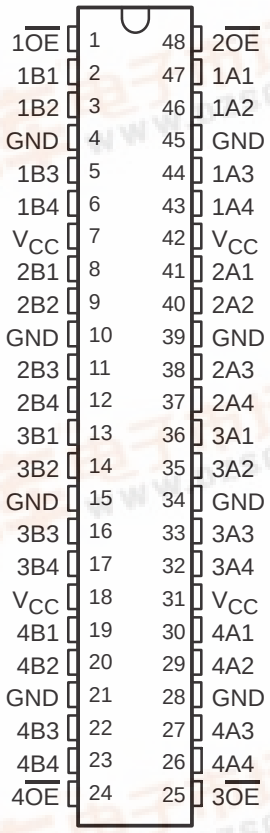
# 16-BIT FET BUS SWITCH
# 5-V BUS SWITCH WITH –2-V UNDERSHOOT PROTECTION

SCDS134A – SEPTEMBER 2003 – REVISED OCTOBER 2003

- Member of the Texas Instruments Widebus™ Family
- Undershoot Protection for Off-Isolation on A and B Ports Up To −2 V
- Bidirectional Data Flow, With Near-Zero Propagation Delay
- Low ON-State Resistance ($r_{on}$) Characteristics ($r_{on}$ = 3 Ω Typical)
- Low Input/Output Capacitance Minimizes Loading and Signal Distortion ($C_{io(OFF)}$ = 5.5 pF Typical)
- Data and Control Inputs Provide Undershoot Clamp Diodes
- Low Power Consumption ($I_{CC}$ = 3 μA Max)
- $V_{CC}$ Operating Range From 4 V to 5.5 V
- Data I/Os Support 0 to 5-V Signaling Levels (0.8-V, 1.2-V, 1.5-V, 1.8-V, 2.5-V, 3.3-V, 5-V)
- Control Inputs Can Be Driven by TTL or 5-V/3.3-V CMOS Outputs
- $I_{off}$ Supports Partial-Power-Down Mode Operation
- Latch-Up Performance Exceeds 100 mA Per JESD 78, Class II
- ESD Performance Tested Per JESD 22
  - 2000-V Human-Body Model (A114-B, Class II)
  - 1000-V Charged-Device Model (C101)
- Supports Both Digital and Analog Applications: PCI Interface, Memory Interleaving, Bus Isolation, Low-Distortion Signal Gating

DGG, DGV, OR DL PACKAGE
(TOP VIEW)




## description/ordering information

### ORDERING INFORMATION

| $T_A$ | PACKAGE† | | ORDERABLE PART NUMBER | TOP-SIDE MARKING |
|---|---|---|---|---|
| −40°C to 85°C | SSOP – DL | Tube | SN74CBT16244CDL | CBT16244C |
| | | Tape and reel | SN74CBT16244CDLR | |
| | TSSOP – DGG | Tube | SN74CBT16244CDGG | CBT16244C |
| | | Tape and reel | SN74CBT16244CDGGR | |
| | TVSOP – DGV | Tape and reel | SN74CBT16244CDGVR | CY244C |

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



Widebus is a trademark of Texas Instruments.

## description/ordering information (continued)

The SN74CBT16244C is a high-speed TTL-compatible FET bus switch with low ON-state resistance ($r_{on}$), allowing for minimal propagation delay. Active Undershoot-Protection Circuitry on the A and B ports of the SN74CBT16244C provides protection for undershoot up to −2 V by sensing an undershoot event and ensuring that the switch remains in the proper OFF state.

The SN74CBT16244C is organized as four 4-bit bus switches with separate output-enable ($1\overline{OE}$, $2\overline{OE}$, $3\overline{OE}$, $4\overline{OE}$) inputs. It can be used as four 4-bit bus switches, two 8-bit bus switches, or as one 16-bit bus switch. When $\overline{OE}$ is low, the associated 4-bit bus switch is ON, and the A port is connected to the B port, allowing bidirectional data flow between ports. When $\overline{OE}$ is high, the associated 4-bit bus switch is OFF, and the high-impedance state exists between the A and B ports.

