

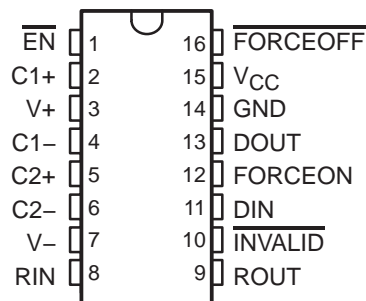
MAX3221

3-V TO 5.5-V SINGLE-CHANNEL RS-232 LINE DRIVER/RECEIVER WITH ± 15 -kV ESD PROTECTION

SLLS348M – JUNE 1999 – REVISED MARCH 2004

- **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**
- **One Driver and One Receiver**
- **Low Standby Current . . . 1 μ A Typical**
- **External Capacitors . . . $4 \times 0.1 \mu$ F**
- **Accepts 5-V Logic Input With 3.3-V Supply**
- **Alternative High-Speed Pin-Compatible Device (1 Mbit/s)**
 - SNx5C3221
- **Auto-Powerdown Feature Automatically Disables Drivers for Power Savings**
- **Applications**
 - Battery-Powered, Hand-Held, and Portable Equipment
 - PDAs and Palmtop PCs
 - Notebooks, Subnotebooks, and Laptops
 - Digital Cameras
 - Mobile Phones and Wireless Devices

DB OR PW PACKAGE
(TOP VIEW)



description/ordering information

The MAX3221 consists of one line driver, one line receiver, 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. These devices operate at data signaling rates up to 250 kbit/s and a maximum of 30-V/ μ s driver output slew rate.

ORDERING INFORMATION

T _A	PACKAGE†		ORDERABLE PART NUMBER	TOP-SIDE MARKING
–0°C to 70°C	SSOP (DB)	Tube of 80	MAX3221CDB	MA3221C
		Reel of 2000	MAX3221CDBR	
	TSSOP (PW)	Tube of 90	MAX3221CPW	MA3221C
		Reel of 2000	MAX3221CPWR	
–40°C to 85°C	SSOP (DB)	Tube of 80	MAX3221IDB	MB3221I
		Reel of 2000	MAX3221IDBR	
	TSSOP (PW)	Tube of 90	MAX3221IPW	MB3221I
		Reel of 2000	MAX3221IPWR	

† Package drawings, standard packing quantities, thermal data, symbolization, and PCB design guidelines are available at www.ti.com/sc/package.



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MAX3221

3-V TO 5.5-V SINGLE-CHANNEL RS-232 LINE DRIVER/RECEIVER WITH ±15-kV ESD PROTECTION

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description/ordering information (continued)

Flexible control options for power management are available when the serial port is inactive. The auto-powerdown feature functions when 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 on the receiver input, the driver output is disabled. If $\overline{\text{FORCEOFF}}$ is set low and $\overline{\text{EN}}$ is high, both the driver and receiver are shut off, and the supply current is reduced to 1 μA . Disconnecting the serial port or turning off the peripheral drivers causes the auto-powerdown condition to occur. Auto-powerdown can be disabled when FORCEON and $\overline{\text{FORCEOFF}}$ are high. With auto-powerdown enabled, the device is activated automatically when a valid signal is applied to the receiver input. The $\overline{\text{INVALID}}$ output notifies the user if an RS-232 signal is present at the receiver input. $\overline{\text{INVALID}}$ is high (valid data) if the 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 . $\overline{\text{INVALID}}$ is low (invalid data) if the receiver input voltage is between -0.3 V and 0.3 V for more than 30 μs . Refer to Figure 5 for receiver input levels.

