

# TLV2432, TLV2432A, TLV2434, TLV2434A 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<sub>A</sub> = 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.

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.

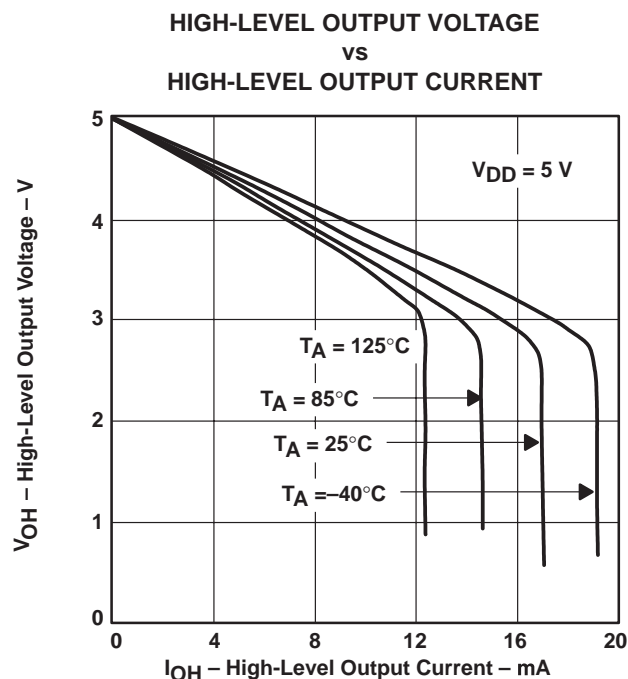


Figure 1



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.

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

 **TEXAS  
INSTRUMENTS**

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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

## Advanced LinCMOS™ RAIL-TO-RAIL OUTPUT

### WIDE-INPUT-VOLTAGE OPERATIONAL AMPLIFIERS

SLOS168E – NOVEMBER 1996 – REVISED NOVEMBER 1999

#### TLV2432 and TLV2432A AVAILABLE OPTIONS

T <sub>A</sub>	V <sub>IO</sub> 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

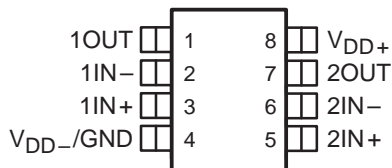
The D packages are available taped and reeled. Add R suffix to device type (e.g., TLV2432CDR). The PW package is available only left-end taped and reeled.

#### TLV2434 AVAILABLE OPTIONS

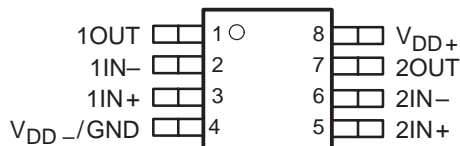
T <sub>A</sub>	V <sub>IO</sub> max AT 25°C	PACKAGED DEVICES	
		SMALL OUTLINE (D)	TSSOP (PW)
0°C to 70°C	2.5 mV	TLV2434CD	TLV2434CPW
–40°C to 125°C	950 μV 2.5 mV	TLV2434AID TLV2434ID	TLV2434AIPW TLV2434IPW

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.

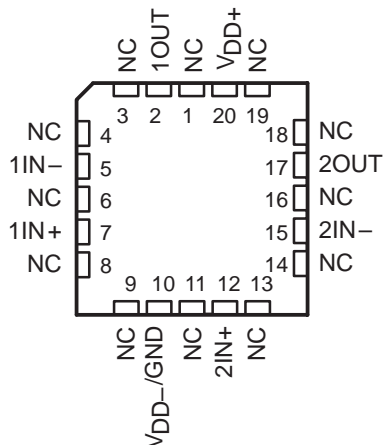
**TLV2432  
D OR JG PACKAGE  
(TOP VIEW)**



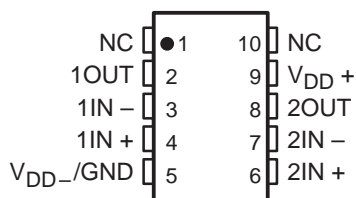
**TLV2432  
PW PACKAGE  
(TOP VIEW)**



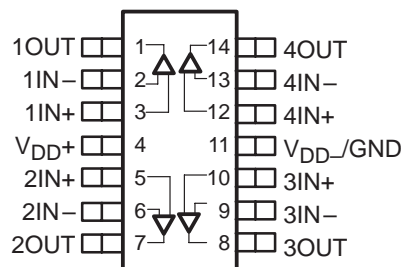
**TLV2432  
FK PACKAGE  
(TOP VIEW)**



**TLV2432  
U PACKAGE  
(TOP VIEW)**



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

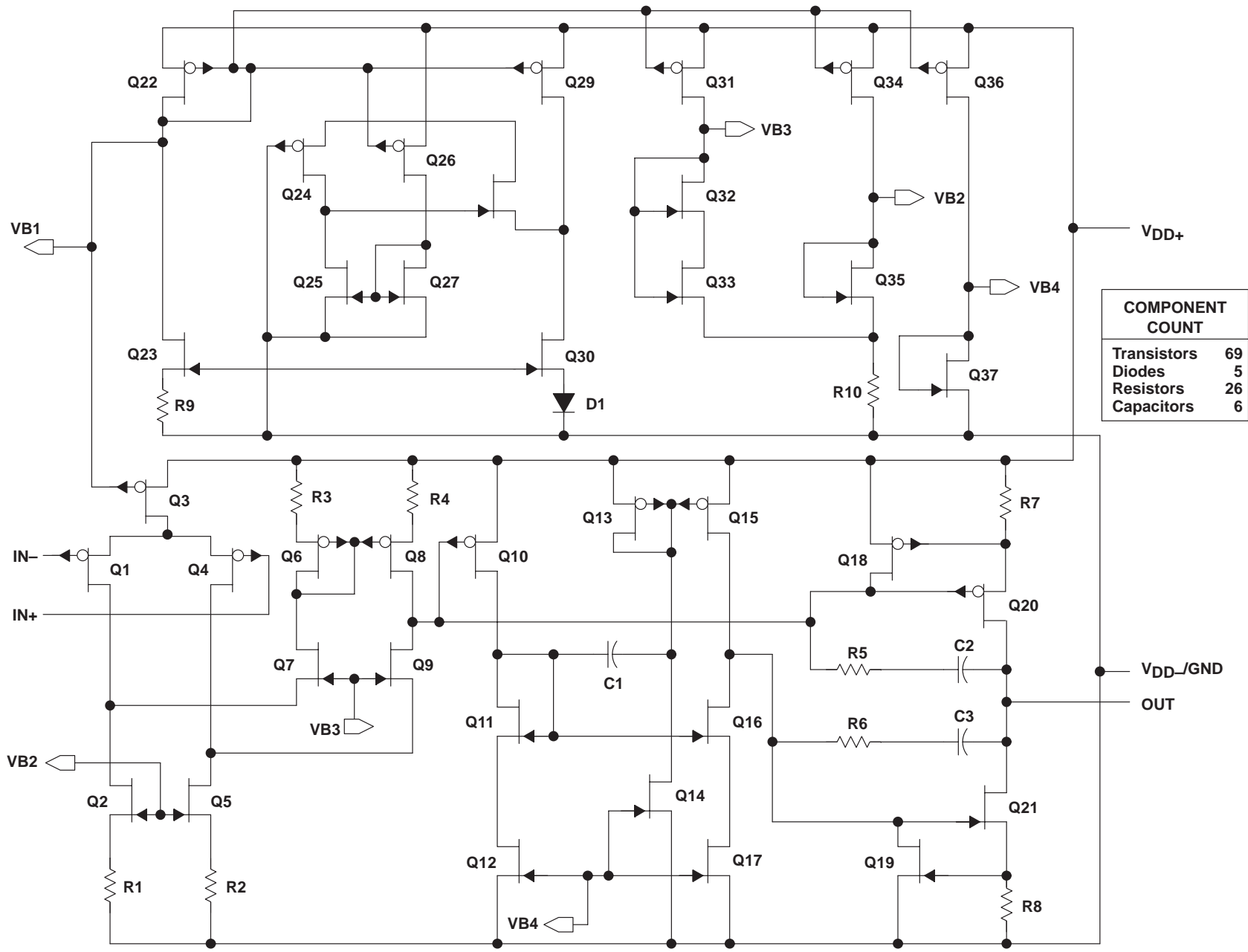


NC – No internal connection



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equivalent schematic (each amplifier)



COMPONENT COUNT	
Transistors	69
Diodes	5
Resistors	26
Capacitors	6

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SLOS168E – NOVEMBER 1996 – REVISED NOVEMBER 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)	$\pm 5$ mA
Output current, $I_O$	$\pm 50$ mA
Total current into $V_{DD+}$	$\pm 50$ mA
Total current out of $V_{DD-}$	$\pm 50$ mA
Duration of short-circuit current at (or below) 25°C (see Note 3)	unlimited
Continuous total 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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SLOS168E – NOVEMBER 1996 – REVISED NOVEMBER 1999

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

PARAMETER	TEST CONDITIONS		$T_A^\dagger$	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	$\mu\text{V}$	
			Full range	2500			
		TLV243xAI	25°C	300	950		
			Full range	1500			
$\alpha_{V_{IO}}$ 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		$\text{pA}$	
			Full range	150			
$I_{IB}$ Input bias current			25°C	1		$\text{pA}$	
			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	$\text{V}$	
			Full range	0 to 2.2			
$V_{OH}$ High-level output voltage	$I_{OH} = -100\ \mu\text{A}$		25°C	2.98		$\text{V}$	
			25°C	$I_{OH} = -3\text{ mA}$	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		$\text{V}$	
			25°C	$I_{OL} = 3\text{ mA}$	0.83		
	Full range	1					
$A_{VD}$ Large-signal differential voltage amplification	$V_{IC} = 2.5\text{ V},$ $V_O = 1\text{ V to }2\text{ V}$	$R_L = 2\text{ k}\Omega^\ddagger$	25°C	1.5	2.5	$\text{V/mV}$	
			Full range	1			
		$R_L = 1\text{ M}\Omega^\ddagger$	25°C	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		$\text{pF}$	
$z_o$ Closed-loop output impedance	$f = 100\text{ kHz},$ $A_V = 10$		25°C	130		$\Omega$	
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	$\text{dB}$	
			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	$\text{dB}$	
			Full range	80			
$I_{DD}$ Supply current (per channel)	$V_O = 1.5\text{ V},$ No load		25°C	98	125	$\mu\text{A}$	
			Full range	125			

$^\dagger$  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.

$^\ddagger$  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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SLOS168E – NOVEMBER 1996 – REVISED NOVEMBER 1999

**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/ $\mu\text{s}$
			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		$\mu\text{V}$
	$f = 0.1\text{ Hz to }10\text{ Hz}$		25°C	4		
$I_n$ Equivalent input noise current			25°C	0.6		fA/ $\sqrt{\text{Hz}}$
THD + N Total harmonic distortion plus noise	$V_O = 0.5\text{ V to }2.5\text{ V}$ , $f = 1\text{ kHz}$ , $R_L = 2\text{ k}\Omega‡$	$A_V = 1$	25°C	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, $R_L = 2\text{ k}\Omega‡$ , $C_L = 100\text{ pF}‡$	To 0.1%	25°C	6.4		$\mu\text{s}$
		To 0.01%		14.1		
$\phi_m$ Phase margin at unity gain	$R_L = 2\text{ k}\Omega‡$	$C_L = 100\text{ pF}‡$	25°C	62°		
Gain margin			25°C	11		

† 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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**Advanced LinCMOS™ RAIL-TO-RAIL OUTPUT**  
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SLOS168E – NOVEMBER 1996 – REVISED NOVEMBER 1999

**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	$\mu\text{V}$	
			Full range	2500			
		TLV243xAQ, TLV243xAM	25°C	300	950		
			Full range	2000			
$\alpha_{V_{IO}}$ 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		$\text{pA}$	
			Full range	150			
$I_{IB}$ Input bias current			25°C	1		$\text{pA}$	
			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	$I_{OH} = -100\ \mu\text{A}$		25°C	2.98		V	
			25°C	2.5			
			Full range	2.25			
$V_{OL}$ Low-level output voltage	$V_{IC} = 1.5\text{ V},$ $I_{OL} = 100\ \mu\text{A}$		25°C	0.02		V	
			25°C	0.83			
	$V_{IC} = 1.5\text{ V},$ $I_{OL} = 3\text{ mA}$	Full range	1				
$A_{VD}$ Large-signal differential voltage amplification	$V_{IC} = 2.5\text{ V},$ $V_O = 1\text{ V to }2\text{ V}$	$R_L = 2\text{ k}\Omega^\ddagger$	25°C	1.5	2.5	V/mV	
			Full range	0.5			
		$R_L = 1\text{ M}\Omega^\ddagger$	25°C	750			
$r_{i(d)}$ Differential input resistance			25°C	1000		G $\Omega$	
$r_{i(c)}$ Common-mode input resistance			25°C	1000		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		$\Omega$	
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	$\mu\text{A}$	
			Full range	260			

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

‡ Referenced to 2.5 V

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

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SLOS168E – NOVEMBER 1996 – REVISED NOVEMBER 1999

**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/ $\mu\text{s}$	
		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		$\mu\text{V}$	
	$f = 0.1\text{ Hz to }10\text{ Hz}$	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	To 0.1%	6.4		
			To 0.01%	14.1		
$\phi_m$ 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 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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SLOS168E – NOVEMBER 1996 – REVISED NOVEMBER 1999

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

PARAMETER	TEST CONDITIONS		$T_A^\dagger$	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	$\mu\text{V}$	
			Full range	2500			
		TLV243xA	25°C	300	950		
			Full range	1500			
$\alpha_{VIO}$ 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		$\text{pA}$	
			Full range	150			
$I_{IB}$ Input bias current			25°C	1		$\text{pA}$	
			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	$\text{V}$	
			Full range	0 to 4.2			
$V_{OH}$ High-level output voltage	$I_{OH} = -100\ \mu\text{A}$		25°C	4.97		$\text{V}$	
			Full range	25°C	4		4.35
				4			
$V_{OL}$ Low-level output voltage	$V_{IC} = 2.5\text{ V},$ $I_{OL} = 100\ \mu\text{A}$		25°C	0.01		$\text{V}$	
			Full range	25°C	0.8		
	$V_{IC} = 2.5\text{ V},$ $I_{OL} = 5\text{ mA}$			1.25			
$A_{VD}$ Large-signal differential voltage amplification	$V_{IC} = 2.5\text{ V},$ $V_O = 1\text{ V to }4\text{ V}$	$R_L = 2\text{ k}\Omega^\ddagger$	25°C	2.5	3.8	$\text{V/mV}$	
			Full range	1.5			
		$R_L = 1\text{ M}\Omega^\ddagger$	25°C	950			
$r_{i(d)}$ 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		$\text{pF}$	
$z_o$ Closed-loop output impedance	$f = 100\text{ kHz},$ $A_V = 10$		25°C	130		$\Omega$	
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	$\text{dB}$	
			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	$\text{dB}$	
			Full range	80			
$I_{DD}$ Supply current (per channel)	$V_O = 2.5\text{ V},$ No load		25°C	100	125	$\mu\text{A}$	
			Full range	125			

$^\dagger$  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.

