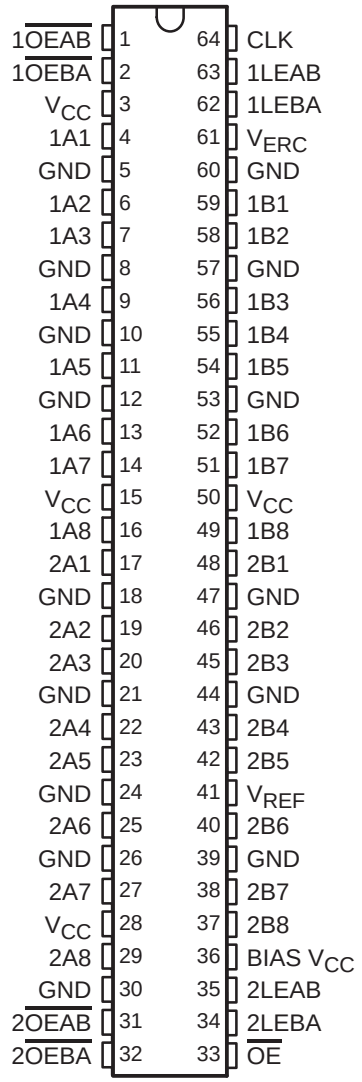
- **Members of the Texas Instruments *Widebus*™ Family**
- ***UBT*™ (Universal Bus Transceiver) Combines D-Type Latches and D-Type Flip-Flops for Operation in Transparent, Latched, or Clocked Mode**
- **Translate Between GTL/GTL+ Signal Level and LVTTL Logic Levels**
- **High-Drive (100 mA), Low-Output-Impedance (12 Ω) Bus Transceiver (B Port)**
- **Edge-Rate-Control Input Configures the B-Port Output Rise and Fall Times**
- **I_{off}, Power-Up 3-State, and BIAS V_{CC} Support Live Insertion**
- **Bus Hold on Data Inputs Eliminates the Need for External Pullup/Pulldown Resistors on A Port**
- **Distributed V_{CC} and GND-Pin Configuration Minimizes High-Speed Switching Noise**
- **Package Options Include Thin Shrink Small-Outline (DGG) and Ceramic Quad Flat (HV) Packages**

SN74GTL1655 . . . DGG PACKAGE
(TOP VIEW)



description

The ’GTL1655 devices are high-drive (100 mA), low-output-impedance (12 Ω) 16-bit universal bus transceivers (UBT) that provide LVTTL-to-GTL/GTL+ and GTL/GTL+-to-LVTTL signal-level translation. They are partitioned as two 8-bit transceivers and combine D-type flip-flops and D-type latches to allow for transparent, latched, and clocked modes of data transfer similar to the ’16501 function. These devices provide an interface between cards operating at LVTTL logic levels and a backplane operating at GTL/GTL+ signal levels. Higher-speed operation is a direct result of the reduced output swing (<1 V), reduced input threshold levels and output edge control (OEC™). The high drive is suitable for driving double-terminated low-impedance backplanes using incident-wave switching.

description (continued)

The user has the flexibility of using this device at either GTL (V_{TT} = 1.2 V and V_{REF} = 0.8 V) or the preferred higher noise margin GTL+ (V_{TT} = 1.5 V and V_{REF} = 1 V) signal levels. GTL+ is the Texas Instruments derivative of the Gunning transceiver logic (GTL) JEDEC standard JESD 8-3. The B port normally operates at GTL or GTL+ signal levels, while the A-port and control inputs are compatible with LVTTL logic levels but are not 5-V tolerant. V_{REF} is the reference input voltage for the B port.

These devices are uniquely partitioned as two 8-bit transceivers with individual latch timing and output signals, but with a common clock and output enable inputs for both transceiver words.

Data flow for each word is determined by the respective latch enables (xLEAB and xLEBA), output enables (x$\overline{\text{OEAB}}$ and x$\overline{\text{OEBA}}$), and clock (CLK). The output enables (1$\overline{\text{OEAB}}$, 1$\overline{\text{OEBA}}$, 2$\overline{\text{OEAB}}$, and 2$\overline{\text{OEBA}}$) control byte 1 and byte 2 data for the A-to-B and B-to-A directions, respectively.

For A-to-B data flow, the devices operate in the transparent mode when LEAB is high. When LEAB transitions low, the A data is latched independent of CLK high or low. If LEAB is low, the A data is registered on the CLK low-to-high transition. When $\overline{\text{OEAB}}$ is low, the outputs are active. With $\overline{\text{OEAB}}$ high, the outputs are in the high-impedance state.

