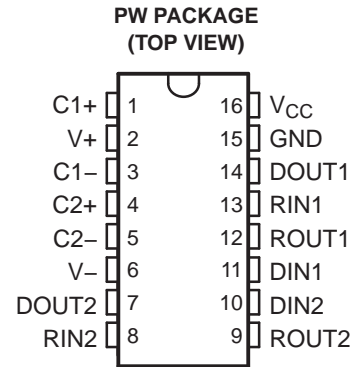


## 3-V TO 5.5-V MULTICHANNEL RS-232 LINE DRIVER/RECEIVER WITH ±15-kV IEC ESD PROTECTION

### FEATURES

- Qualified for Automotive Applications
- 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 . . . 300  $\mu$ A Typical
- External Capacitors . . .  $4 \times 0.1 \mu$ F
- Accepts 5-V Logic Input With 3.3-V Supply
- Pin Compatible to Alternative High-Speed Pin-Compatible Device (1 Mbit/s): SNx5C3232



### DESCRIPTION

The MAX3232E device consists of two line drivers, two line receivers, and a dual charge-pump circuit with  $\pm 15$ -kV IEC 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.

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

$T_A$	PACKAGE <sup>(2)</sup>		ORDERABLE PART NUMBER	TOP-SIDE MARKING
–40°C to 85°C	TSSOP – PW	Reel of 2000	MAX3232EIPWRQ1	MB3232I

- (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).

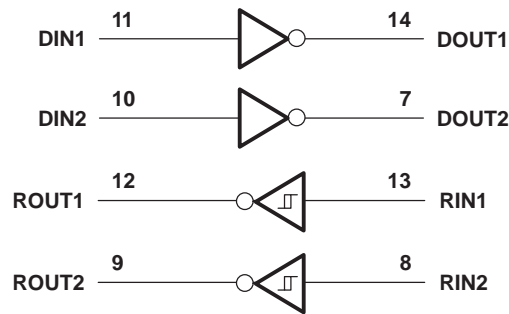
### FUNCTION TABLE

EACH DRIVER <sup>(1)</sup>		EACH RECEIVER <sup>(1)</sup>	
INPUT DIN	OUTPUT DOUT	INPUT RIN	OUTPUT ROUT
L	H	L	H
H	L	H	L
		Open	H

- (1) H = high level, L = low level, Open = input disconnected or connected driver off



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**LOGIC DIAGRAM (POSITIVE LOGIC)****ABSOLUTE MAXIMUM RATINGS**over operating free-air temperature range (unless otherwise noted) <sup>(1)</sup>

		VALUE	UNIT
V <sub>CC</sub>	Supply voltage range <sup>(2)</sup>	–0.3 to 6	V
V+	Positive output supply voltage range <sup>(2)</sup>	–0.3 to 7	V
V–	Negative output supply voltage range <sup>(2)</sup>	0.3 to –7	V
V+ – V–	Supply voltage difference <sup>(2)</sup>	13	V
V <sub>I</sub>	Input voltage range	Drivers	–0.3 to 6
		Receivers	–25 to 25
V <sub>O</sub>	Output voltage range	Drivers	–13.2 to 13.2
		Receivers	–0.3 to V <sub>CC</sub> + 0.3
θ <sub>JA</sub>	Package thermal impedance <sup>(3) (4)</sup>	108	°C/W
T <sub>J</sub>	Operating virtual junction temperature	150	°C
T <sub>stg</sub>	Storage temperature range	–65 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) Maximum power dissipation is a function of T<sub>J(max)</sub>, θ<sub>JA</sub>, and T<sub>A</sub>. The maximum allowable power dissipation at any allowable ambient temperature is P<sub>D</sub> = (T<sub>J(max)</sub> – T<sub>A</sub>)/θ<sub>JA</sub>. Operating at the absolute maximum T<sub>J</sub> of 150°C can affect reliability.
- (4) The package thermal impedance is calculated in accordance with JESD 51-7.

