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

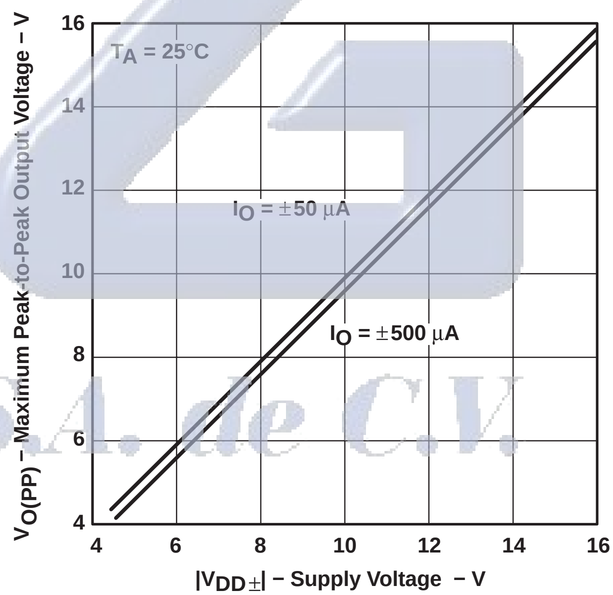
SGLS131B − JULY 2002 − REVISED DECEMBER 2003

- **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.

- **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



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.

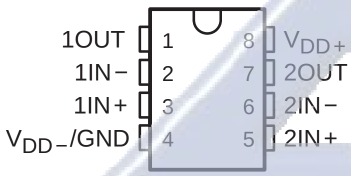
The TLC227xA, exhibiting high input impedance and low noise, is excellent for small-signal conditioning for high-impedance sources, such as piezoelectric transducers. Because of the micro-power dissipation levels, these devices work well in hand-held monitoring and remote-sensing applications. In addition, 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.

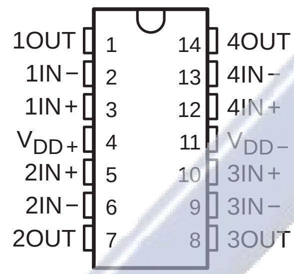
AVAILABLE OPTIONS

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

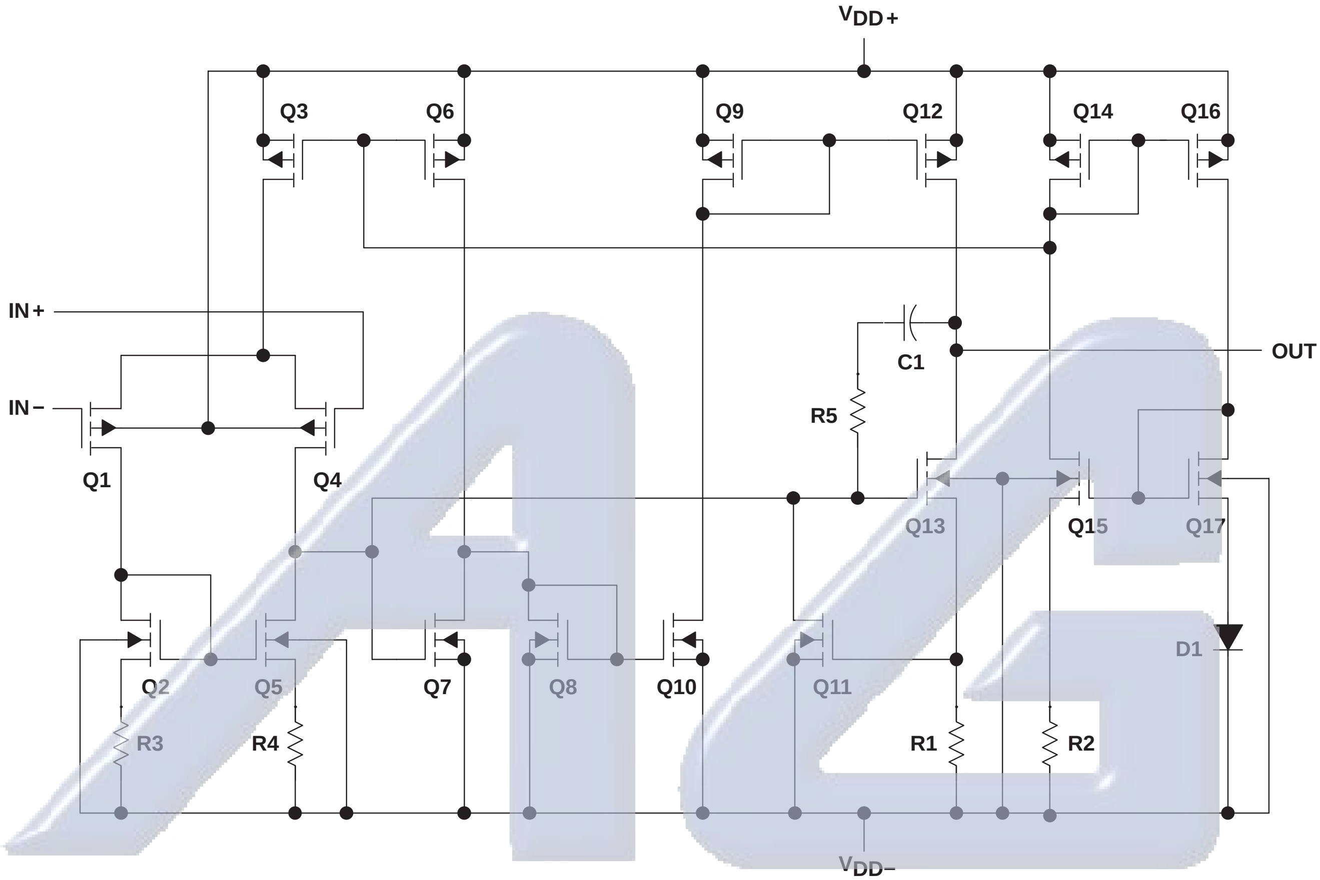
TLC2272
D OR PW PACKAGE
(TOP VIEW)



TLC2274
D OR PW PACKAGE
(TOP VIEW)



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 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 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	$T_A \le 25°C$ POWER RATING	DERATING FACTOR ABOVE T_A = 25°C	T_A = 70°C POWER RATING	T_A = 85°C POWER RATING	T_A = 125°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

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

PARAMETER		TEST CONDITIONS		T_A†	TLC2272-EP MIN	TLC2272-EP TYP	TLC2272-EP MAX	TLC2272A-EP MIN	TLC2272A-EP TYP	TLC2272A-EP MAX	UNIT
V_{IO}	Input offset voltage	V_{IC} = 0 V, V_O = 0 V,	$V_{DD\pm}$ = ±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,	$\lvert V_{IO} \rvert$ ≤ 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
		I_{OH} = −200 µA		25°C	4.85	4.93		4.85	4.93		
				Full range	4.85			4.85			
		I_{OH} = −1 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 V,	I_{OL} = 50 µA	25°C		0.01			0.01		V
		V_{IC} = 2.5 V,	I_{OL} = 500 µA	25°C		0.09	0.15		0.09	0.15	
				Full range			0.15			0.15	
		V_{IC} = 2.5 V,	I_{OL} = 5 mA	25°C		0.9	1.5		0.9	1.5	
				Full range			1.5			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		
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,	P package	25°C		8			8		pF
z_o	Closed-loop output impedance	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		dB
				Full range	70			70			
k_{SVR}	Supply-voltage rejection ratio ($\Delta V_{DD}/\Delta V_{IO}$)	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°C extrapolated to T_A = 25°C using the Arrhenius equation and assuming an activation energy of 0.96 eV.

TLC2272-EP operating characteristics at specified free-air temperature, V_{DD} = 5 V

PARAMETER		TEST CONDITIONS		T_A†	TLC2272-EP MIN	TLC2272-EP TYP	TLC2272-EP MAX	TLC2272A-EP MIN	TLC2272A-EP TYP	TLC2272A-EP MAX	UNIT
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, R_L = 10 kΩ‡, C_L = 100 pF‡		25°C		2.18			2.18		MHz
B_{OM}	Maximum output-swing bandwidth	$V_{O(PP)}$ = 2 V, A_V = 1, R_L = 10 kΩ‡, 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

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

PARAMETER		TEST CONDITIONS	T_A†	TLC2272-EP MIN	TLC2272-EP TYP	TLC2272-EP MAX	TLC2272A-EP MIN	TLC2272A-EP TYP	TLC2272A-EP MAX	UNIT
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	
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, $\lvert V_{IO} \rvert \le$ 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			
		V_O = ±4 V, 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, P 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 ($\Delta V_{DD\pm}/\Delta V_{IO}$)	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 = 2.5 V, 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°C extrapolated to T_A = 25°C using the Arrhenius equation and assuming an activation energy of 0.96 eV.

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

PARAMETER		TEST CONDITIONS		T_A†	TLC2272-EP MIN	TLC2272-EP TYP	TLC2272-EP MAX	TLC2272A-EP MIN	TLC2272A-EP TYP	TLC2272A-EP MAX	UNIT
SR	Slew rate at unity gain	$V_O = \pm 1$ V, $C_L = 100$ pF	$R_L = 10$ kΩ,	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	$V_O = \pm 2.3$ V, $R_L = 10$ kΩ, 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, $C_L = 100$ pF	$R_L = 10$ kΩ,	25°C		2.25			2.25		MHz
B_{OM}	Maximum output-swing bandwidth	$V_{O(PP)} = 4.6$ V, $R_L = 10$ kΩ,	$A_V = 1$, $C_L = 100$ pF	25°C		0.54			0.54		MHz
t_s	Settling time	$A_V = -1$, Step = −2.3 V to 2.3 V, $R_L = 10$ kΩ, $C_L = 100$ 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	$R_L = 10$ kΩ,	$C_L = 100$ 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 V (unless otherwise noted)

PARAMETER		TEST CONDITIONS	T_A†	TLC2274-EP MIN	TLC2274-EP TYP	TLC2274-EP MAX	TLC2274A-EP MIN	TLC2274A-EP TYP	TLC2274A-EP MAX	UNIT
V_{IO}	Input offset voltage	$V_{DD\pm}$ = ±2.5 V, V_{IC} = 0 V, V_O = 0 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
		I_{OH} = −200 µA	25°C	4.85	4.93		4.85	4.93		
			Full range	4.85			4.85			
		I_{OH} = −1 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 V, I_{OL} = 50 µA	25°C		0.01			0.01		V
		V_{IC} = 2.5 V, I_{OL} = 500 µA	25°C		0.09	0.15		0.09	0.15	
			Full range			0.15			0.15	
		V_{IC} = 2.5 V, I_{OL} = 5 mA	25°C		0.9	1.5		0.9	1.5	
			Full range			1.5			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			
		V_{IC} = 2.5 V, V_O = 1 V to 4 V, R_L = 1 MΩ‡	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 kHz, N package	25°C		8			8		pF
z_o	Closed-loop output impedance	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		dB
			Full range	70			70			
k_{SVR}	Supply-voltage rejection ratio ($\Delta V_{DD}/\Delta V_{IO}$)	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		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°C extrapolated to T_A = 25°C using the Arrhenius equation and assuming an activation energy of 0.96 eV.

TLC2274-EP operating characteristics at specified free-air temperature, V_{DD} = 5 V

PARAMETER		TEST CONDITIONS		T_A†	TLC2274-EP MIN	TLC2274-EP TYP	TLC2274-EP MAX	TLC2274A-EP MIN	TLC2274A-EP TYP	TLC2274A-EP MAX	UNIT
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, $V_{DD\pm}$ = ±5 V (unless otherwise noted)

PARAMETER		TEST CONDITIONS	T_A†	TLC2274-EP MIN	TLC2274-EP TYP	TLC2274-EP MAX	TLC2274A-EP MIN	TLC2274A-EP TYP	TLC2274A-EP MAX	UNIT
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	
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, $\lvert V_{IO}\rvert \le$ 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			
		V_O = ±4 V, 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 ($\Delta V_{DD\pm}/\Delta V_{IO}$)	$V_{DD\pm}$ = ± 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°C extrapolated to T_A = 25°C using the Arrhenius equation and assuming an activation energy of 0.96 eV.

