

# TLV2432-Q1, TLV2432A-Q1, TLV2434-Q1, TLV2434A-Q1 Advanced LinCMOS™ RAIL-TO-RAIL OUTPUT WIDE-INPUT-VOLTAGE OPERATIONAL AMPLIFIERS

SGLS182B – SEPTEMBER 2003 – REVISED NOVEMBER 2010

- Qualified for Automotive Applications
- ESD Protection Exceeds 2000 V Per MIL-STD-883, Method 3015; Exceeds 200 V Using Machine Model (C = 200 pF, R = 0)
- 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

## description

The TLV243x and TLV243xA are low-voltage operational amplifier from Texas Instruments. The common-mode input voltage range for each device is extended over the typical CMOS amplifiers making them suitable for a wide range of applications. In addition, these devices do not phase invert when the common-mode input is driven to the supply rails. This satisfies most design requirements without paying a premium for rail-to-rail input performance. They also exhibit rail-to-rail output performance for increased dynamic range in single- or split-supply applications. This family is fully characterized at 3-V and 5-V supplies and is optimized for low-voltage operation. The TLV243x only requires 100 μA (typ) of supply current per channel, making it ideal for battery-powered applications. The TLV243x also has increased output drive over previous rail-to-rail operational amplifiers and can drive 600-Ω loads for telecom applications.

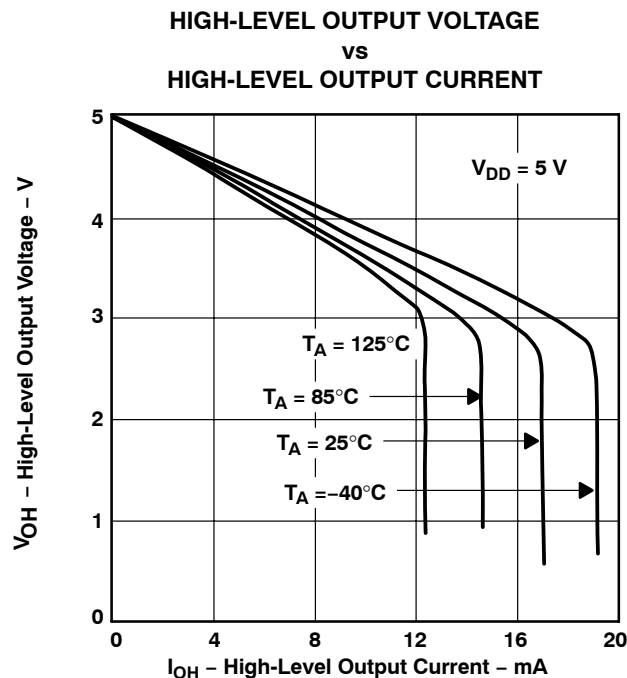


Figure 1

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

The TLV243x, exhibiting high input impedance and low noise, is excellent for small-signal conditioning for high-impedance sources, such as piezoelectric transducers. Because of the micropower dissipation levels and low-voltage operation, these devices work well in hand-held monitoring and remote-sensing applications. In addition, the rail-to-rail output feature with single- or split-supplies makes this family a great choice when interfacing with analog-to-digital converters (ADCs). For precision applications, the TLV243xA is available and has a maximum input offset voltage of 950 μV.

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



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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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# TLV2432-Q1, TLV2432A-Q1, TLV2434-Q1, TLV2434A-Q1

## Advanced LinCMOS™ RAIL-TO-RAIL OUTPUT

### WIDE-INPUT-VOLTAGE OPERATIONAL AMPLIFIERS

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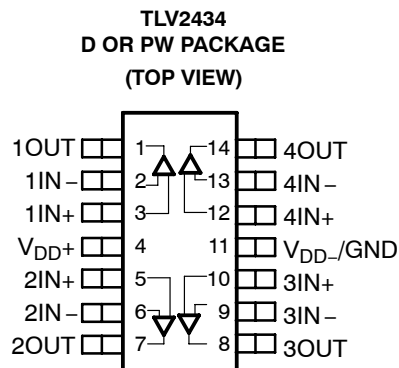
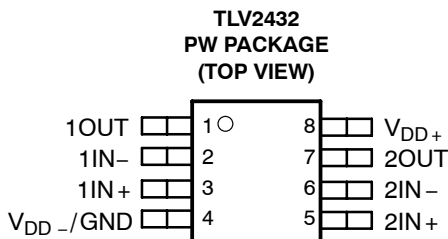
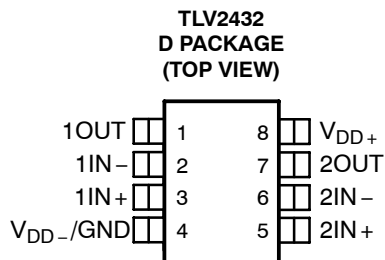
#### ORDERING INFORMATION†

$T_A$	$V_{IOmax}$ AT 25°C	PACKAGE‡		ORDERABLE PART NUMBER	TOP-SIDE MARKING
-40°C to 125°C	950 $\mu$ V	SOIC (D)	Tape and reel	TLV2432AQDRQ1	2432AQ
		TSSOP (PW)	Tape and reel	TLV2432AQPWRQ1§	
	2.5 mV	SOIC (D)	Tape and reel	TLV2432QDRQ1	2432Q1
		TSSOP (PW)	Tape and reel	TLV2432QPWRQ1§	
-40°C to 125°C	950 $\mu$ V	SOIC (D)	Tape and reel	TLV2434AQDRQ1	2434AQ
		TSSOP (PW)	Tape and reel	TLV2434AQPWRQ1§	
	2.5 mV	SOIC (D)	Tape and reel	TLV2434QDRQ1§	
		TSSOP (PW)	Tape and reel	TLV2434QPWRQ1§	

† For the most current package and ordering information, see the Package Option Addendum at the end of this document, or see the TI web site at <http://www.ti.com>.

‡ Package drawings, thermal data, and symbolization are available at <http://www.ti.com/packaging>.

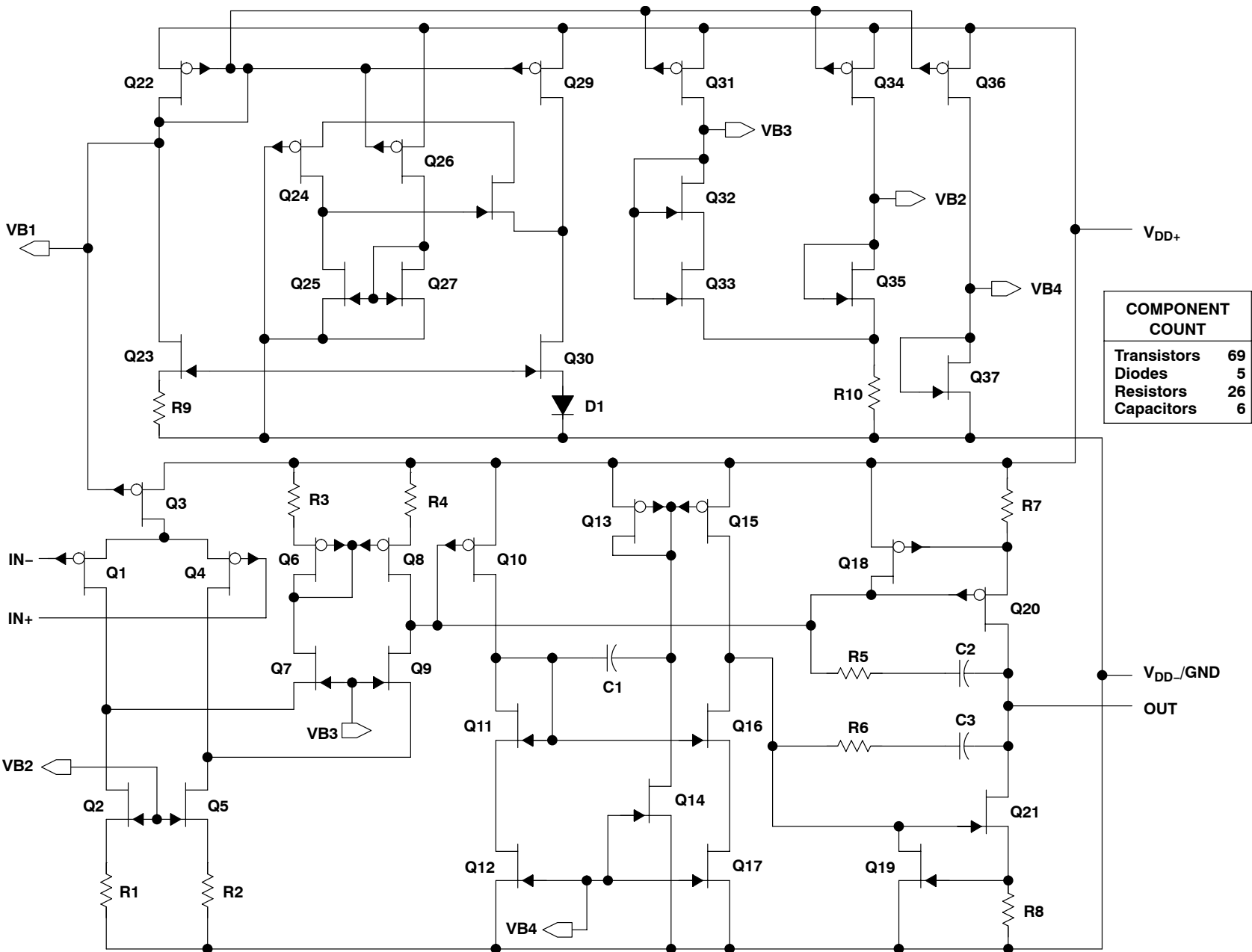
§ Product Preview.



**TLV2432-Q1, TLV2432A-Q1, TLV2434-Q1, TLV2434A-Q1**  
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equivalent schematic (each amplifier)



COMPONENT COUNT	
Transistors	69
Diodes	5
Resistors	26
Capacitors	6

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

Supply voltage, $V_{DD}$ (see Note 1)	12 V
Differential input voltage, $V_{ID}$ (see Note 2)	$\pm V_{DD}$
Input 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, $T_A$ : Q suffix	-40°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
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

**recommended operating conditions**

	MIN	MAX	UNIT
Supply voltage, $V_{DD}$	2.7	10	V
Input voltage range, $V_I$	$V_{DD-}$	$V_{DD+} - 0.8$	V
Common-mode input voltage, $V_{IC}$	$V_{DD-}$	$V_{DD+} - 0.8$	V
Operating free-air temperature, $T_A$	-40	125	°C



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

PARAMETER	TEST CONDITIONS		$T_A^\dagger$	TLV243x-Q1			UNIT
				MIN	TYP	MAX	
$V_{IO}$ Input offset voltage	$V_{IC} = 0,$ $V_O = 0,$ $V_{DD} \pm = \pm 1.5\text{ V},$ $R_S = 50\ \Omega$	TLV243x	25°C	300	2000	$\mu\text{V}$	
			Full range	2500			
		TLV243xA	25°C	300	950		
			Full range	2000			
$\alpha_{V_{IO}}$ Temperature coefficient of input offset voltage			25°C to 70°C	2		$\mu\text{V}/^\circ\text{C}$	
Input offset voltage long-term drift (see Note 4)			25°C	0.003		$\mu\text{V}/\text{mo}$	
$I_{IO}$ Input offset current	$V_{IC} = 0,$ $V_O = 0,$ $V_{DD} \pm = \pm 1.5\text{ V},$ $R_S = 50\ \Omega$			25°C	0.5		pA
				Full range	150		
$I_{IB}$ Input bias current				25°C	1		pA
				Full range	300		
$V_{ICR}$ Common-mode input voltage range	$ V_{IO}  \leq 5\text{ mV},$ $R_S = 50\ \Omega$			25°C	0 to 2.5	V	
				Full range	–0.25 to 2.75		
$V_{OH}$ High-level output voltage	$I_{OH} = -100\ \mu\text{A}$		25°C	2.98		V	
	$I_{OH} = -3\text{ mA}$		25°C	2.5			
			Full range	2.25			
$V_{OL}$ Low-level output voltage	$V_{IC} = 1.5\text{ V},$ $I_{OL} = 100\ \mu\text{A}$		25°C	0.02		V	
	$V_{IC} = 1.5\text{ V},$ $I_{OL} = 3\text{ mA}$		25°C	0.83			
			Full range	1			
$A_{VD}$ Large-signal differential voltage amplification	$V_{IC} = 2.5\text{ V},$ $V_O = 1\text{ V to }2\text{ V}$	$R_L = 2\text{ k}\Omega^\ddagger$	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	$V_{IC} = V_{ICR\text{ MIN}},$ $V_O = 1.5\text{ V},$ $R_S = 50\ \Omega$		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			

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

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

PARAMETER	TEST CONDITIONS	$T_A^\dagger$	TLV243x-Q1, TLV243xA-Q1			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	0.15	0.25	V/ $\mu$ 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		$\mu$ 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	$V_O = 0.5\text{ V to }2.5\text{ V},$ $f = 1\text{ kHz},$ $R_L = 2\text{ k}\Omega^\ddagger$	$A_V = 1$	25°C	0.065%		
		$A_V = 10$		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
$B_{OM}$ 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 V to 2.5 V, $R_L = 2\text{ k}\Omega^\ddagger,$ $C_L = 100\text{ pF}^\ddagger$	$T_o = 0.1\%$	25°C	6.4		$\mu$ s
		$T_o = 0.01\%$		14.1		
$\phi_m$ Phase margin at unity gain			25°C	62°		
Gain margin	$R_L = 2\text{ k}\Omega^\ddagger,$	$C_L = 100\text{ pF}^\ddagger$	25°C	11		dB

