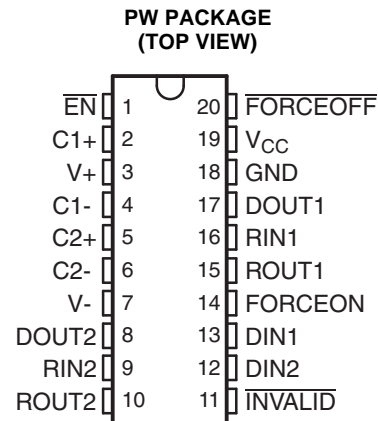


## 3-V To 5.5-V MULTICHANNEL RS-232 LINE DRIVER/RECEIVER WITH $\pm 15$ -kV ESD PROTECTION

### FEATURES

- Qualified for Automotive Applications
- RS-232 Bus-Pin ESD Protection Exceeds  $\pm 15$  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  $\mu$ A Typical
- External Capacitors . . . 4  $\times$  0.1  $\mu$ F
- Accepts 5-V Logic Input With 3.3-V Supply



### DESCRIPTION/ORDERING INFORMATION

The TRS3223 consists of two line drivers, two line receivers, and a dual charge-pump circuit with  $\pm 15$ -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/ $\mu$ s driver output slew rate.

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

### ORDERING INFORMATION<sup>(1)</sup>

$T_A$	PACKAGE <sup>(2)</sup>		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](http://www.ti.com).
- (2) Package drawings, thermal data, and symbolization are available at [www.ti.com/packaging](http://www.ti.com/packaging).



Please be aware that an important notice concerning availability, standard warranty, and use in critical applications of Texas Instruments semiconductor products and disclaimers thereto appears at the end of this data sheet.

**DRIVER FUNCTION TABLE (EACH DRIVER)<sup>(1)</sup>**

INPUTS				OUTPUT DOUT	DRIVER STATUS
DIN	FORCEON	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	

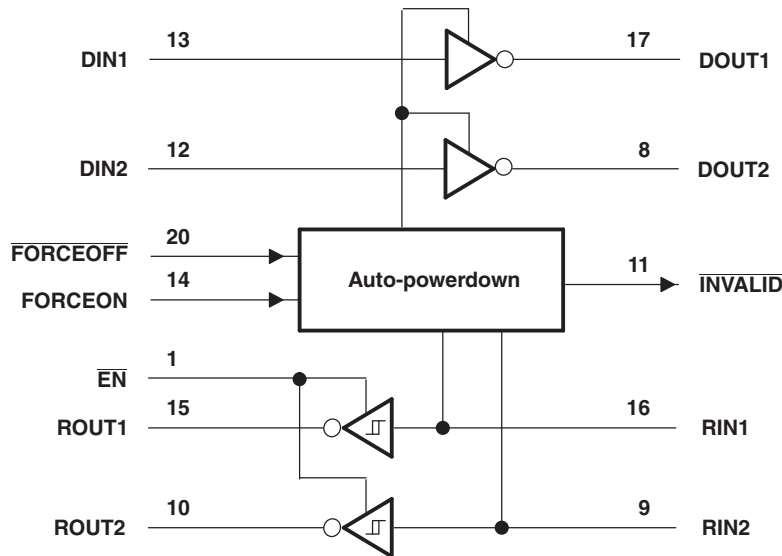
(1) H = high level, L = low level, X = irrelevant, Z = high impedance

**RECEIVER FUNCTION TABLE (EACH RECEIVER)<sup>(1)</sup>**

INPUTS			OUTPUT ROUT
RIN	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<sup>(1)(2)</sup>**

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, $\overline{\text{FORCEOFF}}$ , $\text{FORCEON}$ , $\overline{\text{EN}}$	–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
$\theta_{JA}$	Package thermal impedance <sup>(3)</sup>		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<sup>(1)</sup>**

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

- (1) Test conditions are  $C1-C4 = 0.1 \mu\text{F}$  at  $V_{CC} = 3.3 \text{ V} \pm 0.3 \text{ V}$ ;  $C1 = 0.047 \mu\text{F}$ ,  $C2-C4 = 0.33 \mu\text{F}$  at  $V_{CC} = 5 \text{ V} \pm 0.5 \text{ V}$ .

