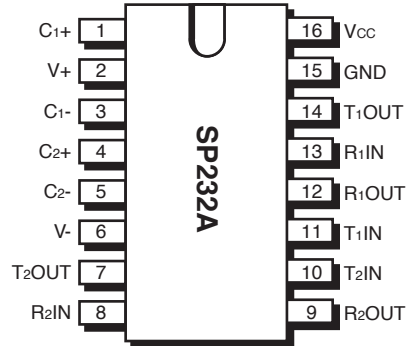


## Enhanced RS-232 Line Drivers/Receivers

### FEATURES

- Operates from Single +5V Power Supply
- Meets All RS-232F and ITU V.28 Specifications
- Operates with 0.1 $\mu$ F to 1 $\mu$ F Capacitors
- High Data Rate – 120Kbps Under Load
- Low Power CMOS – 3mA Operation (SP232A)
- No External Capacitors Required (SP233A)
- Low Power Shutdown (SP310A,SP312A)
- Enhanced ESD Protection (2kV Human Body Model)



*Now Available in Lead Free Packaging*

### DESCRIPTION

The **SP232A/233A/310A/312A** devices are a family of line driver and receiver pairs that meet the specifications of RS-232 and V.28 serial protocols. These devices are pin-to-pin compatible with popular industry standards. As with the initial versions, the **SP232A/233A/310A/312A** devices feature at least 120Kbps data rate under load, 0.1 $\mu$ F charge pump capacitors, and overall ruggedness for commercial applications. This family also features **Sipex's** BiCMOS design allowing low power operation without sacrificing performance. The series is available in plastic DIP and SOIC packages operating over the commercial and industrial temperature ranges.

### SELECTION TABLE

Model	Number of RS232		No. of Receivers Active in Shutdown	No. of External 0.1 $\mu$ F Capacitors	Shutdown	WakeUp	TTL Tri-State
	Drivers	Receivers					
SP232A	2	2	N/A	4	No	No	No
SP233A	2	2	N/A	0	No	No	No
SP310A	2	2	0	4	Yes	No	Yes
SP312A	2	2	2	4	Yes	Yes	Yes

## ABSOLUTE MAXIMUM RATINGS

This is a stress rating only and functional operation of the device at these or any other conditions above those indicated in the operation sections of this specification is not implied. Exposure to absolute maximum rating conditions for extended periods of time may affect reliability.

V <sub>CC</sub> .....	+6V
V <sub>I</sub> <sup>+</sup> .....	(V <sub>CC</sub> -0.3V) to +11.0V
V <sub>I</sub> <sup>-</sup> .....	-11.0V
<b>Input Voltages</b>	
T <sub>IN</sub> .....	-0.3 to (V <sub>CC</sub> +0.3V)
R <sub>IN</sub> .....	±30V

<b>Output Voltages</b>	
T <sub>OUT</sub> .....	(V <sub>I</sub> <sup>+</sup> , +0.3V) to (V <sub>I</sub> <sup>-</sup> , -0.3V)
R <sub>OUT</sub> .....	-0.3V to (V <sub>CC</sub> +0.3V)
<b>Short Circuit Duration</b>	
T <sub>OUT</sub> .....	Continuous
Plastic DIP .....	375mW
(derate 7mW/°C above +70°C)	
Small Outline .....	375mW
(derate 7mW/°C above +70°C)	

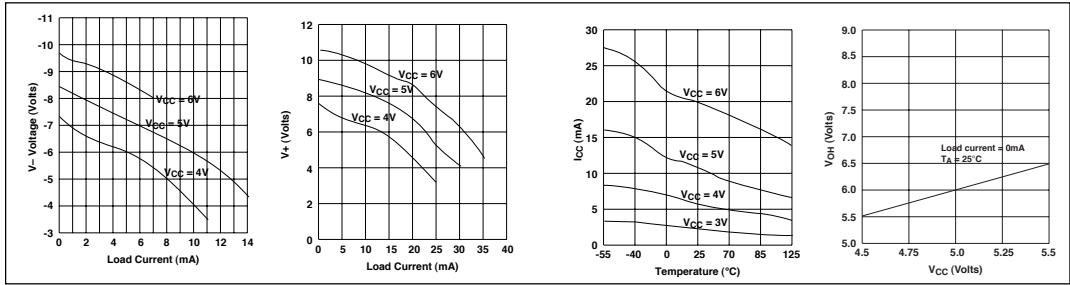
## ELECTRICAL CHARACTERISTICS

V<sub>CC</sub> = +5V ±10%; 0.1µF charge pump capacitors; T<sub>MIN</sub> to T<sub>MAX</sub> unless otherwise noted.

