- **Output Swing Includes Both Supply Rails**
- Low Noise . . . 19 nV/ $\sqrt{\text{Hz}}$  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**

#### description

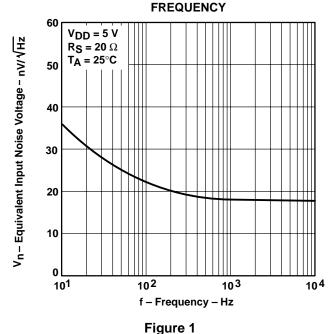
The TLC2252 and TLC2254 are dual and quadruple operational amplifiers from Texas Instruments. Both devices exhibit rail-to-rail output performance for increased dynamic range in single- or split-supply applications. The TLC225x family consumes only 35 µA of supply current per channel. This micropower 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/ $\sqrt{Hz}$  at 1kHz; four times lower than competitive micropower solutions.

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

**Low Input Offset Voltage** 850  $\mu$ V Max at T<sub>A</sub> = 25°C (TLC225xA)

- **Macromodel Included**
- Performance Upgrades for the TS27L2/L4 and TLC27L2/L4
- Available in Q-Temp Automotive **HighRel Automotive Applications Configuration Control / Print Support Qualification to Automotive Standards**

#### **EQUIVALENT INPUT NOISE VOLTAGE** VS



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  $\pm 5$  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.



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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#### **TLC2252 AVAILABLE OPTIONS**

				PACKAGEI	DEVICES		
T <sub>A</sub>	V <sub>IO</sub> max AT 25°C	SMALL OUTLINE† (D)	CHIP CARRIER (FK)	CERAMIC DIP (JG)	PLASTIC DIP (P)	TSSOP‡ (PW)	CERAMIC FLATPACK (U)
0°C to 70°C	1500 μV	TLC2252CD	_	_	TLC2252CP	TLC2252CPW	_
-40°C to 125°C	850 μV 1500 μV	TLC2252AID TLC2252ID	_		TLC2252AIP TLC2252IP	TLC2252AIPW —	_
-40°C to 125°C	850 μV 1500 μV	TLC2252AQD TLC2252QD	_ _	_ _			
−55°C to 125°C	850 μV 1500 μV		TLC2252AMFK TLC2252MFK	TLC2252AMJG TLC2252MJG		1 1	TLC2252AMU TLC2252MU

<sup>†</sup> The D packages are available taped and reeled. Add R suffix to device type (e.g., TLC2262CDR).

#### **TLC2254 AVAILABLE OPTIONS**

				PACKAGI	ED DEVICES		
TA	V <sub>IO</sub> max AT 25°C	SMALL OUTLINE† (D)	CHIP CARRIER (FK)	CERAMIC DIP (J)	PLASTIC DIP (N)	TSSOP‡ (PW)	CERAMIC FLATPACK (W)
0°C to 70°C	1500 μV	TLC2254CD	_	_	TLC2254CN	TLC2254CPW	_
-40°C to 125°C	850 μV 1500 μV	TLC2254AID TLC2254ID	_ _	_	TLC2254AIN TLC2254IN	TLC2254AIPW —	_ _
-40°C to 125°C	850 μV 1500 μV	TLC2254AQD TLC2254QD	_ _	_ _		<u> </u>	_ _
−55°C to 125°C	850 μV 1500 μV		TLC2254AMFK TLC2254MFK	TLC2254AMJ TLC2254MJ		_ _	TLC2254AMW TLC2254MW

The D packages are available taped and reeled. Add R suffix to the device type (e.g., TLC2254CDR).

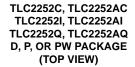


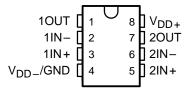
<sup>&</sup>lt;sup>‡</sup> The PW package is available only left-ended taped and reeled.

<sup>§</sup> Chip forms are tested at 25°C only.

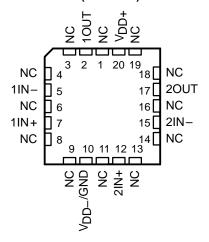
<sup>&</sup>lt;sup>‡</sup> The PW package is available only left-end taped and reeled. Chips are tested at 25°C.

<sup>§</sup> Chip forms are tested at 25°C only.

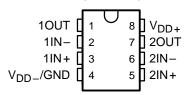




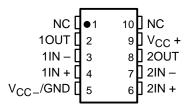
# TLC2252M, TLC2252AM . . . FK PACKAGE (TOP VIEW)



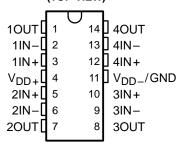
TLC2252M, TLC2252AM . . . JG PACKAGE (TOP VIEW)



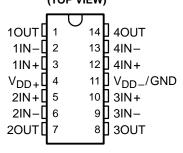
# TLC2262M, TLC2252AM . . . U PACKAGE (TOP VIEW)



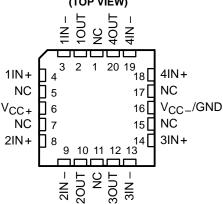
TLC2254C, TLC2254AC TLC2254I, TLC2254AI TLC2254Q, TLC2254AQ D, N, OR PW PACKAGE (TOP VIEW)



TLC2254M, TLC2254AM J OR W PACKAGE (TOP VIEW)

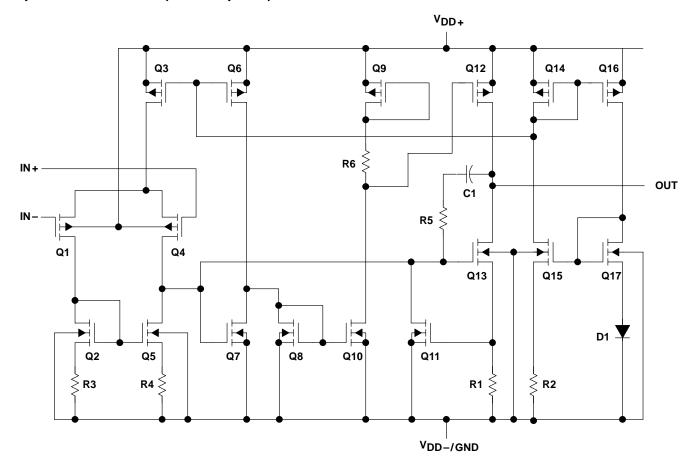


TLC2254M, TLC2254AM FK PACKAGE (TOP VIEW)



NC - No internal connection

### equivalent schematic (each amplifier)



ACTUAL DEVICE COMPONENT COUNT									
COMPONENT TLC2252 TLC2254									
Transistors	38	76							
Resistors	30	56							
Diodes	9	18							
Capacitors	3	6							

<sup>†</sup> 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 <sub>DD+</sub> (see Note 1)		8 V
Supply voltage, V <sub>DD</sub> (see Note 1)		8 V
Differential input voltage, V <sub>ID</sub> (see Note 2)		±16 V
Input voltage, V <sub>I</sub> (any input, see Note 1)		±8 V
Input current, I <sub>I</sub> (each input)		±5 mA
Output current, I <sub>O</sub>		±50 mA
Total current into V <sub>DD+</sub>		±50 mA
Total current out of V <sub>DD</sub>		±50 mA
Duration of short-circuit current at (or below	w) 25°C (see Note 3)	unlimited
Continuous total dissipation		See Dissipation Rating Table
Operating free-air temperature range, T <sub>A</sub> :	C suffix	0°C to 70°C
	I suffix	−40°C to 125°C
	Q suffix	
		–40°C to 125°C
Storage temperature range, T <sub>stg</sub>	Q suffix	40°C to 125°C 55°C to 125°C

<sup>†</sup> 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 VDD+ and VDD -.
  - 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 <sub>A</sub> ≤ 25°C POWER RATING	DERATING FACTOR ABOVE T <sub>A</sub> = 25°C	T <sub>A</sub> = 70°C POWER RATING	T <sub>A</sub> = 85°C POWER RATING	T <sub>A</sub> = 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
FK	1375 mW	11.0 mW/°C	880 mW	715 mW	275 mW
J	1375 mW	11.0 mW/°C	880 mW	715 mW	275 mW
JG	1050 mW	8.4 mW/°C	672 mW	546 mW	275 mW
N	1150 mW	9.2 mW/°C	736 mW	736 mW	_
Р	1000 mW	8.0 mW/°C	640 mW	520 mW	_
PW-8	525 mW	4.2 mW/°C	336 mW	273 mW	_
PW-14	700 mW	5.6 mW/°C	448 mW	448 mW	_
U	700 mW	5.5 mW/°C	246 mW	330 mW	150 mW
W	700 mW	5.5 mW/°C	246 mW	330 mW	150 mW

#### recommended operating conditions

	C SUFFIX		18	I SUFFIX		Q SUFFIX		M SUFFIX	
	MIN	MAX	MIN	MAX	MIN	MAX	MIN	MAX	UNIT
Supply voltage, V <sub>DD±</sub>	±2.2	±8	±2.2	±8	±2.2	±8	±2.2	±8	V
Input voltage range, V <sub>I</sub>	$V_{DD-}$	V <sub>DD+</sub> -1.5	V						
Common-mode input voltage, V <sub>IC</sub>	$V_{DD-}$	V <sub>DD+</sub> -1.5	V						
Operating free-air temperature, TA	0	70	-40	125	-40	125	-55	125	°C



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

	DADAMETES	TEOT 00	NOTIONS		T	LC22520	2	LINUT
	PARAMETER	TEST CO	NDITIONS	T <sub>A</sub> †	MIN	TYP	MAX	UNIT
V/. 0	Input offeet voltage			25°C		200	1500	\/
VIO	Input offset voltage			Full range			1750	μV
αVIO	Temperature coefficient of input offset voltage			25°C to 70°C		0.5		μV/°C
	Input offset voltage long-term drift (see Note 4)	$V_{IC} = 0,$ $V_{O} = 0,$	= 0, $V_{DD} \pm = \pm 2.5 \text{ V},$ = 0, $R_S = 50 \Omega$	25°C		0.003		μV/mo
li a	Input offset current	VO = 0,	KS = 30.22	25°C		0.5	60	n^
ΙΟ	input onset current			Full range			100	pА
l.s	Input bias current			25°C		1	60	pА
IВ	input bias current			Full range			100	PΑ
VICR	Common-mode input voltage range	$R_S = 50 \Omega$	V <sub>IO</sub>   ≤ 5 mV	25°C	0 to 4	-0.3 to 4.2		٧
				Full range	0 to 3.5			
		$I_{OH} = -20  \mu A$		25°C		4.98		
V <sub>ОН</sub>	High-level output voltage	I <sub>OH</sub> = -75 μA		25°C	4.9	4.94		V
VOH	rigir level output voltage	_		Full range	4.8			V
		$I_{OH} = -150 \mu A$		25°C	4.8	4.88		
		$V_{IC} = 2.5 V$ ,	I <sub>OL</sub> = 50 μA	25°C		0.01		
		V <sub>IC</sub> = 2.5 V,	I <sub>OL</sub> = 500 μA	25°C		0.09	0.15	
		V <sub>1</sub> C = 2.5 v,		Full range			0.15	
VOL	Low-level output voltage	V <sub>IC</sub> = 2.5 V,	I <sub>OL</sub> = 1 mA	25°C		0.2	0.3	V
		V <sub>1</sub> C = 2.0 V,	10L = 1 11171	Full range			0.3	
		V <sub>IC</sub> = 2.5 V,	I <sub>OL</sub> = 4 mA	25°C		0.7	1	
		10 =:0 :,		Full range			1.2	
		V:0 - 2 5 V	R <sub>L</sub> = 100 kΩ <sup>‡</sup>	25°C	100	350		
$A_{VD}$	Large-signal differential voltage amplification	$V_{IC} = 2.5 \text{ V},$ $V_{O} = 1 \text{ V to 4 V}$		Full range	10			V/mV
		Ů ·	$R_L = 1 M\Omega^{\ddagger}$	25°C		1700		
r <sub>id</sub>	Differential input resistance			25°C		1012		Ω
ric	Common-mode input resistance			25°C		1012		Ω
cic	Common-mode input capacitance	f = 10 kHz,	P package	25°C		8		pF
z <sub>O</sub>	Closed-loop output impedance	f = 25 kHz,	A <sub>V</sub> = 10	25°C		200		Ω
CMDD	Common mode unication until	$V_{IC} = 0 \text{ to } 2.7 \text{ V},$	V <sub>O</sub> = 2.5 V,	25°C	70	83		40
CMRR	Common-mode rejection ratio	$R_S = 50 \Omega$		Full range	70			dB
leas :=	Cumply voltage rejection water (AV = - (AV )	$V_{DD} = 4.4 \text{ V to}$	16 V,	25°C	80	95		4D
ksvr	Supply-voltage rejection ratio (ΔV <sub>DD</sub> /ΔV <sub>IO</sub> )	$V_{IC} = V_{DD}/2$ ,	No load	Full range	80			dB
la a	Supply current	Vo = 2.5.V	No load	25°C		70	125	^
<sup>1</sup> DD	Supply current	$V_0 = 2.5 V$ ,	No load	Full range			150	μΑ

<sup>†</sup> Full range is 0°C to 70°C.

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



<sup>‡</sup>Referenced to 2.5 V

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

	DADAMETED	TEST COND	ITIONS	- +	TI	LC2252C	;	UNIT
	PARAMETER	TEST COND	IIIONS	T <sub>A</sub> †	MIN	TYP	MAX	UNII
		V- 45V4-25VD				0.12		
SR	Slew rate at unity gain	$V_O = 1.5 \text{ V to } 3.5 \text{ V, R}$ $C_L = 100 \text{ pF}^{\ddagger}$	L = 100 K\$2+,	Full range	0.05			V/μs
V	Equivalent input poins voltage	f = 10 Hz		25°C		36		->// <sub>2</sub> /1/-
V <sub>n</sub>	Equivalent input noise voltage	f = 1 kHz 25°C f = 0.1 Hz to 1 Hz 25°C			19		nV/√Hz	
V	Peak-to-peak equivalent input noise voltage	age		0.7		\/		
V <sub>N(PP)</sub>	reak-to-peak equivalent input noise voltage			25°C	1.1		μV	
In	Equivalent input noise current			25°C		0.6		fA√Hz
THD + N	Total harmonic distortion plus noise	$V_O = 0.5 \text{ V to } 2.5 \text{ V},$ f = 10 kHz,	A <sub>V</sub> = 1	25°C		0.2%		
THEFN	Total Harmonic distortion plus hoise	$R_L = 50 \text{ k}\Omega^{\ddagger}$	A <sub>V</sub> = 10	23 C		1%		
	Gain-bandwidth product	f = 10 kHz, C <sub>L</sub> = 100 pF <sup>‡</sup>	$R_L = 50 \text{ k}\Omega^{\ddagger}$ ,	25°C		0.2		MHz
ВОМ	Maximum output-swing bandwidth	$V_{O(PP)} = 2 \text{ V},$ $R_{L} = 50 \text{ k}\Omega^{\ddagger},$	$A_V = 1,$ $C_L = 100 \text{ pF}^{\ddagger}$	25°C		30		kHz
φm	Phase margin at unity gain	$R_L = 50 \text{ k}\Omega^{\ddagger,}$	C <sub>L</sub> = 100 pF <sup>‡</sup>	25°C		63°		
	Gain margin	K = 20 K75+,	CL = 100 pr+	25°C		15		dB

<sup>†</sup> Full range is 0°C to 70°C. ‡ Referenced to 2.5 V



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

	DADAMETED	TEST CO	NDITIONS	- +	Т	LC22520	;	LINUT
	PARAMETER	TEST CO	NDITIONS	T <sub>A</sub> †	MIN	TYP	MAX	UNIT
VIO	Input offset voltage			25°C		200	1500	μV
VIO	input onset voltage			Full range			1750	μν
αVIO	Temperature coefficient of input offset voltage			25°C to 70°C		0.5		μV/°C
	Input offset voltage long-term drift (see Note 4)	$V_{IC} = 0,$ $R_S = 50 \Omega$	$V_O = 0$ ,	25°C		0.003		μV/mo
lio	Input offset current			25°C		0.5	60	pА
.10	put oncot outlont			Full range			100	Ρ/ \
I <sub>IB</sub>	Input bias current			25°C		1	60	pА
'ID	par side carrein			Full range			100	Ρ, .
VICR	Common-mode input voltage range	V <sub> O</sub>   ≤5 mV,	Re = 50 O	25°C	-5 to 4	-5.3 to 4.2		V
	Common-mode input voltage range	V    O   = 0 IIIV,	113 - 00 22	Full range	-5 to 3.5			٠
		$I_O = -20 \mu A$		25°C		4.98		
Vou	Maximum positive peak output voltage	Ι <sub>Ο</sub> = –100 μΑ		25°C	4.9	4.93		<b> </b>
VOM+	waximum positive peak output voltage	10 = -100 μΑ		Full range	4.7			v
		$I_{O} = -200 \mu\text{A}$		25°C	4.8	4.86		
		$V_{IC} = 0$ ,	$I_{O} = 50 \mu\text{A}$	25°C		-4.99		
		V <sub>IC</sub> = 0,	I <sub>O</sub> = 500 μA	25°C	-4.85	-4.91		1
		VIC = 0,	10 = 000 μ τ	Full range	-4.85			
VOM-	Maximum negative peak output voltage	V <sub>IC</sub> = 0,	I <sub>O</sub> = 1 mA	25°C	-4.7	-4.8		V
		VIC = 0,		Full range	-4.7			
		V <sub>IC</sub> = 0,	IO = 4 mA	25°C	-4	-4.3		
		110 0,		Full range	-3.8			
			R <sub>L</sub> = 100 kΩ	25°C	45	650		
AVD	Large-signal differential voltage amplification	$V_O = \pm 4 V$		Full range	10			V/mV
			$R_L = 1 M\Omega$	25°C		3000		
rid	Differential input resistance			25°C		1012		Ω
r <sub>ic</sub>	Common-mode input resistance			25°C		1012		Ω
c <sub>ic</sub>	Common-mode input capacitance	f = 10 kHz,	P package	25°C		8		pF
z <sub>o</sub>	Closed-loop output impedance	f = 25 kHz,	A <sub>V</sub> = 10	25°C		190		Ω
CMRR	Common-mode rejection ratio	$V_{IC} = -5 \text{ V to } 3$	2.7 V,	25°C	75	88		dB
OWNER	Common mode rejection ratio	$V_{O} = 0$ ,	$R_S = 50 \Omega$	Full range	75			ub_
ksvr	Supply-voltage rejection ratio $(\Delta V_{DD+}/\Delta V_{IO})$	$V_{DD\pm} = 2.2 V$		25°C	80	95		dB
ovk		$V_{IC} = 0$ ,	No load	Full range	80			45
IDD	Supply current	V <sub>O</sub> = 0,	No load	25°C		80	125	μА
IDD		1 *0 = 0,	140 1040	Full range			150	μΛ

<sup>†</sup> Full range is 0°C to 70°C.

