

## FEATURES

- Member of the Texas Instruments Widebus™ Family
- UBT™ Transceiver Combines D-Type Latches and D-Type Flip-Flops for Operation in Transparent, Latched, or Clocked Modes
- OEC™ Circuitry Improves Signal Integrity and Reduces Electromagnetic Interference
- Translates Between GTL/GTL+ Signal Level and LVTTTL 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 Pins Minimize High-Speed Switching Noise

## DESCRIPTION/ORDERING INFORMATION

The SN74GTL1655 is a high-drive (100 mA), low-output-impedance (12 Ω) 16-bit UBT™ transceiver that provides LVTTTL-to-GTL/GTL+ and GTL/GTL+-to-LVTTTL signal-level translation. This device is partitioned as two 8-bit transceivers and combines D-type flip-flops and D-type latches to allow for transparent, latched, and clocked modes of data transfer similar to the '16501 function. This device provides an interface between cards operating at LVTTTL 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 OEC™ circuitry. The high drive is suitable for driving double-terminated low-impedance backplanes using incident-wave switching.

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 LVTTTL logic levels, but are not 5-V tolerant.  $V_{REF}$  is the reference input voltage for the B port.

**DGG PACKAGE  
(TOP VIEW)**

1OEAB	1	64	CLK
1OEBA	2	63	1LEAB
$V_{CC}$	3	62	1LEBA
1A1	4	61	$V_{ERC}$
GND	5	60	GND
1A2	6	59	1B1
1A3	7	58	1B2
GND	8	57	GND
1A4	9	56	1B3
GND	10	55	1B4
1A5	11	54	1B5
GND	12	53	GND
1A6	13	52	1B6
1A7	14	51	1B7
$V_{CC}$	15	50	$V_{CC}$
1A8	16	49	1B8
2A1	17	48	2B1
GND	18	47	GND
2A2	19	46	2B2
2A3	20	45	2B3
GND	21	44	GND
2A4	22	43	2B4
2A5	23	42	2B5
GND	24	41	$V_{REF}$
2A6	25	40	2B6
GND	26	39	GND
2A7	27	38	2B7
$V_{CC}$	28	37	2B8
2A8	29	36	BIAS $V_{CC}$
GND	30	35	2LEAB
2OEAB	31	34	2LEBA
2OEBA	32	33	OE



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# SN74GTL1655

## 16-BIT LVTTL-TO-GTL/GTL+ UNIVERSAL BUS TRANSCEIVER WITH LIVE INSERTION

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### DESCRIPTION/ORDERING INFORMATION (CONTINUED)

This device is partitioned uniquely 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 (LEAB and LEBA), output enables ( $\overline{OEAB}$  and  $\overline{OEBA}$ ), and clock (CLK). The output enables ( $1\overline{OEAB}$ ,  $1\overline{OEBA}$ ,  $2\overline{OEAB}$ , and  $2\overline{OEBA}$ ) 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  $\overline{OEAB}$  is low, the outputs are active. With  $\overline{OEAB}$  high, the outputs are in the high-impedance state.

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

The SN74GTL1655 has 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.

This device is 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,  $\overline{OE}$  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.

### ORDERING INFORMATION

$T_A$	PACKAGE <sup>(1)</sup>		ORDERABLE PART NUMBER	TOP-SIDE MARKING
–40°C to 85°C	TSSOP – DGG	Tape and reel	SN74GTL1655DGGR	GTL1655

(1) 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).

## FUNCTION TABLES

### FUNCTION<sup>(1)</sup>

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 <sub>0</sub> <sup>(2)</sup>	Previous state
L	L	L	X	B <sub>0</sub> <sup>(3)</sup>	Previous state

