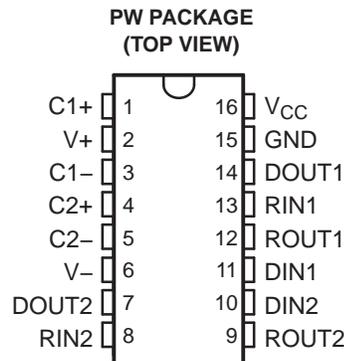


## 3-V TO 5.5-V MULTICHANNEL RS-232 LINE DRIVER/RECEIVER WITH ±15-kV IEC ESD PROTECTION

### 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).

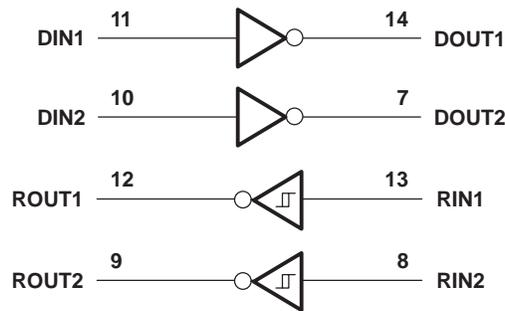
### FUNCTION TABLE

| EACH DRIVER <sup>(1)</sup> |                | EACH RECEIVER <sup>(1)</sup> |                |
|----------------------------|----------------|------------------------------|----------------|
| INPUT<br>DIN               | OUTPUT<br>DOUT | INPUT<br>RIN                 | OUTPUT<br>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) <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](#))

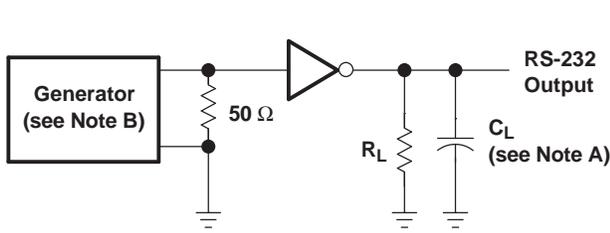
| PARAMETER   |   | TEST CONDITIONS <sup>(1)</sup> | TYP <sup>(2)</sup> | UNIT |
|-------------|---|--------------------------------|--------------------|------|
| $t_{PLH}$   | Propagation delay time, low- to high-level output | $C_L = 150 \text{ pF}$         | 300                | ns   |
| $t_{PHL}$   | 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  $T_A = 25^\circ\text{C}$ .

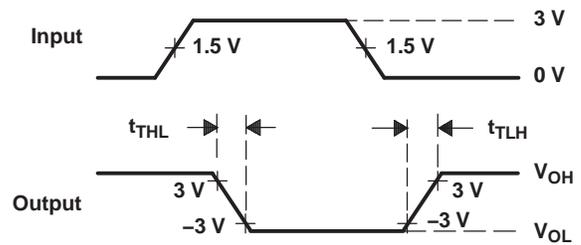
(3) Pulse skew is defined as  $|t_{PLH} - t_{PHL}|$  of each channel of the same device.

PARAMETER MEASUREMENT INFORMATION



TEST CIRCUIT

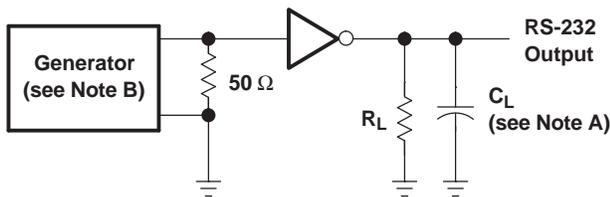
$$SR(tr) = \frac{6V}{t_{THL} \text{ or } t_{TLH}}$$



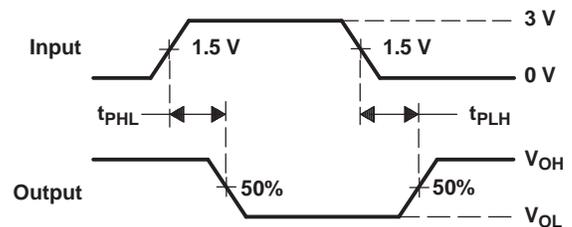
VOLTAGE WAVEFORMS

- 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,  $t_r \leq 10$  ns,  $t_f \leq 10$  ns.

