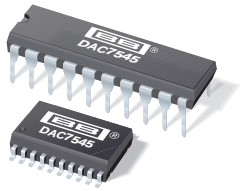
DAC7545



SBAS150A – AUGUST 1987 – REVISED FEBRUARY 2003

CMOS 12-Bit Multiplying DIGITAL-TO-ANALOG CONVERTER Microprocessor Compatible

FEATURES

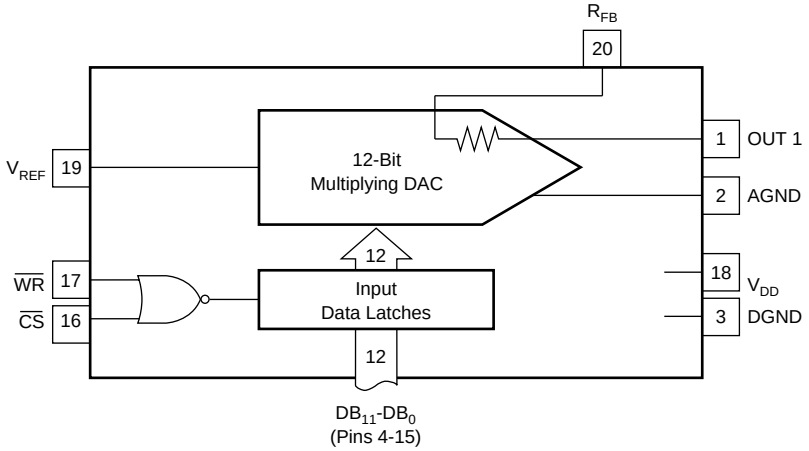
- FOUR-QUADRANT MULTIPLICATION
- LOW-GAIN TC: 2ppm/°C typ
- MONOTONICITY ENSURED OVER TEMPERATURE
- SINGLE 5V TO 15V SUPPLY
- TTL/CMOS LOGIC COMPATIBLE
- LOW OUTPUT LEAKAGE: 10nA max
- LOW OUTPUT CAPACITANCE: 70pF max
- DIRECT REPLACEMENT FOR THE AD7545, PM-7545

DESCRIPTION

The DAC7545 is a low-cost, CMOS, 12-bit, four-quadrant multiplying, digital-to-analog converter (DAC) with input data latches. The input data is loaded into the DAC as a 12-bit data word. The data flows through to the DAC when both the chip select ($\overline{CS}$) and the write ($\overline{WR}$) pins are at a logic low.

Laser-trimmed thin-film resistors and excellent CMOS voltage switches provide true 12-bit integral and differential linearity. The device operates on a single +5V to +15V supply and is available in an SO-20 package; devices are specified over the commercial temperature range.

The DAC7545 is well suited for battery-powered or other low-power applications because the power dissipation is less than 0.5mW when used with CMOS logic inputs and V_{DD} = +5V.



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.

ABSOLUTE MAXIMUM RATINGS[1]

T_A = +25°C, unless otherwise noted.

V_{DD} to DGND	–0.3V, +17
Digital Input to DGND	–0.3V, V_{DD}
V_{RFB}, V_{REF}, to DGND	±25V
$V_{PIN\ 1}$ to DGND	–0.3V, V_{DD}
AGND to DGND	–0.3V, V_{DD}
Power Dissipation: Any Package to +75°C	450mW
Derates above +75°C by	6mW/°C
Operating Temperature:	
Commercial J, K, L, and GL	–40°C to +85°C
Storage Temperature	–65°C to +150°C
Lead Temperature (soldering, 10s)	+300°C

NOTE: (1) Stresses above those listed above may cause permanent damage to the device. This is a stress rating only and functional operation of the device at these or any other condition above those indicated in the operational sections of this specification is not implied. Exposure to absolute maximum rating conditions for extended periods may affect device reliability.

ELECTROSTATIC DISCHARGE SENSITIVITY

This integrated circuit can be damaged by ESD. Texas Instruments recommends that all integrated circuits be handled with appropriate precautions. Failure to observe proper handling and installation procedures can cause damage.

ESD damage can range from subtle performance degradation to complete device failure. Precision integrated circuits may be more susceptible to damage because very small parametric changes could cause the device not to meet its published specifications.

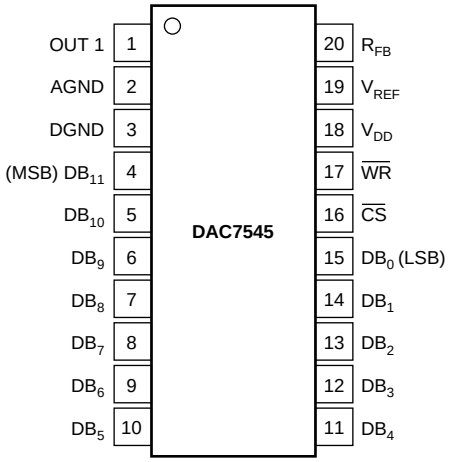
PACKAGE/ORDERING INFORMATION

PRODUCT	RELATIVE ACCURACY (LSB)	GAIN ERROR (LSB) V_{DD} = +5V	PACKAGE-LEAD	PACKAGE DESIGNATOR[1]	SPECIFIED TEMPERATURE RANGE	PACKAGE MARKING	ORDERING NUMBER	TRANSPORT MEDIA, QUANTITY
DAC7545	±2	±20	SO-20	DW	–40°C to +85°C	DAC7545JU	DAC7545JU	Rails, 38
"	±1	±10	"	"	"	DAC7545KU	DAC7545KU	Rails, 38
DAC7545	±1/2	±5	SO-20	DW	–40°C to +85°C	DAC7545LU	DAC7545LU	Rails, 38
"	±1/2	±2	"	"	"	DAC7545GLU	DAC7545GLU	Rails, 38

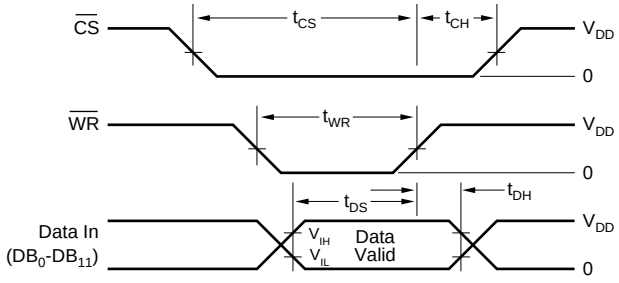
NOTE: (1) For the most current specifications and package information, refer to our web site at www.ti.com.

