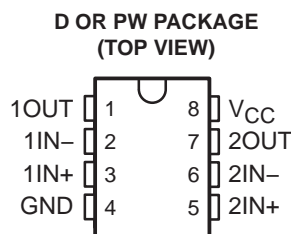


- **Qualification in Accordance With AEC-Q100†**
- **Qualified for Automotive Applications**
- **Customer-Specific Configuration Control Can Be Supported Along With Major-Change Approval**
- **ESD Protection Exceeds 500 V Per MIL-STD-883, Method 3015; Exceeds 200 V Using Machine Model (C = 200 pF, R = 0)**
- **Low Supply-Current Drain Independent of Supply Voltage . . . 0.7 mA Typ**
- **Common-Mode Input Voltage Range Includes Ground, Allowing Direct Sensing Near Ground**
- **Differential Input Voltage Range Equal to Maximum-Rated Supply Voltage:**
 - **Non-V Devices . . . ± 26 V**
 - **V-Suffix Devices . . . ± 32 V**
- **Low Input Bias and Offset Parameters:**
 - **Input Offset Voltage . . . 3 mV Typ**
 - **Input Offset Current . . . 2 nA Typ**
 - **Input Bias Current . . . 20 nA Typ**
- **Open-Loop Differential Voltage Amplification . . . 100 V/mV Typ**
- **Internal Frequency Compensation**



† Contact factory for details. Q100 qualification data available on request.

description/ordering information

This device consists of two independent, high-gain, frequency-compensated operational amplifiers designed to operate from a single supply over a wide range of voltages. Operation from split supplies is possible as long as the difference between the two supplies is 3 V to 26 V (3 V to 32 V for V-suffix devices), and V_{CC} is at least 1.5 V more positive than the input common-mode voltage. The low supply-current drain is independent of the magnitude of the supply voltage.

Applications include transducer amplifiers, dc amplification blocks, and all the conventional operational amplifier circuits that now can be implemented more easily in single-supply-voltage systems. For example, these devices can be operated directly from the standard 5-V supply used in digital systems and easily provide the required interface electronics without additional ± 5 -V supplies.

The LM2904Q is manufactured to demanding automotive requirements.

ORDERING INFORMATION

T_A	V_{IOmax} AT 25°C	MAX V_{CC}	PACKAGE†		ORDERABLE PART NUMBER	TOP-SIDE MARKING
–40°C to 125°C	7 mV	26 V	SOIC (D)	Tape and reel	LM2904QDRQ1	2904Q1
	7 mV	26 V	TSSOP (PW)	Tape and reel	LM2904QPWRQ1	2904Q1
	7 mV	32 V	SOIC (D)	Tape and reel	LM2904VQDRQ1	2904VQ1
	7 mV	32 V	TSSOP (PW)	Tape and reel	LM2904VQPWRQ1	2904VQ1
	2 mV	32 V	SOIC (D)	Tape and reel	LM2904AVQDRQ1	2904AVQ
	2 mV	32 V	TSSOP (PW)	Tape and reel	LM2904AVQPWRQ1	2904AVQ

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



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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**

