4\text{ V}$ , $R_L = 2\text{ k}\Omega$ , $A_{VD} = -1$ , $C_L = 25\text{ pF}$	25°C	2.8			2.8			MHz
$\phi_m$	Phase margin at unity gain	$V_I = 10\text{ mV}$ , $C_L = 25\text{ pF}$ , $R_L = 2\text{ k}\Omega$ , See Figure 2	25°C	56			56			

† Full range is  $-40^\circ\text{C}$  to  $125^\circ\text{C}$ .



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**TLE2072-Q1 electrical characteristics at specified free-air temperature,  $V_{CC\pm} = \pm 15\text{ V}$  (unless otherwise noted)**

PARAMETER	TEST CONDITIONS	$T_A$ †	TLE2072-Q1			TLE2072A-Q1			UNIT	
			MIN	TYP	MAX	MIN	TYP	MAX		
$V_{IO}$ Input offset voltage	$V_{IC} = 0, V_O = 0, R_S = 50\ \Omega$	25°C	1.1	6		0.7	3.5	mV		
		Full range			10		8			
$\alpha_{VIO}$ Temperature coefficient of input offset voltage		Full range	2.4			2.4	20	$\mu\text{V}/^\circ\text{C}$		
$I_{IO}$ Input offset current	$V_{IC} = 0, V_O = 0, \text{See Figure 4}$	25°C	6	100		6	100	pA		
		Full range			20		20	nA		
$I_{IB}$ Input bias current		25°C	20	175		20	175	pA		
		Full range			60		60	nA		
$V_{ICR}$ Common-mode input voltage range	$R_S = 50\ \Omega$	25°C	15 to -11	15 to -11.9		15 to -11	15 to -11.9	V		
		Full range	15 to -10.8			15 to -10.8				
$V_{OM+}$ Maximum positive peak output voltage swing	$I_O = -200\ \mu\text{A}$	25°C	13.8	14.1		13.8	14.1	V		
		Full range	13.6			13.6				
	$I_O = -2\ \text{mA}$	25°C	13.5	13.9		13.5	13.9			
		Full range	13.3			13.3				
	$I_O = -20\ \text{mA}$	25°C	11.5	12.3		11.5	12.3			
		Full range	11.4			11.4				
$V_{OM-}$ Maximum negative peak output voltage swing	$I_O = 200\ \mu\text{A}$	25°C	-13.8	-14.2		-13.8	-14.2	V		
		Full range	-13.6			-13.6				
	$I_O = 2\ \text{mA}$	25°C	-13.5	-14		-13.5	-14			
		Full range	-13.3			-13.3				
	$I_O = 20\ \text{mA}$	25°C	-11.5	-12.4		-11.5	-12.4			
		Full range	-11.4			-11.4				
$A_{VD}$ Large-signal differential voltage amplification	$V_O = \pm 10\ \text{V}$	$R_L = 600\ \Omega$	25°C	80	96		80	96	dB	
			Full range	78			78			
		$R_L = 2\ \text{k}\Omega$	25°C	90	109		90	109		
			Full range	89			89			
		$R_L = 10\ \text{k}\Omega$	25°C	95	118		95	118		
			Full range	93			93			
$r_i$ Input resistance	$V_{IC} = 0$	25°C	$10^{12}$			$10^{12}$			$\Omega$	
$c_i$ Input capacitance	$V_{IC} = 0, \text{See Figure 5}$	Common mode	25°C	7.5			7.5			pF
		Differential	25°C	2.5			2.5			
$z_o$ Open-loop output impedance	$f = 1\ \text{MHz}$	25°C	80			80			$\Omega$	
CMRR Common-mode rejection ratio	$V_{IC} = V_{ICRmin}, V_O = 0, R_S = 50\ \Omega$	25°C	80	98		80	98	dB		
		Full range	78			78				
$k_{SVR}$ Supply-voltage rejection ratio ( $\Delta V_{CC\pm}/\Delta V_{IO}$ )	$V_{CC\pm} = \pm 5\ \text{V to } \pm 15\ \text{V}, V_O = 0, R_S = 50\ \Omega$	25°C	82	99		82	99	dB		
		Full range	80			80				

† Full range is  $-40^\circ\text{C}$  to  $125^\circ\text{C}$ .



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**TLE2072-Q1 electrical characteristics at specified free-air temperature,  $V_{CC\pm} = \pm 15$  V (unless otherwise noted) (continued)**

PARAMETER	TEST CONDITIONS	$T_A$ †	TLE2072-Q1			TLE2072A-Q1			UNIT	
			MIN	TYP	MAX	MIN	TYP	MAX		
$I_{CC}$	Supply current (both channels)	$V_O = 0$ , No load	25°C	2.7	3.1	3.6	2.7	3.1	3.6	mA
			Full range	3.6			3.6			
$a_x$	Crosstalk attenuation	$V_{IC} = 0$ , $R_L = 2$ k $\Omega$	25°C	120			120			dB
$I_{OS}$	Short-circuit output current	$V_O = 0$	25°C	$V_{ID} = 1$ V	-30	-45	-30	-45	mA	
				$V_{ID} = -1$ V	30	48	30	48		

† Full range is -40°C to 125°C.

**TLE2072-Q1 operating characteristics at specified free-air temperature,  $V_{CC\pm} = \pm 15$  V**

PARAMETER	TEST CONDITIONS	$T_A$ †	TLE2072-Q1			TLE2072A-Q1			UNIT
			MIN	TYP	MAX	MIN	TYP	MAX	
SR +	Positive slew rate	$V_{O(PP)} = 10$ V, $A_{VD} = -1$ , $R_L = 2$ k $\Omega$ , $C_L = 100$ pF, See Figure 1	25°C	28	40	28	40	V/ $\mu$ s	
			Full range	20			20		
SR -	Negative slew rate		25°C	30	45	30	45	V/ $\mu$ s	
			Full range	20			20		
$t_s$	Settling time	$A_{VD} = -1$ , 10-V step, $R_L = 1$ k $\Omega$ , $C_L = 100$ pF	25°C	To 10 mV	0.4		0.4		$\mu$ s
				To 1 mV	1.5		1.5		
$V_n$	Equivalent input noise voltage		25°C	$f = 10$ Hz	28	55	28	55	nV/ $\sqrt{\text{Hz}}$
				$f = 10$ kHz	11.6	17	11.6	17	
$V_{N(PP)}$	Peak-to-peak equivalent input noise voltage	$R_S = 20$ $\Omega$ , See Figure 3	25°C	$f = 10$ Hz to 10 kHz	6		6		$\mu$ V
				$f = 0.1$ Hz to 10 Hz	0.6		0.6		
$I_n$	Equivalent input noise current	$V_{IC} = 0$ , $f = 10$ kHz	25°C	2.8		2.8		fA/ $\sqrt{\text{Hz}}$	
THD + N	Total harmonic distortion plus noise	$V_{O(PP)} = 20$ V, $A_{VD} = 10$ , $f = 1$ kHz, $R_S = 25$ $\Omega$ , $R_L = 2$ k $\Omega$	25°C	0.008%		0.008%			
$B_1$	Unity-gain bandwidth	$V_I = 10$ mV, $R_L = 2$ k $\Omega$ , $C_L = 25$ pF, See Figure 2	25°C	8	10	8	10	MHz	
$B_{OM}$	Maximum output-swing bandwidth	$V_{O(PP)} = 20$ V, $A_{VD} = -1$ , $R_L = 2$ k $\Omega$ , $C_L = 25$ pF	25°C	478	637	478	637	kHz	
$\phi_m$	Phase margin at unity gain	$V_I = 10$ mV, $R_L = 2$ k $\Omega$ , $C_L = 25$ pF, See Figure 2	25°C	57		57			

† Full range is -40°C to 125°C.



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**TLE2074-Q1 electrical characteristics at specified free-air temperature,  $V_{CC\pm} = \pm 5\text{ V}$  (unless otherwise noted)**

PARAMETER	TEST CONDITIONS	$T_A$ †	TLE2074-Q1			TLE2074A-Q1			UNIT
			MIN	TYP	MAX	MIN	TYP	MAX	
$V_{IO}$ Input offset voltage	$V_{IC} = 0, V_O = 0, R_S = 50\ \Omega$	25°C	-1.6	7		-0.5	4	mV	
		Full range			11		9		
$\alpha_{VIO}$ Temperature coefficient of input offset voltage		Full range	10.1			10.1 30			$\mu\text{V}/^\circ\text{C}$
$I_{IO}$ Input offset current	$V_{IC} = 0, V_O = 0, \text{See Figure 4}$	25°C	15 100			15 100			pA
		Full range	20			20			nA
$I_{IB}$ Input bias current		25°C	20 175			20 175			pA
		Full range	60			60			nA
$V_{ICR}$ Common-mode input voltage range	$R_S = 50\ \Omega$	25°C	5 to -1	5 to -1.9		5 to -1	5 to -1.9	V	
		Full range	5 to -0.8			5 to -0.8			
$V_{OM+}$ Maximum positive peak output voltage swing	$I_O = -200\ \mu\text{A}$	25°C	3.8	4.1		3.8	4.1	V	
		Full range	3.6			3.6			
	$I_O = -2\ \text{mA}$	25°C	3.5	3.9		3.5	3.9		
		Full range	3.3			3.3			
	$I_O = -20\ \text{mA}$	25°C	1.5	2.3		1.5	2.3		
		Full range	1.4			1.4			
$V_{OM-}$ Maximum negative peak output voltage swing	$I_O = 200\ \mu\text{A}$	25°C	-3.8	-4.2		-3.8	-4.2	V	
		Full range	-3.6			-3.6			
	$I_O = 2\ \text{mA}$	25°C	-3.5	-4.1		-3.5	-4.1		
		Full range	-3.3			-3.3			
	$I_O = 20\ \text{mA}$	25°C	-1.5	-2.4		-1.5	-2.4		
		Full range	-1.4			-1.4			
$A_{VD}$ Large-signal differential voltage amplification	$V_O = \pm 2.3\ \text{V}$	$R_L = 600\ \Omega$	25°C	80	91		80	91	dB
			Full range	78			78		
		$R_L = 2\ \text{k}\Omega$	25°C	90	100		90	100	
			Full range	88			88		
		$R_L = 10\ \text{k}\Omega$	25°C	95	106		95	106	
			Full range	93			93		
$r_i$ Input resistance	$V_{IC} = 0$	25°C	10 <sup>12</sup>			10 <sup>12</sup>			$\Omega$
$C_i$ Input capacitance	Common mode	25°C	11			11			pF
	Differential	25°C	2.5			2.5			
$Z_O$ Open-loop output impedance	$f = 1\ \text{MHz}$	25°C	80			80			$\Omega$
CMRR Common-mode rejection ratio	$V_{IC} = V_{ICRmin}, V_O = 0, R_S = 50\ \Omega$	25°C	70	89		70	89	dB	
		Full range	68			68			
$k_{SVR}$ Supply-voltage rejection ratio ( $\Delta V_{CC\pm} / \Delta V_{IO}$ )	$V_{CC\pm} = \pm 5\ \text{V to } \pm 15\ \text{V}, V_O = 0, R_S = 50\ \Omega$	25°C	82	99		82	99	dB	
		Full range	80			80			

† Full range is -40°C to 125°C.



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**TLE2074-Q1 electrical characteristics at specified free-air temperature,  $V_{CC\pm} = \pm 5\text{ V}$  (unless otherwise noted) (continued)**

PARAMETER	TEST CONDITIONS	$T_A^\dagger$	TLE2074-Q1			TLE2074A-Q1			UNIT
			MIN	TYP	MAX	MIN	TYP	MAX	
$I_{CC}$ Supply current (four amplifiers)	$V_O = 0$ , No load	25°C	5.2	6.3	7.5	5.2	6.3	7.5	mA
		Full range	7.5			7.5			
Crosstalk attenuation	$V_{IC} = 0$ , $R_L = 2\text{ k}\Omega$	25°C	120			120			dB
$I_{OS}$ Short-circuit output current	$V_O = 0$	25°C	$V_{ID} = 1\text{ V}$			-35			mA
			$V_{ID} = -1\text{ V}$			45			

† Full range is  $-40^\circ\text{C}$  to  $125^\circ\text{C}$ .

**TLE2074-Q1 operating characteristics at specified free-air temperature,  $V_{CC\pm} = \pm 5\text{ V}$**

PARAMETER	TEST CONDITIONS	$T_A^\dagger$	TLE2074-Q1			TLE2074A-Q1			UNIT
			MIN	TYP	MAX	MIN	TYP	MAX	
SR+ Positive slew rate	$V_{O(PP)} = \pm 2.3\text{ V}$ , $A_{VD} = -1$ , $C_L = 100\text{ pF}$ , $R_L = 2\text{ k}\Omega$ , See Figure 1	25°C	35			35			$\text{V}/\mu\text{s}$
		Full range	18			18			
SR- Negative slew rate	$V_{O(PP)} = \pm 2.3\text{ V}$ , $A_{VD} = -1$ , $C_L = 100\text{ pF}$ , $R_L = 2\text{ k}\Omega$ , See Figure 1	25°C	38			38			$\text{V}/\mu\text{s}$
		Full range	18			18			
$t_s$ Settling time	$A_{VD} = -1$ , 2-V step, $R_L = 1\text{ k}\Omega$ , $C_L = 100\text{ pF}$	25°C	To 10 mV	0.25		0.25		$\mu\text{s}$	
			To 1 mV	0.4		0.4			
$V_n$ Equivalent input noise voltage	$R_S = 20\ \Omega$ , See Figure 3	25°C	f = 10 Hz	28	55	28	55	$\text{nV}/\sqrt{\text{Hz}}$	
f = 10 kHz			11.6	17	11.6	17			
$V_{N(PP)}$ Peak-to-peak equivalent input noise voltage	$R_S = 20\ \Omega$ , See Figure 3	25°C	f = 10 Hz to 10 kHz	6		6		$\mu\text{V}$	
			f = 0.1 Hz to 10 Hz	0.6		0.6			
$I_n$ Equivalent input noise current	$V_{IC} = 0$ , f = 10 kHz	25°C	2.8		2.8		$\text{fA}/\sqrt{\text{Hz}}$		
THD + N Total harmonic distortion plus noise	$V_{O(PP)} = 5\text{ V}$ , f = 1 kHz, $R_S = 25\ \Omega$	$A_{VD} = 10$ , $R_L = 2\text{ k}\Omega$ , 25°C	0.013%		0.013%				
$B_1$ Unity-gain bandwidth	$V_I = 10\text{ mV}$ , $C_L = 25\text{ pF}$ , $R_L = 2\text{ k}\Omega$ , See Figure 2	25°C	9.4		9.4		MHz		
$B_{OM}$ Maximum output-swing bandwidth	$V_{O(PP)} = 4\text{ V}$ , $R_L = 2\text{ k}\Omega$ , $A_{VD} = -1$ , $C_L = 25\text{ pF}$	25°C	2.8		2.8		MHz		
$f_m$ Phase margin at unity gain	$V_I = 10\text{ mV}$ , $C_L = 25\text{ pF}$ , $R_L = 2\text{ k}\Omega$ , See Figure 2	25°C	56		56				

† Full range is  $-40^\circ\text{C}$  to  $125^\circ\text{C}$ .



