- **Output Swing Includes Both Supply Rails**
- **Low Noise . . . 19 nV/√Hz Typ at f = 1 kHz**
- **Low Input Bias Current . . . 1 pA Typ**
- **Fully Specified for Both Single-Supply and Split-Supply Operation**
- **Very Low Power . . . 35 μA Per Channel Typ**
- **Common-Mode Input Voltage Range Includes Negative Rail**
- **Low Input Offset Voltage**
  850 μV Max at T_A = 25°C (TLC225xA)
- **Macromodel Included**
- **Performance Upgrades for the TS27L2/L4 and TLC27L2/L4**
- **Available in Q–Temp Automotive**
  HighRel Automotive Applications
  Configuration Control / Print Support
  Qualification to Automotive Standards

description

The TLC2252 and TLC2254 are dual and quadruple operational amplifiers from Texas Instruments. Both devices exhibit rail-to-rail output performance for increased dynamic range in single- or split-supply applications. The TLC225x family consumes only 35 μA of supply current per channel. This micropower operation makes them good choices for battery-powered applications. The noise performance has been dramatically improved over previous generations of CMOS amplifiers. Looking at Figure 1, the TLC225x has a noise level of 19 nV/√Hz at 1kHz; four times lower than competitive micropower solutions.

EQUIVALENT INPUT NOISE VOLTAGE
vs
FREQUENCY

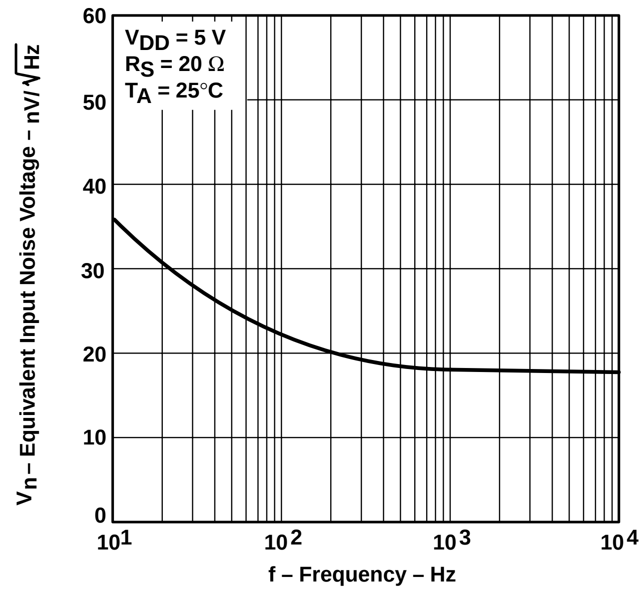


Figure 1

The TLC225x amplifiers, exhibiting high input impedance and low noise, are excellent for small-signal conditioning for high-impedance sources, such as piezoelectric transducers. Because of the micropower dissipation levels, these devices work well in hand-held monitoring and remote-sensing applications. In addition, the rail-to-rail output feature with single or split supplies makes this family a great choice when interfacing with analog-to-digital converters (ADCs). For precision applications, the TLC225xA family is available and has a maximum input offset voltage of 850 μV. This family is fully characterized at 5 V and ±5 V.

The TLC2252/4 also makes great upgrades to the TLC27L2/L4 or TS27L2/L4 in standard designs. They offer increased output dynamic range, lower noise voltage, and lower input offset voltage. This enhanced feature set allows them to be used in a wider range of applications. For applications that require higher output drive and wider input voltage ranges, see the TLV2432 and TLV2442 devices. If the design requires single amplifiers, please see the TLV2211/21/31 family. These devices are single rail-to-rail operational amplifiers in the SOT-23 package. Their small size and low power consumption, make them ideal for high density, battery-powered equipment.

TLC2252 AVAILABLE OPTIONS

T_A	V_{IO}max AT 25°C	PACKAGED DEVICES					
		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	— —	— —	TLC2252AMU TLC2252MU

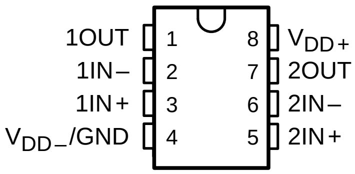
† The D packages are available taped and reeled. Add R suffix to device type (e.g., TLC2262CDR).
‡ The PW package is available only left-ended taped and reeled.
§ Chip forms are tested at 25°C only.

TLC2254 AVAILABLE OPTIONS

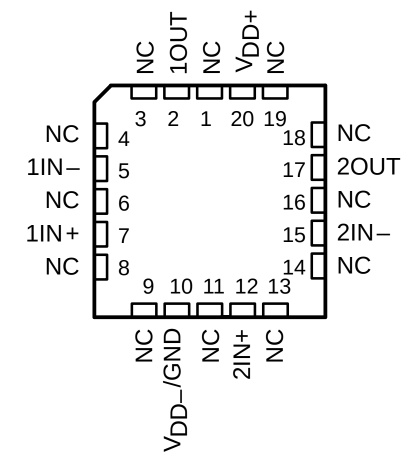
T_A	V_{IO}max AT 25°C	PACKAGED DEVICES					
		SMALL OUTLINE† (D)	CHIP CARRIER (FK)	CERAMIC DIP (J)	PLASTIC DIP (N)	TSSOP‡ (PW)	CERAMIC FLATPACK (W)
0°C to 70°C	1500 µV	TLC2254CD	—	—	TLC2254CN	TLC2254CPW	—
–40°C to 125°C	850 µV 1500 µV	TLC2254AID TLC2254ID	— —	— —	TLC2254AIN TLC2254IN	TLC2254AIPW —	— —
–40°C to 125°C	850 µV 1500 µV	TLC2254AQD TLC2254QD	— —	— —	— —	— —	— —
–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).
‡ The PW package is available only left-end taped and reeled. Chips are tested at 25°C.
§ Chip forms are tested at 25°C only.

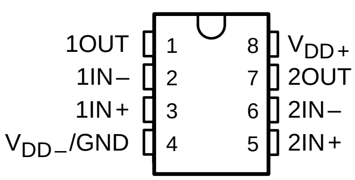
TLC2252C, TLC2252AC
TLC2252I, TLC2252AI
TLC2252Q, TLC2252AQ
D, P, OR PW PACKAGE
(TOP VIEW)



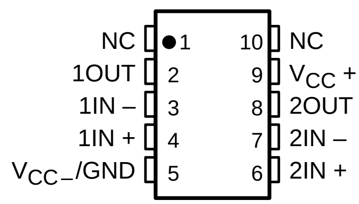
TLC2252M, TLC2252AM . . . FK PACKAGE
(TOP VIEW)



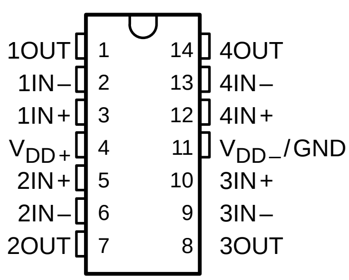
TLC2252M, TLC2252AM . . . JG PACKAGE
(TOP VIEW)



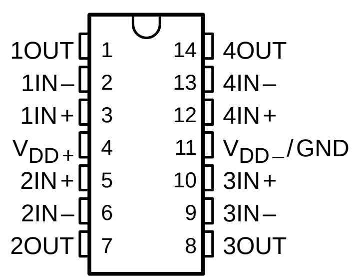
TLC2262M, TLC2252AM . . . U PACKAGE
(TOP VIEW)



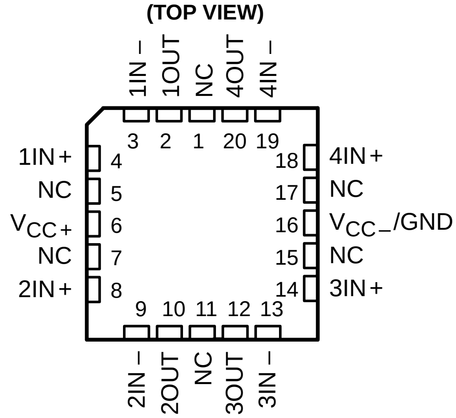
TLC2254C, TLC2254AC
TLC2254I, TLC2254AI
TLC2254Q, TLC2254AQ
D, N, OR PW PACKAGE
(TOP VIEW)



TLC2254M, TLC2254AM
J OR W PACKAGE
(TOP VIEW)

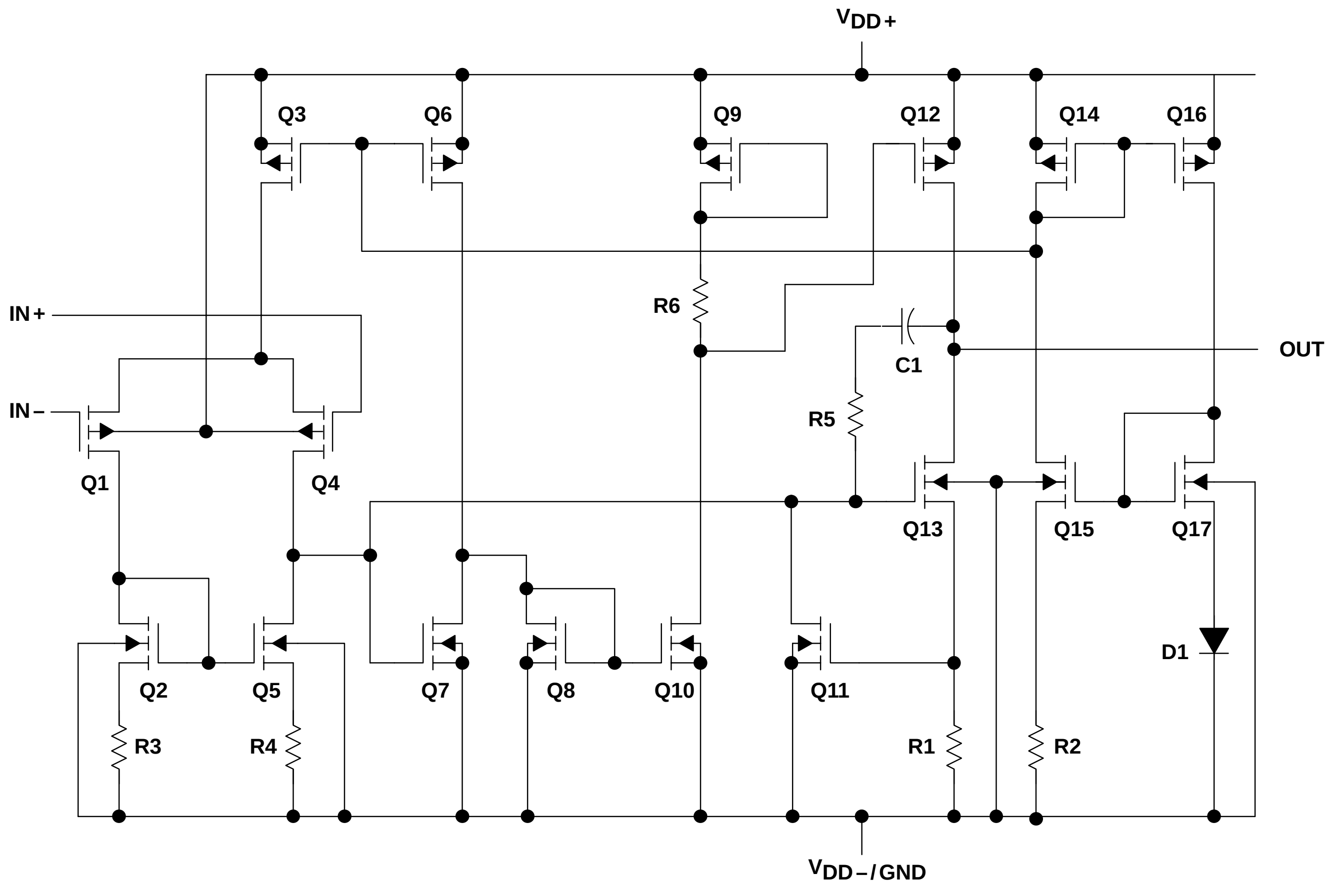


TLC2254M, TLC2254AM
FK PACKAGE
(TOP VIEW)



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

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

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

Supply voltage, V_{DD+} (see Note 1) . . . . . 8 V
Supply voltage, V_{DD-} (see Note 1) . . . . . –8 V
Differential input voltage, V_{ID} (see Note 2) . . . . . ±16 V
Input voltage, V_I (any input, see Note 1) . . . . . ±8 V
Input current, I_I (each input) . . . . . ±5 mA
Output current, I_O . . . . . ±50 mA
Total current into V_{DD+} . . . . . ±50 mA
Total current out of V_{DD-} . . . . . ±50 mA
Duration of short-circuit current at (or below) 25°C (see Note 3) . . . . . unlimited
Continuous total dissipation . . . . . See Dissipation Rating Table
Operating free-air temperature range, T_A: C suffix . . . . . 0°C to 70°C
I suffix . . . . . –40°C to 125°C
Q suffix . . . . . –40°C to 125°C
M suffix . . . . . –55°C to 125°C
Storage temperature range, T_{stg} . . . . . –65°C to 150°C
Lead temperature 1,6 mm (1/16 inch) from case for 10 seconds . . . . . 260°C

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

NOTES: 1. All voltage values, except differential voltages, are with respect to the midpoint between V_{DD+} and V_{DD-}.
2. Differential voltages are at IN+ with respect to IN–. Excessive current flows when input is brought below V_{DD-} – 0.3 V.
3. The output may be shorted to either supply. Temperature and/or supply voltages must be limited to ensure that the maximum dissipation rating is not exceeded.

DISSIPATION RATING TABLE

PACKAGE	$T_A \le 25°C$ POWER RATING	DERATING FACTOR ABOVE T_A = 25°C	T_A = 70°C POWER RATING	T_A = 85°C POWER RATING	T_A = 125°C POWER RATING
D–8	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	—
P	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		I SUFFIX		Q SUFFIX		M SUFFIX		UNIT
	MIN	MAX	MIN	MAX	MIN	MAX	MIN	MAX	
Supply voltage, $V_{DD\pm}$	±2.2	±8	±2.2	±8	±2.2	±8	±2.2	±8	V
Input voltage range, V_I	V_{DD-}	V_{DD+} –1.5	V_{DD-}	V_{DD+} –1.5	V_{DD-}	V_{DD+} –1.5	V_{DD-}	V_{DD+} –1.5	V
Common-mode input voltage, V_{IC}	V_{DD-}	V_{DD+} –1.5	V_{DD-}	V_{DD+} –1.5	V_{DD-}	V_{DD+} –1.5	V_{DD-}	V_{DD+} –1.5	V
Operating free-air temperature, T_A	0	70	–40	125	–40	125	–55	125	°C

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

PARAMETER		TEST CONDITIONS		T_A†	TLC2252C			UNIT
					MIN	TYP	MAX	
V_{IO}	Input offset voltage	V_{IC} = 0, V_O = 0,	$V_{DD}\pm = \pm2.5$ V, R_S = 50 Ω	25°C		200	1500	µV
				Full range			1750	
α_{VIO}	Temperature coefficient of input offset voltage			25°C to 70°C		0.5		µV/°C
	Input offset voltage long-term drift (see Note 4)			25°C		0.003		µV/mo
I_{IO}	Input offset current			25°C		0.5	60	pA
				Full range			100	
I_{IB}	Input bias current			25°C		1	60	pA
				Full range			100	
V_{ICR}	Common-mode input voltage range	R_S = 50 Ω,	$\lvert V_{IO}\rvert \leq 5$ mV	25°C	0 to 4	−0.3 to 4.2		V
				Full range	0 to 3.5			
V_{OH}	High-level output voltage	I_{OH} = −20 µA		25°C		4.98		V
		I_{OH} = −75 µA		25°C	4.9	4.94		
				Full range	4.8			
		I_{OH} = −150 µA		25°C	4.8	4.88		
V_{OL}	Low-level output voltage	V_{IC} = 2.5 V,	I_{OL} = 50 µA	25°C		0.01		V
		V_{IC} = 2.5 V,	I_{OL} = 500 µA	25°C		0.09	0.15	
				Full range			0.15	
		V_{IC} = 2.5 V,	I_{OL} = 1 mA	25°C		0.2	0.3	
				Full range			0.3	
		V_{IC} = 2.5 V,	I_{OL} = 4 mA	25°C		0.7	1	
				Full range			1.2	
A_{VD}	Large-signal differential voltage amplification	V_{IC} = 2.5 V, V_O = 1 V to 4 V	R_L = 100 kΩ‡	25°C	100	350		V/mV
				Full range	10			
			R_L = 1 MΩ‡	25°C		1700		
r_{id}	Differential input resistance			25°C		10^{12}		Ω
r_{ic}	Common-mode input resistance			25°C		10^{12}		Ω
c_{ic}	Common-mode input capacitance	f = 10 kHz,	P package	25°C		8		pF
z_o	Closed-loop output impedance	f = 25 kHz,	A_V = 10	25°C		200		Ω
CMRR	Common-mode rejection ratio	V_{IC} = 0 to 2.7 V, R_S = 50 Ω	V_O = 2.5 V,	25°C	70	83		dB
				Full range	70			
k_{SVR}	Supply-voltage rejection ratio ($\Delta V_{DD}/\Delta V_{IO}$)	V_{DD} = 4.4 V to 16 V, $V_{IC} = V_{DD}/2$,	No load	25°C	80	95		dB
				Full range	80			
I_{DD}	Supply current	V_O = 2.5 V,	No load	25°C		70	125	µA
				Full range			150	

† Full range is 0°C to 70°C.
‡ Referenced to 2.5 V
NOTE 4: Typical values are based on the input offset voltage shift observed through 500 hours of operating life test at T_A = 150°C extrapolated to T_A = 25°C using the Arrhenius equation and assuming an activation energy of 0.96 eV.

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

PARAMETER		TEST CONDITIONS		T_A†	TLC2252C MIN	TLC2252C TYP	TLC2252C MAX	UNIT
SR	Slew rate at unity gain	V_O = 1.5 V to 3.5 V, R_L = 100 kΩ‡, C_L = 100 pF‡		25°C	0.07	0.12		V/μs
				Full range	0.05			
V_n	Equivalent input noise voltage	f = 10 Hz		25°C		36		nV/√Hz
		f = 1 kHz		25°C		19		
$V_{N(PP)}$	Peak-to-peak equivalent input noise voltage	f = 0.1 Hz to 1 Hz		25°C		0.7		μV
		f = 0.1 Hz to 10 Hz		25°C		1.1		
I_n	Equivalent input noise current			25°C		0.6		fA√Hz
THD + N	Total harmonic distortion plus noise	V_O = 0.5 V to 2.5 V, f = 10 kHz, R_L = 50 kΩ‡	A_V = 1	25°C		0.2%		
			A_V = 10			1%		
	Gain-bandwidth product	f = 10 kHz, C_L = 100 pF‡	R_L = 50 kΩ‡,	25°C		0.2		MHz
B_{OM}	Maximum output-swing bandwidth	$V_{O(PP)}$ = 2 V, R_L = 50 kΩ‡,	A_V = 1, C_L = 100 pF‡	25°C		30		kHz
ϕ_m	Phase margin at unity gain	R_L = 50 kΩ‡,	C_L = 100 pF‡	25°C		63°		
	Gain margin			25°C		15		dB

† Full range is 0°C to 70°C.
‡ Referenced to 2.5 V

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

PARAMETER		TEST CONDITIONS		T_A†	TLC2252C MIN	TLC2252C TYP	TLC2252C MAX	UNIT
V_{IO}	Input offset voltage	$V_{IC} = 0$, $R_S = 50\ \Omega$	$V_O = 0$,	25°C		200	1500	µV
				Full range			1750	
α_{VIO}	Temperature coefficient of input offset voltage			25°C to 70°C		0.5		µV/°C
	Input offset voltage long-term drift (see Note 4)			25°C		0.003		µV/mo
I_{IO}	Input offset current			25°C		0.5	60	pA
				Full range			100	
I_{IB}	Input bias current			25°C		1	60	pA
				Full range			100	
V_{ICR}	Common-mode input voltage range	$\|V_{IO}\| \le 5$ mV,	$R_S = 50\ \Omega$	25°C	−5 to 4	−5.3 to 4.2		V
				Full range	−5 to 3.5			
V_{OM+}	Maximum positive peak output voltage	$I_O = -20\ \mu A$		25°C		4.98		V
		$I_O = -100\ \mu A$		25°C	4.9	4.93		
				Full range	4.7			
		$I_O = -200\ \mu A$		25°C	4.8	4.86		
V_{OM-}	Maximum negative peak output voltage	$V_{IC} = 0$,	$I_O = 50\ \mu A$	25°C		−4.99		V
		$V_{IC} = 0$,	$I_O = 500\ \mu A$	25°C	−4.85	−4.91		
				Full range	−4.85			
		$V_{IC} = 0$,	$I_O = 1$ mA	25°C	−4.7	−4.8		
				Full range	−4.7			
		$V_{IC} = 0$,	$I_O = 4$ mA	25°C	−4	−4.3		
				Full range	−3.8			
A_{VD}	Large-signal differential voltage amplification	$V_O = \pm 4$ V	$R_L = 100\ k\Omega$	25°C	45	650		V/mV
				Full range	10			
			$R_L = 1\ M\Omega$	25°C		3000		
r_{id}	Differential input resistance			25°C		10^{12}		Ω
r_{ic}	Common-mode input resistance			25°C		10^{12}		Ω
c_{ic}	Common-mode input capacitance	f = 10 kHz,	P package	25°C		8		pF
z_o	Closed-loop output impedance	f = 25 kHz,	$A_V = 10$	25°C		190		Ω
CMRR	Common-mode rejection ratio	$V_{IC} = -5$ V to 2.7 V, $V_O = 0$,	$R_S = 50\ \Omega$	25°C	75	88		dB
				Full range	75			
k_{SVR}	Supply-voltage rejection ratio ($\Delta V_{DD\pm}/\Delta V_{IO}$)	$V_{DD\pm} = 2.2$ V to ±8 V, $V_{IC} = 0$,	No load	25°C	80	95		dB
				Full range	80			
I_{DD}	Supply current	$V_O = 0$,	No load	25°C		80	125	µA
				Full range			150	

† 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, $V_{DD\pm} = \pm 5$ V

PARAMETER		TEST CONDITIONS		T_A†	TLC2252C MIN	TLC2252C TYP	TLC2252C MAX	UNIT
SR	Slew rate at unity gain	$V_O = \pm 1.9$ V, $C_L = 100$ pF	$R_L = 100$ kΩ,	25°C	0.07	0.12		V/μs
				Full range	0.05			
V_n	Equivalent input noise voltage	f = 10 Hz		25°C		38		nV/√Hz
		f = 1 kHz		25°C		19		
$V_{N(PP)}$	Peak-to-peak equivalent input noise voltage	f = 0.1 Hz to 1 Hz		25°C		0.8		μV
		f = 0.1 Hz to 10 Hz		25°C		1.1		
I_n	Equivalent input noise current			25°C		0.6		fA√Hz
THD + N	Total harmonic distortion pulse duration	$V_O = \pm 2.3$ V, f = 10 kHz, $R_L = 50$ kΩ	$A_V = 1$	25°C		0.2%		
			$A_V = 10$			1%		
	Gain-bandwidth product	f = 10 kHz, $C_L = 100$ pF	$R_L = 50$ kΩ,	25°C		0.21		MHz
B_{OM}	Maximum output-swing bandwidth	$V_{O(PP)} = 4.6$ V, $R_L = 50$ kΩ,	$A_V = 1$, $C_L = 100$ pF	25°C		14		kHz
ϕ_m	Phase margin at unity gain	$R_L = 50$ kΩ,	$C_L = 100$ pF	25°C		63°		
	Gain margin			25°C		15		dB

† Full range is 0°C to 70°C.

