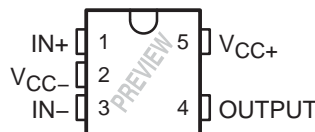


LPV321 SINGLE, LPV358 DUAL, LPV324 QUAD GENERAL-PURPOSE, LOW-VOLTAGE, LOW-POWER, RAIL-TO-RAIL OUTPUT OPERATIONAL AMPLIFIERS

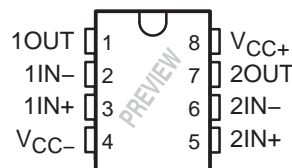
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- **2.7-V and 5-V Performance**
- **–40°C to 125°C Specification at 5 V**
- **No Crossover Distortion**
- **Gain Bandwidth of 152 kHz**
- **Low Supply Current**
 - LPV321 . . . 9 μ A
 - LPV358 . . . 15 μ A
 - LPV324 . . . 28 μ A
- **Rail-to-Rail Output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

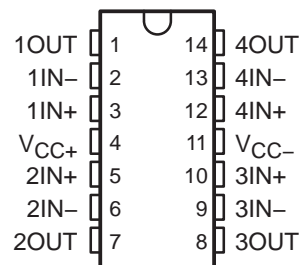
LPV321 . . . DBV OR DCK PACKAGE
(TOP VIEW)



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 μ A 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 μ A 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
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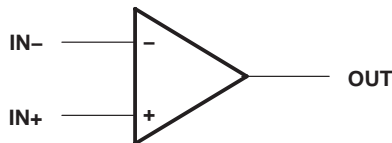
description/ordering information (continued)

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
			Reel of 2500	LPV358DGKR	
	VSSOP-8 (DGK)	Reel of 250	LPV358DGKT	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
			Reel of 2500	LPV358IDGKR	
	VSSOP-8 (DGK)	Reel of 250	LPV358IDGKT	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.

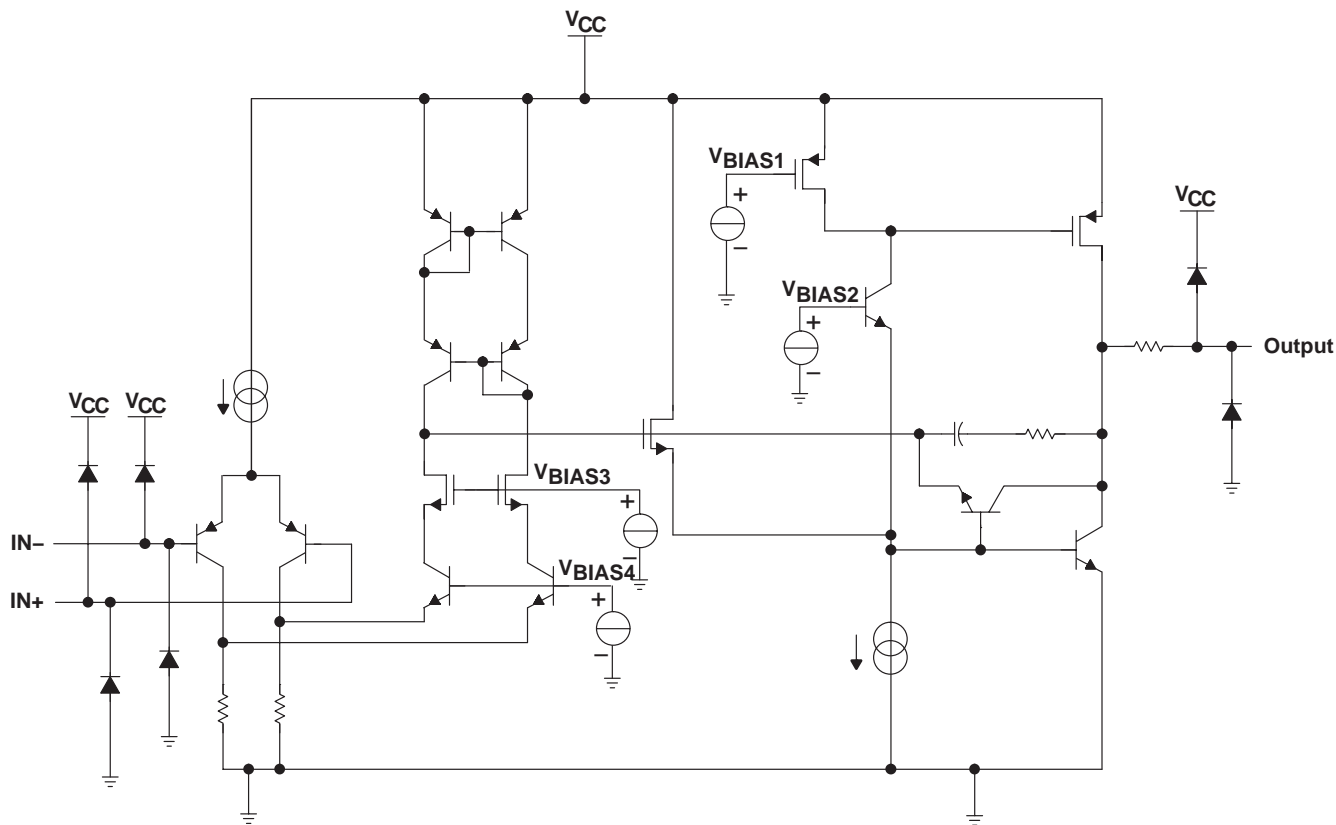
symbol (each amplifier)



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:
- All voltage values, except differential voltages and V_{CC} specified for the measurement of I_{OS} , are with respect to the network GND.
 - Differential voltages are at IN+ with respect to IN-.
 - 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.
 - The package thermal impedance is calculated in accordance with JESD 51-7.

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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



**LPV321 SINGLE, LPV358 DUAL, LPV324 QUAD
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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		$\mu\text{V}/^\circ\text{C}$	
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	$0 \leq V_{IC} \leq 4\text{ V}$	25°C	50	71		dB	
k_{SVR} Supply-voltage rejection ratio	$2.7\text{ V} \leq V_{CC+} \leq 5\text{ V}$, $V_{IC} = 1\text{ V}$, $V_O = 1\text{ V}$	25°C	50	65		dB	
V_{ICR} Common-mode input voltage range	CMRR $\geq 50\text{ dB}$	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	$R_L = 100\text{ k}\Omega$ 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, $V_O = 0\text{ V}$	25°C	2	17	mA		
	Sinking, $V_O = 5\text{ V}$		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	$R_L = 100\text{ k}\Omega$	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.



