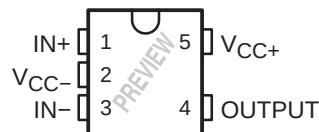


LPV321 SINGLE, LPV358 DUAL, LPV324 QUAD GENERAL-PURPOSE, LOW-VOLTAGE, LOW-POWER, RAIL-TO-RAIL OUTPUT OPERATIONAL AMPLIFIERS

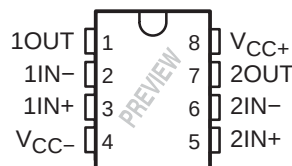
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- 2.7-V and 5-V Performance
- -40°C to 125°C Specification at 5 V
- No Crossover Distortion
- Gain Bandwidth of 152 kHz
- Low Supply Current
 - LPV321 . . . 9 μA
 - LPV358 . . . 15 μA
 - LPV324 . . . 28 μA
- Rail-to-Rail Output Swing at 100-k Ω Load
 - $V_{\text{CC}+} - 3.5\text{ mV}$
 - $V_{\text{CC}-} + 90\text{ mV}$
- V_{ICR} . . . -0.2 V to $V_{\text{CC}+} - 0.8\text{ V}$
- 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)

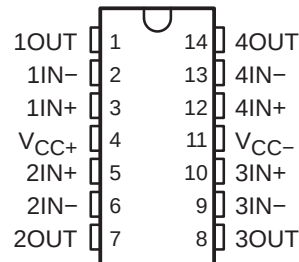
LPV321 . . . DBV OR DCK PACKAGE
(TOP VIEW)



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**

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

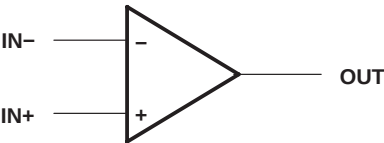
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description/ordering information (continued)

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.

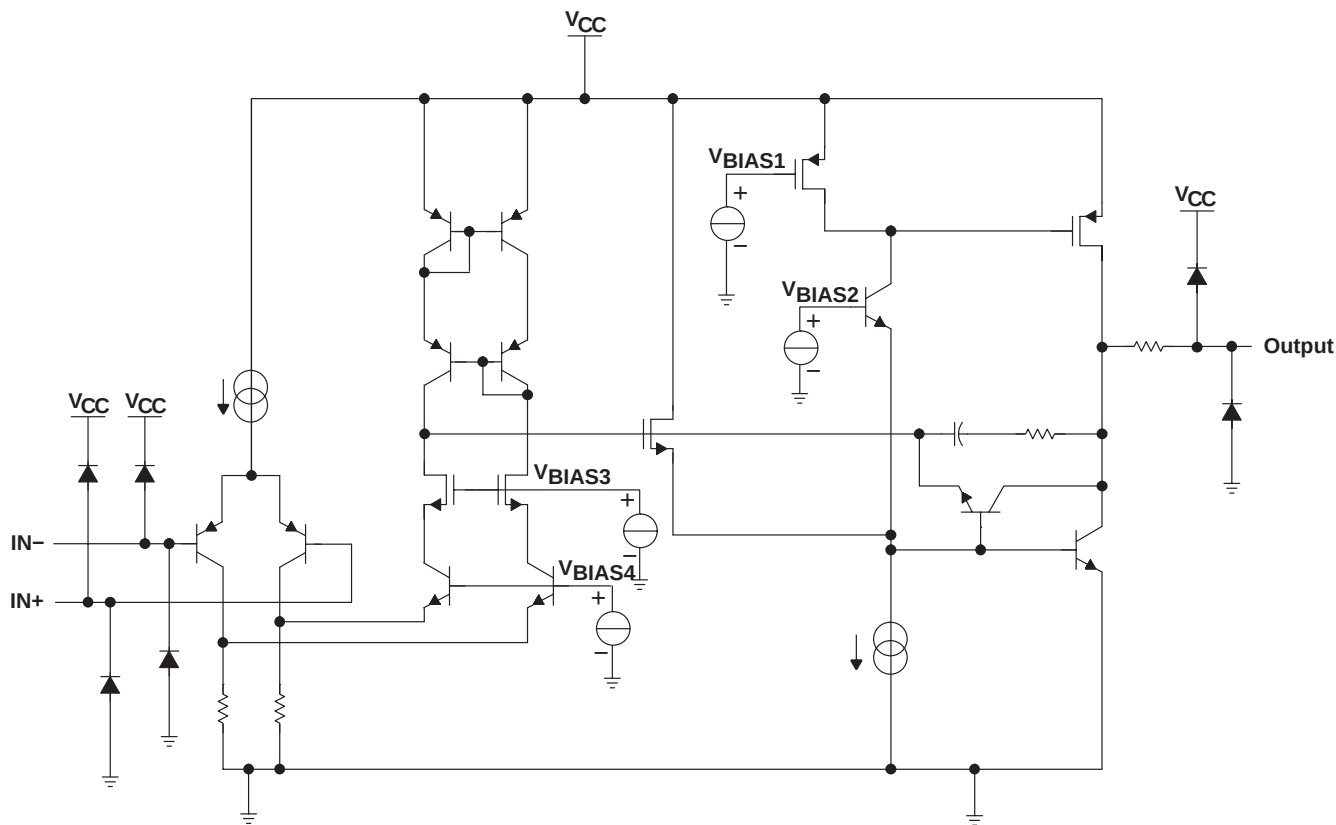
symbol (each amplifier)