Figure 1. Driver Slew Rate



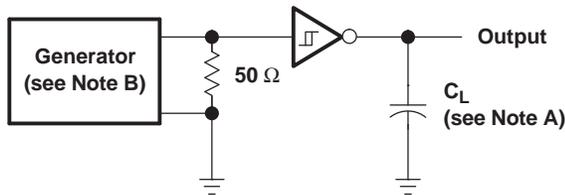
TEST CIRCUIT



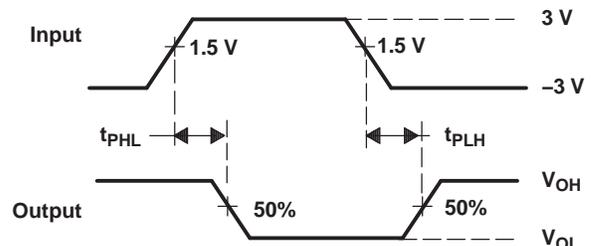
VOLTAGE WAVEFORMS

- 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,  $t_r \leq 10$  ns,  $t_f \leq 10$  ns.

Figure 2. Driver Pulse Skew



TEST CIRCUIT

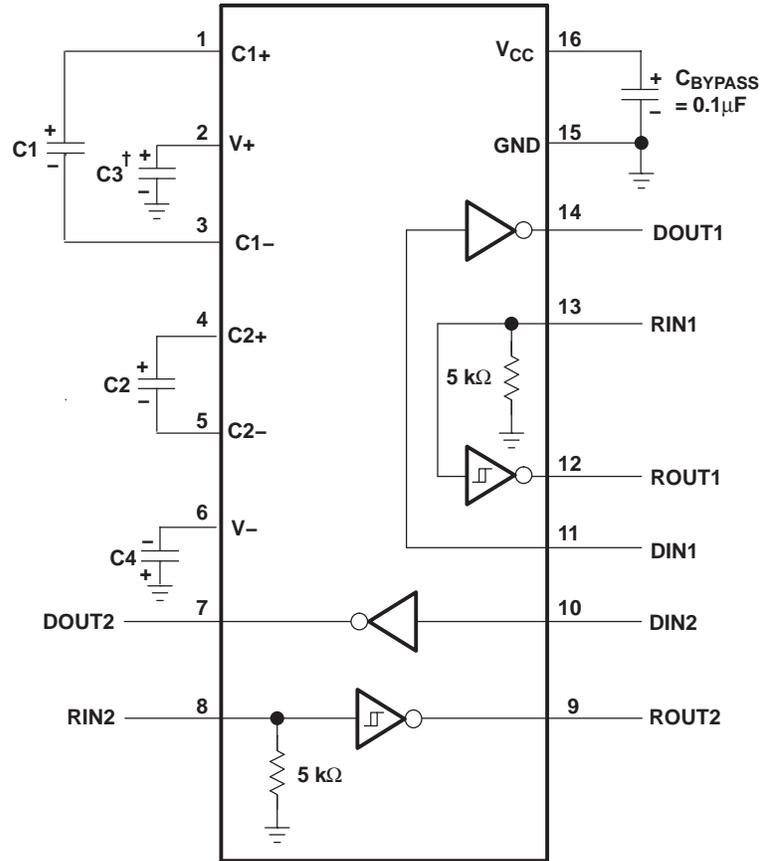


VOLTAGE WAVEFORMS

- A.  $C_L$  includes probe and jig capacitance.
- B. The pulse generator has the following characteristics:  $Z_O = 50 \Omega$ , 50% duty cycle,  $t_r \leq 10$  ns,  $t_f \leq 10$  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<br>(1) | Package Type | Package<br>Drawing | Pins | Package<br>Qty | Eco Plan<br>(2)            | Lead/Ball Finish | MSL Peak Temp<br>(3) | Op Temp (°C) | Top-Side Markings<br>(4) | Samples                 |
|------------------|---------------|--------------|--------------------|------|----------------|----------------------------|------------------|----------------------|--------------|--------------------------|-------------------------|
| MAX3232EIPWRQ1   | ACTIVE        | TSSOP        | PW                 | 16   | 2000           | Green (RoHS<br>& no Sb/Br) | CU NIPDAU        | Level-1-260C-UNLIM   | -40 to 85    | MB3232I                  | <a href="#">Samples</a> |

(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 - 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)

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

(4) Multiple Top-Side Markings will be inside parentheses. Only one Top-Side 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 Top-Side Marking for that device.

