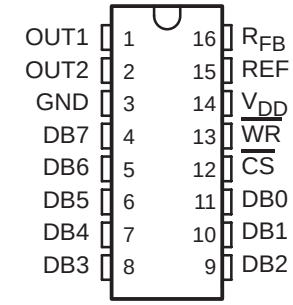
SLAS061D − SEPTEMBER 1986 − REVISED JUNE 2007

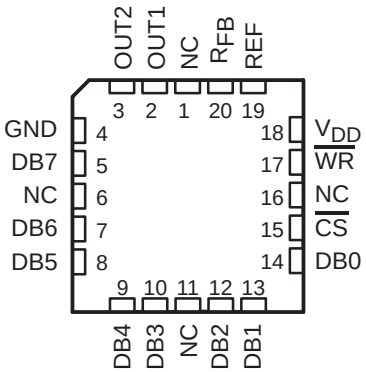
- **Easily Interfaced to Microprocessors**
- **On-Chip Data Latches**
- **Monotonic Over the Entire A/D Conversion Range**
- **Segmented High-Order Bits Ensure Low-Glitch Output**
- **Interchangeable With Analog Devices AD7524, PMI PM-7524, and Micro Power Systems MP7524**
- **Fast Control Signaling for Digital Signal-Processor Applications Including Interface With TMS320**
- **CMOS Technology**

KEY PERFORMANCE SPECIFICATIONS	
Resolution	8 Bits
Linearity error	1/2LSB Max
Power dissipation at V_{DD} = 5V	5mW Max
Setting time	100ns Max
Propagation delay time	80ns Max

D, N, OR PW PACKAGE
(TOP VIEW)



FN PACKAGE
(TOP VIEW)



NC−No internal connection

description

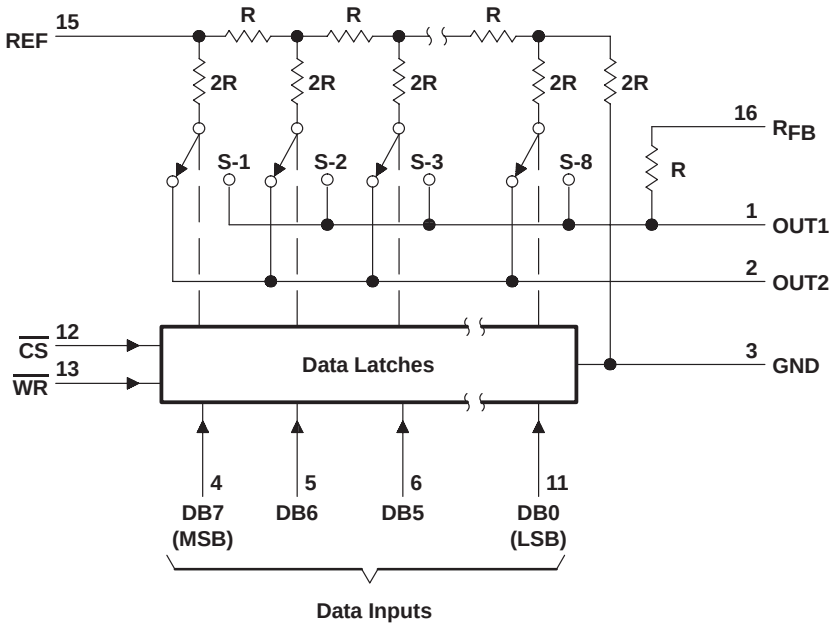
The TLC7524C, TLC7524E, and TLC7524I are CMOS, 8-bit, digital-to-analog converters (DACs) designed for easy interface to most popular microprocessors.

The devices are 8-bit, multiplying DACs with input latches and load cycles similar to the write cycles of a random access memory. Segmenting the high-order bits minimizes glitches during changes in the most significant bits, which produce the highest glitch impulse. The devices provide accuracy to 1/2LSB without the need for thin-film resistors or laser trimming, while dissipating less than 5mW typically.

Featuring operation from a 5V to 15V single supply, these devices interface easily to most microprocessor buses or output ports. The 2- or 4-quadrant multiplying makes these devices an ideal choice for many microprocessor-controlled gain-setting and signal-control applications.

The TLC7524C is characterized for operation from 0°C to 70°C. The TLC7524I is characterized for operation from −25°C to +85°C. The TLC7524E is characterized for operation from −40°C to +85°C.

functional block diagram



Terminal numbers shown are for the D or N package.

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

Supply voltage range, V_{DD} . . . . . −0.3V to 16.5V
Digital input voltage range, V_I . . . . . −0.3V to V_{DD} + 0.3V
Reference voltage, V_{ref} . . . . . ±25V
Peak digital input current, I_I 10µA
Operating free-air temperature range, T_A: TLC7524C . . . . . 0°C to +70°C
TLC7524I . . . . . −25°C to +85°C
TLC7524E . . . . . −40°C to +85°C
Storage temperature range, T_{stg} . . . . . −65°C to +150°C
Case temperature for 10 seconds, T_C: FN package . . . . . +260°C
Lead temperature 1,6mm (1/16 inch) from case for 10 seconds: D, N, or PW package . . . . . +260°C

package/ordering information

For the most current package and ordering information, see the Package Option Addendum at the end of this document, or see the TI website at www.ti.com.

recommended operating conditions

		V_{DD} = 5V			V_{DD} = 15V			UNIT
		MIN	NOM	MAX	MIN	NOM	MAX	
Supply voltage, V_{DD}		4.75	5	5.25	14.5	15	15.5	V
Reference voltage, V_{ref}			±10			±10		V
High-level input voltage, V_{IH}		2.4			13.5			V
Low-level input voltage, V_{IL}				0.8			1.5	V
CS setup time, $t_{su(CS)}$		40			40			ns
CS hold time, $t_{h(CS)}$		0			0			ns
Data bus input setup time, $t_{su(D)}$		25			25			ns
Data bus input hold time, $t_{h(D)}$		10			10			ns
Pulse duration, $\overline{WR}$ low, $t_{w(WR)}$		40			40			ns
Operating free-air temperature, T_A	TLC7524C	0		+70	0		+70	°C
	TLC7524I	−25		+85	−25		+85	
	TLC7524E	−40		+85	−40		+85	

electrical characteristics over recommended operating free-air temperature range, V_{ref} = ±10V, OUT1 and OUT2 at GND (unless otherwise noted)