Data flow for the B-to-A direction is identical, but uses $\overline{\text{OEBA}}$, LEBA, and CLK. Note that CLK is common to both directions and both 8-bit words. $\overline{\text{OE}}$ is also common and is used to disable all I/O ports simultaneously.

The 'GTL1655 is featured with adjustable edge-rate control (V_{ERC}). Changing V_{ERC} input voltage between GND and V_{CC} adjusts the B-port output rise and fall times. This allows the designer to optimize for various loading conditions.

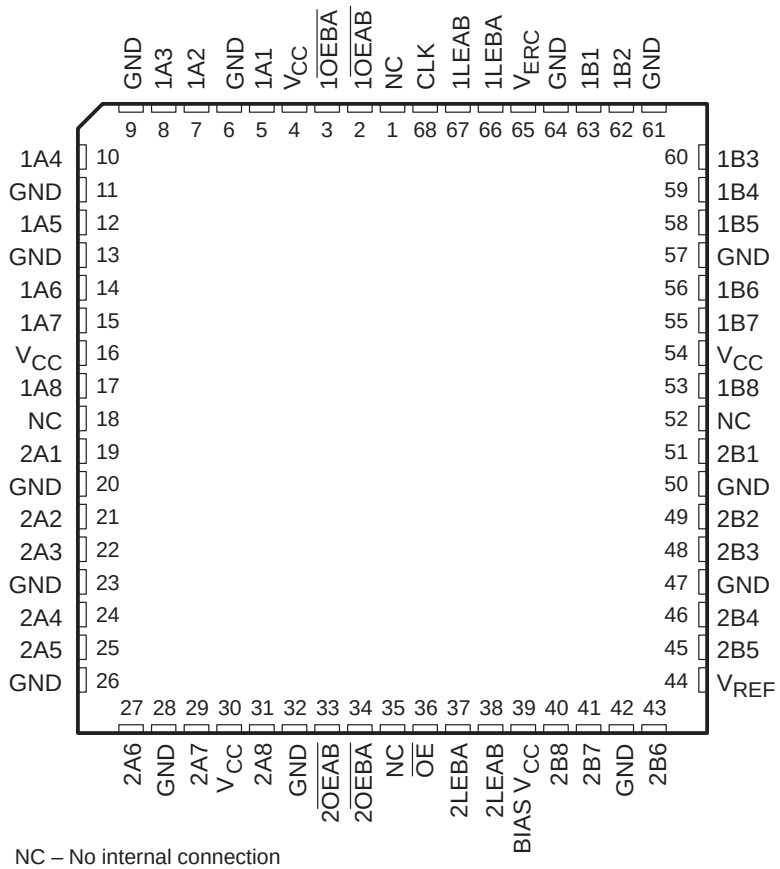
These devices are fully specified for live-insertion applications using I_{off}, power-up 3-state, and BIAS V_{CC}. The I_{off} circuitry disables the outputs, preventing damaging current backflow through the device when it is powered down. The power-up 3-state circuitry places the outputs in the high-impedance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

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; the minimum value of the resistor is determined by the current-sinking capability of the driver.

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

The SN54GTL1655 is characterized for operation over the full military temperature range of –55°C to 125°C. The SN74GTL1655 is characterized for operation from –40°C to 85°C.

SN54GTL1655 . . . HV PACKAGE
(TOP VIEW)



NC – No internal connection

Function Tables

FUNCTION†

INPUTS				OUTPUT B	MODE
$\overline{OEAB}$	LEAB	CLK	A		
H	X	X	X	Z	Isolation
L	H	X	L	L	Transparent
L	H	X	H	H	Transparent
L	L	↑	L	L	Registered
L	L	↑	H	H	Registered
L	L	H	X	B_0‡	Previous State
L	L	L	X	B_0§	Previous State

