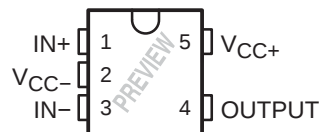


LPV321 SINGLE, LPV358 DUAL, LPV324 QUAD GENERAL-PURPOSE, LOW-VOLTAGE, LOW-POWER, RAIL-TO-RAIL OUTPUT OPERATIONAL AMPLIFIERS

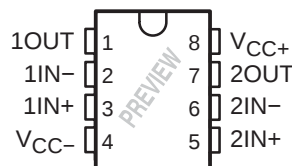
SLOS433H – FEBRUARY 2004 – REVISED OCTOBER 2004

- 2.7-V and 5-V Performance
- -40°C to 125°C Specification at 5 V
- No Crossover Distortion
- Gain Bandwidth of 152 kHz
- Low Supply Current
 - LPV321 . . . 9 μA
 - LPV358 . . . 15 μA
 - LPV324 . . . 28 μA
- Rail-to-Rail Output Swing at 100-k Ω Load
 - $V_{\text{CC}+}$ – 3.5 mV
 - $V_{\text{CC}-}$ + 90 mV
- V_{ICR} . . . -0.2 V to $V_{\text{CC}+}$ – 0.8 V
- Stable With Capacitive Load of 1000 pF
- Applications
 - Active Filters
 - General-Purpose, Low-Voltage Applications
 - Low-Power and/or Portable Applications
- Latch-Up Performance Exceeds 100 mA per JESD 78, Class II
- ESD Protection Exceeds JESD 22
 - 2000-V Human-Body Model (A114-A)
 - 200-V Machine Model (A115-A)
 - 1000-V Charged-Device Model (C101)

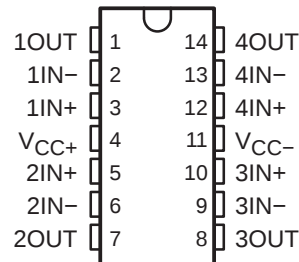
LPV321 . . . DBV OR DCK PACKAGE
(TOP VIEW)



LPV358 . . . D, DDU, OR DGK PACKAGE
(TOP VIEW)



LPV324 . . . D OR PW PACKAGE
(TOP VIEW)



description/ordering information

The LPV321/358/324 devices are low-power (9 μA per channel at 5 V) versions of the LMV321/358/324 operational amplifiers. These are additions to the LMV321/358/324 family of commodity operational amplifiers.

The LPV321/358/324 devices are the most cost-effective solutions for applications where low voltage, low-power operation, space saving, and low price are needed. These devices have rail-to-rail output-swing capability, and the input common-mode voltage range includes ground. They all exhibit excellent speed-power ratios, achieving 152 kHz of bandwidth, with a supply current of only 9 μA typical.

The LPV321, LPV358, and LPV324 are characterized for operation from -40°C to 85°C . The LPV321I, LPV358I, and LPV324I are characterized for operation from -40°C to 125°C .



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.

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**

POST OFFICE BOX 655303 • DALLAS, TEXAS 75265

Copyright © 2004, Texas Instruments Incorporated

LPV321 SINGLE, LPV358 DUAL, LPV324 QUAD
GENERAL-PURPOSE, LOW-VOLTAGE, LOW-POWER, RAIL-TO-RAIL OUTPUT
OPERATIONAL AMPLIFIERS

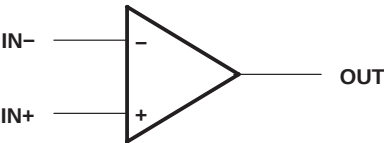
SLOS433H – FEBRUARY 2004 – REVISED OCTOBER 2004

description/ordering information (continued)

ORDERING INFORMATION					
T _A	PACKAGE†			ORDERABLE PART NUMBER	TOP-SIDE MARKING
–40°C to 85°C	Single	SOT23-5 (DBV)	Reel of 3000	LPV321DBVR	PREVIEW
			Reel of 250	LPV321DBVT	
		SOT23-5 (DCK)	Reel of 3000	LPV321DCKR	PREVIEW
			Reel of 250	LPV321DCKT	
	Dual	SOIC-8 (D)	Tube of 75	LPV358D	PREVIEW
			Reel of 2500	LPV358DR	
		VSSOP-8 (DDU)	Reel of 3000	LPV358DDUR	PREVIEW
		VSSOP-8 (DGK)	Reel of 2500	LPV358DGKR	PREVIEW
			Reel of 250	LPV358DGKT	
	Quad	SOIC-14 (D)	Tube of 50	LPV324D	LPV324
			Reel of 2500	LPV324DR	
		TSSOP-14 (PW)	Tube of 90	LPV324PW	PV324
			Reel of 2000	LPV324PWR	
–40°C to 125°C	Single	SOT23-5 (DBV)	Reel of 3000	LPV321IDBVR	PREVIEW
			Reel of 250	LPV321IDBVT	
		SOT23-5 (DCK)	Reel of 3000	LPV321IDCKR	PREVIEW
			Reel of 250	LPV321IDCKT	
	Dual	SOIC-8 (D)	Tube of 75	LPV358ID	PREVIEW
			Reel of 2500	LPV358IDR	
		VSSOP-8 (DDU)	Reel of 3000	LPV358IDDUR	PREVIEW
		VSSOP-8 (DGK)	Reel of 2500	LPV358IDGKR	PREVIEW
			Reel of 250	LPV358IDGKT	
	Quad	SOIC-14 (D)	Tube of 50	LPV324ID	LPV324I
			Reel of 2500	LPV324IDR	
		TSSOP-14 (PW)	Tube of 90	LPV324IPW	PV324I
			Reel of 2000	LPV324IPWR	

† Package drawings, standard packing quantities, thermal data, symbolization, and PCB design guidelines are available at www.ti.com/sc/package.

symbol (each amplifier)



SLOS433H – FEBRUARY 2004 – REVISED OCTOBER 2004

The circuit diagram illustrates a 2.5V CMOS differential amplifier. It features a differential pair of NMOS transistors at the input, biased by a Wilson current source. The Wilson current source is composed of three NMOS transistors and two PMOS transistors, with biasing voltages V_{BIAS1} and V_{BIAS2} . The differential pair is loaded with a Wilson load, which consists of three PMOS transistors and two NMOS transistors, biased by V_{BIAS3} and V_{BIAS4} . The output is taken from the differential nodes, which are also biased by V_{BIAS1} and V_{BIAS2} . The circuit is powered by V_{CC} and ground, and includes input and output buffers.

NOTES:

1. All voltage values, except differential voltages and V_{CC} specified for the measurement of I_{OS} , are with respect to the network GND.
2. Differential voltages are at IN+ with respect to IN-.
3. Maximum power dissipation is a function of $T_J(\text{max})$, θ_{JA} , and T_A . The maximum allowable power dissipation at any allowable ambient temperature is $P_D = (T_J(\text{max}) - T_A)/\theta_{JA}$. Selecting the maximum of 150°C can affect reliability.
4. The package thermal impedance is calculated in accordance with JESD 51-7.

