

# SN74GTLPH3245 32-BIT LVTTTL-TO-GTLP ADJUSTABLE-EDGE-RATE BUS TRANSCEIVER

SCES291D – OCTOBER 1999 – REVISED FEBRUARY 2002

- Member of the Texas Instruments Widebus+™ Family
- TI-OPC™ Circuitry Limits Ringing on Unevenly Loaded Backplanes
- OEC™ Circuitry Improves Signal Integrity and Reduces Electromagnetic Interference
- Bidirectional Interface Between GTLP Signal Levels and LVTTTL Logic Levels
- LVTTTL Interfaces Are 5-V Tolerant
- High-Drive GTLP Outputs (100 mA)
- LVTTTL Outputs (–24 mA/24 mA)
- Variable Edge-Rate Control ( $\overline{\text{ERC}}$ ) Input Selects GTLP Rise and Fall Times for Optimal Data-Transfer Rate and Signal Integrity in Distributed Loads
- $I_{\text{off}}$ , Power-Up 3-State, and BIAS  $V_{\text{CC}}$  Support Live Insertion
- Bus Hold on A-Port Data Inputs
- Distributed  $V_{\text{CC}}$  and GND Pins Minimize High-Speed Switching Noise
- Latch-Up Performance Exceeds 100 mA Per JESD 78, Class II

## description

The SN74GTLPH3245 is a high-drive, 32-bit bus transceiver that provides LVTTTL-to-GTLP and GTLP-to-LVTTTL signal-level translation. It is partitioned as four 8-bit transceivers. The device provides a high-speed interface between cards operating at LVTTTL logic levels and a backplane operating at GTLP signal levels. High-speed (about three times faster than standard LVTTTL or TTL) backplane operation is a direct result of GTLP's reduced output swing ( $<1$  V), reduced input threshold levels, improved differential input, OEC circuitry, and TI-OPC circuitry. Improved GTLP OEC and TI-OPC circuits minimize bus-settling time and have been designed and tested using several backplane models. The high drive allows incident-wave switching in heavily loaded backplanes with equivalent load impedance down to  $11 \Omega$ .

GTLP is the Texas Instruments (TI™) derivative of the Gunning Transceiver Logic (GTL) JEDEC standard JESD 8-3. The ac specification of the SN74GTLPH3245 is given only at the preferred higher noise-margin GTLP, but the user has the flexibility of using this device at either GTL ( $V_{\text{TT}} = 1.2$  V and  $V_{\text{REF}} = 0.8$  V) or GTLP ( $V_{\text{TT}} = 1.5$  V and  $V_{\text{REF}} = 1$  V) signal levels.

Normally, the B port operates at GTLP signal levels. The A-port and control inputs operate at LVTTTL logic levels, but are 5-V tolerant and are compatible with TTL and 5-V CMOS inputs.  $V_{\text{REF}}$  is the B-port differential input reference voltage.

This device is fully specified for live-insertion applications using  $I_{\text{off}}$ , power-up 3-state, and BIAS  $V_{\text{CC}}$ . The  $I_{\text{off}}$  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. The BIAS  $V_{\text{CC}}$  circuitry precharges and preconditions the B-port input/output connections, preventing disturbance of active data on the backplane during card insertion or removal, and permits true live-insertion capability.

This GTLP device features TI-OPC circuitry, which actively limits overshoot caused by improperly terminated backplanes, unevenly distributed cards, or empty slots during low-to-high signal transitions. This improves signal integrity, which allows adequate noise margin to be maintained at higher frequencies.

High-drive GTLP backplane interface devices feature adjustable edge-rate control ( $\overline{\text{ERC}}$ ). Changing the  $\overline{\text{ERC}}$  input voltage between GND and  $V_{\text{CC}}$  adjusts the B-port output rise and fall times. This allows the designer to optimize system data-transfer rate and signal integrity to the backplane load.

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



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INSTRUMENTS**

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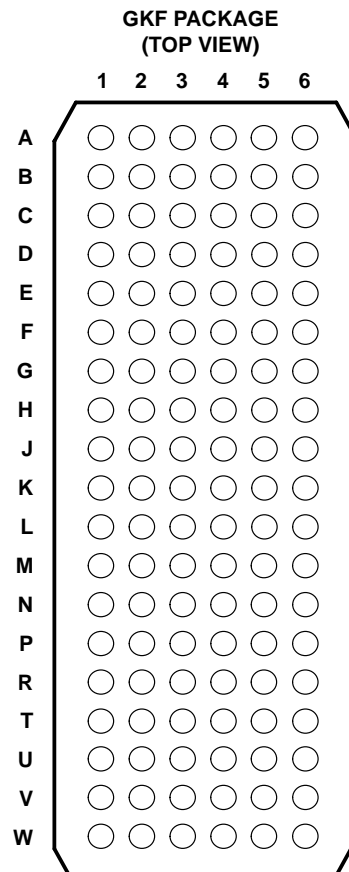
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### description (continued)

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, 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.



