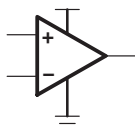


FAMILY OF LOW-POWER WIDE BANDWIDTH SINGLE SUPPLY OPERATIONAL AMPLIFIERS WITH AND WITHOUT SHUTDOWN

FEATURES

- Rail-To-Rail Output
- V_{ICR} Includes Ground
- Gain-Bandwidth Product . . . 9 MHz
- Supply Current . . . 730 μ A/Channel
- Single, Duals, and Quad Versions
- Ultralow Power Down Mode
 $I_{DD}(SHDN) = 4 \mu$ A/Channel
- Specified Temperature Range
–40°C to 125°C . . . Industrial Grade
- Supply Voltage Range . . . 2.7 V to 5.5 V
- Ultrasmall Packaging
5 or 6 Pin SOT-23 (TLV2630/1)
8 or 10 Pin MSOP (TLV2632/3)
- Universal Op-Amp EVM (See SLOU060
for More Information)

Operational Amplifier



DESCRIPTION

The TLV263x single supply operational amplifiers provide rail-to-rail output with an input range that includes ground. The TLV263x takes the minimum operating supply voltage down to 2.7 V over the extended industrial temperature range (–40°C to 125°C) while adding the rail-to-rail output swing feature. The TLV263x also provides a 9 MHz gain-bandwidth product from only 730 μ A of supply current. The maximum recommended supply voltage is 5.5 V, which, when coupled with a 2.7-V minimum, allows the devices to be operated from lithium ion cells.

The combination of wide bandwidth, low noise, and low distortion makes it ideal for high speed and high resolution data converter applications. The ground input range allows it to directly interface to ground rail referred systems.

All members are available in PDIP and SOIC with the singles in the small SOT-23 package, duals in the MSOP, and quads in the TSSOP package.

The 2.7-V operation makes it compatible with Li-Ion powered systems and the operating supply voltage range of many micro-power microcontrollers available today including TI's MSP430.

AMPLIFIER SELECTION TABLE

DEVICE	V_{DD} [V]	I_{DD}/ch [μ A]	V_{ICR} [V]	GBW [MHz]	SLEW RATE [V/ μ s]	V_n , 1 kHz [nV/ $\sqrt{Hz}$]	I_O [mA]
OPAx343	2.5–5.5	850	–0.3 to $V_{DD} + 0.3$	5.5	6	25	40
OPAx743	3.5–12	1100	–0.1 to $V_{DD} + 0.1$	7	10	30	20
TLV278x	1.8–3.6	650	–0.2 to $V_{DD} + 0.2$	8	5	9	10
TLV263x	2.7–5.5	730	GND to $V_{DD} - 1$	9	9.5	50	28
TLV262x	2.7–5.5	750	1 V to $V_{DD} + 0.2$	11	10	27	28
OPAx353	2.7–5.5	8000	–0.1 to $V_{DD} + 0.1$	44	22	7	40



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.

TLV2630, TLV2631
TLV2632, TLV2633
TLV2634, TLV2635

SLOS362A – JUNE 2001 – REVISED JANUARY 2005

PACKAGE/ORDERING INFORMATION⁽¹⁾

PRODUCT	PACKAGE	PACKAGE CODE	SYMBOL	SPECIFIED TEMPERATURE RANGE	ORDER NUMBER	TRANSPORT MEDIA
Single with Shutdown						
TLV2630ID	SOIC–8	D	—	–40°C to 125°C	TLV2630ID TLV2630IDR	Tube Tape and Reel
TLV2630IDBV	SOT–23–6	DBV	VAYI		TLV2630IDBVR [†] TLV2630IDBVT [‡]	Tape and Reel
TLV2630IP	DIP–8	P	—		TLV2630IP	Tube
Single without Shutdown						
TLV2631ID	SOIC–8	D	—	–40°C to 125°C	TLV2631ID TLV2631IDR	Tube Tape and Reel
TLV2631IDBV	SOT–23–5	DBV	VAZI		TLV2631IDBVR [†] TLV2631IDBVT [‡]	Tape and Reel
TLV2631IP	DIP–8	P	—		TLV2631IP	Tube
Dual without Shutdown						
TLV2632ID	SOIC–8	D	—	–40°C to 125°C	TLV2632ID TLV2632IDR	Tube Tape and Reel
TLV2632IDGK	MSOP–8	DGK	AKG		TLV2632IDGK TLV2632IDGKR	Tube Tape and Reel
TLV2632IP	DIP–8	P	—		TLV2632IP	Tube
Dual with Shutdown						
TLV2633ID	SOIC–14	D	—	–40°C to 125°C	TLV2633ID TLV2633IDR	Tube Tape and Reel
TLV2633IDGS	MSOP–10	DGS	AKK		TLV2633IDGS TLV2633IDGSR	Tube Tape and Reel
TLV2633IN	DIP–14	N	—		TLV2633IN	Tube
Quad without Shutdown						
TLV2634ID	SOIC–14	D	—	–40°C to 125°C	TLV2634ID TLV2634IDR	Tube Tape and Reel
TLV2634IN	DIP–14	N	—		TLV2634IN	Tube
TLV2634IPW	TSSOP–14	PW	—		TLV2634IPW TLV2634IPWR	Tube Tape and Reel
Quad with Shutdown						
TLV2635ID	SOIC–16	D	—	–40°C to 125°C	TLV2635ID TLV2635IDR	Tube Tape and Reel
TLV2635IN	DIP–16	N	—		TLV2635IN	Tube
TLV2635IPW	TSSOP–16	PW	—		TLV2635IPW TLV2635IPWR	Tube Tape and Reel

[†] The SOT23 package devices are only available taped and reeled. The **R** Suffix denotes quantities (3,000 pieces per reel).

[‡] The **T** Suffix denotes smaller quantities (250 pieces per mini-reel).

1. For the most current package and ordering information, see the Package Option Addendum at the end of this document, or see the TI website at www.ti.com.

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

Supply voltage, V_{DD} (see Note 1)	6 V
Differential input voltage, V_{ID}	$\pm V_{DD}$
Input voltage range, V_I (see Note 1)	GND to $V_{DD} - 1$ V
Input current, I_I (any input)	± 10 mA
Output current, I_O	± 40 mA
Continuous total power dissipation	See Dissipation Rating Table
Operating free-air temperature range, T_A : I-suffix	-40°C to 125°C
Maximum junction temperature, T_J	150°C
Storage temperature range, T_{stg}	-65°C to 150°C
Lead temperature 1,6 mm (1/16 inch) from case for 10 seconds	260°C

[†] Stresses beyond those listed under “absolute maximum ratings” may cause permanent damage to the device. These are stress ratings only, and functional operation of the device at these or any other conditions beyond those indicated under “recommended operating conditions” is not implied. Exposure to absolute-maximum-rated conditions for extended periods may affect device reliability.

NOTE 2: All voltage values, except differential voltages, are with respect to GND.

recommended operating conditions

		MIN	MAX	UNIT
Supply voltage, V_{DD}	Single supply	2.7	5.5	V
	Split supply	± 1.35	± 2.75	
Common-mode input voltage range, V_{ICR}		GND	$V_{DD} - 1$	V
Operating free-air temperature, T_A	I-suffix	-40	125	$^{\circ}\text{C}$
Shutdown on/off voltage level [‡]	V_{IL}		0.4	V
	V_{IH}	2		

[‡] Relative to GND.

electrical characteristics at specified free-air temperature, $V_{DD} = 2.7$ V, 5 V (unless otherwise noted)

dc performance

PARAMETER		TEST CONDITIONS		T _A	MIN	TYP	MAX	UNIT
V _{IO}	Input offset voltage	V _{IC} = V _{DD} /2, V _O = V _{DD} /2	TLV2634/5	25°C		250	3500	μV
				Full range			4500	
				25°C		250	4200	μV
				Full range			5200	
αV _{IO}	Temperature coefficient of input offset voltage			25°C		3		μV/°C
CMRR	Common-mode rejection ratio	V _{IC} = GND to V _{DD} −1 V	V _{DD} = 2.7 V	25°C	76	100		dB
				Full range	67			
			V _{DD} = 5 V	25°C	77	100		
				Full range	74			
A _{VD}	Large-signal differential voltage amplification	R _L = 2 kΩ, V _{O(PP)} = V _{DD} −1 V		25°C	90	100		dB
				Full range	82			

electrical characteristics at specified free-air temperature, $V_{DD} = 2.7\text{ V}$, 5 V (unless otherwise noted)
(continued)

input characteristics

PARAMETER		TEST CONDITIONS	T _A [†]	MIN	TYP	MAX	UNIT
I _{IO}	Input offset current	V _{IC} = V _{DD} /2, V _O = V _{DD} /2	25°C		1	50	pA
			Full range			100	
I _{IB}	Input bias current		25°C		1	50	
			Full range			200	
r _{i(d)}	Differential input resistance		25°C		1000		GΩ
C _{i(c)}	Common-mode input capacitance	f = 1 kHz	25°C		12		pF

† Full range is –40°C to 125°C for the I-suffix.

