

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

SLOS168E – NOVEMBER 1996 – REVISED NOVEMBER 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 (TLV243xA)
- Low Input Bias Current . . . 1 pA Typ
- Very Low Supply Current . . . 125 μA Per Channel Max
- 600-Ω Output Drive
- Macromodel Included
- Available in Q-Temp Automotive HighRel Automotive Applications Configuration Control / Print Support Qualification to Automotive Standards

description

The TLV243x and TLV243xA are low-voltage operational amplifier from Texas Instruments. The common-mode input voltage range for each device is extended over the typical CMOS amplifiers making them suitable for a wide range of applications. In addition, these 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 TLV243x only requires 100 μA (typ) of supply current per channel, making it ideal for battery-powered applications. The TLV243x also has increased output drive over previous rail-to-rail operational amplifiers and can drive 600-Ω loads for telecom applications.

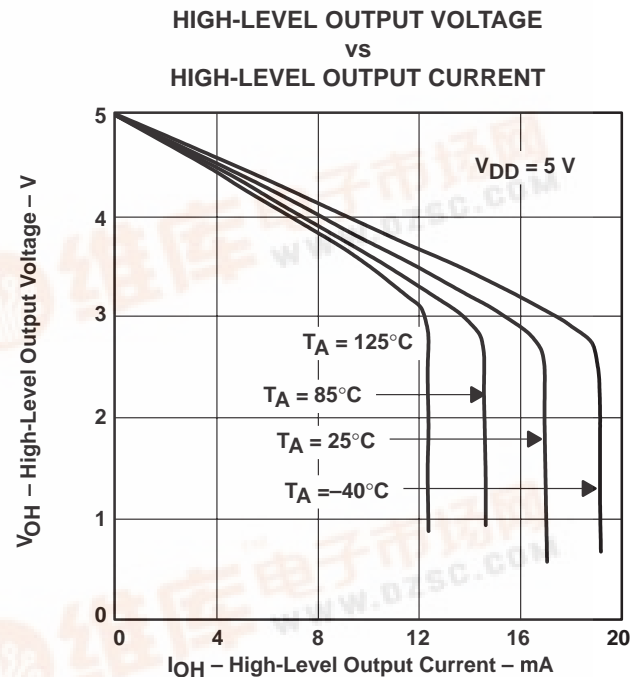


Figure 1

The other members in the TLV243x family are the high-power, TLV244x, and micro-power, TLV2422, versions.

The TLV243x, 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 TLV243xA is available and has 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.

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

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On products compliant to MIL-PRF-38535, all parameters are tested unless otherwise noted. On all other products, production processing does not necessarily include testing of all parameters.

TLV2432, TLV2432A, TLV2434, TLV2434A

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TLV2432 and TLV2432A AVAILABLE OPTIONS

T _A	V _{IO} max AT 25°C	PACKAGED DEVICES				
		SMALL OUTLINE (D)	CHIP CARRIER (FK)	CERAMIC DIP (JG)	TSSOP (PW)	CERAMIC FLAT PACK (U)
0°C to 70°C	2.5 mV	TLV2432CD	—	—	TLV2432CPW	—
–40°C to 85°C	950 μV 2.5 mV	TLV2432AID TLV2432ID	— —	— —	TLV2432AIPW —	— —
–40°C to 125°C	950 μV 2.5 mV	TLV2432AQD TLV2432QD	— —	— —	— —	— —
–55°C to 125°C	950 μV 2.5 mV	— —	TLV2432AMFK TLV2432MFK	TLV2432AMJG TLV2432MJG	— —	TLV2432AMU TLV2432MU

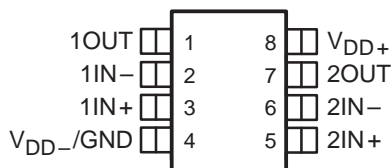
The D packages are available taped and reeled. Add R suffix to device type (e.g., TLV2432CDR). The PW package is available only left-end taped and reeled.

TLV2434 AVAILABLE OPTIONS

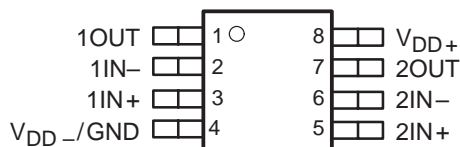
T _A	V _{IO} max AT 25°C	PACKAGED DEVICES	
		SMALL OUTLINE (D)	TSSOP (PW)
0°C to 70°C	2.5 mV	TLV2434CD	TLV2434CPW
–40°C to 125°C	950 μV 2.5 mV	TLV2434AID TLV2434ID	TLV2434AIPW TLV2434IPW

The D packages are available taped and reeled. Add R suffix to device type (e.g., TLV2434CDR). The PW package is available only left-end taped and reeled.

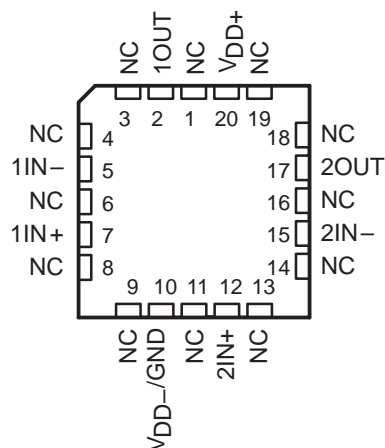
**TLV2432
D OR JG PACKAGE
(TOP VIEW)**



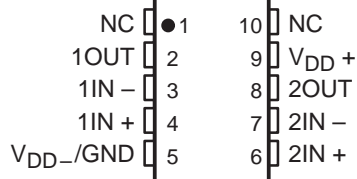
**TLV2432
PW PACKAGE
(TOP VIEW)**



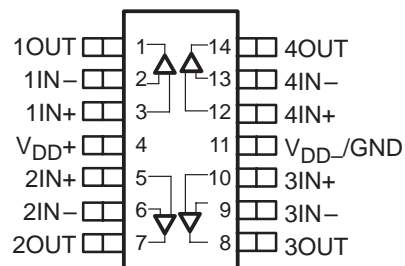
**TLV2432
FK PACKAGE
(TOP VIEW)**



**TLV2432
U PACKAGE
(TOP VIEW)**



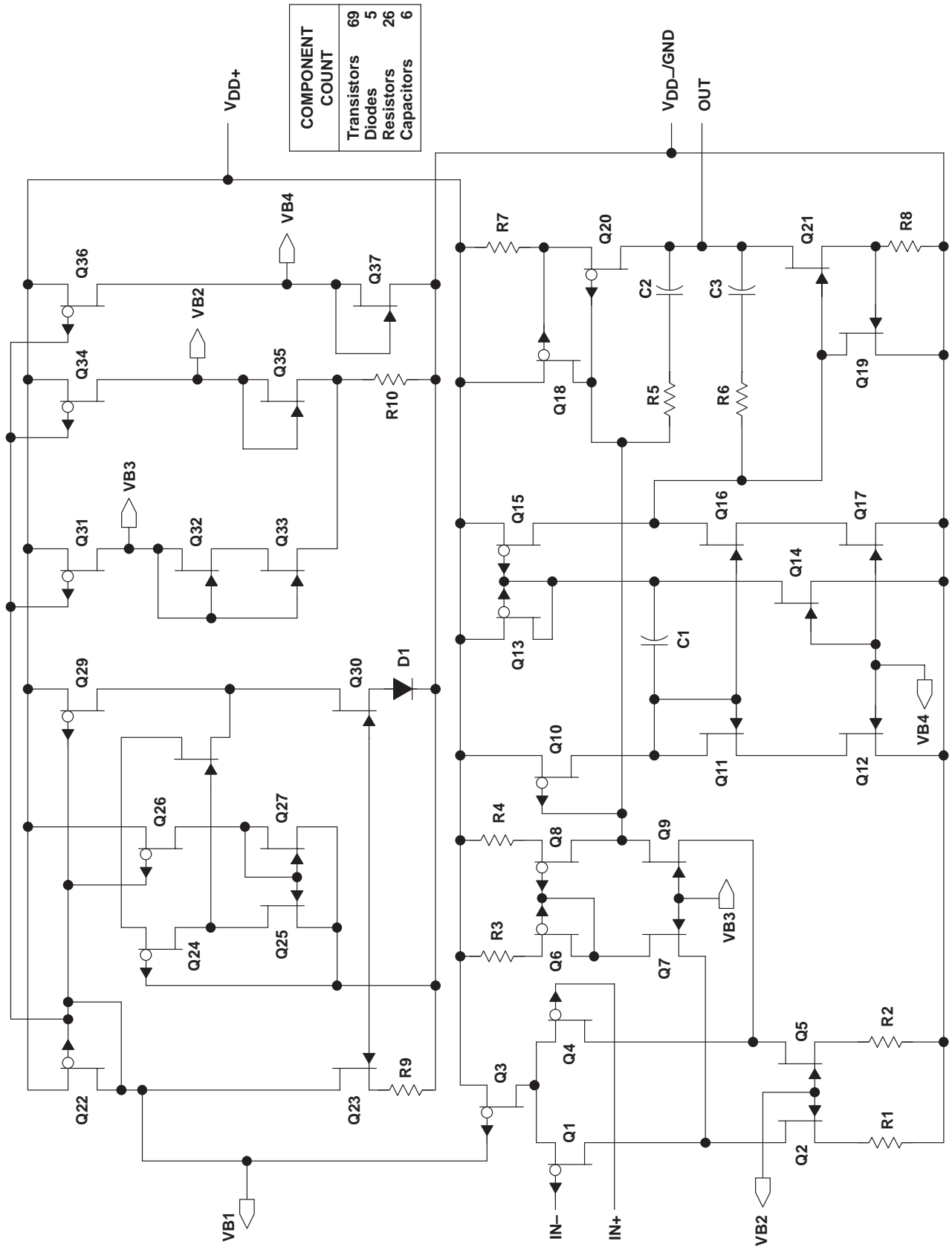
**TLV2434
D OR PW PACKAGE
(TOP VIEW)**



NC – No internal connection

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equivalent schematic (each amplifier)



COMPONENT COUNT	
Transistors	69
Diodes	5
Resistors	26
Capacitors	6

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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 dissipation	See Dissipation Rating Table
Operating free-air temperature range, T_A : C suffix	0°C to 70°C
I suffix (dual)	-40°C to 85°C
I suffix (quad)	-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 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 (8)	725 mW	5.8 mW/°C	464 mW	377 mW	145 mW
D (14)	1022 mW	7.6 mW/°C	900 mW	777 mW	450 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 (8)	525 mW	4.2 mW/°C	336 mW	273 mW	105 mW
PW (14)	720 mW	5.6 mW/°C	634 mW	547 mW	317 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}	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-}	$V_{DD+} - 1.3$	V_{DD-}	$V_{DD+} - 1.3$	V_{DD-}	$V_{DD+} - 1.3$	V_{DD-}	$V_{DD+} - 1.3$	V
Operating free-air temperature, T_A	0	70	-40	125	-40	125	-55	125	°C

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

PARAMETER	TEST CONDITIONS	T_A †	TLV243x			UNIT
			MIN	TYP	MAX	
V_{IO} Input offset voltage	$V_{IC} = 0,$ $V_O = 0,$ $V_{DD} \pm = \pm 1.5\text{ V},$ $R_S = 50\ \Omega$	TLV243xC, TLV243xI	25°C	300	2000	μV
			Full range	2500		
		TLV243xAI	25°C	300	950	
			Full range	1500		
α_{VIO} Temperature coefficient of input offset voltage	$V_{IC} = 0,$ $V_O = 0,$ $V_{DD} \pm = \pm 1.5\text{ V},$ $R_S = 50\ \Omega$	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 2.5	-0.25 to 2.75	V	
		Full range	0 to 2.2			
V_{OH} High-level output voltage	$I_{OH} = -100\ \mu\text{A}$	25°C	2.98		V	
	$I_{OH} = -3\text{ mA}$	25°C	2.5			
		Full range	2.25			
V_{OL} Low-level output voltage	$V_{IC} = 1.5\text{ V},$ $I_{OL} = 100\ \mu\text{A}$	25°C	0.02		V	
	$V_{IC} = 1.5\text{ V},$ $I_{OL} = 3\text{ mA}$	25°C	0.83			
		Full range	1			
A_{VD} Large-signal differential voltage amplification	$V_{IC} = 2.5\text{ V},$ $V_O = 1\text{ V to }2\text{ V}$	$R_L = 2\text{ k}\Omega$ ‡	25°C	1.5	2.5	V/mV
		$R_L = 1\text{ M}\Omega$ ‡	Full range	1		
			25°C	750		
$r_{i(d)}$ Differential input resistance		25°C	1000		G Ω	
$r_{i(c)}$ Common-mode input resistance		25°C	1000		G 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	$V_{IC} = 0\text{ to }2.5\text{ V},$ $V_O = 1.5\text{ V},$ $R_S = 50\ \Omega$	25°C	70	83	dB	
		Full range	70			
k_{SVR} Supply-voltage rejection ratio ($\Delta V_{DD}/\Delta V_{IO}$)	$V_{DD} = 2.7\text{ V to }8\text{ V},$ $V_{IC} = V_{DD}/2,$ No load	25°C	80	95	dB	
		Full range	80			
I_{DD} Supply current (per channel)	$V_O = 1.5\text{ V},$ No load	25°C	98	125	μA	
		Full range	125			

† Full range for the C suffix is 0°C to 70°C. Full range for the dual I suffix is -40°C to 85°C. Full range for the quad I suffix is -40°C to 125°C.

‡ Referenced to 2.5 V

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

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

PARAMETER	TEST CONDITIONS	T_A †	TLV243x			UNIT
			MIN	TYP	MAX	
SR Slew rate at unity gain	$V_O = 1\text{ V to }2\text{ V},$ $C_L = 100\text{ pF}‡$ $R_L = 2\text{ k}\Omega‡$	25°C	0.15	0.25		V/ μ s
		Full range	0.1			
V_n Equivalent input noise voltage	$f = 10\text{ Hz}$	25°C	120		nV/ $\sqrt{\text{Hz}}$	
	$f = 1\text{ kHz}$	25°C	22			
$V_{N(PP)}$ Peak-to-peak equivalent input noise voltage	$f = 0.1\text{ Hz to }1\text{ Hz}$	25°C	2.7		μ V	
	$f = 0.1\text{ Hz to }10\text{ Hz}$	25°C	4			
I_n Equivalent input noise current		25°C	0.6		fA/ $\sqrt{\text{Hz}}$	
THD + N Total harmonic distortion plus noise	$V_O = 0.5\text{ V to }2.5\text{ V},$ $f = 1\text{ kHz},$ $R_L = 2\text{ k}\Omega‡$	25°C	$A_V = 1$	0.065%		
			$A_V = 10$	0.5%		
Gain-bandwidth product	$f = 10\text{ kHz},$ $C_L = 100\text{ pF}‡$ $R_L = 2\text{ k}\Omega‡$	25°C	0.5		MHz	
BOM Maximum output-swing bandwidth	$V_{O(PP)} = 1\text{ V},$ $R_L = 2\text{ k}\Omega‡$ $A_V = 1,$ $C_L = 100\text{ pF}‡$	25°C	220		kHz	
t_s Settling time	$A_V = -1,$ Step = 0.5 V to 2.5 V, $R_L = 2\text{ k}\Omega‡$ $C_L = 100\text{ pF}‡$	25°C	$T_o = 0.1\%$	6.4		μ s
			$T_o = 0.01\%$	14.1		
ϕ_m Phase margin at unity gain	$R_L = 2\text{ k}\Omega‡$ $C_L = 100\text{ pF}‡$	25°C	62°			
Gain margin		25°C	11		dB	

† Full range for the C suffix is 0°C to 70°C. Full range for the dual I suffix is –40°C to 85°C. Full range for the quad I suffix is –40°C to 125°C.