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, $\text{V}_{DD\pm}$ = $\pm5~\text{V}$

	PARAMETER	TEST CO	NDITIONS	- +	T	LC2252C	;	UNIT	
	PARAMETER	lesi co	NDITIONS	T <sub>A</sub> †	MIN	TYP	MAX	UNII	
		\/o - +1.0\/	Pr = 100 kO	25°C	0.07	0.12			
SR	Slew rate at unity gain	$V_O = \pm 1.9 \text{ V},$ $C_L = 100 \text{ pF}$	$R_L = 100 \text{ k}\Omega$ ,	Full range	0.05			V/μs	
V	Equivalent input paige voltage	f = 10 Hz		25°C		38		-> //s/II=	
V <sub>n</sub>	Equivalent input noise voltage			25°C	19		nV/√Hz		
V	Dook to neek equivalent input noise valtage	f = 0.1 Hz to 1 Hz		25°C		0.8		/	
VN(PP)	Peak-to-peak equivalent input noise voltage	f = 0.1 Hz to 10 Hz		25°C		1.1		μV	
In	Equivalent input noise current			25°C		0.6		fA√ <del>Hz</del>	
THD + N	Total harmonic distortion pulse duration	$V_0 = \pm 2.3 \text{ V},$	A <sub>V</sub> = 1	25°C		0.2%			
IND + N	Total harmonic distortion pulse duration	$f = 10 \text{ kHz},$ $R_L = 50 \text{ k}\Omega$	A <sub>V</sub> = 10	25 C		1%			
	Gain-bandwidth product	f = 10 kHz, C <sub>L</sub> = 100 pF	$R_L = 50 \text{ k}\Omega$ ,	25°C		0.21		MHz	
B <sub>OM</sub>	Maximum output-swing bandwidth	$V_{O(PP)} = 4.6 \text{ V},$ $R_{L} = 50 \text{ k}\Omega,$	A <sub>V</sub> = 1, C <sub>L</sub> = 100 pF	25°C		14		kHz	
φm	Phase margin at unity gain	B 50 kO	C 100 pF	25°C		63°			
	Gain margin	$R_L = 50 \text{ k}\Omega$ ,	$C_L = 100 \text{ pF}$	25°C		15		dB	

<sup>†</sup> Full range is 0°C to 70°C.

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

	DADAMETER	7507.00	NOTIONS		T	_C22540	;	
	PARAMETER	TEST CO	NDITIONS	T <sub>A</sub> †	MIN	TYP	MAX	UNIT
V. 0	Input offeet voltage			25°C		200	1500	\/
VIO	Input offset voltage			Full range			1750	μV
αVIO	Temperature coefficient of input offset voltage			25°C to 70°C		0.5		μV/°C
	Input offset voltage long-term drift (see Note 4)	$V_{IC} = 0,$ $V_{O} = 0,$	$V_{DD\pm} = \pm 2.5 \text{ V},$ Rs = 50 \Omega	25°C		0.003		μV/mo
li o	Input offset current	VO = 0,	11/5 = 30 22	25°C		0.5	60	pА
ΙΟ	input onset current			Full range			100	pΑ
lup.	Input bias current			25°C		1	60	pА
IВ	input bias current			Full range			100	pΑ
VICR	Common-mode input voltage range	$R_S = 50 \Omega$ ,	V <sub>IO</sub>   ≤ 5 mV	25°C	0 to 4	-0.3 to 4.2		٧
TION			1101=0	Full range	0 to 3.5			,
		$I_{OH} = -20  \mu A$		25°C		4.98		
Vон	High-level output voltage	I <sub>OH</sub> = -75 μA		25°C	4.9	4.94		V
VOH	riigirieveroutput voitage	10Η = 75 μΑ		Full range	4.8			V
		I <sub>OH</sub> = -150 μA		25°C	4.8	4.88		
		$V_{IC} = 2.5 V$ ,	I <sub>OL</sub> = 50 μA	25°C		0.01		
		V <sub>IC</sub> = 2.5 V,	I <sub>OL</sub> = 500 μA	25°C		0.09	0.15	
		10 =:0 :,	. <u>OL</u> 000 p.s.	Full range			0.15	
VOL	Low-level output voltage	V <sub>IC</sub> = 2.5 V,	I <sub>OL</sub> = 1 mA	25°C		0.2	0.3	V
		10 =:0 :,		Full range			0.3	
		V <sub>IC</sub> = 2.5 V,	I <sub>OL</sub> = 4 mA	25°C		0.7	1	
		10 =:0 :,	·	Full range			1.2	
		V <sub>IC</sub> = 2.5 V,	R <sub>L</sub> = 100 kΩ <sup>‡</sup>	25°C	100	350		
AVD	Large-signal differential voltage amplification	$V_0 = 1 \text{ V to 4 V}$		Full range	10			V/mV
			$R_L = 1 M\Omega^{\ddagger}$	25°C		1700		
r <sub>i(d)</sub>	Differential input resistance			25°C		1012		Ω
r <sub>i(c)</sub>	Common-mode input resistance			25°C		1012		Ω
c <sub>i(c)</sub>	Common-mode input capacitance	f = 10 kHz,	N package	25°C		8		pF
z <sub>0</sub>	Closed-loop output impedance	f = 25 kHz,	A <sub>V</sub> = 10	25°C		200		Ω
CMRR	Common-mode rejection ratio	$V_{IC} = 0 \text{ to } 2.7 \text{ V},$	V <sub>O</sub> = 2.5 V,	25°C	70	83		dB
CIVIKK	Common-mode rejection ratio	$R_S = 50 \Omega$		Full range	70			ub
kovis	Supply-voltage rejection ratio (ΔV <sub>DD</sub> /ΔV <sub>IO</sub> )	$V_{DD} = 4.4 \text{ V to}$	16 V,	25°C	80	95		dB
ksvr	2π <b>bb</b> iλ-λοιιαδε τελεστίου τατίο (Φλ.DD/ΦλΙΟ)	$V_{IC} = V_{DD}/2$ ,	No load	Full range	80			ub
IDE	Supply current (four amplifiers)	V <sub>O</sub> = 2.5 V,	No load	25°C		140	250	μΑ
lDD	Supply current (tout amplifiers)	v () = 2.5 v,	INU IUAU	Full range			300	μΑ

<sup>†</sup> Full range is 0°C to 70°C.

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.



<sup>‡</sup>Referenced to 2.5 V

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

	PARAMETER	TEST COND	ITIONS	- +	TLC2254C			UNIT	
	PARAMETER	TEST COND	IIIONS	T <sub>A</sub> †	MIN	TYP	MAX	UNII	
SR	Slew rate at unity gain	$V_0 = 1.4 \text{ V to } 2.6 \text{ V}$	$R_{L} = 100 \text{ k}\Omega^{\ddagger}$ ,	25°C	0.07	0.12		V/μs	
SK	Siew rate at unity gain	$C_L = 100 \text{ pF}^{\ddagger}$	_	Full range	0.05			V/μS	
\ /	Fault cleat input poice veltage	f = 10 Hz		25°C		36		\ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \	
V <sub>n</sub>	Equivalent input noise voltage	f = 1 kHz		25°C		19		nV/√Hz	
V	Peak-to-peak equivalent input noise	f = 0.1 Hz to 1 Hz		25°C		0.7		\/	
V <sub>N(PP)</sub>	voltage	f = 0.1 Hz to 10 Hz	25°C	1.1			μV		
In	Equivalent input noise current			25°C		0.6		fA/√Hz	
THD + N	Total harmonic distortion plus noise	$V_O = 0.5 \text{ V to } 2.5 \text{ V},$ f = 10 kHz,	A <sub>V</sub> = 1	25°C		0.2%			
THUTN	Total Harmonic distortion plus hoise	$R_L = 50 \text{ k}\Omega^{\ddagger}$	A <sub>V</sub> = 10	23 C		1%			
	Gain-bandwidth product	f = 10 kHz, C <sub>L</sub> = 100 pF <sup>‡</sup>	$R_L = 50 \text{ k}\Omega^{\ddagger}$ ,	25°C		0.2		MHz	
ВОМ	Maximum output-swing bandwidth	$V_{O(PP)} = 2 \text{ V},$ $R_{L} = 50 \text{ k}\Omega^{\ddagger},$	$A_V = 1$ , $C_L = 100 \text{ pF}^{\ddagger}$	25°C		30		kHz	
φm	Phase margin at unity gain	P 50 kOT	C <sub>I</sub> = 100 pF‡	25°C		63°			
	Gain margin	$R_L = 50 \text{ k}\Omega^{\ddagger}$ ,	CL = 100 pr+	25°C		15		dB	

<sup>†</sup> Full range is 0°C to 70°C. ‡ Referenced to 2.5 V

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

	DADAMETED	TEST COL	NDITIONS	_ +	TI	_C22540	;	
	PARAMETER	TEST COI	NDITIONS	T <sub>A</sub> †	MIN	TYP	MAX	UNIT
VIO	Input offset voltage			25°C		200	1500	μV
V10	input onset voitage			Full range			1750	μν
ανιο	Temperature coefficient of input offset voltage	<u></u>		25°C to 70°C		0.5		μV/°C
	Input offset voltage long-term drift (see Note 4)	$V_{IC} = 0,$ R <sub>S</sub> = 50 $\Omega$	$V_{O} = 0$ ,	25°C		0.003		μV/mo
lio	Input offset current	71/5 - 30 22		25°C		0.5	60	pА
lio	input onset current			Full range			100	PΛ
I <sub>IB</sub>	Input bias current			25°C		1	60	pА
чв	mpat bias carrent			Full range			100	PA
VICR	Common-mode input voltage range	V <sub>IO</sub>   ≤5 mV,	Rs = 50 Ω	25°C	-5 to 4	-5.3 to 4.2		V
TON	g-	1110125		Full range	-5 to 3.5			-
		$I_{O} = -20 \mu\text{A}$		25°C		4.98		
V <sub>OM+</sub>	Maximum positive peak output voltage	$I_{O} = -100 \mu A$		25°C	4.9	4.93		V
VOIVI+	Waxiiiaiii posiive poak output voitage	10 = 100 μ/τ		Full range	4.7			v
		$I_{O} = -200 \mu\text{A}$		25°C	4.8	4.86		
		$V_{IC} = 0$ ,	I <sub>O</sub> = 50 μA	25°C		-4.99		
		$V_{IC} = 0$ ,	ΙΟ = 500 μΑ	25°C	-4.85	-4.91		
		10 -7		Full range	-4.85			
VOM-	Maximum negative peak output voltage	V <sub>IC</sub> = 0,	$I_O = 1 \text{ mA}$	25°C	-4.7	-4.8		V
		10 -7		Full range	-4.7			
		V <sub>IC</sub> = 0,	$I_O = 4 \text{ mA}$	25°C	-4	-4.3		
		10 /	<del></del>	Full range	-3.8			
			R <sub>L</sub> = 100 kΩ	25°C	40	150		
AVD	Large-signal differential voltage amplification	$V_O = \pm 4 V$		Full range	10			V/mV
		<u> </u>	$R_L = 1 M\Omega$	25°C		3000		
ri(d)	Differential input resistance			25°C		1012		Ω
r <sub>i(c)</sub>	Common-mode input resistance			25°C		1012		Ω
<sup>C</sup> i(c)	Common-mode input capacitance	f = 10 kHz,	N package	25°C		8		pF
z <sub>O</sub>	Closed-loop output impedance	f = 25 kHz,	A <sub>V</sub> = 10	25°C		190		Ω
CMRR	Common-mode rejection ratio	$V_{IC} = -5 \text{ V to}$		25°C	75	88		dB
		V <sub>O</sub> = 0,	$R_S = 50 \Omega$	Full range	75			
ksvr	Supply-voltage rejection ratio (ΔV <sub>DD±</sub> /ΔV <sub>IO</sub> )	$V_{DD\pm} = \pm 2.2$		25°C	80	95		dB
LUNK	117 - 100 - 100 ± 100	$V_{IC} = 0$ ,	No load	Full range	80			
I <sub>DD</sub>	Supply current (four amplifiers)	$V_{O} = 0$ ,	No load	25°C		160	250	μΑ
ّـــ	· · · · · · · · · · · · · · · · · · ·	<u> </u>		Full range			300	•

<sup>†</sup> Full range is 0°C to 70°C.

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, $\text{V}_{DD\pm}$ = $\pm5~\text{V}$

	PARAMETER	TEST CON	IDITIONS	- +	TL	C22540	;	UNIT
	PARAMETER	TEST CON	IDITIONS	'A'	MIN	TYP	MAX	UNII
SR	Slew rate at unity gain	$V_0 = \pm 1.9 \text{ V},$	$R_L = 100 \text{ k}\Omega$ ,	25°C	0.07	0.12		V/µs
J.K	Siew rate at unity gain	C <sub>L</sub> = 100 pF		Full range	0.05			ν/μ5
V	Equivalent input noise voltage	f = 10 Hz		25°C		38		->//s/II=
V <sub>n</sub>	Equivalent input noise voltage	f = 1 kHz		25°C		19		nV/√Hz
V	Peak-to-peak equivalent input noise voltage	f = 0.1 Hz to 1 Hz		25°C		0.8		μV
V <sub>N(PP)</sub>	reak-to-peak equivalent input hoise voltage	f = 0.1 Hz to 10 H	łz	25°C		1.1		μν
In	Equivalent input noise current			25°C		0.6		fA/√ <del>Hz</del>
THD + N	Total harmonic distortion plus noise	$V_0 = \pm 2.3 \text{ V},$ f = 20 kHz,	A <sub>V</sub> = 1	25°€		0.2%		
THEFN	iotal narmonic distortion plus noise	$R_L = 50 \text{ k}\Omega$	A <sub>V</sub> = 10	25 C		1%		
	Gain-bandwidth product	f = 10 kHz, C <sub>L</sub> = 100 pF	$R_L = 50 \text{ k}\Omega$ ,	25°C		0.21		MHz
ВОМ	Maximum output-swing bandwidth	$V_{O(PP)} = 4.6 \text{ V},$ $R_{L} = 50 \text{ k}\Omega,$	$A_V = 1,$ $C_L = 100 pF$	25°C		14		kHz
φm	Phase margin at unity gain	$R_1 = 50 \text{ k}\Omega$	C <sub>I</sub> = 100 pF	25°C		63°		
	Gain margin	IVE = 20 K22,	CL = 100 pr			dB		

<sup>†</sup> Full range is 0°C to 70°C.

