

TRS213E Multichannel 250kbps RS-232 Line Driver and Receiver with $\pm 9V$ Output and $\pm 15kV$ IEC ESD Protection

1 Features

- ESD Protection for RS-232 bus pins
 - $\pm 15kV$ Human-body model (HBM)
 - $\pm 8kV$ IEC61000-4-2, Contact discharge
 - $\pm 15kV$ IEC61000-4-2, Air-gap discharge
- Meets or exceeds the requirements of TIA/EIA-232-F and ITU v.28 standards
- Operates at 5V V_{CC} supply
- Four drivers and five receivers
- Operates up to 250kbps
- Low supply current in shutdown mode: 15 μA typical
- Designed to be interchangeable with industry standard '213 devices
- Latch-up performance exceeds 100mA per JESD 78, class II

2 Applications

- [Battery-powered](#) systems
- PDAs
- [Notebooks](#)
- [Laptops](#)
- [Palmtop PCs](#)
- [Hand-held equipment](#)

3 Description

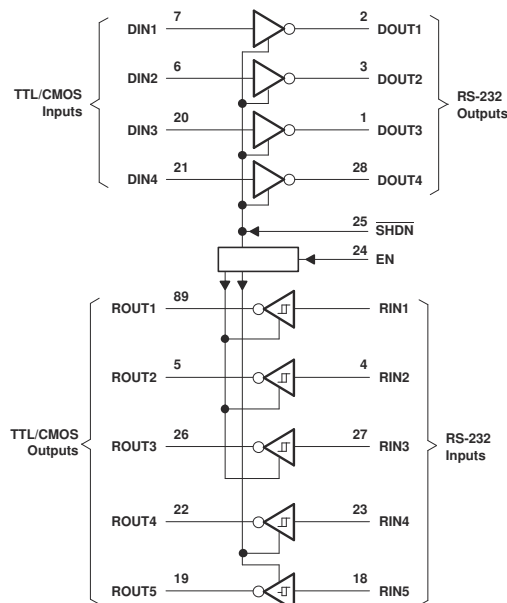
The TRS213E consists of four line drivers, five line receivers, and a dual charge-pump circuit with $\pm 15kV$ IEC ESD protection on the RS-232 bus pins. The device meets the requirements of TIA/EIA-232-F, and provides the electrical interface between an asynchronous communication controller and the serial-port connector. The charge pump and four small external capacitors allow operation from a single 5V supply. The devices operate at data signaling rates up to 250kbit/s and a maximum of 30V/ μs driver output slew rate.

The TRS213E has an active-low shutdown ($\overline{SHDN}$) and an active-high enable control (EN). In shutdown mode, the charge pumps are turned off, $V+$ is pulled down to V_{CC} , $V-$ is pulled to GND, and the transmitter outputs are disabled. This reduces supply current typically to 1 μA . Two receivers of the TRS213E are active during shutdown.

Package Information

PART NUMBER	PACKAGE ⁽¹⁾	PACKAGE SIZE ⁽²⁾
TRS213E	SSOP (DB)	10.2mm x 7.8mm

- (1) For more information, see [Section 11](#).
 (2) The package size (length $\times$ width) is a nominal value and includes pins, where applicable.



Logic Diagram (Positive Logic)



Table of Contents

1 Features	1	6 Parameter Measurement Information	7
2 Applications	1	7 Functional Modes	9
3 Description	1	8 Application and Implementation	10
4 Pin Configuration and Functions	3	8.1 Typical Application.....	10
5 Specifications	4	9 Device and Documentation Support	11
5.1 Absolute Maximum Ratings.....	4	9.1 Receiving Notification of Documentation Updates....	11
5.2 ESD Ratings.....	4	9.2 Support Resources.....	11
5.3 Recommended Operating Conditions.....	4	9.3 Trademarks.....	11
5.4 Thermal Characteristics.....	5	9.4 Electrostatic Discharge Caution.....	11
5.5 Electrical Characteristics, Power and Status.....	5	9.5 Glossary.....	11
5.6 Electrical Characteristics, Driver.....	5	10 Revision History	11
5.7 Electrical Characteristics, Receiver.....	5	11 Mechanical, Packaging, and Orderable	
5.8 Switching Characteristics, Driver.....	6	Information	11
5.9 Switching Characteristics, Receiver.....	6		

4 Pin Configuration and Functions

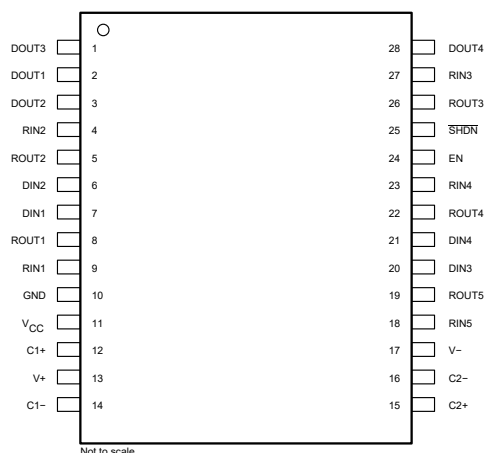


Figure 4-1. DB (SSOP) Package (Top View)

Table 4-1. Pin Functions

PIN		TYPE ⁽¹⁾	DESCRIPTION
NAME ⁽²⁾	NO.		
DOUT3	1	O	RS-232 driver outputs
DOUT1	2		
DOUT2	3		
RIN2	4	I	RS-232 receiver input
ROUT2	5	O	Receiver output
DIN2	6	I	Driver inputs
DIN1	7		
ROUT1	8	O	Receiver output
RIN1	9	I	RS-232 receiver input
GND	10	-	Ground
V _{CC}	11	-	Supply voltage
C1+	12	-	Positive terminal of the voltage-doubler charge-pump capacitor
V+	13	-	Positive charge pump output voltage
C1-	14	-	Negative terminal of the voltage-doubler charge-pump capacitor
C2+	15	-	Positive terminal of the voltage-doubler charge-pump capacitor
C2-	16	-	Negative terminal of the voltage-doubler charge-pump capacitor
V-	17	-	Negative charge pump output voltage
RIN5	18	I	RS-232 receiver input
ROUT5	19	O	Receiver output
DIN3	20	I	Driver inputs
DIN4	21		
ROUT4	22	O	Receiver output
RIN4	23	I	RS-232 receiver input
EN	24	I	Active high enable
SHDN	25	I	Active low shutdown
ROUT3	26	O	Receiver output
RIN3	27	I	RS-232 receiver input
DOUT4	28	O	RS-232 driver output

(1) Signal Types: I = Input, O = Output, I/O = Input or Output.

