- **Qualified for Automotive Applications**
- **ESD Protection Exceeds 2000 V Per MIL-STD-883, Method 3015; Exceeds 150 V (TLC2252/52A) and 100 V (TLC2254/54A) Using Machine Model (C = 200 pF, R = 0)**
- **Output Swing Includes Both Supply Rails**
- **Low Noise . . . 19 nV/√Hz Typ at f = 1 kHz**
- **Low Input Bias Current . . . 1 pA Typ**
- **Fully Specified for Both Single-Supply and Split-Supply Operation**
- **Very Low Power . . . 35 μA Per Channel Typ**
- **Common-Mode Input Voltage Range Includes Negative Rail**
- **Low Input Offset Voltage 850 μV Max at T_A = 25°C (TLC225xA)**
- **Macromodel Included**
- **Performance Upgrades for the TS27L2/L4 and TLC27L2/L4**

description

The TLC2252 and TLC2254 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 TLC225x family consumes only 35 μA of supply current per channel. This micropower operation makes them good choices for battery-powered applications. The noise performance has been dramatically improved over previous generations of CMOS amplifiers. Looking at Figure 1, the TLC225x has a noise level of 19 nV/√Hz at 1kHz; four times lower than competitive micropower solutions.

EQUIVALENT INPUT NOISE VOLTAGE vs FREQUENCY

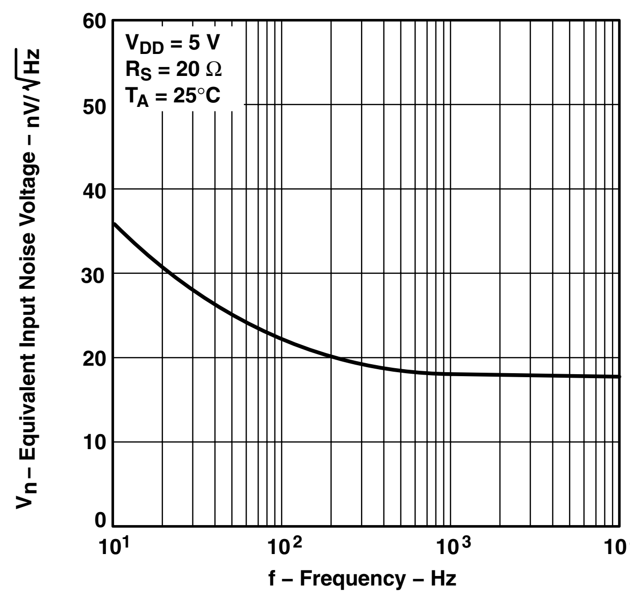


Figure 1

The TLC225x amplifiers, exhibiting high input impedance and low noise, are excellent for small-signal conditioning for high-impedance sources, such as piezoelectric transducers. Because of the micropower 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 TLC225xA family is available and has a maximum input offset voltage of 850 μV. This family is fully characterized at 5 V and ±5 V.

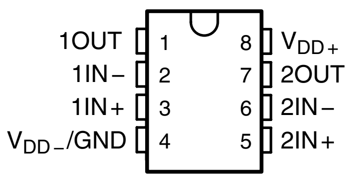
The TLC2252/4 also makes great upgrades to the TLC27L2/L4 or TS27L2/L4 in standard designs. They offer increased output dynamic range, lower noise voltage, and lower input offset voltage. This enhanced feature set allows them to be used in a wider range of applications. For applications that require higher output drive and wider input voltage ranges, see the TLV2432 and TLV2442 devices. If the design requires single amplifiers, please 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.

ORDERING INFORMATION†

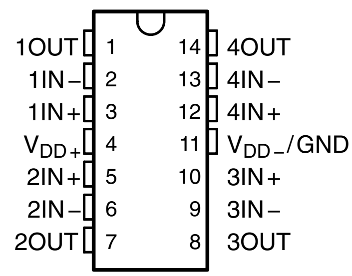
T_A	V_{IO}max AT 25°C	PACKAGE‡		ORDERABLE PART NUMBER	TOP-SIDE MARKING
−40°C to 125°C	850 µV	SOIC (D)	Tape and reel	TLC2252AQDRQ1	2252AQ
		TSSOP (PW)	Tape and reel	TLC2252AQPWRQ1	2252AQ
	1550 µV	SOIC (D)	Tape and reel	TLC2252QDRQ1	2252Q1
		TSSOP (PW)	Tape and reel	TLC2252QPWRQ1	2252Q1
	850 µV	SOIC (D)	Tape and reel	TLC2254AQDRQ1	TLC2254AQ1
		TSSOP (PW)	Tape and reel	TLC2254AQPWRQ1	2254AQ
	1550 µV	SOIC (D)	Tape and reel	TLC2254QDRQ1	TLC2254Q1
		TSSOP (PW)	Tape and reel	TLC2254QPWRQ1	2254Q1

† For the most current package and ordering information, see the Package Option Addendum at the end of this document, or see the TI web site at http://www.ti.com.
‡ Package drawings, thermal data, and symbolization are available at http://www.ti.com/packaging.

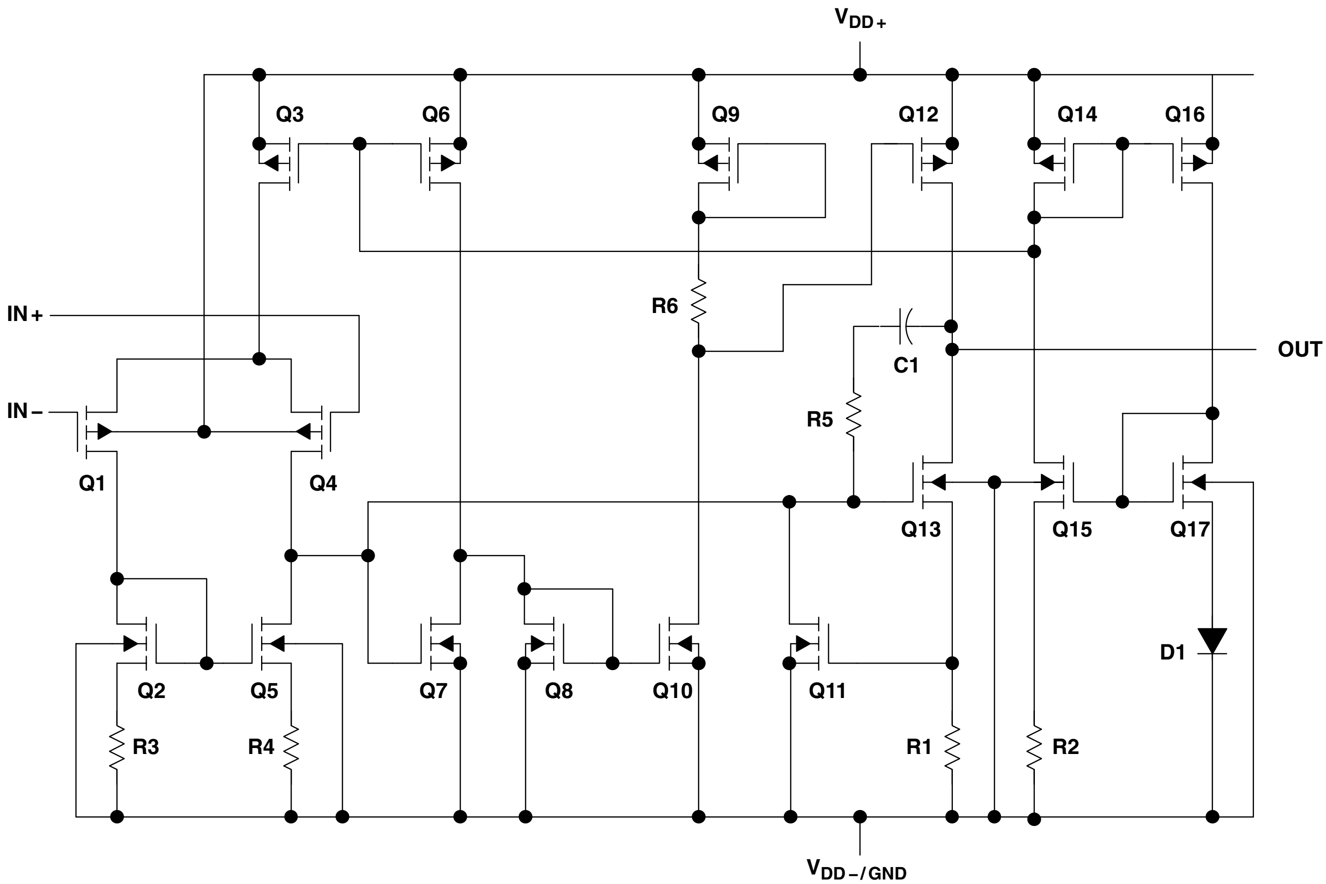
TLC2252, TLC2252A
D OR PW PACKAGE
(TOP VIEW)



TLC2254, TLC2254A
D OR PW PACKAGE
(TOP VIEW)



equivalent schematic (each amplifier)



ACTUAL DEVICE COMPONENT COUNT†		
COMPONENT	**TLC2252**	**TLC2254**
Transistors	38	76
Resistors	30	56
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, V_I (any input, see Note 1) . . . . . ±8 V
Input current, I_I (each 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: Q suffix . . . . . −40°C to 125°C
Storage temperature range, T_{stg} . . . . . −65°C to 150°C
Lead temperature 1,6 mm (1/16 inch) from case for 10 seconds . . . . . 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 flows when 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.

DISSIPATION RATING TABLE

PACKAGE	$T_A \leq 25°C$ 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	724 mW	5.8 mW/°C	464 mW	377 mW	144 mW
D–14	950 mW	7.6 mW/°C	608 mW	450 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	140 mW

recommended operating conditions

	MIN	MAX	UNIT
Supply voltage, $V_{DD\pm}$	±2.2	±8	V
Input voltage range, 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	−40	125	°C

‡ Referenced to 2.5 V

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

PARAMETER		TEST CONDITIONS		T_A†	TLC2252-Q1			TLC2252A-Q1			UNIT
					MIN	TYP	MAX	MIN	TYP	MAX	
V_{IO}	Input offset voltage	$V_{DD\pm}$ = ±2.5 V, V_O = 0,	V_{IC} = 0, R_S = 50 Ω	25°C		200	1500		200	850	µV
				Full range			1750			1000	
α_{VIO}	Temperature coefficient of input offset voltage			25°C to 125°C		0.5			0.5		µV/°C
	Input offset voltage long-term drift (see Note 4)			25°C		0.003			0.003		µV/mo
I_{IO}	Input offset current			25°C		0.5	60		0.5	60	pA
				Full range			1000			1000	
I_{IB}	Input bias current			25°C		1	60		1	60	pA
				Full range			1000			1000	
V_{ICR}	Common-mode input voltage range	R_S = 50 Ω,	$\|V_{IO}\| \le 5$ 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		4.98			4.98		V
		I_{OH} = −75 µA		25°C	4.9	4.94		4.9	4.94		
				Full range	4.8			4.8			
		I_{OH} = −150 µA		25°C	4.8	4.88		4.8	4.88		
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} = 4 mA	25°C		0.8	1		0.7	1	
				Full range			1.2			1.2	
A_{VD}	Large-signal differential voltage amplification	V_{IC} = 2.5 V, V_O = 1 V to 4 V	R_L = 100 kΩ‡	25°C	100	350		100	350		V/mV
				Full range	10			10			
			R_L = 1 MΩ‡	25°C		1700			1700		
r_{id}	Differential input resistance			25°C		10^{12}			10^{12}		Ω
r_{ic}	Common-mode input resistance			25°C		10^{12}			10^{12}		Ω
c_{ic}	Common-mode input capacitance	f = 10 kHz,	f = 10 kHz,	25°C		8			8		pF
z_o	Closed-loop output impedance	f = 25 kHz,	A_V = 10	25°C		200			200		Ω
CMRR	Common-mode rejection ratio	V_{IC} = 0 to 2.7 V, R_S = 50 Ω	V_O = 2.5 V,	25°C	70	83		70	83		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		70	125		70	125	µA
				Full range			150			150	

† Full range is –40°C to 125°C for Q suffix.
‡ Referenced to 2.5 V

NOTE 4: Typical values are based on the input offset voltage shift observed through 500 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.

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

PARAMETER		TEST CONDITIONS		T_A†	TLC2252-Q1			TLC2252A-Q1			UNIT
					MIN	TYP	MAX	MIN	TYP	MAX	
SR	Slew rate at unity gain	V_O = 0.5 V to 3.5 V, R_L = 100 kΩ‡,	C_L = 100 pF‡	25°C	0.07	0.12		0.07	0.12		V/µs
				Full range	0.05			0.05			
V_n	Equivalent input noise voltage	f = 10 Hz		25°C		36			36		nV/√Hz
		f = 1 kHz		25°C		19			19		
$V_{N(PP)}$	Peak-to-peak equivalent input noise voltage	f = 0.1 Hz to 1 Hz		25°C		0.7			0.7		µV
		f = 0.1 Hz to 10 Hz		25°C		1.1			1.1		
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 = 10 kHz, R_L = 50 kΩ‡	A_V = 1	25°C		0.2%			0.2%		
			A_V = 10			1%			1%		
	Gain-bandwidth product	f = 50 kHz, C_L = 100 pF‡	R_L = 50 kΩ‡,	25°C		0.2			0.2		MHz
B_{OM}	Maximum output-swing bandwidth	$V_{O(PP)}$ = 2 V, R_L = 50 kΩ‡,	A_V = 1, C_L = 100 pF‡	25°C		30			30		kHz
ϕ_m	Phase margin at unity gain	R_L = 50 kΩ‡,	C_L = 100 pF‡	25°C		63°			63°		
	Gain margin			25°C		15			15		dB

† Full range is –40°C to 125°C for Q suffix.
‡ Referenced to 2.5 V

TEXAS INSTRUMENTS
POST OFFICE BOX 655303 ● DALLAS, TEXAS 75265
POST OFFICE BOX 1443 ● HOUSTON, TEXAS 77251–1443

electrical characteristics at specified free-air temperature, $V_{DD\pm} = \pm5$ V (unless otherwise noted)

PARAMETER		TEST CONDITIONS	T_A†	TLC2252-Q1			TLC2252A-Q1			UNIT
				MIN	TYP	MAX	MIN	TYP	MAX	
V_{IO}	Input offset voltage	$V_{IC} = 0$, $V_O = 0$, $R_S = 50\ \Omega$	25°C		200	1500		200	850	µV
			Full range			1750			1000	
α_{VIO}	Temperature coefficient of input offset voltage		25°C to 125°C		0.5			0.5		µV/°C
	Input offset voltage long-term drift (see Note 4)		25°C		0.003			0.003		µV/mo
I_{IO}	Input offset current		25°C		0.5	60		0.5	60	pA
			Full range			1000			1000	
I_{IB}	Input bias current		25°C		1	60		1	60	pA
			Full range			1000			1000	
V_{ICR}	Common-mode input voltage range	$R_S = 50\ \Omega$, $\lvert V_{IO} \rvert \le 5$ 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	$I_O = -20\ \mu A$	25°C		4.98			4.98		V
		$I_O = -100\ \mu A$	25°C	4.9	4.93		4.9	4.93		
			Full range	4.7			4.7			
		$I_O = -200\ \mu A$	25°C	4.8	4.86		4.8	4.86		
V_{OM-}	Maximum negative peak output voltage	$V_{IC} = 0$, $I_O = 50\ \mu A$	25°C		−4.99			−4.99		V
		$V_{IC} = 0$, $I_O = 500\ \mu A$	25°C	−4.85	−4.91		−4.85	−4.91		
			Full range	−4.85			−4.85			
		$V_{IC} = 0$, $I_O = 4$ mA	25°C	−4	−4.3		−4	−4.3		
			Full range	−3.8			−3.8			
A_{VD}	Large-signal differential voltage amplification	$V_O = \pm4$ V, $R_L = 100\ k\Omega$	25°C	40	150		40	150		V/mV
			Full range	10			10			
		$V_O = \pm4$ V, $R_L = 1\ M\Omega$	25°C		3000			3000		
r_{id}	Differential input resistance		25°C		10^{12}			10^{12}		Ω
r_{ic}	Common-mode input resistance		25°C		10^{12}			10^{12}		Ω
c_{ic}	Common-mode input capacitance	f = 10 kHz, P package	25°C		8			8		pF
z_o	Closed-loop output impedance	f = 25 kHz, $A_V = 10$	25°C		190			190		Ω
CMRR	Common-mode rejection ratio	$V_{IC} = -5$ V to 2.7 V, $V_O = 0$, $R_S = 50\ \Omega$	25°C	75	88		75	88		dB
			Full range	75			75			
k_{SVR}	Supply-voltage rejection ratio ($\Delta V_{DD\pm}/\Delta V_{IO}$)	$V_{DD} = \pm2.2$ V to ±8 V, $V_{IC} = 0$, 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		80	125		80	125	µA
			Full range			150			150	

† Full range is –40°C to 125°C for Q suffix.

NOTE 4: Typical values are based on the input offset voltage shift observed through 500 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.

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

PARAMETER		TEST CONDITIONS		T_A†	TLC2252-Q1			TLC2252A-Q1			UNIT
					MIN	TYP	MAX	MIN	TYP	MAX	
SR	Slew rate at unity gain	$V_O = \pm2$ V, C_L = 100 pF	R_L = 100 kΩ,	25°C	0.07	0.12		0.07	0.12		V/µs
				Full range	0.05			0.05			
V_n	Equivalent input noise voltage	f = 10 Hz		25°C		38			38		nV/√Hz
		f = 1 kHz		25°C		19			19		
$V_{N(PP)}$	Peak-to-peak equivalent input noise voltage	f = 0.1 Hz to 1 Hz		25°C		0.8			0.8		µV
		f = 0.1 Hz to 10 Hz		25°C		1.1			1.1		
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 = 50 kΩ, f = 10 kHz	A_V = 1	25°C		0.2%			0.2%		
			A_V = 10			1%			1%		
	Gain-bandwidth product	f =10 kHz, C_L = 100 pF	R_L = 50 kΩ,	25°C		0.21			0.21		MHz
B_{OM}	Maximum output-swing bandwidth	$V_{O(PP)}$ = 4.6 V, R_L = 50 kΩ,	A_V = 1, C_L = 100 pF	25°C		14			14		kHz
ϕ_m	Phase margin at unity gain	R_L = 50 kΩ,	C_L = 100 pF	25°C		63°			63°		
	Gain margin			25°C		15			15		dB

† Full range is –40°C to 125°C for Q suffix.