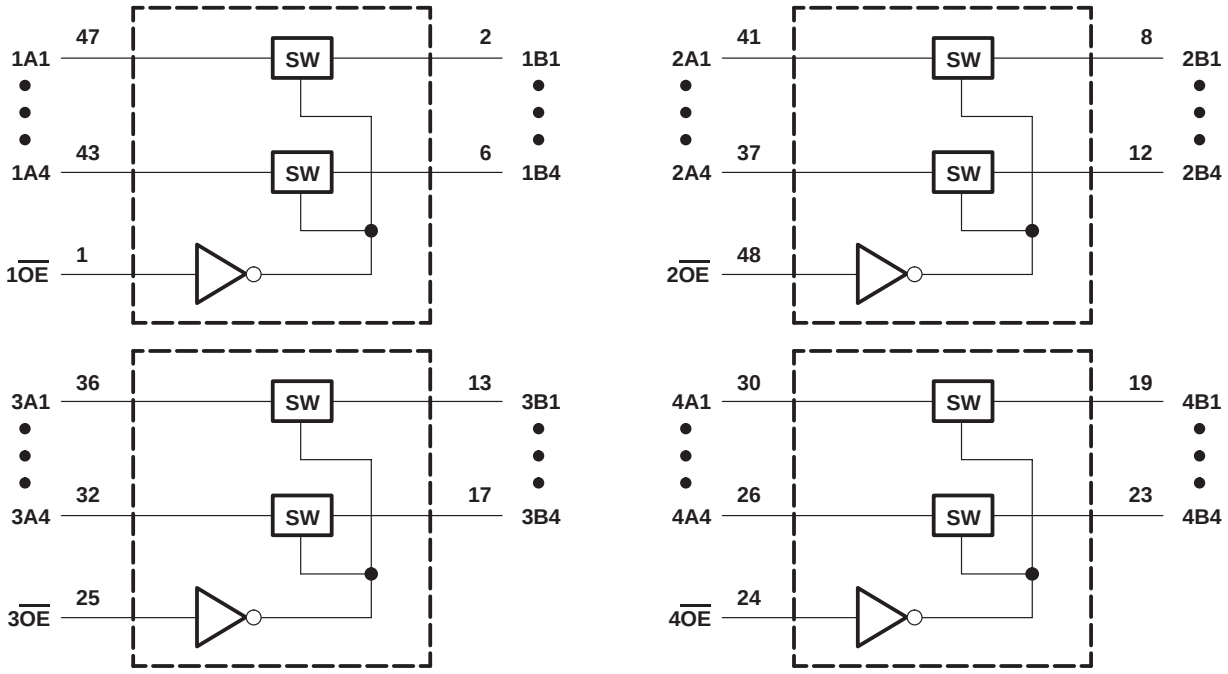
This device is fully specified for partial-power-down applications using $I_{off}$. The $I_{off}$ feature ensures that damaging current will not backflow through the device when it is powered down. The device has isolation during power off.

To ensure the high-impedance state during power up or power down, $\overline{OE}$ should be tied to $V_{CC}$ through a pullup resistor; the minimum value of the resistor is determined by the current-sinking capability of the driver.

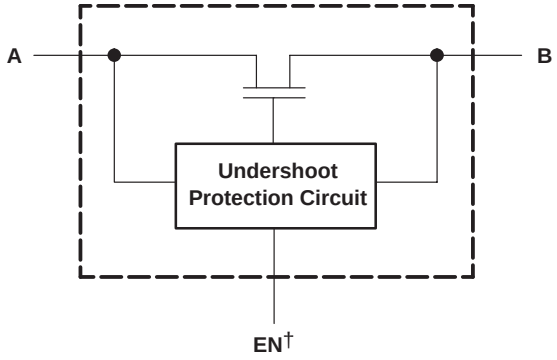
**FUNCTION TABLE**
**(each 4-bit bus switch)**

| INPUT $\overline{OE}$ | INPUT/OUTPUT A | FUNCTION |
|---|---|---|
| L | B | A port = B port |
| H | Z | Disconnect |

## logic diagram (positive logic)



### simplified schematic, each FET switch (SW)




† EN is the internal enable signal applied to the switch.

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

Supply voltage range, $V_{CC}$ . . . . . −0.5 V to 7 V
Control input voltage range, $V_{IN}$ (see Notes 1 and 2) . . . . . −0.5 V to 7 V
Switch I/O voltage range, $V_{I/O}$ (see Notes 1, 2, and 3) . . . . . −0.5 V to 7 V
Control input clamp current, $I_{IK}$ ($V_{IN}$ < 0) . . . . . −50 mA
I/O port clamp current, $I_{I/OK}$ ($V_{I/O}$ < 0) . . . . . −50 mA
ON-state switch current, $I_{I/O}$ (see Note 4) . . . . . ±128 mA
Continuous current through $V_{CC}$ or GND terminals . . . . . ±100 mA
Package thermal impedance, $\theta_{JA}$ (see Note 5): DGG package . . . . . 70°C/W
DGV package . . . . . 58°C/W
DL package . . . . . 63°C/W
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 voltages are with respect to ground unless otherwise specified.
2. The input and output voltage ratings may be exceeded if the input and output clamp-current ratings are observed.
3. $V_I$ and $V_O$ are used to denote specific conditions for $V_{I/O}$.
4. $I_I$ and $I_O$ are used to denote specific conditions for $I_{I/O}$.
5. The package thermal impedance is calculated in accordance with JESD 51-7.

### recommended operating conditions (see Note 6)

| | | MIN | MAX | UNIT |
|---|---|---|---|---|
| $V_{CC}$ | Supply voltage | 4 | 5.5 | V |
| $V_{IH}$ | High-level control input voltage | 2 | 5.5 | V |
| $V_{IL}$ | Low-level control input voltage | 0 | 0.8 | V |
| $V_{I/O}$ | Data input/output voltage | 0 | 5.5 | V |
| $T_A$ | Operating free-air temperature | −40 | 85 | °C |

NOTE 6: All unused control inputs of the device must be held at $V_{CC}$ or GND to ensure proper device operation. Refer to the TI application report, *Implications of Slow or Floating CMOS Inputs*, literature number SCBA004.