(2) DIN pins have 400KΩ internal pull up to V_{CC}.

5 Specifications

5.1 Absolute Maximum Ratings

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

			MIN	MAX	UNIT
V _{CC}	Supply voltage ⁽²⁾		−0.3	6	V
V _{S+}	Positive output supply voltage ⁽²⁾		−0.6	14	V
V _{S−}	Negative output supply voltage ⁽²⁾		−0.3	−14	V
V _I	Input voltage	Driver, $\overline{\text{FORCEOFF}}$, $\overline{\text{FORCEON}}$, $\overline{\text{EN}}$	−0.3	6.3	V
		Receiver	−25	25	
V _O	Output voltage	Driver	−14.3	14.3	V
		Receiver, $\overline{\text{INVALID}}$	−0.3	6.3	
T _J	Operating virtual junction temperature			150	°C
T _{stg}	Storage temperature		−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) All voltages are with respect to network GND.

5.2 ESD Ratings

			VALUE	UNIT
V _(ESD)	Electrostatic discharge	Human body model (HBM), per ANSI/ESDA/JEDEC JS-001, non bus (logic/supply) pins ⁽¹⁾	±2000	V
		Human body model (HBM), per ANSI/ESDA/JEDEC JS-001, RS-232 driver output/receiver input pins	±15000	
		Charged device model (CDM), per JEDEC specification JESD22-C101, all pins ⁽²⁾	±1000	
		IEC 61000-4-2, Contact Discharge, RS-232 driver output/receiver input pins ⁽³⁾	±8000	
		IEC 61000-4-2, Air-Gap Discharge, RS-232 driver output/receiver input pins ⁽⁴⁾	±15000	

(1) JEDEC document JEP155 states that 500-V HBM allows safe manufacturing with a standard ESD control process.

(2) JEDEC document JEP157 states that 250-V CDM allows safe manufacturing with a standard ESD control process.

(3) For IEC ESD contact discharge test, 100 pF capacitor was connected to the DOUT3 pin to GND pin and recommended for given ESD performance.

(4) For IEC ESD Air-Gap discharge test, 50Ω series resistor was connected to SHDN and EN pins for hard bound conditions and recommended for given ESD performance when not driven by the microcontroller.

5.3 Recommended Operating Conditions

			MIN	NOM	MAX	UNIT
V _{CC}	Supply voltage		4.5	5	5.5	V
V _{IH}	Driver and control high-level input voltage ⁽¹⁾	DIN, SHDN, EN	2			V
V _{IL}	Driver and control low-level input voltage ⁽¹⁾	DIN, SHDN, EN			0.8	V
V _I	Driver and control input voltage ⁽¹⁾	DIN, SHDN, EN	0		5.5	V
	Receiver input voltage ⁽¹⁾		−25		25	V
T _A	Operating free-air temperature		−40		85	°C

(1) Test conditions are C1–C4 = 0.1 μF at V_{CC} = 3.3 V ± 0.3 V; C1 = 0.047 mF, C2–C4 = 0.33 μF at V_{CC} = 5 V ± 0.5 V.

5.4 Thermal Characteristics

THERMAL METRIC ⁽¹⁾		DB (SSOP)	UNIT
		28 PINS	
R _{ΘJA}	Junction-to-ambient thermal resistance	66.1	°C/W
R _{ΘJC(top)}	Junction-to-case (top) thermal resistance	33.2	°C/W
R _{ΘJB}	Junction-to-board thermal resistance	37.0	°C/W
Ψ _{JT}	Junction-to-top characterization parameter	4.6	°C/W
Ψ _{JB}	Junction-to-board characterization parameter	36.5	°C/W
R _{ΘJC(bot)}	Junction-to-case (bottom) thermal resistance	-	°C/W

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

5.5 Electrical Characteristics, Power and Status

over recommended ranges of supply voltage and operating free-air temperature (unless otherwise noted)⁽¹⁾

PARAMETER		TEST CONDITIONS	MIN	TYP ⁽²⁾	MAX	UNIT
I _{CC}	Supply current	All outputs open		8	20	mA
I _{SHDN}	Supply current	T _A = 25°C, EN = High or Low, SHDN = High		1	10	μA

(1) Test conditions are C1–C4 = 0.1 μF at V_{CC} = 5 V ± 0.5 V.

(2) All typical values are at V_{CC} = 5 V and T_A = 25°C.

5.6 Electrical Characteristics, Driver

over recommended ranges of supply voltage and operating free-air temperature (unless otherwise noted)⁽¹⁾

PARAMETER		TEST CONDITIONS	MIN	TYP ⁽²⁾	MAX	UNIT
V _{OH}	High-level output voltage	All DOUT at R _L = 3 kΩ to GND, DIN = GND	5	9		V
V _{OL}	Low-level output voltage	All DOUT at R _L = 3 kΩ to GND, DIN = V _{CC}		–9	–5	V
I _{IH}	Control high-level input current (EN and SHDN)	V _I = V _{CC}		3	10	μA
I _{IL}	Control low-level input current (EN and SHDN)	V _I at GND	–10	–3		μA
I _{IL}	Low-level input current (DIN pins) Internal pull up present	V _I at GND	–200	–15		μA
I _{OS}	Short-circuit output current ⁽³⁾	V _{CC} = 5.5 V, Pside ON		10	60	mA
I _{OS}	Short-circuit output current ⁽³⁾	V _{CC} = 5.5 V, Nside ON	–60	–10		mA
r _o	Output resistance	V _{CC} = 0 V, V _{S+} = 0 V, and V _{S–} = 0 V	300			Ω

(1) Test conditions are C1–C4 = 0.1 μF at V_{CC} = 5 V ± 0.5 V.

(2) All typical values are at V_{CC} = 5 V, and T_A = 25°C.

(3) Short-circuit durations must be controlled to prevent exceeding the device absolute power dissipation ratings, and not more than one output should be shorted at a time.