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

$^\ddagger$  Referenced to 2.5 V



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

PARAMETER	TEST CONDITIONS		$T_A^\dagger$	TLV243x-Q1			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	2000			
$\alpha_{V_{IO}}$ Temperature coefficient of input offset voltage			25°C to 70°C	2		$\mu\text{V}/^\circ\text{C}$	
Input offset voltage long-term drift (see Note 4)			25°C	0.003		$\mu\text{V}/\text{mo}$	
$I_{IO}$ Input offset current	$V_{IC} = 0,$ $V_O = 0,$	$V_{DD} \pm = \pm 2.5\text{ V},$ $R_S = 50\ \Omega$	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	$\text{V}$	
			Full range	0 to 4.2			
$V_{OH}$ High-level output voltage	$I_{OH} = -100\ \mu\text{A}$		25°C	4.97		$\text{V}$	
	$I_{OH} = -5\text{ mA}$		25°C	4	4.35		
			Full range	4			
$V_{OL}$ Low-level output voltage	$V_{IC} = 2.5\text{ V},$	$I_{OL} = 100\ \mu\text{A}$	25°C	0.01		$\text{V}$	
	$V_{IC} = 2.5\text{ V},$	$I_{OL} = 5\text{ mA}$	25°C	0.8			
			Full range	1.25			
$A_{VD}$ Large-signal differential voltage amplification	$V_{IC} = 2.5\text{ V},$ $V_O = 1\text{ V to }4\text{ V}$	$R_L = 2\text{ k}\Omega^\ddagger$	25°C	2.5	3.8	$\text{V/mV}$	
			Full range	0.5			
				$R_L = 1\text{ M}\Omega^\ddagger$	25°C		950
$r_{i(d)}$ Differential input resistance			25°C	1000		$\text{G}\Omega$	
$r_{i(c)}$ 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	$V_{IC} = V_{ICR\text{ MIN}},$ $V_O = 2.5\text{ V},$ $R_S = 50\ \Omega$		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	$V_O = 2.5\text{ V},$ No load		25°C	200	250	$\mu\text{A}$	
			Full range	270			

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

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

PARAMETER	TEST CONDITIONS	$T_A^\dagger$	TLV243x-Q1, TLV243xA-Q1			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/ $\mu$ 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		$\mu$ 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	
$B_{OM}$ 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, $R_L = 2\text{ k}\Omega^\ddagger,$ $C_L = 100\text{ pF}^\ddagger$	$T_o = 0.1\%$	6.4		$\mu$ 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°		dB	
Gain margin		25°C	11			

<sup>†</sup> Full range is -40°C to 125°C for Q level part.

<sup>‡</sup> Referenced to 2.5 V





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**TYPICAL CHARACTERISTICS**

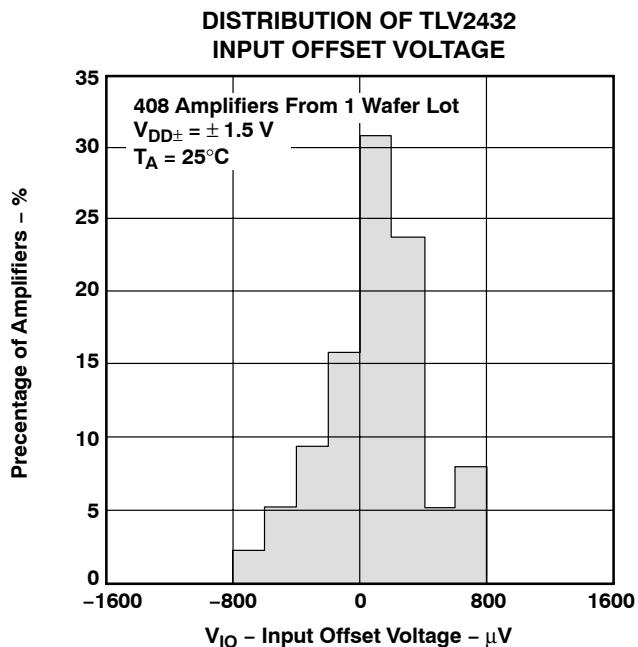
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		vs Free-air temperature	29
$I_{DD}$	Supply current	vs Supply voltage	30
SR	Slew rate	vs Load capacitance	31
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$V_O$	Inverting small-signal pulse response		37,38
$V_O$	Voltage-follower small-signal pulse response		39,40
$V_n$	Equivalent input noise voltage	vs Frequency	41, 42
		Noise voltage (referred to input)	Over a 10-second period
THD + N	Total harmonic distortion plus noise	vs Frequency	44,45
		Gain-bandwidth product	vs Free-air temperature vs Supply voltage
$\phi_m$	Phase margin	vs Frequency	19,20
		vs Load capacitance	48
	Gain margin	vs Load capacitance	49
$B_1$	Unity-gain bandwidth	vs Load capacitance	50

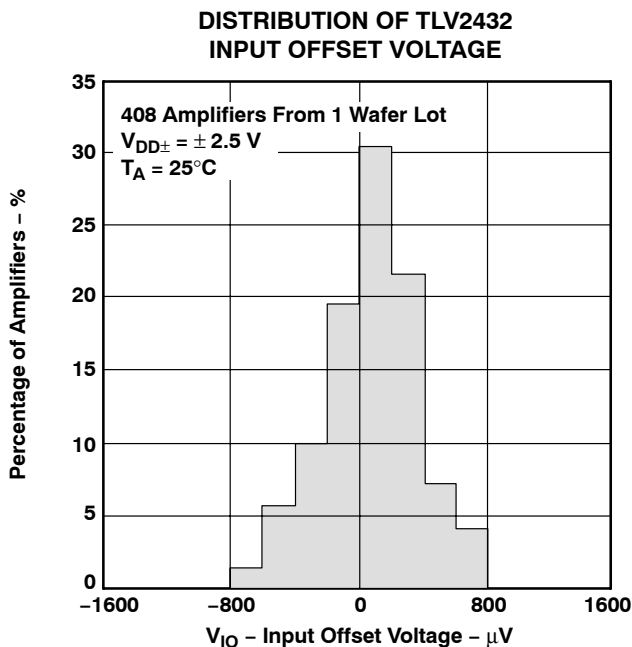
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**WIDE-INPUT-VOLTAGE OPERATIONAL AMPLIFIERS**

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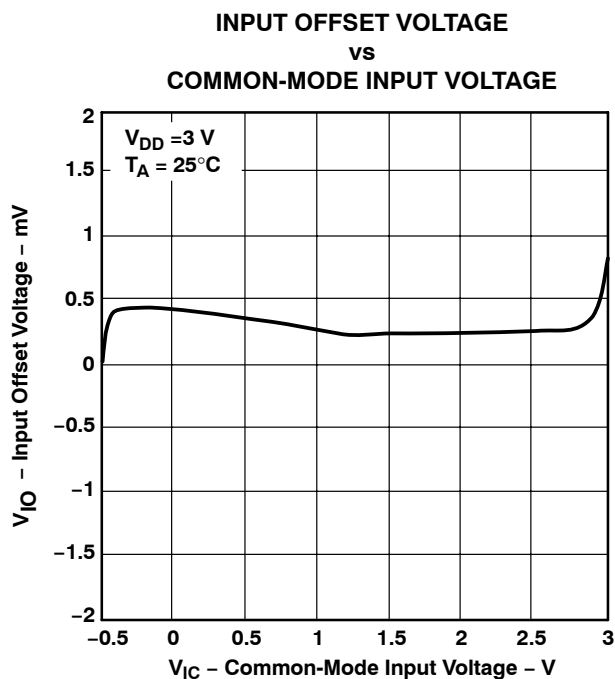
**TYPICAL CHARACTERISTICS**



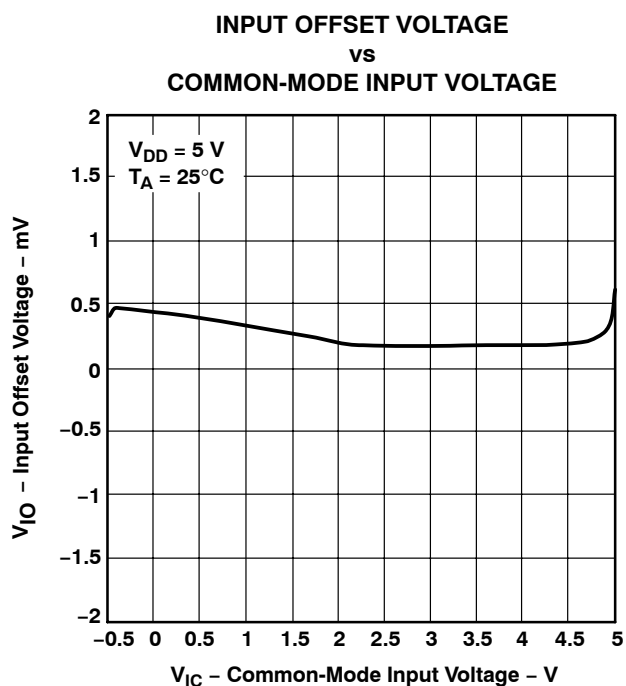
**Figure 2**



**Figure 3**



**Figure 4**



**Figure 5**



TLV2432-Q1, TLV2432A-Q1, TLV2434-Q1, TLV2434A-Q1  
 Advanced LinCMOS™ RAIL-TO-RAIL OUTPUT  
 WIDE-INPUT-VOLTAGE OPERATIONAL AMPLIFIERS