### terminal assignments

	1	2	3	4	5	6
A	1A3	1A2	1A1	1B1	1B2	1B3
B	GND	1A4	1DIR	$1\overline{OE}$	1B4	GND
C	1A6	1A5	GND	GND	1B5	1B6
D	1A8	1A7	$1V_{CC}$	$1V_{CC}$	1B7	1B8
E	$1\overline{ERC}$	GND	GND	GND	$1BIAS V_{CC}$	$1V_{REF}$
F	2A2	2A1	GND	GND	2B1	2B2
G	2A4	2A3	$1V_{CC}$	$1V_{CC}$	2B3	2B4
H	GND	2A5	GND	GND	2B5	GND
J	2A6	2A7	2A8	2B8	2B7	2B6
K	NC	3A1	2DIR	$2\overline{OE}$	3B1	NC
L	3A3	3A2	3DIR	$3\overline{OE}$	3B2	3B3
M	GND	3A4	GND	GND	3B4	GND
N	3A6	3A5	$2V_{CC}$	$2V_{CC}$	3B5	3B6
P	3A8	3A7	GND	GND	3B7	3B8
R	$2\overline{ERC}$	GND	GND	GND	$2BIAS V_{CC}$	$2V_{REF}$
T	4A2	4A1	$2V_{CC}$	$2V_{CC}$	4B1	4B2
U	4A4	4A3	GND	GND	4B3	4B4
V	GND	4A5	4A8	4B8	4B5	GND
W	4A6	4A7	4DIR	$4\overline{OE}$	4B7	4B6

NC – No internal connection

### ORDERING INFORMATION

$T_A$	PACKAGE†	ORDERABLE PART NUMBER	TOP-SIDE MARKING
-40°C to 85°C	LFBGA – GKF Tape and reel	SN74GTLPH3245GKFR	GM45

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

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## 32-BIT LVTTL-TO-GTLP ADJUSTABLE-EDGE-RATE BUS TRANSCEIVER

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### functional description

The SN74GTLP3245 is a high-drive (100 mA), 32-bit bus transceiver partitioned in four 8-bit segments and is designed for asynchronous communication between data buses. The device transmits data from the A port to the B port or from the B port to the A port, depending on the logic level at the direction-control (DIR) input.  $\overline{OE}$  can be used to disable the device so the buses are effectively isolated. Data polarity is noninverting.

For A-to-B data flow, when  $\overline{OE}$  is low and DIR is high, the B outputs take on the logic value of the A inputs. When  $\overline{OE}$  is high, the outputs are in the high-impedance state.

The data flow for B to A is similar to that of A to B, except  $\overline{OE}$  and DIR are low.

### Function Tables

OUTPUT CONTROL

INPUTS		OUTPUT	MODE
$\overline{OE}$	DIR		
H	X	Z	Isolation
L	L	B data to A port	True transparent
L	H	A data to B port	