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

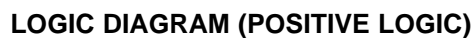
### OUTPUT ENABLE

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

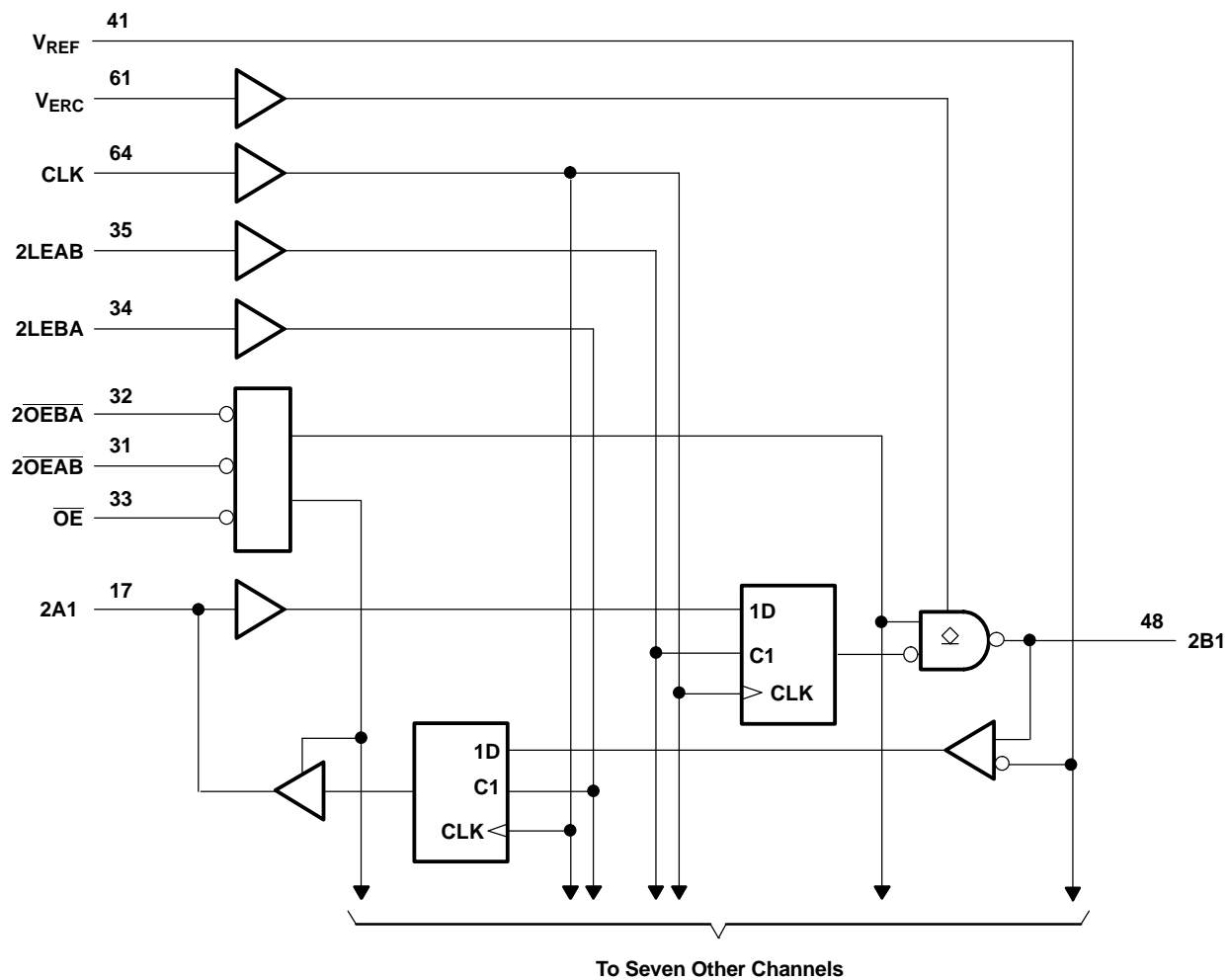
### B-PORT EDGE-RATE CONTROL (V<sub>ERC</sub>)

input V <sub>ERC</sub>		OUTPUT B-PORT EDGE RATE
LOGIC LEVEL	NOMINAL VOLTAGE	
H	V <sub>CC</sub>	Slow
L	GND	Fast

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LOGIC DIAGRAM (POSITIVE LOGIC) (CONTINUED)



# SN74GTL1655

## 16-BIT LVTTTL-TO-GTL/GTL+ UNIVERSAL BUS TRANSCEIVER

### WITH LIVE INSERTION

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#### Absolute Maximum Ratings<sup>(1)</sup>

over operating free-air temperature range (unless otherwise noted)

		MIN	MAX	UNIT
$V_{CC}$ BIAS $V_{CC}$	Supply voltage range	–0.5	4.6	V
$V_I$	Input voltage range <sup>(2)</sup>	A-port and control inputs		–0.5 4.6
		B port, $V_{ERC}$ , and $V_{REF}$		–0.5 4.6
$V_O$	Voltage range applied to any output in the high or power-off state <sup>(2)</sup>	A port		–0.5 4.6
		B port		–0.5 4.6
$I_O$	Current into any output in the low state	A port		48
		B port		200
$I_O$	Current into any A-port output in the high state <sup>(3)</sup>			48
	Continuous current through each $V_{CC}$ or GND			±100
$I_{IK}$	Input clamp current	$V_I < 0$		–50
$I_{OK}$	Output clamp current	$V_O < 0$		–50
$\theta_{JA}$	Package thermal impedance <sup>(4)</sup>			55
$T_{stg}$	Storage temperature range	–65	150	°C

- (1) 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.
- (2) The input and output negative-voltage ratings may be exceeded if the input and output clamp-current ratings are observed.
- (3) The current flows only when the output is in the high state and  $V_O > V_{CC}$ .
- (4) The package thermal impedance is calculated in accordance with JESD 51-7.

