

TLV2422, TLV2422A, TLV2422Y

Advanced LinCMOS™ RAIL-TO-RAIL OUTPUT

WIDE-INPUT-VOLTAGE MICROPOWER DUAL OPERATIONAL AMPLIFIERS

SLOS199B – SEPTEMBER 1997 – REVISED SEPTEMBER 1999

- Output Swing Includes Both Supply Rails
- Extended Common-Mode Input Voltage Range . . . 0 V to 4.5 V (Min) with 5-V Single Supply
- No Phase Inversion
- Low Noise . . . 18 nV/√Hz Typ at f = 1 kHz
- Low Input Offset Voltage
950 μV Max at T_A = 25°C (TLV2422A)
- Low Input Bias Current . . . 1 pA Typ
- Micropower Operation . . . 50 μA Per Channel
- 600-Ω Output Drive
- Available in Q-Temp Automotive
HighRel Automotive Applications
Configuration Control / Print Support
Qualification to Automotive Standards

description

The TLV2422 and TLV2422A are dual low-voltage operational amplifiers from Texas Instruments. The common-mode input voltage range for this device has been extended over the typical CMOS amplifiers making them suitable for a wide range of applications. In addition, the devices do not phase invert when the common-mode input is driven to the supply rails. This satisfies most design requirements without paying a premium for rail-to-rail input performance. They also exhibit rail-to-rail output performance for increased dynamic range in single- or split-supply applications. This family is fully characterized at 3-V and 5-V supplies and is optimized for low-voltage operation. The TLV2422 only requires 50 μA of supply current per channel, making it ideal for battery-powered applications. The TLV2422 also has increased output drive over previous rail-to-rail operational amplifiers and can drive 600-Ω loads for telecom applications.

Other members in the TLV2422 family are the high-power, TLV2442, and low-power, TLV2432, versions.

The TLV2422, exhibiting high input impedance and low noise, is excellent for small-signal conditioning for high-impedance sources, such as piezoelectric transducers. Because of the micropower dissipation levels and low-voltage operation, these devices work well in hand-held monitoring and remote-sensing applications. In addition, the rail-to-rail output feature with single- or split-supplies makes this family a great choice when interfacing with analog-to-digital converters (ADCs). For precision applications, the TLV2422A is available with a maximum input offset voltage of 950 μV.

If the design requires single operational amplifiers, see the TI TLV2211/21/31. This is a family of rail-to-rail output operational amplifiers in the SOT-23 package. Their small size and low power consumption, make them ideal for high density, battery-powered equipment.

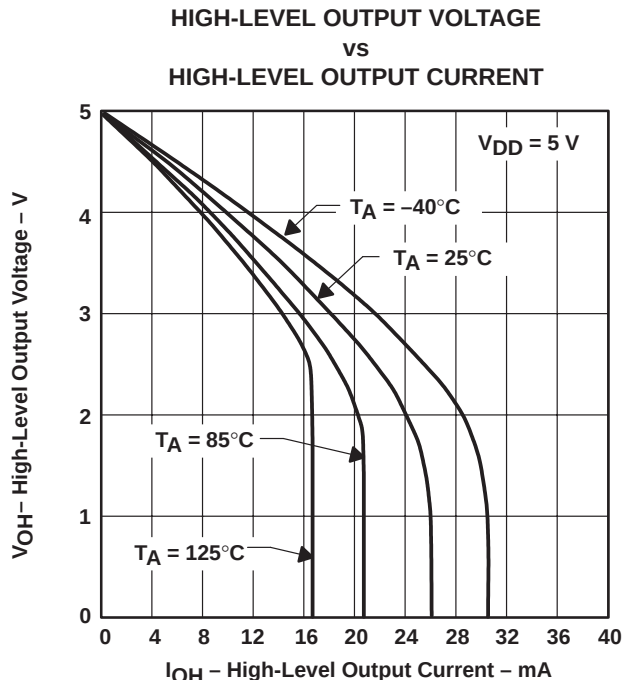


Figure 1



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.

Advanced LinCMOS is a trademark of Texas Instruments Incorporated.

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

**TEXAS
INSTRUMENTS**

POST OFFICE BOX 655303 • DALLAS, TEXAS 75265

Copyright © 1999, Texas Instruments Incorporated
On products compliant to MIL-STD-883, Class B, all parameters are tested unless otherwise noted. On all other products, production processing does not necessarily include testing of all parameters.

TLV2422, TLV2422A, TLV2422Y

Advanced LinCMOS™ RAIL-TO-RAIL OUTPUT

WIDE-INPUT-VOLTAGE MICROPOWER DUAL OPERATIONAL AMPLIFIERS

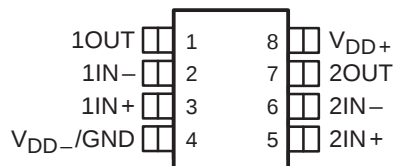
SLOS199B – SEPTEMBER 1997 – REVISED SEPTEMBER 1999

AVAILABLE OPTIONS

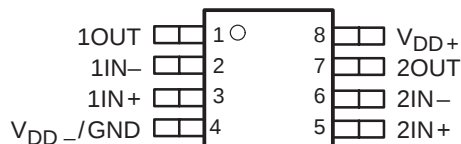
T _A	V _{IO} max AT 25°C	PACKAGED DEVICES					CHIP FORM (Y)
		SMALL OUTLINE (D)	CHIP CARRIER (FK)	CERAMIC DIP (JG)	TSSOP (PW)	CERAMIC FLAT PACK (U)	
0°C to 70°C	2.5 mV	TLV2422CD	—	—	TLV2422CPWLE	—	TLV2422Y
–40°C to 85°C	950 µV 2.5 mV	TLV2422AID TLV2422ID	— —	— —	TLV2422AIPWLE —	— —	
–40°C to 125°C	950 µV 2.5 mV	TLV2422AQD TLV2422QD	— —	— —	— —	— —	
–55°C to 125°C	950 µV 2 mV	— —	TLV2422AMFK TLV2422MFK	TLV2422AMJG TLV2422MJG	— —	TLV2422AMU TLV2422MU	

The D packages are available taped and reeled. Add R suffix to device type (e.g., TLV2422CDR). The PW package is available only left-end taped and reeled. Chips are tested at 25°C.

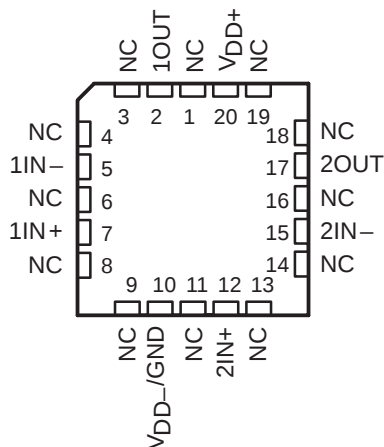
**D OR JG PACKAGE
(TOP VIEW)**



**PW PACKAGE
(TOP VIEW)**

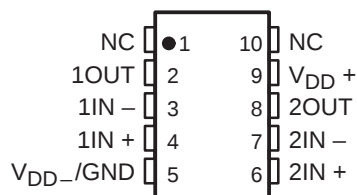


**FK PACKAGE
(TOP VIEW)**



NC – No internal connection

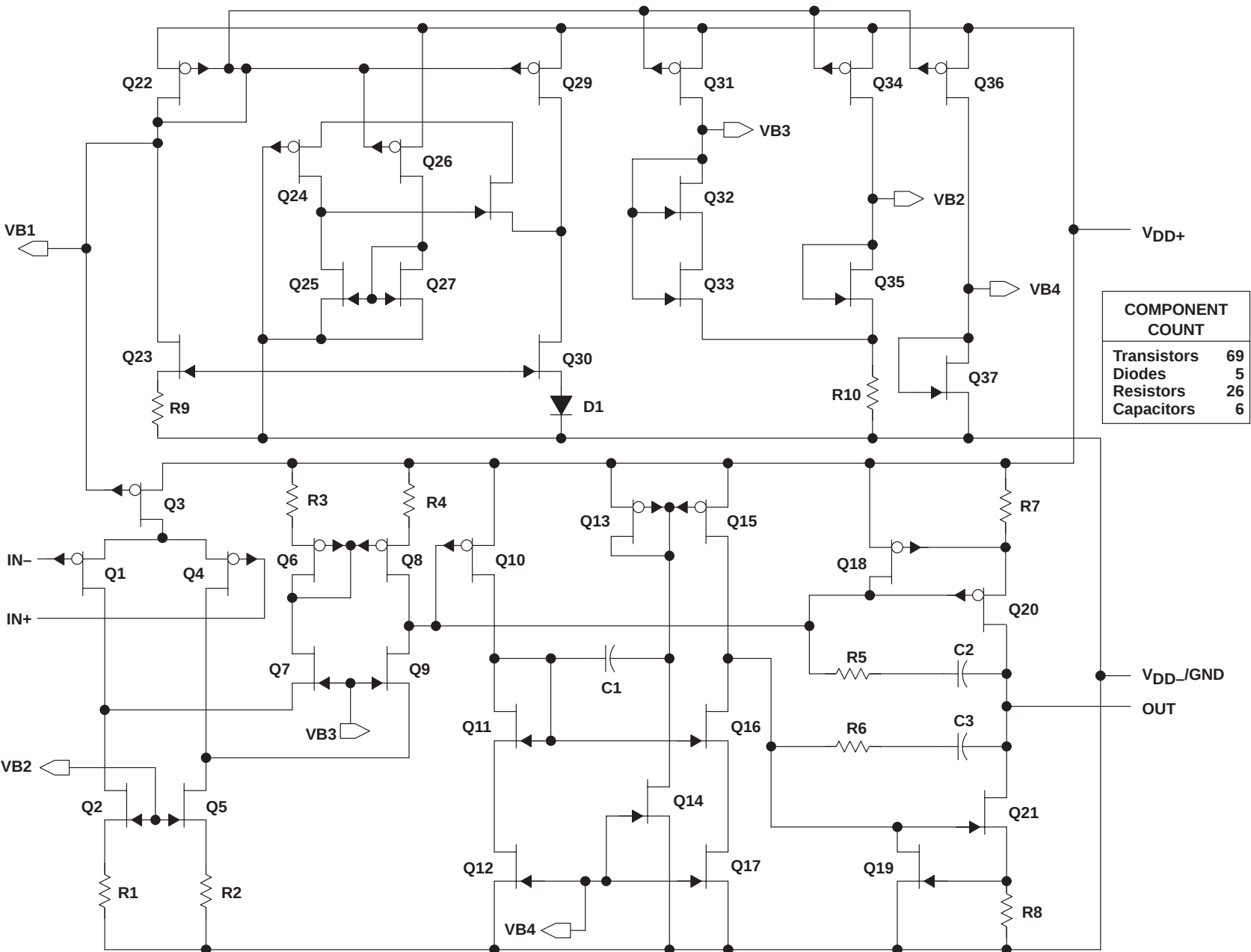
**U PACKAGE
(TOP VIEW)**



TLV2422, TLV2422A
Advanced LinCMOS™ RAIL-TO-RAIL OUTPUT
WIDE-INPUT-VOLTAGE MICROPOWER DUAL OPERATIONAL AMPLIFIERS

SLOS199B – SEPTEMBER 1997 – REVISED SEPTEMBER 1999

equivalent schematic (each amplifier)



TLV2422, TLV2422A
Advanced LinCMOS™ RAIL-TO-RAIL OUTPUT
WIDE-INPUT-VOLTAGE MICROPOWER DUAL OPERATIONAL AMPLIFIERS

SLOS199B – SEPTEMBER 1997 – REVISED SEPTEMBER 1999

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

Supply voltage, V_{DD} (see Note 1)	12 V
Differential input voltage, V_{ID} (see Note 2)	$\pm V_{DD}$
Input voltage, V_I (any input, see Note 1): C and I suffix	–0.3 V to V_{DD}
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 power dissipation	See Dissipation Rating Table
Operating free-air temperature range, T_A : C suffix	0°C to 70°C
I suffix	–40°C to 85°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 if input is brought below $V_{DD-} - 0.3$ V.
3. The output may be shorted to either supply. Temperature and/or supply voltages must be limited to ensure that the maximum dissipation rating is not exceeded.

DISSIPATION RATING TABLE

PACKAGE	$T_A \leq 25^\circ\text{C}$ POWER RATING	DERATING FACTOR ABOVE $T_A = 25^\circ\text{C}$	$T_A = 70^\circ\text{C}$ POWER RATING	$T_A = 85^\circ\text{C}$ POWER RATING	$T_A = 125^\circ\text{C}$ POWER RATING
D	725 mW	5.8 mW/°C	464 mW	377 mW	145 mW
FK	1375 mW	11.0 mW/°C	880 mW	715 mW	275 mW
JG	1050 mW	8.4 mW/°C	672 mW	546 mW	210 mW
PW	525 mW	4.2 mW/°C	336 mW	273 mW	105 mW
U	675 mW	5.4 mW/°C	432 mW	350 mW	135 mW

recommended operating conditions

	C SUFFIX		I SUFFIX		Q SUFFIX		M SUFFIX		UNIT
	MIN	MAX	MIN	MAX	MIN	MAX	MIN	MAX	
Supply voltage, $V_{DD\pm}$	2.7	10	2.7	10	2.7	10	2.7	10	V
Input voltage range, V_I	V_{DD-}	$V_{DD+} - 0.8$	V_{DD-}	$V_{DD+} - 0.8$	V_{DD-}	$V_{DD+} - 0.8$	V_{DD-}	$V_{DD+} - 0.8$	V
Common-mode input voltage, V_{IC}	V_{DD-}	$V_{DD+} - 0.8$	V_{DD-}	$V_{DD+} - 0.8$	V_{DD-}	$V_{DD+} - 0.8$	V_{DD-}	$V_{DD+} - 0.8$	V
Operating free-air temperature, T_A	0	70	–40	85	–40	125	–55	125	°C

TLV2422, TLV2422A
Advanced LinCMOS™ RAIL-TO-RAIL OUTPUT
WIDE-INPUT-VOLTAGE MICROPOWER DUAL OPERATIONAL AMPLIFIERS

SLOS199B – SEPTEMBER 1997 – REVISED SEPTEMBER 1999

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

PARAMETER		TEST CONDITIONS		T _A [†]	TLV2422C		UNIT
					MIN	TYP	
V _{IO}	Input offset voltage	V _{IC} = 0, V _O = 0, V _{DD} ± = ±2.5 V, R _S = 50 Ω		25°C	300	2000	μV
	Full range			2500			
α _{VIO}	Temperature coefficient of input offset voltage			25°C to 70°C	2		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		pA
				Full range	150		
I _{IB}	Input bias current			25°C	1		pA
				Full range	150		
V _{ICR}	Common-mode input voltage range	V _{IO} ≤ 5 mV, R _S = 50 Ω		25°C	0 to 2.5	–0.25 to 2.75	V
				Full range	0 to 2.2		
V _{OH}	High-level output voltage	I _{OH} = –100 μA		25°C	2.97		V
		I _{OH} = –500 μA		25°C	2.75		
				Full range	2.5		
V _{OL}	Low-level output voltage	V _{IC} = 0, I _{OL} = 100 μA		25°C	0.05		V
		V _{IC} = 0, I _{OL} = 250 μA		25°C	0.2		
				Full range	0.5		
A _{VD}	Large-signal differential voltage amplification	V _{IC} = 2.5 V, V _O = 1 V to 2 V	R _L = 10 kΩ [‡]	25°C	6	10	V/mV
				Full range	3		
			R _L = 1 MΩ [‡]	25°C	700		
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		25°C	8		pF
z _o	Closed-loop output impedance	f = 100 kHz, A _V = 10		25°C	130		Ω
CMRR	Common-mode rejection ratio	V _{IC} = 0 to 2.5 V, V _O = 1.5 V, R _S = 50 Ω		25°C	70	83	dB
				Full range	70		
k _{SVR}	Supply-voltage rejection ratio (ΔV _{DD} /ΔV _{IO})	V _{DD} = 2.7 V to 8 V, V _{IC} = V _{DD} /2, No load		25°C	80	95	dB
				Full range	80		
I _{DD}	Supply current	V _O = 1.5 V, No load		25°C	100	150	μA
				Full range	175		

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

TLV2422, TLV2422A
Advanced LinCMOS™ RAIL-TO-RAIL OUTPUT
WIDE-INPUT-VOLTAGE MICROPOWER DUAL OPERATIONAL AMPLIFIERS

SLOS199B – SEPTEMBER1997 – REVISED SEPTEMBER 1999

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

PARAMETER		TEST CONDITIONS		T _A [†]	TLV2422I			TLV2422AI			UNIT	
					MIN	TYP	MAX	MIN	TYP	MAX		
V _{IO}	Input offset voltage	V _{IC} = 0, V _O = 0, V _{DD} ± = ±2.5 V, R _S = 50 Ω		25°C	300	2000		300	950	μV		
Full range				2500			1500					
αV _{IO}	Temperature coefficient of input offset voltage			25°C to 70°C	2			2			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			0.5			pA	
				Full range			150			150		
I _{IB}	Input bias current			25°C	1			1			pA	
				Full range			150			150		
V _{ICR}	Common-mode input voltage range			V _{IO} ≤ 5 mV, R _S = 50 Ω		25°C	0 to 2.5	−0.25 to 2.75		0 to 2.5	−0.25 to 2.75	V
						Full range	0 to 2.2		0 to 2.2			
V _{OH}	High-level output voltage	I _{OH} = −100 μA		25°C	2.97			2.97			V	
		I _{OH} = −500 μA		25°C	2.75			2.75				
				Full range	2.5			2.5				
V _{OL}	Low-level output voltage	V _{IC} = 0, I _{OL} = 100 μA		25°C	0.05			0.05			V	
		V _{IC} = 0, I _{OL} = 250 μA		25°C	0.2			0.2				
				Full range			0.5			0.5		
A _{VD}	Large-signal differential voltage amplification	V _{IC} = 2.5 V, V _O = 1 V to 2 V	R _L = 10 kΩ‡	25°C	6	10		6	10	V/mV		
			R _L = 1 MΩ‡	Full range	3			3				
				25°C	700			700				
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		25°C	8			8			pF	
z _o	Closed-loop output impedance	f = 100 kHz, A _V = 10		25°C	130			130			Ω	
CMRR	Common-mode rejection ratio	V _{IC} = 0 to 2.5 V, V _O = 1.5 V, R _S = 50 Ω		25°C	70	83		70	83	dB		
				Full range			70					
k _{SVR}	Supply-voltage rejection ratio (ΔV _{DD} /ΔV _{IO})	V _{DD} = 2.7 V to 8 V, V _{IC} = V _{DD} /2, No load		25°C	80	95		80	95	dB		
				Full range			80					
I _{DD}	Supply current	V _O = 1.5 V, No load		25°C	100	150		100	150	μA		
				Full range			175					

† Full range is -40°C to 85°C .