‡ Referenced to 2.5 V

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

PARAMETER	TEST CONDITIONS	T_A †	TLV243xQ, TLV243xM			UNIT
			MIN	TYP	MAX	
V_{IO} Input offset voltage	$V_{IC} = 0,$ $V_O = 0,$ $V_{DD} \pm \pm 1.5\text{ V},$ $R_S = 50\ \Omega$	TLV243xQ, TLV243xM	25°C	300	2000	μV
			Full range	2500		
		TLV243xAQ, TLV243xAM	25°C	300	950	
			Full range	2000		
α_{VIO} Temperature coefficient of input offset voltage	$V_{IC} = 0,$ $V_O = 0,$ $V_{DD} \pm \pm 1.5\text{ V},$ $R_S = 50\ \Omega$	25°C to 70°C	2		$\mu\text{V}/^\circ\text{C}$	
Input offset voltage long-term drift (see Note 4)			0.003		$\mu\text{V}/\text{mo}$	
I_{IO} Input offset current			0.5		150	pA
			Full range			
I_{IB} Input bias current		25°C	1		pA	
			Full range	300		
V_{ICR} Common-mode input voltage range	$ V_{IO} \leq 5\text{ mV},$ $R_S = 50\ \Omega$	25°C	0 to 2.5	-0.25 to 2.75	V	
		Full range	0 to 2.2			
V_{OH} High-level output voltage	$I_{OH} = -100\ \mu\text{A}$ $I_{OH} = -3\text{ mA}$	25°C	2.98		V	
		25°C	2.5			
		Full range	2.25			
V_{OL} Low-level output voltage	$V_{IC} = 1.5\text{ V},$ $I_{OL} = 100\ \mu\text{A}$ $V_{IC} = 1.5\text{ V},$ $I_{OL} = 3\text{ mA}$	25°C	0.02		V	
		25°C	0.83			
		Full range	1			
A_{VD} Large-signal differential voltage amplification	$V_{IC} = 2.5\text{ V},$ $V_O = 1\text{ V to }2\text{ V}$	25°C	$R_L = 2\text{ k}\Omega$ ‡	1.5	2.5	V/mV
			Full range	0.5		
		25°C	$R_L = 1\text{ M}\Omega$ ‡		750	
$r_{i(d)}$ Differential input resistance		25°C	1000		$\text{G}\Omega$	
$r_{i(c)}$ Common-mode input resistance		25°C	1000		$\text{G}\Omega$	
$c_{i(c)}$ 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	$V_{IC} = 0\text{ to }2.5\text{ V},$ $V_O = 1.5\text{ V},$ $R_S = 50\ \Omega$	25°C	70	83	dB	
		Full range	70			
k_{SVR} Supply-voltage rejection ratio ($\Delta V_{DD}/\Delta V_{IO}$)	$V_{DD} = 2.7\text{ V to }8\text{ V},$ $V_{IC} = V_{DD}/2,$ No load	25°C	80	95	dB	
		Full range	80			
I_{DD} Supply current	$V_O = 1.5\text{ V},$ No load	25°C	195	250	μA	
		Full range	260			

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

‡ Referenced to 2.5 V

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

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

PARAMETER	TEST CONDITIONS	T_A †	TLV243xQ, TLV243xM, TLV243xAQ, TLV243xAM			UNIT
			MIN	TYP	MAX	
SR Slew rate at unity gain	$V_O = 1\text{ V to }2\text{ V},$ $C_L = 100\text{ pF}‡$	$R_L = 2\text{ k}\Omega‡,$	25°C	0.15	0.25	V/ μs
			Full range	0.1		
V_n Equivalent input noise voltage	$f = 10\text{ Hz}$	25°C	120		nV/ $\sqrt{\text{Hz}}$	
	$f = 1\text{ kHz}$	25°C	22			
$V_{N(PP)}$ Peak-to-peak equivalent input noise voltage	$f = 0.1\text{ Hz to }1\text{ Hz}$	25°C	2.7		μV	
	$f = 0.1\text{ Hz to }10\text{ Hz}$	25°C	4			
I_n Equivalent input noise current		25°C	0.6		fA/ $\sqrt{\text{Hz}}$	
THD + N Total harmonic distortion plus noise	$V_O = 0.5\text{ V to }2.5\text{ V},$ $f = 1\text{ kHz},$ $R_L = 2\text{ k}\Omega‡$	$A_V = 1$	0.065%			
		$A_V = 10$	0.5%			
Gain-bandwidth product	$f = 10\text{ kHz},$ $C_L = 100\text{ pF}‡$	$R_L = 2\text{ k}\Omega‡,$	25°C	0.5		MHz
B_{OM} Maximum output-swing bandwidth	$V_{O(PP)} = 1\text{ V},$ $R_L = 2\text{ k}\Omega‡,$	$A_V = 1,$ $C_L = 100\text{ pF}‡$	25°C	220		kHz
t_s Settling time	$A_V = -1,$ Step = 0.5 V to 2.5 V, $R_L = 2\text{ k}\Omega‡,$ $C_L = 100\text{ pF}‡$	$T_o = 0.1\%$	25°C	6.4		μs
		$T_o = 0.01\%$		14.1		
ϕ_m Phase margin at unity gain	$R_L = 2\text{ k}\Omega‡,$	$C_L = 100\text{ pF}‡$	25°C	62°		
			25°C	11		
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

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

PARAMETER	TEST CONDITIONS	T_A †	TLV243x			UNIT
			MIN	TYP	MAX	
V_{IO} Input offset voltage	$V_{IC} = 0,$ $V_O = 0,$ $V_{DD} \pm = \pm 2.5\text{ V},$ $R_S = 50\ \Omega$	TLV243x	25°C	300	2000	μV
			Full range	2500		
		TLV243xA	25°C	300	950	
			Full range	1500		
α_{VIO} Temperature coefficient of input offset voltage	$V_{IC} = 0,$ $V_O = 0,$ $V_{DD} \pm = \pm 2.5\text{ V},$ $R_S = 50\ \Omega$	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	
	$I_{OH} = -5\text{ mA}$	25°C	4	4.35		
		Full range	4			
V_{OL} Low-level output voltage	$V_{IC} = 2.5\text{ V},$ $I_{OL} = 100\ \mu\text{A}$	25°C	0.01		V	
	$V_{IC} = 2.5\text{ V},$ $I_{OL} = 5\text{ mA}$	25°C	0.8			
		Full range	1.25			
A_{VD} Large-signal differential voltage amplification	$V_{IC} = 2.5\text{ V},$ $V_O = 1\text{ V to }4\text{ V}$	$R_L = 2\text{ k}\Omega$ ‡	25°C	2.5	3.8	V/mV
		$R_L = 1\text{ M}\Omega$ ‡	Full range	1.5		
			25°C	950		
$r_{i(d)}$ Differential input resistance		25°C	1000		G Ω	
$r_{i(c)}$ Common-mode input resistance		25°C	1000		G 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 ($\Delta V_{DD}/\Delta V_{IO}$)	$V_{DD} = 4.4\text{ V to }8\text{ V},$ $V_{IC} = V_{DD}/2,$ No load	25°C	80	95	dB	
		Full range	80			
I_{DD} Supply current (per channel)	$V_O = 2.5\text{ V},$ No load	25°C	100	125	μA	
		Full range	125			

† Full range for the C suffix is 0°C to 70°C. Full range for the dual I suffix is -40°C to 85°C. Full range for the quad I suffix is -40°C to 125°C.

‡ Referenced to 2.5 V

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

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

PARAMETER	TEST CONDITIONS	T_A †	TLV243x			UNIT
			MIN	TYP	MAX	
SR Slew rate at unity gain	$V_O = 1.5\text{ V to }3.5\text{ V}, R_L = 2\text{ k}\Omega\ddagger, C_L = 100\text{ pF}\ddagger$	25°C	0.15	0.25		V/ μ s
		Full range	0.1			
V_n Equivalent input noise voltage	$f = 10\text{ Hz}$	25°C	100		nV/ $\sqrt{\text{Hz}}$	
	$f = 1\text{ kHz}$	25°C	18			
$V_{N(PP)}$ Peak-to-peak equivalent input noise voltage	$f = 0.1\text{ Hz to }1\text{ Hz}$	25°C	1.9		μ V	
	$f = 0.1\text{ Hz to }10\text{ Hz}$	25°C	2.8			
I_n Equivalent input noise current		25°C	0.6		fA/ $\sqrt{\text{Hz}}$	
THD + N Total harmonic distortion plus noise	$V_O = 1.5\text{ V to }3.5\text{ V}, f = 1\text{ kHz}, R_L = 2\text{ k}\Omega\ddagger$	$A_V = 1$	0.045%			
		$A_V = 10$	0.4%			
Gain-bandwidth product	$f = 10\text{ kHz}, C_L = 100\text{ pF}\ddagger, R_L = 2\text{ k}\Omega\ddagger$	25°C	0.55		MHz	
BOM Maximum output-swing bandwidth	$V_{O(PP)} = 2\text{ V}, R_L = 2\text{ k}\Omega\ddagger, A_V = 1, C_L = 100\text{ pF}\ddagger$	25°C	100		kHz	
t_s Settling time	$A_V = -1, \text{ Step} = 1.5\text{ V to }3.5\text{ V}, R_L = 2\text{ k}\Omega\ddagger, C_L = 100\text{ pF}\ddagger$	To 0.1%	6.4		μ s	
		To 0.01%	13.1			
ϕ_m Phase margin at unity gain	$R_L = 2\text{ k}\Omega\ddagger, C_L = 100\text{ pF}\ddagger$	25°C	66°			
Gain margin		25°C	11		dB	

† Full range for the C suffix is 0°C to 70°C. Full range for the dual I suffix is -40°C to 85°C. Full range for the quad I suffix is -40°C to 125°C.

‡ Referenced to 2.5 V

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

PARAMETER	TEST CONDITIONS	T_A †	TLV243xQ, TLV243xM			UNIT
			MIN	TYP	MAX	
V_{IO} Input offset voltage	$V_{IC} = 0,$ $V_O = 0,$ $V_{DD} \pm \pm 2.5\text{ V},$ $R_S = 50\ \Omega$	TLV2453x	25°C	300	2000	μV
			Full range	2500		
		TLV2453xA	25°C	300	950	
			Full range	2000		
α_{VIO} Temperature coefficient of input offset voltage	$V_{IC} = 0,$ $V_O = 0,$ $V_{DD} \pm \pm 2.5\text{ V},$ $R_S = 50\ \Omega$	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	300			
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	
		25°C	$I_{OH} = -5\text{ mA}$			
			Full range	4		
V_{OL} Low-level output voltage	$V_{IC} = 2.5\text{ V},$ $I_{OL} = 100\ \mu\text{A}$	25°C	0.01		V	
		25°C	$I_{OL} = 5\text{ mA}$			
			Full range	1.25		
A_{VD} Large-signal differential voltage amplification	$V_{IC} = 2.5\text{ V},$ $V_O = 1\text{ V to }4\text{ V}$	25°C	$R_L = 2\text{ k}\Omega^\ddagger$		V/mV	
			Full range	0.5		
		25°C	$R_L = 1\text{ M}\Omega^\ddagger$			
$r_{i(d)}$ Differential input resistance		25°C	1000		$\text{G}\Omega$	
$r_{i(c)}$ Common-mode input resistance		25°C	1000		$\text{G}\Omega$	
$c_{i(c)}$ 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 ($\Delta V_{DD}/\Delta V_{IO}$)	$V_{DD} = 4.4\text{ V to }8\text{ V},$ $V_{IC} = V_{DD}/2,$ No load	25°C	80	95	dB	
		Full range	80			
I_{DD} Supply current	$V_O = 2.5\text{ V},$ No load	25°C	200	250	μA	
		Full range	270			

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

‡ Referenced to 2.5 V

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

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

PARAMETER	TEST CONDITIONS	T_A †	TLV243xQ, TLV243xM, TLV243xAQ, TLV243xAM			UNIT
			MIN	TYP	MAX	
SR Slew rate at unity gain	$V_O = 1.5\text{ V to }3.5\text{ V},$ $R_L = 2\text{ k}\Omega^\ddagger,$ $C_L = 100\text{ pF}^\ddagger$	25°C	0.15	0.25	V/ μs	
		Full range	0.1			
V_n Equivalent input noise voltage	$f = 10\text{ Hz}$	25°C	100		nV/ $\sqrt{\text{Hz}}$	
	$f = 1\text{ kHz}$	25°C	18			
$V_{N(PP)}$ Peak-to-peak equivalent input noise voltage	$f = 0.1\text{ Hz to }1\text{ Hz}$	25°C	1.9		μV	
	$f = 0.1\text{ Hz to }10\text{ Hz}$	25°C	2.8			
I_n Equivalent input noise current		25°C	0.6		fA/ $\sqrt{\text{Hz}}$	
THD + N Total harmonic distortion plus noise	$V_O = 1.5\text{ V to }3.5\text{ V},$ $f = 1\text{ kHz},$ $R_L = 2\text{ k}\Omega^\ddagger$	$A_V = 1$	0.045%			
		$A_V = 10$	0.4%			
Gain-bandwidth product	$f = 10\text{ kHz},$ $C_L = 100\text{ pF}^\ddagger$	$R_L = 2\text{ k}\Omega^\ddagger,$ 25°C	0.55		MHz	
BOM Maximum output-swing bandwidth	$V_{O(PP)} = 2\text{ V},$ $R_L = 2\text{ k}\Omega^\ddagger,$	$A_V = 1,$ $C_L = 100\text{ pF}^\ddagger$ 25°C	100		kHz	
t_s Settling time	$A_V = -1,$ Step = 1.5 V to 3.5 V, $R_L = 2\text{ k}\Omega^\ddagger,$ $C_L = 100\text{ pF}^\ddagger$	To 0.1%	6.4		μs	
		To 0.01%	13.1			
ϕ_m Phase margin at unity gain	$R_L = 2\text{ k}\Omega^\ddagger,$ $C_L = 100\text{ pF}^\ddagger$	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

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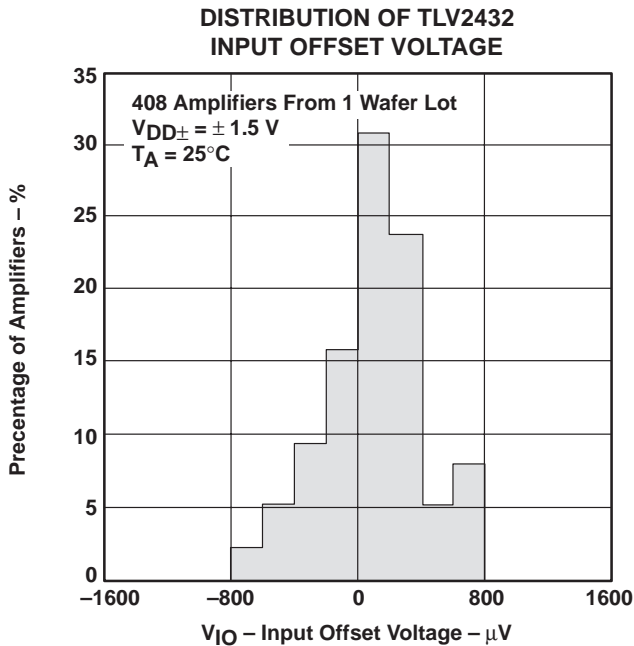