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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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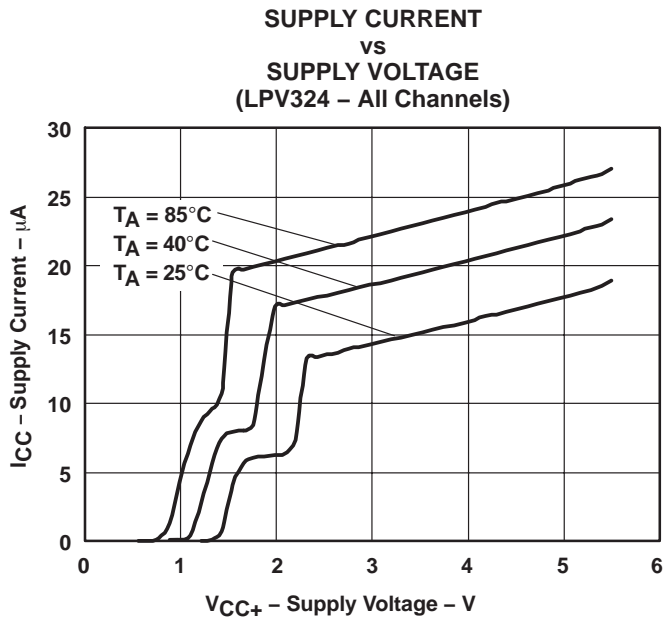


Figure 1

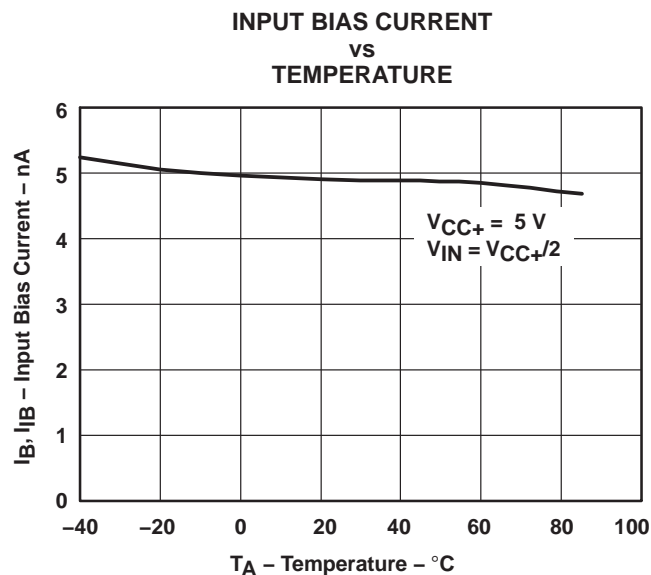


Figure 2

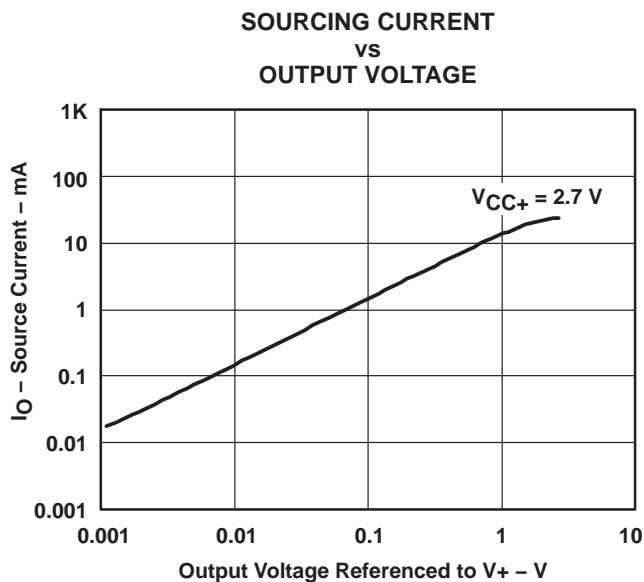


Figure 3

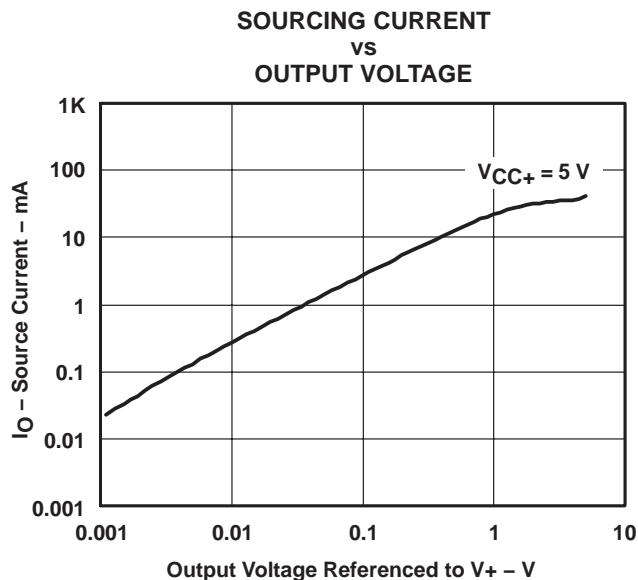


Figure 4

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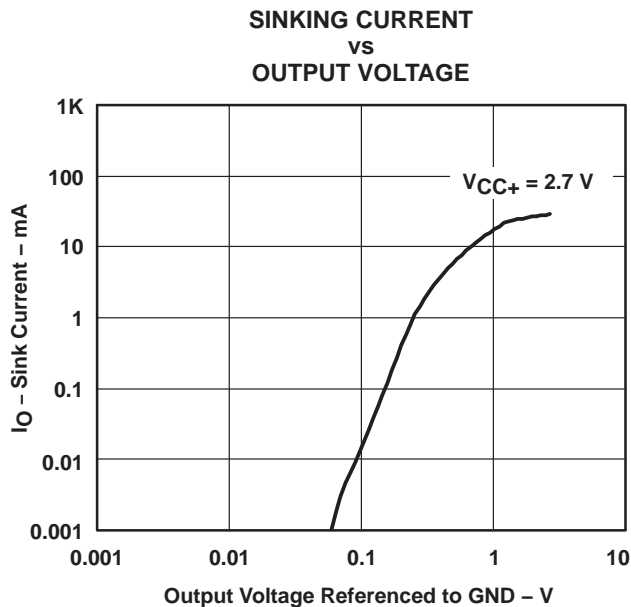