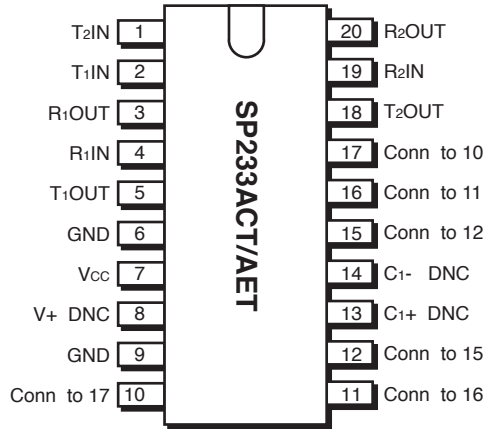
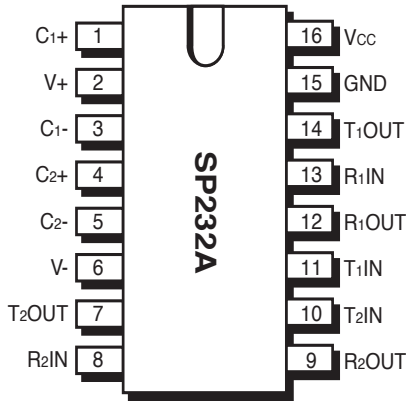
PARAMETERS	MIN.	TYP.	MAX.	UNITS	CONDITIONS
<b>TTL INPUT</b>					
Logic Threshold					
LOW			0.8	Volts	T <sub>IN</sub> ; $\overline{EN}$ , $\overline{SD}$
HIGH	2.0			Volts	T <sub>IN</sub> ; $\overline{EN}$ , $\overline{SD}$
Logic Pull-Up Current		15	200	µA	T <sub>IN</sub> = ZeroV
<b>TTL OUTPUT</b>					
TTL/CMOS Output					
Voltage, Low			0.4	Volts	I <sub>OUT</sub> = 3.2mA; V <sub>CC</sub> = +5V
Voltage, High	3.5			Volts	I <sub>OUT</sub> = -1.0mA
Leakage Current; T <sub>A</sub> = +25°		0.05	±10	µA	$\overline{EN} = V_{CC}$ ; ZeroV ≤ V <sub>OUT</sub> ≤ V <sub>CC</sub> SP310A and SP312A only
<b>RS-232 OUTPUT</b>					
Output Voltage Swing	±5	±6		Volts	All transmitter outputs loaded with 3kΩ to Ground
Output Resistance	300			Ohms	V <sub>CC</sub> = ZeroV; V <sub>OUT</sub> = ±2V
Output Short Circuit Current		±18		mA	Infinite duration
Maximum Data Rate	120	240		Kbps	C <sub>L</sub> = 2500pF, R <sub>L</sub> = 3kΩ
<b>RS-232 INPUT</b>					
Voltage Range	-30		+30	Volts	
Voltage Threshold					
LOW	0.8	1.2		Volts	V <sub>CC</sub> = 5V, T <sub>A</sub> = +25°C
HIGH		1.7	2.4	Volts	V <sub>CC</sub> = 5V, T <sub>A</sub> = +25°C
Hysteresis	0.2	0.5	1.0	Volts	V <sub>CC</sub> = 5V, T <sub>A</sub> = +25°C
Resistance	3	5	7	kΩ	T <sub>A</sub> = +25°C, -15V ≤ V <sub>IN</sub> ≤ +15V
<b>DYNAMIC CHARACTERISTICS</b>					
Driver Propagation Delay		1.5	3.0	µs	TTL to RS-232; C <sub>L</sub> = 50pF
Receiver Propagation Delay		0.1	1.0	µs	RS-232 to TTL
Instantaneous Slew Rate			30	V/µs	C <sub>L</sub> = 10pF, R <sub>L</sub> = 3-7kΩ; T <sub>A</sub> = +25°C
Transition Region Slew Rate		10		V/µs	C <sub>L</sub> = 2500pF, R <sub>L</sub> = 3kΩ; measured from +3V to -3V or -3V to +3V
Output Enable Time		400		ns	SP310A and SP312A only
Output Disable Time		250		ns	SP310A and SP312A only
<b>POWER REQUIREMENTS</b>					
V <sub>CC</sub> Power Supply Current					
SP232A		3	5	mA	No load, T <sub>A</sub> = +25°C; V <sub>CC</sub> = 5V
SP233A, SP310A, SP312A		10	15	mA	No load, T <sub>A</sub> = +25°C; V <sub>CC</sub> = 5V
V <sub>CC</sub> Supply Current, Loaded					
SP232A		15		mA	All transmitters R <sub>L</sub> = 3kΩ; T <sub>A</sub> = +25°C
SP233A, SP310A, SP312A		25		mA	All transmitters R <sub>L</sub> = 3kΩ; T <sub>A</sub> = +25°C
Shutdown Supply Current					
SP310A, SP312A		1	10	µA	V <sub>CC</sub> = 5V, T <sub>A</sub> = +25°C

# PERFORMANCE CURVES

Not 100% tested.

