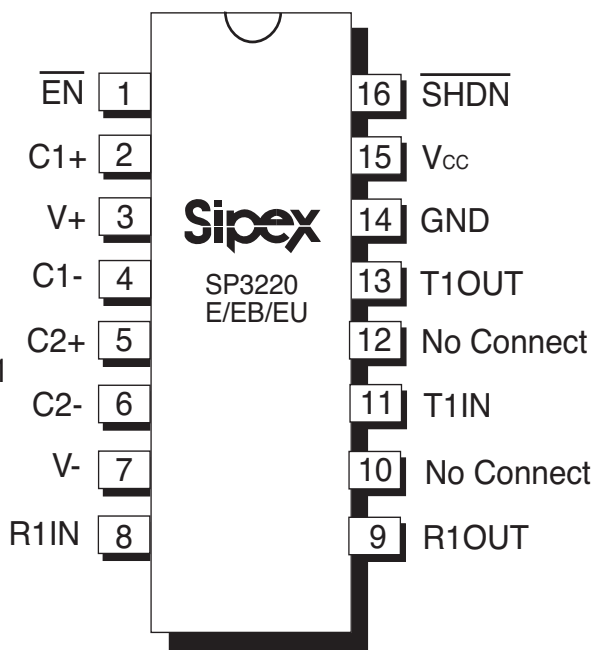


## +3.0V to +5.5V RS-232 Driver/Receiver Pair

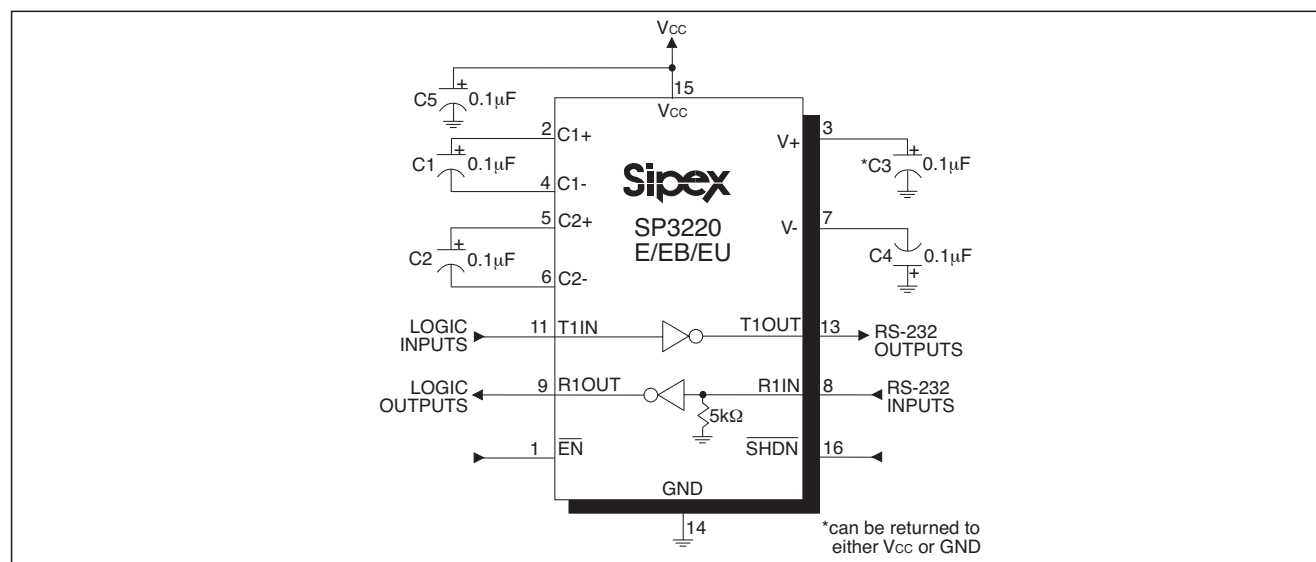
- Meets All EIA-232 and ITU V.28 Specifications from a wide +3.0V to +5.5V power supply
  - Interoperable with RS232 and V.28 at 2.7V
- Supports High Serial DataRates:
  - 120 kbps SP3220E
  - 250 kbps SP3220EB
  - 1 Mbps SP3220EU
- 1 $\mu$ A Low Power Shutdown Mode
- Footprint Compatible with MAX3221E, ISL3221
- 4 x 0.1 $\mu$ F External Charge Pump Capacitors
- Tri-State/Receiver Enable
- Improved ESD Specifications:
  - +15kV Human Body Model
  - +15kV IEC1000-4-2 Air Discharge
  - +8kV IEC1000-4-2 Contact Discharge



Available in Lead Free Packaging

### DESCRIPTION

The **SP3220E** devices are RS-232 driver/receiver solutions intended for portable or hand-held applications such as palmtop computers, instrumentation and consumer products. These devices incorporate a high-efficiency charge-pump power supply that allows the **SP3220E** devices to deliver true RS-232 performance from a single power supply ranging from +3.0V to +5.0V. This charge pump requires only 0.1 $\mu$ F capacitors in 3.3V operation. The ESD tolerance of these devices is over  $\pm 15$ kV for both Human Model and IEC1000-4-2 Air discharge test methods. All devices have a low-power shutdown mode where the driver outputs and charge pumps are disabled. During shutdown, the supply current falls to less than 1 $\mu$ A.



## ABSOLUTE MAXIMUM RATINGS

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.

|                                            |                |
|--------------------------------------------|----------------|
| $V_{CC}$ .....                             | -0.3V to +6.0V |
| $V_+$ (NOTE 1).....                        | -0.3V to +7.0V |
| $V_-$ (NOTE 1).....                        | +0.3V to -7.0V |
| $V_+ + IV-I$ (NOTE 1).....                 | +13V           |
| $I_{CC}$ (DC $V_{CC}$ or GND current)..... | $\pm 100$ mA   |

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

## Input Voltages

|                                                        |                           |
|--------------------------------------------------------|---------------------------|
| $TxIN$ , $\overline{EN}$ , $\overline{SHUTDOWN}$ ..... | -0.3V to $V_{CC} + 0.3$ V |
| $RxIN$ .....                                           | $\pm 25$ V                |

## Output Voltages

|               |                              |
|---------------|------------------------------|
| $TxOUT$ ..... | $\pm 13.2$ V                 |
| $RxOUT$ ..... | -0.3V to ( $V_{CC} + 0.3$ V) |

## Short-Circuit Duration

|                           |                 |
|---------------------------|-----------------|
| $TxOUT$ .....             | Continuous      |
| Storage Temperature ..... | -65°C to +150°C |

## Power Dissipation Per Package

|                                                       |       |
|-------------------------------------------------------|-------|
| 16-pin SSOP (derate 9.69mW/°C above +70°C) .....      | 775mW |
| 16-pin TSSOP (derate 10.5mW/°C above +70°C) .....     | 840mW |
| 16-pin Wide SOIC (derate 11.2mW/°C above +70°C) ..... | 900mW |

## SPECIFICATIONS

Unless otherwise noted, the following specifications apply for  $V_{CC} = +3.0$ V to +5.0V with  $T_{AMB} = T_{MIN}$  to  $T_{MAX}$ . Typical Values apply at  $V_{CC} = +3.3$ V or +5.0V and  $T_{AMB} = 25^\circ\text{C}$ , C1-4=0.1 $\mu$ F.

| PARAMETER                         | MIN.           | TYP.           | MAX.      | UNITS    | CONDITIONS                                                                                              |
|-----------------------------------|----------------|----------------|-----------|----------|---------------------------------------------------------------------------------------------------------|
| DC CHARACTERISTICS                |                |                |           |          |                                                                                                         |
| Supply Current                    |                | 0.3            | 1.0       | mA       | no load, $T_{AMB} = +25^\circ\text{C}$ , $V_{CC} = 3.3$ V, $TxIN = GND$ or $V_{CC}$                     |
| Shutdown Supply Current           |                | 1.0            | 10        | $\mu$ A  | $\overline{SHDN} = GND$ , $T_{AMB} = +25^\circ\text{C}$ , $V_{CC} = +3.3$ V, $TxIN = GND$ or $V_{CC}$   |
| LOGIC INPUTS AND RECEIVER OUTPUTS |                |                |           |          |                                                                                                         |
| Input Logic Threshold LOW         | GND            |                | 0.8       | V        | $TxIN$ , $\overline{EN}$ , $\overline{SHDN}$ , Note 2                                                   |
| Input Logic Threshold HIGH        | 2.0            |                |           | V        | $V_{CC} = 3.3$ V, Note 2                                                                                |
|                                   | 2.4            |                |           | V        | $V_{CC} = 5.0$ V, Note 2                                                                                |
| Input Leakage Current             |                | $\pm 0.01$     | $\pm 1.0$ | $\mu$ A  | $TxIN$ , $\overline{EN}$ , $\overline{SHDN}$ , $T_{AMB} = +25^\circ\text{C}$ $V_{IN} = GND$ to $V_{CC}$ |
| Output Leakage Current            |                | $\pm 0.05$     | $\pm 10$  | $\mu$ A  | Receivers Disabled $V_{OUT} = GND$ to $V_{CC}$                                                          |
| Output Voltage LOW                |                |                | 0.4       | V        | $I_{OUT} = 1.6$ mA                                                                                      |
| Output Voltage HIGH               | $V_{CC} - 0.6$ | $V_{CC} - 0.1$ |           | V        | $I_{OUT} = -1.0$ mA                                                                                     |
| DRIVER OUTPUTS                    |                |                |           |          |                                                                                                         |
| Output Voltage Swing              | $\pm 5.0$      | $\pm 5.4$      |           | V        | 3k $\Omega$ load to ground at all driver outputs, $T_{AMB} = +25^\circ\text{C}$                         |
| Output Resistance                 | 300            |                |           | $\Omega$ | $V_{CC} = V_+ = V_- = GND$ , $T_{OUT} = \pm 2$ V                                                        |
| Output Short-Circuit Current      |                | $\pm 35$       | $\pm 60$  | mA       | $V_{OUT} = GND$                                                                                         |
| Output Leakage Current            |                |                | $\pm 25$  | $\mu$ A  | $V_{OUT} = \pm 12$ V, $V_{CC} = GND$ to 5.5V, drivers disabled                                          |

