

2.5-V/3.3-V 16-BIT BUFFERS/DRIVERS WITH 3-STATE OUTPUTS

SCES070G – JUNE 1996 – REVISED MAY 1999

- **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**
- **5-V I/O Compatible**
- **High Drive Capability (–32 mA/64 mA)**
- **Support Mixed-Mode Signal Operation (5-V Input and Output Voltages With 3.3-V V_{CC})**
- **Support Unregulated Battery Operation Down to 2.3 V**
- **Typical V_{OLP} (Output Ground Bounce) < 0.8 V at $V_{CC} = 3.3$ V, $T_A = 25^\circ\text{C}$**
- **Auto3-State Eliminates Bus Current Loading When Voltage at the Output Exceeds V_{CC}**
- **I_{off} and Power-Up 3-State Support Hot Insertion**
- **Bus Hold on Data Inputs Eliminates the Need for External Pullup/Pulldown Resistors**
- **Latch-Up Performance Exceeds 250 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 300-mil Shrink Small-Outline (DL), Thin Shrink Small-Outline (DGG), Thin Very Small-Outline (DGV) Packages, and 380-mil Fine-Pitch Ceramic Flat (WD) Package**

SN54ALVTH16244 . . . WD PACKAGE
SN74ALVTH16244 . . . DGG, DGV, OR DL PACKAGE
(TOP VIEW)

1OE	1	48	2OE
1Y1	2	47	1A1
1Y2	3	46	1A2
GND	4	45	GND
1Y3	5	44	1A3
1Y4	6	43	1A4
V_{CC}	7	42	V_{CC}
2Y1	8	41	2A1
2Y2	9	40	2A2
GND	10	39	GND
2Y3	11	38	2A3
2Y4	12	37	2A4
3Y1	13	36	3A1
3Y2	14	35	3A2
GND	15	34	GND
3Y3	16	33	3A3
3Y4	17	32	3A4
V_{CC}	18	31	V_{CC}
4Y1	19	30	4A1
4Y2	20	29	4A2
GND	21	28	GND
4Y3	22	27	4A3
4Y4	23	26	4A4
4OE	24	25	3OE

NOTE: For tape and reel order entry:
The DGG package is abbreviated to GR, and
the DGV package is abbreviated to VR.

description

The 'ALVTH16244 devices are 16-bit buffers/line drivers designed for 2.5-V or 3.3-V V_{CC} operation, but with the capability to provide a TTL interface to a 5-V system environment. These devices can be used as four 4-bit buffers, two 8-bit buffers, or one 16-bit buffer.

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

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description (continued)

When V_{CC} is between 0 and 1.2 V, the device is in the high-impedance state during power up or power down. However, to ensure the high-impedance state above 1.2 V, the output-enable (\overline{OE}) input 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.

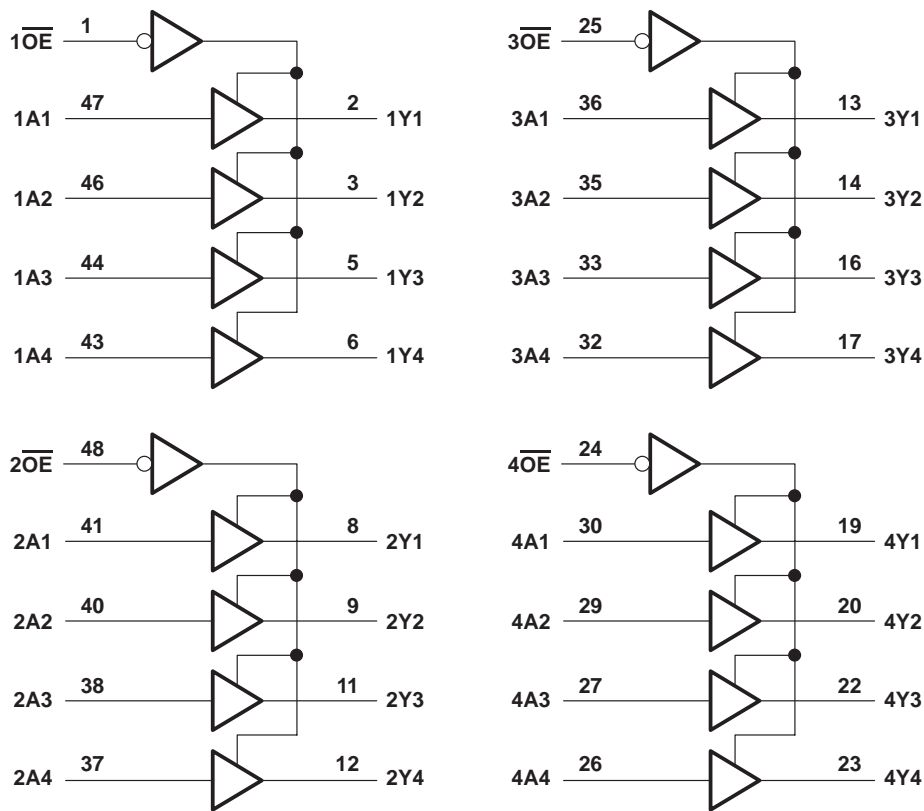
These devices are fully specified for hot-insertion applications using I_{off} and power-up 3-state. The I_{off} circuitry disables the outputs, preventing damaging current backflow through the devices when they are powered down. The power-up 3-state circuitry places the outputs in the high-impedance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

