

**TLV225x, TLV225xA**  
**Advanced LinCMOS™ RAIL-TO-RAIL**  
**VERY LOW-POWER OPERATIONAL AMPLIFIERS**

SLOS185C – FEBRUARY 1997 – REVISED – MARCH 2001

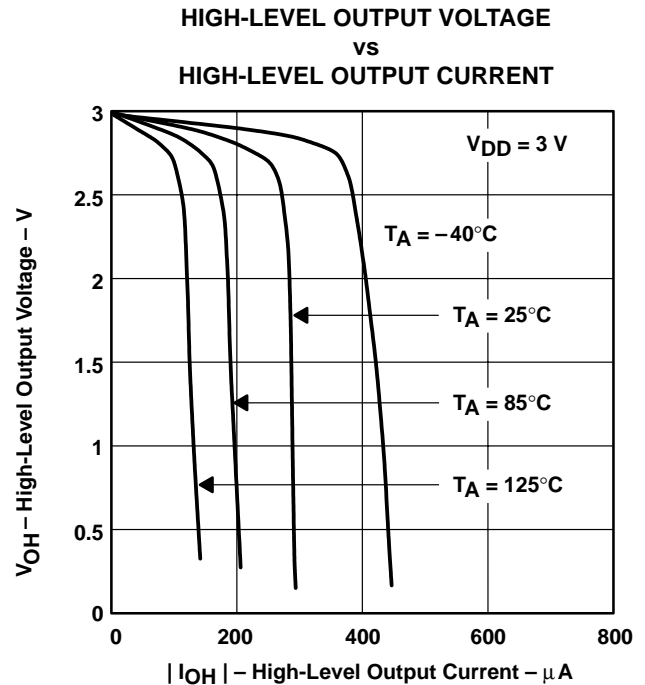
- Output Swing Includes Both Supply Rails
- Low Noise . . . 19 nV/√Hz Typ at f = 1 kHz
- Low Input Bias Current . . . 1 pA Typ
- Fully Specified for Both Single-Supply and Split-Supply Operation
- Very Low Power . . . 34 μA Per Channel Typ
- Common-Mode Input Voltage Range Includes Negative Rail
- Low Input Offset Voltage  
850 μV Max at T<sub>A</sub> = 25°C
- Wide Supply Voltage Range  
2.7 V to 8 V
- Macromodel Included
- Available in Q-Temp Automotive  
HighRel Automotive Applications  
Configuration Control / Print Support  
Qualification to Automotive Standards

### description

The TLV2252 and TLV2254 are dual and quadruple low-voltage operational amplifiers from Texas Instruments. Both devices exhibit rail-to-rail output performance for increased dynamic range in single- or split-supply applications. The TLV225x family consumes only 34 μA of supply current per channel. This micropower operation makes them good choices for battery-powered applications. This family is fully characterized at 3 V and 5 V and is optimized for low-voltage applications. The noise performance has been dramatically improved over previous generations of CMOS amplifiers. The TLV225x has a noise level of 19 nV/√Hz at 1kHz, four times lower than competitive micropower solutions.

The TLV225x, 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 combined with 3-V operation, 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 TLV225xA family is available and has a maximum input offset voltage of 850 μV.

The TLV2252/4 also make great upgrades to the TLV2322/4 in standard designs. They offer increased output dynamic range, lower noise voltage, and lower input offset voltage. This enhanced feature set allows them to be used in a wider range of applications. For applications that require higher output drive and wider input voltage range, see the TLV2432 and TLV2442 devices. If your 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.



Please be aware that an important notice concerning availability, standard warranty, and use in critical applications of Texas Instruments semiconductor products and disclaimers thereto appears at the end of this data sheet.

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PRODUCTION DATA information is current as of publication date. Products conform to specifications per the terms of Texas Instruments standard warranty. Production processing does not necessarily include testing of all parameters.



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**TLV2252 AVAILABLE OPTIONS**

T <sub>A</sub>	V <sub>IOMAX</sub> AT 25°C	PACKAGED DEVICES					
		SMALL OUTLINE† (D)	CHIP CARRIER (FK)	CERAMIC DIP (JG)	PLASTIC DIP (P)	TSSOP‡ (PW)	CERAMIC FLATPACK (U)
-40°C to 125°C	850 μV 1500 μV	TLV2252AID TLV2252ID	— —	— —	TLV2252AIP TLV2252IP	TLV2252AIPWLE —	— —
-40°C to 125°C	850 μV 1500 μV	TLV2252AQD TLV2252QD	— —	— —	— —	— —	— —
-55°C to 125°C	850 μV 1500 μV	— —	TLV2252AMFK TLV2252MFK	TLV2252AMJG TLV2252MJG	— —	— —	TLV2252AMU TLV2252MU

† The D packages are available taped and reeled. Add R suffix to device type (e.g., TLV2252CDR).

‡ The PW package is available only left-end taped and reeled.

§ Chips are tested at 25°C.

**TLV2254 AVAILABLE OPTIONS**

T <sub>A</sub>	V <sub>IOMAX</sub> AT 25°C	PACKAGED DEVICES					
		SMALL OUTLINE† (D)	CHIP CARRIER (FK)	CERAMIC DIP (J)	PLASTIC DIP (N)	TSSOP‡ (PW)	CERAMIC FLATPACK (W)
-40°C to 125°C	850 μV 1500 μV	TLV2254AID TLV2254ID	— —	— —	TLV2254AIN TLV2254IN	TLV2254AIPWLE —	— —
-40°C to 125°C	850 μV 1500 μV	TLV2254AQD TLV2254QD	— —	— —	— —	— —	— —
-55°C to 125°C	850 μV 1500 μV	— —	TLV2254AMFK TLV2254MFK	TLV2254AMJ TLV2254MJ	— —	— —	TLV2254AMW TLV2254MW

† The D packages are available taped and reeled. Add R suffix to device type (e.g., TLV2254CDR).

‡ The PW package is available only left-end taped and reeled.

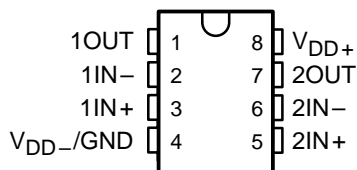
§ Chips are tested at 25°C.



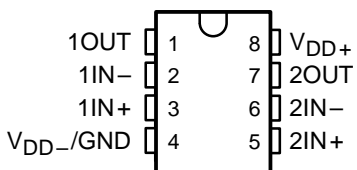
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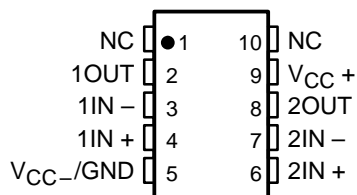
**TLV2252I, TLV2252AI**  
**TLV2252Q, TLV2252AQ**  
**D, P, OR PW PACKAGE**  
**(TOP VIEW)**



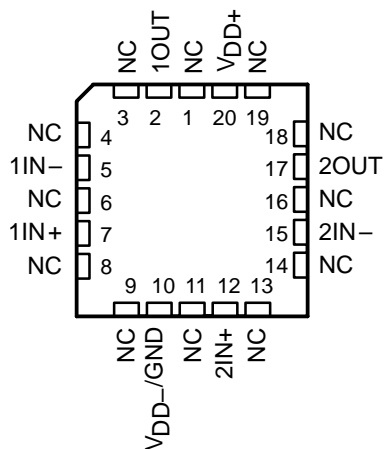
**TLV2252M, TLV2252AM . . . JG PACKAGE**  
**(TOP VIEW)**



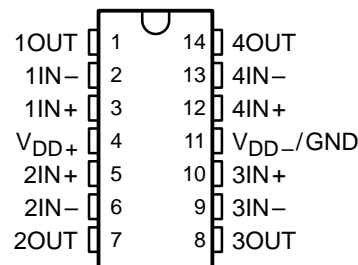
**TLV2252M, TLV2252AM . . . U PACKAGE**  
**(TOP VIEW)**



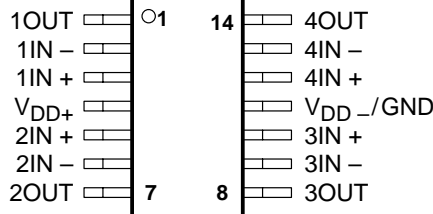
**TLV2252M, TLV2252AM . . . FK PACKAGE**  
**(TOP VIEW)**



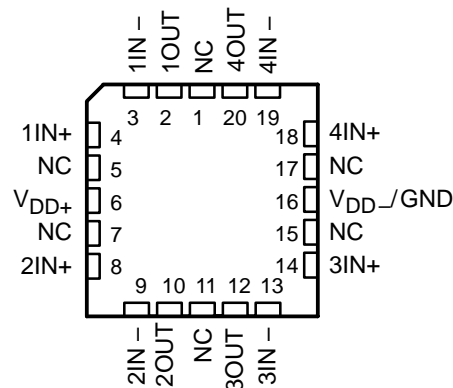
**TLV2254I, TLV2254AI, TLV2254Q, TLV2254AQ . . . D OR N PACKAGE**  
**TLV2254M, TLV2254AM . . . J OR W PACKAGE**  
**(TOP VIEW)**



**TLV2254I, TLV2254AI . . . PW PACKAGE**  
**(TOP VIEW)**



**TLV2254M, TLV2254AM . . . FK PACKAGE**  
**(TOP VIEW)**

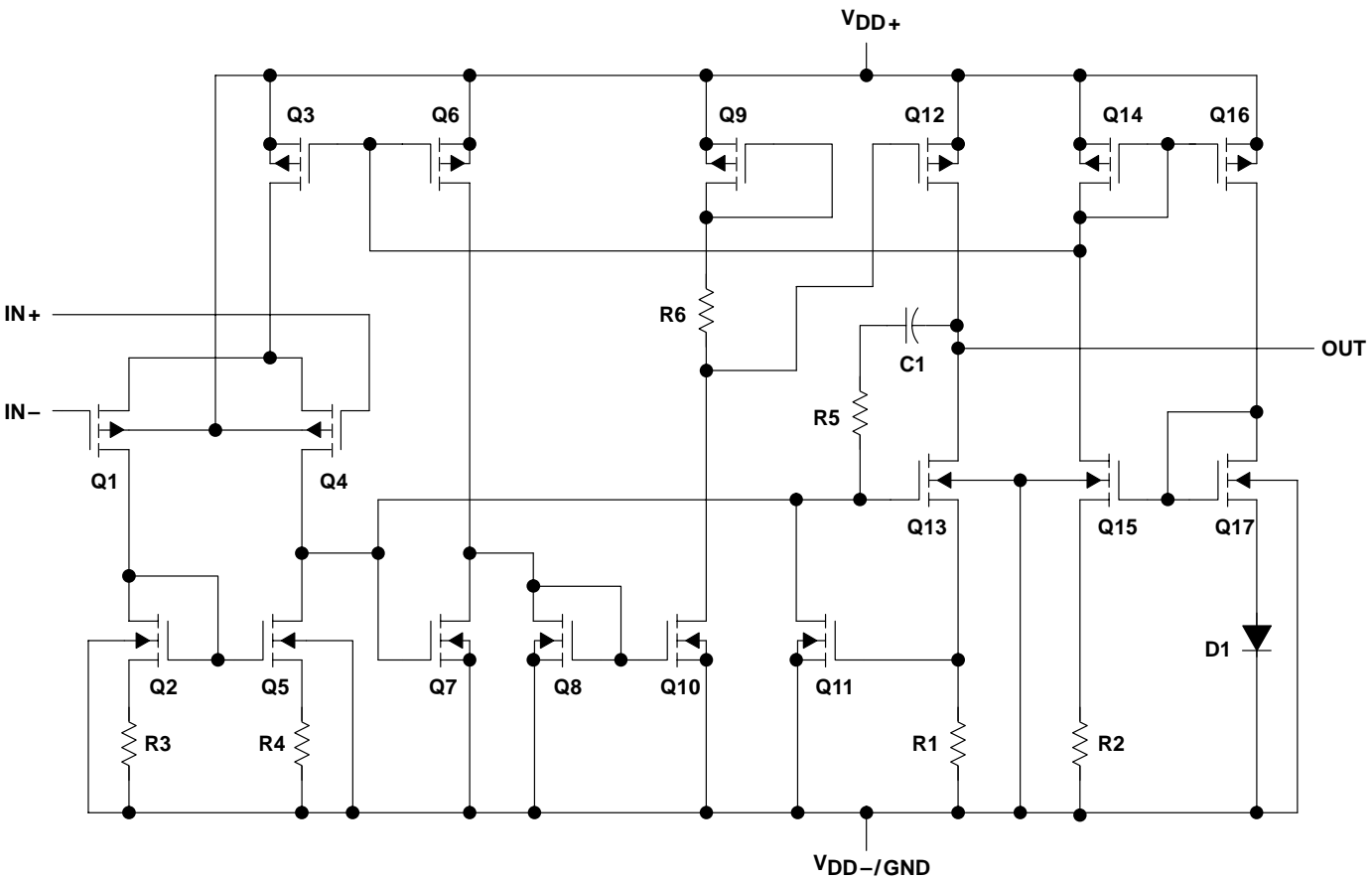


**TLV225x, TLV2252xA**

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**equivalent schematic (each amplifier)**



ACTUAL DEVICE COMPONENT COUNT†		
COMPONENT	TLV2252	TLV2254
Transistors	38	76
Resistors	30	56
Diodes	9	18
Capacitors	3	6

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

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

Supply voltage, $V_{DD}$ (see Note 1)	16 V
Differential input voltage, $V_{ID}$ (see Note 2)	$\pm V_{DD}$
Input voltage range, $V_I$ (any input, see Note 1)	$V_{DD-} - 0.3$ V to $V_{DD+}$
Input current, $I_I$ (each input)	$\pm 5$ mA
Output current, $I_O$	$\pm 50$ mA
Total current into $V_{DD+}$	$\pm 50$ mA
Total current out of $V_{DD-}$	$\pm 50$ mA
Duration of short-circuit current (at or below) 25°C (see Note 3)	unlimited
Continuous total power dissipation	See Dissipation Rating Table
Operating free-air temperature range, $T_A$ :	
I Suffix	-40°C to 125°C
Q Suffix	-40°C to 125°C
M Suffix	-55°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:	
D, N, P, and PW packages	260°C
J, JG, U, and W packages	300°C

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

- NOTES:
- All voltage values, except differential voltages, are with respect to  $V_{DD-}$ .
  - Differential voltages are at the noninverting input with respect to the inverting input. Excessive current flows when input is brought below  $V_{DD-} - 0.3$  V.
  - 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	$T_A \leq 25^\circ\text{C}$ POWER RATING	DERATING FACTOR ABOVE $T_A = 25^\circ\text{C}$	$T_A = 85^\circ\text{C}$ POWER RATING	$T_A = 125^\circ\text{C}$ POWER RATING
D-8	725 mW	5.8 mW/°C	377 mW	145 mW
D-14	950 mW	7.6 mW/°C	494 mW	190 mW
FK	1375 mW	11.0 mW/°C	715 mW	275 mW
J	1375 mW	11.0 mW/°C	715 mW	275 mW
JG	1050 mW	8.4 mW/°C	546 mW	210 mW
N	1150 mW	9.2 mW/°C	598 mW	230 mW
P	1000 mW	8.0 mW/°C	520 mW	200 mW
PW-8	525 mW	4.2 mW/°C	273 mW	105 mW
PW-14	700 mW	5.6 mW/°C	364 mW	140 mW
U	700 mW	5.5 mW/°C	370 mW	150 mW
W	700 mW	5.5 mW/°C	370 mW	150 mW

**recommended operating conditions**

	TLV225xI		TLV225xQ		TLV225xM		UNIT
	MIN	MAX	MIN	MAX	MIN	MAX	
Supply voltage, $V_{DD}$ (see Note 1)	2.7	16	2.7	16	2.7	16	V
Input voltage range, $V_I$	$V_{DD-}$	$V_{DD+} - 1.3$	$V_{DD-}$	$V_{DD+} - 1.3$	$V_{DD-}$	$V_{DD+} - 1.3$	V
Common-mode input voltage, $V_{IC}$	$V_{DD-}$	$V_{DD+} - 1.3$	$V_{DD-}$	$V_{DD+} - 1.3$	$V_{DD-}$	$V_{DD+} - 1.3$	V
Operating free-air temperature, $T_A$	-40	125	-40	125	-55	125	°C

NOTE 1: All voltage values, except differential voltages, are with respect to  $V_{DD-}$ .



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**TLV2252I electrical characteristics at specified free-air temperature,  $V_{DD} = 3\text{ V}$  (unless otherwise noted)**

PARAMETER	TEST CONDITIONS	$T_A$ †	TLV2252I			TLV2252AI			UNIT
			MIN	TYP	MAX	MIN	TYP	MAX	
$V_{IO}$ Input offset voltage		25°C	200	1500		200	850	$\mu\text{V}$	
		Full range			1750		1000		
$\alpha V_{IO}$ Temperature coefficient of input offset voltage		25°C to 85°C	0.5			0.5		$\mu\text{V}/^\circ\text{C}$	
Input offset voltage long-term drift (see Note 4)		25°C	0.003			0.003		$\mu\text{V}/\text{mo}$	
$I_{IO}$ Input offset current	$V_{DD\pm} = \pm 1.5\text{ V}$ , $V_O = 0$ , $V_{IC} = 0$ , $R_S = 50\ \Omega$	25°C	0.5	60		0.5	60	pA	
		-40°C to 85°C			150		150		
		Full range			1000		1000		
$I_{IB}$ Input bias current		25°C	1	60		1	60	pA	
		-40°C to 85°C			150		150		
		Full range			1000		1000		
$V_{ICR}$ Common-mode input voltage range	$R_S = 50\ \Omega$ , $ V_{IO}  \leq 5\text{ mV}$	25°C	0 to 2	-0.3 to 2.2		0 to 2	-0.3 to 2.2	V	
		Full range	0 to 1.7			0 to 1.7			
$V_{OH}$ High-level output voltage	$I_{OH} = -20\ \mu\text{A}$	25°C	2.98		2.98		V		
	$I_{OH} = -75\ \mu\text{A}$	25°C	2.9		2.9				
	Full range	2.8		2.8					
$V_{OL}$ Low-level output voltage	$V_{IC} = 1.5\text{ V}$ , $I_{OL} = 50\ \mu\text{A}$	25°C	10		10		mV		
		Full range	80		80				
	$V_{IC} = 1.5\text{ V}$ , $I_{OL} = 500\ \mu\text{A}$	25°C	100		100				
		Full range	150		150				
	$V_{IC} = 1.5\text{ V}$ , $I_{OL} = 1\text{ mA}$	25°C	200		200				
Full range	300		300						
$A_{VD}$ Large-signal differential voltage amplification	$V_{IC} = 1.5\text{ V}$ , $V_O = 1\text{ V to }2\text{ V}$	$R_L = 100\text{ k}\Omega$ ‡	25°C	100	250	100	250	V/mV	
			Full range	10		10			
		$R_L = 1\text{ M}\Omega$ ‡	25°C	800		800			
$r_{i(d)}$ Differential input resistance		25°C	10 <sup>12</sup>		10 <sup>12</sup>		$\Omega$		
$r_{i(c)}$ Common-mode input resistance		25°C	10 <sup>12</sup>		10 <sup>12</sup>		$\Omega$		
$C_{i(c)}$ Common-mode input capacitance	$f = 10\text{ kHz}$ , P package	25°C	8		8		pF		
$Z_o$ Closed-loop output impedance	$f = 25\text{ kHz}$ , $A_V = 10$	25°C	220		220		$\Omega$		
CMRR Common-mode rejection ratio	$V_{IC} = 0\text{ to }1.7\text{ V}$ , $V_O = 1.5\text{ V}$ , $R_S = 50\ \Omega$	25°C	65	75	65	77	dB		
		Full range	60		60				

† Full range is -40°C to 125°C.

‡ Referenced to 1.5 V

NOTE 4: Typical values are based on the input offset voltage shift observed through 500 hours of operating life test at  $T_A = 150^\circ\text{C}$  extrapolated to  $T_A = 25^\circ\text{C}$  using the Arrhenius equation and assuming an activation energy of 0.96 eV.



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**TLV2252I electrical characteristics at specified free-air temperature,  $V_{DD} = 3\text{ V}$  (unless otherwise noted) (continued)**

PARAMETER	TEST CONDITIONS	$T_A$ †	TLV2252I			TLV2252AI			UNIT	
			MIN	TYP	MAX	MIN	TYP	MAX		
$k_{SVR}$	Supply voltage rejection ratio ( $\Delta V_{DD} / \Delta V_{IO}$ )	$V_{DD} = 2.7\text{ V to } 8\text{ V}$ , $V_{IC} = V_{DD}/2$ , No load	25°C	80	95		80	100	dB	
			Full range	80			80			
$I_{DD}$	Supply current	$V_O = 1.5\text{ V}$ , No load	25°C		68	125		68	125	$\mu\text{A}$
			Full range			150		150		

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

**TLV2252I operating characteristics at specified free-air temperature,  $V_{DD} = 3\text{ V}$**

PARAMETER	TEST CONDITIONS	$T_A$ †	TLV2252I			TLV2252AI			UNIT
			MIN	TYP	MAX	MIN	TYP	MAX	
SR	Slew rate at unity gain	$V_O = 1.1\text{ V to } 1.9\text{ V}$ , $R_L = 100\text{ k}\Omega^\ddagger$ , $C_L = 100\text{ pF}^\ddagger$	25°C	0.07	0.1		0.07	0.1	$\text{V}/\mu\text{s}$
			Full range	0.05			0.05		
$V_n$	Equivalent input noise voltage	$f = 10\text{ Hz}$	25°C		35		35	$\text{nV}/\sqrt{\text{Hz}}$	
			25°C		19		19		
$V_{N(PP)}$	Peak-to-peak equivalent input noise voltage	$f = 0.1\text{ Hz to } 1\text{ Hz}$	25°C		0.6		0.6	$\mu\text{V}$	
			25°C		1.1		1.1		
$I_n$	Equivalent input noise current		25°C		0.6		0.6	$\text{fA}/\sqrt{\text{Hz}}$	
	Gain-bandwidth product	$f = 1\text{ kHz}$ , $C_L = 100\text{ pF}^\ddagger$	$R_L = 50\text{ k}\Omega^\ddagger$ , 25°C		0.187		0.187	MHz	
BOM	Maximum output-swing bandwidth	$V_{O(PP)} = 1\text{ V}$ , $R_L = 50\text{ k}\Omega^\ddagger$	$A_V = 1$ , $C_L = 100\text{ pF}^\ddagger$ , 25°C		60		60	kHz	
$\phi_m$	Phase margin at unity gain	$R_L = 50\text{ k}\Omega^\ddagger$ , $C_L = 100\text{ pF}^\ddagger$	25°C		63°		63°		
			25°C		15		15	dB	

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

‡ Referenced to 1.5 V

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**TLV2252I electrical characteristics at specified free-air temperature,  $V_{DD} = 5\text{ V}$  (unless otherwise noted)**

PARAMETER	TEST CONDITIONS	$T_A$ †	TLV2252I			TLV2252AI			UNIT
			MIN	TYP	MAX	MIN	TYP	MAX	
$V_{IO}$ Input offset voltage		25°C		200	1500		200	850	$\mu\text{V}$
		Full range			1750			1000	
$\alpha_{VIO}$ Temperature coefficient of input offset voltage		25°C to 85°C		0.5			0.5	$\mu\text{V}/^\circ\text{C}$	
Input offset voltage long-term drift (see Note 4)		25°C		0.003			0.003	$\mu\text{V}/\text{mo}$	
$I_{IO}$ Input offset current	$V_{DD\pm} = \pm 2.5\text{ V}$ , $V_O = 0$ , $V_{IC} = 0$ , $R_S = 50\ \Omega$	25°C		0.5	60		0.5	60	pA
		-40°C to 85°C			150			150	
		Full range			1000			1000	
$I_{IB}$ Input bias current		25°C		1	60		1	60	pA
		-40°C to 85°C			150			150	
		Full range			1000			1000	
$V_{ICR}$ Common-mode input voltage range	$ V_{IO}  \leq 5\text{ mV}$ , $R_S = 50\ \Omega$	25°C	0 to 4	-0.3 to 4.2		0 to 4	-0.3 to 4.2	V	
		Full range	0 to 3.5			0 to 3.5			
$V_{OH}$ High-level output voltage	$I_{OH} = -20\ \mu\text{A}$	25°C		4.98			4.98	V	
	$I_{OH} = -75\ \mu\text{A}$	25°C	4.9	4.94		4.9	4.94		
		Full range	4.8			4.8			
	$I_{OH} = -150\ \mu\text{A}$	25°C	4.8	4.88		4.8	4.88		
$V_{OL}$ Low-level output voltage	$V_{IC} = 2.5\text{ V}$ , $I_{OL} = 50\ \mu\text{A}$	25°C		0.01			0.01	V	
		Full range		0.06			0.06		
	$V_{IC} = 2.5\text{ V}$ , $I_{OL} = 500\ \mu\text{A}$	25°C		0.09	0.15		0.09		0.15
		Full range		0.15			0.15		
	$V_{IC} = 2.5\text{ V}$ , $I_{OL} = 1\text{ mA}$	25°C		0.2	0.3		0.2		0.3
		Full range		0.3			0.3		
$AVD$ Large-signal differential voltage amplification	$V_{IC} = 2.5\text{ V}$ , $V_O = 1\text{ V to }4\text{ V}$	$R_L = 100\text{ k}\Omega$ ‡	25°C	100	350		100	350	V/mV
			Full range	10			10		
		$R_L = 1\text{ M}\Omega$ ‡	25°C		1700			1700	
$r_{i(d)}$ Differential input resistance		25°C		$10^{12}$			$10^{12}$	$\Omega$	
$r_{i(c)}$ Common-mode input resistance		25°C		$10^{12}$			$10^{12}$	$\Omega$	
$C_{i(c)}$ Common-mode input capacitance	$f = 10\text{ kHz}$ , P package	25°C		8			8	pF	
$z_o$ Closed-loop output impedance	$f = 25\text{ kHz}$ , $A_V = 10$	25°C		200			200	$\Omega$	
CMRR Common-mode rejection ratio	$V_{IC} = 0\text{ to }2.7\text{ V}$ , $V_O = 2.5\text{ V}$ , $R_S = 50\ \Omega$	25°C		70	83		70	83	dB
		Full range		70			70		

† Full range is -40°C to 125°C.

‡ 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  $T_A = 150^\circ\text{C}$  extrapolated to  $T_A = 25^\circ\text{C}$  using the Arrhenius equation and assuming an activation energy of 0.96 eV.





