

SN74GTL2014 4-Channel LVTTL to GTL Transceiver

1 Features

- Operates as a GTL–/GTL/GTL+ to LVTTL or LVTTL to GTL–/GTL/GTL+ Translator
- The LVTTL Inputs are Tolerant up to 5.5 V Allowing Direct Access to TTL or 5 V CMOS
- The GTL Input/Output Operate up to 3.6 V, Allowing the Device to be Used in High Voltage Open-Drain Applications
- VREF Goes Down to 0.5 V for Low Voltage CPU Usage
- Partial Power-Down Permitted
- Latch-up Protection Exceed 500 mA per JESD78
- Package Option: TSSOP14
- –40°C to 85°C Operating Temperature Range
- ESD Protection on All Terminals
 - 2000 V HBM, JESD22-A114
 - 1000 V CDM, IEC61000-4-2

2 Applications

- Server
- Base Station
- Wireline Communication

3 Description

The SN74GTL2014 is a 4-channel translator to interface between 3.3-V LVTTL chip set I/O and Xeon processor GTL–/GTL/GTL+ I/O.

The SN74GTL2014 integrates ESD protection cells on all terminals and is available in a TSSOP package (5.0 mm × 4.4 mm). The device is characterized over the free air temperature range of –40°C to 85°C.

Device Information⁽¹⁾

PART NUMBER	PACKAGE	BODY SIZE (NOM)
SN74GTL2014	TSSOP (14)	5.00 mm × 4.40 mm

(1) For all available packages, see the orderable addendum at the end of the data sheet.

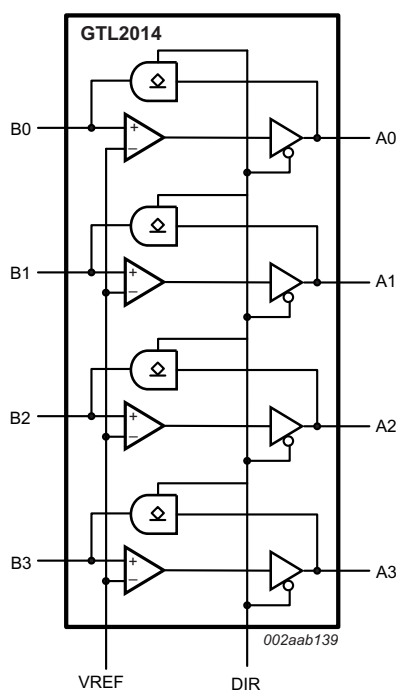


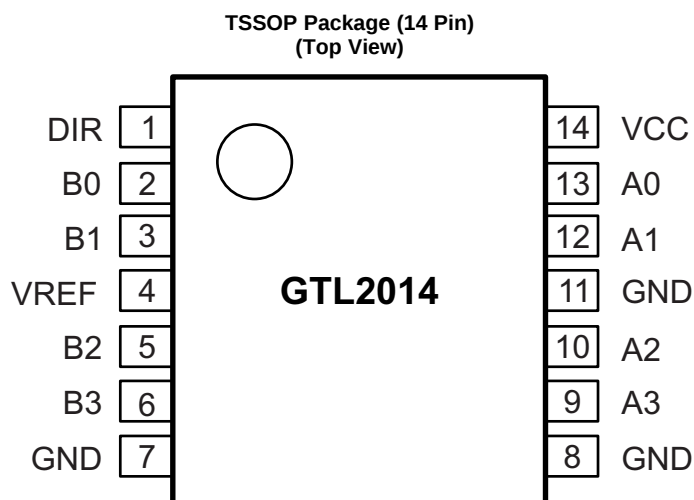
Table of Contents

1 Features	1	8.2 Functional Block Diagram	8
2 Applications	1	8.3 Feature Description.....	8
3 Description	1	8.4 Device Functional Modes.....	8
4 Revision History	2	9 Application and Implementation	9
5 Pin Configuration and Functions	3	9.1 Application Information.....	9
6 Specifications	4	9.2 Typical Application	9
6.1 Absolute Maximum Ratings	4	10 Power Supply Recommendations	12
6.2 Handling Ratings.....	4	11 Layout	12
6.3 Recommended Operating Conditions.....	4	11.1 Layout Guidelines	12
6.4 Thermal Information	5	11.2 Layout Example	12
6.5 Electrical Characteristics.....	5	12 Device and Documentation Support	13
6.6 Dynamic Electrical Characteristics.....	6	12.1 Trademarks	13
6.7 Typical Characteristics	6	12.2 Electrostatic Discharge Caution.....	13
7 Parameter Measurement Information	7	12.3 Glossary	13
8 Detailed Description	8	13 Mechanical, Packaging, and Orderable Information	13
8.1 Overview	8		

4 Revision History

Changes from Original (February 2014) to Revision A	Page
• Added Handling Rating table, Feature Description section, Device Functional Modes, Application and Implementation section, Power Supply Recommendations section, Layout section, Device and Documentation Support section, and Mechanical, Packaging, and Orderable Information section.	1
• Updated Specifications section	4
• Updated LVTTTL/TTL to GTL–/GTL/GTL+ application schematic.	9
• Updated LVTTTL/TTL to GTL–/GTL/GTL+ application schematic.	11
• Added <i>Power Supply Recommendations</i>	12

5 Pin Configuration and Functions



Pin Functions

PIN		DESCRIPTION
NAME	NUMBER	
A0	13	LVTTTL data input/output
A01	12	
A02	10	
A03	9	
B0	2	GTL data input/output
B01	3	
B02	5	
B03	6	
DIR	1	Direction control input (LVTTTL)
GND	7	Ground
	8	
	11	
VCC	14	Supply voltage
VREF	4	GTL reference voltage

6 Specifications

6.1 Absolute Maximum Ratings

Specified at $T_A = -40^{\circ}\text{C}$ to 85°C unless otherwise noted⁽¹⁾

			MIN	MAX	UNIT
V _{CC}	Supply voltage		−0.5	4.6	V
I _{IK}	Input clamping current, V _I < 0 V			−50	mA
V _{SEL}	Input control voltages SEL ⁽²⁾⁽³⁾		−0.5	6	V
V _I	Input voltage	A port	−0.5	7	V
		B port	−0.5	4.6	
I _{OK}	Control input clamp current, V _O < 0 V			−50	mA
V _O	Output voltage	A port	−0.5	7	V
		B port	−0.5	4.6	
I _{OL}	Current into any output in the low state	A port		40	mA
		B port		80	
I _{OH}	Current into any output in the high state			−40	mA

- (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 conditions is not implied. Exposure to absolute-maximum-rated conditions for extended periods may affect device reliability.
- (2) All voltages are with respect to ground, unless otherwise specified
- (3) V_I and V_O are used to denote specific conditions for $V_{I/O}$