Figure 2

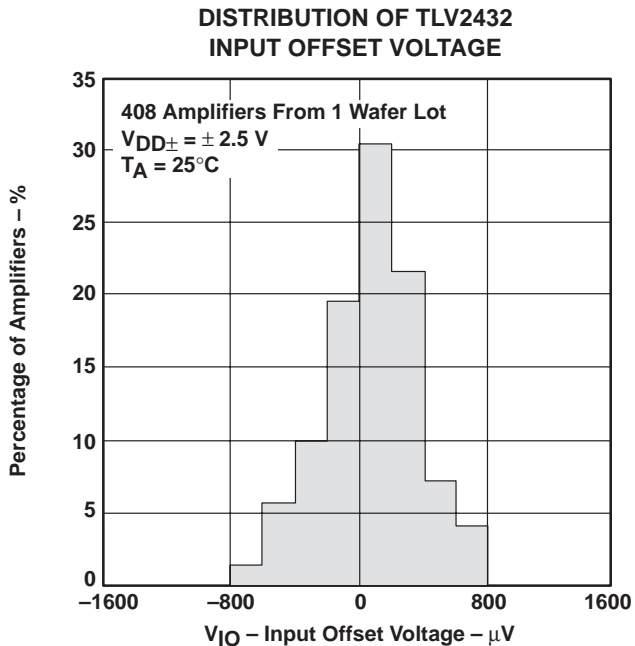


Figure 3

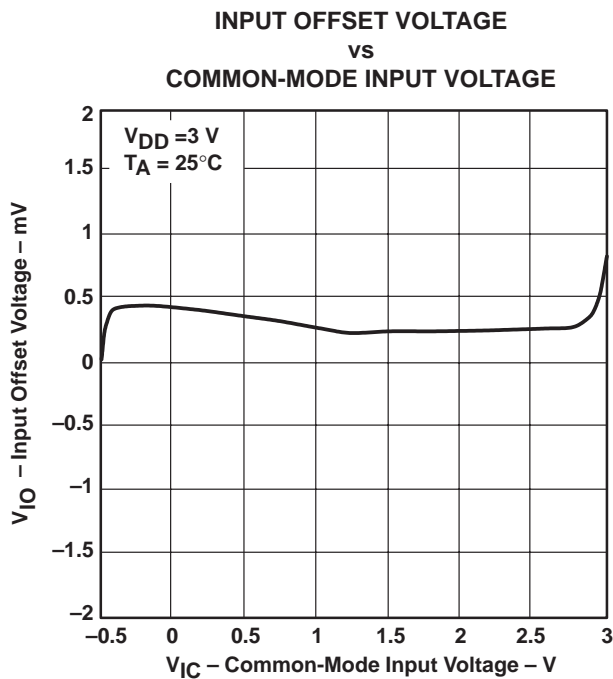


Figure 4

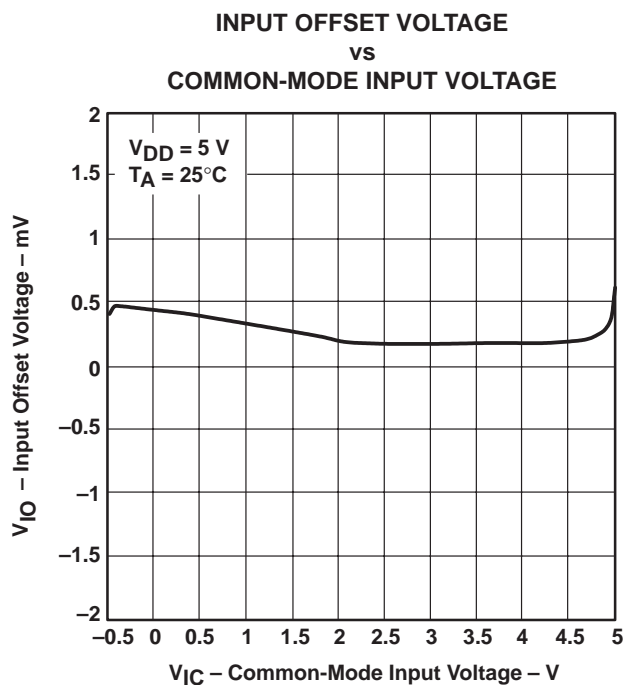


Figure 5

TYPICAL CHARACTERISTICS

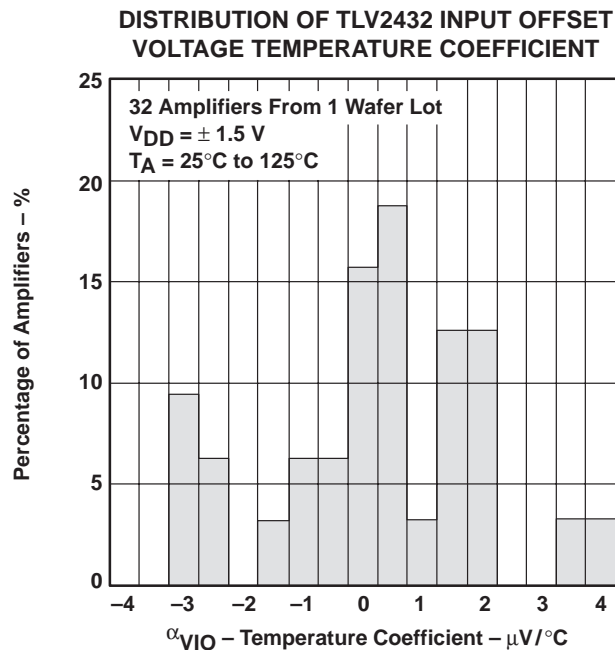


Figure 6

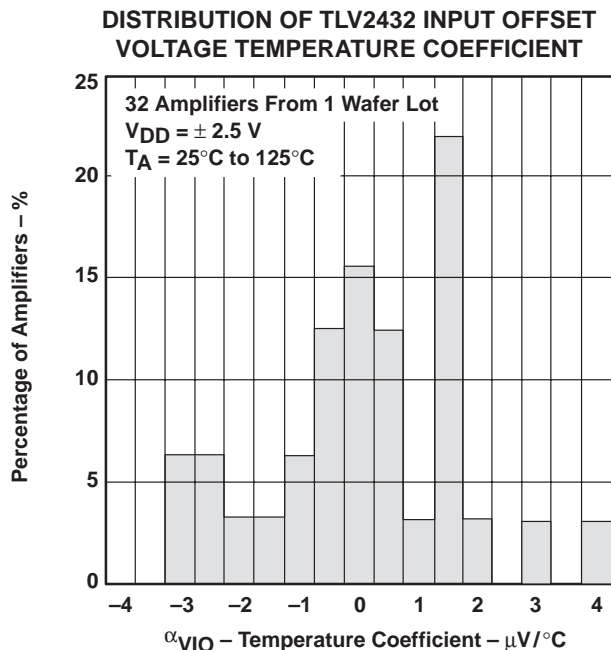


Figure 7

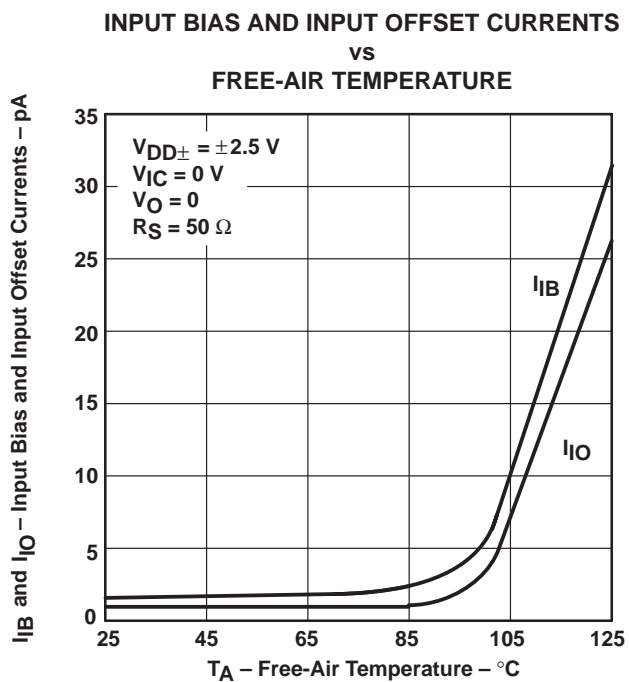


Figure 8

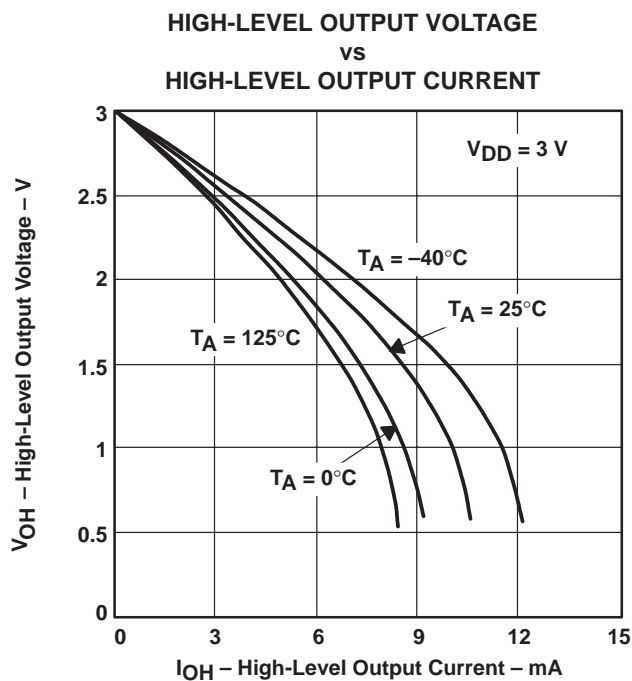


Figure 9

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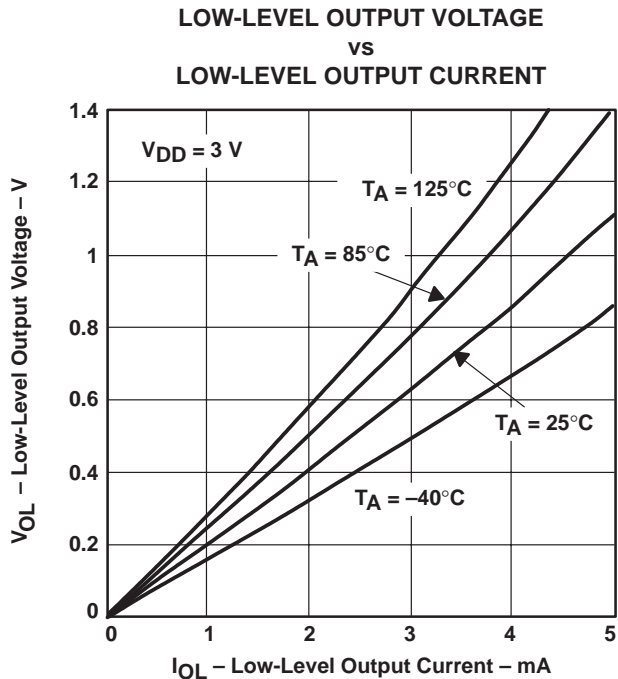


Figure 10

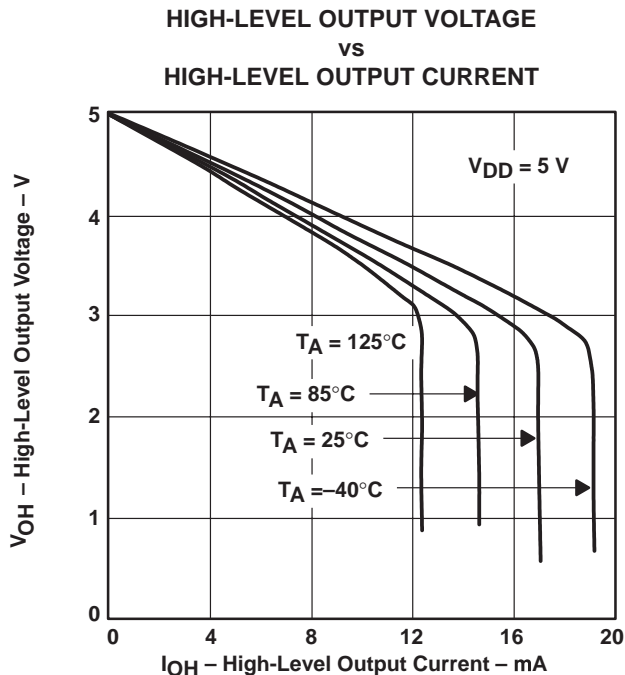


Figure 11

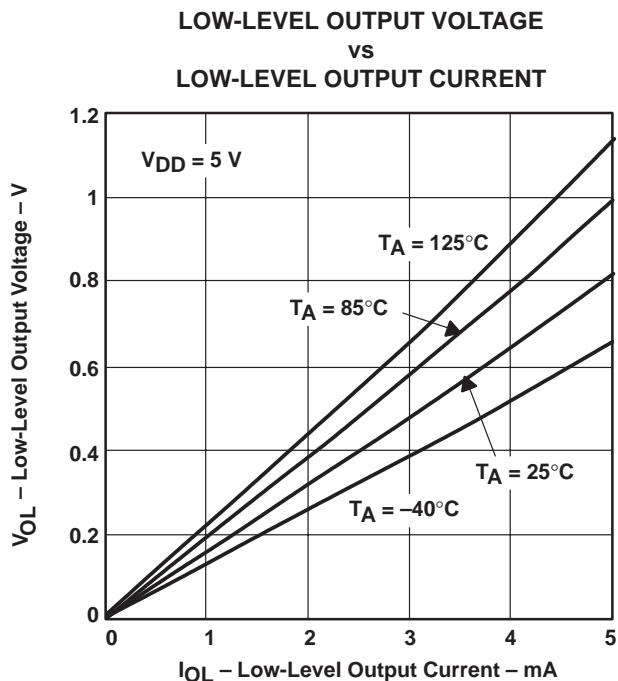


Figure 12

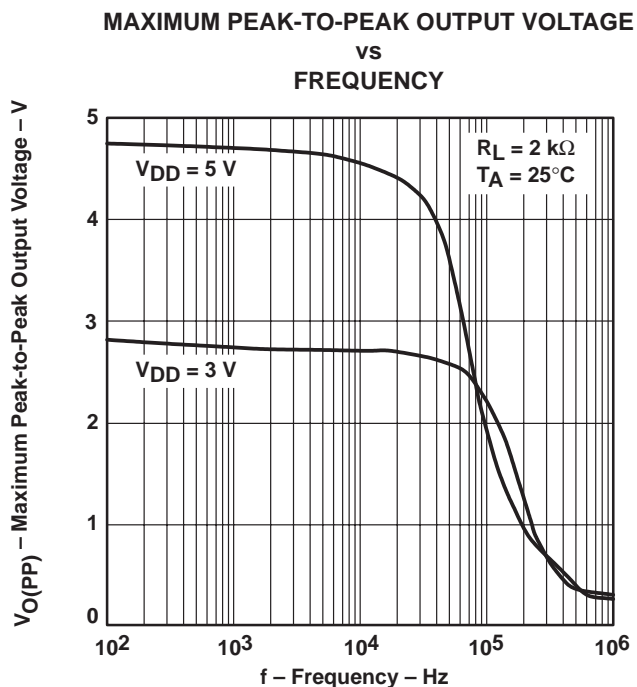


Figure 13

TLV2432, TLV2432A, TLV2434, TLV2434A
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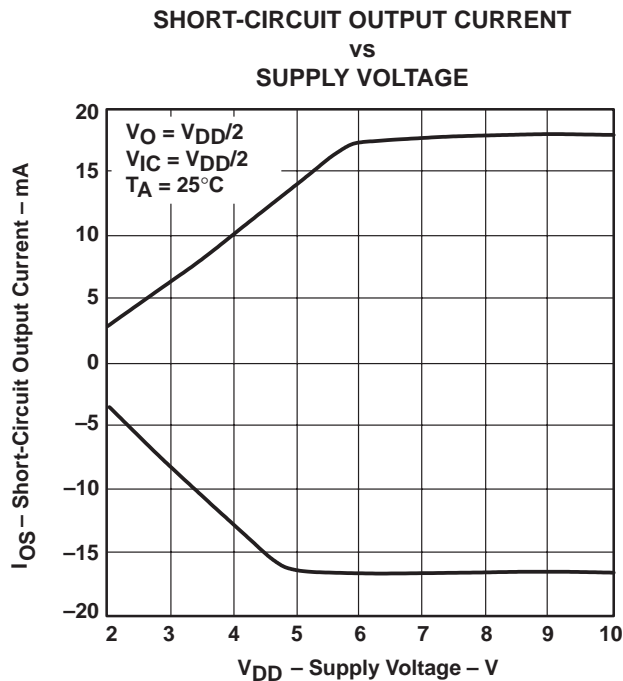


