

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

SGLS131B – JULY 2002 – REVISED DECEMBER 2003

- **Controlled Baseline**
 - One Assembly/Test Site, One Fabrication Site
- **Extended Temperature Performance of –55°C to 125°C**
- **Enhanced Diminishing Manufacturing Sources (DMS) Support**
- **Enhanced Product Change Notification**
- **Qualification Pedigree†**
- **Output Swing Includes Both Supply Rails**

† Component qualification in accordance with JEDEC and industry standards to ensure reliable operation over an extended temperature range. This includes, but is not limited to, Highly Accelerated Stress Test (HAST) or biased 85/85, temperature cycle, autoclave or unbiased HAST, electromigration, bond intermetallic life, and mold compound life. Such qualification testing should not be viewed as justifying use of this component beyond specified performance and environmental limits.

description

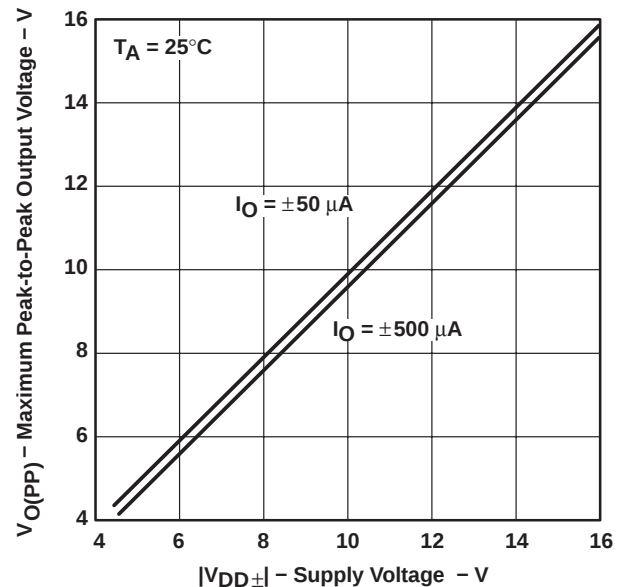
The TLC2272A and TLC2274A are dual and quadruple operational amplifiers from Texas Instruments. Both devices exhibit rail-to-rail output performance for increased dynamic range in single- or split-supply applications. The TLC227xA family offers 2 MHz of bandwidth and 3 V/μs of slew rate for higher speed applications. These devices offer comparable ac performance while having better noise, input offset voltage, and power dissipation than existing CMOS operational amplifiers. The TLC227xA has a noise voltage of 9 nV/√Hz, two times lower than competitive solutions.

The TLC227xA, 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 has 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.

- **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_A = 25°C
- **Macromodel Included**
- **Performance Upgrades for the TS272, TS274, TLC272, and TLC274**

MAXIMUM PEAK-TO-PEAK OUTPUT VOLTAGE
VS
SUPPLY VOLTAGE



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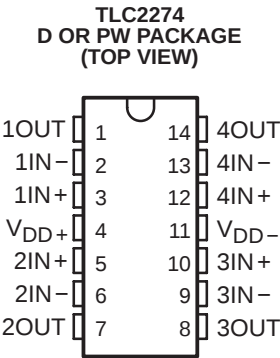
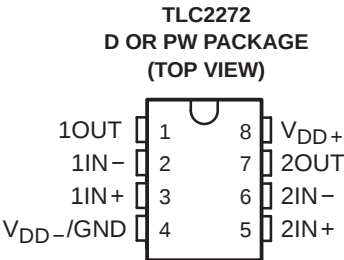
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AVAILABLE OPTIONS

T _A	V _{IO} max At 25°C	PACKAGED DEVICES	
		SMALL OUTLINE (D)	TSSOP (PW)
-55°C to 125°C	950 µV 2.5 mV	TLC2272AMDREP TLC2272MDREP	TLC2272AMPWREP TLC2272MPWREP
-55°C to 125°C	950 µV 2.5 mV	TLC2274AMDREP TLC2274MDREP	TLC2274AMPWREP TLC2274MPWREP



The circuit schematic illustrates a 10-bit SAR ADC. It consists of three main functional blocks: a 10-bit DAC, a 10-bit comparator, and a control logic block.

- 10-bit DAC:** This block is responsible for generating the analog reference voltage. It features a 10-bit digital input (IN+) and a 10-bit digital output (OUT). The DAC is implemented using a series of 10 transistors (Q1-Q10) and resistors (R1-R10). The output of the DAC is connected to the input of the comparator.
- 10-bit Comparator:** This block compares the analog input (IN-) with the DAC output. It is implemented using a series of 10 transistors (Q11-Q20) and resistors (R1-R10). The output of the comparator is connected to the input of the control logic block.
- Control Logic Block:** This block is responsible for controlling the DAC and the comparator. It is implemented using a series of 10 transistors (Q21-Q30) and resistors (R1-R10). The output of the control logic block is connected to the input of the DAC and the input of the comparator.

The circuit is powered by a 10-bit DAC and a 10-bit comparator. The DAC is implemented using a series of 10 transistors (Q1-Q10) and resistors (R1-R10). The comparator is implemented using a series of 10 transistors (Q11-Q20) and resistors (R1-R10). The control logic block is implemented using a series of 10 transistors (Q21-Q30) and resistors (R1-R10).

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

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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
Continuous total dissipation	See Dissipation Rating Table
Operating free-air temperature range, T_A	–55°C to 125°C
Storage temperature range (see Note 4)	–65°C to 150°C
Lead temperature 1,6 mm (1/16 inch) from case for 10 seconds: D or PW package	260°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. Long term high-temperature storage and/or extended use at maximum recommended operating conditions may result in a reduction of overall device life. See http://www.ti.com/ep_quality for additional information on enhanced plastic packaging.

DISSIPATION RATING TABLE

PACKAGE	$T_A \leq 25^\circ\text{C}$ POWER RATING	DERATING FACTOR ABOVE $T_A = 25^\circ\text{C}$	$T_A = 70^\circ\text{C}$ POWER RATING	$T_A = 85^\circ\text{C}$ POWER RATING	$T_A = 125^\circ\text{C}$ POWER RATING
D-8	725 mW	5.8 mW/°C	464 mW	337 mW	145 mW
D-14	950 mW	7.6 mW/°C	608 mW	494 mW	190 mW
PW-8	525 mW	4.2 mW/°C	336 mW	273 mW	105 mW
PW-14	700 mW	5.6 mW/°C	448 mW	364 mW	—

recommended operating conditions

	MIN	MAX	UNIT
Supply voltage, $V_{DD\pm}$	±2.2	±8	V
Input voltage, V_I	V_{DD-}	$V_{DD+} - 1.5$	V
Common-mode input voltage, V_{IC}	V_{DD-}	$V_{DD+} - 1.5$	V
Operating free-air temperature, T_A	–55	125	°C



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TLC2272-EP electrical characteristics at specified free-air temperature, $V_{DD} = 5\text{ V}$ (unless otherwise noted)

PARAMETER		TEST CONDITIONS		T _A [†]	TLC2272-EP			TLC2272A-EP			UNIT		
					MIN	TYP	MAX	MIN	TYP	MAX			
V _{IO}	Input offset voltage	V _{IC} = 0 V, V _O = 0 V, V _{DD±} = ±2.5 V, R _S = 50 Ω		25°C	300	2500		300	950		μV		
	Full range				3000		1500						
α _{VIO}	Temperature coefficient of input offset voltage			25°C to 125°C	2			2			μV/°C		
	Input offset voltage long-term drift (see Note 5)			25°C	0.002			0.002			μV/mo		
I _{IO}	Input offset current			25°C	0.5	60		0.5	60		pA		
				Full range		800		800					
I _{IB}	Input bias current			25°C	1	60		1	60		pA		
				Full range		800		800					
V _{ICR}	Common-mode input voltage	R _S = 50 Ω, V _{IO} ≤ 5 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 μA		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				
				Full range	4.25			4.25					
V _{OL}	Low-level output voltage	V _{IC} = 2.5 V, I _{OL} = 50 μA		25°C	0.01			0.01			V		
				25°C	0.09	0.15		0.09	0.15				
		V _{IC} = 2.5 V, I _{OL} = 500 μA		Full range	0.15			0.15					
				25°C	4.25	4.65		4.25	4.65				
		V _{IC} = 2.5 V, I _{OL} = 5 mA		Full range	4.25			4.25					
				25°C	0.9	1.5		0.9	1.5				
A _{VD}	Large-signal differential voltage amplification	V _{IC} = 2.5 V, V _O = 1 V to 4 V		R _L = 10 kΩ [‡]		25°C	10	35		10	35	V/mV	
						Full range	10			10			
						R _L = 1 mΩ [‡]		25°C	175				175
f = 10 kHz, P package		25°C	10 ¹²					10 ¹²			Ω		
		f = 1 MHz, A _V = 10		25°C	10 ¹²				10 ¹²			Ω	
				f = 10 kHz, P package		25°C	8			8			pF
f = 1 MHz, A _V = 10						25°C	140			140			Ω
		CMRR	Common-mode rejection ratio			V _{IC} = 0 V to 2.7 V, V _O = 2.5 V, R _S = 50 Ω		25°C	70	75		70	75
				Full range	70					70			
k _{SVR}	Supply-voltage rejection ratio (ΔV _{DD} /ΔV _{IO})	V _{DD} = 4.4 V to 16 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 V, No load		25°C	2.2	3		2.2	3	mA			
				Full range		3			3				

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

‡ Referenced to 2.5 V

NOTE 5: 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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TLC2272-EP operating characteristics at specified free-air temperature, $V_{DD} = 5\text{ V}$

PARAMETER		TEST CONDITIONS		T _A [†]	TLC2272-EP			TLC2272A-EP			UNIT
					MIN	TYP	MAX	MIN	TYP	MAX	
SR	Slew rate at unity gain	V _O = 1.25 V to 2.75 V, R _L = 10 kΩ [‡] , C _L = 100 pF [‡]		25°C	2.3	3.6		2.3	3.6		V/μs
				Full range	1.7			1.7			
V _n	Equivalent input noise voltage	f = 10 Hz		25°C	50			50			nV/√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			μV
		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/√Hz
THD + N	Total harmonic distortion plus noise	V _O = 0.5 V to 2.5 V, f = 20 kHz, R _L = 10 kΩ [‡] ,	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, C _L = 100 pF [‡] , R _L = 10 kΩ [‡] ,		25°C	2.18			2.18			MHz
B _{OM}	Maximum output-swing bandwidth	V _{O(PP)} = 2 V, R _L = 10 kΩ [‡] ,	A _V = 1, C _L = 100 pF [‡]	25°C	1			1			MHz
t _s	Settling time	A _V = −1, Step = 0.5 V to 2.5 V, R _L = 10 kΩ [‡] , C _L = 100 pF [‡]	To 0.1%	25°C	1.5			1.5			μs
			To 0.01%		2.6			2.6			
ϕ _m	Phase margin at unity gain	R _L = 10 kΩ [‡] , C _L = 100 pF [‡]		25°C	50°			50°			
	Gain margin			25°C	10			10			dB

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

‡ Referenced to 2.5 V

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TLC2272-EP electrical characteristics at specified free-air temperature, $V_{DD\pm} = \pm 5\text{ V}$ (unless otherwise noted)

PARAMETER	TEST CONDITIONS	$T_A^\dagger$	TLC2272-EP			TLC2272A-EP			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	μV
		Full range			3000			1500	
α_{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 5)		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			800			800	
I_{IB} Input bias current		25°C		1	60		1	60	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		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
	$I_O = -200\ \mu\text{A}$	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		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			
		25°C	-3.5	-4.1		-3.5	-4.1		
	$V_{IC} = 0\text{ V}, I_O = 5\text{ mA}$	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	20	50	20	50		V/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}		Ω
r_i Common-mode input resistance		25°C		10^{12}			10^{12}		Ω
c_i Common-mode input capacitance	$f = 10\text{ kHz}, \text{ P package}$	25°C		8			8		pF
z_o Closed-loop output impedance	$f = 1\text{ MHz}, A_V = 10$	25°C		130			130		Ω
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 ($\Delta V_{DD\pm}/\Delta V_{IO}$)	$V_{DD} = \pm 2.2\text{ V to } \pm 8\text{ V}, V_{IC} = 0\text{ V}, \text{ No load}$	25°C	80	95		80	95		dB
		Full range	80			80			
I_{DD} Supply current	$V_O = 2.5\text{ V}, \text{ No load}$	25°C		2.4	3		2.4	3	mA
		Full range			3			3	

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

NOTE 5: 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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TLC2272-EP operating characteristics at specified free-air temperature, $V_{DD\pm} = \pm 5\text{ V}$

PARAMETER		TEST CONDITIONS		$T_A^\dagger$	TLC2272-EP			TLC2272A-EP			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/ μs
				Full range	1.7			1.7			
V_n	Equivalent input noise voltage	$f = 10\text{ Hz}$		25°C		50			50		nV/ $\sqrt{\text{Hz}}$
		$f = 1\text{ kHz}$		25°C		9			9		
V_{NPP}	Peak-to-peak equivalent input noise voltage	$f = 0.1\text{ Hz to }1\text{ Hz}$		25°C		1			1		μV
		$f = 0.1\text{ Hz to }10\text{ Hz}$		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	$V_O = \pm 2.3\text{ V}$ $R_L = 10\text{ k}\Omega$, $f = 20\text{ kHz}$	$A_V = 1$	25°C		0.0011%			0.0011%		
			$A_V = 10$			0.004%			0.004%		
			$A_V = 100$			0.03%			0.03%		
	Gain-bandwidth product	$f = 10\text{ kHz}$, $C_L = 100\text{ pF}$	$R_L = 10\text{ k}\Omega$	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		μs
			To 0.01%			3.2			3.2		
ϕ_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 -55°C to 125°C for M level part.

TLC2274-EP electrical characteristics at specified free-air temperature, $V_{DD} = 5\text{ V}$ (unless otherwise noted)

PARAMETER	TEST CONDITIONS	$T_A^\dagger$	TLC2274-EP			TLC2274A-EP			UNIT
			MIN	TYP	MAX	MIN	TYP	MAX	
V_{IO} Input offset voltage	$V_{DD} = \pm 2.5\text{ V}, V_{IC} = 0\text{ V}, V_O = 0\text{ V}, R_S = 50\ \Omega$	25°C	300	2500		300	950		μV
		Full range		3000			1500		
α_{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 5)		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		800			800		
I_{IB} Input bias current		25°C	1	60		1	60		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		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
	$I_{OH} = -200\ \mu\text{A}$	25°C	4.85	4.93		4.85	4.93		
		Full range	4.85			4.85			
	$I_{OH} = -1\text{ mA}$	25°C	4.25	4.65		4.25	4.65		
		Full range	4.25			4.25			
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	
	$V_{IC} = 2.5\text{ V}, I_{OL} = 500\ \mu\text{A}$	Full range			0.15			0.15	
		25°C		0.9	1.5		0.9	1.5	
	$V_{IC} = 2.5\text{ V}, I_{OL} = 5\text{ mA}$	Full range			1.5			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	10	35		10	35	V/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}		Ω
r_i Common-mode input resistance		25°C		10^{12}			10^{12}		Ω
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		Ω
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 -55°C to 125°C for M level part.

