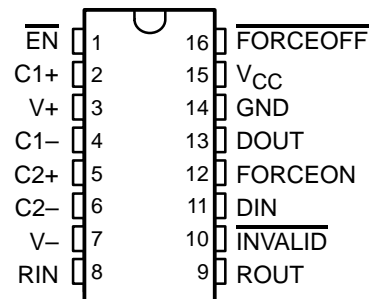


- Meets or Exceeds the Requirements of TIA/EIA-232-F and ITU v.28 Standards
- Operates With 3-V to 5.5-V  $V_{CC}$  Supply
- Operates up to 250 kbit/s
- One Driver and One Receiver
- Low Standby Current . . . 1  $\mu$ A Typical
- External Capacitors . . .  $4 \times 0.1 \mu$ F
- Accepts 5-V Logic Input With 3.3-V Supply
- Designed to Be Interchangeable With Maxim MAX3221
- RS-232 Bus-Pin ESD Protection Exceeds  $\pm 15$  kV Using Human-Body Model (HBM)
- 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  $\pm 15$ -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. These devices operate at data signaling rates up to 250 kbit/s and a maximum of 30-V/ $\mu$ s driver output slew rate.

### ORDERING INFORMATION

$T_A$	PACKAGE†		ORDERABLE PART NUMBER	TOP-SIDE MARKING
–0°C to 70°C	SSOP (DB)	Tape and reel	MAX3221CDBR	MA3221C
	TSSOP (PW)	Tape and reel	MAX3221CPWR	MA3221C
–40°C to 85°C	SSOP (DB)	Tape and reel	MAX3221IDBR	MB3221I
	TSSOP (PW)	Tape and reel	MAX3221IPWR	MB3221I

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



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PRODUCTION DATA information is current as of publication date. Products conform to specifications per the terms of Texas Instruments standard warranty. Production processing does not necessarily include testing of all parameters.

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# MAX3221

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

SLLS348G – JUNE 1999 – REVISED AUGUST 2002

### 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 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 FORCEOFF is set low and 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 FORCEOFF are high. With auto-powerdown enabled, the device is activated automatically when a valid signal is applied to the receiver input. The INVALID output notifies the user if an RS-232 signal is present at the receiver input. 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. 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	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

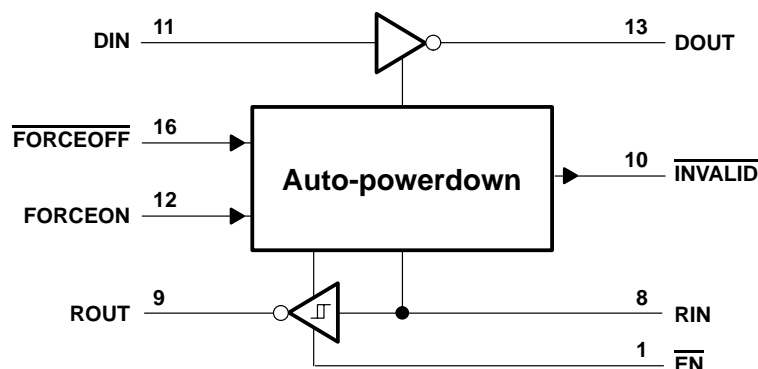
EACH RECEIVER

INPUTS			OUTPUT ROUT
RIN	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



## 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 (INVALID)	–0.3 V to $V_{CC} + 0.3$ V
Package thermal impedance, $\theta_{JA}$ (see Note 2): DB package	82°C/W
PW package	108°C/W
Lead temperature 1,6 mm (1/16 inch) from case for 10 seconds	260°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. The package thermal impedance is calculated in accordance with JESD 51-7.

## recommended operating conditions (see Note 3 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 3: Test conditions are C1–C4 = 0.1  $\mu$ F at  $V_{CC} = 3.3$  V  $\pm$  0.3 V; C1 = 0.047  $\mu$ F, C2–C4 = 0.33  $\mu$ F at  $V_{CC} = 5$  V  $\pm$  0.5 V.