The SN54ALVTH16244 is characterized for operation over the full military temperature range of -55°C to 125°C . The SN74ALVTH16244 is characterized for operation from -40°C to 85°C .

FUNCTION TABLE
(each buffer)

INPUTS		OUTPUT Y
\overline{OE}	A	
L	H	H
L	L	L
H	X	Z

logic diagram (positive logic)



SN54ALVTH16244, SN74ALVTH16244 2.5-V/3.3-V 16-BIT BUFFERS/DRIVERS 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} to 7V
Output current in the low state, I_O : SN54ALVTH16244	96 mA
SN74ALVTH16244	128 mA
Output current in the high state, I_O : SN54ALVTH16244	–48 mA
SN74ALVTH16244	–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, θ_{JA} (see Note 2): DGG package	89°C/W
DGV package	93°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. The package thermal impedance is calculated in accordance with JESD 51.

recommended operating conditions, $V_{CC} = 2.5\text{ V} \pm 0.2\text{ V}$ (see Note 3)

		SN54ALVTH16244		SN74ALVTH16244		UNIT
		MIN	MAX	MIN	MAX	
V_{CC}	Supply voltage	2.3	2.7	2.3	2.7	V
V_{IH}	High-level input voltage	1.7		1.7		V
V_{IL}	Low-level input voltage		0.7		0.7	V
V_I	Input voltage	0	5.5	0	5.5	V
I_{OH}	High-level output current		–6		–8	mA
I_{OL}	Low-level output current		6		8	mA
	Low-level output current; current duty cycle $\leq 50\%$; $f \geq 1\text{ kHz}$		18		24	
$\Delta t/\Delta v$	Input transition rise or fall rate		10		10	ns/V
	Outputs enabled		10		10	ns/V
$\Delta t/\Delta V_{CC}$	Power-up ramp rate	200		200		$\mu\text{s/V}$
T_A	Operating free-air temperature	–55	125	–40	85	°C

NOTE 3: 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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recommended operating conditions, $V_{CC} = 3.3\text{ V} \pm 0.3\text{ V}$ (see Note 3)

			SN54ALVTH16244		SN74ALVTH16244		UNIT
			MIN	MAX	MIN	MAX	
V_{CC}	Supply voltage		3	3.6	3	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		0	5.5	0	5.5	V
I_{OH}	High-level output current			–24		–32	mA
I_{OL}	Low-level output current			24		32	mA
	Low-level output current; current duty cycle $\leq 50\%$; $f \geq 1\text{ kHz}$			48		64	
$\Delta t/\Delta v$	Input transition rise or fall rate	Outputs enabled		10		10	ns/V
$\Delta t/\Delta V_{CC}$	Power-up ramp rate		200		200		$\mu\text{s/V}$
T_A	Operating free-air temperature		–55	125	–40	85	$^{\circ}\text{C}$

NOTE 3: 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,
 $V_{CC} = 2.5 \text{ V} \pm 0.2 \text{ V}$ (unless otherwise noted)

