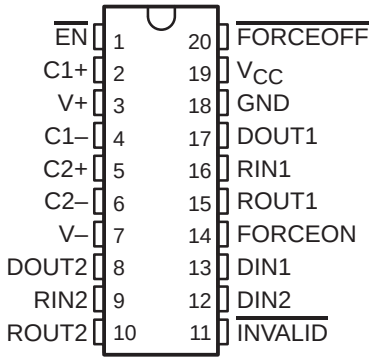
- **Meets or Exceeds the Requirements of TIA/EIA-232-F and ITU v.28 Standards**
- **Operates With 3-V to 5.5-V $V_{CC}$ Supply**
- **Operates up to 250 kbit/s**
- **Low Standby Current . . . 1 μA Typical**
- **External Capacitors . . . 4 × 0.1 μF**
- **Accepts 5-V Logic Input With 3.3-V Supply**
- **Designed to Be Interchangeable With Maxim MAX3223**
- **RS-232 Bus-Pin ESD Protection Exceeds ±15-kV Using Human-Body Model (HBM)**
- **Applications**
  - **Battery-Powered Systems, PDAs, Notebooks, Laptops, Palmtop PCs, and Hand-Held Equipment**
- **Package Options Include Plastic Small-Outline (DW), Shrink Small-Outline (DB), Thin Very Small-Outline (DGV), and Thin Shrink Small-Outline (PW) Packages**

**DB, DGV, DW, OR PW PACKAGE**
**(TOP VIEW)**




PRODUCT PREVIEW

## description

The MAX3223 device 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 devices operate 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 $\overline{\text{FORCEOFF}}$ 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 μA. Disconnecting the serial port or turning off the peripheral drivers causes the auto-powerdown 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 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 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 4 for receiver input levels.

The MAX3223C is characterized for operation from 0°C to 70°C. The MAX3223I is characterized for operation from –40°C to 85°C.

**AVAILABLE OPTIONS**

| $T_A$ | PACKAGED DEVICES | | | |
|---|---|---|---|---|
| | SHRINK SMALL OUTLINE (DB) | THIN VERY SMALL OUTLINE (DGV) | SMALL OUTLINE (DW) | THIN SHRINK SMALL OUTLINE (PW) |
| 0°C to 70°C | MAX3223CDB | MAX3223CDGV | MAX3223CDW | MAX3223CPW |
| –40°C to 85°C | MAX3223IDB | MAX3223IDGV | MAX3223IDW | MAX3223IPW |

The DB, DGV, DW, and PW packages are available taped and reeled. Add the suffix R to device type (e.g., MAX3223CDBR).

## 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

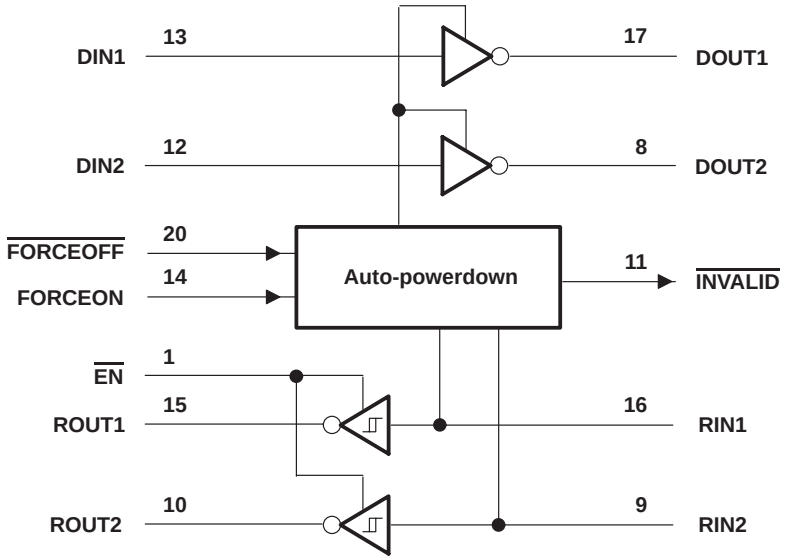
**EACH RECEIVER**

| 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 = input disconnected or connected driver off

PRODUCT PREVIEW

## 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, $\theta_{JA}$ (see Note 2): DB package . . . . . 70°C/W
DGV package . . . . . 92°C/W
DW package . . . . . 58°C/W
PW package . . . . . 83°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.