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

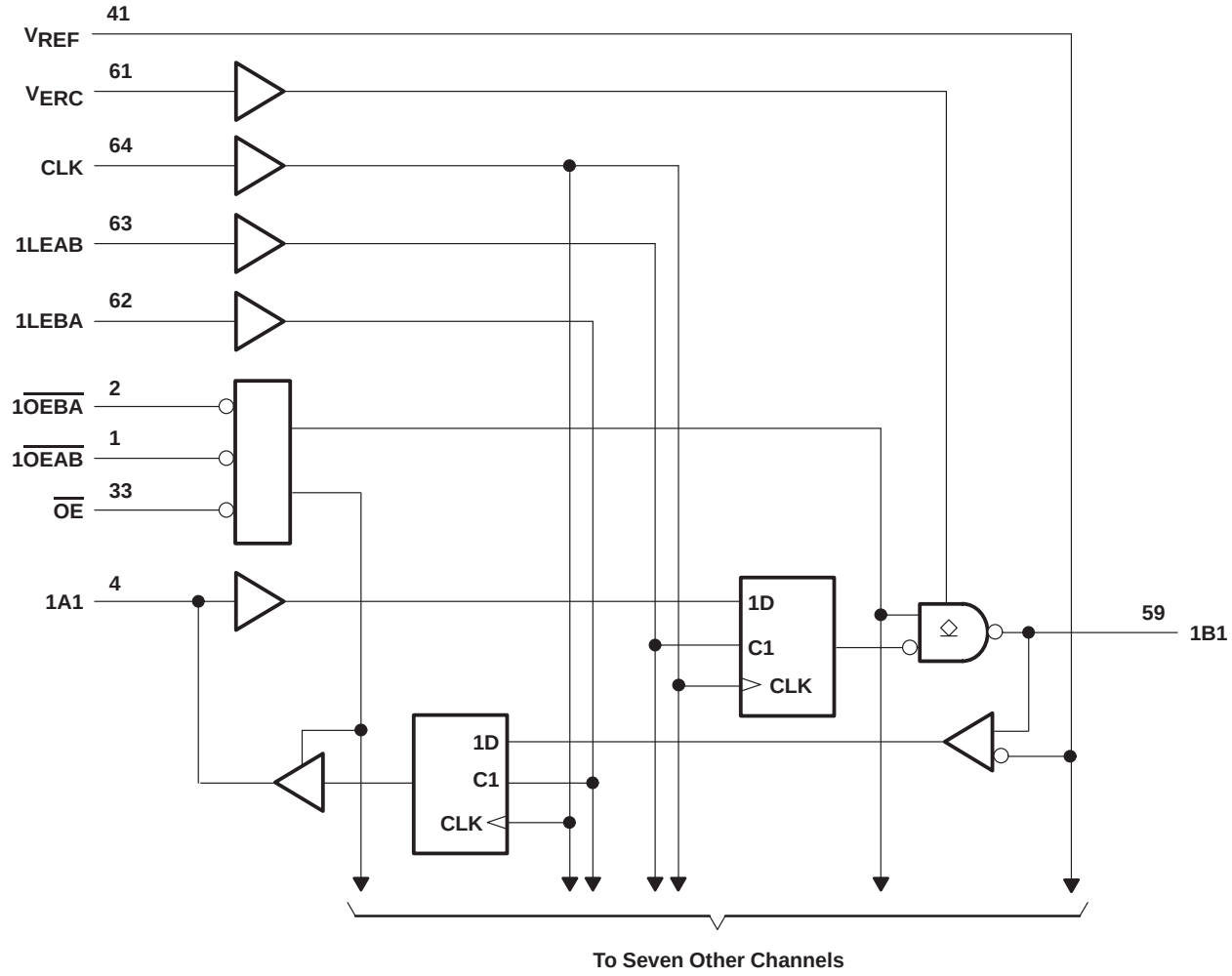
OUTPUT ENABLE

INPUTS			OUTPUTS	
$\overline{OE}$	$\overline{OEAB}$	$\overline{OEBA}$	A PORT	B PORT
L	L	L	Active	Active
L	L	H	Z	Active
L	H	L	Active	Z
L	H	H	Z	Z
H	X	X	Z	Z

B-PORT EDGE-RATE CONTROL (V_{ERC})

