

# LM193, LM293, LM293A LM393, LM393A, LM2903, LM2903V DUAL DIFFERENTIAL COMPARATORS

SLCS005P – JUNE 1976 – REVISED JUNE 2004

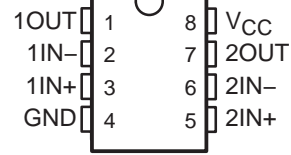
- Single Supply or Dual Supplies
- Wide Range of Supply Voltage
  - Max Rating . . . 2 V to 36 V
  - Tested to 30 V . . . Non-V Devices
  - Tested to 32 V . . . V-Suffix Devices
- Low Supply-Current Drain Independent of Supply Voltage . . . 0.4 mA Typ Per Comparator
- Low Input Bias Current . . . 25 nA Typ
- Low Input Offset Current . . . 3 nA Typ (LM193)
- Low Input Offset Voltage . . . 2 mV Typ
- Common-Mode Input Voltage Range Includes Ground
- Differential Input Voltage Range Equal to Maximum-Rated Supply Voltage . . .  $\pm 36$  V
- Low Output Saturation Voltage
- Output Compatible With TTL, MOS, and CMOS

## description/ordering information

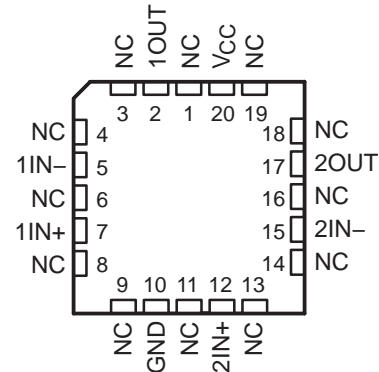
These devices consist of two independent voltage comparators that are designed to operate from a single power supply over a wide range of voltages. Operation from dual supplies also is possible as long as the difference between the two supplies is 2 V to 36 V, and  $V_{CC}$  is at least 1.5 V more positive than the input common-mode voltage. Current drain is independent of the supply voltage. The outputs can be connected to other open-collector outputs to achieve wired-AND relationships.

The LM193 is characterized for operation from  $-55^{\circ}\text{C}$  to  $125^{\circ}\text{C}$ . The LM293 and LM293A are characterized for operation from  $-25^{\circ}\text{C}$  to  $85^{\circ}\text{C}$ . The LM393 and LM393A are characterized for operation from  $0^{\circ}\text{C}$  to  $70^{\circ}\text{C}$ . The LM2903 is characterized for operation from  $-40^{\circ}\text{C}$  to  $125^{\circ}\text{C}$ .

LM193 . . . D OR JG PACKAGE  
LM293 . . . D OR P PACKAGE  
LM293A . . . D PACKAGE  
LM393, LM393A . . . D, DGK, P, PS, OR PW PACKAGE  
LM2903 . . . D, DGK, P, PS, OR PW PACKAGE  
(TOP VIEW)



LM193 . . . FK PACKAGE  
(TOP VIEW)



NC – No internal connection



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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On products compliant to MIL-PRF-38535, all parameters are tested unless otherwise noted. On all other products, production processing does not necessarily include testing of all parameters.

**LM193, LM293, LM293A  
LM393, LM393A, LM2903, LM2903V  
DUAL DIFFERENTIAL COMPARATORS**

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**description/ordering information (continued)**

**ORDERING INFORMATION**

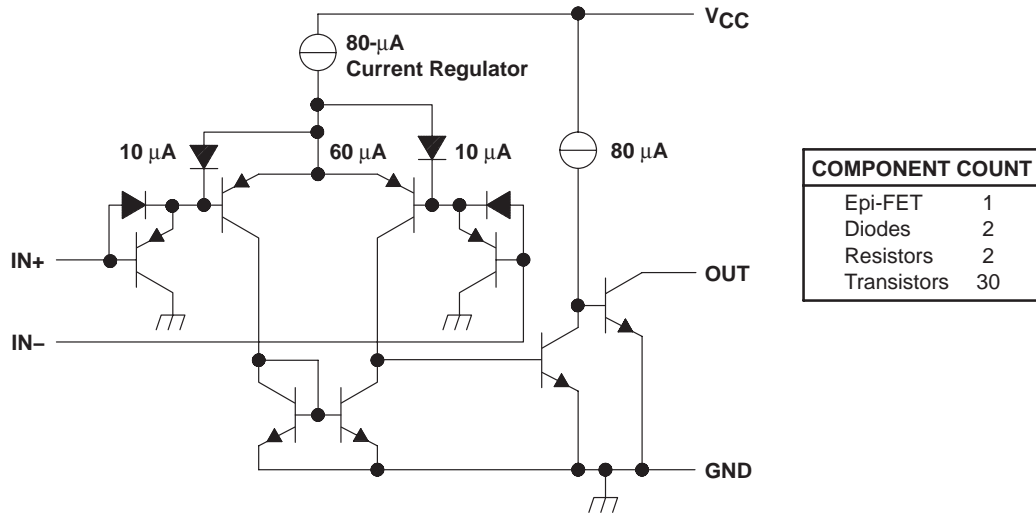
TA	V <sub>IOmax</sub> AT 25°C	MAX V <sub>CC</sub>	PACKAGE†		ORDERABLE PART NUMBER	TOP-SIDE MARKING
0°C to 70°C	5 mV	30 V	PDIP (P)	Tube of 50	LM393P	LM393P
			SOIC (D)	Tube of 75	LM393D	LM393
				Reel of 2500	LM393DR	
			SOP (PS)	Reel of 2000	LM393PSR	L393
			TSSOP (PW)	Tube of 150	LM393PW	L393
	Reel of 2000	LM393PWR				
	MSOP/VSSOP (DGK)	Reel of 2500	LM393DGKR	M9S		
	2 mV	30 V	PDIP (P)	Tube of 50	LM393AP	LM393AP
			SOIC (D)	Tube of 75	LM393AD	LM393A
				Reel of 2500	LM393ADR	
SOP (PS)			Reel of 2000	LM393APSR	L393A	
TSSOP (PW)			Reel of 2000	LM393APWR	L393A	
MSOP/VSSOP (DGK)	Reel of 2500	LM393ADGKR	M8S			
-25°C to 85°C	5 mV	30 V	PDIP (P)	Tube of 50	LM293P	LM293P
			SOIC (D)	Tube of 75	LM293D	LM293
	Reel of 2500	LM293DR				
	2 mV	30 V	SOIC (D)	Tube of 75	LM293AD	LM293A
Reel of 2500			LM293ADR			
-40°C to 125°C	7 mV	30 V	PDIP (P)	Tube of 50	LM2903P	LM2903P
			SOIC (D)	Tube of 75	LM2903D	LM2903
				Reel of 2500	LM2903DR	
			SOP (PS)	Reel of 2000	LM2903PSR	L2903
			TSSOP (PW)	Reel of 2000	LM2903PWR	L2903
	MSOP/VSSOP (DGK)	Reel of 2500	LM2903DGKR	MAS		
	7 mV	32 V	SOIC (D)	Reel of 2500	LM2903VQDR	L2903V
			TSSOP (PW)	Reel of 2000	LM2903VQPWR	L2903V
	2 mV	32 V	SOIC (D)	Reel of 2500	LM2903AVQDR	L2903AV
			TSSOP (PW)	Reel of 2000	LM2903AVQPWR	L2903AV
-55°C to 125°C	5 mV	30 V	CDIP (JG)	Tube of 50	LM193JG	LM193JG
			LCCC (FK)	Tube of 55	LM193FK	LM193FK
			SOIC (D)	Tube of 75	LM193D	LM193D