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**TLE2074-Q1 electrical characteristics at specified free-air temperature,  $V_{CC\pm} = \pm 15$  V (unless otherwise noted)**

PARAMETER	TEST CONDITIONS	$T_A$ †	TLE2074-Q1			TLE2074A-Q1			UNIT
			MIN	TYP	MAX	MIN	TYP	MAX	
$V_{IO}$ Input offset voltage	$V_{IC} = 0, V_O = 0, R_S = 50 \Omega$	25°C	-1.6	7		-0.5	4	mV	
		Full range			11		9		
$\alpha_{VIO}$ Temperature coefficient of input offset voltage		Full range	10.1			10.1 30		$\mu V/^\circ C$	
$I_{IO}$ Input offset current	$V_{IC} = 0, V_O = 0, \text{See Figure 4}$	25°C	15	100		15	100	pA	
		Full range		20		20		nA	
$I_{IB}$ Input bias current		25°C	25	175		25	175	pA	
		Full range		60		60		nA	
$V_{ICR}$ Common-mode input voltage range	$R_S = 50 \Omega$	25°C	15 to -11	15 to -11.9		15 to -11	15 to -11.9	V	
		Full range	15 to -10.8			15 to -10.8			
$V_{OM+}$ Maximum positive peak output voltage swing	$I_O = -200 \mu A$	25°C	13.8	14.1		13.8	14.1	V	
		Full range	13.6			13.6			
	$I_O = -2 \text{ mA}$	25°C	13.5	13.9		13.5	13.9		
		Full range	13.3			13.3			
	$I_O = -20 \text{ mA}$	25°C	11.5	12.3		11.5	12.3		
		Full range	11.4			11.4			
$V_{OM-}$ Maximum negative peak output voltage swing	$I_O = 200 \mu A$	25°C	-13.8	-14.2		-13.8	-14.2	V	
		Full range	-13.6			-13.6			
	$I_O = 2 \text{ mA}$	25°C	-13.5	-14		-13.5	-14		
		Full range	-13.3			-13.3			
	$I_O = 20 \text{ mA}$	25°C	-11.5	-12.4		-11.5	-12.4		
		Full range	-11.4			-11.4			
$A_{VD}$ Large-signal differential voltage amplification	$V_O = \pm 10 \text{ V}$	$R_L = 600 \Omega$	25°C	80	96		80	96	dB
			Full range	78			78		
		$R_L = 2 \text{ k}\Omega$	25°C	90	109		90	109	
			Full range	88			88		
		$R_L = 10 \text{ k}\Omega$	25°C	95	118		95	118	
			Full range	93			93		
$r_i$ Input resistance	$V_{IC} = 0$	25°C	$10^{12}$			$10^{12}$		$\Omega$	
$C_i$ Input capacitance	Common mode	$V_{IC} = 0, \text{See Figure 5}$	25°C	7.5			7.5		pF
	Differential		25°C	2.5			2.5		
$Z_O$ Open-loop output impedance	$f = 1 \text{ MHz}$	25°C	80			80		$\Omega$	
CMRR Common-mode rejection ratio	$V_{IC} = V_{ICRmin}, V_O = 0, R_S = 50 \Omega$	25°C	80	98		80	98	dB	
		Full range	78			78			
$k_{SVR}$ Supply-voltage rejection ratio ( $\Delta V_{CC\pm} / \Delta V_{IO}$ )	$V_{CC\pm} = \pm 5 \text{ V to } \pm 15 \text{ V}, V_O = 0, R_S = 50 \Omega$	25°C	82	99		82	99	dB	
		Full range	80			80			

† Full range is  $-40^\circ C$  to  $125^\circ C$ .





**TLE207x-Q1, TLE207xA-Q1**  
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**TLE2074-Q1 electrical characteristics at specified free-air temperature,  $V_{CC\pm} = \pm 15$  V (unless otherwise noted) (continued)**

PARAMETER	TEST CONDITIONS	$T_A$ †	TLE2074-Q1			TLE2074A-Q1			UNIT	
			MIN	TYP	MAX	MIN	TYP	MAX		
$I_{CC}$	Supply current (four amplifiers)	$V_O = 0$ , No load	25°C	5.2	6.5	7.5	5.2	6.5	7.5	mA
			Full range	7.5			7.5			
	Crosstalk attenuation	$V_{IC} = 0$ , $R_L = 2$ k $\Omega$	25°C	120			120			dB
$I_{OS}$	Short-circuit output current	$V_O = 0$	25°C	$V_{ID} = 1$ V	-30	-45	-30	-45	mA	
				$V_{ID} = -1$ V	30	48	30	48		

† Full range is  $-40^\circ\text{C}$  to  $125^\circ\text{C}$ .

**TLE2074-Q1 operating characteristics at specified free-air temperature,  $V_{CC\pm} = \pm 15$  V**

PARAMETER	TEST CONDITIONS	$T_A$ †	TLE2074-Q1			TLE2074A-Q1			UNIT
			MIN	TYP	MAX	MIN	TYP	MAX	
SR+	Positive slew rate	$V_{O(PP)} = 10$ V, $A_{VD} = -1$ , $R_L = 2$ k $\Omega$ , $C_L = 100$ pF, See Figure 1	25°C	25	40	25	40	$V/\mu\text{s}$	
			Full range	17			17		
SR-	Negative slew rate	See Figure 1	25°C	30	45	30	45	$V/\mu\text{s}$	
			Full range	20			20		
$t_s$	Settling time	$A_{VD} = -1$ , 10-V step, $R_L = 1$ k $\Omega$ , $C_L = 100$ pF	25°C	To 10 mV	0.4		0.4		$\mu\text{s}$
				To 1 mV	1.5		1.5		
$V_n$	Equivalent input noise voltage	$R_S = 20$ $\Omega$ , See Figure 3	25°C	f = 10 Hz	28	55	28	55	$nV/\sqrt{\text{Hz}}$
				f = 10 kHz	11.6	17	11.6	17	
$V_{N(PP)}$	Peak-to-peak equivalent input noise voltage	See Figure 3	25°C	f = 10 Hz to 10 kHz	6		6		$\mu\text{V}$
				f = 0.1 Hz to 10 Hz	0.6		0.6		
$I_n$	Equivalent input noise current	$V_{IC} = 0$ , f = 10 kHz	25°C	2.8		2.8		$fA/\sqrt{\text{Hz}}$	
THD + N	Total harmonic distortion plus noise	$V_{O(PP)} = 20$ V, f = 1 kHz, $R_S = 25$ $\Omega$	25°C	0.008%		0.008%			
$B_1$	Unity-gain bandwidth	$V_I = 10$ mV, $C_L = 25$ pF, $R_L = 2$ k $\Omega$ , See Figure 2	25°C	8	10	8	10	MHz	
$B_{OM}$	Maximum output-swing bandwidth	$V_{O(PP)} = 20$ V, $R_L = 2$ k $\Omega$ , $C_L = 25$ pF	25°C	478	637	478	637	kHz	
$\phi_m$	Phase margin at unity gain	$V_I = 10$ mV, $C_L = 25$ pF, $R_L = 2$ k $\Omega$ , See Figure 2	25°C	57		57			

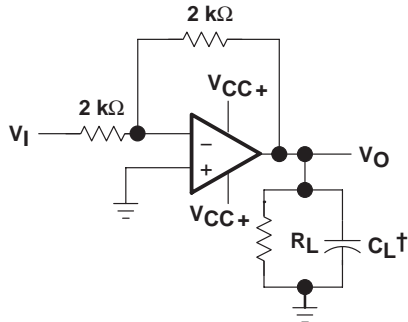
† Full range is  $-40^\circ\text{C}$  to  $125^\circ\text{C}$ .



# TLE207x-Q1, TLE207xA-Q1 EXCALIBUR LOW-NOISE HIGH-SPEED JFET-INPUT OPERATIONAL AMPLIFIERS

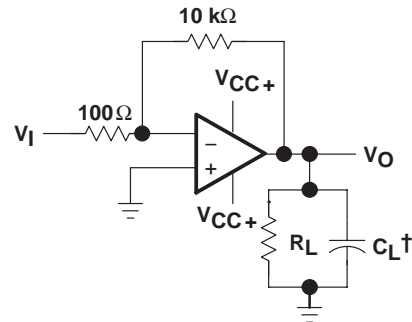
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## PARAMETER MEASUREMENT INFORMATION



† Includes fixture capacitance

Figure 1. Slew-Rate Test Circuit



† Includes fixture capacitance

Figure 2. Unity-Gain Bandwidth and Phase-Margin Test Circuit

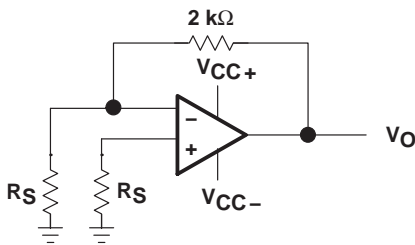


Figure 3. Noise-Voltage Test Circuit

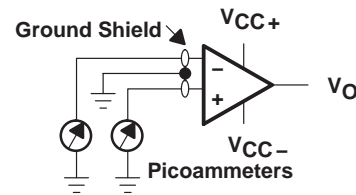


Figure 4. Input-Bias and Offset-Current Test Circuit

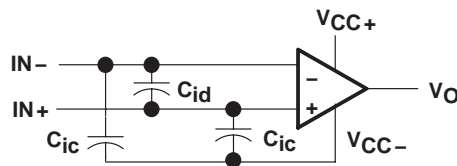


Figure 5. Internal Input Capacitance

### 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 TLE207x and TLE207xA, 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 in the socket and a second test is performed that measures both the socket leakage and the device input bias current. The two measurements are then subtracted algebraically to determine the bias current of the device.

## TYPICAL CHARACTERISTICS

**Table of Graphs**

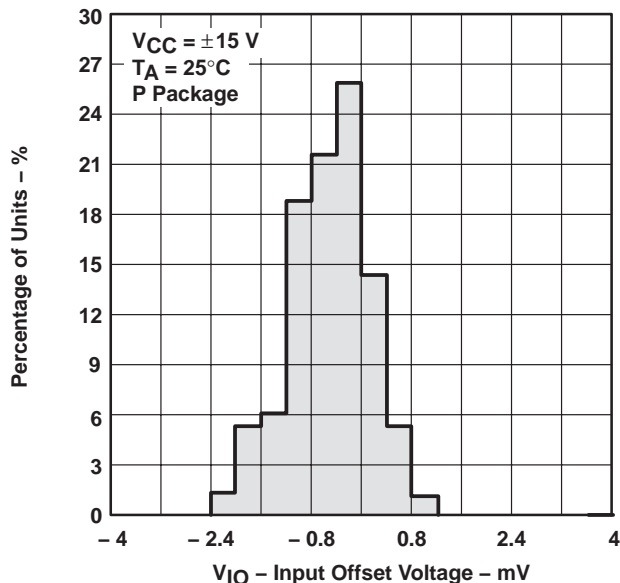
			FIGURE
$V_{IO}$	Input offset voltage	Distribution	6, 7, 8
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$A_{VD}$	Large-signal differential voltage amplification	vs Load resistance vs Free-air temperature	25 26, 27
$A_{VD}$	Small-signal differential voltage amplification	vs Frequency	28, 29
CMRR	Common-mode rejection ratio	vs Frequency vs Free-air temperature	30 31
$k_{SVR}$	Supply-voltage rejection ratio	vs Frequency vs Free-air temperature	32 33
$I_{CC}$	Supply current	vs Supply voltage vs Free-air temperature vs Differential input voltage	34, 35, 36 37, 38, 39 40 – 45
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THD + N	Total harmonic distortion plus noise	vs Frequency	57, 58
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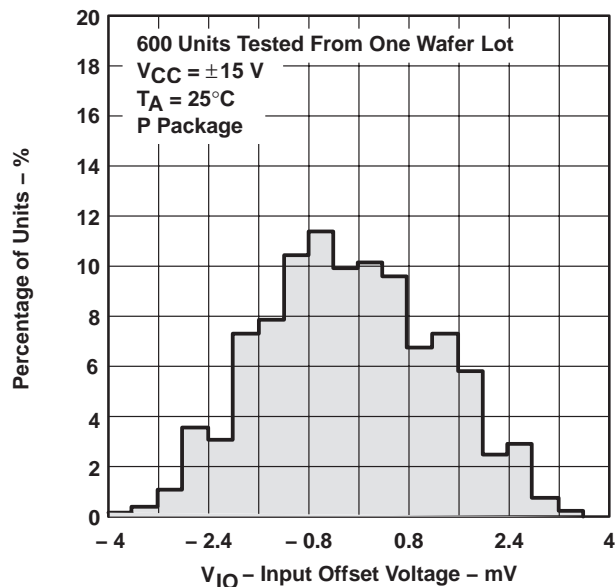
**TYPICAL CHARACTERISTICS**

