

## General Description

The SP3222EB and SP3232EB series are RS-232 transceiver solutions intended for portable or hand-held applications such as notebook or laptop computers. The SP3222EB / SP3232EB series has a high-efficiency, charge-pump power supply that requires only 0.1 $\mu$ F capacitors in 3.3V operation. This charge pump allows the SP3222EB / SP3232EB series to deliver true RS-232 performance from a single power supply ranging from 3.0V to 5.5V. The SP3222EB / SP3232EB are 2-driver / 2-receiver devices. The ESD tolerance of the SP3222EB / SP3232E devices is over  $\pm 15$ kV for both Human Body Model and IEC61000-4-2 Air discharge test methods. The SP3222EB device has a low-power shutdown mode where the devices' driver outputs and charge pumps are disabled. During shutdown, the supply current falls to less than 1 $\mu$ A.

## Features

- Meets true EIA / TIA-232-F standards from a 3.0V to 5.5V power supply
- 250kbps transmission rate under load
- 1 $\mu$ A low power shutdown with receivers active (SP3222EB)
- Interoperable with RS-232 down to a 2.7V power source
- Enhanced ESD specifications:
  - $\pm 15$ kV Human Body Model
  - $\pm 15$ kV IEC61000-4-2 Air Discharge
  - $\pm 8$ kV IEC61000-4-2 Contact Discharge

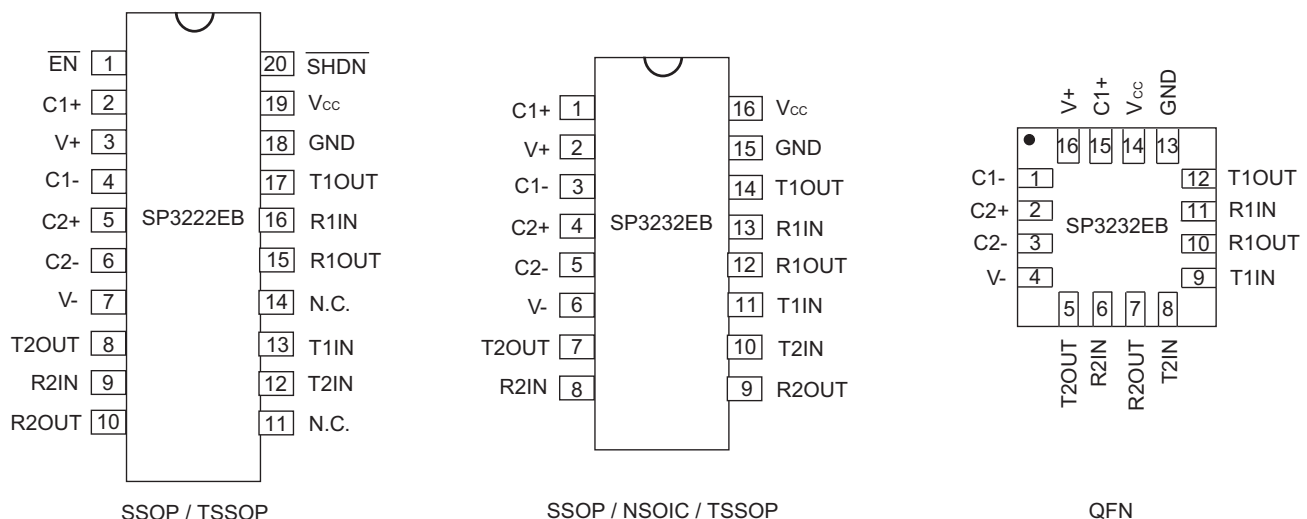
Ordering Information - [page 18](#)

## Selection Table

**Table 1: Selection Table**

| Device   | Power Supplies | RS-232 Drivers | RS-232 Receivers | External Components | Shutdown | TTL 3-State | # of Pins |
|----------|----------------|----------------|------------------|---------------------|----------|-------------|-----------|
| SP3222EB | 3.0V to 5.5V   | 2              | 2                | 4 Capacitors        | Yes      | Yes         | 20        |
| SP3232EB | 3.0V to 5.5V   | 2              | 2                | 4 Capacitors        | No       | No          | 16        |

## Pinouts



**Figure 1: SP3222EB and SP3232EB Pinouts**

## Revision History

| Revision | Release Date | Change Description                                                                                                                                                            |
|----------|--------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| --       | 11/2/05      | Legacy Sipex Datasheet                                                                                                                                                        |
| 1.0.0    | 9/9/09       | Convert to Exar Format. Update ordering information and change revision to 1.0.0.                                                                                             |
| 1.0.1    | 6/7/11       | Remove obsolete devices per PDN 110510-01 and change ESD rating to IEC-61000-4-2..                                                                                            |
| 1.0.2    | 3/14/13      | Correct ype error to RX input voltage range and TX transition region slew rate condition.                                                                                     |
| 1.0.3    | 8/14/14      | Add Max Junction temperature and package thermal information.                                                                                                                 |
| 1.0.4    | 5/28/15      | Update Absolute Max Rating for RxIN input voltage to $\pm 25V$ , update logo.                                                                                                 |
| 1.0.5    | 10/27/15     | Add SP3232EBER (QFN 16) preliminary package option.                                                                                                                           |
| 1.0.6    | 2/23/16      | Remove preliminary status of QFN 16 package option.                                                                                                                           |
| 1.0.7    | 1/24/20      | Update to MaxLinear template and logo. Update Ordering Information. Remove obsolete WSOIC references. Move ESD tolerance levels to new ESD Ratings section located on page 1. |

# Table of Contents

|                                                  |           |
|--------------------------------------------------|-----------|
| <b>General Description</b> .....                 | <b>i</b>  |
| <b>Features</b> .....                            | <b>i</b>  |
| <b>Selection Table</b> .....                     | <b>i</b>  |
| <b>Pinouts</b> .....                             | <b>i</b>  |
| <b>Specifications</b> .....                      | <b>1</b>  |
| Absolute Maximum Ratings.....                    | 1         |
| ESD Ratings .....                                | 1         |
| Operating Conditions.....                        | 2         |
| Electrical Characteristics .....                 | 2         |
| <b>Typical Performance Characteristics</b> ..... | <b>4</b>  |
| <b>Pin Information</b> .....                     | <b>5</b>  |
| Pin Configurations .....                         | 5         |
| Pin Descriptions .....                           | 5         |
| <b>Typical Operating Circuits</b> .....          | <b>6</b>  |
| <b>Description</b> .....                         | <b>7</b>  |
| Theory of Operation .....                        | 7         |
| Drivers .....                                    | 7         |
| Receivers .....                                  | 8         |
| Charge Pump .....                                | 8         |
| ESD Tolerance .....                              | 10        |
| <b>Mechanical Dimensions</b> .....               | <b>12</b> |
| SSOP20 .....                                     | 12        |
| SSOP16 .....                                     | 13        |
| TSSOP16 .....                                    | 15        |
| TSSOP20 .....                                    | 16        |
| QFN16 5x5 .....                                  | 17        |
| <b>Ordering Information</b> .....                | <b>18</b> |

## List of Figures

|                                                                            |    |
|----------------------------------------------------------------------------|----|
| Figure 1: SP3222EB and SP3232EB Pinouts .....                              | i  |
| Figure 2: Transmitter Output Voltage vs. Load Capacitance.....             | 4  |
| Figure 3: Slew Rate vs. Load Capacitance.....                              | 4  |
| Figure 4: Supply Current vs. Load Capacitance When Transmitting Data ..... | 4  |
| Figure 5: Supply Current vs. Supply Voltage.....                           | 4  |
| Figure 6: Transmitter Output Voltage vs. Supply Voltage.....               | 4  |
| Figure 7: Pinout Configurations for the SP3222EB and SP3232EB.....         | 5  |
| Figure 8: SP3222EB Typical Operating Circuit.....                          | 6  |
| Figure 9: SP3232EB Typical Operating Circuit.....                          | 6  |
| Figure 10: SP3222EB / SP3232EB Driver Loopback Test Circuit.....           | 7  |
| Figure 11: Loopback Test Results at 120kbps .....                          | 7  |
| Figure 12: Loopback Test Results at 250kbps .....                          | 8  |
| Figure 13: Charge Pump — Phase 1.....                                      | 9  |
| Figure 14: Charge Pump — Phase 2.....                                      | 9  |
| Figure 15: Charge Pump Waveforms .....                                     | 9  |
| Figure 16: Charge Pump — Phase 3.....                                      | 9  |
| Figure 17: Charge Pump — Phase 4.....                                      | 9  |
| Figure 18: ESD Test Circuit for Human Body Model .....                     | 10 |
| Figure 19: ESD Test Circuit for IEC61000-4-2 .....                         | 10 |
| Figure 20: ESD Test Waveform for IEC61000-4-2 .....                        | 11 |
| Figure 21: Mechanical Dimensions, SSOP20.....                              | 12 |
| Figure 22: Mechanical Dimensions, SSOP16.....                              | 13 |
| Figure 23: Mechanical Dimensions, NSOIC16 .....                            | 14 |
| Figure 24: Mechanical Dimensions, TSSOP16 .....                            | 15 |
| Figure 25: Mechanical Dimensions, TSSOP20 .....                            | 16 |
| Figure 26: Mechanical Dimensions, QFN16 5x5 .....                          | 17 |

## List of Tables

|                                                                           |    |
|---------------------------------------------------------------------------|----|
| Table 1: Selection Table .....                                            | i  |
| Table 1: Absolute Maximum Ratings .....                                   | 1  |
| Table 2: ESD Ratings .....                                                | 1  |
| Table 3: Operating Conditions .....                                       | 2  |
| Table 4: Electrical Characteristics .....                                 | 2  |
| Table 5: Pin Descriptions.....                                            | 5  |
| Table 6: SP3222EB Truth Table Logic for Shutdown and Enable Control ..... | 8  |
| Table 7: Ordering Information.....                                        | 18 |

# Specifications

## Absolute Maximum Ratings

**Important:** These are stress ratings only and functional operation of the device at these ratings or any other above those indicated in the operation sections of the specifications below is not implied. Exposure to absolute maximum rating conditions for extended periods of time may affect reliability and cause permanent damage to the device.

**Table 1: Absolute Maximum Ratings**

| Parameter                             | Minimum    | Maximum        | Units |
|---------------------------------------|------------|----------------|-------|
| $V_{CC}$                              | -0.3       | 6.0            | V     |
| $V_{+}^{(1)}$                         | -0.3       | 7.0            | V     |
| $V_{-}^{(1)}$                         | -7.0       | 0.3            | V     |
| $V_{+} +  V_{-} ^{(1)}$               |            | 13             | V     |
| $I_{CC}$ (DC $V_{CC}$ or GND current) | -100       | 100            | mA    |
| Input Voltages                        |            |                |       |
| TxIN, $\overline{EN}$                 | -0.3       | 6.0            | V     |
| RxIN                                  | -25        | 25             | V     |
| Output Voltages                       |            |                |       |
| TxOUT                                 | -13.2      | 13.2           | V     |
| RxOUT                                 | -0.3       | $V_{CC} + 0.3$ | V     |
| Short-Circuit Duration                |            |                |       |
| TxOUT                                 | Continuous |                |       |
| Temperature                           |            |                |       |
| Storage temperature                   | -65        | 150            | °C    |

1.  $V_{+}$  and  $V_{-}$  can have maximum magnitudes of 7V, but their absolute difference cannot exceed 13V.