**NOTE 2:** Driver input hysteresis is typically 250mV.

## SPECIFICATIONS (continued)

Unless otherwise noted, the following specifications apply for  $V_{CC} = +3.0V$  to  $+5.0V$  with  $T_{AMB} = T_{MIN}$  to  $T_{MAX}$ .  
Typical Values apply at  $V_{CC} = +3.3V$  or  $+5.0V$  and  $T_{AMB} = 25^{\circ}C$ ,  $C1-4=0.1\mu F$ .

| PARAMETER                    | MIN.       | TYP.         | MAX.       | UNITS                    | CONDITIONS                                                                                                                                                           |
|------------------------------|------------|--------------|------------|--------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| RECEIVER INPUTS              |            |              |            |                          |                                                                                                                                                                      |
| Input Voltage Range          | -25        |              | +25        | V                        |                                                                                                                                                                      |
| Input Threshold LOW          | 0.6<br>0.8 | 1.2<br>1.5   |            | V                        | $V_{CC}=3.3V$<br>$V_{CC}=5.0V$                                                                                                                                       |
| Input Threshold HIGH         |            | 1.5<br>1.8   | 2.4<br>2.4 | V                        | $V_{CC}=3.3V$<br>$V_{CC}=5.0V$                                                                                                                                       |
| Input Hysteresis             |            | 0.3          |            | V                        |                                                                                                                                                                      |
| Input Resistance             | 3          | 5            | 7          | k $\Omega$               |                                                                                                                                                                      |
| TIMING CHARACTERISTICS       |            |              |            |                          |                                                                                                                                                                      |
| Data Rate SP3220E            | 120        | 235          |            | Kbps                     | $R_L=3k\Omega$ , $C_L=1000pF$ , one driver switching                                                                                                                 |
| Data Rate SP3220EB           | 250        |              |            | Kbps                     | $R_L=3k\Omega$ , $C_L=1000pF$                                                                                                                                        |
| Data Rate SP3220EU           | 1000       |              |            | Kbps                     | $R_L=3k\Omega$ , $C_L=250pF$                                                                                                                                         |
| Receiver Propagation Delay   |            | 0.15<br>0.15 |            | $\mu s$<br>$\mu s$       | $t_{PHL}$ , RxIN to RxOUT, $C_L = 150pF$<br>$t_{PHL}$ , RxIN to RxOUT, $C_L = 150pF$                                                                                 |
| Receiver Output Enable Time  |            | 200          |            | ns                       |                                                                                                                                                                      |
| Receiver Output Disable Time |            | 200          |            | ns                       |                                                                                                                                                                      |
| Driver Skew                  |            | 100          |            | ns                       | $ t_{PHL} - t_{PLH} $ , $T_{AMB} = 25^{\circ}C$                                                                                                                      |
| Receiver Skew                |            | 50           |            | ns                       | $ t_{PHL} - t_{PLH} $                                                                                                                                                |
| Transition-Region Slew Rate  |            | 90           | 30         | V/ $\mu s$<br>V/ $\mu s$ | $V_{CC} = 3.3V$ , $R_L = 3K\Omega$ , $T_{AMB} = 25^{\circ}C$ ,<br>measurements taken from $-3.0V$ to $+3.0V$<br>or $+3.0V$ to $-3.0V$ (SP3220E and EB)<br>(SP3220EU) |

## TYPICAL PERFORMANCE CHARACTERISTICS

Unless otherwise noted, the following performance characteristics apply for  $V_{CC} = +3.3V$ , 250kbps data rates, all drivers loaded with  $3k\Omega$ ,  $0.1\mu F$  charge pump capacitors, and  $T_{AMB} = +25^\circ C$ .

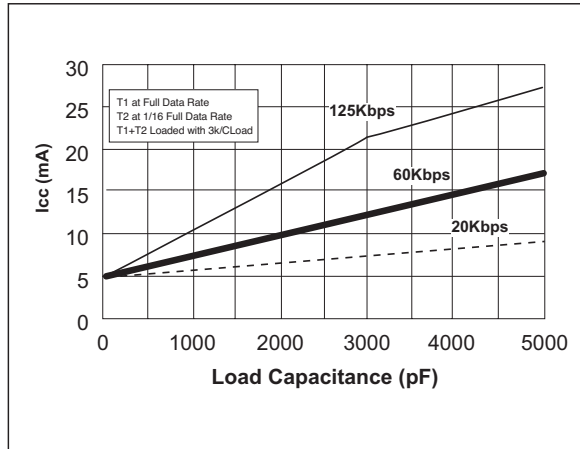


Figure 1.  $I_{CC}$  vs Load Capacitance for the SP3220EB.

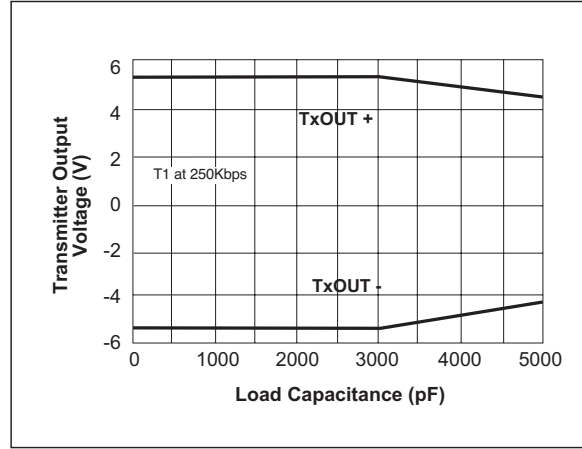


Figure 2. Transmitter Output Voltage vs Load Capacitance for the SP3220EB.

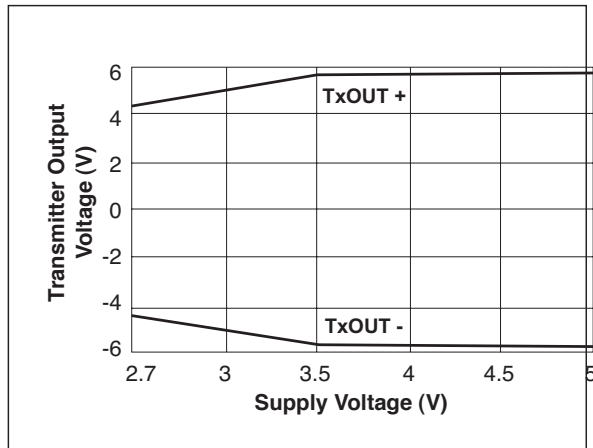


Figure 3. Transmitter Output Voltage vs Supply Voltage for the SP3220EB.

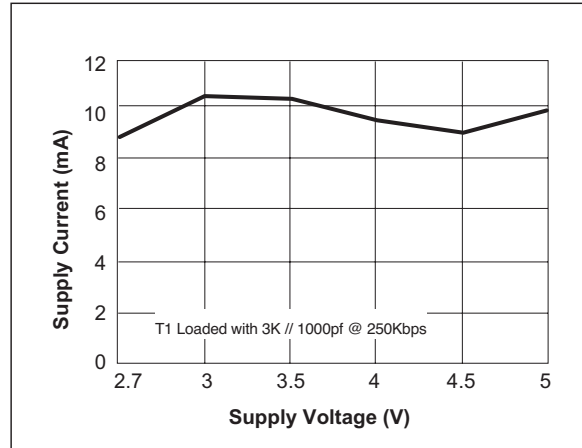


Figure 4. Supply Current vs Supply Voltage for the SP3220EB.