**DISTRIBUTION OF TLE2071  
 INPUT OFFSET VOLTAGE**



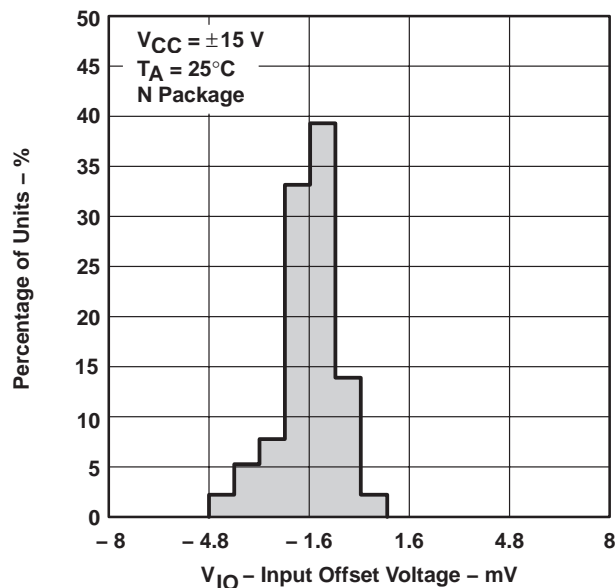
**Figure 6**

**DISTRIBUTION OF TLE2072  
 INPUT OFFSET VOLTAGE**



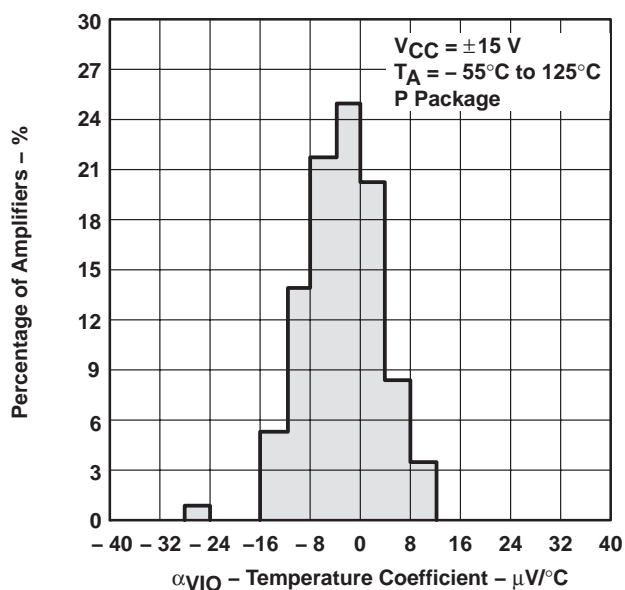
**Figure 7**

**DISTRIBUTION OF TLE2074  
 INPUT OFFSET VOLTAGE**



**Figure 8**

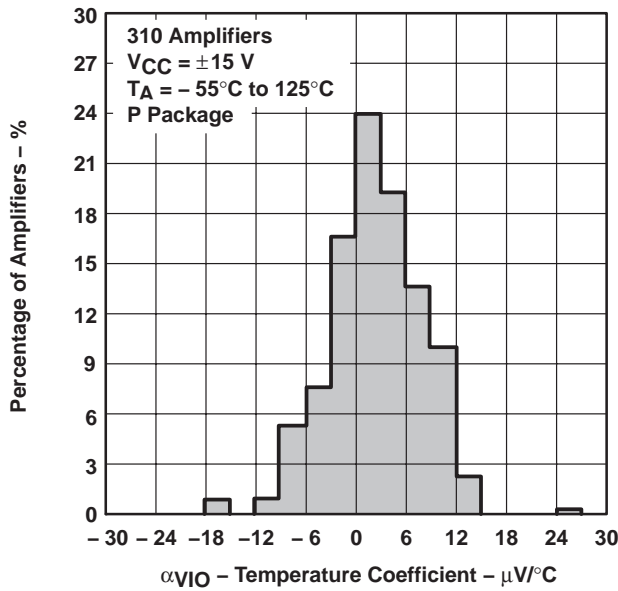
**DISTRIBUTION OF TLE2071 INPUT OFFSET  
 VOLTAGE TEMPERATURE COEFFICIENT**



**Figure 9**

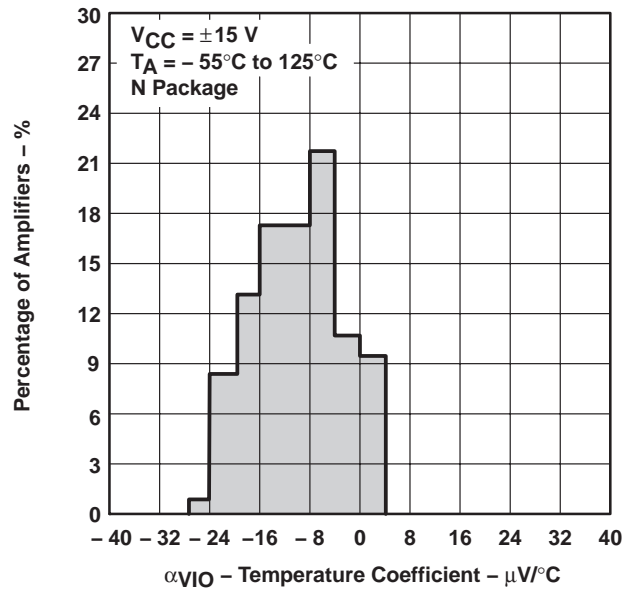
**TYPICAL CHARACTERISTICS**

**DISTRIBUTION OF TLE2072 INPUT OFFSET  
 VOLTAGE TEMPERATURE COEFFICIENT**



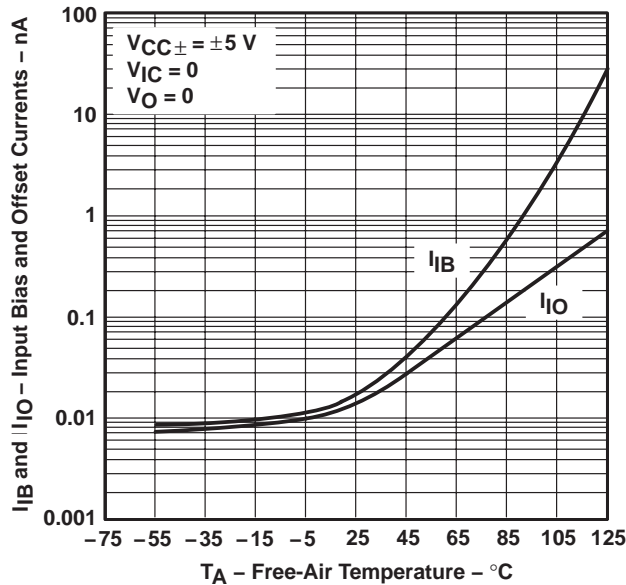
**Figure 10**

**DISTRIBUTION OF TLE2074 INPUT OFFSET  
 VOLTAGE TEMPERATURE COEFFICIENT**



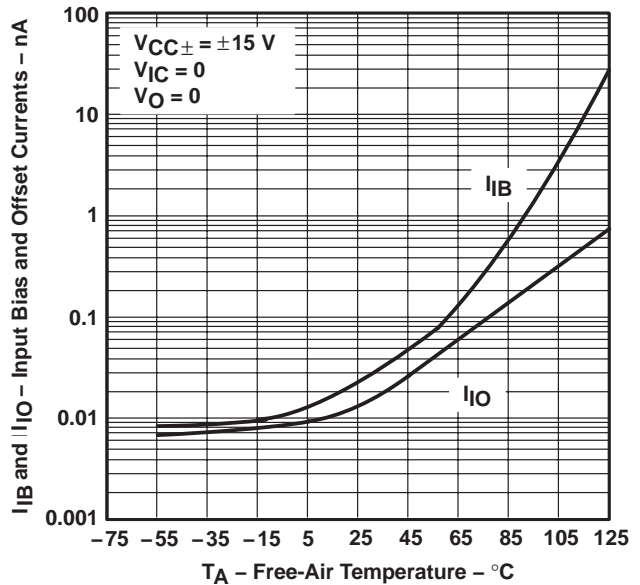
**Figure 11**

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



**Figure 12**

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



**Figure 13**

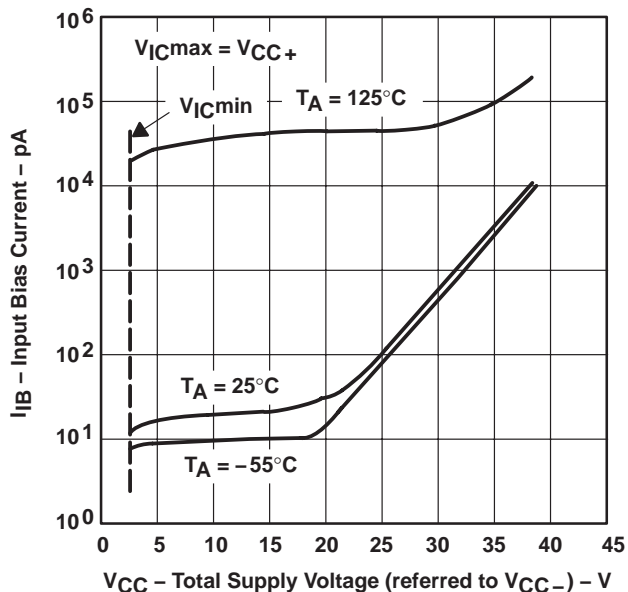
† Data at high and low temperatures are applicable only within the rated operating free-air temperature ranges of the various devices.

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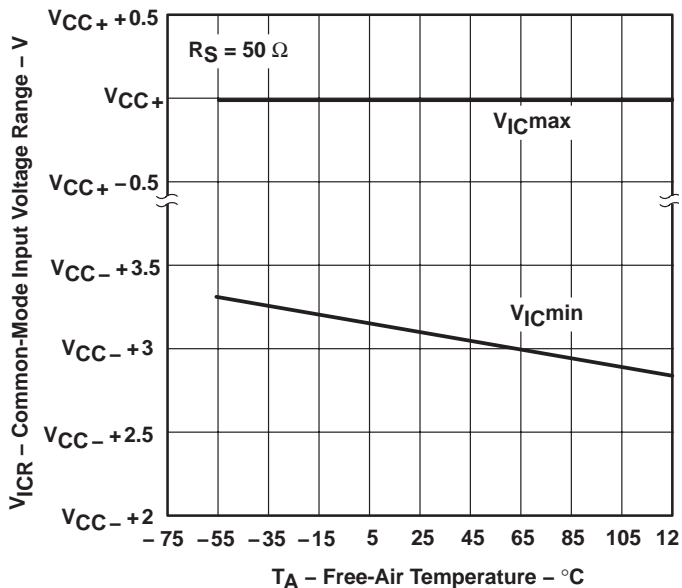
**TYPICAL CHARACTERISTICS**

**INPUT BIAS CURRENT**  
**vs**  
**TOTAL SUPPLY VOLTAGE**



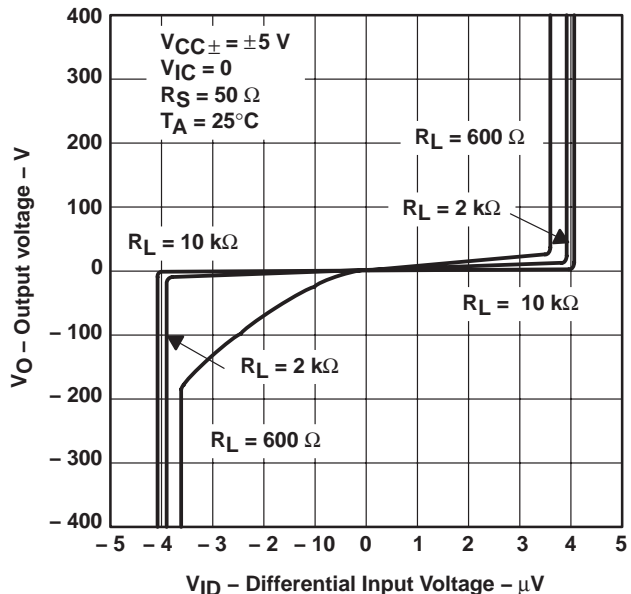
**Figure 14**

**COMMON-MODE INPUT VOLTAGE RANGE†**  
**vs**  
**FREE-AIR TEMPERATURE**



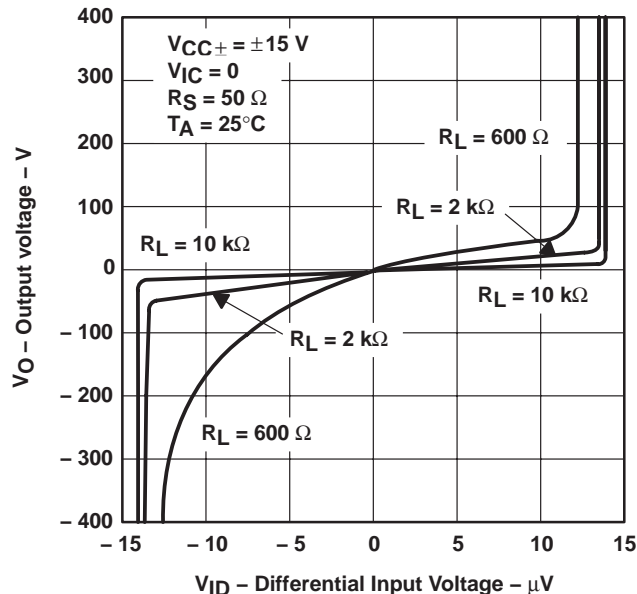
**Figure 15**

**OUTPUT VOLTAGE**  
**vs**  
**DIFFERENTIAL INPUT VOLTAGE**



**Figure 16**

**OUTPUT VOLTAGE**  
**vs**  
**DIFFERENTIAL INPUT VOLTAGE**



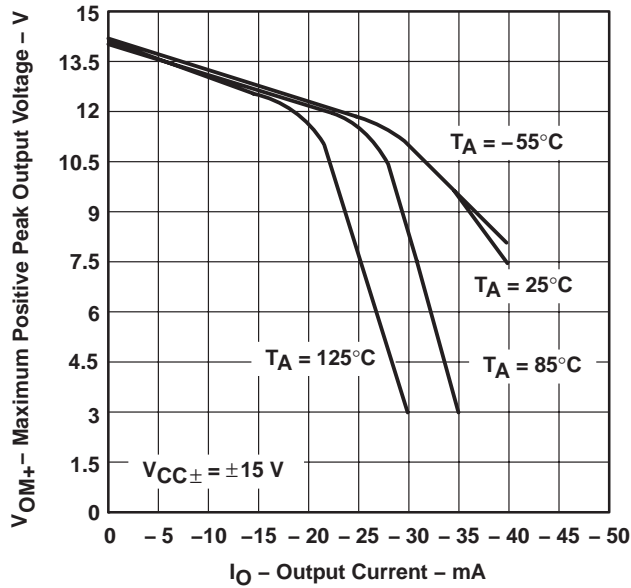
**Figure 17**

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



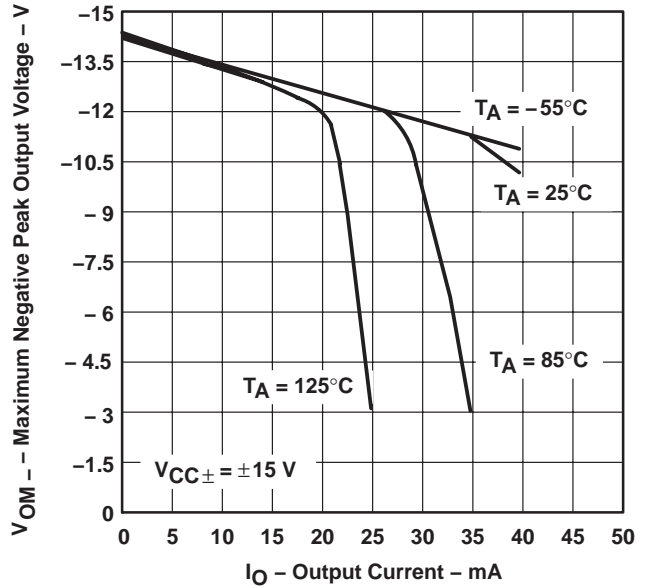
**TYPICAL CHARACTERISTICS**

**MAXIMUM POSITIVE PEAK OUTPUT VOLTAGE†  
 vs  
 OUTPUT CURRENT**



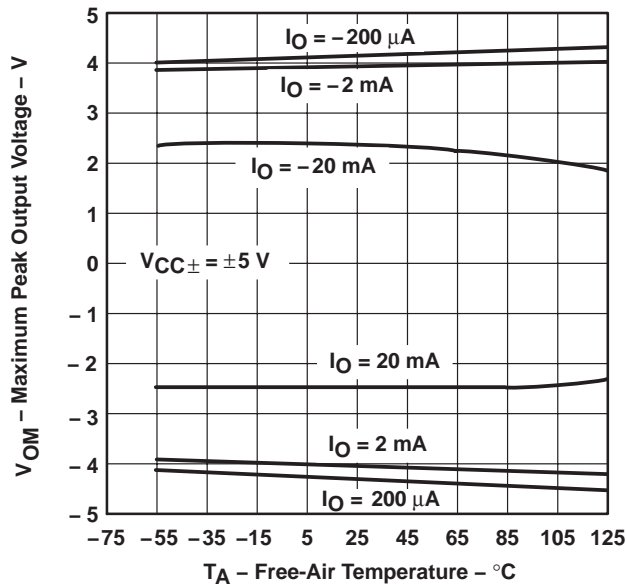
**Figure 18**

**MAXIMUM NEGATIVE PEAK OUTPUT VOLTAGE†  
 vs  
 OUTPUT CURRENT**



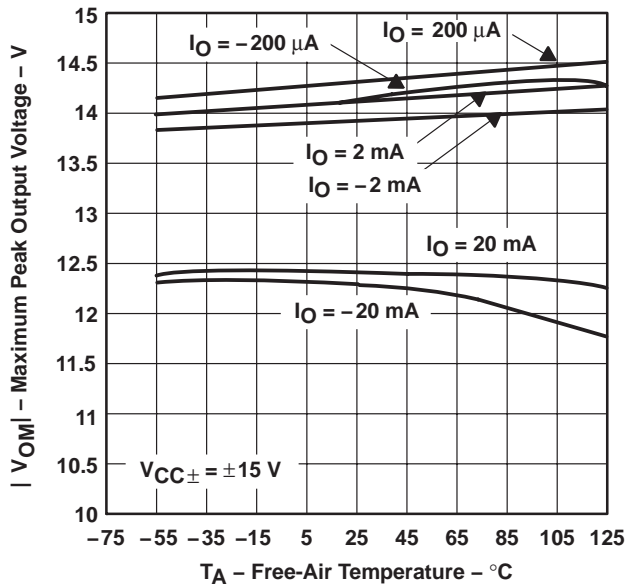
**Figure 19**

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



**Figure 20**

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



**Figure 21**

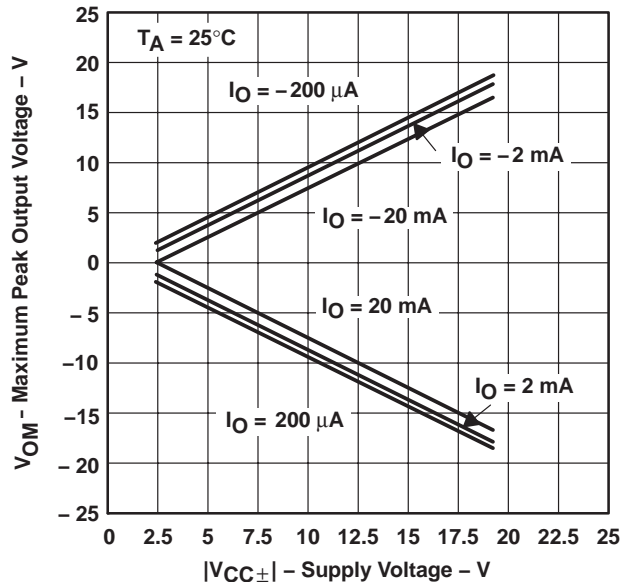
† Data at high and low temperatures are applicable only within the rated operating free-air temperature ranges of the various devices.