**RECOMMENDED OPERATING CONDITIONS<sup>(1)</sup>**see [Figure 4](#)

		MIN	NOM	MAX	UNIT		
Supply voltage	V <sub>CC</sub> = 3.3 V		3	3.3	3.6	V	
	V <sub>CC</sub> = 5 V		4.5	5	5.5		
V <sub>IH</sub>	Driver high-level input voltage	DIN	V <sub>CC</sub> = 3.3 V		2	5.5	V
			V <sub>CC</sub> = 5 V		2.4	5.5	
V <sub>IL</sub>	Driver low-level input voltage	DIN			0	0.8	V
V <sub>I</sub>	Receiver input voltage				–25	25	V
T <sub>A</sub>	Operating free-air temperature	MAX3232I			–40	85	°C

- (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.

## ELECTRICAL CHARACTERISTICS

over recommended ranges of supply voltage and operating free-air temperature (unless otherwise noted) (see [Figure 4](#))

PARAMETER	TEST CONDITIONS <sup>(1)</sup>	MIN	TYP <sup>(2)</sup>	MAX	UNIT
$I_{CC}$ Supply current	No load, $V_{CC} = 3.3\text{ V}$ or $5\text{ V}$		0.3	1	mA

(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

over recommended ranges of supply voltage and operating free-air temperature (unless otherwise noted) (see [Figure 4](#))

PARAMETER	TEST CONDITIONS <sup>(1)</sup>	MIN	TYP <sup>(2)</sup>	MAX	UNIT
$V_{OH}$ High-level output voltage	DOOUT at $R_L = 3\text{ k}\Omega$ to GND, DIN = GND	5	5.4		V
$V_{OL}$ Low-level output voltage	DOOUT 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 <sup>(3)</sup>	$V_{CC} = 3.6\text{ V}$ , $V_O = 0\text{ V}$		$\pm 35$	$\pm 60$	mA
	$V_{CC} = 5.5\text{ V}$ , $V_O = 0\text{ V}$				
$r_o$ Output resistance	$V_{CC}$ , $V_+$ , and $V_- = 0\text{ V}$ , $V_O = 2\text{ V}$	300	10M		$\Omega$

(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  $T_A = 25^\circ\text{C}$ .

(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

over recommended ranges of supply voltage and operating free-air temperature (unless otherwise noted) (see [Figure 4](#))

PARAMETER	TEST CONDITIONS <sup>(1)</sup>	MIN	TYP <sup>(2)</sup>	MAX	UNIT
Maximum data rate	$C_L = 1000\text{ pF}$ , One DOOUT switching, $R_L = 3\text{ k}\Omega$ , See <a href="#">Figure 1</a>	150	250		kbit/s
$t_{sk(p)}$ Pulse skew <sup>(3)</sup>	$C_L = 150\text{ pF}$ to $2500\text{ pF}$ , $R_L = 3\text{ k}\Omega$ to $7\text{ k}\Omega$ , See <a href="#">Figure 2</a>		300		ns
SR(tr) Slew rate, transition region (see <a href="#">Figure 1</a> )	$R_L = 3\text{ k}\Omega$ to $7\text{ k}\Omega$ , $V_{CC} = 3.3\text{ V}$	$C_L = 150\text{ pF}$ to $1000\text{ pF}$		30	v/ $\mu\text{s}$
		$C_L = 150\text{ pF}$ to $2500\text{ pF}$	6	30	
		4		30	

(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  $T_A = 25^\circ\text{C}$ .

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

## RECEIVER SECTION – ELECTRICAL CHARACTERISTICS

over recommended ranges of supply voltage and operating free-air temperature (unless otherwise noted) (see [Figure 4](#))

PARAMETER	TEST CONDITIONS <sup>(1)</sup>	MIN	TYP <sup>(2)</sup>	MAX	UNIT
$V_{OH}$ High-level output voltage	$I_{OH} = -1\text{ mA}$	$V_{CC} - 0.6\text{ V}$	$V_{CC} - 0.1\text{ V}$		V
$V_{OL}$ Low-level output voltage	$I_{OL} = 1.6\text{ mA}$			0.4	V
$V_{IT+}$ Positive-going input threshold voltage	$V_{CC} = 3.3\text{ V}$		1.5	2.4	V
	$V_{CC} = 5\text{ V}$		1.8	2.4	
$V_{IT-}$ Negative-going input threshold voltage	$V_{CC} = 3.3\text{ V}$	0.6	1.2		V
	$V_{CC} = 5\text{ V}$	0.8	1.5		
$V_{hys}$ Input hysteresis ( $V_{IT+} - V_{IT-}$ )			0.3		V
$r_i$ Input resistance	$V_I = \pm 3\text{ V}$ to $\pm 25\text{ V}$	3	5	7	k $\Omega$

(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  $T_A = 25^\circ\text{C}$ .