TLC2274-EP operating characteristics at specified free-air temperature, $V_{DD\pm} = \pm5$ V

PARAMETER		TEST CONDITIONS	T_A†	TLC2274-EP MIN	TLC2274-EP TYP	TLC2274-EP MAX	TLC2274A-EP MIN	TLC2274A-EP TYP	TLC2274A-EP MAX	UNIT
SR	Slew rate at unity gain	$V_O = \pm2.3$ 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	$V_O = \pm2.3$ V, $R_L = 10$ kΩ, 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, $R_L = 10$ kΩ, $C_L = 100$ pF	25°C		2.25			2.25		MHz
B_{OM}	Maximum output-swing bandwidth	$V_{O(PP)} = 4.6$ V, $A_V = 1$, $R_L = 10$ kΩ, $C_L = 100$ pF	25°C		0.54			0.54		MHz
t_s	Settling time	$A_V = -1$, Step = −2.3 V to 2.3 V, $R_L = 10$ kΩ, $C_L = 100$ pF, To 0.1%	25°C		1.5			1.5		µs
		To 0.01%			3.2			3.2		
ϕ_m	Phase margin at unit gain	$R_L = 10$ kΩ, $C_L = 100$ pF	25°C		52°			52°		
	Gain margin		25°C		10			10		dB

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

TYPICAL CHARACTERISTICS

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k_{SVR}	Supply-voltage rejection ratio	vs Frequency vs Free-air temperature	33, 34 35
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THD + N	Total harmonic distortion plus noise	vs Frequency	54
	Gain-bandwidth product	vs Supply voltage vs Free-air temperature	55 56
ϕ_m	Phase margin	vs Load capacitance	57
	Gain margin	vs Load capacitance	58