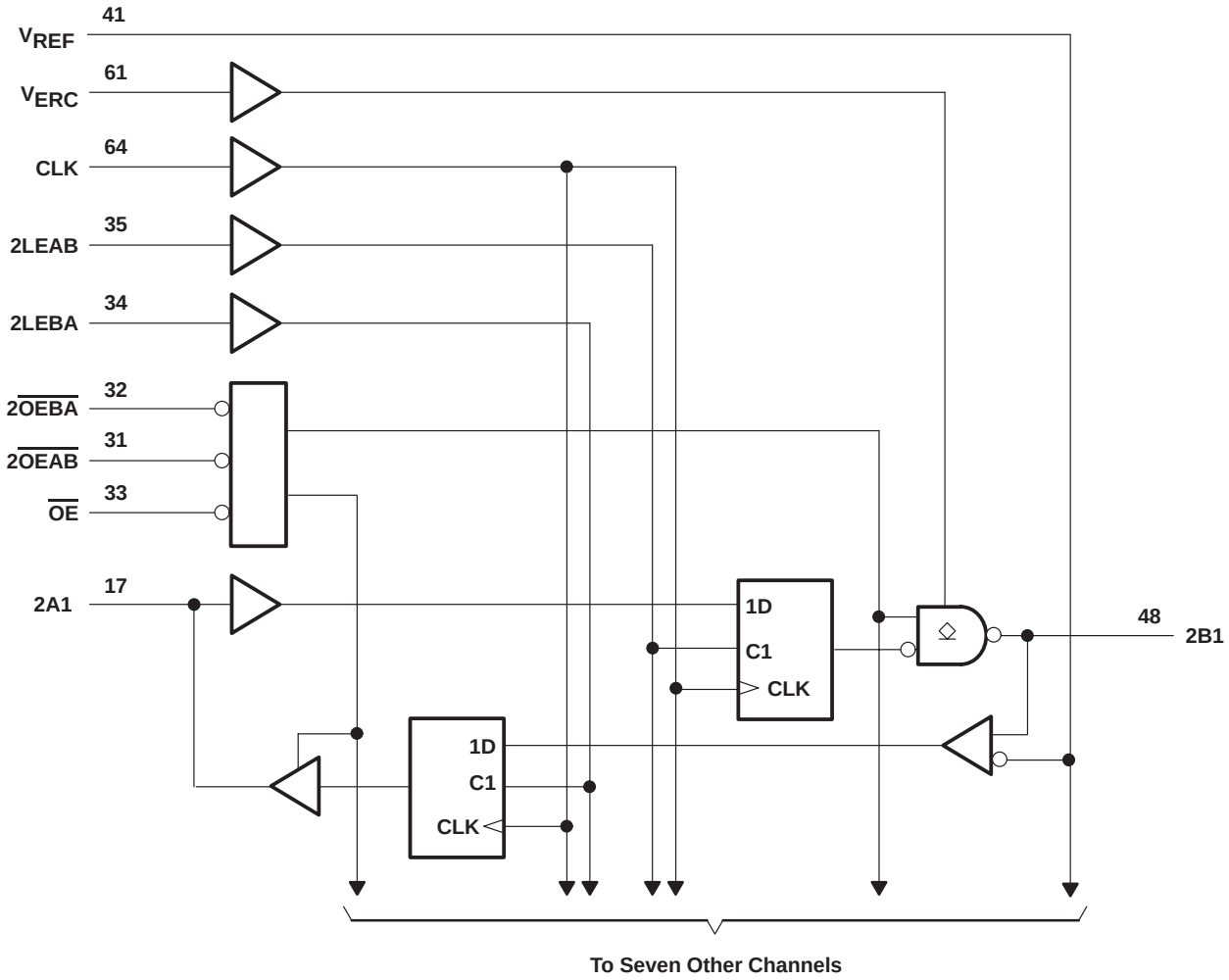
INPUT V_{ERC}		OUTPUT B PORT EDGE RATE
LOGIC LEVEL	NOMINAL VOLTAGE	
H	V_{CC}	Slow
L	GND	Fast

logic diagram (positive logic)



Pin numbers shown are for the DGG package.

logic diagram (positive logic) (continued)



Pin numbers shown are for the DGG package.

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

Supply voltage range, V_{CC}, BIAS V_{CC} . . . . . –0.5 V to 4.6 V
Input voltage range, V_I (see Note 1): A-port and control pins . . . . . –0.5 V to 4.6 V
B port, V_{ERC}, and V_{REF} . . . . . –0.5 V to 4.6 V
Voltage range applied to any output in the high or power-off state, V_O
(see Note 1): A port . . . . . –0.5 V to 4.6 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 . . . . . ±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, θ_{JA} (see Note 3) . . . . . 55°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 Notes 4 through 6)

			SN54GTL1655			SN74GTL1655			UNIT
			MIN	NOM	MAX	MIN	NOM	MAX	
BIAS V_{CC}	Supply voltage		3	3.3	3.6	3	3.3	3.6	V
V_{TT}	Termination voltage	GTL	1.14	1.2	1.26	1.14	1.2	1.26	V
		GTL+	1.35	1.5	1.65	1.35	1.5	1.65	
V_{REF}	Supply voltage	GTL	0.74	0.8	0.87	0.74	0.8	0.87	V
		GTL+	0.87	1	1.1	0.87	1	1.1	
V_I	Input voltage	B port	0		V_{TT}	0		V_{TT}	V
		Except B port	0		V_{CC}	0		V_{CC}	
V_{IH}	High-level input voltage	B port	V_{REF}+50 mV			V_{REF}+50 mV			V
		V_{ERC}	V_{CC}–0.6	V_{CC}		V_{CC}–0.6	V_{CC}		
		Except B port and ERC	2			2			
V_{IL}	Low-level input voltage	B port			V_{REF}–50 mV			V_{REF}–50 mV	V
		V_{ERC}		GND	0.6		GND	0.6	
		Except B port and ERC			0.8			0.8	
I_{IK}	Input clamp current				–18			–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	
$\Delta t/\Delta V_{CC}$	Power-up ramp rate		200			200			µs/V
T_A	Operating free-air temperature		–55		125	–40		85	°C

NOTES: 4. 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.