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**TLV2252I electrical characteristics at specified free-air temperature,  $V_{DD} = 5\text{ V}$  (unless otherwise noted) (continued)**

PARAMETER	TEST CONDITIONS	$T_A$ †	TLV2252I			TLV2252AI			UNIT
			MIN	TYP	MAX	MIN	TYP	MAX	
$k_{SVR}$ Supply voltage rejection ratio ( $\Delta V_{DD}/\Delta V_{IO}$ )	$V_{DD} = 4.4\text{ V to }8\text{ V}$ , $V_{IC} = V_{DD}/2$ , No load	25°C	80	95		80	95		dB
		Full range	80			80			
$I_{DD}$ Supply current	$V_O = 2.5\text{ V}$ , No load	25°C		70	125		70	125	$\mu\text{A}$
		Full range			150			150	

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

**TLV2252I operating characteristics at specified free-air temperature,  $V_{DD} = 5\text{ V}$**

PARAMETER	TEST CONDITIONS	$T_A$ †	TLV2252I			TLV2252AI			UNIT
			MIN	TYP	MAX	MIN	TYP	MAX	
SR Slew rate at unity gain	$V_O = 1.5\text{ V to }3.5\text{ V}$ , $R_L = 100\text{ k}\Omega$ ‡, $C_L = 100\text{ pF}$ ‡	25°C	0.07	0.12		0.07	0.12		$\text{V}/\mu\text{s}$
		Full range	0.05			0.05			
$V_n$ Equivalent input noise voltage	$f = 10\text{ Hz}$ $f = 1\text{ kHz}$	25°C		36			36		$\text{nV}/\sqrt{\text{Hz}}$
		25°C		19			19		
$V_{N(PP)}$ Peak-to-peak equivalent input noise voltage	$f = 0.1\text{ Hz to }1\text{ Hz}$ $f = 0.1\text{ Hz to }10\text{ Hz}$	25°C		0.7			0.7		$\mu\text{V}$
		25°C		1.1			1.1		
$I_n$ Equivalent input noise current		25°C		0.6			0.6	$\text{fA}/\sqrt{\text{Hz}}$	
THD + N Total harmonic distortion plus noise	$V_O = 0.5\text{ V to }2.5\text{ V}$ , $f = 20\text{ kHz}$ , $R_L = 50\text{ k}\Omega$ ‡	25°C	$A_V = 1$		0.2%		0.2%		
			$A_V = 10$		1%		1%		
Gain-bandwidth product	$f = 50\text{ kHz}$ , $C_L = 100\text{ pF}$ ‡	25°C		0.2			0.2	MHz	
$B_{OM}$ Maximum output-swing bandwidth	$V_{O(PP)} = 2\text{ V}$ , $R_L = 50\text{ k}\Omega$ ‡	25°C		30			30	kHz	
$\phi_m$ Phase margin at unity gain	$R_L = 50\text{ k}\Omega$ ‡, $C_L = 100\text{ pF}$ ‡	25°C		63°			63°		
		25°C		15			15		
Gain margin		25°C		15			15	dB	

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

‡ Referenced to 2.5 V

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**TLV2254I electrical characteristics at specified free-air temperature,  $V_{DD} = 3\text{ V}$  (unless otherwise noted)**

PARAMETER	TEST CONDITIONS	$T_A$ †	TLV2254I			TLV2254AI			UNIT
			MIN	TYP	MAX	MIN	TYP	MAX	
$V_{IO}$ Input offset voltage		25°C	200	1500		200	850	$\mu\text{V}$	
		Full range		1750		1000			
$\alpha_{VIO}$ Temperature coefficient of input offset voltage		25°C to 85°C	0.5			0.5			$\mu\text{V}/^\circ\text{C}$
Input offset voltage long-term drift (see Note 4)		25°C	0.003			0.003			$\mu\text{V}/\text{mo}$
$I_{IO}$ Input offset current	$V_{DD\pm} = \pm 1.5\text{ V}, V_O = 0, V_{IC} = 0, R_S = 50\ \Omega$	25°C	0.5	60		0.5	60	pA	
		-40°C to 85°C	150			150			
		Full range	1000			1000			
		25°C	1	60		1	60		
$I_{IB}$ Input bias current		25°C	1			1			pA
		-40°C to 85°C	150			150			
		Full range	1000			1000			
		25°C	1			1			
$V_{ICR}$ Common-mode input voltage range	$R_S = 50\ \Omega,  V_{IO}  \leq 5\text{ mV}$	25°C	0 to 2	-0.3 to 2.2		0 to 2	-0.3 to 2.2	V	
		Full range	0 to 1.7			0 to 1.7			
$V_{OH}$ High-level output voltage	$I_{OH} = -20\ \mu\text{A}$	25°C	2.98			2.98			V
		25°C	2.9			2.9			
		Full range	2.8			2.8			
		25°C	2.8			2.8			
$V_{OL}$ Low-level output voltage	$V_{IC} = 1.5\text{ V}, I_{OL} = 50\ \mu\text{A}$	25°C	10			10			mV
		Full range	80			80			
	$V_{IC} = 1.5\text{ V}, I_{OL} = 500\ \mu\text{A}$	25°C	100			100			
		Full range	150			150			
	$V_{IC} = 1.5\text{ V}, I_{OL} = 1\text{ mA}$	25°C	200			200			
		Full range	300			300			
$A_{VD}$ Large-signal differential voltage amplification	$V_{IC} = 1.5\text{ V}, V_O = 1\text{ V to }2\text{ V}$	$R_L = 100\text{ k}\Omega$ ‡	25°C	100	225		100	225	V/mV
			Full range	10			10		
		$R_L = 1\text{ M}\Omega$ ‡	25°C	800			800		
$r_{i(d)}$ Differential input resistance		25°C	$10^{12}$			$10^{12}$			$\Omega$
$r_{i(c)}$ Common-mode input resistance		25°C	$10^{12}$			$10^{12}$			$\Omega$
$C_{i(c)}$ Common-mode input capacitance	$f = 10\text{ kHz}, \text{ N package}$	25°C	8			8			pF
$z_o$ Closed-loop output impedance	$f = 25\text{ kHz}, A_V = 10$	25°C	220			220			$\Omega$
CMRR Common-mode rejection ratio	$V_{IC} = 0\text{ to }1.7\text{ V}, V_O = 1.5\text{ V}, R_S = 50\ \Omega$	25°C	65	75		65	77	dB	
		Full range	60			60			

† Full range is -40°C to 125°C.

‡ Referenced to 1.5 V

NOTE 4: Typical values are based on the input offset voltage shift observed through 500 hours of operating life test at  $T_A = 150^\circ\text{C}$  extrapolated to  $T_A = 25^\circ\text{C}$  using the Arrhenius equation and assuming an activation energy of 0.96 eV.



**TLV2254I electrical characteristics at specified free-air temperature,  $V_{DD} = 3\text{ V}$  (unless otherwise noted) (continued)**

PARAMETER	TEST CONDITIONS	$T_A$ †	TLV2254I			TLV2254AI			UNIT	
			MIN	TYP	MAX	MIN	TYP	MAX		
$k_{SVR}$	Supply voltage rejection ratio ( $\Delta V_{DD}/\Delta V_{IO}$ )	$V_{DD} = 2.7\text{ V to } 8\text{ V}$ , $V_{IC} = V_{DD}/2$ , No load	25°C	80	95		80	100	dB	
			Full range	80			80			
$I_{DD}$	Supply current (four amplifiers)	$V_O = 1.5\text{ V}$ , No load	25°C		135	250		135	250	μA
			Full range			300			300	

† Full range is –40°C to 125°C.

**TLV2254I operating characteristics at specified free-air temperature,  $V_{DD} = 3\text{ V}$**

PARAMETER	TEST CONDITIONS	$T_A$ †	TLV2254I			TLV2254AI			UNIT
			MIN	TYP	MAX	MIN	TYP	MAX	
SR	Slew rate at unity gain	$V_O = 0.7\text{ V to } 1.7\text{ V}$ , $R_L = 100\text{ k}\Omega$ ‡, $C_L = 100\text{ pF}$ ‡	25°C	0.07	0.1		0.07	0.1	V/μs
			Full range	0.05			0.05		
$V_n$	Equivalent input noise voltage	$f = 10\text{ Hz}$	25°C		35		35	nV/√Hz	
			25°C		19		19		
$V_{N(PP)}$	Peak-to-peak equivalent input noise voltage	$f = 0.1\text{ Hz to } 1\text{ Hz}$	25°C		0.6		0.6	μV	
			25°C		1.1		1.1		
$I_n$	Equivalent input noise current	$f = 0.1\text{ Hz to } 10\text{ Hz}$	25°C		0.6		0.6	fA/√Hz	
	Gain-bandwidth product	$f = 1\text{ kHz}$ , $R_L = 50\text{ k}\Omega$ ‡, $C_L = 100\text{ pF}$ ‡	25°C		0.187		0.187	MHz	
BOM	Maximum output-swing bandwidth	$V_{O(PP)} = 1\text{ V}$ , $A_V = 1$ , $R_L = 50\text{ k}\Omega$ ‡, $C_L = 100\text{ pF}$ ‡	25°C		60		60	kHz	
$\phi_m$	Phase margin at unity gain	$R_L = 50\text{ k}\Omega$ ‡, $C_L = 100\text{ pF}$ ‡	25°C		63°		63°		
	Gain margin		25°C		15		15	dB	

† Full range is –40°C to 85°C.

‡ Referenced to 1.5 V

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**TLV2254I electrical characteristics at specified free-air temperature,  $V_{DD} = 5\text{ V}$  (unless otherwise noted)**

PARAMETER	TEST CONDITIONS	$T_A$ †	TLV2254I			TLV2254AI			UNIT
			MIN	TYP	MAX	MIN	TYP	MAX	
$V_{IO}$ Input offset voltage	$V_{DD\pm} = \pm 2.5\text{ V}$ , $V_{IC} = 0$ , $V_O = 0$ , $R_S = 50\ \Omega$	25°C	200	1500		200	850	$\mu\text{V}$	
		Full range		1750		1000			
$\alpha V_{IO}$ Temperature coefficient of input offset voltage		25°C to 85°C	0.5			0.5		$\mu\text{V}/^\circ\text{C}$	
Input offset voltage long-term drift (see Note 4)		25°C	0.003			0.003		$\mu\text{V}/\text{mo}$	
$I_{IO}$ Input offset current		25°C	0.5	60		0.5	60	$\text{pA}$	
		-40°C to 85°C		150		150			
		Full range		1000		1000			
$I_{IB}$ Input bias current		25°C	1	60		1	60	$\text{pA}$	
	-40°C to 85°C		150		150				
	Full range		1000		1000				
$V_{ICR}$ Common-mode input voltage range	$ V_{IO}  \leq 5\text{ mV}$ , $R_S = 50\ \Omega$	25°C	0 to 4	-0.3 to 4.2		0 to 4	-0.3 to 4.2	V	
		Full range	0 to 3.5		0 to 3.5				
$V_{OH}$ High-level output voltage	$I_{OH} = -20\ \mu\text{A}$	25°C	4.98		4.98		V		
	$I_{OH} = -75\ \mu\text{A}$	25°C	4.9	4.94	4.9	4.94			
	$I_{OH} = -150\ \mu\text{A}$	Full range	4.8		4.8				
$V_{OL}$ Low-level output voltage	$V_{IC} = 2.5\text{ V}$ , $I_{OL} = 50\ \mu\text{A}$	25°C	0.01		0.01		V		
		Full range		0.06		0.06			
	$V_{IC} = 2.5\text{ V}$ , $I_{OL} = 500\ \mu\text{A}$	25°C	0.09	0.15	0.09	0.15			
		Full range		0.15		0.15			
	$V_{IC} = 2.5\text{ V}$ , $I_{OL} = 1\text{ mA}$	25°C	0.2	0.3	0.2	0.3			
		Full range		0.3		0.3			
$A_{VD}$ Large-signal differential voltage amplification	$V_{IC} = 2.5\text{ V}$ , $V_O = 1\text{ V to }4\text{ V}$	$R_L = 100\text{ k}\Omega$ ‡	25°C	100	350	100	350	V/mV	
			Full range	10		10			
		$R_L = 1\text{ M}\Omega$ ‡	25°C	1700		1700			
$r_{i(d)}$ Differential input resistance		25°C	1012		1012		$\Omega$		
$r_{i(c)}$ Common-mode input resistance		25°C	1012		1012		$\Omega$		
$C_{i(c)}$ Common-mode input capacitance	$f = 10\text{ kHz}$ , N package	25°C	8		8		pF		
$z_o$ Closed-loop output impedance	$f = 25\text{ kHz}$ , $A_V = 10$	25°C	200		200		$\Omega$		
CMRR Common-mode rejection ratio	$V_{IC} = 0\text{ to }2.7\text{ V}$ , $V_O = 2.5\text{ V}$ , $R_S = 50\ \Omega$	25°C	70	83	70	83	dB		
		Full range	70		70				

† Full range is -40°C to 125°C.

‡ 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  $T_A = 150^\circ\text{C}$  extrapolated to  $T_A = 25^\circ\text{C}$  using the Arrhenius equation and assuming an activation energy of 0.96 eV.



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**TLV2254I electrical characteristics at specified free-air temperature,  $V_{DD} = 5\text{ V}$  (unless otherwise noted) (continued)**

PARAMETER	TEST CONDITIONS	$T_A$ †	TLV2254I			TLV2254AI			UNIT
			MIN	TYP	MAX	MIN	TYP	MAX	
$k_{SVR}$	Supply voltage rejection ratio ( $\Delta V_{DD}/\Delta V_{IO}$ )	25°C	80	95		80	95		dB
			Full range			80			
$I_{DD}$	Supply current (four amplifiers)	25°C	140		250	140		250	µA
			Full range			300			

† Full range is –40°C to 125°C.

**TLV2254I operating characteristics at specified free-air temperature,  $V_{DD} = 5\text{ V}$**

PARAMETER	TEST CONDITIONS	$T_A$ †	TLV2254I			TLV2254AI			UNIT
			MIN	TYP	MAX	MIN	TYP	MAX	
SR	Slew rate at unity gain	25°C	0.07	0.12		0.07	0.12		V/µs
		Full range	0.05			0.05			
$V_n$	Equivalent input noise voltage	25°C	36			36			nV/√Hz
		25°C	19			19			
$V_{N(PP)}$	Peak-to-peak equivalent input noise voltage	25°C	0.7			0.7			µV
		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	25°C	0.2%			0.2%			
			1%			1%			
	Gain-bandwidth product	25°C	0.2			0.2			MHz
$B_{OM}$	Maximum output-swing bandwidth	25°C	30			30			kHz
$\phi_m$	Phase margin at unity gain	25°C	63°			63°			
		25°C	15			15			

† Full range is –40°C to 125°C.

‡ Referenced to 2.5 V

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**TLV2252Q, and TLV2252M electrical characteristics at specified free-air temperature,  $V_{DD} = 3\text{ V}$  (unless otherwise noted)**

PARAMETER	TEST CONDITIONS	$T_A$ †	TLV2252Q, TLV2252M			TLV2252AQ, TLV2252AM			UNIT
			MIN	TYP	MAX	MIN	TYP	MAX	
$V_{IO}$ Input offset voltage		25°C	200	1500		200	850	$\mu\text{V}$	
		Full range		1750		1000			
$\alpha_{VIO}$ Temperature coefficient of input offset voltage		25°C to 85°C	0.5			0.5			$\mu\text{V}/^\circ\text{C}$
Input offset voltage long-term drift (see Note 4)	$V_{DD} \pm \pm 1.5\text{ V}$ , $V_O = 0$ , $V_{IC} = 0$ , $R_S = 50\ \Omega$	25°C	0.003			0.003			$\mu\text{V}/\text{mo}$
$I_{IO}$ 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		$R_S = 50\ \Omega$ , $ V_{IO}  \leq 5\text{ mV}$	25°C	0 to 2	-0.3 to 2.2		0 to 2	-0.3 to 2.2	V
	Full range		0 to 1.7		0 to 1.7				
$V_{OH}$ High-level output voltage	$I_{OH} = -20\ \mu\text{A}$	25°C	2.98			2.98			V
	$I_{OH} = -75\ \mu\text{A}$	25°C	2.9			2.9			
	Full range	2.8			2.8				
$V_{OL}$ Low-level output voltage	$I_{OH} = -150\ \mu\text{A}$	25°C	2.8			2.8			mV
	$V_{IC} = 1.5\text{ V}$ , $I_{OL} = 50\ \mu\text{A}$	25°C	10			10			
		Full range	100	150		100	150		
	$V_{IC} = 1.5\text{ V}$ , $I_{OL} = 500\ \mu\text{A}$	25°C	165			165			
		Full range	200	300		200	300		
$V_{IC} = 1.5\text{ V}$ , $I_{OL} = 1\text{ mA}$	25°C	300			300				
	Full range	300			300				
	Full range	300			300				
$A_{VD}$ Large-signal differential voltage amplification	$V_{IC} = 1.5\text{ V}$ , $V_O = 1\text{ V to }2\text{ V}$	$R_L = 100\text{ k}\Omega$ ‡	25°C	100	250		100	250	V/mV
			Full range	10			10		
		$R_L = 1\text{ M}\Omega$ ‡	25°C	800			800		
$r_{i(d)}$ Differential input resistance		25°C	$10^{12}$			$10^{12}$			$\Omega$
$r_{i(c)}$ Common-mode input resistance		25°C	$10^{12}$			$10^{12}$			$\Omega$
$C_{i(c)}$ Common-mode input capacitance	$f = 10\text{ kHz}$ , P package	25°C	8			8			pF
$Z_o$ Closed-loop output impedance	$f = 25\text{ kHz}$ , $A_V = 10$	25°C	220			220			$\Omega$
CMRR Common-mode rejection ratio	$V_{IC} = 0\text{ to }1.7\text{ V}$ , $V_O = 1.5\text{ V}$ , $R_S = 50\ \Omega$	25°C	65	75		65	77	dB	
		Full range	60			60			
$k_{SVR}$ Supply voltage rejection ratio ( $\Delta V_{DD} / \Delta V_{IO}$ )	$V_{DD} = 2.7\text{ V to }8\text{ V}$ , $V_{IC} = V_{DD}/2$ , No load	25°C	80	95		80	100	dB	
		Full range	80			80			
$I_{DD}$ Supply current	$V_O = 1.5\text{ V}$ , No load	25°C	68	125		68	125	$\mu\text{A}$	
		Full range	150			150			

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

‡ Referenced to 1.5 V

NOTE 4: Typical values are based on the input offset voltage shift observed through 500 hours of operating life test at  $T_A = 150^\circ\text{C}$  extrapolated to  $T_A = 25^\circ\text{C}$  using the Arrhenius equation and assuming an activation energy of 0.96 eV.



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**TLV2252Q, and TLV2252M operating characteristics at specified free-air temperature,  $V_{DD} = 3\text{ V}$**

PARAMETER	TEST CONDITIONS	$T_A$ †	TLV2252Q, TLV2252M			TLV2252AQ, TLV2252AM			UNIT
			MIN	TYP	MAX	MIN	TYP	MAX	
SR	Slew rate at unity gain $V_O = 0.8\text{ V to }1.4\text{ V}, R_L = 100\text{ k}\Omega^\ddagger,$ $C_L = 100\text{ pF}^\ddagger$	25°C	0.07	0.1		0.07	0.1		V/ $\mu\text{s}$
		Full range	0.05			0.05			
$V_n$	Equivalent input noise voltage	f = 10 Hz	35			35			nV/ $\sqrt{\text{Hz}}$
		f = 1 kHz	19			19			
$V_{N(PP)}$	Peak-to-peak equivalent input noise voltage	f = 0.1 Hz to 1 Hz	0.6			0.6			$\mu\text{V}$
		f = 0.1 Hz to 10 Hz	1.1			1.1			
$I_n$	Equivalent input noise current	25°C	0.6			0.6			fA/ $\sqrt{\text{Hz}}$
	Gain-bandwidth product	f = 1 kHz, $R_L = 50\text{ k}\Omega^\ddagger,$ $C_L = 100\text{ pF}^\ddagger$	0.187			0.187			MHz
$B_{OM}$	Maximum output-swing bandwidth	$V_{O(PP)} = 1\text{ V},$ $R_L = 50\text{ k}\Omega^\ddagger,$ $A_V = 1,$ $C_L = 100\text{ pF}^\ddagger$	60			60			kHz
$\phi_m$	Phase margin at unity gain	$R_L = 50\text{ k}\Omega^\ddagger,$ $C_L = 100\text{ pF}^\ddagger$	63°			63°			
		Gain margin	15			15			dB

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

‡ Referenced to 1.5 V

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**TLV2252Q, and TLV2252M electrical characteristics at specified free-air temperature,  $V_{DD} = 5\text{ V}$  (unless otherwise noted)**

PARAMETER	TEST CONDITIONS	$T_A$ †	TLV2252Q, TLV2252M			TLV2252AQ, TLV2252AM			UNIT
			MIN	TYP	MAX	MIN	TYP	MAX	
$V_{IO}$ Input offset voltage	$V_{DD} \pm \pm 2.5\text{ V}$ , $V_O = 0$ , $V_{IC} = 0$ , $R_S = 50\ \Omega$	25°C	200	1500		200	850	$\mu\text{V}$	
		Full range		1750		1000			
$\alpha_{VIO}$ Temperature coefficient of input offset voltage		25°C to 85°C	0.5			0.5		$\mu\text{V}/^\circ\text{C}$	
Input offset voltage long-term drift (see Note 4)		25°C	0.003			0.003		$\mu\text{V}/\text{mo}$	
$I_{IO}$ 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	$ V_{IO}  \leq 5\text{ mV}$ , $R_S = 50\ \Omega$	25°C	0 to 4	-0.3 to 4.2		0 to 4	-0.3 to 4.2	V	
		Full range	0 to 3.5			0 to 3.5			
$V_{OH}$ High-level output voltage	$I_{OH} = -20\ \mu\text{A}$ $I_{OH} = -75\ \mu\text{A}$ $I_{OH} = -150\ \mu\text{A}$	25°C		4.98		4.98		V	
		25°C	4.9	4.94		4.9	4.94		
		Full range	4.8			4.8			
		25°C	4.8	4.88		4.8	4.88		
$V_{OL}$ Low-level output voltage	$V_{IC} = 2.5\text{ V}$ , $I_{OL} = 50\ \mu\text{A}$ $I_{OL} = 500\ \mu\text{A}$ $I_{OL} = 1\text{ mA}$	25°C		0.01		0.01		V	
		25°C	0.09	0.15		0.09	0.15		
		Full range		0.15			0.15		
		25°C	0.2	0.3		0.2	0.3		
		Full range		0.3			0.3		
$AVD$ Large-signal differential voltage amplification	$V_{IC} = 2.5\text{ V}$ , $V_O = 1\text{ V to }4\text{ V}$	$R_L = 100\text{ k}\Omega$ ‡	25°C	100	350		100	350	V/mV
			Full range	10			10		
		$R_L = 1\text{ M}\Omega$ ‡	25°C		1700		1700		
$r_{i(d)}$ Differential input resistance		25°C		$10^{12}$		$10^{12}$		$\Omega$	
$r_{i(c)}$ Common-mode input resistance		25°C		$10^{12}$		$10^{12}$		$\Omega$	
$C_{i(c)}$ Common-mode input capacitance	$f = 10\text{ kHz}$ , P package	25°C		8		8		pF	
$z_o$ Closed-loop output impedance	$f = 25\text{ kHz}$ , $A_V = 10$	25°C		200		200		$\Omega$	
CMRR Common-mode rejection ratio	$V_{IC} = 0\text{ to }2.7\text{ V}$ , $V_O = 2.5\text{ V}$ , $R_S = 50\ \Omega$	25°C	70	83		70	83	dB	
		Full range	70			70			
$k_{SVR}$ Supply voltage rejection ratio ( $\Delta V_{DD}/\Delta V_{IO}$ )	$V_{DD} = 4.4\text{ V to }8\text{ V}$ , $V_{IC} = V_{DD}/2$ , No load	25°C	80	95		80	95	dB	
		Full range	80			80			

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

‡ Referenced to 2.5 V

NOTE 4: Typical values are based on the input offset voltage shift observed through 500 hours of operating life test at  $T_A = 150^\circ\text{C}$  extrapolated to  $T_A = 25^\circ\text{C}$  using the Arrhenius equation and assuming an activation energy of 0.96 eV.