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

PARAMETER		TEST CONDITIONS		T_A†	TLC2254C MIN	TLC2254C TYP	TLC2254C MAX	UNIT
V_{IO}	Input offset voltage	V_{IC} = 0, V_O = 0,	$V_{DD\pm}$ = ±2.5 V, R_S = 50 Ω	25°C		200	1500	μV
				Full range			1750	
α_{VIO}	Temperature coefficient of input offset voltage			25°C to 70°C		0.5		μV/°C
	Input offset voltage long-term drift (see Note 4)			25°C		0.003		μV/mo
I_{IO}	Input offset current			25°C		0.5	60	pA
				Full range			100	
I_{IB}	Input bias current			25°C		1	60	pA
				Full range			100	
V_{ICR}	Common-mode input voltage range	R_S = 50 Ω,	$\|V_{IO}\| \le 5$ mV	25°C	0 to 4	−0.3 to 4.2		V
				Full range	0 to 3.5			
V_{OH}	High-level output voltage	I_{OH} = −20 μA		25°C		4.98		V
		I_{OH} = −75 μA		25°C	4.9	4.94		
				Full range	4.8			
		I_{OH} = −150 μA		25°C	4.8	4.88		
V_{OL}	Low-level output voltage	V_{IC} = 2.5 V,	I_{OL} = 50 μA	25°C		0.01		V
		V_{IC} = 2.5 V,	I_{OL} = 500 μA	25°C		0.09	0.15	
				Full range			0.15	
		V_{IC} = 2.5 V,	I_{OL} = 1 mA	25°C		0.2	0.3	
				Full range			0.3	
		V_{IC} = 2.5 V,	I_{OL} = 4 mA	25°C		0.7	1	
				Full range			1.2	
A_{VD}	Large-signal differential voltage amplification	V_{IC} = 2.5 V, V_O = 1 V to 4 V	R_L = 100 kΩ‡	25°C	100	350		V/mV
				Full range	10			
			R_L = 1 MΩ‡	25°C		1700		
$r_{i(d)}$	Differential input resistance			25°C		10^{12}		Ω
$r_{i(c)}$	Common-mode input resistance			25°C		10^{12}		Ω
$c_{i(c)}$	Common-mode input capacitance	f = 10 kHz,	N package	25°C		8		pF
z_o	Closed-loop output impedance	f = 25 kHz,	A_V = 10	25°C		200		Ω
CMRR	Common-mode rejection ratio	V_{IC} = 0 to 2.7 V, R_S = 50 Ω	V_O = 2.5 V,	25°C	70	83		dB
				Full range	70			
k_{SVR}	Supply-voltage rejection ratio ($\Delta V_{DD}/\Delta V_{IO}$)	V_{DD} = 4.4 V to 16 V, $V_{IC} = V_{DD}/2$,	No load	25°C	80	95		dB
				Full range	80			
I_{DD}	Supply current (four amplifiers)	V_O = 2.5 V,	No load	25°C		140	250	μA
				Full range			300	

† Full range is 0°C to 70°C.
‡ Referenced to 2.5 V

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

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

PARAMETER		TEST CONDITIONS		T_A†	TLC2254C			UNIT
					MIN	TYP	MAX	
SR	Slew rate at unity gain	V_O = 1.4 V to 2.6 V, C_L = 100 pF‡	R_L = 100 kΩ‡,	25°C	0.07	0.12		V/µs
				Full range	0.05			
V_n	Equivalent input noise voltage	f = 10 Hz		25°C		36		nV/√Hz
		f = 1 kHz		25°C		19		
$V_{N(PP)}$	Peak-to-peak equivalent input noise voltage	f = 0.1 Hz to 1 Hz		25°C		0.7		µV
		f = 0.1 Hz to 10 Hz		25°C		1.1		
I_n	Equivalent input noise current			25°C		0.6		fA /√Hz
THD + N	Total harmonic distortion plus noise	V_O = 0.5 V to 2.5 V, f = 10 kHz, R_L = 50 kΩ‡	A_V = 1	25°C		0.2%		
			A_V = 10			1%		
	Gain-bandwidth product	f = 10 kHz, C_L = 100 pF‡	R_L = 50 kΩ‡,	25°C		0.2		MHz
B_{OM}	Maximum output-swing bandwidth	$V_{O(PP)}$ = 2 V, R_L = 50 kΩ‡,	A_V = 1, C_L = 100 pF‡	25°C		30		kHz
ϕ_m	Phase margin at unity gain	R_L = 50 kΩ‡,	C_L = 100 pF‡	25°C		63°		
	Gain margin			25°C		15		dB

† Full range is 0°C to 70°C.
‡ Referenced to 2.5 V

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

PARAMETER		TEST CONDITIONS		T_A†	TLC2254C MIN	TLC2254C TYP	TLC2254C MAX	UNIT
V_{IO}	Input offset voltage	$V_{IC} = 0$, $R_S = 50\ \Omega$	$V_O = 0$	25°C		200	1500	µV
				Full range			1750	
α_{VIO}	Temperature coefficient of input offset voltage			25°C to 70°C		0.5		µV/°C
	Input offset voltage long-term drift (see Note 4)			25°C		0.003		µV/mo
I_{IO}	Input offset current			25°C		0.5	60	pA
				Full range			100	
I_{IB}	Input bias current			25°C		1	60	pA
				Full range			100	
V_{ICR}	Common-mode input voltage range	$\|V_{IO}\| \le 5$ mV	$R_S = 50\ \Omega$	25°C	−5 to 4	−5.3 to 4.2		V
				Full range	−5 to 3.5			
V_{OM+}	Maximum positive peak output voltage	$I_O = -20\ \mu A$		25°C		4.98		V
		$I_O = -100\ \mu A$		25°C	4.9	4.93		
				Full range	4.7			
		$I_O = -200\ \mu A$		25°C	4.8	4.86		
V_{OM-}	Maximum negative peak output voltage	$V_{IC} = 0$	$I_O = 50\ \mu A$	25°C		−4.99		V
		$V_{IC} = 0$	$I_O = 500\ \mu A$	25°C	−4.85	−4.91		
				Full range	−4.85			
		$V_{IC} = 0$	$I_O = 1$ mA	25°C	−4.7	−4.8		
				Full range	−4.7			
		$V_{IC} = 0$	$I_O = 4$ mA	25°C	−4	−4.3		
				Full range	−3.8			
A_{VD}	Large-signal differential voltage amplification	$V_O = \pm 4$ V	$R_L = 100\ k\Omega$	25°C	40	150		V/mV
				Full range	10			
			$R_L = 1\ M\Omega$	25°C		3000		
$r_{i(d)}$	Differential input resistance			25°C		10^{12}		Ω
$r_{i(c)}$	Common-mode input resistance			25°C		10^{12}		Ω
$c_{i(c)}$	Common-mode input capacitance	f = 10 kHz	N package	25°C		8		pF
z_o	Closed-loop output impedance	f = 25 kHz	$A_V = 10$	25°C		190		Ω
CMRR	Common-mode rejection ratio	$V_{IC} = -5$ V to 2.7 V, $V_O = 0$	$R_S = 50\ \Omega$	25°C	75	88		dB
				Full range	75			
k_{SVR}	Supply-voltage rejection ratio ($\Delta V_{DD\pm}/\Delta V_{IO}$)	$V_{DD\pm} = \pm 2.2$ V to ± 8 V, $V_{IC} = 0$	No load	25°C	80	95		dB
				Full range	80			
I_{DD}	Supply current (four amplifiers)	$V_O = 0$	No load	25°C		160	250	µA
				Full range			300	

† 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, $V_{DD\pm} = \pm 5$ V

PARAMETER		TEST CONDITIONS		T_A†	TLC2254C MIN	TLC2254C TYP	TLC2254C MAX	UNIT
SR	Slew rate at unity gain	$V_O = \pm 1.9$ V, $R_L = 100$ kΩ, $C_L = 100$ pF		25°C	0.07	0.12		V/μs
				Full range	0.05			
V_n	Equivalent input noise voltage	f = 10 Hz		25°C		38		$nV/\sqrt{Hz}$
		f = 1 kHz		25°C		19		
$V_{N(PP)}$	Peak-to-peak equivalent input noise voltage	f = 0.1 Hz to 1 Hz		25°C		0.8		μV
		f = 0.1 Hz to 10 Hz		25°C		1.1		
I_n	Equivalent input noise current			25°C		0.6		$fA/\sqrt{Hz}$
THD + N	Total harmonic distortion plus noise	$V_O = \pm 2.3$ V, f = 20 kHz, $R_L = 50$ kΩ	$A_V = 1$	25°C		0.2%		
			$A_V = 10$			1%		
	Gain-bandwidth product	f = 10 kHz, $R_L = 50$ kΩ, $C_L = 100$ pF		25°C		0.21		MHz
B_{OM}	Maximum output-swing bandwidth	$V_{O(PP)} = 4.6$ V, $A_V = 1$, $R_L = 50$ kΩ, $C_L = 100$ pF		25°C		14		kHz
ϕ_m	Phase margin at unity gain	$R_L = 50$ kΩ, $C_L = 100$ pF		25°C		63°		
	Gain margin			25°C		15		dB

† Full range is 0°C to 70°C.

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

PARAMETER		TEST CONDITIONS		T_A†	TLC2252I			TLC2252AI			UNIT
					MIN	TYP	MAX	MIN	TYP	MAX	
V_{IO}	Input offset voltage	$V_{DD\pm} = \pm 2.5$ V, V_{IC} = 0,	V_O = 0, R_S = 50 Ω	25°C		200	1500		200	850	µV
				Full range			1750			1000	
α_{VIO}	Temperature coefficient of input offset voltage			25°C to 85°C		0.5			0.5		µV/°C
	Input offset voltage long-term drift (see Note 4)			25°C		0.003			0.003		µV/mo
I_{IO}	Input offset current			25°C		0.5	60		0.5	60	pA
				Full range			1000			1000	
I_{IB}	Input bias current			25°C		1	60		1	60	pA
				Full range			1000			1000	
V_{ICR}	Common-mode input voltage range	R_S = 50 Ω,	$\|V_{IO}\| \le 5$ mV	25°C	0 to 4	−0.3 to 4.2		0 to 4	−0.3 to 4.2		V
				Full range	0 to 3.5			0 to 3.5			
V_{OH}	High-level output voltage	I_{OH} = −20 µA		25°C		4.98			4.98		V
		I_{OH} = −75 µA		25°C	4.9	4.94		4.9	4.94		
				Full range	4.8			4.8			
		I_{OH} = −150 µA		25°C	4.8	4.88		4.8	4.88		
V_{OL}	Low-level output voltage	V_{IC} = 2.5 V,	I_{OL} = 50 µA	25°C		0.01			0.01		V
		V_{IC} = 2.5 V,	I_{OL} = 500 µA	25°C		0.09	0.15		0.09	0.15	
				Full range			0.15			0.15	
		V_{IC} = 2.5 V,	I_{OL} = 4 mA	25°C		0.8	1		0.7	1	
				Full range			1.2			1.2	
A_{VD}	Large-signal differential voltage amplification	V_{IC} = 2.5 V, V_O = 1 V to 4 V	R_L = 100 kΩ‡	25°C	100	350		100	350		V/mV
				Full range	10			10			
			R_L = 1 MΩ‡	25°C		1700			1700		
r_{id}	Differential input resistance			25°C		10^{12}			10^{12}		Ω
r_{ic}	Common-mode input resistance			25°C		10^{12}			10^{12}		Ω
c_{ic}	Common-mode input capacitance	f = 10 kHz,	P package	25°C		8			8		pF
z_o	Closed-loop output impedance	f = 25 kHz,	A_V = 10	25°C		200			200		Ω
CMRR	Common-mode rejection ratio	V_{IC} = 0 to 2.7 V, R_S = 50 Ω	V_O = 2.5 V,	25°C	70	83		70	83		dB
				Full range	70			70			
k_{SVR}	Supply-voltage rejection ratio ($\Delta V_{DD}/\Delta V_{IO}$)	V_{DD} = 4.4 V to 16 V, $V_{IC} = V_{DD}/2$,	No load	25°C	80	95		80	95		dB
				Full range	80			80			
I_{DD}	Supply current	V_O = 2.5 V,	No load	25°C		70	125		70	125	µA
				Full range			150			150	

† Full range is – 40°C to 125°C.
‡ Referenced to 2.5 V
NOTE 4: Typical values are based on the input offset voltage shift observed through 500 hours of operating life test at T_A = 150°C extrapolated to T_A = 25°C using the Arrhenius equation and assuming an activation energy of 0.96 eV.

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

PARAMETER		TEST CONDITIONS		T_A†	TLC2252I MIN	TLC2252I TYP	TLC2252I MAX	TLC2252AI MIN	TLC2252AI TYP	TLC2252AI MAX	UNIT
SR	Slew rate at unity gain	V_O = 1.5 V to 3.5 V, R_L = 100 kΩ‡, C_L = 100 pF‡		25°C	0.07	0.12		0.07	0.12		V/μs
				Full range	0.05			0.05			
V_n	Equivalent input noise voltage	f = 10 Hz		25°C		36			36		nV/√Hz
		f = 1 kHz		25°C		19			19		
$V_{N(PP)}$	Peak-to-peak equivalent input noise voltage	f = 0.1 Hz to 1 Hz		25°C		0.7			0.7		μV
		f = 0.1 Hz to 10 Hz		25°C		1.1			1.1		
I_n	Equivalent input noise current			25°C		0.6			0.6		fA√Hz
THD + N	Total harmonic distortion plus noise	V_O = 0.5 V to 2.5 V, f = 10 kHz, R_L = 50 kΩ‡	A_V = 1	25°C		0.2%			0.2%		
			A_V = 10			1%			1%		
	Gain-bandwidth product	f = 50 kHz, C_L = 100 pF‡	R_L = 50 kΩ‡,	25°C		0.2			0.2		MHz
B_{OM}	Maximum output-swing bandwidth	$V_{O(PP)}$ = 2 V, R_L = 50 kΩ‡,	A_V = 1, R_L = 50 kΩ‡,	25°C		30			30		kHz
ϕ_m	Phase margin at unity gain	R_L = 50 kΩ‡,	C_L = 100 pF‡	25°C		63°			63°		
	Gain margin			25°C		15			15		dB

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

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

PARAMETER		TEST CONDITIONS	T_A†	TLC2252I MIN	TLC2252I TYP	TLC2252I MAX	TLC2252AI MIN	TLC2252AI TYP	TLC2252AI MAX	UNIT
V_{IO}	Input offset voltage	$V_{IC} = 0$, $V_O = 0$, $R_S = 50\ \Omega$	25°C		200	1500		200	850	μV
			Full range			1750			1000	
α_{VIO}	Temperature coefficient of input offset voltage		25°C to 85°C		0.5			0.5		μV/°C
	Input offset voltage long-term drift (see Note 4)		25°C		0.003			0.003		μV/mo
I_{IO}	Input offset current		25°C		0.5	60		0.5	60	pA
			Full range			1000			1000	
I_{IB}	Input bias current		25°C		1	60		1	60	pA
			Full range			1000			1000	
V_{ICR}	Common-mode input voltage range	$R_S = 50\ \Omega$, $\|V_{IO}\| \le 5$ mV	25°C	−5 to 4	−5.3 to 4.2		−5 to 4	−5.3 to 4.2		V
			Full range	−5 to 3.5			−5 to 3.5			
V_{OM+}	Maximum positive peak output voltage	$I_O = -20\ \mu A$	25°C		4.98			4.98		V
		$I_O = -100\ \mu A$	25°C	4.9	4.93		4.9	4.93		
			Full range	4.7			4.7			
		$I_O = -200\ \mu A$	25°C	4.8	4.86		4.8	4.86		
V_{OM-}	Maximum negative peak output voltage	$V_{IC} = 0$, $I_O = 50\ \mu A$	25°C		−4.99			−4.99		V
		$V_{IC} = 0$, $I_O = 500\ \mu A$	25°C	−4.85	−4.91		−4.85	−4.91		
			Full range	−4.85			−4.85			
		$V_{IC} = 0$, $I_O = 4$ mA	25°C	−4	−4.3		−4	−4.3		
			Full range	−3.8			−3.8			
A_{VD}	Large-signal differential voltage amplification	$V_O = \pm4$ V, $R_L = 50\ k\Omega$	25°C	40	150		40	150		V/mV
			Full range	10			10			
		$V_O = \pm4$ V, $R_L = 1\ M\Omega$	25°C		3000			3000		
r_{id}	Differential input resistance		25°C		10^{12}			10^{12}		Ω
r_{ic}	Common-mode input resistance		25°C		10^{12}			10^{12}		Ω
c_{ic}	Common-mode input capacitance	f = 10 kHz, P package	25°C		8			8		pF
z_o	Closed-loop output impedance	f = 25 kHz, $A_V = 10$	25°C		190			190		Ω
CMRR	Common-mode rejection ratio	$V_{IC} = -5$ V to 2.7 V, $V_O = 0$, $R_S = 50\ \Omega$	25°C	75	88		75	88		dB
			Full range	75			75			
k_{SVR}	Supply-voltage rejection ratio ($\Delta V_{DD\pm}/\Delta V_{IO}$)	$V_{DD} = 4.4$ V to 16 V, $V_{IC} = V_{DD}/2$, No load	25°C	80	95		80	95		dB
			Full range	80			80			
I_{DD}	Supply current	$V_O = 2.5$ V, No load	25°C		80	125		80	125	μA
			Full range			150			150	

† 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, $V_{DD\pm} = \pm 5$ V

PARAMETER		TEST CONDITIONS		T_A†	TLC2252I MIN	TLC2252I TYP	TLC2252I MAX	TLC2252AI MIN	TLC2252AI TYP	TLC2252AI MAX	UNIT
SR	Slew rate at unity gain	$V_O = \pm 1.9$ V, $R_L = 100$ kΩ, $C_L = 100$ pF		25°C	0.07	0.12		0.07	0.12		V/μs
				Full range	0.05			0.05			
V_n	Equivalent input noise voltage	f = 10 Hz		25°C		38			38		nV/√Hz
		f = 1 kHz		25°C		19			19		
$V_{N(PP)}$	Peak-to-peak equivalent input noise voltage	f = 0.1 Hz to 1 Hz		25°C		0.8			0.8		μV
		f = 0.1 Hz to 10 Hz		25°C		1.1			1.1		
I_n	Equivalent input noise current			25°C		0.6			0.6		fA√Hz
THD + N	Total harmonic distortion plus noise	$V_O = \pm 2.3$ V, $R_L = 50$ kΩ, f = 10 kHz	$A_V = 1$	25°C		0.2%			0.2%		
			$A_V = 10$			1%			1%		
	Gain-bandwidth product	f =10 kHz, $R_L = 50$ kΩ, $C_L = 100$ pF		25°C		0.21			0.21		MHz
B_{OM}	Maximum output-swing bandwidth	$V_{O(PP)} = 4.6$ V, $A_V = 1$, $R_L = 50$ kΩ, $C_L = 100$ pF		25°C		14			14		kHz
ϕ_m	Phase margin at unity gain	$R_L = 50$ kΩ, $C_L = 100$ pF		25°C		63°			63°		
	Gain margin			25°C		15			15		dB

† Full range is –40°C to 125°C.

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

PARAMETER		TEST CONDITIONS		T_A†	TLC2254I MIN	TLC2254I TYP	TLC2254I MAX	TLC2254AI MIN	TLC2254AI TYP	TLC2254AI MAX	UNIT
V_{IO}	Input offset voltage	$V_{DD\pm}$ = ±2.5 V, V_{IC} = 0, V_O = 0, R_S = 50 Ω		25°C		200	1500		200	850	µV
				Full range			1750			1000	
α_{VIO}	Temperature coefficient of input offset voltage			25°C to 125°C		0.5			0.5		µV/°C
	Input offset voltage long-term drift (see Note 4)			25°C		0.003			0.003		µV/mo
I_{IO}	Input offset current			25°C		0.5	60		0.5	60	pA
				Full range			1000			1000	
I_{IB}	Input bias current			25°C		1	60		1	60	pA
				Full range			1000			1000	
V_{ICR}	Common-mode input voltage range	R_S = 50 Ω,	$\|V_{IO}\|$ ≤5 mV	25°C	0 to 4	−0.3 to 4.2		0 to 4	−0.3 to 4.2		V
				Full range	0 to 3.5			0 to 3.5			
V_{OH}	High-level output voltage	I_{OH} = −20 µA		25°C		4.98			4.98		V
		I_{OH} = −75 µA		25°C	4.9	4.94		4.9	4.94		
				Full range	4.8			4.8			
		I_{OH} = −150 µA		25°C	4.8	4.88		4.8	4.88		
V_{OL}	Low-level output voltage	V_{IC} = 2.5 V,	I_{OL} = 50 µA	25°C		0.01			0.01		V
		V_{IC} = 2.5 V,	I_{OL} = 500 µA	25°C		0.09	0.15		0.09	0.15	
				Full range			0.15			0.15	
		V_{IC} = 2.5 V,	I_{OL} = 4 mA	25°C		0.8	1		0.7	1	
				Full range			1.2			1.2	
A_{VD}	Large-signal differential voltage amplification	V_{IC} = 2.5 V, V_O = 1 V to 4 V	R_L = 100 kΩ‡	25°C	100	350		100	350		V/mV
				Full range	10			10			
			R_L = 1 MΩ‡	25°C		1700			1700		
$r_{i(d)}$	Differential input resistance			25°C		10^{12}			10^{12}		Ω
$r_{i(c)}$	Common-mode input resistance			25°C		10^{12}			10^{12}		Ω
$c_{i(c)}$	Common-mode input capacitance	f = 10 kHz,	N package	25°C		8			8		pF
z_o	Closed-loop output impedance	f = 25 kHz,	A_V = 10	25°C		200			200		Ω
CMRR	Common-mode rejection ratio	V_{IC} = 0 to 2.7 V, R_S = 50 Ω	V_O = 2.5 V,	25°C	70	83		70	83		dB
				Full range	70			70			
k_{SVR}	Supply-voltage rejection ratio ($\Delta V_{DD}/\Delta V_{IO}$)	V_{DD} = 4.4 V to 16 V, V_{IC} = V_{DD}/2,	No load	25°C	80	95		80	95		dB
				Full range	80			80			
I_{DD}	Supply current (four amplifiers)	V_O = 2.5 V,	No load	25°C		140	250		140	250	µA
				Full range			300			300	

† Full range is – 40°C to 125°C.
‡ Referenced to 2.5 V
NOTE 4: Typical values are based on the input offset voltage shift observed through 500 hours of operating life test at T_A = 150°C extrapolated to T_A = 25°C using the Arrhenius equation and assuming an activation energy of 0.96 eV.