‡ Referenced to 2.5 V

NOTE 5: 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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TLC2274-EP operating characteristics at specified free-air temperature, $V_{DD} = 5\text{ V}$

PARAMETER		TEST CONDITIONS		T _A [†]	TLC2274-EP			TLC2274A-EP			UNIT
					MIN	TYP	MAX	MIN	TYP	MAX	
SR	Slew rate at unity gain	V _O = 0.5 V to 2.5 V, R _L = 10 kΩ [‡] , C _L = 100 pF [‡]		25°C	2.3	3.6		2.3	3.6		V/μs
				Full range	1.7			1.7			
V _n	Equivalent input noise voltage	f = 10 Hz		25°C	50			50			nV/√Hz
		f = 1 kHz		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			μV
		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/√Hz
THD + N	Total harmonic distortion plus noise	V _O = 0.5 V to 2.5 V, f = 20 kHz, R _L = 10 kΩ [‡]	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, C _L = 100 pF [‡]	R _L = 10 kΩ [‡]	25°C	2.18			2.18			MHz
B _{OM}	Maximum output-swing bandwidth	V _{O(PP)} = 2 V, R _L = 10 kΩ [‡]	A _V = 1, C _L = 100 pF [‡]	25°C	1			1			MHz
t _s	Settling time	A _V = −1, Step = 0.5 V to 2.5 V, R _L = 10 kΩ [‡] , C _L = 100 pF [‡]	To 0.1%	25°C	1.5			1.5			μs
			To 0.01%		2.6			2.6			
ϕ _m	Phase margin at unity gain	R _L = 10 kΩ [‡] , C _L = 100 pF [‡]		25°C	50°			50°			
	Gain margin			25°C	10			10			dB

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

‡ Referenced to 2.5 V

TLC2274-EP electrical characteristics at specified free-air temperature, $V_{DD\pm} = \pm 5\text{ V}$ (unless otherwise noted)

PARAMETER		TEST CONDITIONS		T _A [†]	TLC2274-EP			TLC2274A-EP			UNIT
					MIN	TYP	MAX	MIN	TYP	MAX	
V _{IO}	Input offset voltage	V _{IC} = 0 V, V _O = 0 V, R _S = 50 Ω		25°C	300	2500		300	950	μV	
	Full range			3000		1500					
αV _{IO}	Temperature coefficient of input offset voltage			25°C to 125°C	2		2		μV/°C		
	Input offset voltage long-term drift (see Note 5)			25°C	0.002		0.002		μV/mo		
I _{IO}	Input offset current			25°C	0.5	60	0.5	60	pA		
				Full range	800		800				
I _{IB}	Input bias current			25°C	1	60	1	60	pA		
				Full range	800		800				
V _{ICR}	Common-mode input voltage	R _S = 50 Ω, V _{IO} ≤ 5 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 μA		25°C	4.99		4.99		V		
		I _O = −200 μA		25°C	4.85	4.93	4.85	4.93			
				Full range	4.85		4.85				
		I _O = −1 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 V, I _O = 50 μA		25°C	−4.99		−4.99		V		
		V _{IC} = 0 V, I _O = 500 μA		25°C	−4.85	−4.91	−4.85	−4.91			
				Full range	−4.85		−4.85				
		V _{IC} = 0 V, I _O = 5 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 = ±4 V	R _L = 10 kΩ	25°C	20	50	20	50	V/mV		
				Full range	20		20				
			R _L = 1 MΩ	25°C	300		300				
r _{id}	Differential input resistance			25°C	10 ¹²		10 ¹²		Ω		
r _i	Common-mode input resistance			25°C	10 ¹²		10 ¹²		Ω		
c _i	Common-mode input capacitance	f = 10 kHz, N package		25°C	8		8		pF		
z _o	Closed-loop output impedance	f = 1 MHz, A _V = 10		25°C	130		130		Ω		
CMRR	Common-mode rejection ratio	V _{IC} = −5 V to 2.7 V V _O = 0 V, R _S = 50 Ω		25°C	75	80	75	80	dB		
				Full range	75		75				
k _{SVR}	Supply-voltage rejection ratio (ΔV _{DD±} /ΔV _{IO})	V _{DD±} = ± 2.2 V to ±8 V, V _{IC} = 0 V, No load		25°C	80	95	80	95	dB		
				Full range	80		80				
I _{DD}	Supply current	V _O = 0 V, No load		25°C	4.8	6	4.8	6	mA		
				Full range	6		6				

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

NOTE 5: 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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TLC2274-EP operating characteristics at specified free-air temperature, $V_{DD\pm} = \pm 5\text{ V}$

PARAMETER	TEST CONDITIONS	$T_A^\dagger$	TLC2274-EP			TLC2274A-EP			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/ μs
		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		μV
		f = 0.1 Hz to 10 Hz		1.4			1.4		
I_n	Equivalent input noise current			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	$A_V = 1$		0.0011%			0.0011%		
		$A_V = 10$		0.004%			0.004%		
		$A_V = 100$		0.03%			0.03%		
	Gain-bandwidth product	f = 10 kHz, $R_L = 10\text{ k}\Omega$, $C_L = 100\text{ pF}$		2.25			2.25		MHz
BOM	Maximum output-swing bandwidth	$V_{O(PP)} = 4.6\text{ V}$, $R_L = 10\text{ k}\Omega$, $A_V = 1$, $C_L = 100\text{ pF}$		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%		1.5			1.5		μs
		To 0.01%		3.2			3.2		
ϕ_m	Phase margin at unit gain	$R_L = 10\text{ k}\Omega$, $C_L = 100\text{ pF}$		52°			52°		
	Gain margin			10			10		dB

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

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

TYPICAL CHARACTERISTICS

**DISTRIBUTION OF TLC2272
INPUT OFFSET VOLTAGE**

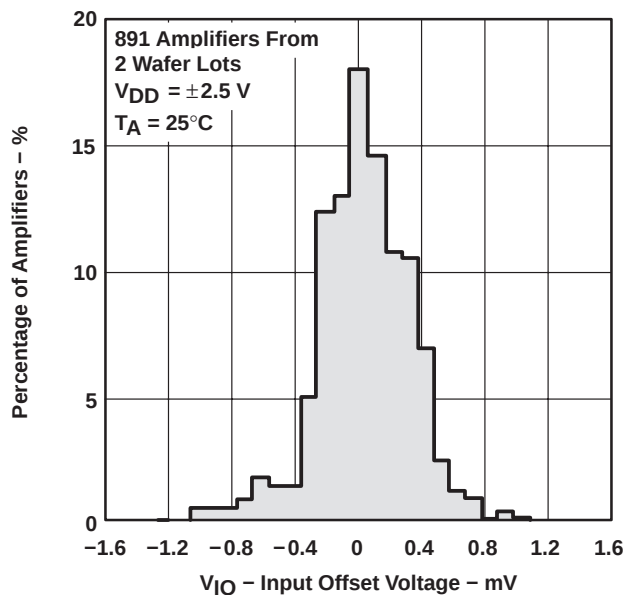


Figure 1

**DISTRIBUTION OF TLC2272
INPUT OFFSET VOLTAGE**

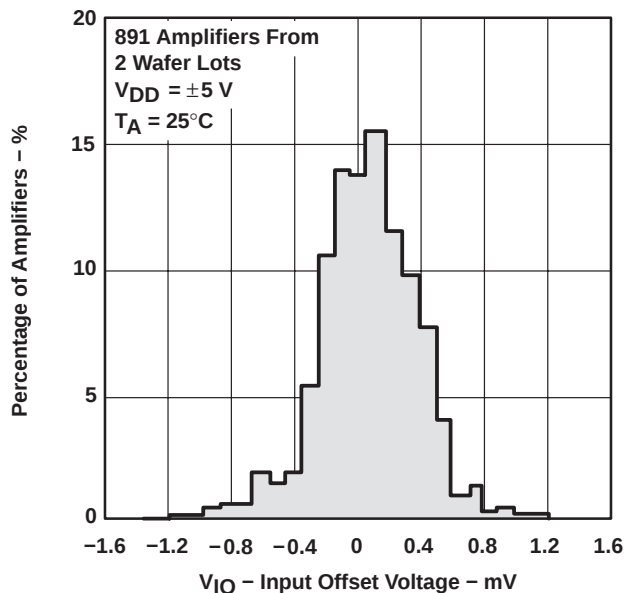


Figure 2

**DISTRIBUTION OF TLC2274
INPUT OFFSET VOLTAGE**

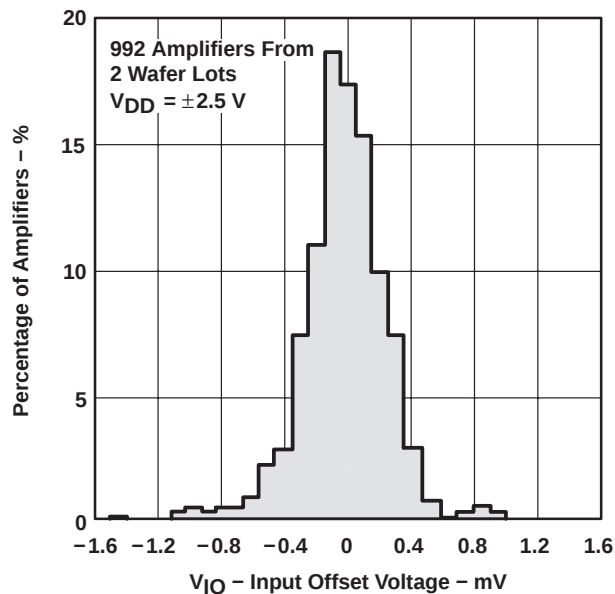


Figure 3

**DISTRIBUTION OF TLC2274
INPUT OFFSET VOLTAGE**

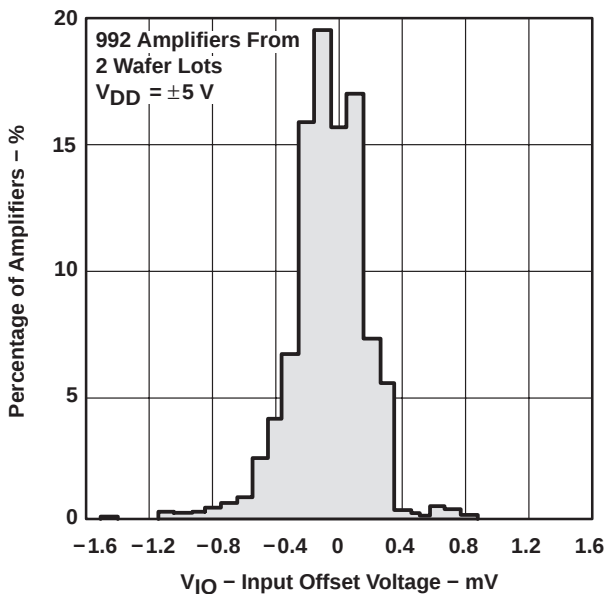
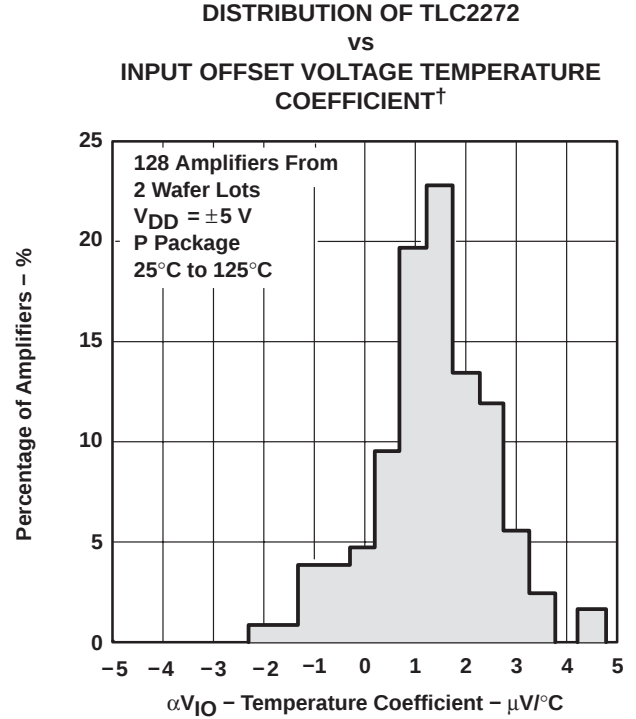
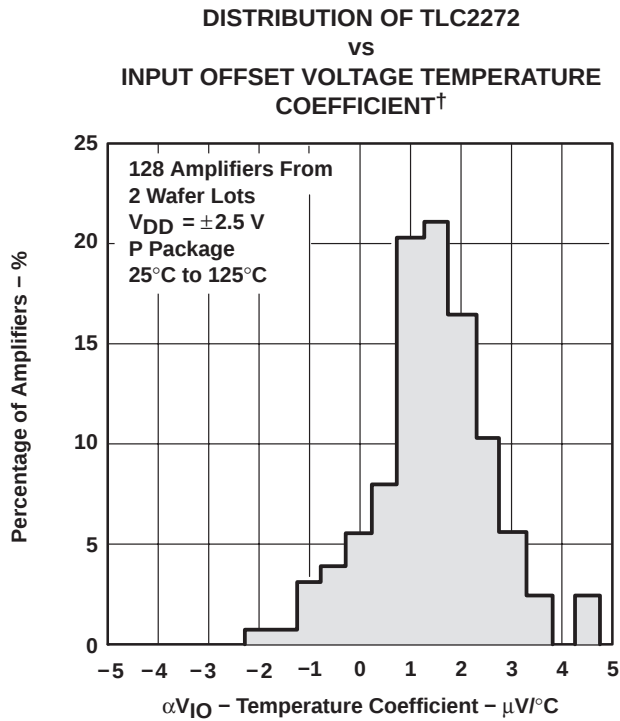
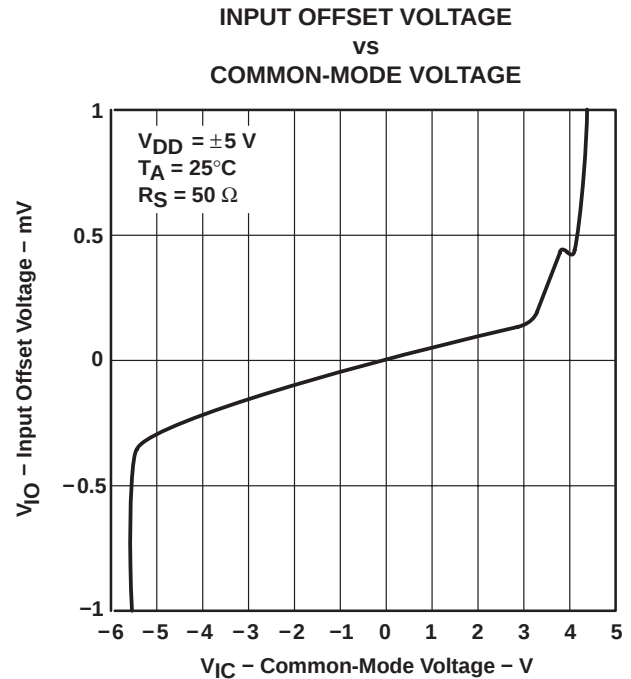
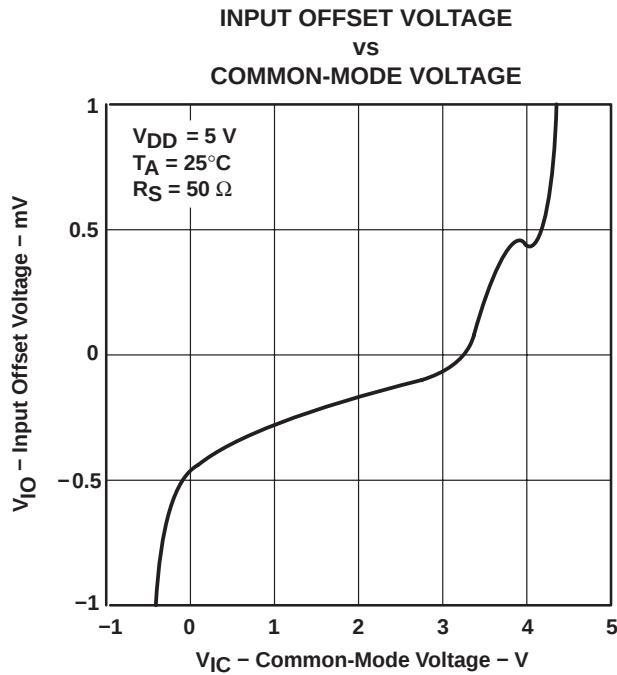


