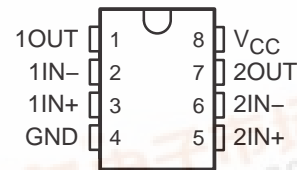


- **Qualification in Accordance With AEC-Q100†**
- **Qualified for Automotive Applications**
- **Customer-Specific Configuration Control Can Be Supported Along With Major-Change Approval**
- **ESD Protection Exceeds 500 V Per MIL-STD-883, Method 3015; Exceeds 200 V Using Machine Model (C = 200 pF, R = 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**

D OR PW PACKAGE
(TOP VIEW)



† 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.

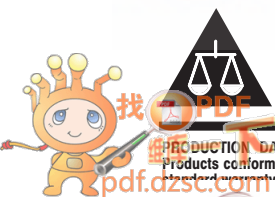
The LM2904Q is manufactured to demanding automotive requirements.

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.

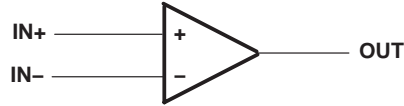
Please be aware that an important notice concerning availability, standard warranty, and use in critical applications of Texas Instruments semiconductor products and disclaimers thereto appears at the end of this data sheet.



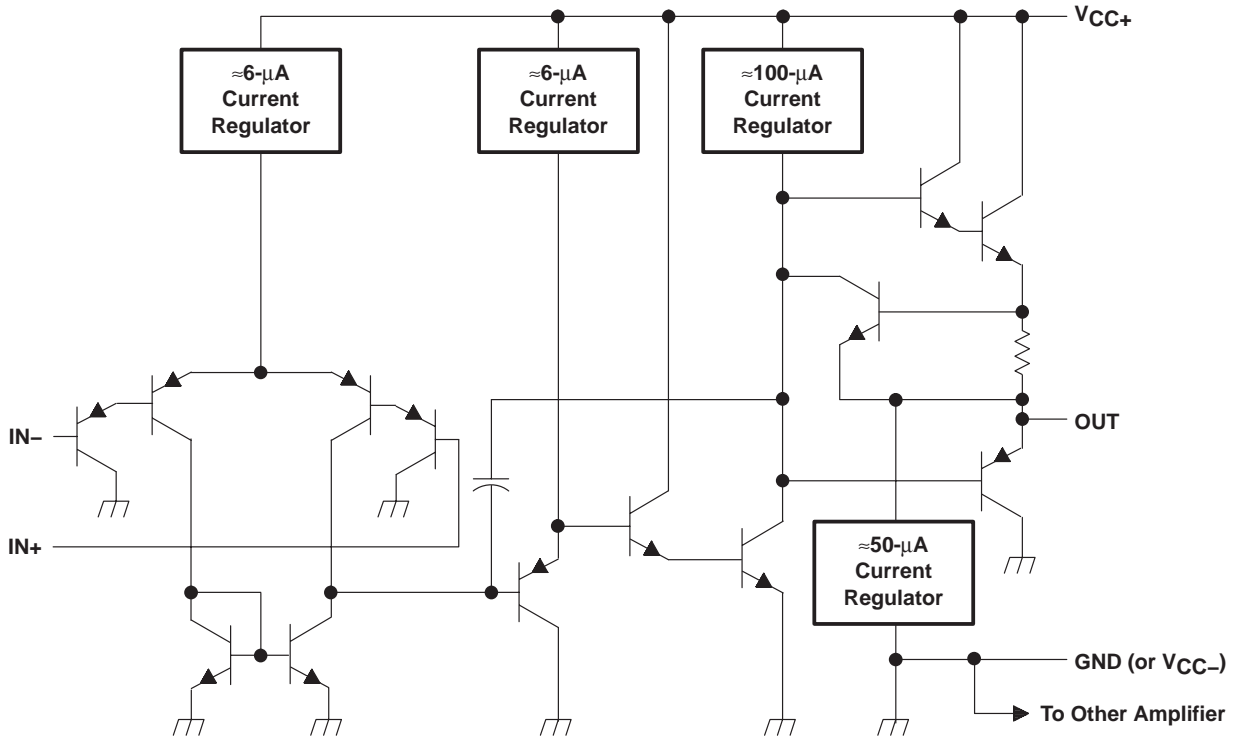
LM2904-Q1 DUAL OPERATIONAL AMPLIFIER

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



LM2904-Q1 DUAL OPERATIONAL AMPLIFIER

SLOS414E – MAY 2003 – REVISED JUNE 2004

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
	$V_{CC} = \text{MAX, } V_O = 0.5 V_{CC}, \text{ No load}$				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 $T_A = 25^\circ\text{C}$.