output characteristics

PARAMETER	TEST CONDITIONS	$T_A^\dagger$	MIN	TYP	MAX	UNIT
V_{OH} High-level output voltage	$V_{IC} = V_{DD}/2$, $I_{OH} = -1\text{ mA}$	$V_{DD} = 2.7\text{ V}$	25°C	2.6	2.67	V
		Full range		2.55		
		$V_{DD} = 5\text{ V}$	25°C	4.92	4.98	
		Full range		4.9		
	$V_{IC} = V_{DD}/2$, $I_{OH} = -10\text{ mA}$	$V_{DD} = 2.7\text{ V}$	25°C	2.25	2.43	
		Full range		2.15		
		$V_{DD} = 5\text{ V}$	25°C	4.7	4.8	
		Full range		4.65		
V_{OL} Low-level output voltage	$V_{IC} = V_{DD}/2$, $I_{OL} = 1\text{ mA}$	$V_{DD} = 2.7\text{ V}$	25°C	0.03	0.1	mV
		Full range			0.15	
		$V_{DD} = 5\text{ V}$	25°C	0.025	0.08	
		Full range			0.1	
	$V_{IC} = V_{DD}/2$, $I_{OL} = 10\text{ mA}$	$V_{DD} = 2.7\text{ V}$	25°C	0.26	0.45	
		Full range			0.47	
		$V_{DD} = 5\text{ V}$	25°C	0.2	0.3	
		Full range			0.35	
I_O Output current	$V_{DD} = 2.7\text{ V}$, $V_O = 0.5\text{ V}$ from rail	Sourcing	25°C	14		mA
		Sinking		19		
	$V_{DD} = 5\text{ V}$, $V_O = 0.5\text{ V}$ from rail	Sourcing		28		
		Sinking		28		
I_{OS} Short-circuit output current	Sourcing	$V_{DD} = 2.7\text{ V}$	25°C	50		mA
		$V_{DD} = 5\text{ V}$		95		
	Sinking	$V_{DD} = 2.7\text{ V}$		50		
		$V_{DD} = 5\text{ V}$		95		

† Full range is –40°C to 125°C for the I-suffix.

power supply

PARAMETER	TEST CONDITIONS	$T_A^\dagger$	MIN	TYP	MAX	UNIT
I_{DD} Supply current (per channel)	$V_O = V_{DD}/2$, $\overline{\text{SHDN}} = V_{DD}$	25°C		730	1000	μA
		Full range			1350	
PSRR Supply voltage rejection ratio ($\Delta V_{DD} / \Delta V_{IO}$)	$V_{DD} = 2.7\text{ V}$ to 5.5 V , $V_{IC} = V_{DD}/2$	25°C	70	90		dB
		Full range	65			

† Full range is –40°C to 125°C for the I-suffix.

electrical characteristics at specified free-air temperature, $V_{DD} = 2.7\text{ V}, 5\text{ V}$ (unless otherwise noted)
(continued)

dynamic performance

PARAMETER		TEST CONDITIONS		T _A [†]	MIN	TYP	MAX	UNIT
GBWP	Gain-bandwidth product	R _L = 2 kΩ, C _L = 10 pF, f = 10 kHz		25°C	9			MHz
SR+	Positive slew rate at unity gain	R _L = 2 kΩ, C _L = 50 pF	V _{DD} = 2.7 V, V _{O(PP)} = 1.7 V		6			V/μs
			V _{DD} = 5 V, V _{O(PP)} = 3.5 V		6			
SR–	Negative slew rate at unity gain	R _L = 2 kΩ, C _L = 50 pF	V _{DD} = 2.7 V, V _{O(PP)} = 1.7 V		10			V/μs
			V _{DD} = 5 V, V _{O(PP)} = 3.5 V		9.5			V/μs
φ _m	Phase margin	R _L = 2 kΩ, C _L = 10 pF			50			°
	Gain margin				20			dB

† Full range is –40°C to 125°C for the I-suffix.

noise/distortion performance

PARAMETER	TEST CONDITIONS	T_A	MIN	TYP	MAX	UNIT
THD + N Total harmonic distortion plus noise	$V_{O(PP)} = V_{DD}/2$, $R_L = 2\text{ k}\Omega$, $f = 10\text{ kHz}$	25°C		0.003%		
				0.02%		
				0.095%		
V_n Equivalent input noise voltage	$f = 1\text{ kHz}$			50		nV/ $\sqrt{\text{Hz}}$
	$f = 10\text{ kHz}$			30		
I_n Equivalent input noise current	$f = 1\text{ kHz}$			0.9		fA/ $\sqrt{\text{Hz}}$

shutdown characteristics

PARAMETER	TEST CONDITIONS	$T_A^\dagger$	MIN	TYP	MAX	UNIT
$I_{DD(SHDN)}$ Supply current, per channel in shutdown mode (TLV2630, TLV2633, TLV2635)	$\overline{\text{SHDN}} = 0.4\text{ V}$	25°C		4	17	μA
		Full range			19	
$t_{(on)}$ Amplifier turnon time ‡	$R_L = 2\text{ k}\Omega$, $C_L = 10\text{ pF}$	25°C		4.5		μs
				1.5		
$t_{(off)}$ Amplifier turnoff time ‡				200		ns

† Full range is –40°C to 125°C for the I-suffix.

‡ Disable time and enable time are defined as the interval between application of the logic signal to $\overline{\text{SHDN}}$ and the point at which the supply current has reached half its final value.

DISSIPATION RATING TABLE

PACKAGE	θ_{JC} (°C/W)	θ_{JA} (°C/W)	$T_A \leq 25^\circ\text{C}$ POWER RATING	$T_A = 125^\circ\text{C}$ POWER RATING
D (8)	38.3	176	710 mW	142 mW
D (14)	26.9	122.3	1022 mW	204.4 mW
D (16)	25.7	114.7	1090 mW	218 mW
DBV (5)	55	324.1	385 mW	77.1 mW
DBV (6)	55	294.3	425 mW	85 mW
DGK (8)	54.2	259.9	481 mW	96.1 mW
DGS (10)	54.1	259.7	485 mW	97 mW
N (14, 16)	32	78	1600 mW	320.5 mW
P (8)	41	104	1200 mW	240.4 mW
PW (14)	29.3	173.6	720 mW	144 mW
PW (16)	28.7	161.4	774 mW	154.9 mW

TYPICAL CHARACTERISTICS

Table of Graphs

			FIGURE
V_{IO}	Input offset voltage	vs Common-mode input voltage	1, 2
CMRR	Common-mode rejection ratio	vs Frequency	3
V_{OH}	High-level output voltage	vs High-level output current	4, 6
V_{OL}	Low-level output voltage	vs Low-level output current	5, 7
I_{DD}	Supply current	vs Supply voltage	8
I_{DD}	Supply current	vs Free-air temperature	9
PSRR	Power supply rejection ratio	vs Frequency	10
A_{VD}	Differential voltage amplification & phase	vs Frequency	11
	Gain-bandwidth product	vs Supply voltage	12
		vs Free-air temperature	13
SR	Slew rate	vs Supply voltage	14
		vs Free-air temperature	15, 16
ϕ_m	Phase margin	vs Load capacitance	17
V_n	Equivalent input noise voltage	vs Frequency	18
	Crosstalk	vs Frequency	19
	Voltage-follower large-signal pulse response		20
	Voltage-follower small-signal pulse response		21
$I_{DD}(SHDN)$	Shutdown supply current	vs Free-air temperature	22
$I_{DD}(SHDN)$	Shutdown supply current	vs Supply voltage	23
$I_{DD}(SHDN)$	Shutdown supply current/output voltage	vs Time	24

TYPICAL CHARACTERISTICS

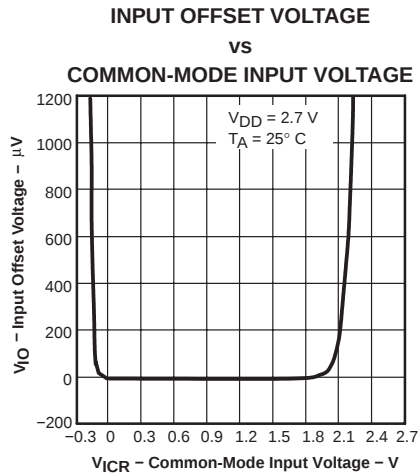


Figure 1

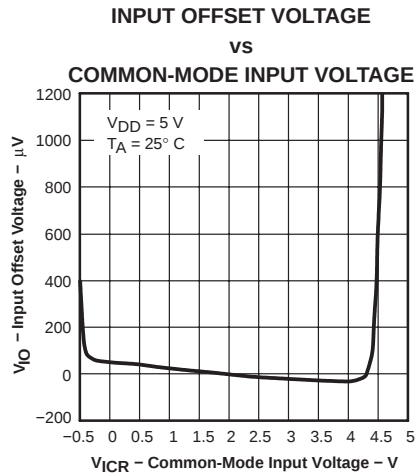


Figure 2

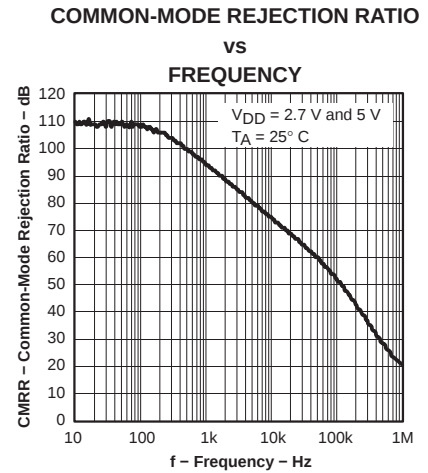


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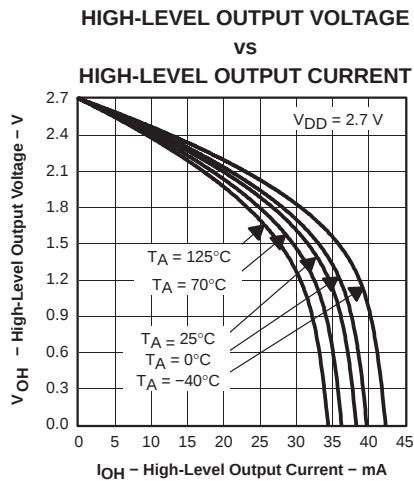