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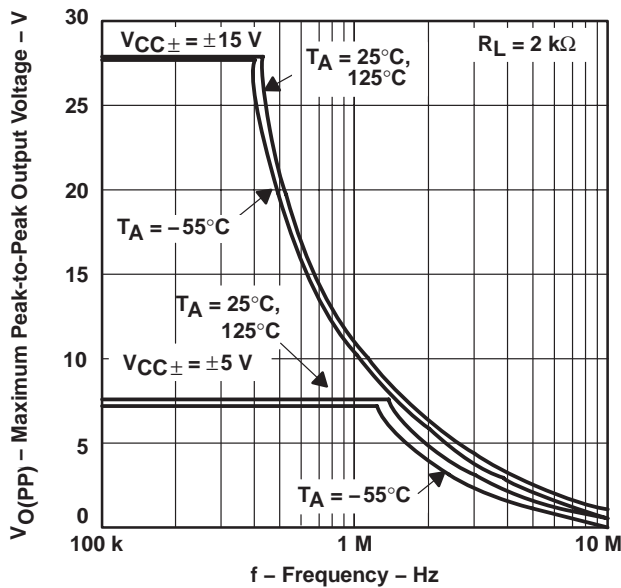
**TYPICAL CHARACTERISTICS**

**MAXIMUM PEAK OUTPUT VOLTAGE**  
**vs**  
**SUPPLY VOLTAGE**



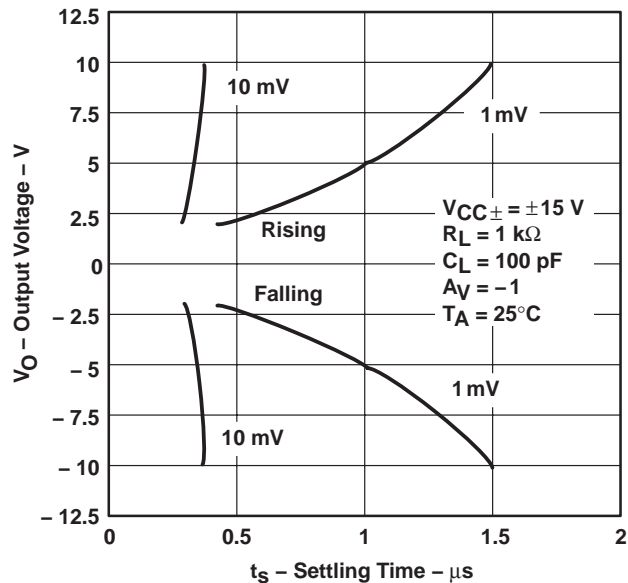
**Figure 22**

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



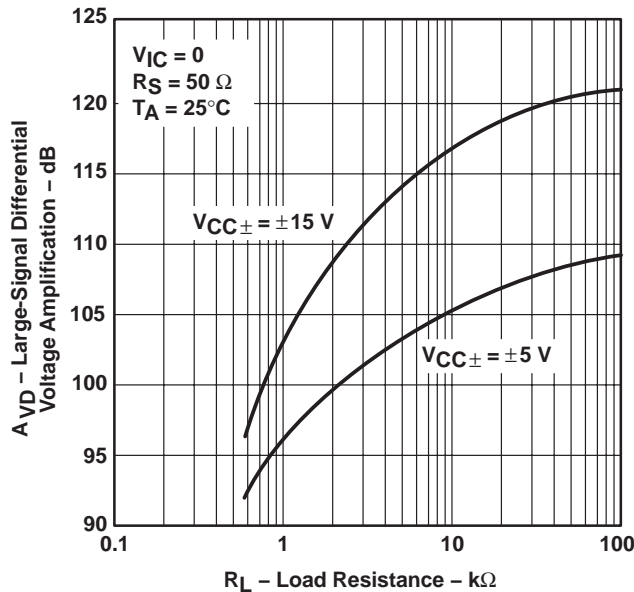
**Figure 23**

**OUTPUT VOLTAGE**  
**vs**  
**SETTLING TIME**



**Figure 24**

**LARGE-SIGNAL DIFFERENTIAL**  
**VOLTAGE AMPLIFICATION**  
**vs**  
**LOAD RESISTANCE**



**Figure 25**

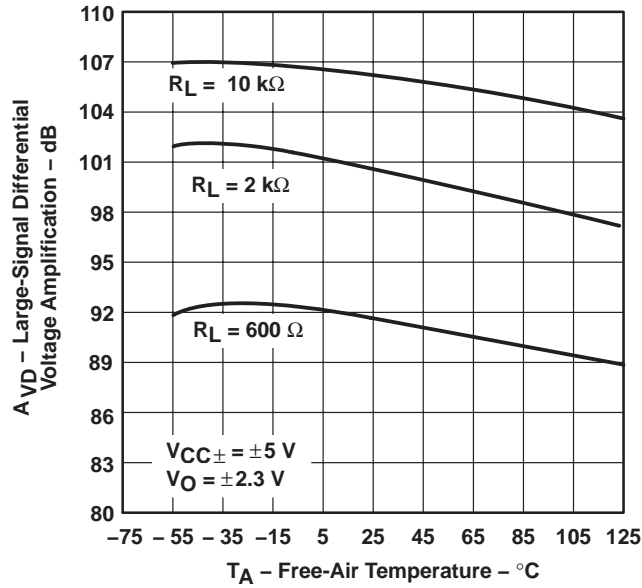
† Data at high and low temperatures are applicable only within the rated operating free-air temperature ranges of the various devices.





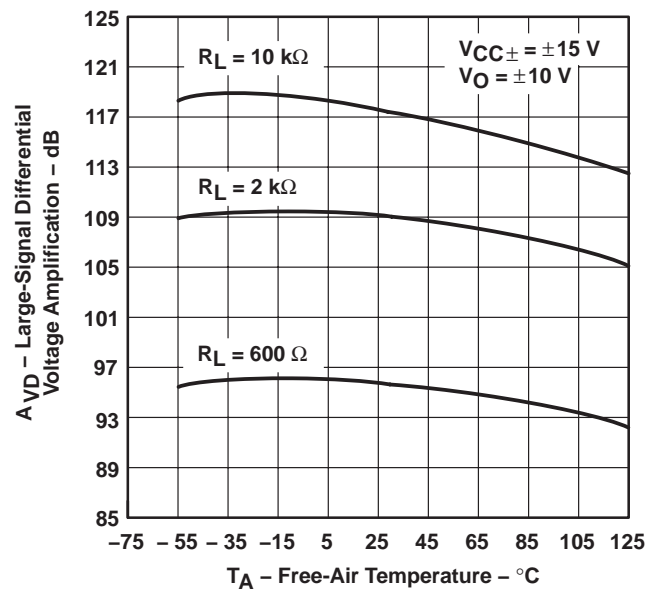
**TYPICAL CHARACTERISTICS**

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



**Figure 26**

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



**Figure 27**

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

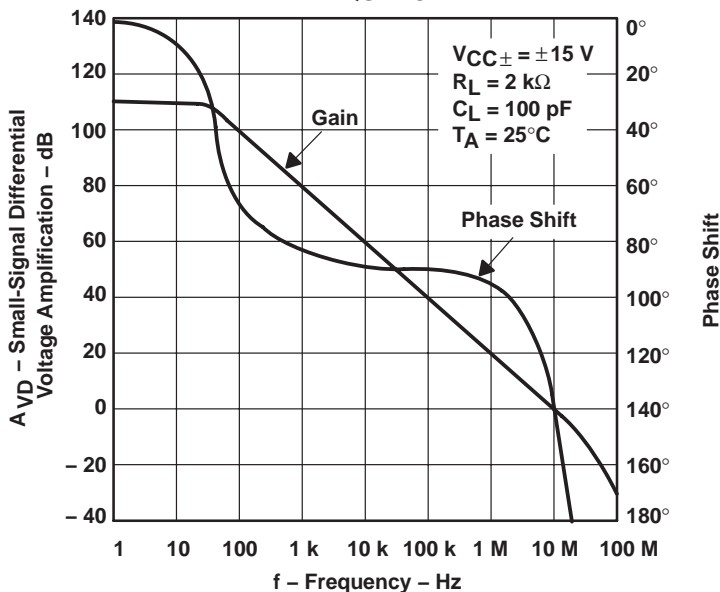
**TLE207x-Q1, TLE207xA-Q1**  
**EXCALIBUR LOW-NOISE HIGH-SPEED**  
**JFET-INPUT OPERATIONAL AMPLIFIERS**