PARAMETER		TEST CONDITIONS		SN54ALVTH16244		SN74ALVTH16244		UNIT	
				MIN	TYP†	MAX	MIN		TYP†
V _{IK}		V _{CC} = 2.3 V, I _I = −18 mA			−1.2		−1.2	V	
V _{OH}		V _{CC} = 2.3 V to 2.7 V, I _{OH} = −100 μA	V _{CC} −0.2			V _{CC} −0.2		V	
		V _{CC} = 2.3 V I _{OH} = −6 mA	1.8						
			I _{OH} = −8 mA			1.8			
V _{OL}		V _{CC} = 2.3 V to 2.7 V, I _{OL} = 100 μA			0.2		0.2	V	
		V _{CC} = 2.3 V	I _{OL} = 6 mA			0.4			
			I _{OL} = 8 mA				0.4		
			I _{OL} = 18 mA			0.5			
			I _{OL} = 24 mA				0.5		
I _I	Control inputs	V _{CC} = 2.7 V, V _I = V _{CC} or GND			±1		±1	μA	
		V _{CC} = 0 or 2.7 V, V _I = 5.5 V			10		10		
	Data inputs	V _{CC} = 2.7 V V _I = V _{CC}			1		1		
			V _I = 0			−5			−5
I _{off}		V _{CC} = 0, V _I or V _O = 0 to 4.5 V					±100	μA	
I _I (hold)	Data inputs	V _{CC} = 2.3 V V _I = 0.7 V			115		115	μA	
			V _I = 1.7 V			−10			−10
		V _{CC} = 2.7 V‡, V _I = 0 to 2.7 V				±300			±300
I _{EX} §		V _{CC} = 2.3 V, V _O = 5.5 V			125		125	μA	
I _{OZ} (PU/PD)¶		V _{CC} ≤ 1.2 V, V _O = 0.5 V to V _{CC} , V _I = GND or V _{CC} , \overline{OE} = don't care			±100		±100	μA	
I _{OZH}		V _{CC} = 2.7 V V _O = 2.3 V, V _I = 0.7 V or 1.7 V			5		5	μA	
I _{OZL}		V _{CC} = 2.7 V V _O = 0.5 V, V _I = 0.7 V or 1.7 V			−5		−5	μA	
I _{CC}		V _{CC} = 2.7 V, I _O = 0, V _I = V _{CC} or GND	Outputs high		0.04	0.1	0.04	0.1	mA
			Outputs low		2.3	4.5	2.3	4.5	
			Outputs disabled		0.04	0.1	0.04	0.1	
C _i		V _{CC} = 2.5 V, V _I = 2.5 V or 0			3		3	pF	
C _O		V _{CC} = 2.5 V, V _O = 2.5 V or 0			6		6	pF	

† All typical values are at $V_{CC} = 2.5 \text{ V}$, $T_A = 25^\circ\text{C}$.

‡ This is the bus-hold maximum dynamic current. It is the minimum overdrive current required to switch the input from one state to another.

§ Current into an output in the high state when $V_O > V_{CC}$

¶ High-impedance state during power up/power down

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electrical characteristics over recommended operating free-air temperature range,
 $V_{CC} = 3.3 \text{ V} \pm 0.3 \text{ V}$ (unless otherwise noted)

