



# **$\pm 15\text{kV}$ ESD-Protected, 1Mbps, 1 $\mu\text{A}$ RS-232 Transmitters in SOT23-6**

## **General Description**

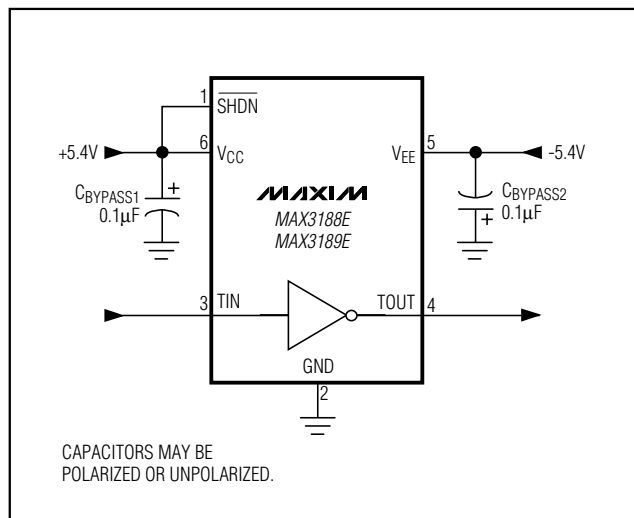
The MAX3188E/MAX3189E single RS-232 transmitters in a SOT23-6 package are for space- and cost-constrained applications requiring minimal RS-232 communications. These devices consume only 150 $\mu\text{A}$  of supply current from  $\pm 4.5\text{V}$  to  $\pm 6\text{V}$  supplies. They feature a shutdown input that reduces current consumption to only 1 $\mu\text{A}$  and forces the transmitter output into a high-impedance state. RS-232 data transmission is guaranteed up to 250kbps with the MAX3188E and up to 1Mbps with the MAX3189E.

The MAX3188E/MAX3189E are EIA/TIA-232 transmitters that convert CMOS/TTL logic levels to RS-232-compliant signals. The transmitter output is protected to  $\pm 15\text{kV}$  using the IEC 1000-4-2 Air-Gap Discharge method, to  $\pm 8\text{kV}$  using the IEC 1000-4-2 Contact Discharge method, and to  $\pm 15\text{kV}$  per the Human Body Model, ensuring strict compliance with international standards. The MAX3188E/MAX3189E transmitters have a standard inverting output.

## **Applications**

Diagnostic Ports  
Telecommunications  
Networking Equipment  
Set-Top Boxes  
Digital Cameras  
Hand-Held Equipment

## **Typical Operating Circuit**



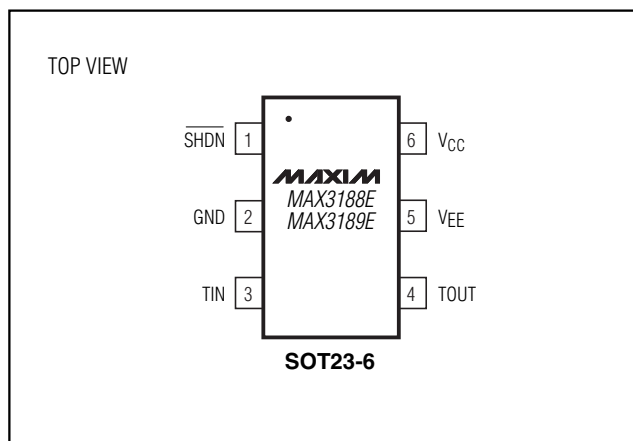
## **Features**

- ◆ Small 6-Pin SOT23 Package
- ◆ ESD-Protected RS-232 Output
  - $\pm 15\text{kV}$  per Human Body Model
  - $\pm 8\text{kV}$  per IEC 1000-4-2, Contact Discharge
  - $\pm 15\text{kV}$  per IEC 1000-4-2, Air-Gap Discharge
- ◆ 150 $\mu\text{A}$  Operating Supply Current
- ◆ Shutdown Reduces Supply Current to 1 $\mu\text{A}$
- ◆ Guaranteed Data Rate
  - 1Mbps (MAX3189E)
  - 250kbps (MAX3188E)
- ◆ Three-State RS-232 Transmitter Output
- ◆ No External Components

## **Ordering Information**

| PART          | TEMP. RANGE    | PIN-PACKAGE | TOP MARK |
|---------------|----------------|-------------|----------|
| MAX3188EEUT-T | -40°C to +85°C | 6 SOT23-6   | AAHD     |
| MAX3189EEUT-T | -40°C to +85°C | 6 SOT23-6   | AAHE     |