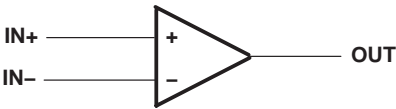
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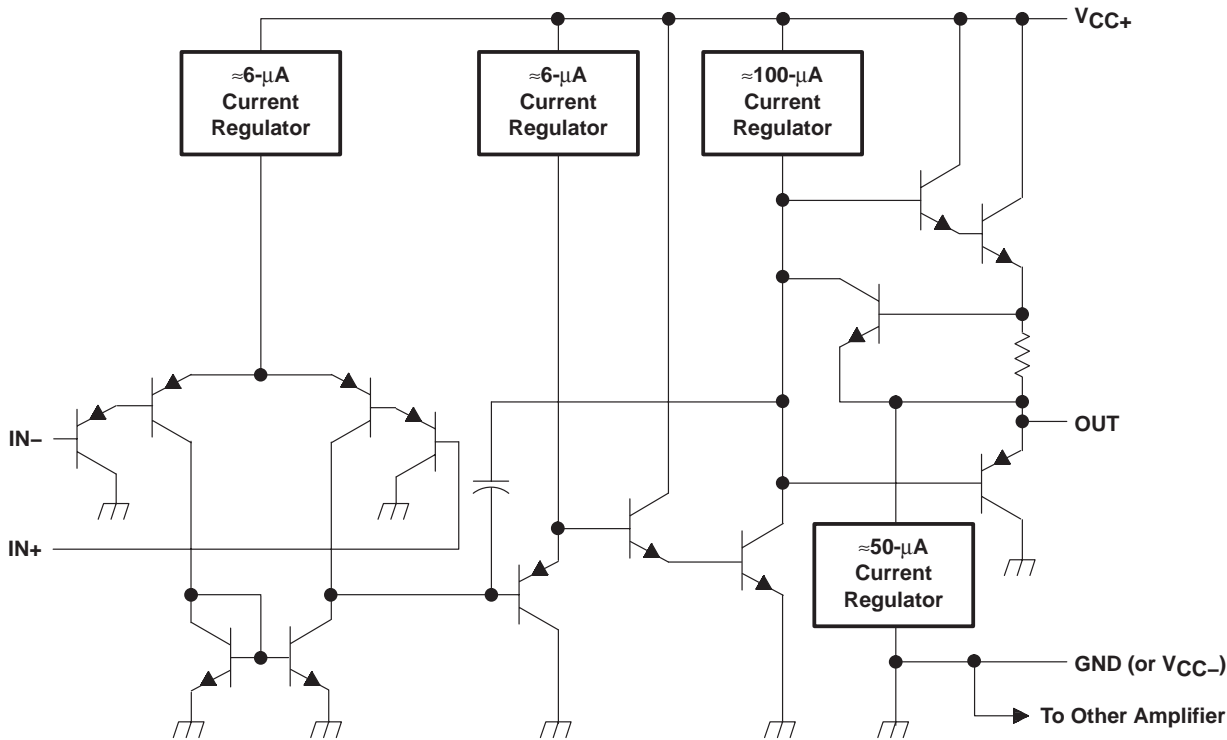
LM2904-Q1
DUAL OPERATIONAL AMPLIFIER

SLOS414E – MAY 2003 – REVISED JUNE 2004

symbol (each amplifier)



schematic (each amplifier)



COMPONENT COUNT	
Epi-FET	1
Diodes	2
Resistors	7
Transistors	51
Capacitors	2

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

Supply voltage, V_{CC} (see Note 1): Non-V devices	26 V
V-suffix devices	32 V
Differential input voltage, V_{ID} (see Note 2): Non-V devices	± 26 V
V-suffix devices	± 32 V
Input voltage range, V_I (either input): Non-V devices	-0.3 V to 26 V
V-suffix devices	-0.3 V to 32 V
Duration of output short circuit (one amplifier) to ground at (or below) 25°C	
free-air temperature ($V_{CC} \leq 15$ V) (see Note 3)	Unlimited
Operating virtual junction temperature, T_J	150°C
Package thermal impedance, θ_{JA} (see Notes 4 and 5): D package	97°C/W
PW package	149°C/W
Operating free-air temperature range, T_A	-40°C to 125°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 measurement of I_{OS} , are with respect to the network ground terminal.
 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 $T_J(\text{max})$, θ_{JA} , and T_A . The maximum allowable power dissipation at any allowable ambient temperature is $P_D = (T_J(\text{max}) - T_A)/\theta_{JA}$. 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.

