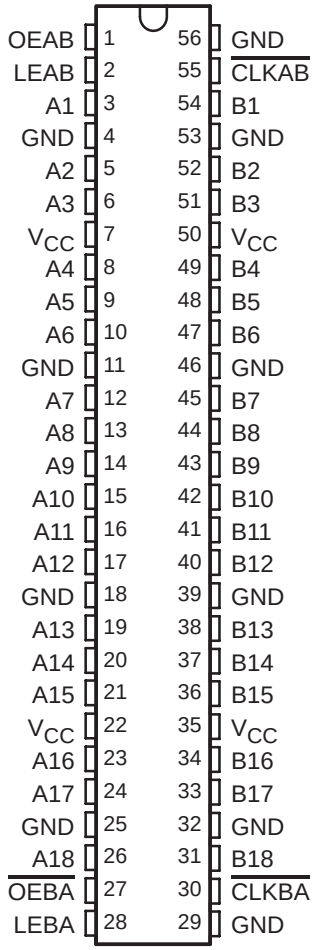
- **Controlled Baseline**
  - **One Assembly/Test Site, One Fabrication Site**
- **Enhanced Diminishing Manufacturing Sources (DMS) Support**
- **Enhanced Product-Change Notification**
- **Qualification Pedigree†**
- **Member of the Texas Instruments Widebus™ Family**
- **UBT™ Transceivers Combine D-Type Latches and D-Type Flip-Flops for Operation in Transparent, Latched, or Clocked Mode**
- **Supports Mixed-Mode Signal Operation (5-V Input and Output Voltages With 3.3-V $V_{CC}$)**
- **Supports Unregulated Battery Operation Down To 2.7 V**
- **Typical $V_{OLP}$ (Output Ground Bounce) <0.8 V at $V_{CC}$ = 3.3 V, $T_A$ = 25°C**
- **$I_{off}$ and Power-Up 3-State Support Hot Insertion**
- **Bus Hold on Data Inputs Eliminates the Need for External Pullup/Pulldown Resistors**
- **Distributed $V_{CC}$ and GND Pins Minimize High-Speed Switching Noise**
- **Flow-Through Architecture Optimizes PCB Layout**
- **Latch-Up Performance Exceeds 500 mA Per JESD 17**
- **ESD Protection Exceeds JESD 22**
  - **2000-V Human-Body Model (A114-A)**
  - **200-V Machine Model (A115-A)**
  - **1000-V Charged-Device Model (C101)**

† Component qualification in accordance with JEDEC and industry standards to ensure reliable operation over an extended temperature range. This includes, but is not limited to, Highly Accelerated Stress Test (HAST) or biased 85/85, temperature cycle, autoclave or unbiased HAST, electromigration, bond intermetallic life, and mold compound life. Such qualification testing should not be viewed as justifying use of this component beyond specified performance and environmental limits.

**DGG PACKAGE**
**(TOP VIEW)**




## description/ordering information

The SN74LVTH16500 is an 18-bit universal bus transceiver designed for low-voltage (3.3-V) $V_{CC}$ operation, but with the capability to provide a TTL interface to a 5-V system environment.

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.

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PRODUCTION DATA information is current as of publication date. Products conform to specifications per the terms of Texas Instruments standard warranty. Production processing does not necessarily include testing of all parameters.

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## description/ordering information (continued)

**ORDERING INFORMATION**

| $T_A$ | PACKAGE† | | ORDERABLE PART NUMBER | TOP-SIDE MARKING |
|---|---|---|---|---|
| −40°C to 85°C | TSSOP − DGG | Tape and reel | CLVTH16500IDGGREP | LH16500EP |

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

Data flow in each direction is controlled by output-enable (OEAB and $\overline{\text{OEBA}}$), latch-enable (LEAB and LEBA), and clock ($\overline{\text{CLKAB}}$ and $\overline{\text{CLKBA}}$) inputs. For A-to-B data flow, the device operates in the transparent mode when LEAB is high. When LEAB is low, the A data is latched if $\overline{\text{CLKAB}}$ is held at a high or low logic level. If LEAB is low, the A data is stored in the latch/flip-flop on the high-to-low transition of $\overline{\text{CLKAB}}$. OEAB is active high. When OEAB is high, the B-port outputs are active. When OEAB is low, the B-port outputs are in the high-impedance state.

Data flow for B to A is similar to that of A to B, but uses $\overline{\text{OEBA}}$, LEBA, and $\overline{\text{CLKBA}}$. The output enables are complementary (OEAB is active high and $\overline{\text{OEBA}}$ is active low).