**ELECTRICAL CHARACTERISTICS<sup>(1)</sup>**

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

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

- (1) Test conditions are  $C1-C4 = 0.1 \mu\text{F}$  at  $V_{CC} = 3.3 \text{ V} \pm 0.3 \text{ V}$ ;  $C1 = 0.047 \mu\text{F}$ ,  $C2-C4 = 0.33 \mu\text{F}$  at  $V_{CC} = 5 \text{ V} \pm 0.5 \text{ V}$ .
- (2) All typical values are at  $V_{CC} = 3.3 \text{ V}$  or  $V_{CC} = 5 \text{ V}$ , and  $T_A = 25^\circ\text{C}$ .

### DRIVER SECTION ELECTRICAL CHARACTERISTICS<sup>(1)</sup>

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

PARAMETER		TEST CONDITIONS	MIN	TYP <sup>(2)</sup>	MAX	UNIT
V <sub>OH</sub>	High-level output voltage	DOUT at R <sub>L</sub> = 3 kΩ to GND	5	5.4		V
V <sub>OL</sub>	Low-level output voltage	DOUT at R <sub>L</sub> = 3 kΩ to GND	–5	–5.4		V
I <sub>IH</sub>	High-level input current	V <sub>I</sub> = V <sub>CC</sub>		±0.01	±1	μA
I <sub>IL</sub>	Low-level input current	V <sub>I</sub> = GND		±0.01	±1	μA
I <sub>OS</sub>	Short-circuit output current <sup>(3)</sup>	V <sub>CC</sub> = 3.6 V, V <sub>O</sub> = 0 V		±35	±60	mA
		V <sub>CC</sub> = 5.5 V, V <sub>O</sub> = 0 V		±35	±60	
r <sub>o</sub>	Output resistance	V <sub>CC</sub> , V+, and V– = 0 V, V <sub>O</sub> = ±2 V	300	10M		Ω
I <sub>off</sub>	Output leakage current	FORCEOFF = GND	V <sub>O</sub> = ±12 V, V <sub>CC</sub> = 3 V to 3.6 V		±25	μA
			V <sub>O</sub> = ±10 V, V <sub>CC</sub> = 4.5 V to 5.5 V		±25	

(1) Test conditions are C1–C4 = 0.1 μF at V<sub>CC</sub> = 3.3 V ± 0.3 V; C1 = 0.047 μF, C2–C4 = 0.33 μF at V<sub>CC</sub> = 5 V ± 0.5 V.

(2) All typical values are at V<sub>CC</sub> = 3.3 V or V<sub>CC</sub> = 5 V, and T<sub>A</sub> = 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<sup>(1)</sup>

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

PARAMETER		TEST CONDITIONS	MIN	TYP <sup>(2)</sup>	MAX	UNIT	
	Maximum data rate	C <sub>L</sub> = 1000 pF, One DOUT switching, R <sub>L</sub> = 3 kΩ (see <a href="#">Figure 1</a> )	250			kbit/s	
t <sub>sk(p)</sub>	Pulse skew <sup>(3)</sup>	C <sub>L</sub> = 150 pF to 2500 pF, R <sub>L</sub> = 3 kΩ to 7 kΩ (see <a href="#">Figure 2</a> )		100		ns	
SR(tr)	Slew rate, transition region (see <a href="#">Figure 1</a> )	V <sub>CC</sub> = 3.3 V, R <sub>L</sub> = 3 kΩ to 7 kΩ	C <sub>L</sub> = 150 pF to 1000 pF		6	30	V/μs
			C <sub>L</sub> = 150 pF to 2500 pF		4	30	

(1) Test conditions are C1–C4 = 0.1 μF at V<sub>CC</sub> = 3.3 V ± 0.3 V; C1 = 0.047 μF, C2–C4 = 0.33 μF at V<sub>CC</sub> = 5 V ± 0.5 V.

(2) All typical values are at V<sub>CC</sub> = 3.3 V or V<sub>CC</sub> = 5 V, and T<sub>A</sub> = 25°C.

(3) Pulse skew is defined as |t<sub>PLH</sub> – t<sub>PHL</sub>| of each channel of the same device.

**RECEIVER SECTION ELECTRICAL CHARACTERISTICS<sup>(1)</sup>**

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

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

 (1) Test conditions are C1–C4 = 0.1 μF at V<sub>CC</sub> = 3.3 V ± 0.3 V; C1 = 0.047 μF, C2–C4 = 0.33 μF at V<sub>CC</sub> = 5 V ± 0.5 V.