2. Driver input hysteresis is typically 250mV.

## ESD Ratings

**Table 2: ESD Ratings**

| Parameter                                                          |         | Value | Units |
|--------------------------------------------------------------------|---------|-------|-------|
| HBM (Human Body Model), driver outputs and receiver inputs         |         | ±15   | kV    |
| IEC61000-4-2 Air Discharge, driver outputs and receiver inputs     | Level 4 | ±15   | kV    |
| IEC61000-4-2 Contact Discharge, driver outputs and receiver inputs | Level 4 | ±8    | kV    |

## Operating Conditions

**Table 3: Operating Conditions**

| Parameter                                   | Value | Units |
|---------------------------------------------|-------|-------|
| Temperature                                 |       |       |
| Maximum junction temperature                | 125   | °C    |
| Power Dissipation Per Package               |       |       |
| 20-pin SSOP (derate 9.25mW/°C above 70°C)   | 750   | mW    |
| 20-pin TSSOP (derate 11.1mW/°C above 70°C)  | 890   | mW    |
| 16-pin SSOP (derate 9.69mW/°C above 70°C)   | 775   | mW    |
| 16-pin TSSOP (derate 10.5mW/°C above 70°C)  | 850   | mW    |
| 16-pin NSOIC (derate 13.57mW/°C above 70°C) | 1086  | mW    |
| Thermal Resistance                          |       |       |
| 16-pin TSSOP $\Theta_{JA}$                  | 100.4 | °C/W  |
| 16-pin TSSOP $\Theta_{JC}$                  | 19.0  | °C/W  |
| 16-pin QFN $\Theta_{JA}$                    | 44.0  | °C/W  |
| 16-pin QFN $\Theta_{JC}$                    | 7.3   | °C/W  |

## Electrical Characteristics

Unless otherwise noted, the following specifications apply for  $V_{CC} = 3.0V$  to  $5.5V$  with  $T_{AMB} = T_{MIN}$  to  $T_{MAX}$ ,  
 $C1 - C4 = 0.1\mu F$ .

**Table 4: Electrical Characteristics**

| Parameter                         | Test Condition                                                                                        | Minimum        | Typical        | Maximum   | Units   |
|-----------------------------------|-------------------------------------------------------------------------------------------------------|----------------|----------------|-----------|---------|
| DC Characteristics                |                                                                                                       |                |                |           |         |
| Supply current                    | No load, $V_{CC} = 3.3V$ , $T_{AMB} = 25^{\circ}C$ ,<br>$T_{XIN} = GND$ or $V_{CC}$                   |                | 0.3            | 1.0       | mA      |
| Shutdown supply current           | $\overline{SHDN} = GND$ , $V_{CC} = 3.3V$ , $T_{AMB} = 25^{\circ}C$ ,<br>$T_{XIN} = V_{CC}$ or $GND$  |                | 1.0            | 10        | $\mu A$ |
| Logic Inputs and Receiver Outputs |                                                                                                       |                |                |           |         |
| Input logic threshold LOW         | $T_{XIN}$ , $\overline{EN}$ , $\overline{SHDN}^{(1)}$                                                 | GND            |                | 0.8       | V       |
| Input logic threshold HIGH        | $V_{CC} = 3.3V^{(1)}$                                                                                 | 2.0            |                | $V_{CC}$  | V       |
| Input logic threshold HIGH        | $V_{CC} = 5.0V^{(1)}$                                                                                 | 2.4            |                | $V_{CC}$  | V       |
| Input leakage current             | $T_{XIN}$ , $\overline{EN}$ , $\overline{SHDN}$ , $T_{AMB} = 25^{\circ}C$ , $V_{IN} = 0V$ to $V_{CC}$ |                | $\pm 0.01$     | $\pm 1.0$ | $\mu A$ |
| Output leakage current            | Receivers disabled, $V_{OUT} = 0V$ to $V_{CC}$                                                        |                | $\pm 0.05$     | $\pm 10$  | $\mu A$ |
| Output voltage LOW                | $I_{OUT} = 1.6mA$                                                                                     |                |                | 0.4       | V       |
| Output voltage HIGH               | $I_{OUT} = -1.0mA$                                                                                    | $V_{CC} - 0.6$ | $V_{CC} - 0.1$ |           | V       |
| Driver Outputs                    |                                                                                                       |                |                |           |         |

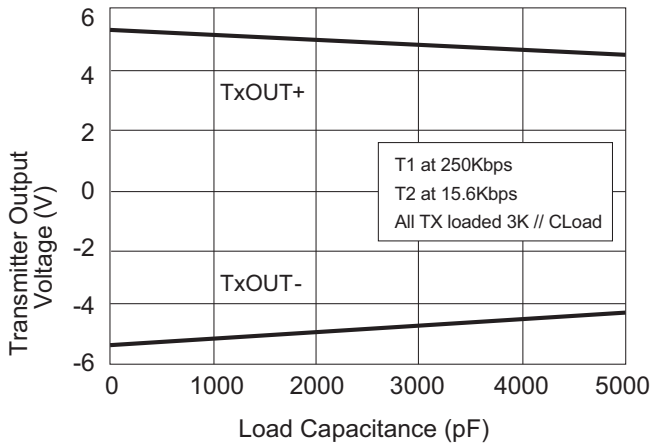
**Table 4: (Continued) Electrical Characteristics**

| Parameter                                    | Test Condition                                                                                                                                                    | Minimum | Typical | Maximum | Units      |
|----------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------|---------|---------|------------|
| Output voltage swing                         | All driver outputs loaded with 3k $\Omega$ to GND, T <sub>AMB</sub> = 25°C                                                                                        | ±5.0    | ±5.4    |         | V          |
| Output resistance                            | V <sub>CC</sub> = V+ = V- = 0V, to V <sub>OUT</sub> = ±2V                                                                                                         | 300     |         |         | $\Omega$   |
| Output Short-circuit current                 | V <sub>OUT</sub> = 0V                                                                                                                                             |         | ±35     | ±60     | mA         |
| Output leakage current                       | V <sub>CC</sub> = 0V or 3.0V to 5.5V, V <sub>OUT</sub> = ±12V, drivers disabled                                                                                   |         |         | ±25     | $\mu$ A    |
| <b>Receiver Inputs</b>                       |                                                                                                                                                                   |         |         |         |            |
| Input voltage range                          |                                                                                                                                                                   | -15     |         | 15      | V          |
| Input threshold LOW                          | V <sub>CC</sub> = 3.3V                                                                                                                                            | 0.6     | 1.2     |         | V          |
| Input threshold LOW                          | V <sub>CC</sub> = 5.0V                                                                                                                                            | 0.8     | 1.5     |         | V          |
| Input threshold HIGH                         | V <sub>CC</sub> = 3.3V                                                                                                                                            |         | 1.5     | 2.4     | V          |
| Input threshold HIGH                         | V <sub>CC</sub> = 5.0V                                                                                                                                            |         | 1.8     | 2.4     | V          |
| Input hysteresis                             |                                                                                                                                                                   |         | 0.3     |         | V          |
| Input resistance                             |                                                                                                                                                                   | 3       | 5       | 7       | k $\Omega$ |
| <b>Timing Characteristics</b>                |                                                                                                                                                                   |         |         |         |            |
| Maximum data rate                            | R <sub>L</sub> = 3k $\Omega$ , C <sub>L</sub> = 1000pF, one driver active                                                                                         | 250     |         |         | kbps       |
| Receiver propagation delay, t <sub>PHL</sub> | Receiver input to receiver output, C <sub>L</sub> = 150pF                                                                                                         |         | 0.15    |         | $\mu$ s    |
| Receiver propagation delay, t <sub>PLH</sub> | Receiver input to receiver output, C <sub>L</sub> = 150pF                                                                                                         |         | 0.15    |         | $\mu$ s    |
| Receiver output enable time                  |                                                                                                                                                                   |         | 200     |         | ns         |
| Receiver output disable time                 |                                                                                                                                                                   |         | 200     |         | ns         |
| Driver skew                                  | t <sub>PHL</sub> - t <sub>PLH</sub>  , T <sub>AMB</sub> = 25°C                                                                                                    |         | 100     |         | ns         |
| Receiver skew                                | t <sub>PHL</sub> - t <sub>PLH</sub>                                                                                                                               |         | 50      |         | ns         |
| Transition-region slew rate                  | V <sub>CC</sub> = 3.3V, R <sub>L</sub> = 3k $\Omega$ , C <sub>L</sub> = 1000pF, T <sub>AMB</sub> = 25°C, measurements taken from -3.0V to +3.0V or +3.0V to -3.0V |         |         | 30      | V/ $\mu$ s |

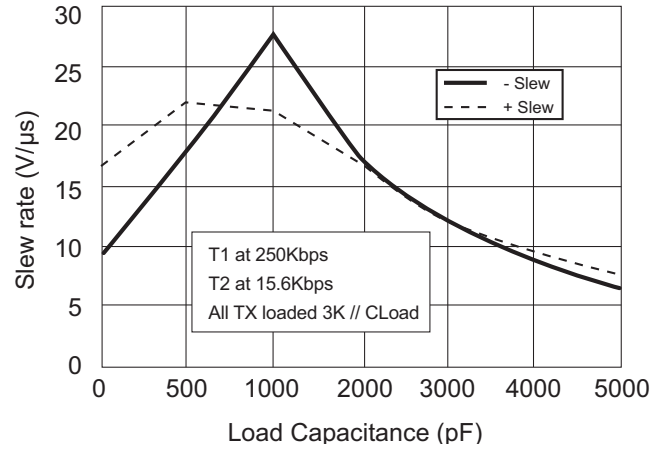
1. Driver input hysteresis is typically 250mV.