6.2 Handling Ratings

			MIN	MAX	UNIT
T_{stg}	Storage temperature range		-55	150	$^{\circ}\text{C}$
$V_{ESD}^{(1)}$	Human Body Model (HBM), JEDEC: JESD22-A114 ⁽²⁾	All pins	0	2	kV
	IEC61000-4-2 contact discharge ⁽³⁾	All pins	0	1	

- (1) Electrostatic discharge (ESD) to measure device sensitivity/immunity to damage caused by assembly line electrostatic discharges into the device.
- (2) Level listed above is the passing level per ANSI/ESDA/JEDEC JS-001. JEDEC document JEP155 states that 500-V HBM allows safe manufacturing with a standard ESD control process. *Pins listed as 250 V may actually have higher performance.*
- (3) Level listed above is the passing level per EIA-JEDEC JESD22-C101. JEDEC document JEP157 states that 250-V CDM allows safe manufacturing with a standard ESD control process. *Pins listed as 250 V may actually have higher performance.*

6.3 Recommended Operating Conditions

over operating free-air temperature range (unless otherwise noted)⁽¹⁾

			MIN	NOM	MAX	UNIT
V _{CC}	Supply voltage		3	3.3	3.6	V
V _{TT}	Termination voltage	GTL–	0.85	0.9	0.95	V
		GTL	1.14	1.2	1.26	
		GTL+	1.35	1.5	1.65	
V _{REF}	Reference voltage	Overall	0.5	2 / 3 V _{TT}	V _{CC} / 2	V
		GTL–	0.5	0.6	0.63	
		GTL	0.76	0.8	0.84	
		GTL+	0.87	1	1.1	
V _I	Input voltage	A port	0	3.3	5.5 ⁽²⁾	V
		B port	0	V _{TT}	3.6	
V _{IH}	High-level input voltage	A port and DIR	2			V
		B port	V _{REF} + 50 mV			

- (1) 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](#).
- (2) The $V_{I(max)}$ of LVTTL port is 3.6 V if configured as output (DIR=L)

Recommended Operating Conditions (continued)

over operating free-air temperature range (unless otherwise noted)⁽¹⁾

			MIN	NOM	MAX	UNIT
V _{IL}	Low-level input voltage	A port and DIR			0.8	V
		B port		V _{REF} – 50 mV		
I _{OH}	High-level input current	A port			–20	mA
I _{OL}	Low-level output current	A port			20	mA
		B port			50	

6.4 Thermal Information

THERMAL METRIC ⁽¹⁾		SN74GTL2014	UNIT
		PW	
		14 PINS	
R _{θJA}	Junction-to-ambient thermal resistance	136.8	°C/W
R _{θJC(top)}	Junction-to-case (top) thermal resistance	63.0	
R _{θJB}	Junction-to-board thermal resistance	78.6	
Ψ _{JT}	Junction-to-top characterization parameter	11.9	
Ψ _{JB}	Junction-to-board characterization parameter	77.9	

(1) For more information about traditional and new thermal metrics, see the *IC Package Thermal Metrics* application report, [SPRA953](#).

6.5 Electrical Characteristics

Specified at T_A = –40°C to 85°C (unless otherwise noted)

PARAMETER		TEST CONDITIONS	–40°C TO 85°C			UNIT	
			MIN	TYP	MAX		
V _{OH}	A port	V _{CC} = 3 to 3.6 V, I _{OH} = –100 μA	V _{CC} – 0.2			V	
		V _{CC} = 3 V, I _{OH} = –16 mA	2				
V _{OL}	A port	V _{CC} = 3 V, I _{OL} = 8 mA	0.28			V	
	A port	V _{CC} = 3 V, I _{OL} = 16 mA	0.55				
	B port	V _{CC} = 3 V, I _{OL} = 40 mA	0.23				
I _I	A port	V _{CC} = 3.6 V, V _I = V _{CC}	±1			μA	
		V _{CC} = 3.6, V _I = 0 V	±1				
		V _{CC} = 3.6, V _I = 5.5 V	5				
	B port	V _{CC} = 3.6 V, V _I = V _{TT} or GND	±1			μA	
	Control pin	V _{CC} = 3.6 V, V _I = V _{CC} or 0 V	±1			μA	
I _{off}	OFF-state output current on A port	V _{CC} = 0 V, V _{IO} = 0 to 3.6 V	±10			μA	
	OFF-state output current on A port	V _{CC} = 0 V, V _{IO} 3.6 to 5.5V	±100				
	OFF-state output current on B port	V _{CC} = 0 V, V _{IO} = 0 to 3.6 V	±10				
I _{CC}	A port	V _{CC} = 3.6 V, V _I = V _{CC} or GND, I _O = 0	3			10	mA
	B port	V _{CC} = 3.6 V, V _I = V _{TT} or GND, I _O = 0	3			10	mA
ΔI _{CC}	A port or control input	V _{CC} = 3.6 V, V _I = V _{CC} – 0.6 V	500			μA	
C _I	Input capacitance of control pin	V _I = 3.0 V or 0 V	2			2.5	pF
C _{IO}	A port	V _O = 3 V or 0	4			6	pF
	B port	V _O = V _{TT} or 0	5.46			5.55	

6.6 Dynamic Electrical Characteristics

over operating range, $T_A = -40^{\circ}\text{C}$ to 85°C , $V_{CC} = 1.65$ to 4.6 V, $\text{GND} = 0$ V for GTL (see [Functional Block Diagram](#))

PARAMETER		GTL–			GTL			GTL+			UNIT
		$V_{CC} = 3.3\text{ V} \pm 0.3\text{ V}$ $V_{REF} = 0.6\text{ V}$ $V_{TT} = 0.9\text{ V}$			$V_{CC} = 3.3\text{ V} \pm 0.3\text{ V}$ $V_{REF} = 0.8\text{ V}$ $V_{TT} = 1.2\text{ V}$			$V_{CC} = 3.3\text{ V} \pm 0.3\text{ V}$ $V_{REF} = 1\text{ V}$ $V_{TT} = 1.5\text{ V}$			
		MIN	TYP	MAX	MIN	TYP	MAX	MIN	TYP	MAX	
t _{PLH} (low to high propagation delay)	An to Bn		2.8	5		2.8	5		2.8	5	ns
t _{PHL} (high to low propagation delay)			3.3	7		3.4	7		3.4	7	
t _{PLH} (low to high propagation delay)	Bn to An		5.3	8		5.2	8		5.1	8	ns
t _{PHL} (high to low propagation delay)			5.2	8		4.9	7.16		4.7	7.16	

