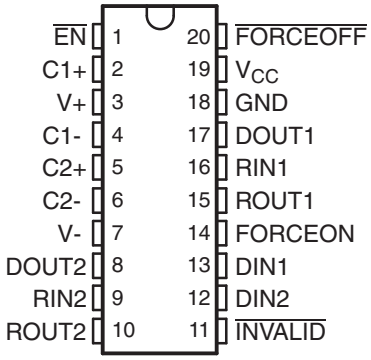
3-V To 5.5-V MULTICHANNEL RS-232 LINE DRIVER/RECEIVER WITH ±15-kV ESD PROTECTION

FEATURES

- **Qualified for Automotive Applications**
- **RS-232 Bus-Pin ESD Protection Exceeds ±15 kV Using Human-Body Model (HBM)**
- **Meets or Exceeds the Requirements of TIA/EIA-232-F and ITU v.28 Standards**
- **Operates With 3-V to 5.5-V V_{CC} Supply**
- **Operates up to 250 kbit/s**
- **Two Drivers and Two Receivers**
- **Low Standby Current . . . 1 μA Typical**
- **External Capacitors . . . 4 × 0.1 μF**
- **Accepts 5-V Logic Input With 3.3-V Supply**

PW PACKAGE
(TOP VIEW)



DESCRIPTION/ORDERING INFORMATION

The TRS3223 consists of two line drivers, two line receivers, and a dual charge-pump circuit with ±15-kV ESD protection pin to pin (serial-port connection pins, including GND). 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 3-V to 5.5-V supply. The device operates at data signaling rates up to 250 kbit/s and a maximum of 30-V/μs driver output slew rate.

Flexible control options for power management are available when the serial port is inactive. The auto-powerdown feature functions when FORCEON is low and FORCEOFF is high. During this mode of operation, if the device does not sense a valid RS-232 signal, the driver outputs are disabled. If FORCEOFF is set low and EN is high, both drivers and receivers are shut off, and the supply current is reduced to 1 μA. Disconnecting the serial port or turning off the peripheral drivers causes auto-powerdown to occur. Auto-powerdown can be disabled when FORCEON and FORCEOFF are high. With auto-powerdown enabled, the device is activated automatically when a valid signal is applied to any receiver input. The INVALID output is used to notify the user if an RS-232 signal is present at any receiver input. INVALID is high (valid data) if any receiver input voltage is greater than 2.7 V or less than –2.7 V, or has been between –0.3 V and 0.3 V for less than 30 μs. INVALID is low (invalid data) if the receiver input voltage is between –0.3 V and 0.3 V for more than 30 μs. See Figure 4 for receiver input levels.

ORDERING INFORMATION(1)

T_A	PACKAGE(2)		ORDERABLE PART NUMBER	TOP-SIDE MARKING
–40°C to 125°C	TSSOP – PW	Reel of 2000	TRS3223QPWRQ1	T3223

(1) For the most current package and ordering information, see the Package Option Addendum at the end of this document, or see the TI web site at www.ti.com.
(2) Package drawings, thermal data, and symbolization are available at www.ti.com/packaging.

DRIVER FUNCTION TABLE (EACH DRIVER)(1)

INPUTS				OUTPUT DOUT	DRIVER STATUS
DIN	FORCEON	$\overline{\text{FORCEOFF}}$	VALID RIN RS-232 LEVEL		
X	X	L	X	Z	Powered off
L	H	H	X	H	Normal operation with auto-powerdown disabled
H	H	H	X	L	
L	L	H	Yes	H	Normal operation with auto-powerdown enabled
H	L	H	Yes	L	
L	L	H	No	Z	Powered off by auto-powerdown feature
H	L	H	No	Z	

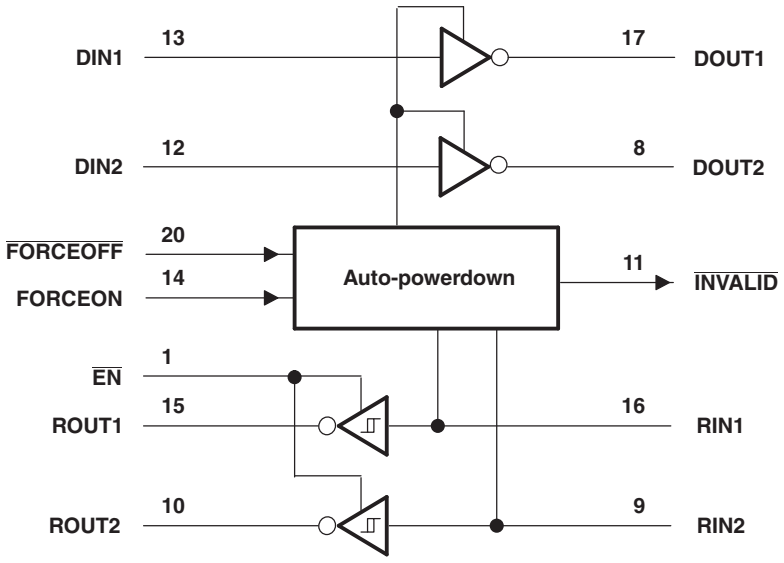
(1) H = high level, L = low level, X = irrelevant, Z = high impedance

RECEIVER FUNCTION TABLE (EACH RECEIVER)(1)

INPUTS			OUTPUT ROUT
RIN	$\overline{\text{EN}}$	VALID RIN RS-232 LEVEL	
L	L	X	H
H	L	X	L
X	H	X	Z
Open	L	No	H