Figure 5

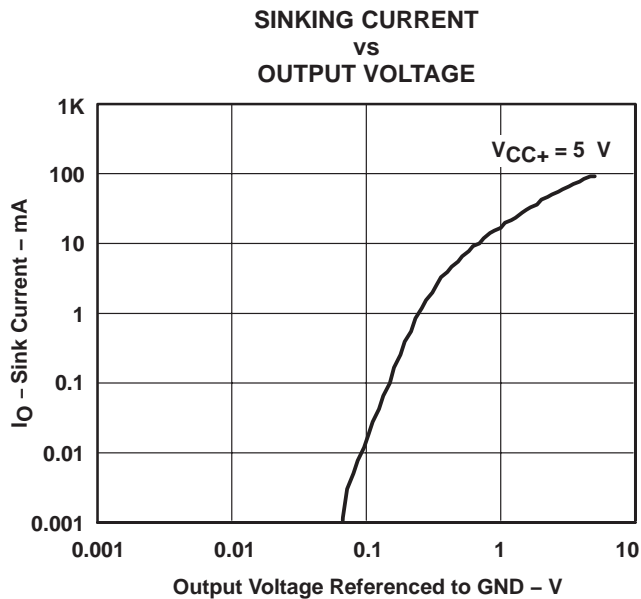


Figure 6

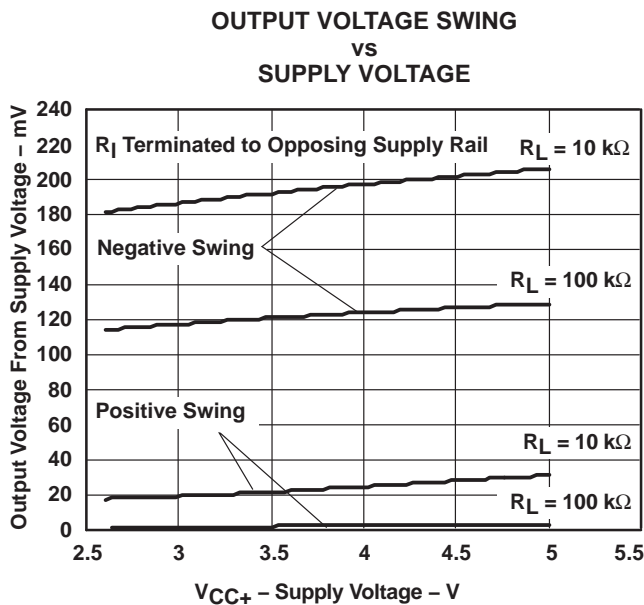


Figure 7

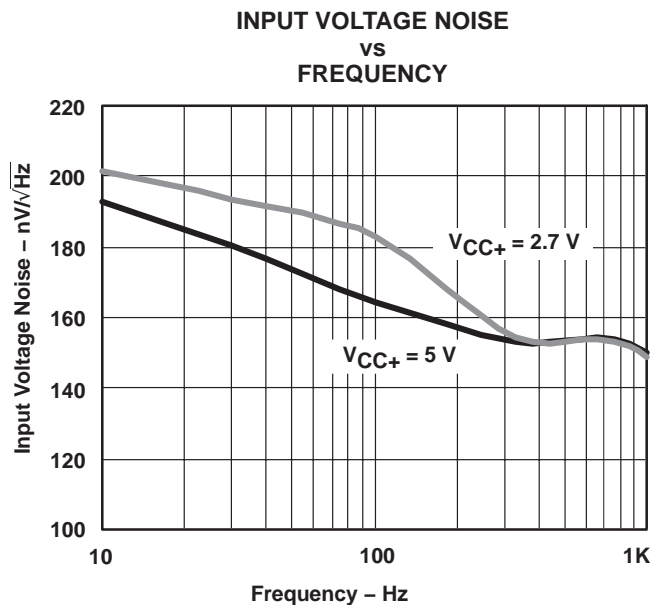


Figure 8

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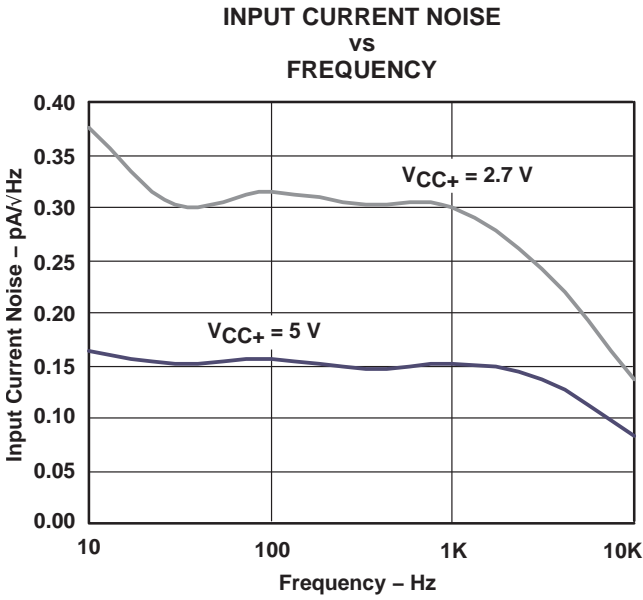