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TYPICAL CHARACTERISTICS

DISTRIBUTION OF TLV2432 INPUT OFFSET VOLTAGE TEMPERATURE COEFFICIENT

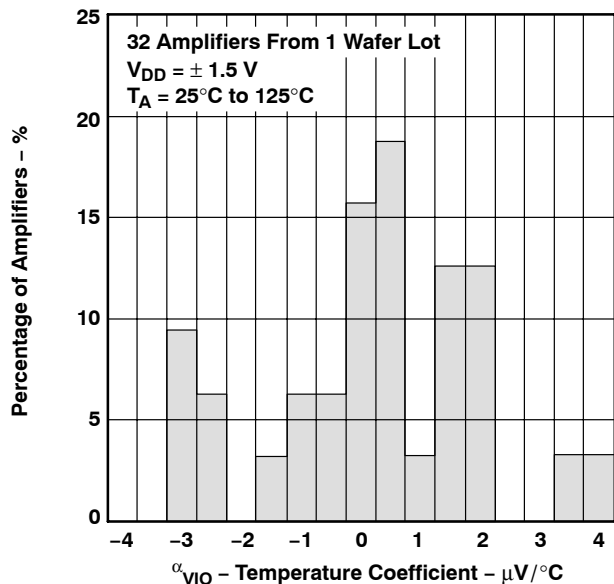


Figure 6

DISTRIBUTION OF TLV2432 INPUT OFFSET VOLTAGE TEMPERATURE COEFFICIENT

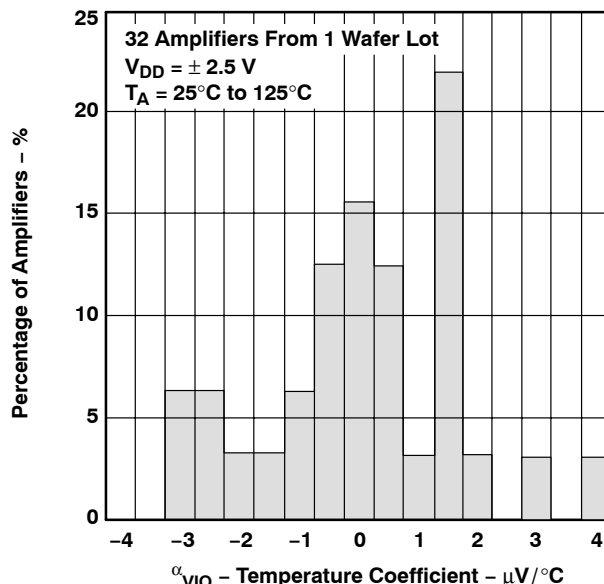


Figure 7

INPUT BIAS AND INPUT OFFSET CURRENTS vs FREE-AIR TEMPERATURE

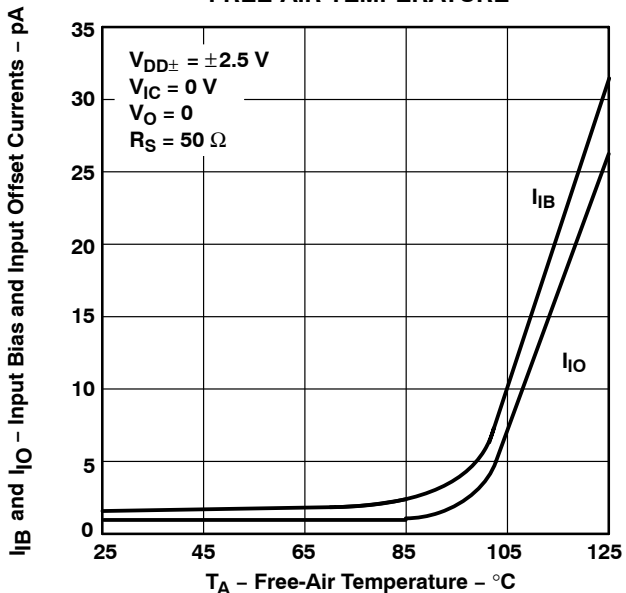


Figure 8

HIGH-LEVEL OUTPUT VOLTAGE vs HIGH-LEVEL OUTPUT CURRENT

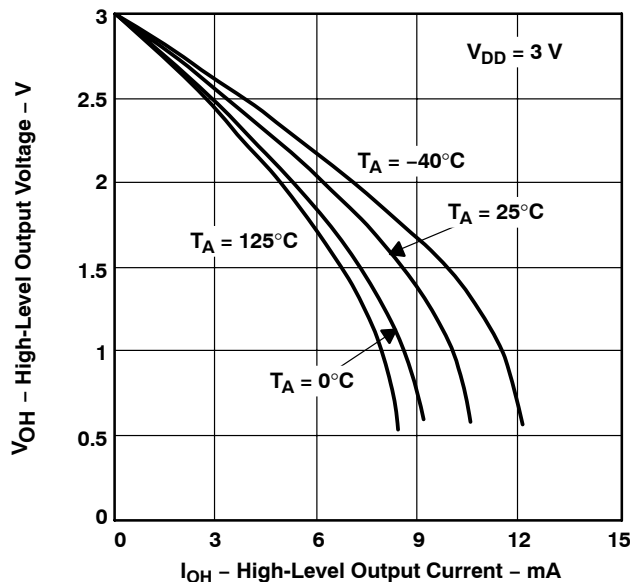
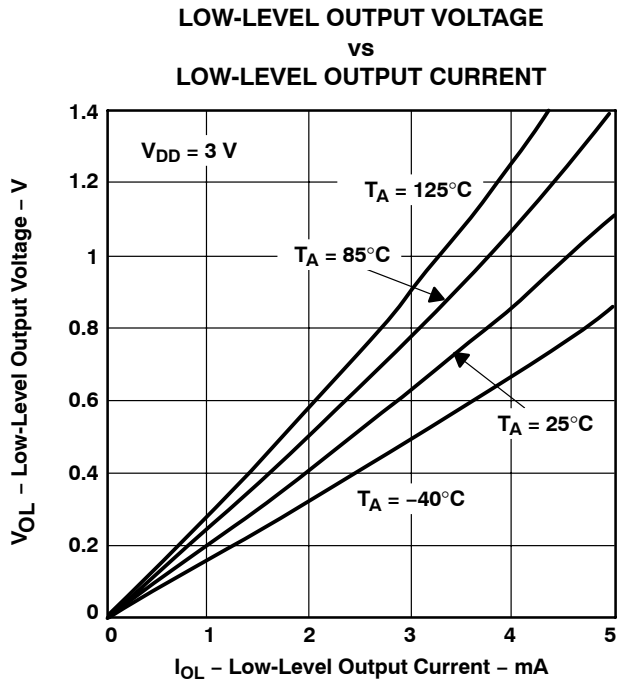
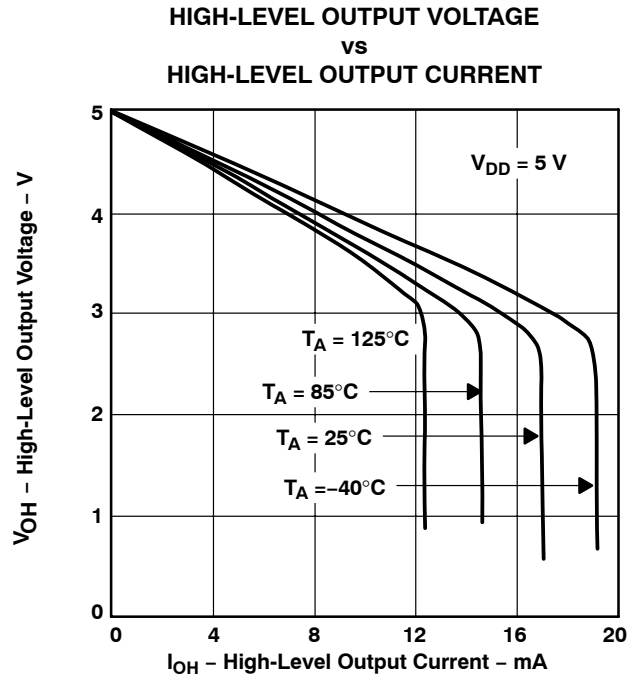


Figure 9

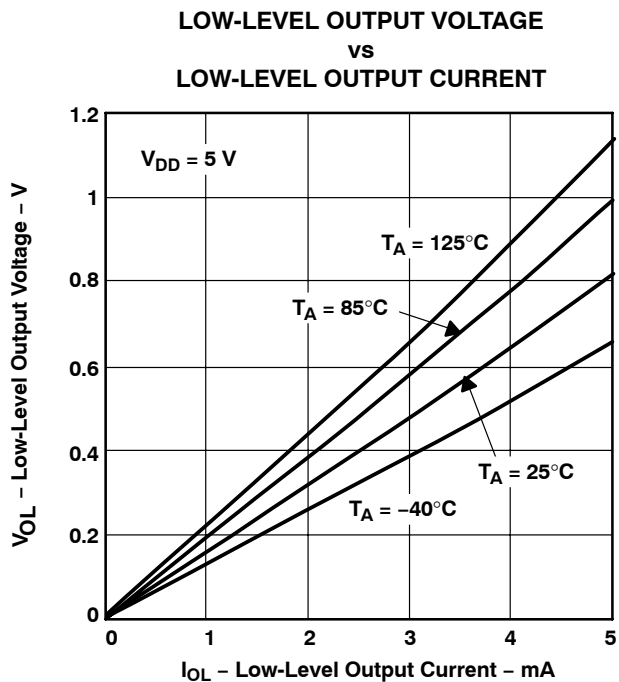
**TYPICAL CHARACTERISTICS**



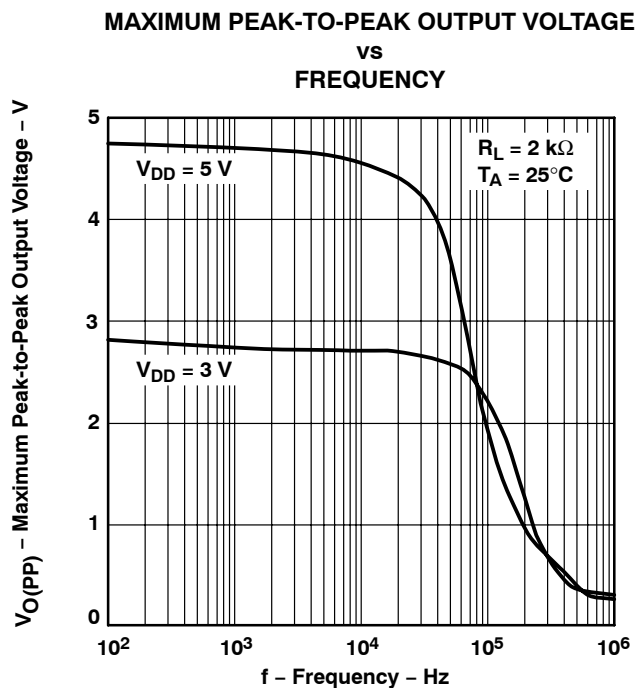
**Figure 10**



**Figure 11**



**Figure 12**

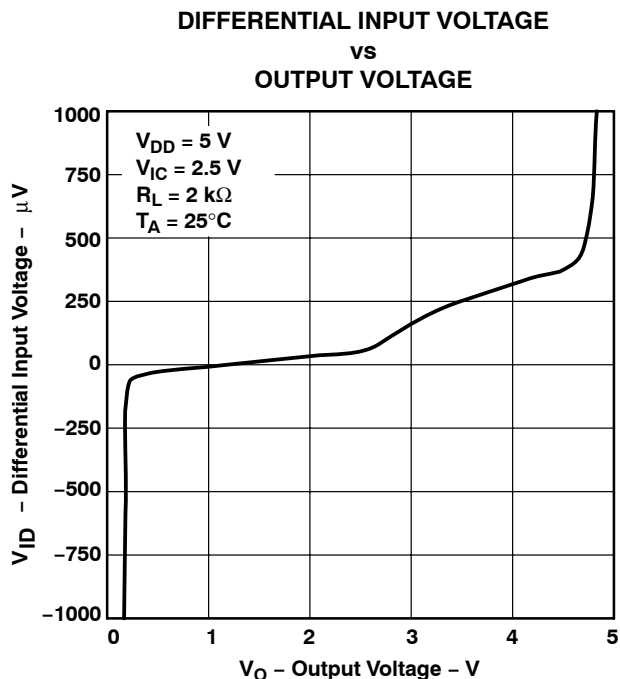
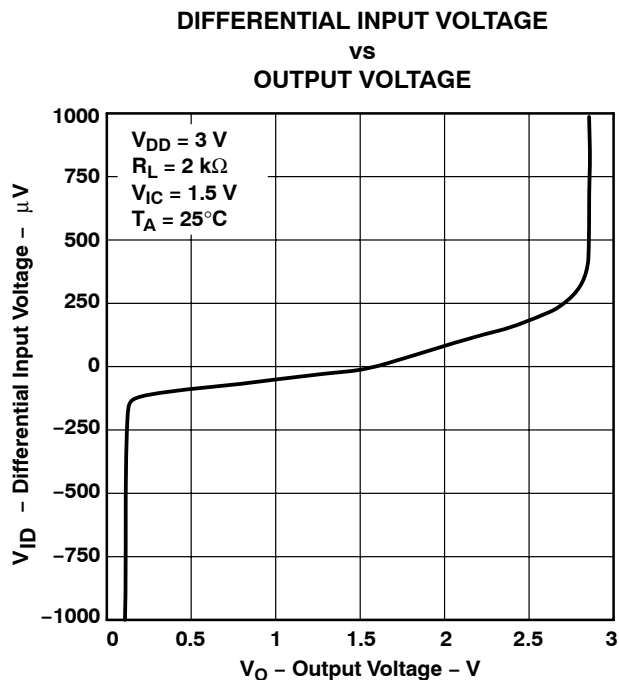
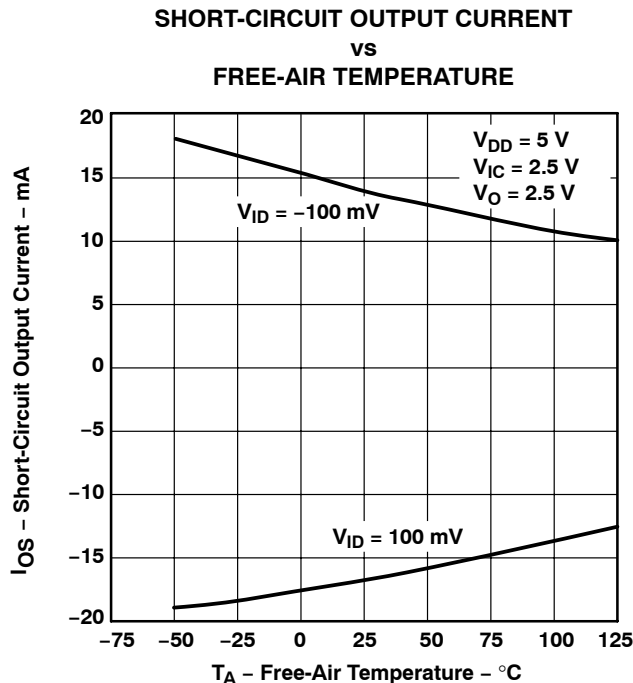
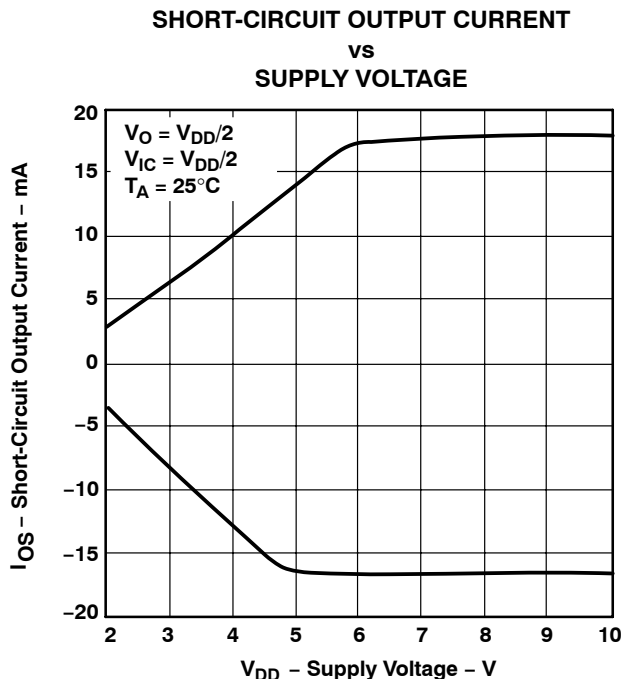


