Interface Transceiver of RS-232 Standard with One Supply Voltage

■ DESCRIPTION

The TK3222 transceivers has a proprietary low-dropout transmitter output stage enabling true RS-232 performance from a 3.0V to 5.5V supply with a dual charge pump.The devices require only four small 0.1μF external charge-pump capacitors. The TK3222 is guaranteed to run at data rates of 120kbps while maintaining RS-232 output levels.The device requires only four small 0.1 μF standard external capacitors for operations from 3.3V supply.

The TK3222 has two receivers and two drivers. The device is guaranteed to run at data rates of 120Kbps while maintaining RS-232 output levels. Typical applications are Notebook, Subnotebook and Palmtop Computers, Battery Powered Equipment, Hand-Held Equipment, Peripherals and Printers. The TK3222 is available in space-saving TSSOP and SSOP packages with operating temperatures of either -40°C to +85°C or 0°C to 70°C.

■ FEATURES

- 300 μA SUPPLY CURRENT
- CHARGE PUMP CIRCUITRY ELIMINATES THE NEED FOR A BIPOLAR ±12V SUPPLY
- 120kbps GUARENTEED DATA RATE
- 3V/μs MINIMUM GUARANTEED SLEW RATE
- WIDE SINGLE-SUPPLY OPERATION FROM +3V TO +5.5V
- ENHANCED ESD SPECIFICATIONS(EC and EE_ only):

  ±15kV IEC61000-4-2 Air Discharge

  ±8kV IEC61000-4-2 Contact Discharge
- AVAILABLE IN SSOP-20,TSSOP20
- 1μA Supply Current in Shutdown Mode While Receiver is Active

■ APPLICATIONS

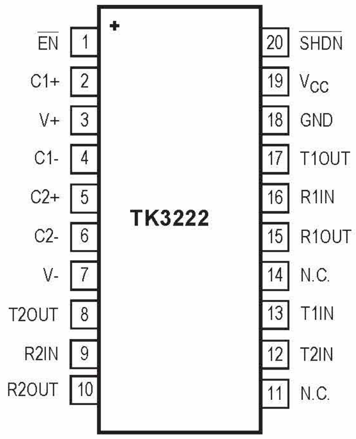
- Battery-Powered Equipment
- Hand-Held Equipment
- Peripherals
- Datacom Equipment

■ ORDERING INFORMATION

Part Number	Package	Packing	Temperature(TA)	Package Qty	ESD
TK3222CUP	TSSOP-20	Reel	0°C ~ 70°C	2500	-
TK3222EUP	TSSOP-20	Reel	-40°C ~ 85°C	2500	-
TK3222ECUP	TSSOP-20	Reel	0°C ~ 70°C	2500	±15KV
TK3222EEUP	TSSOP-20	Reel	-40°C ~ 85°C	2500	±15KV

Note: Please contact us to customize SOIC/DIP packaging device.

■ PIN ASSIGNMENT



SSOP/TSSOP20

■ PIN DESCRIPTION

PIN	NAME	FUNCTION
SSOP/TSSOP		
1	$\overline{\text{EN}}$	Receiver Enable. Active low.
2	C1+	Positive Terminal of Voltage-Doubler Charge-Pump Capacitor
3	V+	+5.5V Generated by the Charge Pump
4	C1-	Negative Terminal of Voltage-Doubler Charge-Pump Capacitor
5	C2+	Positive Terminal of Inverting Charge-Pump Capacitor
6	C2-	Negative Terminal of Inverting Charge-Pump Capacitor
7	V-	-5.5V Generated by the Charge Pump
8, 17	T_OUT	RS-232 Transmitter Outputs
9, 16	R_IN	RS-232 Receiver Inputs
10, 15	R_OUT	TTL/CMOS Receiver Outputs
12, 13	T_IN	TTL/CMOS Transmitter Inputs
18	GND	Ground
19	V_{CC}	+3.0V to +5.5V Supply Voltage
20	$\overline{\text{SHDN}}$	Shutdown Control. Active low.
11, 14	N.C.	No Connection
—	MBAUD	MegaBaud Control Input. Connect to GND for normal operation; connect to V_{CC} for 1Mbps transmission rates.
—	R_OUTB	Noninverting Complementary Receiver Outputs. Always active.