## **Pin Configuration**



# ±15kV ESD-Protected, 1Mbps, 1μA RS-232 Transmitters in SOT23-6

## ABSOLUTE MAXIMUM RATINGS

V<sub>CC</sub> to GND (Note 1).....-0.3V to +7V  
 V<sub>EE</sub> to GND (Note 1).....+0.3V to -7V  
 V<sub>CC</sub> to V<sub>EE</sub> (Note 1) .....+13V  
 T<sub>IN</sub>, S<sub>HDN</sub> to GND.....-0.3V to +7V  
 T<sub>OUT</sub> to GND (S<sub>HDN</sub> = GND).....±13.2V  
 T<sub>OUT</sub> to GND (S<sub>HDN</sub> = V<sub>CC</sub>).....±7V  
 Output Short-Circuit Duration.....Continuous

Continuous Power Dissipation (T<sub>A</sub> = +70°C)  
 6-Pin SOT23 (derate 8.7mW/°C above +70°C).....691mW  
 Operating Temperature Range .....-40°C to +85°C  
 Junction Temperature .....+150°C  
 Storage Temperature Range .....-65°C to +150°C  
 Lead Temperature (soldering, 10s) .....+300°C

**Note 1:** V<sub>CC</sub> and V<sub>EE</sub> can have maximum magnitudes of 7V, but their absolute difference cannot exceed 13V.

Stresses 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 in the operational sections of the specifications is not implied. Exposure to absolute maximum rating conditions for extended periods may affect device reliability.

## ELECTRICAL CHARACTERISTICS

(V<sub>CC</sub> = +4.5V to +6V, V<sub>EE</sub> = -4.5V to -6V, T<sub>A</sub> = T<sub>MIN</sub> to T<sub>MAX</sub>, unless otherwise noted. Typical values are at V<sub>CC</sub> = +5.4V, V<sub>EE</sub> = -5.4V, and T<sub>A</sub> = +25°C.) (Note 2)

| PARAMETER                            | SYMBOL            | CONDITIONS                                                                                                                                                                     |          | MIN  | TYP   | MAX  | UNITS |
|--------------------------------------|-------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------|------|-------|------|-------|
| DC CHARACTERISTICS                   |                   |                                                                                                                                                                                |          |      |       |      |       |
| Positive Supply Voltage              | V <sub>CC</sub>   |                                                                                                                                                                                |          | 4.5  |       | 6    | V     |
| Negative Supply Voltage              | V <sub>EE</sub>   |                                                                                                                                                                                |          | -6   |       | -4.5 | V     |
| Positive Supply Current              | I <sub>CC</sub>   | V <sub>SHDN</sub> = 5V                                                                                                                                                         |          |      |       | 170  | μA    |
| Negative Supply Current              | I <sub>EE</sub>   | V <sub>SHDN</sub> = 5V                                                                                                                                                         |          | 45   |       |      | μA    |
| Shutdown Supply Current              |                   | V <sub>SHDN</sub> = 0                                                                                                                                                          |          |      | 0.2   | 1    | μA    |
| INPUT LOGIC (T <sub>IN</sub> , SHDN) |                   |                                                                                                                                                                                |          |      |       |      |       |
| Input Logic Threshold Low            | V <sub>IL</sub>   |                                                                                                                                                                                |          |      |       | 0.8  | V     |
| Input Logic Threshold High           | V <sub>IH</sub>   |                                                                                                                                                                                |          | 2.0  |       |      | V     |
| Input Leakage                        |                   |                                                                                                                                                                                |          |      | ±0.01 | ±1   | μA    |
| T <sub>IN</sub> Input Hysteresis     |                   |                                                                                                                                                                                |          |      | 100   |      | mV    |
| TRANSMITTER OUTPUTS                  |                   |                                                                                                                                                                                |          |      |       |      |       |
| Output Voltage Swing                 | V <sub>TOUT</sub> | V <sub>CC</sub> = 4.5V, V <sub>EE</sub> = -4.5V, R <sub>L</sub> = 3kΩ                                                                                                          |          | ±3.7 |       |      | V     |
|                                      |                   | V <sub>CC</sub> = 5.4V, V <sub>EE</sub> = -5.4V, R <sub>L</sub> = 3kΩ                                                                                                          |          | ±5   |       |      |       |
| Output Resistance                    | R <sub>TOUT</sub> | V <sub>CC</sub> = V <sub>EE</sub> = 0, V <sub>TOUT</sub> = ±2V                                                                                                                 |          | 300  |       |      | Ω     |
| Output Short-Circuit Current         |                   |                                                                                                                                                                                |          |      | ±35   | ±60  | mA    |
| Output Leakage Current               | I <sub>TOUT</sub> | V <sub>OUT</sub> = ±12V; V <sub>CC</sub> = V <sub>EE</sub> = 0 or V <sub>CC</sub> = 5.4V, V <sub>EE</sub> = -5.4V; $\overline{\text{SHDN}}$ = 0                                |          |      |       | ±25  | μA    |
| TIMING CHARACTERISTICS               |                   |                                                                                                                                                                                |          |      |       |      |       |
| Maximum Data Rate                    |                   | R <sub>L</sub> = 3kΩ, C <sub>L</sub> = 1000pF                                                                                                                                  | MAX3188E | 0.25 |       |      | Mbps  |
|                                      |                   |                                                                                                                                                                                | MAX3189E | 1    |       |      |       |
| Transmitter Skew                     | t <sub>TS</sub>   | t <sub>PHL</sub> - t <sub>PLH</sub>  , Figure 1                                                                                                                                | MAX3188E | 100  |       |      | ns    |
|                                      |                   |                                                                                                                                                                                | MAX3189E | 25   |       |      |       |
| Transition-Region Slew Rate          |                   | R <sub>L</sub> = 3kΩ to 7kΩ, C <sub>L</sub> = 150pF to 1000pF, measured from -3V to +3V or +3V to -3V, V <sub>CC</sub> = 5.4V, V <sub>EE</sub> = -5.4V, T <sub>A</sub> = +25°C | MAX3188E | 6    | 30    |      | V/μs  |
|                                      |                   |                                                                                                                                                                                | MAX3189E | 24   | 150   |      |       |
| Transmitter Enable Time              | t <sub>EN</sub>   |                                                                                                                                                                                |          | 2    |       |      | μs    |