## electrical characteristics over recommended operating free-air temperature range (unless otherwise noted)

| PARAMETER | | TEST CONDITIONS | | | MIN | TYP† | MAX | UNIT |
|---|---|---|---|---|---|---|---|---|
| $V_{IK}$ | Control inputs | $V_{CC}$ = 4.5 V, | $I_{IN}$ = −18 mA | | | | −1.8 | V |
| $V_{IKU}$ | Data inputs | $V_{CC}$ = 5 V, | 0 mA > $I_I$ ≥ −50 mA, $V_{IN}$ = $V_{CC}$ or GND, | Switch OFF | | | −2 | V |
| $I_{IN}$ | Control inputs | $V_{CC}$ = 5.5 V, | $V_{IN}$ = $V_{CC}$ or GND | | | | ±1 | µA |
| $I_{OZ}$‡ | | $V_{CC}$ = 5.5 V, | $V_O$ = 0 to 5.5 V, $V_I$ = 0, | Switch OFF, $V_{IN}$ = $V_{CC}$ or GND | | | ±10 | µA |
| $I_{off}$ | | $V_{CC}$ = 0, | $V_O$ = 0 to 5.5 V, | $V_I$ = 0 | | | 10 | µA |
| $I_{CC}$ | | $V_{CC}$ = 5.5 V, | $I_{I/O}$ = 0, $V_{IN}$ = $V_{CC}$ or GND, | Switch ON or OFF | | | 3 | µA |
| $\Delta I_{CC}$§ | Control inputs | $V_{CC}$ = 5.5 V, | One input at 3.4 V, | Other inputs at $V_{CC}$ or GND | | | 2.5 | mA |
| $C_{in}$ | Control inputs | $V_{IN}$ = 3 V or 0 | | | | 3.5 | | pF |
| $C_{io(OFF)}$ | | $V_{I/O}$ = 3 V or 0, | Switch OFF, | $V_{IN}$ = $V_{CC}$ or GND | | 5.5 | | pF |
| $C_{io(ON)}$ | | $V_{I/O}$ = 3 V or 0, | Switch ON, | $V_{IN}$ = $V_{CC}$ or GND | | 14 | | pF |
| $r_{on}$¶ | | $V_{CC}$ = 4 V, TYP at $V_{CC}$ = 4 V | $V_I$ = 2.4 V, | $I_O$ = −15 mA | | 8 | 12 | Ω |
| | | $V_{CC}$ = 4.5 V | $V_I$ = 0 | $I_O$ = 64 mA | | 3 | 6 | Ω |
| | | | | $I_O$ = 30 mA | | 3 | 6 | Ω |
| | | | $V_I$ = 2.4 V, | $I_O$ = −15 mA | | 5 | 10 | Ω |

$V_{IN}$ and $I_{IN}$ refer to control inputs. $V_I$, $V_O$, $I_I$, and $I_O$ refer to data pins.
† All typical values are at $V_{CC}$ = 5 V (unless otherwise noted), $T_A$ = 25°C.
‡ For I/O ports, the parameter $I_{OZ}$ includes the input leakage current.
§ This is the increase in supply current for each input that is at the specified voltage level, rather than $V_{CC}$ or GND.
¶ Measured by the voltage drop between the A and B terminals at the indicated current through the switch. ON-state resistance is determined by the lower of the voltages of the two (A or B) terminals.

## switching characteristics over recommended operating free-air temperature range (unless otherwise noted) (see Figure 3)

| PARAMETER | FROM (INPUT) | TO (OUTPUT) | $V_{CC}$ = 4 V | | $V_{CC}$ = 5 V ± 0.5 V | | UNIT |
|---|---|---|---|---|---|---|---|
| | | | MIN | MAX | MIN | MAX | |
| $t_{pd}$# | A or B | B or A | | 0.24 | | 0.15 | ns |
| $t_{en}$ | $\overline{OE}$ | A or B | | 5.1 | 1.5 | 4.7 | ns |
| $t_{dis}$ | $\overline{OE}$ | A or B | | 5.2 | 1.5 | 5.4 | ns |

# The propagation delay is the calculated RC time constant of the typical ON-state resistance of the switch and the specified load capacitance, when driven by an ideal voltage source (zero output impedance).

## undershoot characteristics (see Figures 1 and 2)

| PARAMETER | TEST CONDITIONS | | | MIN | TYP† | MAX | UNIT |
|---|---|---|---|---|---|---|---|
| $V_{OUTU}$ | $V_{CC}$ = 5.5 V, | Switch OFF, | $V_{IN}$ = $V_{CC}$ or GND | 2 | $V_{OH}$−0.3 | | V |

† All typical values are at $V_{CC}$ = 5 V (unless otherwise noted), $T_A$ = 25°C.