PIN CONNECTIONS

Top View **SO**



WRITE CYCLE TIMING DIAGRAM



Mode Selection	
Write Mode	**Hold Mode**
$\overline{CS}$ and $\overline{WR}$ low, DAC responds Data Bus (DB_0-DB_{11}) inputs.	Either $\overline{CS}$ or $\overline{WR}$ high, data bus to (DB_0-DB_{11}) is locked out; DAC holds last data present when $\overline{WR}$ or $\overline{CS}$ assumed high state.

NOTES: V_{DD} = +5V, t_R = t_F = 20ns. V_{DD} = +15V, t_R = t_F = 40ns. All inputs signal rise and fall times measured from 10% to 90% of V_{DD}. Timing measurement reference level is (V_{IH} + V_{IL})/2.

ELECTRICAL CHARACTERISTICS

V_{REF} = +10V, $V_{OUT\,1}$ = 0V, and ACOM = DCOM, unless otherwise specified.

		DAC7545					
		V_{DD} = +5V		V_{DD} = +15V			
PARAMETER	GRADE	T_A = +25°C	T_{MAX}-T_{MIN}(1)	T_A = +25°C	T_{MAX}-T_{MIN}(1)	UNITS	TEST CONDITIONS/COMMENTS
STATIC PERFORMANCE							
Resolution	All	12	12	12	12	Bits	
Accuracy	J	±2	±2	±2	±2	LSB	
	K	±1	±1	±1	±1	LSB	
	L	±1/2	±1/2	±1/2	±1/2	LSB	
	GL	±1/2	±1/2	±1/2	±1/2	LSB	
Differential Nonlinearity	J	±4	±4	±4	±4	LSB	10-Bit Monotonic, T_{MIN} to T_{MAX}
	K	±1	±1	±1	±1	LSB	10-Bit Monotonic, T_{MIN} to T_{MAX}
	L	±1	±1	±1	±1	LSB	12-Bit Monotonic, T_{MIN} to T_{MAX}
	GL	±1	±1	±1	±1	LSB	12-Bit Monotonic, T_{MIN} to T_{MAX}
Gain Error (with internal R_{FB})(2)	J	±20	±20	±25	±25	LSB	DAC register loaded with FFF_H. Gain error is adjustable using the circuits in Figures 2 and 3.
	K	±10	±10	±15	±15	LSB	
	L	±5	±6	±10	±10	LSB	
	GL	±2	±3	±6	±7	LSB	
Gain Temperature Coefficient(3) (ΔGain/ΔTemperature)	All	±5	±5	±10	±10	ppm/°C for V_{DD} = +5	Typical Value is 2ppm/°C
DC Supply Rejection(3) (ΔGain/ΔV_{DD})	All	0.015	0.03	0.01	0.02	%/%	ΔV_{DD} ± 5%
Output Leakage Current at Out 1	J, K, L, GL	10	50	10	50	nA	DB_0-DB_{11} = 0V; $\overline{WR}$, $\overline{CS}$ = 0V
DYNAMIC PERFORMANCE							
Current Settling Time(3)	All	2	2	2	2	µs	To 1/2 LSB. Out 1 Load = 100Ω DAC output measured from falling edge of $\overline{WR}$. $\overline{CS}$ = 0V.
Propagation Delay(3) (from digital input change to 90% of final analog output)	All	300		250		ns	Out 1 Load = 100Ω. C_{EXT} = 13pF(4)
Glitch Energy	All	400		250		nV-s(5)	V_{REF} = ACOM
AC Feedback at I_{OUT} 1	All	5	5	5	5	mVp-p(5)	V_{REF} = ±10V, 10kHz Sine Wave
REFERENCE INPUT							
Input Resistance (pin 19 to AGND)	All	7	7	7	7	kΩ(6)	Input Resistance TC = 300ppm/°C(5)
		25	25	25	25	kΩ	
AC OUTPUTS							
Output Capacitance(3): $C_{OUT\,1}$	All	70	70	70	70	pF	DB_0-DB_{11} = 0V; $\overline{WR}$, $\overline{CS}$ = 0V
$C_{OUT\,2}$	All	200	200	200	200	pF	DB_0-DB_{11} = V_{DD}; $\overline{WR}$, $\overline{CS}$ = 0V
DIGITAL INPUTS							
V_{IH} (Input HIGH Voltage)	All	2.4	2.4	13.5	13.5	V(6)	
V_{IL} (Input LOW Voltage)	All	0.8	0.8	1.5	1.5	V	
I_{IN} (Input Current)(7)	All	±1	±10	±1	±10	µA	V_{IN} = 0V or V_{DD}
Input Capacitance(3): DB_0-DB_{11}	All	5	5	5	5	pF	V_{IN} = 0V
$\overline{WR}$, $\overline{CS}$	All	20	20	20	20	pF	V_{IN} = 0V
SWITCHING CHARACTERISTICS(8)							
Chip Select to Write Setup Time, t_{CS}	All	280	380	180	200	ns(6)	See Timing Diagram
		200	270	120	150	ns(5)	
Chip Select to Write Hold Time, t_{CH}	All	0	0	0	0	ns(6)	
Write Pulse Width, t_{WR}	All	250	400	160	240	ns(6)	$t_{CS} \geq t_{WR}$, $t_{CH} \geq 0$
		175	280	100	170	ns(5)	
Data Setup Time, t_{DS}	All	140	210	90	120	ns(6)	
		100	150	60	80	ns(5)	
Data Hold Time, t_{DH}	All	10	10	10	10	ns(6)	
POWER SUPPLY, I_{DD}							
	All	2	2	2	2	mA	All Digital Inputs V_{IL} or V_{IH}
	All	100	500	100	500	µA	All Digital Inputs 0V or V_{DD}
	All	10	10	10	10	µA(5)	All Digital Inputs 0V or V_{DD}