Active bus-hold circuitry holds unused or undriven inputs at a valid logic state. Use of pullup or pulldown resistors with the bus-hold circuitry is not recommended.

When $V_{CC}$ is between 0 and 1.5 V, the device is in the high-impedance state during power up or power down. However, to ensure the high-impedance state above 1.5 V, $\overline{\text{OE}}$ should be tied to $V_{CC}$ through a pullup resistor and OE should be tied to GND through a pulldown resistor; the minimum value of the resistor is determined by the current-sinking/current-sourcing capability of the driver.

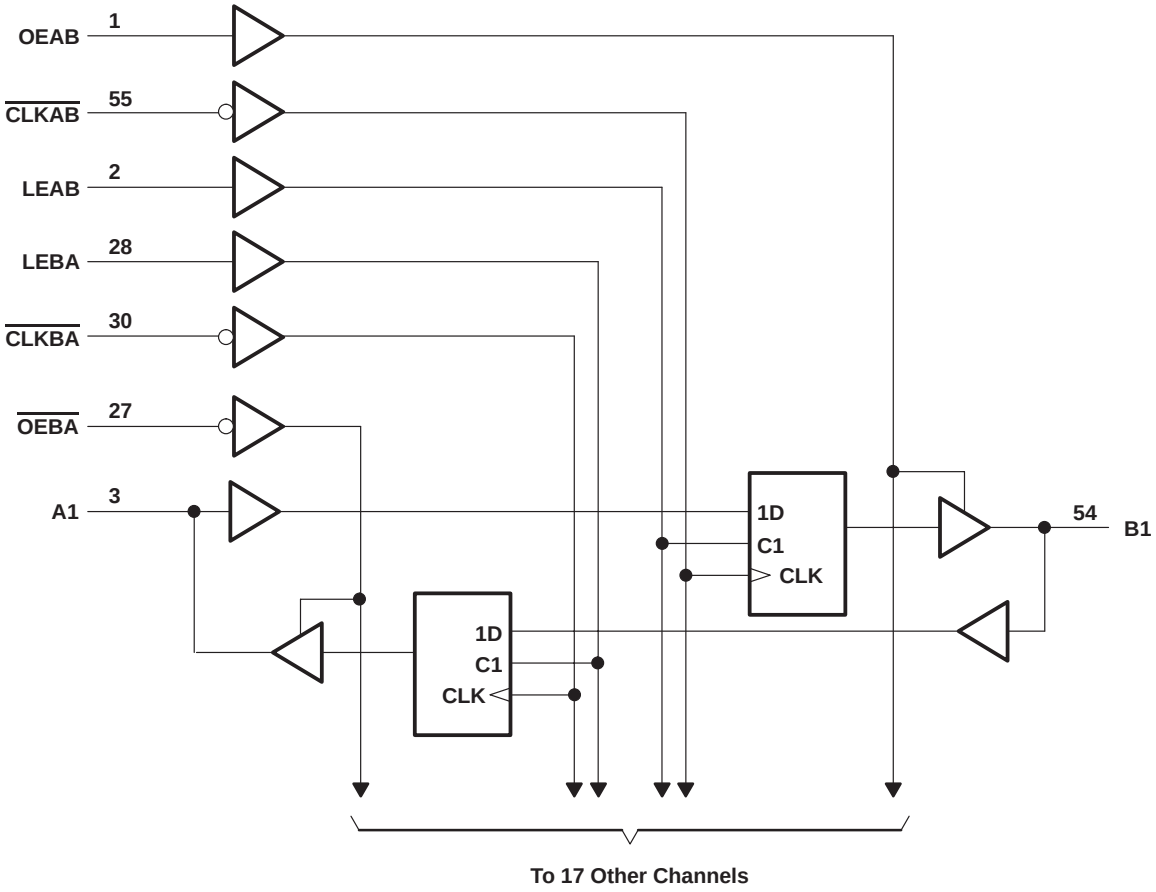
This device is fully specified for hot-insertion applications using $I_{off}$ and power-up 3-state. The $I_{off}$ circuitry disables the outputs, preventing damaging current backflow through the device when it is powered down. The power-up 3-state circuitry places the outputs in the high-impedance state during power up and power down, which prevents driver conflict.

