

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

SLOS168F – NOVEMBER 1996 – REVISED MARCH 2001

- 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.

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.

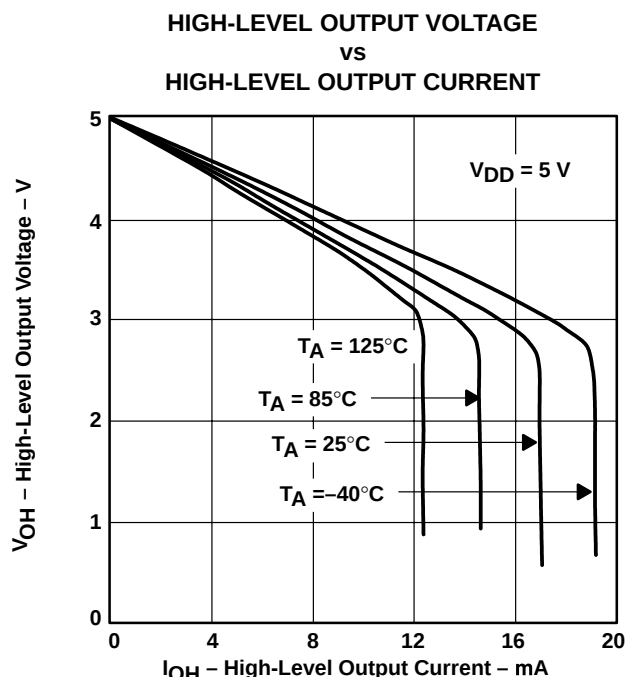


Figure 1



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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**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

SLOS168F – NOVEMBER 1996 – REVISED MARCH 2001

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

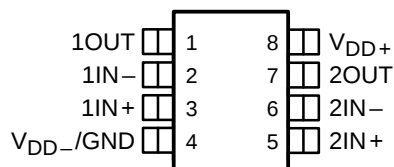
The D packages are available taped and reeled. Add R suffix to device type (e.g., TLV2432CDR). The PW package is available only left-end taped and reeled.

TLV2434 AVAILABLE OPTIONS

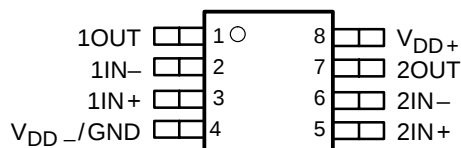
T _A	V _{IO} max AT 25°C	PACKAGED DEVICES	
		SMALL OUTLINE (D)	TSSOP (PW)
0°C to 70°C	2.5 mV	TLV2434CD	TLV2434CPW
–40°C to 125°C	950 µV 2.5 mV	TLV2434AID TLV2434ID	TLV2434AIPW TLV2434IPW

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.

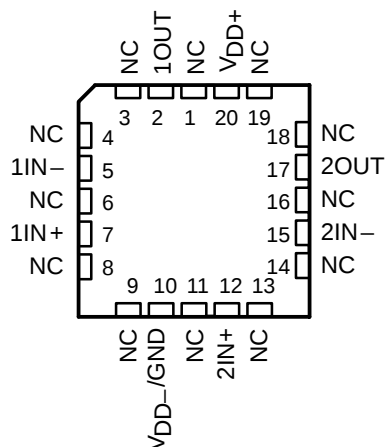
**TLV2432
D OR JG PACKAGE
(TOP VIEW)**



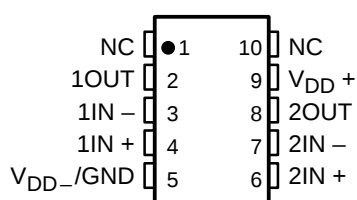
**TLV2432
PW PACKAGE
(TOP VIEW)**



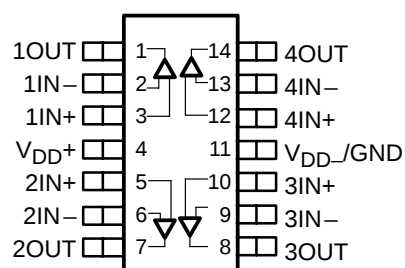
**TLV2432
FK PACKAGE
(TOP VIEW)**



**TLV2432
U PACKAGE
(TOP VIEW)**



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

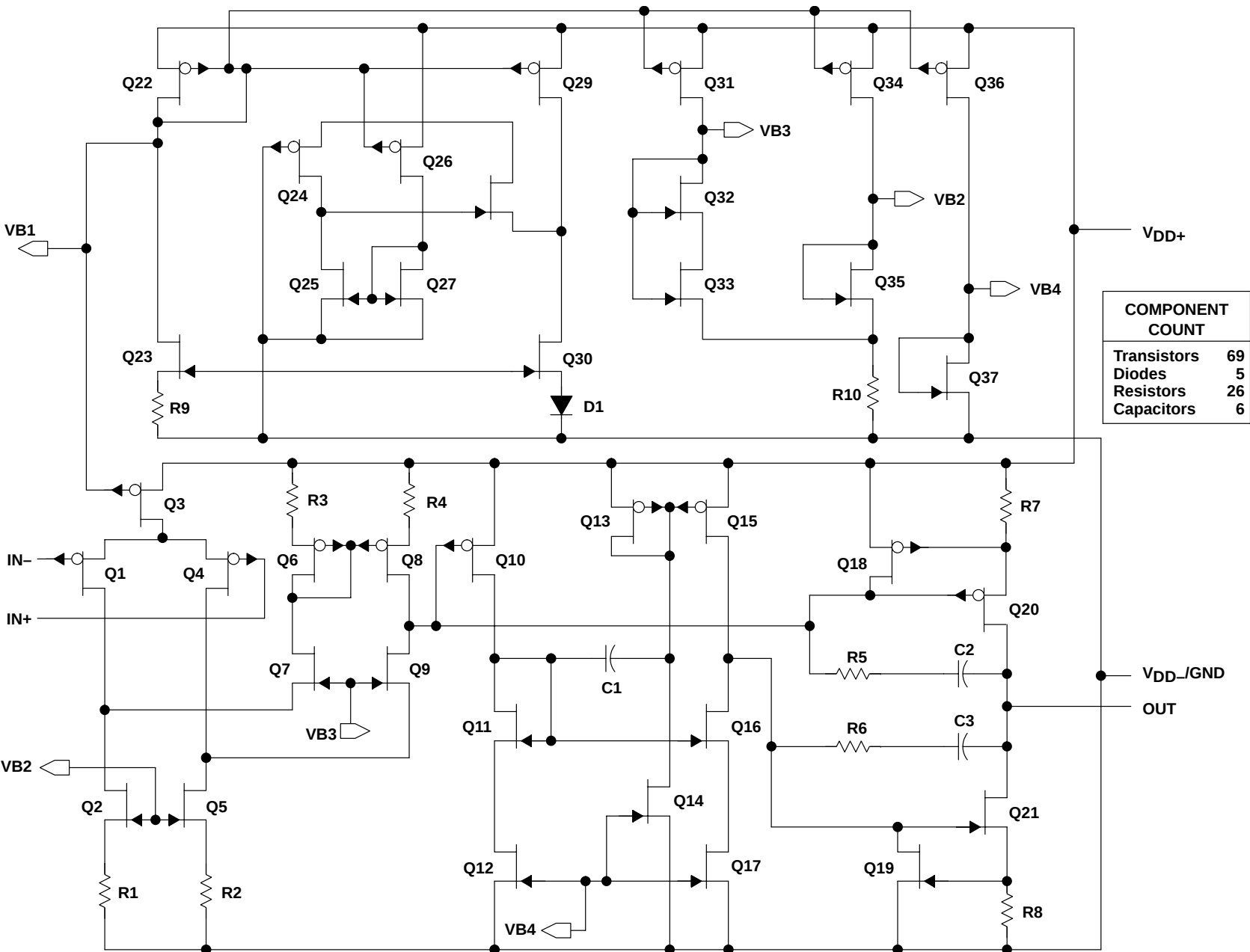


NC – No internal connection

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

SLOS168F – NOVEMBER 1996 – REVISED MARCH 2001

equivalent schematic (each amplifier)



TLV2432, TLV2432A, TLV2434, TLV2434A

Advanced LinCMOS™ RAIL-TO-RAIL OUTPUT

WIDE-INPUT-VOLTAGE OPERATIONAL AMPLIFIERS

SLOS168F – NOVEMBER 1996 – REVISED MARCH 2001

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



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

SLOS168F – NOVEMBER 1996 – REVISED MARCH 2001

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} ± = ±1.5 V, R _S = 50 Ω	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} ± = ±1.5 V, R _S = 50 Ω		25°C to 70°C	2		μV/°C	
Input offset voltage long-term drift (see Note 4)				25°C	0.003		μV/mo	
I _{IO}	Input offset current			25°C	0.5 60		pA	
				Full range	150			
I _{IB}	Input bias current			25°C	1 60		pA	
				Full range	150			
V _{ICR}	Common-mode input voltage range	V _{IO} ≤ 5 mV, R _S = 50 Ω	25°C	0 -0.25 to to 2.5 2.75		V		
			Full range	0 to 2.2				
V _{OH}	High-level output voltage	I _{OH} = −100 μA		25°C	2.98		V	
		I _{OH} = −3 mA		25°C	2.5			
				Full range	2.25			
V _{OL}	Low-level output voltage	V _{IC} = 1.5 V, I _{OL} = 100 μA		25°C	0.02		V	
		V _{IC} = 1.5 V, I _{OL} = 3 mA		25°C	0.83			
				Full range	1			
A _{VD}	Large-signal differential voltage amplification	V _{IC} = 2.5 V, V _O = 1 V to 2 V	R _L = 2 kΩ [‡]	25°C	1.5	2.5	V/mV	
				Full range	1			
			R _L = 1 MΩ [‡]	25°C	750			
r _{i(d)}	Differential input resistance			25°C	1000		GΩ	
r _{i(c)}	Common-mode input resistance			25°C	1000		GΩ	
c _{i(c)}	Common-mode input capacitance	f = 10 kHz		25°C	8		pF	
z _o	Closed-loop output impedance	f = 100 kHz, A _V = 10		25°C	130		Ω	
CMRR	Common-mode rejection ratio	V _{IC} = 0 to 2.5 V, V _O = 1.5 V, R _S = 50 Ω		25°C	70	83	dB	
				Full range	70			
k _{SVR}	Supply-voltage rejection ratio (ΔV _{DD} /ΔV _{IO})	V _{DD} = 2.7 V to 8 V, V _{IC} = V _{DD} /2, No load		25°C	80	95	dB	
				Full range	80			
I _{DD}	Supply current (per channel)	V _O = 1.5 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.

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

SLOS168F – NOVEMBER 1996 – REVISED MARCH 2001

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 V to 2 V, C _L = 100 pF [‡]		R _L = 2 kΩ [‡]	25°C	0.15	0.25	V/μs
					Full range	0.1		
V _n	Equivalent input noise voltage	f = 10 Hz		25°C	120		nV/√Hz	
		f = 1 kHz		25°C	22			
V _{N(PP)}	Peak-to-peak equivalent input noise voltage	f = 0.1 Hz to 1 Hz		25°C	2.7		μV	
		f = 0.1 Hz to 10 Hz		25°C	4			
I _n	Equivalent input noise current			25°C	0.6		fA/√Hz	
THD + N	Total harmonic distortion plus noise	V _O = 0.5 V to 2.5 V, f = 1 kHz, R _L = 2 kΩ [‡]	A _V = 1	25°C	0.065%			
			A _V = 10		0.5%			
Gain-bandwidth product		f = 10 kHz, C _L = 100 pF [‡]	R _L = 2 kΩ [‡]	25°C	0.5		MHz	
B _{OM}	Maximum output-swing bandwidth	V _{O(PP)} = 1 V, R _L = 2 kΩ [‡]	A _V = 1, C _L = 100 pF [‡]	25°C	220		kHz	
t _s	Settling time	A _V = −1, Step = 0.5 V to 2.5 V, R _L = 2 kΩ [‡] , C _L = 100 pF [‡]	To 0.1%	25°C	6.4		μs	
			To 0.01%		14.1			
φ _m	Phase margin at unity gain	R _L = 2 kΩ [‡] , C _L = 100 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

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

SLOS168F – NOVEMBER 1996 – REVISED MARCH 2001

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} ± = ±1.5 V, R _S = 50 Ω	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} ± = ±1.5 V, R _S = 50 Ω		25°C to 70°C	2		μV/°C	
Input offset voltage long-term drift (see Note 4)				25°C	0.003		μV/mo	
I _{IO}	Input offset current			25°C	0.5	60	pA	
				Full range	150			
I _{IB}	Input bias current			25°C	1	60	pA	
				Full range	300			
V _{ICR}	Common-mode input voltage range	V _{IO} ≤ 5 mV, R _S = 50 Ω	25°C	0 to 2.5 −0.25 to 2.75		V		
			Full range	0 to 2.2				
V _{OH}	High-level output voltage	I _{OH} = −100 μA	25°C	2.98		V		
		I _{OH} = −3 mA	25°C	2.5				
			Full range	2.25				
V _{OL}	Low-level output voltage	V _{IC} = 1.5 V, I _{OL} = 100 μA	25°C	0.02		V		
		V _{IC} = 1.5 V, I _{OL} = 3 mA	25°C	0.83				
			Full range	1				
A _{VD}	Large-signal differential voltage amplification	V _{IC} = 2.5 V, V _O = 1 V to 2 V	R _L = 2 kΩ [‡]	25°C	1.5	2.5	V/mV	
				Full range	0.5			
			R _L = 1 MΩ [‡]	25°C	750			
r _{i(d)}	Differential input resistance			25°C	1000		GΩ	
r _{i(c)}	Common-mode input resistance			25°C	1000		GΩ	
c _{i(c)}	Common-mode input capacitance	f = 10 kHz		25°C	8		pF	
z _o	Closed-loop output impedance	f = 100 kHz, A _V = 10		25°C	130		Ω	
CMRR	Common-mode rejection ratio	V _{IC} = 0 to 2.5 V, V _O = 1.5 V, R _S = 50 Ω		25°C	70	83	dB	
				Full range	70			
k _{SVR}	Supply-voltage rejection ratio (ΔV _{DD} /ΔV _{IO})	V _{DD} = 2.7 V to 8 V, V _{IC} = V _{DD} /2, No load		25°C	80	95	dB	
				Full range	80			
I _{DD}	Supply current	V _O = 1.5 V, No load		25°C	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.

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

SLOS168F – NOVEMBER 1996 – REVISED MARCH 2001

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

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

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

SLOS168F – NOVEMBER 1996 – REVISED MARCH 2001

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} ± = ±2.5 V, R _S = 50 Ω	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} ± = ±2.5 V, R _S = 50 Ω		25°C to 70°C	2		μV/°C	
Input offset voltage long-term drift (see Note 4)				25°C	0.003		μV/mo	
I _{IO}	Input offset current			25°C	0.5		60	pA
				Full range	150			
I _{IB}	Input bias current			25°C	1		60	pA
				Full range	150			
V _{ICR}	Common-mode input voltage range	V _{IO} ≤ 5 mV, R _S = 50 Ω	25°C	0 to 4.5		−0.25 to 4.75	V	
			Full range	0 to 4.2				
V _{OH}	High-level output voltage	I _{OH} = −100 μA		25°C	4.97		V	
		I _{OH} = −5 mA		25°C	4			4.35
				Full range	4			
V _{OL}	Low-level output voltage	V _{IC} = 2.5 V, I _{OL} = 100 μA		25°C	0.01		V	
		V _{IC} = 2.5 V, I _{OL} = 5 mA		25°C	0.8			
				Full range	1.25			
A _{VD}	Large-signal differential voltage amplification	V _{IC} = 2.5 V, V _O = 1 V to 4 V	R _L = 2 kΩ [‡]	25°C	2.5	3.8	V/mV	
				Full range	1.5			
			R _L = 1 MΩ [‡]	25°C	950			
r _{i(d)}	Differential input resistance			25°C	1000		GΩ	
r _{i(c)}	Common-mode input resistance			25°C	1000		GΩ	
c _{i(c)}	Common-mode input capacitance	f = 10 kHz		25°C	8		pF	
z _o	Closed-loop output impedance	f = 100 kHz, A _V = 10		25°C	130		Ω	
CMRR	Common-mode rejection ratio	V _{IC} = 0 to 4.5 V, V _O = 2.5 V, R _S = 50 Ω		25°C	70	90	dB	
				Full range	70			
k _{SVR}	Supply-voltage rejection ratio (ΔV _{DD} /ΔV _{IO})	V _{DD} = 4.4 V to 8 V, V _{IC} = V _{DD} /2, No load		25°C	80	95	dB	
				Full range	80			
I _{DD}	Supply current (per channel)	V _O = 2.5 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.

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

SLOS168F – NOVEMBER 1996 – REVISED MARCH 2001

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	$V_O = 1.5\text{ V to }3.5\text{ V},$ $C_L = 100\text{ pF}^\ddagger$	$R_L = 2\text{ k}\Omega^\ddagger,$	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	$V_O = 1.5\text{ V to }3.5\text{ V},$ $f = 1\text{ kHz},$ $R_L = 2\text{ k}\Omega^\ddagger$	$A_V = 1$	25°C		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, $R_L = 2\text{ k}\Omega^\ddagger,$ $C_L = 100\text{ pF}^\ddagger$	$T_o = 0.1\%$	25°C		6.4		μs
			$T_o = 0.01\%$			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

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

SLOS168F – NOVEMBER 1996 – REVISED MARCH 2001

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} ± = ±2.5 V, R _S = 50 Ω	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} ± = ±2.5 V, R _S = 50 Ω		25°C to 70°C	2		μV/°C	
	Input offset voltage long-term drift (see Note 4)			25°C	0.003		μV/mo	
I _{IO}	Input offset current			25°C	0.5	60	pA	
				Full range	150			
I _{IB}	Input bias current			25°C	1	60	pA	
				Full range	300			
V _{ICR}	Common-mode input voltage range	V _{IO} ≤ 5 mV, R _S = 50 Ω		25°C	0 to 4.5	−0.25 to 4.75	V	
				Full range	0 to 4.2			
V _{OH}	High-level output voltage	I _{OH} = −100 μA		25°C	4.97		V	
		I _{OH} = −5 mA		25°C	4	4.35		
				Full range	4			
V _{OL}	Low-level output voltage	V _{IC} = 2.5 V, V _{IC} = 2.5 V,	I _{OL} = 100 μA	25°C	0.01		V	
		I _{OL} = 5 mA		25°C	0.8			
				Full range	1.25			
A _{VD}	Large-signal differential voltage amplification	V _{IC} = 2.5 V, V _O = 1 V to 4 V	R _L = 2 kΩ [‡]	25°C	2.5	3.8	V/mV	
				Full range	0.5			
			R _L = 1 MΩ [‡]	25°C	950			
r _{i(d)}	Differential input resistance			25°C	1000		GΩ	
r _{i(c)}	Common-mode input resistance			25°C	1000		GΩ	
c _{i(c)}	Common-mode input capacitance	f = 10 kHz		25°C	8		pF	
z _o	Closed-loop output impedance	f = 100 kHz, A _V = 10		25°C	130		Ω	
CMRR	Common-mode rejection ratio	V _{IC} = 0 to 4.5 V, V _O = 2.5 V, R _S = 50 Ω		25°C	70	90	dB	
				Full range	70			
k _{SVR}	Supply-voltage rejection ratio (ΔV _{DD} /ΔV _{IO})	V _{DD} = 4.4 V to 8 V, V _{IC} = V _{DD} /2, No load		25°C	80	95	dB	
				Full range	80			
I _{DD}	Supply current	V _O = 2.5 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.