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

PARAMETER		TEST CONDITIONS		T_A†	TLC2254I			TLC2254AI			UNIT
					MIN	TYP	MAX	MIN	TYP	MAX	
SR	Slew rate at unity gain	V_O = 1.4 V to 2.6 V, R_L = 100 kΩ‡, C_L = 100 pF‡		25°C	0.07	0.12		0.07	0.12		V/μs
				Full range	0.05			0.05			
V_n	Equivalent input noise voltage	f = 10 Hz		25°C		36			36		nV/√Hz
		f = 1 kHz		25°C		19			19		
$V_{N(PP)}$	Peak-to-peak equivalent input noise voltage	f = 0.1 Hz to 1 Hz		25°C		0.7			0.7		μV
		f = 0.1 Hz to 10 Hz		25°C		1.1			1.1		
I_n	Equivalent input noise current			25°C		0.6			0.6		fA /√Hz
THD + N	Total harmonic distortion plus noise	V_O = 0.5 V to 2.5 V, f = 20 kHz, R_L = 50 kΩ‡	A_V = 1	25°C		0.2%			0.2%		
			A_V = 10			1%			1%		
	Gain-bandwidth product	f = 50 kHz, C_L = 100 pF‡	R_L = 50 kΩ‡,	25°C		0.2			0.2		MHz
B_{OM}	Maximum output-swing bandwidth	$V_{O(PP)}$ = 2 V, R_L = 50 kΩ‡,	A_V = 1, C_L = 100 pF‡	25°C		30			30		kHz
ϕ_m	Phase margin at unity gain	R_L = 50 kΩ‡,	C_L = 100 pF‡	25°C		63°			63°		
	Gain margin			25°C		15			15		dB

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

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

PARAMETER		TEST CONDITIONS		T_A†	TLC2254I MIN	TLC2254I TYP	TLC2254I MAX	TLC2254AI MIN	TLC2254AI TYP	TLC2254AI MAX	UNIT
V_{IO}	Input offset voltage	$V_{IC} = 0$, $V_O = 0$, $R_S = 50\ \Omega$		25°C		200	1500		200	850	µV
				Full range			1750			1000	
α_{VIO}	Temperature coefficient of input offset voltage			25°C to 125°C		0.5			0.5		µV/°C
	Input offset voltage long-term drift (see Note 4)			25°C		0.003			0.003		µV/mo
I_{IO}	Input offset current			25°C		0.5	60		0.5	60	pA
				Full range			1000			1000	
I_{IB}	Input bias current			25°C		1	60		1	60	pA
				Full range			1000			1000	
V_{ICR}	Common-mode input voltage range	$R_S = 50\ \Omega$, $\|V_{IO}\| \le 5$ mV		25°C	−5 to 4	−5.3 to 4.2		−5 to 4	−5.3 to 4.2		V
				Full range	−5 to 3.5			−5 to 3.5			
V_{OM+}	Maximum positive peak output voltage	$I_O = -20$ µA		25°C		4.98			4.98		V
		$I_O = -100$ µA		25°C	4.9	4.93		4.9	4.93		
				Full range	4.7			4.7			
		$I_O = -200$ µA		25°C	4.8	4.86		4.8	4.86		
V_{OM-}	Maximum negative peak output voltage	$V_{IC} = 0$, $I_O = 50$ µA		25°C		−4.99			−4.99		V
		$V_{IC} = 0$, $I_O = 500$ µA		25°C	−4.85	−4.91		−4.85	−4.91		
				Full range	−4.85			−4.85			
		$V_{IC} = 0$, $I_O = 4$ mA		25°C	−4	−4.3		−4	−4.3		
				Full range	−3.8			−3.8			
A_{VD}	Large-signal differential voltage amplification	$V_O = \pm4$ V	$R_L = 100$ kΩ	25°C	40	150		40	150		V/mV
				Full range	10			10			
			$R_L = 1$ MΩ	25°C		3000			3000		
$r_{i(d)}$	Differential input resistance			25°C		10^{12}			10^{12}		Ω
$r_{i(c)}$	Common-mode input resistance			25°C		10^{12}			10^{12}		Ω
$c_{i(c)}$	Common-mode input capacitance	f = 10 kHz, N package		25°C		8			8		pF
z_o	Closed-loop output impedance	f = 25 kHz, $A_V = 10$		25°C		190			190		Ω
CMRR	Common-mode rejection ratio	$V_{IC} = -5$ V to 2.7 V, $V_O = 0$, $R_S = 50\ \Omega$		25°C	75	88		75	88		dB
				Full range	75			75			
k_{SVR}	Supply-voltage rejection ratio ($\Delta V_{DD\pm}/\Delta V_{IO}$)	$V_{DD\pm} = \pm2.2$ V to ±8 V, $V_{IC} = V_{DD}/2$, No load		25°C	80	95		80	95		dB
				Full range	80			80			
I_{DD}	Supply current (four amplifiers)	$V_O = 0$, No load		25°C		160	250		160	250	µA
				Full range			300			300	

† Full range is – 40°C to 125°C.

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

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

PARAMETER		TEST CONDITIONS		T_A†	TLC2254I			TLC2254AI			UNIT
					MIN	TYP	MAX	MIN	TYP	MAX	
SR	Slew rate at unity gain	$V_O = \pm1.9$ V, $C_L = 100$ pF	$R_L = 100$ kΩ,	25°C	0.07	0.12		0.07	0.12		V/µs
				Full range	0.05			0.05			
V_n	Equivalent input noise voltage	f = 10 Hz		25°C		38			38		nV/√Hz
		f = 1 kHz		25°C		19			19		
$V_{N(PP)}$	Peak-to-peak equivalent input noise voltage	f = 0.1 Hz to 1 Hz		25°C		0.8			0.8		µV
		f = 0.1 Hz to 10 Hz		25°C		1.1			1.1		
I_n	Equivalent input noise current			25°C		0.6			0.6		fA /√Hz
THD + N	Total harmonic distortion plus noise	$V_O = \pm2.3$ V, $R_L = 50$ kΩ, f = 20 kHz	$A_V = 1$	25°C		0.2%			0.2%		
			$A_V = 10$			1%			1%		
	Gain-bandwidth product	f =10 kHz, $C_L = 100$ pF	$R_L = 50$ kΩ,	25°C		0.21			0.21		MHz
B_{OM}	Maximum output-swing bandwidth	$V_{O(PP)} = 4.6$ V, $R_L = 50$ kΩ,	$A_V = 1$, $C_L = 100$ pF	25°C		14			14		kHz
ϕ_m	Phase margin at unity gain	$R_L = 50$ kΩ,	$C_L = 100$ pF	25°C		63°			63°		
	Gain margin			25°C		15			15		dB

† Full range is –40°C to 125°C.

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

PARAMETER		TEST CONDITIONS		T_A†	TLC2252Q TLC2252M MIN	TYP	MAX	TLC2252AQ TLC2252AM MIN	TYP	MAX	UNIT
V_{IO}	Input offset voltage	$V_{DD\pm} = \pm 2.5$ V, $V_O = 0$,	$V_{IC} = 0$, $R_S = 50\ \Omega$	25°C		200	1500		200	850	µV
				Full range			1750			1000	
α_{VIO}	Temperature coefficient of input offset voltage			25°C to 125°C		0.5			0.5		µV/°C
	Input offset voltage long-term drift (see Note 4)			25°C		0.003			0.003		µV/mo
I_{IO}	Input offset current			25°C		0.5	60		0.5	60	pA
				Full range			1000			1000	
I_{IB}	Input bias current			25°C		1	60		1	60	pA
				Full range			1000			1000	
V_{ICR}	Common-mode input voltage range	$R_S = 50\ \Omega$,	$\|V_{IO}\| \le 5$ mV	25°C	0 to 4	−0.3 to 4.2		0 to 4	−0.3 to 4.2		V
				Full range	0 to 3.5			0 to 3.5			
V_{OH}	High-level output voltage	$I_{OH} = -20$ µA		25°C		4.98			4.98		V
		$I_{OH} = -75$ µA		25°C	4.9	4.94		4.9	4.94		
				Full range	4.8			4.8			
		$I_{OH} = -150$ µA		25°C	4.8	4.88		4.8	4.88		
V_{OL}	Low-level output voltage	$V_{IC} = 2.5$ V,	$I_{OL} = 50$ µA	25°C		0.01			0.01		V
		$V_{IC} = 2.5$ V,	$I_{OL} = 500$ µA	25°C		0.09	0.15		0.09	0.15	
				Full range			0.15			0.15	
		$V_{IC} = 2.5$ V,	$I_{OL} = 4$ mA	25°C		0.8	1		0.7	1	
				Full range			1.2			1.2	
A_{VD}	Large-signal differential voltage amplification	$V_{IC} = 2.5$ V, $V_O = 1$ V to 4 V	$R_L = 100$ kΩ‡	25°C	100	350		100	350		V/mV
				Full range	10			10			
			$R_L = 1$ MΩ‡	25°C		1700			1700		
r_{id}	Differential input resistance			25°C		10^{12}			10^{12}		Ω
r_{ic}	Common-mode input resistance			25°C		10^{12}			10^{12}		Ω
c_{ic}	Common-mode input capacitance	f = 10 kHz,	f = 10 kHz,	25°C		8			8		pF
z_o	Closed-loop output impedance	f = 25 kHz,	$A_V = 10$	25°C		200			200		Ω
CMRR	Common-mode rejection ratio	$V_{IC} = 0$ to 2.7 V, $R_S = 50\ \Omega$	$V_O = 2.5$ V,	25°C	70	83		70	83		dB
				Full range	70			70			
k_{SVR}	Supply-voltage rejection ratio ($\Delta V_{DD}/\Delta V_{IO}$)	$V_{DD} = 4.4$ V to 16 V, $V_{IC} = V_{DD}/2$,	No load	25°C	80	95		80	95		dB
				Full range	80			80			
I_{DD}	Supply current	$V_O = 2.5$ V,	No load	25°C		70	125		70	125	µA
				Full range			150			150	

† Full range is – 40°C to 125°C for Q suffix, – 55°C to 125°C for M suffix.
‡ Referenced to 2.5 V
NOTE 4: Typical values are based on the input offset voltage shift observed through 500 hours of operating life test at T_A = 150°C extrapolated to T_A = 25°C using the Arrhenius equation and assuming an activation energy of 0.96 eV.

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

PARAMETER		TEST CONDITIONS		T_A†	TLC2252Q TLC2252M MIN	TYP	MAX	TLC2252AQ TLC2252AM MIN	TYP	MAX	UNIT
SR	Slew rate at unity gain	V_O = 0.5 V to 3.5 V, R_L = 100 kΩ‡,	C_L = 100 pF‡	25°C	0.07	0.12		0.07	0.12		V/μs
				Full range	0.05			0.05			
V_n	Equivalent input noise voltage	f = 10 Hz		25°C		36			36		nV/√Hz
		f = 1 kHz		25°C		19			19		
$V_{N(PP)}$	Peak-to-peak equivalent input noise voltage	f = 0.1 Hz to 1 Hz		25°C		0.7			0.7		μV
		f = 0.1 Hz to 10 Hz		25°C		1.1			1.1		
I_n	Equivalent input noise current			25°C		0.6			0.6		fA√Hz
THD + N	Total harmonic distortion plus noise	V_O = 0.5 V to 2.5 V, f = 10 kHz, R_L = 50 kΩ‡	A_V = 1	25°C		0.2%			0.2%		
			A_V = 10			1%			1%		
	Gain-bandwidth product	f = 50 kHz, C_L = 100 pF‡	R_L = 50 kΩ‡,	25°C		0.2			0.2		MHz
B_{OM}	Maximum output-swing bandwidth	$V_{O(PP)}$ = 2 V, R_L = 50 kΩ‡,	A_V = 1, C_L = 100 pF‡	25°C		30			30		kHz
ϕ_m	Phase margin at unity gain	R_L = 50 kΩ‡,	C_L = 100 pF‡	25°C		63°			63°		
	Gain margin			25°C		15			15		dB

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

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

PARAMETER		TEST CONDITIONS		T_A†	TLC2252Q TLC2252M MIN	TLC2252Q TLC2252M TYP	TLC2252Q TLC2252M MAX	TLC2252AQ TLC2252AM MIN	TLC2252AQ TLC2252AM TYP	TLC2252AQ TLC2252AM MAX	UNIT
V_{IO}	Input offset voltage	$V_{IC} = 0$, $V_O = 0$, $R_S = 50\ \Omega$		25°C		200	1500		200	850	µV
				Full range			1750			1000	
α_{VIO}	Temperature coefficient of input offset voltage			25°C to 125°C		0.5			0.5		µV/°C
	Input offset voltage long-term drift (see Note 4)			25°C		0.003			0.003		µV/mo
I_{IO}	Input offset current			25°C		0.5	60		0.5	60	pA
				Full range			1000			1000	
I_{IB}	Input bias current			25°C		1	60		1	60	pA
				Full range			1000			1000	
V_{ICR}	Common-mode input voltage range	$R_S = 50\ \Omega$, $\|V_{IO}\| \le 5$ mV		25°C	–5 to 4	–5.3 to 4.2		–5 to 4	–5.3 to 4.2		V
				Full range	–5 to 3.5			–5 to 3.5			
V_{OM+}	Maximum positive peak output voltage	$I_O = –20\ \mu A$		25°C		4.98			4.98		V
		$I_O = –100\ \mu A$		25°C	4.9	4.93		4.9	4.93		
				Full range	4.7			4.7			
		$I_O = –200\ \mu A$		25°C	4.8	4.86		4.8	4.86		
V_{OM-}	Maximum negative peak output voltage	$V_{IC} = 0$, $I_O = 50\ \mu A$		25°C		–4.99			–4.99		V
		$V_{IC} = 0$, $I_O = 500\ \mu A$		25°C	–4.85	–4.91		–4.85	–4.91		
				Full range	–4.85			–4.85			
		$V_{IC} = 0$, $I_O = 4$ mA		25°C	–4	–4.3		–4	–4.3		
				Full range	–3.8			–3.8			
A_{VD}	Large-signal differential voltage amplification	$V_O = \pm 4$ V	$R_L = 100\ k\Omega$	25°C	40	150		40	150		V/mV
				Full range	10			10			
			$R_L = 1\ M\Omega$	25°C		3000			3000		
r_{id}	Differential input resistance			25°C		10^{12}			10^{12}		Ω
r_{ic}	Common-mode input resistance			25°C		10^{12}			10^{12}		Ω
c_{ic}	Common-mode input capacitance	f = 10 kHz, P package		25°C		8			8		pF
z_o	Closed-loop output impedance	f = 25 kHz, $A_V = 10$		25°C		190			190		Ω
CMRR	Common-mode rejection ratio	$V_{IC} = –5$ V to 2.7 V, $V_O = 0$, $R_S = 50\ \Omega$		25°C	75	88		75	88		dB
				Full range	75			75			
k_{SVR}	Supply-voltage rejection ratio ($\Delta V_{DD\pm} / \Delta V_{IO}$)	$V_{DD} = \pm 2.2$ V to ± 8 V, $V_{IC} = 0$, No load		25°C	80	95		80	95		dB
				Full range	80			80			
I_{DD}	Supply current	$V_O = 2.5$ V, No load		25°C		80	125		80	125	µA
				Full range			150			150	

† Full range is – 40°C to 125°C for Q suffix, – 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, $V_{DD\pm} = \pm5$ V

PARAMETER		TEST CONDITIONS		T_A†	TLC2252Q TLC2252M			TLC2252AQ TLC2252AM			UNIT
					MIN	TYP	MAX	MIN	TYP	MAX	
SR	Slew rate at unity gain	$V_O = \pm2$ V, $C_L = 100$ pF	$R_L = 100$ kΩ,	25°C	0.07	0.12		0.07	0.12		V/μs
				Full range	0.05			0.05			
V_n	Equivalent input noise voltage	f = 10 Hz		25°C		38			38		nV/√Hz
		f = 1 kHz		25°C		19			19		
$V_{N(PP)}$	Peak-to-peak equivalent input noise voltage	f = 0.1 Hz to 1 Hz		25°C		0.8			0.8		μV
		f = 0.1 Hz to 10 Hz		25°C		1.1			1.1		
I_n	Equivalent input noise current			25°C		0.6			0.6		fA√Hz
THD + N	Total harmonic distortion plus noise	$V_O = \pm2.3$ V, $R_L = 50$ kΩ, f = 10 kHz	$A_V = 1$	25°C		0.2%			0.2%		
			$A_V = 10$			1%			1%		
	Gain-bandwidth product	f =10 kHz, $C_L = 100$ pF	$R_L = 50$ kΩ,	25°C		0.21			0.21		MHz
B_{OM}	Maximum output-swing bandwidth	$V_{O(PP)} = 4.6$ V, $R_L = 50$ kΩ,	$A_V = 1$, $C_L = 100$ pF	25°C		14			14		kHz
ϕ_m	Phase margin at unity gain	$R_L = 50$ kΩ,	$C_L = 100$ pF	25°C		63°			63°		
	Gain margin			25°C		15			15		dB

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

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

PARAMETER		TEST CONDITIONS		T_A†	TLC2254Q TLC2254M MIN	TYP	MAX	TLC2254AQ TLC2254AM MIN	TYP	MAX	UNIT
V_{IO}	Input offset voltage	$V_{DD\pm} = \pm2.5$ V, $V_O = 0$,	$V_{IC} = 0$, $R_S = 50\ \Omega$	25°C		200	1500		200	850	µV
				Full range			1750			1000	
α_{VIO}	Temperature coefficient of input offset voltage			25°C to 125°C		0.5			0.5		µV/°C
	Input offset voltage long-term drift (see Note 4)			25°C		0.003			0.003		µV/mo
I_{IO}	Input offset current			25°C		0.5	60		0.5	60	pA
				125°C			1000			1000	
I_{IB}	Input bias current			25°C		1	60		1	60	pA
				125°C			1000			1000	
V_{ICR}	Common-mode input voltage range	$R_S = 50\ \Omega$,	$\|V_{IO}\| \le 5$ mV	25°C	0 to 4	−0.3 to 4.2		0 to 4	−0.3 to 4.2		V
				Full range	0 to 3.5			0 to 3.5			
V_{OH}	High-level output voltage	$I_{OH} = -20\ \mu A$		25°C		4.98			4.98		V
		$I_{OH} = -75\ \mu A$		25°C	4.9	4.94		4.9	4.94		
				Full range	4.8			4.8			
		$I_{OH} = -150\ \mu A$		25°C	4.8	4.88		4.8	4.88		
V_{OL}	Low-level output voltage	$V_{IC} = 2.5$ V,	$I_{OL} = 50\ \mu A$	25°C		0.01			0.01		V
		$V_{IC} = 2.5$ V,	$I_{OL} = 500\ \mu A$	25°C		0.09	0.15		0.09	0.15	
				Full range			0.15			0.15	
		$V_{IC} = 2.5$ V,	$I_{OL} = 4$ mA	25°C		0.8	1		0.7	1	
				Full range			1.2			1.2	
A_{VD}	Large-signal differential voltage amplification	$V_{IC} = 2.5$ V, $V_O = 1$ V to 4 V	$R_L = 100\ k\Omega$‡	25°C	100	350		100	350		V/mV
				Full range	10			10			
			$R_L = 1\ M\Omega$‡	25°C		1700			1700		
$r_{i(d)}$	Differential input resistance			25°C		10^{12}			10^{12}		Ω
$r_{i(c)}$	Common-mode input resistance			25°C		10^{12}			10^{12}		Ω
$c_{i(c)}$	Common-mode input capacitance	f = 10 kHz,	N package	25°C		8			8		pF
z_o	Closed-loop output impedance	f = 25 kHz,	$A_V = 10$	25°C		200			200		Ω
CMRR	Common-mode rejection ratio	$V_{IC} = 0$ to 2.7 V, $R_S = 50\ \Omega$	$V_O = 2.5$ V,	25°C	70	83		70	83		dB
				Full range	70			70			
k_{SVR}	Supply-voltage rejection ratio ($\Delta V_{DD}/\Delta V_{IO}$)	$V_{DD} = 4.4$ V to 16 V, $V_{IC} = V_{DD}/2$,	No load	25°C	80	95		80	95		dB
				Full range	80			80			
I_{DD}	Supply current (four amplifiers)	$V_O = 2.5$ V,	No load	25°C		140	250		140	250	µA
				Full range			300			300	

† Full range is – 40°C to 125°C for Q suffix, – 55°C to 125°C for M suffix.
‡ Referenced to 2.5 V
NOTE 4: Typical values are based on the input offset voltage shift observed through 500 hours of operating life test at T_A = 150°C extrapolated to T_A = 25°C using the Arrhenius equation and assuming an activation energy of 0.96 eV.

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

PARAMETER		TEST CONDITIONS		T_A†	TLC2254Q TLC2254M MIN	TYP	MAX	TLC2254AQ TLC2254AM MIN	TYP	MAX	UNIT
SR	Slew rate at unity gain	V_O = 0.5 V to 3.5 V, R_L = 100 kΩ‡, C_L = 100 pF‡		25°C	0.07	0.12		0.07	0.12		V/μs
				Full range	0.05			0.05			
V_n	Equivalent input noise voltage	f = 10 Hz		25°C		36			36		nV/√Hz
		f = 1 kHz		25°C		19			19		
$V_{N(PP)}$	Peak-to-peak equivalent input noise voltage	f = 0.1 Hz to 1 Hz		25°C		0.7			0.7		μV
		f = 0.1 Hz to 10 Hz		25°C		1.1			1.1		
I_n	Equivalent input noise current			25°C		0.6			0.6		fA /√Hz
THD + N	Total harmonic distortion plus noise	V_O = 0.5 V to 2.5 V, f = 20 kHz, R_L = 50 kΩ‡	A_V = 1	25°C		0.2%			0.2%		
			A_V = 10			1%			1%		
	Gain-bandwidth product	f = 50 kHz, C_L = 100 pF‡	R_L = 50 kΩ‡,	25°C		0.2			0.2		MHz
B_{OM}	Maximum output-swing bandwidth	$V_{O(PP)}$ = 2 V, R_L = 50 kΩ‡,	A_V = 1, C_L = 100 pF‡	25°C		30			30		kHz
ϕ_m	Phase margin at unity gain	R_L = 50 kΩ‡,	C_L = 100 pF‡	25°C		63°			63°		
	Gain margin			25°C		15			15		dB

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

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

PARAMETER		TEST CONDITIONS		T_A†	TLC2254Q TLC2254M MIN	TLC2254Q TLC2254M TYP	TLC2254Q TLC2254M MAX	TLC2254AQ TLC2254AM MIN	TLC2254AQ TLC2254AM TYP	TLC2254AQ TLC2254AM MAX	UNIT
V_{IO}	Input offset voltage	V_{IC} = 0, V_O = 0, R_S = 50 Ω		25°C		200	1500		200	850	µV
				Full range			1750			1000	
α_{VIO}	Temperature coefficient of input offset voltage			25°C to 125°C		0.5			0.5		µV/°C
	Input offset voltage long-term drift (see Note 4)			25°C		0.003			0.003		µV/mo
I_{IO}	Input offset current			25°C		0.5	60		0.5	60	pA
				125°C			1000			1000	
I_{IB}	Input bias current			25°C		1	60		1	60	pA
				125°C			1000			1000	
V_{ICR}	Common-mode input voltage range	R_S = 50 Ω, $\lvert V_{IO} \rvert$ ≤5 mV		25°C	–5 to 4	–5.3 to 4.2		–5 to 4	–5.3 to 4.2		V
				Full range	–5 to 3.5			–5 to 3.5			
V_{OM+}	Maximum positive peak output voltage	I_O = –20 µA		25°C		4.98			4.98		V
		I_O = –100 µA		25°C	4.9	4.93		4.9	4.93		
				Full range	4.7			4.7			
		I_O = –200 µA		25°C	4.8	4.86		4.8	4.86		
V_{OM-}	Maximum negative peak output voltage	V_{IC} = 0, I_O = 50 µA		25°C		–4.99			–4.99		V
		V_{IC} = 0, I_O = 500 µA		25°C	–4.85	–4.91		–4.85	–4.91		
				Full range	–4.85			–4.85			
		V_{IC} = 0, I_O = 4 mA		25°C	–4	–4.3		–4	–4.3		
				Full range	–3.8			–3.8			
A_{VD}	Large-signal differential voltage amplification	V_O = ±4 V	R_L = 100 kΩ	25°C	40	150		40	150		V/mV
				Full range	10			10			
			R_L = 1 MΩ	25°C		3000			3000		
$r_{i(d)}$	Differential input resistance			25°C		10^{12}			10^{12}		Ω
$r_{i(c)}$	Common-mode input resistance			25°C		10^{12}			10^{12}		Ω
$c_{i(c)}$	Common-mode input capacitance	f = 10 kHz, N package		25°C		8			8		pF
z_o	Closed-loop output impedance	f = 25 kHz, A_V = 10		25°C		190			190		Ω
CMRR	Common-mode rejection ratio	V_{IC} = –5 V to 2.7 V, V_O = 0, R_S = 50 Ω		25°C	75	88		75	88		dB
				Full range	75			75			
k_{SVR}	Supply-voltage rejection ratio ($\Delta V_{DD\pm}/\Delta V_{IO}$)	$V_{DD\pm}$ = ±2.2 V to ±8 V, V_{IC} = V_{DD}/2, No load		25°C	80	95		80	95		dB
				Full range	80			80			
I_{DD}	Supply current (four amplifiers)	V_O = 0, No load		25°C		160	250		160	250	µA
				Full range			300			300	

† Full range is – 40°C to 125°C for Q suffix, – 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, $V_{DD\pm} = \pm 5$ V