LPV321 SINGLE, LPV358 DUAL, LPV324 QUAD GENERAL-PURPOSE, LOW-VOLTAGE, LOW-POWER, RAIL-TO-RAIL OUTPUT OPERATIONAL AMPLIFIERS

SLOS433H – FEBRUARY 2004 – REVISED OCTOBER 2004

recommended operating conditions

			MIN	MAX	UNIT
V _{CC}	Supply voltage		2.7	5	V
T _A	Operating free-air temperature	LPV3xx	−40	85	°C
		LPV3xxI	−40	125	

ESD protection

TEST CONDITIONS	TYP	UNIT
Human-Body Model	2	kV
Machine model	200	V
Charged-Device Model	1	kV



LPV321 SINGLE, LPV358 DUAL, LPV324 QUAD
GENERAL-PURPOSE, LOW-VOLTAGE, LOW-POWER, RAIL-TO-RAIL OUTPUT
OPERATIONAL AMPLIFIERS

SLOS433H – FEBRUARY 2004 – REVISED OCTOBER 2004

2.7-V electrical characteristics

$T_A = 25^\circ\text{C}$, $V_{CC+} = 2.7\text{ V}$, $V_{CC-} = 0\text{ V}$, $V_{IC} = 1\text{ V}$, $V_O = V_{CC+}/2$, and $R_L > 1\text{ M}\Omega$ (unless otherwise noted)

PARAMETER	TEST CONDITIONS	MIN	TYP [†]	MAX	UNIT
V_{IO} Input offset voltage			1.2	7	mV
α_{VIO} Average temperature coefficient of input offset voltage			4		$\mu\text{V}/^\circ\text{C}$
I_{IB} Input bias current			1.7	50	nA
I_{IO} Input offset current			0.6	40	nA
CMRR Common-mode rejection ratio	$0 \leq V_{IC} \leq 1.7\text{ V}$	50	70		dB
k_{SVR} Supply-voltage rejection ratio	$2.7\text{ V} \leq V_{CC+} \leq 5\text{ V}$, $V_{IC} = 1\text{ V}$, $V_O = 1\text{ V}$	50	65		dB
V_{ICR} Common-mode input voltage range	CMRR $\geq 50\text{ dB}$	0 to 1.7	-0.2 to 1.9		V
V_O Output swing	$R_L = 100\text{ k}\Omega$ to 1.35 V	High level	$V_{CC+} - 0.100$	$V_{CC+} - 0.003$	V
		Low level	0.080	0.180	
I_{CC} Supply current	LPV321 [§]		4	8	μA
	LPV358 (both amplifiers) [§]		8	16	
	LPV324 (all four amplifiers)		16	24	
SR Slew rate [‡]			0.1		V/ μs
GBW Gain bandwidth product	$C_L = 22\text{ pF}$ (see Note 5)		205		kHz
Φ_m Phase margin	$C_L = 22\text{ pF}$ (see Note 5)		71		deg
Gain margin	$C_L = 22\text{ pF}$ (see Note 5)		11		dB
V_n Equivalent input noise voltage	$f = 1\text{ kHz}$		178		$\text{nV}/\sqrt{\text{Hz}}$
I_n Equivalent input noise current	$f = 1\text{ kHz}$		0.5		$\text{pA}/\sqrt{\text{Hz}}$

[†] All typical values are at $V_{CC} = 2.7\text{ V}$, $T_A = 25^\circ\text{C}$.

[‡] Number specified is the slower of the positive and negative slew rates.

[§] Product Preview

NOTE 5: Closed-loop gain = 18 dB, $V_{IC} = V_{CC+}/2$

LPV321 SINGLE, LPV358 DUAL, LPV324 QUAD

GENERAL-PURPOSE, LOW-VOLTAGE, LOW-POWER, RAIL-TO-RAIL OUTPUT

OPERATIONAL AMPLIFIERS

SLOS433H – FEBRUARY 2004 – REVISED OCTOBER 2004

5-V electrical characteristics

$T_A = 25^\circ\text{C}$, $V_{CC+} = 5\text{ V}$, $V_{CC-} = 0\text{ V}$, $V_{IC} = 2\text{ V}$, $V_O = V_{CC+}/2$, and $R_L > 1\text{ M}\Omega$ (unless otherwise noted)

PARAMETER		TEST CONDITIONS		T _A	MIN	TYP [†]	MAX	UNIT
V _{IO}	Input offset voltage			25°C		1.5	7	mV
				–40°C to 85°C			10	
				–40°C to 125°C			11	
αV _{IO}	Average temperature coefficient of input offset voltage			25°C		4		μV/°C
I _{IB}	Input bias current			25°C		2	50	nA
				–40°C to 85°C			60	
				–40°C to 125°C			65	
CMRR	Common-mode rejection ratio	0 ≤ V _{IC} ≤ 4 V		25°C	50	71		dB
k _{SVR}	Supply-voltage rejection ratio	2.7 V ≤ V _{CC+} ≤ 5 V, V _{IC} = 1 V, V _O = 1 V		25°C	50	65		dB
V _{ICR}	Common-mode input voltage range	CMRR ≥ 50 dB		25°C	0 to 4	–0.2 to 4.2		V
I _{IO}	Input offset current			25°C		0.6	40	nA
				–40°C to 85°C			50	
				–40°C to 125°C			55	
V _O	Output swing	R _L = 100 kΩ to 2.5 V	High level	25°C	V _{CC+} – 0.100	V _{CC+} – 0.0035		V
				–40°C to 85°C	V _{CC+} – 0.200			
				–40°C to 125°C	V _{CC+} – 0.225			
			Low level	25°C		0.090	0.180	
				–40°C to 85°C			0.220	
				–40°C to 125°C			0.240	
I _{OS}	Output short-circuit current	Sourcing, V _O = 0 V		25°C	2	17	mA	
		Sinking, V _O = 5 V			20	72		
I _{CC}	Supply current	LPV321 [‡]		25°C		9	12	μA
				–40°C to 85°C			15	
				–40°C to 125°C			40	
		LPV358 (both amplifiers) [‡]		25°C		15	20	
				–40°C to 85°C			24	
				–40°C to 125°C			80	
		LPV324 (all four amplifiers)		25°C		28	42	
				–40°C to 85°C			46	
				–40°C to 125°C			125	
A _V [§]	Large-signal voltage gain	R _L = 100 kΩ		25°C	15	100	V/mV	
				–40°C to 85°C	10			
				–40°C to 125°C	10			
SR [¶]	Slew rate			25°C		0.1		V/μs

[†] All typical values are at $V_{CC} = 5\text{ V}$, $T_A = 25^\circ\text{C}$.

[‡] Product Preview

[§] R_L is connected to V_{CC-} . The output voltage is $0.5\text{ V} \leq V_O \leq 4.5\text{ V}$.

[¶] Number specified is the slower of the positive and negative slew rates. Connected as a voltage follower with 3-V step input.