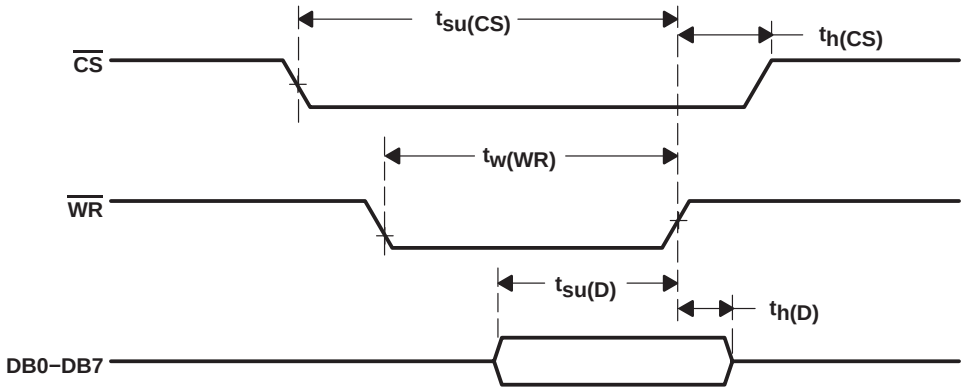
PARAMETER			TEST CONDITIONS	V_{DD} = 5V			V_{DD} = 15V			UNIT
				MIN	TYP	MAX	MIN	TYP	MAX	
I_{IH}	High-level input current		$V_I = V_{DD}$			10			10	µA
I_{IL}	Low-level input current		V_I = 0			−10			−10	µA
I_{Ikg}	Output leakage current	OUT1	DB0−DB7 at 0V, $\overline{WR}$, $\overline{CS}$ at 0V, V_{ref} = ±10V			±400			±200	nA
		OUT2	DB0−DB7 at V_{DD}, $\overline{WR}$, $\overline{CS}$ at 0V, V_{ref} = ±10V			±400			±200	
I_{DD}	Supply current	Quiescent	DB0−DB7 at V_{IH}min or V_{IL}max			1			2	mA
		Standby	DB0−DB7 at 0V or V_{DD}			500			500	µA
k_{SVS}	Supply voltage sensitivity, Δgain/ΔV_{DD}		ΔV_{DD} = ±10%		0.01	0.16		0.005	0.04	%FSR/%
C_i	Input capacitance, DB0−DB7, $\overline{WR}$, $\overline{CS}$		V_I = 0			5			5	pF
C_o	Output capacitance	OUT1	DB0−DB7 at 0V, $\overline{WR}$, $\overline{CS}$ at 0V			30			30	pF
		OUT2				120			120	
		OUT1	DB0−DB7 at V_{DD}, $\overline{WR}$, $\overline{CS}$ at 0V			120			120	
		OUT2				30			30	
	Reference input impedance (REF to GND)			5		20	5		20	kΩ

operating characteristics over recommended operating free-air temperature range, V_{ref} = ±10V, OUT1 and OUT2 at GND (unless otherwise noted)

PARAMETER	TEST CONDITIONS	V_{DD} = 5V			V_{DD} = 15V			UNIT
		MIN	TYP	MAX	MIN	TYP	MAX	
Linearity error				±0.5			±0.5	LSB
Gain error	See Note 1			±2.5			±2.5	LSB
Settling time (to 1/2 LSB)	See Note 2			100			100	ns
Propagation delay from digital input to 90% of final analog output current	See Note 2			80			80	ns
Feedthrough at OUT1 or OUT2	Vref = ±10V (100kHz sinewave) $\overline{WR}$ and $\overline{CS}$ at 0V, DB0−DB7 at 0V			0.5			0.5	%FSR
Temperature coefficient of gain	T_A = +25°C to MAX		±0.004			±0.001		%FSR/°C

NOTES: 1. Gain error is measured using the internal feedback resistor. Nominal full-scale range (FSR) = V_{ref} − 1LSB.
2. OUT1 load = 100Ω, C_{ext} = 13pF, $\overline{WR}$ at 0V, $\overline{CS}$ at 0V, DB0 − DB7 at 0V to V_{DD} or V_{DD} to 0V.

operating sequence



PRINCIPLES OF OPERATION

voltage-mode operation

It is possible to operate the current-multiplying DAC in these devices in a voltage mode. In the voltage mode, a fixed voltage is placed on the current output terminal. The analog output voltage is then available at the reference voltage terminal. Figure 1 is an example of a current-multiplying DAC, which is operated in voltage mode.

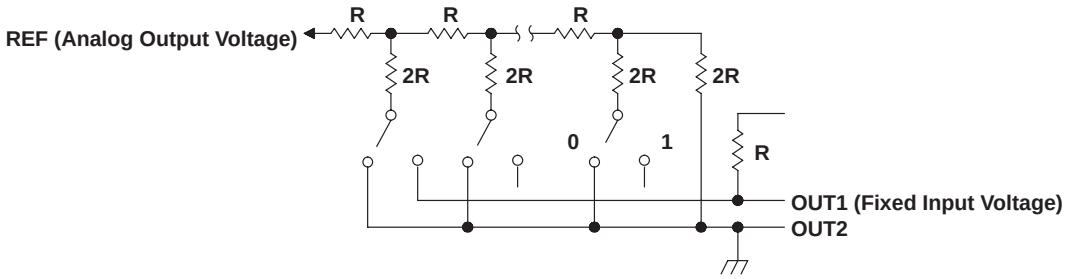


Figure 1. Voltage Mode Operation

The relationship between the fixed-input voltage and the analog-output voltage is given by the following equation:

$$V_O = V_I (D/256)$$

where

V_O = analog output voltage
V_I = fixed input voltage
D = digital input code converted to decimal

In voltage-mode operation, these devices meet the following specification:

PARAMETER	TEST CONDITIONS	MIN	MAX	UNIT
Linearity error at REF	V_{DD} = 5V, OUT1 = 2.5V, OUT2 at GND, T_A = +25°C		1	LSB

PRINCIPLES OF OPERATION

The TLC7524C, TLC7524E, and TLC7524I are 8-bit multiplying DACs consisting of an inverted R-2R ladder, analog switches, and data input latches. Binary-weighted currents are switched between the OUT1 and OUT2 bus lines, thus maintaining a constant current in each ladder leg independent of the switch state. The high-order bits are decoded. These decoded bits, through a modification in the R-2R ladder, control three equally-weighted current sources. Most applications only require the addition of an external operational amplifier and a voltage reference.

The equivalent circuit for all digital inputs low is seen in Figure 2. With all digital inputs low, the entire reference current, I_{ref}, is switched to OUT2. The current source I/256 represents the constant current flowing through the termination resistor of the R-2R ladder, while the current source I_{lkg} represents leakage currents to the substrate. The capacitances appearing at OUT1 and OUT2 are dependent upon the digital input code. With all digital inputs high, the off-state switch capacitance (30pF maximum) appears at OUT2 and the on-state switch capacitance (120pF maximum) appears at OUT1. With all digital inputs low, the situation is reversed as shown in Figure 2. Analysis of the circuit for all digital inputs high is similar to Figure 2; however, in this case, I_{ref} would be switched to OUT1.