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**TLV2252Q, and TLV2252M electrical characteristics at specified free-air temperature,  $V_{DD} = 5\text{ V}$  (unless otherwise noted) (continued)**

PARAMETER	TEST CONDITIONS	$T_A$ †	TLV2252Q, TLV2252M			TLV2252AQ, TLV2252AM			UNIT
			MIN	TYP	MAX	MIN	TYP	MAX	
$I_{DD}$ Supply current	$V_O = 2.5\text{ V}$ , No load	25°C	70	125		70	125	$\mu\text{A}$	
		Full range		150		150			

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

**TLV2252Q, and TLV2252M operating characteristics at specified free-air temperature,  $V_{DD} = 5\text{ V}$**

PARAMETER	TEST CONDITIONS	$T_A$ †	TLV2252Q, TLV2252M			TLV2252AQ, TLV2252AM			UNIT
			MIN	TYP	MAX	MIN	TYP	MAX	
SR Slew rate at unity gain	$V_O = 1.25\text{ V}$ to $2.75\text{ V}$ , $R_L = 100\text{ k}\Omega$ ‡, $C_L = 100\text{ pF}$ ‡	25°C	0.07	0.12		0.07	0.12	$\text{V}/\mu\text{s}$	
		Full range	0.05			0.05			
$V_n$ Equivalent input noise voltage	$f = 10\text{ Hz}$ $f = 1\text{ kHz}$	25°C		36			36	$\text{nV}/\sqrt{\text{Hz}}$	
		25°C		19			19		
$V_{N(PP)}$ Peak-to-peak equivalent input noise voltage	$f = 0.1\text{ Hz}$ to $1\text{ Hz}$ $f = 0.1\text{ Hz}$ to $10\text{ Hz}$	25°C		0.7			0.7	$\mu\text{V}$	
		25°C		1.1			1.1		
$I_n$ Equivalent input noise current		25°C		0.6			0.6	$\text{fA}/\sqrt{\text{Hz}}$	
THD + N Total harmonic distortion plus noise	$V_O = 0.5\text{ V}$ to $2.5\text{ V}$ , $f = 20\text{ kHz}$ , $R_L = 50\text{ k}\Omega$ ‡	25°C	$A_V = 1$		0.2%		0.2%		
			$A_V = 10$		1%		1%		
Gain-bandwidth product	$f = 50\text{ kHz}$ , $C_L = 100\text{ pF}$ ‡	$R_L = 50\text{ k}\Omega$ ‡, 25°C	0.2		0.2		MHz		
$B_{OM}$ Maximum output-swing bandwidth	$V_{O(PP)} = 2\text{ V}$ , $R_L = 50\text{ k}\Omega$ ‡, $C_L = 100\text{ pF}$ ‡	$A_V = 1$ , 25°C	30		30		kHz		
$\phi_m$ Phase margin at unity gain	$R_L = 50\text{ k}\Omega$ ‡, $C_L = 100\text{ pF}$ ‡	25°C	63°		63°				
		25°C	15		15		dB		

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

‡ Referenced to  $2.5\text{ V}$

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**TLV2254Q, and TLV2254M electrical characteristics at specified free-air temperature,  $V_{DD} = 3\text{ V}$  (unless otherwise noted)**

PARAMETER	TEST CONDITIONS	$T_A$ †	TLV2254Q, TLV2254M			TLV2254AQ, TLV2254AM			UNIT
			MIN	TYP	MAX	MIN	TYP	MAX	
$V_{IO}$ Input offset voltage		25°C	200	1500		200	850	$\mu\text{V}$	
		Full range		1750		1000			
$\alpha_{VIO}$ Temperature coefficient of input offset voltage		25°C to 125°C	0.5			0.5			$\mu\text{V}/^\circ\text{C}$
Input offset voltage long-term drift (see Note 4)	$V_{DD\pm} = \pm 1.5\text{ V}$ , $V_O = 0$ , $V_{IC} = 0$ , $R_S = 50\ \Omega$	25°C	0.003			0.003			$\mu\text{V}/\text{mo}$
$I_{IO}$ 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		$R_S = 50\ \Omega$ , $ V_{IO}  \leq 5\text{ mV}$	25°C	0 to 2	-0.3 to 2.2		0 to 2	-0.3 to 2.2	V
	Full range		0 to 1.7			0 to 1.7			
$V_{OH}$ High-level output voltage	$I_{OH} = -20\ \mu\text{A}$ $I_{OH} = -75\ \mu\text{A}$ $I_{OH} = -150\ \mu\text{A}$	25°C	2.98			2.98			V
		25°C	2.9			2.9			
		Full range	2.8			2.8			
		25°C	2.8			2.8			
$V_{OL}$ Low-level output voltage	$V_{IC} = 1.5\text{ V}$ , $I_{OL} = 50\ \mu\text{A}$ $I_{OL} = 500\ \mu\text{A}$ $I_{OL} = 1\text{ mA}$	25°C	10			10			mV
		25°C	100	150		100	150		
		Full range	165			165			
		25°C	200	300		200	300		
		Full range	300			300			
$A_{VD}$ Large-signal differential voltage amplification	$V_{IC} = 1.5\text{ V}$ , $V_O = 1\text{ V to }2\text{ V}$	25°C	$R_L = 100\ \text{k}\Omega$ ‡			100 225			V/mV
			Full range			10			
		25°C	$R_L = 1\ \text{M}\Omega$ ‡			800			
$r_{i(d)}$ Differential input resistance		25°C	$10^{12}$			$10^{12}$			$\Omega$
$r_{i(c)}$ Common-mode input resistance		25°C	$10^{12}$			$10^{12}$			$\Omega$
$C_{i(c)}$ Common-mode input capacitance	$f = 10\ \text{kHz}$ , N package	25°C	8			8			pF
$z_o$ Closed-loop output impedance	$f = 25\ \text{kHz}$ , $A_V = 10$	25°C	220			220			$\Omega$
CMRR Common-mode rejection ratio	$V_{IC} = 0\text{ to }1.7\text{ V}$ , $V_O = 1.5\text{ V}$ , $R_S = 50\ \Omega$	25°C	65	75		65	77	dB	
		Full range	60			60			
$k_{SVR}$ Supply voltage rejection ratio ( $\Delta V_{DD}/\Delta V_{IO}$ )	$V_{DD} = 2.7\text{ V to }8\text{ V}$ , $V_{IC} = V_{DD}/2$ , No load	25°C	80	95		80	100	dB	
		Full range	80			80			

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

‡ Referenced to 1.5 V

NOTE 4: Typical values are based on the input offset voltage shift observed through 500 hours of operating life test at  $T_A = 150^\circ\text{C}$  extrapolated to  $T_A = 25^\circ\text{C}$  using the Arrhenius equation and assuming an activation energy of 0.96 eV.



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**TLV2254Q, and TLV2254M electrical characteristics at specified free-air temperature,  $V_{DD} = 3\text{ V}$  (unless otherwise noted) (continued)**

PARAMETER	TEST CONDITIONS	$T_A$ †	TLV2254Q, TLV2254M			TLV2254AQ, TLV2254AM			UNIT
			MIN	TYP	MAX	MIN	TYP	MAX	
$I_{DD}$ Supply current (four amplifiers)	$V_O = 1.5\text{ V}$ , No load	25°C		135	250		135	250	$\mu\text{A}$
		Full range			300			300	

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

**TLV2254Q, and TLV2254M operating characteristics at specified free-air temperature,  $V_{DD} = 3\text{ V}$**

PARAMETER	TEST CONDITIONS	$T_A$ †	TLV2254Q, TLV2254M			TLV2254AQ, TLV2254AM			UNIT
			MIN	TYP	MAX	MIN	TYP	MAX	
SR Slew rate at unity gain	$V_O = 0.5\text{ V}$ to $1.7\text{ V}$ , $R_L = 100\text{ k}\Omega$ ‡, $C_L = 100\text{ pF}$ ‡	25°C	0.07	0.1		0.07	0.1		$\text{V}/\mu\text{s}$
		Full range	0.05			0.05			
$V_n$ Equivalent input noise voltage	$f = 10\text{ Hz}$ $f = 1\text{ kHz}$	25°C		35			35		$\text{nV}/\sqrt{\text{Hz}}$
		25°C		19			19		
$V_{N(PP)}$ Peak-to-peak equivalent input noise voltage	$f = 0.1\text{ Hz}$ to $1\text{ Hz}$ $f = 0.1\text{ Hz}$ to $10\text{ Hz}$	25°C		0.6			0.6		$\mu\text{V}$
		25°C		1.1			1.1		
$I_n$ Equivalent input noise current		25°C		0.6			0.6	$\text{fA}/\sqrt{\text{Hz}}$	
Gain-bandwidth product	$f = 1\text{ kHz}$ , $R_L = 50\text{ k}\Omega$ ‡, $C_L = 100\text{ pF}$ ‡	25°C		0.187			0.187	MHz	
$B_{OM}$ Maximum output-swing bandwidth	$V_{O(PP)} = 1\text{ V}$ , $A_V = 1$ , $R_L = 50\text{ k}\Omega$ ‡, $C_L = 100\text{ pF}$ ‡	25°C		60			60	kHz	
$\phi_m$ Phase margin at unity gain Gain margin	$R_L = 50\text{ k}\Omega$ ‡, $C_L = 100\text{ pF}$ ‡	25°C		63°			63°		
		25°C		15			15	dB	

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

‡ Referenced to  $1.5\text{ V}$

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**TLV2254Q, and TLV2254M electrical characteristics at specified free-air temperature,  $V_{DD} = 5\text{ V}$  (unless otherwise noted)**

PARAMETER	TEST CONDITIONS	$T_A$ †	TLV2254Q, TLV2254M			TLV2254AQ, TLV2254AM			UNIT
			MIN	TYP	MAX	MIN	TYP	MAX	
$V_{IO}$ Input offset voltage	$V_{DD} = \pm 2.5\text{ V}$ , $V_O = 0$ , $V_{IC} = 0$ , $R_S = 50\ \Omega$	25°C	200	1500		200	850	$\mu\text{V}$	
		Full range		1750		1000			
$\alpha_{VIO}$ Temperature coefficient of input offset voltage		25°C to 125°C	0.5			0.5		$\mu\text{V}/^\circ\text{C}$	
Input offset voltage long-term drift (see Note 4)		25°C	0.003			0.003		$\mu\text{V}/\text{mo}$	
$I_{IO}$ Input offset current		25°C	0.5	60		0.5	60	$\text{pA}$	
		125°C		1000		1000			
$I_{IB}$ Input bias current	25°C	1	60		1	60	$\text{pA}$		
	125°C		1000		1000				
$V_{ICR}$ Common-mode input voltage range	$ V_{IO}  \leq 5\text{ mV}$ , $R_S = 50\ \Omega$	25°C	0 to 4	-0.3 to 4.2		0 to 4	-0.3 to 4.2	V	
		Full range	0 to 3.5			0 to 3.5			
$V_{OH}$ High-level output voltage	$I_{OH} = -20\ \mu\text{A}$ $I_{OH} = -75\ \mu\text{A}$ $I_{OH} = -150\ \mu\text{A}$	25°C	4.98			4.98		V	
		25°C	4.9	4.94		4.9	4.94		
		Full range	4.8			4.8			
		25°C	4.8	4.88		4.8	4.88		
$V_{OL}$ Low-level output voltage	$V_{IC} = 2.5\text{ V}$ , $I_{OL} = 50\ \mu\text{A}$ $I_{OL} = 500\ \mu\text{A}$ $I_{OL} = 1\text{ mA}$	25°C	0.01			0.01		V	
		25°C	0.09	0.15		0.09	0.15		
		Full range		0.15			0.15		
		25°C	0.2	0.3		0.2	0.3		
		Full range		0.3			0.3		
$A_{VD}$ Large-signal differential voltage amplification	$V_{IC} = 2.5\text{ V}$ , $V_O = 1\text{ V to }4\text{ V}$	$R_L = 100\text{ k}\Omega$ ‡	25°C	100	350		100	350	V/mV
			Full range	10			10		
		$R_L = 1\text{ M}\Omega$ ‡	25°C	1700			1700		
$r_{i(d)}$ Differential input resistance		25°C	10 <sup>12</sup>			10 <sup>12</sup>	$\Omega$		
$r_{i(c)}$ Common-mode input resistance		25°C	10 <sup>12</sup>			10 <sup>12</sup>	$\Omega$		
$c_{i(c)}$ Common-mode input capacitance	$f = 10\text{ kHz}$ , N package	25°C	8			8	pF		
$z_o$ Closed-loop output impedance	$f = 25\text{ kHz}$ , $A_V = 10$	25°C	200			200	$\Omega$		
CMRR Common-mode rejection ratio	$V_{IC} = 0\text{ to }2.7\text{ V}$ , $V_O = 2.5\text{ V}$ , $R_S = 50\ \Omega$	25°C	70	83		70	83	dB	
		Full range	70			70			
$k_{SVR}$ Supply voltage rejection ratio ( $\Delta V_{DD}/\Delta V_{IO}$ )	$V_{DD} = 4.4\text{ V to }8\text{ V}$ , $V_{IC} = V_{DD}/2$ , No load	25°C	80	95		80	95	dB	
		Full range	80			80			

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

‡ 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  $T_A = 150^\circ\text{C}$  extrapolated to  $T_A = 25^\circ\text{C}$  using the Arrhenius equation and assuming an activation energy of 0.96 eV.



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**TLV2254Q, and TLV2254M electrical characteristics at specified free-air temperature,  $V_{DD} = 5\text{ V}$  (unless otherwise noted) (continued)**

PARAMETER	TEST CONDITIONS	$T_A$ †	TLV2254Q, TLV2254M			TLV2254AQ, TLV2254AM			UNIT
			MIN	TYP	MAX	MIN	TYP	MAX	
$I_{DD}$ Supply current (four amplifiers)	$V_O = 2.5\text{ V}$ , No load	25°C		140	250		140	250	$\mu\text{A}$
		Full range			300			300	

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

**TLV2254Q, and TLV2254M operating characteristics at specified free-air temperature,  $V_{DD} = 5\text{ V}$**

PARAMETER	TEST CONDITIONS	$T_A$ †	TLV2254Q, TLV2254M			TLV2254AQ, TLV2254AM			UNIT
			MIN	TYP	MAX	MIN	TYP	MAX	
SR Slew rate at unity gain	$V_O = 0.5\text{ V}$ to $3.5\text{ V}$ , $R_L = 100\text{ k}\Omega$ ‡, $C_L = 100\text{ pF}$ ‡	25°C	0.07	0.12		0.07	0.12		$\text{V}/\mu\text{s}$
		Full range	0.05			0.05			
$V_n$ Equivalent input noise voltage	$f = 10\text{ Hz}$ $f = 1\text{ kHz}$	25°C		36			36		$\text{nV}/\sqrt{\text{Hz}}$
		25°C		19			19		
$V_{N(PP)}$ Peak-to-peak equivalent input noise voltage	$f = 0.1\text{ Hz}$ to $1\text{ Hz}$ $f = 0.1\text{ Hz}$ to $10\text{ Hz}$	25°C		0.7			0.7		$\mu\text{V}$
		25°C		1.1			1.1		
$I_n$ Equivalent input noise current		25°C		0.6			0.6	$\text{fA}/\sqrt{\text{Hz}}$	
THD + N Total harmonic distortion plus noise	$V_O = 0.5\text{ V}$ to $2.5\text{ V}$ , $f = 20\text{ kHz}$ , $R_L = 50\text{ k}\Omega$ ‡	25°C	$A_V = 1$		0.2%		0.2%		
			$A_V = 10$		1%		1%		
Gain-bandwidth product	$f = 50\text{ kHz}$ , $C_L = 100\text{ pF}$ ‡	$R_L = 50\text{ k}\Omega$ ‡,	25°C		0.2		0.2	MHz	
$B_{OM}$ Maximum output-swing bandwidth	$V_{O(PP)} = 2\text{ V}$ , $R_L = 50\text{ k}\Omega$ ‡,	$A_V = 1$ , $C_L = 100\text{ pF}$ ‡	25°C		30		30	kHz	
$\phi_m$ Phase margin at unity gain Gain margin	$R_L = 50\text{ k}\Omega$ ‡,	$C_L = 100\text{ pF}$ ‡	25°C		63°		63°		dB
			25°C		15		15		

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

‡ Referenced to 2.5 V

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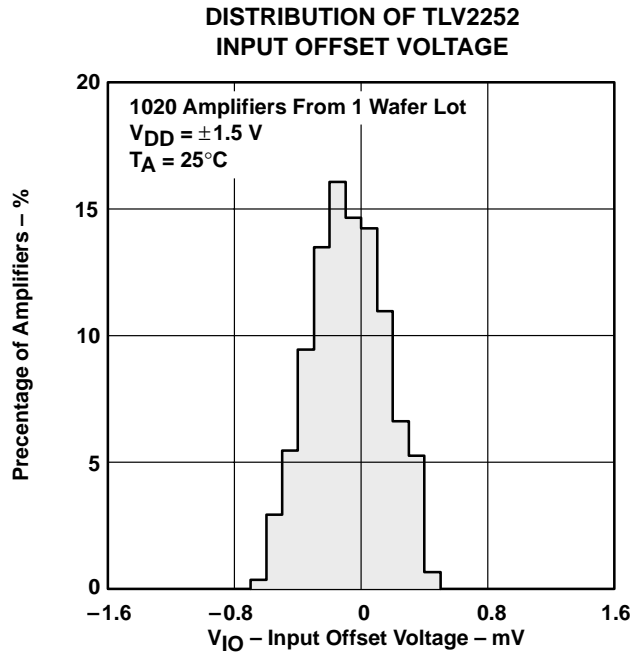
**TYPICAL CHARACTERISTICS**

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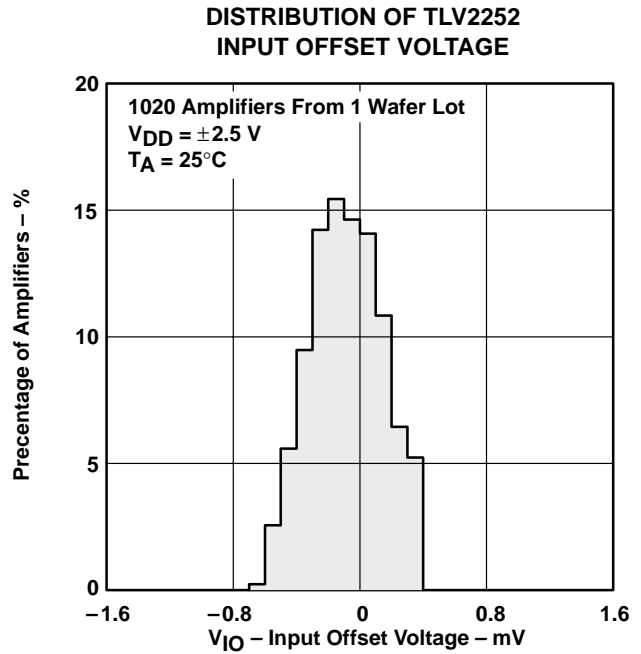
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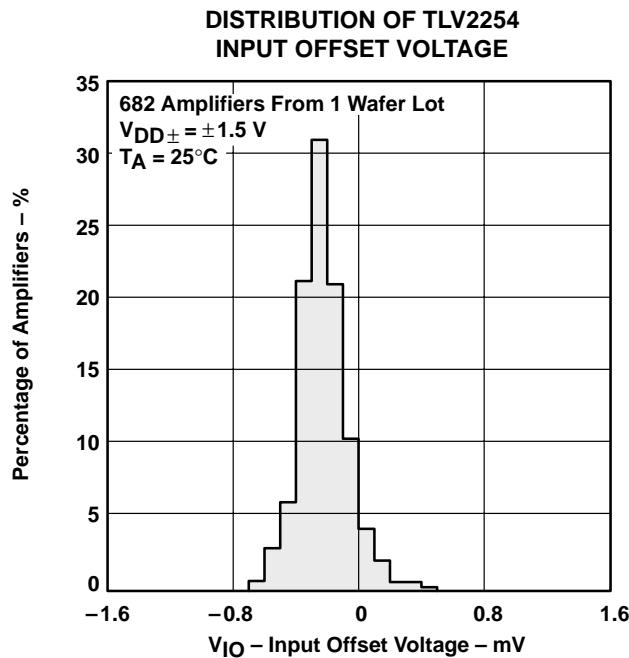
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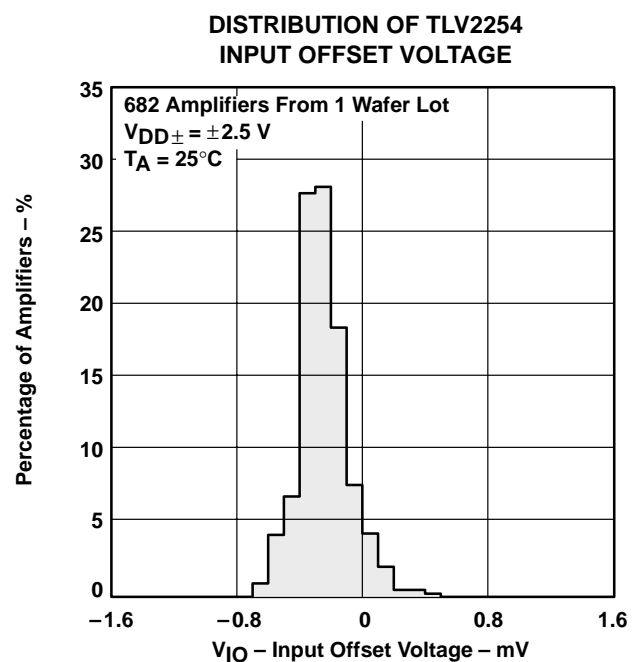
**Figure 2**



**Figure 3**



**Figure 4**

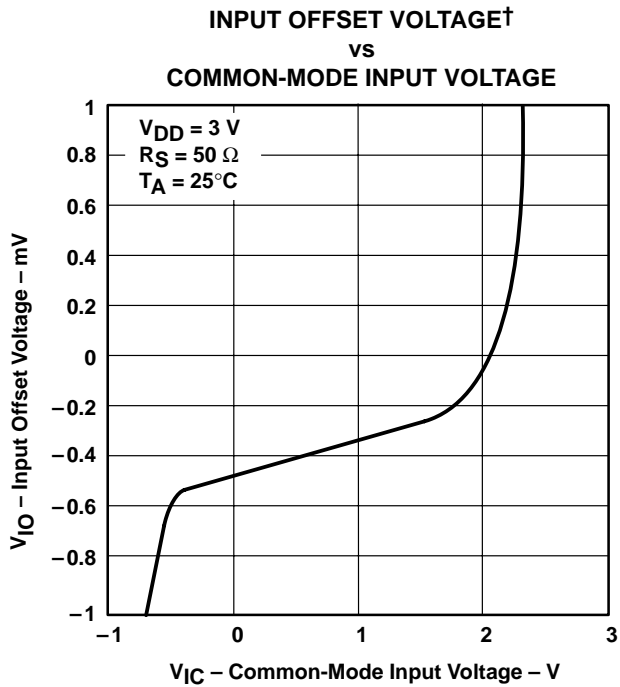


**Figure 5**

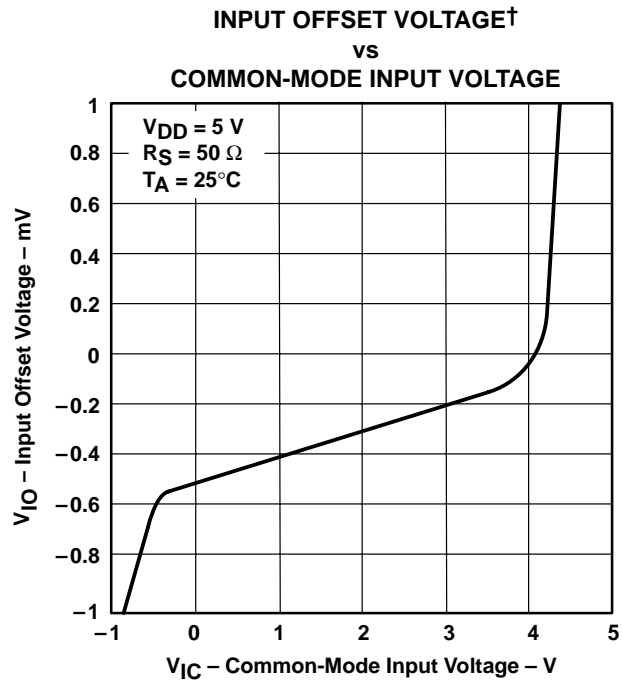
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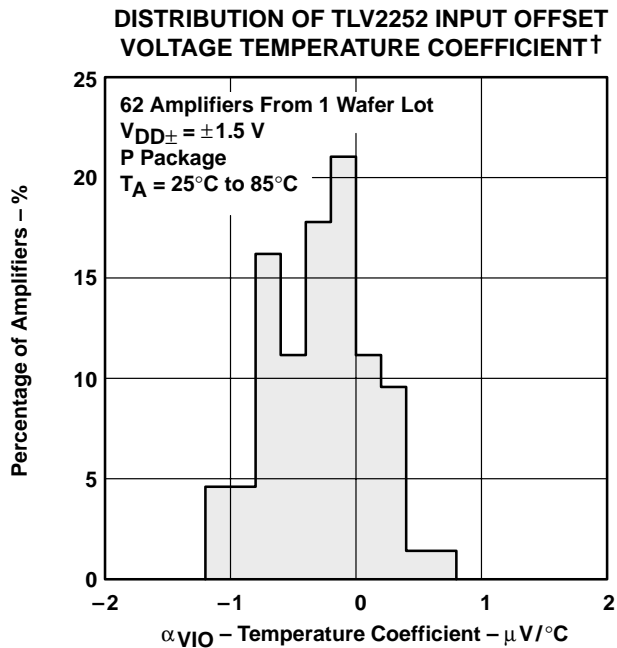
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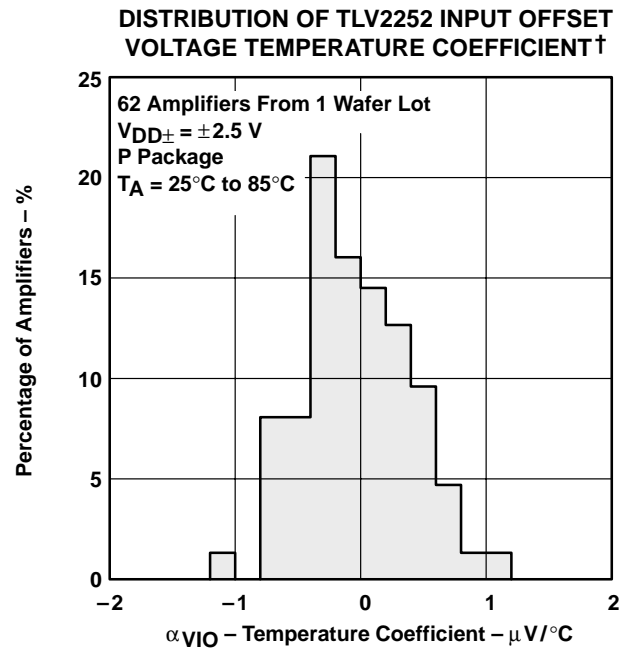
**Figure 6**



**Figure 7**



**Figure 8**



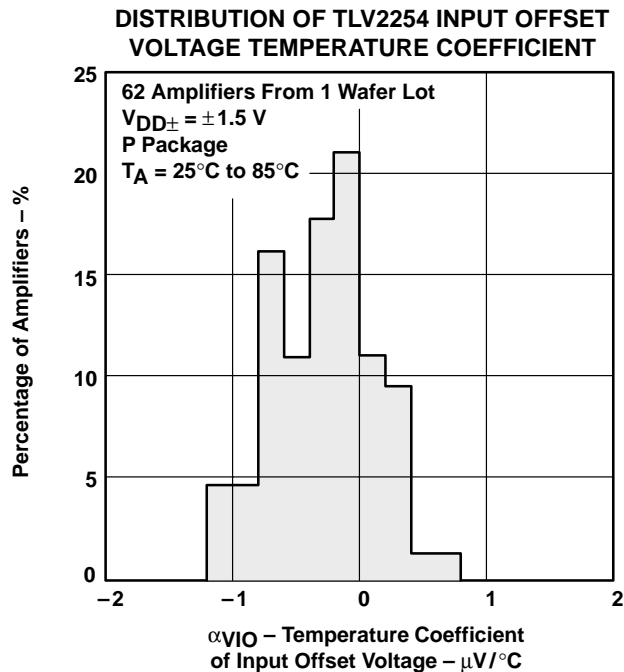
**Figure 9**

† For all curves where  $V_{DD} = 5\text{ V}$ , all loads are referenced to 2.5 V. For all curves where  $V_{DD} = 3\text{ V}$ , all loads are referenced to 1.5 V.

