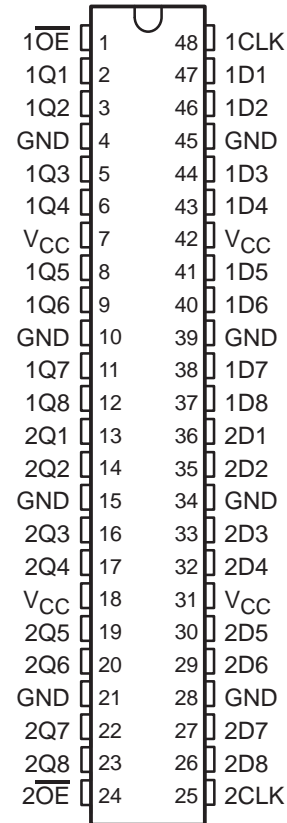


# SN54LVTH162374, SN74LVTH162374 3.3-V ABT 16-BIT EDGE-TRIGGERED D-TYPE FLIP-FLOPS WITH 3-STATE OUTPUTS

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- **Members of the Texas Instruments Widebus™ Family**
- **State-of-the-Art Advanced BiCMOS Technology (ABT) Design for 3.3-V Operation and Low Static-Power Dissipation**
- **Output Ports Have Equivalent 22-Ω Series Resistors, So No External Resistors Are Required**
- **Support Mixed-Mode Signal Operation (5-V Input and Output Voltages With 3.3-V V<sub>CC</sub>)**
- **Support Unregulated Battery Operation Down to 2.7 V**
- **Typical V<sub>OLP</sub> (Output Ground Bounce) < 0.8 V at V<sub>CC</sub> = 3.3 V, T<sub>A</sub> = 25°C**
- **I<sub>off</sub> and Power-Up 3-State Support Hot Insertion**
- **Bus Hold on Data Inputs Eliminates the Need for External Pullup/Pulldown Resistors**
- **Distributed V<sub>CC</sub> and GND Pin Configuration Minimizes High-Speed Switching Noise**
- **Flow-Through Architecture Optimizes PCB Layout**
- **Latch-Up Performance Exceeds 500 mA Per JESD 17**
- **ESD Protection Exceeds 2000 V Per MIL-STD-883, Method 3015; Exceeds 200 V Using Machine Model (C = 200 pF, R = 0)**
- **Package Options Include Plastic Shrink Small-Outline (DL) and Thin Shrink Small-Outline (DGG) Packages and 380-mil Fine-Pitch Ceramic Flat (WD) Package Using 25-mil Center-to-Center Spacings**

SN54LVTH162374 . . . WD PACKAGE  
SN74LVTH162374 . . . DGG OR DL PACKAGE  
(TOP VIEW)



## description

The 'LVTH162374 devices are 16-bit edge-triggered D-type flip-flops with 3-state outputs designed for low-voltage (3.3-V) V<sub>CC</sub> operation, but with the capability to provide a TTL interface to a 5-V system environment. They are particularly suitable for implementing buffer registers, I/O ports, bidirectional bus drivers, and working registers.

These devices can be used as two 8-bit flip-flops or one 16-bit flip-flop. On the positive transition of the clock (CLK), the Q outputs of the flip-flop take on the logic levels set up at the D inputs.



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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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On products compliant to MIL-PRF-38535, all parameters are tested unless otherwise noted. On all other products, production processing does not necessarily include testing of all parameters.

# SN54LVTH162374, SN74LVTH162374

## 3.3-V ABT 16-BIT EDGE-TRIGGERED D-TYPE FLIP-FLOPS

### WITH 3-STATE OUTPUTS

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#### description (continued)

A buffered output-enable ( $\overline{OE}$ ) input can be used to place the eight outputs in either a normal logic state (high or low logic levels) or a high-impedance state. In the high-impedance state, the outputs neither load nor drive the bus lines significantly. The high-impedance state and the increased drive provide the capability to drive bus lines without need for interface or pullup components.

$\overline{OE}$  does not affect internal operations of the flip-flop. Old data can be retained or new data can be entered while the outputs are in the high-impedance state.

The outputs, which are designed to source or sink up to 12 mA, include equivalent 22- $\Omega$  series resistors to reduce overshoot and undershoot.

Active bus-hold circuitry is provided to hold unused or floating data inputs at a valid logic level.

When  $V_{CC}$  is between 0 and 1.5 V, the devices are in the high-impedance state during power up or power down. However, to ensure the high-impedance state above 1.5 V,  $\overline{OE}$  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.