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### electrical characteristics at specified free-air temperature, V<sub>DD</sub> = 5 V (unless otherwise noted)

	PARAMETER	TEST CON	PAOITIONS	+,+	Т	LC2252	I	TI	C2252	NI .	UNIT
	TANAMETER	1231 CON	פאטוויםו	T <sub>A</sub> †	MIN	TYP	MAX	MIN	TYP	MAX	UNII
۷ <sub>IO</sub>	Input offset voltage			25°C		200	1500		200	850	μV
۷IO				Full range			1750			1000	μν
αΛΙΟ	Temperature coefficient of input offset voltage			25°C to 85°C		0.5			0.5		μV/°C
	Input offset voltage long-term drift (see Note 4)	$V_{DD\pm} = \pm 2.5 \text{ V},$ $V_{IC} = 0,$	$V_O = 0$ , R <sub>S</sub> = 50 $\Omega$	25°C		0.003			0.003		μV/mo
lio	Input offset current			25°C		0.5	60		0.5	60	pА
10	mpat oncot carront			Full range			1000			1000	Ρ, ,
Iв	Input bias current			25°C		1	60		1	60	pА
·ID				Full range	-	-	1000		-	1000	P/ ·
\/.op	Common-mode input	$R_S = 50 \Omega$ ,	V <sub>IO</sub>   ≤5 mV	25°C	0 to 4	-0.3 to 4.2		0 to 4	-0.3 to 4.2		V
VICR	voltage range	KS = 50 12,	IAIO I Z 2 IIIA	Full range	0 to 3.5			0 to 3.5			V
		I <sub>OH</sub> = -20 μA		25°C		4.98			4.98		
\/-··	High-level output	Ja., 75., A		25°C	4.9	4.94		4.9	4.94		V
VOH	voltage	$I_{OH} = -75 \mu A$		Full range	4.8			4.8			V
		I <sub>OH</sub> = -150 μA		25°C	4.8	4.88		4.8	4.88		
		$V_{IC} = 2.5 V$ ,	$I_{OL} = 50 \mu A$	25°C		0.01			0.01		
	Low lovel output	V <sub>IC</sub> = 2.5 V,	Ι <sub>Ο</sub> L = 500 μΑ	25°C		0.09	0.15		0.09	0.15	
VOL	Low-level output voltage	V C = 2.5 V,	10L = 300 μΑ	Full range			0.15			0.15	V
		V <sub>IC</sub> = 2.5 V,	I <sub>OL</sub> = 4 mA	25°C		0.8	1		0.7	1	
		V  C = 2.5 V,	10L = +111A	Full range			1.2			1.2	
	Large-signal differential	V <sub>IC</sub> = 2.5 V,	R <sub>L</sub> = 100 kΩ <sup>‡</sup>	25°C	100	350		100	350		
AVD	voltage amplification	$V_0 = 1 \text{ V to 4 V}$	_	Full range	10			10			V/mV
		ŭ	$R_L = 1 M\Omega^{\ddagger}$	25°C		1700			1700		
<sup>r</sup> id	Differential input resistance			25°C		10 <sup>12</sup>			1012		Ω
r <sub>ic</sub>	Common-mode input resistance			25°C		1012			1012		Ω
c <sub>ic</sub>	Common-mode input capacitance	f = 10 kHz,	P package	25°C		8			8		pF
z <sub>o</sub>	Closed-loop output impedance	f = 25 kHz,	A <sub>V</sub> = 10	25°C		200			200		Ω
CMPP	Common-mode	$V_{IC} = 0 \text{ to } 2.7 \text{ V},$	V <sub>O</sub> = 2.5 V,	25°C	70	83		70	83		4D
CMRR	rejection ratio	$R_S = 50 \Omega$		Full range	70			70			dB
ksvr	Supply-voltage rejection ratio	$V_{DD} = 4.4 \text{ V to}$		25°C	80	95		80	95		dB
ovk	(ΔV <sub>DD</sub> /ΔV <sub>IO</sub> )	$V_{IC} = V_{DD}/2$ ,	No load	Full range	80			80			,
la a	Cumply ourrest	Vo - 2 5 V	No lood	25°C		70	125		70	125	^
IDD	Supply current	$V_0 = 2.5 V$ ,	No load	Full range			150			150	μΑ

<sup>†</sup>Full range is – 40°C to 125°C.

NOTE 4: Typical values are based on the input offset voltage shift observed through 500 hours of operating life test at T<sub>A</sub> = 150°C extrapolated to  $T_A = 25$ °C using the Arrhenius equation and assuming an activation energy of 0.96 eV.



<sup>‡</sup>Referenced to 2.5 V

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

	ARAMETER	TEST COND	ITIONE	- +	T	LC2252	l	TL	.C2252A	I	UNIT
	ARAMETER	IESI COND	IIIONS	T <sub>A</sub> †	MIN	TYP	MAX	MIN	TYP	MAX	UNII
	Slew rate at unity	$V_0 = 1.5 \text{ V to } 3.5 \text{ V},$	R <sub>L</sub> = 100 kΩ <sup>‡</sup> ,	25°C	0.07	0.12		0.07	0.12		
SR	gain	C <sub>L</sub> = 100 pF <sup>‡</sup>	_	Full range	0.05			0.05			V/μs
V	Equivalent input	f = 10 Hz		25°C		36			36		nV/√ <del>Hz</del>
Vn	noise voltage	f = 1 kHz		25°C		19			19		110/\П2
V(1/20)	Peak-to-peak	f = 0.1 Hz to 1 Hz		25°C		0.7			0.7		\/
VN(PP)	equivalent input noise voltage	f = 0.1 Hz to 10 Hz		25°C		1.1			1.1		μV
In	Equivalent input noise current			25°C		0.6			0.6		fA√ <del>Hz</del>
THD + N	Total harmonic distortion plus	$V_O = 0.5 \text{ V to } 2.5 \text{ V},$ f = 10 kHz,	A <sub>V</sub> = 1	25°C		0.2%			0.2%		
THEFN	noise	$R_L = 50 \text{ k}\Omega^{\ddagger}$	A <sub>V</sub> = 10	25 0		1%			1%		
	Gain-bandwidth product	f = 50  kHz, $C_L = 100 \text{ pF}^{\ddagger}$	$R_L = 50 \text{ k}\Omega^{\ddagger}$ ,	25°C		0.2			0.2		MHz
Вом	Maximum output- swing bandwidth	$V_{O(PP)} = 2 V,$ $R_{L} = 50 \text{ k}\Omega^{\ddagger},$	$A_V = 1$ , $R_L = 50 \text{ k}\Omega^{\ddagger}$ ,	25°C		30			30		kHz
φm	Phase margin at unity gain	$R_L = 50 \text{ k}\Omega^{\ddagger}$ ,	C <sub>L</sub> = 100 pF‡	25°C		63°			63°		
	Gain margin			25°C		15	·		15		dB

<sup>†</sup> Full range is – 40°C to 125°C. ‡ Referenced to 2.5 V

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

				•		ַליי					
	PARAMETER	TEST CO	ONDITIONS	T <sub>A</sub> †	Т	LC2252	l	TI	_C2252A	NI.	UNIT
	TANAMETER	120100	эныноно	'A'	MIN	TYP	MAX	MIN	TYP	MAX	UNIT
VIO	Input offset voltage			25°C		200	1500		200	850	μV
۷IO	input onset voltage			Full range			1750			1000	μν
$\alpha$ VIO	Temperature coefficient of input offset voltage			25°C to 85°C		0.5			0.5		μV/°C
	Input offset voltage long- term drift (see Note 4)	$V_{IC} = 0,$ RS = 50 $\Omega$	$V_O = 0$ ,	25°C		0.003			0.003		μV/mo
lio	Input offset current			25°C		0.5	60		0.5	60	pА
10		1		Full range			1000		-	1000	F
I <sub>IB</sub>	Input bias current			25°C		1	60		1	60	pА
-1D				Full range			1000			1000	
	Common-mode input			25°C	-5 to 4	-5.3 to 4.2		-5 to 4	-5.3 to 4.2		
VICR	voltage range	$R_S = 50 \Omega$ ,	V <sub>IO</sub>   ≤5 mV	Full range	-5 to 3.5			-5 to 3.5			V
		$I_0 = -20 \mu A$		25°C		4.98			4.98		
.,	Maximum positive peak	100	•	25°C	4.9	4.93		4.9	4.93		.,
VOM+	output voltage	$I_{O} = -100 \mu$	4	Full range	4.7			4.7	-		V
		$I_0 = -200 \mu$	4	25°C	4.8	4.86		4.8	4.86		
		V <sub>IC</sub> = 0,	I <sub>O</sub> = 50 μA	25°C		-4.99			-4.99		
		V 0	I 500 ··· A	25°C	-4.85	-4.91		-4.85	-4.91		
VOM-	Maximum negative peak output voltage	$V_{IC} = 0$ ,	$I_{O} = 500 \mu\text{A}$	Full range	-4.85			-4.85			V
	peak output voltage	V10 - 0	lo - 4 m/	25°C	-4	-4.3		-4	-4.3		
		$V_{IC} = 0,$	$I_O = 4 \text{ mA}$	Full range	-3.8			-3.8			
			R <sub>L</sub> = 50 kΩ	25°C	40	150		40	150		
AVD	Large-signal differential voltage amplification	$V_O = \pm 4 V$	KL = 50 K22	Full range	10			10			V/m\
			$R_L = 1 M\Omega$	25°C		3000			3000		
r <sub>id</sub>	Differential input resistance			25°C		10 <sup>12</sup>			1012		Ω
r <sub>ic</sub>	Common-mode input resistance			25°C		10 <sup>12</sup>			10 <sup>12</sup>		Ω
c <sub>ic</sub>	Common-mode input capacitance	f = 10 kHz,	P package	25°C		8			8		pF
z <sub>o</sub>	Closed-loop output impedance	f = 25 kHz,	A <sub>V</sub> = 10	25°C		190			190		Ω
CMDD	Common-mode	$V_{IC} = -5 V to$	o 2.7 V,	25°C	75	88		75	88		<b>ئا</b> ك
CMRR	rejection ratio	$V_{O} = 0$ ,	$R_S = 50 \Omega$	Full range	75			75			dB
ka. /-	Supply-voltage rejection	V <sub>DD</sub> = 4.4 V		25°C	80	95		80	95		dB
<sup>k</sup> SVR	ratio (ΔV <sub>DD±</sub> /ΔV <sub>IO</sub> )	$V_{IC} = V_{DD}/2$		Full range	80			80			uB
loo	Supply current	Vo = 25 V	No load	25°C		80	125		80	125	^
IDD	Supply current	$V_0 = 2.5 V,$	เพบ เบลน์	Full range			150			150	μΑ

<sup>†</sup> Full range is – 40°C to 125°C.

NOTE 4: Typical values are based on the input offset voltage shift observed through 500 hours of operating life test at  $T_A = 150^{\circ}C$  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, $\text{V}_{DD\pm}$ = $\pm5~\text{V}$

	PARAMETER	TEST COL	NDITIONS	<b>-</b> +	Т	LC2252		TL	38 19 0.8 1.1 0.6 0.2% 1% 0.21	UNIT	
	PARAMETER	l lesi coi	NDITIONS	T <sub>A</sub> †	MIN	TYP	MAX	MIN	TYP	MAX	UNII
		Vo - +1 0 V	Pr = 100 kO	25°C	0.07	0.12		0.07	0.12		
SR	Slew rate at unity gain	$V_O = \pm 1.9 \text{ V},$ $C_L = 100 \text{ pF}$	KL = 100 K22,	Full range	0.05			0.05			V/µs
V	Equivalent input noise	f = 10 Hz		25°C		38			38		*) //s/I-
V <sub>n</sub>	voltage	f = 1 kHz		25°C		19			19		nV/√Hz
V	Peak-to-peak equivalent	f = 0.1 Hz to 1	Hz	25°C		0.8			0.8		\/
VN(PP)	input noise voltage	f = 0.1 Hz to 10	) Hz	25°C		1.1			1.1		μV
In	Equivalent input noise current			25°C		0.6			0.6		fA√Hz
THD + N	Total harmonic distortion	$V_0 = \pm 2.3 \text{ V},$	A <sub>V</sub> = 1	25°C		0.2%			0.2%		
I I I I I I I I I I I I I I I I I I I	plus noise	$R_L = 50 \text{ k}\Omega$ , $f = 10 \text{ kHz}$	A <sub>V</sub> = 10	25 C		1%			1%		
	Gain-bandwidth product	f =10 kHz, C <sub>L</sub> = 100 pF	$R_L = 50 \text{ k}\Omega$ ,	25°C		0.21			0.21		MHz
ВОМ	Maximum output-swing bandwidth	$V_{O(PP)} = 4.6   \text{R}_{L} = 50  \text{k}\Omega,$	/,A <sub>V</sub> = 1, C <sub>L</sub> = 100 pF	25°C		14			14		kHz
φm	Phase margin at unity gain	$R_L = 50 \text{ k}\Omega$ ,	C <sub>L</sub> = 100 pF	25°C		63°			63°		·
	Gain margin	]		25°C		15			15		dB

<sup>†</sup> Full range is –40°C to 125°C.

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

	DADAMETED	TEST 001	IDITIONS		Т	LC2254	ı	TL	LC2254/	AI .	
	PARAMETER	TEST CON	IDITIONS	T <sub>A</sub> †	MIN	TYP	MAX	MIN	TYP	MAX	UNIT
V <sub>IO</sub>	Input offset voltage			25°C		200	1500		200	850	μV
۷IO	input onset voltage			Full range			1750			1000	μν
αVIO	Temperature coefficient of input offset voltage	V <sub>DD±</sub> = ±2.5 V,		25°C to 125°C		0.5			0.5		μV/°C
	Input offset voltage long-term drift (see Note 4)	$V_{IC} = 0,$ $V_{O} = 0,$ $R_{S} = 50 \Omega$		25°C		0.003			0.003		μV/mo
lio	Input offset current			25°C		0.5	60		0.5	60	рA
10				Full range			1000			1000	P* *
I <sub>IB</sub>	Input bias current			25°C		1	60		1	60	pА
10				Full range		_	1000			1000	ľ
.,	Common-mode input	B 50.0	N 145 N	25°C	0 to 4	-0.3 to 4.2		0 to 4	-0.3 to 4.2		
VICR	voltage range	$R_S = 50 \Omega$ ,	V <sub>IO</sub>   ≤5 mV	Full range	0 to 3.5			0 to 3.5			V
		$I_{OH} = -20  \mu A$		25°C		4.98			4.98		
V0	High-level output	I <sub>OH</sub> = -75 μA		25°C	4.9	4.94		4.9	4.94		V
VOH	voltage	ΙΟΗ = -75 μΑ		Full range	4.8			4.8			V
		$I_{OH} = -150 \mu A$		25°C	4.8	4.88		4.8	4.88		
		$V_{IC} = 2.5 V$ ,	$I_{OL} = 50 \mu A$	25°C		0.01			0.01		
	Low-level output	V <sub>IC</sub> = 2.5 V,	I <sub>OL</sub> = 500 μA	25°C		0.09	0.15		0.09	0.15	
VOL	voltage	10 = 1,	-OL	Full range			0.15			0.15	V
		V <sub>IC</sub> = 2.5 V,	IOL = 4 mA	25°C		0.8	1		0.7	1	
		10 ,		Full range			1.2			1.2	
	Large-signal	V <sub>IC</sub> = 2.5 V,	$R_L = 100 \text{ k}\Omega^{\ddagger}$	25°C	100	350		100	350		
AVD	differential voltage amplification	$V_0 = 1 \text{ V to 4 V}$	_	Full range	10			10			V/mV
			$R_L = 1 M\Omega^{\ddagger}$	25°C		1700			1700		
<sup>r</sup> i(d)	Differential input resistance			25°C		1012			1012		Ω
r <sub>i(c)</sub>	Common-mode input resistance			25°C		10 <sup>12</sup>			10 <sup>12</sup>		Ω
c <sub>i(c)</sub>	Common-mode input capacitance	f = 10 kHz,	N package	25°C		8			8		pF
z <sub>O</sub>	Closed-loop output impedance	f = 25 kHz,	A <sub>V</sub> = 10	25°C		200			200		Ω
CMRR	Common-mode	$V_{IC} = 0 \text{ to } 2.7 \text{ V},$	V <sub>O</sub> = 2.5 V,	25°C	70	83		70	83		40
CIVIKK	rejection ratio	$R_S = 50 \Omega$	•	Full range	70			70			dB
ksvr	Supply-voltage rejection ratio	$V_{DD} = 4.4 \text{ V to}$		25°C	80	95		80	95		dB
	$(\Delta V_{DD}/\Delta V_{IO})$	$V_{IC} = V_{DD}/2$ ,	No load	Full range	80			80			
I <sub>DD</sub>	Supply current	V <sub>O</sub> = 2.5 V,	No load	25°C		140	250		140	250	μА
יטט.	(four amplifiers)	10 = 2.5 v,		Full range			300			300	μΛ

<sup>†</sup> Full range is – 40°C to 125°C.

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.



