

# TLE214x, TLE214xA EXCALIBUR LOW-NOISE HIGH-SPEED PRECISION OPERATIONAL AMPLIFIERS

SLOS183B – FEBRUARY 1997 – REVISED APRIL 2004

- **Low Noise**  
10 Hz . . . 15 nV/ $\sqrt{\text{Hz}}$   
1 kHz . . . 10.5 nV/ $\sqrt{\text{Hz}}$
- **10000-pF Load Capability**
- **20-mA Min Short-Circuit Output Current**
- **27-V/ $\mu\text{s}$  Min Slew Rate**
- **High Gain-Bandwidth Product . . . 5.9 MHz**
- **Low  $V_{IO}$  . . . 500  $\mu\text{V}$  Max at 25°C**
- **Single or Split Supply . . . 4 V to 44 V**
- **Fast Settling Time**  
340 ns to 0.1%  
400 ns to 0.01%
- **Saturation Recovery . . . 150 ns**
- **Large Output Swing**  
 $V_{CC-} + 0.1 \text{ V}$  to  $V_{CC+} - 1 \text{ V}$

## description

The TLE214x and TLE214xA devices are high-performance, internally compensated operational amplifiers built using Texas Instruments complementary bipolar Excalibur process. The TLE214xA is a tighter offset voltage grade of the TLE214x. Both are pin-compatible upgrades to standard industry products.

The design incorporates an input stage that simultaneously achieves low audio-band noise of 10.5 nV/ $\sqrt{\text{Hz}}$  with a 10-Hz 1/f corner and symmetrical 40-V/ $\mu\text{s}$  slew rate typically with loads up to 800 pF. The resulting low distortion and high power bandwidth are important in high-fidelity audio applications. A fast settling time of 340 ns to 0.1% of a 10-V step with a 2-k $\Omega$ /100-pF load is useful in fast actuator/positioning drivers. Under similar test conditions, settling time to 0.01% is 400 ns.

The devices are stable with capacitive loads up to 10 nF, although the 6-MHz bandwidth decreases to 1.8 MHz at this high loading level. As such, the TLE214x and TLE214xA are useful for low-droop sample-and-holds and direct buffering of long cables, including 4-mA to 20-mA current loops.

The special design also exhibits an improved insensitivity to inherent integrated circuit component mismatches as is evidenced by a 500- $\mu\text{V}$  maximum offset voltage and 1.7- $\mu\text{V}/^\circ\text{C}$  typical drift. Minimum common-mode rejection ratio and supply-voltage rejection ratio are 85 dB and 90 dB, respectively.

Device performance is relatively independent of supply voltage over the  $\pm 2\text{-V}$  to  $\pm 22\text{-V}$  range. Inputs can operate between  $V_{CC-} - 0.3$  to  $V_{CC+} - 1.8 \text{ V}$  without inducing phase reversal, although excessive input current may flow out of each input exceeding the lower common-mode input range. The all-npn output stage provides a nearly rail-to-rail output swing of  $V_{CC-} - 0.1$  to  $V_{CC+} - 1 \text{ V}$  under light current-loading conditions. The device can sustain shorts to either supply since output current is internally limited, but care must be taken to ensure that maximum package power dissipation is not exceeded.

Both versions can also be used as comparators. Differential inputs of  $V_{CC\pm}$  can be maintained without damage to the device. Open-loop propagation delay with TTL supply levels is typically 200 ns. This gives a good indication as to output stage saturation recovery when the device is driven beyond the limits of recommended output swing.

Both the TLE214x and TLE214xA are available in a wide variety of packages, including both the industry-standard 8-pin small-outline version and chip form for high-density system applications. The C-suffix devices are characterized for operation from 0°C to 70°C, I-suffix devices from -40°C to 105°C, and M-suffix devices over the full military temperature range of -55°C to 125°C.



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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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# TLE214x, TLE214xA EXCALIBUR LOW-NOISE HIGH-SPEED PRECISION OPERATIONAL AMPLIFIERS

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## TLE2141 AVAILABLE OPTIONS

T <sub>A</sub>	V <sub>IO</sub> max AT 25°C	PACKAGED DEVICES		
		SMALL OUT- LINE† (D)	CERAMIC DIP (JG)	PLASTIC DIP (P)
0°C to 70°C	500 µV 900 µV	TLE2141ACD TLE2141CD	—	TLE2141ACP TLE2141CP
–40°C to 105°C	500 µV 900 µV	TLE2141AID TLE2141ID	—	TLE2141AIP TLE2141IP
–55°C to 125°C	500 µV 900 µV	— TLE2141MD	TLE2141AMJG TLE2141MJG	— —

† The D packages are available taped and reeled. Add R suffix to device type (e.g., TLE2141ACDR).

## TLE2142 AVAILABLE OPTIONS

PACKAGED DEVICES							
T <sub>A</sub>	V <sub>IO</sub> max AT 25°C	SMALL OUTLINE† (D)	CHIP CARRIER (FK)	CERAMIC DIP (JG)	PLASTIC DIP (P)	TSSOP‡ (PW)	CERAMIC FLAT PACK (U)
0°C to 70°C	750 µV 1200 µV	TLE2142ACD TLE2142CD	— —	— —	TLE2142ACP TLE2142CP	— TLE2142CPWLE	— —
–40°C to 105°C	750 µV 1200 µV	TLE2142AID TLE2142ID	— —	— —	TLC2142AIP TLC2142IP	— —	— —
–55°C to 125°C	750 µV 1200 µV	TLE2142AMD TLE2142MD	TLE2142AMFK TLE2142MFK	TLE2142AMJG TLE2142MJG	— —	— —	TLE2142AMU TLE2142MU

† The D packages are available taped and reeled. Add R suffix to device type (e.g., TLC2142ACDR).

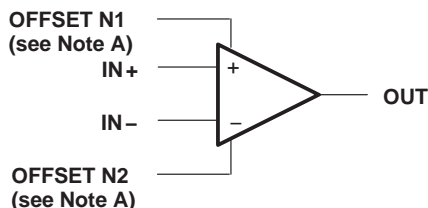
‡ The PW packages are available left-ended taped and reeled. Add LE the suffix to device type (e.g., TLC2142CPWLE).

## TLE2144 AVAILABLE OPTIONS

T <sub>A</sub>	V <sub>IO</sub> max AT 25°C	PACKAGED DEVICES			
		SMALL OUTLINE† (DW)	CHIP CARRIER (FK)	CERAMIC DIP (J)	PLASTIC DIP (N)
0°C to 70°C	1.5 mV 2.4 mV	— TLE2144CDW	— —	— —	TLE2144ACN TLE2144CN
–40°C to 105°C	1.5 mV 2.4 mV	— TLE2144IDW	— —	— —	TLE2144AIN TLE2144IN
–55°C to 125°C	1.5 mV 2.5 mV	— TLE2144MDW	TLE2144AMFK TLE2144MFK	TLE2144AMJ TLE2144MJ	— —

† The DW packages are available taped and reeled. Add R suffix to device type (e.g., TLE2144CDWR).

## symbol

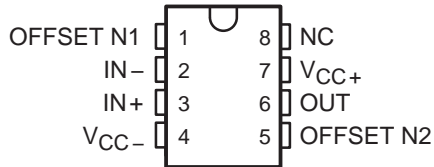


NOTES: A. OFFSET N1 AND OFFSET N2 are only available on the TLE2241x devices.

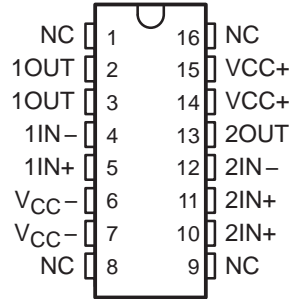
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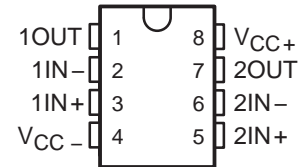
**TLE2141**  
D, JG, OR P PACKAGE  
(TOP VIEW)



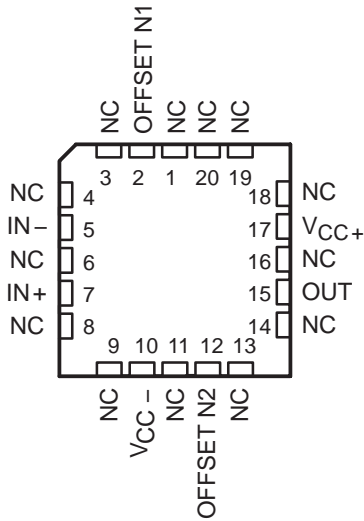
**TLE2142**  
PW PACKAGE  
(TOP VIEW)



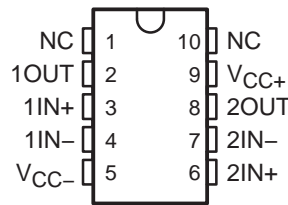
**TLE2142**  
D, JG, OR P PACKAGE  
(TOP VIEW)



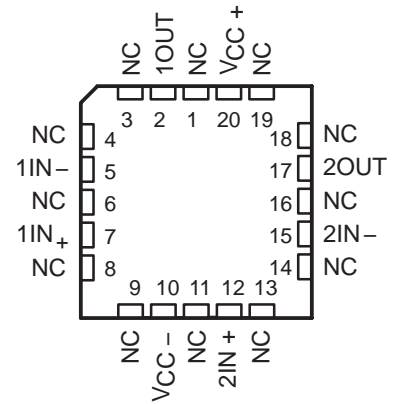
**TLE2141**  
FK PACKAGE  
(TOP VIEW)



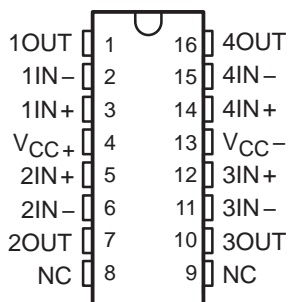
**TLE2142**  
U PACKAGE  
(TOP VIEW)



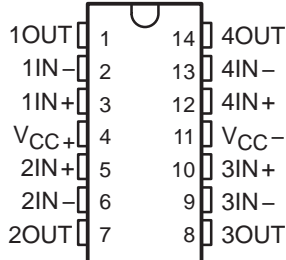
**TLE2142**  
FK PACKAGE  
(TOP VIEW)



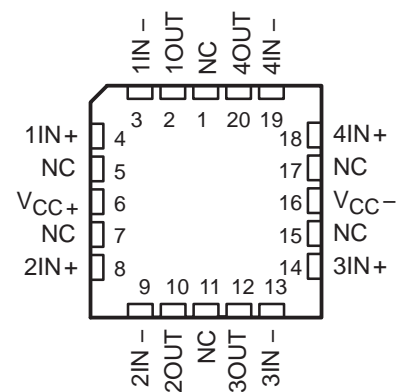
**TLE2144**  
DW PACKAGE  
(TOP VIEW)



**TLE2144**  
J OR N PACKAGE  
(TOP VIEW)



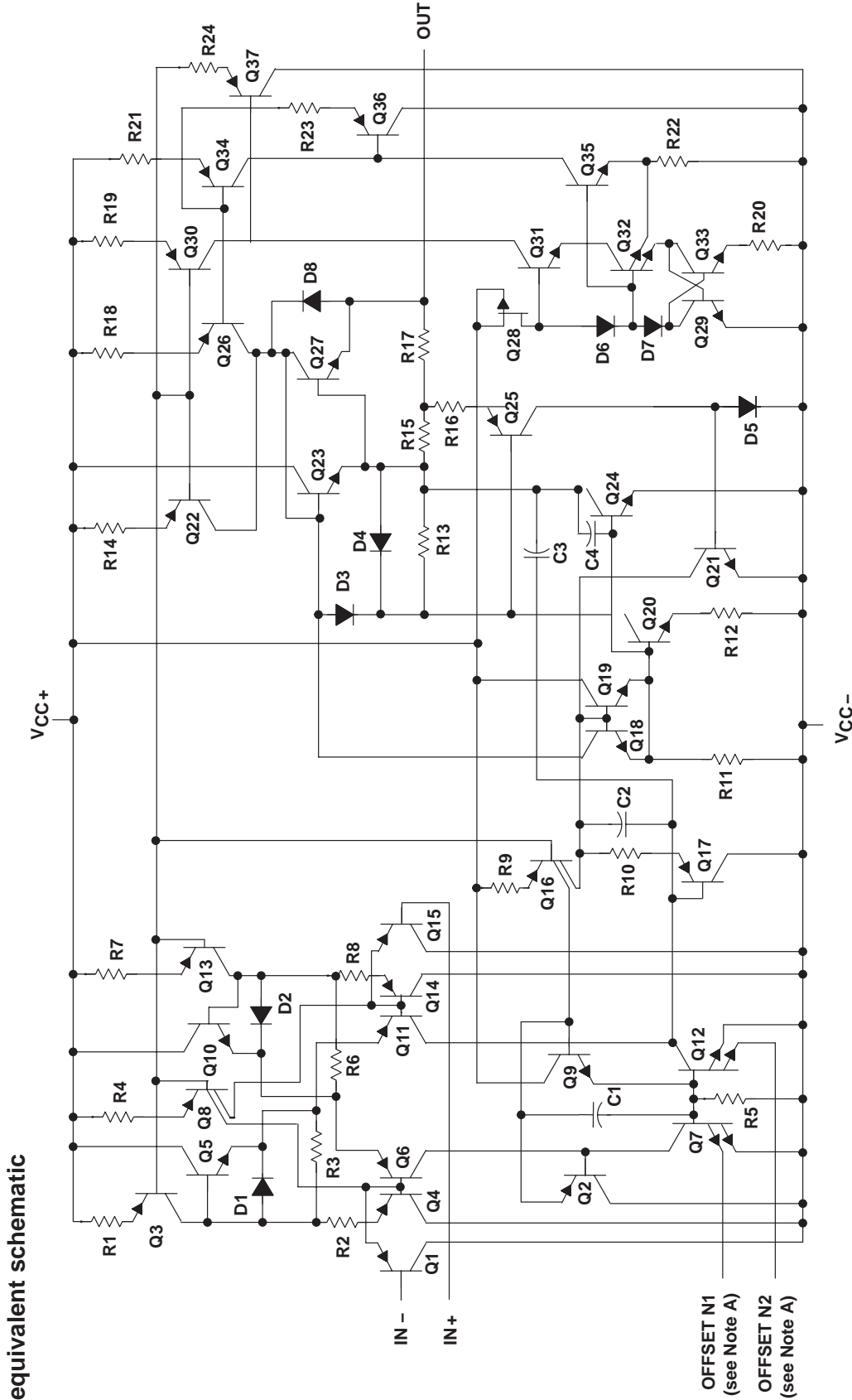
**TLE2144**  
FK PACKAGE  
(TOP VIEW)



NC – No internal connection

# TLE214x, TLE214xA, TLE214xY EXCALIBUR LOW-NOISE HIGH-SPEED PRECISION OPERATIONAL AMPLIFIERS

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equivalent schematic

NOTE A: OFFSET N1 AND OFFSET N2 are only available on the TLE2241x devices.

COMPONENT	ACTUAL DEVICE COMPONENT COUNT		
	TLE2241	TLE2242	TLE2244
Transistors	46	65	130
Resistors	24	43	86
Diodes	8	14	28
Capacitors	4	8	16
Epi-FET	1	1	2

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

Supply voltage, $V_{CC+}$ (see Note 1)	22 V
Supply voltage, $V_{CC-}$	–22 V
Differential input voltage, $V_{ID}$ (see Note 2)	±44 V
Input voltage range, $V_I$ (any input)	$V_{CC+}$ to $V_{CC-} - 0.3$ V
Input current, $I_I$ (each input)	±1 mA
Output current, $I_O$	±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
Package thermal impedance, $\theta_{JA}$ (see Notes 4 and 5):	
D package	97.1°C/W
DW package	57.3°C/W
N package	79.7°C/W
P package	84.6°C/W
PW package	108.4°C/W
Package thermal impedance, $\theta_{JC}$ (see Notes 4 and 5):	
FK package	5.6°C/W
J package	15.1°C/W
JG package	14.5°C/W
U package	14.7°C/W
Operating free-air temperature range, $T_A$ : C suffix	0°C to 70°C
I suffix	–40°C to 105°C
M suffix	–55°C to 125°C
Storage temperature range	–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, DW, N, P, or PW package	260°C
Lead temperature 1,6 mm (1/16 inch) from case for 60 seconds: J or JG package	300°C

† Stresses beyond those listed under “absolute maximum ratings” may cause permanent damage to the device. These are stress ratings only, and functional operation of the device at these or any other conditions beyond those indicated under “recommended operating conditions” is not implied. Exposure to absolute-maximum-rated conditions for extended periods may affect device reliability.

- NOTES:
1. All voltage values, except differential voltages, are with respect to the midpoint between  $V_{CC+}$  and  $V_{CC-}$ .
  2. Differential voltages are at  $IN+$  with respect to  $IN-$ . Excessive current flows, if input, are brought below  $V_{CC-} - 0.3$  V.
  3. The output may be shorted to either supply. Temperature and/or supply voltages must be limited to ensure that the maximum dissipation rating is not exceeded.
  4. Maximum power dissipation is a function of  $T_{J(max)}$ ,  $\theta_{JA}$ , and  $T_A$ . The maximum allowable power dissipation at any allowable ambient temperature is  $P_D = (T_{J(max)} - T_A)/\theta_{JA}$ . Operating at the absolute maximum  $T_J$  of 150°C can affect reliability.
  5. The package thermal impedance is calculated in accordance with JESD 51-7 (plastic) or MIL-STD-883 Method 1012 (ceramic).

**recommended operating conditions**

		C SUFFIX		I SUFFIX		M SUFFIX		UNIT
		MIN	MAX	MIN	MAX	MIN	MAX	
Supply voltage, $V_{CC\pm}$		±2	±22	±2	±22	±2	±22	V
Common-mode input voltage, $V_{IC}$	$V_{CC} = 5$ V	0	2.9	0	2.7	0	2.7	V
	$V_{CC\pm} = \pm 15$ V	–15	12.9	–15	12.7	–15	12.7	
Operating free-air temperature, $T_A$		0	70	–40	105	–55	125	°C



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**TLE2141C electrical characteristics at specified free-air temperature,  $V_{CC} = 5\text{ V}$  (unless otherwise noted)**

PARAMETER	TEST CONDITIONS	$T_A$ †	TLE2141C			TLE2141AC			UNIT
			MIN	TYP	MAX	MIN	TYP	MAX	
$V_{IO}$ Input offset voltage	$V_O = 2.5\text{ V}$ $V_{IC} = 2.5\text{ V}$ $R_S = 50\ \Omega$	25°C	225	1400		200	1000	$\mu\text{V}$	
		Full range			1700		1300		
$\alpha_{VIO}$ Temperature coefficient of input offset voltage		Full range	1.7			1.7		$\mu\text{V}/^\circ\text{C}$	
$I_{IO}$ Input offset current		25°C	8	100		8	100	nA	
		Full range			150		150		
$I_{IB}$ Input bias current		25°C	-0.8	-2		-0.8	-2	$\mu\text{A}$	
	Full range			-2.1		-2.1			
$V_{ICR}$ Common-mode input voltage range	$R_S = 50\ \Omega$	25°C	0 to 3	-0.3 to 3.2		0 to 3	-0.3 to 3.2	V	
		Full range	0 to 2.9			0 to 2.9			
$V_{OH}$ High-level output voltage	$I_{OH} = -150\ \mu\text{A}$	25°C	3.9	4.1		3.9	4.1	V	
		Full range	3.8			3.8			
	$I_{OH} = -1.5\text{ mA}$	25°C	3.8	4		3.8	4		
		Full range	3.7			3.7			
	$I_{OH} = -15\text{ mA}$	25°C	3.2	3.7		3.2	3.7		
		Full range	3.2			3.2			
$V_{OL}$ Low-level output voltage	$I_{OL} = 150\ \mu\text{A}$	25°C		75	125		75	125	mV
		Full range			150		150		
	$I_{OL} = 1.5\text{ mA}$	25°C		150	225		150	225	
		Full range			250		250		
	$I_{OL} = 15\text{ mA}$	25°C		1.2	1.6		1.2	1.6	V
		Full range			1.7		1.7		
$A_{VD}$ Large-signal differential voltage amplification	$V_{CC} = \pm 2.5\text{ V}$ , $R_L = 2\text{ k}\Omega$ , $V_O = 1\text{ V to } -1.5\text{ V}$	25°C	50	220		50	220	V/mV	
		Full range	25			25			
$r_i$ Input resistance		25°C		70		70	$\text{M}\Omega$		
$c_i$ Input capacitance		25°C		2.5		2.5	pF		
$z_o$ Open-loop output impedance	$f = 1\text{ MHz}$	25°C		30		30	$\Omega$		
CMRR Common-mode rejection ratio	$V_{IC} = V_{ICRmin}$ , $R_S = 50\ \Omega$	25°C	85	118		85	118	dB	
		Full range	80			80			
$k_{SVR}$ Supply-voltage rejection ratio ( $\Delta V_{CC\pm} / \Delta V_{IO}$ )	$V_{CC\pm} = \pm 2.5\text{ V to } \pm 15\text{ V}$ , $R_S = 50\ \Omega$	25°C	90	106		90	106	dB	
		Full range	85			85			
$I_{CC}$ Supply current	$V_O = 2.5\text{ V}$ , No load, $V_{IC} = 2.5\text{ V}$	25°C	3.4	4.4		3.4	4.4	mA	
		Full range			4.6		4.6		

† Full range is 0°C to 70°C.



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**TLE2141C operating characteristics,  $V_{CC} = 5\text{ V}$ ,  $T_A = 25^\circ\text{C}$**

PARAMETER	TEST CONDITIONS	TLE2141C			TLE2141AC			UNIT
		MIN	TYP	MAX	MIN	TYP	MAX	
SR+	Positive slew rate	$A_{VD} = -1$ , $C_L = 500\text{ pF}^\dagger$ , $R_L = 2\text{ k}\Omega^\dagger$		45	45		V/ $\mu\text{s}$	
SR-	Negative slew rate			42	42			
$t_s$	Settling time	$A_{VD} = -1$ , 2.5-V step	To 0.1%	0.16	0.16		$\mu\text{s}$	
			To 0.01%	0.22	0.22			
$V_n$	Equivalent input noise voltage	$R_S = 20\ \Omega$ , $f = 10\text{ Hz}$	15	15		nV/ $\sqrt{\text{Hz}}$		
		$R_S = 20\ \Omega$ , $f = 1\text{ kHz}$	10.5	10.5				
$V_{N(PP)}$	Peak-to-peak equivalent input noise voltage	$f = 0.1\text{ Hz to }1\text{ Hz}$	0.48	0.48		$\mu\text{V}$		
		$f = 0.1\text{ Hz to }10\text{ Hz}$	0.51	0.51				
$I_n$	Equivalent input noise current	$f = 10\text{ Hz}$	1.92	1.92		pA/ $\sqrt{\text{Hz}}$		
		$f = 1\text{ kHz}$	0.5	0.5				
THD + N	Total harmonic distortion plus noise	$V_O = 1\text{ V to }3\text{ V}$ , $A_{VD} = 2$ , $R_L = 2\text{ k}\Omega^\dagger$ , $f = 10\text{ kHz}$	0.0052%	0.0052%				
$B_1$	Unity-gain bandwidth	$R_L = 2\text{ k}\Omega^\dagger$ , $C_L = 100\text{ pF}^\dagger$	5.9	5.9		MHz		
	Gain-bandwidth product	$R_L = 2\text{ k}\Omega^\dagger$ , $f = 100\text{ kHz}$	5.8	5.8		MHz		
$B_{OM}$	Maximum output-swing bandwidth	$V_{O(PP)} = 2\text{ V}$ , $A_{VD} = 1$ , $R_L = 2\text{ k}\Omega^\dagger$ , $C_L = 100\text{ pF}^\dagger$	660	660		kHz		
$\phi_m$	Phase margin at unity gain	$R_L = 2\text{ k}\Omega^\dagger$ , $C_L = 100\text{ pF}^\dagger$	$57^\circ$	$57^\circ$				

$^\dagger R_L$  and  $C_L$  terminated to 2.5 V.