PRODUCT PREVIEW

## 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, $\overline{EN}$, $\overline{FORCEOFF}$, FORCEON | $V_{CC}$ = 3.3 V | 2 | | | V |
| | | | $V_{CC}$ = 5 V | 2.4 | | | |
| $V_{IL}$ | Driver and control low-level input voltage | DIN, $\overline{EN}$, $\overline{FORCEOFF}$, FORCEON | | | | 0.8 | V |
| $V_I$ | Driver and control input voltage | DIN, $\overline{EN}$, $\overline{FORCEOFF}$, FORCEON | | 0 | | 5.5 | V |
| $V_I$ | Receiver input voltage | | | –25 | | 25 | V |
| $T_A$ | Operating free-air temperature | | MAX3223C | 0 | | 70 | °C |
| | | | MAX3223I | –40 | | 85 | |

NOTE 3: 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 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 | $\overline{EN}$, $\overline{FORCEOFF}$, FORCEON | | | ±0.01 | ±1 | μA |
| $I_{CC}$ | Supply current | Auto-powerdown disabled | No load, $\overline{FORCEOFF}$, FORCEON at $V_{CC}$ | | 0.3 | 1 | mA |
| | | Powered off | No load, $\overline{FORCEOFF}$ at GND | | 1 | 10 | μA |
| | | Auto-powerdown enabled | No load, $\overline{FORCEOFF}$ 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°C.

NOTE 3: 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 3 and Figure 6)

| PARAMETER | | TEST CONDITIONS | | | MIN | TYP† | 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 | $V_I$ 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 | mA |
| $r_o$ | 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, | $V_{CC}$ = 0 to 5.5 V, | | | ±25 | mA |

† All typical values are at $V_{CC}$ = 3.3 V or $V_{CC}$ = 5 V, and $T_A$ = 25°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 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 3 and Figure 6)

| PARAMETER | | TEST CONDITIONS | | MIN | TYP† | 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§ | $C_L$ = 150 pF to 2500 pF, See Figure 2 | $R_L$ = 3 kΩ to 7 kΩ, | | 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°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 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.

PRODUCT PREVIEW

## 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 |
|---|---|---|---|---|---|---|
| $V_{OH}$ | 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 | mA |
| $r_i$ | 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 3: 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 3)

| 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 | | | 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 | | | 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 3: 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.

PRODUCT PREVIEW

## 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 | TYP† | 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, $\overline{\text{FORCEOFF}} = V_{CC}$ | FORCEON = GND, | $V_{CC}$–0.6 | | | V |
| $V_{OL}$ | $\overline{\text{INVALID}}$ low-level output voltage | $I_{OL}$ = 1.6 mA, $\overline{\text{FORCEOFF}} = V_{CC}$ | FORCEON = GND, | | | 0.4 | V |

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

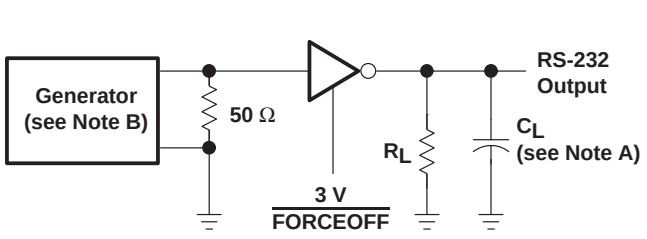
### switching characteristics over recommended ranges of supply voltage and operating free-air temperature (unless otherwise noted) (see Figure 5)

| 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 |

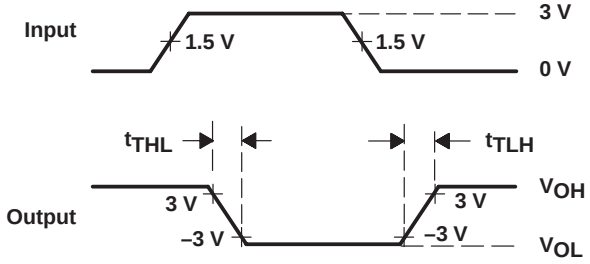
† All typical values are at $V_{CC}$ = 3.3 V or $V_{CC}$ = 5 V, and $T_A$ = 25°C.

