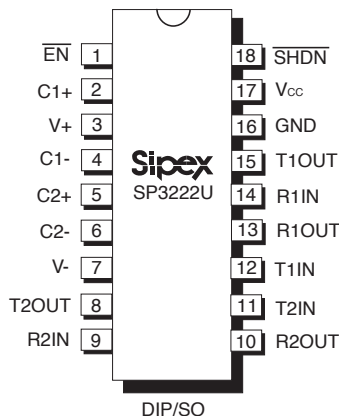


3.3V, 1000 Kbps RS-232 Transceivers

FEATURES

- Meets true EIA/TIA-232-F Standards from a +3.0V to +5.5V power supply
- Interoperable with EIA/TIA - 232 and adheres to EIA/TIA - 562 down to a +2.7V power source
- 1 μ A Low-Power Shutdown with Receivers Active (**SP3222U**)
- ESD Specifications:
±2kV Human Body Model
- 1000 kbps Minimum Transmission Rate
- Ideal for Handheld, Battery Operated Applications



Now Available in Lead Free Packaging

Note: See page 6 for other pinouts

DESCRIPTION

The SP3222U and the SP3232U are 2 driver, 2 receiver RS-232 transceiver solutions intended for portable or hand-held applications such as notebook or palmtop computers. Their data transmission rate of 1000 kbps meets the demands of high speed RS-232 applications. Both ICs have a high-efficiency, charge-pump power supply that requires only 0.1 μ F capacitors in 3.3V operation. This charge pump allows the SP3222U and the 3232U to deliver true RS-232 performance from a single power supply ranging from +3.0V to +5.5V.

The SP3222U 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 μ A.

SELECTION TABLE

MODEL	Power Supplies	RS-232 Drivers	RS-232 Receivers	External Components	Shutdown	TTL 3-State	No. of Pins
SP3222U	+3.0V to +5.5V	2	2	4	Yes	Yes	18, 20
SP3232U	+3.0V to +5.5V	2	2	4	No	No	16

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) $\pm 100mA$

Input Voltages

$TxIN, EN$ -0.3V to +6.0V
 $RxIN$ $\pm 25V$

Output Voltages

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

Short-Circuit Duration

$TxOUT$ Continuous

Storage Temperature -65°C to +150°C

Power	Dissipation	Per	Package
20-pin SSOP (derate 9.25mW/°C above +70°C)		750mW	
18-pin PDIP (derate 15.2mW/°C above +70°C)		1220mW	
18-pin SOIC (derate 15.7mW/°C above +70°C)		1260mW	
20-pin TSSOP (derate 11.1mW/°C above +70°C)		890mW	
16-pin SSOP (derate 9.69mW/°C above +70°C)		775mW	
16-pin PDIP (derate 14.3mW/°C above +70°C)		1150mW	
16-pin Wide SOIC (derate 11.2mW/°C above +70°C)		900mW	
16-pin TSSOP (derate 10.5mW/°C above +70°C)		850mW	
16-pin nSOIC (derate 13.57mW/°C above +70°C)		1086mW	

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

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} , C_1 to $C_4 = 0.1\mu F$

PARAMETER	MIN.	TYP.	MAX.	UNITS	CONDITIONS
DC CHARACTERISTICS					
Supply Current		0.3	1.0	mA	no load, $T_{AMB} = +25^\circ C$, $V_{CC} = 3.3V$, $TxIN = GND$ or V_{CC}
Shutdown Supply Current		1.0	10	μA	$\overline{SHDN} = GND$, $T_{AMB} = +25^\circ C$, $V_{CC} = +3.3V$, $TxIN = GND$ or V_{CC}
LOGIC INPUTS AND RECEIVER OUTPUTS					
Input Logic Threshold LOW			0.8	V	$TxIN, \overline{EN}, \overline{SHDN}$, Note 2
Input Logic Threshold HIGH	2.0 2.4			V	$V_{CC} = 3.3V$, Note2 $V_{CC} = 5.0V$, Note 2
Input Leakage Current		± 0.01	± 1.0	μA	$TxIN, \overline{EN}, \overline{SHDN}$, $T_{AMB} = +25^\circ C$, $V_{IN} = 0V$ to V_{CC}
Output Leakage Current		± 0.05	± 10	μA	receivers disabled, $V_{OUT} = 0V$ to V_{CC}
Output Voltage LOW			0.4	V	$I_{OUT} = 1.6mA$
Output Voltage HIGH	$V_{CC}-0.6$	$V_{CC}-0.1$		V	$I_{OUT} = -1.0mA$
DRIVER OUTPUTS					
Output Voltage Swing	± 5.0	± 5.4		V	3k Ω load to ground at all driver outputs, $T_{AMB} = +25^\circ C$
Output Resistance	300			Ω	$V_{CC} = V+ = V- = 0V$, $T_{OUT} = +2V$
Output Short-Circuit Current		± 35	± 60	mA	$V_{OUT} = 0V$
Output Leakage Current			± 25	μA	$V_{OUT} = +12V$, $V_{CC} = 0V$ to $5.5V$, drivers disabled

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} , C_1 to $C_4 = 0.1\mu F$. Typical Values apply at $V_{CC} = +3.3V$ or $+5.5V$ and $T_{AMB} = 25^\circ C$.

PARAMETER	MIN.	TYP.	MAX.	UNITS	CONDITIONS
RECEIVER INPUTS					
Input Voltage Range	-25		+25	V	
Input Threshold LOW	0.6	1.2		V	$V_{CC}=3.3V$
	0.8	1.5		V	$V_{CC}=5.0V$
Input Threshold HIGH		1.5	2.4	V	$V_{CC}=3.3V$
		1.8	2.4	V	$V_{CC}=5.0V$
Input Hysteresis		0.3		V	
Input Resistance	3	5	7	k Ω	
TIMING CHARACTERISTICS					
Maximum Data Rate	1000			kbps	$R_L=3k\Omega$, $C_L=250pF$, one driver switching
Receiver Propagation Delay		0.15		μs	t_{PHL} , RxIN to RxOUT, $C_L=150pF$
		0.15		μs	t_{PLH} , 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		V/ μs	$V_{CC} = 3.3V$, $R_L = 3K\Omega$, $T_{AMB} = 25^\circ C$, measurements taken from -3.0V to +3.0V or +3.0V to -3.0V

NOTE 2: Driver input hysteresis is typically 250mV.