‡ Referenced to 2.5 V

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



TLV2422, TLV2422A
Advanced LinCMOS™ RAIL-TO-RAIL OUTPUT
WIDE-INPUT-VOLTAGE MICROPOWER DUAL OPERATIONAL AMPLIFIERS

SLOS199B – SEPTEMBER 1997 – REVISED SEPTEMBER 1999

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

PARAMETER		TEST CONDITIONS		T _A [†]	TLV2422C, TLV2422I TLV2422AI			UNIT
					MIN	TYP	MAX	
SR	Slew rate at unity gain	V _O = 1.5 V to 3.5 V, R _L = 10 kΩ [‡] , C _L = 100 pF [‡]		25°C	0.01	0.02	V/μs	
				Full range	0.008			
V _n	Equivalent input noise voltage	f = 10 Hz		25°C	100		nV/√Hz	
		f = 1 kHz		25°C	23			
V _{N(PP)}	Peak-to-peak equivalent input noise voltage	f = 0.1 Hz to 1 Hz		25°C	2.7		μV	
		f = 0.1 Hz to 10 Hz		25°C	4			
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 = 1 kHz, R _L = 10 kΩ [‡]	A _V = 1	25°C	0.25%			
			A _V = 10		1.8%			
Gain-bandwidth product		f = 10 kHz, C _L = 100 pF [‡]	R _L = 10 kΩ [‡] ,	25°C	46		kHz	
B _{OM}	Maximum output-swing bandwidth	V _{O(PP)} = 1 V, R _L = 10 kΩ [‡] ,	A _V = 1, C _L = 100 pF [‡]	25°C	8.3		kHz	
t _s	Settling time	A _V = −1, Step = 0.5 V to 2.5 V, R _L = 10 kΩ [‡] , C _L = 100 pF [‡]	To 0.1%	25°C	8.6		μs	
			To 0.01%		16			
φ _m	Phase margin at unity gain	R _L = 10 kΩ [‡] , C _L = 100 pF [‡]		25°C	62°			
	Gain margin			25°C	11		dB	

† Full range for the C version is 0°C to 70°C. Full range for the I version is –40°C to 85°C.

‡ Referenced to 2.5 V

TLV2422, TLV2422A
Advanced LinCMOS™ RAIL-TO-RAIL OUTPUT
WIDE-INPUT-VOLTAGE MICROPOWER DUAL OPERATIONAL AMPLIFIERS

SLOS199B – SEPTEMBER 1997 – REVISED SEPTEMBER 1999

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

PARAMETER	TEST CONDITIONS	$T_A^\dagger$	TLV2422Q, TLV2422M			TLV2422AQ, TLV2422AM			UNIT
			MIN	TYP	MAX	MIN	TYP	MAX	
V_{IO} Input offset voltage	$V_{IC} = 0, V_O = 0, V_{DD} \pm \pm 1.5\text{ V}, R_S = 50\ \Omega$	25°C	300	2000		300	950		μV
		Full range		2500			1800		
α_{VIO} Temperature coefficient of input offset voltage		Full range		2			2		$\mu\text{V}/^\circ\text{C}$
Input offset voltage long-term drift (see Note 4)		25°C		0.003			0.003		$\mu\text{V}/\text{mo}$
I_{IO} Input offset current		25°C		0.5			0.5		pA
		Full range		150			150		
I_{IB} Input bias current		25°C		1			1		pA
		Full range		300			300		
V_{ICR} Common-mode input voltage range		25°C	0 to 2.5	-0.25 to 2.75		0 to 2.5	-0.25 to 2.75		V
		Full range	0 to 2.2			0 to 2.2			
V_{OH} High-level output voltage	$I_{OH} = -100\ \mu\text{A}$	25°C		2.97			2.97		V
	$I_{OH} = -500\ \mu\text{A}$	25°C		2.75			2.75		
		Full range		2.5			2.5		
V_{OL} Low-level output voltage	$V_{IC} = 0, I_{OL} = 100\ \mu\text{A}$	25°C		0.05			0.05		V
	$V_{IC} = 0, I_{OL} = 250\ \mu\text{A}$	25°C		0.2			0.2		
		Full range		0.5			0.5		
A_{VD} Large-signal differential voltage amplification	$V_{IC} = 1.5\text{ V}, V_O = 1\text{ V to } 2\text{ V}$	25°C	6	10		6	10		V/mV
		Full range	2			2			
		25°C		700			700		
$r_{i(d)}$ 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	$f = 10\text{ kHz}$	25°C		8			8		pF
z_o Closed-loop output impedance	$f = 100\text{ kHz}, A_V = 10$	25°C		130			130		Ω
CMRR Common-mode rejection ratio	$V_{IC} = V_{ICR}\text{ min}, V_O = 1.5\text{ V}, R_S = 50\ \Omega$	25°C	70	83		70	83		dB
		Full range	70			70			
k_{SVR} Supply-voltage rejection ratio ($\Delta V_{DD}/\Delta V_{IO}$)	$V_{DD} = 2.7\text{ V to } 8\text{ V}, V_{IC} = V_{DD}/2, \text{ No load}$	25°C	80	95		80	95		dB
		Full range	80			80			
I_{DD} Supply current	$V_O = 1.5\text{ V}, \text{ No load}$	25°C	100	150		100	150		μA
		Full range		175			175		

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

‡ Referenced to 1.5 V

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



TLV2422, TLV2422A
Advanced LinCMOS™ RAIL-TO-RAIL OUTPUT
WIDE-INPUT-VOLTAGE MICROPOWER DUAL OPERATIONAL AMPLIFIERS

SLOS199B – SEPTEMBER1997 – REVISED SEPTEMBER 1999

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

PARAMETER		TEST CONDITIONS		T _A [†]	TLV2422Q, TLV2422M, TLV2422AQ, TLV2422AM			UNIT
					MIN	TYP	MAX	
SR	Slew rate at unity gain	V _O = 1.1 V to 1.9 V, R _L = 10 kΩ [‡] , C _L = 100 pF [‡]		25°C	0.01	0.02	V/μs	
				Full range	0.008			
V _n	Equivalent input noise voltage	f = 10 Hz		25°C	100		nV/√Hz	
		f = 1 kHz		25°C	23			
V _{N(PP)}	Peak-to-peak equivalent input noise voltage	f = 0.1 Hz to 1 Hz		25°C	2.7		μV	
		f = 0.1 Hz to 10 Hz		25°C	4			
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 = 1 kHz, R _L = 10 kΩ [‡]	A _V = 1	25°C	0.25%			
			A _V = 10		1.8%			
Gain-bandwidth product		f = 10 kHz, C _L = 100 pF [‡]		25°C	46		kHz	
B _{OM}	Maximum output-swing bandwidth	V _{O(PP)} = 1 V, R _L = 10 kΩ [‡] ,		25°C	8.3		kHz	
t _s	Settling time	A _V = −1, Step = 0.5 V to 2.5 V, R _L = 10 kΩ [‡] , C _L = 100 pF [‡]	To 0.1%	25°C	8.6		μs	
			To 0.01%		16			
φ _m	Phase margin at unity gain	R _L = 10 kΩ [‡] , C _L = 100 pF [‡]		25°C	62°			
Gain margin				25°C	11		dB	

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

‡ Referenced to 1.5 V

TLV2422, TLV2422A
Advanced LinCMOS™ RAIL-TO-RAIL OUTPUT
WIDE-INPUT-VOLTAGE MICROPOWER DUAL OPERATIONAL AMPLIFIERS

SLOS199B – SEPTEMBER1997 – REVISED SEPTEMBER 1999

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

PARAMETER	TEST CONDITIONS	$T_A^\dagger$	TLV2422C			UNIT
			MIN	TYP	MAX	
V_{IO} Input offset voltage	$V_{IC} = 0, V_O = 0, V_{DD} \pm = \pm 2.5\text{ V}, R_S = 50\ \Omega$	25°C		300	2000	μV
		Full range			2500	
αV_{IO} Temperature coefficient of input offset voltage		25°C to 70°C		2		$\mu\text{V}/^\circ\text{C}$
Input offset voltage long-term drift (see Note 4)		25°C		0.003		$\mu\text{V}/\text{mo}$
I_{IO} Input offset current		25°C		0.5		pA
		Full range			150	
I_{IB} Input bias current		25°C		1		pA
		Full range			150	
V_{ICR} Common-mode input voltage range	$ V_{IO} \leq 5\text{ mV}, R_S = 50\ \Omega$	25°C	0 to 4.5	-0.25 to 4.75		V
		Full range	0 to 4.2			
V_{OH} High-level output voltage	$I_{OH} = -100\ \mu\text{A}$	25°C		4.97		V
	$I_{OH} = -1\text{ mA}$	25°C		4.5	4.75	
		Full range		4.25		
V_{OL} Low-level output voltage	$V_{IC} = 2.5\text{ V}, I_{OL} = 100\ \mu\text{A}$	25°C		0.04		V
	$V_{IC} = 2.5\text{ V}, I_{OL} = 500\ \mu\text{A}$	25°C		0.15		
		Full range			0.5	
A_{VD} Large-signal differential voltage amplification	$V_{IC} = 2.5\text{ V}, V_O = 1\text{ V to }4\text{ V}$	25°C		8	12	V/mV
		Full range		5		
		25°C			1000	
$r_{i(d)}$ 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	$f = 10\text{ kHz}$	25°C		8		pF
z_O Closed-loop output impedance	$f = 100\text{ kHz}, A_V = 10$	25°C		130		Ω
CMRR Common-mode rejection ratio	$V_{IC} = 0\text{ to }4.5\text{ V}, V_O = 2.5\text{ V}, R_S = 50\ \Omega$	25°C		70	90	dB
		Full range		70		
k_{SVR} Supply-voltage rejection ratio ($\Delta V_{DD}/\Delta V_{IO}$)	$V_{DD} = 4.4\text{ V to }8\text{ V}, V_{IC} = V_{DD}/2, \text{ No load}$	25°C		80	95	dB
		Full range		80		
I_{DD} Supply current	$V_O = 2.5\text{ V}, \text{ No load}$	25°C		100	150	μA
		Full range			175	

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

TLV2422, TLV2422A

Advanced LinCMOS™ RAIL-TO-RAIL OUTPUT
WIDE-INPUT-VOLTAGE MICROPOWER DUAL OPERATIONAL AMPLIFIERS

SLOS199B – SEPTEMBER1997 – REVISED SEPTEMBER 1999

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

PARAMETER		TEST CONDITIONS		T _A [†]	TLV2422I			TLV2422AI			UNIT
					MIN	TYP	MAX	MIN	TYP	MAX	
V _{IO}	Input offset voltage	V _{IC} = 0, V _O = 0, V _{DD} ± = ±2.5 V, R _S = 50 Ω		25°C	300 2000			300 950			μV
	Full range			2500			1500				
α _{VIO}	Temperature coefficient of input offset voltage			25°C to 70°C	2			2			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			0.5			pA
				Full range	150			150			
I _{IB}	Input bias current			25°C	1			1			pA
				Full range	150			150			
V _{ICR}	Common-mode input voltage range	V _{IO} ≤ 5 mV, R _S = 50 Ω		25°C	0 to 4.5	−0.25 to 4.75	0 to 4.5		−0.25 to 4.75	V	
				Full range	0 to 4.2		0 to 4.2				
V _{OH}	High-level output voltage	I _{OH} = −100 μA		25°C	4.97			4.97			V
		I _{OH} = −1 mA		25°C	4.5	4.75	4.5		4.75		
				Full range	4.25			4.25			
V _{OL}	Low-level output voltage	V _{IC} = 2.5 V, I _{OL} = 100 μA		25°C	0.04			0.04			V
		V _{IC} = 2.5 V, I _{OL} = 500 μA		25°C	0.15			0.15			
				Full range	0.5			0.5			
A _{VD}	Large-signal differential voltage amplification	V _{IC} = 2.5 V, V _O = 1 V to 4 V	R _L = 10 kΩ [‡]	25°C	8	12	8		12	V/mV	
				Full range	5			5			
			R _L = 1 MΩ [‡]	25°C	1000			1000			
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		25°C	8			8			pF
z _o	Closed-loop output impedance	f = 100 kHz, A _V = 10		25°C	130			130			Ω
CMRR	Common-mode rejection ratio	V _{IC} = 0 to 4.5 V, V _O = 2.5 V, R _S = 50 Ω		25°C	70	90	70		90	dB	
				Full range	70			70			
k _{SVR}	Supply-voltage rejection ratio (ΔV _{DD} /ΔV _{IO})	V _{DD} = 4.4 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	V _O = 2.5 V, No load		25°C	100	150	100		150	μA	
				Full range	175			175			

† Full range is -40°C to 85°C .

‡ Referenced to 2.5 V

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

TLV2422, TLV2422A
Advanced LinCMOS™ RAIL-TO-RAIL OUTPUT
WIDE-INPUT-VOLTAGE MICROPOWER DUAL OPERATIONAL AMPLIFIERS

SLOS199B – SEPTEMBER1997 – REVISED SEPTEMBER 1999

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

PARAMETER		TEST CONDITIONS		T _A [†]	TLV2422C, TLV2422I TLV2422AI			UNIT
					MIN	TYP	MAX	
SR	Slew rate at unity gain	V _O = 1.5 V to 3.5 V, R _L = 10 kΩ [‡] , C _L = 100 pF [‡]		25°C	0.01	0.02	V/μs	
				Full range	0.008			
V _n	Equivalent input noise voltage	f = 10 Hz		25°C	100		nV/√Hz	
		f = 1 kHz		25°C	18			
V _{N(PP)}	Peak-to-peak equivalent input noise voltage	f = 0.1 Hz to 1 Hz		25°C	1.9		μV	
		f = 0.1 Hz to 10 Hz		25°C	2.8			
I _n	Equivalent input noise current			25°C	0.6		fA/√Hz	
THD + N	Total harmonic distortion plus noise	V _O = 1.5 V to 3.5 V, f = 1 kHz, R _L = 10 kΩ [‡]	A _V = 1	25°C	0.24%			
			A _V = 10		1.7%			
Gain-bandwidth product		f = 10 kHz, C _L = 100 pF [‡]	R _L =10 kΩ [‡] ,	25°C	52		kHz	
B _{OM}	Maximum output-swing bandwidth	V _{O(PP)} = 2 V, R _L = 10 kΩ [‡] ,	A _V = 1, C _L = 100 pF [‡]	25°C	5.3		kHz	
t _s	Settling time	A _V = −1, Step = 1.5 V to 3.5 V, R _L = 10 kΩ [‡] , C _L = 100 pF [‡]	To 0.1%	25°C	8.5		μs	
			To 0.01%		15.5			
φ _m	Phase margin at unity gain	R _L = 10 kΩ [‡] , C _L = 100 pF [‡]		25°C	66°			
Gain margin				25°C	11		dB	

† Full range for the C version is 0°C to 70°C. Full range for the I version is –40°C to 85°C.