**Important Information and Disclaimer:** The information provided on this page represents TI's knowledge and belief as of the date that it is provided. TI bases its knowledge and belief on information provided by third parties, and makes no representation or warranty as to the accuracy of such information. Efforts are underway to better integrate information from third parties. TI has taken and continues to take reasonable steps to provide representative and accurate information but may not have conducted destructive testing or chemical analysis on incoming materials and chemicals. TI and TI suppliers consider certain information to be proprietary, and thus CAS numbers and other limited information may not be available for release.

In no event shall TI's liability arising out of such information exceed the total purchase price of the TI part(s) at issue in this document sold by TI to Customer on an annual basis.

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

- Catalog: [MAX3232E](#)

NOTE: Qualified Version Definitions:

- Catalog - TI's standard catalog product

## TAPE AND REEL INFORMATION



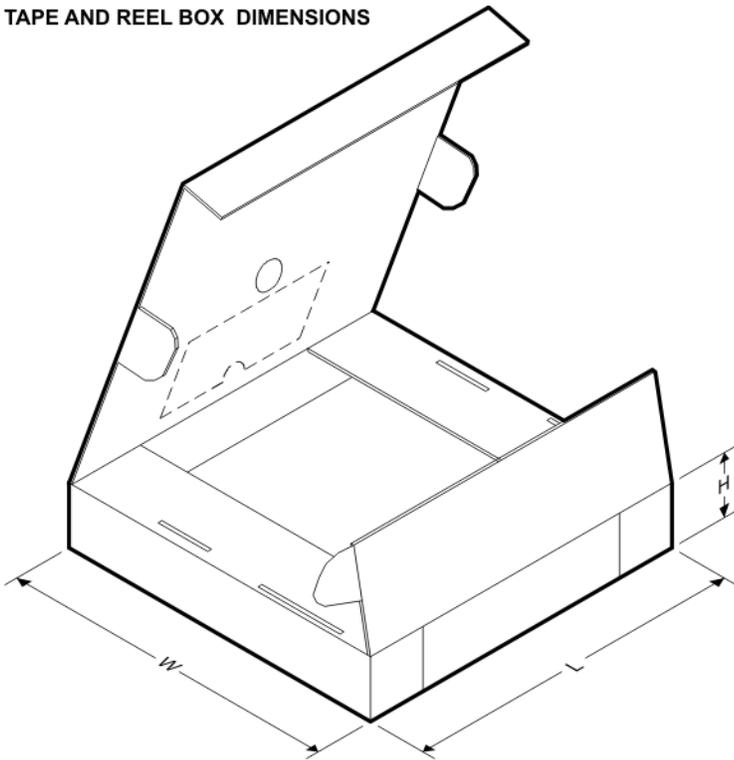
### QUADRANT ASSIGNMENTS FOR PIN 1 ORIENTATION IN TAPE



\*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**

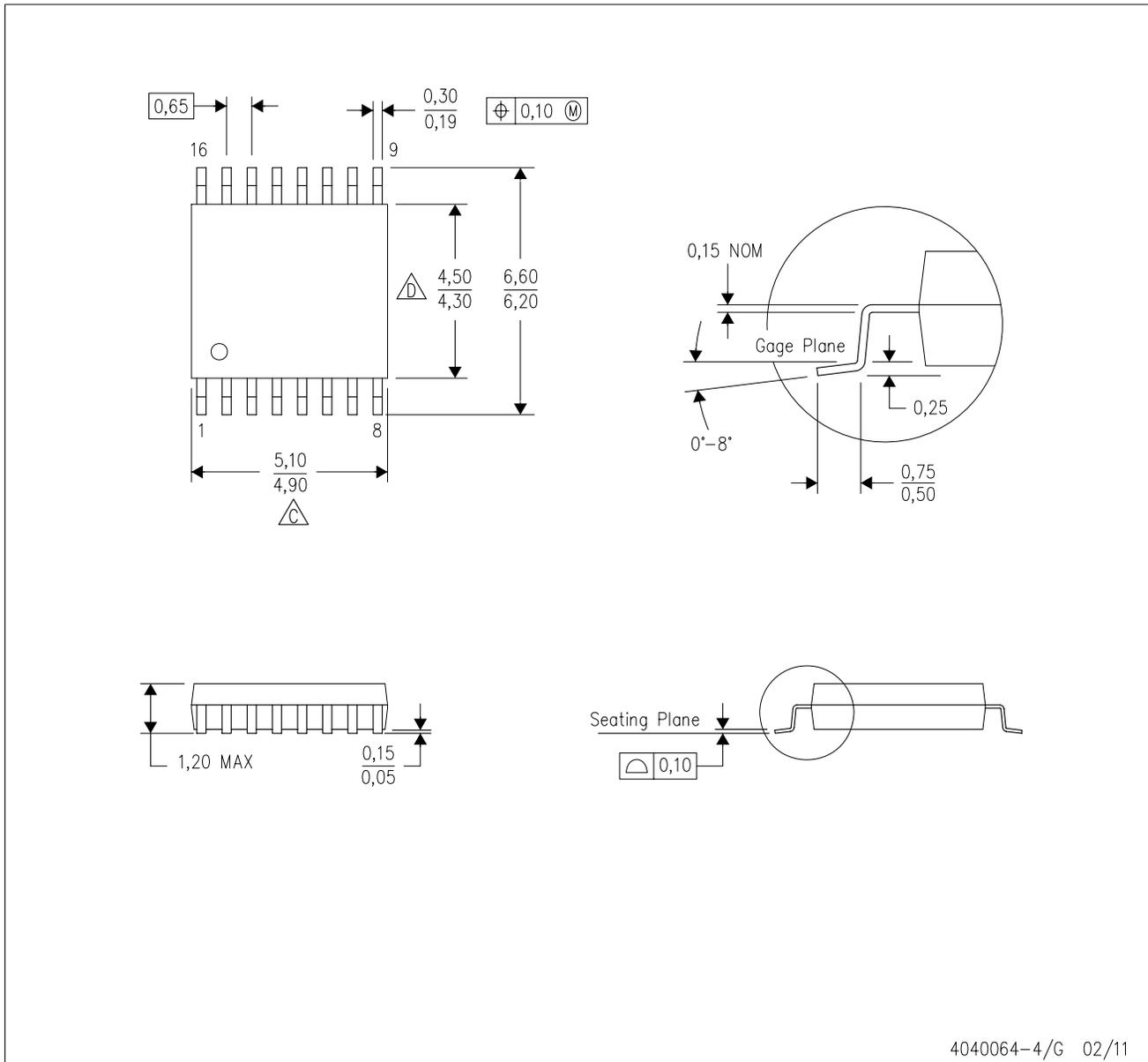


\*All dimensions are nominal

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

PW (R-PDSO-G16)