TYPICAL PERFORMANCE CHARACTERISTICS

Unless otherwise noted, the following performance characteristics apply for $V_{CC} = +3.3V$, 1000kbps data rates, all drivers loaded with $3k\Omega$, $0.1\mu F$ charge pump capacitors, and $T_{AMB} = +25^{\circ}C$.

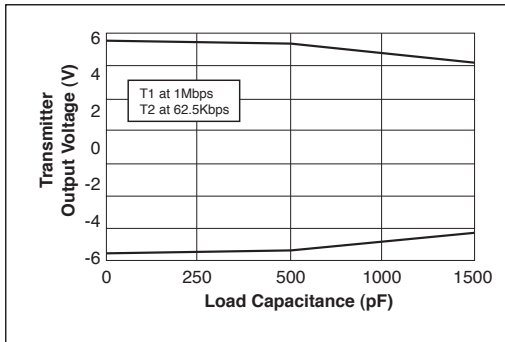


Figure 1. Transmitter Output Voltage vs Load Capacitance for the SP3222U and the SP3232U

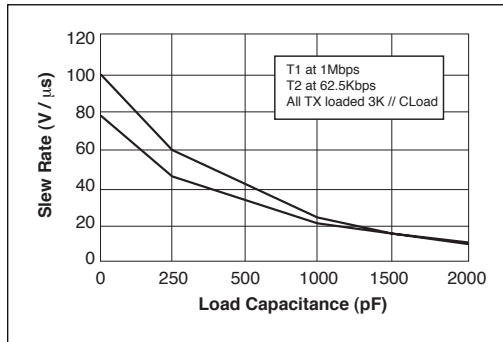


Figure 2. Slew Rate vs Load Capacitance for the SP3222U and the SP3232U

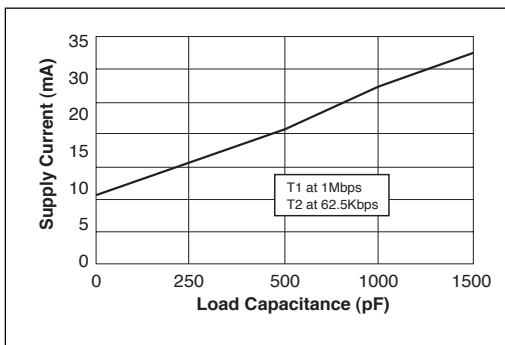


Figure 3. Supply Current vs Load Capacitance when Transmitting Data for the SP3222U and the SP3232U

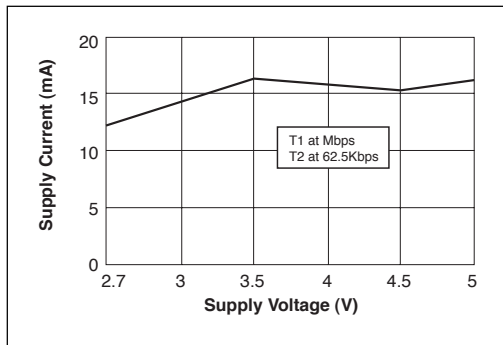


Figure 4. Supply Current vs Supply Voltage for the SP3222U and the SP3232U

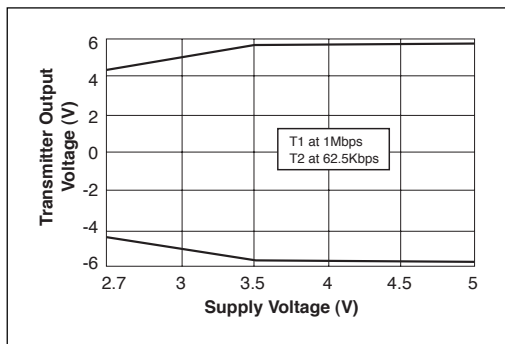


Figure 5. Transmitter Output Voltage vs Supply Voltage for the SP3222U and the SP3232U

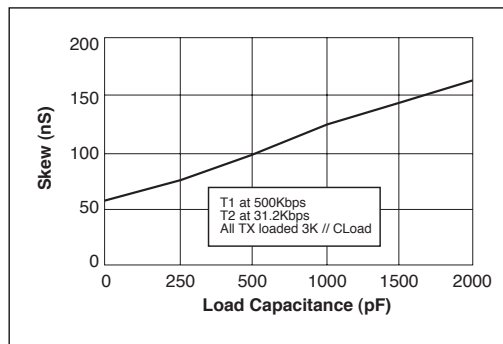


Figure 6. Transmitter Skew vs Load Capacitance for the SP3222U and the SP3232U

NAME	FUNCTION	PIN NUMBER		
		SP3222U		SP3232U
		DIP/SO	SSOP TSSOP	
$\overline{\text{EN}}$	Receiver Enable. Apply logic LOW for normal operation. Apply logic HIGH to disable the receiver outputs (high-Z state).	1	1	-
C1+	Positive terminal of the voltage doubler charge-pump capacitor.	2	2	1
V+	+5.5V generated by the charge pump.	3	3	2
C1-	Negative terminal of the voltage doubler charge-pump capacitor.	4	4	3
C2+	Positive terminal of the inverting charge-pump capacitor.	5	5	4
C2-	Negative terminal of the inverting charge-pump capacitor.	6	6	5
V-	-5.5V generated by the charge pump.	7	7	6
T1OUT	RS-232 driver output.	15	17	14
T2OUT	RS-232 driver output.	8	8	7
R1IN	RS-232 receiver input.	14	16	13
R2IN	RS-232 receiver input.	9	9	8
R1OUT	TTL/CMOS receiver output.	13	15	12
R2OUT	TTL/CMOS receiver output.	10	10	9
T1IN	TTL/CMOS driver input.	12	13	11
T2IN	TTL/CMOS driver input.	11	12	10
GND	Ground.	16	18	15
V _{CC}	+3.0V to +5.5V supply voltage	17	19	16
$\overline{\text{SHDN}}$	Shutdown Control Input. Drive HIGH for normal device operation. Drive LOW to shutdown the drivers (high-Z output) and the on-board power supply.	18	20	-
N.C.	No Connect.	-	11, 14	-