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

**symbol (each comparator)**



**schematic (each comparator)**



Current values shown are nominal.

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

Supply voltage, $V_{CC}$ (see Note 1)	36 V
Differential input voltage, $V_{ID}$ (see Note 2)	$\pm 36$ V
Input voltage range, $V_I$ (either input)	-0.3 V to 36 V
Output voltage, $V_O$	36 V
Output current, $I_O$	20 mA
Duration of output short-circuit to ground (see Note 3)	Unlimited
Package thermal impedance, $\theta_{JA}$ (see Notes 4 and 5):	
D package	97°C/W
DGK package	172°C/W
P package	85°C/W
PS package	95°C/W
PW package	149°C/W
Package thermal impedance, $\theta_{JC}$ (see Notes 6 and 7):	
FK package	5.61°C/W
JG package	14.5°C/W
Operating virtual junction temperature, $T_J$	150°C
Case temperature for 60 seconds: FK package	260°C
Lead temperature 1,6 mm (1/16 inch) from case for 60 seconds: JG package	300°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, are with respect to GND.
  2. Differential voltages are at IN+, with respect to IN-.
  3. Short circuits from outputs to  $V_{CC}$  can cause excessive heating and eventual destruction.
  4. Maximum power dissipation is a function of  $T_J(\max)$ ,  $\theta_{JA}$ , and  $T_A$ . The maximum allowable power dissipation at any allowable ambient temperature is  $P_D = (T_J(\max) - T_A)/\theta_{JA}$ . Operating at the absolute maximum  $T_J$  of 150°C can affect reliability.
  5. The package thermal impedance is calculated in accordance with JESD 51-7.
  6. Maximum power dissipation is a function of  $T_J(\max)$ ,  $\theta_{JC}$ , and  $T_C$ . The maximum allowable power dissipation at any allowable case temperature is  $P_D = (T_J(\max) - T_C)/\theta_{JC}$ . Operating at the absolute maximum  $T_J$  of 150°C can affect reliability.
  7. The package thermal impedance is calculated in accordance with MIL-STD-883.

**LM193, LM293, LM293A**  
**LM393, LM393A, LM2903, LM2903V**  
**DUAL DIFFERENTIAL COMPARATORS**

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

PARAMETER	TEST CONDITIONS	$T_A$ †	LM193			LM293 LM393			UNIT
			MIN	TYP	MAX	MIN	TYP	MAX	
$V_{IO}$ Input offset voltage	$V_{CC} = 5\text{ V to }30\text{ V}$ , $V_O = 1.4\text{ V}$ , $V_{IC} = V_{IC(min)}$	25°C		2	5		2	5	mV
		Full range			9		9		
$I_{IO}$ Input offset current	$V_O = 1.4\text{ V}$	25°C		3	25		5	50	nA
		Full range			100		250		
$I_{IB}$ Input bias current	$V_O = 1.4\text{ V}$	25°C		-25	-100		-25	-250	nA
		Full range			-300		-400		
$V_{ICR}$ Common-mode input voltage range‡		25°C	0 to $V_{CC}-1.5$			0 to $V_{CC}-1.5$			V
		Full range	0 to $V_{CC}-2$			0 to $V_{CC}-2$			
$A_{VD}$ Large-signal differential-voltage amplification	$V_{CC} = 15\text{ V}$ , $V_O = 1.4\text{ V to }11.4\text{ V}$ , $R_L \geq 15\text{ k}\Omega\text{ to }V_{CC}$	25°C	50	200		50	200	V/mV	
$I_{OH}$ High-level output current	$V_{OH} = 5\text{ V}$ , $V_{ID} = 1\text{ V}$	25°C	0.1			0.1	50	nA	
	$V_{OH} = 30\text{ V}$ , $V_{ID} = 1\text{ V}$	Full range				1	1	$\mu\text{A}$	
$V_{OL}$ Low-level output voltage	$I_{OL} = 4\text{ mA}$ , $V_{ID} = -1\text{ V}$	25°C	150			400	150	400	mV
		Full range				700	700		
$I_{OL}$ Low-level output current	$V_{OL} = 1.5\text{ V}$ , $V_{ID} = -1\text{ V}$	25°C	6			6		mA	
$I_{CC}$ Supply current	$R_L = \infty$	$V_{CC} = 5\text{ V}$	25°C	0.8		1	0.8	1	mA
		$V_{CC} = 30\text{ V}$	Full range			2.5	2.5		