Figure 4

TYPICAL CHARACTERISTICS

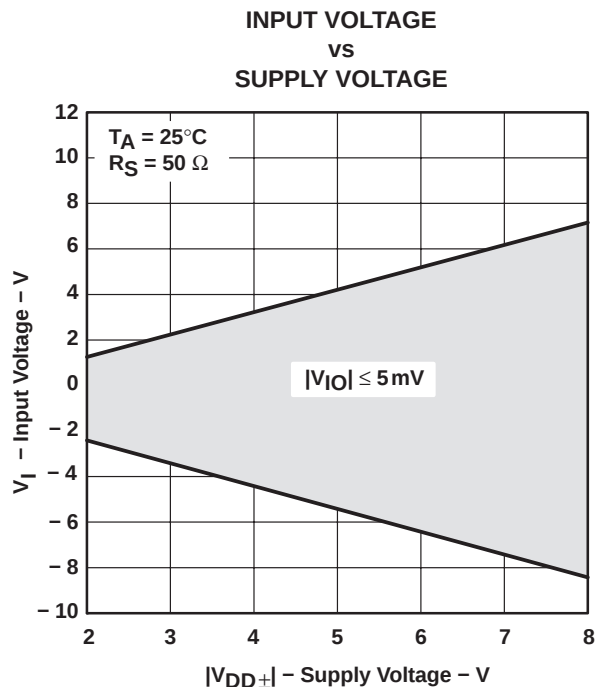
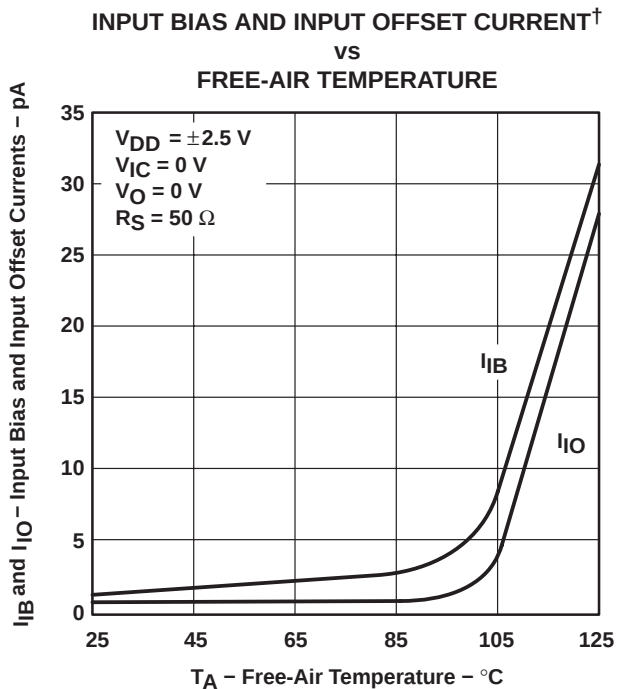
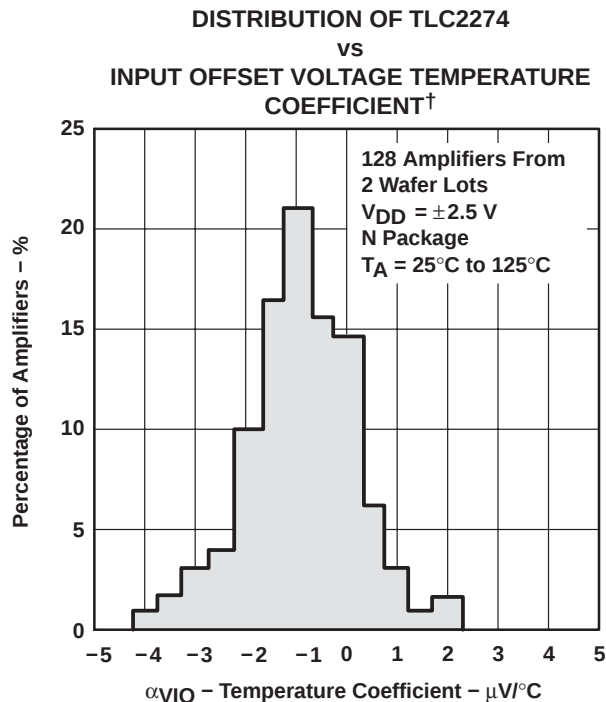
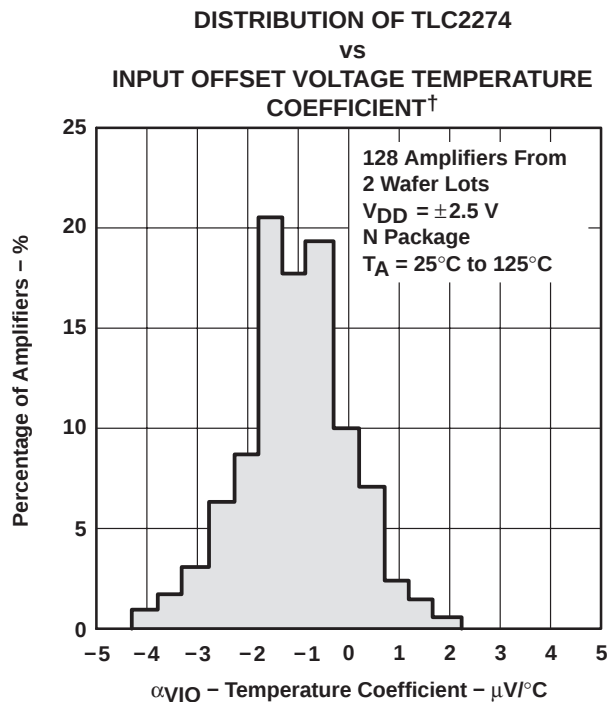


† Data at high and low temperatures are applicable only within the rated operating free-air temperature ranges of the various devices.

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

TYPICAL CHARACTERISTICS

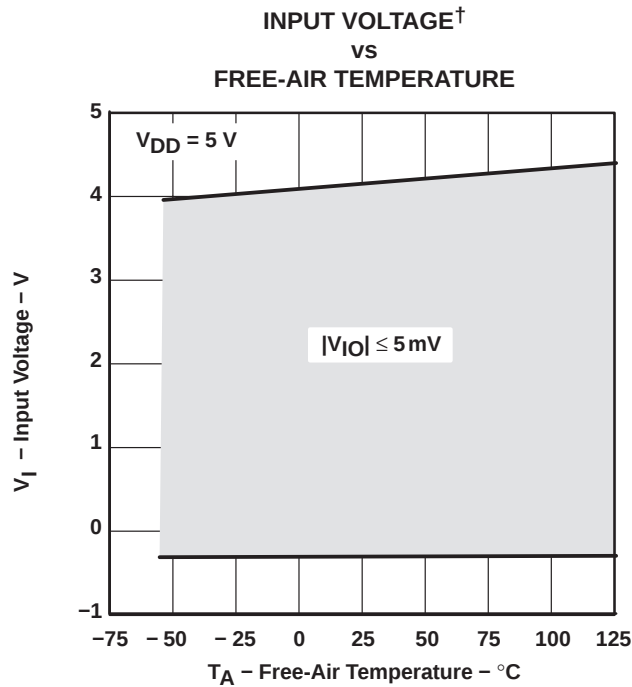


Figure 13

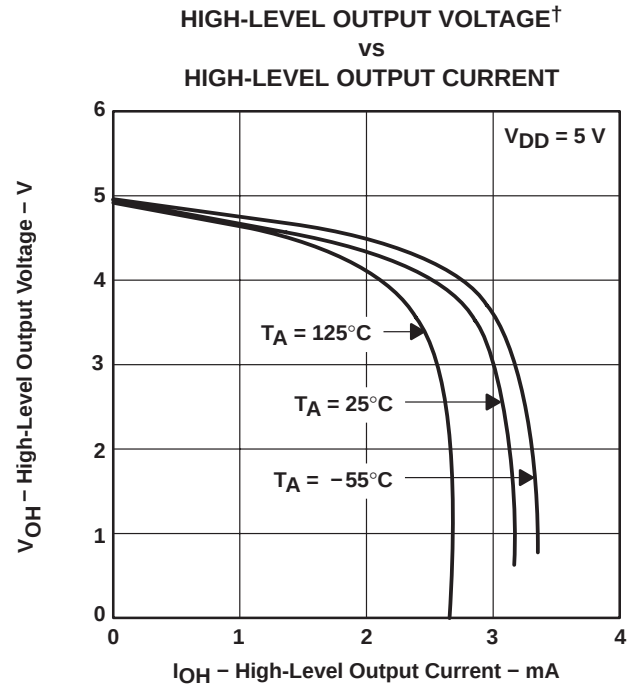


Figure 14

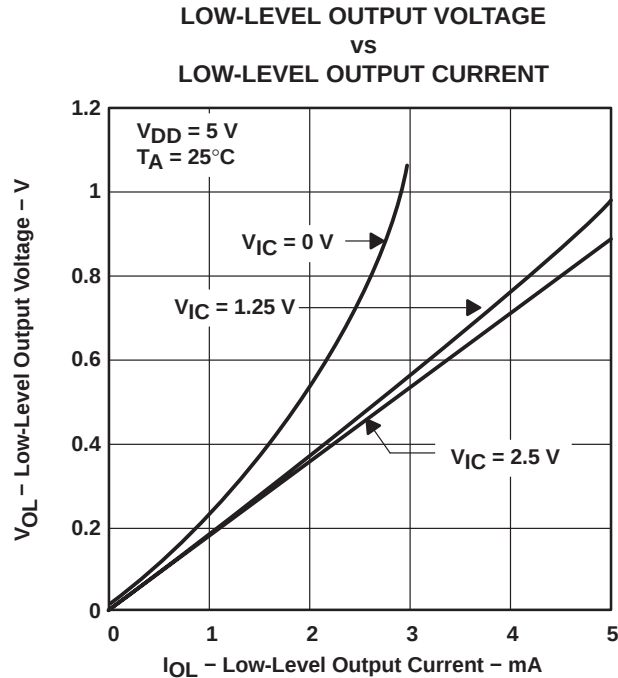


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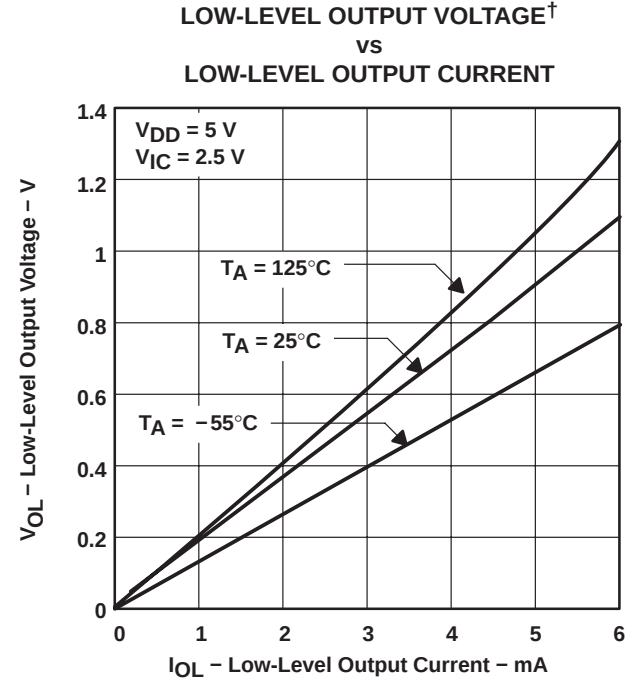


Figure 16

[†] 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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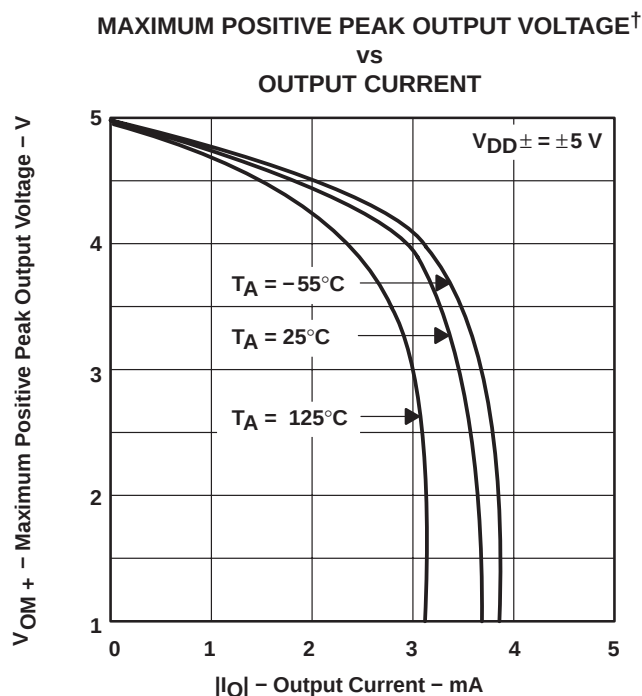