‡ Referenced to 2.5 V



TLV2422, TLV2422A

Advanced LinCMOS™ RAIL-TO-RAIL OUTPUT
WIDE-INPUT-VOLTAGE MICROPOWER DUAL OPERATIONAL AMPLIFIERS

SLOS199B – SEPTEMBER1997 – REVISED SEPTEMBER 1999

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

PARAMETER	TEST CONDITIONS	$T_A^\dagger$	TLV2422Q, TLV2422M			TLV2422AQ, TLV2422AM			UNIT
			MIN	TYP	MAX	MIN	TYP	MAX	
V_{IO} Input offset voltage	$V_{IC} = 0, V_O = 0, V_{DD} \pm = \pm 2.5\text{ V}, R_S = 50\ \Omega$	25°C	300	2000		300	950		μV
		Full range		2500			1800		
α_{VIO} Temperature coefficient of input offset voltage		Full range	2			2			$\mu\text{V}/^\circ\text{C}$
Input offset voltage long-term drift (see Note 4)		25°C	0.003			0.003			$\mu\text{V}/\text{mo}$
I_{IO} Input offset current		25°C	0.5			0.5			pA
		Full range		150			150		
I_{IB} Input bias current		25°C	1			1			pA
		Full range		300			300		
V_{ICR} Common-mode input voltage range		25°C	0 to 4.5	-0.25 to 4.75		0 to 4.5	-0.25 to 4.75		V
		Full range	0 to 4.2			0 to 4.2			
V_{OH} High-level output voltage	$I_{OH} = -100\ \mu\text{A}$	25°C	4.97			4.97			V
	$I_{OH} = -1\text{ mA}$	25°C	4.75			4.75			
		Full range	4.5			4.5			
V_{OL} Low-level output voltage	$V_{IC} = 2.5\text{ V}, I_{OL} = 100\ \mu\text{A}$	25°C	0.04			0.04			V
	$V_{IC} = 2.5\text{ V}, I_{OL} = 500\ \mu\text{A}$	25°C	0.15			0.15			
		Full range		0.5			0.5		
A_{VD} Large-signal differential voltage amplification	$V_{IC} = 2.5\text{ V}, V_O = 1\text{ V to }4\text{ V}$	$R_L = 10\text{ k}\Omega^\ddagger$	25°C	8	12	8	12		V/mV
			Full range	3		3			
		$R_L = 1\text{ M}\Omega^\ddagger$	25°C	1000		1000			
$r_{i(d)}$ 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	$f = 10\text{ kHz}$	25°C	8			8			pF
z_o Closed-loop output impedance	$f = 100\text{ kHz}, A_V = 10$	25°C	130			130			Ω
CMRR Common-mode rejection ratio	$V_{IC} = V_{ICR}\text{ min}, V_O = 2.5\text{ V}, R_S = 50\ \Omega$	25°C	70	90		70	90		dB
		Full range	70			70			
k_{SVR} Supply-voltage rejection ratio ($\Delta V_{DD}/\Delta V_{IO}$)	$V_{DD} = 4.4\text{ V to }8\text{ V}, V_{IC} = V_{DD}/2, \text{ No load}$	25°C	80	95		80	95		dB
		Full range	80			80			
I_{DD} Supply current	$V_O = 2.5\text{ V}, \text{ No load}$	25°C	100	150		100	150		μA
		Full range		175			175		

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

‡ Referenced to 2.5 V

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



TLV2422, TLV2422A
Advanced LinCMOS™ RAIL-TO-RAIL OUTPUT
WIDE-INPUT-VOLTAGE MICROPPOWER DUAL OPERATIONAL AMPLIFIERS

SLOS199B – SEPTEMBER1997 – REVISED SEPTEMBER 1999

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

PARAMETER		TEST CONDITIONS		T _A [†]	TLV2422Q, TLV2422M, TLV2422AQ, TLV2422AM			UNIT
					MIN	TYP	MAX	
SR	Slew rate at unity gain	V _O = 1.5 V to 3.5 V, R _L = 10 kΩ [‡] , C _L = 100 pF [‡]		25°C	0.01	0.02	V/μs	
				Full range	0.008			
V _n	Equivalent input noise voltage	f = 10 Hz		25°C	100		nV/√Hz	
		f = 1 kHz		25°C	18			
V _{N(PP)}	Peak-to-peak equivalent input noise voltage	f = 0.1 Hz to 1 Hz		25°C	1.9		μV	
		f = 0.1 Hz to 10 Hz		25°C	2.8			
I _n	Equivalent input noise current			25°C	0.6		fA/√Hz	
THD + N	Total harmonic distortion plus noise	V _O = 1.5 V to 3.5 V, f = 1 kHz, R _L = 10 kΩ [‡]	A _V = 1	25°C	0.24%			
			A _V = 10		1.7%			
Gain-bandwidth product		f = 10 kHz, C _L = 100 pF [‡]	R _L = 10 kΩ [‡] ,	25°C	52		kHz	
B _{OM}	Maximum output-swing bandwidth	V _{O(PP)} = 2 V, R _L = 10 kΩ [‡] ,	A _V = 1, C _L = 100 pF [‡]	25°C	5.3		kHz	
t _s	Settling time	A _V = −1, Step = 1.5 V to 3.5 V, R _L = 10 kΩ [‡] , C _L = 100 pF [‡]	To 0.1%	25°C	8.5		μs	
			To 0.01%		15.5			
φ _m	Phase margin at unity gain	R _L = 10 kΩ [‡] , C _L = 100 pF [‡]		25°C	66°			
Gain margin				25°C	11		dB	

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

‡ Referenced to 2.5 V

TYPICAL CHARACTERISTICS

Table of Graphs

			FIGURE
V_{IO}	Input offset voltage	Distribution vs Common-mode input voltage	2,3 4,5
α_{VIO}	Temperature coefficient	Distribution	6,7
I_{IB}/I_{IO}	Input bias and input offset currents	vs Free-air temperature	8
V_{OH}	High-level output voltage	vs High-level output current	9,11
V_{OL}	Low-level output voltage	vs Low-level output current	10,12
$V_{O(PP)}$	Maximum peak-to-peak output voltage	vs Frequency	13
I_{OS}	Short-circuit output current	vs Supply voltage vs Free-air temperature	14 15
V_{ID}	Differential input voltage	vs Output voltage	16,17
	Differential gain	vs Load resistance	18
A_{VD}	Large-signal differential voltage amplification	vs Frequency vs Free-air temperature	19,20 21,22
z_o	Output impedance	vs Frequency	23,24
CMRR	Common-mode rejection ratio	vs Frequency vs Free-air temperature	25 26
k_{SVR}	Supply-voltage rejection ratio	vs Frequency vs Free-air temperature	27,28 29
I_{DD}	Supply current	vs Supply voltage	30
SR	Slew rate	vs Load capacitance vs Free-air temperature	31 32
V_O	Inverting large-signal pulse response		33,34
V_O	Voltage-follower large-signal pulse response		35,36
V_O	Inverting small-signal pulse response		37,38
V_O	Voltage-follower small-signal pulse response		39,40
V_n	Equivalent input noise voltage	vs Frequency	41, 42
	Noise voltage (referred to input)	Over a 10-second period	43
THD + N	Total harmonic distortion plus noise	vs Frequency	44,45
	Gain-bandwidth product	vs Supply voltage vs Free-air temperature	46 47
ϕ_m	Phase margin	vs Frequency vs Load capacitance	19,20 48
	Gain margin	vs Load capacitance	49
B_1	Unity-gain bandwidth	vs Load capacitance	50