6.7 Typical Characteristics

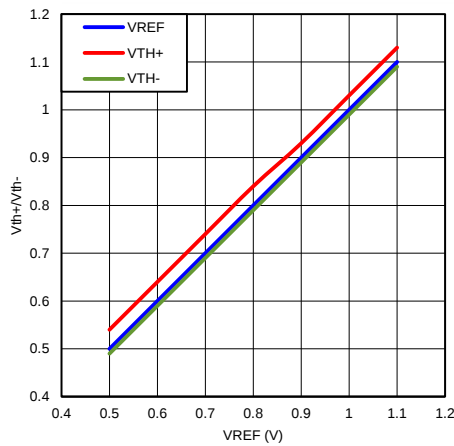


Figure 1. GTL Vth+ and Vth– vs VREF (25°C)

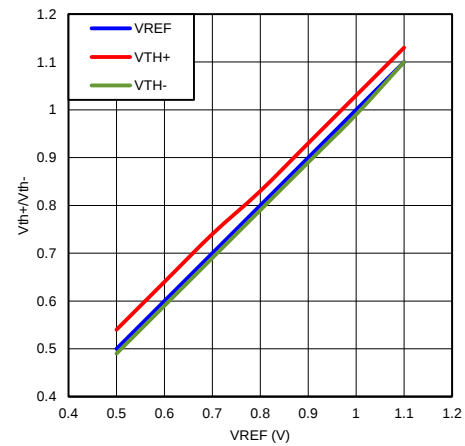


Figure 2. GTL Vth+ and Vth– vs VREF (–40°C)

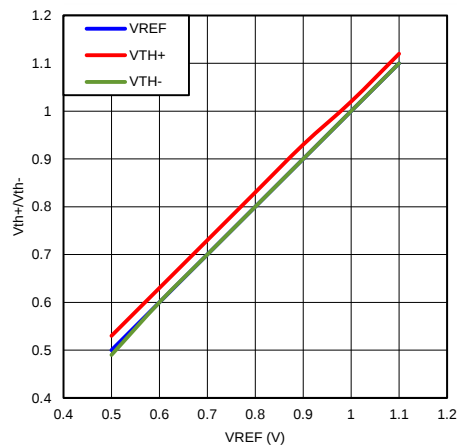
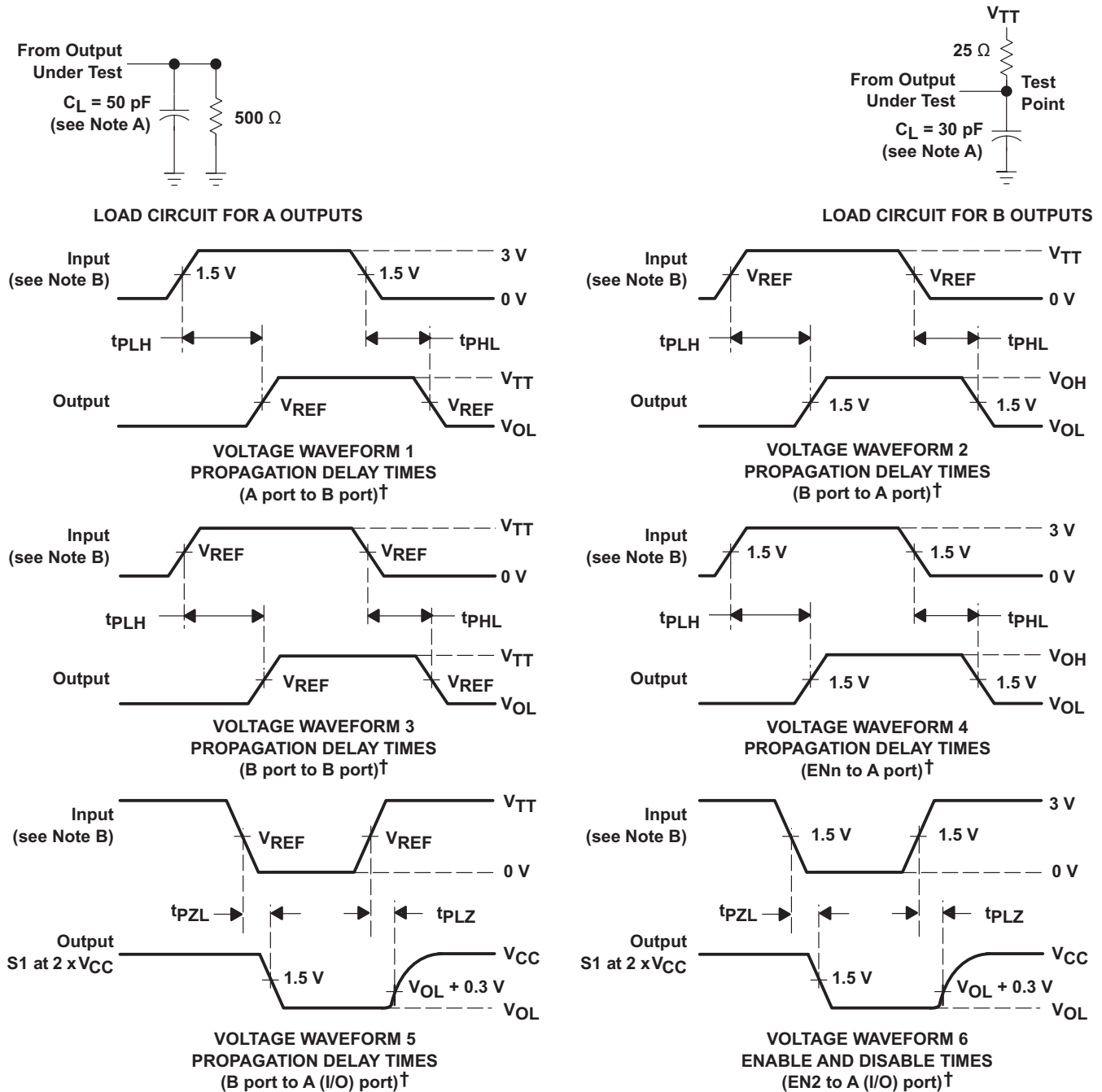


Figure 3. GTL Vth+ and Vth– vs VREF (125°C)

7 Parameter Measurement Information

$V_{TT} = 1.2\text{ V}$, $V_{REF} = 0.8\text{ V}$ for GTL and $V_{TT} = 1.5\text{ V}$, $V_{REF} = 1\text{ V}$ FOR GTL+



[†] All control inputs are LVTTTL levels.

NOTES: A. C_L includes probe and jig capacitance.

B. All input pulses are supplied by generators having the following characteristics: $PRR \leq 10\text{ MHz}$, $Z_O = 50\text{ }\Omega$, $t_r \leq 2.5\text{ ns}$, $t_f \leq 2.5\text{ ns}$.