Figure 17

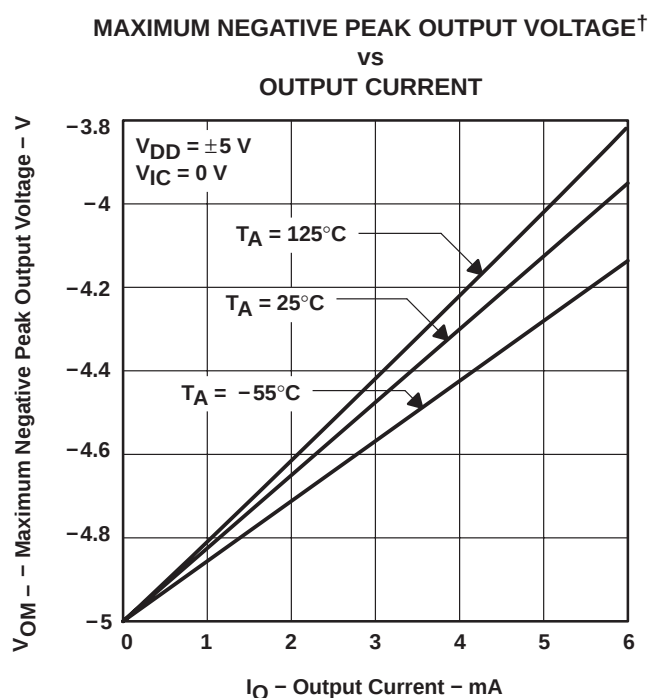


Figure 18

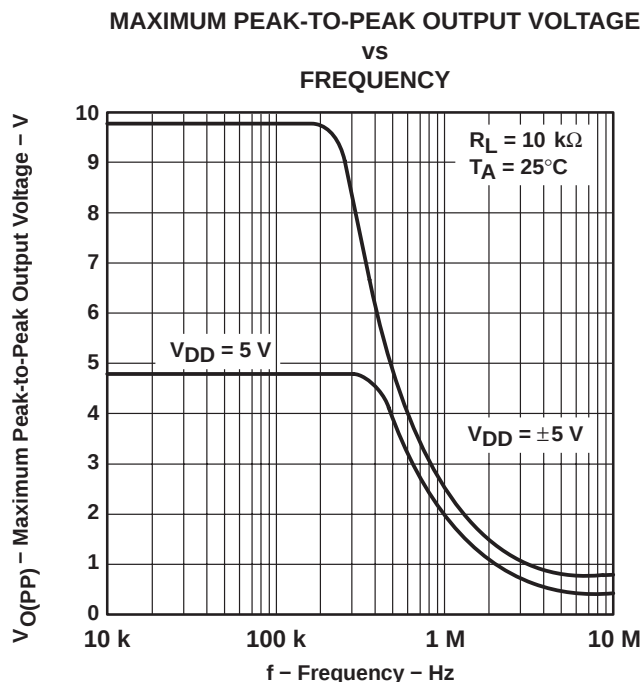


Figure 19

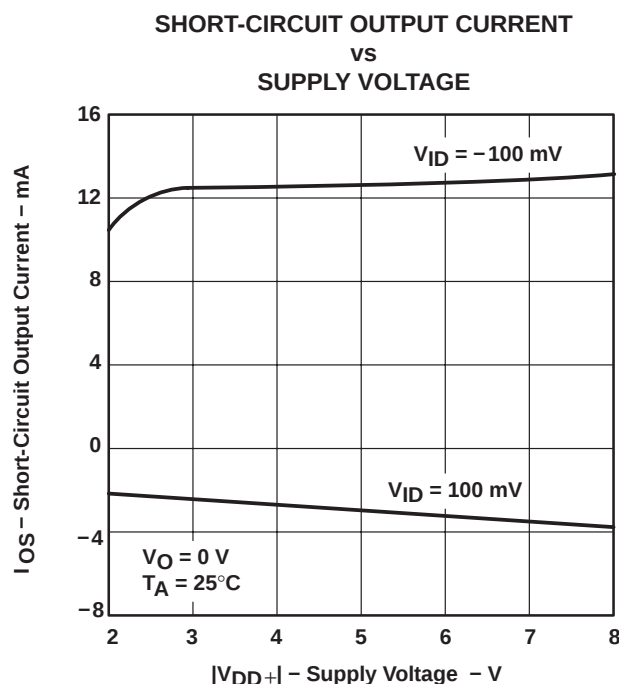


Figure 20

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

TYPICAL CHARACTERISTICS

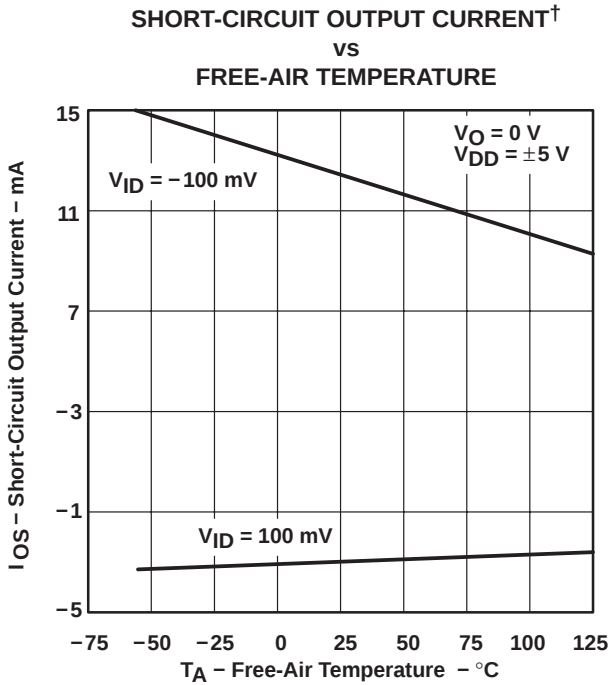


Figure 21

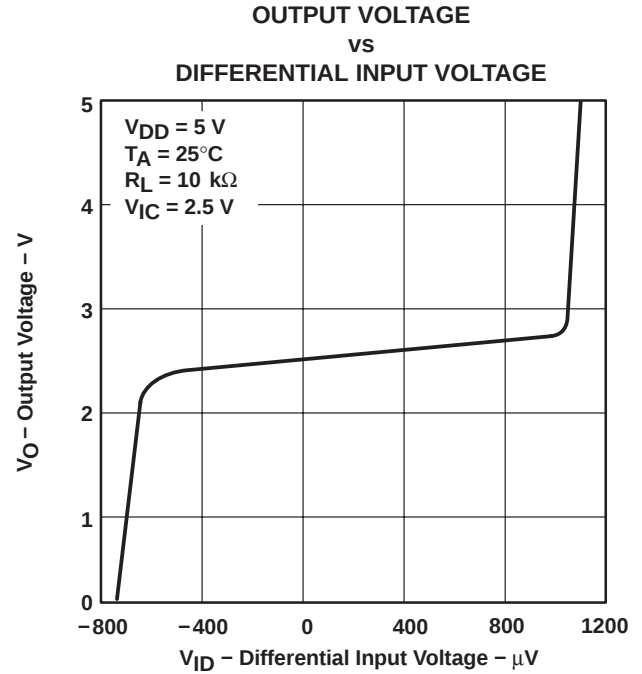


Figure 22

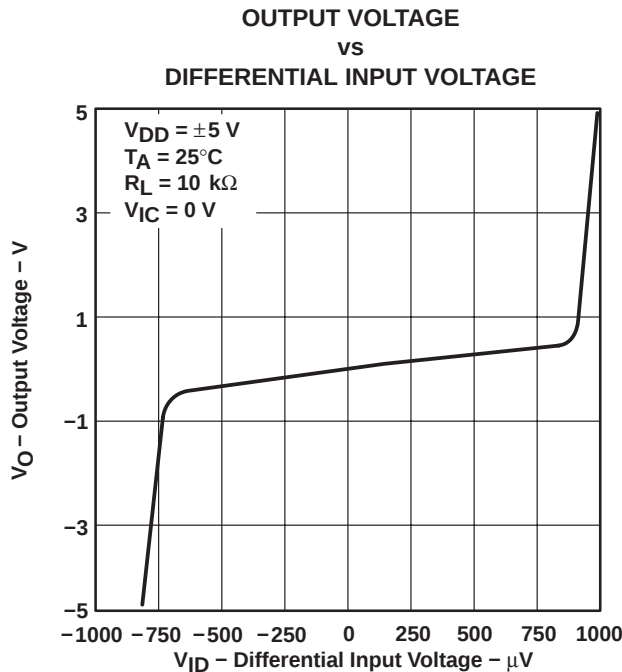


Figure 23

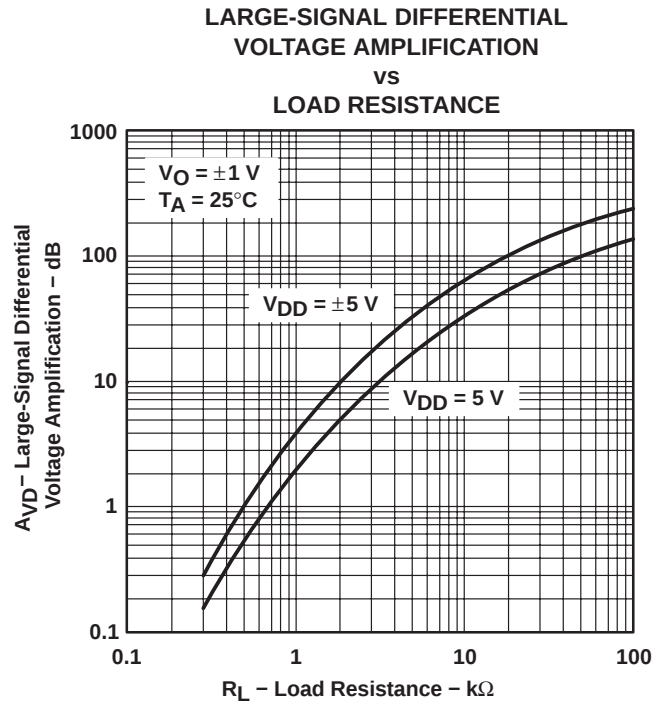


Figure 24

[†] 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

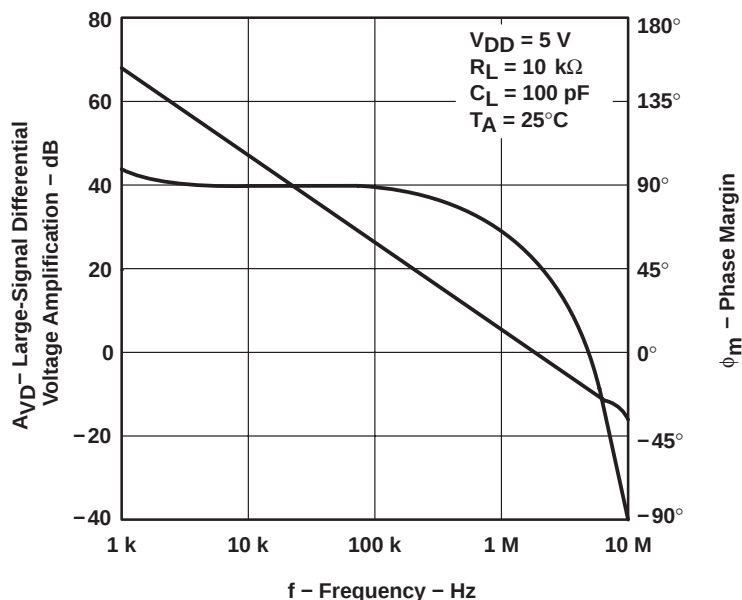


Figure 25

LARGE-SIGNAL DIFFERENTIAL VOLTAGE AMPLIFICATION AND PHASE MARGIN

vs
FREQUENCY

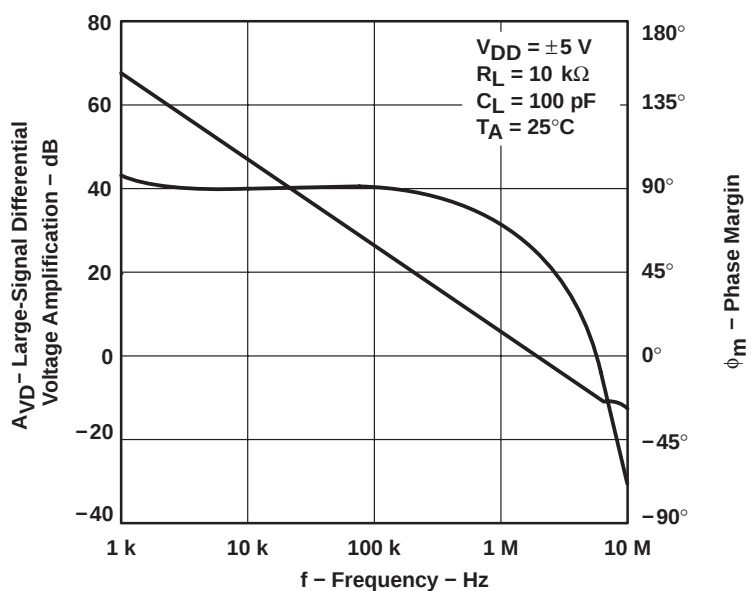


Figure 26

TYPICAL CHARACTERISTICS

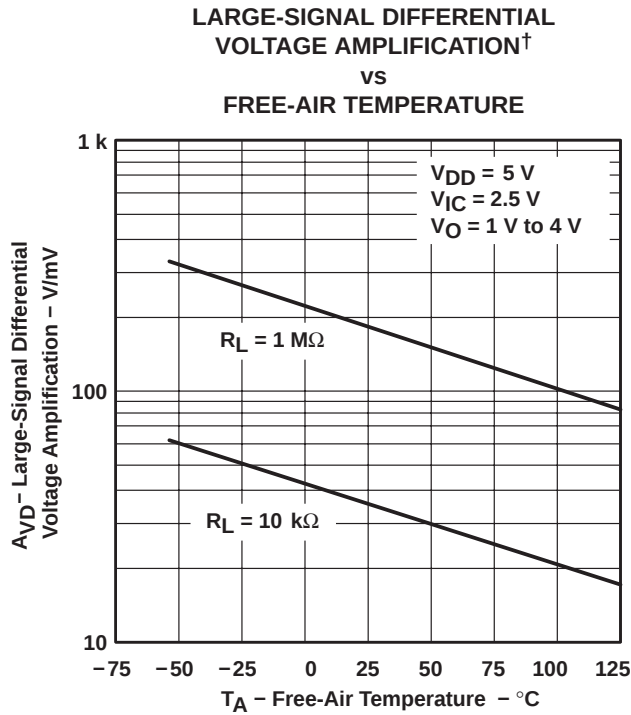


Figure 27

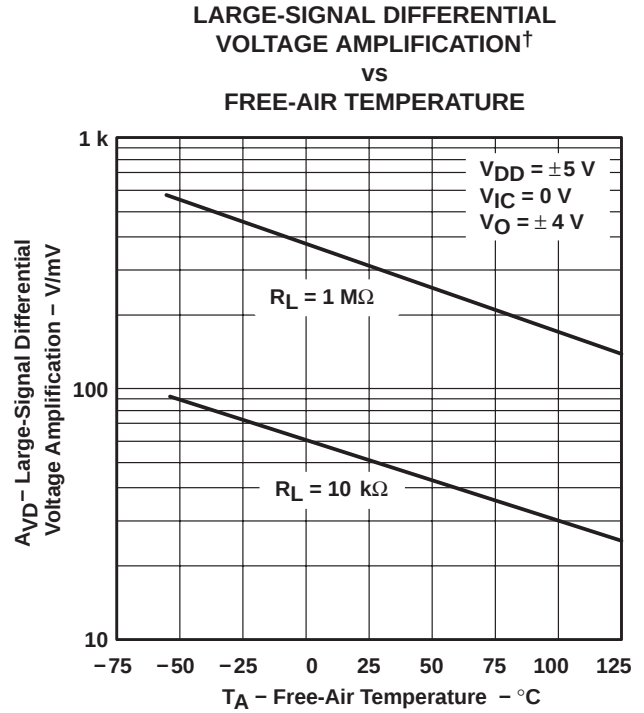