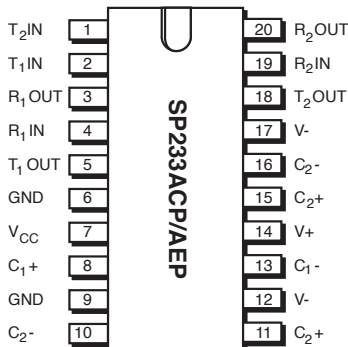


# PINOUTS

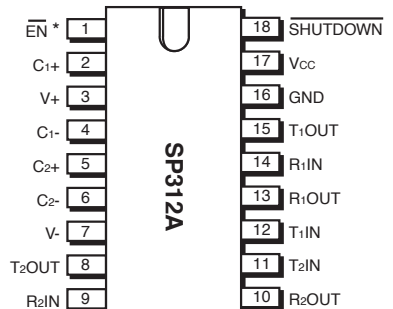
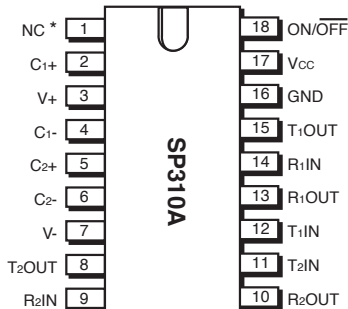


20-PIN SOIC

See Figure 2 for Pin Connections



20-PIN PLASTIC DIP



\* N.C. for SP310E\_A, EN for SP312E\_A

## FEATURES...

The **SP232A/233A/310A/312A** devices are a family of line driver and receiver pairs that meet the specifications of RS-232 and V.28 serial protocols. The ESD tolerance has been improved on these devices to over  $\pm 2\text{KV}$  for the Human Body Model. These devices are pin-to-pin compatible with popular industry standards. The **SP232A/233A/310A/312A** devices feature  $10\text{V}/\mu\text{s}$  slew rate,  $120\text{Kbps}$  data rate under load,  $0.1\mu\text{F}$  charge pump capacitors, overall ruggedness for commercial applications, and increased drive current for longer and more flexible cable configurations. This family also features **Sipex's** BiCMOS design allowing low power operation without sacrificing performance.

The **SP232A/233A/310A/312A** devices have internal charge pump voltage converters which allow them to operate from a single  $+5\text{V}$  supply. The charge pumps will operate with polarized or non-polarized capacitors ranging from  $0.1$  to  $1\mu\text{F}$  and will generate the  $\pm 6\text{V}$  needed for the RS-232 output levels. Both meet all EIA RS-232F and ITU V.28 specifications.

The **SP310A** provides identical features as the **SP232A** with the addition of a single control line which simultaneously shuts down the internal DC/DC converter and puts all transmitter and receiver outputs into a high impedance state. The **SP312A** is identical to the **SP310A** with separate tri-state and shutdown control lines.

## THEORY OF OPERATION

The **SP232A**, **SP233A**, **SP310A** and **SP312A** devices are made up of three basic circuit blocks – 1) a driver/transmitter, 2) a receiver and 3) a charge pump. Each block is described below.

### Driver/Transmitter

The drivers are inverting transmitters, which accept TTL or CMOS inputs and output the RS-232 signals with an inverted sense relative to the input logic levels. Typically the RS-232 output voltage swing is  $\pm 6\text{V}$ . Even under worst case loading conditions of  $3\text{k}\Omega$  and  $2500\text{pF}$ , the output is guaranteed to be  $\pm 5\text{V}$ , which is consistent with the RS-232 standard specifications. The transmitter outputs are protected against infinite short-circuits to ground without degradation in reliability.