NOTES: (1) Temperature ranges—J, K, L, and GL: –40°C to +85°C. (2) This includes the effect of 5ppm max, gain TC. (3) Ensured but not tested. (4) DB_0-DB_{11} = 0V to V_{DD} or V_{DD} to 0V. (5) Typical. (6) Minimum. (7) Logic inputs are MOS gates. Typical input current (+25°C) is less than 1nA. (8) Sample tested at +25°C to ensure compliance.

DISCUSSION OF SPECIFICATIONS

RELATIVE ACCURACY

This term (also known as end point linearity) describes the transfer function of analog output to digital input code. Relative accuracy describes the deviation from a straight line after zero and full-scale have been adjusted.

DIFFERENTIAL NONLINEARITY

Differential nonlinearity is the deviation from an ideal 1LSB change in the output, for adjacent input code changes. A differential nonlinearity specification of 1LSB ensures monotonicity.

GAIN ERROR

Gain error is the difference in measure of full-scale output versus the ideal DAC output; the ideal output for the DAC7545 is $-(4095/4096)(V_{REF})$. Gain error can be adjusted to zero using external trims, see the Applications section.

OUTPUT LEAKAGE CURRENT

The current that appears at OUT 1 with the DAC loaded with all zeros.

MULTIPLYING FEEDTHROUGH ERROR

The AC output error due to capacitive feedthrough from V_{REF} to OUT 1 with the DAC loaded with all zeros; this test is performed using a 10kHz sine wave.

OUTPUT CURRENT SETTLING TIME

The time required for the output to settle within ±0.5 LSB of final value from a change in code of all zeros to all ones, or all ones to all zeros.

PROPAGATION DELAY

The delay of the internal circuitry is measured as the time from a digital code change to the point at which the output reaches 90% of final value.

DIGITAL-TO-ANALOG GLITCH IMPULSE

The area of the glitch energy measured in nanovolt-seconds. Key contributions to glitch energy are internal circuitry timing differences and charge injected from digital logic. The measurement is performed with V_{REF} = GND, an OPA600 as the output op amp, and G_1 (phase compensation) = 0pF.

MONOTONICITY

Monotonicity assures that the analog output will increase or stay the same for increasing digital input codes. The DAC7545 is ensured monotonic to 12 bits, except the J grade is specified to be 10-bit monotonic.

POWER-SUPPLY REJECTION

Power-supply rejection is the measure of the sensitivity of the output (full-scale) to a change in the power-supply voltage.

CIRCUIT DESCRIPTION

Figure 1 shows a simplified schematic of the DAC portion of the DAC7545. The current from the V_{REF} pin is switched from OUT 1 to AGND by the FET switch. This circuit architecture keeps the resistance at the reference pin constant and equal to R_{LDR}, so the reference can be provided by either a voltage or current, AC or DC, positive or negative polarity, and have a voltage range up to ±20V even with V_{DD} = 5V. The R_{LDR} is equal to R and is typically 11kW.

The output capacitance of the DAC7545 is code dependent and varies from a minimum value (70pF) at code 000h to a maximum (200pF) at code FFFh.

The input buffers are CMOS inverters, designed so that when the DAC7545 is operated from a 5V supply (V_{DD}), the logic threshold is TTL-compatible. Being simple CMOS inverters, there is a range of operation where the inverters operate in the linear region and thus draw more supply current than normal. Minimizing this transition time through the linear region and insuring that the digital inputs are operated as close to the rails as possible will minimize the supply drain current.

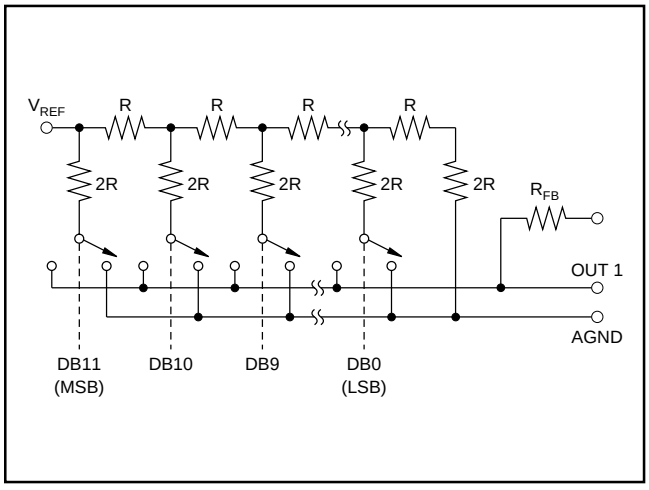


FIGURE 1. Simplified DAC Circuit of the DAC7545.