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

SLOS168F – NOVEMBER 1996 – REVISED MARCH 2001

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 V to 3.5 V, R _L = 2 kΩ [‡] , C _L = 100 pF [‡]		25°C	0.15	0.25	V/μs	
				Full range	0.1			
V _n	Equivalent input noise voltage	f = 10 Hz		25°C	100		nV/√Hz	
		f = 1 kHz		25°C	18			
V _{N(PP)}	Peak-to-peak equivalent input noise voltage	f = 0.1 Hz to 1 Hz		25°C	1.9		μV	
		f = 0.1 Hz to 10 Hz		25°C	2.8			
I _n	Equivalent input noise current			25°C	0.6		fA/√Hz	
THD + N	Total harmonic distortion plus noise	V _O = 1.5 V to 3.5 V, f = 1 kHz, R _L = 2 kΩ [‡]	A _V = 1	25°C	0.045%			
			A _V = 10		0.4%			
Gain-bandwidth product		f = 10 kHz, R _L = 2 kΩ [‡] , C _L = 100 pF [‡]		25°C	0.55		MHz	
B _{OM}	Maximum output-swing bandwidth	V _{O(PP)} = 2 V, R _L = 2 kΩ [‡] ,	A _V = 1, C _L = 100 pF [‡]	25°C	100		kHz	
t _s	Settling time	A _V = −1, Step = 1.5 V to 3.5 V, R _L = 2 kΩ [‡] , C _L = 100 pF [‡]	To 0.1%	25°C	6.4		μs	
			To 0.01%		13.1			
φ _m	Phase margin at unity gain	R _L = 2 kΩ [‡] , C _L = 100 pF [‡]		25°C	66°			
Gain margin				25°C	11		dB	

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

‡ Referenced to 2.5 V

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

SLOS168F – NOVEMBER 1996 – REVISED MARCH 2001

TYPICAL CHARACTERISTICS

Table of Graphs

			FIGURE
V_{IO}	Input offset voltage	Distribution vs Common-mode input voltage	2,3 4,5
α_{VIO}	Temperature coefficient	Distribution	6,7
I_{IB}/I_{IO}	Input bias and input offset currents	vs Free-air temperature	8
V_{OH}	High-level output voltage	vs High-level output current	9,11
V_{OL}	Low-level output voltage	vs Low-level output current	10,12
$V_{O(PP)}$	Maximum peak-to-peak output voltage	vs Frequency	13
I_{OS}	Short-circuit output current	vs Supply voltage vs Free-air temperature	14 15
V_{ID}	Differential input voltage	vs Output voltage	16,17
	Differential gain	vs Load resistance	18
A_{VD}	Large-signal differential voltage amplification	vs Frequency	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
ϕ_m	Phase margin	vs Frequency vs Load capacitance	19,20 48
	Gain margin	vs Load capacitance	49
B_1	Unity-gain bandwidth	vs Load capacitance	50