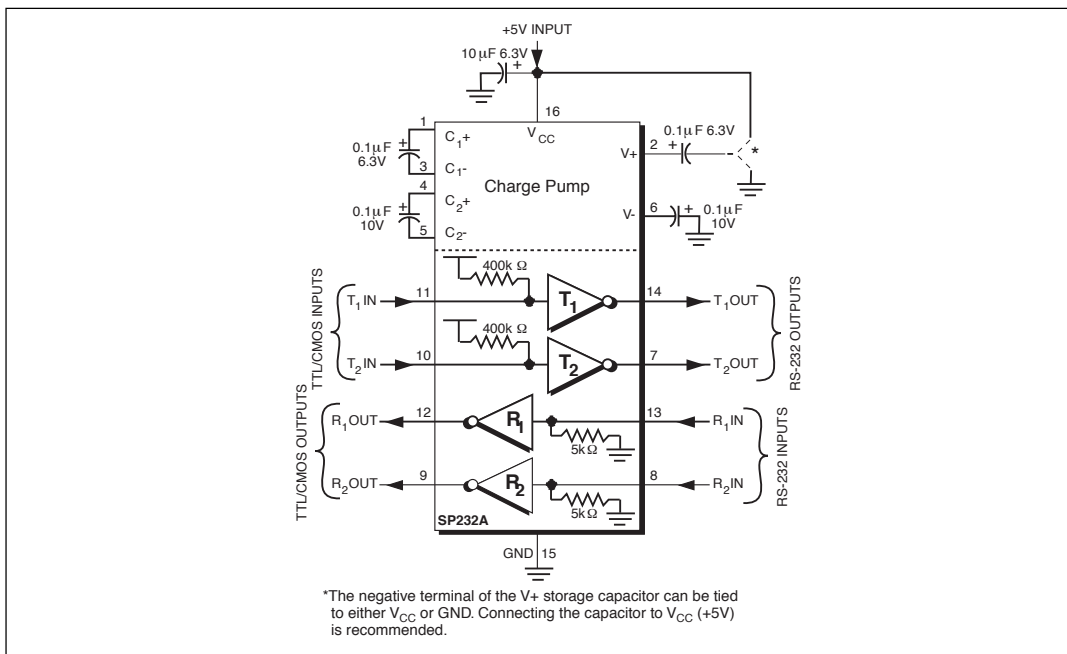


Figure 1. Typical Circuit using the SP232A.

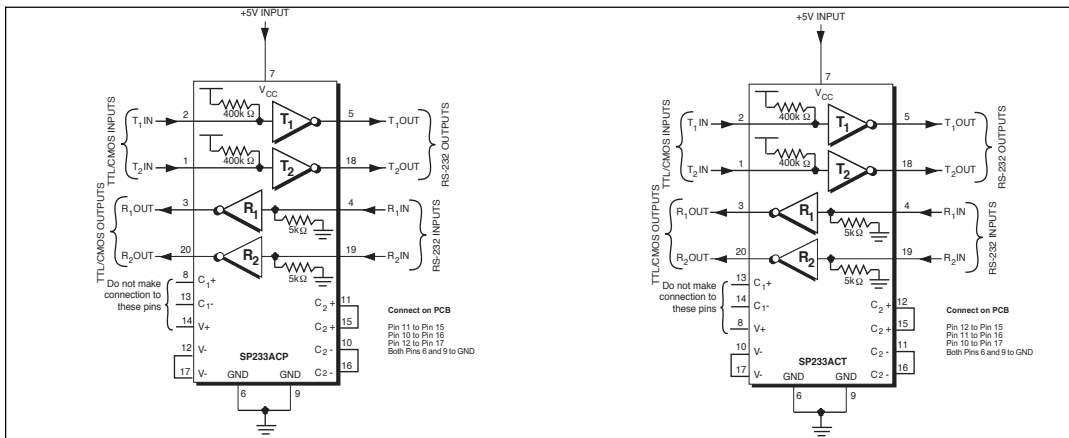


Figure 2. Typical Circuits using the SP233ACP and SP233ACT

The instantaneous slew rate of the transmitter output is internally limited to a maximum of 30V/ $\mu$ s in order to meet the standards [EIA RS-232-F]. The transition region slew rate of these enhanced products is typically 10V/ $\mu$ s. The smooth transition of the loaded output from  $V_{OL}$  to  $V_{OH}$  clearly meets the monotonicity requirements of the standard [EIA RS-232-F].

### Receivers

The receivers convert RS-232 input signals to inverted TTL signals. Since the 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 500mV. This ensures that the receiver is virtually immune to noisy transmission lines.

The input thresholds are 0.8V minimum and 2.4V maximum, again well within the  $\pm 3V$  RS-232 requirements. The receiver inputs are also protected against voltages up to  $\pm 25V$ . Should an input be left unconnected, a 5K $\Omega$  pull-down resistor to ground will commit the output of the receiver to a high state.