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**TLE2141C electrical characteristics at specified free-air temperature,  $V_{CC\pm} = \pm 15\text{ V}$  (unless otherwise noted)**

PARAMETER	TEST CONDITIONS	$T_A$ †	TLE2141C			TLE2141AC			UNIT
			MIN	TYP	MAX	MIN	TYP	MAX	
$V_{IO}$ Input offset voltage	$V_{IC} = 0,$ $V_O = 0$ $R_S = 50\ \Omega$	25°C	200	900		175	500	$\mu\text{V}$	
		Full range			1300		800		
$\alpha_{VIO}$ Temperature coefficient of input offset voltage		Full range	1.7			1.7		$\mu\text{V}/^\circ\text{C}$	
$I_{IO}$ Input offset current		25°C	7	100		7	100	nA	
		Full range			150		150		
$I_{IB}$ Input bias current		25°C	-0.7	-1.5		-0.7	-1.5	$\mu\text{A}$	
	Full range			-1.6		-1.6			
$V_{ICR}$ Common-mode input voltage range	$R_S = 50\ \Omega$	25°C	-15 to 13	-15.3 to 13.2		-15 to 13	-15.3 to 13.2	V	
		Full range	-15 to 12.9	-15.3 to 13.1		-15 to 12.9	-15.3 to 13.1		
$V_{OM+}$ Maximum positive peak output voltage swing	$I_O = -150\ \mu\text{A}$	25°C	13.8	14.1		13.8	14.1	V	
		Full range	13.7			13.7			
	$I_O = -1.5\ \text{mA}$	25°C	13.7	14		13.7	14		
		Full range	13.6			13.6			
	$I_O = -15\ \text{mA}$	25°C	13.1	13.7		13.1	13.7		
		Full range	13			13			
$V_{OM-}$ Maximum negative peak output voltage swing	$I_O = 150\ \mu\text{A}$	25°C	-14.7	-14.9		-14.7	-14.9	V	
		Full range	-14.6			-14.6			
	$I_O = 1.5\ \text{mA}$	25°C	-14.5	-14.8		-14.5	-14.8		
		Full range	-14.4			-14.4			
	$I_O = 15\ \text{mA}$	25°C	-13.4	-13.8		-13.4	-13.8		
		Full range	-13.3			-13.3			
$A_{VD}$ Large-signal differential voltage amplification	$V_O = \pm 10\ \text{V}$	25°C	100	450		100	450	V/mV	
		Full range	75			75			
$r_i$ Input resistance	$R_L = 2\ \text{k}\Omega$	25°C	65			65	$\text{M}\Omega$		
$c_i$ Input capacitance		25°C	2.5			2.5	pF		
$z_o$ Open-loop output impedance	$f = 1\ \text{MHz}$	25°C	30			30	$\Omega$		
CMRR Common-mode rejection ratio	$V_{IC} = V_{ICRmin}, R_S = 50\ \Omega$	25°C	85	108		85	108	dB	
		Full range	80			80			
$k_{SVR}$ Supply-voltage rejection ratio ( $\Delta V_{CC\pm} / \Delta V_{IO}$ )	$V_{CC\pm} = \pm 2.5\ \text{V to } \pm 15\ \text{V}, R_S = 50\ \Omega$	25°C	90	106		90	106	dB	
		Full range	85			85			
$I_{OS}$ Short-circuit output current	$V_O = 0$	25°C	$V_{ID} = 1\ \text{V}$	-25	-50		-25	-50	mA
			$V_{ID} = -1\ \text{V}$	20	31		20	31	
$I_{CC}$ Supply current	$V_O = 0,$ No load	25°C	3.5	4.5		3.5	4.5	mA	
		Full range			4.7		4.7		

† Full range is 0°C to 70°C.





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**TLE2141C operating characteristics,  $V_{CC\pm} = \pm 15\text{ V}$ ,  $T_A = 25^\circ\text{C}$**

PARAMETER		TEST CONDITIONS		TLE2141C			TLE2141AC			UNIT
				MIN	TYP	MAX	MIN	TYP	MAX	
SR+	Positive slew rate	$A_{VD} = -1$ , $C_L = 500\text{ pF}$	$R_L = 2\text{ k}\Omega$	27	45		27	45	V/ $\mu\text{s}$	
SR-	Negative slew rate			27	42		27	42		
$t_s$	Settling time	$A_{VD} = -1$ , 10-V step	To 0.1%	0.34			0.34			$\mu\text{s}$
			To 0.01%	0.4			0.4			
$V_n$	Equivalent input noise voltage	$R_S = 20\ \Omega$	$f = 10\text{ Hz}$	15			15			nV/ $\sqrt{\text{Hz}}$
			$f = 1\text{ kHz}$	10.5			10.5			
$V_{N(PP)}$	Peak-to-peak equivalent input noise voltage	$f = 0.1\text{ Hz to }1\text{ Hz}$		0.48			0.48			$\mu\text{V}$
		$f = 0.1\text{ Hz to }10\text{ Hz}$		0.51			0.51			
$I_n$	Equivalent input noise current	$f = 10\text{ Hz}$		1.89			1.89			pA/ $\sqrt{\text{Hz}}$
		$f = 1\text{ kHz}$		0.47			0.47			
THD + N	Total harmonic distortion plus noise	$V_{O(PP)} = 20\text{ V}$ , $A_{VD} = 10$ ,	$R_L = 2\text{ k}\Omega$ , $f = 10\text{ kHz}$	0.01%			0.01%			
$B_1$	Unity-gain bandwidth	$R_L = 2\text{ k}\Omega$ ,	$C_L = 100\text{ pF}$	6			6			MHz
	Gain-bandwidth product	$R_L = 2\text{ k}\Omega$ , $f = 100\text{ kHz}$	$C_L = 100\text{ pF}$	5.9			5.9			MHz
$B_{OM}$	Maximum output-swing bandwidth	$V_{O(PP)} = 20\text{ V}$ , $A_{VD} = 1$ ,	$R_L = 2\text{ k}\Omega$ , $C_L = 100\text{ pF}$	668			668			kHz
$\phi_m$	Phase margin at unity gain	$R_L = 2\text{ k}\Omega$ ,	$C_L = 100\text{ pF}$	58°			58°			

# TLE214x, TLE214xA EXCALIBUR LOW-NOISE HIGH-SPEED PRECISION OPERATIONAL AMPLIFIERS

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**TLE2142C electrical characteristics at specified free-air temperature,  $V_{CC} = 5\text{ V}$  (unless otherwise noted)**

PARAMETER	TEST CONDITIONS	$T_A$ †	TLE2142C			TLE2142AC			UNIT
			MIN	TYP	MAX	MIN	TYP	MAX	
$V_{IO}$ Input offset voltage	$V_O = 2.5\text{ V},$ $V_{IC} = 2.5\text{ V}$ $R_S = 50\ \Omega$	25°C	220	1900		200	1500	$\mu\text{V}$	
		Full range			2200		1800		
$\alpha_{VIO}$ Temperature coefficient of input offset voltage		Full range	1.7			1.7		$\mu\text{V}/^\circ\text{C}$	
$I_{IO}$ Input offset current		25°C	8	100		8	100	nA	
		Full range			150		150		
$I_{IB}$ Input bias current		25°C	-0.8	-2		-0.8	-2	$\mu\text{A}$	
	Full range			-2.1		-2.1			
$V_{ICR}$ Common-mode input voltage range	$R_S = 50\ \Omega$	25°C	0 to 3	-0.3 to 3.2		0 to 3	-0.3 to 3.2	V	
		Full range	0 to 2.9			0 to 2.9			
$V_{OH}$ High-level output voltage	$I_{OH} = -150\ \mu\text{A}$	25°C	3.9	4.1		3.9	4.1	V	
		Full range	3.8			3.8			
	$I_{OH} = -1.5\text{ mA}$	25°C	3.8	4		3.8	4		
		Full range	3.7			3.7			
	$I_{OH} = -15\text{ mA}$	25°C	3.4	3.7		3.4	3.7		
		Full range	3.4			3.4			
$V_{OL}$ Low-level output voltage	$I_{OL} = 150\ \mu\text{A}$	25°C		75	125		75	125	mV
		Full range			150			150	
	$I_{OL} = 1.5\text{ mA}$	25°C		150	225		150	225	
		Full range			250			250	
	$I_{OL} = 15\text{ mA}$	25°C		1.2	1.4		1.2	1.4	V
		Full range			1.5			1.5	
$A_{VD}$ Large-signal differential voltage amplification	$V_{CC} = \pm 2.5\text{ V},$ $R_L = 2\text{ k}\Omega,$ $V_O = 1\text{ V to } -1.5\text{ V}$	25°C	50	220		50	220	V/mV	
		Full range	25			25			
$r_i$ Input resistance		25°C	70			70	$\text{M}\Omega$		
$c_i$ Input capacitance		25°C	2.5			2.5	pF		
$z_o$ Open-loop output impedance	$f = 1\text{ MHz}$	25°C	30			30	$\Omega$		
CMRR Common-mode rejection ratio	$V_{IC} = V_{ICRmin},$ $R_S = 50\ \Omega$	25°C	85	118		85	118	dB	
		Full range	80			80			
$k_{SVR}$ Supply-voltage rejection ratio ( $\Delta V_{CC\pm} / \Delta V_{IO}$ )	$V_{CC\pm} = \pm 2.5\text{ V to } \pm 15\text{ V},$ $R_S = 50\ \Omega$	25°C	90	106		90	106	dB	
		Full range	85			85			
$I_{CC}$ Supply current	$V_O = 2.5\text{ V},$ $V_{IC} = 2.5\text{ V}$ No load,	25°C	6.6	8.8		6.6	8.8	mA	
		Full range			9.2		9.2		

† Full range is 0°C to 70°C.



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**TLE2142C operating characteristics,  $V_{CC} = 5\text{ V}$ ,  $T_A = 25^\circ\text{C}$**

PARAMETER	TEST CONDITIONS	TLE2142C			TLE2142AC			UNIT
		MIN	TYP	MAX	MIN	TYP	MAX	
SR+	Positive slew rate	$A_{VD} = -1$ , $C_L = 500\text{ pF}$		$R_L = 2\text{ k}\Omega^\dagger$	45			V/ $\mu\text{s}$
SR-	Negative slew rate				42			
$t_s$	Settling time	$A_{VD} = -1$ , 2.5-V step	To 0.1%	0.16			$\mu\text{s}$	
			To 0.01%	0.22				
$V_n$	Equivalent input noise voltage	$R_S = 20\ \Omega$ , $f = 10\text{ Hz}$	15			nV/ $\sqrt{\text{Hz}}$		
		$R_S = 20\ \Omega$ , $f = 1\text{ kHz}$	10.5					
$V_{N(PP)}$	Peak-to-peak equivalent input noise voltage	$f = 0.1\text{ Hz to }1\text{ Hz}$	0.48			$\mu\text{V}$		
		$f = 0.1\text{ Hz to }10\text{ Hz}$	0.51					
$I_n$	Equivalent input noise current	$f = 10\text{ Hz}$	1.92			pA/ $\sqrt{\text{Hz}}$		
		$f = 1\text{ kHz}$	0.5					
THD + N	Total harmonic distortion plus noise	$V_O = 1\text{ V to }3\text{ V}$ , $A_{VD} = 2$	$R_L = 2\text{ k}\Omega^\dagger$ , $f = 10\text{ kHz}$	0.0052%				
B1	Unity-gain bandwidth	$R_L = 2\text{ k}\Omega^\dagger$	$C_L = 100\text{ pF}$	5.9			MHz	
	Gain-bandwidth product	$R_L = 2\text{ k}\Omega^\dagger$ , $f = 100\text{ kHz}$	$C_L = 100\text{ pF}$	5.8			MHz	
$B_{OM}$	Maximum output-swing bandwidth	$V_{O(PP)} = 2\text{ V}$ , $A_{VD} = 1$	$R_L = 2\text{ k}\Omega^\dagger$ , $C_L = 100\text{ pF}$	660			kHz	
$\phi_m$	Phase margin at unity gain	$R_L = 2\text{ k}\Omega^\dagger$	$C_L = 100\text{ pF}$	57°				

$^\dagger R_L$  terminates at 2.5 V.

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**TLE2142C electrical characteristics at specified free-air temperature,  $V_{CC\pm} = \pm 15$  V (unless otherwise noted)**

PARAMETER	TEST CONDITIONS	$T_A$ †	TLE2142C			TLE2142AC			UNIT
			MIN	TYP	MAX	MIN	TYP	MAX	
$V_{IO}$ Input offset voltage	$V_{IC} = 0,$ $V_O = 0$ $R_S = 50 \Omega,$	25°C	290	1200		275	750	$\mu V$	
		Full range			1600		1200		
$\alpha_{VIO}$ Temperature coefficient of input offset voltage		Full range	1.7			1.7		$\mu V/^\circ C$	
$I_{IO}$ Input offset current		25°C	7	100		7	100	nA	
		Full range			150		150		
$I_{IB}$ Input bias current		25°C	-0.7	-1.5		-0.7	-1.5	$\mu A$	
	Full range			-1.6		-1.6			
$V_{ICR}$ Common-mode input voltage range	$R_S = 50 \Omega$	25°C	-15 to 13	-15.3 to 13.2		-15 to 13	-15.3 to 13.2	V	
		Full range	-15 to 12.9	-15.3 to 13.1		-15 to 12.9	-15.3 to 13.1		
$V_{OM+}$ Maximum positive peak output voltage swing	$I_O = -150 \mu A$	25°C	13.8	14.1		13.8	14.1	V	
		Full range			13.7		13.7		
	$I_O = -1.5$ mA	25°C	13.7	14		13.7	14		
		Full range			13.6		13.6		
	$I_O = -15$ mA	25°C	13.3	13.7		13.3	13.7		
		Full range			13.2		13.2		
$V_{OM-}$ Maximum negative peak output voltage swing	$I_O = 150 \mu A$	25°C	-14.7	-14.9		-14.7	-14.9	V	
		Full range			-14.6		-14.6		
	$I_O = 1.5$ mA	25°C	-14.5	-14.8		-14.5	-14.8		
		Full range			-14.4		-14.4		
	$I_O = 15$ mA	25°C	-13.4	-13.8		-13.4	-13.8		
		Full range			-13.3		-13.3		
$A_{VD}$ Large-signal differential voltage amplification	$V_O = \pm 10$ V	25°C	100	450		100	450	V/mV	
		Full range			75		75		
$r_i$ Input resistance	$R_L = 2$ k $\Omega$	25°C		65		65	M $\Omega$		
$c_i$ Input capacitance		25°C		2.5		2.5	pF		
$z_o$ Open-loop output impedance	$f = 1$ MHz	25°C		30		30	$\Omega$		
CMRR Common-mode rejection ratio	$V_{IC} = V_{ICRmin},$ $R_S = 50 \Omega$	25°C	85	108		85	108	dB	
		Full range			80		80		
$k_{SVR}$ Supply-voltage rejection ratio ( $\Delta V_{CC\pm} / \Delta V_{IO}$ )	$V_{CC\pm} = \pm 2.5$ V to $\pm 15$ V, $R_S = 50 \Omega$	25°C	90	106		90	106	dB	
		Full range			85		85		
$I_{OS}$ Short-circuit output current	$V_O = 0$	25°C	$V_{ID} = 1$ V	-25	-50		-25	-50	mA
			$V_{ID} = -1$ V	20	31		20	31	
$I_{CC}$ Supply current	$V_O = 0,$ No load	25°C	6.9	9		6.9	9	mA	
		Full range			9.4		9.4		

† Full range is 0°C to 70°C.



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**TLE2142C operating characteristics,  $V_{CC\pm} = \pm 15\text{ V}$ ,  $T_A = 25^\circ\text{C}$**

PARAMETER	TEST CONDITIONS	TLE2142C			TLE2142AC			UNIT	
		MIN	TYP	MAX	MIN	TYP	MAX		
SR+	Positive slew rate	$A_{VD} = -1$ , $C_L = 500\text{ pF}$		$R_L = 2\text{ k}\Omega$	27	45	27	45	V/ $\mu\text{s}$
SR-	Negative slew rate				27	42	27	42	
$t_s$	Settling time	$A_{VD} = -1$ , 10-V step	To 0.1%	0.34	0.34	0.4	0.4	$\mu\text{s}$	
			To 0.01%	0.4	0.4				
$V_n$	Equivalent input noise voltage	$R_S = 20\ \Omega$ , $f = 10\text{ Hz}$	15		15		nV/ $\sqrt{\text{Hz}}$		
		$R_S = 20\ \Omega$ , $f = 1\text{ kHz}$	10.5		10.5				
$V_{N(PP)}$	Peak-to-peak equivalent input noise voltage	$f = 0.1\text{ Hz to }1\text{ Hz}$		0.48	0.48	0.51	0.51	$\mu\text{V}$	
		$f = 0.1\text{ Hz to }10\text{ Hz}$		0.51	0.51				
$I_n$	Equivalent input noise current	$f = 10\text{ Hz}$		1.89	1.89	0.47	0.47	pA/ $\sqrt{\text{Hz}}$	
		$f = 1\text{ kHz}$		0.47	0.47				
THD + N	Total harmonic distortion plus noise	$V_{O(PP)} = 20\text{ V}$ , $A_{VD} = 10$ ,	$R_L = 2\text{ k}\Omega$ , $f = 10\text{ kHz}$	0.01%		0.01%			
$B_1$	Unity-gain bandwidth	$R_L = 2\text{ k}\Omega$ ,	$C_L = 100\text{ pF}$	6		6		MHz	
	Gain-bandwidth product	$R_L = 2\text{ k}\Omega$ , $f = 100\text{ kHz}$	$C_L = 100\text{ pF}$ ,	5.9		5.9		MHz	
$B_{OM}$	Maximum output-swing bandwidth	$V_{O(PP)} = 20\text{ V}$ , $A_{VD} = 1$ ,	$R_L = 2\text{ k}\Omega$ , $C_L = 100\text{ pF}$	668		668		kHz	
$\phi_m$	Phase margin at unity gain	$R_L = 2\text{ k}\Omega$ ,	$C_L = 100\text{ pF}$	58°		58°			

# TLE214x, TLE214xA EXCALIBUR LOW-NOISE HIGH-SPEED PRECISION OPERATIONAL AMPLIFIERS

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**TLE2144C electrical characteristics at specified free-air temperature,  $V_{CC} = 5\text{ V}$  (unless otherwise noted)**

PARAMETER	TEST CONDITIONS	$T_A$ †	TLE2144C			TLE2144AC			UNIT
			MIN	TYP	MAX	MIN	TYP	MAX	
$V_{IO}$ Input offset voltage	$V_O = 2.5\text{ V}$ , $V_{IC} = 2.5\text{ V}$ $R_S = 50\ \Omega$	25°C	0.5	3.8		0.5	3	mV	
		Full range			4.4		3.6		
$\alpha_{VIO}$ Temperature coefficient of input offset voltage		Full range		1.7			1.7	$\mu\text{V}/^\circ\text{C}$	
$I_{IO}$ Input offset current		25°C	8	100		8	100	nA	
		Full range			150		150		
$I_{IB}$ Input bias current		25°C	-0.8	-2		-0.8	-2	$\mu\text{A}$	
		Full range			-2.1		-2.1		
$V_{ICR}$ Common-mode input voltage range		$R_S = 50\ \Omega$	25°C	0 to 3	-0.3 to 3.2		0 to 3	-0.3 to 3.2	V
			Full range	0 to 2.9			0 to 2.9		
$V_{OH}$ High-level output voltage		$I_{OH} = -150\ \mu\text{A}$	25°C	3.9	4.1		3.9	4.1	V
	Full range		3.8			3.8			
	$I_{OH} = -1.5\text{ mA}$	25°C	3.8	4		3.8	4		
		Full range	3.7			3.7			
	$I_{OH} = -15\text{ mA}$	25°C	3.4	3.7		3.4	3.7		
		Full range	3.4			3.4			
$V_{OL}$ Low-level output voltage	$I_{OL} = 150\ \mu\text{A}$	25°C		75	125		75	125	mV
		Full range			150			150	
	$I_{OL} = 1.5\text{ mA}$	25°C		150	225		150	225	
		Full range			250			250	
	$I_{OL} = 15\text{ mA}$	25°C		1.2	1.6		1.2	1.6	V
		Full range			1.7			1.7	
$AVD$ Large-signal differential voltage amplification	$V_{CC} = \pm 2.5\text{ V}$ , $V_O = 1\text{ V to } -1.5\text{ V}$ $R_L = 2\text{ k}\Omega$	25°C	50	95		50	95	V/mV	
		Full range	25			25			
$r_i$ Input resistance		25°C		70			70	$\text{M}\Omega$	
$c_i$ Input capacitance		25°C		2.5			2.5	pF	
$z_o$ Open-loop output impedance	$f = 1\text{ MHz}$	25°C		30			30	$\Omega$	
CMRR Common-mode rejection ratio	$V_{IC} = V_{ICRmin}$ , $R_S = 50\ \Omega$	25°C	85	118		85	118	dB	
		Full range	80			80			
$k_{SVR}$ Supply-voltage rejection ratio ( $\Delta V_{CC\pm} / \Delta V_{IO}$ )	$V_{CC\pm} = \pm 2.5\text{ V to } \pm 15\text{ V}$ , $R_S = 50\ \Omega$	25°C	90	106		90	106	dB	
		Full range	85			85			
$I_{CC}$ Supply current	$V_O = 2.5\text{ V}$ , $V_{IC} = 2.5\text{ V}$ No load,	25°C		13.2	17.6		13.2	17.6	mA
		Full range			18.5			18.5	

† Full range is 0°C to 70°C.



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**TLE2144C operating characteristics,  $V_{CC} = 5\text{ V}$ ,  $T_A = 25^\circ\text{C}$**

PARAMETER	TEST CONDITIONS	TLE2144C			TLE2144AC			UNIT
		MIN	TYP	MAX	MIN	TYP	MAX	
SR+	Positive slew rate	$A_{VD} = -1$ , $C_L = 500\text{ pF}$		$R_L = 2\text{ k}\Omega^\dagger$	45			V/ $\mu\text{s}$
SR-	Negative slew rate				42			
$t_s$	Settling time	$A_{VD} = -1$ , 2.5-V step	To 0.1%	0.16			$\mu\text{s}$	
			To 0.01%	0.22				
$V_n$	Equivalent input noise voltage	$R_S = 20\ \Omega$ , $f = 10\text{ Hz}$	15			nV/ $\sqrt{\text{Hz}}$		
		$R_S = 20\ \Omega$ , $f = 1\text{ kHz}$	10.5					
$V_{N(PP)}$	Peak-to-peak equivalent input noise voltage	$f = 0.1\text{ Hz to }1\text{ Hz}$	0.48			$\mu\text{V}$		
		$f = 0.1\text{ Hz to }10\text{ Hz}$	0.51					
$I_n$	Equivalent input noise current	$f = 10\text{ Hz}$	1.92			pA/ $\sqrt{\text{Hz}}$		
		$f = 1\text{ kHz}$	0.5					
THD + N	Total harmonic distortion plus noise	$V_O = 1\text{ V to }3\text{ V}$ , $A_{VD} = 2$ ,	$R_L = 2\text{ k}\Omega^\dagger$ , $f = 10\text{ kHz}$	0.0052%				
$B_1$	Unity-gain bandwidth	$R_L = 2\text{ k}\Omega^\dagger$ ,	$C_L = 100\text{ pF}$	5.9			MHz	
	Gain-bandwidth product	$R_L = 2\text{ k}\Omega^\dagger$ , $f = 100\text{ kHz}$	$C_L = 100\text{ pF}$	5.8			MHz	
$B_{OM}$	Maximum output-swing bandwidth	$V_{O(PP)} = 2\text{ V}$ , $A_{VD} = 1$ ,	$R_L = 2\text{ k}\Omega^\dagger$ , $C_L = 100\text{ pF}$	660			kHz	
$\phi_m$	Phase margin at unity gain	$R_L = 2\text{ k}\Omega^\dagger$ ,	$C_L = 100\text{ pF}$	57°				

$^\dagger R_L$  terminates at 2.5 V

# TLE214x, TLE214xA EXCALIBUR LOW-NOISE HIGH-SPEED PRECISION OPERATIONAL AMPLIFIERS

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**TLE2144C electrical characteristics at specified free-air temperature,  $V_{CC\pm} = \pm 15$  V (unless otherwise noted)**

PARAMETER	TEST CONDITIONS	$T_A$ †	TLE2144C			TLE2144AC			UNIT
			MIN	TYP	MAX	MIN	TYP	MAX	
$V_{IO}$ Input offset voltage	$V_{IC} = 0,$ $V_O = 0$ $R_S = 50 \Omega$	25°C	0.6	2.4		0.5	1.5	mV	
		Full range			3.2		2.4		
$\alpha_{VIO}$ Temperature coefficient of input offset voltage		Full range	1.7			1.7		$\mu V/^\circ C$	
$I_{IO}$ Input offset current		25°C	7	100		7	100	nA	
		Full range			150		150		
$I_{IB}$ Input bias current		25°C	-0.7	-1.5		-0.7	-1.5	$\mu A$	
	Full range			-1.6		-1.6			
$V_{ICR}$ Common-mode input voltage range	$R_S = 50 \Omega$	25°C	-15 to 13	-15.3 to 13.2		-15 to 13	-15.3 to 13.2	V	
		Full range	-15 to 12.9	-15.3 to 13.1		-15 to 12.9	-15 to 13.1		
$V_{OM+}$ Maximum positive peak output voltage swing	$I_O = -150 \mu A$	25°C	13.8	14.1		13.8	14.1	V	
		Full range			13.7		13.7		
	$I_O = -1.5$ mA	25°C	13.7	14		13.7	14		
		Full range			13.6		13.6		
	$I_O = -15$ mA	25°C	13.1	13.7		13.1	13.7		
		Full range			13		13		
$V_{OM-}$ Maximum negative peak output voltage swing	$I_O = 150 \mu A$	25°C	-14.7	-14.9		-14.7	-14.9	V	
		Full range			-14.6		-14.6		
	$I_O = 1.5$ mA	25°C	-14.5	-14.8		-14.5	-14.8		
		Full range			-14.4		-14.4		
	$I_O = 15$ mA	25°C	-13.4	-13.8		-13.4	-13.8		
		Full range			-13.3		-13.3		
$A_{VD}$ Large-signal differential voltage amplification	$V_O = \pm 10$ V	25°C	100	170		100	170	V/mV	
		Full range			75		75		
$r_i$ Input resistance	$R_L = 2$ k $\Omega$	25°C		65			65	M $\Omega$	
$c_i$ Input capacitance		25°C		2.5			2.5	pF	
$z_o$ Open-loop output impedance	$f = 1$ MHz	25°C		30			30	$\Omega$	
CMRR Common-mode rejection ratio	$V_{IC} = V_{ICRmin}, R_S = 50 \Omega$	25°C	85	108		85	108	dB	
		Full range			80		80		
$k_{SVR}$ Supply-voltage rejection ratio ( $\Delta V_{CC\pm} / \Delta V_{IO}$ )	$V_{CC\pm} = \pm 2.5$ V to $\pm 15$ V, $R_S = 50 \Omega$	25°C	90	106		90	106	dB	
		Full range			85		85		
$I_{OS}$ Short-circuit output current	$V_O = 0$	25°C	$V_{ID} = 1$ V	-25	-50		-25	-50	mA
			$V_{ID} = -1$ V	20	31		20	31	
$I_{CC}$ Supply current	$V_O = 0,$ No load	25°C		13.8	18		13.8	18	mA
		Full range			18.8		18.8		

† Full range is 0°C to 70°C.