**RECEIVER SECTION – SWITCHING CHARACTERISTICS**

over recommended ranges of supply voltage and operating free-air temperature (unless otherwise noted) (see [Figure 3](#))

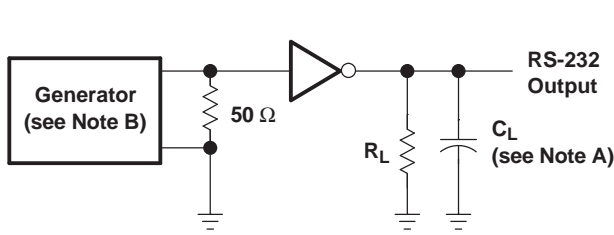
PARAMETER		TEST CONDITIONS <sup>(1)</sup>	TYP <sup>(2)</sup>	UNIT
$t_{PLH}$	Propagation delay time, low- to high-level output	$C_L = 150 \text{ pF}$	300	ns
$t_{PHL}$	Propagation delay time, high- to low-level output	$C_L = 150 \text{ pF}$	300	ns
$t_{sk(p)}$	Pulse skew <sup>(3)</sup>		300	ns

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

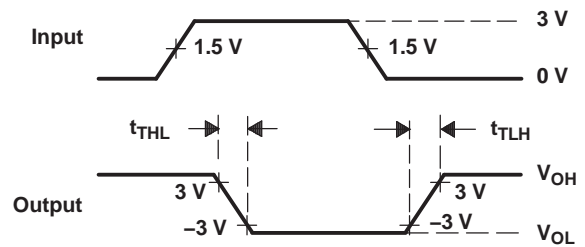
(3) Pulse skew is defined as  $|t_{PLH} - t_{PHL}|$  of each channel of the same device.

PARAMETER MEASUREMENT INFORMATION



TEST CIRCUIT

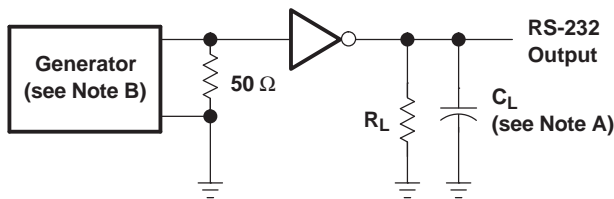
$$SR(tr) = \frac{6\text{ V}}{t_{THL} \text{ or } t_{TLH}}$$