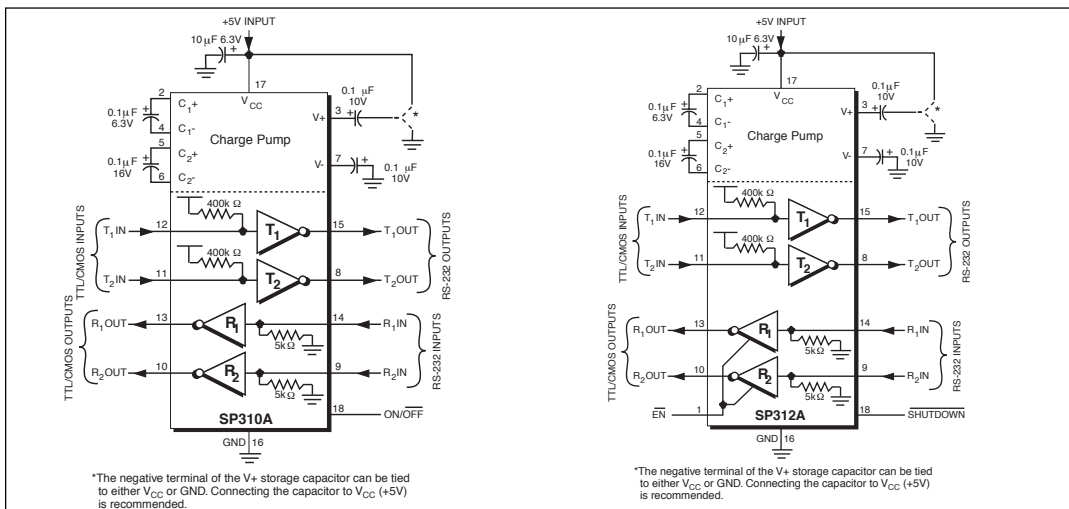
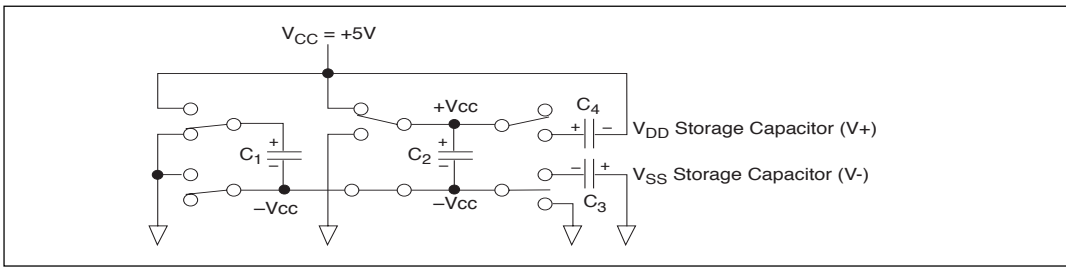


Figure 3. Typical Circuits using the SP310A and SP312A



**Figure 4. Charge Pump — Phase 1**

In actual system applications, it is quite possible for signals to be applied to the receiver inputs before power is applied to the receiver circuitry. This occurs, for example, when a PC user attempts to print, only to realize the printer wasn't turned on. In this case an RS-232 signal from the PC will appear on the receiver input at the printer. When the printer power is turned on, the receiver will operate normally. All of these enhanced devices are fully protected.

### 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 power supplies. There is a free-running oscillator that 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 +5V.  $C_1^+$  is then switched to ground and the charge in  $C_1^-$  is transferred to  $C_2^-$ . Since  $C_2^+$  is connected to +5V, the voltage potential across capacitor  $C_2$  is now 10V.

#### 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 ground, and transfers the generated -10V to  $C_3$ . Simultaneously, the positive side of capacitor  $C_1$  is switched to +5V and the negative side is connected to ground.

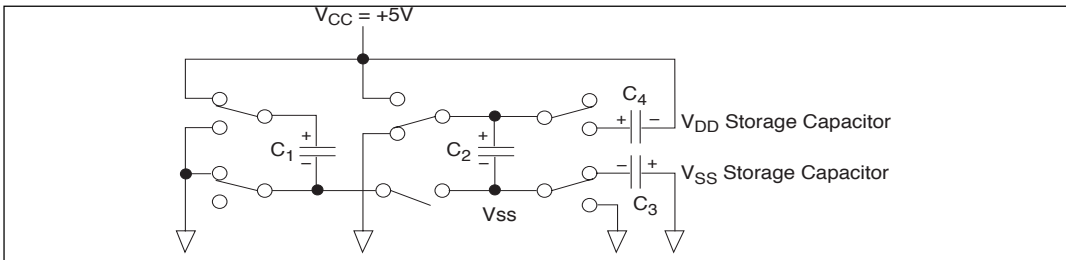
#### Phase 3

—  $V_{DD}$  charge storage — The third phase of the clock is identical to the first phase — the charge transferred in  $C_1$  produces -5V in the negative terminal of  $C_1$ , which is applied to the negative terminal of capacitor  $C_2$ . Since  $C_2^+$  is at +5V, the voltage potential across  $C_2$  is a maximum of 10V.