Figure 4

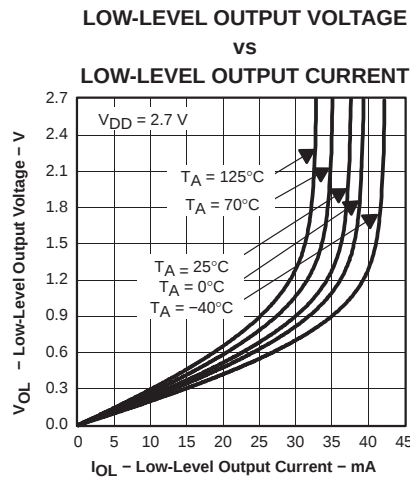


Figure 5

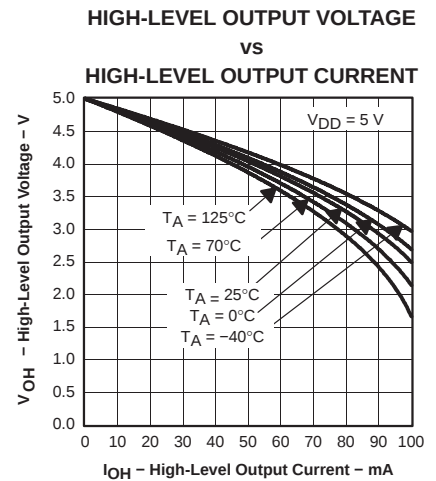


Figure 6

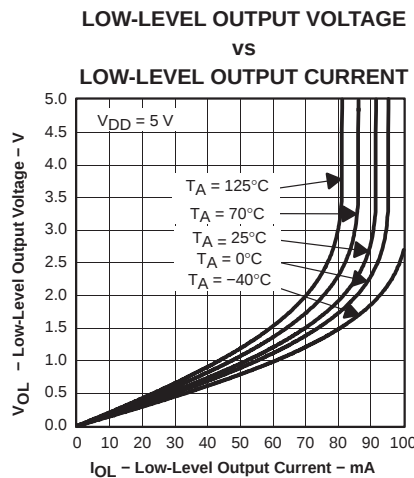


Figure 7

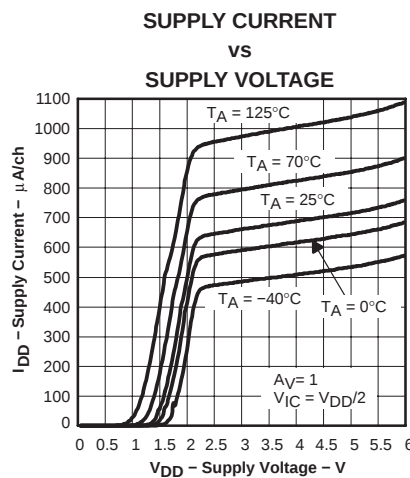


Figure 8

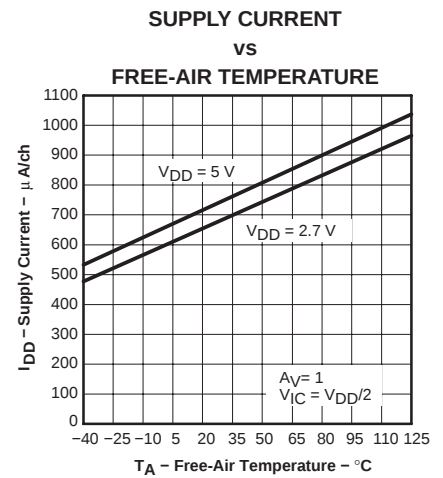


Figure 9

TYPICAL CHARACTERISTICS

POWER SUPPLY REJECTION RATIO

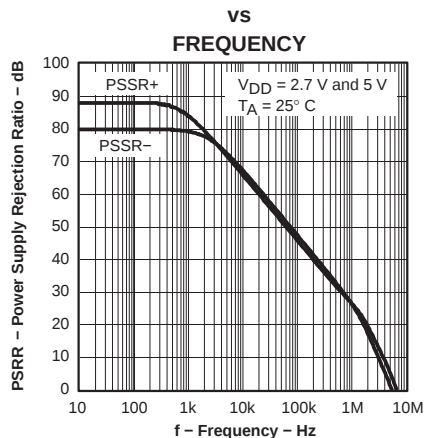


Figure 10

DIFFERENTIAL VOLTAGE AMPLIFICATION AND PHASE

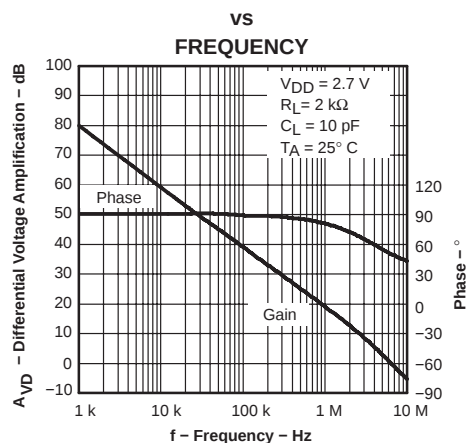


Figure 11

GAIN-BANDWIDTH PRODUCT

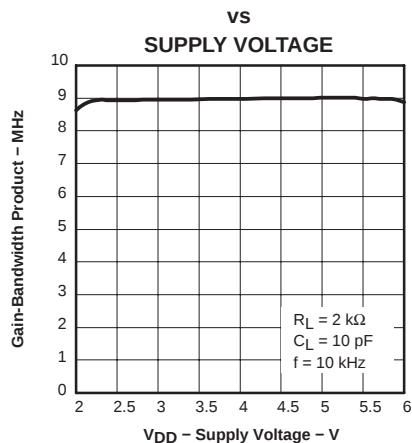


Figure 12

GAIN-BANDWIDTH PRODUCT

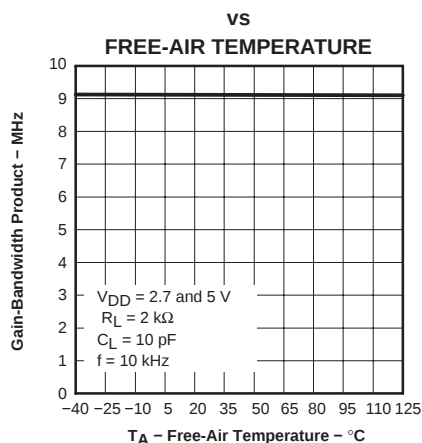


Figure 13

SLEW RATE

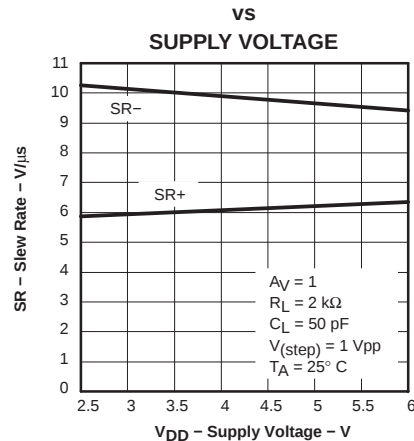


Figure 14

SLEW RATE

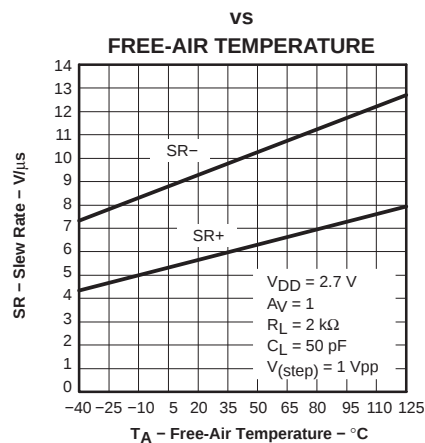


Figure 15

SLEW RATE

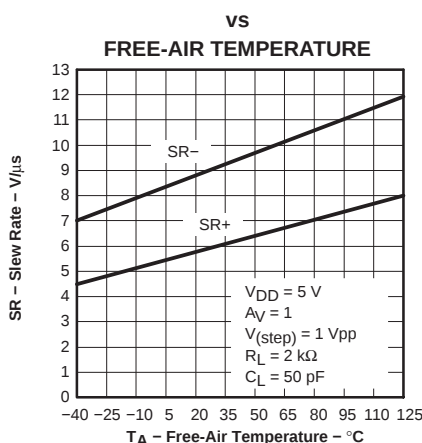


Figure 16

PHASE MARGIN