5. Normal connection sequence is GND first, BIAS V_{CC} = 3.3 V second, and V_{CC} = 3.3 V, I/O, control inputs, V_{TT} and V_{REF} (any order) last. However, if the B-port I/O precharge is not required, the acceptable connection sequence is GND first and V_{CC} = 3.3 V, BIAS V_{CC} = 3.3 V, I/O, control inputs, V_{TT} and V_{REF} (any order) last. When V_{CC} is connected, the BIAS V_{CC} circuitry is disabled.

6. V_{TT} and R_{TT} can be adjusted to accommodate backplane impedances as long as they do not exceed the DC absolute I_{OL} ratings. Similarly, V_{REF} can be adjusted to optimize noise margins, but normally is 2/3 V_{TT}.

electrical characteristics over recommended operating free-air temperature range, V_{REF} = 1 V and V_{TT} = 1.5 V (unless otherwise noted)

PARAMETER		TEST CONDITIONS		SN54GTL1655			SN74GTL1655			UNIT
				MIN	TYP†	MAX	MIN	TYP†	MAX	
V_{IK}		V_{CC} = 3 V,	I_I = –18 mA			–1.2			–1.2	V
V_{OH}	A port	V_{CC} = 3 V to 3.6 V,	I_{OH} = –100 μA	V_{CC}–0.2			V_{CC}–0.2			V
		V_{CC} = 3 V	I_{OH} = –12 mA	2.4			2.4			
			I_{OH} = –24 mA	2.2			2.2			
V_{OL}	A port	V_{CC} = 3 V to 3.6 V,	I_{OL} = 100 μA			0.2			0.2	V
		V_{CC} = 3 V	I_{OL} = 12 mA			0.4			0.4	
			I_{OL} = 24 mA			0.55			0.55	
	B port	V_{CC} = 3 V	I_{OL} = 40 mA			0.2			0.2	
			I_{OL} = 80 mA			0.4			0.4	
			I_{OL} = 100 mA			0.5			0.5	
I_I	Control inputs	V_{CC} = 3.6 V	V_I = V_{CC} or GND			±10			±10	μA
	B port		V_I = V_{TT} or GND			±10			±10	
I_{off}		V_{CC} = 0,	V_I or V_O = 0 to 3.6 V						±100	μA
$I_{I(hold)}$	A port	V_{CC} = 3 V	V_I = 0.8 V	75			75			μA
			V_I = 2 V	–75			–75			
		V_{CC} = 3.6 V‡,	V_I = 0 to V_{CC}			±500			±500	
I_{OZH}	B port	V_{CC} = 3.6 V,	V_O = 1.5 V			10			10	μA
I_{OZL}	B port	V_{CC} = 3.6 V,	V_O = 0.4 V			–10			–10	μA
I_{OZ}§	A port	V_{CC} = 3.6 V,	V_O = V_{CC} or GND			±10			±10	μA
I_{OZPU}	A port	V_{CC} = 0 to 3.6 V, V_O = 0.5 V to 3 V, $\overline{OE}$ = low				±50*			±50	μA
I_{OZPD}	A port	V_{CC} = 3.6 V to 0, V_O = 0.5 V to 3 V, $\overline{OE}$ = low				±50*			±50	μA
I_{CC}	A or B port	V_{CC} = 3.6 V, I_O = 0, V_I = V_{CC} or GND	Outputs high			80			80	mA
			Outputs low			80			80	
			Outputs disabled			80			80	
ΔI_{CC}¶	Except B port	V_{CC} = 3.6 V, A-port or control inputs at V_{CC} or GND, One input at V_{CC} – 0.6 V				1			1	mA
C_i	Control inputs	V_I = V_{CC} or 0			3	5		3	5	pF
C_{io}	A port	V_O = V_{CC} or 0			5	6		5	6	pF
	B port				6	8		6	8	

* On products compliant to MIL-PRF-38535, this parameter is not production tested.
† All typical values are at V_{CC} = 3.3 V, T_A = 25°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.
§ 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 TTL voltage level rather than V_{CC} or GND.

live-insertion specifications over recommended operating free-air temperature range

PARAMETER		TEST CONDITIONS		SN54GTL1655		SN74GTL1655		UNIT
				MIN	MAX	MIN	MAX	
I_{CC} (BIAS V_{CC})		V_{CC} = 0 to 3 V	V (B port) = 0 to 1.2 V, V_I (BIAS V_{CC}) = 3 V to 3.6 V		5		5	mA
		V_{CC} = 3 V to 3.6 V			10		10	µA
V_O	B port	V_{CC} = 0,	V_I (BIAS V_{CC}) = 3.3 V	1	1.2	1	1.2	V
I_O	B port	V_{CC} = 0,	V (B port) = 0.4 V, V_I (BIAS V_{CC}) = 3 V to 3.6 V	–1		–1		µA
		V_{CC} = 0 to 3.6 V,	$\overline{OE}$ = 3.3 V		100		100	
		V_{CC} = 0 to 1.5 V,	$\overline{OE}$ = 0 to 3.3 V		100		100	

timing requirements over recommended ranges of supply voltage and operating free-air temperature, V_{TT} = 1.2 V, V_{REF} = 0.8 V and V_{ERC} = V_{CC} or GND for GTL (unless otherwise noted)