5.7 Electrical Characteristics, Receiver

over recommended ranges of supply voltage and operating free-air temperature (unless otherwise noted)⁽¹⁾

PARAMETER		TEST CONDITIONS	MIN	TYP ⁽²⁾	MAX	UNIT
V _{OH}	High-level output voltage	I _{OH} = –1 mA	3.5			V
V _{OL}	Low-level output voltage	I _{OH} = 1.6 mA			0.4	V
V _{IT+}	Positive-going input threshold voltage	V _{CC} = 5 V, T _A = 25°C		1.7	2.4	V
V _{IT–}	Negative-going input threshold voltage	V _{CC} = 5 V, T _A = 25°C	0.8	1.2		V
V _{hys}	Input hysteresis (V _{IT+} – V _{IT–})		0.2	0.5	1	V
r _I	Input resistance	V _I = ±3V to ±25V	3	5	7	kΩ

5.7 Electrical Characteristics, Receiver (continued)

over recommended ranges of supply voltage and operating free-air temperature (unless otherwise noted)⁽¹⁾

PARAMETER		TEST CONDITIONS	MIN	TYP ⁽²⁾	MAX	UNIT
IOZ	Output leakage current	EN=0V, 0V<ROUT<VCC, R1-R3	-10	0.05	10	uA

(1) Test conditions are C1–C4 = 0.1 µF at V_{CC} = 5 V ± 0.5 V.

(2) All typical values are at V_{CC} = 5 V, and T_A = 25°C.

5.8 Switching Characteristics, Driver

over recommended ranges of supply voltage and operating free-air temperature(unless otherwise noted)⁽¹⁾

PARAMETER		TEST CONDITIONS		MIN	TYP ⁽²⁾	MAX	UNIT
	Maximum data rate	R _L = 3 kΩ to 7 kΩ One DOUT switching	C _L = 50pF to 1000 pF See Figure 6-1	250			kbps
t _{sk(p)}	Pulse skew ⁽³⁾	R _L = 3 kΩ to 7 kΩ	C _L = 150 pF to 2500 pF See Figure 6-2		300		ns
t _{PLH(D)}	Propagation delay time, low to high level output	R _L = 3 kΩ	C _L = 2500 pF, all outputs loaded See Figure 6-3		2		us
t _{PHL(D)}	Propagation delay time, high to low level output	R _L = 3 kΩ	C _L = 2500 pF, all outputs loaded See Figure 6-4		2		us
SR(tr)	Slew rate, transition region	R _L = 3 kΩ to 7 kΩ	C _L = 50pF to 1000 pF	3	6	30	V/us

(1) Test conditions are C1–C4 = 0.1 µF at V_{CC} = 5 V ± 0.5 V.

(2) All typical values are at V_{CC} = 5 V, and T_A = 25°C.

(3) Pulse skew is defined as|t_{PLH} – t_{PHL}| of each channel of the same device.

5.9 Switching Characteristics, Receiver

over recommended ranges of supply voltage and operating free-air temperature (unless otherwise noted)⁽¹⁾

PARAMETER		TEST CONDITIONS	MIN	TYP ⁽²⁾	MAX	UNIT
t _{PLH}	Propagation delay time, low- to high-level output	C _L = 150 pF		0.5	10	us
t _{PHL}	Propagation delay time, high- to low-level output			0.5	10	us
t _{sk(p)}	Pulse skew ⁽³⁾	C _L = 150 pF, V _{CC} = 5V, T _A = 25°C		300		ns
t _{en}	Output enable time	C _L = 150 pF		600		ns
t _{dis}	Output disable time	C _L = 150 pF		200		ns

(1) Test conditions are C1–C4 = 0.1 µF at V_{CC} = 5 V ± 0.5 V.

(2) All typical values are at V_{CC} = 5 V, and T_A = 25°C.

(3) Pulse skew is defined as|t_{PLH} – t_{PHL}| of each channel of the same device.

6 Parameter Measurement Information

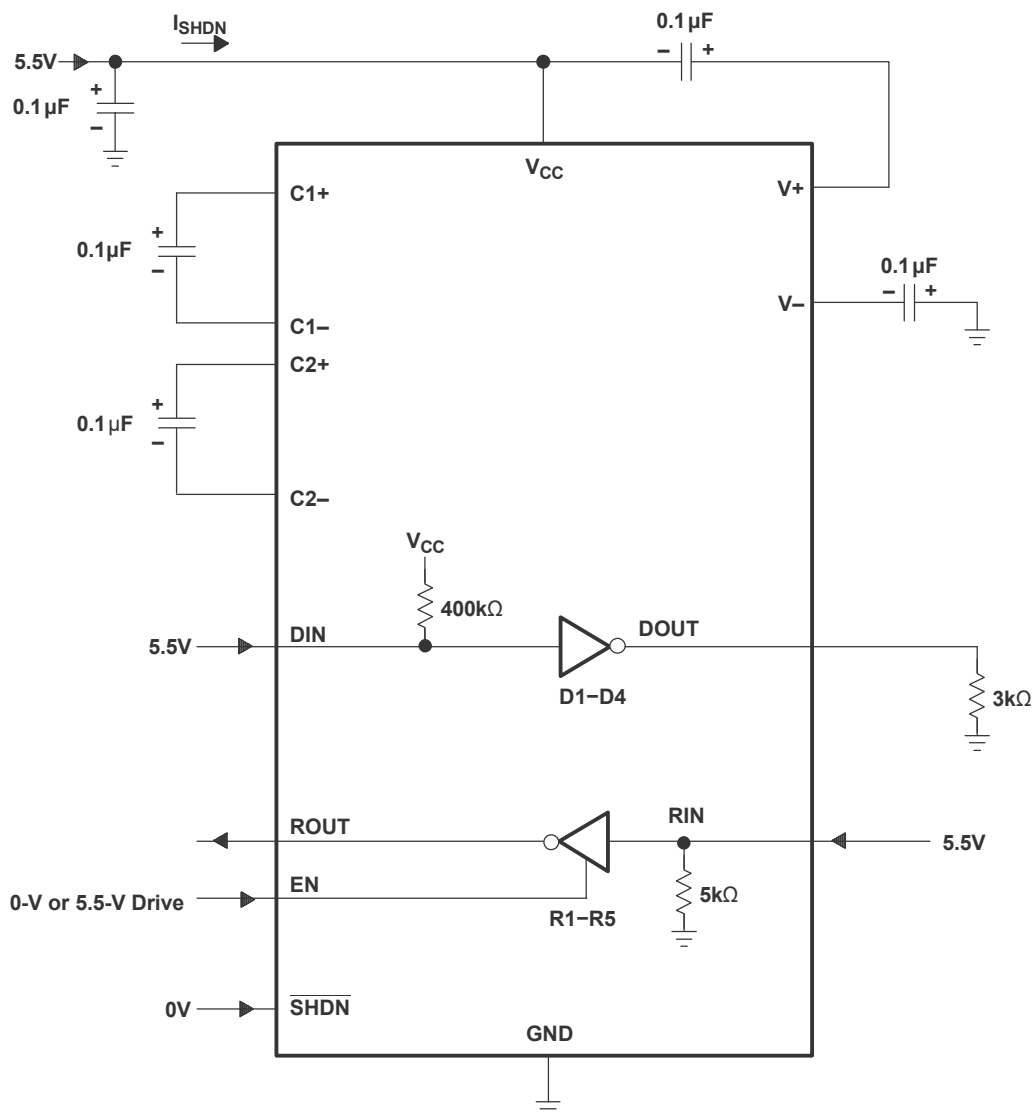
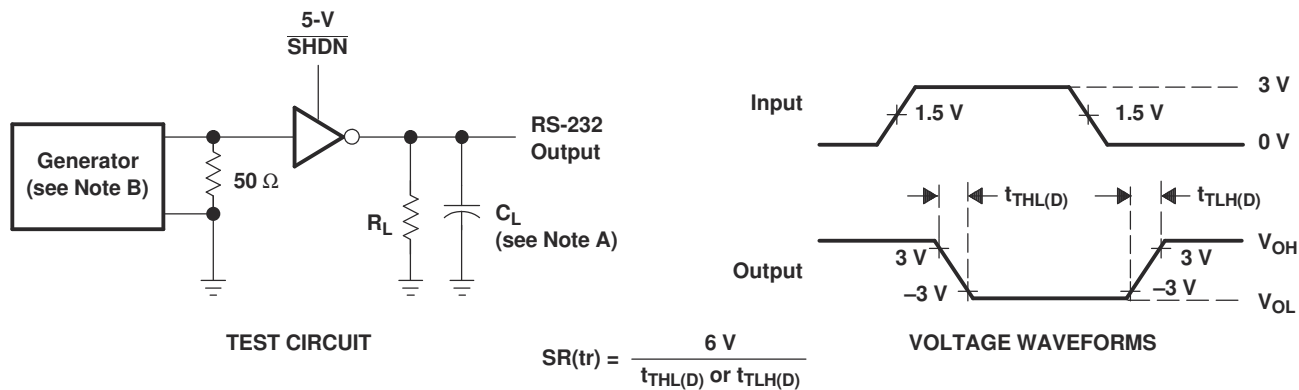