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

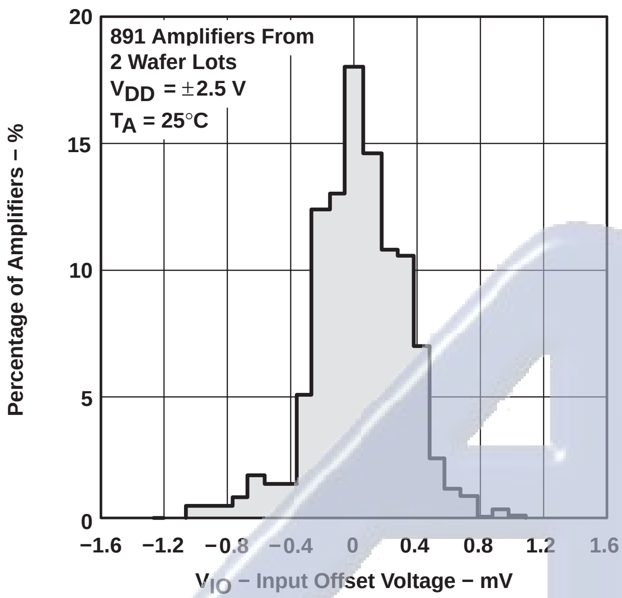


Figure 1

DISTRIBUTION OF TLC2272
INPUT OFFSET VOLTAGE

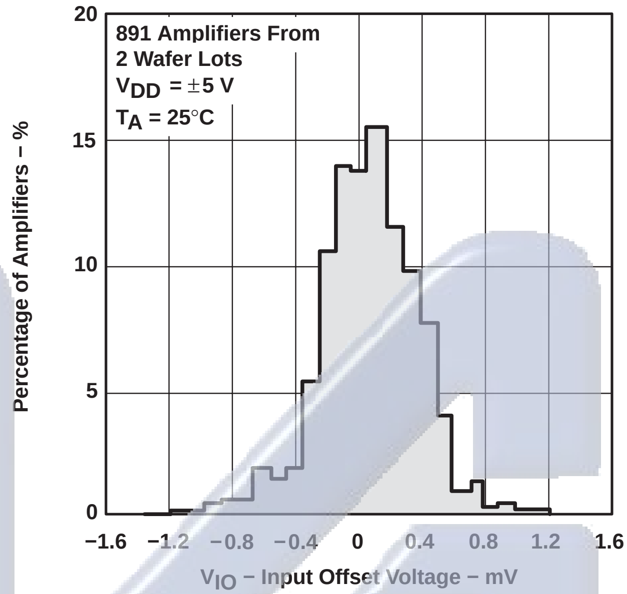


Figure 2

DISTRIBUTION OF TLC2274
INPUT OFFSET VOLTAGE

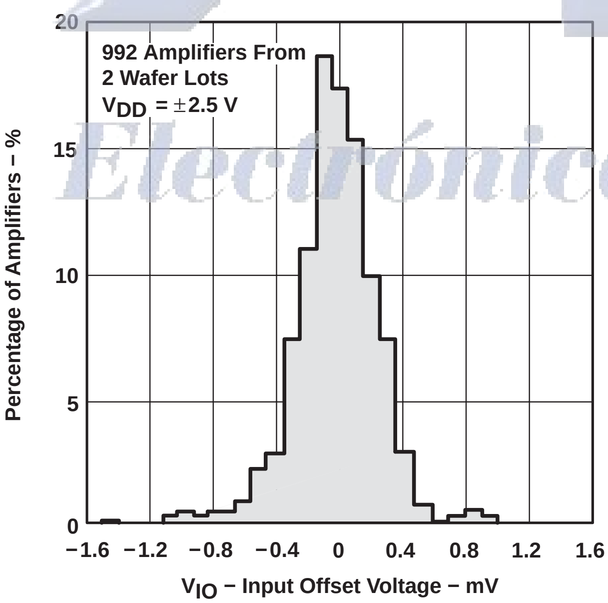


Figure 3

DISTRIBUTION OF TLC2274
INPUT OFFSET VOLTAGE

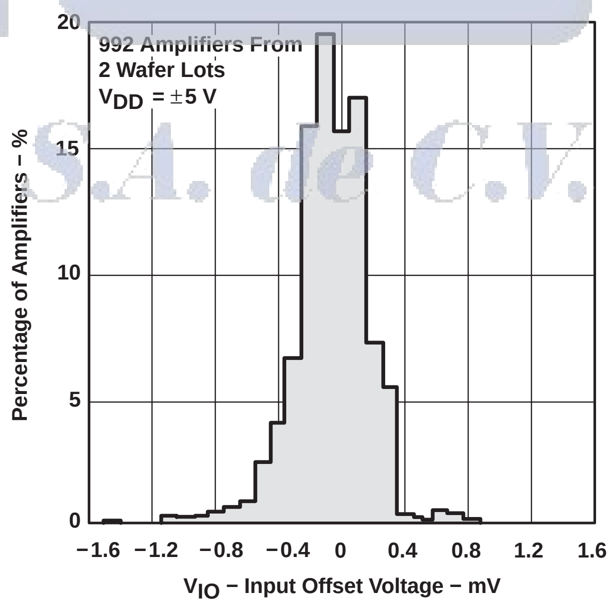


Figure 4

TYPICAL CHARACTERISTICS

INPUT OFFSET VOLTAGE
vs
COMMON-MODE VOLTAGE

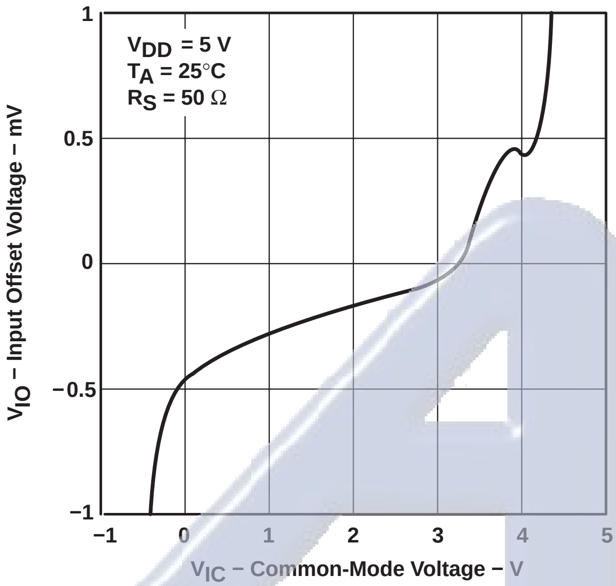


Figure 5

INPUT OFFSET VOLTAGE
vs
COMMON-MODE VOLTAGE

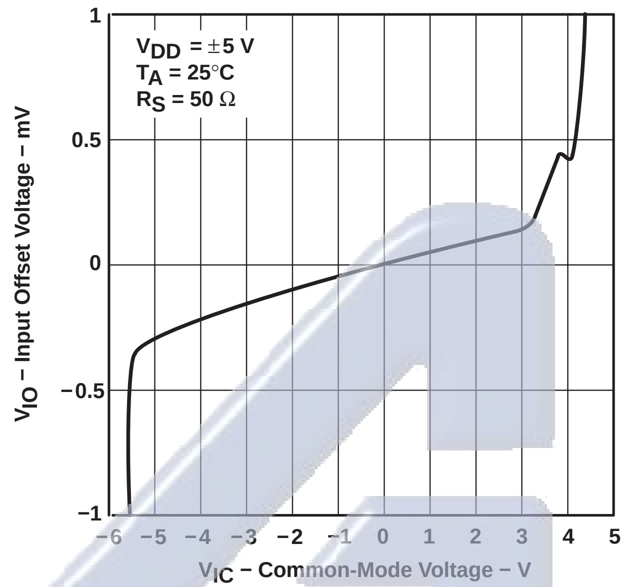


Figure 6

DISTRIBUTION OF TLC2272
vs
INPUT OFFSET VOLTAGE TEMPERATURE COEFFICIENT†

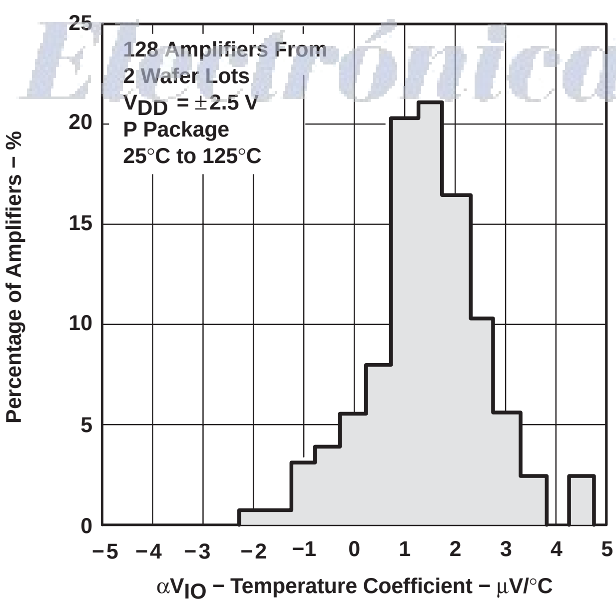


Figure 7

DISTRIBUTION OF TLC2272
vs
INPUT OFFSET VOLTAGE TEMPERATURE COEFFICIENT†

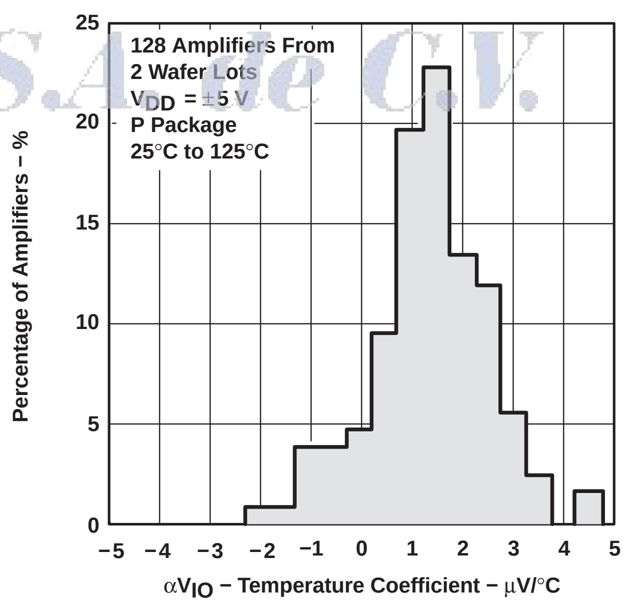


Figure 8

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

TYPICAL CHARACTERISTICS

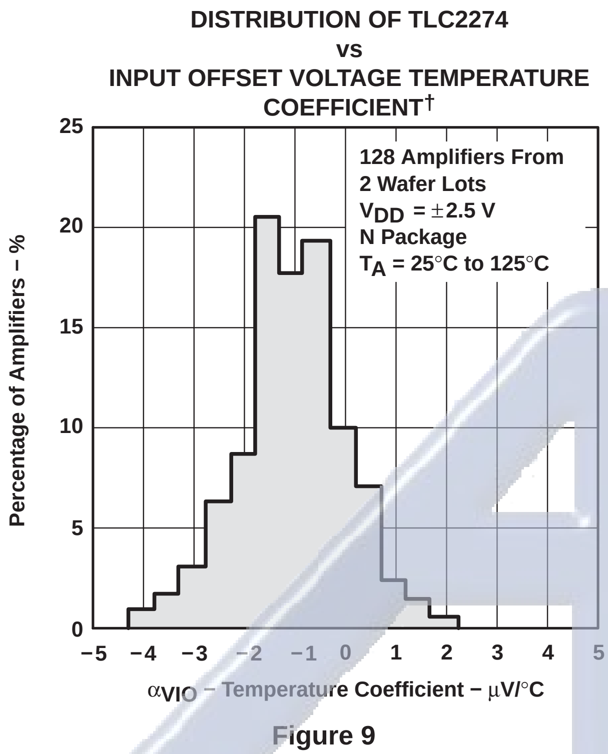


Figure 9

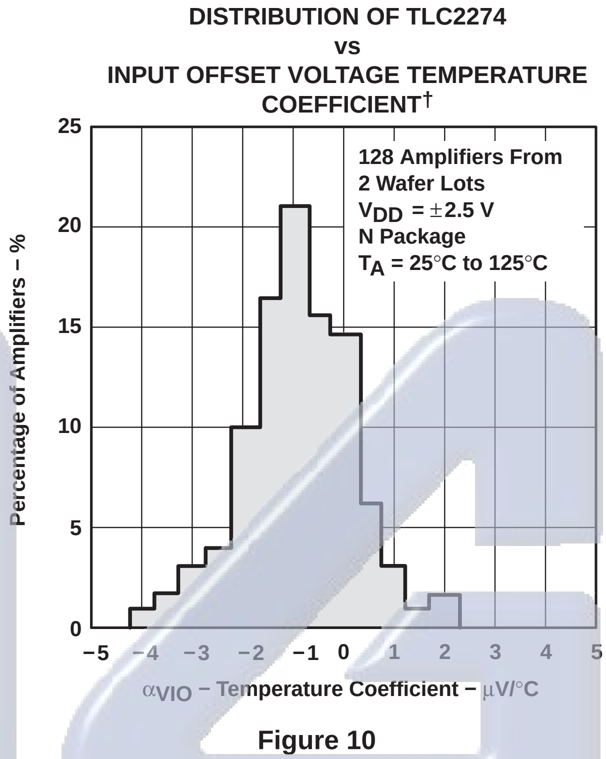


Figure 10

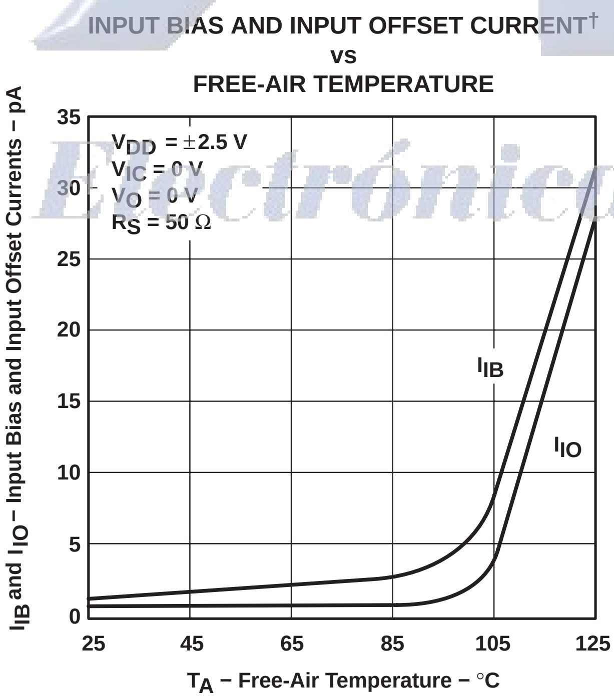


Figure 11

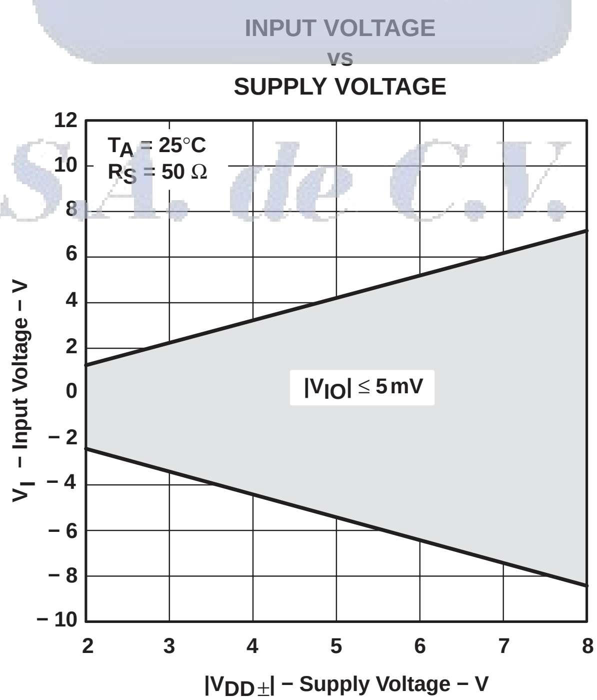


Figure 12

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

TYPICAL CHARACTERISTICS

INPUT VOLTAGE†
vs
FREE-AIR TEMPERATURE

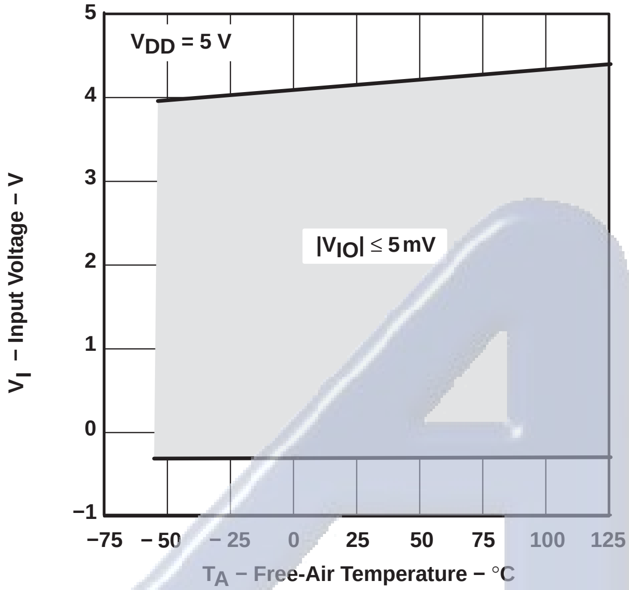


Figure 13

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