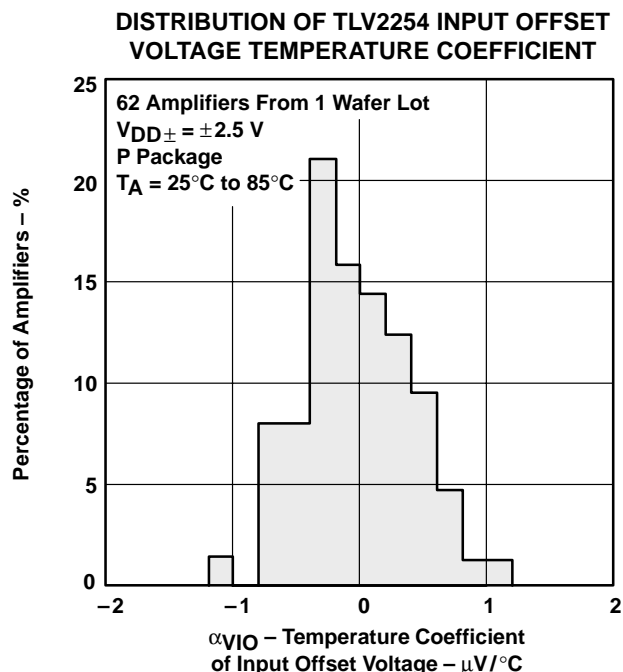




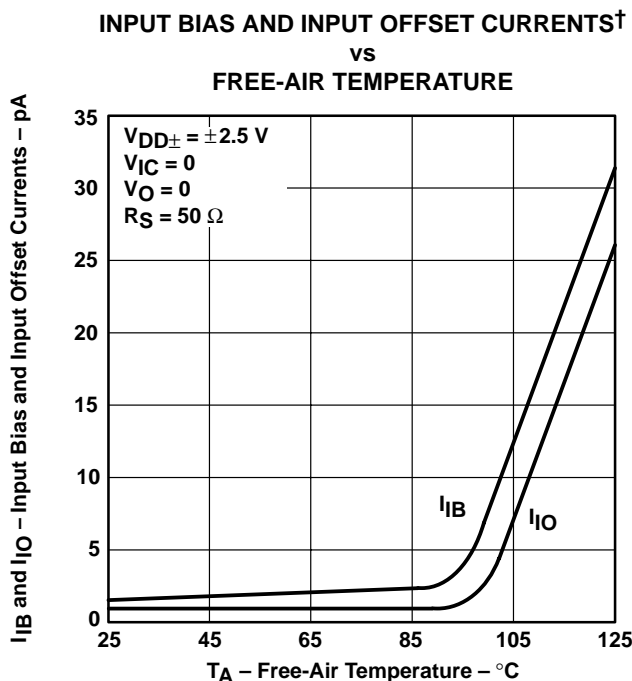
**TYPICAL CHARACTERISTICS**



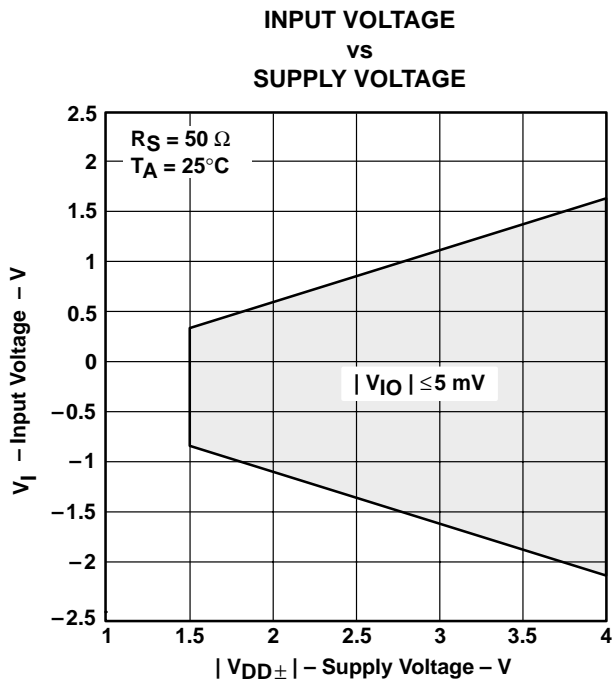
**Figure 10**



**Figure 11**



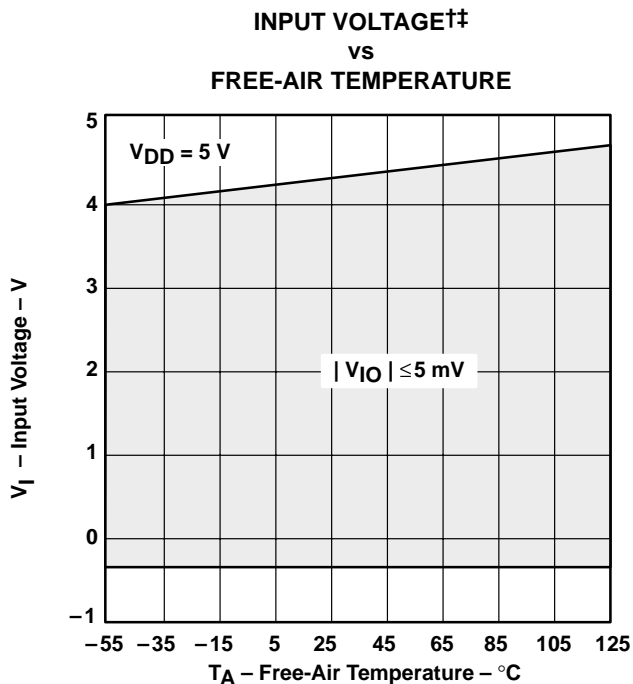
**Figure 12**



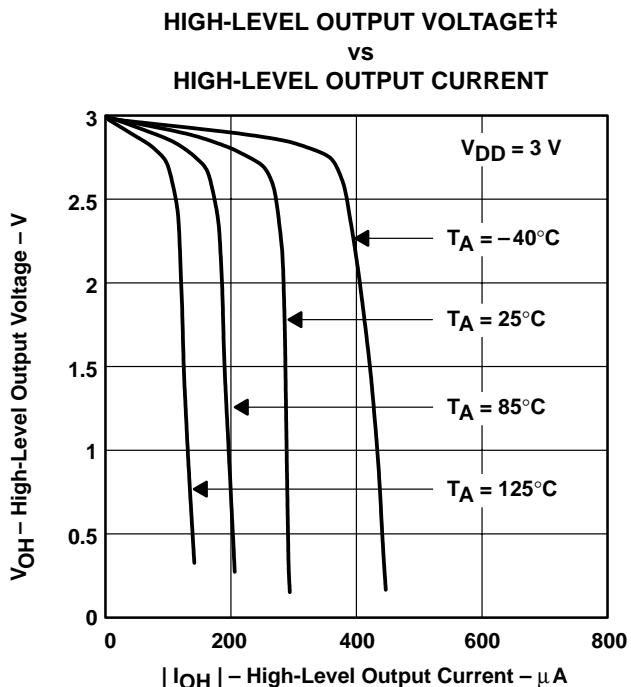
**Figure 13**

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

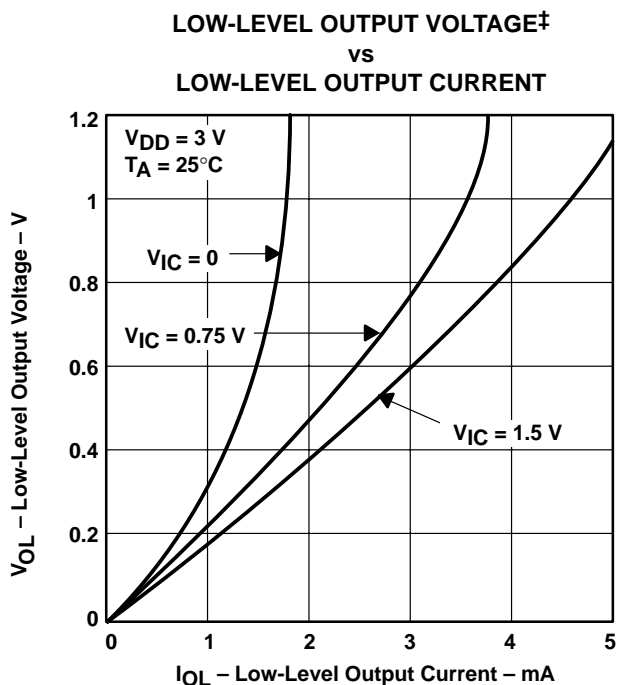
**TYPICAL CHARACTERISTICS**



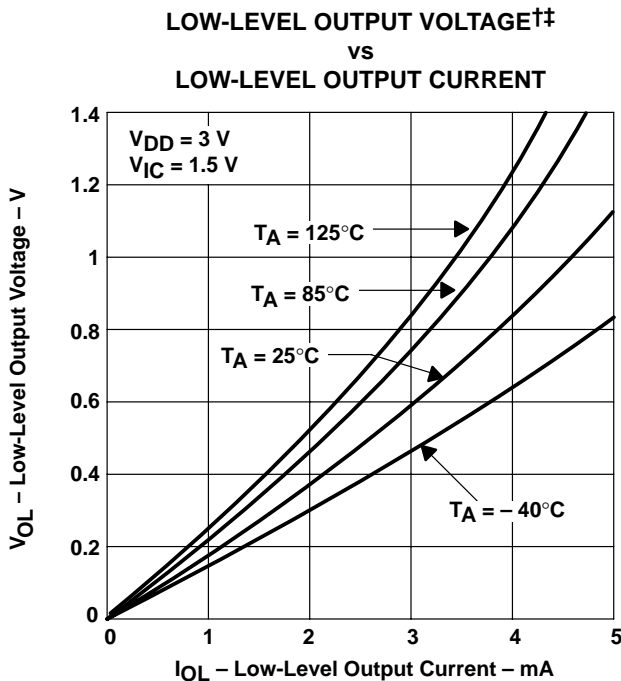
**Figure 14**



**Figure 15**



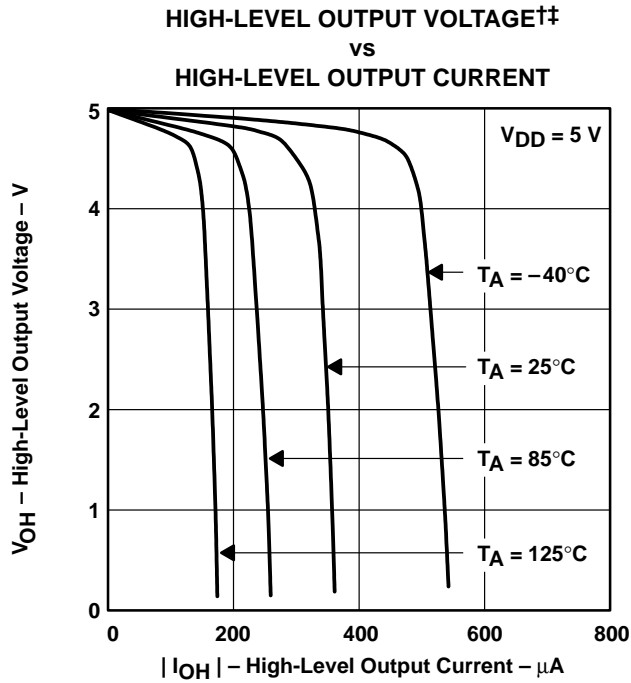
**Figure 16**



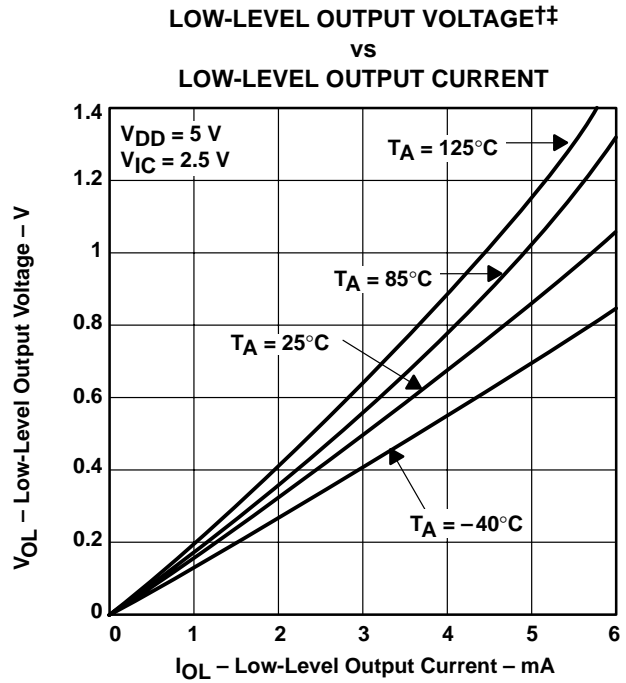
**Figure 17**

† Data at high and low temperatures are applicable only within the rated operating free-air temperature ranges of the various devices.  
 ‡ For all curves where  $V_{DD} = 5\text{ V}$ , all loads are referenced to 2.5 V. For all curves where  $V_{DD} = 3\text{ V}$ , all loads are referenced to 1.5 V.

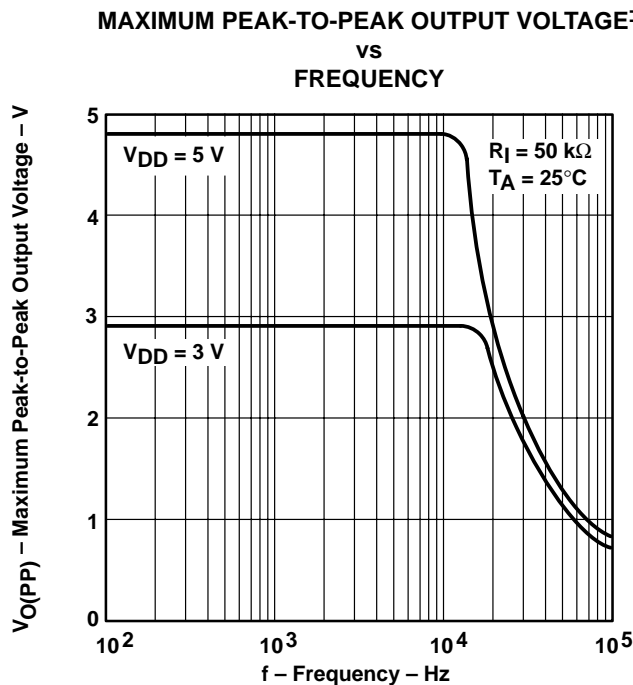
**TYPICAL CHARACTERISTICS**



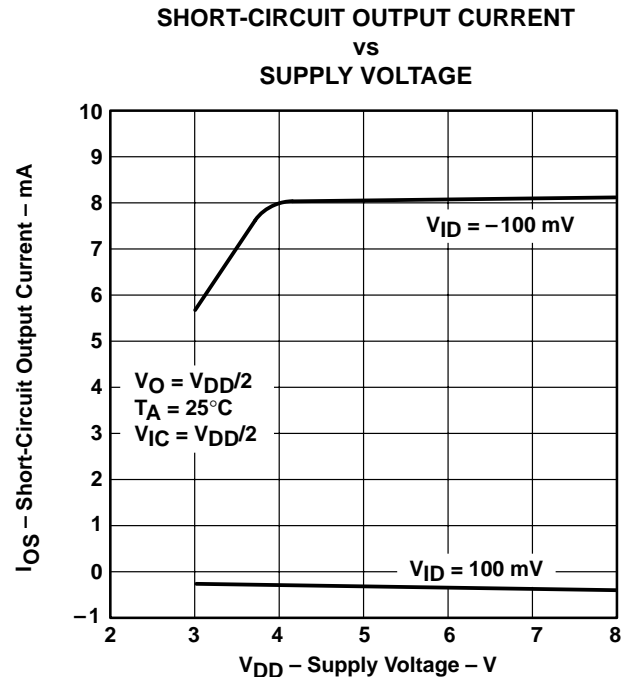
**Figure 18**



**Figure 19**



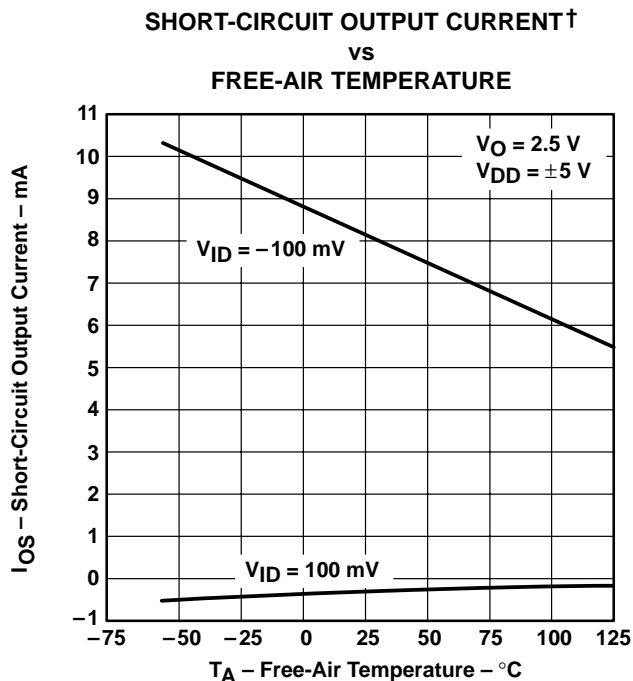
**Figure 20**



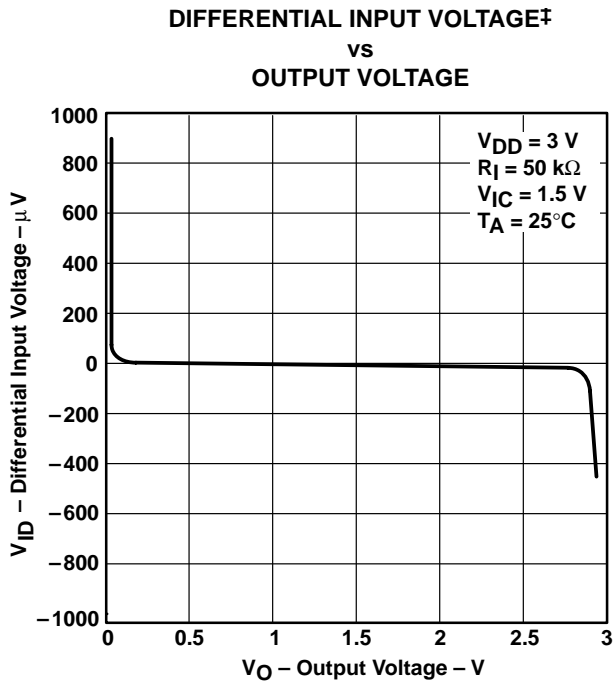
**Figure 21**

† Data at high and low temperatures are applicable only within the rated operating free-air temperature ranges of the various devices.  
 ‡ For all curves where  $V_{DD} = 5\text{ V}$ , all loads are referenced to 2.5 V. For all curves where  $V_{DD} = 3\text{ V}$ , all loads are referenced to 1.5 V.

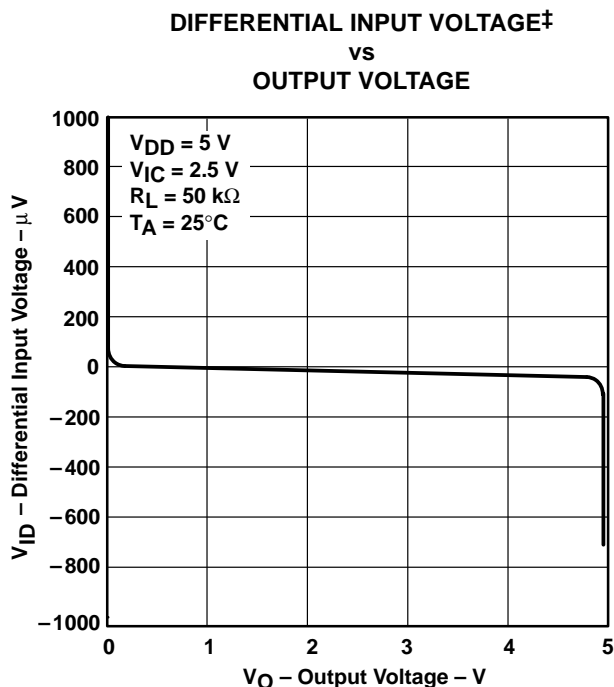
**TYPICAL CHARACTERISTICS**



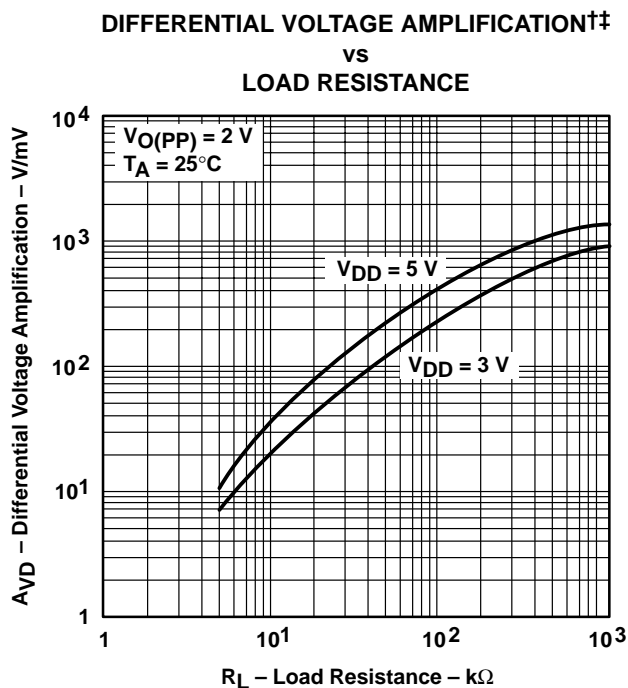
**Figure 22**



**Figure 23**



**Figure 24**

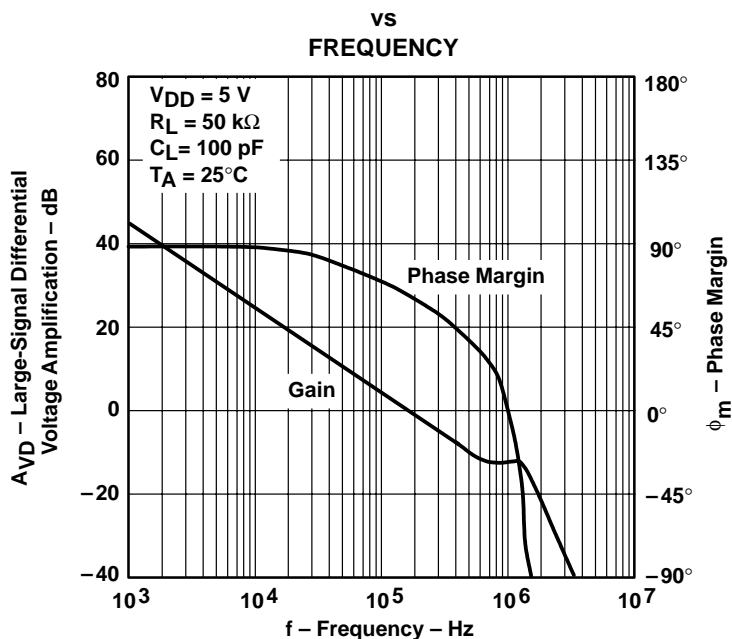


**Figure 25**

† Data at high and low temperatures are applicable only within the rated operating free-air temperature ranges of the various devices.  
 ‡ For all curves where  $V_{DD} = 5\text{ V}$ , all loads are referenced to 2.5 V. For all curves where  $V_{DD} = 3\text{ V}$ , all loads are referenced to 1.5 V.

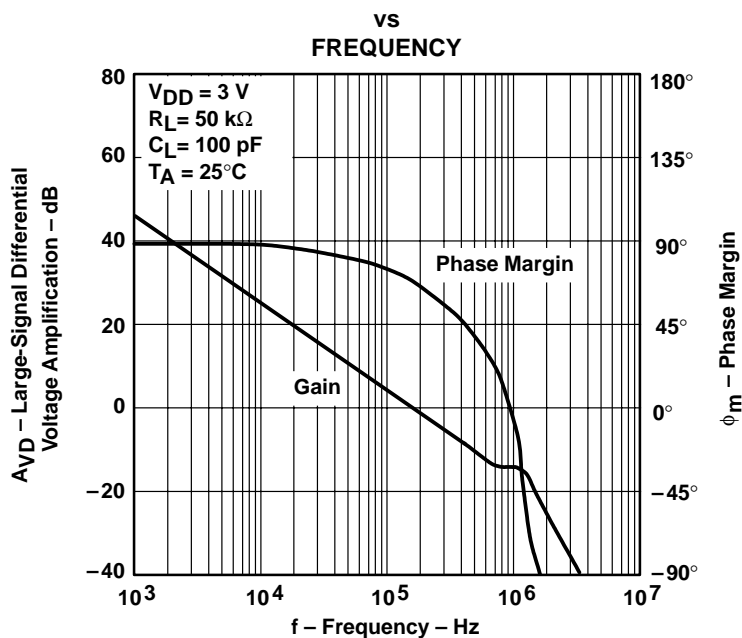
**TYPICAL CHARACTERISTICS**

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



**Figure 26**

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



**Figure 27**

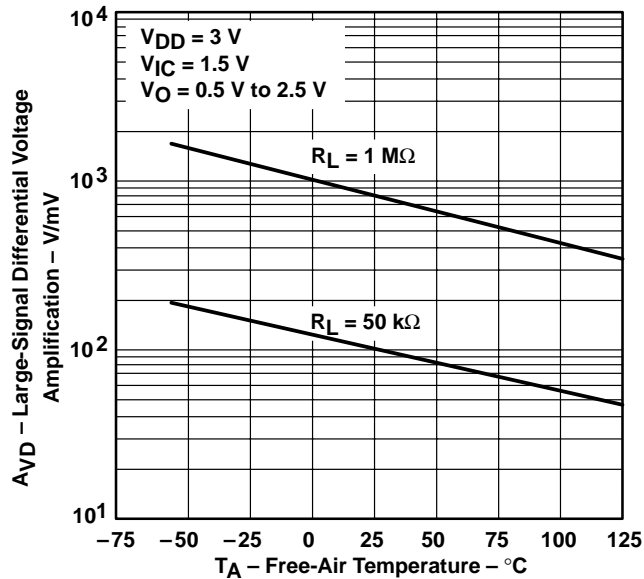
† For all curves where  $V_{DD} = 5\text{ V}$ , all loads are referenced to 2.5 V. For all curves where  $V_{DD} = 3\text{ V}$ , all loads are referenced to 1.5 V.