The DAC on these devices interfaces to a microprocessor through the data bus and the $\overline{CS}$ and $\overline{WR}$ control signals. When $\overline{CS}$ and $\overline{WR}$ are both low, analog output on these devices responds to the data activity on the DB0−DB7 data bus inputs. In this mode, the input latches are transparent and input data directly affects the analog output. When either the $\overline{CS}$ signal or $\overline{WR}$ signal goes high, the data on the DB0−DB7 inputs are latched until the $\overline{CS}$ and $\overline{WR}$ signals go low again. When $\overline{CS}$ is high, the data inputs are disabled regardless of the state of the $\overline{WR}$ signal.

These devices are capable of performing 2-quadrant or full 4-quadrant multiplication. Circuit configurations for 2-quadrant or 4-quadrant multiplication are shown in Figure 3 and Figure 4. Table 1 and Table 2 summarize input coding for unipolar and bipolar operation respectively.

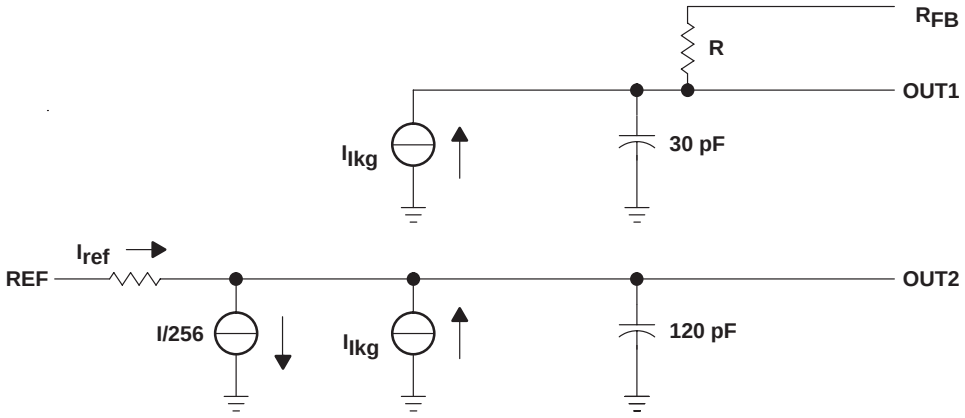
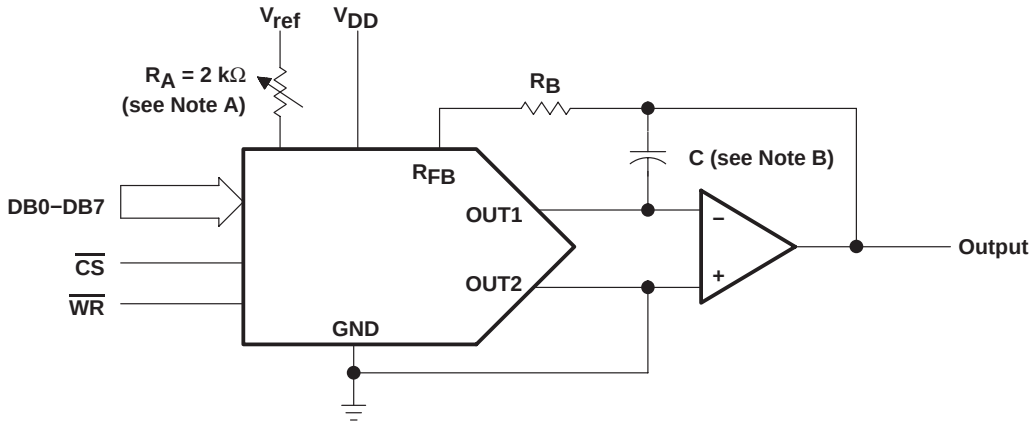


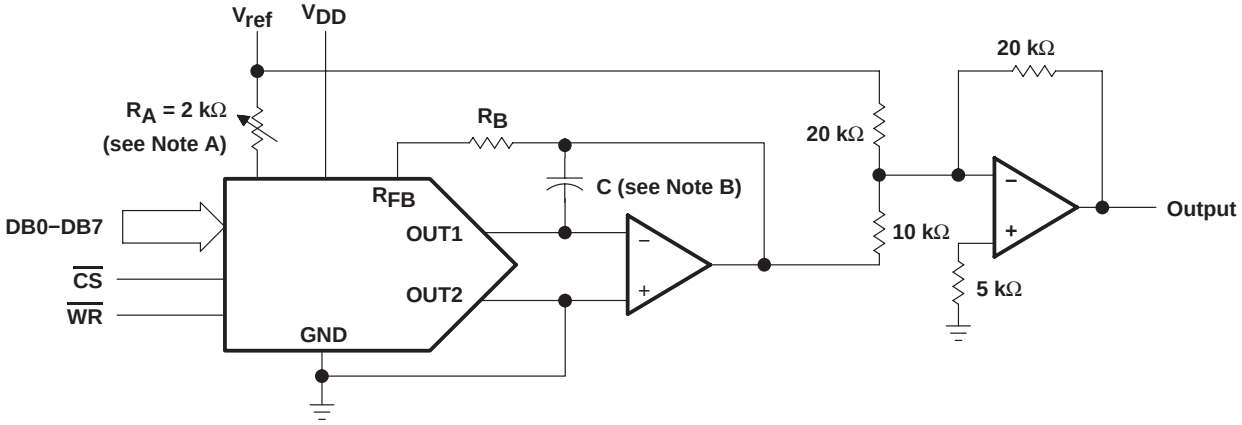
Figure 2. TLC7524 Equivalent Circuit With All Digital Inputs Low

PRINCIPLES OF OPERATION



NOTES: A. R_A and R_B used only if gain adjustment is required.
B. C phase compensation (10-15 pF) is required when using high-speed amplifiers to prevent ringing or oscillation.

Figure 3. Unipolar Operation (2-Quadrant Multiplication)



NOTES: A. R_A and R_B used only if gain adjustment is required.
B. C phase compensation (10-15 pF) is required when using high-speed amplifiers to prevent ringing or oscillation.