† Full range (MIN or MAX) for LM193 is  $-55^\circ\text{C}$  to  $125^\circ\text{C}$ , for LM293 is  $25^\circ\text{C}$  to  $85^\circ\text{C}$ , and for LM393 is  $0^\circ\text{C}$  to  $70^\circ\text{C}$ . All characteristics are measured with zero common-mode input voltage, unless otherwise specified.

‡ The voltage at either input or common-mode should not be allowed to go negative by more than 0.3 V. The upper end of the common-mode voltage range is  $V_{CC+} - 1.5\text{ V}$ , but either or both inputs can go to 30 V without damage.



**LM193, LM293, LM293A**  
**LM393, LM393A, LM2903, LM2903V**  
**DUAL DIFFERENTIAL COMPARATORS**  
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electrical characteristics at specified free-air temperature,  $V_{CC} = 5\text{ V}$  (unless otherwise noted)

PARAMETER	TEST CONDITIONS	$T_A$ †	LM293A LM393A			UNIT
			MIN	TYP	MAX	
$V_{IO}$ Input offset voltage	$V_{CC} = 5\text{ V to }30\text{ V}$ , $V_O = 1.4\text{ V}$ , $V_{IC} = V_{IC(min)}$	25°C	1	2		mV
		Full range			4	
$I_{IO}$ Input offset current	$V_O = 1.4\text{ V}$	25°C	5	50		nA
		Full range			150	
$I_{IB}$ Input bias current	$V_O = 1.4\text{ V}$	25°C	-25	-250		nA
		Full range			-400	
$V_{ICR}$ Common-mode input voltage range§		25°C	0 to $V_{CC}-1.5$			V
		Full range	0 to $V_{CC}-2$			
$A_{VD}$ Large-signal differential-voltage amplification	$V_{CC} = 15\text{ V}$ , $V_O = 1.4\text{ V to }11.4\text{ V}$ , $R_L \geq 15\text{ k}\Omega$ to $V_{CC}$	25°C	50	200		V/mV
$I_{OH}$ High-level output current	$V_{OH} = 5\text{ V}$ , $V_{ID} = 1\text{ V}$	25°C	0.1	50		nA
	$V_{OH} = 30\text{ V}$ , $V_{ID} = 1\text{ V}$	Full range			1	$\mu\text{A}$
$V_{OL}$ Low-level output voltage	$I_{OL} = 4\text{ mA}$ , $V_{ID} = -1\text{ V}$	25°C	150	400		mV
		Full range			700	
$I_{OL}$ Low-level output current	$V_{OL} = 1.5\text{ V}$ , $V_{ID} = -1\text{ V}$	25°C	6			mA
$I_{CC}$ Supply current	$R_L = \infty$	$V_{CC} = 5\text{ V}$	25°C	0.8	1	mA
		$V_{CC} = 30\text{ V}$	Full range		2.5	

† Full range (MIN or MAX) for LM293A is 25°C to 85°C, and for LM393A is 0°C to 70°C. All characteristics are measured with zero common-mode input voltage, unless otherwise specified.

§ The voltage at either input or common-mode should not be allowed to go negative by more than 0.3 V. The upper end of the common-mode voltage range is  $V_{CC+} - 1.5\text{ V}$ , but either or both inputs can go to 30 V without damage.

**LM193, LM293, LM293A**  
**LM393, LM393A, LM2903, LM2903V**  
**DUAL DIFFERENTIAL COMPARATORS**

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

PARAMETER	TEST CONDITIONS	$T_A$ †	LM2903			LM2903A			UNIT	
			MIN	TYP	MAX	MIN	TYP	MAX		
$V_{IO}$ Input offset voltage	$V_{CC} = 5\text{ V to MAX}^\ddagger$ , $V_O = 1.4\text{ V}$ , $V_{IC} = V_{IC(min)}$	25°C	2		7	1		2	mV	
		Full range	15			4				
$I_{IO}$ Input offset current	$V_O = 1.4\text{ V}$	25°C	5		50	5		50	nA	
		Full range	200			200				
$I_{IB}$ Input bias current	$V_O = 1.4\text{ V}$	25°C	-25		-250	-25		-250	nA	
		Full range	-500			-500				
$V_{ICR}$ Common-mode input voltage range§		25°C	0 to $V_{CC}-1.5$			0 to $V_{CC}-1.5$			V	
		Full range	0 to $V_{CC}-2$			0 to $V_{CC}-2$				
$A_{VD}$ Large-signal differential-voltage amplification	$V_{CC} = 15\text{ V}$ , $V_O = 1.4\text{ V to }11.4\text{ V}$ , $R_L \geq 15\text{ k}\Omega\text{ to }V_{CC}$	25°C	25	100		25	100		V/mV	
$I_{OH}$ High-level output current	$V_{OH} = 5\text{ V}$ , $V_{ID} = 1\text{ V}$	25°C	0.1		50	0.1		50	nA	
	$V_{OH} = V_{CC\text{ MAX}}$ , $V_{ID} = 1\text{ V}$	Full range	1			1			$\mu\text{A}$	
$V_{OL}$ Low-level output voltage	$I_{OL} = 4\text{ mA}$ , $V_{ID} = -1\text{ V}$	25°C	150		400	150		400	mV	
		Full range	700			700				
$I_{OL}$ Low-level output current	$V_{OL} = 1.5\text{ V}$ , $V_{ID} = -1\text{ V}$	25°C	6			6			mA	
$I_{CC}$ Supply current	$R_L = \infty$	$V_{CC} = 5\text{ V}$	25°C	0.8		1	0.8		1	mA
		$V_{CC} = \text{MAX}$	Full range	2.5			2.5			