TLV2432, TLV2432A, TLV2434, TLV2434A

Advanced LinCMOS™ RAIL-TO-RAIL OUTPUT

WIDE-INPUT-VOLTAGE OPERATIONAL AMPLIFIERS

SLOS168F – NOVEMBER 1996 – REVISED MARCH 2001

TYPICAL CHARACTERISTICS

**DISTRIBUTION OF TLV2432
INPUT OFFSET VOLTAGE**

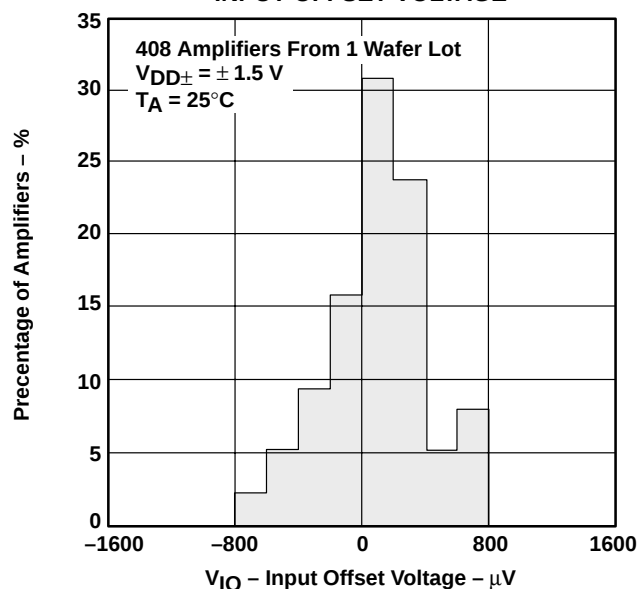


Figure 2

**DISTRIBUTION OF TLV2432
INPUT OFFSET VOLTAGE**

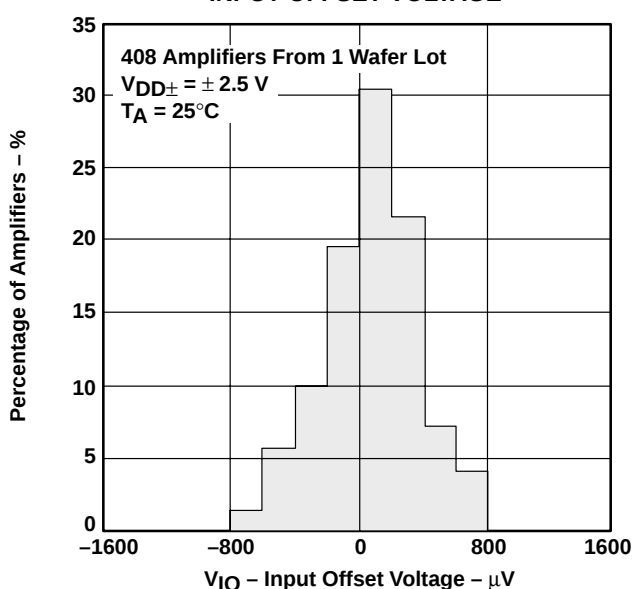


Figure 3

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

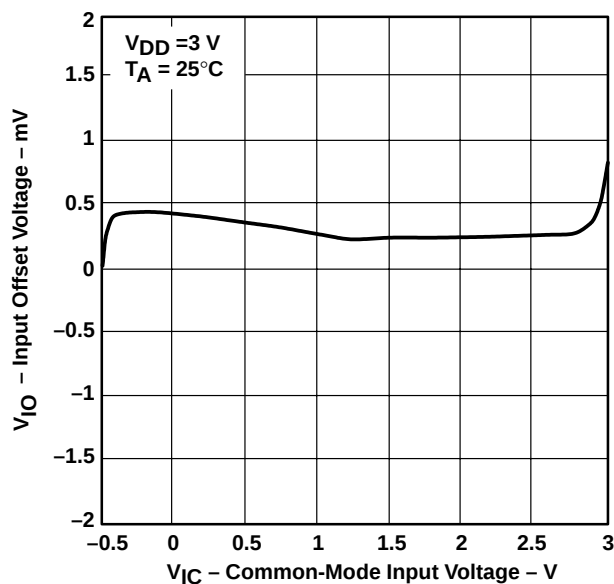


Figure 4

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

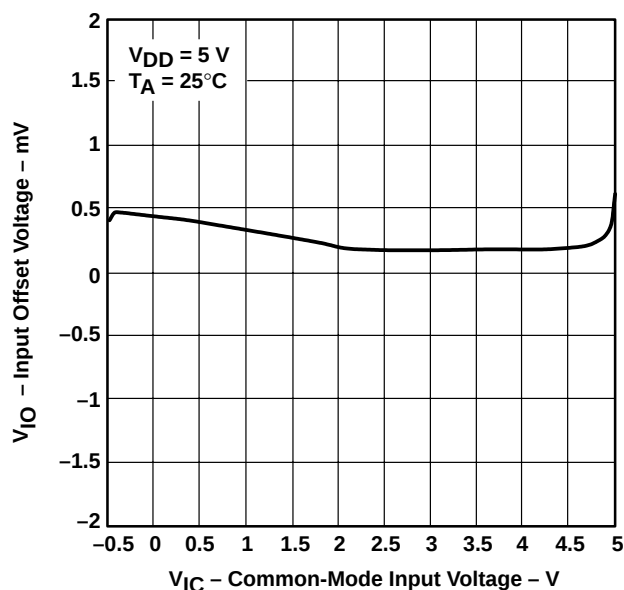


Figure 5

TYPICAL CHARACTERISTICS

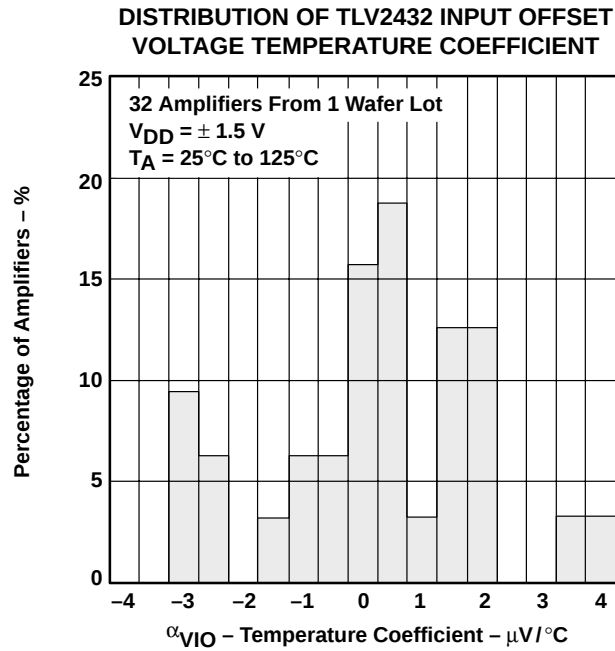


Figure 6

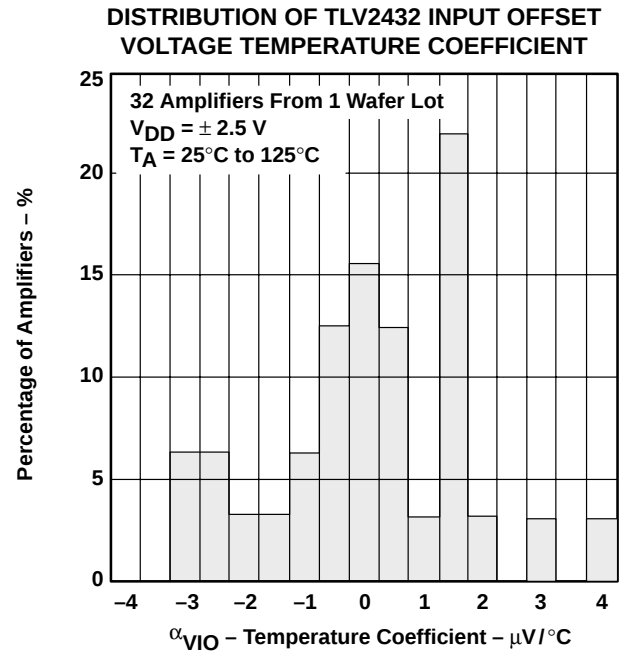


Figure 7

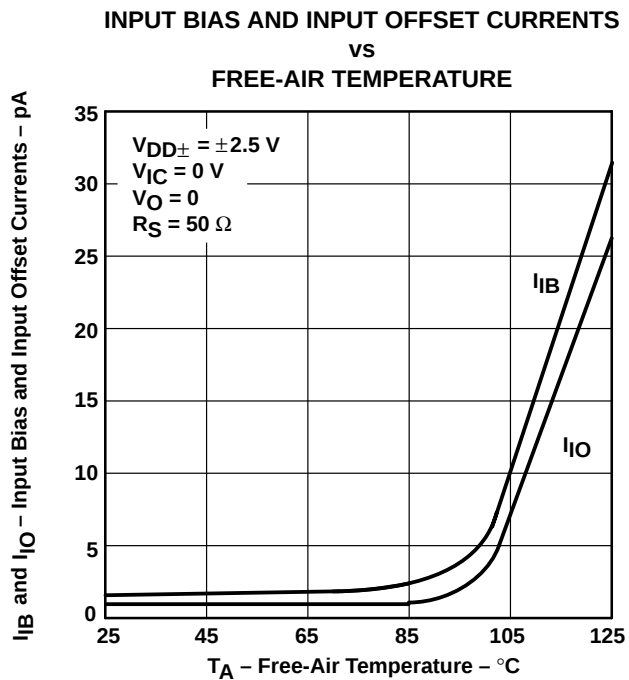


Figure 8

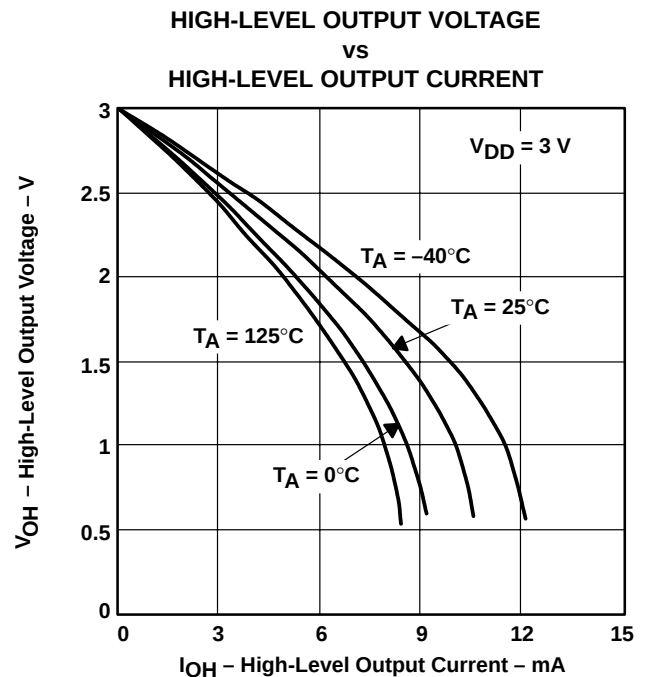


Figure 9

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

SLOS168F – NOVEMBER 1996 – REVISED MARCH 2001

TYPICAL CHARACTERISTICS

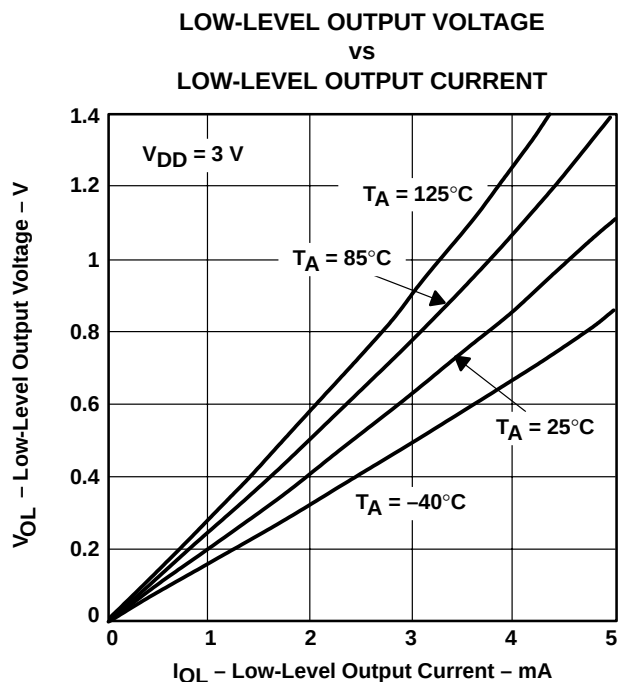


Figure 10

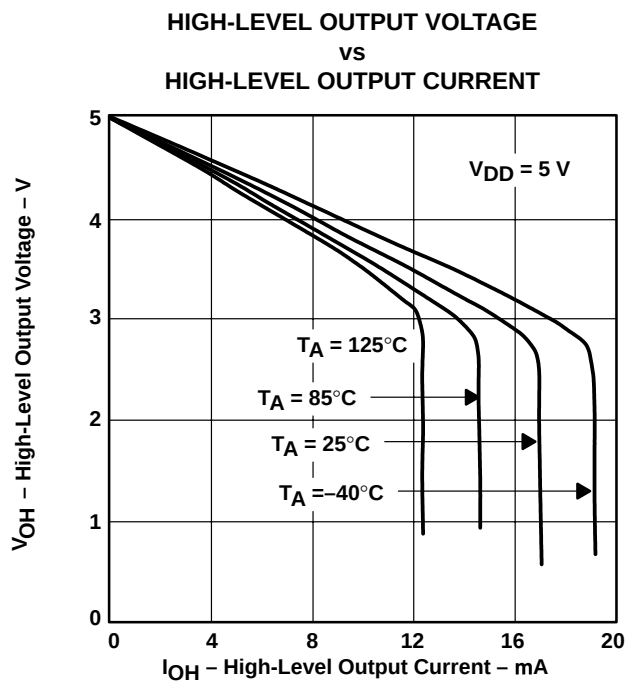


Figure 11

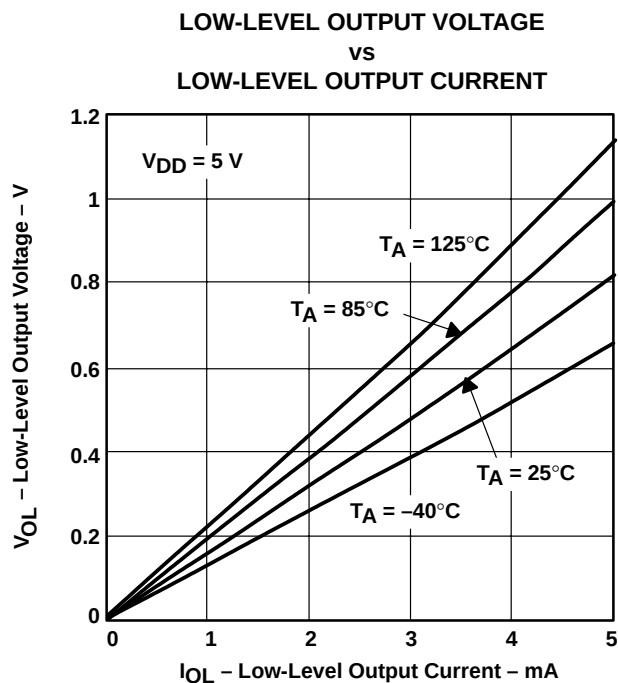


Figure 12

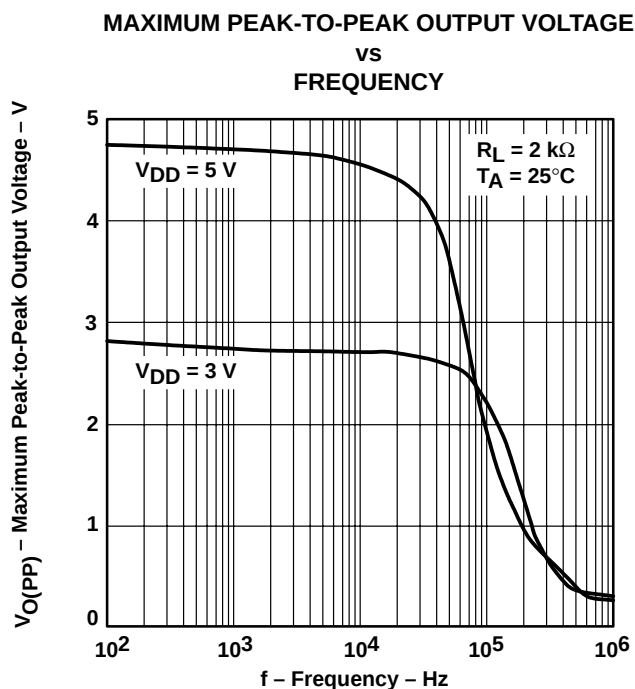


Figure 13

TYPICAL CHARACTERISTICS

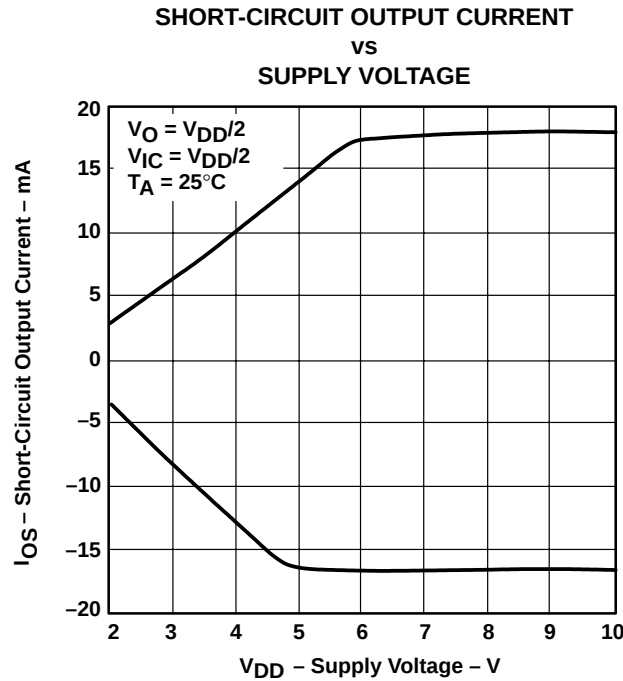


Figure 14

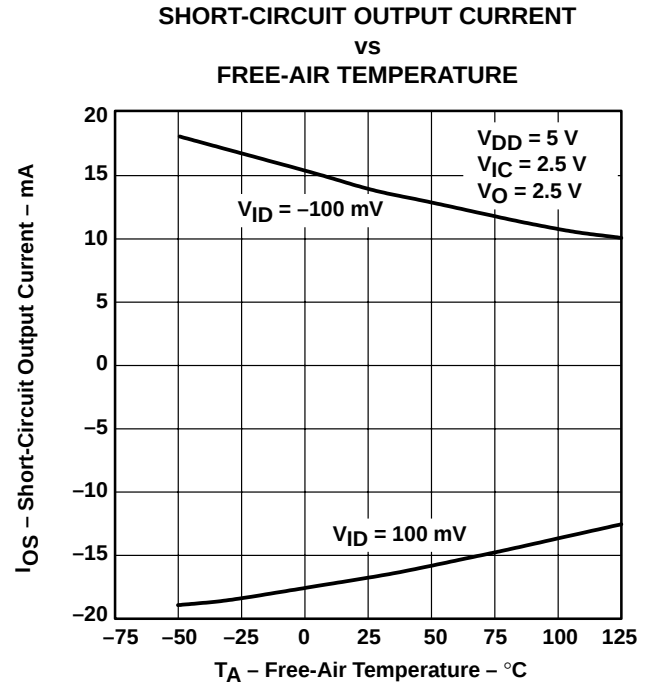


Figure 15

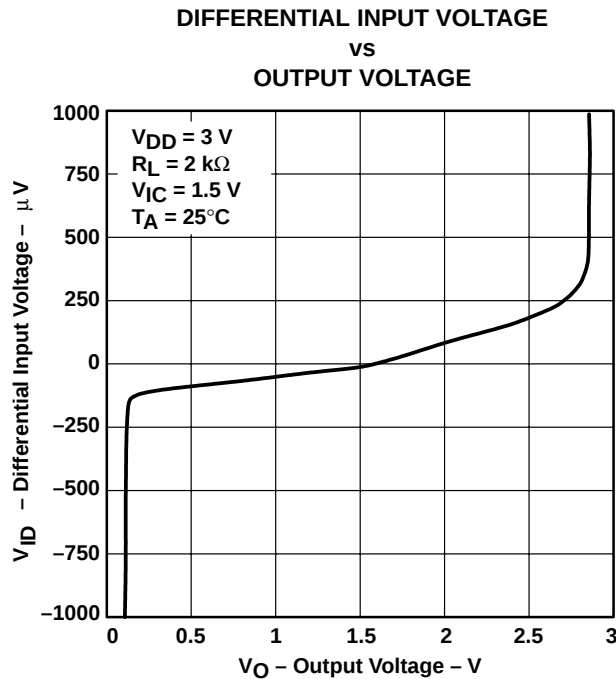


Figure 16

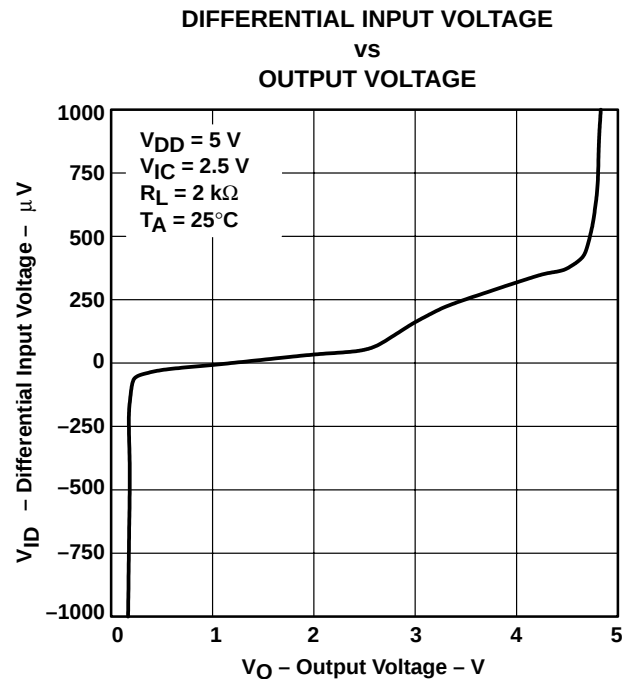


Figure 17

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

SLOS168F – NOVEMBER 1996 – REVISED MARCH 2001

TYPICAL CHARACTERISTICS

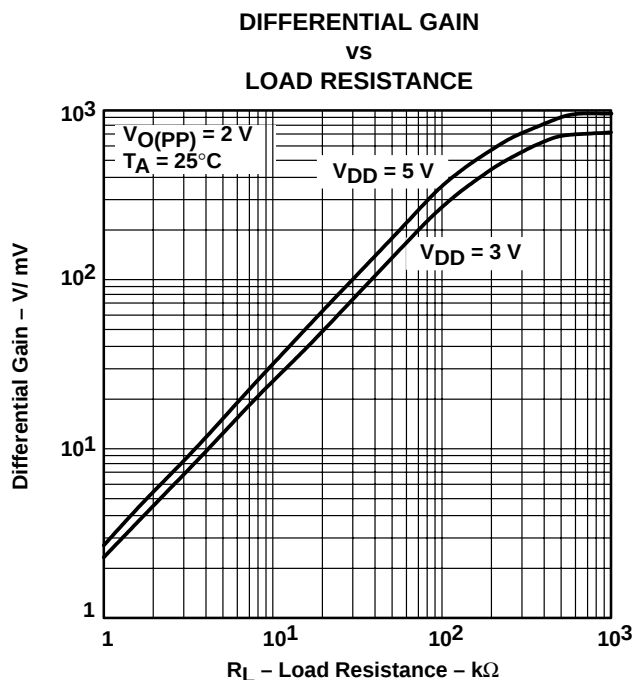


Figure 18

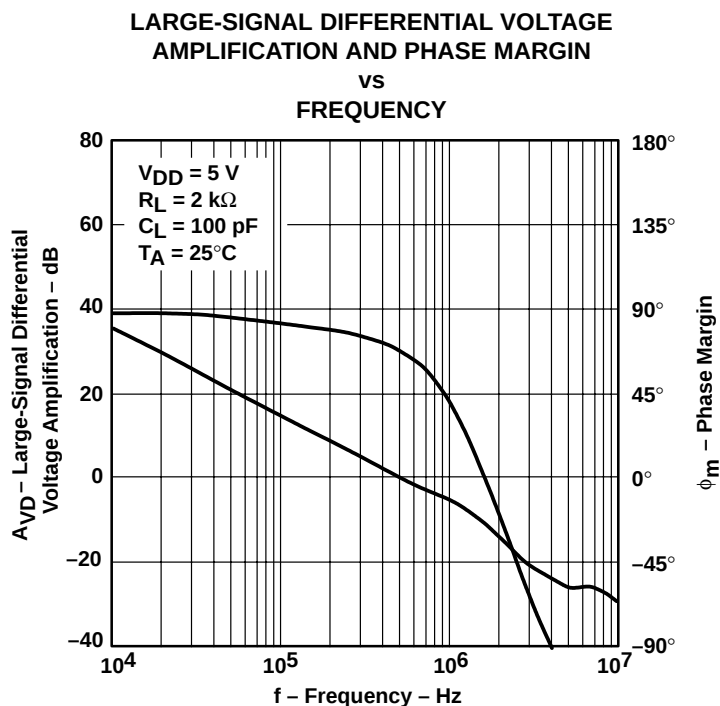


Figure 19