LM2904-Q1 DUAL OPERATIONAL AMPLIFIER

SLOS414E – MAY 2003 – REVISED JUNE 2004

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	$R_S = 100\ \Omega$, $V_I = 0\text{ V}$, $f = 1\text{ kHz}$ (see Figure 2)	40	$\text{nV}/\sqrt{\text{Hz}}$

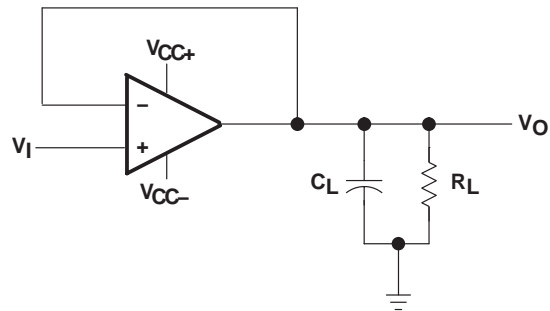


Figure 1. Unity-Gain Amplifier

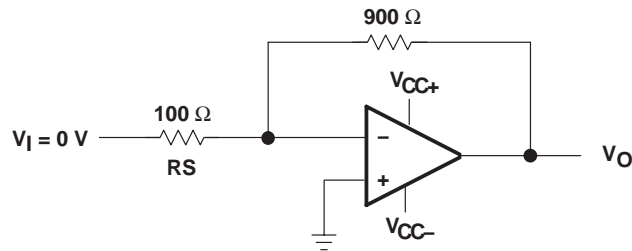


Figure 2. Noise-Test Circuit



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.

Important Information and Disclaimer: The information provided on this page represents TI's knowledge and belief as of the date that it is provided. TI bases its knowledge and belief on information provided by third parties, and makes no representation or warranty as to the accuracy of such information. Efforts are underway to better integrate information from third parties. TI has taken and continues to take reasonable steps to provide representative and accurate information but may not have conducted destructive testing or chemical analysis on incoming materials and chemicals. TI and TI suppliers consider certain information to be proprietary, and thus CAS numbers and other limited information may not be available for release.