**Figure 13**

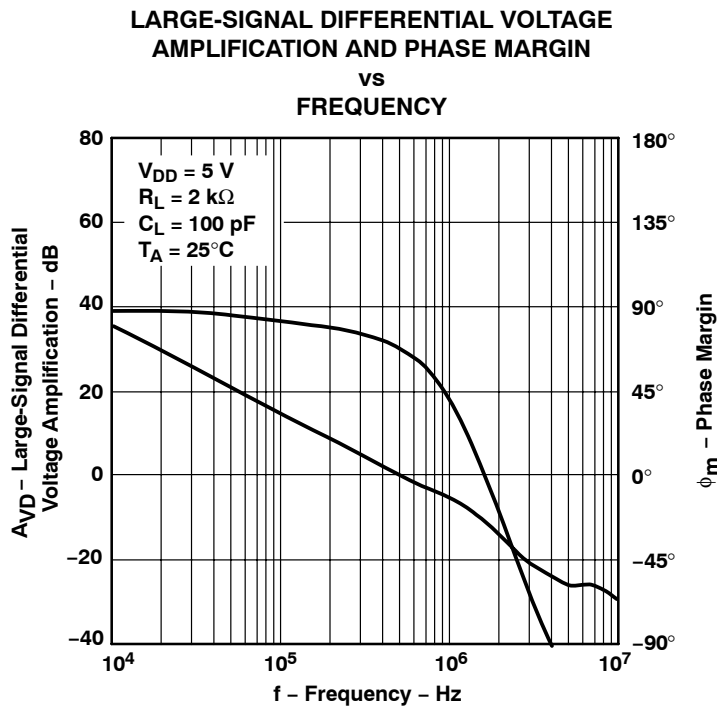
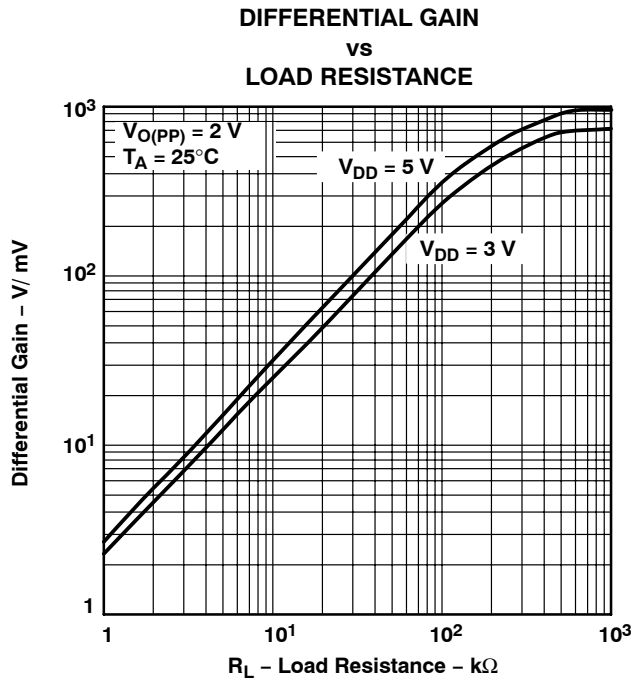
TLV2432-Q1, TLV2432A-Q1, TLV2434-Q1, TLV2434A-Q1  
**Advanced LinCMOS™ RAIL-TO-RAIL OUTPUT**  
**WIDE-INPUT-VOLTAGE OPERATIONAL AMPLIFIERS**

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TYPICAL CHARACTERISTICS



**TYPICAL CHARACTERISTICS**



TLV2432-Q1, TLV2432A-Q1, TLV2434-Q1, TLV2434A-Q1  
 Advanced LinCMOS™ RAIL-TO-RAIL OUTPUT  
 WIDE-INPUT-VOLTAGE OPERATIONAL AMPLIFIERS

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TYPICAL CHARACTERISTICS

LARGE-SIGNAL DIFFERENTIAL VOLTAGE  
 AMPLIFICATION AND PHASE MARGIN

vs  
 FREQUENCY

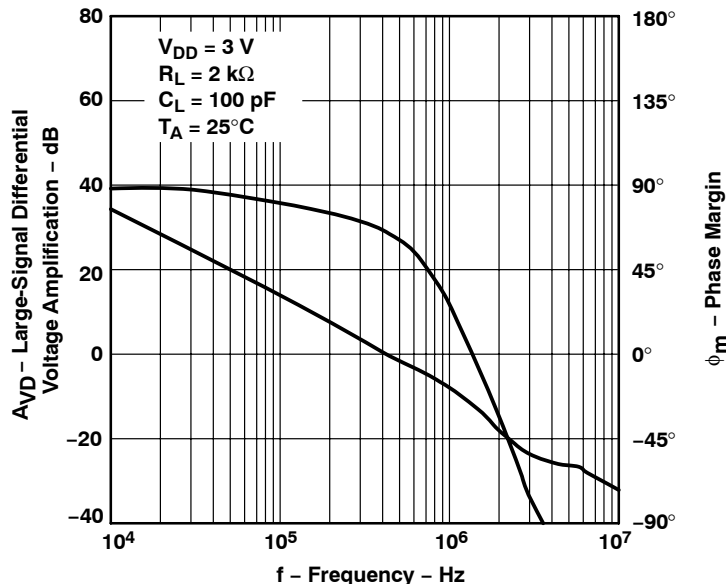


Figure 20

DIFFERENTIAL VOLTAGE AMPLIFICATION  
 vs  
 FREE-AIR TEMPERATURE

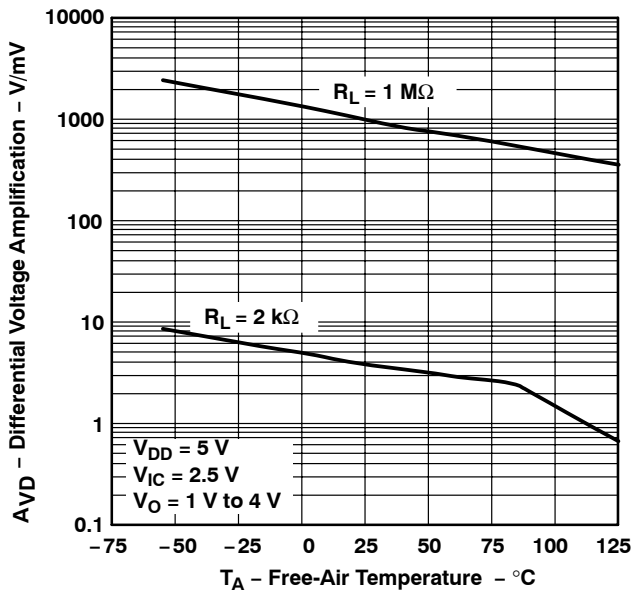


Figure 21

DIFFERENTIAL VOLTAGE AMPLIFICATION  
 vs  
 FREE-AIR TEMPERATURE

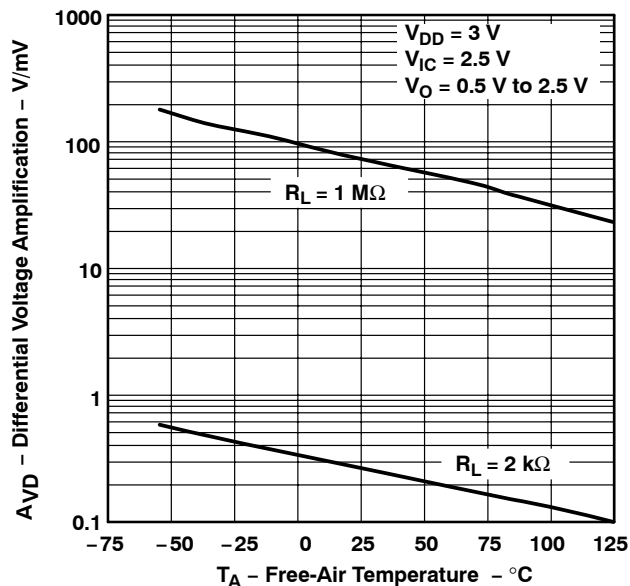


Figure 22

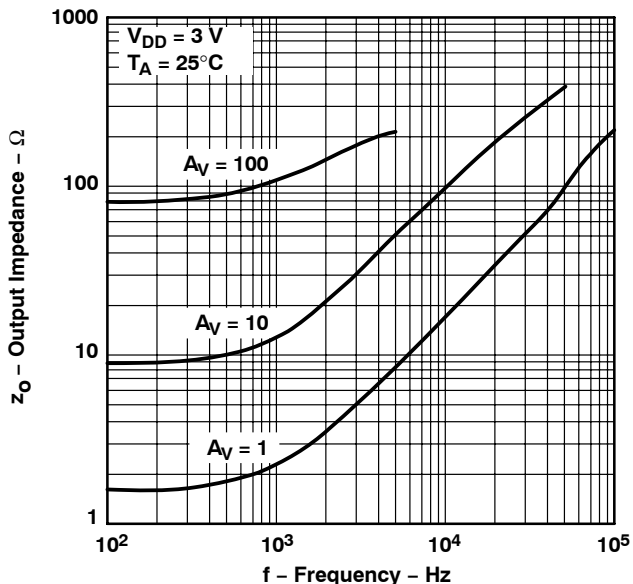


**TLV2432-Q1, TLV2432A-Q1, TLV2434-Q1, TLV2434A-Q1**  
**Advanced LinCMOS™ RAIL-TO-RAIL OUTPUT**  
**WIDE-INPUT-VOLTAGE OPERATIONAL AMPLIFIERS**

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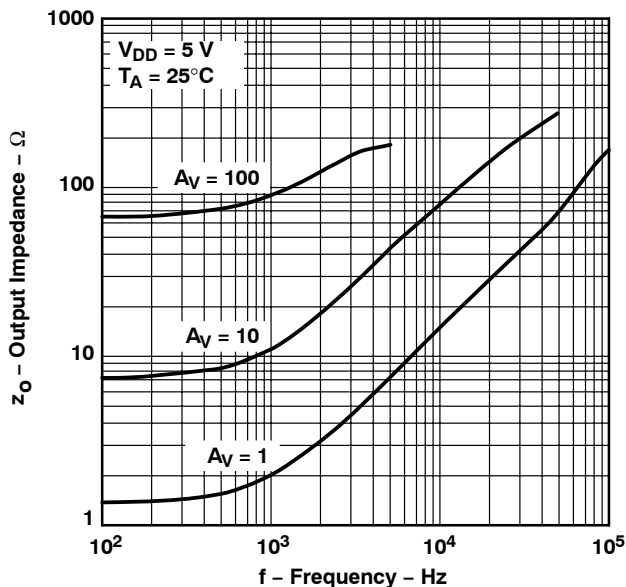
**TYPICAL CHARACTERISTICS**