These devices are 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 devices when they are 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.

The SN54LVTH162374 is characterized for operation over the full military temperature range of  $-55^{\circ}\text{C}$  to  $125^{\circ}\text{C}$ . The SN74LVTH162374 is characterized for operation from  $-40^{\circ}\text{C}$  to  $85^{\circ}\text{C}$ .

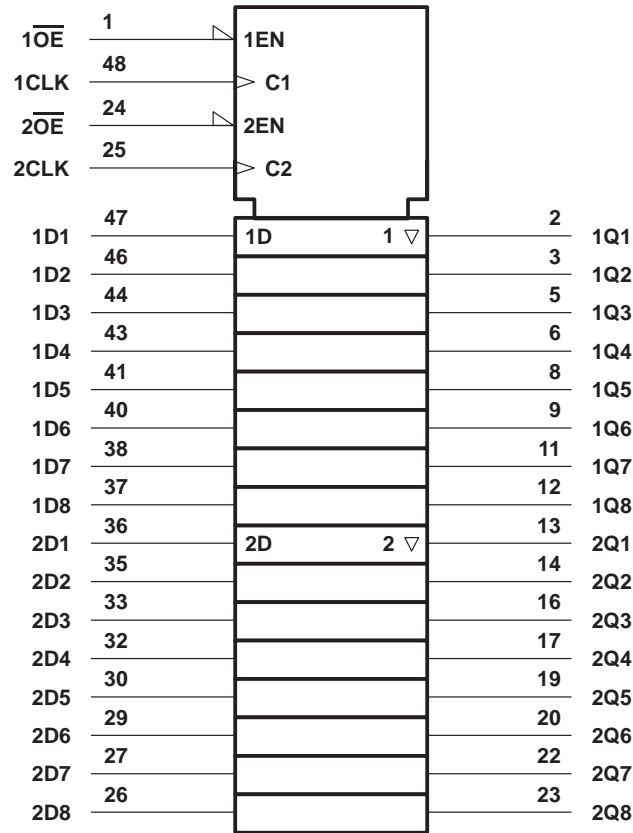
FUNCTION TABLE  
(each flip-flop)

| INPUTS          |            |   | OUTPUT |
|-----------------|------------|---|--------|
| $\overline{OE}$ | CLK        | D | Q      |
| L               | $\uparrow$ | H | H      |
| L               | $\uparrow$ | L | L      |
| L               | H or L     | X | $Q_0$  |
| H               | X          | X | Z      |

# SN54LVTH162374, SN74LVTH162374 3.3-V ABT 16-BIT EDGE-TRIGGERED D-TYPE FLIP-FLOPS WITH 3-STATE OUTPUTS

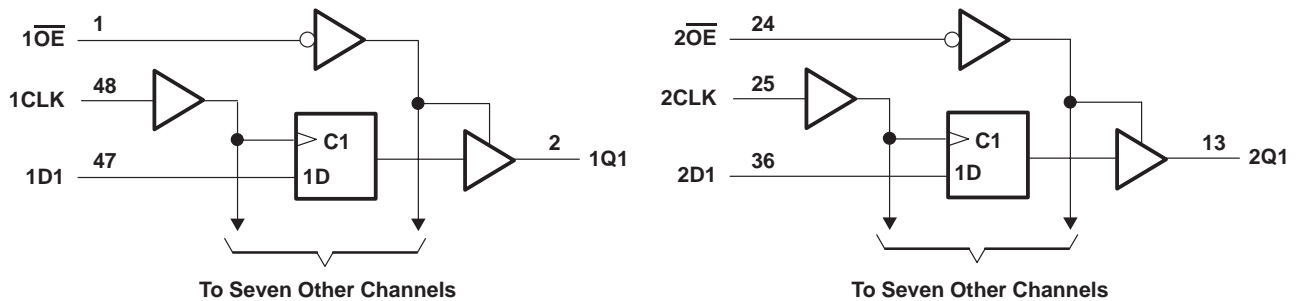
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## logic symbol†



† This symbol is in accordance with ANSI/IEEE Std 91-1984 and IEC Publication 617-12.

## logic diagram (positive logic)



**SN54LVTH162374, SN74LVTH162374**  
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**WITH 3-STATE OUTPUTS**

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**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, $I_O$ .....  | 30 mA                      |
| Current into any output in the high state, $I_O$ (see Note 2) .....                                    | 30 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): DGG package .....                               | 89°C/W                     |
| DL package .....   | 94°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.