PARAMETER		TEST CONDITIONS	SN54ALVTH16244			SN74ALVTH16244			UNIT
			MIN	TYP†	MAX	MIN	TYP†	MAX	
V_{IK}		$V_{CC} = 3 \text{ V}$, $I_I = -18 \text{ mA}$			-1.2			-1.2	V
V_{OH}		$V_{CC} = 3 \text{ V to } 3.6 \text{ V}$, $I_{OH} = -100 \mu\text{A}$	$V_{CC}-0.2$			$V_{CC}-0.2$			V
		$V_{CC} = 3 \text{ V}$, $I_{OH} = -24 \text{ mA}$	2						
		$I_{OH} = -32 \text{ mA}$				2			
V_{OL}		$V_{CC} = 3 \text{ V to } 3.6 \text{ V}$, $I_{OL} = 100 \mu\text{A}$			0.2			0.2	V
		$V_{CC} = 3 \text{ V}$, $I_{OL} = 16 \text{ mA}$						0.4	
		$I_{OL} = 24 \text{ mA}$			0.5				
		$I_{OL} = 32 \text{ mA}$						0.5	
		$I_{OL} = 48 \text{ mA}$			0.55				
		$I_{OL} = 64 \text{ mA}$						0.55	
I_I	Control inputs	$V_{CC} = 3.6 \text{ V}$, $V_I = V_{CC} \text{ or GND}$			± 1			± 1	μA
		$V_{CC} = 0 \text{ or } 3.6 \text{ V}$, $V_I = 5.5 \text{ V}$			10			10	
	Data inputs	$V_{CC} = 3.6 \text{ V}$, $V_I = 5.5 \text{ V}$			20			20	
		$V_I = V_{CC}$			1			1	
		$V_I = 0$			-5			-5	
I_{off}		$V_{CC} = 0$, $V_I \text{ or } V_O = 0 \text{ to } 4.5 \text{ V}$						± 100	μA
$I_I(\text{hold})$	Data inputs	$V_{CC} = 3 \text{ V}$, $V_I = 0.8 \text{ V}$	75			75			μA
		$V_I = 2 \text{ V}$	-75			-75			
		$V_{CC} = 3.6 \text{ V}^\ddagger$, $V_I = 0 \text{ to } 3.6 \text{ V}$			± 500			± 500	
I_{EX}^\S		$V_{CC} = 3 \text{ V}$, $V_O = 5.5 \text{ V}$			125			125	μA
$I_{OZ}(\text{PU/PD})^\P$		$V_{CC} \leq 1.2 \text{ V}$, $V_O = 0.5 \text{ V to } V_{CC}$, $V_I = \text{GND or } V_{CC}$, $\overline{OE} = \text{don't care}$			± 100			± 100	μA
I_{OZH}		$V_{CC} = 3.6 \text{ V}$, $V_O = 3 \text{ V}$, $V_I = 0.8 \text{ V or } 2 \text{ V}$			5			5	μA
I_{OZL}		$V_{CC} = 3.6 \text{ V}$, $V_O = 0.5 \text{ V}$, $V_I = 0.8 \text{ V or } 2 \text{ V}$			-5			-5	μA
I_{CC}		$V_{CC} = 3.6 \text{ V}$, $I_O = 0$, $V_I = V_{CC} \text{ or GND}$							mA
		Outputs high	0.07	0.1		0.07	0.1		
		Outputs low	3.2	5		3.2	5		
		Outputs disabled	0.07	0.1		0.07	0.1		
$\Delta I_{CC}^\#$		$V_{CC} = 3 \text{ V to } 3.6 \text{ V}$, One input at $V_{CC} - 0.6 \text{ V}$, Other inputs at $V_{CC} \text{ or GND}$			0.4			0.4	mA
C_i		$V_{CC} = 3.3 \text{ V}$, $V_I = 3.3 \text{ V or } 0$			3			3	pF
C_o		$V_{CC} = 3.3 \text{ V}$, $V_O = 3.3 \text{ V or } 0$			6			6	pF

† 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.

§ Current into an output in the high state when $V_O > V_{CC}$

¶ High-impedance state during power up/power down

This is the increase in supply current for each input that is at the specified TTL voltage level rather than V_{CC} or GND.

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switching characteristics over recommended operating free-air temperature range, $C_L = 30 \text{ pF}$, $V_{CC} = 2.5 \text{ V} \pm 0.2 \text{ V}$ (unless otherwise noted) (see Figure 1)

PARAMETER	FROM (INPUT)	TO (OUTPUT)	SN54ALVTH16244		SN74ALVTH16244		UNIT
			MIN	MAX	MIN	MAX	
t_{PLH}	A	Y	1	3.1	1	3	ns
t_{PHL}			1	3.6	1	3.5	
t_{PZH}	\overline{OE}	Y	1.1	6	1.1	5.9	ns
t_{PZL}			1.1	4.8	1.1	4.7	
t_{PHZ}	\overline{OE}	Y	1.5	4.5	1.5	4.4	ns
t_{PLZ}			1	3.5	1	3.4	

switching characteristics over recommended operating free-air temperature range, $C_L = 50 \text{ pF}$, $V_{CC} = 3.3 \text{ V} \pm 0.3 \text{ V}$ (unless otherwise noted) (see Figure 2)