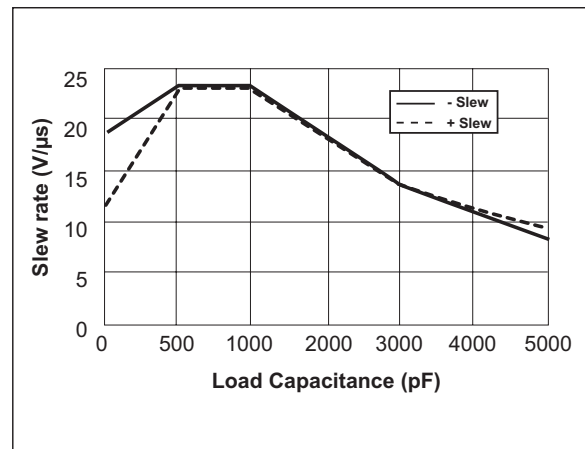


Figure 5. Slew Rate vs Load Capacitance for the SP3220EB.

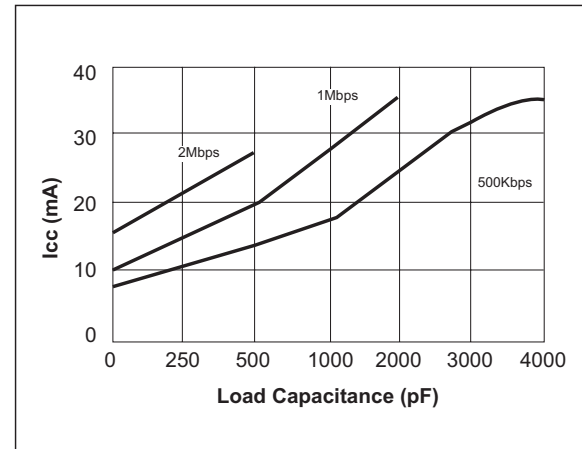


Figure 4. Supply Current vs Supply Voltage for the SP3220EU.

## TYPICAL PERFORMANCE CHARACTERISTICS: Continued

Unless otherwise noted, the following performance characteristics apply for  $V_{CC} = +3.3V$ , 250kbps data rates, all drivers loaded with  $3k\Omega$ ,  $0.1\mu F$  charge pump capacitors, and  $T_{AMB} = +25^{\circ}C$ .

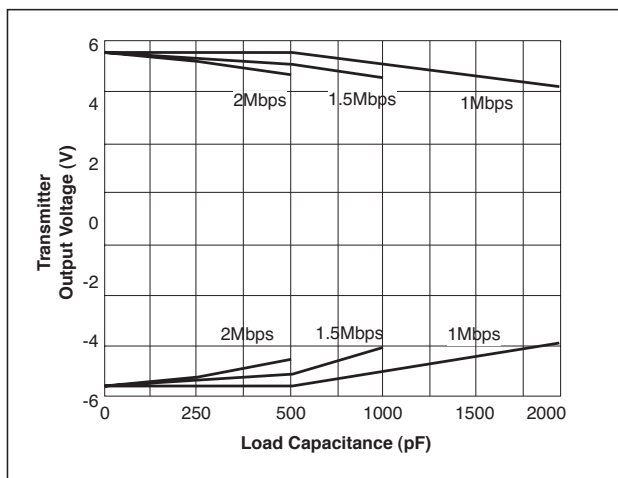


Figure 7. Transmitter Output Voltage vs Load Capacitance for the SP3220EU.

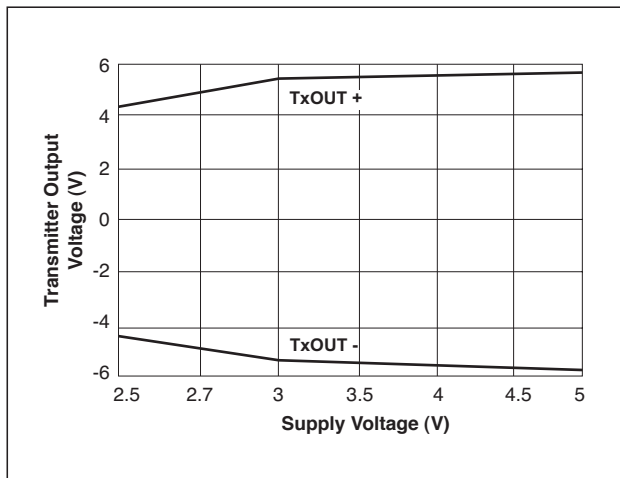


Figure 8. Transmitter Output Voltage vs Supply Voltage for the SP3220EU.

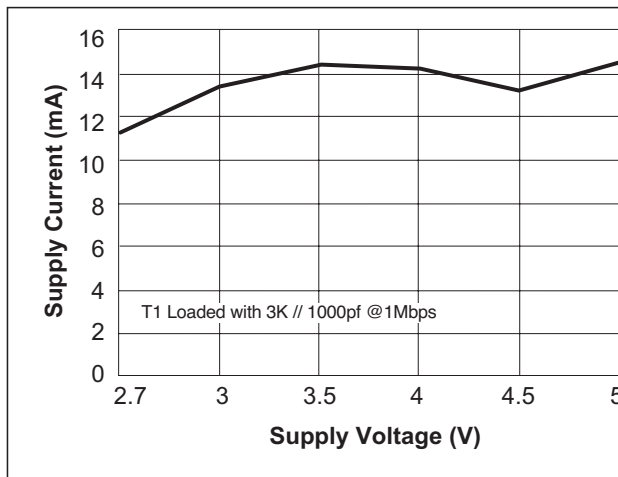


Figure 9. Supply Current vs Supply Voltage for the SP3220EU.

| NAME                     | FUNCTION                                                                                                                                                     | PIN NUMBER |
|--------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------|------------|
| $\overline{\text{EN}}$   | Receiver Enable Control. Drive LOW for normal operation. Drive HIGH to Tri-State the receiver outputs (high-Z state).                                        | 1          |
| C1+                      | Positive terminal of the voltage doubler charge-pump capacitor.                                                                                              | 2          |
| V+                       | +5.5V generated by the charge pump.                                                                                                                          | 3          |
| C1-                      | Negative terminal of the voltage doubler charge-pump capacitor.                                                                                              | 4          |
| C2+                      | Positive terminal of the inverting charge-pump capacitor.                                                                                                    | 5          |
| C2-                      | Negative terminal of the inverting charge-pump capacitor.                                                                                                    | 6          |
| V-                       | -5.5V generated by the charge pump.                                                                                                                          | 7          |
| R1IN                     | RS-232 receiver input.                                                                                                                                       | 8          |
| R1OUT                    | TTL/CMOS receiver output.                                                                                                                                    | 9          |
| N.C.                     | No Connect.                                                                                                                                                  | 10, 12     |
| T1IN                     | TTL/CMOS driver input.                                                                                                                                       | 11         |
| T1OUT                    | RS-232 driver output.                                                                                                                                        | 13         |
| GND                      | Ground.                                                                                                                                                      | 14         |
| V <sub>CC</sub>          | +3.0V to +5.5V supply voltage                                                                                                                                | 15         |
| $\overline{\text{SHDN}}$ | Shutdown Control Input. Drive HIGH for normal device operation. Drive LOW to shutdown the drivers (high-Z output) and the on-board charge pump power supply. | 16         |

