

# TLC227x, TLC227xA Advanced LinCMOS™ RAIL-TO-RAIL OPERATIONAL AMPLIFIERS

SLOS190G – FEBRUARY 1997 – REVISED MAY 2004

- Output Swing Includes Both Supply Rails
- Low Noise . . . 9 nV/√Hz Typ at f = 1 kHz
- Low Input Bias Current . . . 1 pA Typ
- Fully Specified for Both Single-Supply and Split-Supply Operation
- Common-Mode Input Voltage Range Includes Negative Rail
- High-Gain Bandwidth . . . 2.2 MHz Typ
- High Slew Rate . . . 3.6 V/μs Typ
- Low Input Offset Voltage  
950 μV Max at T<sub>A</sub> = 25°C
- Macromodel Included
- Performance Upgrades for the TS272, TS274, TLC272, and TLC274
- Available in Q-Temp Automotive HighRel Automotive Applications Configuration Control / Print Support Qualification to Automotive Standards

## description

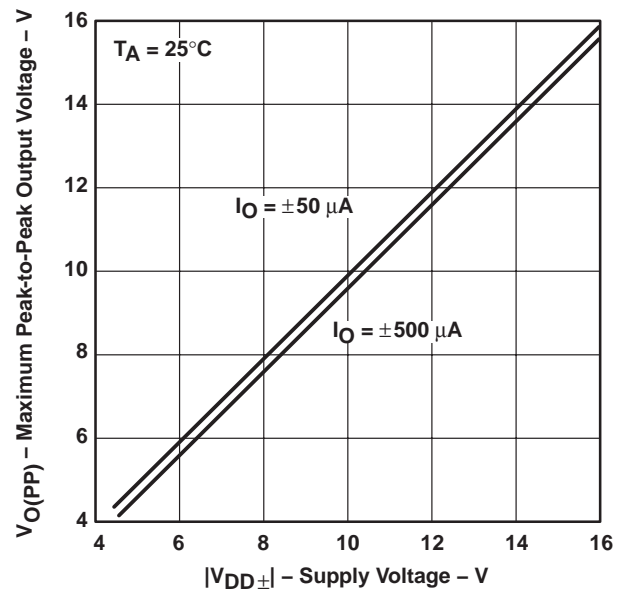
The TLC2272 and TLC2274 are dual and quadruple operational amplifiers from Texas Instruments. Both devices exhibit rail-to-rail output performance for increased dynamic range in single- or split-supply applications. The TLC227x family offers 2 MHz of bandwidth and 3 V/μs of slew rate for higher speed applications. These devices offer comparable ac performance while having better noise, input offset voltage, and power dissipation than existing CMOS operational amplifiers. The TLC227x has a noise voltage of 9 nV/√Hz, two times lower than competitive solutions.

The TLC227x, exhibiting high input impedance and low noise, is excellent for small-signal conditioning for high-impedance sources, such as piezoelectric transducers. Because of the micro-power dissipation levels, these devices work well in hand-held monitoring and remote-sensing applications. In addition, the rail-to-rail output feature, with single- or split-supplies, makes this family a great choice when interfacing with analog-to-digital converters (ADCs). For precision applications, the TLC227xA family is available with a maximum input offset voltage of 950 μV. This family is fully characterized at 5 V and ±5 V.

The TLC2272/4 also makes great upgrades to the TLC272/4 or TS272/4 in standard designs. They offer increased output dynamic range, lower noise voltage, and lower input offset voltage. This enhanced feature set allows them to be used in a wider range of applications. For applications that require higher output drive and wider input voltage range, see the TLV2432 and TLV2442 devices.

If the design requires single amplifiers, see the TLV2211/21/31 family. These devices are single rail-to-rail operational amplifiers in the SOT-23 package. Their small size and low power consumption, make them ideal for high density, battery-powered equipment.

MAXIMUM PEAK-TO-PEAK OUTPUT VOLTAGE  
VS  
SUPPLY VOLTAGE



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 **TEXAS  
INSTRUMENTS**

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# TLC227x, TLC227xA

## Advanced LinCMOS™ RAIL-TO-RAIL OPERATIONAL AMPLIFIERS

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### TLC2272 AVAILABLE OPTIONS

T <sub>A</sub>	V <sub>IOMAX</sub> At 25°C	PACKAGED DEVICES					
		SMALL OUTLINE† (D)	CERAMIC LCC (FK)	CERAMIC DIP (JG)	PLASTIC DIP (P)	TSSOP‡ (PW)	CERAMIC FLAT PACK (U)
0°C to 70°C	950 μV 2.5 mV	TLC2272ACD TLC2272CD	— —	— —	TLC2272ACP TLC2272CP	TLC2272ACPW TLC2272CPW	— —
-40°C to 125°C	950 μV 2.5 mV	TLC2272AID TLC2272ID	— —	— —	TLC2272AIP TLC2272IP	— TLC2272IPW	— —
	950 μV 2.5 mV	TLC2272AQD TLC2272QD	— —	— —	—	TLC2272AQPW TLC2272QPW	— —
-55°C to 125°C	950 μV 2.5 mV	TLC2272AMD TLC2272MD	TLC2272AMFK TLC2272MFK	TLC2272AMJG TLC2272MJG	TLC2272AMP TLC2272MP	—	TLC2272AMU TLC2272MU

† The D packages are available taped and reeled. Add R suffix to the device type (e.g., TLC2272CDR).

‡ The PW package is available taped and reeled. Add R suffix to the device type (e.g., TLC2272PWR).

§ Chips are tested at 25°C.

### TLC2274 AVAILABLE OPTIONS

T <sub>A</sub>	V <sub>IOMAX</sub> AT 25°C	PACKAGED DEVICES					
		SMALL OUTLINE† (D)	CERAMIC LCC (FK)	CERAMIC DIP (J)	PLASTIC DIP (N)	TSSOP‡ (PW)	CERAMIC FLAT PACK (W)
0°C to 70°C	950 μV 2.5 mV	TLC2274ACD TLC2274CD	—	—	TLC2274ACN TLC2274CN	TLC2274ACPW TLC2274CPW	—
-40°C to 125°C	950 μV 2.5 mV	TLC2274AID TLC2274ID	—	—	TLC2274AIN TLC2274IN	TLC2274AIPW TLC2274IPW	—
	950 μV 2.5 mV	TLC2274AQD TLC2274QD	—	—	—	—	—
-55°C to 125°C	950 μV 2.5 mV	TLC2274AMD TLC2274MD	TLC2274AMFK TLC2274MFK	TLC2274AMJ TLC2274MJ	TLC2274AMN TLC2274MN	—	TLC2274AMW TLC2274MW

† The D packages are available taped and reeled. Add R suffix to device type (e.g., TLC2274CDR).

‡ The PW package is available taped and reeled.

§ Chips are tested at 25°C.

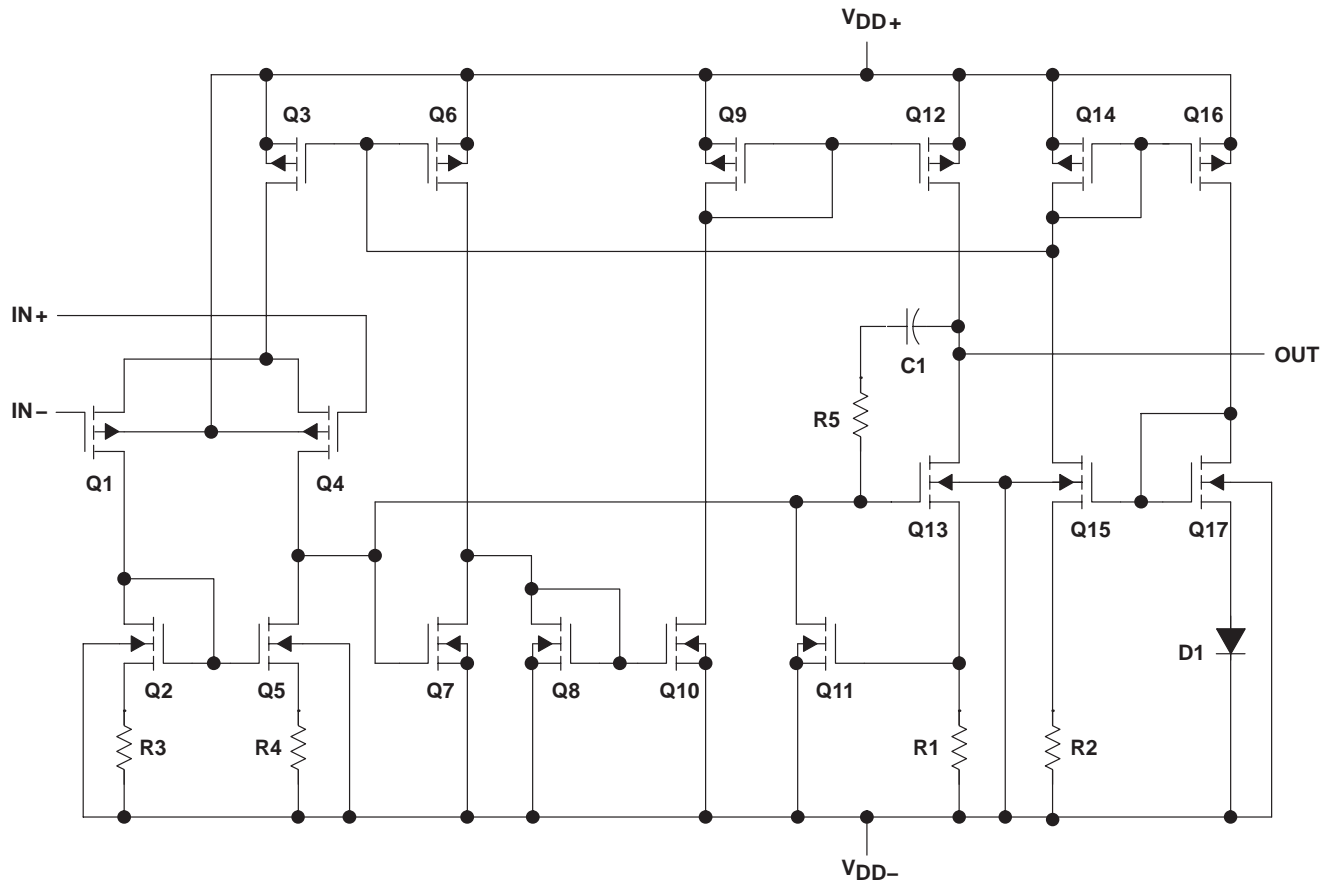




# TLC227x, TLC227xA Advanced LinCMOS™ RAIL-TO-RAIL OPERATIONAL AMPLIFIERS

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equivalent schematic (each amplifier)



ACTUAL DEVICE COMPONENT COUNT†		
COMPONENT	TLC2272	TLC2274
Transistors	38	76
Resistors	26	52
Diodes	9	18
Capacitors	3	6

† Includes both amplifiers and all ESD, bias, and trim circuitry

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

Supply voltage, $V_{DD+}$ (see Note 1)	8 V
Supply voltage, $V_{DD-}$ (see Note 1)	–8 V
Differential input voltage, $V_{ID}$ (see Note 2)	±16 V
Input voltage range, $V_I$ (any input, see Note 1)	$V_{DD-} - 0.3 \text{ V}$ to $V_{DD+}$
Input current, $I_I$ (any input)	±5 mA
Output current, $I_O$	±50 mA
Total current into $V_{DD+}$	±50 mA
Total current out of $V_{DD-}$	±50 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 (8 pin)	97.1°C/W
D package (14 pin)	86.2°C/W
N package	79.7°C/W
P package	84.6°C/W
PW package (8 pin)	149°C/W
PW package (14 pin)	113°C/W
Package thermal impedance, $\theta_{JC}$ (see Notes 4 and 5): FK package	5.6°C/W
J package	15.1°C/W
U package	14.7°C/W
Operating free-air temperature range, $T_A$ : C suffix	0°C to 70°C
I, Q suffix	–40°C to 125°C
M suffix	–55°C to 125°C
Storage temperature range	–65°C to 150°C
Lead temperature 1,6 mm (1/16 inch) from case for 10 seconds: D, N, P or PW package	260°C
Lead temperature 1,6 mm (1/16 inch) from case for 60 seconds: J or U 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  $V_{DD+}$  and  $V_{DD-}$ .
  2. Differential voltages are at  $IN+$  with respect to  $IN-$ . Excessive current will flow if input is brought below  $V_{DD-} - 0.3 \text{ V}$ .
  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  $T_J(\text{max})$ ,  $\theta_{JA}$ , and  $T_A$ . The maximum allowable power dissipation at any allowable ambient temperature is  $P_D = (T_J(\text{max}) - T_A)/\theta_{JA}$ . 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		Q SUFFIX		M SUFFIX		UNIT
	MIN	MAX	MIN	MAX	MIN	MAX	MIN	MAX	
Supply voltage, $V_{DD\pm}$	±2.2	±8	±2.2	±8	±2.2	±8	±2.2	±8	V
Input voltage, $V_I$	$V_{DD-}$	$V_{DD+} - 1.5$	$V_{DD-}$	$V_{DD+} - 1.5$	$V_{DD-}$	$V_{DD+} - 1.5$	$V_{DD-}$	$V_{DD+} - 1.5$	V
Common-mode input voltage, $V_{IC}$	$V_{DD-}$	$V_{DD+} - 1.5$	$V_{DD-}$	$V_{DD+} - 1.5$	$V_{DD-}$	$V_{DD+} - 1.5$	$V_{DD-}$	$V_{DD+} - 1.5$	V
Operating free-air temperature, $T_A$	0	70	–40	125	–40	125	–55	125	°C

# TLC227x, TLC227xA Advanced LinCMOS™ RAIL-TO-RAIL OPERATIONAL AMPLIFIERS

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**TLC2272C electrical characteristics at specified free-air temperature,  $V_{DD} = 5\text{ V}$  (unless otherwise noted)**

PARAMETER	TEST CONDITIONS	$T_A$ †	TLC2272C			TLC2272AC			UNIT
			MIN	TYP	MAX	MIN	TYP	MAX	
$V_{IO}$ Input offset voltage	$V_{IC} = 0\text{ V}$ , $V_{DD} \pm \pm 2.5\text{ V}$ , $V_O = 0\text{ V}$ , $R_S = 50\ \Omega$	25°C	300	2500		300	950	$\mu\text{V}$	
		Full range			3000		1500		
$\alpha_{VIO}$ Temperature coefficient of input offset voltage		25°C to 70°C	2			2		$\mu\text{V}/^\circ\text{C}$	
Input offset voltage long-term drift (see Note 4)		25°C	0.002			0.002		$\mu\text{V}/\text{mo}$	
$I_{IO}$ Input offset current		25°C	0.5	60		0.5	60	$\text{pA}$	
		Full range			100		100		
$I_{IB}$ Input bias current	25°C	1	60		1	60	$\text{pA}$		
	Full range			100		100			
$V_{ICR}$ Common-mode input voltage	$R_S = 50\ \Omega$ , $ V_{IO}  \leq 5\text{ mV}$	25°C	0 to 4	-0.3 to 4.2		0 to 4	-0.3 to 4.2	$\text{V}$	
		Full range	0 to 3.5			0 to 3.5			
$V_{OH}$ High-level output voltage	$I_{OH} = -20\ \mu\text{A}$	25°C		4.99			4.99	$\text{V}$	
		25°C	4.85	4.93		4.85	4.93		
		Full range	4.85			4.85			
		25°C	4.25	4.65		4.25	4.65		
$V_{OL}$ Low-level output voltage	$I_{OL} = 50\ \mu\text{A}$	25°C		0.01			0.01	$\text{V}$	
		25°C	0.09	0.15		0.09	0.15		
		Full range			0.15		0.15		
		25°C	0.9	1.5		0.9	1.5		
$V_{OL}$ Low-level output voltage	$I_{OL} = 500\ \mu\text{A}$	25°C		0.01			0.01	$\text{V}$	
		25°C	0.09	0.15		0.09	0.15		
		Full range			0.15		0.15		
		25°C	0.9	1.5		0.9	1.5		
$V_{OL}$ Low-level output voltage	$I_{OL} = 5\text{ mA}$	25°C		0.01			0.01	$\text{V}$	
		25°C	0.09	0.15		0.09	0.15		
		Full range			0.15		0.15		
		25°C	0.9	1.5		0.9	1.5		
$A_{VD}$ Large-signal differential voltage amplification	$V_{IC} = 2.5\text{ V}$ , $V_O = 1\text{ V to }4\text{ V}$	$R_L = 10\text{ k}\Omega^\ddagger$	25°C	15	35		15	35	$\text{V}/\text{mV}$
			Full range	15			15		
			25°C		175			175	
$A_{VD}$ Large-signal differential voltage amplification	$V_{IC} = 2.5\text{ V}$ , $V_O = 1\text{ V to }4\text{ V}$	$R_L = 1\text{ m}\Omega^\ddagger$	25°C		175			175	$\text{V}/\text{mV}$
			Full range			175			
			25°C		175			175	
$r_{id}$ Differential input resistance		25°C		$10^{12}$			$10^{12}$	$\Omega$	
$r_i$ Common-mode input resistance		25°C		$10^{12}$			$10^{12}$	$\Omega$	
$c_i$ Common-mode input capacitance	$f = 10\text{ kHz}$ , P package	25°C		8			8	$\text{pF}$	
$z_o$ Closed-loop output impedance	$f = 1\text{ MHz}$ , $A_V = 10$	25°C		140			140	$\Omega$	
CMRR Common-mode rejection ratio	$V_{IC} = 0\text{ V to }2.7\text{ V}$ , $V_O = 2.5\text{ V}$ , $R_S = 50\ \Omega$	25°C	70	75		70	75	$\text{dB}$	
		Full range	70			70			
$k_{SVR}$ Supply-voltage rejection ratio ( $\Delta V_{DD}/\Delta V_{IO}$ )	$V_{DD} = 4.4\text{ V to }16\text{ V}$ , $V_{IC} = V_{DD}/2$ , No load	25°C	80	95		80	95	$\text{dB}$	
		Full range	80			80			
$I_{DD}$ Supply current	$V_O = 2.5\text{ V}$ , No load	25°C	2.2	3		2.2	3	$\text{mA}$	
		Full range			3		3		

† Full range is 0°C to 70°C.

‡ Referenced to 0 V

NOTE 6: Typical values are based on the input offset voltage shift observed through 168 hours of operating life test at  $T_A = 150^\circ\text{C}$  extrapolated to  $T_A = 25^\circ\text{C}$  using the Arrhenius equation and assuming an activation energy of 0.96 eV.



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**TLC2272C operating characteristics at specified free-air temperature,  $V_{DD} = 5\text{ V}$**

PARAMETER	TEST CONDITIONS	$T_A$ †	TLC2272C			TLC2272AC			UNIT
			MIN	TYP	MAX	MIN	TYP	MAX	
SR	Slew rate at unity gain $V_O = 0.5\text{ V to }2.5\text{ V}$ , $R_L = 10\text{ k}\Omega$ ‡, $C_L = 100\text{ pF}$ ‡	25°C	2.3	3.6		2.3	3.6		V/ $\mu\text{s}$
		Full range	1.7			1.7			
$V_n$	Equivalent input noise voltage $f = 10\text{ Hz}$ $f = 1\text{ kHz}$	25°C		50			50		nV/ $\sqrt{\text{Hz}}$
		25°C		9			9		
$V_{NPP}$	Peak-to-peak equivalent input noise voltage $f = 0.1\text{ Hz to }1\text{ Hz}$ $f = 0.1\text{ Hz to }10\text{ Hz}$	25°C		1			1		$\mu\text{V}$
		25°C		1.4			1.4		
$I_n$	Equivalent input noise current	25°C		0.6			0.6		fA/ $\sqrt{\text{Hz}}$
THD + N	Total harmonic distortion plus noise $V_O = 0.5\text{ V to }2.5\text{ V}$ , $f = 20\text{ kHz}$ , $R_L = 10\text{ k}\Omega$ ‡	25°C		$A_V = 1$	0.0013%		0.0013%		
				$A_V = 10$	0.004%		0.004%		
				$A_V = 100$	0.03%		0.03%		
	Gain-bandwidth product $f = 10\text{ kHz}$ , $R_L = 10\text{ k}\Omega$ ‡, $C_L = 100\text{ pF}$ ‡	25°C		2.18			2.18		MHz
$B_{OM}$	Maximum output-swing bandwidth $V_{O(PP)} = 2\text{ V}$ , $A_V = 1$ , $R_L = 10\text{ k}\Omega$ ‡, $C_L = 100\text{ pF}$ ‡	25°C		1			1		MHz
$t_s$	Settling time $A_V = -1$ , Step = 0.5 V to 2.5 V, $R_L = 10\text{ k}\Omega$ ‡, $C_L = 100\text{ pF}$ ‡	25°C		To 0.1%	1.5		1.5		$\mu\text{s}$
				To 0.01%	2.6		2.6		
$\phi_m$	Phase margin at unity gain $R_L = 10\text{ k}\Omega$ ‡, $C_L = 100\text{ pF}$ ‡	25°C		50°			50°		
		25°C		10			10		dB

† Full range is 0°C to 70°C.