(1) H = high level, L = low level, X = irrelevant, Z = high impedance (off), Open = input disconnected or connected driver off

LOGIC DIAGRAM



ABSOLUTE MAXIMUM RATINGS(1)(2)

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

V_{CC}	Supply voltage range		–0.3 V to 6 V
V+	Positive output supply voltage range		–0.3 V to 7 V
V–	Negative output supply voltage range		0.3 V to –7 V
V+ – V–	Supply voltage difference		13 V
V_I	Input voltage range	Driver, $\overline{\text{FORCEOFF}}$, FORCEON, $\overline{\text{EN}}$	–0.3 V to 6 V
		Receiver	–25 V to 25 V
V_O	Output voltage range	Driver	–13.2 V to 13.2 V
		Receiver, $\overline{\text{INVALID}}$	–0.3 V to V_{CC} + 0.3 V
θ_{JA}	Package thermal impedance(3)		83°C/W
T_J	Operating virtual-junction temperature		150°C
T_{stg}	Storage temperature range		–65°C to 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.
(3) The package thermal impedance is calculated in accordance with JESD 51-7.

RECOMMENDED OPERATING CONDITIONS(1)

see Figure 6

				MIN	NOM	MAX	UNIT
V_{CC}	Supply voltage		V_{CC} = 3.3 V	3	3.3	3.6	V
			V_{CC} = 5 V	4.5	5	5.5	
V_{IH}	High-level input voltage	Driver and control, DIN, $\overline{\text{EN}}$, $\overline{\text{FORCEOFF}}$, FORCEON	V_{CC} = 3.3 V	2			V
			V_{CC} = 5 V	2.4			
V_{IL}	Low-level input voltage	Driver and control, DIN, $\overline{\text{EN}}$, $\overline{\text{FORCEOFF}}$, FORCEON				0.8	V
V_I	Input voltage	Driver and control, DIN, $\overline{\text{EN}}$, $\overline{\text{FORCEOFF}}$, FORCEON		0		5.5	V
		Receiver		–25		25	
T_A	Operating free-air temperature			–40		125	°C

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

ELECTRICAL CHARACTERISTICS(1)

over recommended ranges of supply voltage and operating free-air temperature (unless otherwise noted) (see Figure 6)

PARAMETER			TEST CONDITIONS		MIN	TYP(2)	MAX	UNIT
I_I	Input leakage current		$\overline{\text{EN}}$, $\overline{\text{FORCEOFF}}$, FORCEON			±0.01	±1	µA
I_{CC}	Supply current	Auto-powerdown disabled	V_{CC} = 3.3 V or 5 V, T_A = 25°C	No load, $\overline{\text{FORCEOFF}}$ and FORCEON at V_{CC}		0.3	2	mA
		Powered off		No load, $\overline{\text{FORCEOFF}}$ at GND		1	20	µA
		Auto-powerdown enabled		No load, $\overline{\text{FORCEOFF}}$ at V_{CC}, FORCEON at GND, All RIN are open or grounded		1	20	

(1) Test conditions are C1–C4 = 0.1 µF at V_{CC} = 3.3 V ± 0.3 V; C1 = 0.047 µF, C2–C4 = 0.33 µF at V_{CC} = 5 V ± 0.5 V.
(2) All typical values are at V_{CC} = 3.3 V or V_{CC} = 5 V, and T_A = 25°C.

DRIVER SECTION ELECTRICAL CHARACTERISTICS(1)

over recommended ranges of supply voltage and operating free-air temperature (unless otherwise noted) (see Figure 6)

PARAMETER		TEST CONDITIONS		MIN	TYP(2)	MAX	UNIT
V_{OH}	High-level output voltage	DOUT at R_L = 3 kΩ to GND		5	5.4		V
V_{OL}	Low-level output voltage	DOUT at R_L = 3 kΩ to GND		–5	–5.4		V
I_{IH}	High-level input current	$V_I = V_{CC}$			±0.01	±1	µA
I_{IL}	Low-level input current	V_I = GND			±0.01	±1	µA
I_{OS}	Short-circuit output current(3)	V_{CC} = 3.6 V, V_O = 0 V			±35	±60	mA
		V_{CC} = 5.5 V, V_O = 0 V			±35	±60	
r_o	Output resistance	V_{CC}, V+, and V– = 0 V, V_O = ±2 V		300	10M		Ω
I_{off}	Output leakage current	$\overline{\text{FORCEOFF}}$ = GND	V_O = ±12 V, V_{CC} = 3 V to 3.6 V			±25	µA
			V_O = ±10 V, V_{CC} = 4.5 V to 5.5 V			±25	

(1) Test conditions are C1–C4 = 0.1 µF at V_{CC} = 3.3 V ± 0.3 V; C1 = 0.047 µF, C2–C4 = 0.33 µF at V_{CC} = 5 V ± 0.5 V.
(2) All typical values are at V_{CC} = 3.3 V or V_{CC} = 5 V, and T_A = 25°C.
(3) Short-circuit durations should be controlled to prevent exceeding the device absolute power-dissipation ratings, and not more than one output should be shorted at a time.