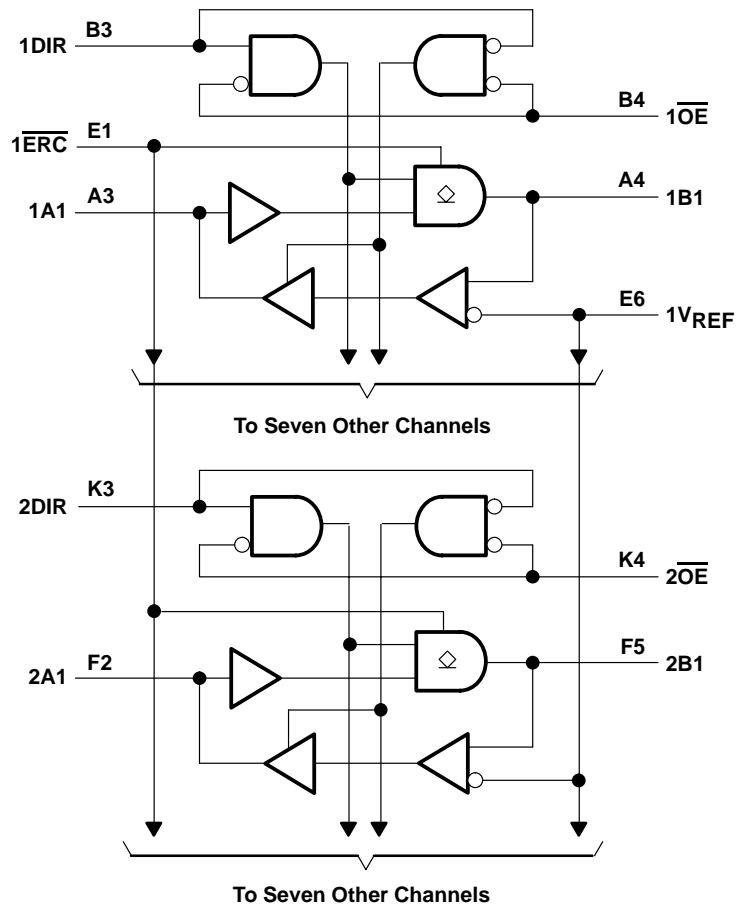
B-PORT EDGE-RATE CONTROL ( $\overline{ERC}$ )

INPUT $\overline{ERC}$		OUTPUT B-PORT EDGE RATE
LOGIC LEVEL	NOMINAL VOLTAGE	
L	GND	Slow
H	V <sub>CC</sub>	Fast

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## logic diagram (positive logic)†



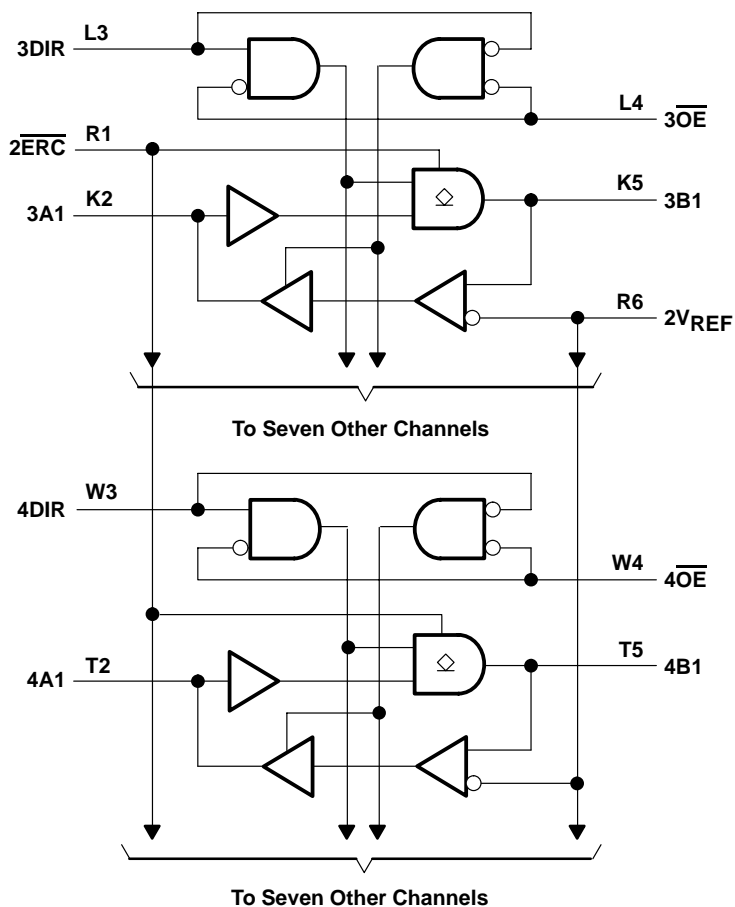
† 1V<sub>CC</sub> and 1BIAS V<sub>CC</sub> are associated with these channels.

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logic diagram (positive logic) (continued)†



† 2V<sub>CC</sub> and 2BIAS V<sub>CC</sub> are associated with these channels.