$^\ddagger$  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.

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

SLOS168E – NOVEMBER 1996 – REVISED NOVEMBER 1999

**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/ $\mu\text{s}$
		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		$\mu\text{V}$	
	$f = 0.1\text{ Hz to }10\text{ Hz}$	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	$f = 10\text{ kHz}, R_L = 2\text{ k}\Omega\ddagger, C_L = 100\text{ pF}\ddagger$	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	$A_V = -1, \text{ Step} = 1.5\text{ V to }3.5\text{ V}, R_L = 2\text{ k}\Omega\ddagger, C_L = 100\text{ pF}\ddagger$	$T_o = 0.1\%$	6.4		$\mu\text{s}$	
		$T_o = 0.01\%$	13.1			
$\phi_m$ 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



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

SLOS168E – NOVEMBER 1996 – REVISED NOVEMBER 1999

**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	$\mu\text{V}$
			Full range	2500		
		TLV2453xA	25°C	300	950	
			Full range	2000		
$\alpha_{V_{IO}}$ 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		$\text{pA}$	
		Full range	150			
$I_{IB}$ Input bias current		25°C	1		$\text{pA}$	
		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	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	
		25°C	0.8			
	$V_{IC} = 2.5\text{ V},$ $I_{OL} = 5\text{ mA}$	Full range	1.25			
$A_{VD}$ Large-signal differential voltage amplification	$V_{IC} = 2.5\text{ V},$ $V_O = 1\text{ V to }4\text{ V}$	$R_L = 2\text{ k}\Omega^\ddagger$	25°C	2.5	3.8	V/mV
			Full range	0.5		
		$R_L = 1\text{ M}\Omega^\ddagger$	25°C	950		
$r_{i(d)}$ Differential input resistance		25°C	1000		G $\Omega$	
$r_{i(c)}$ Common-mode input resistance		25°C	1000		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		$\Omega$	
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	$\mu\text{A}$	
		Full range	270			

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

‡ Referenced to 2.5 V

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

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

SLOS168E – NOVEMBER 1996 – REVISED NOVEMBER 1999

**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/ $\mu\text{s}$
		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		$\mu\text{V}$	
	$f = 0.1\text{ Hz to }10\text{ Hz}$	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	$A_V = -1, \text{ Step} = 1.5\text{ V to }3.5\text{ V}, R_L = 2\text{ k}\Omega\ddagger, C_L = 100\text{ pF}\ddagger$	$T_o = 0.1\%$	6.4		$\mu\text{s}$	
		$T_o = 0.01\%$	13.1			
$\phi_m$ 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  $-40^\circ\text{C}$  to  $125^\circ\text{C}$  for Q level part,  $-55^\circ\text{C}$  to  $125^\circ\text{C}$  for M level part.

‡ Referenced to 2.5 V



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

SLOS168E – NOVEMBER 1996 – REVISED NOVEMBER 1999

**TYPICAL CHARACTERISTICS**

**Table of Graphs**

			<b>FIGURE</b>
$V_{IO}$	Input offset voltage	Distribution vs Common-mode input voltage	2,3 4,5
$\alpha_{VIO}$	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	19,20
$A_{VD}$	Differential voltage amplification	vs Free-air temperature	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 Free-air temperature vs Supply voltage	46 47
$\phi_m$	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