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MAX3188E/MAX3189E

## ELECTRICAL CHARACTERISTICS (continued)

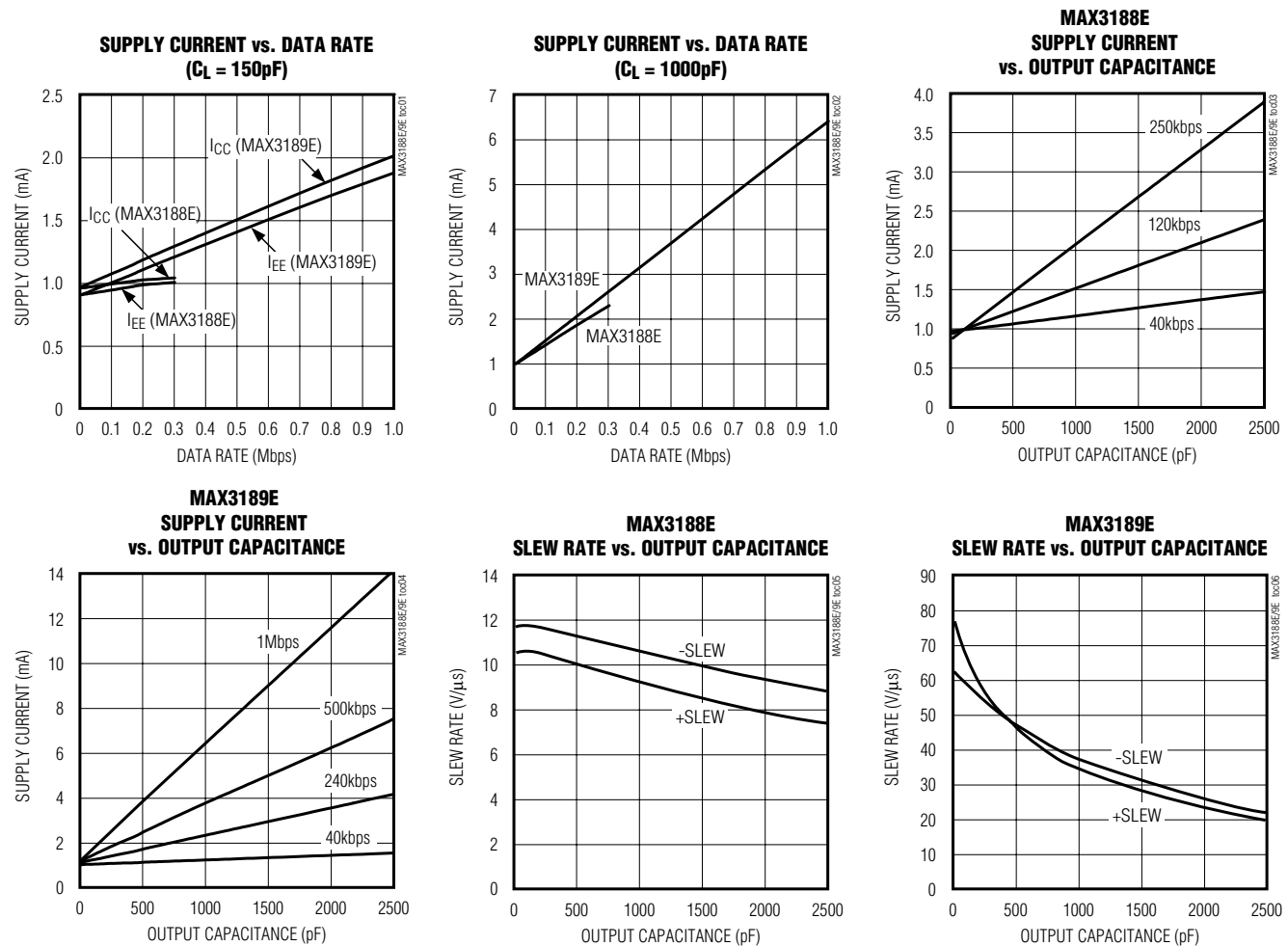
( $V_{CC} = +4.5V$  to  $+6V$ ,  $V_{EE} = -4.5V$  to  $-6V$ ,  $T_A = T_{MIN}$  to  $T_{MAX}$ , unless otherwise noted. Typical values are at  $V_{CC} = +5.4V$ ,  $V_{EE} = -5.4V$ , and  $T_A = +25^\circ C$ .) (Note 2)