Figure 14

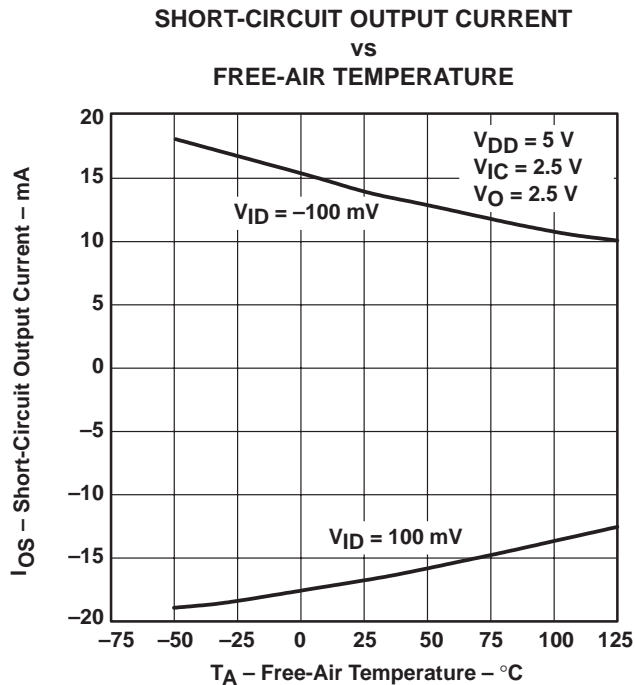


Figure 15

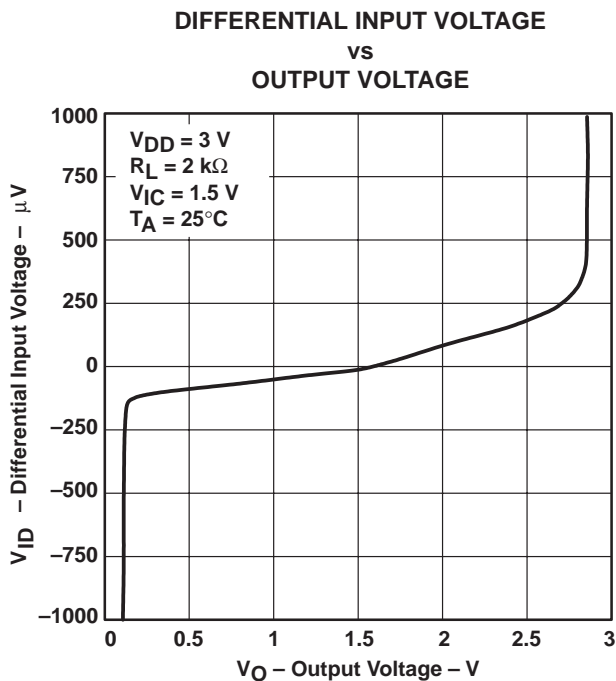


Figure 16

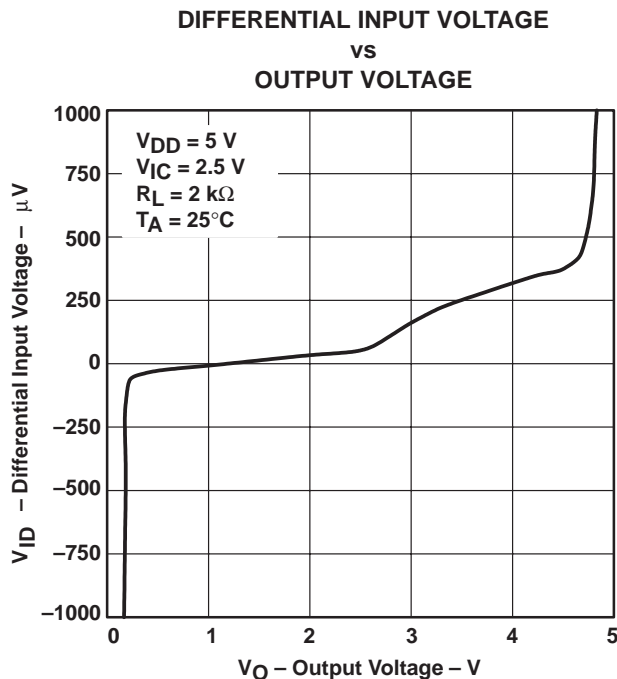


Figure 17

TLV2432, TLV2432A, TLV2434, TLV2434A
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TYPICAL CHARACTERISTICS

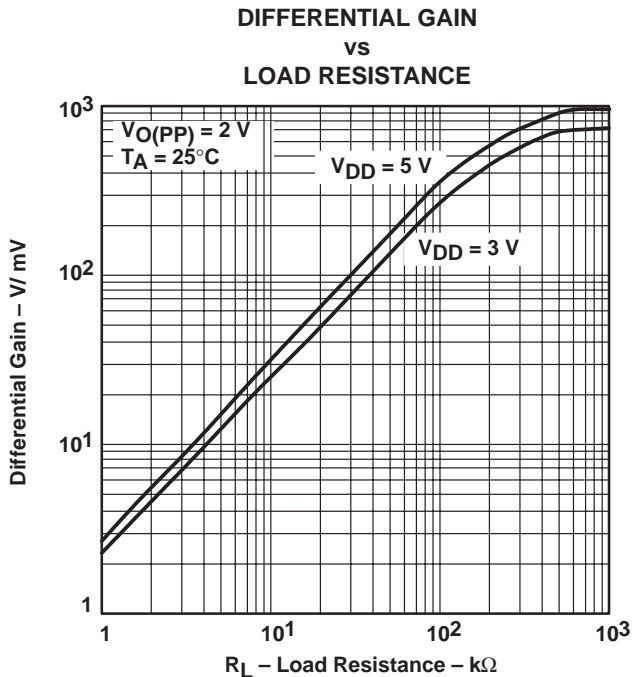


Figure 18

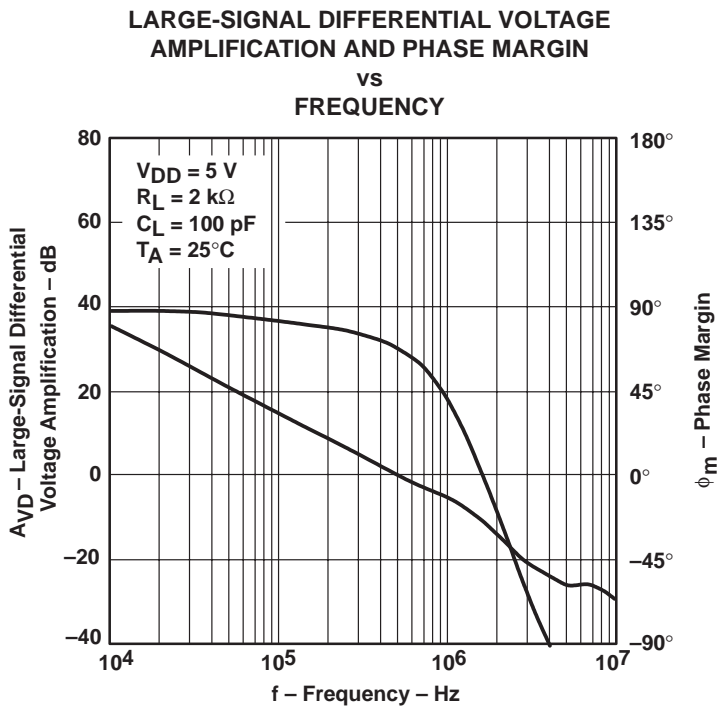


Figure 19

TYPICAL CHARACTERISTICS

LARGE-SIGNAL DIFFERENTIAL VOLTAGE
 AMPLIFICATION AND PHASE MARGIN
 VS
 FREQUENCY

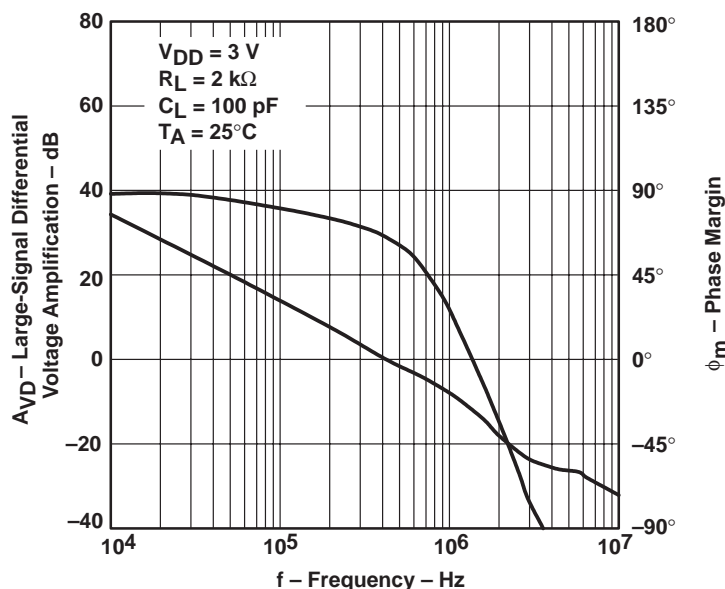


Figure 20

DIFFERENTIAL VOLTAGE AMPLIFICATION
 VS
 FREE-AIR TEMPERATURE

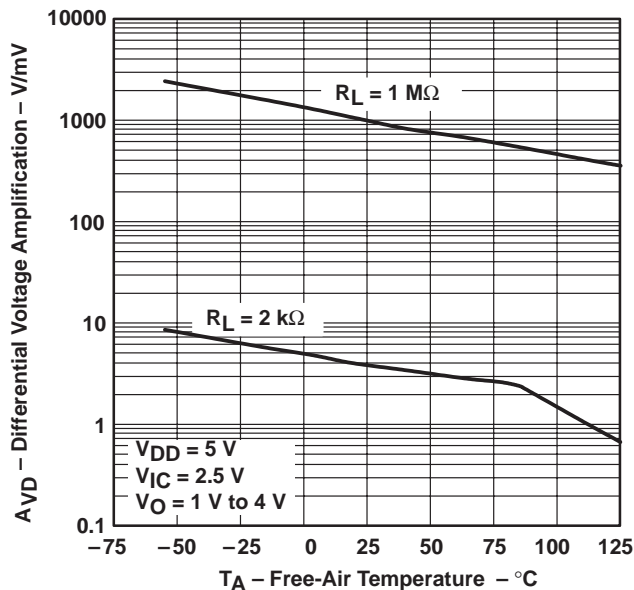


Figure 21

DIFFERENTIAL VOLTAGE AMPLIFICATION
 VS
 FREE-AIR TEMPERATURE

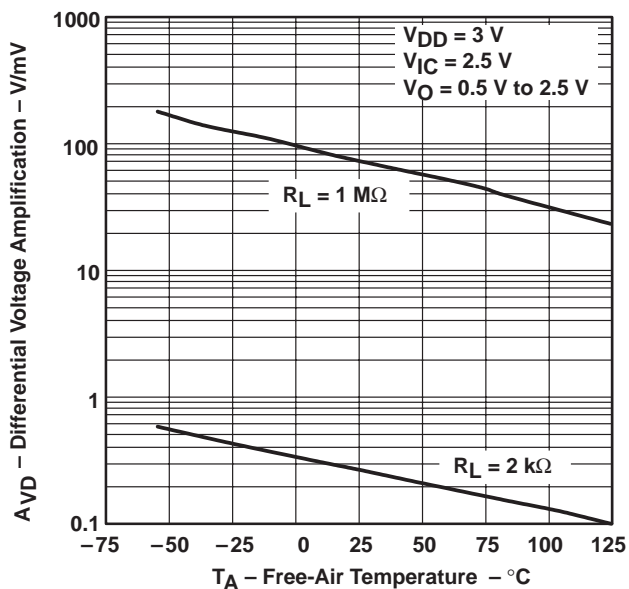


Figure 22

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**OUTPUT IMPEDANCE
 vs
 FREQUENCY**