**TLE214x, TLE214xA**  
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**TLE2144C operating characteristics,  $V_{CC\pm} = \pm 15\text{ V}$ ,  $T_A = 25^\circ\text{C}$**

PARAMETER		TEST CONDITIONS		TLE2144C			TLE2144AC			UNIT
				MIN	TYP	MAX	MIN	TYP	MAX	
SR+	Positive slew rate	$A_{VD} = -1$ , $C_L = 500\text{ pF}$	$R_L = 2\text{ k}\Omega$	27	45		27	45		$\text{V}/\mu\text{s}$
SR-	Negative slew rate			27	42		27	42		
$t_s$	Settling time	$A_{VD} = -1$ , 10-V step	To 0.1%	0.34			0.34			$\mu\text{s}$
			To 0.01%	0.4			0.4			
$V_n$	Equivalent input noise voltage	$R_S = 20\ \Omega$	$f = 10\text{ Hz}$	15			15			$\text{nV}/\sqrt{\text{Hz}}$
			$f = 1\text{ kHz}$	10.5			10.5			
$V_{N(PP)}$	Peak-to-peak equivalent input noise voltage	$f = 0.1\text{ Hz to }1\text{ Hz}$		0.48			0.48			$\mu\text{V}$
		$f = 0.1\text{ Hz to }10\text{ Hz}$		0.51			0.51			
$I_n$	Equivalent input noise current	$f = 10\text{ Hz}$		1.89			1.89			$\text{pA}/\sqrt{\text{Hz}}$
		$f = 1\text{ kHz}$		0.47			0.47			
THD + N	Total harmonic distortion plus noise	$V_{O(PP)} = 20\text{ V}$ , $A_{VD} = 10$ ,	$R_L = 2\text{ k}\Omega$ , $f = 10\text{ kHz}$	0.01%			0.01%			
$B_1$	Unity-gain bandwidth	$R_L = 2\text{ k}\Omega$ ,	$C_L = 100\text{ pF}$	6			6			MHz
	Gain-bandwidth product	$R_L = 2\text{ k}\Omega$ , $f = 100\text{ kHz}$	$C_L = 100\text{ pF}$	5.9			5.9			MHz
$B_{OM}$	Maximum output-swing bandwidth	$V_{O(PP)} = 20\text{ V}$ , $A_{VD} = 1$ ,	$R_L = 2\text{ k}\Omega$ , $C_L = 100\text{ pF}$	668			668			kHz
$\phi_m$	Phase margin at unity gain	$R_L = 2\text{ k}\Omega$ ,	$C_L = 100\text{ pF}$	58°			58°			

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TLE2141I electrical characteristics at specified free-air temperature,  $V_{CC} = 5\text{ V}$  (unless otherwise noted)

PARAMETER	TEST CONDITIONS	$T_A$ †	TLE2141I			TLE2141AI			UNIT
			MIN	TYP	MAX	MIN	TYP	MAX	
$V_{IO}$ Input offset voltage	$V_O = 2.5\text{ V}$ , $V_{IC} = 2.5\text{ V}$ $R_S = 50\ \Omega$	25°C	225	1400		200	1000	$\mu\text{V}$	
		Full range			1900		1500		
$\alpha_{VIO}$ Temperature coefficient of input offset voltage		Full range	1.7			1.7		$\mu\text{V}/^\circ\text{C}$	
$I_{IO}$ Input offset current		25°C	8	100		8	100	nA	
		Full range			200		200		
$I_{IB}$ Input bias current		25°C	-0.8	-2		-0.8	-2	$\mu\text{A}$	
	Full range			-2.2		-2.2			
$V_{ICR}$ Common-mode input voltage range	$R_S = 50\ \Omega$	25°C	0 to 3	-0.3 to 3.2		0 to 3	-0.3 to 3.2	V	
		Full range	0 to 2.7	-0.3 to 2.9		0 to 2.7	-0.3 to 2.9		
$V_{OH}$ High-level output voltage	$I_{OH} = -150\ \mu\text{A}$	25°C	3.9	4.1		3.9	4.1	V	
	$I_{OH} = -1.5\text{ mA}$		3.8	4		3.8	4		
	$I_{OH} = -15\text{ mA}$	Full range	3.2	3.7		3.2	3.7		
	$I_{OH} = -100\ \mu\text{A}$		3.8			3.8			
	$I_{OH} = -1\text{ mA}$		3.7			3.7			
	$I_{OH} = -10\text{ mA}$		3.3			3.3			
$V_{OL}$ Low-level output voltage	$I_{OL} = 150\ \mu\text{A}$	25°C	75	125		75	125	mV	
	$I_{OL} = 1.5\ \mu\text{A}$		150	225		150	225		
	$I_{OL} = 15\text{ mA}$		1.2	1.6		1.2	1.6		
	$I_{OL} = 100\ \mu\text{A}$	Full range			175		175	mV	
	$I_{OL} = 1\text{ mA}$				225		225		
	$I_{OL} = 10\text{ mA}$				1.4		1.4		
$A_{VD}$ Large-signal differential voltage amplification	$V_{CC} = \pm 2.5\text{ V}$ , $R_L = 2\text{ k}\Omega$ , $V_O = 1\text{ V to } -1.5\text{ V}$	25°C	50	220		50	220	V/mV	
		Full range	10			10			
$r_i$ Input resistance		25°C	70			70	$\text{M}\Omega$		
$c_i$ Input capacitance		25°C	2.5			2.5	pF		
$z_o$ Open-loop output impedance	$f = 1\text{ MHz}$	25°C	30			30	$\Omega$		
CMRR Common-mode rejection ratio	$V_{IC} = V_{ICRmin}$ , $R_S = 50\ \Omega$	25°C	85	118		85	118	dB	
		Full range	80			80			
$k_{SVR}$ Supply-voltage rejection ratio ( $\Delta V_{CC\pm} / \Delta V_{IO}$ )	$V_{CC\pm} = \pm 2.5\text{ V to } \pm 15\text{ V}$ , $R_S = 50\ \Omega$	25°C	90	106		90	106	dB	
		Full range	85			85			
$I_{CC}$ Supply current	$V_O = 2.5\text{ V}$ , $V_{IC} = 2.5\text{ V}$ No load,	25°C	3.4	4.4		3.4	4.4	mA	
		Full range			4.6		4.6		

† Full range is  $-40^\circ\text{C}$  to  $105^\circ\text{C}$ .



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**TLE2141I operating characteristics,  $V_{CC} = 5\text{ V}$ ,  $T_A = 25^\circ\text{C}$**

PARAMETER	TEST CONDITIONS	TLE2141I			TLE2141AI			UNIT
		MIN	TYP	MAX	MIN	TYP	MAX	
SR+	Positive slew rate	$A_{VD} = -1$ , $C_L = 500\text{ pF}$		$R_L = 2\text{ k}\Omega^\dagger$		45		V/ $\mu\text{s}$
SR-	Negative slew rate					42		
$t_s$	Settling time	$A_{VD} = -1$ , 2.5-V step		To 0.1%		0.16		$\mu\text{s}$
				To 0.01%		0.22		
$V_n$	Equivalent input noise voltage	$R_S = 20\ \Omega$ , $f = 10\text{ Hz}$		15		15		nV/ $\sqrt{\text{Hz}}$
		$R_S = 20\ \Omega$ , $f = 1\text{ kHz}$		10.5		10.5		
$V_{N(PP)}$	Peak-to-peak equivalent input noise voltage	$f = 0.1\text{ Hz to }1\text{ Hz}$		0.48		0.48		$\mu\text{V}$
		$f = 0.1\text{ Hz to }10\text{ Hz}$		0.51		0.51		
$I_n$	Equivalent input noise current	$f = 10\text{ Hz}$		1.92		1.92		pA/ $\sqrt{\text{Hz}}$
		$f = 1\text{ kHz}$		0.5		0.5		
THD + N	Total harmonic distortion plus noise	$V_O = 1\text{ V to }3\text{ V}$ , $A_{VD} = 2$ , $R_L = 2\text{ k}\Omega^\dagger$ , $f = 10\text{ kHz}$		0.0052%		0.0052%		
$B_1$	Unity-gain bandwidth	$R_L = 2\text{ k}\Omega^\dagger$ , $C_L = 100\text{ pF}^\dagger$		5.9		5.9		MHz
	Gain-bandwidth product	$R_L = 2\text{ k}\Omega^\dagger$ , $f = 100\text{ kHz}$		5.8		5.8		MHz
$B_{OM}$	Maximum output-swing bandwidth	$V_{O(PP)} = 2\text{ V}$ , $A_{VD} = 1$ , $R_L = 2\text{ k}\Omega^\dagger$ , $C_L = 100\text{ pF}^\dagger$		660		660		kHz
$\phi_m$	Phase margin at unity gain	$R_L = 2\text{ k}\Omega^\dagger$ , $C_L = 100\text{ pF}^\dagger$		57°		57°		

$^\dagger R_L$  and  $C_L$  terminated to 2.5 V.

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**TLE2141I electrical characteristics at specified free-air temperature,  $V_{CC\pm} = \pm 15\text{ V}$  (unless otherwise noted)**

PARAMETER	TEST CONDITIONS	$T_A$ †	TLE2141I			TLE2141AI			UNIT
			MIN	TYP	MAX	MIN	TYP	MAX	
$V_{IO}$ Input offset voltage	$V_{IC} = 0, R_S = 50\ \Omega, V_O = 0$	25°C	200	900		175	500	$\mu\text{V}$	
		Full range			1500		1000		
$\alpha_{VIO}$ Temperature coefficient of input offset voltage		Full range	1.7			1.7		$\mu\text{V}/^\circ\text{C}$	
$I_{IO}$ Input offset current		25°C	7	100		7	100	nA	
		Full range			200		200		
$I_{IB}$ Input bias current		25°C	-0.7	-1.5		-0.7	-1.5	$\mu\text{A}$	
	Full range			-1.7		-1.7			
$V_{ICR}$ Common-mode input voltage range	$R_S = 50\ \Omega$	25°C	-15 to 13	-15.3 to 13.2		-15 to 13	-15.3 to 13.2	V	
		Full range	-15 to 12.7	-15.3 to 12.9		-15 to 12.7	-15.3 to 12.9		
$V_{OM+}$ Maximum positive peak output voltage swing	$I_O = -150\ \mu\text{A}$ $I_O = -1.5\ \text{mA}$ $I_O = -15\ \text{mA}$ $I_O = -100\ \mu\text{A}$ $I_O = -1\ \text{mA}$ $I_O = -10\ \text{mA}$	25°C	13.8	14.1		13.8	14.1	V	
			13.7	14		13.7	14		
			13.1	13.7		13.1	13.7		
		Full range	13.7			13.7			
			13.6			13.6			
			13.1			13.1			
$V_{OM-}$ Maximum negative peak output voltage swing	$I_O = 150\ \mu\text{A}$ $I_O = 1.5\ \text{mA}$ $I_O = 15\ \text{mA}$ $I_O = 100\ \mu\text{A}$ $I_O = 1\ \text{mA}$ $I_O = 10\ \text{mA}$	25°C	-14.7	-14.9		-14.7	-14.9	V	
			-14.5	-14.8		-14.5	-14.8		
			-13.4	-13.8		-13.4	-13.8		
		Full range	-14.6			-14.6			
			-14.5			-14.5			
			-13.4			-13.4			
$A_{VD}$ Large-signal differential voltage amplification	$V_O = \pm 10\ \text{V}, R_L = 2\ \text{k}\Omega$	25°C	100	450		100	450	V/mV	
		Full range	40			40			
$r_i$ Input resistance		25°C	65			65	$\text{M}\Omega$		
$c_i$ Input capacitance		25°C	2.5			2.5	pF		
$z_o$ Open-loop output impedance	$f = 1\ \text{MHz}$	25°C	30			30	$\Omega$		
CMRR Common-mode rejection ratio	$V_{IC} = V_{ICRmin}, R_S = 50\ \Omega$	25°C	85	108		85	108	dB	
		Full range	80			80			
$k_{SVR}$ Supply-voltage rejection ratio ( $\Delta V_{CC\pm} / \Delta V_{IO}$ )	$V_{CC\pm} = \pm 2.5\ \text{V to } \pm 15\ \text{V}, R_S = 50\ \Omega$	25°C	90	106		90	106	dB	
		Full range	85			85			
$I_{OS}$ Short-circuit output current	$V_O = 0$	25°C	$V_{ID} = 1\ \text{V}$	-25	-50		-25	-50	mA
			$V_{ID} = -1\ \text{V}$	20	31		20	31	
$I_{CC}$ Supply current	$V_O = 0, \text{ No load}$	25°C	3.5	4.5		3.5	4.5	mA	
		Full range			4.7		4.7		

† Full range is  $-40^\circ\text{C}$  to  $105^\circ\text{C}$ .



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**TLE2141I operating characteristics,  $V_{CC\pm} = \pm 15\text{ V}$ ,  $T_A = 25^\circ\text{C}$**

PARAMETER		TEST CONDITIONS		TLE2141I			TLE2141AI			UNIT
				MIN	TYP	MAX	MIN	TYP	MAX	
SR+	Positive slew rate	$A_{VD} = -1$ , $C_L = 500\text{ pF}$	$R_L = 2\text{ k}\Omega$	27	45		27	45		V/ $\mu\text{s}$
SR-	Negative slew rate			27	42		27	42		
$t_s$	Settling time	$A_{VD} = -1$ , 10-V step	To 0.1%	0.34			0.34			$\mu\text{s}$
			To 0.01%	0.4			0.4			
$V_n$	Equivalent input noise voltage	$R_S = 20\ \Omega$	$f = 10\text{ Hz}$	15			15			nV/ $\sqrt{\text{Hz}}$
			$f = 1\text{ kHz}$	10.5			10.5			
$V_{N(PP)}$	Peak-to-peak equivalent input noise voltage	$f = 0.1\text{ Hz to }1\text{ Hz}$		0.48			0.48			$\mu\text{V}$
		$f = 0.1\text{ Hz to }10\text{ Hz}$		0.51			0.51			
$I_n$	Equivalent input noise current	$f = 10\text{ Hz}$		1.89			1.89			pA/ $\sqrt{\text{Hz}}$
		$f = 1\text{ kHz}$		0.47			0.47			
THD + N	Total harmonic distortion plus noise	$V_{O(PP)} = 20\text{ V}$ , $A_{VD} = 10$	$R_L = 2\text{ k}\Omega$ , $f = 10\text{ kHz}$	0.01%			0.01%			
$B_1$	Unity-gain bandwidth	$R_L = 2\text{ k}\Omega$	$C_L = 100\text{ pF}$	6			6			MHz
	Gain-bandwidth product	$R_L = 2\text{ k}\Omega$ , $f = 100\text{ kHz}$	$C_L = 100\text{ pF}$	5.9			5.9			MHz
$B_{OM}$	Maximum output-swing bandwidth	$V_{O(PP)} = 20\text{ V}$ , $A_{VD} = 1$	$R_L = 2\text{ k}\Omega$ , $C_L = 100\text{ pF}$	668			668			kHz
$\phi_m$	Phase margin at unity gain	$R_L = 2\text{ k}\Omega$	$C_L = 100\text{ pF}$	58°			58°			

# TLE214x, TLE214xA EXCALIBUR LOW-NOISE HIGH-SPEED PRECISION OPERATIONAL AMPLIFIERS

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TLE2142I electrical characteristics at specified free-air temperature,  $V_{CC} = 5\text{ V}$  (unless otherwise noted)

PARAMETER	TEST CONDITIONS	$T_A$ †	TLE2142I			TLE2142AI			UNIT	
			MIN	TYP	MAX	MIN	TYP	MAX		
$V_{IO}$ Input offset voltage	$V_O = 2.5\text{ V},$ $V_{IC} = 2.5\text{ V}$ $R_S = 50\ \Omega,$	25°C	220	1900		220	1500		$\mu\text{V}$	
		Full range			2400		2000			
$\alpha_{VIO}$ Temperature coefficient of input offset voltage		Full range	1.7			1.7			$\mu\text{V}/^\circ\text{C}$	
$I_{IO}$ Input offset current		25°C	8	100		8	100		nA	
		Full range			200		200			
$I_{IB}$ Input bias current		25°C	-0.8	-2		-0.8	-2		$\mu\text{A}$	
	Full range			-2.2		-2.2				
$V_{ICR}$ Common-mode input voltage range	$R_S = 50\ \Omega$	25°C	0 to 3	-0.3 to 3.2		0 to 3	-0.3 to 3.2		V	
		Full range	0 to 2.7	-0.3 to 2.9		0 to 2.7	-0.3 to 2.9			
$V_{OH}$ High-level output voltage	$I_{OH} = -150\ \mu\text{A}$ $I_{OH} = -1.5\text{ mA}$ $I_{OH} = -15\text{ mA}$ $I_{OH} = 100\ \mu\text{A}$ $I_{OH} = 1\text{ mA}$ $I_{OH} = 10\text{ mA}$	25°C	3.9	4.1		3.9	4.1		V	
			3.8	4		3.8	4			
			3.4	3.7		3.4	3.7			
		Full range	3.8			3.8				
			3.7			3.7				
			3.5			3.5				
$V_{OL}$ Low-level output voltage	$I_{OL} = 150\ \mu\text{A}$ $I_{OL} = 1.5\text{ mA}$ $I_{OL} = 15\text{ mA}$ $I_{OL} = 100\ \mu\text{A}$ $I_{OL} = 1\text{ mA}$ $I_{OL} = 10\text{ mA}$	25°C	75	125		75	125		mV	
			150	225		150	225			
			1.2	1.4		1.2	1.4			
		Full range	175			175			mV	
			225			225				
			1.2			1.2				
$A_{VD}$ Large-signal differential voltage amplification	$V_{IC} = \pm 2.5\text{ V},$ $V_O = 1\text{ V to } -1.5\text{ V}$ $R_L = 2\text{ k}\Omega,$	25°C	50	220		50	220		V/mV	
		Full range	10			10				
$r_i$ Input resistance		25°C	70			70		$\text{M}\Omega$		
$c_i$ Input capacitance		25°C	2.5			2.5		pF		
$z_o$ Open-loop output impedance	$f = 1\text{ MHz}$	25°C	30			30		$\Omega$		
CMRR Common-mode rejection ratio	$V_{IC} = V_{ICRmin},$ $R_S = 50\ \Omega$	25°C	85	118		85	118		dB	
		Full range	80			80				
$k_{SVR}$ Supply-voltage rejection ratio ( $\Delta V_{CC\pm} / \Delta V_{IO}$ )	$V_{CC\pm} = \pm 2.5\text{ V to } \pm 15\text{ V},$ $R_S = 50\ \Omega$	25°C	90	106		90	106		dB	
		Full range	85			85				
$I_{CC}$ Supply current	$V_O = 2.5\text{ V},$ $V_{IC} = 2.5\text{ V}$ No load,	25°C	6.6	8.8		6.6	8.8		mA	
		Full range			9.2		9.2			

† Full range is  $-40^\circ\text{C}$  to  $105^\circ\text{C}$ .



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**TLE2142I operating characteristics,  $V_{CC} = 5\text{ V}$ ,  $T_A = 25^\circ\text{C}$**

PARAMETER	TEST CONDITIONS	TLE2142I			TLE2142AI			UNIT
		MIN	TYP	MAX	MIN	TYP	MAX	
SR+	Positive slew rate	$A_{VD} = -1$ , $R_L = 2\text{ k}\Omega^\dagger$ , $C_L = 500\text{ pF}$			45			V/ $\mu\text{s}$
SR-	Negative slew rate				42			
$t_s$	Settling time	$A_{VD} = -1$ , 2.5-V step	To 0.1%	0.16			$\mu\text{s}$	
			To 0.01%	0.22				
$V_n$	Equivalent input noise voltage	$R_S = 20\ \Omega$ , $f = 10\text{ Hz}$	15			nV/ $\sqrt{\text{Hz}}$		
		$R_S = 20\ \Omega$ , $f = 1\text{ kHz}$	10.5					
$V_{N(PP)}$	Peak-to-peak equivalent input noise voltage	$f = 0.1\text{ Hz to }1\text{ Hz}$	0.48			$\mu\text{V}$		
		$f = 0.1\text{ Hz to }10\text{ Hz}$	0.51					
$I_n$	Equivalent input noise current	$f = 10\text{ Hz}$	1.92			pA/ $\sqrt{\text{Hz}}$		
		$f = 1\text{ kHz}$	0.5					
THD + N	Total harmonic distortion plus noise	$V_O = 1\text{ V to }3\text{ V}$ , $R_L = 2\text{ k}\Omega^\dagger$ , $A_{VD} = 2$ , $f = 10\text{ kHz}$	0.0052%					
$B_1$	Unity-gain bandwidth	$R_L = 2\text{ k}\Omega^\dagger$ , $C_L = 100\text{ pF}$	5.9			MHz		
	Gain-bandwidth product	$R_L = 2\text{ k}\Omega^\dagger$ , $C_L = 100\text{ pF}$ , $f = 100\text{ kHz}$	5.8			MHz		
$B_{OM}$	Maximum output-swing bandwidth	$V_{O(PP)} = 2\text{ V}$ , $R_L = 2\text{ k}\Omega^\dagger$ , $A_{VD} = 1$ , $C_L = 100\text{ pF}$	660			kHz		
$\phi_m$	Phase margin at unity gain	$R_L = 2\text{ k}\Omega^\dagger$ , $C_L = 100\text{ pF}$	57°					

$^\dagger R_L$  terminates at 2.5 V.