ELECTRICAL CHARACTERISTICS

(VCC = +3.0V to +5.5V, C1–C4 = 0.1μF (Note 2), TA = TMIN to TMAX, unless otherwise noted. Typical values are at TA = +25°C.)

PARAMETER	CONDITIONS		MIN	TYP	MAX	UNITS
DC CHARACTERISTICS						
V_{CC} Power-Supply Current	No load, V_{CC} = 3.3V or 5.0V, T_A = +25°C			0.3	1.0	mA
Shutdown Supply Current	$\overline{SHDN}$ = GND, T_A = +25°C			1.0	10	μA
LOGIC INPUTS AND RECEIVER OUTPUTS						
Input Logic Threshold Low	T_IN, $\overline{EN}$, $\overline{SHDN}$, MBAUD				0.8	V
Input Logic Threshold High	V_{CC} = 3.3V		2.0			V
	V_{CC} = 5.0V		2.4			
Input Leakage Current	T_IN, $\overline{EN}$, $\overline{SHDN}$, MBAUD			±0.01	±1.0	μA
Output Leakage Current	Receivers disabled			±0.05	±10	μA
Output Voltage Low	I_{OUT} = 1.6mA				0.4	V
Output Voltage High	I_{OUT} = -1.0mA		V_{CC} - 0.6	V_{CC} - 0.1		V
RECEIVER INPUTS						
Input Voltage Range			-25		25	V
Input Threshold Low	T_A = +25°C	V_{CC} = 3.3V	0.6	1.2		V
		V_{CC} = 5.0V	0.8	1.5		
Input Threshold High	T_A = +25°C	V_{CC} = 3.3V		1.5	2.4	V
		V_{CC} = 5.0V		1.8	2.4	
Input Hysteresis				0.3		V
Input Resistance	T_A = +25°C		3	5	7	kΩ
TRANSMITTER OUTPUTS						
Output Voltage Swing	All transmitter outputs loaded with 3kΩ to ground		±5.0	±5.4		V
Output Resistance	V_{CC} = V+ = V- = 0V, V_{OUT} = ±2V		300	10M		Ω
Output Short-Circuit Current				±35	±60	mA
Output Leakage Current	V_{OUT} = ±12V, V_{CC} = 0V or 3V to 5.5V, transmitters disabled				±25	μA

TIMING CHARACTERISTICS

(VCC = +3.0V to +5.5V, C1–C4 = 0.1μF, TA = TMIN to TMAX, unless otherwise noted. Typical values are at TA = +25°C.)

PARAMETER	CONDITIONS		MIN	TYP	MAX	UNITS
Maximum Data Rate	R_L = 3kΩ, C_L = 1000pF, one transmitter switching		120	235		kbps
Receiver Propagation Delay	R_IN to R_OUT, C_L = 150pF	t_{PHL}		0.3		μs
		t_{PLH}		0.3		
Receiver Output Enable Time	Normal operation			200		ns
Receiver Output Disable Time	Normal operation			200		ns
Transmitter Skew	| t_{PHL} - t_{PLH} |			300		ns
Receiver Skew	| t_{PHL} - t_{PLH} |			300		ns
Transition-Region Slew Rate	V_{CC} = 3.3V, R_L = 3kΩ to 7kΩ, +3V to -3V or -3V to +3V, T_A = +25°C, one transmitter switching	C_L = 150pF to 1000pF	6		30	V/μs
		C_L = 150pF to 2500pF	4		30	

■ ABSOLUTE MAXIMUM RATING

Symbol	Parameter	Value	Unit
V_{CC}	Supply Voltage	-0.3 to 6	V
V+	Doubled Voltage Terminal	(V_{CC} - 0.3) to 7	V
V-	Inverted Voltage Terminal	0.3 to -7	V
V+ +|V-|		13	V
T_{IN}	Transmitter Input Voltage Range	-0.3 to 6	V
R_{IN}	Receiver Input Voltage Range	± 25	V
T_{OUT}	Transmitter Output Voltage Range	± 13.2	V
R_{OUT}	Receiver Output Voltage Range	-0.3 to (V_{CC} + 0.3)	V
Ta	Operating Temerature	-40 to 85	°C
Ts	Storage Temperature	-60 to 150	°C
t_{SHORT}	Transmitter Output Short to GND Time	Continuous	

