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

FEATURES

- **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 4.25 V (Min) at 5-V Single Supply**
- **No Phase Inversion**
- **Low Noise: 16 nV/√Hz Typ at f = 1 kHz**
- **Low Input Offset Voltage: 950 µV Max at T_A = 25°C (TLV244xA)**
- **Low Input Bias Current: 1 pA (Typ)**
- **600-Ω Output Drive**
- **High-Gain Bandwidth: 1.8 MHz (Typ)**
- **Low Supply Current: 750 µA Per Channel (Typ)**
- **Macromodel Included**

DESCRIPTION

The TLV244x and TLV244xA are low-voltage operational amplifiers from Texas Instruments. The common-mode input voltage range of these devices has been extended over typical standard 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. Both devices offer comparable ac performance while having lower noise, input offset voltage, and power dissipation than existing CMOS operational amplifiers. The TLV244x has increased output drive over previous rail-to-rail operational amplifiers and can drive 600-Ω loads for telecommunications applications.

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

HIGH-LEVEL OUTPUT VOLTAGE
vs
HIGH-LEVEL OUTPUT CURRENT

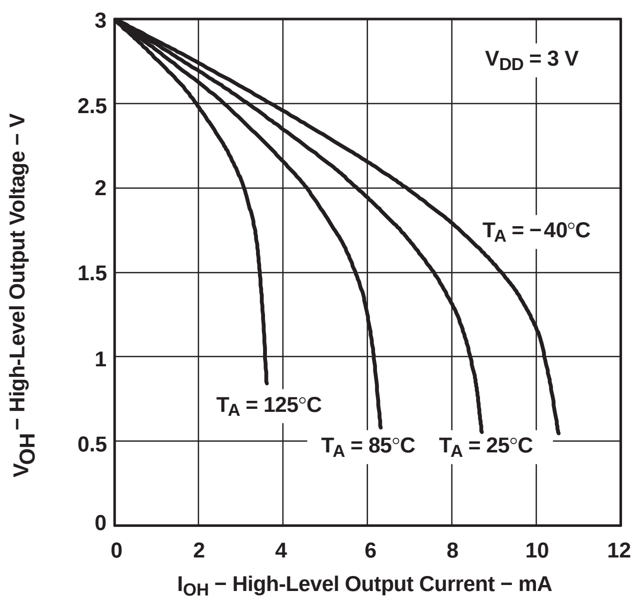


Figure 1.

The TLV244x, 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 TLV244xA is available with a maximum input offset voltage of 950 µV.

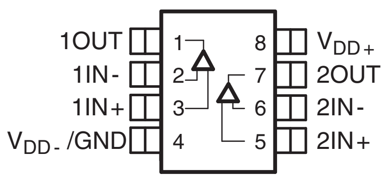
If the design requires single operational amplifiers, see the TI TLV2211/21/31. This is a family of rail-to-rail output operational amplifiers in the SOT-23 package. Their small size and low power consumption make them ideal for high-density battery-powered equipment.

ORDERING INFORMATION(1)

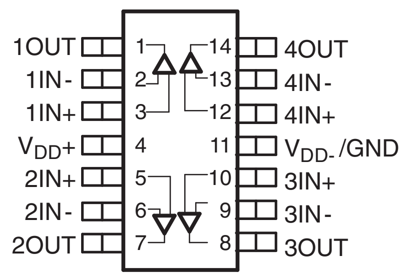
T_A	V_{IO}max AT 25 = C	PACKAGE(2)			ORDERABLE PART NUMBER	TOP-SIDE MARKING
–40°C to 125°C	950 μV	Dual	SOIC – D	Reel of 2500	TLV2442AQDRQ1	2442AQ
			TSSOP – PW	Reel of 2000	TLV2442AQPWRQ1	2442AQ
	2.5 mV	Dual	MSOP – DGK	Reel of 2500	TLV2442QDGKRQ1	OBR
			SOIC – D	Reel of 2500	TLV2442QDRQ1	2442Q1
			TSSOP – PW	Reel of 2000	TLV2442QPWRQ1	2442Q1
	950 μV	Quad	TSSOP – PW	Reel of 2000	TLV2444AQPWRQ1	2444AQ

(1) 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 www.ti.com.
(2) Package drawings, thermal data, and symbolization are available at www.ti.com/packaging.

TLV2442
D, DGK, OR PW PACKAGE
(TOP VIEW)

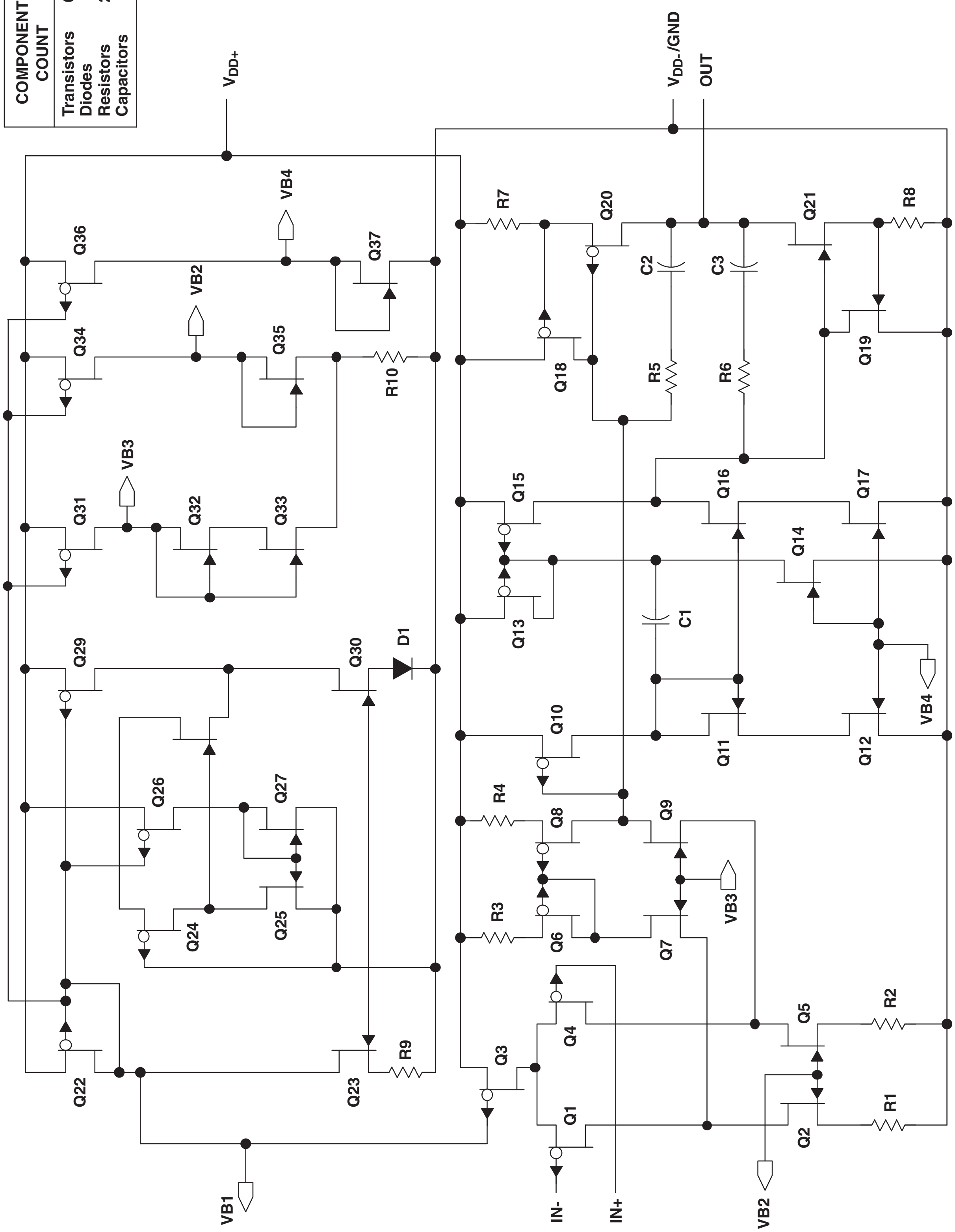


TLV2444
PW PACKAGE
(TOP VIEW)



EQUIVALENT SCHEMATIC (EACH AMPLIFIER)

COMPONENT COUNT	
Transistors	69
Diodes	5
Resistors	26
Capacitors	6



ABSOLUTE MAXIMUM RATINGS[1]

over operating free-air temperature range (unless otherwise noted)

V_{DD}	Supply voltage[2]	12 V
V_{ID}	Differential input voltage[3]	$\pm V_{DD}$
V_I	Input voltage (any input)[2]	–0.3 V to V_{DD}
I_I	Input current (any input)	±5 mA
I_O	Output current	±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[4]	Unlimited
	Continuous total dissipation	See Dissipation Rating Table
T_A	Operating free-air temperature range	–40°C to 125°C
T_{stg}	Storage temperature range	–65°C to 150°C
	Lead temperature 1,6 mm (1/16 inch) from case for 10 seconds	260°C

(1) 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.
(2) All voltage values, except differential voltages, are with respect to the midpoint between V_{DD+} and V_{DD-}.
(3) Differential voltages are at IN+ with respect to IN–. Excessive current will flow if input is brought below V_{DD-} – 0.3 V.
(4) 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 RATINGS

PACKAGE	$T_A \leq 25°C$ POWER RATING	DERATING FACTOR ABOVE T_A = 25°C	T_A = 70°C POWER RATING	T_A = 85°C POWER RATING	T_A = 125°C POWER RATING
D (8 pin)	725 mW	5.8 mW/°C	464 mW	377 mW	145 mW
DGK (8 pin)	606 mW	4.847 mW/°C	388 mW	315 mW	121 mW
PW (8 pin)	525 mW	4.2 mW/°C	336 mW	273 mW	105 mW
PW (14 pin)	720 mW	5.6 mW/°C	634 mW	547 mW	317 mW

RECOMMENDED OPERATING CONDITIONS

		MIN	MAX	UNIT
V_{DD}	Supply voltage	2.7	10	V
V_I	Input voltage	V_{DD-}	V_{DD+} – 1	V
V_{IC}	Common-mode input voltage	V_{DD-}	V_{DD+} – 1	V
T_A	Operating free-air temperature	–40	125	°C

ELECTRICAL CHARACTERISTICS

V_{DD} = 3 V, at specified free-air temperature (unless otherwise noted)

PARAMETER		TEST CONDITIONS		T_A (1)	MIN	TYP	MAX	UNIT
V_{IO}	Input offset voltage	V_{IC} = 1.5 V, V_O = 1.5 V, R_S = 50 Ω	TLV244x	25°C		300	2000	µV
				Full range			2500	
			TLV244xA	25°C		300	950	
				Full range			1600	
α_{VIO}	Temperature coefficient of input offset voltage	V_{IC} = 1.5 V, V_O = 1.5 V, R_S = 50 Ω		25°C to 85°C		2		µV/°C
	Input offset voltage long-term drift(2)	V_{IC} = 1.5 V, V_O = 1.5 V, R_S = 50 Ω		25°C		0.002		µV/mo
I_{IO}	Input offset current	V_{IC} = 1.5 V, V_O = 1.5 V, R_S = 50 Ω		25°C		0.5		pA
				Full range			150	
I_{IB}	Input bias current	V_{IC} = 1.5 V, V_O = 1.5 V, R_S = 50 Ω		25°C		1		pA
				Full range			260	
V_{ICR}	Common-mode input voltage range	$\|V_{IO}\|$ ≤ 8 mV, R_S = 50 Ω		25°C	0 to 2.25	–0.25 to 2.5		V
				Full range	0.2 to 2			
V_{OH}	High-level output voltage	I_O = –100 µA		25°C		2.98		V
		I_O = –3 mA		25°C		2.5		
				Full range	2.25			
V_{OL}	Low-level output voltage	V_{IC} = 1.5 V	I_O = 100 µA	25°C		0.02		V
			I_O = 3 mA	25°C		0.63		
				Full range			1	
A_{VD}	Large-signal differential voltage amplification	V_O = 1 V to 2 V	R_L = 600 Ω	25°C	0.7	1		V/mV
				Full range	0.4			
			R_L = 1 MΩ	25°C		750		
r_{id}	Differential input resistance			25°C		1000		GΩ
r_i	Common-mode input resistance			25°C		1000		GΩ
c_i	Common-mode input capacitance	f = 10 kHz		25°C		8		pF
z_o	Closed-loop output impedance	f = 1 MHz, A_V = 10		25°C		130		Ω
CMRR	Common-mode rejection ratio	V_{IC} = V_{ICR} MIN, V_O = V_{DD}/2, R_S = 50 Ω		25°C	65	75		dB
				Full range	50			
k_{SVR}	Supply-voltage rejection ratio ($\Delta V_{DD\pm}/\Delta V_{IO}$)	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		725	1100	µA
				Full range			1100	

(1) Full range is –40°C to 125°C.
(2) Typical values are based on the input offset voltage shift observed through 168 hours of operating life test at T_A = 150°C extrapolated to T_A = 25°C using the Arrhenius equation and assuming an activation energy of 0.96 eV.

OPERATING CHARACTERISTICS

V_{DD} = 3 V, at specified free-air temperature (unless otherwise noted)

PARAMETER		TEST CONDITIONS		T_A (1)	MIN	TYP	MAX	UNIT
SR	Slew rate at unity gain	V_O = 1 V to 2 V, R_L = 600 Ω, C_L = 100 pF		25°C	0.65	1.3		V/µs
				Full range	0.4			
V_n	Equivalent input noise voltage	f = 10 Hz		25°C		170		nV/√Hz
		f = 1 kHz				18		
$V_{n(PP)}$	Peak-to-peak equivalent input noise voltage	f = 0.1 Hz to 1 Hz		25°C		2.6		µV
		f = 0.1 Hz to 10 Hz				5.1		
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, R_L = 600 Ω, f = 1 kHz	A_V = 1	25°C		0.08		%
			A_V = 10			0.3		
			A_V = 100			2		
	Gain-bandwidth product	f = 10 kHz, R_L = 600 Ω, C_L = 100 pF		25°C		1.75		MHz
BOM	Maximum output-swing bandwidth	$V_{O(PP)}$ = 1 V, R_L = 600 Ω, A_V = 1, C_L = 100 pF		25°C		0.9		MHz
t_s	Settling time	A_V = –1, Step = –2.3 V to 2.3 V, R_L = 600 Ω, C_L = 100 pF	To 0.1%	25°C		1.5		µs
			To 0.01%			3.2		
ϕ_m	Phase margin at unity gain	R_L = 600 Ω, C_L = 100 pF		25°C		65		°
	Gain margin	R_L = 600 Ω, C_L = 100 pF		25°C		9		dB

(1) Full range is –40°C to 125°C.