TYPICAL CHARACTERISTICS

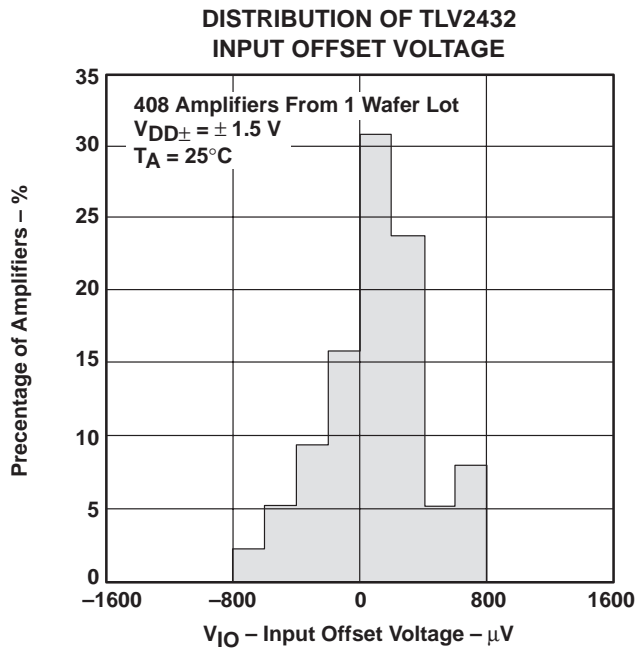


Figure 2

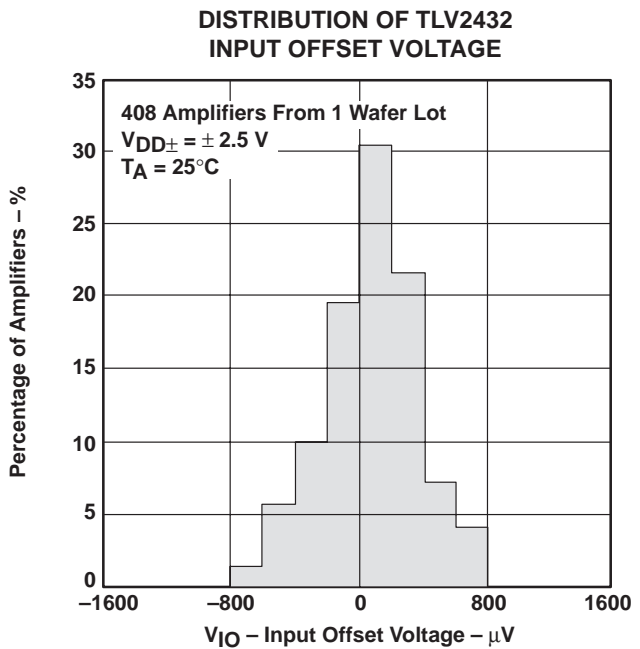


Figure 3

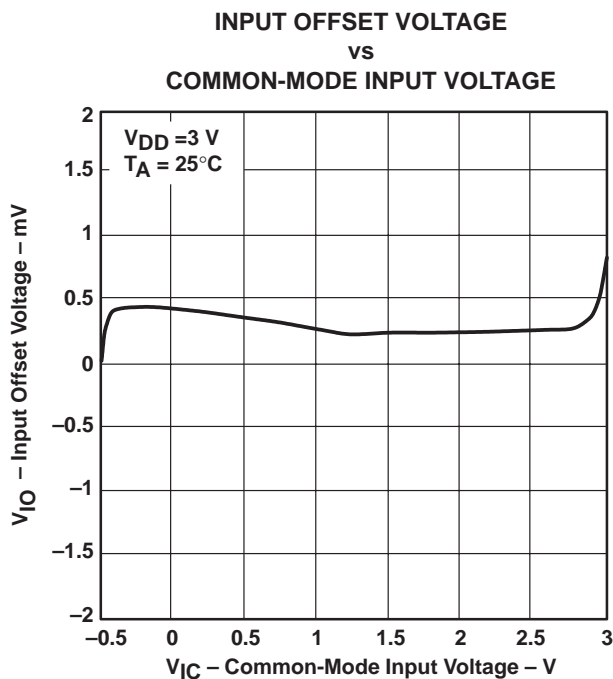


Figure 4

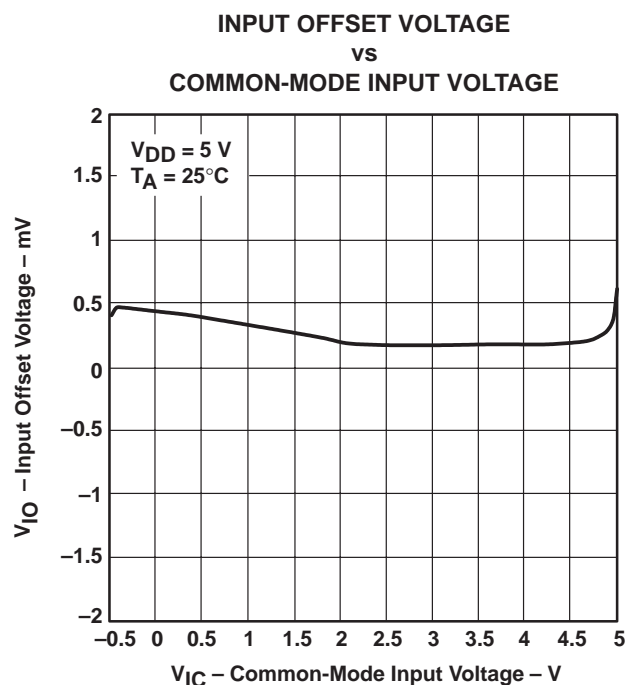


Figure 5

TYPICAL CHARACTERISTICS

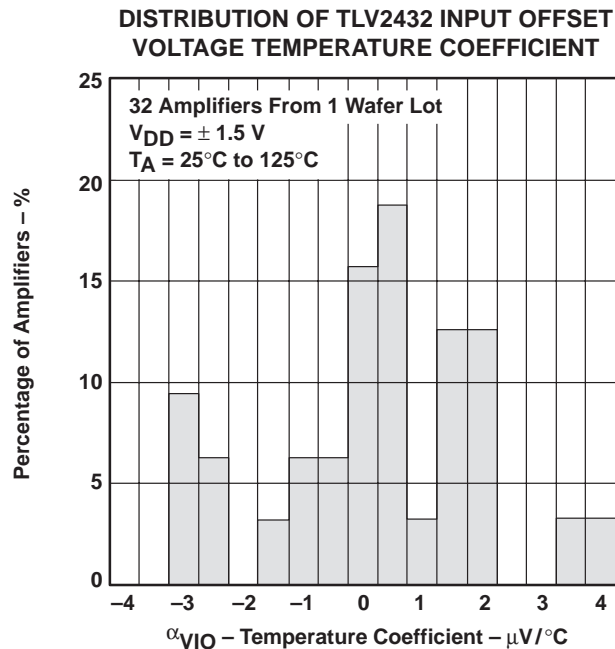


Figure 6

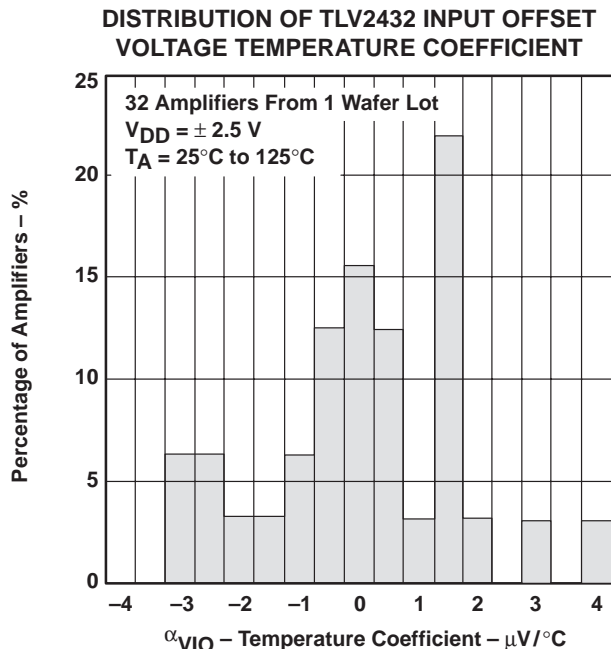


Figure 7

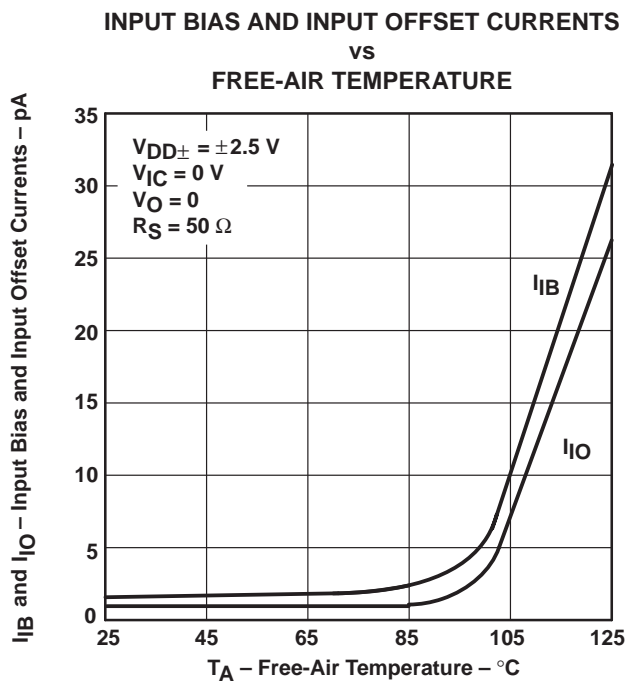


Figure 8

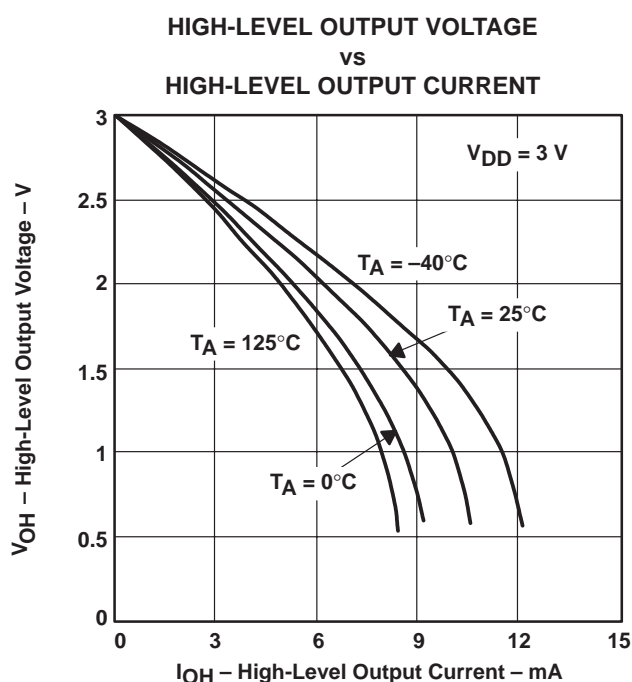


Figure 9

TYPICAL CHARACTERISTICS

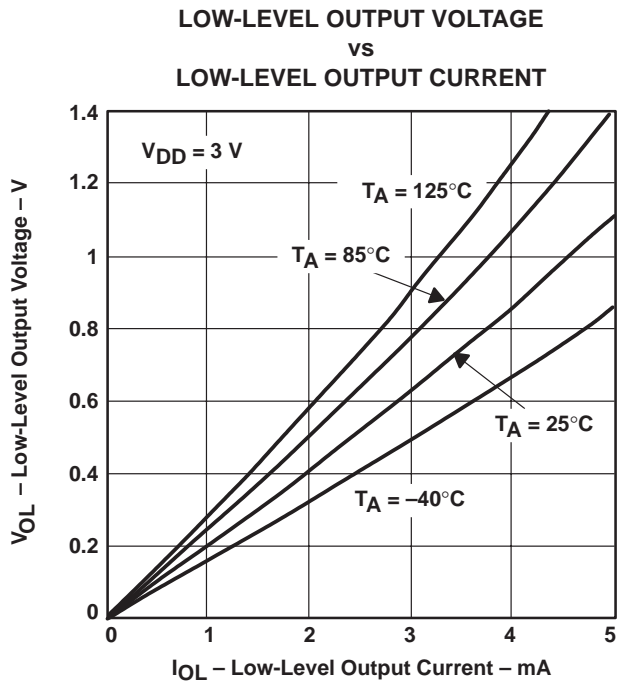


Figure 10

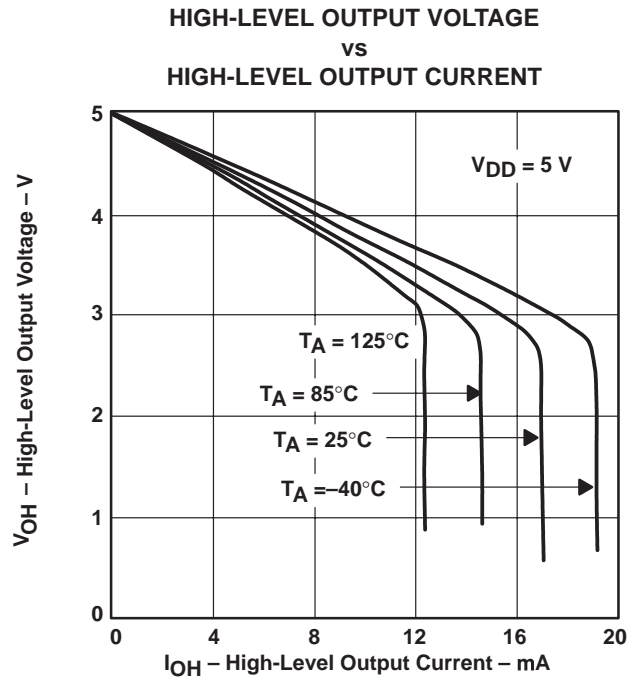


Figure 11

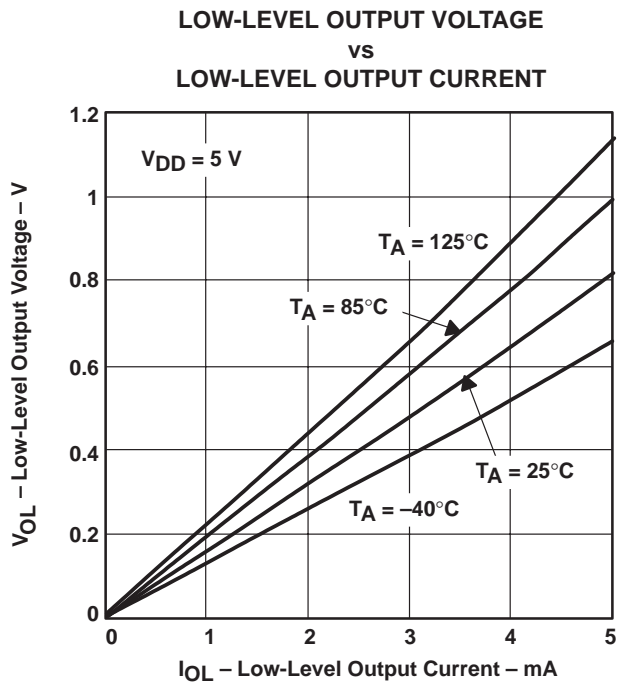


Figure 12

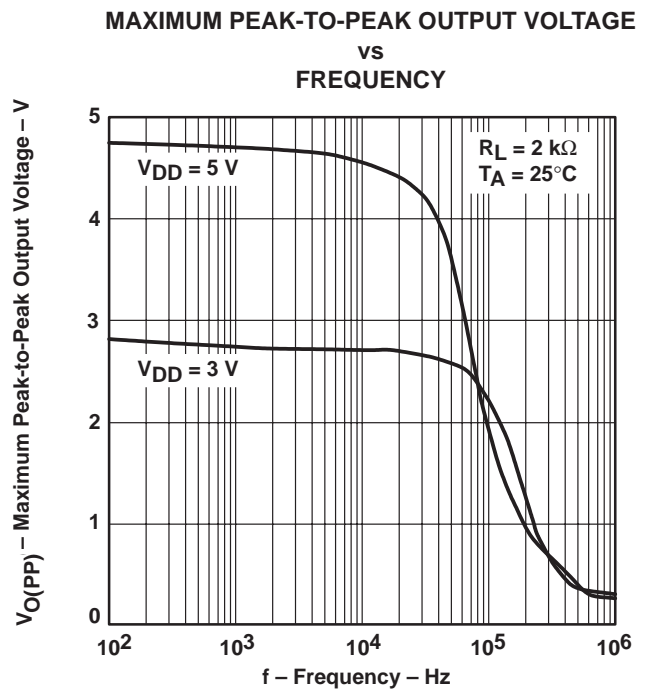


Figure 13



TYPICAL CHARACTERISTICS