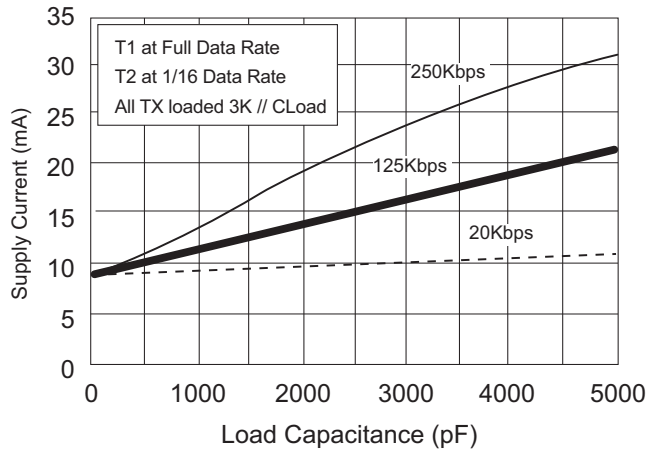
# Typical Performance Characteristics



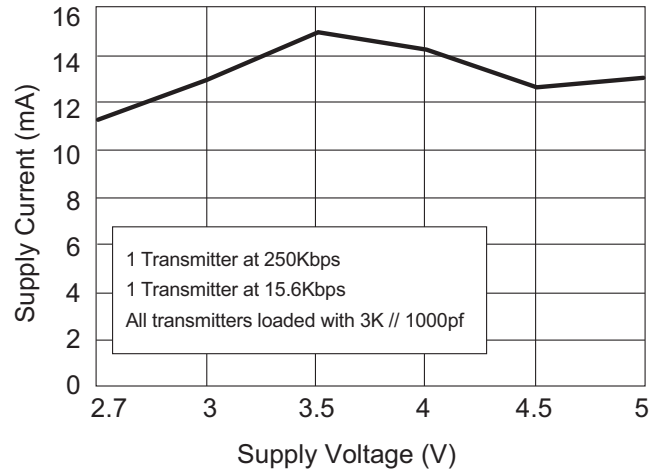
**Figure 2: Transmitter Output Voltage vs. Load Capacitance**



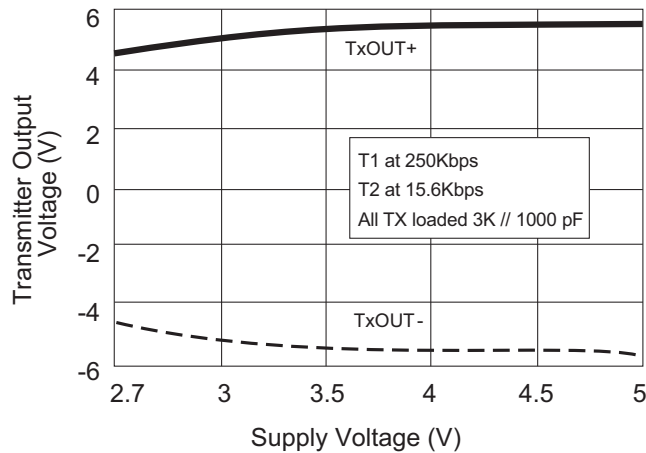
**Figure 3: Slew Rate vs. Load Capacitance**



**Figure 4: Supply Current vs. Load Capacitance When Transmitting Data**



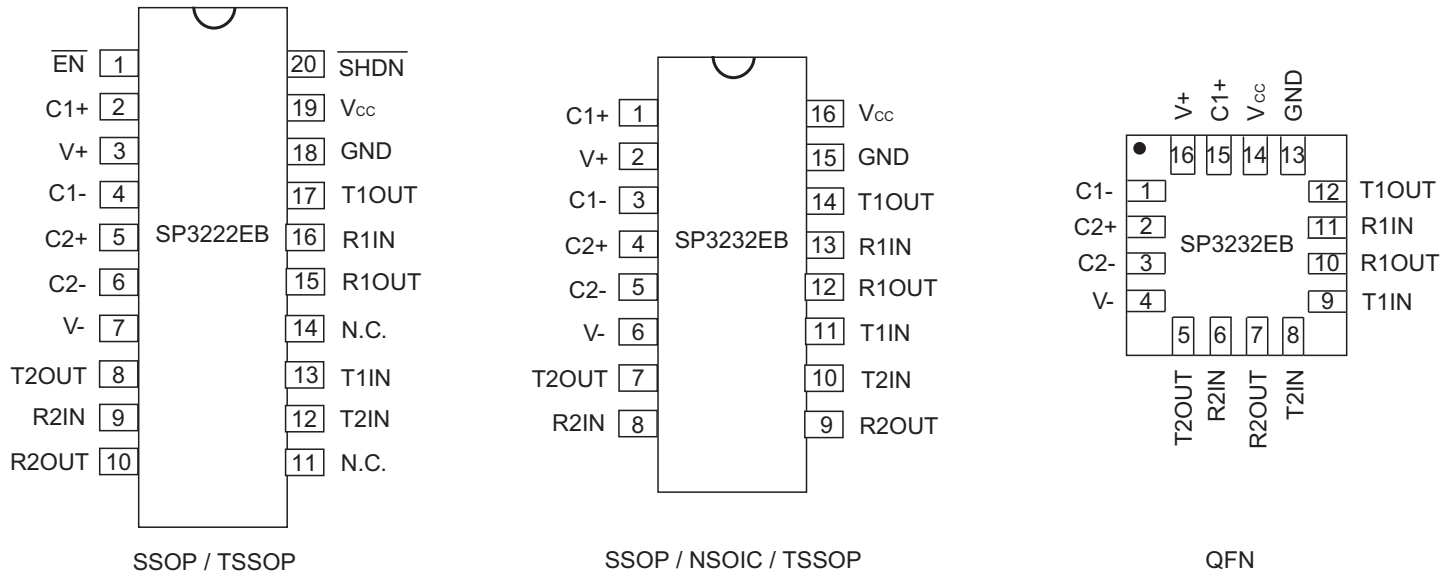
**Figure 5: Supply Current vs. Supply Voltage**



**Figure 6: Transmitter Output Voltage vs. Supply Voltage**

## Pin Information

### Pin Configurations



**Figure 7: Pinout Configurations for the SP3222EB and SP3232EB**

### Pin Descriptions

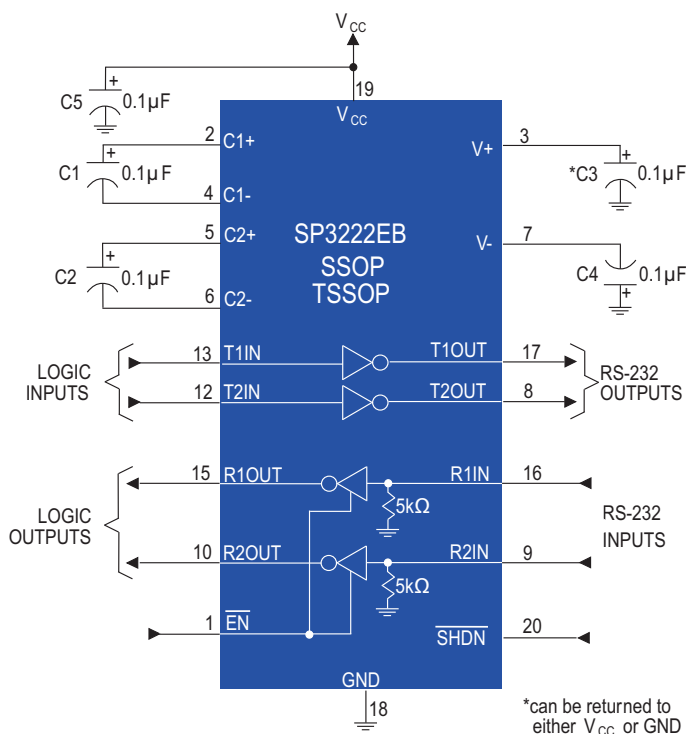
**Table 5: Pin Descriptions**

| Pin Name           | Function / Description                                                                                                  | Pin Number    |                        |     |
|--------------------|-------------------------------------------------------------------------------------------------------------------------|---------------|------------------------|-----|
|                    |                                                                                                                         | SP3222EB      | SP3232EB               |     |
|                    |                                                                                                                         | SSOP<br>TSSOP | SSOP<br>TSSOP<br>NSOIC | QFN |
| EN                 | Receiver enable. Apply logic LOW for normal operation. Apply logic HIGH to disable the receiver outputs (high-Z state). | 1             | -                      | -   |
| C1+                | Positive terminal of the voltage doubler charge-pump capacitor.                                                         | 2             | 1                      | 15  |
| V+                 | 5.5V output generated by the charge pump.                                                                               | 3             | 2                      | 16  |
| C1-                | Negative terminal of the voltage doubler charge-pump capacitor.                                                         | 4             | 3                      | 1   |
| C2+                | Positive terminal of the inverting charge-pump capacitor.                                                               | 5             | 4                      | 2   |
| C2-                | Negative terminal of the inverting charge-pump capacitor.                                                               | 6             | 5                      | 3   |
| V-                 | -5.5V output generated by the charge pump.                                                                              | 7             | 6                      | 4   |
| T <sub>1</sub> OUT | RS-232 driver output.                                                                                                   | 17            | 14                     | 12  |
| T <sub>2</sub> OUT | RS-232 driver output.                                                                                                   | 8             | 7                      | 5   |
| R <sub>1</sub> IN  | RS-232 receiver input.                                                                                                  | 16            | 13                     | 11  |
| R <sub>2</sub> IN  | RS-232 receiver input.                                                                                                  | 9             | 8                      | 6   |
| R <sub>1</sub> OUT | TTL / CMOS receiver output.                                                                                             | 15            | 12                     | 10  |

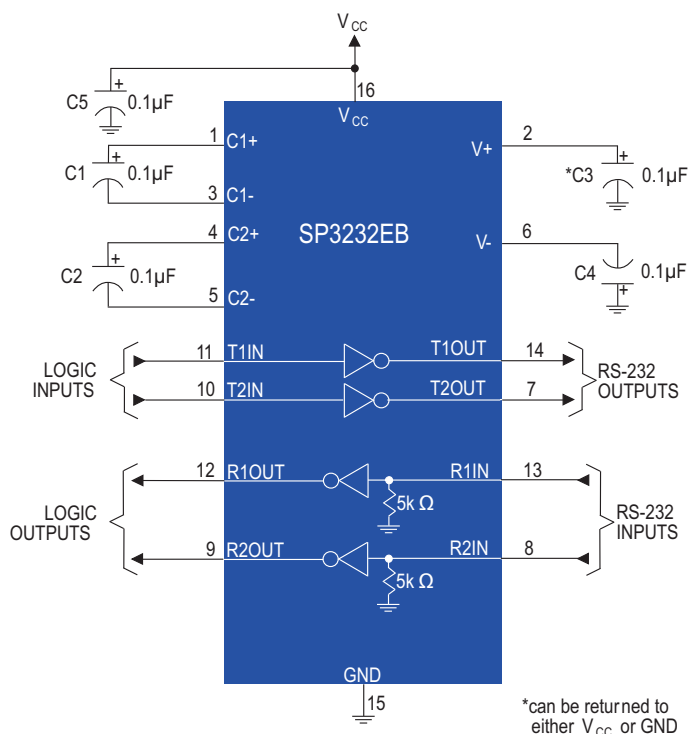
**Table 5: Pin Descriptions**

| Pin Name                 | Function / Description                                                                                                                              | Pin Number    |                        |     |
|--------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------|---------------|------------------------|-----|
|                          |                                                                                                                                                     | SP3222EB      | SP3232EB               |     |
|                          |                                                                                                                                                     | SSOP<br>TSSOP | SSOP<br>TSSOP<br>NSOIC | QFN |
| R <sub>2</sub> OUT       | TTL / CMOS receiver output.                                                                                                                         | 10            | 9                      | 7   |
| T <sub>1</sub> IN        | TTL / CMOS driver input.                                                                                                                            | 13            | 11                     | 9   |
| T <sub>2</sub> IN        | TTL / CMOS driver input.                                                                                                                            | 12            | 10                     | 8   |
| GND                      | Ground.                                                                                                                                             | 18            | 15                     | 13  |
| V <sub>CC</sub>          | 3.0V to 5.5V supply voltage.                                                                                                                        | 19            | 16                     | 14  |
| $\overline{\text{SHDN}}$ | Shutdown control Input. Drive HIGH for normal device operation.<br>Drive LOW to shutdown the drivers (high-Z output) and the on-board power supply. | 20            | -                      | -   |
| N. C.                    | No connect.                                                                                                                                         | 11, 14        | -                      | -   |

## Typical Operating Circuits



**Figure 8: SP3222EB Typical Operating Circuit**



**Figure 9: SP3232EB Typical Operating Circuit**

## Description

The SP3222EB / SP3232EB transceivers meet the EIA / TIA-232 and ITU-T V.28/V.24 communication protocols and can be implemented in battery-powered, portable, or hand-held applications such as notebook or palmtop computers. The SP3222EB / SP3232EB devices feature MaxLinear’s proprietary on-board charge pump circuitry that generates  $\pm 5.5V$  for RS-232 voltage levels from a single 3.0V to 5.5V power supply. This series is ideal for 3.3V-only systems, mixed 3.3V to 5.5V systems, or 5.0V-only systems that require true RS-232 performance. The SP3222EB / SP3232EB devices can operate at a data rate of 250kbps when fully loaded.