PRODUCT PREVIEW

## PARAMETER MEASUREMENT INFORMATION




TEST CIRCUIT



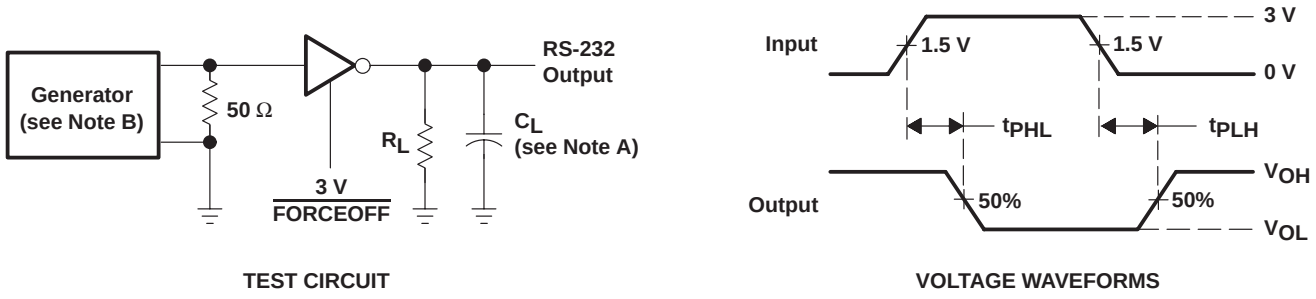

VOLTAGE WAVEFORMS

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

NOTES: 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, $t_r \le 10$ ns, $t_f \le 10$ ns.

**Figure 1. Driver Slew Rate**

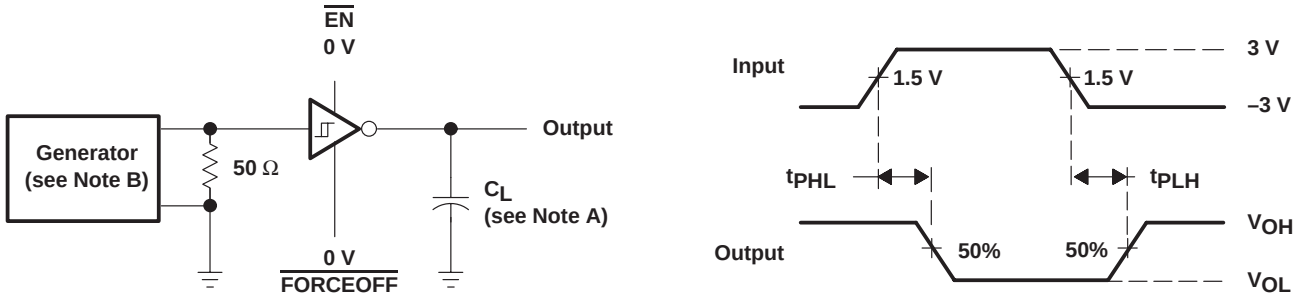
## PARAMETER MEASUREMENT INFORMATION




TEST CIRCUIT VOLTAGE WAVEFORMS

NOTES: 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, $t_r \le 10$ ns, $t_f \le 10$ ns.