‡ Referenced to 0 V

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**TLC2272C electrical characteristics at specified free-air temperature,  $V_{DD\pm} = \pm 5\text{ V}$  (unless otherwise specified)**

PARAMETER	TEST CONDITIONS	$T_A$ †	TLC2272C			TLC2272AC			UNIT
			MIN	TYP	MAX	MIN	TYP	MAX	
$V_{IO}$ Input offset voltage	$V_{IC} = 0\text{ V}, R_S = 50\ \Omega, V_O = 0\text{ V},$	25°C	300	2500		300	950	$\mu\text{V}$	
		Full range			3000		1500		
$\alpha_{VIO}$ Temperature coefficient of input offset voltage		25°C to 70°C	2			2			$\mu\text{V}/^\circ\text{C}$
Input offset voltage long-term drift (see Note 4)		25°C	0.002			0.002			$\mu\text{V}/\text{mo}$
$I_{IO}$ Input offset current		25°C	0.5	60		0.5	60	$\text{pA}$	
		Full range			100		100		
$I_{IB}$ Input bias current	25°C	1			1			$\text{pA}$	
	Full range			100		100			
$V_{ICR}$ Common-mode input voltage	$R_S = 50\ \Omega,  V_{IO}  \leq 5\text{ mV}$	25°C	-5 to 4	-5.3 to 4.2		-5 to 4	-5.3 to 4.2	$\text{V}$	
		Full range	-5 to 3.5			-5 to 3.5			
$V_{OM+}$ Maximum positive peak output voltage	$I_O = -20\ \mu\text{A}$	25°C	4.99			4.99			$\text{V}$
		25°C	4.85	4.93		4.85	4.93		
	$I_O = -1\text{ mA}$	25°C	4.25	4.65		4.25	4.65		
		Full range	4.25			4.25			
$V_{OM-}$ Maximum negative peak output voltage	$V_{IC} = 0\text{ V}, I_O = 50\ \mu\text{A}$	25°C	-4.99			-4.99			$\text{V}$
		25°C	-4.85	-4.91		-4.85	-4.91		
	$V_{IC} = 0\text{ V}, I_O = 500\ \mu\text{A}$	Full range	-4.85			-4.85			
		$V_{IC} = 0\text{ V}, I_O = 5\text{ mA}$	25°C	-3.5	-4.1		-3.5	-4.1	
Full range	-3.5			-3.5					
$AVD$ Large-signal differential voltage amplification	$V_O = \pm 4\text{ V}$	$R_L = 10\ \text{k}\Omega$	25°C	25	50		25	50	$\text{V}/\text{mV}$
			Full range	25			25		
		$R_L = 1\ \text{m}\Omega$	25°C	300			300		
$r_{id}$ Differential input resistance		25°C	1012			1012			$\Omega$
$r_i$ Common-mode input resistance		25°C	1012			1012			$\Omega$
$c_i$ Common-mode input capacitance	$f = 10\ \text{kHz}, \text{ P package}$	25°C	8			8			$\text{pF}$
$z_o$ Closed-loop output impedance	$f = 1\ \text{MHz}, A_V = 10$	25°C	130			130			$\Omega$
CMRR Common-mode rejection ratio	$V_{IC} = -5\text{ V to } 2.7\text{ V}, V_O = 0\text{ V}, R_S = 50\ \Omega$	25°C	75	80		75	80	$\text{dB}$	
		Full range	75			75			
$k_{SVR}$ Supply-voltage rejection ratio ( $\Delta V_{DD\pm} / \Delta V_{IO}$ )	$V_{DD\pm} = 2.2\text{ V to } \pm 8\text{ V}, V_{IC} = 0\text{ V}, \text{ No load}$	25°C	80	95		80	95	$\text{dB}$	
		Full range	80			80			
$I_{DD}$ Supply current	$V_O = 0\text{ V}, \text{ No load}$	25°C	2.4			2.4			$\text{mA}$
		Full range			3		3		

† Full range is 0°C to 70°C.

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



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**TLC2272C operating characteristics at specified free-air temperature,  $V_{DD\pm} = \pm 5\text{ V}$**

PARAMETER	TEST CONDITIONS	$T_A$ †	TLC2272C			TLC2272AC			UNIT
			MIN	TYP	MAX	MIN	TYP	MAX	
SR	Slew rate at unity gain $V_O = \pm 2.3\text{ V}$ , $C_L = 100\text{ pF}$ $R_L = 10\text{ k}\Omega$	25°C	2.3	3.6		2.3	3.6		V/ $\mu\text{s}$
		Full range	1.7			1.7			
$V_n$	Equivalent input noise voltage	f = 10 Hz		50			50		nV/ $\sqrt{\text{Hz}}$
		f = 1 kHz	25°C		9		9		
$V_{NPP}$	Peak-to-peak equivalent input noise voltage	f = 0.1 Hz to 1 Hz	25°C		1		1		$\mu\text{V}$
		f = 0.1 Hz to 10 Hz	25°C		1.4		1.4		
$I_n$	Equivalent input noise current		25°C		0.6		0.6		fA/ $\sqrt{\text{Hz}}$
THD + N	Total harmonic distortion pulse duration $V_O = \pm 2.3\text{ V}$ , f = 20 kHz, $R_L = 10\text{ k}\Omega$	$A_V = 1$	25°C		0.0011%		0.0011%		
		$A_V = 10$			0.004%		0.004%		
		$A_V = 100$			0.03%		0.03%		
	Gain-bandwidth product	f = 10 kHz, $R_L = 10\text{ k}\Omega$ , $C_L = 100\text{ pF}$	25°C		2.25		2.25		MHz
BOM	Maximum output-swing bandwidth	$V_{O(PP)} = 4.6\text{ V}$ , $R_L = 10\text{ k}\Omega$ , $A_V = 1$ , $C_L = 100\text{ pF}$	25°C		0.54		0.54		MHz
$t_s$	Settling time	$A_V = -1$ , Step = $-2.3\text{ V}$ to $2.3\text{ V}$ , $R_L = 10\text{ k}\Omega$ , $C_L = 100\text{ pF}$	To 0.1%	25°C		1.5		1.5	$\mu\text{s}$
			To 0.01%			3.2		3.2	
$\phi_m$	Phase margin at unity gain	$R_L = 10\text{ k}\Omega$ , $C_L = 100\text{ pF}$	25°C		52°		52°		
	Gain margin		25°C		10		10	dB	

† Full range is 0°C to 70°C.

# TLC227x, TLC227xA Advanced LinCMOS™ RAIL-TO-RAIL OPERATIONAL AMPLIFIERS

SLOS190G – FEBRUARY 1997 – REVISED MAY 2004

**TLC2274C electrical characteristics at specified free-air temperature,  $V_{DD} = 5\text{ V}$  (unless otherwise noted)**

PARAMETER	TEST CONDITIONS	$T_A$ †	TLC2274C			TLC2274AC			UNIT
			MIN	TYP	MAX	MIN	TYP	MAX	
$V_{IO}$ Input offset voltage	$V_{DD\pm} = \pm 2.5\text{ V}$ , $V_O = 0\text{ V}$ , $V_{IC} = 0\text{ V}$ , $R_S = 50\ \Omega$	25°C	300	2500		300	950	$\mu\text{V}$	
		Full range			3000		1500		
$\alpha_{VIO}$ Temperature coefficient of input offset voltage		25°C to 70°C		2			2	$\mu\text{V}/^\circ\text{C}$	
Input offset voltage long-term drift (see Note 4)		25°C		0.002			0.002	$\mu\text{V}/\text{mo}$	
$I_{IO}$ Input offset current		25°C		0.5	60		0.5	60	$\text{pA}$
		Full range			100			100	
$I_{IB}$ Input bias current		25°C		1	60		1	60	$\text{pA}$
		Full range			100			100	
$V_{ICR}$ Common-mode input voltage	$R_S = 50\ \Omega$ , $ V_{IO}  \leq 5\text{ mV}$	25°C	0 to 4	-0.3 to 4.2		0 to 4	-0.3 to 4.2	$\text{V}$	
		Full range	0 to 3.5			0 to 3.5			
$V_{OH}$ High-level output voltage	$I_{OH} = -20\ \mu\text{A}$	25°C		4.99			4.99	$\text{V}$	
		25°C	4.85	4.93		4.85	4.93		
		Full range	4.85			4.85			
		25°C	4.25	4.65		4.25	4.65		
$V_{OL}$ Low-level output voltage	$I_{OL} = -1\text{ mA}$	25°C		0.01			0.01	$\text{V}$	
		25°C	0.09	0.15		0.09	0.15		
		Full range		0.15			0.15		
		25°C	0.9	1.5		0.9	1.5		
$A_{VD}$ Large-signal differential voltage amplification	$V_{IC} = 2.5\text{ V}$ , $V_O = 1\text{ V to }4\text{ V}$	$R_L = 10\text{ k}\Omega$ ‡	25°C	15	35		15	35	$\text{V}/\text{mV}$
			Full range	15			15		
		$R_L = 1\text{ m}\Omega$ ‡	25°C		175			175	
			Full range		1.5			1.5	
$r_{id}$ Differential input resistance		25°C		$10^{12}$			$10^{12}$	$\Omega$	
$r_i$ Common-mode input resistance		25°C		$10^{12}$			$10^{12}$	$\Omega$	
$c_i$ Common-mode input capacitance	$f = 10\text{ kHz}$ , N package	25°C		8			8	$\text{pF}$	
$z_o$ Closed-loop output impedance	$f = 1\text{ MHz}$ , $A_V = 10$	25°C		140			140	$\Omega$	
CMRR Common-mode rejection ratio	$V_{IC} = 0\text{ V to }2.7\text{ V}$ , $V_O = 2.5\text{ V}$ , $R_S = 50\ \Omega$	25°C	70	75		70	75	$\text{dB}$	
		Full range	70			70			
$k_{SVR}$ Supply-voltage rejection ratio ( $\Delta V_{DD}/\Delta V_{IO}$ )	$V_{DD} = 4.4\text{ V to }16\text{ V}$ , $V_{IC} = V_{DD}/2$ , No load	25°C	80	95		80	95	$\text{dB}$	
		Full range	80			80			
$I_{DD}$ Supply current	$V_O = 2.5\text{ V}$ , No load	25°C	4.4	6		4.4	6	$\text{mA}$	
		Full range		6			6		

† Full range is 0°C to 70°C.

‡ Referenced to 0 V

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



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**TLC2274C operating characteristics at specified free-air temperature,  $V_{DD} = 5\text{ V}$**

PARAMETER	TEST CONDITIONS	$T_A$ †	TLC2274C			TLC2274AC			UNIT
			MIN	TYP	MAX	MIN	TYP	MAX	
SR	Slew rate at unity gain $V_O = 0.5\text{ V to }2.5\text{ V}$ , $R_L = 10\text{ k}\Omega$ ‡, $C_L = 100\text{ pF}$ ‡	25°C	2.3	3.6		2.3	3.6		V/ $\mu\text{s}$
		Full range	1.7			1.7			
$V_n$	Equivalent input noise voltage $f = 10\text{ Hz}$ $f = 1\text{ kHz}$	25°C		50			50		nV/ $\sqrt{\text{Hz}}$
		25°C		9			9		
$V_{N(PP)}$	Peak-to-peak equivalent input noise voltage $f = 0.1\text{ Hz to }1\text{ Hz}$ $f = 0.1\text{ Hz to }10\text{ Hz}$	25°C		1			1		$\mu\text{V}$
		25°C		1.4			1.4		
$I_n$	Equivalent input noise current	25°C		0.6			0.6		fA/ $\sqrt{\text{Hz}}$
THD + N	Total harmonic distortion plus noise $V_O = 0.5\text{ V to }2.5\text{ V}$ , $f = 20\text{ kHz}$ , $R_L = 10\text{ k}\Omega$ ‡	$A_V = 1$	25°C	0.0013%		0.0013%			
		$A_V = 10$		0.004%		0.004%			
		$A_V = 100$		0.03%		0.03%			
	Gain-bandwidth product $f = 10\text{ kHz}$ , $C_L = 100\text{ pF}$ ‡	$R_L = 10\text{ k}\Omega$ ‡, 25°C		2.18			2.18		MHz
BOM	Maximum output-swing bandwidth $V_{O(PP)} = 2\text{ V}$ , $R_L = 10\text{ k}\Omega$ ‡, $A_V = 1$ , $C_L = 100\text{ pF}$ ‡	25°C		1			1		MHz
$t_s$	Settling time $A_V = -1$ , Step = 0.5 V to 2.5 V, $R_L = 10\text{ k}\Omega$ ‡, $C_L = 100\text{ pF}$ ‡	To 0.1%	25°C	1.5		1.5		$\mu\text{s}$	
		To 0.01%		2.6		2.6			
$\phi_m$	Phase margin at unity gain $R_L = 10\text{ k}\Omega$ ‡, $C_L = 100\text{ pF}$ ‡	25°C		50°			50°		
	Gain margin	25°C		10			10	dB	

† Full range is 0°C to 70°C.

‡ Referenced to 0 V

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**TLC2274C electrical characteristics at specified free-air temperature,  $V_{DD\pm} = \pm 5\text{ V}$  (unless otherwise noted)**

PARAMETER	TEST CONDITIONS	$T_A$ †	TLC2274C			TLC2274AC			UNIT
			MIN	TYP	MAX	MIN	TYP	MAX	
$V_{IO}$ Input offset voltage	$V_{IC} = 0\text{ V}, V_O = 0\text{ V}, R_S = 50\ \Omega$	25°C	300	2500		300	950	$\mu\text{V}$	
		Full range			3000		1500		
$\alpha V_{IO}$ Temperature coefficient of input offset voltage		25°C to 70°C	2			2			$\mu\text{V}/^\circ\text{C}$
Input offset voltage long-term drift (see Note 4)		25°C	0.002			0.002			$\mu\text{V}/\text{mo}$
$I_{IO}$ Input offset current		25°C	0.5	60		0.5	60	pA	
		Full range		100		100			
$I_{IB}$ Input bias current	25°C	1	60		1	60	pA		
	Full range		100		100				
$V_{ICR}$ Common-mode input voltage	$R_S = 50\ \Omega,  V_{IO}  \leq 5\text{ mV}$	25°C	-5 to 4	-5.3 to 4.2		-5 to 4	-5.3 to 4.2	V	
		Full range	-5 to 3.5			-5 to 3.5			
$V_{OM+}$ Maximum positive peak output voltage	$I_O = -20\ \mu\text{A}$	25°C	4.99		4.99		V		
		25°C	4.85	4.93	4.85	4.93			
		Full range	4.85		4.85				
		25°C	4.25	4.65	4.25	4.65			
$V_{OM-}$ Maximum negative peak output voltage	$I_O = -1\text{ mA}$	25°C	-4.99		-4.99		V		
		25°C	-4.85	-4.91	-4.85	-4.91			
		Full range	-4.85		-4.85				
		25°C	-3.5	-4.1	-3.5	-4.1			
$V_{IC-}$ Maximum negative peak output voltage	$V_{IC} = 0\text{ V}, I_O = 500\ \mu\text{A}$	25°C	-4.85	-4.91	-4.85	-4.91	V		
		Full range	-4.85		-4.85				
		25°C	-3.5	-4.1	-3.5	-4.1			
		Full range	-3.5		-3.5				
$A_{VD}$ Large-signal differential voltage amplification	$V_O = \pm 4\text{ V}$	25°C	$R_L = 10\text{ k}\Omega$	25	50	25	50	V/mV	
			Full range	25		25			
		25°C	$R_L = 1\text{ M}\Omega$	300		300			
$r_{id}$ Differential input resistance		25°C	$10^{12}$		$10^{12}$		$\Omega$		
$r_i$ Common-mode input resistance		25°C	$10^{12}$		$10^{12}$		$\Omega$		
$c_i$ Common-mode input capacitance	$f = 10\text{ kHz}, \text{ N package}$	25°C	8		8		pF		
$z_o$ Closed-loop output impedance	$f = 1\text{ MHz}, A_V = 10$	25°C	130		130		$\Omega$		
CMRR Common-mode rejection ratio	$V_{IC} = -5\text{ V to } 2.7\text{ V}, V_O = 0\text{ V}, R_S = 50\ \Omega$	25°C	75	80	75	80	dB		
		Full range	75		75				
$k_{SVR}$ Supply-voltage rejection ratio ( $\Delta V_{DD\pm}/\Delta V_{IO}$ )	$V_{DD\pm} = \pm 2.2\text{ V to } \pm 8\text{ V}, V_{IC} = 0\text{ V}, \text{ No load}$	25°C	80	95	80	95	dB		
		Full range	80		80				
$I_{DD}$ Supply current	$V_O = 0\text{ V}, \text{ No load}$	25°C	4.8	6	4.8	6	mA		
		Full range	6		6				

† Full range is 0°C to 70°C.

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



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**TLC2274C operating characteristics at specified free-air temperature,  $V_{DD\pm} = \pm 5\text{ V}$**

PARAMETER	TEST CONDITIONS	$T_A$ †	TLC2274C			TLC2274AC			UNIT
			MIN	TYP	MAX	MIN	TYP	MAX	
SR	Slew rate at unity gain $V_O = \pm 2.3\text{ V}$ , $C_L = 100\text{ pF}$ , $R_L = 10\text{ k}\Omega$	25°C	2.3	3.6		2.3	3.6		V/ $\mu\text{s}$
		Full range	1.7			1.7			
$V_n$	Equivalent input noise voltage	f = 10 Hz		50			50		nV/ $\sqrt{\text{Hz}}$
		f = 1 Hz	25°C		9		9		
$V_{N(PP)}$	Peak-to-peak equivalent input noise voltage	f = 0.1 Hz to 1 Hz	25°C		1		1		$\mu\text{V}$
		f = 0.1 Hz to 10 Hz	25°C		1.4		1.4		
$I_n$	Equivalent input noise current	25°C		0.6		0.6		fA/ $\sqrt{\text{Hz}}$	
THD + N	Total harmonic distortion plus noise $V_O = \pm 2.3\text{ V}$ , f = 20 kHz, $R_L = 10\text{ k}\Omega$	$A_V = 1$	25°C		0.0011%		0.0011%		
		$A_V = 10$			0.004%		0.004%		
		$A_V = 100$			0.03%		0.03%		
	Gain-bandwidth product	f = 10 kHz, $C_L = 100\text{ pF}$ , $R_L = 10\text{ k}\Omega$	25°C		2.25		2.25		MHz
BOM	Maximum output-swing bandwidth	$V_{O(PP)} = 4.6\text{ V}$ , $R_L = 10\text{ k}\Omega$ , $A_V = 1$ , $C_L = 100\text{ pF}$	25°C		0.54		0.54		MHz
$t_s$	Settling time	$A_V = -1$ , Step = $-2.3\text{ V}$ to $2.3\text{ V}$ , $R_L = 10\text{ k}\Omega$ , $C_L = 100\text{ pF}$	To 0.1%	25°C		1.5		1.5	$\mu\text{s}$
			To 0.01%			3.2		3.2	
$\phi_m$	Phase margin at unity gain	$R_L = 10\text{ k}\Omega$ , $C_L = 100\text{ pF}$	25°C		52°		52°		
	Gain margin		25°C		10		10	dB	

† Full range is 0°C to 70°C.

# TLC227x, TLC227xA Advanced LinCMOS™ RAIL-TO-RAIL OPERATIONAL AMPLIFIERS

SLOS190G – FEBRUARY 1997 – REVISED MAY 2004

**TLC2272I electrical characteristics at specified free-air temperature,  $V_{DD} = 5\text{ V}$  (unless otherwise noted)**

PARAMETER	TEST CONDITIONS	$T_A$ †	TLC2272I			TLC2272AI			UNIT
			MIN	TYP	MAX	MIN	TYP	MAX	
$V_{IO}$ Input offset voltage		25°C	300	2500		300	950	$\mu\text{V}$	
		Full range			3000		1500		
$\alpha_{VIO}$ Temperature coefficient of input offset voltage		25°C to 85°C	2			2			$\mu\text{V}/^\circ\text{C}$
Input offset voltage long-term drift (see Note 4)	$V_{IC} = 0\text{ V},$ $V_O = 0\text{ V},$ $V_{DD\pm} = \pm 2.5\text{ V}$ $R_S = 50\ \Omega$	25°C	0.002			0.002			$\mu\text{V}/\text{mo}$
$I_{IO}$ Input offset current		25°C	0.5	60		0.5	60	pA	
	-40°C to 85°C	150			150				
	Full range	800			800				
$I_{IB}$ Input bias current		25°C	1	60		1	60	pA	
		-40°C to 85°C	150			150			
		Full range	800			800			
$V_{ICR}$ Common-mode input voltage	$R_S = 50\ \Omega,$ $ V_{IO}  \leq 5\text{ mV}$	25°C	0 to 4	-0.3 to 4.2		0 to 4	-0.3 to 4.2	V	
		Full range	0 to 3.5			0 to 3.5			
$V_{OH}$ High-level output voltage	$I_{OH} = -20\ \mu\text{A}$ $I_{OH} = -200\ \mu\text{A}$ $I_{OH} = -1\text{ mA}$	25°C	4.99			4.99			V
		25°C	4.85	4.93		4.85	4.93		
		Full range	4.85			4.85			
		25°C	4.25	4.65		4.25	4.65		
$V_{OL}$ Low-level output voltage	$V_{IC} = 2.5\text{ V},$ $I_{OL} = 50\ \mu\text{A}$ $V_{IC} = 2.5\text{ V},$ $I_{OL} = 500\ \mu\text{A}$ $V_{IC} = 2.5\text{ V},$ $I_{OL} = 5\text{ mA}$	25°C	0.01			0.01			V
		25°C	0.09	0.15		0.09	0.15		
		Full range	0.15			0.15			
		25°C	0.9	1.5		0.9	1.5		
$A_{VD}$ Large-signal differential voltage amplification	$V_{IC} = 2.5\text{ V},$ $V_O = 1\text{ V to }4\text{ V}$	$R_L = 10\text{ k}\Omega^\ddagger$	25°C	15	35		15	35	V/mV
			Full range	15			15		
		$R_L = 1\text{ m}\Omega^\ddagger$	25°C	175			175		
$r_{id}$ Differential input resistance		25°C	$10^{12}$			$10^{12}$			$\Omega$
$r_i$ Common-mode input resistance		25°C	$10^{12}$			$10^{12}$			$\Omega$
$C_i$ Common-mode input capacitance	$f = 10\text{ kHz},$ P package	25°C	8			8			pF
$Z_o$ Closed-loop output impedance	$f = 1\text{ MHz},$ $A_V = 10$	25°C	140			140			$\Omega$
CMRR Common-mode rejection ratio	$V_{IC} = 0\text{ V to }2.7\text{ V},$ $V_O = 2.5\text{ V},$ $R_S = 50\ \Omega$	25°C	70	75		70	75	dB	
		Full range	70			70			
$k_{SVR}$ Supply-voltage rejection ratio ( $\Delta V_{DD}/\Delta V_{IO}$ )	$V_{DD} = 4.4\text{ V to }16\text{ V},$ $V_{IC} = V_{DD}/2,$ No load	25°C	80	95		80	95	dB	
		Full range	80			80			
$I_{DD}$ Supply current	$V_O = 2.5\text{ V},$ No load	25°C	2.2	3		2.2	3	mA	
		Full range	3			3			

† Full range is -40°C to 125°C.