#### Recommended Operating Conditions<sup>(1)(2)(3)(4)</sup>

			MIN	NOM	MAX	UNIT
BIAS $V_{CC}$	Supply voltage		3	3.3	3.6	V
$V_{TT}$	Termination voltage	GTL	1.14	1.2	1.26	V
		GTL+	1.35	1.5	1.65	
$V_{REF}$	Reference voltage	GTL	0.74	0.8	0.87	V
		GTL+	0.87	1	1.1	
$V_I$	Input voltage	B port	0		$V_{TT}$	V
		Except B port	0		$V_{CC}$	
$V_{IH}$	High-level input voltage	B port	$V_{REF} + 50 \text{ mV}$			V
		$V_{ERC}$	$V_{CC} - 0.6$	$V_{CC}$		
		Except B port and ERC	2			
$V_{IL}$	Low-level input voltage	B port	$V_{REF} - 50 \text{ mV}$			V
		$V_{ERC}$	GND 0.6			
		Except B port and 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			
$\Delta t/\Delta V_{CC}$	Power-up ramp rate		200			$\mu\text{s/V}$
$T_A$	Operating free-air temperature		-40 85			$^{\circ}\text{C}$

- (1) 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.
- (2) Normal connection sequence is GND first, BIAS  $V_{CC} = 3.3 \text{ V}$  second, and  $V_{CC} = 3.3 \text{ V}$ , 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  $V_{CC} = 3.3 \text{ V}$ , BIAS  $V_{CC} = 3.3 \text{ V}$ , I/O, control inputs,  $V_{TT}$  and  $V_{REF}$  (any order) last. When  $V_{CC}$  is connected, the BIAS  $V_{CC}$  circuitry is disabled.
- (3)  $V_{TT}$  and  $R_{TT}$  can be adjusted to accommodate backplane impedances if the dc recommended  $I_{OL}$  ratings are not exceeded.
- (4)  $V_{REF}$  can be adjusted to optimize noise margins, but normally is two-thirds  $V_{TT}$ .

## Electrical Characteristics

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

PARAMETER		TEST CONDITIONS		MIN	TYP <sup>(1)</sup>	MAX	UNIT
$V_{IK}$		$V_{CC} = 3\text{ V}$ ,	$I_I = -18\text{ mA}$			-1.2	V
$V_{OH}$	A port	$V_{CC} = 3\text{ V to } 3.6\text{ V}$ ,	$I_{OH} = -100\text{ }\mu\text{A}$	$V_{CC} - 0.2$			V
		$V_{CC} = 3\text{ V}$	$I_{OH} = -12\text{ mA}$	2.4			
			$I_{OH} = -24\text{ mA}$	2.2			
$V_{OL}$	A port	$V_{CC} = 3\text{ V to } 3.6\text{ V}$ ,	$I_{OL} = 100\text{ }\mu\text{A}$			0.2	V
		$V_{CC} = 3\text{ V}$	$I_{OL} = 12\text{ mA}$			0.4	
			$I_{OL} = 24\text{ mA}$			0.55	
	B port	$V_{CC} = 3\text{ V}$	$I_{OL} = 40\text{ mA}$			0.2	
			$I_{OL} = 80\text{ mA}$			0.4	
			$I_{OL} = 100\text{ mA}$			0.5	
$I_I$	Control inputs	$V_{CC} = 3.6\text{ V}$	$V_I = V_{CC}$ or GND			$\pm 10$	$\mu\text{A}$
	B port		$V_I = V_{TT}$ or GND			$\pm 10$	
$I_{off}$		$V_{CC} = 0$ ,	$V_I$ or $V_O = 0\text{ to } 3.6\text{ V}$			$\pm 100$	$\mu\text{A}$
$I_{I(hold)}$	A port	$V_{CC} = 3\text{ V}$	$V_I = 0.8\text{ V}$	75			$\mu\text{A}$
			$V_I = 2\text{ V}$	-75			
		$V_{CC} = 3.6\text{ V}^{(2)}$ ,	$V_I = 0\text{ to } V_{CC}$			$\pm 500$	
$I_{OZH}$	B port	$V_{CC} = 3.6\text{ V}$ ,	$V_O = 1.5\text{ V}$			10	$\mu\text{A}$
$I_{OZL}$	B port	$V_{CC} = 3.6\text{ V}$ ,	$V_O = 0.4\text{ V}$			-10	$\mu\text{A}$
$I_{OZ}^{(3)}$	A port	$V_{CC} = 3.6\text{ V}$ ,	$V_O = V_{CC}$ or GND			$\pm 10$	$\mu\text{A}$
$I_{OZPU}$	A port	$V_{CC} = 0\text{ to } 3.6\text{ V}$ , $V_O = 0.5\text{ V to } 3\text{ V}$ , $\overline{OE} = \text{low}$				$\pm 50$	$\mu\text{A}$
$I_{OZPD}$	A port	$V_{CC} = 3.6\text{ V to } 0$ , $V_O = 0.5\text{ V to } 3\text{ V}$ , $\overline{OE} = \text{low}$				$\pm 50$	$\mu\text{A}$
$I_{CC}$	A or B port	$V_{CC} = 3.6\text{ V}$ , $I_O = 0$ , $V_I = V_{CC}$ or GND	Outputs high			80	mA
			Outputs low			80	
			Outputs disabled			80	
$\Delta I_{CC}^{(4)}$	Except B port	$V_{CC} = 3.6\text{ V}$ , A-port or control inputs at $V_{CC}$ or GND, One input at $V_{CC} - 0.6\text{ V}$				1	mA
$C_i$	Control inputs	$V_I = V_{CC}$ or 0			3	5	pF
$C_{io}$	A port	$V_O = V_{CC}$ or 0			5	6	pF
	B port				6	8	

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

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

(3) For I/O ports, the parameter  $I_{OZ}$  includes the input leakage current.