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

Supply voltage range, $V_{CC}$ and BIAS $V_{CC}$	.....	-0.5 V to 4.6 V
Input voltage range, $V_I$ (see Note 1): A port, $\overline{ERC}$ , and control inputs	.....	-0.5 V to 7 V
B port and $V_{REF}$	.....	-0.5 V to 4.6 V
Voltage range applied to any output in the high-impedance or power-off state, $V_O$		
(see Note 1): A port	.....	-0.5 V to 7 V
B port	.....	-0.5 V to 4.6 V
Current into any output in the low state, $I_O$ : A port	.....	48 mA
B port	.....	200 mA
Current into any A port output in the high state, $I_O$ (see Note 2)	.....	48 mA
Continuous current through each $V_{CC}$ or GND	.....	$\pm 100$ 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)	.....	36°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.



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### recommended operating conditions (see Notes 4 through 7)

		MIN	NOM	MAX	UNIT		
$V_{CC}$ , BIAS $V_{CC}$	Supply voltage	3.15	3.3	3.45	V		
$V_{TT}$	Termination voltage	GTL	1.14	1.2	1.26	V	
		GTLP	1.35	1.5	1.65		
$V_{REF}$	Reference voltage	GTL	0.74	0.8	0.87	V	
		GTLP	0.87	1	1.1		
$V_I$	Input voltage	B port	$V_{TT}$		V		
		Except B port	$V_{CC}$	5.5			
$V_{IH}$	High-level input voltage	B port	$V_{REF}+0.05$			V	
		$\overline{ERC}$	$V_{CC}-0.6$	$V_{CC}$	5.5		
		Except B port and $\overline{ERC}$	2				
$V_{IL}$	Low-level input voltage	B port	$V_{REF}-0.05$			V	
		$\overline{ERC}$	GND	0.6			
		Except B port and $\overline{ERC}$	0.8				
$I_{IK}$	Input clamp current				-18	mA	
$I_{OH}$	High-level output current	A port				-24	mA
$I_{OL}$	Low-level output current	A port				24	mA
		B port				100	
$\Delta t/\Delta v$	Input transition rise or fall rate	Outputs enabled			10	ns/V	
$\Delta t/\Delta V_{CC}$	Power-up ramp rate	20				$\mu$ s/V	
$T_A$	Operating free-air temperature	-40			85	$^{\circ}$ C	

- NOTES:
- All unused 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.
  - Proper connection sequence for use of the B-port I/O precharge feature is GND and BIAS  $V_{CC} = 3.3$  V first, I/O second, and  $V_{CC} = 3.3$  V last, because the BIAS  $V_{CC}$  precharge circuitry is disabled when any  $V_{CC}$  pin is connected. The control and  $V_{REF}$  inputs can be connected anytime, but normally are connected during the I/O stage. If B-port precharge is not required, any connection sequence is acceptable, but generally, GND is connected first.
  - $V_{TT}$  and  $R_{TT}$  can be adjusted to accommodate backplane impedances if the dc recommended  $I_{OL}$  ratings are not exceeded.
  - $V_{REF}$  can be adjusted to optimize noise margins, but normally is two-thirds  $V_{TT}$ . TI-OPC circuitry is enabled in the A-to-B direction and is activated when  $V_{TT} > 0.7$  V above  $V_{REF}$ . If operated in the A-to-B direction,  $V_{REF}$  should be set to within 0.6 V of  $V_{TT}$  to minimize current drain.