**FUNCTION TABLE†**

| INPUTS | | | | OUTPUT |
|---|---|---|---|---|
| OEAB | LEAB | $\overline{\text{CLKAB}}$ | A | B |
| L | X | X | X | Z |
| H | H | X | L | L |
| H | H | X | H | H |
| H | L | ↓ | L | L |
| H | L | ↓ | H | H |
| H | L | H | X | $B_0$‡ |
| H | L | L | X | $B_0$§ |

† A-to-B data flow is shown: B-to-A flow is similar, but uses $\overline{\text{OEBA}}$, LEBA, and $\overline{\text{CLKBA}}$.
‡ Output level before the indicated steady-state input conditions were established
§ Output level before the indicated steady-state input conditions were established, provided that $\overline{\text{CLKAB}}$ was low before LEAB went low

## logic diagram (positive logic)




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

Supply voltage range, $V_{CC}$ . . . . . −0.5 V to 4.6 V
Input voltage range, $V_I$ (see Note 1) . . . . . −0.5 V to 7 V
Voltage range applied to any output in the high-impedance or power-off state, $V_O$ (see Note 1) . . . . . −0.5 V to 7 V
Voltage range applied to any output in the high state, $V_O$ (see Note 1) . . . . . −0.5 V to $V_{CC}$ + 0.5 V
Current into any output in the low state, $I_O$ . . . . . 128 mA
Current into any output in the high state, $I_O$ (see Note 2) . . . . . 64 mA
Input clamp current, $I_{IK}$ ($V_I$ < 0) . . . . . −50 mA
Output clamp current, $I_{OK}$ ($V_O$ < 0) . . . . . −50 mA
Package thermal impedance, $\theta_{JA}$ (see Note 3) . . . . . 64°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. The input and output negative-voltage ratings may be exceeded if the input and output clamp-current ratings are observed.
2. This current flows only when the output is in the high state and $V_O > V_{CC}$.
3. The package thermal impedance is calculated in accordance with JESD 51-7.

## recommended operating conditions (see Note 4)

| | | | MIN | MAX | UNIT |
|---|---|---|---|---|---|
| $V_{CC}$ | Supply voltage | | 2.7 | 3.6 | V |
| $V_{IH}$ | High-level input voltage | | 2 | | V |
| $V_{IL}$ | Low-level input voltage | | | 0.8 | V |
| $V_I$ | Input voltage | | | 5.5 | V |
| $I_{OH}$ | High-level output current | | | −32 | mA |
| $I_{OL}$ | Low-level output current | | | 64 | mA |
| $\Delta t/\Delta v$ | Input transition rise or fall rate | Outputs enabled | | 10 | ns/V |
| $\Delta t/\Delta V_{CC}$ | Power-up ramp rate | | 200 | | μs/V |
| $T_A$ | Operating free-air temperature | | −40 | 85 | °C |

NOTE 4: 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 |
|---|---|---|---|---|---|---|---|
| $V_{IK}$ | | $V_{CC}$ = 2.7 V, | $I_I$ = −18 mA | | | −1.2 | V |
| $V_{OH}$ | | $V_{CC}$ = 2.7 V to 3.6 V, | $I_{OH}$ = −100 μA | $V_{CC}$−0.2 | | | V |
| | | $V_{CC}$ = 2.7 V, | $I_{OH}$ = −8 mA | 2.4 | | | |
| | | $V_{CC}$ = 3 V, | $I_{OH}$ = −32 mA | 2 | | | |
| $V_{OL}$ | | $V_{CC}$ = 2.7 V | $I_{OL}$ = 100 μA | | | 0.2 | V |
| | | | $I_{OL}$ = 24 mA | | | 0.5 | |
| | | $V_{CC}$ = 3 V | $I_{OL}$ = 16 mA | | | 0.4 | |
| | | | $I_{OL}$ = 32 mA | | | 0.5 | |
| | | | $I_{OL}$ = 64 mA | | | 0.55 | |
| $I_I$ | Control inputs | $V_{CC}$ = 3.6 V, | $V_I$ = $V_{CC}$ or GND | | | ±1 | μA |
| | | $V_{CC}$ = 0 or 3.6 V, | $V_I$ = 5.5 V | | | 10 | |
| | A or B ports‡ | $V_{CC}$ = 3.6 V | $V_I$ = 5.5 V | | | 20 | |
| | | | $V_I$ = $V_{CC}$ | | | 1 | |
| | | | $V_I$ = 0 | | | −5 | |
| $I_{off}$ | | $V_{CC}$ = 0, | $V_I$ or $V_O$ = 0 to 4.5 V | | | ±100 | μA |
| $I_{I(hold)}$ | A or B ports | $V_{CC}$ = 3 V | $V_I$ = 0.8 V | 75 | | | μA |
| | | | $V_I$ = 2 V | −75 | | | |
| | | $V_{CC}$ = 3.6 V§, | $V_I$ = 0 to 3.6 V | | | ±500 | |
| $I_{OZPU}$ | | $V_{CC}$ = 0 to 1.5 V, $V_O$ = 0.5 V to 3 V, $\overline{OE}$/OE = don't care | | | | ±100 | μA |
| $I_{OZPD}$ | | $V_{CC}$ = 1.5 V to 0, $V_O$ = 0.5 V to 3 V, $\overline{OE}$/OE = don't care | | | | ±100 | μA |
| $I_{CC}$ | | $V_{CC}$ = 3.6 V, $I_O$ = 0, $V_I$ = $V_{CC}$ or GND | Outputs high | | | 0.19 | mA |
| | | | Outputs low | | | 5 | |
| | | | Outputs disabled | | | 0.19 | |
| $\Delta I_{CC}$¶ | | $V_{CC}$ = 3 V to 3.6 V, One input at $V_{CC}$ − 0.6 V, Other inputs at $V_{CC}$ or GND | | | | 0.2 | mA |
| $C_i$ | | $V_I$ = 3 V or 0 | | | 4 | | pF |
| $C_{io}$ | | $V_O$ = 3 V or 0 | | | 10 | | pF |