**Table 1. Device Pin Description**

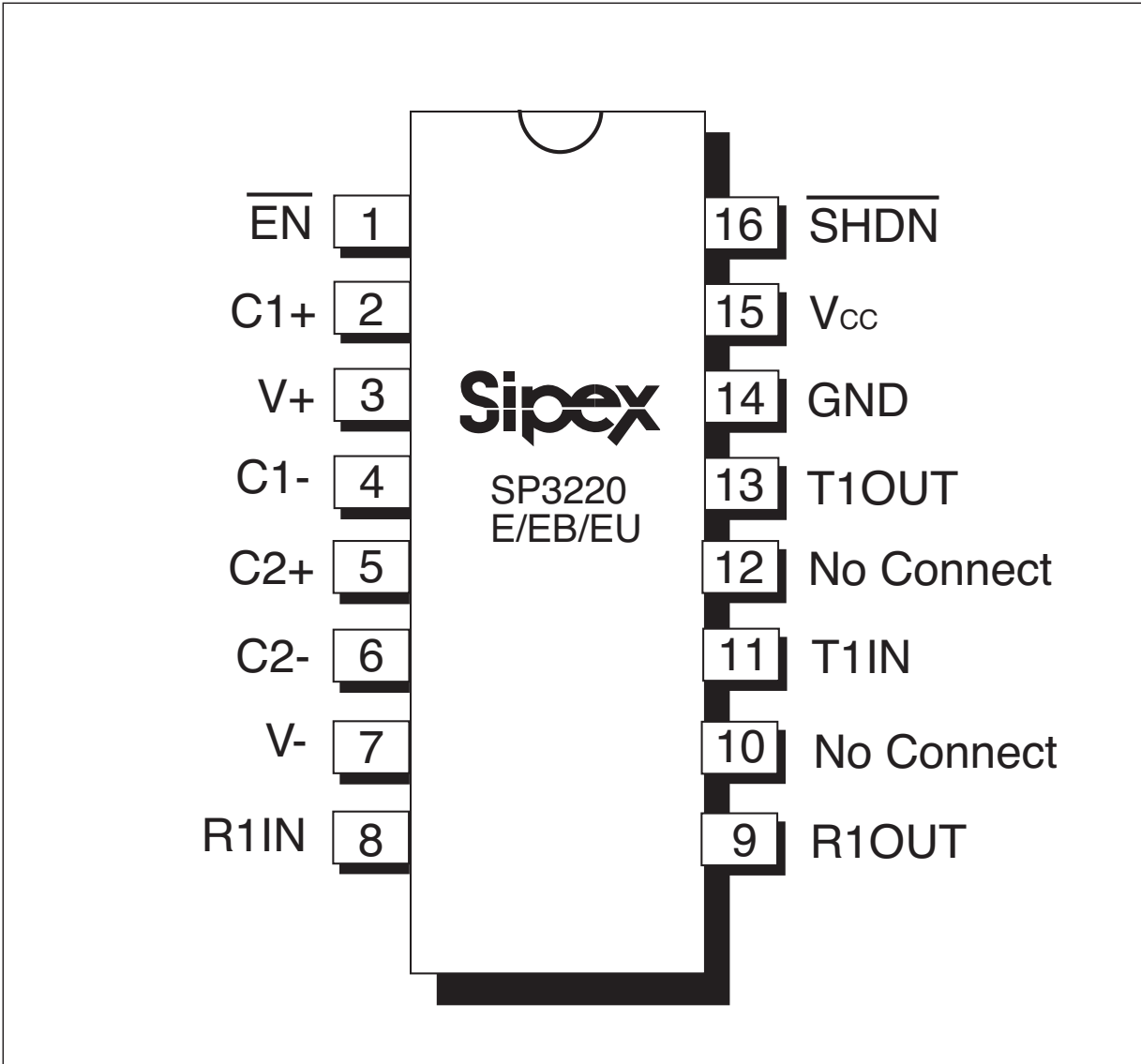


Figure 10. Pinout Configurations for the SP3220E/EB/EU

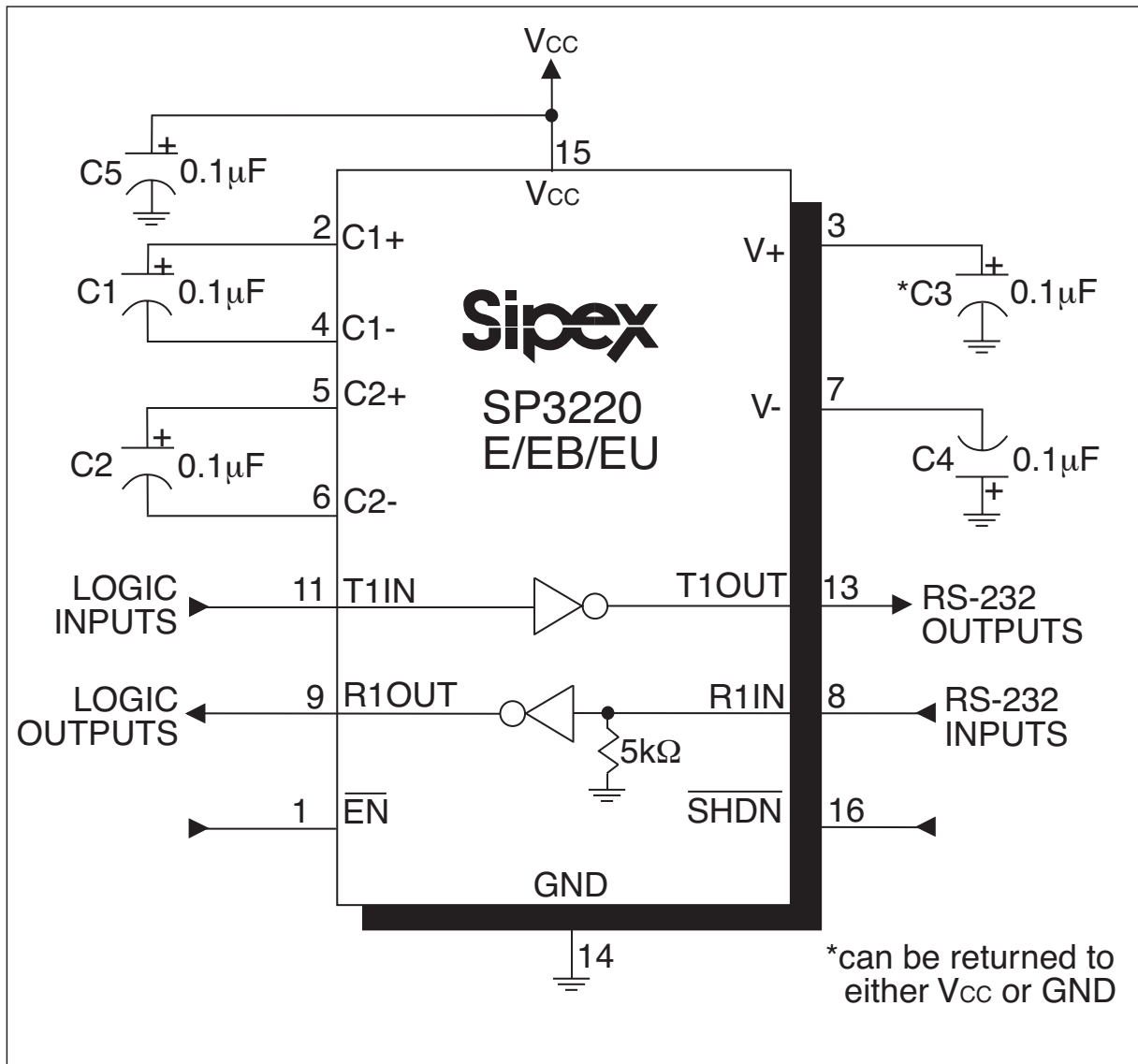


Figure 11. SP3220E/EB/EU Typical Operating Circuits



## DESCRIPTION

The **SP3220E/EB/EU** devices meet the EIA/TIA-232 and 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 **SP3220E/EB/EU** devices feature Sipex's proprietary on-board charge pump circuitry that generates  $2 \times V_{CC}$  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 +3.0V to +5.5V systems, or +5.0V-only systems that require true RS-232 performance. The SP3220EB device has a driver that can operate at a data rate of 250Kbps fully loaded. The SP3220EU can operate at 1000Kbps; the SP3220E operates at a typical data rate of 235Kbps fully loaded.

The **SP3220E/EB/EU** is a 1-driver/1-receiver device ideal for portable or hand-held applications. The **SP3220E/EB/EU** features a  $1\mu\text{A}$  shutdown mode that reduces power consumption and extends battery life in portable systems. Its receivers remain active in shutdown mode, allowing external devices to be monitored using only  $1\mu\text{A}$  supply current.

## THEORY OF OPERATION

The **SP3220E/EB/EU** devices are made up of three basic circuit blocks: 1. Driver, 2. Receiver, and 3. the Sipex proprietary charge pump.

### Driver

The driver is an inverting level transmitter that converts TTL or CMOS logic levels to  $\pm 5.0\text{V}$  EIA/TIA-232 levels, inverted relative to the input logic levels. Typically, the RS-232 output voltage swing is  $\pm 5.5\text{V}$  with no load and at least  $\pm 5\text{V}$  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  $\pm 3.7\text{V}$  with supply voltages as low as  $2.7\text{V}$ .

The SP3220EB driver typically can operate at a data rate of 250Kbps fully loaded with  $3\text{K}\Omega$  in parallel with  $1000\text{pF}$ , ensuring compatibility with

PC-to-PC communication software. The SP3220EU driver can guarantee a data rate of 1000Kbps fully loaded with  $3\Omega$  in parallel with  $250\text{pF}$ .

The slew rate of the SP3220E and SP3220EB outputs are internally limited to a maximum of  $30\text{V}/\mu\text{s}$  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 meets the monotonicity requirements of the standard. The slew rate of the SP3220EU is not internally limited. This allows it to transmit at much faster data rates.

*Figure 12* shows a loopback circuit used to test the RS-232 driver. *Figure 13* shows the test results of the loopback circuit with the SP3220EB driver active at 250Kbps with an RS-232 load in parallel with a  $1000\text{pF}$  capacitor. *Figure 14* shows the test results where the SP3220EU driver was active at 1000Kbps and loaded with an RS-232 receiver in parallel with a  $250\text{pF}$  capacitor. A solid RS-232 data transmission rate of 250Kbps provides compatibility with many designs in personal computer peripherals and LAN applications.

The **SP3220E/EB/EU** driver's output stage is turned off (high-Z) when the device is in shutdown mode. When the power is off, the **SP3220E/EB/EU** device permits the outputs to be driven up to  $\pm 12\text{V}$ . The driver's input does not have pull-up resistors. Designers should connect an unused input to  $V_{CC}$  or GND.

In the shutdown mode, the supply current falls to less than  $1\mu\text{A}$ , where  $\text{SHDN} = \text{LOW}$ . When the **SP3220E/EB/EU** device is shut down, the device's driver output is disabled (high-Z) and the charge pump is turned off with  $V+$  pulled down to  $V_{CC}$  and  $V-$  pulled to GND. The time required to exit shutdown is typically 100ms. Connect  $\text{SHDN}$  to  $V_{CC}$  if the shutdown mode is not used.  $\text{SHDN}$  has no effect on RxOUT. Note that the driver is enabled only when the magnitude of  $V-$  exceeds approximately  $3\text{V}$ .