PLASTIC SMALL OUTLINE

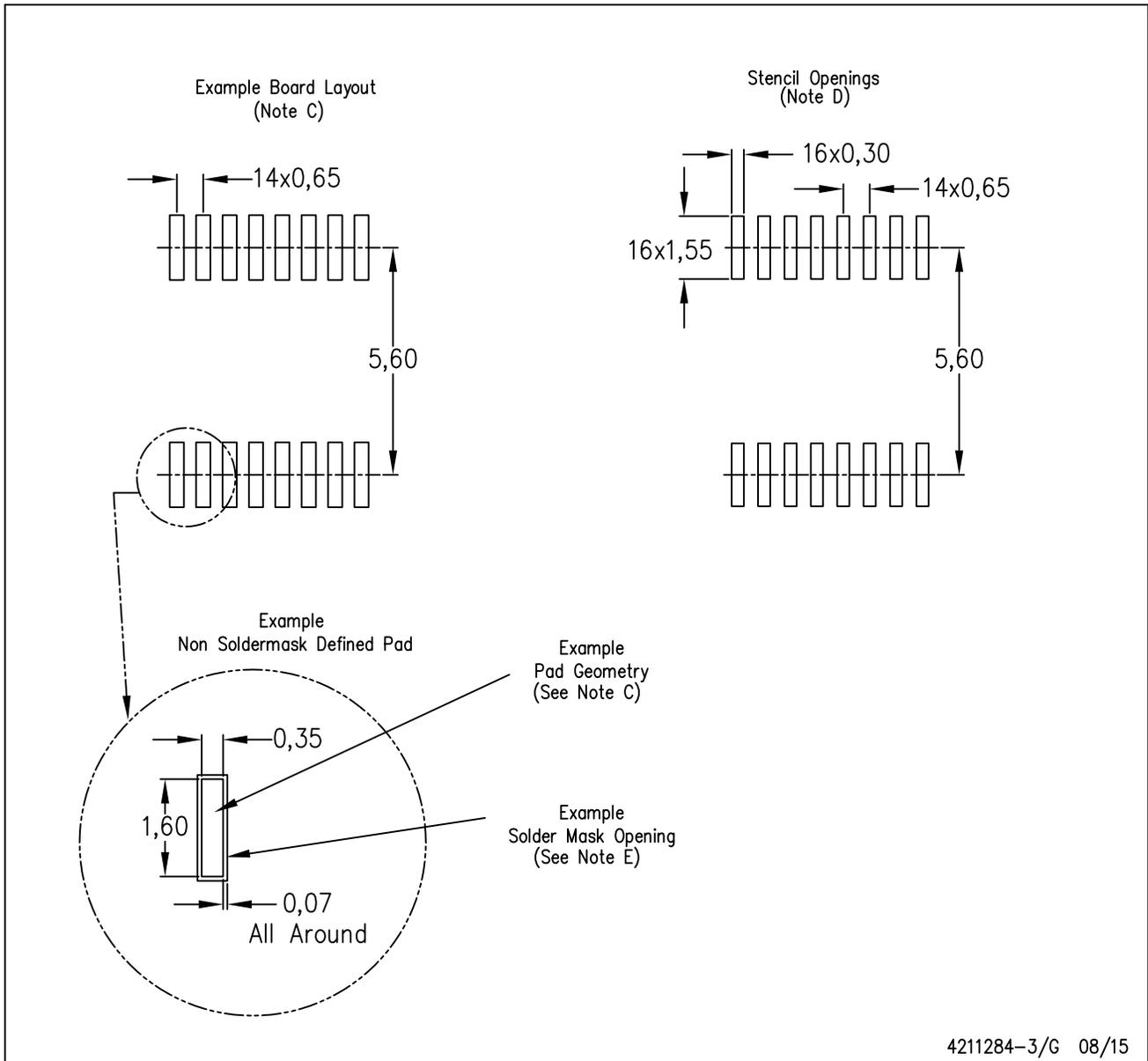


4040064-4/G 02/11

- NOTES:
- A. All linear dimensions are in millimeters. Dimensioning and tolerancing per ASME Y14.5M-1994.
  - B. This drawing is subject to change without notice.
  - C. Body length does not include mold flash, protrusions, or gate burrs. Mold flash, protrusions, or gate burrs shall not exceed 0,15 each side.
  - D. Body width does not include interlead flash. Interlead flash shall not exceed 0,25 each side.
  - E. Falls within JEDEC MO-153

PW (R-PDSO-G16)

PLASTIC SMALL OUTLINE



4211284-3/G 08/15

- NOTES:
- All linear dimensions are in millimeters.
  - This drawing is subject to change without notice.
  - Publication IPC-7351 is recommended for alternate designs.
  - Laser cutting apertures with trapezoidal walls and also rounding corners will offer better paste release. Customers should contact their board assembly site for stencil design recommendations. Refer to IPC-7525 for other stencil recommendations.
  - Customers should contact their board fabrication site for solder mask tolerances between and around signal pads.

## IMPORTANT NOTICE

Texas Instruments Incorporated and its subsidiaries (TI) reserve the right to make corrections, enhancements, improvements and other changes to its semiconductor products and services per JESD46, latest issue, and to discontinue any product or service per JESD48, latest issue. Buyers should obtain the latest relevant information before placing orders and should verify that such information is current and complete. All semiconductor products (also referred to herein as "components") are sold subject to TI's terms and conditions of sale supplied at the time of order acknowledgment.

TI warrants performance of its components to the specifications applicable at the time of sale, in accordance with the warranty in TI's terms and conditions of sale of semiconductor products. Testing and other quality control techniques are used to the extent TI deems necessary to support this warranty. Except where mandated by applicable law, testing of all parameters of each component is not necessarily performed.

TI assumes no liability for applications assistance or the design of Buyers' products. Buyers are responsible for their products and applications using TI components. To minimize the risks associated with Buyers' products and applications, Buyers should provide adequate design and operating safeguards.

TI does not warrant or represent that any license, either express or implied, is granted under any patent right, copyright, mask work right, or other intellectual property right relating to any combination, machine, or process in which TI components or services are used. Information published by TI regarding third-party products or services does not constitute a license to use such products or services or a warranty or endorsement thereof. Use of such information may require a license from a third party under the patents or other intellectual property of the third party, or a license from TI under the patents or other intellectual property of TI.