† Full range (MIN or MAX) for LM2903 is  $-40^\circ\text{C}$  to  $125^\circ\text{C}$ . All characteristics are measured with zero common-mode input voltage, unless otherwise specified.

‡  $V_{CC\text{ MAX}} = 30\text{ V}$  for non-V devices and  $32\text{ V}$  for V-suffix devices.

§ The voltage at either input or common-mode should not be allowed to go negative by more than  $0.3\text{ V}$ . The upper end of the common-mode voltage range is  $V_{CC+} - 1.5\text{ V}$ , but either or both inputs can go to  $30\text{ V}$  ( $32\text{ V}$  for V-suffix devices) without damage.

**switching characteristics,  $V_{CC} = 5\text{ V}$ ,  $T_A = 25^\circ\text{C}$**

PARAMETER	TEST CONDITIONS	LM193 LM293, LM293A LM393, LM393A LM2903	UNIT	
		TYP		
Response time	$R_L$ connected to $5\text{ V}$ through $5.1\text{ k}\Omega$ , $C_L = 15\text{ pF}$ †, See Note 8	100-mV input step with 5-mV overdrive	1.3	$\mu\text{s}$
		TTL-level input step	0.3	

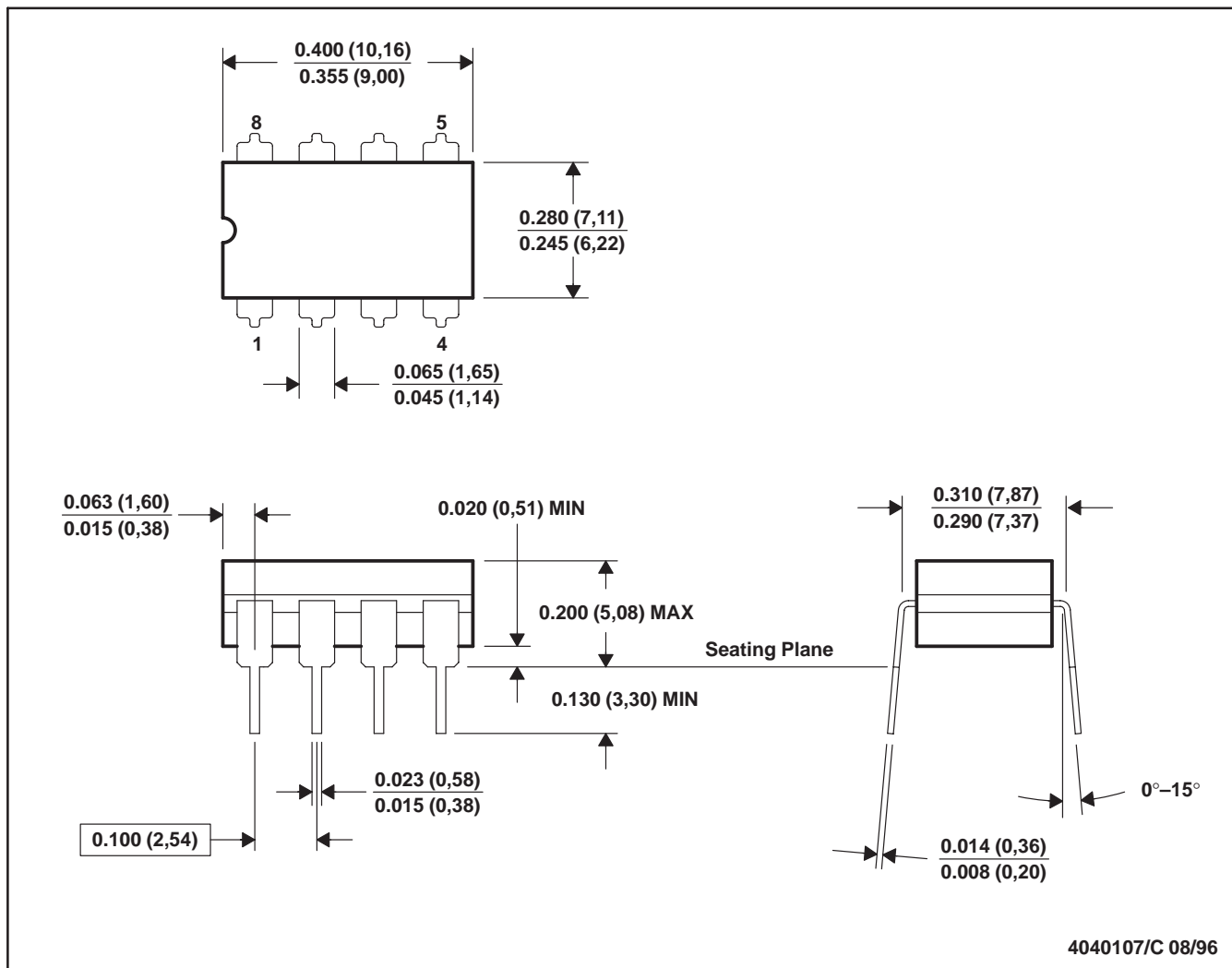
†  $C_L$  includes probe and jig capacitance.