‡ Referenced to 0 V

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



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**TLC2272I operating characteristics at specified free-air temperature,  $V_{DD} = 5\text{ V}$**

PARAMETER	TEST CONDITIONS	$T_A$ †	TLC2272I			TLC2272AI			UNIT
			MIN	TYP	MAX	MIN	TYP	MAX	
SR	Slew rate at unity gain $V_O = 0.5\text{ V to }2.5\text{ V}$ , $R_L = 10\text{ k}\Omega$ ‡, $C_L = 100\text{ pF}$ ‡	25°C	2.3	3.6		2.3	3.6		V/ $\mu\text{s}$
		Full range	1.7			1.7			
$V_n$	Equivalent input noise voltage	f = 10 Hz		50			50		nV $\sqrt{\text{Hz}}$
		f = 1 kHz	25°C		9		9		
$V_{NPP}$	Peak-to-peak equivalent input noise voltage	f = 0.1 Hz to 1 Hz	25°C		1		1		$\mu\text{V}$
		f = 0.1 Hz to 10 Hz	25°C		1.4		1.4		
$I_n$	Equivalent input noise current	25°C		0.6		0.6		fA $\sqrt{\text{Hz}}$	
THD + N	Total harmonic distortion plus noise f = 20 kHz, $R_L = 10\text{ k}\Omega$ ‡	$A_V = 1$	25°C		0.0013%		0.0013%		
		$A_V = 10$			0.004%		0.004%		
		$A_V = 100$			0.03%		0.03%		
	Gain-bandwidth product	f = 10 kHz, $R_L = 10\text{ k}\Omega$ ‡, $C_L = 100\text{ pF}$ ‡	25°C		2.18		2.18		MHz
BOM	Maximum output-swing bandwidth	$V_{O(PP)} = 2\text{ V}$ , $R_L = 10\text{ k}\Omega$ ‡, $A_V = 1$ , $C_L = 100\text{ pF}$ ‡	25°C		1		1		MHz
$t_s$	Settling time	$A_V = -1$ , Step = 0.5 V to 2.5 V, $R_L = 10\text{ k}\Omega$ ‡, $C_L = 100\text{ pF}$ ‡	To 0.1%	25°C		1.5		1.5	$\mu\text{s}$
			To 0.01%			2.6		2.6	
$\phi_m$	Phase margin at unity gain	$R_L = 10\text{ k}\Omega$ ‡, $C_L = 100\text{ pF}$ ‡	25°C		50°		50°		
	Gain margin		25°C		10		10		dB

† Full range is – 40°C to 125°C.

‡ Referenced to 0 V

# TLC227x, TLC227xA

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TLC2272I electrical characteristics at specified free-air temperature,  $V_{DD\pm} = \pm 5\text{ V}$  (unless otherwise noted)

PARAMETER	TEST CONDITIONS	$T_A^\dagger$	TLC2272I			TLC2272AI			UNIT
			MIN	TYP	MAX	MIN	TYP	MAX	
$V_{IO}$ Input offset voltage	$V_{IC} = 0\text{ V},$ $R_S = 50\ \Omega$ $V_O = 0\text{ V},$	25°C	300 2500		300 950		$\mu\text{V}$		
		Full range	3000		1500				
$\alpha_{VIO}$ Temperature coefficient of input offset voltage		25°C to 85°C	2		2		$\mu\text{V}/^\circ\text{C}$		
Input offset voltage long-term drift (see Note 4)		25°C	0.002		0.002		$\mu\text{V}/\text{mo}$		
$I_{IO}$ Input offset current		25°C	0.5	60	0.5	60	$\text{pA}$		
		-40°C to 85°C	150		150				
	Full range	800		800					
$I_{IB}$ Input bias current	25°C	1	60	1	60	$\text{pA}$			
	-40°C to 85°C	150		150					
	Full range	800		800					
$V_{ICR}$ Common-mode input voltage	$R_S = 50\ \Omega,$ $ V_{IO}  \leq 5\text{ mV}$	25°C	-5 to 4	-5.3 to 4.2	-5 to 4	-5.3 to 4.2	$\text{V}$		
		Full range	-5 to 3.5		-5 to 3.5				
$V_{OM+}$ Maximum positive peak output voltage	$I_O = -20\ \mu\text{A}$	25°C	4.99		4.99		$\text{V}$		
	$I_O = -200\ \mu\text{A}$	25°C	4.85	4.93	4.85	4.93			
		Full range	4.85		4.85				
	$I_O = -1\text{ mA}$	25°C	4.25	4.65	4.25	4.65			
Full range		4.25		4.25					
$V_{OM-}$ Maximum negative peak output voltage	$V_{IC} = 0\text{ V},$ $I_O = 50\ \mu\text{A}$	25°C	-4.99		-4.99		$\text{V}$		
	$V_{IC} = 0\text{ V},$ $I_O = 500\ \mu\text{A}$	25°C	-4.85	-4.91	-4.85	-4.91			
		Full range	-4.85		-4.85				
	$V_{IC} = 0\text{ V},$ $I_O = 5\text{ mA}$	25°C	-3.5	-4.1	-3.5	-4.1			
Full range		-3.5		-3.5					
$A_{VD}$ Large-signal differential voltage amplification	$V_O = \pm 4\text{ V}$	$R_L = 10\text{ k}\Omega$	25°C	25	50	25	50	$\text{V}/\text{mV}$	
			Full range	25		25			
		$R_L = 1\text{ m}\Omega$	25°C	300		300			
$r_{id}$ Differential input resistance		25°C	$10^{12}$		$10^{12}$		$\Omega$		
$r_i$ Common-mode input resistance		25°C	$10^{12}$		$10^{12}$		$\Omega$		
$c_i$ Common-mode input capacitance	$f = 10\text{ kHz},$ P package	25°C	8		8		$\text{pF}$		
$z_o$ Closed-loop output impedance	$f = 1\text{ MHz},$ $A_V = 10$	25°C	130		130		$\Omega$		
CMRR Common-mode rejection ratio	$V_{IC} = -5\text{ V to } 2.7\text{ V},$ $V_O = 0\text{ V},$ $R_S = 50\ \Omega$	25°C	75	80	75	80	$\text{dB}$		
		Full range	75		75				
$k_{SVR}$ Supply-voltage rejection ratio ( $\Delta V_{DD\pm}/\Delta V_{IO}$ )	$V_{DD} = 4.4\text{ V to } 16\text{ V},$ $V_{IC} = V_{DD}/2,$ No load	25°C	80	95	80	95	$\text{dB}$		
		Full range	80		80				
$I_{DD}$ Supply current	$V_O = 0\text{ V},$ No load	25°C	2.4	3	2.4	3	$\text{mA}$		
		Full range	3		3				

$^\dagger$  Full range is -40°C to 125°C.

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



**TLC227x, TLC227xA**  
**Advanced LinCMOS™ RAIL-TO-RAIL**  
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**TLC2272I operating characteristics at specified free-air temperature,  $V_{DD\pm} = \pm 5\text{ V}$**

PARAMETER	TEST CONDITIONS	$T_A$ †	TLC2272I			TLC2272AI			UNIT
			MIN	TYP	MAX	MIN	TYP	MAX	
SR	Slew rate at unity gain $V_O = \pm 2.3\text{ V}$ , $C_L = 100\text{ pF}$ , $R_L = 10\text{ k}\Omega$	25°C	2.3	3.6		2.3	3.6		V/ $\mu\text{s}$
		Full range	1.7			1.7			
$V_n$	Equivalent input noise voltage $f = 10\text{ Hz}$ $f = 1\text{ kHz}$	25°C		50			50		nV/ $\sqrt{\text{Hz}}$
		25°C		9			9		
$V_{NPP}$	Peak-to-peak equivalent input noise voltage $f = 0.1\text{ Hz to }1\text{ Hz}$ $f = 0.1\text{ Hz to }10\text{ Hz}$	25°C		1			1		$\mu\text{V}$
		25°C		1.4			1.4		
$I_n$	Equivalent input noise current	25°C		0.6			0.6		fA/ $\sqrt{\text{Hz}}$
THD + N	Total harmonic distortion plus noise $V_O = \pm 2.3\text{ V}$ $R_L = 10\text{ k}\Omega$ , $f = 20\text{ kHz}$	25°C		$A_V = 1$	0.0011%		0.0011%		
				$A_V = 10$	0.004%		0.004%		
				$A_V = 100$	0.03%		0.03%		
	Gain-bandwidth product $f = 10\text{ kHz}$ , $C_L = 100\text{ pF}$ , $R_L = 10\text{ k}\Omega$	25°C		2.25			2.25		MHz
$B_{OM}$	Maximum output-swing bandwidth $V_{O(PP)} = 4.6\text{ V}$ , $R_L = 10\text{ k}\Omega$ , $A_V = 1$ , $C_L = 100\text{ pF}$	25°C		0.54			0.54		MHz
$t_s$	Settling time $A_V = -1$ , Step = $-2.3\text{ V to }2.3\text{ V}$ , $R_L = 10\text{ k}\Omega$ , $C_L = 100\text{ pF}$	25°C		To 0.1%	1.5		1.5		$\mu\text{s}$
				To 0.01%	3.2		3.2		
$\phi_m$	Phase margin at unity gain $R_L = 10\text{ k}\Omega$ , $C_L = 100\text{ pF}$	25°C		52°			52°		
		25°C		10			10		
	Gain margin	25°C		10			10		dB

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

# TLC227x, TLC227xA

## Advanced LinCMOS™ RAIL-TO-RAIL OPERATIONAL AMPLIFIERS

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**TLC2274I electrical characteristics at specified free-air temperature,  $V_{DD} = 5\text{ V}$  (unless otherwise noted)**

PARAMETER	TEST CONDITIONS	$T_A$ †	TLC2274I			TLC2274AI			UNIT
			MIN	TYP	MAX	MIN	TYP	MAX	
$V_{IO}$ Input offset voltage	$V_{DD\pm} = \pm 2.5\text{ V}$ , $V_{IC} = 0\text{ V}$ , $V_O = 0\text{ V}$ , $R_S = 50\ \Omega$	25°C	300	2500		300	950	$\mu\text{V}$	
		Full range			3000		1500		
$\alpha_{VIO}$ Temperature coefficient of input offset voltage		25°C to 85°C	2			2			$\mu\text{V}/^\circ\text{C}$
Input offset voltage long-term drift (see Note 4)		25°C	0.002			0.002			$\mu\text{V}/\text{mo}$
$I_{IO}$ Input offset current		25°C	0.5	60		0.5	60	$\text{pA}$	
		-40°C to 85°C	150			150			
		Full range	800			800			
$I_{IB}$ Input bias current		25°C	1	60		1	60	$\text{pA}$	
	-40°C to 85°C	150			150				
	Full range	800			800				
$V_{ICR}$ Common-mode input voltage	$R_S = 50\ \Omega$ , $ V_{IO}  \leq 5\text{ mV}$	25°C	0 to 4	-0.3 to 4.2		0 to 4	-0.3 to 4.2	V	
		Full range	0 to 3.5			0 to 3.5			
$V_{OH}$ High-level output voltage	$I_{OH} = -20\ \mu\text{A}$	25°C	4.99		4.99		V		
		25°C	4.85	4.93	4.85	4.93			
		Full range	4.85		4.85				
		25°C	4.25	4.65	4.25	4.65			
$V_{OL}$ Low-level output voltage	$V_{IC} = 2.5\text{ V}$ , $I_{OL} = 50\ \mu\text{A}$	25°C	0.01		0.01		V		
		25°C	0.09	0.15	0.09	0.15			
		Full range	0.15		0.15				
		25°C	0.9	1.5	0.9	1.5			
$A_{VD}$ Large-signal differential voltage amplification	$V_{IC} = 2.5\text{ V}$ , $V_O = 1\text{ V to }4\text{ V}$	$R_L = 10\text{ k}\Omega^\ddagger$	25°C	15	35	15	35	V/mV	
			Full range	15		15			
		$R_L = 1\text{ M}\Omega^\ddagger$	25°C	175		175			
			Full range	1.5		1.5			
$r_{id}$ Differential input resistance		25°C	$10^{12}$			$10^{12}$	$\Omega$		
$r_i$ Common-mode input resistance		25°C	$10^{12}$			$10^{12}$	$\Omega$		
$C_i$ Common-mode input capacitance	$f = 10\text{ kHz}$ , N package	25°C	8			8	pF		
$Z_o$ Closed-loop output impedance	$f = 1\text{ MHz}$ , $A_V = 10$	25°C	140			140	$\Omega$		
CMRR Common-mode rejection ratio	$V_{IC} = 0\text{ V to }2.7\text{ V}$ , $V_O = 2.5\text{ V}$ , $R_S = 50\ \Omega$	25°C	70	75	70	75	dB		
		Full range	70		70				
$k_{SVR}$ Supply-voltage rejection ratio ( $\Delta V_{DD}/\Delta V_{IO}$ )	$V_{DD} = 4.4\text{ V to }16\text{ V}$ , $V_{IC} = V_{DD}/2$ , No load	25°C	80	95	80	95	dB		
		Full range	80		80				
$I_{DD}$ Supply current	$V_O = 2.5\text{ V}$ , No load	25°C	4.4	6	4.4	6	mA		
		Full range	6		6				

† Full range is -40°C to 125°C.

‡ Referenced to 0 V

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



**TLC227x, TLC227xA**  
**Advanced LinCMOS™ RAIL-TO-RAIL**  
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**TLC2274I operating characteristics at specified free-air temperature,  $V_{DD} = 5\text{ V}$**

PARAMETER	TEST CONDITIONS	$T_A$ †	TLC2274I			TLC2274AI			UNIT
			MIN	TYP	MAX	MIN	TYP	MAX	
SR	Slew rate at unity gain $V_O = 0.5\text{ V to }2.5\text{ V}$ , $R_L = 10\text{ k}\Omega^\ddagger$ , $C_L = 100\text{ pF}^\ddagger$	25°C	2.3	3.6		2.3	3.6	V/ $\mu\text{s}$	
		Full range	1.7			1.7			
$V_n$	Equivalent input noise voltage	f = 10 Hz		50			50	nV/ $\sqrt{\text{Hz}}$	
		f = 1 kHz		9			9		
$V_{N(PP)}$	Peak-to-peak equivalent input noise voltage	f = 0.1 Hz to 1 Hz		1			1	$\mu\text{V}$	
		f = 0.1 Hz to 10 Hz		1.4			1.4		
$I_n$	Equivalent input noise current	25°C		0.6			0.6	fA/ $\sqrt{\text{Hz}}$	
THD + N	Total harmonic distortion plus noise $V_O = 0.5\text{ V to }2.5\text{ V}$ , f = 20 kHz, $R_L = 10\text{ k}\Omega^\ddagger$	$A_V = 1$		0.0013%			0.0013%		
		$A_V = 10$	25°C		0.004%		0.004%		
		$A_V = 100$			0.03%		0.03%		
	Gain-bandwidth product f = 10 kHz, $R_L = 10\text{ k}\Omega^\ddagger$ , $C_L = 100\text{ pF}^\ddagger$	25°C		2.18			2.18	MHz	
BOM	Maximum output-swing bandwidth $V_{O(PP)} = 2\text{ V}$ , $A_V = 1$ , $R_L = 10\text{ k}\Omega^\ddagger$ , $C_L = 100\text{ pF}^\ddagger$	25°C		1			1	MHz	
$t_s$	Settling time $A_V = -1$ , Step = 0.5 V to 2.5 V, $R_L = 10\text{ k}\Omega^\ddagger$ , $C_L = 100\text{ pF}^\ddagger$	To 0.1%		1.5			1.5	$\mu\text{s}$	
		To 0.01%	25°C		2.6		2.6		
$\phi_m$	Phase margin at unity gain $R_L = 10\text{ k}\Omega^\ddagger$ , $C_L = 100\text{ pF}^\ddagger$	25°C		50°			50°		
	Gain margin	25°C		10			10	dB	

† Full range is – 40°C to 125°C.

‡ Referenced to 0 V

# TLC227x, TLC227xA Advanced LinCMOS™ RAIL-TO-RAIL OPERATIONAL AMPLIFIERS

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**TLC2274I electrical characteristics at specified free-air temperature,  $V_{DD\pm} = \pm 5\text{ V}$  (unless otherwise noted)**

PARAMETER	TEST CONDITIONS	$T_A$ †	TLC2274I			TLC2274AI			UNIT
			MIN	TYP	MAX	MIN	TYP	MAX	
$V_{IO}$ Input offset voltage	$V_{IC} = 0\text{ V}, V_O = 0\text{ V}, R_S = 50\ \Omega$	25°C	300	2500		300	950	$\mu\text{V}$	
		Full range			3000		1500		
$\alpha_{VIO}$ Temperature coefficient of input offset voltage		25°C to 85°C	2			2		$\mu\text{V}/^\circ\text{C}$	
Input offset voltage long-term drift (see Note 4)		25°C	0.002			0.002		$\mu\text{V}/\text{mo}$	
$I_{IO}$ Input offset current		25°C	0.5	60		0.5	60	$\text{pA}$	
		-40°C to 85°C			150		150		
		Full range			800		800		
$I_{IB}$ Input bias current		25°C	1	60		1	60	$\text{pA}$	
		-40°C to 85°C			150		150		
		Full range			800		800		
$V_{ICR}$ Common-mode input voltage	$R_S = 50\ \Omega,  V_{IO}  \leq 5\text{ mV}$	25°C	-5 to 4	-5.3 to 4.2		-5 to 4	-5.3 to 4.2	V	
		Full range	-5 to 3.5			-5 to 3.5			
$V_{OM+}$ Maximum positive peak output voltage	$I_O = -20\ \mu\text{A}$	25°C	4.99			4.99	V		
		Full range	4.85	4.93		4.85		4.93	
	$I_O = -1\text{ mA}$	25°C	4.25	4.65		4.25		4.65	
		Full range	4.25			4.25			
$V_{OM-}$ Maximum negative peak output voltage	$V_{IC} = 0\text{ V}, I_O = 50\ \mu\text{A}$	25°C	-4.99			-4.99	V		
		Full range	-4.85	-4.91		-4.85		-4.91	
	$V_{IC} = 0\text{ V}, I_O = 500\ \mu\text{A}$	25°C	-3.5	-4.1		-3.5		-4.1	
		Full range	-3.5			-3.5			
$A_{VD}$ Large-signal differential voltage amplification	$V_O = \pm 4\text{ V}$	$R_L = 10\text{ k}\Omega$	25°C	25	50		25	50	V/mV
			Full range	25			25		
		$R_L = 1\text{ M}\Omega$	25°C	300			300		
$r_{id}$ Differential input resistance		25°C	$10^{12}$			$10^{12}$	$\Omega$		
$r_i$ Common-mode input resistance		25°C	$10^{12}$			$10^{12}$	$\Omega$		
$c_i$ Common-mode input capacitance	$f = 10\text{ kHz}, \text{ N package}$	25°C	8			8	pF		
$z_o$ Closed-loop output impedance	$f = 1\text{ MHz}, A_V = 10$	25°C	130			130	$\Omega$		
CMRR Common-mode rejection ratio	$V_{IC} = -5\text{ V to } 2.7\text{ V}, V_O = 0\text{ V}, R_S = 50\ \Omega$	25°C	75	80		75	80	dB	
		Full range	75			75			
$k_{SVR}$ Supply-voltage rejection ratio ( $\Delta V_{DD\pm}/\Delta V_{IO}$ )	$V_{DD\pm} = \pm 2.2\text{ V to } \pm 8\text{ V}, V_{IC} = 0\text{ V}, \text{ No load}$	25°C	80	95		80	95	dB	
		Full range	80			80			
$I_{DD}$ Supply current	$V_O = 0\text{ V}, \text{ No load}$	25°C	4.8	6		4.8	6	mA	
		Full range			6		6		

† Full range is -40°C to 125°C.

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



**TLC227x, TLC227xA**  
**Advanced LinCMOS™ RAIL-TO-RAIL**  
**OPERATIONAL AMPLIFIERS**

SLOS190G – FEBRUARY 1997 – REVISED MAY 2004

**TLC2274I operating characteristics at specified free-air temperature,  $V_{DD\pm} = \pm 5\text{ V}$**

PARAMETER	TEST CONDITIONS	$T_A$ †	TLC2274I			TLC2274AI			UNIT
			MIN	TYP	MAX	MIN	TYP	MAX	
SR	Slew rate at unity gain $V_O = \pm 2.3\text{ V}$ , $C_L = 100\text{ pF}$ , $R_L = 10\text{ k}\Omega$	25°C	2.3	3.6		2.3	3.6		V/ $\mu\text{s}$
		Full range	1.7			1.7			
$V_n$	Equivalent input noise voltage	f = 10 Hz		50			50		nV/ $\sqrt{\text{Hz}}$
		f = 1 kHz		9			9		
$V_{N(PP)}$	Peak-to-peak equivalent input noise voltage	f = 0.1 Hz to 1 Hz		1			1		$\mu\text{V}$
		f = 0.1 Hz to 10 Hz		1.4			1.4		
$I_n$	Equivalent input noise current	25°C		0.6			0.6	fA/ $\sqrt{\text{Hz}}$	
THD + N	Total harmonic distortion plus noise $V_O = \pm 2.3\text{ V}$ , $R_L = 10\text{ k}\Omega$ , f = 20 kHz	$A_V = 1$	25°C	0.0011%		0.0011%			
		$A_V = 10$		0.004%		0.004%			
		$A_V = 100$		0.03%		0.03%			
	Gain-bandwidth product f = 10 kHz, $C_L = 100\text{ pF}$ , $R_L = 10\text{ k}\Omega$	25°C		2.25			2.25	MHz	
BOM	Maximum output-swing bandwidth $V_{O(PP)} = 4.6\text{ V}$ , $R_L = 10\text{ k}\Omega$ , $A_V = 1$ , $C_L = 100\text{ pF}$	25°C		0.54			0.54	MHz	
$t_s$	Settling time $A_V = -1$ , Step = -2.3 V to 2.3 V, $R_L = 10\text{ k}\Omega$ , $C_L = 100\text{ pF}$	To 0.1%	25°C	1.5		1.5		$\mu\text{s}$	
		To 0.01%		3.2		3.2			
$\phi_m$	Phase margin at unity gain $R_L = 10\text{ k}\Omega$ , $C_L = 100\text{ pF}$	25°C		52°			52°		
	Gain margin	25°C		10			10	dB	

† Full range is -40°C to 125°C.