 (2) All typical values are at V<sub>CC</sub> = 3.3 V or V<sub>CC</sub> = 5 V, and T<sub>A</sub> = 25°C.

**RECEIVER SECTION SWITCHING CHARACTERISTICS<sup>(1)</sup>**

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

PARAMETER		TEST CONDITIONS	TYP <sup>(2)</sup>	UNIT
t <sub>PLH</sub>	Propagation delay time, low-level to high-level output	C <sub>L</sub> = 150 pF, See <a href="#">Figure 3</a>	150	ns
t <sub>PHL</sub>	Propagation delay time, high-level to low-level output	C <sub>L</sub> = 150 pF, See <a href="#">Figure 3</a>	150	ns
t <sub>en</sub>	Output enable time	C <sub>L</sub> = 150 pF, R <sub>L</sub> = 3 kΩ, See <a href="#">Figure 4</a>	200	ns
t <sub>dis</sub>	Output disable time	C <sub>L</sub> = 150 pF, R <sub>L</sub> = 3 kΩ, See <a href="#">Figure 4</a>	200	ns
t <sub>sk(p)</sub>	Pulse skew <sup>(3)</sup>	See <a href="#">Figure 3</a>	50	ns

 (1) Test conditions are C1–C4 = 0.1 μF at V<sub>CC</sub> = 3.3 V ± 0.3 V; C1 = 0.047 μF, C2–C4 = 0.33 μF at V<sub>CC</sub> = 5 V ± 0.5 V.

 (2) All typical values are at V<sub>CC</sub> = 3.3 V or V<sub>CC</sub> = 5 V, and T<sub>A</sub> = 25°C.

 (3) Pulse skew is defined as |t<sub>PLH</sub> - t<sub>PHL</sub>| 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

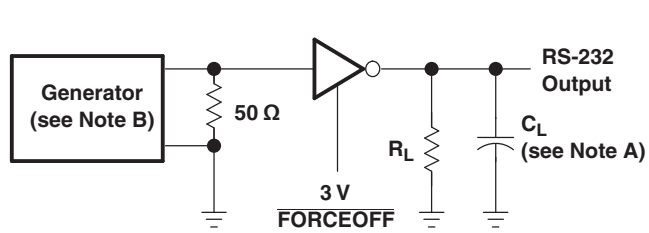
### AUTO-POWERDOWN SECTION SWITCHING CHARACTERISTICS

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

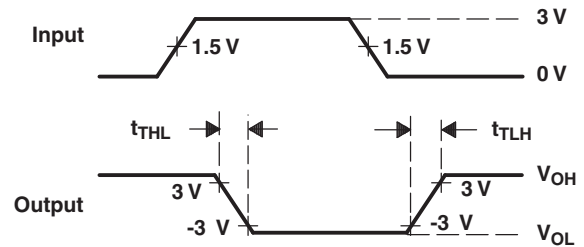
PARAMETER		TYP <sup>(1)</sup>	UNIT
$t_{valid}$	Propagation delay time, low- to high-level output	1	$\mu$ s
$t_{invalid}$	Propagation delay time, high- to low-level output	30	$\mu$ s
$t_{en}$	Supply enable time	100	$\mu$ s

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

PARAMETER MEASUREMENT INFORMATION



TEST CIRCUIT



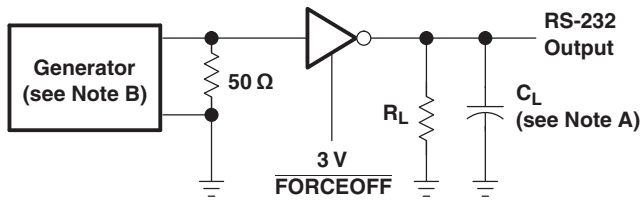
VOLTAGE WAVEFORMS

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

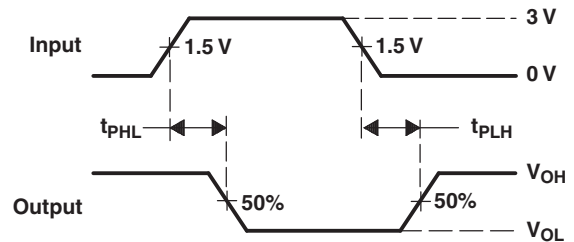
A.  $C_L$  includes probe and jig capacitance.