**OUTPUT IMPEDANCE  
vs  
FREQUENCY**



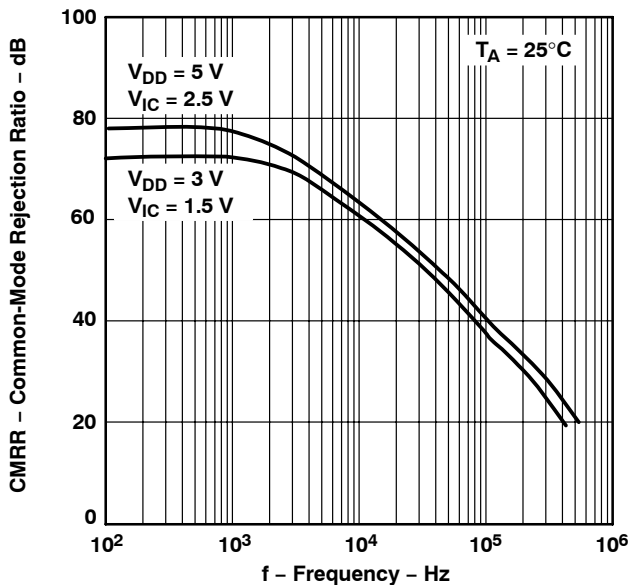
**Figure 23**

**OUTPUT IMPEDANCE  
vs  
FREQUENCY**



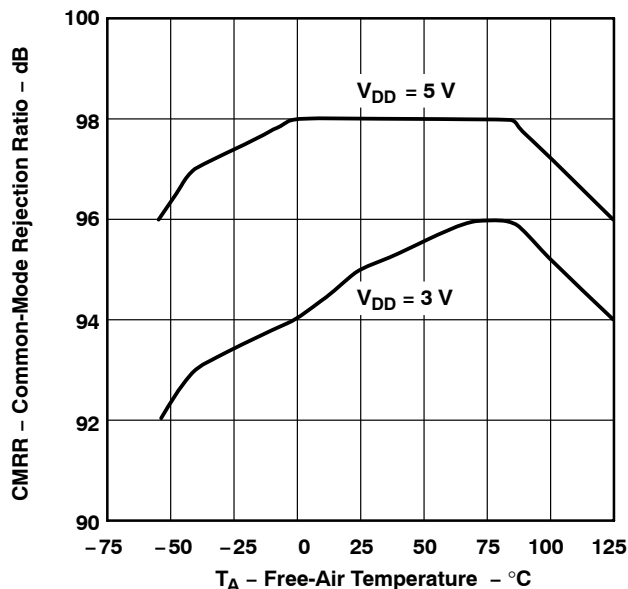
**Figure 24**

**COMMON-MODE REJECTION RATIO  
vs  
FREQUENCY**



**Figure 25**

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



**Figure 26**





TYPICAL CHARACTERISTICS

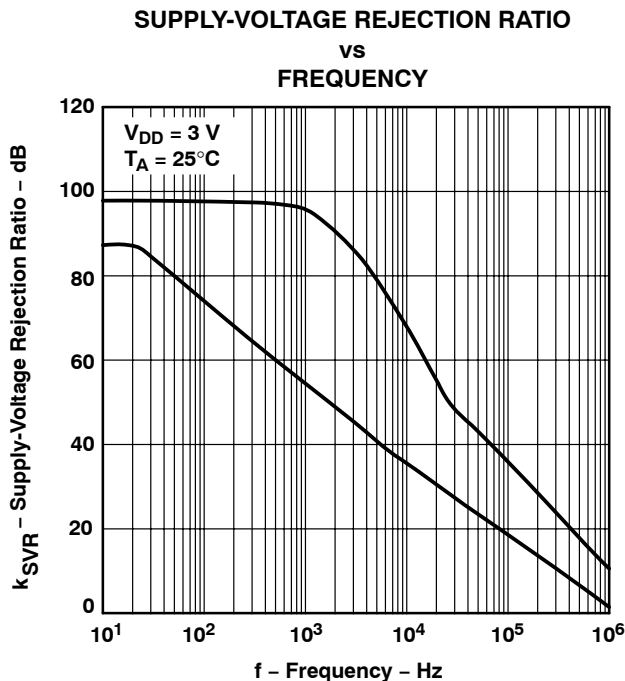


Figure 27

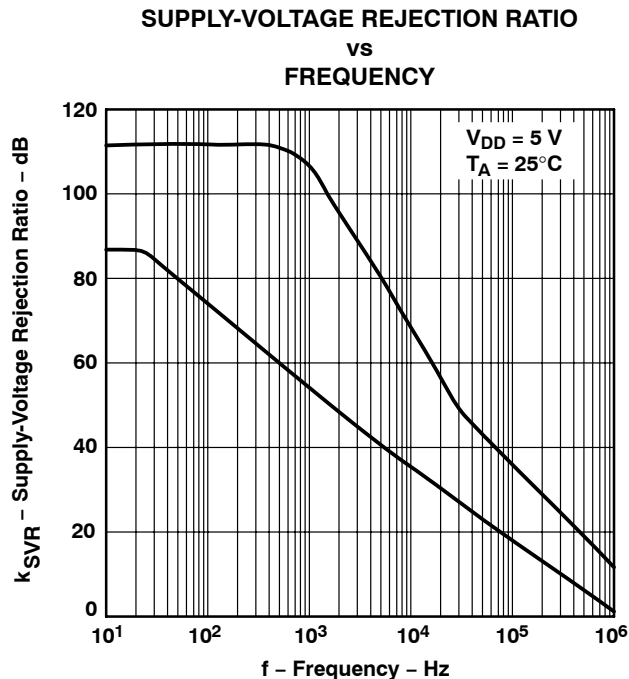


Figure 28

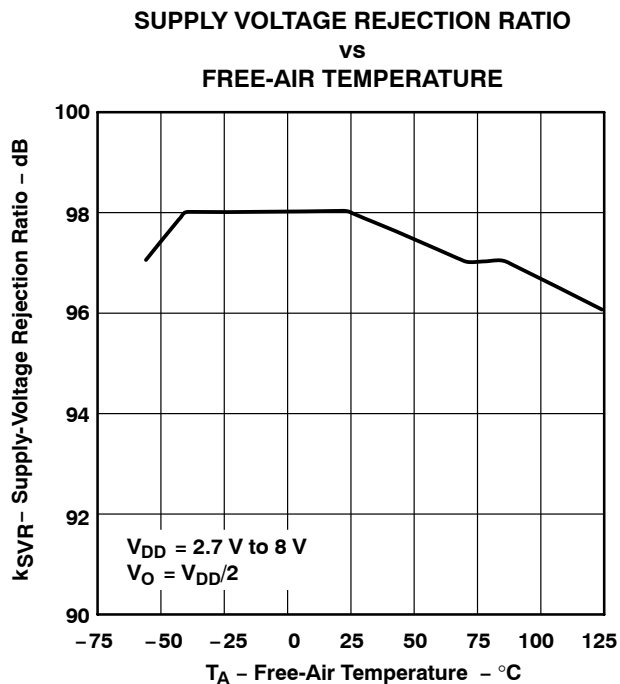


Figure 29

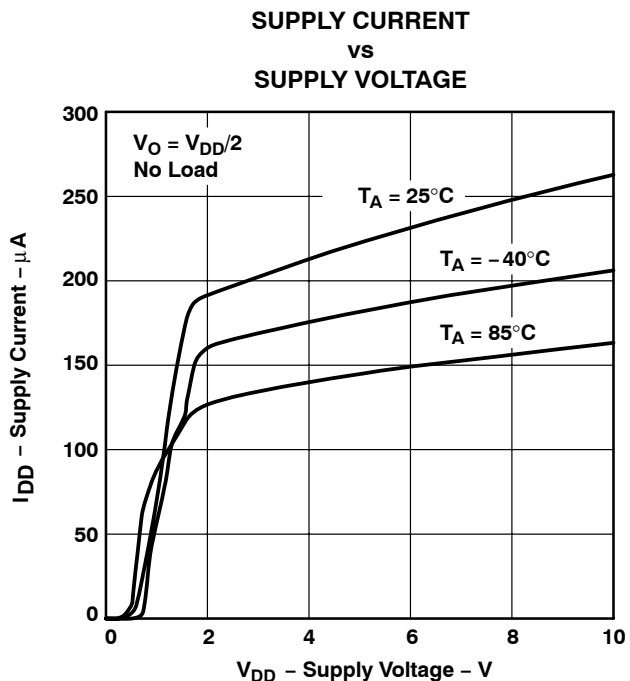
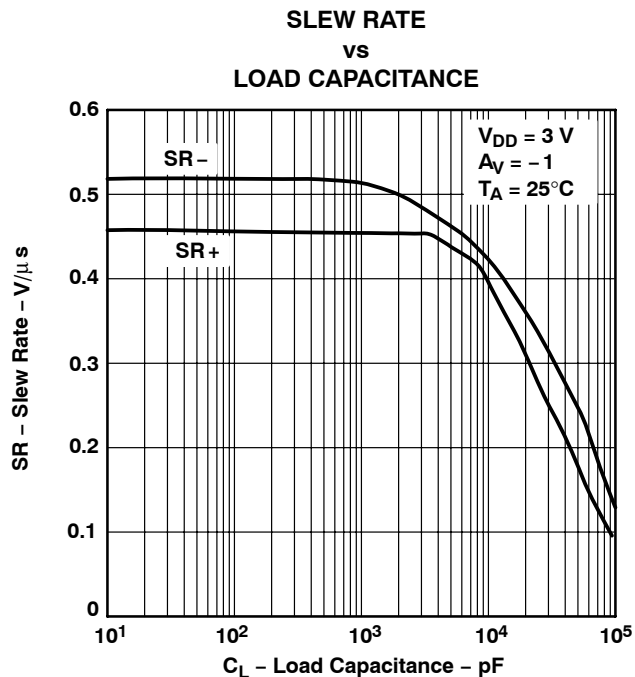


Figure 30

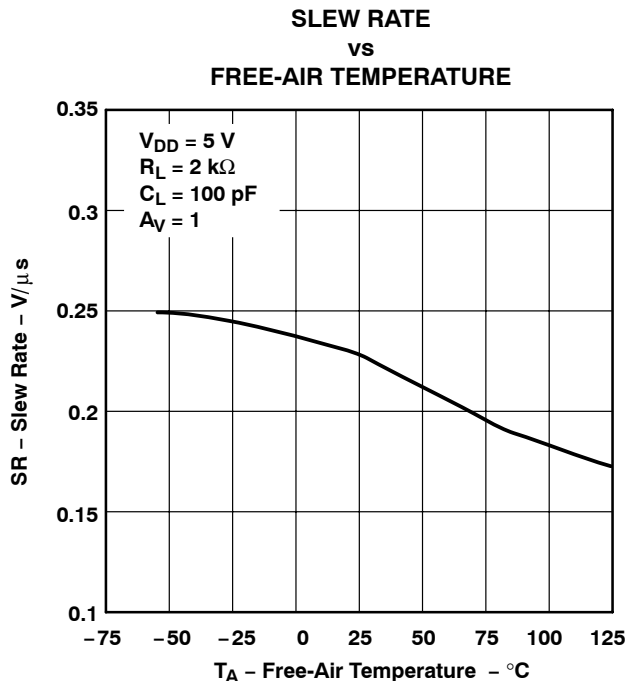
**TLV2432-Q1, TLV2432A-Q1, TLV2434-Q1, TLV2434A-Q1**  
**Advanced LinCMOS™ RAIL-TO-RAIL OUTPUT**  
**WIDE-INPUT-VOLTAGE OPERATIONAL AMPLIFIERS**

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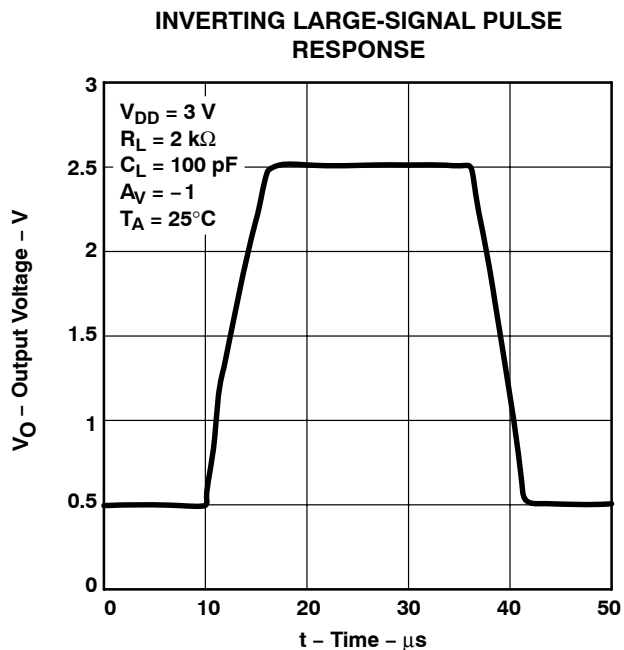
**TYPICAL CHARACTERISTICS**