# TLC227x, TLC227xA Advanced LinCMOS™ RAIL-TO-RAIL OPERATIONAL AMPLIFIERS

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**TLC2272Q and TLC2272M electrical characteristics at specified free-air temperature,  $V_{DD} = 5\text{ V}$  (unless otherwise noted)**

PARAMETER	TEST CONDITIONS	$T_A$ †	TLC2272Q, TLC2272M			TLC2272AQ, TLC2272AM			UNIT	
			MIN	TYP	MAX	MIN	TYP	MAX		
$V_{IO}$ Input offset voltage		25°C	300	2500		300	950	$\mu\text{V}$		
		Full range		3000		1500				
$\alpha_{VIO}$ Temperature coefficient of input offset voltage		25°C to 125°C	2			2			$\mu\text{V}/^\circ\text{C}$	
Input offset voltage long-term drift (see Note 4)	$V_{IC} = 0\text{ V},$ $V_O = 0\text{ V},$ $V_{DD\pm} = \pm 2.5\text{ V},$ $R_S = 50\ \Omega$	25°C	0.002			0.002			$\mu\text{V}/\text{mo}$	
$I_{IO}$ Input offset current		25°C	0.5	60		0.5	60	$\text{pA}$		
		Full range		800		800				
$I_{IB}$ Input bias current		25°C	1	60		1	60	$\text{pA}$		
		Full range		800		800				
$V_{ICR}$ Common-mode input voltage	$R_S = 50\ \Omega,$ $ V_{IO}  \leq 5\text{ mV}$	25°C	0 to 4	-0.3 to 4.2		0 to 4	-0.3 to 4.2	$\text{V}$		
		Full range	0 to 3.5			0 to 3.5				
$V_{OH}$ High-level output voltage	$I_{OH} = -20\ \mu\text{A}$ $I_{OH} = -200\ \mu\text{A}$ $I_{OH} = -1\text{ mA}$	25°C	4.99			4.99			$\text{V}$	
		25°C	4.85	4.93		4.85	4.93			
		Full range	4.85			4.85				
		25°C	4.25	4.65		4.25	4.65			
$V_{OL}$ Low-level output voltage	$V_{IC} = 2.5\text{ V},$ $I_{OL} = 50\ \mu\text{A}$ $V_{IC} = 2.5\text{ V},$ $I_{OL} = 500\ \mu\text{A}$ $V_{IC} = 2.5\text{ V},$ $I_{OL} = 5\text{ mA}$	25°C	0.01			0.01			$\text{V}$	
		25°C	0.09	0.15		0.09	0.15			
		Full range	0.15			0.15				
		25°C	0.9	1.5		0.9	1.5			
$A_{VD}$ Large-signal differential voltage amplification	$V_{IC} = 2.5\text{ V},$ $V_O = 1\text{ V to } 4\text{ V}$	$R_L = 10\text{ k}\Omega$ ‡ $R_L = 1\text{ m}\Omega$ ‡	25°C	10	35		10	35	$\text{V}/\text{mV}$	
			Full range	10			10			
			25°C	175			175			
$r_{id}$ Differential input resistance		25°C	$10^{12}$			$10^{12}$			$\Omega$	
$r_i$ Common-mode input resistance		25°C	$10^{12}$			$10^{12}$			$\Omega$	
$C_i$ Common-mode input capacitance	$f = 10\text{ kHz},$ P package	25°C	8			8			$\text{pF}$	
$z_o$ Closed-loop output impedance	$f = 1\text{ MHz},$ $A_V = 10$	25°C	140			140			$\Omega$	
CMRR Common-mode rejection ratio	$V_{IC} = 0\text{ V to } 2.7\text{ V},$ $V_O = 2.5\text{ V},$ $R_S = 50\ \Omega$	25°C	70	75		70	75	$\text{dB}$		
		Full range	70			70				
$k_{SVR}$ Supply-voltage rejection ratio ( $\Delta V_{DD}/\Delta V_{IO}$ )	$V_{DD} = 4.4\text{ V to } 16\text{ V},$ $V_{IC} = V_{DD}/2,$ No load	25°C	80	95		80	95	$\text{dB}$		
		Full range	80			80				
$I_{DD}$ Supply current	$V_O = 2.5\text{ V},$ No load	25°C	2.2	3		2.2	3	$\text{mA}$		
		Full range	3			3				

† Full range is  $-40^\circ\text{C}$  to  $125^\circ\text{C}$  for Q level part,  $-55^\circ\text{C}$  to  $125^\circ\text{C}$  for M level part.

‡ Referenced to 2.5 V

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



**TLC227x, TLC227xA**  
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**OPERATIONAL AMPLIFIERS**

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**TLC2272Q and TLC2272M operating characteristics at specified free-air temperature,  $V_{DD} = 5\text{ V}$**

PARAMETER	TEST CONDITIONS	$T_A$ †	TLC2272Q, TLC2272M			TLC2272AQ, TLC2272AM			UNIT
			MIN	TYP	MAX	MIN	TYP	MAX	
SR	Slew rate at unity gain $V_O = 1.25\text{ V to }2.75\text{ V}$ , $R_L = 10\text{ k}\Omega$ ‡, $C_L = 100\text{ pF}$ ‡	25°C	2.3	3.6		2.3	3.6		V/ $\mu\text{s}$
		Full range	1.7			1.7			
$V_n$	Equivalent input noise voltage	f = 10 Hz		50			50		nV/ $\sqrt{\text{Hz}}$
		f = 1 kHz		9			9		
$V_{NPP}$	Peak-to-peak equivalent input noise voltage	f = 0.1 Hz to 1 Hz		1			1		$\mu\text{V}$
		f = 0.1 Hz to 10 Hz		1.4			1.4		
$I_n$	Equivalent input noise current	25°C		0.6			0.6	fA/ $\sqrt{\text{Hz}}$	
THD + N	Total harmonic distortion plus noise $V_O = 0.5\text{ V to }2.5\text{ V}$ , f = 20 kHz, $R_L = 10\text{ k}\Omega$ ‡	$A_V = 1$		0.0013%			0.0013%		
		$A_V = 10$	25°C		0.004%		0.004%		
		$A_V = 100$			0.03%		0.03%		
	Gain-bandwidth product	f = 10 kHz, $R_L = 10\text{ k}\Omega$ ‡, $C_L = 100\text{ pF}$ ‡	25°C		2.18		2.18		MHz
$B_{OM}$	Maximum output-swing bandwidth	$V_{O(PP)} = 2\text{ V}$ , $R_L = 10\text{ k}\Omega$ ‡, $A_V = 1$ , $C_L = 100\text{ pF}$ ‡	25°C		1		1		MHz
$t_s$	Settling time	$A_V = -1$ , Step = 0.5 V to 2.5 V, $R_L = 10\text{ k}\Omega$ ‡, $C_L = 100\text{ pF}$ ‡	To 0.1%		1.5		1.5		$\mu\text{s}$
		To 0.01%	25°C		2.6		2.6		
$\phi_m$	Phase margin at unity gain	$R_L = 10\text{ k}\Omega$ ‡, $C_L = 100\text{ pF}$ ‡	25°C		50°		50°		
	Gain margin		25°C		10		10	dB	

† Full range is  $-40^\circ\text{C}$  to  $125^\circ\text{C}$  for Q level part,  $-55^\circ\text{C}$  to  $125^\circ\text{C}$  for M level part.

‡ Referenced to 2.5 V

# TLC227x, TLC227xA Advanced LinCMOS™ RAIL-TO-RAIL OPERATIONAL AMPLIFIERS

SLOS190G – FEBRUARY 1997 – REVISED MAY 2004

**TLC2272Q and TLC2272M electrical characteristics at specified free-air temperature,  $V_{DD\pm} = \pm 5\text{ V}$  (unless otherwise noted)**

PARAMETER	TEST CONDITIONS	$T_A$ †	TLC2272Q, TLC2272M			TLC2272AQ, TLC2272AM			UNIT
			MIN	TYP	MAX	MIN	TYP	MAX	
$V_{IO}$ Input offset voltage		25°C	300	2500		300	950	$\mu\text{V}$	
		Full range			3000		1500		
$\alpha_{VIO}$ Temperature coefficient of input offset voltage		25°C to 125°C	2			2			$\mu\text{V}/^\circ\text{C}$
Input offset voltage long-term drift (see Note 4)	$V_{IC} = 0\text{ V},$ $R_S = 50\ \Omega$ $V_O = 0\text{ V},$	25°C	0.002			0.002			$\mu\text{V}/\text{mo}$
$I_{IO}$ Input offset current		25°C	0.5	60		0.5	60	$\text{pA}$	
		Full range			800		800		
$I_{IB}$ Input bias current		25°C	1		60	1		60	$\text{pA}$
		Full range			800			800	
$V_{ICR}$ Common-mode input voltage	$R_S = 50\ \Omega,$ $ V_{IO}  \leq 5\text{ mV}$	25°C	-5 to 4	-5.3 to 4.2		-5 to 4	-5.3 to 4.2	$\text{V}$	
		Full range	-5 to 3.5			-5 to 3.5			
$V_{OM+}$ Maximum positive peak output voltage	$I_O = -20\ \mu\text{A}$ $I_O = -200\ \mu\text{A}$ $I_O = -1\text{ mA}$	25°C	4.99			4.99		$\text{V}$	
		25°C	4.85	4.93		4.85	4.93		
		Full range	4.85			4.85			
		25°C	4.25	4.65		4.25	4.65		
$V_{OM-}$ Maximum negative peak output voltage	$V_{IC} = 0\text{ V},$ $I_O = 50\ \mu\text{A}$ $V_{IC} = 0\text{ V},$ $I_O = 500\ \mu\text{A}$ $V_{IC} = 0\text{ V},$ $I_O = 5\text{ mA}$	25°C	-4.99			-4.99		$\text{V}$	
		25°C	-4.85	-4.91		-4.85	-4.91		
		Full range	-4.85			-4.85			
		25°C	-3.5	-4.1		-3.5	-4.1		
$AVD$ Large-signal differential voltage amplification	$V_O = \pm 4\text{ V}$	$R_L = 10\ \text{k}\Omega$	25°C	20	50		20	50	$\text{V}/\text{mV}$
			Full range	20			20		
		$R_L = 1\ \text{m}\Omega$	25°C	300			300		
$r_{id}$ Differential input resistance		25°C	$10^{12}$			$10^{12}$			$\Omega$
$r_i$ Common-mode input resistance		25°C	$10^{12}$			$10^{12}$			$\Omega$
$c_i$ Common-mode input capacitance	$f = 10\ \text{kHz},$ P package	25°C	8			8			$\text{pF}$
$z_o$ Closed-loop output impedance	$f = 1\ \text{MHz},$ $A_V = 10$	25°C	130			130			$\Omega$
CMRR Common-mode rejection ratio	$V_{IC} = -5\text{ V to } 2.7\text{ V},$ $V_O = 0\text{ V},$ $R_S = 50\ \Omega$	25°C	75	80		75	80	$\text{dB}$	
		Full range	75			75			
$k_{SVR}$ Supply-voltage rejection ratio ( $\Delta V_{DD\pm}/\Delta V_{IO}$ )	$V_{DD} = \pm 2.2\text{ V to } \pm 8\text{ V},$ $V_{IC} = 0\text{ V},$ No load	25°C	80	95		80	95	$\text{dB}$	
		Full range	80			80			
$I_{DD}$ Supply current	$V_O = 2.5\text{ V},$ No load	25°C	2.4	3		2.4	3	$\text{mA}$	
		Full range	3			3			

† Full range is -40°C to 125°C for Q level part, -55°C to 125°C for M level part.

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



**TLC227x, TLC227xA**  
**Advanced LinCMOS™ RAIL-TO-RAIL**  
**OPERATIONAL AMPLIFIERS**

SLOS190G – FEBRUARY 1997 – REVISED MAY 2004

**TLC2272Q and TLC2272M operating characteristics at specified free-air temperature,  
 $V_{DD\pm} = \pm 5\text{ V}$**

PARAMETER	TEST CONDITIONS	$T_A$ †	TLC2272Q, TLC2272M			TLC2272AQ, TLC2272AM			UNIT
			MIN	TYP	MAX	MIN	TYP	MAX	
SR	Slew rate at unity gain $V_O = \pm 1\text{ V},$ $C_L = 100\text{ pF}$ $R_L = 10\text{ k}\Omega,$	25°C	2.3	3.6		2.3	3.6		V/ $\mu\text{s}$
		Full range	1.7			1.7			
$V_n$	Equivalent input noise voltage	f = 10 Hz		50			50		nV/ $\sqrt{\text{Hz}}$
		f = 1 kHz	25°C		9		9		
$V_{NPP}$	Peak-to-peak equivalent input noise voltage	f = 0.1 Hz to 1 Hz	25°C		1		1		$\mu\text{V}$
		f = 0.1 Hz to 10 Hz	25°C		1.4		1.4		
$I_n$	Equivalent input noise current		25°C		0.6		0.6	fA/ $\sqrt{\text{Hz}}$	
THD + N	Total harmonic distortion plus noise $V_O = \pm 2.3\text{ V}$ $R_L = 10\text{ k}\Omega,$ f = 20 kHz	$A_V = 1$	25°C		0.0011%		0.0011%		
		$A_V = 10$			0.004%		0.004%		
		$A_V = 100$			0.03%		0.03%		
	Gain-bandwidth product	f = 10 kHz, $C_L = 100\text{ pF}$ $R_L = 10\text{ k}\Omega,$	25°C		2.25		2.25	MHz	
BOM	Maximum output-swing bandwidth	$V_{O(PP)} = 4.6\text{ V},$ $R_L = 10\text{ k}\Omega,$ $A_V = 1,$ $C_L = 100\text{ pF}$	25°C		0.54		0.54	MHz	
$t_s$	Settling time	$A_V = -1,$ Step = -2.3 V to 2.3 V, $R_L = 10\text{ k}\Omega,$ $C_L = 100\text{ pF}$	To 0.1%	25°C		1.5		1.5	$\mu\text{s}$
			To 0.01%			3.2		3.2	
$\phi_m$	Phase margin at unity gain	$R_L = 10\text{ k}\Omega,$ $C_L = 100\text{ pF}$	25°C		52°		52°		
	Gain margin		25°C		10		10	dB	

† Full range is -40°C to 125°C for Q level part, -55°C to 125°C for M level part.

# TLC227x, TLC227xA Advanced LinCMOS™ RAIL-TO-RAIL OPERATIONAL AMPLIFIERS

SLOS190G – FEBRUARY 1997 – REVISED MAY 2004

**TLC2274Q and TLC2274M electrical characteristics at specified free-air temperature,  $V_{DD} = 5\text{ V}$  (unless otherwise noted)**

PARAMETER	TEST CONDITIONS	$T_A$ †	TLC2274Q, TLC2274M			TLC2274AQ, TLC2274AM			UNIT
			MIN	TYP	MAX	MIN	TYP	MAX	
$V_{IO}$ Input offset voltage		25°C	300	2500		300	950	$\mu\text{V}$	
		Full range		3000		1500			
$\alpha_{VIO}$ Temperature coefficient of input offset voltage		25°C to 125°C	2			2			$\mu\text{V}/^\circ\text{C}$
Input offset voltage long-term drift (see Note 4)	$V_{DD\pm} = \pm 2.5\text{ V}$ , $V_O = 0\text{ V}$ , $V_{IC} = 0\text{ V}$ , $R_S = 50\ \Omega$	25°C	0.002			0.002			$\mu\text{V}/\text{mo}$
$I_{IO}$ Input offset current		25°C	0.5	60		0.5	60	$\text{pA}$	
		Full range		800		800			
$I_{IB}$ Input bias current		25°C	1		60	1		60	$\text{pA}$
	Full range			800			800		
$V_{ICR}$ Common-mode input voltage	$R_S = 50\ \Omega$ , $ V_{IO}  \leq 5\text{ mV}$	25°C	0 to 4	-0.3 to 4.2		0 to 4	-0.3 to 4.2	$\text{V}$	
		Full range	0 to 3.5			0 to 3.5			
$V_{OH}$ High-level output voltage	$I_{OH} = -20\ \mu\text{A}$ $I_{OH} = -200\ \mu\text{A}$ $I_{OH} = -1\text{ mA}$	25°C	4.99		4.99		$\text{V}$		
		25°C	4.85	4.93		4.85		4.93	
		Full range	4.85			4.85			
		25°C	4.25	4.65		4.25		4.65	
$V_{OL}$ Low-level output voltage	$V_{IC} = 2.5\text{ V}$ , $I_{OL} = 50\ \mu\text{A}$ $V_{IC} = 2.5\text{ V}$ , $I_{OL} = 500\ \mu\text{A}$ $V_{IC} = 2.5\text{ V}$ , $I_{OL} = 5\text{ mA}$	25°C	0.01		0.01		$\text{V}$		
		25°C	0.09	0.15		0.09		0.15	
		Full range	0.15			0.15			
		25°C	0.9	1.5		0.9		1.5	
AVD Large-signal differential voltage amplification	$V_{IC} = 2.5\text{ V}$ , $V_O = 1\text{ V to }4\text{ V}$	$R_L = 10\text{ k}\Omega^\ddagger$	25°C	10	35		10	35	$\text{V}/\text{mV}$
			Full range	10			10		
		$R_L = 1\text{ M}\Omega^\ddagger$	25°C	175			175		
$r_{id}$ Differential input resistance		25°C	$10^{12}$			$10^{12}$			$\Omega$
$r_i$ Common-mode input resistance		25°C	$10^{12}$			$10^{12}$			$\Omega$
$c_i$ Common-mode input capacitance	$f = 10\text{ kHz}$ , N package	25°C	8			8			$\text{pF}$
$z_o$ Closed-loop output impedance	$f = 1\text{ MHz}$ , $A_V = 10$	25°C	140			140			$\Omega$
CMRR Common-mode rejection ratio	$V_{IC} = 0\text{ V to }2.7\text{ V}$ , $V_O = 2.5\text{ V}$ , $R_S = 50\ \Omega$	25°C	70	75		70	75	$\text{dB}$	
		Full range	70			70			
$k_{SVR}$ Supply-voltage rejection ratio ( $\Delta V_{DD}/\Delta V_{IO}$ )	$V_{DD} = 4.4\text{ V to }16\text{ V}$ , $V_{IC} = V_{DD}/2$ , No load	25°C	80	95		80	95	$\text{dB}$	
		Full range	80			80			
$I_{DD}$ Supply current	$V_O = 2.5\text{ V}$ , No load	25°C	4.4	6		4.4	6	$\text{mA}$	
		Full range	6			6			

† Full range is  $-40^\circ\text{C}$  to  $125^\circ\text{C}$  for Q level part,  $-55^\circ\text{C}$  to  $125^\circ\text{C}$  for M level part.

‡ Referenced to 2.5 V

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



**TLC227x, TLC227xA**  
**Advanced LinCMOS™ RAIL-TO-RAIL**  
**OPERATIONAL AMPLIFIERS**

SLOS190G – FEBRUARY 1997 – REVISED MAY 2004

**TLC2274Q and TLC2274M operating characteristics at specified free-air temperature,  $V_{DD} = 5\text{ V}$**

PARAMETER	TEST CONDITIONS	$T_A$ †	TLC2274Q, TLC2274M			TLC2274AQ, TLC2274AM			UNIT	
			MIN	TYP	MAX	MIN	TYP	MAX		
SR	Slew rate at unity gain $V_O = 0.5\text{ V to }2.5\text{ V}, C_L = 100\text{ pF}‡$ $R_L = 10\text{ k}\Omega‡$	25°C	2.3	3.6		2.3	3.6		V/ $\mu$ s	
		Full range	1.7			1.7				
$V_n$	Equivalent input noise voltage $f = 10\text{ Hz}$ $f = 1\text{ kHz}$	25°C	50			50			nV/ $\sqrt{\text{Hz}}$	
		25°C	9			9				
$V_{N(PP)}$	Peak-to-peak equivalent input noise voltage $f = 0.1\text{ Hz to }1\text{ Hz}$ $f = 0.1\text{ Hz to }10\text{ Hz}$	25°C	1			1			$\mu$ V	
		25°C	1.4			1.4				
$I_n$	Equivalent input noise current	25°C	0.6			0.6			fA/ $\sqrt{\text{Hz}}$	
THD + N	Total harmonic distortion plus noise $V_O = 0.5\text{ V to }2.5\text{ V}, f = 20\text{ kHz}, R_L = 10\text{ k}\Omega‡$	25°C	$A_V = 1$	0.0013%			0.0013%			
			$A_V = 10$	0.004%			0.004%			
			$A_V = 100$	0.03%			0.03%			
	Gain-bandwidth product $f = 10\text{ kHz}, C_L = 100\text{ pF}‡$	25°C	2.18			2.18			MHz	
$B_{OM}$	Maximum output-swing bandwidth $V_{O(PP)} = 2\text{ V}, R_L = 10\text{ k}\Omega‡$	25°C	1			1			MHz	
$t_s$	Settling time $A_V = -1, \text{ Step} = 0.5\text{ V to }2.5\text{ V}, R_L = 10\text{ k}\Omega‡, C_L = 100\text{ pF}‡$	25°C	To 0.1%	1.5			1.5			$\mu$ s
			To 0.01%	2.6			2.6			
$\phi_m$	Phase margin at unity gain $R_L = 10\text{ k}\Omega‡, C_L = 100\text{ pF}‡$	25°C	50°			50°				
		25°C	10			10			dB	

† Full range is  $-40^\circ\text{C}$  to  $125^\circ\text{C}$  for Q level part,  $-55^\circ\text{C}$  to  $125^\circ\text{C}$  for M level part.

‡ Referenced to 2.5 V

# TLC227x, TLC227xA Advanced LinCMOS™ RAIL-TO-RAIL OPERATIONAL AMPLIFIERS

SLOS190G – FEBRUARY 1997 – REVISED MAY 2004

**TLC2274Q and TLC2274M electrical characteristics at specified free-air temperature,  $V_{DD\pm} = \pm 5\text{ V}$  (unless otherwise noted)**

PARAMETER	TEST CONDITIONS	$T_A$ †	TLC2274Q, TLC2274M			TLC2274AQ, TLC2274AM			UNIT
			MIN	TYP	MAX	MIN	TYP	MAX	
$V_{IO}$ Input offset voltage	$V_{IC} = 0\text{ V}, V_O = 0\text{ V}, R_S = 50\ \Omega$	25°C	300	2500	300	950	$\mu\text{V}$		
		Full range	3000		1500				
$\alpha_{VIO}$ Temperature coefficient of input offset voltage		25°C to 125°C	2		2		$\mu\text{V}/^\circ\text{C}$		
Input offset voltage long-term drift (see Note 4)		25°C	0.002		0.002		$\mu\text{V}/\text{mo}$		
$I_{IO}$ Input offset current		25°C	0.5	60	0.5	60	$\text{pA}$		
		Full range	800		800				
$I_{IB}$ Input bias current	25°C	1	60	1	60	$\text{pA}$			
	Full range	800		800					
$V_{ICR}$ Common-mode input voltage	$R_S = 50\ \Omega,  V_{IO}  \leq 5\text{ mV}$	25°C	-5 to 4	-5.3 to 4.2	-5 to 4	-5.3 to 4.2	$\text{V}$		
		Full range	-5 to 3.5		-5 to 3.5				
$V_{OM+}$ Maximum positive peak output voltage	$I_O = -20\ \mu\text{A}$	25°C	4.85	4.93	4.85	4.93	$\text{V}$		
		Full range	4.85		4.85				
		25°C	4.25	4.65	4.25	4.65			
		Full range	4.25		4.25				
$V_{OM-}$ Maximum negative peak output voltage	$V_{IC} = 0\text{ V}, I_O = 50\ \mu\text{A}$	25°C	-4.85	-4.91	-4.85	-4.91	$\text{V}$		
		Full range	-4.85		-4.85				
		25°C	-3.5	-4.1	-3.5	-4.1			
		Full range	-3.5		-3.5				
$V_{IC} = 0\text{ V}, I_O = 500\ \mu\text{A}$	25°C	-4.85	-4.91	-4.85	-4.91	$\text{V}$			
	Full range	-4.85		-4.85					
	25°C	-3.5	-4.1	-3.5	-4.1				
$V_{IC} = 0\text{ V}, I_O = 5\text{ mA}$	25°C	-3.5	-4.1	-3.5	-4.1	$\text{V}$			
	Full range	-3.5		-3.5					
	25°C	-3.5	-4.1	-3.5	-4.1				
$A_{VD}$ Large-signal differential voltage amplification	$V_O = \pm 4\text{ V}$	$R_L = 10\text{ k}\Omega$	25°C	20	50	20	50	$\text{V}/\text{mV}$	
			Full range	20		20			
		$R_L = 1\text{ M}\Omega$	25°C	300		300			
$r_{id}$ Differential input resistance		25°C	$10^{12}$		$10^{12}$		$\Omega$		
$r_i$ Common-mode input resistance		25°C	$10^{12}$		$10^{12}$		$\Omega$		
$c_i$ Common-mode input capacitance	$f = 10\text{ kHz}, \text{ N package}$	25°C	8		8		$\text{pF}$		
$z_o$ Closed-loop output impedance	$f = 1\text{ MHz}, A_V = 10$	25°C	130		130		$\Omega$		
CMRR Common-mode rejection ratio	$V_{IC} = -5\text{ V to } 2.7\text{ V}, V_O = 0\text{ V}, R_S = 50\ \Omega$	25°C	75	80	75	80	$\text{dB}$		
		Full range	75		75				
$k_{SVR}$ Supply-voltage rejection ratio ( $\Delta V_{DD\pm}/\Delta V_{IO}$ )	$V_{DD\pm} = \pm 2.2\text{ V to } \pm 8\text{ V}, V_{IC} = 0\text{ V}, \text{ No load}$	25°C	80	95	80	95	$\text{dB}$		
		Full range	80		80				
$I_{DD}$ Supply current	$V_O = 0\text{ V}, \text{ No load}$	25°C	4.8	6	4.8	6	$\text{mA}$		
		Full range	6		6				

† Full range is  $-40^\circ\text{C}$  to  $125^\circ\text{C}$  for Q level part,  $-55^\circ\text{C}$  to  $125^\circ\text{C}$  for M level part.