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**TYPICAL CHARACTERISTICS**

**SMALL-SIGNAL DIFFERENTIAL VOLTAGE AMPLIFICATION AND PHASE SHIFT**

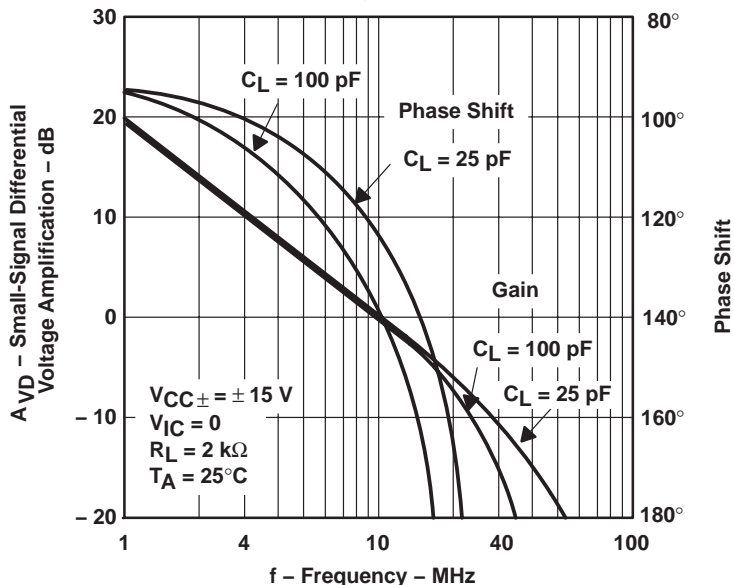
vs  
**FREQUENCY**



**Figure 28**

**SMALL-SIGNAL DIFFERENTIAL VOLTAGE AMPLIFICATION AND PHASE SHIFT**

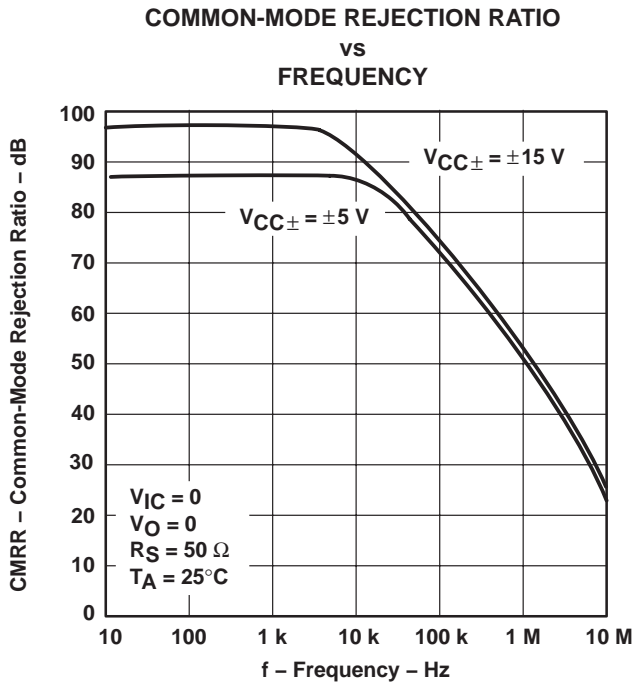
vs  
**FREQUENCY**



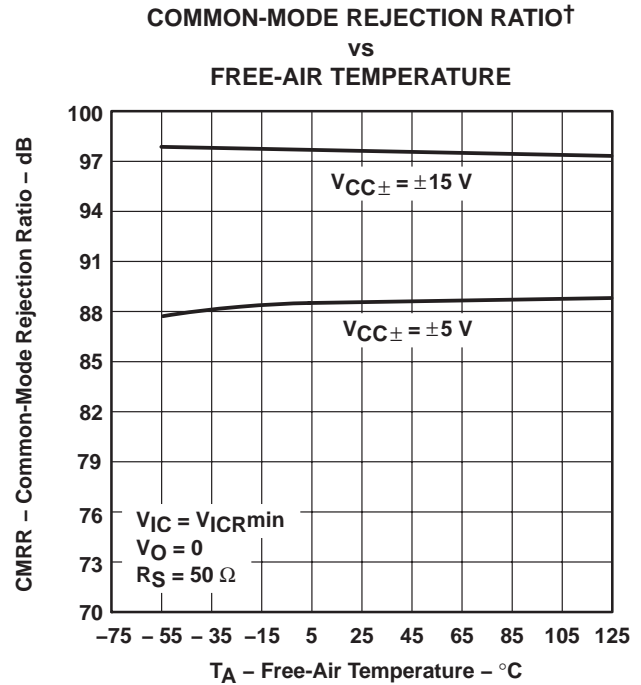
**Figure 29**



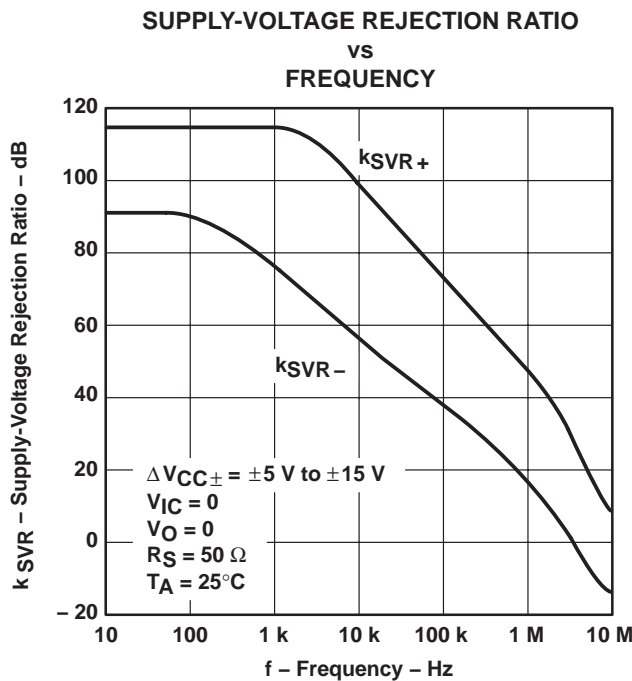
**TYPICAL CHARACTERISTICS**



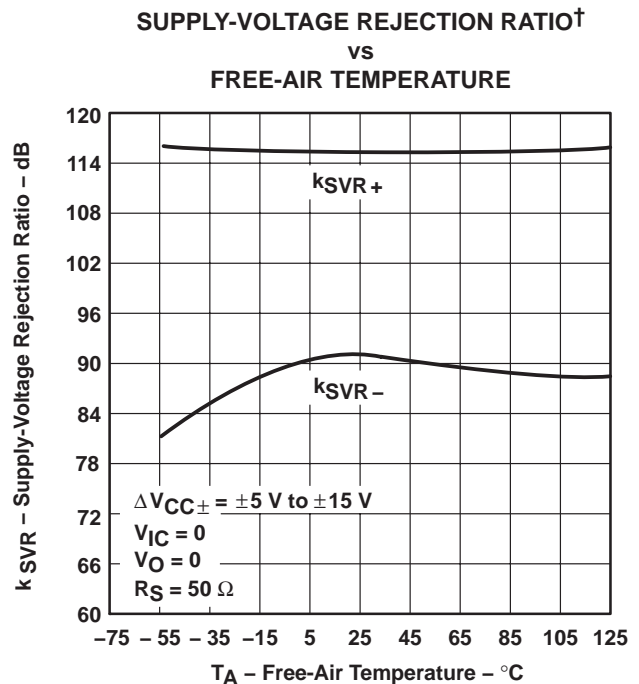
**Figure 30**



**Figure 31**



**Figure 32**



**Figure 33**

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

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## TYPICAL CHARACTERISTICS

**TLE2071  
SUPPLY CURRENT  
vs  
SUPPLY VOLTAGE**

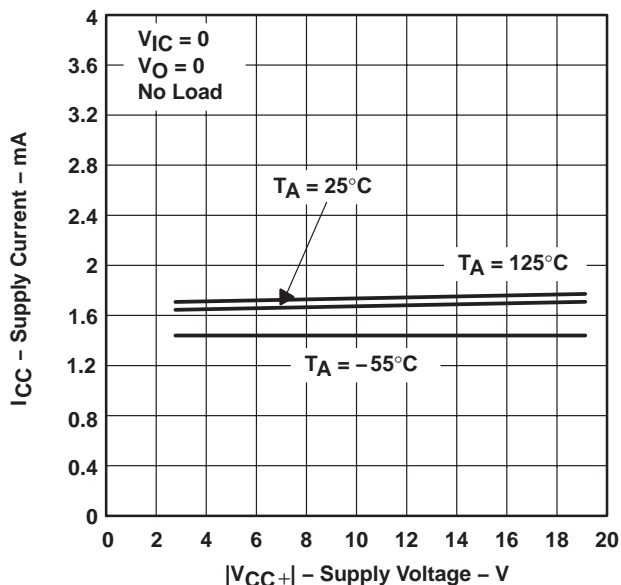


Figure 34

**TLE2072  
SUPPLY CURRENT  
vs  
SUPPLY VOLTAGE**

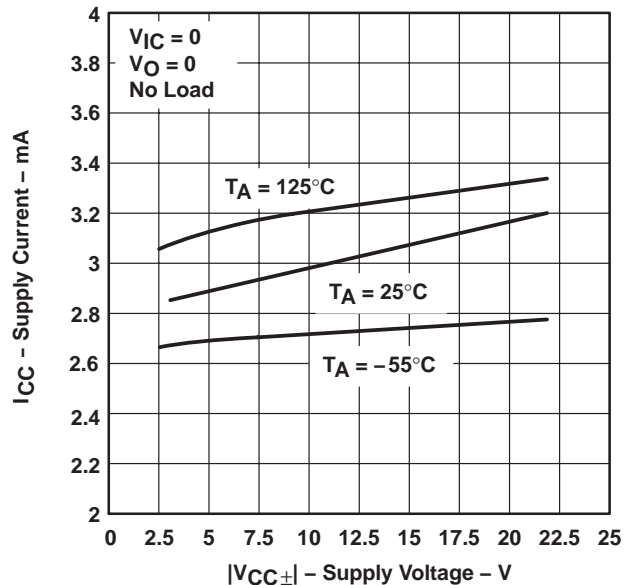


Figure 35

**TLE2074  
SUPPLY CURRENT  
vs  
SUPPLY VOLTAGE**

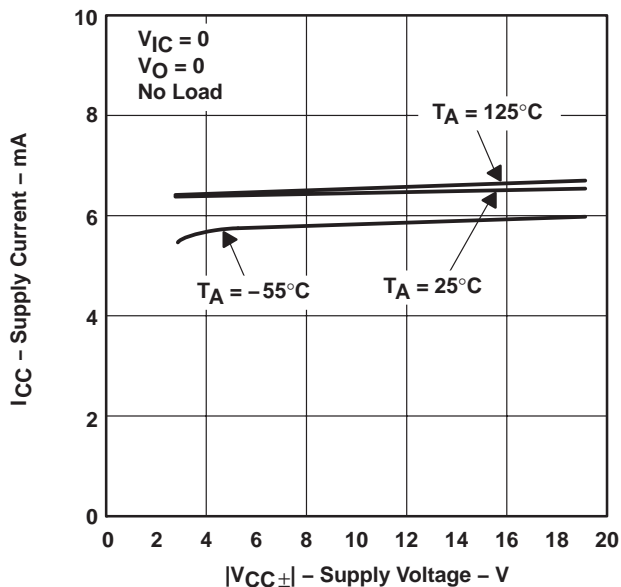


Figure 36

**TLE2071  
SUPPLY CURRENT†  
vs  
FREE-AIR TEMPERATURE**

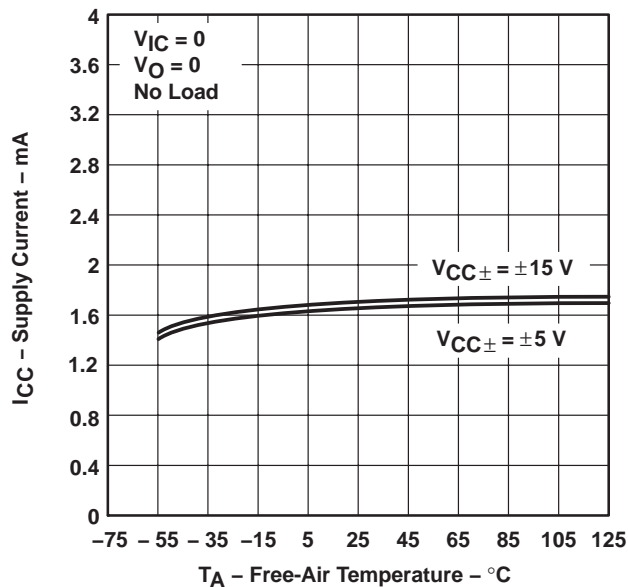
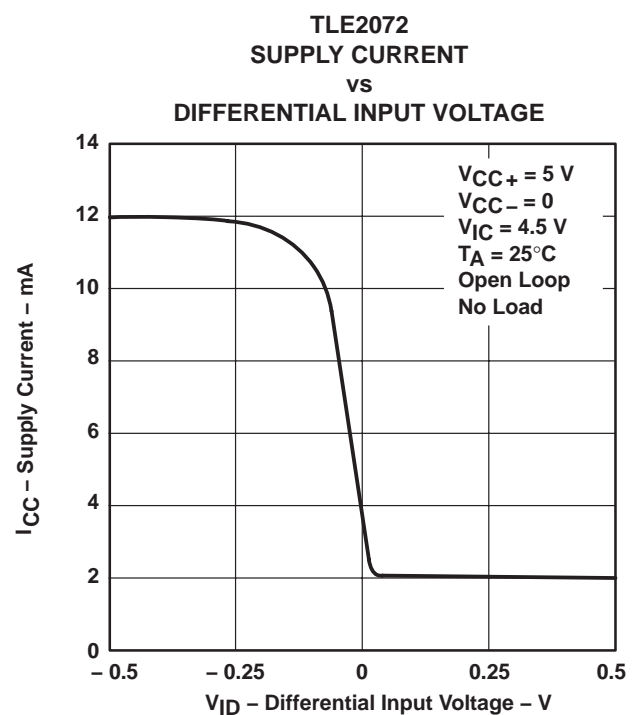
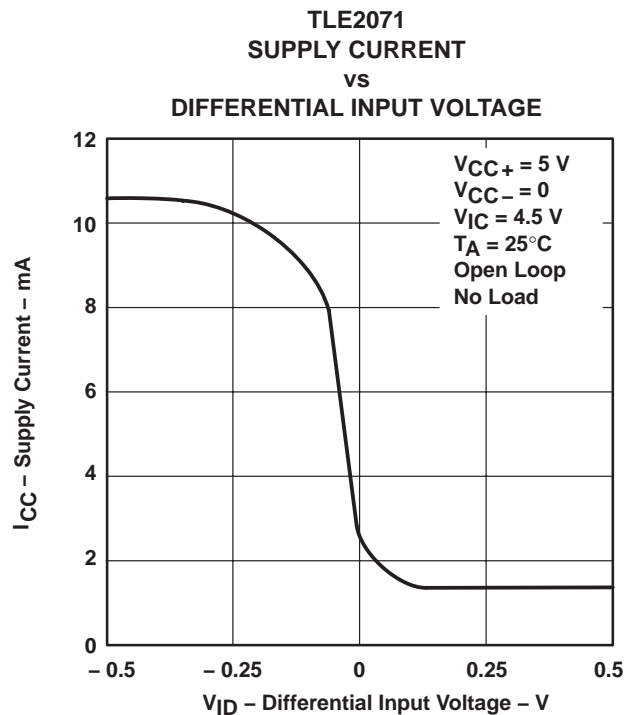
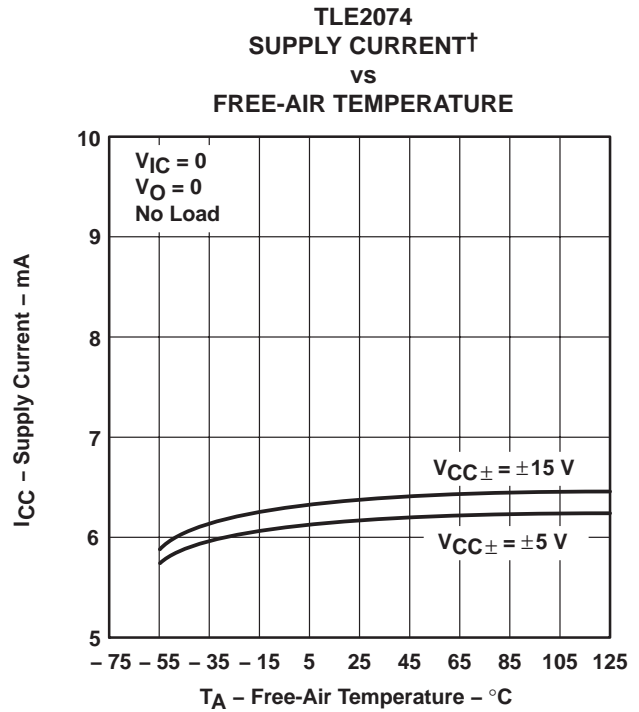
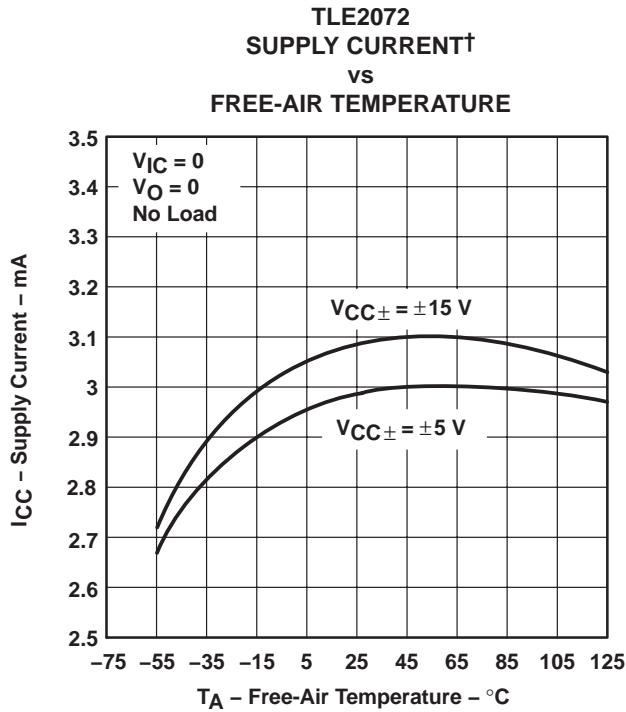


Figure 37

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

TYPICAL CHARACTERISTICS

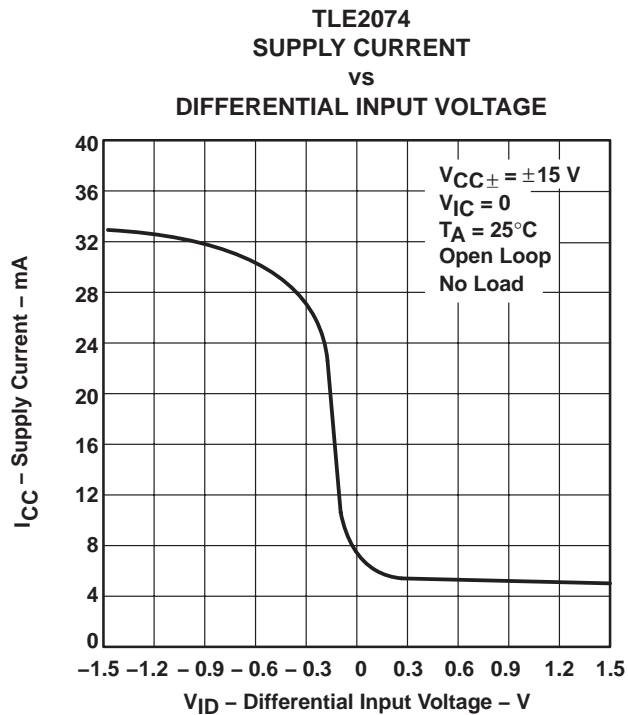
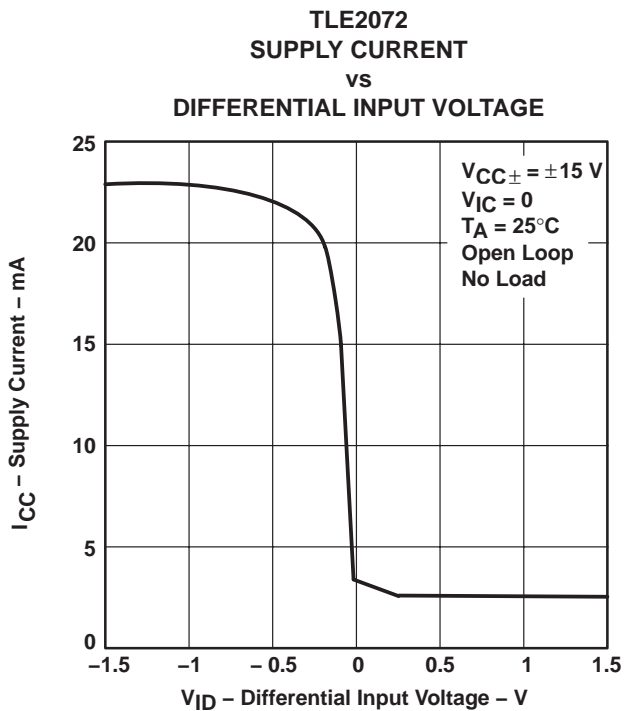
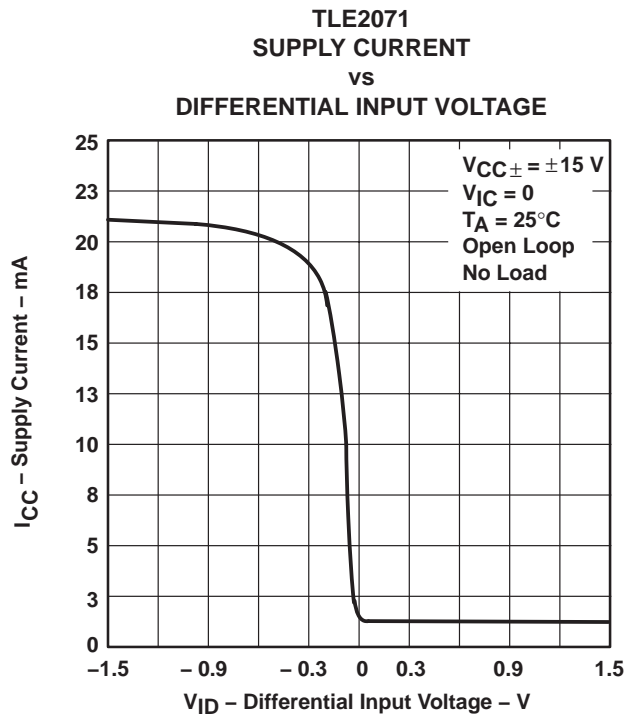
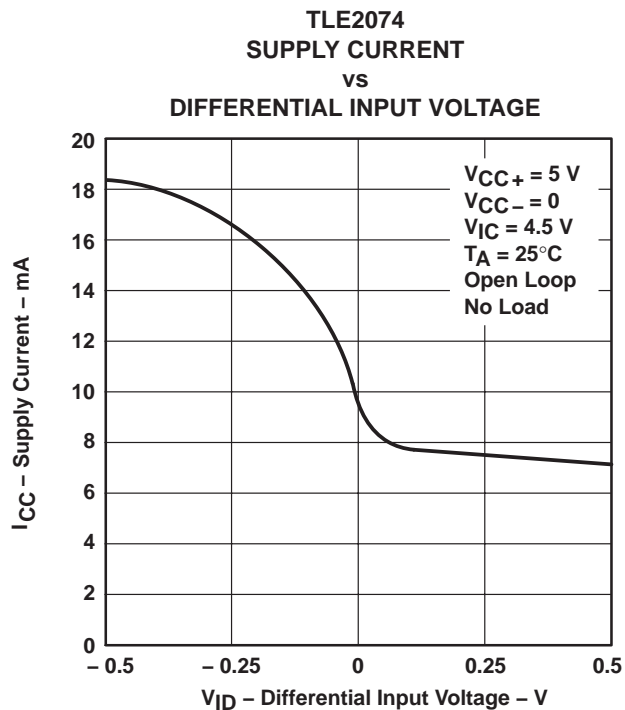


† Data at high and low temperatures are applicable only within the rated operating free-air temperature ranges of the various devices.