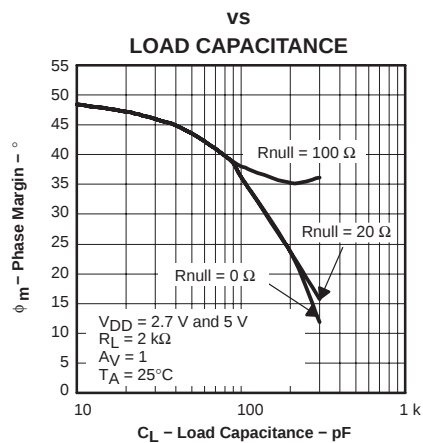


Figure 17

TYPICAL CHARACTERISTICS

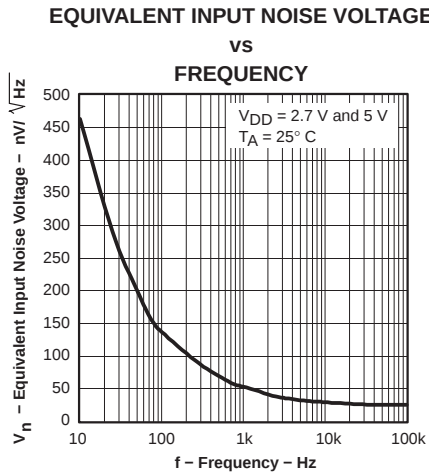


Figure 18

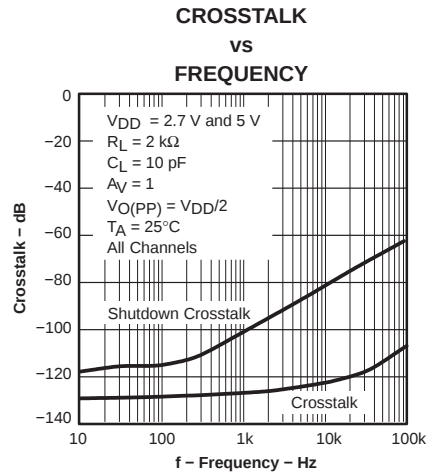


Figure 19

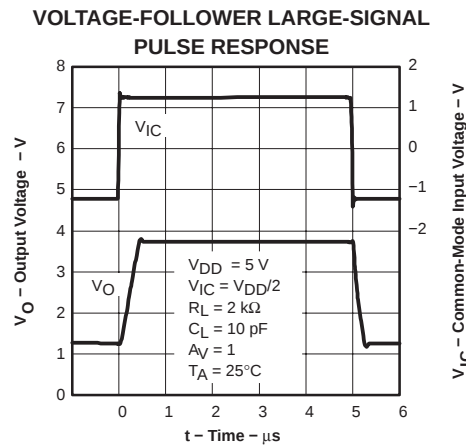


Figure 20

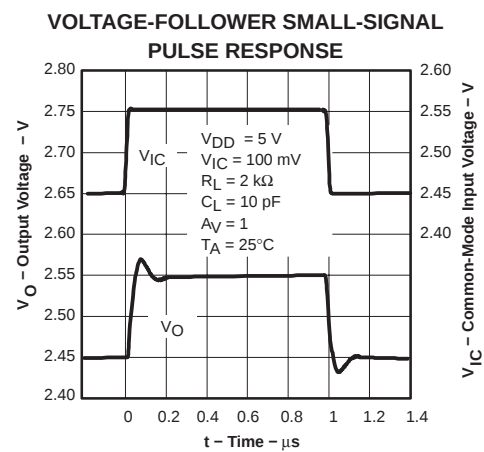


Figure 21

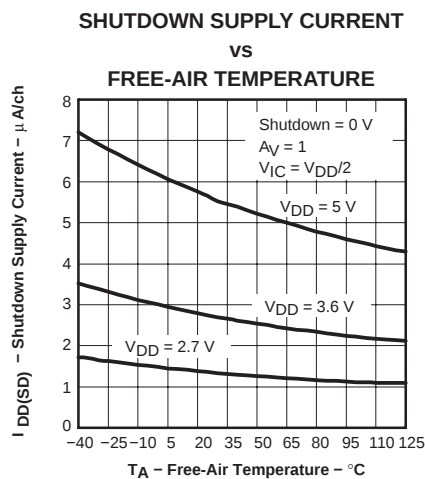


Figure 22

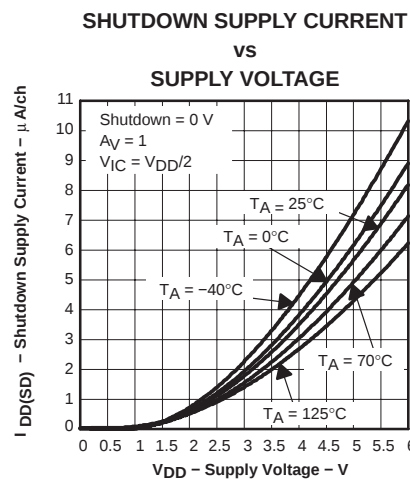


Figure 23

TYPICAL CHARACTERISTICS

SHUTDOWN SUPPLY CURRENT / OUTPUT VOLTAGE vs TIME

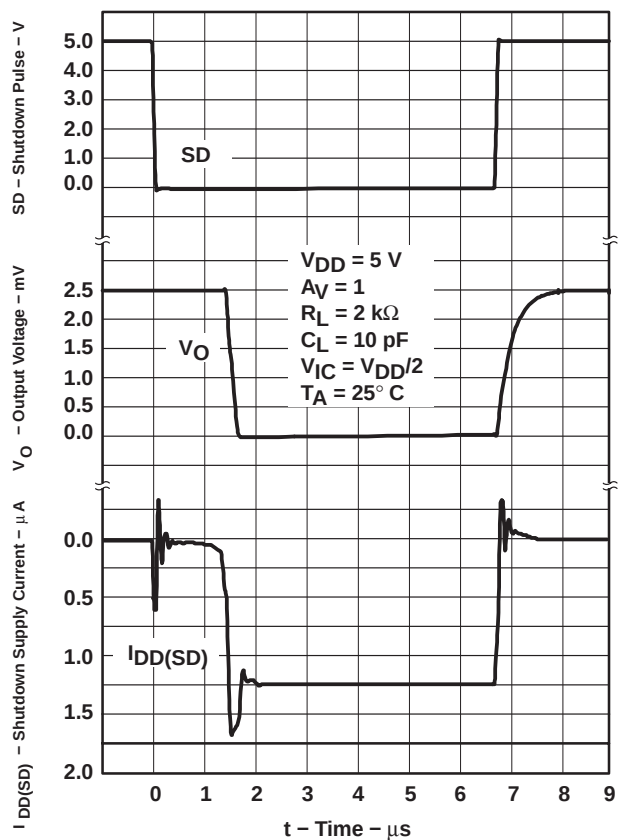
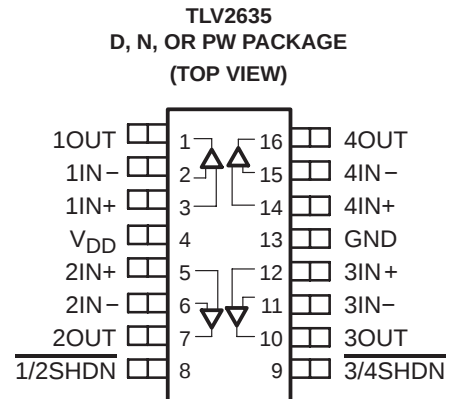
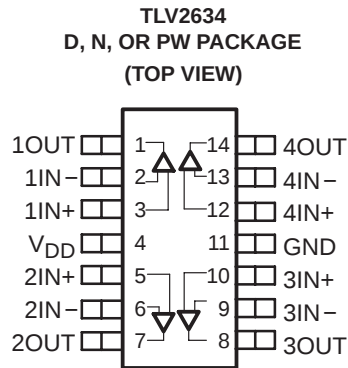
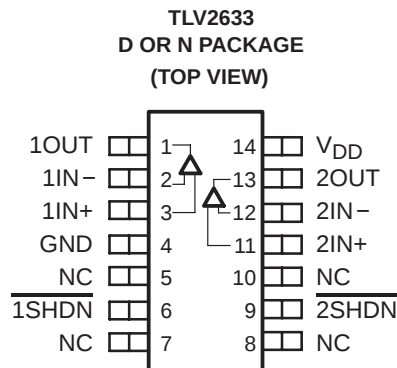
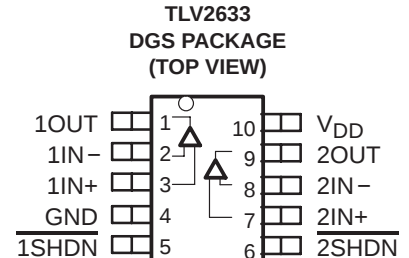
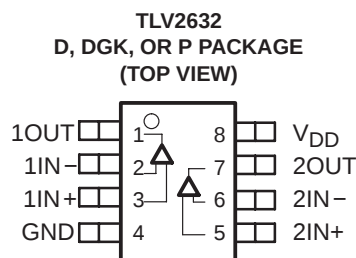
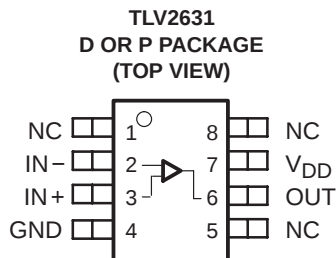
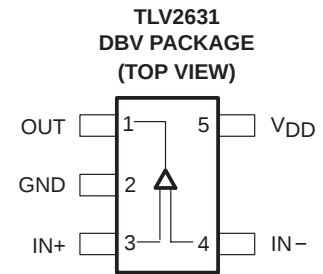
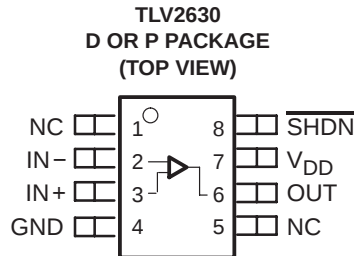
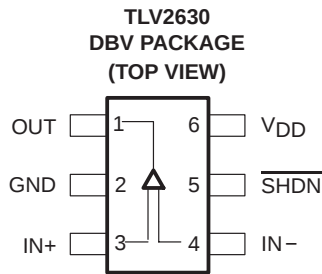