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

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LPV324 simplified schematic



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

Supply voltage, $V_{CC+} - V_{CC-}$ (see Note 1)	5.5 V
Differential input voltage, V_{ID} (see Note 2)	$\pm V_{CC}$
Input voltage range, V_I (either input)	V_{CC-} to $V_{CC+} - 1$ V
Package thermal impedance, θ_{JA} (see Notes 3 and 4):	
5-pin DBV package	206°C/W
5-pin DCK package	252°C/W
8-pin D package	97°C/W
8-pin DDU package	TBD°C/W
8-pin DGK package	172°C/W
14-pin D package	86°C/W
14-pin PW package	113°C/W
Maximum junction temperature, T_J	150°C
Storage temperature range, T_{Stg}	-65°C to 150°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 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 $T_J(max)$, θ_{JA} , and T_A . The maximum allowable power dissipation at any allowable ambient temperature is $P_D = (T_J(max) - T_A)/\theta_{JA}$. 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

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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



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

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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

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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	
α _{VIO}	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

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

^{\P} 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

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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

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

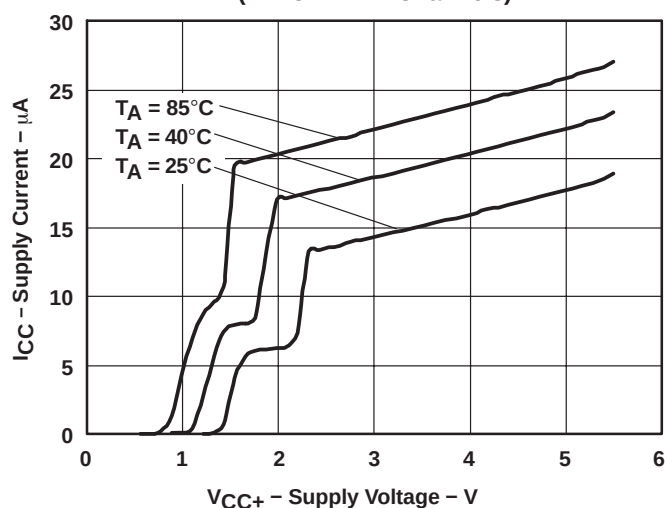


Figure 1

**INPUT BIAS CURRENT
vs
TEMPERATURE**

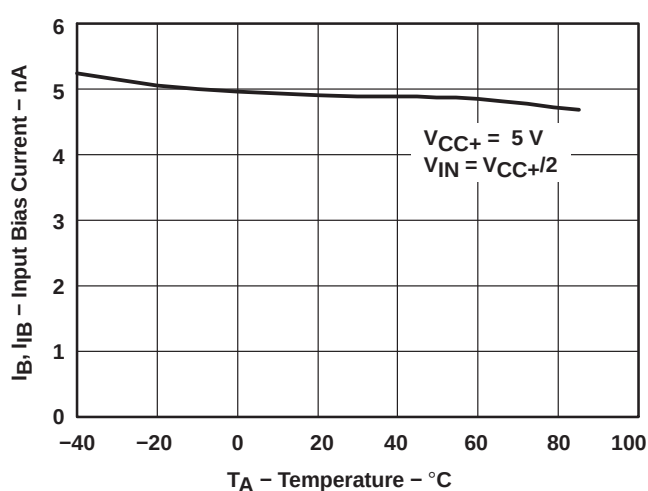


Figure 2

**SOURCING CURRENT
vs
OUTPUT VOLTAGE**

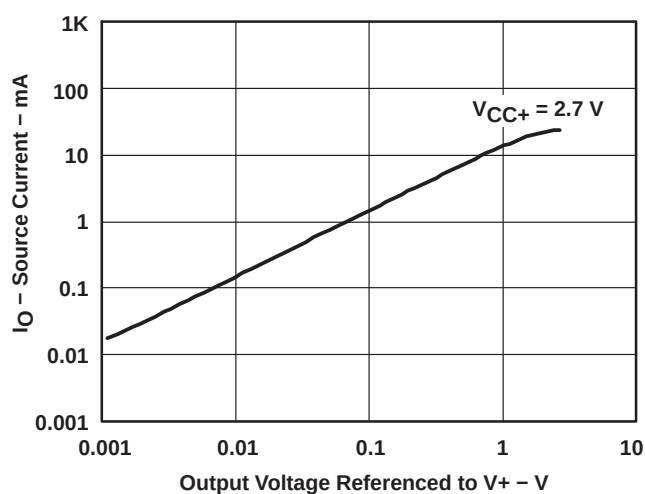


Figure 3

**SOURCING CURRENT
vs
OUTPUT VOLTAGE**

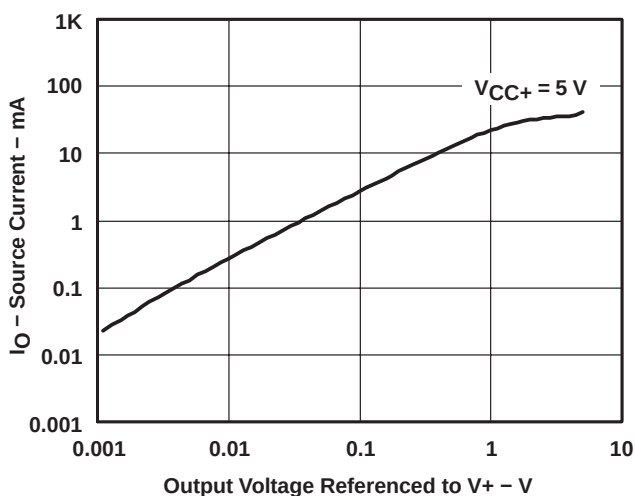


Figure 4

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

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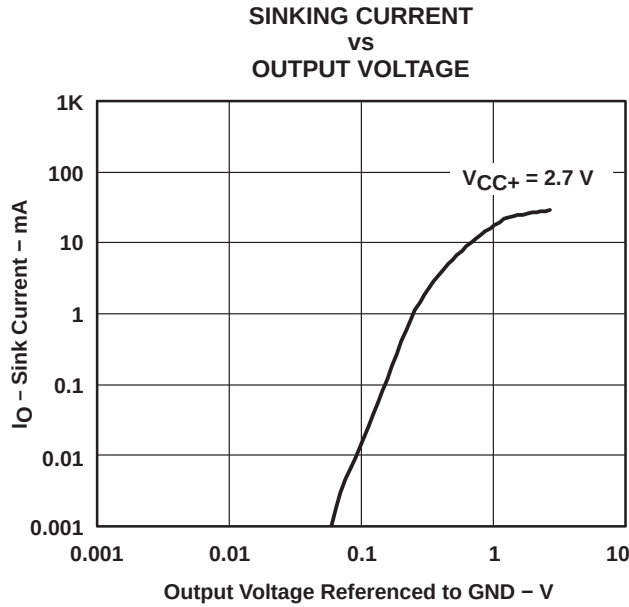