C. The outputs are measured one at a time, with one transition per measurement.

Figure 4. Load Circuits and Voltage Waveforms

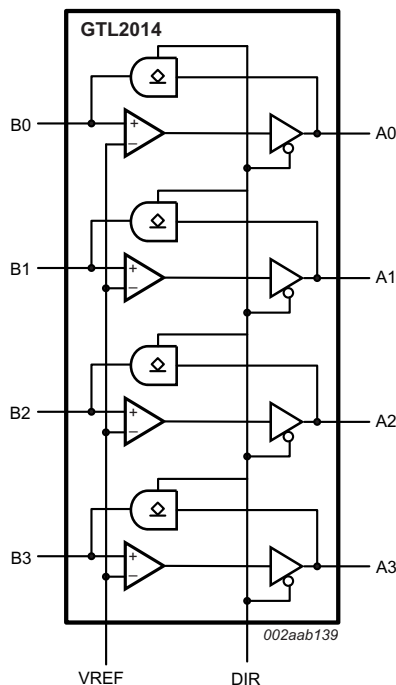
8 Detailed Description

8.1 Overview

The GTL2014 is a 4-channel translating transceiver designed for 3.3-V LVTTTL system interface with a GTL–/GTL/GTL+ bus, where GTL–/GTL/GTL+ refers to the reference voltage of the GTL bus and the input/output voltage thresholds associated with it.

The direction pin allows the part to function as either a GTL-to-LVTTTL sampling receiver or as a LVTTTL-to-GTL interface.

8.2 Functional Block Diagram



8.3 Feature Description

8.3.1 5 V tolerance on LVTTTL input

The GTL2014 LVTTTL inputs (only) are tolerant up to 5.5 V and allows direct access to TTL or 5 V CMOS inputs. The LVTTTL outputs are not 5.5 V tolerant.

8.3.2 3.6 V tolerance on GTL Input/Output

The GTL2014 GTL inputs and outputs operate up to 3.6 V, allowing the device to be used in higher voltage open-drain output applications.

8.3.3 Ultra-Low VREF and High Bandwidth

GTL2014's VREF tracks down to 0.5 V for low voltage CPUs with excellent propagation delay performance. This feature allows the GTL2014 to support high data rates with the GTL– bus.

8.4 Device Functional Modes

The GTL2014 performs translation in two directions. One direction is GTL–/GTL/GTL+ to LVTTTL when DIR is tied to GND. With appropriate VREF set up, the GTL input can be compliant with GTL–/GTL/GTL+. Another direction is LVTTTL to GTL–/GTL/GTL+ when DIR is tied to VCC. 3.6 V tolerance on the GTL output allows the GTL outputs to pull up to any voltage level under 3.6 V.

9 Application and Implementation

NOTE

Information in the following applications sections is not part of the TI component specification, and TI does not warrant its accuracy or completeness. TI's customers are responsible for determining suitability of components for their purposes. Customers should validate and test their design implementation to confirm system functionality.

9.1 Application Information

GTL2014 is the voltage translator for GTL–/GTL/GTL+ to LVTTTL or LVTTTL to GTL–/GTL/GTL+. Please find the reference schematic and recommend value for passive component in the [Typical Application](#).

9.2 Typical Application

9.2.1 GTL–/GTL/GTL+ to LVTTTL

Select appropriate VTT/VREF based upon GTL–/GTL/GTL+. The parameters in [Recommended Operating Conditions](#) are compliant to the GTL specification.

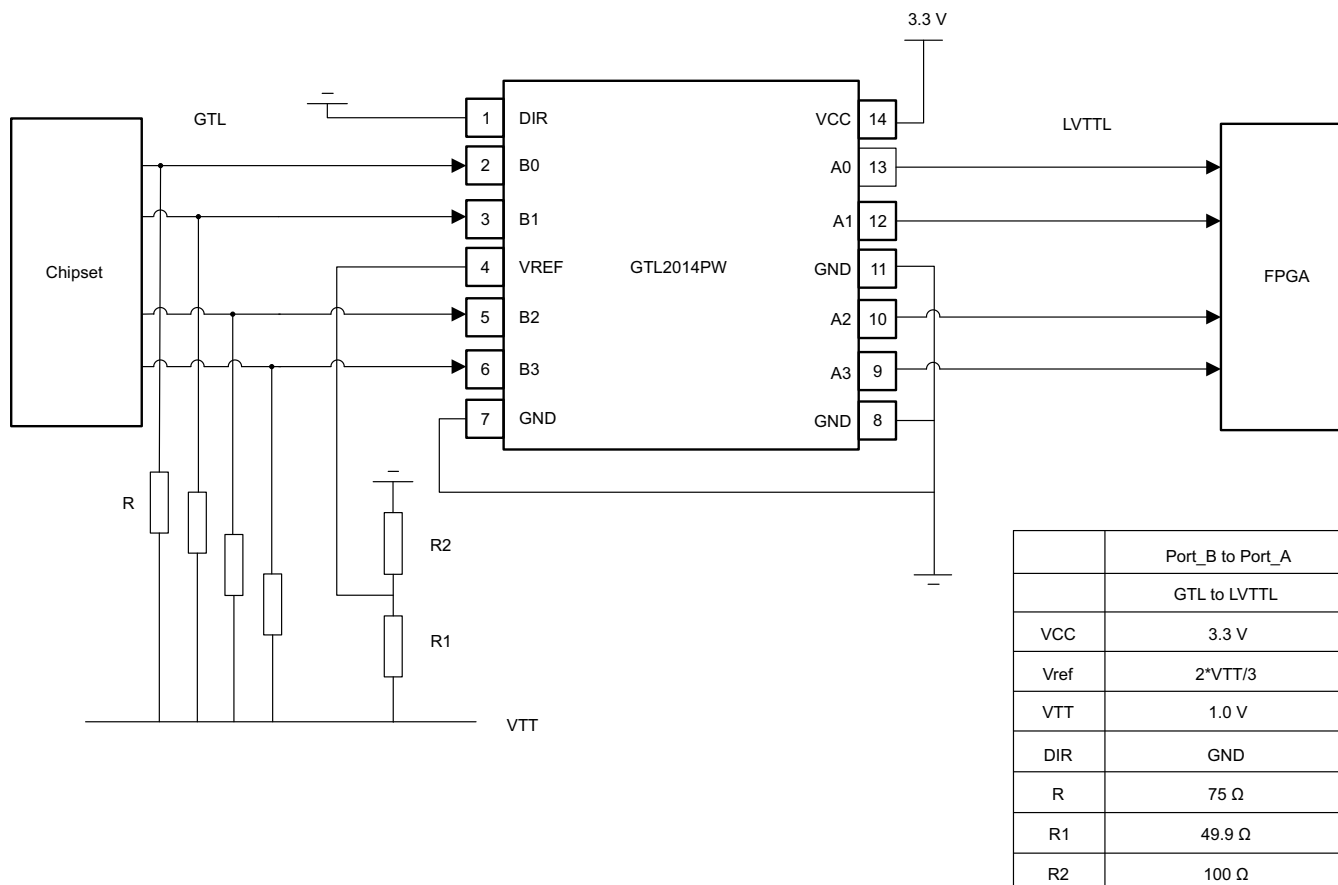


Figure 5. Application Diagram for GTL to LVTTTL

Typical Application (continued)

9.2.1.1 Design Requirements

The GTL2014 requires industrial standard LVTTTL and GTL inputs. The design example in [Application Information](#) show standard voltage level and typical resistor values.