B. The pulse generator has the following characteristics: PRR = 250 kbit/s,  $Z_O = 50 \Omega$ , 50% duty cycle,  $t_r \leq 10 \text{ ns}$ ,  $t_f \leq 10 \text{ ns}$ .

Figure 1. Driver Slew Rate



TEST CIRCUIT

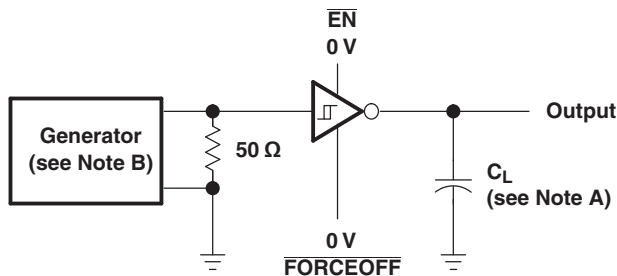


VOLTAGE WAVEFORMS

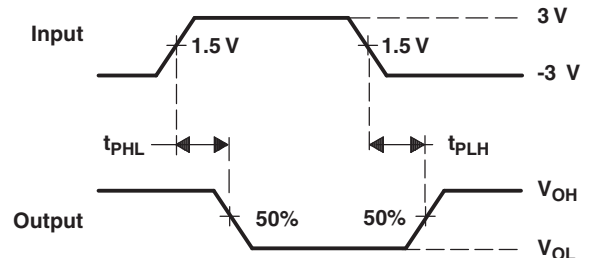
A.  $C_L$  includes probe and jig capacitance.

B. The pulse generator has the following characteristics: PRR = 250 kbit/s,  $Z_O = 50 \Omega$ , 50% duty cycle,  $t_r \leq 10 \text{ ns}$ ,  $t_f \leq 10 \text{ ns}$ .

Figure 2. Driver Pulse Skew



TEST CIRCUIT



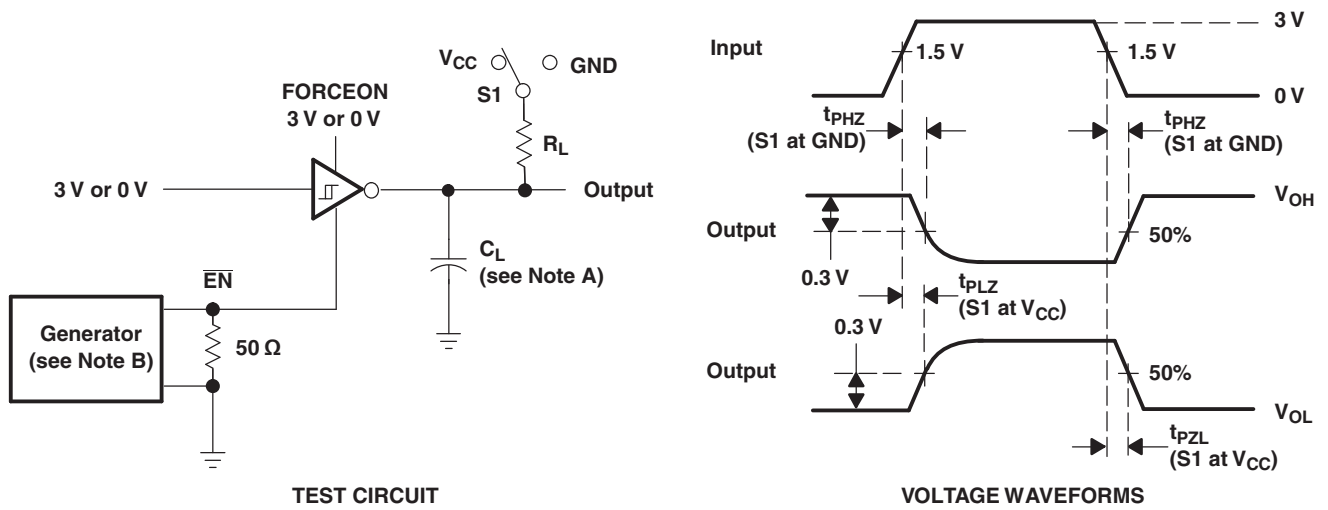
VOLTAGE WAVEFORMS

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 3. Receiver Propagation Delay Times

PARAMETER MEASUREMENT INFORMATION (continued)