Figure 4. Bipolar Operation (4-Quadrant Operation)

Table 1. Unipolar Binary Code

DIGITAL INPUT (see Note 3)		ANALOG OUTPUT
MSB	LSB	
1 1 1 1 1 1 1 1		$-V_{ref}$ (255/256)
1 0 0 0 0 0 0 1		$-V_{ref}$ (129/256)
1 0 0 0 0 0 0 0		$-V_{ref}$ (128/256) = $-V_{ref}/2$
0 1 1 1 1 1 1 1		$-V_{ref}$ (127/256)
0 0 0 0 0 0 0 1		$-V_{ref}$ (1/256)
0 0 0 0 0 0 0 0		0

NOTE 3: LSB = 1/256 (V_{ref})

Table 2. Bipolar (Offset Binary) Code

DIGITAL INPUT (see Note 4)		ANALOG OUTPUT
MSB	LSB	
1 1 1 1 1 1 1 1		V_{ref} (127/128)
1 0 0 0 0 0 0 1		V_{ref} (1/128)
1 0 0 0 0 0 0 0		0
0 1 1 1 1 1 1 1		$-V_{ref}$ (1/128)
0 0 0 0 0 0 0 1		$-V_{ref}$ (127/128)
0 0 0 0 0 0 0 0		$-V_{ref}$

NOTE 4: LSB = 1/128 (V_{ref})

PRINCIPLES OF OPERATION

microprocessor interfaces

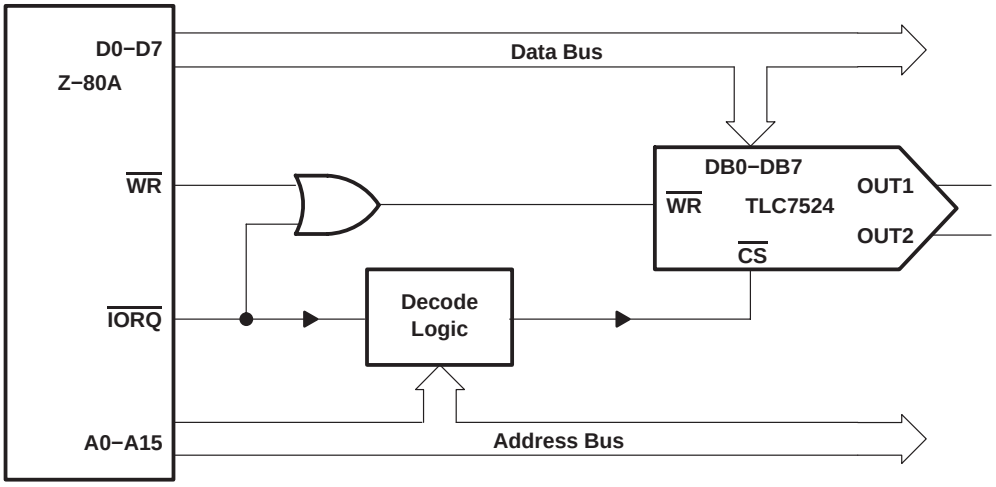


Figure 5. TLC7524: Z-80A Interface

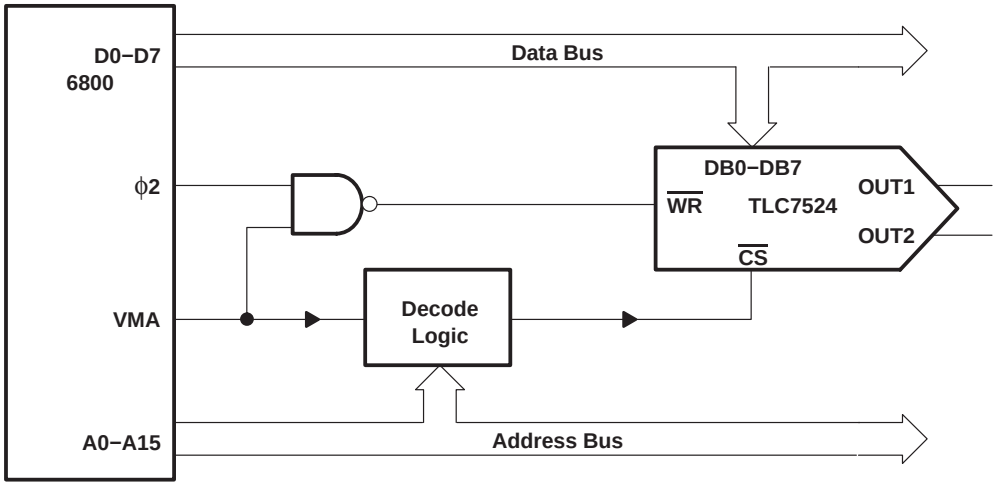


Figure 6. TLC7524: 6800 Interface

PRINCIPLES OF OPERATION

microprocessor interfaces (continued)

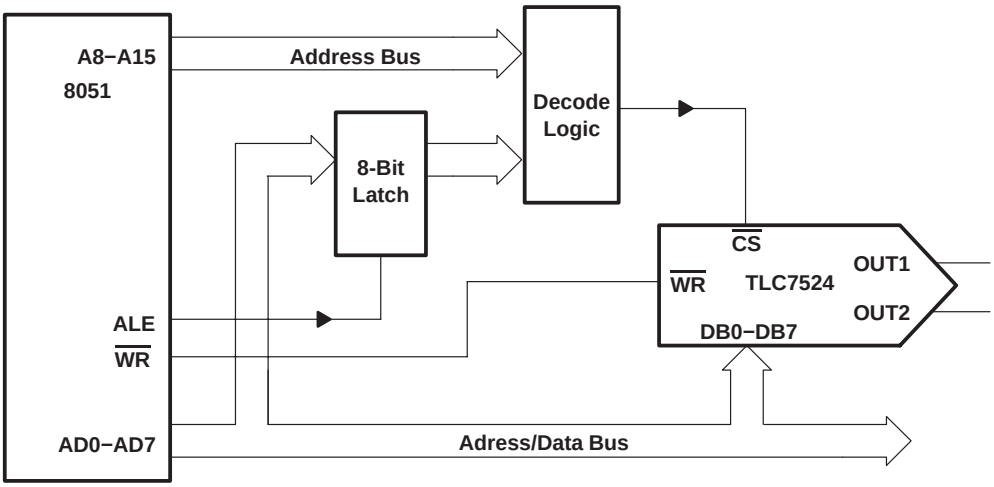


Figure 7. TLC7524: 8051 Interface

Revision History

DATE	REV	PAGE	SECTION	DESCRIPTION
6/07	D	Front Page	—	Deleted Available Options table.
		2	—	Inserted Package/Ordering information.

NOTE: Page numbers for previous revisions may differ from page numbers in the current version.

