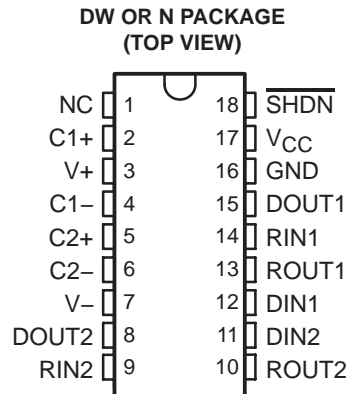


MAX222

5-V DUAL RS-232 LINE DRIVER/RECEIVER WITH ± 15 -kV ESD PROTECTION

SLLS590D – SEPTEMBER 2003 – REVISED AUGUST 2004

- ESD Protection for RS-232 Bus Pins
 - ± 15 -kV Human-Body Model
- Meets or Exceeds the Requirements of TIA/EIA-232-F and ITU v.28 Standards
- Operates at 5-V V_{CC} Supply
- Operates Up To 200 kbit/s
- Low Supply Current in Shutdown Mode . . . 2 μ A Typical
- External Capacitors . . . $4 \times 0.1 \mu$ F
- Latch-Up Performance Exceeds 100 mA Per JESD 78, Class II
- Applications
 - Battery-Powered Systems, PDAs, Notebooks, Laptops, Palmtop PCs, and Hand-Held Equipment



description/ordering information

The MAX222 consists of two line drivers, two line receivers, and a dual charge-pump circuit with ± 15 -kV ESD protection pin to pin (serial-port connection pins, including GND). This device meets the requirements of TIA/EIA-232-F and provides the electrical interface between an asynchronous communication controller and the serial-port connector. The charge pump and four small external capacitors allow operation from a single 5-V supply. This device operates at data signaling rates up to 200 kbit/s and a maximum of 30-V/ μ s driver output slew rate. By using $\overline{\text{SHDN}}$, all receivers can be disabled.

ORDERING INFORMATION

| T_A | PACKAGE† | | ORDERABLE PART NUMBER | TOP-SIDE MARKING |
|---------------|-----------|--------------|-----------------------|------------------|
| 0°C to 70°C | PDIP (N) | Tube of 20 | MAX222CN | MAX222CN |
| | SOIC (DW) | Tube of 20 | MAX222CDW | MAX222C |
| | | Reel of 1000 | MAX222CDWR | |
| –40°C to 85°C | PDIP (N) | Tube of 20 | MAX222IN | MAX222IN |
| | SOIC (DW) | Tube of 20 | MAX222IDW | MAX222I |
| | | Reel of 1000 | MAX222IDWR | |

† Package drawings, standard packing quantities, thermal data, symbolization, and PCB design guidelines are available at www.ti.com/sc/package.



Please be aware that an important notice concerning availability, standard warranty, and use in critical applications of Texas Instruments semiconductor products and disclaimers thereto appears at the end of this data sheet.

PRODUCTION DATA information is current as of publication date. Products conform to specifications per the terms of Texas Instruments standard warranty. Production processing does not necessarily include testing of all parameters.



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MAX222
5-V DUAL RS-232 LINE DRIVER/RECEIVER
WITH ±15-kV ESD PROTECTION

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Function Tables

EACH DRIVER

| INPUT D _{IN} | OUTPUT D _{OUT} |
|--------------------------|----------------------------|
| L | H |
| H | L |

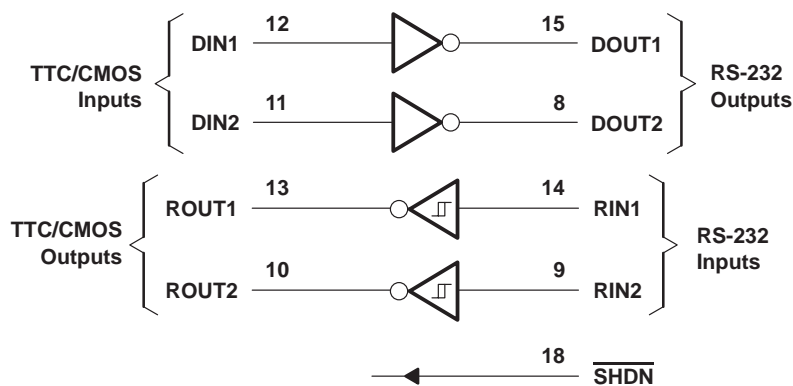
H = high level, L = low level

EACH RECEIVER

| INPUT R _{IN} | OUTPUT R _{OUT} |
|--------------------------|----------------------------|
| L | H |
| H | L |
| Open | H |

H = high level, L = low level, Open = input disconnected or connected driver off

logic diagram (positive logic)