**recommended operating conditions (see Note 4)**

|                          |                                    | SN54LVTH162374  |     | SN74LVTH162374 |     | UNIT      |
|--------------------------|------------------------------------|-----------------|-----|----------------|-----|-----------|
|                          |                                    | MIN             | MAX | MIN            | MAX |           |
| $V_{CC}$                 | Supply voltage                     | 2.7             | 3.6 | 2.7            | 3.6 | V         |
| $V_{IH}$                 | High-level input voltage           | 2               |     | 2              |     | V         |
| $V_{IL}$                 | Low-level input voltage            |                 | 0.8 |                | 0.8 | V         |
| $V_I$                    | Input voltage                      |                 | 5.5 |                | 5.5 | V         |
| $I_{OH}$                 | High-level output current          |                 | -12 |                | -12 | mA        |
| $I_{OL}$                 | Low-level output current           |                 | 12  |                | 12  | mA        |
| $\Delta t/\Delta v$      | Input transition rise or fall rate | Outputs enabled |     | 10             | 10  | ns/V      |
| $\Delta t/\Delta V_{CC}$ | Power-up ramp rate                 | 200             |     | 200            |     | $\mu$ s/V |
| $T_A$                    | Operating free-air temperature     | -55             | 125 | -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.



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

| PARAMETER          |                | TEST CONDITIONS  |  | SN54LVTH162374 |      | SN74LVTH162374 |             | UNIT          |
|--------------------|----------------|--|--|----------------|------|----------------|-------------|---------------|
|                    |                |  |  | MIN            | TYP† | MAX            | MIN         |               |
| $V_{IK}$           |                | $V_{CC} = 2.7\text{ V}$ ,  | $I_I = -18\text{ mA}$                          |                |      | -1.2           | -1.2        | V             |
| $V_{OH}$           |                | $V_{CC} = 3\text{ V}$ ,  | $I_{OH} = -12\text{ mA}$                       | 2              |      | 2              |             | V             |
| $V_{OL}$           |                | $V_{CC} = 3\text{ V}$ ,  | $I_{OL} = 12\text{ mA}$                        |                |      | 0.8            | 0.8         | V             |
| $I_I$              |                | $V_{CC} = 0\text{ or }3.6\text{ V}$ ,  | $V_I = 5.5\text{ V}$                           |                |      | 10             | 10          | $\mu\text{A}$ |
|                    | Control inputs | $V_{CC} = 3.6\text{ V}$ ,  | $V_I = V_{CC}\text{ or GND}$                   |                |      | $\pm 1$        | $\pm 1$     |               |
|                    | Data inputs    | $V_{CC} = 3.6\text{ V}$  | $V_I = V_{CC}$<br>$V_I = 0$                    |                |      | 1<br>-5        | 1<br>-5     |               |
| $I_{off}$          |                | $V_{CC} = 0$ ,   | $V_I\text{ or }V_O = 0\text{ to }4.5\text{ V}$ |                |      |                | $\pm 100$   | $\mu\text{A}$ |
| $I_I(\text{hold})$ | Data inputs    | $V_{CC} = 3\text{ V}$  | $V_I = 0.8\text{ V}$                           | 75             |      | 75             |             | $\mu\text{A}$ |
|                    |                |  | $V_I = 2\text{ V}$                             | -75            |      | -75            |             |               |
|                    |                | $V_{CC} = 3.6\text{ V}^\ddagger$ ,   | $V_I = 0\text{ to }3.6\text{ V}$               |                |      |                | 500<br>-750 |               |
| $I_{OZH}$          |                | $V_{CC} = 3.6\text{ V}$ ,  | $V_O = 3\text{ V}$                             |                |      | 5              | 5           | $\mu\text{A}$ |
| $I_{OZL}$          |                | $V_{CC} = 3.6\text{ V}$ ,  | $V_O = 0.5\text{ V}$                           |                |      | -5             | -5          | $\mu\text{A}$ |
| $I_{OZPU}$         |                | $V_{CC} = 0\text{ to }1.5\text{ V}$ , $V_O = 0.5\text{ V to }3\text{ V}$ ,<br>$OE = \text{don't care}$                   |  |                |      | $\pm 100^*$    | $\pm 100$   | $\mu\text{A}$ |
| $I_{OZPD}$         |                | $V_{CC} = 1.5\text{ V to }0$ , $V_O = 0.5\text{ V to }3\text{ V}$ ,<br>$OE = \text{don't care}$                          |  |                |      | $\pm 100^*$    | $\pm 100$   | $\mu\text{A}$ |
| $I_{CC}$           |                | $V_{CC} = 3.6\text{ V}$ , $I_O = 0$ ,<br>$V_I = V_{CC}\text{ or GND}$  | Outputs high                                   |                |      | 0.19           | 0.19        | mA            |
|                    |                |  | Outputs low                                    |                |      | 5              | 5           |               |
|                    |                |  | Outputs disabled                               |                |      | 0.19           | 0.19        |               |
| $\Delta I_{CC}^\S$ |                | $V_{CC} = 3\text{ V to }3.6\text{ V}$ , One input at $V_{CC} - 0.6\text{ V}$ ,<br>Other inputs at $V_{CC}\text{ or GND}$ |  |                |      | 0.2            | 0.2         | mA            |
| $C_i$              |                | $V_I = 3\text{ V or }0$  |  |                |      | 3              | 3           | pF            |
| $C_o$              |                | $V_O = 3\text{ V or }0$  |  |                |      | 9              | 9           | pF            |