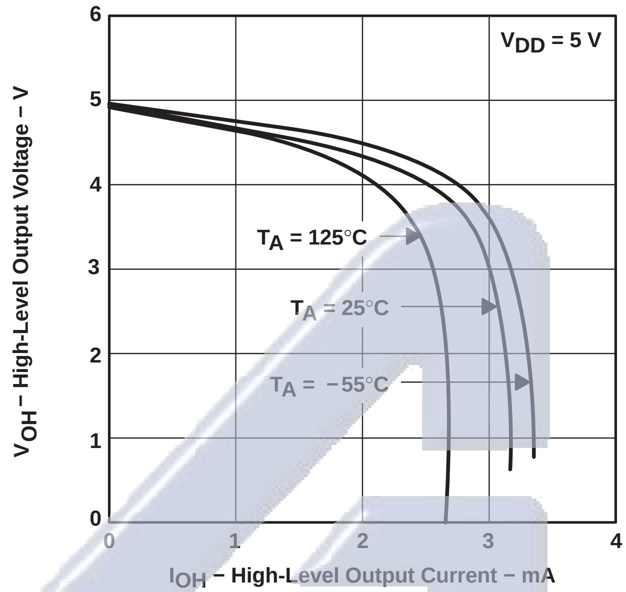


Figure 14

LOW-LEVEL OUTPUT VOLTAGE
vs
LOW-LEVEL OUTPUT CURRENT

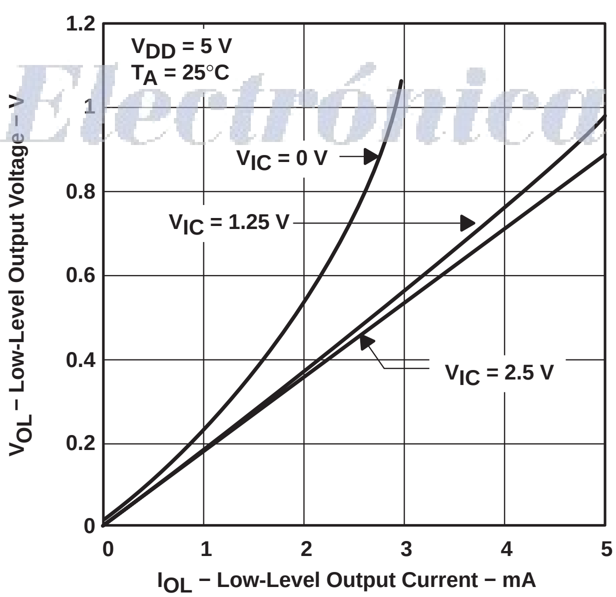


Figure 15

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

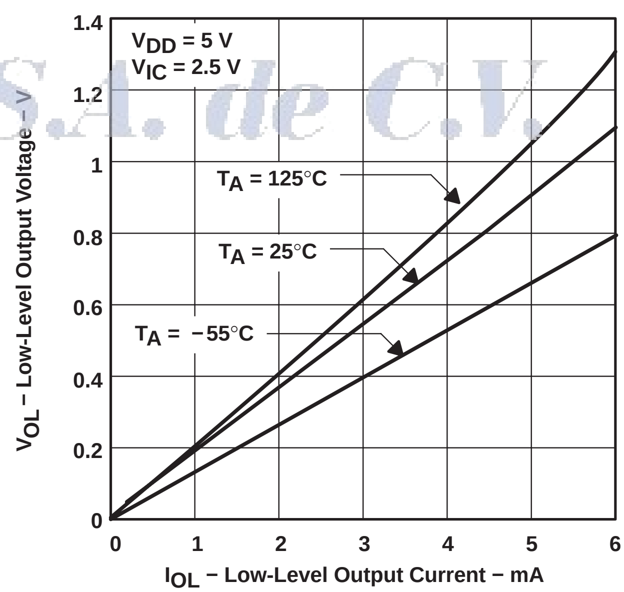


Figure 16

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

TYPICAL CHARACTERISTICS

MAXIMUM POSITIVE PEAK OUTPUT VOLTAGE†
vs
OUTPUT CURRENT

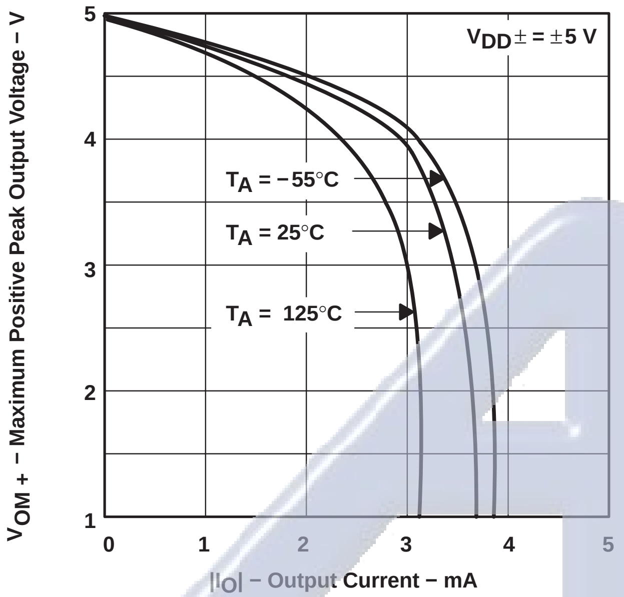


Figure 17

MAXIMUM NEGATIVE PEAK OUTPUT VOLTAGE†
vs
OUTPUT CURRENT

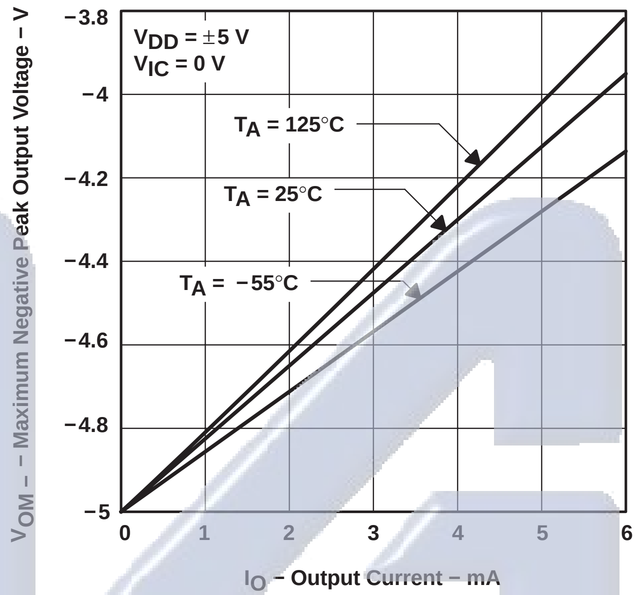


Figure 18

MAXIMUM PEAK-TO-PEAK OUTPUT VOLTAGE
vs
FREQUENCY

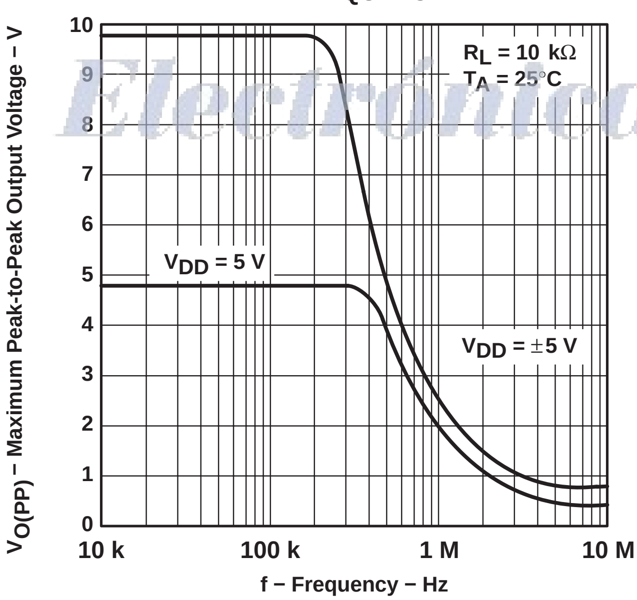


Figure 19

SHORT-CIRCUIT OUTPUT CURRENT
vs
SUPPLY VOLTAGE

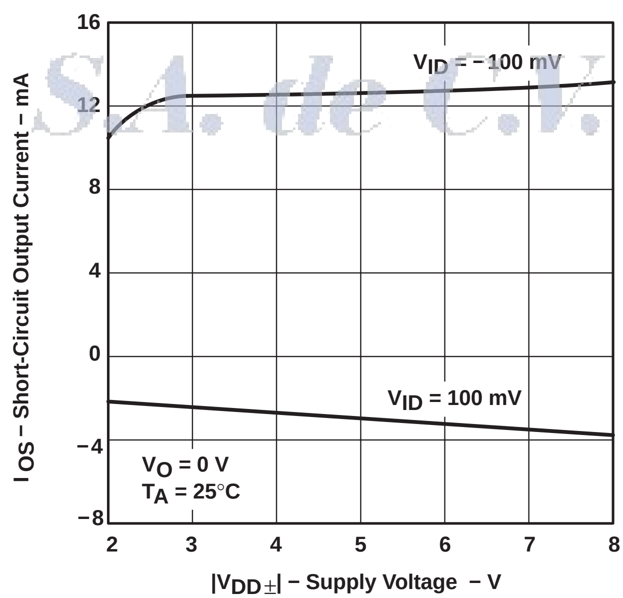


Figure 20

† 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

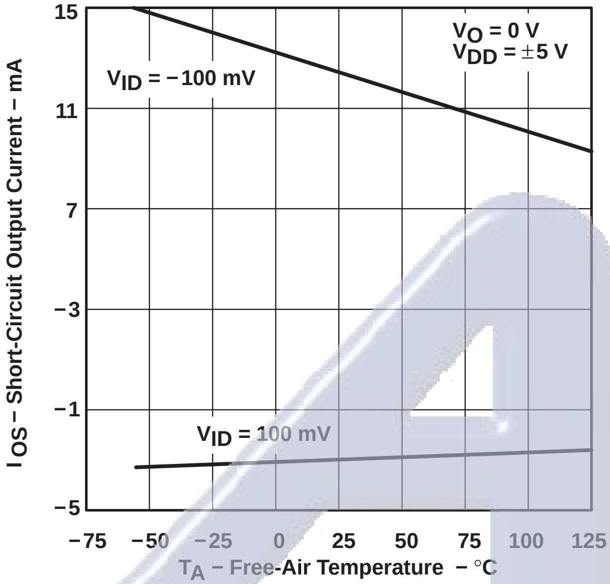


Figure 21

OUTPUT VOLTAGE vs DIFFERENTIAL INPUT VOLTAGE

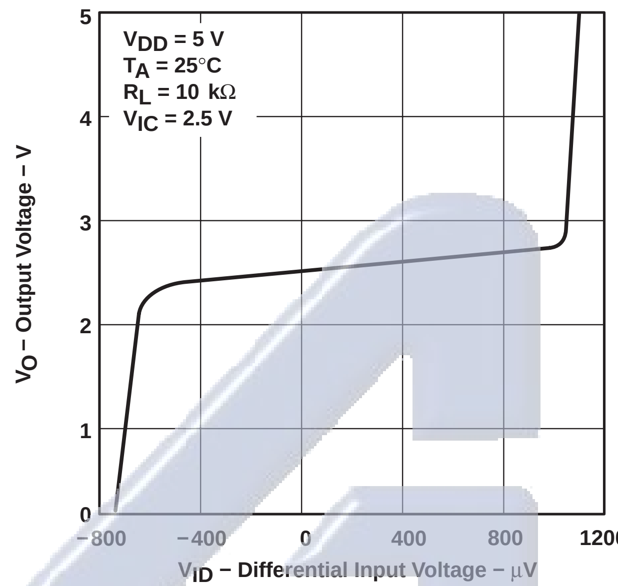


Figure 22

OUTPUT VOLTAGE vs DIFFERENTIAL INPUT VOLTAGE

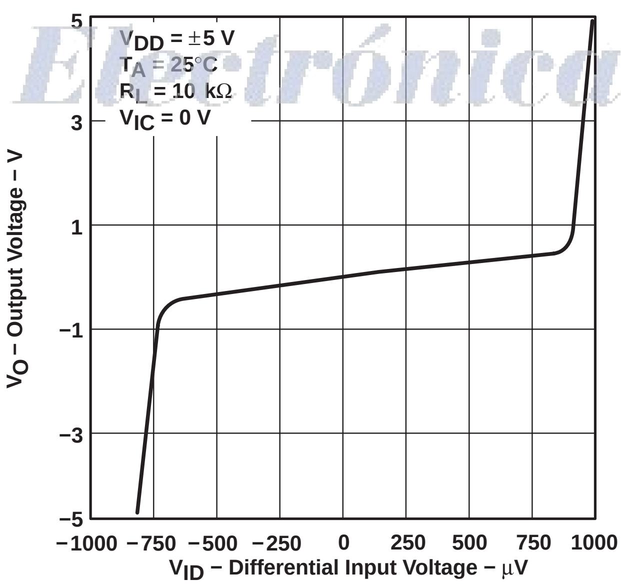


Figure 23

LARGE-SIGNAL DIFFERENTIAL VOLTAGE AMPLIFICATION vs LOAD RESISTANCE

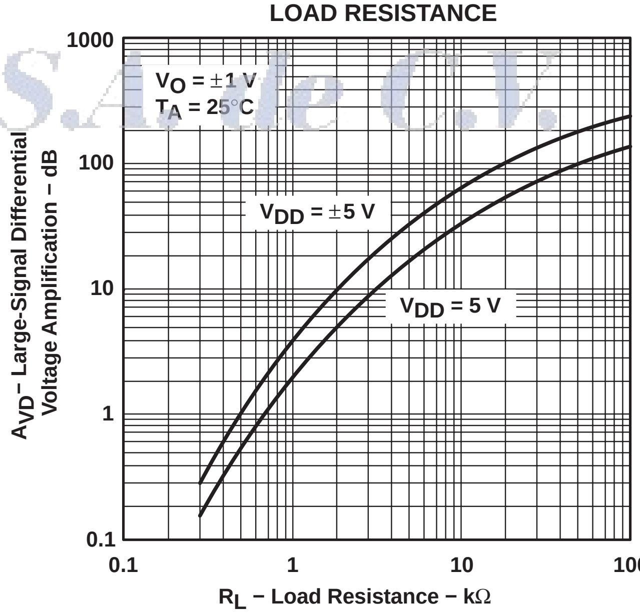


Figure 24

† 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

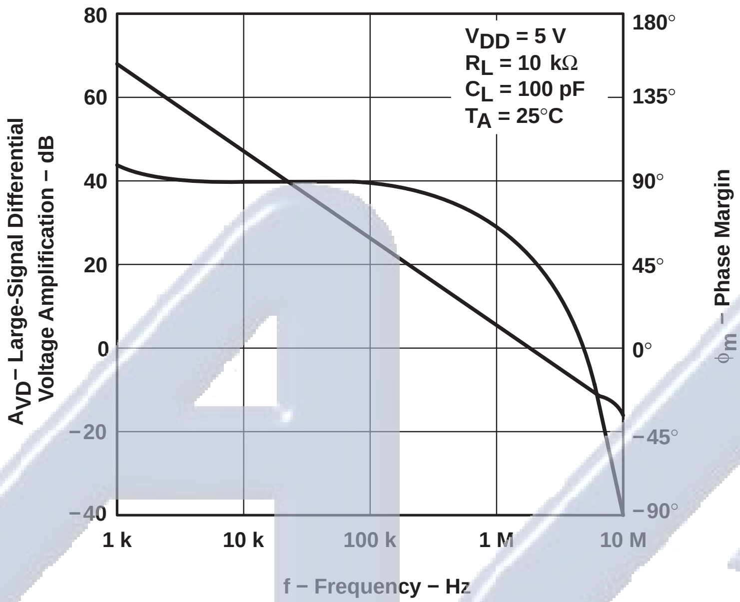


Figure 25

LARGE-SIGNAL DIFFERENTIAL VOLTAGE AMPLIFICATION AND PHASE MARGIN vs FREQUENCY