Table 1. Device Pin Description

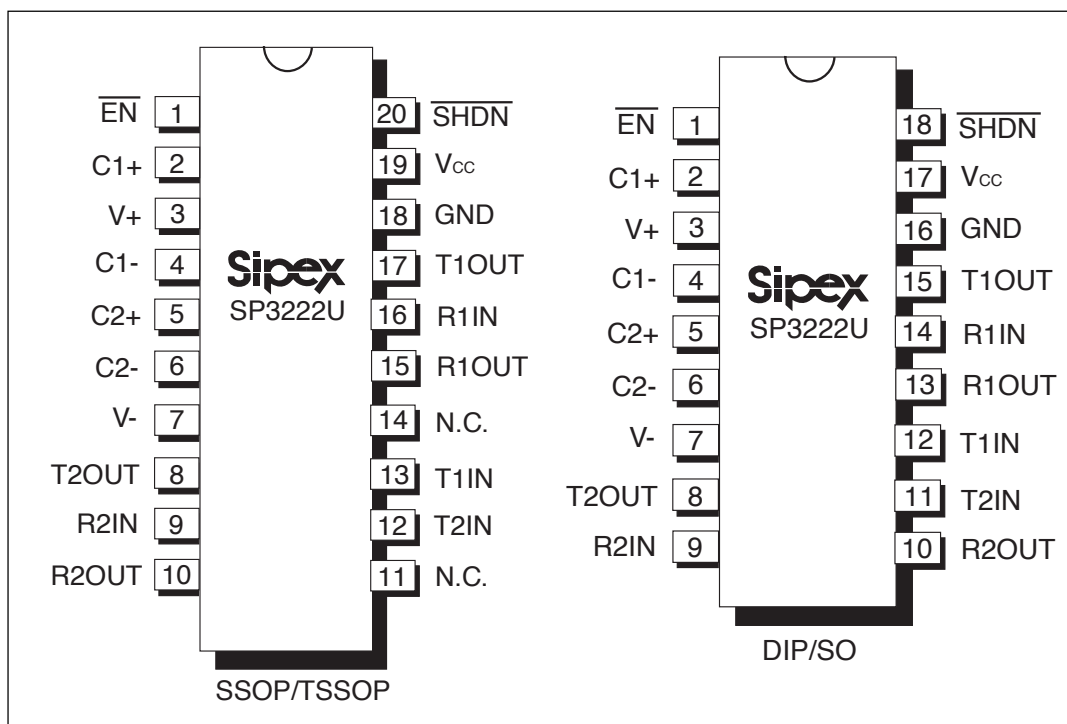


Figure 7. Pinout Configurations for the SP3222U

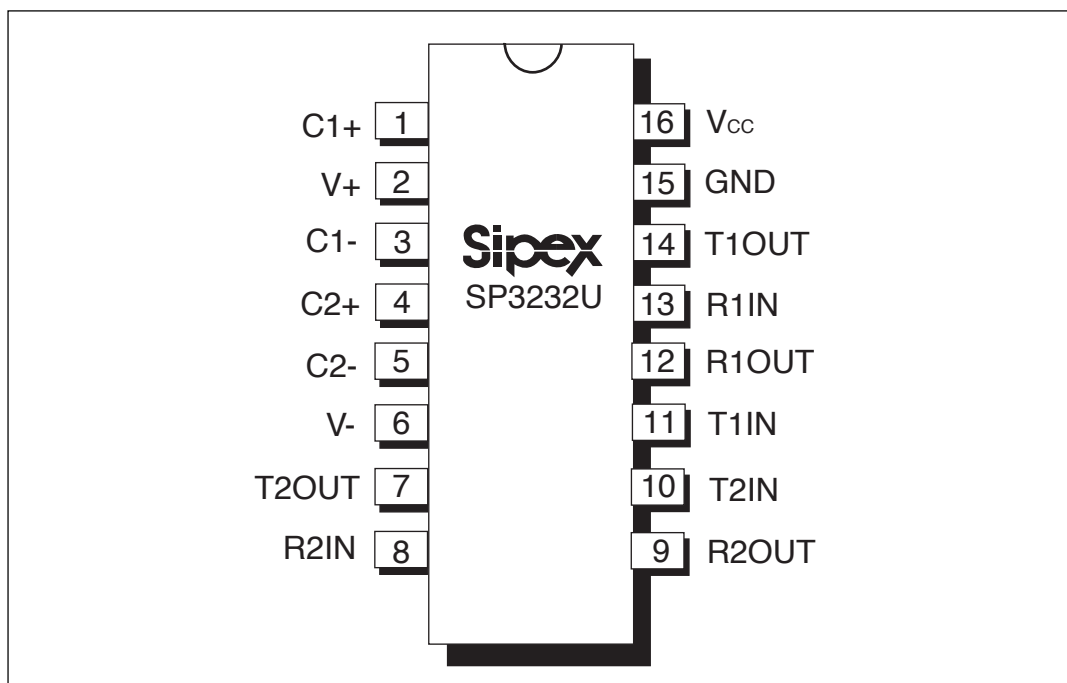


Figure 8. Pinout Configuration for the SP3232U

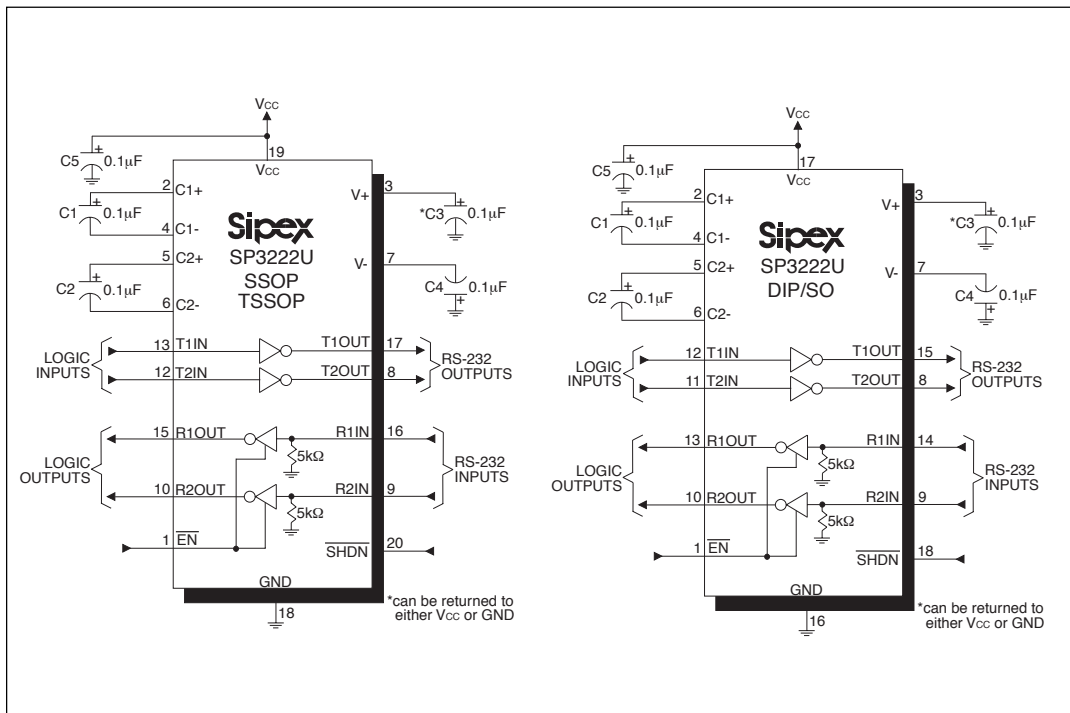


Figure 9. SP3222U Typical Operating Circuits

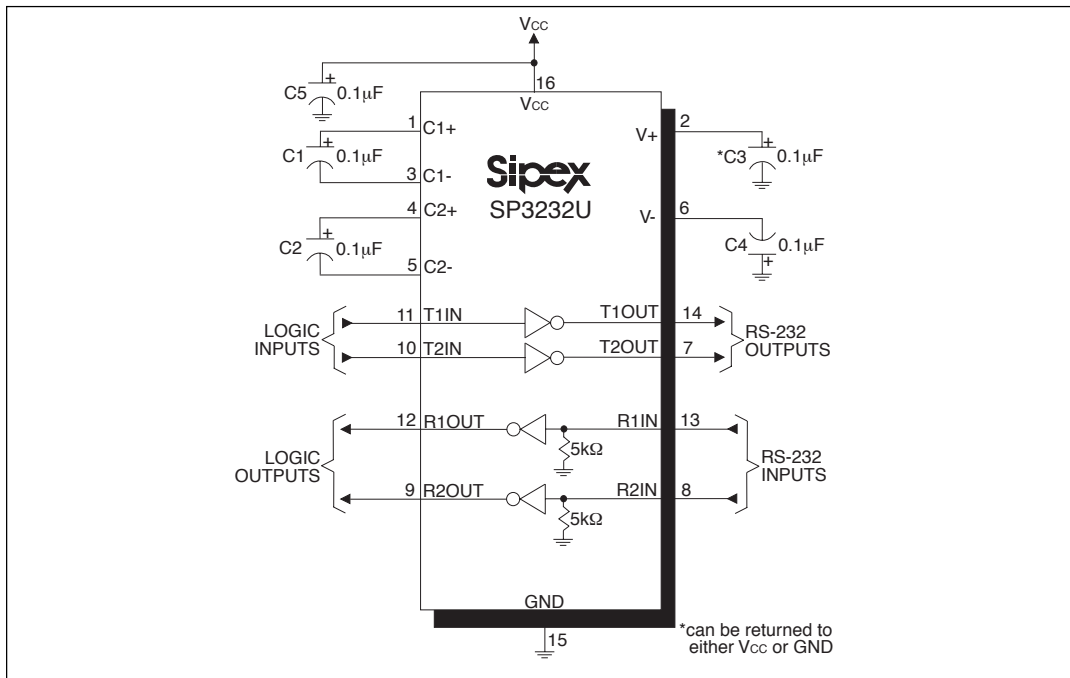


Figure 10. SP3232U Typical Operating Circuit

DESCRIPTION

The **SP3222U** and **SP3232U** are 2 driver/ 2-receiver devices ideal for portable or hand-held applications. The **SP3222U** features a 1 μ 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 μ A supply current.

The **SP3222U/3232U** transceivers meet the EIA/TIA-232 and V.28/V.24 communication protocols. They feature **Sipex's** proprietary on-board charge pump circuitry that generates 2 x V_{CC} for RS-232 voltage levels from a single +3.0V to +5.5V power supply. The **SP3222U/3232U** drivers operate at a minimum data rate of 1000kbps.

THEORY OF OPERATION

The **SP3222U/3232U** series are made up of three basic circuit blocks: 1. Drivers, 2. Receivers, and 3. the Sipex proprietary charge pump.

Drivers

The drivers are inverting level transmitters that convert TTL or CMOS logic levels to $\pm 5.0V$ EIA/TIA-232 levels inverted relative to the input logic levels. Typically, the RS-232 output voltage swing is $\pm 5.5V$ with no load and at least $\pm 5V$ 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 have a minimum data rate of 1000kbps fully loaded with 3K Ω in parallel with 250pF, ensuring compatibility with PC-to-PC communication software.