#### Phase 4

—  $V_{DD}$  transfer — The fourth phase of the clock connects the negative terminal of  $C_2$  to ground, and transfers the generated 10V across  $C_2$  to  $C_4$ , the  $V_{DD}$  storage capacitor. Again, simultaneously with this, the positive side of capacitor  $C_1$  is switched to +5V and the negative side is connected to ground, and the cycle begins again.

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



**Figure 5. Charge Pump — Phase 2**

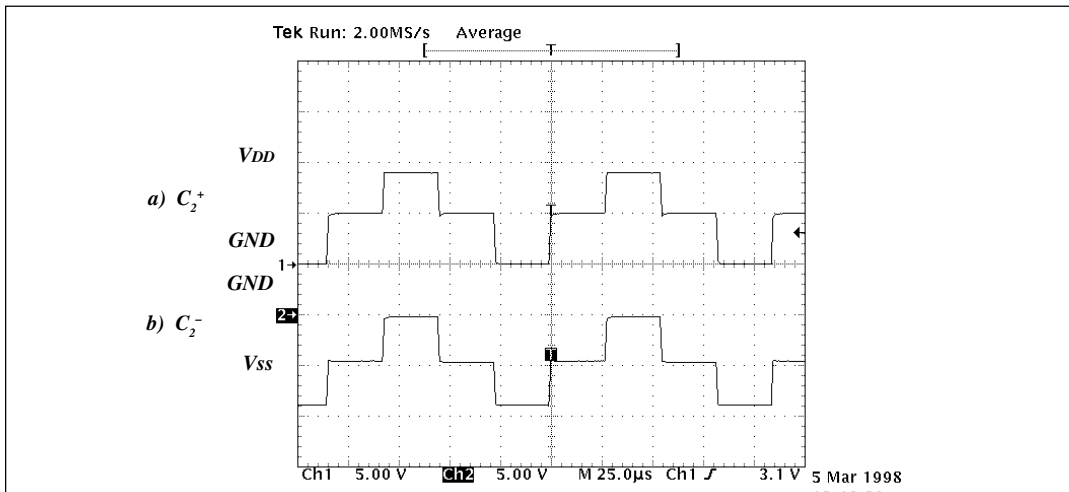


Figure 6. Charge Pump Waveforms

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 15kHz. The external capacitors can be as low as  $0.1\mu\text{F}$  with a 10V breakdown voltage rating.

### Shutdown (SD) and Enable (EN) for the SP310A and SP312A

Both the SP310A and SP312A have a shutdown/standby mode to conserve power in battery-powered systems. To activate the shutdown mode, which stops the operation of the charge pump, a logic "0" is applied to the appropriate control line. For the SP310A, this control line is ON/OFF (pin 18). Activating the shutdown mode also puts the