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**TLE2142I electrical characteristics at specified free-air temperature,  $V_{CC\pm} = \pm 15\text{ V}$  (unless otherwise noted)**

PARAMETER	TEST CONDITIONS	$T_A$ †	TLE2142I			TLE2142I			UNIT
			MIN	TYP	MAX	MIN	TYP	MAX	
$V_{IO}$ Input offset voltage	$V_{IC} = 0, V_O = 0, R_S = 50\ \Omega$	25°C	290	1200		275	750	$\mu\text{V}$	
		Full range			1800		1400		
$\alpha_{VIO}$ Temperature coefficient of input offset voltage		Full range		1.7			1.7	$\mu\text{V}/^\circ\text{C}$	
$I_{IO}$ Input offset current		25°C	7	100		7	100	nA	
		Full range			200		200		
$I_{IB}$ Input bias current		25°C	-0.7	-1.5		-0.7	-1.5	$\mu\text{A}$	
	Full range			-1.7		-1.7			
$V_{ICR}$ Common-mode input voltage range	$R_S = 50\ \Omega$	25°C	-15 to 13	-15.3 to 13.2		-15 to 13	-15.3 to 13.2	V	
		Full range	-15 to 12.7	-15.3 to 12.9		-15 to 12.7	-15.3 to 12.9		
$V_{OM+}$ Maximum positive peak output voltage swing	$I_O = -150\ \mu\text{A}$ $I_O = -1.5\ \text{mA}$ $I_O = -15\ \text{mA}$ $I_O = -100\ \mu\text{A}$ $I_O = -1\ \text{mA}$ $I_O = -10\ \text{mA}$	25°C	13.8	14.1		13.8	14.1	V	
			13.7	14		13.7	14		
			13.3	13.7		13.3	13.7		
		Full range	13.7			13.7			
			13.6			13.6			
			13.3			13.3			
$V_{OM-}$ Maximum negative peak output voltage swing	$I_O = 150\ \mu\text{A}$ $I_O = 1.5\ \text{mA}$ $I_O = 15\ \text{mA}$ $I_O = 100\ \mu\text{A}$ $I_O = 1\ \text{mA}$ $I_O = 10\ \text{mA}$	25°C	-14.7	-14.9		-14.7	-14.9	V	
			-14.5	-14.8		-14.5	-14.8		
			-13.4	-13.8		-13.4	-13.8		
		Full range	-14.6			-14.6			
			-14.5			-14.5			
			-13.4			-13.4			
$A_{VD}$ Large-signal differential voltage amplification	$V_O = \pm 10\ \text{V}, R_L = 2\ \text{k}\Omega$	25°C	100	450		100	450	V/mV	
		Full range	40			40			
$r_i$ Input resistance		25°C	65			65	$\text{M}\Omega$		
$c_i$ Input capacitance		25°C	2.5			2.5	pF		
$z_o$ Open-loop output impedance	$f = 1\ \text{MHz}$	25°C	30			30	$\Omega$		
CMRR Common-mode rejection ratio	$V_{IC} = V_{ICRmin}$	25°C	85	108		85	108	dB	
	$R_S = 50\ \Omega$	Full range	80			80			
$k_{SVR}$ Supply-voltage rejection ratio ( $\Delta V_{CC\pm} / \Delta V_{IO}$ )	$V_{CC\pm} = \pm 2.5\ \text{V to } \pm 15\ \text{V}, R_S = 50\ \Omega$	25°C	90	106		90	106	dB	
		Full range	85			85			
$I_{OS}$ Short-circuit output current	$V_O = 0$	25°C	$V_{ID} = 1\ \text{V}$	-25	-50		-25	-50	mA
			$V_{ID} = -1\ \text{V}$	20	31		20	31	
$I_{CC}$ Supply current	$V_O = 0,$	No load	25°C	6.9	9		6.9	9	mA
			Full range			9.4		9.4	

† Full range is  $-40^\circ\text{C}$  to  $105^\circ\text{C}$ .





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**TLE2142I operating characteristics,  $V_{CC\pm} = \pm 15\text{ V}$ ,  $T_A = 25^\circ\text{C}$**

PARAMETER	TEST CONDITIONS	TLE2142I			TLE2142AI			UNIT		
		MIN	TYP	MAX	MIN	TYP	MAX			
SR+	Positive slew rate	$A_{VD} = -1$ , $C_L = 500\text{ pF}$		$R_L = 2\text{ k}\Omega$		30	45	30	45	$\text{V}/\mu\text{s}$
SR-	Negative slew rate					30	42	30	42	
$t_s$	Settling time	$A_{VD} = -1$ , 10-V step		To 0.1%		0.34		0.34		$\mu\text{s}$
				To 0.01%		0.4		0.4		
$V_n$	Equivalent input noise voltage	$R_S = 20\ \Omega$ , $f = 10\text{ Hz}$		15		15		$\text{nV}/\sqrt{\text{Hz}}$		
		$R_S = 20\ \Omega$ , $f = 1\text{ kHz}$		10.5		10.5				
$V_{N(PP)}$	Peak-to-peak equivalent input noise voltage	$f = 0.1\text{ Hz to }1\text{ Hz}$		0.48		0.48		$\mu\text{V}$		
		$f = 0.1\text{ Hz to }10\text{ Hz}$		0.51		0.51				
$I_n$	Equivalent input noise current	$f = 10\text{ Hz}$		1.89		1.89		$\text{pA}/\sqrt{\text{Hz}}$		
		$f = 1\text{ kHz}$		0.47		0.47				
THD + N	Total harmonic distortion plus noise	$V_{O(PP)} = 20\text{ V}$ , $A_{VD} = 10$		$R_L = 2\text{ k}\Omega$ , $f = 10\text{ kHz}$		0.01%		0.01%		
$B_1$	Unity-gain bandwidth	$R_L = 2\text{ k}\Omega$ , $C_L = 100\text{ pF}$		6		6		MHz		
	Gain-bandwidth product	$R_L = 2\text{ k}\Omega$ , $f = 100\text{ kHz}$		5.9		5.9		MHz		
$B_{OM}$	Maximum output-swing bandwidth	$V_{O(PP)} = 20\text{ V}$ , $A_{VD} = 1$		$R_L = 2\text{ k}\Omega$ , $C_L = 100\text{ pF}$		668		668		kHz
$\phi_m$	Phase margin at unity gain	$R_L = 2\text{ k}\Omega$ , $C_L = 100\text{ pF}$		58°		58°				

# TLE214x, TLE214xA EXCALIBUR LOW-NOISE HIGH-SPEED PRECISION OPERATIONAL AMPLIFIERS

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TLE2144I electrical characteristics at specified free-air temperature,  $V_{CC} = 5\text{ V}$  (unless otherwise noted)

PARAMETER	TEST CONDITIONS	$T_A$ †	TLE2144I			TLE2144AI			UNIT
			MIN	TYP	MAX	MIN	TYP	MAX	
$V_{IO}$ Input offset voltage	$V_{IC} = 0,$ $V_O = 0$ $R_S = 50\ \Omega,$	25°C	0.5	3.8		0.5	3	mV	
		Full range			4.8		4		
$\alpha_{VIO}$ Temperature coefficient of input offset voltage		Full range	1.7			1.7		$\mu\text{V}/^\circ\text{C}$	
$I_{IO}$ Input offset current		25°C	8	100		8	100	nA	
		Full range			200		200		
$I_{IB}$ Input bias current		25°C	-0.8	-2		-0.8	-2	$\mu\text{A}$	
	Full range			-2.2		-2.2			
$V_{ICR}$ Common-mode input voltage range	$R_S = 50\ \Omega$	25°C	0 to 3	-0.3 to 3.2		0 to 3	-0.3 to 3.2	V	
		Full range	0 to 2.7	-0.3 to 2.9		0 to 2.7	-0.3 to 2.9		
$V_{OH}$ High-level output voltage	$I_{OH} = -150\ \mu\text{A}$ $I_{OH} = -1.5\ \text{mA}$ $I_{OH} = -15\ \text{mA}$ $I_{OH} = 100\ \mu\text{A}$ $I_{OH} = 1\ \text{mA}$ $I_{OH} = 10\ \text{mA}$	25°C	3.9	4.1		3.9	4.1	V	
			3.8	4		3.8	4		
			3.4	3.7		3.4	3.7		
		Full range	3.8			3.8			
			3.7			3.7			
			3.5			3.5			
$V_{OL}$ Low-level output voltage	$I_{OL} = 150\ \mu\text{A}$ $I_{OL} = 1.5\ \mu\text{A}$ $I_{OL} = 15\ \text{mA}$ $I_{OL} = 100\ \mu\text{A}$ $I_{OL} = 1\ \text{mA}$ $I_{OL} = 10\ \text{mA}$	25°C	75	125		75	125	mV	
			150	225		150	225		
			1.2	1.6		1.2	1.6	V	
		Full range	175			175			
			225			225			
			1.4			1.4			
$A_{VD}$ Large-signal differential voltage amplification	$V_{IC} = \pm 2.5\ \text{V},$ $V_O = 1\ \text{V to } -1.5\ \text{V}$ $R_L = 2\ \text{k}\Omega,$	25°C	50	95		50	95	V/mV	
		Full range	10			10			
$r_i$ Input resistance		25°C	70			70	$\text{M}\Omega$		
$c_i$ Input capacitance		25°C	2.5			2.5	pF		
$z_o$ Open-loop output impedance	$f = 1\ \text{MHz}$	25°C	30			30	$\Omega$		
CMRR Common-mode rejection ratio	$V_{IC} = V_{ICR\text{min}},$ $R_S = 50\ \Omega$	25°C	85	118		85	118	dB	
		Full range	80			80			
$k_{SVR}$ Supply-voltage rejection ratio ( $\Delta V_{CC\pm}/\Delta V_{IO}$ )	$V_{CC\pm} = \pm 2.5\ \text{V to } \pm 15\ \text{V},$ $R_S = 50\ \Omega$	25°C	90	106		90	106	dB	
		Full range	85			85			
$I_{CC}$ Supply current	$V_O = 2.5\ \text{V},$ $V_{IC} = 2.5\ \text{V}$ No load,	25°C	13.2	17.6		13.2	17.6	mA	
		Full range			18.4		18.4		

† Full range is  $-40^\circ\text{C}$  to  $105^\circ\text{C}$ .



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**TLE2144I operating characteristics,  $V_{CC} = 5\text{ V}$ ,  $T_A = 25^\circ\text{C}$**

PARAMETER	TEST CONDITIONS	TLE2144I			TLE2144AI			UNIT	
		MIN	TYP	MAX	MIN	TYP	MAX		
SR+	Positive slew rate	$A_{VD} = -1$ , $C_L = 500\text{ pF}$		$R_L = 2\text{ k}\Omega^\dagger$		45		$\text{V}/\mu\text{s}$	
SR-	Negative slew rate					42			
$t_s$	Settling time	$A_{VD} = -1$ , 2.5-V step	To 0.1%		0.16		$\mu\text{s}$		
			To 0.01%		0.22				
$V_n$	Equivalent input noise voltage	$R_S = 20\ \Omega$ , $f = 10\text{ Hz}$	15		15		$\text{nV}/\sqrt{\text{Hz}}$		
		$R_S = 20\ \Omega$ , $f = 1\text{ kHz}$	10.5		10.5				
$V_{N(PP)}$	Peak-to-peak equivalent input noise voltage	$f = 0.1\text{ Hz to }1\text{ Hz}$		0.48		0.48		$\mu\text{V}$	
		$f = 0.1\text{ Hz to }10\text{ Hz}$		0.51		0.51			
$I_n$	Equivalent input noise current	$f = 10\text{ Hz}$		1.92		1.92		$\text{pA}/\sqrt{\text{Hz}}$	
		$f = 10\text{ kHz}$		0.5		0.5			
THD + N	Total harmonic distortion plus noise	$V_O = 1\text{ V to }3\text{ V}$ , $A_{VD} = 2$ ,	$R_L = 2\text{ k}\Omega^\dagger$ , $f = 10\text{ kHz}$		0.0052%		0.0052%		
$B_1$	Unity-gain bandwidth	$R_L = 2\text{ k}\Omega^\dagger$ ,	$C_L = 100\text{ pF}$		5.9		5.9		MHz
	Gain-bandwidth product	$R_L = 2\text{ k}\Omega^\dagger$ , $f = 100\text{ kHz}$	$C_L = 100\text{ pF}$		5.8		5.8		MHz
$B_{OM}$	Maximum output-swing bandwidth	$V_{O(PP)} = 2\text{ V}$ , $A_{VD} = 1$ ,	$R_L = 2\text{ k}\Omega^\dagger$ , $C_L = 100\text{ pF}$		660		660		kHz
$\phi_m$	Phase margin at unity gain	$R_L = 2\text{ k}\Omega^\dagger$ ,	$C_L = 100\text{ pF}$		57°		57°		

$^\dagger R_L$  terminates at 2.5 V

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**TLE2144I electrical characteristics at specified free-air temperature,  $V_{CC\pm} = \pm 15\text{ V}$  (unless otherwise noted)**

PARAMETER	TEST CONDITIONS	$T_A$ †	TLE2144I			TLE2144AI			UNIT
			MIN	TYP	MAX	MIN	TYP	MAX	
$V_{IO}$ Input offset voltage	$V_{IC} = 0,$ $V_O = 0$ $R_S = 50\ \Omega$	25°C	0.6	2.4		0.5	1.5	mV	
		Full range			3.2		2.8		
$\alpha_{VIO}$ Temperature coefficient of input offset voltage		Full range	1.7			1.7		$\mu\text{V}/^\circ\text{C}$	
$I_{IO}$ Input offset current		25°C	7	100		7	100	nA	
		Full range			200		200		
$I_{IB}$ Input bias current		25°C	-0.7	-1.5		-0.7	-1.5	$\mu\text{A}$	
	Full range			-1.7		-1.7			
$V_{ICR}$ Common-mode input voltage range	$R_S = 50\ \Omega$	25°C	-15 to 13	-15.3 to 13.2		-15 to 13	-15.3 to 13.2	V	
		Full range	-15 to 12.7	-15.3 to 12.9		-15 to 12.7	-15.3 to 12.9		
$V_{OM+}$ Maximum positive peak output voltage swing	$I_O = -150\ \mu\text{A}$ $I_O = -1.5\ \text{mA}$ $I_O = -15\ \text{mA}$ $I_O = -100\ \mu\text{A}$ $I_O = -1\ \text{mA}$ $I_O = -10\ \text{mA}$	25°C	13.8	14.1		13.8	14.1	V	
			13.7	14		13.7	14		
			13.1	13.7		13.1	13.7		
		Full range	13.7			13.7			
			13.6			13.6			
			13.1			13.1			
$V_{OM-}$ Maximum negative peak output voltage swing	$I_O = 150\ \mu\text{A}$ $I_O = 1.5\ \text{mA}$ $I_O = 15\ \text{mA}$ $I_O = 100\ \mu\text{A}$ $I_O = 1\ \text{mA}$ $I_O = 10\ \text{mA}$	25°C	-14.7	-14.9		-14.7	-14.9	V	
			-14.5	-14.8		-14.5	-14.8		
			-13.4	-13.8		-13.4	-13.8		
		Full range	-14.6			-14.6			
			-14.5			-14.5			
			-13.4			-13.4			
$A_{VD}$ Large-signal differential voltage amplification	$V_O = \pm 10\ \text{V},$ $R_L = 2\ \text{k}\Omega$	25°C	100	170		100	170	V/mV	
		Full range	40			40			
$r_i$ Input resistance		25°C	65			65	$\text{M}\Omega$		
$c_i$ Input capacitance		25°C	2.5			2.5	pF		
$z_o$ Open-loop output impedance	$f = 1\ \text{MHz}$	25°C	30			30	$\Omega$		
CMRR Common-mode rejection ratio	$V_{IC} = V_{ICRmin},$ $R_S = 50\ \Omega$	25°C	85	108		85	108	dB	
		Full range	80			80			
$k_{SVR}$ Supply-voltage rejection ratio ( $\Delta V_{CC\pm} / \Delta V_{IO}$ )	$V_{CC\pm} = \pm 2.5\ \text{V to } \pm 15\ \text{V},$ $R_S = 50\ \Omega$	25°C	90	106		90	106	dB	
		Full range	85			85			
$I_{OS}$ Short-circuit output current	$V_O = 0$ $\frac{V_{ID} = 1\ \text{V}}{V_{ID} = -1\ \text{V}}$	25°C	-25	-50		-25	-50	mA	
			20	31		20	31		
$I_{CC}$ Supply current	$V_O = 0,$ No load	25°C	13.8	18		13.8	18	mA	
		Full range			18.8		18.8		

† Full range is -40°C to 105°C.



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**TLE2144I operating characteristics,  $V_{CC\pm} = \pm 15\text{ V}$ ,  $T_A = 25^\circ\text{C}$**

PARAMETER		TEST CONDITIONS		TLE2144I			TLE2144AI			UNIT
				MIN	TYP	MAX	MIN	TYP	MAX	
SR+	Positive slew rate	$A_{VD} = -1$ , $C_L = 500\text{ pF}$	$R_L = 2\text{ k}\Omega$	27	45		27	45		$\text{V}/\mu\text{s}$
SR-	Negative slew rate			27	42		27	42		
$t_s$	Settling time	$A_{VD} = -1$ , 10-V step	To 0.1%	0.34			0.34			$\mu\text{s}$
			To 0.01%	0.4			0.4			
$V_n$	Equivalent input noise voltage	$R_S = 20\ \Omega$	$f = 10\text{ Hz}$	15			15			$\text{nV}/\sqrt{\text{Hz}}$
			$f = 1\text{ kHz}$	10.5			10.5			
$V_{N(PP)}$	Peak-to-peak equivalent input noise voltage	$f = 0.1\text{ Hz to }1\text{ Hz}$		0.48			0.48			$\mu\text{V}$
		$f = 0.1\text{ Hz to }10\text{ Hz}$		0.51			0.51			
$I_n$	Equivalent input noise current	$f = 10\text{ Hz}$		1.89			1.89			$\text{pA}/\sqrt{\text{Hz}}$
		$f = 1\text{ kHz}$		0.47			0.47			
THD + N	Total harmonic distortion plus noise	$V_{O(PP)} = 20\text{ V}$ , $A_{VD} = 10$ ,	$R_L = 2\text{ k}\Omega$ , $f = 10\text{ kHz}$	0.01%			0.01%			
$B_1$	Unity-gain bandwidth	$R_L = 2\text{ k}\Omega$ ,	$C_L = 100\text{ pF}$	6			6			MHz
	Gain-bandwidth product	$R_L = 2\text{ k}\Omega$ , $f = 100\text{ kHz}$	$C_L = 100\text{ pF}$ ,	5.9			5.9			MHz
$B_{OM}$	Maximum output-swing bandwidth	$V_{O(PP)} = 20\text{ V}$ , $A_{VD} = 1$ ,	$R_L = 2\text{ k}\Omega$ , $C_L = 100\text{ pF}$	668			668			kHz
$\phi_m$	Phase margin at unity gain	$R_L = 2\text{ k}\Omega$ ,	$C_L = 100\text{ pF}$	58°			58°			

# TLE214x, TLE214xA EXCALIBUR LOW-NOISE HIGH-SPEED PRECISION OPERATIONAL AMPLIFIERS

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**TLE2141M electrical characteristics at specified free-air temperature,  $V_{CC} = 5\text{ V}$  (unless otherwise noted)**

PARAMETER	TEST CONDITIONS	$T_A$ †	TLE2141M			TLE2141AM			UNIT
			MIN	TYP	MAX	MIN	TYP	MAX	
$V_{IO}$ Input offset voltage	$V_O = 2.5\text{ V}$ $V_{IC} = 2.5\text{ V}$ $R_S = 50\ \Omega$	25°C	225	1400		200	1000	$\mu\text{V}$	
		Full range			2100		1700		
$\alpha_{VIO}$ Temperature coefficient of input offset voltage		Full range	1.7			1.7		$\mu\text{V}/^\circ\text{C}$	
$I_{IO}$ Input offset current		25°C	8	100		8	100	nA	
		Full range			250		250		
$I_{IB}$ Input bias current		25°C	-0.8	-2		-0.8	-2	$\mu\text{A}$	
	Full range			-2.3		-2.3			
$V_{ICR}$ Common-mode input voltage range	$R_S = 50\ \Omega$	25°C	0 to 3	-0.3 to 3.2		0 to 3	-0.3 to 3.2	V	
		Full range	0 to 2.7	-0.3 to 2.9		0 to 2.7	-0.3 to 2.9		
$V_{OH}$ High-level output voltage	$I_{OH} = -150\ \mu\text{A}$ $I_{OH} = -1.5\text{ mA}$ $I_{OH} = -15\text{ mA}$ $I_{OH} = -100\ \mu\text{A}$ $I_{OH} = -1\text{ mA}$ $I_{OH} = -10\text{ mA}$	25°C	3.9	4.1		3.9	4.1	V	
			3.8	4		3.8	4		
		Full range	3.2	3.7		3.2	3.7		
			3.75			3.75			
			3.65			3.65			
			3.25			3.25			
$V_{OL}$ Low-level output voltage	$I_{OL} = 150\ \mu\text{A}$ $I_{OL} = 1.5\text{ mA}$ $I_{OL} = 15\text{ mA}$ $I_{OL} = 100\ \mu\text{A}$ $I_{OL} = 1\text{ mA}$ $I_{OL} = 10\text{ mA}$	25°C	75	125		75	125	mV	
			150	225		150	225		
		Full range	1.2	1.4		1.2	1.4		
			200			200			
			250			225			
			1.25			1.25			
$A_{VD}$ Large-signal differential voltage amplification	$V_{IC} = \pm 2.5\text{ V}$ , $R_L = 2\text{ k}\Omega$ , $V_O = 1\text{ V to } -1.5\text{ V}$	25°C	50	220		50	220	V/mV	
		Full range	5			5			
$r_i$ Input resistance		25°C	70		70		$\text{M}\Omega$		
$c_i$ Input capacitance		25°C	2.5		2.5		pF		
$z_o$ Open-loop output impedance	$f = 1\text{ MHz}$	25°C	30		30		$\Omega$		
CMRR Common-mode rejection ratio	$V_{IC} = V_{ICRmin}$ , $R_S = 50\ \Omega$	25°C	85	118		85	118	dB	
		Full range	80			80			
$k_{SVR}$ Supply-voltage rejection ratio ( $\Delta V_{CC\pm} / \Delta V_{IO}$ )	$V_{CC\pm} = \pm 2.5\text{ V to } \pm 15\text{ V}$ , $R_S = 50\ \Omega$	25°C	90	106		90	106	dB	
		Full range	85			85			
$I_{CC}$ Supply current	$V_O = 2.5\text{ V}$ , $V_{IC} = 2.5\text{ V}$ No load,	25°C	3.4	4.4		3.4	4.4	mA	
		Full range			4.6		4.6		

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



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**TLE2141M operating characteristics,  $V_{CC} = 5\text{ V}$ ,  $T_A = 25^\circ\text{C}$**

PARAMETER	TEST CONDITIONS	TLE2141M			TLE2141AM			UNIT
		MIN	TYP	MAX	MIN	TYP	MAX	
SR+	Positive slew rate	$A_{VD} = -1$ , $C_L = 500\text{ pF}$		$R_L = 2\text{ k}\Omega^\dagger$		45		V/ $\mu\text{s}$
SR-	Negative slew rate					42		
$t_s$	Settling time	$A_{VD} = -1$ , 2.5-V step		To 0.1%		0.16		$\mu\text{s}$
				To 0.01%		0.22		
$V_n$	Equivalent input noise voltage	$R_S = 20\ \Omega$ , $f = 10\text{ Hz}$		15		15		nV/ $\sqrt{\text{Hz}}$
		$R_S = 20\ \Omega$ , $f = 1\text{ kHz}$		10.5		10.5		
$V_{N(PP)}$	Peak-to-peak equivalent input noise voltage	$f = 0.1\text{ Hz to }1\text{ Hz}$		0.48		0.48		$\mu\text{V}$
		$f = 0.1\text{ Hz to }10\text{ Hz}$		0.51		0.51		
$I_n$	Equivalent input noise current	$f = 10\text{ Hz}$		1.92		1.92		pA/ $\sqrt{\text{Hz}}$
		$f = 1\text{ kHz}$		0.5		0.5		
THD + N	Total harmonic distortion plus noise	$V_O = 1\text{ V to }3\text{ V}$ , $A_{VD} = 2$		$R_L = 2\text{ k}\Omega^\dagger$ , $f = 10\text{ kHz}$		0.0052%		
$B_1$	Unity-gain bandwidth	$R_L = 2\text{ k}\Omega^\dagger$ , $C_L = 100\text{ pF}^\dagger$		5.9		5.9		MHz
	Gain-bandwidth product	$R_L = 2\text{ k}\Omega^\dagger$ , $f = 100\text{ kHz}$		5.8		5.8		MHz
$B_{OM}$	Maximum output-swing bandwidth	$V_{O(PP)} = 2\text{ V}$ , $A_{VD} = 1$		$R_L = 2\text{ k}\Omega^\dagger$		660		kHz
$\phi_m$	Phase margin at unity gain	$R_L = 2\text{ k}\Omega^\dagger$ , $C_L = 100\text{ pF}^\dagger$		57°		57°		

$^\dagger R_L$  and  $C_L$  terminated to 2.5 V.