NOTE

Only LVTTTL terminals (A1/A2/A3/A4) are tolerant to 5 V.

9.2.1.2 Detailed Design Procedure

To begin the design process, determine the following:

1. Select direction base upon application (GTL–/GTL/GTL+ to LVTTTL or LVTTTL to GTL–/GTL/GTL+).
2. Set up appropriate DIR pin and VREF/VTT.
3. Choose correct pullup resistor value base upon data rate and driving current requirement (for LVTTTL to GTL–/GTL/GTL+).

9.2.1.3 Application Curve

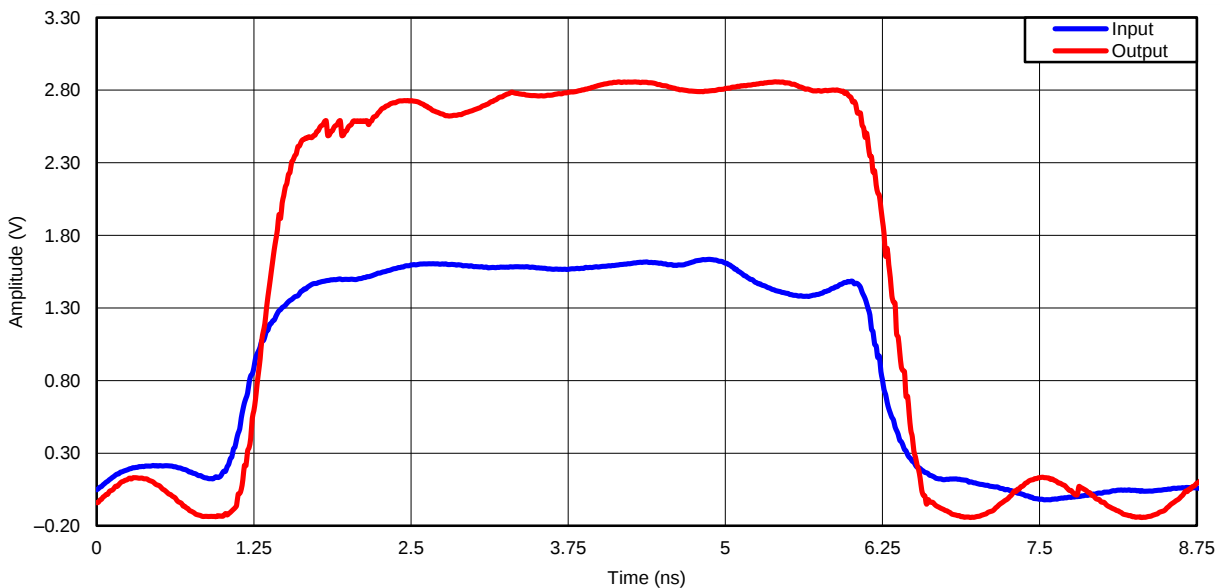


Figure 6. GTL-to-LVTTTL, VREF = 1 V, VIN = 1.5 V, 100 MHz

Typical Application (continued)

9.2.2 LVTTL/TTL to GTL–/GTL/GTL+

Because GTL is an open-drain interface, the selection of pullup resistor depends on the application requirement (for example, data rate) and PCB trace capacitance.

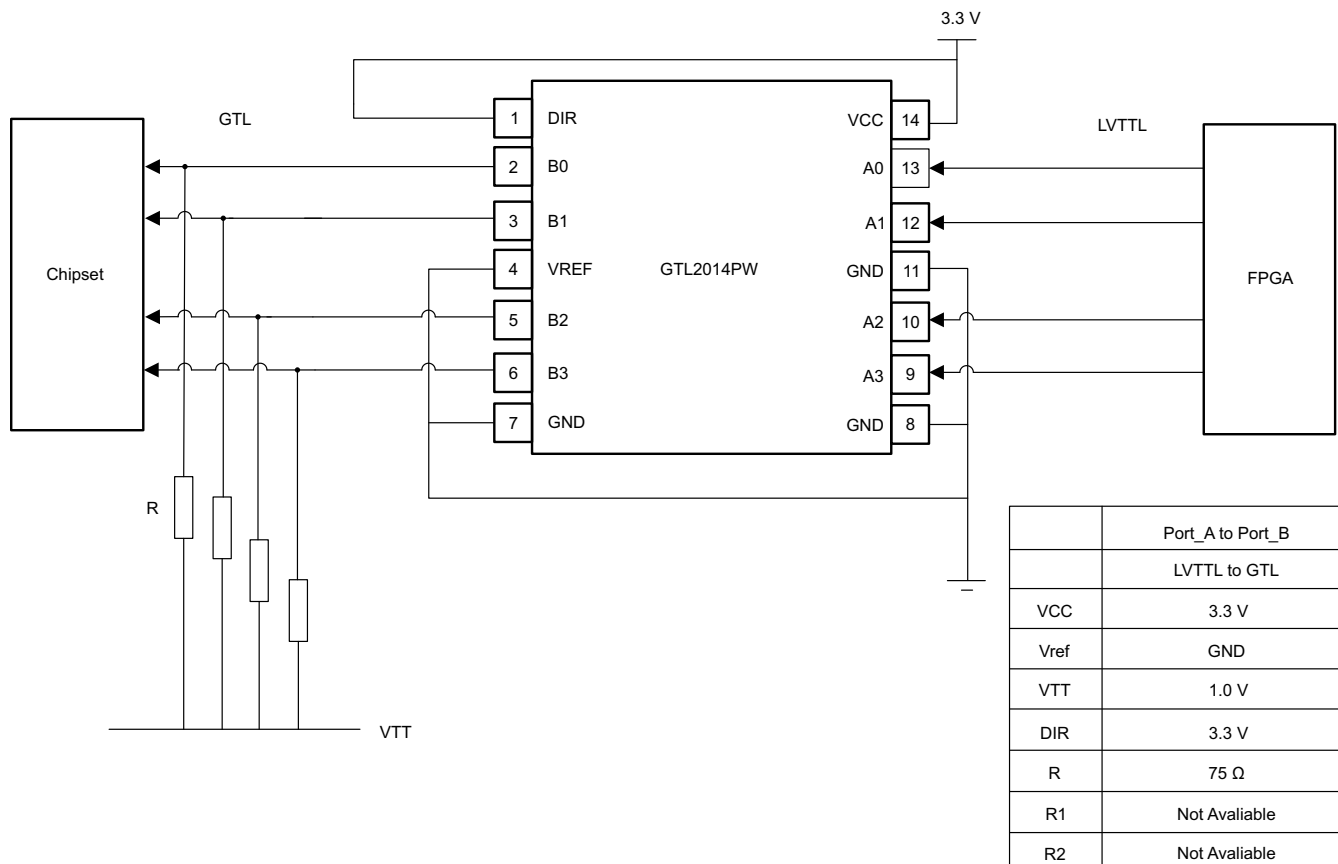


Figure 7. Application Diagram for LVTTL to GTL

9.2.2.1 Design Requirements

The GTL2014 requires industrial standard LVTTL and GTL inputs. The design example in the [Application Information](#) section show standard voltage level and typical resistor values.