Function Tables

EACH DRIVER

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	

H = high level, L = low level, X = irrelevant, Z = high impedance

EACH RECEIVER

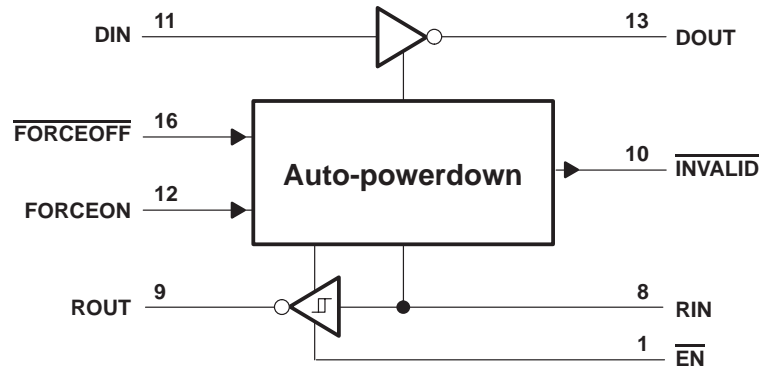
INPUTS			OUTPUT ROUT
RIN	$\overline{\text{EN}}$	VALID RIN RS-232 LEVEL	
L	L	X	H
H	L	X	L
X	H	X	Z
Open	L	No	H

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

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logic diagram (positive logic)



absolute maximum ratings over operating free-air temperature range (unless otherwise noted)†

Supply voltage range, V_{CC} (see Note 1)	–0.3 V to 6 V
Positive output supply voltage range, $V+$ (see Note 1)	–0.3 V to 7 V
Negative output supply voltage range, $V-$ (see Note 1)	0.3 V to –7 V
Supply voltage difference, $V+ - V-$ (see Note 1)	13 V
Input voltage range, V_I : Driver ($\overline{\text{FORCEOFF}}$, FORCEON , $\overline{\text{EN}}$)	–0.3 V to 6 V
Receiver	–25 V to 25 V
Output voltage range, V_O : Driver	–13.2 V to 13.2 V
Receiver ($\overline{\text{INVALID}}$)	–0.3 V to $V_{CC} + 0.3$ V
Package thermal impedance, θ_{JA} (see Notes 2 and 3): DB package	82°C/W
PW package	108°C/W
Operating virtual junction temperature, T_J	150°C
Storage temperature range, T_{stg}	–65°C to 150°C

† 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.

- NOTES: 1. All voltages are with respect to network GND.
 2. Maximum power dissipation is a function of $T_J(\text{max})$, θ_{JA} , and T_A . The maximum allowable power dissipation at any allowable ambient temperature is $P_D = (T_J(\text{max}) - T_A)/\theta_{JA}$. Operating at the absolute maximum T_J of 150°C can affect reliability.
 3. The package thermal impedance is calculated in accordance with JESD 51-7.

recommended operating conditions (see Note 4 and Figure 6)

		MIN	NOM	MAX	UNIT	
Supply voltage		$V_{CC} = 3.3$ V	3	3.3	3.6	V
		$V_{CC} = 5$ V	4.5	5	5.5	
V_{IH} Driver and control high-level input voltage	DIN, $\overline{\text{FORCEOFF}}$, FORCEON , $\overline{\text{EN}}$	$V_{CC} = 3.3$ V	2		V	
		$V_{CC} = 5$ V	2.4			
V_{IL} Driver and control low-level input voltage	DIN, $\overline{\text{FORCEOFF}}$, FORCEON , $\overline{\text{EN}}$			0.8	V	
V_I Driver and control input voltage	DIN, $\overline{\text{FORCEOFF}}$, FORCEON	0	5.5		V	
V_I Receiver input voltage		–25	25		V	
T_A Operating free-air temperature	MAX3221C	0	70		°C	
	MAX3221I	–40	85			

NOTE 4: Test conditions are C1–C4 = 0.1 μF at $V_{CC} = 3.3$ V \pm 0.3 V; C1 = 0.047 μF , C2–C4 = 0.33 μF at $V_{CC} = 5$ V \pm 0.5 V.



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electrical characteristics over recommended ranges of supply voltage and operating free-air temperature (unless otherwise noted) (see Note 4 and Figure 6)

PARAMETER		TEST CONDITIONS		MIN	TYP†	MAX	UNIT
I_I	Input leakage current	FORCEOFF, FORCEON, EN		±0.01		±1	μA
I_{CC}	Supply current	Auto-powerdown disabled	No load, FORCEOFF and FORCEON at V_{CC}	0.3		1	mA
		Powered off	No load, FORCEOFF at GND		1	10	μA
		Auto-powerdown enabled	No load, FORCEOFF at V_{CC} , FORCEON at GND, All RIN are open or grounded		1	10	