* tresses beyond those listed under “absolute maximum ratings” may cause permanent damage to the device.
These are stress ratings only and functional operation of the device at these or any other conditions beyond those indicated under “recommended operating conditions” is not implied.
Exposure to absolute-maximum-rated conditions for extended periods may affect device reliability.
V+ and V-can have a maximum magnitude of +7V, but their absolute addition cannot exceed 13 V.

■ Detailed Description

Dual Charge-Pump Voltage Converter

The TK3222's internal power supply consists of a regulated dual charge pump that provides output voltages of +5.5V (doubling charge pump) and -5.5V (inverting charge pump), regardless of the input voltage (VCC) over the 3.0V to 5.5V range. The charge pumps operate in a discontinuous mode; if the output voltages are less than 5.5V, the charge pumps are enabled, and if the output voltages exceed 5.5V, the charge pumps are disabled. Each charge pump requires a flying capacitor (C1, C2) and a reservoir capacitor (C3, C4) to generate the V+ and V- supplies.

RS-232 Transmitters

The transmitters are inverting level translators that convert CMOS-logic levels to 5.0V EIA/TIA-232 levels. The transmitters guar-antee a 120kbps data rate with worst-case loads of 3kΩ in parallel with 1000pF, providing compatibility with PC-to-PC communication software (such as LapLink™). Typically, these three devices can operate at data rates of 235kbps. Transmitters can be paralleled to drive multiple receivers or mice.

RS-232 Receivers

The receivers convert RS-232 signals to CMOS-logic output levels. The MAX3222/MAX3237/MAX3241 receiv-ers have inverting three-state outputs. In shutdown, the receivers can be active or inactive (Table 1).

Shutdown Mode

Supply current falls to less than 1µA in shutdown mode ($\overline{SHDN}$ = low). When shut down, the device's charge pumps are turned off, V+ is pulled down to VCC, V- is pulled to ground, and the transmitter outputs are disabled (high impedance). The time required to exit shutdown is typically 100µs, as shown in Figure 3. Connect SHDN to VCC if the shutdown mode is not used.

Enable Control

The inverting receiver outputs (R_OUT) are put into a high-impedance state when $\overline{EN}$ is high. The complemen-tary outputs R1OUTB and R2OUTB are always active, regardless of the state of $\overline{EN}$ and $\overline{SHDN}$ (Table 1). $\overline{EN}$ has no effect on T_OUT.

Table1. Shutdown and Enable Control Truth Table

$\overline{SHDN}$	$\overline{EN}$	T_OUT	R_OUT
0	0	High-Z	Active
0	1	High-Z	High-Z
1	0	Active	Active
1	1	Active	High-Z

Table 2. Required Minimum Capacitor Values

V_{CC} (V)	C1 (µF)	C2, C3, C4 (µF)
3.0 to 3.6	0.1	0.1
4.5 to 5.5	0.047	0.33
3.0 to 5.5	0.1	0.47