Reproduction of significant portions of TI information in TI data books or data sheets is permissible only if reproduction is without alteration and is accompanied by all associated warranties, conditions, limitations, and notices. TI is not responsible or liable for such altered documentation. Information of third parties may be subject to additional restrictions.

Resale of TI components or services with statements different from or beyond the parameters stated by TI for that component or service voids all express and any implied warranties for the associated TI component or service and is an unfair and deceptive business practice. TI is not responsible or liable for any such statements.

Buyer acknowledges and agrees that it is solely responsible for compliance with all legal, regulatory and safety-related requirements concerning its products, and any use of TI components in its applications, notwithstanding any applications-related information or support that may be provided by TI. Buyer represents and agrees that it has all the necessary expertise to create and implement safeguards which anticipate dangerous consequences of failures, monitor failures and their consequences, lessen the likelihood of failures that might cause harm and take appropriate remedial actions. Buyer will fully indemnify TI and its representatives against any damages arising out of the use of any TI components in safety-critical applications.

In some cases, TI components may be promoted specifically to facilitate safety-related applications. With such components, TI's goal is to help enable customers to design and create their own end-product solutions that meet applicable functional safety standards and requirements. Nonetheless, such components are subject to these terms.

No TI components are authorized for use in FDA Class III (or similar life-critical medical equipment) unless authorized officers of the parties have executed a special agreement specifically governing such use.

Only those TI components which TI has specifically designated as military grade or "enhanced plastic" are designed and intended for use in military/aerospace applications or environments. Buyer acknowledges and agrees that any military or aerospace use of TI components which have **not** been so designated is solely at the Buyer's risk, and that Buyer is solely responsible for compliance with all legal and regulatory requirements in connection with such use.

TI has specifically designated certain components as meeting ISO/TS16949 requirements, mainly for automotive use. In any case of use of non-designated products, TI will not be responsible for any failure to meet ISO/TS16949.

### Products

|                              |  |
|------------------------------|--|
| Audio                        | <a href="http://www.ti.com/audio">www.ti.com/audio</a>                               |
| Amplifiers                   | <a href="http://amplifier.ti.com">amplifier.ti.com</a>                               |
| Data Converters              | <a href="http://dataconverter.ti.com">dataconverter.ti.com</a>                       |
| DLP® Products                | <a href="http://www.dlp.com">www.dlp.com</a>   |
| DSP                          | <a href="http://dsp.ti.com">dsp.ti.com</a>   |
| Clocks and Timers            | <a href="http://www.ti.com/clocks">www.ti.com/clocks</a>                             |
| Interface                    | <a href="http://interface.ti.com">interface.ti.com</a>                               |
| Logic                        | <a href="http://logic.ti.com">logic.ti.com</a>                                       |
| Power Mgmt                   | <a href="http://power.ti.com">power.ti.com</a>                                       |
| Microcontrollers             | <a href="http://microcontroller.ti.com">microcontroller.ti.com</a>                   |
| RFID                         | <a href="http://www.ti-rfid.com">www.ti-rfid.com</a>                                 |
| OMAP Applications Processors | <a href="http://www.ti.com/omap">www.ti.com/omap</a>                                 |
| Wireless Connectivity        | <a href="http://www.ti.com/wirelessconnectivity">www.ti.com/wirelessconnectivity</a> |

### Applications

|                               |  |
|-------------------------------|--|
| Automotive and Transportation | <a href="http://www.ti.com/automotive">www.ti.com/automotive</a>                         |
| Communications and Telecom    | <a href="http://www.ti.com/communications">www.ti.com/communications</a>                 |
| Computers and Peripherals     | <a href="http://www.ti.com/computers">www.ti.com/computers</a>                           |
| Consumer Electronics          | <a href="http://www.ti.com/consumer-apps">www.ti.com/consumer-apps</a>                   |
| Energy and Lighting           | <a href="http://www.ti.com/energy">www.ti.com/energy</a>                                 |
| Industrial                    | <a href="http://www.ti.com/industrial">www.ti.com/industrial</a>                         |
| Medical                       | <a href="http://www.ti.com/medical">www.ti.com/medical</a>                               |
| Security                      | <a href="http://www.ti.com/security">www.ti.com/security</a>                             |
| Space, Avionics and Defense   | <a href="http://www.ti.com/space-avionics-defense">www.ti.com/space-avionics-defense</a> |
| Video and Imaging             | <a href="http://www.ti.com/video">www.ti.com/video</a>                                   |

### TI E2E Community

[e2e.ti.com](http://e2e.ti.com)