LPV321 SINGLE, LPV358 DUAL, LPV324 QUAD **GENERAL-PURPOSE, LOW-VOLTAGE, LOW-POWER, RAIL-TO-RAIL OUTPUT** **OPERATIONAL AMPLIFIERS**

SLOS433H – FEBRUARY 2004 – REVISED OCTOBER 2004

5-V electrical characteristics

$T_A = 25^\circ\text{C}$, $V_{CC+} = 5\text{ V}$, $V_{CC-} = 0\text{ V}$, $V_{IC} = 2\text{ V}$, $V_O = V_{CC+}/2$, and $R_L > 1\text{ M}\Omega$ (unless otherwise noted)
(continued)

PARAMETER		TEST CONDITIONS	T_A	MIN	TYP [†]	MAX	UNIT
GBW	Gain bandwidth product	$C_L = 22\text{ pF}$ (see Note 5)	25°C		237		kHz
Φ_m	Phase margin	$C_L = 22\text{ pF}$ (see Note 5)	25°C		74		deg
	Gain margin	$C_L = 22\text{ pF}$ (see Note 5)	25°C		12		dB
V_n	Equivalent input noise voltage	$f = 1\text{ kHz}$	25°C		146		$\text{nV}/\sqrt{\text{Hz}}$
I_n	Equivalent input noise current	$f = 1\text{ kHz}$	25°C		0.3		$\text{pA}/\sqrt{\text{Hz}}$

[†] All typical values are at $V_{CC} = 5\text{ V}$, $T_A = 25^\circ\text{C}$.

NOTE 5: Closed-loop gain = 18 dB, $V_{IC} = V_{CC+}/2$



LPV321 SINGLE, LPV358 DUAL, LPV324 QUAD GENERAL-PURPOSE, LOW-VOLTAGE, LOW-POWER, RAIL-TO-RAIL OUTPUT OPERATIONAL AMPLIFIERS

SLOS433H – FEBRUARY 2004 – REVISED OCTOBER 2004

**SUPPLY CURRENT
vs
SUPPLY VOLTAGE
(LPV324 – All Channels)**

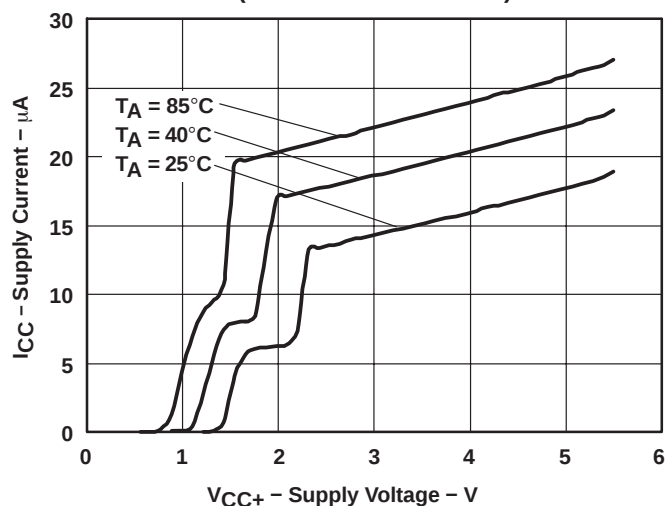


Figure 1

**INPUT BIAS CURRENT
vs
TEMPERATURE**

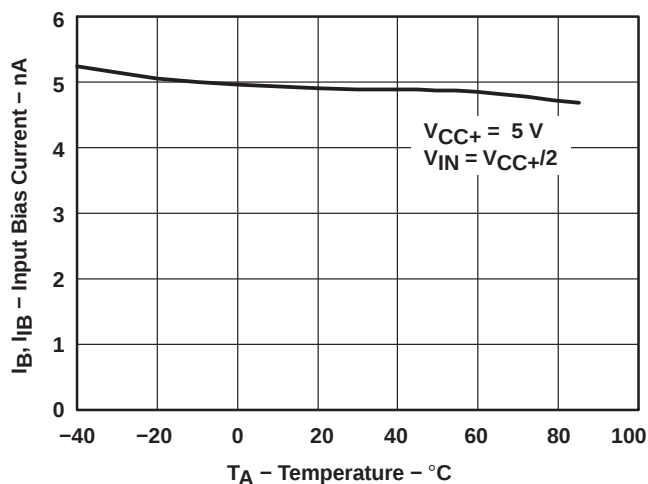


Figure 2

**SOURCING CURRENT
vs
OUTPUT VOLTAGE**

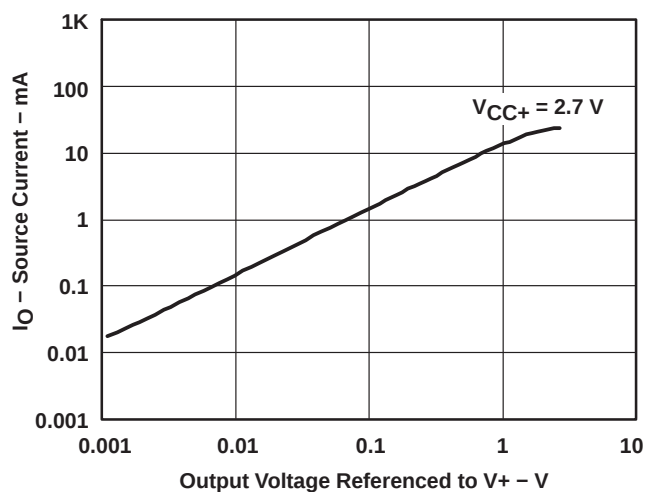


Figure 3

**SOURCING CURRENT
vs
OUTPUT VOLTAGE**

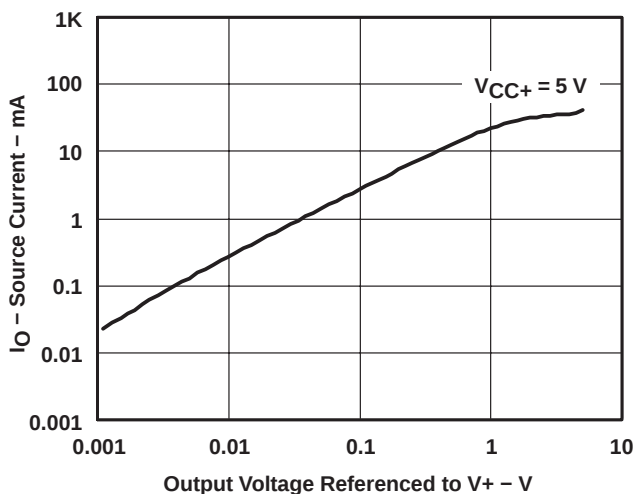


Figure 4

LPV321 SINGLE, LPV358 DUAL, LPV324 QUAD GENERAL-PURPOSE, LOW-VOLTAGE, LOW-POWER, RAIL-TO-RAIL OUTPUT OPERATIONAL AMPLIFIERS