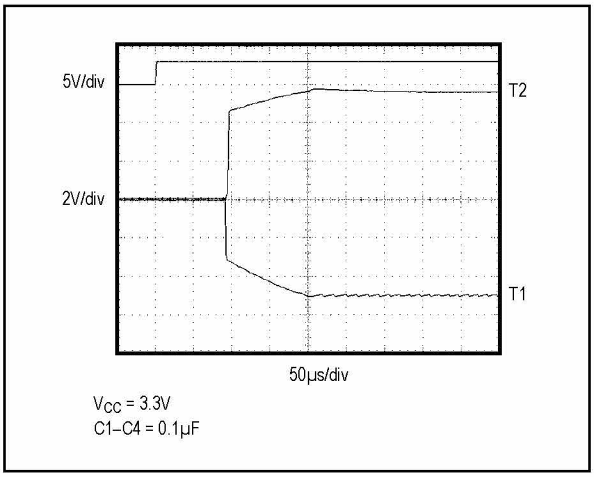


Figure 1. Transmitter Outputs when Exiting Shutdown or Powering Up

Capacitor Selection

The capacitor type used for C1–C4 is not critical for proper operation; polarized or nonpolarized capacitors can be used. The charge pump requires 0.1μF capaci-tors for 3.3V operation. For other supply voltages, refer to Table 2 for required capacitor values. Do not use values lower than those listed in Table 2. Increasing the capacitor values (e.g., by a factor of 2) reduces ripple on the trans-mitter outputs and slightly reduces power consumption. C2, C3, and C4 can be increased without changing C1's value. However, do not increase C1 without also increas-ing the values of C2, C3, and C4, to maintain the proper ratios (C1 to the other capacitors).

When using the minimum required capacitor values, make sure the capacitor value does not degrade exces-sively with temperature. If in doubt, use capacitors with a higher nominal value. The capacitor's equivalent series resistance (ESR), which usually rises at low tempera-tures, influences the amount of ripple on V+ and V-.

Power-Supply Decoupling

In most circumstances, a 0.1μF bypass capacitor is adequate. 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. Connect bypass capacitors as close to the IC as possible.

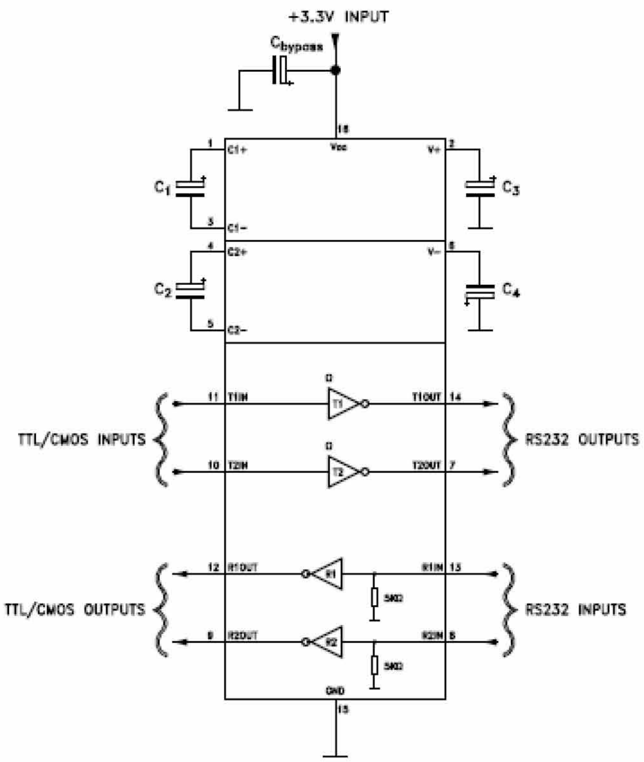
Operation Down to 2.7V

Transmitter outputs will meet EIA/TIA-562 levels of ±3.7V with supply voltages as low as 2.7V.

Transmitter Outputs when Exiting Shutdown

Figure 1 shows two transmitter outputs when exiting shut-down mode. As they become active, the two transmitter outputs are shown going to opposite RS-232 levels (one transmitter input is high, the other is low). Each transmit-ter is loaded with 3kΩ in parallel with 2500pF. The trans-mitter outputs display no ringing or undesirable transients as they come out of shutdown. Note that the transmitters are enabled only when the magnitude of V- exceeds approximately 3V.