TYPICAL CHARACTERISTICS

LARGE-SIGNAL DIFFERENTIAL VOLTAGE AMPLIFICATION AND PHASE MARGIN

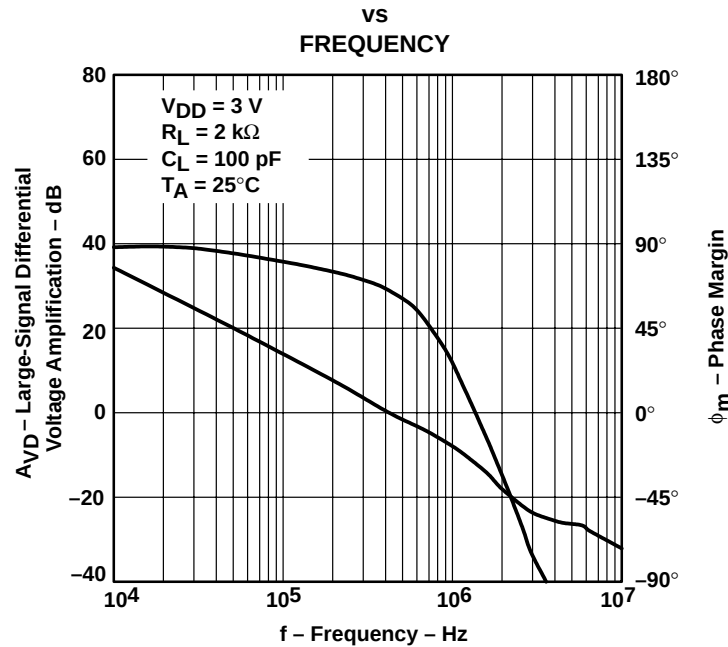


Figure 20

DIFFERENTIAL VOLTAGE AMPLIFICATION vs FREE-AIR TEMPERATURE

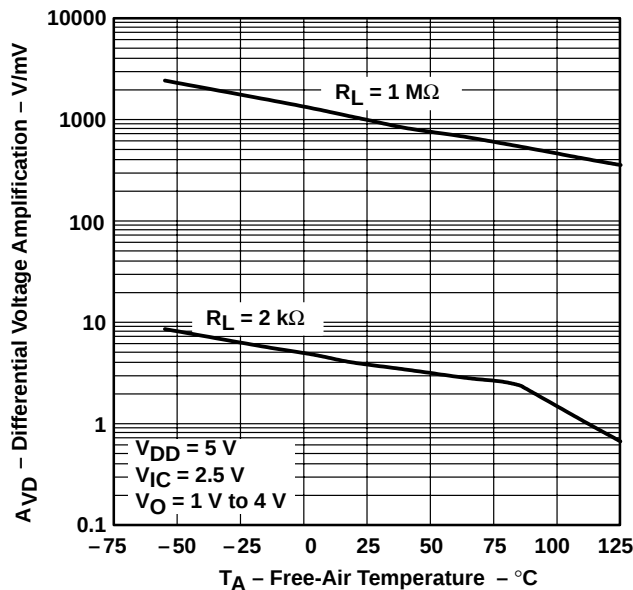


Figure 21

DIFFERENTIAL VOLTAGE AMPLIFICATION vs FREE-AIR TEMPERATURE

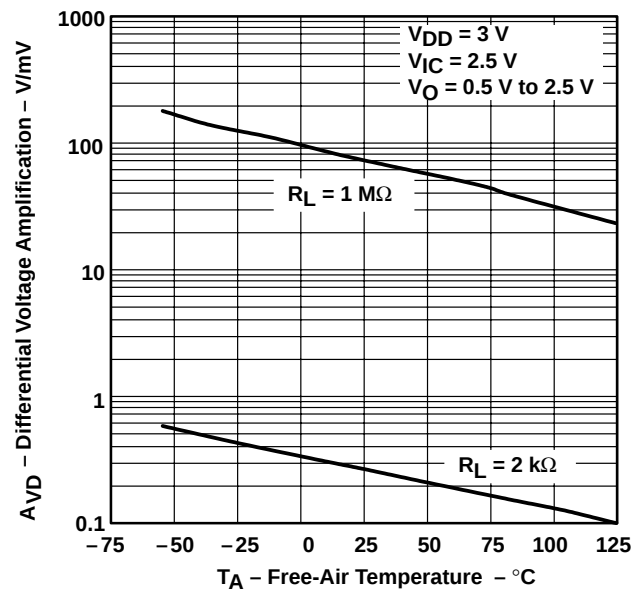


Figure 22

TLV2432, TLV2432A, TLV2434, TLV2434A

Advanced LinCMOS™ RAIL-TO-RAIL OUTPUT

WIDE-INPUT-VOLTAGE OPERATIONAL AMPLIFIERS

SLOS168F – NOVEMBER 1996 – REVISED MARCH 2001

TYPICAL CHARACTERISTICS

OUTPUT IMPEDANCE
VS
FREQUENCY

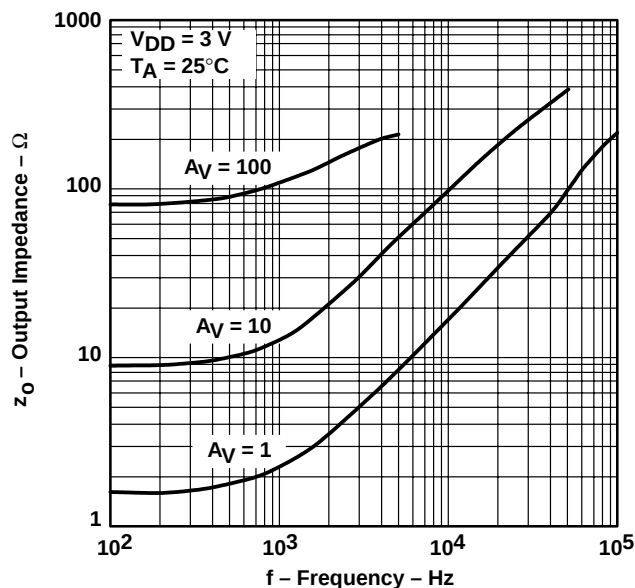


Figure 23

OUTPUT IMPEDANCE
VS
FREQUENCY

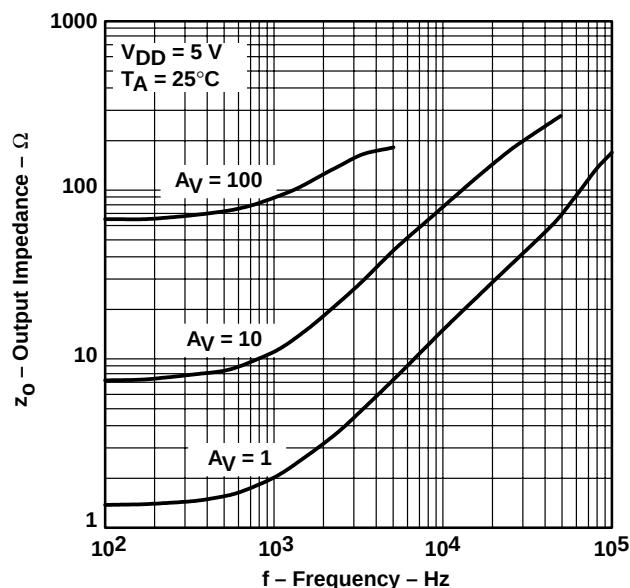


Figure 24

COMMON-MODE REJECTION RATIO
VS
FREQUENCY

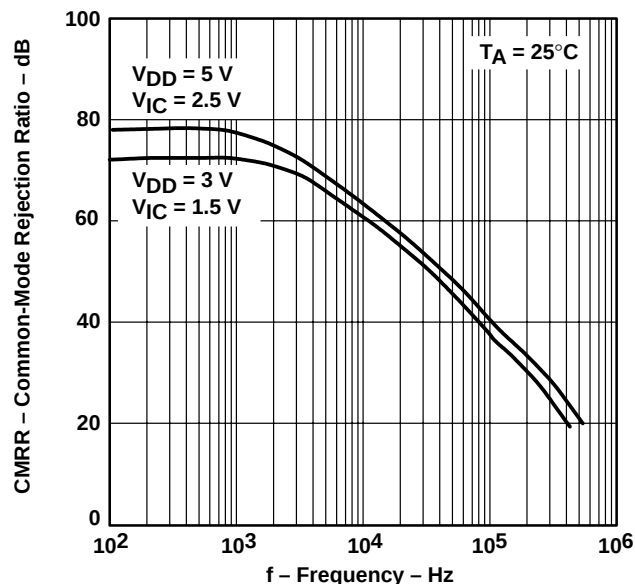


Figure 25

COMMON-MODE REJECTION RATIO
VS
FREE-AIR TEMPERATURE

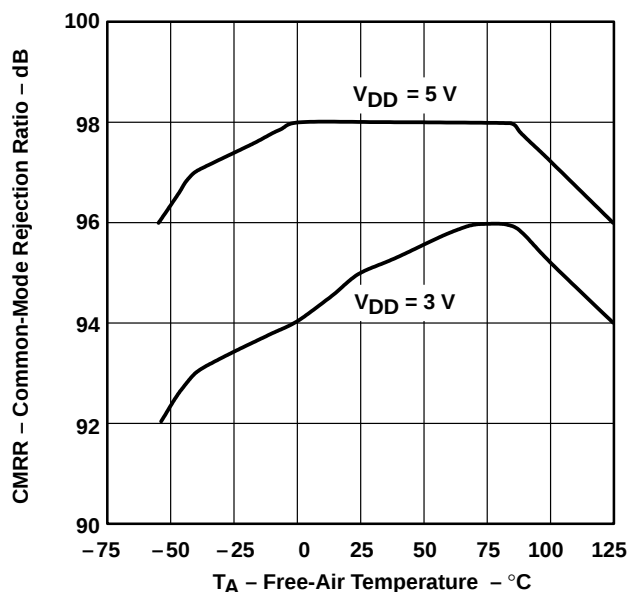


Figure 26

TYPICAL CHARACTERISTICS

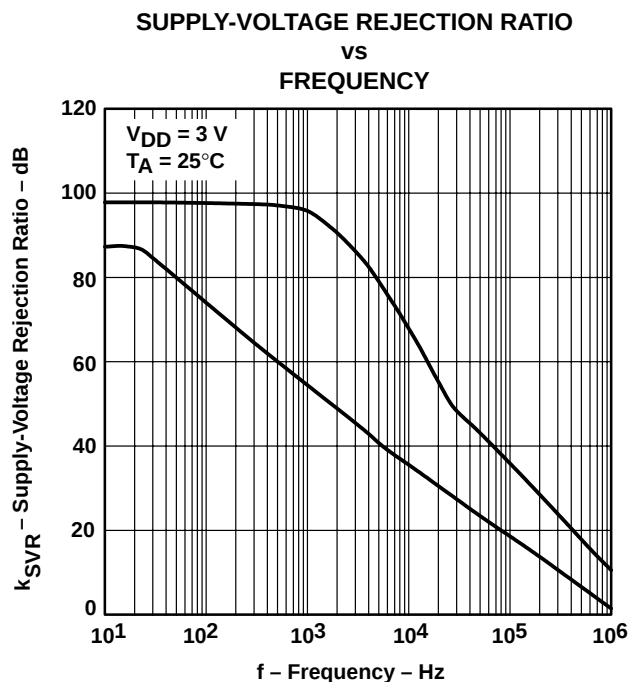


Figure 27

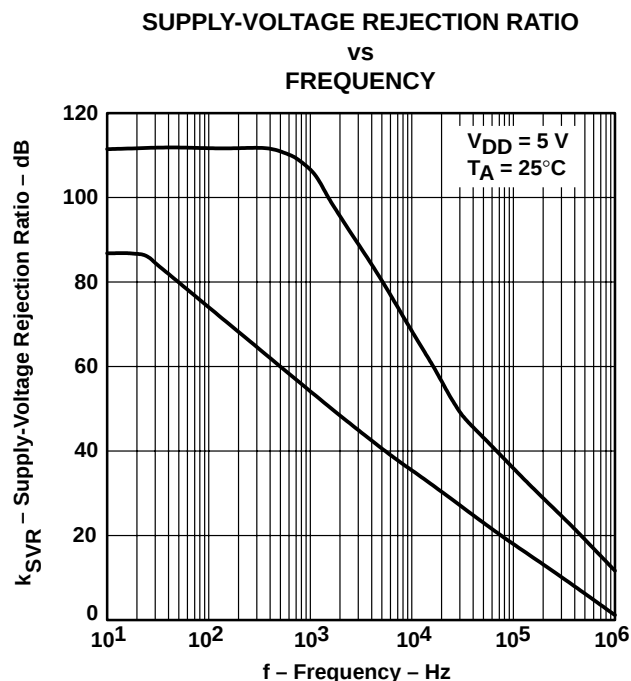


Figure 28

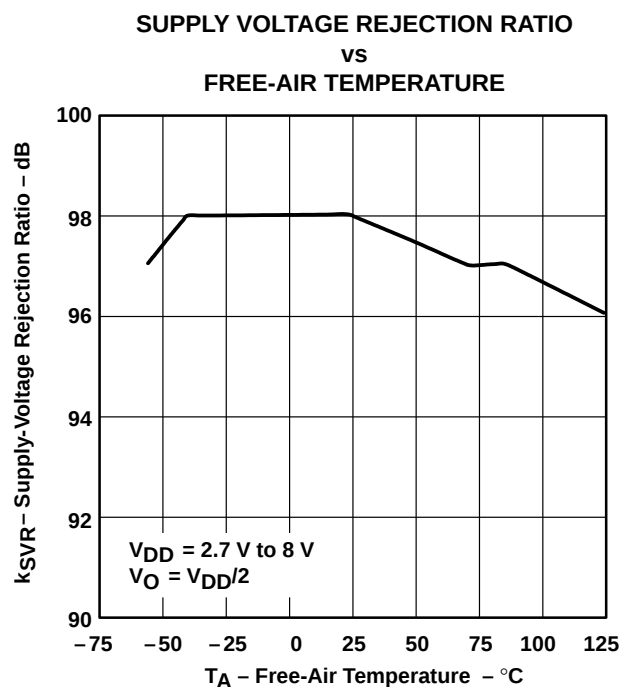


Figure 29

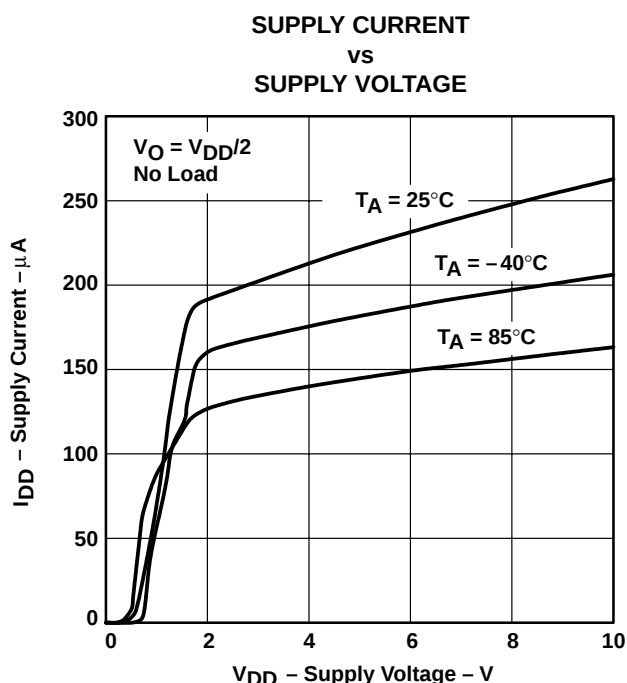


Figure 30

TLV2432, TLV2432A, TLV2434, TLV2434A

Advanced LinCMOS™ RAIL-TO-RAIL OUTPUT

WIDE-INPUT-VOLTAGE OPERATIONAL AMPLIFIERS

SLOS168F – NOVEMBER 1996 – REVISED MARCH 2001

TYPICAL CHARACTERISTICS

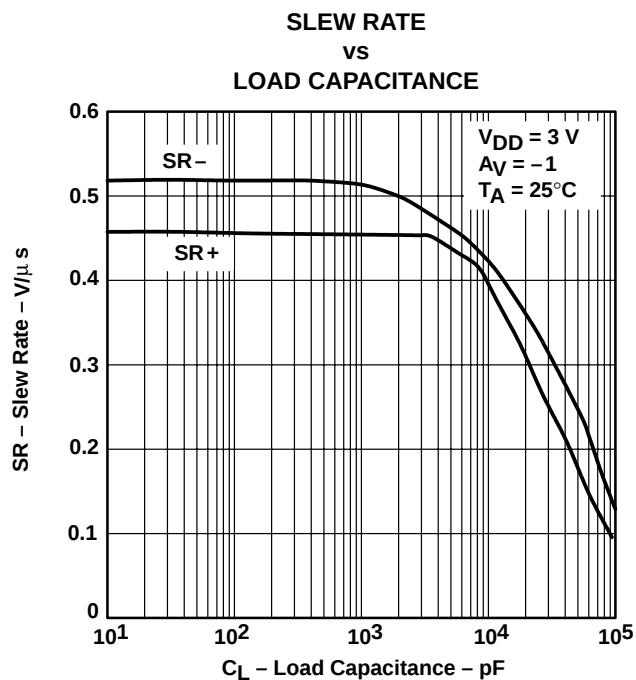


Figure 31

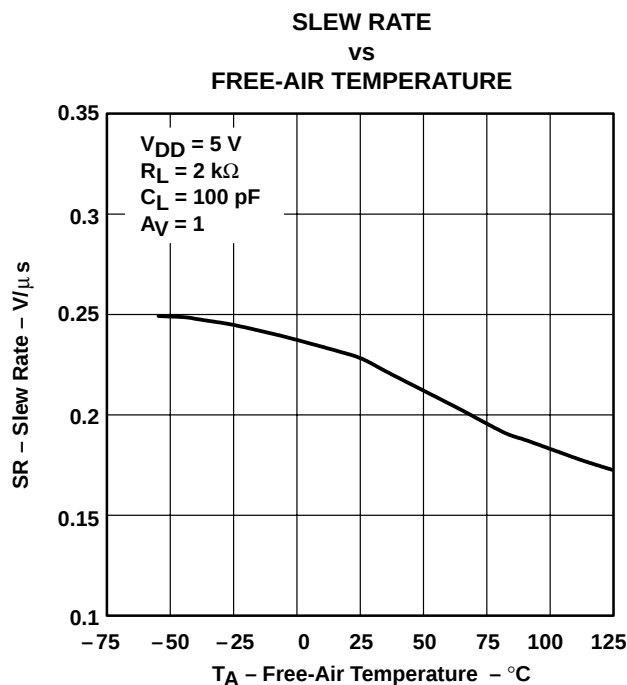


Figure 32

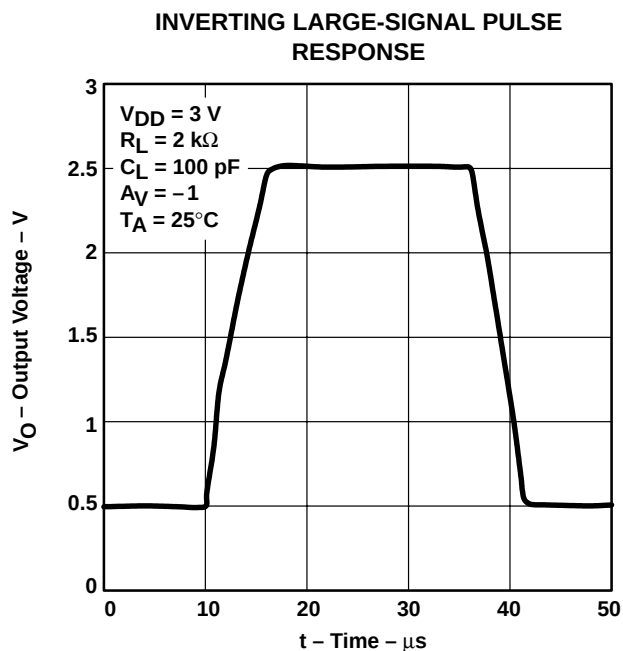


Figure 33

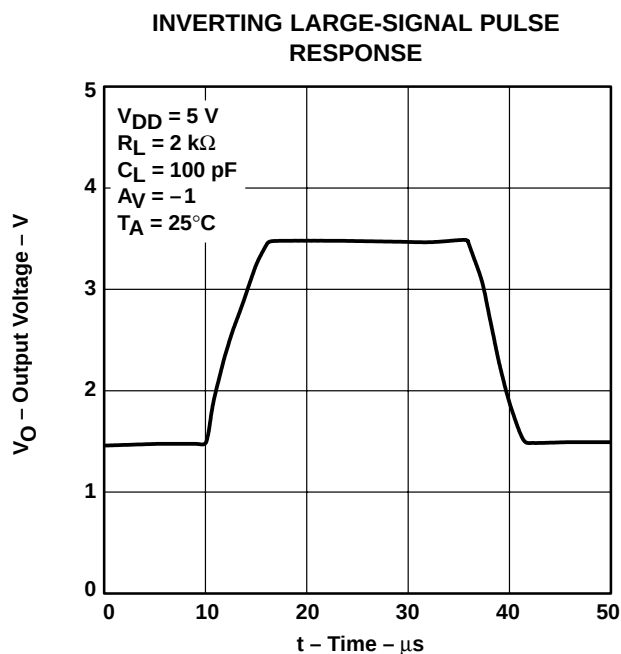


Figure 34

TYPICAL CHARACTERISTICS

VOLTAGE-FOLLOWER LARGE-SIGNAL
PULSE RESPONSE

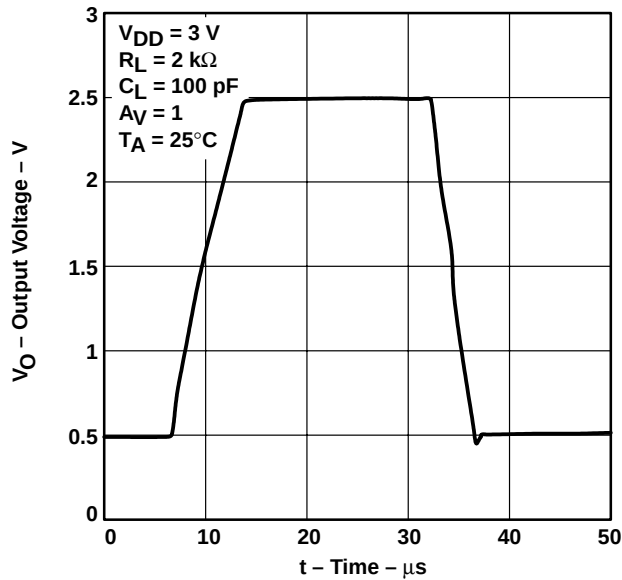