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

PARAMETER		TEST CONDITIONS		T_A†	TLC2254-Q1 MIN	TLC2254-Q1 TYP	TLC2254-Q1 MAX	TLC2254A-Q1 MIN	TLC2254A-Q1 TYP	TLC2254A-Q1 MAX	UNIT
V_{IO}	Input offset voltage	$V_{DD\pm}$ = ±2.5 V, V_O = 0,	V_{IC} = 0, R_S = 50 Ω	25°C		200	1500		200	850	μV
				Full range			1750			1000	
α_{VIO}	Temperature coefficient of input offset voltage			25°C to 125°C		0.5			0.5		μV/°C
	Input offset voltage long-term drift (see Note 4)			25°C		0.003			0.003		μV/mo
I_{IO}	Input offset current			25°C		0.5	60		0.5	60	pA
				125°C			1000			1000	
I_{IB}	Input bias current			25°C		1	60		1	60	pA
				125°C			1000			1000	
V_{ICR}	Common-mode input voltage range	R_S = 50 Ω,	$\|V_{IO}\| \le 5$ 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		4.98			4.98		V
		I_{OH} = −75 μA		25°C	4.9	4.94		4.9	4.94		
				Full range	4.8			4.8			
		I_{OH} = −150 μA		25°C	4.8	4.88		4.8	4.88		
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} = 4 mA	25°C		0.8	1		0.7	1	
				Full range			1.2			1.2	
A_{VD}	Large-signal differential voltage amplification	V_{IC} = 2.5 V, V_O = 1 V to 4 V	R_L = 100 kΩ‡	25°C	100	350		100	350		V/mV
				Full range	10			10			
			R_L = 1 MΩ‡	25°C		1700			1700		
$r_{i(d)}$	Differential input resistance			25°C		10^{12}			10^{12}		Ω
$r_{i(c)}$	Common-mode input resistance			25°C		10^{12}			10^{12}		Ω
$c_{i(c)}$	Common-mode input capacitance	f = 10 kHz,	N package	25°C		8			8		pF
z_o	Closed-loop output impedance	f = 25 kHz,	A_V = 10	25°C		200			200		Ω
CMRR	Common-mode rejection ratio	V_{IC} = 0 to 2.7 V, R_S = 50 Ω	V_O = 2.5 V,	25°C	70	83		70	83		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 (four amplifiers)	V_O = 2.5 V,	No load	25°C		140	250		140	250	μA
				Full range			300			300	

† Full range is –40°C to 125°C for Q suffix.
‡ Referenced to 2.5 V
NOTE 4: Typical values are based on the input offset voltage shift observed through 500 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.

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

PARAMETER		TEST CONDITIONS	T_A†	TLC2254-Q1 MIN	TLC2254-Q1 TYP	TLC2254-Q1 MAX	TLC2254A-Q1 MIN	TLC2254A-Q1 TYP	TLC2254A-Q1 MAX	UNIT
SR	Slew rate at unity gain	V_O = 0.5 V to 3.5 V, R_L = 100 kΩ‡, C_L = 100 pF‡	25°C	0.07	0.12		0.07	0.12		V/µs
			Full range	0.05			0.05			
V_n	Equivalent input noise voltage	f = 10 Hz	25°C		36			36		nV/√Hz
		f = 1 kHz	25°C		19			19		
$V_{N(PP)}$	Peak-to-peak equivalent input noise voltage	f = 0.1 Hz to 1 Hz	25°C		0.7			0.7		µV
		f = 0.1 Hz to 10 Hz	25°C		1.1			1.1		
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 = 50 kΩ‡, A_V = 1	25°C		0.2%			0.2%		
		A_V = 10			1%			1%		
	Gain-bandwidth product	f = 50 kHz, R_L = 50 kΩ‡, C_L = 100 pF‡	25°C		0.2			0.2		MHz
B_{OM}	Maximum output-swing bandwidth	$V_{O(PP)}$ = 2 V, A_V = 1, R_L = 50 kΩ‡, C_L = 100 pF‡	25°C		30			30		kHz
ϕ_m	Phase margin at unity gain	R_L = 50 kΩ‡, C_L = 100 pF‡	25°C		63°			63°		
	Gain margin		25°C		15			15		dB

† Full range is –40°C to 125°C for Q suffix.
‡ Referenced to 2.5 V

electrical characteristics at specified free-air temperature, $V_{DD\pm} = \pm5$ V (unless otherwise noted)

PARAMETER		TEST CONDITIONS	T_A†	TLC2254-Q1 MIN	TLC2254-Q1 TYP	TLC2254-Q1 MAX	TLC2254A-Q1 MIN	TLC2254A-Q1 TYP	TLC2254A-Q1 MAX	UNIT
V_{IO}	Input offset voltage	$V_{IC} = 0$, $V_O = 0$, $R_S = 50\ \Omega$	25°C		200	1500		200	850	µV
			Full range			1750			1000	
α_{VIO}	Temperature coefficient of input offset voltage		25°C to 125°C		0.5			0.5		µV/°C
	Input offset voltage long-term drift (see Note 4)		25°C		0.003			0.003		µV/mo
I_{IO}	Input offset current		25°C		0.5	60		0.5	60	pA
			125°C			1000			1000	
I_{IB}	Input bias current		25°C		1	60		1	60	pA
			125°C			1000			1000	
V_{ICR}	Common-mode input voltage range	$R_S = 50\ \Omega$, $\lvert V_{IO} \rvert \le 5$ 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	$I_O = -20\ \mu A$	25°C		4.98			4.98		V
		$I_O = -100\ \mu A$	25°C	4.9	4.93		4.9	4.93		
			Full range	4.7			4.7			
		$I_O = -200\ \mu A$	25°C	4.8	4.86		4.8	4.86		
V_{OM-}	Maximum negative peak output voltage	$V_{IC} = 0$, $I_O = 50\ \mu A$	25°C		−4.99			−4.99		V
		$V_{IC} = 0$, $I_O = 500\ \mu A$	25°C	−4.85	−4.91		−4.85	−4.91		
			Full range	−4.85			−4.85			
		$V_{IC} = 0$, $I_O = 4$ mA	25°C	−4	−4.3		−4	−4.3		
			Full range	−3.8			−3.8			
A_{VD}	Large-signal differential voltage amplification	$V_O = \pm4$ V, $R_L = 100\ k\Omega$	25°C	40	150		40	150		V/mV
			Full range	10			10			
		$V_O = \pm4$ V, $R_L = 1\ M\Omega$	25°C		3000			3000		
$r_{i(d)}$	Differential input resistance		25°C		10^{12}			10^{12}		Ω
$r_{i(c)}$	Common-mode input resistance		25°C		10^{12}			10^{12}		Ω
$c_{i(c)}$	Common-mode input capacitance	f = 10 kHz, N package	25°C		8			8		pF
z_o	Closed-loop output impedance	f = 25 kHz, $A_V = 10$	25°C		190			190		Ω
CMRR	Common-mode rejection ratio	$V_{IC} = -5$ V to 2.7 V, $V_O = 0$, $R_S = 50\ \Omega$	25°C	75	88		75	88		dB
			Full range	75			75			
k_{SVR}	Supply-voltage rejection ratio ($\Delta V_{DD\pm}/\Delta V_{IO}$)	$V_{DD\pm} = \pm2.2$ V to ±8 V, $V_{IC} = V_{DD}/2$, No load	25°C	80	95		80	95		dB
			Full range	80			80			
I_{DD}	Supply current (four amplifiers)	$V_O = 0$, No load	25°C		160	250		160	250	µA
			Full range			300			300	

† Full range is –40°C to 125°C for Q suffix.

NOTE 4: Typical values are based on the input offset voltage shift observed through 500 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.

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

PARAMETER		TEST CONDITIONS		T_A†	TLC2254-Q1			TLC2254A-Q1			UNIT
					MIN	TYP	MAX	MIN	TYP	MAX	
SR	Slew rate at unity gain	$V_O = \pm2$ V, C_L = 100 pF	R_L = 100 kΩ,	25°C	0.07	0.12		0.07	0.12		V/µs
				Full range	0.05			0.05			
V_n	Equivalent input noise voltage	f = 10 Hz		25°C		38			38		nV/√Hz
		f = 1 kHz		25°C		19			19		
$V_{N(PP)}$	Peak-to-peak equivalent input noise voltage	f = 0.1 Hz to 1 Hz		25°C		0.8			0.8		µV
		f = 0.1 Hz to 10 Hz		25°C		1.1			1.1		
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 = 50 kΩ, f = 20 kHz	A_V = 1	25°C		0.2%			0.2%		
			A_V = 10			1%			1%		
	Gain-bandwidth product	f =10 kHz, C_L = 100 pF	R_L = 50 kΩ,	25°C		0.21			0.21		MHz
B_{OM}	Maximum output-swing bandwidth	$V_{O(PP)}$ = 4.6 V, R_L = 50 kΩ,	A_V = 1, C_L = 100 pF	25°C		14			14		kHz
ϕ_m	Phase margin at unity gain	R_L = 50 kΩ,	C_L = 100 pF	25°C		63°			63°		
	Gain margin			25°C		15			15		dB

† Full range is –40°C to 125°C for Q suffix.

TYPICAL CHARACTERISTICS

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TYPICAL CHARACTERISTICS

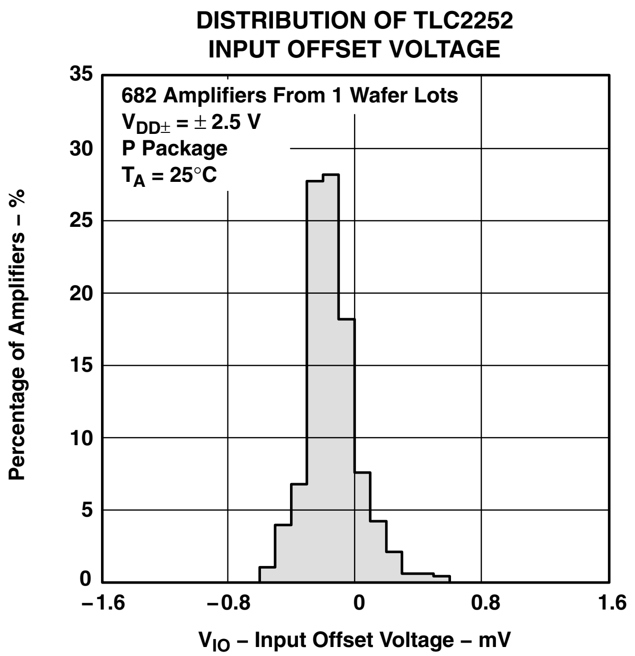


Figure 2

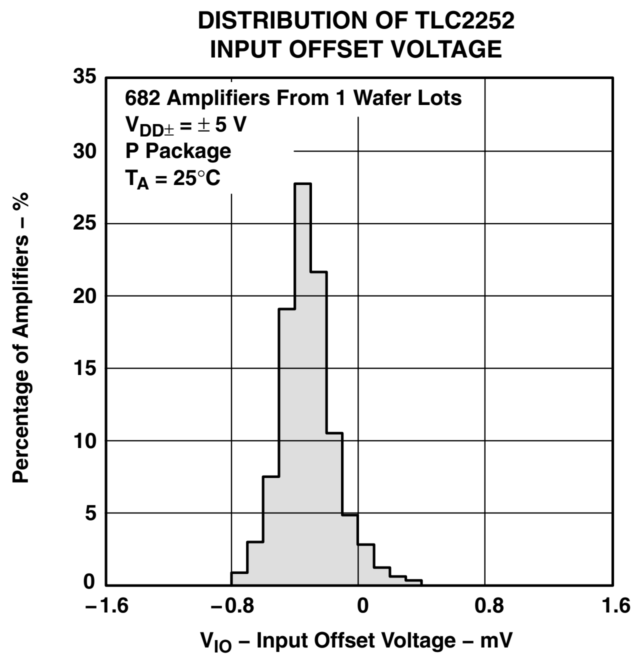


Figure 3

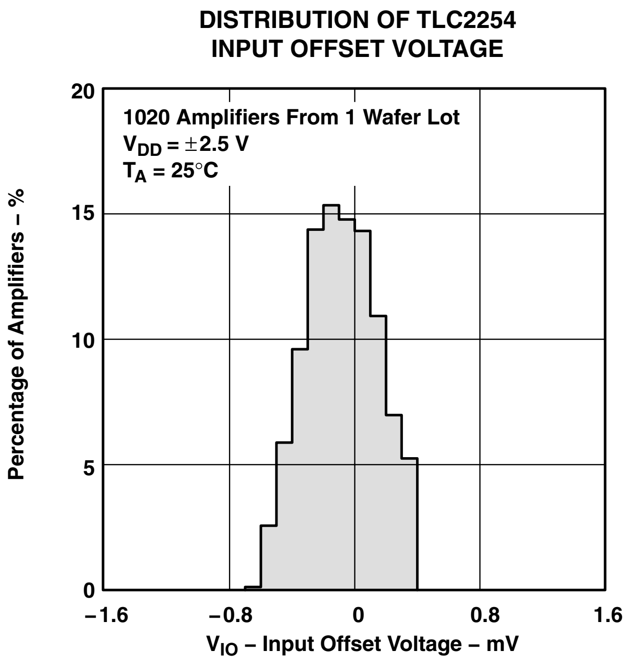


Figure 4

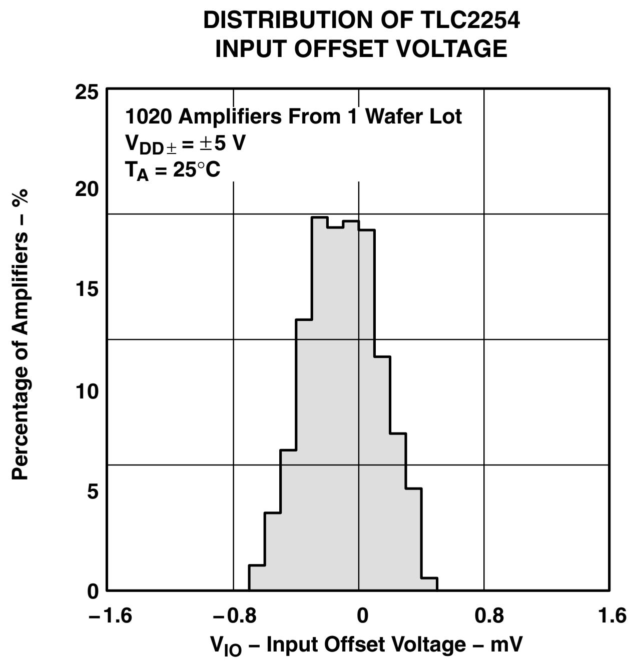


Figure 5

TYPICAL CHARACTERISTICS

INPUT OFFSET VOLTAGE† vs COMMON-MODE INPUT VOLTAGE

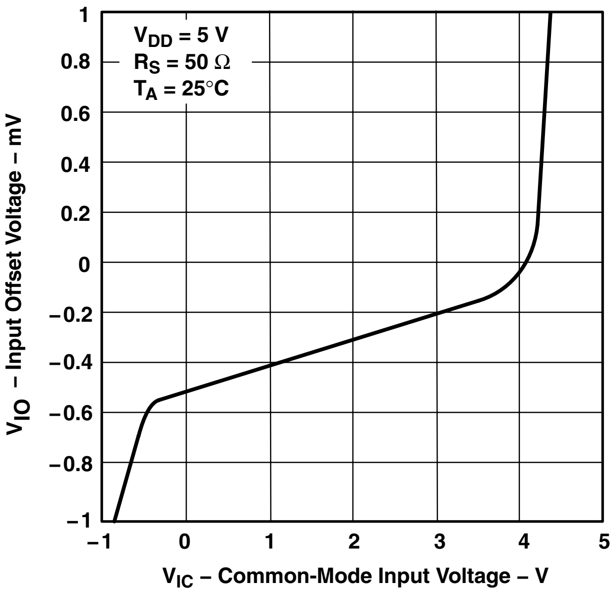


Figure 6

INPUT OFFSET VOLTAGE vs COMMON-MODE INPUT VOLTAGE

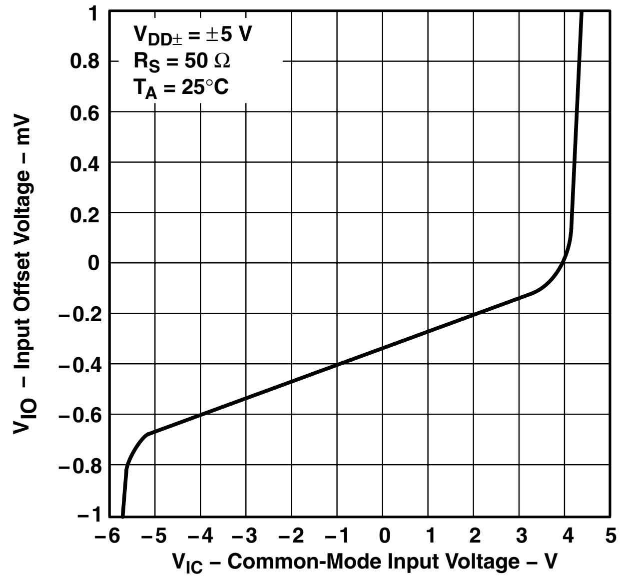


Figure 7

DISTRIBUTION OF TLC2252 INPUT OFFSET VOLTAGE TEMPERATURE COEFFICIENT

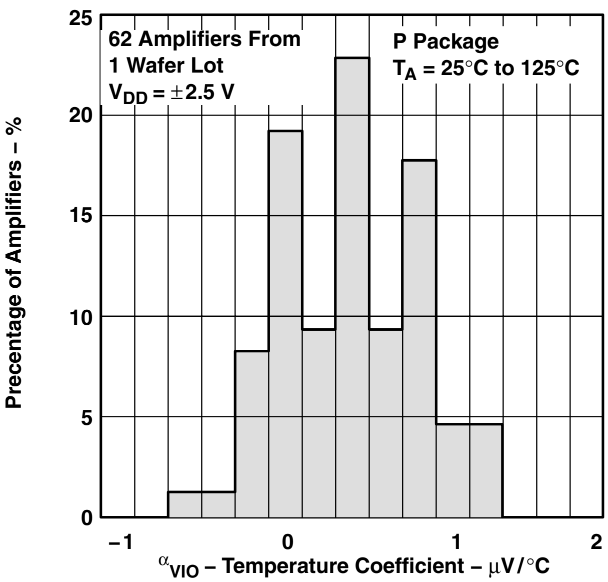


Figure 8

DISTRIBUTION OF TLC2252 INPUT OFFSET VOLTAGE TEMPERATURE COEFFICIENT

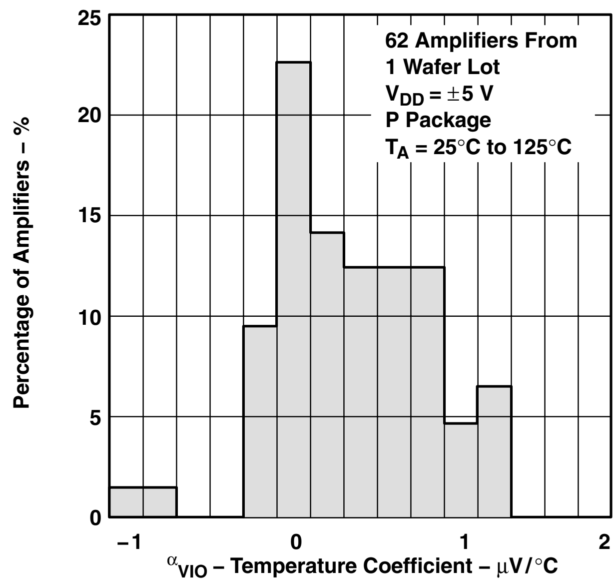


Figure 9

† For curves where V_{DD} = 5 V, all loads are referenced to 2.5 V.