PARAMETER	FROM (INPUT)	TO (OUTPUT)	SN54ALVTH16244		SN74ALVTH16244		UNIT
			MIN	MAX	MIN	MAX	
t_{PLH}	A	Y	1	2.6	1	2.4	ns
t_{PHL}			1	2.6	1	2.5	
t_{PZH}	\overline{OE}	Y	1	3.9	1	3.8	ns
t_{PZL}			1	3	1	2.9	
t_{PHZ}	\overline{OE}	Y	1.5	4.3	1.5	4.2	ns
t_{PLZ}			1.5	3.7	1.5	3.6	

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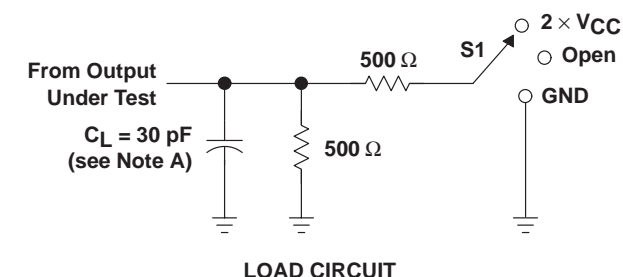
2.5-V/3.3-V 16-BIT BUFFERS/DRIVERS

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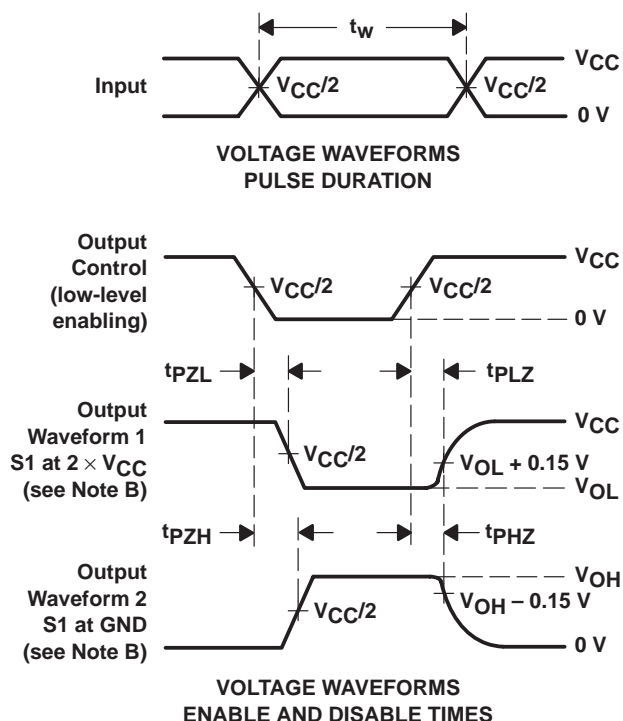
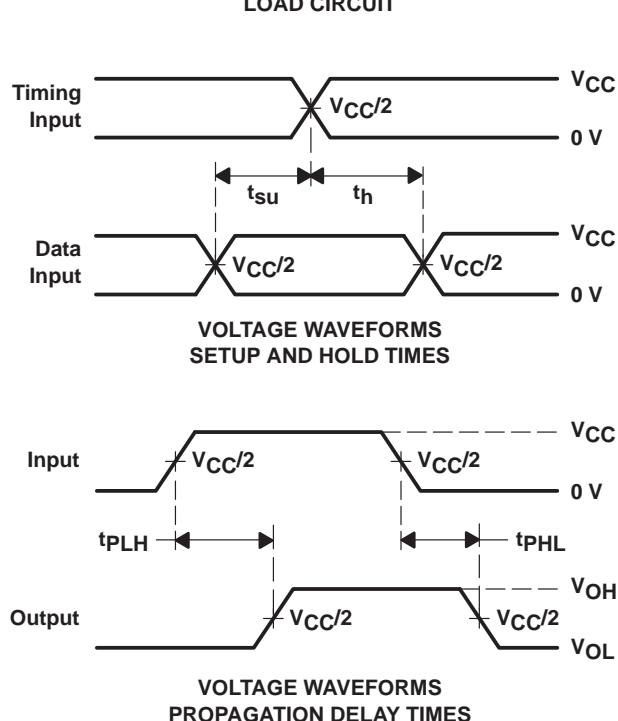
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PARAMETER MEASUREMENT INFORMATION

$$V_{CC} = 2.5 \text{ V} \pm 0.2 \text{ V}$$



TEST	S1
t_{PLH}/t_{PHL}	Open
t_{PLZ}/t_{PZL}	2 $\times V_{CC}$
t_{PHZ}/t_{PZH}	GND