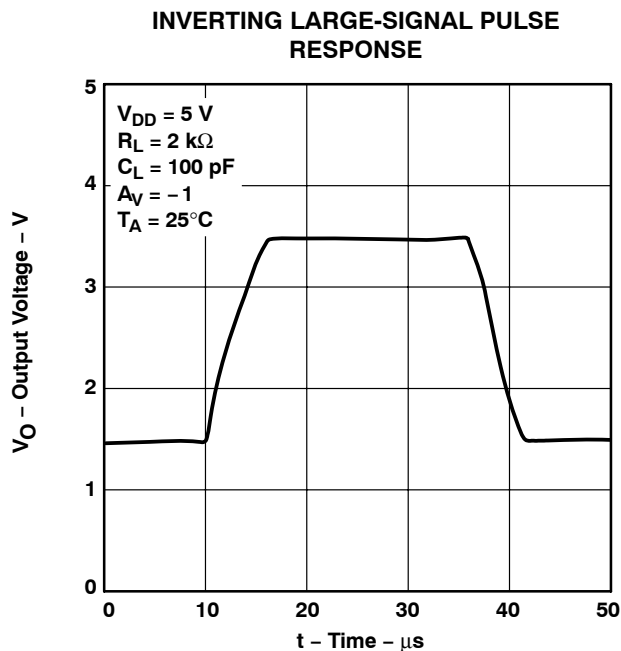
**Figure 31**



**Figure 32**



**Figure 33**



**Figure 34**



TYPICAL CHARACTERISTICS

VOLTAGE-FOLLOWER LARGE-SIGNAL PULSE RESPONSE

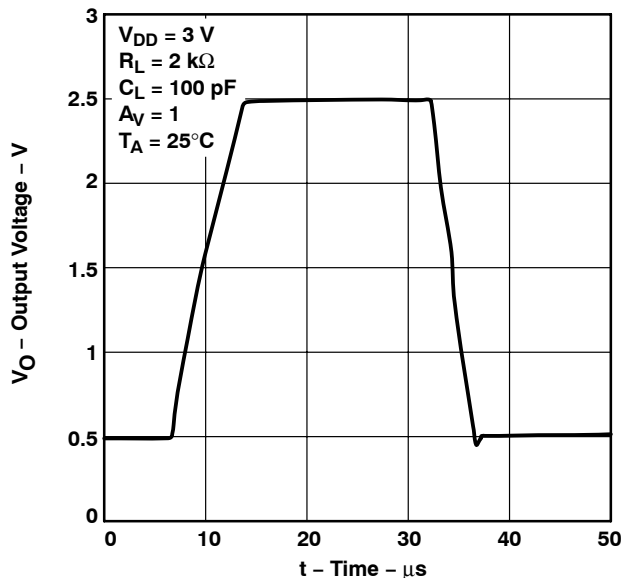


Figure 35

VOLTAGE-FOLLOWER LARGE-SIGNAL PULSE RESPONSE

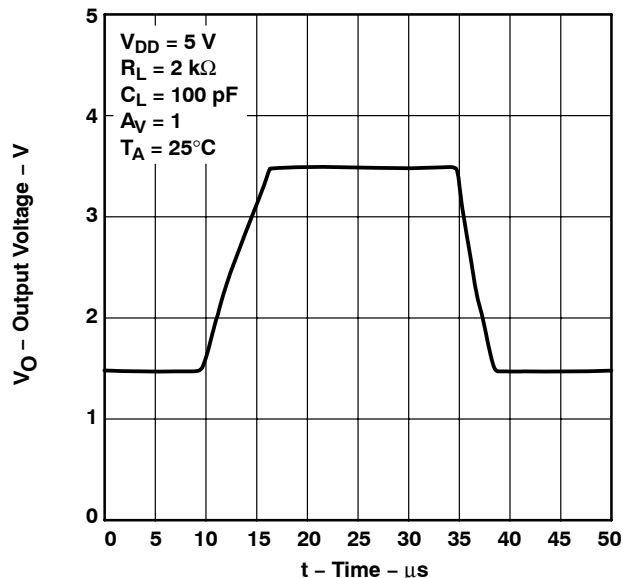


Figure 36

INVERTING SMALL-SIGNAL PULSE RESPONSE

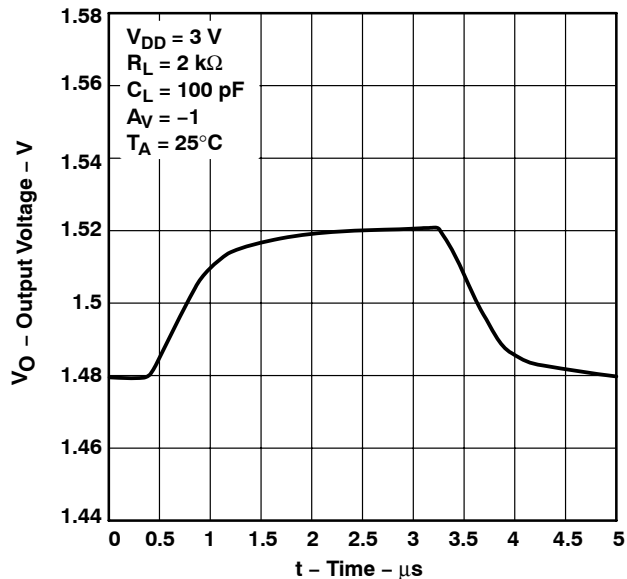


Figure 37

INVERTING SMALL-SIGNAL PULSE RESPONSE

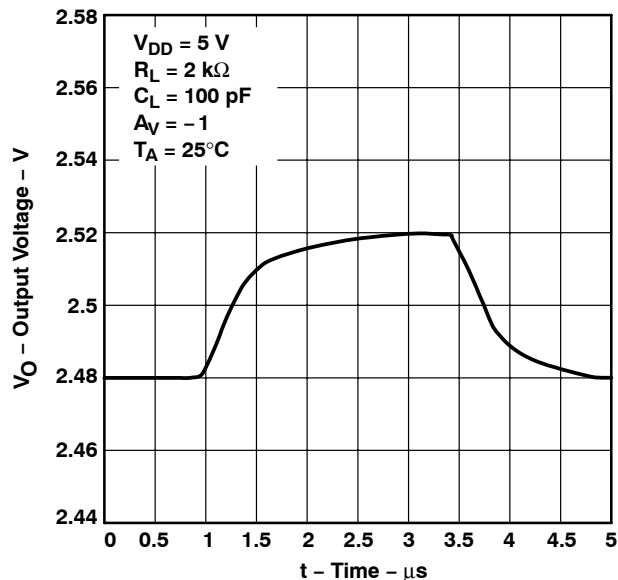


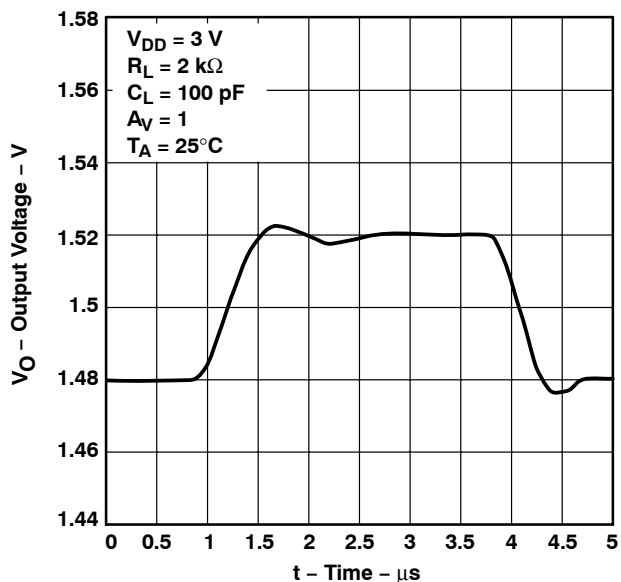
Figure 38

**TLV2432-Q1, TLV2432A-Q1, TLV2434-Q1, TLV2434A-Q1**  
**Advanced LinCMOS™ RAIL-TO-RAIL OUTPUT**  
**WIDE-INPUT-VOLTAGE OPERATIONAL AMPLIFIERS**

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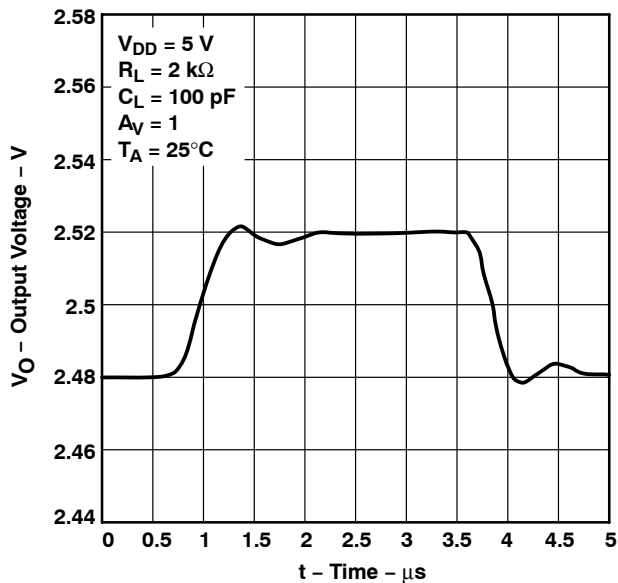
**TYPICAL CHARACTERISTICS**

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



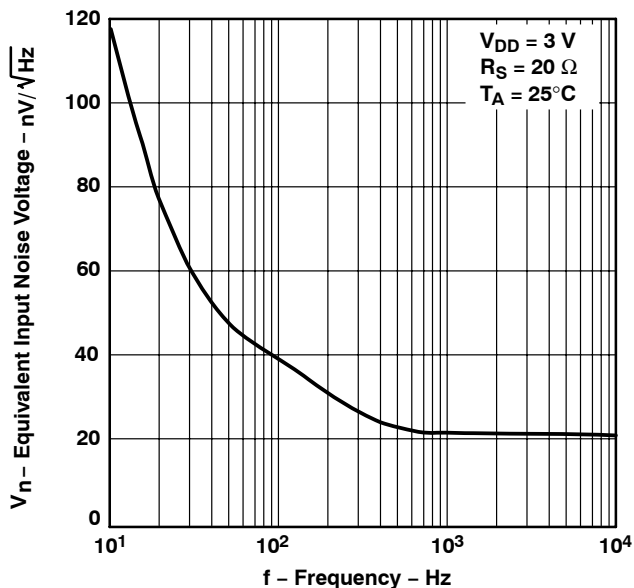
**Figure 39**

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



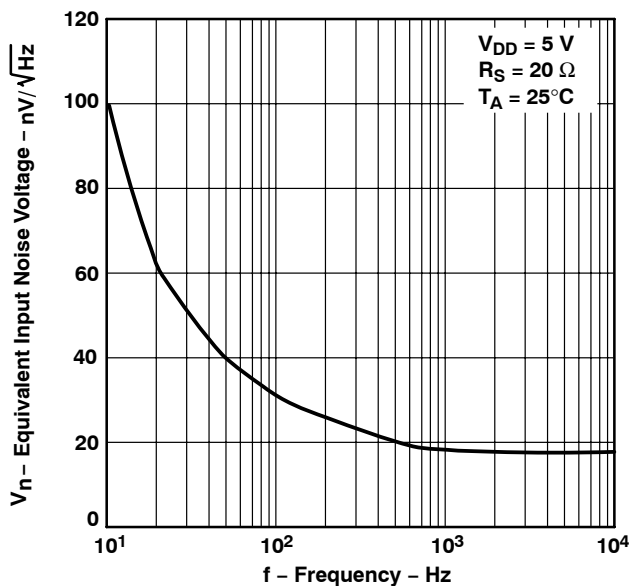
**Figure 40**

**EQUIVALENT INPUT NOISE VOLTAGE VS FREQUENCY**



**Figure 41**

**EQUIVALENT INPUT NOISE VOLTAGE VS FREQUENCY**



**Figure 42**



TLV2432-Q1, TLV2432A-Q1, TLV2434-Q1, TLV2434A-Q1  
 Advanced LinCMOS™ RAIL-TO-RAIL OUTPUT  
 WIDE-INPUT-VOLTAGE OPERATIONAL AMPLIFIERS

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TYPICAL CHARACTERISTICS

NOISE VOLTAGE OVER A 10-SECOND PERIOD

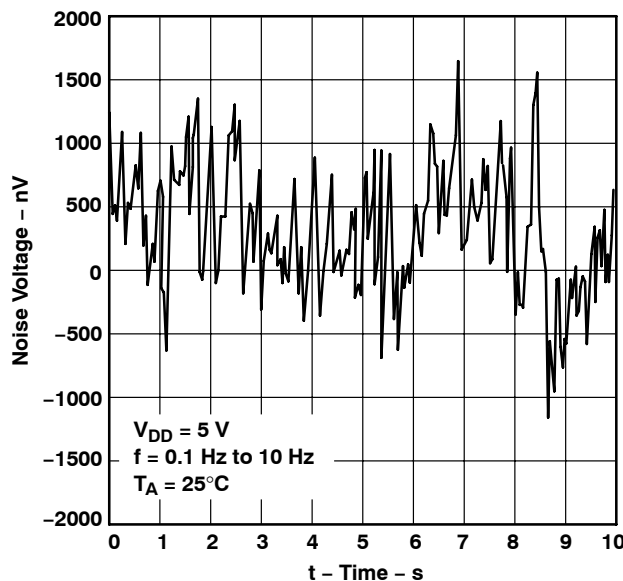


Figure 43

TOTAL HARMONIC DISTORTION PLUS NOISE  
 vs  
 FREQUENCY

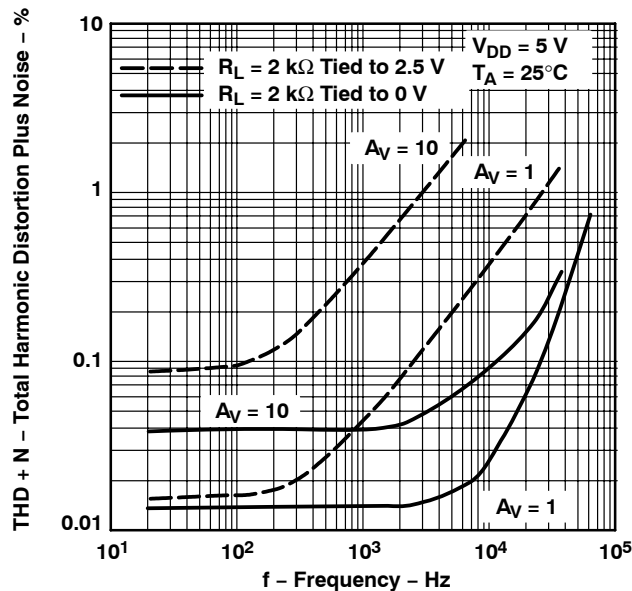


Figure 44

TOTAL HARMONIC DISTORTION PLUS NOISE  
 vs  
 FREQUENCY

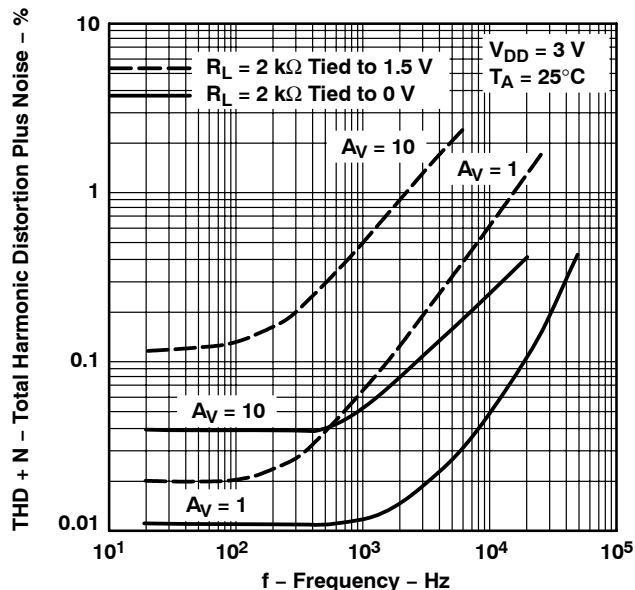
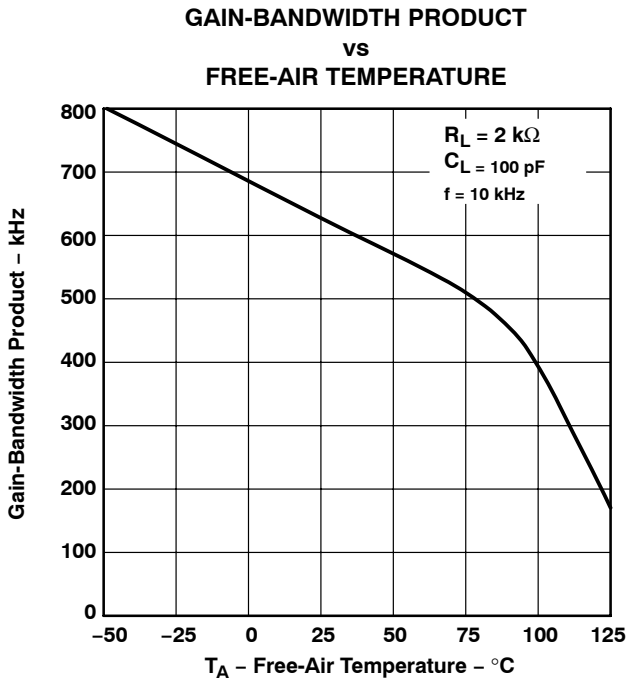
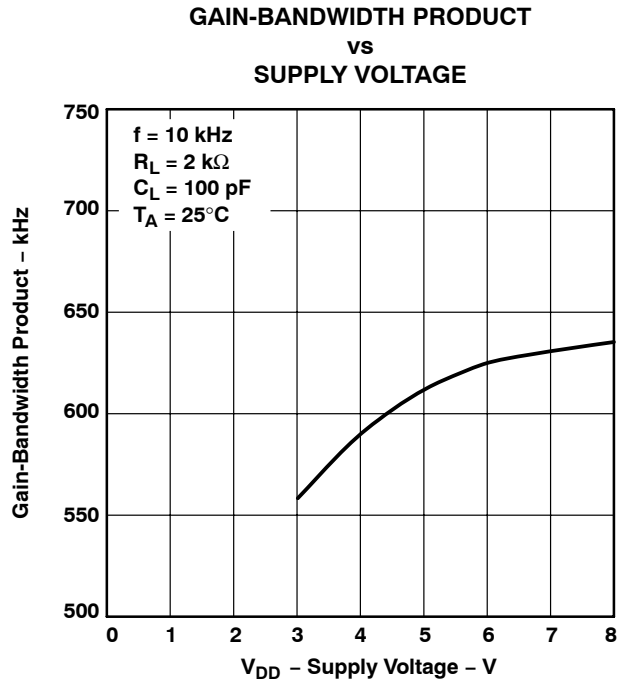