Figure 5

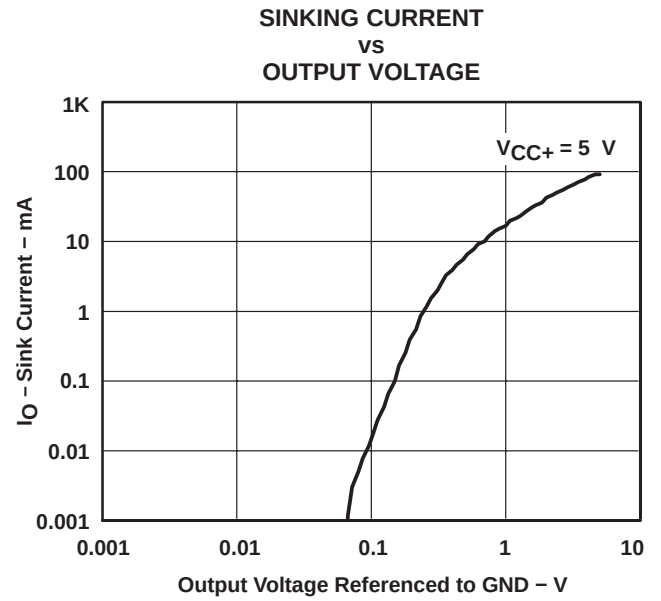


Figure 6

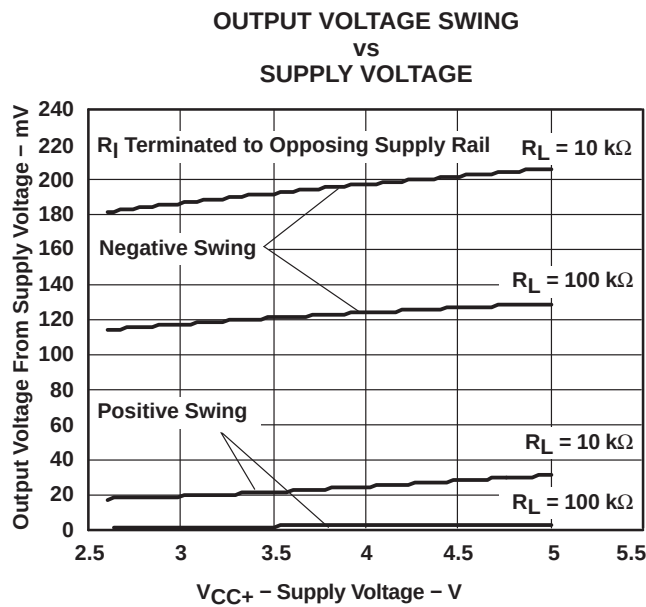


Figure 7

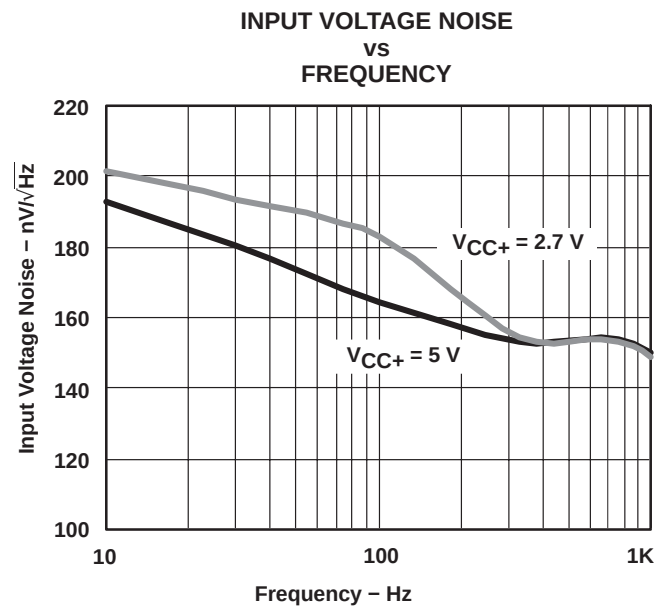


Figure 8

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

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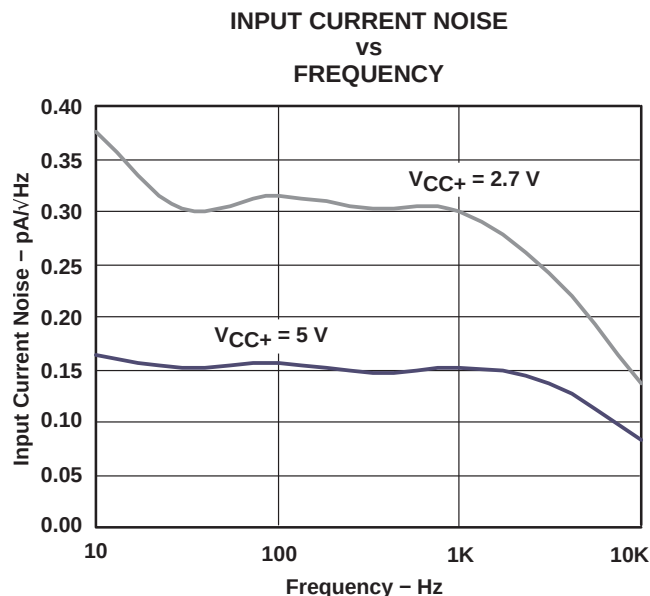