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

PARAMETER		TEST CONDITIONS		MIN	TYP†	MAX	UNIT
V <sub>IK</sub>		V <sub>CC</sub> = 3.15 V,	I <sub>I</sub> = -18 mA			-1.2	V
V <sub>OH</sub>	A port	V <sub>CC</sub> = 3.15 V to 3.45 V,	I <sub>OH</sub> = -100 μA	V <sub>CC</sub> -0.2			V
		V <sub>CC</sub> = 3.15 V	I <sub>OH</sub> = -12 mA	2.4			
			I <sub>OH</sub> = -24 mA	2			
V <sub>OL</sub>	A port	V <sub>CC</sub> = 3.15 V to 3.45 V,	I <sub>OL</sub> = 100 μA			0.2	V
		V <sub>CC</sub> = 3.15 V	I <sub>OL</sub> = 12 mA			0.4	
			I <sub>OL</sub> = 24 mA			0.5	
	B port	V <sub>CC</sub> = 3.15 V	I <sub>OL</sub> = 10 mA			0.2	
			I <sub>OL</sub> = 64 mA			0.4	
			I <sub>OL</sub> = 100 mA			0.55	
I <sub>I‡</sub>	A-port and control inputs	V <sub>CC</sub> = 3.45 V	V <sub>I</sub> = 0 or V <sub>CC</sub>			±10	μA
			V <sub>I</sub> = 5.5 V			±20	
	B port		V <sub>I</sub> = 0 to 1.5 V			±10	
I <sub>BHL</sub> §	A port	V <sub>CC</sub> = 3.15 V,	V <sub>I</sub> = 0.8 V	75			μA
I <sub>BHH</sub> ¶	A port	V <sub>CC</sub> = 3.15 V,	V <sub>I</sub> = 2 V	-75			μA
I <sub>BHLO</sub> #	A port	V <sub>CC</sub> = 3.45 V,	V <sub>I</sub> = 0 to V <sub>CC</sub>	500			μA
I <sub>BHHO</sub>	A port	V <sub>CC</sub> = 3.45 V,	V <sub>I</sub> = 0 to V <sub>CC</sub>	-500			μA
I <sub>CC</sub>	A or B port	V <sub>CC</sub> = 3.45 V, I <sub>O</sub> = 0, V <sub>I</sub> (A-port or control input) = V <sub>CC</sub> or GND, V <sub>I</sub> (B port) = V <sub>TT</sub> or GND	Outputs high			80	mA
			Outputs low			80	
			Outputs disabled			80	
ΔI <sub>CC</sub> *		V <sub>CC</sub> = 3.45 V, One A-port or control input at V <sub>CC</sub> - 0.6 V, Other A-port or control inputs at V <sub>CC</sub> or GND				1.5	mA
C <sub>i</sub>	Control inputs	V <sub>I</sub> = 3.15 V or 0			4	5	pF
C <sub>io</sub>	A port	V <sub>O</sub> = 3.15 V or 0			6.5	7.5	pF
	B port	V <sub>O</sub> = 1.5 V or 0			9.5	11	

† All typical values are at V<sub>CC</sub> = 3.3 V, T<sub>A</sub> = 25°C.

‡ For I/O ports, the parameter I<sub>I</sub> includes the off-state output leakage current.

§ The bus-hold circuit can sink at least the minimum low sustaining current at V<sub>IL</sub>max. I<sub>BHL</sub> should be measured after lowering V<sub>IN</sub> to GND and then raising it to V<sub>IL</sub>max.

¶ The bus-hold circuit can source at least the minimum high sustaining current at V<sub>IH</sub>min. I<sub>BHH</sub> should be measured after raising V<sub>IN</sub> to V<sub>CC</sub> and then lowering it to V<sub>IH</sub>min.

# An external driver must source at least I<sub>BHLO</sub> to switch this node from low to high.

|| An external driver must sink at least I<sub>BHHO</sub> to switch this node from high to low.

\* This is the increase in supply current for each input that is at the specified TTL voltage level rather than V<sub>CC</sub> or GND.

**hot-insertion specifications for A port over recommended operating free-air temperature range**

PARAMETER	TEST CONDITIONS			MIN	MAX	UNIT
I <sub>off</sub>	V <sub>CC</sub> = 0,	BIAS V <sub>CC</sub> = 0,	V <sub>I</sub> or V <sub>O</sub> = 0 to 5.5 V		10	μA
I <sub>OZPU</sub>	V <sub>CC</sub> = 0 to 1.5 V,	V <sub>O</sub> = 0.5 V to 3 V,	$\overline{OE}$ = 0		±30	μA
I <sub>OZPD</sub>	V <sub>CC</sub> = 1.5 V to 0,	V <sub>O</sub> = 0.5 V to 3 V,	$\overline{OE}$ = 0		±30	μA





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### live-insertion specifications for B port over recommended operating free-air temperature range

PARAMETER	TEST CONDITIONS			MIN	MAX	UNIT
$I_{off}$	$V_{CC} = 0,$	BIAS $V_{CC} = 0,$	$V_I$ or $V_O = 0$ to 1.5 V		10	$\mu A$
$I_{OZPU}$	$V_{CC} = 0$ to 1.5 V,	BIAS $V_{CC} = 0,$	$V_O = 0.5$ V to 1.5 V, $\overline{OE} = 0$		$\pm 30$	$\mu A$
$I_{OZPD}$	$V_{CC} = 1.5$ V to 0,	BIAS $V_{CC} = 0,$	$V_O = 0.5$ V to 1.5 V, $\overline{OE} = 0$		$\pm 30$	$\mu A$
$I_{CC}$ (BIAS $V_{CC}$ )	$V_{CC} = 0$ to 3.15 V	BIAS $V_{CC} = 3.15$ V to 3.45 V,	$V_O$ (B port) = 0 to 1.5 V		5	mA
	$V_{CC} = 3.15$ V to 3.45 V				10	$\mu A$
$V_O$	$V_{CC} = 0,$	BIAS $V_{CC} = 3.3$ V,	$I_O = 0$	0.95	1.05	V
$I_O$	$V_{CC} = 0,$	BIAS $V_{CC} = 3.15$ V to 3.45 V,	$V_O$ (B port) = 0.6 V	-1		$\mu A$