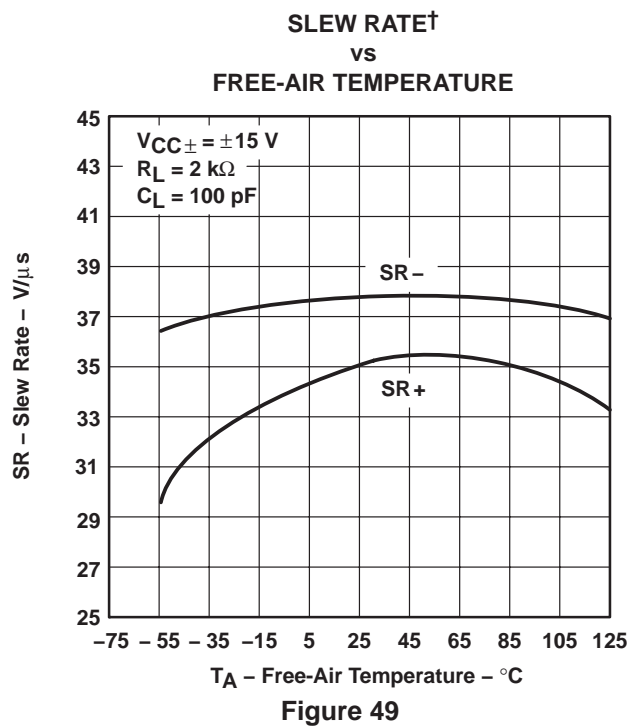
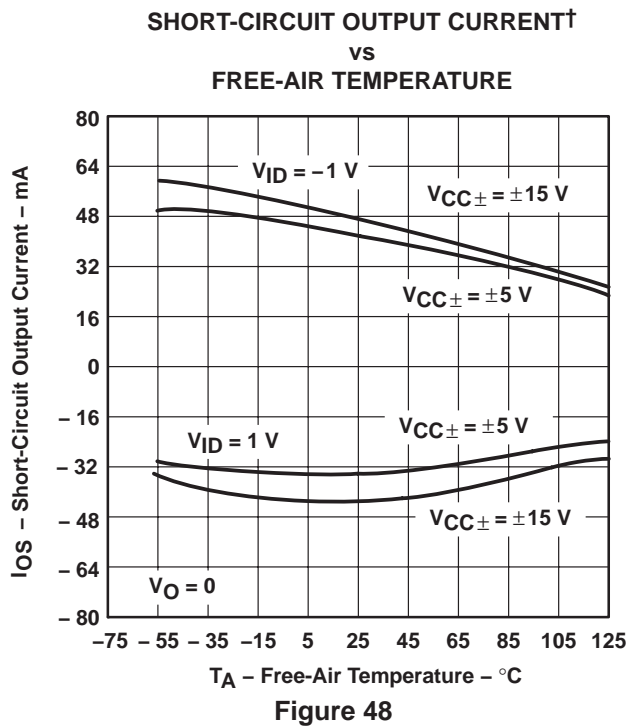
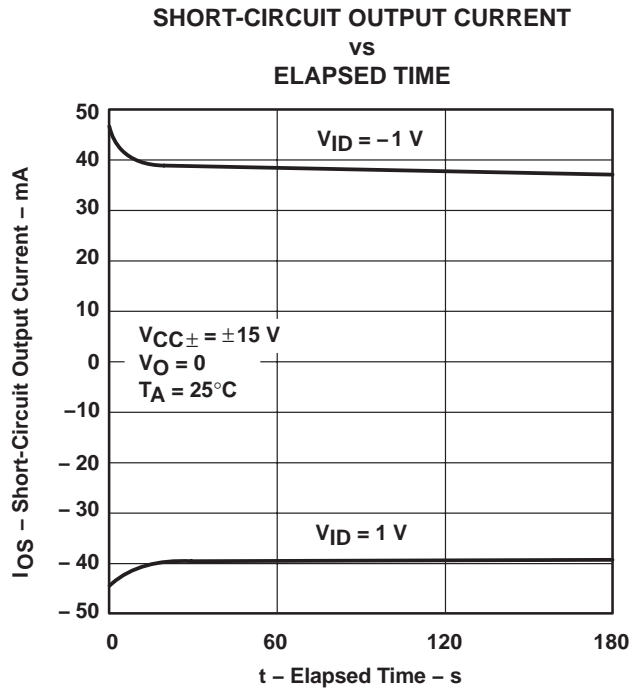
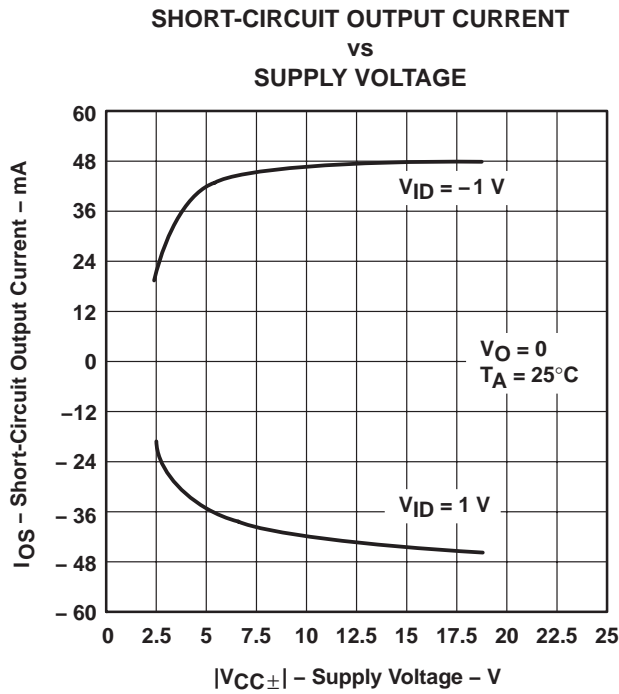
# TLE207x-Q1, TLE207xA-Q1 EXCALIBUR LOW-NOISE HIGH-SPEED JFET-INPUT OPERATIONAL AMPLIFIERS

SGLS226A – DECEMBER 2003 – REVISED AUGUST 2004

## TYPICAL CHARACTERISTICS



**TYPICAL CHARACTERISTICS**

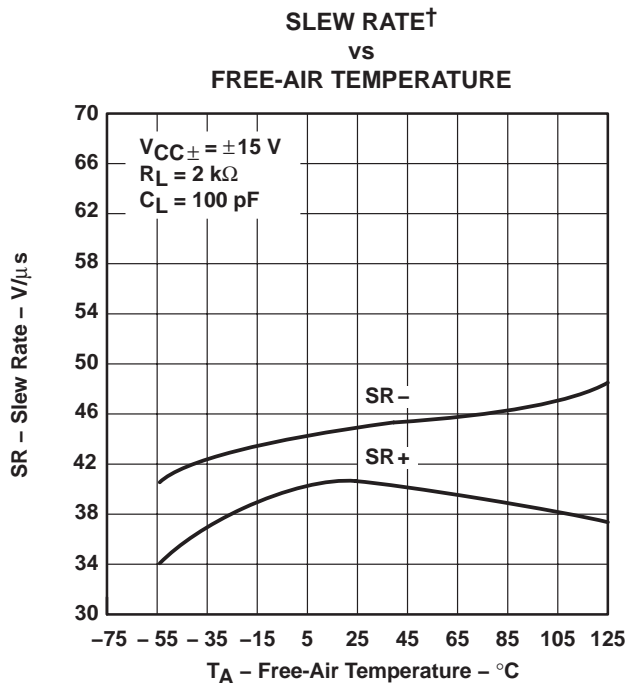


† Data at high and low temperatures are applicable only within the rated operating free-air temperature ranges of the various devices.

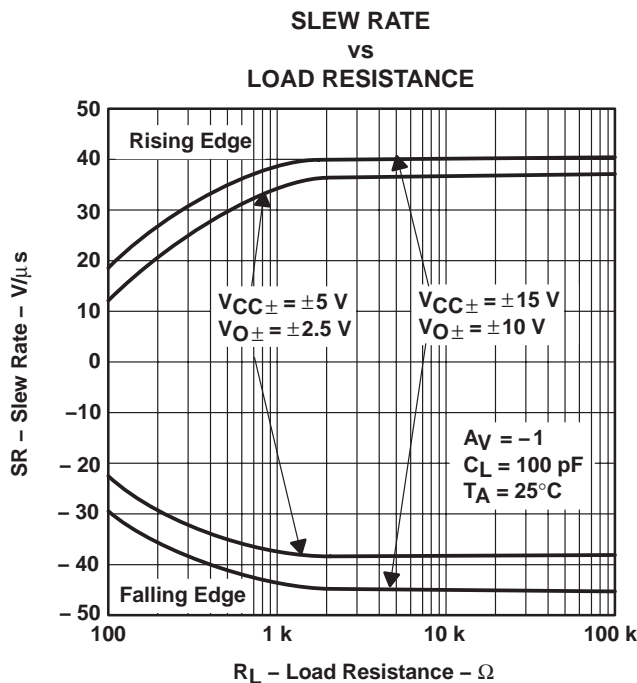
**TLE207x-Q1, TLE207xA-Q1**  
**EXCALIBUR LOW-NOISE HIGH-SPEED**  
**JFET-INPUT OPERATIONAL AMPLIFIERS**

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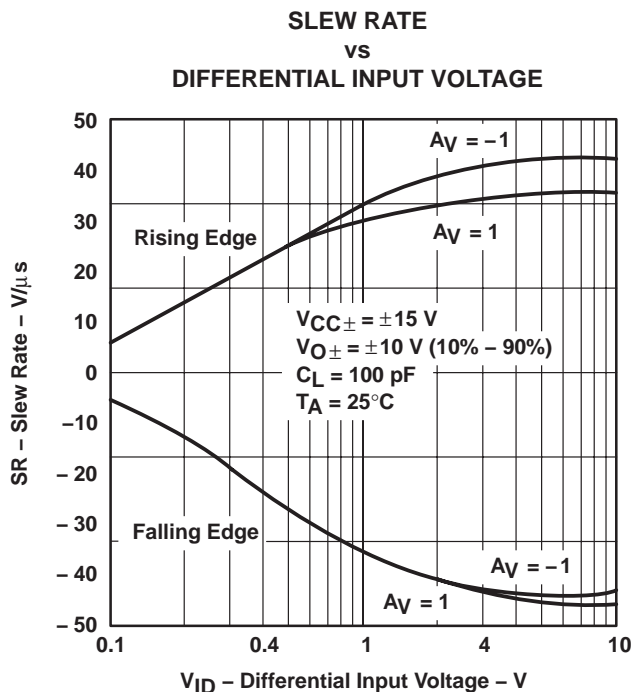
**TYPICAL CHARACTERISTICS**