NOTE 8: The response time specified is the interval between the input step function and the instant when the output crosses  $1.4\text{ V}$ .



JG (R-GDIP-T8)

CERAMIC DUAL-IN-LINE

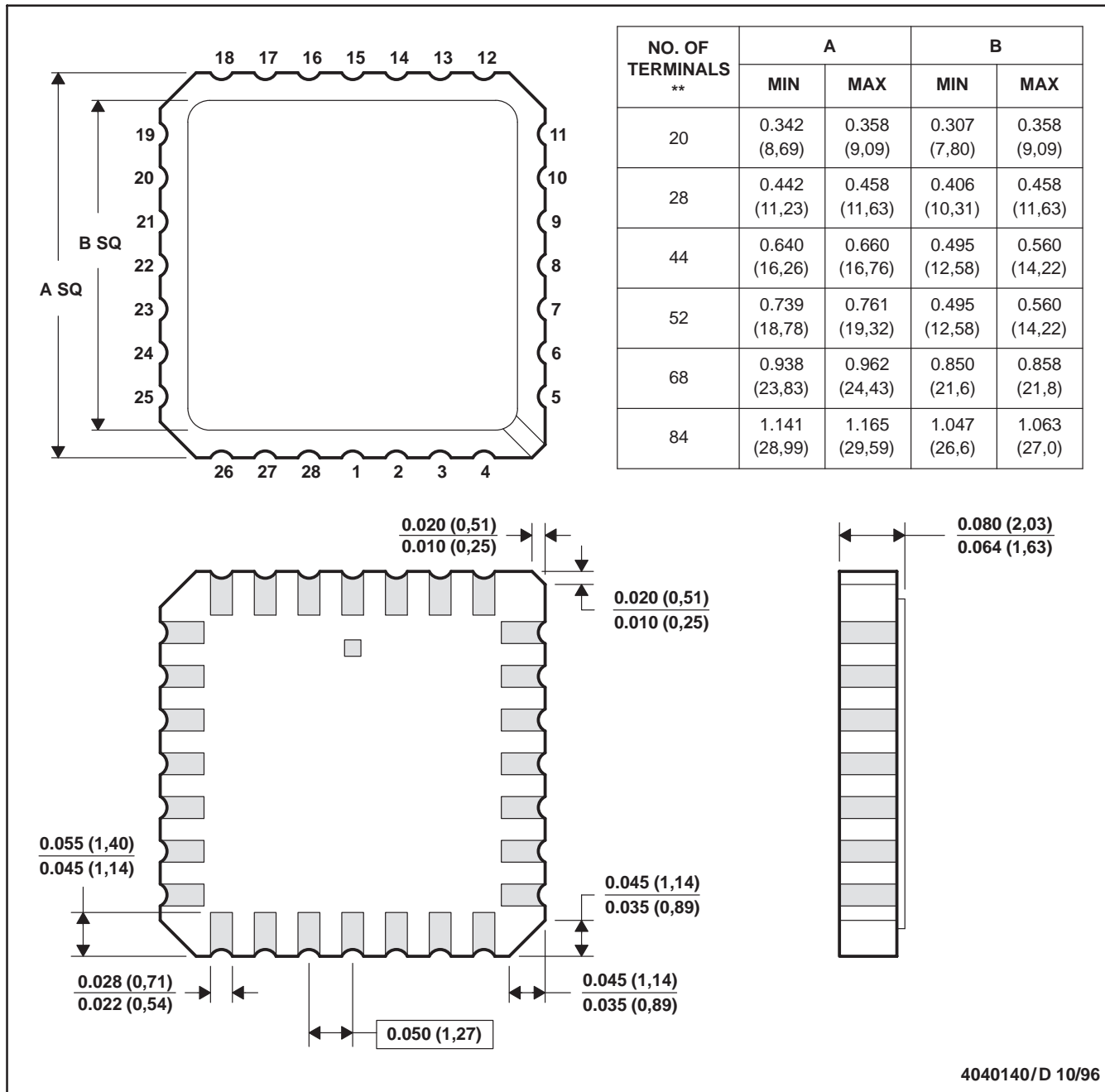


- NOTES: A. All linear dimensions are in inches (millimeters).  
 B. This drawing is subject to change without notice.  
 C. This package can be hermetically sealed with a ceramic lid using glass frit.  
 D. Index point is provided on cap for terminal identification.  
 E. Falls within MIL STD 1835 GDIP1-T8

FK (S-CQCC-N\*\*)