DRIVER SECTION SWITCHING CHARACTERISTICS(1)

over recommended ranges of supply voltage and operating free-air temperature (unless otherwise noted) (see Figure 6)

PARAMETER		TEST CONDITIONS		MIN	TYP(2)	MAX	UNIT
	Maximum data rate	C_L = 1000 pF, One DOUT switching, R_L = 3 kΩ (see Figure 1)		250			kbit/s
$t_{sk(p)}$	Pulse skew(3)	C_L = 150 pF to 2500 pF, R_L = 3 kΩ to 7 kΩ (see Figure 2)			100		ns
SR(tr)	Slew rate, transition region (see Figure 1)	V_{CC} = 3.3 V, R_L = 3 kΩ to 7 kΩ	C_L = 150 pF to 1000 pF	6		30	V/µs
			C_L = 150 pF to 2500 pF	4		30	

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

RECEIVER SECTION ELECTRICAL CHARACTERISTICS(1)

over recommended ranges of supply voltage and operating free-air temperature (unless otherwise noted) (see Figure 6)

PARAMETER		TEST CONDITIONS	MIN	TYP(2)	MAX	UNIT
V_{OH}	High-level output voltage	I_{OH} = –1 mA	V_{CC} – 0.6	V_{CC} – 0.1		V
V_{OL}	Low-level output voltage	I_{OL} = 1.6 mA			0.4	V
V_{IT+}	Positive-going input threshold voltage	V_{CC} = 3.3 V		1.6	2.4	V
		V_{CC} = 5 V		1.9	2.4	
$V_{IT–}$	Negative-going input threshold voltage	V_{CC} = 3.3 V	0.6	1.1		V
		V_{CC} = 5 V	0.8	1.4		
V_{hys}	Input hysteresis ($V_{IT+} – V_{IT–}$)			0.5		V
I_{off}	Output leakage current	$\overline{EN}$ = V_{CC}		±0.05	±10	µA
r_i	Input resistance	V_I = ±3 V to ±25 V	3	5	8.3	kΩ

(1) Test conditions are C1–C4 = 0.1 µF at V_{CC} = 3.3 V ± 0.3 V; C1 = 0.047 µF, C2–C4 = 0.33 µF at V_{CC} = 5 V ± 0.5 V.
(2) All typical values are at V_{CC} = 3.3 V or V_{CC} = 5 V, and T_A = 25°C.

RECEIVER SECTION SWITCHING CHARACTERISTICS(1)

over recommended ranges of supply voltage and operating free-air temperature (unless otherwise noted) (see Figure 6)

PARAMETER		TEST CONDITIONS	TYP(2)	UNIT
t_{PLH}	Propagation delay time, low-level to high-level output	C_L = 150 pF, See Figure 3	150	ns
t_{PHL}	Propagation delay time, high-level to low-level output	C_L = 150 pF, See Figure 3	150	ns
t_{en}	Output enable time	C_L = 150 pF, R_L = 3 kΩ, See Figure 4	200	ns
t_{dis}	Output disable time	C_L = 150 pF, R_L = 3 kΩ, See Figure 4	200	ns
$t_{sk(p)}$	Pulse skew(3)	See Figure 3	50	ns

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

AUTO-POWERDOWN SECTION ELECTRICAL CHARACTERISTICS

over recommended ranges of supply voltage and operating free-air temperature (unless otherwise noted) (see Figure 5)

PARAMETER		TEST CONDITIONS	MIN	MAX	UNIT
$V_{T+(valid)}$	Receiver input threshold for $\overline{INVALID}$ high-level output voltage	FORCEON = GND, $\overline{FORCEOFF}$ = V_{CC}		2.7	V
$V_{T-(valid)}$	Receiver input threshold for $\overline{INVALID}$ high-level output voltage	FORCEON = GND, $\overline{FORCEOFF}$ = V_{CC}	–2.7		V
$V_{T(invalid)}$	Receiver input threshold for $\overline{INVALID}$ low-level output voltage	FORCEON = GND, $\overline{FORCEOFF}$ = V_{CC}	–0.3	0.3	V
V_{OH}	$\overline{INVALID}$ high-level output voltage	I_{OH} = –1 mA, FORCEON = GND, $\overline{FORCEOFF}$ = V_{CC}	V_{CC} – 0.6		V
V_{OL}	$\overline{INVALID}$ low-level output voltage	I_{OL} = 1.6 mA, FORCEON = GND, $\overline{FORCEOFF}$ = V_{CC}		0.4	V

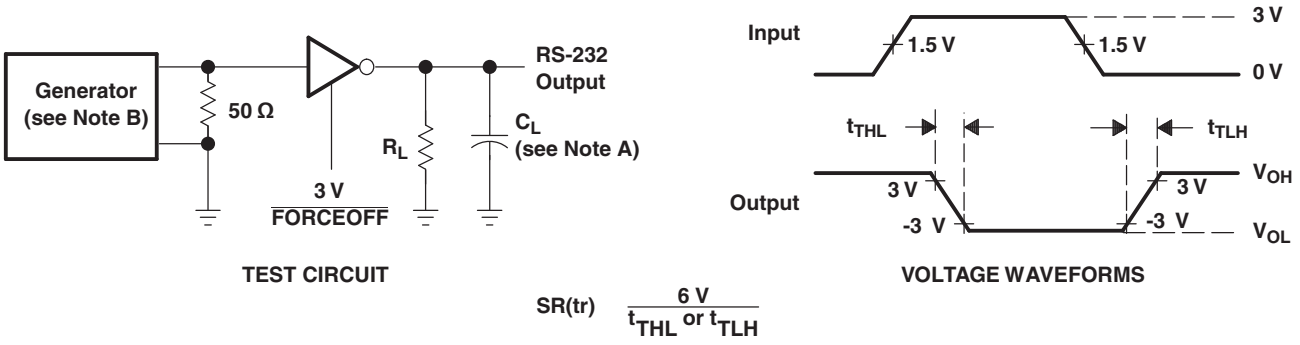
AUTO-POWERDOWN SECTION SWITCHING CHARACTERISTICS

over recommended ranges of supply voltage and operating free-air temperature (unless otherwise noted) (see Figure 5)

PARAMETER		TYP(1)	UNIT
t_{valid}	Propagation delay time, low- to high-level output	1	µs
$t_{invalid}$	Propagation delay time, high- to low-level output	30	µs
t_{en}	Supply enable time	100	µs

(1) All typical values are at V_{CC} = 3.3 V or V_{CC} = 5 V, and T_A = 25°C.