PACKAGING INFORMATION

Orderable Device	Status (1)	Package Type	Package Drawing	Pins	Package Qty	Eco Plan (2)	Lead/Ball Finish	MSL Peak Temp (3)
TLC7524CD	ACTIVE	SOIC	D	16	40	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
TLC7524CDG4	ACTIVE	SOIC	D	16	40	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
TLC7524CDR	ACTIVE	SOIC	D	16	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
TLC7524CDRG4	ACTIVE	SOIC	D	16	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
TLC7524CFN	ACTIVE	PLCC	FN	20	46	Green (RoHS & no Sb/Br)	CU SN	Level-1-260C-UNLIM
TLC7524CFNG3	ACTIVE	PLCC	FN	20	46	Green (RoHS & no Sb/Br)	CU SN	Level-1-260C-UNLIM
TLC7524CFNR	ACTIVE	PLCC	FN	20	1000	Green (RoHS & no Sb/Br)	CU SN	Level-1-260C-UNLIM
TLC7524CFNRG3	ACTIVE	PLCC	FN	20	1000	Green (RoHS & no Sb/Br)	CU SN	Level-1-260C-UNLIM
TLC7524CN	ACTIVE	PDIP	N	16	25	Pb-Free (RoHS)	CU NIPDAU	N / A for Pkg Type
TLC7524CNE4	ACTIVE	PDIP	N	16	25	Pb-Free (RoHS)	CU NIPDAU	N / A for Pkg Type
TLC7524CNS	ACTIVE	SO	NS	16	50	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
TLC7524CNSG4	ACTIVE	SO	NS	16	50	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
TLC7524CNSR	ACTIVE	SO	NS	16	2000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
TLC7524CNSRG4	ACTIVE	SO	NS	16	2000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
TLC7524CPW	ACTIVE	TSSOP	PW	16	90	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
TLC7524CPWG4	ACTIVE	TSSOP	PW	16	90	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
TLC7524CPWR	ACTIVE	TSSOP	PW	16	2000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
TLC7524CPWRG4	ACTIVE	TSSOP	PW	16	2000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
TLC7524ED	ACTIVE	SOIC	D	16	40	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
TLC7524EDG4	ACTIVE	SOIC	D	16	40	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
TLC7524EDR	ACTIVE	SOIC	D	16	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
TLC7524EDRG4	ACTIVE	SOIC	D	16	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
TLC7524EN	ACTIVE	PDIP	N	16	25	Pb-Free (RoHS)	CU NIPDAU	N / A for Pkg Type
TLC7524ENE4	ACTIVE	PDIP	N	16	25	Pb-Free (RoHS)	CU NIPDAU	N / A for Pkg Type
TLC7524ID	ACTIVE	SOIC	D	16	40	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM

Orderable Device	Status (1)	Package Type	Package Drawing	Pins	Package Qty	Eco Plan (2)	Lead/Ball Finish	MSL Peak Temp (3)
TLC7524IDG4	ACTIVE	SOIC	D	16	40	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
TLC7524IDR	ACTIVE	SOIC	D	16	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
TLC7524IDRG4	ACTIVE	SOIC	D	16	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
TLC7524IFN	ACTIVE	PLCC	FN	20	46	Green (RoHS & no Sb/Br)	CU SN	Level-1-260C-UNLIM
TLC7524IFNG3	ACTIVE	PLCC	FN	20	46	Green (RoHS & no Sb/Br)	CU SN	Level-1-260C-UNLIM
TLC7524IFNR	ACTIVE	PLCC	FN	20	1000	Green (RoHS & no Sb/Br)	CU SN	Level-1-260C-UNLIM
TLC7524IFNRG3	ACTIVE	PLCC	FN	20	1000	Green (RoHS & no Sb/Br)	CU SN	Level-1-260C-UNLIM
TLC7524IN	ACTIVE	PDIP	N	16	25	Pb-Free (RoHS)	CU NIPDAU	N / A for Pkg Type
TLC7524INE4	ACTIVE	PDIP	N	16	25	Pb-Free (RoHS)	CU NIPDAU	N / A for Pkg Type
TLC7524IPW	ACTIVE	TSSOP	PW	16	90	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
TLC7524IPWG4	ACTIVE	TSSOP	PW	16	90	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
TLC7524IPWR	ACTIVE	TSSOP	PW	16	2000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
TLC7524IPWRG4	ACTIVE	TSSOP	PW	16	2000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-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.

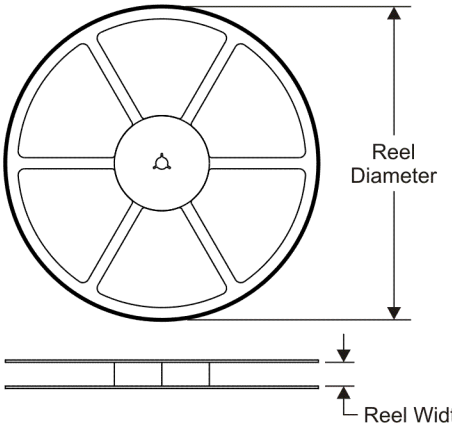
(2) Eco Plan - The planned eco-friendly classification: Pb-Free (RoHS), Pb-Free (RoHS Exempt), or Green (RoHS & no Sb/Br) - please check http://www.ti.com/productcontent for the latest availability information and additional product content details.
TBD: The Pb-Free/Green conversion plan has not been 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.

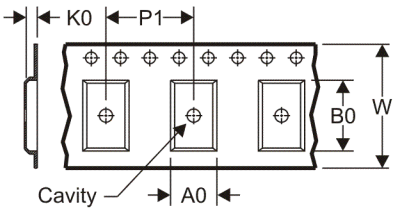
In no event shall TI's liability arising out of such information exceed the total purchase price of the TI part(s) at issue in this document sold by TI to Customer on an annual basis.

TAPE AND REEL INFORMATION

REEL DIMENSIONS

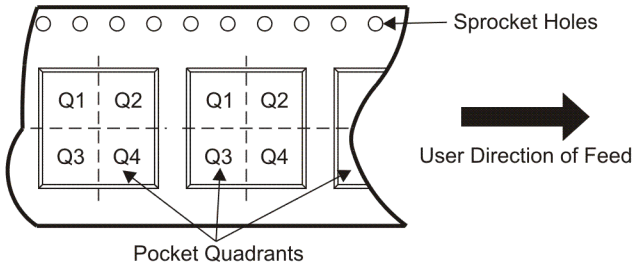


TAPE DIMENSIONS



A0	Dimension designed to accommodate the component width
B0	Dimension designed to accommodate the component length
K0	Dimension designed to accommodate the component thickness
W	Overall width of the carrier tape
P1	Pitch between successive cavity centers