Figure 45

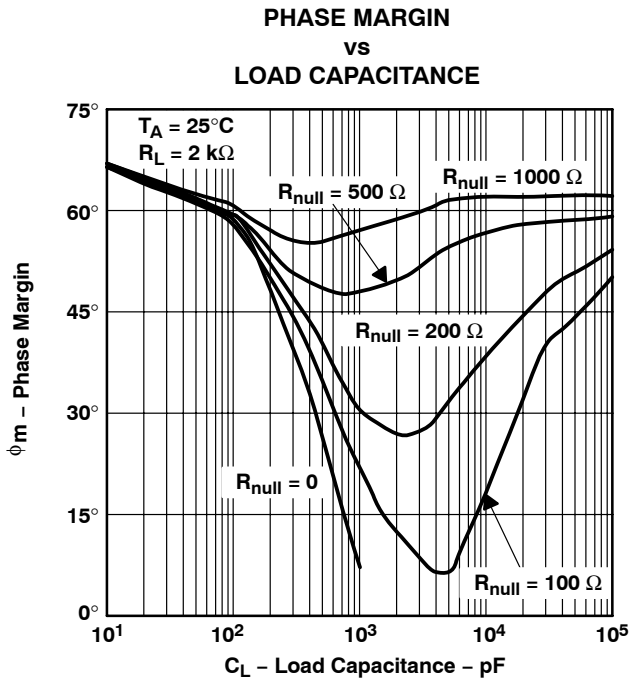
**TYPICAL CHARACTERISTICS**



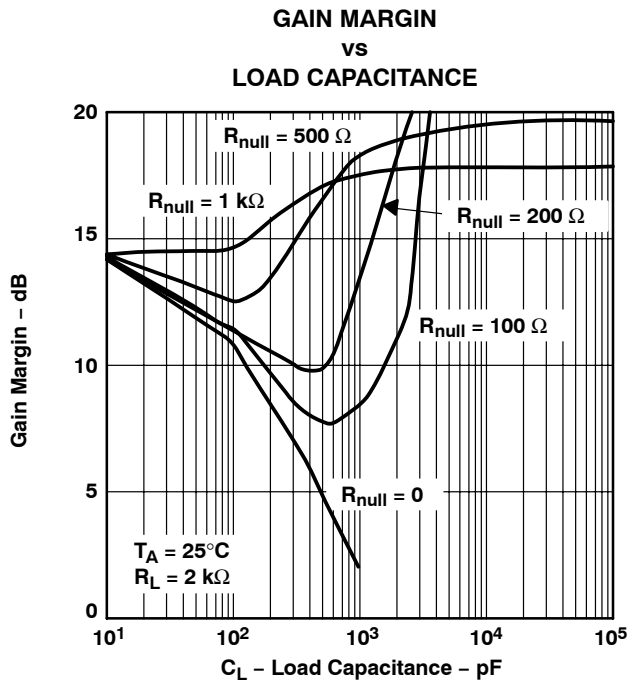
**Figure 46**



**Figure 47**



**Figure 48**



**Figure 49**

TLV2432-Q1, TLV2432A-Q1, TLV2434-Q1, TLV2434A-Q1  
Advanced LinCMOS™ RAIL-TO-RAIL OUTPUT  
WIDE-INPUT-VOLTAGE OPERATIONAL AMPLIFIERS

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TYPICAL CHARACTERISTICS

UNITY-GAIN BANDWIDTH  
vs  
LOAD CAPACITANCE

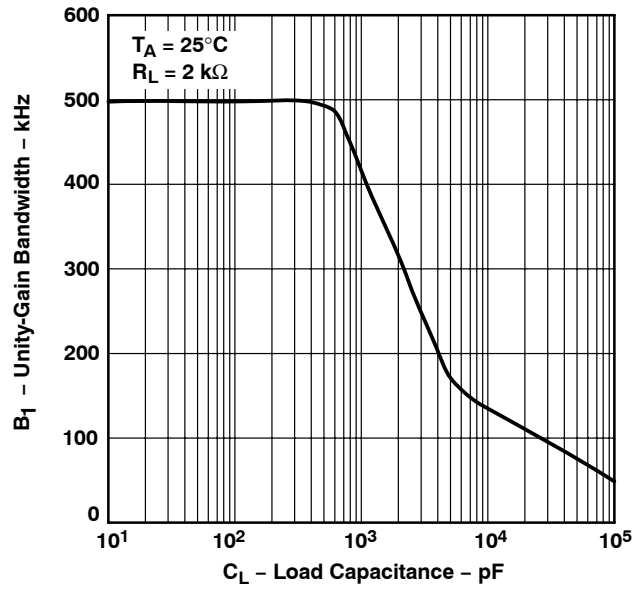


Figure 50

# TLV2432-Q1, TLV2432A-Q1, TLV2434-Q1, TLV2434A-Q1

## 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).

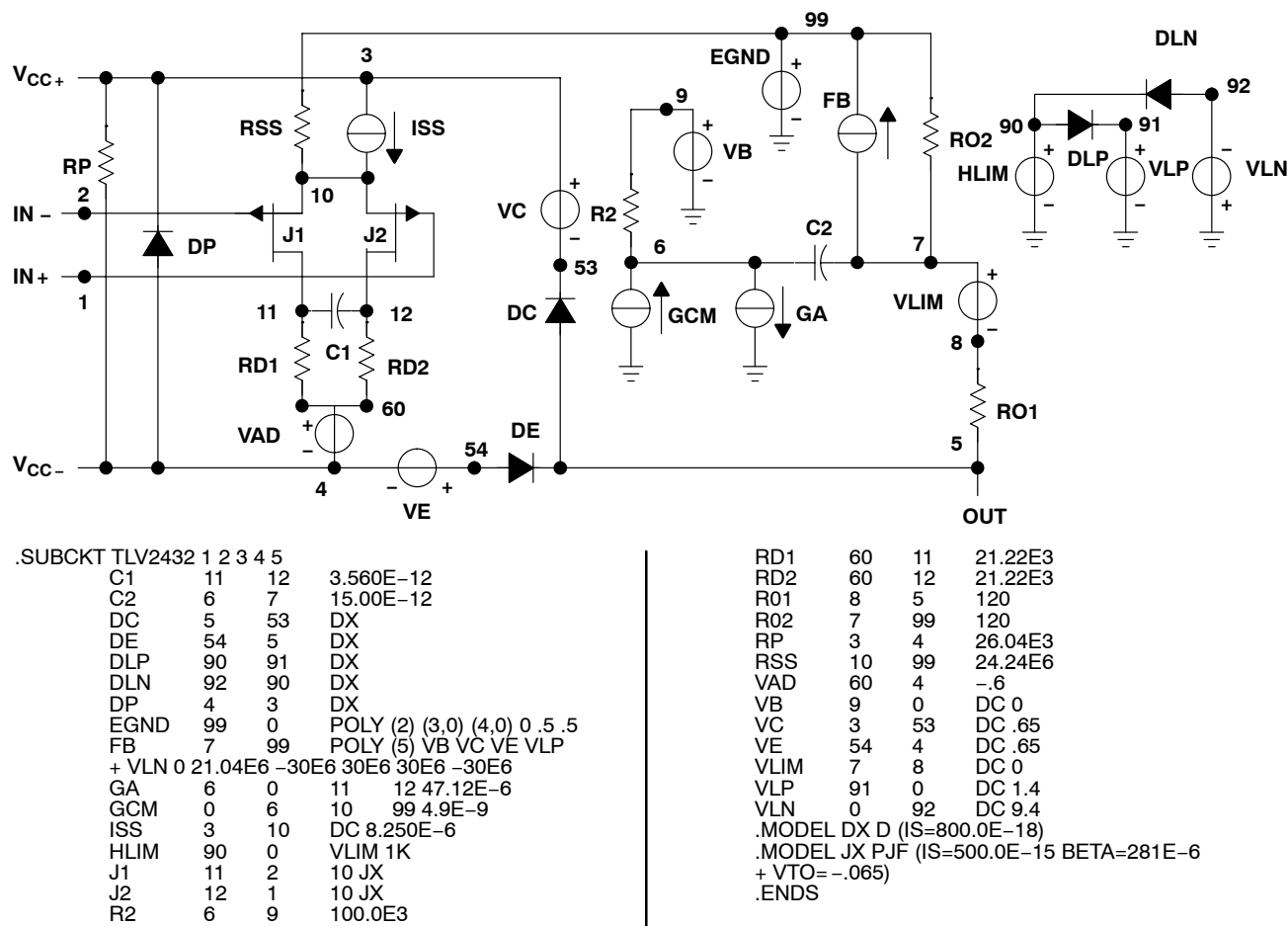


Figure 51. Boyle Macromodel and Subcircuit

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POST OFFICE BOX 655303 • DALLAS, TEXAS 75265



**PACKAGING INFORMATION**

Orderable Device	Status (1)	Package Type	Package Drawing	Pins	Package Qty	Eco Plan (2)	Lead finish/ Ball material (6)	MSL Peak Temp (3)	Op Temp (°C)	Device Marking (4/5)	Samples
TLV2432AQDRQ1	ACTIVE	SOIC	D	8	2500	RoHS & Green	NIPDAU	Level-1-260C-UNLIM	-40 to 125	2432AQ	<a href="#">Samples</a>
TLV2432QDRG4Q1	ACTIVE	SOIC	D	8	2500	RoHS & Green	NIPDAU	Level-1-260C-UNLIM	-40 to 125	2432Q1	<a href="#">Samples</a>
TLV2434AQDRQ1	ACTIVE	SOIC	D	14	2500	RoHS & Green	NIPDAU	Level-1-260C-UNLIM	-40 to 125	2434AQ	<a href="#">Samples</a>
TLV2434AQPWRQ1	ACTIVE	TSSOP	PW	14	2000	RoHS & Green	NIPDAU	Level-3-260C-168 HR	-40 to 125	2434AQ	<a href="#">Samples</a>

(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) **RoHS:** TI defines "RoHS" to mean semiconductor products that are compliant with the current EU RoHS requirements for all 10 RoHS substances, including the requirement that RoHS substance do not exceed 0.1% by weight in homogeneous materials. Where designed to be soldered at high temperatures, "RoHS" products are suitable for use in specified lead-free processes. TI may reference these types of products as "Pb-Free".

**RoHS Exempt:** TI defines "RoHS Exempt" to mean products that contain lead but are compliant with EU RoHS pursuant to a specific EU RoHS exemption.

**Green:** TI defines "Green" to mean the content of Chlorine (Cl) and Bromine (Br) based flame retardants meet JS709B low halogen requirements of <=1000ppm threshold. Antimony trioxide based flame retardants must also meet the <=1000ppm threshold requirement.

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

(4) There may be additional marking, which relates to the logo, the lot trace code information, or the environmental category on the device.

(5) Multiple Device Markings will be inside parentheses. Only one Device Marking contained in parentheses and separated by a "-" will appear on a device. If a line is indented then it is a continuation of the previous line and the two combined represent the entire Device Marking for that device.

(6) Lead finish/Ball material - Orderable Devices may have multiple material finish options. Finish options are separated by a vertical ruled line. Lead finish/Ball material values may wrap to two lines if the finish value exceeds the maximum column width.

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continues to take reasonable steps to provide representative and accurate information but may not have conducted destructive testing or chemical analysis on incoming materials and chemicals. TI and TI suppliers consider certain information to be proprietary, and thus CAS numbers and other limited information may not be available for release.

In no event shall TI's liability arising out of such information exceed the total purchase price of the TI part(s) at issue in this document sold by TI to Customer on an annual basis.