The SP3222EB and SP3232EB are 2-driver / 2-receiver devices ideal for portable or hand-held applications. The SP3222EB features a 1 $\mu A$  shutdown mode that reduces power consumption and extends battery life in portable systems. Its receivers remain active in shutdown mode, allowing external devices such as modems to be monitored using only 1 $\mu A$  supply current.

## Theory of Operation

The SP3222EB/SP3232EB series is made up of three basic circuit blocks:

1. Drivers
2. Receivers
3. The MaxLinear proprietary charge pump

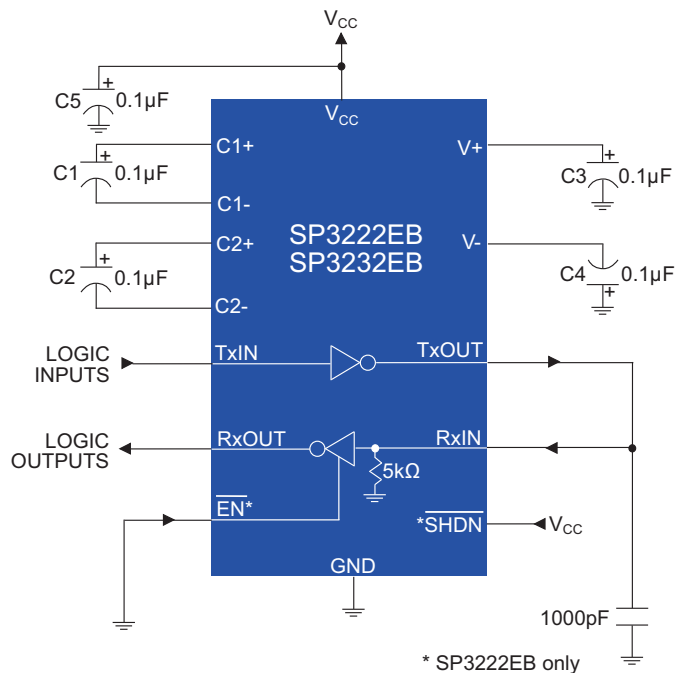
## Drivers

The drivers are inverting level transmitters that convert TTL or CMOS logic levels to 5.0V EIA / TIA-232 levels with an inverted sense relative to the input logic levels. Typically, the RS-232 output voltage swing is  $\pm 5.4V$  with no load and  $\pm 5V$  minimum fully loaded. The driver outputs are protected against infinite short-circuits to ground without degradation in reliability. Driver outputs will meet EIA / TIA-562 levels of  $\pm 3.7V$  with supply voltages as low as 2.7V.

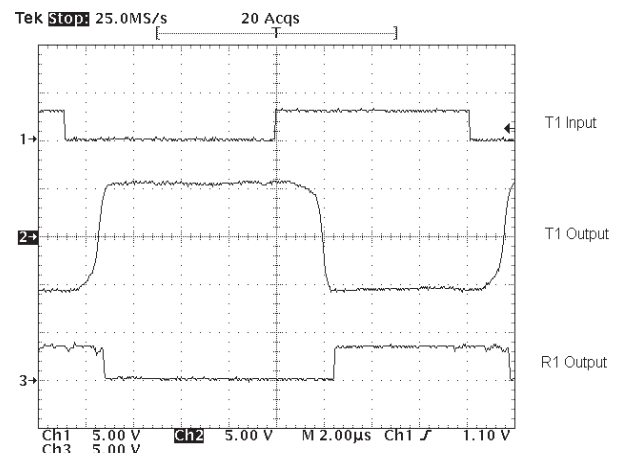
The drivers can guarantee a data rate of 250kbps fully loaded with 3k $\Omega$  in parallel with 1000pF, ensuring compatibility with PC-to-PC communication software.

The slew rate of the driver is internally limited to a maximum of 30V/ $\mu s$  in order to meet the EIA standards (EIA RS-232D 2.1.7, Paragraph 5). The transition of the loaded output from HIGH to LOW also meet the monotonicity requirements of the standard.

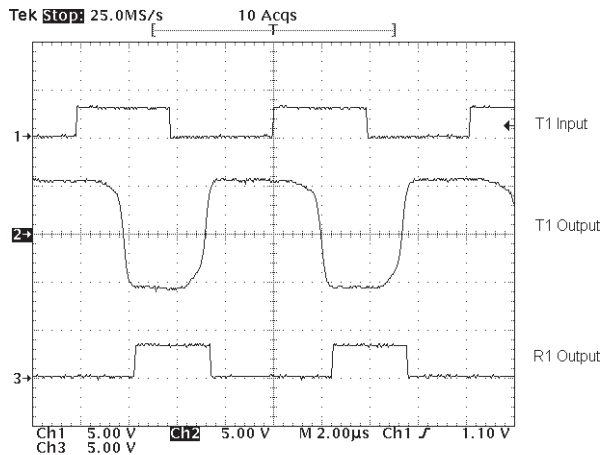
Figure 10 shows a loopback test circuit used to test the RS-232 Drivers. Figure 11 shows the test results of the loopback circuit with all drivers active at 120kbps with RS-232 loads in parallel with a 1000pF capacitor. Figure 12 shows the test results where one driver was active at 250kbps and all drivers loaded with an RS-232 receiver in parallel with 1000pF capacitors. A solid RS-232 data transmission rate of 250kbps provides compatibility with many designs in personal computer peripherals and LAN applications.



**Figure 10: SP3222EB / SP3232EB Driver Loopback Test Circuit**



**Figure 11: Loopback Test Results at 120kbps**



**Figure 12: Loopback Test Results at 250kbps**

The SP3222EB driver's output stages are turned off (tri-state) when the device is in shutdown mode. When the power is off, the SP3222EB device permits the outputs to be driven up to  $\pm 12V$ . The driver's inputs do not have pull-up resistors. Designers should connect unused inputs to  $V_{CC}$  or GND.

In the shutdown mode, the supply current falls to less than  $1\mu A$ , where  $\overline{SHDN} = \text{LOW}$ . When the SP3222EB device is shut down, the device's driver outputs are disabled (tri-stated) and the charge pumps are turned off with  $V+$  pulled down to  $V_{CC}$  and  $V-$  pulled to GND. The time required to exit shutdown is typically  $100\mu s$ . Connect  $\overline{SHDN}$  to  $V_{CC}$  if the shutdown mode is not used.

## Receivers

The receivers convert EIA / TIA-232 levels to TTL or CMOS logic output levels. The SP3222EB receivers have an inverting tri-state output. These receiver outputs (RxOUT) are tri-stated when the enable control  $\overline{EN} = \text{HIGH}$ . In the shutdown mode, the receivers can be active or inactive.  $\overline{EN}$  has no effect on TxOUT. The truth table logic of the SP3222EB driver and receiver outputs can be found in Table 6.

**Table 6: SP3222EB Truth Table Logic for Shutdown and Enable Control**

| $\overline{SHDN}$ | $\overline{EN}$ | TxOUT     | RxOUT     |
|-------------------|-----------------|-----------|-----------|
| 0                 | 0               | Tri-state | Active    |
| 0                 | 1               | Tri-state | Tri-state |
| 1                 | 0               | Active    | Active    |
| 1                 | 1               | Active    | Tri-state |

Since receiver input is usually from a transmission line where long cable lengths and system interference can degrade the signal, the inputs have a typical hysteresis margin of 300mV. This ensures that the receiver is virtually immune to noisy transmission lines. Should an input be left unconnected, an internal  $5k\Omega$  pulldown resistor to ground will commit the output of the receiver to a HIGH state.

## Charge Pump

The charge pump is an MaxLinear-patented design (U.S. 5,306,954) and uses a unique approach compared to older less-efficient designs. The charge pump still requires four external capacitors, but uses a four-phase voltage shifting technique to attain symmetrical 5.5V power supplies. The internal power supply consists of a regulated dual charge pump that provides output voltages of  $\pm 5.5V$  regardless of the input voltage ( $V_{CC}$ ) over the 3.0V to 5.5V range.

In most circumstances, decoupling the power supply can be achieved adequately using a  $0.1\mu F$  bypass capacitor at C5 (refer to Figure 8 and Figure 9).

In applications that are sensitive to power-supply noise, decouple  $V_{CC}$  to ground with a capacitor of the same value as charge-pump capacitor C1. Physically connect bypass capacitors as close to the IC as possible.

The charge pump operates in a discontinuous mode using an internal oscillator. If the output voltages are less than a magnitude of 5.5V, the charge pump is enabled. If the output voltages exceed a magnitude of 5.5V, the charge pump is disabled. This oscillator controls the four phases of the voltage shifting. A description of each phase follows.

### Phase 1: $V_{SS}$ charge storage

During this phase of the clock cycle, the positive side of capacitors  $C_1$  and  $C_2$  are initially charged to  $V_{CC}$ .  $C_1^+$  is then switched to GND and the charge in  $C_1^-$  is transferred to  $C_2^-$ . Since  $C_2^+$  is connected to  $V_{CC}$ , the voltage potential across capacitor  $C_2$  is now 2 times  $V_{CC}$ .

### Phase 2: $V_{SS}$ transfer

Phase two of the clock connects the negative terminal of  $C_2$  to the  $V_{SS}$  storage capacitor and the positive terminal of  $C_2$  to GND. This transfers a negative generated voltage to  $C_3$ . This generated voltage is regulated to a minimum voltage of  $-5.5V$ . Simultaneous with the transfer of the voltage to  $C_3$ , the positive side of capacitor  $C_1$  is switched to  $V_{CC}$  and the negative side is connected to GND.