Figure 24

TLV263x PACKAGE PINOUTS



NC – No internal connection

PACKAGING INFORMATION

Orderable Device	Status ⁽¹⁾	Package Type	Package Drawing	Pins	Package Qty	Eco Plan ⁽²⁾	Lead/Ball Finish	MSL Peak Temp ⁽³⁾
TLV2630ID	ACTIVE	SOIC	D	8	75	Pb-Free (RoHS)	CU NIPDAU	Level-2-260C-1YEAR/ Level-1-220C-UNLIM
TLV2630IDBVR	ACTIVE	SOT-23	DBV	6	3000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
TLV2630IDBVT	ACTIVE	SOT-23	DBV	6	250	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
TLV2630IDR	ACTIVE	SOIC	D	8	2500	Pb-Free (RoHS)	CU NIPDAU	Level-2-260C-1YEAR/ Level-1-220C-UNLIM
TLV2630IP	ACTIVE	PDIP	P	8	50	Pb-Free (RoHS)	CU NIPDAU	Level-NC-NC-NC
TLV2631ID	ACTIVE	SOIC	D	8	75	Pb-Free (RoHS)	CU NIPDAU	Level-2-260C-1YEAR/ Level-1-220C-UNLIM
TLV2631IDBVR	ACTIVE	SOT-23	DBV	5	3000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
TLV2631IDBVT	ACTIVE	SOT-23	DBV	5	250	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
TLV2631IDR	ACTIVE	SOIC	D	8	2500	Pb-Free (RoHS)	CU NIPDAU	Level-2-260C-1YEAR/ Level-1-220C-UNLIM
TLV2631IP	ACTIVE	PDIP	P	8	50	Pb-Free (RoHS)	CU NIPDAU	Level-NC-NC-NC
TLV2632ID	ACTIVE	SOIC	D	8	75	Pb-Free (RoHS)	CU NIPDAU	Level-2-260C-1YEAR/ Level-1-220C-UNLIM
TLV2632IDGK	ACTIVE	MSOP	DGK	8	80	None	CU NIPDAU	Level-1-220C-UNLIM
TLV2632IDGKR	ACTIVE	MSOP	DGK	8	2500	None	CU NIPDAU	Level-1-220C-UNLIM
TLV2632IDR	ACTIVE	SOIC	D	8	2500	Pb-Free (RoHS)	CU NIPDAU	Level-2-260C-1YEAR/ Level-1-220C-UNLIM
TLV2632IP	ACTIVE	PDIP	P	8	50	Pb-Free (RoHS)	CU NIPDAU	Level-NC-NC-NC
TLV2633ID	ACTIVE	SOIC	D	14	50	Pb-Free (RoHS)	CU NIPD	Level-2-260C-1YEAR/ Level-1-220C-UNLIM
TLV2633IDGS	ACTIVE	MSOP	DGS	10	80	None	CU SNPB	Level-1-220C-UNLIM
TLV2633IDGSR	ACTIVE	MSOP	DGS	10	2500	None	CU SNPB	Level-1-220C-UNLIM
TLV2633IDR	ACTIVE	SOIC	D	14	2500	Pb-Free (RoHS)	CU NIPD	Level-2-260C-1YEAR/ Level-1-220C-UNLIM
TLV2633IN	ACTIVE	PDIP	N	14	25	Pb-Free (RoHS)	CU NIPD	Level-NC-NC-NC
TLV2634ID	ACTIVE	SOIC	D	14	50	Pb-Free (RoHS)	CU NIPDAU	Level-2-260C-1YEAR/ Level-1-220C-UNLIM
TLV2634IDR	ACTIVE	SOIC	D	14	2500	Pb-Free (RoHS)	CU NIPDAU	Level-2-260C-1YEAR/ Level-1-220C-UNLIM
TLV2634IN	ACTIVE	PDIP	N	14	25	Pb-Free (RoHS)	CU NIPD	Level-NC-NC-NC
TLV2634IPW	ACTIVE	TSSOP	PW	14	90	None	CU NIPDAU	Level-1-220C-UNLIM
TLV2634IPWR	ACTIVE	TSSOP	PW	14	2000	None	CU NIPDAU	Level-1-220C-UNLIM
TLV2635ID	ACTIVE	SOIC	D	16	40	Pb-Free (RoHS)	CU NIPDAU	Level-2-260C-1YEAR/ Level-1-220C-UNLIM
TLV2635IDR	ACTIVE	SOIC	D	16	2500	Pb-Free (RoHS)	CU NIPDAU	Level-2-260C-1YEAR/ Level-1-220C-UNLIM

Orderable Device	Status ⁽¹⁾	Package Type	Package Drawing	Pins	Package Qty	Eco Plan ⁽²⁾	Lead/Ball Finish	MSL Peak Temp ⁽³⁾
TLV2635IN	ACTIVE	PDIP	N	16	25	Pb-Free (RoHS)	CU NIPDAU	Level-NC-NC-NC
TLV2635IPW	ACTIVE	TSSOP	PW	16	90	None	CU NIPDAU	Level-1-220C-UNLIM
TLV2635IPWR	ACTIVE	TSSOP	PW	16	2000	None	CU NIPDAU	Level-1-220C-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.

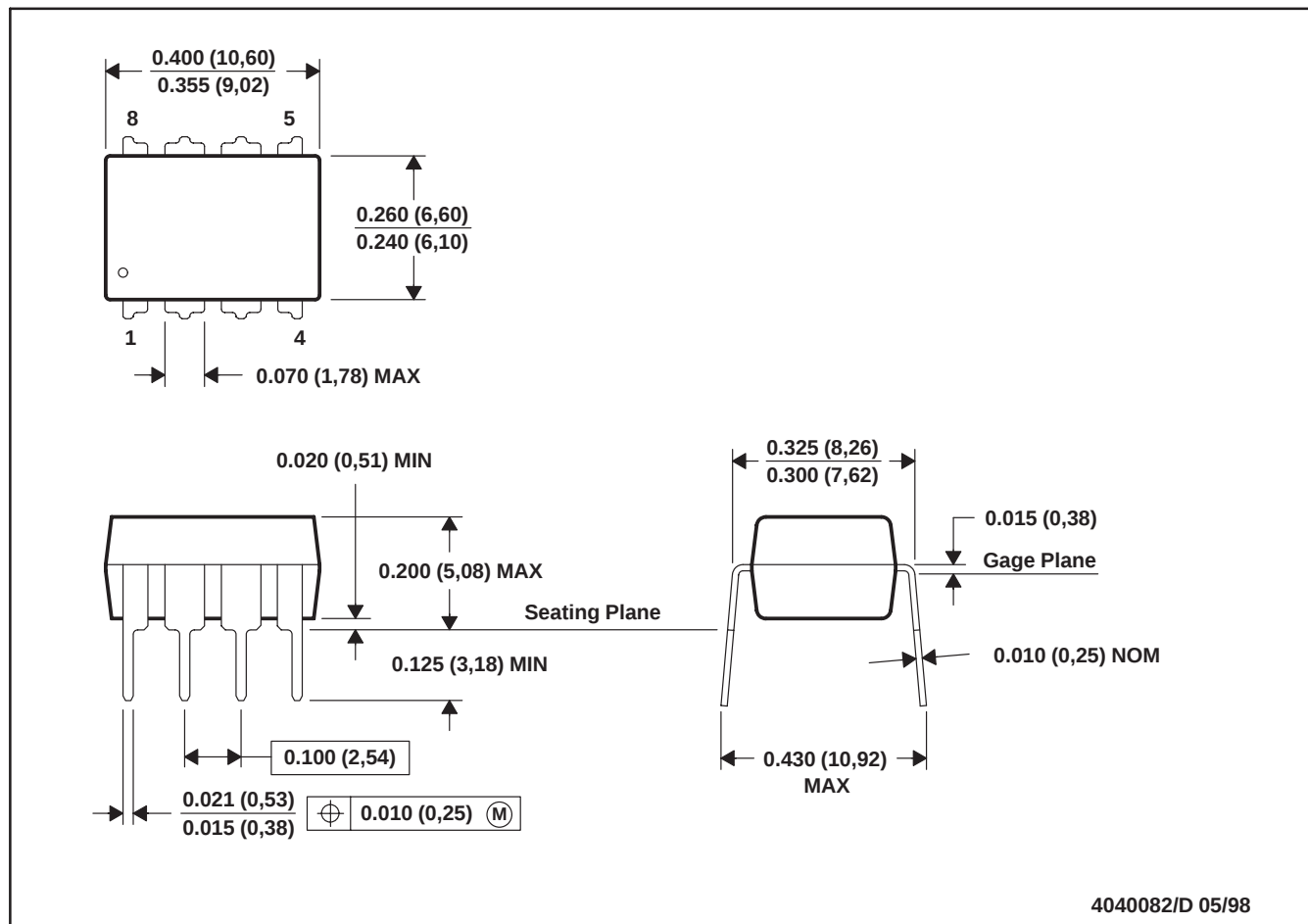
⁽³⁾ MSL, Peak Temp. -- The Moisture Sensitivity Level rating according to the JEDEC industry standard classifications, and peak solder temperature.