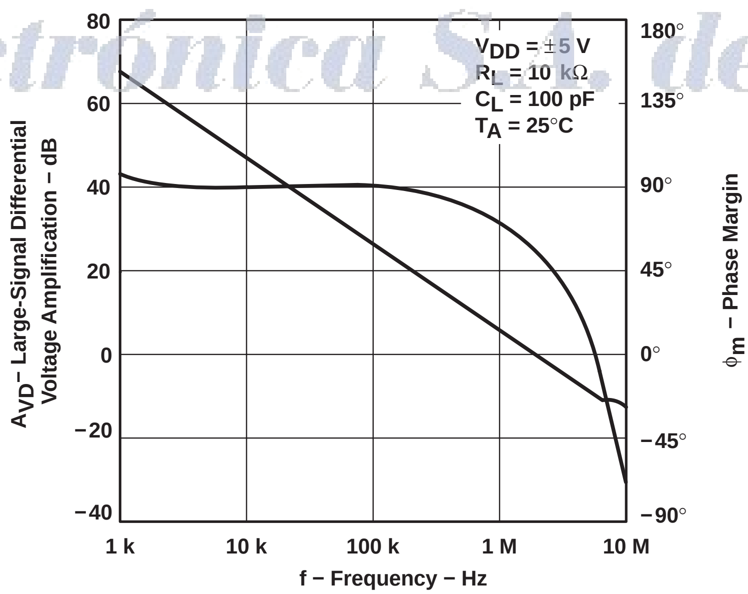


Figure 26

TYPICAL CHARACTERISTICS

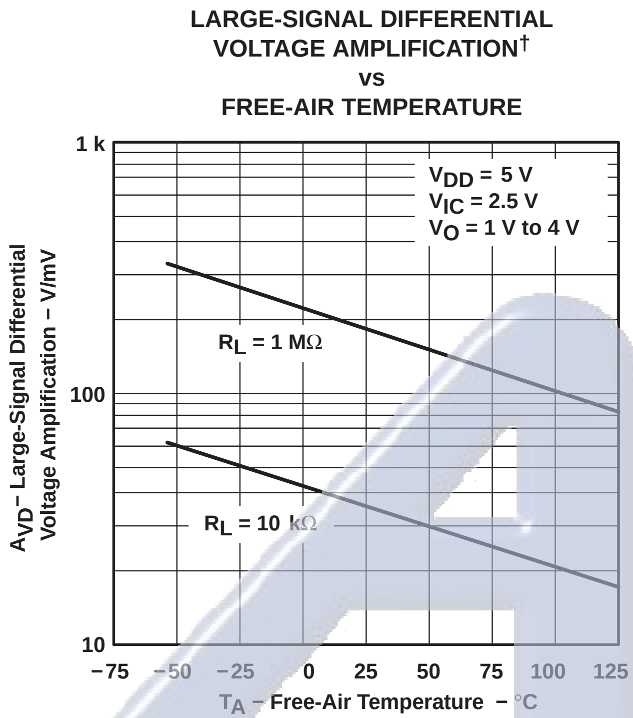


Figure 27

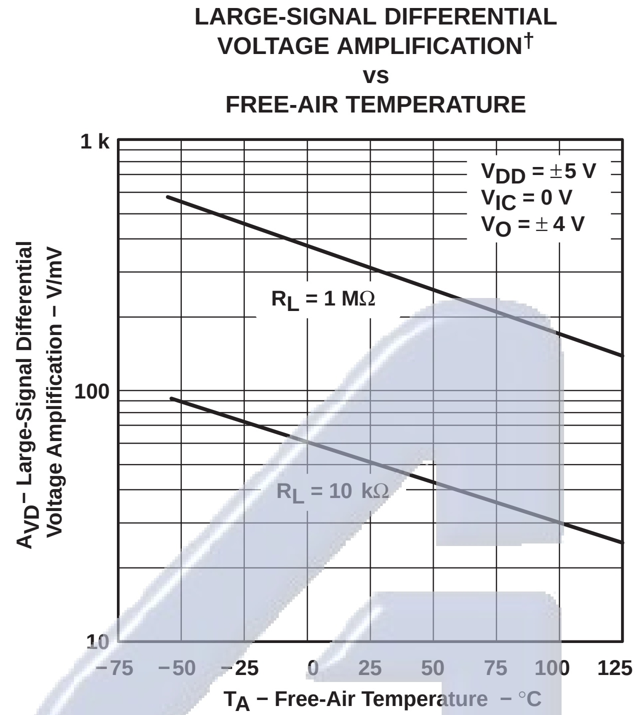


Figure 28

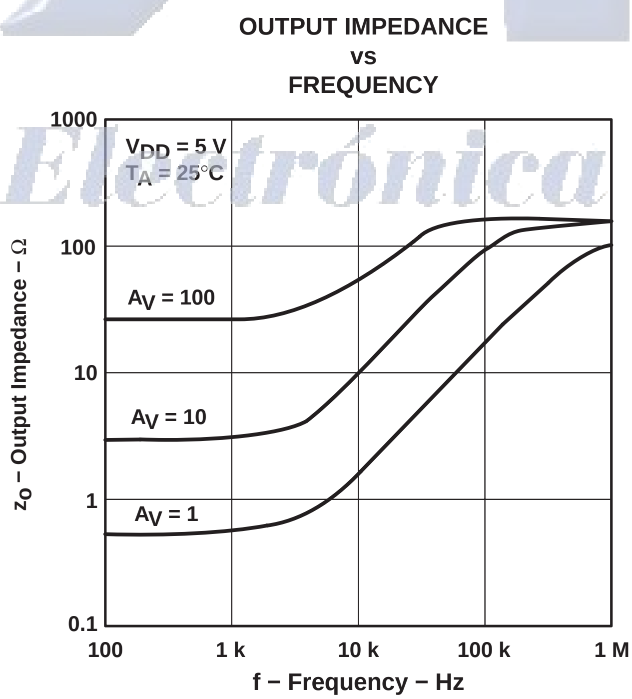


Figure 29

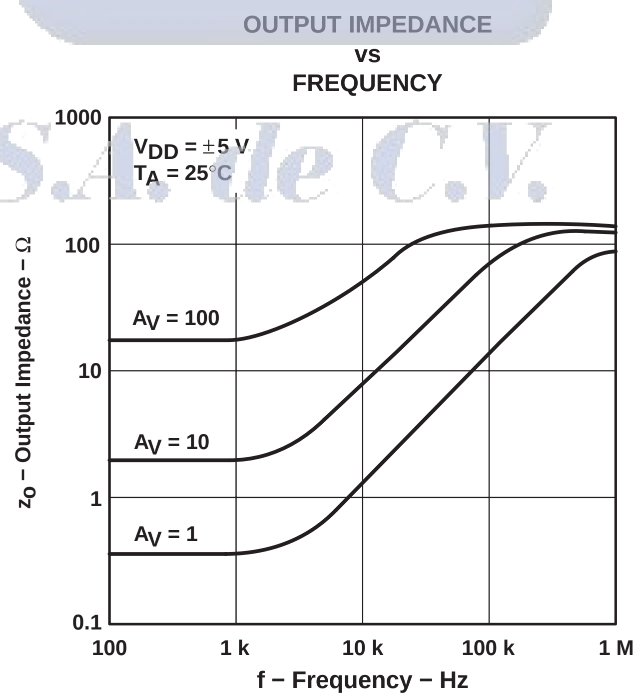


Figure 30

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

TYPICAL CHARACTERISTICS

COMMON-MODE REJECTION RATIO vs FREQUENCY

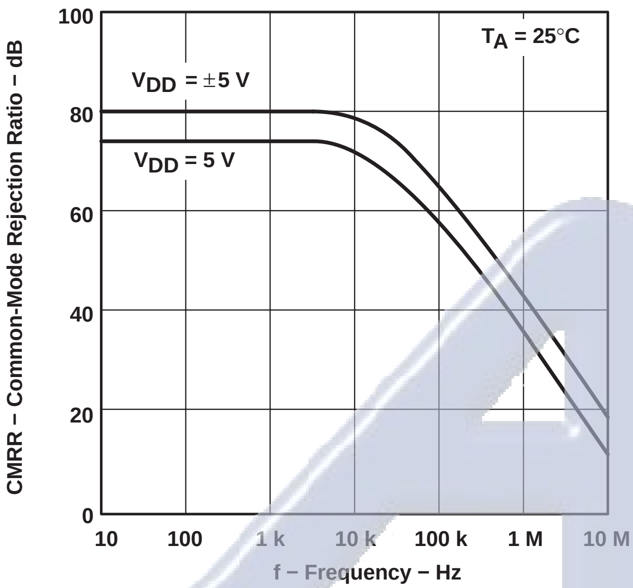


Figure 31

COMMON-MODE REJECTION RATIO vs FREE-AIR TEMPERATURE

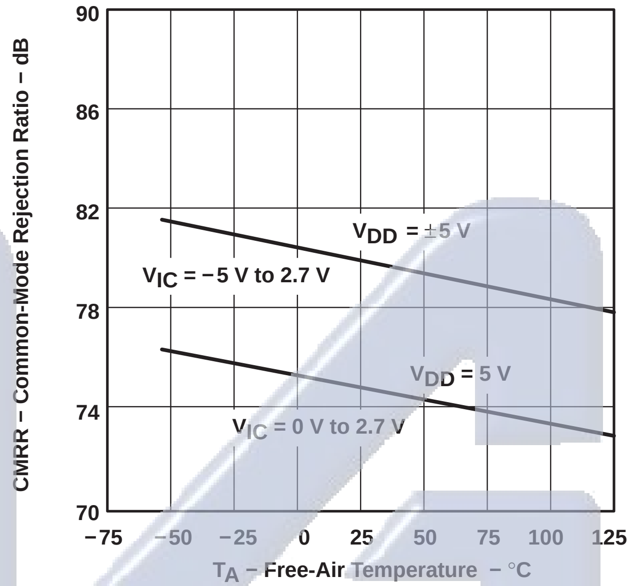


Figure 32

SUPPLY-VOLTAGE REJECTION RATIO vs FREQUENCY

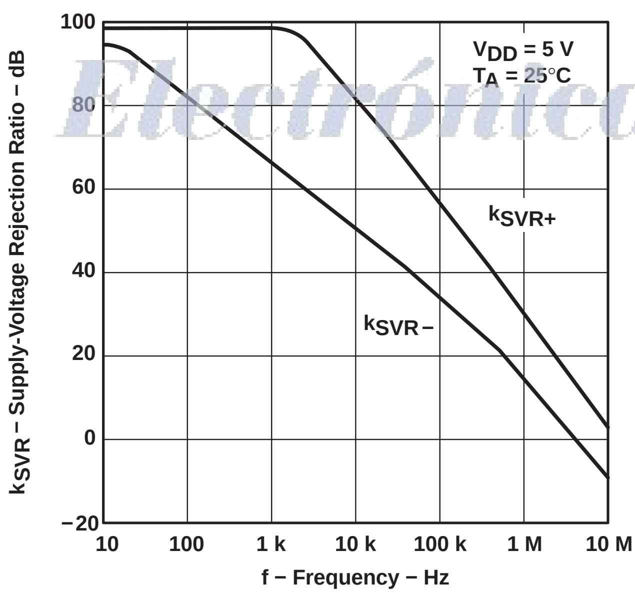


Figure 33

SUPPLY-VOLTAGE REJECTION RATIO vs FREQUENCY

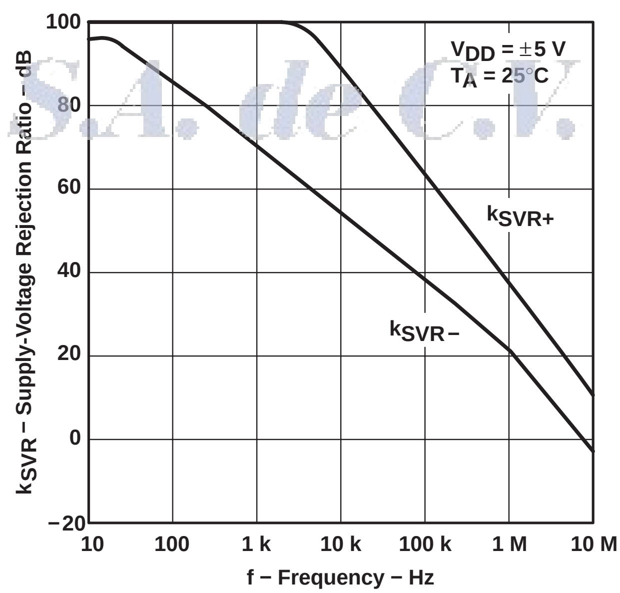


Figure 34

TYPICAL CHARACTERISTICS

SUPPLY VOLTAGE REJECTION RATIO† vs FREE-AIR TEMPERATURE

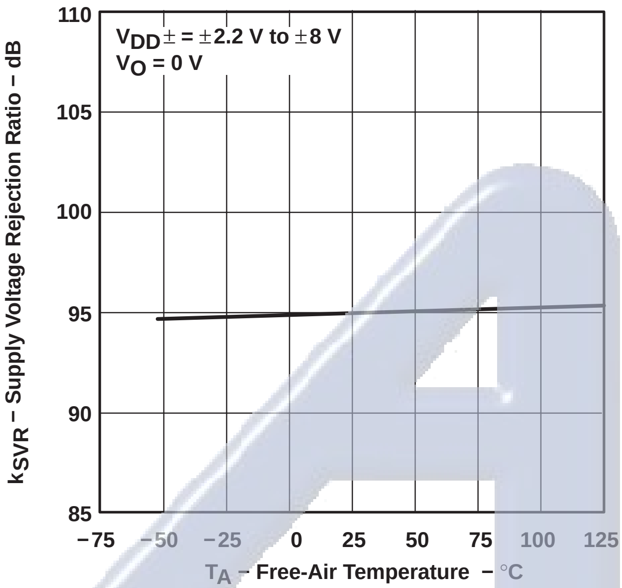


Figure 35

TLC2272 SUPPLY CURRENT† vs SUPPLY VOLTAGE

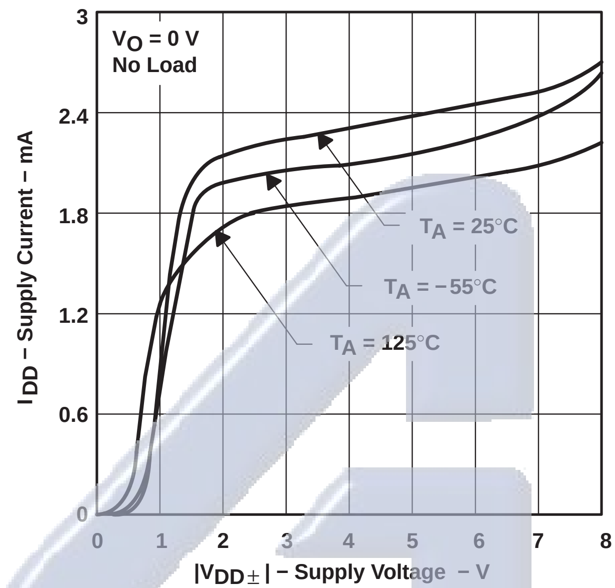


Figure 36

TLC2274 SUPPLY CURRENT† vs SUPPLY VOLTAGE

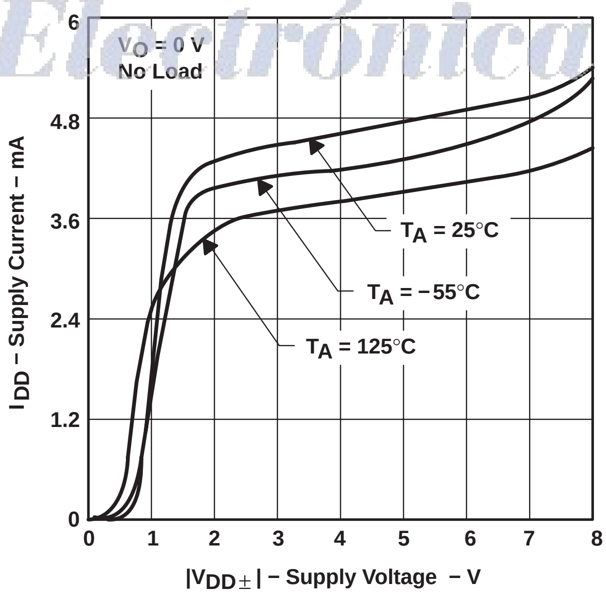


Figure 37

TLC2272 SUPPLY CURRENT† vs FREE-AIR TEMPERATURE

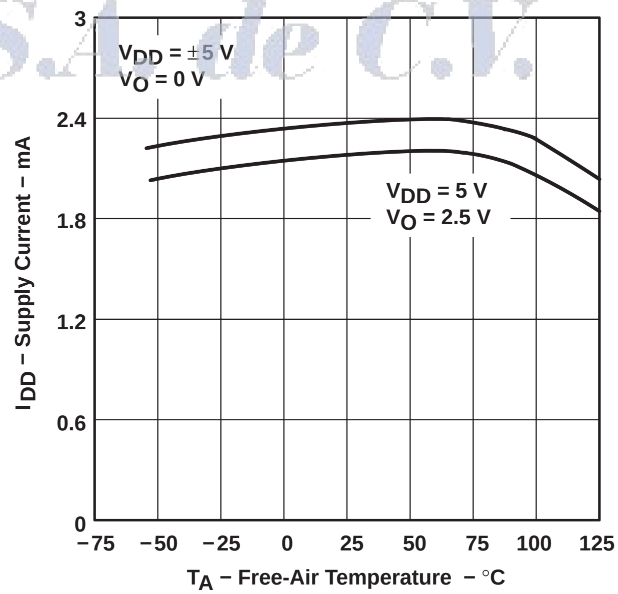


Figure 38

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

TYPICAL CHARACTERISTICS

TLC2274
SUPPLY CURRENT†
vs
FREE-AIR TEMPERATURE

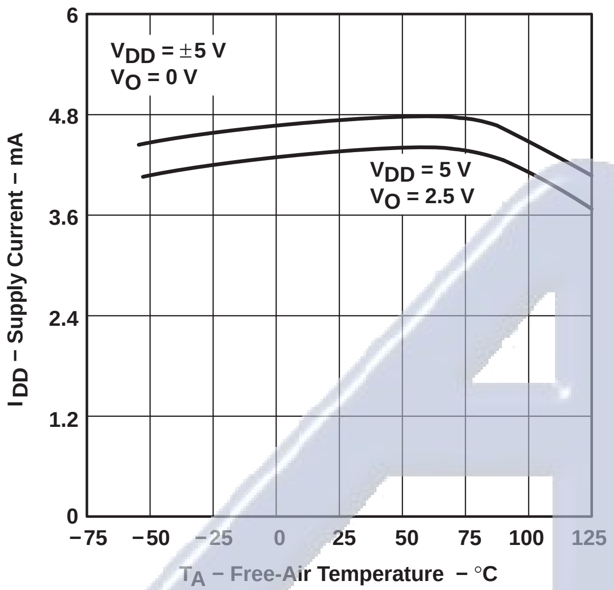


Figure 39

SLEW RATE
vs
LOAD CAPACITANCE