NOTE

Only LVTTL terminals (A1/A2/A3/A4) are tolerant to 5 V.

9.2.2.2 Detailed Design Procedure

To begin the design process, determine the following:

1. Select direction based upon application (GTL–/GTL/GTL+ to LVTTL or LVTTL to GTL–/GTL/GTL+).
2. Set up appropriate DIR pin and VREF/VTT.
3. Choose correct pullup resistor value base upon data rate and driving current requirement (for LVTTL to GTL–/GTL/GTL+).

Typical Application (continued)

9.2.2.3 Application Curve

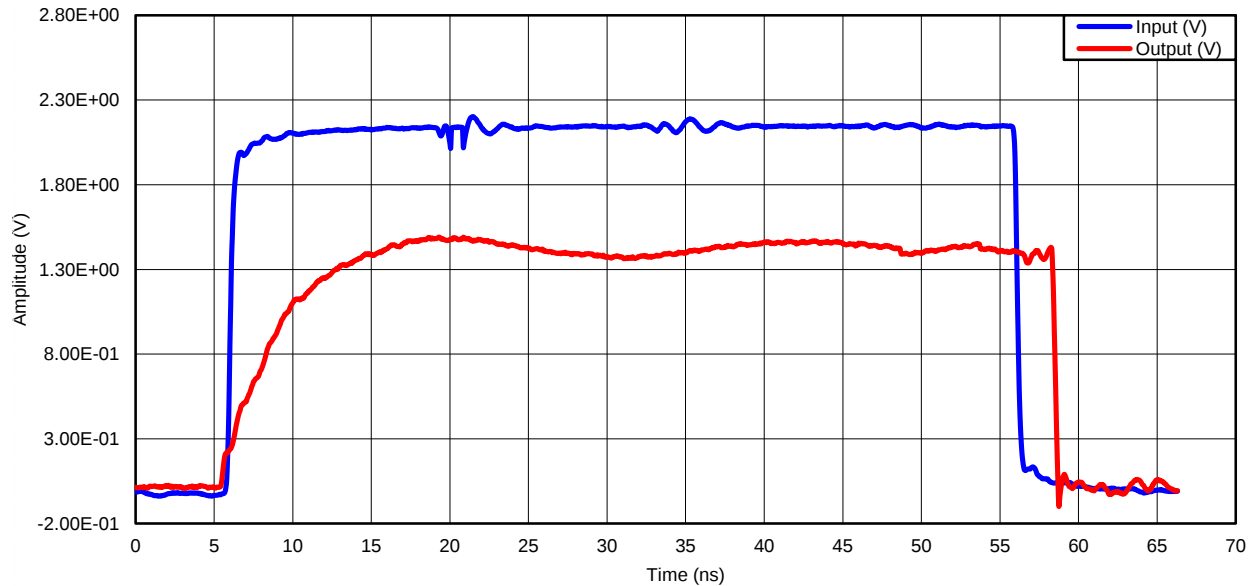


Figure 8. LVTTL-to-GTL, VREF = 1 V, VTT = 1.5 V, 10 MHz

10 Power Supply Recommendations

Because GTL is a low voltage interface, TI recommends a 0.1- μ F decoupling capacitor for VREF.

11 Layout

11.1 Layout Guidelines

Typically, GTL/LVTTL is running at a low data rate; however, the GTL2014 is optimized for excellent propagation delay, slew rate, bandwidth, and is able support 100-MHz frequencies.

11.2 Layout Example

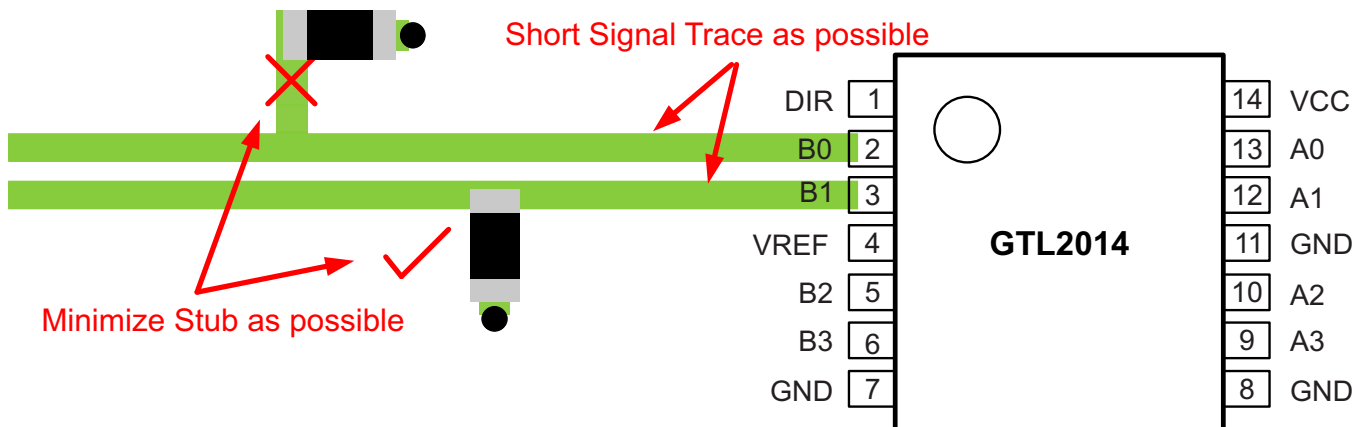


Figure 9. Layout Example for GTL Trace

12 Device and Documentation Support

12.1 Trademarks

All trademarks are the property of their respective owners.

12.2 Electrostatic Discharge Caution



This integrated circuit can be damaged by ESD. Texas Instruments recommends that all integrated circuits be handled with appropriate precautions. Failure to observe proper handling and installation procedures can cause damage.

ESD damage can range from subtle performance degradation to complete device failure. Precision integrated circuits may be more susceptible to damage because very small parametric changes could cause the device not to meet its published specifications.

12.3 Glossary

[SLYZ022](#) — *TI Glossary*.

This glossary lists and explains terms, acronyms, and definitions.