ELECTRICAL CHARACTERISTICS

V_{DD} = 5 V, at specified free-air temperature (unless otherwise noted)

PARAMETER		TEST CONDITIONS		T_A (1)	MIN	TYP	MAX	UNIT
V_{IO}	Input offset voltage	$V_{DD\pm}$ = ±2.5 V, V_{IC} = 0, V_O = 0, R_S = 50 Ω	TLV244x	25°C		300	2000	µV
				Full range			2500	
			TLV244xA	25°C		300	950	
				Full range			1600	
α_{VIO}	Temperature coefficient of input offset voltage	$V_{DD\pm}$ = ±2.5 V, V_{IC} = 0, V_O = 0, R_S = 50 Ω		25°C to 85°C		2		µV/°C
	Input offset voltage long-term drift (2)	$V_{DD\pm}$ = ±2.5 V, V_{IC} = 0, V_O = 0, R_S = 50 Ω		25°C		0.002		µV/mo
I_{IO}	Input offset current	$V_{DD\pm}$ = ±2.5 V, V_{IC} = 0, V_O = 0, R_S = 50 Ω		25°C		0.5		pA
				Full range			150	
I_{IB}	Input bias current	$V_{DD\pm}$ = ±2.5 V, V_{IC} = 0, V_O = 0, R_S = 50 Ω		25°C		1		pA
				Full range			260	
V_{ICR}	Common-mode input voltage range	$\|V_{IO}\|$ ≤ 5 mV, R_S = 50 Ω		25°C	0 to 4.25	–0.25 to 4.5		V
				Full range	0 to 4			
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
			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 = 600 Ω (3)	25°C	0.9	1.3		V/mV
				Full range	0.5			
			R_L = 1 MΩ (3)	25°C		950		
r_{id}	Differential input resistance			25°C		1000		GΩ
r_i	Common-mode input resistance			25°C		1000		GΩ
c_i	Common-mode input capacitance	f = 10 kHz		25°C		8		pF
z_o	Closed-loop output impedance	f = 1 MHz, A_V = 10		25°C		140		Ω
CMRR	Common-mode rejection ratio	V_{IC} = V_{ICR} MIN, V_O = V_{DD}/2, R_S = 50 Ω		25°C	70	75		dB
				Full range	70			
k_{SVR}	Supply-voltage rejection ratio ($\Delta V_{DD}/\Delta V_{IO}$)	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		750	1100	µA
				Full range			1100	

(1) Full range is –40°C to 125°C.
(2) Typical values are based on the input offset voltage shift observed through 168 hours of operating life test at T_A = 150°C extrapolated to T_A = 25°C using the Arrhenius equation and assuming an activation energy of 0.96 eV.
(3) Referenced to 2.5 V

OPERATING CHARACTERISTICS

V_{DD} = 5 V, at specified free-air temperature (unless otherwise noted)

PARAMETER		TEST CONDITIONS		T_A (1)	MIN	TYP	MAX	UNIT
SR	Slew rate at unity gain	V_O = 0.5 V to 2.5 V, R_L = 600 Ω (2), C_L = 100 pF (2)		25°C	0.75	1.4		V/μs
				Full range	0.5			
V_n	Equivalent input noise voltage	f = 10 Hz		25°C		130		nV/√Hz
		f = 1 kHz				16		
$V_{n(PP)}$	Peak-to-peak equivalent input noise voltage	f = 0.1 Hz to 1 Hz		25°C		1.8		μV
		f = 0.1 Hz to 10 Hz				3.6		
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 3.5V, f = 1 kHz, R_L = 600 Ω (2)	A_V = 1	25°C		0.017		%
			A_V = 10			0.17		
			A_V = 100			1.5		
	Gain-bandwidth product	f = 10 kHz, R_L = 600 Ω (2), C_L = 100 pF (2)		25°C		1.81		MHz
BOM	Maximum output-swing bandwidth	$V_{O(PP)}$ = 2 V, A_V = 1, R_L = 600 Ω (2), C_L = 100 pF (2)		25°C		0.5		MHz
t_s	Settling time	A_V = –1, Step = –0.5 V to 2.5 V, R_L = 600 Ω (2), C_L = 100 pF (2)	To 0.1%	25°C		1.5		μs
			To 0.01%			2.6		
ϕ_m	Phase margin at unity gain	R_L = 600 Ω (2), C_L = 100 pF (2)		25°C		68		°
	Gain margin	R_L = 600 Ω (2), C_L = 100 pF (2)		25°C		8		dB

(1) Full range is –40°C to 125°C.
(2) Referenced to 2.5 V

TYPICAL CHARACTERISTICS

Table of Graphs(1)

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

(1) For all graphs where V_{DD} = 5 V, all loads are referenced to 2.5 V.

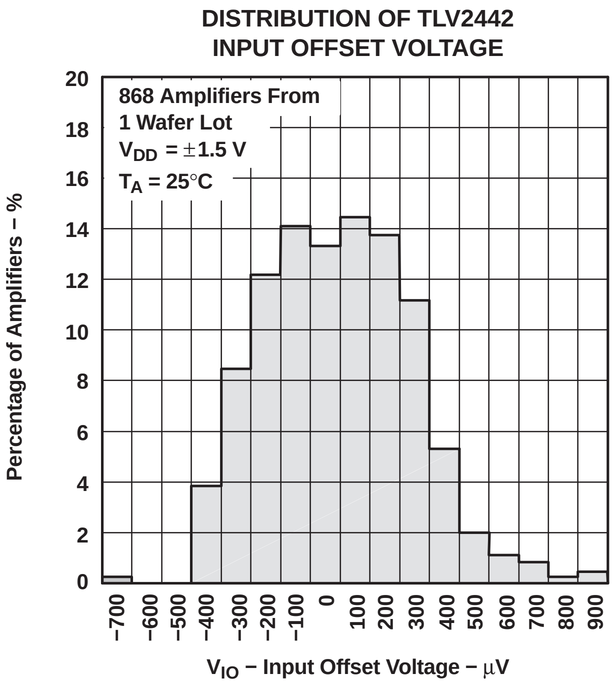


Figure 2.

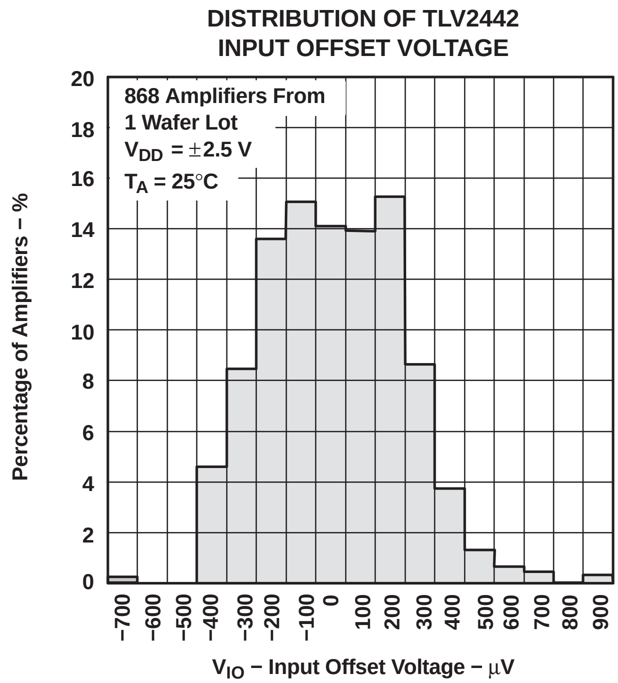


Figure 3.

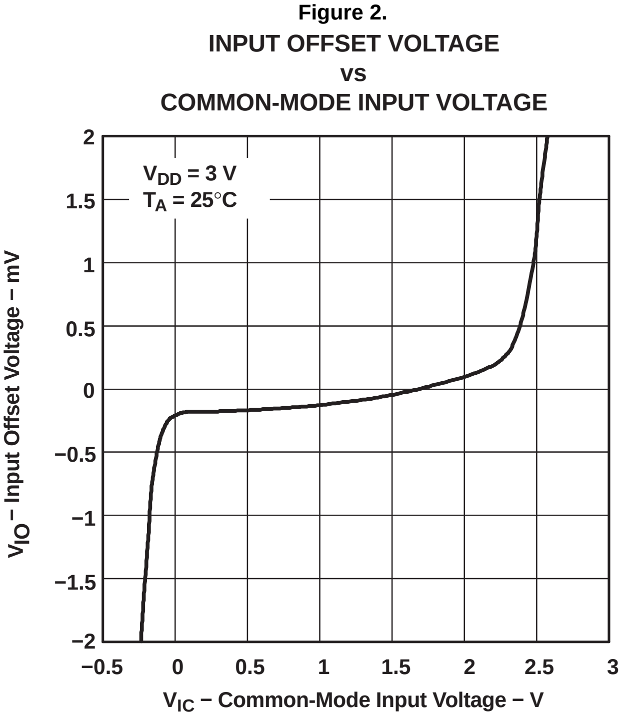


Figure 4.

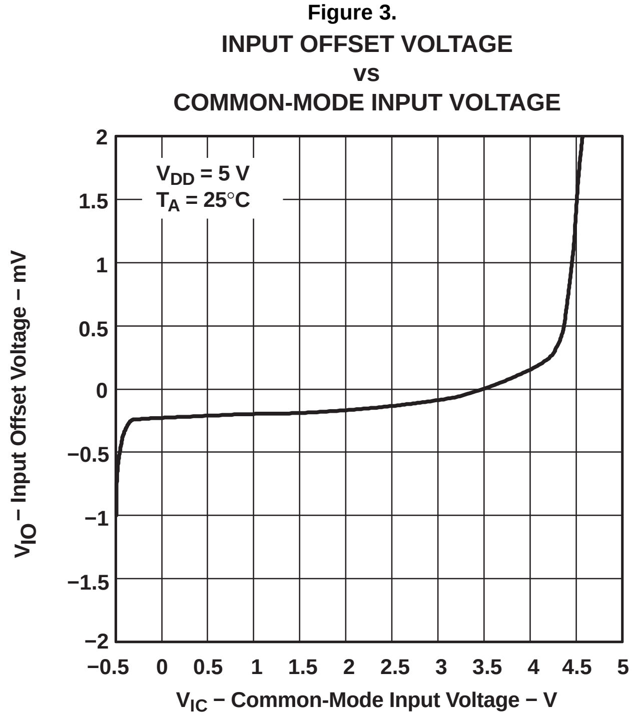


Figure 5.

DISTRIBUTION OF TLV2442 INPUT OFFSET VOLTAGE TEMPERATURE COEFFICIENT

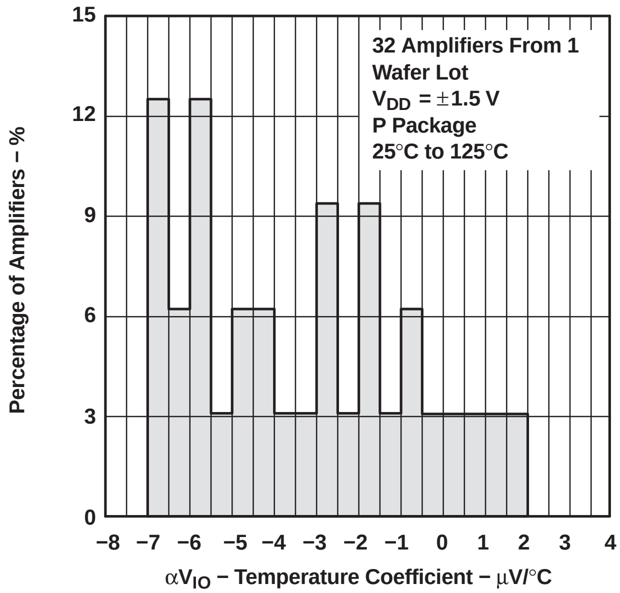


Figure 6.

DISTRIBUTION OF TLV2442 INPUT OFFSET VOLTAGE TEMPERATURE COEFFICIENT

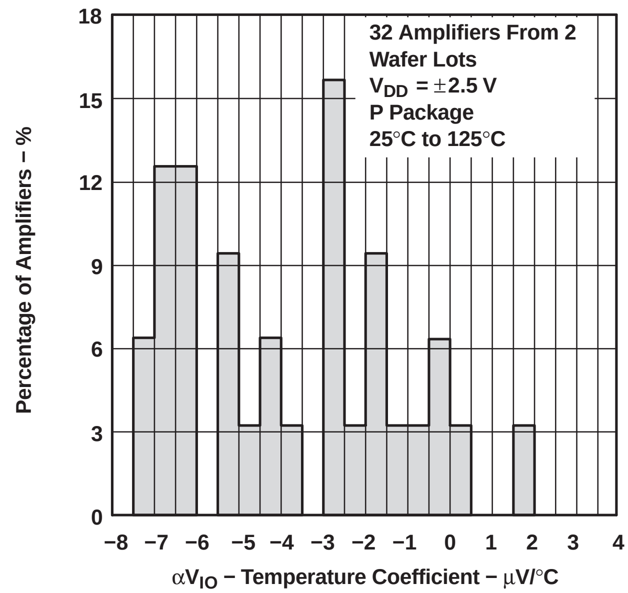


Figure 7.

INPUT BIAS AND INPUT OFFSET CURRENTS vs FREE-AIR TEMPERATURE

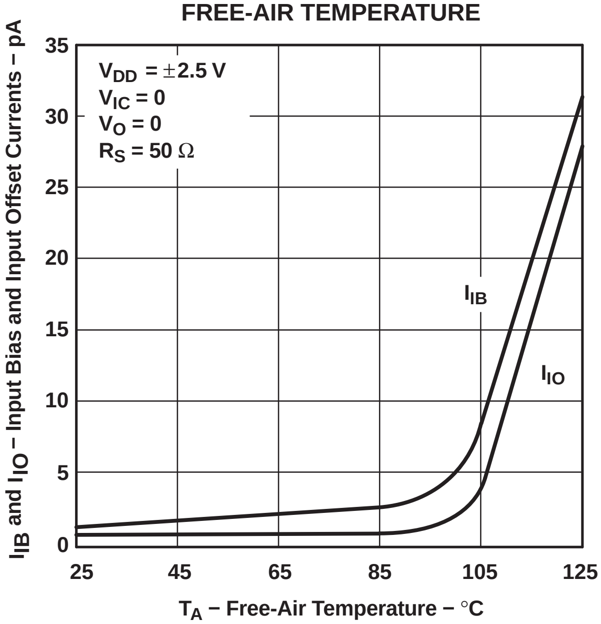


Figure 8.

HIGH-LEVEL OUTPUT VOLTAGE vs HIGH-LEVEL OUTPUT CURRENT

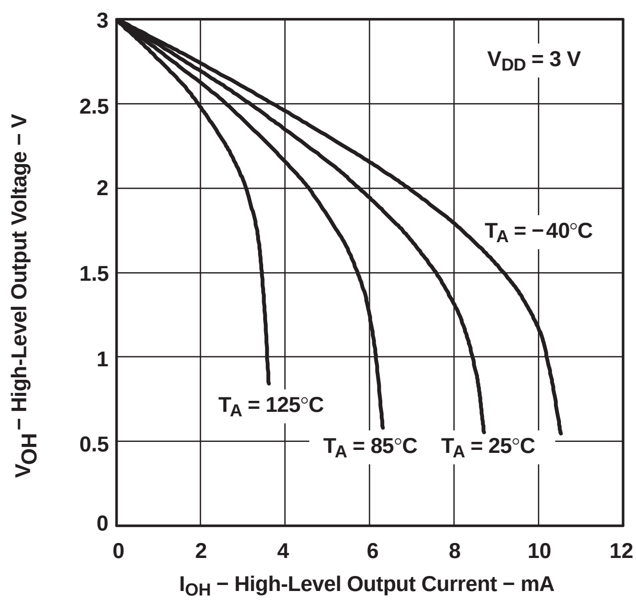


Figure 9.