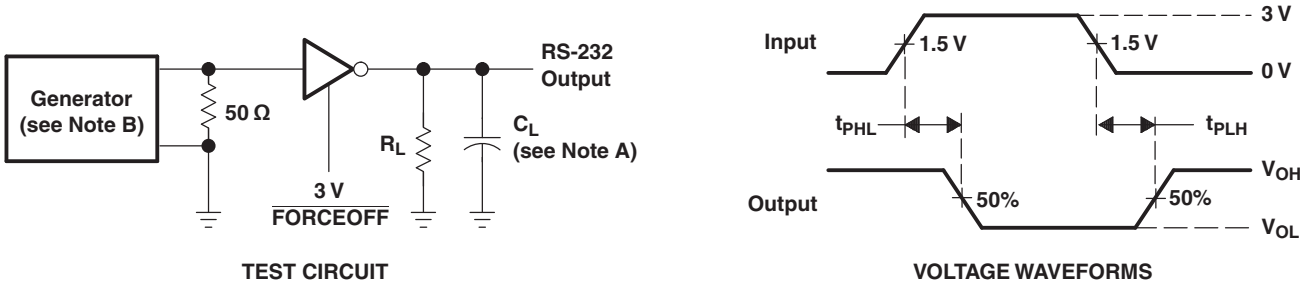
PARAMETER MEASUREMENT INFORMATION



$$SR(tr) \quad \frac{6\ V}{t_{THL} \text{ or } t_{TLH}}$$

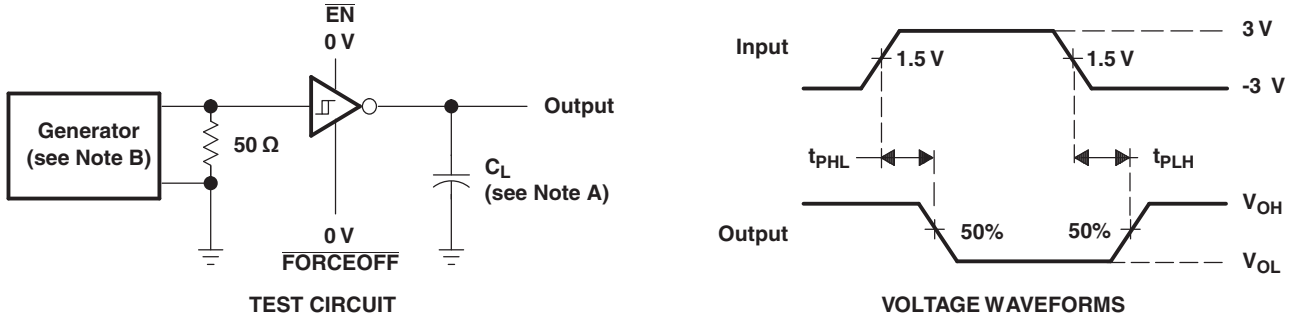
A.C_L includes probe and jig capacitance.
B.The pulse generator has the following characteristics: PRR = 250 kbit/s, Z_O = 50 Ω, 50% duty cycle, t_r ≤ 10 ns, t_f ≤ 10 ns.

Figure 1. Driver Slew Rate



A.C_L includes probe and jig capacitance.
B.The pulse generator has the following characteristics: PRR = 250 kbit/s, Z_O = 50 Ω, 50% duty cycle, t_r ≤ 10 ns, t_f ≤ 10 ns.