# MAX3221

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

SLLS348G – JUNE 1999 – REVISED AUGUST 2002

**electrical characteristics over recommended ranges of supply voltage and operating free-air temperature (unless otherwise noted) (see Note 3 and Figure 6)**

PARAMETER		TEST CONDITIONS	MIN	TYP†	MAX	UNIT
$I_I$	Input leakage current	$\overline{\text{FORCEOFF}}, \overline{\text{FORCEON}}, \overline{\text{EN}}$		$\pm 0.01$	$\pm 1$	$\mu\text{A}$
$I_{CC}$	Supply current ( $T_A = 25^\circ\text{C}$ )	Auto-powerdown disabled	No load, $\overline{\text{FORCEOFF}}$ and $\overline{\text{FORCEON}}$ at $V_{CC}$	0.3	1	mA
		Powered off	No load, $\overline{\text{FORCEOFF}}$ at GND	1	10	$\mu\text{A}$
		Auto-powerdown enabled	No load, $\overline{\text{FORCEOFF}}$ at $V_{CC}$ , $\overline{\text{FORCEON}}$ at GND, All RIN are open or grounded	1	10	

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

NOTE 3: 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  $V_{CC} = 5\text{ V} \pm 0.5\text{ V}$ .

### DRIVER SECTION

**electrical characteristics over recommended ranges of supply voltage and operating free-air temperature (unless otherwise noted) (see Note 3 and Figure 6)**

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

† All typical values are at  $V_{CC} = 3.3\text{ V}$  or  $V_{CC} = 5\text{ V}$ , 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 3: 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  $V_{CC} = 5\text{ V} \pm 0.5\text{ V}$ .

**switching characteristics over recommended ranges of supply voltage and operating free-air temperature (unless otherwise noted) (see Note 3 and Figure 6)**

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

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

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

NOTE 3: 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  $V_{CC} = 5\text{ V} \pm 0.5\text{ V}$ .

### ESD protection

TERMINAL		TEST CONDITIONS	TYP	UNIT
NAME	NO.			
DOUT	13	HBM	$\pm 15$	kV



# MAX3221

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

SLLS348G – JUNE 1999 – REVISED AUGUST 2002

### RECEIVER SECTION

**electrical characteristics over recommended ranges of supply voltage and operating free-air temperature (unless otherwise noted) (see Note 3 and Figure 6)**

PARAMETER		TEST CONDITIONS	MIN	TYP†	MAX	UNIT
V <sub>OH</sub>	High-level output voltage	I <sub>OH</sub> = -1 mA	V <sub>CC</sub> -0.6 V	V <sub>CC</sub> -0.1 V		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	FORCEOFF = 0 V		±0.05	±10	µA
r <sub>i</sub>	Input resistance	V <sub>I</sub> = ±3 V to ±25 V	3	5	7	kΩ

† 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.

NOTE 3: 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.

**switching characteristics over recommended ranges of supply voltage and operating free-air temperature (unless otherwise noted) (see Note 3)**

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

† 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.

‡ Pulse skew is defined as |t<sub>PLH</sub> - t<sub>PHL</sub>| of each channel of the same device.

NOTE 3: 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.

### ESD protection

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

**MAX3221**  
**3-V TO 5.5-V SINGLE-CHANNEL RS-232 LINE DRIVER/RECEIVER**

SLLS348G – JUNE 1999 – REVISED AUGUST 2002

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

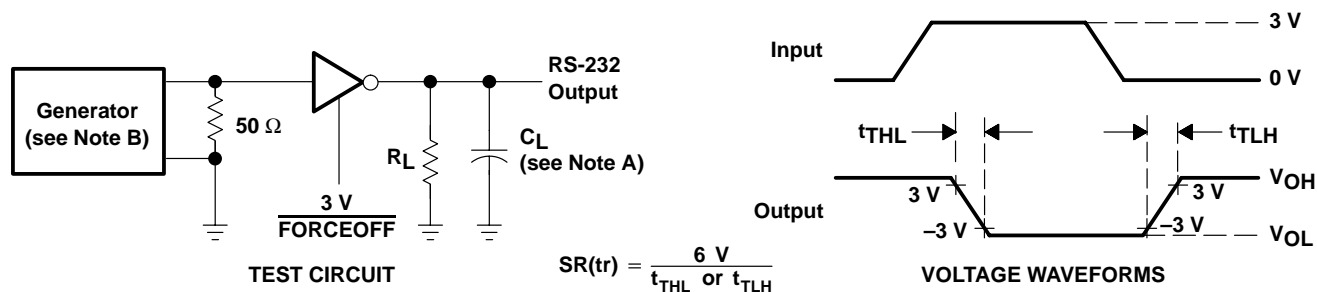
**switching characteristics over recommended ranges of supply voltage and operating free-air temperature (unless otherwise noted) (see Figure 5)**

