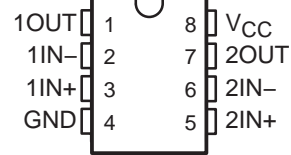- **Single Supply or Dual Supplies**
- **Wide Range of Supply Voltage**
  - **Max Rating . . . 2 V to 36 V**
  - **Tested to 30 V . . . Non-V Devices**
  - **Tested to 32 V . . . V-Suffix Devices**
- **Low Supply-Current Drain Independent of Supply Voltage . . . 0.4 mA Typ Per Comparator**
- **Low Input 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 . . . ±36 V**
- **Low Output Saturation Voltage**
- **Output Compatible With TTL, MOS, and CMOS**

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)

1OUT	1	8	V_{CC}
1IN–	2	7	2OUT
1IN+	3	6	2IN–
GND	4	5	2IN+

LM193 . . . FK PACKAGE
(TOP VIEW)

Pins (top): NC, 1OUT, NC, V_{CC}, NC — positions 3, 2, 1, 20, 19

Left	Pin		Pin	Right
NC	4		18	NC
1IN–	5		17	2OUT
NC	6		16	NC
1IN+	7		15	2IN–
NC	8		14	NC

Pins (bottom): 9, 10, 11, 12, 13 — NC, GND, NC, 2IN+, NC

NC – No internal connection
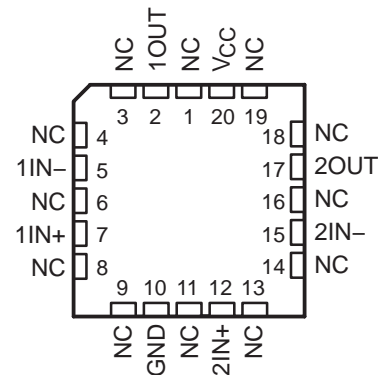
description/ordering information

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°C to 125°C. The LM293 and LM293A are characterized for operation from –25°C to 85°C. The LM393 and LM393A are characterized for operation from 0°C to 70°C. The LM2903 is 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.

TEXAS INSTRUMENTS

description/ordering information (continued)

ORDERING INFORMATION

T_A	V_{IO}max AT 25°C	MAX V_{CC}	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.

symbol (each comparator)

TEXAS
INSTRUMENTS

POST OFFICE BOX 655303 ● DALLAS, TEXAS 75265

schematic (each comparator)

80-μA Current Regulator

10 μA   60 μA   10 μA   80 μA

V$_{CC}$

IN+

IN–

OUT

GND

COMPONENT COUNT	
Epi-FET	1
Diodes	2
Resistors	2
Transistors	30
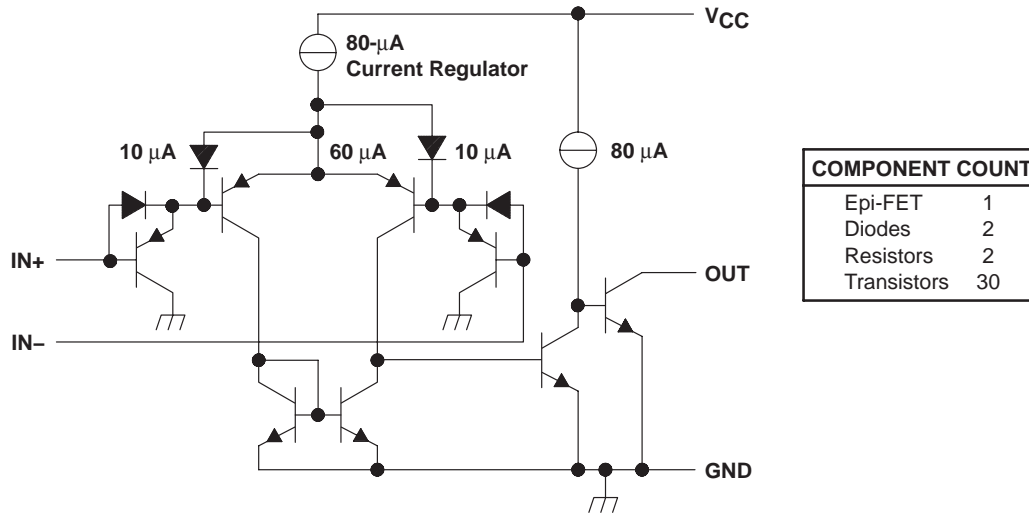
Current values shown are nominal.