HIGH-LEVEL OUTPUT VOLTAGE
vs
HIGH-LEVEL OUTPUT CURRENT

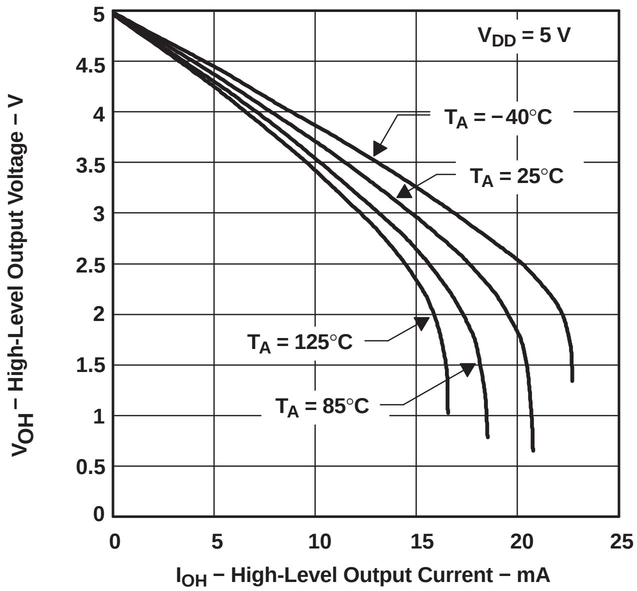


Figure 10.

LOW-LEVEL OUTPUT VOLTAGE
vs
LOW-LEVEL OUTPUT CURRENT

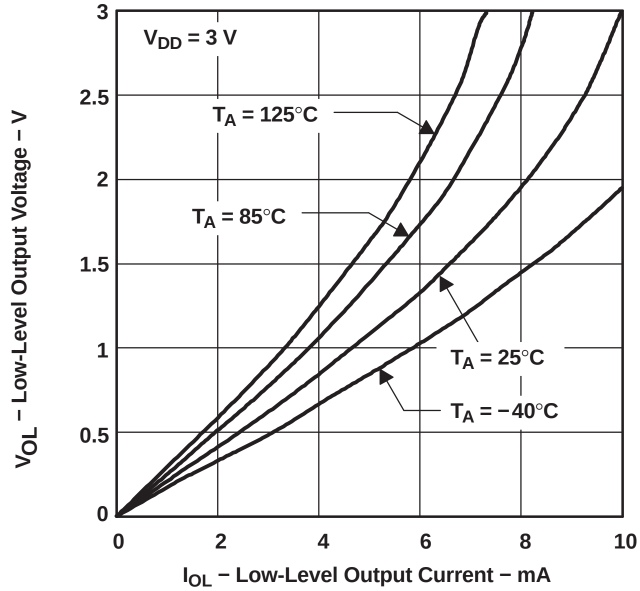


Figure 11.

LOW-LEVEL OUTPUT VOLTAGE
vs
LOW-LEVEL OUTPUT CURRENT

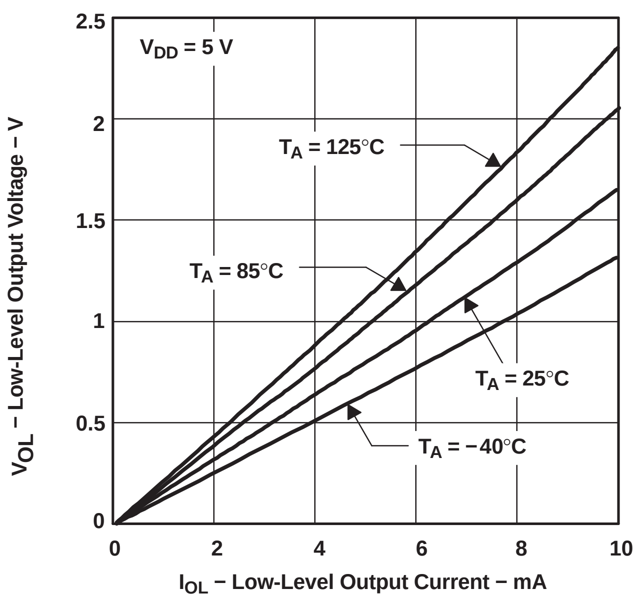


Figure 12.

MAXIMUM PEAK-TO-PEAK OUTPUT VOLTAGE
vs
FREQUENCY

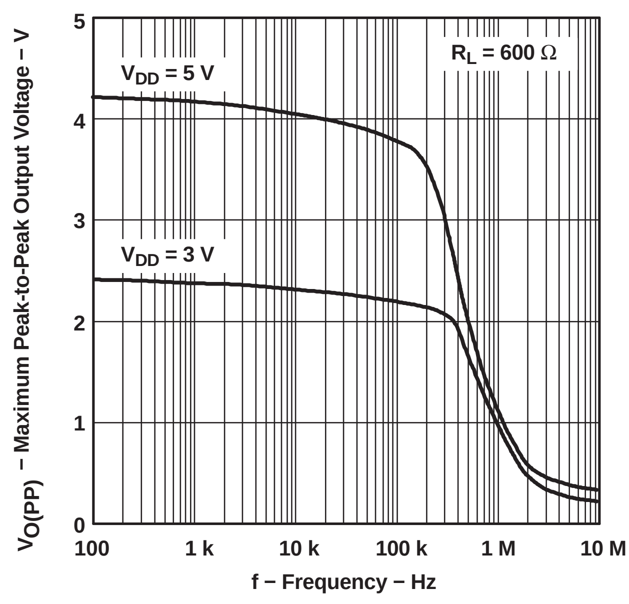


Figure 13.

SHORT-CIRCUIT OUTPUT CURRENT vs SUPPLY VOLTAGE

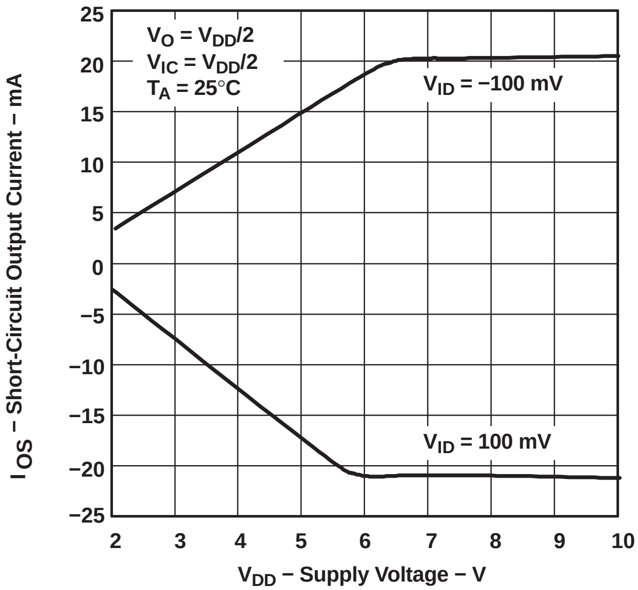


Figure 14.

SHORT-CIRCUIT OUTPUT CURRENT vs FREE-AIR TEMPERATURE

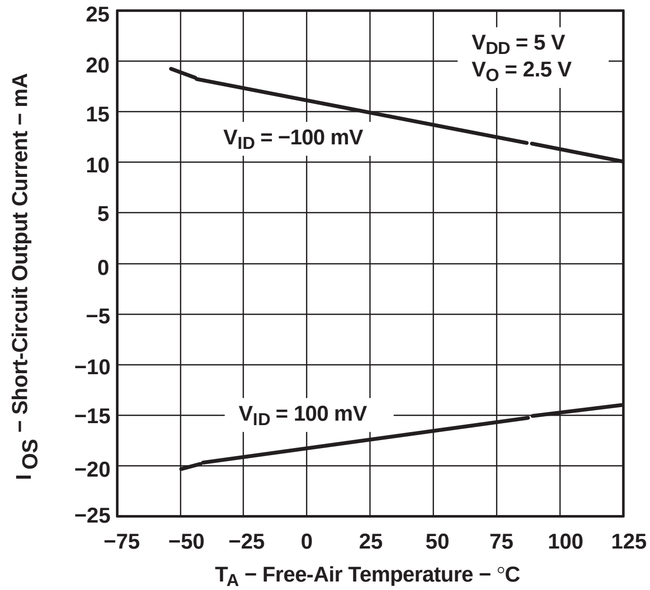


Figure 15.

OUTPUT VOLTAGE vs DIFFERENTIAL INPUT VOLTAGE

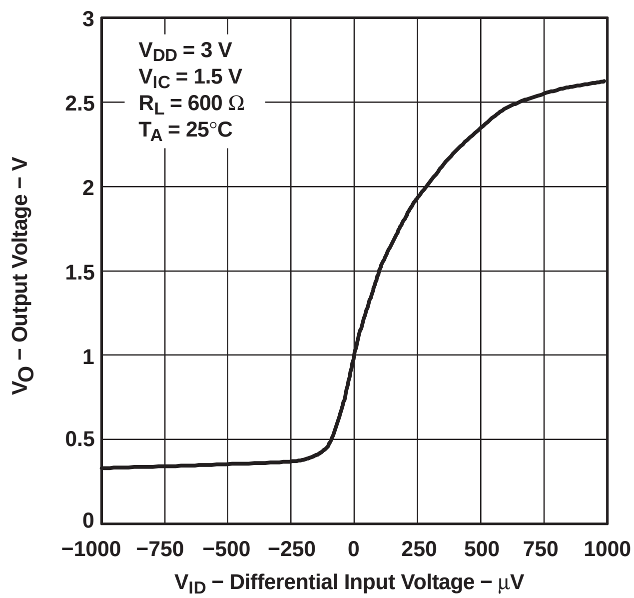


Figure 16.

OUTPUT VOLTAGE vs DIFFERENTIAL INPUT VOLTAGE

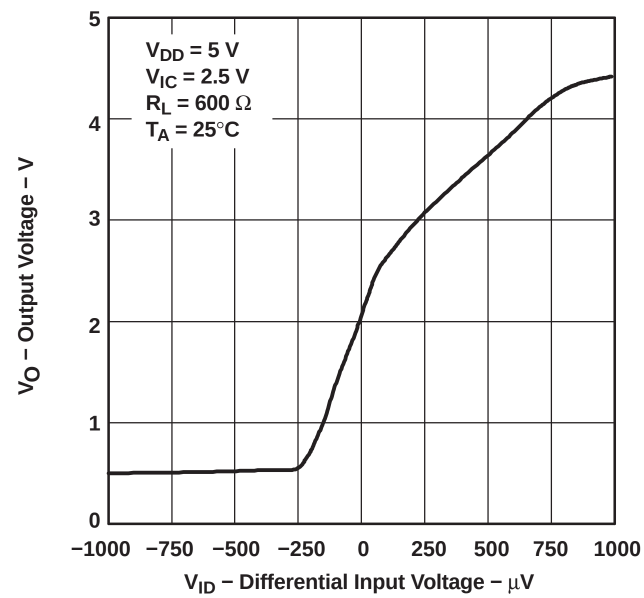


Figure 17.

**DIFFERENTIAL VOLTAGE AMPLIFICATION
vs
LOAD RESISTANCE**

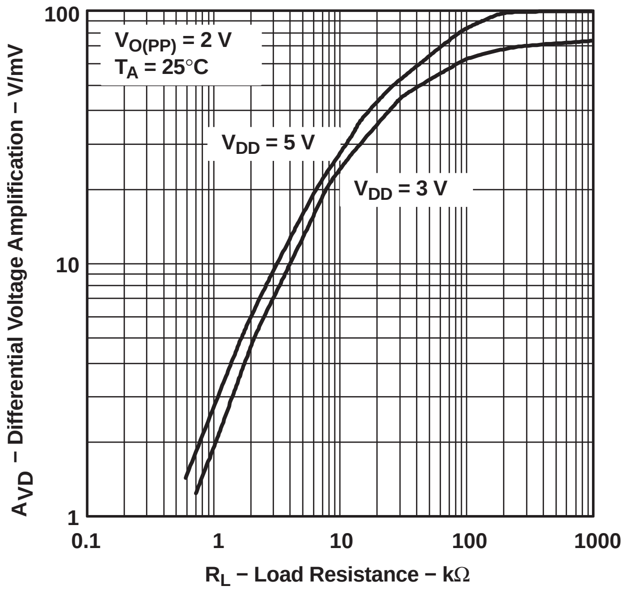


Figure 18.

**LARGE-SIGNAL DIFFERENTIAL VOLTAGE
AMPLIFICATION AND PHASE MARGIN
vs
FREQUENCY**

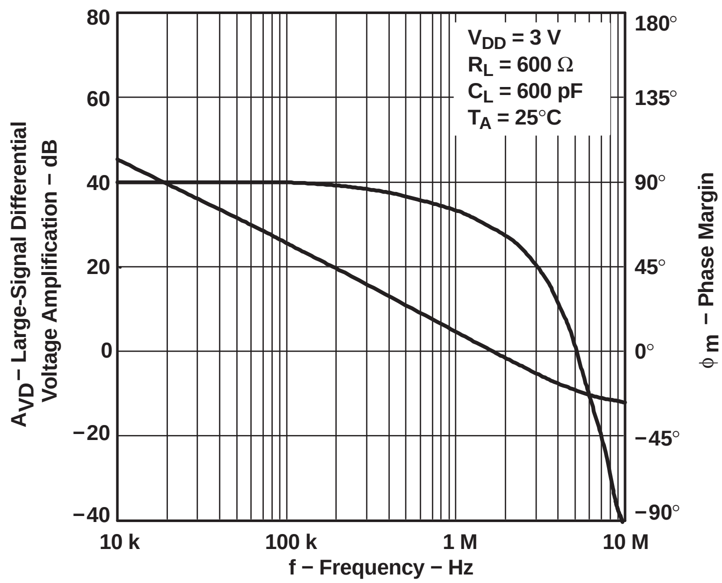


Figure 19.

LARGE-SIGNAL DIFFERENTIAL VOLTAGE AMPLIFICATION AND PHASE MARGIN vs FREQUENCY

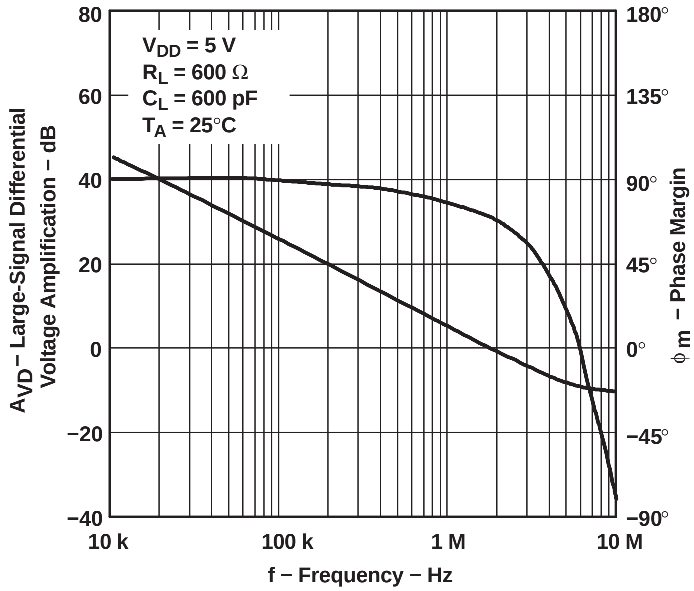


Figure 20.

LARGE-SIGNAL DIFFERENTIAL VOLTAGE AMPLIFICATION vs FREE-AIR TEMPERATURE

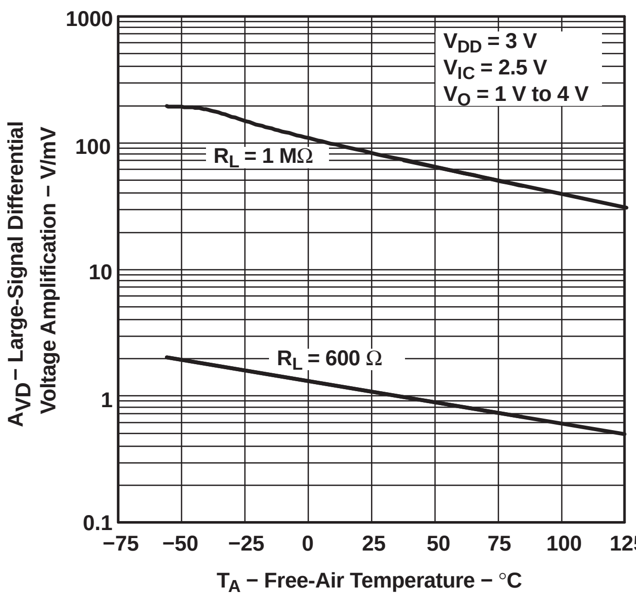


Figure 21.