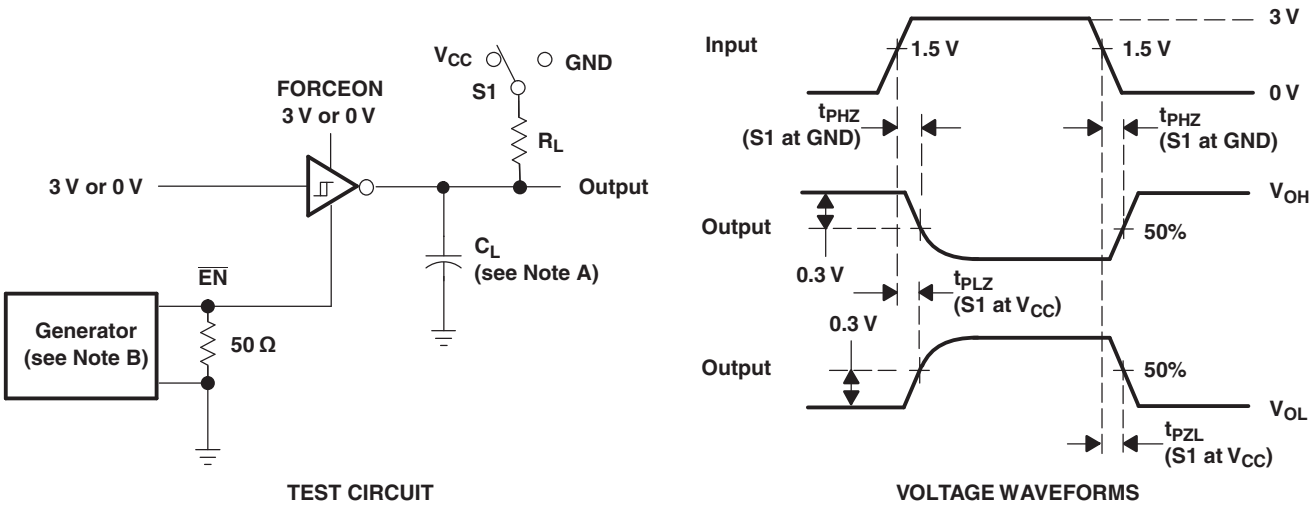
Figure 2. Driver Pulse Skew



A.C_L includes probe and jig capacitance.
B.The pulse generator has the following characteristics: Z_O = 50 Ω, 50% duty cycle, t_r ≤ 10 ns, t_f ≤ 10 ns.

Figure 3. Receiver Propagation Delay Times

PARAMETER MEASUREMENT INFORMATION (continued)

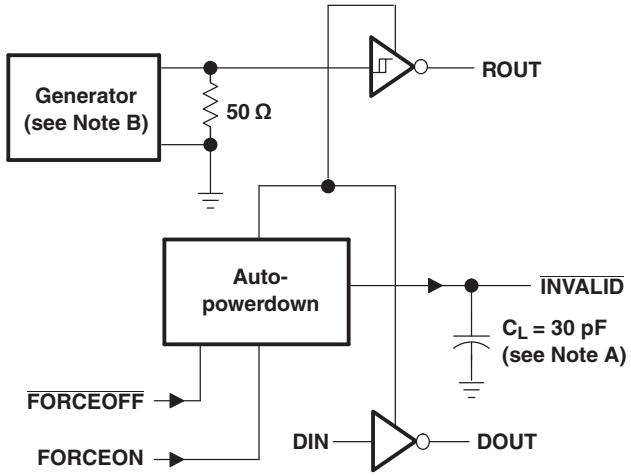


TEST CIRCUIT VOLTAGE WAVEFORMS

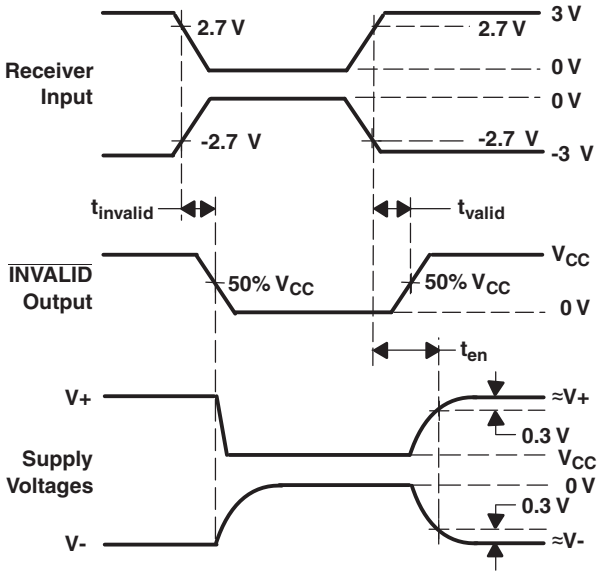
A. C_L includes probe and jig capacitance.
B. The pulse generator has the following characteristics: Z_O = 50 Ω, 50% duty cycle, t_r ≤ 10 ns, t_f ≤ 10 ns.

Figure 4. Receiver Enable and Disable Times

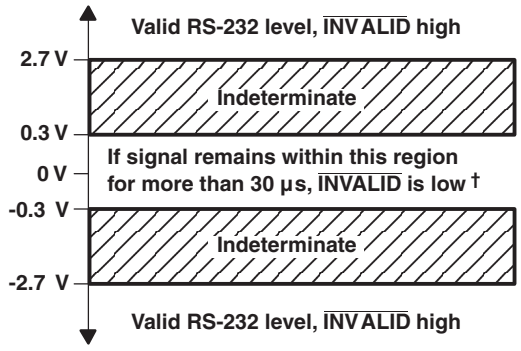
PARAMETER MEASUREMENT INFORMATION (continued)