PARAMETER		MIN	TYP†	MAX	UNIT
t <sub>valid</sub>	Propagation delay time, low- to high-level output		1		μs
t <sub>invalid</sub>	Propagation delay time, high- to low-level output		30		μs
t <sub>en</sub>	Supply enable time		100		μs

† 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.

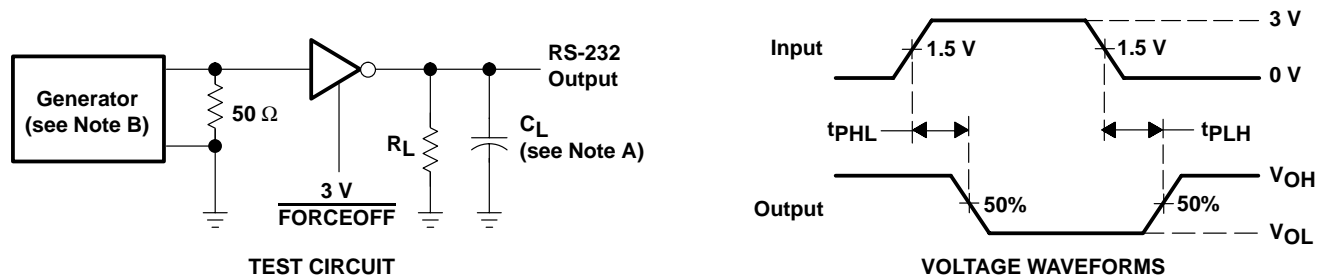


PARAMETER MEASUREMENT INFORMATION



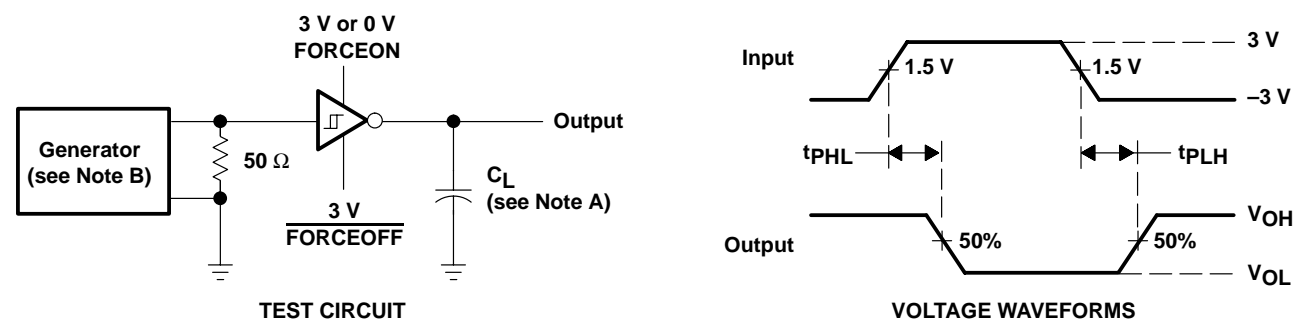
NOTES: A.  $C_L$  includes probe and jig capacitance.  
 B. The pulse generator has the following characteristics: PRR = 250 kbit/s,  $Z_O = 50 \Omega$ , 50% duty cycle,  $t_r \leq 10 \text{ ns}$ ,  $t_f \leq 10 \text{ ns}$ .

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,  $t_r \leq 10 \text{ ns}$ ,  $t_f \leq 10 \text{ ns}$ .