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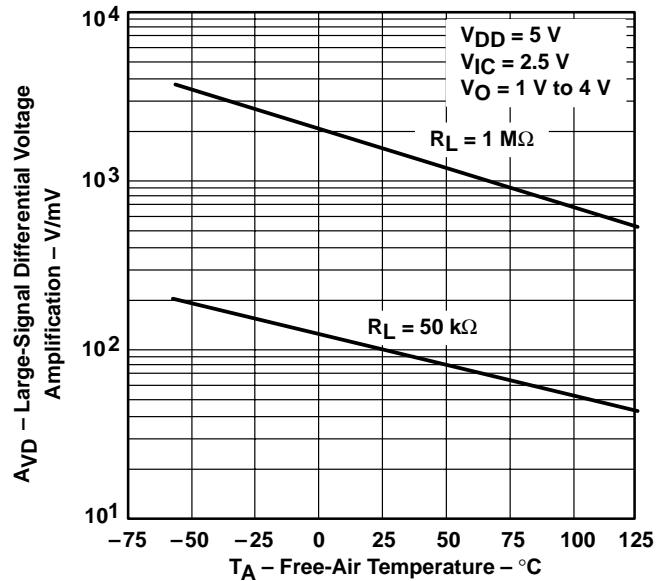
**TYPICAL CHARACTERISTICS**

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



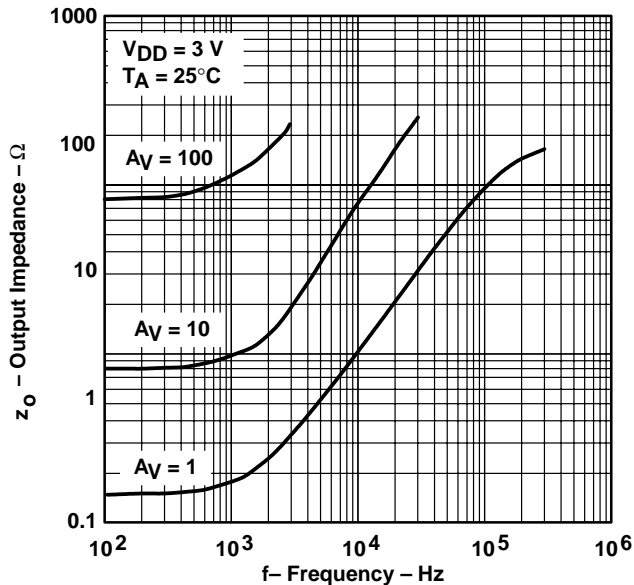
**Figure 28**

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



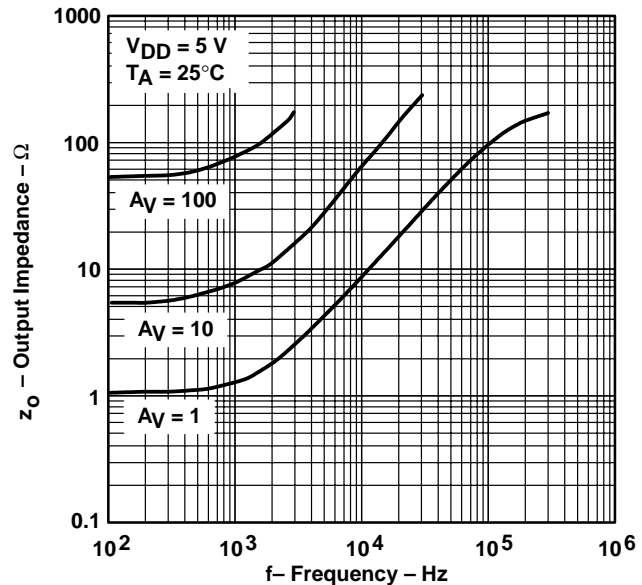
**Figure 29**

**OUTPUT IMPEDANCE†  
 vs  
 FREQUENCY**



**Figure 30**

**OUTPUT IMPEDANCE†  
 vs  
 FREQUENCY**



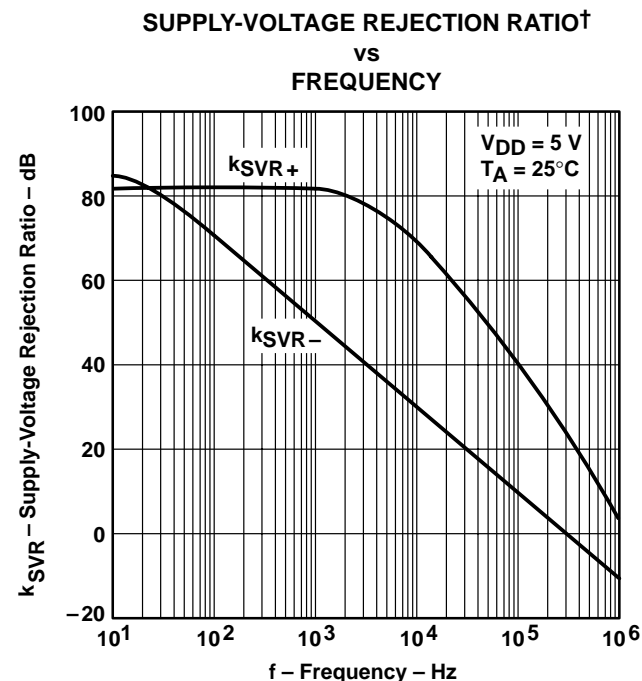
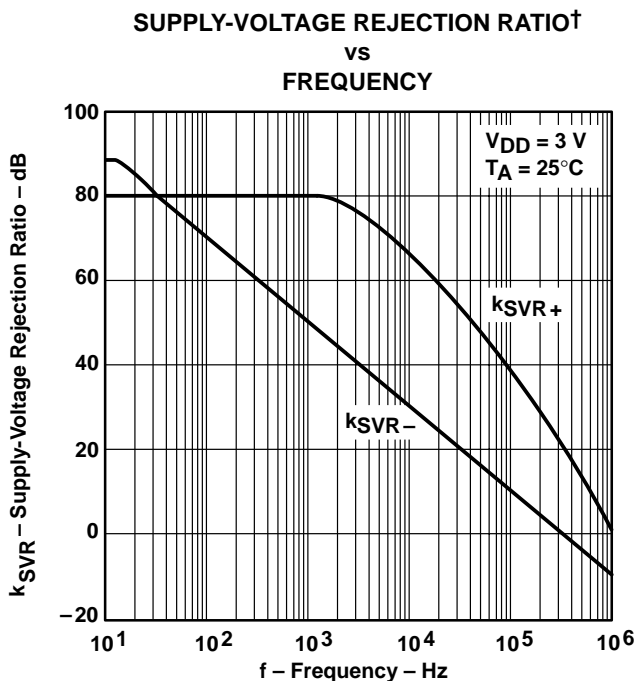
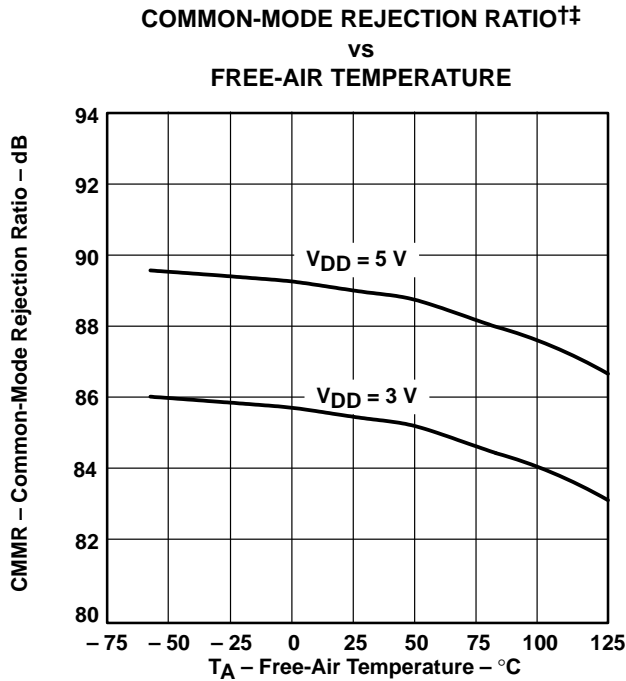
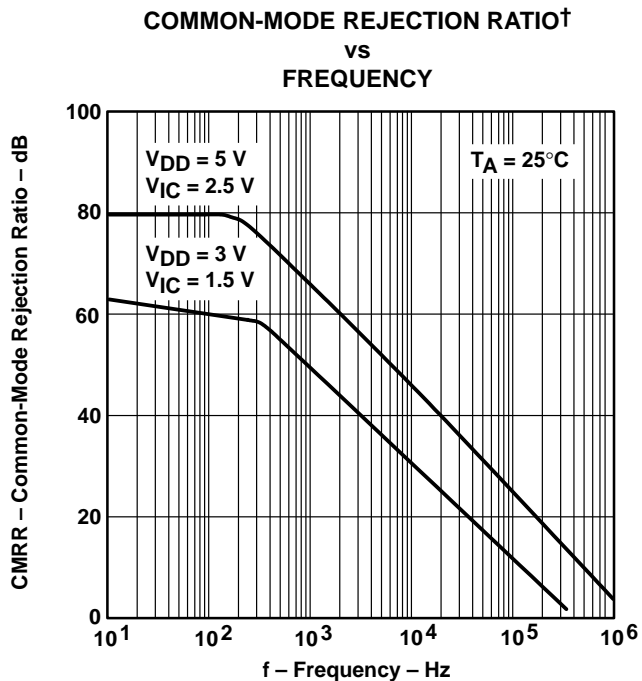
**Figure 31**

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

‡ For all curves where  $V_{DD} = 5\text{ V}$ , all loads are referenced to 2.5 V. For all curves where  $V_{DD} = 3\text{ V}$ , all loads are referenced to 1.5 V.



**TYPICAL CHARACTERISTICS**



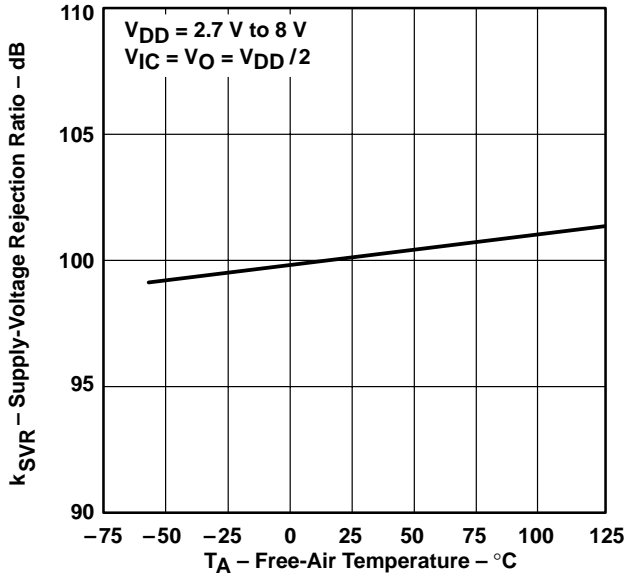
† For all curves where  $V_{DD} = 5\text{ V}$ , all loads are referenced to 2.5 V. For all curves where  $V_{DD} = 3\text{ V}$ , all loads are referenced to 1.5 V.  
 †† Data at high and low temperatures are applicable only within the rated operating free-air temperature ranges of the various devices.

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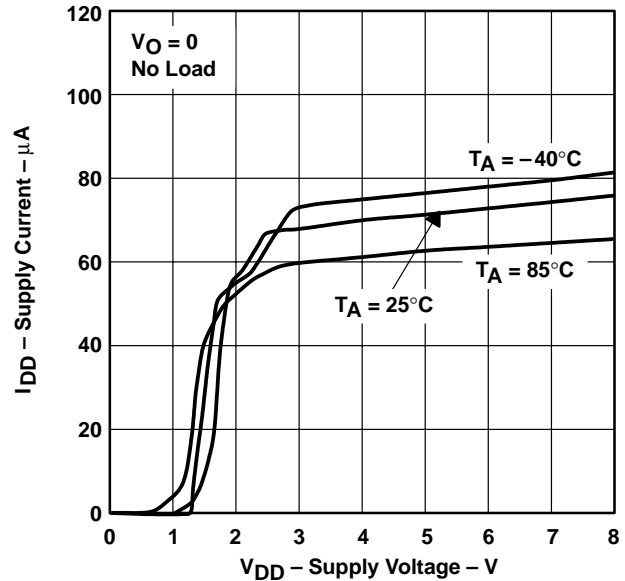
**TYPICAL CHARACTERISTICS**

**SUPPLY-VOLTAGE REJECTION RATIO†**  
**vs**  
**FREE-AIR TEMPERATURE**



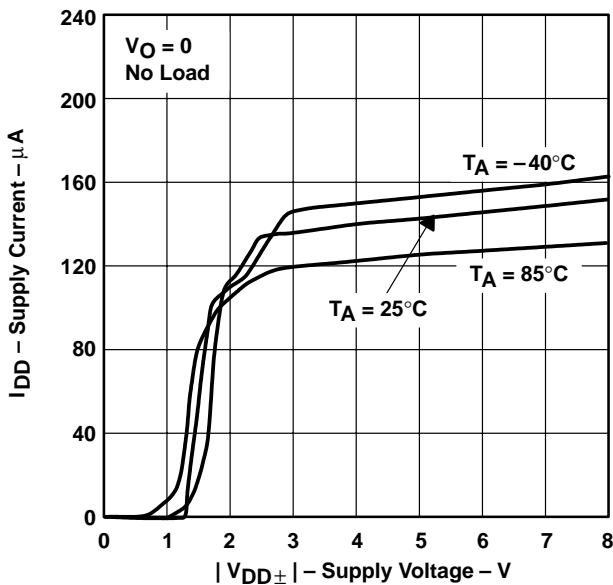
**Figure 36**

**TLV2252**  
**SUPPLY CURRENT†**  
**vs**  
**SUPPLY VOLTAGE**



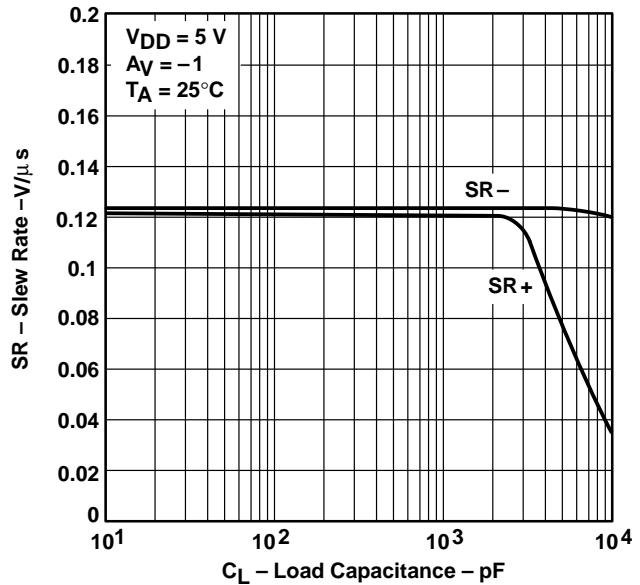
**Figure 37**

**TLV2254**  
**SUPPLY CURRENT†**  
**vs**  
**SUPPLY VOLTAGE**



**Figure 38**

**SLEW RATE‡**  
**vs**  
**LOAD CAPACITANCE**



**Figure 39**

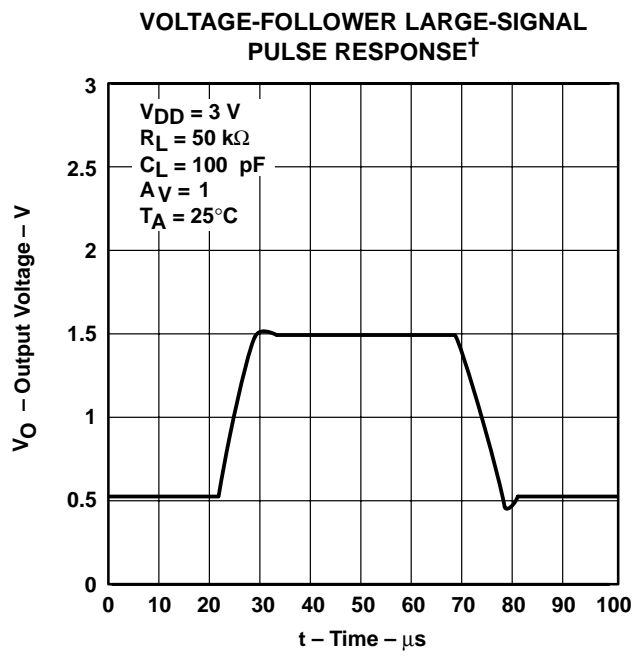
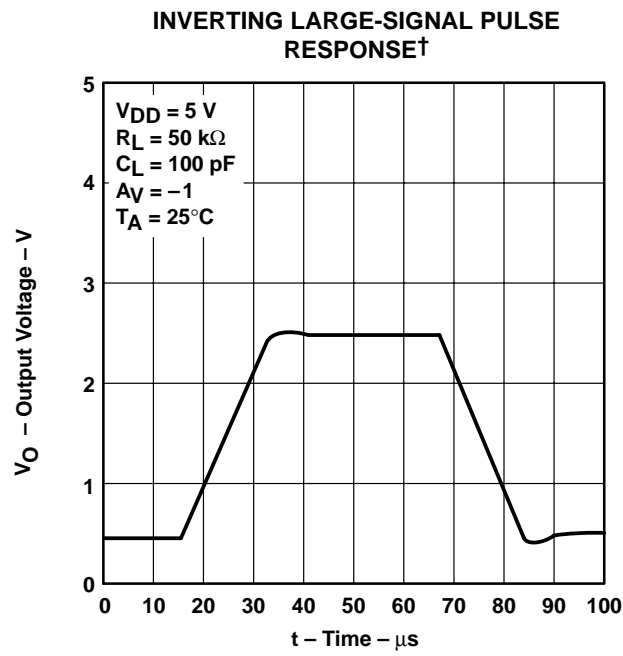
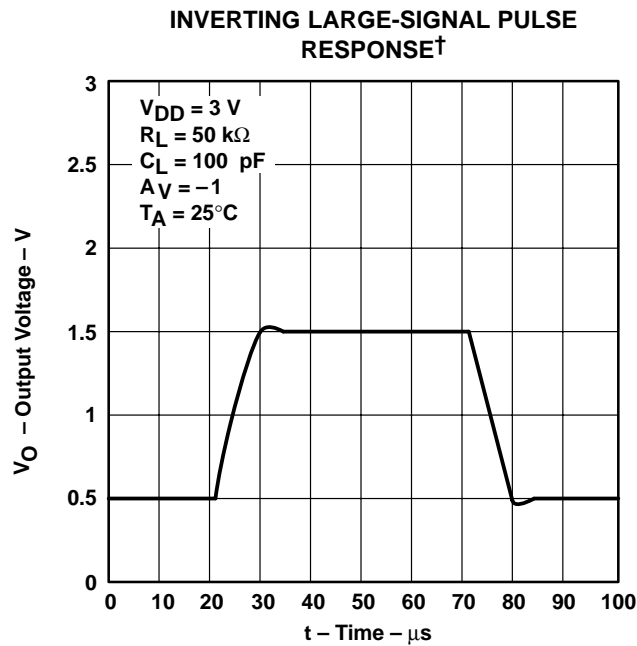
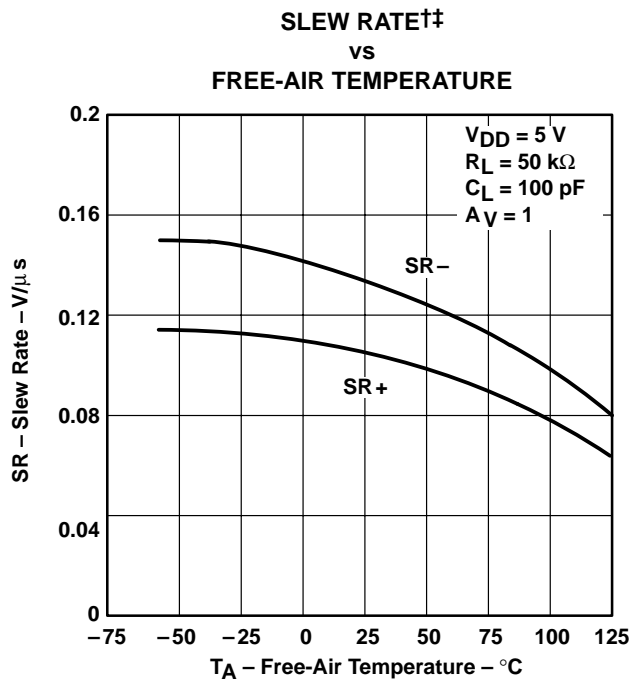
† Data at high and low temperatures are applicable only within the rated operating free-air temperature ranges of the various devices.

‡ For all curves where  $V_{DD} = 5$  V, all loads are referenced to 2.5 V. For all curves where  $V_{DD} = 3$  V, all loads are referenced to 1.5 V.





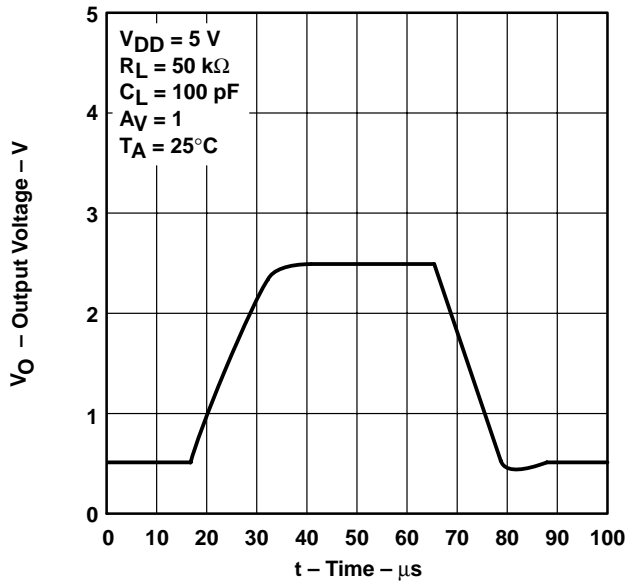
**TYPICAL CHARACTERISTICS**



† Data at high and low temperatures are applicable only within the rated operating free-air temperature ranges of the various devices.  
 ‡ For all curves where  $V_{DD} = 5\text{ V}$ , all loads are referenced to 2.5 V. For all curves where  $V_{DD} = 3\text{ V}$ , all loads are referenced to 1.5 V.

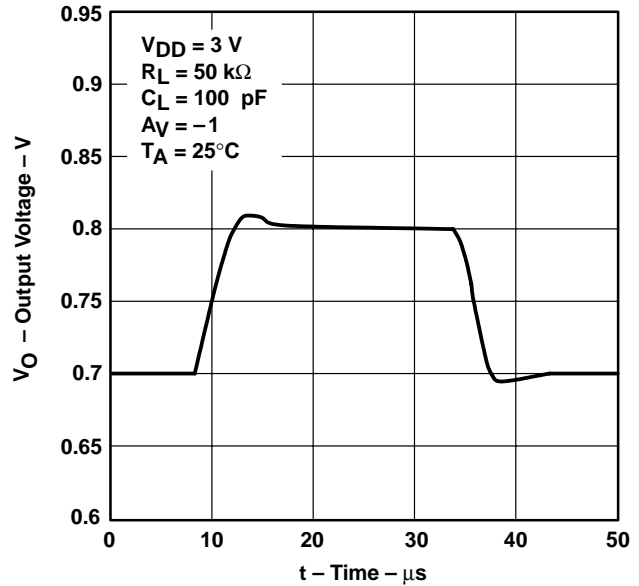
**TYPICAL CHARACTERISTICS**

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



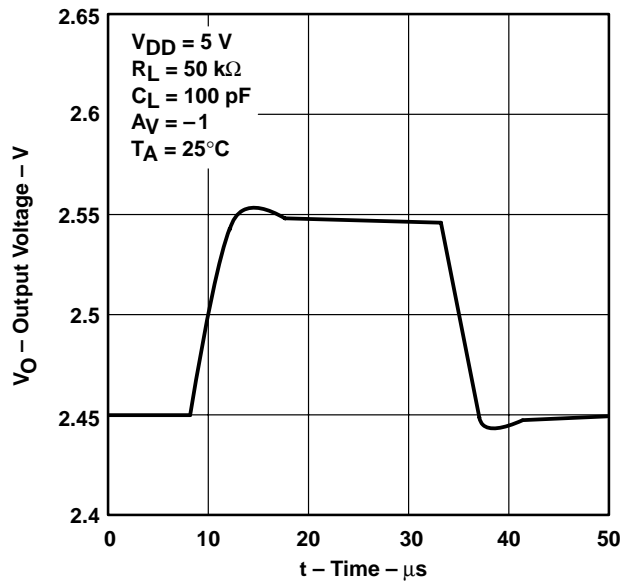
**Figure 44**

**INVERTING SMALL-SIGNAL PULSE RESPONSE†**



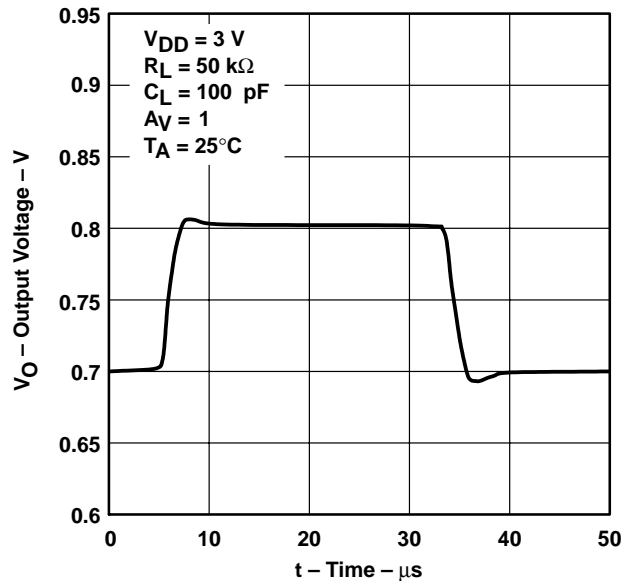
**Figure 45**

**INVERTING SMALL-SIGNAL PULSE RESPONSE†**



**Figure 46**

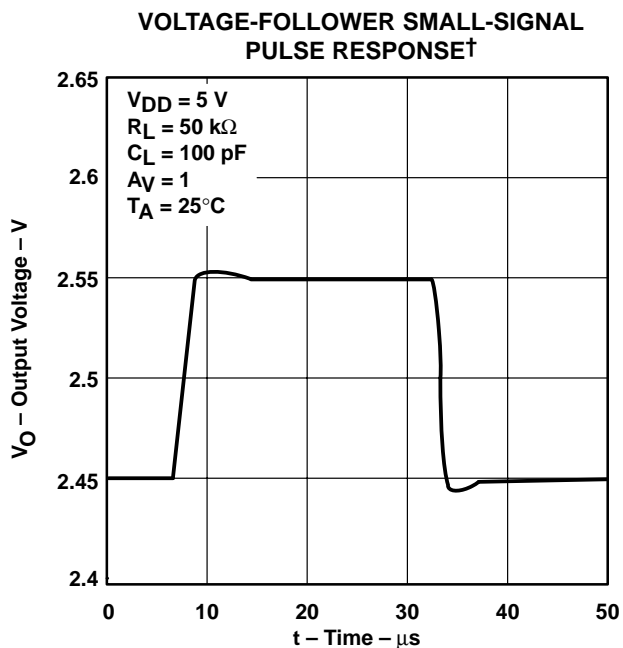
**VOLTAGE-FOLLOWER SMALL-SIGNAL PULSE RESPONSE†**



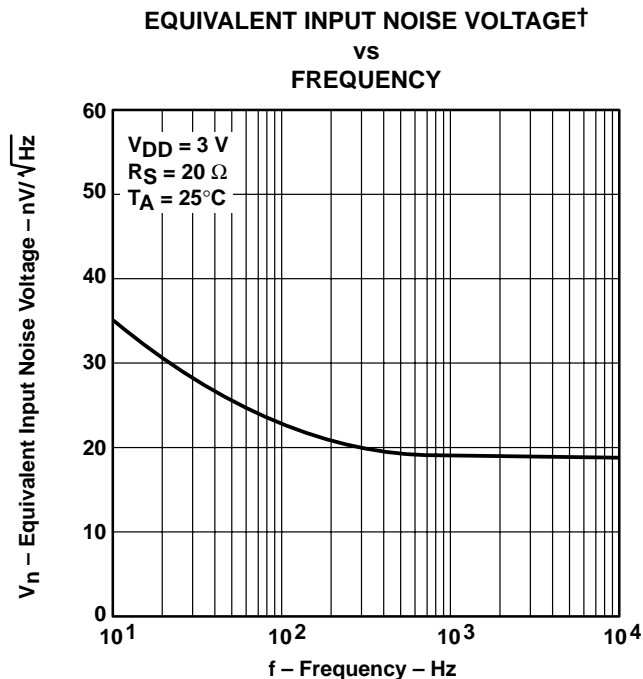
**Figure 47**

† For all curves where  $V_{DD} = 5\text{ V}$ , all loads are referenced to 2.5 V. For all curves where  $V_{DD} = 3\text{ V}$ , all loads are referenced to 1.5 V.