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P (R-PDIP-T8)

PLASTIC DUAL-IN-LINE



- NOTES: A. All linear dimensions are in inches (millimeters).
 B. This drawing is subject to change without notice.
 C. Falls within JEDEC MS-001

For the latest package information, go to http://www.ti.com/sc/docs/package/pkg_info.htm

N (R-PDIP-T**)

16 PINS SHOWN

PLASTIC DUAL-IN-LINE PACKAGE



PINS ** DIM	14	16	18	20
A MAX	0.775 (19,69)	0.775 (19,69)	0.920 (23,37)	1.060 (26,92)
A MIN	0.745 (18,92)	0.745 (18,92)	0.850 (21,59)	0.940 (23,88)
MS-001 VARIATION	AA	BB	AC	AD

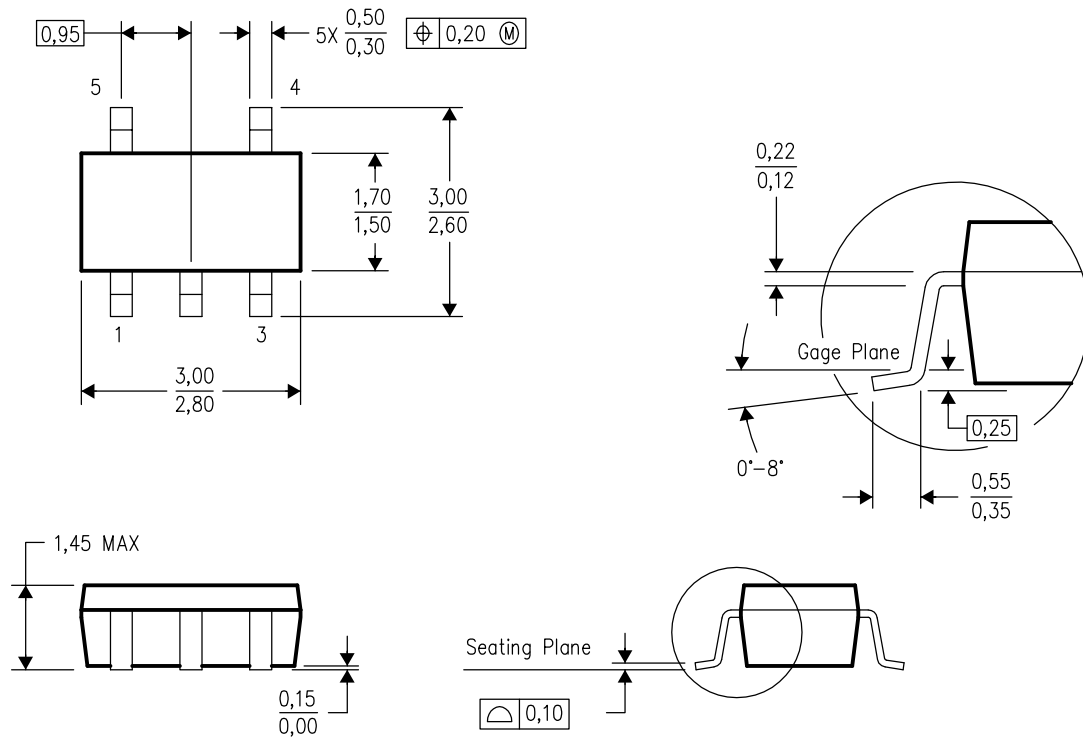


4040049/E 12/2002

- NOTES:
- A. All linear dimensions are in inches (millimeters).
 - B. This drawing is subject to change without notice.
 -  Falls within JEDEC MS-001, except 18 and 20 pin minimum body length (Dim A).
 -  The 20 pin end lead shoulder width is a vendor option, either half or full width.

DBV (R-PDSO-G5)

PLASTIC SMALL-OUTLINE PACKAGE

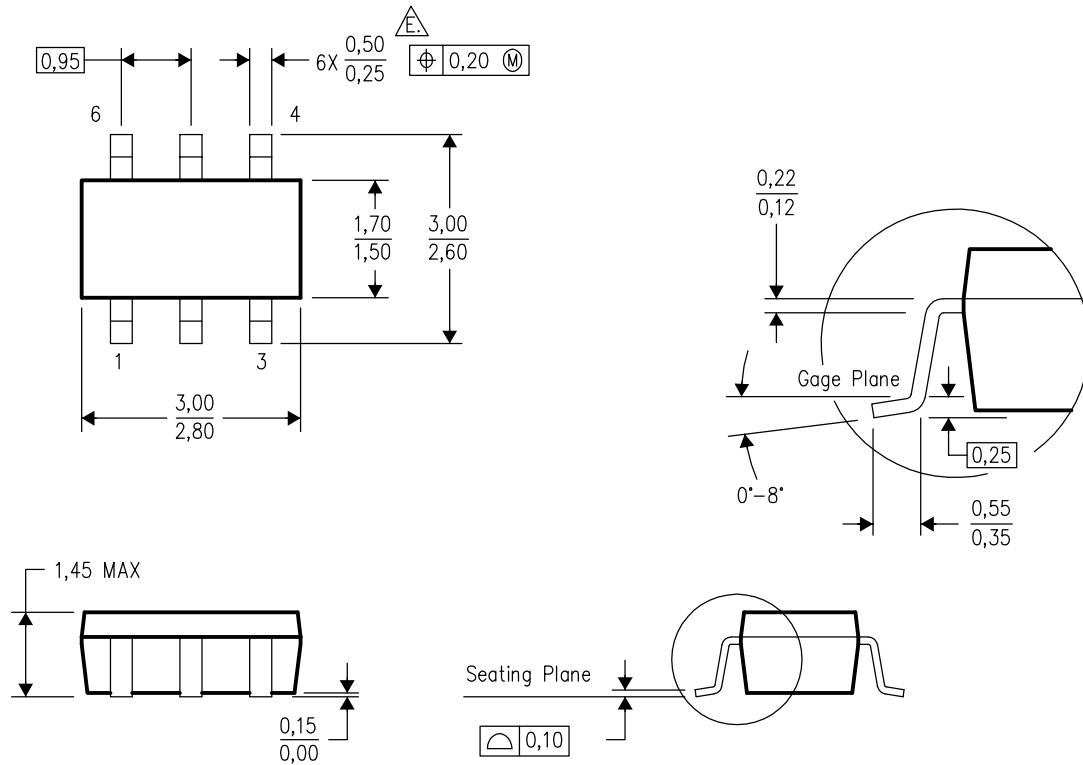


4073253-4/H 10/2003

- 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.

DBV (R-PDSO-G6)