LEADLESS CERAMIC CHIP CARRIER

28 TERMINAL SHOWN



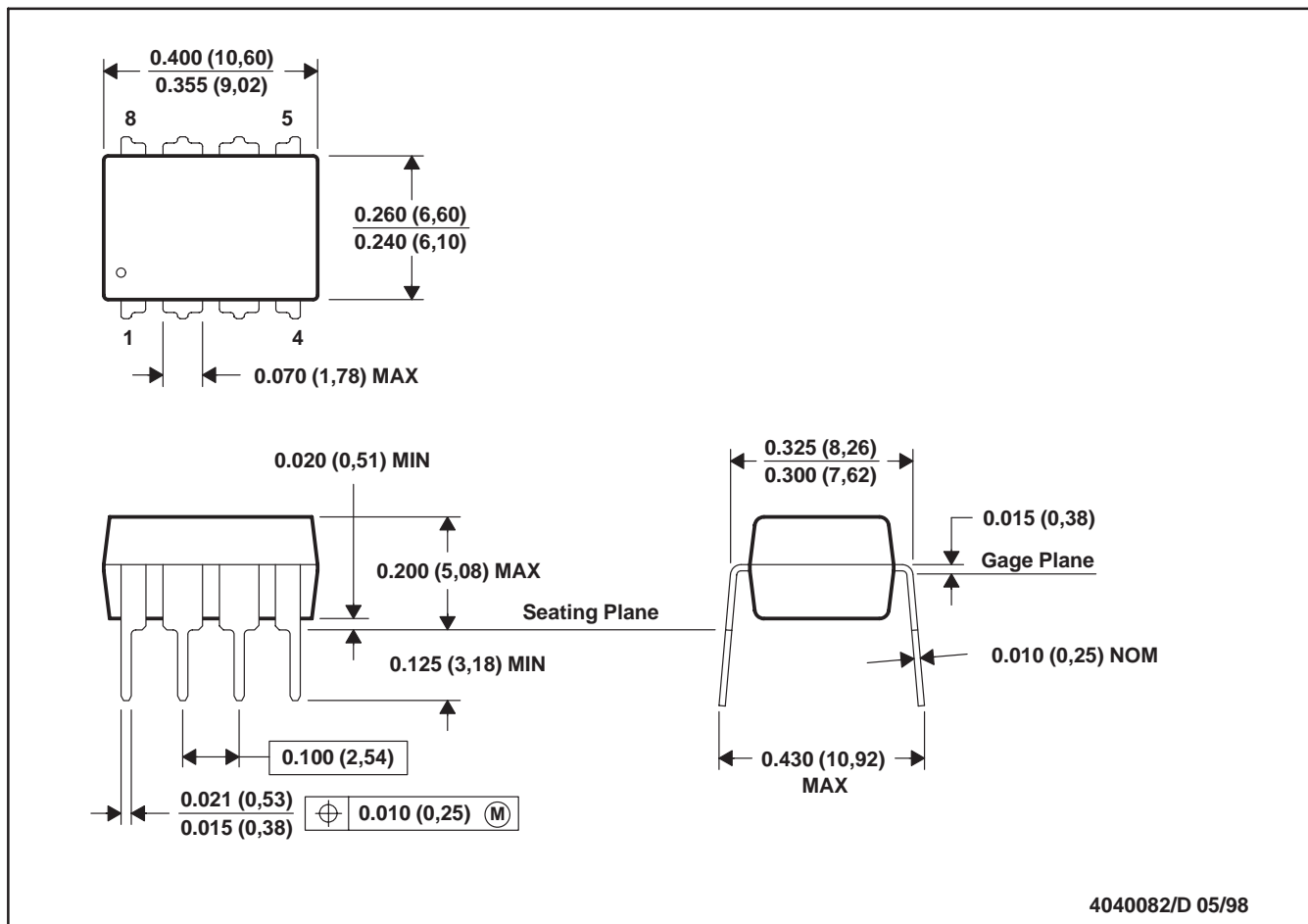
4040140/D 10/96

- NOTES:
- A. All linear dimensions are in inches (millimeters).
  - B. This drawing is subject to change without notice.
  - C. This package can be hermetically sealed with a metal lid.
  - D. The terminals are gold plated.
  - E. Falls within JEDEC MS-004



P (R-PDIP-T8)