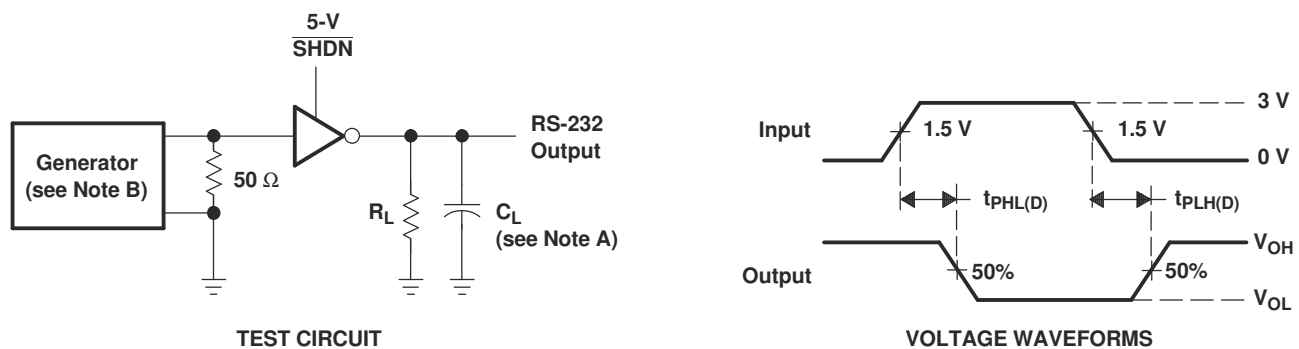
Figure 6-1. Shutdown Current Test Circuit



NOTES: A. C_L includes probe and jig capacitance.

B. The pulse generator has the following characteristics: $Z_O = 50\ \Omega$, 50% duty cycle, $t_r \leq 10\text{ ns}$, $t_f \leq 10\text{ ns}$.

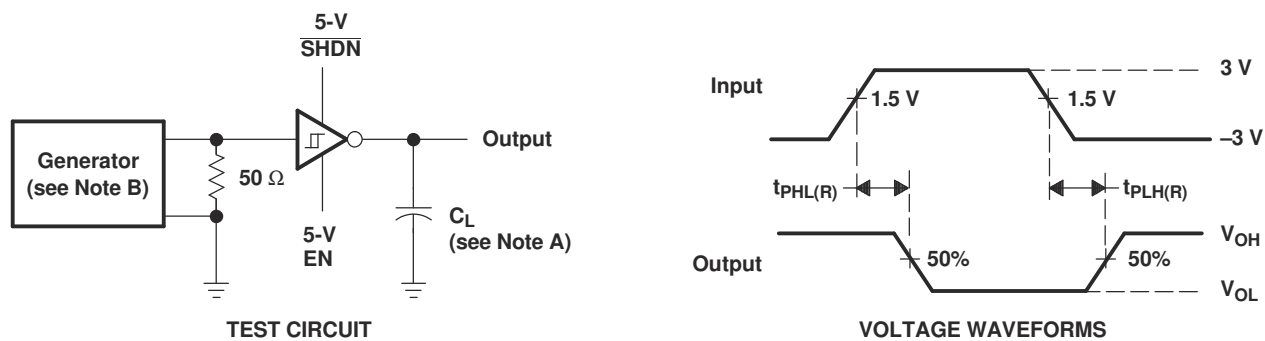
Figure 6-2. Driver Slew Rate



NOTES: A. C_L includes probe and jig capacitance.

B. The pulse generator has the following characteristics: $Z_O = 50\ \Omega$, 50% duty cycle, $t_r \leq 10\text{ ns}$, $t_f \leq 10\text{ ns}$.