- NOTES:
- C_L includes probe and jig capacitance.
 - 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.
 - All input pulses are supplied by generators having the following characteristics: $PRR \leq 10 \text{ MHz}$, $Z_O = 50 \Omega$, $t_r \leq 2 \text{ ns}$, $t_f \leq 2 \text{ ns}$.
 - The outputs are measured one at a time with one transition per measurement.

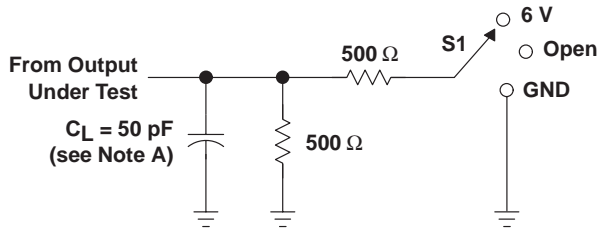
Figure 1. Load Circuit and Voltage Waveforms

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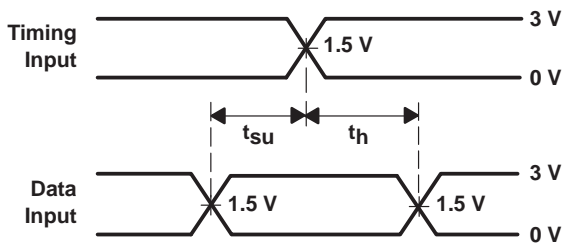
PARAMETER MEASUREMENT INFORMATION

$$V_{CC} = 3.3 \text{ V} \pm 0.3 \text{ V}$$

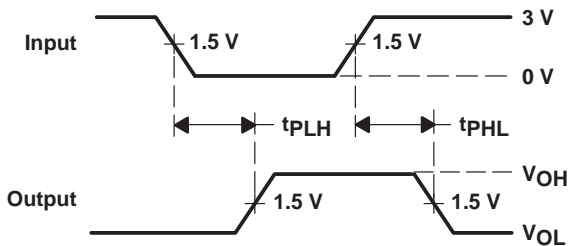


LOAD CIRCUIT

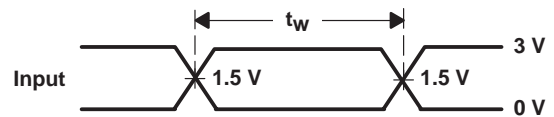
TEST	S1
t_{PLH}/t_{PHL}	Open
t_{PLZ}/t_{PZL}	6 V
t_{PHZ}/t_{PZH}	GND



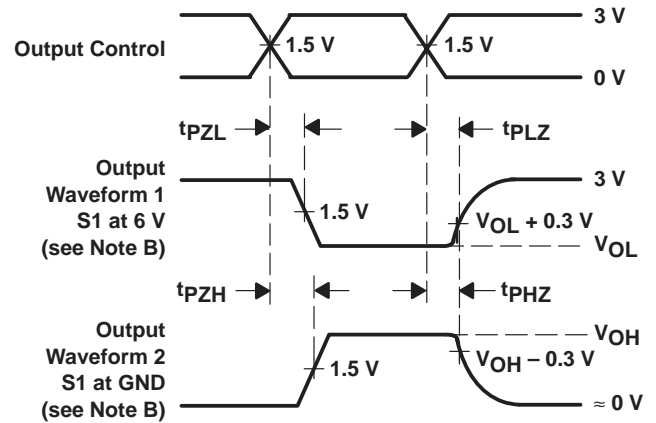
VOLTAGE WAVEFORMS
SETUP AND HOLD TIMES



VOLTAGE WAVEFORMS
PROPAGATION DELAY TIMES
INVERTING AND NONINVERTING OUTPUTS



VOLTAGE WAVEFORMS
PULSE DURATION



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

Figure 2. Load Circuit and Voltage Waveforms

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