Figure 28

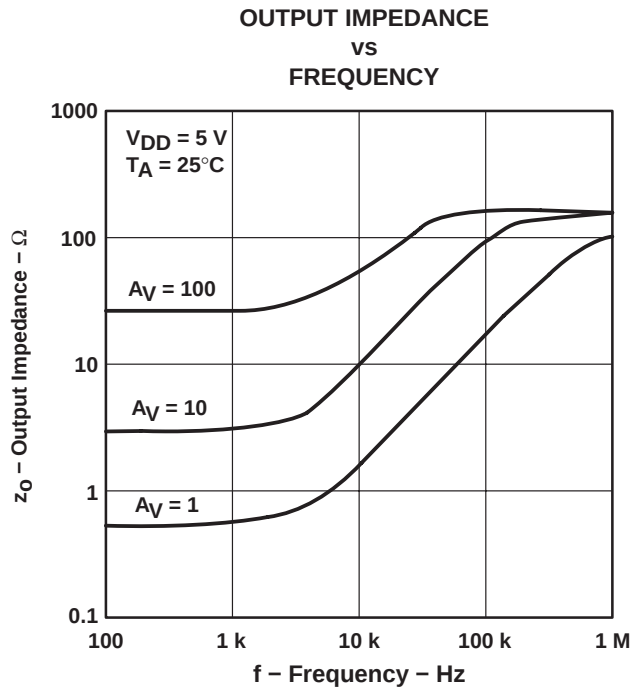


Figure 29

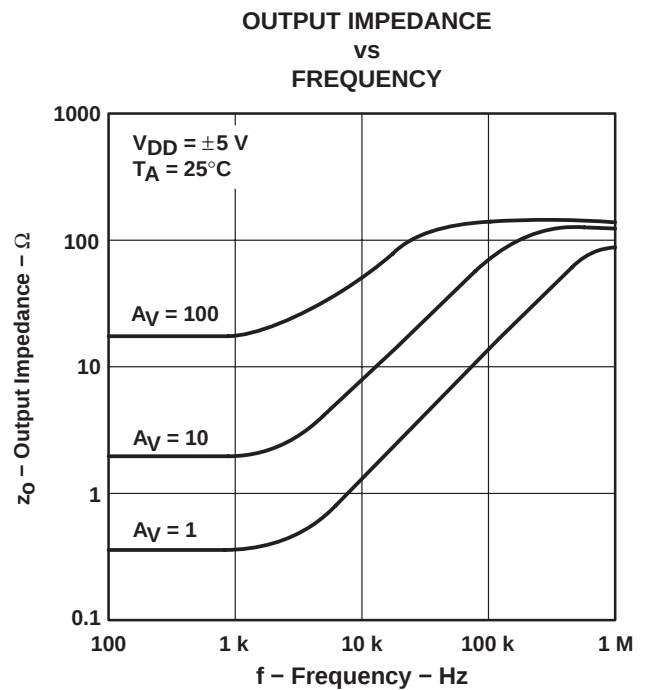


Figure 30

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

TYPICAL CHARACTERISTICS

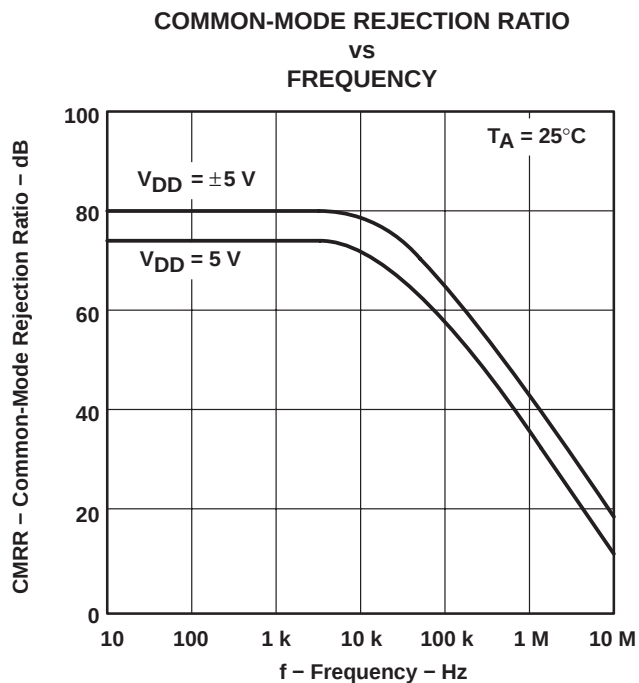


Figure 31

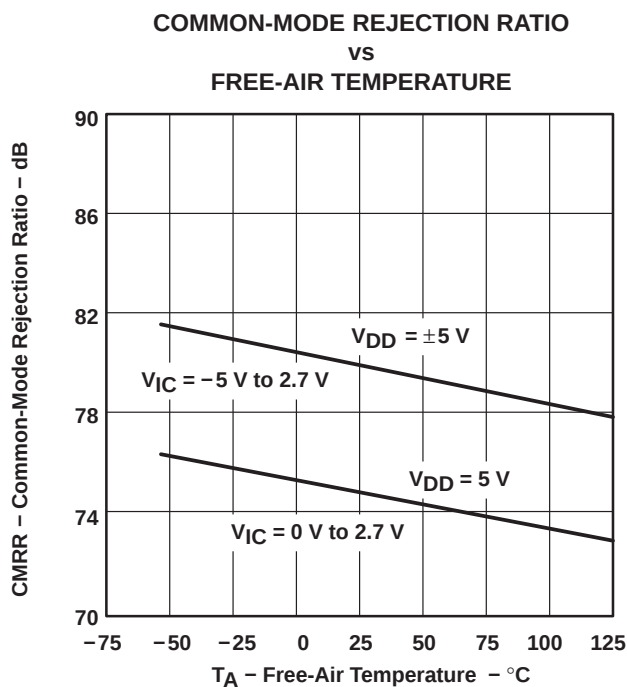


Figure 32

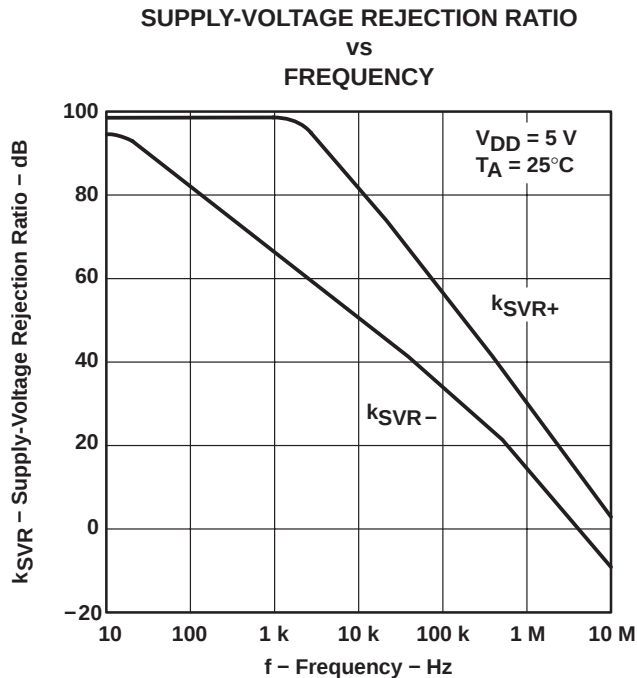


Figure 33

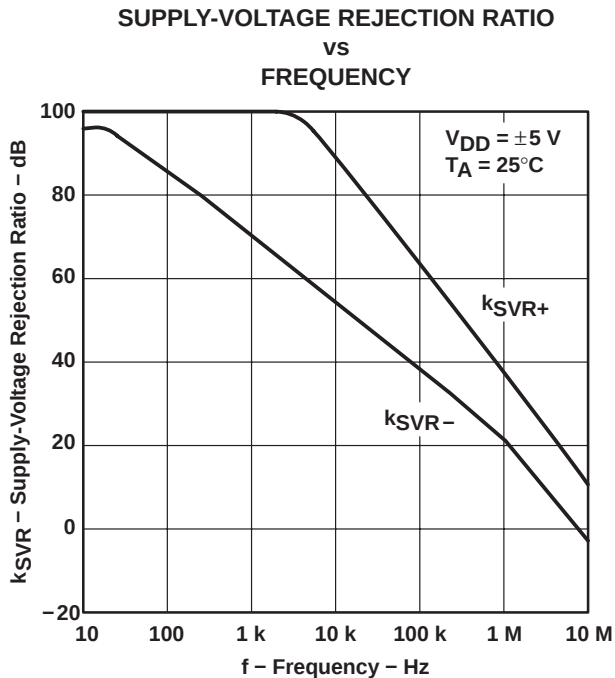


Figure 34

TYPICAL CHARACTERISTICS

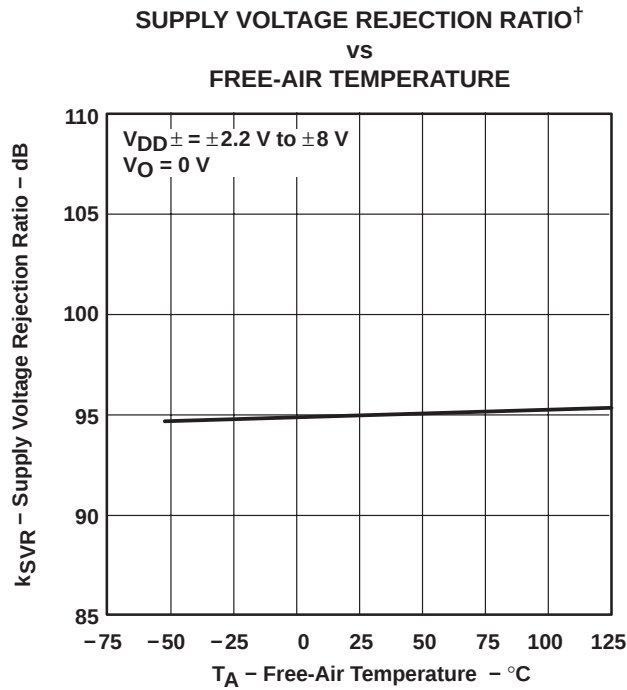


Figure 35

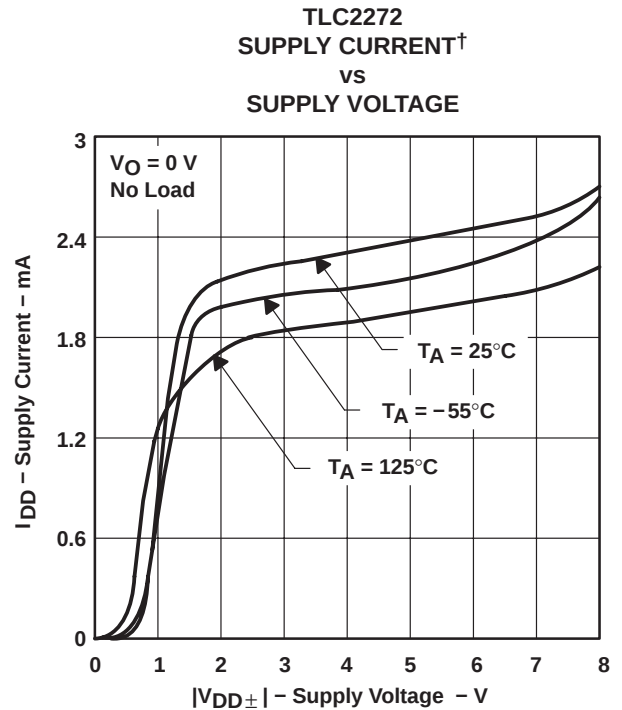


Figure 36

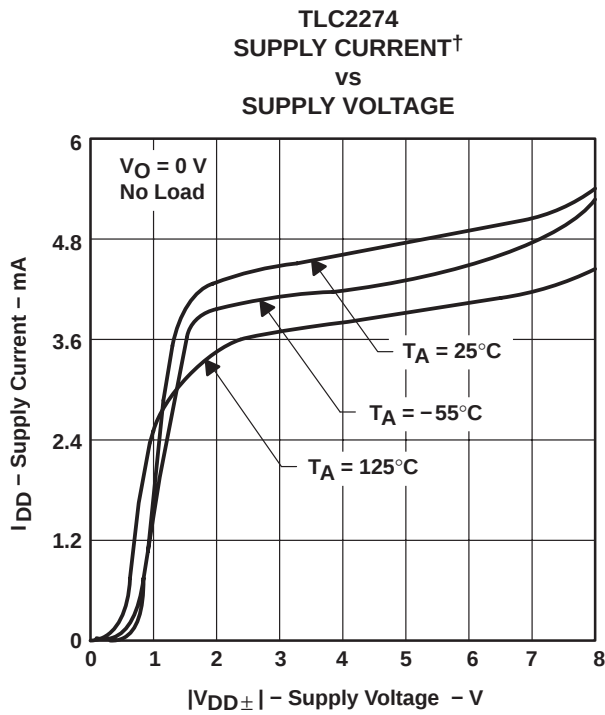


Figure 37

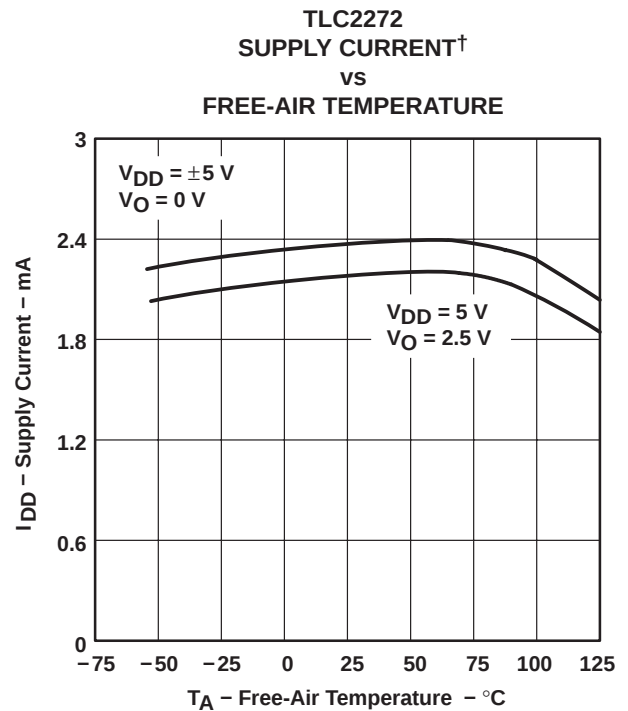


Figure 38

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

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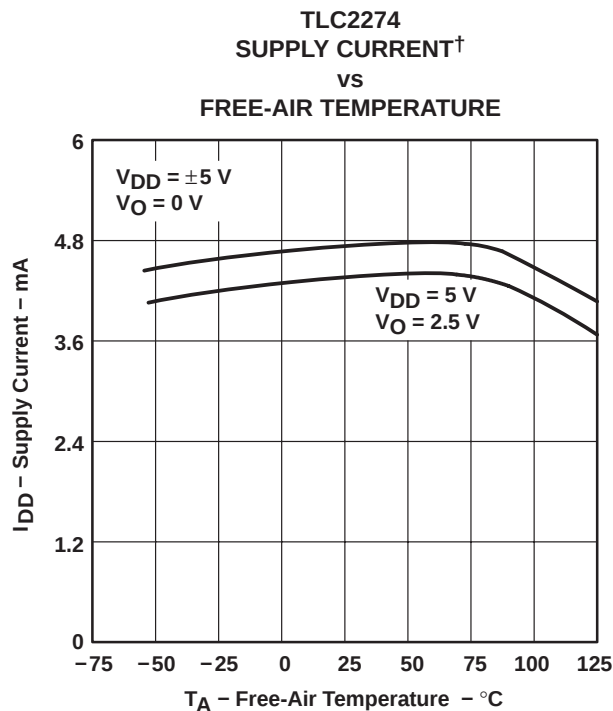