PARAMETER		TEST CONDITIONS		T_A†	TLC2254Q TLC2254M MIN	TYP	MAX	TLC2254AQ TLC2254AM MIN	TYP	MAX	UNIT
SR	Slew rate at unity gain	$V_O = \pm 2$ V, $C_L = 100$ pF	$R_L = 100$ kΩ,	25°C	0.07	0.12		0.07	0.12		V/μs
				Full range	0.05			0.05			
V_n	Equivalent input noise voltage	f = 10 Hz		25°C		38			38		nV/√Hz
		f = 1 kHz		25°C		19			19		
$V_{N(PP)}$	Peak-to-peak equivalent input noise voltage	f = 0.1 Hz to 1 Hz		25°C		0.8			0.8		μV
		f = 0.1 Hz to 10 Hz		25°C		1.1			1.1		
I_n	Equivalent input noise current			25°C		0.6			0.6		fA /√Hz
THD + N	Total harmonic distortion plus noise	$V_O = \pm 2.3$ V, $R_L = 50$ kΩ, f = 20 kHz	$A_V = 1$	25°C		0.2%			0.2%		
			$A_V = 10$			1%			1%		
	Gain-bandwidth product	f =10 kHz, $C_L = 100$ pF	$R_L = 50$ kΩ,	25°C		0.21			0.21		MHz
B_{OM}	Maximum output-swing bandwidth	$V_{O(PP)} = 4.6$ V, $R_L = 50$ kΩ,	$A_V = 1$, $C_L = 100$ pF	25°C		14			14		kHz
ϕ_m	Phase margin at unity gain	$R_L = 50$ kΩ,	$C_L = 100$ pF	25°C		63°			63°		
	Gain margin			25°C		15			15		dB