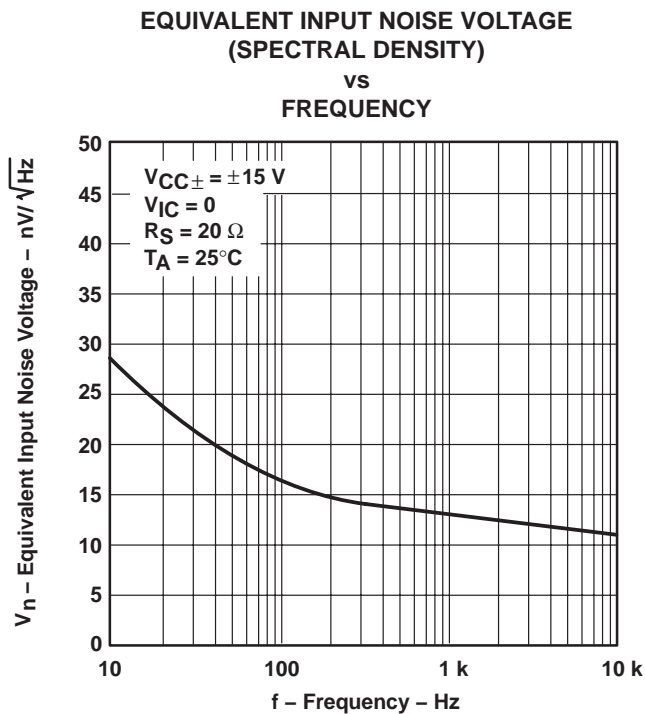
**Figure 50**



**Figure 51**



**Figure 52**



**Figure 53**

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



TYPICAL CHARACTERISTICS

INPUT-REFERRED NOISE VOLTAGE  
 vs  
 NOISE BANDWIDTH

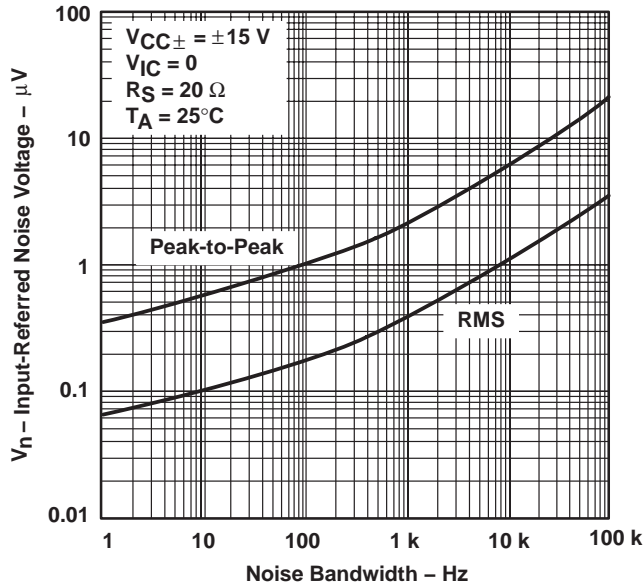


Figure 54

INPUT-REFERRED NOISE VOLTAGE  
 OVER A 10-SECOND TIME INTERVAL

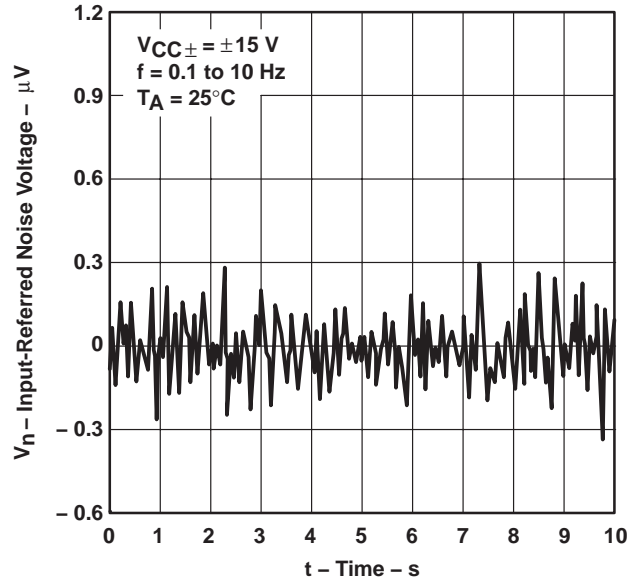


Figure 55

THIRD-OCTAVE SPECTRAL NOISE DENSITY  
 vs  
 FREQUENCY BANDS

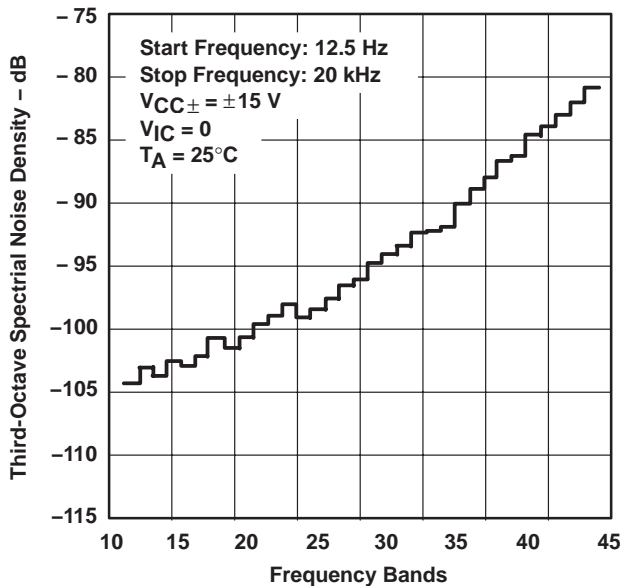


Figure 56

TOTAL HARMONIC DISTORTION PLUS NOISE  
 vs  
 FREQUENCY

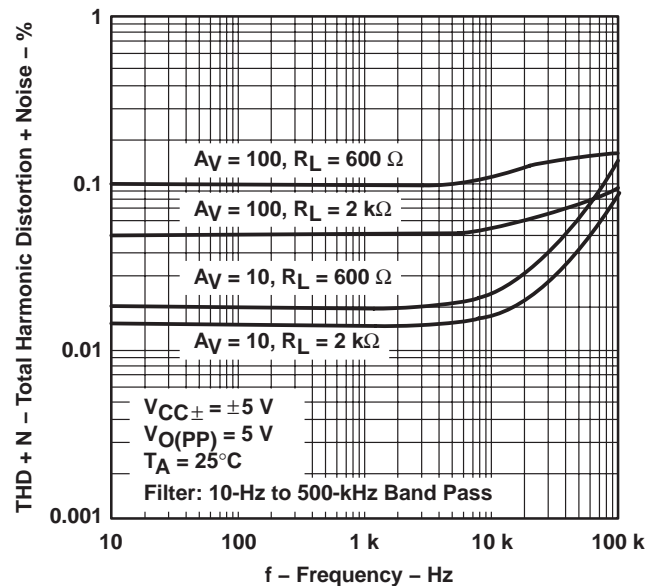


Figure 57

# TLE207x-Q1, TLE207xA-Q1 EXCALIBUR LOW-NOISE HIGH-SPEED JFET-INPUT OPERATIONAL AMPLIFIERS

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## TYPICAL CHARACTERISTICS

**TOTAL HARMONIC DISTORTION PLUS NOISE  
vs  
FREQUENCY**

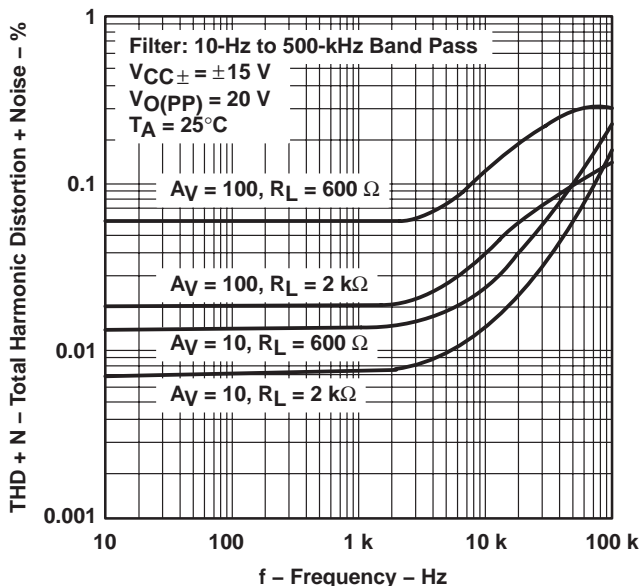


Figure 58

**UNITY-GAIN BANDWIDTH  
vs  
LOAD CAPACITANCE**

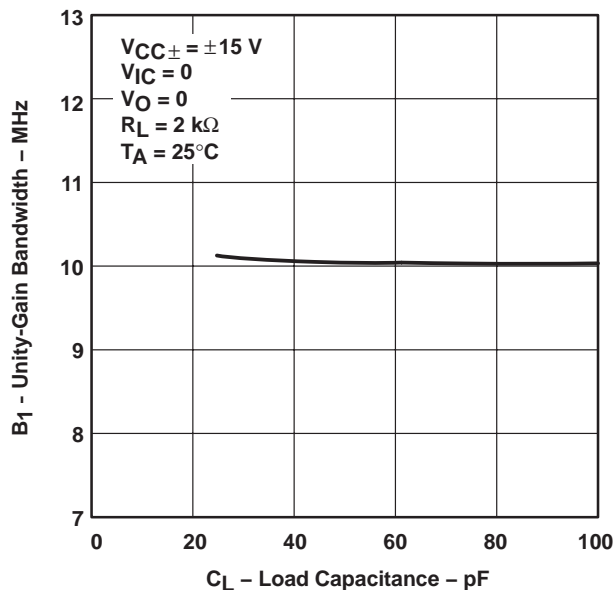


Figure 59

**GAIN-BANDWIDTH PRODUCT†  
vs  
FREE-AIR TEMPERATURE**

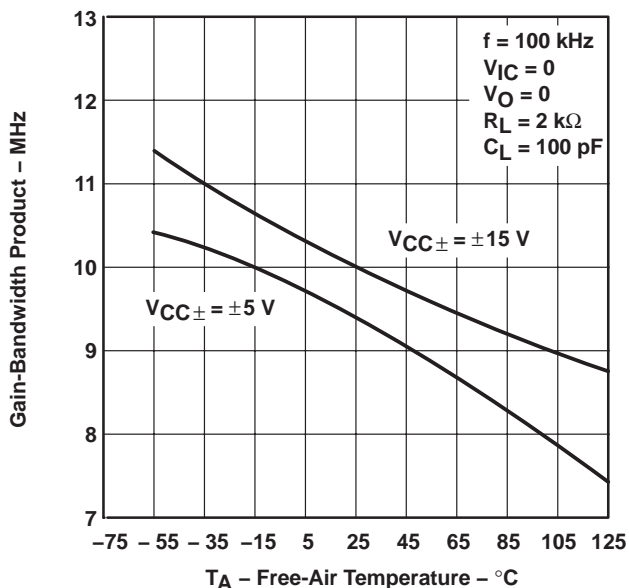


Figure 60

**GAIN-BANDWIDTH PRODUCT  
vs  
SUPPLY VOLTAGE**

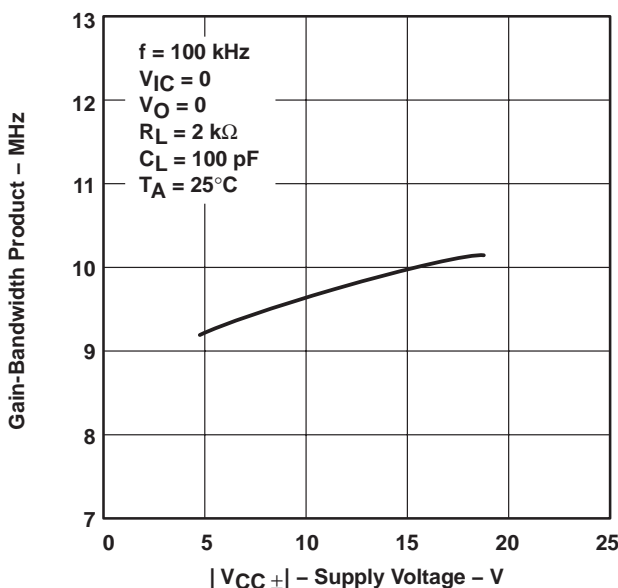


Figure 61

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

TYPICAL CHARACTERISTICS

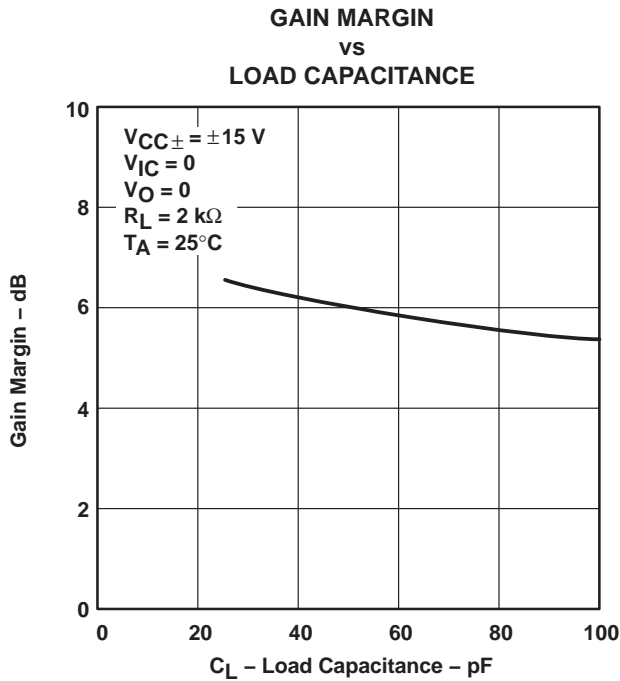


Figure 62

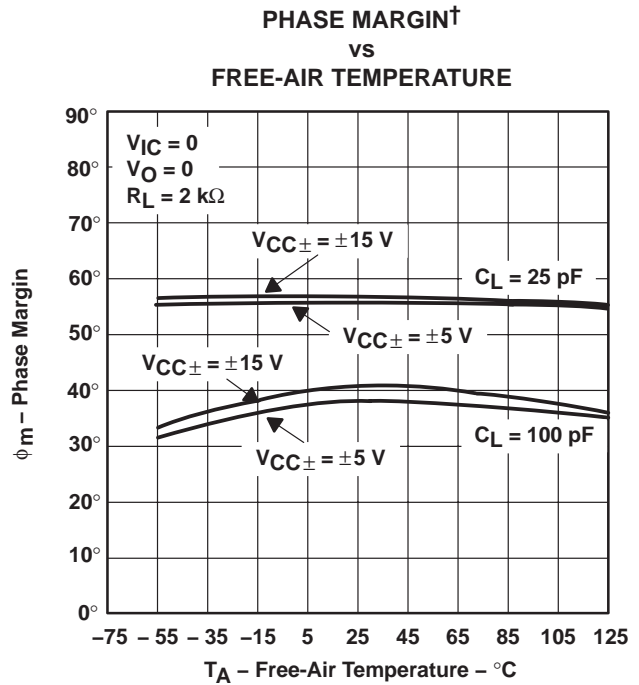


Figure 63

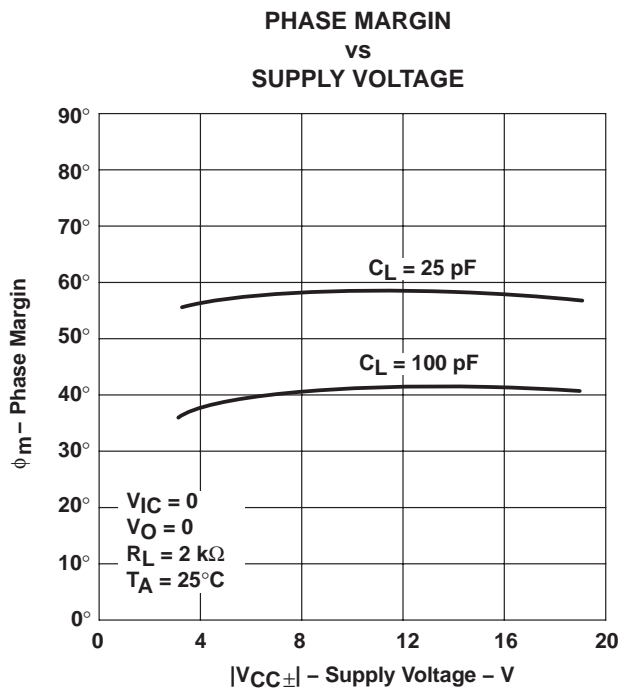


Figure 64

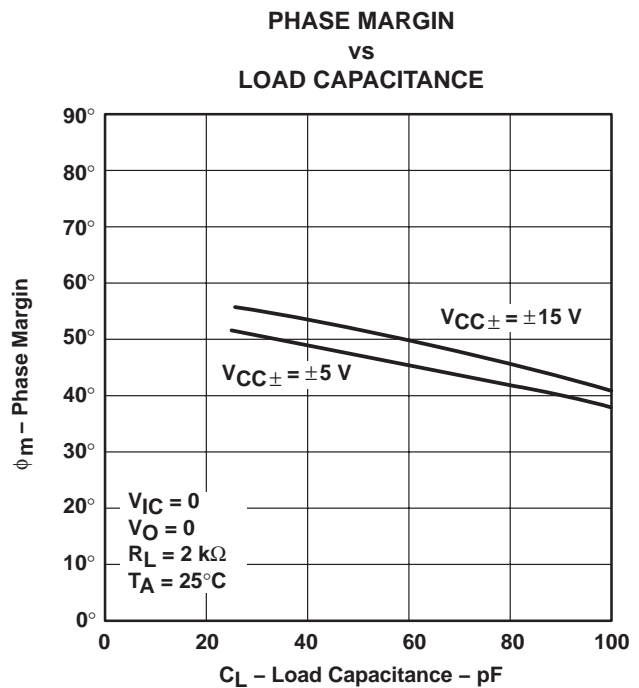


Figure 65

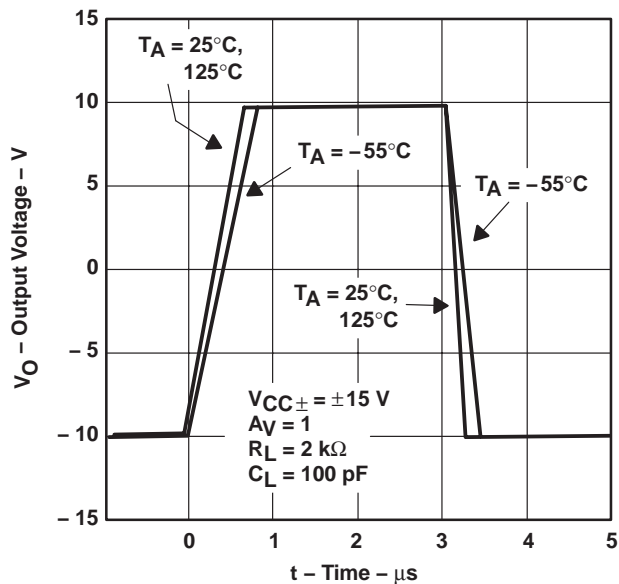
† Data at high and low temperatures are applicable only within the rated operating free-air temperature ranges of the various devices.