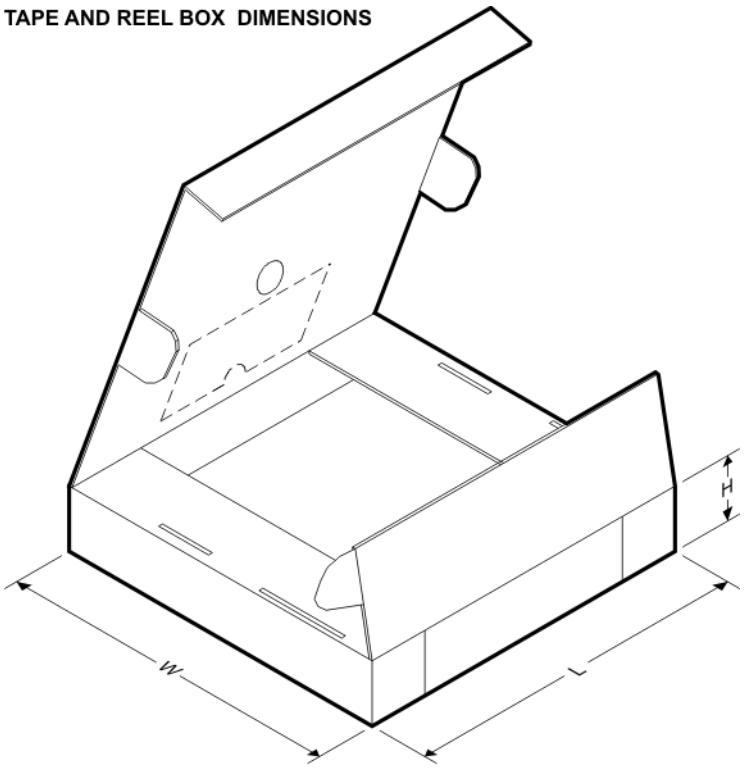
QUADRANT ASSIGNMENTS FOR PIN 1 ORIENTATION IN TAPE



*All dimensions are nominal

Device	Package Type	Package Drawing	Pins	SPQ	Reel Diameter (mm)	Reel Width W1 (mm)	A0 (mm)	B0 (mm)	K0 (mm)	P1 (mm)	W (mm)	Pin1 Quadrant
TLC7524CDR	SOIC	D	16	2500	330.0	16.4	6.5	10.3	2.1	8.0	16.0	Q1
TLC7524CNSR	SO	NS	16	2000	330.0	16.4	8.2	10.5	2.5	12.0	16.0	Q1
TLC7524CPWR	TSSOP	PW	16	2000	330.0	12.4	7.0	5.6	1.6	8.0	12.0	Q1
TLC7524EDR	SOIC	D	16	2500	330.0	16.4	6.5	10.3	2.1	8.0	16.0	Q1
TLC7524IDR	SOIC	D	16	2500	330.0	16.4	6.5	10.3	2.1	8.0	16.0	Q1
TLC7524IPWR	TSSOP	PW	16	2000	330.0	12.4	7.0	5.6	1.6	8.0	12.0	Q1

TAPE AND REEL BOX DIMENSIONS

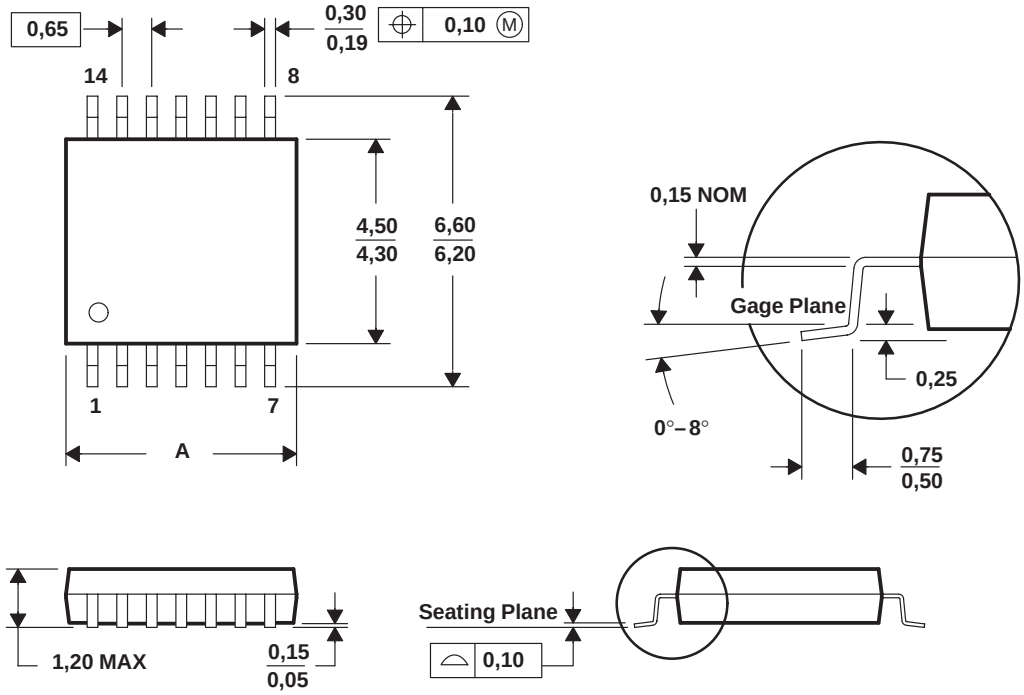


*All dimensions are nominal

Device	Package Type	Package Drawing	Pins	SPQ	Length (mm)	Width (mm)	Height (mm)
TLC7524CDR	SOIC	D	16	2500	346.0	346.0	33.0
TLC7524CNSR	SO	NS	16	2000	346.0	346.0	33.0
TLC7524CPWR	TSSOP	PW	16	2000	346.0	346.0	29.0
TLC7524EDR	SOIC	D	16	2500	346.0	346.0	33.0
TLC7524IDR	SOIC	D	16	2500	346.0	346.0	33.0
TLC7524IPWR	TSSOP	PW	16	2000	346.0	346.0	29.0