SLOS433H – FEBRUARY 2004 – REVISED OCTOBER 2004

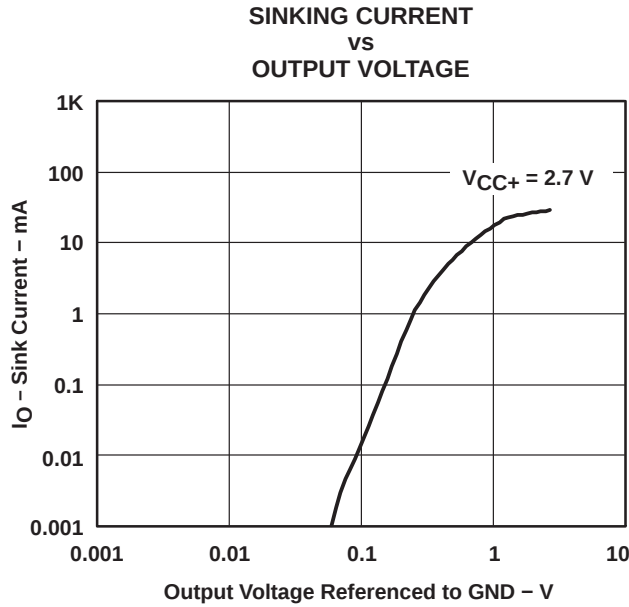


Figure 5

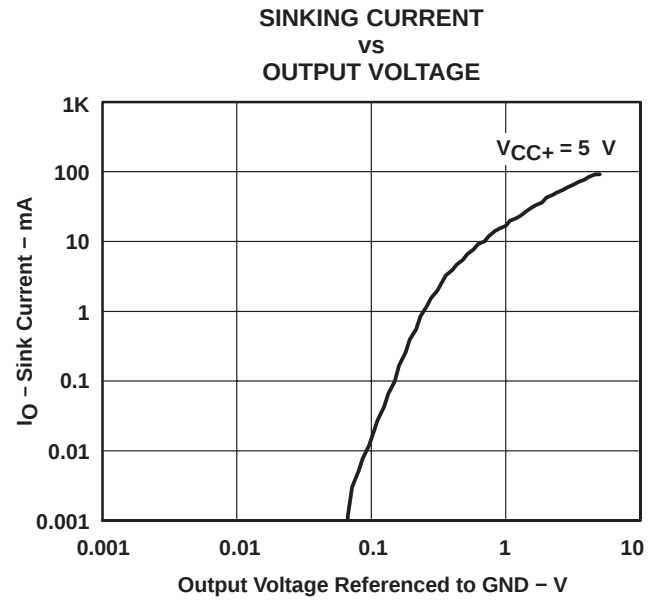


Figure 6

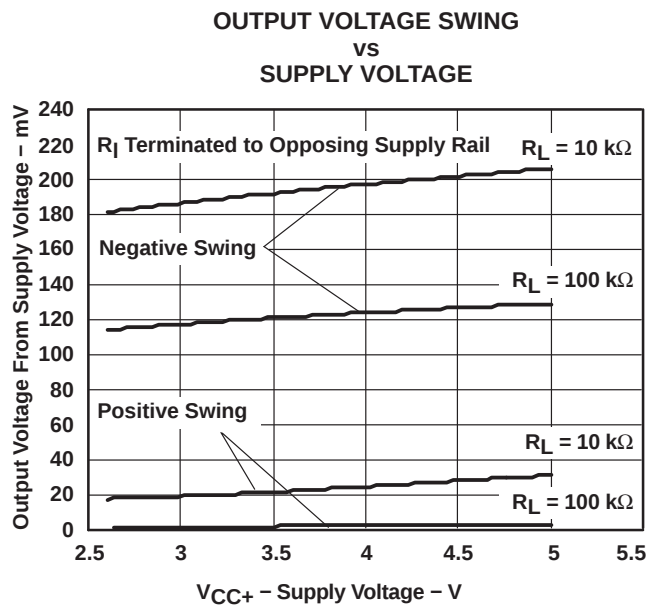


Figure 7

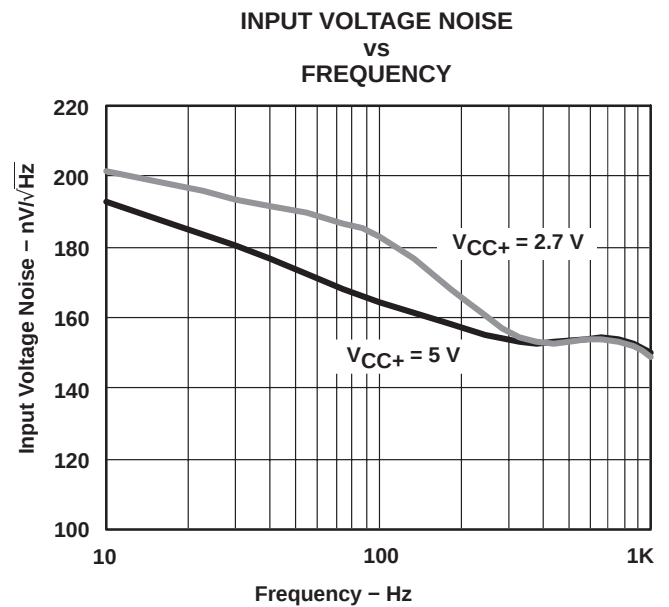


Figure 8

LPV321 SINGLE, LPV358 DUAL, LPV324 QUAD GENERAL-PURPOSE, LOW-VOLTAGE, LOW-POWER, RAIL-TO-RAIL OUTPUT OPERATIONAL AMPLIFIERS