TLV2422, TLV2422A
Advanced LinCMOS™ RAIL-TO-RAIL OUTPUT
WIDE-INPUT-VOLTAGE MICROPOWER DUAL OPERATIONAL AMPLIFIERS

SLOS199B – SEPTEMBER 1997 – REVISED SEPTEMBER 1999

TYPICAL CHARACTERISTICS

**DISTRIBUTION OF TLV2422
INPUT OFFSET VOLTAGE**

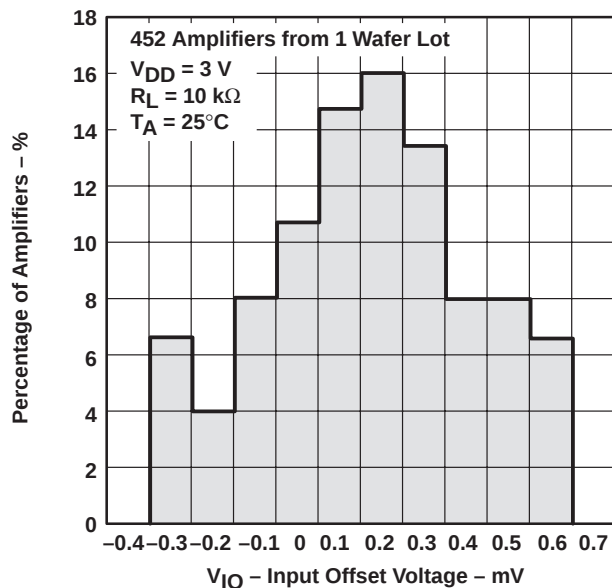


Figure 2

**DISTRIBUTION OF TLV2422
INPUT OFFSET VOLTAGE**

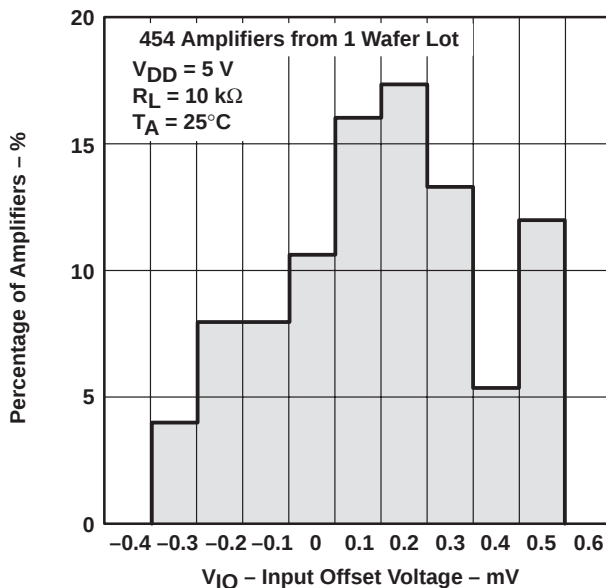


Figure 3

**INPUT OFFSET VOLTAGE
VS
COMMON-MODE INPUT VOLTAGE**

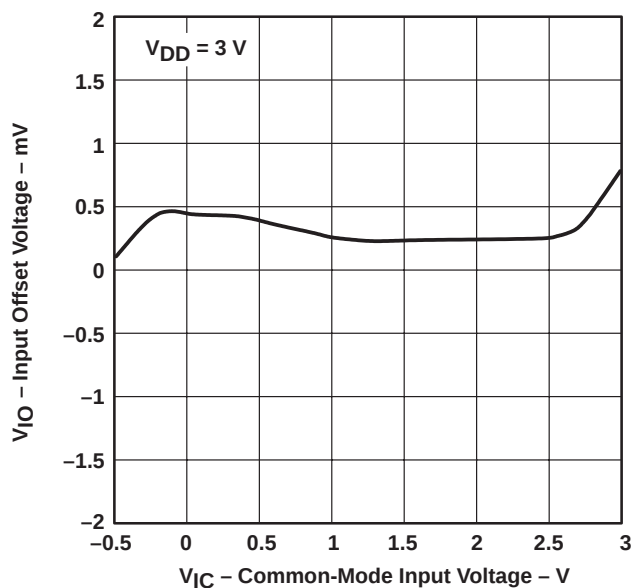


Figure 4

**INPUT OFFSET VOLTAGE
VS
COMMON-MODE INPUT VOLTAGE**

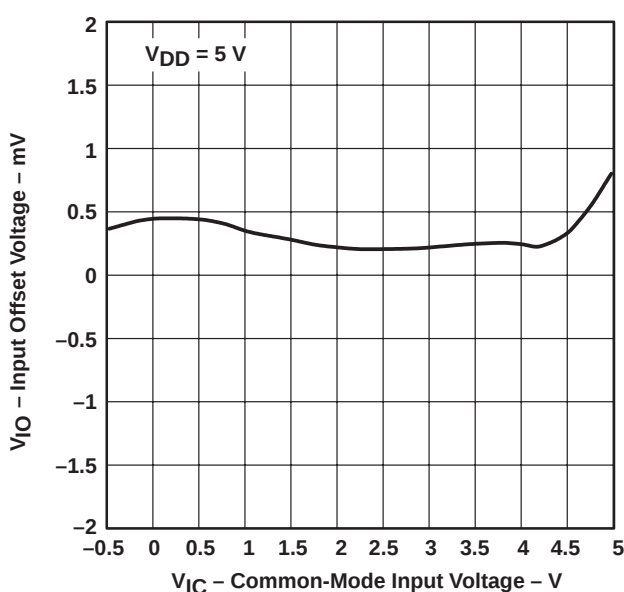


Figure 5

TYPICAL CHARACTERISTICS

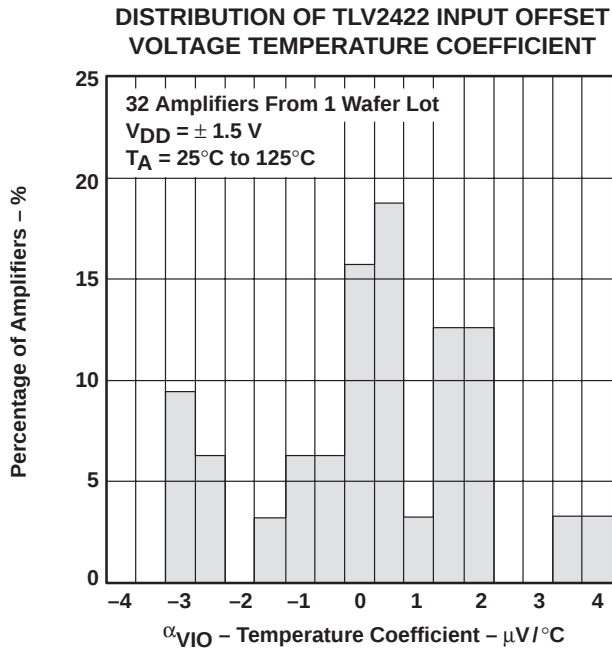


Figure 6

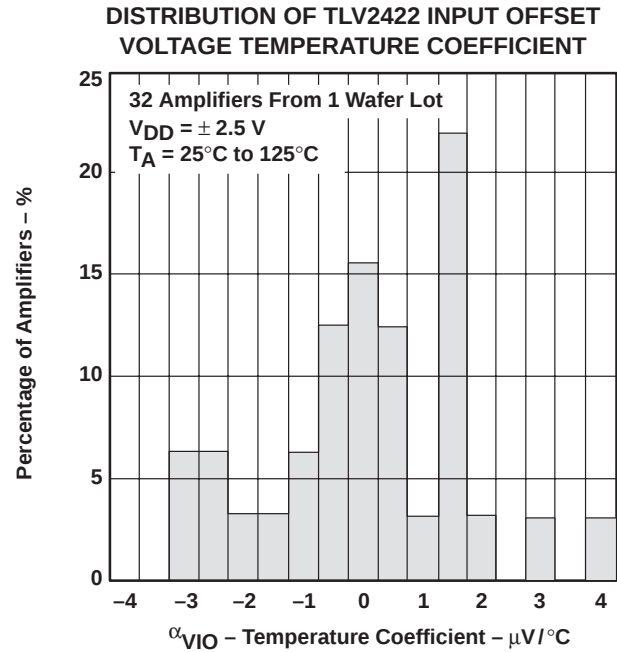


Figure 7

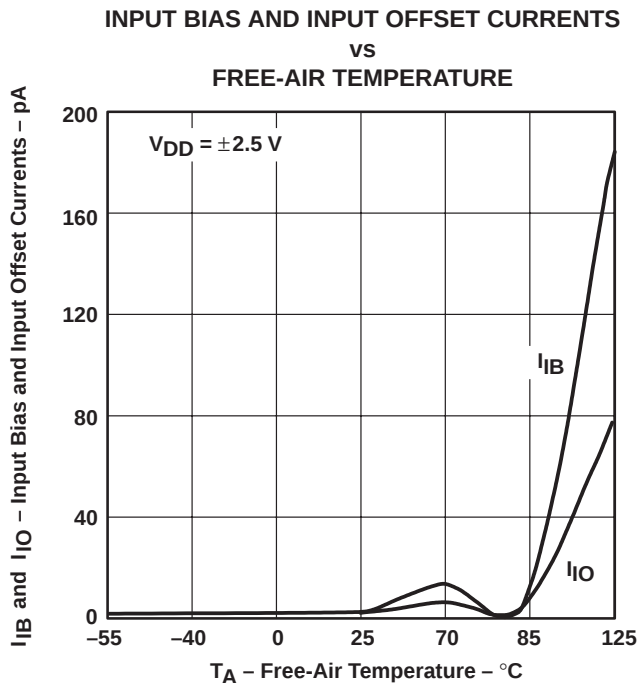


Figure 8

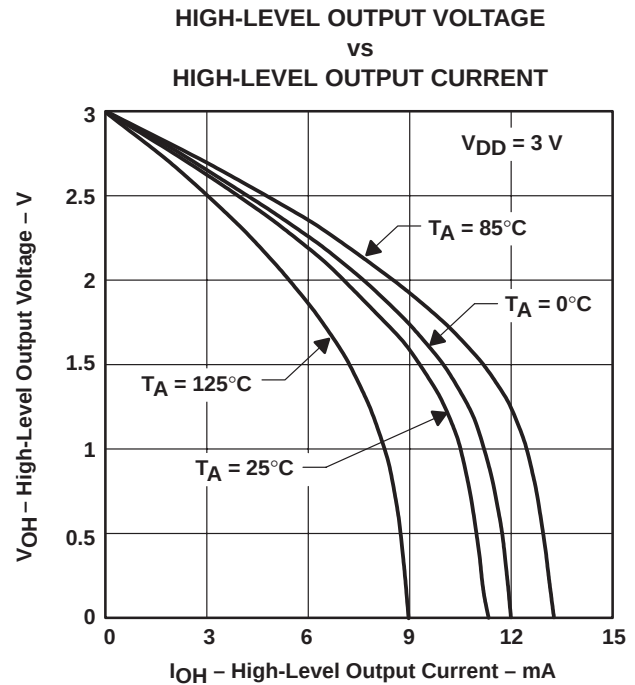


Figure 9

TYPICAL CHARACTERISTICS

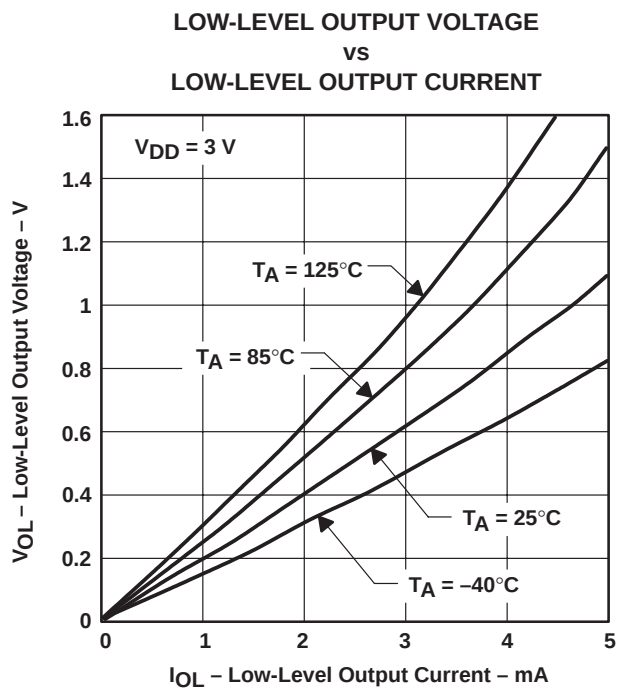


Figure 10

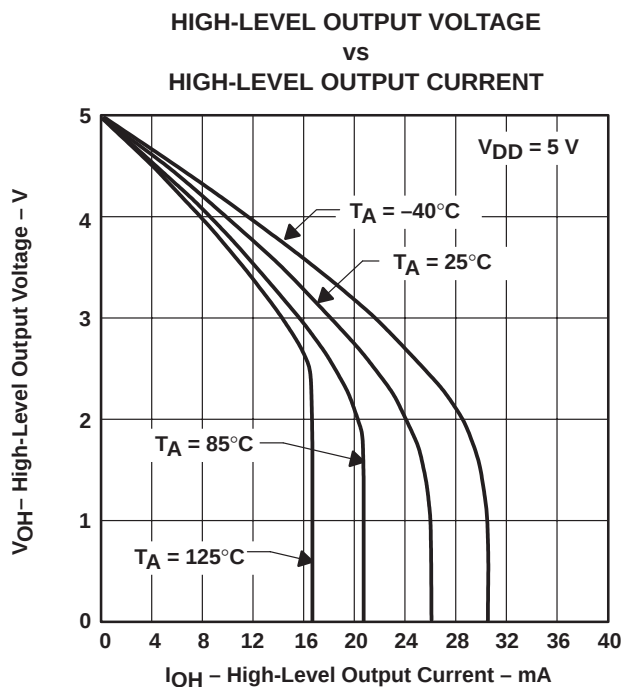


Figure 11

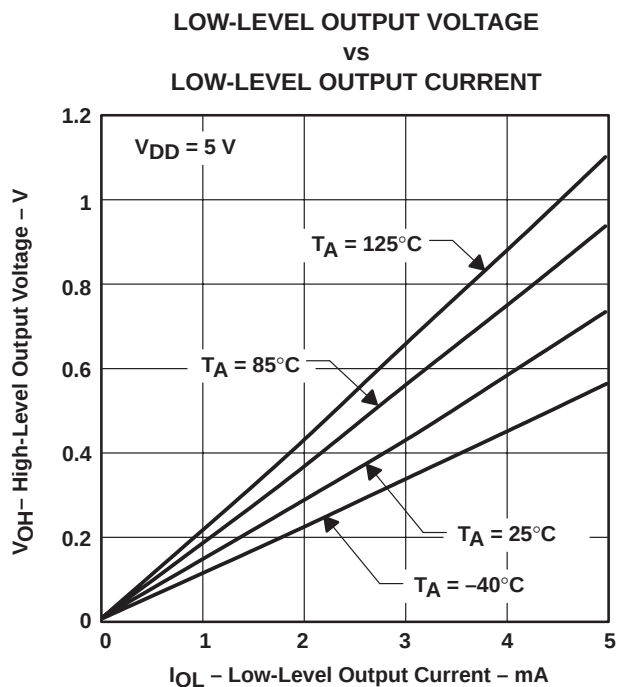


Figure 12

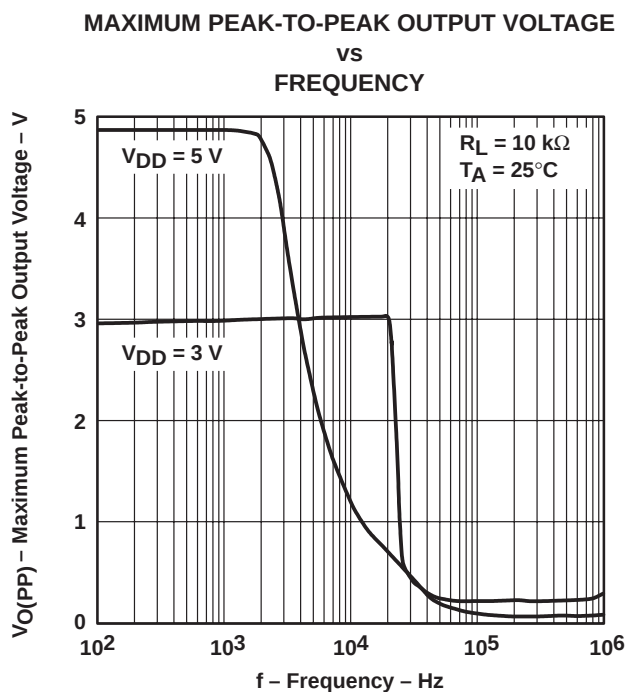
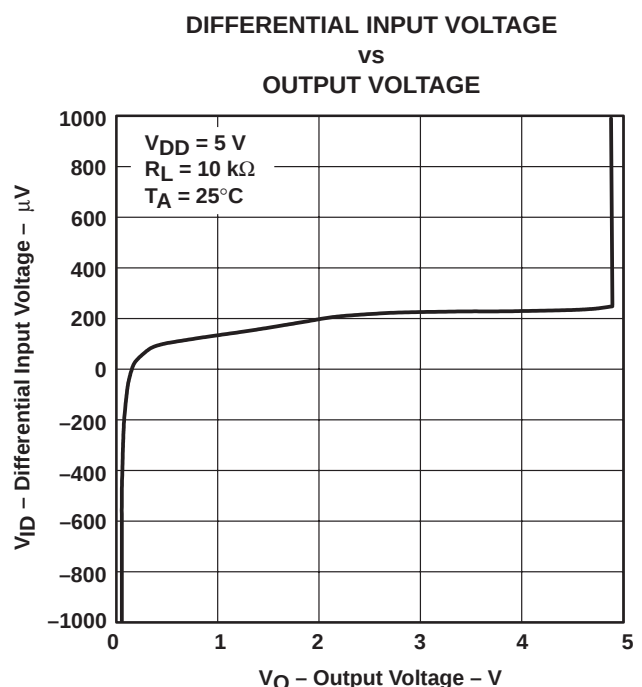
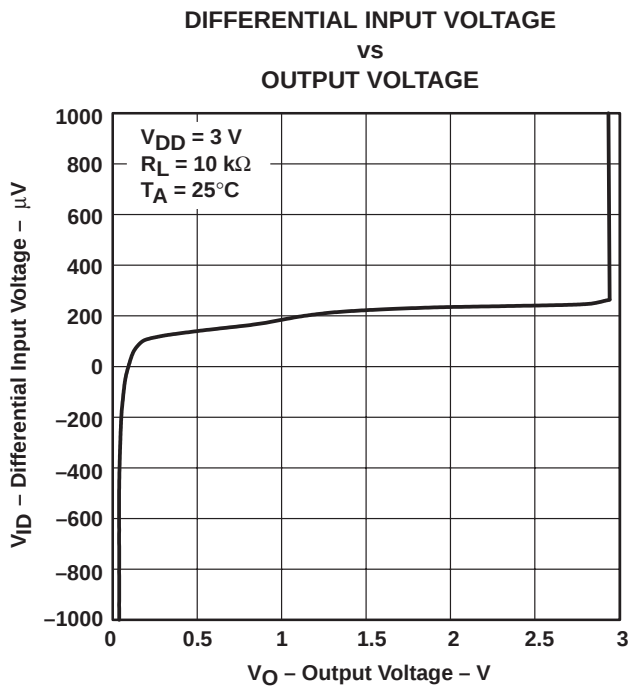
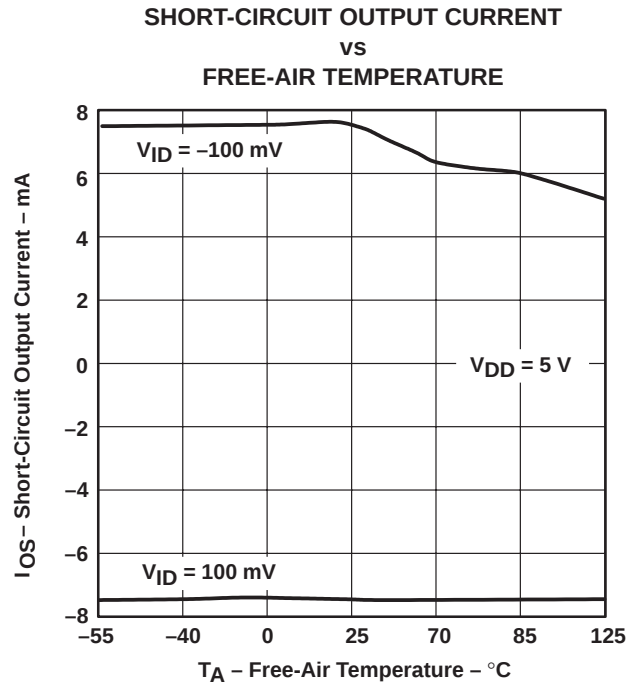
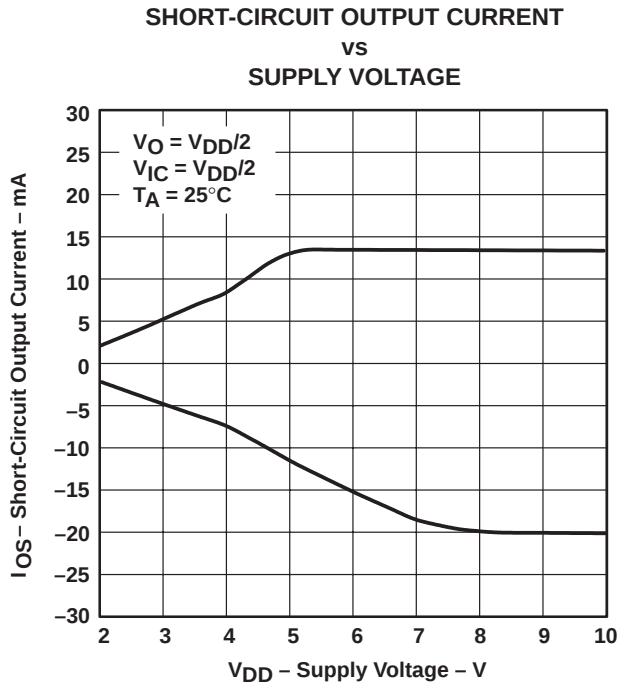