PLASTIC DUAL-IN-LINE

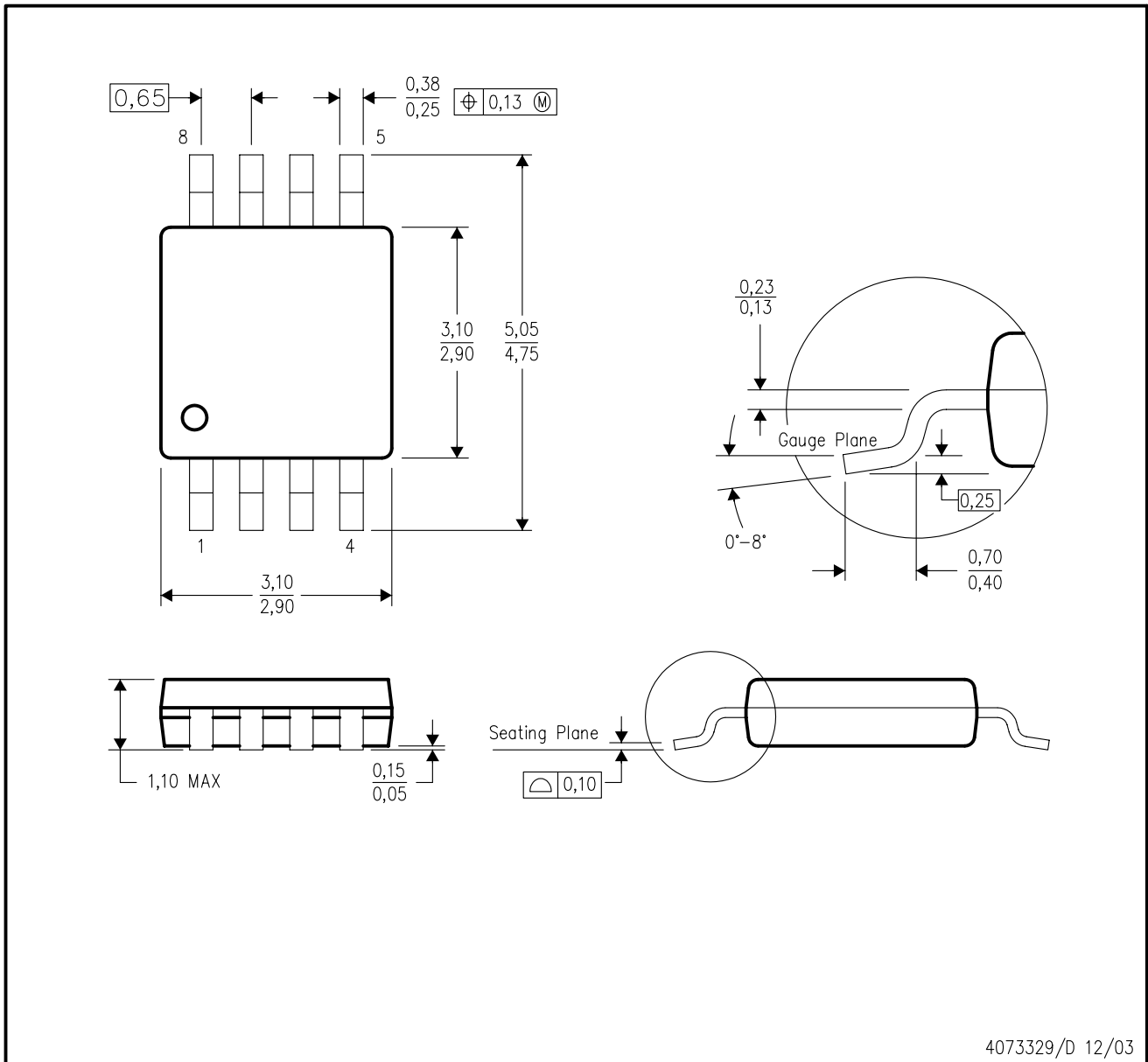


- NOTES: A. All linear dimensions are in inches (millimeters).  
 B. This drawing is subject to change without notice.  
 C. Falls within JEDEC MS-001

For the latest package information, go to [http://www.ti.com/sc/docs/package/pkg\\_info.htm](http://www.ti.com/sc/docs/package/pkg_info.htm)

DGK (S-PDSO-G8)

PLASTIC SMALL-OUTLINE PACKAGE

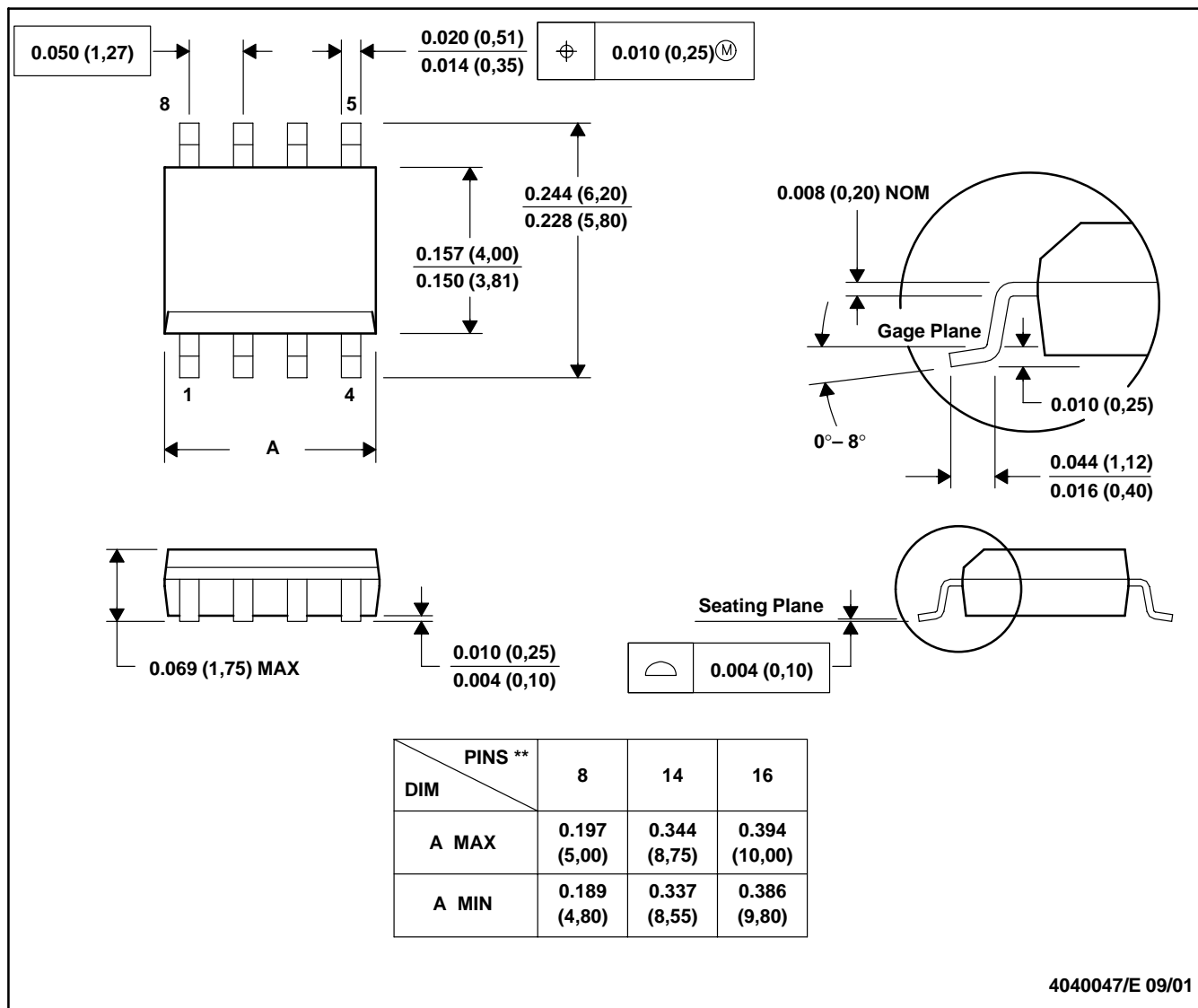


- NOTES:
- A. All linear dimensions are in millimeters.
  - B. This drawing is subject to change without notice.
  - C. Body dimensions do not include mold flash or protrusion.
  - D. Falls within JEDEC MO-187 variation AA.