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

14 PINS SHOWN



DIM \ PINS **	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

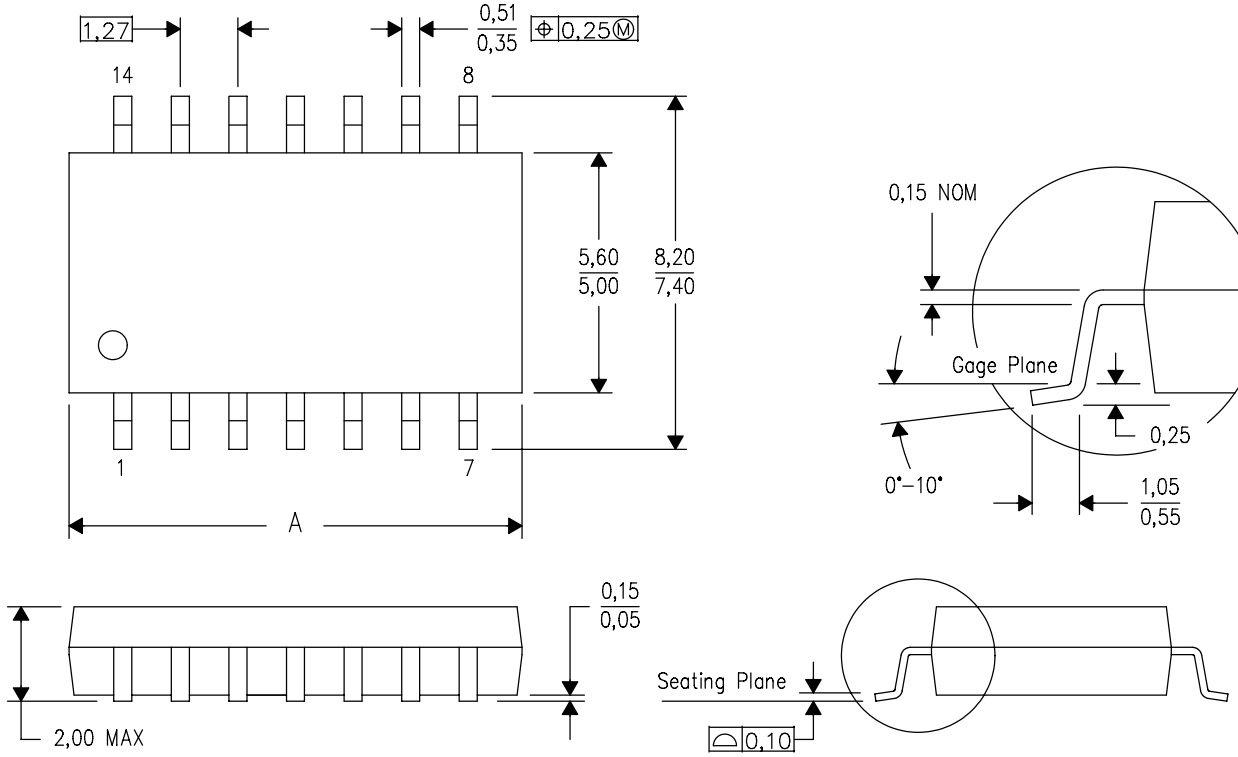
4040064/F 01/97

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

MECHANICAL DATA

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

14-PINS SHOWN

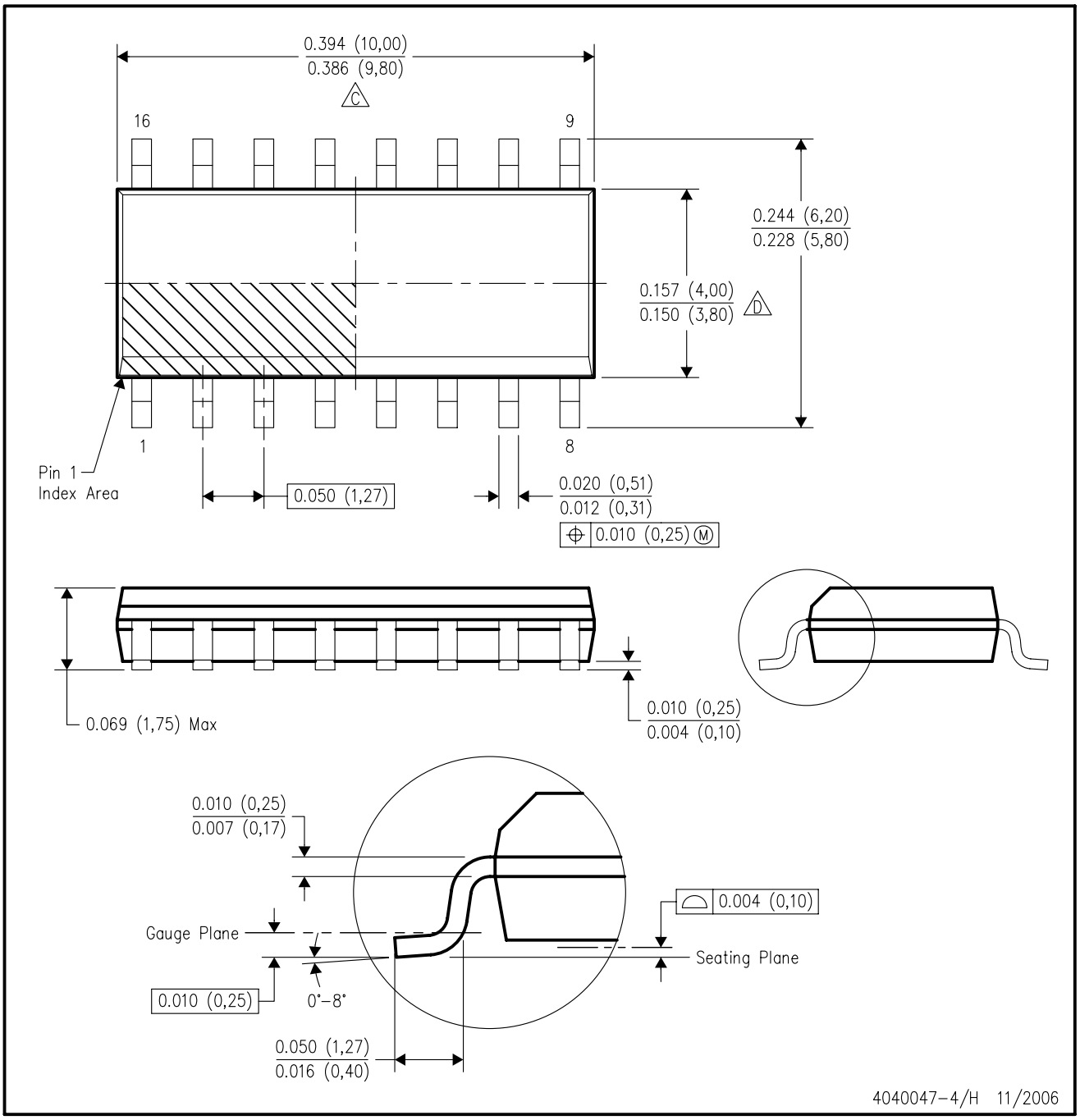


DIM \ PINS **	14	16	20	24
A MAX	10,50	10,50	12,90	15,30
A MIN	9,90	9,90	12,30	14,70

4040062/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.