PLASTIC SMALL-OUTLINE PACKAGE

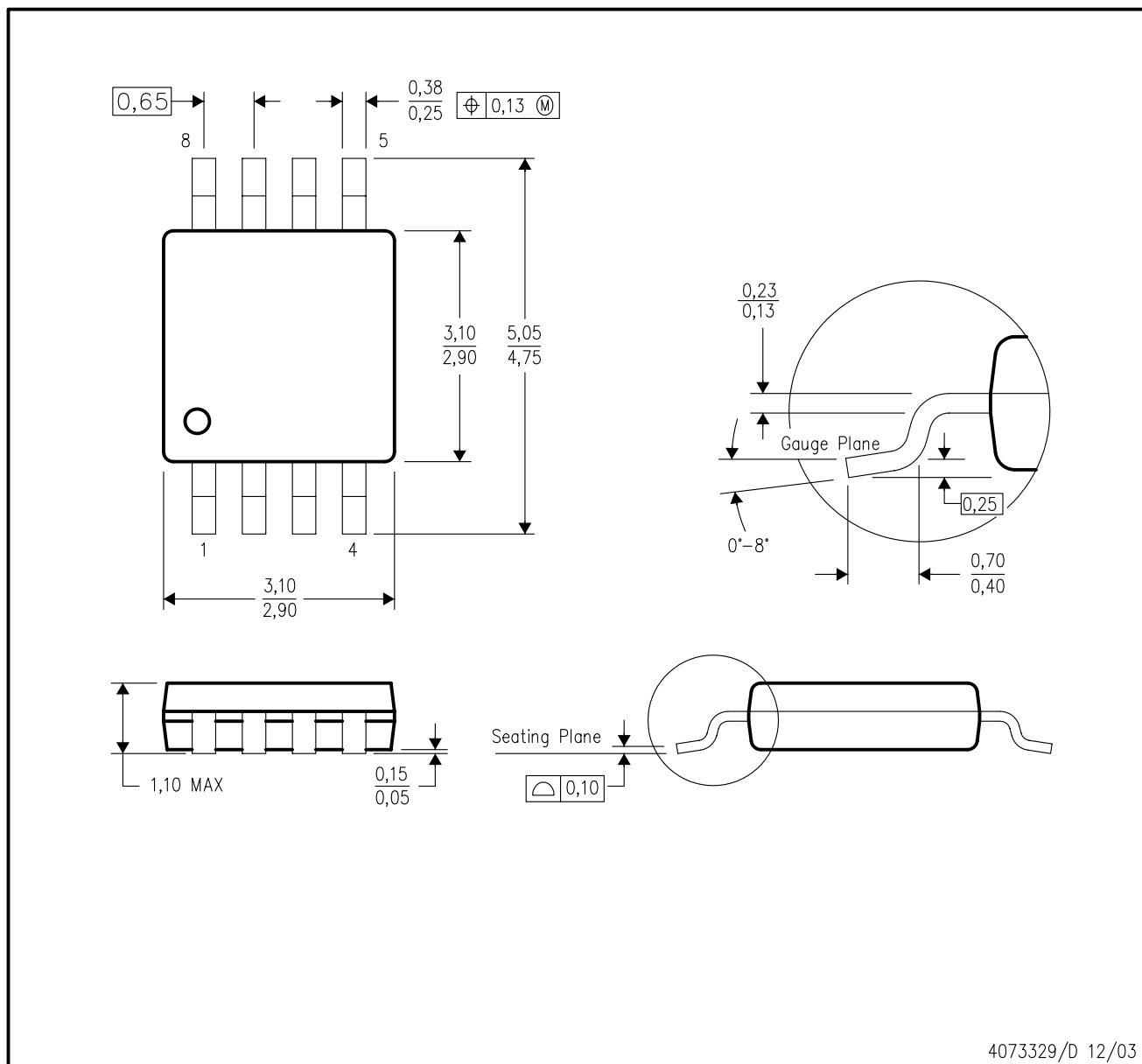


4073253-5/H 10/2003

- 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. Leads 1,2,3 may be wider than leads 4,5,6 for package orientation.
 -  Falls within JEDEC MO-178 Variation AB, except minimum lead width.

DGK (S-PDSO-G8)

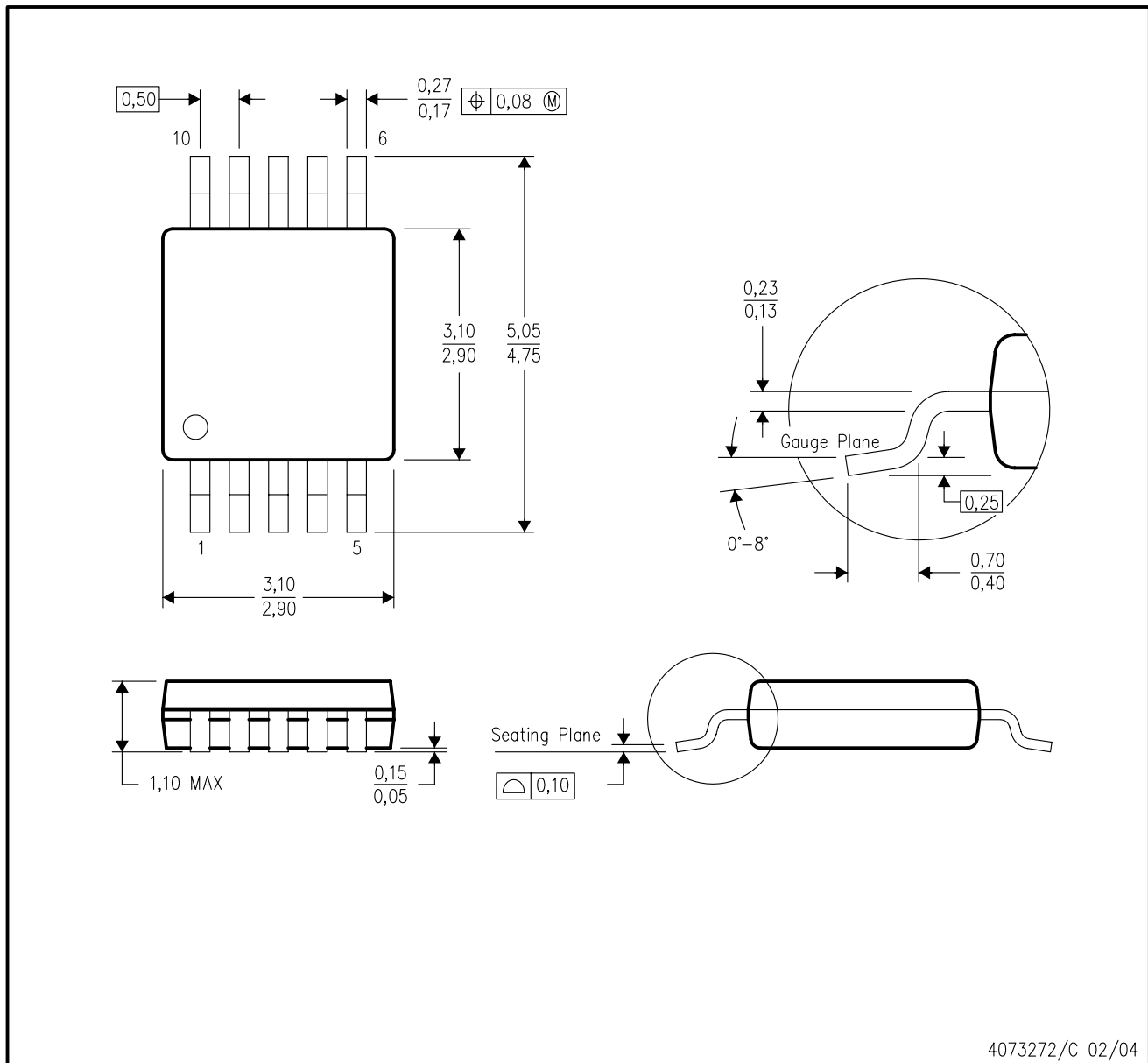
PLASTIC SMALL-OUTLINE PACKAGE



- 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-187 variation AA.

DGS (S-PDSO-G10)

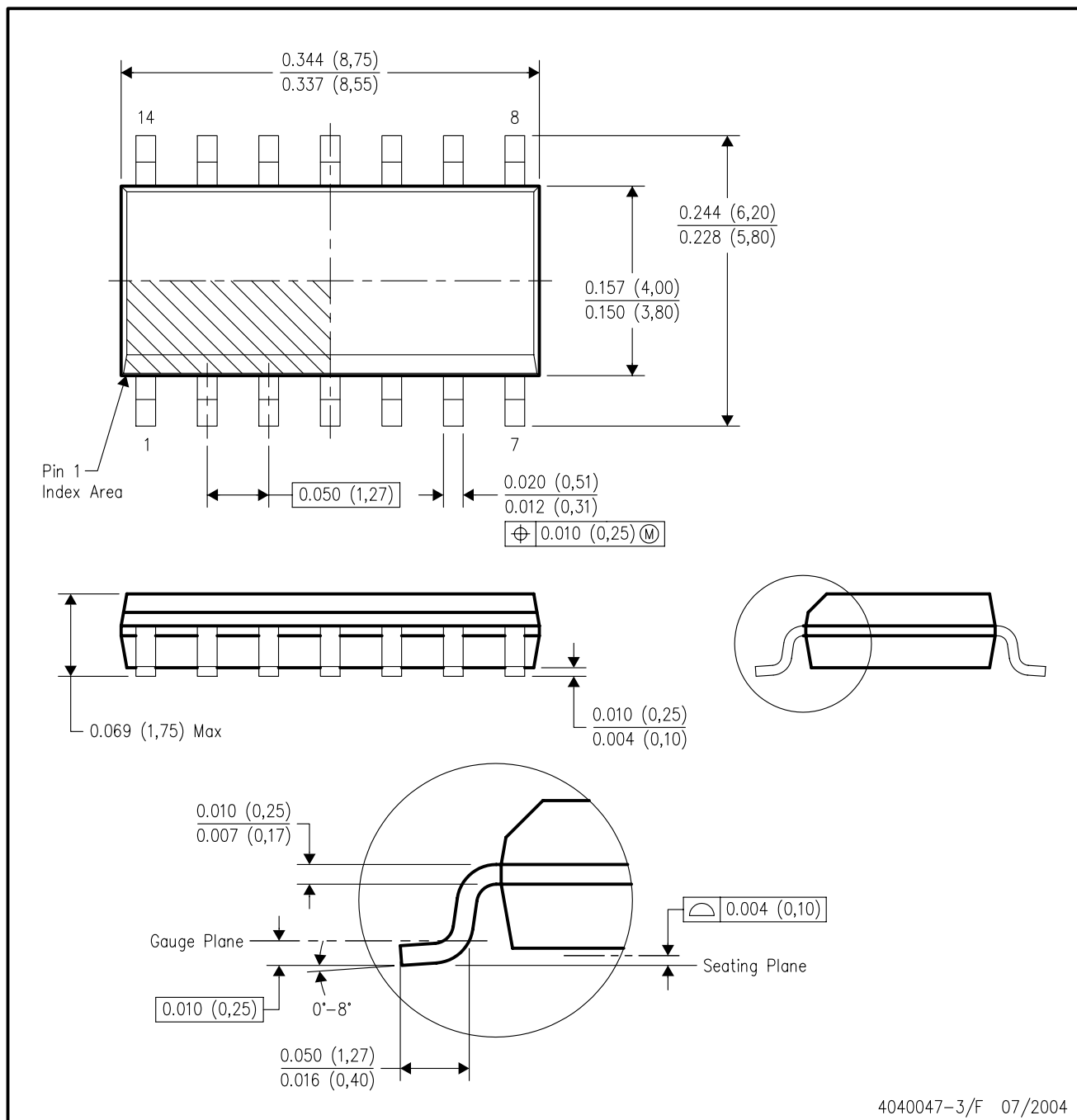
PLASTIC SMALL-OUTLINE PACKAGE



- NOTES:
- All linear dimensions are in millimeters.
 - This drawing is subject to change without notice.
 - Body dimensions do not include mold flash or protrusion.
 - Falls within JEDEC MO-187 variation BA.