(4) 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		MIN	MAX	UNIT
$I_{CC}$ (BIAS $V_{CC}$ )		$V_{CC} = 0\text{ to } 3\text{ V}$	$V_O$ (B port) = 0 to 1.2 V, $V_I$ (BIAS $V_{CC}$ ) = 3 V to 3.6 V		5	mA
		$V_{CC} = 3\text{ V to } 3.6\text{ V}$			10	
$V_O$	B port	$V_{CC} = 0$ ,	$V_I$ (BIAS $V_{CC}$ ) = 3.3 V	1	1.2	V
$I_O$	B port	$V_{CC} = 0$ ,	$V_O$ (B port) = 0.4 V, $V_I$ (BIAS $V_{CC}$ ) = 3 V to 3.6 V	-1		$\mu\text{A}$
		$V_{CC} = 0\text{ to } 3.6\text{ V}$ ,	$\overline{OE} = 3.3\text{ V}$		100	
		$V_{CC} = 0\text{ to } 1.5\text{ V}$ ,	$\overline{OE} = 0\text{ to } 3.3\text{ V}$		100	

# SN74GTL1655

## 16-BIT LVTTTL-TO-GTL/GTL+ UNIVERSAL BUS TRANSCEIVER

### WITH LIVE INSERTION

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## Timing Requirements

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

			MIN	MAX	UNIT
$f_{\text{clock}}$	Clock frequency			160	MHz
$t_w$	Pulse duration	LE high	3		ns
		CLK high or low	3		
$t_{\text{su}}$	Setup time	Data before CLK $\uparrow$	2.7		ns
		Data before LE $\downarrow$	CLK high	2.8	
			CLK low	2.6	
$t_h$	Hold time	Data after CLK $\uparrow$	0.4		ns
		Data after LE $\downarrow$	CLK high or low	0.9	

## A-to-B Switching Characteristics

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

PARAMETER		FROM (INPUT)	TO (OUTPUT)	MIN	TYP	MAX	UNIT
f <sub>max</sub>				160			MHz
t <sub>PLH</sub>		A V <sub>ERC</sub> = V <sub>CC</sub>	B	3.1		5.2	ns
t <sub>PHL</sub>				2.6		6.2	
t <sub>PLH</sub>		CLK V <sub>ERC</sub> = V <sub>CC</sub>	B	3.4		5.5	ns
t <sub>PHL</sub>				2.4		5.8	
t <sub>PLH</sub>		LEAB V <sub>ERC</sub> = V <sub>CC</sub>	B	3.5		5.8	ns
t <sub>PHL</sub>				2.6		6.4	
t <sub>en</sub>		$\overline{\text{OEAB}}$ or $\overline{\text{OE}}$ V <sub>ERC</sub> = V <sub>CC</sub>	B	3.3		5.4	ns
t <sub>dis</sub>				2.7		5.9	
t <sub>PLH</sub>		A V <sub>ERC</sub> = GND	B	2.3		4.3	ns
t <sub>PHL</sub>				1.9		4.3	
t <sub>PLH</sub>		CLK V <sub>ERC</sub> = GND	B	2.7		4.8	ns
t <sub>PHL</sub>				1.8		4.3	
t <sub>PLH</sub>		LEAB V <sub>ERC</sub> = GND	B	2.8		4.9	ns
t <sub>PHL</sub>				2		4.8	
t <sub>en</sub>		$\overline{\text{OEAB}}$ or $\overline{\text{OE}}$ V <sub>ERC</sub> = GND	B	2.5		4.5	ns
t <sub>dis</sub>				2		4.2	
t <sub>r</sub>	V <sub>ERC</sub> = GND	Transition time, B outputs (0.6 V to 1 V)			0.6		ns
	V <sub>ERC</sub> = V <sub>CC</sub>				1.2		
t <sub>f</sub>	V <sub>ERC</sub> = GND	Transition time, B outputs (1 V to 0.6 V)			1.1		ns
	V <sub>ERC</sub> = V <sub>CC</sub>				1.7		
t <sub>sk(o)</sub> <sup>(1)</sup>		Skew between drivers in the same package switching in the same direction			1		ns
t <sub>sk(o)</sub> <sup>(2)</sup>		Skew between drivers switching in any direction in the same package			1		ns

(1) Skew values are applicable for through mode only.

(2) 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,  
 $V_{TT} = 1.2\text{ V}$  and  $V_{REF} = 0.8\text{ V}$  for GTL (see Figure 1)

PARAMETER	FROM (INPUT)	TO (OUTPUT)	MIN	MAX	UNIT
f <sub>max</sub>			160		MHz
t <sub>PLH</sub>	B	A	1.8	4.7	ns
t <sub>PHL</sub>			2.3	4.6	
t <sub>PLH</sub>	CLK	A	1.6	4	ns
t <sub>PHL</sub>			1.5	3.4	
t <sub>PLH</sub>	LEBA	A	1.7	4	ns
t <sub>PHL</sub>			1.4	3.5	
t <sub>en</sub>	$\overline{OEBA}$ or $\overline{OE}$	A	1.2	4.2	ns
t <sub>dis</sub>			1.2	6.1	
t <sub>sk(o)</sub> <sup>(1)</sup>	Skew between drivers in the same package switching in the same direction			1	ns
t <sub>sk(o)</sub> <sup>(2)</sup>	Skew between drivers switching in any direction in the same package			1	ns

(1) Skew values are applicable for through mode only.