**Phase 3:  $V_{DD}$  charge storage**

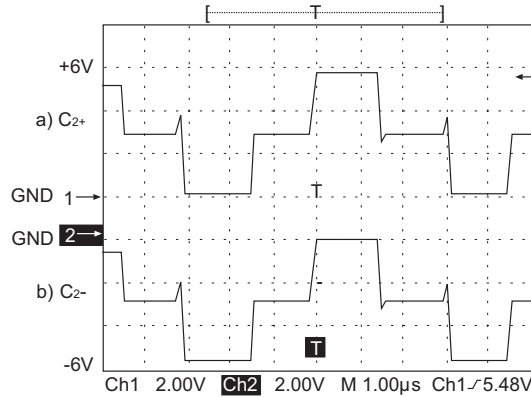
The third phase of the clock is identical to the first phase; the charge transferred in  $C_1$  produces  $-V_{CC}$  in the negative terminal of  $C_1$ , which is applied to the negative side of capacitor  $C_2$ . Since  $C_2^+$  is at  $V_{CC}$ , the voltage potential across  $C_2$  is 2 times  $V_{CC}$ .

**Phase 4:  $V_{DD}$  transfer**

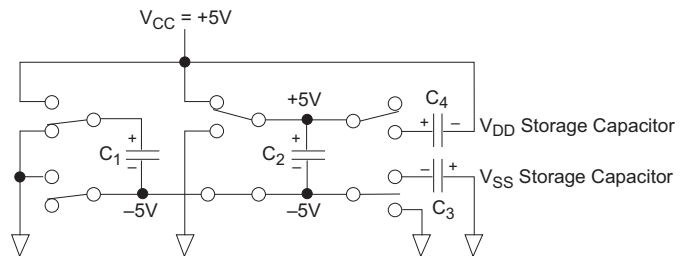
The fourth phase of the clock connects the negative terminal of  $C_2$  to GND, and transfers this positive generated voltage across  $C_2$  to  $C_4$ , the  $V_{DD}$  storage capacitor. This voltage is regulated to 5.5V. At this voltage, the internal oscillator is disabled. Simultaneous with the transfer of the voltage to  $C_4$ , the positive side of capacitor  $C_1$  is switched to  $V_{CC}$  and the negative side is connected to GND, allowing the charge pump cycle to begin again. The charge pump cycle will continue as long as the operational conditions for the internal oscillator are present.

Since both  $V+$  and  $V-$  are separately generated from  $V_{CC}$ , in a no-load condition  $V+$  and  $V-$  will be symmetrical. Older charge pump approaches that generate  $V-$  from  $V+$  will show a decrease in the magnitude of  $V-$  compared to  $V+$  due to the inherent inefficiencies in the design.

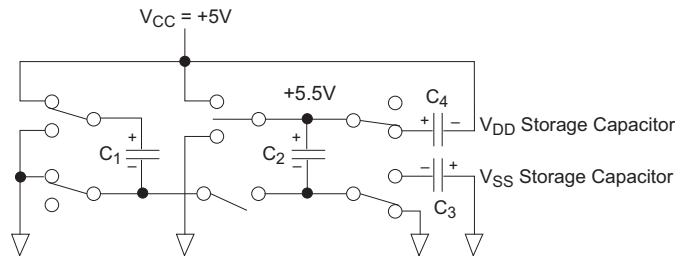
The clock rate for the charge pump typically operates at greater than 250kHz. The external capacitors can be as low as 0.1 $\mu$ F with a 16V breakdown voltage rating.



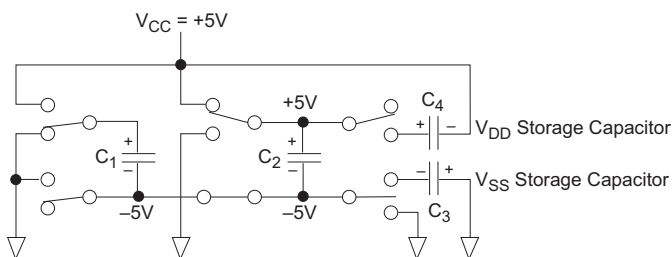
**Figure 15: Charge Pump Waveforms**



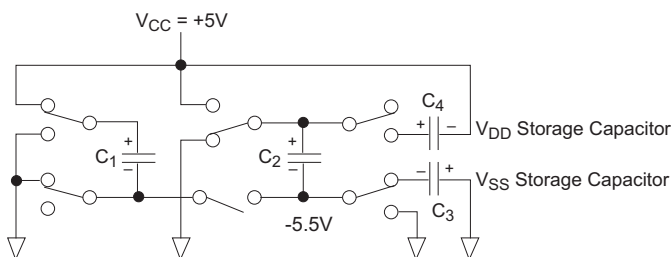
**Figure 16: Charge Pump — Phase 3**



**Figure 17: Charge Pump — Phase 4**



**Figure 13: Charge Pump — Phase 1**



**Figure 14: Charge Pump — Phase 2**

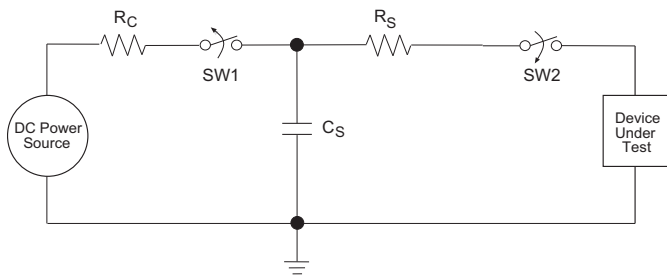
## ESD Tolerance

The SP3222EB / SP3232EB Series incorporates ruggedized ESD cells on all driver output and receiver input pins. The ESD structure is improved over our previous family for more rugged applications and environments sensitive to electro-static discharges and associated transients. The improved ESD tolerance is at least  $\pm 15\text{kV}$  without damage nor latch-up.

There are different methods of ESD testing applied:

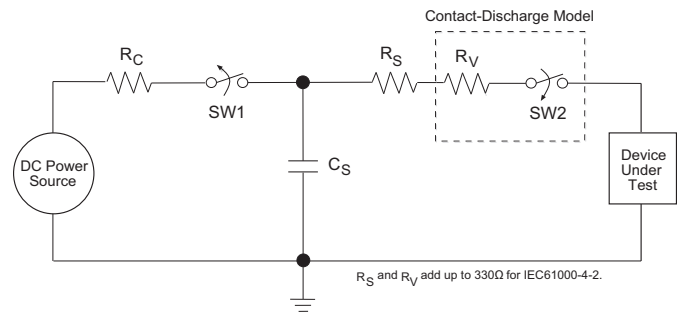
- a. MIL-STD-883, Method 3015.7
- b. IEC61000-4-2 Air-Discharge
- c. IEC61000-4-2 Direct Contact

The Human Body Model has been the generally accepted ESD testing method for semiconductors. This method is also specified in MIL-STD-883, Method 3015.7 for ESD testing. The premise of this ESD test is to simulate the human body's potential to store electro-static energy and discharge it to an integrated circuit. The simulation is performed by using a test model as shown in [Figure 18](#). This method will test the IC's capability to withstand an ESD transient during normal handling such as in manufacturing areas where the IC's tend to be handled frequently.



**Figure 18: ESD Test Circuit for Human Body Model**

The IEC61000-4-2, formerly IEC801-2, is generally used for testing ESD on equipment and systems. System manufacturers must guarantee a certain amount of ESD protection since the system itself is exposed to the outside environment and human presence. The premise with IEC61000-4-2 is that the system is required to withstand an amount of static electricity when ESD is applied to points and surfaces of the equipment that are accessible to personnel during normal usage. The transceiver IC receives most of the ESD current when the ESD source is applied to the connector pins. The test circuit for IEC61000-4-2 is shown on [Figure 19](#). There are two methods within IEC61000-4-2, the Air Discharge method and the Contact Discharge method.



**Figure 19: ESD Test Circuit for IEC61000-4-2**

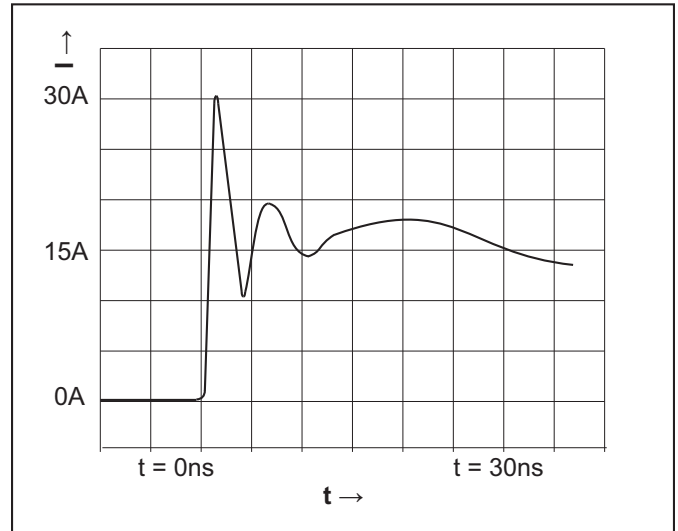
With the Air Discharge Method, an ESD voltage is applied to the equipment under test (EUT) through air. This simulates an electrically charged person ready to connect a cable onto the rear of the system only to find an unpleasant zap just before the person touches the back panel. The high energy potential on the person discharges through an arcing path to the rear panel of the system before he or she even touches the system. This energy, whether discharged directly or through air, is predominantly a function of the discharge current rather than the discharge voltage. Variables with an air discharge such as approach speed of the object carrying the ESD potential to the system and humidity will tend to change the discharge current. For example, the rise time of the discharge current varies with the approach speed.

The Contact Discharge Method applies the ESD current directly to the EUT. This method was devised to reduce the unpredictability of the ESD arc. The discharge current rise time is constant since the energy is directly transferred without the air-gap arc. In situations such as hand held systems, the ESD charge can be directly discharged to the equipment from a person already holding the equipment. The current is transferred on to the keypad or the serial port of the equipment directly and then travels through the PCB and finally to the IC.

The circuit model in [Figure 18](#) and [Figure 19](#) represent the typical ESD testing circuit used for all three methods. The  $C_S$  is initially charged with the DC power supply when the first switch (SW1) is on. Now that the capacitor is charged, the second switch (SW2) is on while SW1 switches off. The voltage stored in the capacitor is then applied through  $R_S$ , the current limiting resistor, onto the device under test (DUT). In ESD tests, the SW2 switch is pulsed so that the device under test receives a duration of voltage.

For the Human Body Model, the current limiting resistor ( $R_S$ ) and the source capacitor ( $C_S$ ) are  $1.5k\Omega$  and  $100pF$ , respectively. For IEC-61000-4-2, the current limiting resistor ( $R_S$ ) and the source capacitor ( $C_S$ ) are  $330\Omega$  and  $150pF$ , respectively.