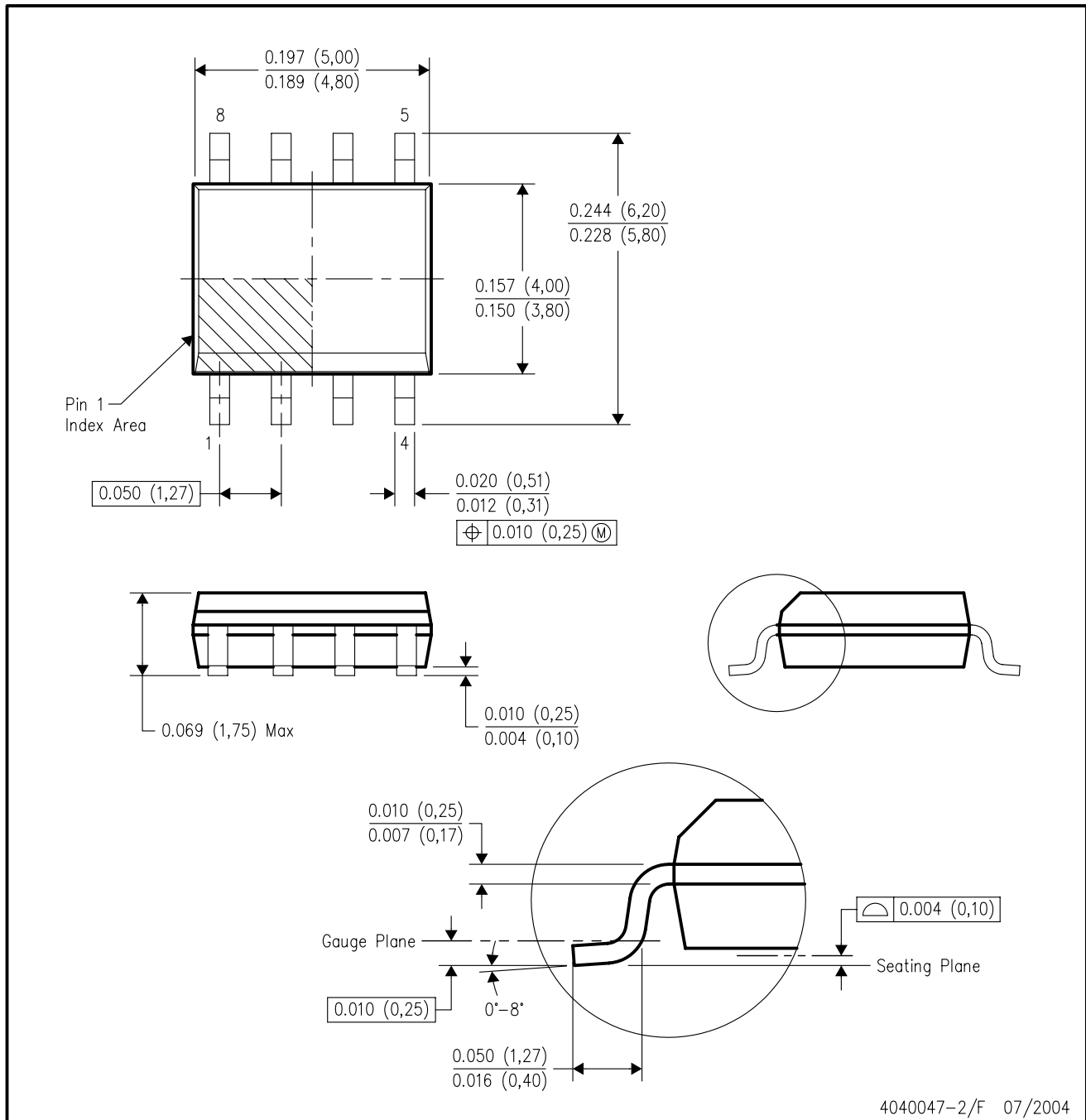
In no event shall TI's liability arising out of such information exceed the total purchase price of the TI part(s) at issue in this document sold by TI to Customer on an annual basis.



MECHANICAL DATA

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.