MAX222

5-V DUAL RS-232 LINE DRIVER/RECEIVER WITH ± 15 -kV ESD PROTECTION

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absolute maximum ratings over operating free-air temperature range (unless otherwise noted)†

| | |
|--|----------------------------|
| Supply voltage range, V_{CC} (see Note 1) | –0.3 V to 6 V |
| Input voltage range, V_I : Drivers | –0.3 V to $V_{CC} - 0.3$ V |
| Receivers | ± 30 V |
| Output voltage range, V_O : Drivers | ± 15 V |
| Receivers | –0.3 V to $V_{CC} + 0.3$ V |
| Short-circuit duration, D_{OUT} | Continuous |
| Package thermal impedance, θ_{JA} (see Notes 2 and 3): DW package | TBD°C/W |
| N package | TBD°C/W |
| Operating virtual junction temperature, T_J | 150°C |
| Storage temperature range, T_{stg} | –65°C to 150°C |

† 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 under “recommended operating conditions” is not implied. Exposure to absolute-maximum-rated conditions for extended periods may affect device reliability.

- NOTES:
1. All voltages are with respect to network GND.
 2. Maximum power dissipation is a function of $T_J(\max)$, θ_{JA} , and T_A . The maximum allowable power dissipation at any allowable ambient temperature is $P_D = (T_J(\max) - T_A)/\theta_{JA}$. Operating at the absolute maximum T_J of 150°C can affect reliability.
 3. The package thermal impedance is calculated in accordance with JESD 51-7.

recommended operating conditions (see Note 4 and Figure 4)

| | | | MIN | NOM | MAX | UNIT |
|----------|-----------------------------------|-------------------|-----|-----|-----|------|
| V_{CC} | Supply voltage | | 4.5 | 5 | 5.5 | V |
| V_{IH} | Driver high-level input voltage | D_{IN} | 2 | | | V |
| | Shutdown high-level input voltage | \overline{SHDN} | 2 | | | V |
| V_{IL} | Driver low-level input voltage | D_{IN} | | | 0.8 | V |
| | Shutdown low-level input voltage | \overline{SHDN} | | | 0.8 | V |
| V_I | Driver input voltage | D_{IN} | 0 | | 5.5 | V |
| | Receiver input voltage | | –30 | | 30 | |
| T_A | Operating free-air temperature | MAX222C | 0 | | 70 | °C |
| | | MAX222I | –40 | | 85 | |

NOTE 4: Test conditions are C1–C4 = 0.1 μ F at $V_{CC} = 5$ V \pm 0.5 V.

electrical characteristics over recommended ranges of supply voltage and operating free-air temperature (unless otherwise noted) (see Note 4 and Figure 4)

| PARAMETER | | TEST CONDITIONS | | | MIN | TYP | MAX | UNIT |
|-------------------|--------------------------------|-----------------|----------------------------|-----------------------------|-----|-----|---------|---------|
| I_{CC} | Supply current | $V_{CC} = 5$ V | $\overline{SHDN} = V_{CC}$ | No load | | 4 | 10 | mA |
| | | | | 3 k Ω on both inputs | | 15 | | |
| | Shutdown supply current | | | | | 2 | 50 | μ A |
| \overline{SHDN} | Shutdown input leakage current | | | | | | ± 1 | μ A |

NOTE 4: Test conditions are C1–C4 = 0.1 μ F at $V_{CC} = 5$ V \pm 0.5 V.



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5-V DUAL RS-232 LINE DRIVER/RECEIVER
WITH ±15-kV ESD PROTECTION

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DRIVER SECTION

electrical characteristics over recommended ranges of supply voltage and operating free-air temperature (unless otherwise noted) (see Note 4 and Figure 4)

| PARAMETER | | TEST CONDITIONS | MIN | TYP† | MAX | UNIT |
|-------------------|----------------------------------|---|-----|-------|-----|------|
| V _{OH} | High-level output voltage | DOUT at R _L = 3 kΩ to GND, D _{IN} = GND | 5 | 8 | | V |
| V _{OL} | Low-level output voltage | DOUT at R _L = 3 kΩ to GND, D _{IN} = V _{CC} | -5 | -8 | | V |
| I _{IH} | Driver high-level input current | DIN = V _{CC} | | 5 | 40 | μA |
| | Control high-level input current | SHDN = V _{CC} | | 0.01 | 1 | |
| I _{IL} | Driver low-level input current | DIN = 0 V | | -5 | -40 | μA |
| | Control low-level input current | SHDN = 0 V | | -0.01 | -1 | |
| I _{OS} ‡ | Short-circuit output current | V _{CC} = 5.5 V, V _O = 0 V | ±7 | ±22 | | mA |
| I _{off} | Output leakage current | V _{CC} = 5.5 V, SHDN = GND, V _O = ±10 V | | ±0.01 | ±10 | μA |
| r _o | Output resistance | V _{CC} , V+, and V- = 0 V, V _O = ±2 V | 300 | 10 M | | Ω |

† All typical values are at V_{CC} = 5 V, and T_A = 25°C.

‡ Short-circuit durations should be controlled to prevent exceeding the device absolute power-dissipation ratings, and not more than one output should be shorted at a time.