Figure 11 shows a loopback test circuit used to the RS-232 drivers. *Figure 12* shows the test results of the loopback circuit with all drivers

active at 250kbps with RS-232 loads in parallel with 1000pF capacitors. *Figure 13* shows the test results where one driver was active at 1000kbps and all drivers loaded with an RS-232 receiver in parallel with a 250pF capacitor.

The **SP3222U** driver's output stages are tristated in shutdown mode. When the power is off, the **SP3222U** device permits the outputs to be driven up to $\pm 12V$. Because the driver's inputs do not have pull-up resistors, unused inputs should be connected to V_{CC} or GND.

In the shutdown mode, the supply current is less than 1 μ A, where SHDN = LOW. When the **SP3222U** 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 μ s. Connect 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 **SP3222U** receivers have an inverting tri-state output. Receiver outputs (RxOUT) are tri-stated when the enable control EN = HIGH. In the shutdown mode, the receivers can be active or inactive. EN has no effect on TxOUT. The truth table logic of the **SP3222U** 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 and inject noise, the inputs have a typical hysteresis margin of 300mV. Should an input be left unconnected, a 5k Ω pulldown resistor to ground will commit the output of the receiver to a HIGH state.

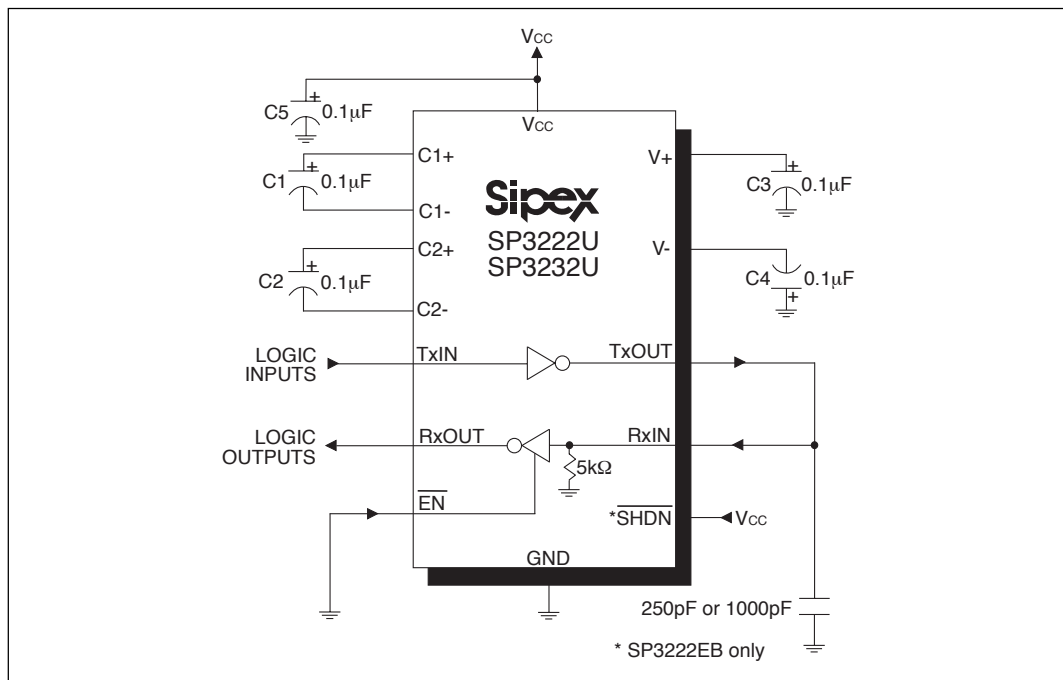


Figure 11. SP3222U/3232U Driver Loopback Test Circuit

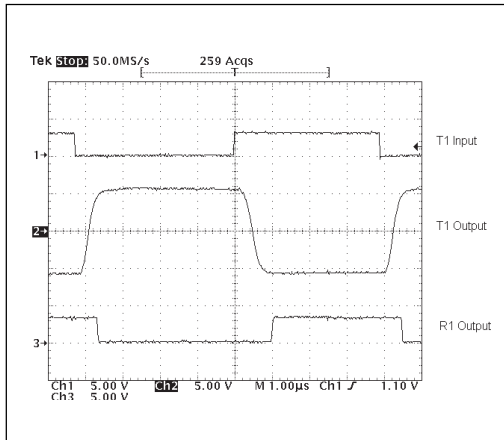


Figure 12. Driver Loopback Test All Drivers at 250kbps

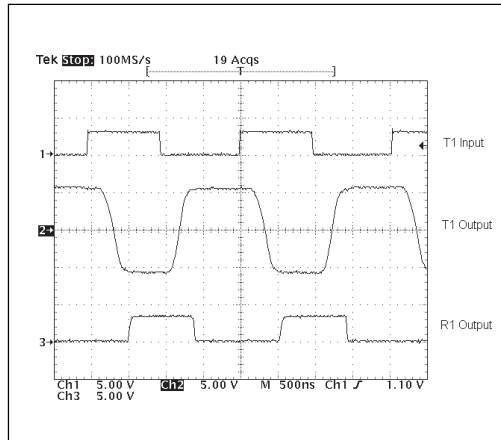


Figure 13. Driver Loopback Test One Driver 1Mbps

Charge Pump

The charge pump is a **Sipex**–patented design (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_{CC}) over the +3.0V to +5.5V range.

In most circumstances, decoupling the power supply can be achieved adequately using a 0.1 μ F bypass capacitor at C5 (refer to *Figures 9 and 10*). 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 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 voltage 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_{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.

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

Table 2. SP3222U Truth Table Logic for Shutdown and Enable Control

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

ESD Tolerance

The **SP3222U/3232U** 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 electrostatic discharges and associated transients.

The Human Body Model has been the generally accepted ESD testing method for semiconduc-

tors. 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 electrostatic 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.

For the Human Body Model, the current limiting resistor (R_s) and the source capacitor (C_s) are 1.5k Ω and 100pF, respectively.