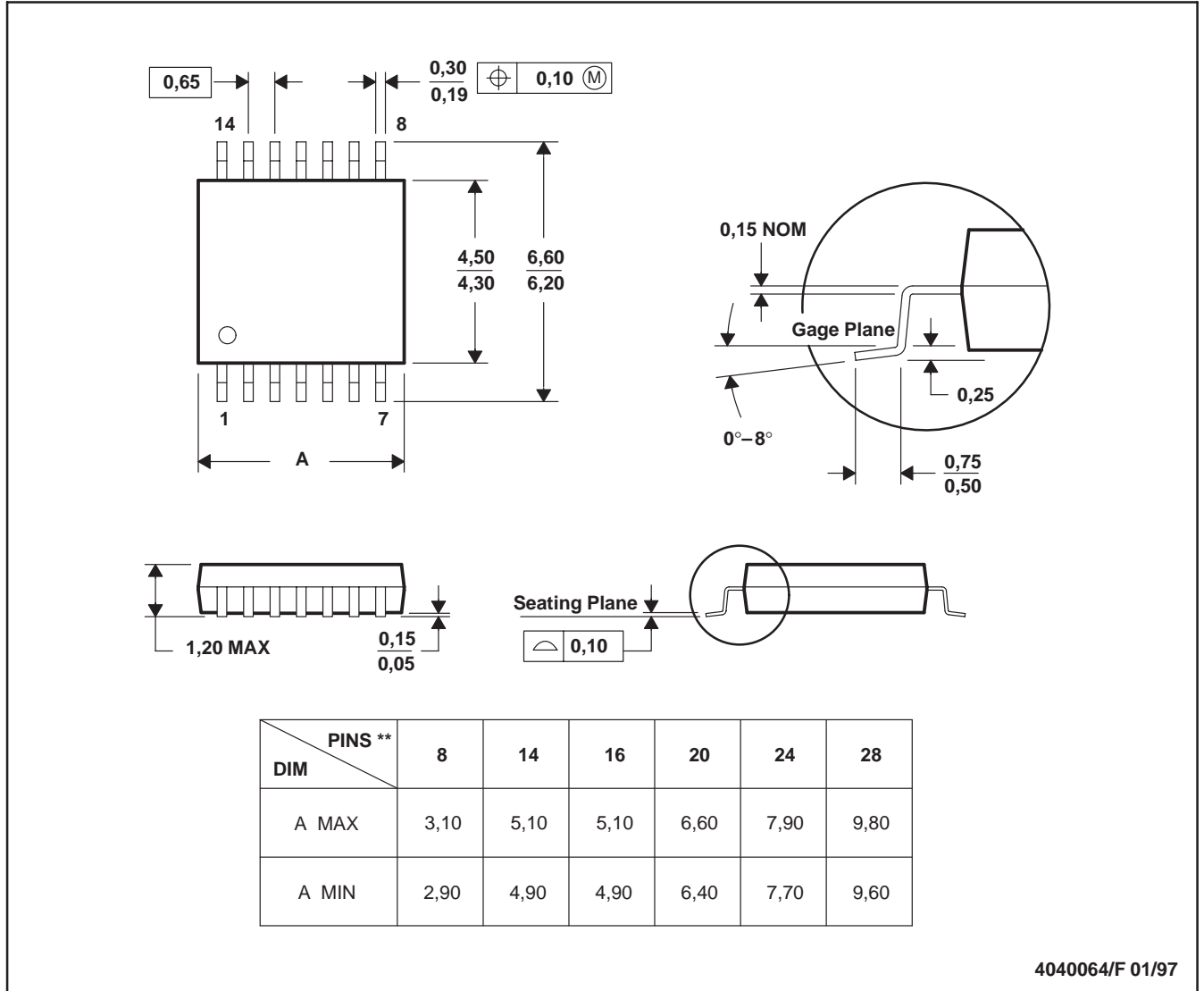
MECHANICAL DATA

MTSS001C – JANUARY 1995 – REVISED FEBRUARY 1999

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



IMPORTANT NOTICE

Texas Instruments Incorporated and its subsidiaries (TI) reserve the right to make corrections, modifications, enhancements, improvements, and other changes to its products and services at any time and to discontinue any product or service without notice. Customers should obtain the latest relevant information before placing orders and should verify that such information is current and complete. All products are sold subject to TI's terms and conditions of sale supplied at the time of order acknowledgment.

TI warrants performance of its hardware products to the specifications applicable at the time of sale in accordance with TI's standard warranty. Testing and other quality control techniques are used to the extent TI deems necessary to support this warranty. Except where mandated by government requirements, testing of all parameters of each product is not necessarily performed.

TI assumes no liability for applications assistance or customer product design. Customers are responsible for their products and applications using TI components. To minimize the risks associated with customer products and applications, customers should provide adequate design and operating safeguards.

TI does not warrant or represent that any license, either express or implied, is granted under any TI patent right, copyright, mask work right, or other TI intellectual property right relating to any combination, machine, or process in which TI products or services are used. Information published by TI regarding third-party products or services does not constitute a license from TI to use such products or services or a warranty or endorsement thereof. Use of such information may require a license from a third party under the patents or other intellectual property of the third party, or a license from TI under the patents or other intellectual property of TI.

Reproduction of information in TI data books or data sheets is permissible only if reproduction is without alteration and is accompanied by all associated warranties, conditions, limitations, and notices. Reproduction of this information with alteration is an unfair and deceptive business practice. TI is not responsible or liable for such altered documentation.

Resale of TI products or services with statements different from or beyond the parameters stated by TI for that product or service voids all express and any implied warranties for the associated TI product or service and is an unfair and deceptive business practice. TI is not responsible or liable for any such statements.

Following are URLs where you can obtain information on other Texas Instruments products and application solutions:

Products		Applications	
Amplifiers	amplifier.ti.com	Audio	www.ti.com/audio
Data Converters	dataconverter.ti.com	Automotive	www.ti.com/automotive
DSP	dsp.ti.com	Broadband	www.ti.com/broadband
Interface	interface.ti.com	Digital Control	www.ti.com/digitalcontrol
Logic	logic.ti.com	Military	www.ti.com/military
Power Mgmt	power.ti.com	Optical Networking	www.ti.com/opticalnetwork
Microcontrollers	microcontroller.ti.com	Security	www.ti.com/security
		Telephony	www.ti.com/telephony
		Video & Imaging	www.ti.com/video
		Wireless	www.ti.com/wireless

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