TEST CIRCUIT



VOLTAGE WAVEFORMS

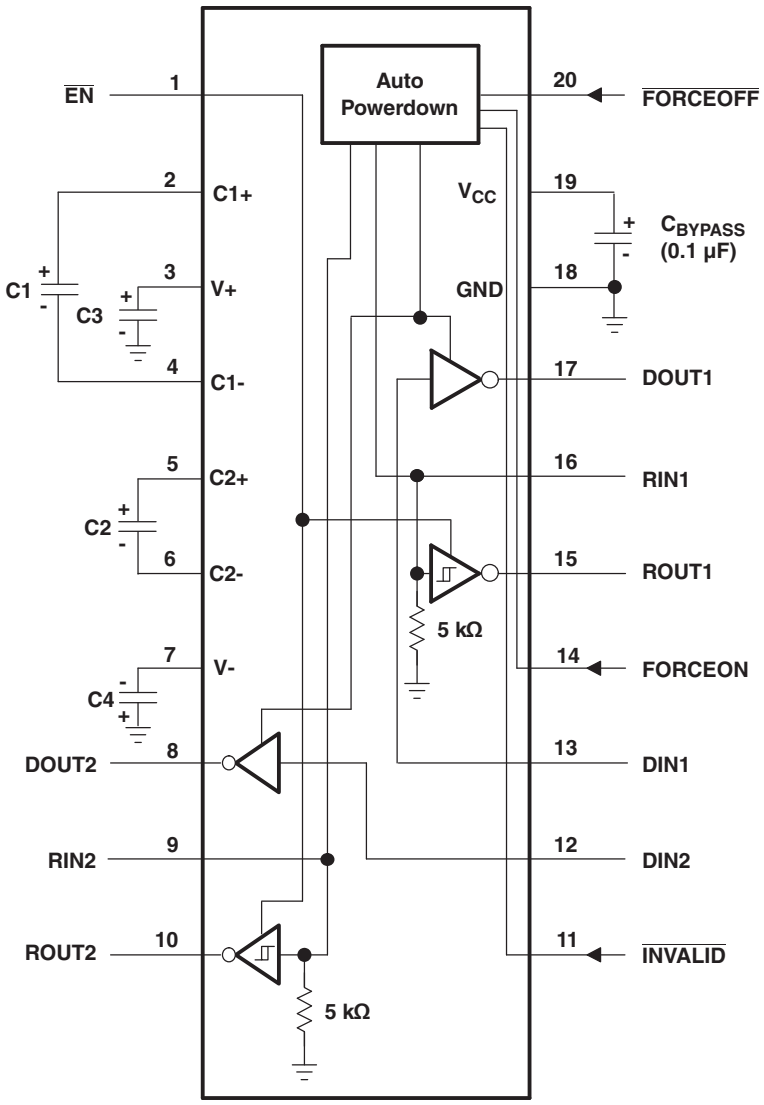


† Auto-powerdown disables drivers and reduces supply current to 1 µA.

A. C_L includes probe and jig capacitance.
B. The pulse generator has the following characteristics: PRR = 5 kbit/s, Z_O = 50 Ω, 50% duty cycle, t_r ≤ 10 ns, t_f ≤ 10 ns.

Figure 5. INVALID Propagation Delay Times and Supply Enabling Time

APPLICATION INFORMATION



A. C3 can be connected to V_{CC} or GND.
B. Resistor values shown are nominal.
C. Nonpolarized ceramic capacitors are acceptable. If polarized tantalum or electrolytic capacitors are used, they should be connected as shown.

V_{CC} vs CAPACITOR VALUES

V_{CC}	C1	C2, C3, C4
3.3 V ± 0.3 V	0.1 µF	0.1 µF
5 V ± 0.5 V	0.047 µF	0.33 µF
3 V to 5.5 V	0.1 µF	0.47 µF

Figure 6. Typical Operating Circuit and Capacitor Values

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)
TRS3223QPWRQ1	Active	Production	TSSOP (PW) | 20	2000 | LARGE T&R	Yes	NIPDAU	Level-1-260C-UNLIM	-40 to 125	T3223
TRS3223QPWRQ1.A	Active	Production	TSSOP (PW) | 20	2000 | LARGE T&R	Yes	NIPDAU	Level-1-260C-UNLIM	-40 to 125	T3223

(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.

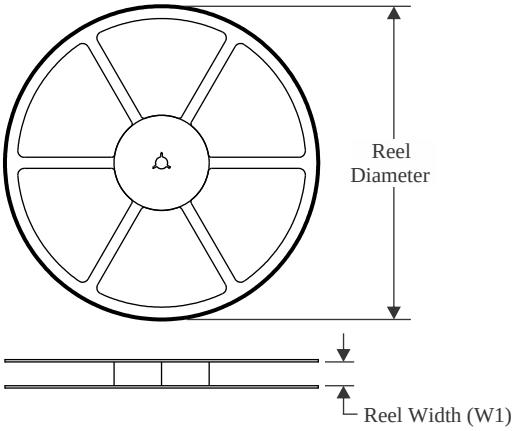
(5) **MSL rating/Peak reflow:** The moisture sensitivity level ratings and peak solder (reflow) temperatures. In the event that a part has multiple moisture sensitivity ratings, only the lowest level per JEDEC standards is shown. Refer to the shipping label for the actual reflow temperature that will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

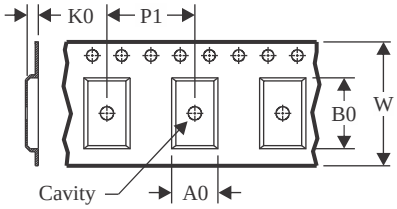
Multiple part markings will be inside parentheses. Only one part marking contained in parentheses and separated by a "~" will appear on a part. If a line is indented then it is a continuation of the previous line and the two combined represent the entire part marking for that device.

TAPE AND REEL INFORMATION

REEL DIMENSIONS

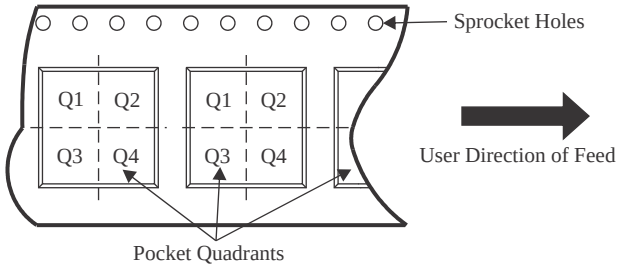


TAPE DIMENSIONS



A0	Dimension designed to accommodate the component width
B0	Dimension designed to accommodate the component length
K0	Dimension designed to accommodate the component thickness
W	Overall width of the carrier tape
P1	Pitch between successive cavity centers