Figure 39

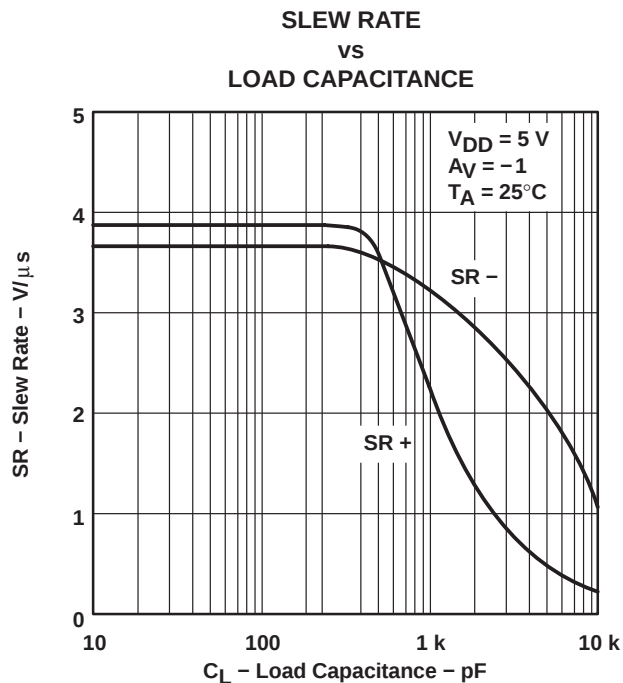


Figure 40

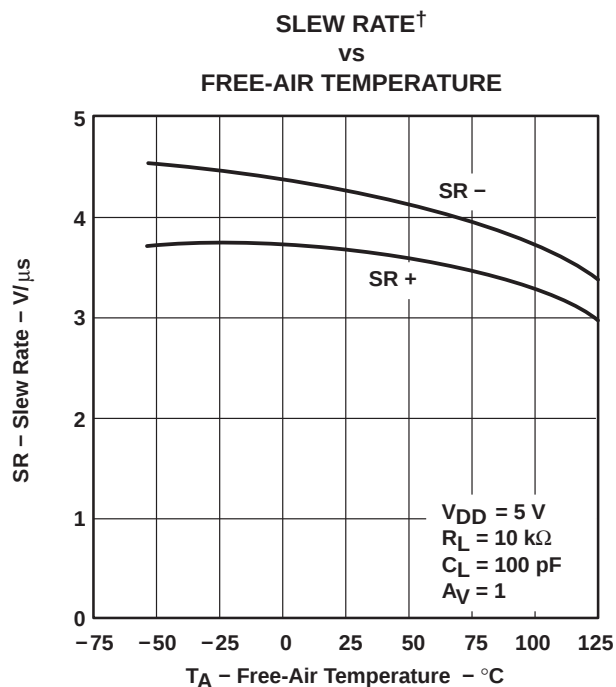


Figure 41

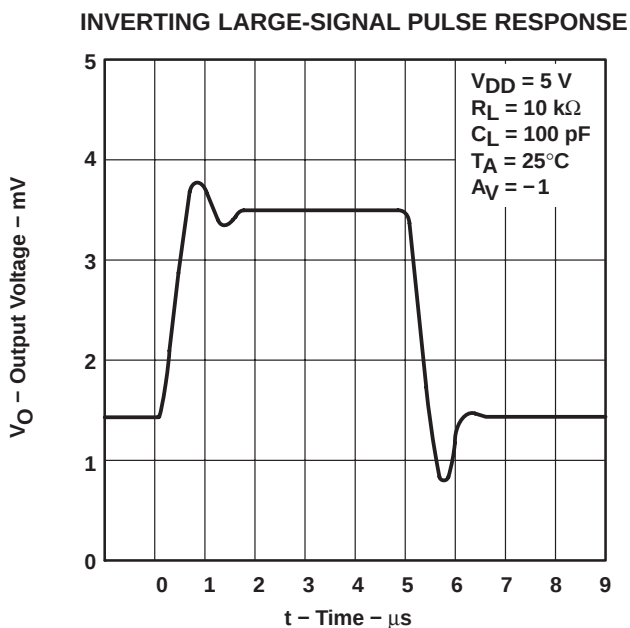


Figure 42

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

TYPICAL CHARACTERISTICS

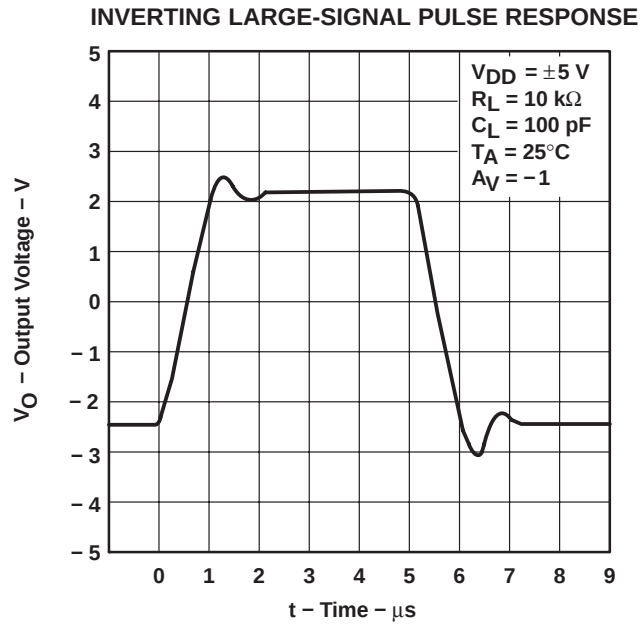


Figure 43

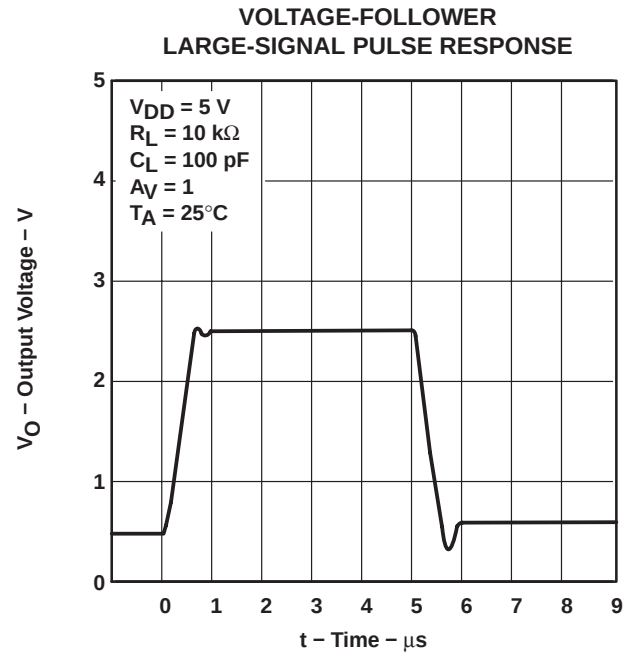


Figure 44

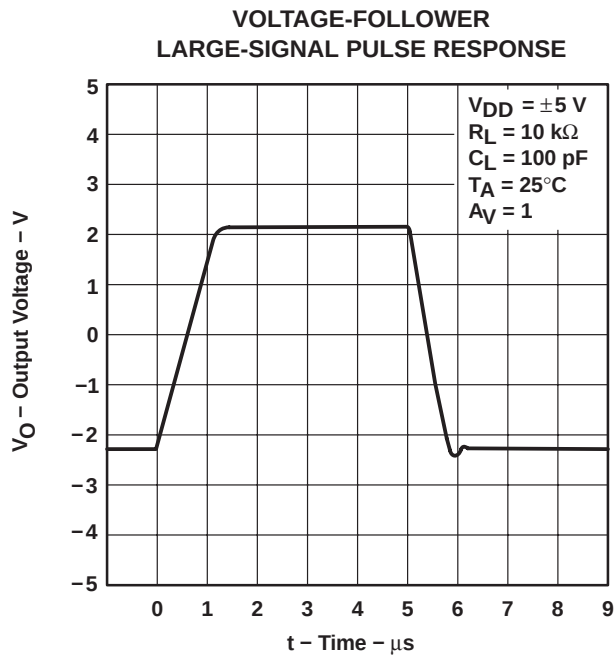


Figure 45

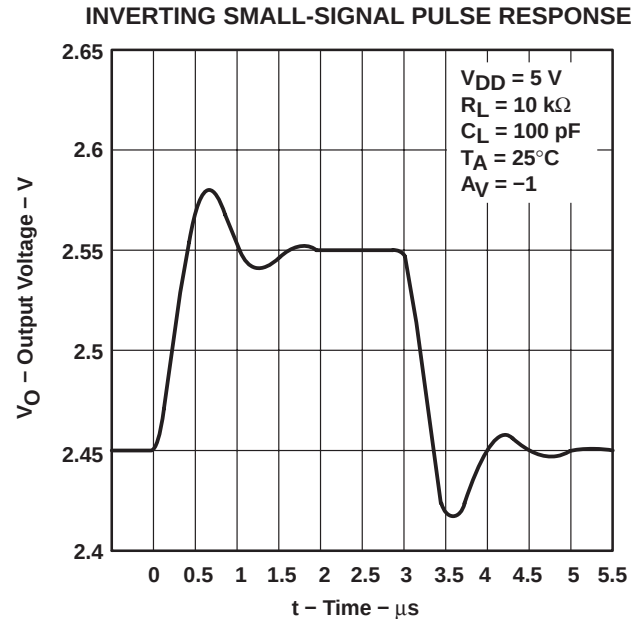


Figure 46

TLC227x-EP, TLC227xA-EP

Advanced LinCMOS™ RAIL-TO-RAIL

OPERATIONAL AMPLIFIERS

SGLS131A – JULY 2002 – REVISED NOVEMBER 2003

TYPICAL CHARACTERISTICS

INVERTING SMALL-SIGNAL PULSE RESPONSE

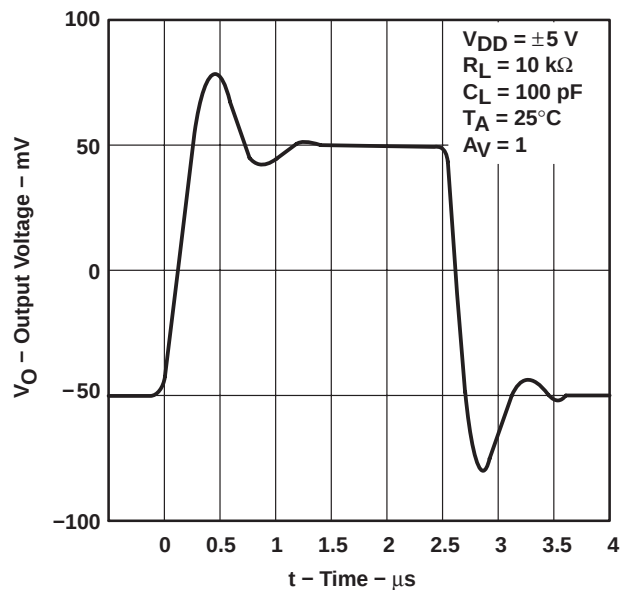


Figure 47

VOLTAGE-FOLLOWER
SMALL-SIGNAL PULSE RESPONSE

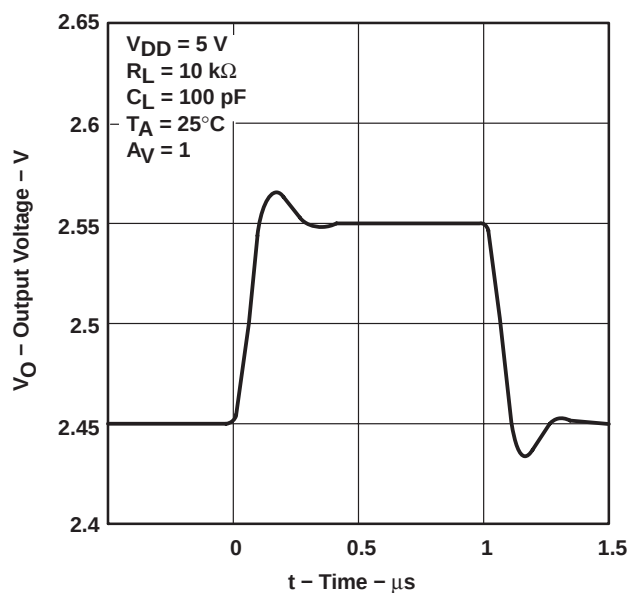


Figure 48

VOLTAGE-FOLLOWER
SMALL-SIGNAL PULSE RESPONSE

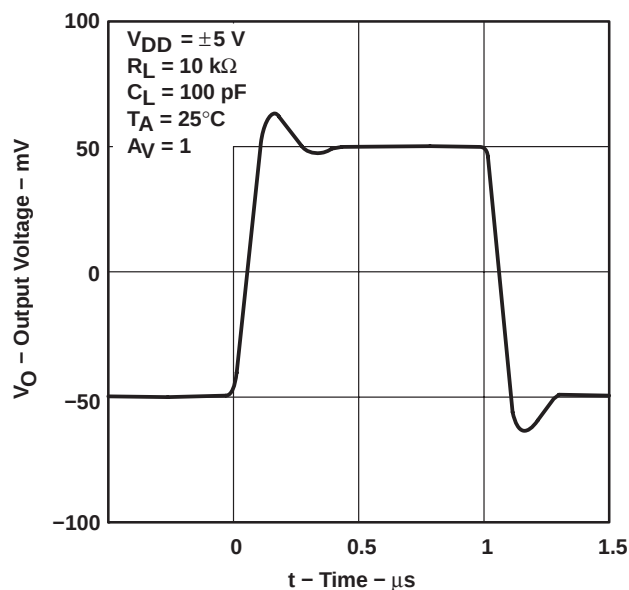


Figure 49

EQUIVALENT INPUT NOISE VOLTAGE
VS
FREQUENCY

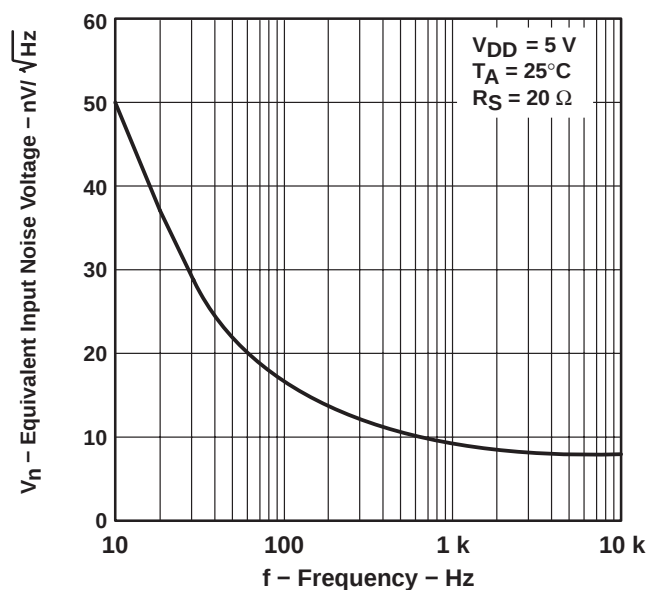


Figure 50

TYPICAL CHARACTERISTICS

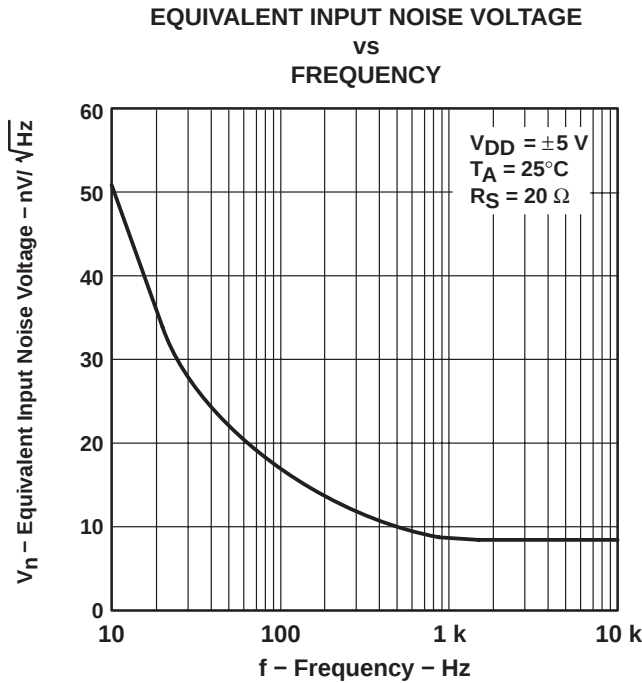


Figure 51

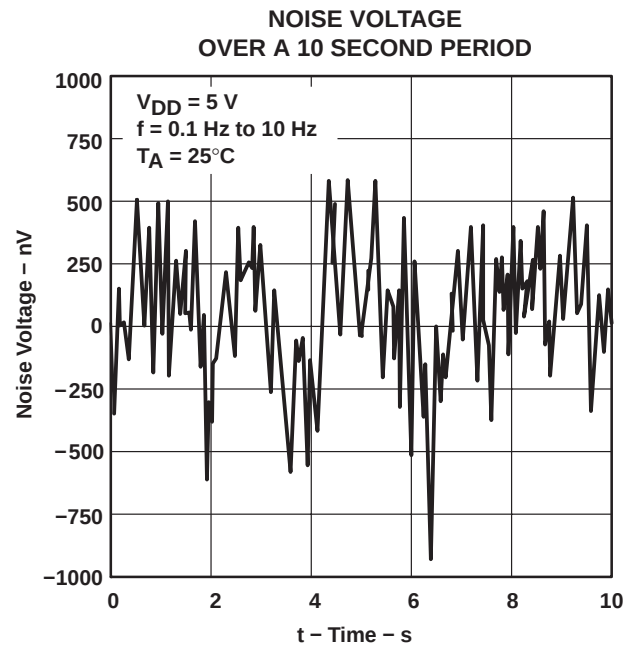


Figure 52

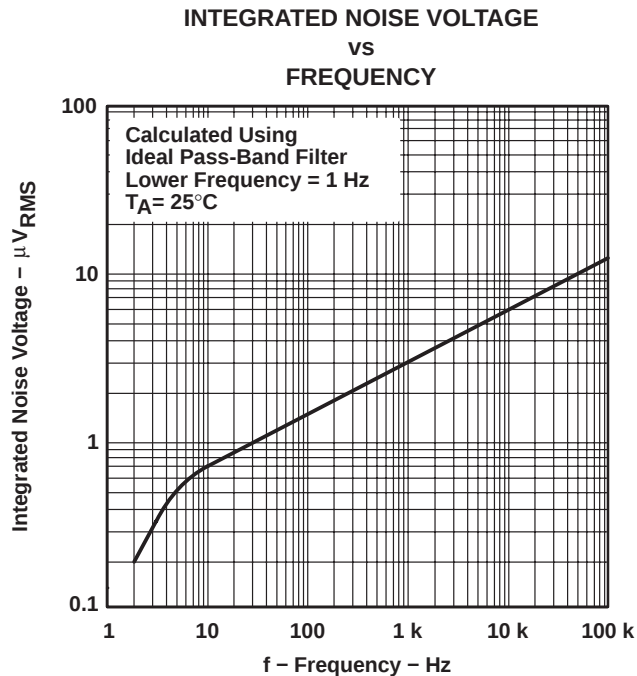


Figure 53

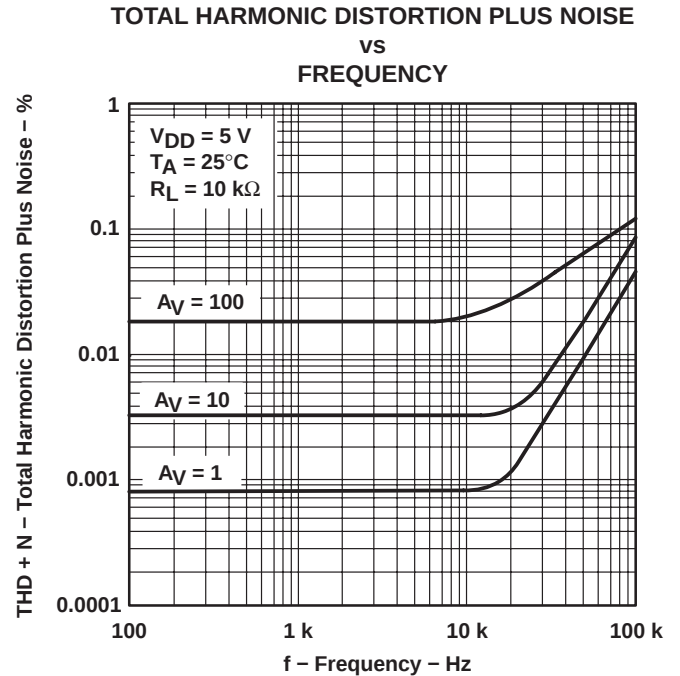


Figure 54

TLC227x-EP, TLC227xA-EP

Advanced LinCMOS™ RAIL-TO-RAIL

OPERATIONAL AMPLIFIERS

SGLS131A – JULY 2002 – REVISED NOVEMBER 2003

TYPICAL CHARACTERISTICS

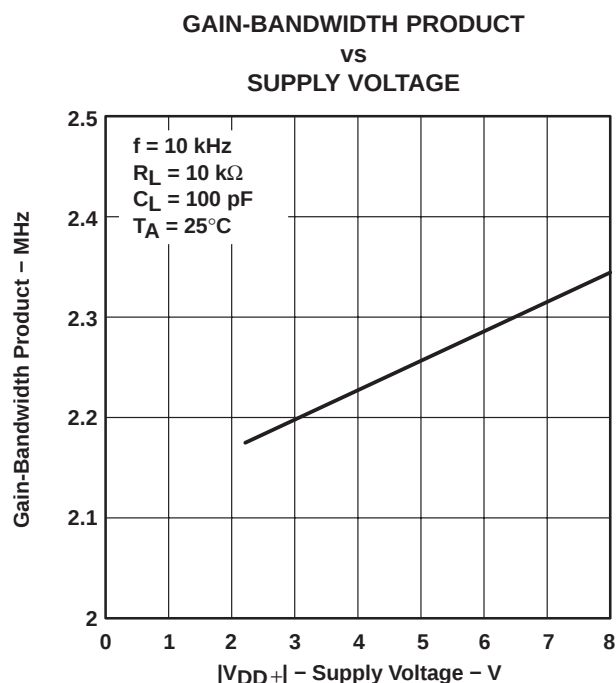


Figure 55

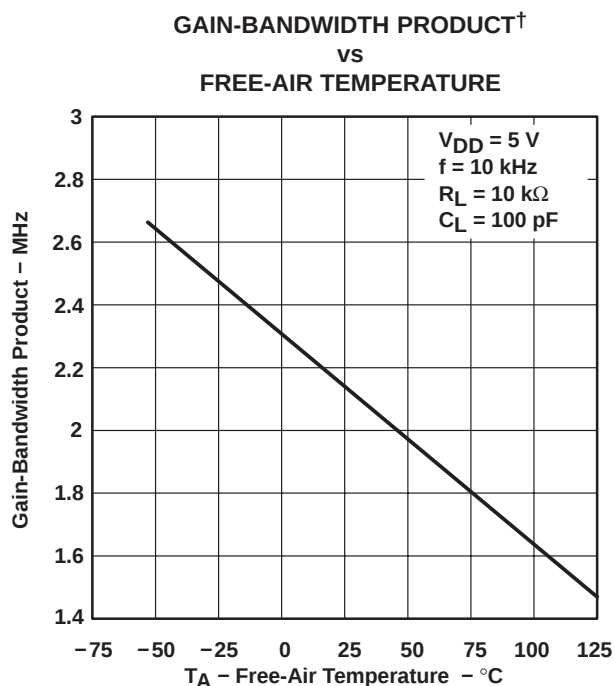


Figure 56

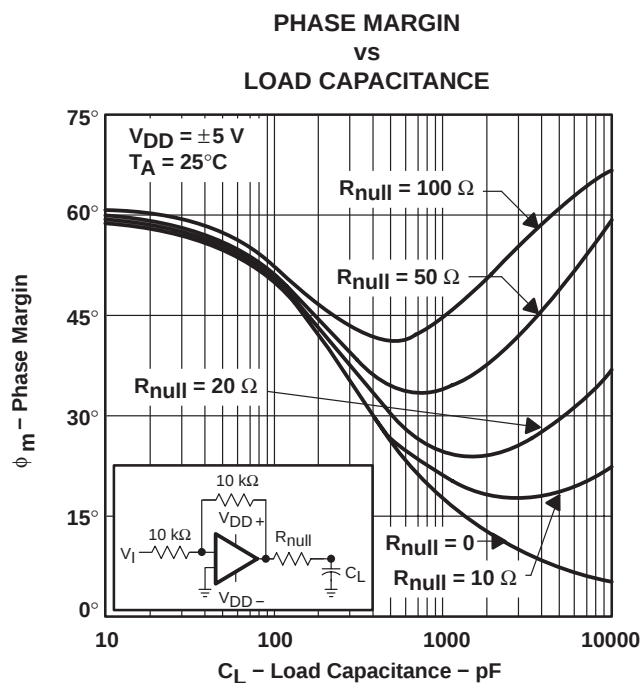


Figure 57

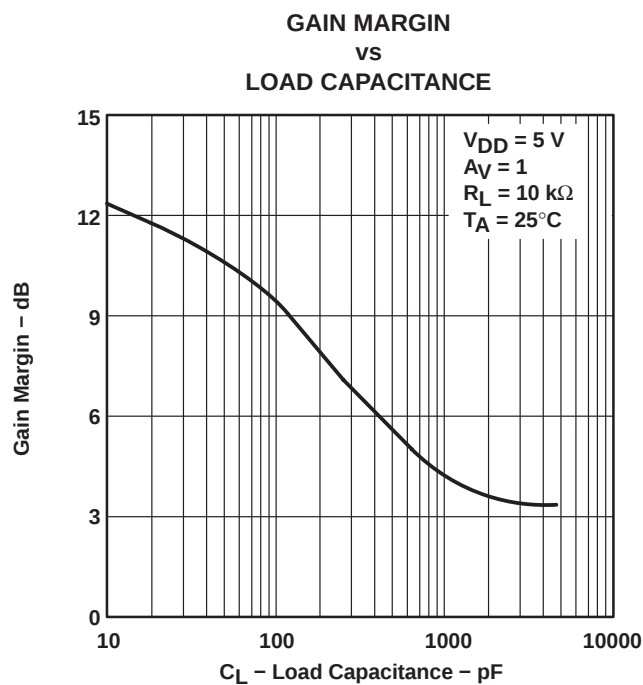


Figure 58

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

APPLICATION INFORMATION

macromodel information

Macromodel information provided was derived using Microsim *Parts*™, the model generation software used with Microsim *PSpice*™. The Boyle macromodel (see Note 6) and subcircuit in Figure 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 6: G. R. Boyle, B. M. Cohn, D. O. Pederson, and J. E. Solomon, "Macromodeling of Integrated Circuit Operational Amplifiers", *IEEE Journal of Solid-State Circuits*, SC-9, 353 (1974).

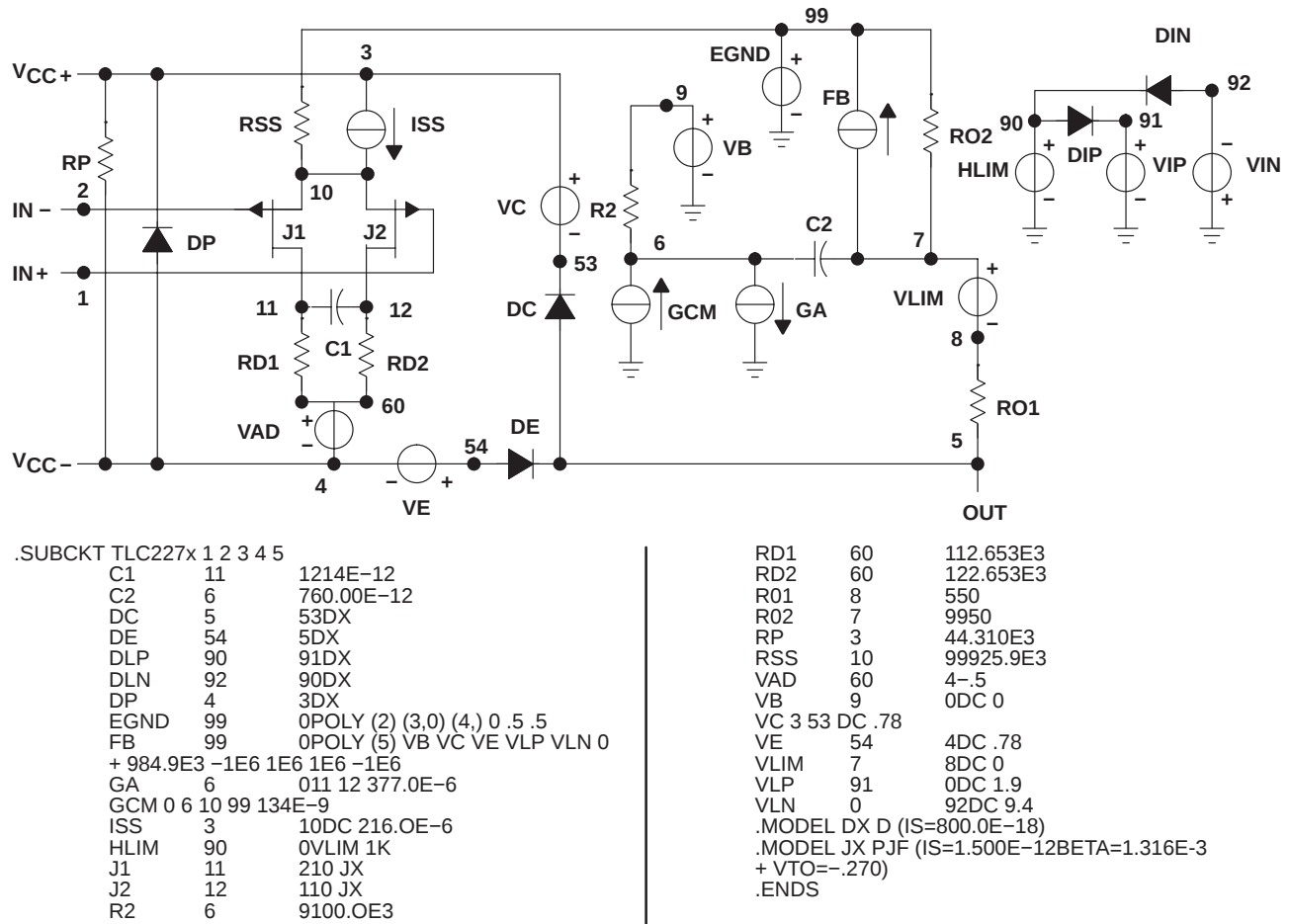


Figure 59. Boyle Macromodel and Subcircuit

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Macromodels, simulation models, or other models provided by TI, directly or indirectly, are not warranted by TI as fully representing all of the specification and operating characteristics of the semiconductor product to which the model relates.



PACKAGING INFORMATION

