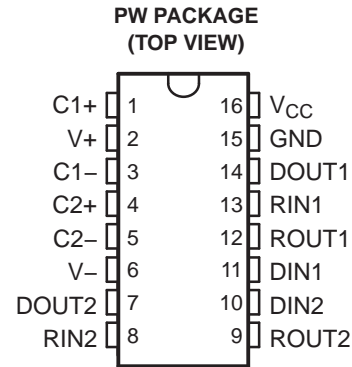


3-V TO 5.5-V MULTICHANNEL RS-232 LINE DRIVER/RECEIVER WITH ±15-kV IEC ESD PROTECTION

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 μ 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 ± 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/ μ s driver output slew rate.

ORDERING INFORMATION⁽¹⁾

T_A	PACKAGE ⁽²⁾		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.
(2) Package drawings, thermal data, and symbolization are available at www.ti.com/packaging.

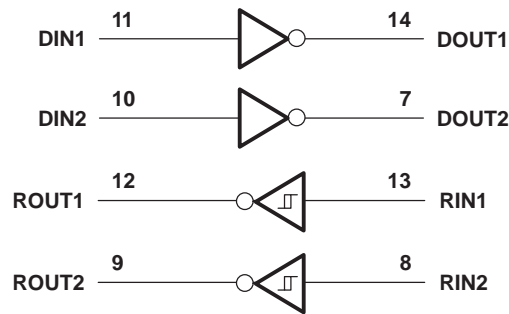
FUNCTION TABLE

EACH DRIVER ⁽¹⁾		EACH RECEIVER ⁽¹⁾	
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



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.

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

		VALUE	UNIT
V _{CC}	Supply voltage range ⁽²⁾	–0.3 to 6	V
V+	Positive output supply voltage range ⁽²⁾	–0.3 to 7	V
V–	Negative output supply voltage range ⁽²⁾	0.3 to –7	V
V+ – V–	Supply voltage difference ⁽²⁾	13	V
V _I	Input voltage range	Drivers	–0.3 to 6
		Receivers	–25 to 25
V _O	Output voltage range	Drivers	–13.2 to 13.2
		Receivers	–0.3 to V _{CC} + 0.3
θ _{JA}	Package thermal impedance ^{(3) (4)}	108	°C/W
T _J	Operating virtual junction temperature	150	°C
T _{stg}	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_{J(max)}, θ_{JA}, and T_A. The maximum allowable power dissipation at any allowable ambient temperature is P_D = (T_{J(max)} – T_A)/θ_{JA}. Operating at the absolute maximum T_J of 150°C can affect reliability.
- (4) The package thermal impedance is calculated in accordance with JESD 51-7.

RECOMMENDED OPERATING CONDITIONS⁽¹⁾see [Figure 4](#)

		MIN	NOM	MAX	UNIT
Supply voltage	V _{CC} = 3.3 V		3	3.3	3.6
	V _{CC} = 5 V		4.5	5	5.5
V _{IH}	Driver high-level input voltage	DIN	V _{CC} = 3.3 V		2
			V _{CC} = 5 V		5.5
V _{IL}	Driver low-level input voltage	DIN	0	0.8	V
V _I	Receiver input voltage		–25	25	V
T _A	Operating free-air temperature	MAX3232I		–40	85
					°C

- (1) 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 [Figure 4](#))

PARAMETER	TEST CONDITIONS ⁽¹⁾	MIN	TYP ⁽²⁾	MAX	UNIT
I_{CC} Supply current	No load, $V_{CC} = 3.3\text{ V}$ or 5 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 ⁽¹⁾	MIN	TYP ⁽²⁾	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	$V_I = V_{CC}$		± 0.01	± 1	μA
I_{IL} Low-level input current	V_I at GND		± 0.01	± 1	μA
I_{OS} Short-circuit output current ⁽³⁾	$V_{CC} = 3.6\text{ V}$, $V_O = 0\text{ V}$		± 35	± 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		Ω

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

(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](#))

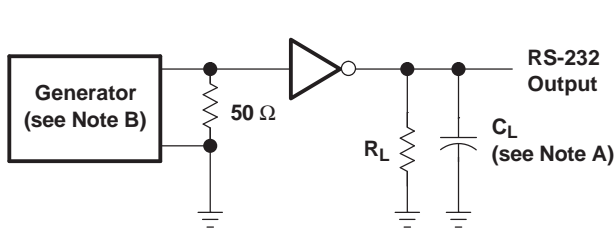
PARAMETER		TEST CONDITIONS ⁽¹⁾	TYP ⁽²⁾	UNIT
t_{PLH}	Propagation delay time, low- to high-level output	$C_L = 150 \text{ pF}$	300	ns
t_{PHL}	Propagation delay time, high- to low-level output	$C_L = 150 \text{ pF}$	300	ns
$t_{sk(p)}$	Pulse skew ⁽³⁾		300	ns