NOTE 4: Test conditions are C1–C4 = 0.1 μF at V_{CC} = 5 V ± 0.5 V.

switching characteristics over recommended ranges of supply voltage and operating free-air temperature (unless otherwise noted) (see Note 4 and Figure 4)

| PARAMETER | | TEST CONDITIONS | MIN | TYP† | MAX | UNIT |
|---|---|---|-----|------|-----|--------|
| | Data rate | C _L = 1000 pF, R _L = 3 kΩ, One DOUT switching, See Figure 1 | 200 | | | kbit/s |
| t _{PLH} (D) | Propagation delay time, low- to high-level output | See Figure 1 | | 1.5 | 3.5 | μs |
| t _{PHL} (D) | Propagation delay time, high- to low-level output | See Figure 1 | | 1.3 | 3.5 | μs |
| t _{PHL} (D) – t _{PLH} (D) | Driver (+ to –) propagation delay difference | | | 300 | | ns |
| t _{sk(p)} | Pulse skew§ | C _L = 150 pF to 2500 pF, R _L = 3 kΩ to 7 kΩ, See Figure 2 | | 300 | | ns |
| SR(tr) | Slew rate, transition region (see Figure 1) | R _L = 3 kΩ to 7 kΩ, V _{CC} = 5 V, C _L = 50 pF to 2500 pF | 6 | 12 | 30 | V/μs |
| t _{ET} | Driver output enable time (after SHDN goes high) | | | 250 | | μs |
| t _{DT} | Driver output disable time (after SHDN goes low) | | | 300 | | ns |

† All typical values are at V_{CC} = 5 V and T_A = 25°C.

§ Pulse skew is defined as |t_{PLH} – t_{PHL}| of each channel of the same device.

NOTE 4: Test conditions are C1–C4 = 0.1 μF at V_{CC} = 5 V ± 0.5 V.



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5-V DUAL RS-232 LINE DRIVER/RECEIVER
WITH ± 15 -kV ESD PROTECTION

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RECEIVER SECTION

electrical characteristics over recommended ranges of supply voltage and operating free-air temperature (unless otherwise noted) (see Note 4 and Figure 4)

| PARAMETER | | TEST CONDITIONS | MIN | TYP† | MAX | UNIT |
|-----------|--|-------------------------------|-----|------------------|-----|------------|
| V_{OH} | High-level output voltage | $I_{OH} = -1$ mA | 3.5 | $V_{CC} - 0.2$ V | | V |
| V_{OL} | Low-level output voltage | $I_{OL} = 3.2$ mA | | | 0.4 | V |
| V_{IT+} | Positive-going input threshold voltage | $V_{CC} = 5$ V | | 1.7 | 2.4 | V |
| V_{IT-} | Negative-going input threshold voltage | $V_{CC} = 5$ V | 0.8 | 1.3 | | V |
| V_{hys} | Input hysteresis ($V_{IT+} - V_{IT-}$) | | 0.2 | 0.5 | 1 | V |
| r_i | Input resistance | $V_I = \pm 3$ V to ± 25 V | 3 | 5 | 7 | k Ω |

† All typical values are at $V_{CC} = 5$ V, and $T_A = 25^\circ\text{C}$.

NOTE 4: Test conditions are C1–C4 = 0.1 μF at $V_{CC} = 5$ V ± 0.5 V.

switching characteristics over recommended ranges of supply voltage and operating free-air temperature (unless otherwise noted) (see Note 4 and Figure 3)

| PARAMETER | | TEST CONDITIONS | MIN | TYP† | MAX | UNIT |
|----------------------------------|---|-----------------|-----|------|-----|---------------|
| t_{PLH} (R) | Propagation delay time, low- to high-level output | $C_L = 150$ pF | | 0.6 | 1 | μs |
| t_{PHL} (R) | Propagation delay time, high- to low-level output | $C_L = 150$ pF | | 0.5 | 1 | μs |
| t_{PHL} (R) – t_{PLH} (R) | Receiver (+ to –) propagation delay difference | | | 100 | | ns |
| $t_{sk(p)}$ | Pulse skew‡ | | | 100 | | ns |

† All typical values are at $V_{CC} = 5$ V and $T_A = 25^\circ\text{C}$.

‡ Pulse skew is defined as $|t_{PLH} - t_{PHL}|$ of each channel of the same device.

NOTE 4: Test conditions are C1–C4 = 0.1 μF , at $V_{CC} = 5$ V ± 0.5 V.