SLOS433H – FEBRUARY 2004 – REVISED OCTOBER 2004

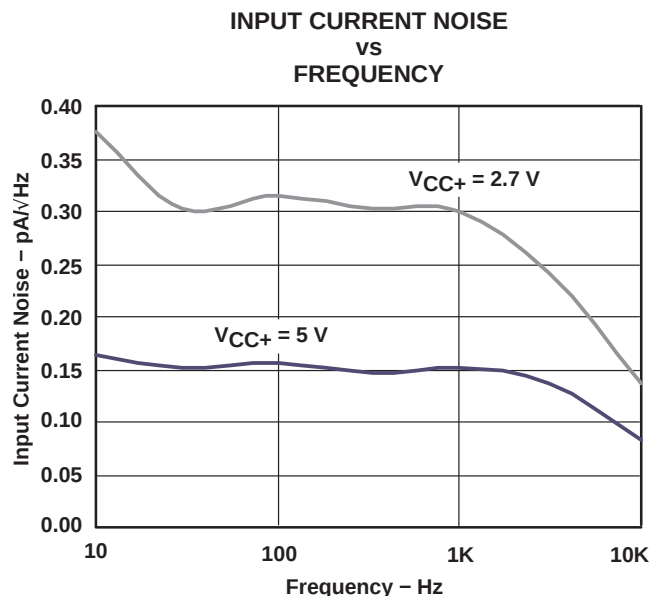


Figure 9

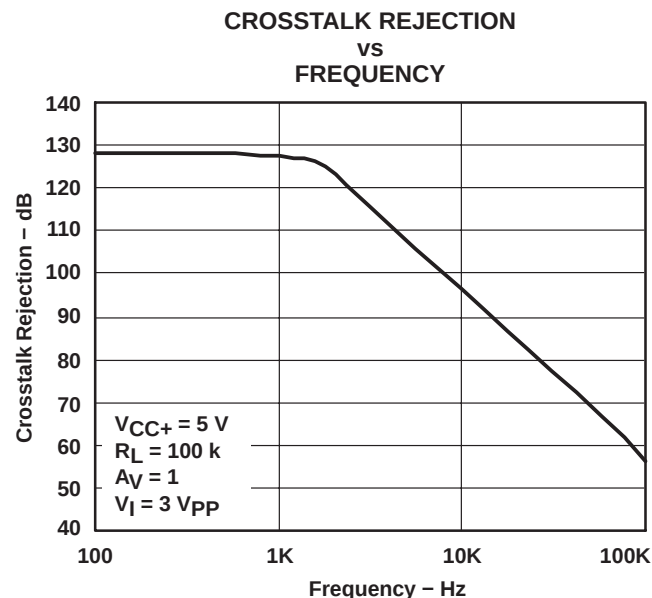


Figure 10

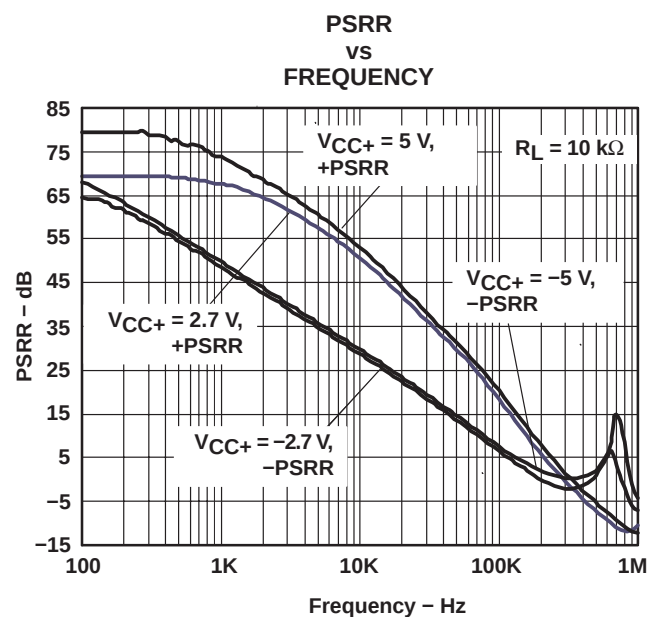


Figure 11

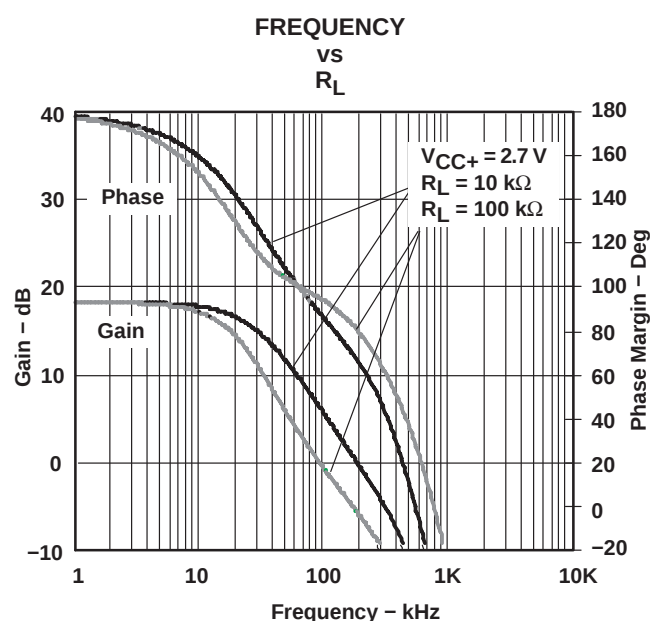


Figure 12

LPV321 SINGLE, LPV358 DUAL, LPV324 QUAD GENERAL-PURPOSE, LOW-VOLTAGE, LOW-POWER, RAIL-TO-RAIL OUTPUT OPERATIONAL AMPLIFIERS

SLOS433H – FEBRUARY 2004 – REVISED OCTOBER 2004

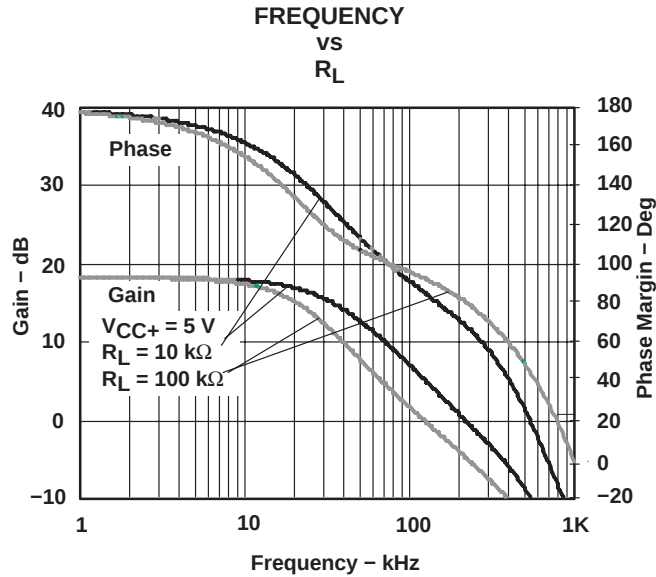


Figure 13

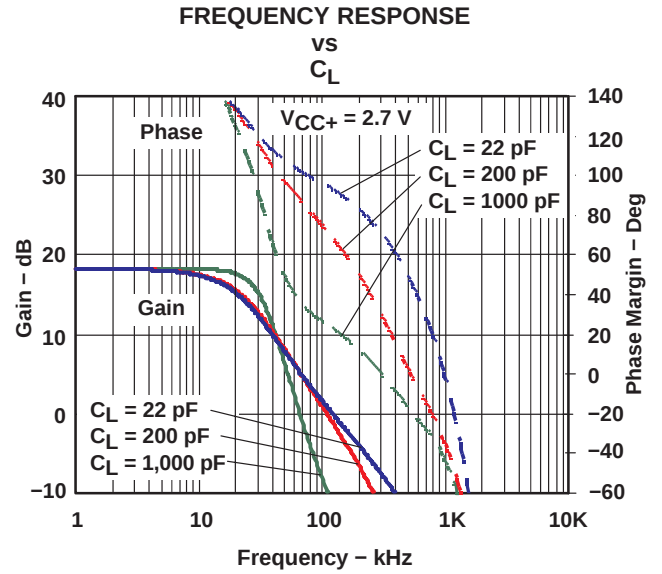


Figure 14

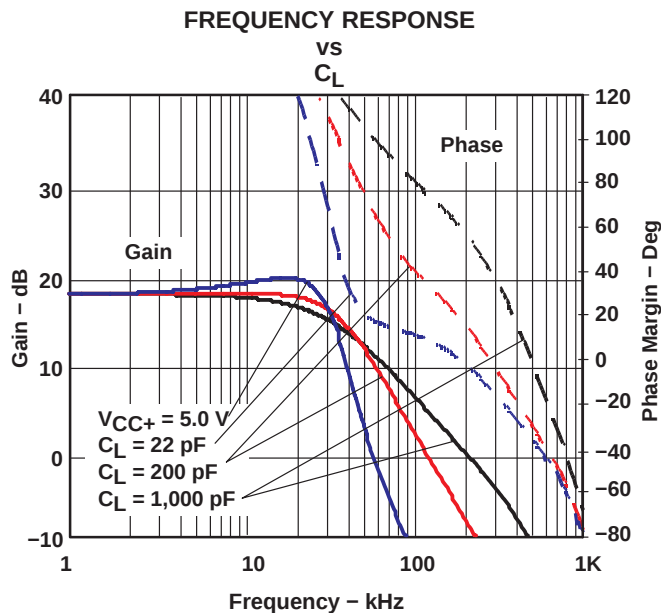


Figure 15

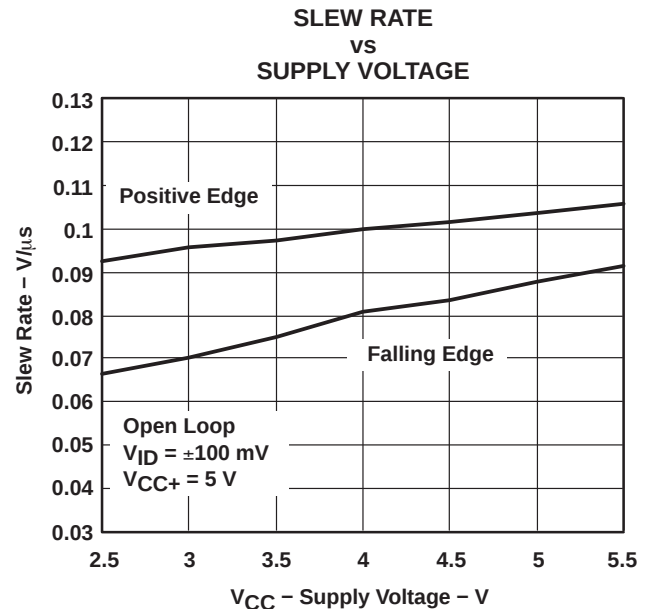


Figure 16

LPV321 SINGLE, LPV358 DUAL, LPV324 QUAD GENERAL-PURPOSE, LOW-VOLTAGE, LOW-POWER, RAIL-TO-RAIL OUTPUT OPERATIONAL AMPLIFIERS