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

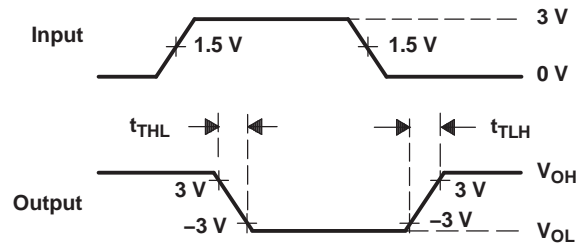
(3) Pulse skew is defined as $|t_{PLH} - t_{PHL}|$ of each channel of the same device.

PARAMETER MEASUREMENT INFORMATION



TEST CIRCUIT

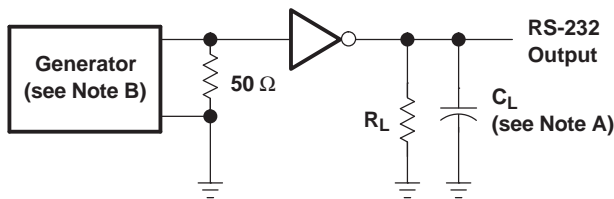
$$SR(tr) = \frac{6\text{ V}}{t_{THL} \text{ or } t_{TLH}}$$



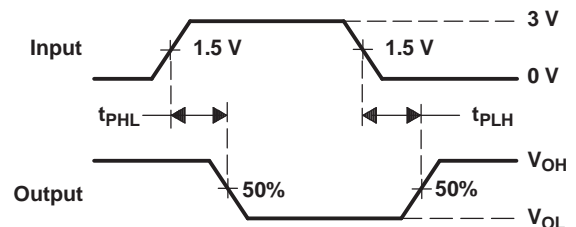
VOLTAGE WAVEFORMS

- 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



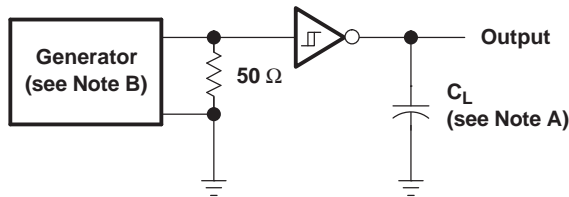
TEST CIRCUIT



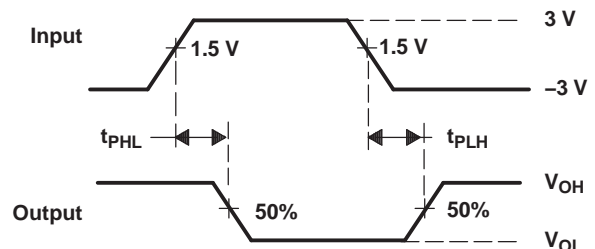
VOLTAGE WAVEFORMS

- 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

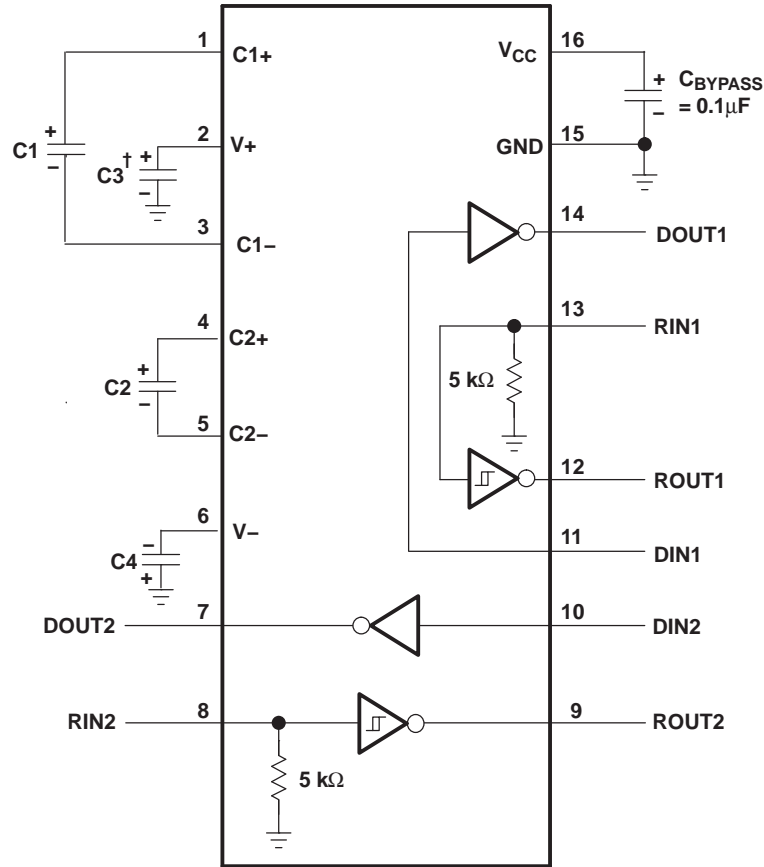


VOLTAGE WAVEFORMS

- 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_{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, 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 (1)	Package Type	Package Drawing	Pins	Package Qty	Eco Plan (2)	Lead/Ball Finish (6)	MSL Peak Temp (3)	Op Temp (°C)	Device Marking (4/5)	Samples
MAX3232EIPWRQ1	ACTIVE	TSSOP	PW	16	2000	Green (RoHS & no Sb/Br)	NIPDAU	Level-1-260C-UNLIM	-40 to 85	MB3232I	Samples

(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.

OBSELETE: TI has discontinued the production of the device.

(2) **RoHS:** TI defines "RoHS" to mean semiconductor products that are compliant with the current EU RoHS requirements for all 10 RoHS substances, including the requirement that RoHS substance do not exceed 0.1% by weight in homogeneous materials. Where designed to be soldered at high temperatures, "RoHS" products are suitable for use in specified lead-free processes. TI may reference these types of products as "Pb-Free".

RoHS Exempt: TI defines "RoHS Exempt" to mean products that contain lead but are compliant with EU RoHS pursuant to a specific EU RoHS exemption.

Green: TI defines "Green" to mean the content of Chlorine (Cl) and Bromine (Br) based flame retardants meet JS709B low halogen requirements of <=1000ppm threshold. Antimony trioxide based flame retardants must also meet the <=1000ppm threshold requirement.

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

(4) There may be additional marking, which relates to the logo, the lot trace code information, or the environmental category on the device.

(5) Multiple Device Markings will be inside parentheses. Only one Device Marking contained in parentheses and separated by a "~" will appear on a device. If a line is indented then it is a continuation of the previous line and the two combined represent the entire Device Marking for that device.