13 Mechanical, Packaging, and Orderable Information

The following pages include mechanical, packaging, and orderable information. This information is the most current data available for the designated devices. This data is subject to change without notice and revision of this document. For browser-based versions of this data sheet, refer to the left-hand navigation.

PACKAGING INFORMATION

Orderable part number	Status (1)	Material type (2)	Package Pins	Package qty Carrier	RoHS (3)	Lead finish/ Ball material (4)	MSL rating/ Peak reflow (5)	Op temp (°C)	Part marking (6)
SN74GTL2014PWR	Active	Production	TSSOP (PW) 14	2000 LARGE T&R	Yes	NIPDAU SN	Level-1-260C-UNLIM	-40 to 85	GT14
SN74GTL2014PWR.B	Active	Production	TSSOP (PW) 14	2000 LARGE T&R	Yes	NIPDAU	Level-1-260C-UNLIM	-40 to 85	GT14
SN74GTL2014PWRG4	Active	Production	TSSOP (PW) 14	2000 LARGE T&R	Yes	NIPDAU	Level-1-260C-UNLIM	-40 to 85	GT14
SN74GTL2014PWRG4.B	Active	Production	TSSOP (PW) 14	2000 LARGE T&R	Yes	NIPDAU	Level-1-260C-UNLIM	-40 to 85	GT14

⁽¹⁾ **Status:** For more details on status, see our [product life cycle](#).

⁽²⁾ **Material type:** When designated, preproduction parts are prototypes/experimental devices, and are not yet approved or released for full production. Testing and final process, including without limitation quality assurance, reliability performance testing, and/or process qualification, may not yet be complete, and this item is subject to further changes or possible discontinuation. If available for ordering, purchases will be subject to an additional waiver at checkout, and are intended for early internal evaluation purposes only. These items are sold without warranties of any kind.

⁽³⁾ **RoHS values:** Yes, No, RoHS Exempt. See the [TI RoHS Statement](#) for additional information and value definition.

⁽⁴⁾ **Lead finish/Ball material:** Parts may have multiple material finish options. Finish options are separated by a vertical ruled line. Lead finish/Ball material values may wrap to two lines if the finish value exceeds the maximum column width.

⁽⁵⁾ **MSL rating/Peak reflow:** The moisture sensitivity level ratings and peak solder (reflow) temperatures. In the event that a part has multiple moisture sensitivity ratings, only the lowest level per JEDEC standards is shown. Refer to the shipping label for the actual reflow temperature that will be used to mount the part to the printed circuit board.

⁽⁶⁾ **Part marking:** There may be an additional marking, which relates to the logo, the lot trace code information, or the environmental category of the part.

Multiple part markings will be inside parentheses. Only one part marking contained in parentheses and separated by a "-" will appear on a part. If a line is indented then it is a continuation of the previous line and the two combined represent the entire part marking for that device.

Important Information and Disclaimer: The information provided on this page represents TI's knowledge and belief as of the date that it is provided. TI bases its knowledge and belief on information provided by third parties, and makes no representation or warranty as to the accuracy of such information. Efforts are underway to better integrate information from third parties. TI has taken and continues to take reasonable steps to provide representative and accurate information but may not have conducted destructive testing or chemical analysis on incoming materials and chemicals. TI and TI suppliers consider certain information to be proprietary, and thus CAS numbers and other limited information may not be available for release.

In no event shall TI's liability arising out of such information exceed the total purchase price of the TI part(s) at issue in this document sold by TI to Customer on an annual basis.

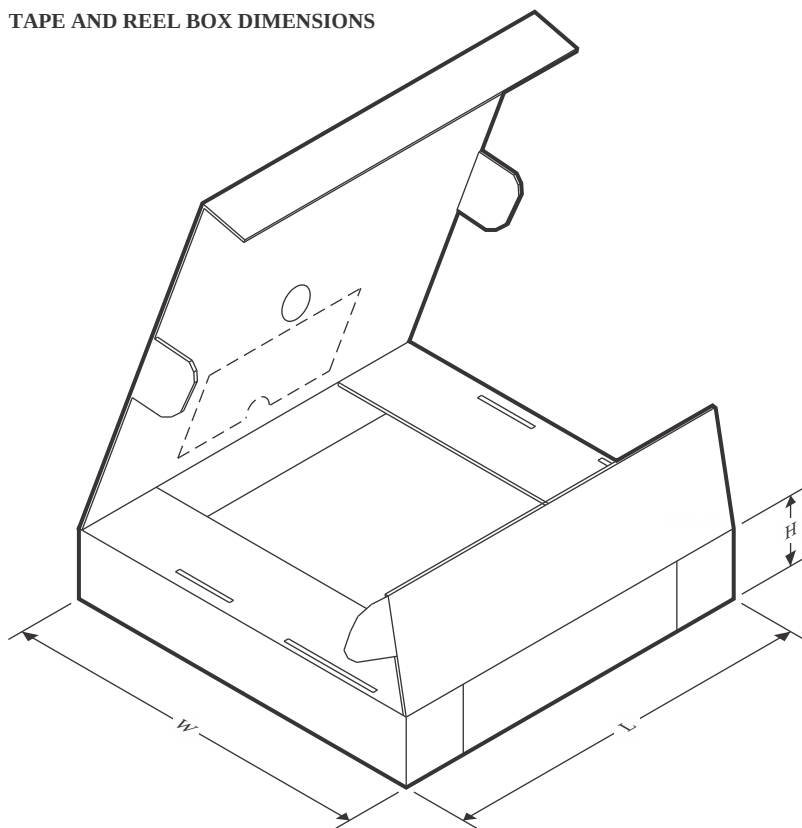
TAPE AND REEL INFORMATION



*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
SN74GTL2014PWR	TSSOP	PW	14	2000	330.0	12.4	6.9	5.6	1.6	8.0	12.0	Q1
SN74GTL2014PWR	TSSOP	PW	14	2000	330.0	12.4	6.9	5.3	1.6	8.0	12.0	Q1
SN74GTL2014PWR	TSSOP	PW	14	2000	330.0	12.4	6.9	5.6	1.6	8.0	12.0	Q1
SN74GTL2014PWRG4	TSSOP	PW	14	2000	330.0	12.4	6.9	5.6	1.6	8.0	12.0	Q1