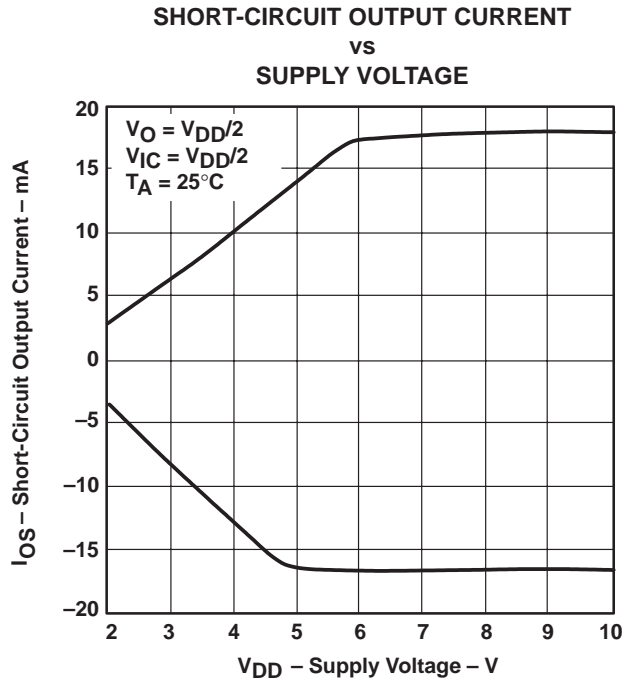


Figure 14

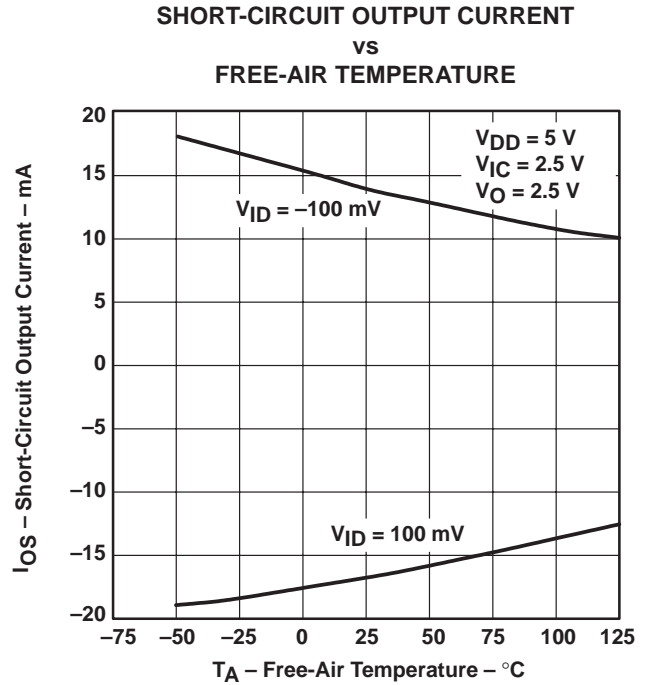


Figure 15

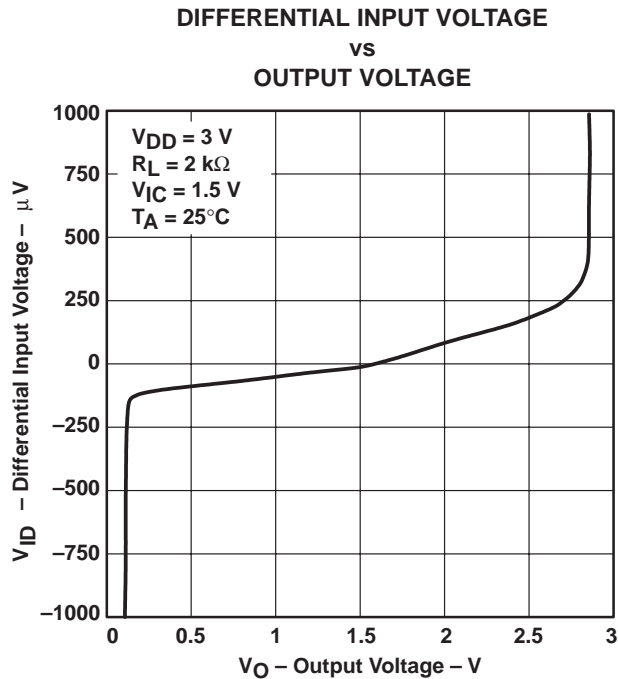


Figure 16

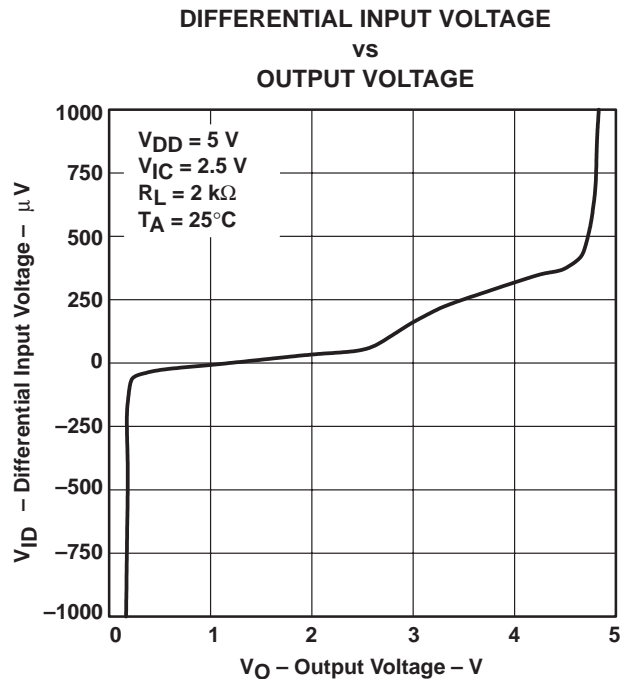


Figure 17

TYPICAL CHARACTERISTICS

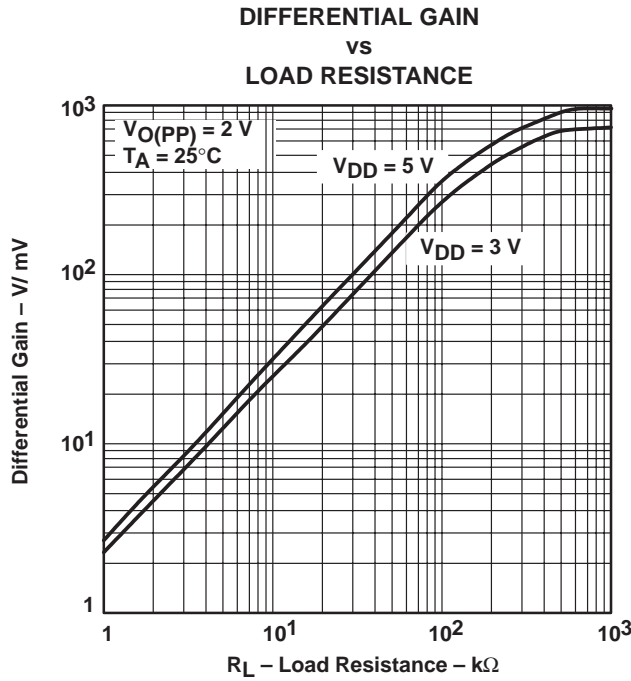


Figure 18

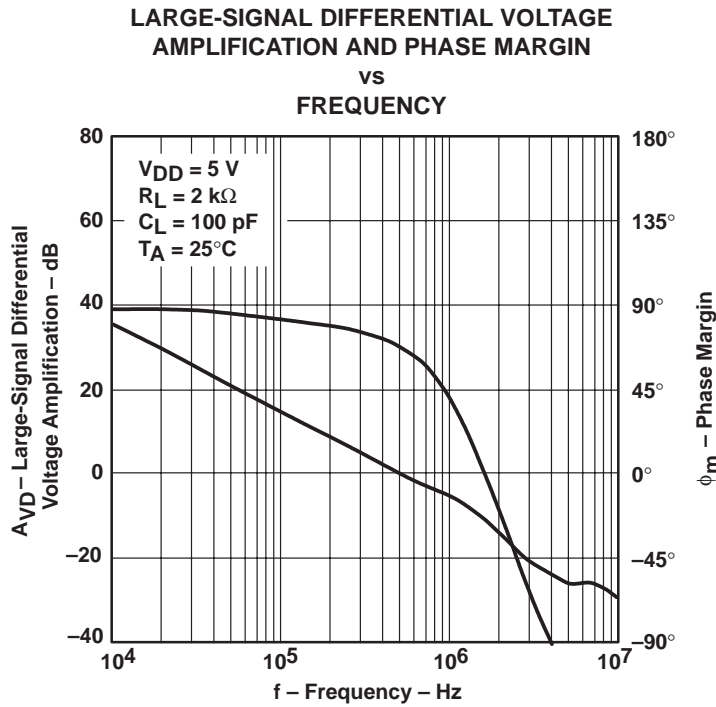


Figure 19

TYPICAL CHARACTERISTICS

LARGE-SIGNAL DIFFERENTIAL VOLTAGE  
 AMPLIFICATION AND PHASE MARGIN

vs  
 FREQUENCY

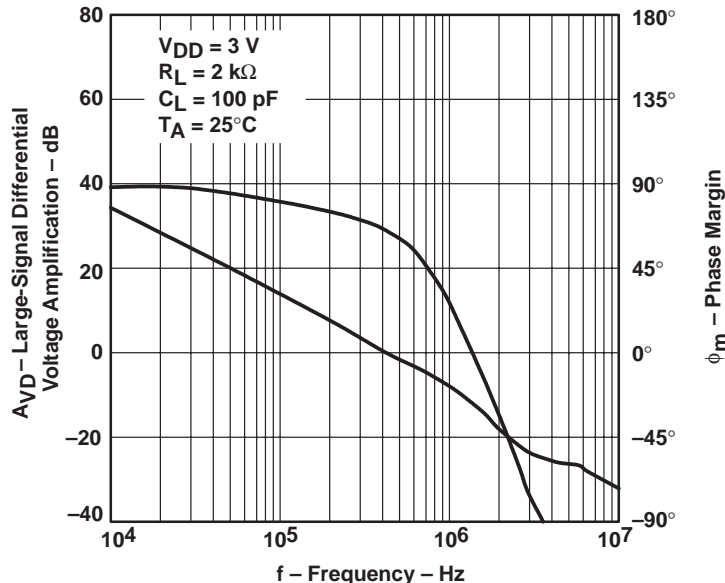


Figure 20

DIFFERENTIAL VOLTAGE AMPLIFICATION  
 vs  
 FREE-AIR TEMPERATURE

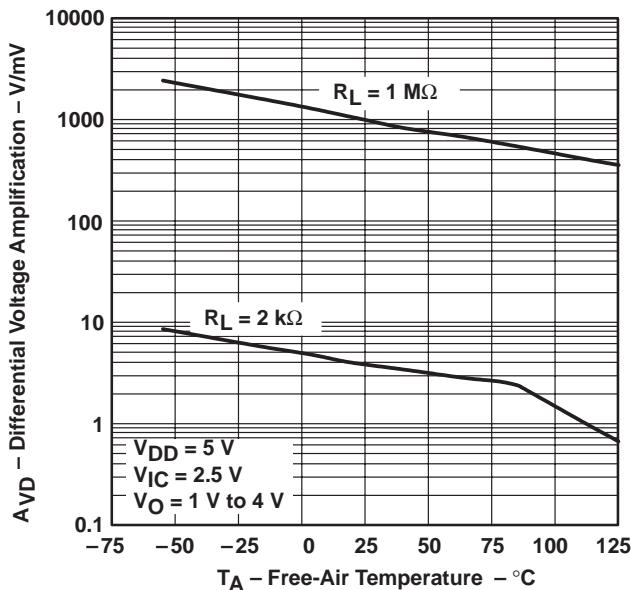


Figure 21

DIFFERENTIAL VOLTAGE AMPLIFICATION  
 vs  
 FREE-AIR TEMPERATURE

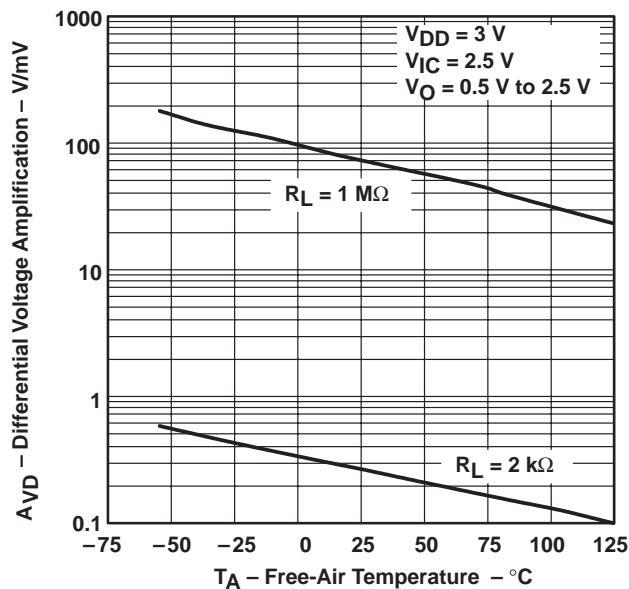


Figure 22

TYPICAL CHARACTERISTICS