The higher  $C_S$  value and lower  $R_S$  value in the IEC61000-4-2 model are more stringent than the Human Body Model. The larger storage capacitor injects a higher voltage to the test point when SW2 is switched on. The lower current limiting resistor increases the current charge onto the test point.

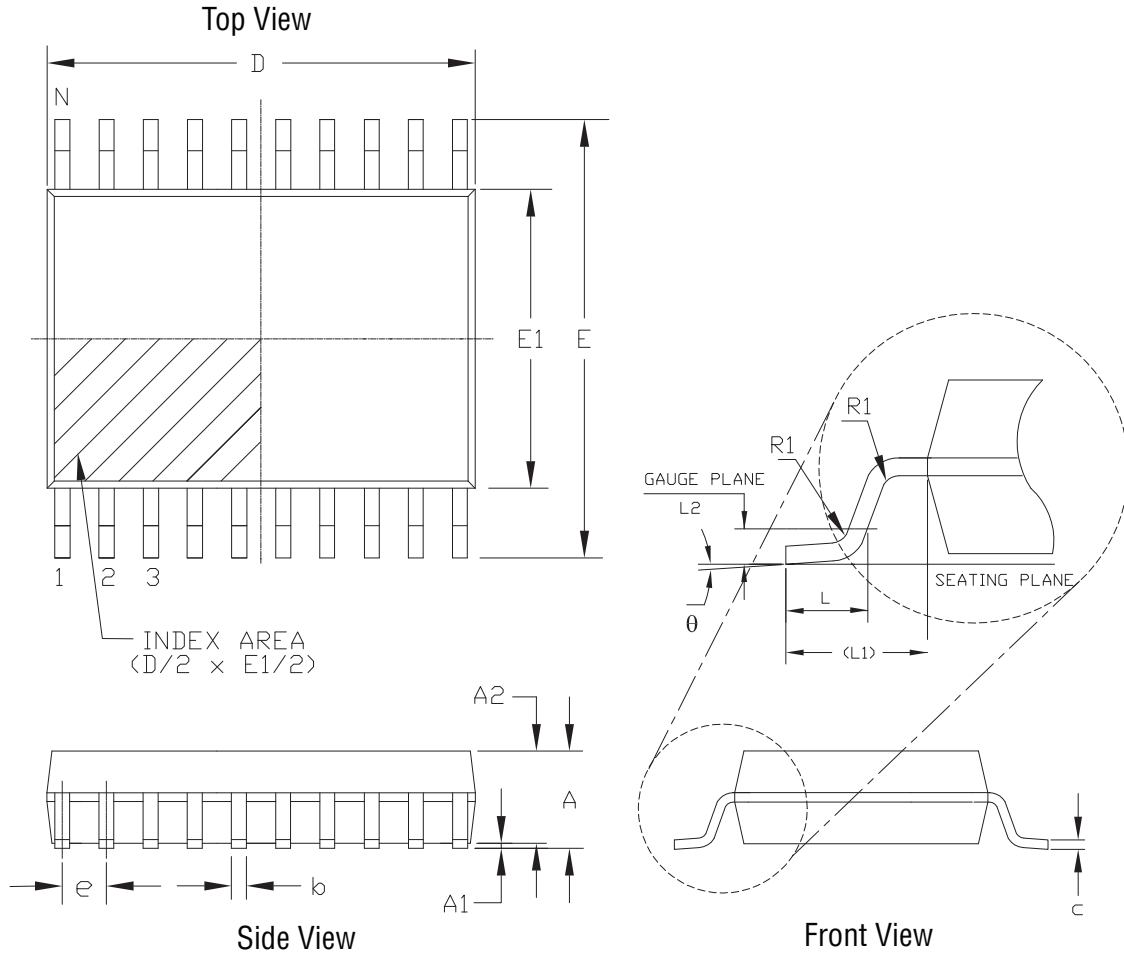


**Figure 20: ESD Test Waveform for IEC61000-4-2**



# Mechanical Dimensions

## SSOP20



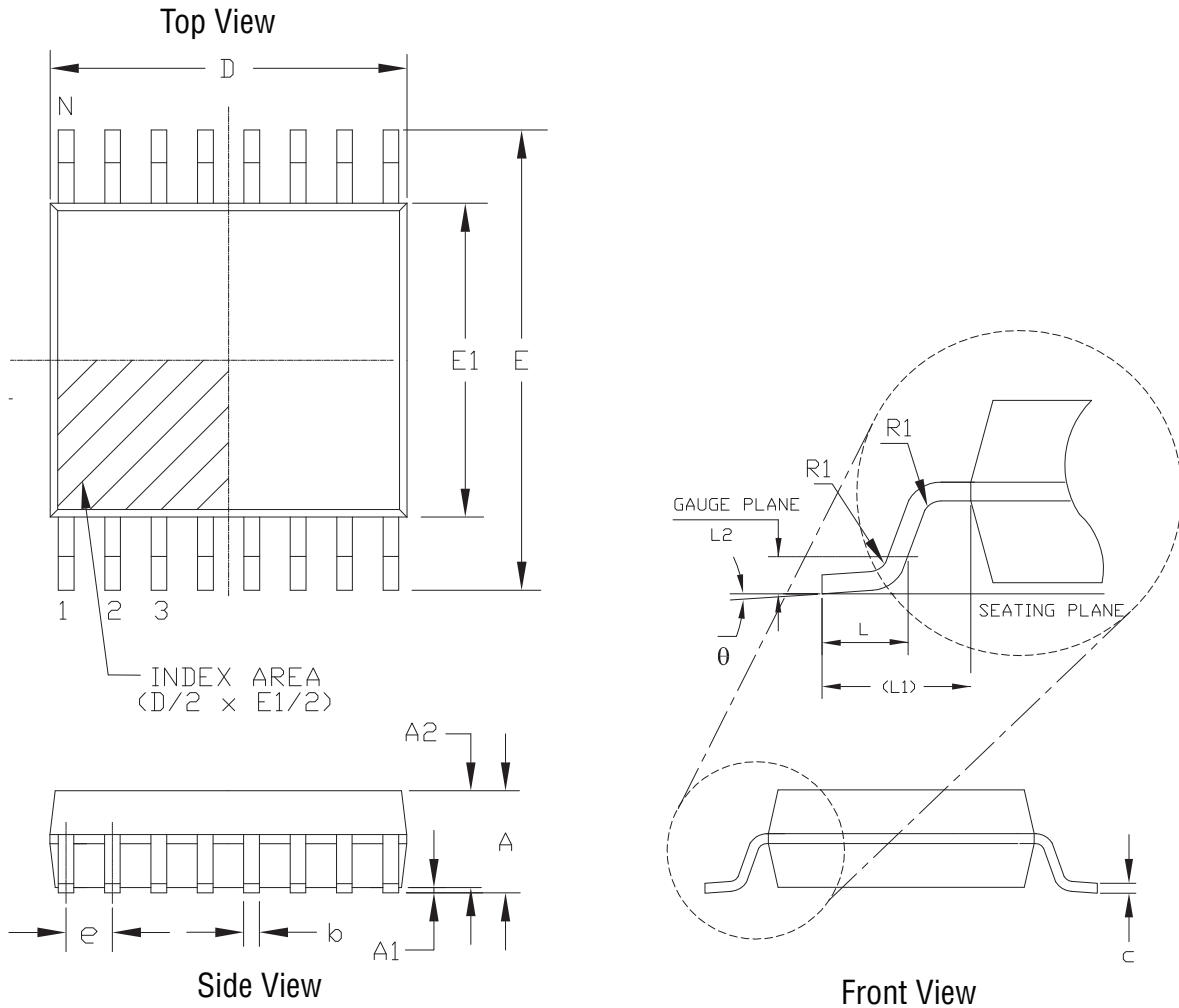
| PACKAGE OUTLINE SSOP 5.3mm BODY<br>JEDEC MO-150 VARIATION A E |                                           |      |      |                                               |       |       |
|---------------------------------------------------------------|-------------------------------------------|------|------|-----------------------------------------------|-------|-------|
| SYMBOLS                                                       | COMMON DIMENSIONS IN MM<br>(Control Unit) |      |      | COMMON DIMENSIONS IN INCH<br>(Reference Unit) |       |       |
|                                                               | MIN                                       | NOM  | MAX  | MIN                                           | NOM   | MAX   |
| A                                                             | —                                         | —    | 2.00 | —                                             | —     | 0.079 |
| A1                                                            | 0.05                                      | —    | —    | 0.002                                         | —     | —     |
| A2                                                            | 1.65                                      | 1.75 | 1.85 | 0.065                                         | 0.069 | 0.073 |
| b                                                             | 0.22                                      | —    | 0.38 | 0.009                                         | —     | 0.015 |
| c                                                             | 0.09                                      | —    | 0.25 | 0.004                                         | —     | 0.010 |
| E                                                             | 7.40                                      | 7.80 | 8.20 | 0.291                                         | 0.307 | 0.323 |
| E1                                                            | 5.00                                      | 5.30 | 5.60 | 0.197                                         | 0.209 | 0.220 |
| e                                                             | 0.65 BSC                                  |      |      | 0.026 BSC                                     |       |       |
| L                                                             | 0.55                                      | 0.75 | 0.95 | 0.022                                         | 0.030 | 0.037 |
| L1                                                            | 1.25 REF                                  |      |      | 0.049 REF                                     |       |       |
| L2                                                            | 0.25 BSC                                  |      |      | 0.010 BSC                                     |       |       |
| R1                                                            | 0.09                                      | —    | —    | 0.004                                         | —     | —     |
| θ                                                             | 0°                                        | 4°   | 8°   | 0°                                            | 4°    | 8°    |
| D                                                             | 6.90                                      | 7.20 | 7.50 | .272                                          | 0.283 | 0.295 |
| N                                                             | 20                                        |      |      |                                               |       |       |