LARGE-SIGNAL DIFFERENTIAL VOLTAGE AMPLIFICATION vs FREE-AIR TEMPERATURE

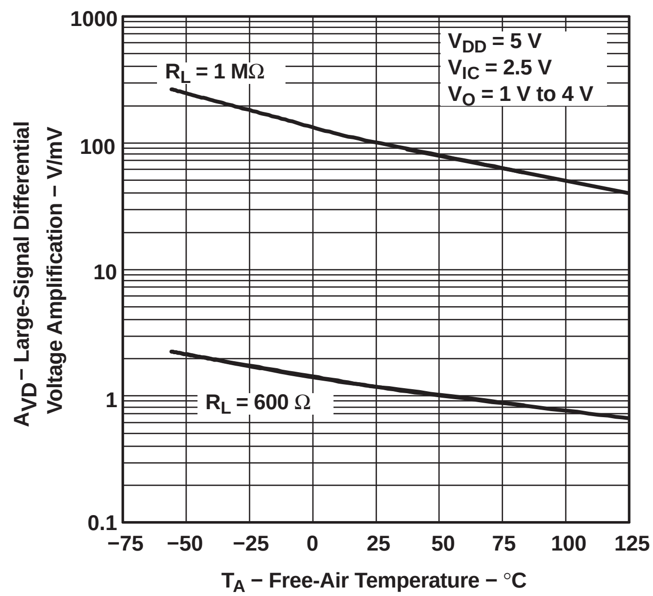


Figure 22.

**OUTPUT IMPEDANCE
vs
FREQUENCY**

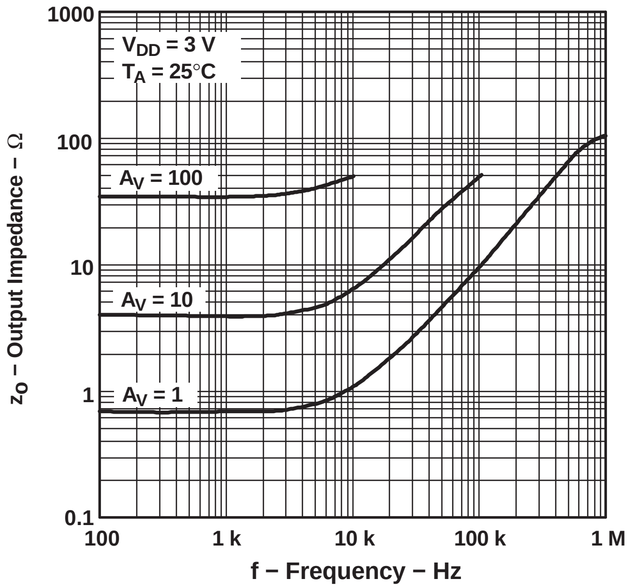


Figure 23.

**OUTPUT IMPEDANCE
vs
FREQUENCY**

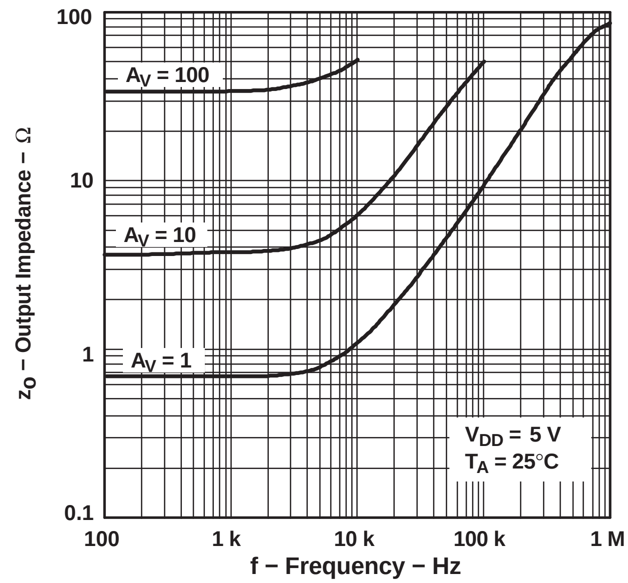


Figure 24.

**COMMON-MODE REJECTION RATIO
vs
FREQUENCY**

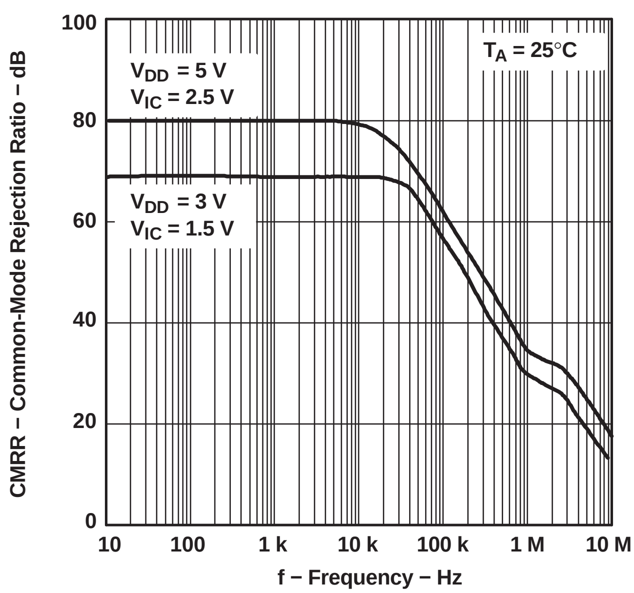


Figure 25.

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

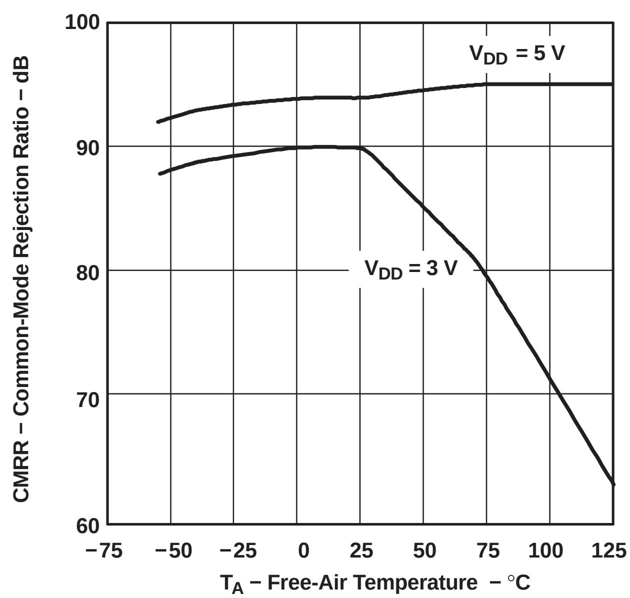


Figure 26.

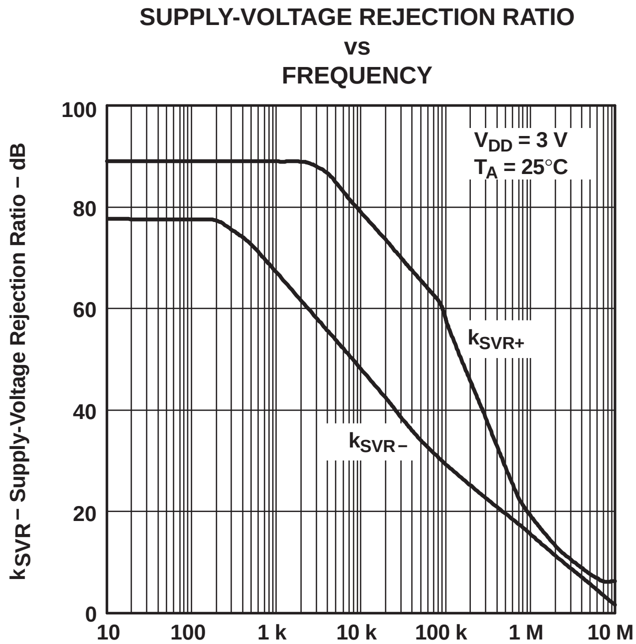


Figure 27.

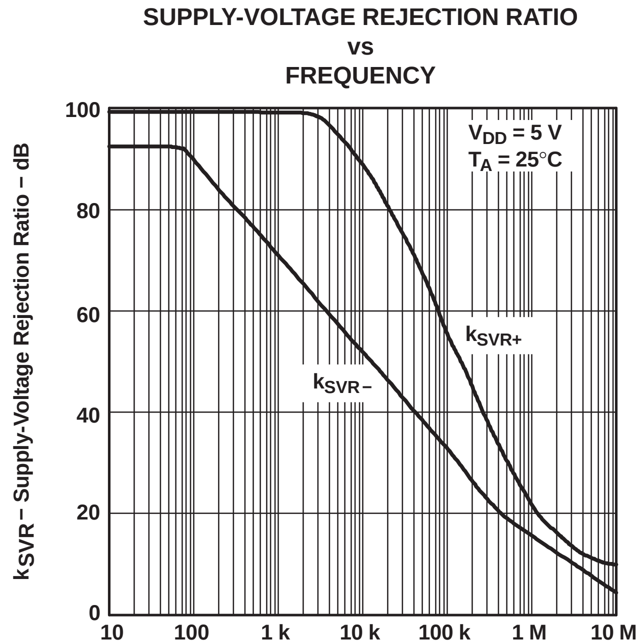


Figure 28.

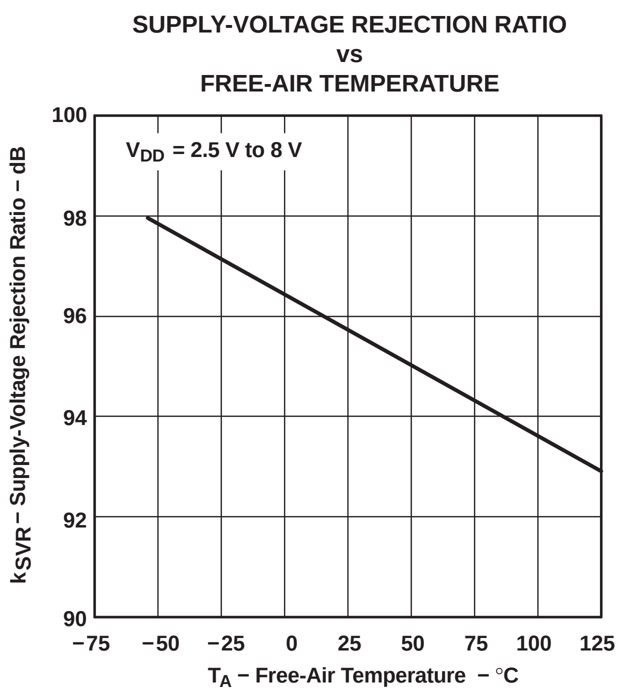


Figure 29.

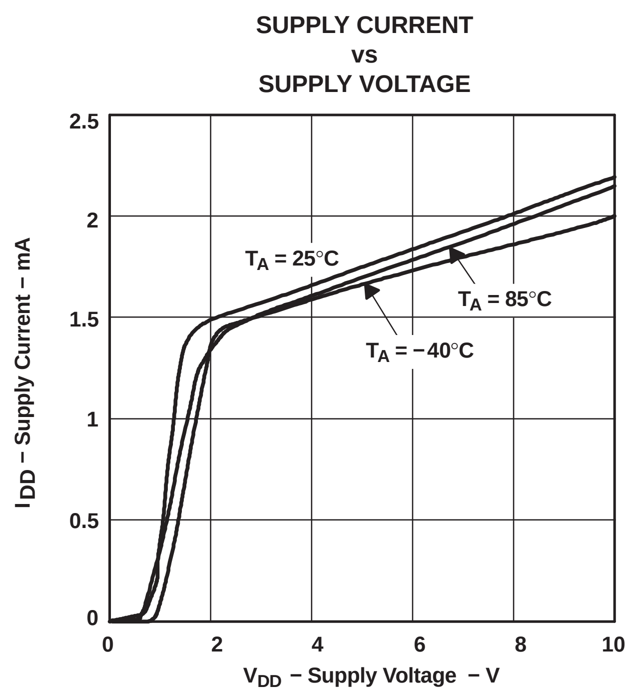


Figure 30.

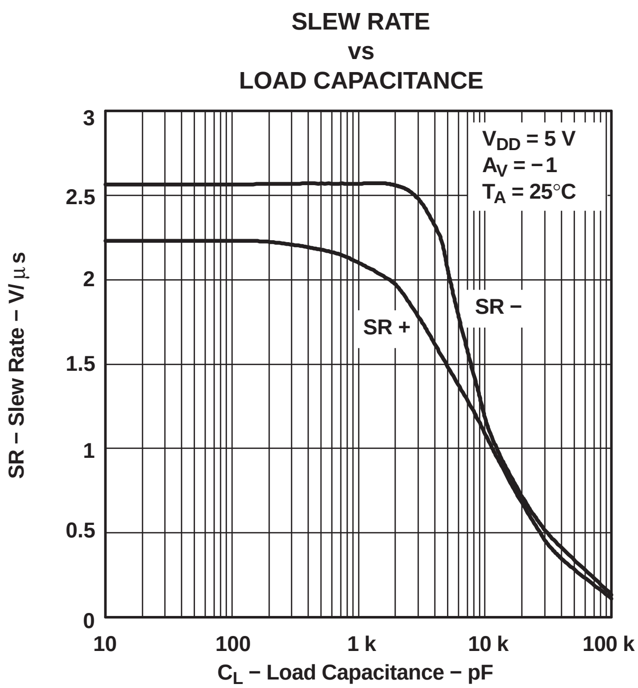


Figure 31.

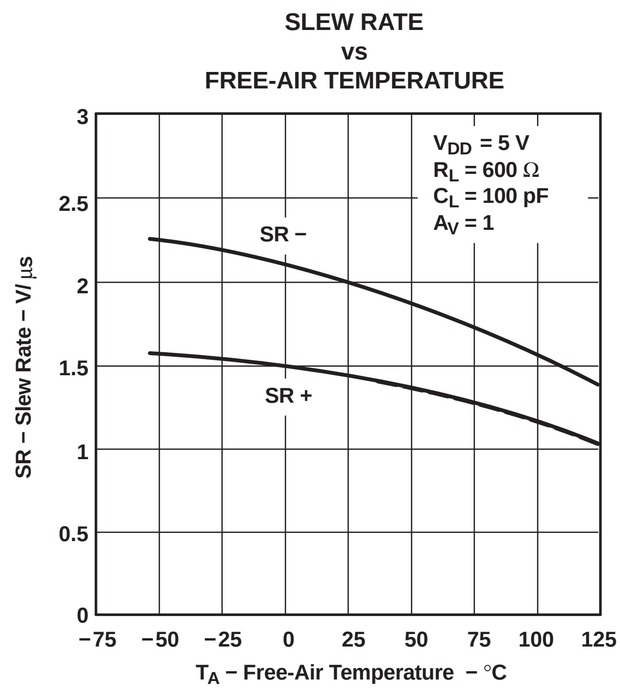


Figure 32.