† All typical values are at $V_{CC}$ = 3.3 V, $T_A$ = 25°C.
‡ Unused pins at $V_{CC}$ or GND
§ This is the bus-hold maximum dynamic current. It is the minimum overdrive current required to switch the input from one state to another.
¶ This is the increase in supply current for each input that is at the specified TTL voltage level, rather than $V_{CC}$ or GND.

**timing requirements over recommended operating free-air temperature range (unless otherwise noted) (see Figure 1)**

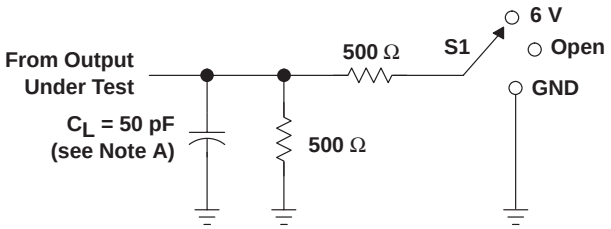
| | | | | $V_{CC}$ = 3.3 V ± 0.3 V | | $V_{CC}$ = 2.7 V | | UNIT |
|---|---|---|---|---|---|---|---|---|
| | | | | MIN | MAX | MIN | MAX | |
| $f_{clock}$ | Clock frequency | | | | 150 | | 150 | MHz |
| $t_w$ | Pulse duration | LE high | | 3.3 | | 3.3 | | ns |
| | | $\overline{CLK}$ high or low | | 3.3 | | 3.3 | | |
| $t_{su}$ | Setup time | A before $\overline{CLKAB}$↓ | | 2.9 | | 2.9 | | ns |
| | | B before $\overline{CLKBA}$↓ | | 2.9 | | 2.9 | | |
| | | A or B before LE↓ | $\overline{CLK}$ high | 1.4 | | 0.5 | | |
| | | | $\overline{CLK}$ low | 2.9 | | 2.3 | | |
| $t_h$ | Hold time | A or B after $\overline{CLK}$↓ | | 0.4 | | 0.4 | | ns |
| | | A or B after LE↓ | | 1.6 | | 1.6 | | |

**switching characteristics over recommended operating free-air temperature range, $C_L$ = 50 pF (unless otherwise noted) (see Figure 1)**