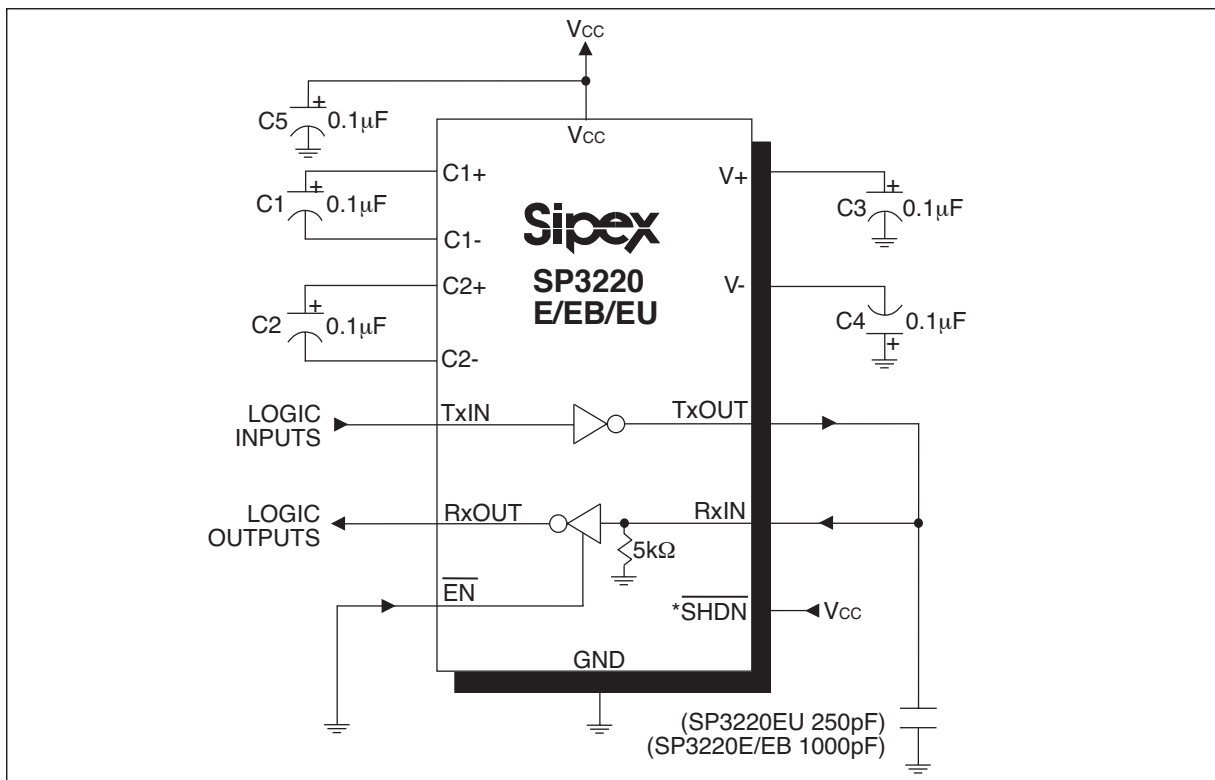


Figure 12. SP3220E/EB/EU Driver Loopback Test Circuit

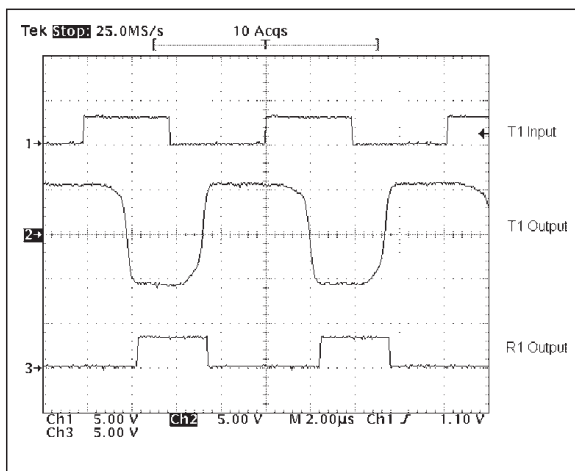


Figure 13. SP3220EB Driver Loopback Test Results at 250Kbps

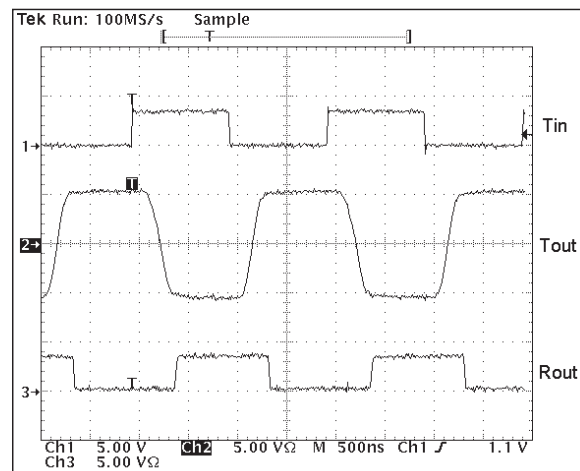


Figure 14. SP3220EU Driver Loopback Test Results at 1Mbps

## Receivers

The receiver converts EIA/TIA-232 levels to TTL or CMOS logic output levels. The receiver has an inverting high-impedance output. This receiver output (RxOUT) is at high-impedance when the enable control  $\overline{\text{EN}} = \text{HIGH}$ . In the shutdown mode, the receiver can be active or inactive.  $\overline{\text{EN}}$  has no effect on TxOUT. The truth table logic of the **SP3220E/EB/EU** driver and receiver outputs can be found in *Table 2*.

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, a 5k $\Omega$  pulldown resistor to ground will commit the output of the receiver to a HIGH state.

## CHARGE PUMP

The charge pump is a **Sipex**—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 5.5V regardless of the input voltage ( $V_{\text{CC}}$ ) over the +3.0V to +5.5V range.

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

*Table 2. Truth Table Logic for Shutdown and Enable Control*

In most circumstances, decoupling the power supply can be achieved adequately using a 0.1 $\mu\text{F}$  bypass capacitor at C5 (*refer to Figure 11*). In applications that are sensitive to power-supply noise, decouple  $V_{\text{CC}}$  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 pumps operate in a discontinuous mode using an internal oscillator. If the output voltages are *less than* a magnitude of 5.5V, the charge pumps are *enabled*; if the output voltages *exceed* a magnitude of 5.5V, the charge pumps are *disabled*. This oscillator controls the four phases of the voltage shifting. A description of each phase follows.

### Phase 1

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

### Phase 2

—  $V_{\text{SS}}$  transfer — Phase two of the clock connects the negative terminal of  $C_2$  to the  $V_{\text{SS}}$  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  $V_{\text{CC}}$  and the negative side is connected to GND.

### Phase 3

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

## 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.

In a no-load condition  $V^+$  and  $V^-$  will be symmetrical, since both  $V^+$  and  $V^-$  are separately generated from  $V_{CC}$ . 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.

## CHARGE PUMP DESIGN GUIDELINES

The charge pump operates with 0.1 $\mu$ F capacitors for 3.3V operation. For other supply voltages, see the table for required capacitor values. Do not use values smaller than those listed. Increasing the capacitor values (e.g., by doubling in value) reduces ripple on the transmitter outputs and may slightly reduce power consumption. C2, C3, and C4 may be increased without changing C1's value.

| Minimum recommended charge pump capacitor value |                                               |
|-------------------------------------------------|-----------------------------------------------|
| Input Voltage $V_{CC}$                          | Charge pump Capacitor value for SP3220E/EB/EU |
| 3.0V to 3.6V                                    | $C1 - C4 = 0.1\mu F$                          |
| 3.0V to 5.5V                                    | $C1 - C4 = 0.22\mu F$                         |

The charge pump oscillator typically operates at greater than 250kHz allowing the pump to run efficiently with small 0.1 $\mu$ F capacitors. Efficient operation depends on rapidly charging and discharging  $C_1$  and  $C_2$ , therefore capacitors should be mounted close to the IC and have low ESR (equivalent series resistance).

Low cost surface mount ceramic capacitors (such as are widely used for power-supply decoupling) are ideal for use on the charge pump. However the charge pumps are designed to be able to function properly with a wide range of capacitor styles and values. If polarized capacitors are used the positive and negative terminals should be connected as shown in the Typical Operating Circuit.

Voltage potential across any of the capacitors will never exceed  $2 \times V_{CC}$ . Therefore capacitors with working voltages as low as 6.3V rating may be used with a 3.0V  $V_{CC}$  supply. The reference terminal of the  $V^+$  capacitor may be connected either to  $V_{CC}$  or ground, but if connected to ground a minimum 10V working voltage is required. Higher working voltages and/or capacitance values may be advised if operating at higher  $V_{CC}$  or to provide greater stability as the capacitors age.