APPLICATIONS

UNIPOLAR OPERATION

Figure 2 shows the DAC7545 connected for unipolar operation. The high-grade DAC7545 is specified for a 1LSB gain error, so gain adjust is typically not needed; however, the resistors shown are for adjusting full-scale errors. The value of R_1 should be minimized to reduce the effects of mismatching temperature coefficients between the internal and external resistors. A range of adjustment of 1.5 times the desired range will be adequate. For example, for a DAC7545JP, the gain error is specified to be ±25LSB, therefore, a range of adjustment of ±37LSB will be adequate. Equation 1 results in a value of 458W for the potentiometer (use 500Ω).

$$R_1 = \frac{R_{LADDER}}{4096}\left(3 \bullet \text{Gain Error}\right) \quad (1)$$

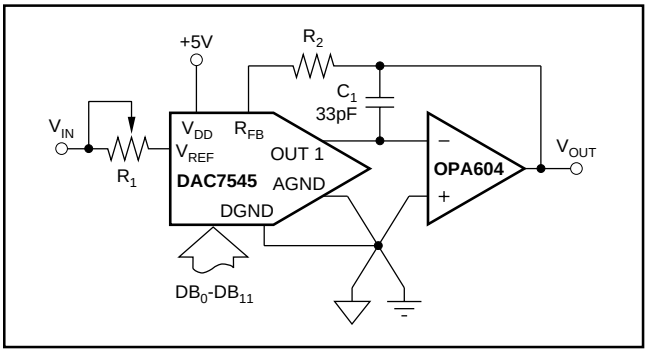


FIGURE 2. Unipolar Binary Operation.

The addition of R_1 will cause a negative gain error. To compensate for this error, R_2 must be added. The value of R_2 should be one-third the value of R_1.

The capacitor across the feedback resistor is used to compensate for the phase shift due to stray capacitances of the circuit board, the DAC output capacitance, and op amp input capacitance. Eliminating this capacitor will result in excessive ringing and an increase in glitch energy, therefore, this capacitor must be as small as possible to minimize settling time.

The circuit of Figure 2 can be used with input voltages up to ±20V as long as the output amplifier is biased to handle the excursions. Table I represents the analog output for four codes into the DAC for Figure 2.

BIPOLAR OPERATION

Figure 3 and Table II illustrate the recommended circuit and code relationship for bipolar operation. The DAC function uses offset binary code. The inverter, U_1, on the MSB line converts binary two's complement input code to offset binary code. If the inversion is done in software, U_1 can be omitted.

BINARY CODE	ANALOG OUTPUT
MSB LSB	
1111 1111 1111	$-V_{IN}$ (4095/4096)
1000 0000 0000	$-V_{IN}$ (2048/4096) = $-1/2V_{IN}$
0000 0000 0001	$-V_{IN}$ (1/4096)
0000 0000 0000	0V

TABLE I. Unipolar Codes.

DATA INPUT	ANALOG OUTPUT
MSB LSB	
0111 1111 1111	$+V_{IN}$ (2047/2048)
0000 0000 0001	$+V_{IN}$ (1/2048)
0000 0000 0000	0V
1111 1111 1111	$-V_{IN}$ (1/2048)
1000 0000 0000	$-V_{IN}$ (2048/2048)

TABLE II. Binary Two's Complement Code Table for Circuit of Figure 3.

R_3, R_4, and R_5 must match within 0.01% and must be the same type of resistors (preferably wire-wound or metal foil), so that the temperature coefficients match; mismatch of R_3 value to R_4 causes both offset and full-scale error. Mismatch of R_5 to R_4 and R_3 causes full-scale error.

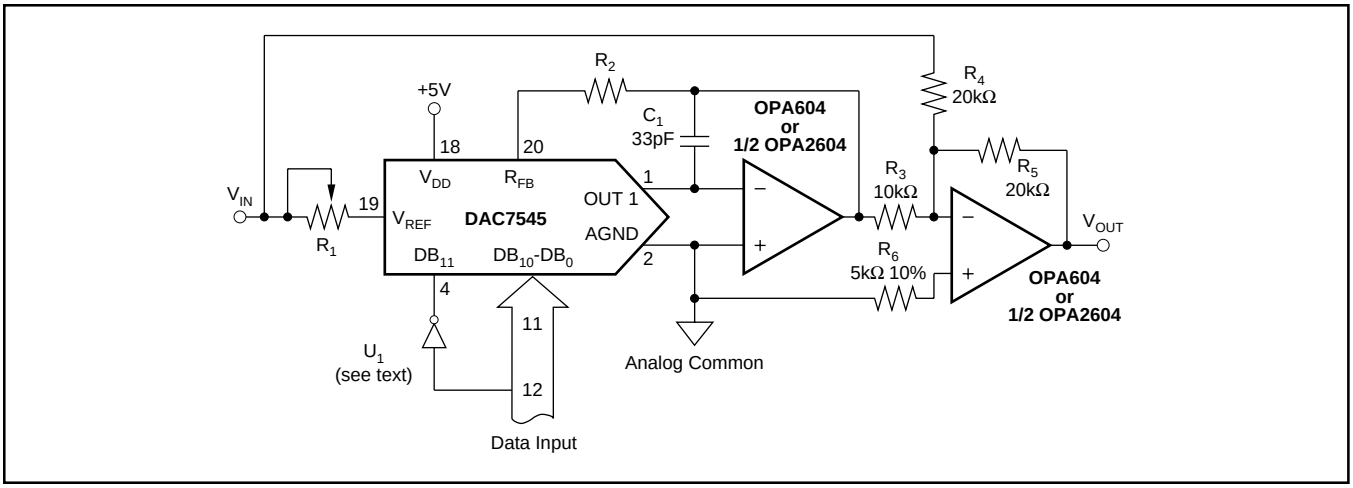


FIGURE 3. Bipolar Operation (binary two's complement code).

DIGITALLY-CONTROLLED GAIN BLOCK

Figure 4 shows a circuit for a digitally-controlled gain block. The feedback for the op amp is made up of the FET switch and the R-2R ladder. The input resistor to the gain block is the R_{FB} of the DAC7545. As the FET switch is in the feedback loop, a zero code into the DAC will result in the op amp having no feedback, and a saturated op amp output.