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) . . . . ±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, θ$_{JA}$ (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, θ$_{JC}$ (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), θ$_{JA}$, and T$_A$. The maximum allowable power dissipation at any allowable ambient temperature is P$_D$ = (T$_J$(max) – T$_A$)/θ$_{JA}$. 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), θ$_{JC}$, and T$_C$. The maximum allowable power dissipation at any allowable case temperature is P$_D$ = (T$_J$(max) – T$_C$)/θ$_{JC}$. 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.

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

PARAMETER		TEST CONDITIONS		T_A†	LM193 MIN	LM193 TYP	LM193 MAX	LM293 LM393 MIN	LM293 LM393 TYP	LM293 LM393 MAX	UNIT
V_{IO}	Input offset voltage	V_{CC} = 5 V to 30 V, V_O = 1.4 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 V		25°C		3	25		5	50	nA
				Full range			100			250	
I_{IB}	Input bias current	V_O = 1.4 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 V, V_O = 1.4 V to 11.4 V, $R_L \geq$ 15 kΩ to V_{CC}		25°C	50	200		50	200		V/mV
I_{OH}	High-level output current	V_{OH} = 5 V,	V_{ID} = 1 V	25°C		0.1			0.1	50	nA
		V_{OH} = 30 V,	V_{ID} = 1 V	Full range			1			1	µA
V_{OL}	Low-level output voltage	I_{OL} = 4 mA,	V_{ID} = −1 V	25°C		150	400		150	400	mV
				Full range			700			700	
I_{OL}	Low-level output current	V_{OL} = 1.5 V,	V_{ID} = −1 V	25°C	6			6			mA
I_{CC}	Supply current	$R_L = \infty$	V_{CC} = 5 V	25°C		0.8	1		0.8	1	mA
			V_{CC} = 30 V	Full range			2.5			2.5	

† Full range (MIN or MAX) for LM193 is −55°C to 125°C, for LM293 is 25°C to 85°C, and for LM393 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 V, but either or both inputs can go to 30 V without damage.

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

PARAMETER		TEST CONDITIONS	T_A†	LM293A LM393A			LM2903			UNIT
				MIN	TYP	MAX	MIN	TYP	MAX	
V_{IO}	Input offset voltage	V_{CC} = 5 V to MAX‡, V_O = 1.4 V, V_{IC} = $V_{IC(min)}$	25°C		1	2		2	7	mV
			Full range			4			15	
I_{IO}	Input offset current	V_O = 1.4 V	25°C		5	50		5	50	nA
			Full range			150			200	
I_{IB}	Input bias current	V_O = 1.4 V	25°C		−25	−250		−25	−250	nA
			Full range			−400			−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 V, V_O = 1.4 V to 11.4 V, $R_L \geq$ 15 kΩ to V_{CC}	25°C	50	200		25	100		V/mV
I_{OH}	High-level output current	V_{OH} = 5 V, V_{ID} = 1 V	25°C		0.1	50		0.1	50	nA
		V_{OH} = V_{CC} MAX, V_{ID} = 1 V	Full range			1			1	μA
V_{OL}	Low-level output voltage	I_{OL} = 4 mA, V_{ID} = −1 V	25°C		150	400		150	400	mV
			Full range			700			700	
I_{OL}	Low-level output current	V_{OL} = 1.5 V, V_{ID} = −1 V	25°C	6			6			mA
I_{CC}	Supply current	$R_L = \infty$	V_{CC} = 5 V, 25°C		0.8	1		0.8	1	mA
			V_{CC} = MAX, Full range			2.5			2.5	