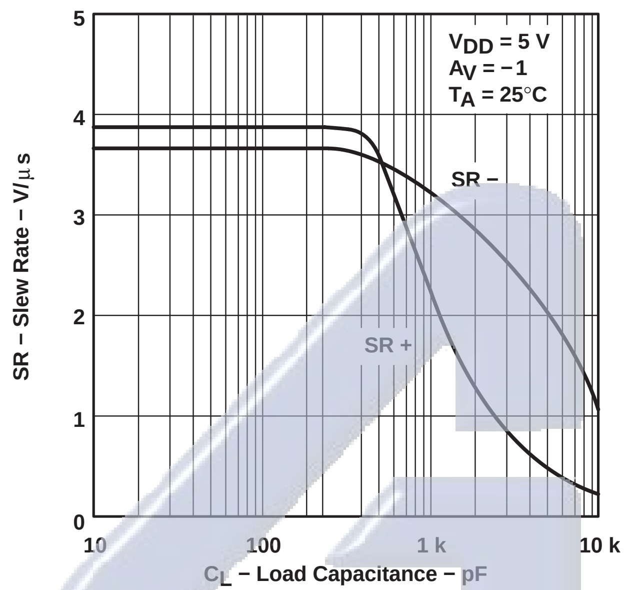


Figure 40

SLEW RATE†
vs
FREE-AIR TEMPERATURE

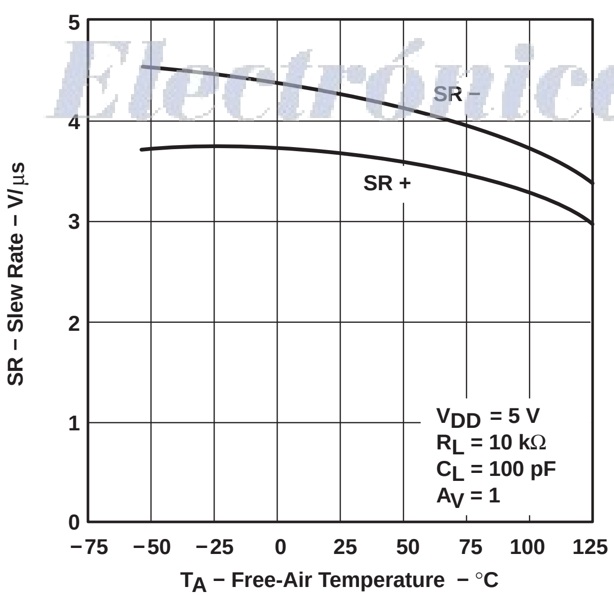


Figure 41

INVERTING LARGE-SIGNAL PULSE RESPONSE

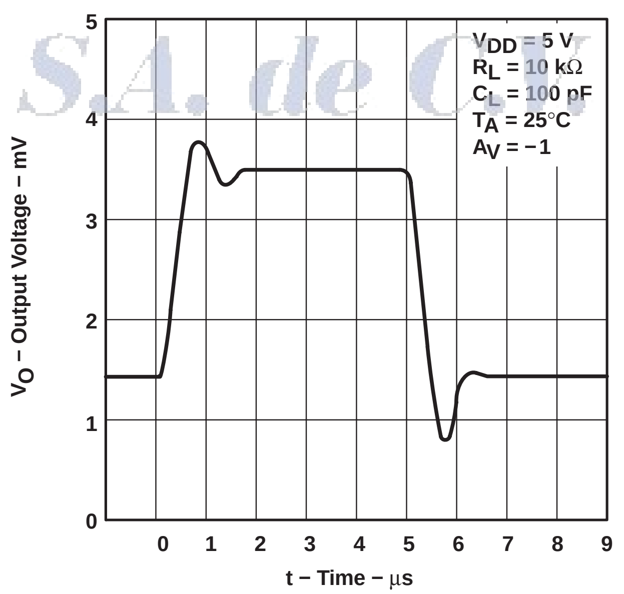


Figure 42

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

TYPICAL CHARACTERISTICS

INVERTING LARGE-SIGNAL PULSE RESPONSE

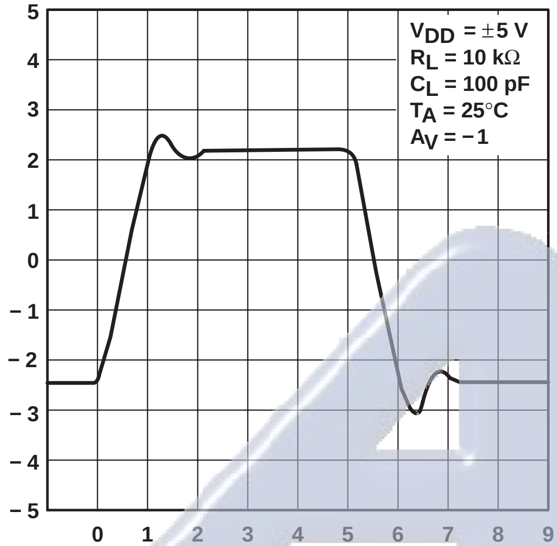


Figure 43

VOLTAGE-FOLLOWER LARGE-SIGNAL PULSE RESPONSE

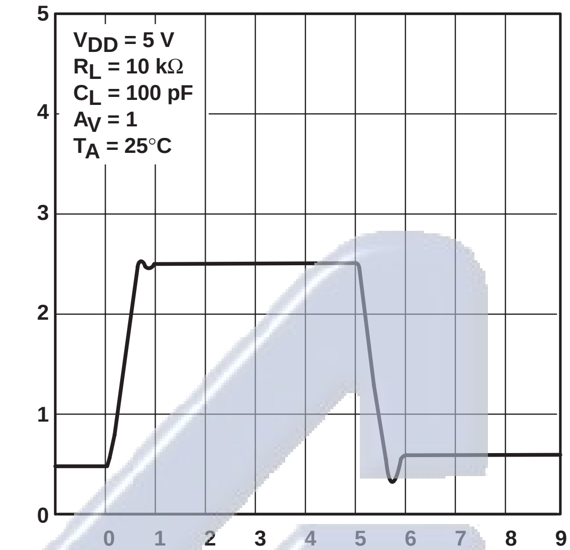


Figure 44

VOLTAGE-FOLLOWER LARGE-SIGNAL PULSE RESPONSE

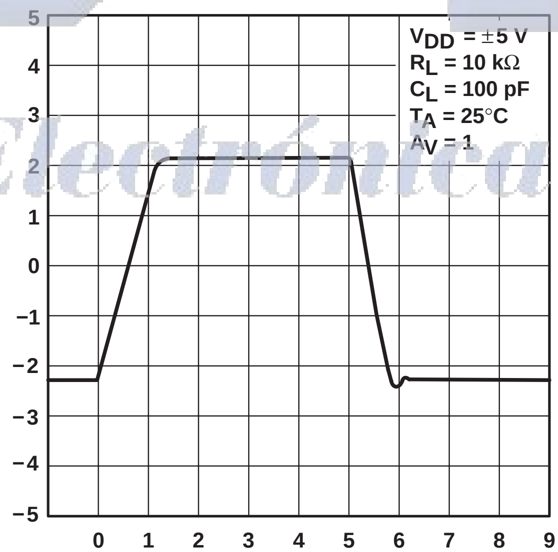


Figure 45

INVERTING SMALL-SIGNAL PULSE RESPONSE

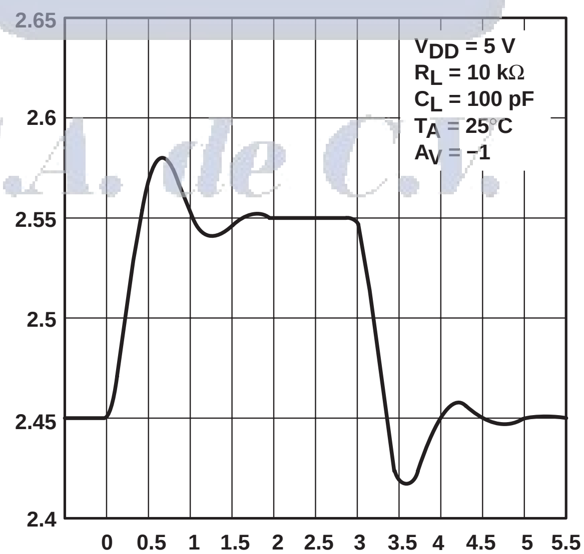


Figure 46

TYPICAL CHARACTERISTICS

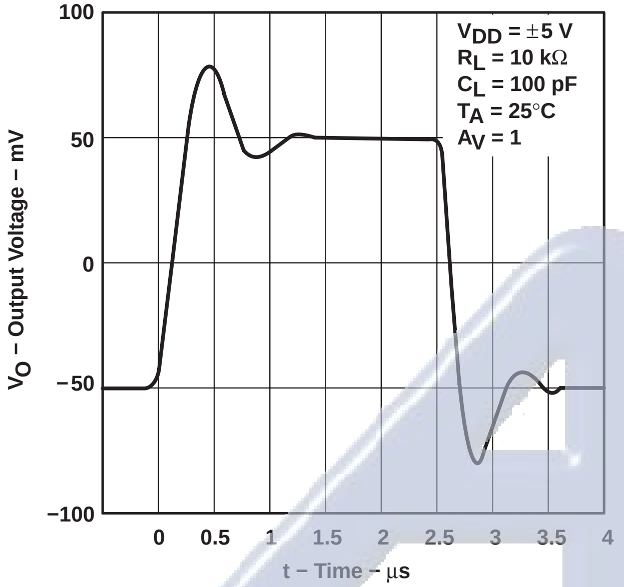


Figure 47

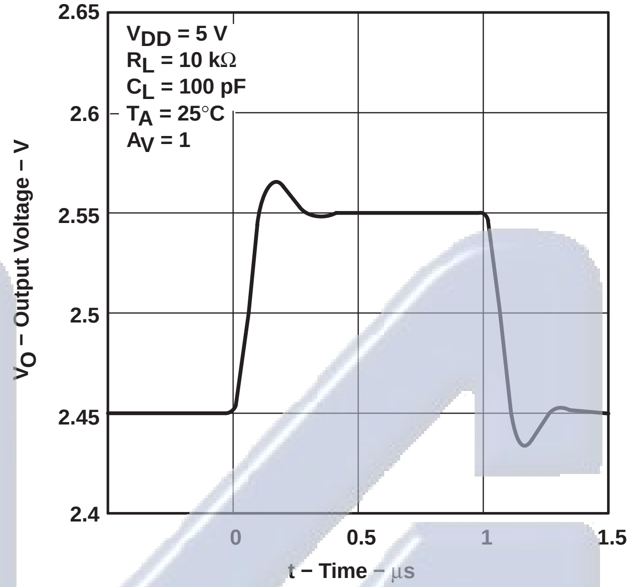


Figure 48

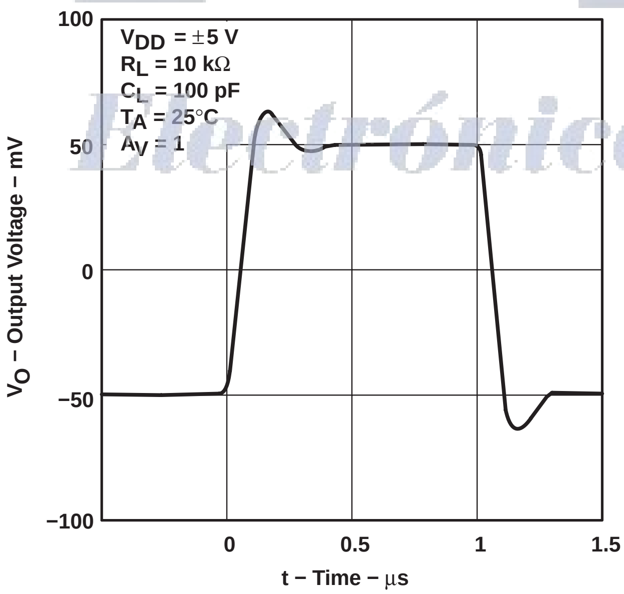


Figure 49

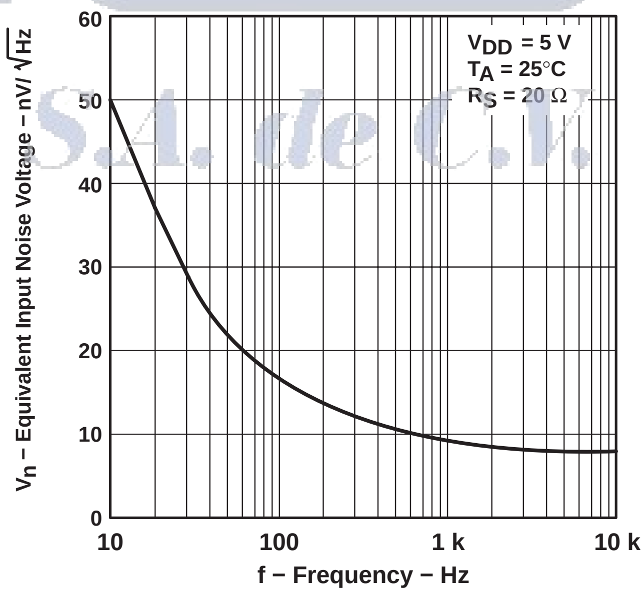


Figure 50

TYPICAL CHARACTERISTICS

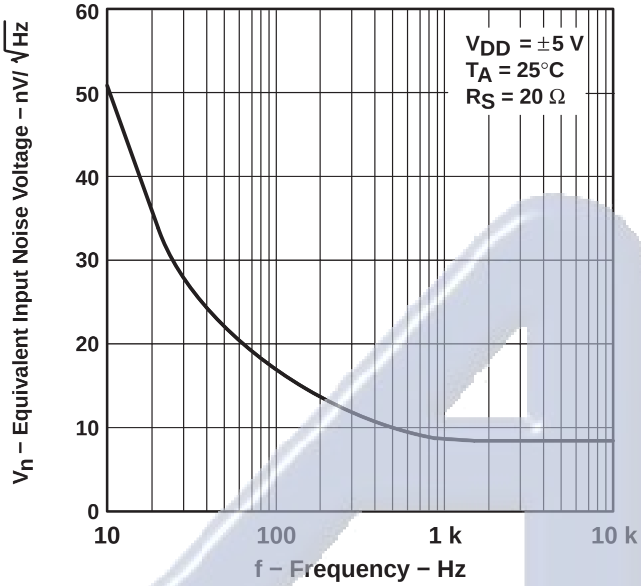


Figure 51

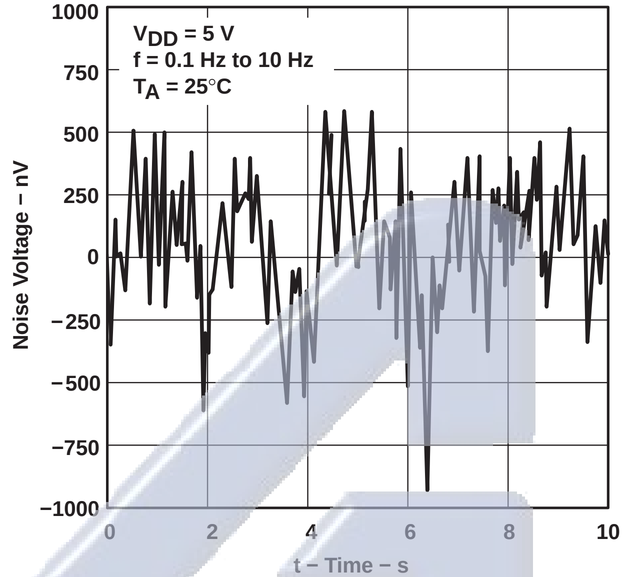


Figure 52

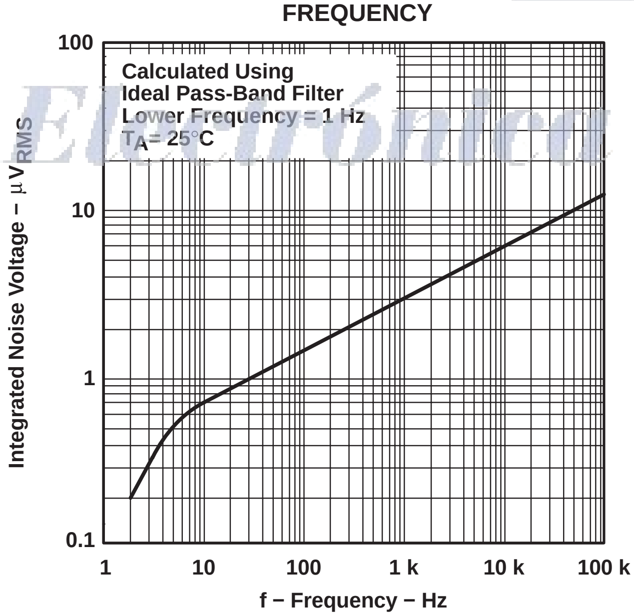


Figure 53

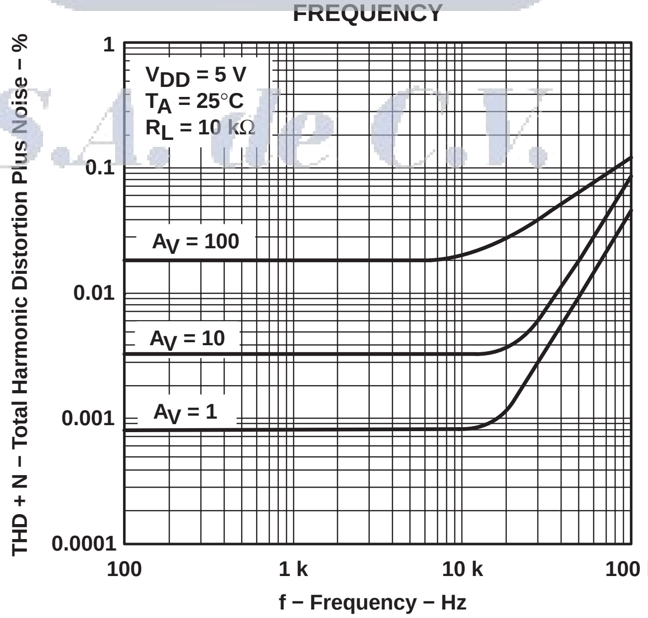


Figure 54

TYPICAL CHARACTERISTICS

GAIN-BANDWIDTH PRODUCT
vs
SUPPLY VOLTAGE

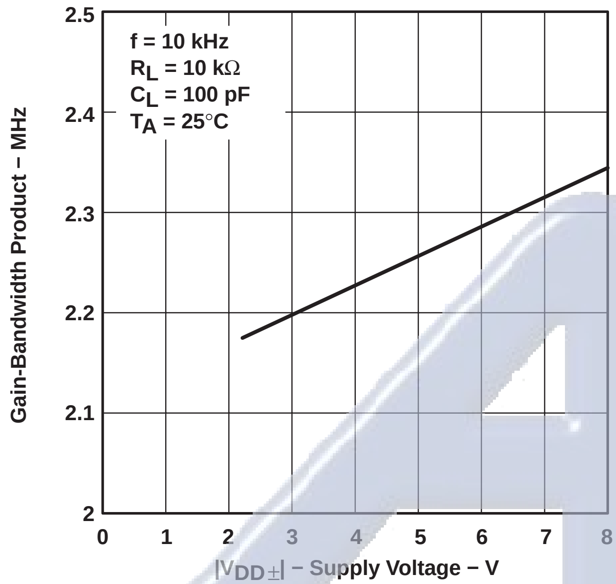


Figure 55

GAIN-BANDWIDTH PRODUCT†
vs
FREE-AIR TEMPERATURE

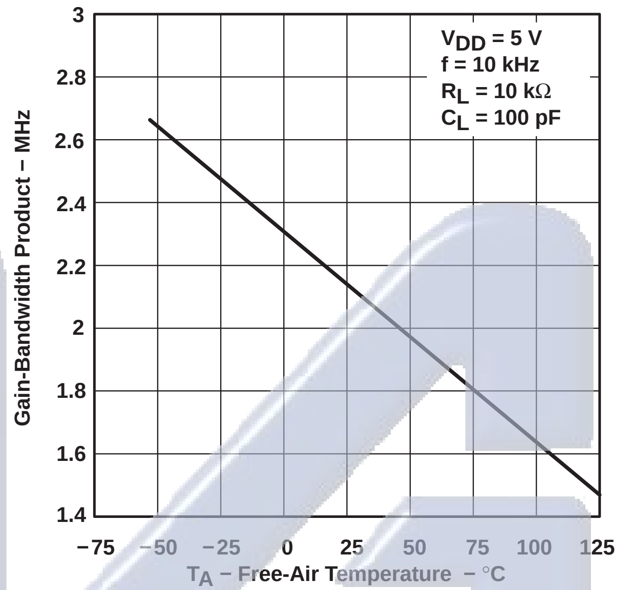


Figure 56

PHASE MARGIN