### switching characteristics over recommended ranges of supply voltage and operating free-air temperature, $V_{TT} = 1.5$ V and $V_{REF} = 1$ V for GTLP (see Figure 1)

PARAMETER	FROM (INPUT)	TO (OUTPUT)	EDGE RATE†	MIN	TYP‡	MAX	UNIT
$t_{PLH}$	A	B	Slow	3.9		7.2	ns
$t_{PHL}$				3.1		8.4	
$t_{PLH}$	A	B	Fast	2.6		5.7	ns
$t_{PHL}$				2.1		5.8	
$t_{en}$	$\overline{OE}$	B	Slow	4.1		7.3	ns
$t_{dis}$				4		9.4	
$t_{en}$	$\overline{OE}$	B	Fast	2.9		5.9	ns
$t_{dis}$				4		6.9	
$t_r$	Rise time, B outputs (20% to 80%)		Slow	3		ns	
			Fast	1.5			
$t_f$	Fall time, B outputs (80% to 20%)		Slow	4		ns	
			Fast	2.5			
$t_{PLH}$	B	A	—	0.5		6.7	ns
$t_{PHL}$				1.2		4.5	
$t_{en}$	$\overline{OE}$	A	—	1.1		6.3	ns
$t_{dis}$				1.7		5.1	

† Slow ( $\overline{ERC} = GND$ ) and Fast ( $\overline{ERC} = V_{CC}$ )

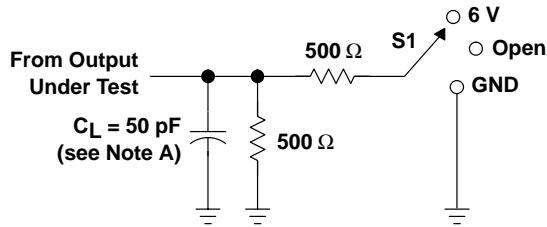
‡ All typical values are at  $V_{CC} = 3.3$  V,  $T_A = 25^\circ C$ .

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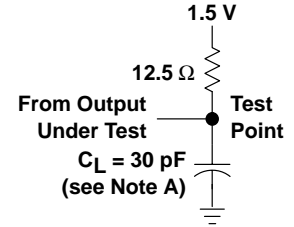
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### PARAMETER MEASUREMENT INFORMATION

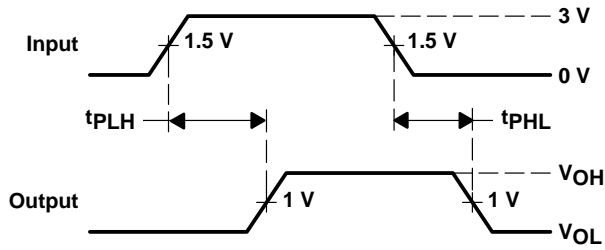


LOAD CIRCUIT FOR A OUTPUTS

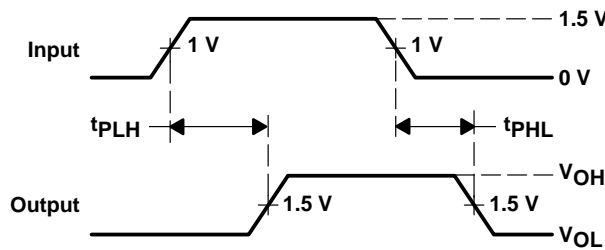
TEST	S1
$t_{PLH}/t_{PHL}$	Open
$t_{PLZ}/t_{PZL}$	6 V
$t_{PHZ}/t_{PZH}$	GND