				SN54GTL1655		SN74GTL1655		UNIT
				MIN	MAX	MIN	MAX	
f_{clock}	Clock frequency				160		160	MHz
t_w	Pulse duration	LE high		3		3		ns
		CLK high or low		3		3		
t_{su}	Setup time	Data before CLK↑		2.7		2.7		ns
		Data before LE↓	CLK high	2.8		2.8		
			CLK low	2.6		2.6		
t_h	Hold time	Data after CLK↑		0.4		0.4		ns
		Data after LE↓	CLK high or low	0.9		0.9		

A-to-B switching characteristics over recommended ranges of supply voltage and operating free-air temperature, V_{TT} = 1.2 V, V_{REF} = 0.8 V and V_{ERC} = V_{CC} or GND for GTL (see Figure 1)

PARAMETER	FROM (INPUT)	TO (OUTPUT)	SN54GTL1655		SN74GTL1655		UNIT
			MIN	MAX	MIN	MAX	
f_{max}			160		160		MHz
t_{PLH}	A V_{ERC} = V_{CC}	B	3.1	5.2	3.1	5.2	ns
t_{PHL}			2.6	6.2	2.6	6.2	
t_{PLH}	CLK V_{ERC} = V_{CC}	B	3.4	5.5	3.4	5.5	ns
t_{PHL}			2.4	5.8	2.4	5.8	
t_{PLH}	LEAB V_{ERC} = V_{CC}	B	3.5	5.8	3.5	5.8	ns
t_{PHL}			2.6	6.4	2.6	6.4	
t_{en}	$\overline{OEAB}$ or $\overline{OE}$ V_{ERC} = V_{CC}	B	3.3	5.4	3.3	5.4	ns
t_{dis}			2.7	5.9	2.7	5.9	
t_{PLH}	A V_{ERC} = GND	B	2.3	4.3	2.3	4.3	ns
t_{PHL}			1.9	4.3	1.9	4.3	
t_{PLH}	CLK V_{ERC} = GND	B	2.7	4.8	2.7	4.8	ns
t_{PHL}			1.8	4.3	1.8	4.3	
t_{PLH}	LEAB V_{ERC} = GND	B	2.8	4.9	2.8	4.9	ns
t_{PHL}			2	4.8	2	4.8	
t_{en}	$\overline{OEAB}$ or $\overline{OE}$ V_{ERC} = GND	B	2.5	4.5	2.5	4.5	ns
t_{dis}			2	4.2	2	4.2	
Slew rate (V_{ERC} = V_{CC})	Both transitions, B outputs (0.6 V to 1.3 V)			1		1	ns/V
Slew rate (V_{ERC} = GND)	Both transitions, B outputs (0.6 V to 1.3 V)			1		1	ns/V
$t_{sk(o)}$†	Skew between drivers in the same package (switching in the same direction)			1		1	ns
$t_{sk(o)}$‡	Skew between drivers switching in any direction in the same package			1		1	ns

† Skew values are applicable for through mode only.
‡ Skew values are applicable for CLK mode only, with all outputs switching simultaneously.

B-to-A switching characteristics over recommended ranges of supply voltage and operating free-air temperature, V_{TT} = 1.2 V and V_{REF} = 0.8 V for GTL (see Figure 1)

PARAMETER	FROM (INPUT)	TO (OUTPUT)	SN54GTL1655		SN74GTL1655		UNIT
			MIN	MAX	MIN	MAX	
f_{max}				160		160	MHz
t_{PLH}	B	A	1.8	4.7	1.8	4.7	ns
t_{PHL}			2.3	4.6	2.3	4.6	
t_{PLH}	CLK	A	1.6	4	1.6	4	ns
t_{PHL}			1.5	3.4	1.5	3.4	
t_{PLH}	LEBA	A	1.7	4	1.7	4	ns
t_{PHL}			1.4	3.5	1.4	3.5	
t_{en}	$\overline{OEBA}$ or $\overline{OE}$	A	1.3	4.2	1.3	4.2	ns
t_{dis}			2	6.1	2	6.1	
$t_{sk(o)}$†	Skew between drivers in the same package (switching in the same direction)			1		1	ns
$t_{sk(o)}$‡	Skew between drivers switching in any direction in the same package			1		1	ns