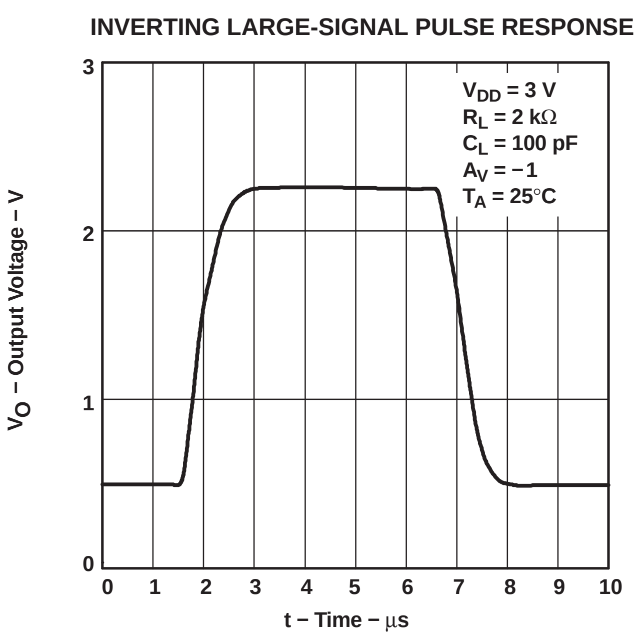


Figure 33.

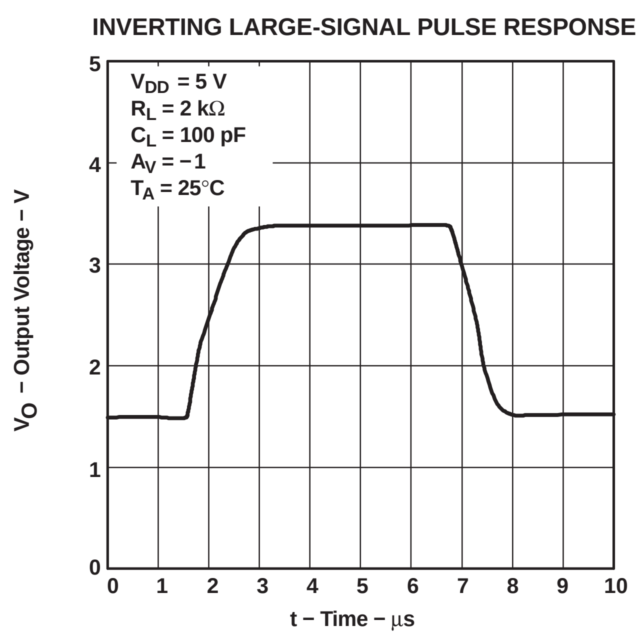


Figure 34.

**VOLTAGE-FOLLOWER
LARGE-SIGNAL PULSE RESPONSE**

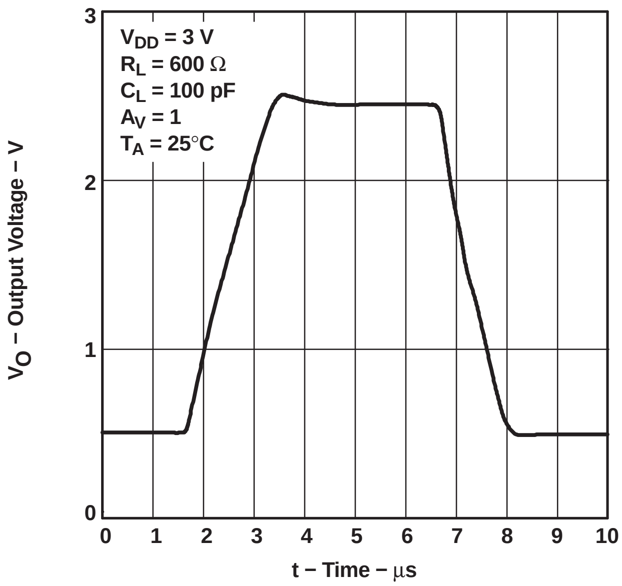


Figure 35.

**VOLTAGE-FOLLOWER
LARGE-SIGNAL PULSE RESPONSE**

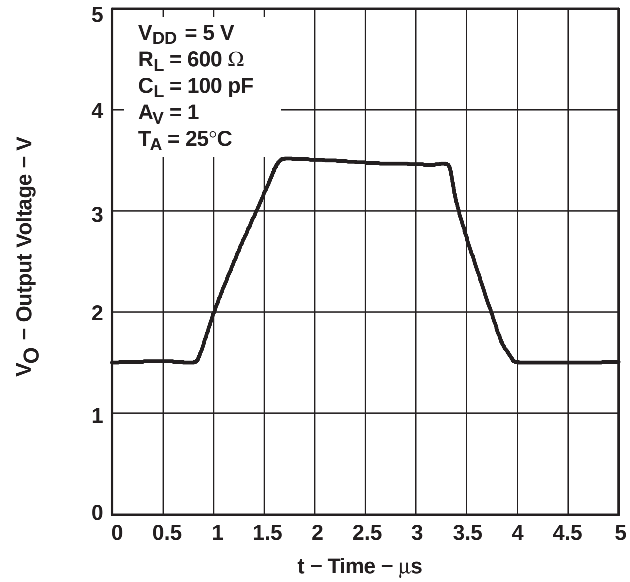


Figure 36.

INVERTING SMALL-SIGNAL PULSE RESPONSE

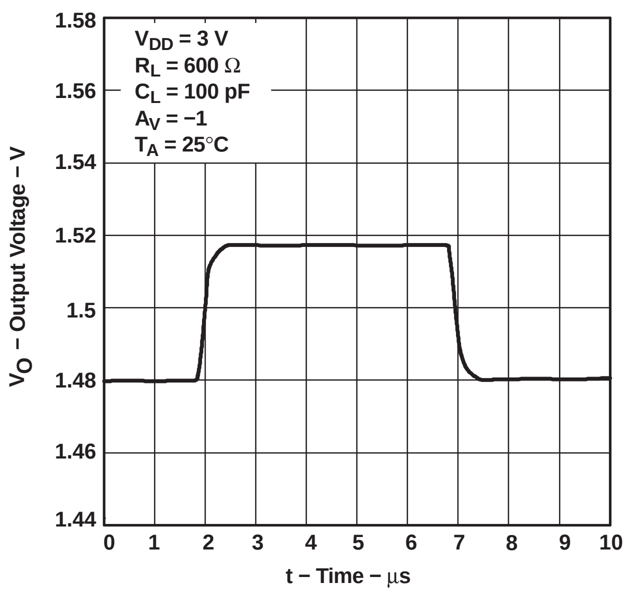


Figure 37.

INVERTING SMALL-SIGNAL PULSE RESPONSE

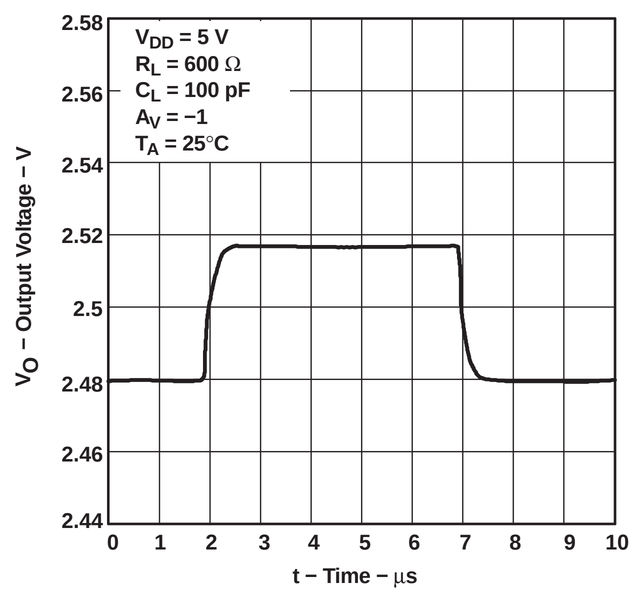


Figure 38.

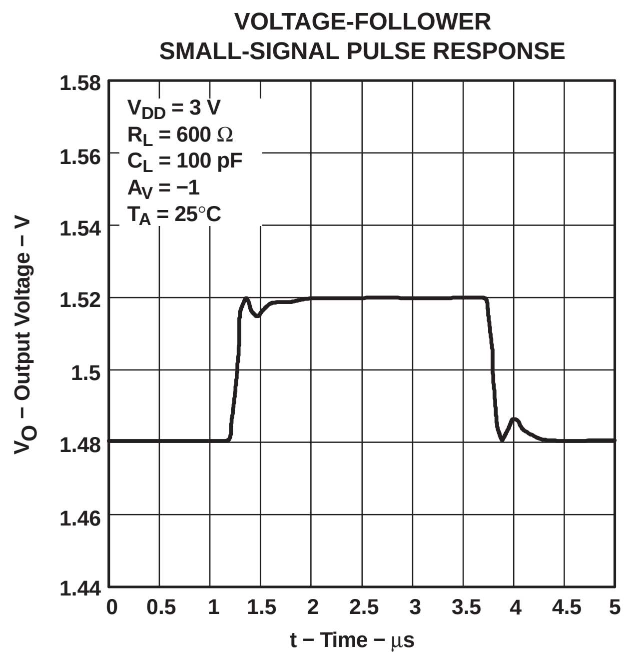


Figure 39.

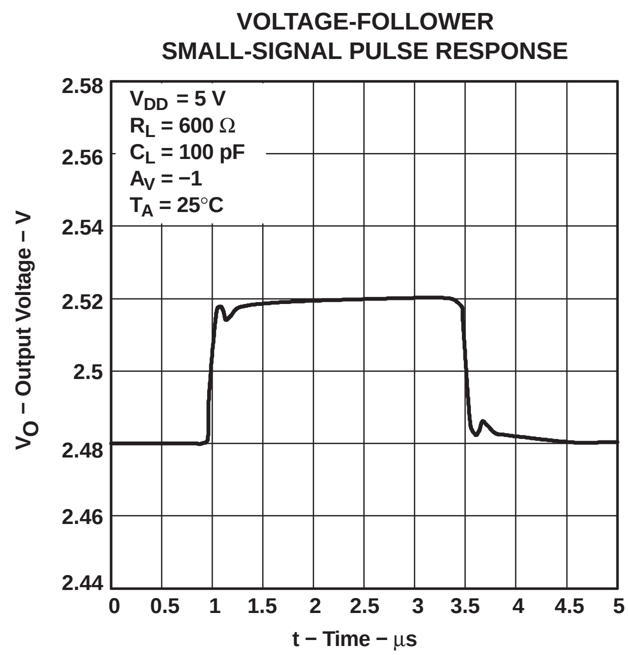


Figure 40.

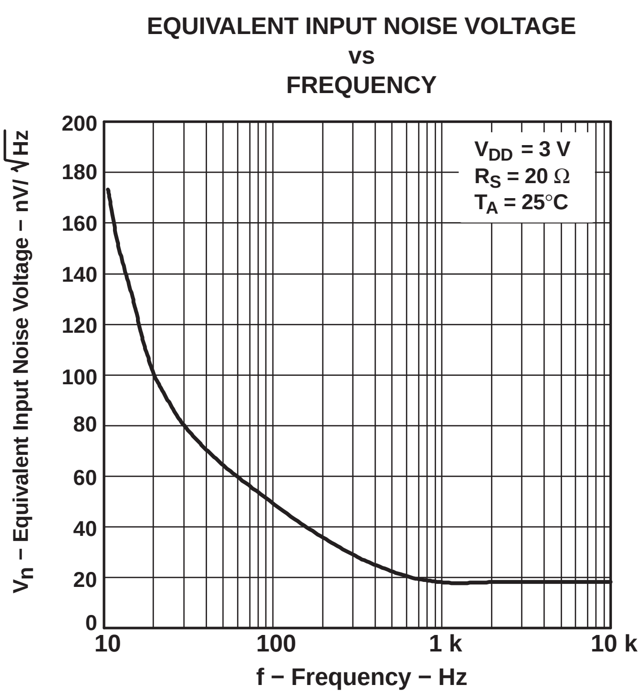


Figure 41.

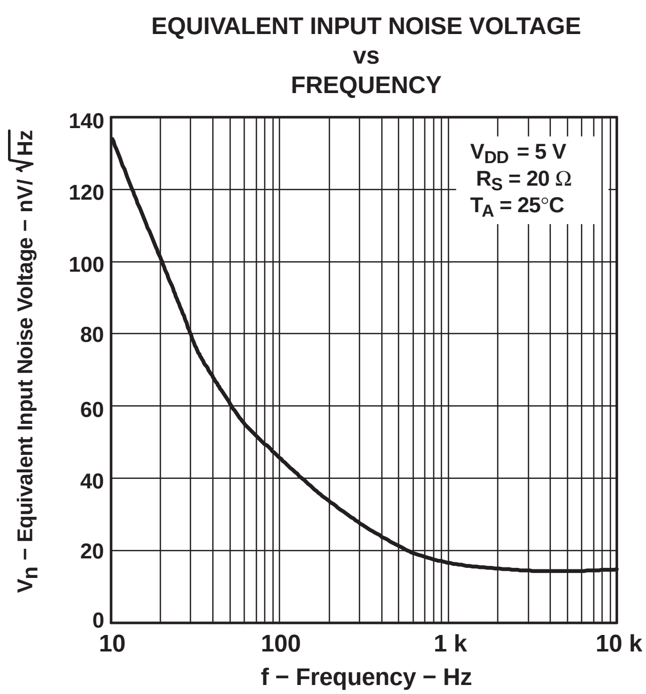


Figure 42.

NOISE VOLTAGE
OVER A 10-SECOND PERIOD

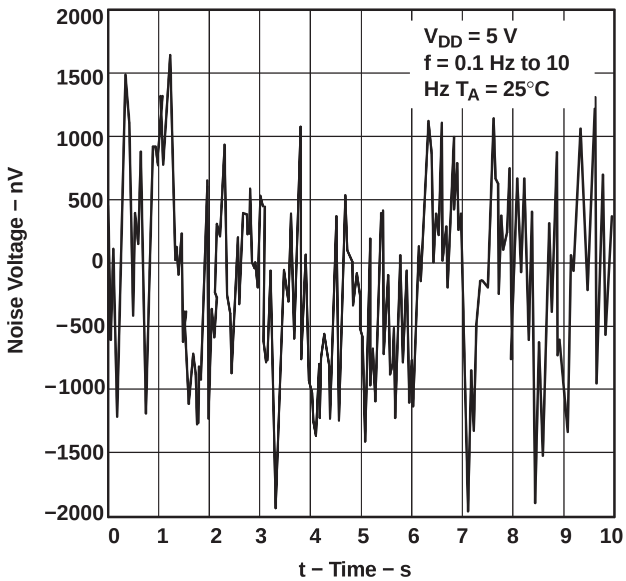


Figure 43.

TOTAL HARMONIC DISTORTION PLUS NOISE
vs
FREQUENCY

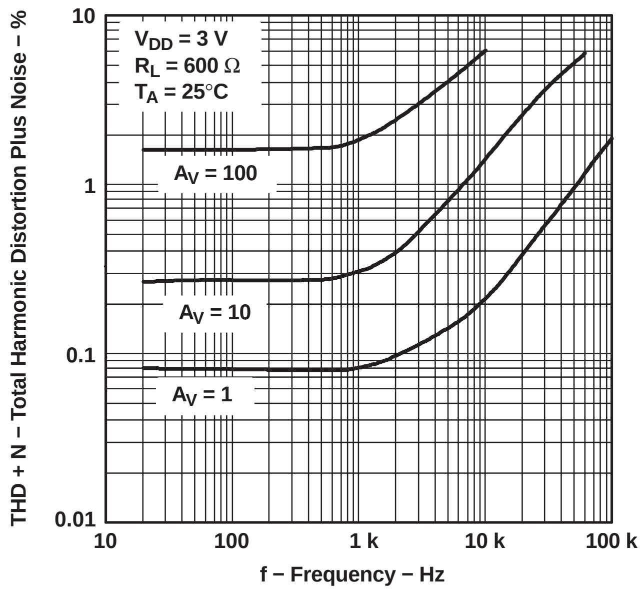


Figure 44.