Figure 9

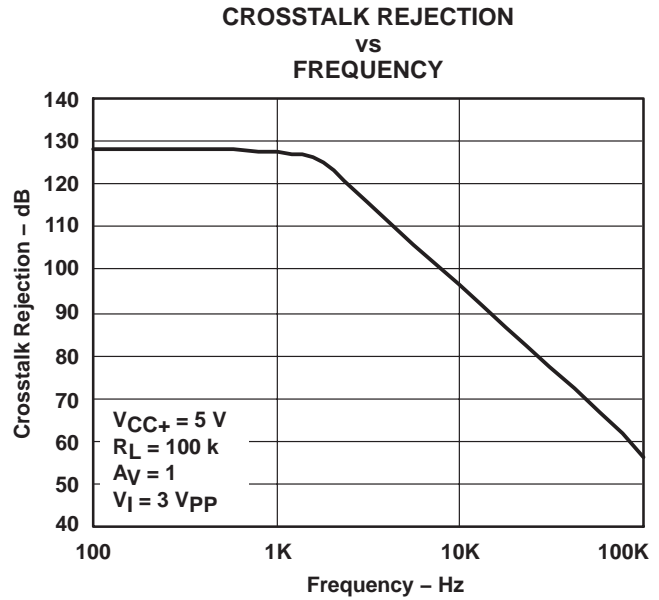


Figure 10

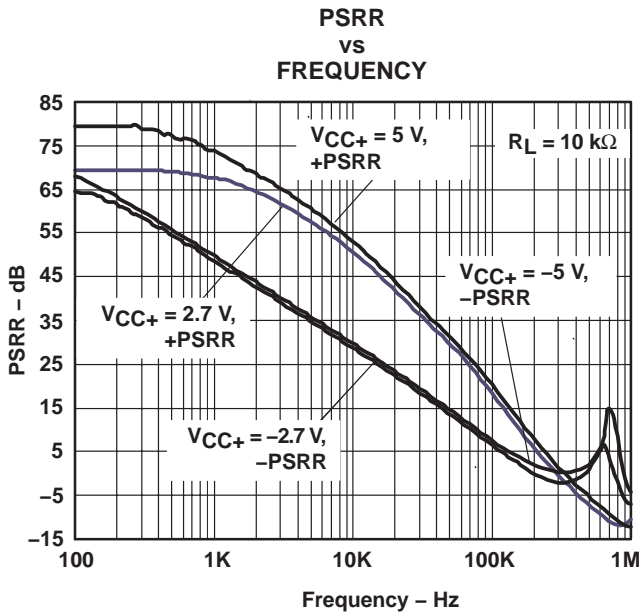


Figure 11

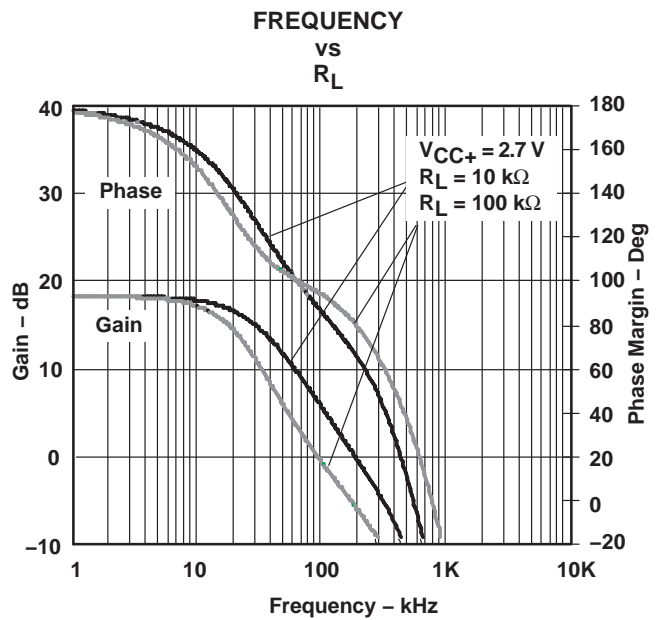


Figure 12



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

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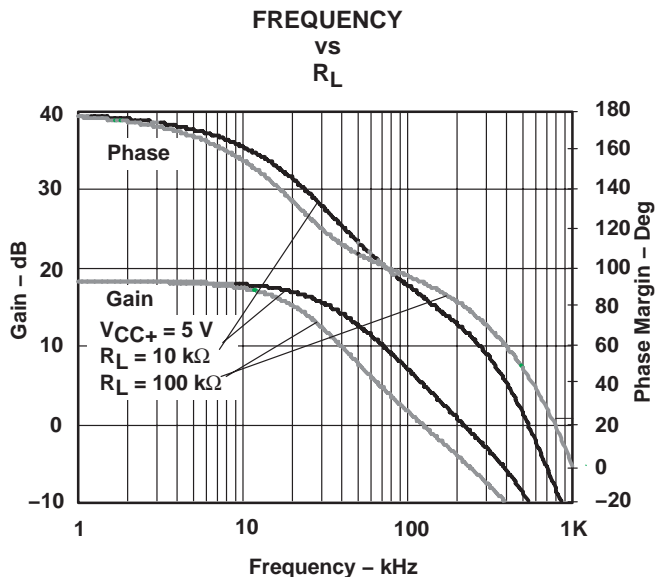