| PARAMETER | FROM (INPUT) | TO (OUTPUT) | $V_{CC}$ = 3.3 V ± 0.3 V | | | $V_{CC}$ = 2.7 V | | UNIT |
|---|---|---|---|---|---|---|---|---|
| | | | MIN | TYP† | MAX | MIN | MAX | |
| $f_{max}$ | | | 150 | | | 150 | | MHz |
| $t_{PLH}$ | B or A | A or B | 1.3 | 2.8 | 3.7 | | 4 | ns |
| $t_{PHL}$ | | | 1.3 | 2.6 | 3.7 | | 4 | |
| $t_{PLH}$ | LEBA or LEAB | A or B | 1.5 | 3.8 | 5.1 | | 5.7 | ns |
| $t_{PHL}$ | | | 1.5 | 3.8 | 5.1 | | 5.7 | |
| $t_{PLH}$ | $\overline{CLKBA}$ or $\overline{CLKAB}$ | A or B | 1.3 | 3.6 | 5 | | 5.9 | ns |
| $t_{PHL}$ | | | 1.3 | 3.5 | 5 | | 5.9 | |
| $t_{PZH}$ | $\overline{OEBA}$ or OEAB | A or B | 1.3 | 3.6 | 4.8 | | 5.5 | ns |
| $t_{PZL}$ | | | 1.3 | 3.6 | 4.8 | | 5.5 | |
| $t_{PHZ}$ | $\overline{OEBA}$ or OEAB | A or B | 1.7 | 4.5 | 5.8 | | 6.3 | ns |
| $t_{PLZ}$ | | | 1.7 | 4.1 | 5.8 | | 6.3 | |

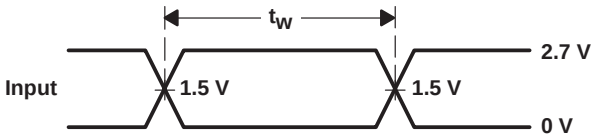
† All typical values are at $V_{CC}$ = 3.3 V, $T_A$ = 25°C.

## PARAMETER MEASUREMENT INFORMATION

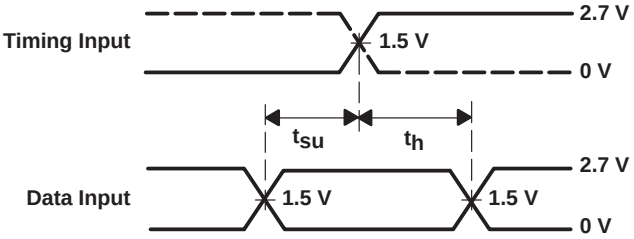



| TEST | S1 |
|---|---|
| $t_{PHL}/t_{PLH}$ | Open |
| $t_{PLZ}/t_{PZL}$ | 6 V |
| $t_{PHZ}/t_{PZH}$ | GND |

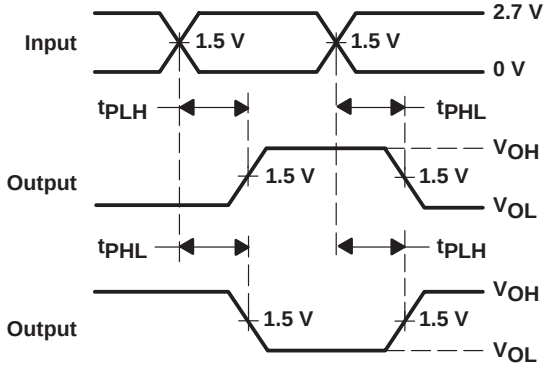
LOAD CIRCUIT



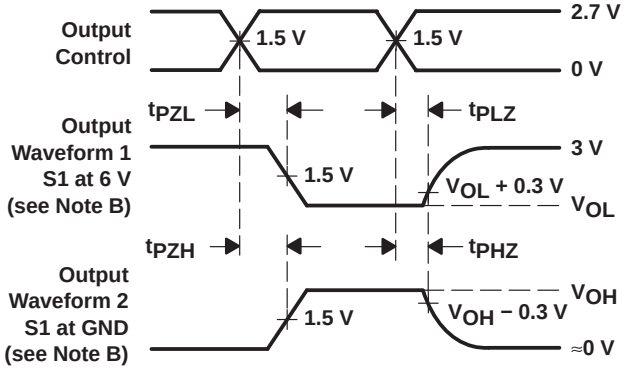

VOLTAGE WAVEFORMS
PULSE DURATION




VOLTAGE WAVEFORMS
SETUP AND HOLD TIMES




VOLTAGE WAVEFORMS
PROPAGATION DELAY TIMES
INVERTING AND NONINVERTING OUTPUTS




VOLTAGE WAVEFORMS
ENABLE AND DISABLE TIMES
LOW- AND HIGH-LEVEL ENABLING

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.

**Figure 1. Load 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) |
|---|---|---|---|---|---|---|---|---|
| CLVTH16500IDGGREP | ACTIVE | TSSOP | DGG | 56 | 2000 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-1-260C-UNLIM |
| V62/04713-01XE | ACTIVE | TSSOP | DGG | 56 | 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.