| PARAMETER      | SYMBOL | CONDITIONS                     | MIN | TYP | MAX | UNITS |
|----------------|--------|--------------------------------|-----|-----|-----|-------|
| ESD PROTECTION |        |                                |     |     |     |       |
| TOUT           |        | IEC 1000-4-2 Air-Gap Discharge | ±15 |     | kV  |       |
|                |        | IEC 1000-4-2 Contact Discharge | ±8  |     |     |       |
|                |        | Human Body Model               | ±15 |     |     |       |

**Note 2:** All devices are 100% tested at  $T_A = +25^\circ C$ . All limits over temperature are guaranteed by design.

## Typical Operating Characteristics

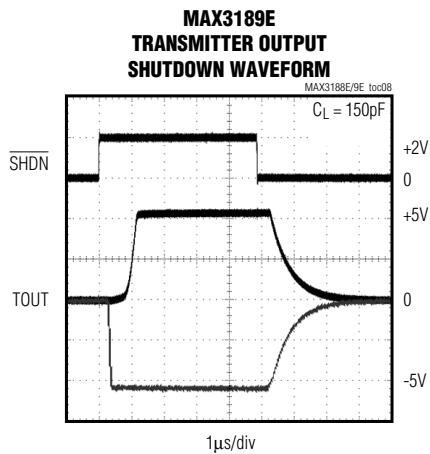
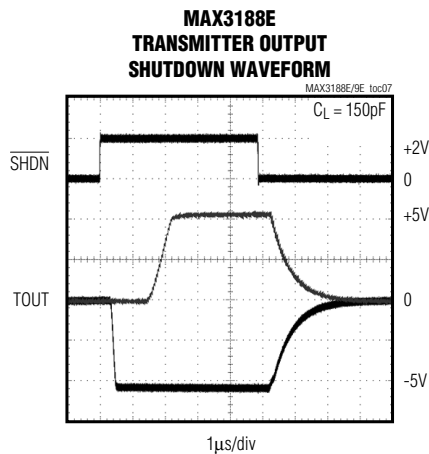
( $V_{CC} = +5.4V$ ,  $V_{EE} = -5.4V$ ,  $R_L = 3k\Omega$ ,  $T_A = +25^\circ C$ , unless otherwise noted.)



# ±15kV ESD-Protected, 1Mbps, 1μA RS-232 Transmitters in SOT23-6

## Typical Operating Characteristics (continued)

( $V_{CC} = +5.4V$ ,  $V_{EE} = -5.4V$ ,  $R_L = 3k\Omega$ ,  $T_A = +25^\circ C$ , unless otherwise noted.)