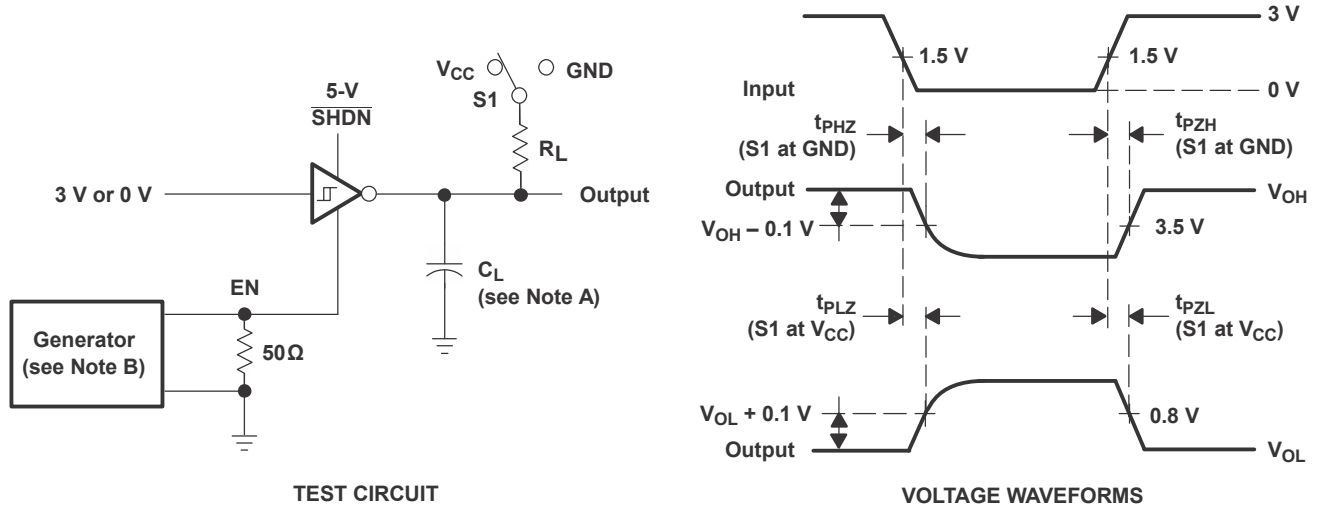
Figure 6-3. Driver Pulse Skew and Propagation Delay Times



NOTES: A. C_L includes probe and jig capacitance.

B. The pulse generator has the following characteristics: $Z_O = 50\ \Omega$, 50% duty cycle, $t_r \leq 10\text{ ns}$, $t_f \leq 10\text{ ns}$.

Figure 6-4. Receiver Propagation Delay Times



- NOTES:
- A. C_L includes probe and jig capacitance.
 - B. The pulse generator has the following characteristics: $Z_0 = 50\ \Omega$, 50% duty cycle, $t_r \leq 10\ \text{ns}$, $t_f \leq 10\ \text{ns}$.
 - C. t_{PLZ} and t_{PHZ} are the same as t_{dis} .
 - D. t_{PZL} and t_{PZH} are the same as t_{en} .

Figure 6-5. Receiver Enable and Disable Times

7 Functional Modes

Table 7-1. Function Table

INPUTS		DRIVER D1–D4	RECEIVER		DEVICE STATUS
SHDN	EN		R1–R3	R4–R5	
L	L	Z	Z	Z	Shutdown
L	H	Z	Z	Active ⁽¹⁾	Shutdown
H	L	All active	Z	Z	Normal operation
H	H	All active	Active	Active	Normal operation

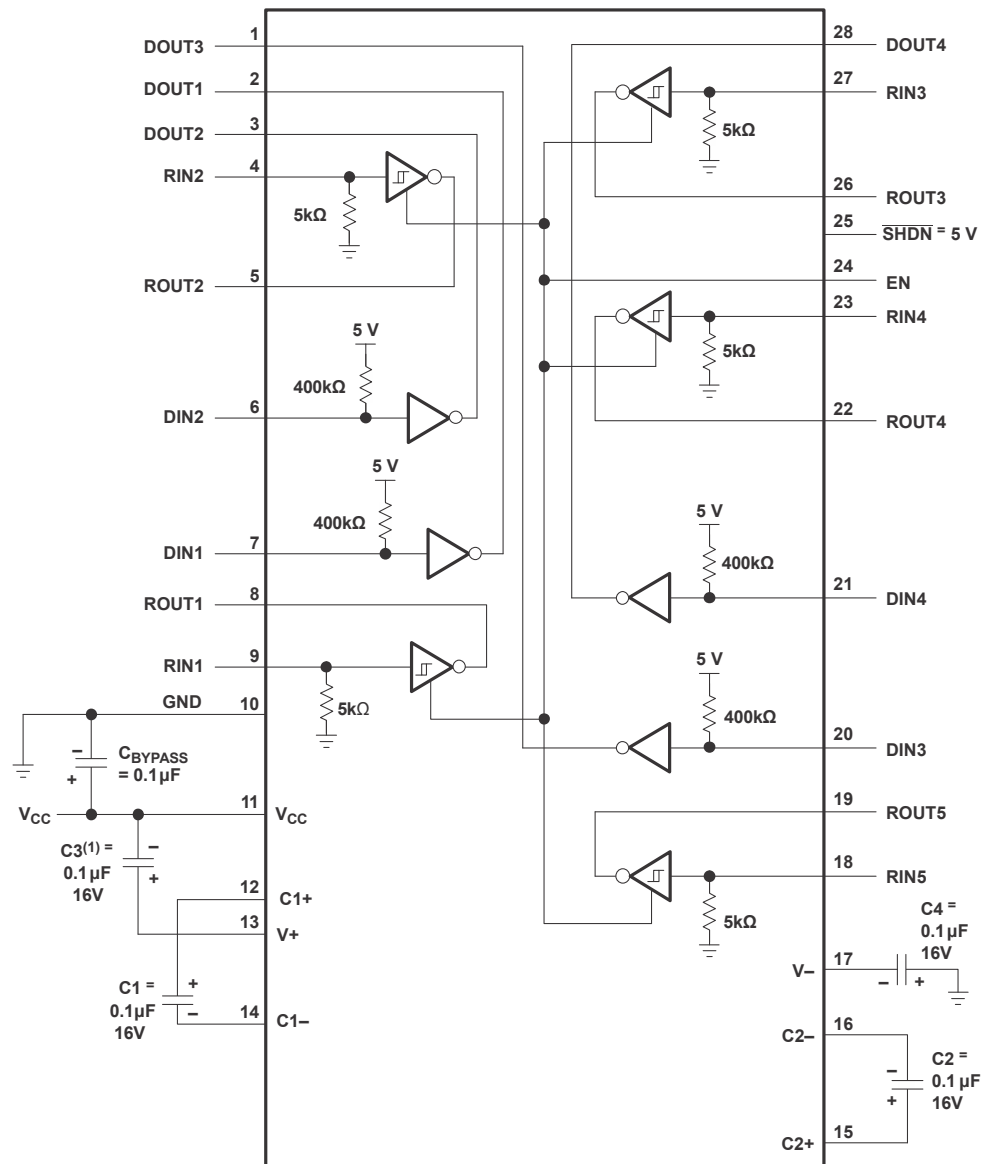
(1) See the V_{IT+} and V_{IT-} change in the *Electrical Characteristics* table.