TYPICAL CHARACTERISTICS

DISTRIBUTION OF TLC2254 INPUT OFFSET VOLTAGE TEMPERATURE COEFFICIENT

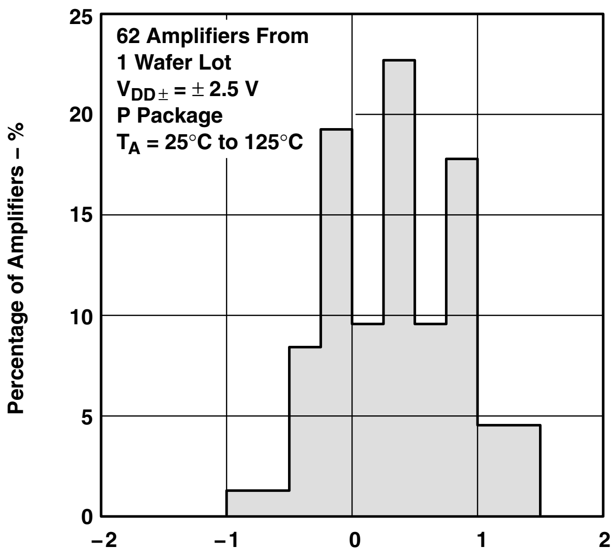


Figure 10

DISTRIBUTION OF TLC2254 INPUT OFFSET VOLTAGE TEMPERATURE COEFFICIENT

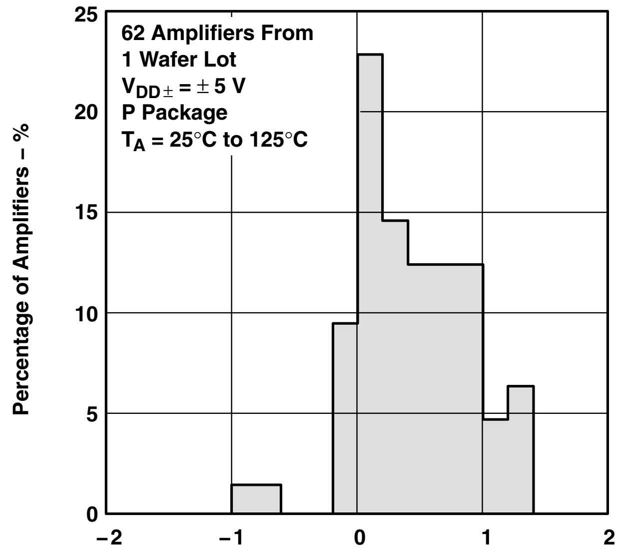


Figure 11

INPUT BIAS AND INPUT OFFSET CURRENTS† vs FREE-AIR TEMPERATURE

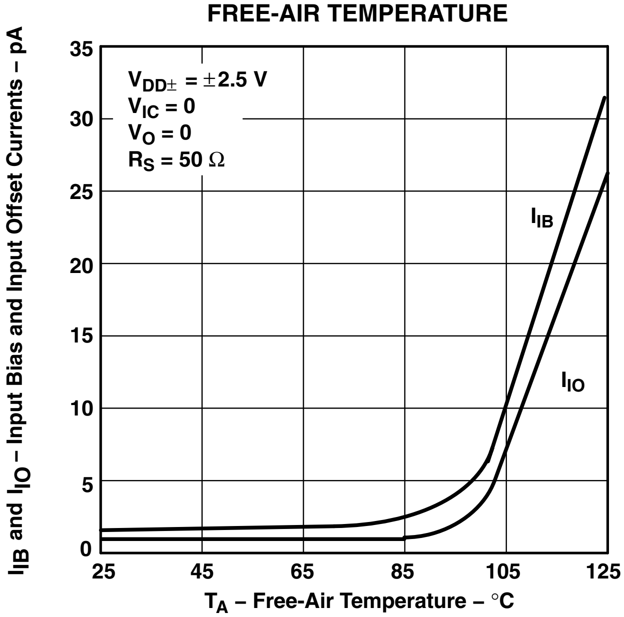


Figure 12

INPUT VOLTAGE RANGE vs SUPPLY VOLTAGE

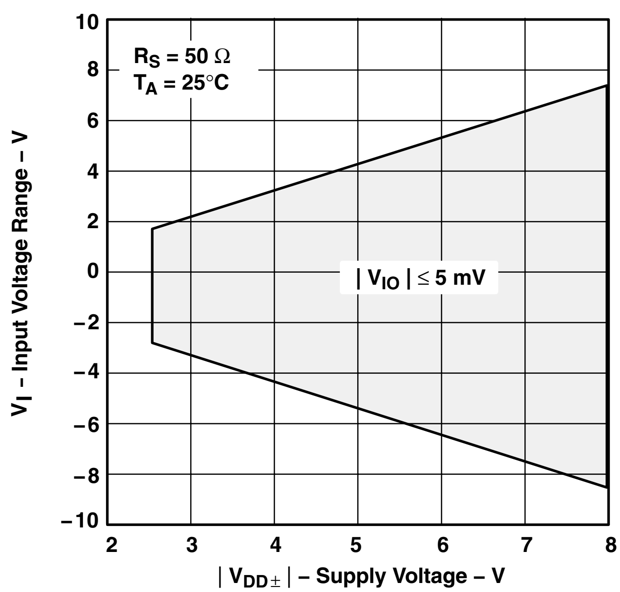


Figure 13

† 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 RANGE†
vs
FREE-AIR TEMPERATURE

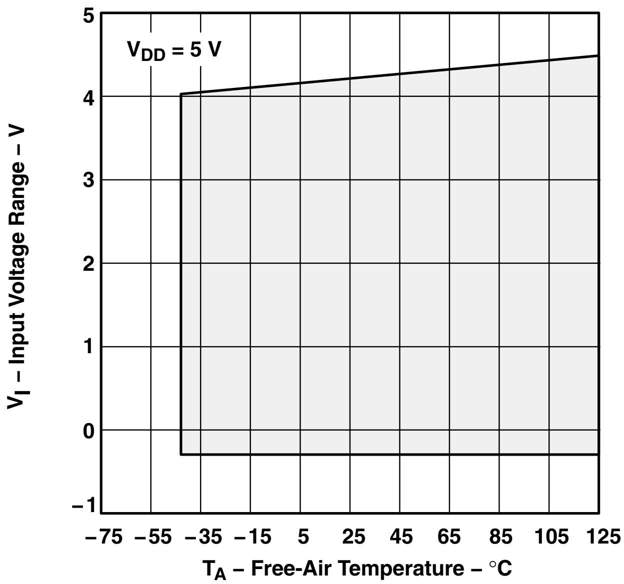


Figure 14

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

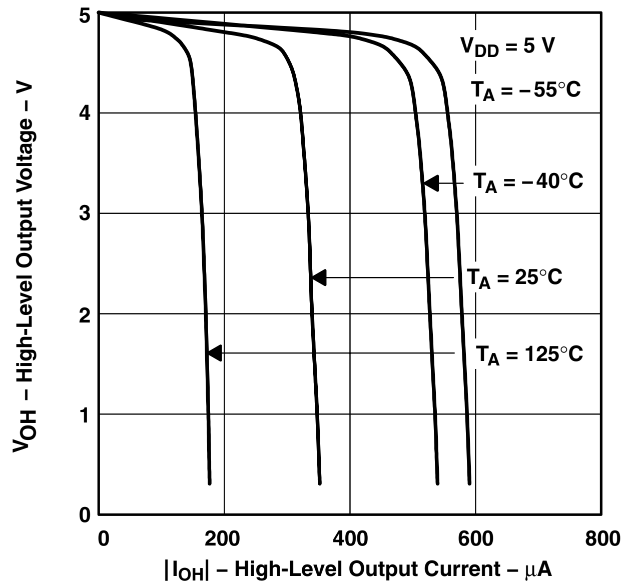


Figure 15

LOW-LEVEL OUTPUT VOLTAGE‡
vs
LOW-LEVEL OUTPUT CURRENT

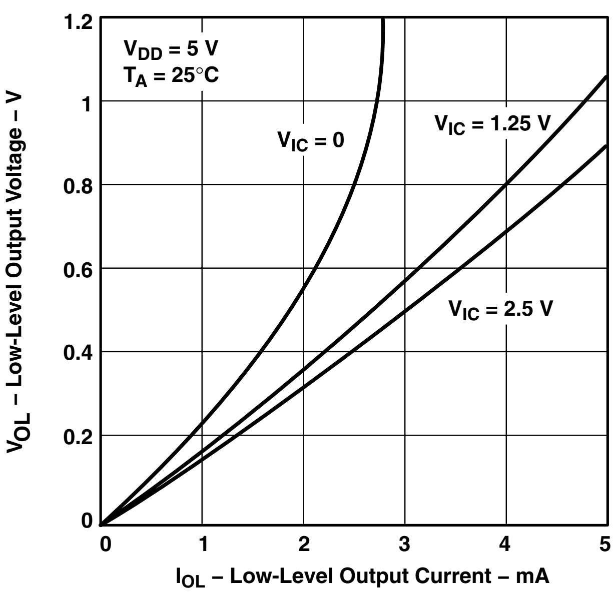


Figure 16

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

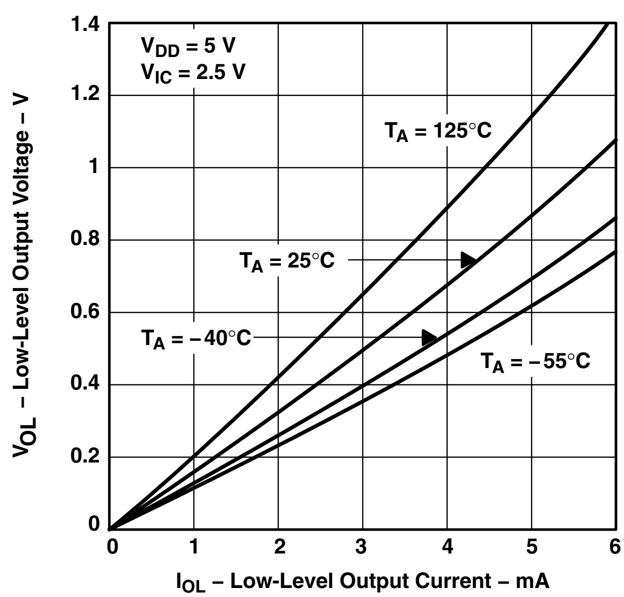


Figure 17

† Data at high and low temperatures are applicable only within the rated operating free-air temperature ranges of the various devices.
‡ For curves where V_{DD} = 5 V, all loads are referenced to 2.5 V.

TYPICAL CHARACTERISTICS

MAXIMUM POSITIVE PEAK OUTPUT VOLTAGE† vs OUTPUT CURRENT

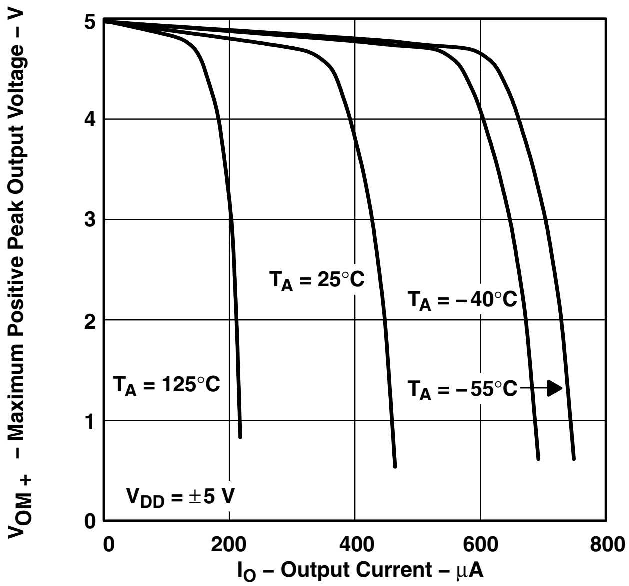


Figure 18

MAXIMUM NEGATIVE PEAK OUTPUT VOLTAGE† vs OUTPUT CURRENT

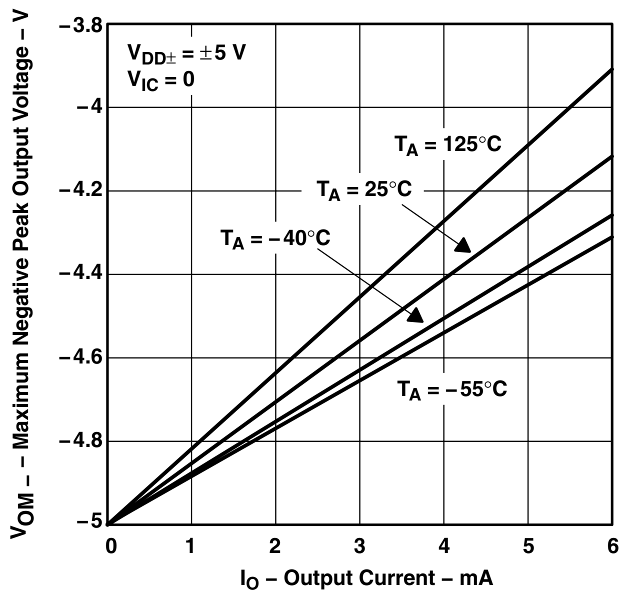


Figure 19

MAXIMUM PEAK-TO-PEAK OUTPUT VOLTAGE‡ vs FREQUENCY

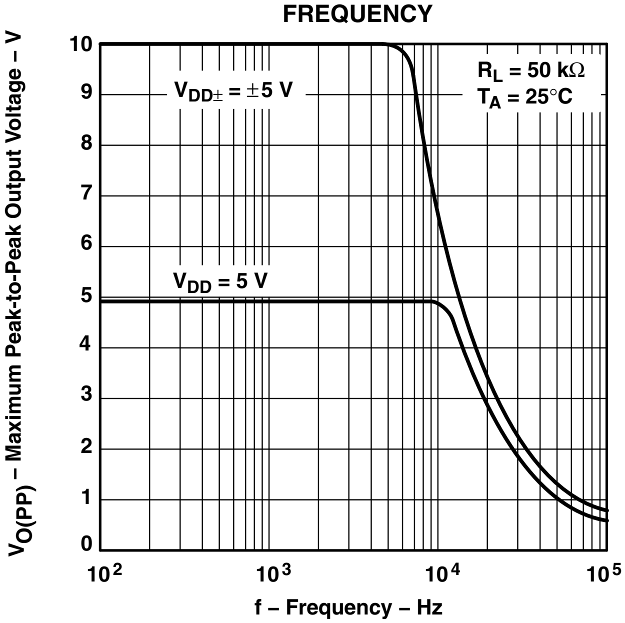


Figure 20

SHORT-CIRCUIT OUTPUT CURRENT vs SUPPLY VOLTAGE

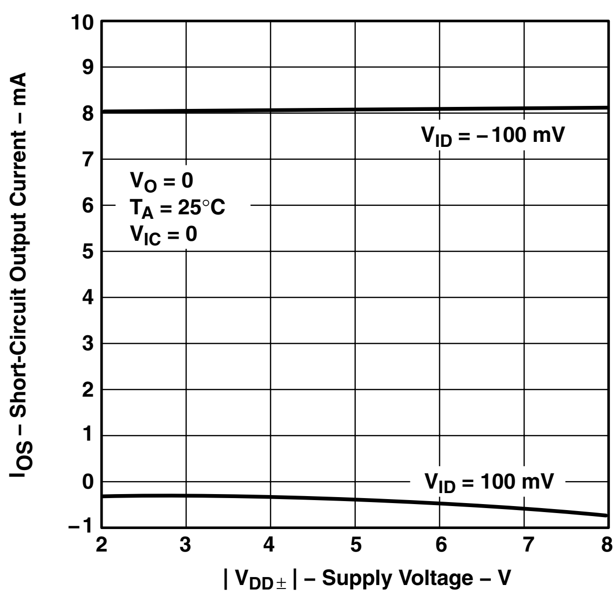


Figure 21

† Data at high and low temperatures are applicable only within the rated operating free-air temperature ranges of the various devices.
‡ For curves where V_{DD} = 5 V, all loads are referenced to 2.5 V.