Drawing No: POD-00000119

Revision: A

**Figure 21: Mechanical Dimensions, SSOP20**

# SSOP16



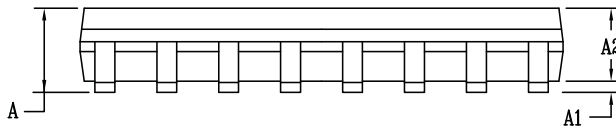
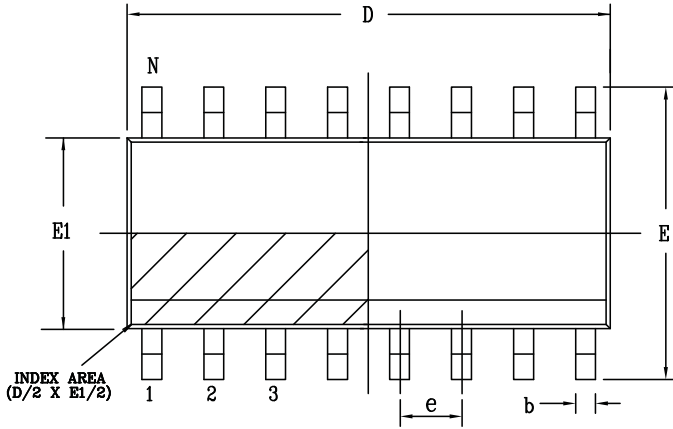
| PACKAGE OUTLINE SSOP 5.3mm BODY<br>JEDEC MO-150 VARIATION AC |                                           |      |           |                                               |       |       |
|--------------------------------------------------------------|-------------------------------------------|------|-----------|-----------------------------------------------|-------|-------|
| SYMBOLS                                                      | COMMON DIMENSIONS IN MM<br>(Control Unit) |      |           | COMMON DIMENSIONS IN INCH<br>(Reference Unit) |       |       |
|                                                              | MIN                                       | NOM  | MAX       | MIN                                           | NOM   | MAX   |
| A                                                            | —                                         | —    | 2.00      | —                                             | —     | 0.079 |
| A1                                                           | 0.05                                      | —    | —         | 0.002                                         | —     | —     |
| A2                                                           | 1.65                                      | 1.75 | 1.85      | 0.065                                         | 0.069 | 0.073 |
| b                                                            | 0.22                                      | —    | 0.38      | 0.009                                         | —     | 0.015 |
| c                                                            | 0.09                                      | —    | 0.25      | 0.004                                         | —     | 0.010 |
| E                                                            | 7.40                                      | 7.80 | 8.20      | 0.291                                         | 0.307 | 0.323 |
| E1                                                           | 5.00                                      | 5.30 | 5.60      | 0.197                                         | 0.209 | 0.220 |
| e                                                            | 0.65 BSC                                  |      | 0.026 BSC |                                               |       |       |
| L                                                            | 0.55                                      | 0.75 | 0.95      | 0.022                                         | 0.030 | 0.037 |
| L1                                                           | 1.25 REF                                  |      | 0.049 REF |                                               |       |       |
| L2                                                           | 0.25 BSC                                  |      | 0.010 BSC |                                               |       |       |
| R1                                                           | 0.09                                      | —    | —         | 0.004                                         | —     | —     |
| $\theta$                                                     | 0°                                        | 4°   | 8°        | 0°                                            | 4°    | 8°    |
| D                                                            | 5.90                                      | 6.20 | 6.50      | 0.232                                         | 0.244 | 0.256 |
| N                                                            | 16                                        |      |           |                                               |       |       |

Drawing No: POD-00000116  
Revision: A

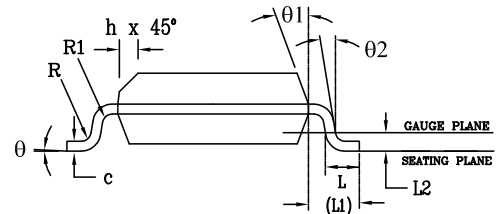
**Figure 22: Mechanical Dimensions, SSOP16**

# NSOIC16

Top View



Side View



Front View

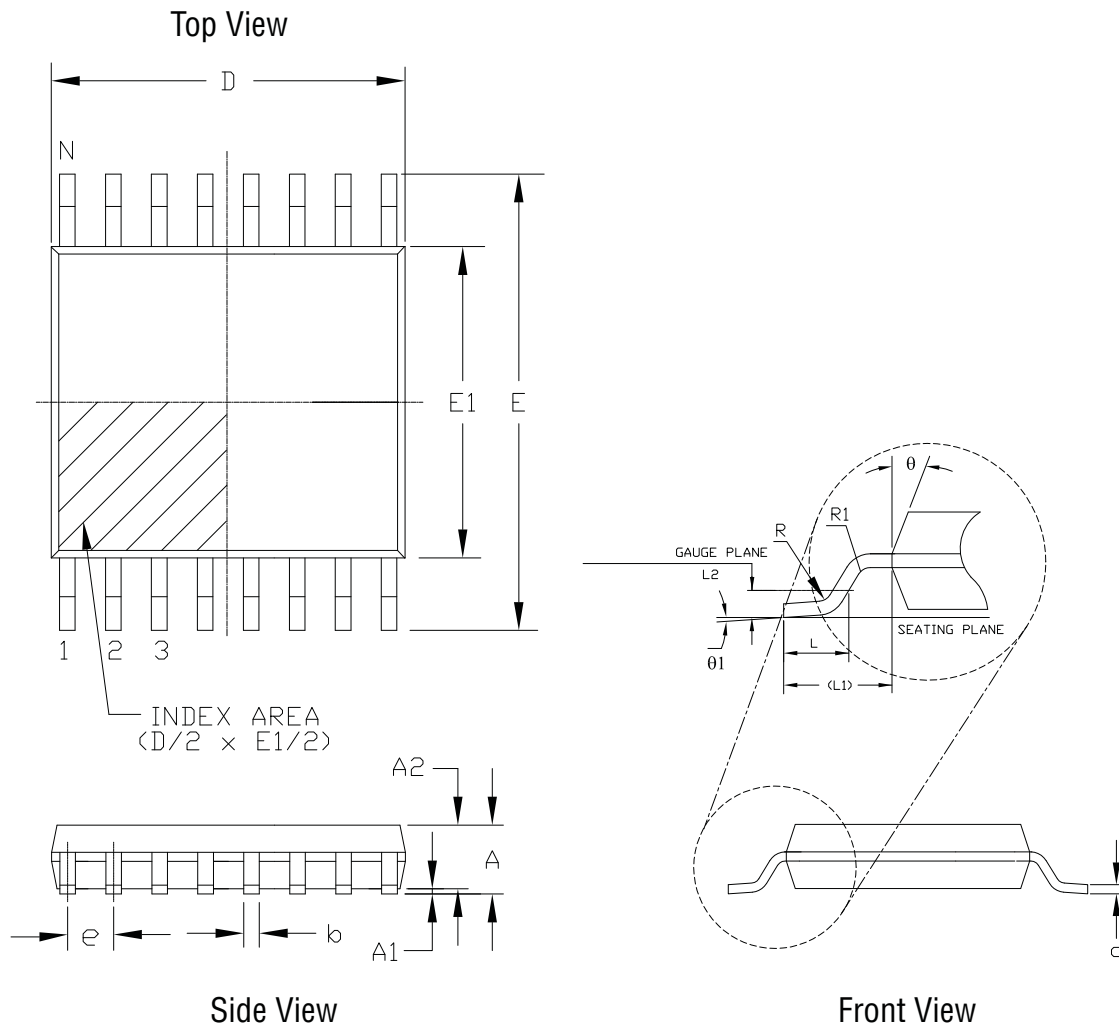
| PACKAGE OUTLINE NSOIC .150" BODY<br>JEDEC MS-012 VARIATION A C |                                           |     |      |                                               |     |       |
|----------------------------------------------------------------|-------------------------------------------|-----|------|-----------------------------------------------|-----|-------|
| SYMBOLS                                                        | COMMON DIMENSIONS IN MM<br>(Control Unit) |     |      | COMMON DIMENSIONS IN INCH<br>(Reference Unit) |     |       |
|                                                                | MIN                                       | NOM | MAX  | MIN                                           | NOM | MAX   |
| A                                                              | 1.35                                      | —   | 1.75 | 0.053                                         | —   | 0.069 |
| A1                                                             | 0.10                                      | —   | 0.25 | 0.004                                         | —   | 0.010 |
| A2                                                             | 1.25                                      | —   | 1.65 | 0.049                                         | —   | 0.065 |
| b                                                              | 0.31                                      | —   | 0.51 | 0.012                                         | —   | 0.020 |
| c                                                              | 0.17                                      | —   | 0.25 | 0.007                                         | —   | 0.010 |
| E                                                              | 6.00 BSC                                  |     |      | 0.236 BSC                                     |     |       |
| E1                                                             | 3.90 BSC                                  |     |      | 0.154 BSC                                     |     |       |
| e                                                              | 1.27 BSC                                  |     |      | 0.050 BSC                                     |     |       |
| h                                                              | 0.25                                      | —   | 0.50 | 0.010                                         | —   | 0.020 |
| L                                                              | 0.40                                      | —   | 1.27 | 0.016                                         | —   | 0.050 |
| L1                                                             | 1.04 REF                                  |     |      | 0.041 REF                                     |     |       |
| L2                                                             | 0.25 BSC                                  |     |      | 0.010 BSC                                     |     |       |
| R                                                              | 0.07                                      | —   | —    | 0.003                                         | —   | —     |
| R1                                                             | 0.07                                      | —   | —    | 0.003                                         | —   | —     |
| q                                                              | 0°                                        | —   | 8°   | 0°                                            | —   | 8°    |
| q1                                                             | 5°                                        | —   | 15°  | 5°                                            | —   | 15°   |
| q2                                                             | 0°                                        | —   | —    | 0°                                            | —   | —     |
| D                                                              | 9.90 BSC                                  |     |      | 0.390 BSC                                     |     |       |
| N                                                              | 16                                        |     |      |                                               |     |       |