SLOS433H – FEBRUARY 2004 – REVISED OCTOBER 2004

NONINVERTING LARGE-SIGNAL PULSE RESPONSE

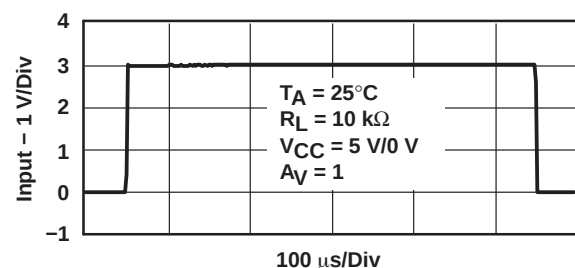


Figure 17

NONINVERTING SMALL-SIGNAL PULSE RESPONSE

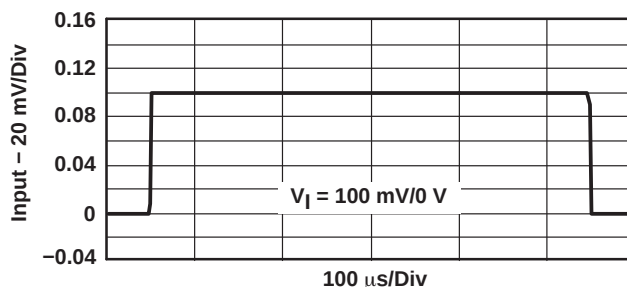


Figure 18

INVERTING LARGE-SIGNAL PULSE RESPONSE

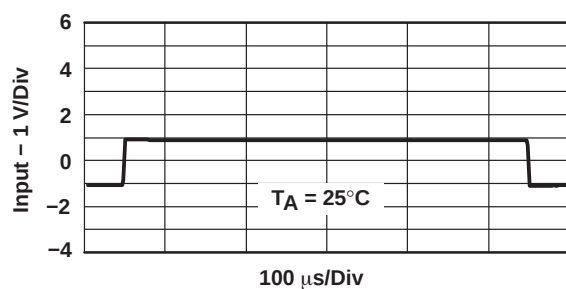


Figure 19

INVERTING SMALL-SIGNAL PULSE RESPONSE

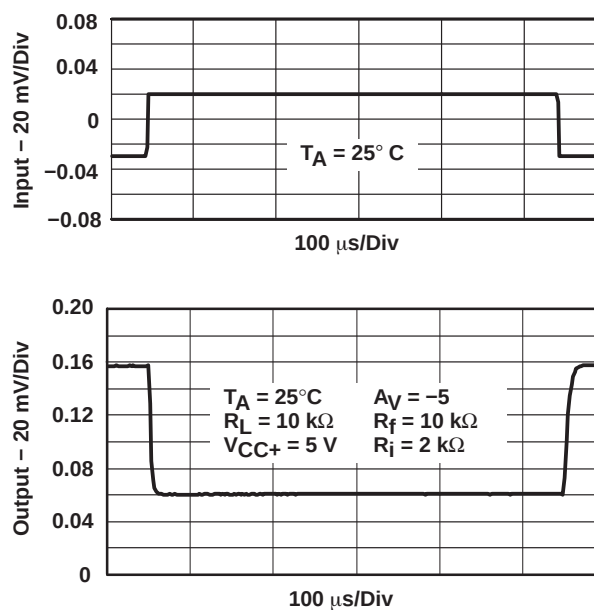
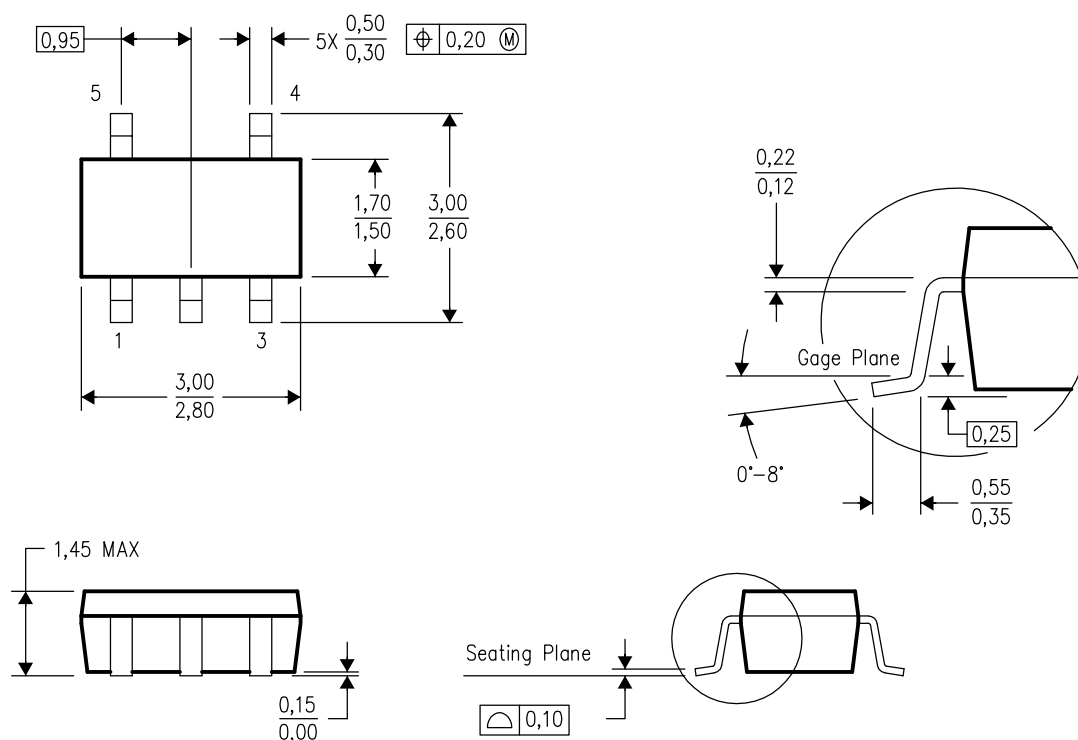


Figure 20

DBV (R-PDSO-G5)