(2) Skew values are applicable for CLK mode only, with all outputs switching simultaneously.

# SN74GTL1655

## 16-BIT LVTTTL-TO-GTL/GTL+ UNIVERSAL BUS TRANSCEIVER

### WITH LIVE INSERTION

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## Timing Requirements

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

			MIN	MAX	UNIT
$f_{\text{clock}}$	Clock frequency			160	MHz
$t_w$	Pulse duration	LE high	3		ns
		CLK high or low	3		
$t_{\text{su}}$	Setup time	Data before CLK $\uparrow$	2.7		ns
		Data before LE $\downarrow$	CLK high	2.8	
			CLK low	2.6	
$t_h$	Hold time	Data after CLK $\uparrow$	0.4		ns
		Data after LE $\downarrow$	CLK high or low	0.9	

## A-to-B Switching Characteristics

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

PARAMETER	FROM (INPUT)	TO (OUTPUT)	MIN	TYP	MAX	UNIT
$f_{\text{max}}$			160			MHz
$t_{\text{PLH}}$	A $V_{ERC} = V_{CC}$	B	3		5.1	ns
$t_{\text{PHL}}$			2.9		6.5	
$t_{\text{PLH}}$	CLK $V_{ERC} = V_{CC}$	B	3.4		5.4	ns
$t_{\text{PHL}}$			2.7		6.2	
$t_{\text{PLH}}$	LEAB $V_{ERC} = V_{CC}$	B	3.5		5.7	ns
$t_{\text{PHL}}$			2.8		6.7	
$t_{\text{en}}$	$\overline{\text{OEAB}}$ $V_{ERC} = V_{CC}$	B	3.3		5.4	ns
$t_{\text{dis}}$			3		6.3	
$t_{\text{en}}$	$\overline{\text{OE}}$ $V_{ERC} = V_{CC}$	B	3		5.5	ns
$t_{\text{dis}}$			3.6		5.8	
$t_{\text{PLH}}$	A $V_{ERC} = \text{GND}$	B	2.3		4.3	ns
$t_{\text{PHL}}$			2		4.4	
$t_{\text{PLH}}$	CLK $V_{ERC} = \text{GND}$	B	2.7		4.8	ns
$t_{\text{PHL}}$			1.9		4.5	
$t_{\text{PLH}}$	LEAB $V_{ERC} = \text{GND}$	B	2.8		4.9	ns
$t_{\text{PHL}}$			2.1		4.9	
$t_{\text{en}}$	$\overline{\text{OEAB}}$ $V_{ERC} = \text{GND}$	B	2.5		4.5	ns
$t_{\text{dis}}$			2.1		4.4	
$t_{\text{en}}$	$\overline{\text{OE}}$ $V_{ERC} = \text{GND}$	B	2.5		4.6	ns
$t_{\text{dis}}$			2.9		4.9	
$t_r$	$V_{ERC} = \text{GND}$	Transition time, B outputs (0.6 V to 1.3 V)		0.9		ns
	$V_{ERC} = V_{CC}$			1.7		
$t_f$	$V_{ERC} = \text{GND}$	Transition time, B outputs (1.3 V to 0.6 V)		1.6		ns
	$V_{ERC} = V_{CC}$			2.4		
$t_{\text{sk(o)}}^{(1)}$		Skew between drivers in the same package switching in the same direction			1	ns
$t_{\text{sk(o)}}^{(2)}$		Skew between drivers switching in any direction in the same package			1	ns

(1) Skew values are applicable for through mode only.

(2) Skew values are applicable for CLK mode only, with all outputs switching simultaneously.

## B-to-A Switching Characteristics

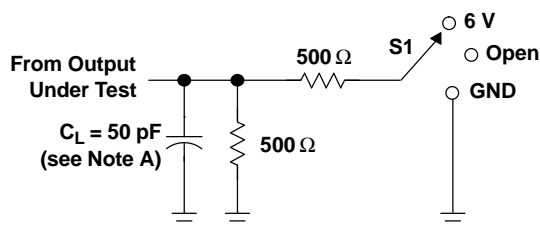
over recommended ranges of supply voltage and operating free-air temperature,  
 $V_{TT} = 1.5\text{ V}$  and  $V_{REF} = 1\text{ V}$  for GTL+ (see Figure 1)

PARAMETER	FROM (INPUT)	TO (OUTPUT)	MIN	MAX	UNIT
f <sub>max</sub>			160		MHz
t <sub>PLH</sub>	B	A	2	4.8	ns
t <sub>PHL</sub>			2.4	4.7	
t <sub>PLH</sub>	CLK	A	1.6	4.4	ns
t <sub>PHL</sub>			1.5	3.4	
t <sub>PLH</sub>	LEBA	A	1.7	4	ns
t <sub>PHL</sub>			1.4	3.5	
t <sub>en</sub>	OEBA	A	1.2	4.2	ns
t <sub>dis</sub>			1.2	6.1	
t <sub>en</sub>	OE	A	1.2	4.7	ns
t <sub>dis</sub>			1.2	6.3	
t <sub>sk(o)</sub> <sup>(1)</sup>	Skew between drivers in the same package switching in the same direction		1		ns
t <sub>sk(o)</sub> <sup>(2)</sup>	Skew between drivers switching in any direction in the same package		1		ns

(1) Skew values are applicable for through mode only.