Drawing No: POD-00000114

Revision: A

**Figure 23: Mechanical Dimensions, NSOIC16**

TSSOP16

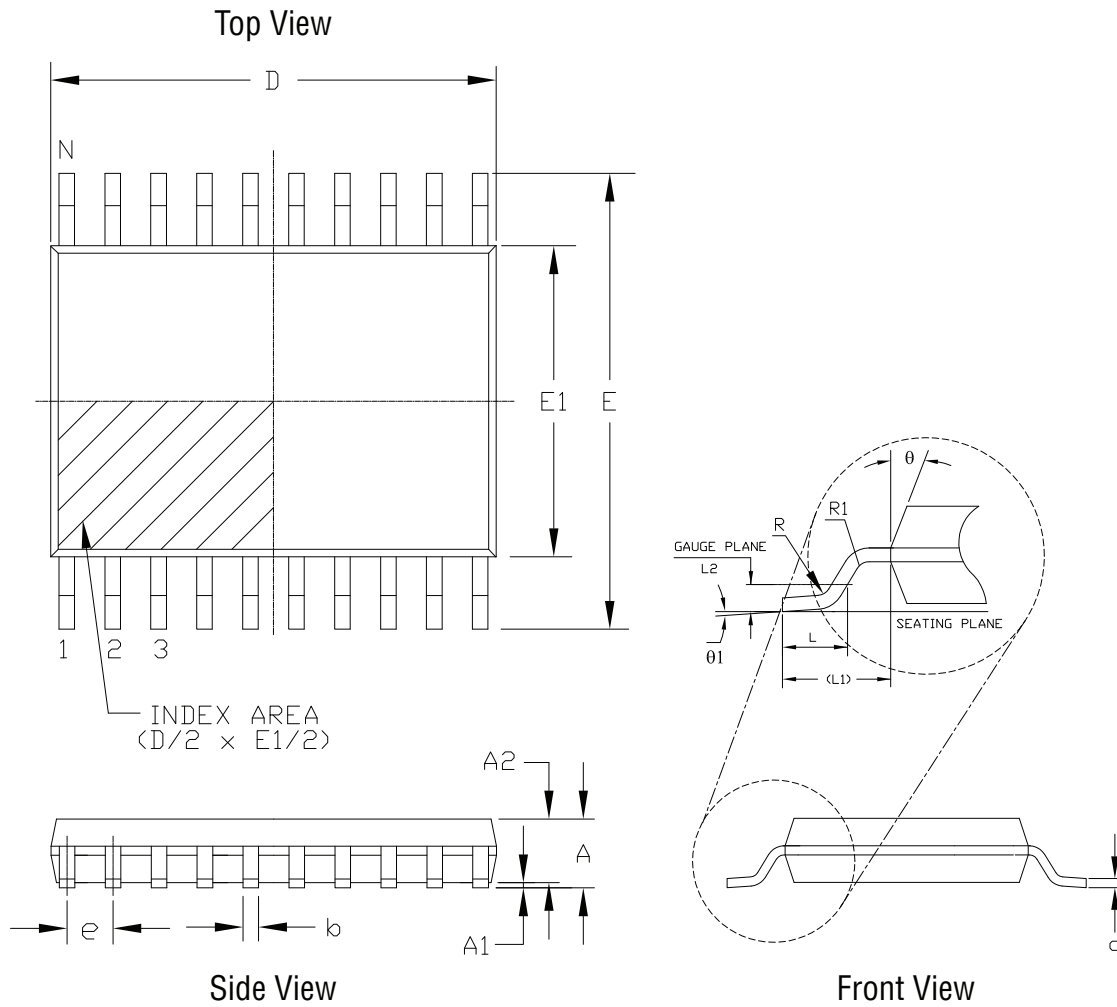


| 16 Pin TSSOP JEDEC MO-153 Variation AB |                                    |      |      |                                        |       |       |
|----------------------------------------|------------------------------------|------|------|----------------------------------------|-------|-------|
| SYMBOLS                                | DIMENSIONS IN MM<br>(Control Unit) |      |      | DIMENSIONS IN INCH<br>(Reference Unit) |       |       |
|                                        | MIN                                | NOM  | MAX  | MIN                                    | NOM   | MAX   |
| A                                      | —                                  | —    | 1.20 | —                                      | —     | 0.047 |
| A1                                     | 0.05                               | —    | 0.15 | 0.002                                  | —     | 0.006 |
| A2                                     | 0.80                               | 1.00 | 1.05 | 0.031                                  | 0.039 | 0.041 |
| b                                      | 0.19                               | —    | 0.30 | 0.007                                  | —     | 0.012 |
| c                                      | 0.09                               | —    | 0.20 | 0.004                                  | —     | 0.008 |
| E                                      | 6.40 BSC                           |      |      | 0.252 BSC                              |       |       |
| E1                                     | 4.30                               | 4.40 | 4.50 | 0.169                                  | 0.173 | 0.177 |
| e                                      | 0.65 BSC                           |      |      | 0.026 BSC                              |       |       |
| L                                      | 0.45                               | 0.60 | 0.75 | 0.018                                  | 0.024 | 0.030 |
| L1                                     | 1.00 REF                           |      |      | 0.039 REF                              |       |       |
| L2                                     | 0.25 BSC                           |      |      | 0.010 BSC                              |       |       |
| R                                      | 0.09                               | —    | —    | 0.035                                  | —     | —     |
| R1                                     | 0.09                               | —    | —    | 0.035                                  | —     | —     |
| θ                                      | 12° REF                            |      |      | 12° REF                                |       |       |
| θ1                                     | 0°                                 | —    | 8°   | 0°                                     | —     | 8°    |
| D                                      | 4.90                               | 5.00 | 5.10 | 0.193                                  | 0.197 | 0.200 |
| N                                      | 16                                 |      |      | 16                                     |       |       |

Drawing No: POD-0000117  
Revision: A

**Figure 24: Mechanical Dimensions, TSSOP16**

# TSSOP20

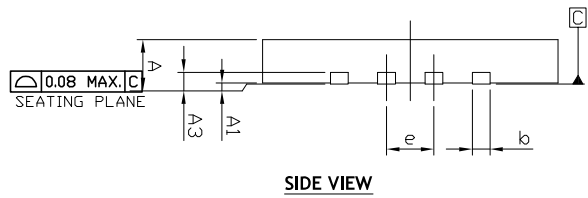
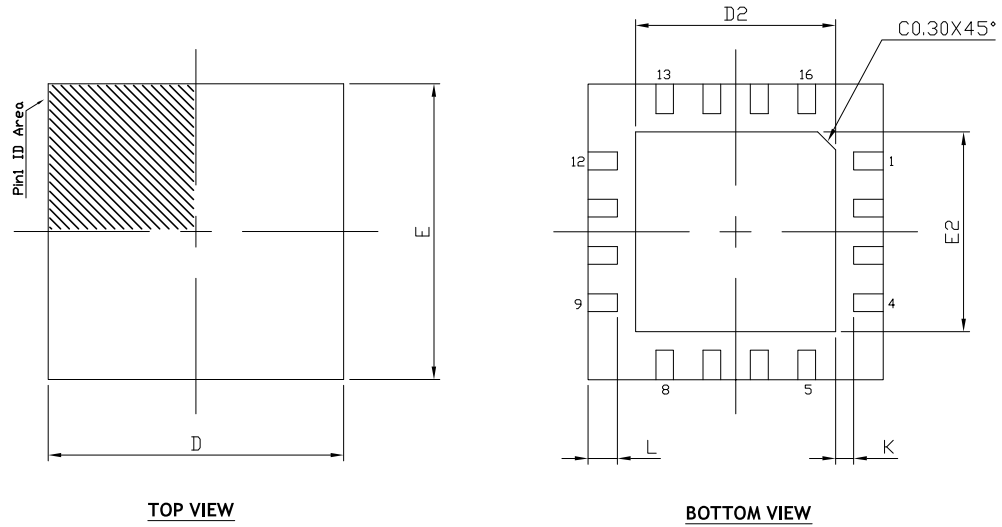


| 20 Pin TSSOP JEDEC MO-153 Variation AC |                                    |      |      |                                        |       |       |
|----------------------------------------|------------------------------------|------|------|----------------------------------------|-------|-------|
| SYMBOLS                                | DIMENSIONS IN MM<br>(Control Unit) |      |      | DIMENSIONS IN INCH<br>(Reference Unit) |       |       |
|                                        | MIN                                | NOM  | MAX  | MIN                                    | NOM   | MAX   |
| A                                      | —                                  | —    | 1.20 | —                                      | —     | 0.047 |
| A1                                     | 0.05                               | —    | 0.15 | 0.002                                  | —     | 0.006 |
| A2                                     | 0.80                               | 1.00 | 1.05 | 0.031                                  | 0.039 | 0.041 |
| b                                      | 0.19                               | —    | 0.30 | 0.007                                  | —     | 0.012 |
| c                                      | 0.09                               | —    | 0.20 | 0.004                                  | —     | 0.008 |
| E                                      | 6.40 BSC                           |      |      | 0.252 BSC                              |       |       |
| E1                                     | 4.30                               | 4.40 | 4.50 | 0.169                                  | 0.173 | 0.177 |
| e                                      | 0.65 BSC                           |      |      | 0.026 BSC                              |       |       |
| L                                      | 0.45                               | 0.60 | 0.75 | 0.018                                  | 0.024 | 0.030 |
| L1                                     | 1.00 REF                           |      |      | 0.039 REF                              |       |       |
| L2                                     | 0.25 BSC                           |      |      | 0.010 BSC                              |       |       |
| R                                      | 0.09                               | —    | —    | 0.035                                  | —     | —     |
| R1                                     | 0.09                               | —    | —    | 0.035                                  | —     | —     |
| $\theta$                               | 12° REF                            |      |      | 12° REF                                |       |       |
| $\theta1$                              | 0°                                 | —    | 8°   | 0°                                     | —     | 8°    |
| D                                      | 6.40                               | 6.50 | 6.60 | 0.252                                  | 0.256 | 0.260 |
| N                                      | 20                                 |      |      | 20                                     |       |       |

Drawing No: POD-00000120  
Revision: A

**Figure 25: Mechanical Dimensions, TSSOP20**

QFN16 5x5



| DIMENSION TABLE |           |      |      |      |
|-----------------|-----------|------|------|------|
| SYMBOL          | MIN       | NOM  | MAX  | NOTE |
| A               | 0.80      | 0.85 | 0.90 |      |
| A1              | 0.00      | 0.02 | 0.05 |      |
| A3              | 0.203 Ref |      |      |      |
| b               | 0.25      | 0.30 | 0.35 |      |
| D               | 4.95      | 5.00 | 5.05 |      |
| E               | 4.95      | 5.00 | 5.05 |      |
| e               | 0.80 BSC  |      |      |      |
| D2              | 3.28      | 3.38 | 3.43 |      |
| E2              | 3.28      | 3.38 | 3.43 |      |
| L               | 0.45      | 0.50 | 0.55 |      |
| K               | 0.20      | -    | -    |      |

**TERMINAL DETAILS**

- ALL DIMENSIONS ARE IN MILLIMETERS.
- DIMENSIONS AND TOLERANCE PER JEDEC MO-220.

Drawing No.: POD-00000160

Revision: A

**Figure 26: Mechanical Dimensions, QFN16 5x5**

## Ordering Information

**Table 7: Ordering Information<sup>(1)</sup>**

| Ordering Part Number | Operating Temperature Range | Package      | Packaging Method | Lead-Free <sup>(2)</sup> |
|----------------------|-----------------------------|--------------|------------------|--------------------------|
| SP3222EB             |                             |              |                  |                          |
| SP3222EBEA-L/TR      | −40°C to 85°C               | 20 Pin SSOP  | Reel             | Yes                      |
| SP3222EBEY-L/TR      | −40°C to 85°C               | 20 Pin TSSOP | Reel             | Yes                      |
| SP3232EB             |                             |              |                  |                          |
| SP3232EBCA-L/TR      | 0°C to 70°C                 | 16 Pin SSOP  | Reel             | Yes                      |
| SP3232EBCN-L         | 0°C to 70°C                 | 16-pin NSOIC | Tube             | Yes                      |
| SP3232EBCN-L/TR      | 0°C to 70°C                 | 16-pin NSOIC | Reel             | Yes                      |
| SP3232EBCY-L/TR      | 0°C to 70°C                 | 16 Pin TSSOP | Reel             | Yes                      |
| SP3232EBEA-L/TR      | −40°C to 85°C               | 16 Pin SSOP  | Reel             | Yes                      |
| SP3232EBEN-L/TR      | −40°C to 85°C               | 16-pin NSOIC | Reel             | Yes                      |
| SP3232EBEY-L/TR      | −40°C to 85°C               | 16 Pin TSSOP | Reel             | Yes                      |
| SP3232EBER-L/TR      | −40°C to 85°C               | 16 Pin QFN   | Reel             | Yes                      |

1. Refer to [www.maxlinear.com/SP3222EB](http://www.maxlinear.com/SP3222EB) and [www.maxlinear.com/SP3232EB](http://www.maxlinear.com/SP3232EB) for most up-to-date Ordering Information.
2. Visit [www.maxlinear.com](http://www.maxlinear.com) for additional information on Environmental Rating.