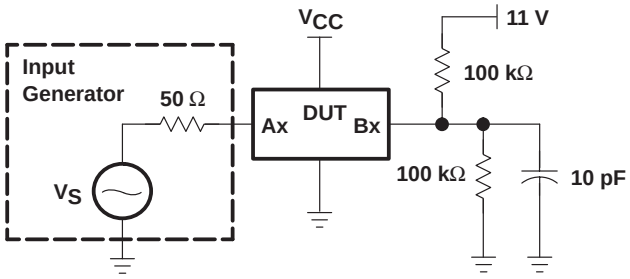



**Figure 1. Device Test Setup**

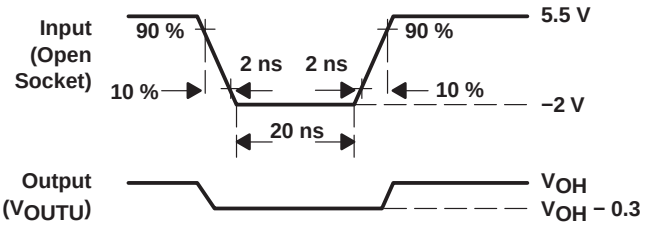
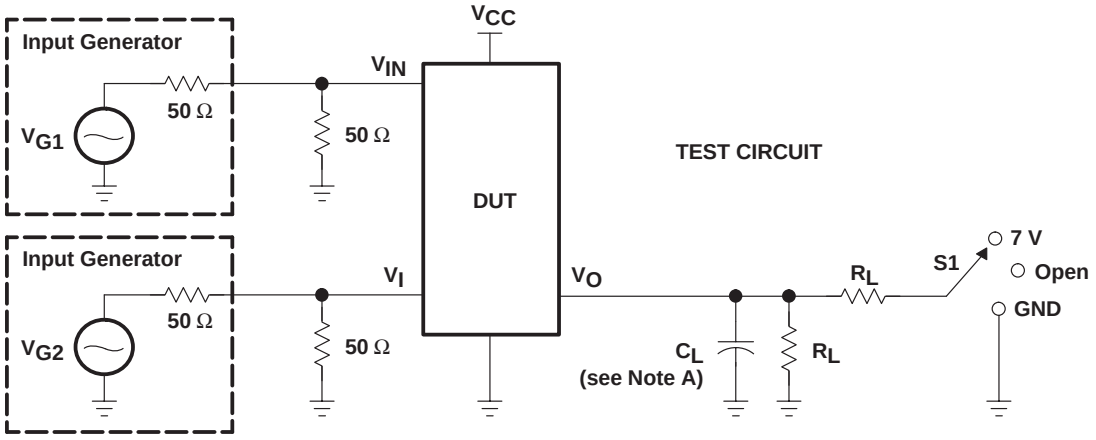
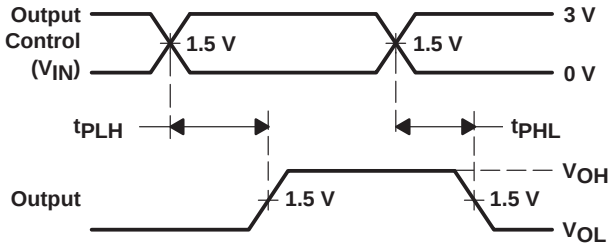



**Figure 2. Transient Input Voltage ($V_I$) and Output Voltage ($V_{OUTU}$) Waveforms (Switch OFF)**

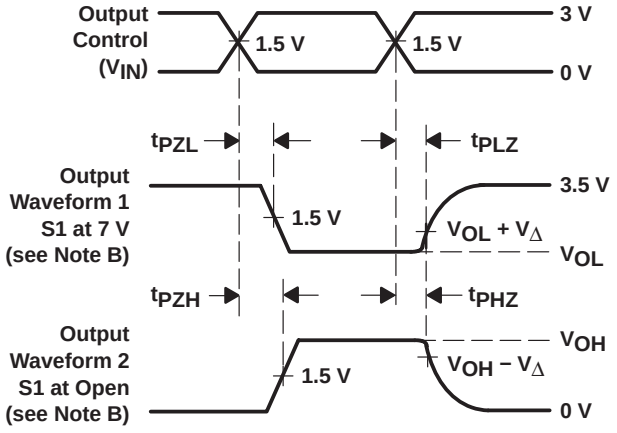
## PARAMETER MEASUREMENT INFORMATION




| TEST | $V_{CC}$ | S1 | $R_L$ | $V_I$ | $C_L$ | $V_\Delta$ |
|---|---|---|---|---|---|---|
| $t_{pd(s)}$ | 5 V ± 0.5 V<br>4 V | Open<br>Open | 500 Ω<br>500 Ω | $V_{CC}$ or GND<br>$V_{CC}$ or GND | 50 pF<br>50 pF | |
| $t_{PLZ}/t_{PZL}$ | 5 V ± 0.5 V<br>4 V | 7 V<br>7 V | 500 Ω<br>500 Ω | GND<br>GND | 50 pF<br>50 pF | 0.3 V<br>0.3 V |
| $t_{PHZ}/t_{PZH}$ | 5 V ± 0.5 V<br>4 V | Open<br>Open | 500 Ω<br>500 Ω | $V_{CC}$<br>$V_{CC}$ | 50 pF<br>50 pF | 0.3 V<br>0.3 V |




VOLTAGE WAVEFORMS
PROPAGATION DELAY TIMES ($t_{pd(s)}$)




VOLTAGE WAVEFORMS
ENABLE AND DISABLE TIMES

NOTES:
A. $C_L$ includes probe and jig capacitance.
B. Waveform 1 is for an output with internal conditions such that the output is low except when disabled by the output control. Waveform 2 is for an output with internal conditions such that the output is high except when disabled by the output control.
C. All input pulses are supplied by generators having the following characteristics: PRR ≤ 10 MHz, $Z_O$ = 50 Ω, $t_r$ ≤ 2.5 ns, $t_f$ ≤ 2.5 ns.
D. The outputs are measured one at a time with one transition per measurement.
E. $t_{PLZ}$ and $t_{PHZ}$ are the same as $t_{dis}$.
F. $t_{PZL}$ and $t_{PZH}$ are the same as $t_{en}$.
G. $t_{PLH}$ and $t_{PHL}$ are the same as $t_{pd(s)}$. The tpd propagation delay is the calculated RC time constant of the typical ON-state resistance of the switch and the specified load capacitance, when driven by an ideal voltage source (zero output impedance).
H. All parameters and waveforms are not applicable to all devices.