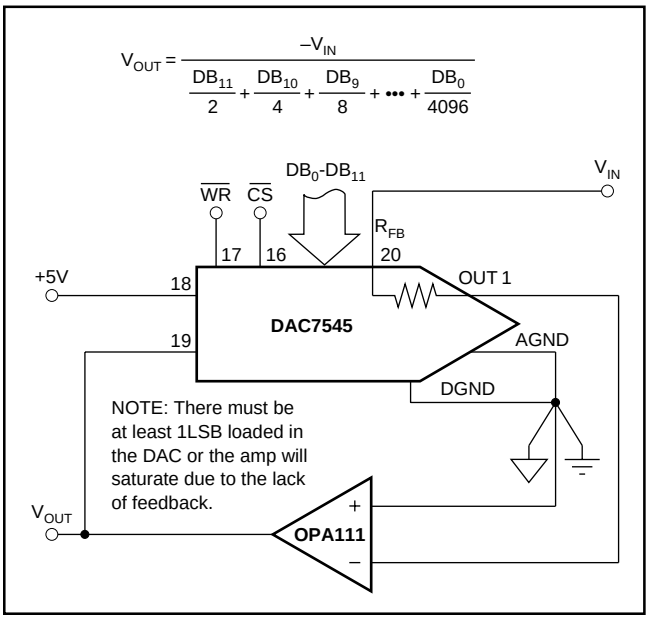


FIGURE 4. Digitally Controlled Gain Block.

APPLICATION HINTS

CMOS DACs, such as the DAC7545, exhibit a code-dependent out resistance. The effect of this is a code-dependent differential nonlinearity at the amplifier output that depends on the offset voltage, V_{OS}, of the amplifier. Thus linearity depends upon the potential of OUT 1 and AGND being exactly equal to each other. Usually the DAC is connected to an external op amp with the noninverting input connected to AGND. The op amp selected should have a low input bias current and low V_{OS} and V_{OS} drift over temperature. The op amp offset voltage should be less than $(25 \bullet 10^{-6})(V_{REF})$ over operating conditions. Suitable op amps are the OPA37 and the OPA627 for fixed reference applications and low-bandwidth requirement; the OPA37 has low V_{OS} and does not require an offset trim. For wide bandwidth, high slew rate, or fast-settling applications, the OPA604 or 1/2 OPA2604 are recommended.

Unused digital inputs must be connected to V_{DD} or to DGND, this prevents noise from triggering the high impedance digital input. It is suggested that the unused digital inputs also be given a path to ground or V_{DD} through a 1mW resistor to prevent the accumulation of static charge if the PC card is unplugged from the system. In addition, in systems where the AGND to DGND connection is on a backplane, it is recommended that two diodes be connected in inverse parallel between AGND and DGND.

INTERFACING TO MICROPROCESSORS

The DAC7545 can be directly interfaced to either an 8- or 16-bit microprocessor through its 12-bit wide data latch using the $\overline{CS}$ and $\overline{WR}$ controls.

An 8-bit processor interface is shown in Figure 5. It uses two memory addresses: one for the lower 8 bits and one for the upper 4 bits of data into the DAC via the latch.

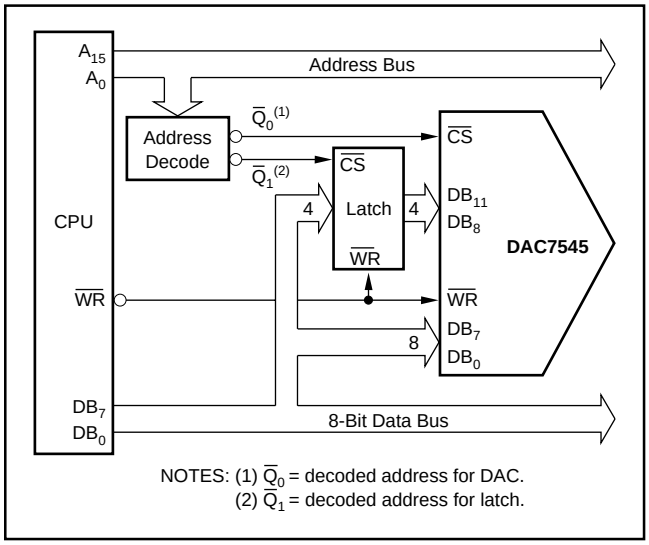


FIGURE 5. 8-Bit Processor Interface.

PACKAGING INFORMATION

Orderable Device	Status (1)	Package Type	Package Drawing	Pins	Package Qty	Eco Plan (2)	Lead/Ball Finish (6)	MSL Peak Temp (3)	Op Temp (°C)	Device Marking (4/5)	Samples
DAC7545GLP	OBSOLETE	ZZ (BB)	ZZ222	20		TBD	Call TI	Call TI	-40 to 85		
DAC7545GLU	NRND	SOIC	DW	20	25	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-3-260C-168 HR	-40 to 85	DAC7545GLU	
DAC7545GLUG4	NRND	SOIC	DW	20	25	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-3-260C-168 HR	-40 to 85	DAC7545GLU	
DAC7545JP	OBSOLETE	ZZ (BB)	ZZ222	20		TBD	Call TI	Call TI	-40 to 85		
DAC7545JU	NRND	SOIC	DW	20	25	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-3-260C-168 HR	-40 to 85	DAC7545JU	
DAC7545KP	OBSOLETE	ZZ (BB)	ZZ222	20		TBD	Call TI	Call TI	-40 to 85		
DAC7545KU	NRND	SOIC	DW	20	25	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-3-260C-168 HR	-40 to 85	DAC7545KU	
DAC7545KUG4	NRND	SOIC	DW	20	25	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-3-260C-168 HR	-40 to 85	DAC7545KU	
DAC7545LP	OBSOLETE	ZZ (BB)	ZZ222	20		TBD	Call TI	Call TI	-40 to 85		
DAC7545LU	NRND	SOIC	DW	20	25	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-3-260C-168 HR	-40 to 85	DAC7545LU	