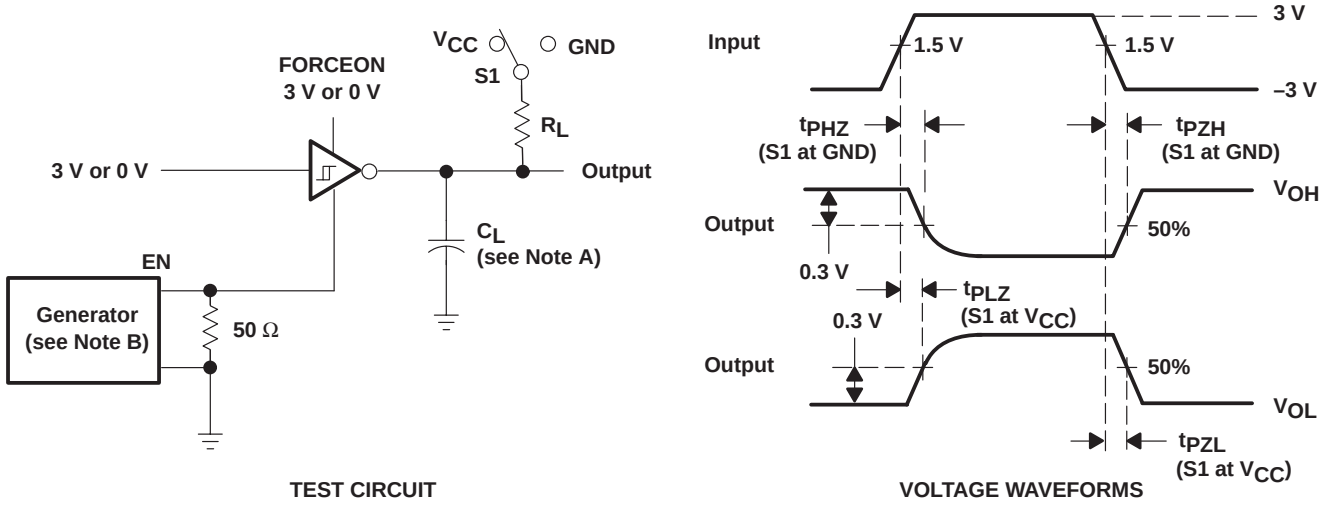
**Figure 2. Driver Pulse Skew**




TEST CIRCUIT VOLTAGE WAVEFORMS

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

**Figure 3. Receiver Propagation Delay Times**

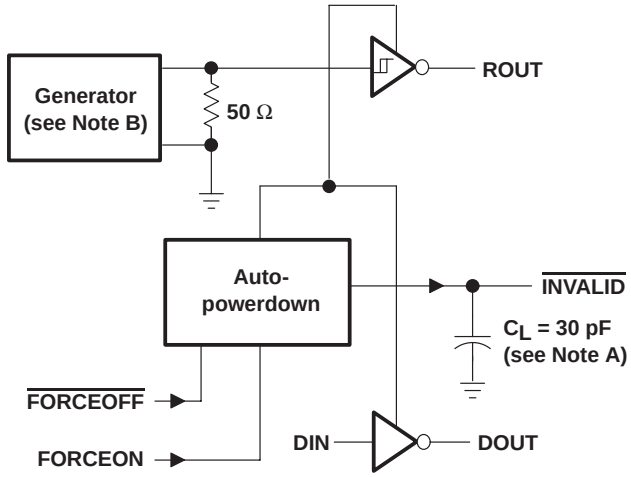



TEST CIRCUIT VOLTAGE WAVEFORMS

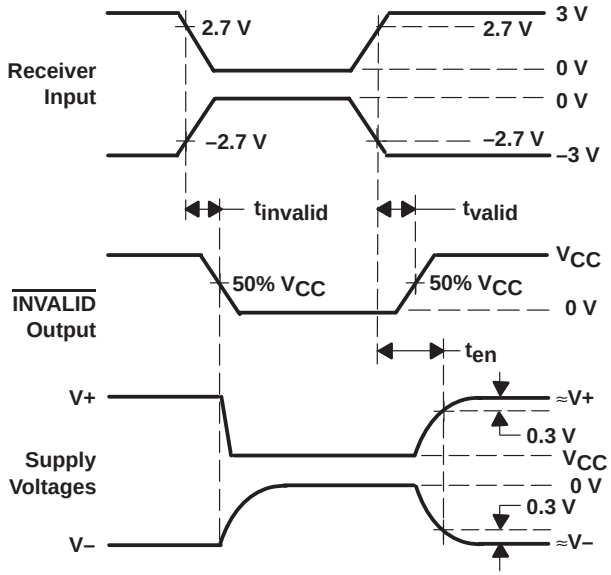
NOTES: A. $C_L$ includes probe and jig capacitance.
B. The pulse generator has the following characteristics: $Z_O$ = 50 Ω, 50% duty cycle, $t_r \le 10$ ns, $t_f \le 10$ ns.