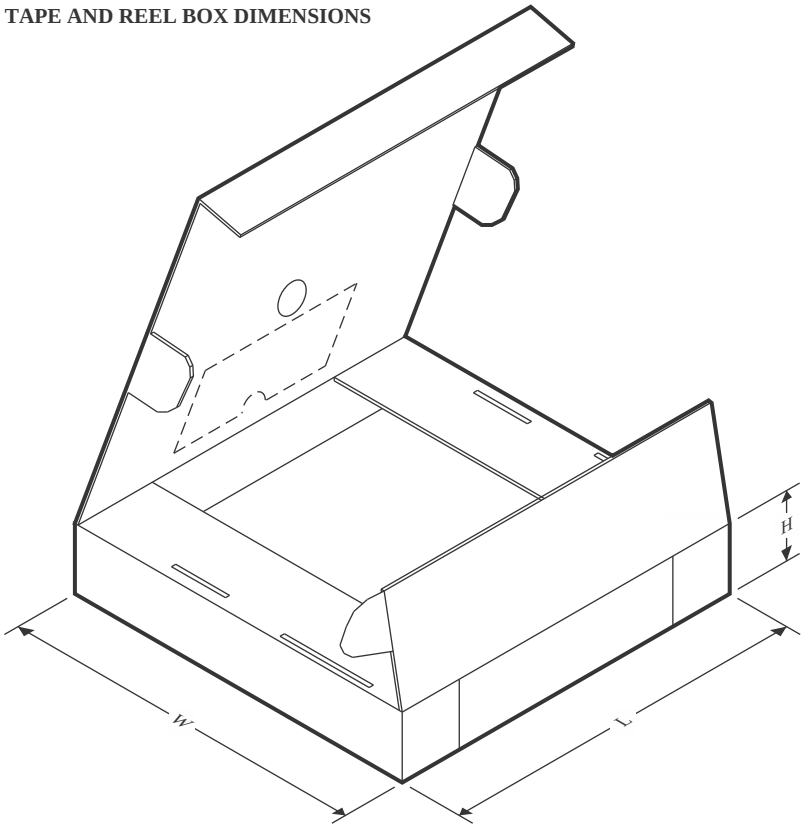
QUADRANT ASSIGNMENTS FOR PIN 1 ORIENTATION IN TAPE



*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
TRS3223QPWRQ1	TSSOP	PW	20	2000	330.0	16.4	6.95	7.0	1.4	8.0	16.0	Q1

TAPE AND REEL BOX DIMENSIONS



*All dimensions are nominal

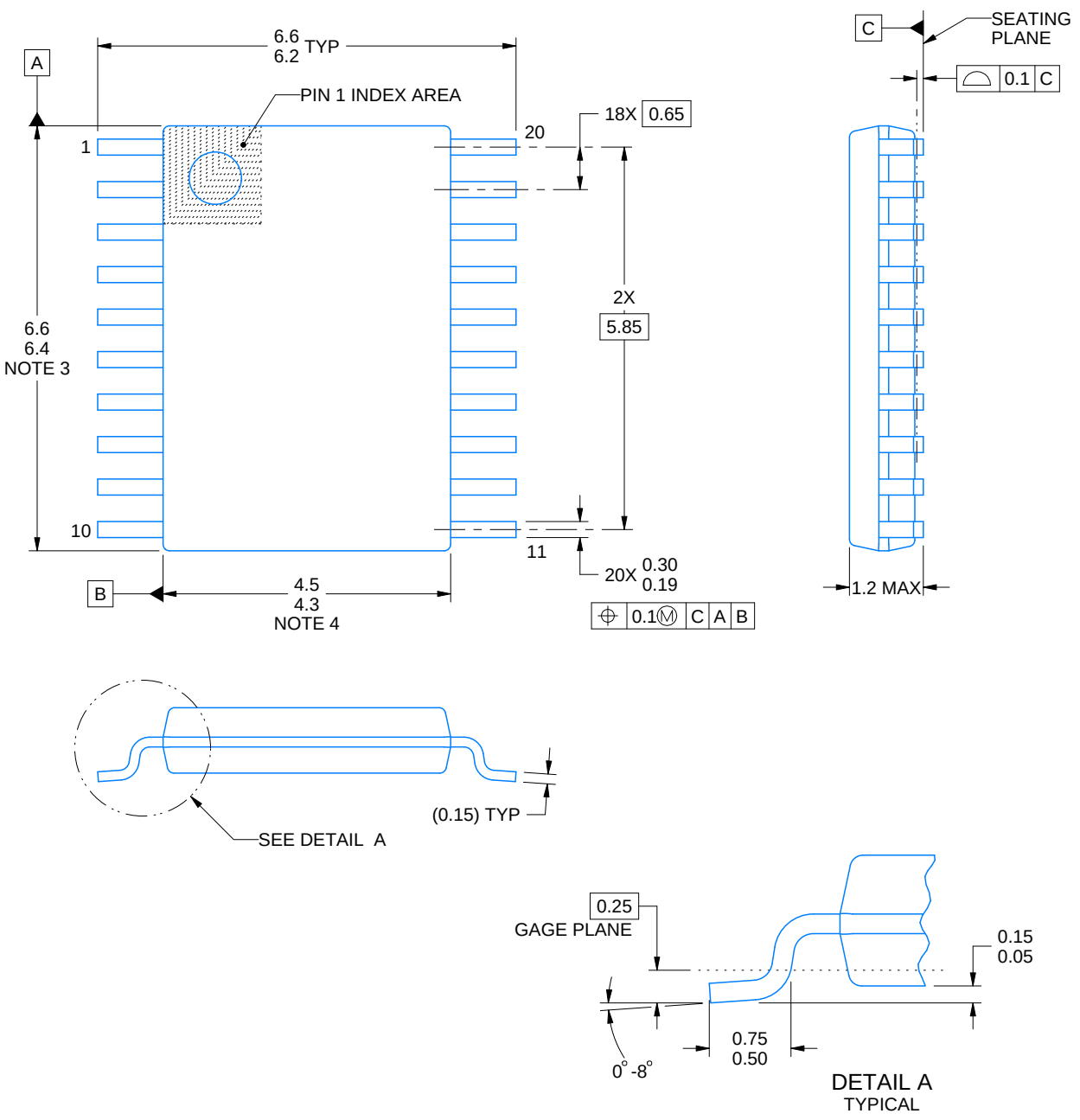
Device	Package Type	Package Drawing	Pins	SPQ	Length (mm)	Width (mm)	Height (mm)
TRS3223QPWRQ1	TSSOP	PW	20	2000	353.0	353.0	32.0