8 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, as well as validating and testing their design implementation to confirm system functionality.

8.1 Typical Application



(1) C3 can be connected to VCC or GND.

NOTES: A. Resistor values shown are nominal.

B. Nonpolarized ceramic capacitors are acceptable. If polarized tantalum or electrolytic capacitors are used, they should be connected as shown.

Figure 8-1. Typical Operating Circuit and Capacitor Values

9 Device and Documentation Support

TI offers an extensive line of development tools. Tools and software to evaluate the performance of the device, generate code, and develop solutions are listed below.

9.1 Receiving Notification of Documentation Updates

To receive notification of documentation updates, navigate to the device product folder on [ti.com](https://www.ti.com). Click on *Notifications* to register and receive a weekly digest of any product information that has changed. For change details, review the revision history included in any revised document.

9.2 Support Resources

[TI E2E™ support forums](#) are an engineer's go-to source for fast, verified answers and design help — straight from the experts. Search existing answers or ask your own question to get the quick design help you need.

Linked content is provided "AS IS" by the respective contributors. They do not constitute TI specifications and do not necessarily reflect TI's views; see TI's [Terms of Use](#).

9.3 Trademarks

TI E2E™ is a trademark of Texas Instruments.

All trademarks are the property of their respective owners.

9.4 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.

9.5 Glossary

[TI Glossary](#) This glossary lists and explains terms, acronyms, and definitions.

10 Revision History

NOTE: Page numbers for previous revisions may differ from page numbers in the current version.

Changes from Revision * (July 2024) to Revision A (January 2025)	Page
• Changed the value of 120kbps to 250kbps in the data sheet <i>Title</i>	1
• Changed the value of 120kbits to 250kbits in the <i>Features</i> and <i>Description</i>	1
• Deleted the Maximum data rate TYP value and changed the MIN value to 250kbps from 120kbps in the <i>Switching Characteristics, Driver</i>	6

11 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)
TRS213EIDBR	Active	Production	SSOP (DB) 28	2000 LARGE T&R	Yes	NIPDAU	Level-1-260C-UNLIM	-40 to 85	TRS213I
TRS213EIDBR.A	Active	Production	SSOP (DB) 28	2000 LARGE T&R	Yes	NIPDAU	Level-1-260C-UNLIM	-40 to 85	TRS213I

⁽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.

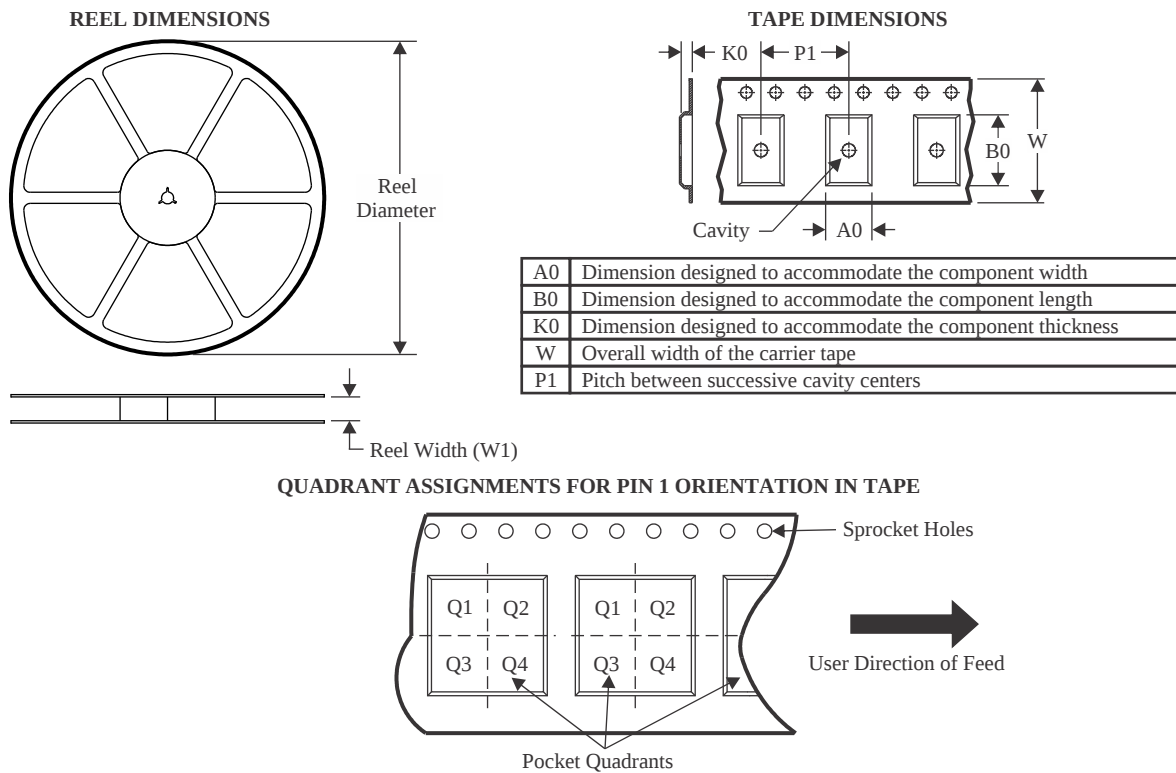
⁽⁶⁾ **Part marking:** There may be an additional marking, which relates to the logo, the lot trace code information, or the environmental category of the part.

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.