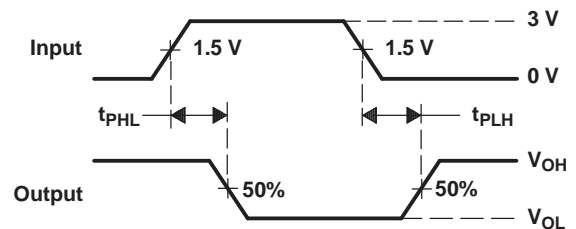
VOLTAGE WAVEFORMS

- 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 1. Driver Slew Rate



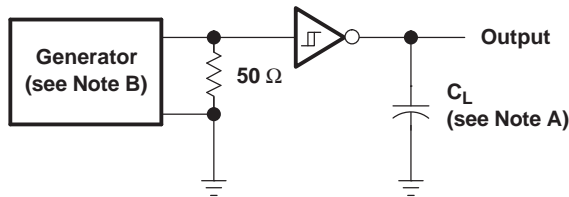
TEST CIRCUIT



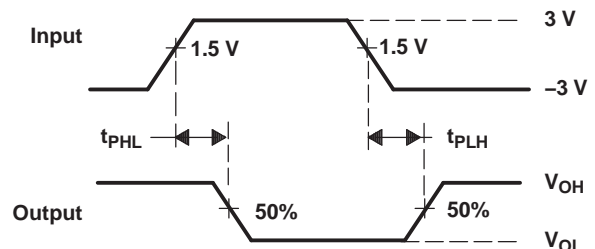
VOLTAGE WAVEFORMS

- 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

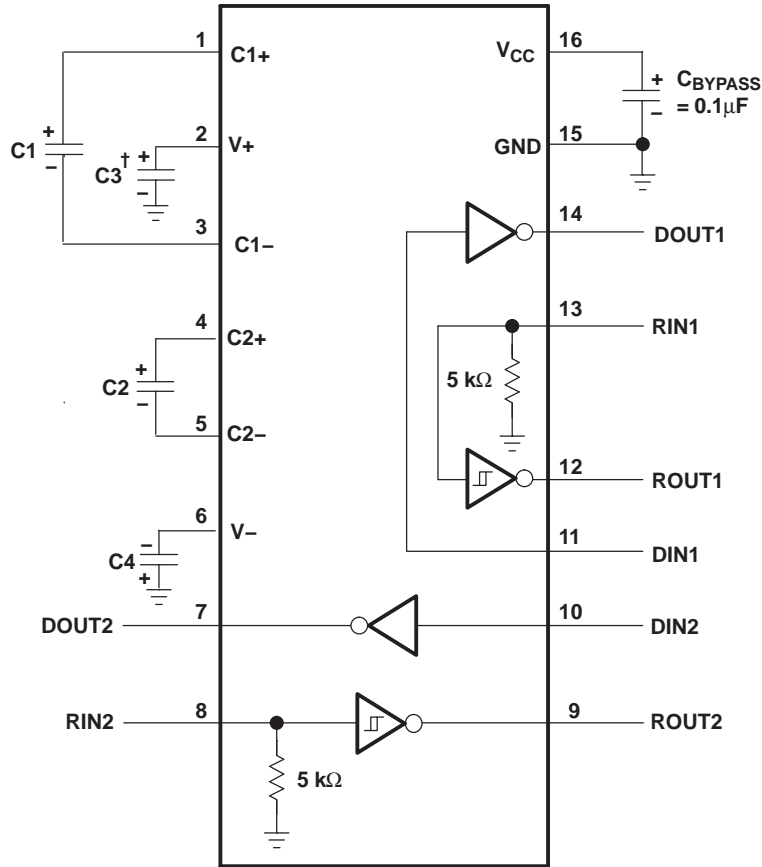


VOLTAGE WAVEFORMS

- 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

APPLICATION INFORMATION



† C3 can be connected to V<sub>CC</sub> 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<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 4. Typical Operating Circuit and Capacitor Values

**PACKAGING INFORMATION**

Orderable Device	Status <sup>(1)</sup>	Package Type	Package Drawing	Pins	Package Qty	Eco Plan <sup>(2)</sup>	Lead/Ball Finish	MSL Peak Temp <sup>(3)</sup>
MAX3232EIPWRQ1	ACTIVE	TSSOP	PW	16	2000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM

<sup>(1)</sup> 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.

<sup>(2)</sup> Eco Plan - The planned eco-friendly classification: Pb-Free (RoHS), Pb-Free (RoHS Exempt), or Green (RoHS & no Sb/Br) - please check <http://www.ti.com/productcontent> for the latest availability information and additional product content details.

**TBD:** The Pb-Free/Green conversion plan has not been defined.

**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.

**Pb-Free (RoHS Exempt):** This component has a RoHS exemption for either 1) lead-based flip-chip solder bumps used between the die and package, or 2) lead-based die adhesive used between the die and leadframe. The component is otherwise considered Pb-Free (RoHS compatible) as defined above.

**Green (RoHS & no Sb/Br):** TI defines "Green" to mean Pb-Free (RoHS compatible), and free of Bromine (Br) and Antimony (Sb) based flame retardants (Br or Sb do not exceed 0.1% by weight in homogeneous material)

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

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**OTHER QUALIFIED VERSIONS OF MAX3232E-Q1 :**

- Catalog: [MAX3232E](#)

NOTE: Qualified Version Definitions:

- Catalog - TI's standard catalog product

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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