vs
LOAD CAPACITANCE

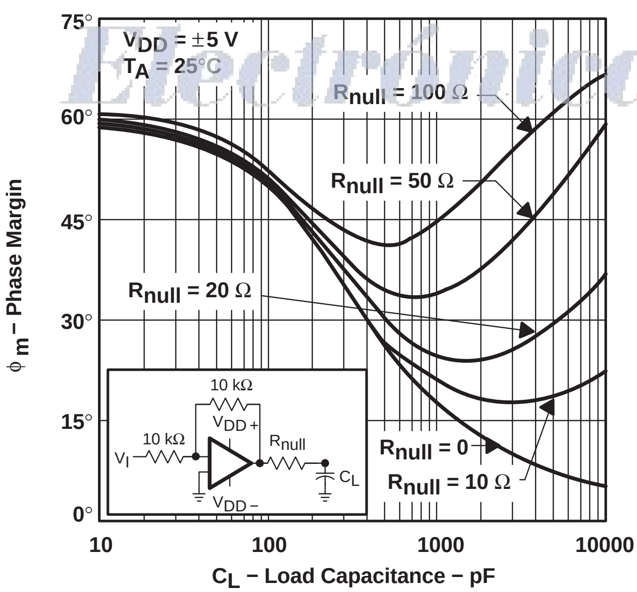


Figure 57

GAIN MARGIN
vs
LOAD CAPACITANCE

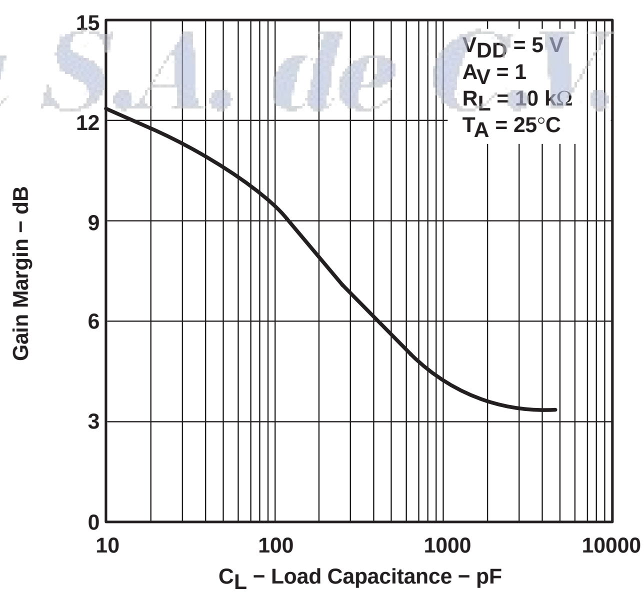


Figure 58

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

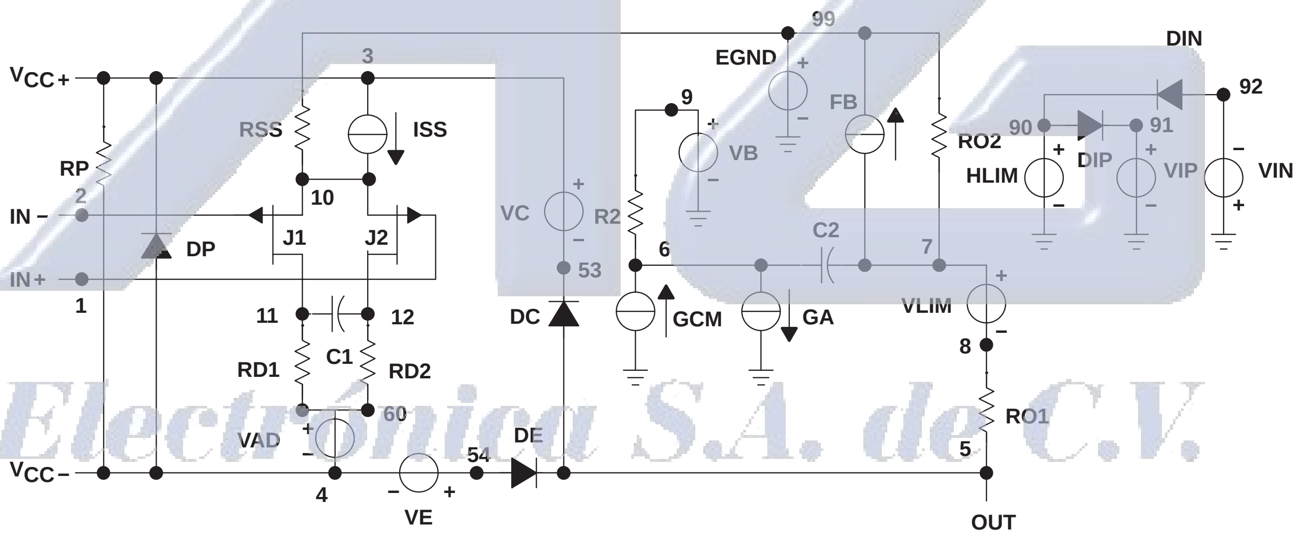
APPLICATION INFORMATION

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°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).




```
.SUBCKT TLC227x 1 2 3 4 5
        C1      11      1214E−12
        C2      6       760.00E−12
        DC      5       53DX
        DE      54      5DX
        DLP     90      91DX
        DLN     92      90DX
        DP      4       3DX
        EGND    99      0POLY (2) (3,0) (4,) 0 .5 .5
        FB      99      0POLY (5) VB VC VE VLP VLN 0
        + 984.9E3 −1E6 1E6 1E6 −1E6
        GA      6       011 12 377.0E−6
        GCM 0 6 10 99 134E−9
        ISS     3       10DC 216.OE−6
        HLIM    90      0VLIM 1K
        J1      11      210 JX
        J2      12      110 JX
        R2      6       9100.OE3

RD1     60      112.653E3
RD2     60      122.653E3
R01     8       550
R02     7       9950
RP      3       44.310E3
RSS     10      99925.9E3
VAD     60      4−.5
VB      9       0DC 0
VC 3 53 DC .78
VE      54      4DC .78
VLIM    7       8DC 0
VLP     91      0DC 1.9
VLN     0       92DC 9.4
.MODEL DX D (IS=800.0E−18)
.MODEL JX PJF (IS=1.500E−12BETA=1.316E-3
+ VTO=−.270)
.ENDS
```