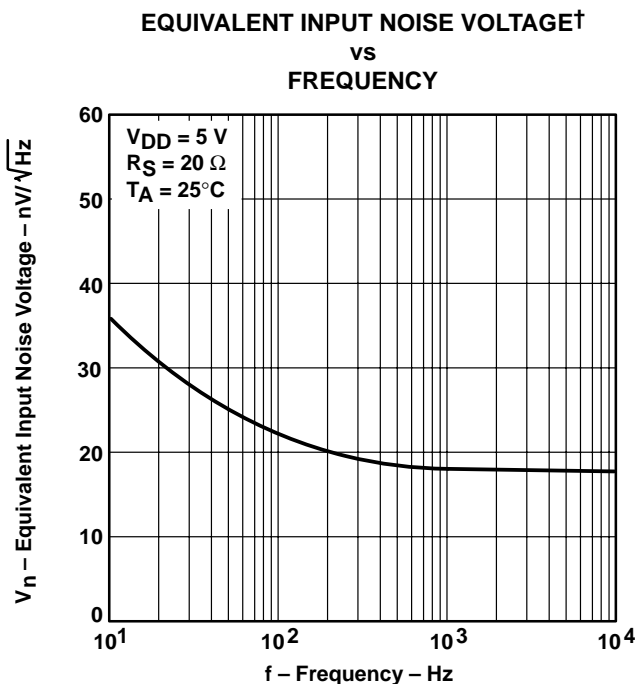
**TYPICAL CHARACTERISTICS**



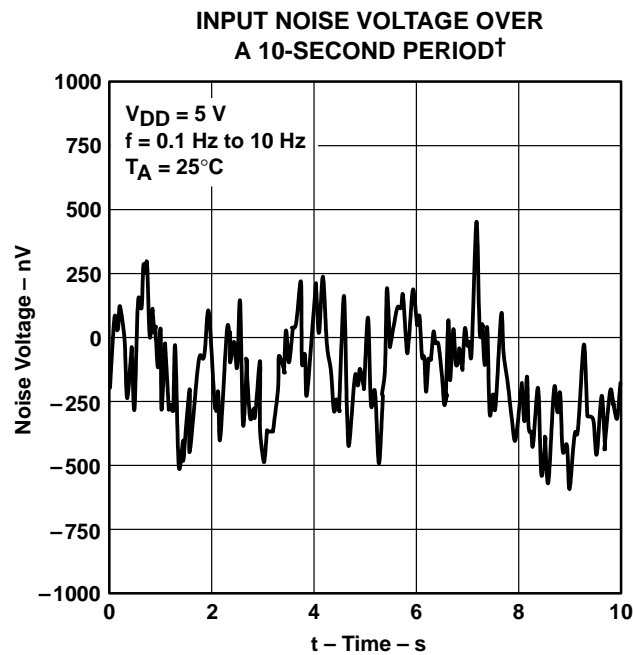
**Figure 48**



**Figure 49**



**Figure 50**



**Figure 51**

† For all curves where  $V_{DD} = 5\text{ V}$ , all loads are referenced to 2.5 V. For all curves where  $V_{DD} = 3\text{ V}$ , all loads are referenced to 1.5 V.

TYPICAL CHARACTERISTICS

INTEGRATED NOISE VOLTAGE†  
 vs  
 FREQUENCY

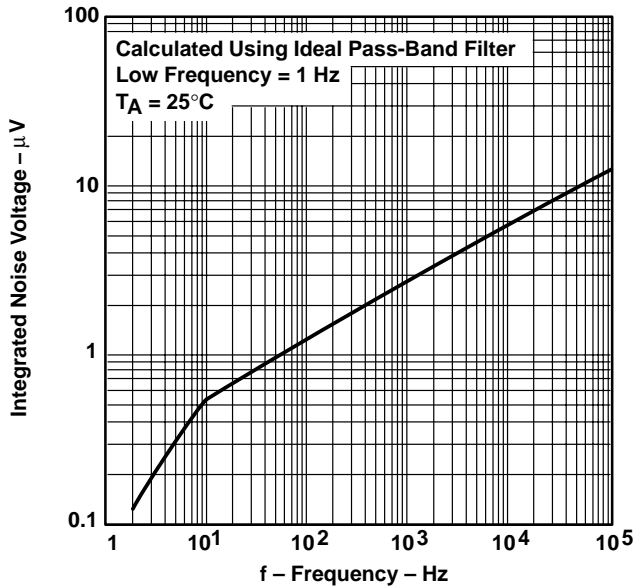


Figure 52

TOTAL HARMONIC DISTORTION PLUS NOISE†  
 vs  
 FREQUENCY

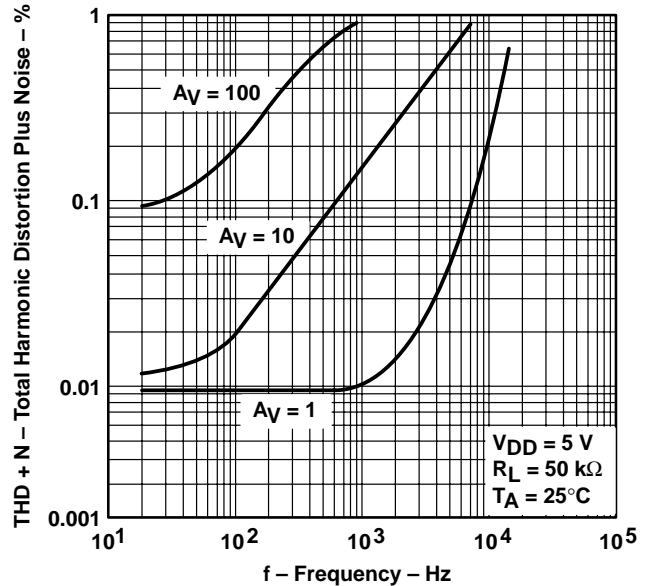


Figure 53

GAIN-BANDWIDTH PRODUCT  
 vs  
 SUPPLY VOLTAGE

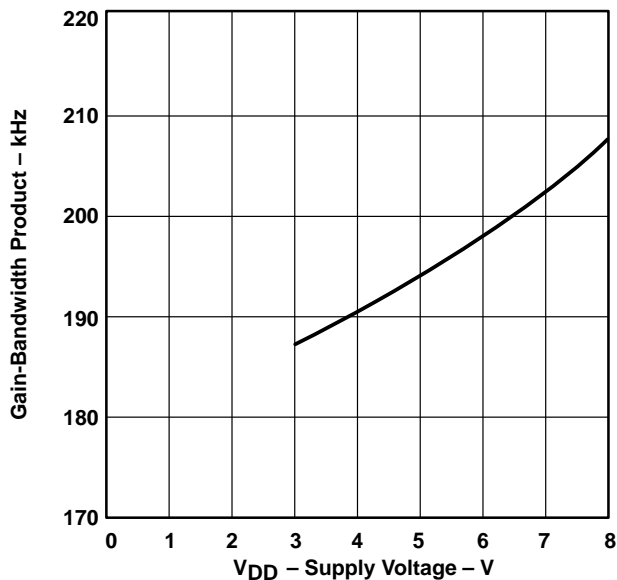


Figure 54

GAIN-BANDWIDTH PRODUCT†  
 vs  
 FREE-AIR TEMPERATURE

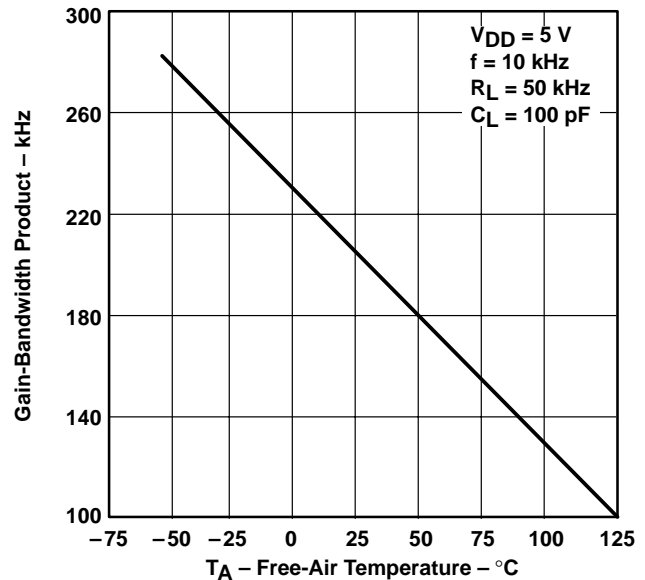
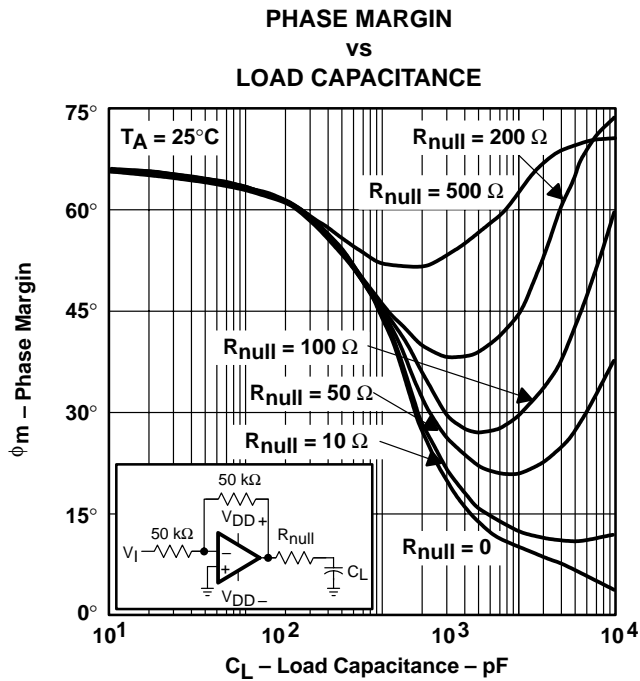


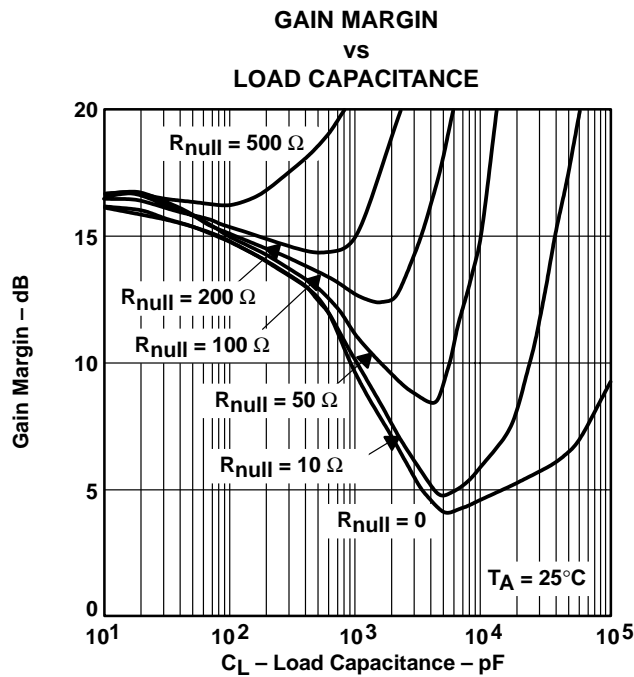
Figure 55

† For all curves where  $V_{DD} = 5\text{ V}$ , all loads are referenced to 2.5 V. For all curves where  $V_{DD} = 3\text{ V}$ , all loads are referenced to 1.5 V.

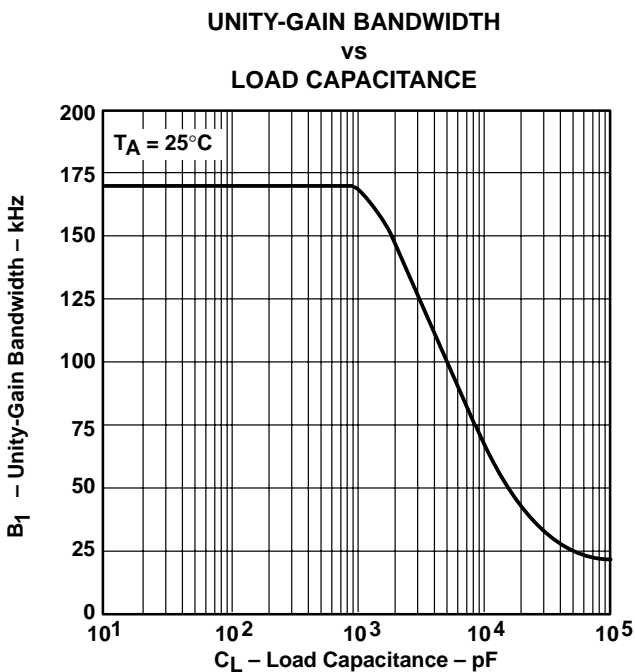
**TYPICAL CHARACTERISTICS**



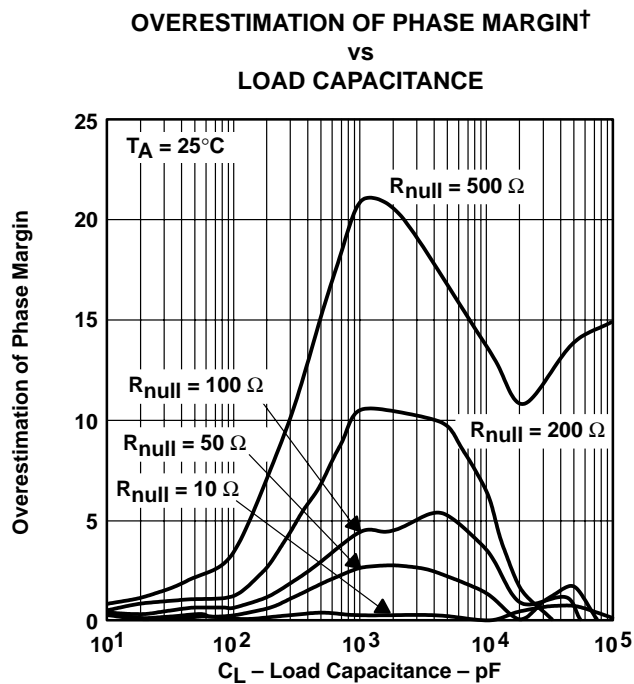
**Figure 56**



**Figure 57**



**Figure 58**



† See application information

**Figure 59**

† For all curves where  $V_{DD} = 5\text{ V}$ , all loads are referenced to 2.5 V. For all curves where  $V_{DD} = 3\text{ V}$ , all loads are referenced to 1.5 V.  
 ‡ Data at high and low temperatures are applicable only within the rated operating free-air temperature ranges of the various devices.

**APPLICATION INFORMATION**

**driving large capacitive loads**

The TLV2252 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 55 and Figure 56 show the effects of adding series resistances of 10  $\Omega$ , 50  $\Omega$ , 100  $\Omega$ , 200  $\Omega$ , and 500  $\Omega$ . The addition of this series resistor has two effects: the first adds a zero to the transfer function and the second 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.

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

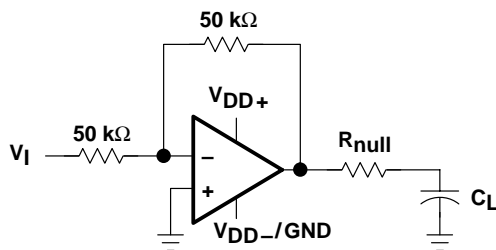
Where :

- $\Delta\phi_{m1}$  = 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, 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**

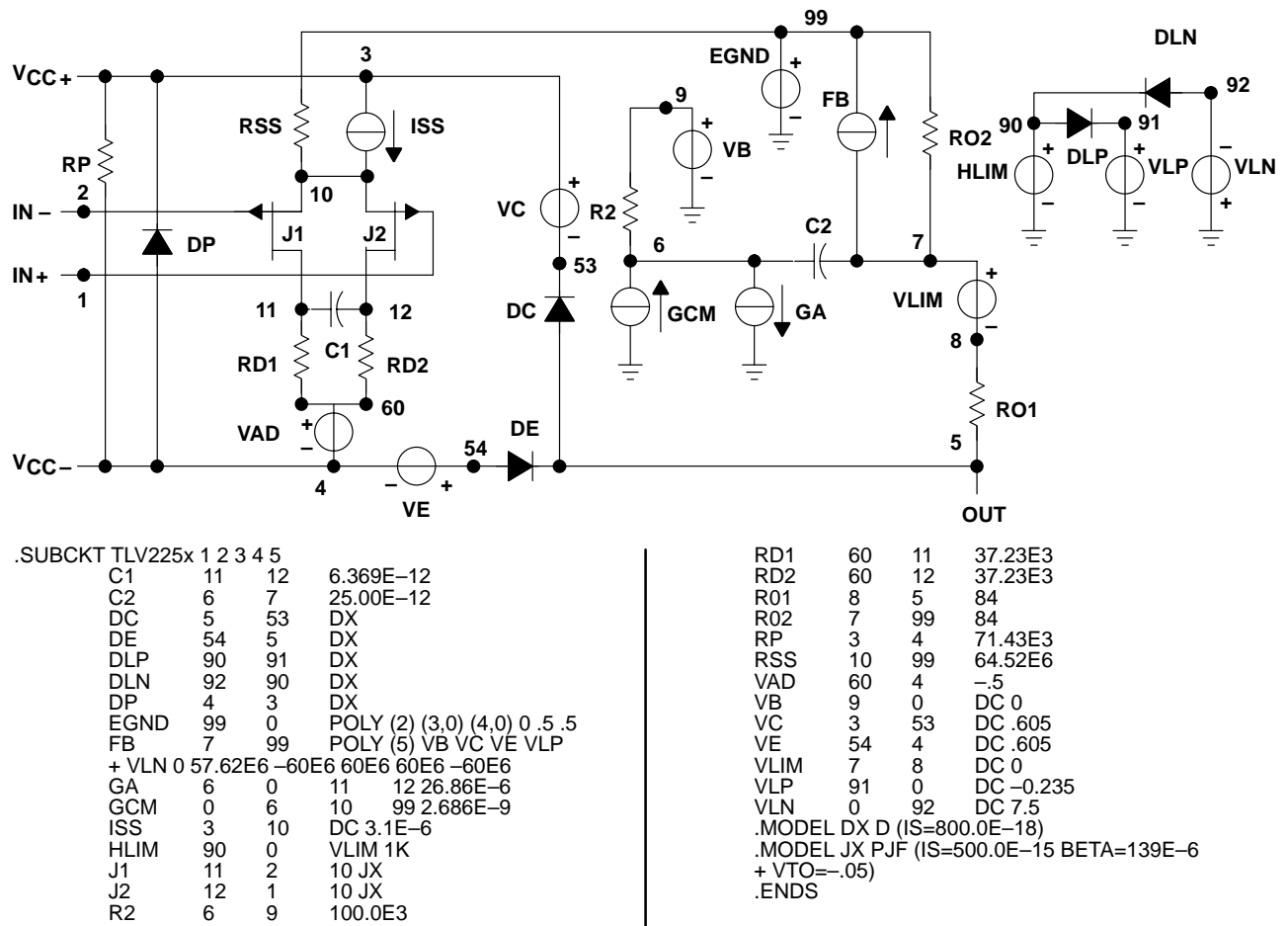
## APPLICATION INFORMATION

### 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 TLV2252 typical electrical and operating characteristics at  $T_A = 25^\circ\text{C}$ . Using this information, output simulations of the following key parameters can be generated to a tolerance of 20% (in most cases):

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

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



**Figure 61. Boyle Macromodel and Subcircuit**

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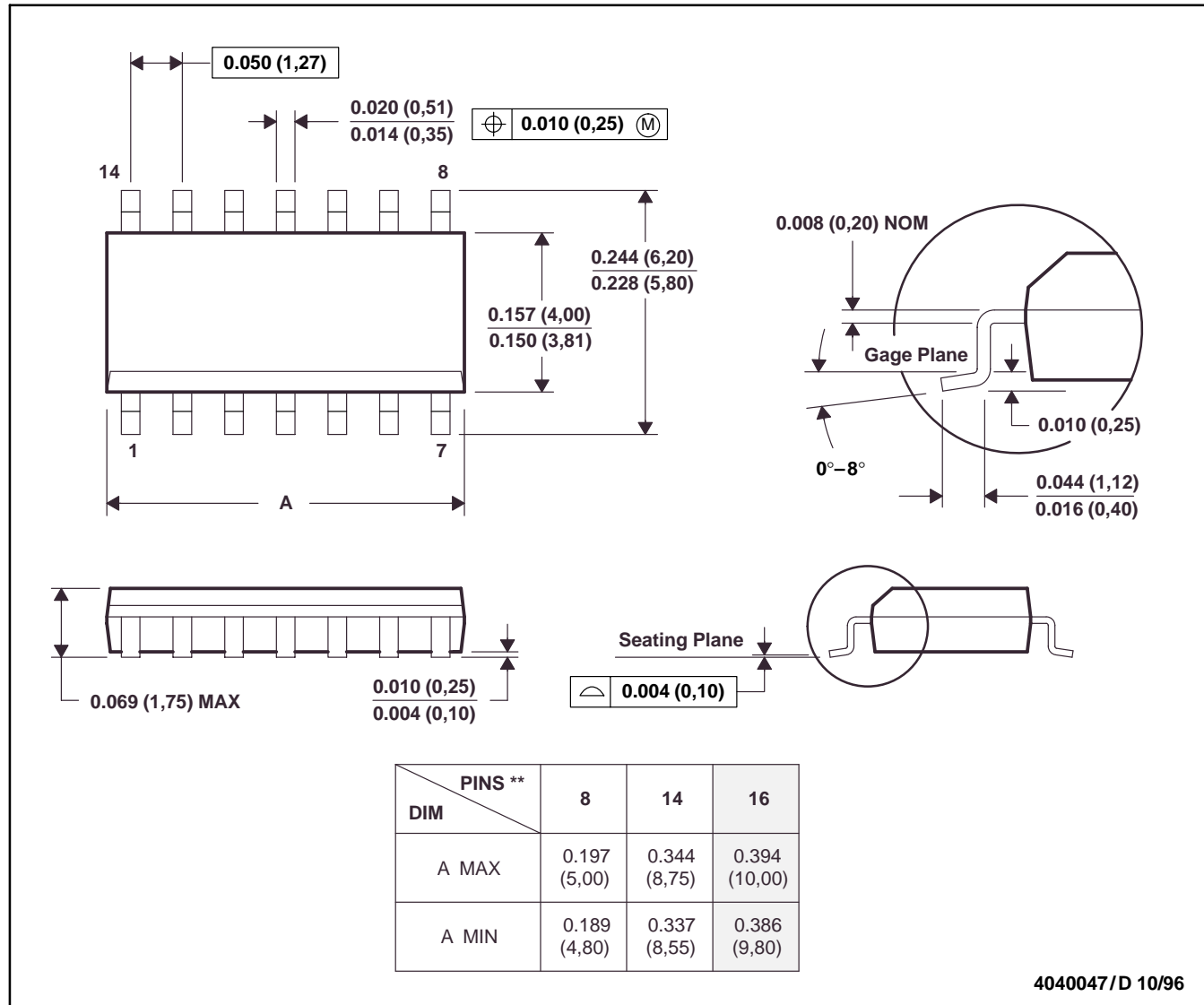
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**MECHANICAL INFORMATION**