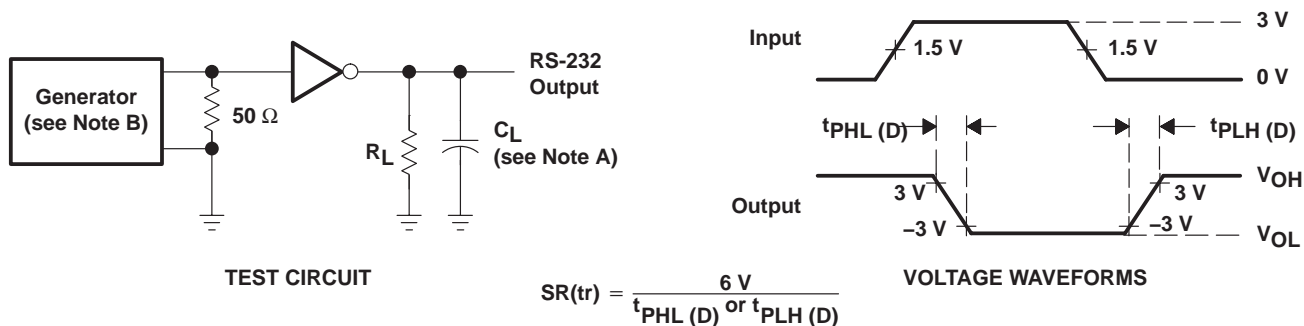
ESD protection

| PIN | TEST CONDITIONS | TYP | UNIT |
|----------------------|------------------|----------|------|
| D_{OUT} , R_{IN} | Human-Body Model | ± 15 | kV |

MAX222
5-V DUAL RS-232 LINE DRIVER/RECEIVER
WITH ±15-kV ESD PROTECTION

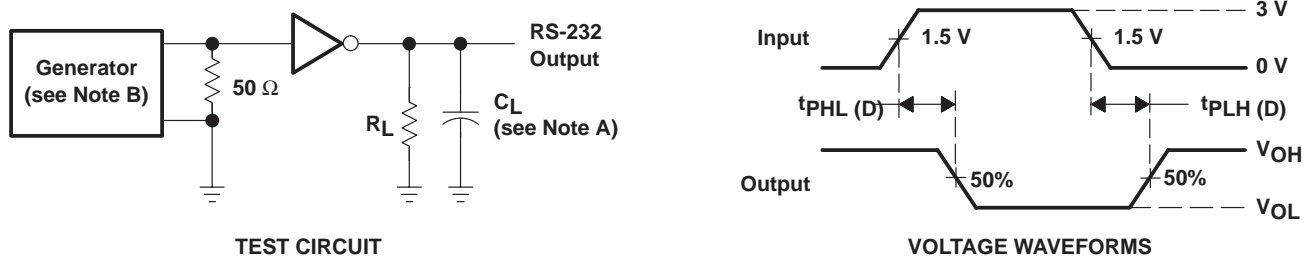
SLLS590D – SEPTEMBER 2003 – REVISED AUGUST 2004

PARAMETER MEASUREMENT INFORMATION



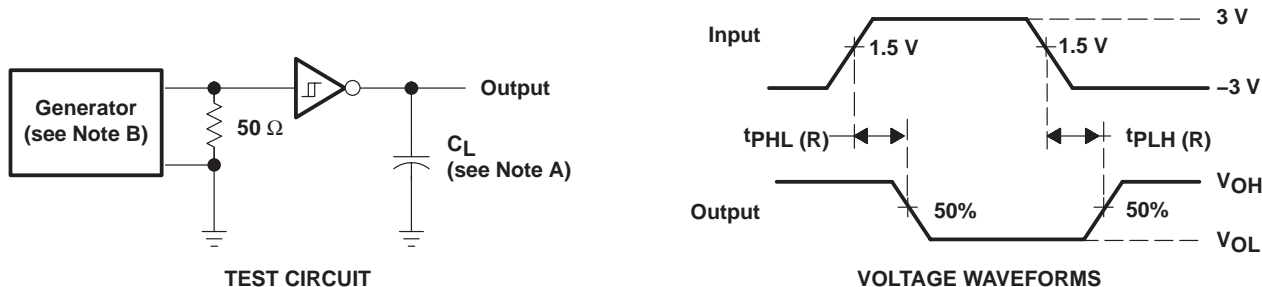
NOTES: A. C_L includes probe and jig capacitance.
 B. The pulse generator has the following characteristics: PRR = 250 kbit/s, $Z_O = 50\ \Omega$, 50% duty cycle, $t_r \leq 10\text{ ns}$, $t_f \leq 10\text{ ns}$.

Figure 1. Driver Slew Rate



NOTES: A. C_L includes probe and jig capacitance.
 B. The pulse generator has the following characteristics: PRR = 250 kbit/s, $Z_O = 50\ \Omega$, 50% duty cycle, $t_r \leq 10\text{ ns}$, $t_f \leq 10\text{ ns}$.