**Figure 4. Receiver Enable and Disable Times**

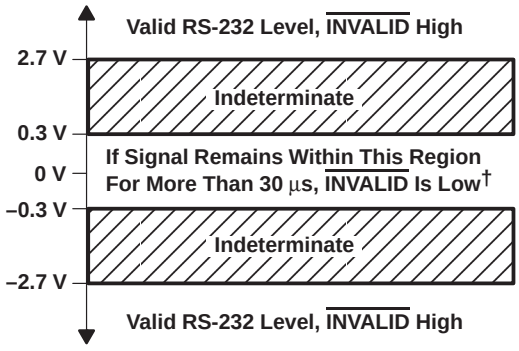
## PARAMETER MEASUREMENT INFORMATION




TEST CIRCUIT




VOLTAGE WAVEFORMS



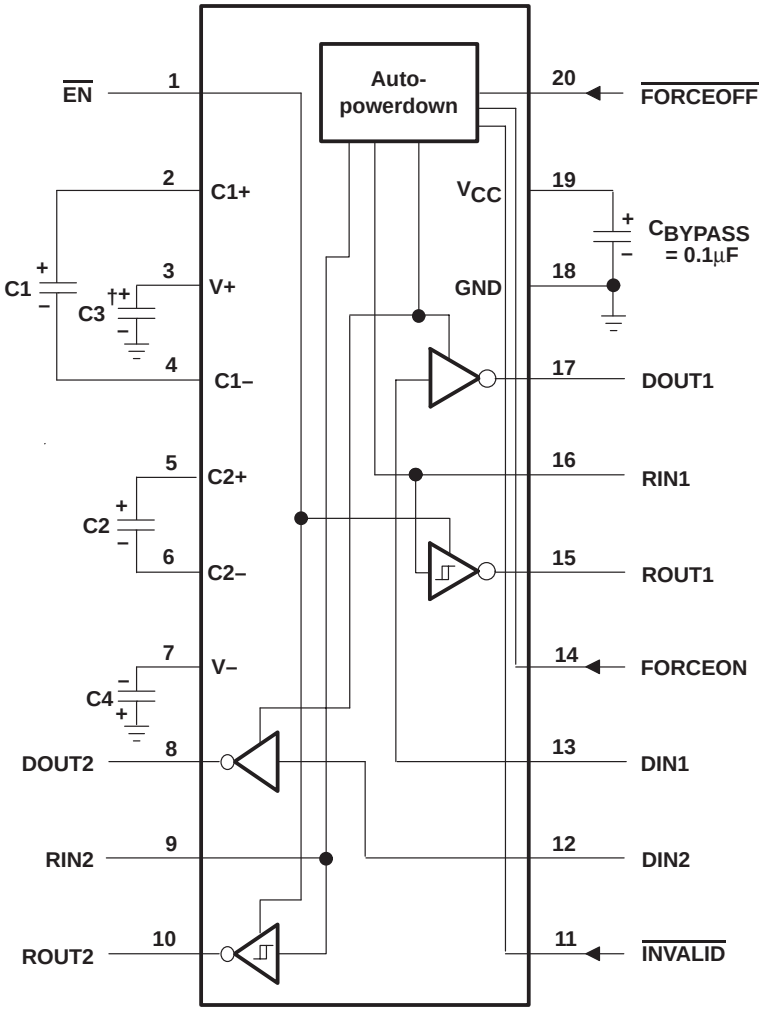

† Auto-powerdown disables drivers and reduces supply current to 1 μA.

NOTES: 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, $t_r \le 10$ ns, $t_f \le 10$ ns.

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

PRODUCT PREVIEW

## APPLICATION INFORMATION




† C3 can be connected to $V_{CC}$ or GND.
NOTE A: Resistor values shown are nominal.

**$V_{CC}$ 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**

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