Figure 35

VOLTAGE-FOLLOWER LARGE-SIGNAL
PULSE RESPONSE

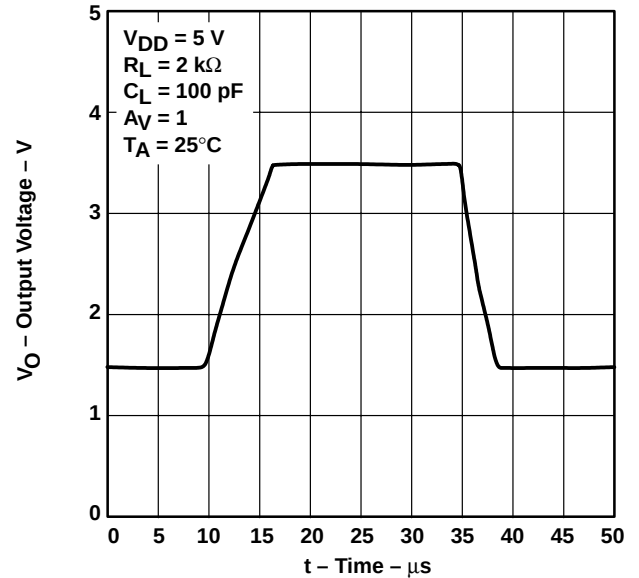


Figure 36

INVERTING SMALL-SIGNAL PULSE
RESPONSE

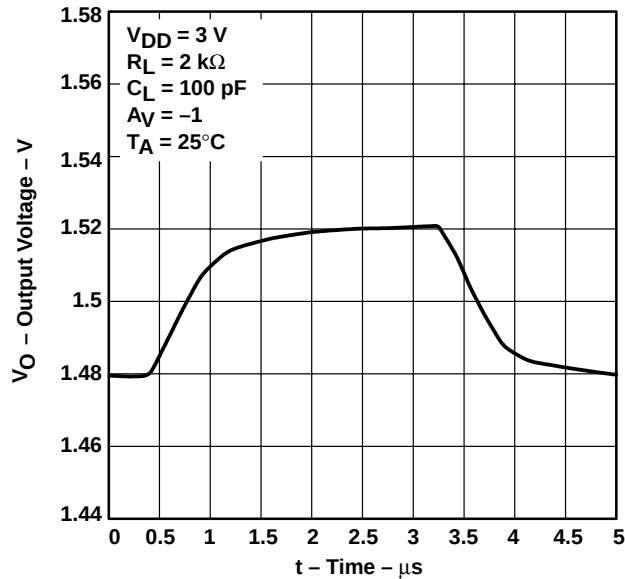


Figure 37

INVERTING SMALL-SIGNAL PULSE
RESPONSE

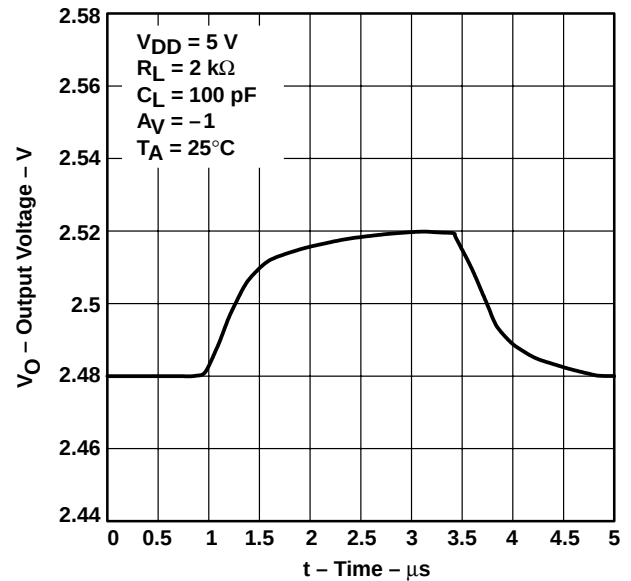


Figure 38

TLV2432, TLV2432A, TLV2434, TLV2434A

Advanced LinCMOS™ RAIL-TO-RAIL OUTPUT

WIDE-INPUT-VOLTAGE OPERATIONAL AMPLIFIERS

SLOS168F – NOVEMBER 1996 – REVISED MARCH 2001

TYPICAL CHARACTERISTICS

VOLTAGE-FOLLOWER SMALL-SIGNAL
PULSE RESPONSE

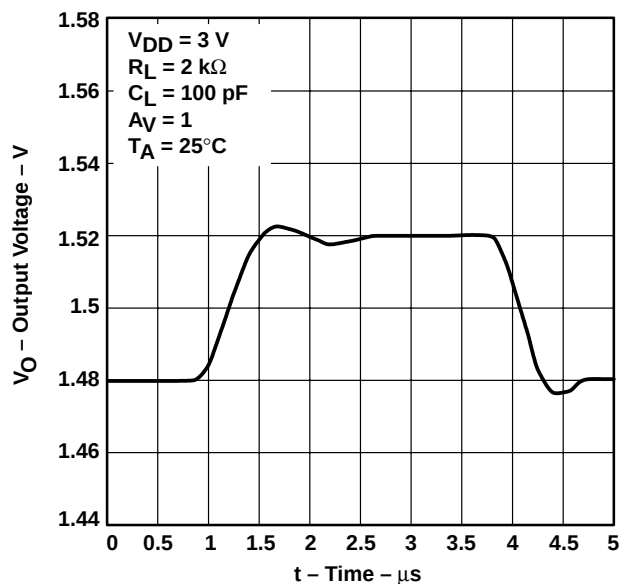


Figure 39

VOLTAGE-FOLLOWER SMALL-SIGNAL
PULSE RESPONSE

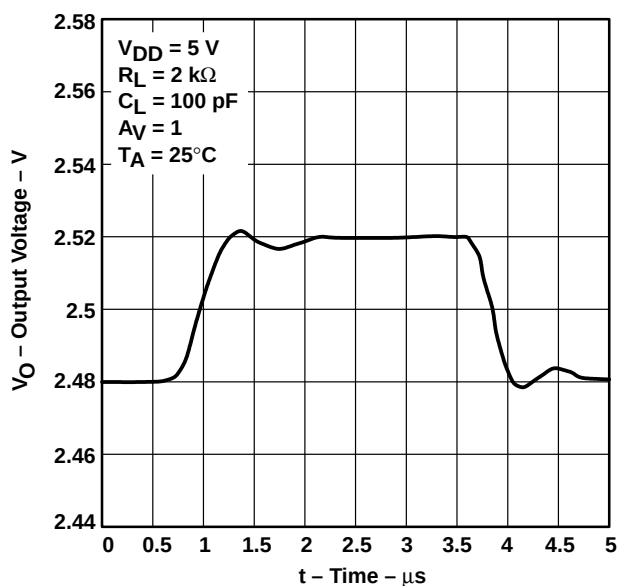


Figure 40

EQUIVALENT INPUT NOISE VOLTAGE
VS
FREQUENCY

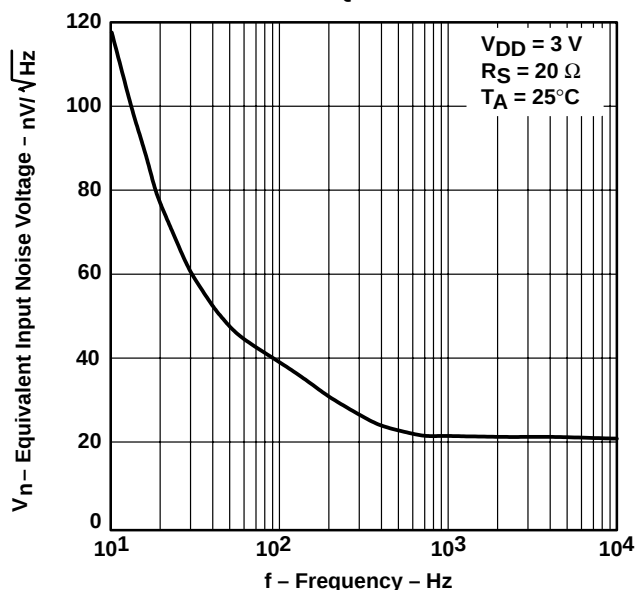


Figure 41

EQUIVALENT INPUT NOISE VOLTAGE
VS
FREQUENCY

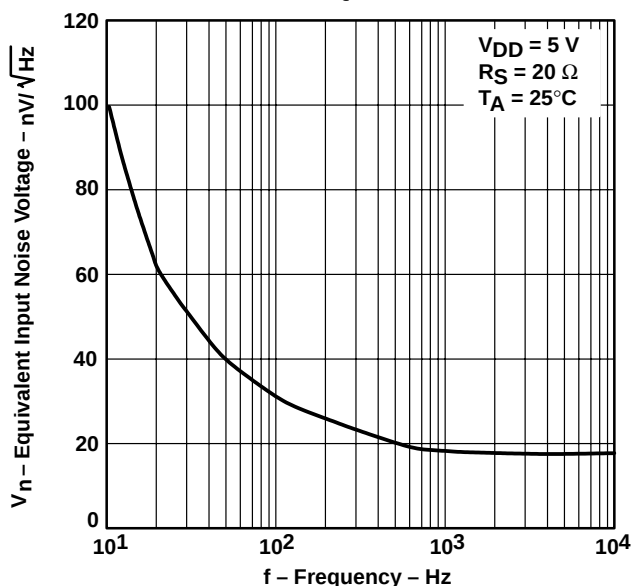


Figure 42

TYPICAL CHARACTERISTICS

NOISE VOLTAGE OVER A 10-SECOND PERIOD

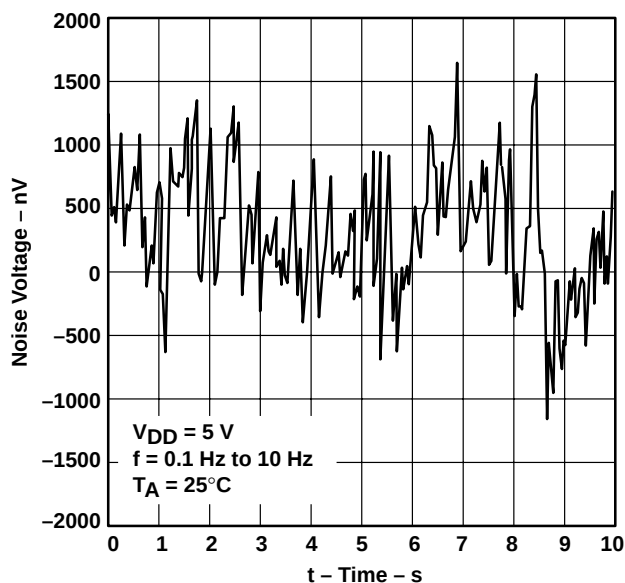


Figure 43

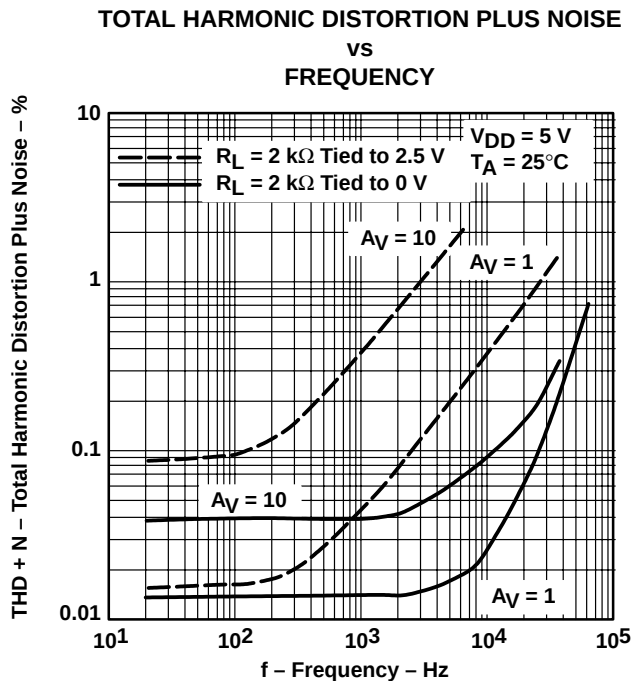


Figure 44

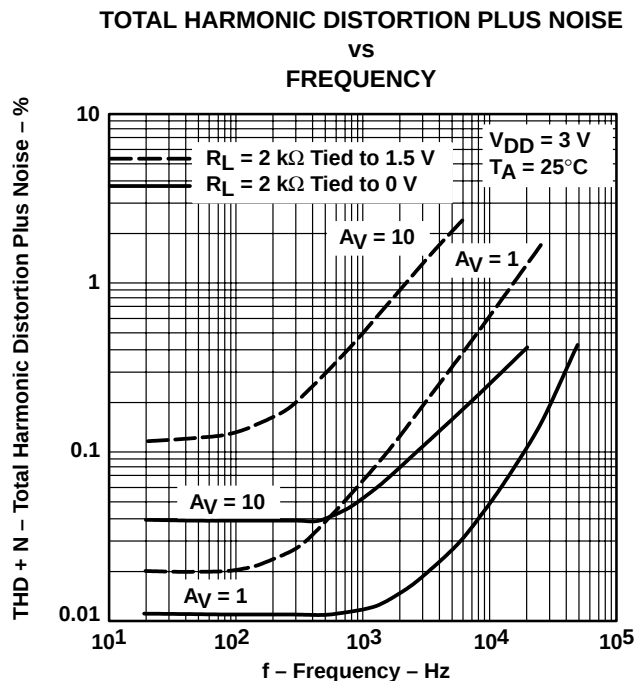


Figure 45

TLV2432, TLV2432A, TLV2434, TLV2434A

Advanced LinCMOS™ RAIL-TO-RAIL OUTPUT

WIDE-INPUT-VOLTAGE OPERATIONAL AMPLIFIERS

SLOS168F – NOVEMBER 1996 – REVISED MARCH 2001

TYPICAL CHARACTERISTICS

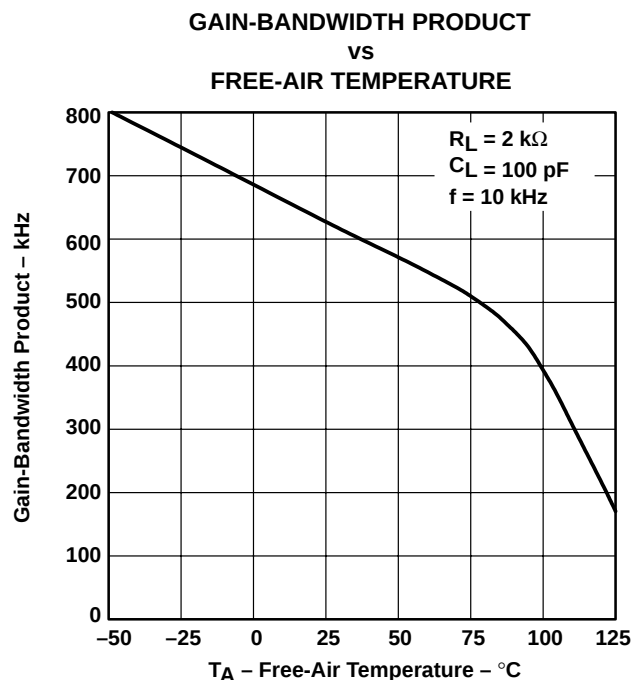


Figure 46

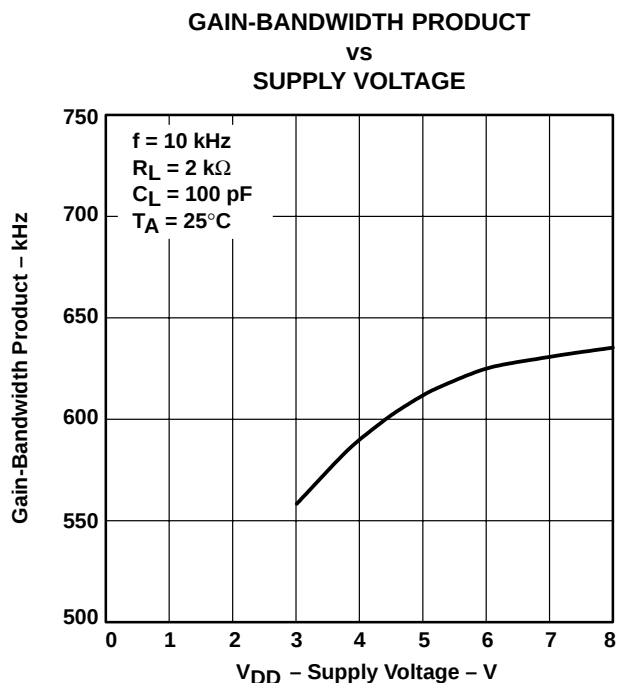


Figure 47

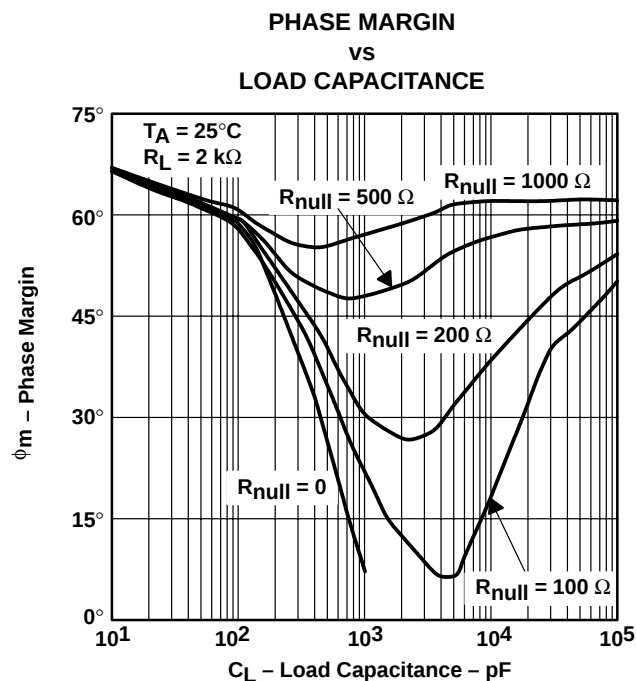


Figure 48

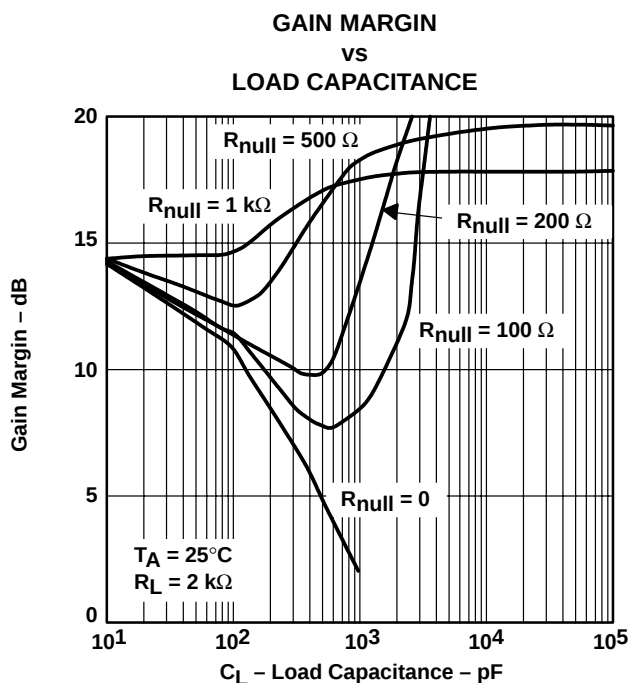


Figure 49

TYPICAL CHARACTERISTICS

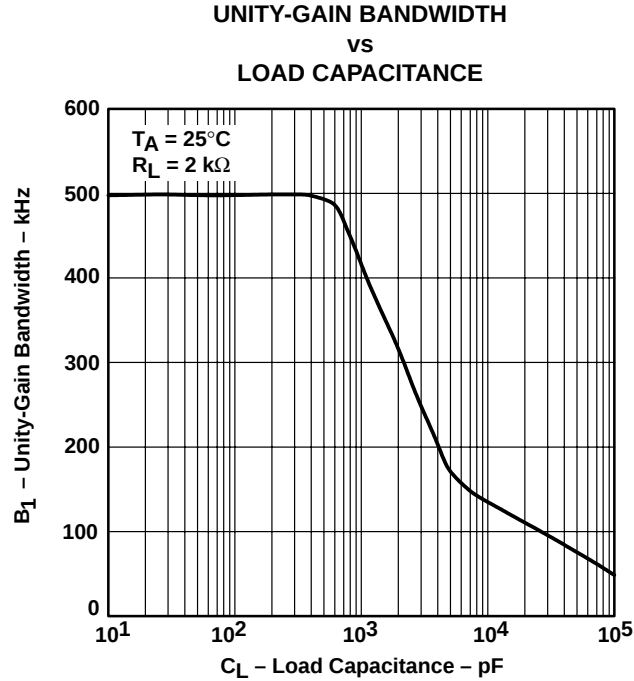


Figure 50

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).