OUTPUT IMPEDANCE  
 VS  
 FREQUENCY

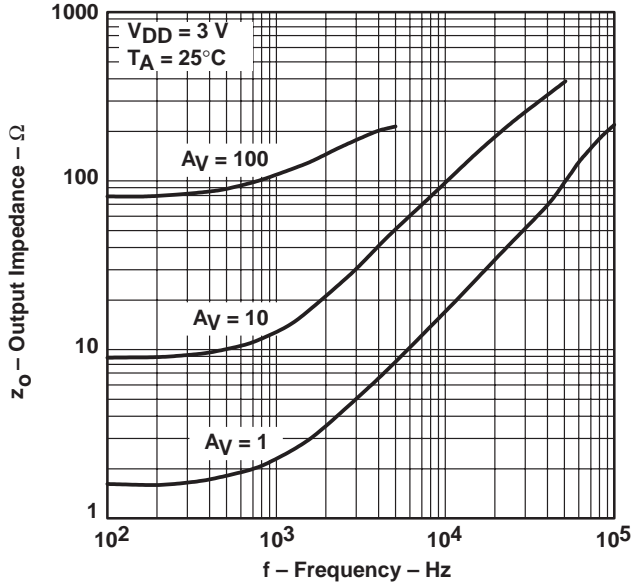


Figure 23

OUTPUT IMPEDANCE  
 VS  
 FREQUENCY

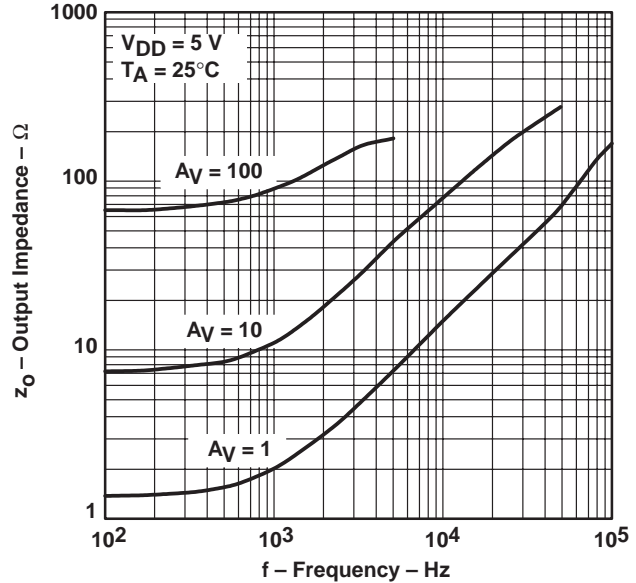


Figure 24

COMMON-MODE REJECTION RATIO  
 VS  
 FREQUENCY

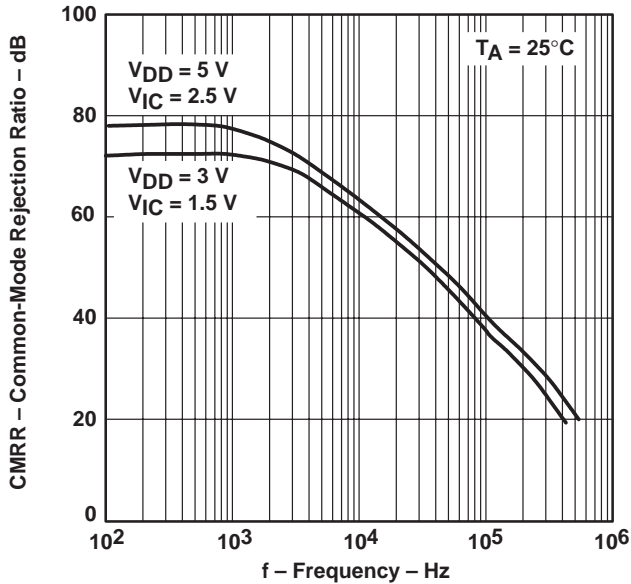


Figure 25

COMMON-MODE REJECTION RATIO  
 VS  
 FREE-AIR TEMPERATURE

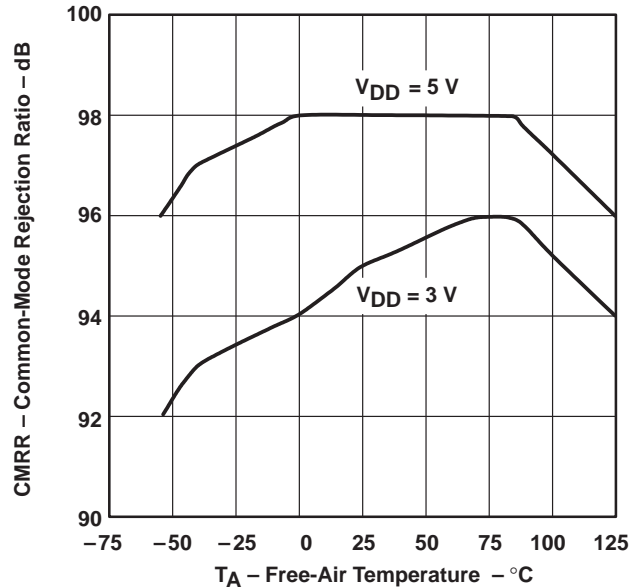


Figure 26

TYPICAL CHARACTERISTICS

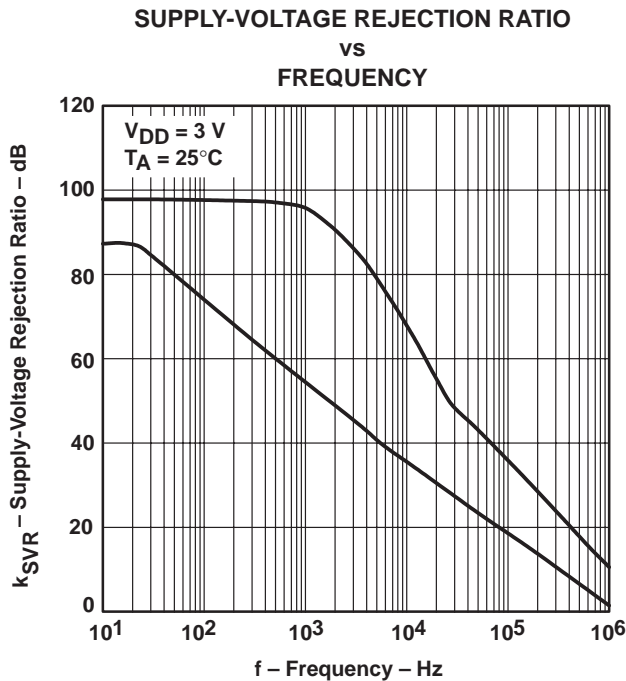


Figure 27

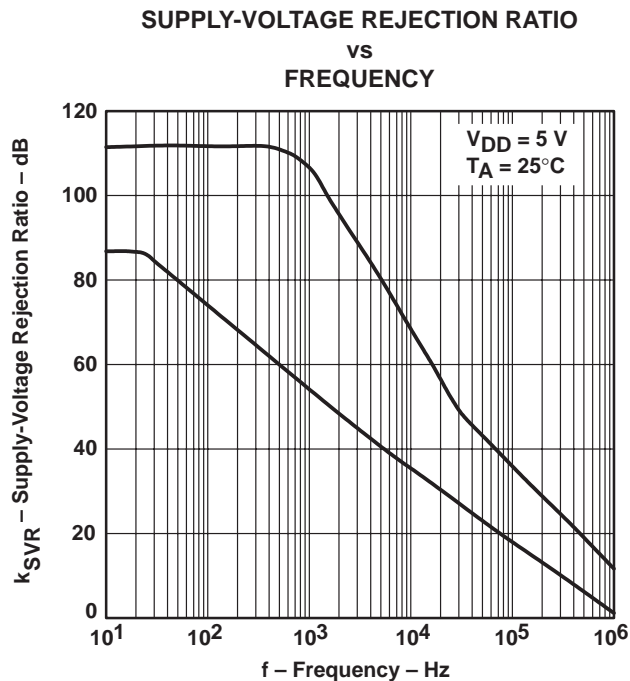


Figure 28

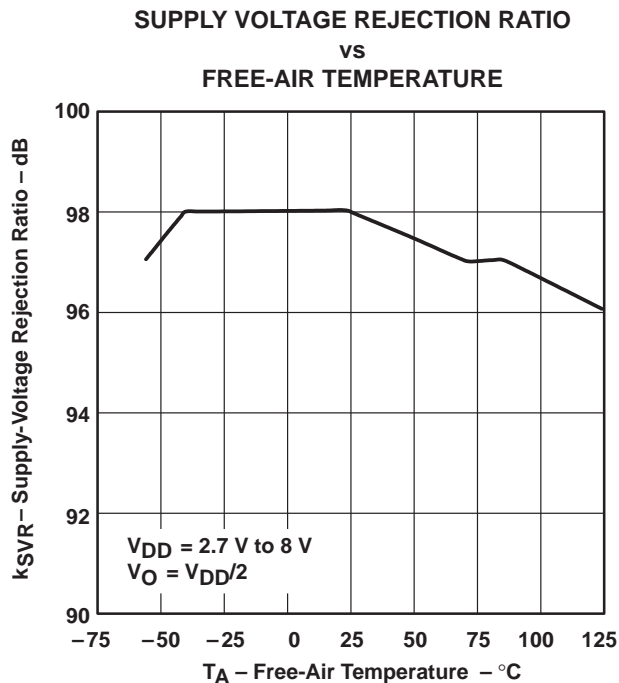


Figure 29

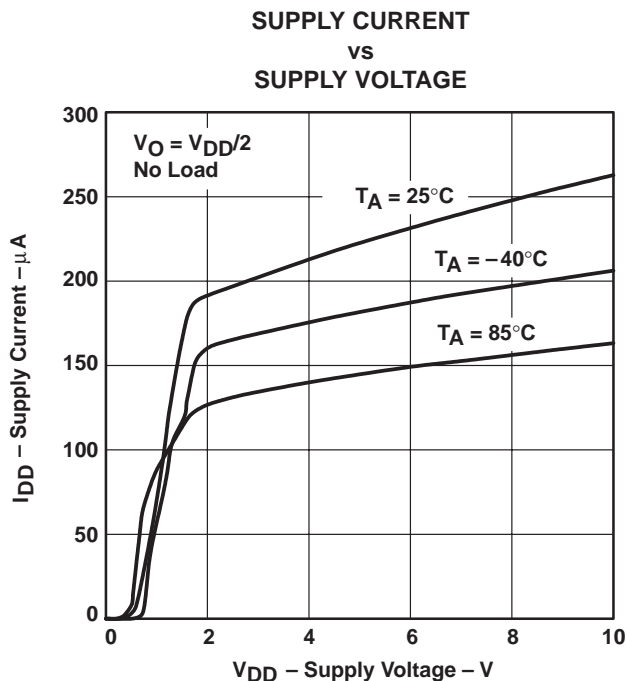


Figure 30

TYPICAL CHARACTERISTICS

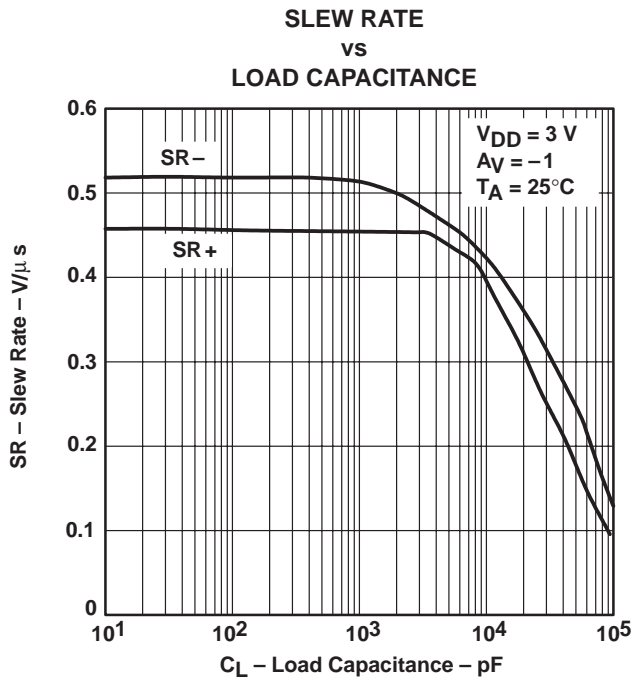


Figure 31

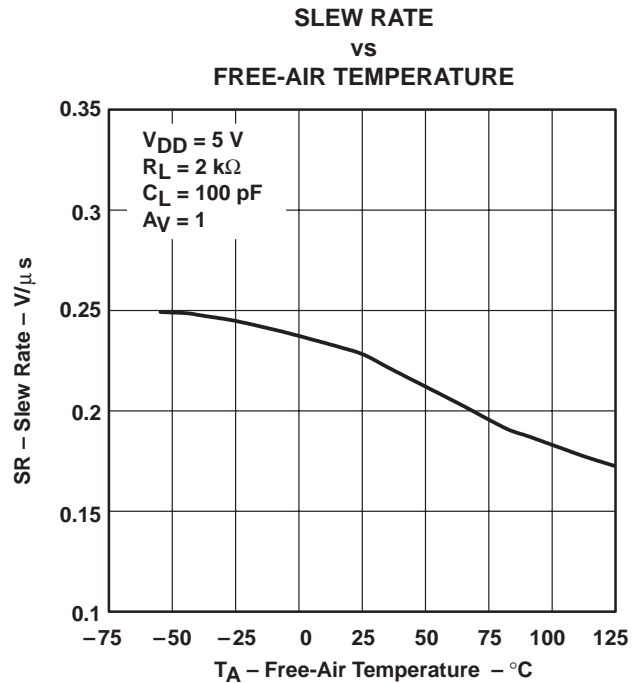