† Full range (MIN or MAX) for LM293A is 25°C to 85°C, for LM393A is 0°C to 70°C, and for LM2903 is −40°C to 125°C. All characteristics are measured with zero common-mode input voltage, unless otherwise specified.
‡ V_{CC} MAX = 30 V for non-V devices and 32 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 V. The upper end of the common-mode voltage range is V_{CC+} − 1.5 V, but either or both inputs can go to 30 V (32 V for V-Suffix devices) without damage.

switching characteristics, V_{CC} = 5 V, T_A = 25°C

PARAMETER	TEST CONDITIONS		LM193 LM293, LM293A LM393, LM393A LM2903	UNIT
			TYP	
Response time	R_L connected to 5 V through 5.1 kΩ, C_L = 15 pF¶, See Note 8	100-mV input step with 5-mV overdrive	1.3	μs
		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 V.

JG (R-GDIP-T8)   **CERAMIC DUAL-IN-LINE**

0.400 (10,16)
0.355 (9,00)

8   5

0.280 (7,11)
0.245 (6,22)

1   4

0.065 (1,65)
0.045 (1,14)

0.063 (1,60)
0.015 (0,38)

0.020 (0,51) MIN

0.310 (7,87)
0.290 (7,37)

0.200 (5,08) MAX

Seating Plane

0.130 (3,30) MIN

0.023 (0,58)
0.015 (0,38)

0.100 (2,54)

0°–15°

0.014 (0,36)
0.008 (0,20)

4040107/C 08/96

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 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**)

28 TERMINAL SHOWN

LEADLESS CERAMIC CHIP CARRIER

NO. OF TERMINALS **	A		B	
	MIN	MAX	MIN	MAX
20	0.342 (8,69)	0.358 (9,09)	0.307 (7,80)	0.358 (9,09)
28	0.442 (11,23)	0.458 (11,63)	0.406 (10,31)	0.458 (11,63)
44	0.640 (16,26)	0.660 (16,76)	0.495 (12,58)	0.560 (14,22)
52	0.739 (18,78)	0.761 (19,32)	0.495 (12,58)	0.560 (14,22)
68	0.938 (23,83)	0.962 (24,43)	0.850 (21,6)	0.858 (21,8)
84	1.141 (28,99)	1.165 (29,59)	1.047 (26,6)	1.063 (27,0)

0.020 (0,51)
0.010 (0,25)

0.020 (0,51)
0.010 (0,25)

0.080 (2,03)
0.064 (1,63)

0.055 (1,40)
0.045 (1,14)

0.045 (1,14)
0.035 (0,89)

0.028 (0,71)
0.022 (0,54)

0.045 (1,14)
0.035 (0,89)

0.050 (1,27)