Figure 9

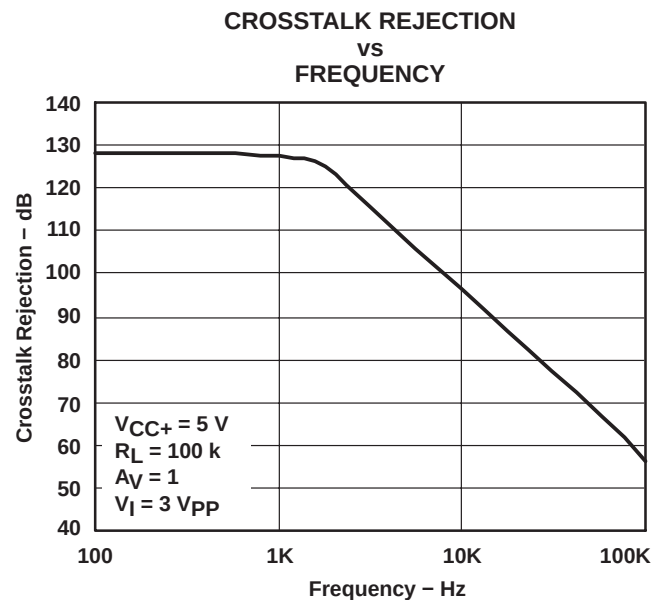


Figure 10

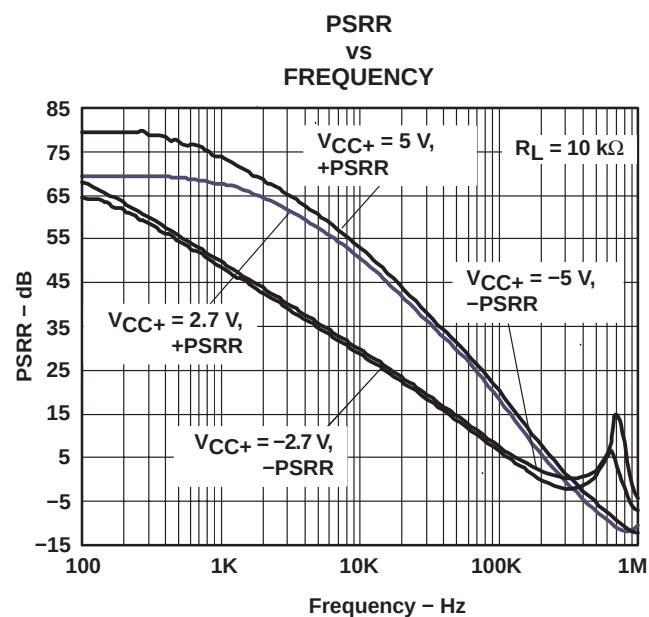


Figure 11

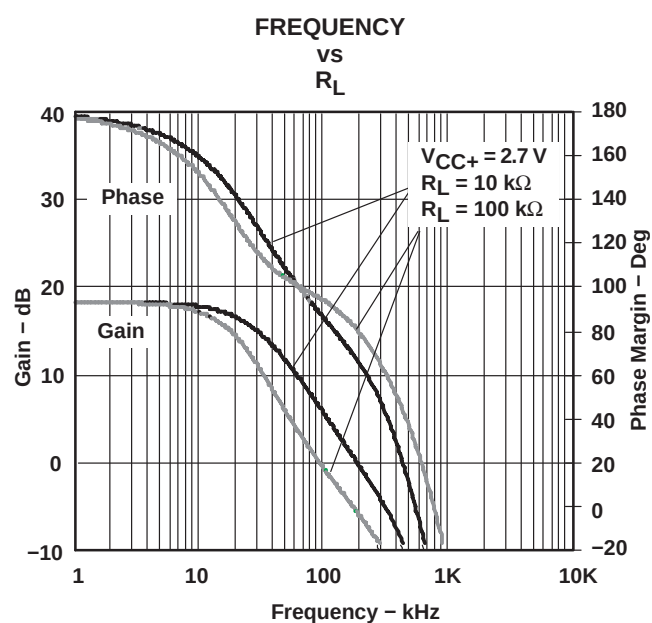


Figure 12

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

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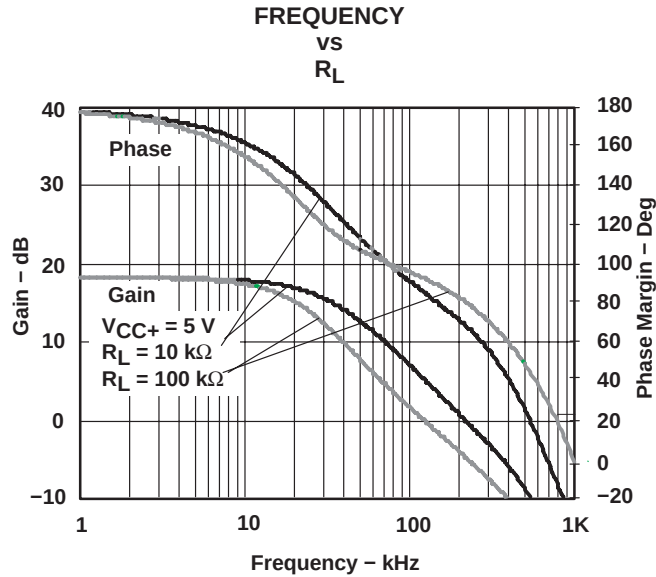