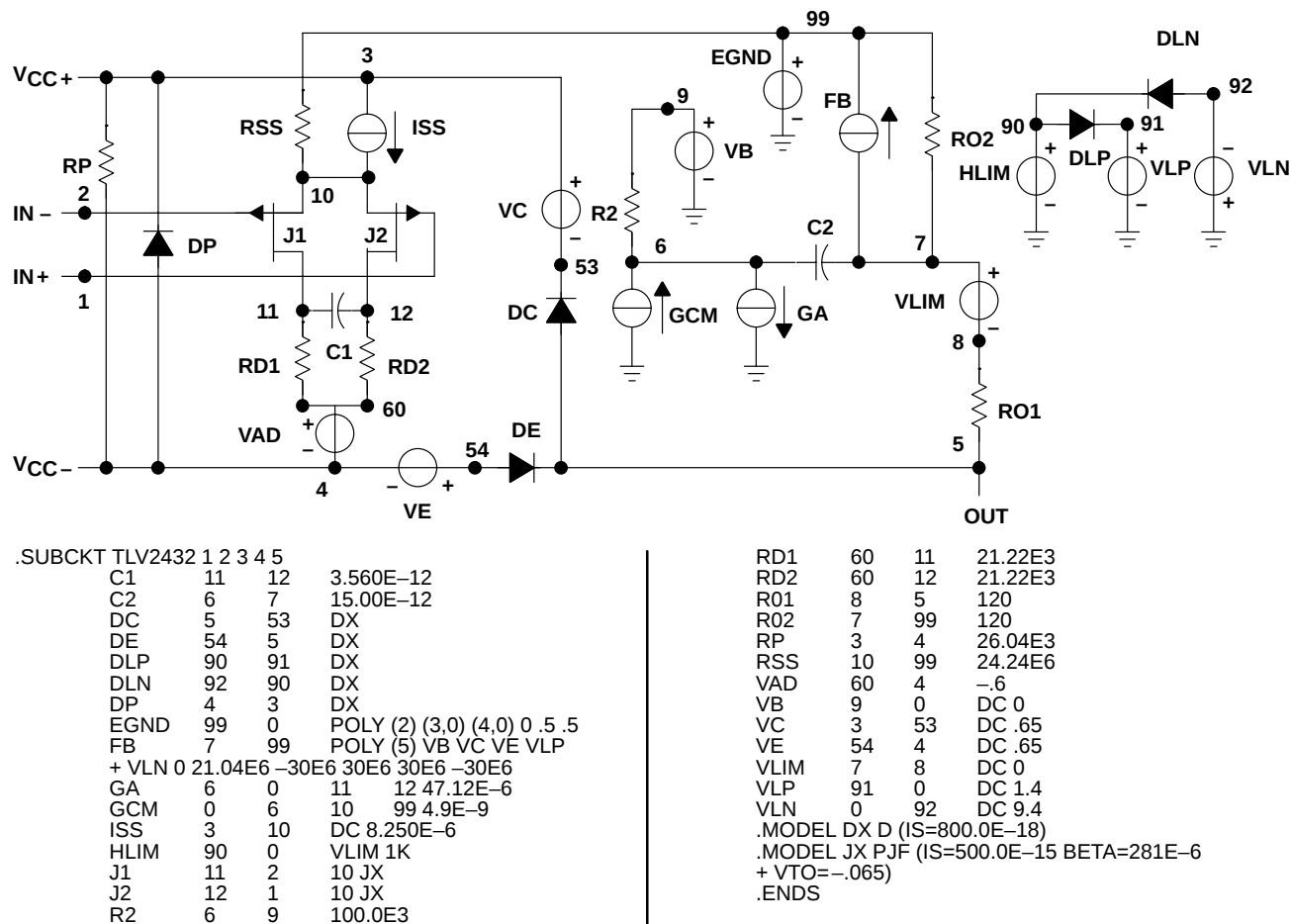


Figure 51. Boyle Macromodel and Subcircuit

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

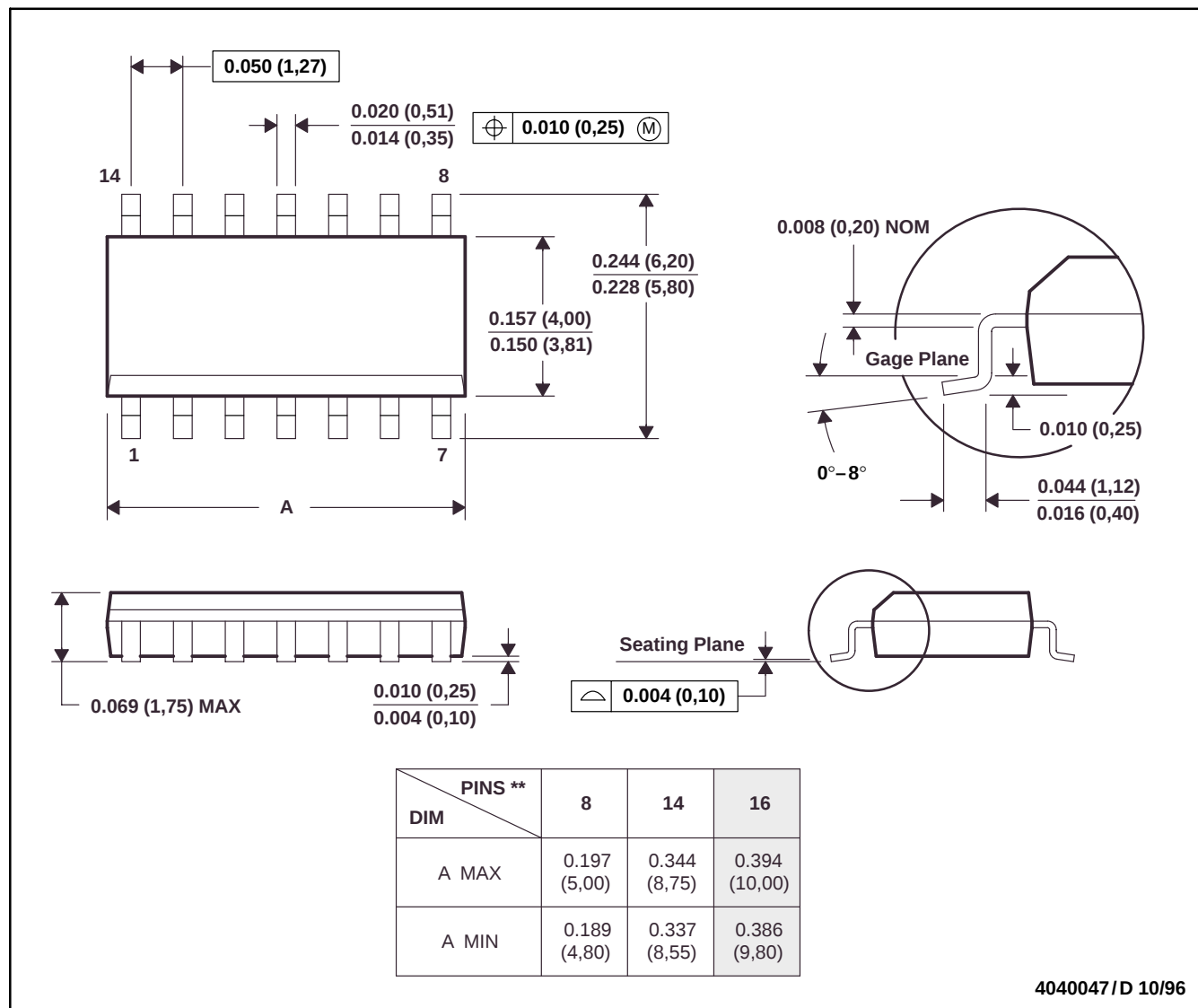
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MECHANICAL DATA

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

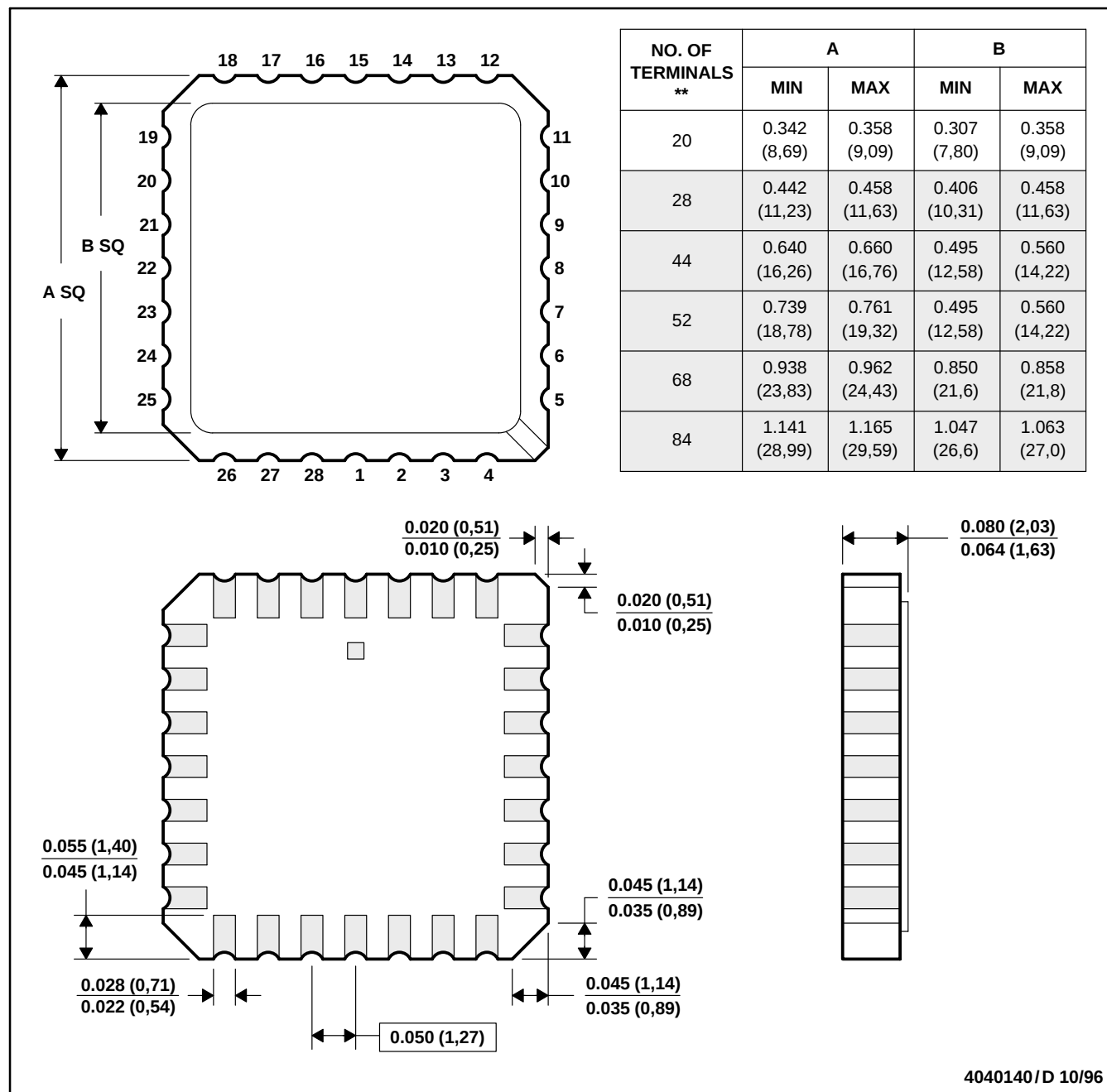
SLOS168F – NOVEMBER 1996 – REVISED MARCH 2001

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

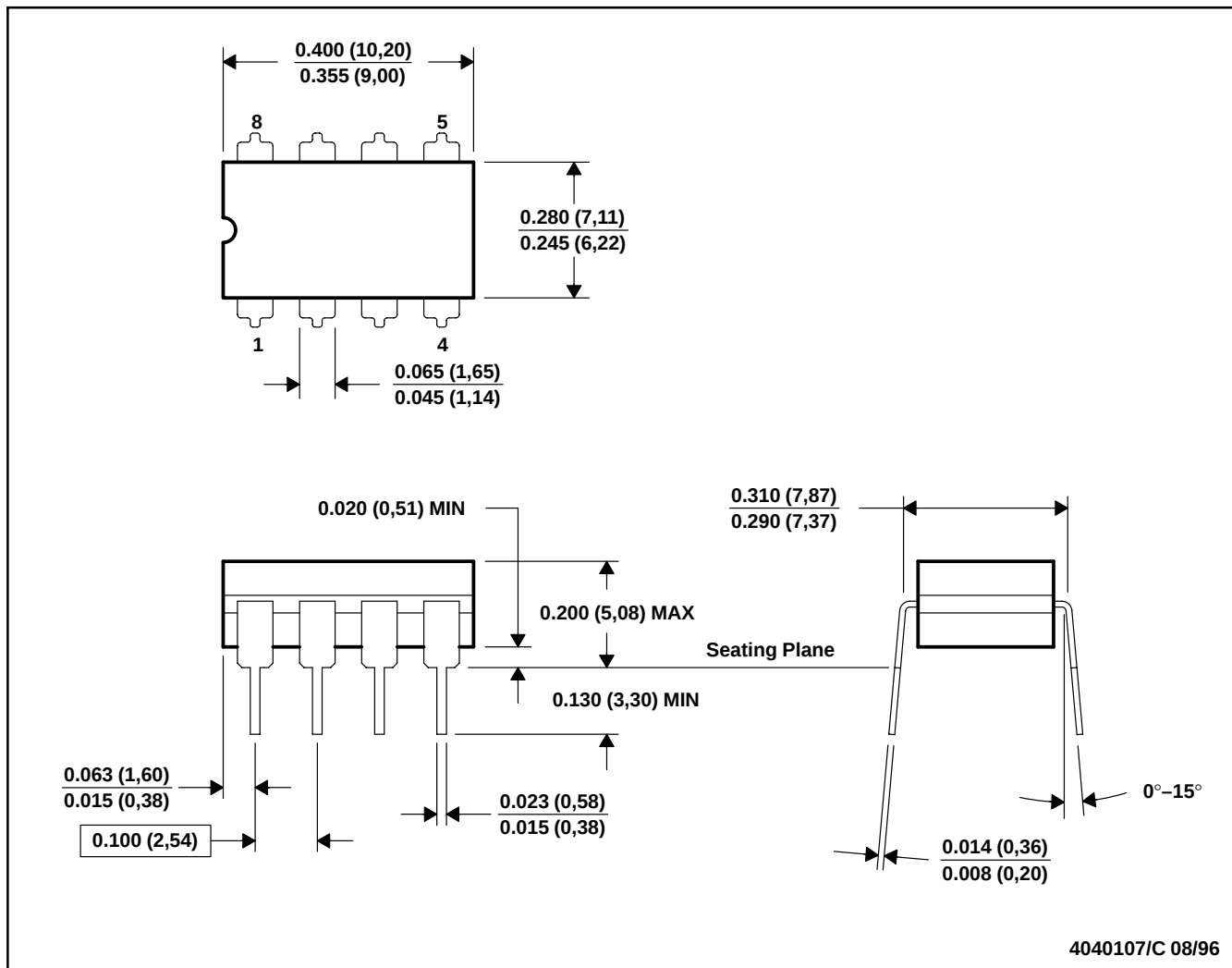
TLV2432, TLV2432A, TLV2434, TLV2434A
Advanced LinCMOS™ RAIL-TO-RAIL OUTPUT
WIDE-INPUT-VOLTAGE OPERATIONAL AMPLIFIERS

SLOS168F – NOVEMBER 1996 – REVISED MARCH 2001

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 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

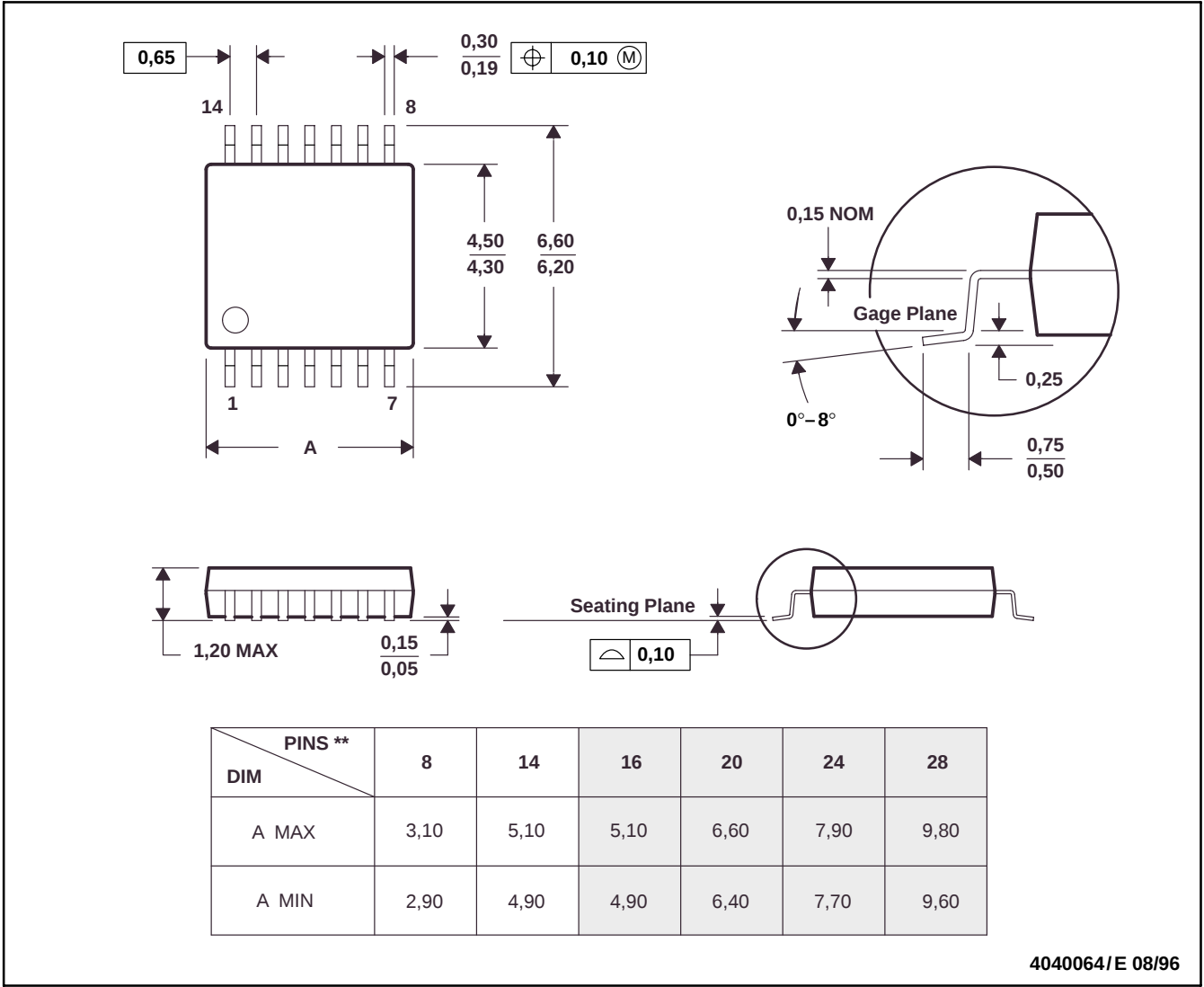
WIDE-INPUT-VOLTAGE OPERATIONAL AMPLIFIERS