Figure 59. Boyle Macromodel and Subcircuit

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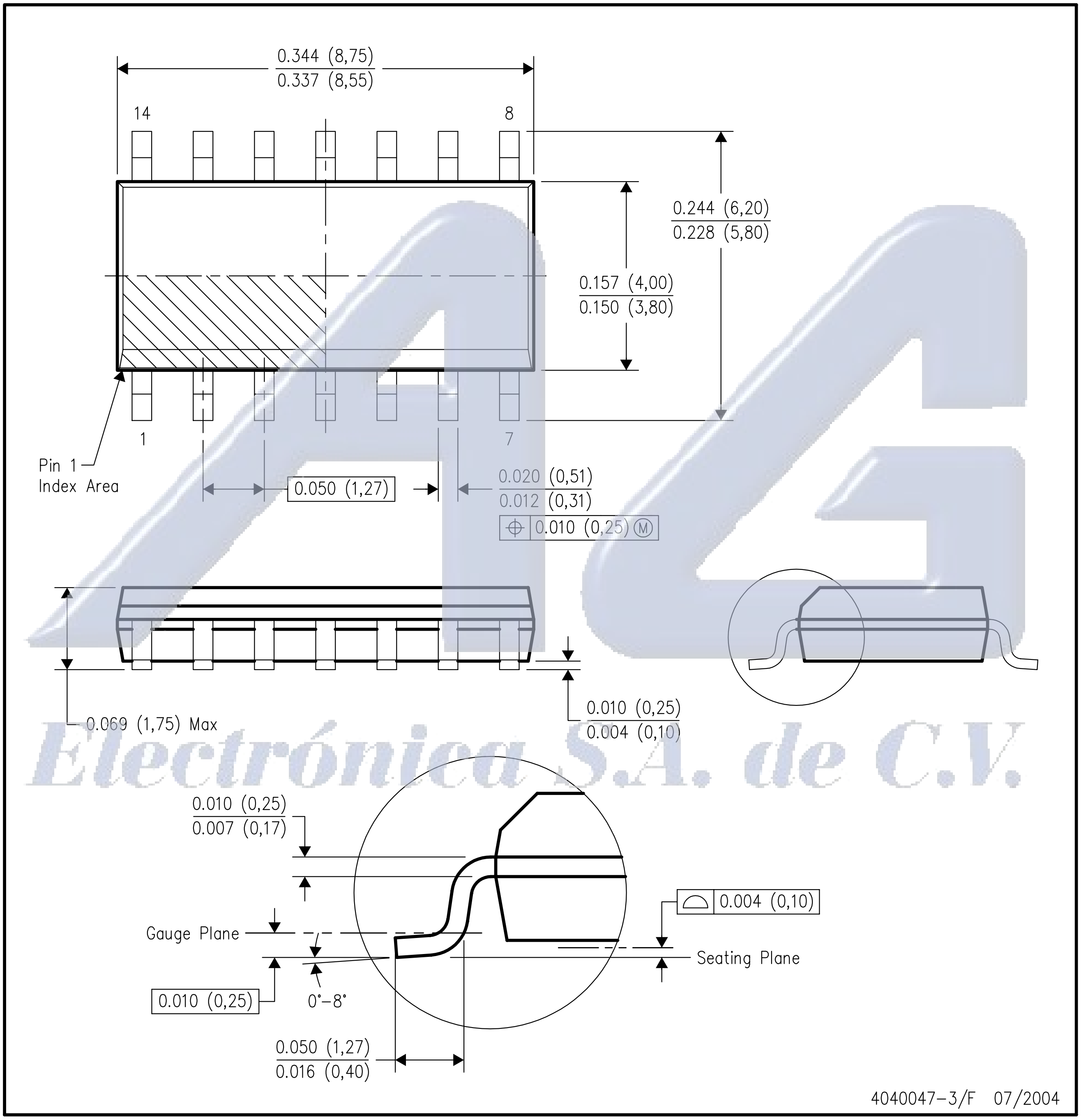
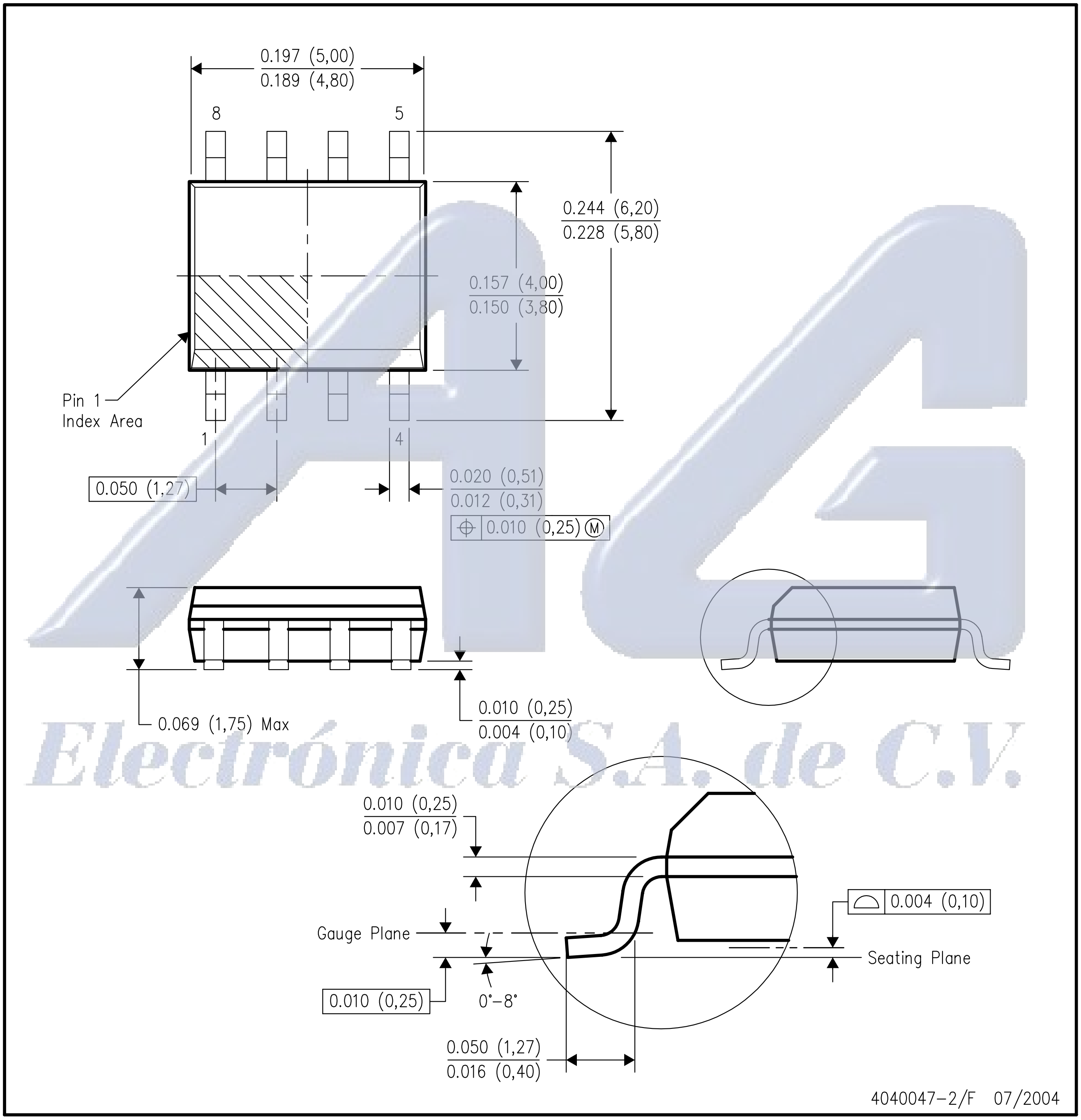
D (R–PDSO–G14) PLASTIC SMALL–OUTLINE PACKAGE



NOTES:
- A. All linear dimensions are in inches (millimeters).
- B. This drawing is subject to change without notice.
- C. Body dimensions do not include mold flash or protrusion not to exceed 0.006 (0,15).
- D. Falls within JEDEC MS–012 variation AB.

D (R-PDSO-G8) PLASTIC SMALL-OUTLINE PACKAGE



NOTES: A. All linear dimensions are in inches (millimeters).
B. This drawing is subject to change without notice.
C. Body dimensions do not include mold flash or protrusion not to exceed 0.006 (0,15).
D. Falls within JEDEC MS-012 variation AA.

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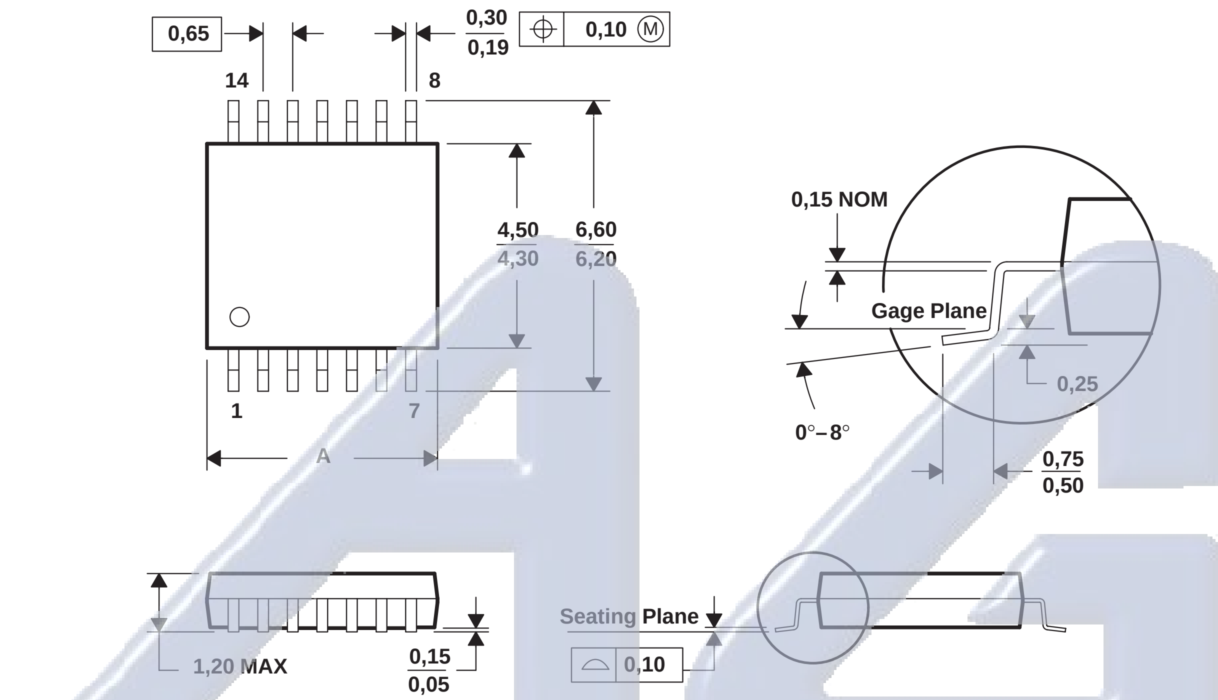
PW (R-PDSO-G**)

PLASTIC SMALL-OUTLINE PACKAGE

14 PINS SHOWN



DIM \ PINS **	8	14	16	20	24	28
A MAX	3,10	5,10	5,10	6,60	7,90	9,80
A MIN	2,90	4,90	4,90	6,40	7,70	9,60

4040064/F 01/97

NOTES: A. All linear dimensions are in millimeters.
B. This drawing is subject to change without notice.
C. Body dimensions do not include mold flash or protrusion not to exceed 0,15.
D. Falls within JEDEC MO-153

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