**Figure 3. Test Circuit and Voltage Waveforms**

## PACKAGING INFORMATION

| Orderable Device | Status (1) | Package Type | Package Drawing | Pins | Package Qty | Eco Plan (2) | Lead/Ball Finish | MSL Peak Temp (3) |
|---|---|---|---|---|---|---|---|---|
| 74CBT16244CDGGRE4 | ACTIVE | TSSOP | DGG | 48 | 2000 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-1-260C-UNLIM |
| 74CBT16244CDGGRG4 | ACTIVE | TSSOP | DGG | 48 | 2000 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-1-260C-UNLIM |
| 74CBT16244CDGVRE4 | ACTIVE | TVSOP | DGV | 48 | 2000 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-1-260C-UNLIM |
| 74CBT16244CDGVRG4 | ACTIVE | TVSOP | DGV | 48 | 2000 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-1-260C-UNLIM |
| SN74CBT16244CDGGR | ACTIVE | TSSOP | DGG | 48 | 2000 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-1-260C-UNLIM |
| SN74CBT16244CDGVR | ACTIVE | TVSOP | DGV | 48 | 2000 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-1-260C-UNLIM |
| SN74CBT16244CDL | ACTIVE | SSOP | DL | 48 | 25 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-1-260C-UNLIM |
| SN74CBT16244CDLG4 | ACTIVE | SSOP | DL | 48 | 25 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-1-260C-UNLIM |
| SN74CBT16244CDLR | ACTIVE | SSOP | DL | 48 | 1000 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-1-260C-UNLIM |
| SN74CBT16244CDLRG4 | ACTIVE | SSOP | DL | 48 | 1000 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-1-260C-UNLIM |

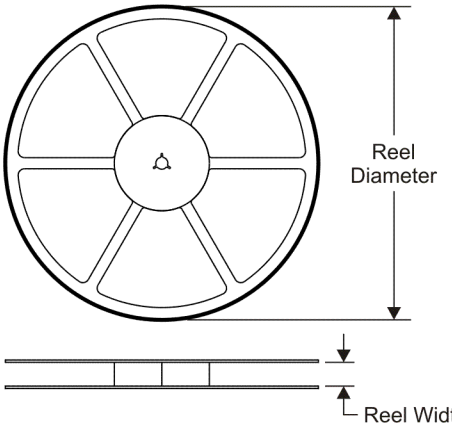
(1) The marketing status values are defined as follows:
**ACTIVE:** Product device recommended for new designs.
**LIFEBUY:** TI has announced that the device will be discontinued, and a lifetime-buy period is in effect.
**NRND:** Not recommended for new designs. Device is in production to support existing 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)

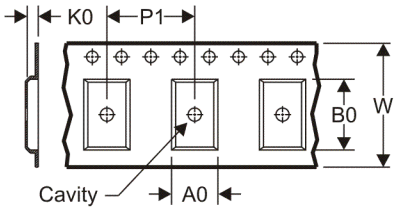
(3) MSL, Peak Temp. -- The Moisture Sensitivity Level rating according to the JEDEC industry standard classifications, and peak solder temperature.