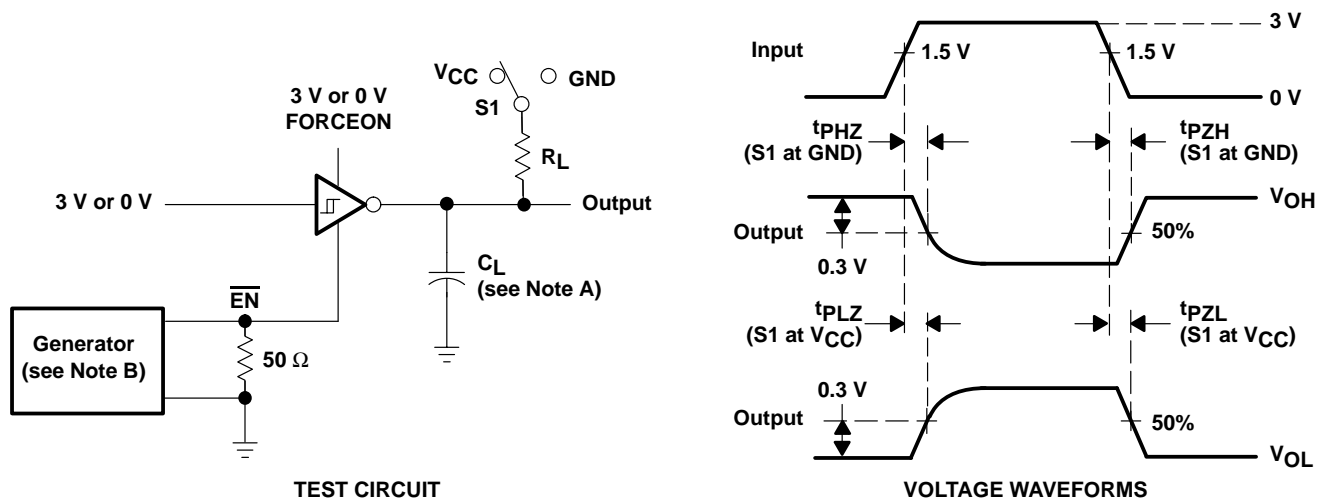
Figure 3. Receiver Propagation Delay Times

# MAX3221

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

SLLS348G – JUNE 1999 – REVISED AUGUST 2002

### PARAMETER MEASUREMENT INFORMATION

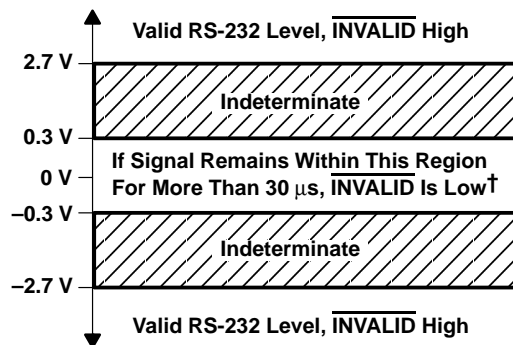
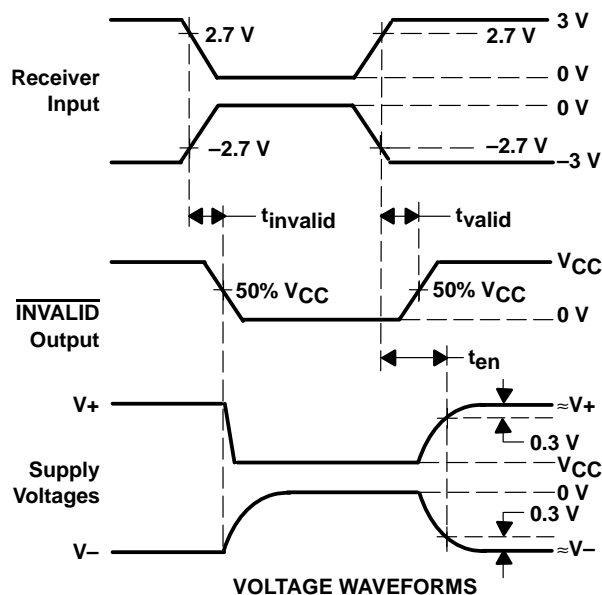
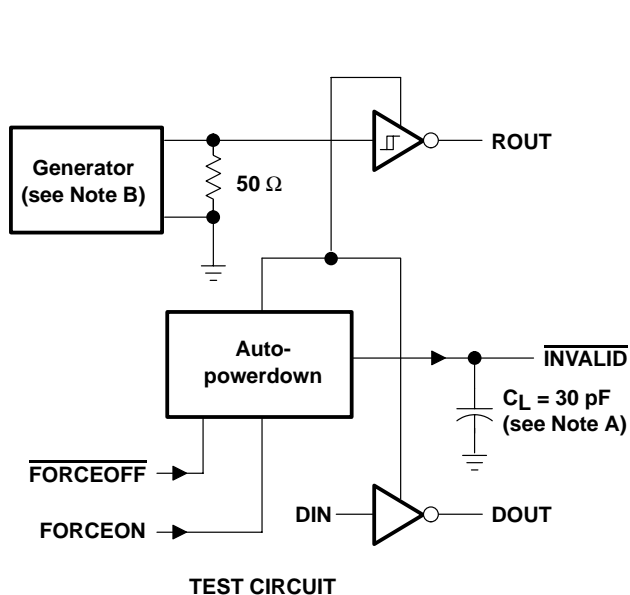