SLOS168F – NOVEMBER 1996 – REVISED MARCH 2001

MECHANICAL DATA

PW (R-PDSO-G**)
14 PIN SHOWN

PLASTIC SMALL-OUTLINE PACKAGE



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

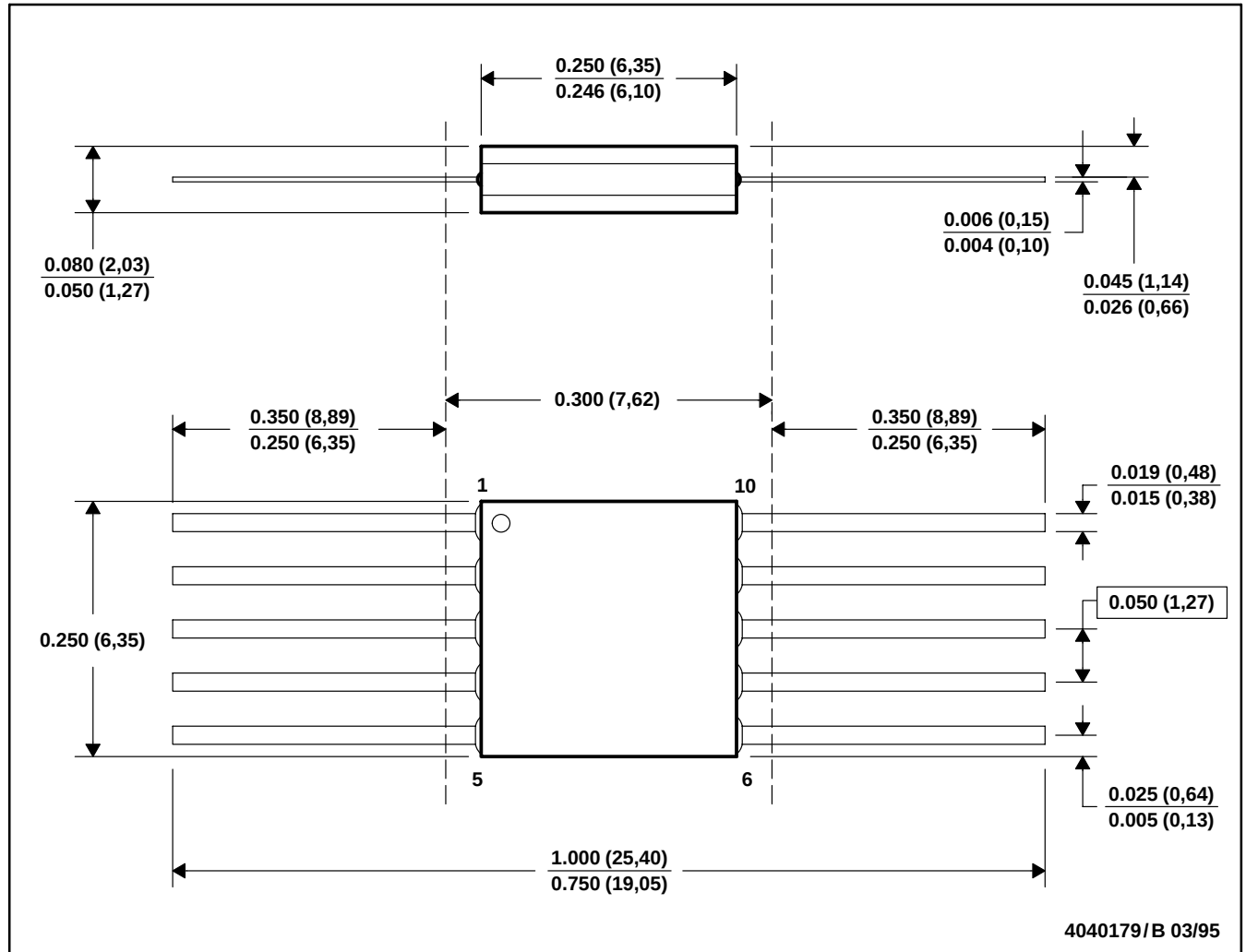
TLV2432, TLV2432A, TLV2434, TLV2434A
Advanced LinCMOS™ RAIL-TO-RAIL OUTPUT
WIDE-INPUT-VOLTAGE OPERATIONAL AMPLIFIERS

SLOS168F – NOVEMBER 1996 – REVISED MARCH 2001

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

PACKAGING INFORMATION

Orderable Device	Status ⁽¹⁾	Package Type	Package Drawing	Pins	Package Qty	Eco Plan ⁽²⁾	Lead/Ball Finish	MSL Peak Temp ⁽³⁾
5962-9751001Q2A	ACTIVE	LCCC	FK	20	1	TBD	POST-PLATE	N / A for Pkg Type
5962-9751001QHA	ACTIVE	CFP	U	10	1	TBD	A42 SNPB	N / A for Pkg Type
5962-9751001QPA	ACTIVE	CDIP	JG	8	1	TBD	A42 SNPB	N / A for Pkg Type
5962-9751002Q2A	ACTIVE	LCCC	FK	20	1	TBD	POST-PLATE	N / A for Pkg Type
5962-9751002QHA	ACTIVE	CFP	U	10	1	TBD	A42 SNPB	N / A for Pkg Type
5962-9751002QPA	ACTIVE	CDIP	JG	8	1	TBD	A42 SNPB	N / A for Pkg Type
TLV2432AID	ACTIVE	SOIC	D	8	75	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
TLV2432AIDG4	ACTIVE	SOIC	D	8	75	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
TLV2432AIDR	ACTIVE	SOIC	D	8	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
TLV2432AIDRG4	ACTIVE	SOIC	D	8	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
TLV2432AIPW	ACTIVE	TSSOP	PW	8	150	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
TLV2432AIPWG4	ACTIVE	TSSOP	PW	8	150	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
TLV2432AIPWLE	OBSOLETE	TSSOP	PW	8		TBD	Call TI	Call TI
TLV2432AIPWR	ACTIVE	TSSOP	PW	8	2000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
TLV2432AIPWRG4	ACTIVE	TSSOP	PW	8	2000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
TLV2432AMFKB	ACTIVE	LCCC	FK	20	1	TBD	POST-PLATE	N / A for Pkg Type
TLV2432AMJGB	ACTIVE	CDIP	JG	8	1	TBD	A42 SNPB	N / A for Pkg Type
TLV2432AMUB	ACTIVE	CFP	U	10	1	TBD	A42 SNPB	N / A for Pkg Type
TLV2432AQD	ACTIVE	SOIC	D	8	75	TBD	CU NIPDAU	Level-1-220C-UNLIM
TLV2432AQDR	ACTIVE	SOIC	D	8	2500	TBD	CU NIPDAU	Level-1-220C-UNLIM
TLV2432CD	ACTIVE	SOIC	D	8	75	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
TLV2432CDG4	ACTIVE	SOIC	D	8	75	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
TLV2432CDR	ACTIVE	SOIC	D	8	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
TLV2432CDRG4	ACTIVE	SOIC	D	8	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
TLV2432CPWR	ACTIVE	TSSOP	PW	8	2000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
TLV2432CPWRG4	ACTIVE	TSSOP	PW	8	2000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
TLV2432ID	ACTIVE	SOIC	D	8	75	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
TLV2432IDG4	ACTIVE	SOIC	D	8	75	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
TLV2432IDR	ACTIVE	SOIC	D	8	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
TLV2432IDRG4	ACTIVE	SOIC	D	8	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM

Orderable Device	Status ⁽¹⁾	Package Type	Package Drawing	Pins	Package Qty	Eco Plan ⁽²⁾	Lead/Ball Finish	MSL Peak Temp ⁽³⁾
no Sb/Br)								
TLV2432MFKB	ACTIVE	LCCC	FK	20	1	TBD	POST-PLATE	N / A for Pkg Type
TLV2432MJGB	ACTIVE	CDIP	JG	8	1	TBD	A42 SNPB	N / A for Pkg Type
TLV2432MUB	ACTIVE	CFP	U	10	1	TBD	A42 SNPB	N / A for Pkg Type
TLV2432QD	ACTIVE	SOIC	D	8	75	TBD	CU NIPDAU	Level-1-220C-UNLIM
TLV2432QDR	ACTIVE	SOIC	D	8	2500	TBD	CU NIPDAU	Level-1-220C-UNLIM
TLV2434AID	ACTIVE	SOIC	D	14	50	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
TLV2434AIDG4	ACTIVE	SOIC	D	14	50	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
TLV2434AIDR	ACTIVE	SOIC	D	14	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
TLV2434AIDRG4	ACTIVE	SOIC	D	14	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
TLV2434AIPWR	ACTIVE	TSSOP	PW	14	2000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
TLV2434AIPWRG4	ACTIVE	TSSOP	PW	14	2000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
TLV2434CD	ACTIVE	SOIC	D	14	50	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
TLV2434CDG4	ACTIVE	SOIC	D	14	50	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
TLV2434CDR	ACTIVE	SOIC	D	14	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
TLV2434CDRG4	ACTIVE	SOIC	D	14	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
TLV2434CPW	ACTIVE	TSSOP	PW	14	90	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
TLV2434CPWG4	ACTIVE	TSSOP	PW	14	90	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
TLV2434CPWR	ACTIVE	TSSOP	PW	14	2000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
TLV2434CPWRG4	ACTIVE	TSSOP	PW	14	2000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
TLV2434ID	ACTIVE	SOIC	D	14	50	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
TLV2434IDG4	ACTIVE	SOIC	D	14	50	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
TLV2434IDR	ACTIVE	SOIC	D	14	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
TLV2434IDRG4	ACTIVE	SOIC	D	14	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
TLV2434IPW	ACTIVE	TSSOP	PW	14	90	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
TLV2434IPWG4	ACTIVE	TSSOP	PW	14	90	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
TLV2434IPWR	ACTIVE	TSSOP	PW	14	2000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
TLV2434IPWRG4	ACTIVE	TSSOP	PW	14	2000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM

⁽¹⁾ The marketing status values are defined as follows:

ACTIVE: Product device recommended for new designs.

LIFEBUY: TI has announced that the device will be discontinued, and a lifetime-buy period is in effect.

NRND: Not recommended for new designs. Device is in production to support existing customers, but TI does not recommend using this part in a new design.

PREVIEW: Device has been announced but is not in production. Samples may or may not be available.

OBSOLETE: TI has discontinued the production of the device.

⁽²⁾ Eco Plan - The planned eco-friendly classification: Pb-Free (RoHS), Pb-Free (RoHS Exempt), or Green (RoHS & no Sb/Br) - please check <http://www.ti.com/productcontent> for the latest availability information and additional product content details.

TBD: The Pb-Free/Green conversion plan has not been defined.

Pb-Free (RoHS): TI's terms "Lead-Free" or "Pb-Free" mean semiconductor products that are compatible with the current RoHS requirements for all 6 substances, including the requirement that lead not exceed 0.1% by weight in homogeneous materials. Where designed to be soldered at high temperatures, TI Pb-Free products are suitable for use in specified lead-free processes.

Pb-Free (RoHS Exempt): This component has a RoHS exemption for either 1) lead-based flip-chip solder bumps used between the die and package, or 2) lead-based die adhesive used between the die and leadframe. The component is otherwise considered Pb-Free (RoHS compatible) as defined above.

Green (RoHS & no Sb/Br): TI defines "Green" to mean Pb-Free (RoHS compatible), and free of Bromine (Br) and Antimony (Sb) based flame retardants (Br or Sb do not exceed 0.1% by weight in homogeneous material)

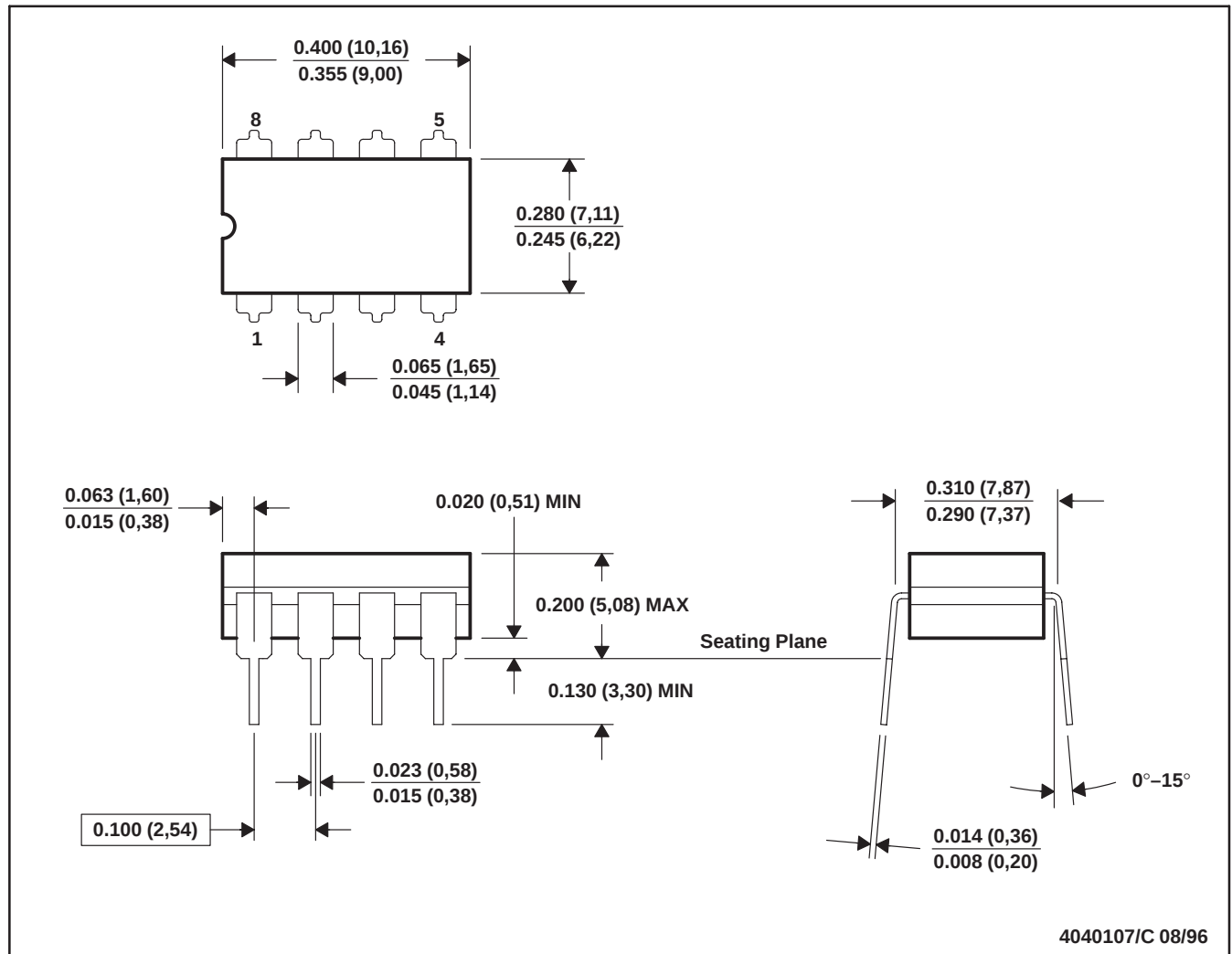
⁽³⁾ MSL, Peak Temp. -- The Moisture Sensitivity Level rating according to the JEDEC industry standard classifications, and peak solder temperature.