4040140/D 10/96

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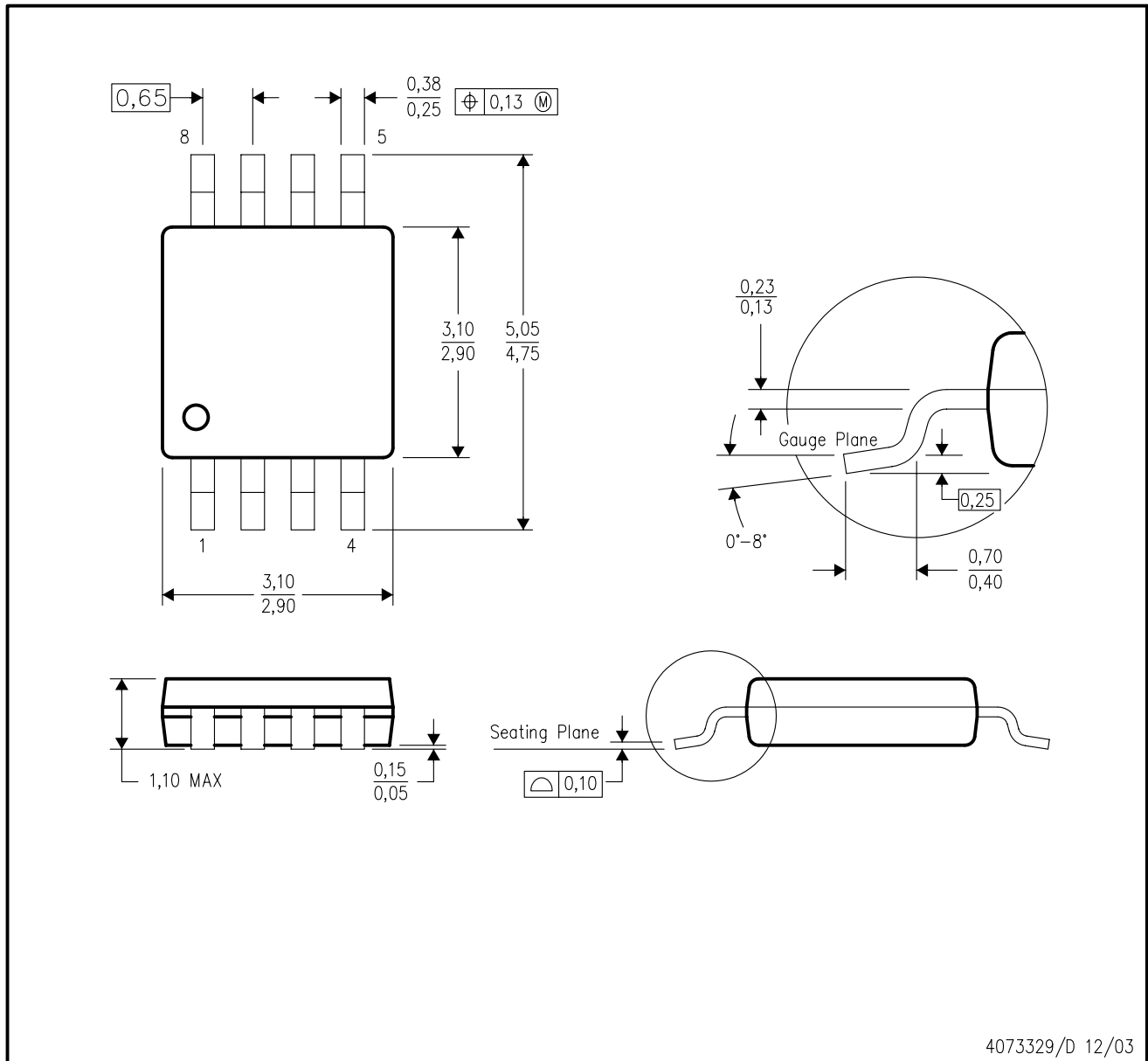   B. This drawing is subject to change without notice.
        C. This package can be hermetically sealed with a metal lid.
        D. The terminals are gold plated.
        E. Falls within JEDEC MS-004

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P (R-PDIP-T8) **PLASTIC DUAL-IN-LINE**

0.400 (10,60)
0.355 (9,02)

8   5

0.260 (6,60)
0.240 (6,10)

1   4

0.070 (1,78) MAX

0.020 (0,51) MIN

0.200 (5,08) MAX

0.125 (3,18) MIN

Seating Plane

0.100 (2,54)

0.021 (0,53)
0.015 (0,38)   ⊕ | 0.010 (0,25) | Ⓜ

0.325 (8,26)
0.300 (7,62)