PACKAGE OUTLINE

PW0020A

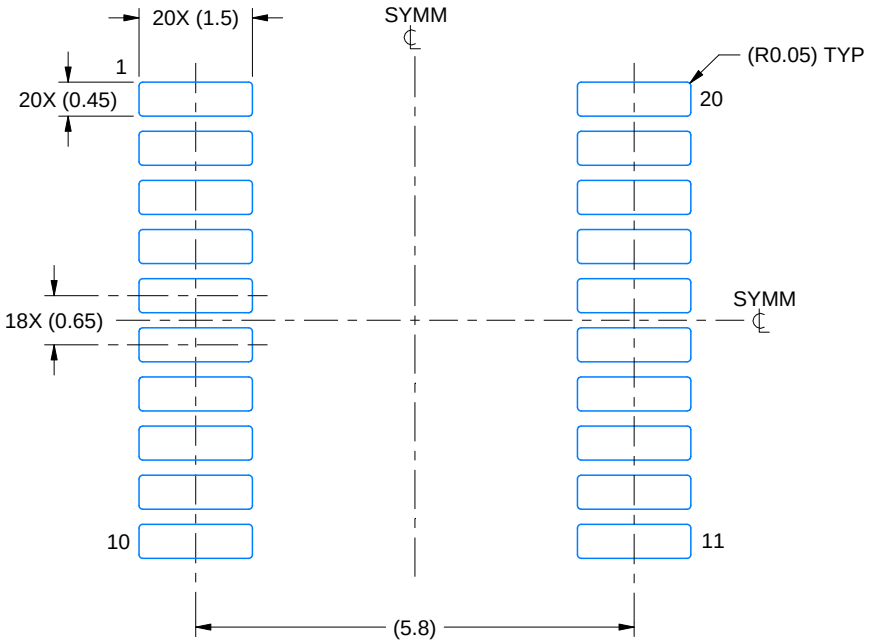
TSSOP - 1.2 mm max height

SMALL OUTLINE PACKAGE



NOTES:

1. All linear dimensions are in millimeters. Any dimensions in parenthesis are for reference only. Dimensioning and tolerancing per ASME Y14.5M.
2. This drawing is subject to change without notice.
3. This dimension does not include mold flash, protrusions, or gate burrs. Mold flash, protrusions, or gate burrs shall not exceed 0.15 mm per side.
4. This dimension does not include interlead flash. Interlead flash shall not exceed 0.25 mm per side.
5. Reference JEDEC registration MO-153.



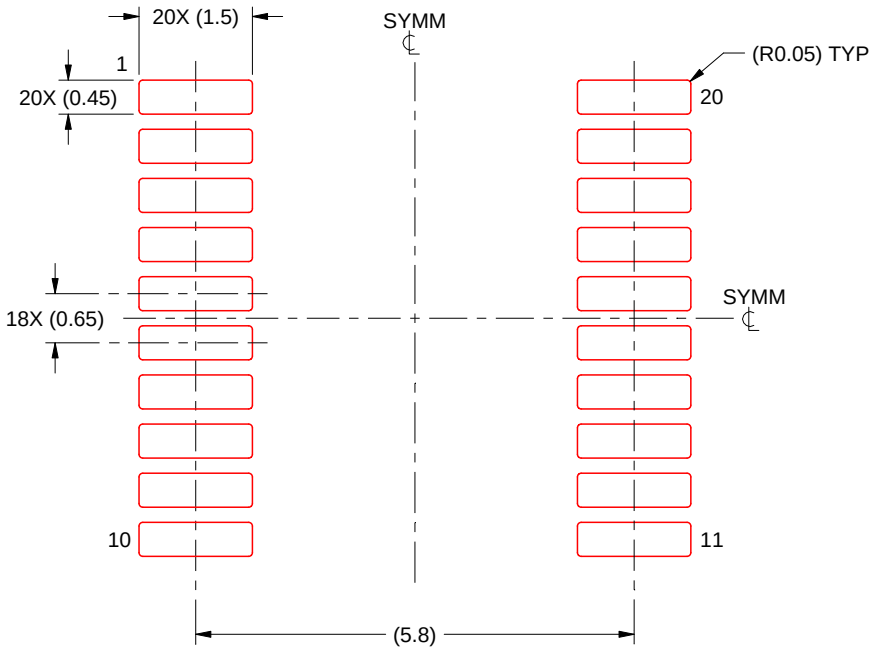
LAND PATTERN EXAMPLE
EXPOSED METAL SHOWN
SCALE: 10X

SOLDER MASK DETAILS

4220206/A 02/2017

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.



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

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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.

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