D (R–PDSO–G16) PLASTIC SMALL–OUTLINE PACKAGE



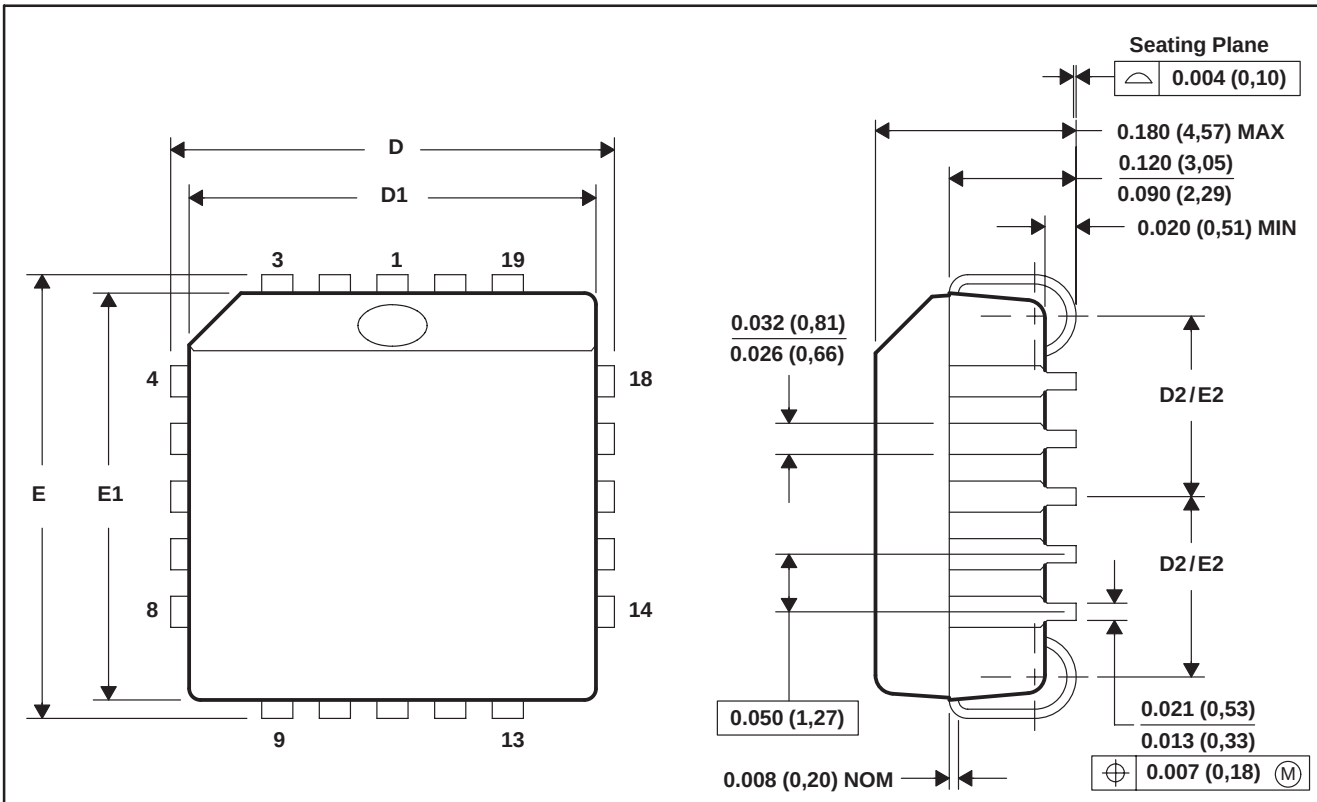
NOTES:
A. All linear dimensions are in inches (millimeters).
B. This drawing is subject to change without notice.
C. Body length does not include mold flash, protrusions, or gate burrs. Mold flash, protrusions, or gate burrs shall not exceed .006 (0,15) per end.
D. Body width does not include interlead flash. Interlead flash shall not exceed .017 (0,43) per side.
E. Reference JEDEC MS–012 variation AC.

MPLC004A – OCTOBER 1994

FN (S-PQCC-J**)

PLASTIC J-LEADED CHIP CARRIER

20 PIN SHOWN



NO. OF PINS **	D/E		D1/E1		D2/E2	
	MIN	MAX	MIN	MAX	MIN	MAX
20	0.385 (9,78)	0.395 (10,03)	0.350 (8,89)	0.356 (9,04)	0.141 (3,58)	0.169 (4,29)
28	0.485 (12,32)	0.495 (12,57)	0.450 (11,43)	0.456 (11,58)	0.191 (4,85)	0.219 (5,56)
44	0.685 (17,40)	0.695 (17,65)	0.650 (16,51)	0.656 (16,66)	0.291 (7,39)	0.319 (8,10)
52	0.785 (19,94)	0.795 (20,19)	0.750 (19,05)	0.756 (19,20)	0.341 (8,66)	0.369 (9,37)
68	0.985 (25,02)	0.995 (25,27)	0.950 (24,13)	0.958 (24,33)	0.441 (11,20)	0.469 (11,91)
84	1.185 (30,10)	1.195 (30,35)	1.150 (29,21)	1.158 (29,41)	0.541 (13,74)	0.569 (14,45)

4040005/B 03/95

NOTES: A. All linear dimensions are in inches (millimeters).
B. This drawing is subject to change without notice.
C. Falls within JEDEC MS-018

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 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. Reproduction of this information with alteration is an unfair and deceptive business practice. TI is not responsible or liable for such altered documentation. Information of third parties may be subject to additional restrictions.

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.

TI products are not authorized for use in safety-critical applications (such as life support) where a failure of the TI product would reasonably be expected to cause severe personal injury or death, unless officers of the parties have executed an agreement specifically governing such use. Buyers represent that they have all necessary expertise in the safety and regulatory ramifications of their applications, and acknowledge and agree that they are solely responsible for all legal, regulatory and safety-related requirements concerning their products and any use of TI products in such safety-critical applications, notwithstanding any applications-related information or support that may be provided by TI. Further, Buyers must fully indemnify TI and its representatives against any damages arising out of the use of TI products in such safety-critical applications.

TI products are neither designed nor intended for use in military/aerospace applications or environments unless the TI products are specifically designated by TI as military-grade or "enhanced plastic." Only products designated by TI as military-grade meet military specifications. Buyers acknowledge and agree that any such use of TI products which TI has not designated as military-grade is solely at the Buyer's risk, and that they are solely responsible for compliance with all legal and regulatory requirements in connection with such use.

TI products are neither designed nor intended for use in automotive applications or environments unless the specific TI products are designated by TI as compliant with ISO/TS 16949 requirements. Buyers acknowledge and agree that, if they use any non-designated products in automotive applications, TI will not be responsible for any failure to meet such requirements.

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
Clocks and Timers	www.ti.com/clocks	Digital Control	www.ti.com/digitalcontrol
Interface	interface.ti.com	Medical	www.ti.com/medical
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
RFID	www.ti-rfid.com	Telephony	www.ti.com/telephony
RF/IF and ZigBee® Solutions	www.ti.com/lprf	Video & Imaging	www.ti.com/video
		Wireless	www.ti.com/wireless

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