# TLE214x, TLE214xA EXCALIBUR LOW-NOISE HIGH-SPEED PRECISION OPERATIONAL AMPLIFIERS

SLOS183B – FEBRUARY 1997 – REVISED APRIL 2004

**TLE2141M electrical characteristics at specified free-air temperature,  $V_{CC\pm} = \pm 15\text{ V}$  (unless otherwise noted)**

PARAMETER	TEST CONDITIONS	$T_A$ †	TLE2141M			TLE2141AM			UNIT
			MIN	TYP	MAX	MIN	TYP	MAX	
$V_{IO}$ Input offset voltage	$V_{IC} = 0, R_S = 50\ \Omega$	25°C	200	900		175	500	$\mu\text{V}$	
		Full range			1700		1200		
$\alpha_{VIO}$ Temperature coefficient of input offset voltage		Full range	1.7			1.7		$\mu\text{V}/^\circ\text{C}$	
$I_{IO}$ Input offset current		25°C	7	100		7	100	nA	
		Full range			250		250		
$I_{IB}$ Input bias current		25°C	-0.7	-1.5		-0.7	-1.5	$\mu\text{A}$	
	Full range			-1.8		-1.8			
$V_{ICR}$ Common-mode input voltage range	$R_S = 50\ \Omega$	25°C	-15 to 13	-15.3 to 13.2		-15 to 13	-15.3 to 13.2	V	
		Full range	-15 to 12.7	-15.3 to 12.9		-15 to 12.7	-15.3 to 12.9		
$V_{OM+}$ Maximum positive peak output voltage swing	$I_O = -150\ \mu\text{A}$	25°C	13.8	14.1		13.8	14.1	V	
	$I_O = -1.5\ \text{mA}$		13.7	14		13.7	14		
	$I_O = -15\ \text{mA}$	Full range	13.1	13.7		13.1	13.7		
	$I_O = -100\ \mu\text{A}$		13.7			13.7			
	$I_O = -1\ \text{mA}$		13.6			13.6			
	$I_O = -10\ \text{mA}$		13.1			13.1			
$V_{OM-}$ Maximum negative peak output voltage swing	$I_O = 150\ \mu\text{A}$	25°C	-14.7	-14.9		-14.7	-14.9	V	
	$I_O = 1.5\ \text{mA}$		-14.5	-14.8		-14.5	-14.8		
	$I_O = 15\ \text{mA}$	Full range	-13.4	-13.8		-13.4	-13.8		
	$I_O = 100\ \mu\text{A}$		-14.6			-14.6			
	$I_O = 1\ \text{mA}$		-14.5			-14.5			
	$I_O = 10\ \text{mA}$		-13.4			-13.4			
$A_{VD}$ Large-signal differential voltage amplification	$V_O = \pm 10\ \text{V}, R_L = 2\ \text{k}\Omega$	25°C	100	450		100	450	V/mV	
		Full range	20			20			
$r_i$ Input resistance		25°C	65			65	$\text{M}\Omega$		
$c_i$ Input capacitance		25°C	2.5			2.5	pF		
$z_o$ Open-loop output impedance	$f = 1\ \text{MHz}$	25°C	30			30	$\Omega$		
CMRR Common-mode rejection ratio	$V_{IC} = V_{ICRmin}, R_S = 50\ \Omega$	25°C	85	108		85	108	dB	
		Full range	80			80			
$k_{SVR}$ Supply-voltage rejection ratio ( $\Delta V_{CC\pm} / \Delta V_{IO}$ )	$V_{CC\pm} = \pm 2.5\ \text{V to } \pm 15\ \text{V}, R_S = 50\ \Omega$	25°C	90	106		90	106	dB	
		Full range	85			85			
$I_{OS}$ Short-circuit output current	$V_O = 0$	25°C	$V_{ID} = 1\ \text{V}$	-25	-50		-25	-50	mA
			$V_{ID} = -1\ \text{V}$	20	31		20	31	
$I_{CC}$ Supply current	$V_O = 0, V_{IC} = 2.5\ \text{V}$	No load,	25°C	3.5	4.5		3.5	4.5	mA
			Full range			4.7		4.7	

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





**TLE214x, TLE214xA**  
**EXCALIBUR LOW-NOISE HIGH-SPEED**  
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**TLE2141M operating characteristics,  $V_{CC\pm} = \pm 15\text{ V}$ ,  $T_A = 25^\circ\text{C}$**

PARAMETER		TEST CONDITIONS		TLE2141M			TLE2141AM			UNIT
				MIN	TYP	MAX	MIN	TYP	MAX	
SR+	Positive slew rate	$A_{VD} = -1$ , $C_L = 100\text{ pF}$	$R_L = 2\text{ k}\Omega$	27	45		27	45	V/ $\mu\text{s}$	
SR-	Negative slew rate			27	42		27	42		
$t_s$	Settling time	$A_{VD} = -1$ , 10-V step	To 0.1%	0.34			0.34			$\mu\text{s}$
			To 0.01%	0.4			0.4			
$V_n$	Equivalent input noise voltage	$R_S = 20\ \Omega$	$f = 10\text{ Hz}$	15			15			nV/ $\sqrt{\text{Hz}}$
			$f = 1\text{ kHz}$	10.5			10.5			
$V_{N(PP)}$	Peak-to-peak equivalent input noise voltage	$f = 0.1\text{ Hz to }1\text{ Hz}$		0.48			0.48			$\mu\text{V}$
		$f = 0.1\text{ Hz to }10\text{ Hz}$		0.51			0.51			
$I_n$	Equivalent input noise current	$f = 10\text{ Hz}$		1.89			1.89			pA/ $\sqrt{\text{Hz}}$
		$f = 1\text{ kHz}$		0.47			0.47			
THD + N	Total harmonic distortion plus noise	$V_{O(PP)} = 20\text{ V}$ , $A_{VD} = 10$	$R_L = 2\text{ k}\Omega$ , $f = 10\text{ kHz}$	0.01%			0.01%			
$B_1$	Unity-gain bandwidth	$R_L = 2\text{ k}\Omega$	$C_L = 100\text{ pF}$	6			6			MHz
	Gain-bandwidth product	$R_L = 2\text{ k}\Omega$ , $f = 100\text{ kHz}$	$C_L = 100\text{ pF}$	5.9			5.9			MHz
$B_{OM}$	Maximum output-swing bandwidth	$V_{O(PP)} = 20\text{ V}$ , $A_{VD} = 1$	$R_L = 2\text{ k}\Omega$ , $C_L = 100\text{ pF}$	668			668			kHz
$\phi_m$	Phase margin at unity gain	$R_L = 2\text{ k}\Omega$	$C_L = 100\text{ pF}$	58°			58°			

# TLE214x, TLE214xA EXCALIBUR LOW-NOISE HIGH-SPEED PRECISION OPERATIONAL AMPLIFIERS

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**TLE2142M electrical characteristics at specified free-air temperature,  $V_{CC} = 5\text{ V}$  (unless otherwise noted)**

PARAMETER	TEST CONDITIONS	$T_A$ †	TLE2142M			TLE2142AM			UNIT
			MIN	TYP	MAX	MIN	TYP	MAX	
$V_{IO}$ Input offset voltage	$V_O = 2.5\text{ V},$ $V_{IC} = 2.5\text{ V}$ $R_S = 50\ \Omega,$	25°C	220	1900		200	1500	$\mu\text{V}$	
		Full range			2600		2200		
$\alpha_{VIO}$ Temperature coefficient of input offset voltage		Full range	1.7			1.7		$\mu\text{V}/^\circ\text{C}$	
$I_{IO}$ Input offset current		25°C	8	100		8	100	nA	
		Full range			200		200		
$I_{IB}$ Input bias current		25°C	-0.8	-2		-0.8	-2	$\mu\text{A}$	
	Full range			-2.3		-2.3			
$V_{ICR}$ Common-mode input voltage range	$R_S = 50\ \Omega$	25°C	0 to 3	-0.3 to 3.2		0 to 3	-0.3 to 3.2	V	
		Full range	0 to 2.7	-0.3 to 2.9		0 to 2.7	-0.3 to 2.9		
$V_{OH}$ High-level output voltage	$I_{OH} = -150\ \mu\text{A}$	25°C	3.9	4.1		3.9	4.1	V	
	$I_{OH} = -1.5\text{ mA}$		3.8	4		3.8	4		
	$I_{OH} = -15\text{ mA}$		3.4	3.7		3.4	3.7		
	$I_{OH} = 100\ \mu\text{A}$	Full range	3.75			3.75			
	$I_{OH} = 1\text{ mA}$		3.65			3.65			
	$I_{OH} = 10\text{ mA}$		3.45			3.45			
$V_{OL}$ Low-level output voltage	$I_{OL} = 150\ \mu\text{A}$	25°C	75	125		75	125	mV	
	$I_{OL} = 1.5\text{ mA}$		150	225		150	225		
	$I_{OL} = 15\text{ mA}$		1.2	1.4		1.2	1.4	V	
	$I_{OL} = 100\ \mu\text{A}$	Full range			200		200	mV	
	$I_{OL} = 1\text{ mA}$				250		250		
	$I_{OL} = 10\text{ mA}$				1.25		1.25	V	
$A_{VD}$ Large-signal differential voltage amplification	$V_{IC} = \pm 2.5\text{ V},$ $R_L = 2\text{ k}\Omega,$ $V_O = 1\text{ V to } -1.5\text{ V}$	25°C	50	220		50	220	V/mV	
		Full range	5			5			
$r_i$ Input resistance		25°C	70			70	$\text{M}\Omega$		
$c_i$ Input capacitance		25°C	2.5			2.5	pF		
$z_o$ Open-loop output impedance	$f = 1\text{ MHz}$	25°C	30			30	$\Omega$		
CMRR Common-mode rejection ratio	$V_{IC} = V_{ICRmin},$ $R_S = 50\ \Omega$	25°C	85	118		85	118	dB	
		Full range	80			80			
$k_{SVR}$ Supply-voltage rejection ratio ( $\Delta V_{CC\pm} / \Delta V_{IO}$ )	$V_{CC\pm} = \pm 2.5\text{ V to } \pm 15\text{ V},$ $R_S = 50\ \Omega$	25°C	90	106		90	106	dB	
		Full range	85			85			
$I_{CC}$ Supply current	$V_O = 2.5\text{ V},$ $V_{IC} = 2.5\text{ V}$ No load,	25°C	6.6	8.8		6.6	8.8	mA	
		Full range			9.2		9.2		

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



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**TLE2142M operating characteristics,  $V_{CC} = 5\text{ V}$ ,  $T_A = 25^\circ\text{C}$**

PARAMETER		TEST CONDITIONS		TLE2142M			TLE2142AM			UNIT
				MIN	TYP	MAX	MIN	TYP	MAX	
SR+	Positive slew rate	$A_{VD} = -1$ , $C_L = 500\text{ pF}$	$R_L = 2\text{ k}\Omega^\dagger$	45			45			$\text{V}/\mu\text{s}$
SR-	Negative slew rate			42			42			
$t_s$	Settling time	$A_{VD} = -1$ , 2.5-V step	To 0.1%	0.16			0.16			$\mu\text{s}$
			To 0.01%	0.22			0.22			
$V_n$	Equivalent input noise voltage	$R_S = 20\ \Omega$ ,	$f = 10\text{ Hz}$	15			15			$\text{nV}/\sqrt{\text{Hz}}$
			$f = 1\text{ kHz}$	10.5			10.5			
$V_{N(PP)}$	Peak-to-peak equivalent input noise voltage	$f = 0.1\text{ Hz to }1\text{ Hz}$		0.48			0.48			$\mu\text{V}$
		$f = 0.1\text{ Hz to }10\text{ Hz}$		0.51			0.51			
$I_n$	Equivalent input noise current	$f = 10\text{ Hz}$		1.92			1.92			$\text{pA}/\sqrt{\text{Hz}}$
		$f = 1\text{ kHz}$		0.5			0.5			
THD + N	Total harmonic distortion plus noise	$V_O = 1\text{ V to }3\text{ V}$ ,	$R_L = 2\text{ k}\Omega^\dagger$ ,	0.0052%			0.0052%			
$B_1$	Unity-gain bandwidth	$R_L = 2\text{ k}\Omega^\dagger$ ,	$C_L = 100\text{ pF}$	5.9			5.9			MHz
	Gain-bandwidth product	$R_L = 2\text{ k}\Omega^\dagger$ ,	$C_L = 100\text{ pF}$ , $f = 100\text{ kHz}$	5.8			5.8			MHz
$B_{OM}$	Maximum output-swing bandwidth	$V_{O(PP)} = 2\text{ V}$ ,	$R_L = 2\text{ k}\Omega^\dagger$ ,	660			660			kHz
$\phi_m$	Phase margin	$R_L = 2\text{ k}\Omega^\dagger$ ,	$C_L = 100\text{ pF}$	$57^\circ$			$57^\circ$			

$^\dagger R_L$  terminates at 2.5 V.

# TLE214x, TLE214xA EXCALIBUR LOW-NOISE HIGH-SPEED PRECISION OPERATIONAL AMPLIFIERS

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**TLE2142M electrical characteristics at specified free-air temperature,  $V_{CC\pm} = \pm 15$  V (unless otherwise noted)**

PARAMETER	TEST CONDITIONS	$T_A$ †	TLE2142M			TLE2142AM			UNIT
			MIN	TYP	MAX	MIN	TYP	MAX	
$V_{IO}$ Input offset voltage	$V_{IC} = 0, R_S = 50 \Omega$	25°C	290	1200		275	750	$\mu V$	
		Full range		2000		1600			
$\alpha_{VIO}$ Temperature coefficient of input offset voltage		Full range	1.7			1.7		$\mu V/^\circ C$	
$I_{IO}$ Input offset current		25°C	7	100		7	100	nA	
		Full range		250		250			
$I_{IB}$ Input bias current		25°C	-0.7	-1.5		-0.7	-1.5	$\mu A$	
	Full range		-1.8		-1.8				
$V_{ICR}$ Common-mode input voltage range	$R_S = 50 \Omega$	25°C	-15 to 13	-15.3 to 13.2		-15 to 13	-15.3 to 13.2	V	
		Full range	-15 to 12.7	-15.3 to 12.9		-15 to 12.7	-15.3 to 12.9		
$V_{OM+}$ Maximum positive peak output voltage swing	$I_O = -150 \mu A$	25°C	13.8	14.1		13.8	14.1	V	
	$I_O = -1.5 mA$		13.7	14		13.7	14		
	$I_O = -15 mA$		13.3	13.7		13.3	13.7		
	$I_O = -100 \mu A$	Full range	13.7			13.7			
	$I_O = -1 mA$		13.6			13.6			
	$I_O = -10 mA$		13.3			13.3			
$V_{OM-}$ Maximum negative peak output voltage swing	$I_O = 150 \mu A$	25°C	-14.7	-14.9		-14.7	-14.9	V	
	$I_O = 1.5 mA$		-14.5	-14.8		-14.5	-14.8		
	$I_O = 15 mA$		-13.4	-13.8		-13.4	-13.8		
	$I_O = 100 \mu A$	Full range	-14.6			-14.6			
	$I_O = 1 mA$		-14.5			-14.5			
	$I_O = 10 mA$		-13.4			-13.4			
$A_{VD}$ Large-signal differential voltage amplification	$V_O = \pm 10 V, R_L = 2 k\Omega$	25°C	100	450		100	450	V/mV	
		Full range	20			20			
$r_i$ Input resistance		25°C	65			65	$M\Omega$		
$c_i$ Input capacitance		25°C	2.5			2.5	pF		
$z_o$ Open-loop output impedance	$f = 1 MHz$	25°C	30			30	$\Omega$		
CMRR Common-mode rejection ratio	$V_{IC} = V_{ICRmin}, R_S = 50 \Omega$	25°C	85	108		85	108	dB	
		Full range	80			80			
$k_{SVR}$ Supply-voltage rejection ratio ( $\Delta V_{CC\pm} / \Delta V_{IO}$ )	$V_{CC\pm} = \pm 2.5 V$ to $\pm 15 V, R_S = 50 \Omega$	25°C	90	106		90	106	dB	
		Full range	85			85			
$I_{OS}$ Short-circuit output current	$V_O = 0$	25°C	$V_{ID} = 1 V$	-25	-50		-25	-50	mA
			$V_{ID} = -1 V$	20	31		20	31	
$I_{CC}$ Supply current	$V_O = 0, V_{IC} = 2.5 V$	No load,	25°C	6.9	9		6.9	9	mA
			Full range		9.4			9.4	

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



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**TLE2142M operating characteristics,  $V_{CC\pm} = \pm 15\text{ V}$ ,  $T_A = 25^\circ\text{C}$**

PARAMETER	TEST CONDITIONS	TLE2142M			TLE2142AM			UNIT
		MIN	TYP	MAX	MIN	TYP	MAX	
SR+	Positive slew rate	$R_L = 2\text{ k}\Omega$ , $A_{VD} = -1$ , $C_L = 100\text{ pF}$		27	45	27	45	V/ $\mu\text{s}$
SR-	Negative slew rate			27	42	27	42	
$t_s$	Settling time	$A_{VD} = -1$ , 10-V step	To 0.1%	0.34		0.34		$\mu\text{s}$
			To 0.01%	0.4		0.4		
$V_n$	Equivalent input noise voltage	$R_S = 20\ \Omega$ , $f = 10\text{ Hz}$	15		15		nV/ $\sqrt{\text{Hz}}$	
		$R_S = 20\ \Omega$ , $f = 1\text{ kHz}$	10.5		10.5			
$V_{N(PP)}$	Peak-to-peak equivalent input noise voltage	$f = 0.1\text{ Hz to }1\text{ Hz}$	0.48		0.48		$\mu\text{V}$	
		$f = 0.1\text{ Hz to }10\text{ Hz}$	0.51		0.51			
$I_n$	Equivalent input noise current	$f = 10\text{ Hz}$	1.89		1.89		pA/ $\sqrt{\text{Hz}}$	
		$f = 1\text{ kHz}$	0.47		0.47			
THD + N	Total harmonic distortion plus noise	$V_{O(PP)} = 20\text{ V}$ , $R_L = 2\text{ k}\Omega$ , $A_{VD} = 10$ , $f = 10\text{ kHz}$	0.01%		0.01%			
$B_1$	Unity-gain bandwidth	$R_L = 2\text{ k}\Omega$ , $C_L = 100\text{ pF}$	6		6		MHz	
	Gain-bandwidth product	$R_L = 2\text{ k}\Omega$ , $C_L = 100\text{ pF}$ , $f = 100\text{ kHz}$	5.9		5.9		MHz	
$B_{OM}$	Maximum output-swing bandwidth	$V_{O(PP)} = 20\text{ V}$ , $R_L = 2\text{ k}\Omega$ , $A_{VD} = 1$ , $C_L = 100\text{ pF}$	668		668		kHz	
$\phi_m$	Phase margin at unity gain	$R_L = 2\text{ k}\Omega$ , $C_L = 100\text{ pF}$	58°		58°			

# TLE214x, TLE214xA EXCALIBUR LOW-NOISE HIGH-SPEED PRECISION OPERATIONAL AMPLIFIERS

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**TLE2144M electrical characteristics at specified free-air temperature,  $V_{CC} = 5\text{ V}$  (unless otherwise noted)**

PARAMETER	TEST CONDITIONS	$T_A$ †	TLE2144M			TLE2144AM			UNIT
			MIN	TYP	MAX	MIN	TYP	MAX	
$V_{IO}$ Input offset voltage	$V_O = 2.5\text{ V}$ , $V_{IC} = 2.5\text{ V}$ $R_S = 50\ \Omega$	25°C	0.5	3.8		0.5	3	mV	
		Full range			5.2		4.4		
$\alpha_{VIO}$ Temperature coefficient of input offset voltage		Full range		1.7			1.7	$\mu\text{V}/^\circ\text{C}$	
$I_{IO}$ Input offset current		25°C	8	100		8	100	nA	
		Full range			250		250		
$I_{IB}$ Input bias current		25°C	-0.8	-2		-0.8	-2	$\mu\text{A}$	
	Full range			-2.3		-2.3			
$V_{ICR}$ Common-mode input voltage range	$R_S = 50\ \Omega$	25°C	0 to 3	-0.3 to 3.2		0 to 3	-0.3 to 3.2	V	
		Full range	0 to 2.7	-0.3 to 2.9		0 to 2.7	-0.3 to 2.9		
$V_{OH}$ High-level output voltage	$I_{OH} = -150\ \mu\text{A}$	25°C	3.9	4.1		3.9	4.1	V	
	$I_{OH} = -1.5\text{ mA}$		3.8	4		3.8	4		
	$I_{OH} = -15\text{ mA}$		3.4	3.7		3.4	3.7		
	$I_{OH} = 100\ \mu\text{A}$	Full range	3.75			3.75			
	$I_{OH} = 1\text{ mA}$		3.65			3.65			
	$I_{OH} = 10\text{ mA}$		3.45			3.45			
$V_{OL}$ Low-level output voltage	$I_{OL} = 150\ \mu\text{A}$	25°C	75	125		75	125	mV	
	$I_{OL} = 1.5\ \mu\text{A}$		150	225		150	225		
	$I_{OL} = 15\text{ mA}$		1.2	1.6		1.2	1.6	V	
	$I_{OL} = 100\ \mu\text{A}$	Full range			200		200	mV	
	$I_{OL} = 1\text{ mA}$				250		250		
	$I_{OL} = 10\text{ mA}$				1.45		1.45	V	
$AVD$ Large-signal differential voltage amplification	$V_{IC} = \pm 2.5\text{ V}$ , $V_O = 1\text{ V to } -1.5\text{ V}$ , $R_L = 2\text{ k}\Omega$	25°C	50	95		50	95	V/mV	
		Full range	5			5			
$r_i$ Input resistance		25°C		70		70	$M\Omega$		
$c_i$ Input capacitance		25°C		2.5		2.5	pF		
$z_o$ Open-loop output impedance	$f = 1\text{ MHz}$	25°C		30		30	$\Omega$		
CMRR Common-mode rejection ratio	$V_{IC} = V_{ICRmin}$ , $R_S = 50\ \Omega$	25°C	85	118		85	118	dB	
		Full range	80			80			
$k_{SVR}$ Supply-voltage rejection ratio ( $\Delta V_{CC\pm} / \Delta V_{IO}$ )	$V_{CC\pm} = \pm 2.5\text{ V to } \pm 15\text{ V}$ , $R_S = 50\ \Omega$	25°C	90	106		90	106	dB	
		Full range	85			85			
$I_{CC}$ Supply current	$V_O = 2.5\text{ V}$ , $V_{IC} = 2.5\text{ V}$ , No load,	25°C	13.2	17.6		13.2	17.6	mA	
		Full range			18.4		18.4		

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



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**TLE2144M operating characteristics,  $V_{CC} = 5\text{ V}$ ,  $T_A = 25^\circ\text{C}$**

PARAMETER		TEST CONDITIONS		TLE2144M			TLE2144AM			UNIT
				MIN	TYP	MAX	MIN	TYP	MAX	
SR+	Positive slew rate	$A_{VD} = -1$ , $C_L = 500\text{ pF}$		$R_L = 2\text{ k}\Omega^\dagger$		45			$\text{V}/\mu\text{s}$	
SR-	Negative slew rate					42				
$t_s$	Settling time	$A_{VD} = -1$ , 2.5-V step		To 0.1%		0.16			$\mu\text{s}$	
				To 0.01%		0.22				
$V_n$	Equivalent input noise voltage	$R_S = 20\ \Omega$ , $f = 10\text{ Hz}$		15		15			$\text{nV}/\sqrt{\text{Hz}}$	
		$R_S = 20\ \Omega$ , $f = 1\text{ kHz}$		10.5		10.5				
$V_{N(PP)}$	Peak-to-peak equivalent input noise voltage	$f = 0.1\text{ Hz to }1\text{ Hz}$		0.48		0.48			$\mu\text{V}$	
		$f = 0.1\text{ Hz to }10\text{ Hz}$		0.51		0.51				
$I_n$	Equivalent input noise current	$f = 10\text{ Hz}$		1.92		1.92			$\text{pA}/\sqrt{\text{Hz}}$	
		$f = 1\text{ kHz}$		0.5		0.5				
THD + N	Total harmonic distortion plus noise	$V_O = 1\text{ V to }3\text{ V}$ , $A_{VD} = 2$		$R_L = 2\text{ k}\Omega^\dagger$ , $f = 10\text{ kHz}$		0.0052%				
$B_1$	Unity-gain bandwidth	$R_L = 2\text{ k}\Omega^\dagger$ , $C_L = 100\text{ pF}$		5.9		5.9			MHz	
	Gain-bandwidth product	$R_L = 2\text{ k}\Omega^\dagger$ , $f = 100\text{ kHz}$		5.8		5.8			MHz	
$B_{OM}$	Maximum output-swing bandwidth	$V_{O(PP)} = 2\text{ V}$ , $A_{VD} = 1$		$R_L = 2\text{ k}\Omega^\dagger$		660			kHz	
$\phi_m$	Phase margin	$R_L = 2\text{ k}\Omega^\dagger$ , $C_L = 100\text{ pF}$		57°		57°				

$^\dagger R_L$  terminates at 2.5 V

# TLE214x, TLE214xA EXCALIBUR LOW-NOISE HIGH-SPEED PRECISION OPERATIONAL AMPLIFIERS

SLOS183B – FEBRUARY 1997 – REVISED APRIL 2004

**TLE2144M electrical characteristics at specified free-air temperature,  $V_{CC\pm} = \pm 15$  V (unless otherwise noted)**