LM2904-Q1

DUAL OPERATIONAL AMPLIFIER

SLOS414E – MAY 2003 – REVISED JUNE 2004

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

PARAMETER	TEST CONDITIONS†		T_A ‡	MIN	TYP§	MAX	UNIT
V_{IO} Input offset voltage	$V_{CC} = 5\text{ V to MAX,}$ $V_{IC} = V_{ICR(min)},$ $V_O = 1.4\text{ V}$	Non-A devices	25°C	3	7		mV
			Full range			10	
		A-suffix devices	25°C	1	2		
			Full range			4	
$\alpha_{V_{IO}}$ Average temperature coefficient of input offset voltage			Full range	7			$\mu\text{V}/^\circ\text{C}$
I_{IO} Input offset current	$V_O = 1.4\text{ V}$	Non-V devices	25°C	2	50		nA
			Full range			300	
		V-suffix devices	25°C	5	50		
			Full range			150	
$\alpha_{I_{IO}}$ Average temperature coefficient of input offset current			Full range	10			$\text{pA}/^\circ\text{C}$
I_{IB} Input bias current	$V_O = 1.4\text{ V}$		25°C	–20	–250		nA
			Full range		–500		
I_B Drift			Full range	50			$\text{pA}/^\circ\text{C}$
V_{ICR} Common-mode input voltage range	$V_{CC} = 5\text{ V to MAX}$		25°C	0 to $V_{CC}-1.5$			V
			Full range	0 to $V_{CC}-2$			
V_{OH} High-level output voltage	$R_L \geq 10\text{ k}\Omega$		25°C	$V_{CC}-1.5$			V
	$V_{CC} = \text{MAX,}$ Non-V devices	$R_L = 2\text{ k}\Omega$	Full range	22			
		$R_L \geq 10\text{ k}\Omega$		23	24		
	$V_{CC} = \text{MAX,}$ V-suffix devices	$R_L = 2\text{ k}\Omega$	Full range	26			
		$R_L \geq 10\text{ k}\Omega$		27	28		
V_{OL} Low-level output voltage	$R_L \leq 10\text{ k}\Omega$		Full range	5	20		mV
A_{VD} Large-signal differential voltage amplification	$V_{CC} = 15\text{ V, } V_O = 1\text{ V to } 11\text{ V,}$ $R_L \geq 2\text{ k}\Omega$		25°C	25	100		V/mV
			Full range	15			
CMRR Common-mode rejection ratio	$V_{CC} = 5\text{ V to MAX,}$ $V_{IC} = V_{ICR(min)}$		25°C	65	80		dB
k_{SVR} Supply-voltage rejection ratio ($\Delta V_{DD}/\Delta V_{IO}$)	$V_{CC} = 5\text{ V to MAX}$		25°C	65	100		dB
V_{O1}/V_{O2} Crosstalk attenuation	$f = 1\text{ kHz to } 20\text{ kHz}$		25°C	120			dB
I_O Output current	$V_{CC} = 15\text{ V, } V_{ID} = 1\text{ V, } V_O = 0$		25°C	–20	–30		mA
			Full range	–10			
	$V_{CC} = 15\text{ V, } V_{ID} = -1\text{ V, } V_O = 15\text{ V}$		25°C	10	20		
			Full range	5			
	$V_{ID} = -1\text{ V, } V_O = 200\text{ mV}$		25°C	12	40		μA
I_{OS} Short-circuit output current	V_{CC} at 5 V, GND at –5 V, $V_O = 0$		25°C	± 40	± 60		mA
I_{CC} Supply current (two amplifiers)	$V_O = 2.5\text{ V,}$ No load		Full range	0.7	1.2		mA
	$V_{CC} = \text{MAX, } V_O = 0.5 V_{CC},$ No load			1	2		

† All characteristics are measured under open-loop conditions, with zero common-mode input voltage, unless otherwise specified. MAX V_{CC} for testing purposes is 26 V for non-V devices and 32 V for V-suffix devices.

‡ Full range is –40°C to 125°C for LM2904Q.S

§ All typical values are at $T_A = 25^\circ\text{C}$.