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



**TLC227x, TLC227xA**  
**Advanced LinCMOS™ RAIL-TO-RAIL**  
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SLOS190G – FEBRUARY 1997 – REVISED MAY 2004

**TLC2274Q and TLC2274M operating characteristics at specified free-air temperature,  
 $V_{DD\pm} = \pm 5\text{ V}$**

PARAMETER	TEST CONDITIONS	$T_A$ †	TLC2274Q, TLC2274M			TLC2274AQ, TLC2274AM			UNIT
			MIN	TYP	MAX	MIN	TYP	MAX	
SR	Slew rate at unity gain $V_O = \pm 2.3\text{ V},$ $R_L = 10\text{ k}\Omega,$ $C_L = 100\text{ pF}$	25°C	2.3	3.6		2.3	3.6		V/ $\mu\text{s}$
		Full range	1.7			1.7			
$V_n$	Equivalent input noise voltage $f = 10\text{ Hz}$ $f = 1\text{ kHz}$	25°C		50			50		nV/ $\sqrt{\text{Hz}}$
		25°C		9			9		
$V_{N(PP)}$	Peak-to-peak equivalent input noise voltage $f = 0.1\text{ Hz to }1\text{ Hz}$ $f = 0.1\text{ Hz to }10\text{ Hz}$	25°C		1			1		$\mu\text{V}$
		25°C		1.4			1.4		
$I_n$	Equivalent input noise current	25°C		0.6			0.6		fA/ $\sqrt{\text{Hz}}$
THD + N	Total harmonic distortion plus noise $V_O = \pm 2.3\text{ V},$ $R_L = 10\text{ k}\Omega,$ $f = 20\text{ kHz}$	25°C		$A_V = 1$		0.0011%		0.0011%	
				$A_V = 10$		0.004%		0.004%	
				$A_V = 100$		0.03%		0.03%	
	Gain-bandwidth product $f = 10\text{ kHz},$ $R_L = 10\text{ k}\Omega,$ $C_L = 100\text{ pF}$	25°C		2.25			2.25		MHz
BOM	Maximum output-swing bandwidth $V_{O(PP)} = 4.6\text{ V},$ $R_L = 10\text{ k}\Omega,$ $A_V = 1,$ $C_L = 100\text{ pF}$	25°C		0.54			0.54		MHz
$t_s$	Settling time $A_V = -1,$ Step = $-2.3\text{ V to }2.3\text{ V},$ $R_L = 10\text{ k}\Omega,$ $C_L = 100\text{ pF}$	25°C		To 0.1%		1.5		1.5	$\mu\text{s}$
				To 0.01%		3.2		3.2	
$\phi_m$	Phase margin at unit gain $R_L = 10\text{ k}\Omega,$ $C_L = 100\text{ pF}$	25°C		52°			52°		
		25°C		10			10		dB

† Full range is  $-40^\circ\text{C}$  to  $125^\circ\text{C}$  for Q level part,  $-55^\circ\text{C}$  to  $125^\circ\text{C}$  for M level part.

**TLC227x, TLC227xA**  
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**TYPICAL CHARACTERISTICS**

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CMRR	Common-mode rejection ratio	vs Frequency	31
		vs Free-air temperature	32
kSVR	Supply-voltage rejection ratio	vs Frequency	33, 34
		vs Free-air temperature	35
$I_{DD}$	Supply current	vs Supply voltage	36, 37
		vs Free-air temperature	38, 39
SR	Slew rate	vs Load capacitance	40
		vs Free-air temperature	41
$V_O$	Inverting large-signal pulse response		42, 43
	Voltage-follower large-signal pulse response		44, 45
	Inverting small-signal pulse response		46, 47
	Voltage-follower small-signal pulse response		48, 49
$V_n$	Equivalent input noise voltage	vs Frequency	50, 51
	Noise voltage over a 10-second period		52
	Integrated noise voltage	vs Frequency	53
THD + N	Total harmonic distortion plus noise	vs Frequency	54
	Gain-bandwidth product	vs Supply voltage	55
		vs Free-air temperature	56
$\phi_m$	Phase margin	vs Load capacitance	57
	Gain margin	vs Load capacitance	58

NOTE: For all graphs where  $V_{DD} = 5\text{ V}$ , all loads are referenced to 2.5 V.



TYPICAL CHARACTERISTICS

DISTRIBUTION OF TLC2272  
 INPUT OFFSET VOLTAGE

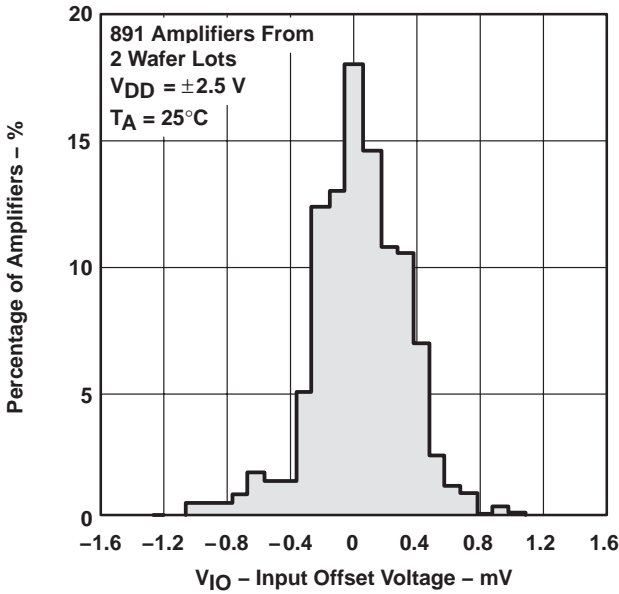


Figure 1

DISTRIBUTION OF TLC2272  
 INPUT OFFSET VOLTAGE

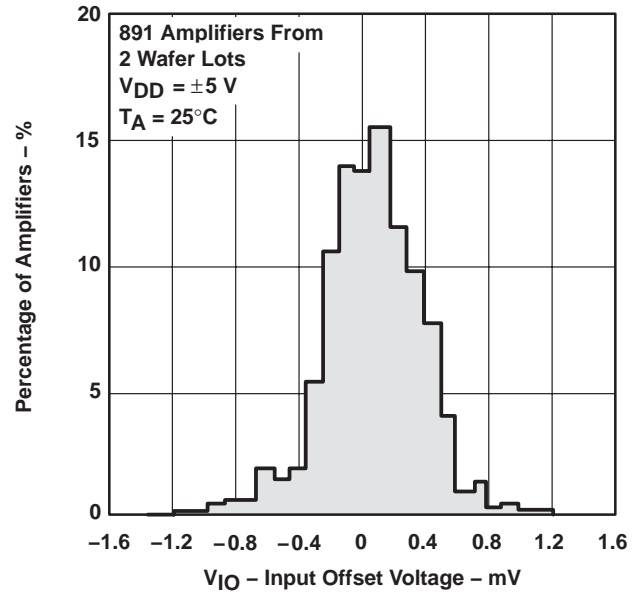


Figure 2

DISTRIBUTION OF TLC2274  
 INPUT OFFSET VOLTAGE

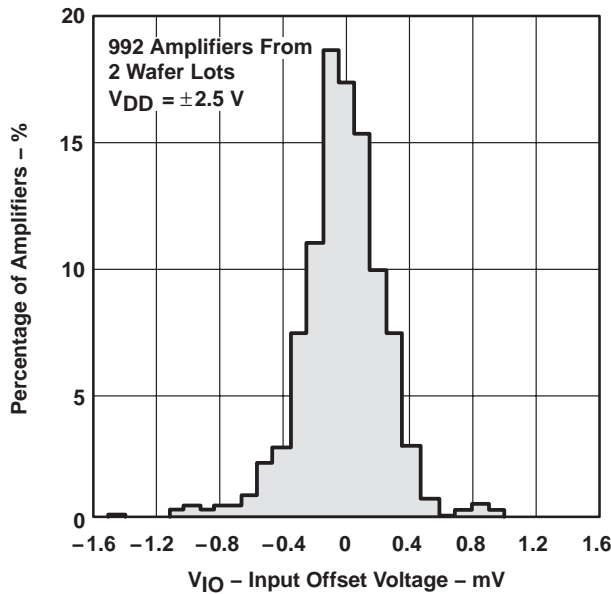


Figure 3

DISTRIBUTION OF TLC2274  
 INPUT OFFSET VOLTAGE

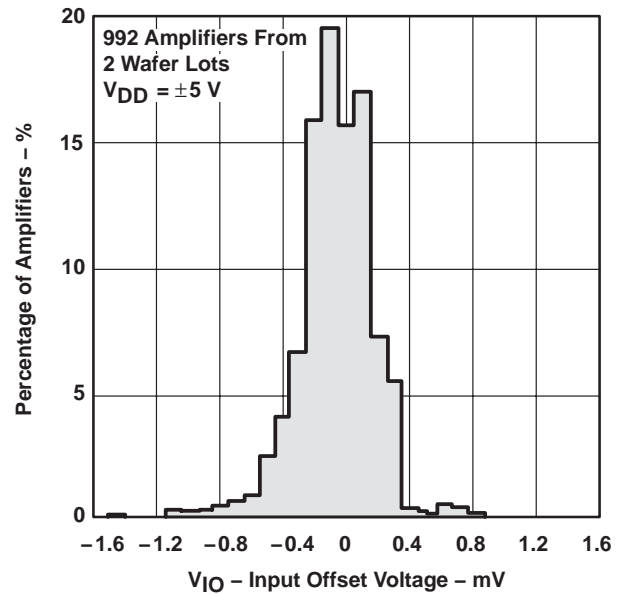
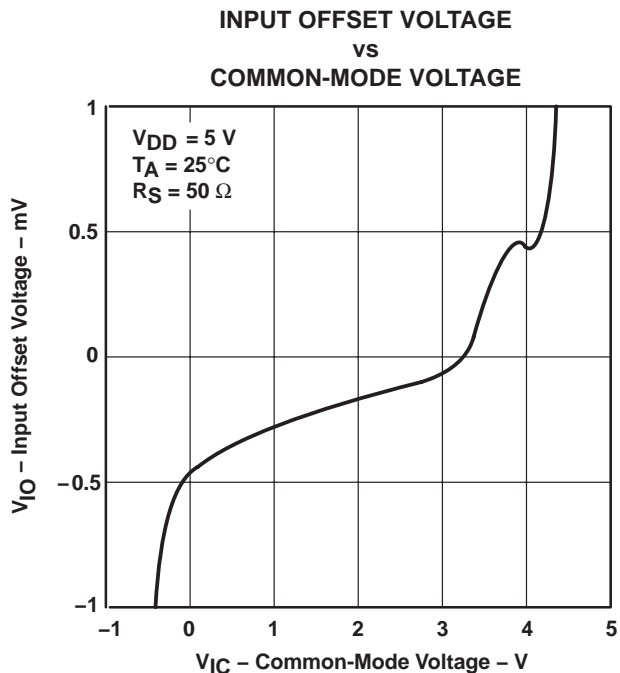
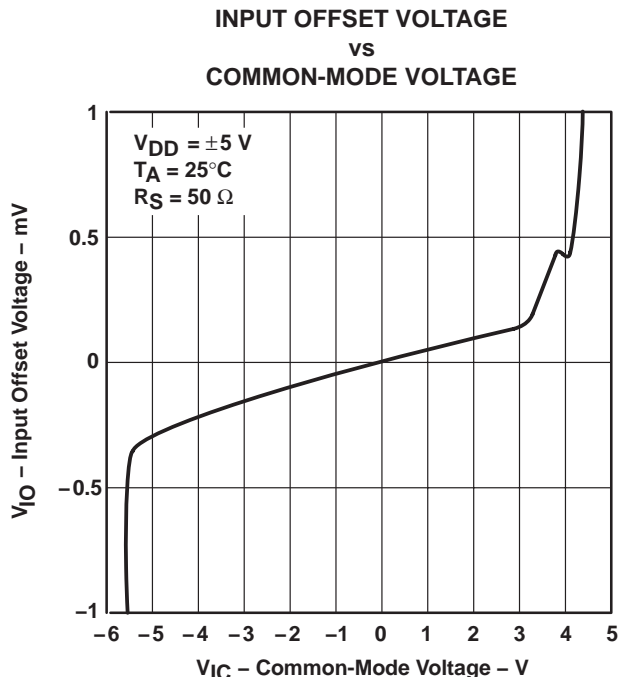


Figure 4

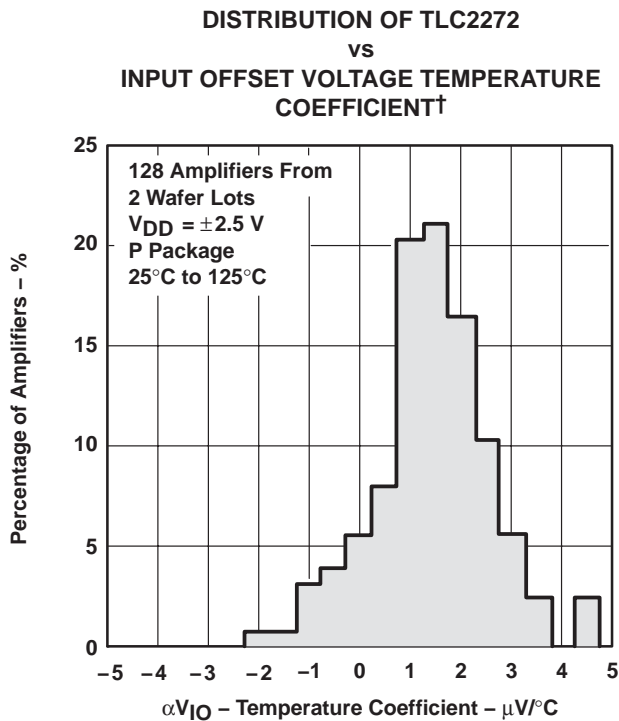
**TYPICAL CHARACTERISTICS**



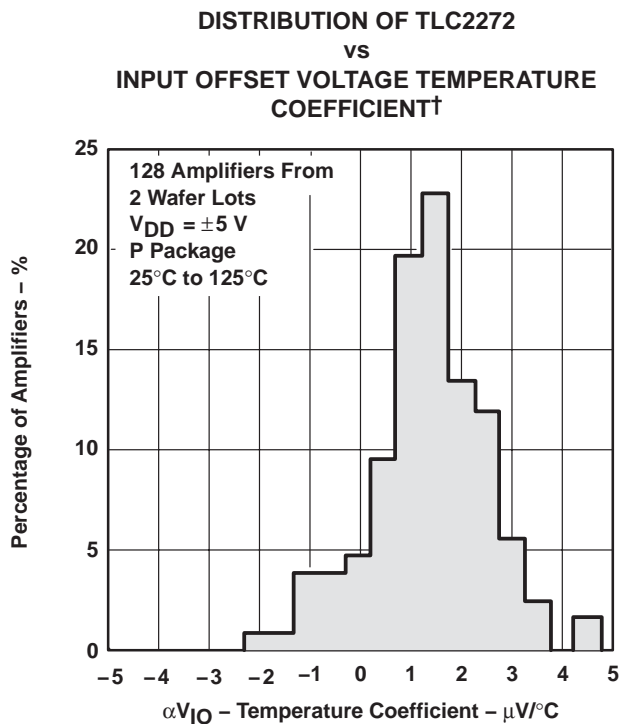
**Figure 5**



**Figure 6**



**Figure 7**



**Figure 8**

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

TYPICAL CHARACTERISTICS

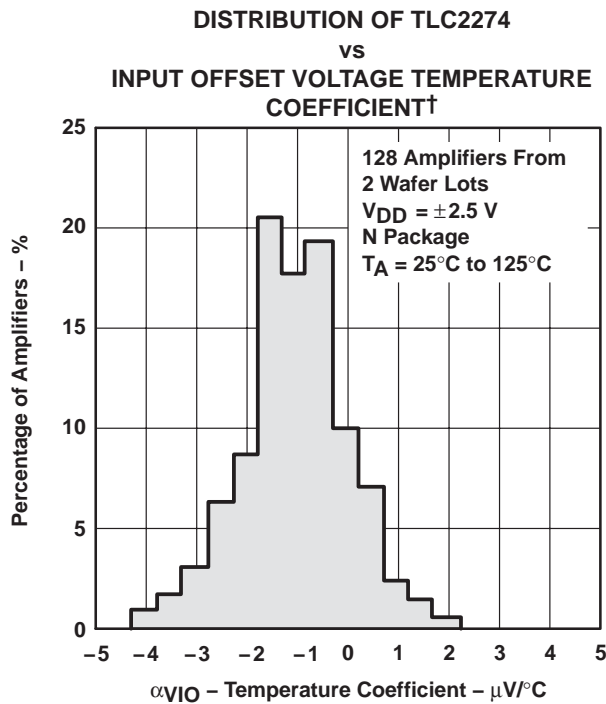


Figure 9

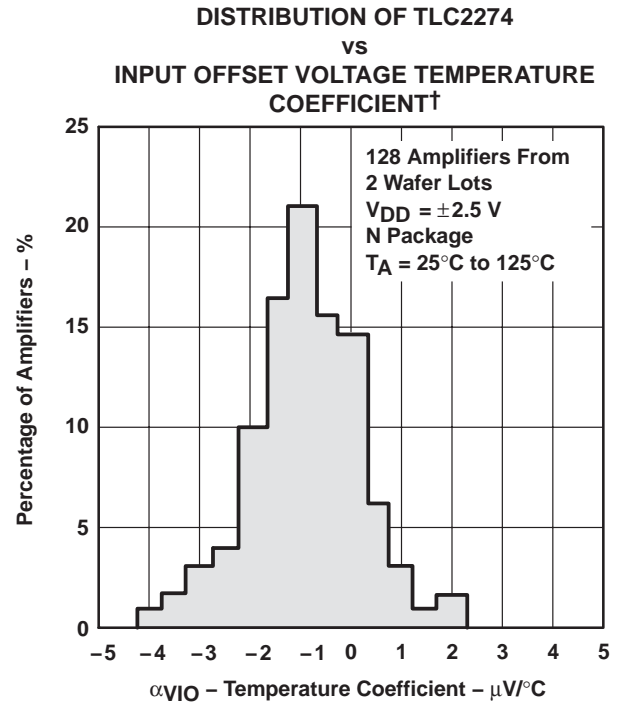


Figure 10

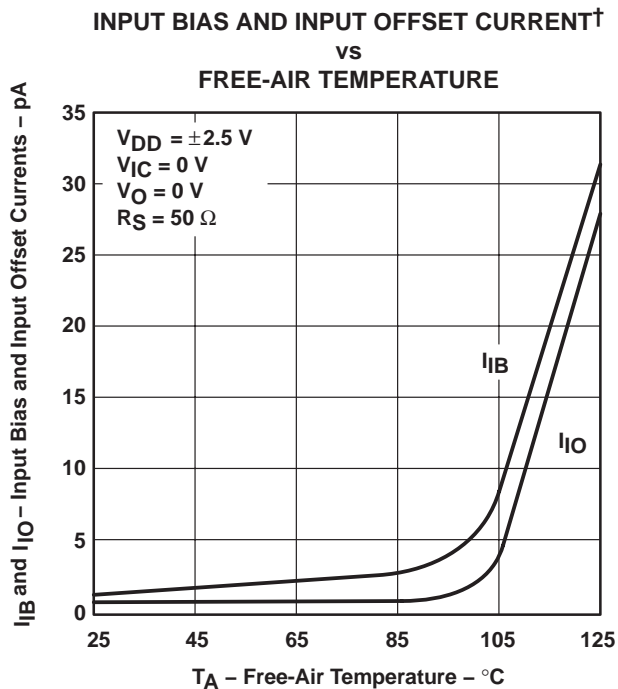


Figure 11

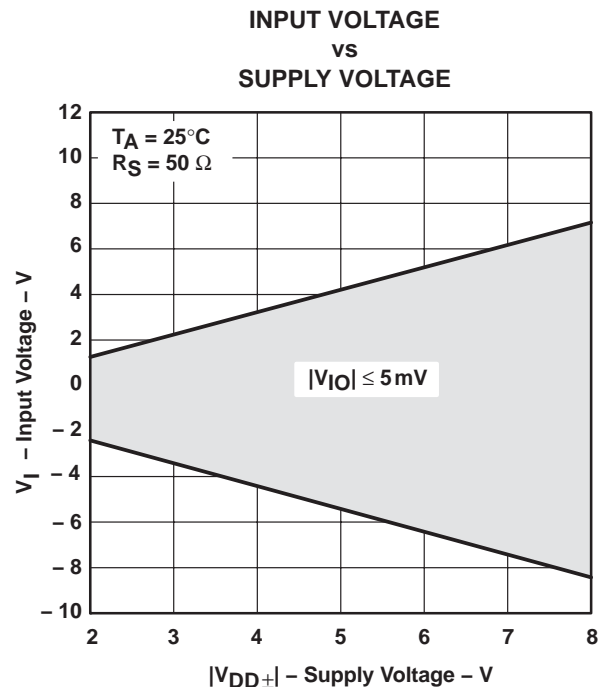
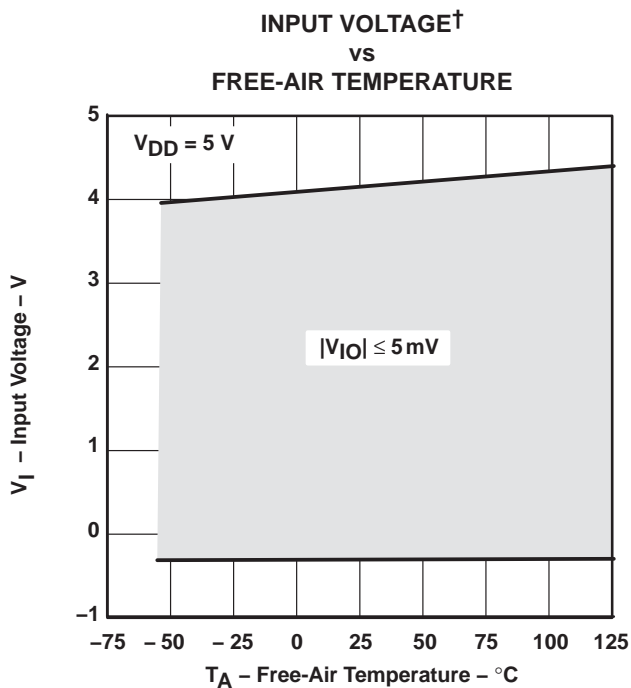