Orderable Device	Status (1)	Package Type	Package Drawing	Pins	Package Qty	Eco Plan (2)	Lead/Ball Finish (6)	MSL Peak Temp (3)	Op Temp (°C)	Device Marking (4/5)	Samples
TLC2272AMDREP	ACTIVE	SOIC	D	8	2500	Green (RoHS & no Sb/Br)	NIPDAU	Level-1-260C-UNLIM	-55 to 125	2272AE	Samples
TLC2272AMDREPG4	ACTIVE	SOIC	D	8	2500	Green (RoHS & no Sb/Br)	NIPDAU	Level-1-260C-UNLIM	-55 to 125	2272AE	Samples
TLC2274AMDREP	ACTIVE	SOIC	D	14	2500	Green (RoHS & no Sb/Br)	NIPDAU	Level-1-260C-UNLIM	-55 to 125	2274AME	Samples
TLC2274AMPWREP	ACTIVE	TSSOP	PW	14	2000	Green (RoHS & no Sb/Br)	NIPDAU	Level-1-260C-UNLIM	-55 to 125	2274AME	Samples
TLC2274MDREP	ACTIVE	SOIC	D	14	2500	Green (RoHS & no Sb/Br)	NIPDAU	Level-1-260C-UNLIM	-55 to 125	2274ME	Samples
V62/03618-01XE	ACTIVE	SOIC	D	8	2500	Green (RoHS & no Sb/Br)	NIPDAU	Level-1-260C-UNLIM	-55 to 125	2272AE	Samples
V62/03618-02UE	ACTIVE	TSSOP	PW	14	2000	Green (RoHS & no Sb/Br)	NIPDAU	Level-1-260C-UNLIM	-55 to 125	2274AME	Samples
V62/03618-02YE	ACTIVE	SOIC	D	14	2500	Green (RoHS & no Sb/Br)	NIPDAU	Level-1-260C-UNLIM	-55 to 125	2274AME	Samples
V62/03618-04YE	ACTIVE	SOIC	D	14	2500	Green (RoHS & no Sb/Br)	NIPDAU	Level-1-260C-UNLIM	-55 to 125	2274ME	Samples

(1) The marketing status values are defined as follows:

ACTIVE: Product device recommended for new designs.

LIFEBUY: TI has announced that the device will be discontinued, and a lifetime-buy period is in effect.

NRND: Not recommended for new designs. Device is in production to support existing customers, but TI does not recommend using this part in a new design.

PREVIEW: Device has been announced but is not in production. Samples may or may not be available.

OBSOLETE: TI has discontinued the production of the device.

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

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

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

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

⁽⁴⁾ There may be additional marking, which relates to the logo, the lot trace code information, or the environmental category on the device.

⁽⁵⁾ Multiple Device Markings will be inside parentheses. Only one Device Marking contained in parentheses and separated by a "~" will appear on a device. If a line is indented then it is a continuation of the previous line and the two combined represent the entire Device Marking for that device.

⁽⁶⁾ Lead/Ball Finish - Orderable Devices may have multiple material finish options. Finish options are separated by a vertical ruled line. Lead/Ball Finish values may wrap to two lines if the finish value exceeds the maximum column width.