D (R-PDSO-G\*\*)

PLASTIC SMALL-OUTLINE PACKAGE

8 PINS SHOWN

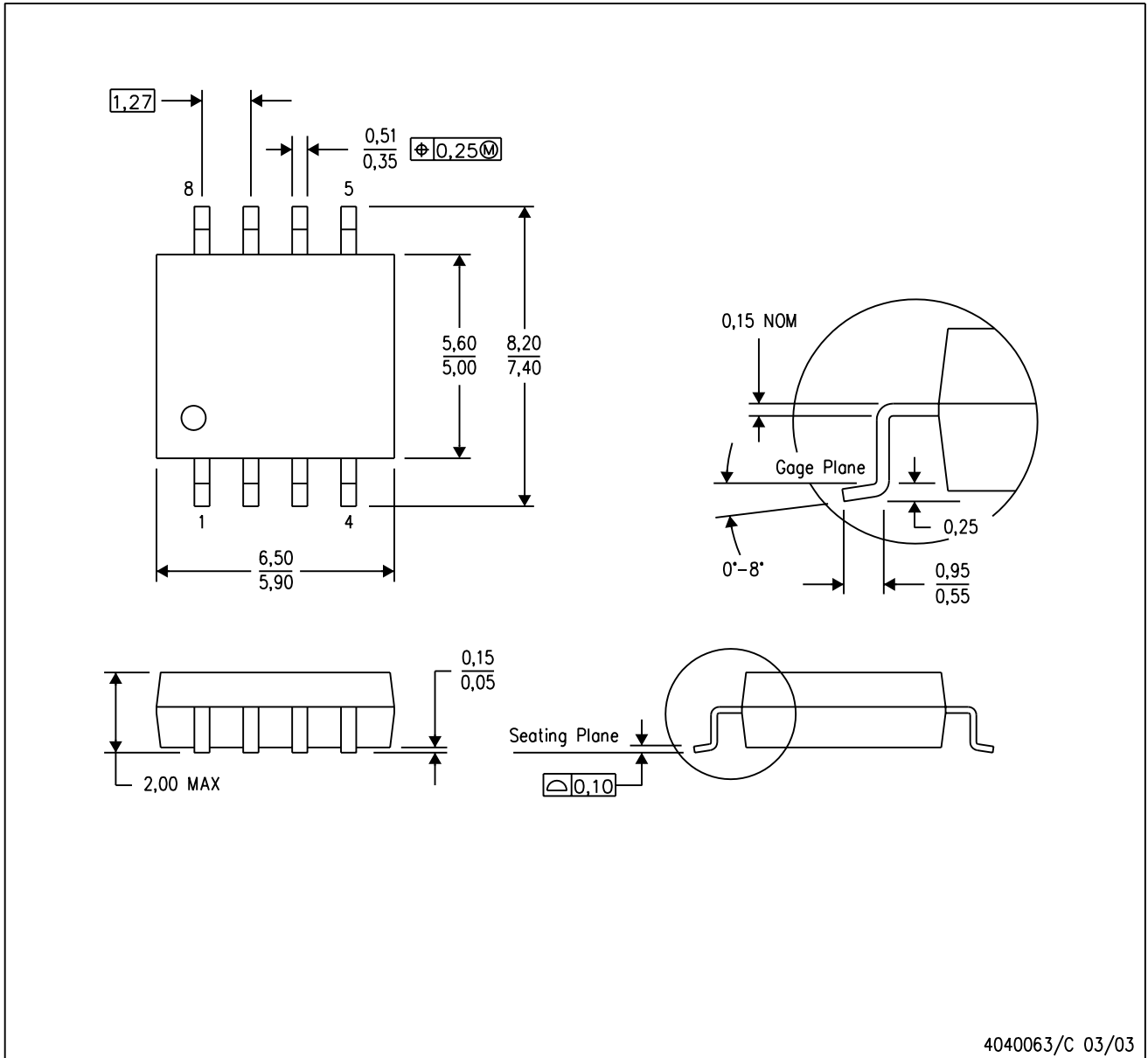


- NOTES: A. All linear dimensions are in inches (millimeters).  
 B. This drawing is subject to change without notice.  
 C. Body dimensions do not include mold flash or protrusion, not to exceed 0.006 (0,15).  
 D. Falls within JEDEC MS-012

## MECHANICAL DATA

PS (R-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, not to exceed 0,15.

PW (R-PDSO-G\*\*)

PLASTIC SMALL-OUTLINE PACKAGE

14 PINS SHOWN



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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DSP	<a href="http://dsp.ti.com">dsp.ti.com</a>	Broadband	<a href="http://www.ti.com/broadband">www.ti.com/broadband</a>
Interface	<a href="http://interface.ti.com">interface.ti.com</a>	Digital Control	<a href="http://www.ti.com/digitalcontrol">www.ti.com/digitalcontrol</a>
Logic	<a href="http://logic.ti.com">logic.ti.com</a>	Military	<a href="http://www.ti.com/military">www.ti.com/military</a>
Power Mgmt	<a href="http://power.ti.com">power.ti.com</a>	Optical Networking	<a href="http://www.ti.com/opticalnetwork">www.ti.com/opticalnetwork</a>
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		Telephony	<a href="http://www.ti.com/telephony">www.ti.com/telephony</a>
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