Figure 13

TYPICAL CHARACTERISTICS



TYPICAL CHARACTERISTICS

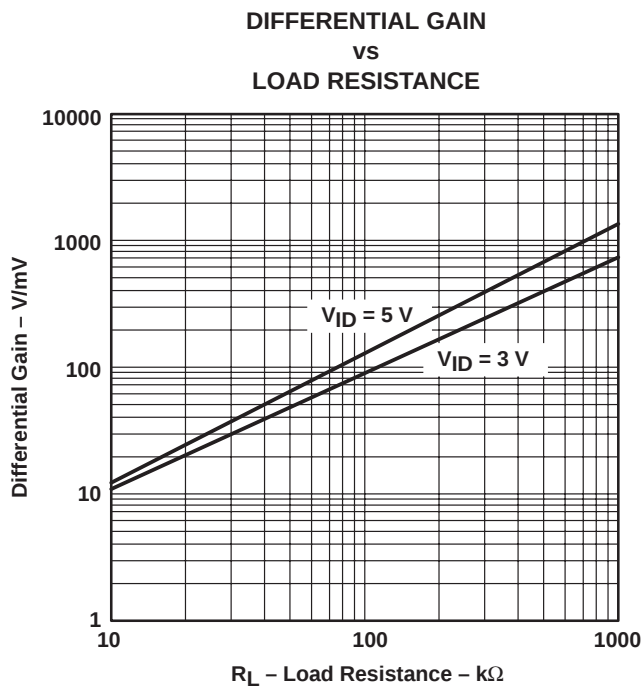


Figure 18

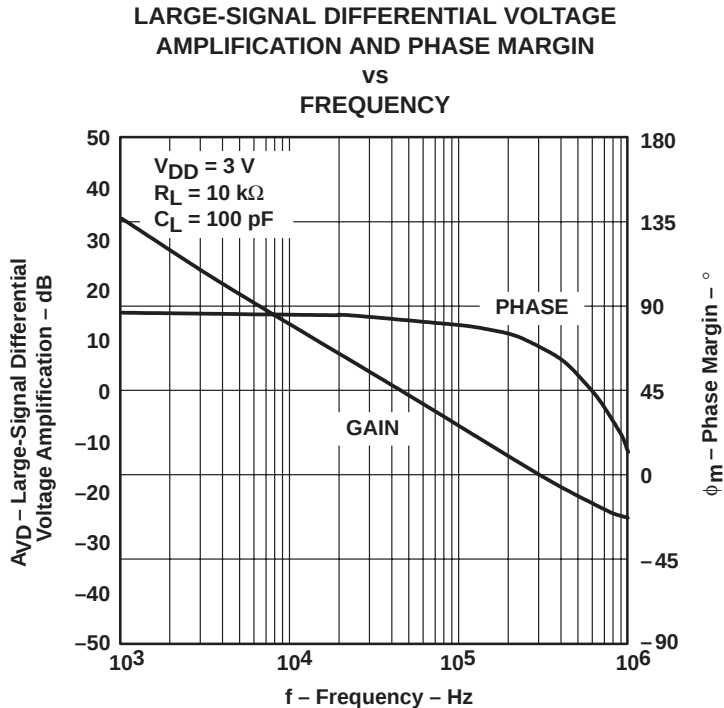


Figure 19

TYPICAL CHARACTERISTICS

LARGE-SIGNAL DIFFERENTIAL VOLTAGE AMPLIFICATION AND PHASE MARGIN

VS
FREQUENCY

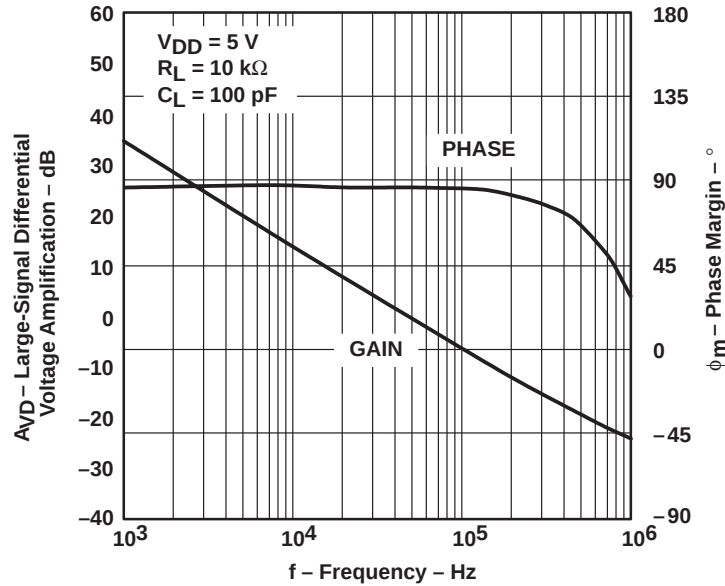


Figure 20

DIFFERENTIAL VOLTAGE AMPLIFICATION VS FREE-AIR TEMPERATURE

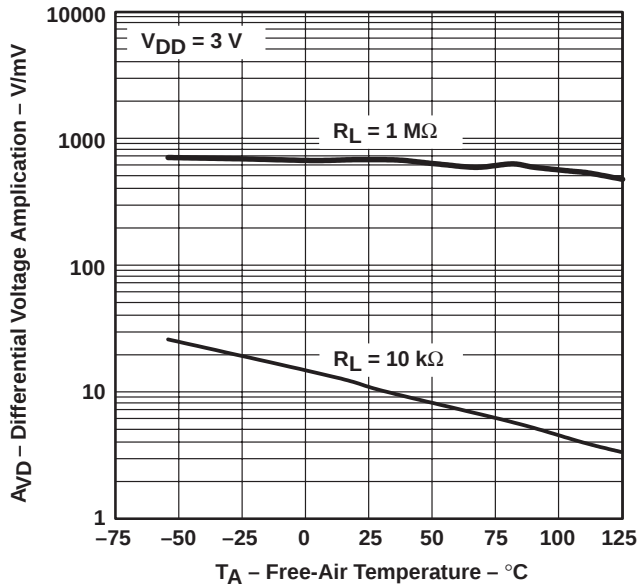


Figure 21

DIFFERENTIAL VOLTAGE AMPLIFICATION VS FREE-AIR TEMPERATURE

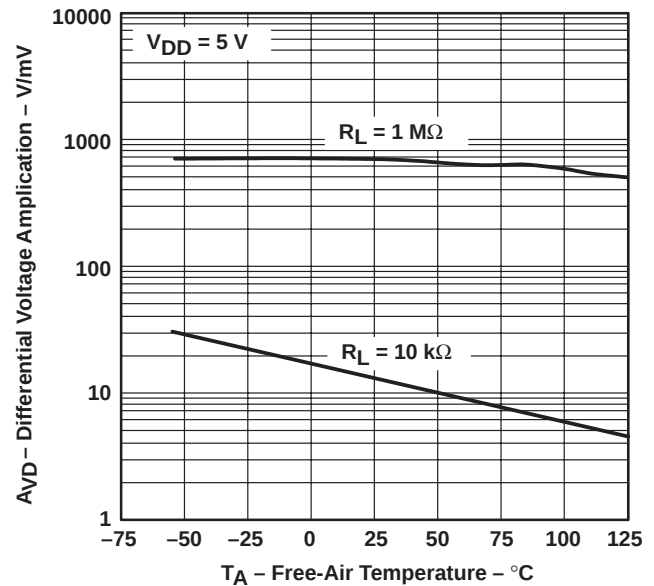


Figure 22

TYPICAL CHARACTERISTICS

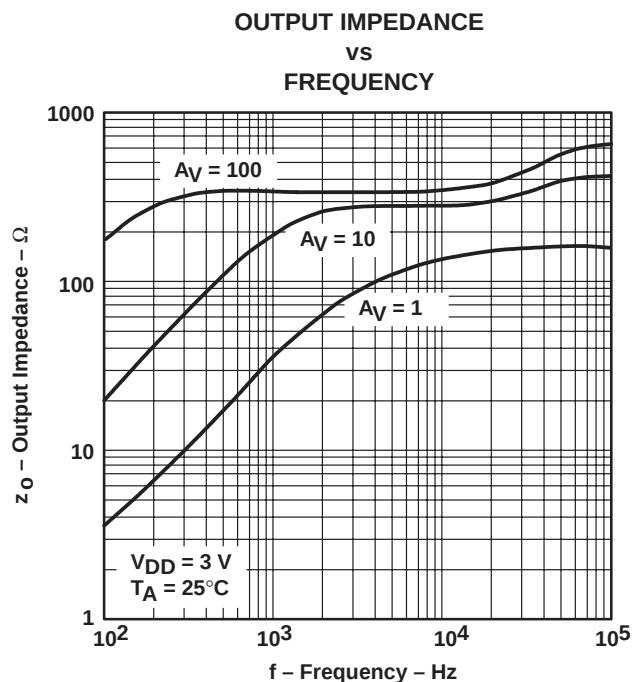


Figure 23

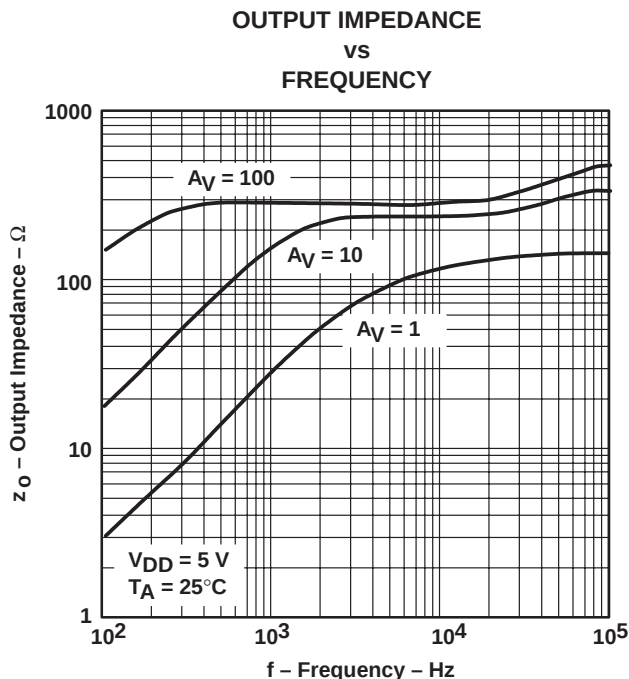


Figure 24

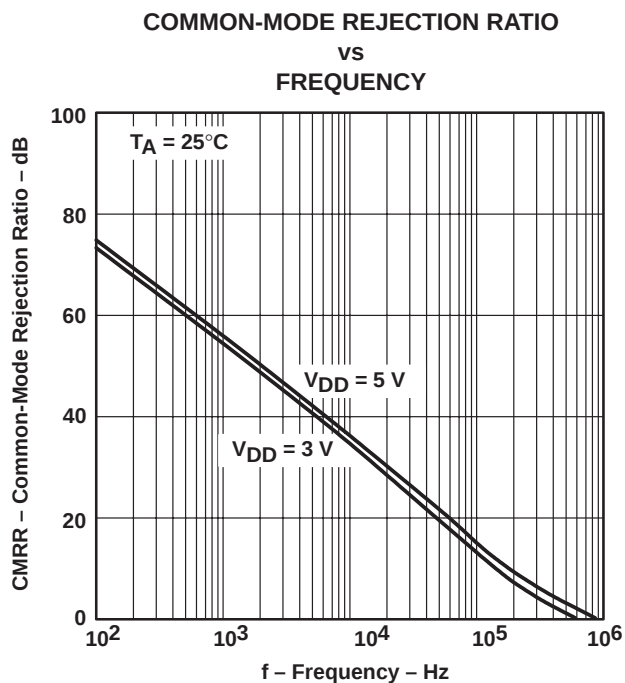


Figure 25

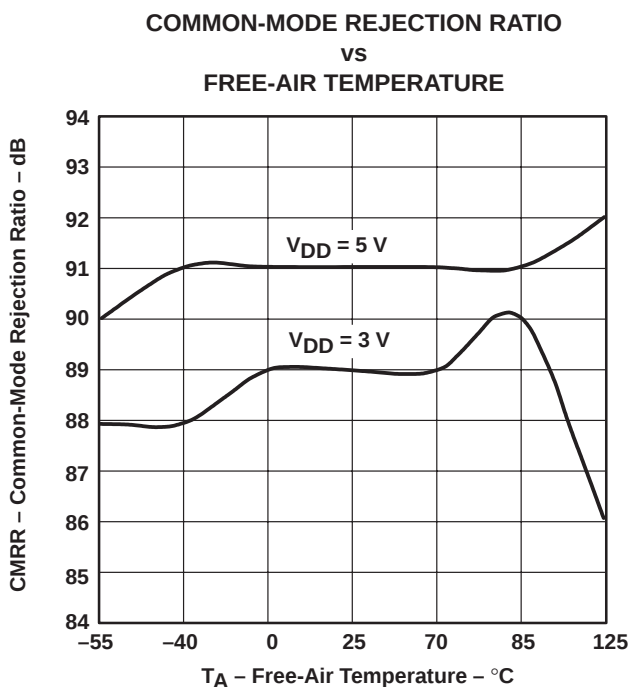


Figure 26

TYPICAL CHARACTERISTICS

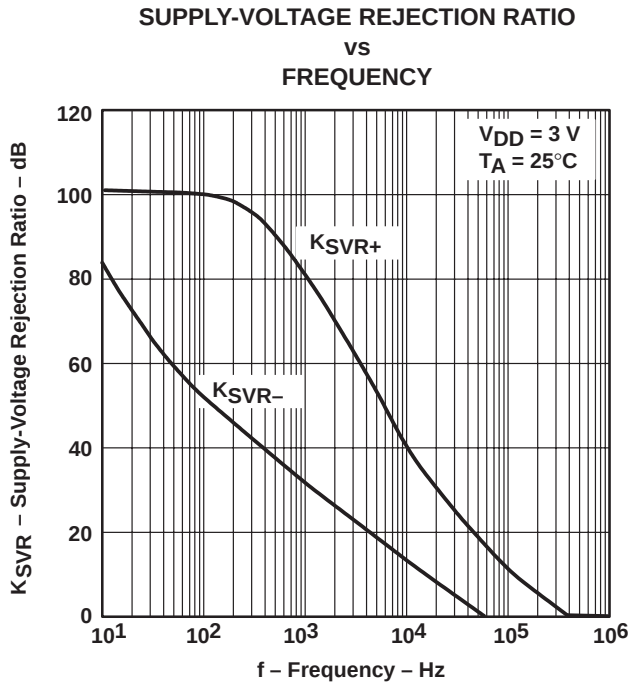


Figure 27

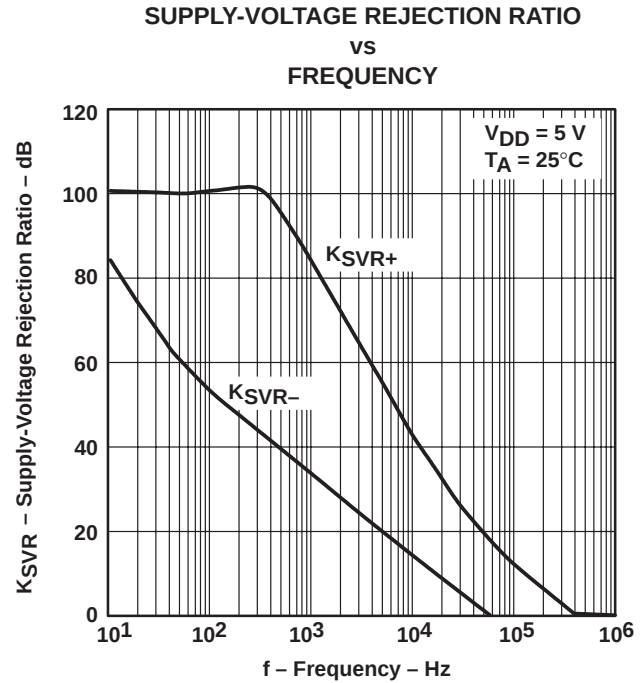


Figure 28