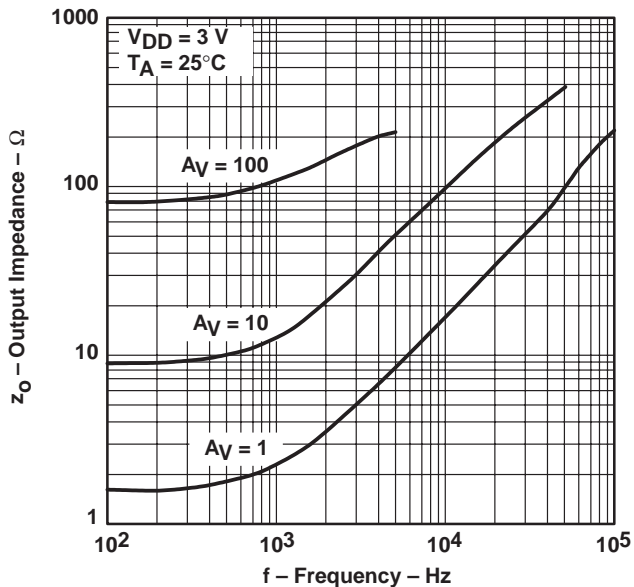


Figure 23

**OUTPUT IMPEDANCE
 vs
 FREQUENCY**

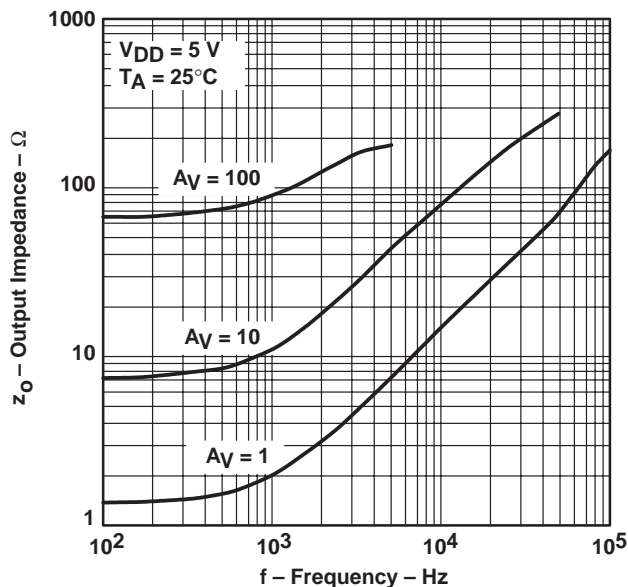


Figure 24

**COMMON-MODE REJECTION RATIO
 vs
 FREQUENCY**

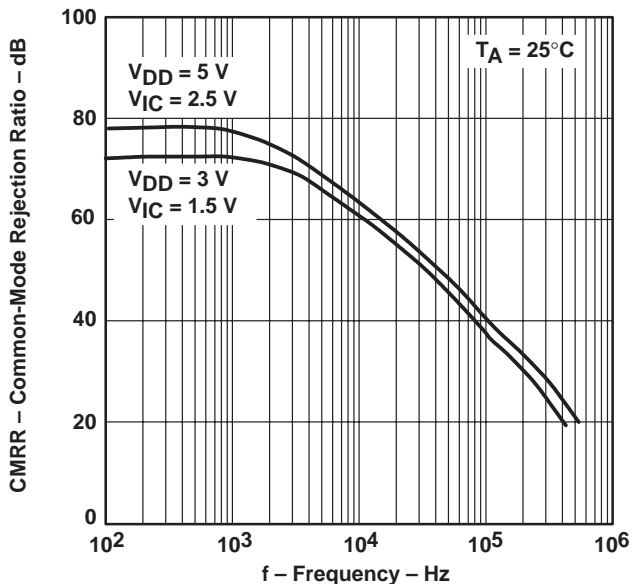


Figure 25

**COMMON-MODE REJECTION RATIO
 vs
 FREE-AIR TEMPERATURE**

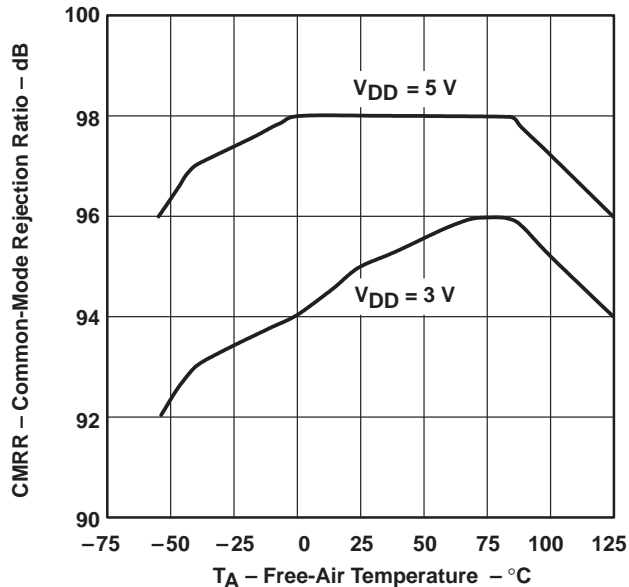


Figure 26

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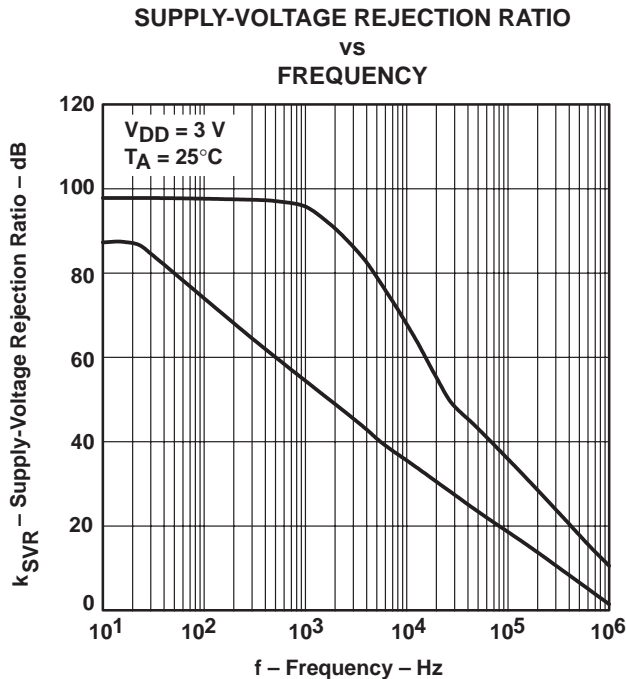


Figure 27

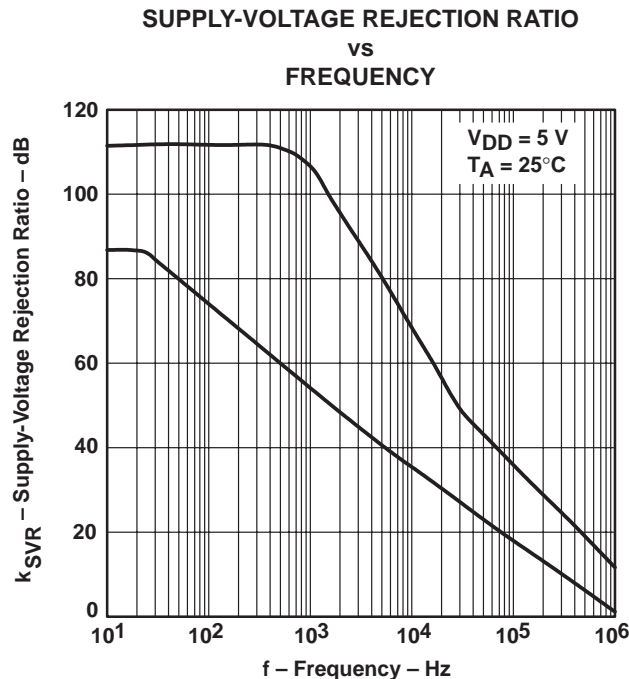


Figure 28

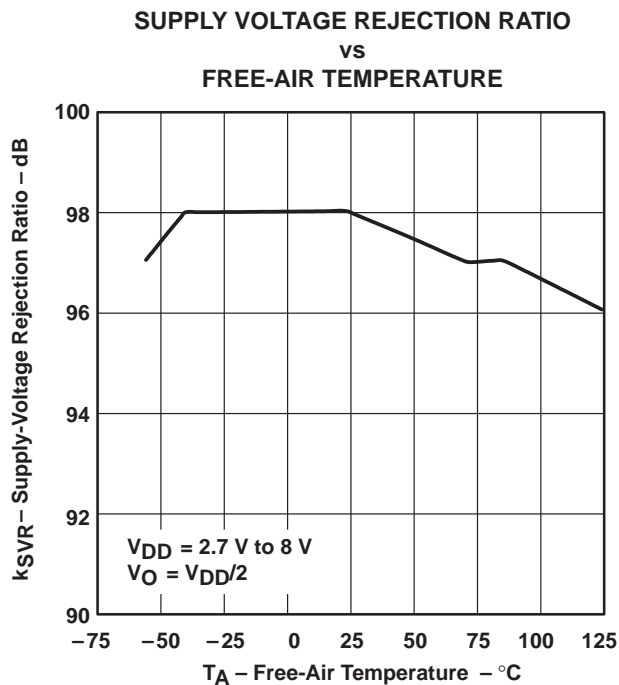


Figure 29

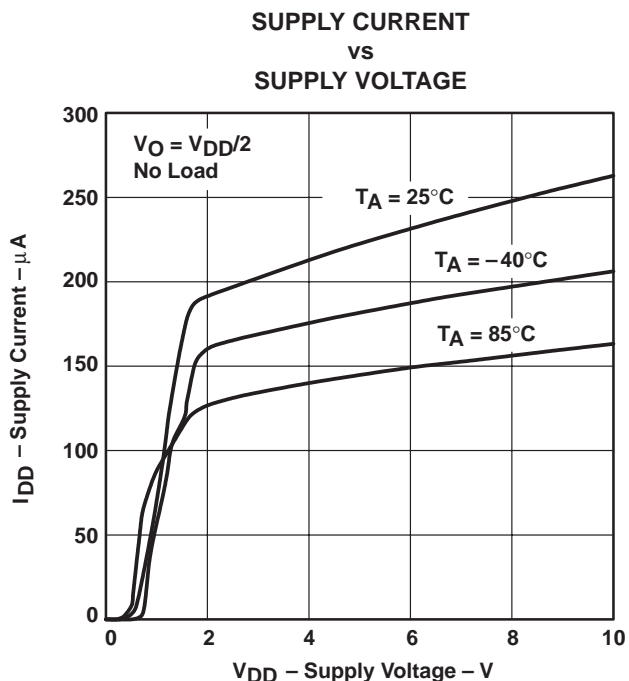


Figure 30

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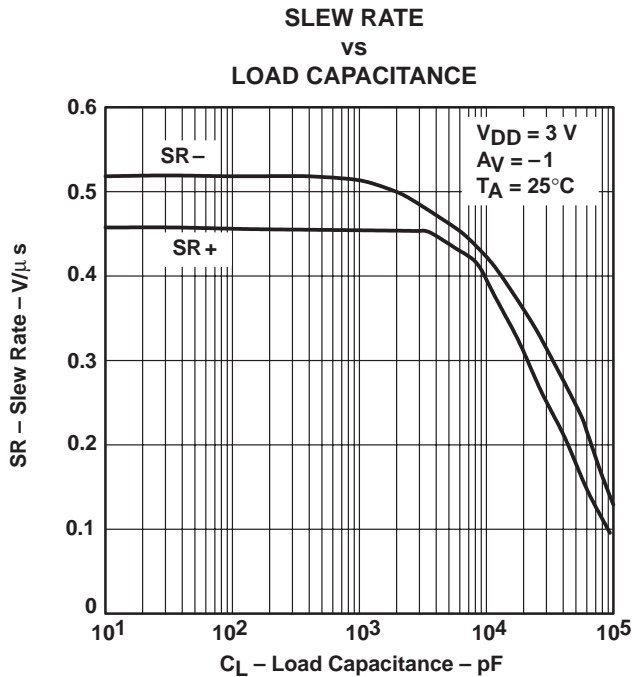