<sup>‡</sup>Referenced to 2.5 V

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

	ARAMETER	TEST COND	ITIONE	- +	Т	LC2254		TL	.C2254A	Al .	UNIT
"	ARAMETER	TEST COND	IIIONS	T <sub>A</sub> †	MIN	TYP	MAX	MIN	TYP	MAX	UNII
	Slew rate at unity	$V_0 = 1.4 \text{ V to } 2.6 \text{ V},$		25°C	0.07	0.12		0.07	0.12		
SR	gain	$R_L = 100 \text{ k}\Omega^{\ddagger},$ $C_L = 100 \text{ pF}^{\ddagger}$		Full range	0.05			0.05			V/µs
V	Equivalent input	f = 10 Hz		25°C		36			36		nV/√ <del>Hz</del>
Vn	noise voltage	f = 1 kHz		25°C		19			19		nv/√HZ
V	Peak-to-peak	f = 0.1 Hz to 1 Hz		25°C		0.7			0.7		\/
V <sub>N(PP)</sub>	equivalent input noise voltage	f = 0.1 Hz to 10 Hz		25°C		1.1			1.1		μV
In	Equivalent input noise current			25°C		0.6			0.6		fA/√ <del>Hz</del>
THD + N	Total harmonic distortion plus	$V_O = 0.5 \text{ V to } 2.5 \text{ V},$ f = 20 kHz,	A <sub>V</sub> = 1	25°C		0.2%			0.2%		
IIID + N	noise	$R_L = 50 \text{ k}\Omega^{\ddagger}$	A <sub>V</sub> = 10	25 0		1%			1%		
	Gain-bandwidth product	f = 50 kHz, C <sub>L</sub> = 100 pF‡	$R_L = 50 \text{ k}\Omega^{\ddagger}$ ,	25°C		0.2			0.2		MHz
Вом	Maximum output- swing bandwidth	$V_{O(PP)} = 2 V,$ $R_L = 50 \text{ k}\Omega^{\ddagger},$	$A_V = 1,$ $C_L = 100 \text{ pF}^{\ddagger}$	25°C		30			30		kHz
φm	Phase margin at unity gain	$R_L = 50 \text{ k}\Omega^{\ddagger}$ ,	C <sub>L</sub> = 100 pF‡	25°C		63°			63°		
	Gain margin			25°C		15			15		dB

<sup>†</sup> Full range is – 40°C to 125°C. ‡ Referenced to 2.5 V



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

		1			-	1.00054		-	COOF 4 A		
	PARAMETER	TEST CO	ONDITIONS	T <sub>A</sub> †	MIN	TYP	MAX	MIN	_C2254A TYP	MAX	UNIT
			-	25°C		200	1500		200	850	
VIO	Input offset voltage			Full range			1750			1000	μV
αVIO	Temperature coefficient of input offset voltage	1		25°C to 125°C		0.5			0.5		μV/°C
	Input offset voltage long-term drift (see Note 4)	$V_{IC} = 0$ , R <sub>S</sub> = 50 $\Omega$	$V_O = 0$ ,	25°C		0.003			0.003		μV/mc
lio	Input offset current			25°C Full range		0.5	60 1000		0.5	60 1000	pА
l <sub>IB</sub>	Input bias current	1		25°C		1	60		1	60	pА
	•			Full range			1000			1000	
VICR	Common-mode input	Ro = 50.0	V <sub>IO</sub>   ≤5 mV	25°C	-5 to 4	-5.3 to 4.2		–5 to 4	-5.3 to 4.2		٧
VICR	voltage range	NS = 50 22,	v  O	Full range	-5 to 3.5			-5 to 3.5			V
		$I_{O} = -20 \mu$	<u> </u>	25°C		4.98			4.98		
	Maximum positive peak		•	25°C	4.9	4.93		4.9	4.93		.,
VOM+	output voltage	$I_{O} = -100 \mu$	А	Full range	4.7	-		4.7	-		V
		$I_{O} = -200 \mu$	A	25°C	4.8	4.86		4.8	4.86		
		V <sub>IC</sub> = 0,	ΙΟ = 50 μΑ	25°C		-4.99			-4.99		
				25°C	-4.85	-4.91		-4.85	-4.91		
V <sub>OM</sub> -	Maximum negative peak	$V_{IC} = 0$ ,	$I_{O} = 500 \mu\text{A}$	Full range	-4.85			-4.85			V
•	output voltage			25°C	-4	-4.3		-4	-4.3		
		VIC = 0,	$I_O = 4 \text{ mA}$	Full range	-3.8	-		-3.8			
				25°C	40	150		40	150		
AVD	Large-signal differential	V <sub>O</sub> = ±4 V	$R_L = 100 \text{ k}\Omega$	Full range	10			10			V/mV
	voltage amplification		R <sub>L</sub> = 1 MΩ	25°C		3000			3000		
r <sub>i(d)</sub>	Differential input resistance			25°C		1012			1012		Ω
r <sub>i(c)</sub>	Common-mode input resistance			25°C		10 <sup>12</sup>			1012		Ω
<sup>C</sup> i(c)	Common-mode input capacitance	f = 10 kHz,	N package	25°C		8			8		pF
z <sub>o</sub>	Closed-loop output impedance	f = 25 kHz,	A <sub>V</sub> = 10	25°C		190			190		Ω
CMDD	Common-mode rejection	V <sub>IC</sub> = -5 V	to 2.7 V,	25°C	75	88		75	88		70
CMRR	ratio	$V_{O} = 0$ ,	$R_S = 50 \Omega$	Full range	75			75			dB
lea. :-	Supply-voltage rejection	$V_{DD+} = \pm 2.$	2 V to ±8 V,	25°C	80	95		80	95		AID.
ksvr	ratio $(\Delta V_{DD\pm}/\Delta V_{IO})$	$V_{IC} = V_{DD}$		Full range	80			80			dB
<u></u>	Supply current	Vo = 0	Noload	25°C		160	250		160	250	,. ^
IDD	(four amplifiers)	$V_O = 0$ ,	No load	Full range			300			300	μA

<sup>†</sup> Full range is – 40°C to 125°C.

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, $\text{V}_{DD\pm}$ = $\pm5~\text{V}$

	PARAMETER	TEST CON	DITIONS	- +	Т	LC2254		TL	.C2254A	Al .	UNIT
	PARAMETER	TEST CON	DITIONS	T <sub>A</sub> †	MIN	TYP	MAX	MIN	TYP	MAX	UNII
		$V_0 = \pm 1.9 \text{ V},$	$R_1 = 100 \text{ k}\Omega$	25°C	0.07	0.12		0.07	0.12		
SR	Slew rate at unity gain	C <sub>L</sub> = 100 pF	K[ = 100 K22,	Full range	0.05			0.05			V/µs
Vn	Equivalent input noise	f = 10 Hz		25°C		38			38		nV/√ <del>Hz</del>
٧n	voltage	f = 1 kHz		25°C		19			19		IIV/∀⊓Z
V	Peak-to-peak	f = 0.1 Hz to 1 Hz		25°C		0.8			8.0		\
VN(PP)	equivalent input noise voltage	f = 0.1 Hz to 10 H	z	25°C		1.1			1.1		μV
In	Equivalent input noise current			25°C		0.6			0.6		fA/√ <del>Hz</del>
THD + N	Total harmonic	$V_0 = \pm 2.3 \text{ V},$	A <sub>V</sub> = 1	25°C		0.2%			0.2%		
IIID + N	distortion plus noise	$R_L = 50 \text{ k}\Omega$ , f = 20 kHz	A <sub>V</sub> = 10	25 0		1%			1%		
	Gain-bandwidth product	f =10 kHz, C <sub>L</sub> = 100 pF	$R_L = 50 \text{ k}\Omega$ ,	25°C		0.21			0.21		MHz
Вом	Maximum output-swing bandwidth	$V_{O(PP)} = 4.6 \text{ V},$ $R_{L} = 50 \text{ k}\Omega,$	A <sub>V</sub> = 1, C <sub>L</sub> = 100 pF	25°C		14			14		kHz
φm	Phase margin at unity gain	R <sub>L</sub> = 50 kΩ,	C <sub>L</sub> = 100 pF	25°C		63°			63°		
	Gain margin			25°C		15			15		dB

<sup>†</sup> Full range is -40°C to 125°C.

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

	PARAMETER	TEST CON	DITIONS	T <sub>A</sub> †		LC22520 LC22521			.C2252A .C2252A		UNIT
					MIN	TYP	MAX	MIN	TYP	MAX	
.,				25°C		200	1500		200	850	`,,
VIO	Input offset voltage			Full range			1750			1000	μV
ανιο	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)	$V_{DD\pm} = \pm 2.5 \text{ V},$ $V_{O} = 0,$	$V_{IC} = 0$ , $R_S = 50 \Omega$	25°C		0.003			0.003		μV/mo
IO	Input offset current			25°C		0.5	60		0.5	60	pА
-10	mpar oncor carron	]		Full range			1000		_	1000	Ρ/ \
IIB	Input bias current			25°C		1	60		1	60	pА
·ID				Full range			1000			1000	Ρ
	Common-mode input			25°C	0 to 4	-0.3 to 4.2		0 to 4	-0.3 to 4.2		
VICR	voltage range	$R_S = 50 \Omega$ ,	V <sub>IO</sub>   ≤5 mV	Full range	0 to 3.5			0 to 3.5			V
		$I_{OH} = -20  \mu A$		25°C		4.98			4.98		
\	High-level output			25°C	4.9	4.94		4.9	4.94		l ,,
VOH	voltage	I <sub>OH</sub> = -75 μA		Full range	4.8			4.8			V
		I <sub>OH</sub> = -150 μA		25°C	4.8	4.88		4.8	4.88		
		$V_{IC} = 2.5 V$ ,	$I_{OL} = 50 \mu A$	25°C		0.01			0.01		
	Low-level output	V <sub>IC</sub> = 2.5 V,	I <sub>OL</sub> = 500 μA	25°C		0.09	0.15		0.09	0.15	
VOL	voltage	V <sub>1</sub> C = 2.0 V,	- ΙΟΕ = 000 μ/τ	Full range			0.15			0.15	V
	· ·	V <sub>IC</sub> = 2.5 V,	IOL = 4 mA	25°C		8.0	1		0.7	1	
		10 = 10 1,	-OL	Full range			1.2			1.2	
	Large-signal differential	V <sub>IC</sub> = 2.5 V,	$R_L = 100 \text{ k}\Omega^{\ddagger}$	25°C	100	350		100	350		
AVD	voltage amplification	$V_0 = 1 \text{ V to 4 V}$	_	Full range	10			10			V/mV
			$R_L = 1 M\Omega^{\ddagger}$	25°C		1700			1700		
rid	Differential input resistance			25°C		1012			1012		Ω
r <sub>ic</sub>	Common-mode input resistance			25°C		1012			1012		Ω
c <sub>ic</sub>	Common-mode input capacitance	f = 10 kHz,	f = 10 kHz,	25°C		8			8		pF
z <sub>o</sub>	Closed-loop output impedance	f = 25 kHz,	A <sub>V</sub> = 10	25°C		200			200		Ω
CMDC	Common-mode	V <sub>IC</sub> = 0 to 2.7 V,	V <sub>O</sub> = 2.5 V,	25°C	70	83		70	83		4D
CMRR	rejection ratio	$R_S = 50 \Omega$		Full range	70			70			dB
ksvr	Supply-voltage rejection ratio	$V_{DD} = 4.4 \text{ V to } 10^{-1}$	6 V, No load	25°C	80	95		80	95		dB
	$(\Delta V_{DD}/\Delta V_{IO})$	$V_{IC} = V_{DD}/2$ ,	INU IUAU	Full range	80			80			
I <sub>DD</sub>	Supply current	V <sub>O</sub> = 2.5 V,	No load	25°C		70	125		70	125	μΑ
-טט		10 = 2.5 v,		Full range			150			150	μΛ

<sup>&</sup>lt;sup>†</sup> Full range is – 40°C to 125°C for Q suffix, – 55°C to 125°C for M 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.



<sup>‡</sup>Referenced to 2.5 V

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

P.	ARAMETER	TEST COND	ITIONS	T <sub>A</sub> †		.C22520 .C22521			C2252A C2252A		UNIT
				- 1	MIN	TYP	MAX	MIN	TYP	MAX	
	Slew rate at unity	Vo = 0.5 V to 3.5 V		25°C	0.07	0.12		0.07	0.12		
SR	gain	$V_O = 0.5 \text{ V to } 3.5 \text{ V},$ $R_L = 100 \text{ k}\Omega^{\ddagger},$	$C_L = 100 \text{ pF}^{\ddagger}$	Full range	0.05			0.05			V/μs
V	Equivalent input	f = 10 Hz		25°C		36			36		nV/√ <del>Hz</del>
V <sub>n</sub>	noise voltage	f = 1 kHz		25°C		19			19		IIV/√⊓Z
VN/DD)	Peak-to-peak equivalent input	f = 0.1 Hz to 1 Hz		25°C		0.7			0.7		μV
V <sub>N(PP)</sub>	noise voltage	f = 0.1 Hz to 10 Hz		25°C		1.1			1.1		μν
In	Equivalent input noise current			25°C		0.6			0.6		fA√ <del>Hz</del>
THD + N	Total harmonic distortion plus	$V_O = 0.5 \text{ V to } 2.5 \text{ V},$ f = 10 kHz,	A <sub>V</sub> = 1	25°C		0.2%			0.2%		
IIIDTI	noise	$R_L = 50 \text{ k}\Omega^{\ddagger}$	A <sub>V</sub> = 10	25 0		1%			1%		
	Gain-bandwidth product	f = 50  kHz, $C_L = 100 \text{ pF}^{\ddagger}$	$R_L = 50 \text{ k}\Omega^{\ddagger}$ ,	25°C		0.2			0.2		MHz
ВОМ	Maximum output- swing bandwidth	$V_{O(PP)} = 2 V,$ $R_{L} = 50 \text{ k}\Omega^{\ddagger},$	$A_V = 1,$ $C_L = 100 \text{ pF}^{\ddagger}$	25°C		30			30		kHz
φm	Phase margin at unity gain	$R_L = 50 \text{ k}\Omega^{\ddagger}$ ,	C <sub>L</sub> = 100 pF‡	25°C		63°			63°		
	Gain margin			25°C		15			15		dB

<sup>†</sup> Full range is – 40°C to 125°C for Q suffix, – 55°C to 125°C for M suffix. ‡ Referenced to 2.5 V



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

	PARAMETER	TEST CO	ONDITIONS	τ <sub>Α</sub> †		LC22520 LC2252N	-		.C2252A .C2252A	-	UNIT
					MIN	TYP	MAX	MIN	TYP	MAX	
.,	least offerteelle			25°C		200	1500		200	850	
VIO	Input offset voltage			Full range			1750			1000	μV
αΛΙΟ	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)	$V_{IC} = 0,$ $R_S = 50 \Omega$	$V_O = 0$ ,	25°C		0.003			0.003		μV/mo
ما	Input offset current	1		25°C		0.5	60		0.5	60	pА
lio	input onset current			Full range			1000			1000	ÞΑ
lin.	Input bias current	1		25°C		1	60		1	60	pА
ΙΒ	input bias current			Full range			1000			1000	pΑ
VICR	Common-mode input voltage range	$R_S = 50 \Omega$ ,	V <sub>IO</sub>   ≤5 mV	25°C	-5 to 4 -5	-5.3 to 4.2		-5 to 4 -5	-5.3 to 4.2		<b>V</b>
	voltage range			Full range	-5 to 3.5			-5 to 3.5			ļ
		$I_{O} = -20 \mu A$		25°C		4.98			4.98		
V/ <b>\^ \^ \ \</b> .	Maximum positive peak output voltage	1- 400		25°C	4.9	4.93		4.9	4.93		V
		I <sub>O</sub> = -100 μA		Full range	4.7			4.7			V
		$I_{O} = -200 \mu$	4	25°C	4.8	4.86		4.8	4.86		
		V <sub>IC</sub> = 0,	I <sub>O</sub> = 50 μA	25°C		-4.99			-4.99		
		\/. = 0	I 500 A	25°C	-4.85	-4.91		-4.85	-4.91		
$V_{OM-}$	Maximum negative peak output voltage	$V_{IC} = 0$ ,	$I_O = 500 \mu\text{A}$	Full range	-4.85			-4.85			V
	pour output voltago	V <sub>IC</sub> = 0,		25°C	-4	-4.3		-4	-4.3		
		V C=0	$I_O = 4 \text{ mA}$	Full range	-3.8			-3.8			
			R <sub>L</sub> = 100 kΩ	25°C	40	150		40	150		
AVD	Large-signal differential voltage amplification	$V_O = \pm 4 V$	K_ = 100 K22	Full range	10			10			V/mV
	voltago amplinoation		$R_L = 1 M\Omega$	25°C		3000			3000		
r <sub>id</sub>	Differential input resistance			25°C		10 <sup>12</sup>			10 <sup>12</sup>		Ω
r <sub>ic</sub>	Common-mode input resistance			25°C		10 <sup>12</sup>			10 <sup>12</sup>		Ω
c <sub>ic</sub>	Common-mode input capacitance	f = 10 kHz,	P package	25°C		8			8		pF
z <sub>0</sub>	Closed-loop output impedance	f = 25 kHz,	A <sub>V</sub> = 10	25°C		190			190		Ω
CMRR	Common-mode	$V_{IC} = -5 V t$	o 2.7 V,	25°C	75	88		75	88		40
CIVIRR	rejection ratio	$V_{O} = 0,$	$R_S = 50 \Omega$	Full range	75			75			dB
le = . :-	Supply-voltage rejection	$V_{DD} = \pm 2.2$	√ to ±8 V,	25°C	80	95		80	95		מוה
ksvr	ratio (ΔV <sub>DD±</sub> /ΔV <sub>IO</sub> )	$V_{IC} = 0$ ,	No load	Full range	80			80			dB
<b>I</b> = =	Supply current	Vo = 2.5.V	No load	25°C		80	125		80	125	,. Λ
IDD	Supply current	$V_0 = 2.5 V$ ,	INU IUaU	Full range			150			150	μΑ

<sup>†</sup> Full range is – 40°C to 125°C for Q suffix, – 55°C to 125°C for M 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, $\text{V}_{DD\pm}$ = $\pm5~\text{V}$

	PARAMETER		TEST CONDITIONS		TEST CONDITIONS			.C22520 .C22521			C2252A C2252A	-	UNIT
				T <sub>A</sub> †	MIN	TYP	MAX	MIN	TYP	MAX			
		Vo - +2 V	Pr = 100 kO	25°C	0.07	0.12		0.07	0.12				
SR	Slew rate at unity gain	$V_0 = \pm 2 V$ , $C_L = 100 pF$	$R_L = 100 \text{ k}\Omega$ ,	Full range	0.05			0.05			V/µs		
Vn	Equivalent input noise	f = 10 Hz	f = 10 Hz 25°			38			38		nV/√ <del>Hz</del>		
٧n	voltage	f = 1 kHz		25°C	19		19			IIV/√⊓Z			
VALCED)	Peak-to-peak equivalent	f = 0.1 Hz to 1 H:	Z	25°C		0.8			0.8		μV		
VN(PP)	input noise voltage	f = 0.1 Hz to 10 H	f = 0.1 Hz to 10 Hz		1.1		1.1			μν			
In	Equivalent input noise current			25°C		0.6			0.6		fA√Hz		
THD + N	Total harmonic distortion	$V_O = \pm 2.3 \text{ V},$ $R_I = 50 \text{ k}\Omega,$	A <sub>V</sub> = 1	25°C		0.2%			0.2%				
IIID + N	plus noise	f = 10  kHz	A <sub>V</sub> = 10	25 0		1%			1%				
	Gain-bandwidth product	f =10 kHz, C <sub>L</sub> = 100 pF	$R_L = 50 \text{ k}\Omega$ ,	25°C		0.21			0.21		MHz		
Вом	Maximum output-swing bandwidth	$V_{O(PP)} = 4.6 \text{ V},$ $R_{L} = 50 \text{ k}\Omega,$	A <sub>V</sub> = 1, C <sub>L</sub> = 100 pF	25°C		14			14		kHz		
φm	Phase margin at unity gain	R <sub>L</sub> = 50 kΩ,	C <sub>L</sub> = 100 pF	25°C		63°	·		63°				
	Gain margin			25°C		15			15		dB		

<sup>†</sup> Full range is – 40°C to 125°C for Q suffix, – 55°C to 125°C for M suffix.