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In no event shall TI's liability arising out of such information exceed the total purchase price of the TI part(s) at issue in this document sold by TI to Customer on an annual basis.

OTHER QUALIFIED VERSIONS OF TLC2272A-EP, TLC2274-EP, TLC2274A-EP :

- Catalog: [TLC2272A](#), [TLC2274](#), [TLC2274A](#)
- Automotive: [TLC2272A-Q1](#), [TLC2274-Q1](#), [TLC2274A-Q1](#)
- Military: [TLC2272AM](#), [TLC2274M](#), [TLC2274AM](#)

NOTE: Qualified Version Definitions:

- Catalog - TI's standard catalog product
- Automotive - Q100 devices qualified for high-reliability automotive applications targeting zero defects
- Military - QML certified for Military and Defense Applications

TAPE AND REEL INFORMATION


*All dimensions are nominal

Device	Package Type	Package Drawing	Pins	SPQ	Reel Diameter (mm)	Reel Width W1 (mm)	A0 (mm)	B0 (mm)	K0 (mm)	P1 (mm)	W (mm)	Pin1 Quadrant
TLC2272AMDREP	SOIC	D	8	2500	330.0	12.4	6.4	5.2	2.1	8.0	12.0	Q1
TLC2274AMDREP	SOIC	D	14	2500	330.0	16.4	6.5	9.0	2.1	8.0	16.0	Q1
TLC2274AMPWREP	TSSOP	PW	14	2000	330.0	12.4	6.9	5.6	1.6	8.0	12.0	Q1
TLC2274MDREP	SOIC	D	14	2500	330.0	16.4	6.5	9.0	2.1	8.0	16.0	Q1

TAPE AND REEL BOX DIMENSIONS



*All dimensions are nominal

Device	Package Type	Package Drawing	Pins	SPQ	Length (mm)	Width (mm)	Height (mm)
TLC2272AMDREP	SOIC	D	8	2500	350.0	350.0	43.0
TLC2274AMDREP	SOIC	D	14	2500	333.2	345.9	28.6
TLC2274AMPWREP	TSSOP	PW	14	2000	367.0	367.0	35.0
TLC2274MDREP	SOIC	D	14	2500	333.2	345.9	28.6

D (R-PDSO-G14)

PLASTIC SMALL OUTLINE



4040047-5/M 06/11

NOTES:

- A. All linear dimensions are in inches (millimeters).
- B. This drawing is subject to change without notice.
- C. Body length does not include mold flash, protrusions, or gate burrs. Mold flash, protrusions, or gate burrs shall not exceed 0.006 (0,15) each side.
- D. Body width does not include interlead flash. Interlead flash shall not exceed 0.017 (0,43) each side.
- E. Reference JEDEC MS-012 variation AB.

D (R-PDSO-G14)

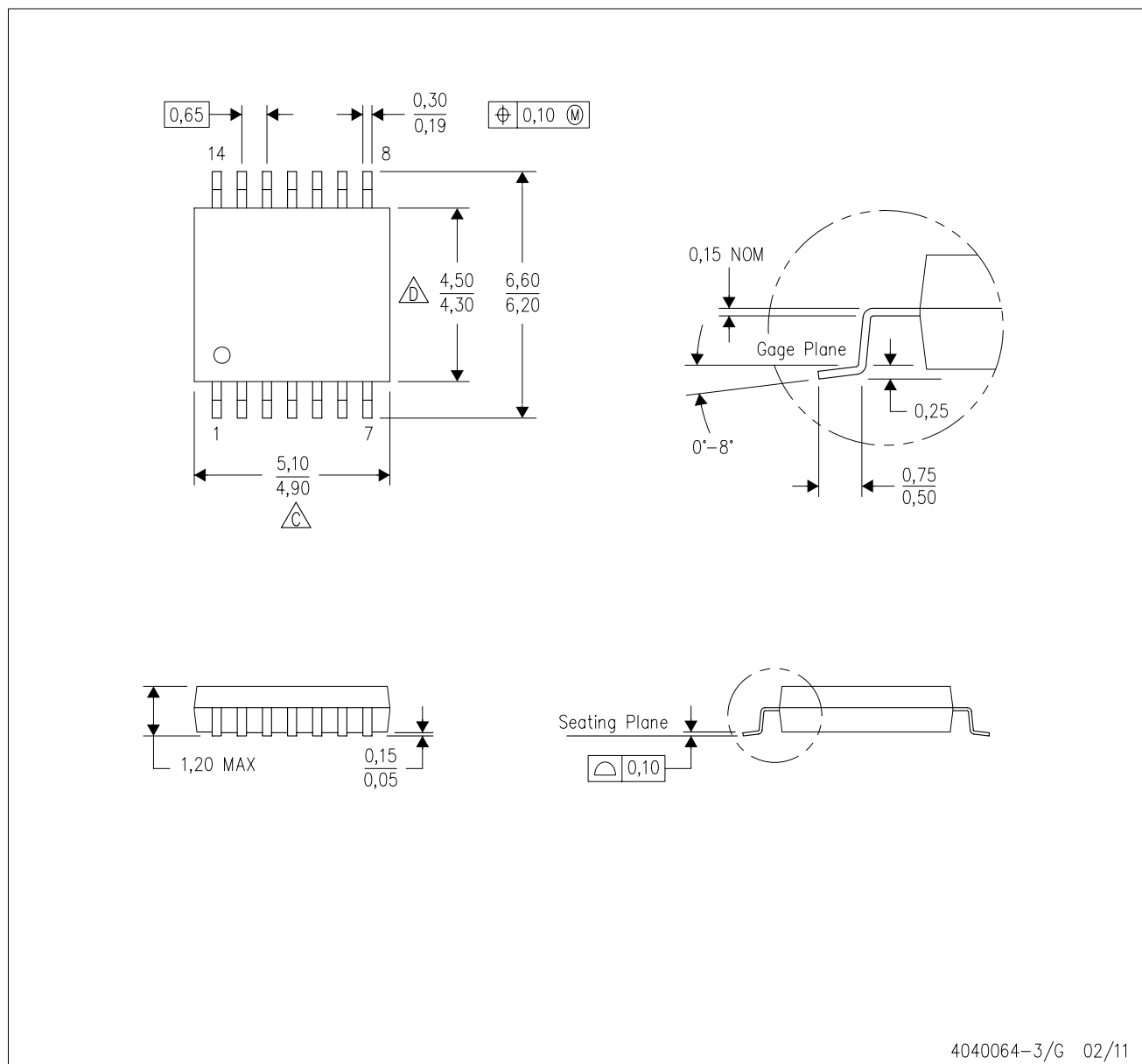
PLASTIC SMALL OUTLINE



- NOTES:
- A. All linear dimensions are in millimeters.
 - B. This drawing is subject to change without notice.
 - C. Publication IPC-7351 is recommended for alternate designs.
 - D. Laser cutting apertures with trapezoidal walls and also rounding corners will offer better paste release. Customers should contact their board assembly site for stencil design recommendations. Refer to IPC-7525 for other stencil recommendations.
 - E. Customers should contact their board fabrication site for solder mask tolerances between and around signal pads.

PW (R-PDSO-G14)

PLASTIC SMALL OUTLINE



- NOTES:
- A. All linear dimensions are in millimeters. Dimensioning and tolerancing per ASME Y14.5M-1994.
 - B. This drawing is subject to change without notice.
 - C. Body length does not include mold flash, protrusions, or gate burrs. Mold flash, protrusions, or gate burrs shall not exceed 0,15 each side.
 - D. Body width does not include interlead flash. Interlead flash shall not exceed 0,25 each side.
 - E. Falls within JEDEC MO-153

PW (R-PDSO-G14)

PLASTIC SMALL OUTLINE



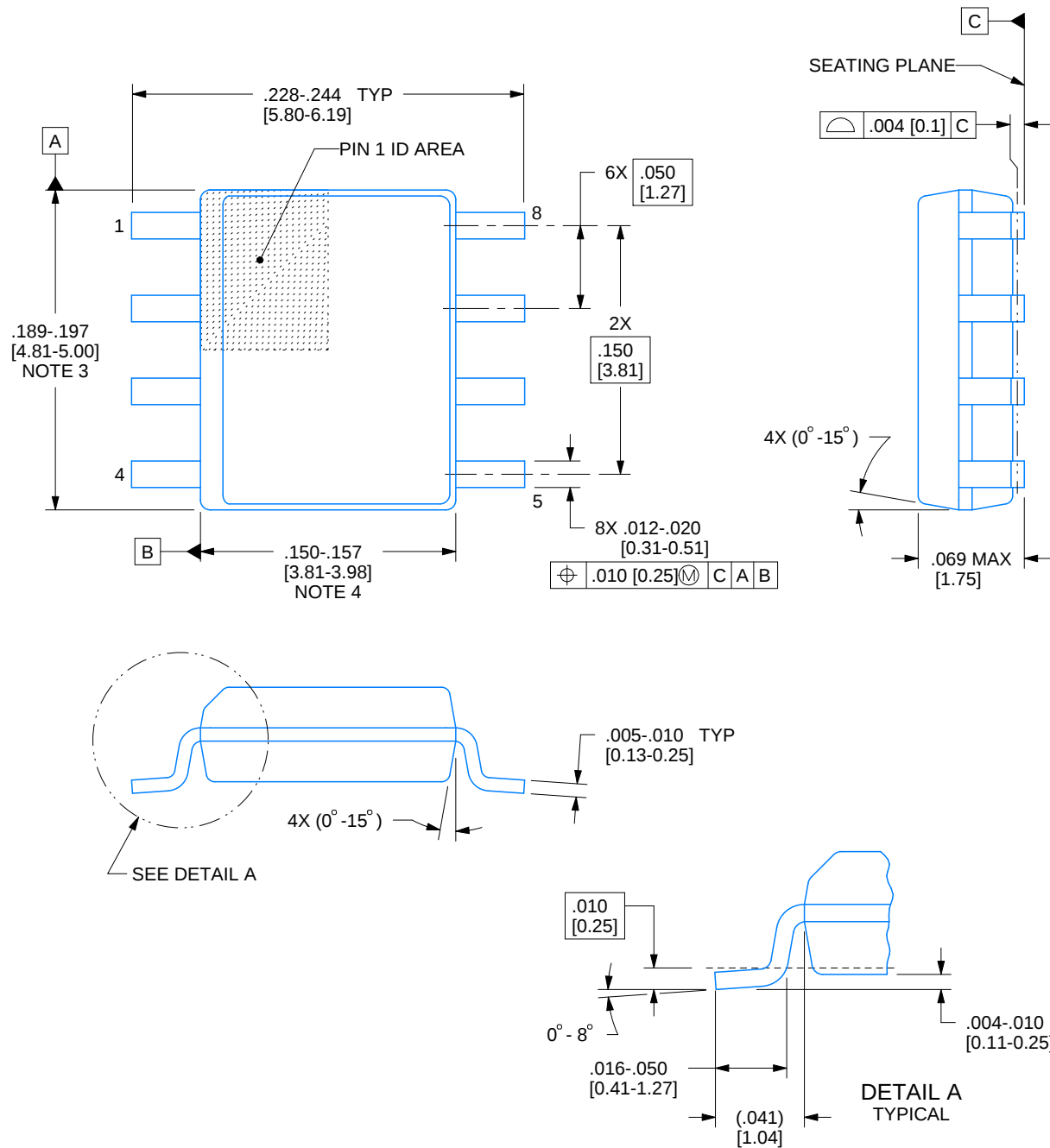
- NOTES:
- All linear dimensions are in millimeters.
 - This drawing is subject to change without notice.
 - Publication IPC-7351 is recommended for alternate designs.
 - Laser cutting apertures with trapezoidal walls and also rounding corners will offer better paste release. Customers should contact their board assembly site for stencil design recommendations. Refer to IPC-7525 for other stencil recommendations.
 - Customers should contact their board fabrication site for solder mask tolerances between and around signal pads.

D0008A

PACKAGE OUTLINE

SOIC - 1.75 mm max height

SMALL OUTLINE INTEGRATED CIRCUIT



4214825/C 02/2019

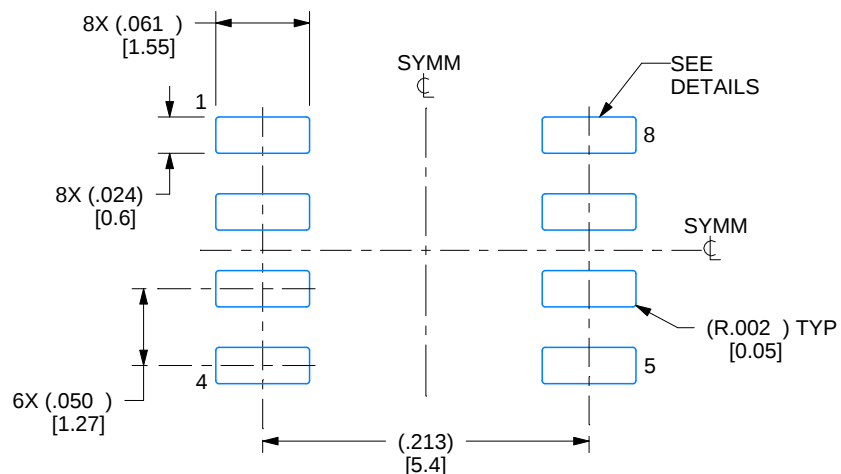
NOTES:

1. Linear dimensions are in inches [millimeters]. Dimensions in parenthesis are for reference only. Controlling dimensions are in inches. Dimensioning and tolerancing per ASME Y14.5M.
2. This drawing is subject to change without notice.
3. This dimension does not include mold flash, protrusions, or gate burrs. Mold flash, protrusions, or gate burrs shall not exceed .006 [0.15] per side.
4. This dimension does not include interlead flash.
5. Reference JEDEC registration MS-012, variation AA.

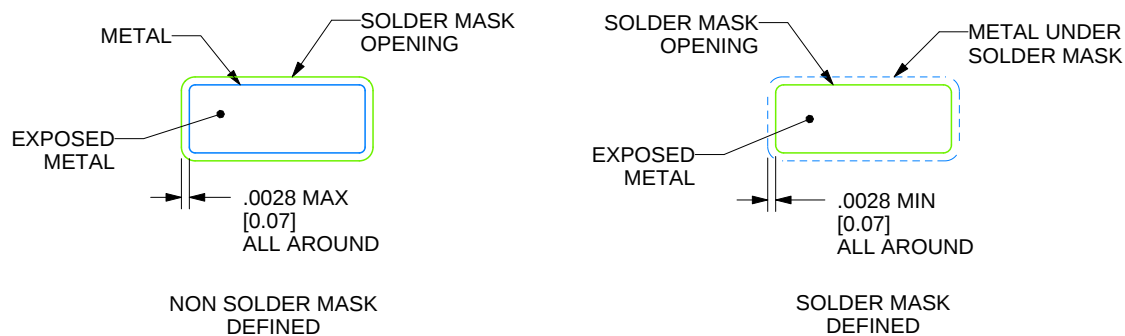
D0008A

SOIC - 1.75 mm max height

SMALL OUTLINE INTEGRATED CIRCUIT



LAND PATTERN EXAMPLE
EXPOSED METAL SHOWN
SCALE:8X



SOLDER MASK DETAILS

4214825/C 02/2019

NOTES: (continued)

6. Publication IPC-7351 may have alternate designs.

7. Solder mask tolerances between and around signal pads can vary based on board fabrication site.

EXAMPLE STENCIL DESIGN

D0008A

SOIC - 1.75 mm max height

SMALL OUTLINE INTEGRATED CIRCUIT



SOLDER PASTE EXAMPLE
BASED ON .005 INCH [0.125 MM] THICK STENCIL
SCALE:8X

4214825/C 02/2019

NOTES: (continued)

8. Laser cutting apertures with trapezoidal walls and rounded corners may offer better paste release. IPC-7525 may have alternate design recommendations.
9. Board assembly site may have different recommendations for stencil design.

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