Figure 31

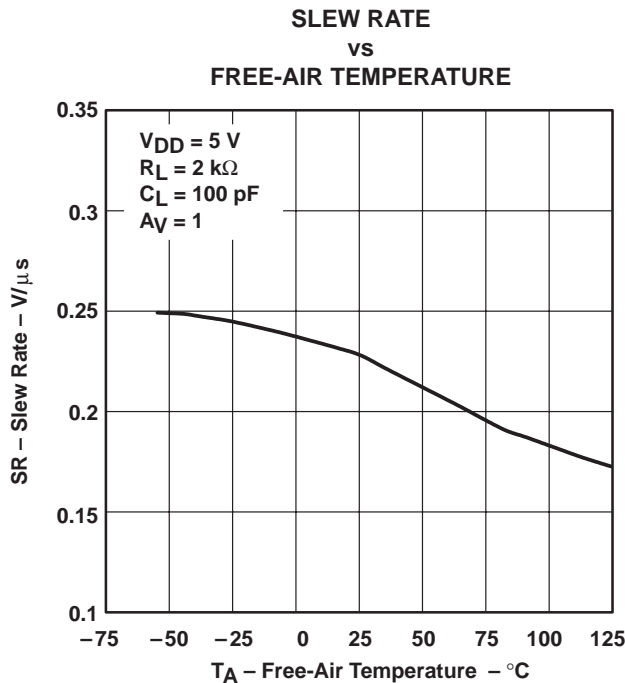


Figure 32

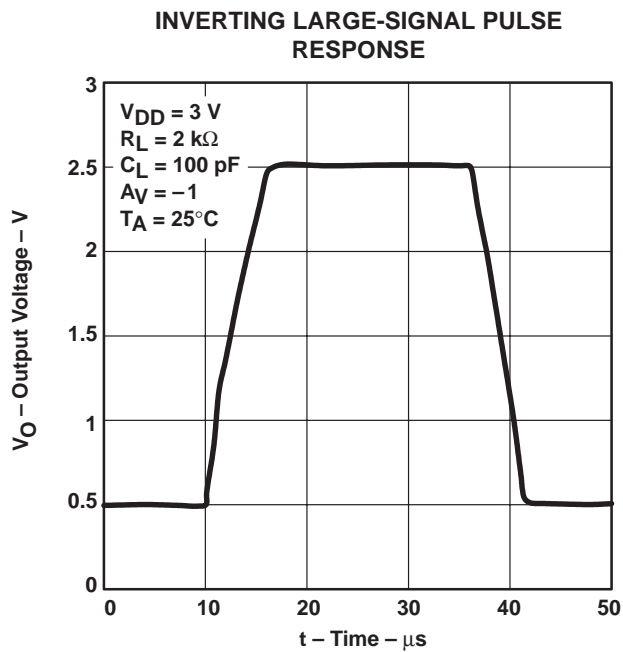


Figure 33

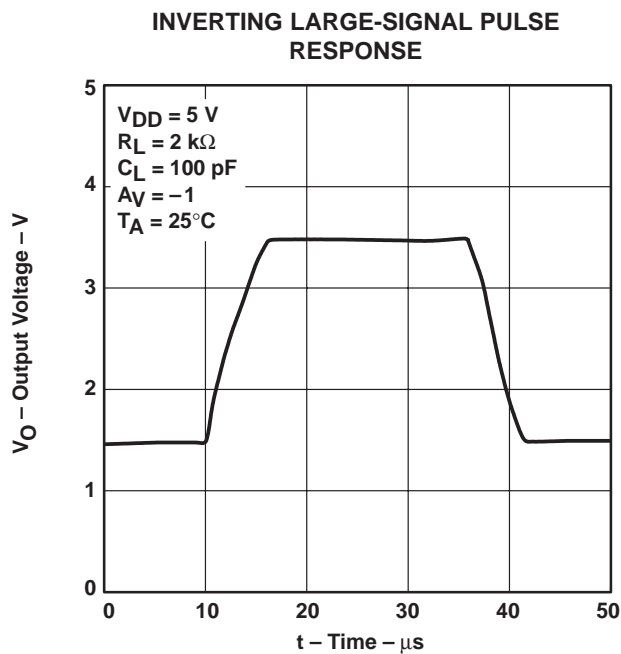


Figure 34

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VOLTAGE-FOLLOWER LARGE-SIGNAL PULSE RESPONSE

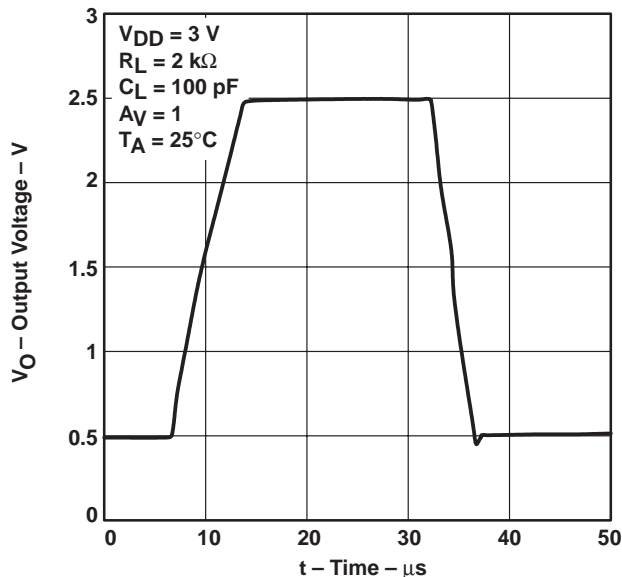


Figure 35

VOLTAGE-FOLLOWER LARGE-SIGNAL PULSE RESPONSE

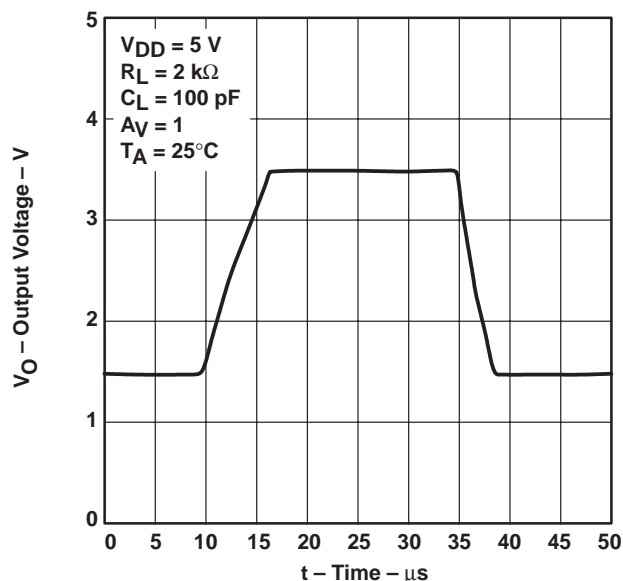


Figure 36

INVERTING SMALL-SIGNAL PULSE RESPONSE

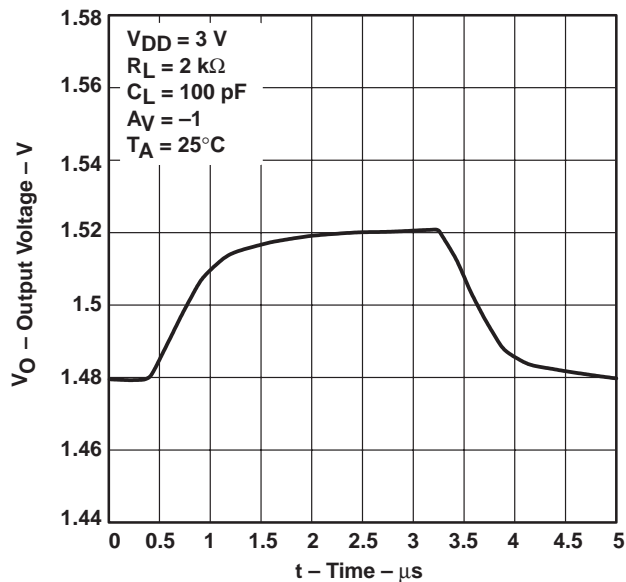


Figure 37

INVERTING SMALL-SIGNAL PULSE RESPONSE

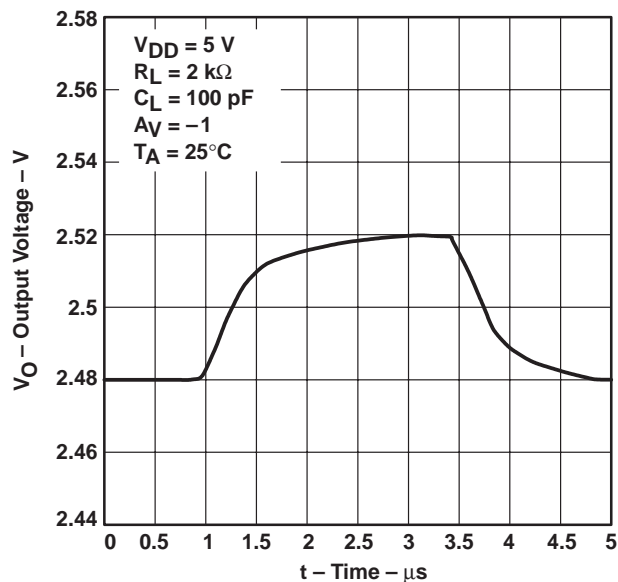


Figure 38

TLV2432, TLV2432A, TLV2434, TLV2434A
Advanced LinCMOS™ RAIL-TO-RAIL OUTPUT
WIDE-INPUT-VOLTAGE OPERATIONAL AMPLIFIERS
 SLOS168E – NOVEMBER 1996 – REVISED NOVEMBER 1999

TYPICAL CHARACTERISTICS

VOLTAGE-FOLLOWER SMALL-SIGNAL PULSE RESPONSE

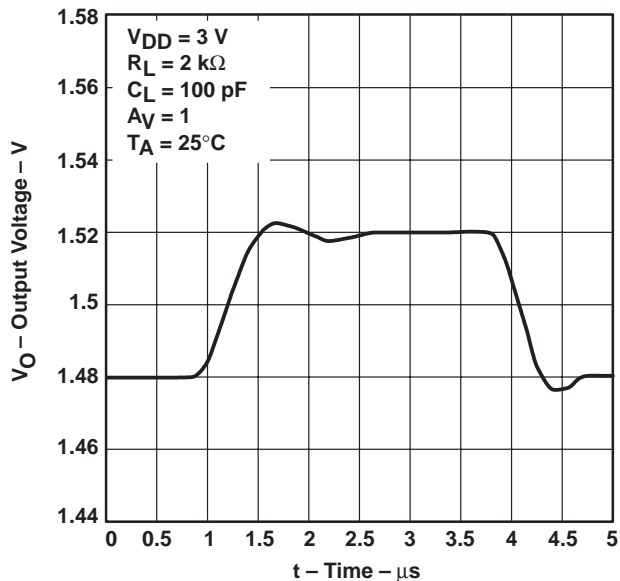


Figure 39

VOLTAGE-FOLLOWER SMALL-SIGNAL PULSE RESPONSE

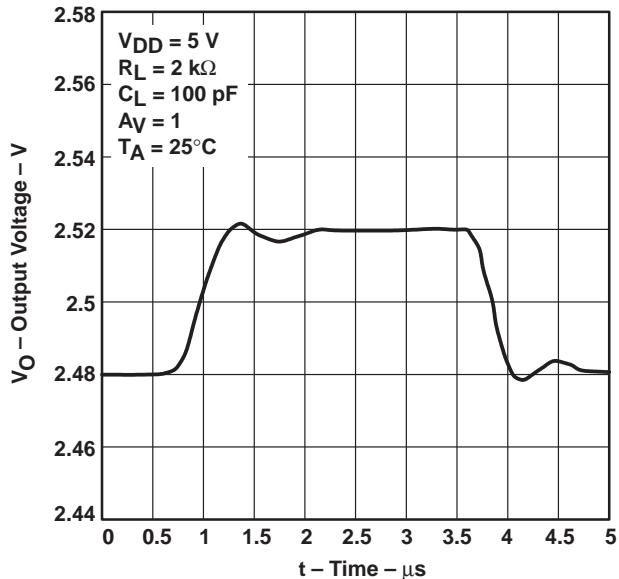


Figure 40

EQUIVALENT INPUT NOISE VOLTAGE vs FREQUENCY

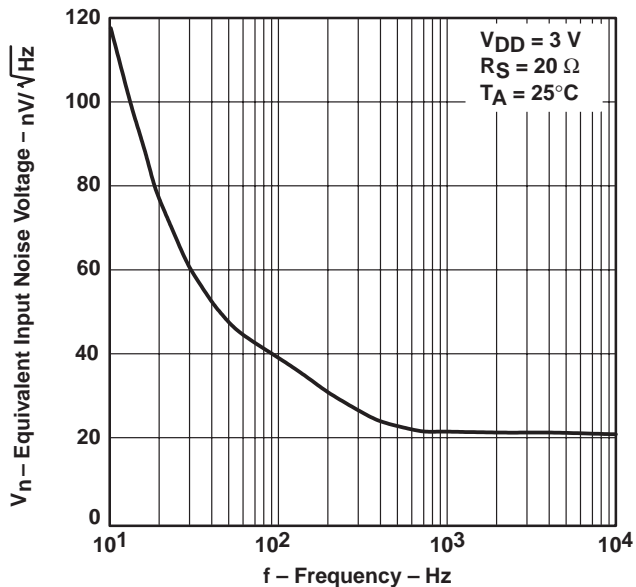


Figure 41

EQUIVALENT INPUT NOISE VOLTAGE vs FREQUENCY

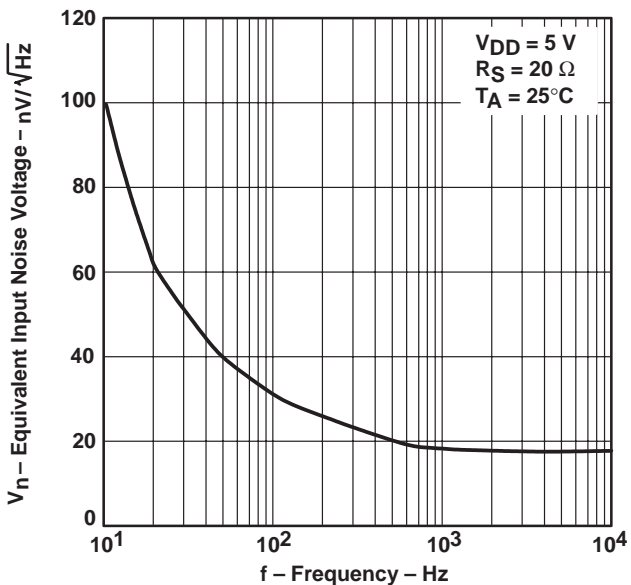


Figure 42

TYPICAL CHARACTERISTICS

NOISE VOLTAGE OVER A 10-SECOND PERIOD

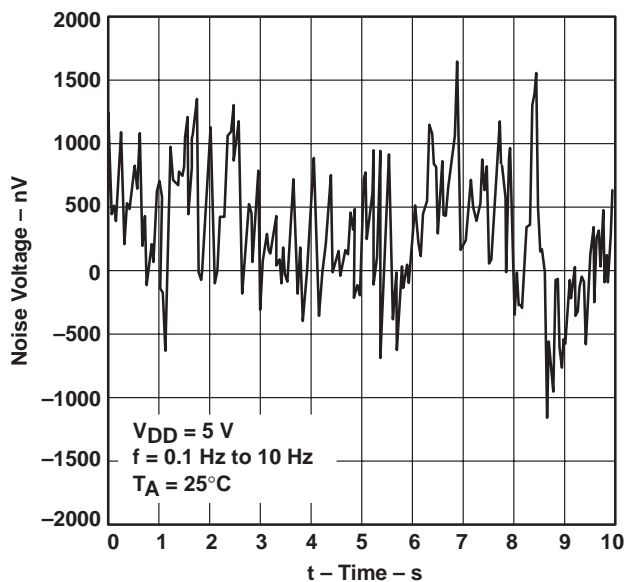


Figure 43

TOTAL HARMONIC DISTORTION PLUS NOISE
 VS
 FREQUENCY

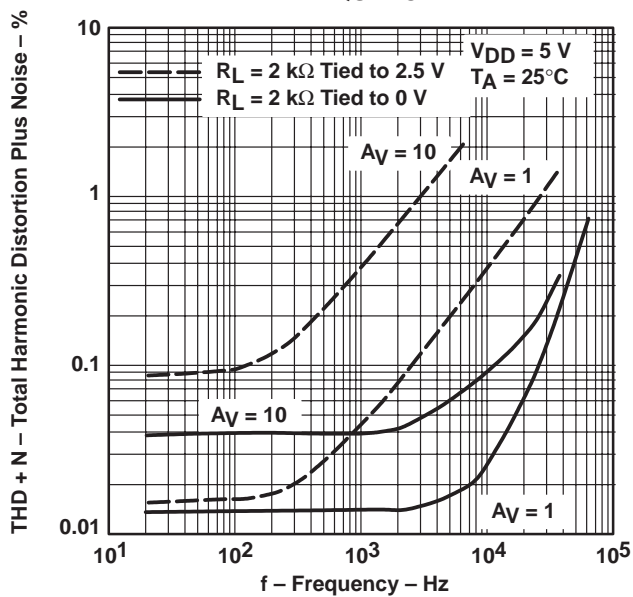


Figure 44

TOTAL HARMONIC DISTORTION PLUS NOISE
 VS
 FREQUENCY

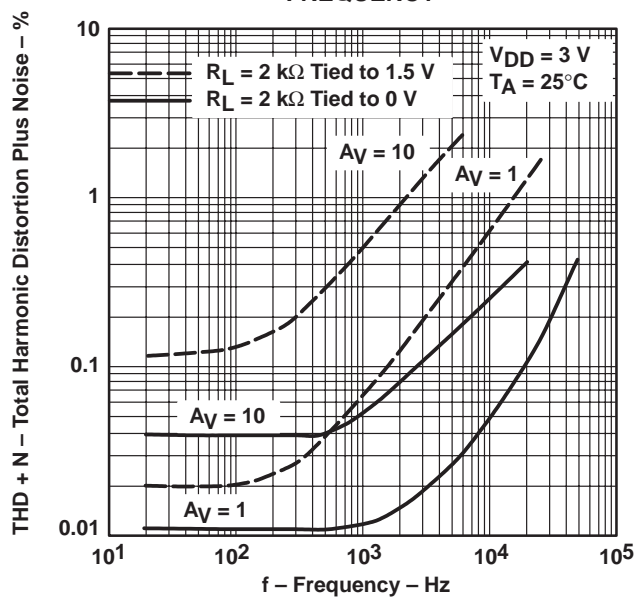


Figure 45

TLV2432, TLV2432A, TLV2434, TLV2434A
Advanced LinCMOS™ RAIL-TO-RAIL OUTPUT
WIDE-INPUT-VOLTAGE OPERATIONAL AMPLIFIERS
 SLOS168E – NOVEMBER 1996 – REVISED NOVEMBER 1999