† All typical values are at $V_{CC} = 3.3$ V or $V_{CC} = 5$ V, and $T_A = 25^\circ\text{C}$.NOTE 4: 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.**DRIVER SECTION****electrical characteristics over recommended ranges of supply voltage and operating free-air temperature (unless otherwise noted) (see Note 4 and Figure 6)**

PARAMETER		TEST CONDITIONS		MIN	TYP†	MAX	UNIT
V_{OH}	High-level output voltage	DOUT at $R_L = 3$ kΩ to GND, DIN = GND		5	5.4		V
V_{OL}	Low-level output voltage	DOUT at $R_L = 3$ kΩ to GND, DIN = V_{CC}		–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 at GND		±0.01		±1	μA
I_{OS}	Short-circuit output current‡	$V_{CC} = 3.6$ 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, $V_O = \pm 2$ V		300	10M		Ω
I_{off}	Output leakage current	FORCEOFF = GND	$V_O = \pm 12$ V, $V_{CC} = 3$ V to 3.6 V			±25	μA
			$V_O = \pm 10$ V, $V_{CC} = 4.5$ V to 5.5 V			±25	

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

‡ 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.

NOTE 4: 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.**switching characteristics over recommended ranges of supply voltage and operating free-air temperature (unless otherwise noted) (see Note 4 and Figure 6)**

PARAMETER		TEST CONDITIONS		MIN	TYP†	MAX	UNIT
	Maximum data rate	$C_L = 1000$ pF, $R_L = 3$ kΩ, See Figure 1		150	250		kbit/s
$t_{sk(p)}$	Pulse skew§	$C_L = 150$ 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	

† All typical values are at $V_{CC} = 3.3$ V or $V_{CC} = 5$ V, and $T_A = 25^\circ\text{C}$.§ Pulse skew is defined as $|t_{PLH} - t_{PHL}|$ of each channel of the same device.NOTE 4: 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.

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ESD protection

TERMINAL		TEST CONDITIONS	TYP	UNIT
NAME	NO.			
DOUT	13	HBM	±15	kV

RECEIVER SECTION

electrical characteristics over recommended ranges of supply voltage and operating free-air temperature (unless otherwise noted) (see Note 4 and Figure 6)

PARAMETER	TEST CONDITIONS	MIN	TYP†	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	FORCEOFF = 0 V		±0.05	±10	µA
r _i Input resistance	V _I = ±3 V to ±25 V	3	5	7	kΩ

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

NOTE 4: 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.

switching characteristics over recommended ranges of supply voltage and operating free-air temperature (unless otherwise noted) (see Note 4)

PARAMETER	TEST CONDITIONS	MIN	TYP†	MAX	UNIT
t _{PLH} Propagation delay time, low- to high-level output	C _L = 150 pF, See Figure 3		150		ns
t _{PHL} Propagation delay time, high- 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‡	See Figure 3		50		ns

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

‡ Pulse skew is defined as |t_{PLH} - t_{PHL}| of each channel of the same device.

NOTE 4: 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.

ESD protection

TERMINAL		TEST CONDITIONS	TYP	UNIT
NAME	NO.			
RIN	8	HBM	±15	kV



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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 $\overline{\text{INVALID}}$ high-level output voltage	FORCEON = GND, $\overline{\text{FORCEOFF}} = V_{CC}$		2.7	V
V _{T-(valid)}	Receiver input threshold for $\overline{\text{INVALID}}$ high-level output voltage	FORCEON = GND, $\overline{\text{FORCEOFF}} = V_{CC}$	-2.7		V
V _{T(invalid)}	Receiver input threshold for $\overline{\text{INVALID}}$ low-level output voltage	FORCEON = GND, $\overline{\text{FORCEOFF}} = V_{CC}$	-0.3	0.3	V
V _{OH}	$\overline{\text{INVALID}}$ high-level output voltage	I _{OH} = -1 mA, FORCEON = GND, $\overline{\text{FORCEOFF}} = V_{CC}$	V _{CC} -0.6		V
V _{OL}	$\overline{\text{INVALID}}$ low-level output voltage	I _{OL} = 1.6 mA, FORCEON = GND, $\overline{\text{FORCEOFF}} = V_{CC}$		0.4	V