■ APPLICATION CIRCUITS

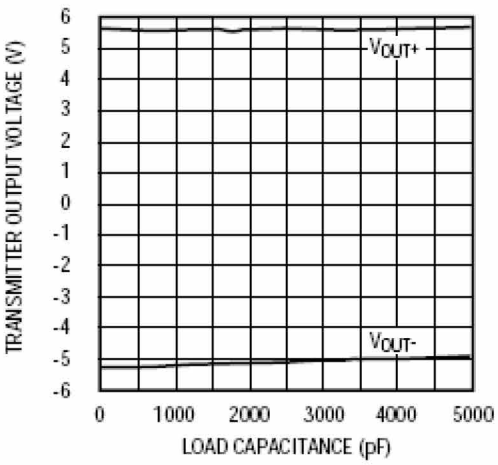


CAPACITANCE VALUE (μF)

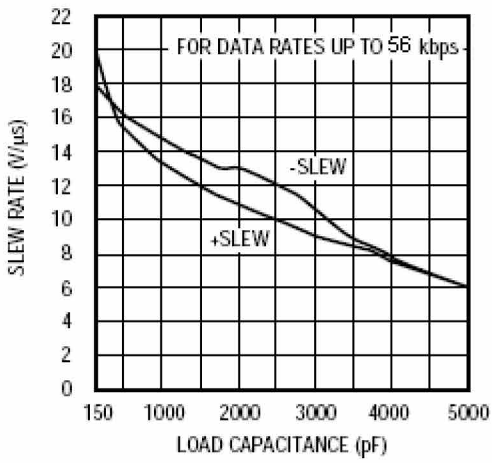
V_{CC}	C1	C2	C3	C4	Cbypass
3.0 to 5.5	1.0	1.0	1.0	1.0	1.0

■ TYPICAL OPERATING CHARACTERISTICS

(V_{CC} = +3.3V, 120kbps data rate, 0.1μF capacitors, all transmitters loaded with 3kΩ, T_A = +25°C, unless otherwise noted.)



TRANSMITTER OUTPUT VOLTAGE vs. LOAD CAPACITANCE



SLEW RATE vs. LOAD CAPACITANCE

■ ESD PROTECTION

The TK3222 incorporates ruggedized ESD cells on all driver output and receiver input pins. The ESD structure is for rugged applications and environments sensitive to electro-static discharges and associated transients. The ESD tolerance is at least ±15kV without damage or latch-up.

There are different methods of ESD testing applied:
a) MIL-STD-883, Method 3015.7
b) IEC1000-4-2 Air-Discharge

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 testi s 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 1*. 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 systems. For 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 IEC1000-4-2 is shown on *Figure 2*. There are two methods within IEC1000-4-2, 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 of the system before he or she even touches the system. This energy, whether discharged directly or through air, is predominantly a function of the discharge current rather than the discharge voltage. Variables with an air discharge such as approach speed of the object carrying the ESD potential to the system and humidity will tend to change the discharge current. For example, the rise time of the discharge current varies with the approach speed.

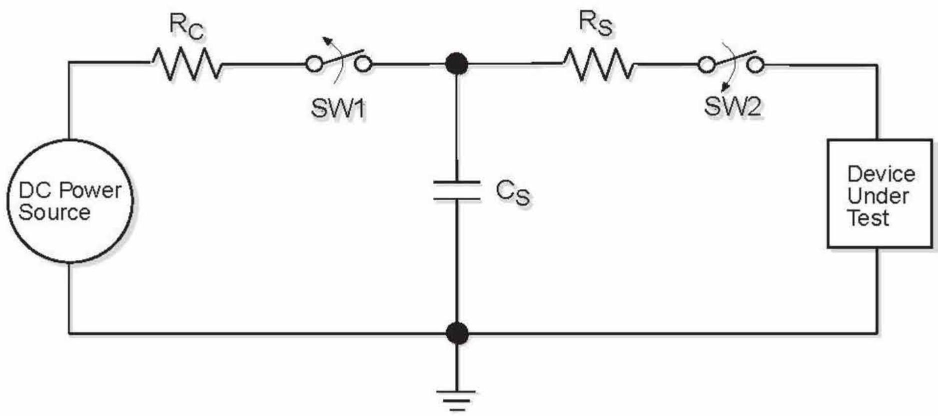


Fig. 1 ESD Test Circuit for Human Body Model

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 already holding the equipment. The current is transferred on to the keypad or the serial port of the equipment directly and then travels through the PCB and finally to the IC.

The circuit models in *Figures 1* and *2* represent the typical ESD testing circuits used for these methods. The CS 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 RS, 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.