PARAMETER	TEST CONDITIONS	$T_A$ †	TLE2144M			TLE2144AM			UNIT
			MIN	TYP	MAX	MIN	TYP	MAX	
$V_{IO}$ Input offset voltage	$V_{IC} = 0, R_S = 50 \Omega$	25°C	0.6	2.4		0.5	1.5	mV	
		Full range			4		3.2		
$\alpha_{VIO}$ Temperature coefficient of input offset voltage		Full range	1.7			1.7		$\mu V/^\circ C$	
$I_{IO}$ Input offset current		25°C	7	100		7	100	nA	
		Full range			250		250		
$I_{IB}$ Input bias current		25°C	-0.7	-1.5		-0.7	-1.5	$\mu A$	
	Full range			-1.8		-1.8			
$V_{ICR}$ Common-mode input voltage range	$R_S = 50 \Omega$	25°C	-15 to 13	-15.3 to 13.2		-15 to 13	-15.3 to 13.2	V	
		Full range	-15 to 12.7	-15.3 to 12.9		-15 to 12.7	-15.3 to 12.9		
$V_{OM+}$ Maximum positive peak output voltage swing	$I_O = -150 \mu A$ $I_O = -1.5 mA$ $I_O = -15 mA$ $I_O = -100 \mu A$ $I_O = -1 mA$ $I_O = -10 mA$	25°C	13.8	14.1		13.8	14.1	V	
			13.7	14		13.7	14		
			13.1	13.7		13.1	13.7		
		Full range	13.7			13.7			
			13.6			13.6			
			13.1			13.1			
$V_{OM-}$ Maximum negative peak output voltage swing	$I_O = 150 \mu A$ $I_O = 1.5 mA$ $I_O = 15 mA$ $I_O = 100 \mu A$ $I_O = 1 mA$ $I_O = 10 mA$	25°C	-14.7	-14.9		-14.7	-14.9	V	
			-14.5	-14.8		-14.5	-14.8		
			-13.4	-13.8		-13.4	-13.8		
		Full range	-14.6			-14.6			
			-14.5			-14.5			
			-13.4			-13.4			
$A_{VD}$ Large-signal differential voltage amplification	$V_O = \pm 10 V, R_L = 2 k\Omega$	25°C	100	170		100	170	V/mV	
		Full range	20			20			
$r_i$ Input resistance		25°C	65			65	$M\Omega$		
$c_i$ Input capacitance		25°C	2.5			2.5	pF		
$z_o$ Open-loop output impedance	$f = 1 MHz$	25°C	30			30	$\Omega$		
CMRR Common-mode rejection ratio	$V_{IC} = V_{ICRmin}, R_S = 50 \Omega$	25°C	85	108		85	108	dB	
		Full range	80			80			
$k_{SVR}$ Supply-voltage rejection ratio ( $\Delta V_{CC\pm} / \Delta V_{IO}$ )	$V_{CC\pm} = \pm 2.5 V$ to $\pm 15 V, R_S = 50 \Omega$	25°C	90	106		90	106	dB	
		Full range	85			85			
$I_{OS}$ Short-circuit output current	$V_O = 0$	25°C	$V_{ID} = 1 V$	-25	-50		-25	-50	mA
			$V_{ID} = -1 V$	20	31		20	31	
$I_{CC}$ Supply current	$V_O = 0, V_{IC} = 2.5 V$	No load,	25°C	13.8	18		13.8	18	mA
			Full range			18.8		18.8	

† Full range is -55°C to 125°C





**TLE214x, TLE214xA**  
**EXCALIBUR LOW-NOISE HIGH-SPEED**  
**PRECISION OPERATIONAL AMPLIFIERS**

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**TLE2144M operating characteristics,  $V_{CC\pm} = \pm 15\text{ V}$ ,  $T_A = 25^\circ\text{C}$**

PARAMETER		TEST CONDITIONS		TLE2144M			TLE2144AM			UNIT
				MIN	TYP	MAX	MIN	TYP	MAX	
SR+	Positive slew rate	$R_L = 2\text{ k}\Omega$ , $C_L = 100\text{ pF}$	$A_{VD} = -1$ ,	27	45		27	45	$\text{V}/\mu\text{s}$	
SR-	Negative slew rate			27	42		27	42		
$t_s$	Settling time	$A_{VD} = -1$ , 10-V step	To 0.1%	0.34			0.34			$\mu\text{s}$
			To 0.01%	.4			.4			
$V_n$	Equivalent input noise voltage	$R_S = 20\ \Omega$ ,	$f = 10\text{ Hz}$	15			15			$\text{nV}/\sqrt{\text{Hz}}$
			$f = 1\text{ kHz}$	10.5			10.5			
$V_{N(PP)}$	Peak-to-peak equivalent input noise voltage	$f = 0.1\text{ Hz to }1\text{ Hz}$		0.48			0.48			$\mu\text{V}$
		$f = 0.1\text{ Hz to }10\text{ Hz}$		0.51			0.51			
$I_n$	Equivalent input noise current	$f = 10\text{ Hz}$		1.89			1.89			$\text{pA}/\sqrt{\text{Hz}}$
		$f = 10\text{ kHz}$		0.47			0.47			
THD + N	Total harmonic distortion plus noise	$V_{O(PP)} = 20\text{ V}$ , $A_{VD} = 10$ ,	$R_L = 2\text{ k}\Omega$ , $f = 10\text{ kHz}$	0.01%			0.01%			
$B_1$	Unity-gain bandwidth	$R_L = 2\text{ k}\Omega$ ,	$C_L = 100\text{ pF}$	6			6			MHz
	Gain-bandwidth product	$R_L = 2\text{ k}\Omega$ , $f = 100\text{ kHz}$	$C_L = 100\text{ pF}$ ,	5.9			5.9			MHz
$B_{OM}$	Maximum output-swing bandwidth	$V_{O(PP)} = 20\text{ V}$ , $A_{VD} = 1$ ,	$R_L = 2\text{ k}\Omega$ , $C_L = 100\text{ pF}$	668			668			kHz
$\phi_m$	Phase margin at unity gain	$R_L = 2\text{ k}\Omega$ ,	$C_L = 100\text{ pF}$	58°			58°			

**TLE214x, TLE214xA**  
**EXCALIBUR LOW-NOISE HIGH-SPEED**  
**PRECISION OPERATIONAL AMPLIFIERS**

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**TLE2141Y electrical characteristics at specified free-air temperature,  $V_{CC\pm} = \pm 15\text{ V}$ ,  $T_A = 25^\circ\text{C}$  (unless otherwise noted)**

PARAMETER	TEST CONDITIONS	TLE2141Y			UNIT
		MIN	TYP	MAX	
$V_{IO}$ Input offset voltage	$V_{IC} = 0$ , $R_S = 50\ \Omega$ , $V_O = 0$		200	1000	$\mu\text{V}$
$I_{IO}$ Input offset current			7	100	nA
$I_{IB}$ Input bias current			-0.7	-1.5	$\mu\text{A}$
$V_{ICR}$ Common-mode input voltage range	$R_S = 50\ \Omega$	-15 to 13	-15.3 to 13.2		V
$V_{OM+}$ Maximum positive peak output voltage swing	$I_O = -150\ \mu\text{A}$	13.8	14.1		V
	$I_O = -1.5\ \text{mA}$	13.7	14		
	$I_O = -15\ \text{mA}$	13.3	13.7		
$V_{OM-}$ Maximum negative peak output voltage swing	$I_O = 150\ \mu\text{A}$	-14.7	-14.9		V
	$I_O = 1.5\ \text{mA}$	-14.5	-14.8		
	$I_O = 15\ \text{mA}$	-13.4	-13.8		
$A_{VD}$ Large-signal differential voltage amplification	$V_O = \pm 10\ \text{V}$ , $R_L = 2\ \text{k}\Omega$	100	450		V/mV
$r_i$ Input resistance			65		$\text{M}\Omega$
$c_i$ Input capacitance			2.5		pF
$z_o$ Open-loop output impedance	$f = 1\ \text{MHz}$		30		$\Omega$
CMRR Common-mode rejection ratio	$V_{IC} = V_{ICRmin}$ , $R_S = 50\ \Omega$	80	108		dB
$k_{SVR}$ Supply-voltage rejection ratio ( $\Delta V_{CC\pm}/\Delta V_{IO}$ )	$V_{CC\pm} = \pm 2.5\ \text{V}$ to $\pm 15\ \text{V}$ , $R_S = 50\ \Omega$	85	106		dB
$I_{OS}$ Short-circuit output current	$V_O = 0$	$V_{ID} = 1\ \text{V}$	-25	-50	mA
		$V_{ID} = -1\ \text{V}$	20	31	
$I_{CC}$ Supply current	$V_O = 0$ , No load		3.5	4.5	mA

**TLE214x, TLE214xA**  
**EXCALIBUR LOW-NOISE HIGH-SPEED**  
**PRECISION OPERATIONAL AMPLIFIERS**

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**TLE2142Y electrical characteristics at specified free-air temperature,  $V_{CC\pm} = \pm 15\text{ V}$ ,  $T_A = 25^\circ\text{C}$**

PARAMETER		TEST CONDITIONS	TLE2142Y			UNIT
			MIN	TYP	MAX	
$V_{IO}$	Input offset voltage	$V_{IC} = 0,$ $V_O = 0$ $R_S = 50\ \Omega,$		150	875	$\mu\text{V}$
$I_{IO}$	Input offset current			7	100	nA
$I_{IB}$	Input bias current			-0.7	-1.5	$\mu\text{A}$
$V_{ICR}$	Common-mode input voltage range	$R_S = 50\ \Omega$	-15 to 13	-15.3 to 13.2		V
$V_{OM+}$	Maximum positive peak output voltage swing	$I_O = -150\ \mu\text{A}$	13.8	14.1		V
		$I_O = -1.5\ \text{mA}$	13.7	14		
		$I_O = -15\ \text{mA}$	13.3	13.7		
$V_{OM-}$	Maximum negative peak output voltage swing	$I_O = 150\ \mu\text{A}$	-14.7	-14.9		V
		$I_O = 1.5\ \text{mA}$	-14.5	-14.8		
		$I_O = 15\ \text{mA}$	-13.4	-13.8		
$A_{VD}$	Large-signal differential voltage amplification	$V_O = \pm 10\ \text{V},$ $R_L = 2\ \text{k}\Omega$	100	450		V/mV
$r_i$	Input resistance			65		M $\Omega$
$c_i$	Input capacitance			2.5		pF
$z_o$	Open-loop output impedance	$f = 1\ \text{MHz}$		30		$\Omega$
CMRR	Common-mode rejection ratio	$V_{IC} = V_{ICRmin},$ $R_S = 50\ \Omega$	80	108		dB
$k_{SVR}$	Supply-voltage rejection ratio ( $\Delta V_{CC\pm} / \Delta V_{IO}$ )	$V_{CC\pm} = \pm 2.5\ \text{V to } \pm 15\ \text{V},$ $R_S = 50\ \Omega$	85	106		dB
$I_{OS}$	Short-circuit output current	$V_O = 0$	$V_{ID} = 1\ \text{V}$	-25	-50	mA
			$V_{ID} = -1\ \text{V}$	20	31	
$I_{CC}$	Supply current	$V_O = 0,$ No load		6.9	9	mA

# TLE214x, TLE214xA EXCALIBUR LOW-NOISE HIGH-SPEED PRECISION OPERATIONAL AMPLIFIERS

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## TLE2144Y electrical characteristics at $V_{CC\pm} = \pm 15\text{ V}$ , $T_A = 25^\circ\text{C}$ (unless otherwise noted)

PARAMETER	TEST CONDITIONS	TLE2144Y			UNIT
		MIN	TYP	MAX	
$V_{IO}$ Input offset voltage	$V_{IC} = 0$ , $V_O = 0$ $R_S = 50\ \Omega$ ,	0.3	1.8		mV
$I_{IO}$ Input offset current		7	100		nA
$I_{IB}$ Input bias current		-0.7	-1.5		$\mu\text{A}$
$V_{ICR}$ Common-mode input voltage range	$R_S = 50\ \Omega$	-15 to 13	-15.3 to 13.2		V
$V_{OM+}$ Maximum positive peak output voltage swing	$I_O = -150\ \mu\text{A}$	13.8	14.1		V
	$I_O = -1.5\ \text{mA}$	13.7	14		
	$I_O = -15\ \text{mA}$	13.3	13.7		
$V_{OM-}$ Maximum negative peak output voltage swing	$I_O = 150\ \mu\text{A}$	-14.7	-14.9		V
	$I_O = 1.5\ \text{mA}$	-14.5	-14.8		
	$I_O = 15\ \text{mA}$	-13.4	-13.8		
$A_{VD}$ Large-signal differential voltage amplification	$V_O = \pm 10\ \text{V}$ , $R_L = 2\ \text{k}\Omega$	100	450		V/mV
$r_i$ Input resistance		65			$\text{M}\Omega$
$c_i$ Input capacitance		2.5			pF
$z_o$ Open-loop output impedance	$f = 1\ \text{MHz}$	30			$\Omega$
CMRR Common-mode rejection ratio	$V_{IC} = V_{ICRmin}$ , $R_S = 50\ \Omega$	80	108		dB
$k_{SVR}$ Supply-voltage rejection ratio ( $\Delta V_{CC\pm} / \Delta V_{IO}$ )	$V_{CC\pm} = \pm 2.5\ \text{V}$ to $\pm 15\ \text{V}$ , $R_S = 50\ \Omega$	85	106		dB
$I_{OS}$ Short-circuit output current	$V_O = 0$	$V_{ID} = 1\ \text{V}$	-25	-50	mA
		$V_{ID} = -1\ \text{V}$	20	31	
$I_{CC}$ Supply current	$V_O = 0$ , No load	13.8	18		mA

## TYPICAL CHARACTERISTICS

**Table of Graphs**

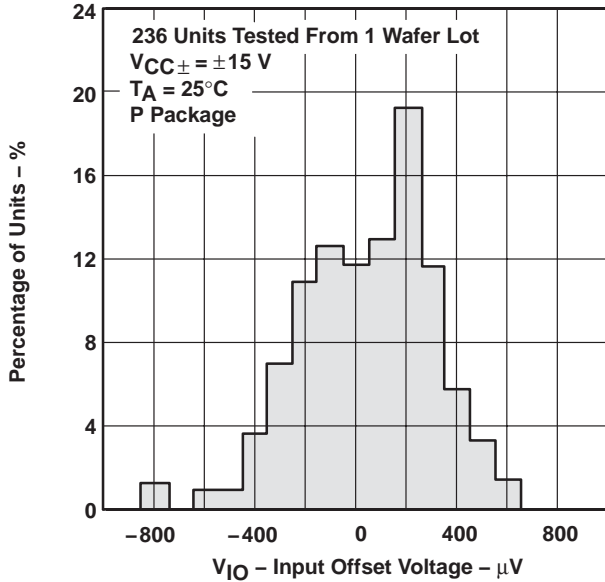
		<b>FIGURE</b>	
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**TLE214x, TLE214xA**  
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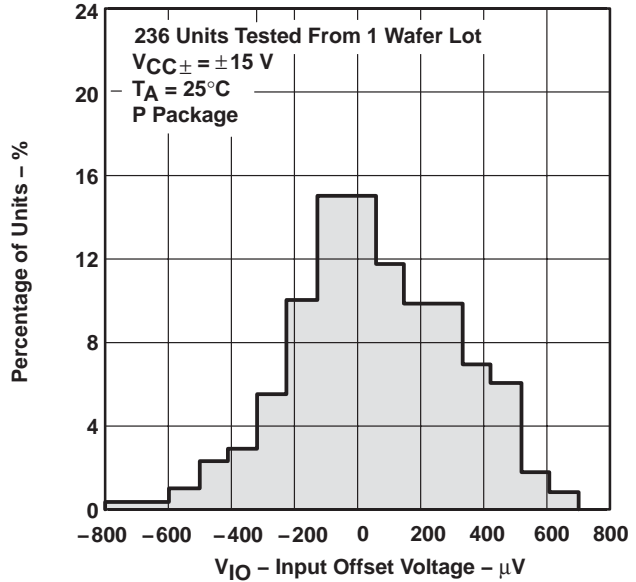
**TYPICAL CHARACTERISTICS**

**TLE2141**  
**DISTRIBUTION OF**  
**INPUT OFFSET VOLTAGE**



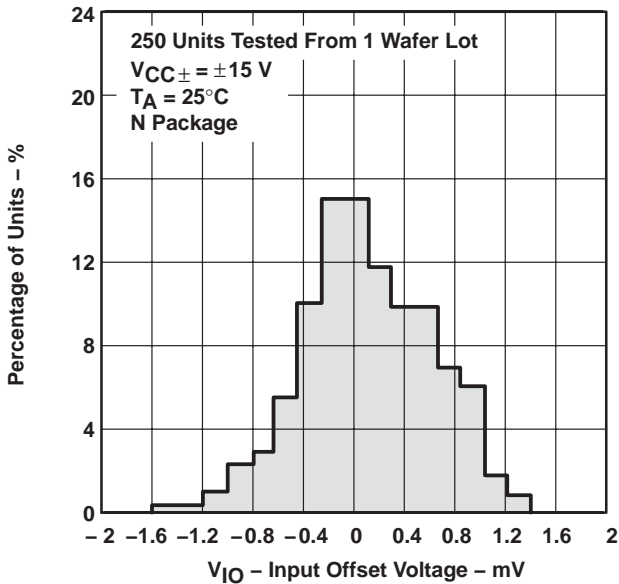
**Figure 1**

**TLE2142**  
**DISTRIBUTION OF**  
**INPUT OFFSET VOLTAGE**



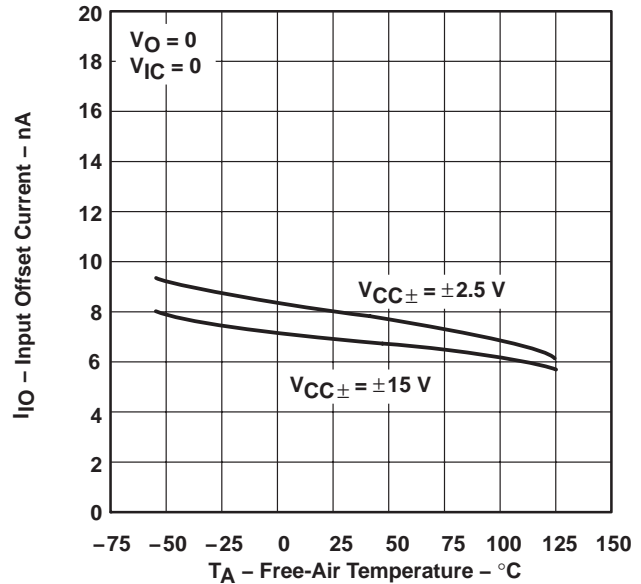
**Figure 2**

**TLE2144**  
**DISTRIBUTION OF**  
**INPUT OFFSET VOLTAGE**



**Figure 3**

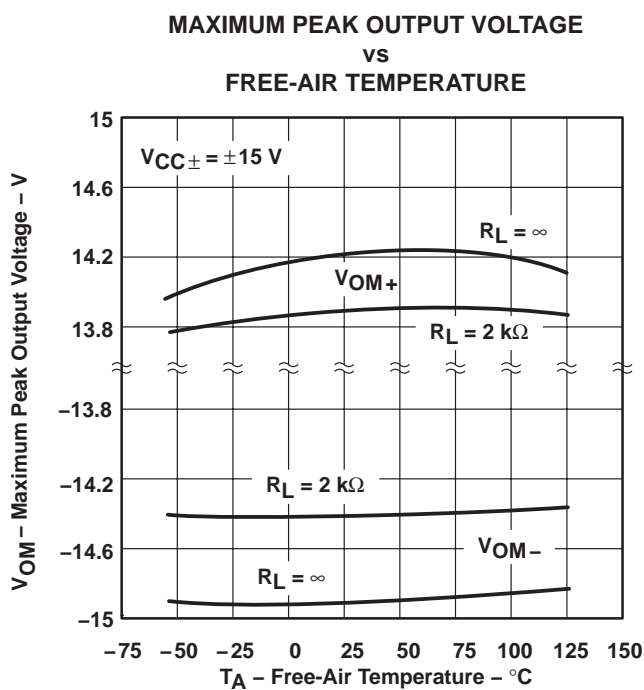
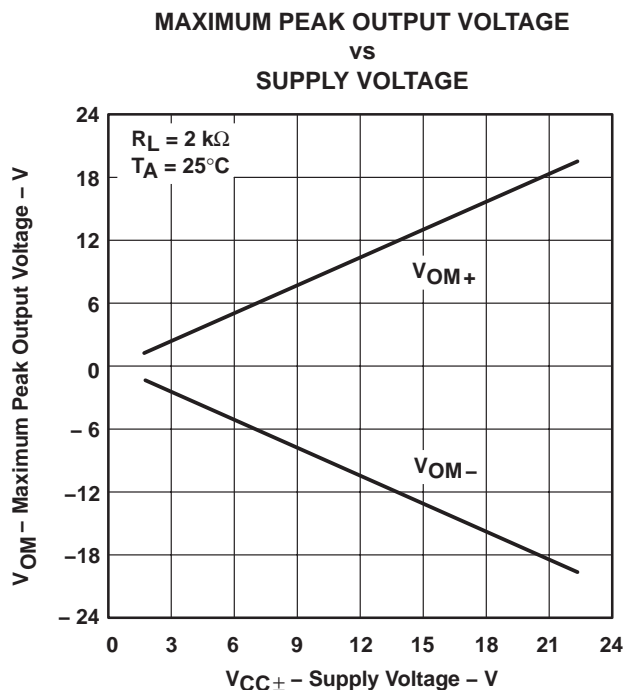
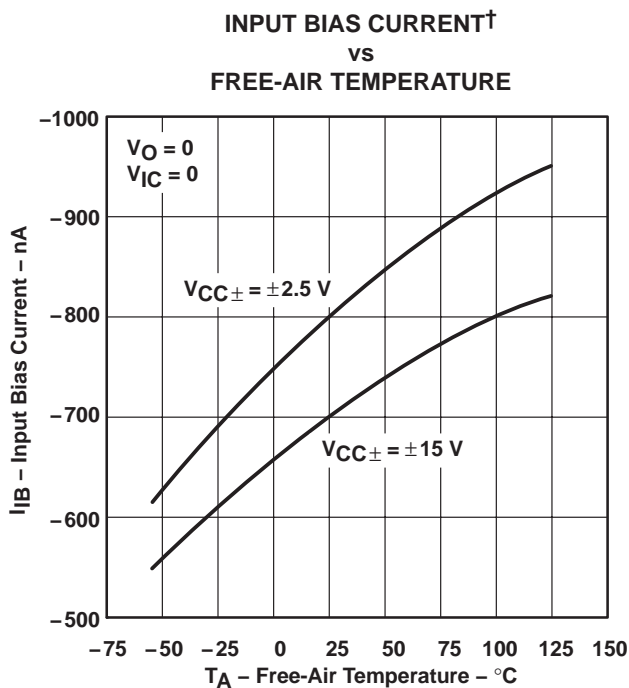
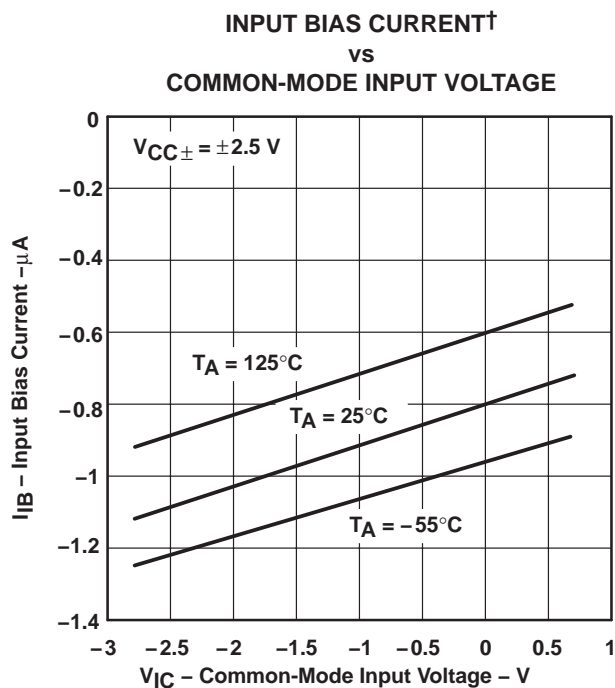
**INPUT OFFSET CURRENT†**  
**VS**  
**FREE-AIR TEMPERATURE**



**Figure 4**

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

TYPICAL CHARACTERISTICS



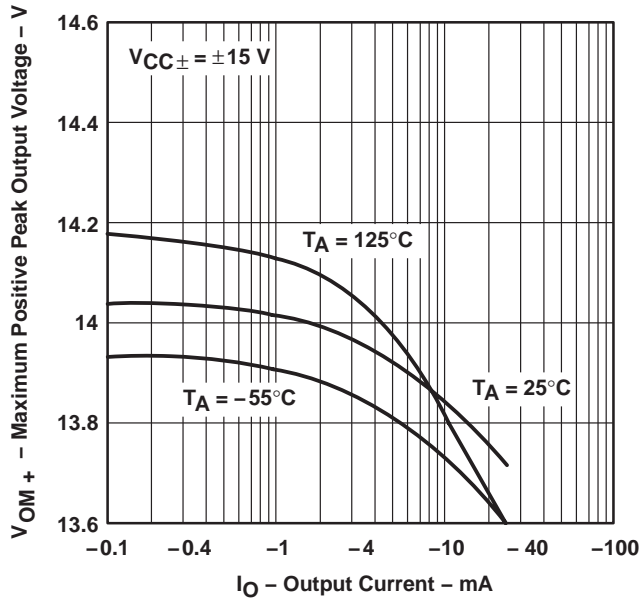
† Data at high and low temperatures are applicable only within the rated operating free-air temperature ranges of the various devices.