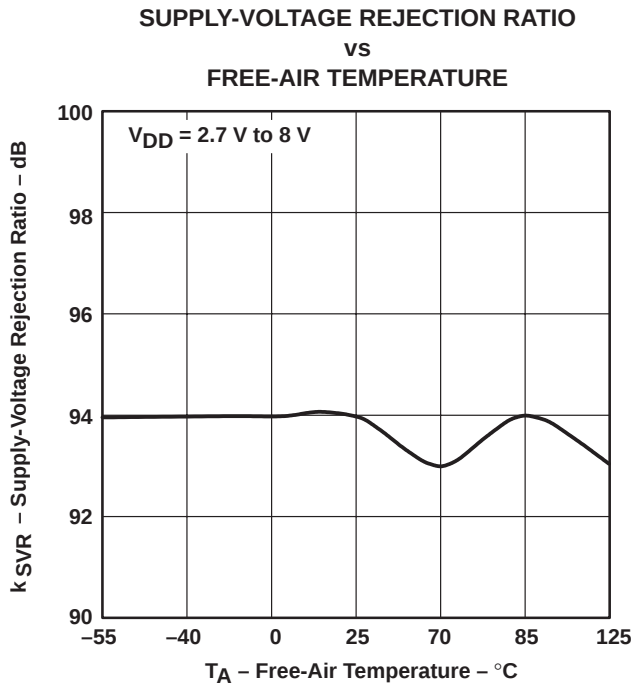


Figure 29

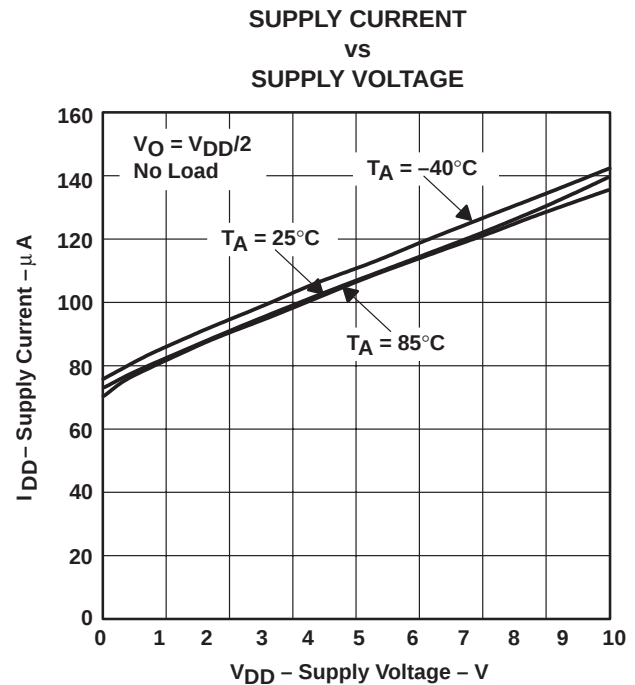


Figure 30

TYPICAL CHARACTERISTICS

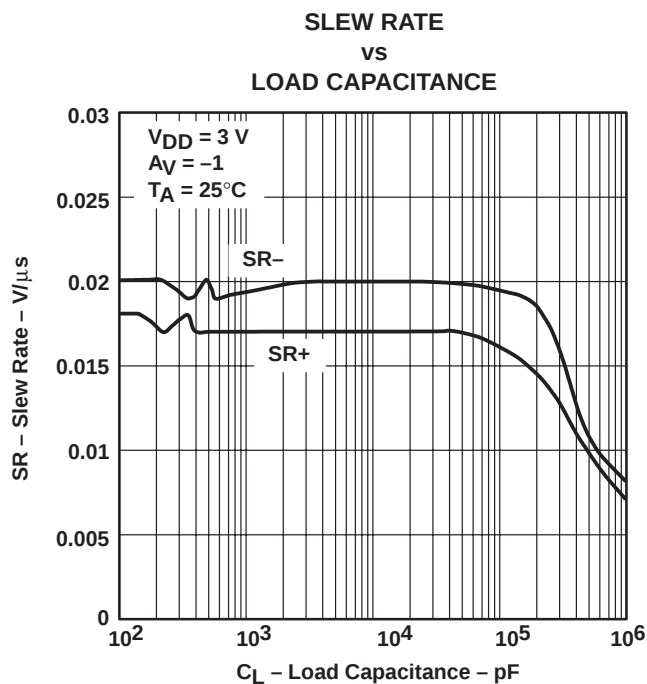


Figure 31

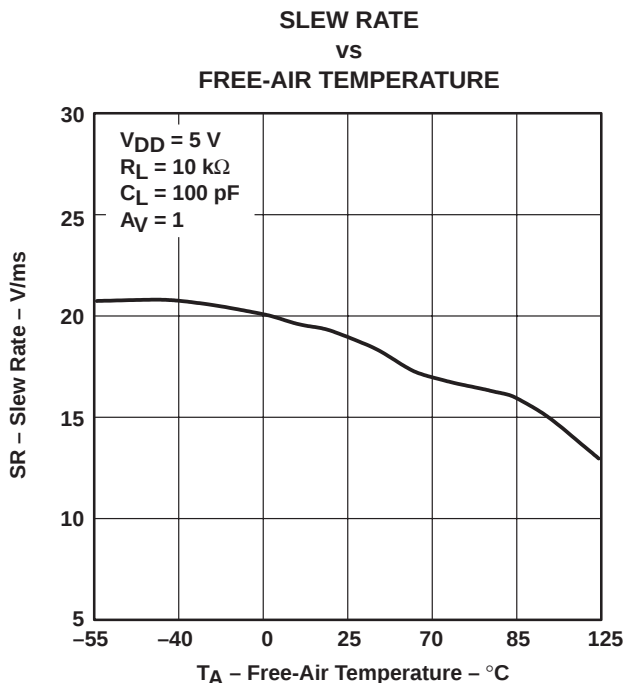


Figure 32

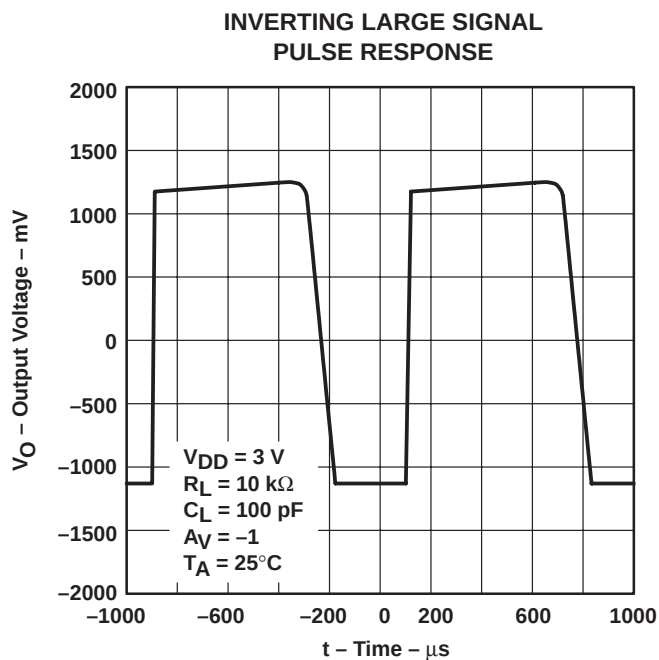


Figure 33

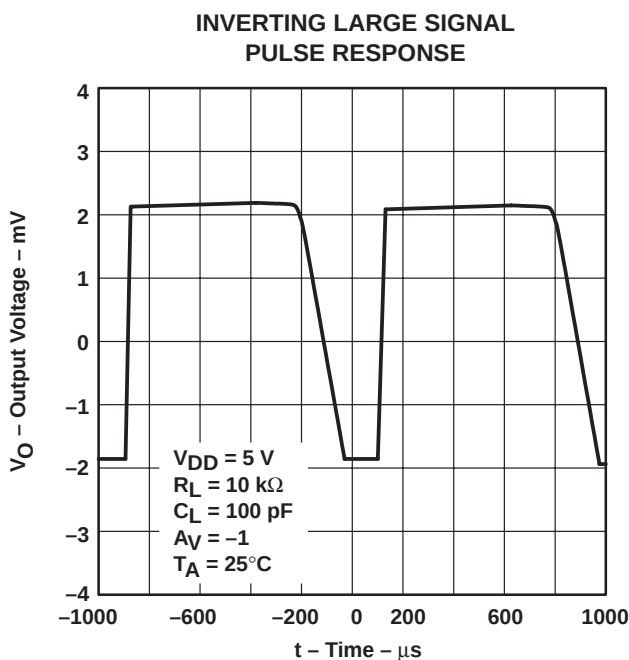


Figure 34

TYPICAL CHARACTERISTICS

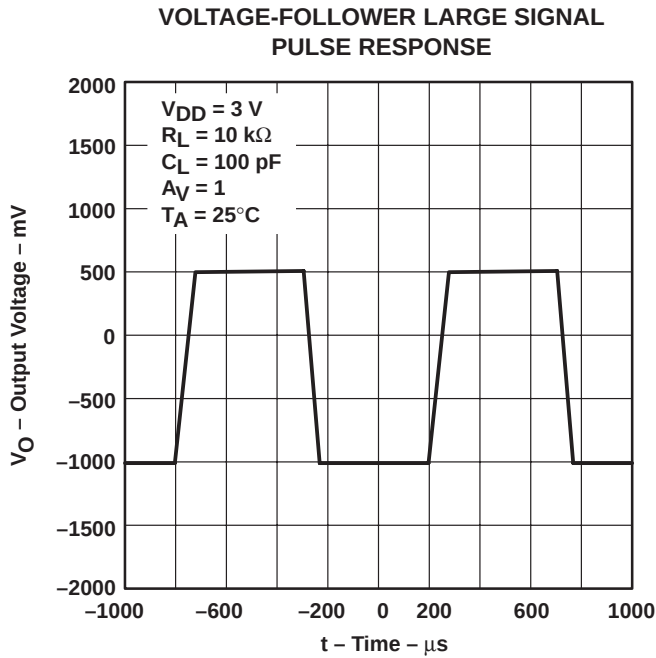


Figure 35

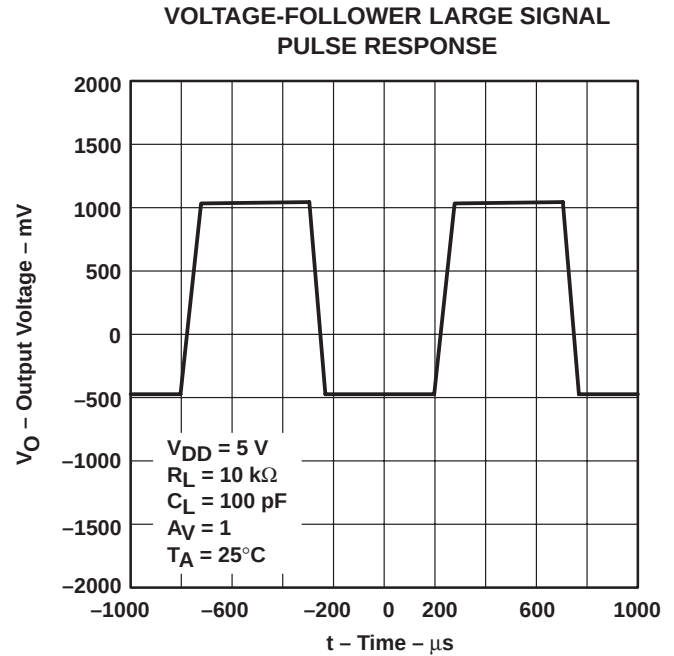


Figure 36

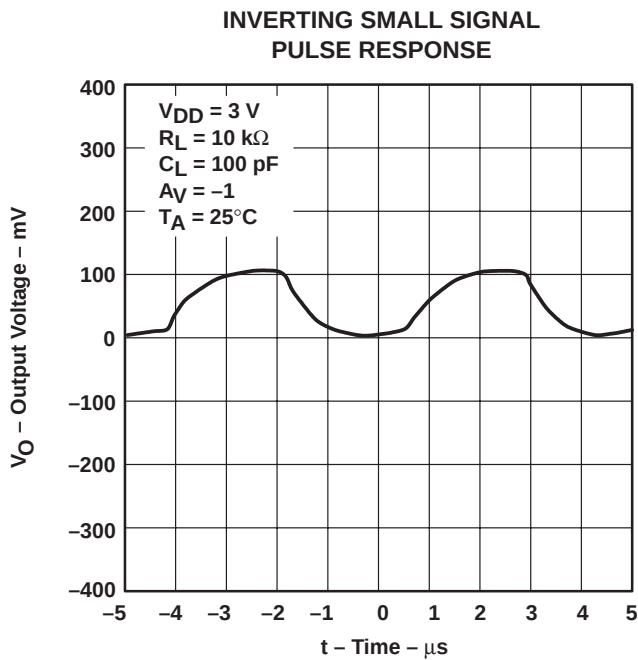


Figure 37

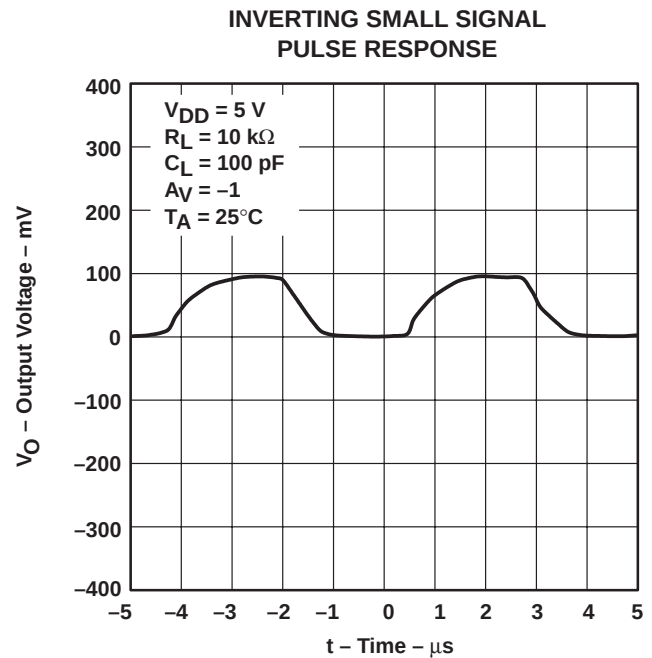


Figure 38

TLV2422, TLV2422A

Advanced LinCMOS™ RAIL-TO-RAIL OUTPUT

WIDE-INPUT-VOLTAGE MICROPOWER DUAL OPERATIONAL AMPLIFIERS

SLOS199B – SEPTEMBER 1997 – REVISED SEPTEMBER 1999

TYPICAL CHARACTERISTICS

VOLTAGE-FOLLOWER SMALL-SIGNAL
PULSE RESPONSE

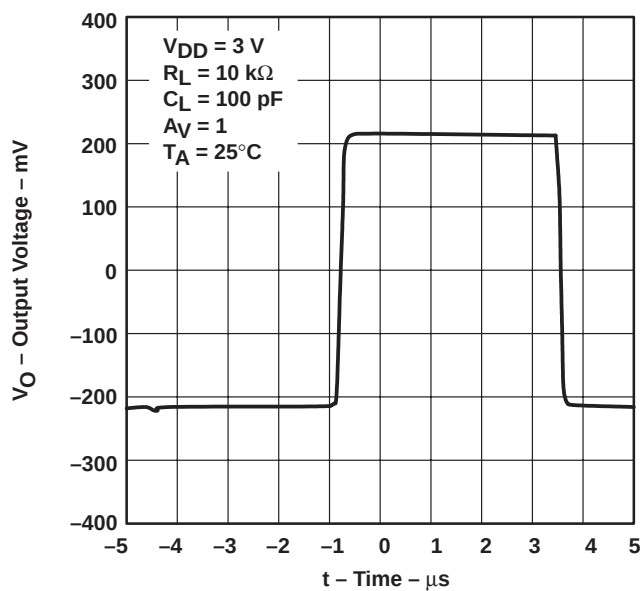


Figure 39

VOLTAGE-FOLLOWER SMALL-SIGNAL
PULSE RESPONSE

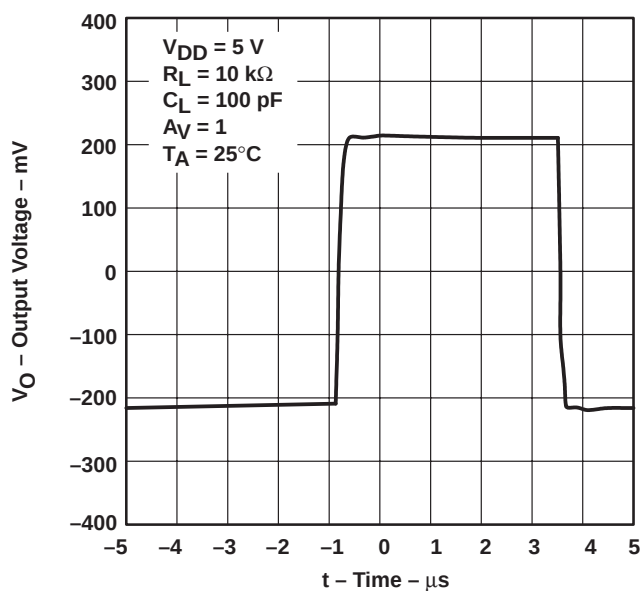