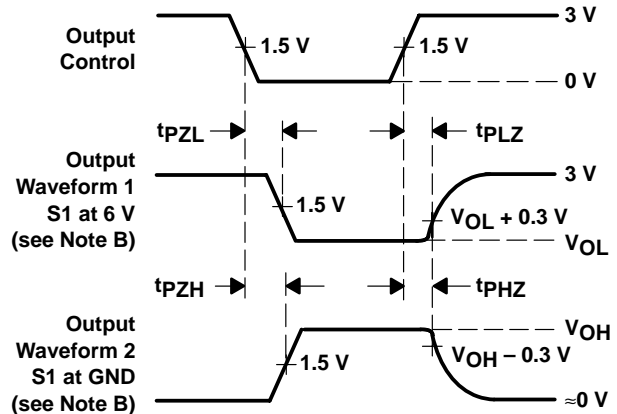
LOAD CIRCUIT FOR B OUTPUTS



VOLTAGE WAVEFORMS  
PROPAGATION DELAY TIMES  
(A port to B port)



VOLTAGE WAVEFORMS  
PROPAGATION DELAY TIMES  
(B port to A port)



VOLTAGE WAVEFORMS  
ENABLE AND DISABLE TIMES  
(A port)

- 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  $\approx$  10 MHz,  $Z_O = 50 \Omega$ ,  $t_r \approx 2$  ns,  $t_f \approx 2$  ns.
  - D. The outputs are measured one at a time with one transition per measurement.

Figure 1. Load Circuits and Voltage Waveforms

## DISTRIBUTED-LOAD BACKPLANE SWITCHING CHARACTERISTICS

The preceding switching characteristics table shows the switching characteristics of the device into a lumped load (Figure 1). However, the designer's backplane application probably is a distributed load. The physical representation is shown in Figure 2. This backplane, or distributed load, can be approximated closely to a resistor inductance capacitance (RLC) circuit, as shown in Figure 3. This device has been designed for optimum performance in this RLC circuit. The following switching characteristics table shows the switching characteristics of the device into the RLC load, to help the designer better understand the performance of the GTLP device in this typical backplane. See [www.ti.com/sc/gtlp](http://www.ti.com/sc/gtlp) for more information.

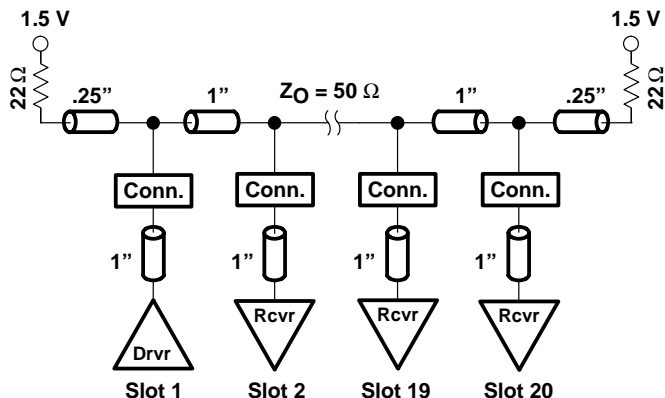


Figure 2. High-Drive Test Backplane

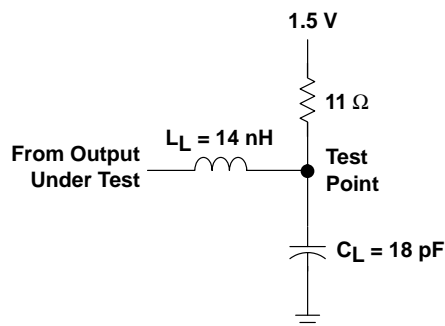


Figure 3. High-Drive RLC Network

switching characteristics over recommended ranges of supply voltage and operating free-air temperature,  $V_{TT} = 1.5\text{ V}$  and  $V_{REF} = 1\text{ V}$  for GTLP (see Figure 3)