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

TYPICAL CHARACTERISTICS

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TYPICAL CHARACTERISTICS

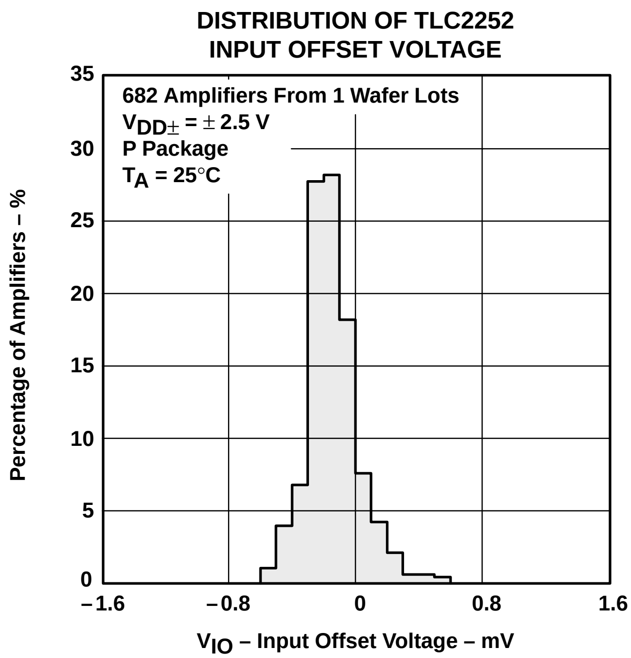


Figure 2

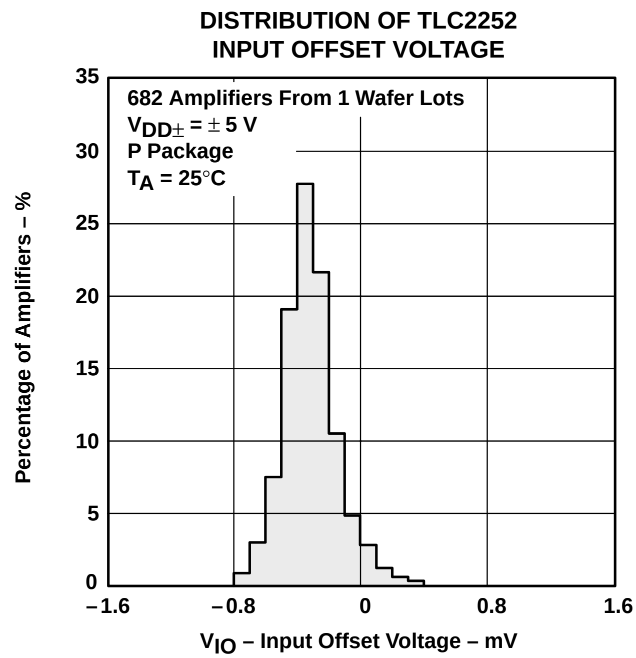


Figure 3

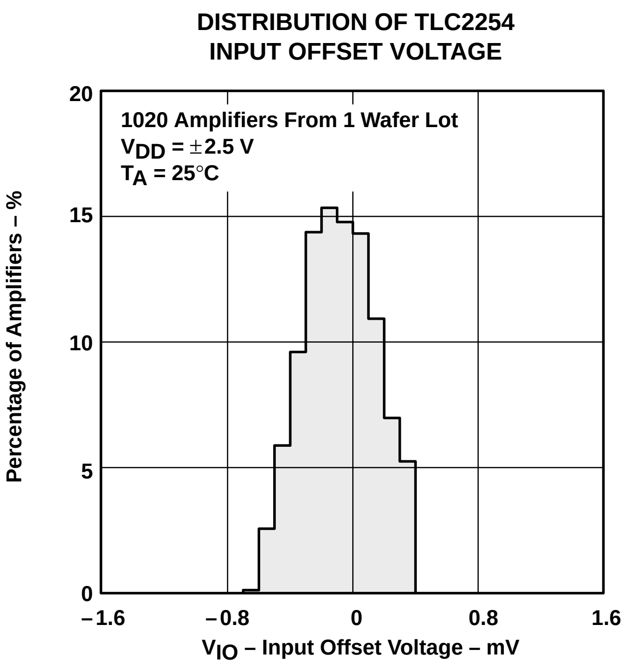


Figure 4

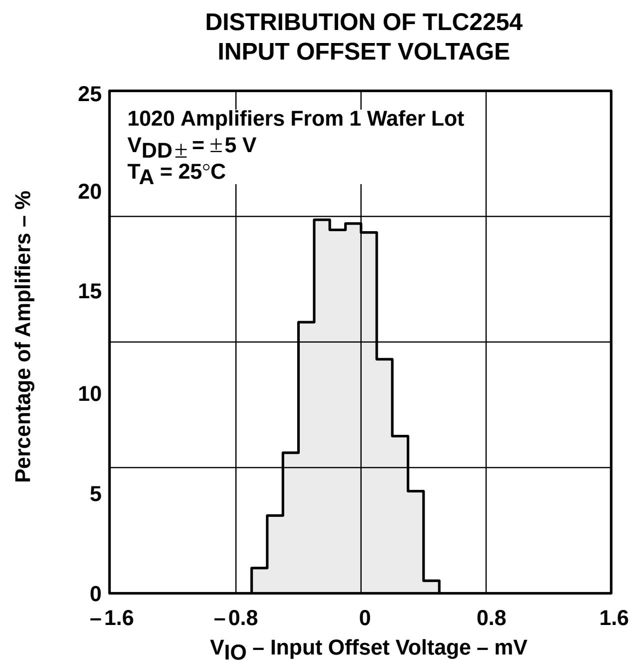


Figure 5

TYPICAL CHARACTERISTICS

INPUT OFFSET VOLTAGE†
vs
COMMON-MODE INPUT VOLTAGE

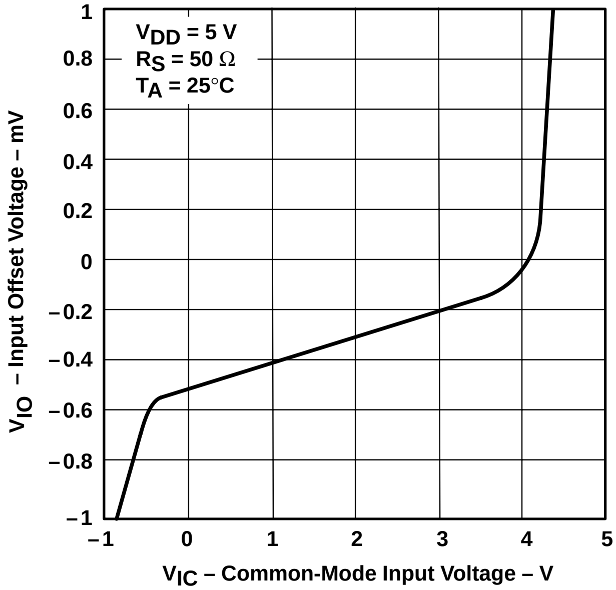


Figure 6

INPUT OFFSET VOLTAGE
vs
COMMON-MODE INPUT VOLTAGE

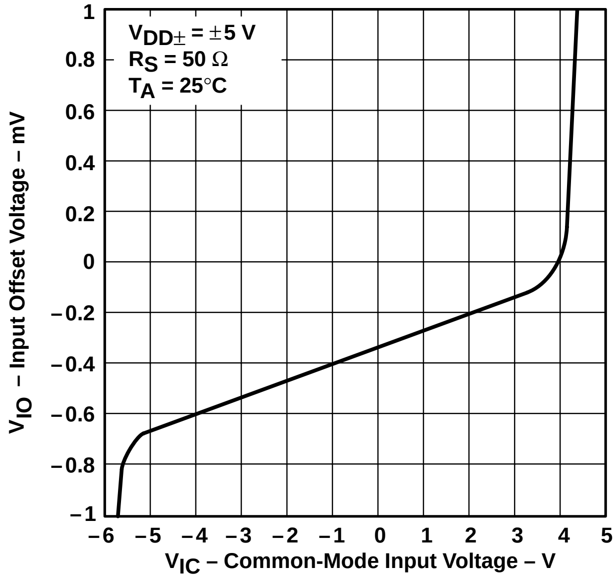


Figure 7

DISTRIBUTION OF TLC2252 INPUT OFFSET
VOLTAGE TEMPERATURE COEFFICIENT

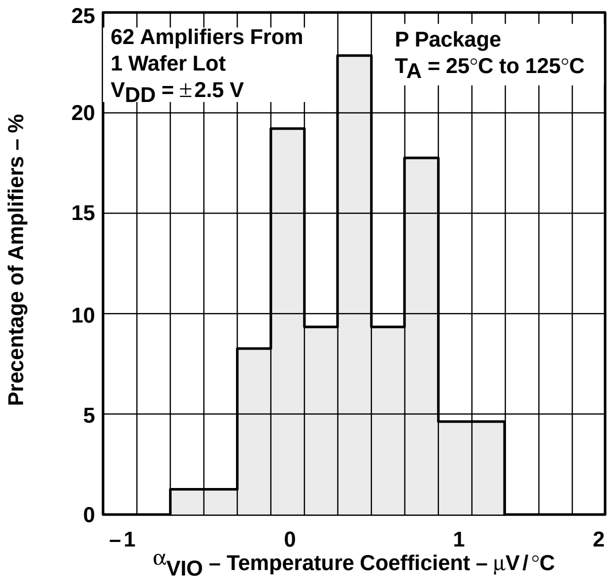


Figure 8

DISTRIBUTION OF TLC2252 INPUT OFFSET
VOLTAGE TEMPERATURE COEFFICIENT

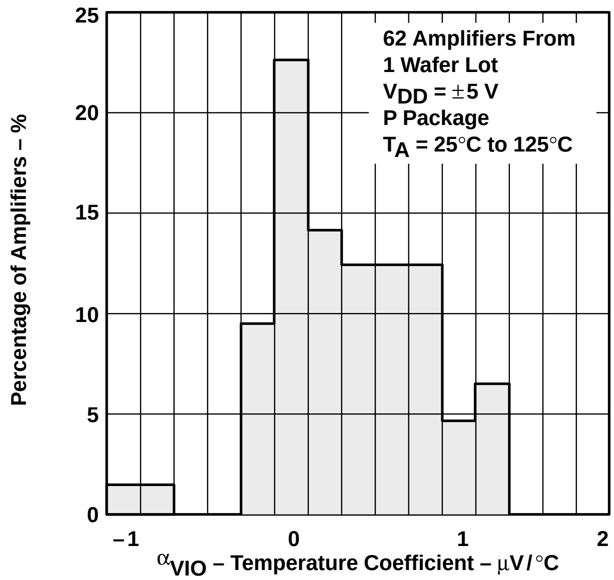


Figure 9

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

TYPICAL CHARACTERISTICS

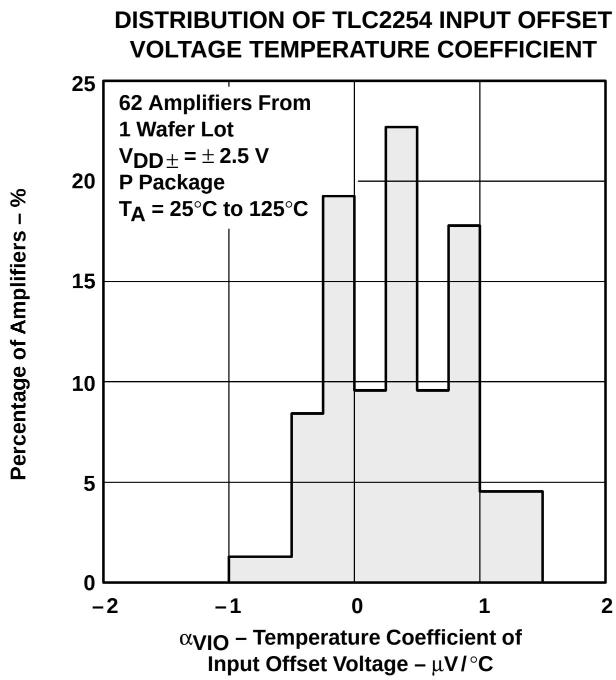


Figure 10

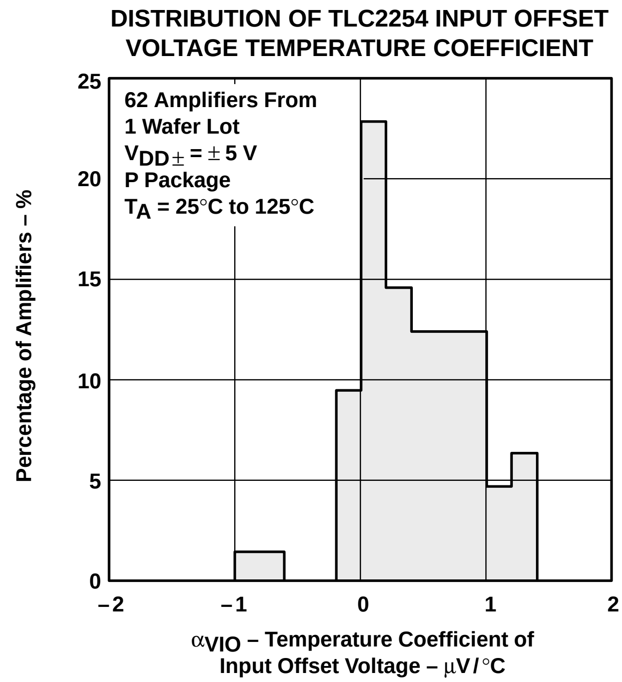


Figure 11

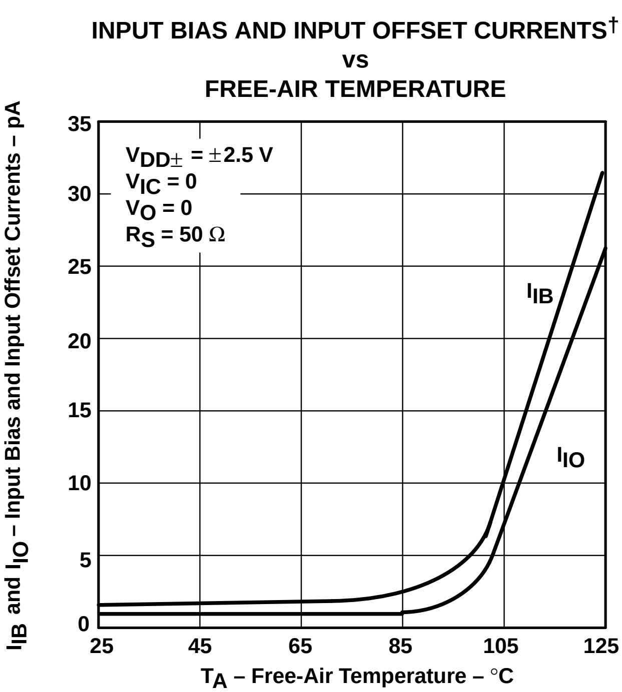


Figure 12

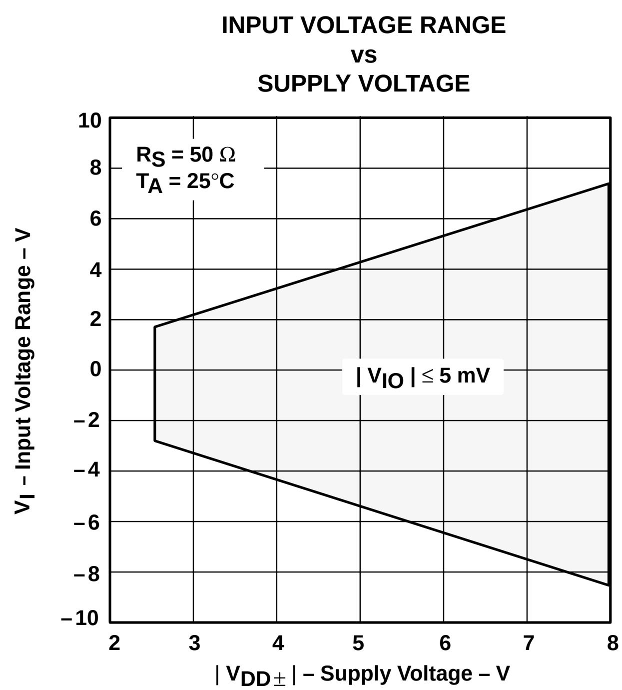


Figure 13

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

TYPICAL CHARACTERISTICS

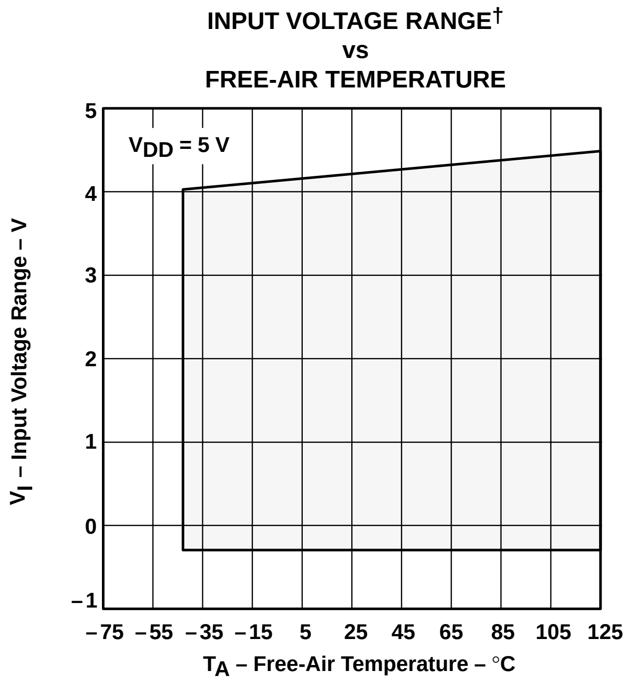


Figure 14

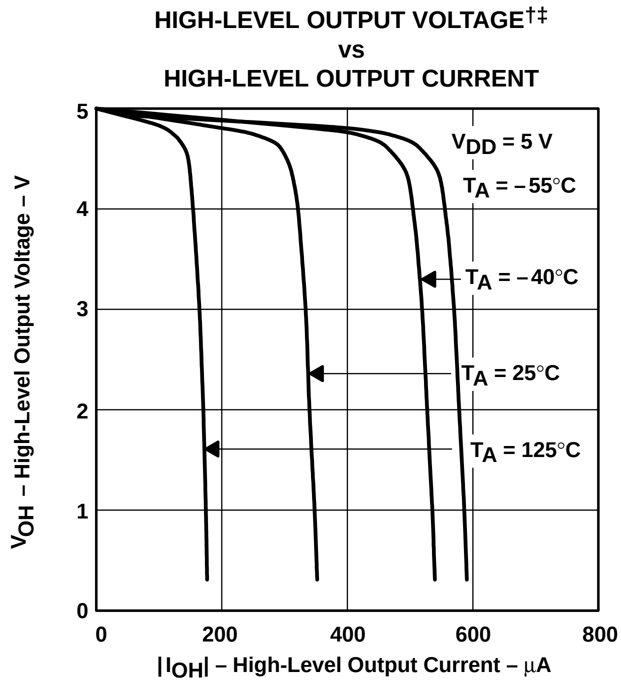


Figure 15

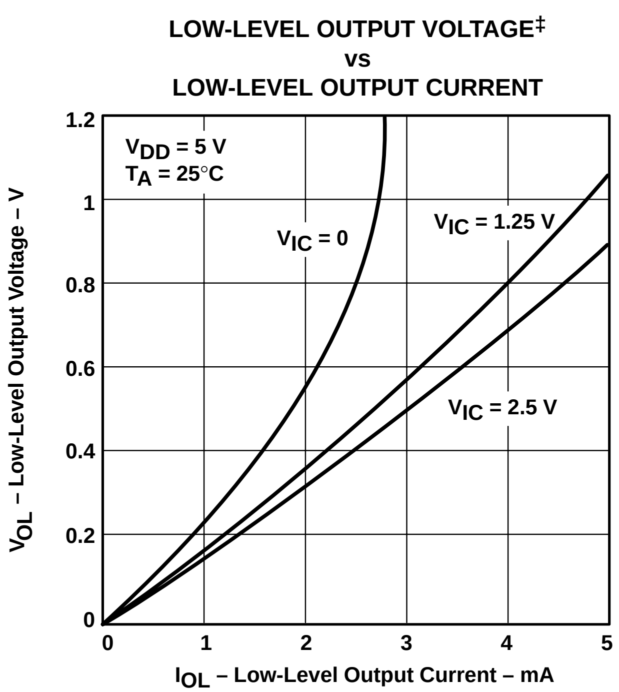


Figure 16

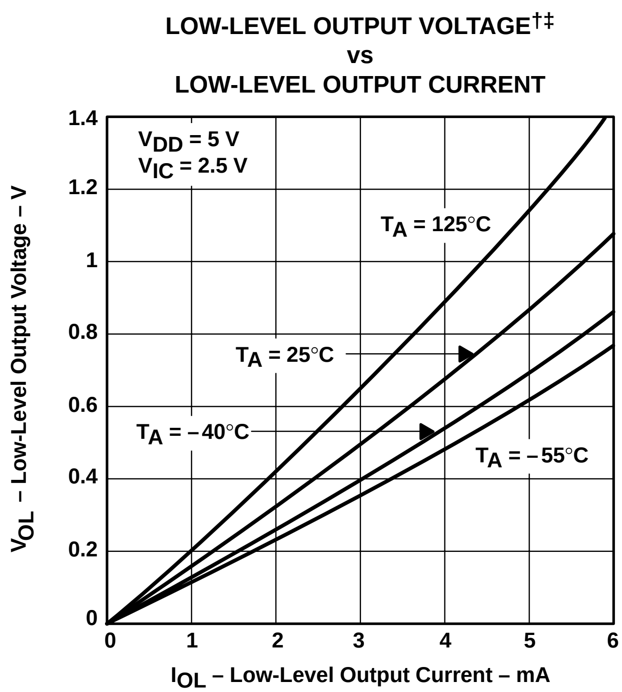


Figure 17

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

TYPICAL CHARACTERISTICS

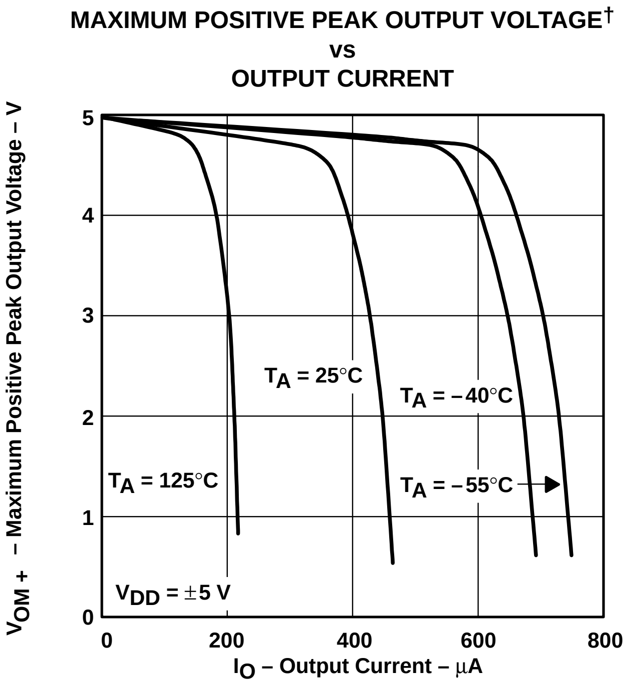


Figure 18

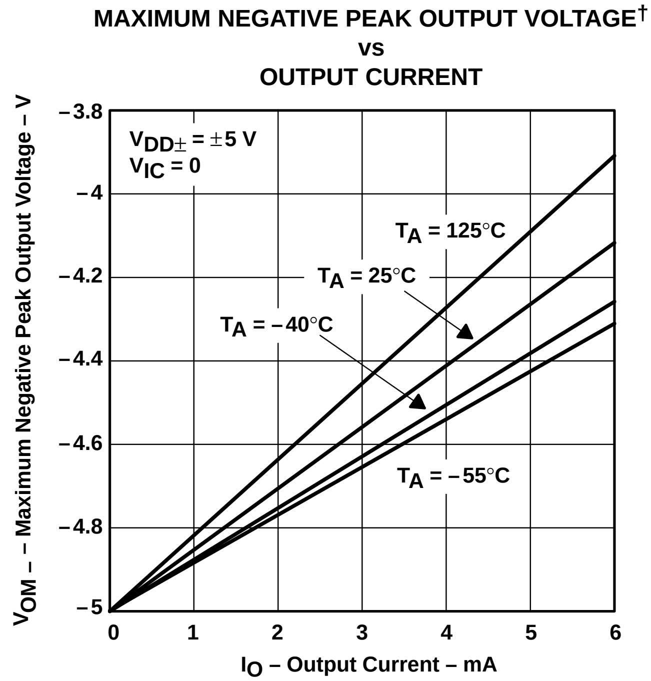


Figure 19

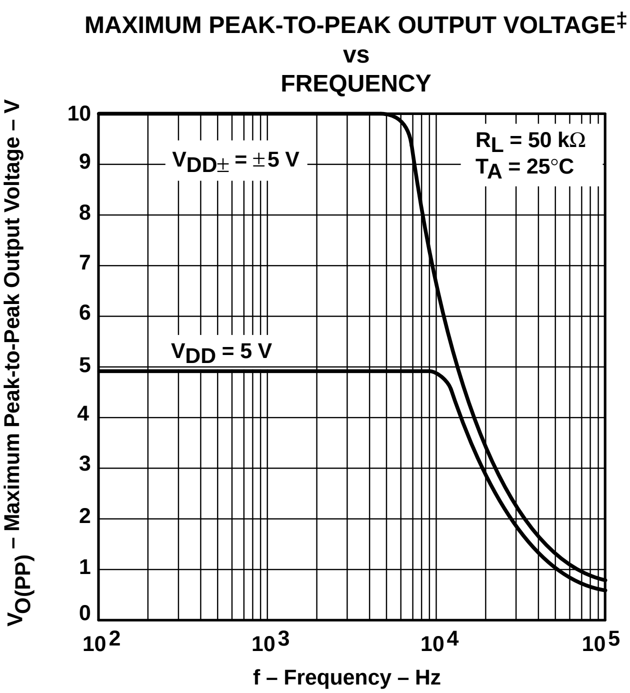


Figure 20

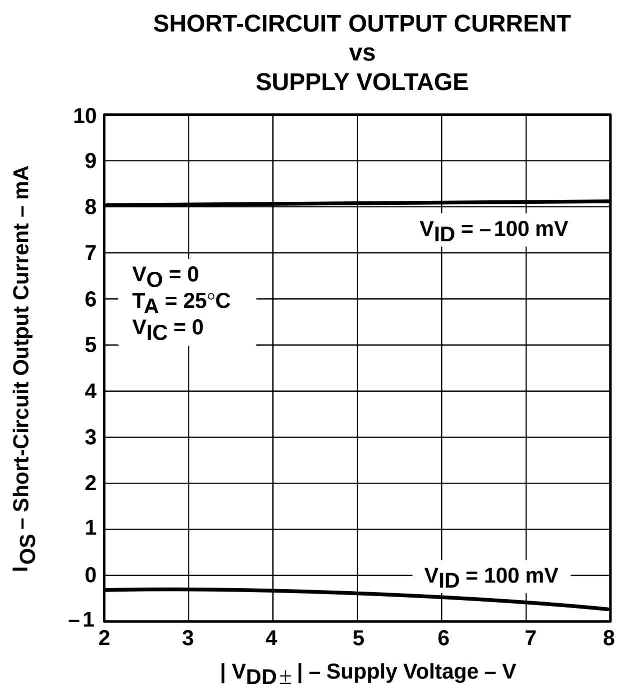


Figure 21

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

TYPICAL CHARACTERISTICS

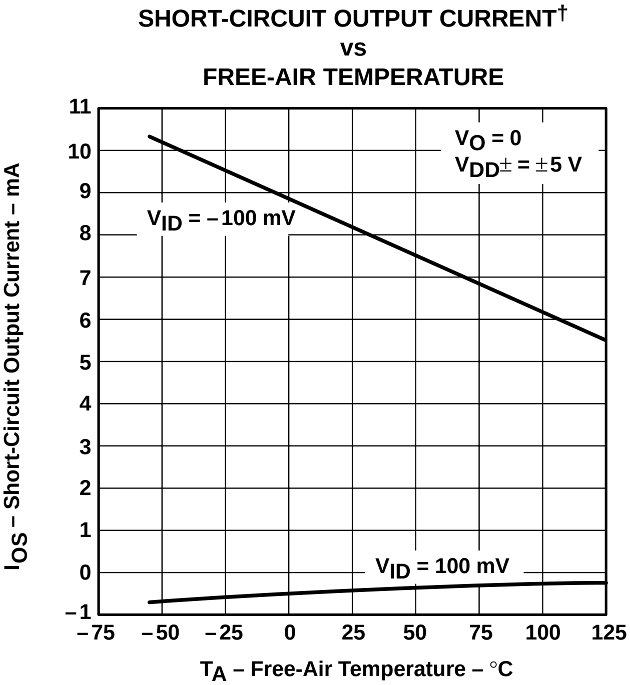


Figure 22

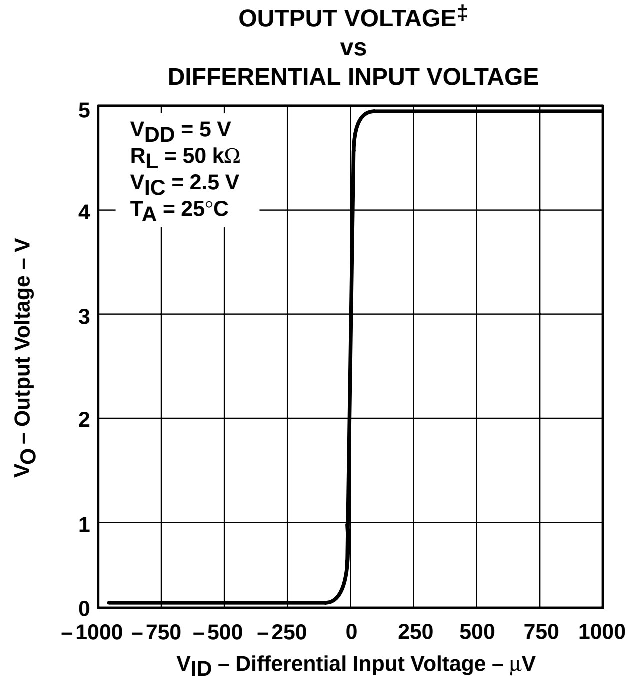


Figure 23

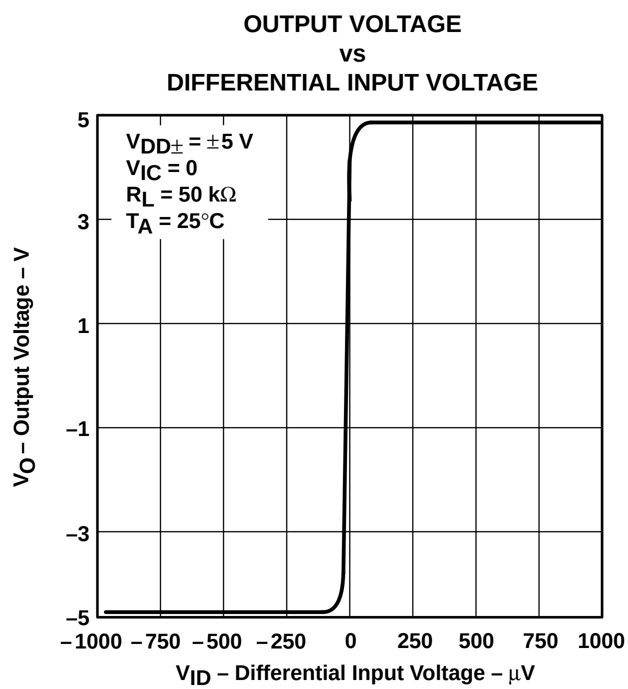


Figure 24

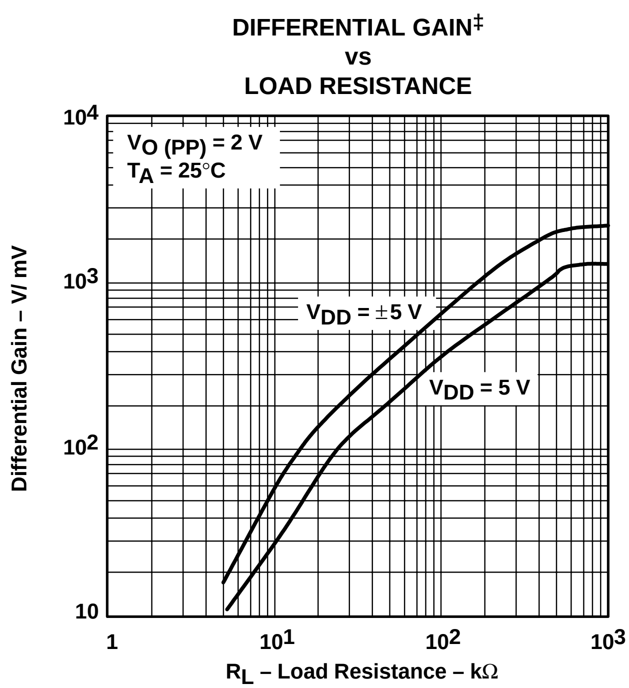


Figure 25

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

TYPICAL CHARACTERISTICS

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

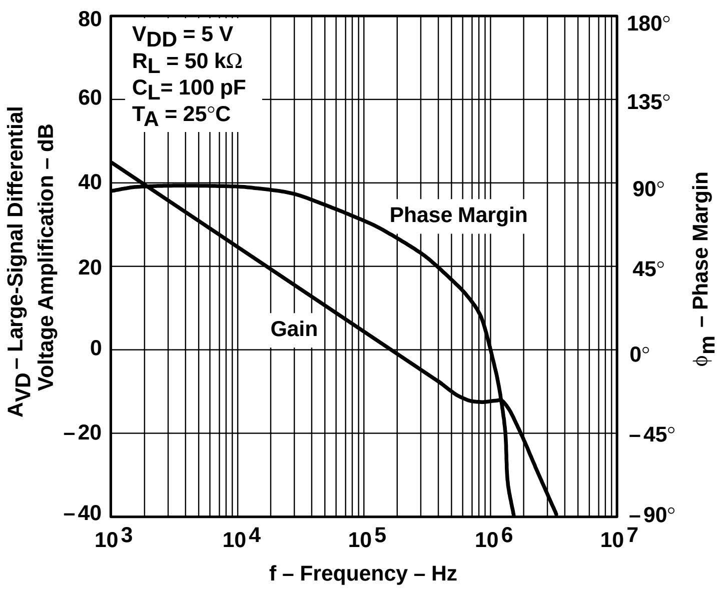


Figure 26

LARGE-SIGNAL DIFFERENTIAL VOLTAGE AMPLIFICATION AND PHASE MARGIN
vs
FREQUENCY

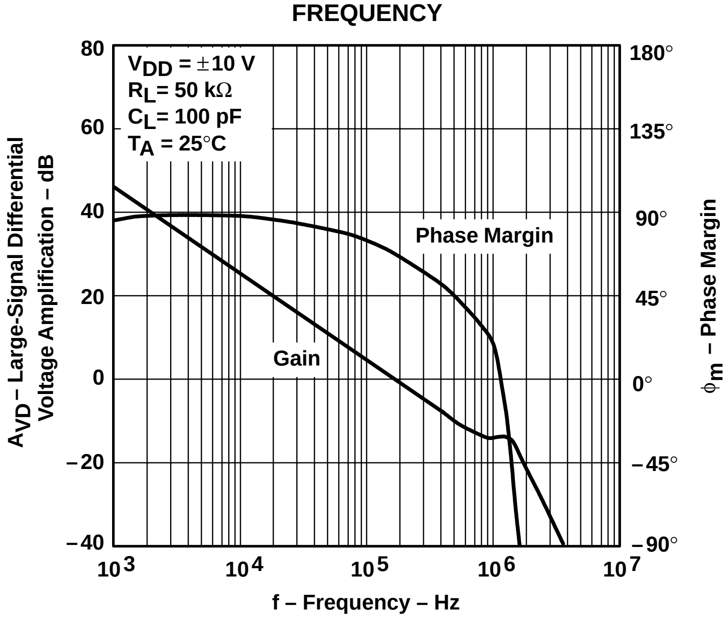


Figure 27

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

TYPICAL CHARACTERISTICS

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

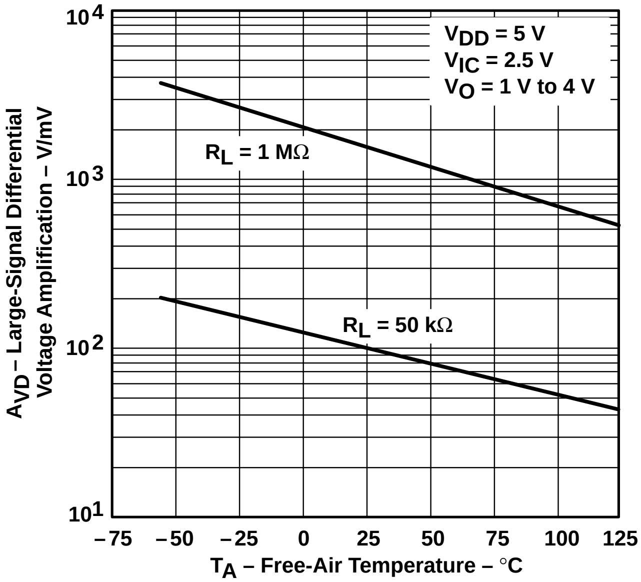


Figure 28

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

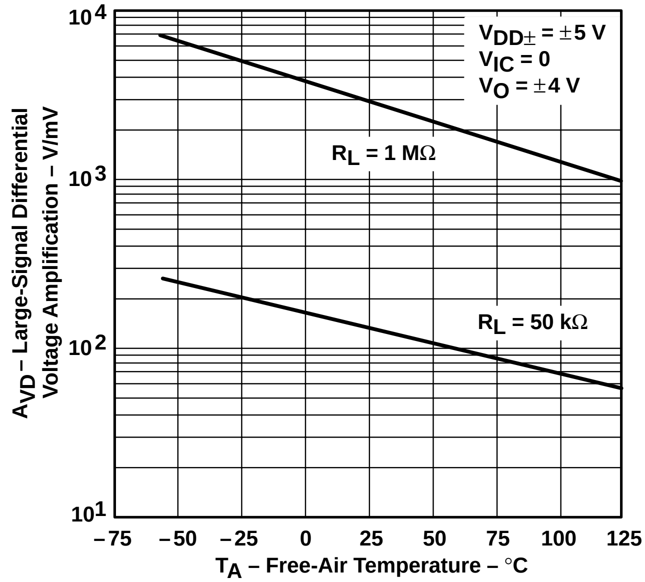


Figure 29

OUTPUT IMPEDANCE‡ vs FREQUENCY

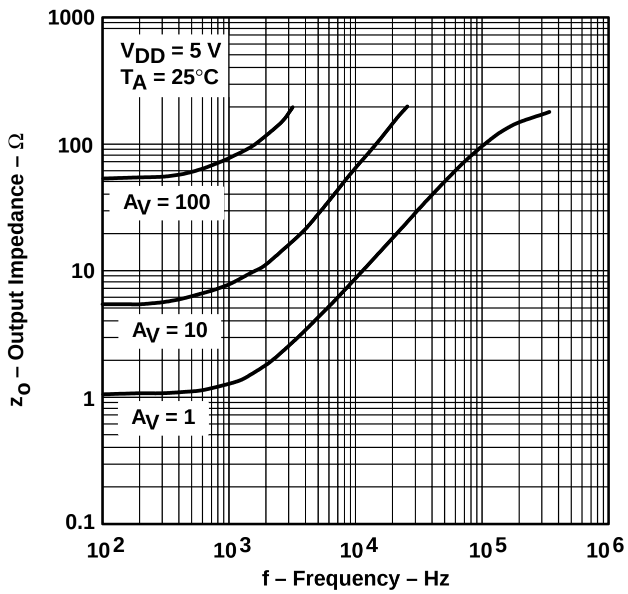


Figure 30

OUTPUT IMPEDANCE vs FREQUENCY

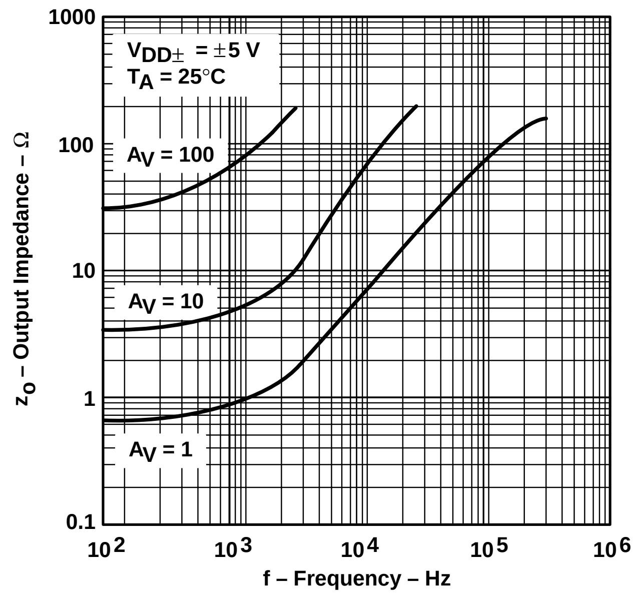


Figure 31

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

TYPICAL CHARACTERISTICS

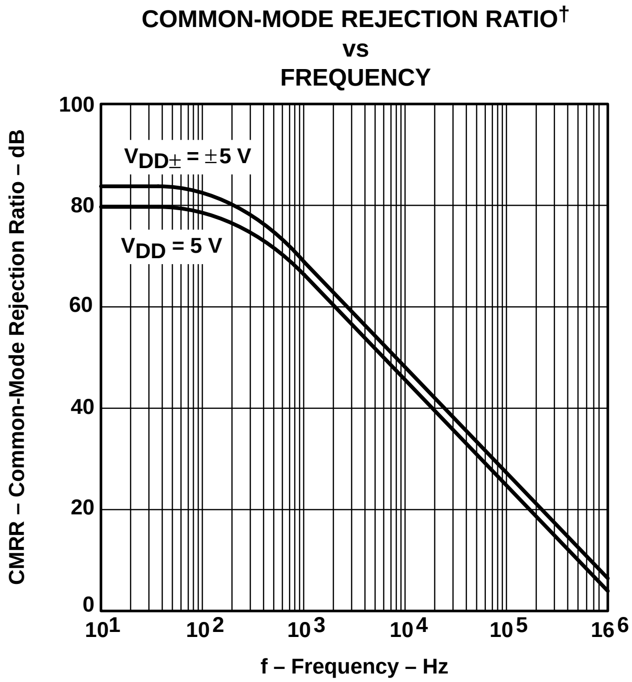


Figure 32

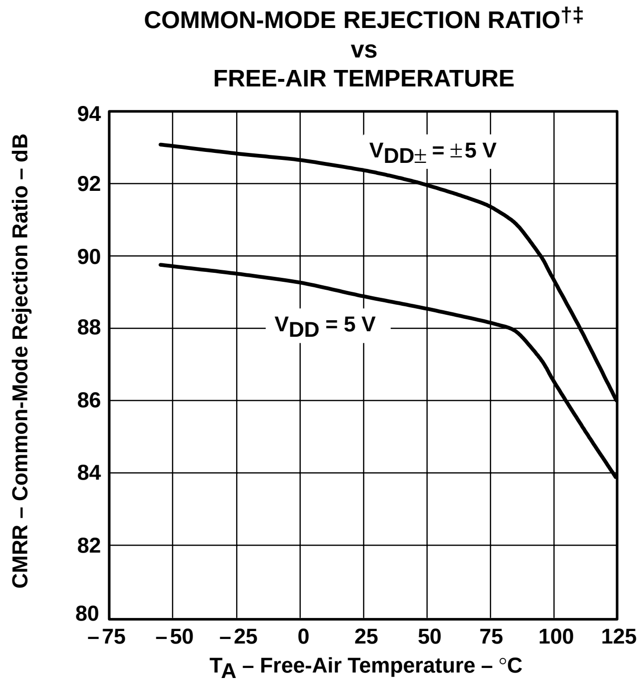


Figure 33

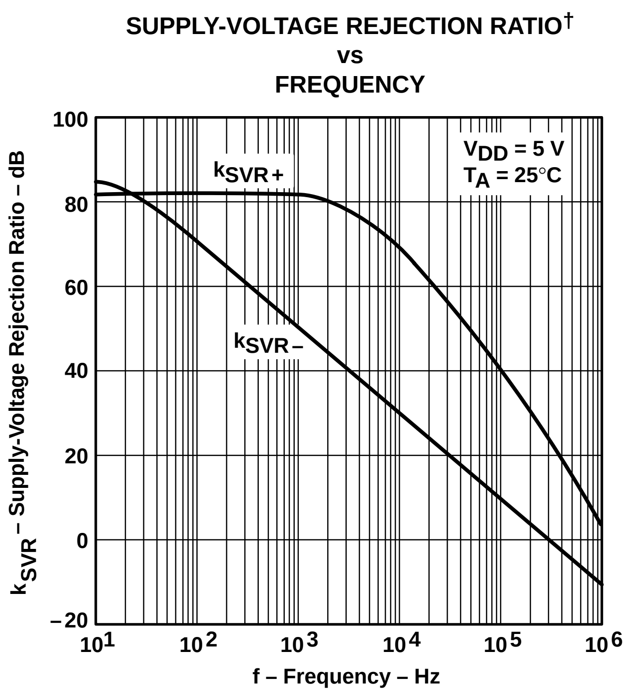


Figure 34

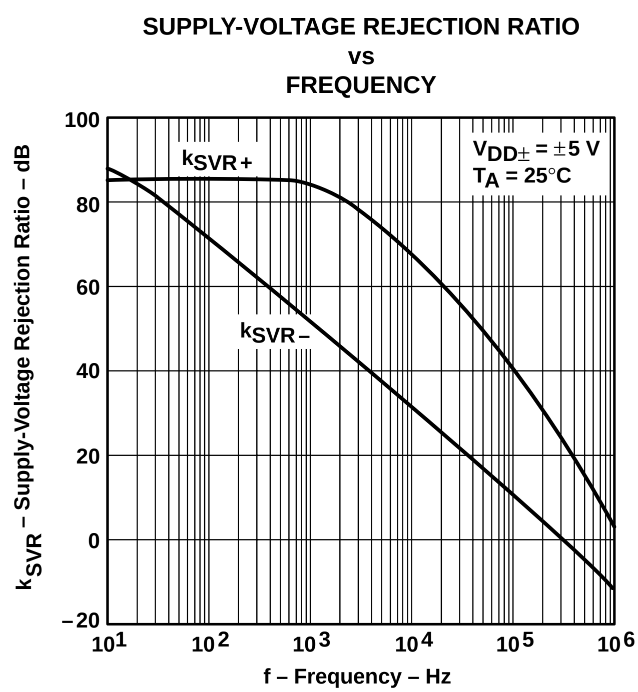


Figure 35

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