Figure 2. Driver Pulse Skew



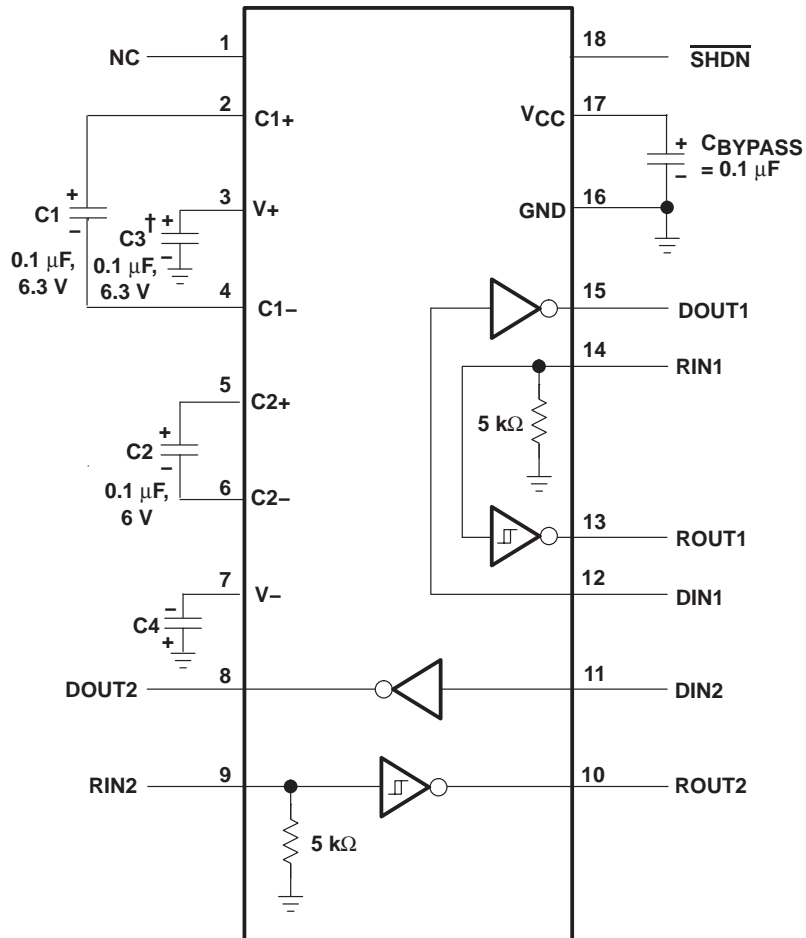
NOTES: A. C_L includes probe and jig capacitance.
 B. The pulse generator has the following characteristics: $Z_O = 50\ \Omega$, 50% duty cycle, $t_r \leq 10\text{ ns}$, $t_f \leq 10\text{ ns}$.

Figure 3. Receiver Propagation Delay Times

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APPLICATION INFORMATION



† C3 can be connected to V_{CC} or GND.

NOTES: A. Resistor values shown are nominal.

B. Nonpolarized ceramic capacitors are acceptable. If polarized tantalum or electrolytic capacitors are used, they should be connected as shown.

Figure 4. Typical Operating Circuit and Capacitor Values

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5-V DUAL RS-232 LINE DRIVER/RECEIVER

WITH ± 15 -kV ESD PROTECTION

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APPLICATION INFORMATION

capacitor selection

The capacitor type used for C1–C4 is not critical for proper operation. The MAX222 requires 0.1- μ F capacitors, although capacitors up to 10 μ F can be used without harm. Ceramic dielectrics are suggested for the 0.1- μ F capacitors. When using the minimum recommended capacitor values, ensure that the capacitance value does not degrade excessively as the operating temperature varies. If in doubt, use capacitors with a larger (e.g., 2 \times) nominal value. The capacitors' effective series resistance (ESR), which usually rises at low temperatures, influences the amount of ripple on V_+ and V_- .

Use larger capacitors (up to 10 μ F) to reduce the output impedance at V_+ and V_- .

Bypass V_{CC} to ground with at least 0.1 μ F. In applications sensitive to power-supply noise generated by the charge pumps, decouple V_{CC} to ground with a capacitor the same size as (or larger than) the charge-pump capacitors (C1–C4).

ESD protection

TI MAX222 devices have standard ESD protection structures incorporated on the pins to protect against electrostatic discharges encountered during assembly and handling. In addition, the RS232 bus pins (driver outputs and receiver inputs) of these devices have an extra level of ESD protection. Advanced ESD structures were designed to successfully protect these bus pins against ESD discharge of ± 15 -kV when powered down.

ESD test conditions

ESD testing stringently is performed by TI, based on various conditions and procedures. Contact TI for a reliability report that documents test setup, methodology, and results.

Human-Body Model

The Human-Body Model (HBM) of ESD testing is shown in Figure 5, while Figure 6 shows the current waveform that is generated during a discharge into a low impedance. The model consists of a 100-pF capacitor, charged to the ESD voltage of concern, and subsequently discharged into the DUT through a 1.5-k Ω resistor.