\* On products compliant to MIL-PRF-38535, this parameter is not production tested.

† All typical values are at  $V_{CC} = 3.3\text{ V}$ ,  $T_A = 25^\circ\text{C}$ .

‡ 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)**

|                    |  | SN54LVTH162374                                |     |                         |     | SN74LVTH162374                                |     |                         |     | UNIT |
|--------------------|--|---|-----|-------------------------|-----|---|-----|-------------------------|-----|------|
|                    |  | $V_{CC} = 3.3\text{ V}$<br>$\pm 0.3\text{ V}$ |     | $V_{CC} = 2.7\text{ V}$ |     | $V_{CC} = 3.3\text{ V}$<br>$\pm 0.3\text{ V}$ |     | $V_{CC} = 2.7\text{ V}$ |     |      |
|                    |  | MIN   | MAX | MIN                     | MAX | MIN   | MAX | MIN                     | MAX |      |
| $f_{\text{clock}}$ | Clock frequency                        |   | 160 |                         | 160 |   | 160 |                         | 160 | MHz  |
| $t_w$              | Pulse duration, CLK high or low        |   | 3   |                         | 3.3 |   | 3   |                         | 3   | ns   |
| $t_{su}$           | Setup time, data before CLK $\uparrow$ |   | 2.8 | High or low             | 3.2 |   | 1.8 | High or low             | 2   | ns   |
| $t_h$              | Hold time, data after CLK $\uparrow$   |   | 1.2 | High or low             | 0.5 |   | 0.8 | High or low             | 0.1 | ns   |



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

| PARAMETER   | FROM (INPUT)    | TO (OUTPUT) | SN54LVTH162374                           |     |                         |     | SN74LVTH162374                           |      |     |                         | UNIT |     |
|-------------|-----------------|-------------|--|-----|-------------------------|-----|--|------|-----|-------------------------|------|-----|
|             |                 |             | $V_{CC} = 3.3\text{ V} \pm 0.3\text{ V}$ |     | $V_{CC} = 2.7\text{ V}$ |     | $V_{CC} = 3.3\text{ V} \pm 0.3\text{ V}$ |      |     | $V_{CC} = 2.7\text{ V}$ |      |     |
|             |                 |             | MIN                                      | MAX | MIN                     | MAX | MIN                                      | TYP† | MAX | MIN                     |      | MAX |
| $f_{max}$   |                 |             | 160                                      |     | 160                     |     | 160                                      |      |     | 160                     |      | MHz |
| $t_{PLH}$   | CLK             | Q           | 1.4                                      | 6.6 | 7.4                     |     | 2  | 3.4  | 5.3 | 6.2                     |      | ns  |
| $t_{PHL}$   |                 |             | 1.4                                      | 5.8 | 6                       |     | 2.2                                      | 3.3  | 4.9 | 5.1                     |      |     |
| $t_{PZH}$   | $\overline{OE}$ | Q           | 1  | 6.6 | 7.4                     |     | 1.8                                      | 3.5  | 5.6 | 6.9                     |      | ns  |
| $t_{PZL}$   |                 |             | 1.4                                      | 6   | 6.8                     |     | 1.8                                      | 3.5  | 4.9 | 6                       |      |     |
| $t_{PHZ}$   | $\overline{OE}$ | Q           | 1  | 6.6 | 7.4                     |     | 2.4                                      | 4.2  | 5.4 | 5.7                     |      | ns  |
| $t_{PLZ}$   |                 |             | 1.4                                      | 6   | 6                       |     | 2  | 3.8  | 5   | 5.1                     |      |     |
| $t_{sk(o)}$ |                 |             |  |     |                         |     |  | 0.5  |     |                         | ns   |     |