TOTAL HARMONIC DISTORTION PLUS NOISE
vs
FREQUENCY

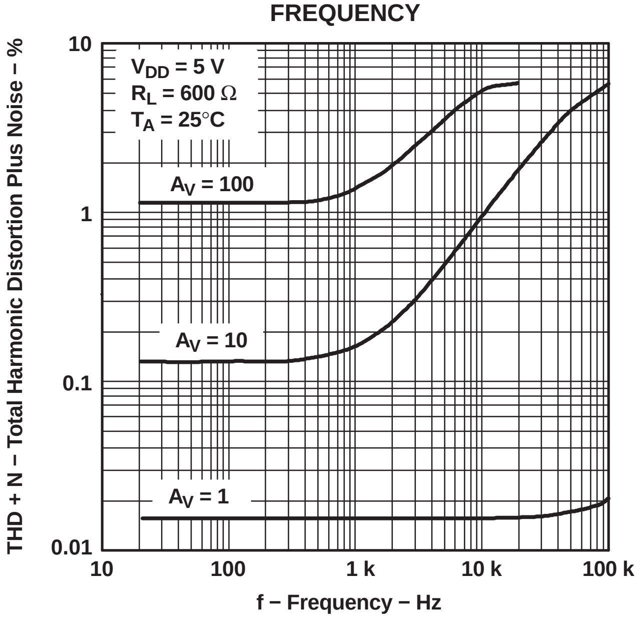


Figure 45.

GAIN-BANDWIDTH PRODUCT
vs
FREE-AIR TEMPERATURE

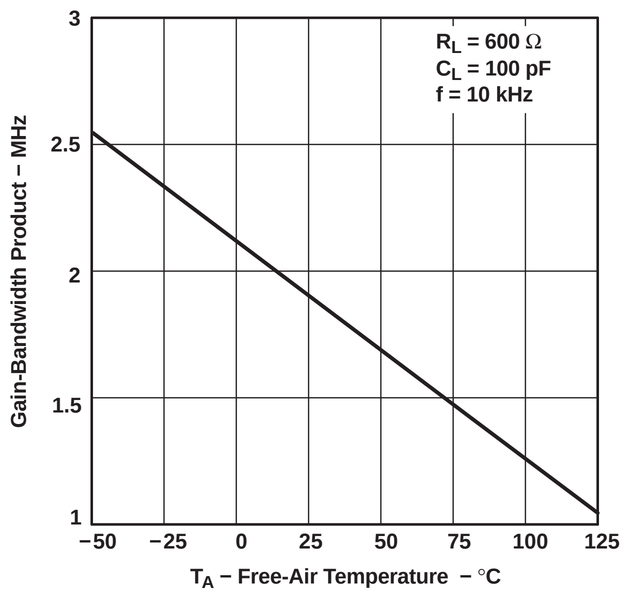


Figure 46.

GAIN-BANDWIDTH PRODUCT
vs
SUPPLY VOLTAGE

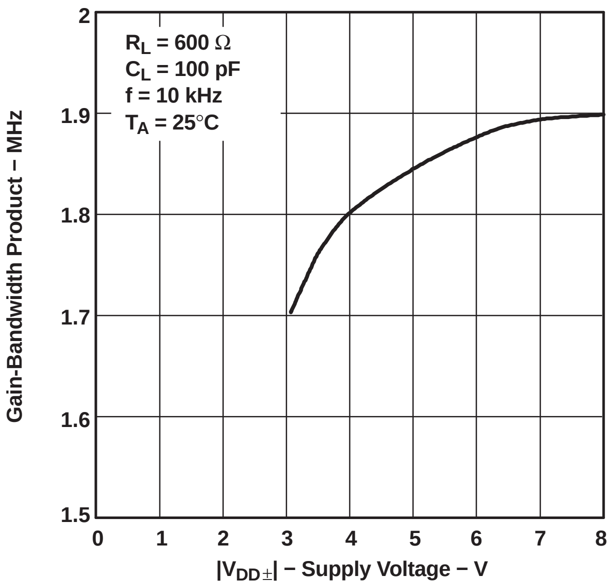


Figure 47.

PHASE MARGIN
vs
LOAD CAPACITANCE

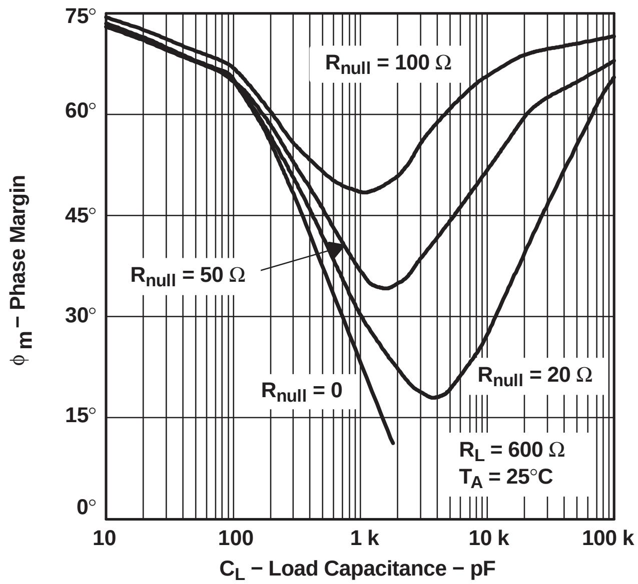


Figure 48.

GAIN MARGIN
vs
LOAD CAPACITANCE

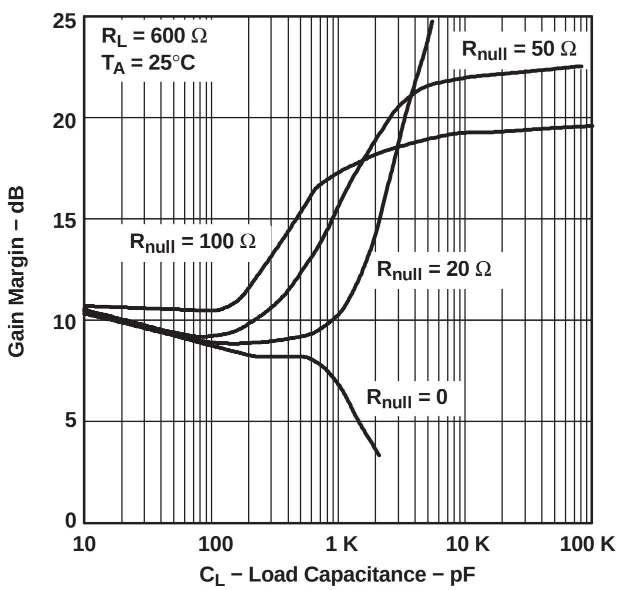


Figure 49.

UNITY-GAIN BANDWIDTH
vs
LOAD CAPACITANCE

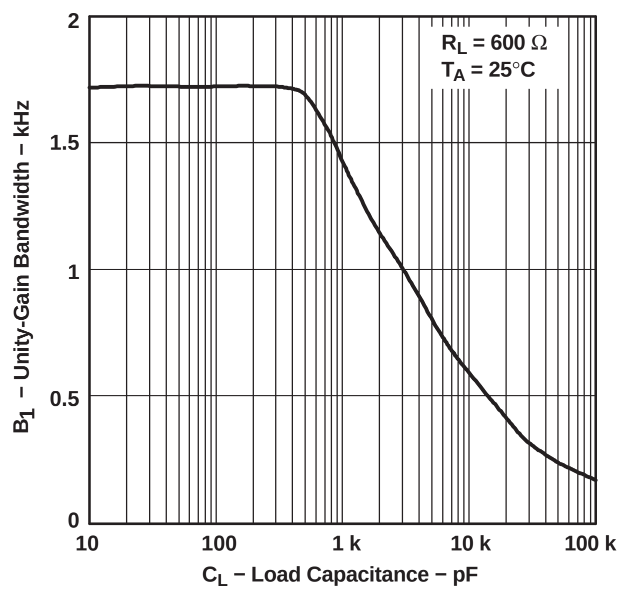


Figure 50.

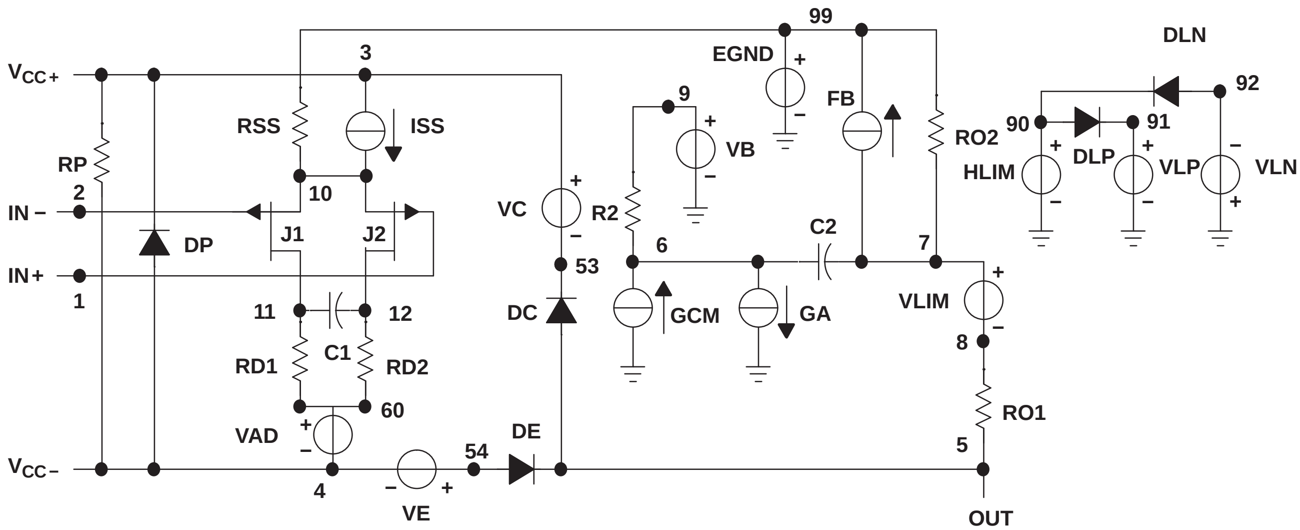
APPLICATION INFORMATION

macromodel information

Macromodel information provided was derived using PSpice™ Parts™ model generation software. The Boyle macromodel(2) and subcircuit in Figure 51 were generated using the TLV244x typical electrical and operating characteristics at T_A = 25°C. Using this information, output simulations of the following key parameters can be generated to a tolerance of 20% (in most cases):

(2) 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).

- 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




```
.SUBCKT TLV2442 1 2 3 4 5
C1     11     12     14E−12
C2     6      7      60.00E−12
DC     5      53     DX
DE     54     5      DX
DLP    90     91     DX
DLN    92     90     DX
DP     4      3      DX
EGND   99     0      POLY (2) (3,0) (4,) 0 .5 .5
FB     7      99     POLY (5) VB VC VE VLP VLN 0
+ 984.9E3 −1E6 1E6 1E6 −1E6
GA     6      0      11     12 377.0E−6
GCM    0      6      10     99 134E−9
ISS    3      10     DC 216.0E−6
HLIM   90     0      VLIM 1K
J1     11     2      10 JX
J2     12     1      10 JX
R2     6      9      100.OE3
RD1    60     11     2.653E3
RD2    60     12     2.653E3
R01    8      5      50
R02    7      99     50
RP     3      4      4.310E3
RSS    10     99     925.9E3
VAD    60     4      −.5
VB     9      0      DC 0
VC     3      53     DC .78
VE     54     4      DC .78
VLIM   7      8      DC 0
VLP    91     0      DC 1.9
VLN    0      92     DC 9.4
.MODEL DX D (IS=800.0E−18)
.MODEL JX PJF (IS=1.500E−12BETA=1.316E-3
+ VTO=−.270)
.ENDS
```

Figure 51. Boyle Macromodel and Subcircuit

PACKAGING INFORMATION

Orderable Device	Status (1)	Package Type	Package Drawing	Pins	Package Qty	Eco Plan (2)	Lead/ Ball Finish	MSL Peak Temp (3)	Samples (Requires Login)
TLV2442AQDRG4Q1	ACTIVE	SOIC	D	8	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	Purchase Samples
TLV2442AQDRQ1	ACTIVE	SOIC	D	8	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	Purchase Samples
TLV2442AQPWRG4Q1	ACTIVE	TSSOP	PW	8	2000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	Purchase Samples
TLV2442AQPWRQ1	ACTIVE	TSSOP	PW	8	2000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	Purchase Samples
TLV2442QDGKRQ1	ACTIVE	MSOP	DGK	8	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-2-260C-1 YEAR	Purchase Samples
TLV2442QDRG4Q1	ACTIVE	SOIC	D	8	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	Purchase Samples
TLV2442QDRQ1	ACTIVE	SOIC	D	8	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	Purchase Samples
TLV2442QPWRG4Q1	ACTIVE	TSSOP	PW	8	2000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	Purchase Samples
TLV2442QPWRQ1	ACTIVE	TSSOP	PW	8	2000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	Purchase Samples
TLV2444AQPWRQ1	ACTIVE	TSSOP	PW	14	2000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	Purchase Samples

(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.