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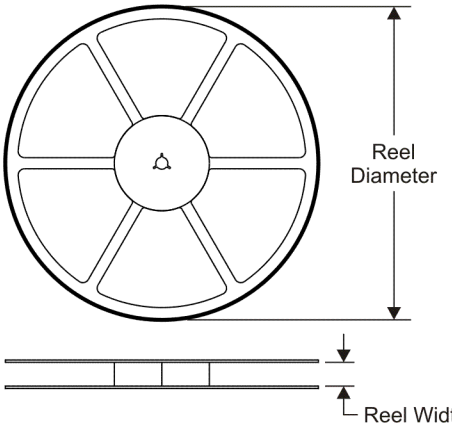
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**OTHER QUALIFIED VERSIONS OF SN74LVTH16500-EP :**
- Catalog: SN74LVTH16500

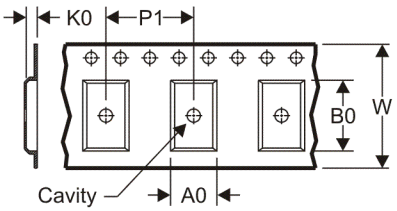
NOTE: Qualified Version Definitions:
- Catalog - TI's standard catalog product

## TAPE AND REEL INFORMATION

**REEL DIMENSIONS**

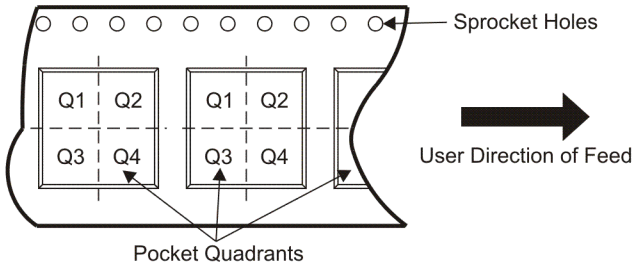



**TAPE DIMENSIONS**




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

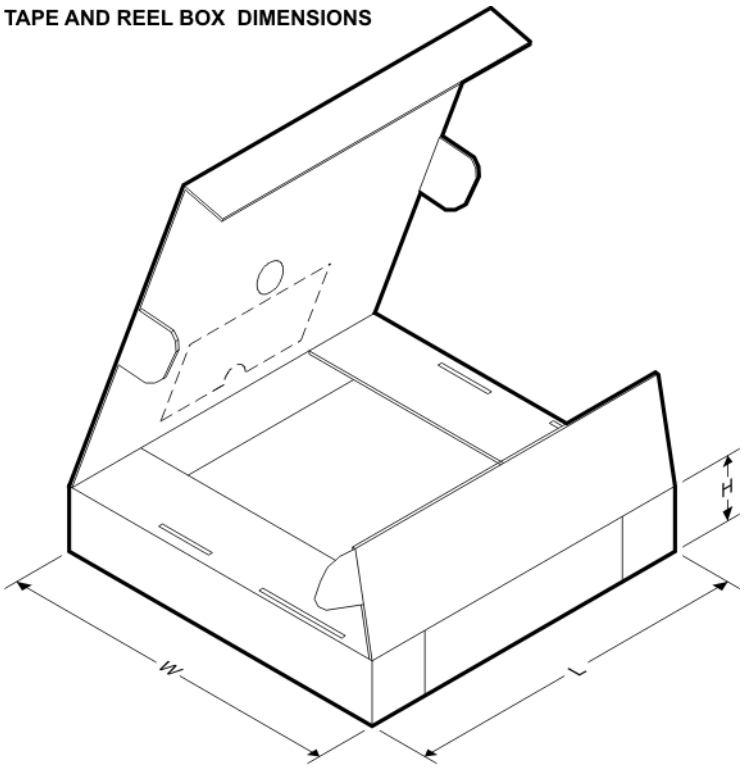
**QUADRANT ASSIGNMENTS FOR PIN 1 ORIENTATION IN TAPE**




*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 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CLVTH16500IDGGREP | TSSOP | DGG | 56 | 2000 | 330.0 | 24.4 | 8.6 | 15.6 | 1.8 | 12.0 | 24.0 | Q1 |

**TAPE AND REEL BOX DIMENSIONS**




*All dimensions are nominal

| Device | Package Type | Package Drawing | Pins | SPQ | Length (mm) | Width (mm) | Height (mm) |
|---|---|---|---|---|---|---|---|
| CLVTH16500IDGGREP | TSSOP | DGG | 56 | 2000 | 346.0 | 346.0 | 41.0 |

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