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operating conditions, $V_{CC} = \pm 15\text{ V}$, $T_A = 25^\circ\text{C}$

PARAMETER		TEST CONDITIONS	TYP	UNIT
SR	Slew rate at unity gain	$R_L = 1\text{ M}\Omega$, $C_L = 30\text{ pF}$, $V_I = \pm 10\text{ V}$ (see Figure 1)	0.3	$\text{V}/\mu\text{s}$
B_1	Unity-gain bandwidth	$R_L = 1\text{ M}\Omega$, $C_L = 20\text{ pF}$ (see Figure 1)	0.7	MHz
V_n	Equivalent input noise voltage	$R_S = 100\text{ }\Omega$, $V_I = 0\text{ V}$, $f = 1\text{ kHz}$ (see Figure 2)	40	$\text{nV}/\sqrt{\text{Hz}}$

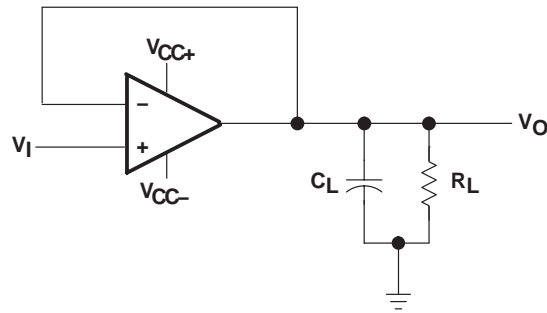


Figure 1. Unity-Gain Amplifier

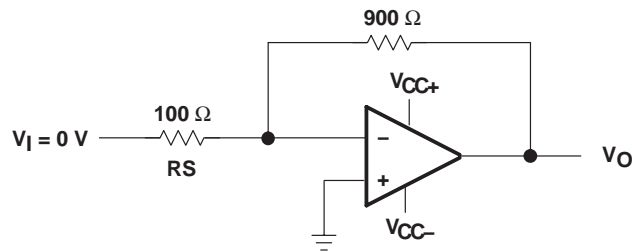


Figure 2. Noise-Test Circuit

PACKAGING INFORMATION

Orderable Device	Status ⁽¹⁾	Package Type	Package Drawing	Pins	Package Qty	Eco Plan ⁽²⁾	Lead/Ball Finish	MSL Peak Temp ⁽³⁾
LM2904AVQDRQ1	ACTIVE	SOIC	D	8	2500	Pb-Free (RoHS)	CU NIPDAU	Level-2-250C-1 YEAR/ Level-1-235C-UNLIM
LM2904AVQPWRQ1	ACTIVE	TSSOP	PW	8	2000	None	CU NIPDAU	Level-1-250C-UNLIM
LM2904QDRQ1	ACTIVE	SOIC	D	8	2500	Pb-Free (RoHS)	CU NIPDAU	Level-2-250C-1 YEAR/ Level-1-235C-UNLIM
LM2904QPWRQ1	ACTIVE	TSSOP	PW	8	2000	None	CU NIPDAU	Level-1-250C-UNLIM
LM2904VQDRQ1	ACTIVE	SOIC	D	8	2500	Pb-Free (RoHS)	CU NIPDAU	Level-2-250C-1 YEAR/ Level-1-235C-UNLIM
LM2904VQPWRQ1	ACTIVE	TSSOP	PW	8	2000	None	CU NIPDAU	Level-1-250C-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.