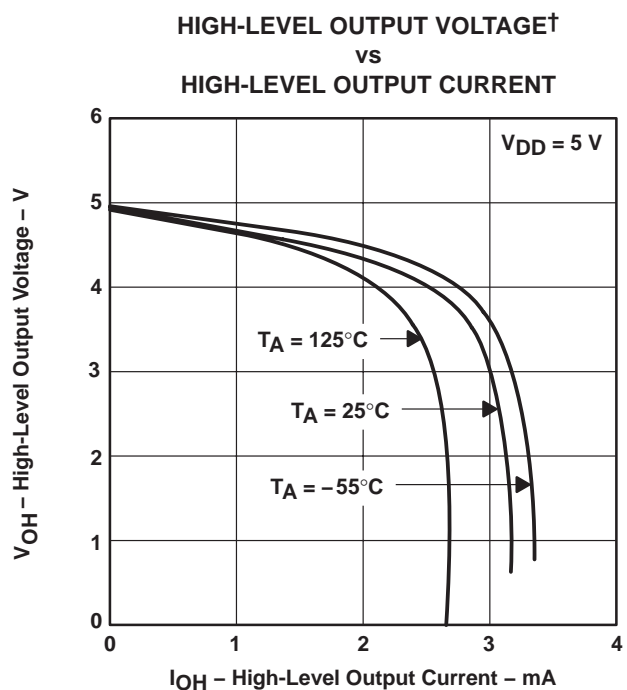
Figure 12

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

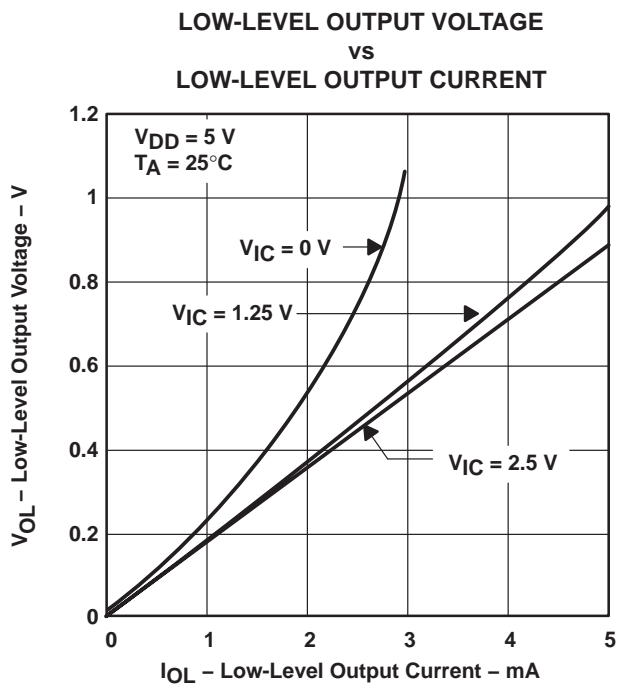
**TYPICAL CHARACTERISTICS**



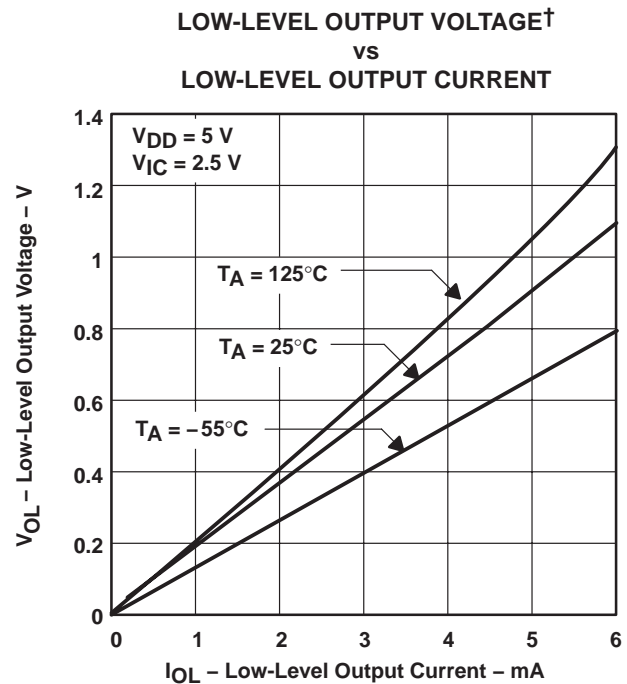
**Figure 13**



**Figure 14**



**Figure 15**



**Figure 16**

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

TYPICAL CHARACTERISTICS

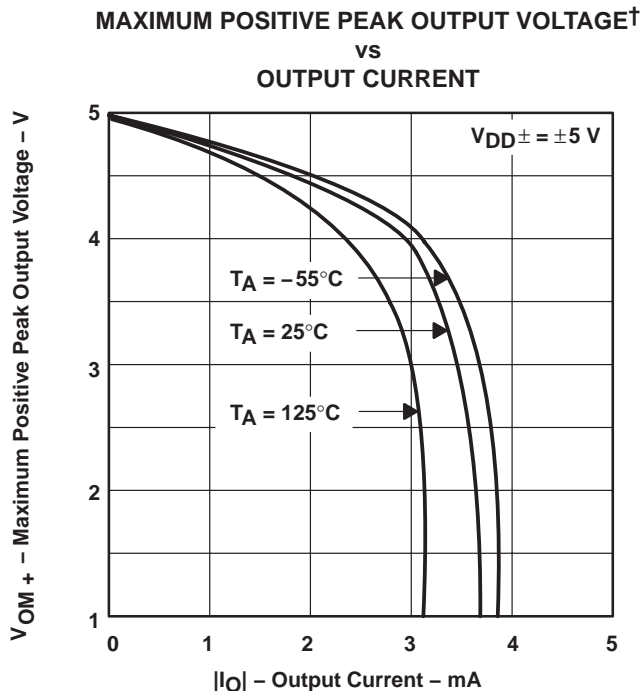


Figure 17

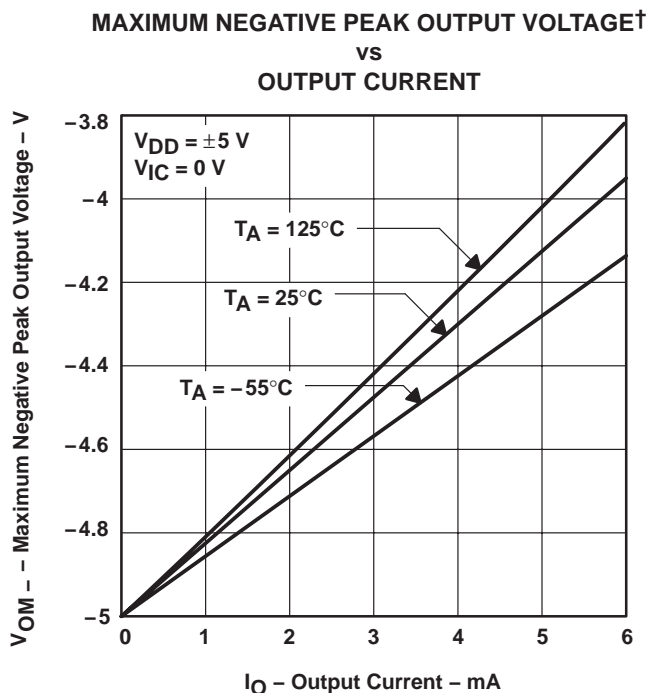


Figure 18

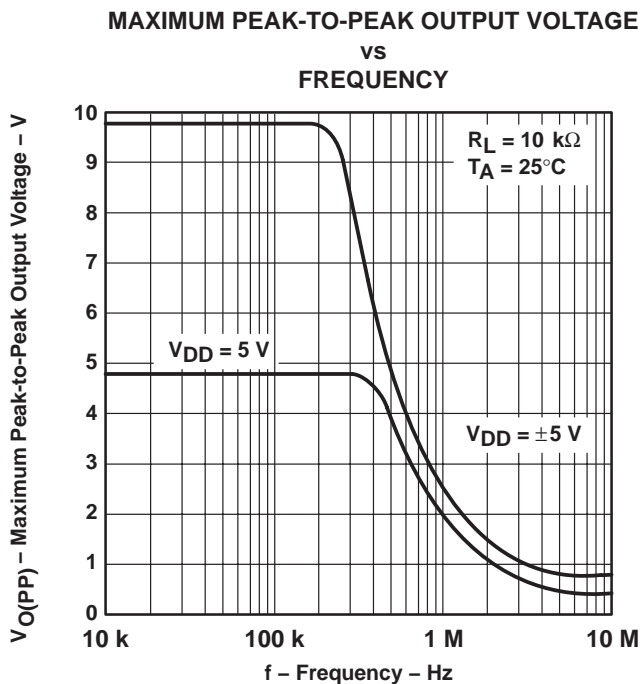


Figure 19

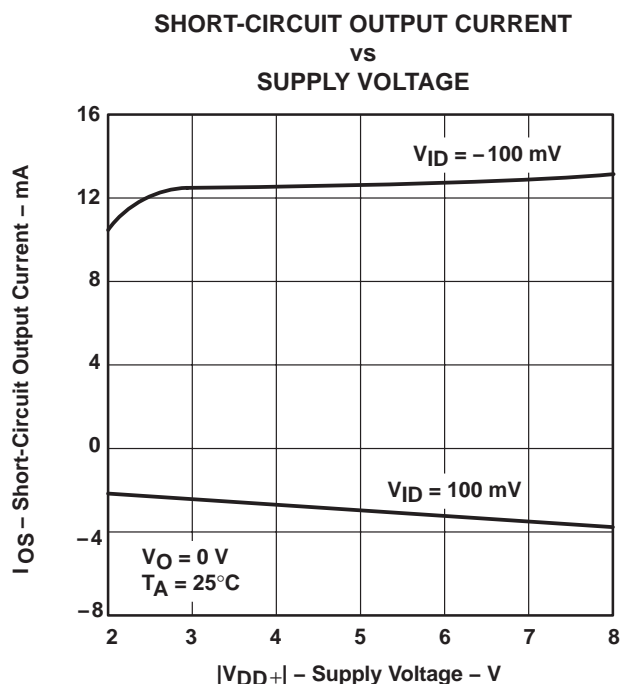
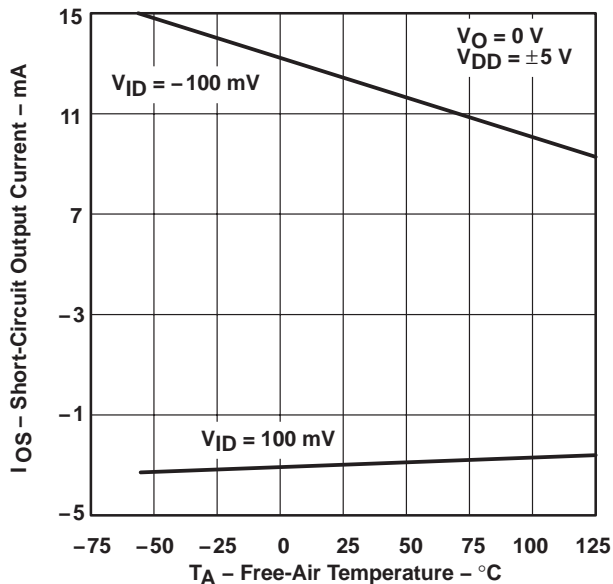


Figure 20

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

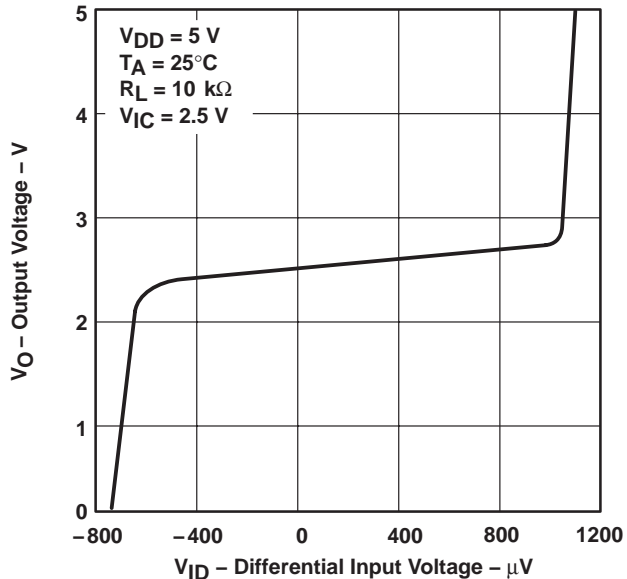
**TYPICAL CHARACTERISTICS**

**SHORT-CIRCUIT OUTPUT CURRENT†**  
**vs**  
**FREE-AIR TEMPERATURE**



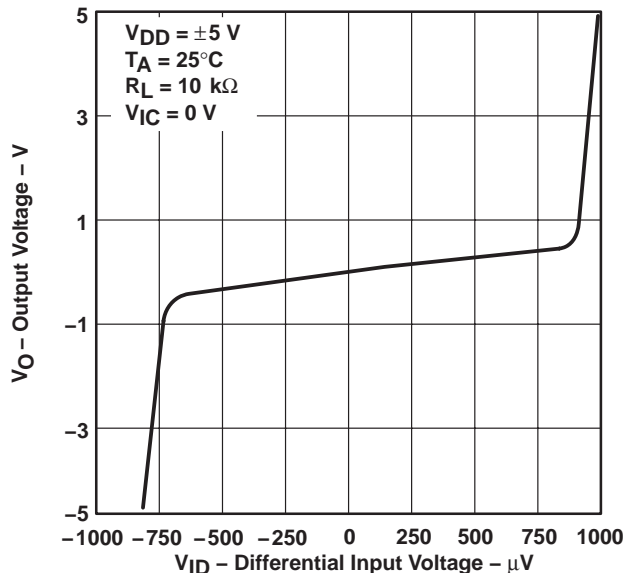
**Figure 21**

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



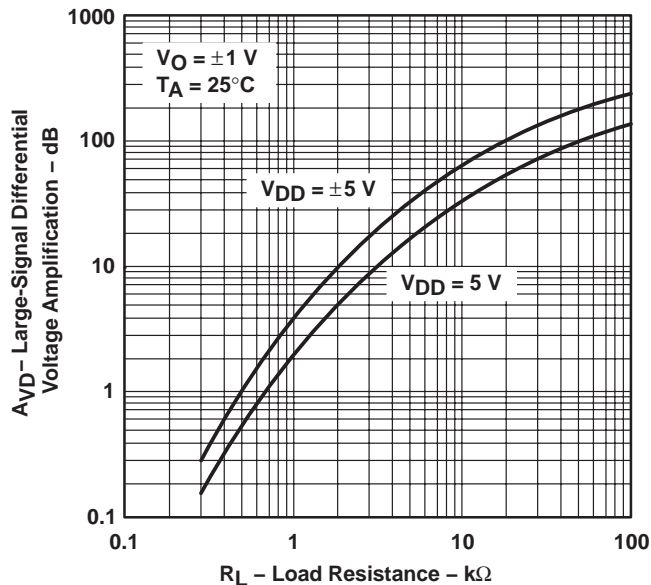
**Figure 22**

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



**Figure 23**

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



**Figure 24**

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

TYPICAL CHARACTERISTICS

LARGE-SIGNAL DIFFERENTIAL VOLTAGE  
 AMPLIFICATION AND PHASE MARGIN  
 vs  
 FREQUENCY

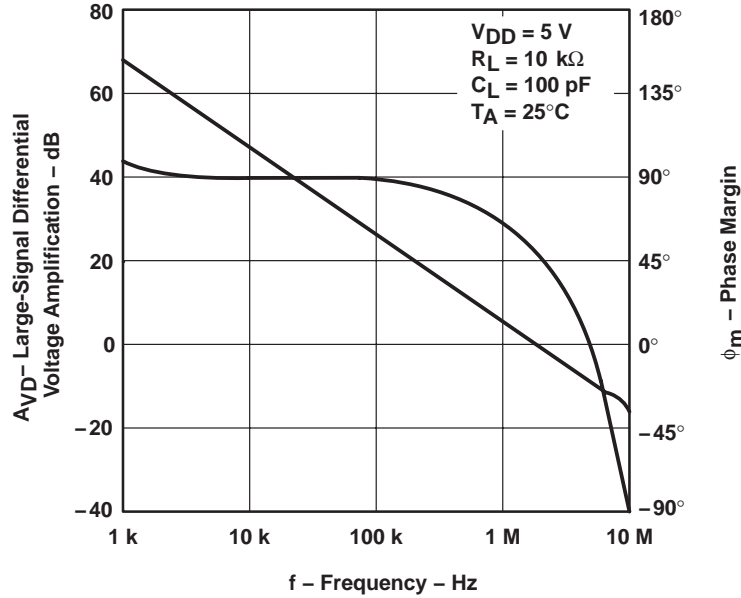


Figure 25

LARGE-SIGNAL DIFFERENTIAL VOLTAGE  
 AMPLIFICATION AND PHASE MARGIN  
 vs  
 FREQUENCY

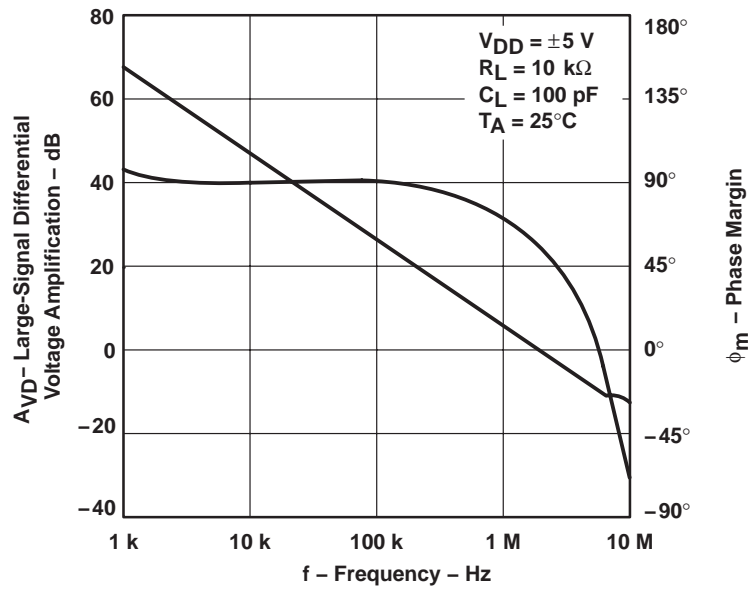
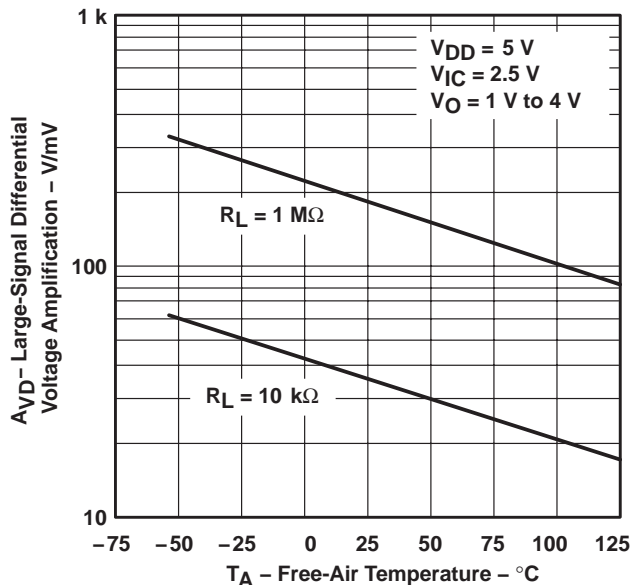