Figure 13

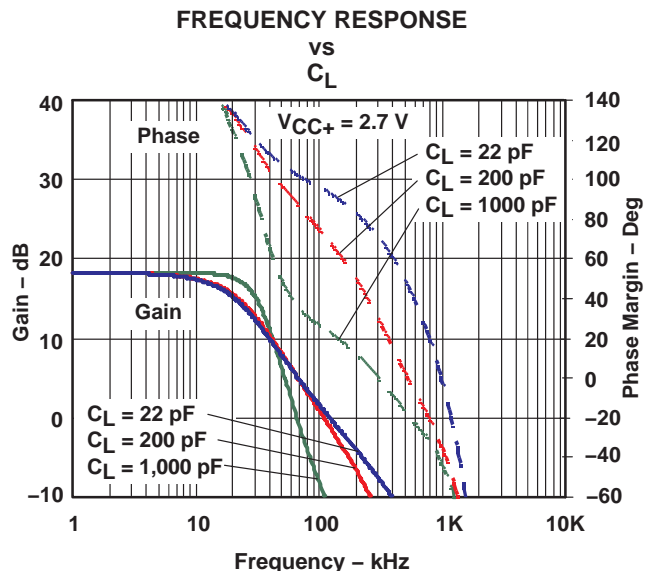


Figure 14

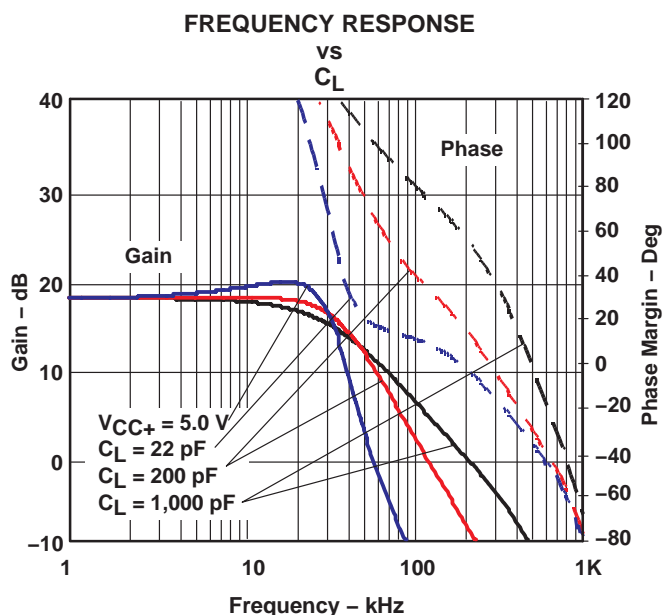


Figure 15

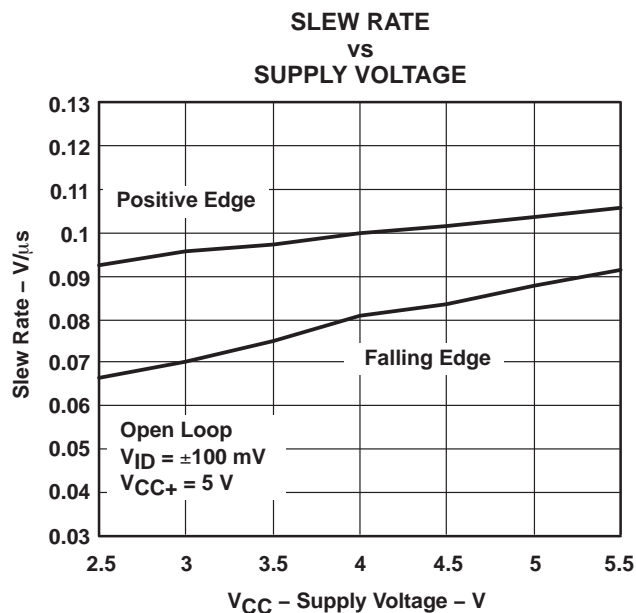


Figure 16

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

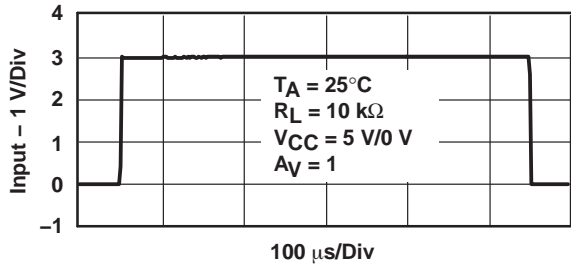


Figure 17

NONINVERTING SMALL-SIGNAL PULSE RESPONSE

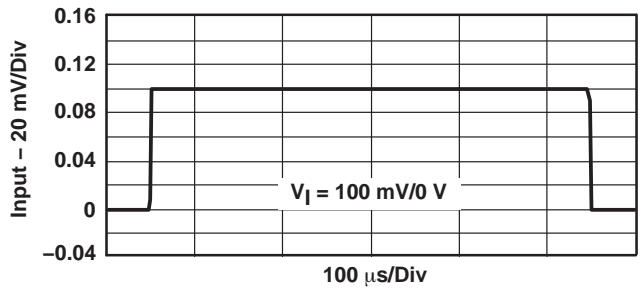


Figure 18

INVERTING LARGE-SIGNAL PULSE RESPONSE

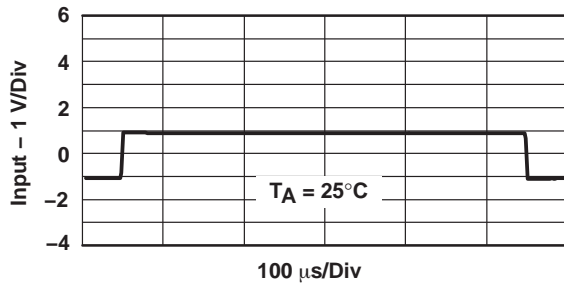


Figure 19

INVERTING SMALL-SIGNAL PULSE RESPONSE

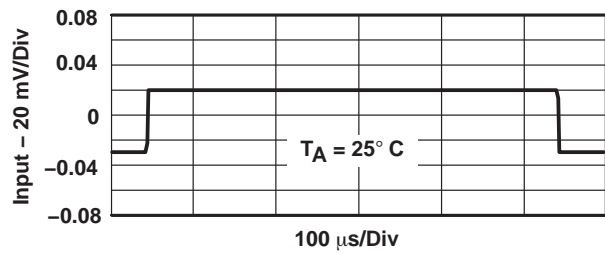
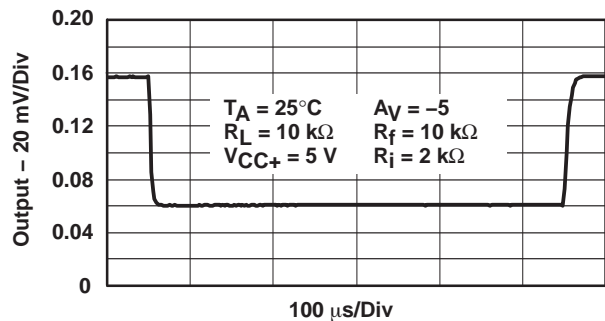
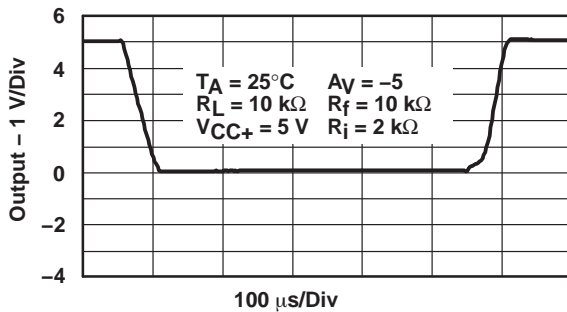


Figure 20



PACKAGING INFORMATION

Orderable Device	Status ⁽¹⁾	Package Type	Package Drawing	Pins	Package Qty	Eco Plan ⁽²⁾	Lead/Ball Finish	MSL Peak Temp ⁽³⁾
LPV321DBVR	ACTIVE	SOT-23	DBV	5	3000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
LPV321DCKR	ACTIVE	SC70	DCK	5	3000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
LPV321IDBVR	ACTIVE	SOT-23	DBV	5	3000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
LPV321IDCKR	ACTIVE	SC70	DCK	5	3000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
LPV324D	ACTIVE	SOIC	D	14	50	Pb-Free (RoHS)	CU NIPDAU	Level-2-260C-1 YEAR/ Level-1-235C-UNLIM
LPV324DR	ACTIVE	SOIC	D	14	2500	Pb-Free (RoHS)	CU NIPDAU	Level-2-260C-1 YEAR/ Level-1-235C-UNLIM
LPV324ID	ACTIVE	SOIC	D	14	50	Pb-Free (RoHS)	CU NIPDAU	Level-2-260C-1 YEAR/ Level-1-235C-UNLIM
LPV324IDR	ACTIVE	SOIC	D	14	2500	Pb-Free (RoHS)	CU NIPDAU	Level-2-260C-1 YEAR/ Level-1-235C-UNLIM
LPV324IPW	ACTIVE	TSSOP	PW	14	90	Pb-Free (RoHS)	CU NIPDAU	Level-1-250C-UNLIM
LPV324IPWR	ACTIVE	TSSOP	PW	14	2000	Pb-Free (RoHS)	CU NIPDAU	Level-1-250C-UNLIM
LPV324PW	ACTIVE	TSSOP	PW	14	90	Pb-Free (RoHS)	CU NIPDAU	Level-1-250C-UNLIM
LPV324PWR	ACTIVE	TSSOP	PW	14	2000	Pb-Free (RoHS)	CU NIPDAU	Level-1-250C-UNLIM
LPV358D	ACTIVE	SOIC	D	8	75	Pb-Free (RoHS)	CU NIPDAU	Level-2-260C-1 YEAR/ Level-1-235C-UNLIM
LPV358DDUR	ACTIVE	VSSOP	DDU	8	3000	Pb-Free (RoHS)	CU NIPDAU	Level-1-260C-UNLIM
LPV358DGKR	ACTIVE	MSOP	DGK	8	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
LPV358DR	ACTIVE	SOIC	D	8	2500	Pb-Free (RoHS)	CU NIPDAU	Level-2-260C-1 YEAR/ Level-1-235C-UNLIM
LPV358ID	ACTIVE	SOIC	D	8	75	Pb-Free (RoHS)	CU NIPDAU	Level-2-260C-1 YEAR/ Level-1-235C-UNLIM
LPV358IDDUR	ACTIVE	VSSOP	DDU	8	3000	Pb-Free (RoHS)	CU NIPDAU	Level-1-260C-UNLIM
LPV358IDGKR	ACTIVE	MSOP	DGK	8	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
LPV358IDR	ACTIVE	SOIC	D	8	2500	Pb-Free (RoHS)	CU NIPDAU	Level-2-260C-1 YEAR/ Level-1-235C-UNLIM

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

ACTIVE: Product device recommended for new designs.

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

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

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

OBsolete: TI has discontinued the production of the device.

⁽²⁾ Eco Plan - May not be currently available - please check <http://www.ti.com/productcontent> for the latest availability information and additional product content details.

None: Not yet available Lead (Pb-Free).

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.