## Pin Description

| PIN | NAME              | FUNCTION                                                                                                  |
|-----|-------------------|-----------------------------------------------------------------------------------------------------------|
| 1   | $\overline{SHDN}$ | Active-Low Shutdown. Pull low to reduce the supply current and to force TOUT into a high-impedance state. |
| 2   | GND               | Ground                                                                                                    |
| 3   | TIN               | TTL/CMOS Transmitter Input                                                                                |
| 4   | TOUT              | RS-232 Transmitter Output                                                                                 |
| 5   | $V_{EE}$          | Negative Supply Voltage                                                                                   |
| 6   | $V_{CC}$          | Positive Supply Voltage                                                                                   |

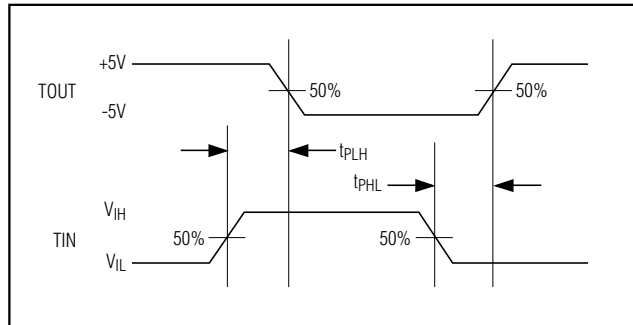


Figure 1. Transmitter Propagation-Delay Timing

## Detailed Description

The MAX3188E/MAX3189E are EIA/TIA-232 transmitters that convert CMOS/TTL logic levels to RS-232 signals. They operate on  $\pm 4.5V$  to  $\pm 6V$  supplies and feature enhanced electrostatic discharge protection (see *ESD Protection*). The MAX3188E guarantees a 250kbps data rate, and the MAX3189E guarantees a 1Mbps data rate with worst-case loads of  $3k\Omega$  in parallel with  $1000pF$ . The MAX3188E/MAX3189E invert the TOUT signal relative to TIN (standard RS-232). The transmitter input does not have a pull-up resistor and should be connected to GND if unused.

## Shutdown

The MAX3188E/MAX3189E feature a shutdown input. Drive  $\overline{SHDN}$  low to reduce the supply current to  $1\mu A$  (max). Shutdown also forces TOUT into a high-impedance state, allowing the signal line to be safely controlled by other transmitters. Drive  $\overline{SHDN}$  high for normal operation.

## ESD Protection

As with all Maxim devices, ESD protection structures are incorporated on all pins to protect against ESD encountered during handling and assembly. The MAX3188E/MAX3189Es' transmitter output has extra protection against static electricity. Maxim has developed state-of-the-art structures enabling this pin to withstand ESD up

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to ±15kV without damage or latch-up. The MAX3188E/MAX3189E's transmitter output is characterized for protection to the following limits:

- ±15kV using the Human Body Model
- ±8kV using the Contact Discharge method specified in IEC 1000-4-2
- ±15kV using the Air-Gap Discharge method specified in IEC 1000-4-2

## Human Body Model

Figure 2 shows the Human Body Model, and Figure 3 shows the current waveform it generates when discharged into a low impedance. This model consists of a 100pF capacitor charged to the ESD voltage of interest, and then discharged into the test device through a 1.5kΩ resistor.

## IEC 1000-4-2

The IEC 1000-4-2 standard covers ESD testing and performance of finished equipment; it does not specifically refer to ICs. The MAX3188E/MAX3189E enable the design of equipment that meets the highest level (Level 4) of IEC 1000-4-2 without the need for additional ESD-protection components. The major difference between tests done using the Human Body Model and IEC 1000-4-2 is higher peak current in IEC 1000-4-2. Because series resistance is lower in the IEC 1000-4-2 model, the ESD withstand voltage measured to this standard is generally lower than that measured using the Human Body. Figure 4 shows the IEC 1000-4-2 model, and Figure 5 shows the current waveform for the ±8kV IEC 1000-4-2 Level 4 ESD Contact Discharge test. The Air-Gap test involves approaching the device with a charged probe. The Contact Discharge method connects the probe to the device before the probe is energized.

## Power-Supply Decoupling

In most circumstances, 0.1μF bypass capacitors are adequate for power-supply decoupling. Connect the bypass capacitors as close to the IC as possible.