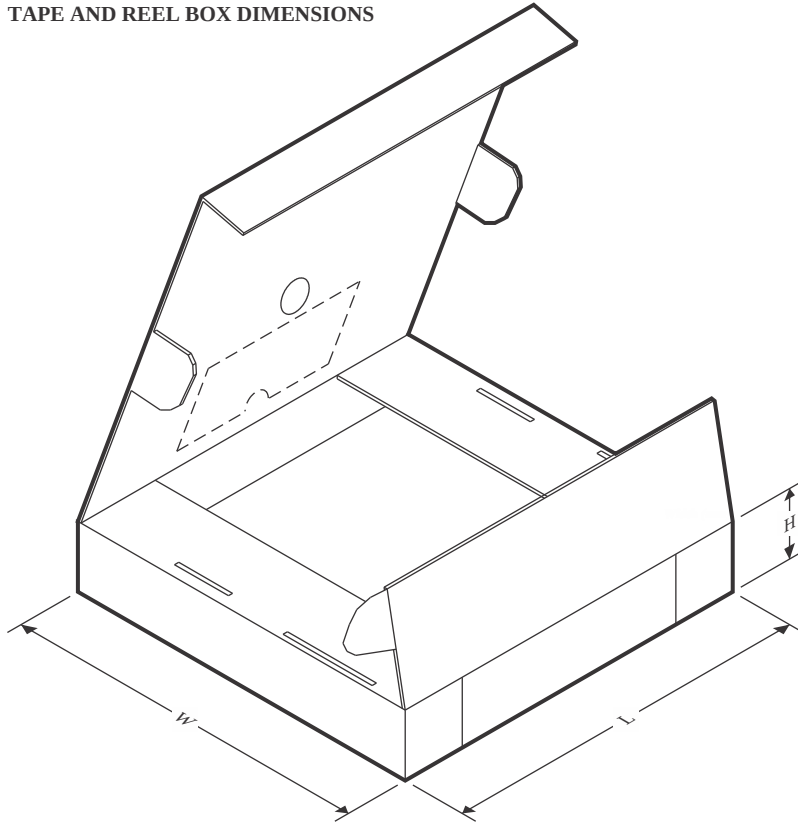
TAPE AND REEL INFORMATION



*All dimensions are nominal

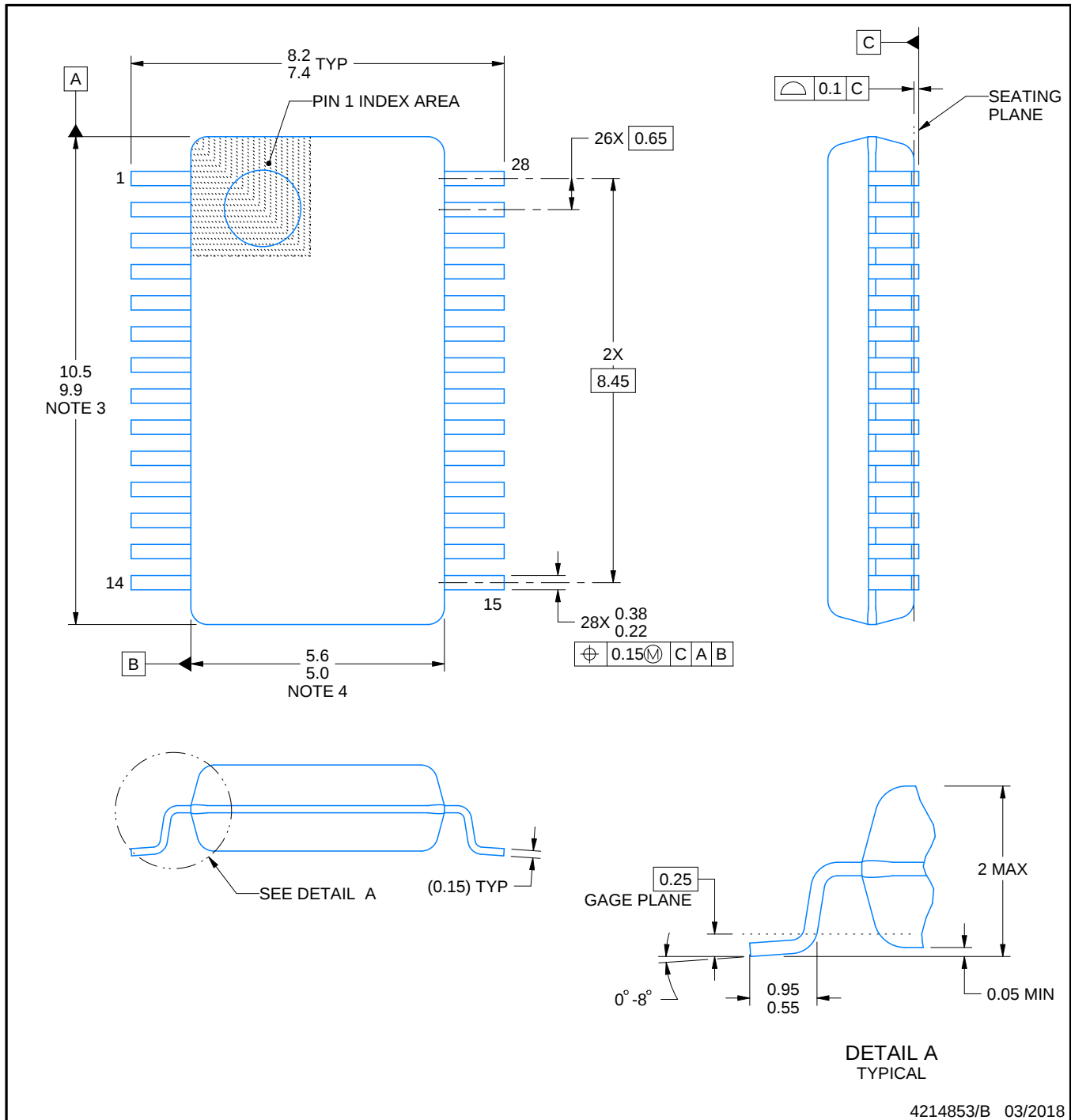
Device	Package Type	Package Drawing	Pins	SPQ	Reel Diameter (mm)	Reel Width W1 (mm)	A0 (mm)	B0 (mm)	K0 (mm)	P1 (mm)	W (mm)	Pin1 Quadrant
TRS213EIDBR	SSOP	DB	28	2000	330.0	16.4	8.45	10.55	2.5	12.0	16.2	Q1

TAPE AND REEL BOX DIMENSIONS



*All dimensions are nominal

Device	Package Type	Package Drawing	Pins	SPQ	Length (mm)	Width (mm)	Height (mm)
TRS213EIDBR	SSOP	DB	28	2000	356.0	356.0	35.0