TYPICAL CHARACTERISTICS

SUPPLY-VOLTAGE REJECTION RATIO†
vs
FREE-AIR TEMPERATURE

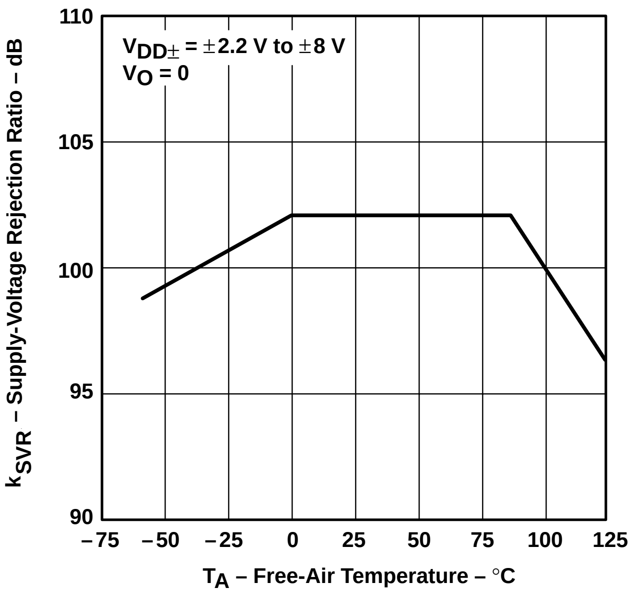


Figure 36

SUPPLY CURRENT†
vs
SUPPLY VOLTAGE

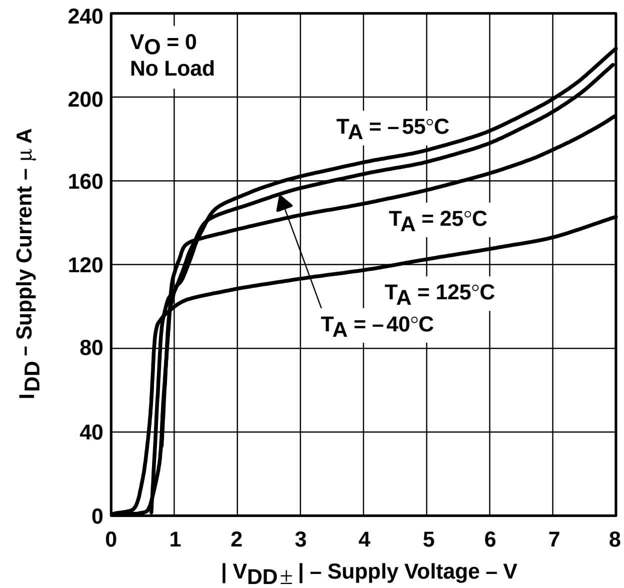


Figure 37

SUPPLY CURRENT†‡
vs
FREE-AIR TEMPERATURE

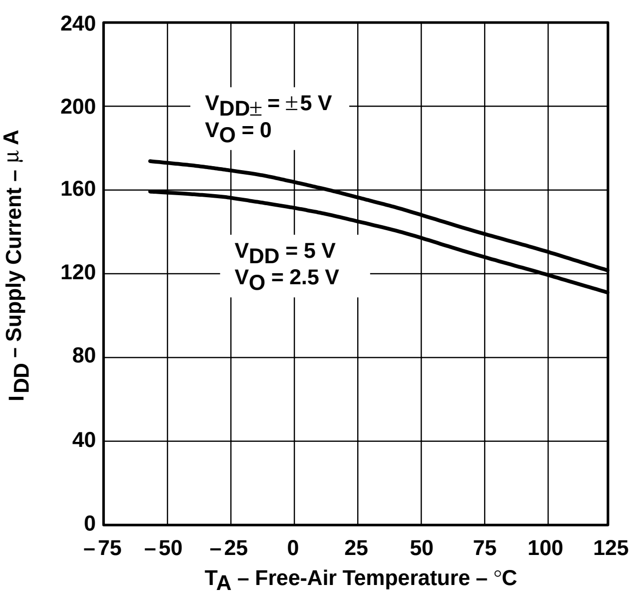


Figure 38

SLEW RATE‡
vs
LOAD CAPACITANCE

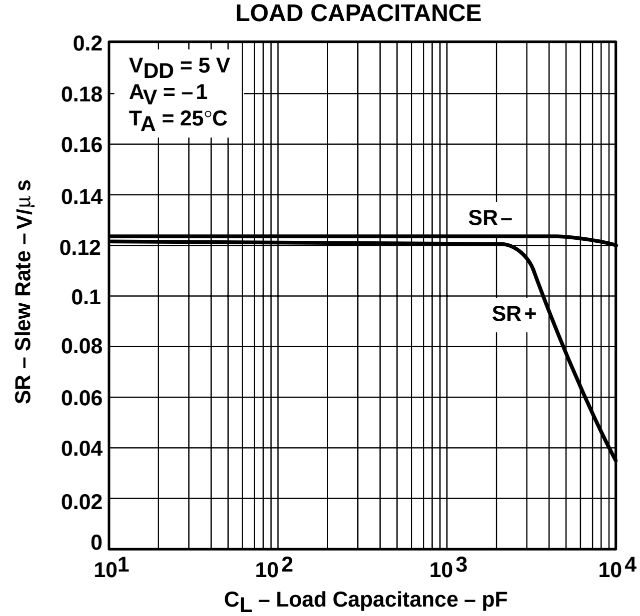


Figure 39

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

TYPICAL CHARACTERISTICS

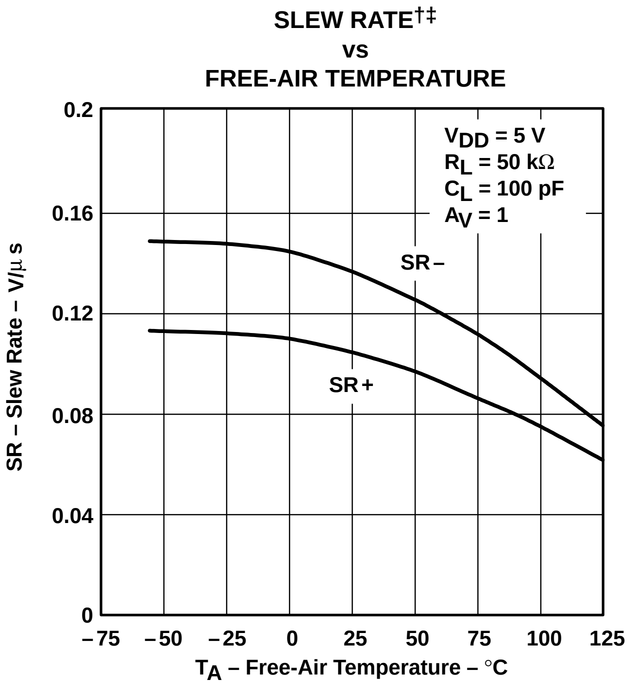


Figure 40

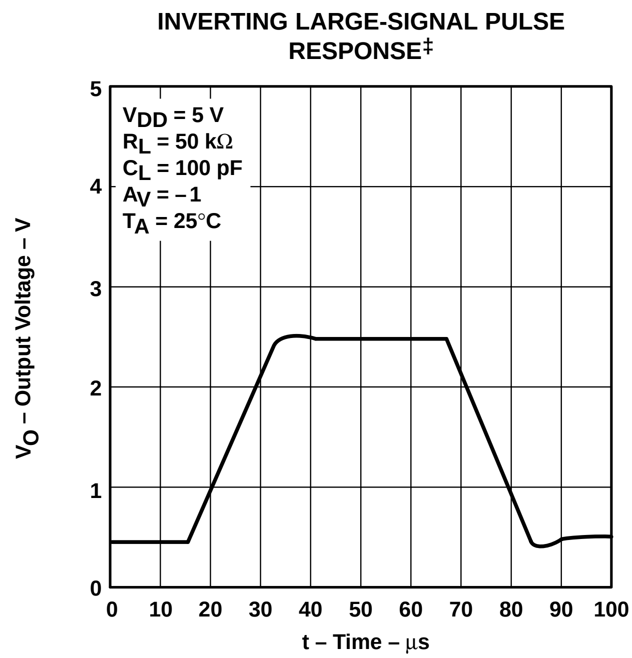


Figure 41

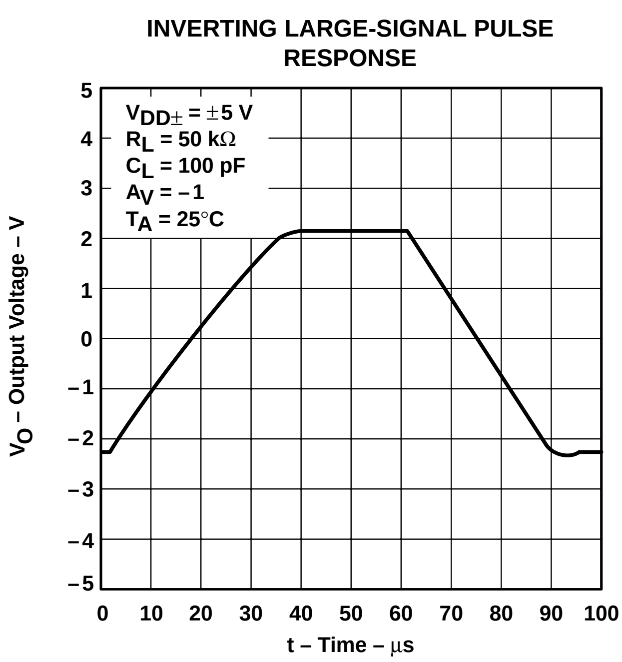


Figure 42

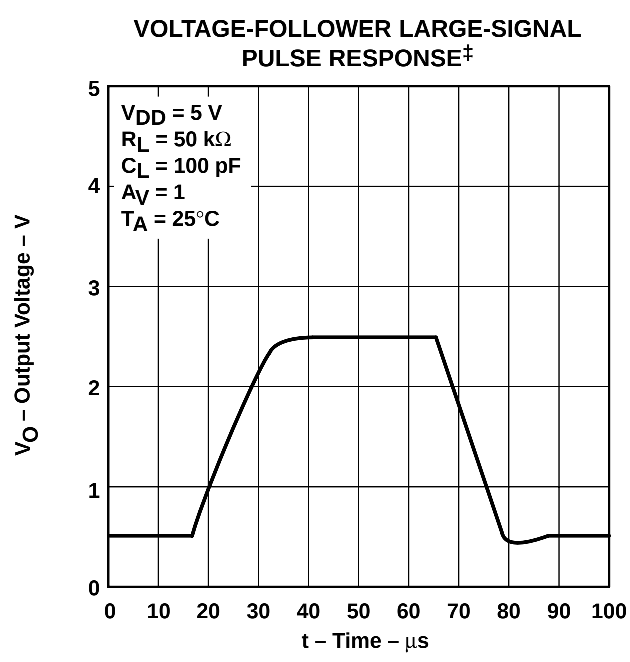


Figure 43

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

TYPICAL CHARACTERISTICS

VOLTAGE-FOLLOWER LARGE-SIGNAL PULSE RESPONSE

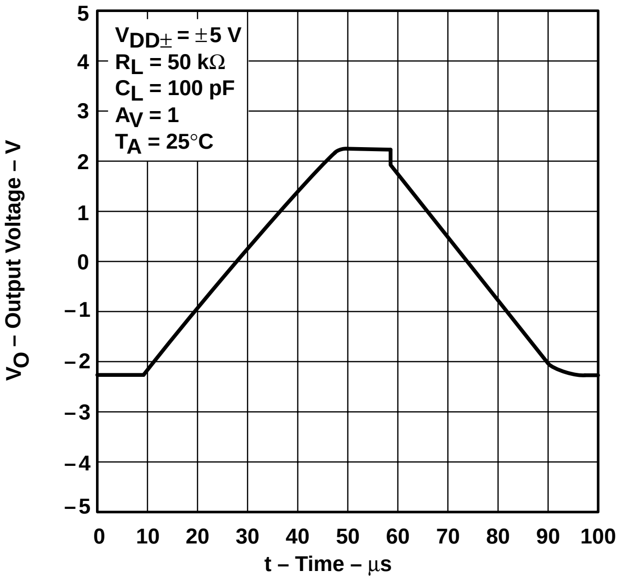


Figure 44

INVERTING SMALL-SIGNAL PULSE RESPONSE†

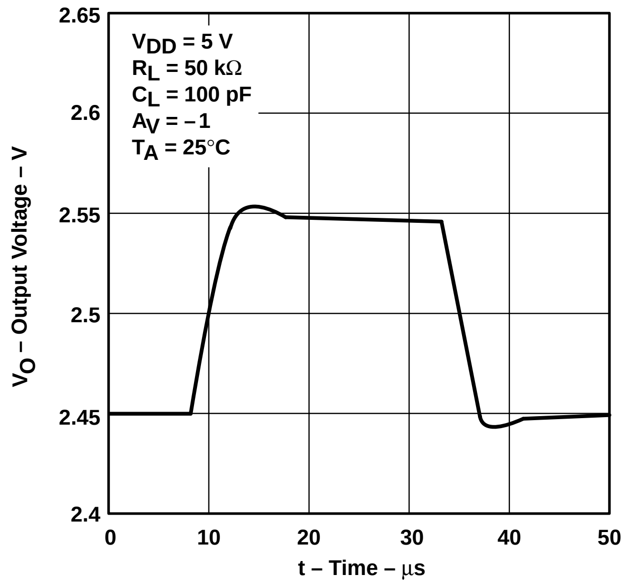


Figure 45

INVERTING SMALL-SIGNAL PULSE RESPONSE

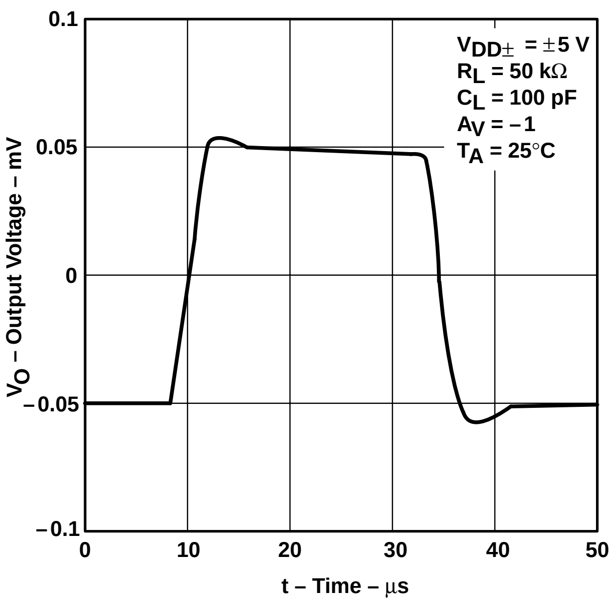


Figure 46

VOLTAGE-FOLLOWER SMALL-SIGNAL PULSE RESPONSE†

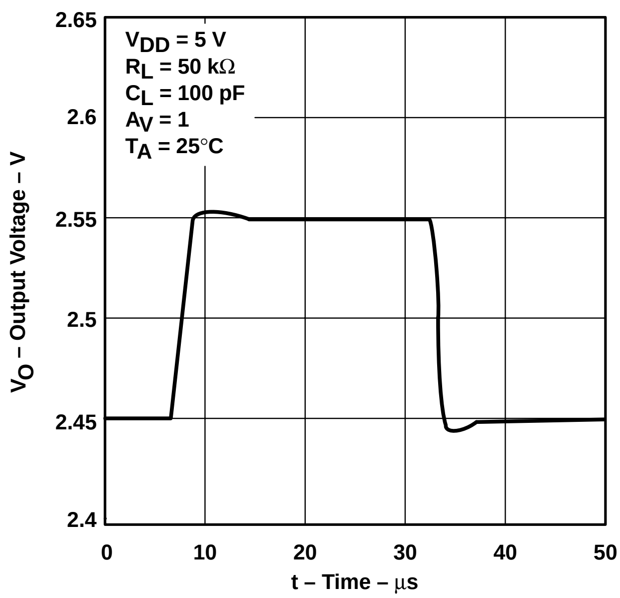


Figure 47

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

TYPICAL CHARACTERISTICS

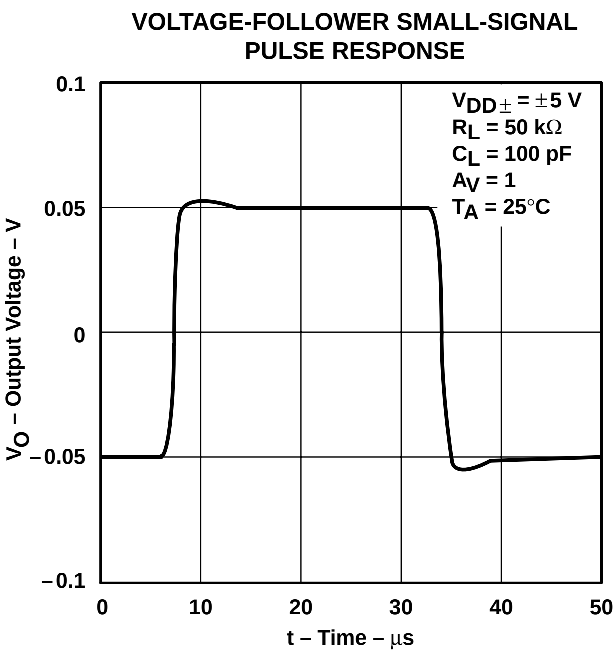


Figure 48

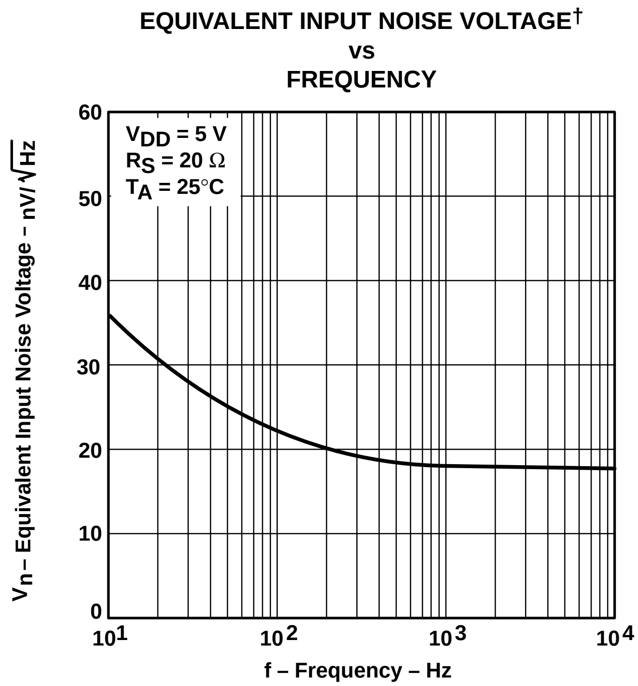


Figure 49

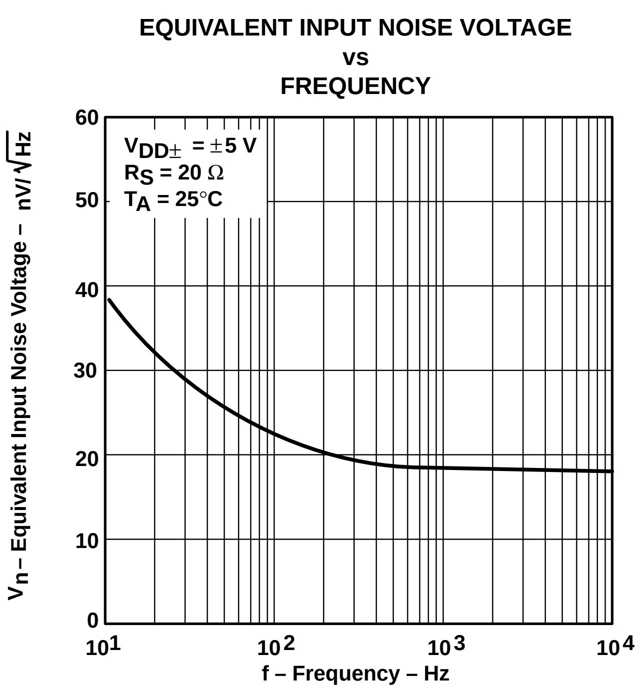


Figure 50

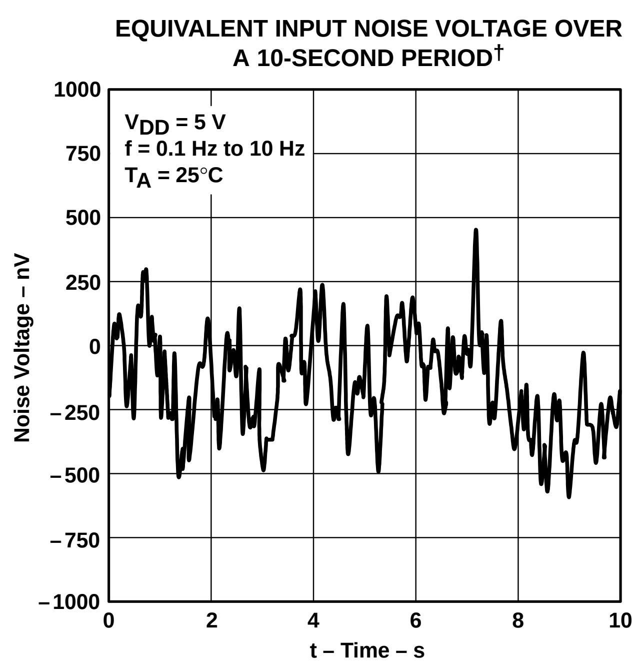


Figure 51

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

TYPICAL CHARACTERISTICS

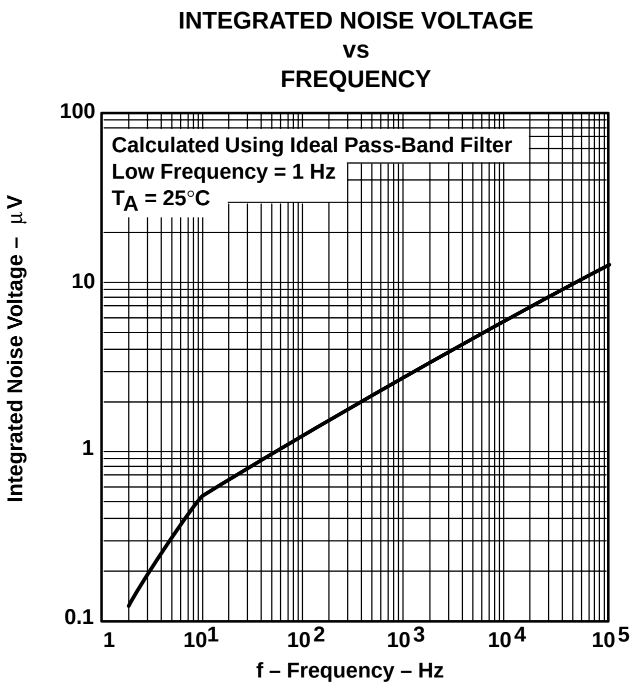


Figure 52

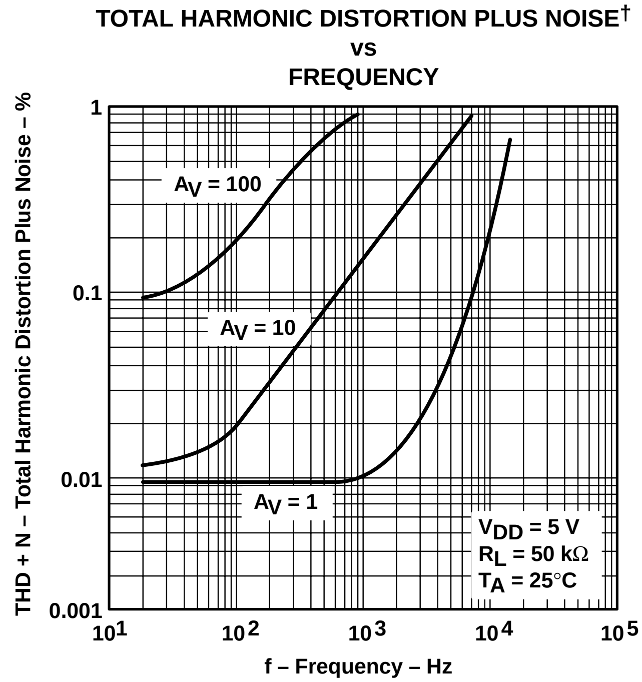


Figure 53

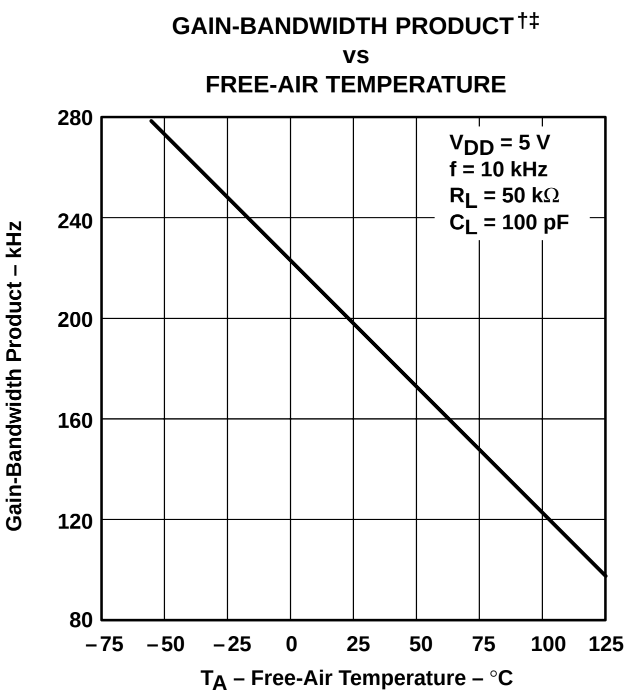


Figure 54

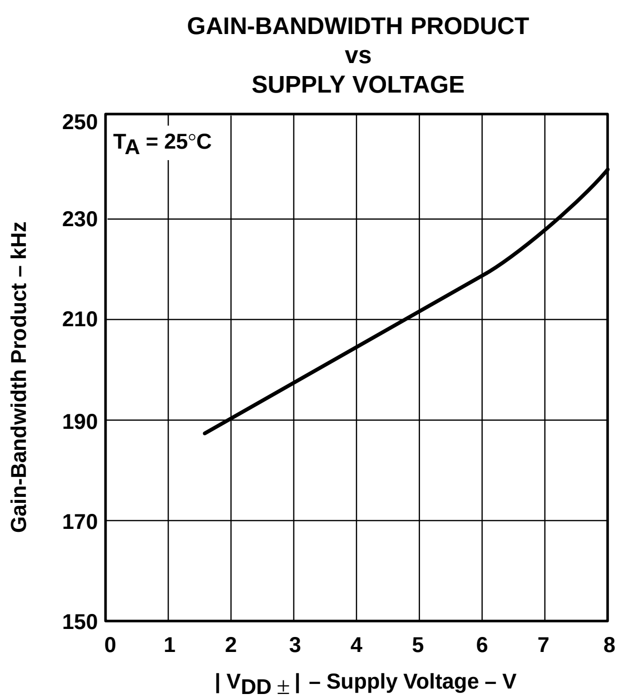


Figure 55

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

TYPICAL CHARACTERISTICS

PHASE MARGIN vs LOAD CAPACITANCE

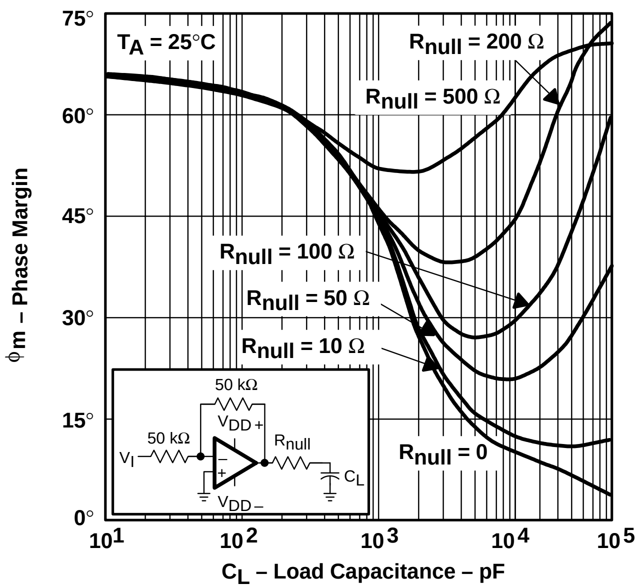


Figure 56

GAIN MARGIN vs LOAD CAPACITANCE

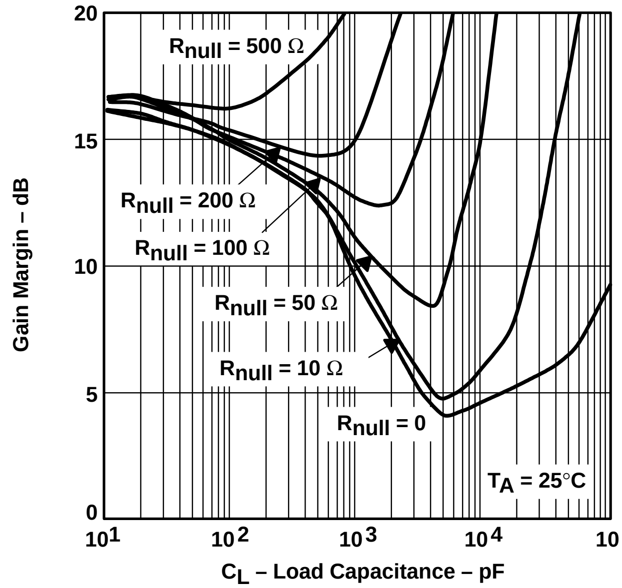


Figure 57

UNITY-GAIN BANDWIDTH† vs LOAD CAPACITANCE

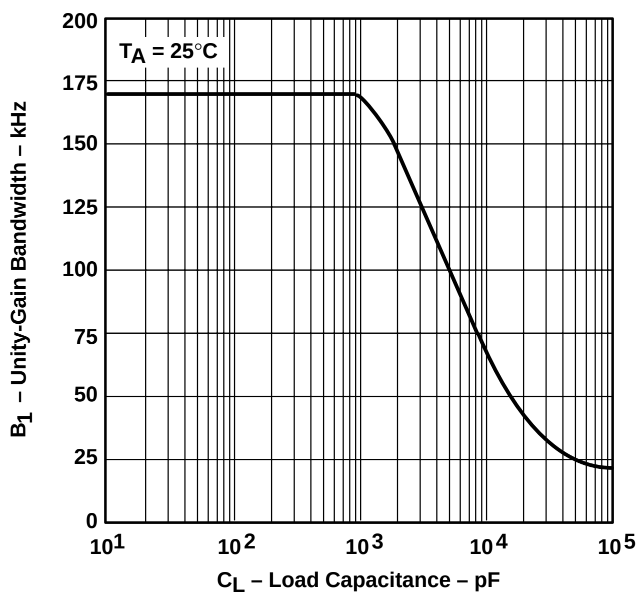


Figure 58

OVERESTIMATION OF PHASE MARGIN† vs LOAD CAPACITANCE

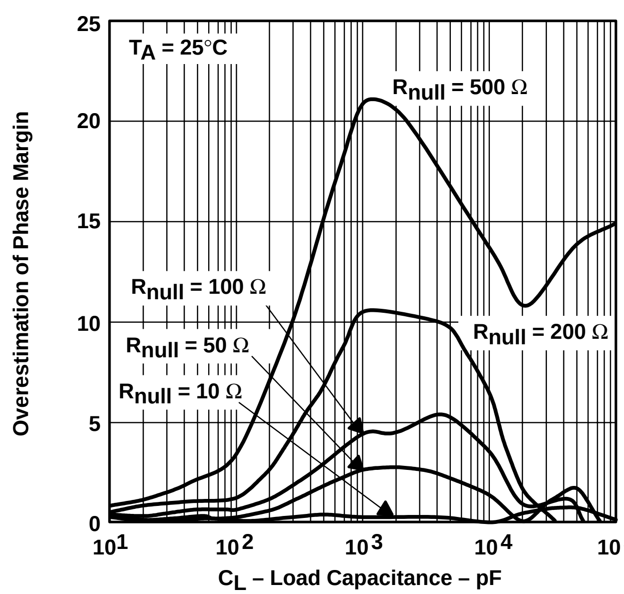


Figure 59

† See application information

APPLICATION INFORMATION

driving large capacitive loads

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

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

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

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

Where :

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

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

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

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

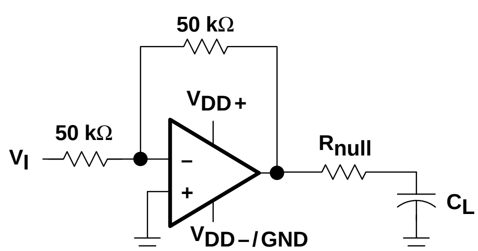


Figure 60. Series-Resistance Circuit

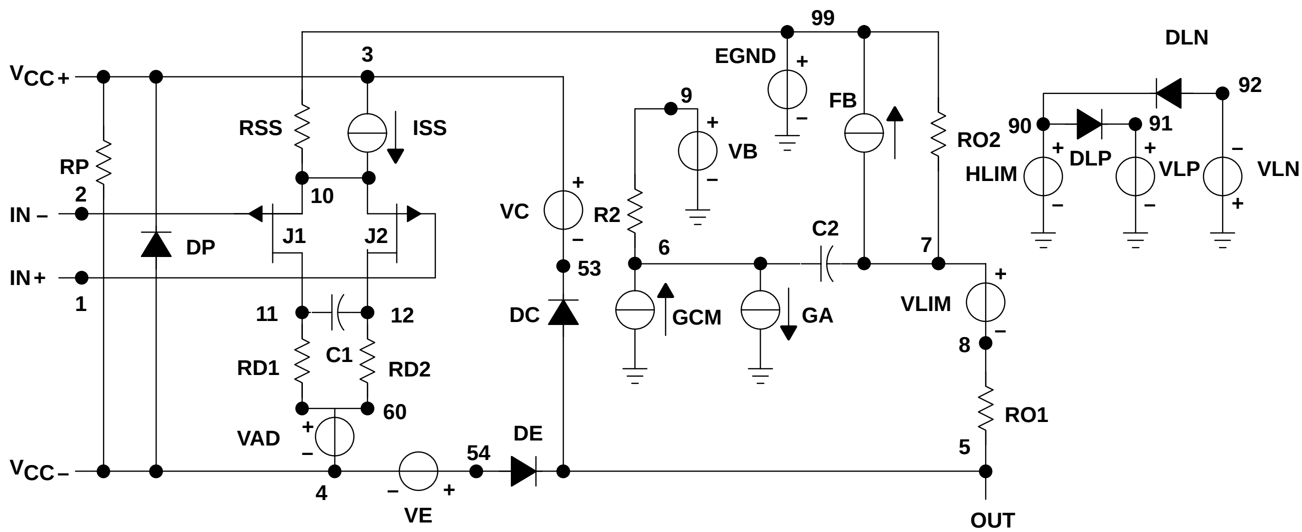
APPLICATION INFORMATION

macromodel information

Macromodel information provided was derived using MicroSim *Parts*™, the model generation software used with MicroSim *PSpice*™. The Boyle macromodel (see Note 5) and subcircuit in Figure 61 are generated using the TLC225x typical electrical and operating characteristics at T_A = 25°C. Using this information, output simulations of the following key parameters can be generated to a tolerance of 20% (in most cases):