Figure 40

EQUIVALENT INPUT NOISE VOLTAGE
VS
FREQUENCY

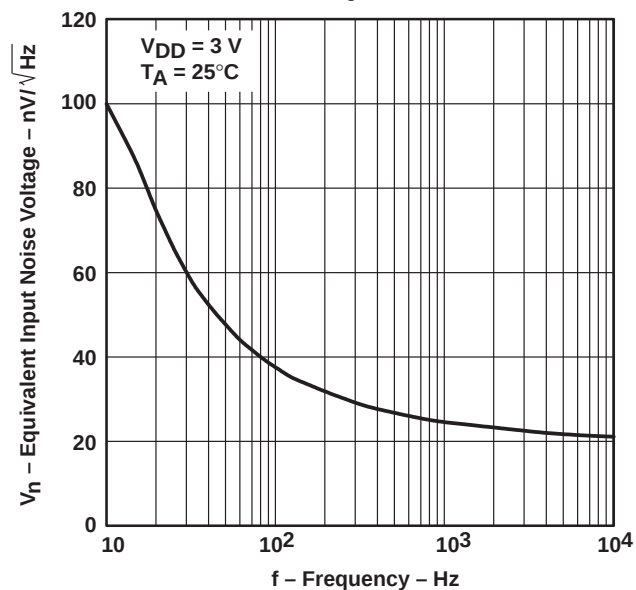


Figure 41

EQUIVALENT INPUT NOISE VOLTAGE
VS
FREQUENCY

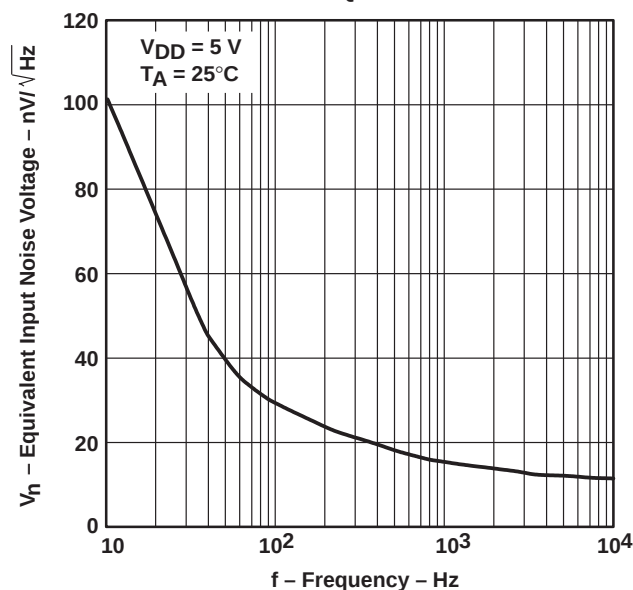


Figure 42

TYPICAL CHARACTERISTICS

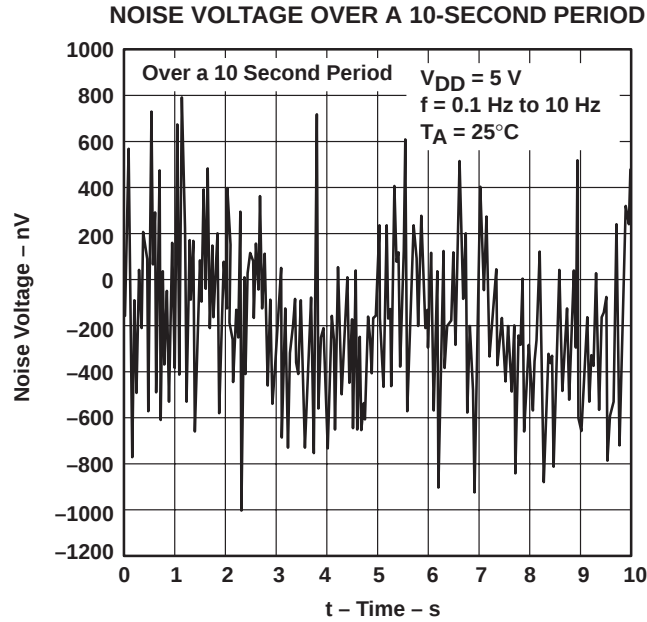


Figure 43

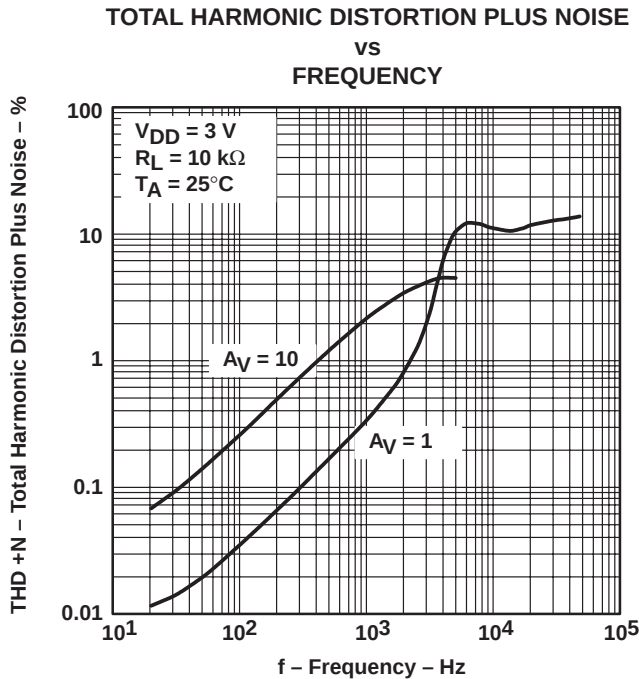


Figure 44

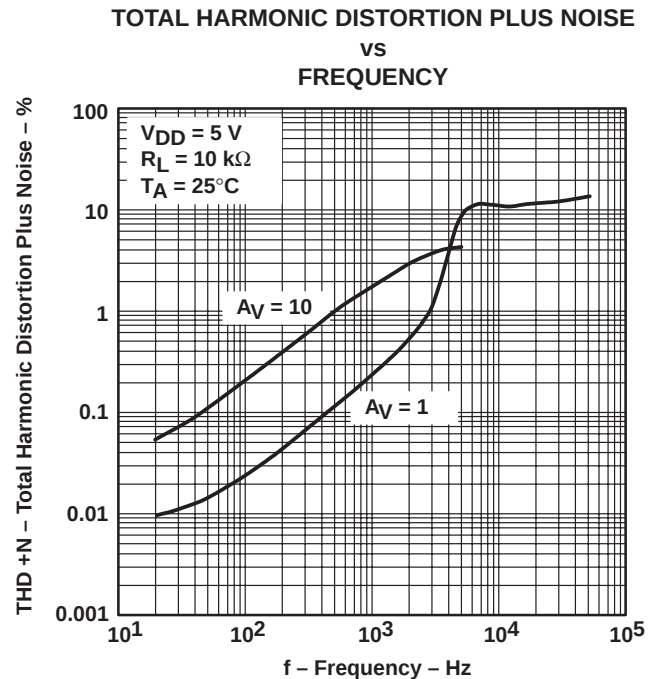


Figure 45

TYPICAL CHARACTERISTICS

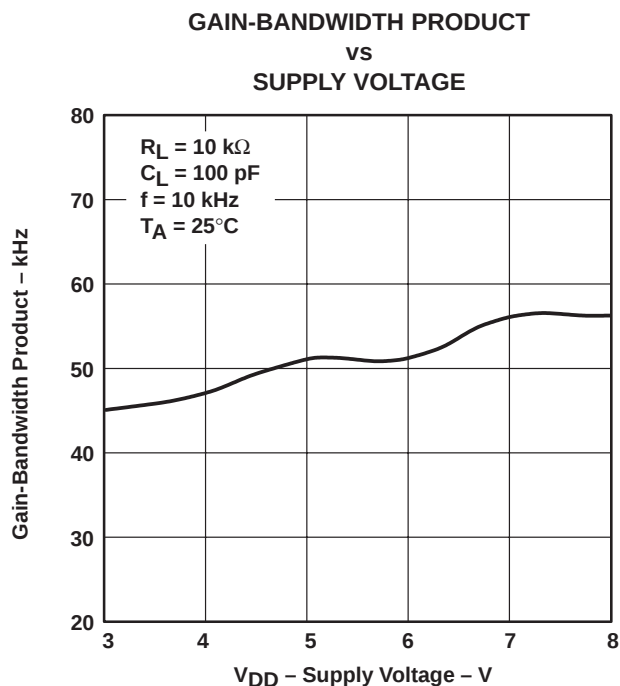


Figure 46

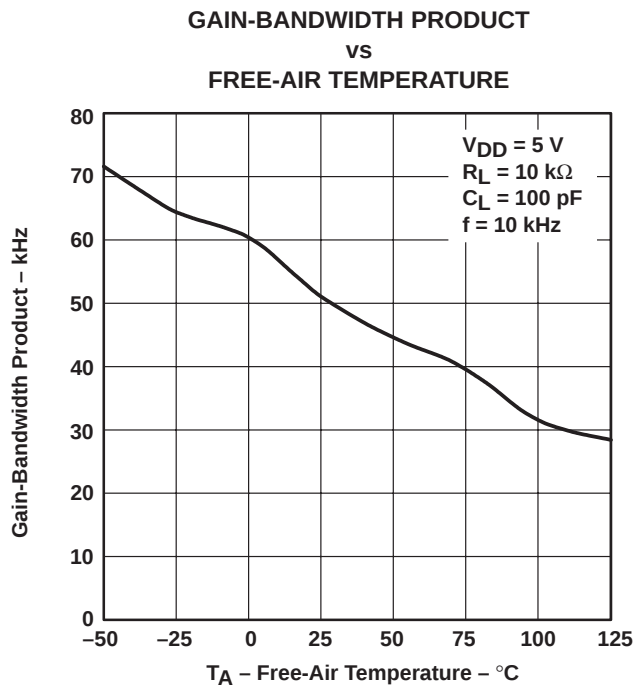


Figure 47

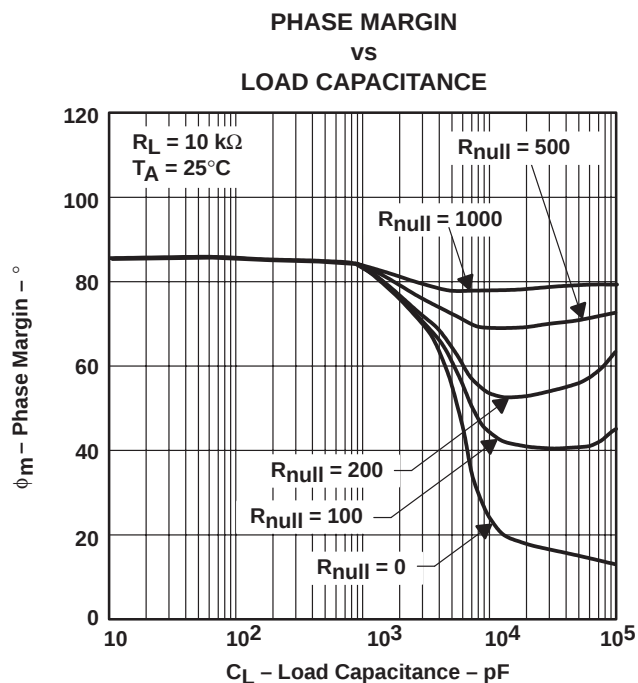


Figure 48

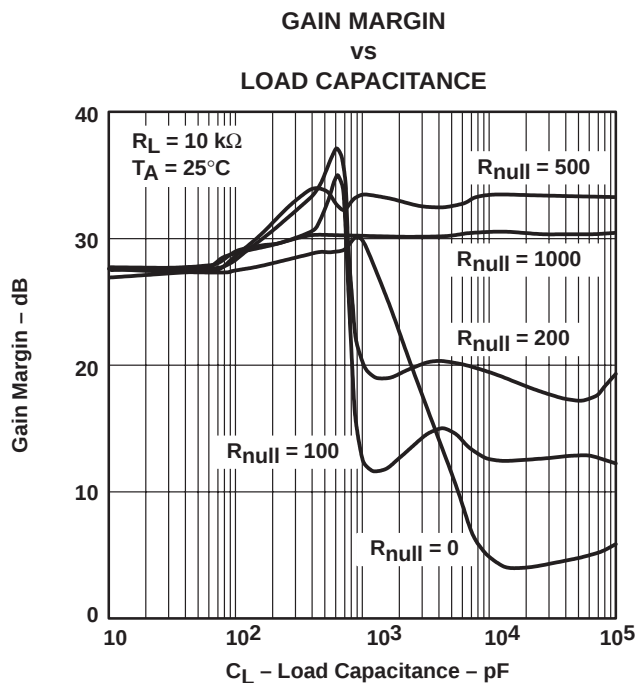


Figure 49

TYPICAL CHARACTERISTICS

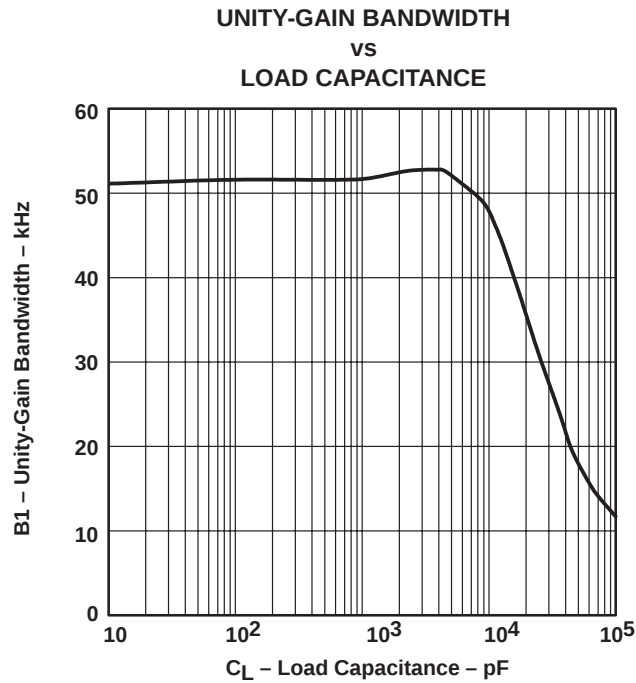


Figure 50

TLV2422, TLV2422A
Advanced LinCMOS™ RAIL-TO-RAIL OUTPUT
WIDE-INPUT-VOLTAGE MICROPOWER DUAL OPERATIONAL AMPLIFIERS

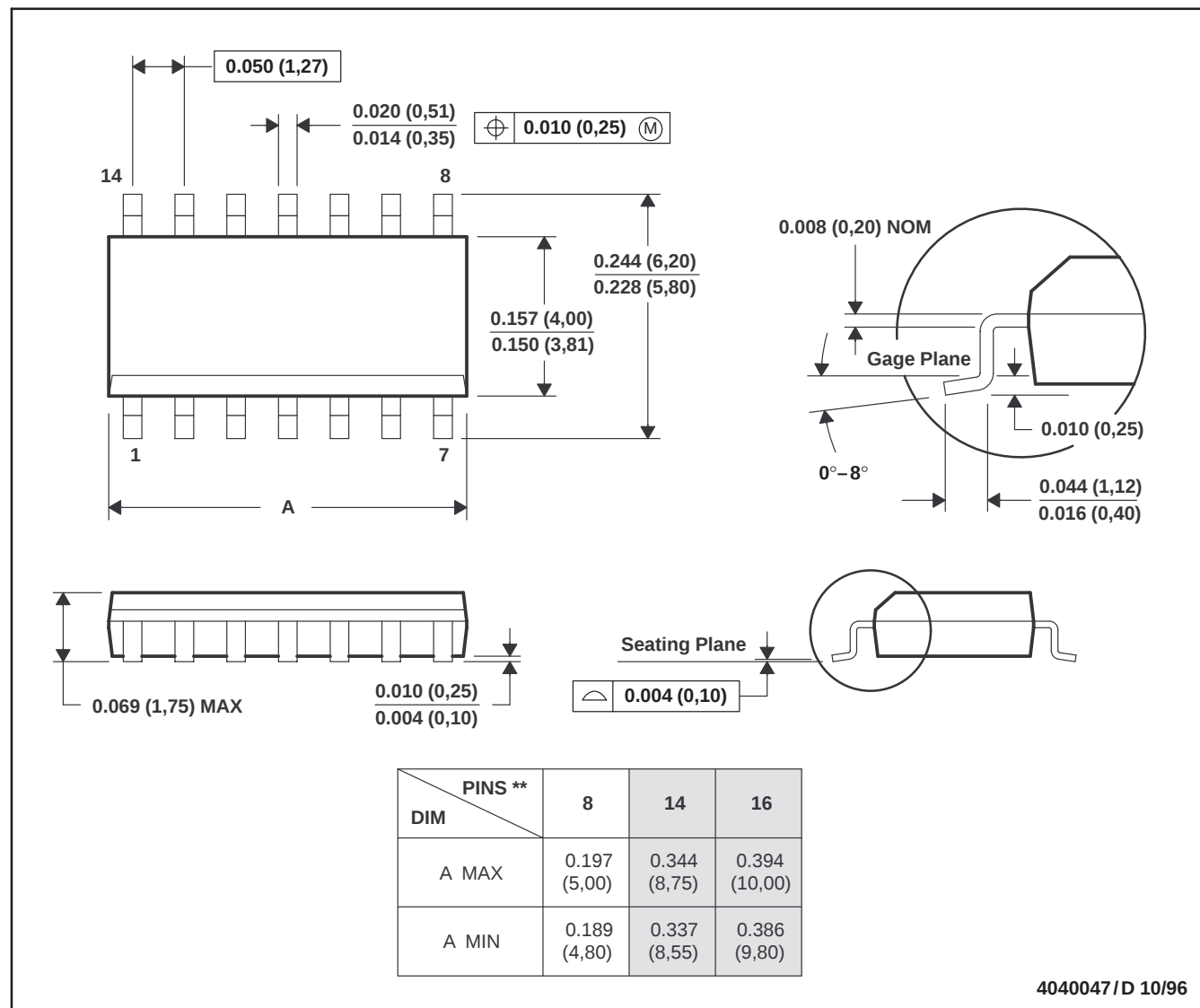
SLOS199B – SEPTEMBER1997 – REVISED SEPTEMBER 1999