**OTHER QUALIFIED VERSIONS OF TLV2432-Q1, TLV2432A-Q1, TLV2434A-Q1 :**

- Catalog : [TLV2432](#), [TLV2432A](#), [TLV2434A](#)

NOTE: Qualified Version Definitions:

- Catalog - TI's standard catalog product

**TAPE AND REEL INFORMATION**

**QUADRANT ASSIGNMENTS FOR PIN 1 ORIENTATION IN TAPE**


\*All dimensions are nominal

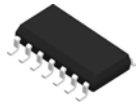
Device	Package Type	Package Drawing	Pins	SPQ	Reel Diameter (mm)	Reel Width W1 (mm)	A0 (mm)	B0 (mm)	K0 (mm)	P1 (mm)	W (mm)	Pin1 Quadrant
TLV2434AQPWRQ1	TSSOP	PW	14	2000	330.0	12.4	6.9	5.6	1.6	8.0	12.0	Q1

**TAPE AND REEL BOX DIMENSIONS**


\*All dimensions are nominal

Device	Package Type	Package Drawing	Pins	SPQ	Length (mm)	Width (mm)	Height (mm)
TLV2434AQPWRQ1	TSSOP	PW	14	2000	356.0	356.0	35.0

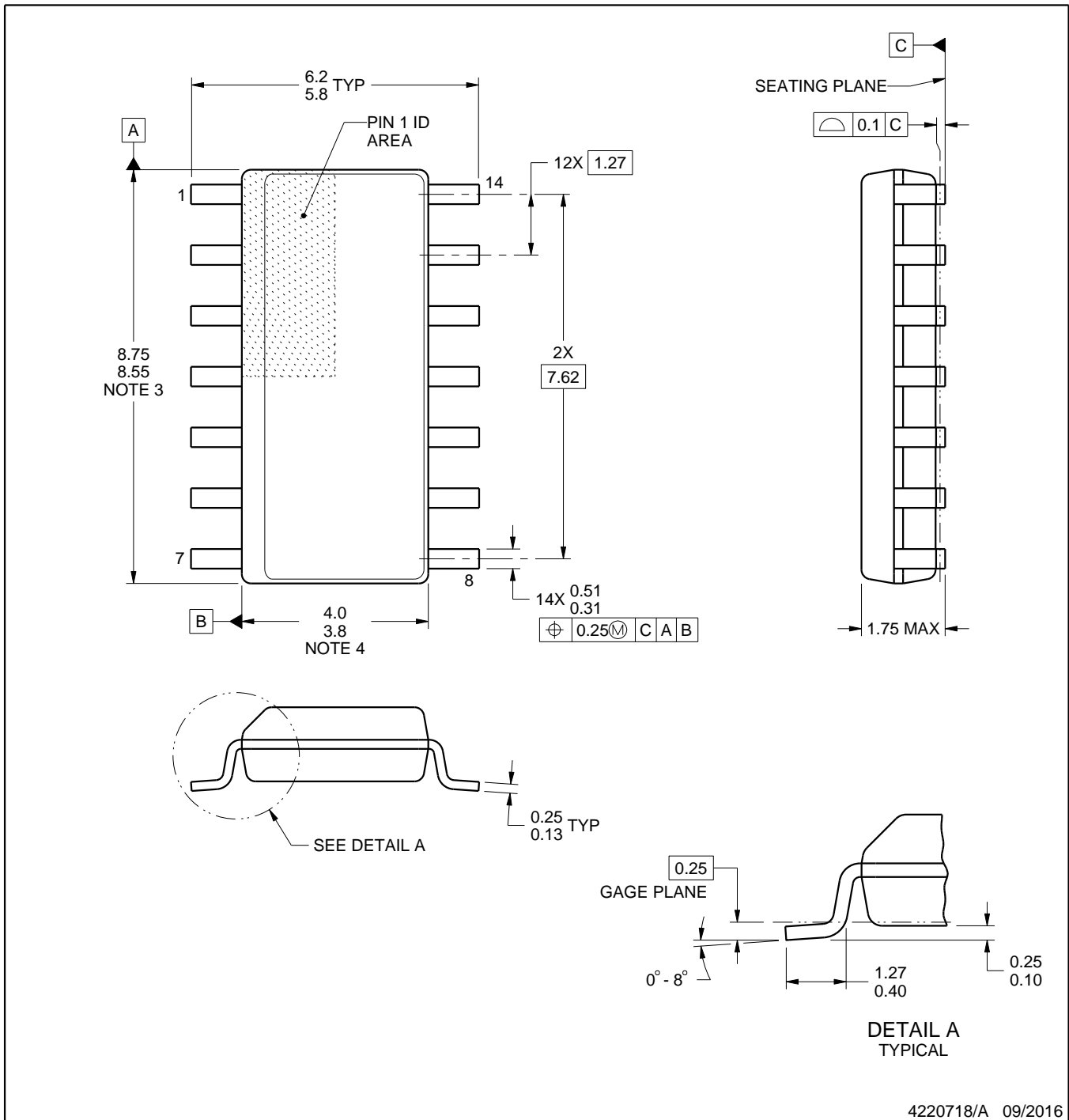
D0014A



# PACKAGE OUTLINE

## SOIC - 1.75 mm max height

SMALL OUTLINE INTEGRATED CIRCUIT



4220718/A 09/2016

NOTES:

- All linear dimensions are in millimeters. Dimensions in parenthesis are for reference only. Dimensioning and tolerancing per ASME Y14.5M.
- This drawing is subject to change without notice.
- This dimension does not include mold flash, protrusions, or gate burrs. Mold flash, protrusions, or gate burrs shall not exceed 0.15 mm, per side.
- This dimension does not include interlead flash. Interlead flash shall not exceed 0.43 mm, per side.
- Reference JEDEC registration MS-012, variation AB.

# EXAMPLE BOARD LAYOUT

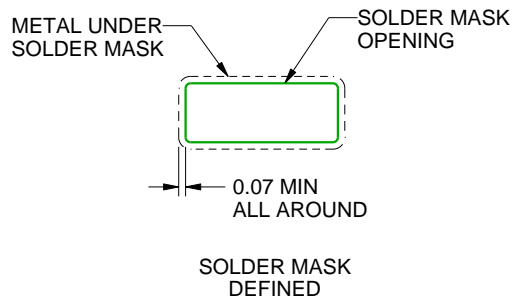
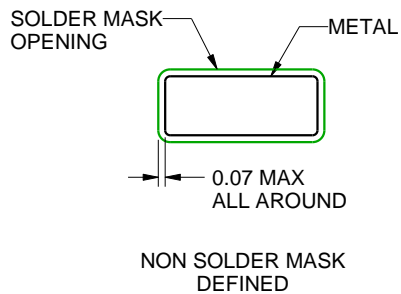
D0014A

SOIC - 1.75 mm max height

SMALL OUTLINE INTEGRATED CIRCUIT



LAND PATTERN EXAMPLE  
SCALE:8X



SOLDER MASK DETAILS

4220718/A 09/2016

NOTES: (continued)

6. Publication IPC-7351 may have alternate designs.
7. Solder mask tolerances between and around signal pads can vary based on board fabrication site.

# EXAMPLE STENCIL DESIGN

D0014A

SOIC - 1.75 mm max height

SMALL OUTLINE INTEGRATED CIRCUIT



SOLDER PASTE EXAMPLE  
BASED ON 0.125 mm THICK STENCIL  
SCALE:8X

4220718/A 09/2016

NOTES: (continued)

8. Laser cutting apertures with trapezoidal walls and rounded corners may offer better paste release. IPC-7525 may have alternate design recommendations.
9. Board assembly site may have different recommendations for stencil design.



D0008A

# PACKAGE OUTLINE

SOIC - 1.75 mm max height

SMALL OUTLINE INTEGRATED CIRCUIT



4214825/C 02/2019

NOTES:

1. Linear dimensions are in inches [millimeters]. Dimensions in parenthesis are for reference only. Controlling dimensions are in inches. Dimensioning and tolerancing per ASME Y14.5M.
2. This drawing is subject to change without notice.
3. This dimension does not include mold flash, protrusions, or gate burrs. Mold flash, protrusions, or gate burrs shall not exceed .006 [0.15] per side.
4. This dimension does not include interlead flash.
5. Reference JEDEC registration MS-012, variation AA.



# EXAMPLE BOARD LAYOUT

D0008A

SOIC - 1.75 mm max height

SMALL OUTLINE INTEGRATED CIRCUIT



LAND PATTERN EXAMPLE  
EXPOSED METAL SHOWN  
SCALE:8X



SOLDER MASK DETAILS

4214825/C 02/2019

NOTES: (continued)

6. Publication IPC-7351 may have alternate designs.

7. Solder mask tolerances between and around signal pads can vary based on board fabrication site.

# EXAMPLE STENCIL DESIGN

D0008A

SOIC - 1.75 mm max height

SMALL OUTLINE INTEGRATED CIRCUIT



SOLDER PASTE EXAMPLE  
BASED ON .005 INCH [0.125 MM] THICK STENCIL  
SCALE:8X

4214825/C 02/2019

NOTES: (continued)

8. Laser cutting apertures with trapezoidal walls and rounded corners may offer better paste release. IPC-7525 may have alternate design recommendations.
9. Board assembly site may have different recommendations for stencil design.

PW0014A



# PACKAGE OUTLINE

## TSSOP - 1.2 mm max height

SMALL OUTLINE PACKAGE



NOTES:

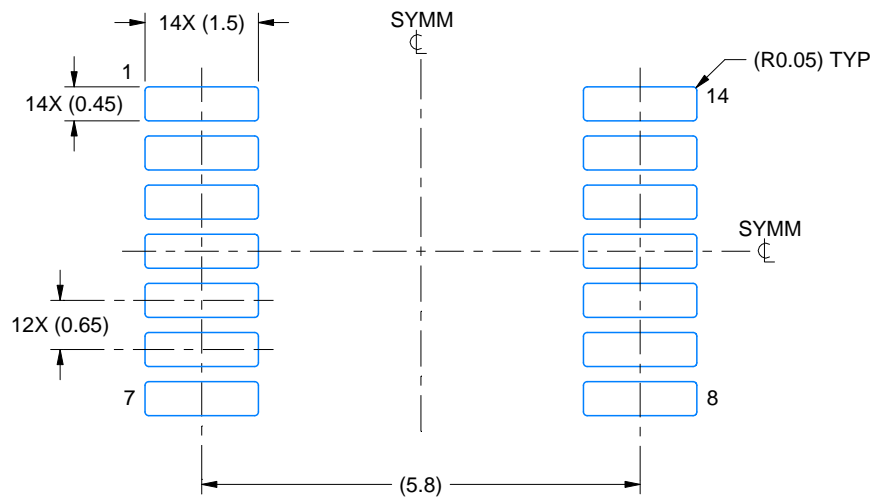
1. All linear dimensions are in millimeters. Any dimensions in parenthesis are for reference only. Dimensioning and tolerancing per ASME Y14.5M.
2. This drawing is subject to change without notice.
3. This dimension does not include mold flash, protrusions, or gate burrs. Mold flash, protrusions, or gate burrs shall not exceed 0.15 mm per side.
4. This dimension does not include interlead flash. Interlead flash shall not exceed 0.25 mm per side.
5. Reference JEDEC registration MO-153.

# EXAMPLE BOARD LAYOUT

PW0014A

TSSOP - 1.2 mm max height

SMALL OUTLINE PACKAGE



LAND PATTERN EXAMPLE  
EXPOSED METAL SHOWN  
SCALE: 10X



4220202/B 12/2023

NOTES: (continued)

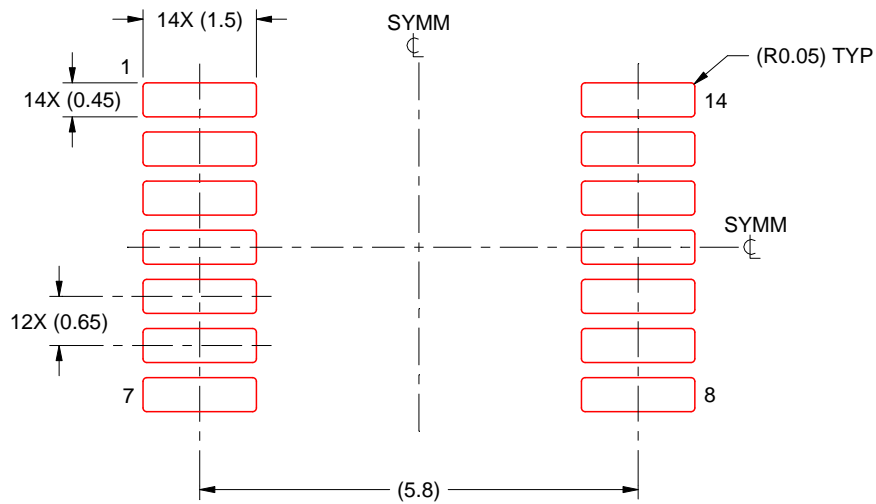
- 6. Publication IPC-7351 may have alternate designs.
- 7. Solder mask tolerances between and around signal pads can vary based on board fabrication site.

# EXAMPLE STENCIL DESIGN

PW0014A

TSSOP - 1.2 mm max height

SMALL OUTLINE PACKAGE



SOLDER PASTE EXAMPLE  
BASED ON 0.125 mm THICK STENCIL  
SCALE: 10X

4220202/B 12/2023

NOTES: (continued)

8. Laser cutting apertures with trapezoidal walls and rounded corners may offer better paste release. IPC-7525 may have alternate design recommendations.
9. Board assembly site may have different recommendations for stencil design.

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