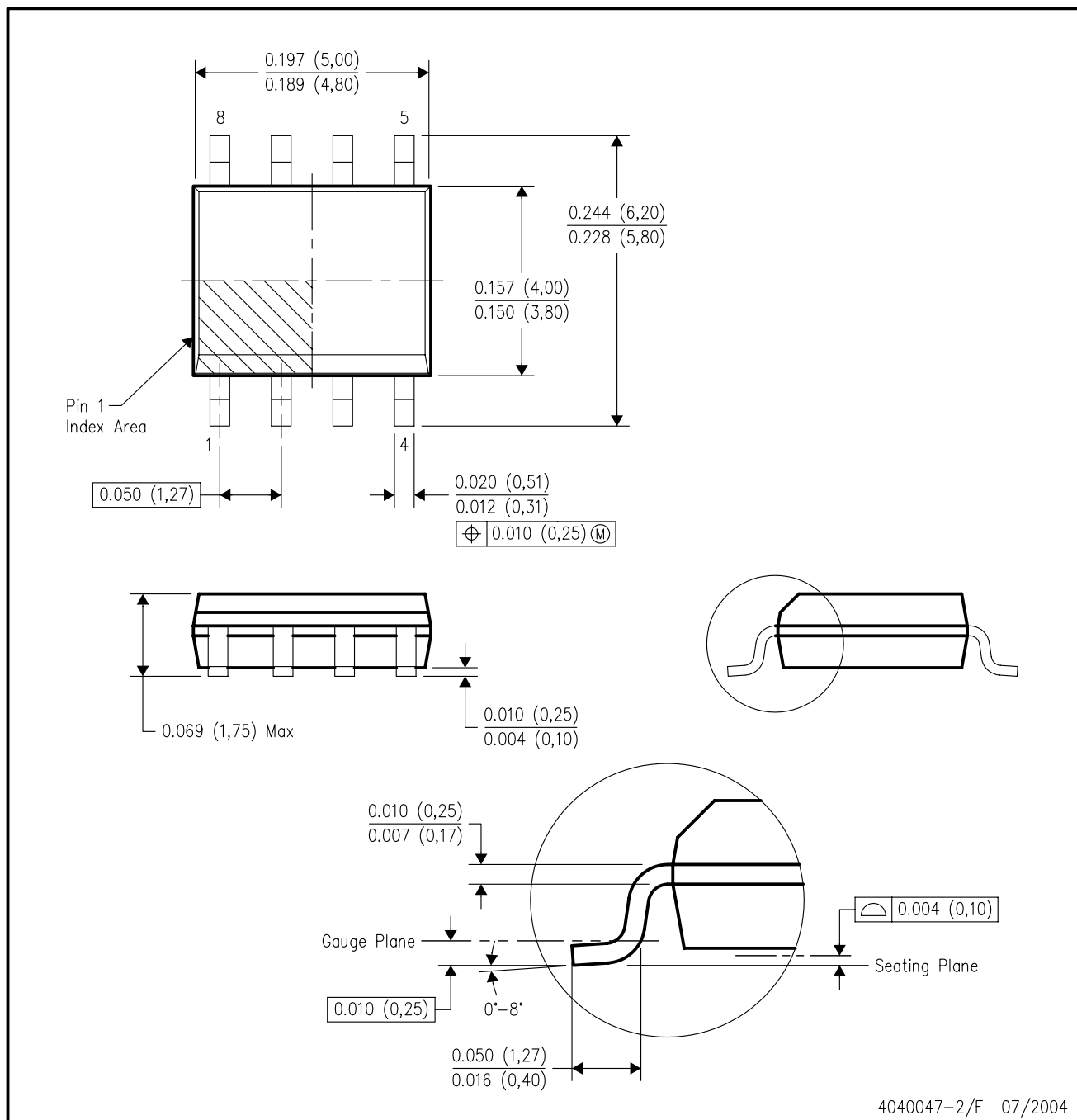
⁽³⁾ MSL, Peak Temp. -- The Moisture Sensitivity Level rating according to the JEDEC industry standard classifications, and peak solder temperature.