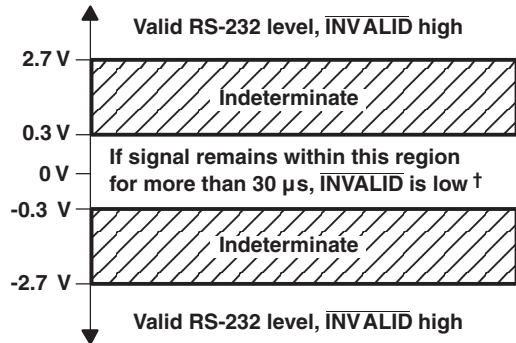
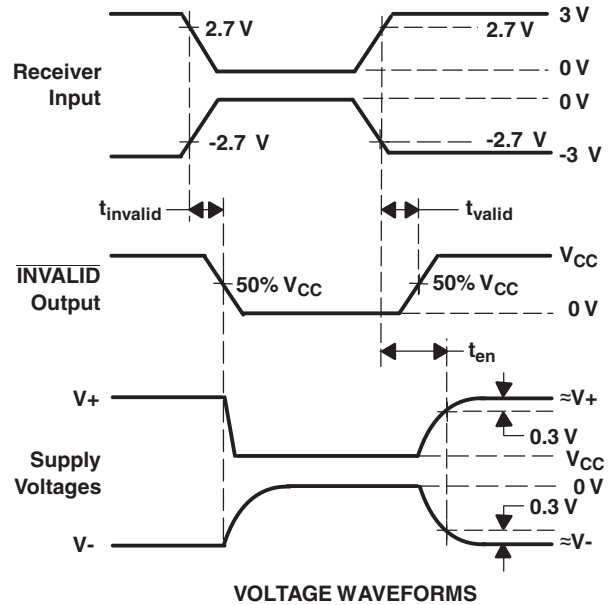
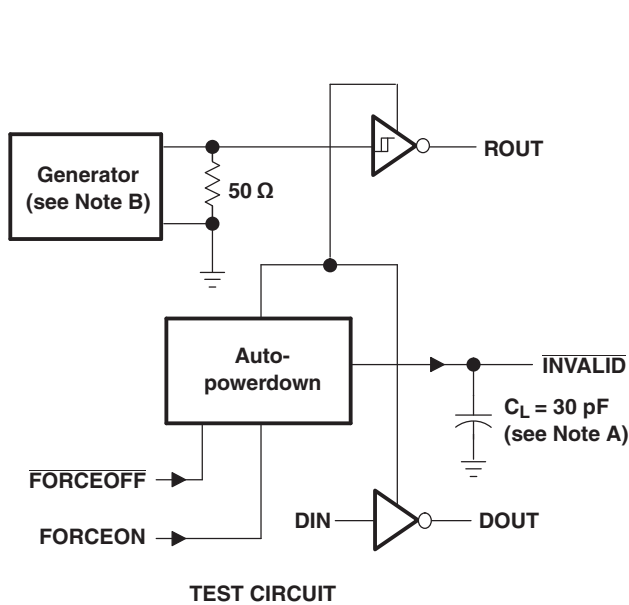
A.  $C_L$  includes probe and jig capacitance.

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 4. Receiver Enable and Disable Times



PARAMETER MEASUREMENT INFORMATION (continued)