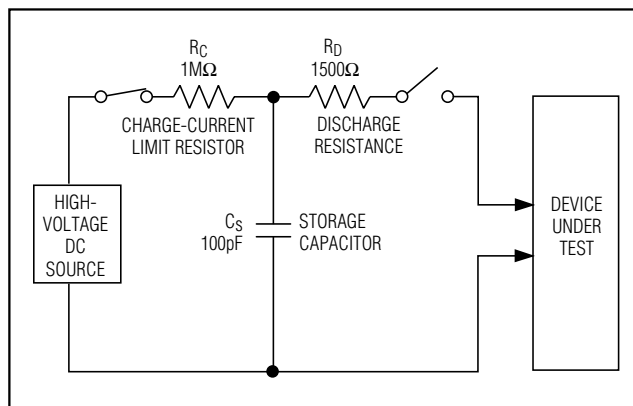


Figure 2. Human Body ESD Test Model

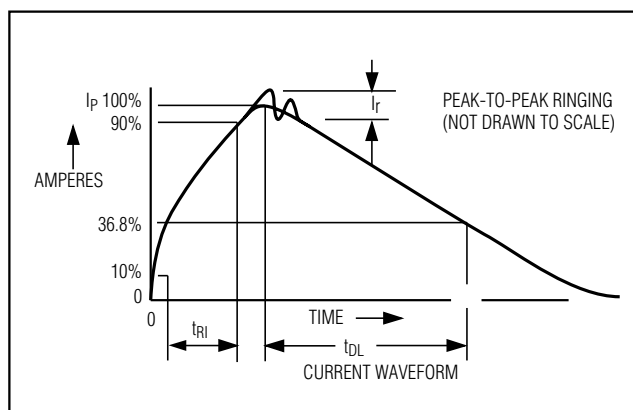


Figure 3. Human Body Model Current Waveform

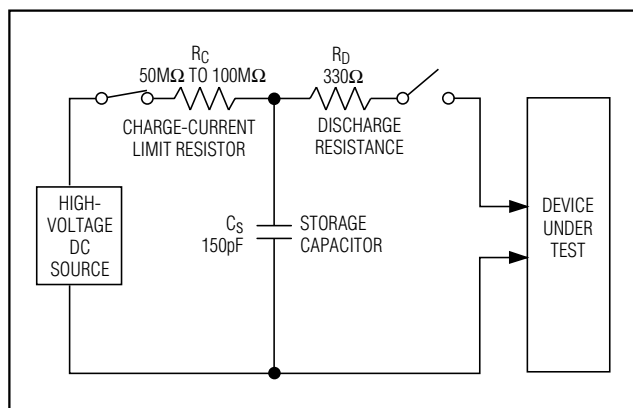


Figure 4. IEC 1000-4-2 ESD Test Model

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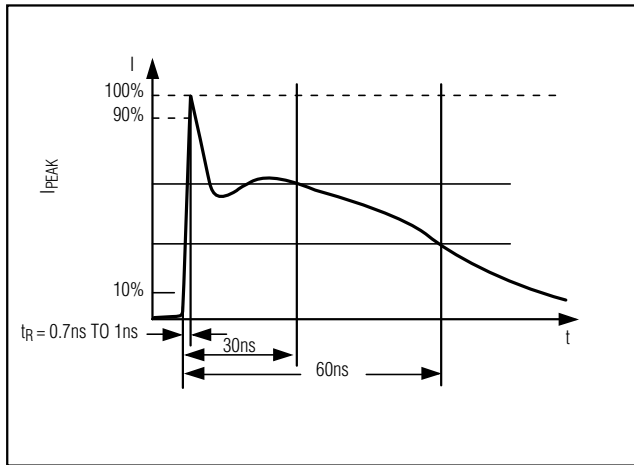


Figure 5. IEC 1000-4-2 ESD Generator Current Waveform

## Applications Information

### Power-Supply Sources

The MAX3188E/MAX3189E require  $\pm 4.5\text{V}$  to  $\pm 6\text{V}$  dual supplies. For applications where these supply voltages are not present, a DC-DC converter must be added. Due to the MAX3188E/MAX3189Es' low current consumption, a charge pump can provide the proper supply voltages and requires a minimal amount of board space and cost.

When using another RS-232 device containing an internal regulated charge pump (Table 1), the MAX3188E/MAX3189E may be powered from the internal charge pump (Figure 6). This eliminates the need for additional external DC-DC converters to generate the required  $\pm 4.5\text{V}$  to  $\pm 6\text{V}$  dual supplies.