Figure 13

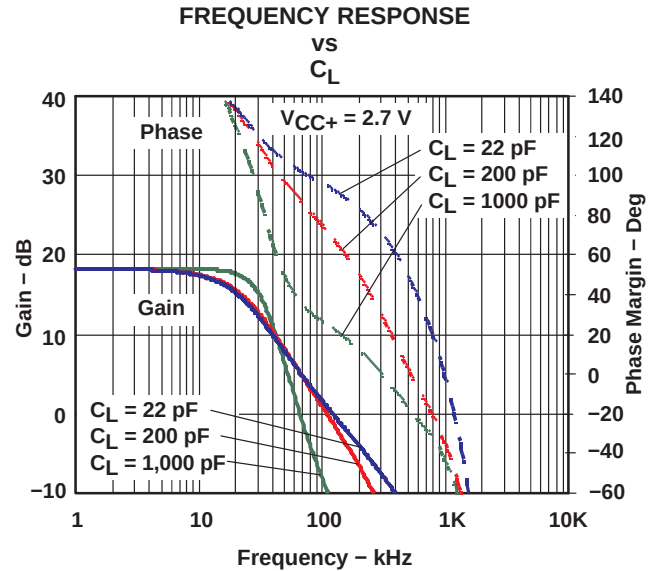


Figure 14

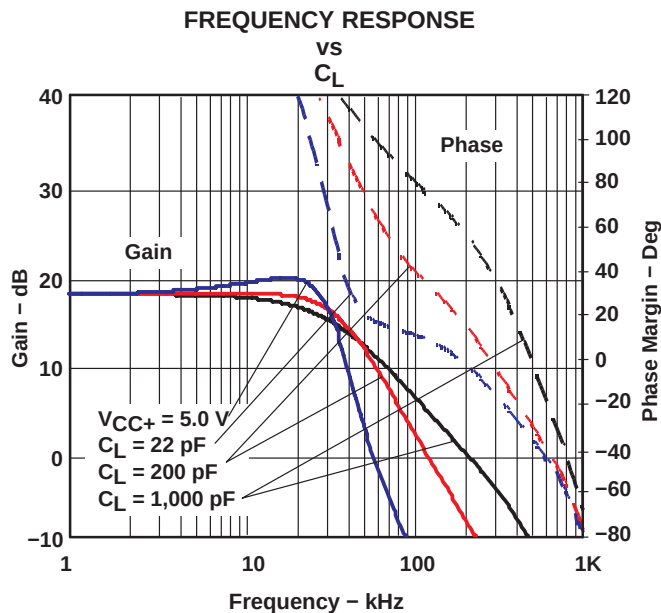


Figure 15

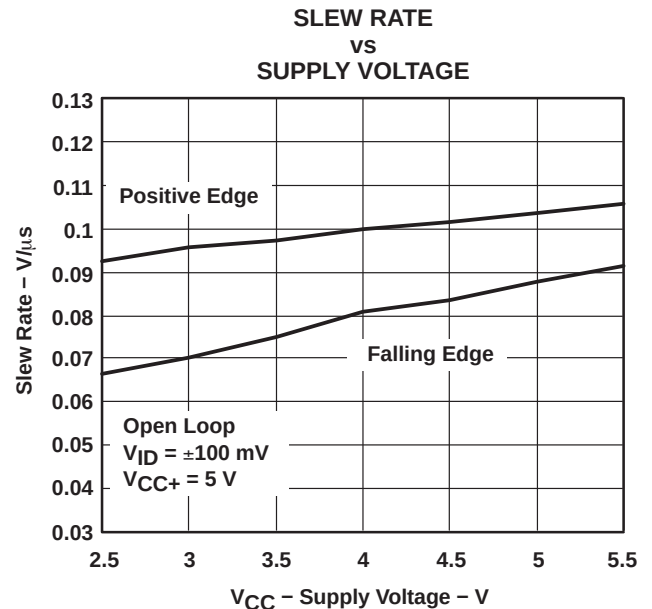


Figure 16

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

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NONINVERTING LARGE-SIGNAL PULSE RESPONSE

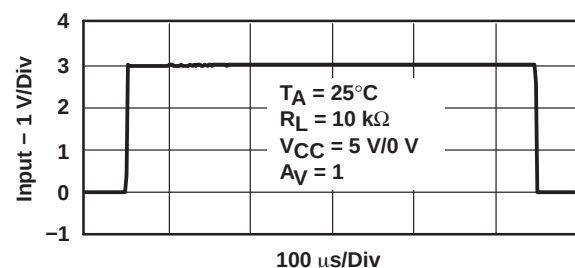