## TAPE AND REEL INFORMATION

**REEL DIMENSIONS**

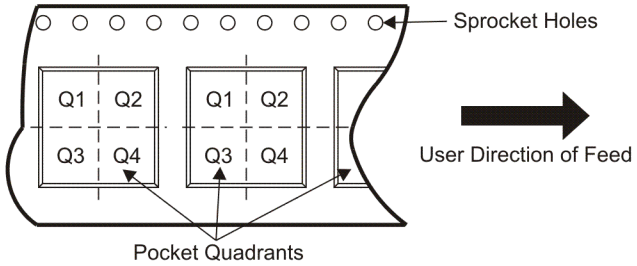



**TAPE DIMENSIONS**




| | |
|---|---|
| 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 |

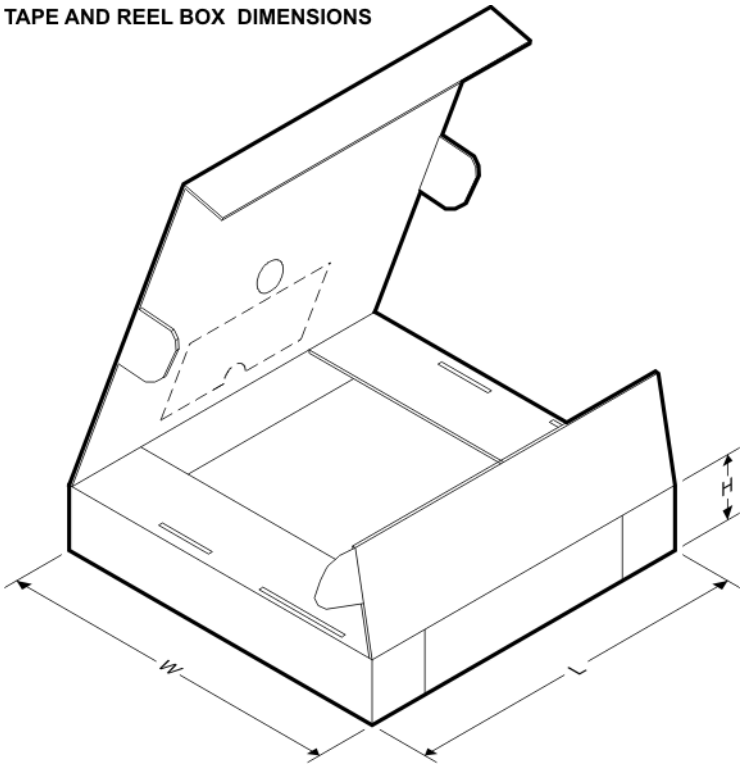
**QUADRANT ASSIGNMENTS FOR PIN 1 ORIENTATION IN TAPE**




*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 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| SN74CBT16244CDGGR | TSSOP | DGG | 48 | 2000 | 330.0 | 24.4 | 8.6 | 15.8 | 1.8 | 12.0 | 24.0 | Q1 |
| SN74CBT16244CDGVR | TVSOP | DGV | 48 | 2000 | 330.0 | 24.4 | 6.8 | 10.1 | 1.6 | 12.0 | 24.0 | Q1 |
| SN74CBT16244CDLR | SSOP | DL | 48 | 1000 | 330.0 | 32.4 | 11.35 | 16.2 | 3.1 | 16.0 | 32.0 | Q1 |