Important Information and Disclaimer: The information provided on this page represents TI's knowledge and belief as of the date that it is provided. TI bases its knowledge and belief on information provided by third parties, and makes no representation or warranty as to the accuracy of such information. Efforts are underway to better integrate information from third parties. TI has taken and 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 TLV2442-Q1, TLV2442A-Q1, TLV2444A-Q1 :

- Catalog: TLV2442, TLV2442A, TLV2444A

- Military: TLV2442M, TLV2442AM

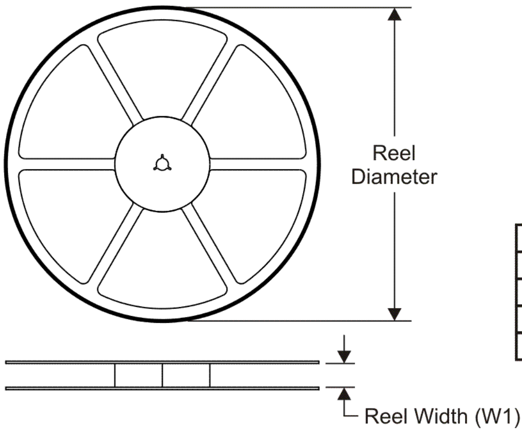
NOTE: Qualified Version Definitions:

- Catalog - TI's standard catalog product

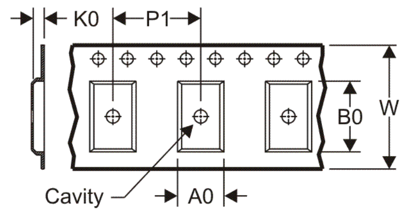
- Military - QML certified for Military and Defense Applications

TAPE AND REEL INFORMATION

REEL DIMENSIONS

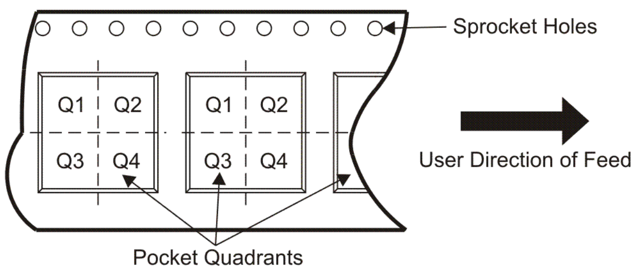


TAPE DIMENSIONS



A0	Dimension designed to accommodate the component width
B0	Dimension designed to accommodate the component length
K0	Dimension designed to accommodate the component thickness
W	Overall width of the carrier tape
P1	Pitch between successive cavity centers

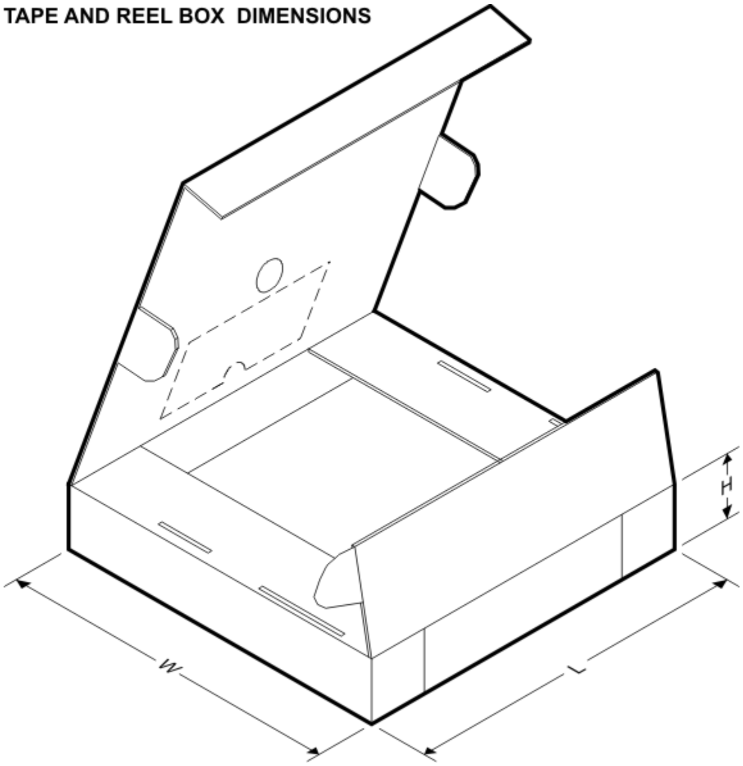
QUADRANT ASSIGNMENTS FOR PIN 1 ORIENTATION IN TAPE



*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
TLV2442QDGKRQ1	MSOP	DGK	8	2500	330.0	12.4	5.3	3.4	1.4	8.0	12.0	Q1
TLV2442QPWRG4Q1	TSSOP	PW	8	2000	330.0	12.4	7.0	3.6	1.6	8.0	12.0	Q1
TLV2442QPWRQ1	TSSOP	PW	8	2000	330.0	12.4	7.0	3.6	1.6	8.0	12.0	Q1

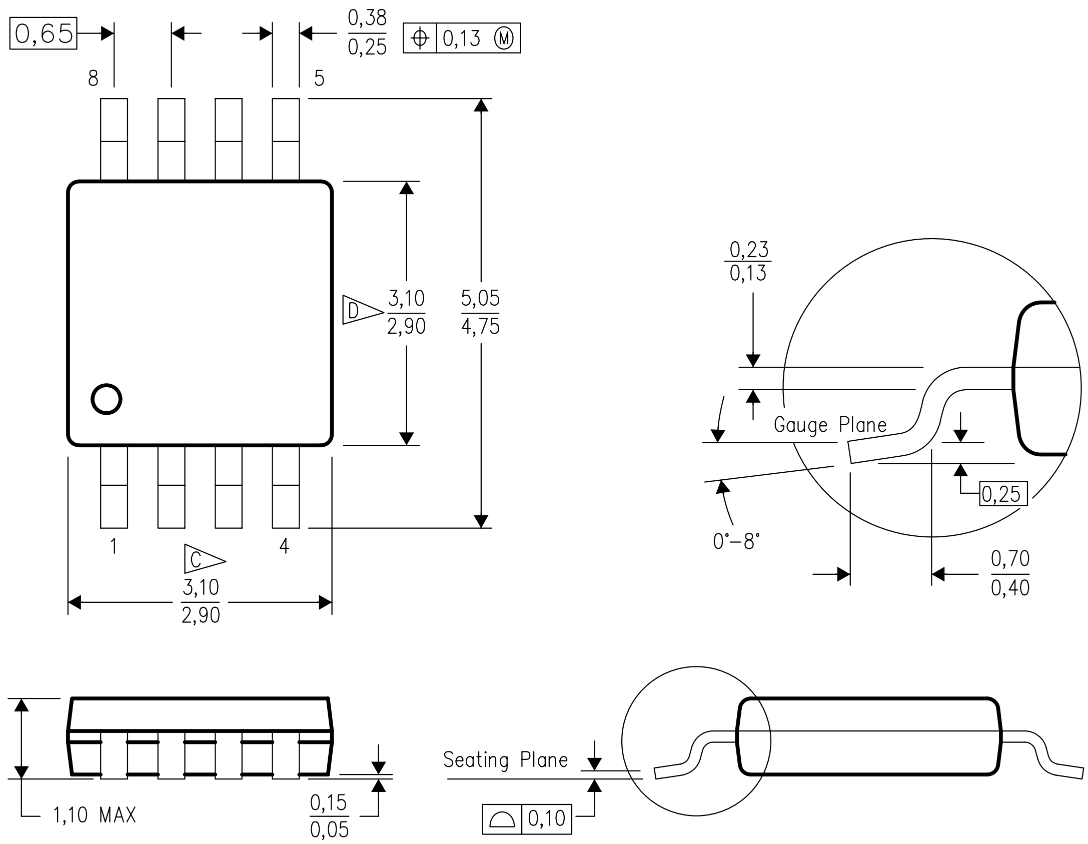
TAPE AND REEL BOX DIMENSIONS



*All dimensions are nominal

Device	Package Type	Package Drawing	Pins	SPQ	Length (mm)	Width (mm)	Height (mm)
TLV2442QDGKRQ1	MSOP	DGK	8	2500	346.0	346.0	29.0
TLV2442QPWRG4Q1	TSSOP	PW	8	2000	346.0	346.0	29.0
TLV2442QPWRQ1	TSSOP	PW	8	2000	346.0	346.0	29.0

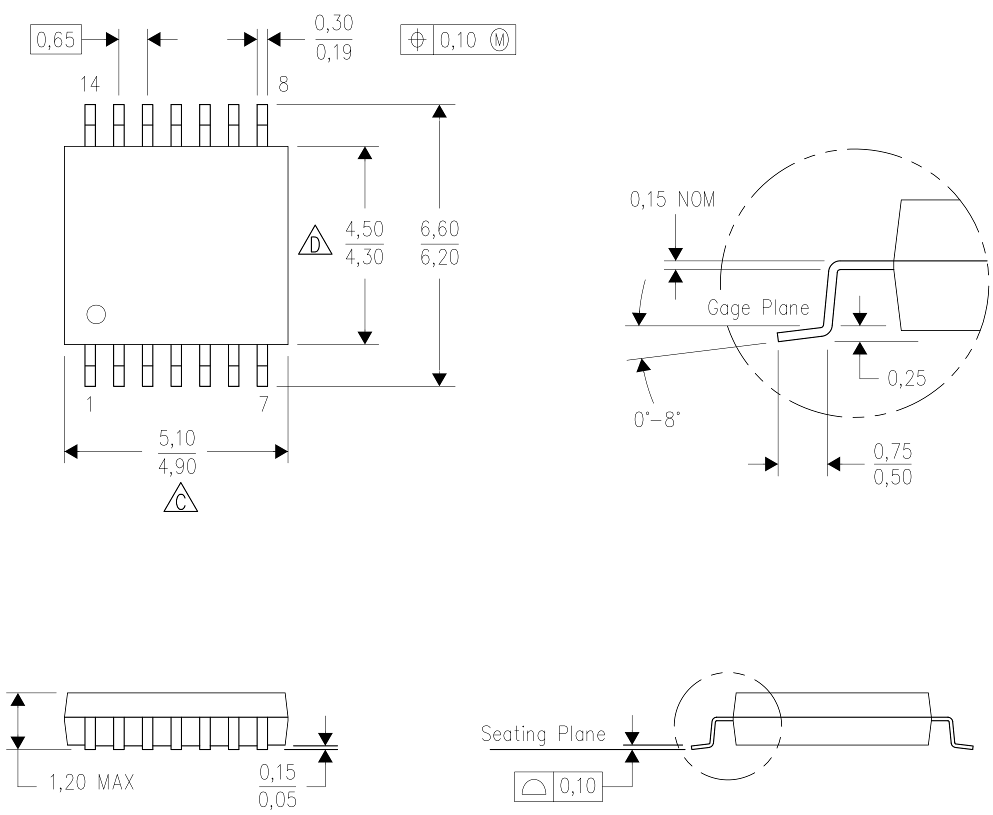
DGK (S-PDSO-G8) PLASTIC SMALL-OUTLINE PACKAGE



4073329/E 05/06

NOTES:
- A. All linear dimensions are in 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 0.15 per end.
- D Body width does not include interlead flash. Interlead flash shall not exceed 0.50 per side.
- E. Falls within JEDEC MO-187 variation AA, except interlead flash.

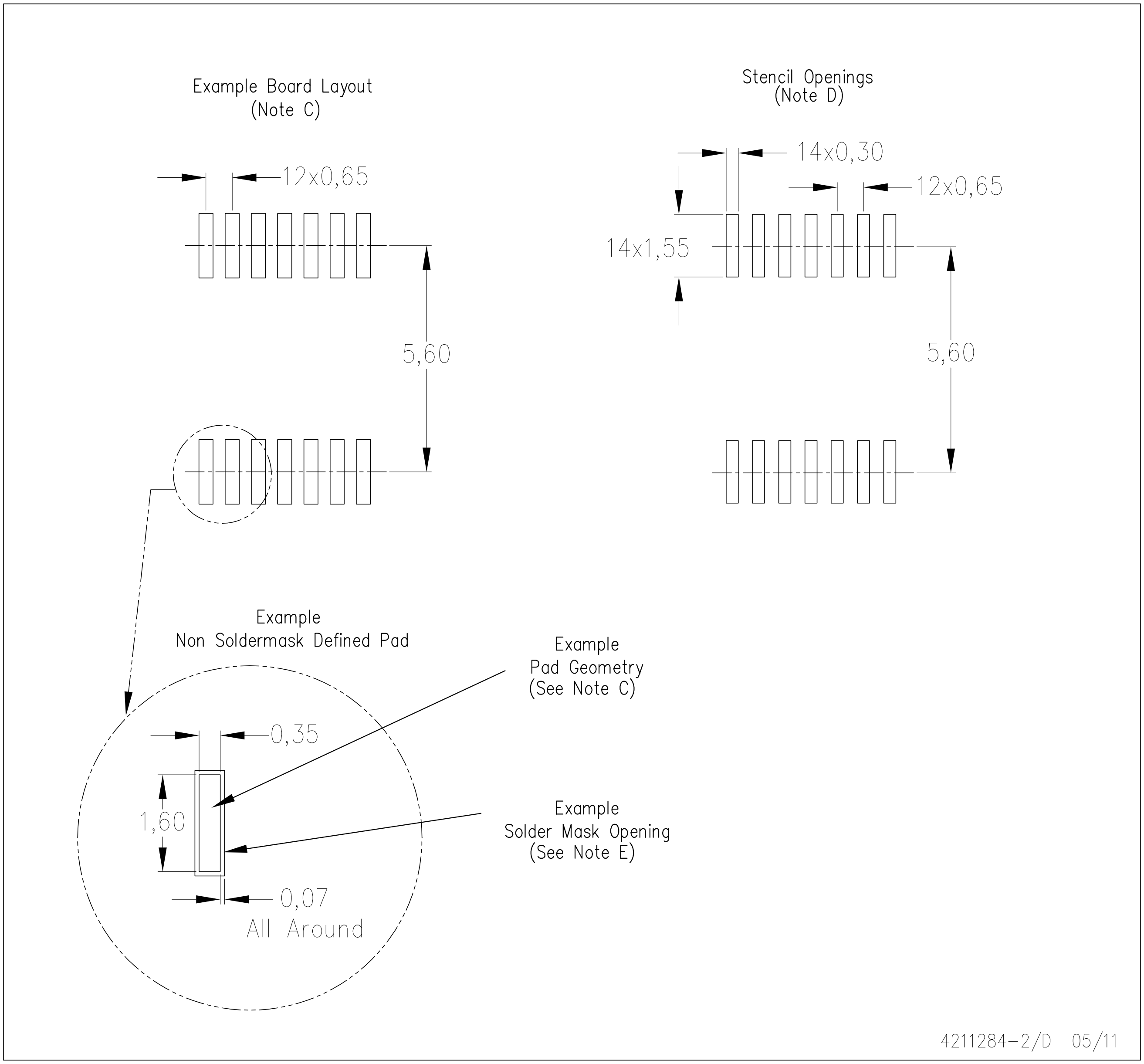
PW (R-PDSO-G14) PLASTIC SMALL OUTLINE



4040064-3/G 02/11

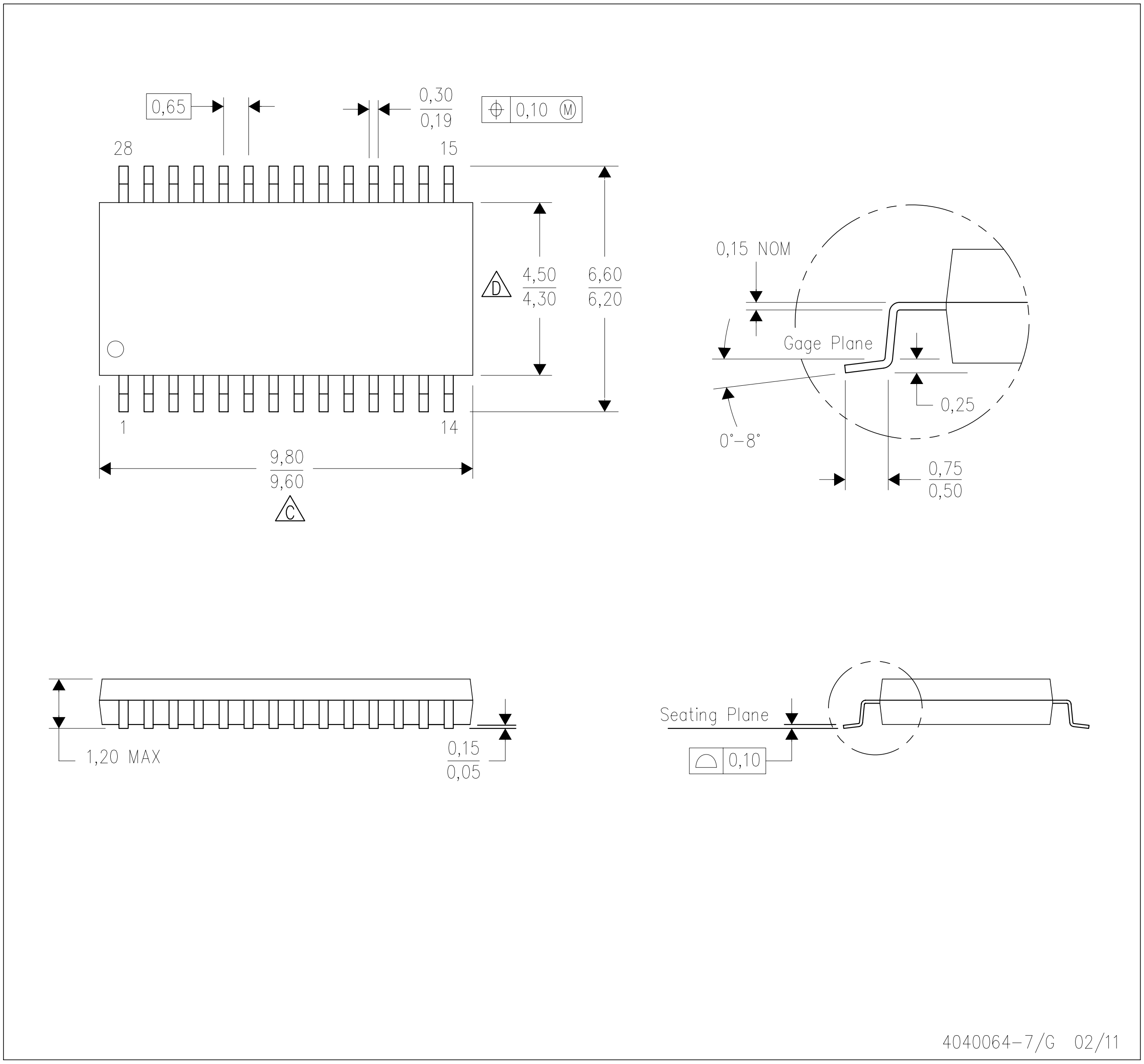
NOTES:
- A. All linear dimensions are in millimeters. Dimensioning and tolerancing per ASME Y14.5M–1994.
- B. This drawing is subject to change without notice.
- C. Body length does not include mold flash, protrusions, or gate burrs. Mold flash, protrusions, or gate burrs shall not exceed 0,15 each side.
- D. Body width does not include interlead flash. Interlead flash shall not exceed 0,25 each side.
- E. Falls within JEDEC MO-153