TYPICAL CHARACTERISTICS

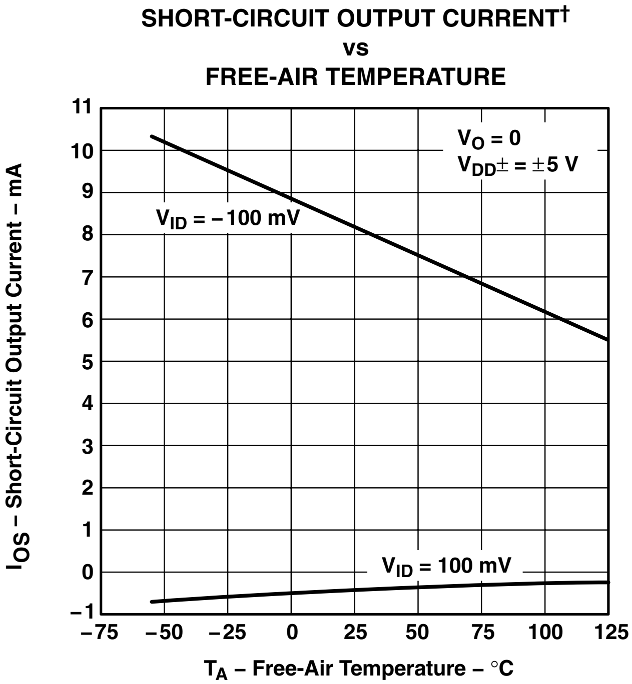


Figure 22

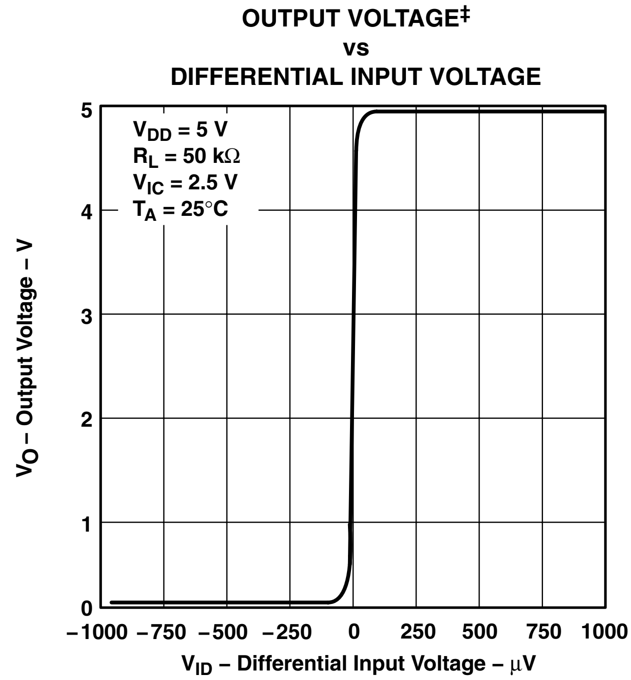


Figure 23

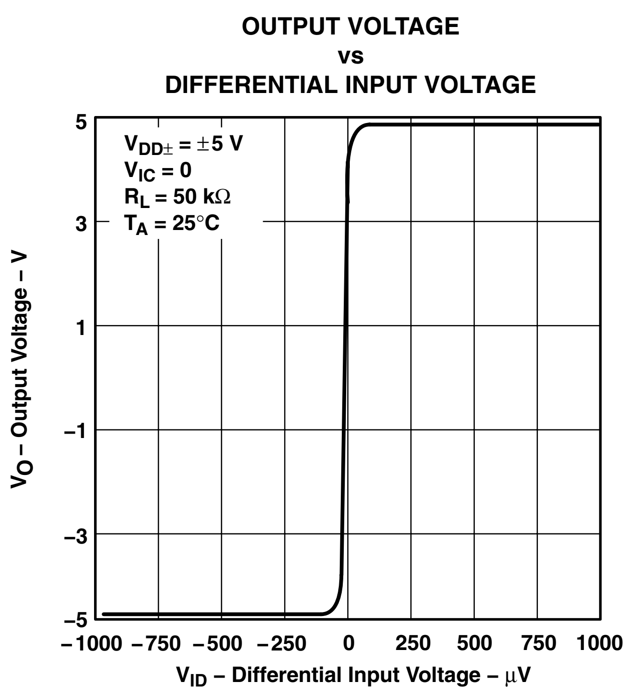


Figure 24

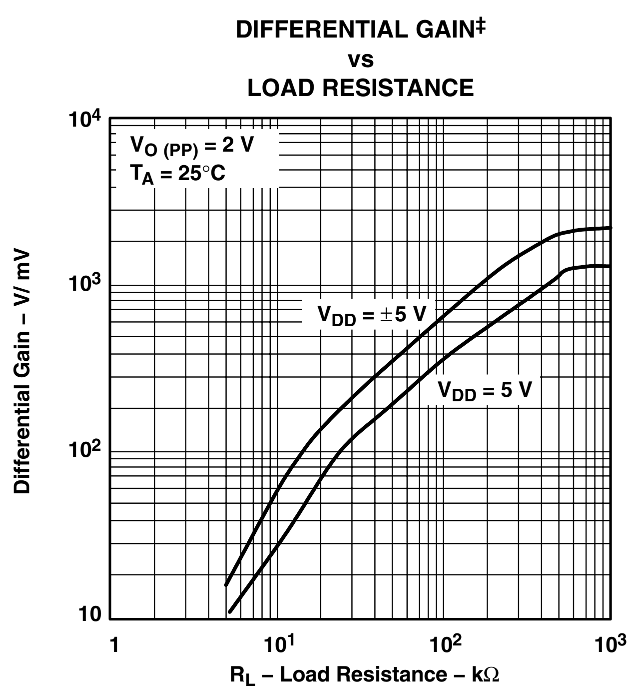


Figure 25

† Data at high and low temperatures are applicable only within the rated operating free-air temperature ranges of the various devices.
‡ For curves where $V_{DD} = 5$ V, all loads are referenced to 2.5 V.

TYPICAL CHARACTERISTICS

**LARGE-SIGNAL DIFFERENTIAL VOLTAGE AMPLIFICATION AND PHASE MARGIN†
vs
FREQUENCY**

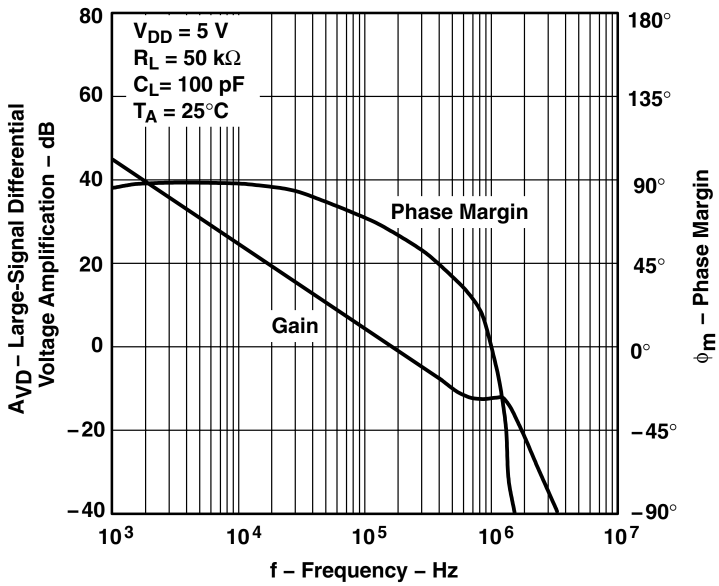


Figure 26

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

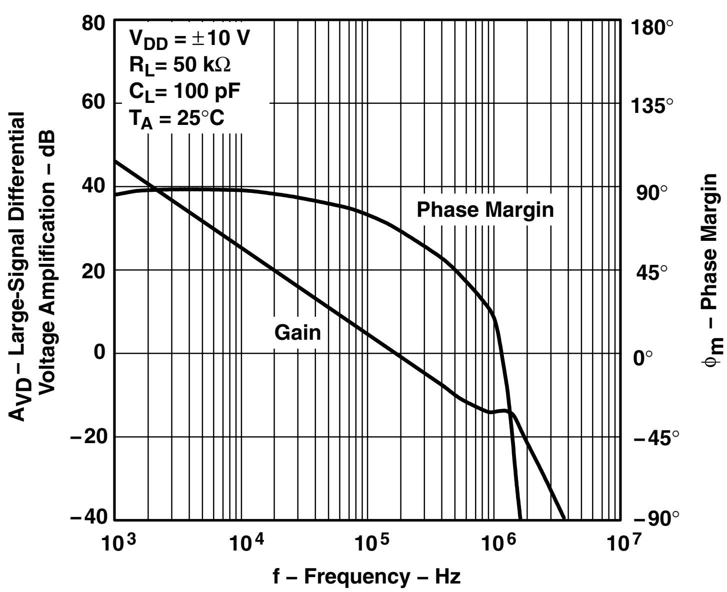


Figure 27

† For curves where V_{DD} = 5 V, all loads are referenced to 2.5 V.

TYPICAL CHARACTERISTICS

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

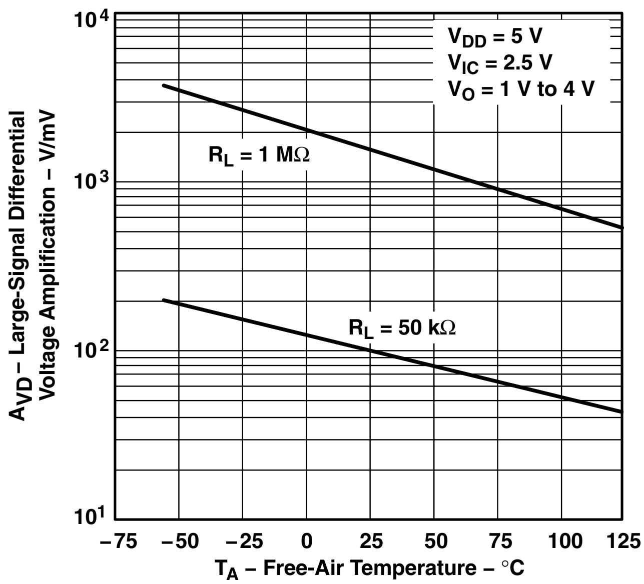


Figure 28

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

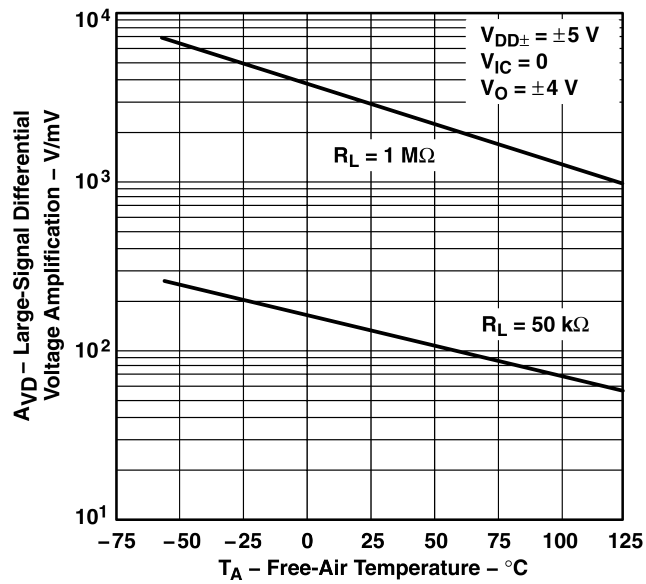


Figure 29

OUTPUT IMPEDANCE‡ vs FREQUENCY

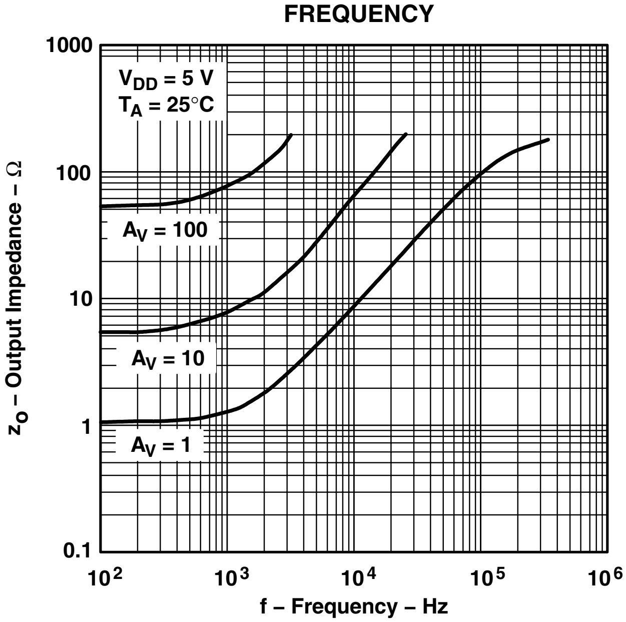


Figure 30

OUTPUT IMPEDANCE vs FREQUENCY

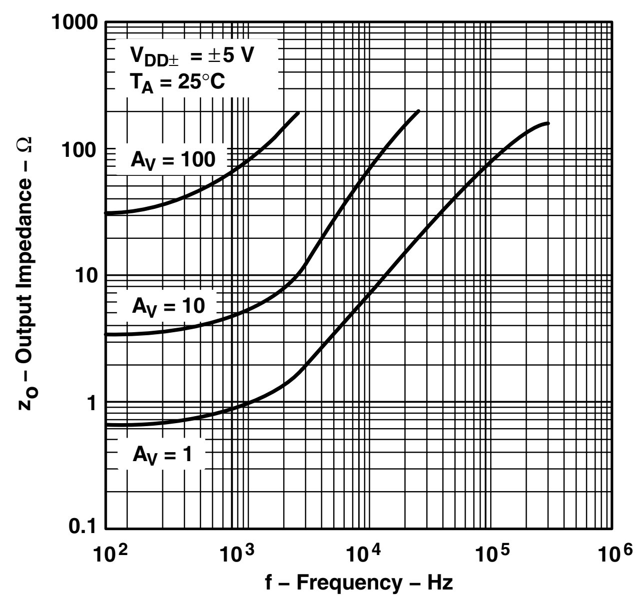


Figure 31

† Data at high and low temperatures are applicable only within the rated operating free-air temperature ranges of the various devices.
‡ For curves where V_{DD} = 5 V, all loads are referenced to 2.5 V.

TYPICAL CHARACTERISTICS

COMMON-MODE REJECTION RATIO† vs FREQUENCY

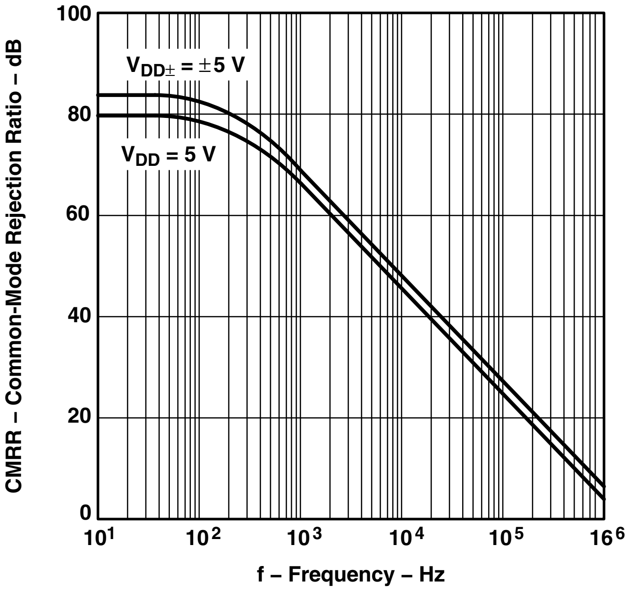


Figure 32

COMMON-MODE REJECTION RATIO†‡ vs FREE-AIR TEMPERATURE

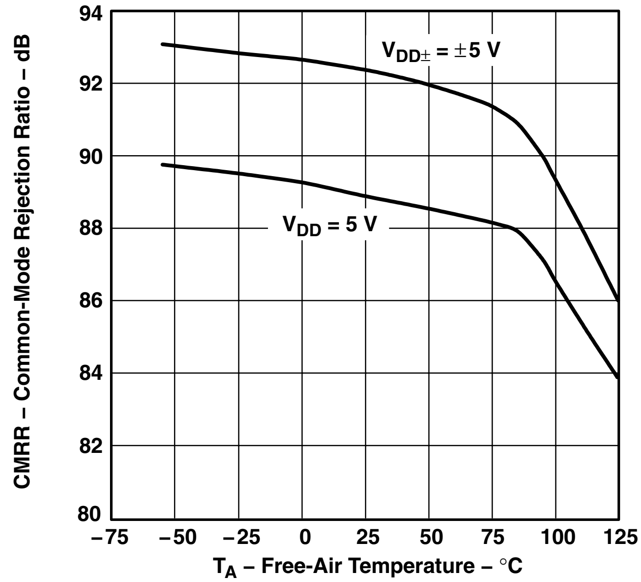


Figure 33

SUPPLY-VOLTAGE REJECTION RATIO† vs FREQUENCY

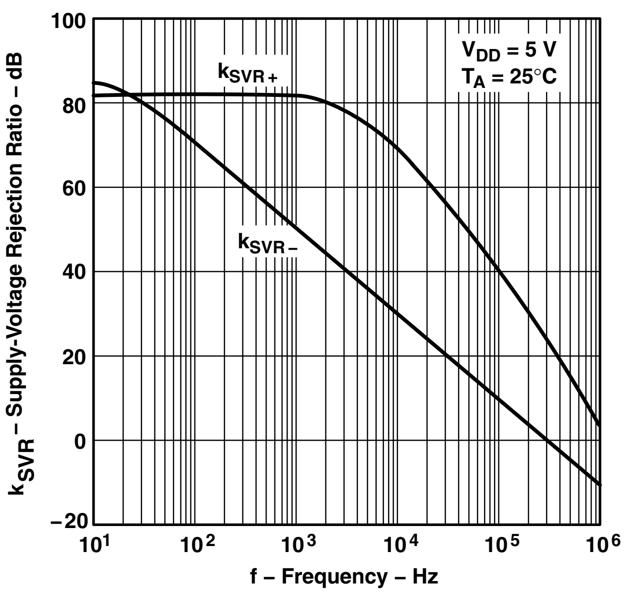


Figure 34

SUPPLY-VOLTAGE REJECTION RATIO vs FREQUENCY

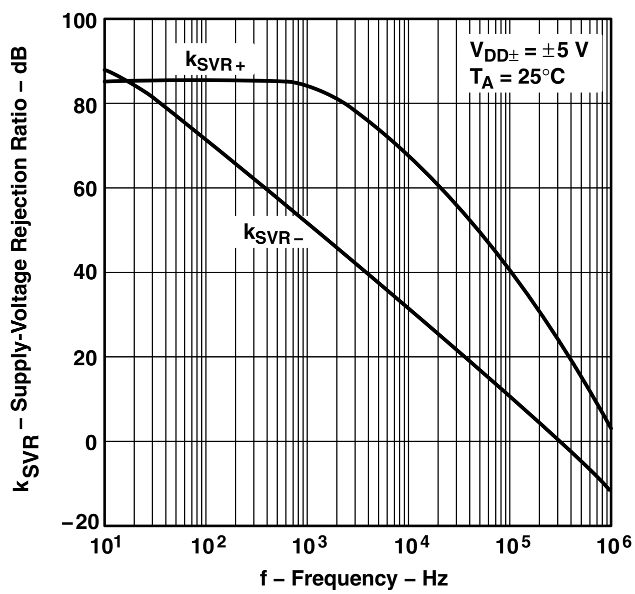


Figure 35

† For curves where $V_{DD} = 5$ V, all loads are referenced to 2.5 V.
‡ Data at high and low temperatures are applicable only within the rated operating free-air temperature ranges of the various devices.