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

	PARAMETER	TEST CONDITIONS		T <sub>A</sub> †	TLC2254Q TLC2254M				.C2254A .C2254A		UNIT	
				'^	MIN	TYP	MAX	MIN	TYP	MAX		
\/	land offers welleng			25°C		200	1500		200	850	\/	
VIO	Input offset voltage			Full range			1750		-	1000	μV	
αVIO	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)	$V_{DD\pm} = \pm 2.5 \text{ V},$ $V_{O} = 0,$	$V_{IC} = 0$ , RS = 50 $\Omega$	25°C		0.003			0.003		μV/mo	
I <sub>IO</sub>	Input offset current			25°C		0.5	60		0.5	60	рA	
10		_		125°C			1000			1000	ľ	
lв	Input bias current			25°C		1	60		1	60	pА	
				125°C			1000			1000		
	Common-mode input			25°C	0 to 4	-0.3 to 4.2		0 to 4	-0.3 to 4.2			
VICR	voltage range	$R_S = 50 \Omega$ ,	V <sub>IO</sub>   ≤5 mV	Full range	0 to 3.5			0 to 3.5			V	
		I <sub>OH</sub> = -20 μA		25°C		4.98			4.98			
.,	High-level output voltage			25°C	4.9	4.94		4.9	4.94		1 ,	
VOH		I <sub>OH</sub> = -75 μA		Full range	4.8			4.8			V	
		$I_{OH} = -150 \mu A$		25°C	4.8	4.88		4.8	4.88			
		$V_{IC} = 2.5 \text{ V},$	I <sub>OL</sub> = 50 μA	25°C		0.01			0.01			
	Low lovel output	V <sub>IC</sub> = 2.5 V,	I <sub>OL</sub> = 500 μA	25°C		0.09	0.15		0.09	0.15		
VOL	Low-level output voltage	V <sub>1</sub> C = 2.5 v,	ΙΟΕ = 000 μ/τ	Full range			0.15			0.15	V	
	3.1.0	V <sub>IC</sub> = 2.5 V,	I <sub>OL</sub> = 4 mA	25°C		0.8	1		0.7	1		
		V <sub>1</sub> C = 2.5 v,	10L = +110K	Full range			1.2			1.2		
	Large-signal	V <sub>IC</sub> = 2.5 V,	$R_L = 100 \text{ k}\Omega^{\ddagger}$	25°C	100	350		100	350			
AVD	differential	$V_0 = 1 \text{ V to 4 V}$		Full range	10			10			V/mV	
	voltage amplification		$R_L = 1 M\Omega^{\ddagger}$	25°C		1700			1700			
<sup>r</sup> i(d)	Differential input resistance			25°C		1012			1012		Ω	
ri(c)	Common-mode input resistance			25°C		1012			1012		Ω	
<sup>C</sup> i(c)	Common-mode input capacitance	f = 10 kHz,	N package	25°C		8			8		pF	
z <sub>o</sub>	Closed-loop output impedance	f = 25 kHz,	A <sub>V</sub> = 10	25°C		200			200		Ω	
CMRR	Common-mode	$V_{IC} = 0 \text{ to } 2.7 \text{ V},$	V <sub>O</sub> = 2.5 V,	25°C	70	83		70	83		dB	
JIVIITIT	rejection ratio	$R_S = 50 \Omega$		Full range	70			70			ub	
k <sub>SVR</sub>	Supply-voltage rejection ratio	$V_{DD} = 4.4 \text{ V to 1}$ $V_{IC} = V_{DD}/2$ ,	6 V, No load	25°C	80	95		80	95		dB	
	(ΔVDD/ΔVIO)	*IC = *DD/2,	z, INO IOAU	Full range	80			80			₩	
IDD	Supply current	V <sub>O</sub> = 2.5 V,	No load	25°C		140	250		140	250	μА	
<i></i>	(four amplifiers)			Full range			300			300	μ,	

<sup>†</sup> Full range is – 40°C to 125°C for Q suffix, – 55°C to 125°C for M 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.



<sup>‡</sup>Referenced to 2.5 V

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

PARAMETER		TEST CONDITIONS		T <sub>A</sub> †		.C22540 .C22541	•		C2254A C2254A	-	UNIT	
					MIN	TYP	MAX	MAX MIN TYP MAX		MAX		
	Slew rate at unity	$V_0 = 0.5 \text{ V to } 3.5 \text{ V},$	$V_{O} = 0.5 \text{ V to } 3.5 \text{ V},$		0.07	0.12		0.07	0.12			
SR	gain	$R_L = 100 \text{ k}\Omega^{\ddagger},$ $C_L = 100 \text{ pF}^{\ddagger}$		Full range	0.05			0.05			V/µs	
V	Equivalent input	f = 10 Hz	= 10 Hz 2			36			36		nV/√ <del>Hz</del>	
V <sub>n</sub>	noise voltage	f = 1 kHz		25°C		19			19		IIV/√⊓Z	
VALCED)	Peak-to-peak equivalent input	f = 0.1 Hz to 1 Hz	Hz to 1 Hz		0.7		0.7			μV		
VN(PP)	noise voltage	f = 0.1 Hz to 10 Hz		25°C	1.1		1.1			μν		
In	Equivalent input noise current			25°C		0.6			0.6		fA /√Hz	
THD + N	Total harmonic distortion plus	$V_O = 0.5 \text{ V to } 2.5 \text{ V},$ f = 20 kHz,	A <sub>V</sub> = 1	25°C		0.2%			0.2%			
I I I D + N	noise	$R_L = 50 \text{ k}\Omega^{\ddagger}$	A <sub>V</sub> = 10	25 C		1%			1%			
	Gain-bandwidth product	f = 50  kHz, $C_L = 100 \text{ pF}^{\ddagger}$	$R_L = 50 \text{ k}\Omega^{\ddagger}$ ,	25°C		0.2			0.2		MHz	
ВОМ	Maximum output- swing bandwidth	$V_{O(PP)} = 2 V,$ $R_L = 50 \text{ k}\Omega^{\ddagger},$	$A_V = 1,$ $C_L = 100 \text{ pF}^{\ddagger}$	25°C		30			30		kHz	
φm	Phase margin at unity gain	$R_L = 50 \text{ k}\Omega^{\ddagger}$ ,	C <sub>L</sub> = 100 pF‡	25°C		63°			63°			
	Gain margin			25°C		15			15		dB	

<sup>†</sup> Full range is – 40°C to 125°C for Q suffix, – 55°C to 125°C for M suffix. ‡ Referenced to 2.5 V

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

PARAMETER		TEST CONDITIONS		T <sub>A</sub> †		LC22540 LC2254N			.C2254A .C2254A		UNIT
					MIN	TYP	MAX	MIN	TYP	MAX	
.,				25°C		200	1500		200	850	
VIO	Input offset voltage			Full range			1750			1000	μV
αΛΙΟ	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)	V <sub>IC</sub> = 0, R <sub>S</sub> = 50 Ω	$V_O = 0$ ,	25°C		0.003			0.003		μV/mo
I	Innut offeet europt	]		25°C		0.5	60		0.5	60	~^
lo	Input offset current			125°C			1000			1000	pА
l.s	Input bigg gurrent			25°C		1	60		1	60	- Α
ΙΒ	Input bias current			125°C			1000			1000	pΑ
VICR	Common-mode input voltage range	$R_S = 50 \Omega$ ,	V <sub>IO</sub>   ≤5 mV	25°C	-5 to 4 -5	-5.3 to 4.2		-5 to 4 -5	-5.3 to 4.2		٧
				Full range	to 3.5			to 3.5			
		$I_{O} = -20  \mu A$		25°C		4.98			4.98		
V/	Maximum positive peak output voltage	Ι <sub>Ο</sub> = -100 μΑ		25°C	4.9	4.93		4.9	4.93		] <sub>v</sub>
VOM+				Full range	4.7			4.7			V
		$I_{O} = -200 \mu$	A	25°C	4.8	4.86		4.8	4.86		
		V <sub>IC</sub> = 0,	ΙΟ = 50 μΑ	25°C		-4.99			-4.99		
		V:- 0	I- F00 A	25°C	-4.85	-4.91		-4.85	-4.91		
$^{V}OM-$	Maximum negative peak output voltage	$V_{IC} = 0$ ,	I <sub>O</sub> = 500 μA	Full range	-4.85			-4.85			V
	output voltago	V <sub>IC</sub> = 0,	I <sub>O</sub> = 4 mA	25°C	-4	-4.3		-4	-4.3		
		V C=0	10 = 4 IIIA	Full range	-3.8			-3.8			
			R <sub>L</sub> = 100 kΩ	25°C	40	150		40	150		
AVD	Large-signal differential voltage amplification	$V_O = \pm 4 V$	K_ = 100 K22	Full range	10			10			V/mV
	Tonage ampimoation		$R_L = 1 M\Omega$	25°C		3000			3000		
r <sub>i(d)</sub>	Differential input resistance			25°C		1012			1012		Ω
ri(c)	Common-mode input resistance			25°C		1012			1012		Ω
Ci(c)	Common-mode input capacitance	f = 10 kHz,	N package	25°C		8			8		pF
z <sub>O</sub>	Closed-loop output impedance	f = 25 kHz,	A <sub>V</sub> = 10	25°C		190			190		Ω
CMDD	Common-mode rejection	V <sub>IC</sub> = -5 V t	to 2.7 V,	25°C	75	88		75	88		40
CMRR	ratio	$V_{O} = 0,$	$R_S = 50 \Omega$	Full range	75			75			dB
lea. :-	Supply-voltage rejection	V <sub>DD+</sub> = ±2	.2 V to ±8 V,	25°C	80	95		80	95		40
ksvr	ratio ( $\Delta V_{DD\pm}/\Delta V_{IO}$ )	$V_{IC} = V_{DD}/2$		Full range	80			80			dB
la a	Supply current	\/o = 0	Nolood	25°C		160	250		160	250	
IDD	(four amplifiers)	$V_O = 0$ ,	No load	Full range			300			300	μΑ

† Full range is – 40°C to 125°C for Q suffix, – 55°C to 125°C for M suffix.

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



# operating characteristics at specified free-air temperature, $\text{V}_{DD\pm}$ = $\pm5~\text{V}$

PARAMETER		TEST CONDITIONS		T <sub>A</sub> †		C22540			C2254A C2254A		UNIT										
					MIN	TYP	MAX	MIN	MIN TYP												
		V <sub>O</sub> = ±2 V,	$R_1 = 100 \text{ k}\Omega$	25°C	0.07	0.12		0.07	0.12												
SR	Slew rate at unity gain	$C_L = 100 \text{ pF}$	K[ = 100 K22,	Full range	0.05			0.05			V/μs										
v <sub>n</sub>	Equivalent input noise	f = 10 Hz	lz 2			38			38		nV/√ <del>Hz</del>										
∨n	voltage	f = 1 kHz		25°C		19			IIV/VIIZ												
V <sub>N(PP)</sub>	Peak-to-peak equivalent input noise	f = 0.1 Hz to 1 Hz	f = 0.1 Hz to 1 Hz 25°C		0.8			0.8			μV										
VN(PP)	voltage	f = 0.1 Hz to 10 H	z	25°C	25°C 1.1		1.1			μν											
In	Equivalent input noise current			25°C		0.6			0.6		fA /√Hz										
THD + N	Total harmonic	$V_{O} = \pm 2.3 \text{ V},$ $R_{L} = 50 \text{ k}\Omega,$	A <sub>V</sub> = 1	25°C		0.2%			0.2%												
IIID+N	distortion plus noise	f = 20  kHz	A <sub>V</sub> = 10	25 C		1%			1%												
	Gain-bandwidth product	f =10 kHz, C <sub>L</sub> = 100 pF	$R_L = 50 \text{ k}\Omega$ ,	25°C	0.21		0.21		0.21		0.21		0.21		0.21		0.21		0.21		MHz
Вом	Maximum output-swing bandwidth	$V_{O(PP)} = 4.6 \text{ V},$ $R_{L} = 50 \text{ k}\Omega,$	A <sub>V</sub> = 1, C <sub>L</sub> = 100 pF	25°C	14			14		kHz											
φm	Phase margin at unity gain	$R_L = 50 \text{ k}\Omega$ ,	C <sub>L</sub> = 100 pF	25°C		63°			63°												
	Gain margin			25°C		15			15		dB										

<sup>†</sup> Full range is – 40°C to 125°C for Q suffix, – 55°C to 125°C for M suffix.

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35

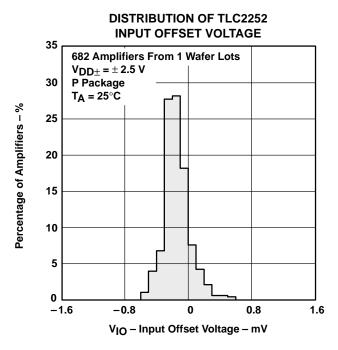


Figure 2

**DISTRIBUTION OF TLC2254** 

**INPUT OFFSET VOLTAGE** 

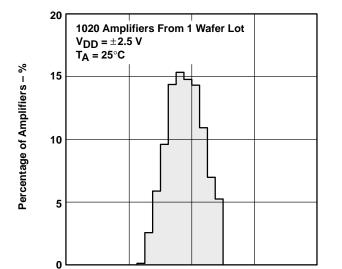


Figure 4

0

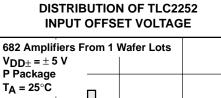
V<sub>IO</sub> - Input Offset Voltage - mV

8.0

1.6

-0.8

-1.6



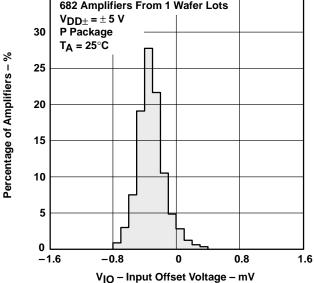


Figure 3

#### **DISTRIBUTION OF TLC2254 INPUT OFFSET VOLTAGE**

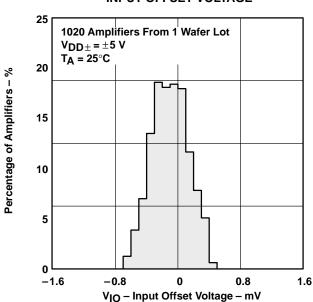
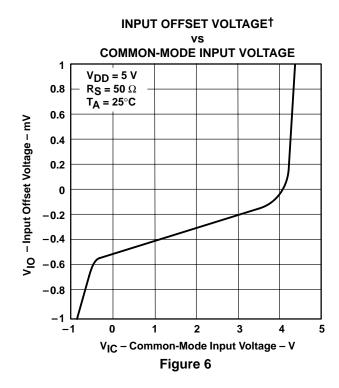
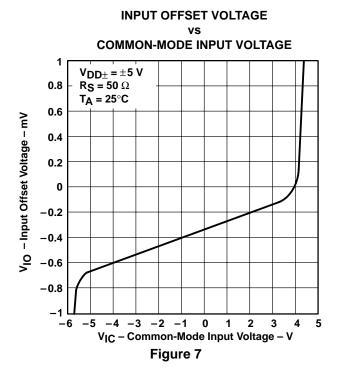
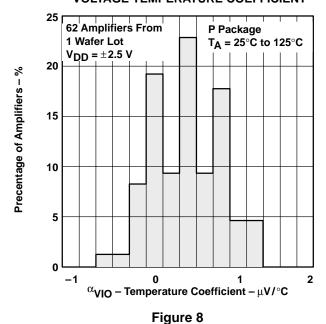


Figure 5





#### **DISTRIBUTION OF TLC2252 INPUT OFFSET VOLTAGE TEMPERATURE COEFFICIENT**



#### DISTRIBUTION OF TLC2252 INPUT OFFSET **VOLTAGE TEMPERATURE COEFFICIENT**

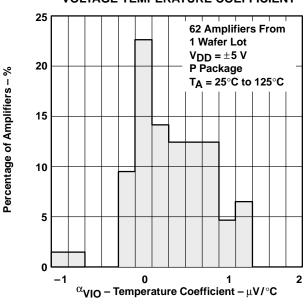


Figure 9

 $<sup>\</sup>dagger$  For curves where  $V_{DD}$  = 5 V, all loads are referenced to 2.5 V.