PW (R–PDSO–G14) PLASTIC SMALL OUTLINE



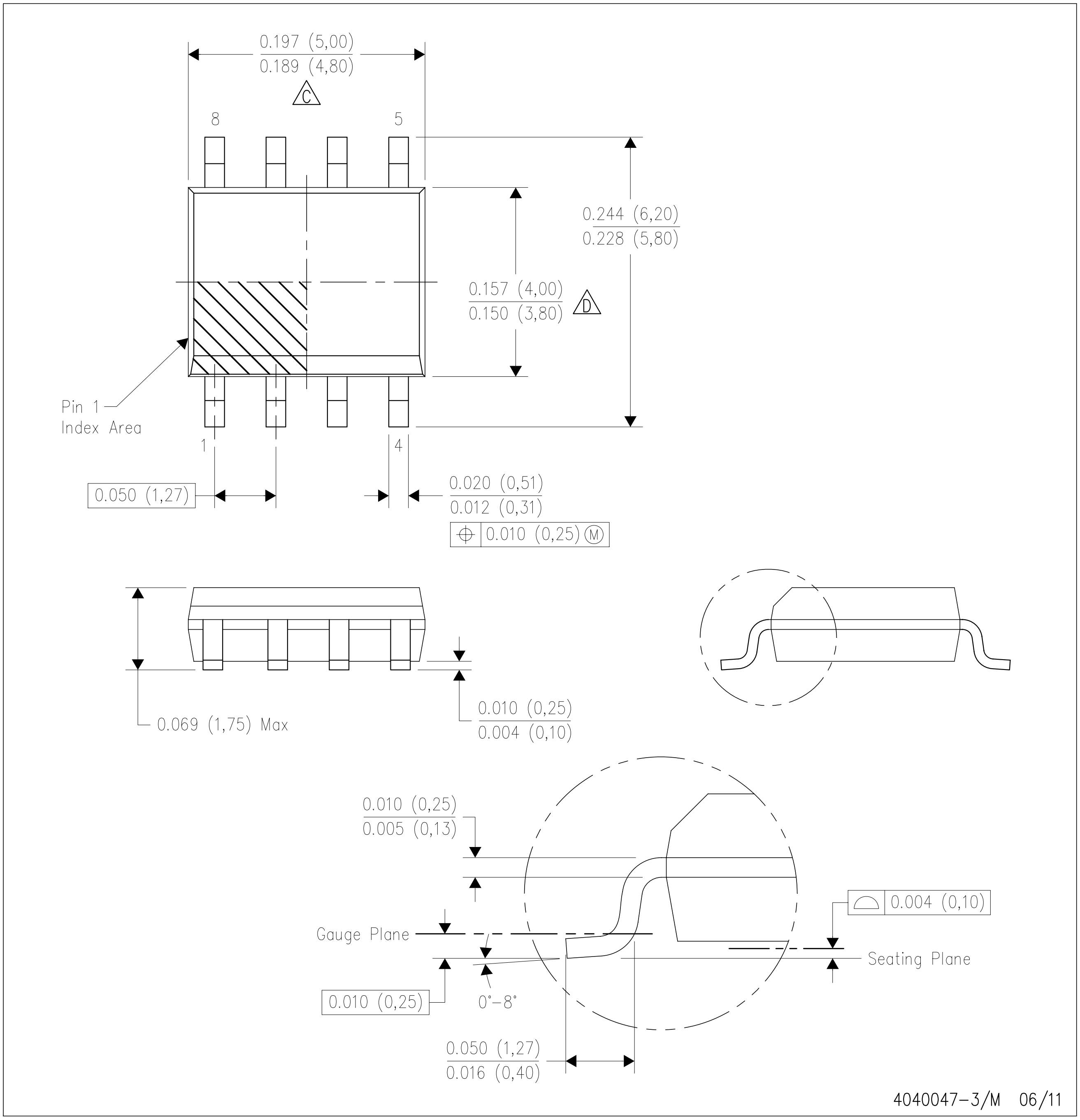
NOTES:
A. All linear dimensions are in millimeters.
B. This drawing is subject to change without notice.
C. Publication IPC–7351 is recommended for alternate designs.
D. Laser cutting apertures with trapezoidal walls and also rounding corners will offer better paste release. Customers should contact their board assembly site for stencil design recommendations. Refer to IPC–7525 for other stencil recommendations.
E. Customers should contact their board fabrication site for solder mask tolerances between and around signal pads.

PW (R-PDSO-G28) PLASTIC SMALL OUTLINE



NOTES:
A. All linear dimensions are in millimeters. Dimensioning and tolerancing per ASME Y14.5M–1994.
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 0,15 each side.
D. Body width does not include interlead flash. Interlead flash shall not exceed 0,25 each side.
E. Falls within JEDEC MO–153

D (R-PDSO-G8) PLASTIC SMALL OUTLINE



NOTES:

A. All linear dimensions are in inches (millimeters).

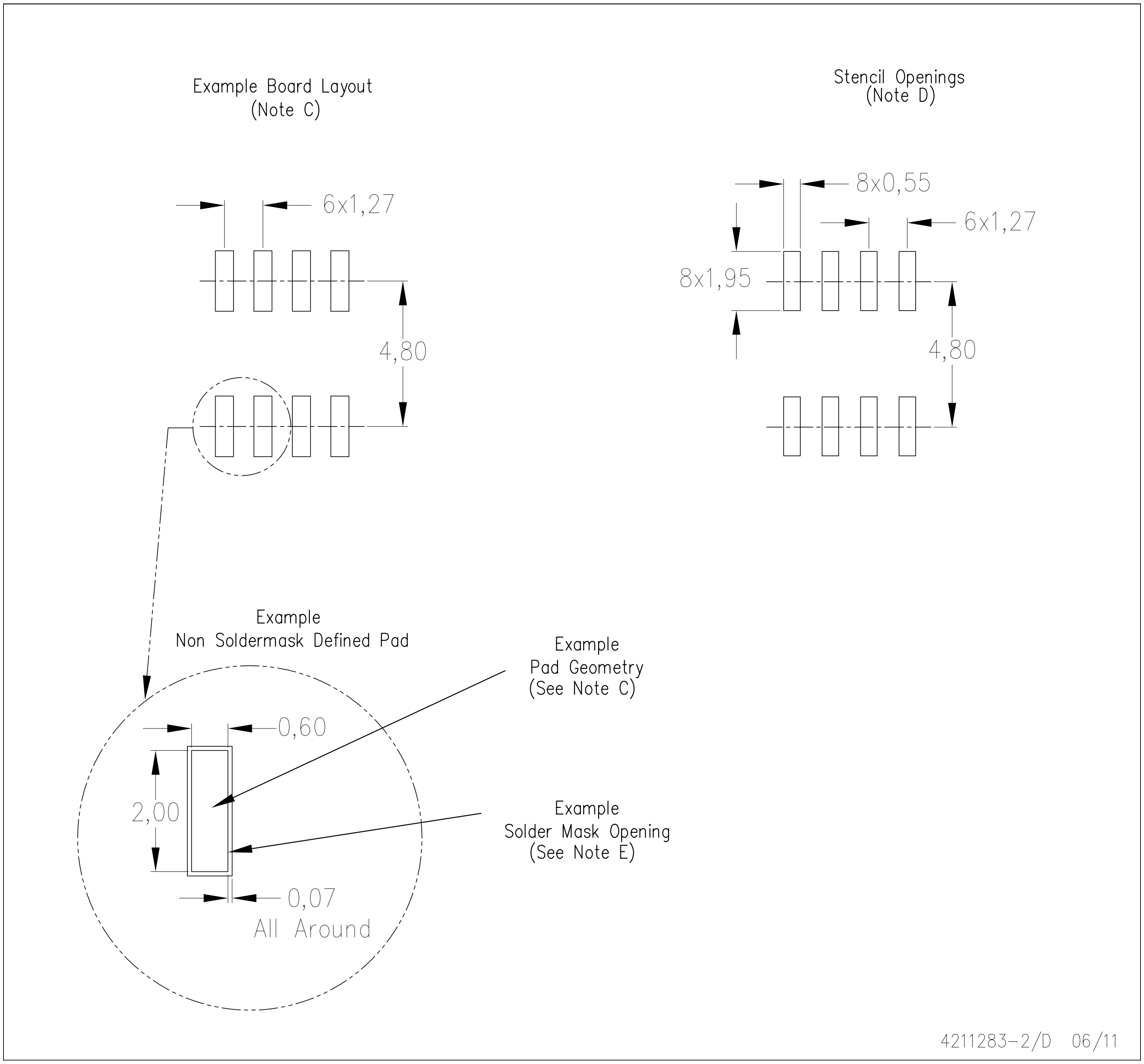
B. This drawing is subject to change without notice.

C. Body length does not include mold flash, protrusions, or gate burrs. Mold flash, protrusions, or gate burrs shall not exceed 0.006 (0,15) each side.

D. Body width does not include interlead flash. Interlead flash shall not exceed 0.017 (0,43) each side.

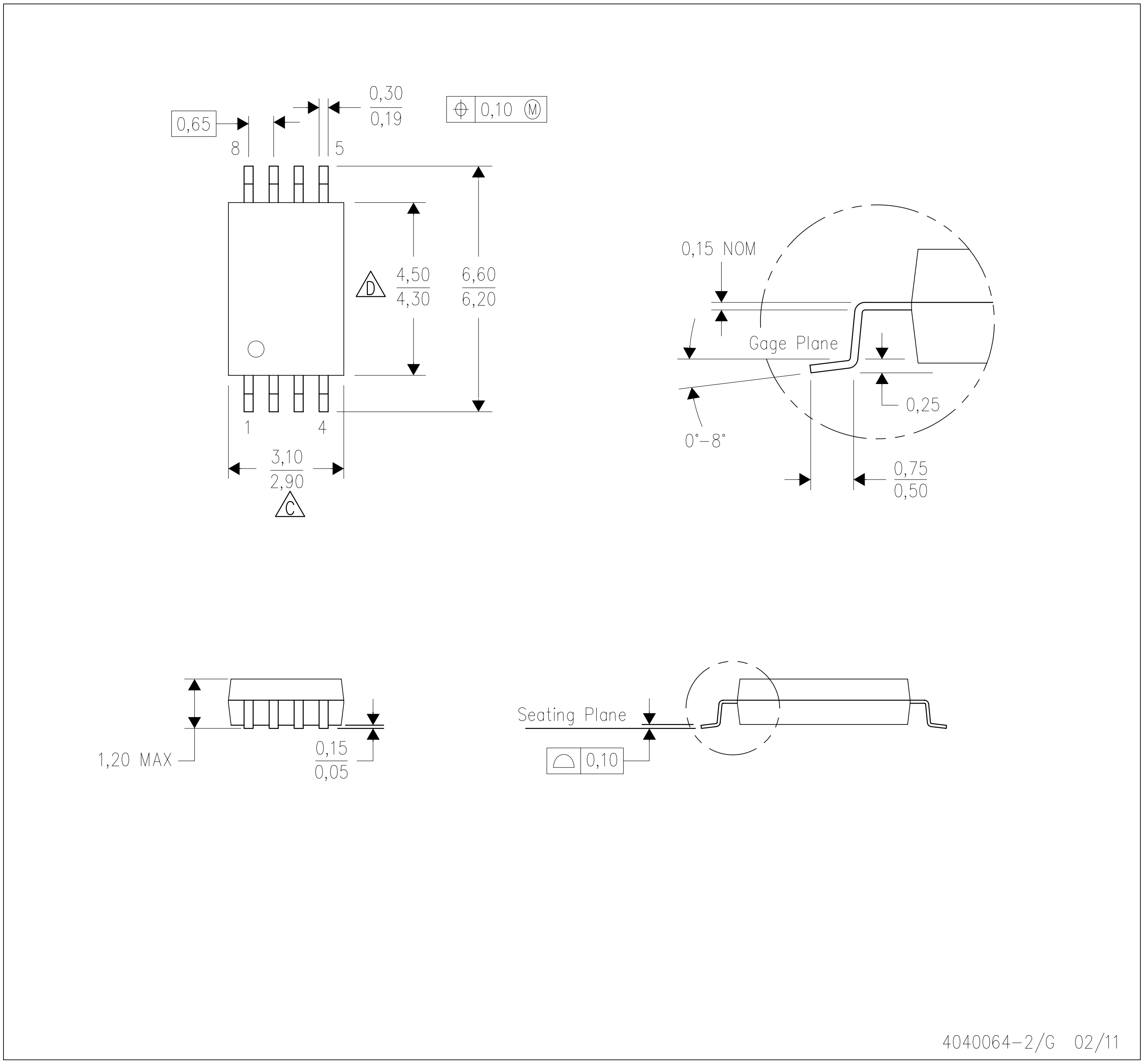
E. Reference JEDEC MS-012 variation AA.

D (R-PDSO-G8) PLASTIC SMALL OUTLINE



NOTES:
- A. All linear dimensions are in millimeters.
- B. This drawing is subject to change without notice.
- C. Publication IPC-7351 is recommended for alternate designs.
- D. Laser cutting apertures with trapezoidal walls and also rounding corners will offer better paste release. Customers should contact their board assembly site for stencil design recommendations. Refer to IPC-7525 for other stencil recommendations.
- E. Customers should contact their board fabrication site for solder mask tolerances between and around signal pads.

PW (R–PDSO–G8) PLASTIC SMALL OUTLINE



NOTES: A. All linear dimensions are in millimeters. Dimensioning and tolerancing per ASME Y14.5M–1994.
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 0,15 each side.
D. Body width does not include interlead flash. Interlead flash shall not exceed 0,25 each side.
E. Falls within JEDEC MO–153

IMPORTANT NOTICE

Following are URLs where you can obtain information on other Texas Instruments products and application solutions:

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Data Converters	dataconverter.ti.com	Consumer Electronics	www.ti.com/consumer-apps
DLP® Products	www.dlp.com	Energy and Lighting	www.ti.com/energy
DSP	dsp.ti.com	Industrial	www.ti.com/industrial
Clocks and Timers	www.ti.com/clocks	Medical	www.ti.com/medical
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