PLASTIC SMALL-OUTLINE PACKAGE

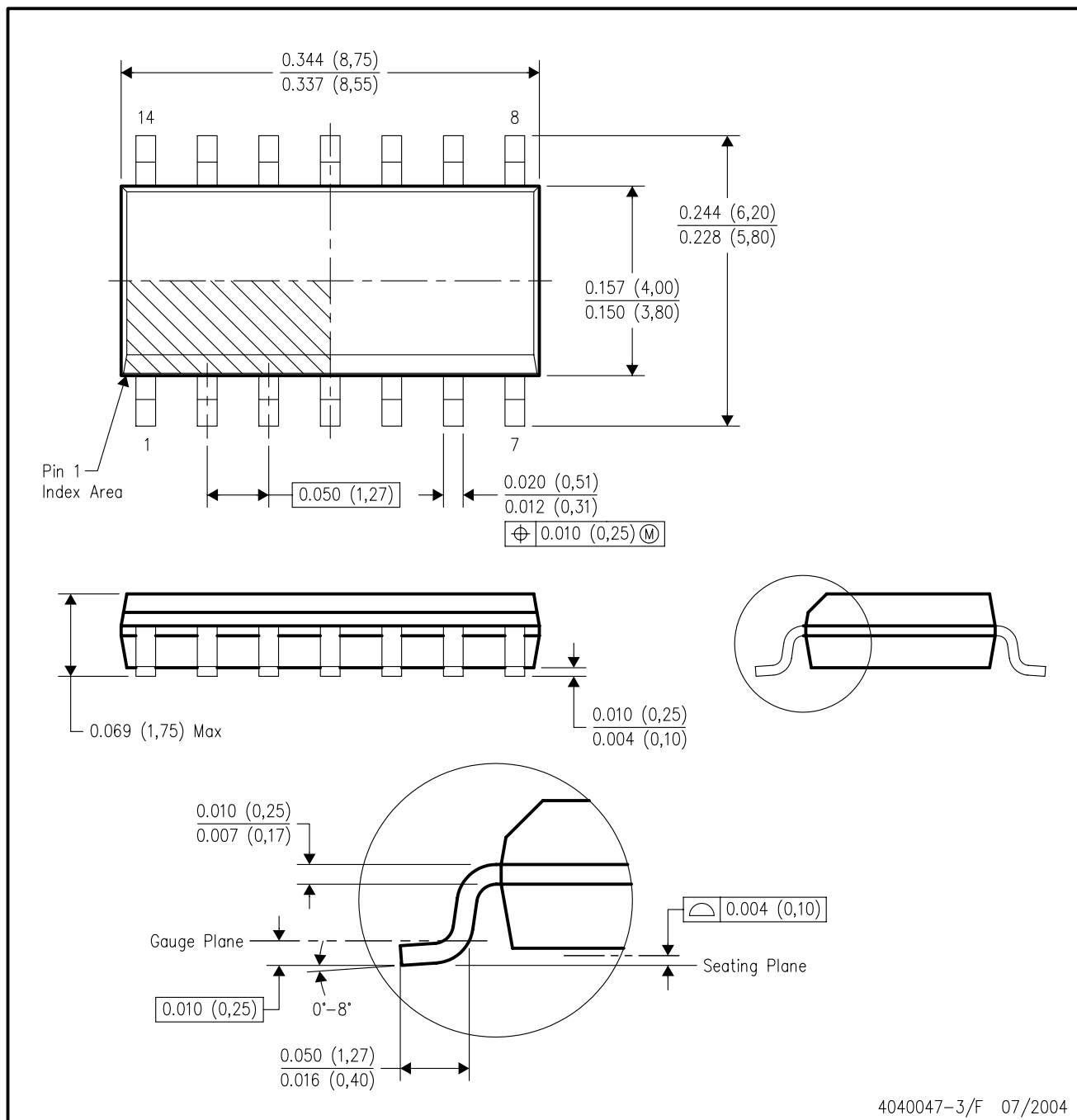


4073253-4/H 10/2003

- 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.
D. Falls within JEDEC MO-178 Variation AA.

D (R-PDSO-G14)

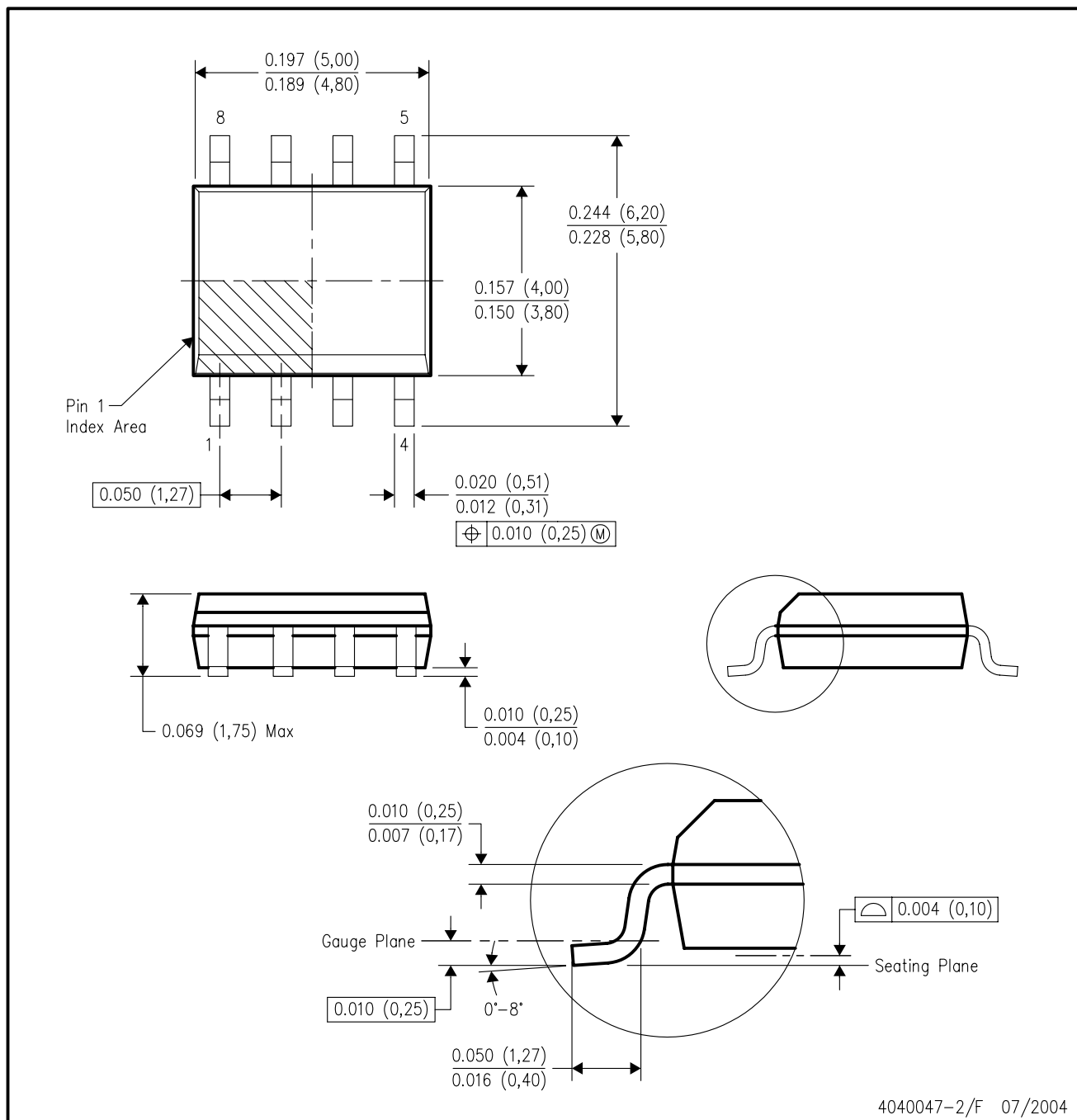
PLASTIC SMALL-OUTLINE PACKAGE



- NOTES:
- All linear dimensions are in inches (millimeters).
 - This drawing is subject to change without notice.
 - Body dimensions do not include mold flash or protrusion not to exceed 0.006 (0,15).
 - Falls within JEDEC MS-012 variation AB.