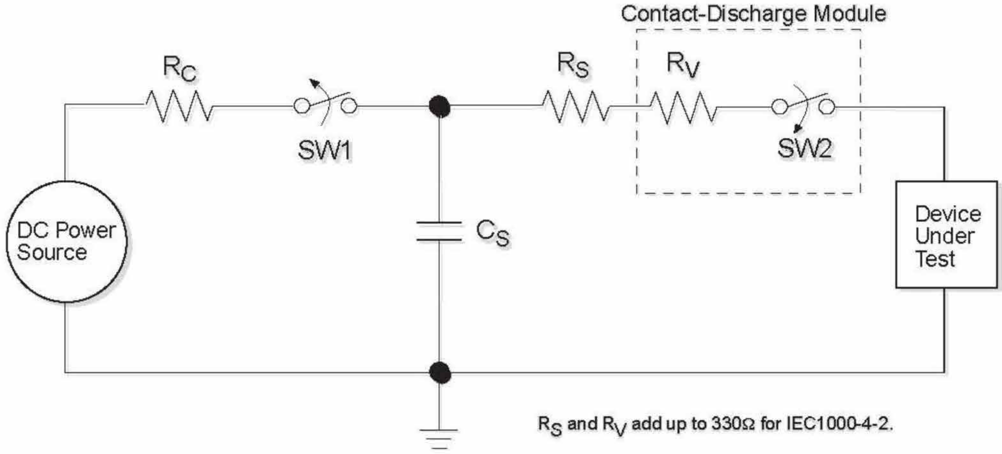


Fig. 2. ESD Test Circuit for IEC1000-4-2

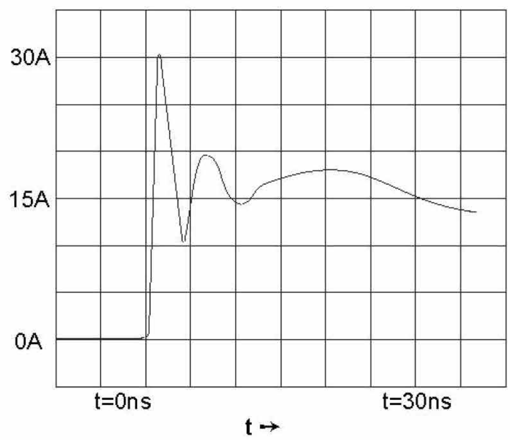
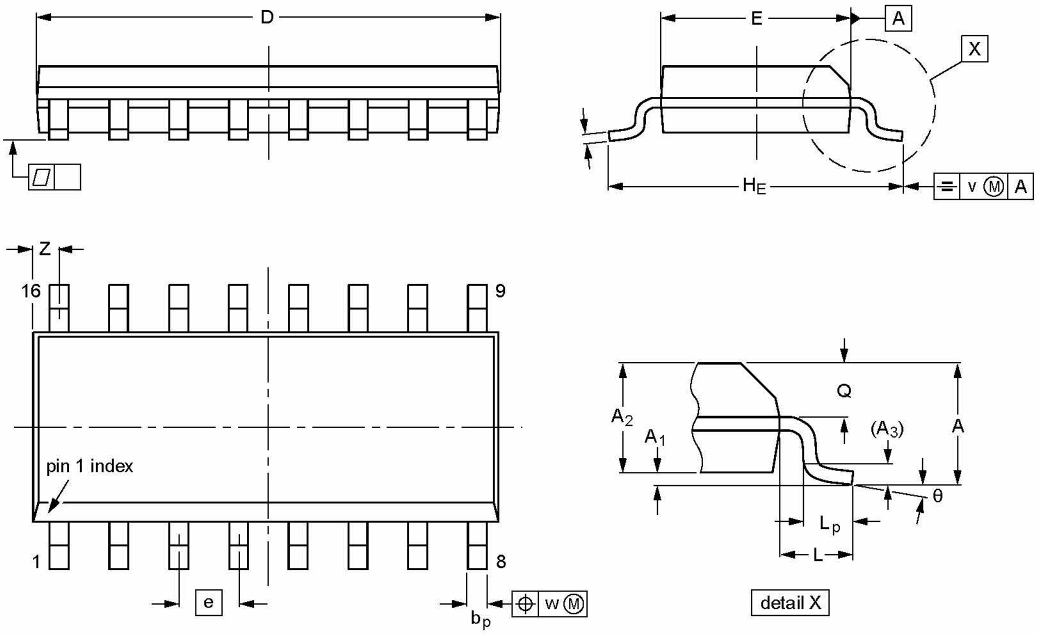