# TLE207x-Q1, TLE207xA-Q1 EXCALIBUR LOW-NOISE HIGH-SPEED JFET-INPUT OPERATIONAL AMPLIFIERS

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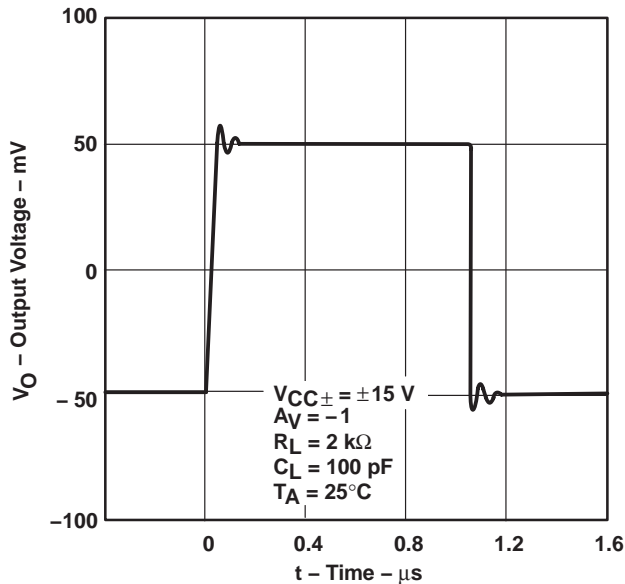
## TYPICAL CHARACTERISTICS

**NONINVERTING LARGE-SIGNAL  
PULSE RESPONSE†**



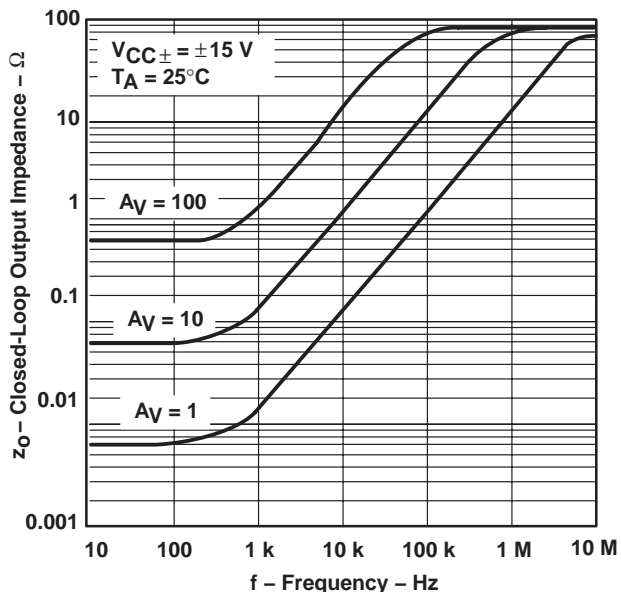
**Figure 66**

**SMALL-SIGNAL PULSE RESPONSE**



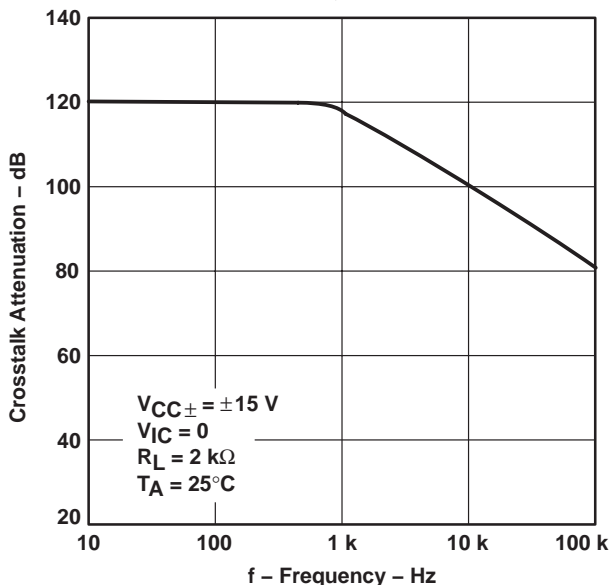
**Figure 67**

**CLOSED-LOOP OUTPUT IMPEDANCE  
vs  
FREQUENCY**



**Figure 68**

**TLE2072 AND TLE2074  
CROSSTALK ATTENUATION  
vs  
FREQUENCY**



**Figure 69**

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



## APPLICATION INFORMATION

### input characteristics

The TLE207x, TLE207xA, and TLE207xB 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 TLE207x, TLE207xA, and TLE207xB 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 good practice to include guard rings around inputs (see Figure 70). These guards should be driven from a low-impedance source at the same voltage level as the common-mode input.

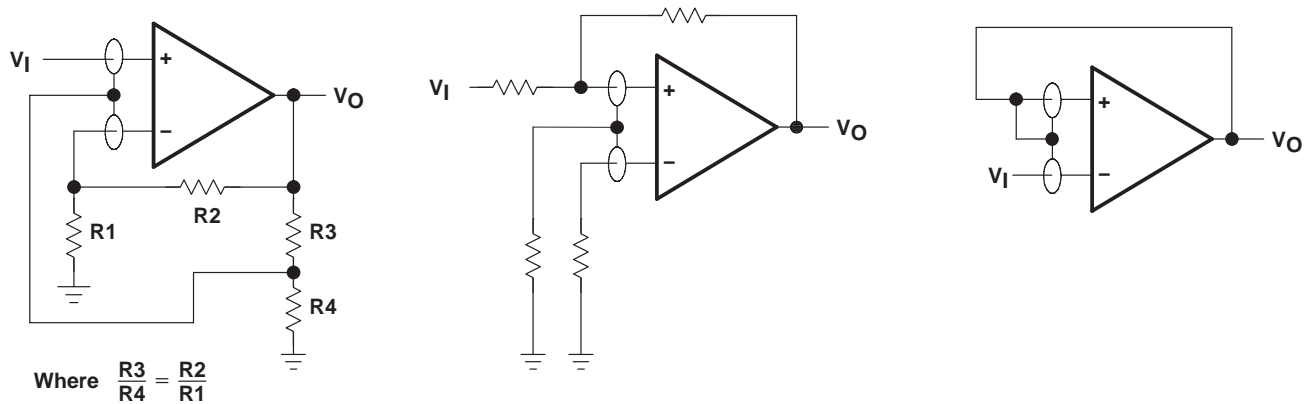


Figure 70. Use of Guard Rings

### TLE2071 input offset voltage nulling

The TLE2071 series offers external null pins that can be used to further reduce the input offset voltage. The circuit of Figure 71 can be connected as shown if the feature is desired. When external nulling is not needed, the null pins may be left unconnected.

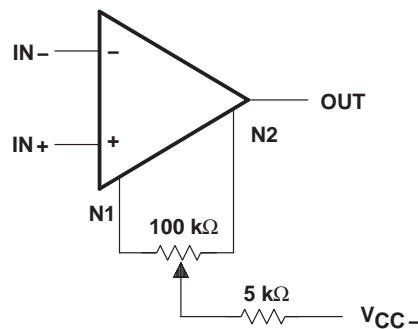


Figure 71. Input Offset Voltage Nulling

# TLE207x-Q1, TLE207xA-Q1 EXCALIBUR LOW-NOISE HIGH-SPEED JFET-INPUT OPERATIONAL AMPLIFIERS

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## APPLICATION INFORMATION

### macromodel information

Macromodel information provided was derived using PSpice™ Parts™ model generation software. The Boyle macromodel (see Note 4) and subcircuit Figure 72 were generated using the TLE207x typical electrical and operating characteristics at  $T_A = 25^\circ\text{C}$ . Using this information, output simulations of the following key parameters can be generated to a tolerance of 20% (in most cases):

- Maximum positive output voltage swing
- Maximum negative output voltage swing
- Slew rate
- Quiescent power dissipation
- Input bias current
- Open-loop voltage amplification
- Unity-gain frequency
- Common-mode rejection ratio
- Phase margin
- DC output resistance
- AC output resistance
- Short-circuit output current limit

NOTE 4: 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).

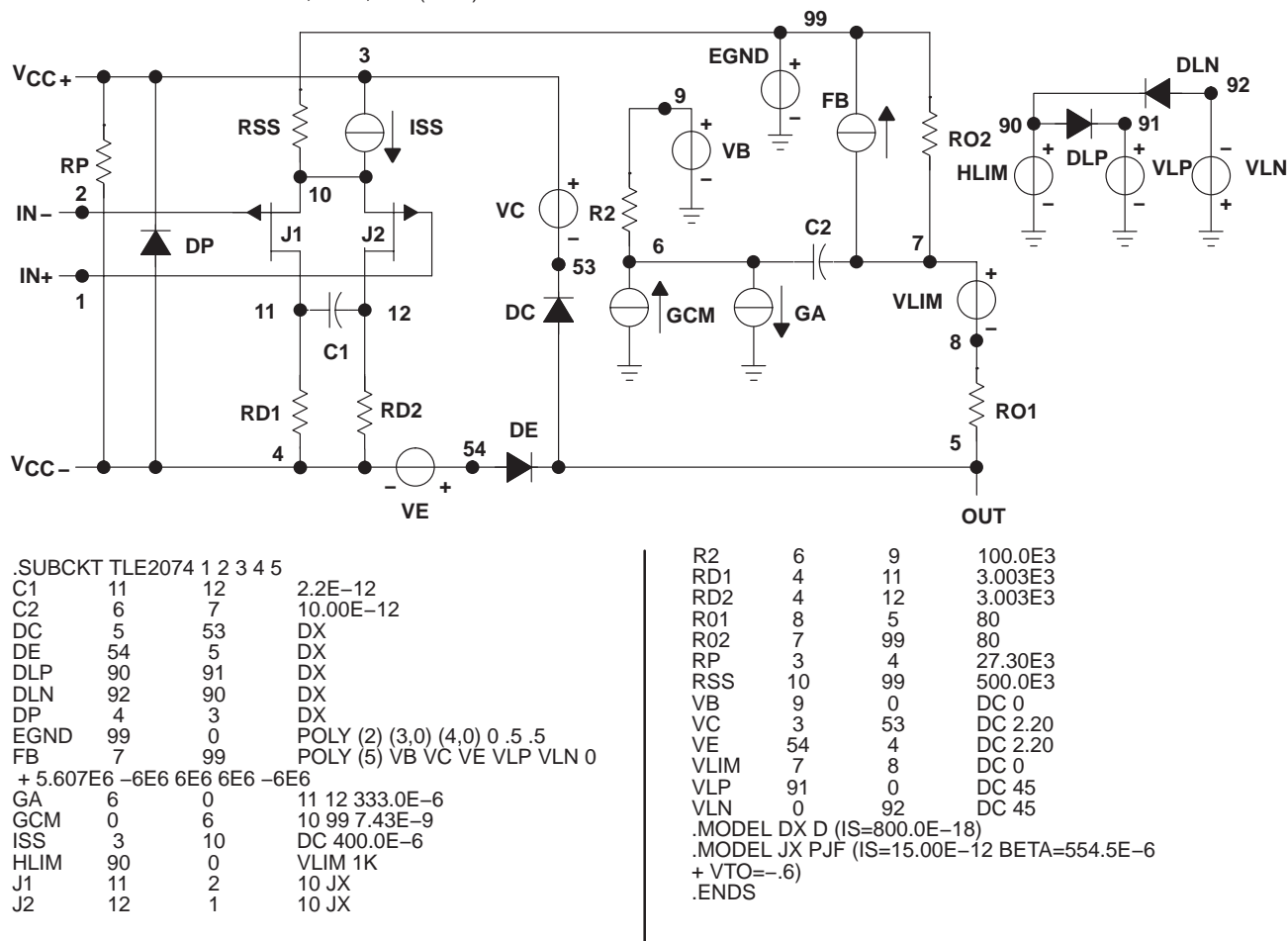


Figure 72. Boyle Macromodel and Subcircuit

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**PACKAGING INFORMATION**

Orderable Device	Status <sup>(1)</sup>	Package Type	Package Drawing	Pins	Package Qty	Eco Plan <sup>(2)</sup>	Lead/Ball Finish	MSL Peak Temp <sup>(3)</sup>
TLE2071AQDRG4Q1	ACTIVE	SOIC	D	8	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
TLE2071AQDRQ1	ACTIVE	SOIC	D	8	2500	Pb-Free (RoHS)	CU NIPDAU	Level-2-250C-1 YEAR/ Level-1-235C-UNLIM
TLE2071QDRG4Q1	ACTIVE	SOIC	D	8	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
TLE2071QDRQ1	ACTIVE	SOIC	D	8	2500	Pb-Free (RoHS)	CU NIPDAU	Level-2-250C-1 YEAR/ Level-1-235C-UNLIM
TLE2072AQDRG4Q1	ACTIVE	SOIC	D	8	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
TLE2072AQDRQ1	ACTIVE	SOIC	D	8	2500	Pb-Free (RoHS)	CU NIPDAU	Level-2-250C-1 YEAR/ Level-1-235C-UNLIM
TLE2072QDRG4Q1	ACTIVE	SOIC	D	8	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
TLE2072QDRQ1	ACTIVE	SOIC	D	8	2500	Pb-Free (RoHS)	CU NIPDAU	Level-2-250C-1 YEAR/ Level-1-235C-UNLIM

<sup>(1)</sup> 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.

<sup>(2)</sup> Eco Plan - The planned eco-friendly classification: Pb-Free (RoHS), Pb-Free (RoHS Exempt), or Green (RoHS & no Sb/Br) - please check <http://www.ti.com/productcontent> for the latest availability information and additional product content details.

**TBD:** The Pb-Free/Green conversion plan has not been defined.

**Pb-Free (RoHS):** TI's terms "Lead-Free" or "Pb-Free" mean semiconductor products that are compatible with the current RoHS requirements for all 6 substances, including the requirement that lead not exceed 0.1% by weight in homogeneous materials. Where designed to be soldered at high temperatures, TI Pb-Free products are suitable for use in specified lead-free processes.

**Pb-Free (RoHS Exempt):** This component has a RoHS exemption for either 1) lead-based flip-chip solder bumps used between the die and package, or 2) lead-based die adhesive used between the die and leadframe. The component is otherwise considered Pb-Free (RoHS compatible) as defined above.

**Green (RoHS & no Sb/Br):** TI defines "Green" to mean Pb-Free (RoHS compatible), and free of Bromine (Br) and Antimony (Sb) based flame retardants (Br or Sb do not exceed 0.1% by weight in homogeneous material)

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

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**OTHER QUALIFIED VERSIONS OF TLE2071-Q1, TLE2071A-Q1, TLE2072-Q1, TLE2072A-Q1 :**

- Catalog: [TLE2071](#), [TLE2071A](#), [TLE2072](#), [TLE2072A](#)
- Military: [TLE2071M](#), [TLE2071AM](#), [TLE2072M](#), [TLE2072AM](#)

NOTE: Qualified Version Definitions:

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



D (R-PDSO-G8)

PLASTIC SMALL-OUTLINE PACKAGE



- NOTES:
- A. All linear dimensions are in inches (millimeters).
  - B. This drawing is subject to change without notice.
  - C. Body length does not include mold flash, protrusions, or gate burrs. Mold flash, protrusions, or gate burrs shall not exceed .006 (0,15) per end.
  - D. Body width does not include interlead flash. Interlead flash shall not exceed .017 (0,43) per side.
  - E. Reference JEDEC MS-012 variation AA.

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