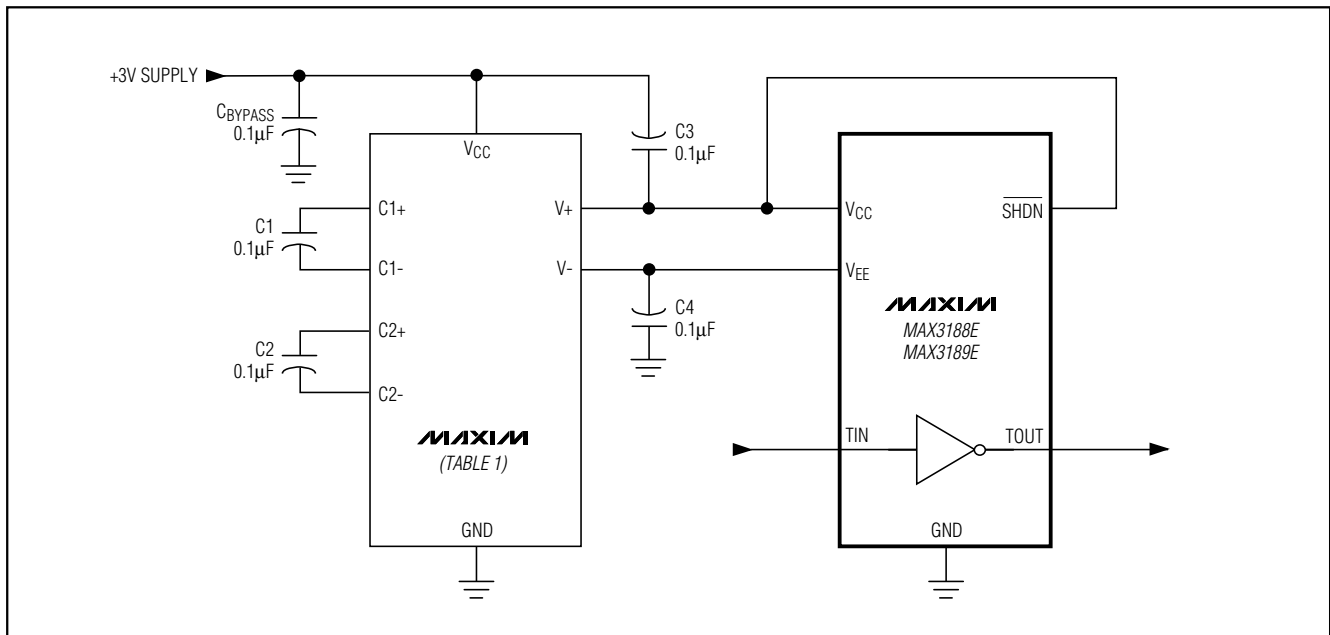


Figure 6. Powering the MAX3188E/MAX3189E

# **$\pm 15\text{kV}$ ESD-Protected, 1Mbps, 1 $\mu\text{A}$ RS-232 Transmitters in SOT23-6**

**MAX3188E/MAX3189E**

**Table 1. RS-232 Devices with Internal Regulated Charge Pumps**

| PART     | NO. OF Tx/Rx | $\pm 15\text{kV}$ ESD PROTECTION | AutoShutdown Plus™ | AutoShutdown™ | DATA RATE (bps) |
|----------|--------------|----------------------------------|--------------------|---------------|-----------------|
| MAX3221  | 1/1          |                                  |                    | ✓             | 120k            |
| MAX3221E | 1/1          | ✓                                |                    | ✓             | 250k            |
| MAX3222  | 2/2          |                                  |                    |               | 120k            |
| MAX3222E | 2/2          | ✓                                |                    |               | 250k            |
| MAX3223  | 2/2          |                                  |                    | ✓             | 120k            |
| MAX3223E | 2/2          | ✓                                |                    | ✓             | 250k            |
| MAX3224  | 2/2          |                                  | ✓                  |               | 250k            |
| MAX3224E | 2/2          | ✓                                | ✓                  |               | 250k            |
| MAX3225  | 2/2          |                                  | ✓                  |               | 1M              |
| MAX3225E | 2/2          | ✓                                | ✓                  |               | 1M              |
| MAX3226  | 1/1          |                                  | ✓                  |               | 250k            |
| MAX3226E | 1/1          | ✓                                | ✓                  |               | 250k            |
| MAX3227  | 1/1          |                                  | ✓                  |               | 1M              |
| MAX3227E | 1/1          | ✓                                | ✓                  |               | 1M              |
| MAX3232  | 2/2          |                                  |                    |               | 120k            |
| MAX3232E | 2/2          | ✓                                |                    |               | 250k            |
| MAX3237  | 5/3          |                                  |                    |               | 1M              |
| MAX3238  | 5/3          |                                  | ✓                  |               | 250k            |
| MAX3241  | 3/5          |                                  |                    |               | 120k            |
| MAX3241E | 3/5          | ✓                                |                    |               | 250k            |
| MAX3243  | 3/5          |                                  |                    | ✓             | 120k            |
| MAX3243E | 3/5          | ✓                                |                    | ✓             | 250k            |
| MAX3244  | 3/5          |                                  | ✓                  |               | 250k            |
| MAX3244E | 3/5          | ✓                                | ✓                  |               | 250k            |
| MAX3245  | 3/5          |                                  | ✓                  |               | 1M              |
| MAX3245E | 3/5          | ✓                                | ✓                  |               | 1M              |