Figure 32

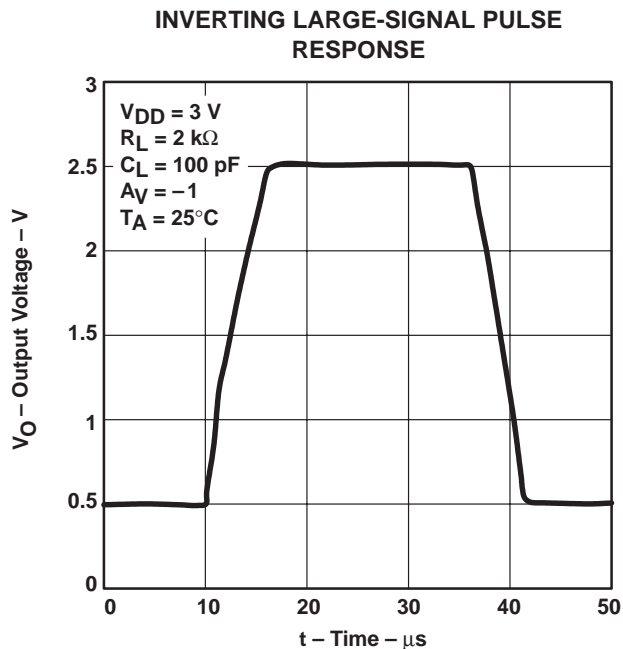


Figure 33

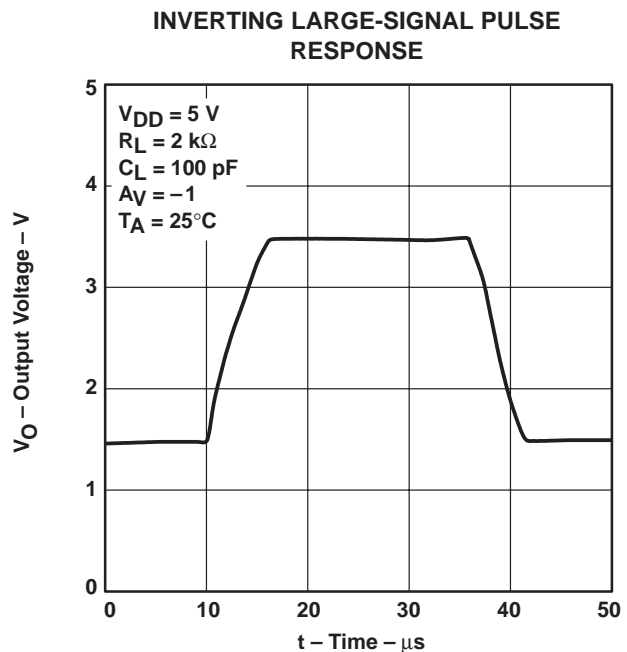


Figure 34

TYPICAL CHARACTERISTICS

VOLTAGE-FOLLOWER LARGE-SIGNAL  
 PULSE RESPONSE

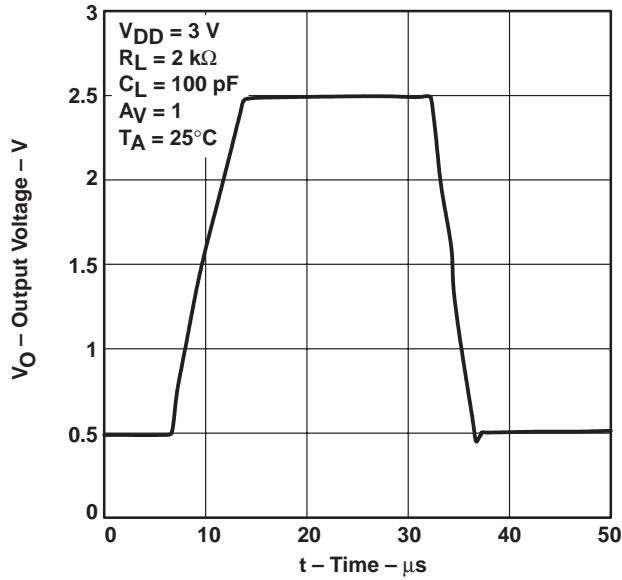


Figure 35

VOLTAGE-FOLLOWER LARGE-SIGNAL  
 PULSE RESPONSE

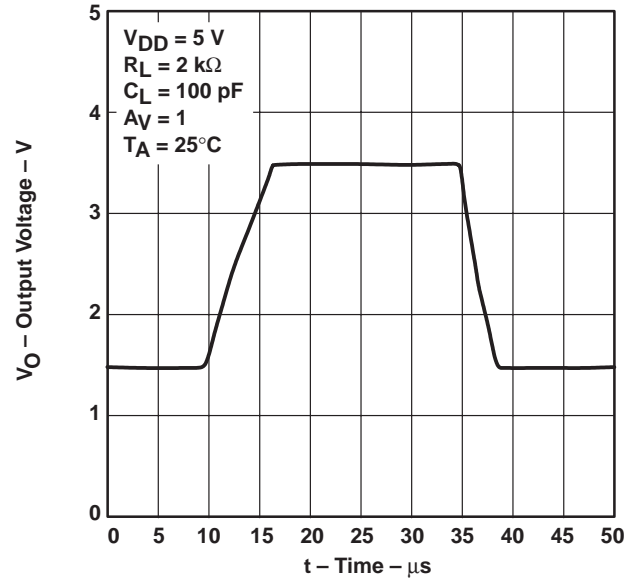


Figure 36

INVERTING SMALL-SIGNAL PULSE  
 RESPONSE

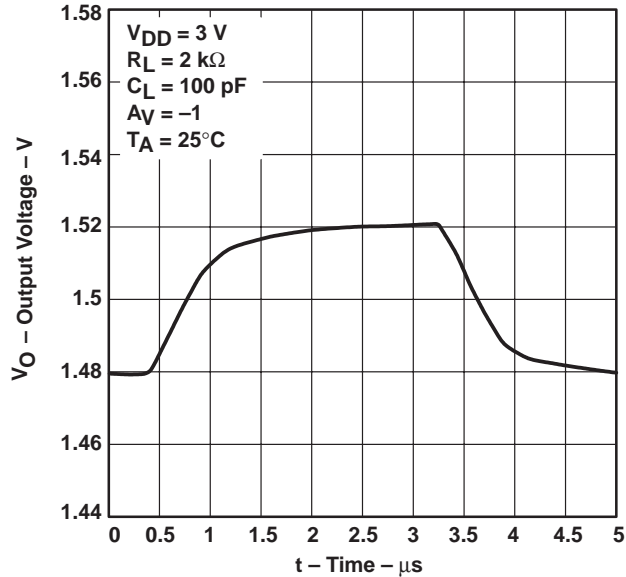


Figure 37

INVERTING SMALL-SIGNAL PULSE  
 RESPONSE

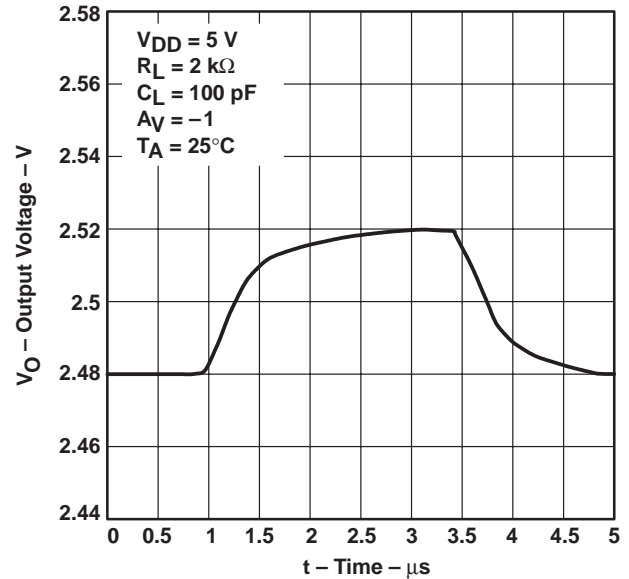


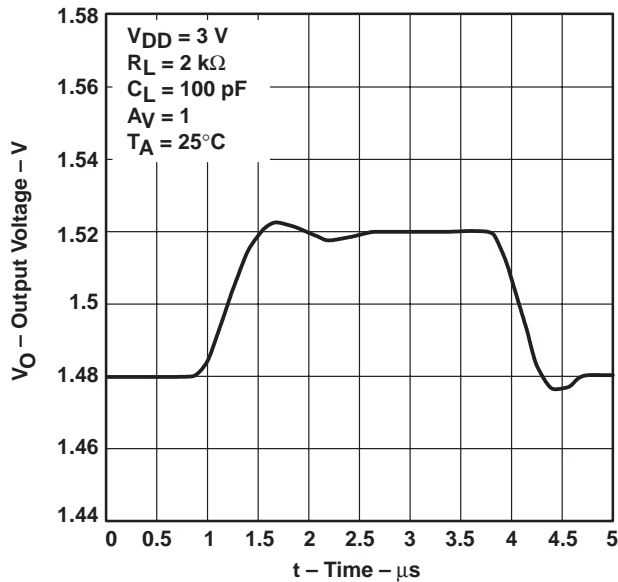
Figure 38

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

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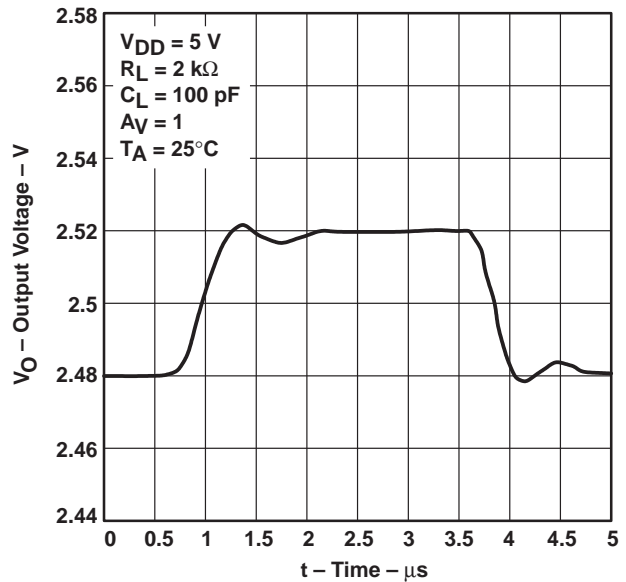
**TYPICAL CHARACTERISTICS**