(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 - The planned eco-friendly classification: Pb-Free (RoHS), Pb-Free (RoHS Exempt), or Green (RoHS & no Sb/Br) - please check http://www.ti.com/productcontent for the latest availability information and additional product content details.
TBD: The Pb-Free/Green conversion plan has not been defined.
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.
Pb-Free (RoHS Exempt): This component has a RoHS exemption for either 1) lead-based flip-chip solder bumps used between the die and package, or 2) lead-based die adhesive used between the die and leadframe. The component is otherwise considered Pb-Free (RoHS compatible) as defined above.
Green (RoHS & no Sb/Br): TI defines "Green" to mean Pb-Free (RoHS compatible), and free of Bromine (Br) and Antimony (Sb) based flame retardants (Br or Sb do not exceed 0.1% by weight in homogeneous material)

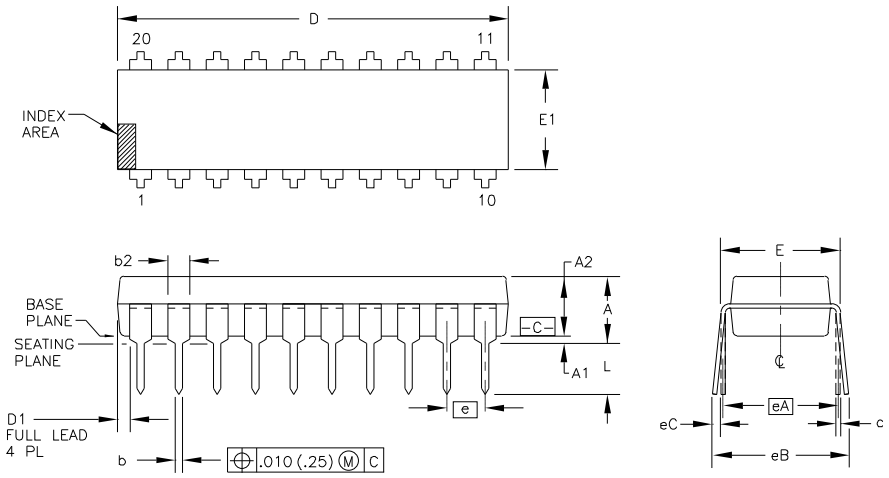
(3) MSL, Peak Temp. - The Moisture Sensitivity Level rating according to the JEDEC industry standard classifications, and peak solder temperature.

(4) There may be additional marking, which relates to the logo, the lot trace code information, or the environmental category on the device.

(5) Multiple Device Markings will be inside parentheses. Only one Device Marking contained in parentheses and separated by a "~" will appear on a device. If a line is indented then it is a continuation of the previous line and the two combined represent the entire Device Marking for that device.

(6) Lead/Ball Finish - Orderable Devices may have multiple material finish options. Finish options are separated by a vertical ruled line. Lead/Ball Finish values may wrap to two lines if the finish value exceeds the maximum column width.

Package Number 222 - 20-Pin Plastic, Single-Wide DIP



DIM	INCHES		MILLIMETERS		NOTE
	MIN.	MAX.	MIN.	MAX.	
A	--	.210	--	5.33	3
A1	.015	--	0.38	--	3
A2	.115	.195	2.92	4.95	
b	.014	.022	0.36	0.56	
b2	.045	.070	1.14	1.78	9
c	.008	.014	0.20	0.36	
D	.980	1.060	24.89	26.92	4
D1	.005	--	0.13	--	4
E	.300	.325	7.62	8.26	5
E1	.240	.280	6.10	7.11	4
e	.100 BASIC		2.54 BASIC		
eA	.300 BASIC		7.63 BASIC		5
eB	--	.430	--	10.92	6
eC	.000	.060	0.00	1.52	6

DIM	INCHES		MILLIMETERS		NOTE
	MIN.	MAX.	MIN.	MAX.	
L	.115	.150	2.92	3.81	3
N	20		20		7

NOTES:

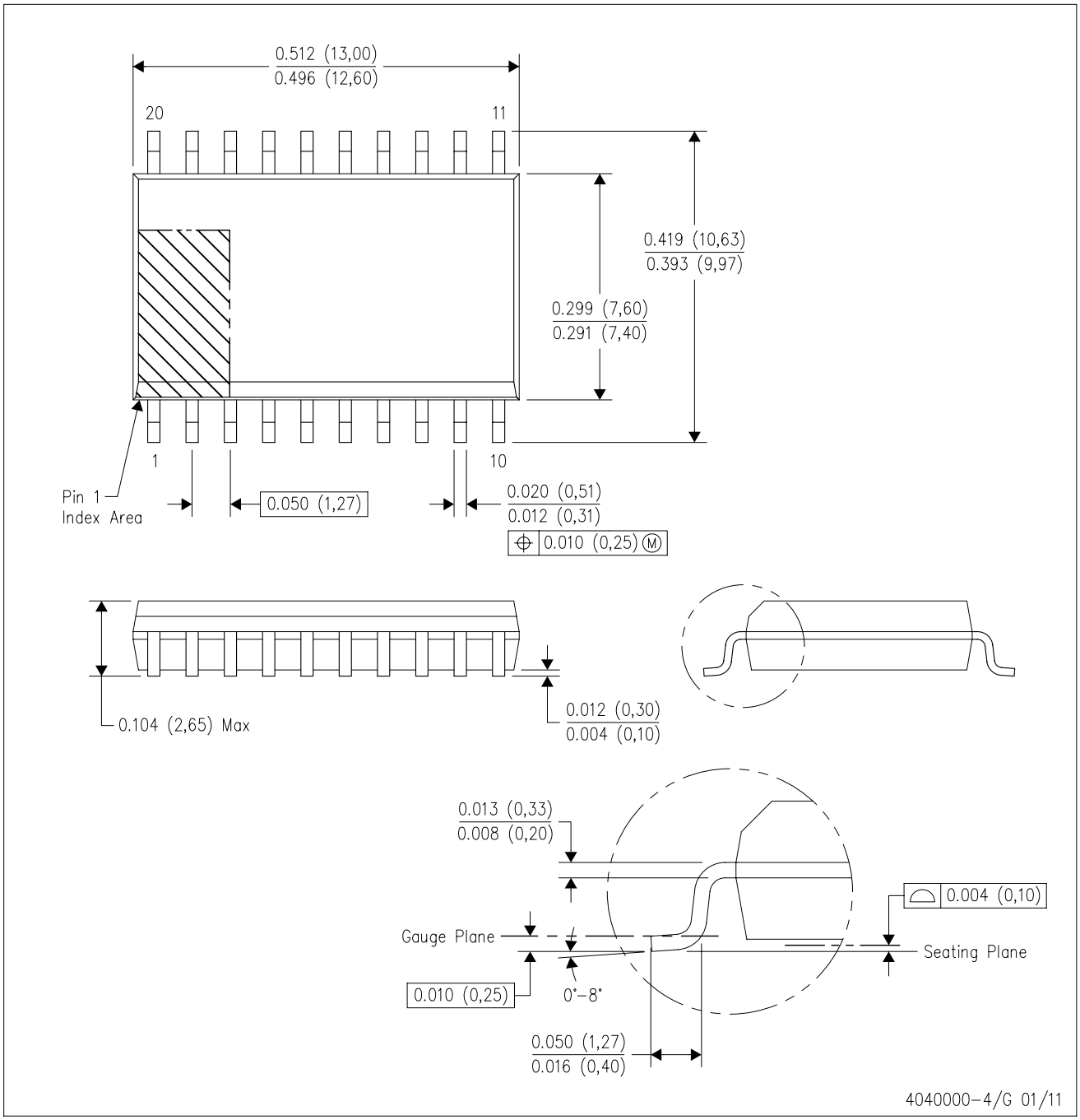
1. ALL DIMENSIONS ARE IN INCHES.
2. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M-1982.
3. DIMENSIONS A, A1, AND L ARE MEASURED WITH THE PACKAGE SEATED IN JEDEC SEATING PLANE GAUGE GS-3.
4. D, D1, AND E1 DIMENSIONS DO NOT INCLUDE MOLD FLASH OR PROTRUSIONS. MOLD FLASH OR PROTRUSIONS SHALL NOT EXCEED .010 (0.25mm).
5. E AND eA MEASURED WITH THE LEADS CONSTRAINED TO BE PERPENDICULAR TO DATUM -C- .
6. eB AND eC ARE MEASURED AT THE LEAD TIPS WITH THE LEADS UNCONSTRAINED.
7. N IS THE MAXIMUM OF TERMINAL POSITIONS.
8. POINTED OR ROUNDED LEAD TIPS ARE PREFERRED TO EASE INSERTION.
9. b2 MAXIMUM DIMENSION DOES NOT INCLUDE DAMBAR PROTRUSIONS. DAMBAR PROTRUSIONS SHALL NOT EXCEED .010 (0.25mm).
10. DISTANCE BETWEEN LEADS INCLUDING DAMBAR PROTRUSIONS TO BE .005 (0.13mm) MINIMUM.
11. A VISUAL INDEX FEATURE MUST BE LOCATED WITHIN THE CROSS-HATCHED AREA.
12. FOR AUTOMATIC INSERTION, ANY RAISED IRREGULARITY ON THE TOP SURFACE (STEP, MESA, ETC.) SHALL BE SYMMETRICAL ABOUT THE LATERAL AND LONGITUDINAL PACKAGE CENTERLINES.