Figure 26

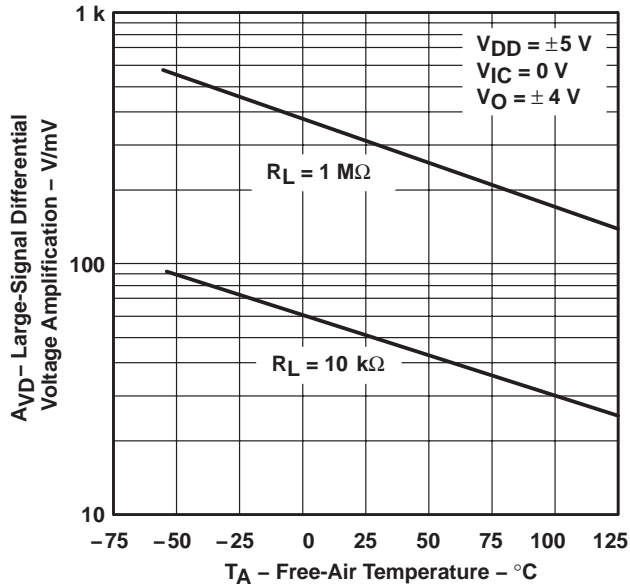
**TYPICAL CHARACTERISTICS**

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



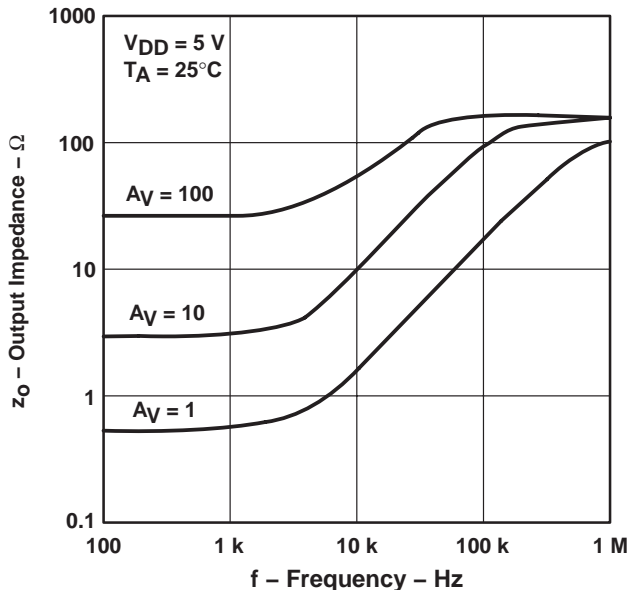
**Figure 27**

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



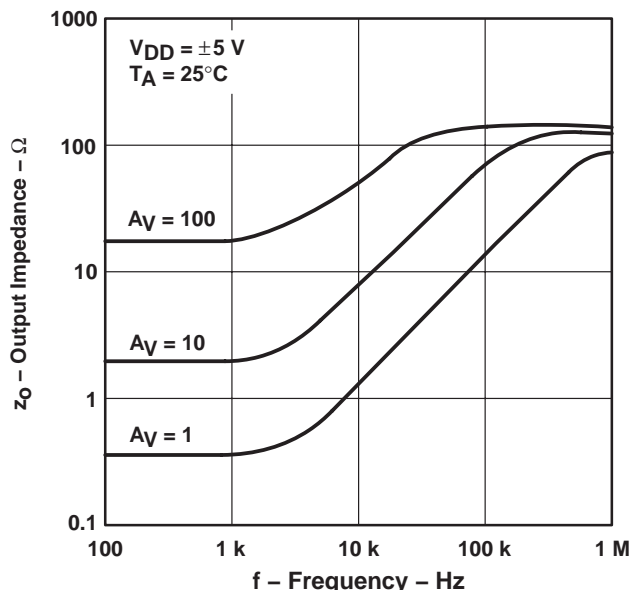
**Figure 28**

**OUTPUT IMPEDANCE**  
**vs**  
**FREQUENCY**



**Figure 29**

**OUTPUT IMPEDANCE**  
**vs**  
**FREQUENCY**



**Figure 30**

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

TYPICAL CHARACTERISTICS

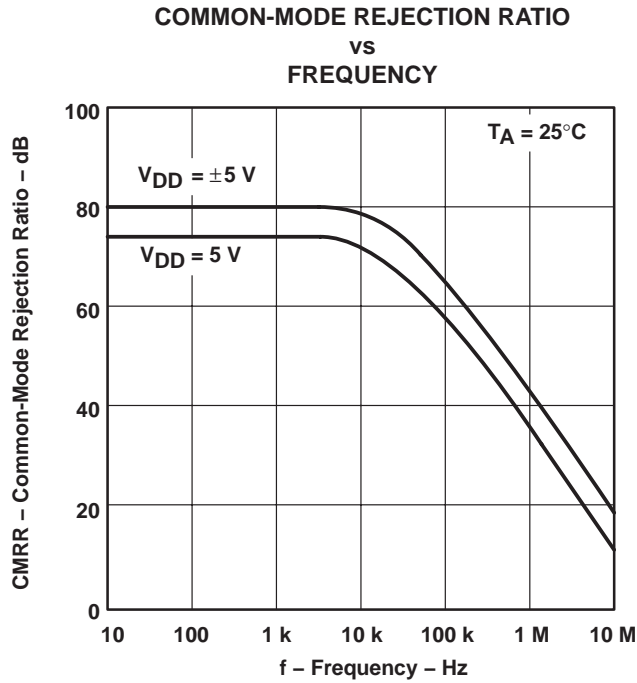


Figure 31

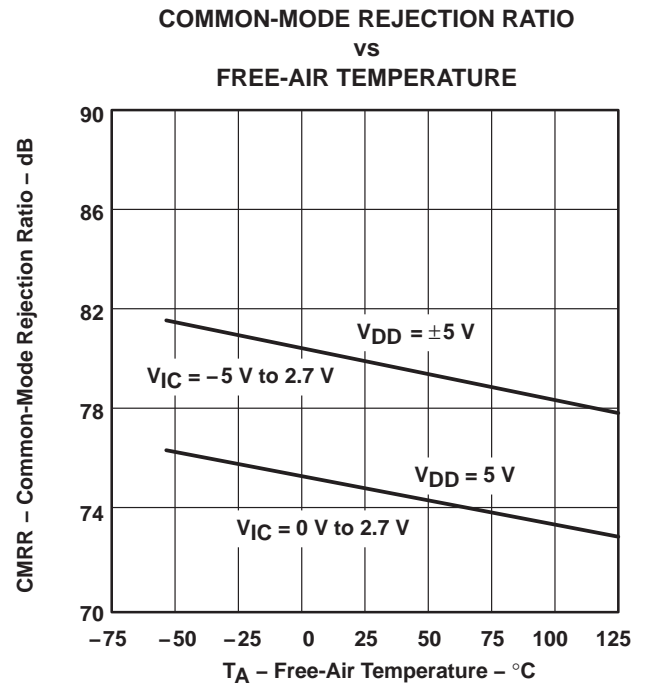


Figure 32

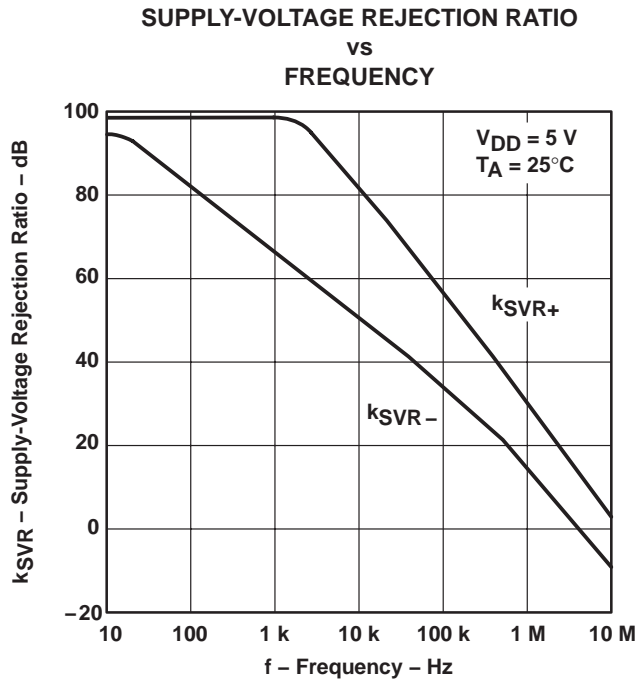


Figure 33

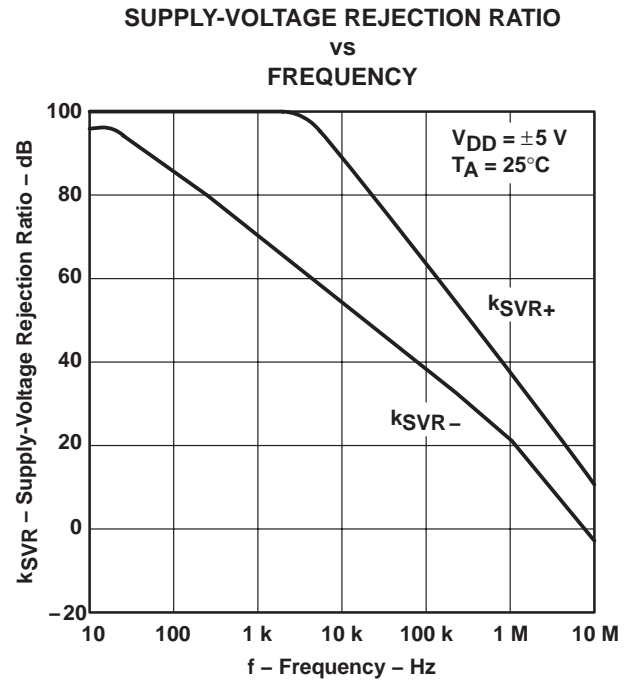
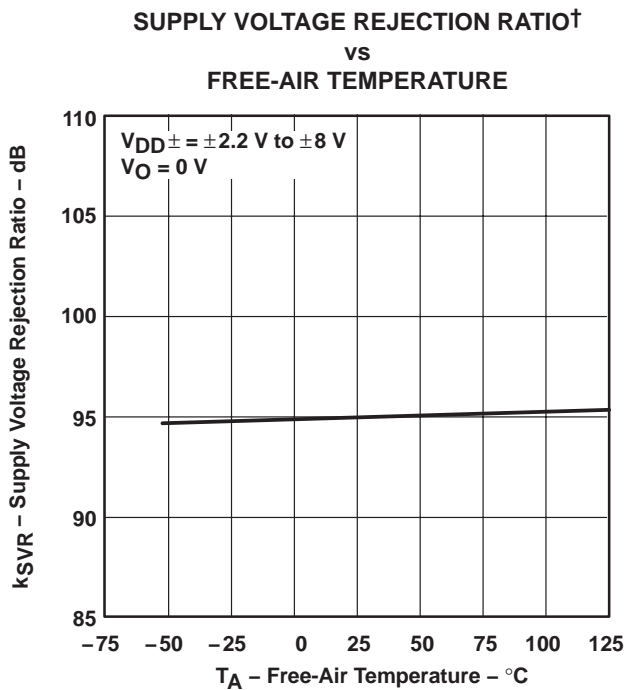
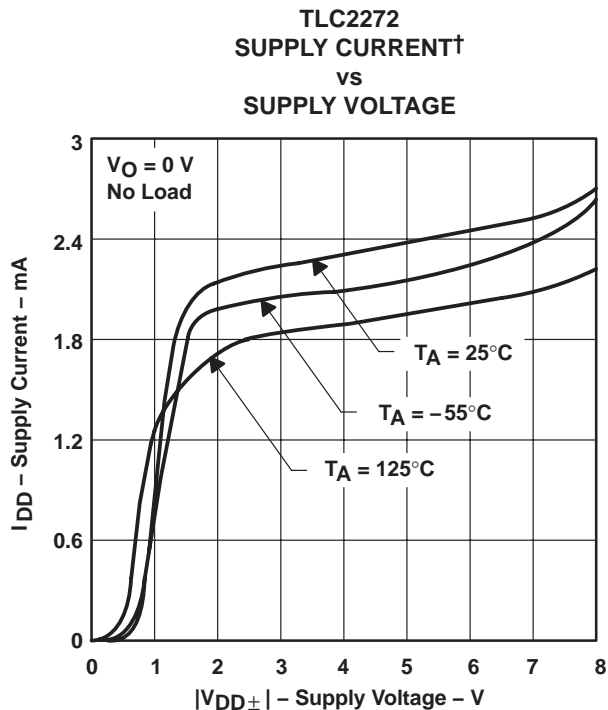


Figure 34

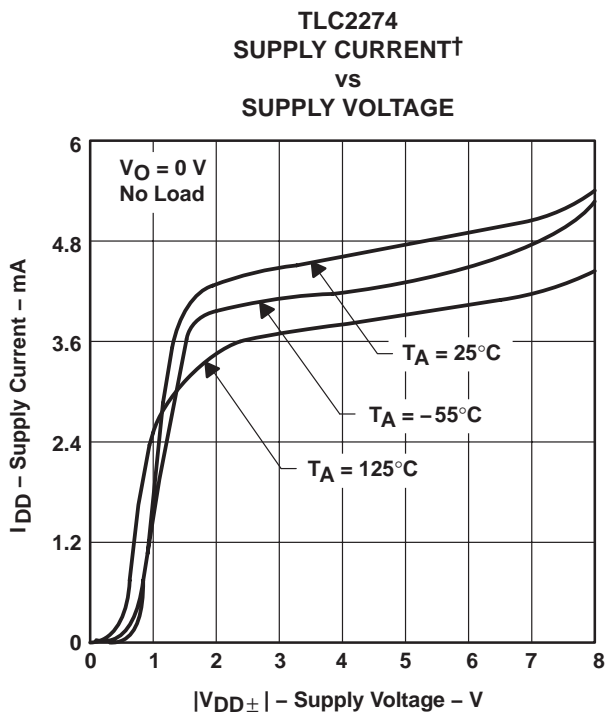
**TYPICAL CHARACTERISTICS**



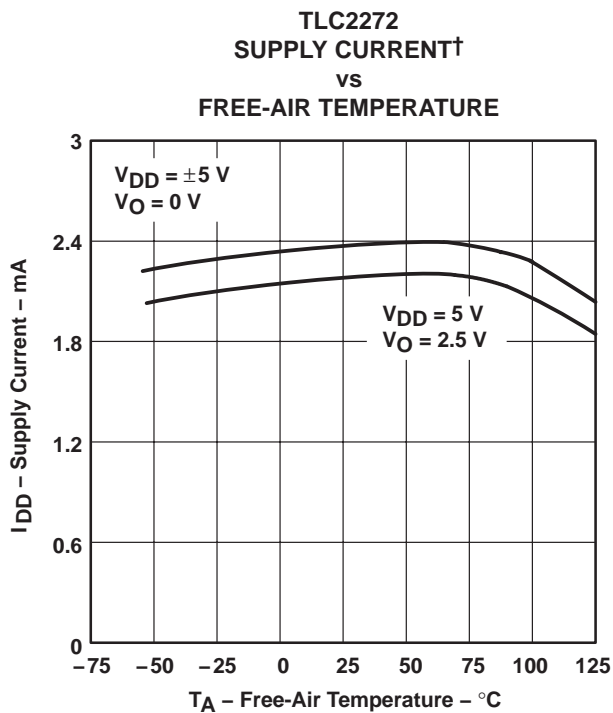
**Figure 35**



**Figure 36**



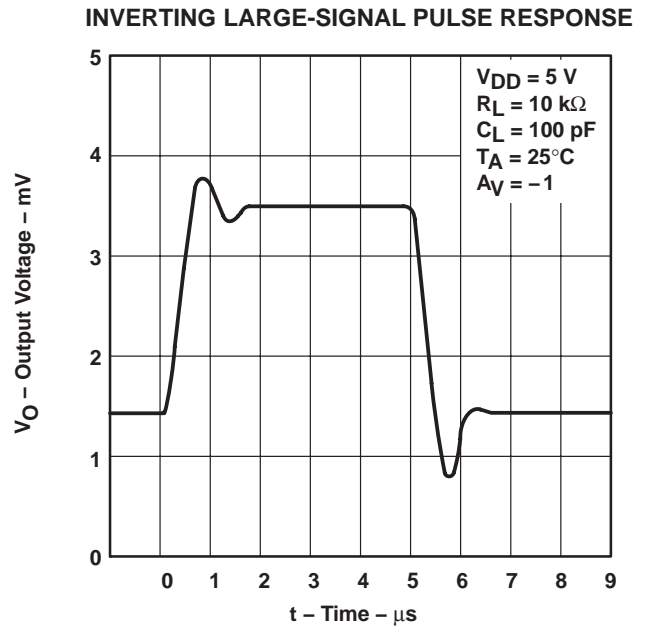
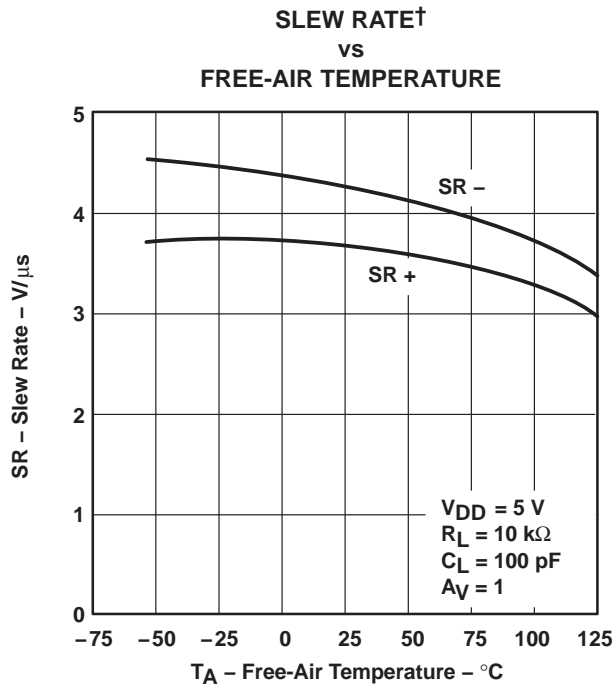
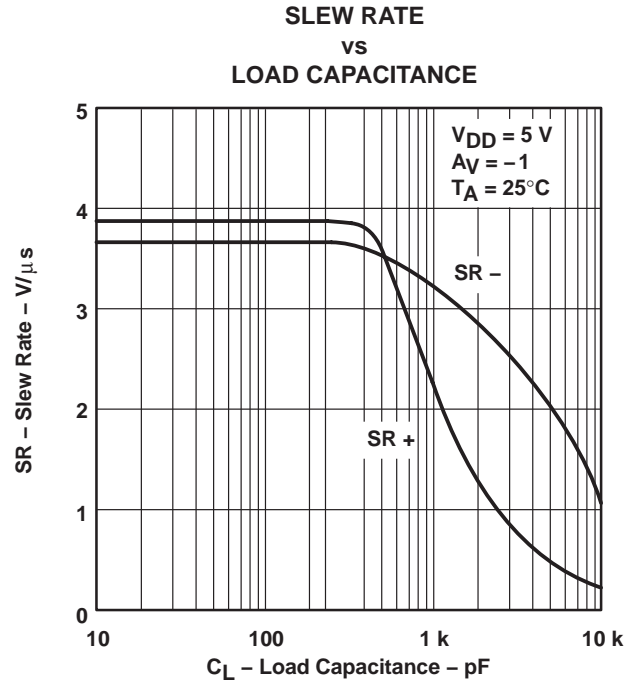
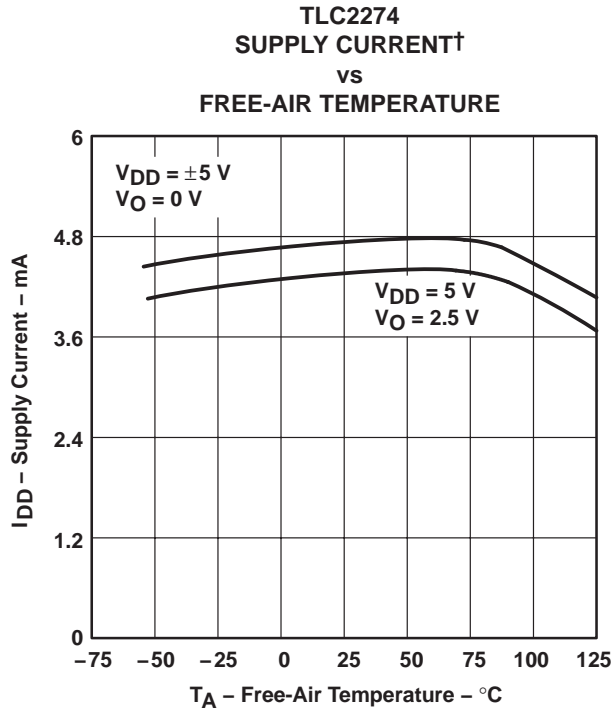
**Figure 37**