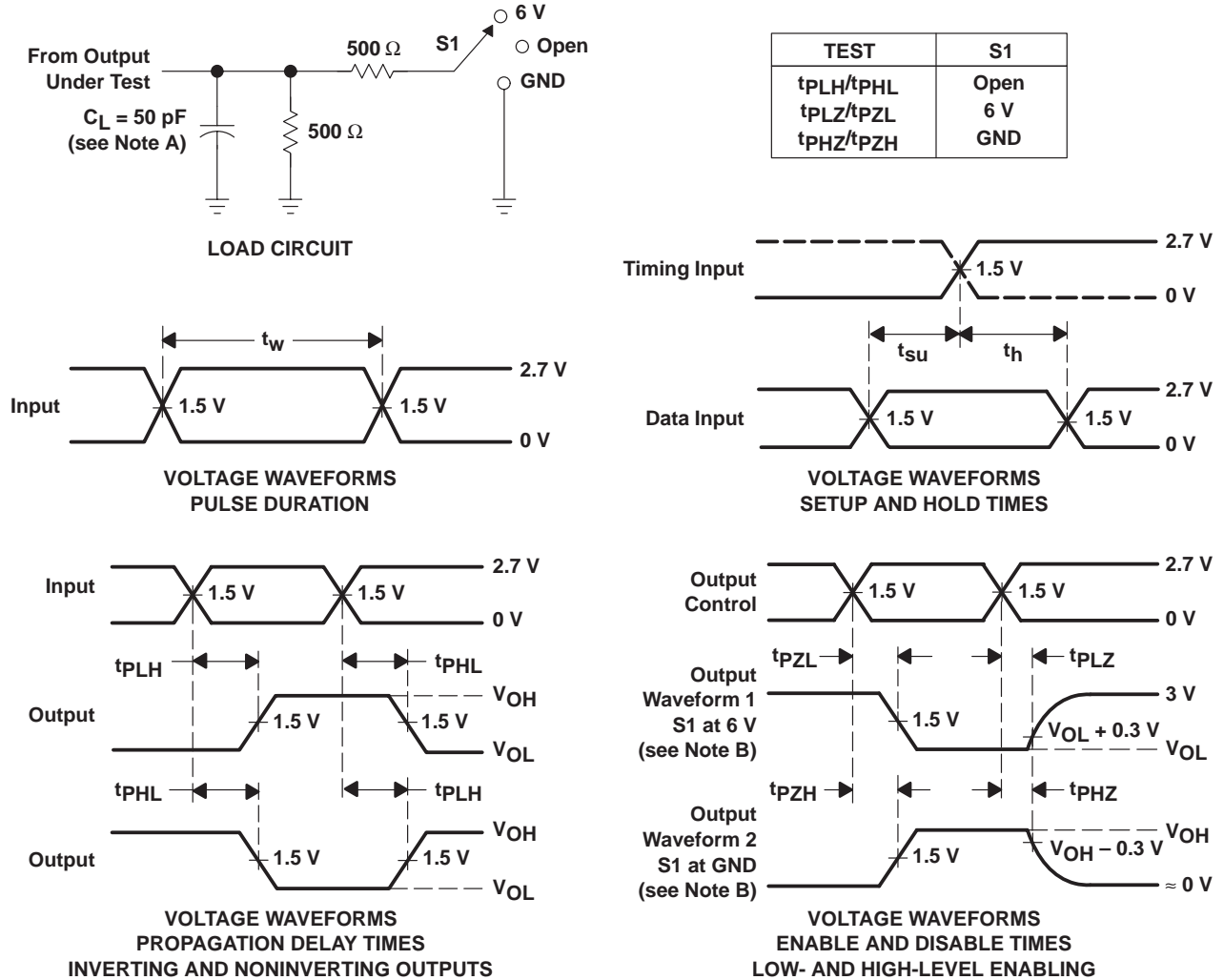
† All typical values are at  $V_{CC} = 3.3\text{ V}$ ,  $T_A = 25^\circ\text{C}$ .



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**PARAMETER MEASUREMENT INFORMATION**



- 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:  $PRR \leq 10 \text{ MHz}$ ,  $Z_O = 50 \Omega$ ,  $t_r \leq 2.5 \text{ ns}$ ,  $t_f \leq 2.5 \text{ ns}$ .  
 D. The outputs are measured one at a time with one transition per measurement.

**Figure 1. Load Circuit and Voltage Waveforms**

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