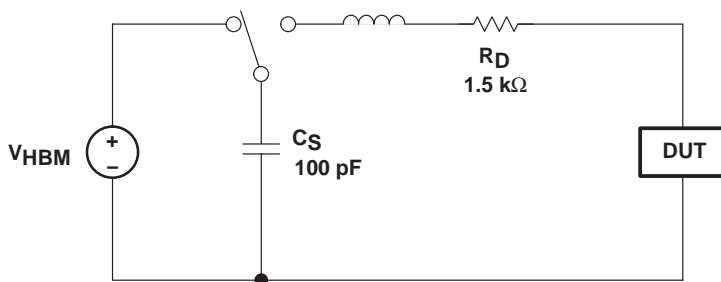


Figure 5. HBM ESD Test Circuit

APPLICATION INFORMATION

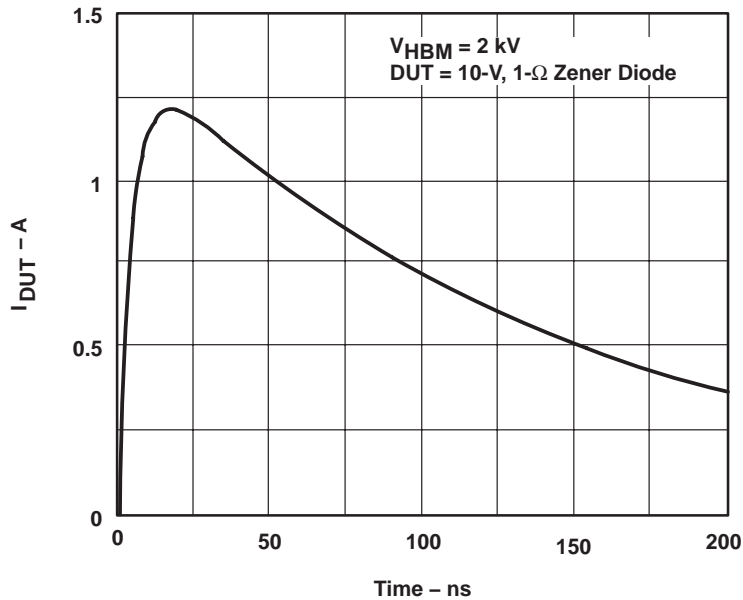


Figure 6. Typical HBM Current Waveform

Machine Model

The Machine Model (MM) ESD test applies to all pins using a 200-pF capacitor with no discharge resistance. The purpose of the MM test is to simulate possible ESD conditions that can occur during the handling and assembly processes of manufacturing. In this case, ESD protection is required for all pins, not just RS-232 pins. However, after PC board assembly, the MM test no longer is as pertinent to the RS-232 pins.