**D (R-PDSO-G\*\*)**

**PLASTIC SMALL-OUTLINE PACKAGE**

14 PIN SHOWN



- 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



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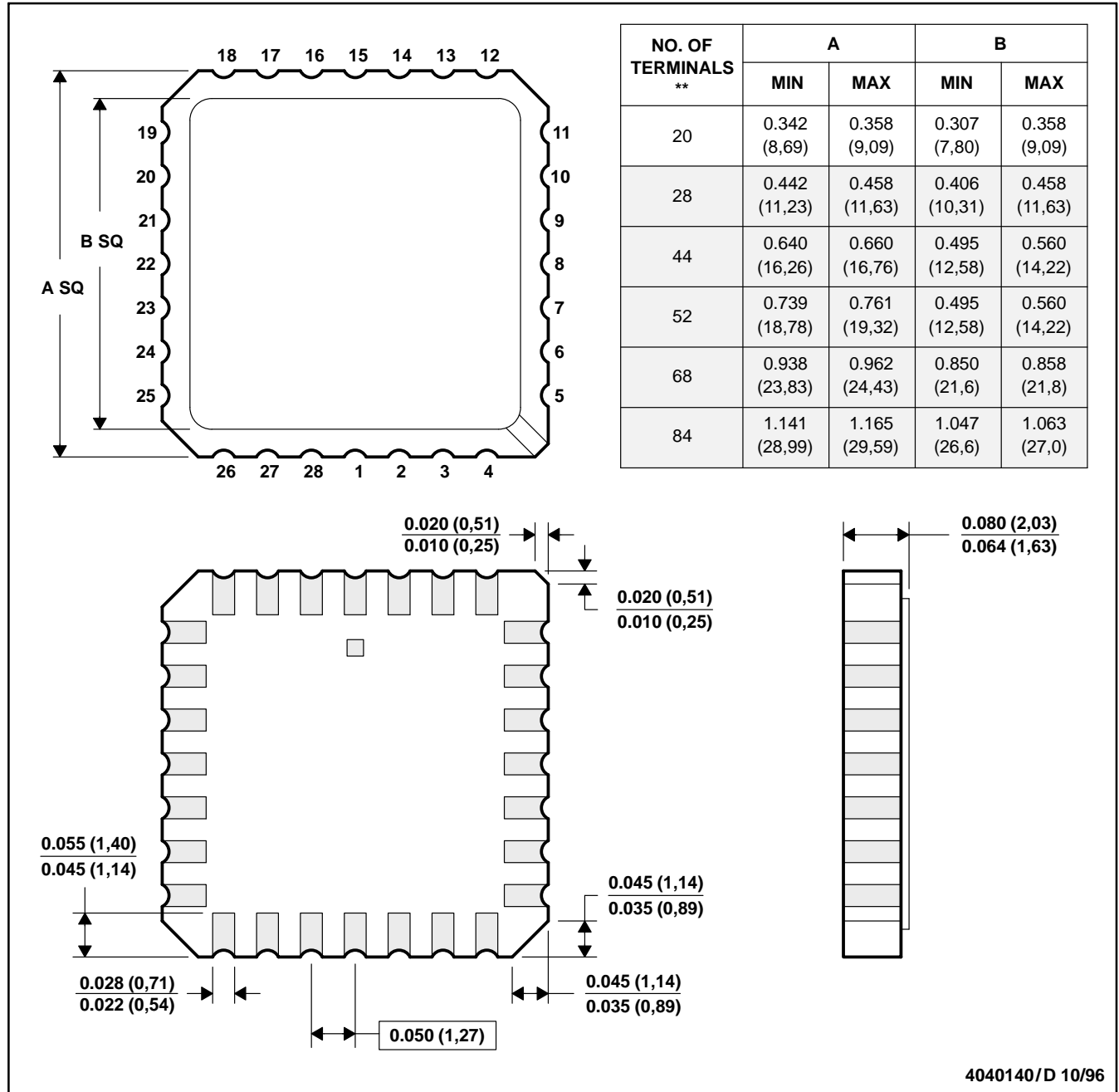
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**MECHANICAL INFORMATION**

**FK (S-CQCC-N\*\*)**

**LEADLESS CERAMIC CHIP CARRIER**

28 TERMINAL SHOWN



- NOTES: A. All linear dimensions are in inches (millimeters).  
 B. This drawing is subject to change without notice.  
 C. This package can be hermetically sealed with a metal lid.  
 D. The terminals are gold plated.  
 E. Falls within JEDEC MS-004

**TLV225x, TLV225xA**  
**Advanced LinCMOS™ RAIL-TO-RAIL**  
**VERY LOW-POWER OPERATIONAL AMPLIFIERS**

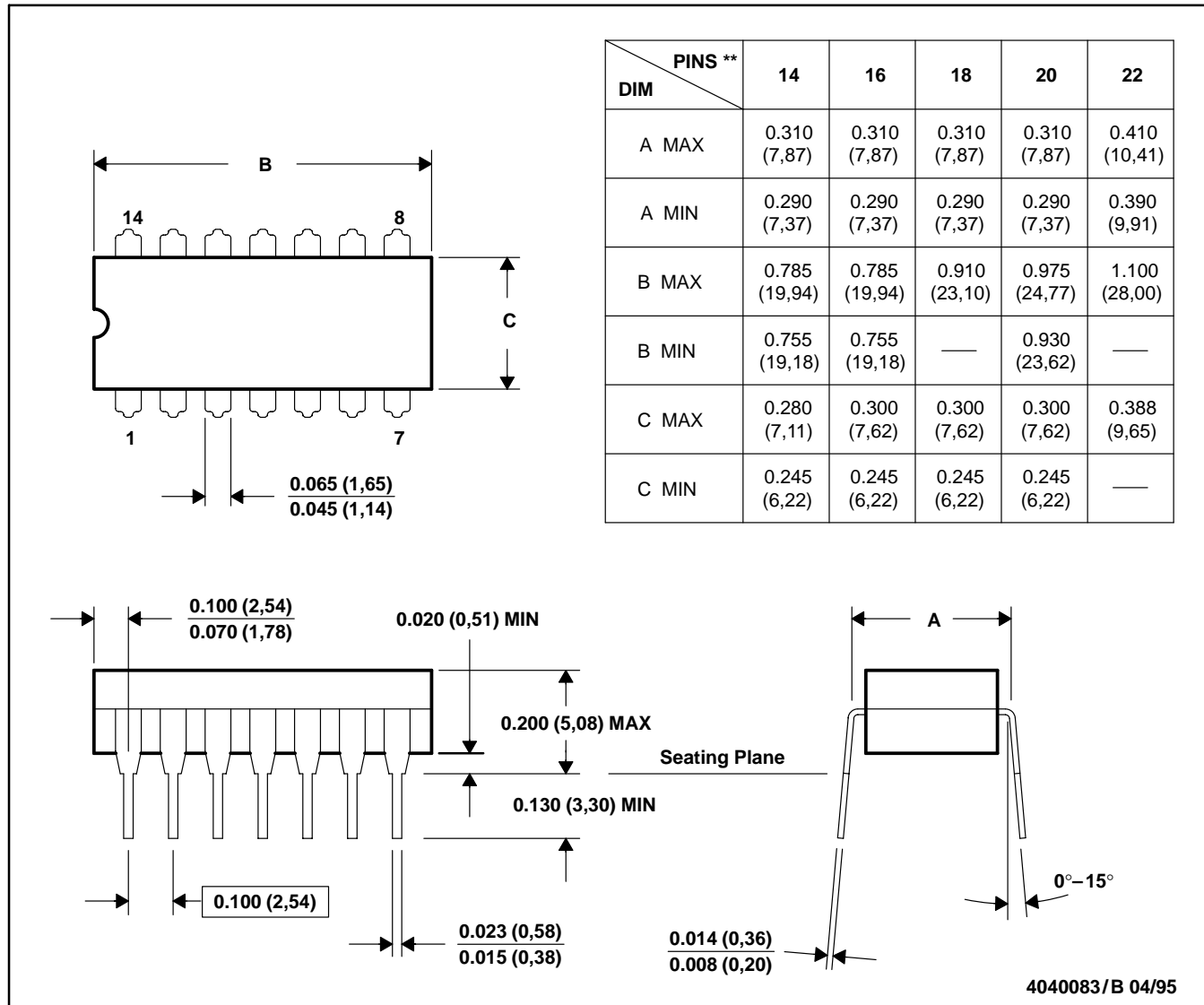
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**MECHANICAL INFORMATION**

**J (R-GDIP-T\*\*)**

**CERAMIC DUAL-IN-LINE PACKAGE**

14 PIN SHOWN

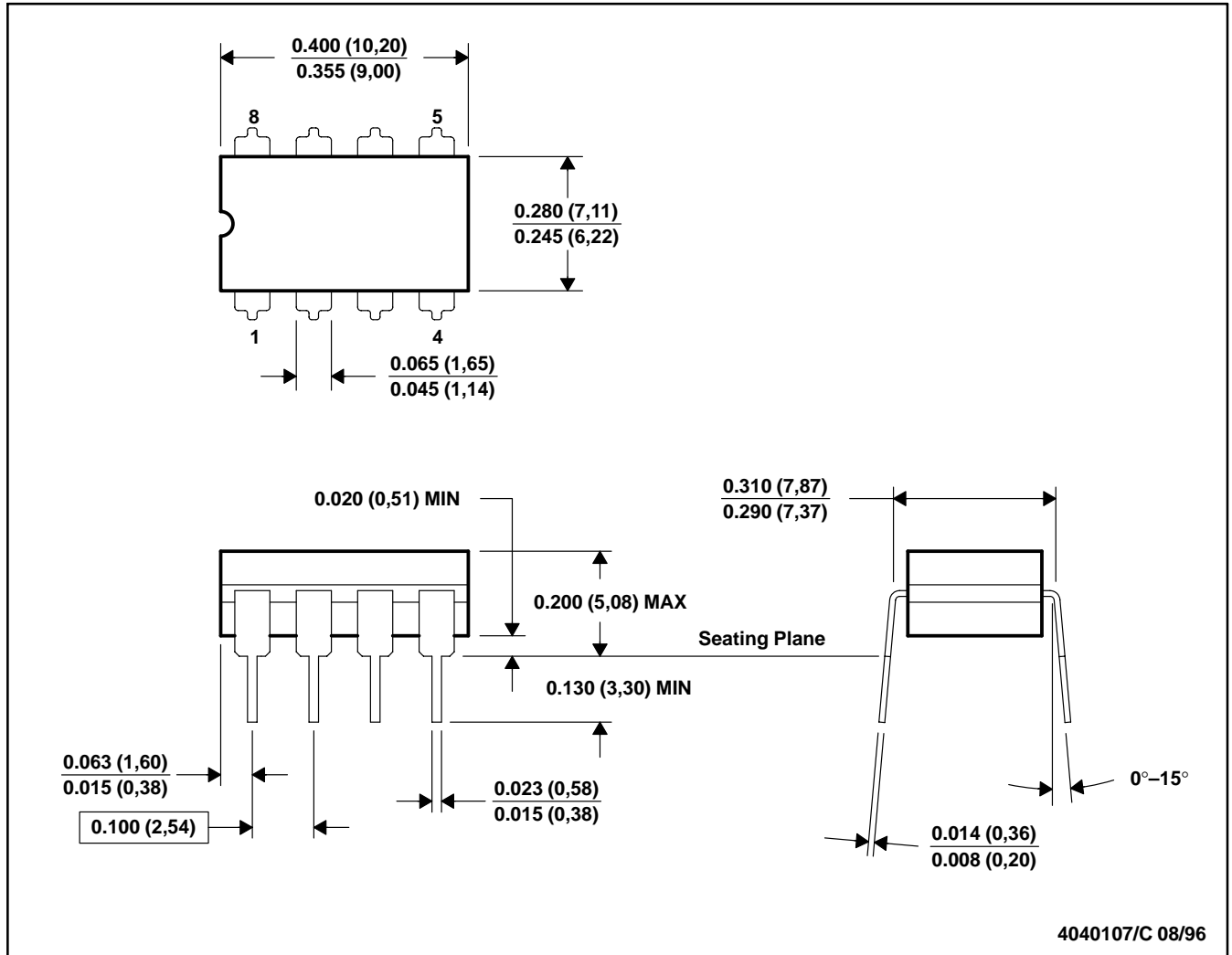


- NOTES: A. All linear dimensions are in inches (millimeters).  
 B. This drawing is subject to change without notice.  
 C. This package can be hermetically sealed with a ceramic lid using glass frit.  
 D. Index point is provided on cap for terminal identification only on press ceramic glass frit seal only.  
 E. Falls within MIL STD 1835 GDIP1-T14, GDIP1-T16, GDIP1-T18, GDIP1-T20, and GDIP1-T22.

**MECHANICAL INFORMATION**

**JG (R-GDIP-T8)**

**CERAMIC DUAL-IN-LINE PACKAGE**



- NOTES: A. All linear dimensions are in inches (millimeters).  
 B. This drawing is subject to change without notice.  
 C. This package can be hermetically sealed with a ceramic lid using glass frit.  
 D. Index point is provided on cap for terminal identification only on press ceramic glass frit seal only.  
 E. Falls within MIL-STD-1835 GDIP1-T8

**TLV225x, TLV225xA**  
**Advanced LinCMOS™ RAIL-TO-RAIL**  
**VERY LOW-POWER OPERATIONAL AMPLIFIERS**

SLOS185C – FEBRUARY 1997 – REVISED – MARCH 2001

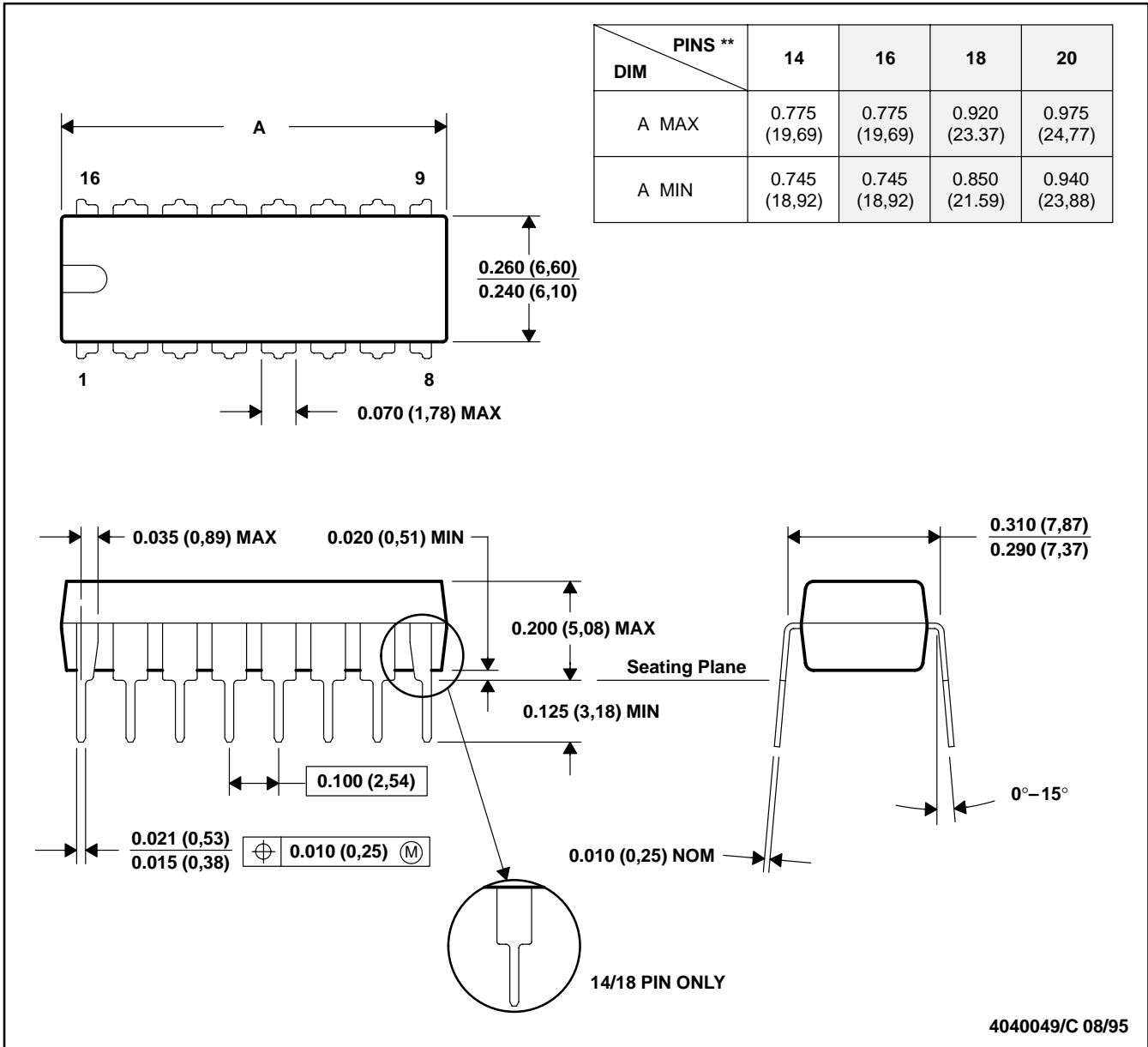
**MECHANICAL INFORMATION**

**N (R-PDIP-T\*\*)**

**PLASTIC DUAL-IN-LINE PACKAGE**

16 PIN SHOWN

DIM \ PINS **	14	16	18	20
A MAX	0.775 (19,69)	0.775 (19,69)	0.920 (23,37)	0.975 (24,77)
A MIN	0.745 (18,92)	0.745 (18,92)	0.850 (21,59)	0.940 (23,88)

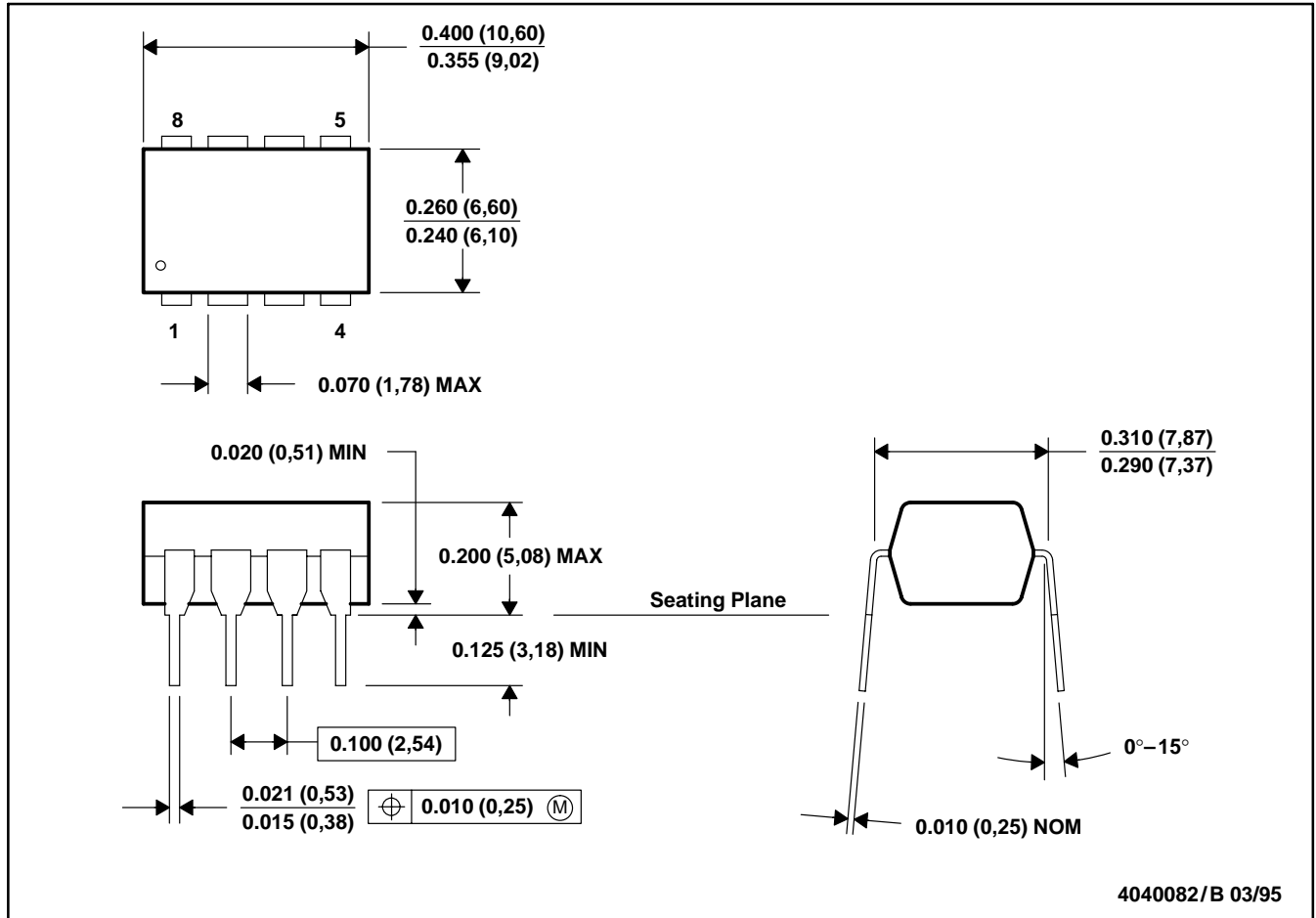


- NOTES: A. All linear dimensions are in inches (millimeters).  
 B. This drawing is subject to change without notice.  
 C. Falls within JEDEC MS-001 (20 pin package is shorter than MS-001.)

**MECHANICAL INFORMATION**

**P (R-PDIP-T8)**

**PLASTIC DUAL-IN-LINE PACKAGE**



- NOTES: A. All linear dimensions are in inches (millimeters).  
 B. This drawing is subject to change without notice.  
 C. Falls within JEDEC MS-001

**TLV225x, TLV225xA**  
**Advanced LinCMOS™ RAIL-TO-RAIL**  
**VERY LOW-POWER OPERATIONAL AMPLIFIERS**

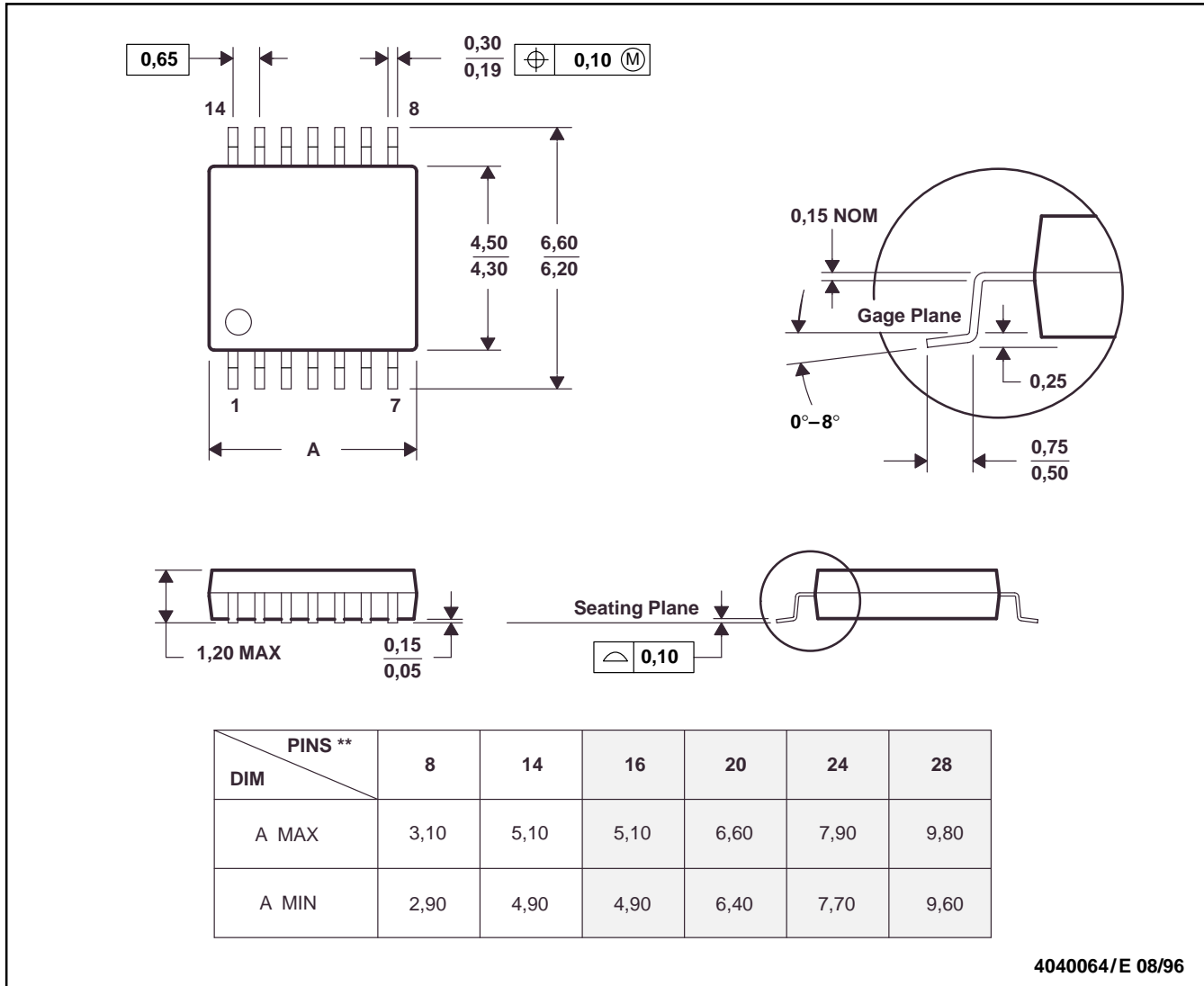
SLOS185C – FEBRUARY 1997 – REVISED – MARCH 2001