Fig. 3. ESD Test Waveform for IEC1000-4-2

For the Human Body Model, the current limiting resistor (R_S) and the source capacitor (C_S) are 1.5kΩ an 100pF, respectively. For IEC-1000-4-2, the current limiting resistor (R_S) and the source capacitor (C_S) are 330Ω an 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.

Device Pin Tested	IEC1000-4-2	
	Air Discharge	Level
Driver Outputs Receiver Inputs	±15kV ±15kV	4 4

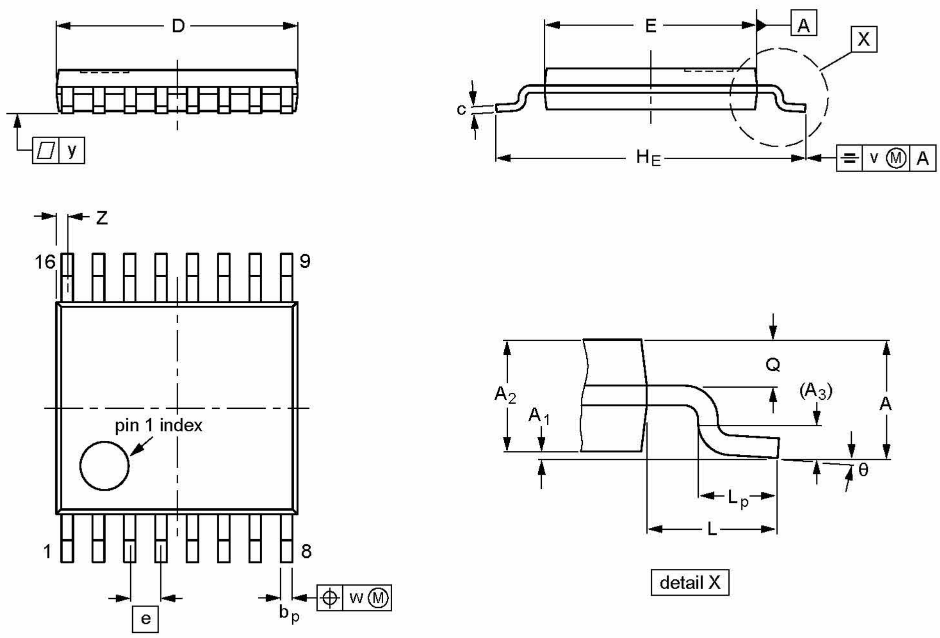
SOIC16: plastic small outline package; 16 leads; body width 3.9 mm



DIMENSIONS (mm are the original dimensions)

UNIT	A max.	A_1	A_2	A_3	b_p	c	D(1)	E(1)	e	H_E	L	L_p	Q	v	w	y	Z(1)	θ
mm	1.75	0.25 0.10	1.45 1.25	0.25	0.49 0.36	0.25 0.19	10.0 9.8	4.0 3.8	1.27	6.2 5.8	1.05	1.0 0.4	0.7 0.6	0.25	0.25	0.1	0.7 0.3	8° 0

TSSOP16: plastic thin shrink small outline package; 16 leads; body width 4.4 mm



DIMENSIONS (mm are the original dimensions)

UNIT	A max.	A_1	A_2	A_3	b_p	c	D(1)	E(2)	e	H_E	L	L_p	Q	v	w	y	Z(1)	θ
mm	1.1	0.15 0.05	0.95 0.80	0.25	0.30 0.19	0.2 0.1	5.1 4.9	4.5 4.3	0.65	6.6 6.2	1	0.75 0.50	0.4 0.3	0.2	0.13	0.1	0.40 0.06	8° 0°