Green (RoHS & no Sb/Br): TI defines "Green" to mean "Pb-Free" and in addition, uses package materials that do not contain halogens, including bromine (Br) or antimony (Sb) above 0.1% of total product weight.

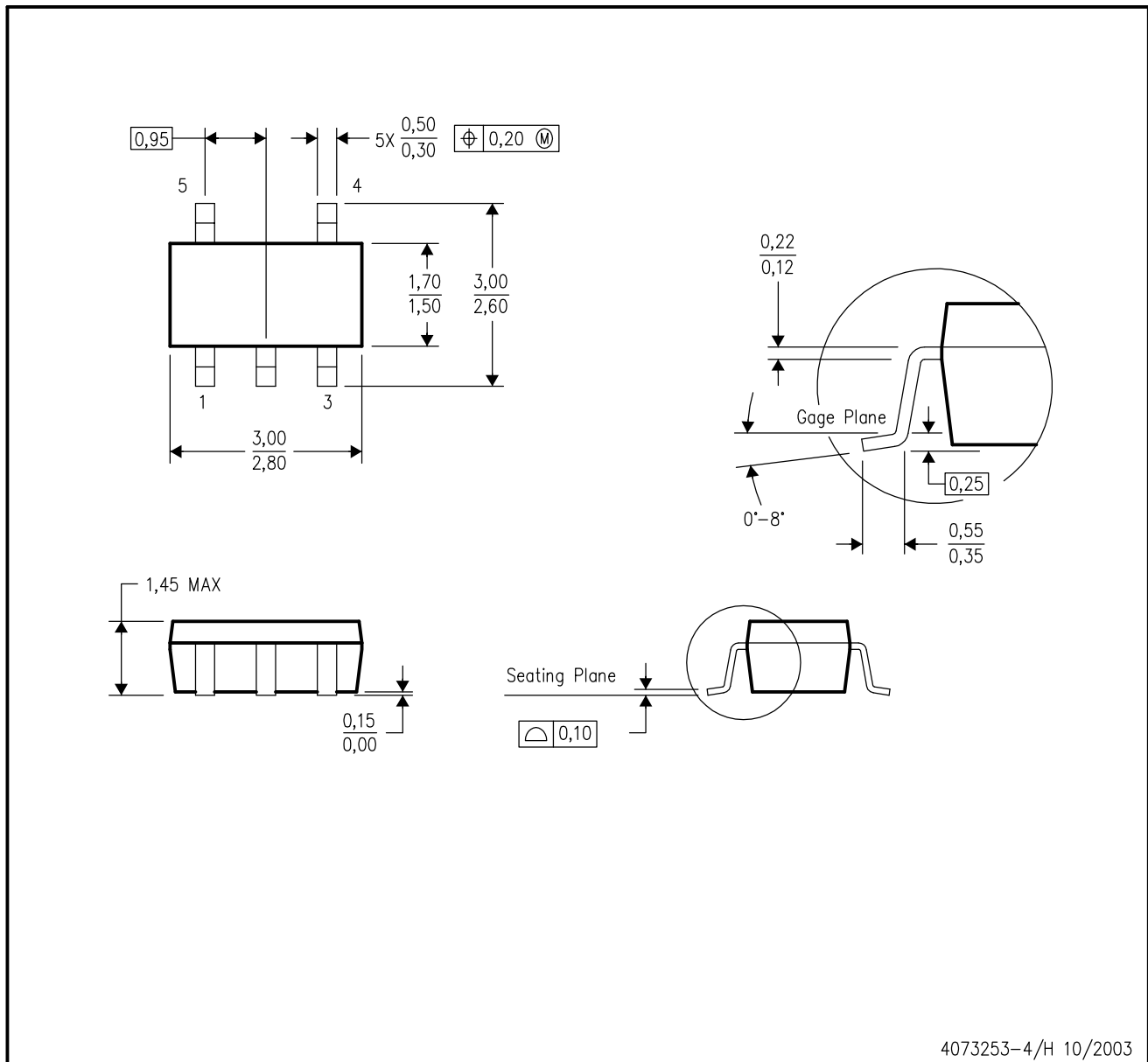
⁽³⁾ MSL, Peak Temp. -- The Moisture Sensitivity Level rating according to the JEDEC industry standard classifications, and peak solder temperature.

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DBV (R-PDSO-G5)