TYPICAL CHARACTERISTICS

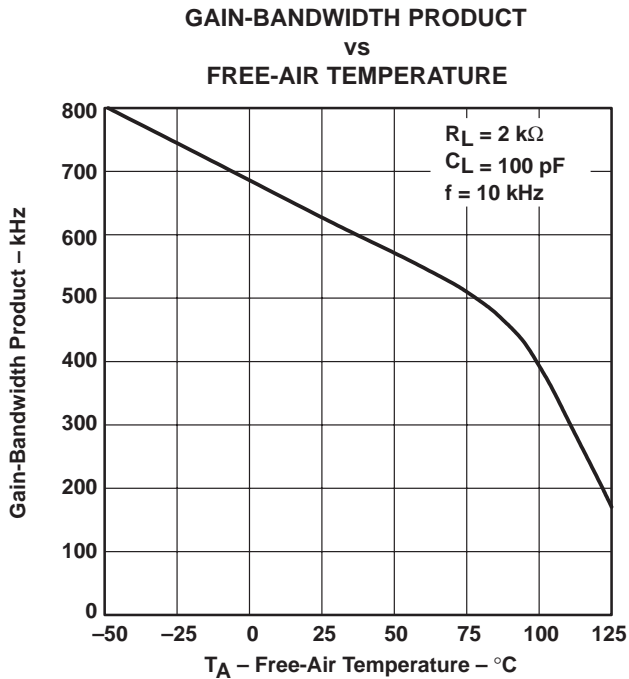


Figure 46

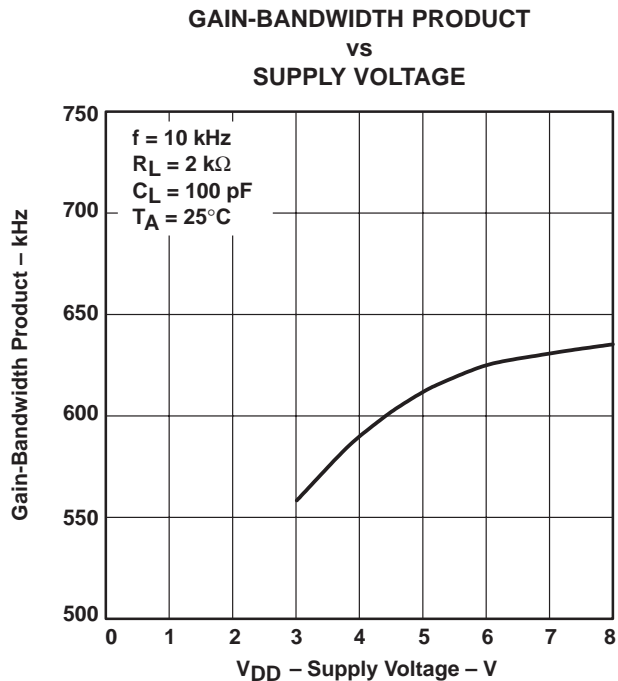


Figure 47

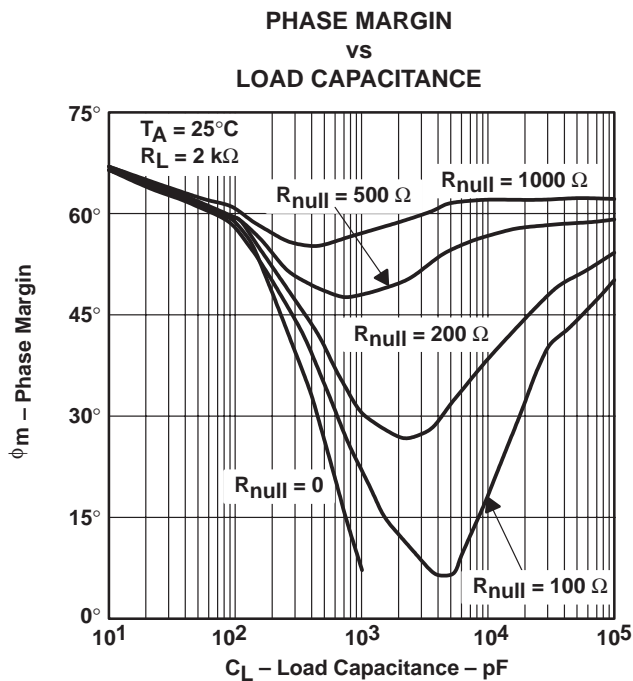


Figure 48

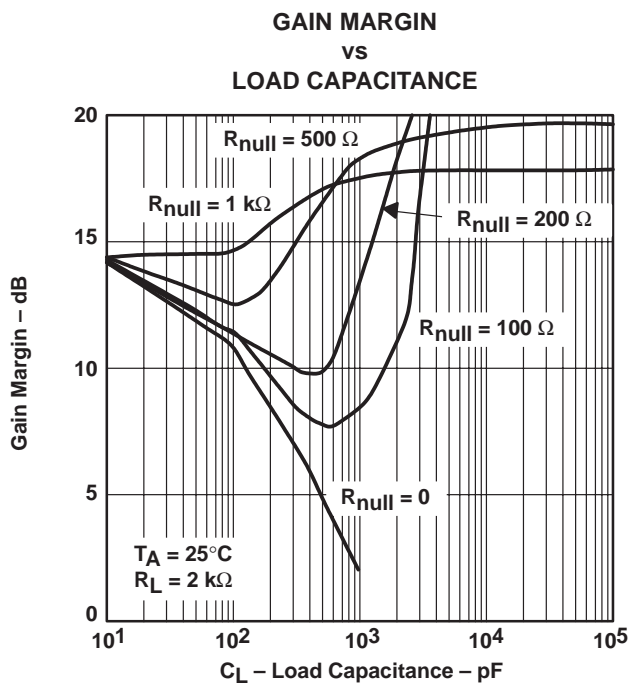


Figure 49

TYPICAL CHARACTERISTICS

UNITY-GAIN BANDWIDTH
vs
LOAD CAPACITANCE

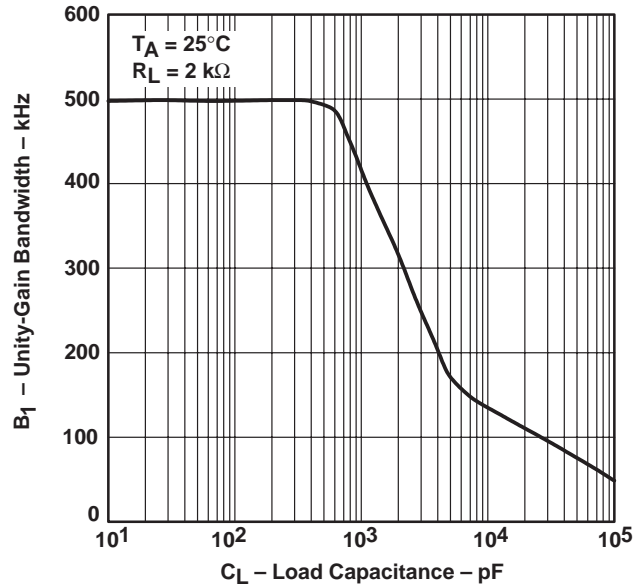


Figure 50

TLV2432, TLV2432A, TLV2434, TLV2434A Advanced LinCMOS™ RAIL-TO-RAIL OUTPUT WIDE-INPUT-VOLTAGE OPERATIONAL AMPLIFIERS

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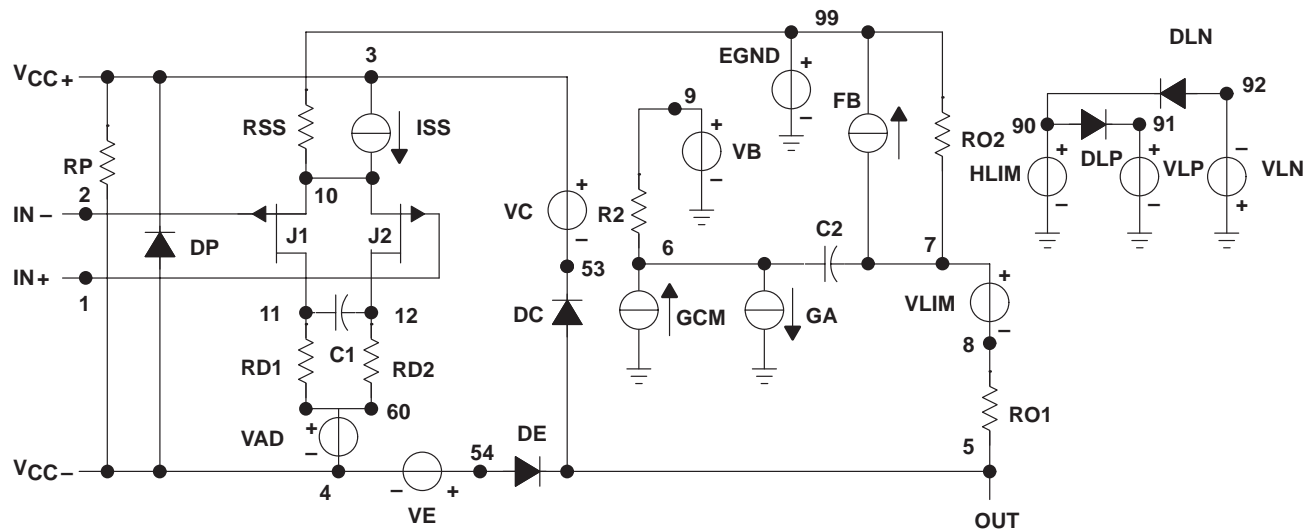
APPLICATION INFORMATION

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 51 are generated using the TLV243x typical electrical and operating characteristics at $T_A = 25^\circ\text{C}$. Using this information, output simulations of the following key parameters can be generated to a tolerance of 20% (in most cases):

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

NOTE 4: G. R. Boyle, B. M. Cohn, D. O. Pederson, and J. E. Solomon, "Macromodeling of Integrated Circuit Operational Amplifiers", *IEEE Journal of Solid-State Circuits*, SC-9, 353 (1974).



```
.SUBCKT TLV2432 1 2 3 4 5
C1      11  12  3.560E-12
C2      6   7   15.00E-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 21.04E6 -30E6 30E6 30E6 -30E6
GA      6   0   11  12 47.12E-6
GCM     0   6   10  99 4.9E-9
ISS     3   10  DC 8.250E-6
HLIM    90  0   VLIM 1K
J1      11  2   10 JX
J2      12  1   10 JX
R2      6   9   100.0E3
RD1     60  11  21.22E3
RD2     60  12  21.22E3
R01     8   5   120
R02     7   99  120
RP      3   4   26.04E3
RSS     10  99  24.24E6
VAD     60  4   -.6
VB      9   0   DC 0
VC      3   53  DC .65
VE      54  4   DC .65
VLIM    7   8   DC 0
VLP     91  0   DC 1.4
VLN     0   92  DC 9.4
.MODEL DX D (IS=800.0E-18)
.MODEL JX PJF (IS=500.0E-15 BETA=281E-6)
+ VTO=-.065)
.ENDS
```

Figure 51. Boyle Macromodel and Subcircuit

TLV2432, TLV2432A, TLV2434, TLV2434A
 Advanced LinCMOS™ RAIL-TO-RAIL OUTPUT
 WIDE-INPUT-VOLTAGE OPERATIONAL AMPLIFIERS

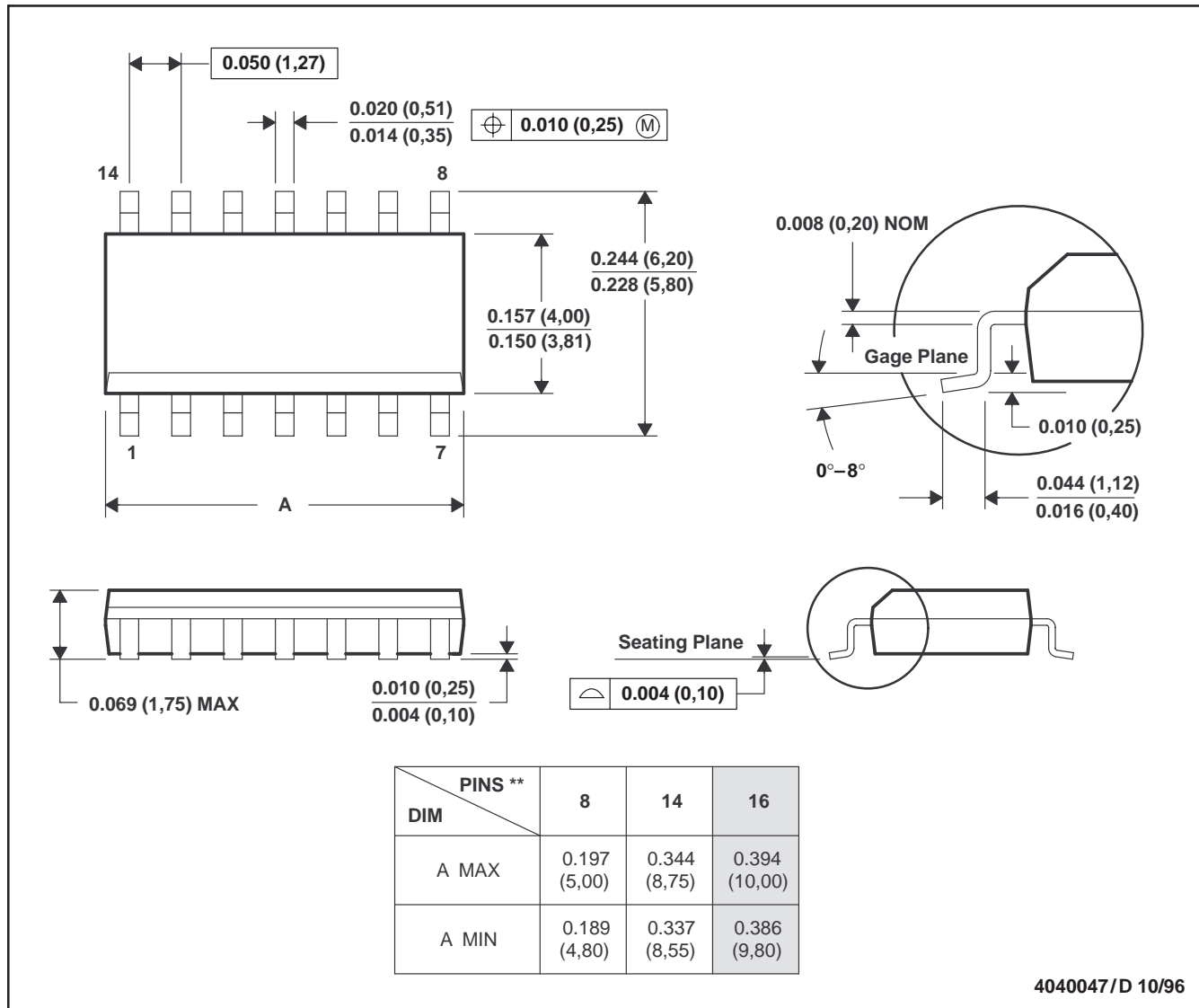
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MECHANICAL DATA