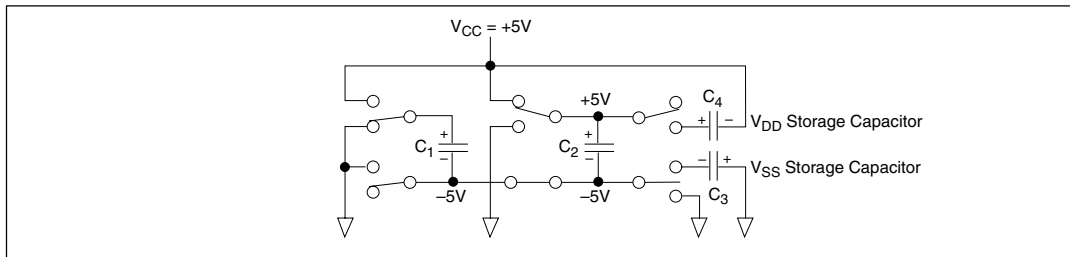


Figure 15. Charge Pump — Phase 1

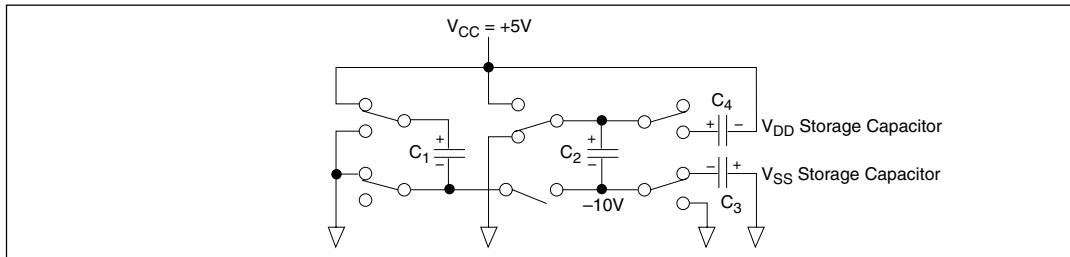


Figure 16. Charge Pump — Phase 2

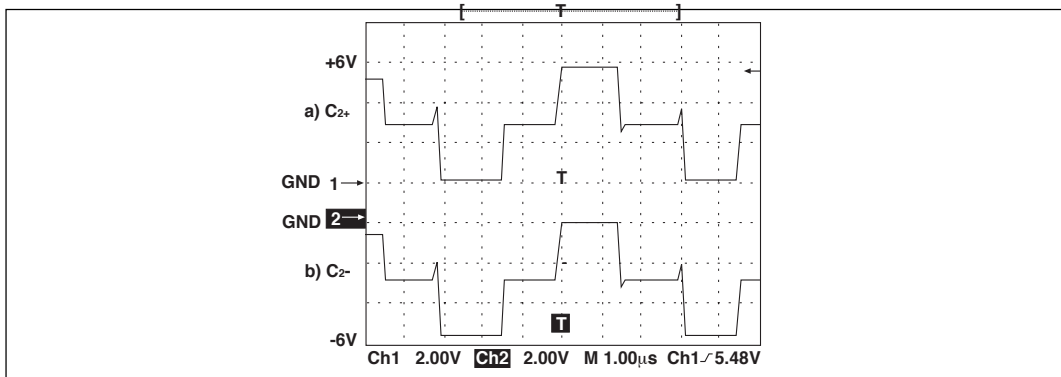


Figure 17. Charge Pump Waveforms

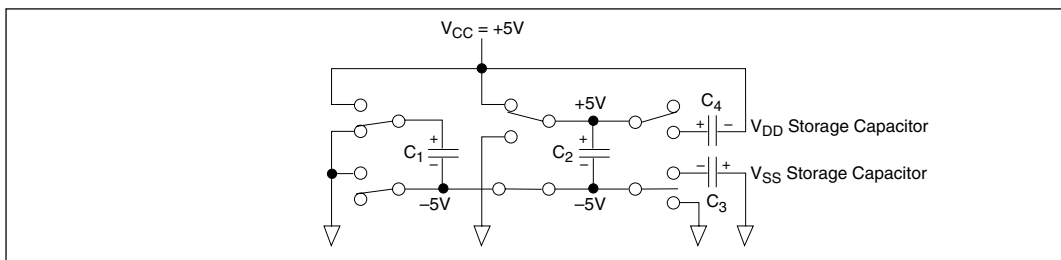


Figure 18. Charge Pump — Phase 3

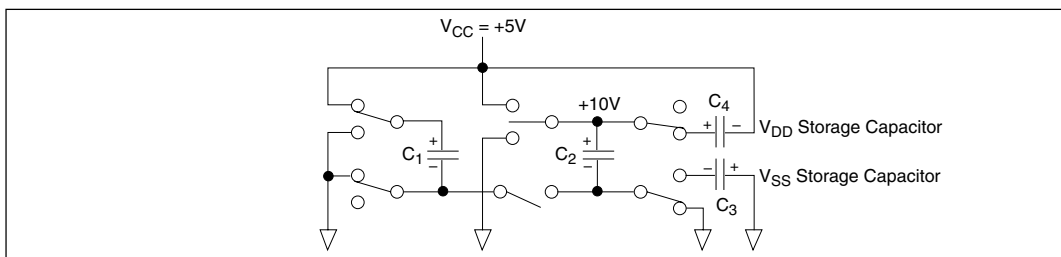


Figure 19. Charge Pump — Phase 4

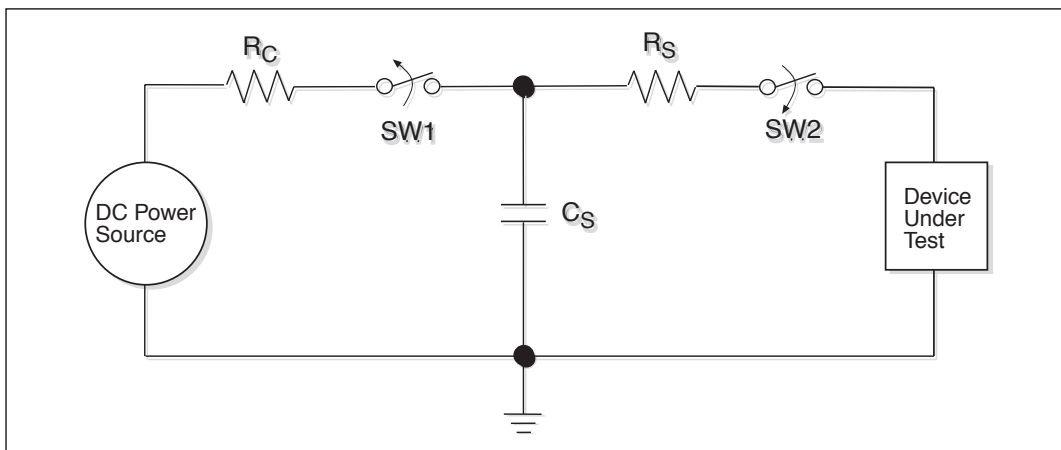
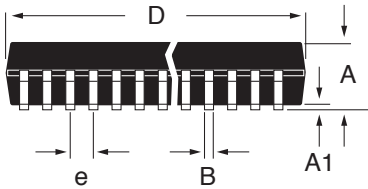
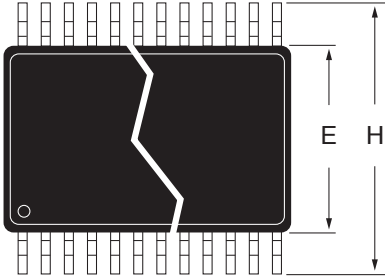


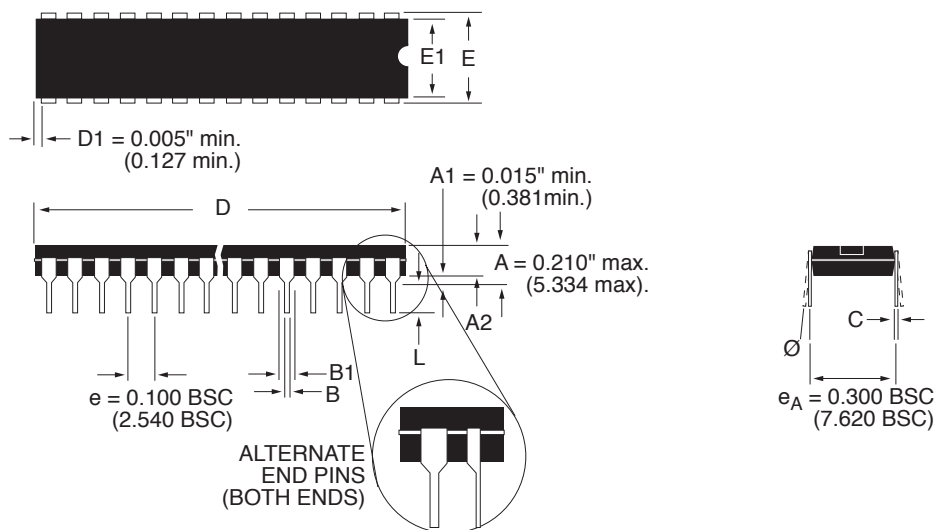
Figure 20. ESD Test Circuit for Human Body Model

PACKAGE: PLASTIC SHRINK SMALL OUTLINE (SSOP)



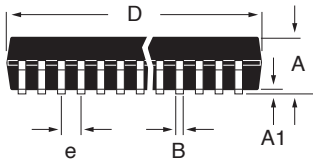
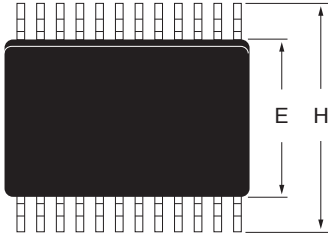
DIMENSIONS (Inches) Minimum/Maximum (mm)	16-PIN	20-PIN
A	0.068/0.078 (1.73/1.99)	0.068/0.078 (1.73/1.99)
A1	0.002/0.008 (0.05/0.21)	0.002/0.008 (0.05/0.21)