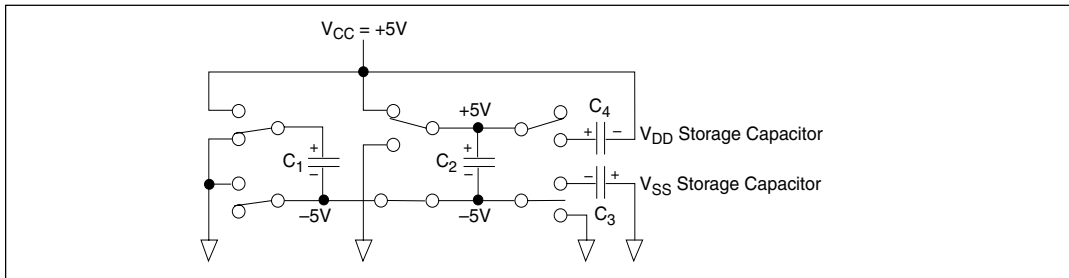


Figure 7. Charge Pump — Phase 3

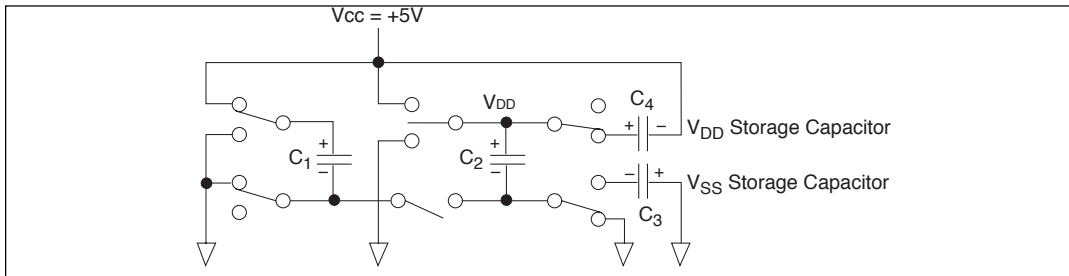


Figure 8. Charge Pump — Phase 4

**SP310A** transmitter and receiver outputs in a high impedance condition (tri-stated). The shutdown mode is controlled on the **SP312A** by a logic “0” on the **SHUTDOWN** control line (pin 18); this also puts the transmitter outputs in a tri-state mode. The receiver outputs can be tri-stated separately during normal operation or shutdown by a logic “1” on the **ENABLE** line (pin 1).

### Wake-Up Feature for the SP312A

The **SP312A** has a wake-up feature that keeps all the receivers in an enabled state when the device is in the shutdown mode. *Table 1* defines the truth table for the wake-up function.

With only the receivers activated, the **SP312A** typically draws less than 5 $\mu$ A supply current. In the case of a modem interfaced to a computer in power down mode, the Ring Indicator (RI) signal from the modem would be used to "wake up" the computer, allowing it to accept data transmission.

After the ring indicator signal has propagated through the **SP312A** receiver, it can be used to trigger the power management circuitry of the computer to power up the microprocessor, and bring the **SD** pin of the **SP312A** to a logic high, taking it out of the shutdown mode. The receiver propagation delay is typically 1 $\mu$ s. The enable time for V<sup>+</sup> and V<sup>-</sup> is typically 2ms. After V<sup>+</sup> and V<sup>-</sup> have settled to their final values, a signal can be sent back to the modem on the data terminal ready (DTR) pin signifying that the computer is ready to accept and transmit data.

$\overline{\text{SD}}$	$\overline{\text{EN}}$	Power Up/Down	Receiver Outputs
0	0	Down	Enable
0	1	Down	Tri-state
1	0	Up	Enable
1	1	Up	Tri-state

*Table 1. Wake-up Function Truth Table.*

### Pin Strapping for the SP233ACT/ACP

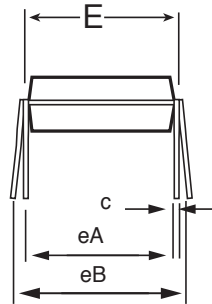
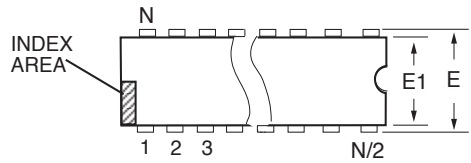
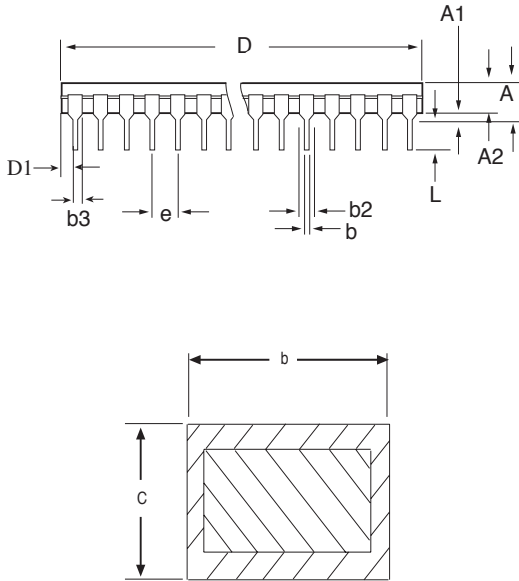
The **SP233A** packaged in the 20-pin SOIC package (**SP233ACT**) has a slightly different pinout than the **SP233A** in PDIP packaging (**SP233ACP**). To operate properly, the following pairs of pins must be externally wired together:

Pins Wired Together	SOIC	PDIP
Two V- Pins	10 & 17	12 & 17
Two C2+ Pins	12 & 15	11 & 15
Two C2- Pins	11 & 16	10 & 16
	No Connections for Pins 8, 13, and 14	
	Connect Pins 6 and 9 to GND	