### **DISTRIBUTION OF TLC2254 INPUT OFFSET VOLTAGE TEMPERATURE COEFFICIENT** 25 **62 Amplifiers From** 1 Wafer Lot $V_{DD\pm} = \pm 2.5 \text{ V}$ 20 P Package Percentage of Amplifiers - % $T_A = 25^{\circ}C$ to $125^{\circ}C$ 15 10 5 -2 0 2

Figure 10

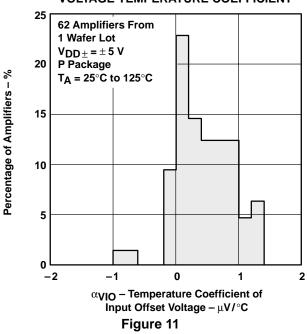
 $\alpha_{\mbox{VIO}}$  – Temperature Coefficient of

Input Offset Voltage – μV/°C

INPUT BIAS AND INPUT OFFSET CURRENTS†

### vs FREE-AIR TEMPERATURE IB and I<sub>O</sub> – Input Bias and Input Offset Currents – pA 35 $V_{DD\pm}$ = ±2.5 V VIC = 030 $V_O = 0$ $R_S = 50 \Omega$ 25 lΒ 20 15 lю 10 5 T<sub>A</sub> - Free-Air Temperature - °C Figure 12

DISTRIBUTION OF TLC2254 INPUT OFFSET VOLTAGE TEMPERATURE COEFFICIENT



# INPUT VOLTAGE RANGE VS SUPPLY VOLTAGE

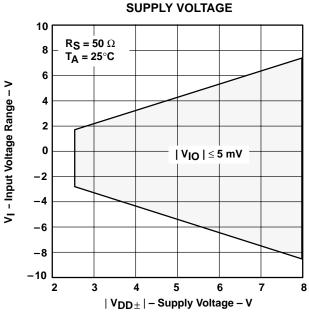
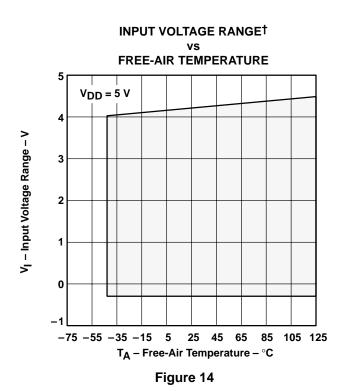
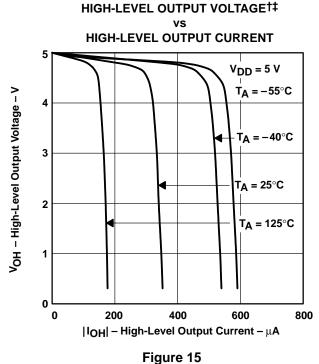


Figure 13

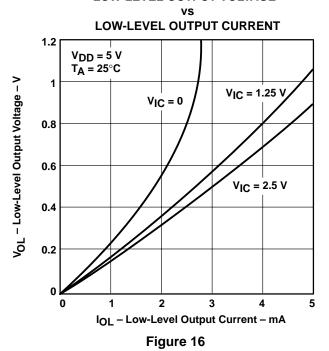
† Data at high and low temperatures are applicable only within the rated operating free-air temperature ranges of the various devices.







LOW-LEVEL OUTPUT VOLTAGE‡



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

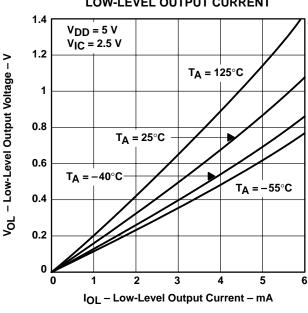


Figure 17

 $<sup>\</sup>ddagger$  For curves where  $V_{DD}$  = 5 V, all loads are referenced to 2.5 V.

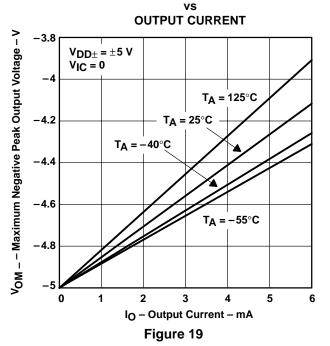


<sup>†</sup>Data at high and low temperatures are applicable only within the rated operating free-air temperature ranges of the various devices.

#### **MAXIMUM POSITIVE PEAK OUTPUT VOLTAGE**†

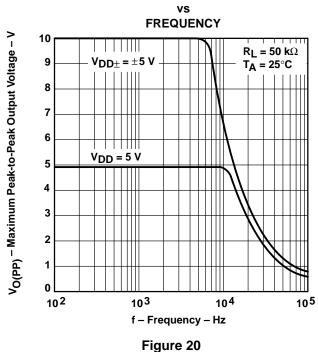
## **OUTPUT CURRENT** V<sub>OM+</sub> - Maximum Positive Peak Output Voltage - V T<sub>A</sub> = 25°C $T_A = -40^{\circ}C$ 2 T<sub>A</sub> = 125°C $T_A = -55^{\circ}C$ 1 $V_{DD} = \pm 5 V$ 0 200 400 600 800 $I_O$ – Output Current – $\mu$ A

#### **MAXIMUM NEGATIVE PEAK OUTPUT VOLTAGE**†

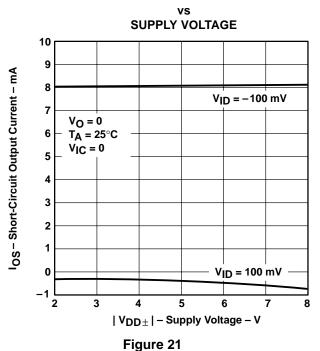


#### MAXIMUM PEAK-TO-PEAK OUTPUT VOLTAGE‡

Figure 18



#### SHORT-CIRCUIT OUTPUT CURRENT



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

<sup>‡</sup> For curves where  $V_{DD} = 5 \text{ V}$ , all loads are referenced to 2.5 V.



#### SHORT-CIRCUIT OUTPUT CURRENT<sup>†</sup> vs FREE-AIR TEMPERATURE 11 $V_O = 0$ 10 $V_{DD}^{\pm} = \pm 5 V$ I<sub>OS</sub> – Short-Circuit Output Current – mA 9 $V_{ID} = -100 \text{ mV}$ 8 $V_{ID} = 100 \text{ mV}$ 0 -75 -50 -25 25 50 75 100 125 T<sub>A</sub> - Free-Air Temperature - °C

Figure 22

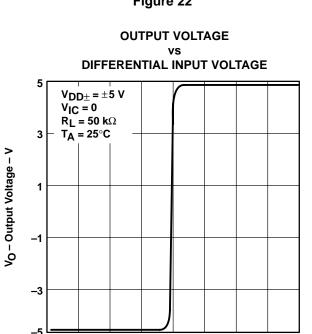


Figure 24

 $V_{ID}$  - Differential Input Voltage -  $\mu$ V

250

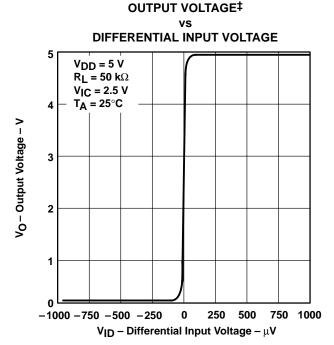
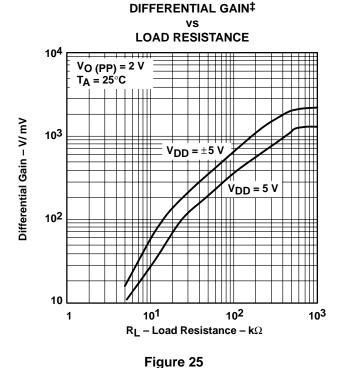


Figure 23



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

-1000 -750 -500 -250



<sup>‡</sup> For curves where  $V_{DD} = 5 \text{ V}$ , all loads are referenced to 2.5 V.

# LARGE-SIGNAL DIFFERENTIAL VOLTAGE AMPLIFICATION AND PHASE MARGIN<sup>†</sup>

#### ٧S **FREQUENCY** 80 180° $V_{DD} = 5 V$ $R_L = 50 \text{ k}\Omega$ CL= 100 pF 60 135° $T_A = 25^{\circ}C$ A<sub>VD</sub>-Large-Signal Differential Voltage Amplification - dB 40 <sup>6</sup>m − Phase Margin 90° **Phase Margin** 20 45° Gain 0 **0**° -20-45° -40 -90° 10<sup>3</sup> 107 104 105 106 f - Frequency - Hz Figure 26

# LARGE-SIGNAL DIFFERENTIAL VOLTAGE AMPLIFICATION AND PHASE MARGIN

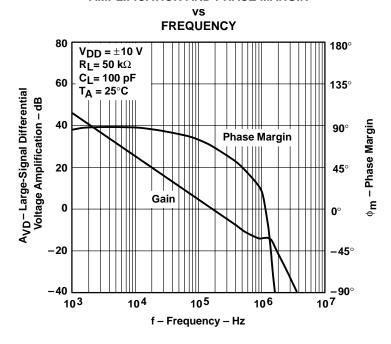
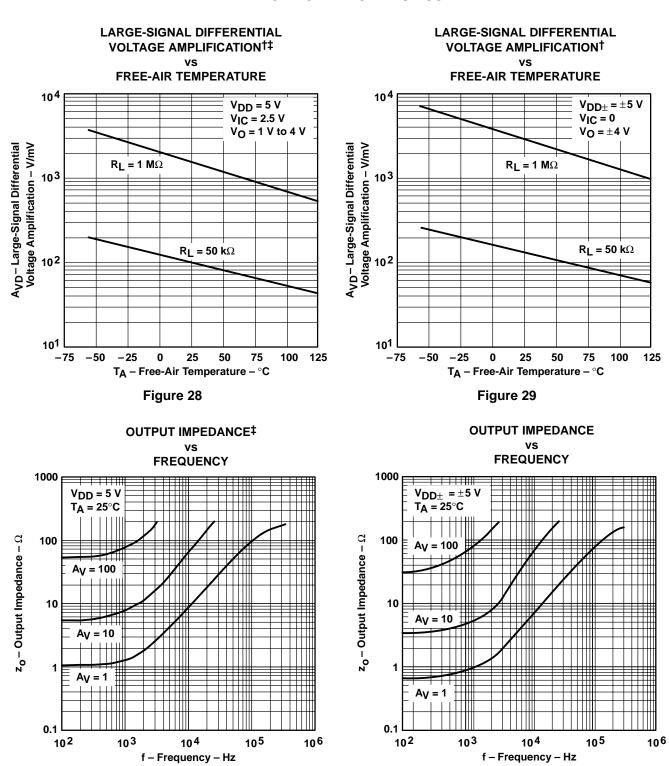


Figure 27

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





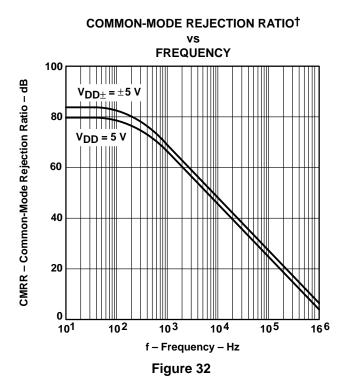
<sup>†</sup> Data at high and low temperatures are applicable only within the rated operating free-air temperature ranges of the various devices.

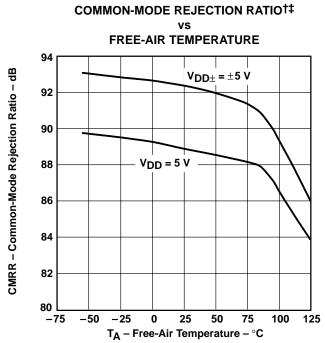
Figure 30



Figure 31

<sup>‡</sup> For curves where  $V_{DD} = 5 \text{ V}$ , all loads are referenced to 2.5 V.





# SUPPLY-VOLTAGE REJECTION RATIO†

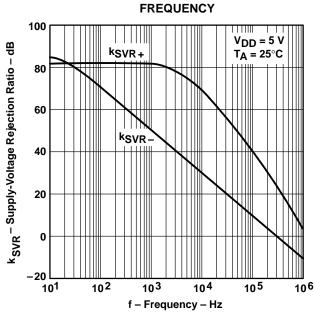
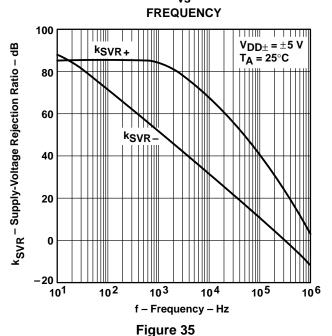




Figure 33



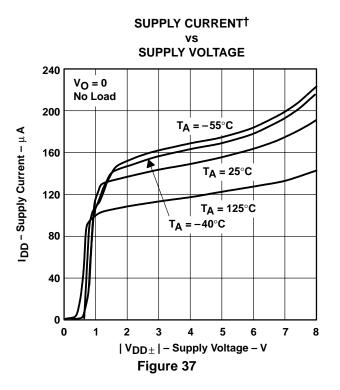
 $<sup>\</sup>dagger$  For curves where  $V_{DD}$  = 5 V, all loads are referenced to 2.5 V.

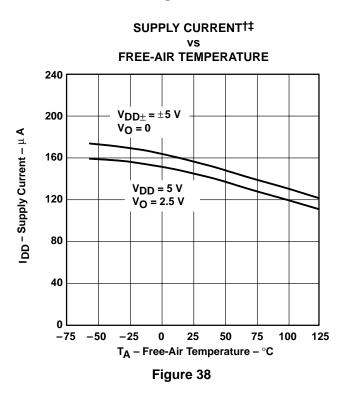
Figure 34

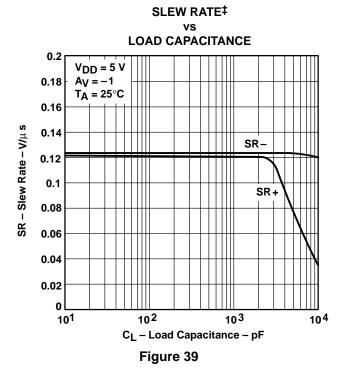
<sup>‡</sup> Data at high and low temperatures are applicable only within the rated operating free-air temperature ranges of the various devices.



## SUPPLY-VOLTAGE REJECTION RATIO† FREE-AIR TEMPERATURE 110 $V_{DD\pm}$ = ±2.2 V to ±8 V k SVR - Supply-Voltage Rejection Ratio - dB $V_O = 0$ 105 100 95 90 -75 -50 -25 75 100 125 T<sub>A</sub> – Free-Air Temperature – °C Figure 36



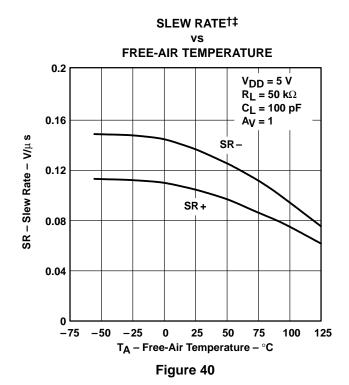


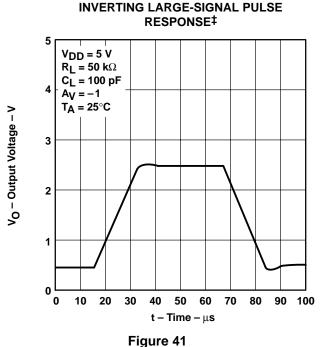


<sup>†</sup> Data at high and low temperatures are applicable only within the rated operating free-air temperature ranges of the various devices.

<sup>‡</sup> For curves where  $V_{DD} = 5 \text{ V}$ , all loads are referenced to 2.5 V.







# **INVERTING LARGE-SIGNAL PULSE RESPONSE** $V_{DD\pm} = \pm 5 V$ $R_L = 50 \text{ k}\Omega$ C<sub>L</sub> = 100 pF 3 $A_V = -1$ TA = 25°C V<sub>O</sub> - Output Voltage - V 2

1 0

-1 -2

-3 \_4 -5

> 10 20 30 40 50 60 70 80





V<sub>O</sub> - Output Voltage - V

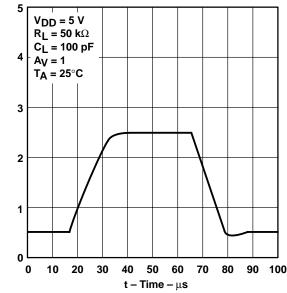


Figure 42 Figure 43

 $t - Time - \mu s$ 

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

 $<sup>\</sup>ddagger$  For curves where  $V_{DD}$  = 5 V, all loads are referenced to 2.5 V.

# VOLTAGE-FOLLOWER LARGE-SIGNAL PULSE RESPONSE

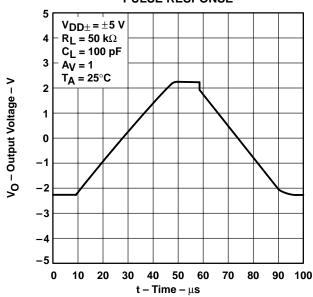


Figure 44

# INVERTING SMALL-SIGNAL PULSE RESPONSE

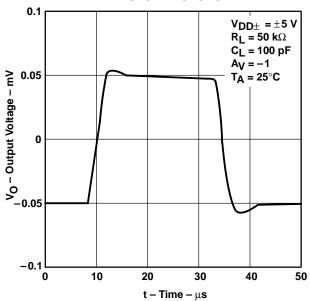


Figure 46

# INVERTING SMALL-SIGNAL PULSE RESPONSE†

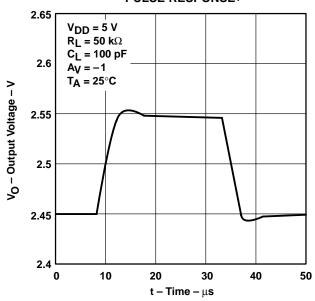


Figure 45

# VOLTAGE-FOLLOWER SMALL-SIGNAL PULSE RESPONSE<sup>†</sup>

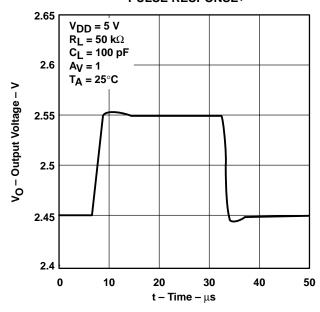


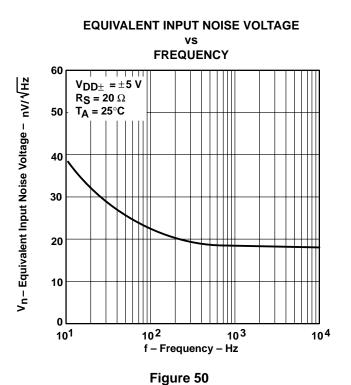
Figure 47

 $<sup>\</sup>dagger$  For curves where  $V_{DD}$  = 5 V, all loads are referenced to 2.5 V.