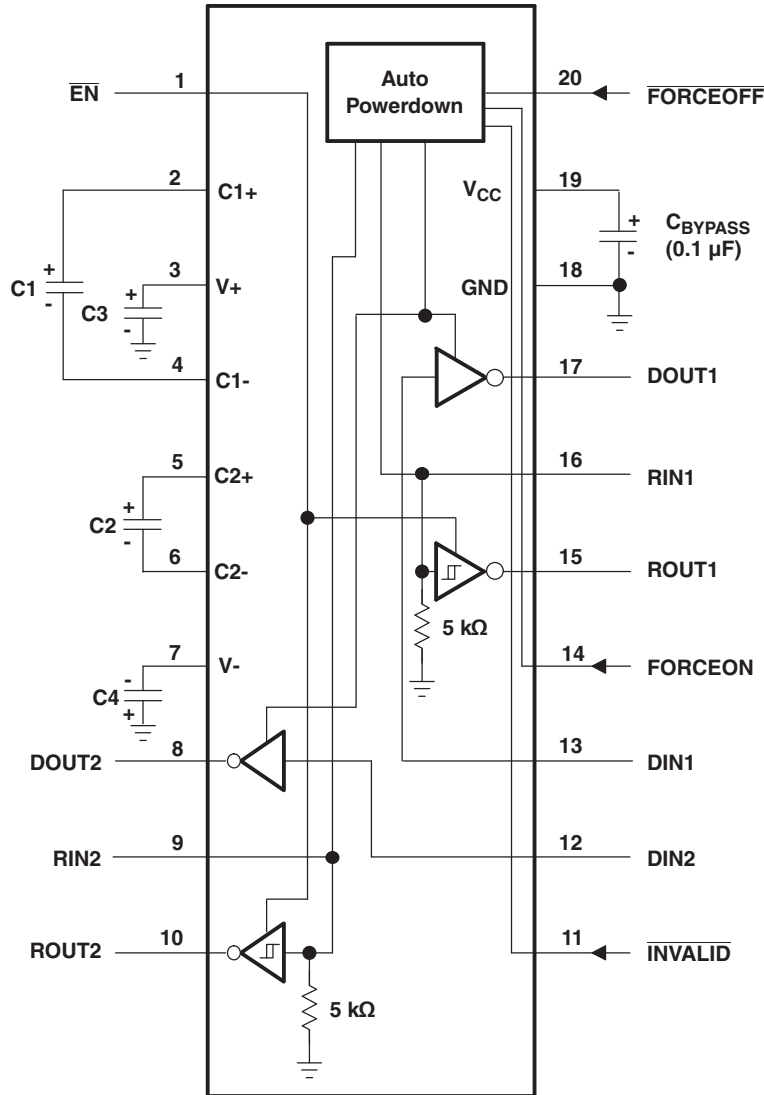
† Auto-powerdown disables drivers and reduces supply current to 1  $\mu$ A.

A.  $C_L$  includes probe and jig capacitance.

B. The pulse generator has the following characteristics: PRR = 5 kbit/s,  $Z_O = 50 \Omega$ , 50% duty cycle,  $t_r \leq 10$  ns,  $t_f \leq 10$  ns.

Figure 5.  $\overline{\text{INVALID}}$  Propagation Delay Times and Supply Enabling Time

APPLICATION INFORMATION



- A. C3 can be connected to V<sub>CC</sub> 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<sub>CC</sub> vs CAPACITOR VALUES