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

NOTE 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).




```
.SUBCKT TLC225x 1 2 3 4 5
    C1     11    12    6.369E–12
    C2     6     7     25.00E–12
    DC     5     53    DX
    DE     54    5     DX
    DLP    90    91    DX
    DLN    92    90    DX
    DP     4     3     DX
    EGND   99    0     POLY (2) (3,0) (4,0) 0 .5 .5
    FB     7     99    POLY (5) VB VC VE VLP
    + VLN 0 57.62E6 –60E6 60E6 60E6 –60E6
    GA     6     0     11    12 26.86E–6
    GCM    0     6     10    99 2.686E–9
    ISS    3     10    DC 3.1E–6
    HLIM   90    0     VLIM 1K
    J1     11    2     10 JX
    J2     12    1     10 JX
    R2     6     9     100.0E3
RD1    60    11    37.23E3
RD2    60    12    37.23E3
R01    8     5     84
R02    7     99    84
RP     3     4     71.43E3
RSS    10    99    64.52E6
VAD    60    4     –.5
VB     9     0     DC 0
VC     3     53    DC .605
VE     54    4     DC .605
VLIM   7     8     DC 0
VLP    91    0     DC –.235
VLN    0     92    DC 7.5
.MODEL DX D (IS=800.0E–18)
.MODEL JX PJF (IS=500.0E–15 BETA=139E–6
+ VTO=–.05)
.ENDS
```

Figure 61. Boyle Macromodel and Subcircuit

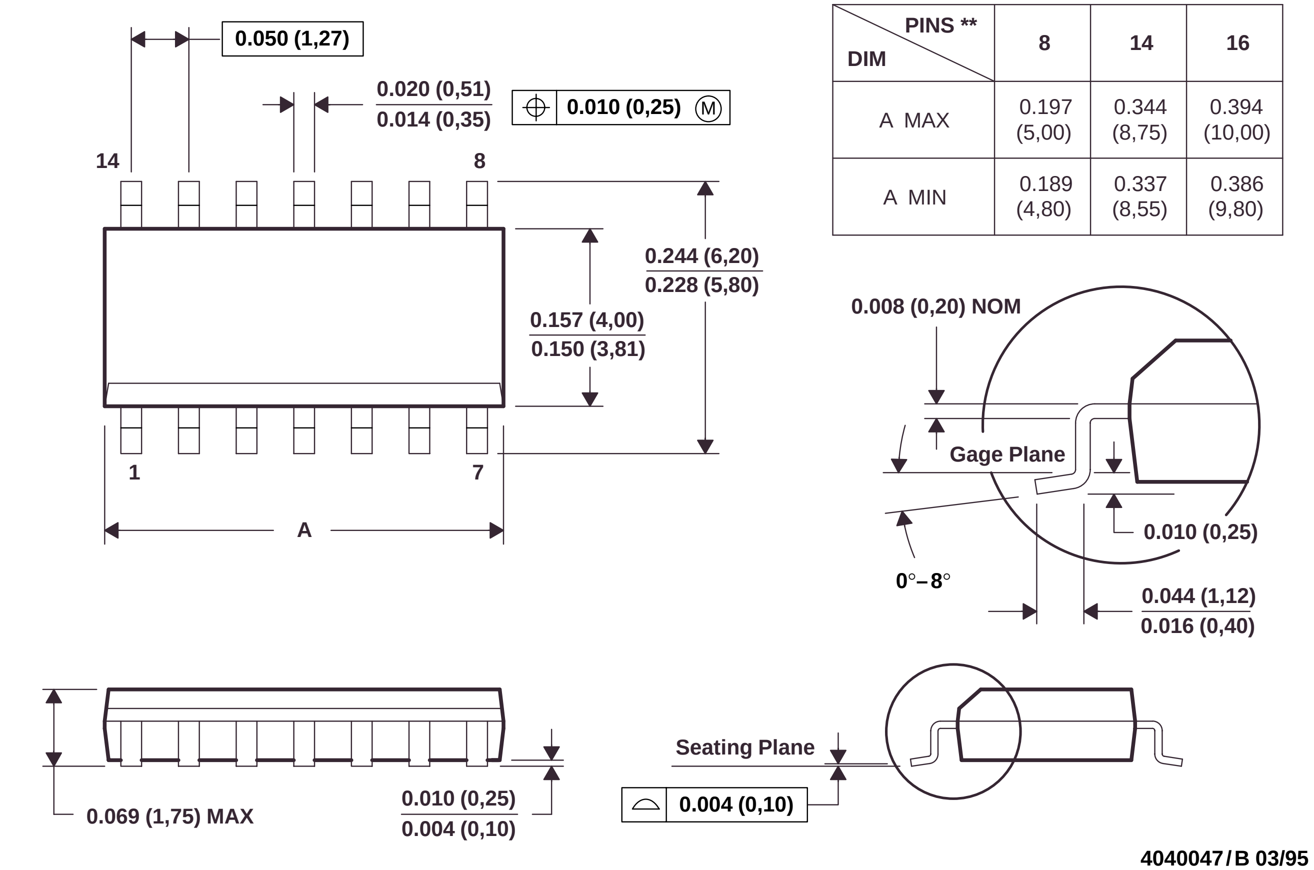
PSpice and *Parts* are trademarks of MicroSim Corporation.

MECHANICAL INFORMATION

D (R-PDSO-G)** **PLASTIC SMALL-OUTLINE PACKAGE**

14 PIN SHOWN

PINS ** / DIM	8	14	16
A MAX	0.197 (5,00)	0.344 (8,75)	0.394 (10,00)
A MIN	0.189 (4,80)	0.337 (8,55)	0.386 (9,80)

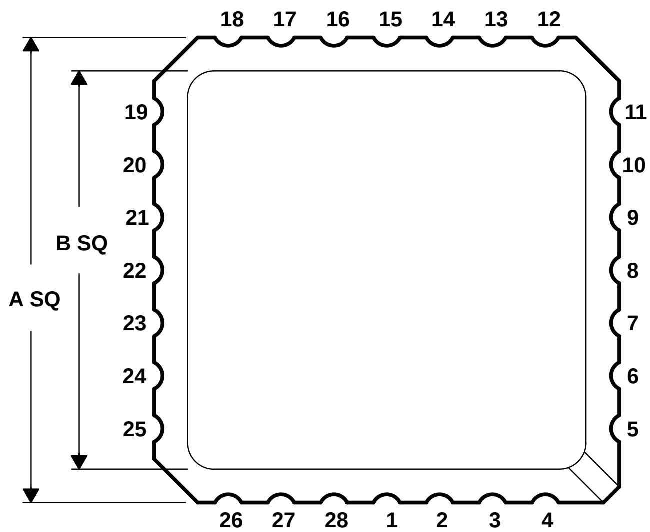


NOTES:
A. All linear dimensions are in inches (millimeters).
B. This drawing is subject to change without notice.
C. Body dimensions do not include mold flash or protrusion, not to exceed 0.006 (0,15).
D. Four center pins are connected to die mount pad.
E. Falls within JEDEC MS-012

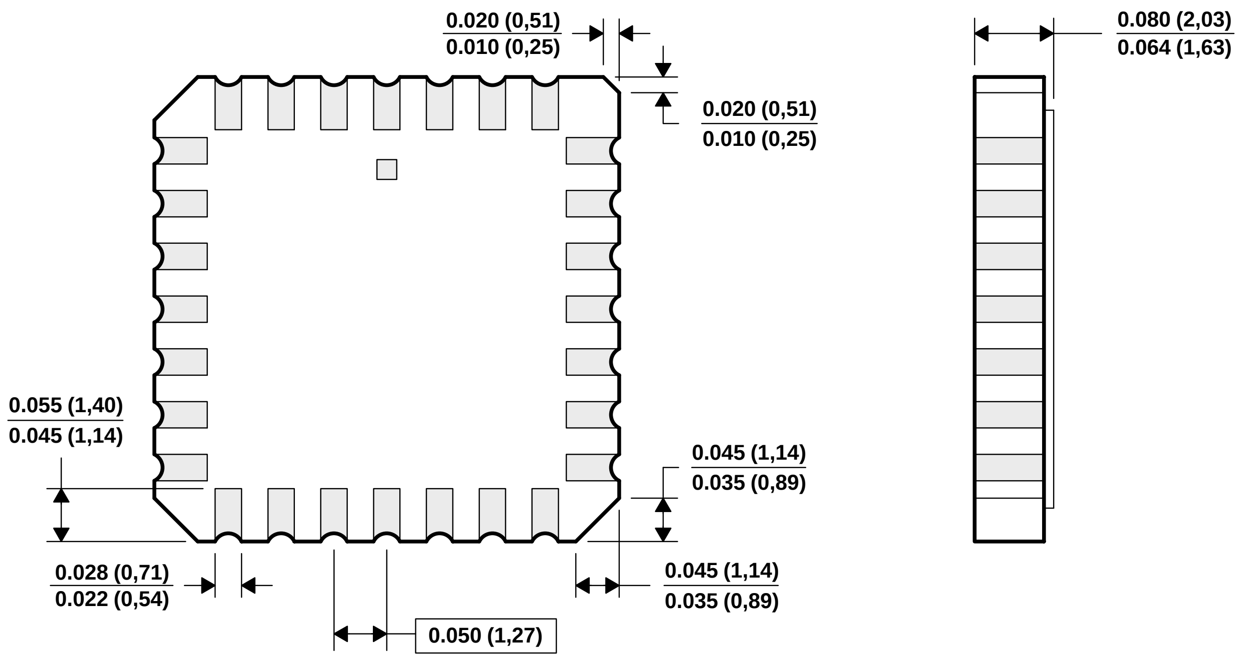
MECHANICAL INFORMATION

FK (S-CQCC-N)** **LEADLESS CERAMIC CHIP CARRIER**

28 TERMINAL SHOWN



NO. OF TERMINALS **	A		B	
	MIN	MAX	MIN	MAX
20	0.342 (8,69)	0.358 (9,09)	0.307 (7,80)	0.358 (9,09)
28	0.442 (11,23)	0.458 (11,63)	0.406 (10,31)	0.458 (11,63)
44	0.640 (16,26)	0.660 (16,76)	0.495 (12,58)	0.560 (14,22)
52	0.740 (18,78)	0.761 (19,32)	0.495 (12,58)	0.560 (14,22)
68	0.938 (23,83)	0.962 (24,43)	0.850 (21,6)	0.858 (21,8)
84	1.141 (28,99)	1.165 (29,59)	1.047 (26,6)	1.063 (27,0)



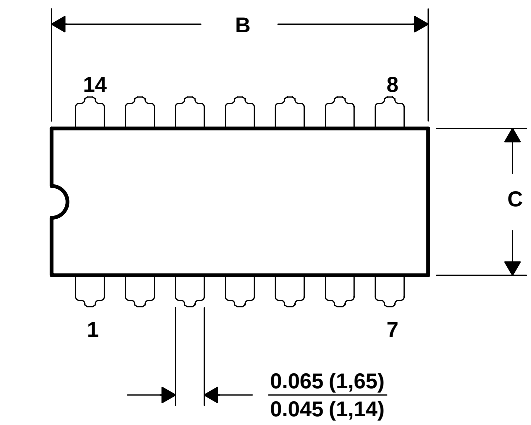
4040140 / C 11/95

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

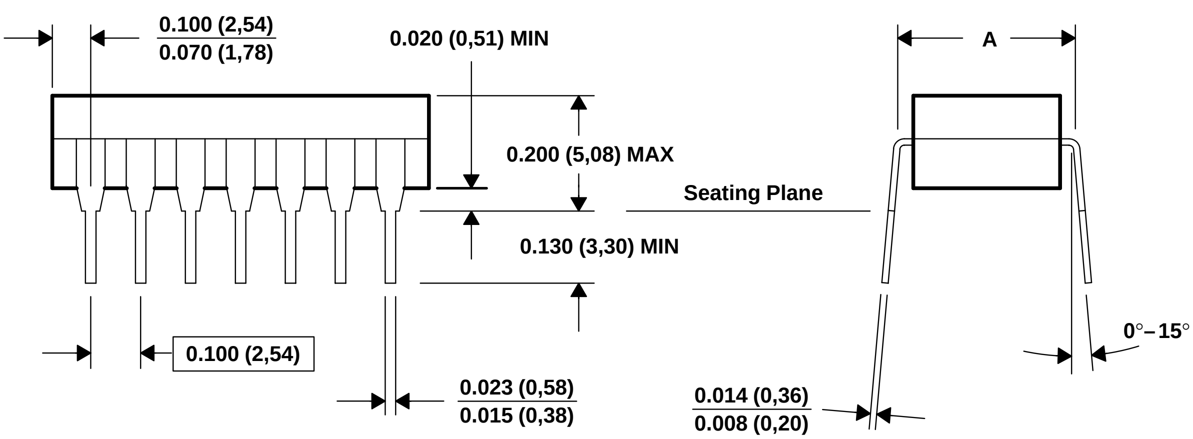
MECHANICAL INFORMATION

J (R-GDIP-T)** **CERAMIC DUAL-IN-LINE PACKAGE**

14 PIN SHOWN



DIM \ PINS **	14	16	18	20	22
A MAX	0.310 (7,87)	0.310 (7,87)	0.310 (7,87)	0.310 (7,87)	0.410 (10,41)
A MIN	0.290 (7,37)	0.290 (7,37)	0.290 (7,37)	0.290 (7,37)	0.390 (9,91)
B MAX	0.785 (19,94)	0.785 (19,94)	0.910 (23,10)	0.975 (24,77)	1.100 (28,00)
B MIN	0.755 (19,18)	0.755 (19,18)	—	0.930 (23,62)	—
C MAX	0.280 (7,11)	0.300 (7,62)	0.300 (7,62)	0.300 (7,62)	0.388 (9,65)
C MIN	0.245 (6,22)	0.245 (6,22)	0.245 (6,22)	0.245 (6,22)	—