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D (R-PDSO-G8)

PLASTIC SMALL-OUTLINE PACKAGE

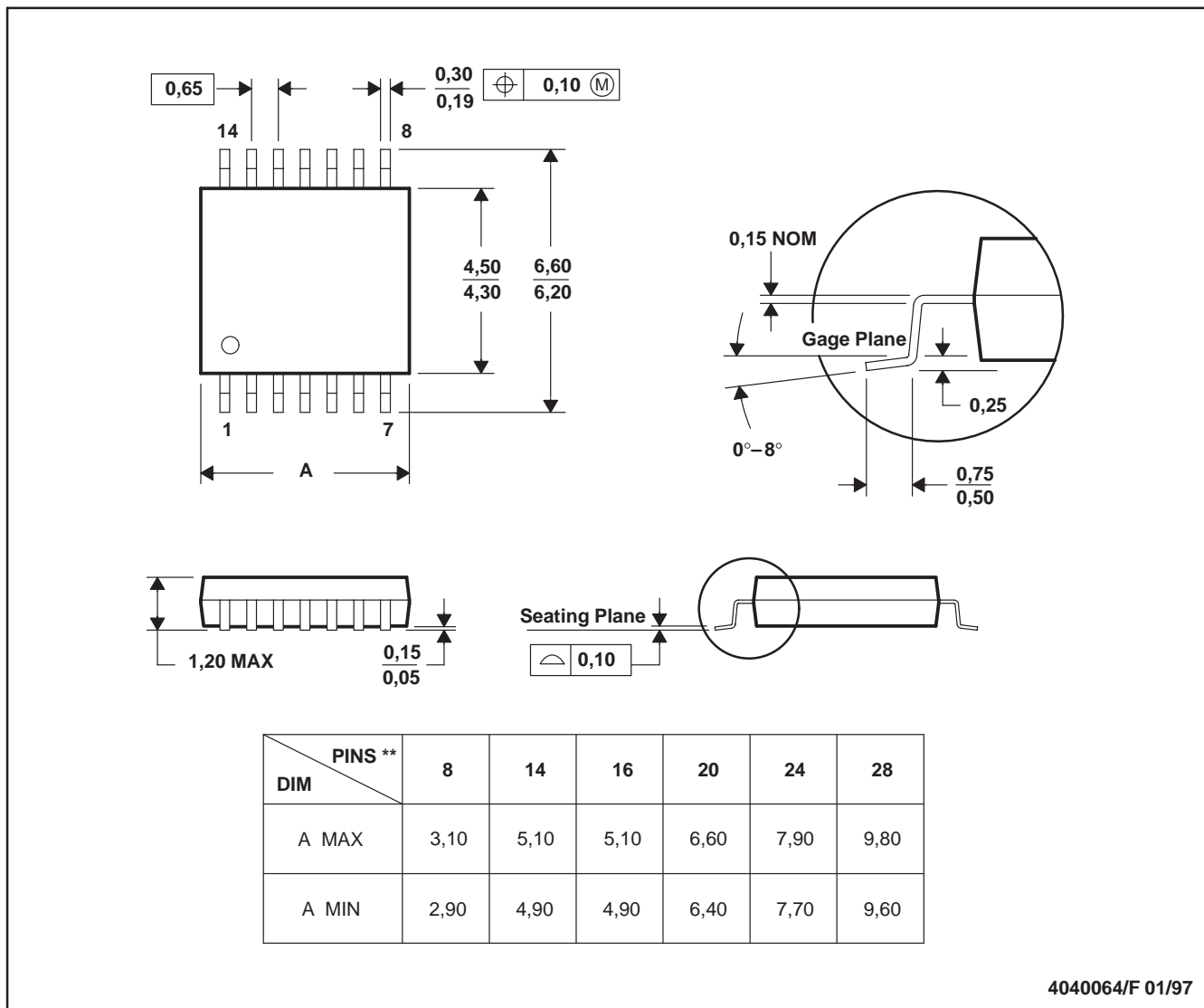


- NOTES:
- All linear dimensions are in inches (millimeters).
 - This drawing is subject to change without notice.
 - Body dimensions do not include mold flash or protrusion not to exceed 0.006 (0,15).
 - Falls within JEDEC MS-012 variation AA.

PW (R-PDSO-G**)

PLASTIC SMALL-OUTLINE PACKAGE

14 PINS SHOWN



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