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

TLV2432, TLV2432A, TLV2434, TLV2434A
Advanced LinCMOS™ RAIL-TO-RAIL OUTPUT
WIDE-INPUT-VOLTAGE OPERATIONAL AMPLIFIERS

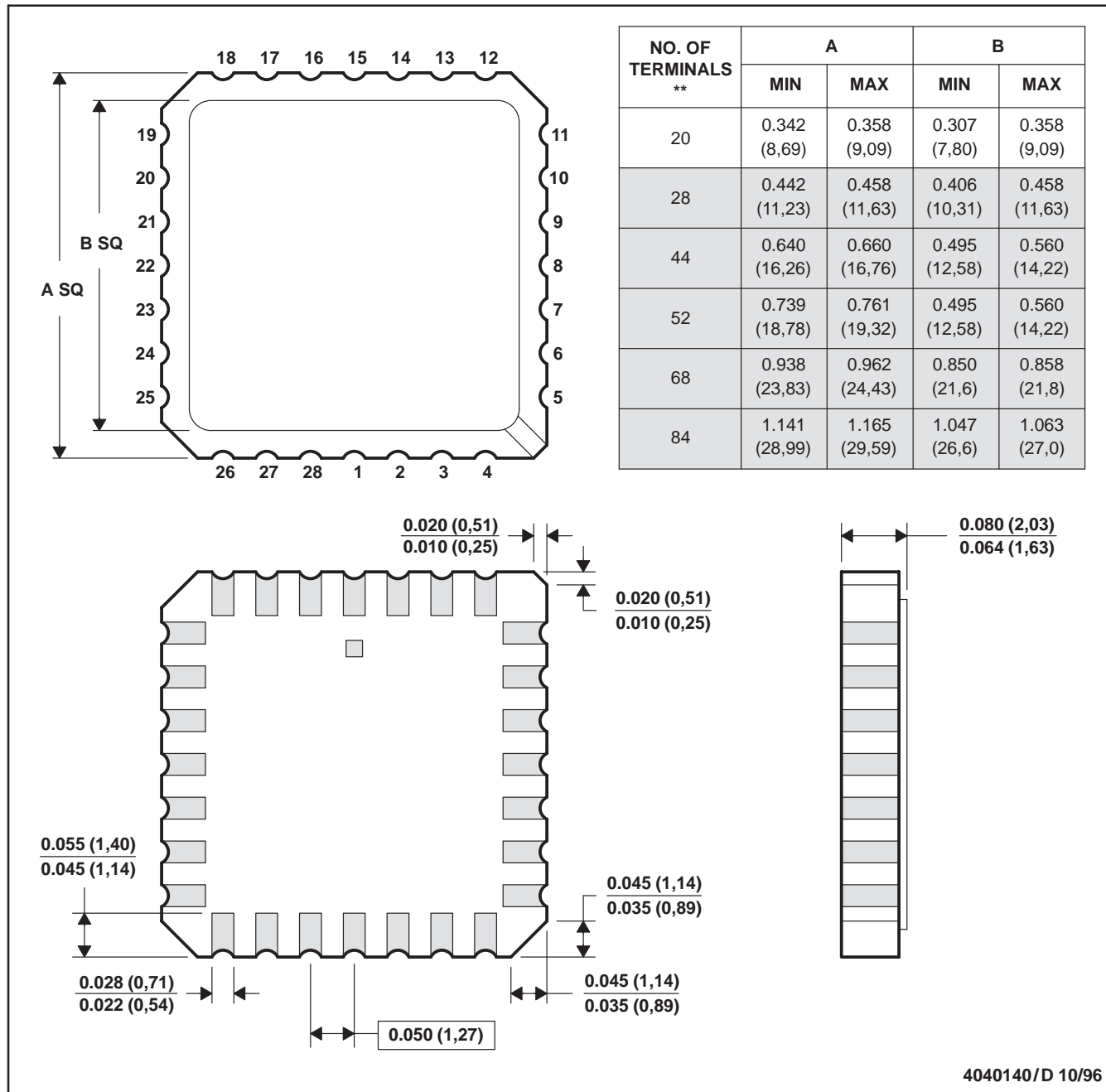
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MECHANICAL DATA

FK (S-CQCC-N)**

LEADLESS CERAMIC CHIP CARRIER

28 TERMINAL SHOWN



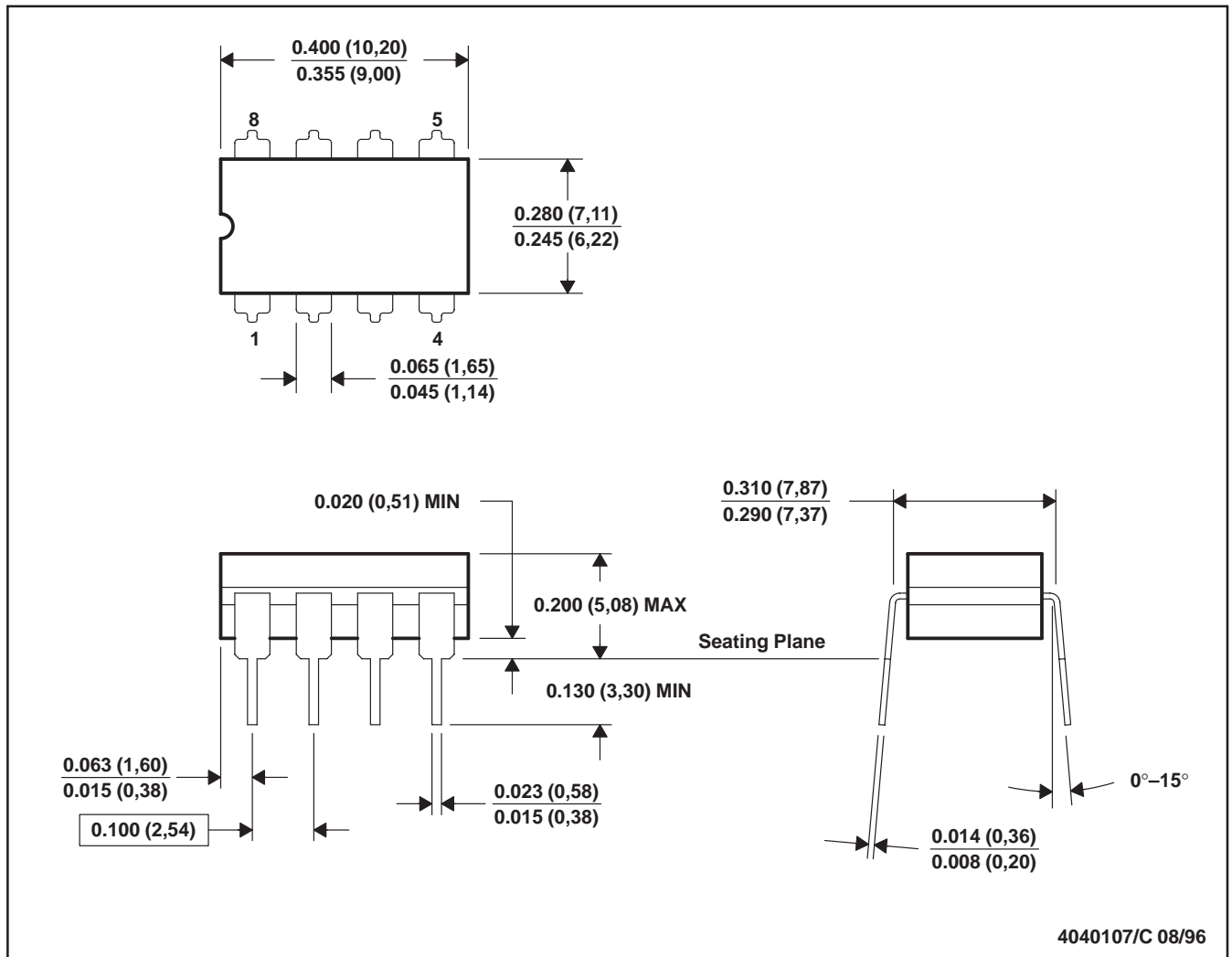
- NOTES: A. All linear dimensions are in inches (millimeters).
 B. This drawing is subject to change without notice.
 C. This package can be hermetically sealed with a metal lid.
 D. The terminals are gold plated.
 E. Falls within JEDEC MS-004

TLV2432, TLV2432A, TLV2434, TLV2434A
Advanced LinCMOS™ RAIL-TO-RAIL OUTPUT
WIDE-INPUT-VOLTAGE OPERATIONAL AMPLIFIERS
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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

TLV2432, TLV2432A, TLV2434, TLV2434A
Advanced LinCMOS™ RAIL-TO-RAIL OUTPUT
WIDE-INPUT-VOLTAGE OPERATIONAL AMPLIFIERS

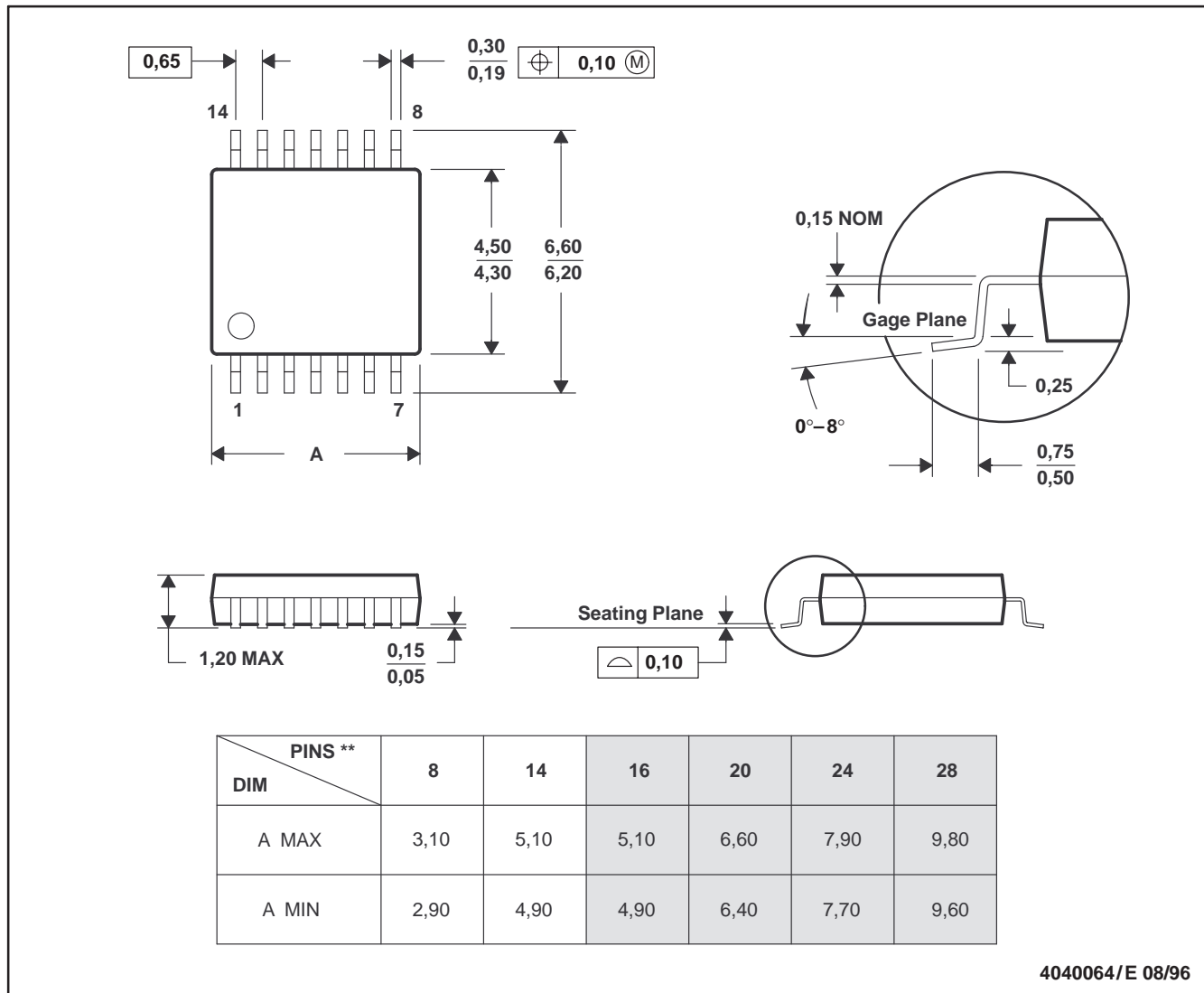
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MECHANICAL DATA

PW (R-PDSO-G)**

PLASTIC SMALL-OUTLINE PACKAGE

14 PIN SHOWN



4040064/E 08/96

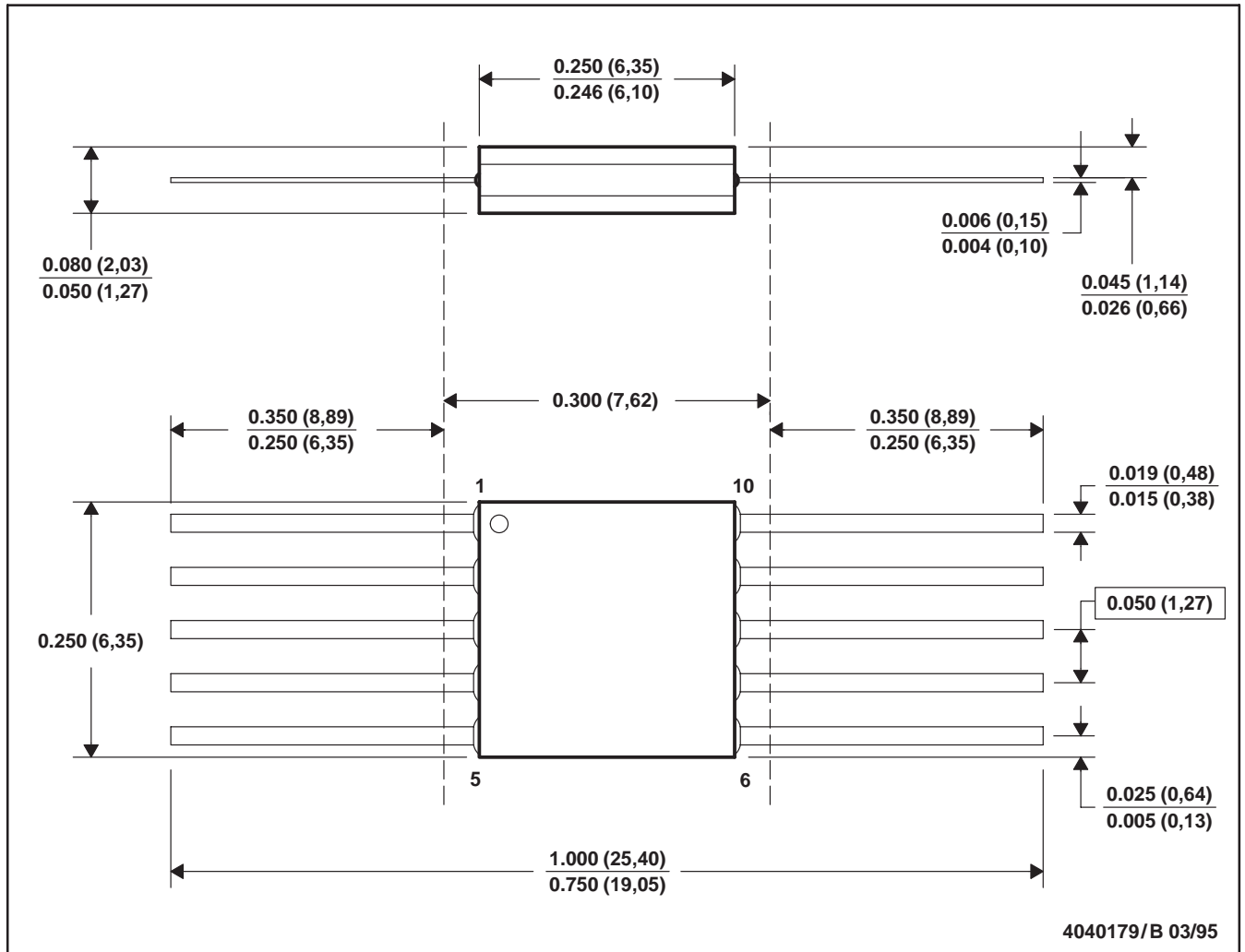
- NOTES: A. All linear dimensions are in millimeters.
 B. This drawing is subject to change without notice.
 C. Body dimensions do not include mold flash or protrusion not to exceed 0,15.
 D. Falls within JEDEC MO-153

TLV2432, TLV2432A, TLV2434, TLV2434A
Advanced LinCMOS™ RAIL-TO-RAIL OUTPUT
WIDE-INPUT-VOLTAGE OPERATIONAL AMPLIFIERS
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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

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