0.015 (0,38)
Gage Plane

0.010 (0,25) NOM

0.430 (10,92)
MAX

4040082/D 05/98

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

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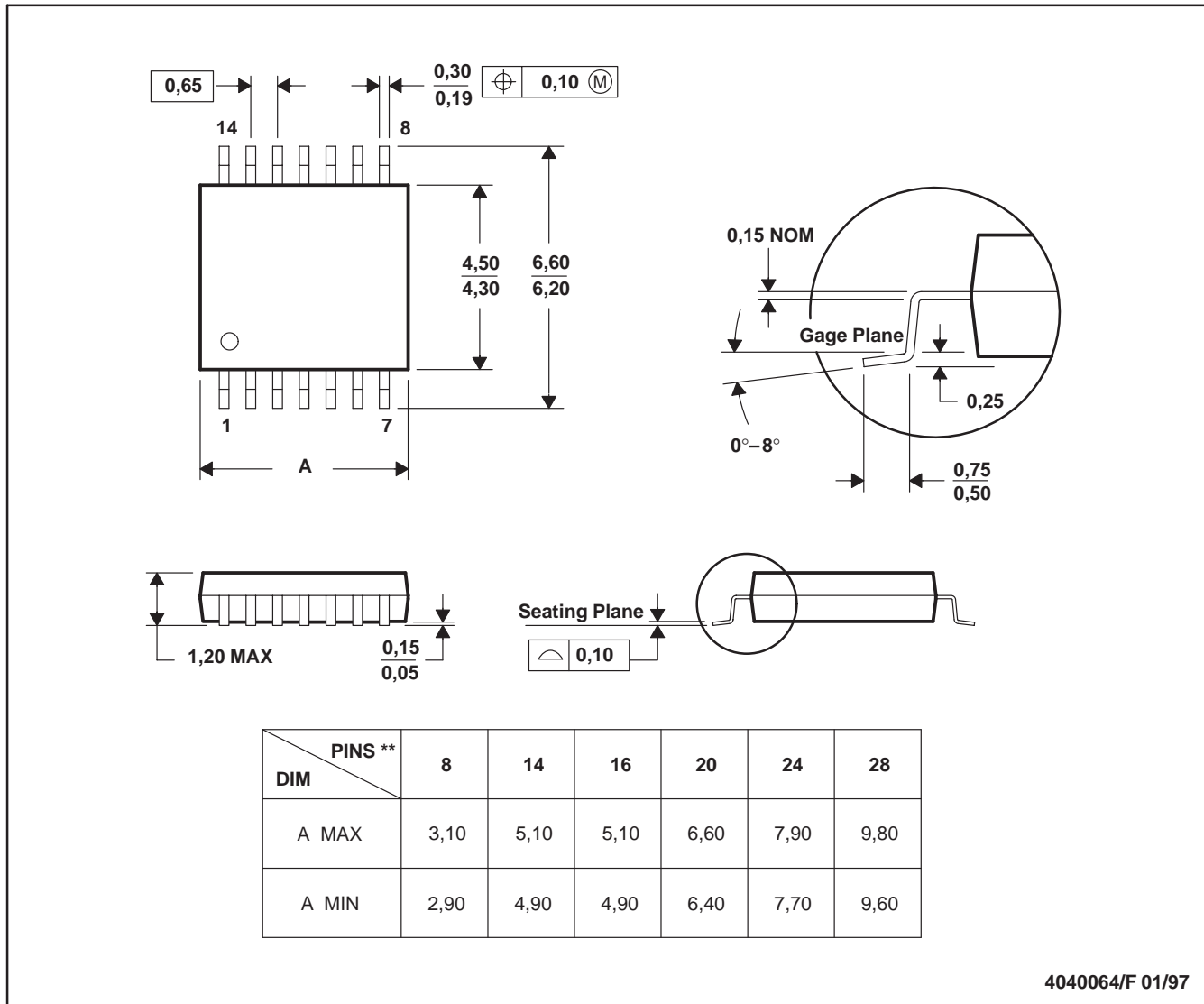## DGK (S−PDSO−G8) PLASTIC SMALL−OUTLINE PACKAGE

4073329/D 12/03

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.