Under lightly loaded conditions the intelligent pump oscillator maximizes efficiency by running only as needed to maintain  $V^+$  and  $V^-$ . Since interface transceivers often spend much of their time at idle, this power-efficient innovation can greatly reduce total power consumption. This improvement is made possible by the independent phase sequence of the **Sipex** charge-pump design.

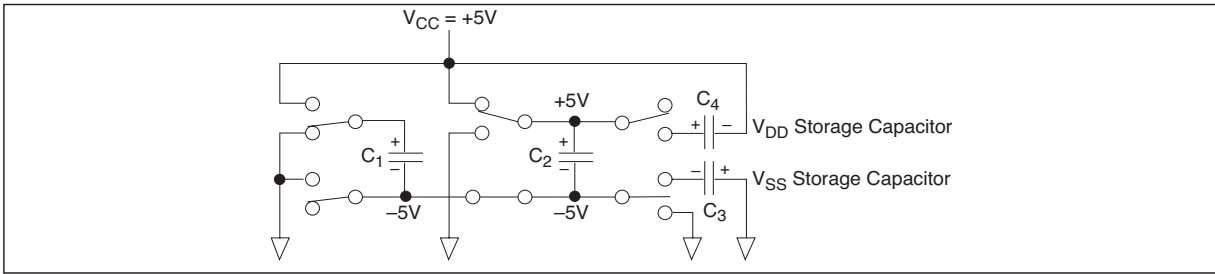


Figure 15. Charge Pump — Phase 1

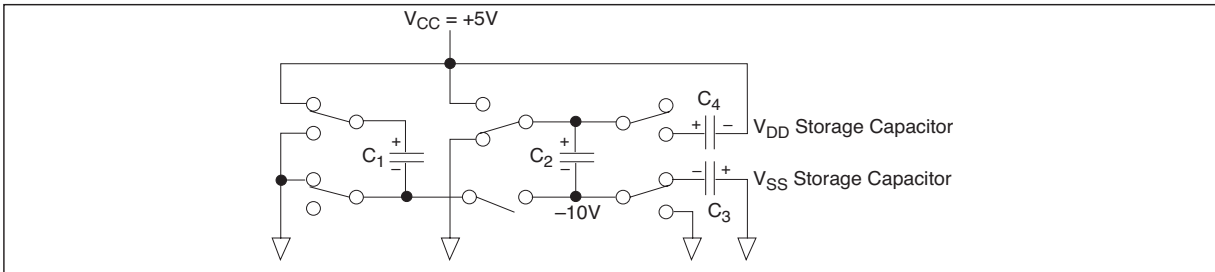


Figure 16. Charge Pump — Phase 2

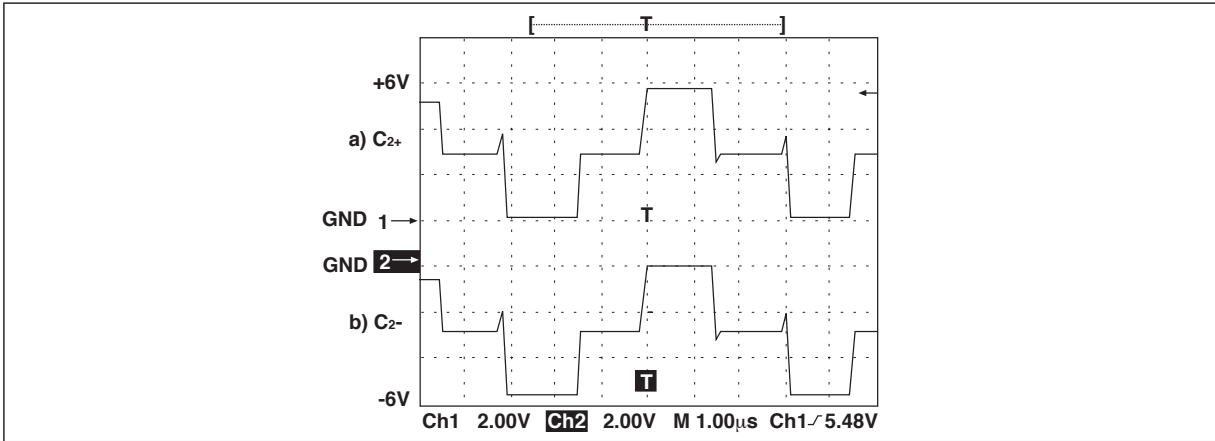


Figure 17. Charge Pump Waveforms

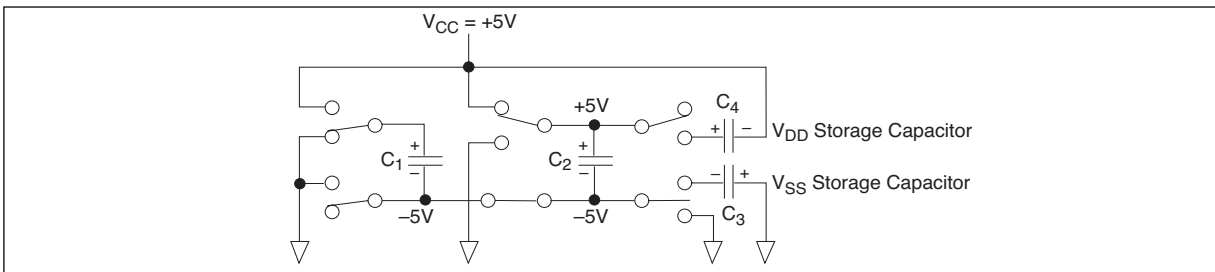


Figure 18. Charge Pump — Phase 3

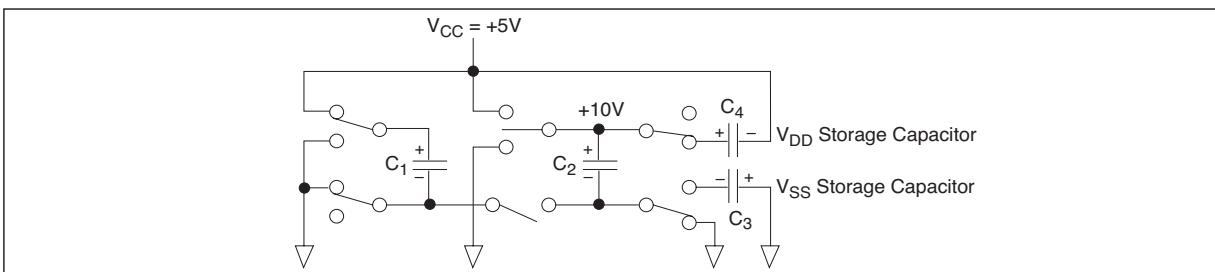


Figure 19. Charge Pump — Phase 4

## ESD TOLERANCE

The **SP3220E/EB/EU** device 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) IEC1000-4-2 Air Discharge
- c) IEC1000-4-2 Direct Contact

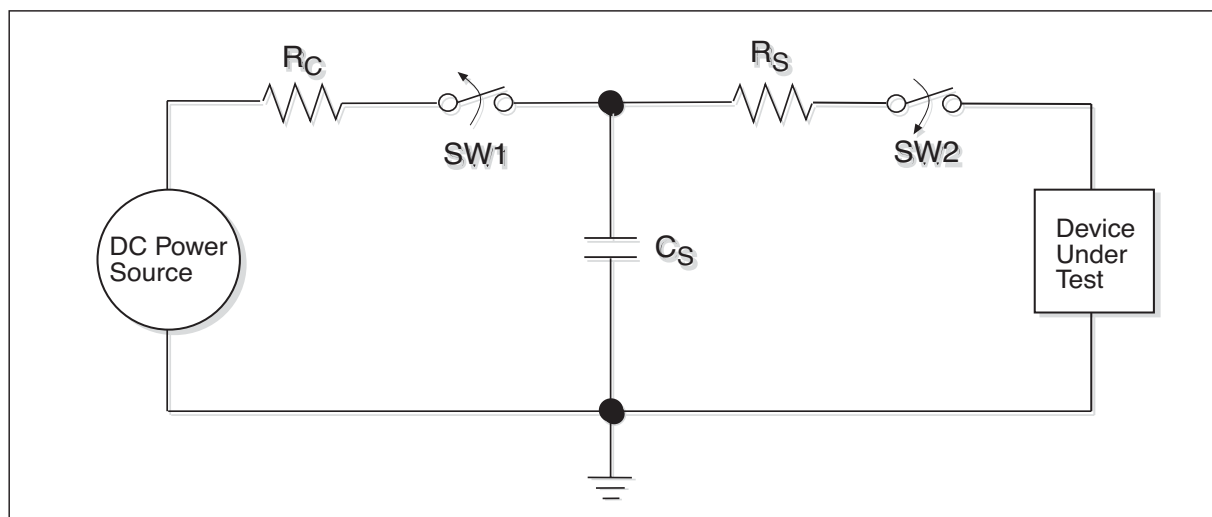
The Human Body Model has been the generally accepted ESD testing method for semiconductors. This method is also specified in MIL-STD-883, Method 3015.7 for ESD testing. The premise of this ESD test is to simulate the human body's potential to store electro-static energy and discharge it to an integrated circuit. The simulation is performed by using a test model as shown in *Figure 20*. This method will test the IC's capability to withstand an ESD transient during normal handling such as in manufacturing areas where the ICs tend to be handled frequently.