Figure 17

NONINVERTING SMALL-SIGNAL PULSE RESPONSE

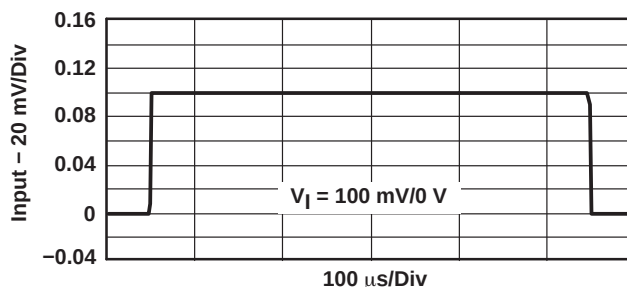


Figure 18

INVERTING LARGE-SIGNAL PULSE RESPONSE

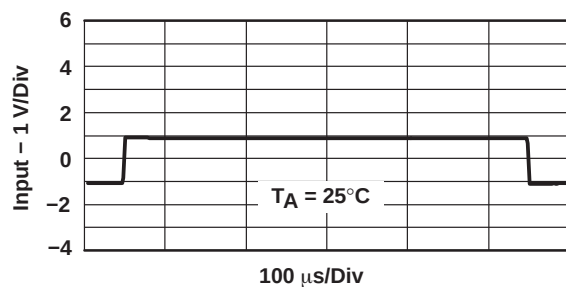


Figure 19

INVERTING SMALL-SIGNAL PULSE RESPONSE

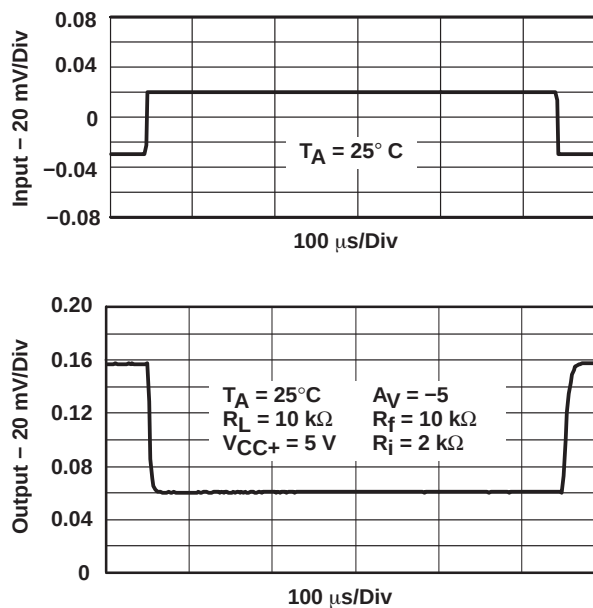
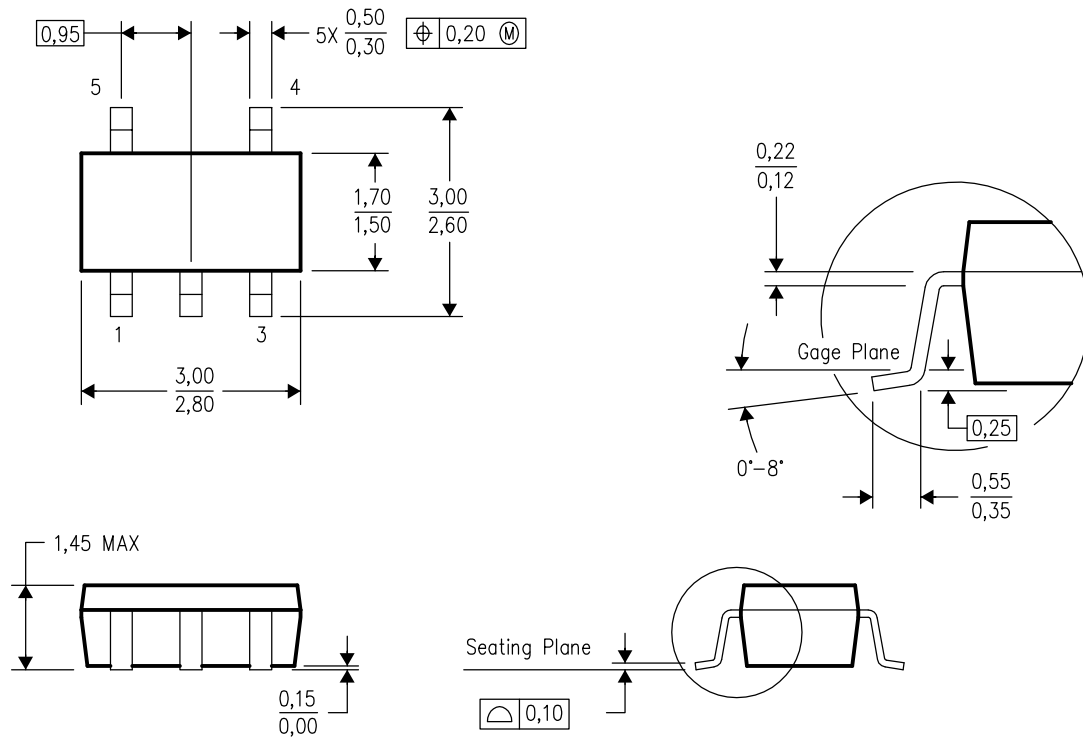


Figure 20

DBV (R-PDSO-G5)