**TLE214x, TLE214xA**  
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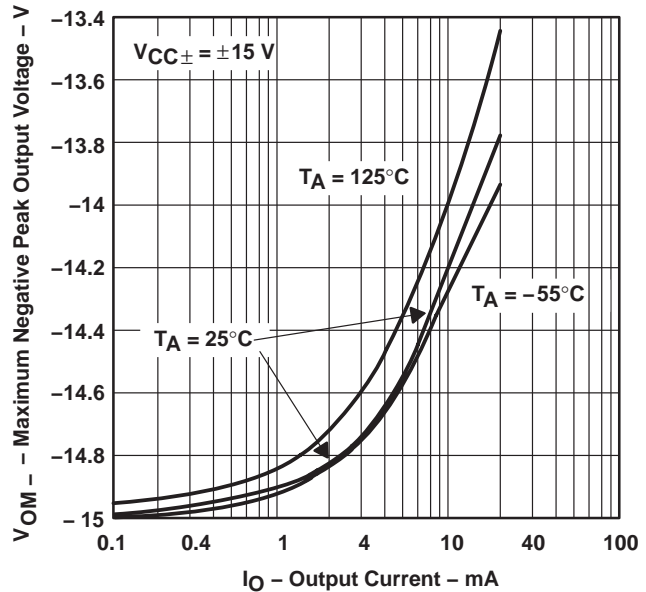
**TYPICAL CHARACTERISTICS**

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



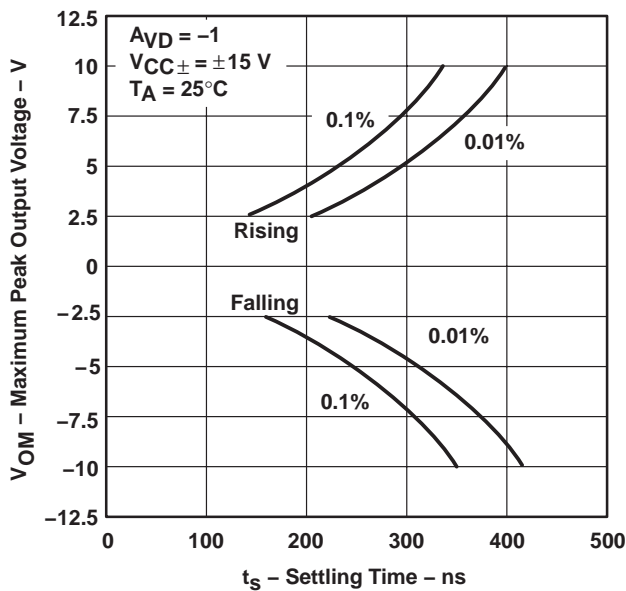
**Figure 9**

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



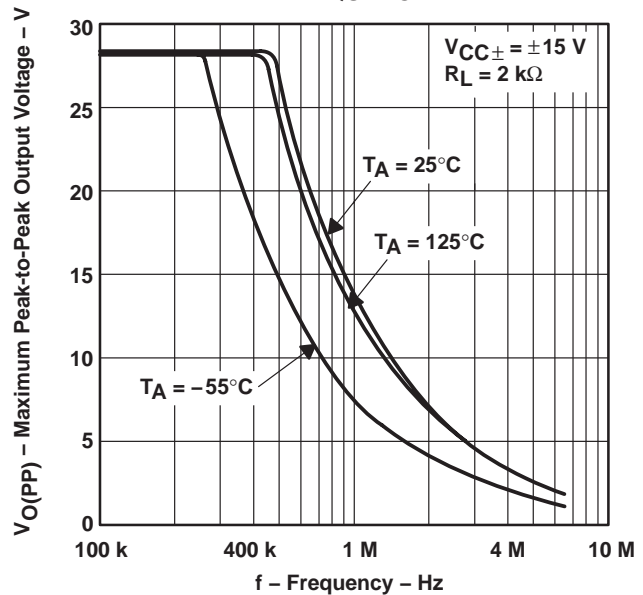
**Figure 10**

**MAXIMUM PEAK OUTPUT VOLTAGE**  
**vs**  
**SETTLING TIME**



**Figure 11**

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



**Figure 12**

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





**TYPICAL CHARACTERISTICS**

**HIGH-LEVEL OUTPUT VOLTAGE†  
 vs  
 OUTPUT CURRENT**

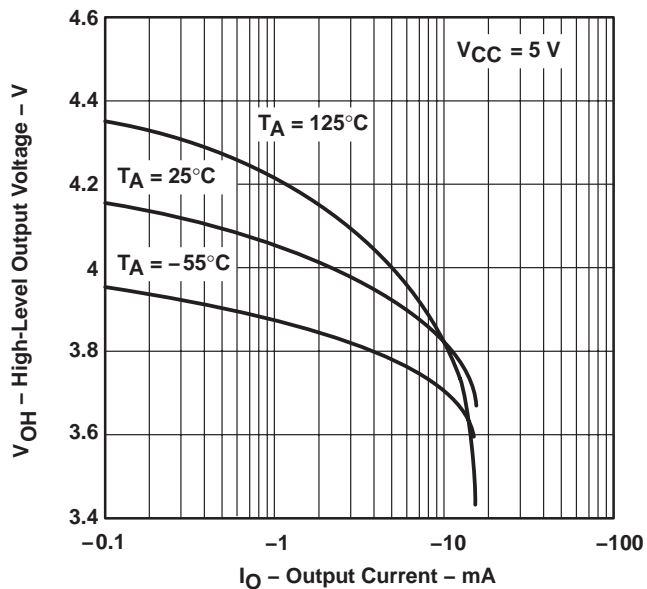


Figure 13

**LOW-LEVEL OUTPUT VOLTAGE†  
 vs  
 OUTPUT CURRENT**

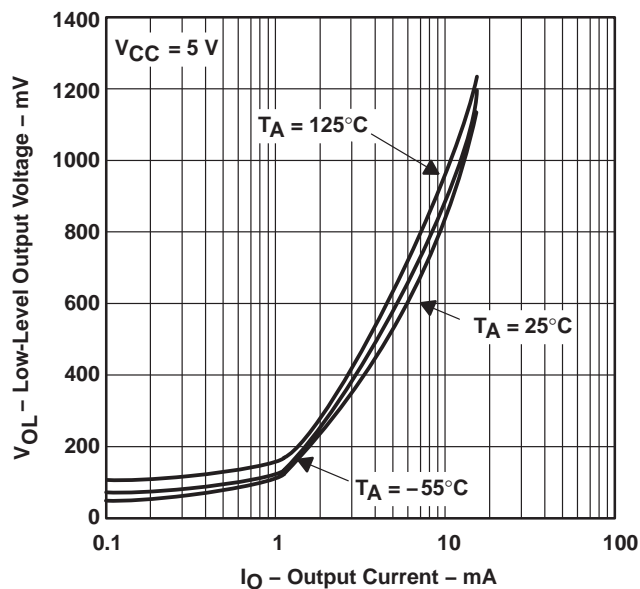


Figure 14

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

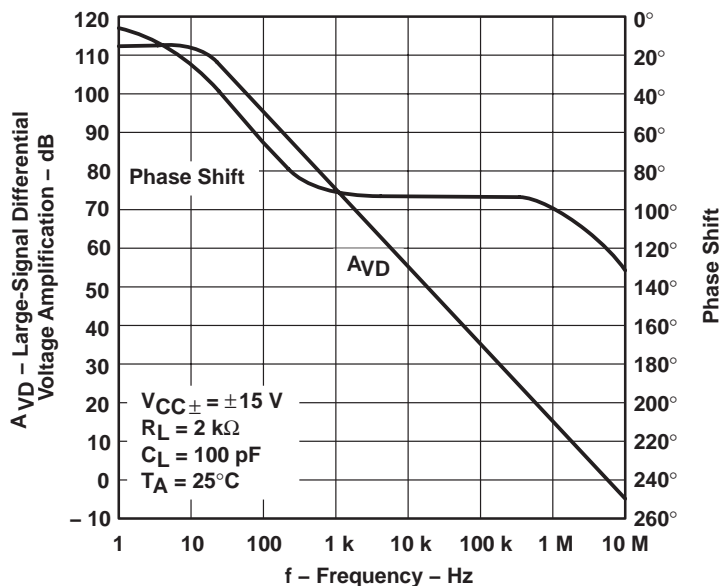


Figure 15

† 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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**EXCALIBUR LOW-NOISE HIGH-SPEED**  
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**TYPICAL CHARACTERISTICS**

**LARGE-SIGNAL DIFFERENTIAL VOLTAGE AMPLIFICATION†**

vs

**FREE-AIR TEMPERATURE**

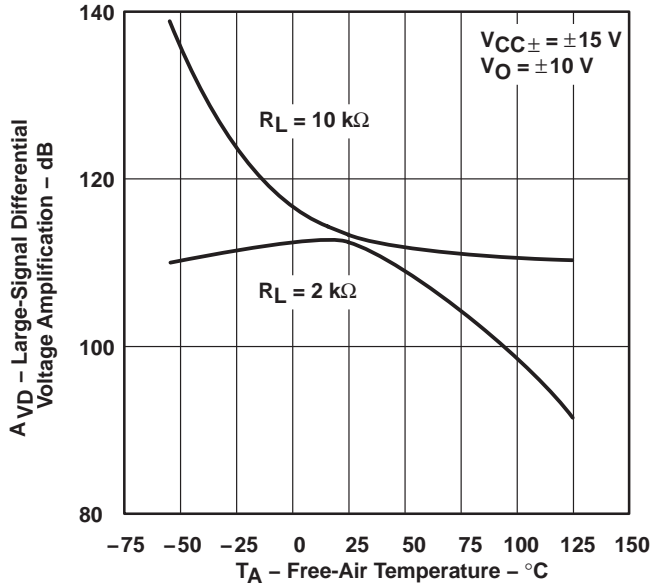


Figure 16

**CLOSED-LOOP OUTPUT IMPEDANCE**

vs

**FREQUENCY**

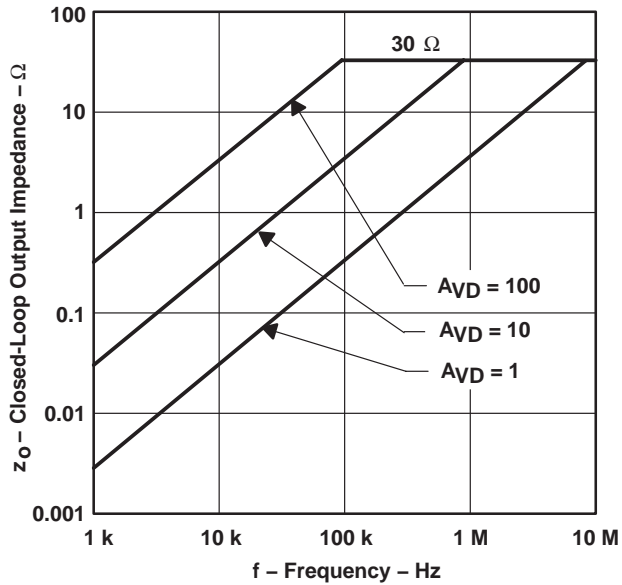


Figure 17

**SHORT-CIRCUIT OUTPUT CURRENT†**

vs

**FREE-AIR TEMPERATURE**

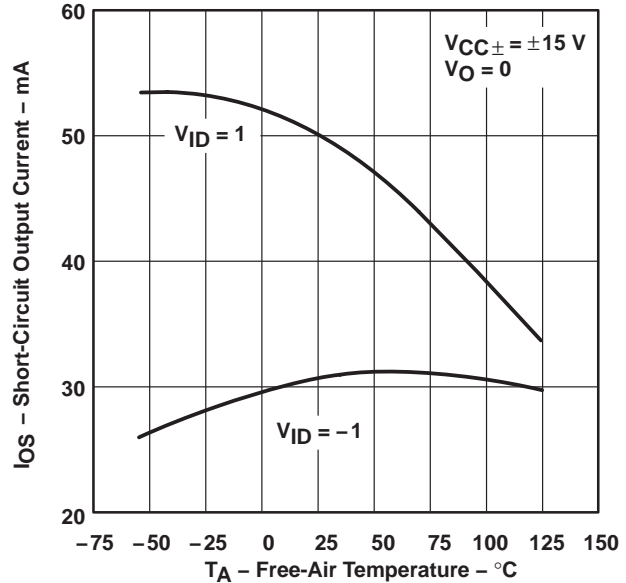
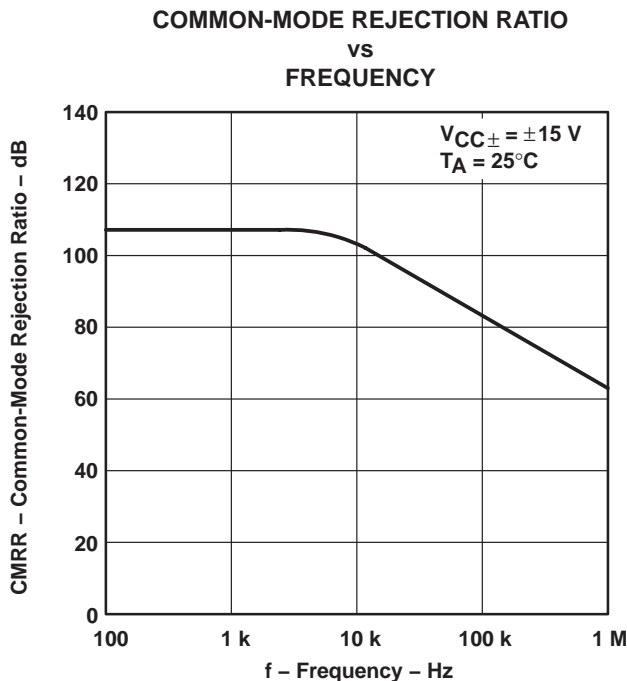


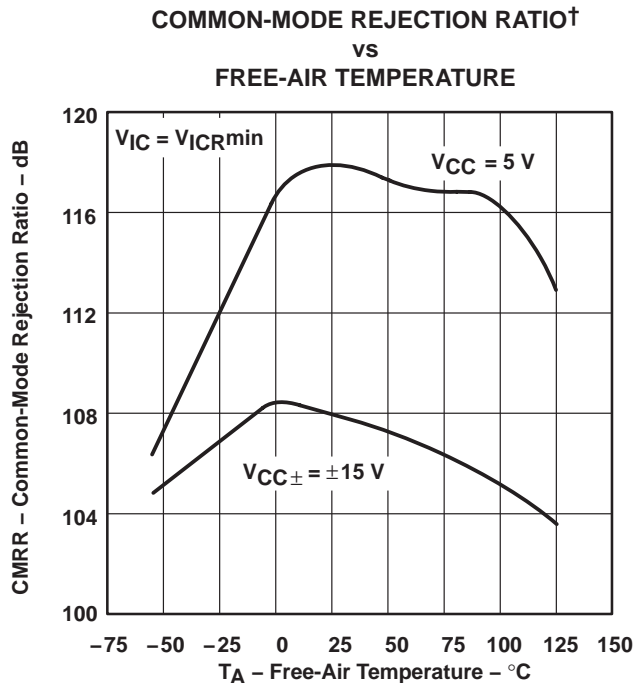
Figure 18

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

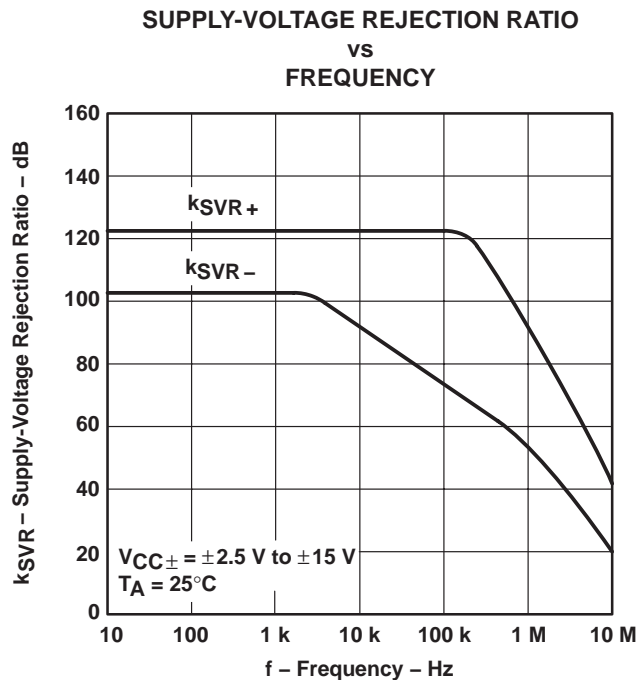
**TYPICAL CHARACTERISTICS**



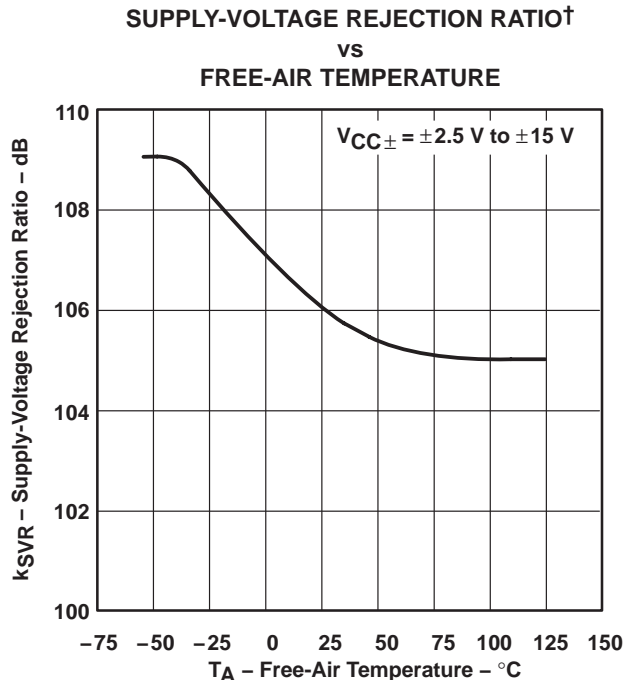
**Figure 19**



**Figure 20**



**Figure 21**



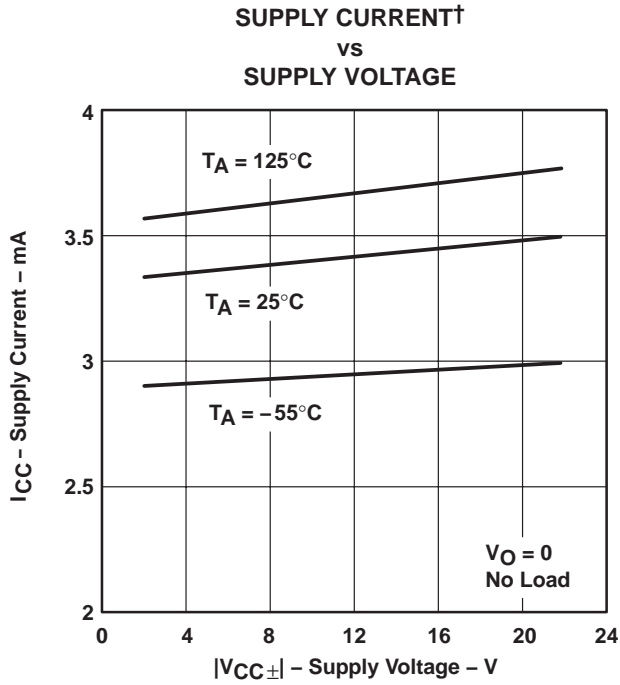
**Figure 22**

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

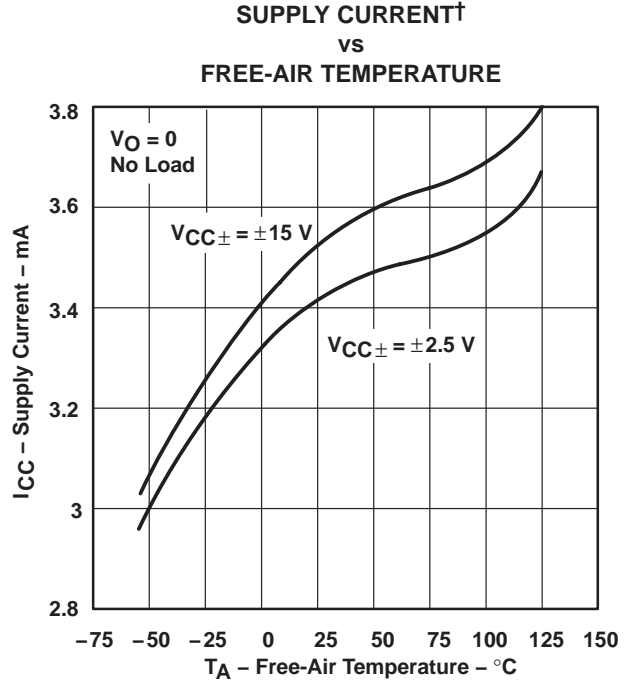
**TLE214x, TLE214xA**  
**EXCALIBUR LOW-NOISE HIGH-SPEED**  
**PRECISION OPERATIONAL AMPLIFIERS**

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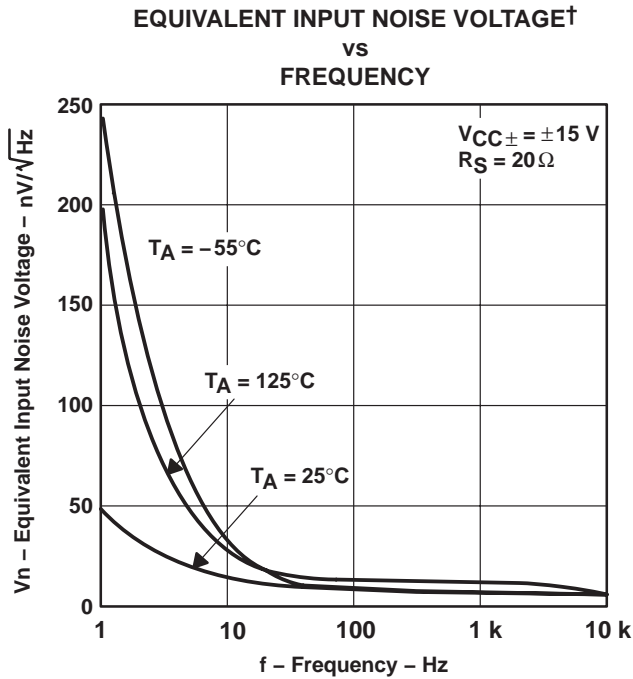
**TYPICAL CHARACTERISTICS**