- NOTES:
- A.  $C_L$  includes probe and jig capacitance.
  - B. The pulse generator has the following characteristics:  $Z_O = 50 \Omega$ , 50% duty cycle,  $t_r \leq 10 \text{ ns}$ ,  $t_f \leq 10 \text{ ns}$ .
  - C.  $t_{PLZ}$  and  $t_{PHZ}$  are the same as  $t_{dis}$ .
  - D.  $t_{PZL}$  and 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

Figure 4. Receiver Enable and Disable Times



**PARAMETER MEASUREMENT INFORMATION**



<sup>†</sup> Auto-powerdown disables drivers and reduces supply current to 1  $\mu\text{A}$ .

- 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,  $t_r \leq 10 \text{ ns}$ ,  $t_f \leq 10 \text{ ns}$ .

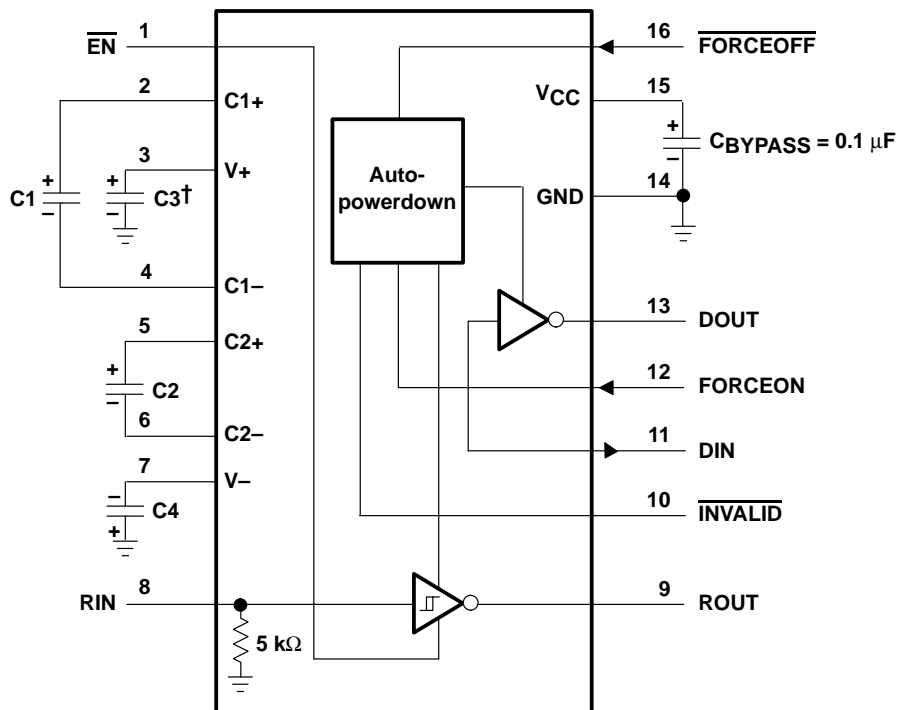
**Figure 5.  $\overline{\text{INVALID}}$  Propagation Delay Times and Driver Enabling Time**

# MAX3221

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

SLLS348G – JUNE 1999 – REVISED AUGUST 2002

### APPLICATION INFORMATION



† C3 can be connected to V<sub>CC</sub> or GND.  
 NOTE A: Resistor values shown are nominal.

V<sub>CC</sub> vs CAPACITOR VALUES

V <sub>CC</sub>	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

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