TYPICAL CHARACTERISTICS

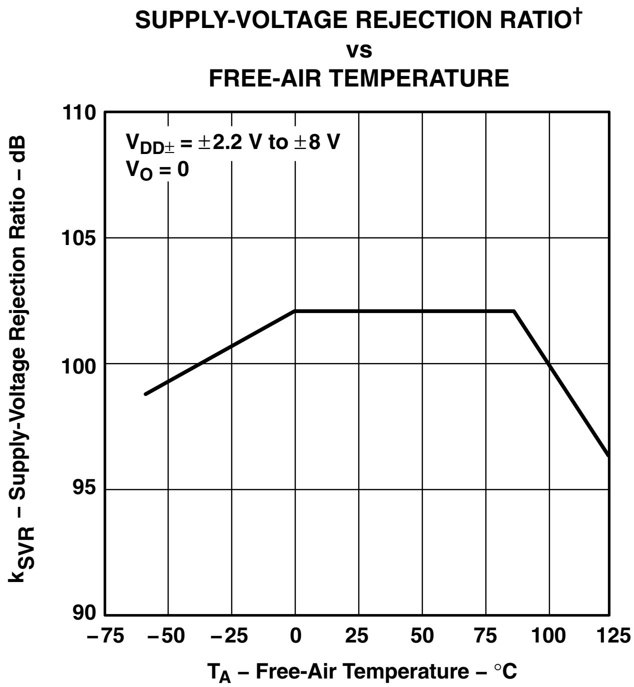


Figure 36

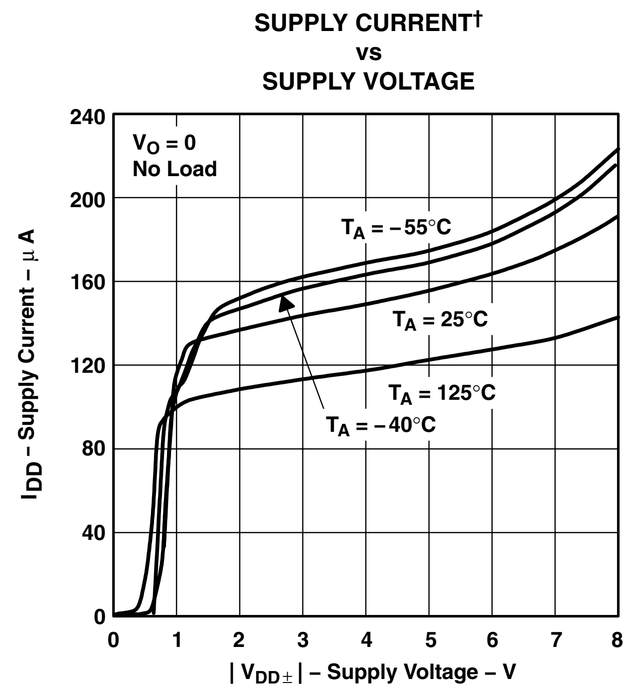


Figure 37

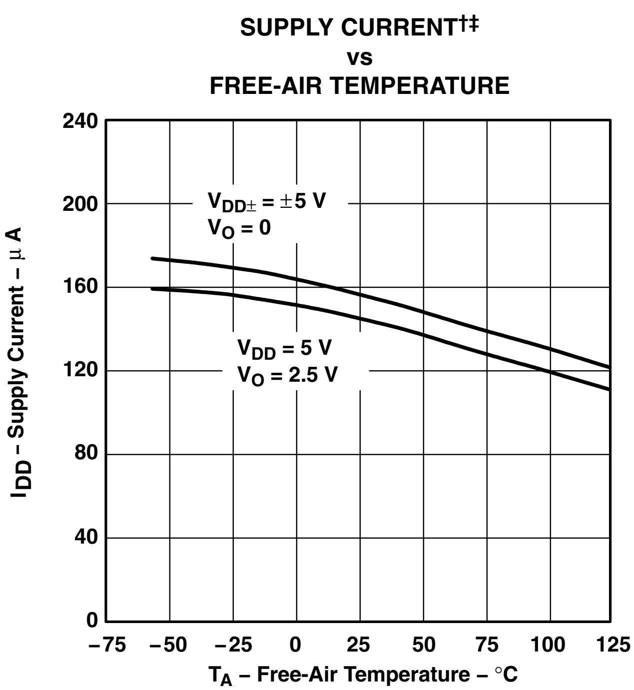


Figure 38

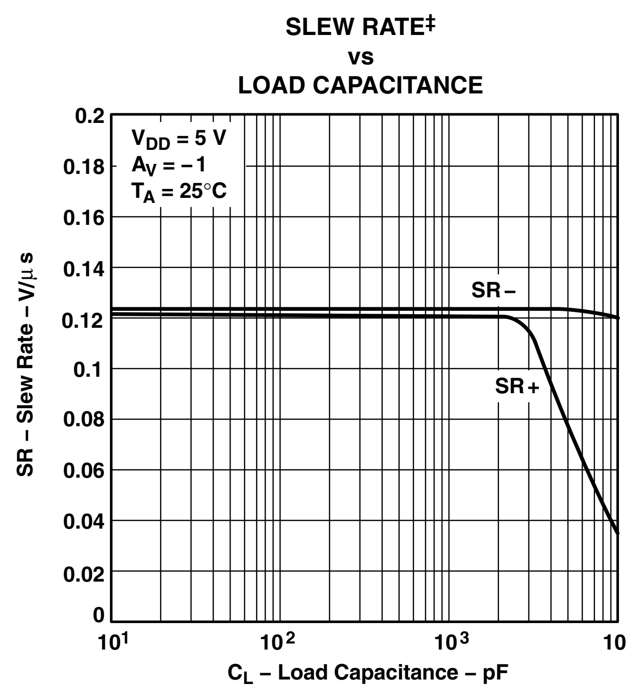


Figure 39

† Data at high and low temperatures are applicable only within the rated operating free-air temperature ranges of the various devices.
‡ For curves where V_{DD} = 5 V, all loads are referenced to 2.5 V.

TYPICAL CHARACTERISTICS

SLEW RATE†‡
vs
FREE-AIR TEMPERATURE

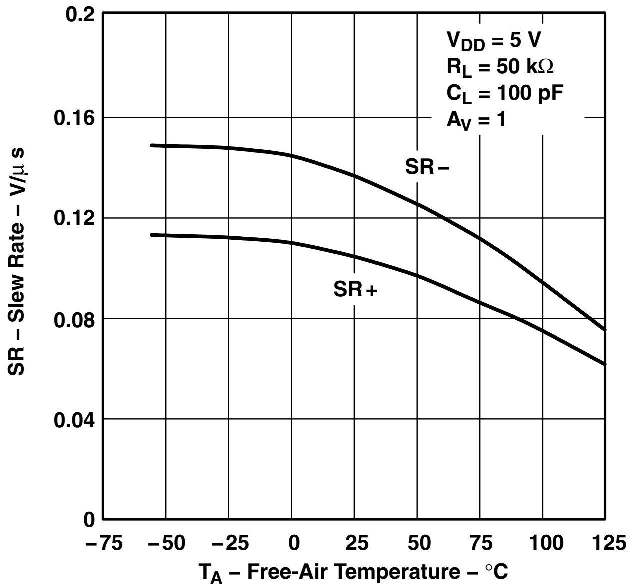


Figure 40

INVERTING LARGE-SIGNAL PULSE RESPONSE‡

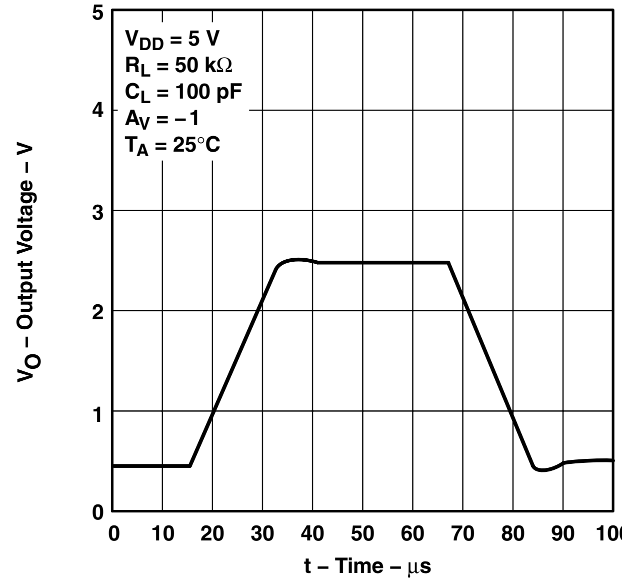


Figure 41

INVERTING LARGE-SIGNAL PULSE RESPONSE

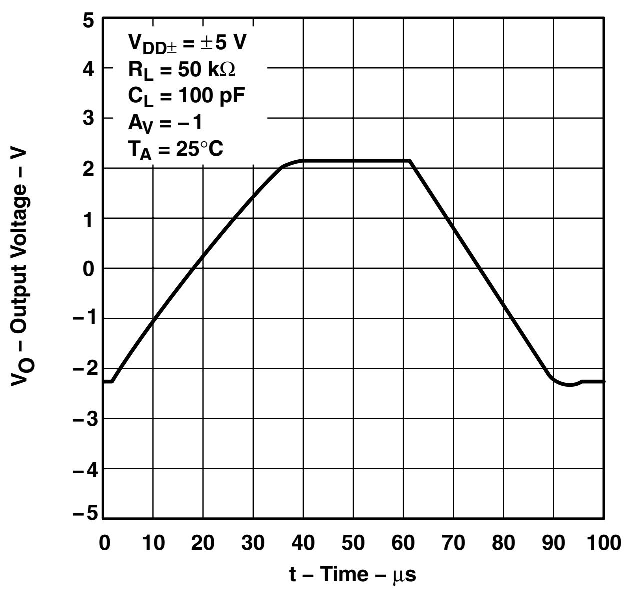


Figure 42

VOLTAGE-FOLLOWER LARGE-SIGNAL PULSE RESPONSE‡

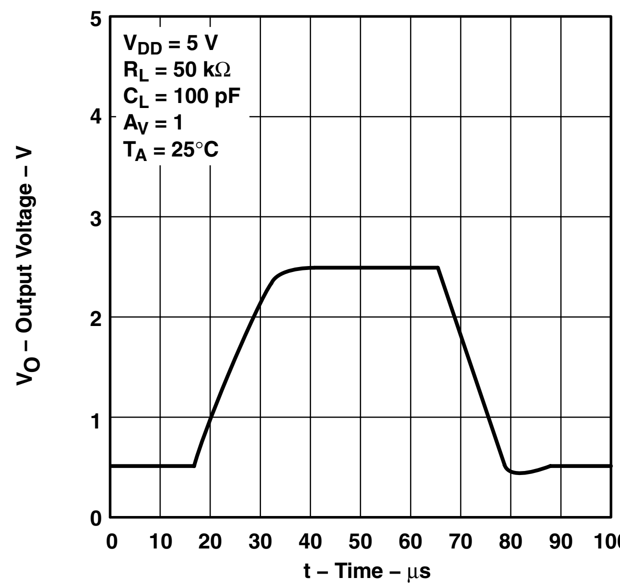


Figure 43

† Data at high and low temperatures are applicable only within the rated operating free-air temperature ranges of the various devices.
‡ For curves where V_{DD} = 5 V, all loads are referenced to 2.5 V.

TYPICAL CHARACTERISTICS

VOLTAGE-FOLLOWER LARGE-SIGNAL PULSE RESPONSE

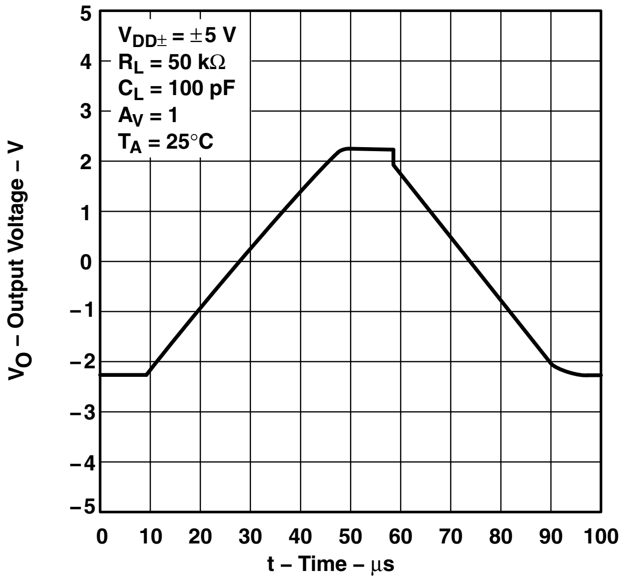


Figure 44

INVERTING SMALL-SIGNAL PULSE RESPONSE†

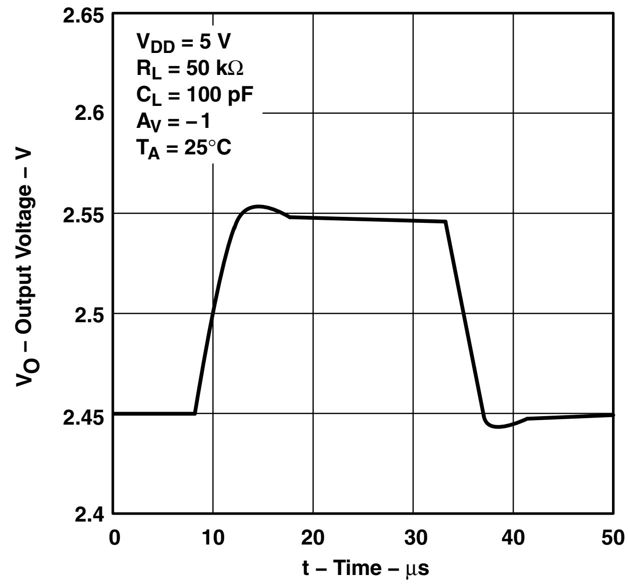


Figure 45

INVERTING SMALL-SIGNAL PULSE RESPONSE

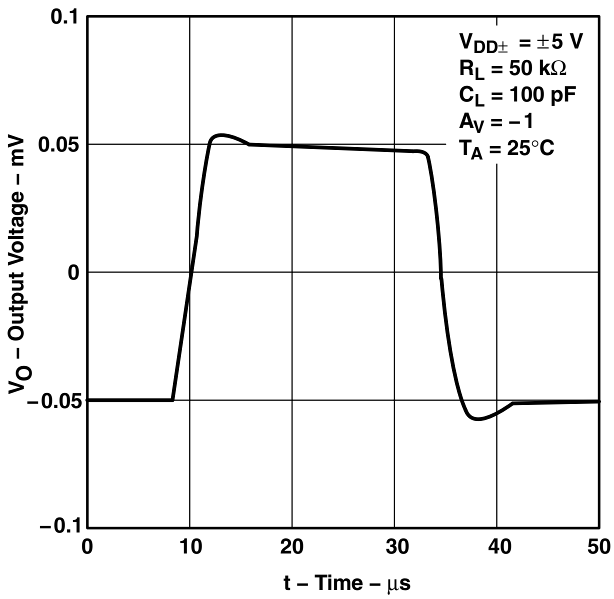


Figure 46

VOLTAGE-FOLLOWER SMALL-SIGNAL PULSE RESPONSE†

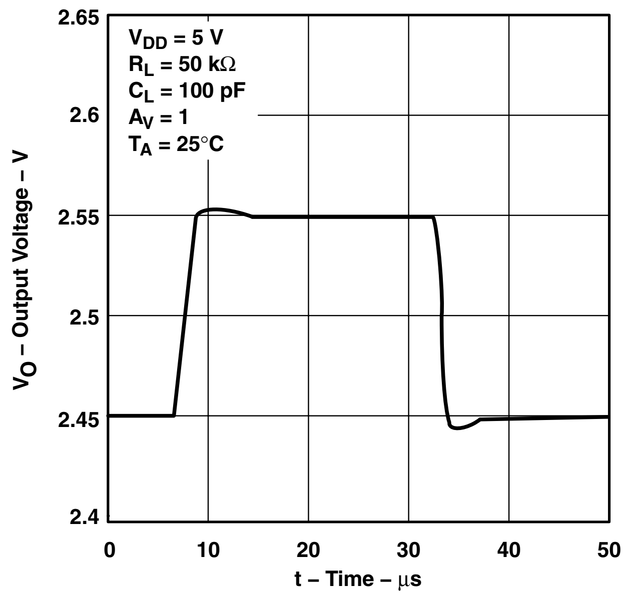


Figure 47

† For curves where $V_{DD} = 5$ V, all loads are referenced to 2.5 V.