D (R-PDSO-G8)

PLASTIC SMALL-OUTLINE PACKAGE

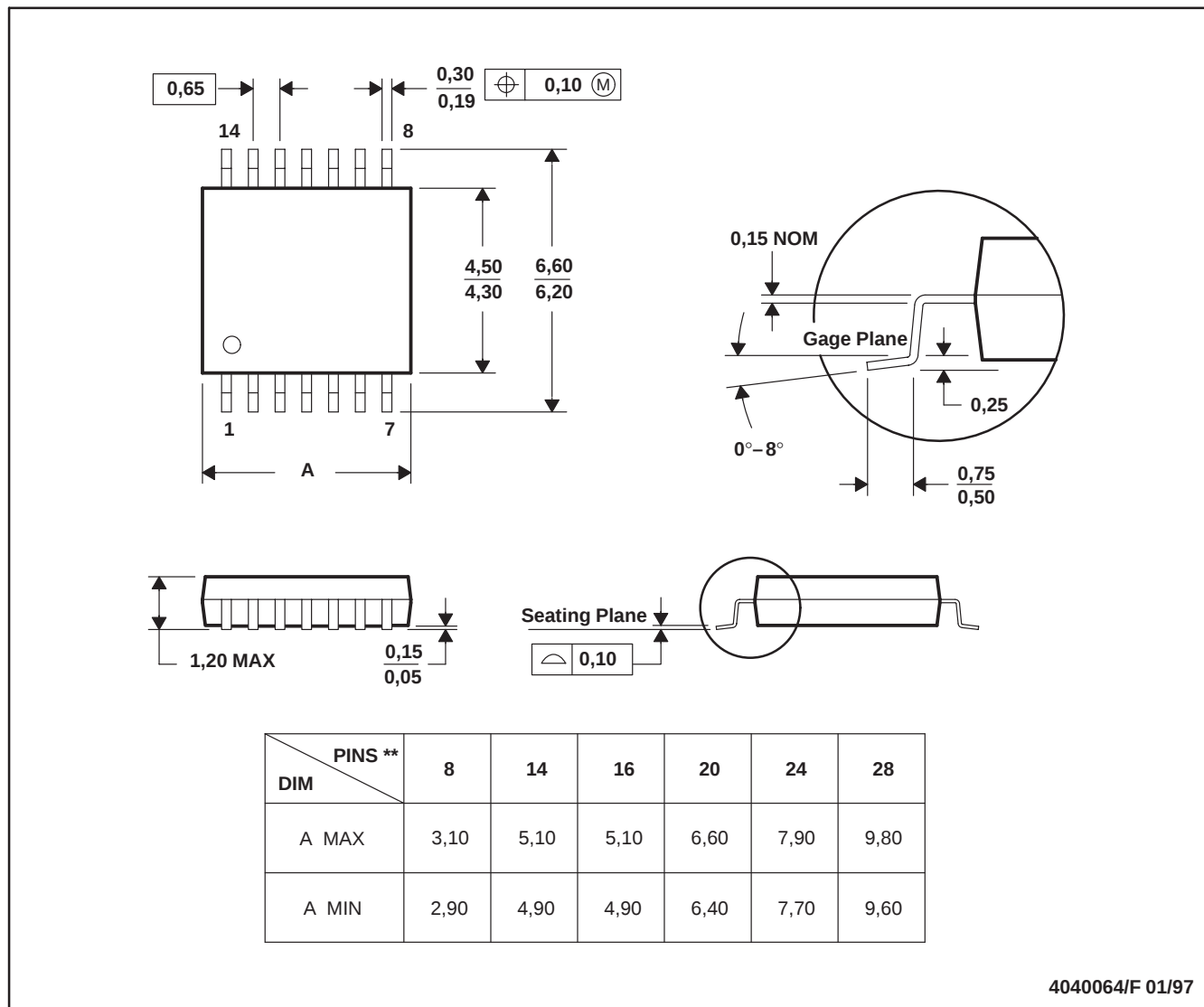


- NOTES:
- All linear dimensions are in inches (millimeters).
 - This drawing is subject to change without notice.
 - Body dimensions do not include mold flash or protrusion not to exceed 0.006 (0,15).
 - Falls within JEDEC MS-012 variation AA.

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

IMPORTANT NOTICE

Texas Instruments Incorporated and its subsidiaries (TI) reserve the right to make corrections, modifications, enhancements, improvements, and other changes to its products and services at any time and to discontinue any product or service without notice. Customers should obtain the latest relevant information before placing orders and should verify that such information is current and complete. All products are sold subject to TI's terms and conditions of sale supplied at the time of order acknowledgment.

TI warrants performance of its hardware products to the specifications applicable at the time of sale in accordance with TI's standard warranty. Testing and other quality control techniques are used to the extent TI deems necessary to support this warranty. Except where mandated by government requirements, testing of all parameters of each product is not necessarily performed.

TI assumes no liability for applications assistance or customer product design. Customers are responsible for their products and applications using TI components. To minimize the risks associated with customer products and applications, customers should provide adequate design and operating safeguards.

TI does not warrant or represent that any license, either express or implied, is granted under any TI patent right, copyright, mask work right, or other TI intellectual property right relating to any combination, machine, or process in which TI products or services are used. Information published by TI regarding third-party products or services does not constitute a license from TI to use such products or services or a warranty or endorsement thereof. Use of such information may require a license from a third party under the patents or other intellectual property of the third party, or a license from TI under the patents or other intellectual property of TI.

Reproduction of information in TI data books or data sheets is permissible only if reproduction is without alteration and is accompanied by all associated warranties, conditions, limitations, and notices. Reproduction of this information with alteration is an unfair and deceptive business practice. TI is not responsible or liable for such altered documentation.

Resale of TI products or services with statements different from or beyond the parameters stated by TI for that product or service voids all express and any implied warranties for the associated TI product or service and is an unfair and deceptive business practice. TI is not responsible or liable for any such statements.

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

Products		Applications	
Amplifiers	amplifier.ti.com	Audio	www.ti.com/audio
Data Converters	dataconverter.ti.com	Automotive	www.ti.com/automotive
DSP	dsp.ti.com	Broadband	www.ti.com/broadband
Interface	interface.ti.com	Digital Control	www.ti.com/digitalcontrol
Logic	logic.ti.com	Military	www.ti.com/military
Power Mgmt	power.ti.com	Optical Networking	www.ti.com/opticalnetwork
Microcontrollers	microcontroller.ti.com	Security	www.ti.com/security
		Telephony	www.ti.com/telephony
		Video & Imaging	www.ti.com/video
		Wireless	www.ti.com/wireless

Mailing Address: Texas Instruments
Post Office Box 655303 Dallas, Texas 75265

Copyright © 2004, Texas Instruments Incorporated