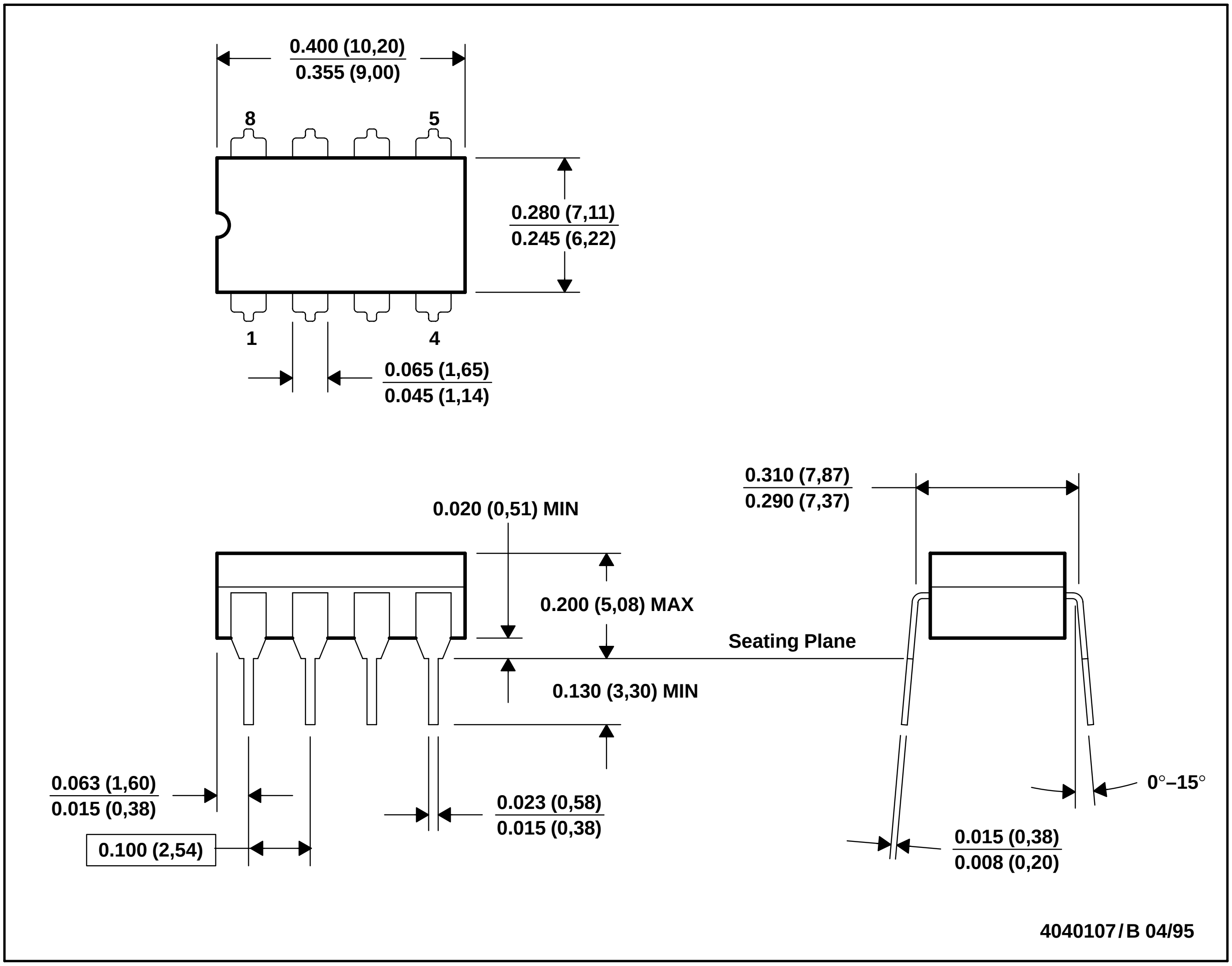


4040083/B 04/95

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

MECHANICAL INFORMATION

JG (R-GDIP-T8) **CERAMIC DUAL-IN-LINE PACKAGE**



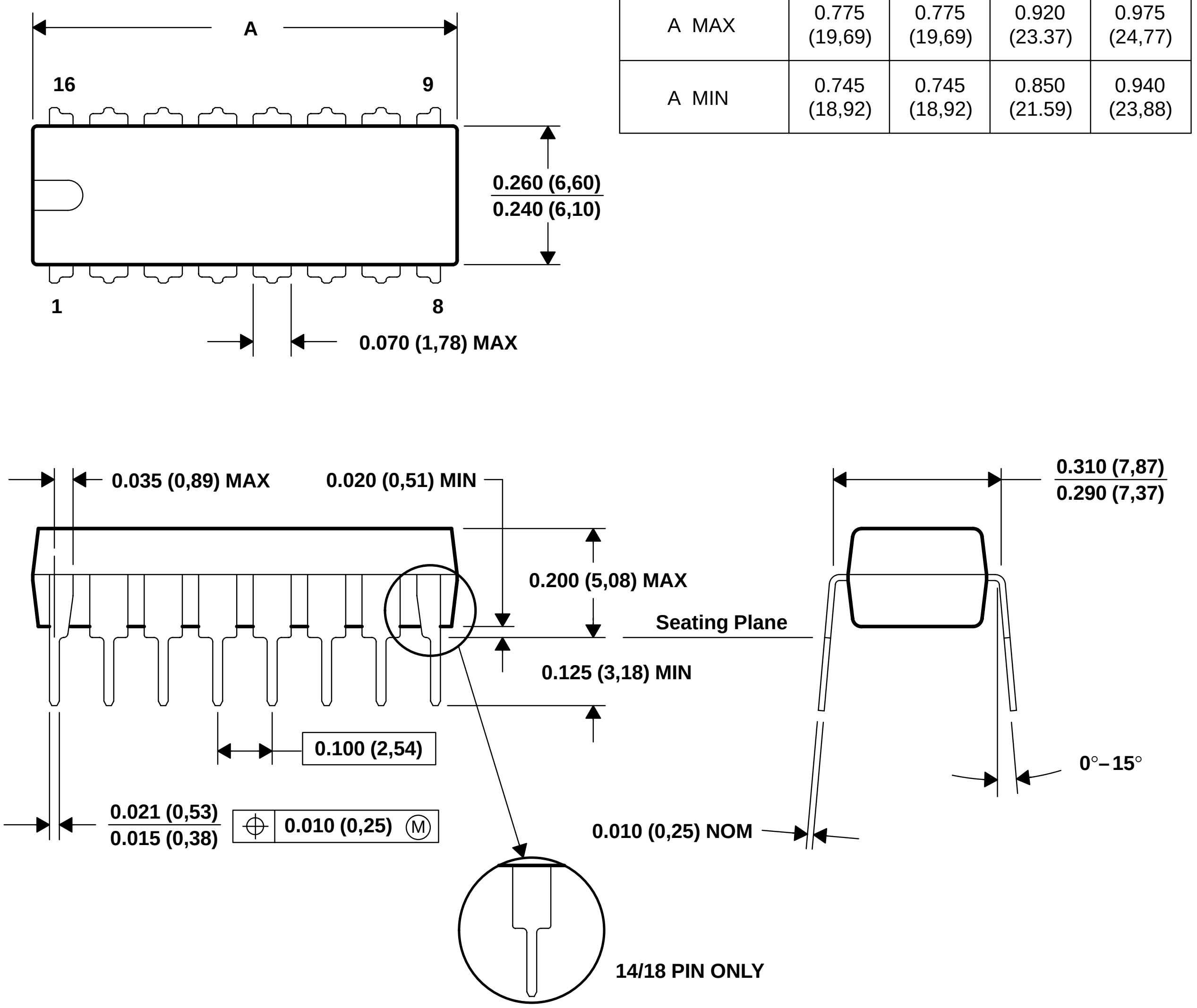
NOTES: A. All linear dimensions are in inches (millimeters).
B. This drawing is subject to change without notice.
C. This package can be hermetically sealed with a ceramic lid using glass frit.
D. Index point is provided on cap for terminal identification and/or on pressed ceramic glass frit seal.
E.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

MECHANICAL INFORMATION

N (R-PDIP-T)** **PLASTIC DUAL-IN-LINE PACKAGE**

16 PIN SHOWN

PINS ** / DIM	14	16	18	20
A MAX	0.775 (19,69)	0.775 (19,69)	0.920 (23.37)	0.975 (24,77)
A MIN	0.745 (18,92)	0.745 (18,92)	0.850 (21.59)	0.940 (23,88)

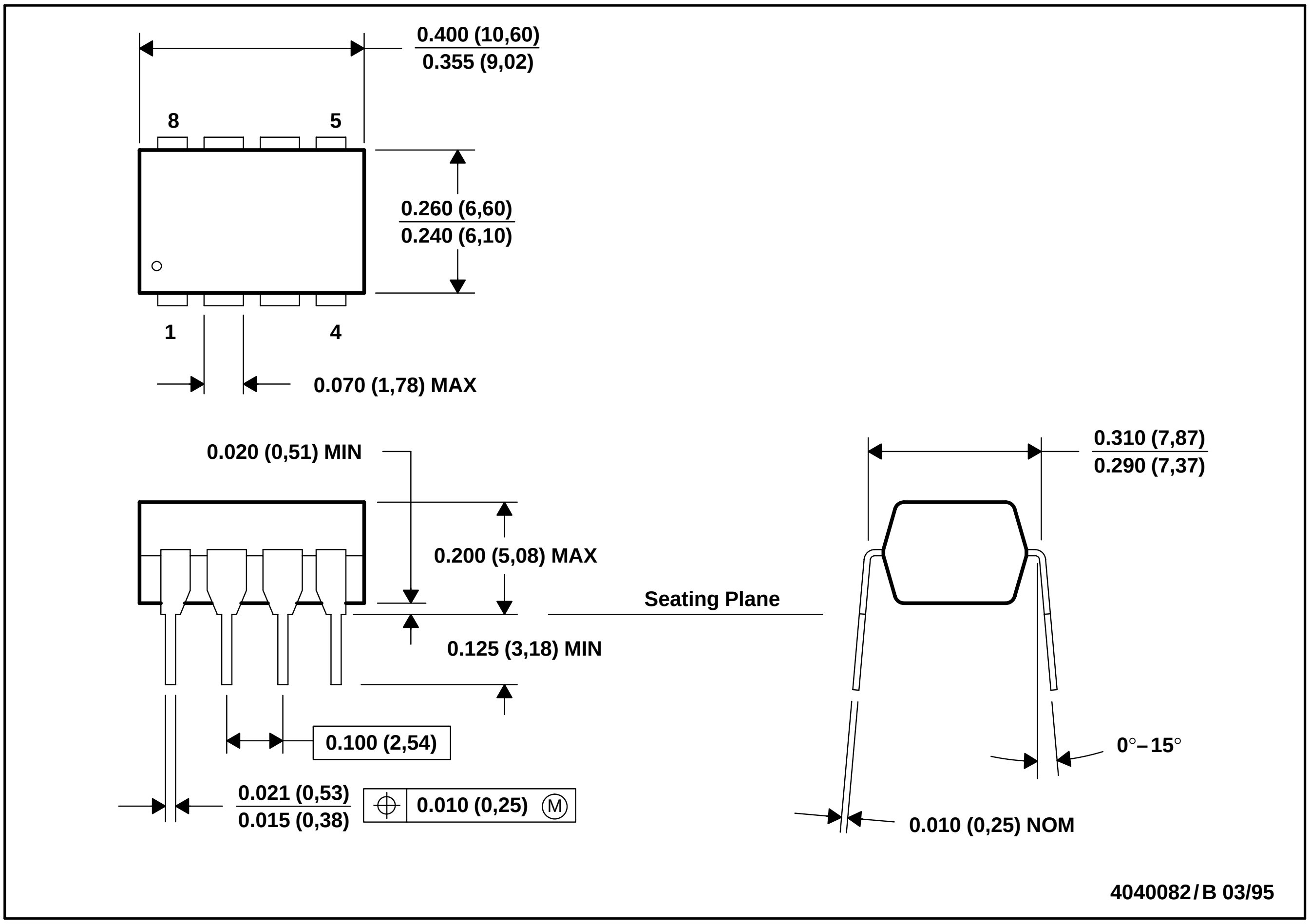


4040049/C 08/95

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

MECHANICAL INFORMATION

P (R-PDIP-T8) **PLASTIC DUAL-IN-LINE PACKAGE**

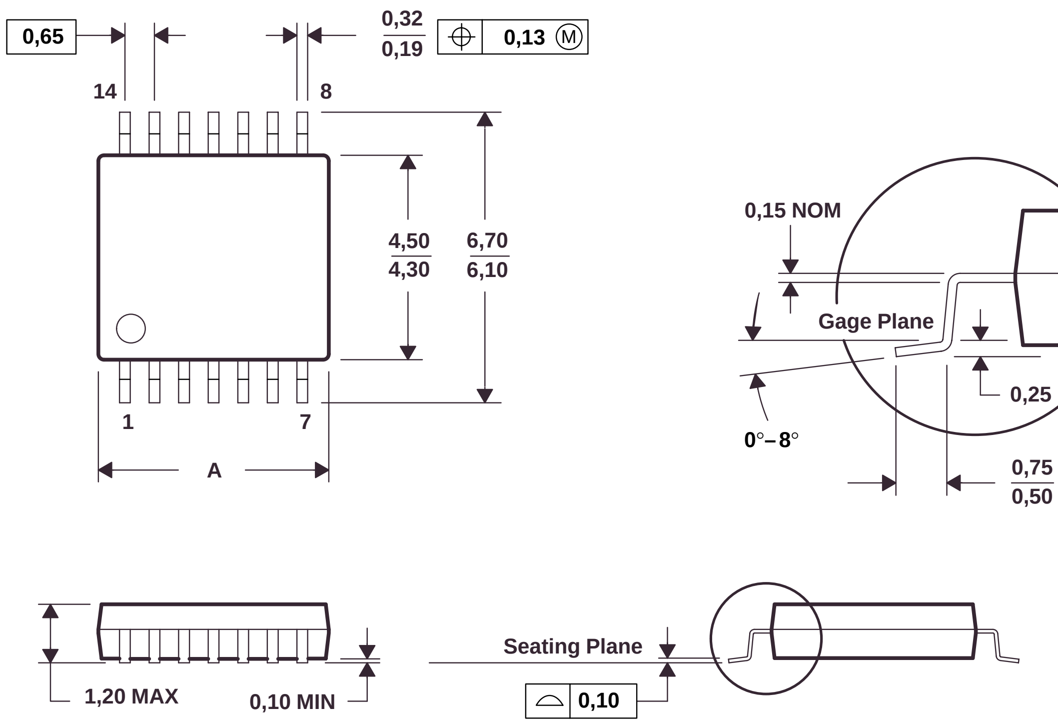


NOTES: A. All linear dimensions are in inches (millimeters).
B. This drawing is subject to change without notice.
C. Falls within JEDEC MS-001

MECHANICAL INFORMATION

PW (R-PDSO-G)** **PLASTIC SMALL-OUTLINE PACKAGE**

14 PIN SHOWN



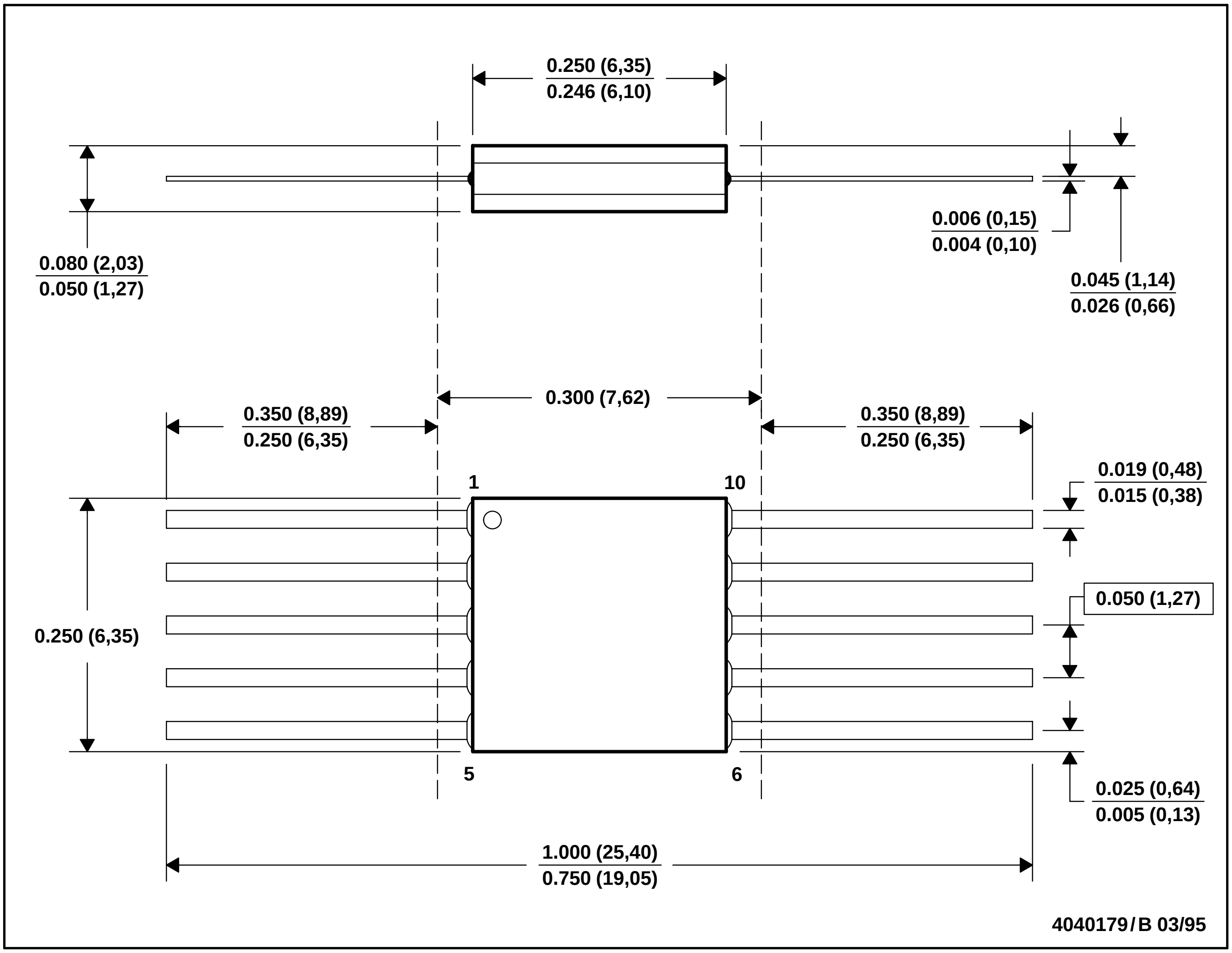
PINS ** / DIM	8	14	16	20	24	28
A MAX	3,10	5,10	5,10	6,60	7,90	9,80
A MIN	2,90	4,90	4,90	6,40	7,70	9,60

4040064/D 10/95

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

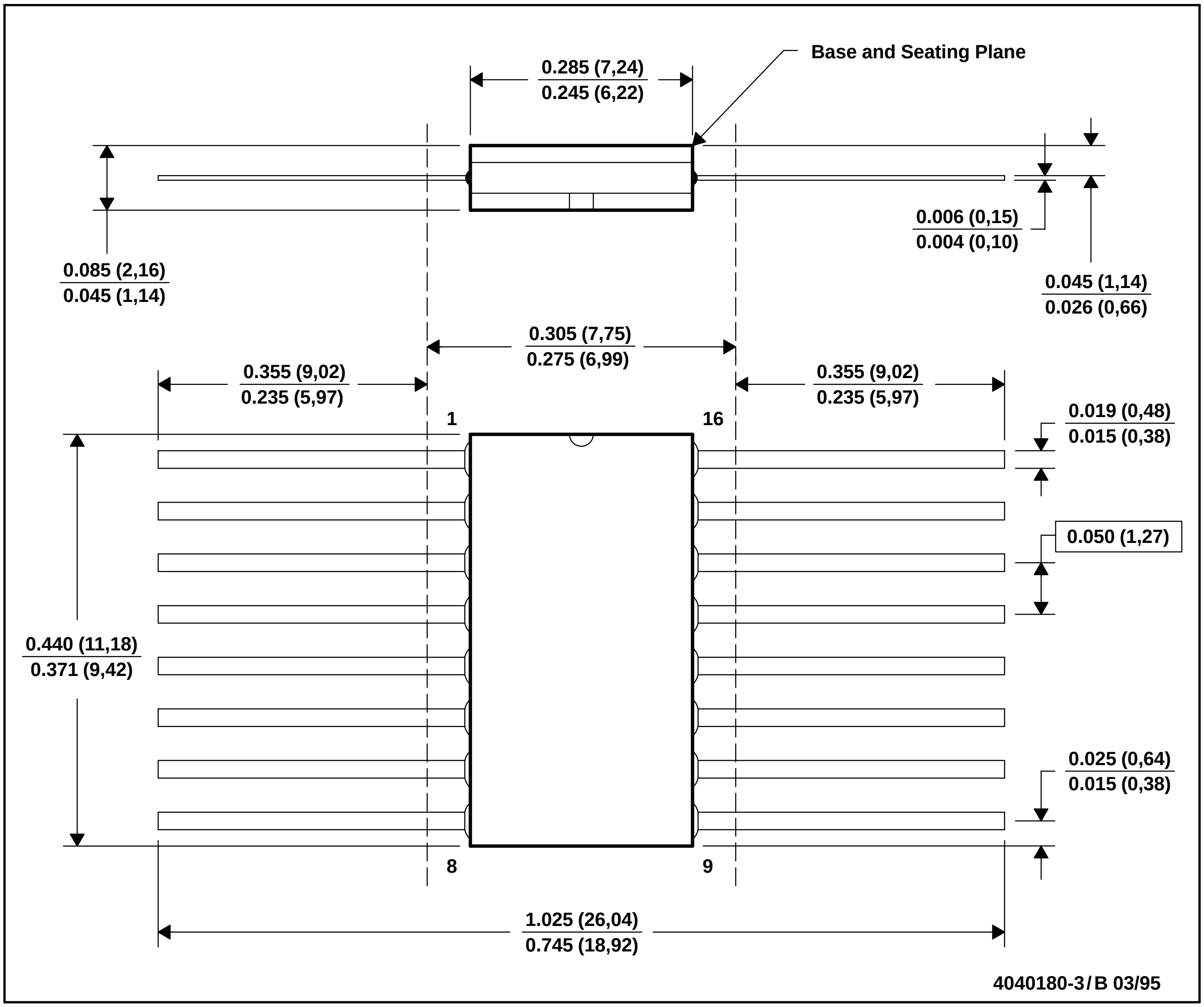
U (S-GDFP-F10) **CERAMIC DUAL FLATPACK**



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

MECHANICAL INFORMATION

W (R-GDFP-F16) **CERAMIC DUAL FLATPACK**



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

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