TYPICAL CHARACTERISTICS

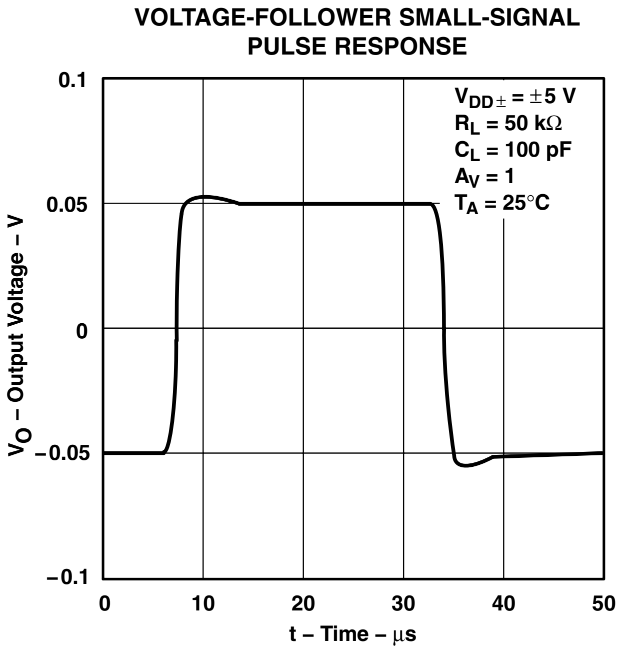


Figure 48

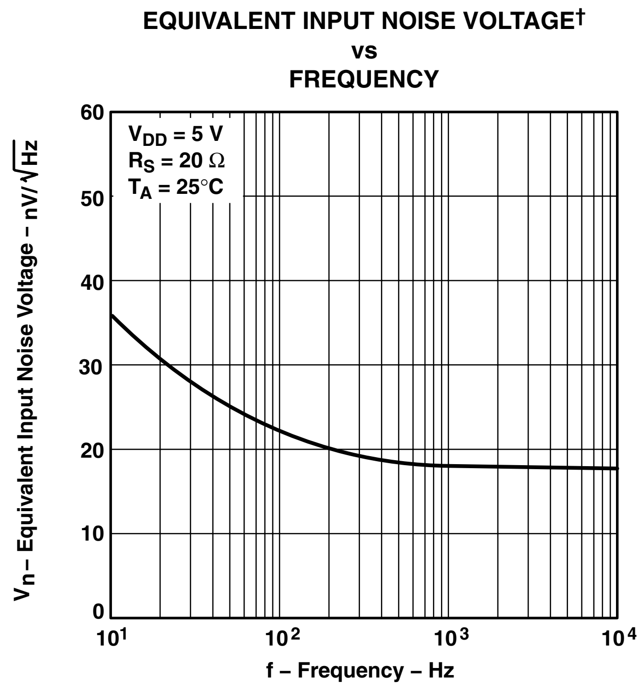


Figure 49

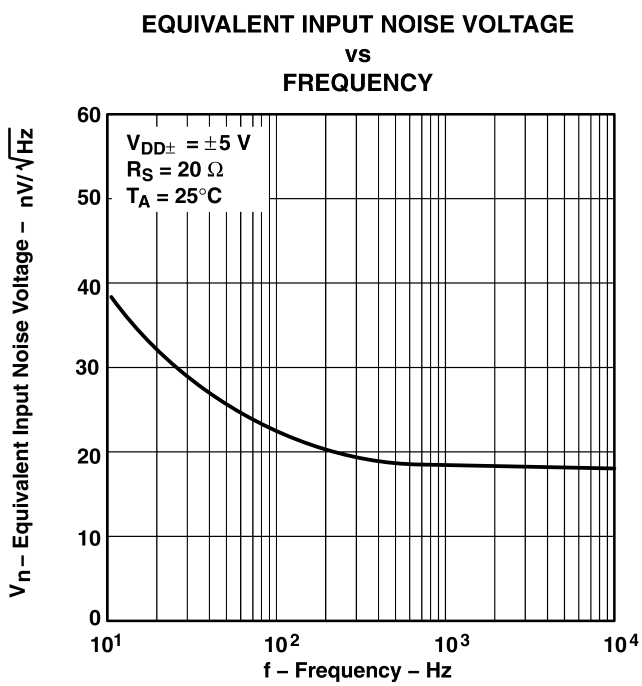


Figure 50

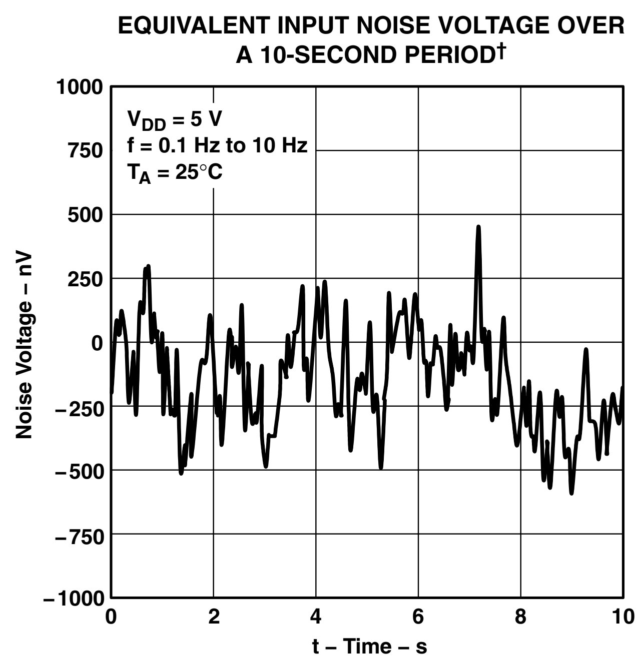


Figure 51

† For curves where V_{DD} = 5 V, all loads are referenced to 2.5 V.

TYPICAL CHARACTERISTICS

INTEGRATED NOISE VOLTAGE
vs
FREQUENCY

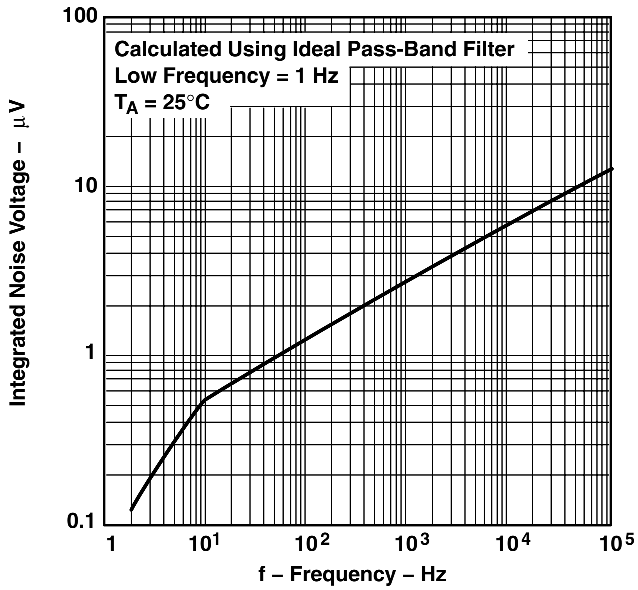


Figure 52

TOTAL HARMONIC DISTORTION PLUS NOISE†
vs
FREQUENCY

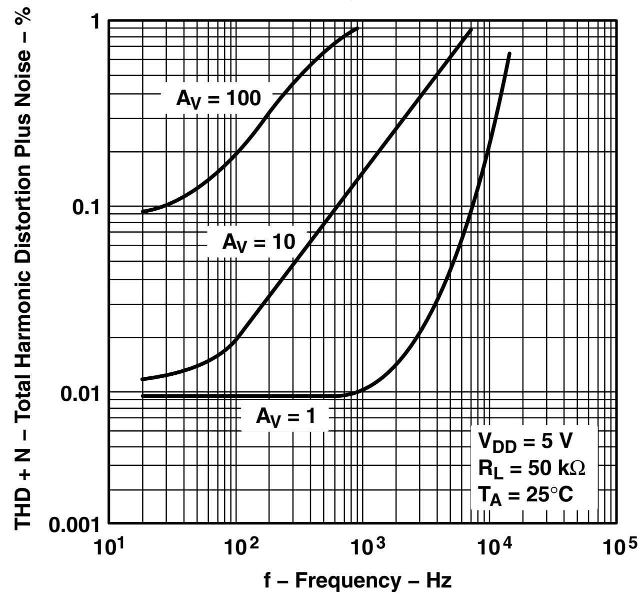


Figure 53

GAIN-BANDWIDTH PRODUCT†‡
vs
FREE-AIR TEMPERATURE

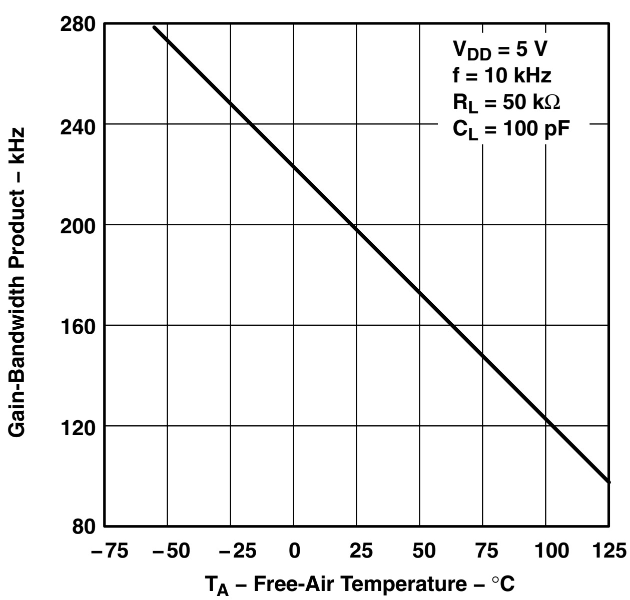


Figure 54

GAIN-BANDWIDTH PRODUCT
vs
SUPPLY VOLTAGE

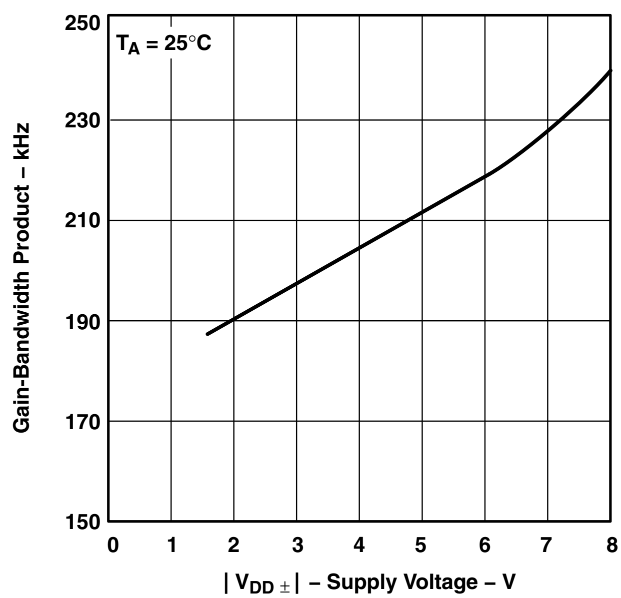


Figure 55

† For curves where V_{DD} = 5 V, all loads are referenced to 2.5 V.
‡ Data at high and low temperatures are applicable only within the rated operating free-air temperature ranges of the various devices.

TYPICAL CHARACTERISTICS

PHASE MARGIN vs LOAD CAPACITANCE

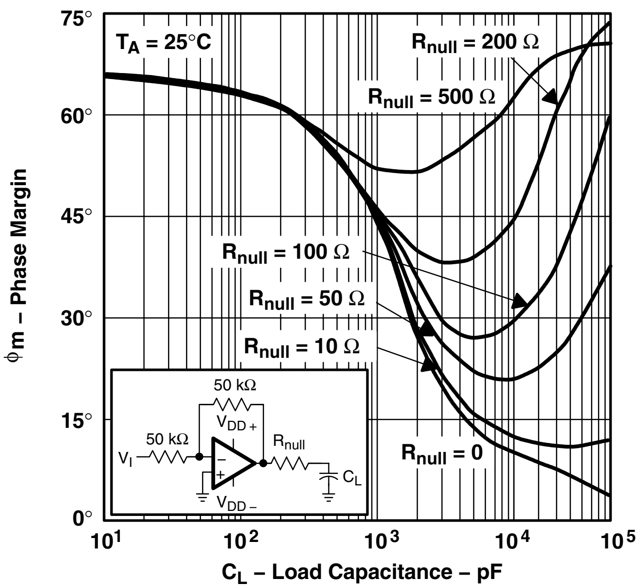


Figure 56

GAIN MARGIN vs LOAD CAPACITANCE

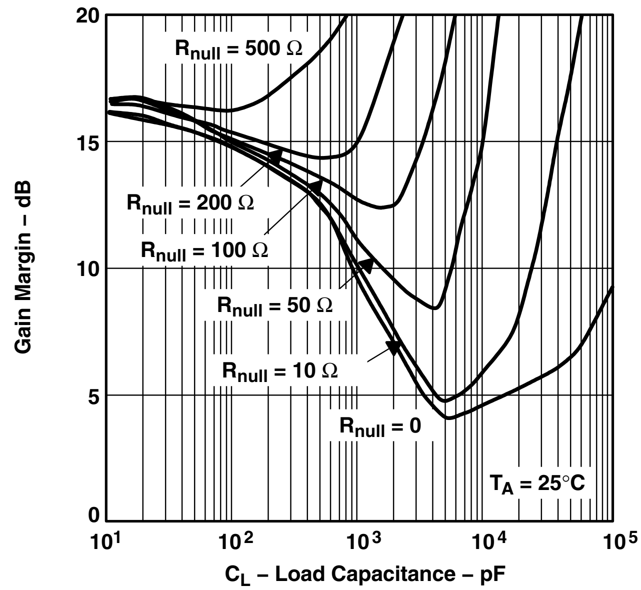


Figure 57

UNITY-GAIN BANDWIDTH† vs LOAD CAPACITANCE

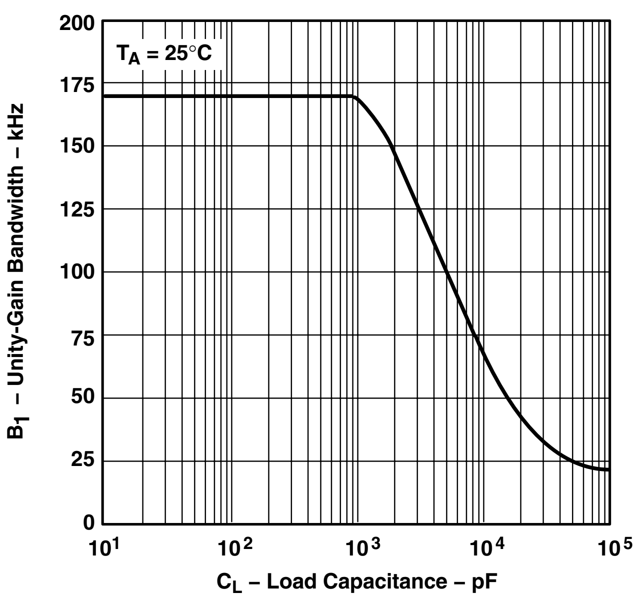


Figure 58

OVERESTIMATION OF PHASE MARGIN† vs LOAD CAPACITANCE

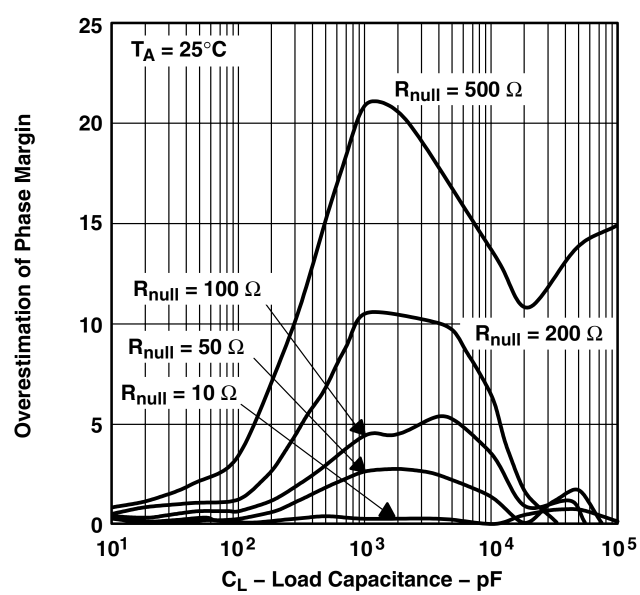


Figure 59

† See application information

APPLICATION INFORMATION

driving large capacitive loads

The TLC225x is designed to drive larger capacitive loads than most CMOS operational amplifiers. Figure 56 and Figure 57 illustrate its ability to drive loads up to 1000 pF while maintaining good gain and phase margins (R_{null} = 0).

A smaller series resistor (R_{null}) at the output of the device (see Figure 60) improves the gain and phase margins when driving large capacitive loads. Figure 56 and Figure 57 show the effects of adding series resistances of 10 Ω, 50 Ω, 100 Ω, 200 Ω, and 500 Ω. The addition of this series resistor has two effects: the first is that it adds a zero to the transfer function and the second is that it reduces the frequency of the pole associated with the output load in the transfer function.