**TAPE AND REEL BOX DIMENSIONS**



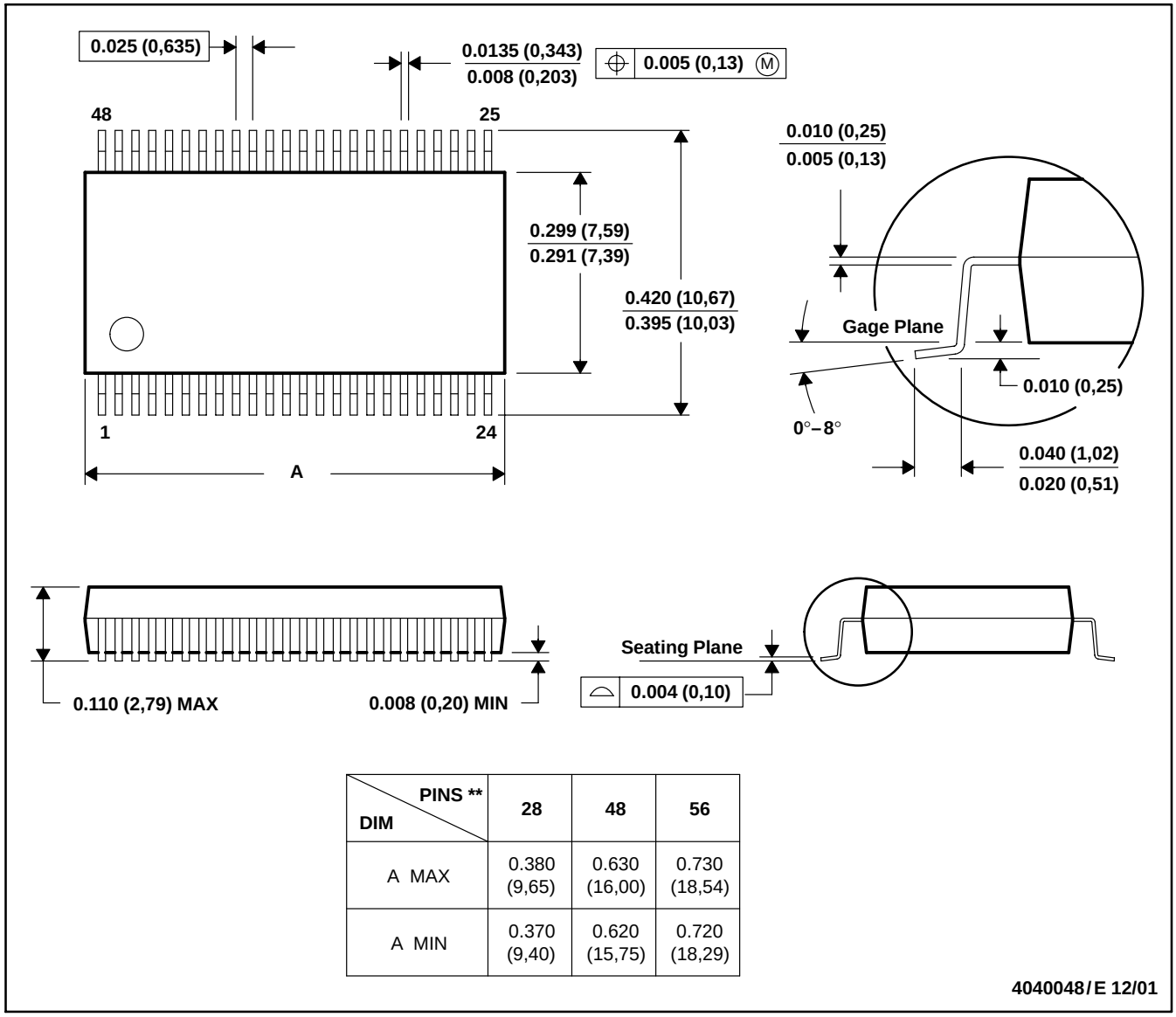

*All dimensions are nominal

| Device | Package Type | Package Drawing | Pins | SPQ | Length (mm) | Width (mm) | Height (mm) |
|---|---|---|---|---|---|---|---|
| SN74CBT16244CDGGR | TSSOP | DGG | 48 | 2000 | 346.0 | 346.0 | 41.0 |
| SN74CBT16244CDGVR | TVSOP | DGV | 48 | 2000 | 346.0 | 346.0 | 41.0 |
| SN74CBT16244CDLR | SSOP | DL | 48 | 1000 | 346.0 | 346.0 | 49.0 |

MSSO001C – JANUARY 1995 – REVISED DECEMBER 2001

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

**48 PINS SHOWN**




| DIM \ PINS ** | 28 | 48 | 56 |
|---|---|---|---|
| A MAX | 0.380 (9,65) | 0.630 (16,00) | 0.730 (18,54) |
| A MIN | 0.370 (9,40) | 0.620 (15,75) | 0.720 (18,29) |