The IEC-1000-4-2, formerly IEC801-2, is generally used for testing ESD on equipment and system manufacturers; they must guarantee a certain amount of ESD protection since the system itself is

exposed to the outside environment and human presence. The premise with IEC1000-4-2 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 IEC-1000-4-2 is shown in *Figure 21*. There are two methods within IEC-4-2: the Air Discharge method and the Contact Discharge method.

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 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.



*Figure 20. ESD Test Circuit for Human Body Model*



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 in contact with 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 models in *Figure 20 and 21* represent the typical ESD testing circuits 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.

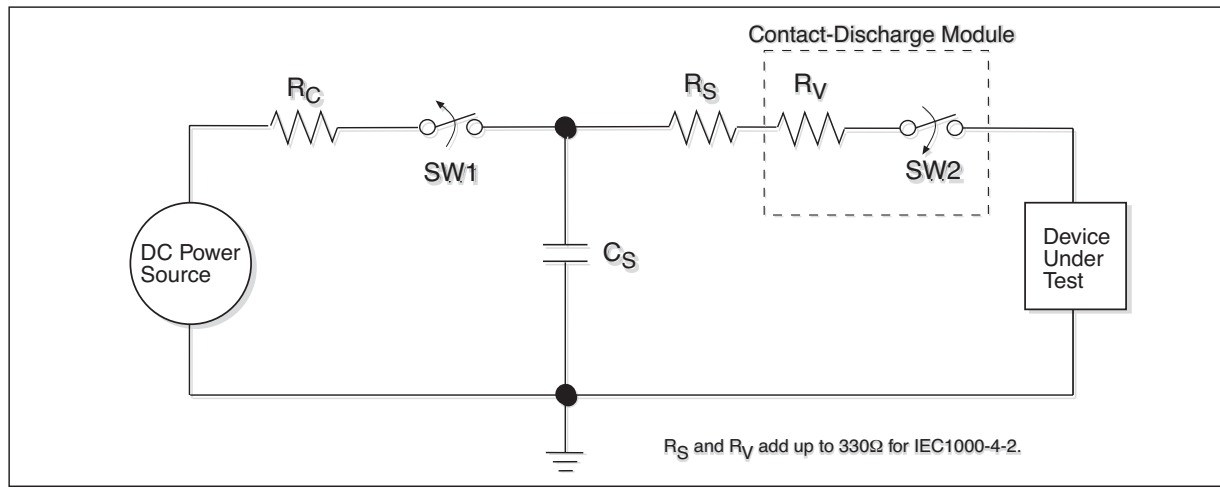


Figure 21. ESD Test Circuit for IEC1000-4-2

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-1000-4-2, 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 IEC1000-4-2 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.

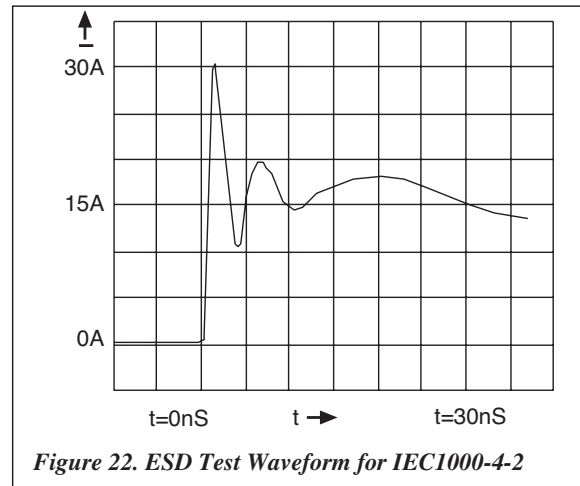
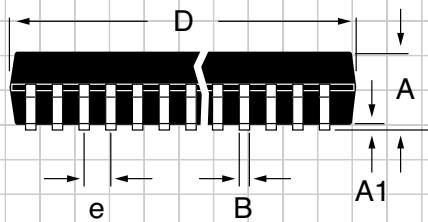
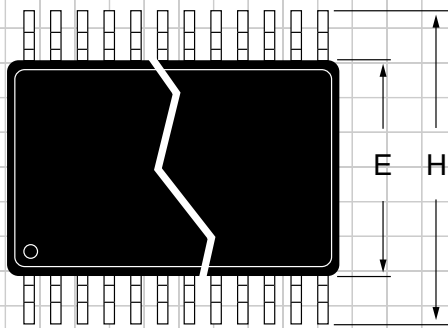


Figure 22. ESD Test Waveform for IEC1000-4-2

| Device Pin Tested | Human Body Model | IEC1000-4-2   |                |       |
|-------------------|------------------|---------------|----------------|-------|
|                   |                  | Air Discharge | Direct Contact | Level |
| Driver Outputs    | $\pm 15kV$       | $\pm 15kV$    | $\pm 8kV$      | 4     |
| Receiver Inputs   | $\pm 15kV$       | $\pm 15kV$    | $\pm 8kV$      | 4     |

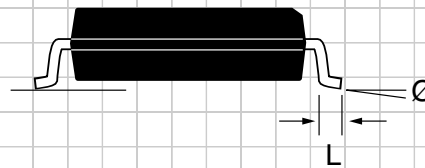
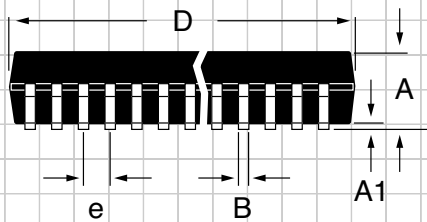
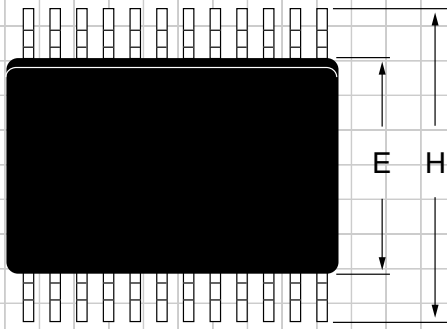
**PACKAGE: PLASTIC SHRINK  
SMALL OUTLINE  
(SSOP)**



| DIMENSIONS (Inches)<br>Minimum/Maximum<br>(mm) | 16-PIN                     | 20-PIN                     | 24-PIN                     | 28-PIN                       |
|------------------------------------------------|----------------------------|----------------------------|----------------------------|------------------------------|
| A                                              | 0.068/0.078<br>(1.73/1.99) | 0.068/0.078<br>(1.73/1.99) | 0.068/0.078<br>(1.73/1.99) | 0.068/0.078<br>(1.73/1.99)   |
| A1                                             | 0.002/0.008<br>(0.05/0.21) | 0.002/0.008<br>(0.05/0.21) | 0.002/0.008<br>(0.05/0.21) | 0.002/0.008<br>(0.05/0.21)   |
| B                                              | 0.010/0.015<br>(0.25/0.38) | 0.010/0.015<br>(0.25/0.38) | 0.010/0.015<br>(0.25/0.38) | 0.010/0.015<br>(0.25/0.38)   |
| D                                              | 0.239/0.249<br>(6.07/6.33) | 0.278/0.289<br>(7.07/7.33) | 0.317/0.328<br>(8.07/8.33) | 0.397/0.407<br>(10.07/10.33) |
| E                                              | 0.205/0.212<br>(5.20/5.38) | 0.205/0.212<br>(5.20/5.38) | 0.205/0.212<br>(5.20/5.38) | 0.205/0.212<br>(5.20/5.38)   |
| e                                              | 0.0256 BSC<br>(0.65 BSC)   | 0.0256 BSC<br>(0.65 BSC)   | 0.0256 BSC<br>(0.65 BSC)   | 0.0256 BSC<br>(0.65 BSC)     |
| H                                              | 0.301/0.311<br>(7.65/7.90) | 0.301/0.311<br>(7.65/7.90) | 0.301/0.311<br>(7.65/7.90) | 0.301/0.311<br>(7.65/7.90)   |
| L                                              | 0.022/0.037<br>(0.55/0.95) | 0.022/0.037<br>(0.55/0.95) | 0.022/0.037<br>(0.55/0.95) | 0.022/0.037<br>(0.55/0.95)   |
| Ø                                              | 0°/8°<br>(0°/8°)           | 0°/8°<br>(0°/8°)           | 0°/8°<br>(0°/8°)           | 0°/8°<br>(0°/8°)             |

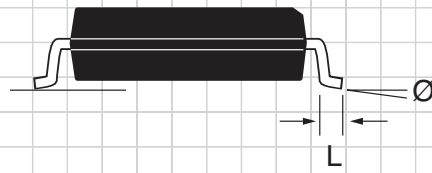
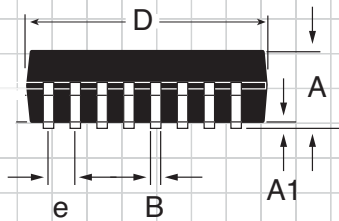
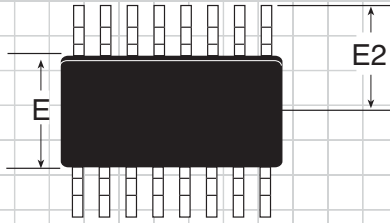