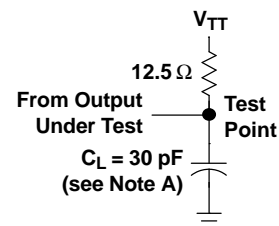
(2) Skew values are applicable for CLK mode only, with all outputs switching simultaneously.

## PARAMETER MEASUREMENT INFORMATION

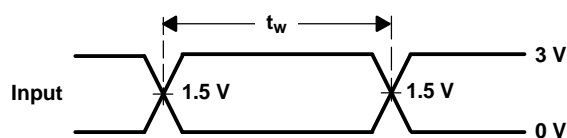


LOAD CIRCUIT FOR A OUTPUTS

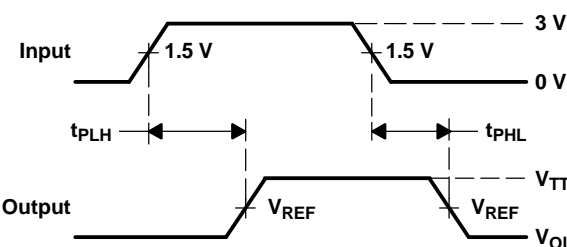
TEST	S1
$t_{PLH}/t_{PHL}$	Open
$t_{PLZ}/t_{PZL}$	6 V
$t_{PHZ}/t_{PZH}$	GND



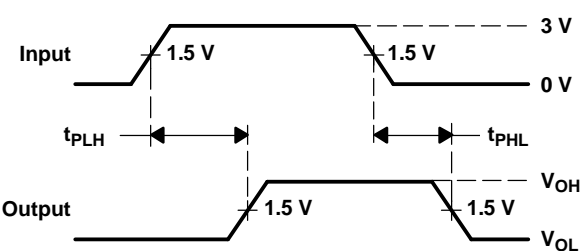
LOAD CIRCUIT FOR B OUTPUTS



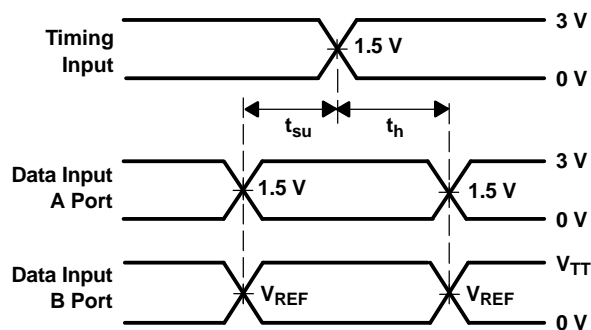
VOLTAGE WAVEFORMS  
PULSE DURATION



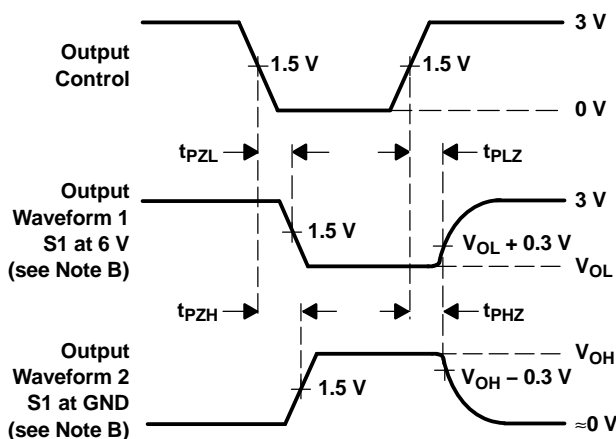
VOLTAGE WAVEFORMS  
PROPAGATION DELAY TIMES  
(CLK to B port)



VOLTAGE WAVEFORMS  
PROPAGATION DELAY TIMES  
(CLK to A port)



VOLTAGE WAVEFORMS  
SETUP AND HOLD TIMES



VOLTAGE WAVEFORMS  
ENABLE AND DISABLE TIMES  
(A port)

- NOTES:
- $C_L$  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:  $PRR \leq 10 \text{ MHz}$ ,  $Z_O = 50 \Omega$ ,  $t_r \leq 2.5 \text{ ns}$ ,  $t_f \leq 2.5 \text{ ns}$ .
  - The outputs are measured one at a time, with one transition per measurement.
  - $t_{PLZ}$  and  $t_{PHZ}$  are the same as  $t_{dis}$ .
  - $t_{PZL}$  and  $t_{PZH}$  are the same as  $t_{en}$ .

Figure 1. Load Circuits and Voltage Waveforms

## PACKAGING INFORMATION

Orderable Device	Status <sup>(1)</sup>	Package Type	Package Drawing	Pins	Package Qty	Eco Plan <sup>(2)</sup>	Lead/Ball Finish	MSL Peak Temp <sup>(3)</sup>
SN74GTL1655DGGR	ACTIVE	TSSOP	DGG	64	2000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
SN74GTL1655DGGRE4	ACTIVE	TSSOP	DGG	64	2000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
SN74GTL1655DGGRG4	ACTIVE	TSSOP	DGG	64	2000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM

<sup>(1)</sup> 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.