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

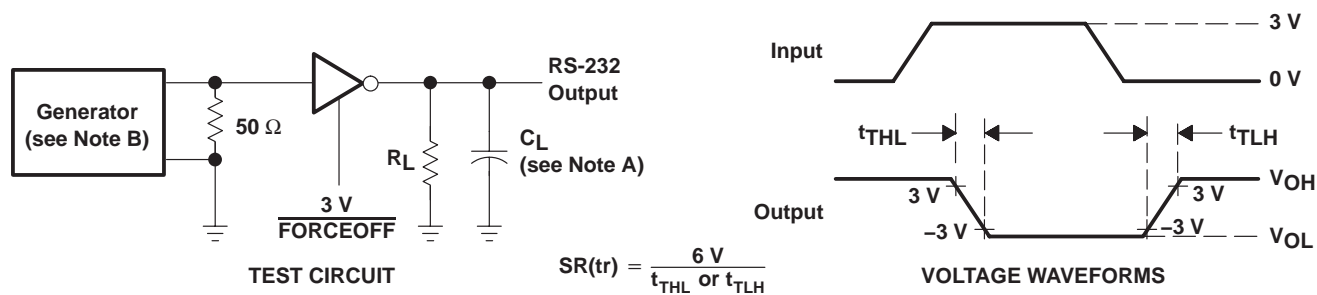
PARAMETER		MIN	TYP†	MAX	UNIT
t _{valid}	Propagation delay time, low- to high-level output		1		μs
t _{invalid}	Propagation delay time, high- to low-level output		30		μs
t _{en}	Supply enable time		100		μs

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

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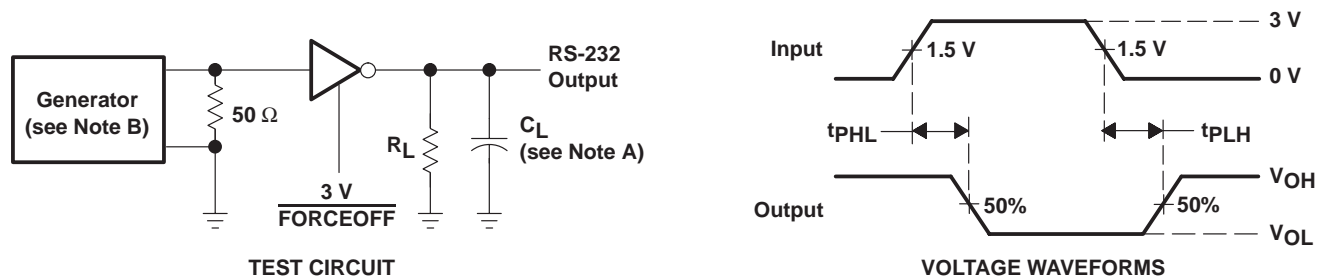
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PARAMETER MEASUREMENT INFORMATION



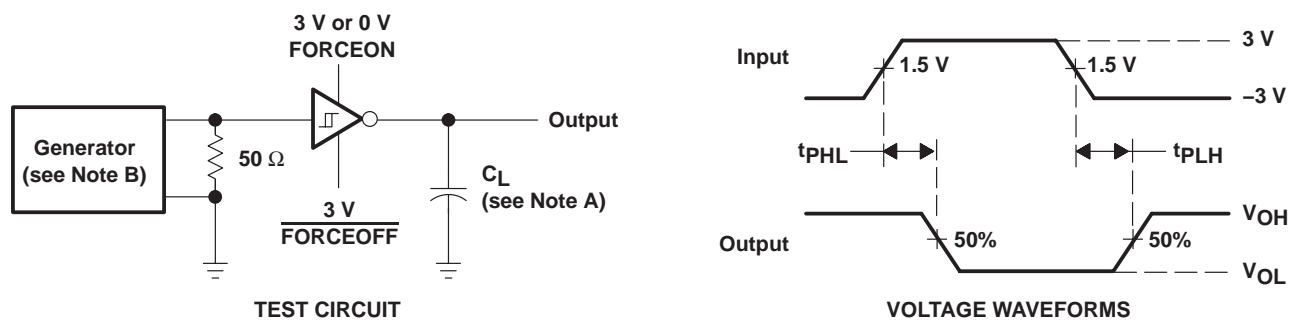
NOTES: A. C_L includes probe and jig capacitance.
 B. The pulse generator has the following characteristics: PRR = 250 kbit/s, $Z_O = 50\ \Omega$, 50% duty cycle, $t_r \leq 10\text{ ns}$, $t_f \leq 10\text{ ns}$.