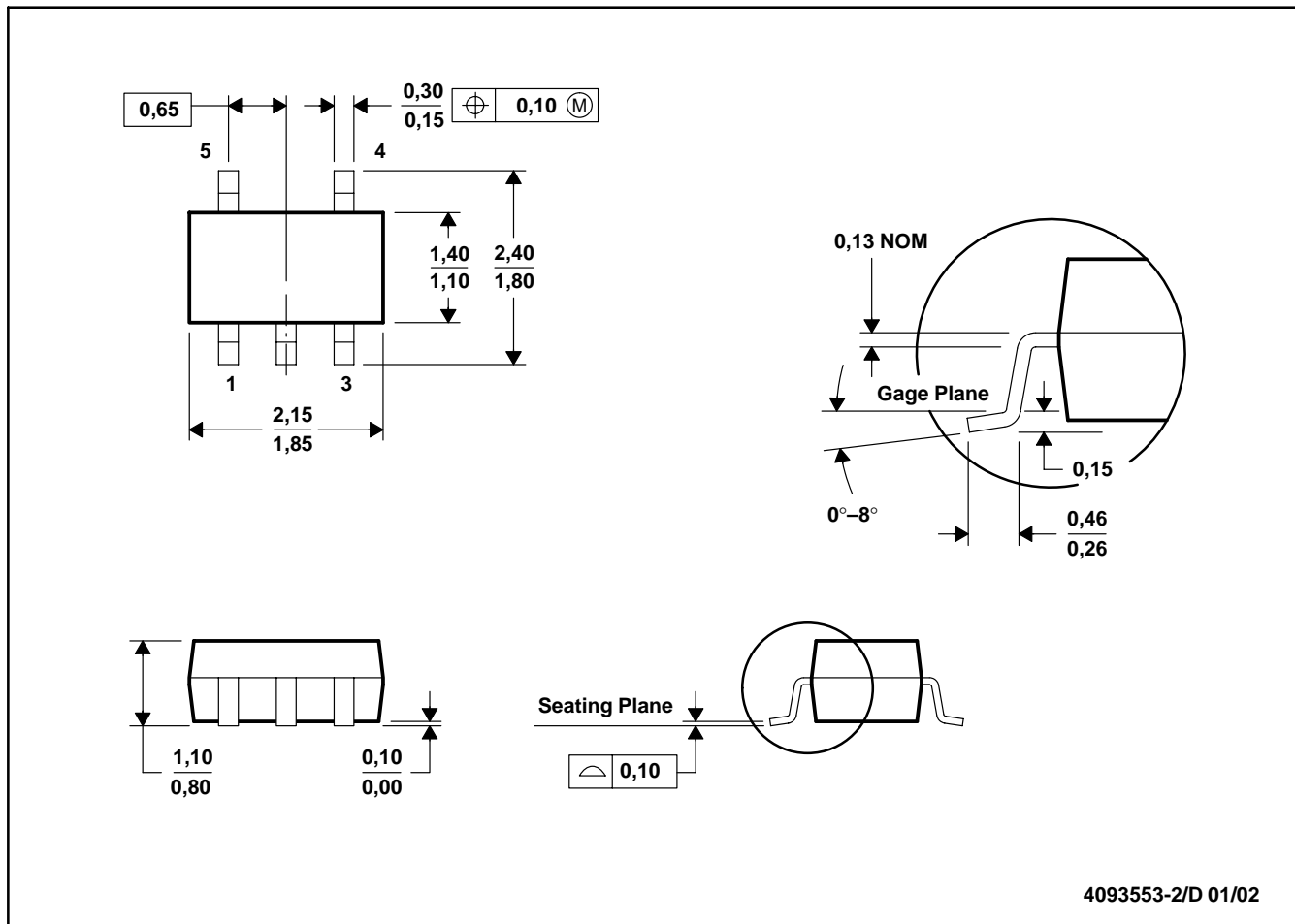
PLASTIC SMALL-OUTLINE PACKAGE



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

DCK (R-PDSO-G5)

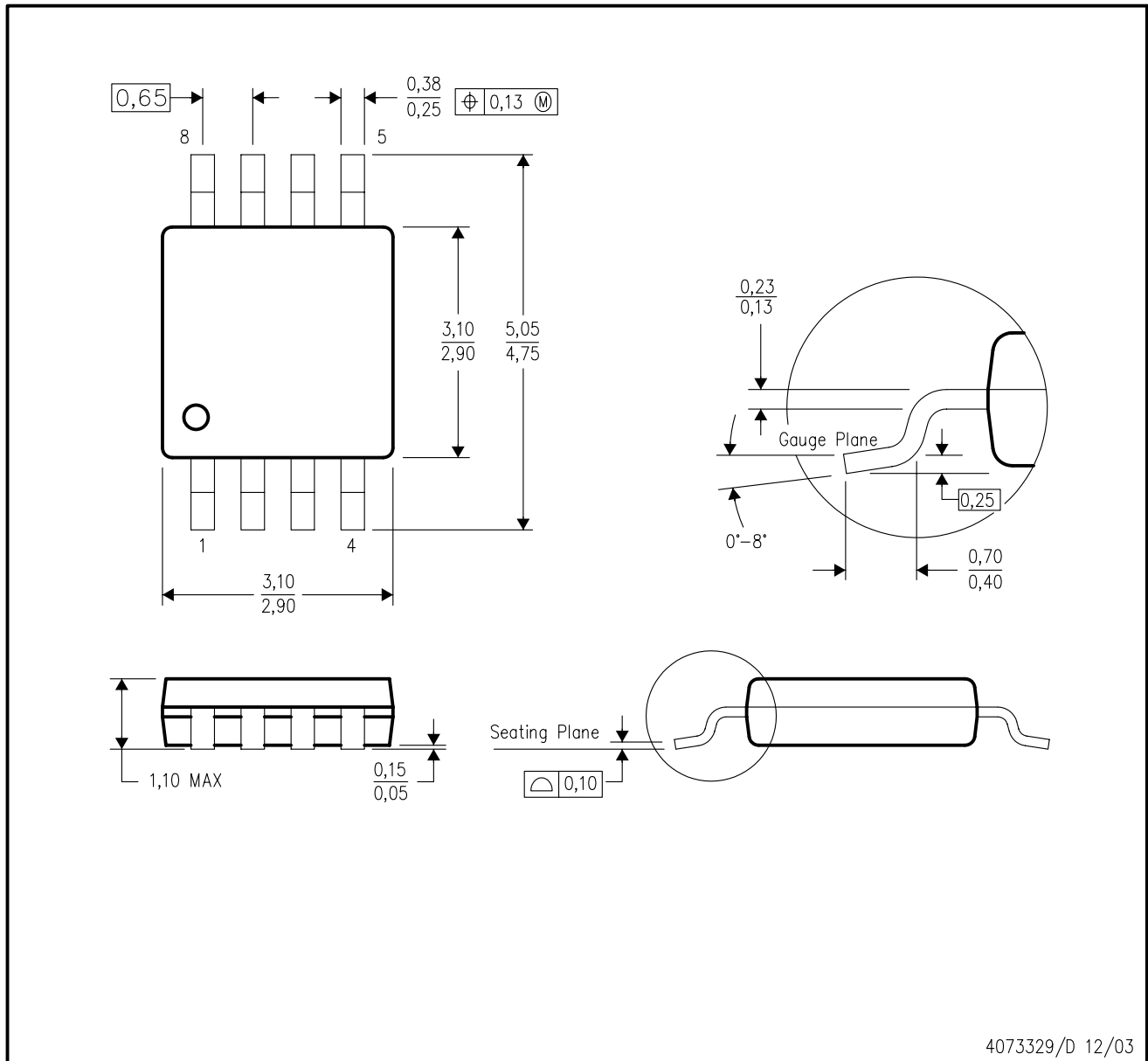
PLASTIC SMALL-OUTLINE PACKAGE



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 B. This drawing is subject to change without notice.
 C. Body dimensions do not include mold flash or protrusion.
 D. Falls within JEDEC MO-203

DGK (S-PDSO-G8)