D (R-PDSO-G14)

PLASTIC SMALL-OUTLINE PACKAGE

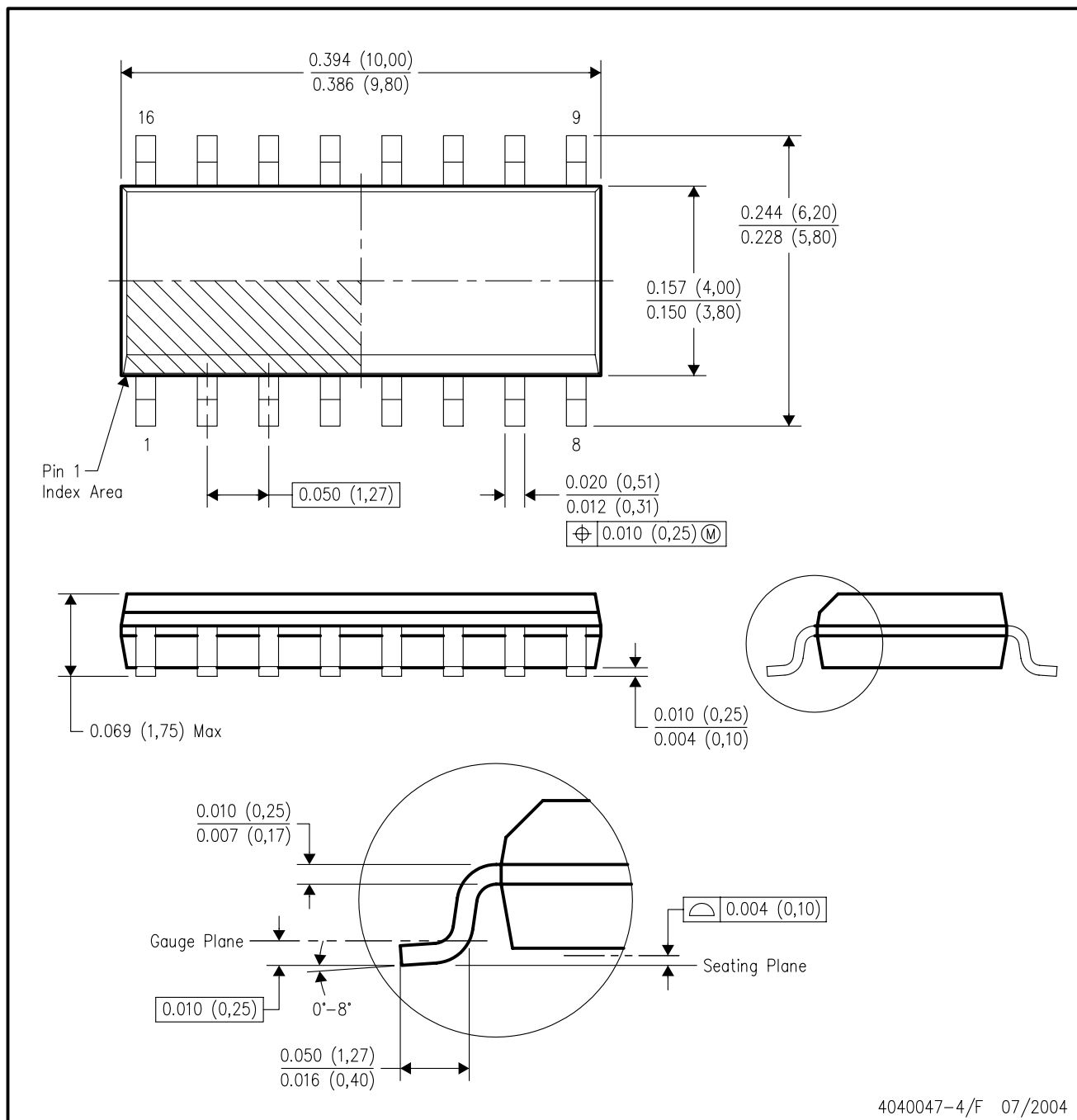


4040047-3/F 07/2004

- 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-G16)

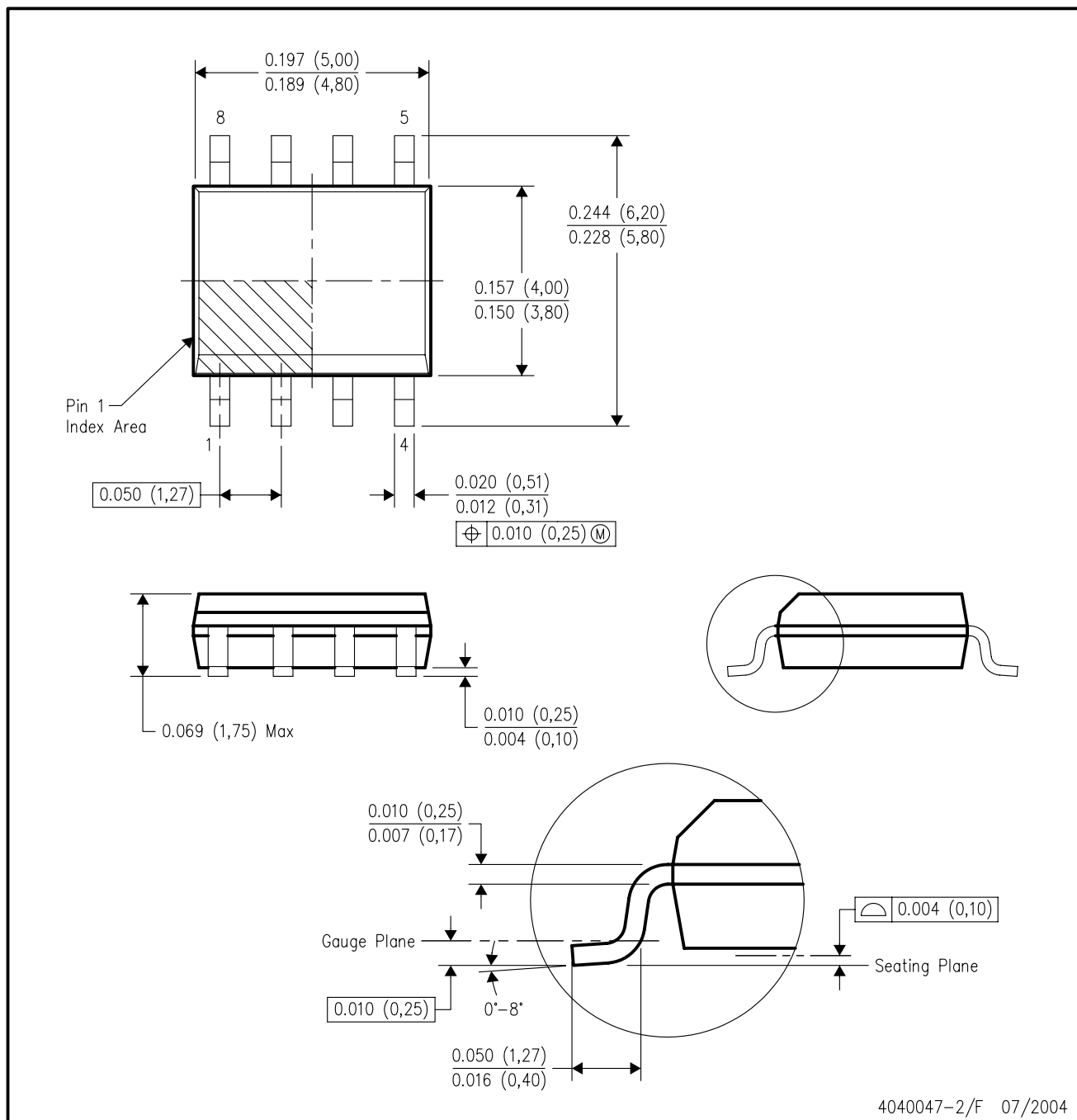
PLASTIC SMALL-OUTLINE PACKAGE



4040047-4/F 07/2004

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

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

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