PACKAGE NUMBER: ZZ222	REV.: C
JEDEC NUMBER: MS-001-AD	

BURR-BROWN®

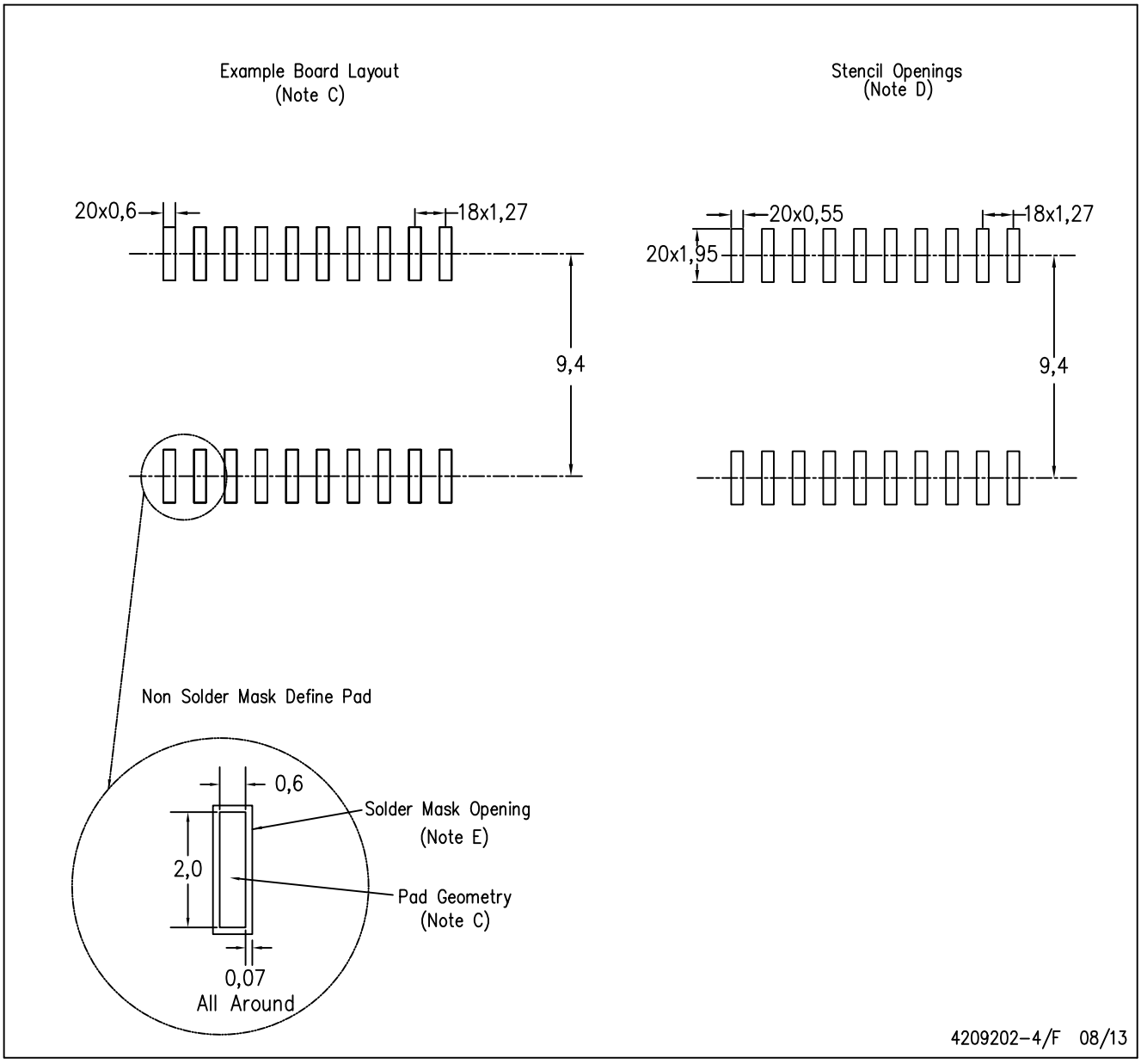
PACKAGE DRAWING

DW (R–PDSO–G20) PLASTIC SMALL OUTLINE



NOTES:
A. All linear dimensions are in inches (millimeters). Dimensioning and tolerancing per ASME Y14.5M–1994.
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–013 variation AC.

DW (R–PDSO–G20) PLASTIC SMALL OUTLINE



NOTES:
A. All linear dimensions are in millimeters.
B. This drawing is subject to change without notice.
C. Refer to IPC7351 for alternate board design.
D. Laser cutting apertures with trapezoidal walls and also rounding corners will offer better paste release. Customers should contact their board assembly site for stencil design recommendations. Refer to IPC–7525
E. Customers should contact their board fabrication site for solder mask tolerances between and around signal pads.

IMPORTANT NOTICE

Texas Instruments Incorporated and its subsidiaries (TI) reserve the right to make corrections, enhancements, improvements and other changes to its semiconductor products and services per JESD46, latest issue, and to discontinue any product or service per JESD48, latest issue. Buyers should obtain the latest relevant information before placing orders and should verify that such information is current and complete. All semiconductor products (also referred to herein as “components”) are sold subject to TI’s terms and conditions of sale supplied at the time of order acknowledgment.

TI warrants performance of its components to the specifications applicable at the time of sale, in accordance with the warranty in TI’s terms and conditions of sale of semiconductor products. Testing and other quality control techniques are used to the extent TI deems necessary to support this warranty. Except where mandated by applicable law, testing of all parameters of each component is not necessarily performed.

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

TI does not warrant or represent that any license, either express or implied, is granted under any patent right, copyright, mask work right, or other intellectual property right relating to any combination, machine, or process in which TI components or services are used. Information published by TI regarding third-party products or services does not constitute a license 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 significant portions of TI 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. TI is not responsible or liable for such altered documentation. Information of third parties may be subject to additional restrictions.

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

Buyer acknowledges and agrees that it is solely responsible for compliance with all legal, regulatory and safety-related requirements concerning its products, and any use of TI components in its applications, notwithstanding any applications-related information or support that may be provided by TI. Buyer represents and agrees that it has all the necessary expertise to create and implement safeguards which anticipate dangerous consequences of failures, monitor failures and their consequences, lessen the likelihood of failures that might cause harm and take appropriate remedial actions. Buyer will fully indemnify TI and its representatives against any damages arising out of the use of any TI components in safety-critical applications.

In some cases, TI components may be promoted specifically to facilitate safety-related applications. With such components, TI’s goal is to help enable customers to design and create their own end-product solutions that meet applicable functional safety standards and requirements. Nonetheless, such components are subject to these terms.

No TI components are authorized for use in FDA Class III (or similar life-critical medical equipment) unless authorized officers of the parties have executed a special agreement specifically governing such use.

Only those TI components which TI has specifically designated as military grade or “enhanced plastic” are designed and intended for use in military/aerospace applications or environments. Buyer acknowledges and agrees that any military or aerospace use of TI components which have ***not*** been so designated is solely at the Buyer's risk, and that Buyer is solely responsible for compliance with all legal and regulatory requirements in connection with such use.

TI has specifically designated certain components as meeting ISO/TS16949 requirements, mainly for automotive use. In any case of use of non-designated products, TI will not be responsible for any failure to meet ISO/TS16949.

Products		**Applications**	
Audio	www.ti.com/audio	Automotive and Transportation	www.ti.com/automotive
Amplifiers	amplifier.ti.com	Communications and Telecom	www.ti.com/communications
Data Converters	dataconverter.ti.com	Computers and Peripherals	www.ti.com/computers
DLP® Products	www.dlp.com	Consumer Electronics	www.ti.com/consumer-apps
DSP	dsp.ti.com	Energy and Lighting	www.ti.com/energy
Clocks and Timers	www.ti.com/clocks	Industrial	www.ti.com/industrial
Interface	interface.ti.com	Medical	www.ti.com/medical
Logic	logic.ti.com	Security	www.ti.com/security
Power Mgmt	power.ti.com	Space, Avionics and Defense	www.ti.com/space-avionics-defense
Microcontrollers	microcontroller.ti.com	Video and Imaging	www.ti.com/video
RFID	www.ti-rfid.com		
OMAP Applications Processors	www.ti.com/omap	**TI E2E Community**	e2e.ti.com
Wireless Connectivity	www.ti.com/wirelessconnectivity		

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