B	0.010/0.015 (0.25/0.38)	0.010/0.015 (0.25/0.38)
D	0.239/0.249 (6.07/6.33)	0.278/0.289 (7.07/7.33)
E	0.205/0.212 (5.20/5.38)	0.205/0.212 (5.20/5.38)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

PACKAGE: PLASTIC DUAL-IN-LINE (NARROW)



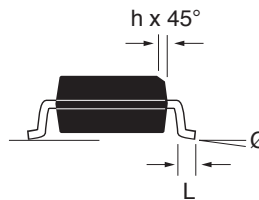
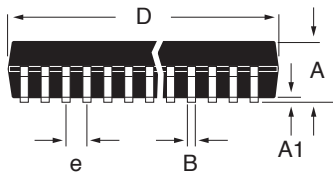
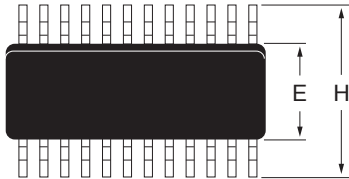
DIMENSIONS (Inches) Minimum/Maximum (mm)	16-PIN	18-PIN
A2	0.115/0.195 (2.921/4.953)	0.115/0.195 (2.921/4.953)
B	0.014/0.022 (0.356/0.559)	0.014/0.022 (0.356/0.559)
B1	0.045/0.070 (1.143/1.778)	0.045/0.070 (1.143/1.778)
C	0.008/0.014 (0.203/0.356)	0.008/0.014 (0.203/0.356)
D	0.780/0.800 (19.812/20.320)	0.880/0.920 (22.352/23.368)
E	0.300/0.325 (7.620/8.255)	0.300/0.325 (7.620/8.255)
E1	0.240/0.280 (6.096/7.112)	0.240/0.280 (6.096/7.112)
L	0.115/0.150 (2.921/3.810)	0.115/0.150 (2.921/3.810)
$\emptyset$	0°/ 15° (0°/15°)	0°/ 15° (0°/15°)