PDIP JEDEC MS-001 Common Dimensions			
Dimensions in Inches.			
Controlling Dimension.			
SYMBOL	MIN	NOM	MAX
A	-	-	0.21
A1	0.15	-	-
A2	0.115	0.13	0.195
b	0.014	0.018	0.022
b2	0.045	0.06	0.07
b3	0.3	0.039	0.045
c	0.008	0.01	0.014
D1	0.005	-	-
E	0.3	0.31	0.325
E1	0.24	0.25	0.28
e	.100 BSC		
eA	.300 BSC		
eB	-	-	0.43
L	0.115	0.13	0.15
PDIP JEDEC MS-001 VARIATION AB N = 16 Pins			
D	0.78	0.79	0.8
PDIP JEDEC MS-001 VARIATION AC N = 18 Pins			
D	0.88	0.9	0.92
PDIP JEDEC MS-001 VARIATION AD N = 20 Pins			
D	0.98	1.03	1.06

PDIP JEDEC MS-001 Common Dimensions			
Dimensions in Millimeters.			
Conversion factor: 1 inch = 25.40 mm.			
SYMBOL	MIN	NOM	MAX
A	-	-	5.33
A1	3.81	-	-
A2	2.79	3.30	4.83
b	0.25	0.25	0.51
b2	1.02	1.52	1.78
b3	7.62	0.76	1.02
c	0.00	0.25	0.25
D1	0.00	-	-
E	7.62	7.87	8.13
E1	6.10	6.35	7.11
e	2.54 BSC		
eA	7.62 BSC		
eB	-	-	10.92
L	2.79	3.30	3.81
PDIP JEDEC MS-001 VARIATION AB N = 16 Pins			
D	19.81	20.07	20.32
PDIP JEDEC MS-001 VARIATION AC N = 18 Pins			
D	22.35	22.86	23.37
PDIP JEDEC MS-001 VARIATION AD N = 20 Pins			
D	24.89	26.16	26.92

Part Number	Temperature Range	Topmark	Package
SP232ACN	.....0°C to +70°C	.....SP232ACN	.....16-pin NSOIC
SP232ACN/TR	.....0°C to +70°C	.....SP232ACN	.....16-pin NSOIC
SP232ACP	.....0°C to +70°C	.....SP232ACP	.....16-pin PDIP
SP232ACT	.....0°C to +70°C	.....SP232ACT	.....16-pin WSOIC
SP232ACT/TR	.....0°C to +70°C	.....SP232ACT	.....16-pin WSOIC
SP232AEN	.....-40°C to +85°C	.....SP232AEN	.....16-pin NSOIC
SP232AEN/TR	.....-40°C to +85°C	.....SP232AEN	.....16-pin NSOIC
SP232AEP	.....-40°C to +85°C	.....SP232AEP	.....16-pin PDIP
SP232AET	.....-40°C to +85°C	.....SP232AET	.....16-pin WSOIC
SP232AET/TR	.....-40°C to +85°C	.....SP232AET	.....16-pin WSOIC
SP233ACP	.....0°C to +70°C	.....SP233ACP	.....20-pin PDIP
SP233ACT	.....0°C to +70°C	.....SP233ACT	.....20-pin WSOIC
SP233ACT/TR	.....0°C to +70°C	.....SP233ACT	.....20-pin WSOIC
SP233AEP	.....-40°C to +85°C	.....SP233AEP	.....20-pin PDIP
SP233AET	.....-40°C to +85°C	.....SP233AET	.....20-pin WSOIC
SP233AET/TR	.....-40°C to +85°C	.....SP233AET	.....20-pin WSOIC
SP310ACP	.....0°C to +70°C	.....SP310ACP	.....18-pin PDIP
SP310ACT	.....0°C to +70°C	.....SP310ACT	.....18-pin WSOIC
SP310ACT/TR	.....0°C to +70°C	.....SP310ACT	.....18-pin WSOIC
SP310AEP	.....-40°C to +85°C	.....SP310AEP	.....18-pin PDIP
SP310AET	.....-40°C to +85°C	.....SP310AET	.....18-pin WSOIC
SP310AET/TR	.....-40°C to +85°C	.....SP310AET	.....18-pin WSOIC
SP312ACP	.....0°C to +70°C	.....SP312ACP	.....18-pin PDIP
SP312ACT	.....0°C to +70°C	.....SP312ACT	.....18-pin WSOIC
SP312ACT/TR	.....0°C to +70°C	.....SP312ACT	.....18-pin WSOIC
SP312AEP	.....-40°C to +85°C	.....SP312AEP	.....18-pin PDIP
SP312AET	.....-40°C to +85°C	.....SP312AET	.....18-pin WSOIC
SP312AET/TR	.....-40°C to +85°C	.....SP312AET	.....18-pin WSOIC

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

Example: SP312AEA/TR = standard; SP312AEA-L/TR = lead free.

/TR = Tape and Reel

Pack quantity is 1,500 for WSOIC and 2,500 for NSOIC.



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