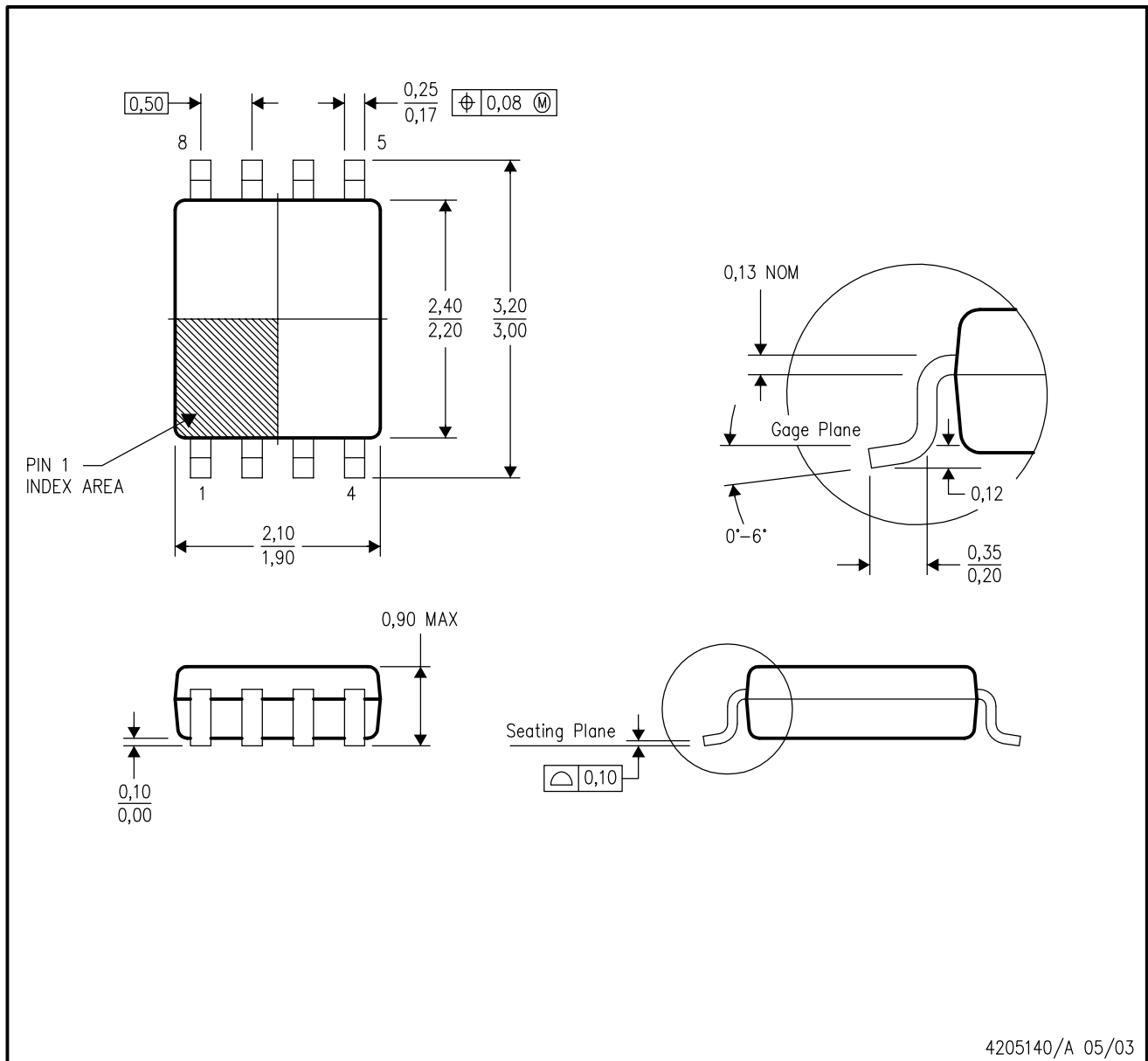
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 - D. Falls within JEDEC MO-187 variation AA.

DDU (R-PDSO-G8)

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- NOTES:
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 - B. This drawing is subject to change without notice.
 - C. Body dimensions do not include mold flash or protrusion.
 - D. Falls within JEDEC MO-187 variation CA.

D (R-PDSO-G14)

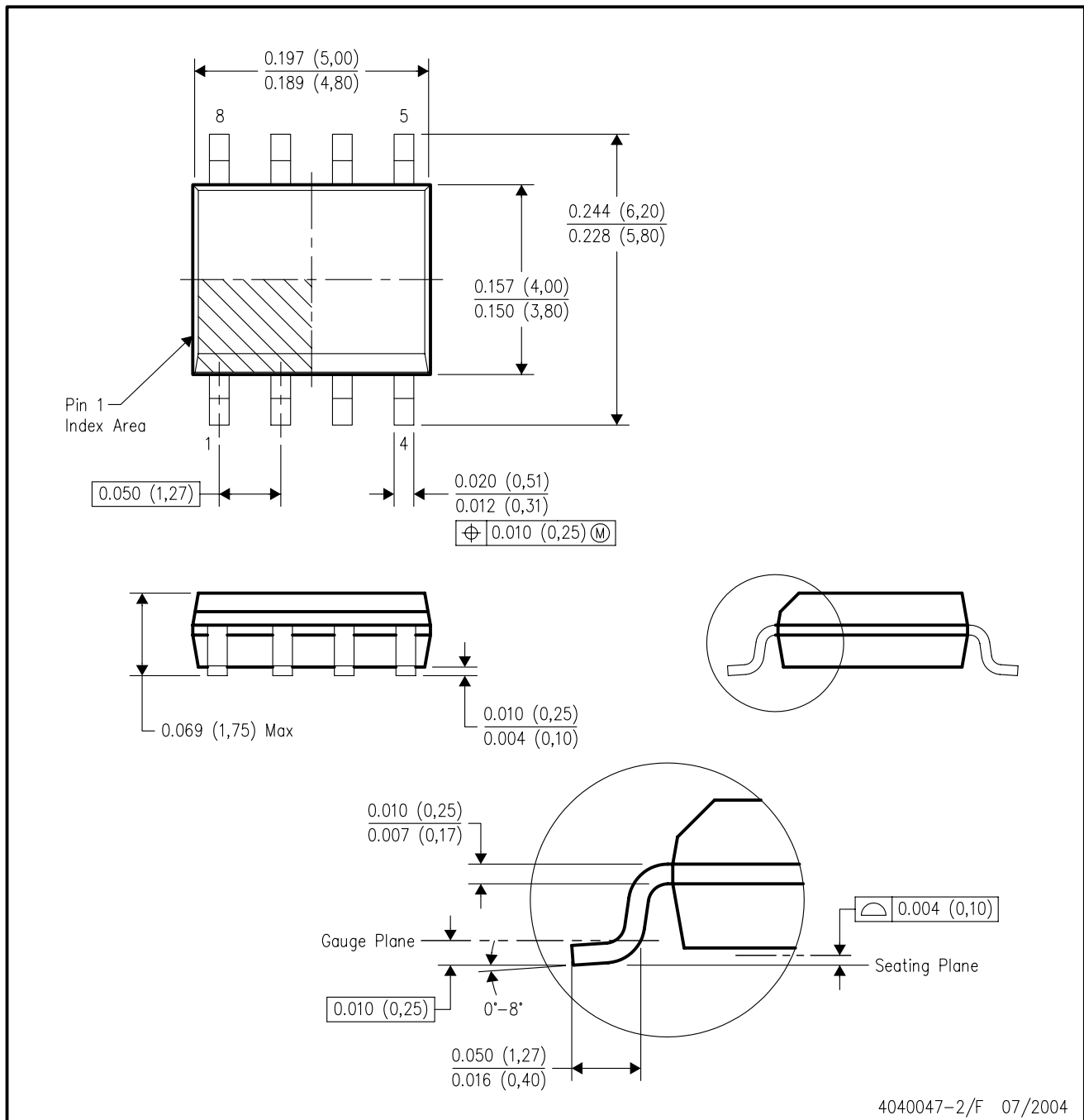
PLASTIC SMALL-OUTLINE PACKAGE



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

D (R-PDSO-G8)

PLASTIC SMALL-OUTLINE PACKAGE



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

PW (R-PDSO-G**)

PLASTIC SMALL-OUTLINE PACKAGE

14 PINS SHOWN



4040064/F 01/97

- NOTES: A. All linear dimensions are in millimeters.
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 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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