<sup>(2)</sup> 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.

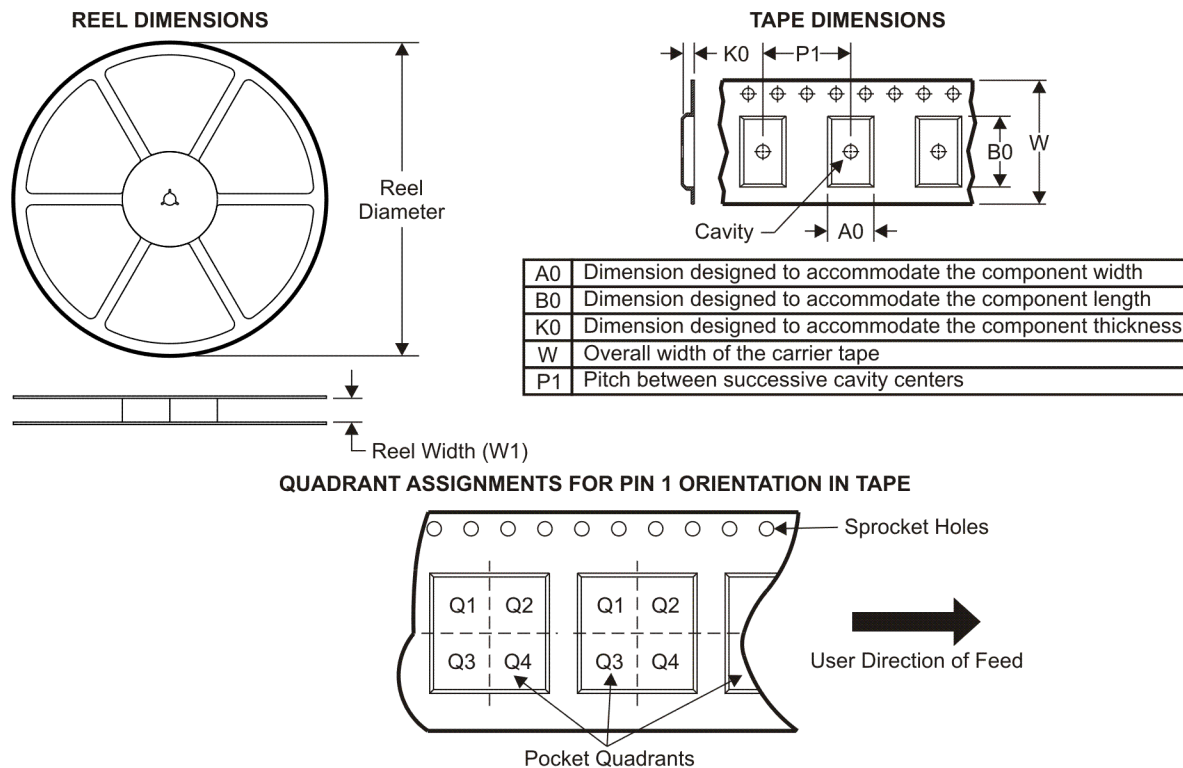
**Green (RoHS & no Sb/Br):** TI defines "Green" to mean Pb-Free (RoHS compatible), and free of Bromine (Br) and Antimony (Sb) based flame retardants (Br or Sb do not exceed 0.1% by weight in homogeneous material)

<sup>(3)</sup> MSL, Peak Temp. -- The Moisture Sensitivity Level rating according to the JEDEC industry standard classifications, and peak solder temperature.

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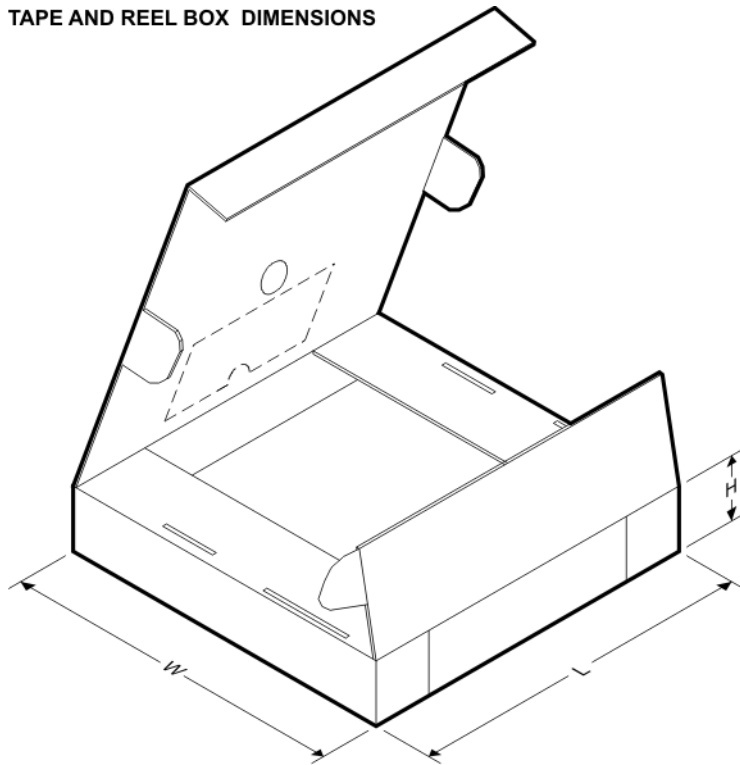
## TAPE AND REEL INFORMATION