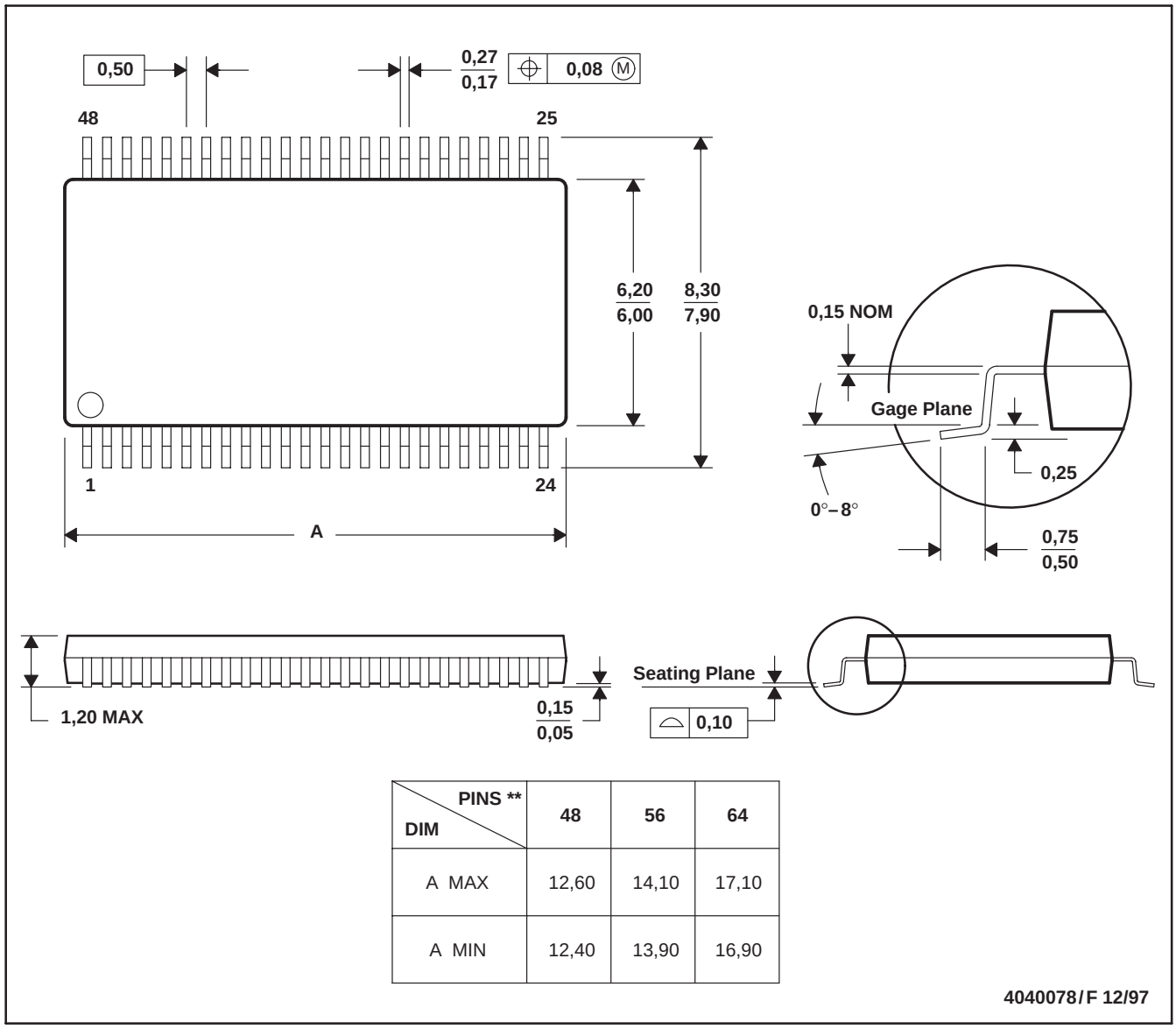
**4040048/E 12/01**

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 MO-118

MTSS003D – JANUARY 1995 – REVISED JANUARY 1998

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

**48 PINS SHOWN**




| DIM \ PINS ** | 48 | 56 | 64 |
|---|---|---|---|
| A MAX | 12,60 | 14,10 | 17,10 |
| A MIN | 12,40 | 13,90 | 16,90 |

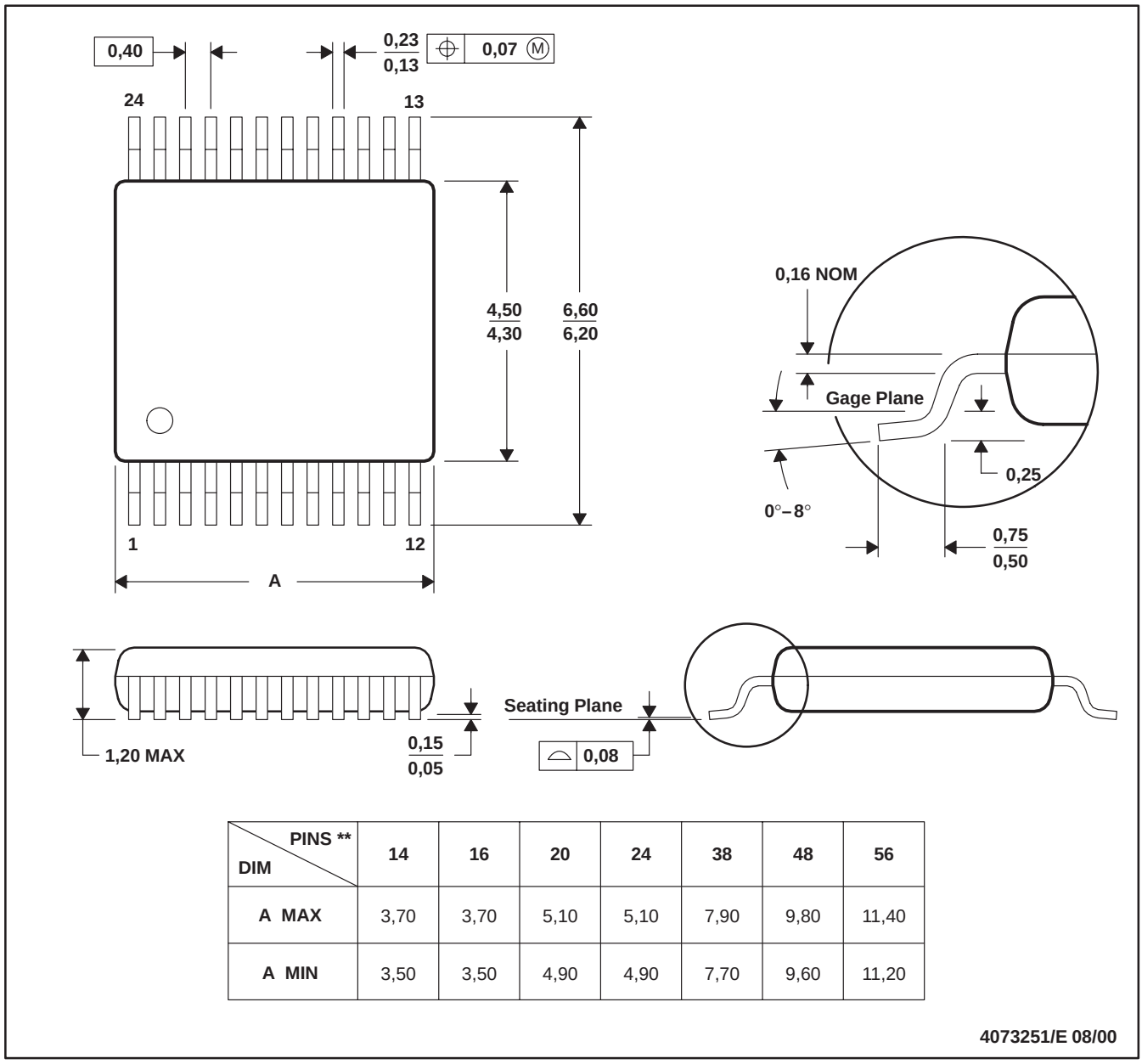
**4040078/F 12/97**

NOTES: A. All linear dimensions are in millimeters.
B. This drawing is subject to change without notice.
C. Body dimensions do not include mold protrusion not to exceed 0,15.
D. Falls within JEDEC MO-153

MPDS006C – FEBRUARY 1996 – REVISED AUGUST 2000

**DGV (R-PDSO-G**)** **PLASTIC SMALL-OUTLINE**

**24 PINS SHOWN**




| DIM \ PINS ** | 14 | 16 | 20 | 24 | 38 | 48 | 56 |
|---|---|---|---|---|---|---|---|
| A MAX | 3,70 | 3,70 | 5,10 | 5,10 | 7,90 | 9,80 | 11,40 |
| A MIN | 3,50 | 3,50 | 4,90 | 4,90 | 7,70 | 9,60 | 11,20 |

**4073251/E 08/00**

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 per side.
D. Falls within JEDEC: 24/48 Pins – MO-153
14/16/20/56 Pins – MO-194

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