MECHANICAL DATA

D (R-PDSO-G)**

PLASTIC SMALL-OUTLINE PACKAGE

14 PIN SHOWN



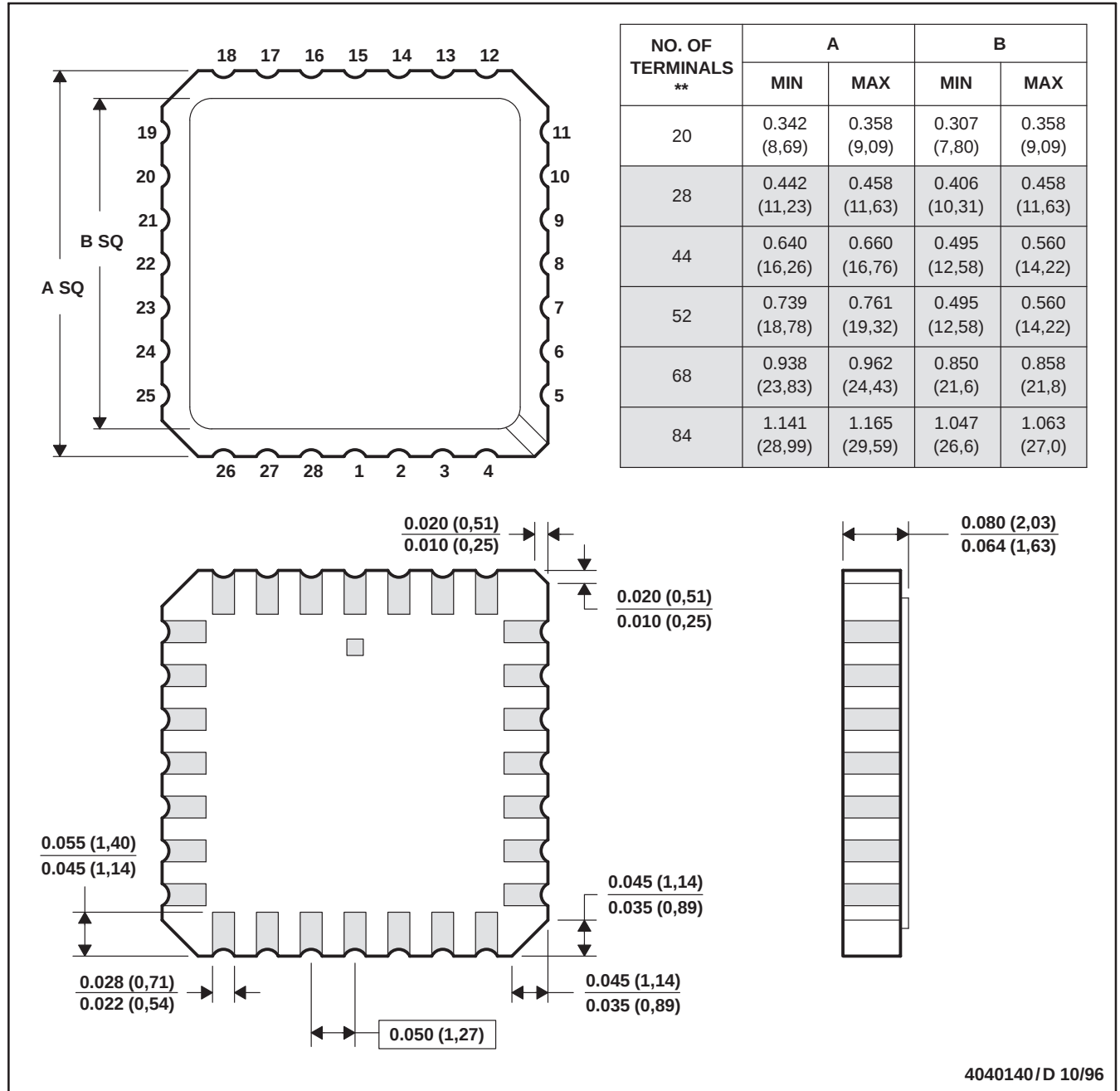
- NOTES: A. All linear dimensions are in inches (millimeters).
 B. This drawing is subject to change without notice.
 C. Body dimensions do not include mold flash or protrusion, not to exceed 0.006 (0,15).
 D. Falls within JEDEC MS-012

MECHANICAL DATA

FK (S-CQCC-N**)

LEADLESS CERAMIC CHIP CARRIER

28 TERMINAL SHOWN



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

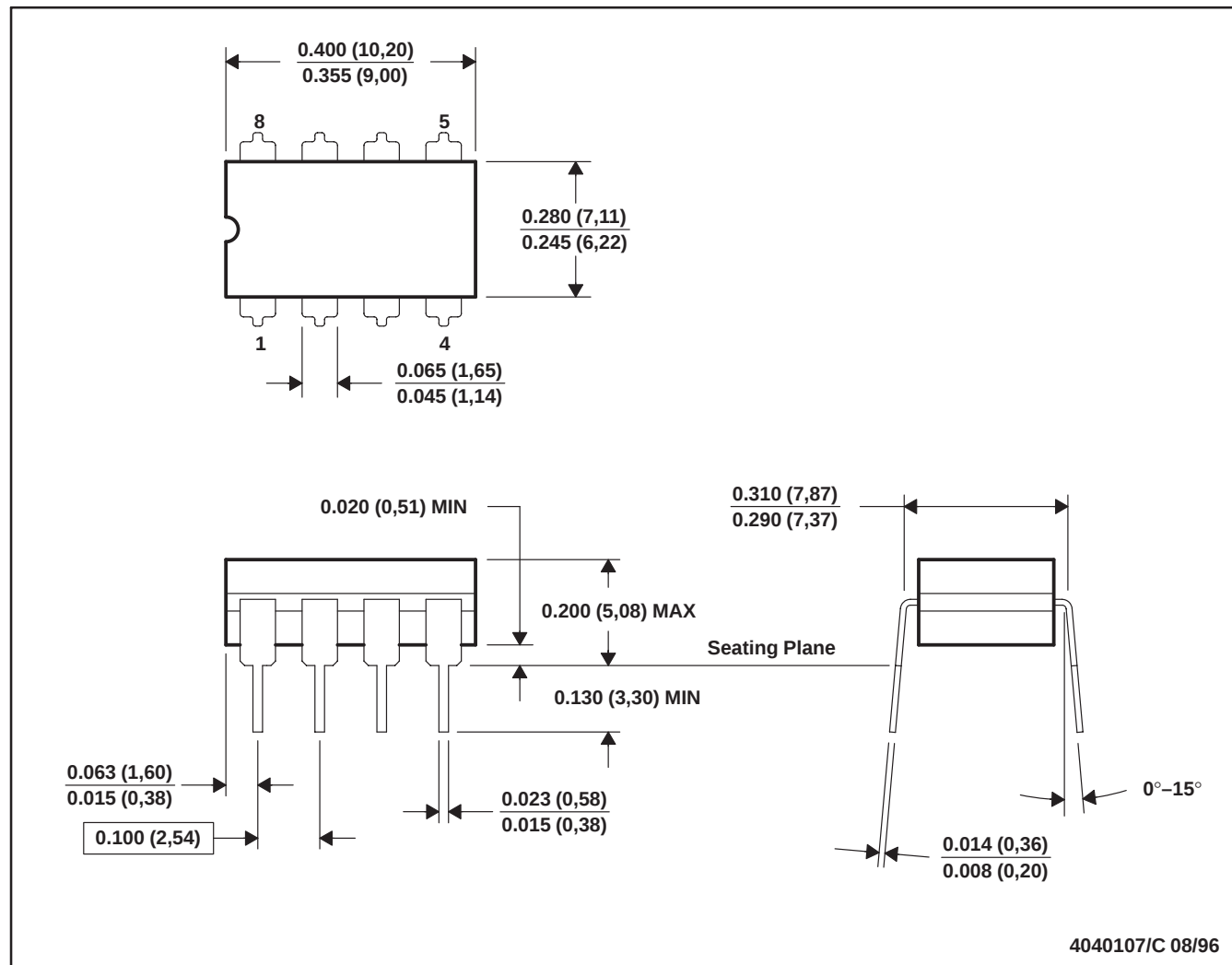
TLV2422, TLV2422A
Advanced LinCMOS™ RAIL-TO-RAIL OUTPUT
WIDE-INPUT-VOLTAGE MICROPOWER DUAL OPERATIONAL AMPLIFIERS

SLOS199B – SEPTEMBER 1997 – REVISED SEPTEMBER 1999

MECHANICAL DATA

JG (R-GDIP-T8)

CERAMIC DUAL-IN-LINE PACKAGE



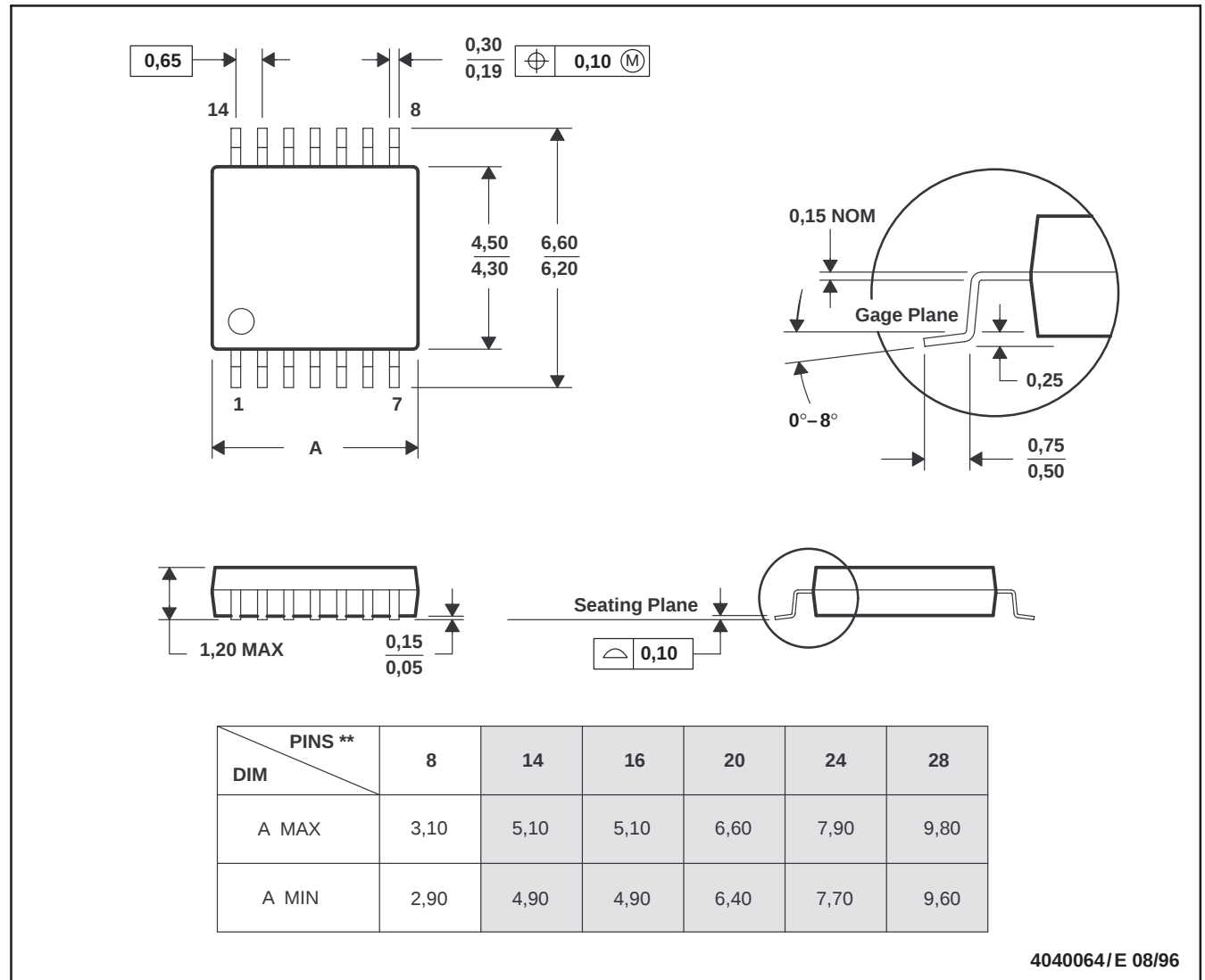
- NOTES: A. All linear dimensions are in inches (millimeters).
 B. This drawing is subject to change without notice.
 C. This package can be hermetically sealed with a ceramic lid using glass frit.
 D. Index point is provided on cap for terminal identification only on press ceramic glass frit seal only.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

MECHANICAL DATA

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

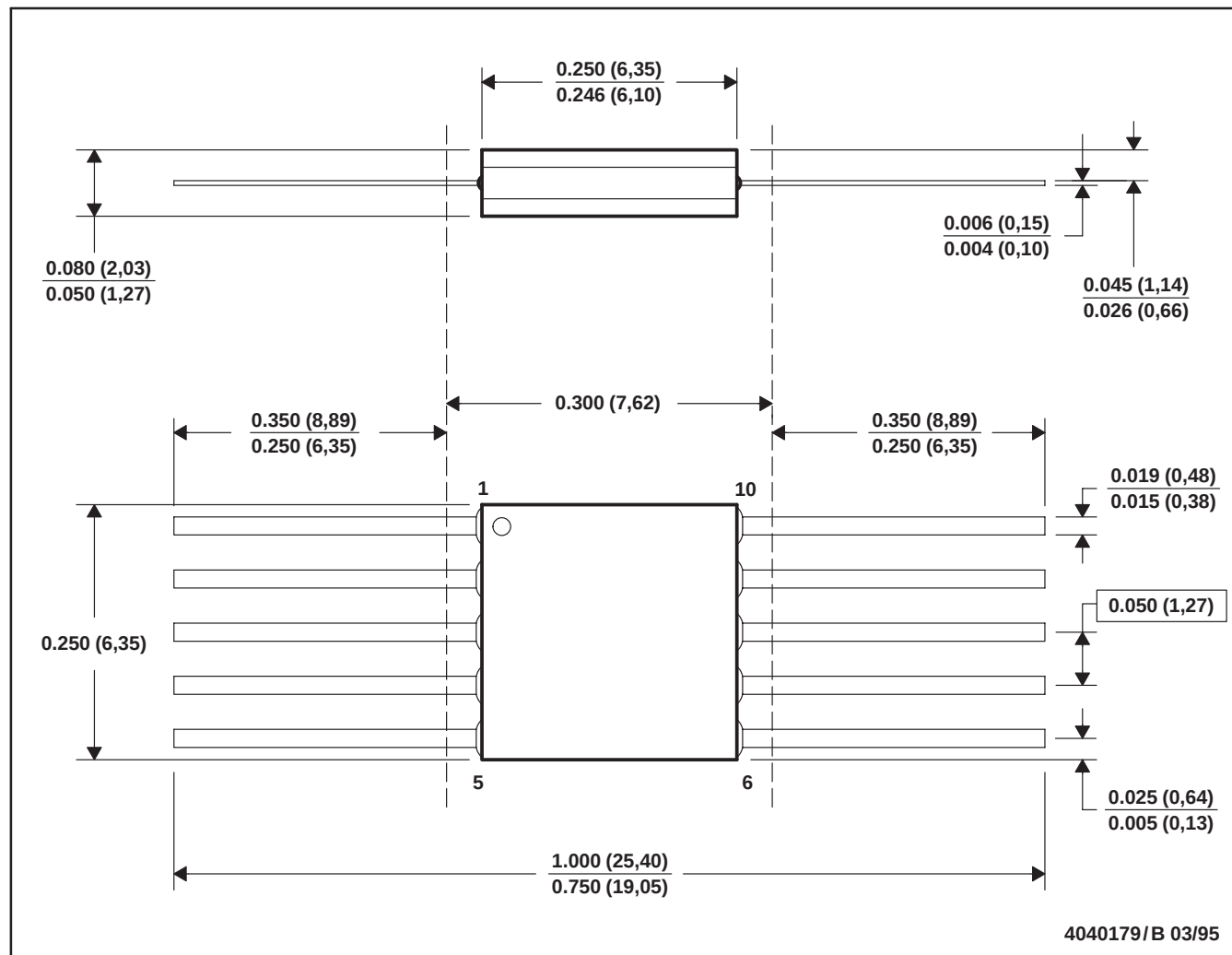
TLV2422, TLV2422A
Advanced LinCMOS™ RAIL-TO-RAIL OUTPUT
WIDE-INPUT-VOLTAGE MICROPOWER DUAL OPERATIONAL AMPLIFIERS

SLOS199B – SEPTEMBER 1997 – REVISED SEPTEMBER 1999

MECHANICAL DATA

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

IMPORTANT NOTICE

Texas Instruments and its subsidiaries (TI) reserve the right to make changes to their products or to discontinue any product or service without notice, and advise customers to obtain the latest version of relevant information to verify, before placing orders, that information being relied on is current and complete. All products are sold subject to the terms and conditions of sale supplied at the time of order acknowledgement, including those pertaining to warranty, patent infringement, and limitation of liability.

TI warrants performance of its semiconductor products to the specifications applicable at the time of sale in accordance with TI's standard warranty. Testing and other quality control techniques are utilized to the extent TI deems necessary to support this warranty. Specific testing of all parameters of each device is not necessarily performed, except those mandated by government requirements.

CERTAIN APPLICATIONS USING SEMICONDUCTOR PRODUCTS MAY INVOLVE POTENTIAL RISKS OF DEATH, PERSONAL INJURY, OR SEVERE PROPERTY OR ENVIRONMENTAL DAMAGE ("CRITICAL APPLICATIONS"). TI SEMICONDUCTOR PRODUCTS ARE NOT DESIGNED, AUTHORIZED, OR WARRANTED TO BE SUITABLE FOR USE IN LIFE-SUPPORT DEVICES OR SYSTEMS OR OTHER CRITICAL APPLICATIONS. INCLUSION OF TI PRODUCTS IN SUCH APPLICATIONS IS UNDERSTOOD TO BE FULLY AT THE CUSTOMER'S RISK.

In order to minimize risks associated with the customer's applications, adequate design and operating safeguards must be provided by the customer to minimize inherent or procedural hazards.

TI assumes no liability for applications assistance or customer product design. TI does not warrant or represent that any license, either express or implied, is granted under any patent right, copyright, mask work right, or other intellectual property right of TI covering or relating to any combination, machine, or process in which such semiconductor products or services might be or are used. TI's publication of information regarding any third party's products or services does not constitute TI's approval, warranty or endorsement thereof.