(6) Lead/Ball Finish - Orderable Devices may have multiple material finish options. Finish options are separated by a vertical ruled line. Lead/Ball Finish values may wrap to two lines if the finish value exceeds the maximum column width.

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OTHER QUALIFIED VERSIONS OF MAX3232E-Q1 :

- Catalog: [MAX3232E](#)

NOTE: Qualified Version Definitions:

- Catalog - TI's standard catalog product

TAPE AND REEL INFORMATION



QUADRANT ASSIGNMENTS FOR PIN 1 ORIENTATION IN TAPE



*All dimensions are nominal

Device	Package Type	Package Drawing	Pins	SPQ	Reel Diameter (mm)	Reel Width W1 (mm)	A0 (mm)	B0 (mm)	K0 (mm)	P1 (mm)	W (mm)	Pin1 Quadrant
MAX3232EIPWRQ1	TSSOP	PW	16	2000	330.0	12.4	6.9	5.6	1.6	8.0	12.0	Q1

TAPE AND REEL BOX DIMENSIONS


*All dimensions are nominal

Device	Package Type	Package Drawing	Pins	SPQ	Length (mm)	Width (mm)	Height (mm)
MAX3232EIPWRQ1	TSSOP	PW	16	2000	367.0	367.0	35.0



4220204/A 02/2017

NOTES:

1. All linear dimensions are in millimeters. Any dimensions in parenthesis are for reference only. Dimensioning and tolerancing per ASME Y14.5M.
2. This drawing is subject to change without notice.
3. This dimension does not include mold flash, protrusions, or gate burrs. Mold flash, protrusions, or gate burrs shall not exceed 0.15 mm per side.
4. This dimension does not include interlead flash. Interlead flash shall not exceed 0.25 mm per side.
5. Reference JEDEC registration MO-153.

EXAMPLE BOARD LAYOUT

PW0016A

TSSOP - 1.2 mm max height

SMALL OUTLINE PACKAGE



LAND PATTERN EXAMPLE
EXPOSED METAL SHOWN
SCALE: 10X



4220204/A 02/2017

NOTES: (continued)

- 6. Publication IPC-7351 may have alternate designs.
- 7. Solder mask tolerances between and around signal pads can vary based on board fabrication site.

EXAMPLE STENCIL DESIGN

PW0016A

TSSOP - 1.2 mm max height

SMALL OUTLINE PACKAGE



SOLDER PASTE EXAMPLE
BASED ON 0.125 mm THICK STENCIL
SCALE: 10X

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NOTES: (continued)

8. Laser cutting apertures with trapezoidal walls and rounded corners may offer better paste release. IPC-7525 may have alternate design recommendations.
9. Board assembly site may have different recommendations for stencil design.

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