TAPE AND REEL BOX DIMENSIONS



*All dimensions are nominal

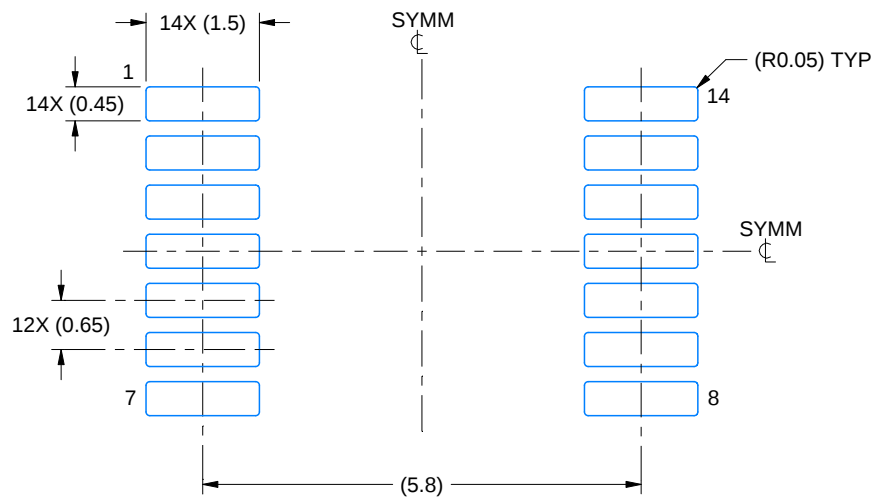
Device	Package Type	Package Drawing	Pins	SPQ	Length (mm)	Width (mm)	Height (mm)
SN74GTL2014PWR	TSSOP	PW	14	2000	353.0	353.0	32.0
SN74GTL2014PWR	TSSOP	PW	14	2000	367.0	367.0	35.0
SN74GTL2014PWR	TSSOP	PW	14	2000	356.0	356.0	35.0
SN74GTL2014PWRG4	TSSOP	PW	14	2000	353.0	353.0	32.0

EXAMPLE BOARD LAYOUT

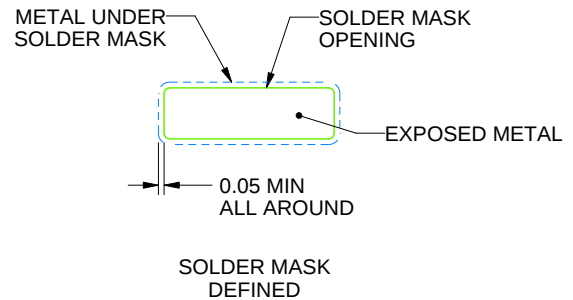
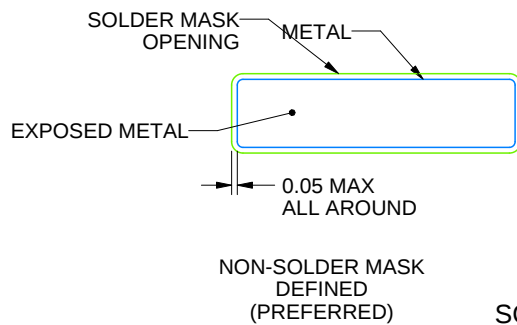
PW0014A

TSSOP - 1.2 mm max height

SMALL OUTLINE PACKAGE



LAND PATTERN EXAMPLE
EXPOSED METAL SHOWN
SCALE: 10X



SOLDER MASK DETAILS

4220202/B 12/2023

NOTES: (continued)

6. Publication IPC-7351 may have alternate designs.

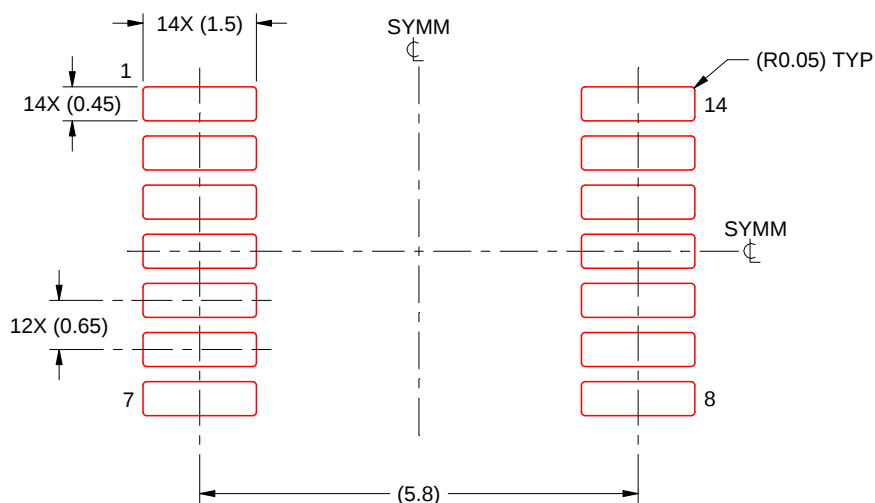
7. Solder mask tolerances between and around signal pads can vary based on board fabrication site.

EXAMPLE STENCIL DESIGN

PW0014A

TSSOP - 1.2 mm max height

SMALL OUTLINE PACKAGE



SOLDER PASTE EXAMPLE
BASED ON 0.125 mm THICK STENCIL
SCALE: 10X

4220202/B 12/2023

NOTES: (continued)

8. Laser cutting apertures with trapezoidal walls and rounded corners may offer better paste release. IPC-7525 may have alternate design recommendations.
9. Board assembly site may have different recommendations for stencil design.

IMPORTANT NOTICE AND DISCLAIMER

TI PROVIDES TECHNICAL AND RELIABILITY DATA (INCLUDING DATASHEETS), DESIGN RESOURCES (INCLUDING REFERENCE DESIGNS), APPLICATION OR OTHER DESIGN ADVICE, WEB TOOLS, SAFETY INFORMATION, AND OTHER RESOURCES "AS IS" AND WITH ALL FAULTS, AND DISCLAIMS ALL WARRANTIES, EXPRESS AND IMPLIED, INCLUDING WITHOUT LIMITATION ANY IMPLIED WARRANTIES OF MERCHANTABILITY, FITNESS FOR A PARTICULAR PURPOSE OR NON-INFRINGEMENT OF THIRD PARTY INTELLECTUAL PROPERTY RIGHTS.

These resources are intended for skilled developers designing with TI products. You are solely responsible for (1) selecting the appropriate TI products for your application, (2) designing, validating and testing your application, and (3) ensuring your application meets applicable standards, and any other safety, security, regulatory or other requirements.

These resources are subject to change without notice. TI grants you permission to use these resources only for development of an application that uses the TI products described in the resource. Other reproduction and display of these resources is prohibited. No license is granted to any other TI intellectual property right or to any third party intellectual property right. TI disclaims responsibility for, and you fully indemnify TI and its representatives against any claims, damages, costs, losses, and liabilities arising out of your use of these resources.

TI's products are provided subject to [TI's Terms of Sale](#), [TI's General Quality Guidelines](#), or other applicable terms available either on ti.com or provided in conjunction with such TI products. TI's provision of these resources does not expand or otherwise alter TI's applicable warranties or warranty disclaimers for TI products. Unless TI explicitly designates a product as custom or customer-specified, TI products are standard, catalog, general purpose devices.

TI objects to and rejects any additional or different terms you may propose.

Copyright © 2026, Texas Instruments Incorporated

Last updated 10/2025