† Skew values are applicable for through mode only.
‡ Skew values are applicable for CLK mode only, with all outputs switching simultaneously.

timing requirements over recommended ranges of supply voltage and operating free-air temperature, V_{TT} = 1.5 V, V_{REF} = 1 V and V_{ERC} = V_{CC} or GND for GTL+ (unless otherwise noted)

				SN54GTL1655		SN74GTL1655		UNIT
				MIN	MAX	MIN	MAX	
f_{clock}	Clock frequency				160		160	MHz
t_w	Pulse duration	LE high		3		3		ns
		CLK high or low		3		3		
t_{su}	Setup time	Data before CLK↑		2.7		2.7		ns
		Data before LE↓	CLK high	2.8		2.8		
			CLK low	2.6		2.6		
t_h	Hold time	Data after CLK↑		0.4		0.4		ns
		Data after LE↓	CLK high or low	0.9		0.9		

A-to-B switching characteristics over recommended ranges of supply voltage and operating free-air temperature, V_{TT} = 1.5 V, V_{REF} = 1 V and V_{ERC} = V_{CC} or GND for GTL+ (see Figure 1)

PARAMETER	FROM (INPUT)	TO (OUTPUT)	SN54GTL1655		SN74GTL1655		UNIT
			MIN	MAX	MIN	MAX	
f_{max}			160		160		MHz
t_{PLH}	A V_{ERC} = V_{CC}	B	3	5.1	3	5.1	ns
t_{PHL}			2.9	6.5	2.9	6.5	
t_{PLH}	CLK V_{ERC} = V_{CC}	B	3.4	5.4	3.4	5.4	ns
t_{PHL}			2.7	6.2	2.7	6.2	
t_{PLH}	LEAB V_{ERC} = V_{CC}	B	3.5	5.7	3.5	5.7	ns
t_{PHL}			2.8	6.7	2.8	6.7	
t_{en}	$\overline{OEAB}$ V_{ERC} = V_{CC}	B	3.3	5.4	3.3	5.4	ns
t_{dis}			3	6.3	3	6.3	
t_{en}	$\overline{OE}$ V_{ERC} = V_{CC}	B	3	5.5	3	5.5	ns
t_{dis}			3.6	5.8	3.6	5.8	
t_{PLH}	A V_{ERC} = GND	B	2.3	4.3	2.3	4.3	ns
t_{PHL}			2	4.4	2	4.4	
t_{PLH}	CLK V_{ERC} = GND	B	2.7	4.8	2.7	4.8	ns
t_{PHL}			1.9	4.5	1.9	4.5	
t_{PLH}	LEAB V_{ERC} = GND	B	2.8	4.9	2.8	4.9	ns
t_{PHL}			2.1	4.9	2.1	4.9	
t_{en}	$\overline{OEAB}$ V_{ERC} = GND	B	2.5	4.5	2.5	4.5	ns
t_{dis}			2.1	4.4	2.1	4.4	
t_{en}	$\overline{OE}$ V_{ERC} = GND	B	2.5	4.6	2.5	4.6	ns
t_{dis}			2.9	4.9	2.9	4.9	
Slew rate (V_{ERC} = V_{CC})	Both transitions, B outputs (0.6 V to 1.3 V)			1		1	ns/V
Slew rate (V_{ERC} = GND)	Both transitions, B outputs (0.6 V to 1.3 V)			1		1	ns/V
$t_{sk(o)}$†	Skew between drivers in the same package (switching in the same direction)			1		1	ns
$t_{sk(o)}$‡	Skew between drivers switching in any direction in the same package			1		1	ns

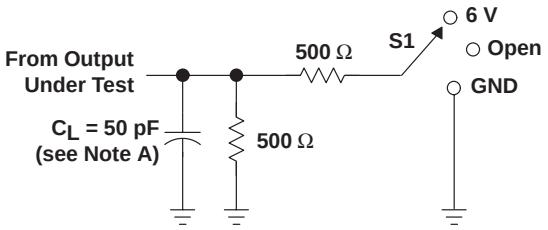
† Skew values are applicable for through mode only.
‡ Skew values are applicable for CLK mode only, with all outputs switching simultaneously.