The zero introduced to the transfer function is equal to the series resistance times the load capacitance. To calculate the improvement in phase margin, equation 1 can be used.

$$\Delta\phi_{m1} = \tan^{-1}\left(2 \times \pi \times UGBW \times R_{null} \times C_L\right) \quad (1)$$

Where :

$\Delta\phi_{m1}$ = Improvement in phase margin
UGBW = Unity-gain bandwidth frequency
R_{null} = Output series resistance
C_L = Load capacitance

The unity-gain bandwidth (UGBW) frequency decreases as the capacitive load increases (see Figure 58). To use equation 1, UGBW must be approximated from Figure 58.

Using equation 1 alone overestimates the improvement in phase margin, as illustrated in Figure 59. The overestimation is caused by the decrease in the frequency of the pole associated with the load, thus providing additional phase shift and reducing the overall improvement in phase margin.

Using Figure 60, with equation 1 enables the designer to choose the appropriate output series resistance to optimize the design of circuits driving large capacitance loads.

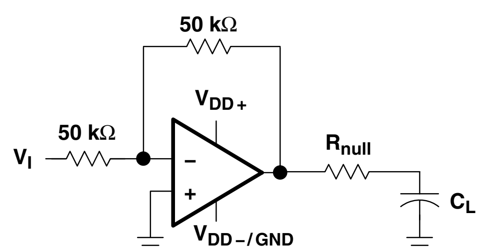


Figure 60. Series-Resistance Circuit

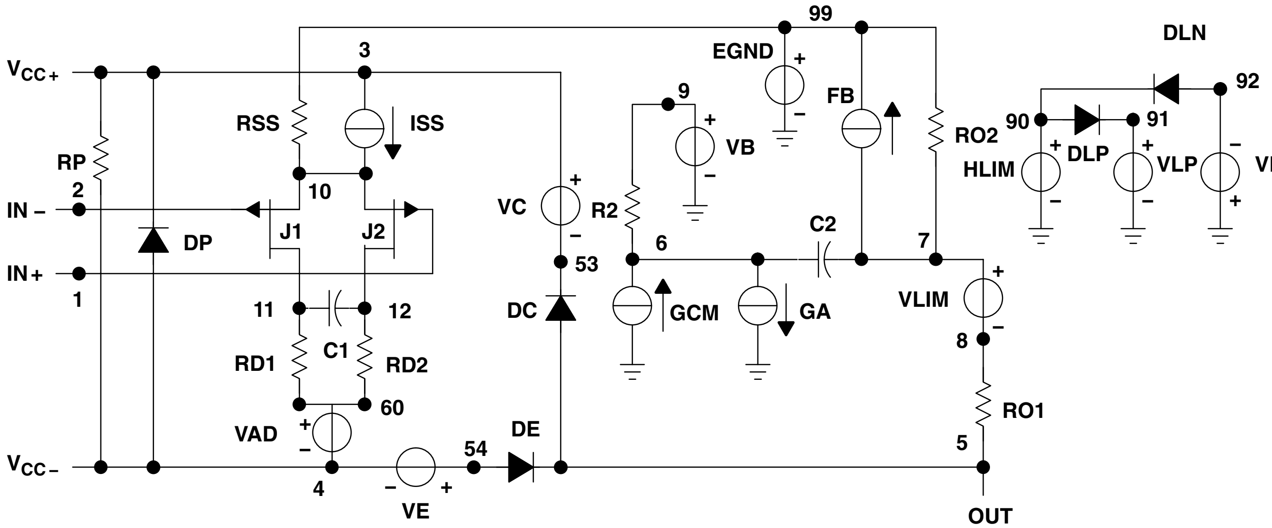
APPLICATION INFORMATION

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 61 are generated using the TLC225x 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 4: G. R. Boyle, B. M. Cohn, D. O. Pederson, and J. E. Solomon, “Macromodeling of Integrated Circuit Operational Amplifiers”, *IEEE Journal of Solid-State Circuits,* SC-9, 353 (1974).




```
.SUBCKT TLC225x 1 2 3 4 5
     C1    11   12   6.369E–12
     C2    6    7    25.00E–12
     DC    5    53   DX
     DE    54   5    DX
     DLP   90   91   DX
     DLN   92   90   DX
     DP    4    3    DX
     EGND  99   0    POLY (2) (3,0) (4,0) 0 .5 .5
     FB    7    99   POLY (5) VB VC VE VLP
     + VLN 0 57.62E6 –60E6 60E6 60E6 –60E6
     GA    6    0    11     12 26.86E–6
     GCM   0    6    10     99 2.686E–9
     ISS   3    10   DC 3.1E–6
     HLIM  90   0    VLIM 1K
     J1    11   2    10 JX
     J2    12   1    10 JX
     R2    6    9    100.0E3

RD1    60   11   37.23E3
RD2    60   12   37.23E3
R01    8    5    84
R02    7    99   84
RP     3    4    71.43E3
RSS    10   99   64.52E6
VAD    60   4    –.5
VB     9    0    DC 0
VC     3    53   DC .605
VE     54   4    DC .605
VLIM   7    8    DC 0
VLP    91   0    DC –.235
VLN    0    92   DC 7.5
.MODEL DX D (IS=800.0E–18)
.MODEL JX PJF (IS=500.0E–15 BETA=139E–6
+ VTO=–.05)
.ENDS
```

Figure 61. Boyle Macromodel and Subcircuit

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PACKAGING INFORMATION

Orderable Device	Status [1]	Package Type	Package Drawing	Pins	Package Qty	Eco Plan [2]	Lead/ Ball Finish	MSL Peak Temp [3]	Samples (Requires Login)
TLC2252AQDRG4Q1	ACTIVE	SOIC	D	8	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	Request Free Samples
TLC2252AQDRQ1	ACTIVE	SOIC	D	8	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	Purchase Samples
TLC2252AQPWRG4Q1	ACTIVE	TSSOP	PW	8	2000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	Purchase Samples
TLC2252AQPWRQ1	ACTIVE	TSSOP	PW	8	2000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	Purchase Samples
TLC2252QDRG4Q1	ACTIVE	SOIC	D	8	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	Purchase Samples
TLC2252QDRQ1	ACTIVE	SOIC	D	8	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	Purchase Samples
TLC2252QPWRG4Q1	ACTIVE	TSSOP	PW	8	2000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	Purchase Samples
TLC2252QPWRQ1	ACTIVE	TSSOP	PW	8	2000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	Purchase Samples
TLC2254AQDRG4Q1	ACTIVE	SOIC	D	14	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	Purchase Samples
TLC2254AQDRQ1	ACTIVE	SOIC	D	14	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	Purchase Samples
TLC2254AQPWRG4Q1	ACTIVE	TSSOP	PW	14	2000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	Purchase Samples
TLC2254AQPWRQ1	ACTIVE	TSSOP	PW	14	2000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	Purchase Samples
TLC2254QDRG4Q1	ACTIVE	SOIC	D	14	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	Purchase Samples
TLC2254QDRQ1	ACTIVE	SOIC	D	14	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	Purchase Samples
TLC2254QPWRG4Q1	ACTIVE	TSSOP	PW	14	2000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	Purchase Samples
TLC2254QPWRQ1	ACTIVE	TSSOP	PW	14	2000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-3-260C-168 HR	Purchase 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) Eco Plan - The planned eco-friendly classification: Pb-Free (RoHS), Pb-Free (RoHS Exempt), or Green (RoHS & no Sb/Br) - please check http://www.ti.com/productcontent for the latest availability information and additional product content details.
TBD: The Pb-Free/Green conversion plan has not been defined.
Pb-Free (RoHS): TI's terms "Lead-Free" or "Pb-Free" mean semiconductor products that are compatible with the current RoHS requirements for all 6 substances, including the requirement that lead not exceed 0.1% by weight in homogeneous materials. Where designed to be soldered at high temperatures, TI Pb-Free products are suitable for use in specified lead-free processes.
Pb-Free (RoHS Exempt): This component has a RoHS exemption for either 1) lead-based flip-chip solder bumps used between the die and package, or 2) lead-based die adhesive used between the die and leadframe. The component is otherwise considered Pb-Free (RoHS compatible) as defined above.
Green (RoHS & no Sb/Br): TI defines "Green" to mean Pb-Free (RoHS compatible), and free of Bromine (Br) and Antimony (Sb) based flame retardants (Br or Sb do not exceed 0.1% by weight in homogeneous material)

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

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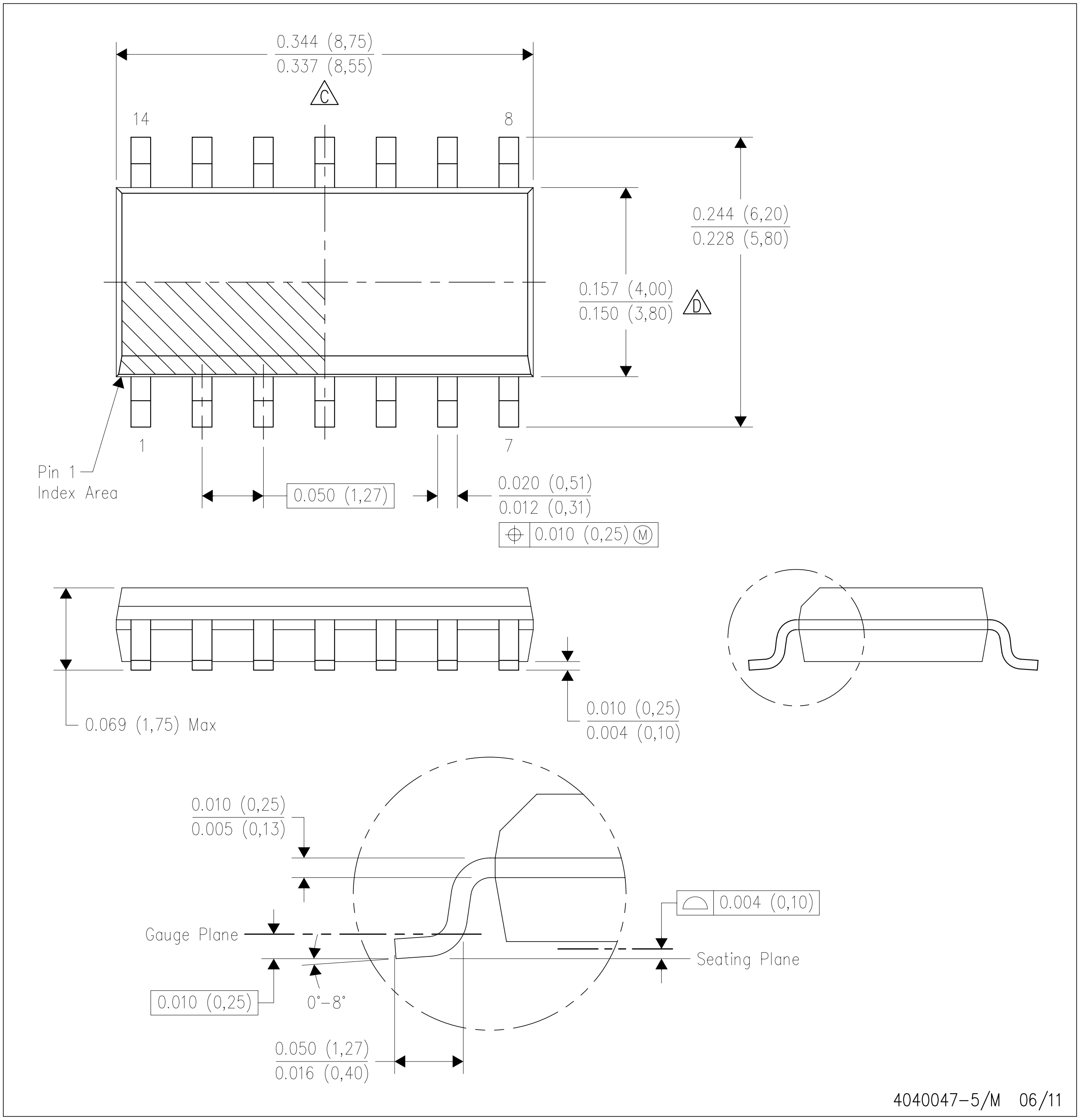
- Catalog: TLC2252, TLC2252A, TLC2254, TLC2254A
- Enhanced Product: TLC2252-EP, TLC2252A-EP, TLC2254-EP, TLC2254A-EP
- Military: TLC2252M, TLC2252AM, TLC2254M, TLC2254AM

NOTE: Qualified Version Definitions:

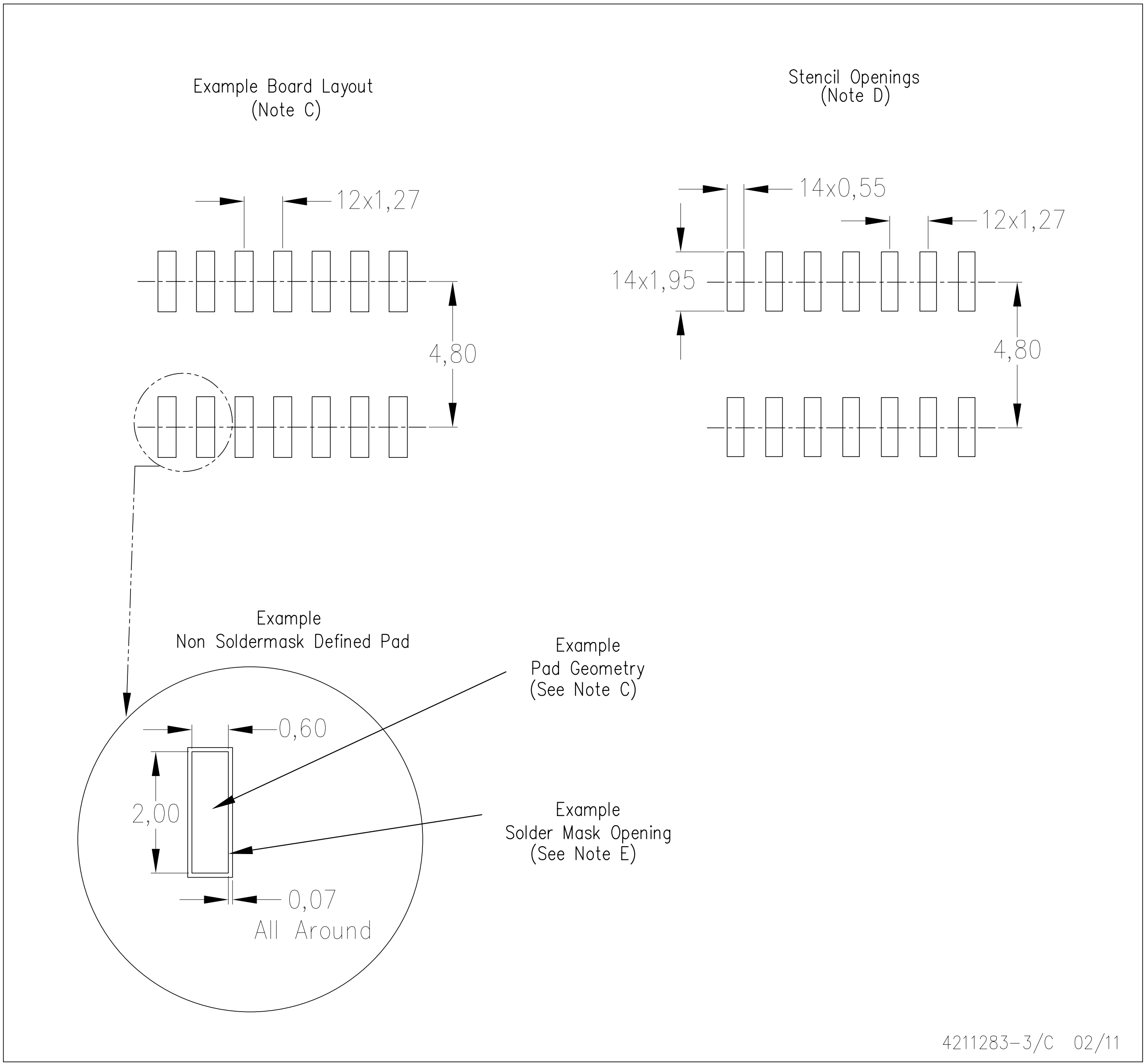
- Catalog - TI's standard catalog product
- Enhanced Product - Supports Defense, Aerospace and Medical Applications
- Military - QML certified for Military and Defense Applications