**Figure 38**

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

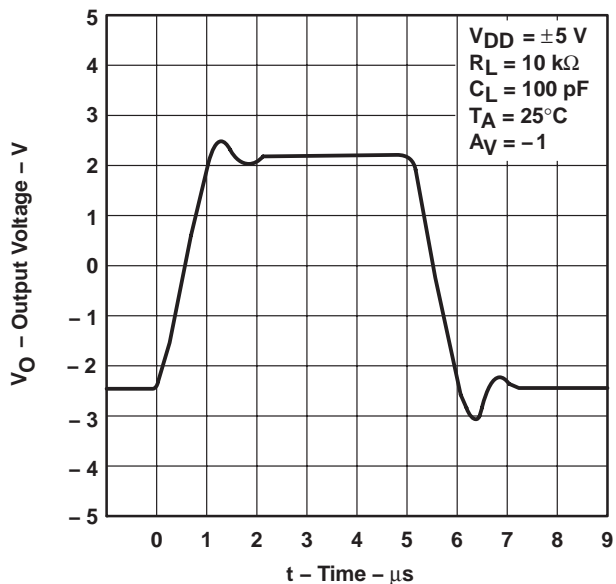
TYPICAL CHARACTERISTICS



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

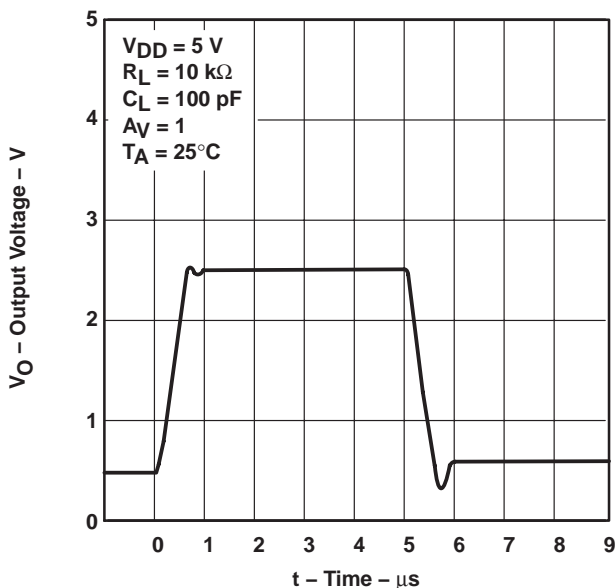
**TYPICAL CHARACTERISTICS**

**INVERTING LARGE-SIGNAL PULSE RESPONSE**



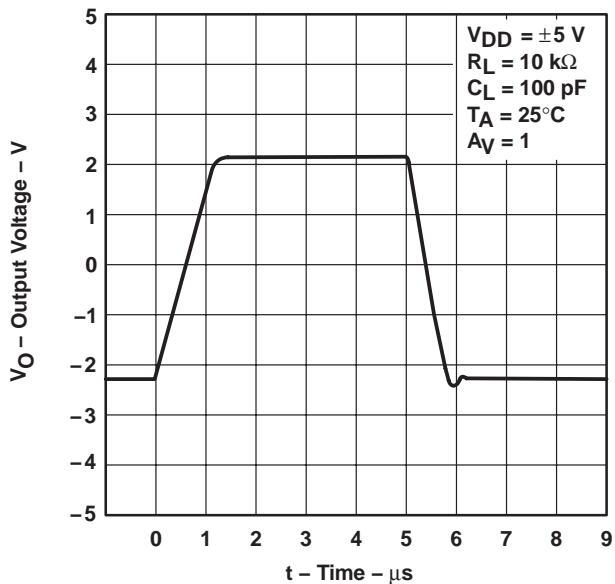
**Figure 43**

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



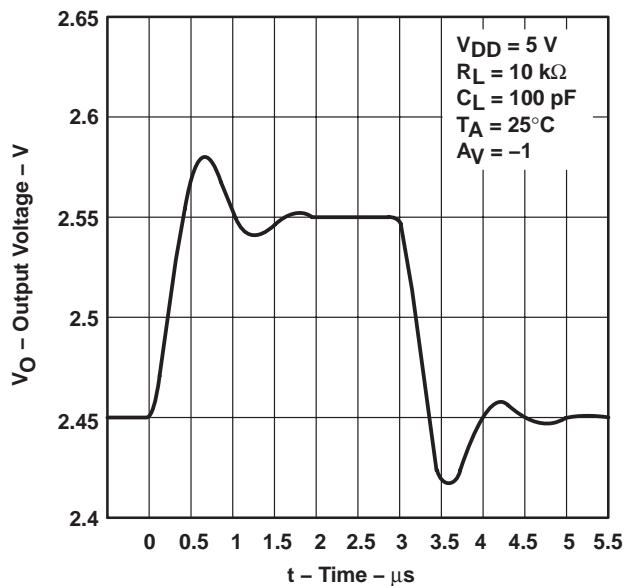
**Figure 44**

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



**Figure 45**

**INVERTING SMALL-SIGNAL PULSE RESPONSE**



**Figure 46**

TYPICAL CHARACTERISTICS

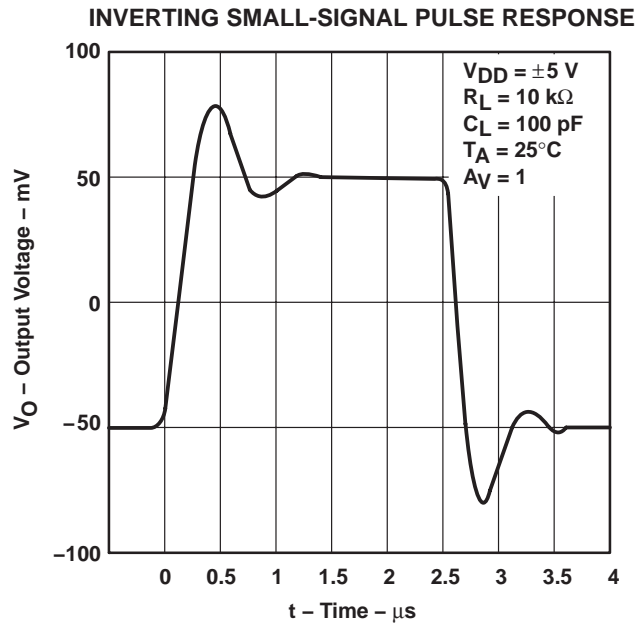


Figure 47

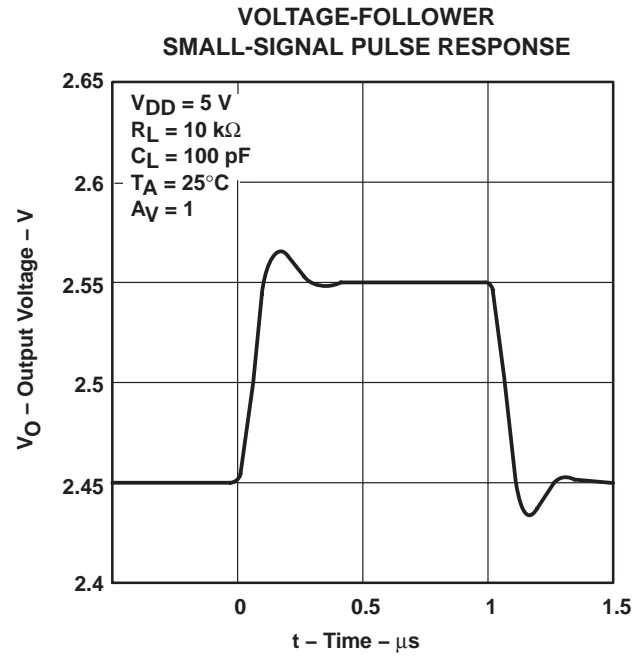


Figure 48

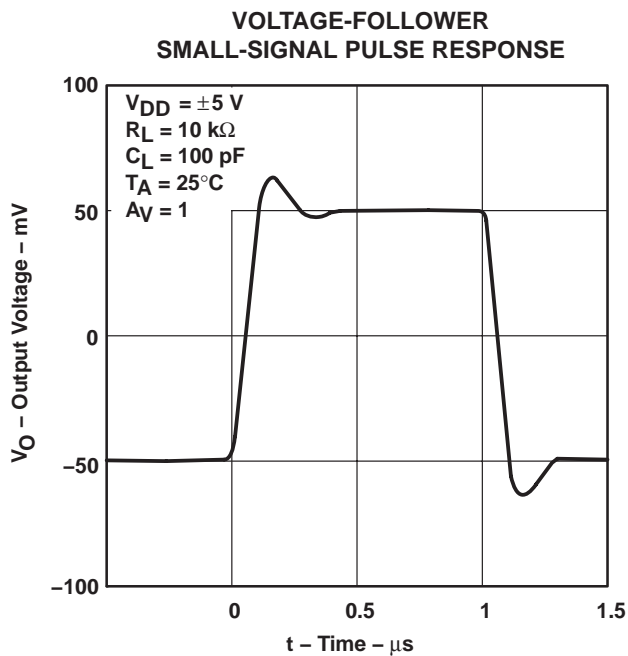


Figure 49

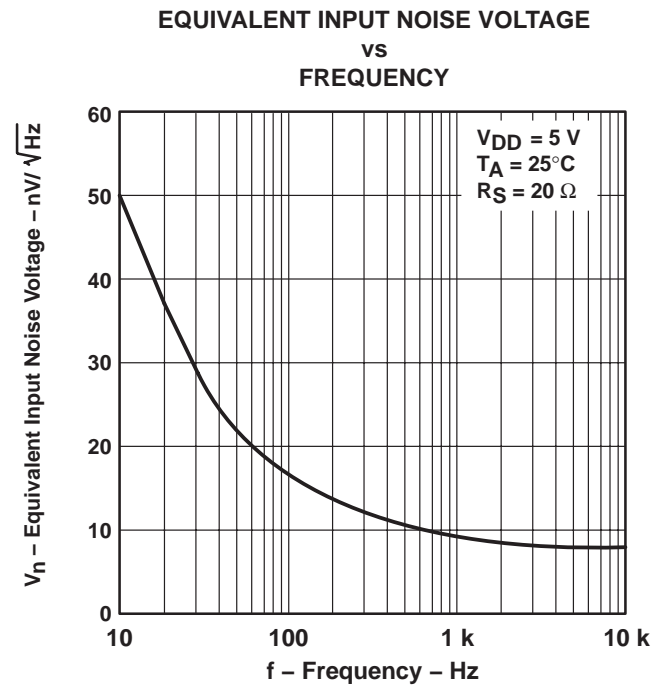
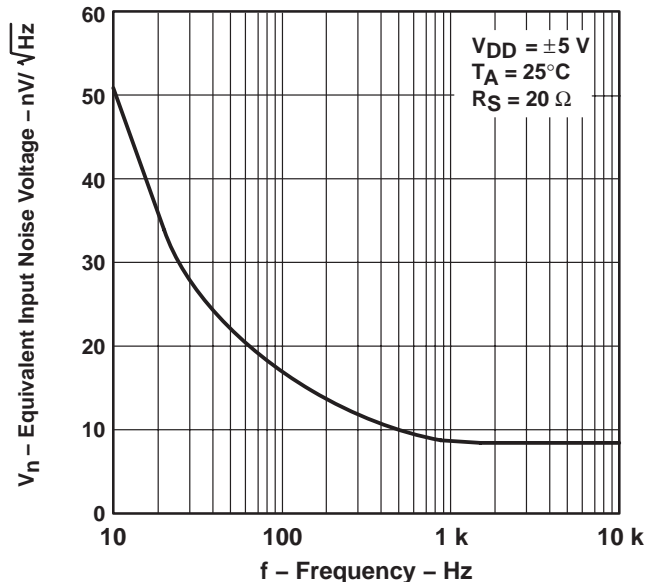


Figure 50

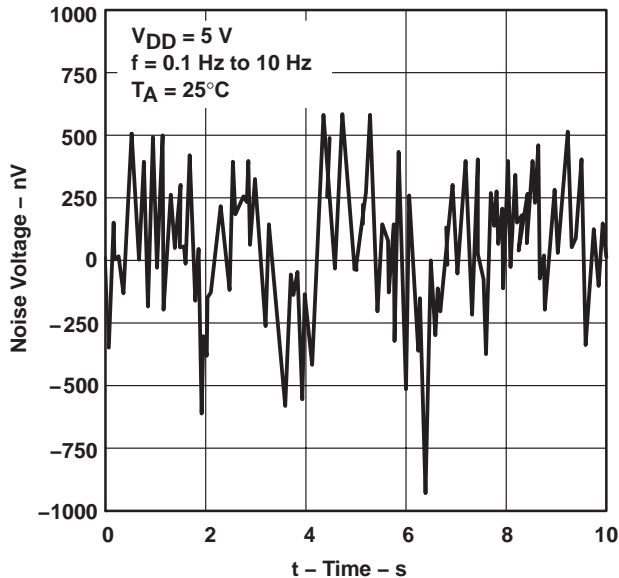
**TYPICAL CHARACTERISTICS**

**EQUIVALENT INPUT NOISE VOLTAGE  
 vs  
 FREQUENCY**



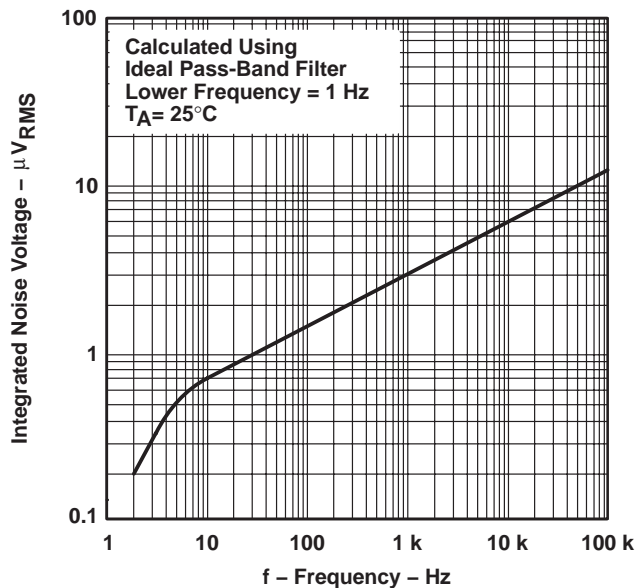
**Figure 51**

**NOISE VOLTAGE  
 OVER A 10 SECOND PERIOD**



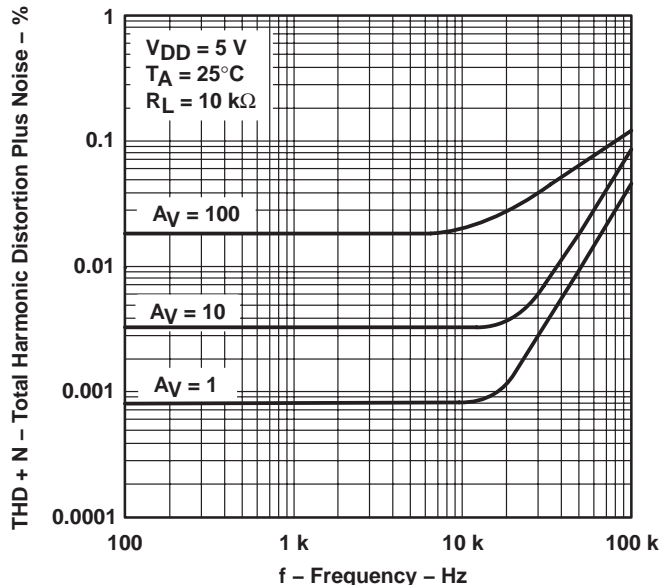
**Figure 52**

**INTEGRATED NOISE VOLTAGE  
 vs  
 FREQUENCY**



**Figure 53**

**TOTAL HARMONIC DISTORTION PLUS NOISE  
 vs  
 FREQUENCY**



**Figure 54**

TYPICAL CHARACTERISTICS

GAIN-BANDWIDTH PRODUCT  
VS  
SUPPLY VOLTAGE

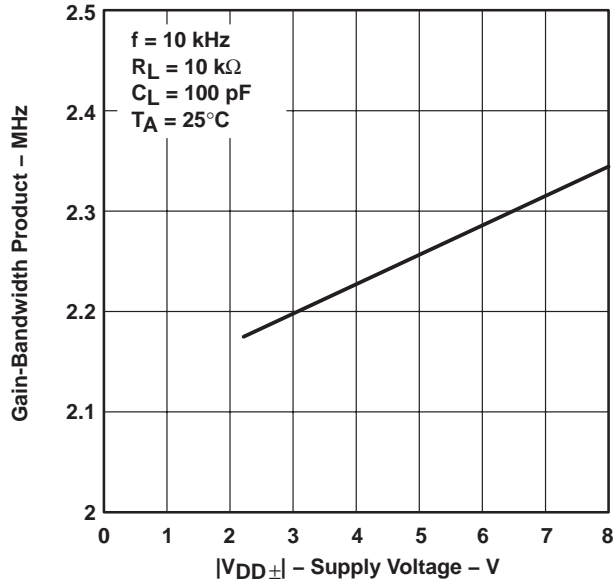


Figure 55

GAIN-BANDWIDTH PRODUCT†  
VS  
FREE-AIR TEMPERATURE

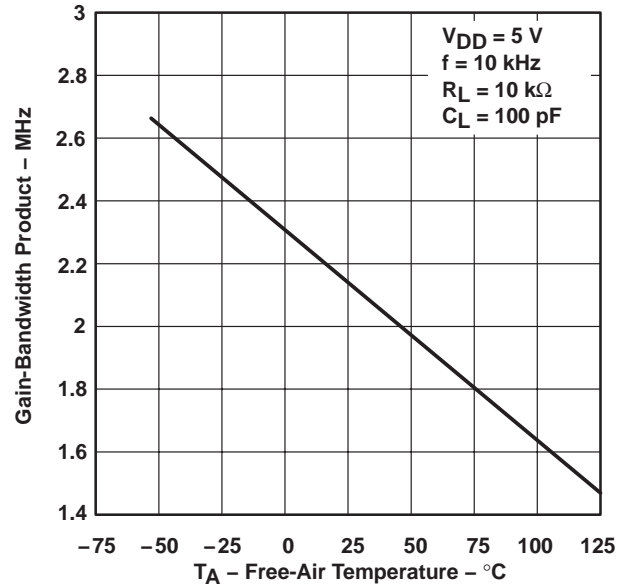


Figure 56

PHASE MARGIN  
VS  
LOAD CAPACITANCE

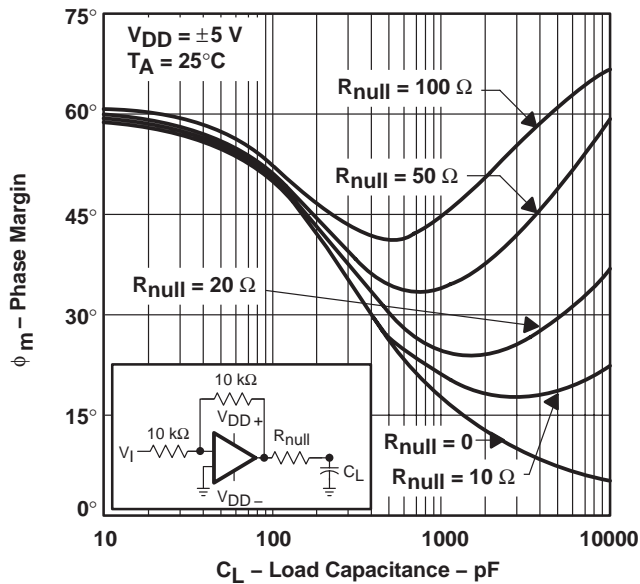


Figure 57

GAIN MARGIN  
VS  
LOAD CAPACITANCE

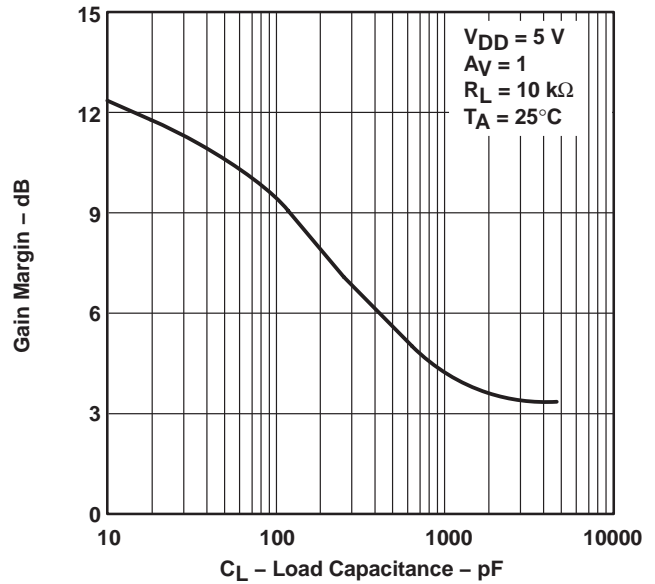


Figure 58

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

# TLC227x, TLC227xA Advanced LinCMOS™ RAIL-TO-RAIL OPERATIONAL AMPLIFIERS

SLOS190G – FEBRUARY 1997 – REVISED MAY 2004

## APPLICATION INFORMATION

### macromodel information

Macromodel information provided was derived using Microsim *Parts*™, the model generation software used with Microsim *PSpice*™. The Boyle macromodel (see Note 5) and subcircuit in Figure 59 were generated using the TLC227x typical electrical and operating characteristics at  $T_A = 25^\circ\text{C}$ . Using this information, output simulations of the following key parameters can be generated to a tolerance of 20% (in most cases):

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

NOTE 5: G. R. Boyle, B. M. Cohn, D. O. Pederson, and J. E. Solomon, "Macromodeling of Integrated Circuit Operational Amplifiers", *IEEE Journal of Solid-State Circuits*, SC-9, 353 (1974).

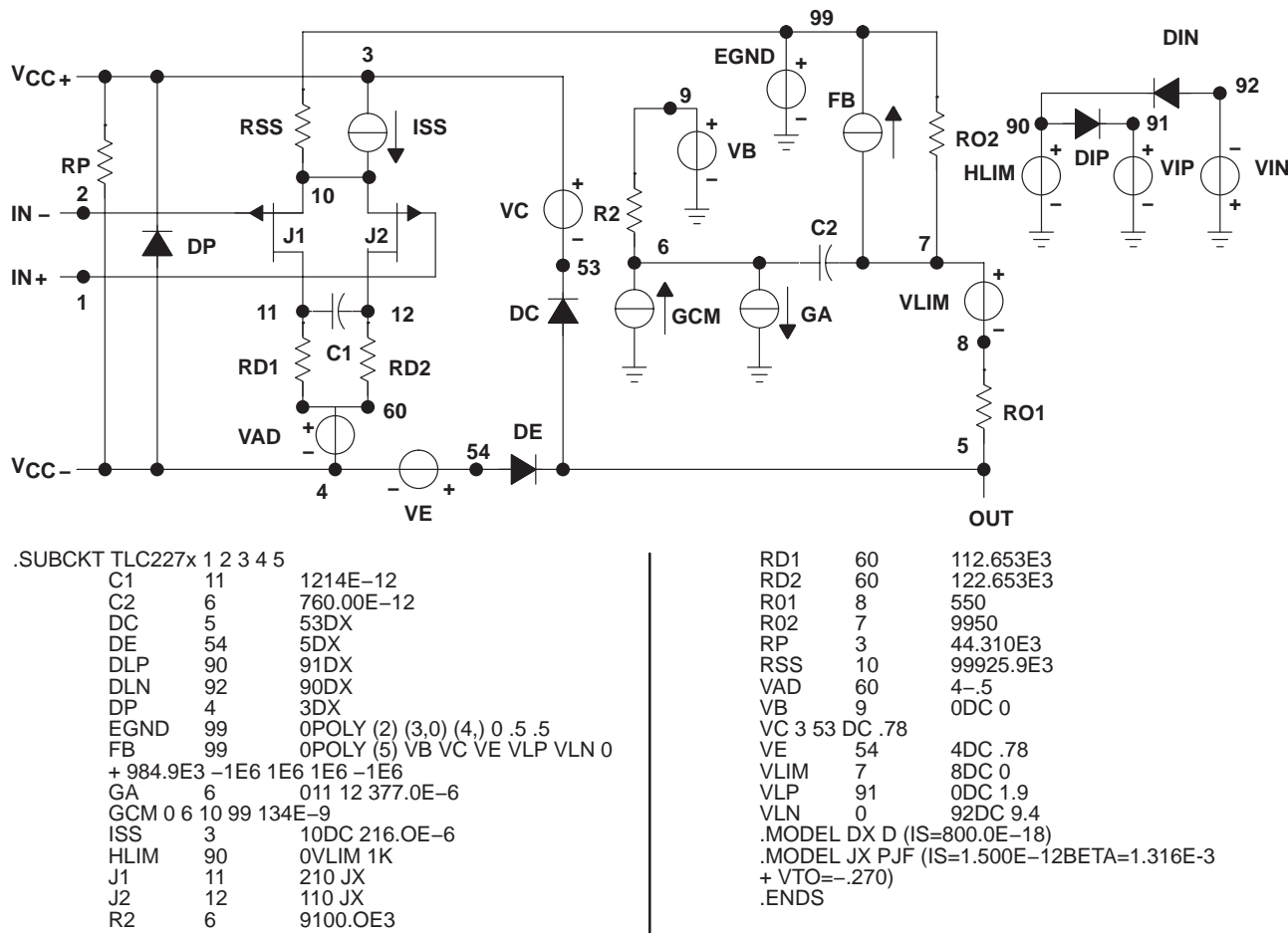


Figure 59. Boyle Macromodel and Subcircuit

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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>
Power Mgmt	<a href="http://power.ti.com">power.ti.com</a>	Optical Networking	<a href="http://www.ti.com/opticalnetwork">www.ti.com/opticalnetwork</a>
Microcontrollers	<a href="http://microcontroller.ti.com">microcontroller.ti.com</a>	Security	<a href="http://www.ti.com/security">www.ti.com/security</a>
		Telephony	<a href="http://www.ti.com/telephony">www.ti.com/telephony</a>
		Video & Imaging	<a href="http://www.ti.com/video">www.ti.com/video</a>
		Wireless	<a href="http://www.ti.com/wireless">www.ti.com/wireless</a>

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