B-to-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 GTL+ (see Figure 1)

PARAMETER	FROM (INPUT)	TO (OUTPUT)	SN54GTL1655		SN74GTL1655		UNIT
			MIN	MAX	MIN	MAX	
f_{max}			160		160		MHz
t_{PLH}	B	A	2	4.8	2	4.8	ns
t_{PHL}			2.4	4.7	2.4	4.7	
t_{PLH}	CLK	A	1.6	4.4	1.6	4.4	ns
t_{PHL}			1.5	3.4	1.5	3.4	
t_{PLH}	LEBA	A	1.7	4	1.7	4	ns
t_{PHL}			1.4	3.5	1.4	3.5	
t_{en}	$\overline{OEBA}$	A	1.3	4.2	1.3	4.2	ns
t_{dis}			2	6.1	2	6.1	
t_{en}	$\overline{OE}$	A	2.2	4.7	2.2	4.7	ns
t_{dis}			4.1	6.3	4.1	6.3	
$t_{sk(o)}$†	Skew between drivers in the same package (switching in the same direction)			1		1	ns
$t_{sk(o)}$‡	Skew between drivers switching in any direction in the same package			1		1	ns

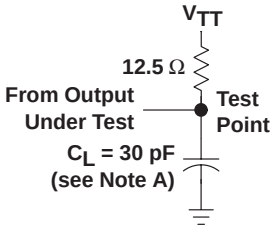
† Skew values are applicable for through mode only.
‡ Skew values are applicable for CLK mode only, with all outputs switching simultaneously.

PARAMETER MEASUREMENT INFORMATION

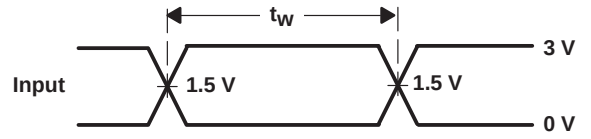


TEST	S1
t_{PLH}/t_{PHL}	Open
t_{PLZ}/t_{PZL}	6 V
t_{PHZ}/t_{PZH}	GND

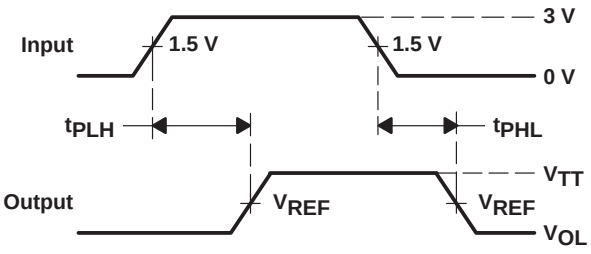
LOAD CIRCUIT FOR A OUTPUTS



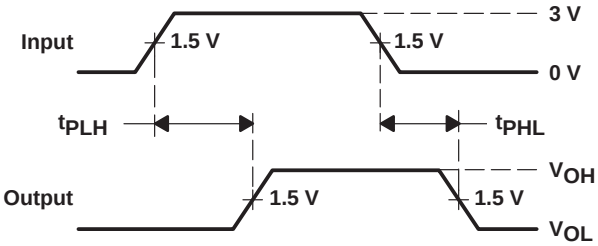
LOAD CIRCUIT FOR B OUTPUTS



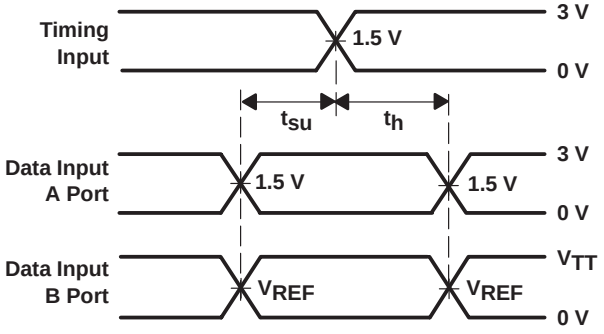
VOLTAGE WAVEFORMS
PULSE DURATION



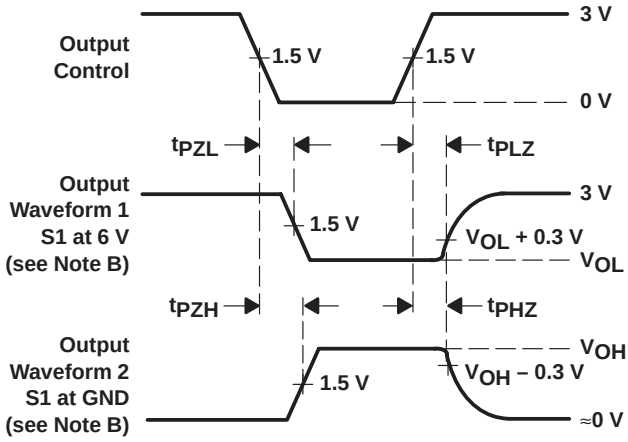
VOLTAGE WAVEFORMS
PROPAGATION DELAY TIMES
(CLK to B port)



VOLTAGE WAVEFORMS
PROPAGATION DELAY TIMES
(CLK to A port)



VOLTAGE WAVEFORMS
SETUP AND HOLD TIMES



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 ≤ 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}.

Figure 1. Load Circuits and Voltage Waveforms

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