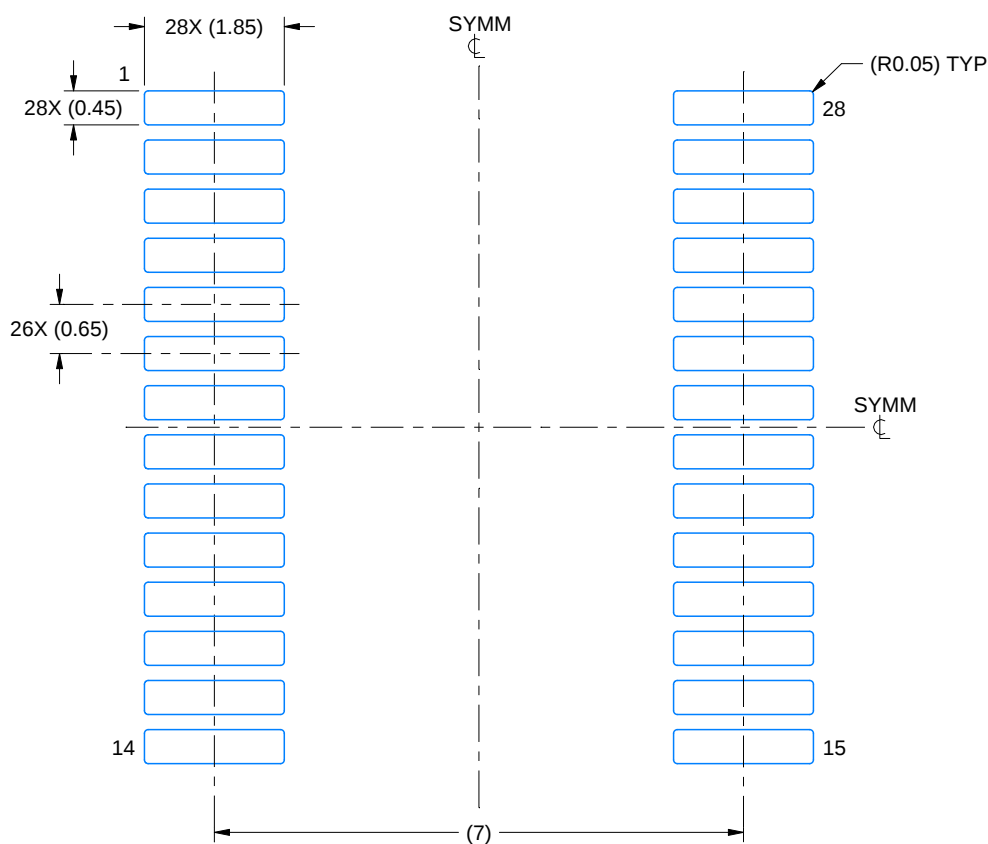


4214853/B 03/2018

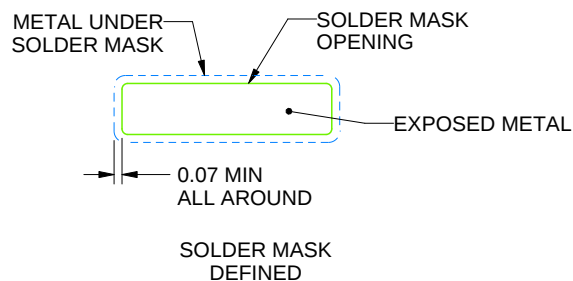
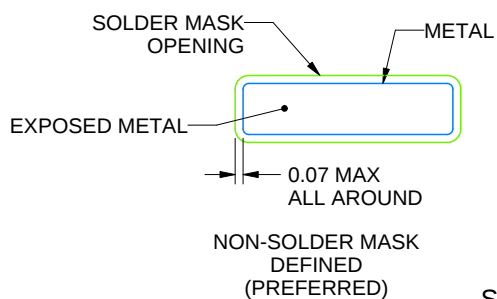
DB0028A

SSOP - 2 mm max height

SMALL OUTLINE PACKAGE



LAND PATTERN EXAMPLE
EXPOSED METAL SHOWN
SCALE: 10X



SOLDER MASK DETAILS

4214853/B 03/2018

NOTES: (continued)

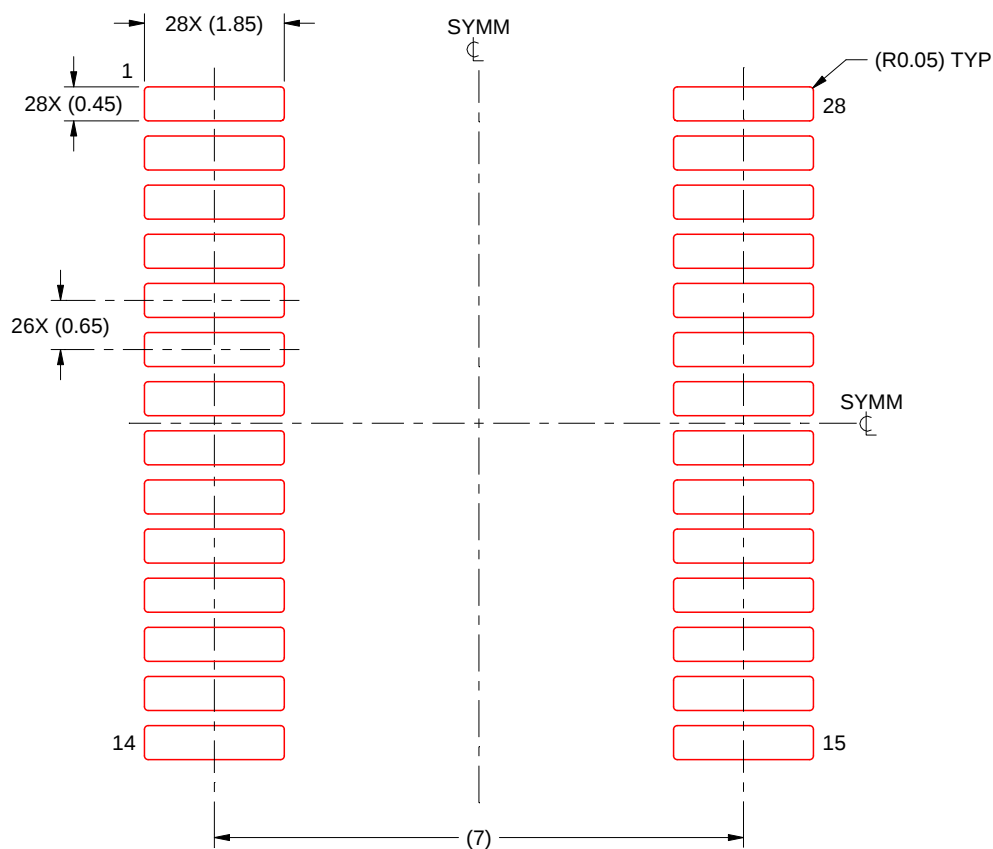
6. Publication IPC-7351 may have alternate designs.
7. Solder mask tolerances between and around signal pads can vary based on board fabrication site.

EXAMPLE STENCIL DESIGN

DB0028A

SSOP - 2 mm max height

SMALL OUTLINE PACKAGE



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

4214853/B 03/2018

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 DATA SHEETS), 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 will 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](#) or other applicable terms available either on [ti.com](https://www.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.

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

Mailing Address: Texas Instruments, Post Office Box 655303, Dallas, Texas 75265
Copyright © 2025, Texas Instruments Incorporated