**MECHANICAL INFORMATION**

**PW (R-PDSO-G\*\*)**

**PLASTIC SMALL-OUTLINE PACKAGE**

14 PIN SHOWN



4040064/E 08/96

- 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

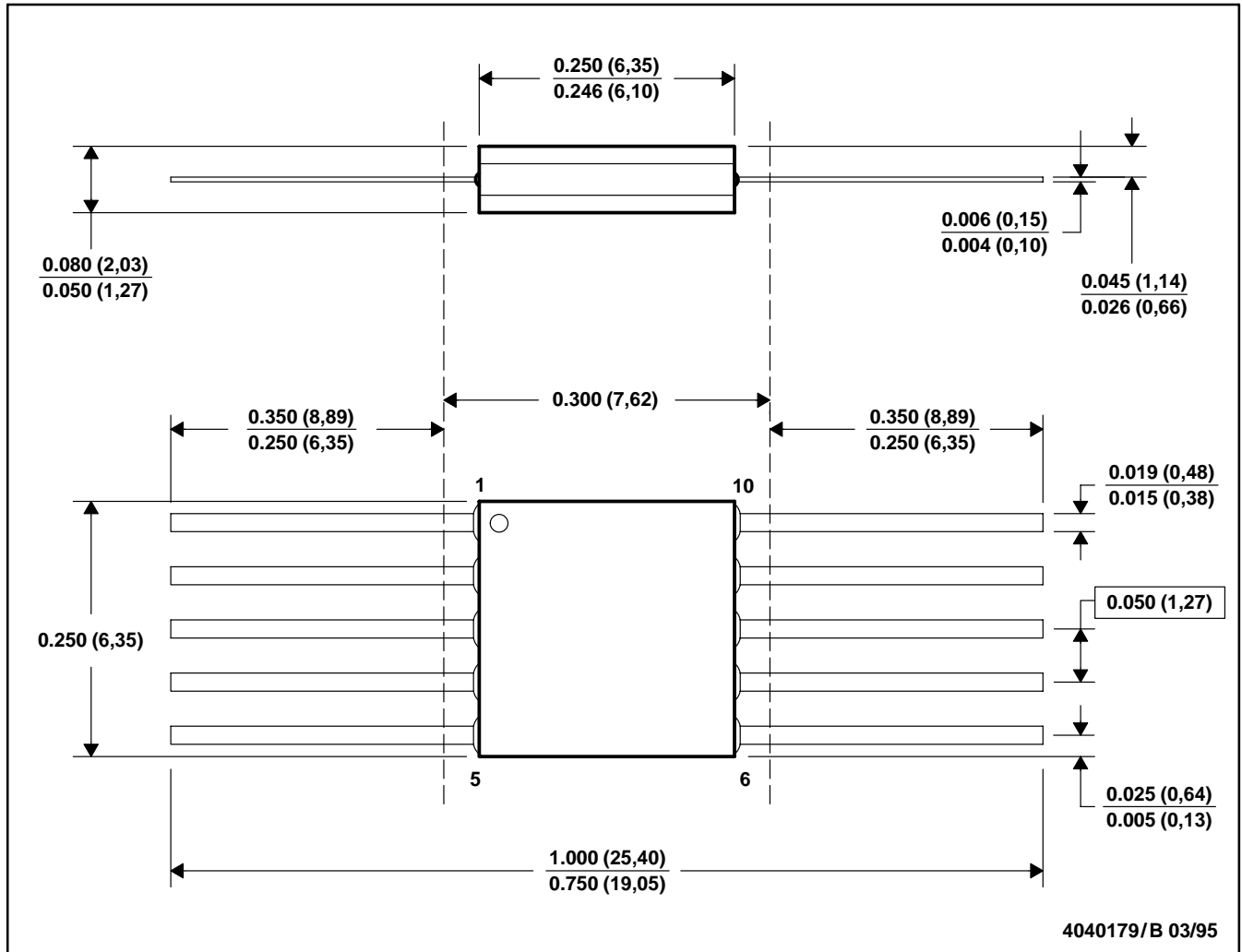
**TLV225x, TLV225xA**  
**Advanced LinCMOS™ RAIL-TO-RAIL**  
**VERY LOW-POWER OPERATIONAL AMPLIFIERS**

SLOS185C – FEBRUARY 1997 – REVISED – MARCH 2001

**MECHANICAL INFORMATION**

**U (S-GDFP-F10)**

**CERAMIC DUAL FLATPACK**



- NOTES:
- All linear dimensions are in inches (millimeters).
  - This drawing is subject to change without notice.
  - This package can be hermetically sealed with a ceramic lid using glass frit.
  - Index point is provided on cap for terminal identification only.
  - Falls within MIL STD 1835 GDFP1-F10 and JEDEC MO-092AA

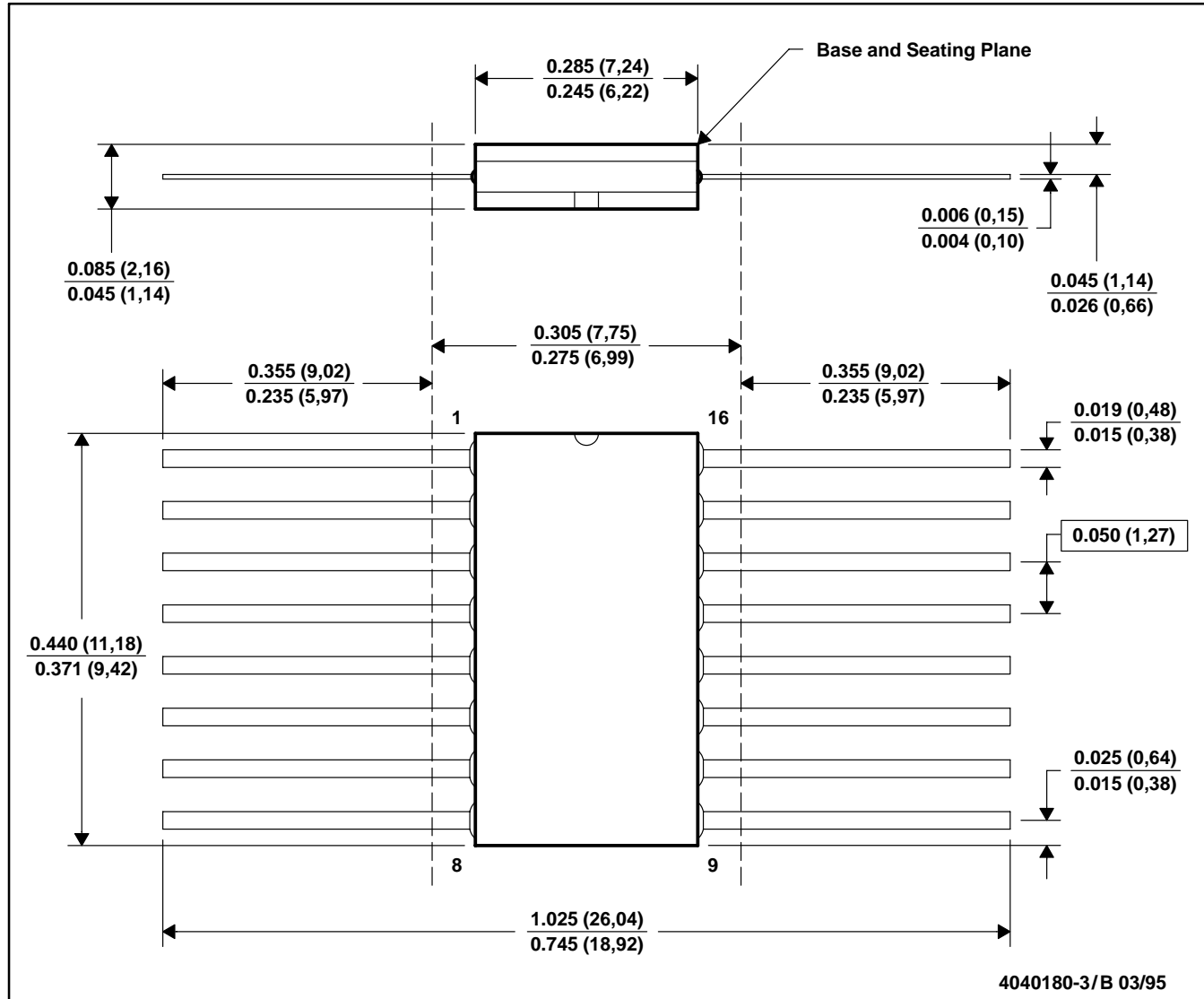
**TLV225x, TLV225xA**  
**Advanced LinCMOS™ RAIL-TO-RAIL**  
**VERY LOW-POWER OPERATIONAL AMPLIFIERS**

SLOS185C – FEBRUARY 1997 – REVISED – MARCH 2001

**MECHANICAL INFORMATION**

**W (R-GDFP-F16)**

**CERAMIC DUAL FLATPACK**



- NOTES: A. All linear dimensions are in inches (millimeters).  
 B. This drawing is subject to change without notice.  
 C. This package can be hermetically sealed with a ceramic lid using glass frit.  
 D. Index point is provided on cap for terminal identification only.  
 E. Falls within MIL-STD-1835 GDFP1-F16 and JEDEC MO-092AC





JG (R-GDIP-T8)

CERAMIC DUAL-IN-LINE

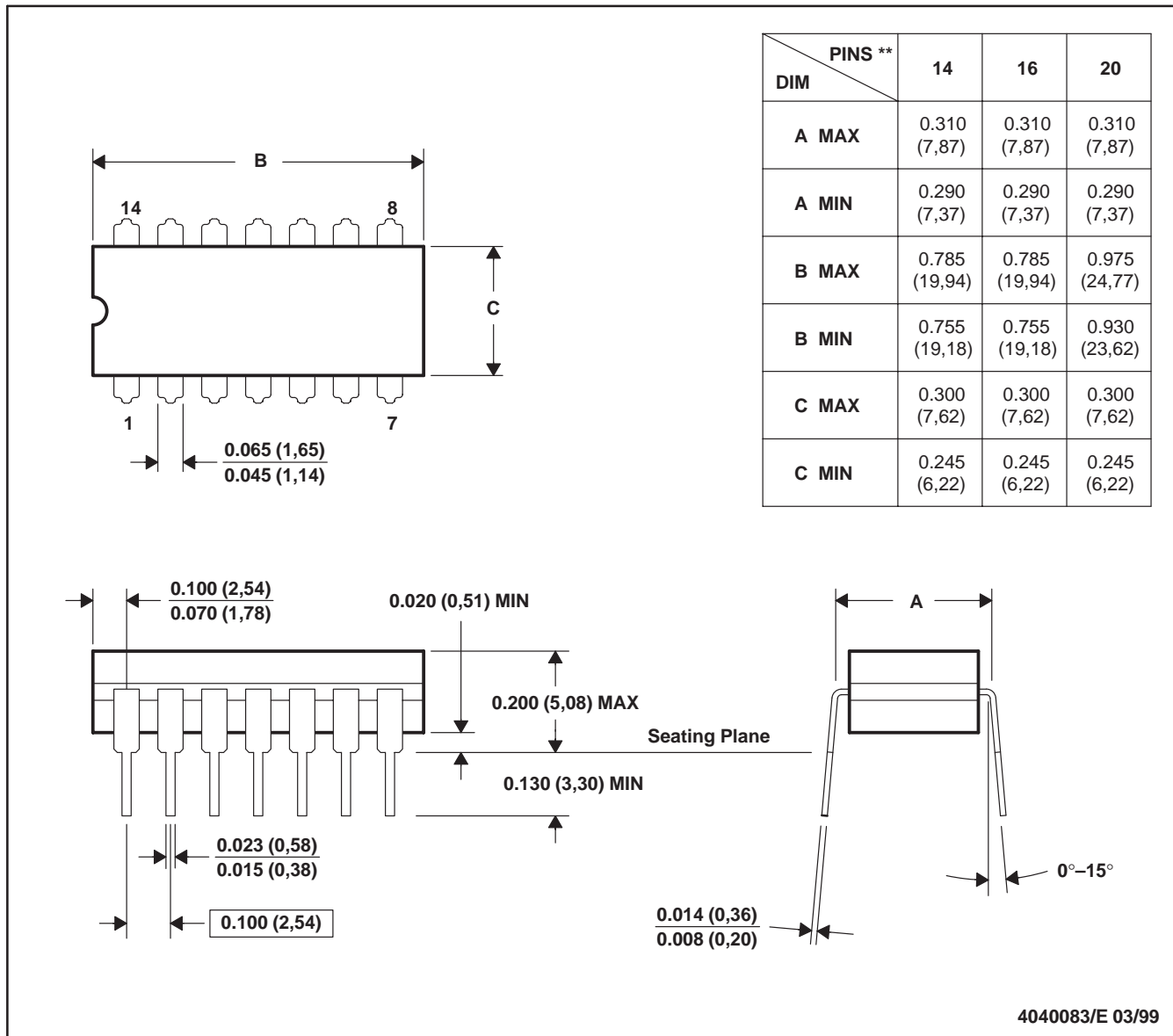


- NOTES: A. All linear dimensions are in inches (millimeters).  
 B. This drawing is subject to change without notice.  
 C. This package can be hermetically sealed with a ceramic lid using glass frit.  
 D. Index point is provided on cap for terminal identification.  
 E. Falls within MIL STD 1835 GDIP1-T8

J (R-GDIP-T\*\*)

CERAMIC DUAL-IN-LINE

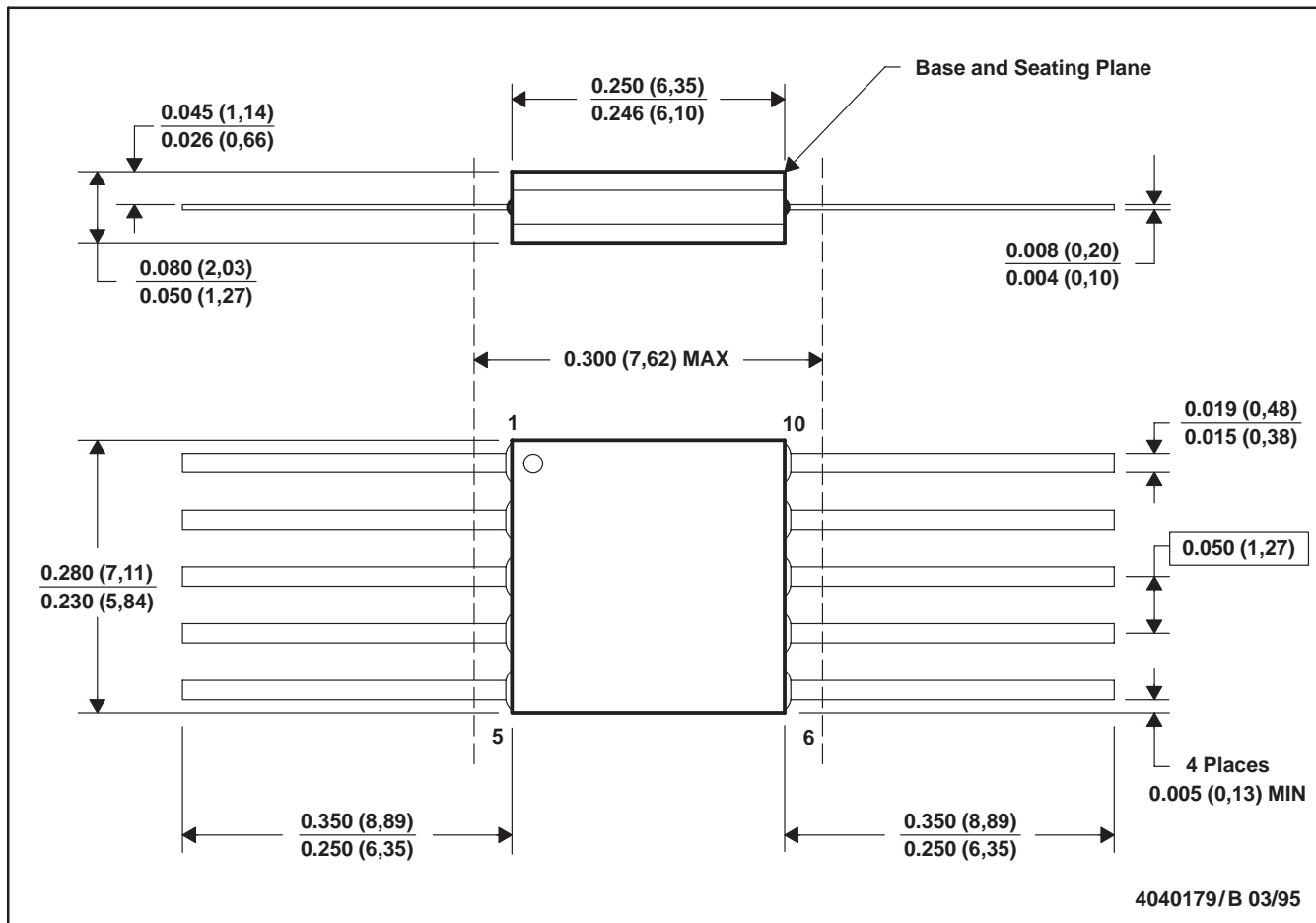
14 LEADS SHOWN



- NOTES: A. All linear dimensions are in inches (millimeters).  
 B. This drawing is subject to change without notice.  
 C. This package is hermetically sealed with a ceramic lid using glass frit.  
 D. Index point is provided on cap for terminal identification.  
 E. Falls within MIL STD 1835 GDIP1-T14, GDIP1-T16, and GDIP1-T20

U (S-GDFP-F10)

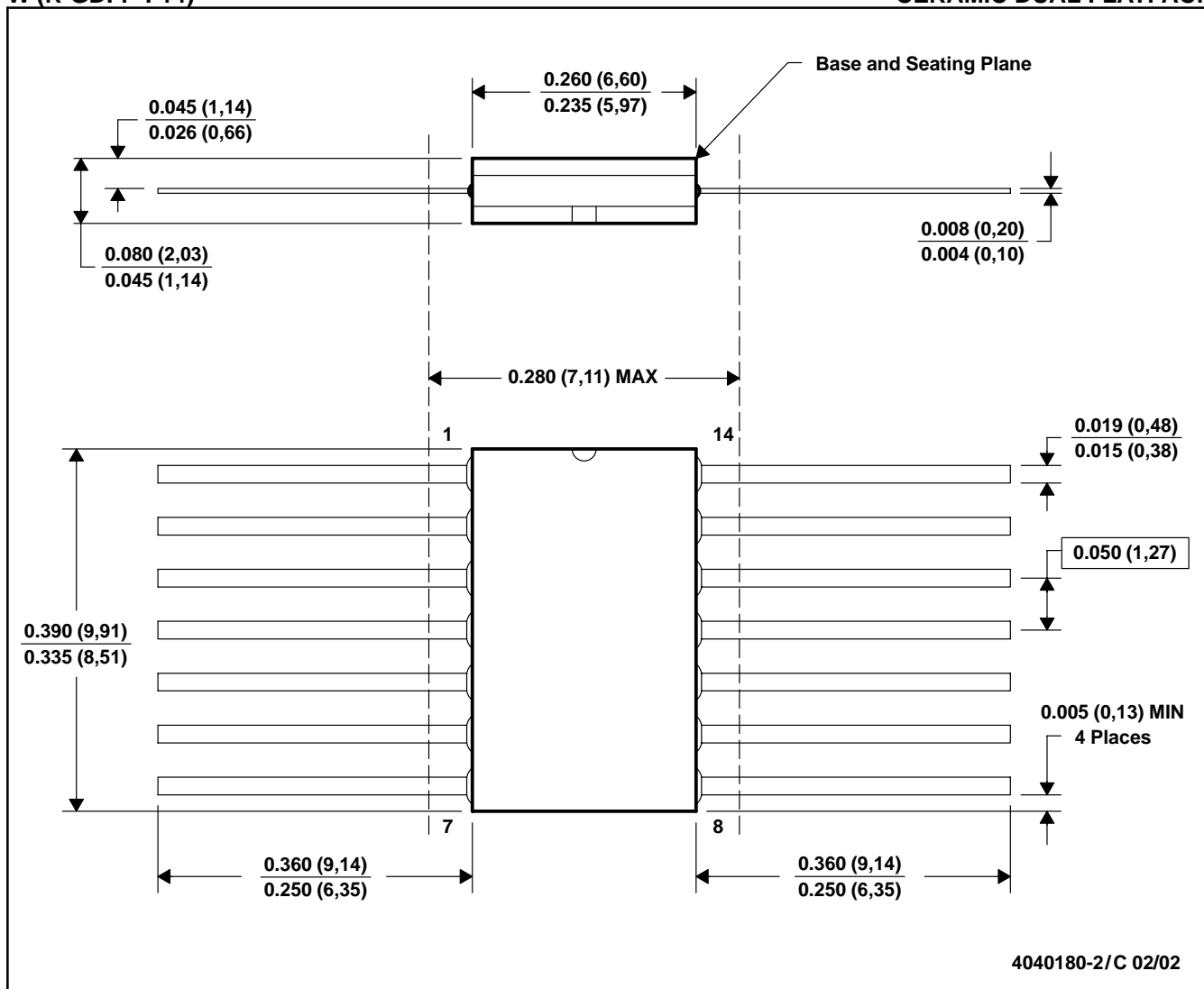
CERAMIC DUAL FLATPACK



- NOTES: A. All linear dimensions are in inches (millimeters).  
 B. This drawing is subject to change without notice.  
 C. This package can be hermetically sealed with a ceramic lid using glass frit.  
 D. Index point is provided on cap for terminal identification only.  
 E. Falls within MIL STD 1835 GDFP1-F10 and JEDEC MO-092AA

W (R-GDFP-F14)

CERAMIC DUAL FLATPACK



- NOTES: A. All linear dimensions are in inches (millimeters).  
 B. This drawing is subject to change without notice.  
 C. This package can be hermetically sealed with a ceramic lid using glass frit.  
 D. Index point is provided on cap for terminal identification only.  
 E. Falls within MIL STD 1835 GDFP1-F14 and JEDEC MO-092AB

FK (S-CQCC-N\*\*)

LEADLESS CERAMIC CHIP CARRIER

28 TERMINAL SHOWN



- NOTES:
- A. All linear dimensions are in inches (millimeters).
  - B. This drawing is subject to change without notice.
  - C. This package can be hermetically sealed with a metal lid.
  - D. The terminals are gold plated.
  - E. Falls within JEDEC MS-004

P (R-PDIP-T8)

PLASTIC DUAL-IN-LINE



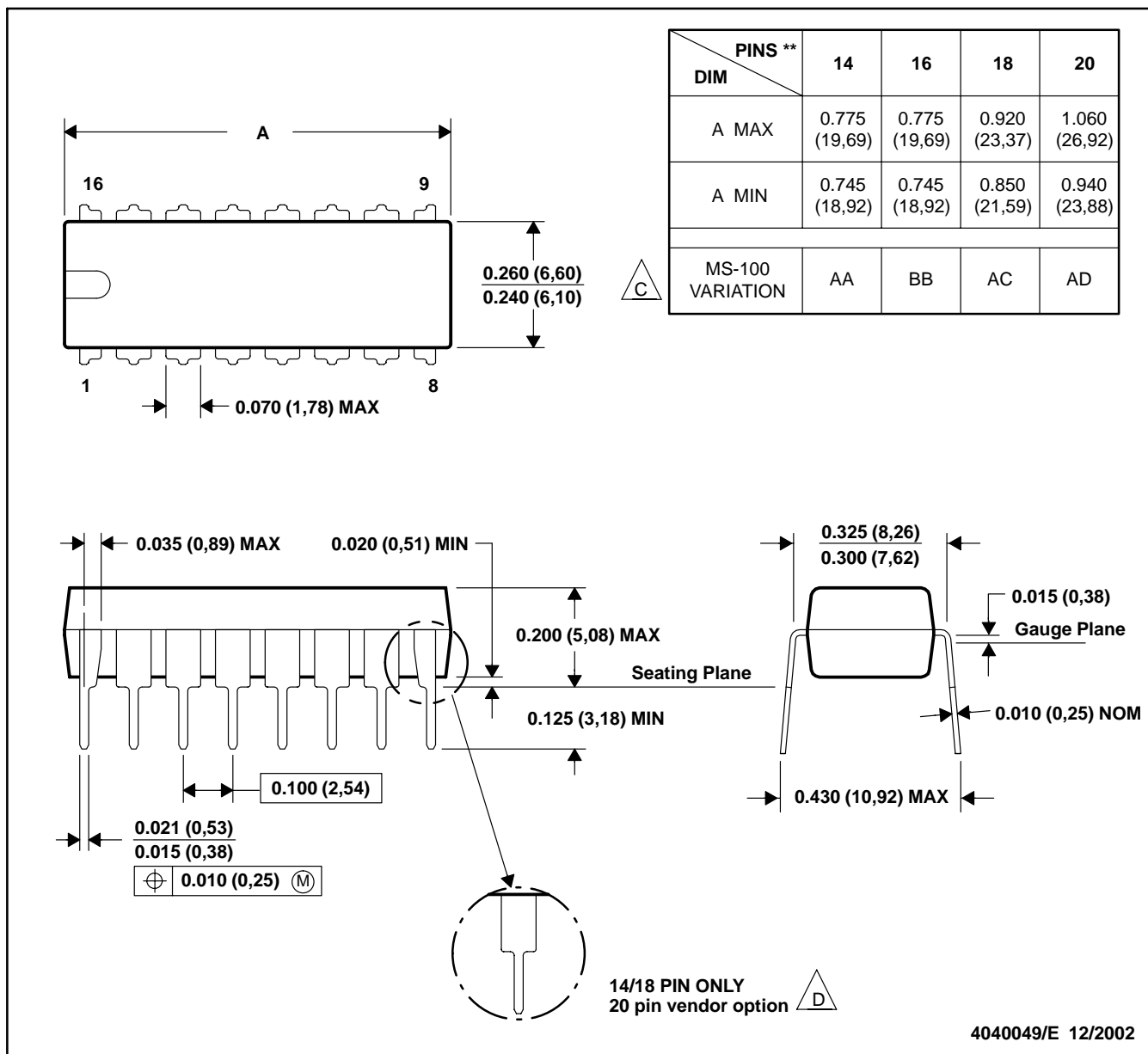
- NOTES: A. All linear dimensions are in inches (millimeters).  
 B. This drawing is subject to change without notice.  
 C. Falls within JEDEC MS-001

For the latest package information, go to [http://www.ti.com/sc/docs/package/pkg\\_info.htm](http://www.ti.com/sc/docs/package/pkg_info.htm)

N (R-PDIP-T\*\*)

PLASTIC DUAL-IN-LINE PACKAGE

16 PINS SHOWN



NOTES: A. All linear dimensions are in inches (millimeters).

B. This drawing is subject to change without notice.

C Falls within JEDEC MS-001, except 18 and 20 pin minimum body length (Dim A).

D The 20 pin end lead shoulder width is a vendor option, either half or full width.

D (R-PDSO-G\*\*)

PLASTIC SMALL-OUTLINE PACKAGE

8 PINS SHOWN



- 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



PW (R-PDSO-G\*\*)

PLASTIC SMALL-OUTLINE PACKAGE

14 PINS SHOWN



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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