## **VOLTAGE-FOLLOWER SMALL-SIGNAL PULSE RESPONSE** 0.1 $V_{DD\pm} = \pm 5 V$ $R_L = 50 \text{ k}\Omega$ C<sub>L</sub> = 100 pF A<sub>V</sub> = 1 T<sub>A</sub> = 25°C 0.05 VO - Output Voltage - V - 0.05 -0.1 0 10 20 30 40 50 t – Time – $\mu$ s

Figure 48



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

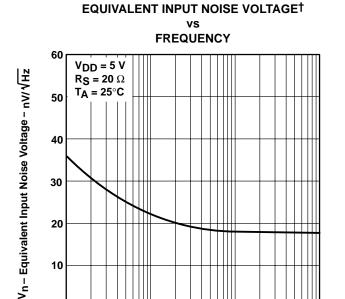


Figure 49

102

101

# EQUIVALENT INPUT NOISE VOLTAGE OVER A 10-SECOND PERIOD<sup>†</sup>

f - Frequency - Hz

103

104

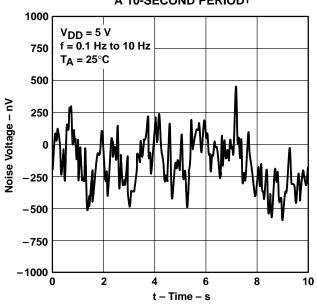


Figure 51



# INTEGRATED NOISE VOLTAGE VS FREQUENCY Calculated Using Ideal Pass-Band Filter Low Frequency = 1 Hz TA = 25°C Ta = 25°C 10 0.1 1 101 102 103 104 105 f - Frequency - Hz

#### TOTAL HARMONIC DISTORTION PLUS NOISE<sup>†</sup>

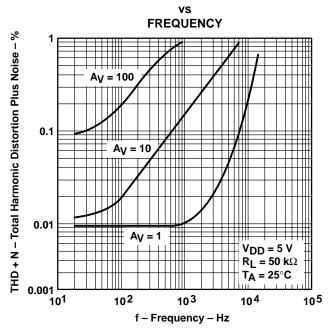
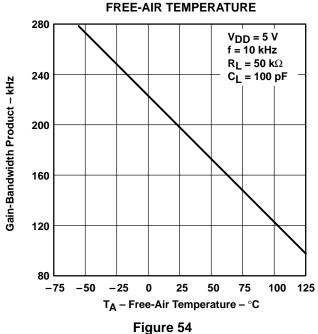


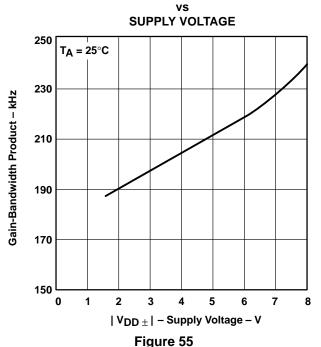
Figure 53



Figure 52



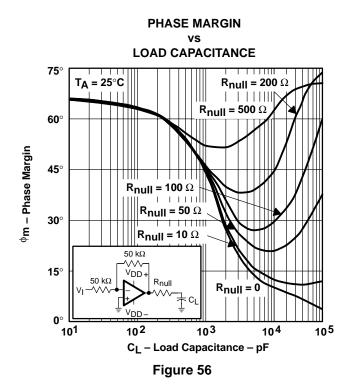
## GAIN-BANDWIDTH PRODUCT

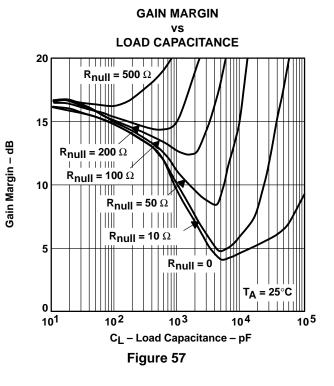


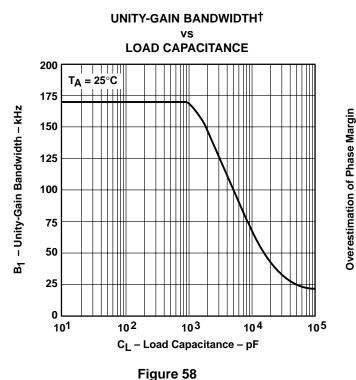
<sup>†</sup> For curves where  $V_{DD} = 5 \text{ V}$ , all loads are referenced to 2.5 V.

<sup>‡</sup> Data at high and low temperatures are applicable only within the rated operating free-air temperature ranges of the various devices.











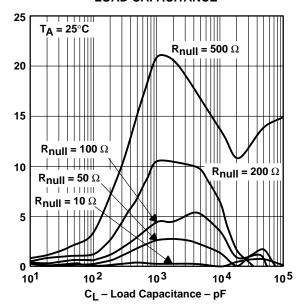


Figure 59



<sup>†</sup> 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  $(R_{\text{null}} = 0)$ .

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  $\Omega$ , 50  $\Omega$ , 100  $\Omega$ , 200  $\Omega$ , and 500  $\Omega$ . 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.

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

Where:

 $\Delta \phi_{m1}$  = Improvement in phase margin

UGBW = Unity-gain bandwidth frequency

R<sub>null</sub> = Output series resistance

 $C_1$  = 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.

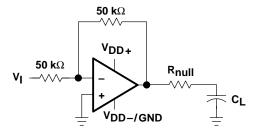


Figure 60. Series-Resistance Circuit



#### APPLICATION INFORMATION

#### macromodel information

Macromodel information provided was derived using MicroSim  $Parts^{TM}$ , the model generation software used with MicroSim  $PSpice^{TM}$ . 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 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).

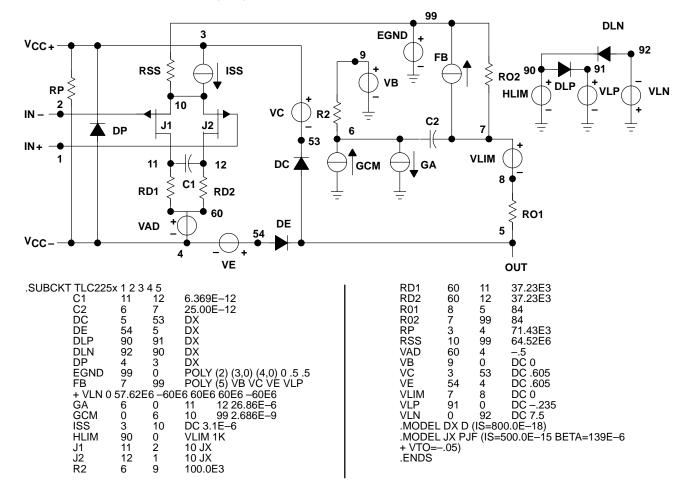


Figure 61. Boyle Macromodel and Subcircuit

PSpice and Parts are trademarks of MicroSim Corporation.

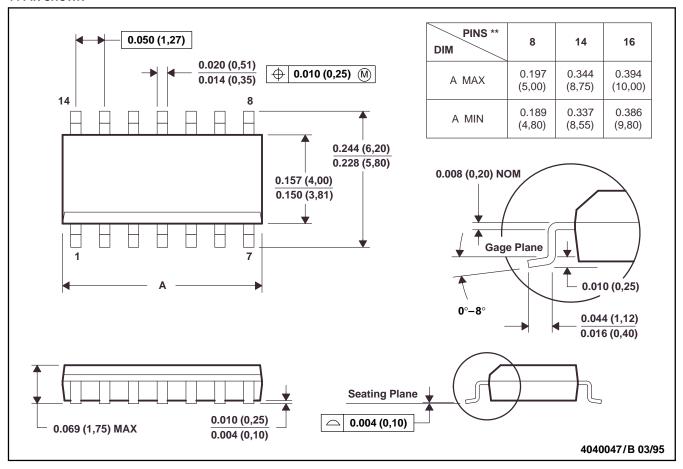


#### **MECHANICAL INFORMATION**

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

#### PLASTIC SMALL-OUTLINE PACKAGE

#### 14 PIN SHOWN



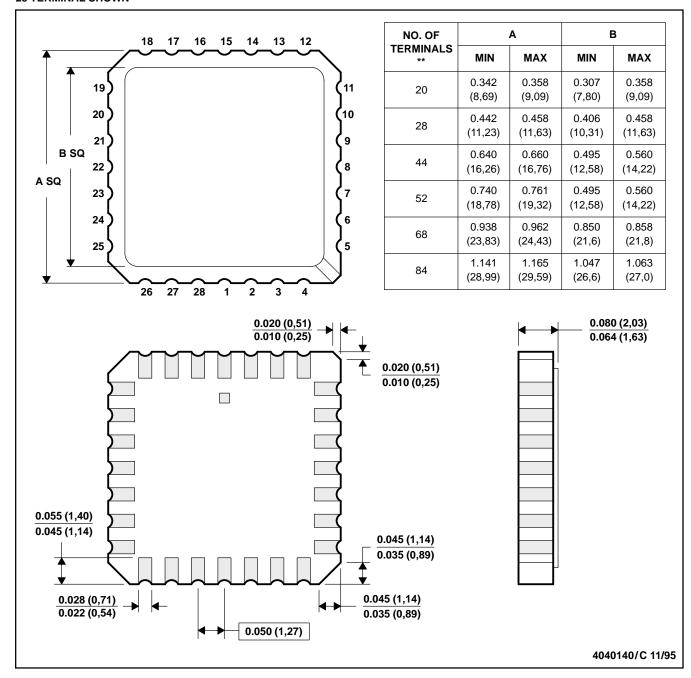
- B. This drawing is subject to change without notice.
- C. Body dimensions do not include mold flash or protrusion, not to exceed 0.006 (0,15).
- D. Four center pins are connected to die mount pad.
- E. Falls within JEDEC MS-012

#### **MECHANICAL INFORMATION**

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

#### **28 TERMINAL SHOWN**

#### **LEADLESS CERAMIC CHIP CARRIER**



- 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

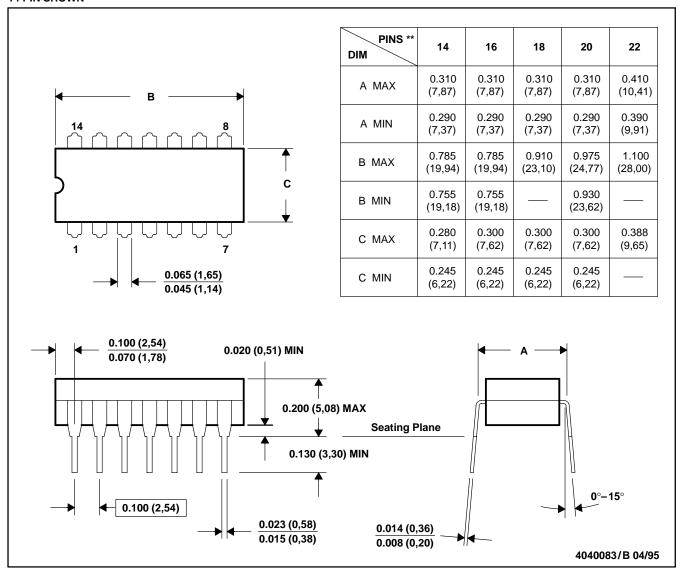


#### **MECHANICAL INFORMATION**

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

#### **CERAMIC DUAL-IN-LINE PACKAGE**

#### 14 PIN SHOWN



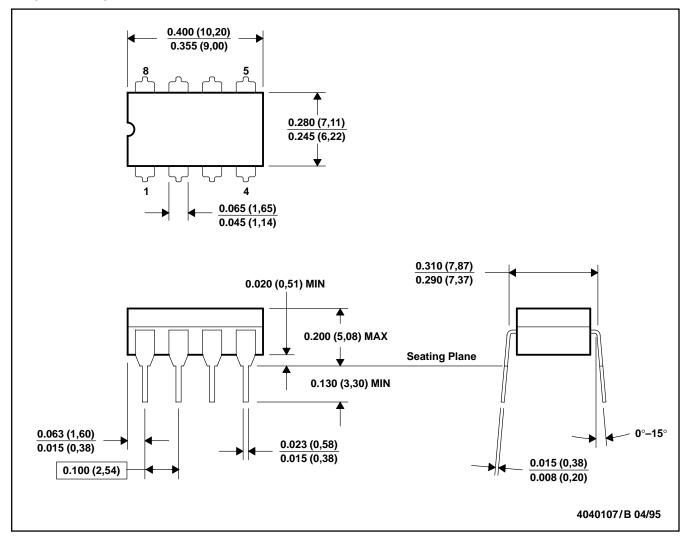
- B. This drawing is subject to change without notice.
- C. This package can be hermetically sealed with a ceramic lid using glass frit.
- D. Index point is provided on cap for terminal identification only.
- E. Falls within MIL-STD-1835 GDIP1-T14, GDIP1-T16, GDIP1-T18, GDIP1-T20, and GDIP1-T22



#### **MECHANICAL INFORMATION**

#### JG (R-GDIP-T8)

#### **CERAMIC DUAL-IN-LINE PACKAGE**



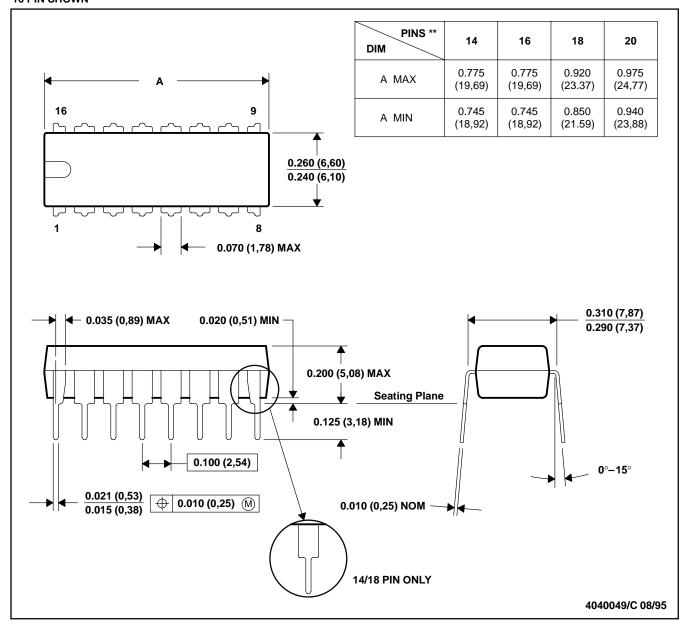
- B. This drawing is subject to change without notice.
- C. This package can be hermetically sealed with a ceramic lid using glass frit.
- D. Index point is provided on cap for terminal identification and/or on pressed ceramic glass frit seal.
- E. Falls within MIL-STD-1835 GDIP1-T8

#### **MECHANICAL INFORMATION**

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

#### 16 PIN SHOWN

#### PLASTIC DUAL-IN-LINE PACKAGE



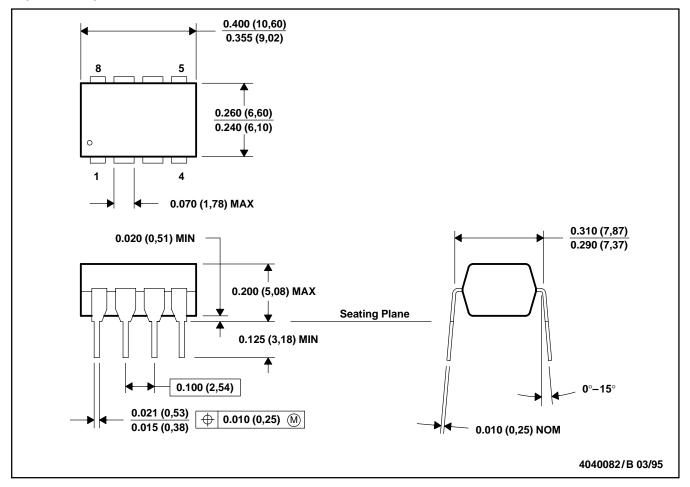
- B. This drawing is subject to change without notice.
- C. Falls within JEDEC MS-001 (20 pin package is shorter then MS-001.)