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



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

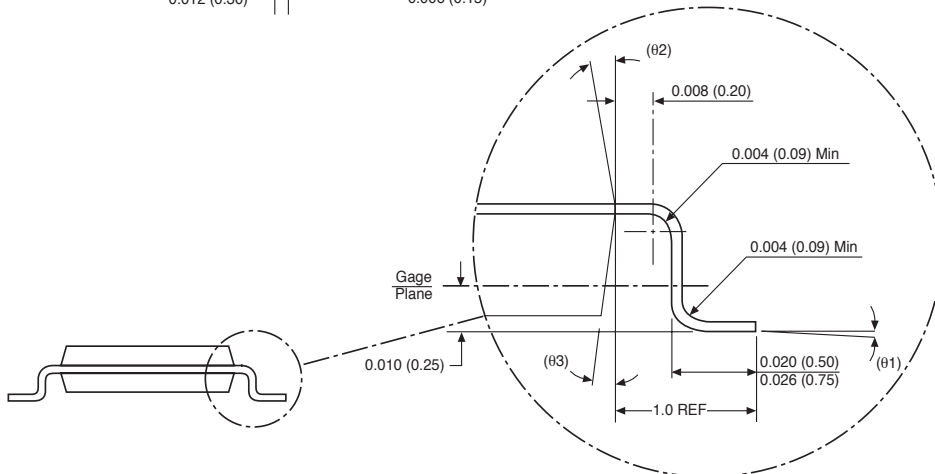
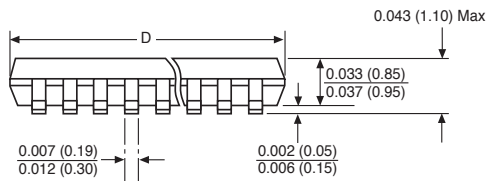
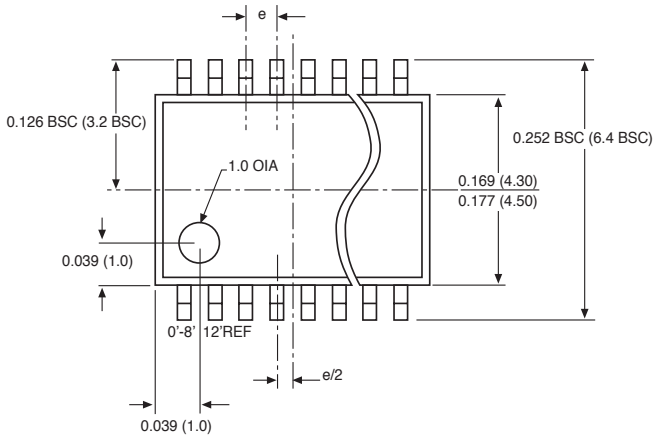
**PACKAGE: PLASTIC
SMALL OUTLINE (SOIC)
(NARROW)**



DIMENSIONS (Inches) Minimum/Maximum (mm)	16-PIN
A	0.053/0.069 (1.346/1.748)
A1	0.004/0.010 (0.102/0.249)
B	0.013/0.020 (0.330/0.508)
D	0.386/0.394 (9.802/10.000)
E	0.150/0.157 (3.802/3.988)
e	0.050 BSC (1.270 BSC)
H	0.228/0.244 (5.801/6.198)
h	0.010/0.020 (0.254/0.498)
L	0.016/0.050 (0.406/1.270)
Ø	0°/8° (0°/8°)

PACKAGE: PLASTIC THIN SMALL OUTLINE (TSSOP)

DIMENSIONS						
in inches (mm) Minimum/Maximum						
Symbol	14 Lead	16 Lead	20 Lead	24 Lead	28 Lead	38 Lead
D	0.193/0.201 (4.90/5.10)	0.193/0.201 (4.90/5.10)	0.252/0.260 (6.40/6.60)	0.303/0.311 (7.70/7.90)	0.378/0.386 (9.60/9.80)	0.378/0.386 (9.60/9.80)
e	0.026 BSC (0.65 BSC)	0.026 BSC (0.65 BSC)	0.026 BSC (0.65 BSC)	0.026 BSC (0.65 BSC)	0.026 BSC (0.65 BSC)	0.020 BSC (0.50 BSC)



ORDERING INFORMATION

Model	Temperature Range	Package Type
SP3222UCA	0°C to +70°C	20-Pin SSOP
SP3222UCA/TR	0°C to +70°C	20-Pin SSOP
SP3222UCP	0°C to +70°C	18-Pin PDIP
SP3222UCT	0°C to +70°C	18-Pin WSOIC
SP3222UCT/TR	0°C to +70°C	18-Pin WSOIC
SP3222UCY	0°C to +70°C	20-Pin TSSOP
SP3222UCY/TR	0°C to +70°C	20-Pin TSSOP
SP3232UCA	0°C to +70°C	16-Pin SSOP
SP3232UCA/TR	0°C to +70°C	16-Pin SSOP
SP3232UCP	0°C to +70°C	16-Pin PDIP
SP3232UCT	0°C to +70°C	16-Pin WSOIC
SP3232UCT/TR	0°C to +70°C	16-Pin WSOIC
SP3232UCY	0°C to +70°C	16-Pin TSSOP
SP3232UCY/TR	0°C to +70°C	16-Pin TSSOP
SP3232UCN	0°C to +70°C	16-Pin nSOIC
SP3232UCN/TR	0°C to +70°C	16-Pin nSOIC

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

Example: SP3232UCN/TR = standard; SP3232UCN-L/TR = lead free

/TR = Tape and Reel

Pack quantity is 1,500 for SSOP, TSSOP or WSOIC and 2,500 for nSOIC.


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ANALOG EXCELLENCE

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