Figure 1. Driver Slew Rate



NOTES: 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



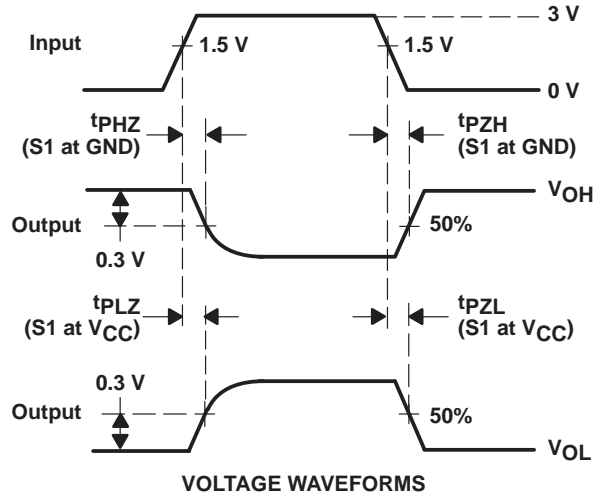
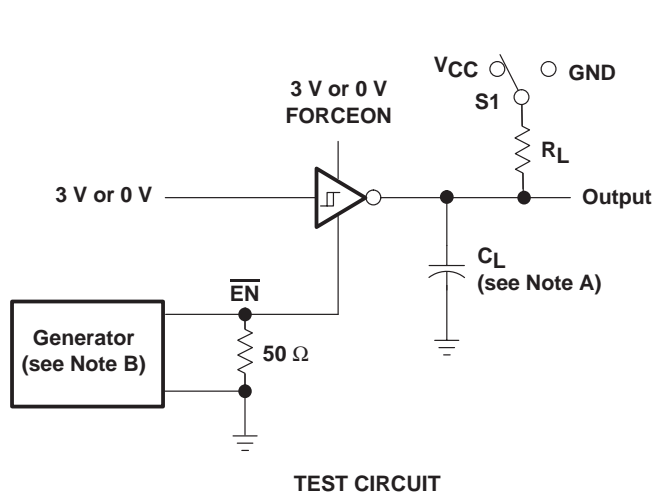
NOTES: A. C_L includes probe and jig capacitance.
 B. The pulse generator has the following characteristics: $Z_O = 50\ \Omega$, 50% duty cycle, $t_r \leq 10\text{ ns}$, $t_f \leq 10\text{ ns}$.

Figure 3. Receiver Propagation Delay Times

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PARAMETER MEASUREMENT INFORMATION