#### **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.

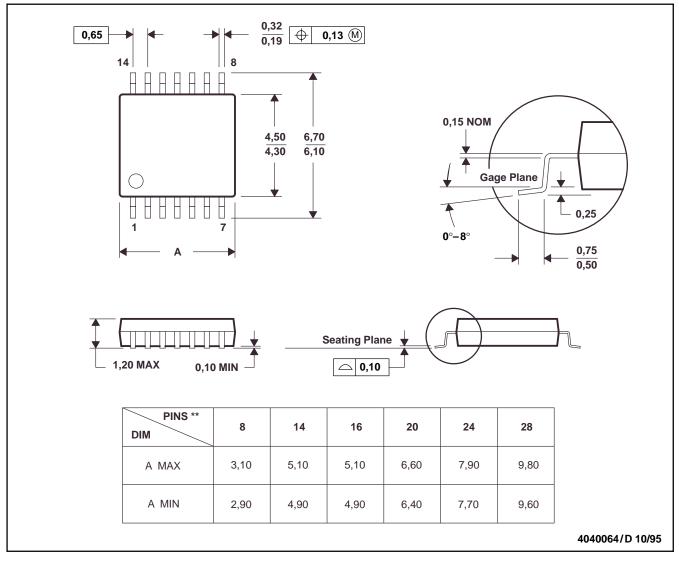
C. Falls within JEDEC MS-001

#### **MECHANICAL INFORMATION**

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

#### PLASTIC SMALL-OUTLINE PACKAGE

#### 14 PIN SHOWN



NOTES: A. All linear dimensions are in millimeters.

B. This drawing is subject to change without notice.

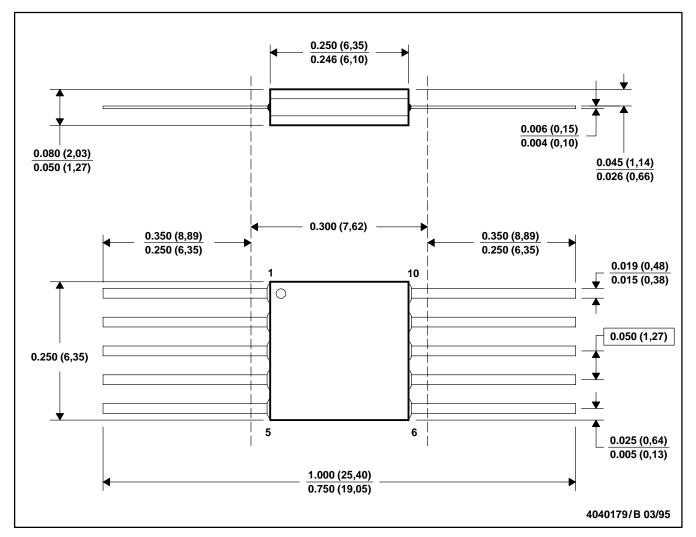
C. Body dimensions do not include mold flash or protrusion not to exceed 0,15.

D. Falls within JEDEC MO-153

#### **MECHANICAL INFORMATION**

#### U (S-GDFP-F10)

#### **CERAMIC DUAL FLATPACK**



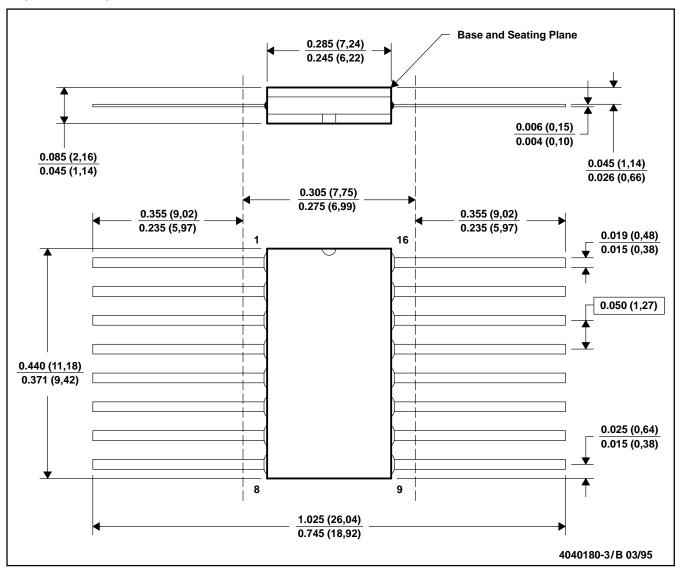
- B. This drawing is subject to change without notice.
- C. This package can be hermetically sealed with a ceramic lid using glass frit.
- D. Index point is provided on cap for terminal identification only.
- E. Falls within MIL STD 1835 GDFP1-F10 and JEDEC MO-092AA



#### **MECHANICAL INFORMATION**

#### W (R-GDFP-F16)

#### **CERAMIC DUAL FLATPACK**



- 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





#### **PACKAGING INFORMATION**

Orderable Device	Status <sup>(1)</sup>	Package Type	Package Drawing	Pins	Package Qty	e Eco Plan <sup>(2)</sup>	Lead/Ball Finish	MSL Peak Temp <sup>(3)</sup>
5962-9564001NXDR	ACTIVE	SOIC	D	8	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
5962-9564001Q2A	ACTIVE	LCCC	FK	20	1	TBD	POST-PLATE	N / A for Pkg Type
5962-9564001QHA	ACTIVE	CFP	U	10	1	TBD	A42 SNPB	N / A for Pkg Type
5962-9564001QPA	ACTIVE	CDIP	JG	8	1	TBD	A42 SNPB	N / A for Pkg Type
5962-9564002NYDR	ACTIVE	SOIC	D	14	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
5962-9564002Q2A	ACTIVE	LCCC	FK	20	1	TBD	POST-PLATE	N / A for Pkg Type
5962-9564002QCA	ACTIVE	CDIP	J	14	1	TBD	A42 SNPB	N / A for Pkg Type
5962-9564002QDA	ACTIVE	CFP	W	14	1	TBD	A42 SNPB	N / A for Pkg Type
5962-9564003NXDR	ACTIVE	SOIC	D	8	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
5962-9564003Q2A	ACTIVE	LCCC	FK	20	1	TBD	POST-PLATE	N / A for Pkg Type
5962-9564003QHA	ACTIVE	CFP	U	10	1	TBD	A42 SNPB	N / A for Pkg Type
5962-9564003QPA	ACTIVE	CDIP	JG	8	1	TBD	A42 SNPB	N / A for Pkg Type
5962-9564004NYDR	ACTIVE	SOIC	D	14	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
5962-9564004Q2A	ACTIVE	LCCC	FK	20	1	TBD	POST-PLATE	N / A for Pkg Type
5962-9564004QCA	ACTIVE	CDIP	J	14	1	TBD	A42 SNPB	N / A for Pkg Type
5962-9564004QDA	ACTIVE	CFP	W	14	1	TBD	A42 SNPB	N / A for Pkg Type
TLC2252AID	ACTIVE	SOIC	D	8	75	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
TLC2252AIDG4	ACTIVE	SOIC	D	8	75	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
TLC2252AIDR	ACTIVE	SOIC	D	8	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
TLC2252AIDRG4	ACTIVE	SOIC	D	8	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
TLC2252AIP	ACTIVE	PDIP	Р	8	50	Pb-Free (RoHS)	CU NIPDAU	N / A for Pkg Type
TLC2252AIPE4	ACTIVE	PDIP	Р	8	50	Pb-Free (RoHS)	CU NIPDAU	N / A for Pkg Type
TLC2252AIPW	ACTIVE	TSSOP	PW	8	150	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
TLC2252AIPWG4	ACTIVE	TSSOP	PW	8	150	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
TLC2252AIPWLE	OBSOLETE	TSSOP	PW	8		TBD	Call TI	Call TI
TLC2252AIPWR	ACTIVE	TSSOP	PW	8	2000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
TLC2252AIPWRG4	ACTIVE	TSSOP	PW	8	2000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
TLC2252AMFKB	ACTIVE	LCCC	FK	20	1	TBD	POST-PLATE	N / A for Pkg Type
TLC2252AMJGB	ACTIVE	CDIP	JG	8	1	TBD	A42 SNPB	N / A for Pkg Type
TLC2252AMUB	ACTIVE	CFP	U	10	1	TBD	A42 SNPB	N / A for Pkg Type
TLC2252AQD	ACTIVE	SOIC	D	8	75	Pb-Free (RoHS)	CU NIPDAU	Level-2-250C-1 YEA Level-1-235C-UNLIM
TLC2252AQDR	ACTIVE	SOIC	D	8	2500	Pb-Free	CU NIPDAU	Level-2-250C-1 YEAR





om 6-Dec-2006

Orderable Device	Status <sup>(1)</sup>	Package Type	Package Drawing	Pins	Package Qty	e Eco Plan <sup>(2)</sup>	Lead/Ball Finish	MSL Peak Temp <sup>(3)</sup>
						(RoHS)		Level-1-235C-UNLIM
TLC2252CD	ACTIVE	SOIC	D	8	75	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
TLC2252CDG4	ACTIVE	SOIC	D	8	75	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
TLC2252CDR	ACTIVE	SOIC	D	8	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
TLC2252CDRG4	ACTIVE	SOIC	D	8	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
TLC2252CP	ACTIVE	PDIP	Р	8	50	Pb-Free (RoHS)	CU NIPDAU	N / A for Pkg Type
TLC2252CPE4	ACTIVE	PDIP	Р	8	50	Pb-Free (RoHS)	CU NIPDAU	N / A for Pkg Type
TLC2252CPW	ACTIVE	TSSOP	PW	8	150	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
TLC2252CPWG4	ACTIVE	TSSOP	PW	8	150	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
TLC2252CPWLE	OBSOLETE	TSSOP	PW	8		TBD	Call TI	Call TI
TLC2252CPWR	ACTIVE	TSSOP	PW	8	2000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
TLC2252CPWRG4	ACTIVE	TSSOP	PW	8	2000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
TLC2252ID	ACTIVE	SOIC	D	8	75	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
TLC2252IDG4	ACTIVE	SOIC	D	8	75	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
TLC2252IDR	ACTIVE	SOIC	D	8	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
TLC2252IDRG4	ACTIVE	SOIC	D	8	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
TLC2252IP	ACTIVE	PDIP	Р	8	50	Pb-Free (RoHS)	CU NIPDAU	N / A for Pkg Type
TLC2252IPE4	ACTIVE	PDIP	Р	8	50	Pb-Free (RoHS)	CU NIPDAU	N / A for Pkg Type
TLC2252MFKB	ACTIVE	LCCC	FK	20	1	TBD	POST-PLATE	N / A for Pkg Type
TLC2252MJGB	ACTIVE	CDIP	JG	8	1	TBD	A42 SNPB	N / A for Pkg Type
TLC2252MUB	ACTIVE	CFP	U	10	1	TBD	A42 SNPB	N / A for Pkg Type
TLC2252QD	ACTIVE	SOIC	D	8	75	TBD	CU NIPDAU	Level-1-220C-UNLIM
TLC2252QDR	ACTIVE	SOIC	D	8	2500	TBD	CU NIPDAU	Level-1-220C-UNLIM
TLC2254AID	ACTIVE	SOIC	D	14	50	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
TLC2254AIDG4	ACTIVE	SOIC	D	14	50	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
TLC2254AIDR	ACTIVE	SOIC	D	14	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
TLC2254AIDRG4	ACTIVE	SOIC	D	14	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
TLC2254AIN	ACTIVE	PDIP	N	14	25	Pb-Free (RoHS)	CU NIPDAU	N / A for Pkg Type
TLC2254AINE4	ACTIVE	PDIP	N	14	25	Pb-Free	CU NIPDAU	N / A for Pkg Type





6-Dec-2006

Orderable Device	Status <sup>(1)</sup>	Package Type	Package Drawing	Pins	Package Qty	e Eco Plan <sup>(2)</sup>	Lead/Ball Finish	MSL Peak Temp (3)
						(RoHS)		
TLC2254AIPW	ACTIVE	TSSOP	PW	14	90	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
TLC2254AIPWG4	ACTIVE	TSSOP	PW	14	90	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
TLC2254AIPWLE	OBSOLETE	TSSOP	PW	14		TBD	Call TI	Call TI
TLC2254AIPWR	ACTIVE	TSSOP	PW	14	2000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
TLC2254AIPWRG4	ACTIVE	TSSOP	PW	14	2000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
TLC2254AMFKB	ACTIVE	LCCC	FK	20	1	TBD	POST-PLATE	N / A for Pkg Type
TLC2254AMJB	ACTIVE	CDIP	J	14	1	TBD	A42 SNPB	N / A for Pkg Type
TLC2254AMWB	ACTIVE	CFP	W	14	1	TBD	A42 SNPB	N / A for Pkg Type
TLC2254AQD	ACTIVE	SOIC	D	14	50	TBD	CU NIPDAU	Level-1-220C-UNLIM
TLC2254AQDR	ACTIVE	SOIC	D	14	2500	TBD	Call TI	Call TI
TLC2254CD	ACTIVE	SOIC	D	14	50	Green (RoHS & no Sb/Br)	Call TI	Level-1-260C-UNLIM
TLC2254CDG4	ACTIVE	SOIC	D	14	50	Green (RoHS & no Sb/Br)	Call TI	Level-1-260C-UNLIM
TLC2254CDR	ACTIVE	SOIC	D	14	2500	Green (RoHS & no Sb/Br)	Call TI	Level-1-260C-UNLIM
TLC2254CDRG4	ACTIVE	SOIC	D	14	2500	Green (RoHS & no Sb/Br)	Call TI	Level-1-260C-UNLIM
TLC2254CN	ACTIVE	PDIP	N	14	25	Pb-Free (RoHS)	CU NIPDAU	N / A for Pkg Type
TLC2254CNE4	ACTIVE	PDIP	N	14	25	Pb-Free (RoHS)	CU NIPDAU	N / A for Pkg Type
TLC2254CPW	ACTIVE	TSSOP	PW	14	90	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
TLC2254CPWG4	ACTIVE	TSSOP	PW	14	90	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
TLC2254CPWLE	OBSOLETE	TSSOP	PW	14		TBD	Call TI	Call TI
TLC2254CPWR	ACTIVE	TSSOP	PW	14	2000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
TLC2254CPWRG4	ACTIVE	TSSOP	PW	14	2000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
TLC2254ID	ACTIVE	SOIC	D	14	50	Green (RoHS & no Sb/Br)	Call TI	Level-1-260C-UNLIM
TLC2254IDG4	ACTIVE	SOIC	D	14	50	Green (RoHS & no Sb/Br)	Call TI	Level-1-260C-UNLIM
TLC2254IDR	ACTIVE	SOIC	D	14	2500	Green (RoHS & no Sb/Br)	Call TI	Level-1-260C-UNLIM
TLC2254IDRG4	ACTIVE	SOIC	D	14	2500	Green (RoHS & no Sb/Br)	Call TI	Level-1-260C-UNLIM
TLC2254IN	ACTIVE	PDIP	N	14	25	Pb-Free (RoHS)	CU NIPDAU	N / A for Pkg Type
TLC2254INE4	ACTIVE	PDIP	N	14	25	Pb-Free (RoHS)	CU NIPDAU	N / A for Pkg Type
TLC2254MFKB	ACTIVE	LCCC	FK	20	1	TBD	POST-PLATE	N / A for Pkg Type
TLC2254MJB	ACTIVE	CDIP	J	14	1	TBD	A42 SNPB	N / A for Pkg Type



#### PACKAGE OPTION ADDENDUM

6-Dec-2006

Orderable Device	Status <sup>(1)</sup>	Package Type	Package Drawing	Pins	Package Qty	Eco Plan <sup>(2)</sup>	Lead/Ball Finish	MSL Peak Temp <sup>(3)</sup>
TLC2254MWB	ACTIVE	CFP	W	14	1	TBD	A42 SNPB	N / A for Pkg Type
TLC2254QD	ACTIVE	SOIC	D	14	50	TBD	CU NIPDAU	Level-1-220C-UNLIM
TLC2254QDR	ACTIVE	SOIC	D	14	2500	TBD	CU NIPDAU	Level-1-220C-UNLIM

<sup>(1)</sup> 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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#### JG (R-GDIP-T8)

#### **CERAMIC DUAL-IN-LINE**



- 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

#### 14 LEADS SHOWN



- 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 only on press ceramic glass frit seal only.
- E. Falls within MIL STD 1835 GDIP1-T14, GDIP1-T16, GDIP1-T18 and GDIP1-T20.

# U (S-GDFP-F10)

## CERAMIC DUAL FLATPACK



- 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



- 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\*\*)

#### **28 TERMINAL SHOWN**

#### **LEADLESS CERAMIC CHIP CARRIER**



- 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  $http://www.ti.com/sc/docs/package/pkg\_info.htm$ 

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

## PLASTIC DUAL-IN-LINE PACKAGE

16 PINS SHOWN



- A. All linear dimensions are in inches (millimeters).
- B. This drawing is subject to change without notice.
- Falls within JEDEC MS-001, except 18 and 20 pin minimum body length (Dim A).
- The 20 pin end lead shoulder width is a vendor option, either half or full width.



# D (R-PDSO-G14)

## PLASTIC SMALL-OUTLINE PACKAGE



- A. All linear dimensions are in inches (millimeters).
- B. This drawing is subject to change without notice.
- Body length does not include mold flash, protrusions, or gate burrs. Mold flash, protrusions, or gate burrs shall not exceed .006 (0,15) per end.
- Body width does not include interlead flash. Interlead flash shall not exceed .017 (0,43) per side.
- E. Reference JEDEC MS-012 variation AB.



# D (R-PDSO-G8)

## PLASTIC SMALL-OUTLINE PACKAGE



- A. All linear dimensions are in inches (millimeters).
- B. This drawing is subject to change without notice.
- Body length does not include mold flash, protrusions, or gate burrs. Mold flash, protrusions, or gate burrs shall not exceed .006 (0,15) per end.
- Body width does not include interlead flash. Interlead flash shall not exceed .017 (0,43) per side.
- E. Reference JEDEC MS-012 variation AA.



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

#### 14 PINS SHOWN

#### PLASTIC SMALL-OUTLINE PACKAGE



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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Mailing Address: Texas Instruments

Post Office Box 655303 Dallas, Texas 75265

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