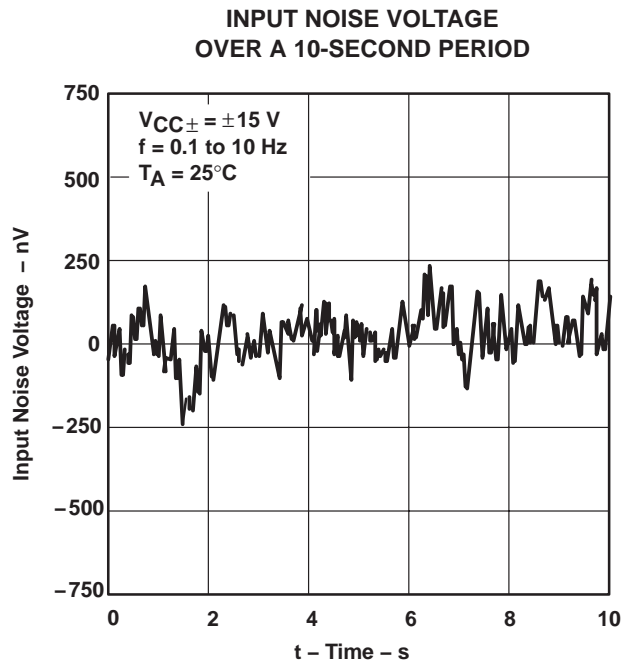
**Figure 23**



**Figure 24**



**Figure 25**

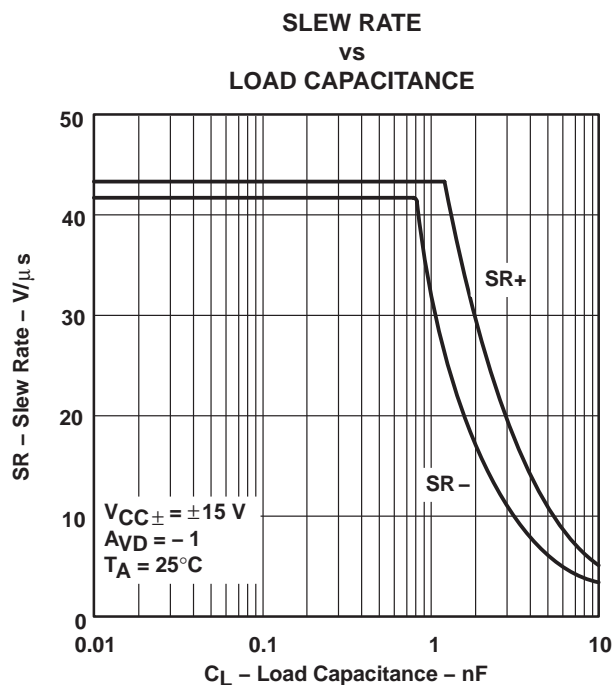
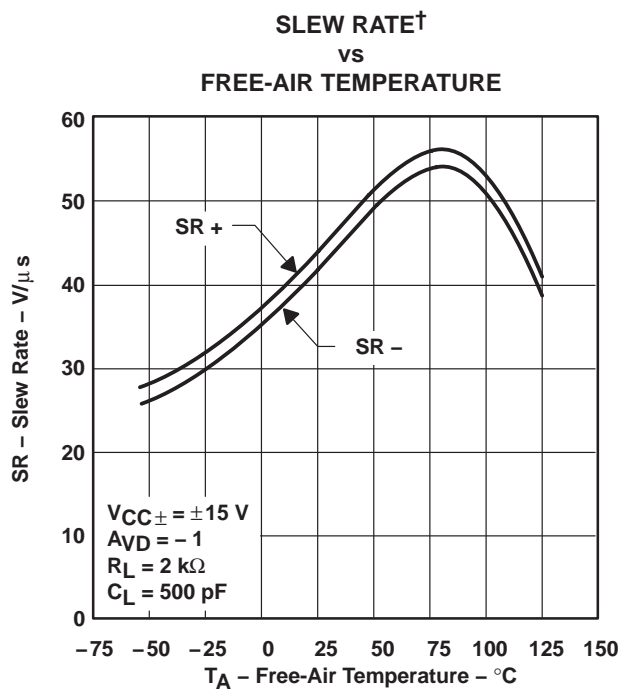
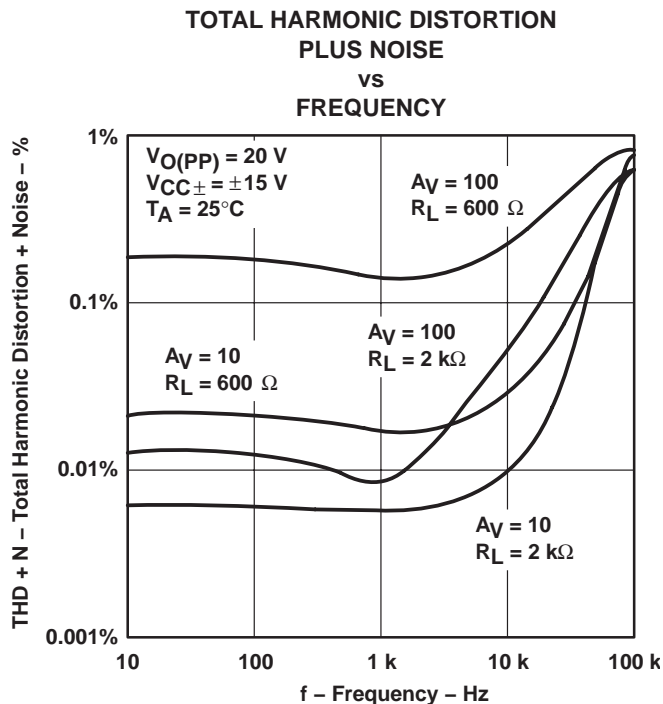
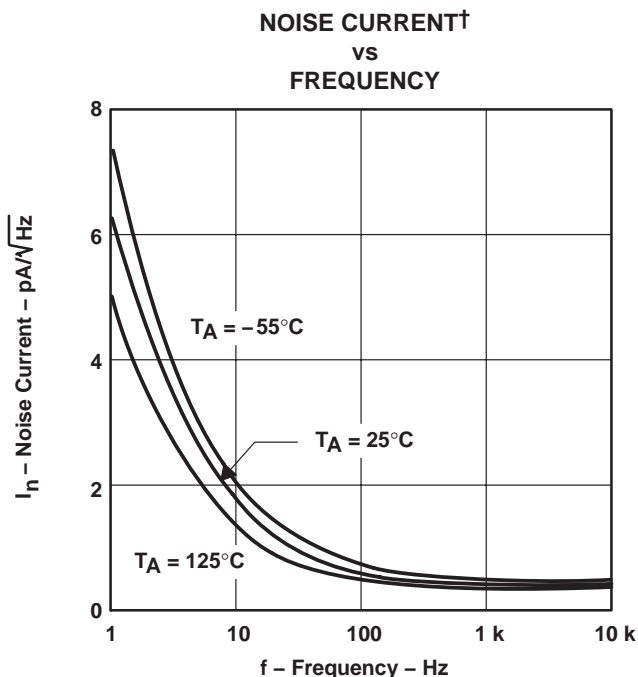


**Figure 26**

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



TYPICAL CHARACTERISTICS

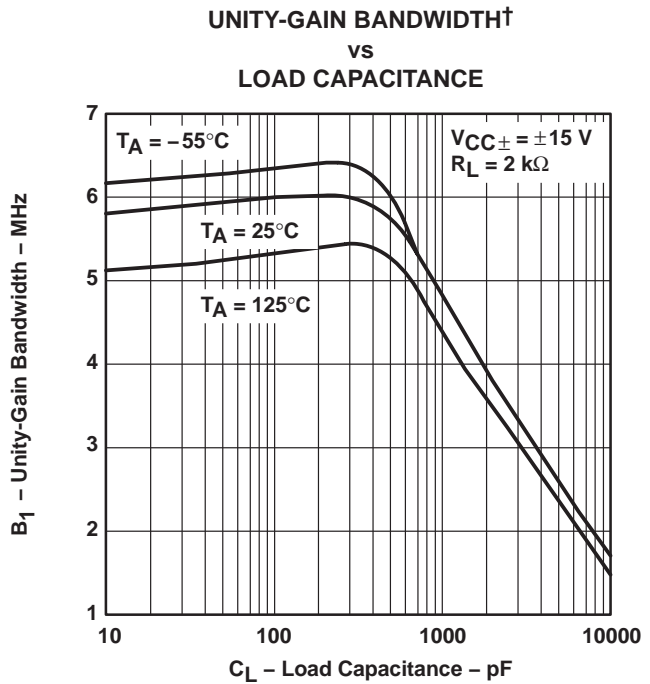
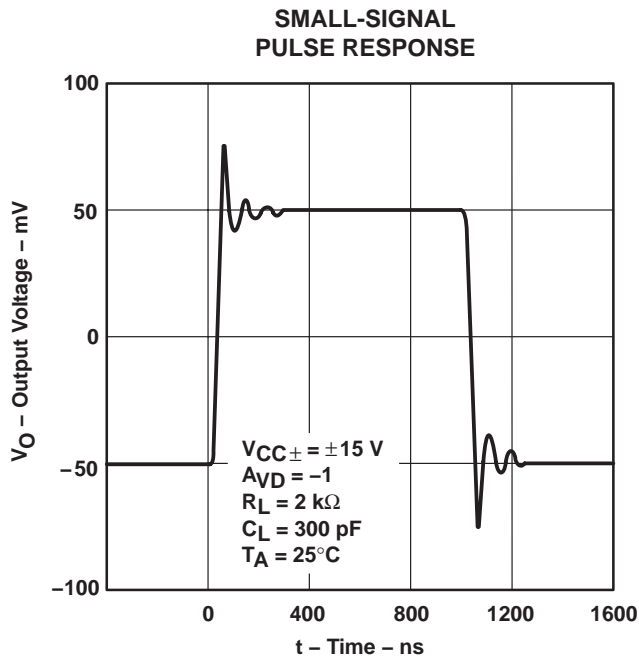
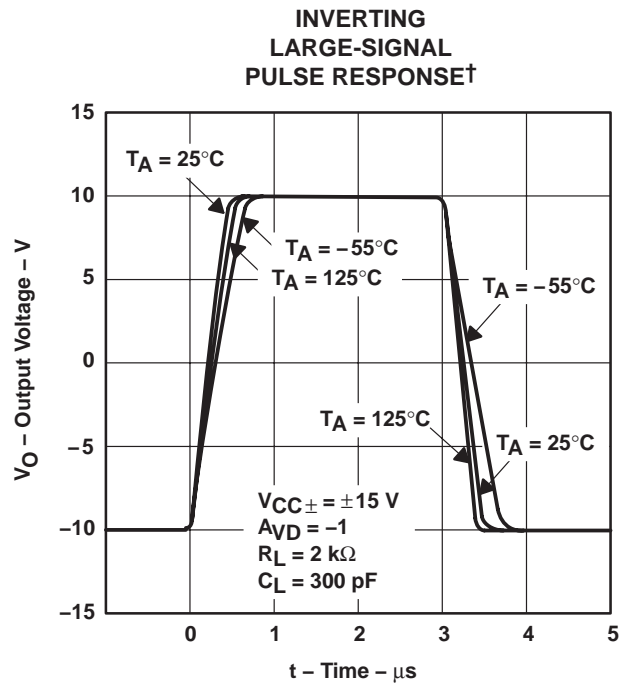
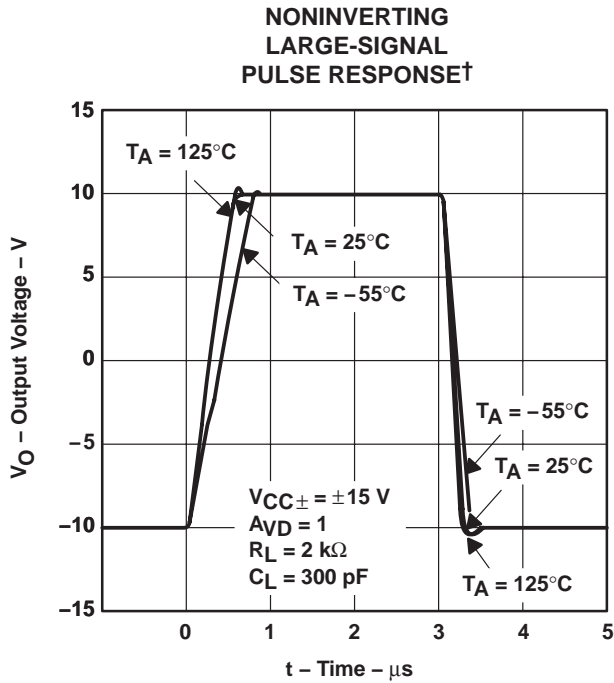


† Data at high and low temperatures are applicable only within the rated operating free-air temperature ranges of the various devices.

**TLE214x, TLE214xA**  
**EXCALIBUR LOW-NOISE HIGH-SPEED**  
**PRECISION OPERATIONAL AMPLIFIERS**

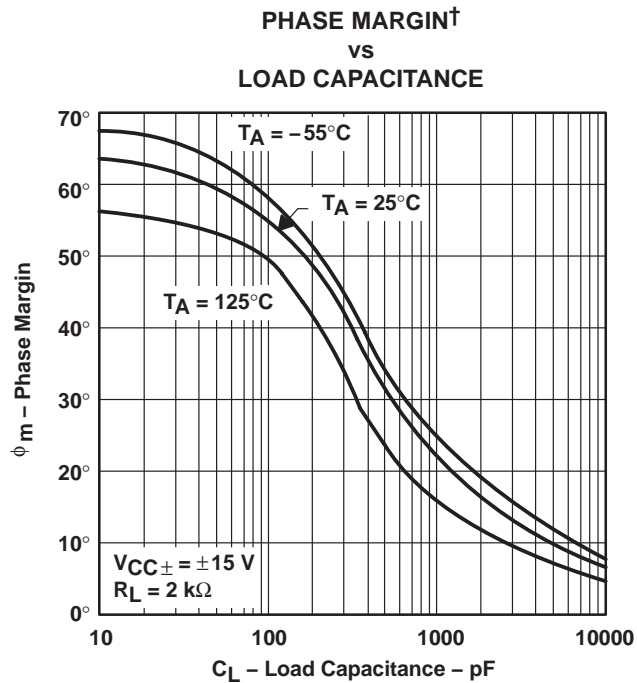
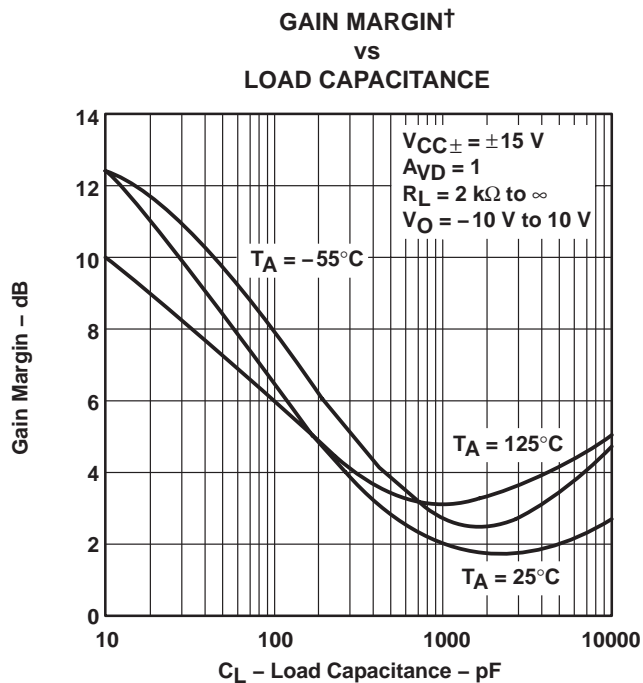
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**TYPICAL CHARACTERISTICS**



† 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.

# TLE214x, TLE214xA EXCALIBUR LOW-NOISE HIGH-SPEED PRECISION OPERATIONAL AMPLIFIERS

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## APPLICATION INFORMATION

### input offset voltage nulling

The TLE2141 series offers external null pins that can be used to further reduce the input offset voltage. If this feature is desired, connect the circuit of Figure 37 as shown. If external nulling is not needed, the null pins may be left unconnected.

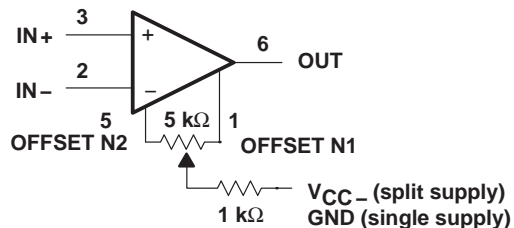


Figure 37. Input Offset Voltage Null Circuit



**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>
5962-9321601QPA	ACTIVE	CDIP	JG	8	1	None	A42 SNPB	Level-NC-NC-NC
5962-9321602QPA	ACTIVE	CDIP	JG	8	1	None	A42 SNPB	Level-NC-NC-NC
5962-9321603Q2A	ACTIVE	LCCC	FK	20	1	None	POST-PLATE	Level-NC-NC-NC
5962-9321603QHA	ACTIVE	CFP	U	10	1	None	A42 SNPB	Level-NC-NC-NC
5962-9321603QPA	ACTIVE	CDIP	JG	8	1	None	A42 SNPB	Level-NC-NC-NC
5962-9321604Q2A	ACTIVE	LCCC	FK	20	1	None	POST-PLATE	Level-NC-NC-NC
5962-9321604QHA	ACTIVE	CFP	U	10	1	None	A42 SNPB	Level-NC-NC-NC
5962-9321604QPA	ACTIVE	CDIP	JG	8	1	None	A42 SNPB	Level-NC-NC-NC
5962-9321605Q2A	ACTIVE	LCCC	FK	20	1	None	POST-PLATE	Level-NC-NC-NC
5962-9321605QCA	ACTIVE	CDIP	J	14	1	None	A42 SNPB	Level-NC-NC-NC
5962-9321606Q2A	ACTIVE	LCCC	FK	20	1	None	POST-PLATE	Level-NC-NC-NC
5962-9321606QCA	ACTIVE	CDIP	J	14	1	None	A42 SNPB	Level-NC-NC-NC
TLE2141ACD	ACTIVE	SOIC	D	8	75	Pb-Free (RoHS)	CU NIPDAU	Level-2-260C-1YEAR/ Level-1-220C-UNLIM
TLE2141ACP	ACTIVE	PDIP	P	8	50	Pb-Free (RoHS)	CU NIPDAU	Level-NC-NC-NC
TLE2141AID	ACTIVE	SOIC	D	8	75	Pb-Free (RoHS)	CU NIPDAU	Level-2-260C-1YEAR/ Level-1-220C-UNLIM
TLE2141AIDR	ACTIVE	SOIC	D	8	2500	Pb-Free (RoHS)	CU NIPDAU	Level-2-260C-1YEAR/ Level-1-220C-UNLIM
TLE2141AIP	ACTIVE	PDIP	P	8	50	Pb-Free (RoHS)	CU NIPDAU	Level-NC-NC-NC
TLE2141AMFKB	OBSOLETE	LCCC	FK	20		None	POST-PLATE	Level-NC-NC-NC
TLE2141AMJGB	ACTIVE	CDIP	JG	8	1	None	A42 SNPB	Level-NC-NC-NC
TLE2141CD	ACTIVE	SOIC	D	8	75	Pb-Free (RoHS)	CU NIPDAU	Level-2-260C-1YEAR/ Level-1-220C-UNLIM
TLE2141CDR	ACTIVE	SOIC	D	8	2500	Pb-Free (RoHS)	CU NIPDAU	Level-2-260C-1YEAR/ Level-1-220C-UNLIM
TLE2141CP	ACTIVE	PDIP	P	8	50	Pb-Free (RoHS)	CU NIPDAU	Level-NC-NC-NC
TLE2141ID	ACTIVE	SOIC	D	8	75	Pb-Free (RoHS)	CU NIPDAU	Level-2-260C-1YEAR/ Level-1-220C-UNLIM
TLE2141IDR	ACTIVE	SOIC	D	8	2500	Pb-Free (RoHS)	CU NIPDAU	Level-2-260C-1YEAR/ Level-1-220C-UNLIM
TLE2141IP	ACTIVE	PDIP	P	8	50	Pb-Free (RoHS)	CU NIPDAU	Level-NC-NC-NC
TLE2141MD	ACTIVE	SOIC	D	8	75	None	CU NIPDAU	Level-1-220C-UNLIM
TLE2141MDR	ACTIVE	SOIC	D	8	2500	None	CU NIPDAU	Level-1-220C-UNLIM
TLE2141MFKB	OBSOLETE	LCCC	FK	20		None	POST-PLATE	Level-NC-NC-NC
TLE2141MJGB	ACTIVE	CDIP	JG	8	1	None	A42 SNPB	Level-NC-NC-NC
TLE2142ACD	ACTIVE	SOIC	D	8	75	Pb-Free (RoHS)	CU NIPDAU	Level-2-260C-1YEAR/ Level-1-220C-UNLIM
TLE2142ACDR	ACTIVE	SOIC	D	8	2500	Pb-Free (RoHS)	CU NIPDAU	Level-2-260C-1YEAR/ Level-1-220C-UNLIM
TLE2142ACP	OBSOLETE	PDIP	P	8		None	Call TI	Call TI
TLE2142AID	ACTIVE	SOIC	D	8	75	Pb-Free	CU NIPDAU	Level-2-260C-1YEAR/

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>
						(RoHS)		Level-1-220C-UNLIM
TLE2142AIDR	ACTIVE	SOIC	D	8	2500	Pb-Free (RoHS)	CU NIPDAU	Level-2-260C-1YEAR/ Level-1-220C-UNLIM
TLE2142AIP	OBSOLETE	PDIP	P	8		None	Call TI	Call TI
TLE2142AMD	ACTIVE	SOIC	D	8	75	None	CU NIPDAU	Level-1-220C-UNLIM
TLE2142AMDR	ACTIVE	SOIC	D	8	2500	None	CU NIPDAU	Level-1-220C-UNLIM
TLE2142AMFKB	ACTIVE	LCCC	FK	20	1	None	POST-PLATE	Level-NC-NC-NC
TLE2142AMJGB	ACTIVE	CDIP	JG	8	1	None	A42 SNPB	Level-NC-NC-NC
TLE2142AMUB	ACTIVE	CFP	U	10	1	None	A42 SNPB	Level-NC-NC-NC
TLE2142CD	ACTIVE	SOIC	D	8	75	Pb-Free (RoHS)	CU NIPDAU	Level-2-260C-1YEAR/ Level-1-220C-UNLIM
TLE2142CDR	ACTIVE	SOIC	D	8	2500	Pb-Free (RoHS)	CU NIPDAU	Level-2-260C-1YEAR/ Level-1-220C-UNLIM
TLE2142CP	ACTIVE	PDIP	P	8	50	Pb-Free (RoHS)	CU NIPDAU	Level-NC-NC-NC
TLE2142CPW	ACTIVE	TSSOP	PW	16	90	None	CU NIPDAU	Level-1-220C-UNLIM
TLE2142CPWLE	OBSOLETE	TSSOP	PW	16		None	Call TI	Call TI
TLE2142CPWR	ACTIVE	TSSOP	PW	16	2000	None	CU NIPDAU	Level-1-220C-UNLIM
TLE2142ID	ACTIVE	SOIC	D	8	75	Pb-Free (RoHS)	CU NIPDAU	Level-2-260C-1YEAR/ Level-1-220C-UNLIM
TLE2142IDR	ACTIVE	SOIC	D	8	2500	Pb-Free (RoHS)	CU NIPDAU	Level-2-260C-1YEAR/ Level-1-220C-UNLIM
TLE2142IP	ACTIVE	PDIP	P	8	50	Pb-Free (RoHS)	CU NIPDAU	Level-NC-NC-NC
TLE2142MD	ACTIVE	SOIC	D	8	75	None	CU NIPDAU	Level-1-220C-UNLIM
TLE2142MDR	ACTIVE	SOIC	D	8	2500	None	CU NIPDAU	Level-1-220C-UNLIM
TLE2142MFKB	ACTIVE	LCCC	FK	20	1	None	POST-PLATE	Level-NC-NC-NC
TLE2142MJGB	ACTIVE	CDIP	JG	8	1	None	A42 SNPB	Level-NC-NC-NC
TLE2142MUB	ACTIVE	CFP	U	10	1	None	A42 SNPB	Level-NC-NC-NC
TLE2144ACN	ACTIVE	PDIP	N	14	25	Pb-Free (RoHS)	CU NIPDAU	Level-NC-NC-NC
TLE2144AIN	ACTIVE	PDIP	N	14	25	Pb-Free (RoHS)	CU NIPDAU	Level-NC-NC-NC
TLE2144AMFKB	ACTIVE	LCCC	FK	20	1	None	POST-PLATE	Level-NC-NC-NC
TLE2144AMJB	ACTIVE	CDIP	J	14	1	None	A42 SNPB	Level-NC-NC-NC
TLE2144CDW	ACTIVE	SOIC	DW	16	40	Pb-Free (RoHS)	CU NIPDAU	Level-2-250C-1YEAR/ Level-1-220C-UNLIM
TLE2144CDWR	ACTIVE	SOIC	DW	16	2000	Pb-Free (RoHS)	CU NIPDAU	Level-2-250C-1YEAR/ Level-1-220C-UNLIM
TLE2144CN	ACTIVE	PDIP	N	14	25	Pb-Free (RoHS)	CU NIPDAU	Level-NC-NC-NC
TLE2144IDW	ACTIVE	SOIC	DW	16	40	Pb-Free (RoHS)	CU NIPDAU	Level-2-250C-1YEAR/ Level-1-220C-UNLIM
TLE2144IDWR	ACTIVE	SOIC	DW	16	2000	Pb-Free (RoHS)	CU NIPDAU	Level-2-250C-1YEAR/ Level-1-220C-UNLIM
TLE2144IN	ACTIVE	PDIP	N	14	25	Pb-Free (RoHS)	CU NIPDAU	Level-NC-NC-NC
TLE2144MDW	ACTIVE	SOIC	DW	16	40	None	CU NIPDAU	Level-1-220C-UNLIM

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>
TLE2144MFKB	ACTIVE	LCCC	FK	20	1	None	POST-PLATE	Level-NC-NC-NC
TLE2144MJB	ACTIVE	CDIP	J	14	1	None	A42 SNPB	Level-NC-NC-NC
TLE2144MN	OBSOLETE	PDIP	N	14		None	Call TI	Call TI

<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 - May not be currently available - please check <http://www.ti.com/productcontent> for the latest availability information and additional product content details.

**None:** Not yet available Lead (Pb-Free).

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

**Green (RoHS & no Sb/Br):** TI defines "Green" to mean "Pb-Free" and in addition, uses package materials that do not contain halogens, including bromine (Br) or antimony (Sb) above 0.1% of total product weight.

<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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Data Converters	<a href="http://dataconverter.ti.com">dataconverter.ti.com</a>	Automotive	<a href="http://www.ti.com/automotive">www.ti.com/automotive</a>
DSP	<a href="http://dsp.ti.com">dsp.ti.com</a>	Broadband	<a href="http://www.ti.com/broadband">www.ti.com/broadband</a>
Interface	<a href="http://interface.ti.com">interface.ti.com</a>	Digital Control	<a href="http://www.ti.com/digitalcontrol">www.ti.com/digitalcontrol</a>
Logic	<a href="http://logic.ti.com">logic.ti.com</a>	Military	<a href="http://www.ti.com/military">www.ti.com/military</a>
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