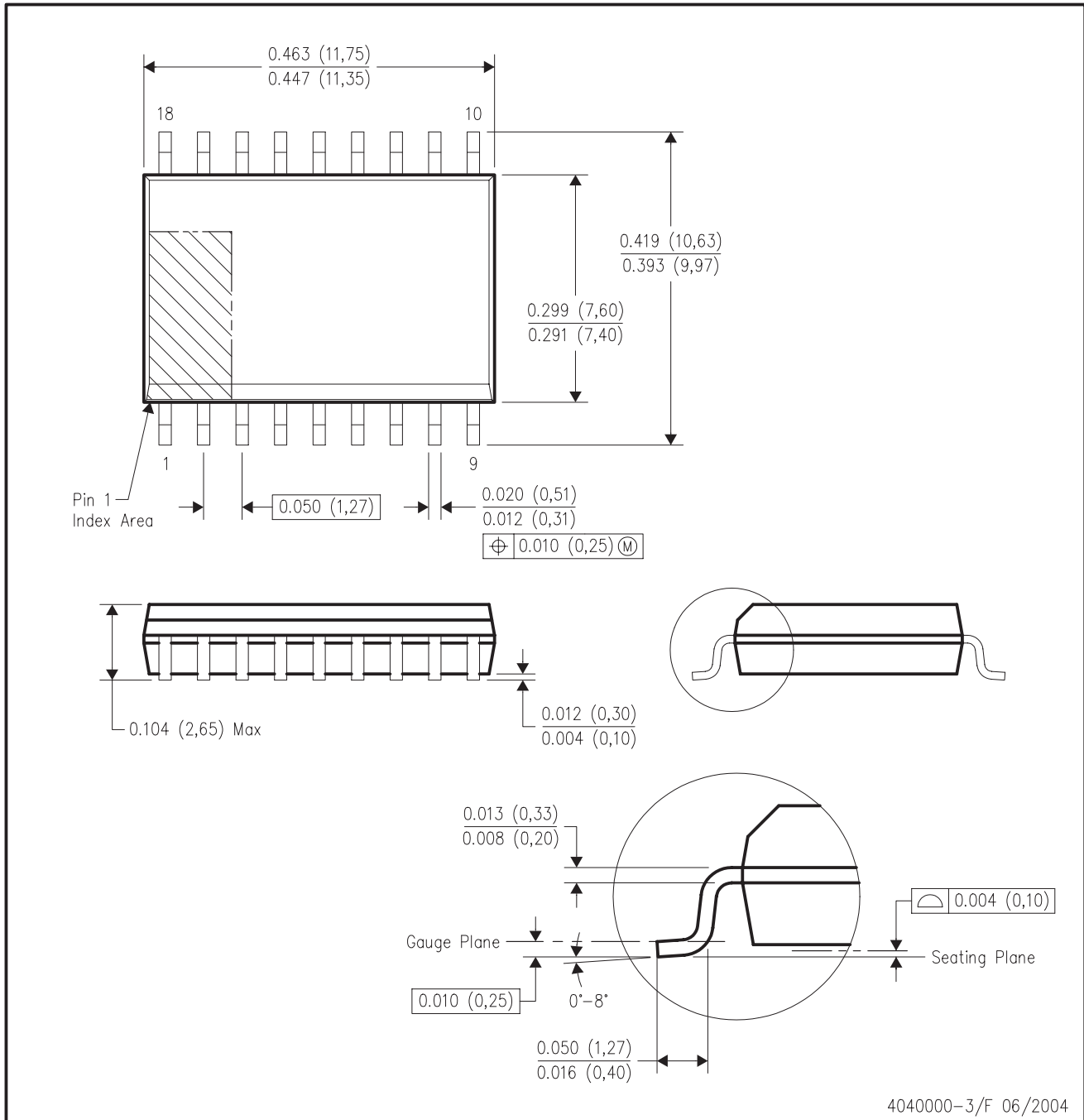
MAX222
5-V DUAL RS-232 LINE DRIVER/RECEIVER
WITH ±15-kV ESD PROTECTION

MECHANICAL DATA

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DW (R-PDSO-G18)

PLASTIC SMALL-OUTLINE PACKAGE



4040000-3/F 06/2004

- NOTES:
- All linear dimensions are in inches (millimeters).
 - This drawing is subject to change without notice.
 - Body dimensions do not include mold flash or protrusion not to exceed 0.006 (0,15).
 - Falls within JEDEC MS-013 variation AB.



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PACKAGING INFORMATION

| Orderable Device | Status ⁽¹⁾ | Package Type | Package Drawing | Pins | Package Qty | Eco Plan ⁽²⁾ | Lead/Ball Finish | MSL Peak Temp ⁽³⁾ |
|------------------|-----------------------|--------------|-----------------|------|-------------|-------------------------|------------------|------------------------------|
| MAX222CDW | ACTIVE | SOIC | DW | 18 | 40 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-2-260C-1YEAR |
| MAX222CDWG4 | ACTIVE | SOIC | DW | 18 | 40 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-2-260C-1YEAR |
| MAX222CDWR | ACTIVE | SOIC | DW | 18 | 2000 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-2-260C-1YEAR |
| MAX222CDWRG4 | ACTIVE | SOIC | DW | 18 | 2000 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-2-260C-1YEAR |
| MAX222CN | ACTIVE | PDIP | N | 18 | 20 | Pb-Free (RoHS) | CU NIPDAU | N / A for Pkg Type |
| MAX222CNE4 | ACTIVE | PDIP | N | 18 | 20 | Pb-Free (RoHS) | CU NIPDAU | N / A for Pkg Type |
| MAX222IDW | ACTIVE | SOIC | DW | 18 | 40 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-2-260C-1YEAR |
| MAX222IDWG4 | ACTIVE | SOIC | DW | 18 | 40 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-2-260C-1YEAR |
| MAX222IDWR | ACTIVE | SOIC | DW | 18 | 2000 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-2-260C-1YEAR |
| MAX222IDWRG4 | ACTIVE | SOIC | DW | 18 | 2000 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-2-260C-1YEAR |
| MAX222IN | ACTIVE | PDIP | N | 18 | 20 | Pb-Free (RoHS) | CU NIPDAU | N / A for Pkg Type |
| MAX222INE4 | ACTIVE | PDIP | N | 18 | 20 | Pb-Free (RoHS) | CU NIPDAU | N / A for Pkg Type |

⁽¹⁾ The marketing status values are defined as follows:

ACTIVE: Product device recommended for new designs.

LIFEBUY: TI has announced that the device will be discontinued, and a lifetime-buy period is in effect.

NRND: Not recommended for new designs. Device is in production to support existing customers, but TI does not recommend using this part in a new design.

PREVIEW: Device has been announced but is not in production. Samples may or may not be available.

OBSOLETE: TI has discontinued the production of the device.

⁽²⁾ Eco Plan - The planned eco-friendly classification: Pb-Free (RoHS), Pb-Free (RoHS Exempt), or Green (RoHS & no Sb/Br) - please check <http://www.ti.com/productcontent> for the latest availability information and additional product content details.

TBD: The Pb-Free/Green conversion plan has not been defined.

Pb-Free (RoHS): TI's terms "Lead-Free" or "Pb-Free" mean semiconductor products that are compatible with the current RoHS requirements for all 6 substances, including the requirement that lead not exceed 0.1% by weight in homogeneous materials. Where designed to be soldered at high temperatures, TI Pb-Free products are suitable for use in specified lead-free processes.

Pb-Free (RoHS Exempt): This component has a RoHS exemption for either 1) lead-based flip-chip solder bumps used between the die and package, or 2) lead-based die adhesive used between the die and leadframe. The component is otherwise considered Pb-Free (RoHS compatible) as defined above.