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JG (R-GDIP-T8)

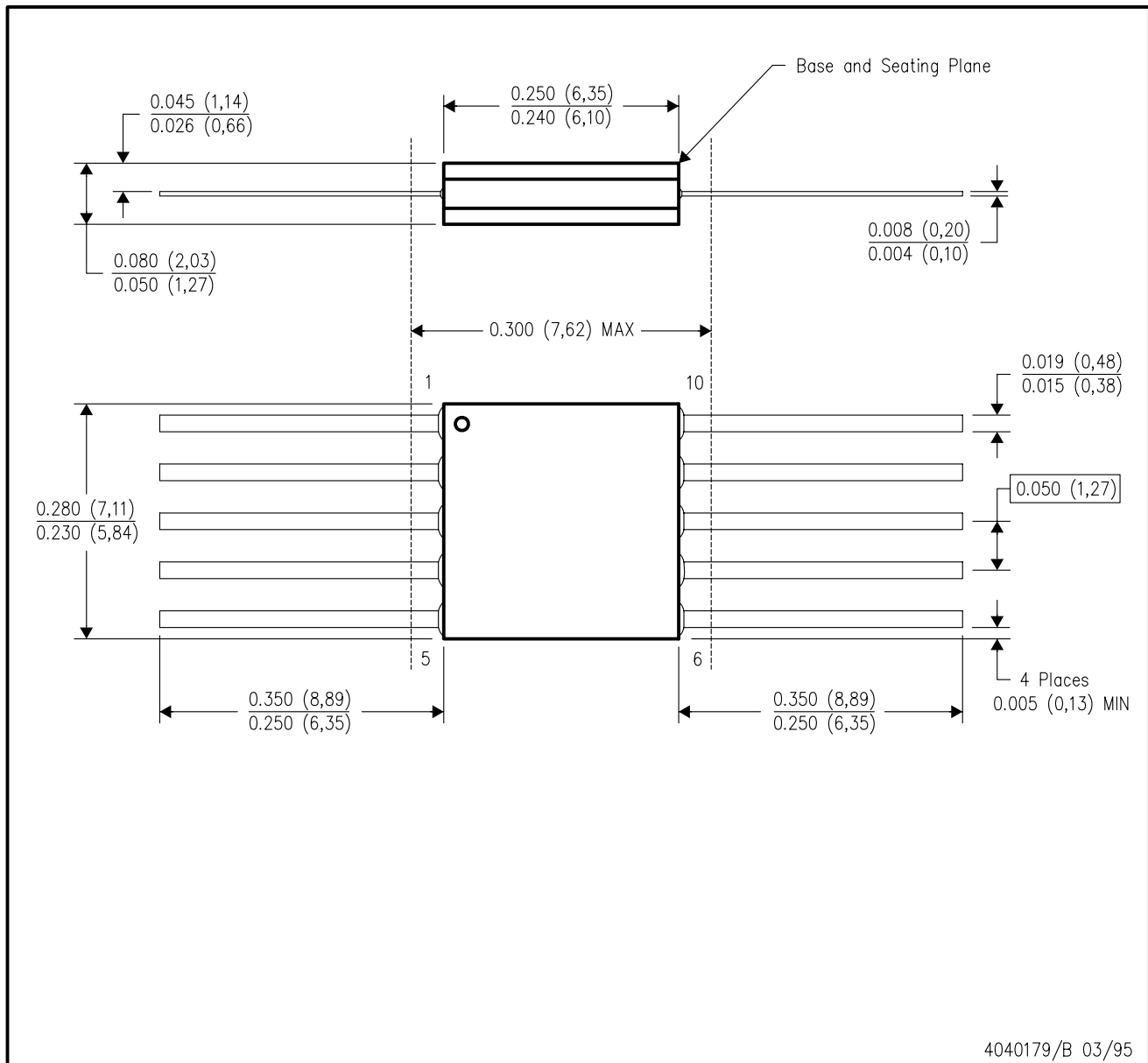
CERAMIC DUAL-IN-LINE



- 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.
 - E. Falls within MIL STD 1835 GDIP1-T8

U (S-GDFP-F10)

CERAMIC DUAL FLATPACK

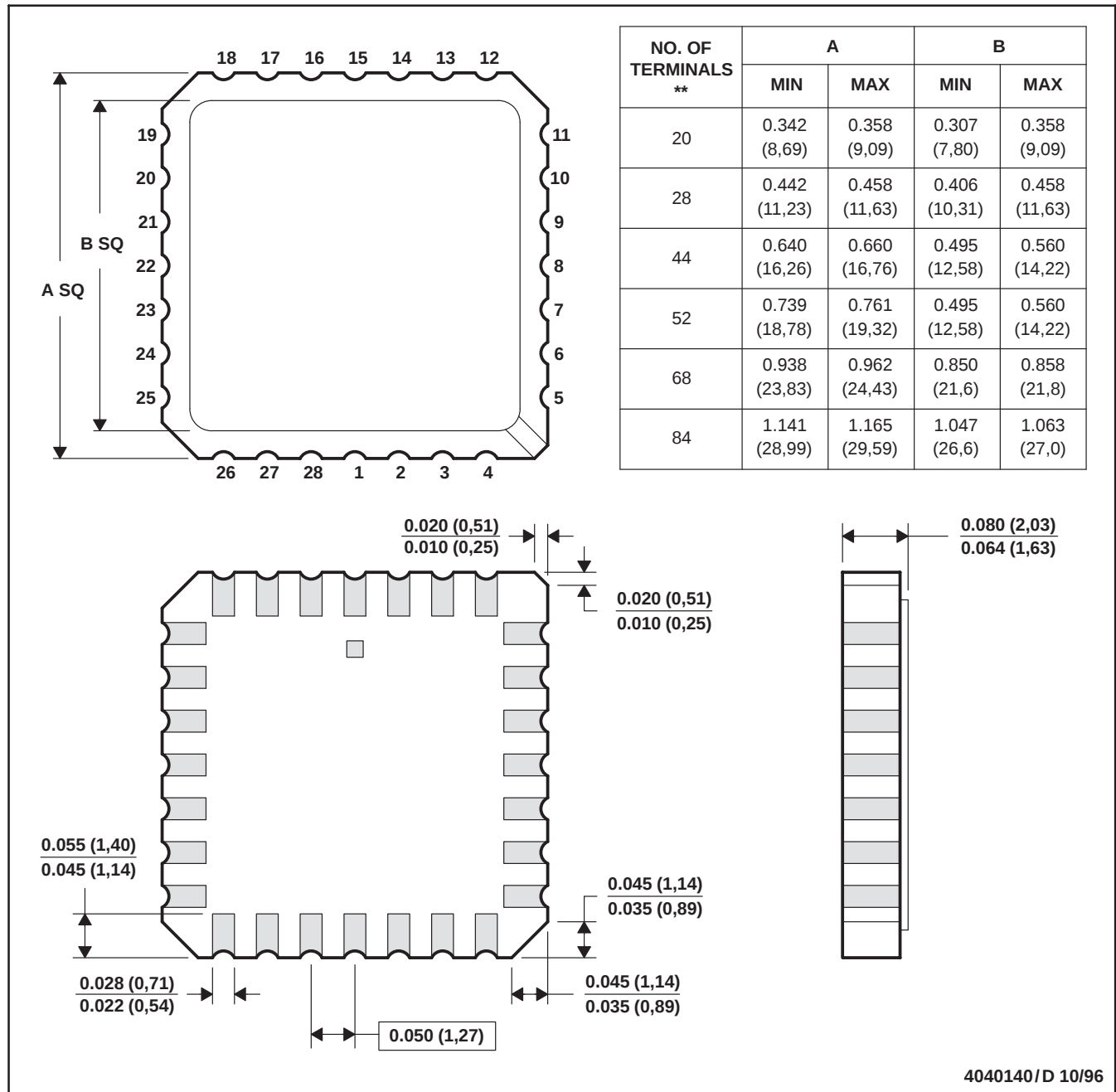


- NOTES:
- A. All linear dimensions are in inches (millimeters).
 - B. This drawing is subject to change without notice.
 - C. This package can be hermetically sealed with a ceramic lid using glass frit.
 - D. Index point is provided on cap for terminal identification only.
 - E. Falls within MIL STD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

FK (S-CQCC-N**)

LEADLESS CERAMIC CHIP CARRIER

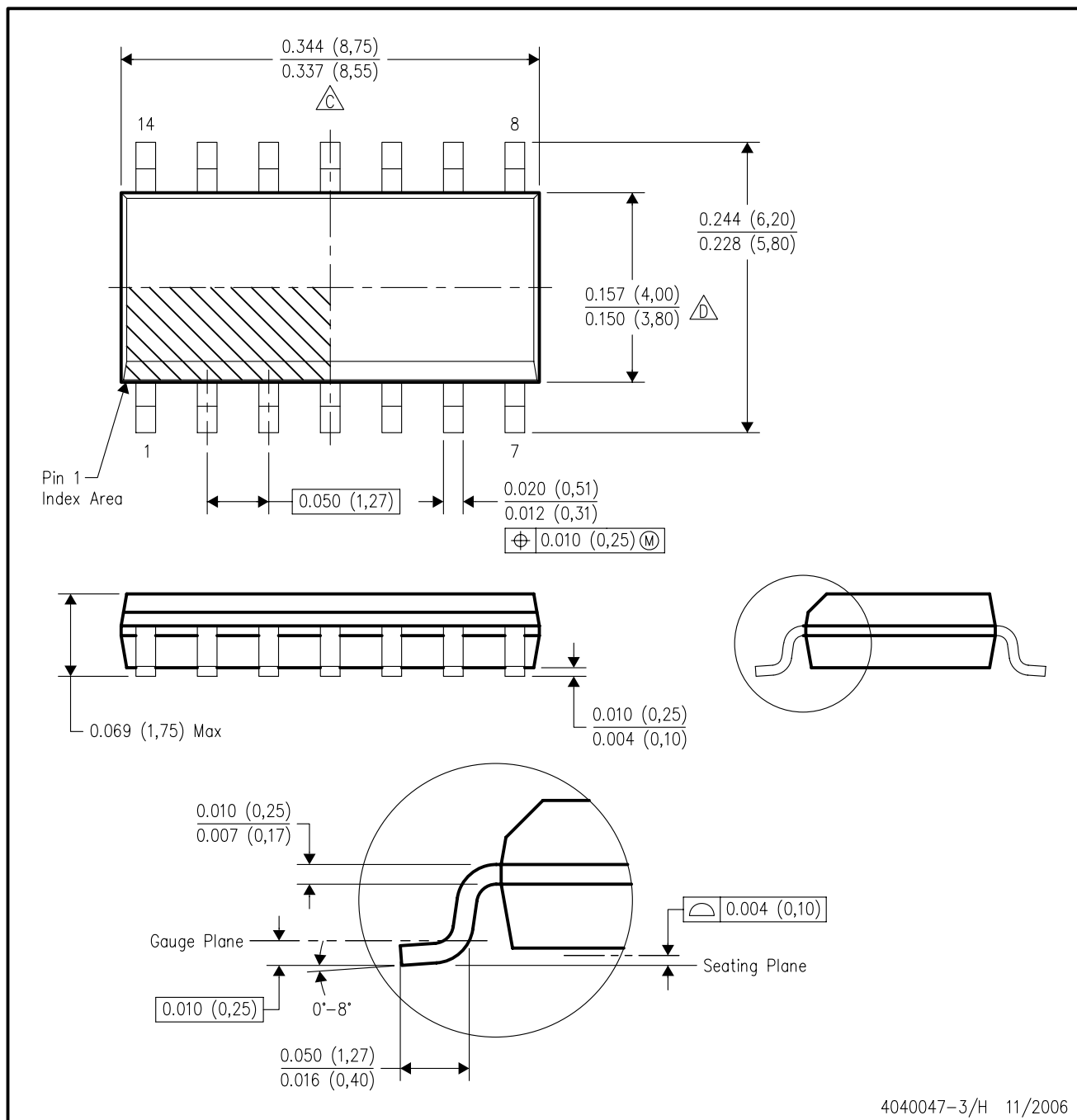
28 TERMINAL SHOWN



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

D (R-PDSO-G14)

PLASTIC SMALL-OUTLINE PACKAGE



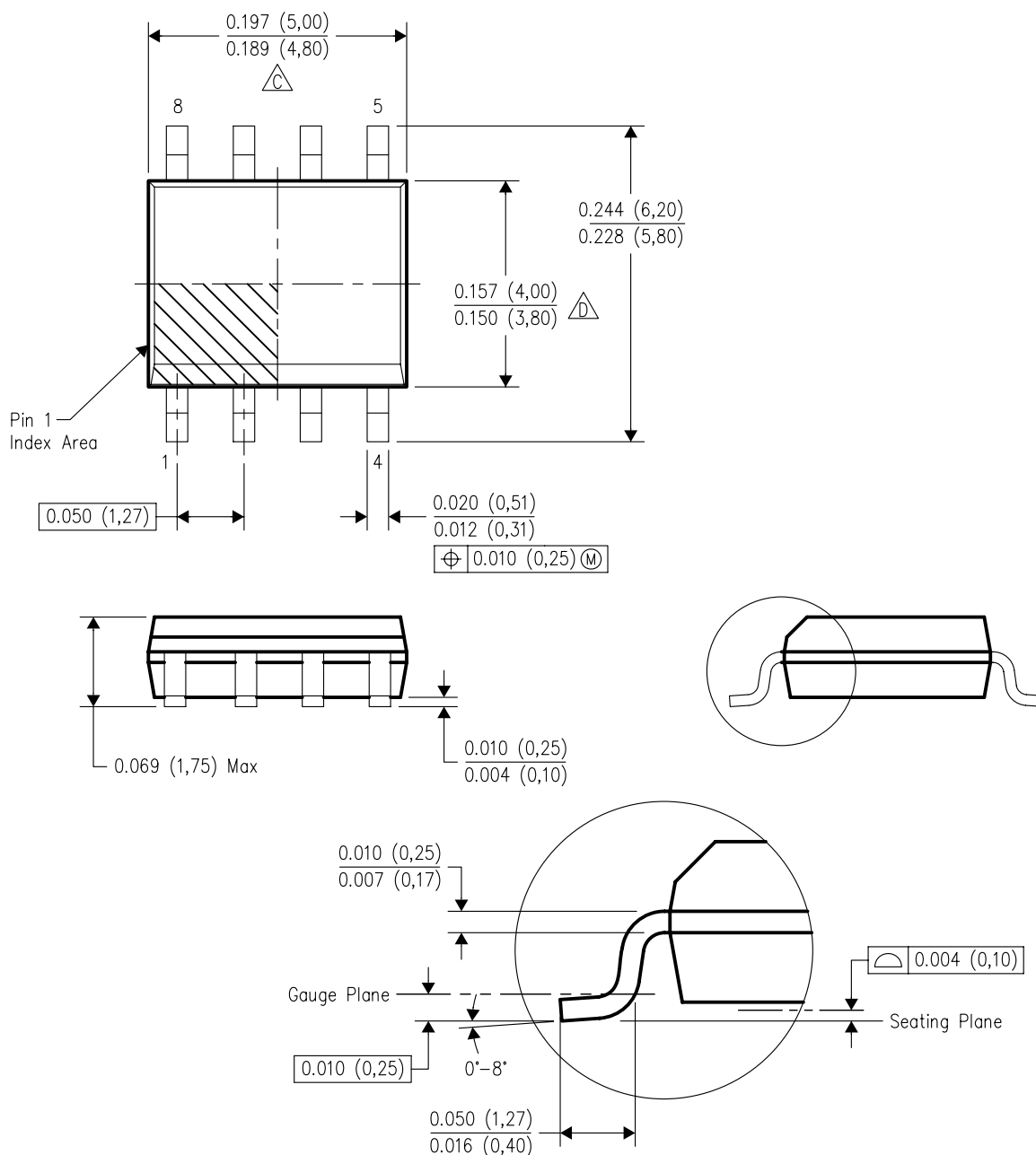
4040047-3/H 11/2006

NOTES:

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

D (R-PDSO-G8)

PLASTIC SMALL-OUTLINE PACKAGE



4040047-2/H 11/2006

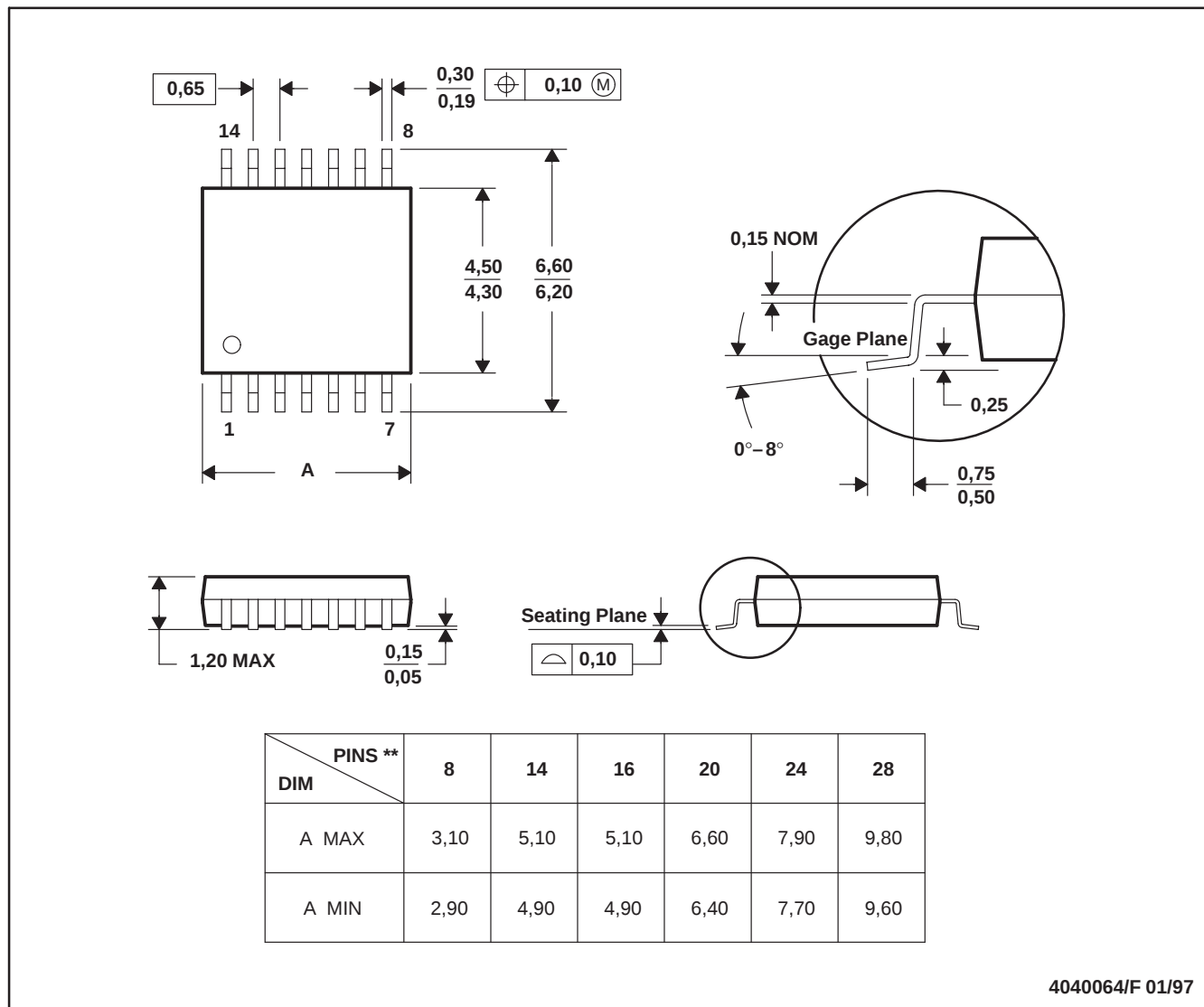
NOTES:

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

PW (R-PDSO-G**)

PLASTIC SMALL-OUTLINE PACKAGE

14 PINS SHOWN



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

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