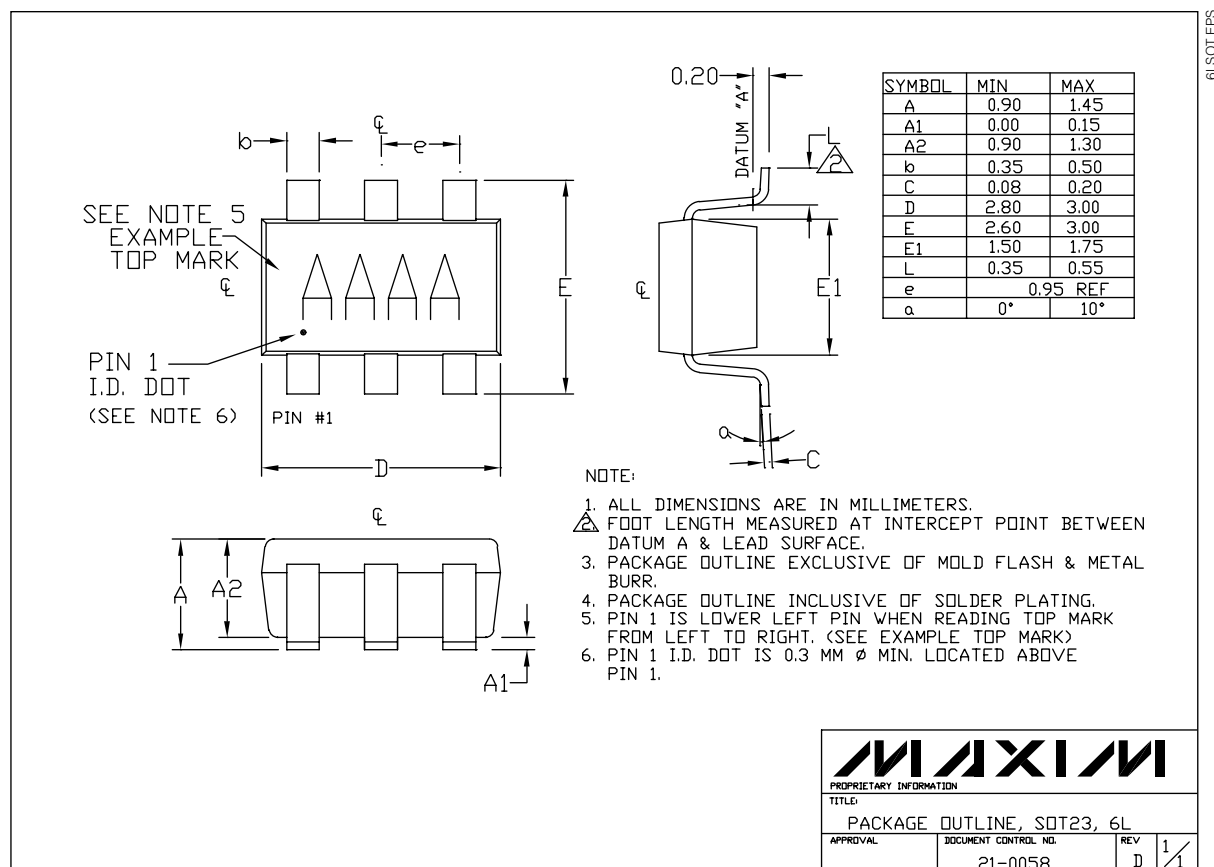
## **Chip Information**

TRANSISTOR COUNT: 111

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## Package Information



Maxim cannot assume responsibility for use of any circuitry other than circuitry entirely embodied in a Maxim product. No circuit patent licenses are implied. Maxim reserves the right to change the circuitry and specifications without notice at any time.

8 **Maxim Integrated Products, 120 San Gabriel Drive, Sunnyvale, CA 94086 408-737-7600**