Green (RoHS & no Sb/Br): TI defines "Green" to mean Pb-Free (RoHS compatible), and free of Bromine (Br) and Antimony (Sb) based flame retardants (Br or Sb do not exceed 0.1% by weight in homogeneous material)

⁽³⁾ MSL, Peak Temp. -- The Moisture Sensitivity Level rating according to the JEDEC industry standard classifications, and peak solder temperature.

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N (R-PDIP-T**)

PLASTIC DUAL-IN-LINE PACKAGE

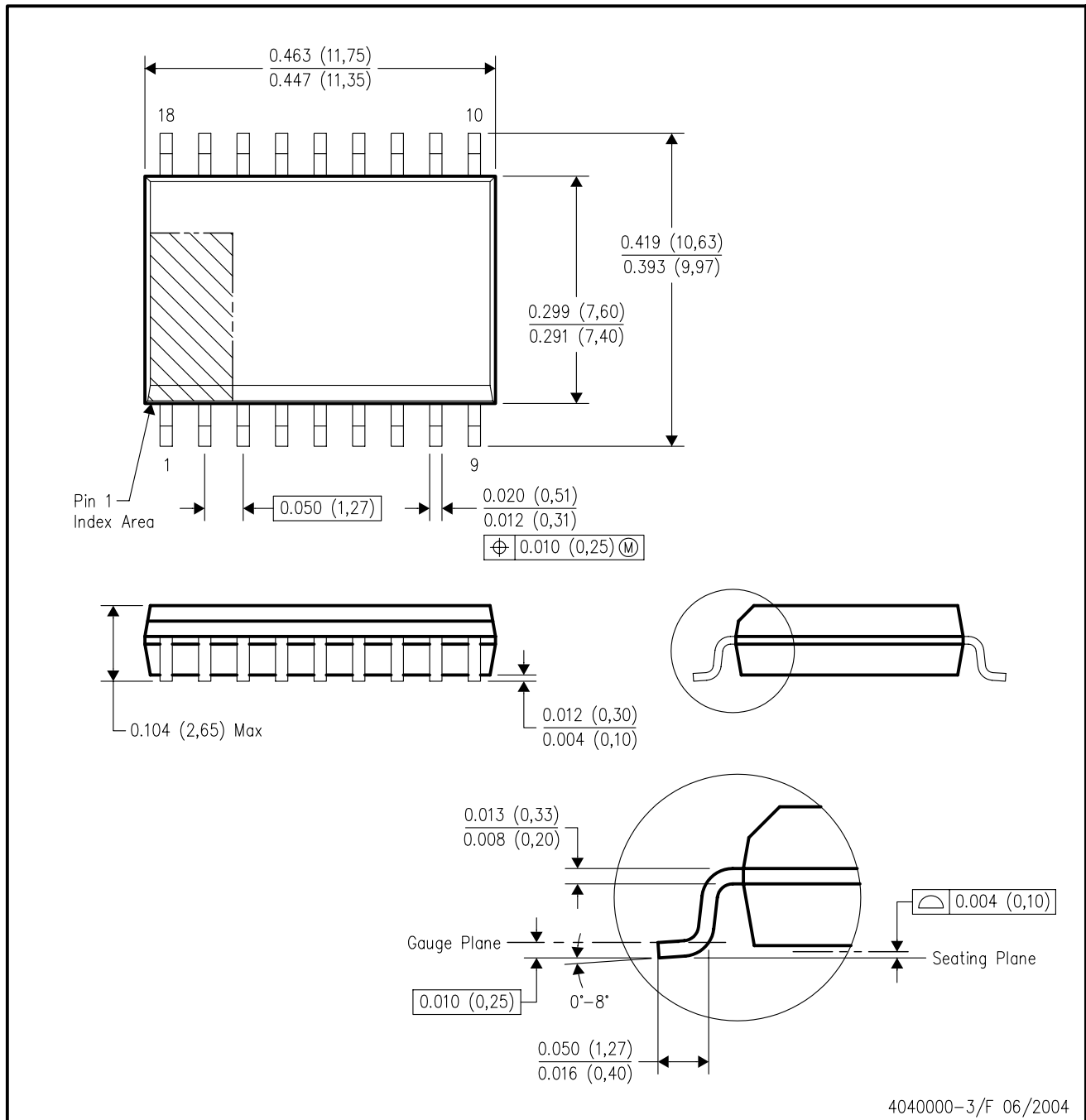
16 PINS SHOWN



- NOTES:
- A. All linear dimensions are in inches (millimeters).
 - B. This drawing is subject to change without notice.
 - C Falls within JEDEC MS-001, except 18 and 20 pin minimum body length (Dim A).
 - D The 20 pin end lead shoulder width is a vendor option, either half or full width.

DW (R-PDSO-G18)

PLASTIC SMALL-OUTLINE PACKAGE



4040000-3/F 06/2004

- NOTES:
- A. All linear dimensions are in inches (millimeters).
 - B. This drawing is subject to change without notice.
 - C. Body dimensions do not include mold flash or protrusion not to exceed 0.006 (0,15).
 - D. Falls within JEDEC MS-013 variation AB.

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