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D (R-PDSO-G**)   **PLASTIC SMALL-OUTLINE PACKAGE**

8 PINS SHOWN
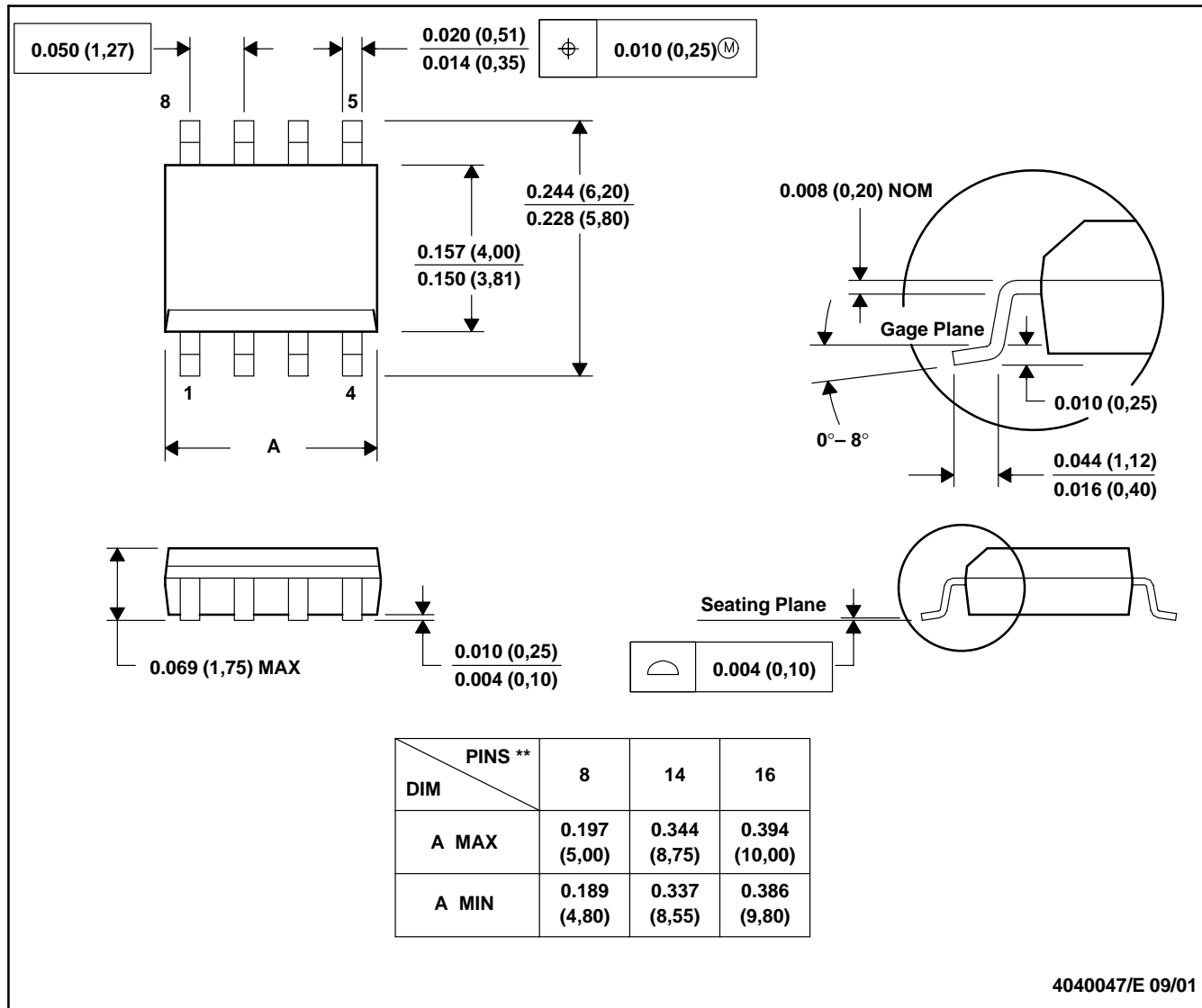
PINS ** DIM	8	14	16
A MAX	0.197 (5,00)	0.344 (8,75)	0.394 (10,00)
A MIN	0.189 (4,80)	0.337 (8,55)	0.386 (9,80)

4040047/E 09/01

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

4040063/C 03/03

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.

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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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Mailing Address: Texas Instruments
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