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



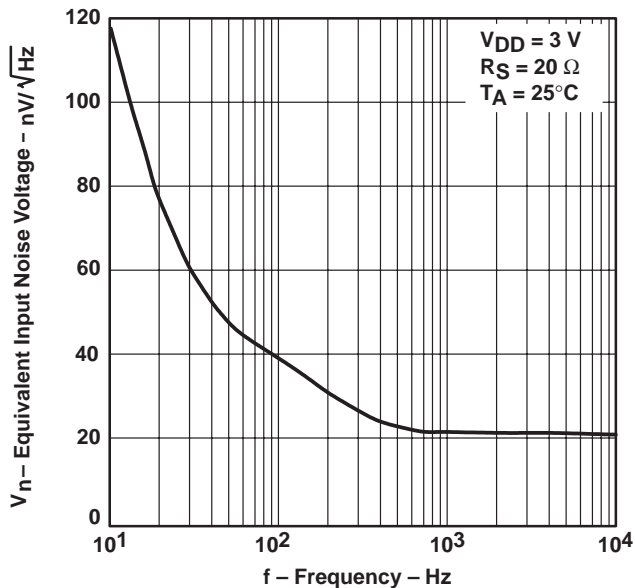
**Figure 39**

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



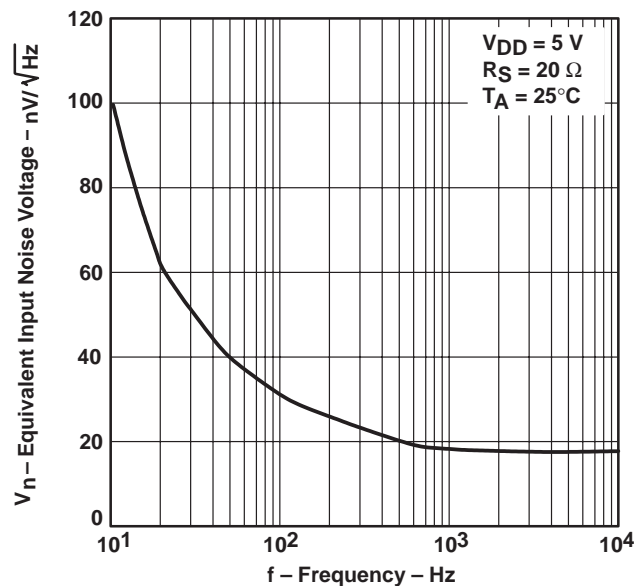
**Figure 40**

**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

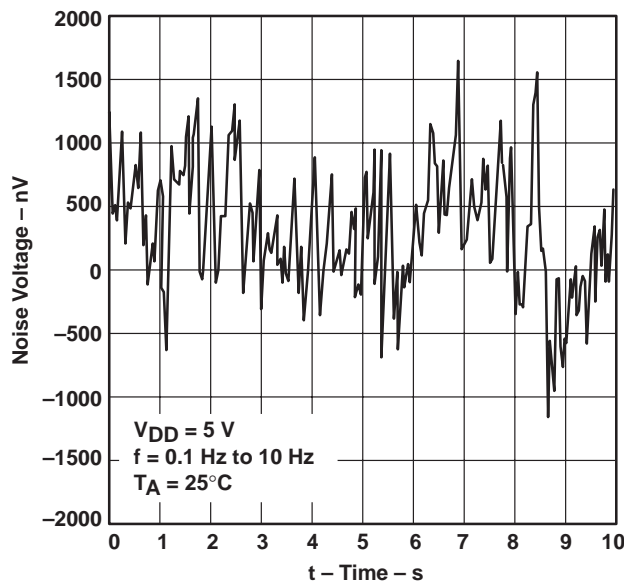


Figure 43

TOTAL HARMONIC DISTORTION PLUS NOISE  
 VS  
 FREQUENCY

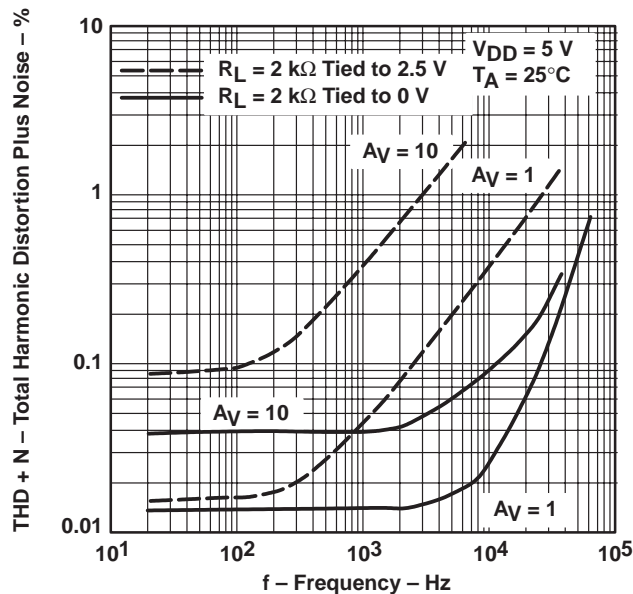


Figure 44

TOTAL HARMONIC DISTORTION PLUS NOISE  
 VS  
 FREQUENCY

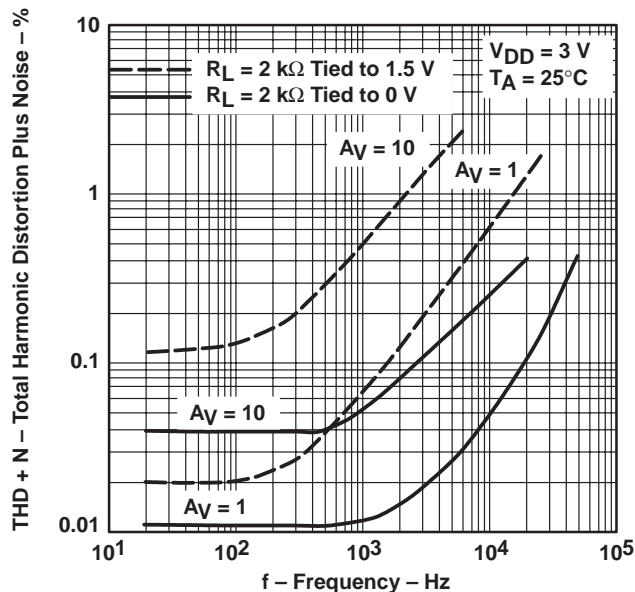


Figure 45

TYPICAL CHARACTERISTICS

GAIN-BANDWIDTH PRODUCT  
 vs  
 FREE-AIR TEMPERATURE

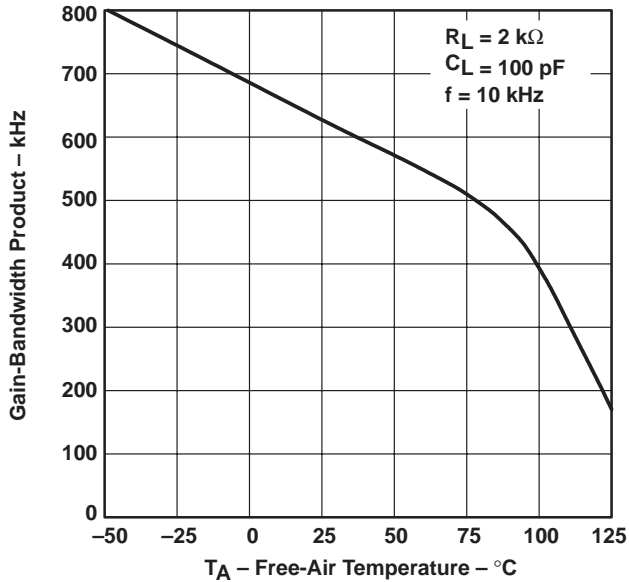


Figure 46

GAIN-BANDWIDTH PRODUCT  
 vs  
 SUPPLY VOLTAGE

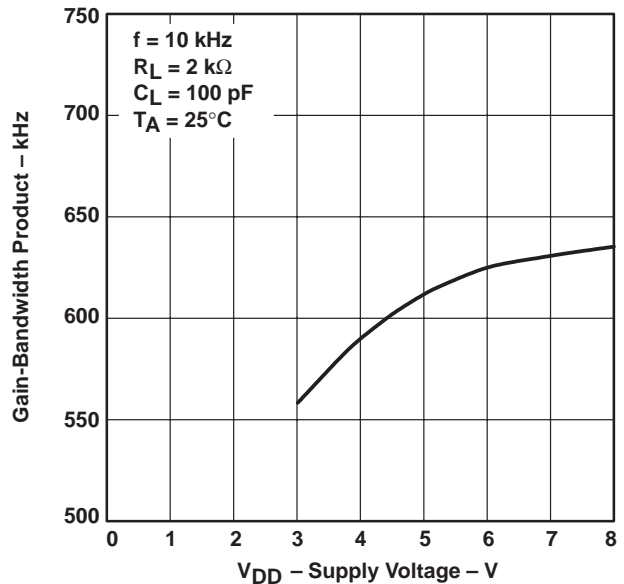


Figure 47

PHASE MARGIN  
 vs  
 LOAD CAPACITANCE

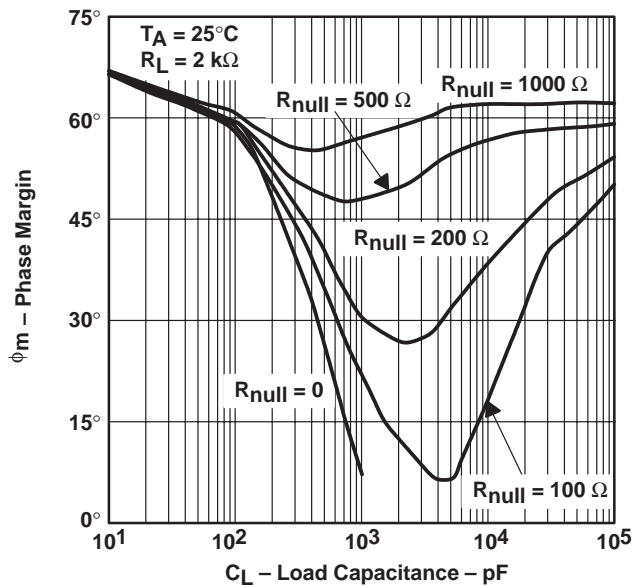


Figure 48

GAIN MARGIN  
 vs  
 LOAD CAPACITANCE

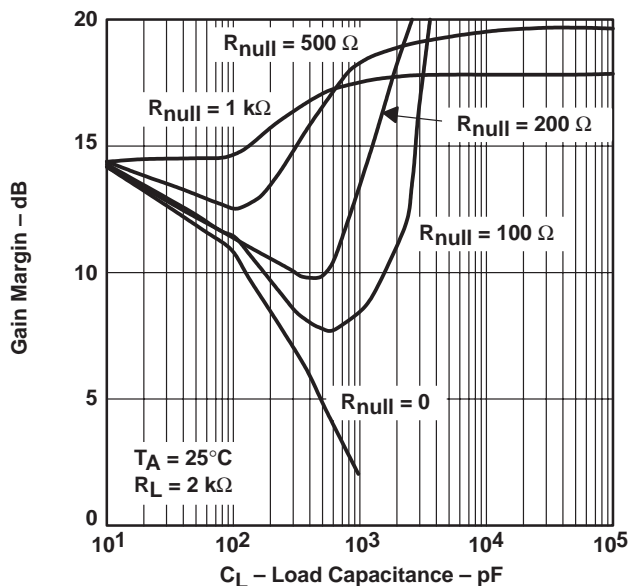


Figure 49

TYPICAL CHARACTERISTICS

UNITY-GAIN BANDWIDTH  
vs  
LOAD CAPACITANCE

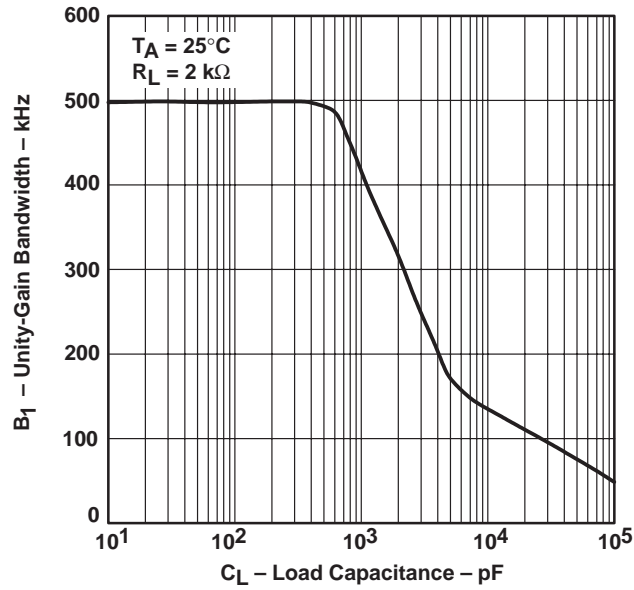


Figure 50

# 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 Intergrated Circuit Operational Amplifiers", *IEEE Journal of Solid-State Circuits*, SC-9, 353 (1974).

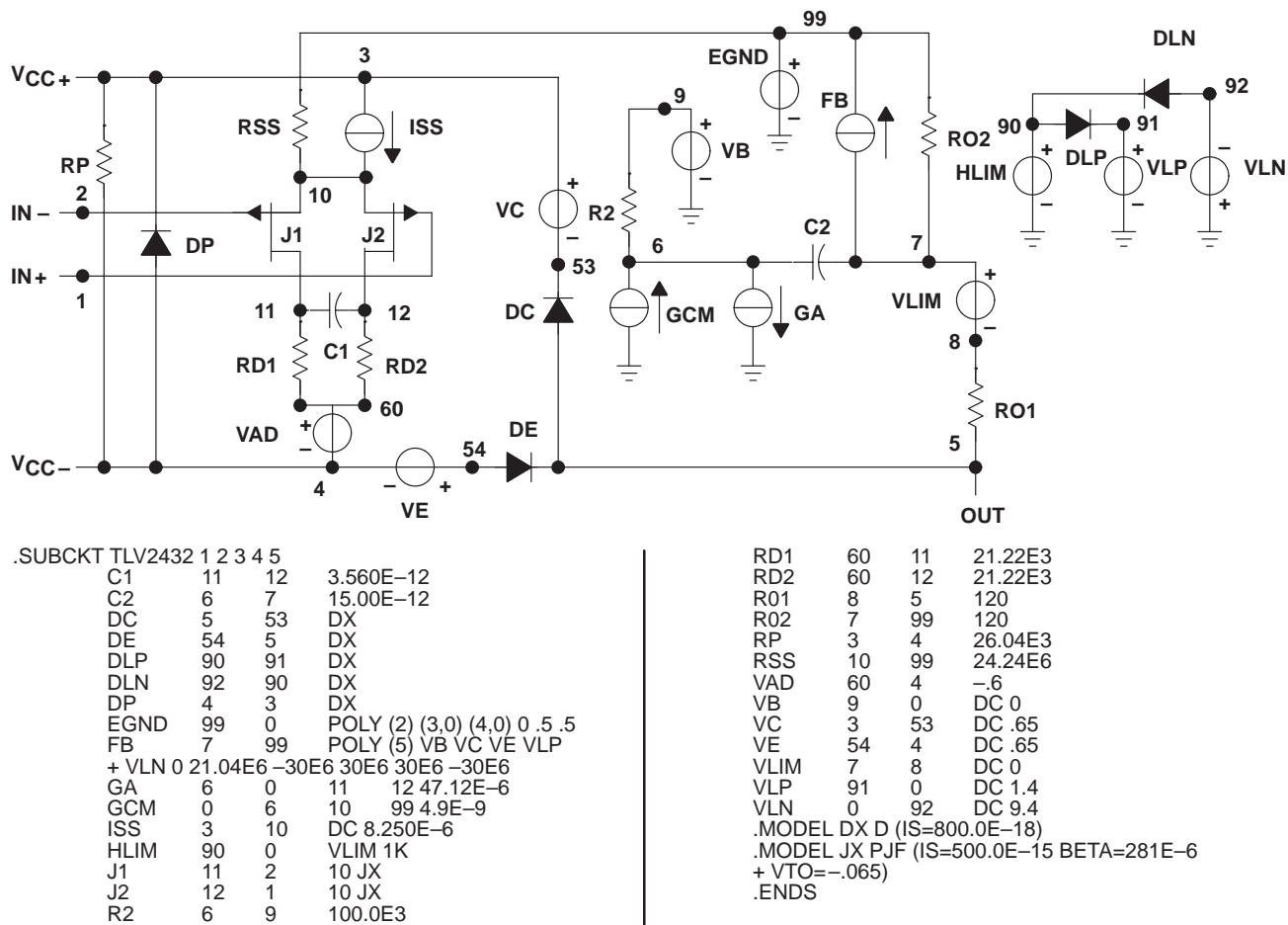


Figure 51. Boyle Macromodel and Subcircuit

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TLV2432, TLV2432A, TLV2434, TLV2434A  
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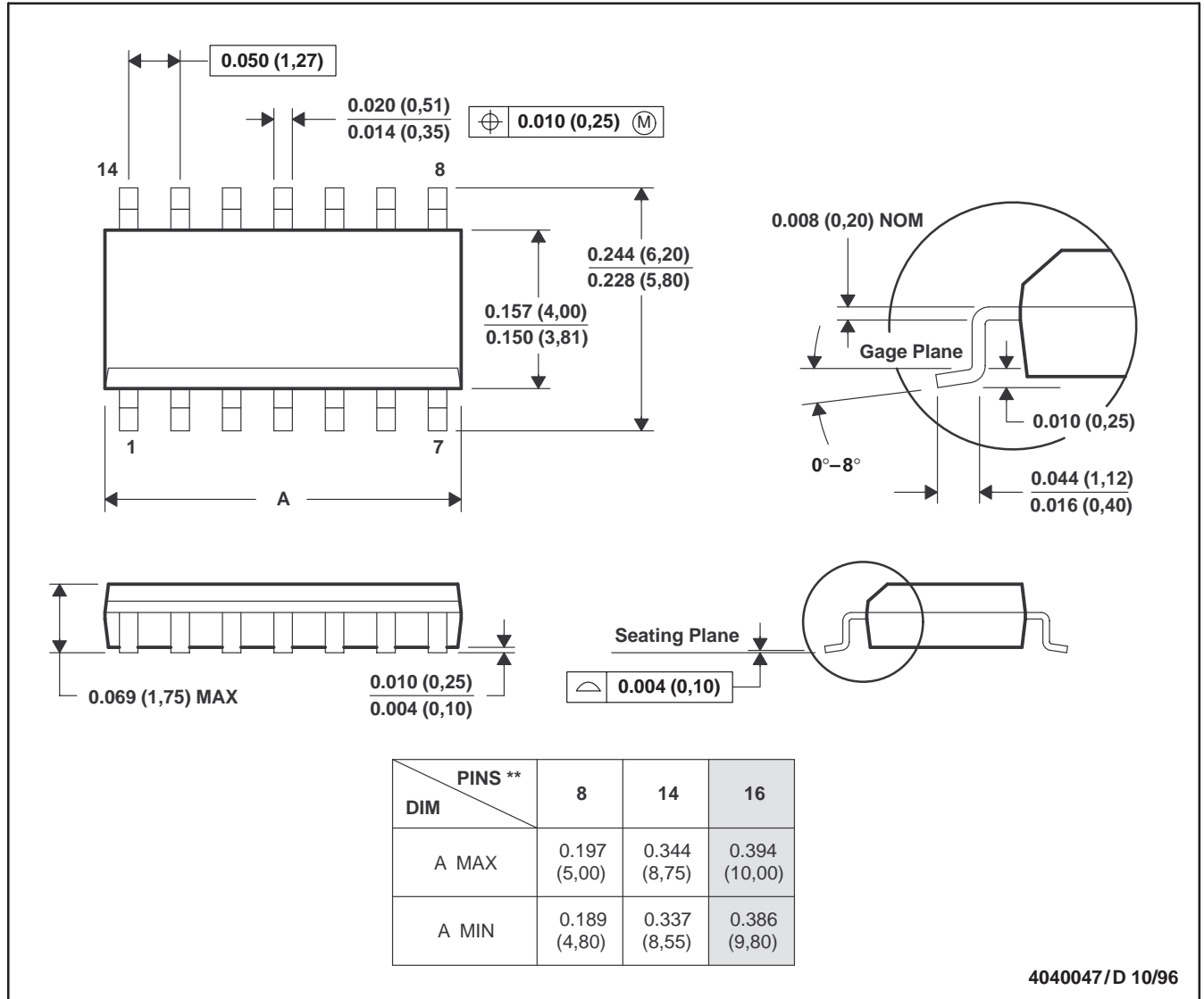
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MECHANICAL DATA

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**

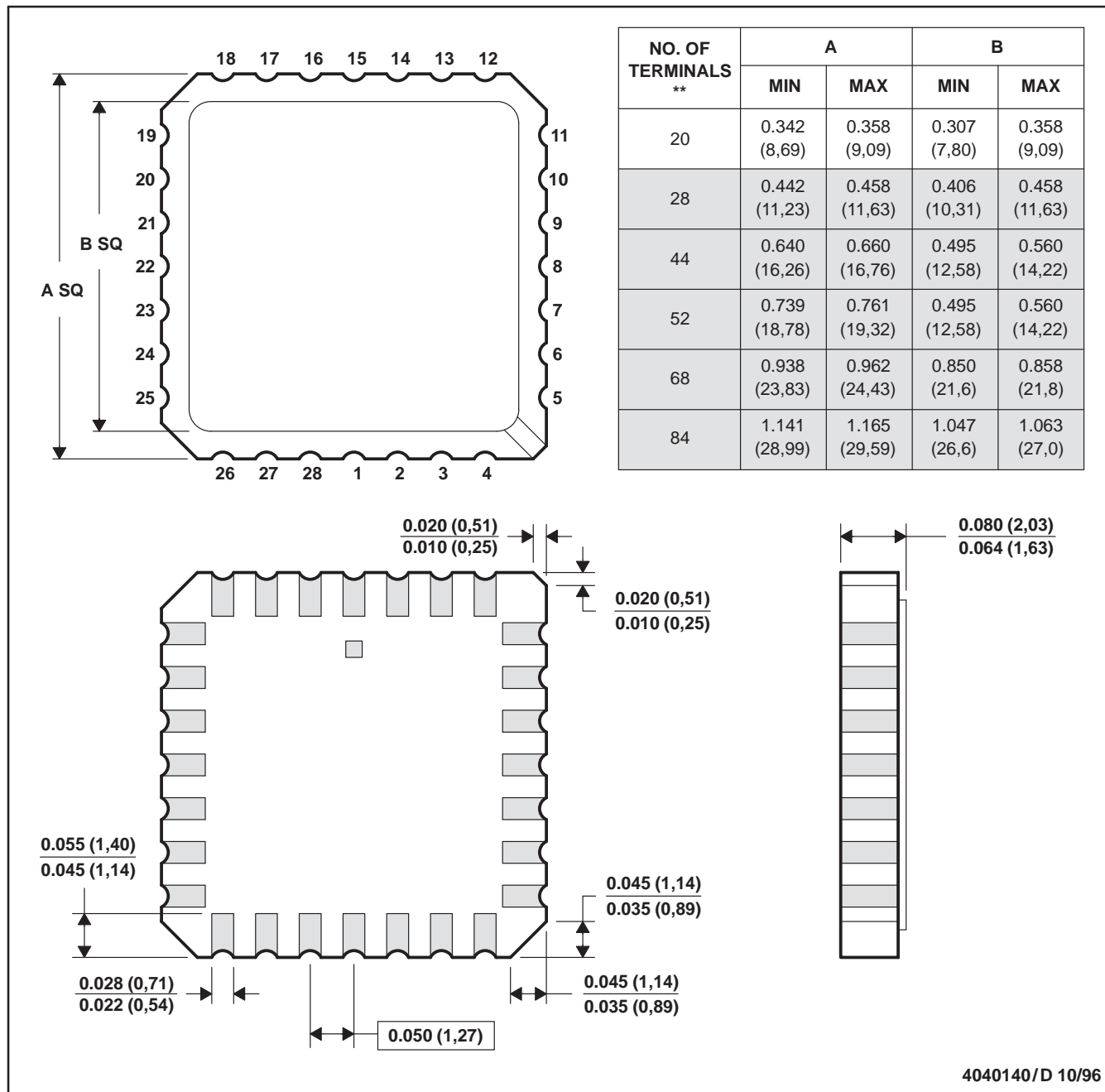
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**MECHANICAL DATA**