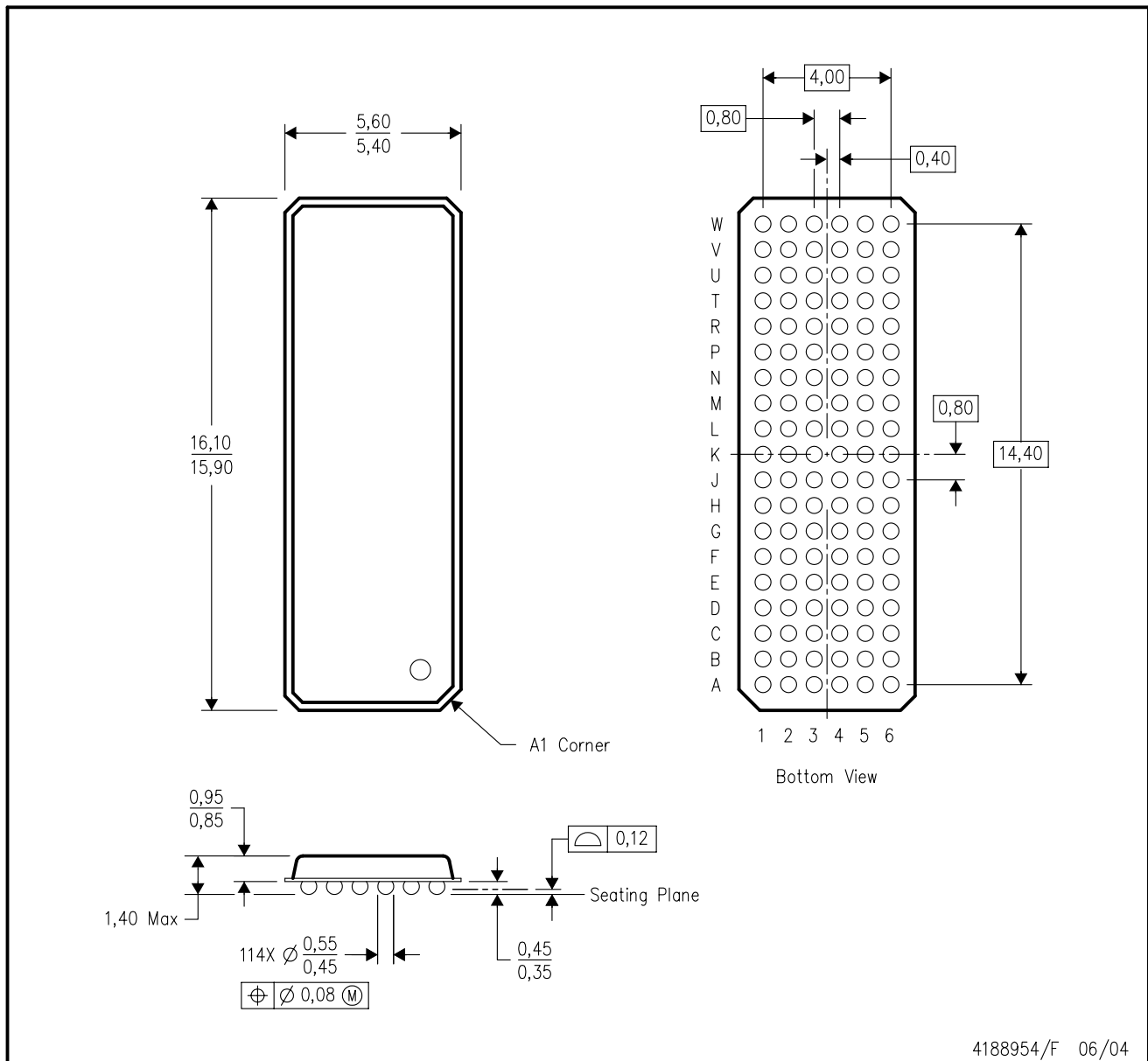
PARAMETER	FROM (INPUT)	TO (OUTPUT)	EDGE RATE†	TYP‡	UNIT
$t_{PLH}$	A	B	Slow	4.9	ns
$t_{PHL}$				4.9	
$t_{PLH}$	A	B	Fast	3.7	ns
$t_{PHL}$				3.7	
$t_{en}$	$\overline{OE}$	B	Slow	5.1	ns
$t_{dis}$				5.4	
$t_{en}$	$\overline{OE}$	B	Fast	4.1	ns
$t_{dis}$				4.1	
$t_r$	Rise time, B outputs (20% to 80%)		Slow	2	ns
			Fast	1.2	
$t_f$	Fall time, B outputs (80% to 20%)		Slow	2.5	ns
			Fast	1.8	

† Slow (ERC = GND) and Fast (ERC =  $V_{CC}$ )

‡ All typical values are at  $V_{CC} = 3.3\text{ V}$ ,  $T_A = 25^\circ\text{C}$ . All values are derived from TI-SPICE models.

GKF (R-PBGA-N114)

PLASTIC BALL GRID ARRAY



4188954/F 06/04

- NOTES:
- A. All linear dimensions are in millimeters.
  - B. This drawing is subject to change without notice.
  - C. Falls within JEDEC MO-205 variation DC.
  - D. This package is tin-lead (SnPb). Refer to the 114 ZKF package (drawing 4204494) for lead-free.

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