D (R-PDSO-G14) PLASTIC SMALL OUTLINE



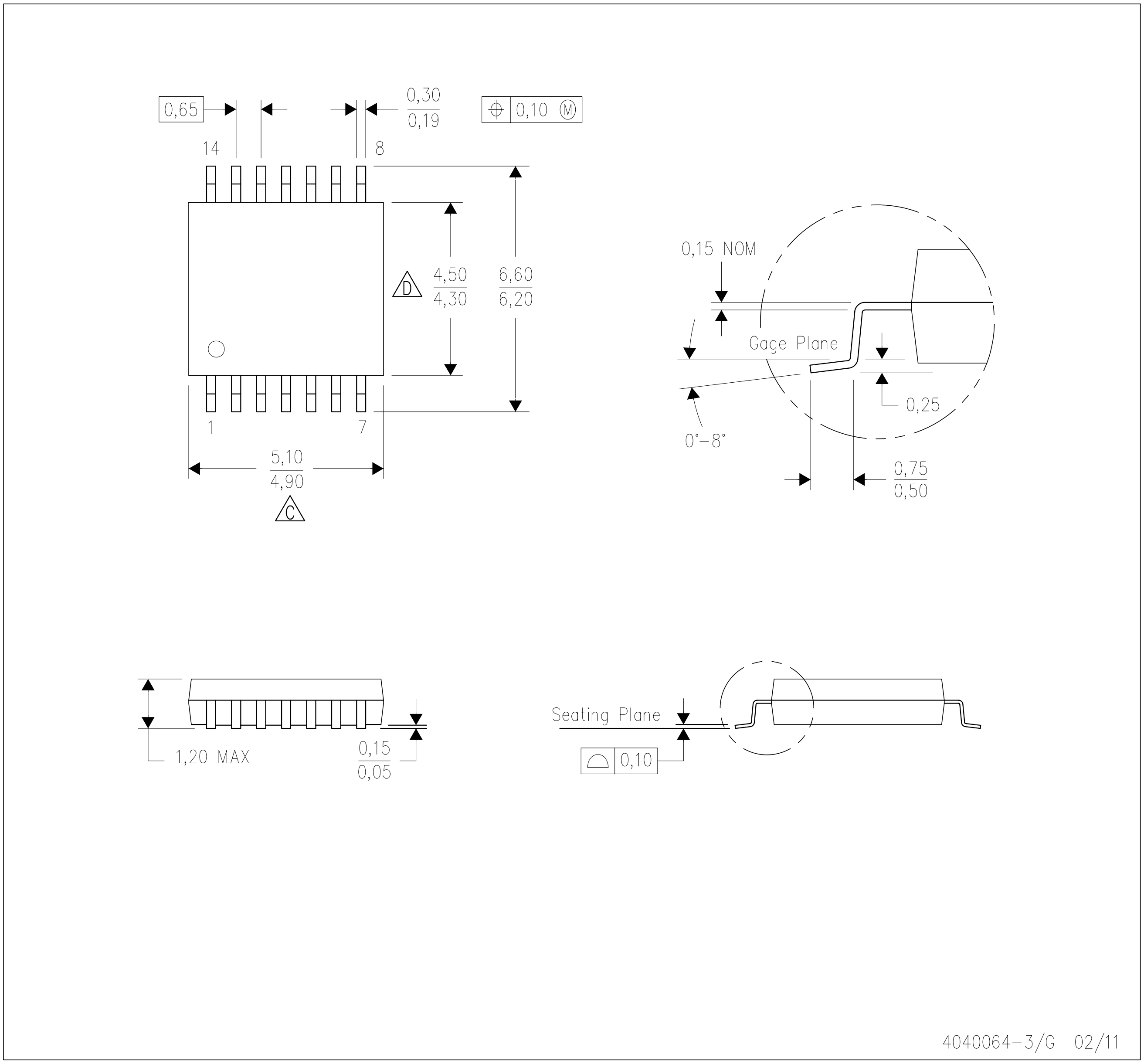
NOTES:
A. All linear dimensions are in inches (millimeters).
B. This drawing is subject to change without notice.
C. Body length does not include mold flash, protrusions, or gate burrs. Mold flash, protrusions, or gate burrs shall not exceed 0.006 (0,15) each side.
D. Body width does not include interlead 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.
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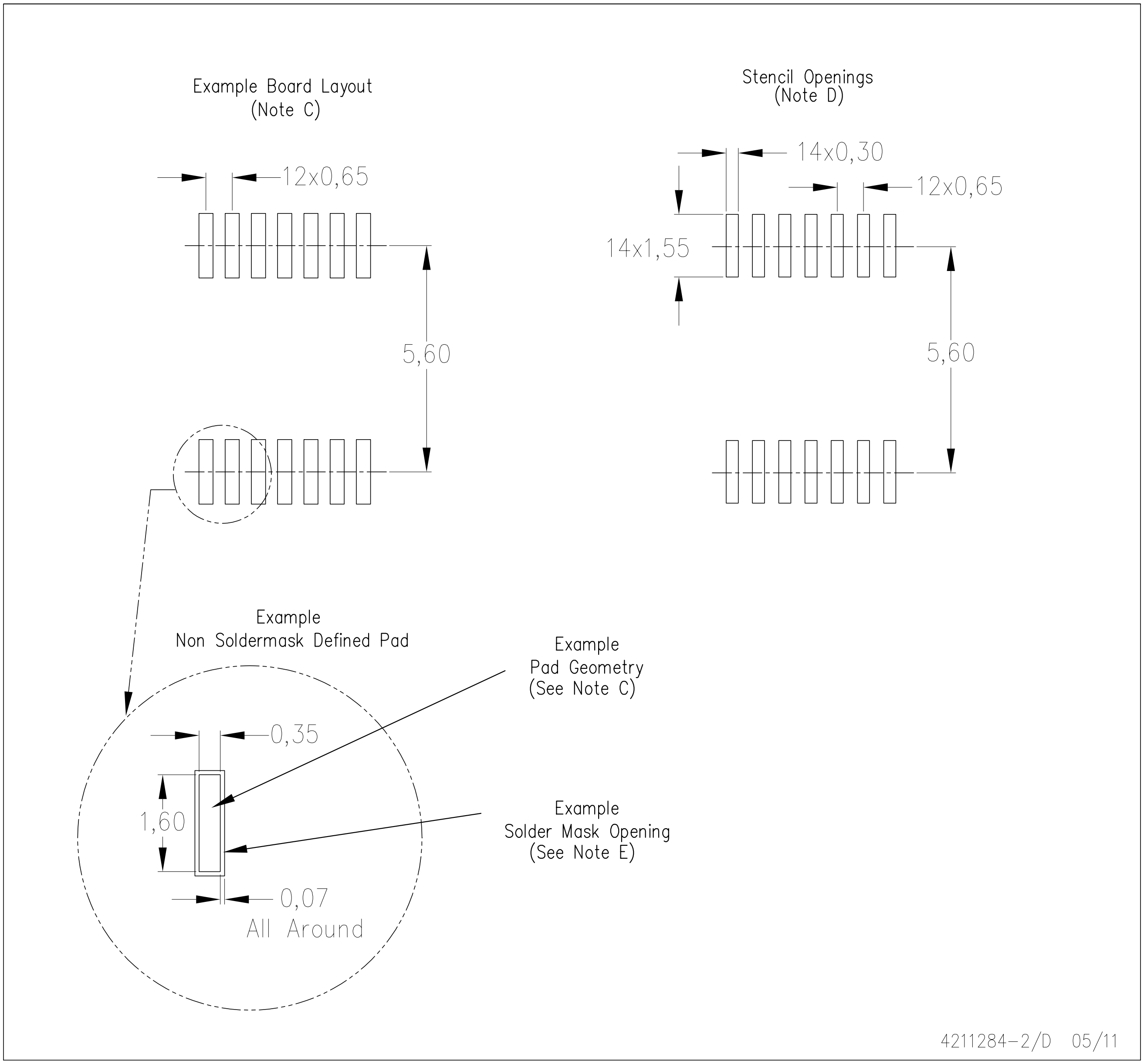
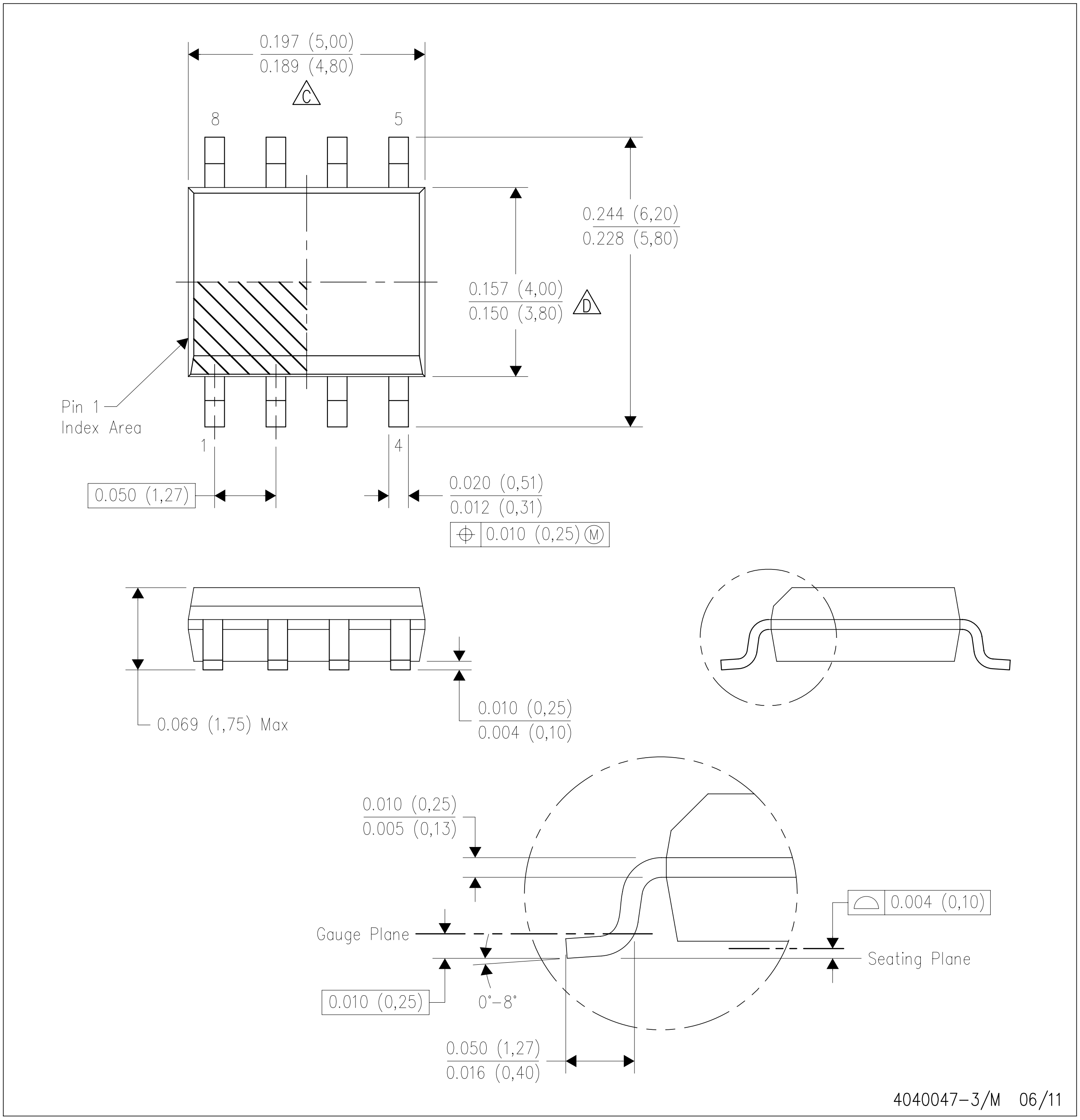
- D. Body width does not include interlead flash. Interlead flash shall not exceed 0,25 each side.
- E. Falls within JEDEC MO–153

PW (R–PDSO–G14) PLASTIC SMALL OUTLINE



NOTES:
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.

D (R–PDSO–G8) PLASTIC SMALL OUTLINE



NOTES:
A. All linear dimensions are in inches (millimeters).
B. This drawing is subject to change without notice.
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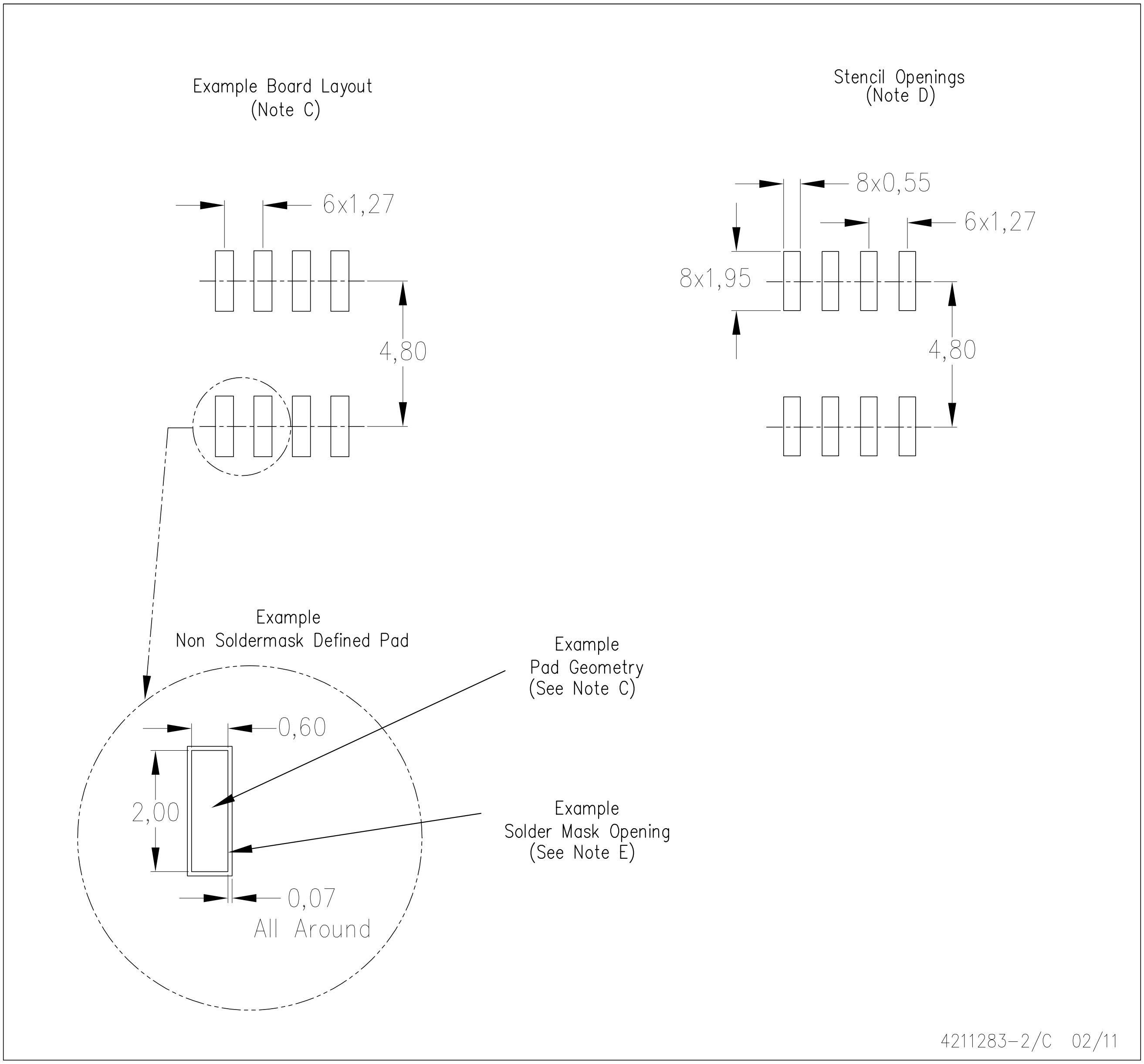
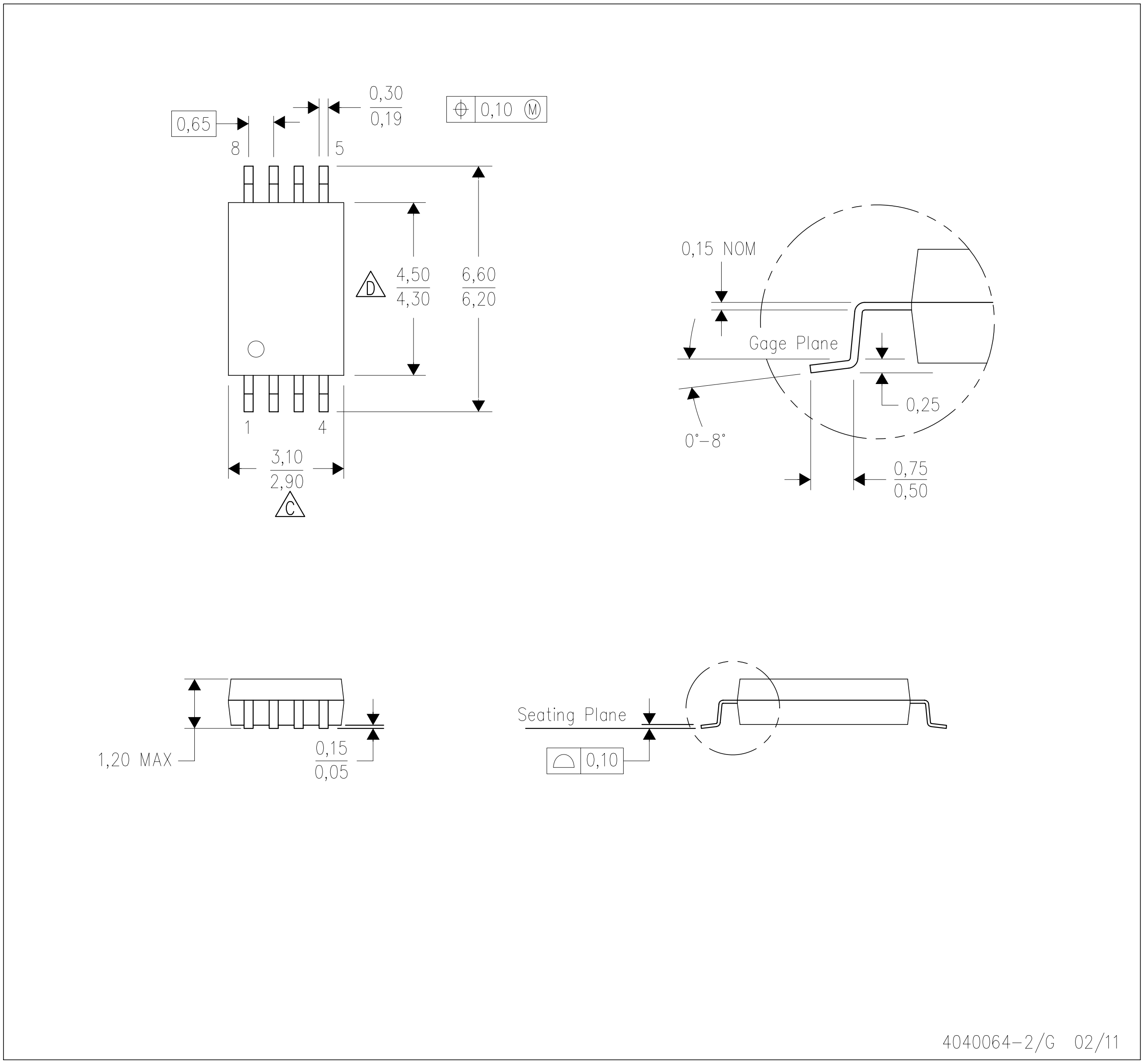
D. Body width does not include interlead flash. Interlead flash shall not exceed 0.017 (0,43) each side.
E. Reference JEDEC MS-012 variation AA.

D (R-PDSO-G8) 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–G8) 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

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