**PACKAGE: PLASTIC**  
**SMALL OUTLINE (SOIC)**



| DIMENSIONS (Inches)<br>Minimum/Maximum<br>(mm) | 16-PIN                       | 18-PIN                       |
|------------------------------------------------|------------------------------|------------------------------|
| A                                              | 0.090/0.104<br>(2.29/2.649)  | 0.090/0.104<br>(2.29/2.649)  |
| A1                                             | 0.004/0.012<br>(0.102/0.300) | 0.004/0.012<br>(0.102/0.300) |
| B                                              | 0.013/0.020<br>(0.330/0.508) | 0.013/0.020<br>(0.330/0.508) |
| D                                              | 0.398/0.413<br>(10.10/10.49) | 0.447/0.463<br>(11.35/11.74) |
| E                                              | 0.291/0.299<br>(7.402/7.600) | 0.291/0.299<br>(7.402/7.600) |
| e                                              | 0.050 BSC<br>(1.270 BSC)     | 0.050 BSC<br>(1.270 BSC)     |
| H                                              | 0.394/0.419<br>(10.00/10.64) | 0.394/0.419<br>(10.00/10.64) |
| L                                              | 0.016/0.050<br>(0.406/1.270) | 0.016/0.050<br>(0.406/1.270) |
| Ø                                              | 0°/8°<br>(0°/8°)             | 0°/8°<br>(0°/8°)             |

# PACKAGE: PLASTIC THIN SMALL OUTLINE (TSSOP)



| DIMENSIONS<br>in inches (mm)<br>Minimum/Maximum | 16-PIN                     | 20-PIN                     |
|-------------------------------------------------|----------------------------|----------------------------|
| A                                               | - /0.043<br>(- /1.10)      | - /0.043<br>(- /1.10)      |
| A1                                              | 0.002/0.006<br>(0.05/0.15) | 0.002/0.006<br>(0.05/0.15) |
| B                                               | 0.007/0.012<br>(0.19/0.30) | 0.007/0.012<br>(0.19/0.30) |
| D                                               | 0.193/0.201<br>(4.90/5.10) | 0.252/0.260<br>(6.40/6.60) |
| E                                               | 0.169/0.177<br>(4.30/4.50) | 0.169/0.177<br>(4.30/4.50) |
| e                                               | 0.026 BSC<br>(0.65 BSC)    | 0.026 BSC<br>(0.65 BSC)    |
| E2                                              | 0.126 BSC<br>(3.20 BSC)    | 0.126 BSC<br>(3.20 BSC)    |
| L                                               | 0.020/0.030<br>(0.50/0.75) | 0.020/0.030<br>(0.50/0.75) |
| Ø                                               | 0°/8°                      | 0°/8°                      |

## RECOMMENDED UPGRADES

Contact factory for availability of the following legacy part numbers. For long term availability Sipex recommends upgrades as listed below. All upgrade part numbers shown are fully pinout and function compatible with legacy part numbers. Upgrade part numbers may contain feature and/or performance enhancements or other changes to datasheet parameters.

| Legacy Part Number | Recommended Upgrade |
|--------------------|---------------------|
| SP3220CA .....     | SP3220ECA           |
| SP3220CA-L .....   | SP3220ECA-L         |
| SP3220CT .....     | SP3220ECT           |
| SP3220CY .....     | SP3220ECY           |
| SP3220EA .....     | SP3220EEA           |
| SP3220ET .....     | SP3220EET           |
| SP3220EY .....     | SP3220EEY           |
| SP3220BCA .....    | SP3220EBCA          |
| SP3220BCT .....    | SP3220EBCT          |
| SP3220BCY .....    | SP3220EBCY          |
| SP3220BEA .....    | SP3220EBEA          |
| SP3220BET .....    | SP3220EBET          |
| SP3220BEY .....    | SP3220EBEY          |
| SP3220UCA .....    | SP3220EUCA          |
| SP3220UCT .....    | SP3220EUCT          |
| SP3220UCY .....    | SP3220EUCY          |
| SP3220UEA .....    | SP3220EUEA          |
| SP3220UET .....    | SP3220EUET          |
| SP3220UEY .....    | SP3220EUEY          |

## ORDERING INFORMATION

| Model               | Temperature Range    | Package Type     |
|---------------------|----------------------|------------------|
| SP3220EBCA .....    | 0°C to +70°C .....   | 16-Pin SSOP      |
| SP3220EBCA/TR ..... | 0°C to +70°C .....   | 16-Pin SSOP      |
| SP3220EBCT .....    | 0°C to +70°C .....   | 16-Pin Wide SOIC |
| SP3220EBCT/TR ..... | 0°C to +70°C .....   | 16-Pin Wide SOIC |
| SP3220EBCY .....    | 0°C to +70°C .....   | 16-Pin TSSOP     |
| SP3220EBCY/TR ..... | 0°C to +70°C .....   | 16-Pin TSSOP     |
|                     |                      |                  |
| SP3220EBEA .....    | -40°C to +85°C ..... | 16-Pin SSOP      |
| SP3220EBEA/TR ..... | -40°C to +85°C ..... | 16-Pin SSOP      |
| SP3220EBET .....    | -40°C to +85°C ..... | 16-Pin Wide SOIC |
| SP3220EBET/TR ..... | -40°C to +85°C ..... | 16-Pin Wide SOIC |
| SP3220EBEY .....    | -40°C to +85°C ..... | 16-Pin TSSOP     |
| SP3220EBEY/TR ..... | -40°C to +85°C ..... | 16-Pin TSSOP     |
|                     |                      |                  |
| SP3220ECA .....     | 0°C to +70°C .....   | 16-Pin SSOP      |
| SP3220ECA/TR .....  | 0°C to +70°C .....   | 16-Pin SSOP      |
| SP3220ECT .....     | 0°C to +70°C .....   | 16-Pin WSOIC     |
| SP3220ECT/TR .....  | 0°C to +70°C .....   | 16-Pin WSOIC     |
| SP3220ECY .....     | 0°C to +70°C .....   | 16-Pin TSSOP     |
| SP3220ECY/TR .....  | 0°C to +70°C .....   | 16-Pin TSSOP     |

Available in lead free packaging. To order add "-L" suffix to part number.

Example: SP3220ECA/TR = standard; SP3220ECA-L/TR = Lead Free

/TR = Tape and Reel

Pack quantity is 1,500 for WSOIC, or SSOP; pack quantity is 2,500 for 16-pin TSSOP.

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e-mail: sales@sipex.com

## ORDERING INFORMATION

| Model               | Temperature Range    | Package Type     |
|---------------------|----------------------|------------------|
| SP3220EEA .....     | -40°C to +85°C ..... | 16-Pin SSOP      |
| SP3220EEA/TR .....  | -40°C to +85°C ..... | 16-Pin SSOP      |
| SP3220EET .....     | -40°C to +85°C ..... | 16-Pin WSOIC     |
| SP3220EET/TR .....  | -40°C to +85°C ..... | 16-Pin WSOIC     |
| SP3220EEY .....     | -40°C to +85°C ..... | 16-Pin TSSOP     |
| SP3220EEY/TR .....  | -40°C to +85°C ..... | 16-Pin TSSOP     |
|                     |                      |                  |
| SP3220EUCA .....    | 0°C to +70°C .....   | 16-Pin SSOP      |
| SP3220EUCA/TR ..... | 0°C to +70°C .....   | 16-Pin SSOP      |
| SP3220EUCT .....    | 0°C to +70°C .....   | 16-Pin Wide SOIC |
| SP3220EUCT/TR ..... | 0°C to +70°C .....   | 16-Pin Wide SOIC |
| SP3220EUCY/TR ..... | 0°C to +70°C .....   | 16-Pin TSSOP     |
| SP3220EUCY .....    | 0°C to +70°C .....   | 16-Pin TSSOP     |
|                     |                      |                  |
| SP3220EUEA .....    | -40°C to +85°C ..... | 16-Pin SSOP      |
| SP3220EUEA/TR ..... | -40°C to +85°C ..... | 16-Pin SSOP      |
| SP3220EUET .....    | -40°C to +85°C ..... | 16-Pin Wide SOIC |
| SP3220EUET/TR ..... | -40°C to +85°C ..... | 16-Pin Wide SOIC |
| SP3220EUEY .....    | -40°C to +85°C ..... | 16-Pin TSSOP     |
| SP3220EUEY/TR ..... | -40°C to +85°C ..... | 16-Pin TSSOP     |

Available in lead free packaging. To order add "-L" suffix to part number.

Example: SP3220ECA/TR = standard; SP3220ECA-L/TR = Lead Free

/TR = Tape and Reel

Pack quantity is 1,500 for WSOIC, or SSOP; pack quantity is 2,500 for 16-pin TSSOP.

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e-mail: sales@sipex.com



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Электрон  
Связь**

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**Электронная почта:** [sales@st-electron.ru](mailto:sales@st-electron.ru)

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