**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



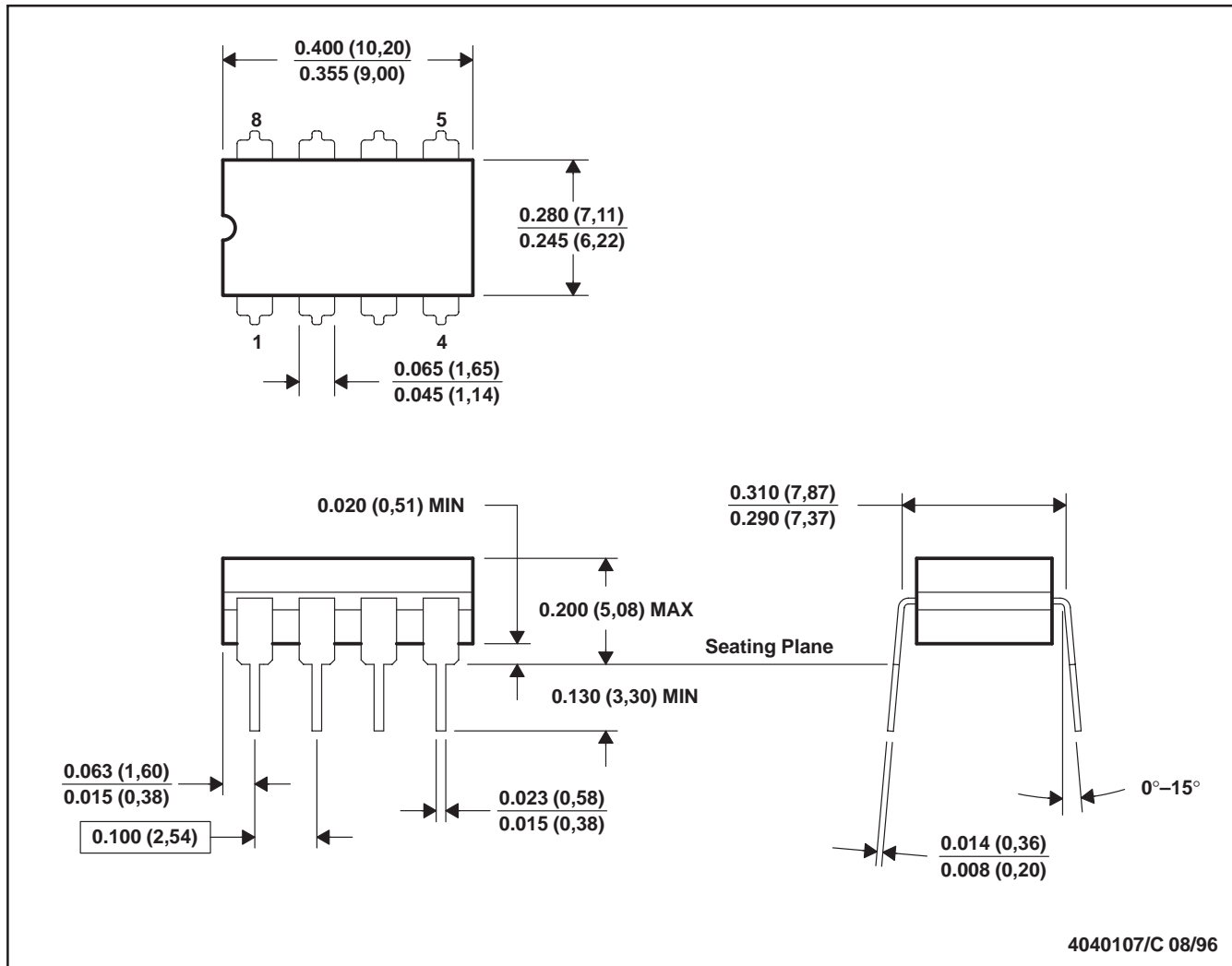
TLV2432, TLV2432A, TLV2434, TLV2434A  
 Advanced LinCMOS™ RAIL-TO-RAIL OUTPUT  
 WIDE-INPUT-VOLTAGE OPERATIONAL AMPLIFIERS

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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**

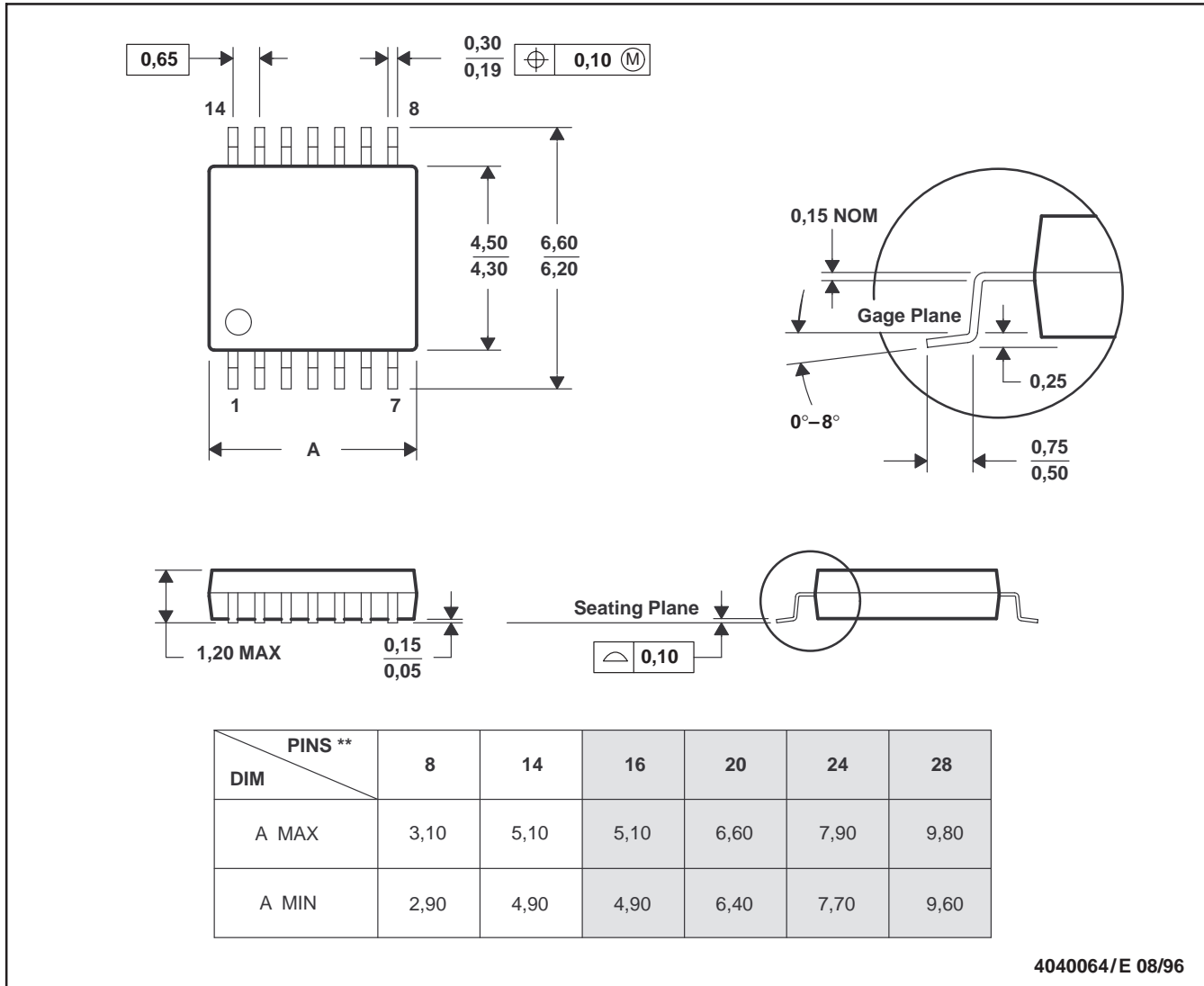
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**MECHANICAL DATA**

**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



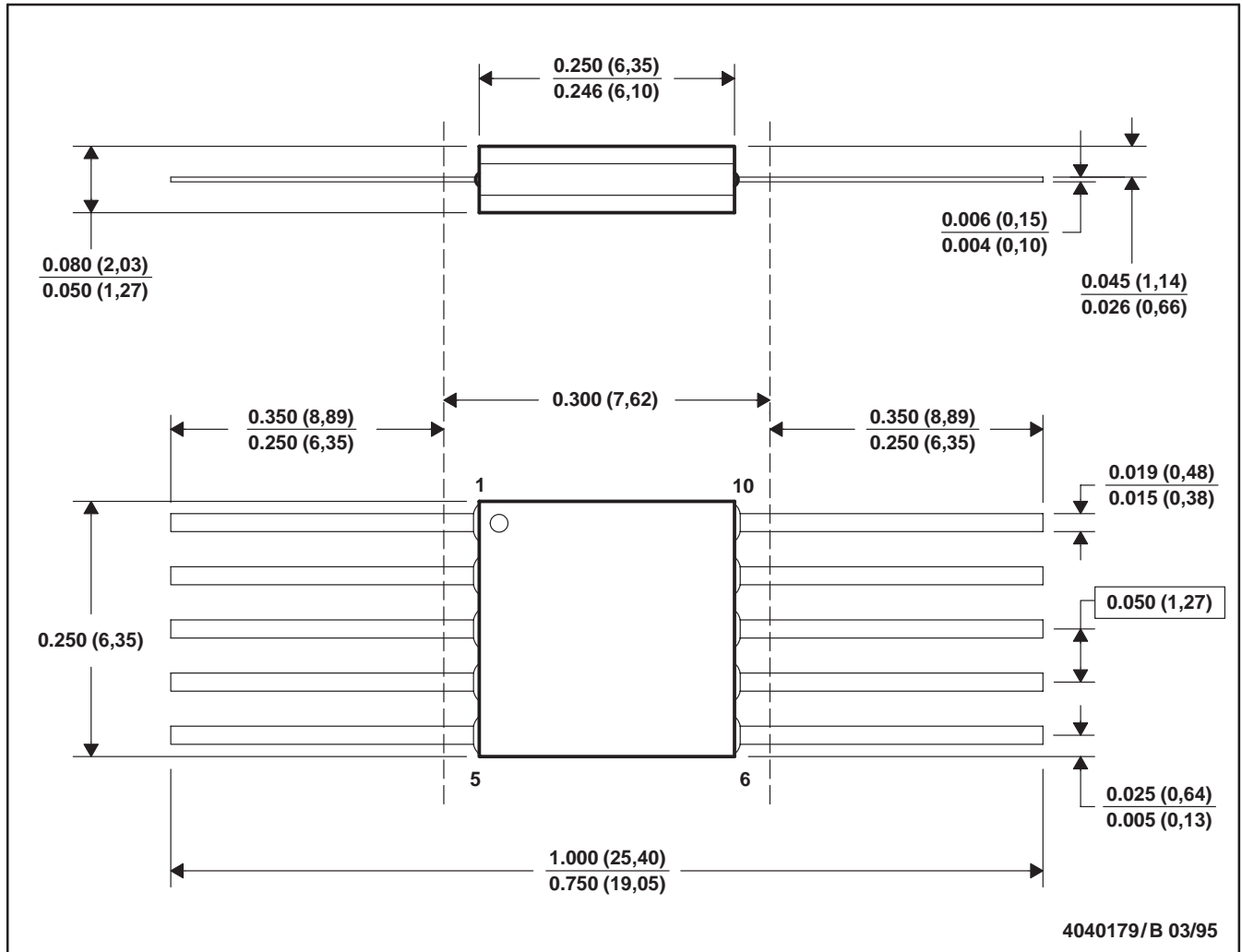
TLV2432, TLV2432A, TLV2434, TLV2434A  
 Advanced LinCMOS™ RAIL-TO-RAIL OUTPUT  
 WIDE-INPUT-VOLTAGE OPERATIONAL AMPLIFIERS

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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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