PLASTIC SMALL-OUTLINE PACKAGE

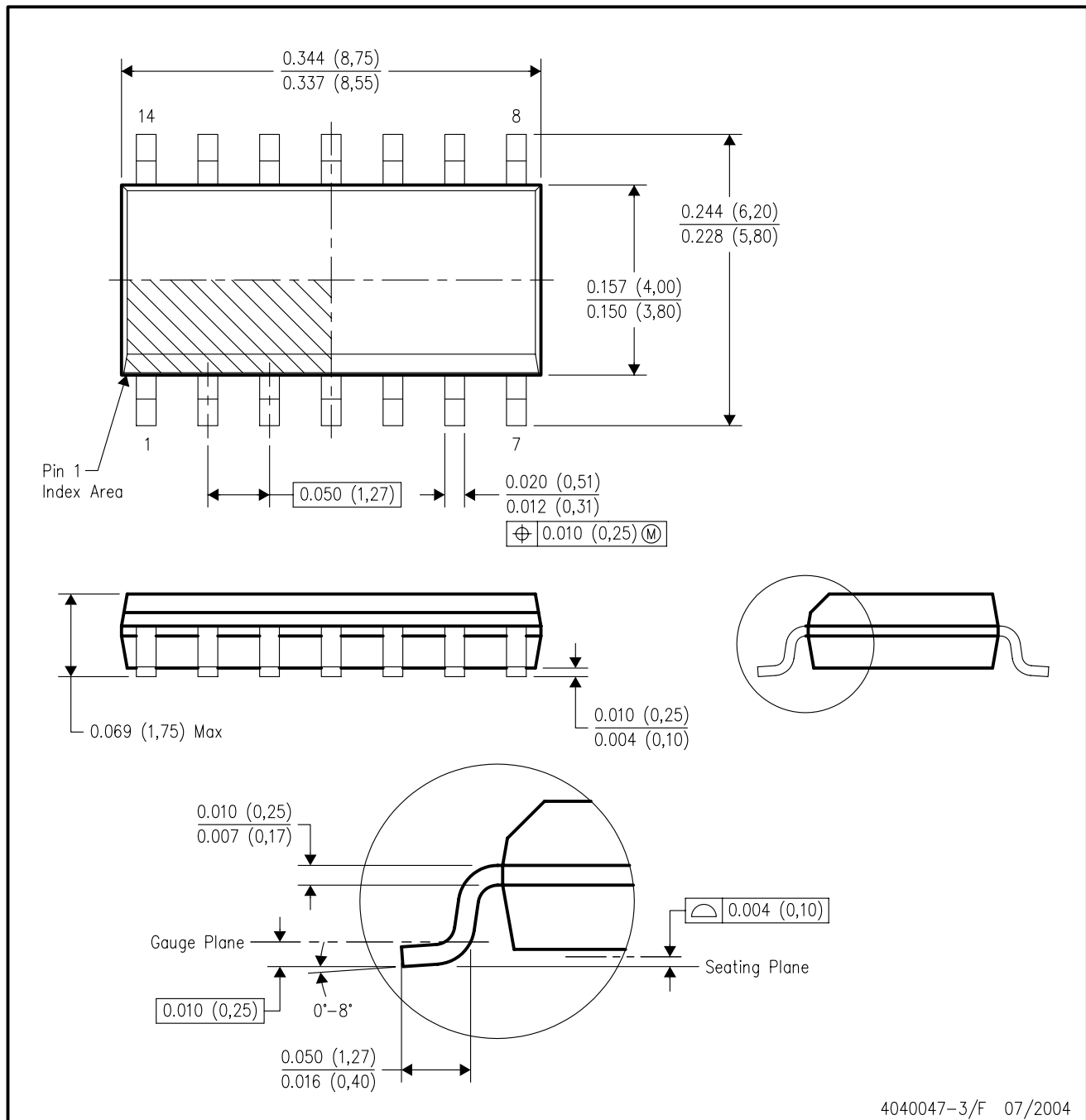


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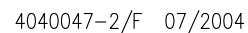
- NOTES:
- A. All linear dimensions are in millimeters.
 - B. This drawing is subject to change without notice.
 - C. Body dimensions do not include mold flash or protrusion.
 - D. Falls within JEDEC MO-178 Variation AA.

D (R-PDSO-G14)

PLASTIC SMALL-OUTLINE PACKAGE



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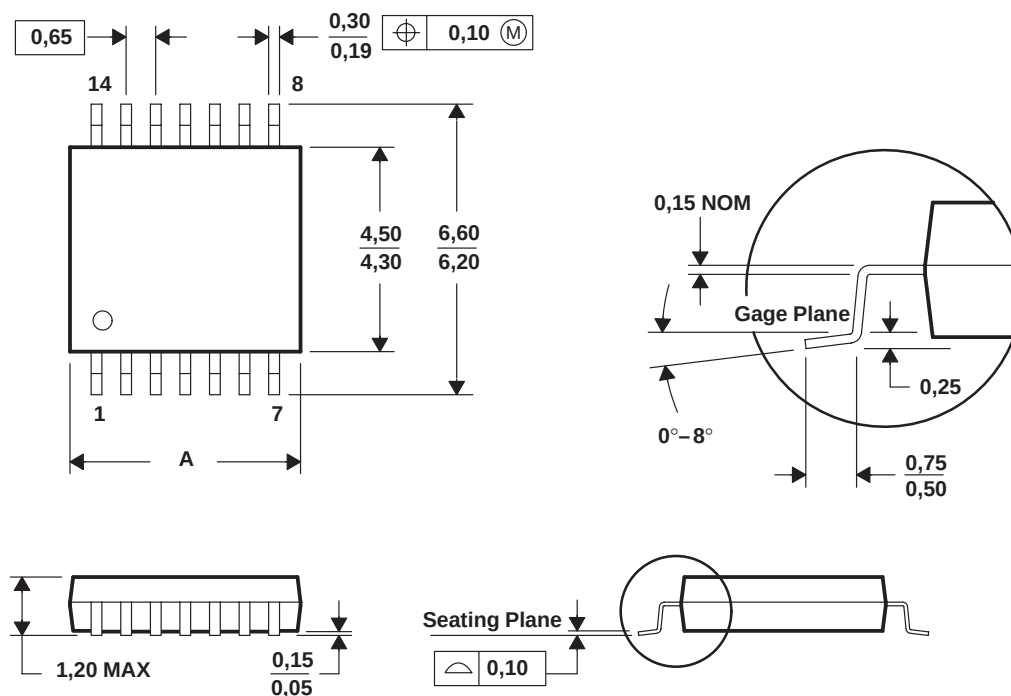


A. All linear dimensions are in inches (millimeters).
B. This drawing is subject to change without notice.
C. Body dimensions do not include mold flash or protrusion not to exceed 0.006 (0,15).
D. Falls within JEDEC MS-012 variation AA.

PW (R-PDSO-G**)

PLASTIC SMALL-OUTLINE PACKAGE

14 PINS SHOWN



PINS ** DIM	8	14	16	20	24	28
A MAX	3,10	5,10	5,10	6,60	7,90	9,80
A MIN	2,90	4,90	4,90	6,40	7,70	9,60

4040064/F 01/97

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

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