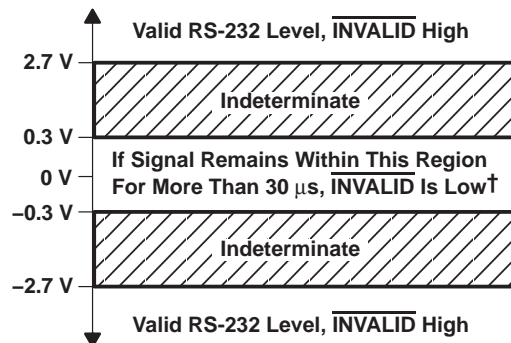
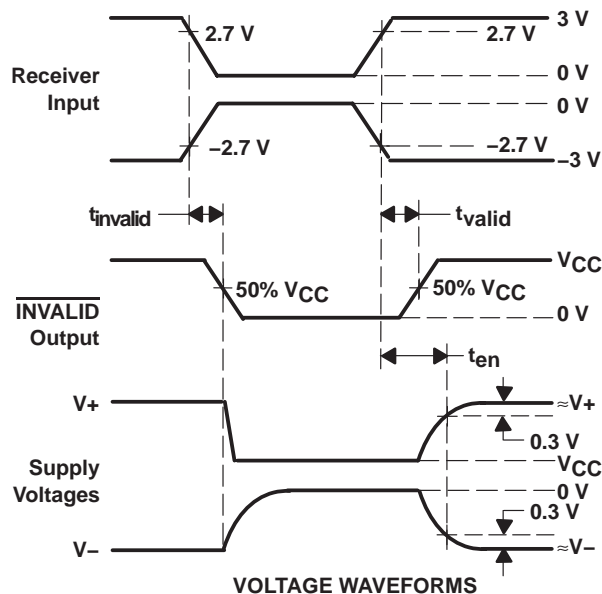
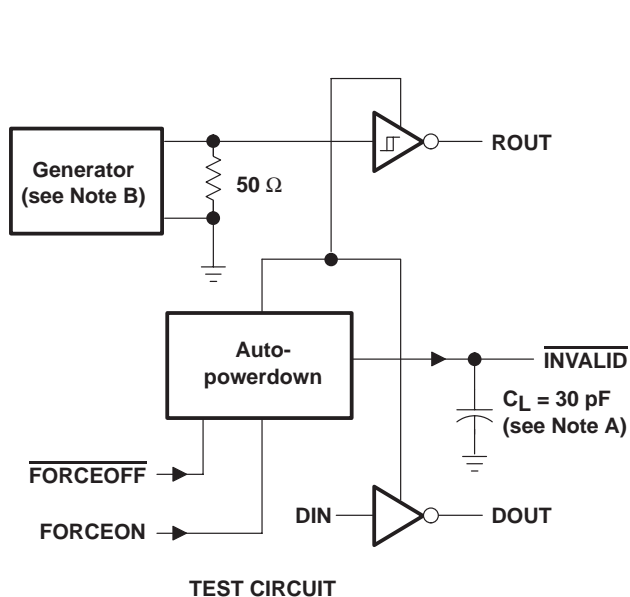
- NOTES: A. C_L includes probe and jig capacitance.
 B. The pulse generator has the following characteristics: Z_O = 50 Ω, 50% duty cycle, t_r ≤ 10 ns, t_f ≤ 10 ns.
 C. t_{PLZ} and t_{PHZ} are the same as t_{dis}.
 D. t_{PZL} and t_{PZH} are the same as t_{en}.

Figure 4. Receiver Enable and Disable Times

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PARAMETER MEASUREMENT INFORMATION



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

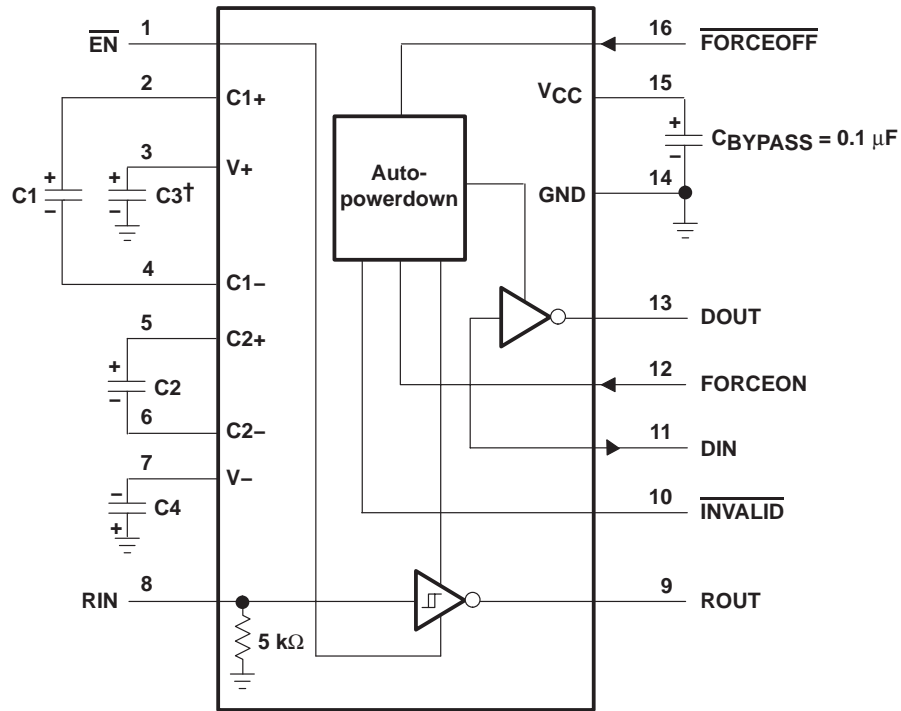
- NOTES: A. C_L includes probe and jig capacitance.
 B. The pulse generator has the following characteristics: PRR = 5 kbit/s, $Z_O = 50 \Omega$, 50% duty cycle, $t_r \leq 10$ ns, $t_f \leq 10$ ns.