\*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
SN74GTL1655DGGR	TSSOP	DGG	64	2000	330.0	24.4	8.4	17.3	1.7	12.0	24.0	Q1

## TAPE AND REEL BOX DIMENSIONS



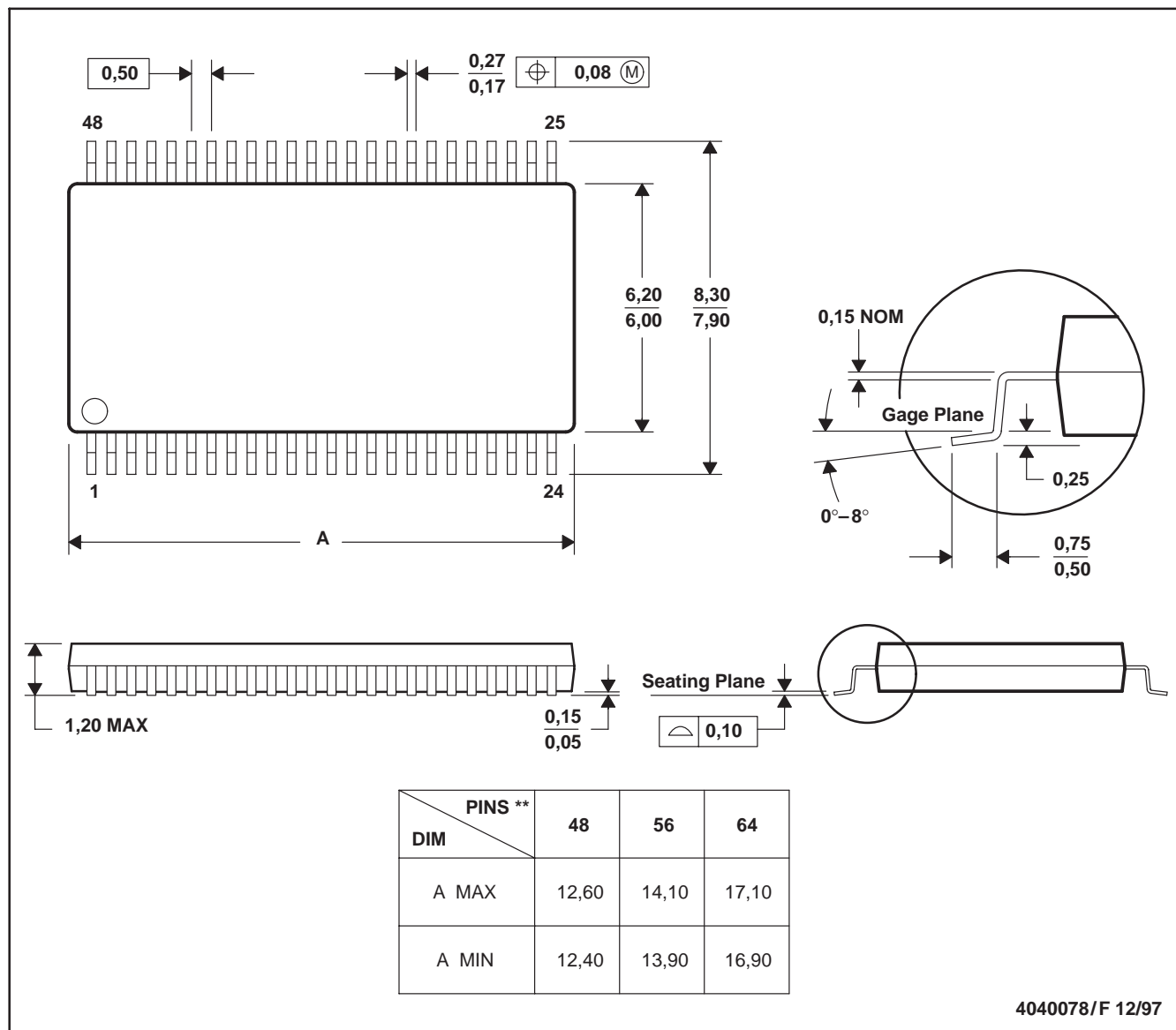
\*All dimensions are nominal

Device	Package Type	Package Drawing	Pins	SPQ	Length (mm)	Width (mm)	Height (mm)
SN74GTL1655DGGR	TSSOP	DGG	64	2000	346.0	346.0	41.0

## DGG (R-PDSO-G\*\*)

## PLASTIC SMALL-OUTLINE PACKAGE

48 PINS SHOWN



- NOTES: A. All linear dimensions are in millimeters.  
 B. This drawing is subject to change without notice.  
 C. Body dimensions do not include mold protrusion not to exceed 0,15.  
 D. Falls within JEDEC MO-153

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