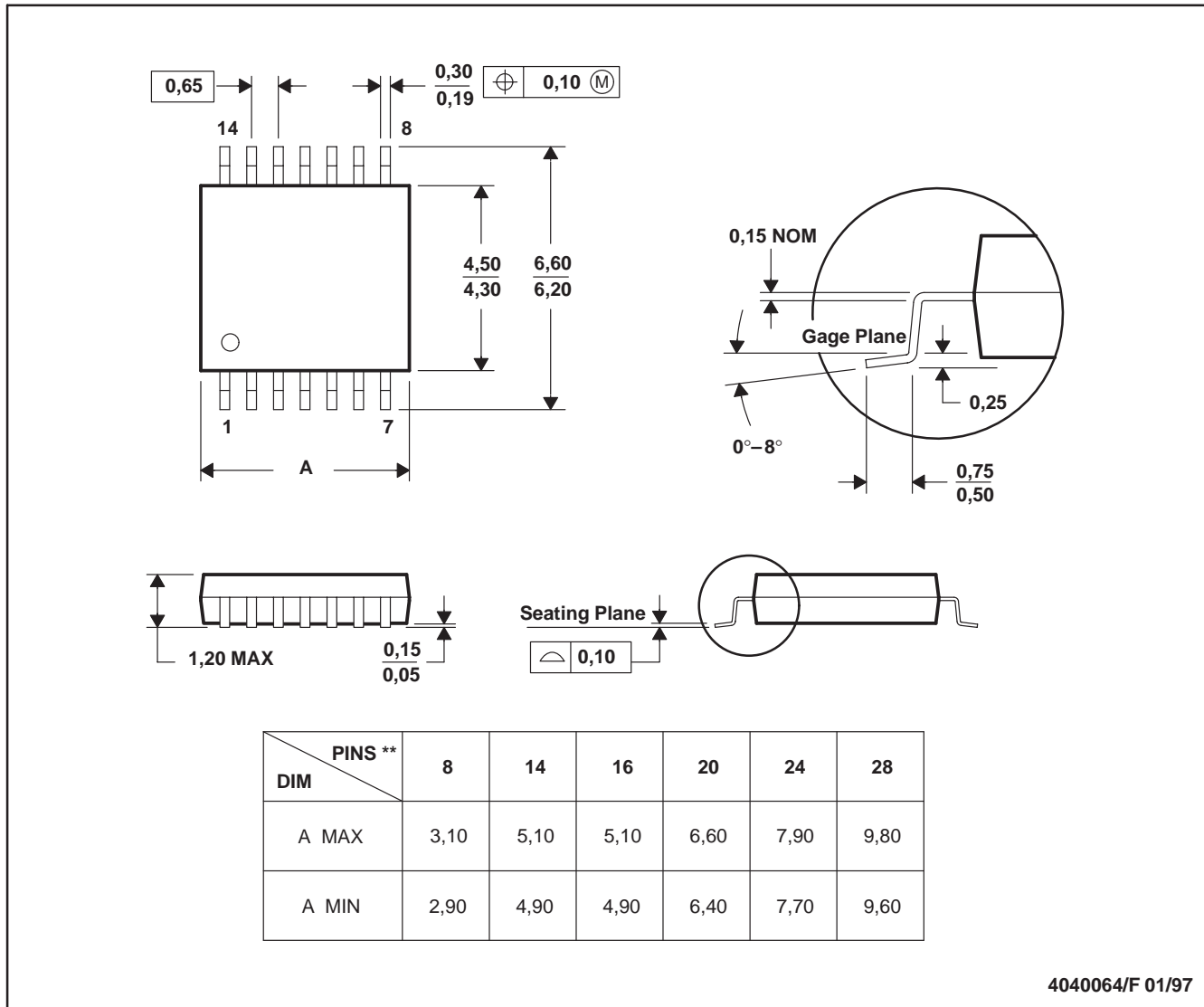
V <sub>CC</sub>	C1	C2, C3, C4
3.3 V ± 0.3 V	0.1 μF	0.1 μF
5 V ± 0.5 V	0.047 μF	0.33 μF
3 V to 5.5 V	0.1 μF	0.47 μF

Figure 6. Typical Operating Circuit and Capacitor Values

PW (R-PDSO-G\*\*)

PLASTIC SMALL-OUTLINE PACKAGE

14 PINS SHOWN



4040064/F 01/97

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

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Amplifiers	<a href="http://amplifier.ti.com">amplifier.ti.com</a>
Data Converters	<a href="http://dataconverter.ti.com">dataconverter.ti.com</a>
DSP	<a href="http://dsp.ti.com">dsp.ti.com</a>
Clocks and Timers	<a href="http://www.ti.com/clocks">www.ti.com/clocks</a>
Interface	<a href="http://interface.ti.com">interface.ti.com</a>
Logic	<a href="http://logic.ti.com">logic.ti.com</a>
Power Mgmt	<a href="http://power.ti.com">power.ti.com</a>
Microcontrollers	<a href="http://microcontroller.ti.com">microcontroller.ti.com</a>
RFID	<a href="http://www.ti-rfid.com">www.ti-rfid.com</a>
RF/IF and ZigBee® Solutions	<a href="http://www.ti.com/lprf">www.ti.com/lprf</a>

### Applications

Audio	<a href="http://www.ti.com/audio">www.ti.com/audio</a>
Automotive	<a href="http://www.ti.com/automotive">www.ti.com/automotive</a>
Broadband	<a href="http://www.ti.com/broadband">www.ti.com/broadband</a>
Digital Control	<a href="http://www.ti.com/digitalcontrol">www.ti.com/digitalcontrol</a>
Medical	<a href="http://www.ti.com/medical">www.ti.com/medical</a>
Military	<a href="http://www.ti.com/military">www.ti.com/military</a>
Optical Networking	<a href="http://www.ti.com/opticalnetwork">www.ti.com/opticalnetwork</a>
Security	<a href="http://www.ti.com/security">www.ti.com/security</a>
Telephony	<a href="http://www.ti.com/telephony">www.ti.com/telephony</a>
Video & Imaging	<a href="http://www.ti.com/video">www.ti.com/video</a>
Wireless	<a href="http://www.ti.com/wireless">www.ti.com/wireless</a>

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