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

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3-V TO 5.5-V SINGLE-CHANNEL RS-232 LINE DRIVER/RECEIVER
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APPLICATION INFORMATION



† C3 can be connected to V_{CC} 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.

V_{CC} vs CAPACITOR VALUES

V _{CC}	C1	C2, C3, and 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 Device	Status ⁽¹⁾	Package Type	Package Drawing	Pins	Package Qty	Eco Plan ⁽²⁾	Lead/Ball Finish	MSL Peak Temp ⁽³⁾
MAX3221CDB	ACTIVE	SSOP	DB	16	80	Pb-Free (RoHS)	CU NIPDAU	Level-2-260C-1 YEAR/ Level-1-235C-UNLIM
MAX3221CDBR	ACTIVE	SSOP	DB	16	2000	Pb-Free (RoHS)	CU NIPDAU	Level-2-260C-1 YEAR/ Level-1-235C-UNLIM
MAX3221CPW	ACTIVE	TSSOP	PW	16	90	Pb-Free (RoHS)	CU NIPDAU	Level-1-250C-UNLIM
MAX3221CPWR	ACTIVE	TSSOP	PW	16	2000	Pb-Free (RoHS)	CU NIPDAU	Level-1-250C-UNLIM
MAX3221IDB	ACTIVE	SSOP	DB	16	80	Pb-Free (RoHS)	CU NIPDAU	Level-2-260C-1 YEAR/ Level-1-235C-UNLIM
MAX3221IDBR	ACTIVE	SSOP	DB	16	2000	Pb-Free (RoHS)	CU NIPDAU	Level-2-260C-1 YEAR/ Level-1-235C-UNLIM
MAX3221IPW	ACTIVE	TSSOP	PW	16	90	Pb-Free (RoHS)	CU NIPDAU	Level-1-250C-UNLIM
MAX3221IPWR	ACTIVE	TSSOP	PW	16	2000	Pb-Free (RoHS)	CU NIPDAU	Level-1-250C-UNLIM

⁽¹⁾ The marketing status values are defined as follows:

ACTIVE: Product device recommended for new designs.

LIFEBUY: TI has announced that the device will be discontinued, and a lifetime-buy period is in effect.

NRND: Not recommended for new designs. Device is in production to support existing customers, but TI does not recommend using this part in a new design.

PREVIEW: Device has been announced but is not in production. Samples may or may not be available.

OBSOLETE: TI has discontinued the production of the device.

⁽²⁾ Eco Plan - May not be currently available - please check <http://www.ti.com/productcontent> for the latest availability information and additional product content details.

None: Not yet available Lead (Pb-Free).

Pb-Free (RoHS): TI's terms "Lead-Free" or "Pb-Free" mean semiconductor products that are compatible with the current RoHS requirements for all 6 substances, including the requirement that lead not exceed 0.1% by weight in homogeneous materials. Where designed to be soldered at high temperatures, TI Pb-Free products are suitable for use in specified lead-free processes.

Green (RoHS & no Sb/Br): TI defines "Green" to mean "Pb-Free" and in addition, uses package materials that do not contain halogens, including bromine (Br) or antimony (Sb) above 0.1% of total product weight.

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

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DB (R-PDSO-G**)

PLASTIC SMALL-OUTLINE

28 PINS SHOWN



- NOTES: A. All linear dimensions are in millimeters.
 B. This drawing is subject to change without notice.
 C. Body dimensions do not include mold flash or protrusion not to exceed 0,15.
 D. Falls within JEDEC MO-150

PW (R-PDSO-G**)

PLASTIC SMALL-OUTLINE PACKAGE

14 PINS SHOWN



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

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