

MAX3160/MAX3161/MAX3162

+3.0V to+5.5V, 1μA, RS-232/ RS-485/422 Multiprotocol Transceivers

| | |
|---|-----------------------------------|
| V _{CC} to GND..... | -0.3V to +6V |
| V+ to GND..... | -0.3V to +7V |
| V- to GND..... | 0.3V to -7V |
| V+ - V- (Note 1)..... | +13V |
| Input Voltages | |
| T1IN, T2IN, DI, DE485, <u>RE485</u> , TE232, <u>RE232</u> , <u>SHDN</u> , | |
| FAST, HDPLX, RS485/ <u>RS232</u> to GND..... | -0.3V to +6V |
| A, B, R1IN, R2IN to GND..... | ±25V |
| Output Voltages | |
| T1OUT, T2OUT, Y, Z to GND..... | ±13.2V |
| R2OUT, R1OUT, RO to GND..... | -0.3V to (V _{CC} + 0.3V) |
| Output Short-Circuit Duration | |
| T1OUT, T2OUT, Y, Z..... | Continuous |

| | |
|---|-----------------|
| Continuous Power Dissipation (T _A = +70°C) | |
| 20-Pin SSOP (derate 11.9W/°C above +70°C)..... | 952mW |
| 24-Pin SSOP (derate 14.9W/°C above +70°C)..... | 1195mW |
| 28-Pin SSOP (derate 15W/°C above +70°C)..... | 1201mW |
| Operating Temperature Ranges | |
| MAX316_CA..... | 0°C to +70°C |
| MAX316_EA..... | -40°C to +85°C |
| Storage Temperature Range..... | -65°C to +150°C |
| Junction Temperature..... | +150°C |
| Lead Temperature (soldering, 10s)..... | +300°C |

Note 1: V+ and V- 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_{CC} = +3V to +5.5V, C1–C4 = 0.1μF when tested at +3.3V ±10%; C1 = 0.047μF and C2, C3, C4 = 0.33μF when tested at +5V ±10%; T_A = T_{MIN} to T_{MAX}, unless otherwise noted. Typical values are at T_A = +25°C.)

| PARAMETER | SYMBOL | CONDITIONS | MIN | TYP | MAX | UNITS |
|---|------------------|---|-----------------------|-------|-----|-------|
| DC CHARACTERISTICS | | | | | | |
| V _{CC} Standby Current | I _{CC} | MAX3160/MAX3161, no load, RS485/RS232 = GND | | 1.2 | 2.5 | mA |
| | | MAX3160/MAX3161, no load, RS485/RS232 = V _{CC} | | 2.5 | 5.5 | |
| | | MAX3162 No Load | | 3.0 | 6 | |
| V _{CC} Shutdown Current | I _{CC} | <u>SHDN</u> = GND, receiver inputs open or grounded | | 1 | 10 | μA |
| TRANSMITTER AND LOGIC INPUTS (DI, T1IN, T2IN, DE485, <u>RE485</u>, TE232, <u>RE232</u>, FAST, HDPLX, <u>SHDN</u>, RS485/RS232) | | | | | | |
| Logic Input Low | V _{IL} | | | | 0.8 | V |
| Logic Input High | V _{IH} | V _{CC} = +3.3V | 2.0 | | | V |
| | | V _{CC} = +5V | 2.4 | | | |
| Logic Input Leakage Current | I _{INL} | | | ±0.01 | ±1 | μA |
| Transmitter Logic Hysteresis | V _{HYS} | | | 0.5 | | V |
| RS-232 AND RS-485/422 RECEIVER OUTPUTS (R1OUT, R2OUT, RO) | | | | | | |
| Receiver Output Voltage Low | V _{OL} | I _{OUT} = 2.5mA | | | 0.4 | V |
| Receiver Output Voltage High | V _{OH} | I _{OUT} = -1.5mA | V _{CC} - 0.6 | | | V |
| Receiver Output Short Circuit Current | I _{OSR} | 0 < V _O < V _{CC} | | ±20 | ±60 | mA |
| Receiver Output Leakage Current | I _{OZR} | Receivers disabled | | ±0.05 | ±1 | μA |

Electrical Characteristics (continued)(V_{CC} = +3V to +5.5V, C1–C4 = 0.1μF when tested at +3.3V ±10%; C1 = 0.047μF and C2, C3, C4 = 0.33μF when tested at +5V)

| PARAMETER | SYMBOL | CONDITIONS | MIN | TYP | MAX | UNITS |
|--|------------------|---|------------------------|------|--------|-------|
| RS-232 RECEIVER INPUTS (R1IN, R2IN) | | | | | | |
| Input Voltage Range | | | -25 | | 25 | V |
| Input Threshold Low | | V _{CC} = +3.3V | 0.6 | | | V |
| | | V _{CC} = +5V | 0.8 | | | |
| Input Threshold High | | V _{CC} = +3.3V | | | 2.0 | V |
| | | V _{CC} = +5V | | | 2.4 | |
| Input Hysteresis | | | | 0.5 | | V |
| Input Resistance | | | 3 | 5 | 7 | kΩ |
| RS-485/422 RECEIVER INPUTS (NOTE 2) | | | | | | |
| Input Resistance | R _{IN} | -7V < V _{CM} < +12V | MAX3160 | 48 | | kΩ |
| | | | MAX3161/ MAX3162 | 96 | | |
| Input Current | I _{IN} | MAX3160 | V _{CM} = +12V | | 0.25 | mA |
| | | | V _{CM} = -7V | | -0.15 | |
| | | MAX3161/MAX3162 | V _{CM} = +12V | | 0.125 | |
| | | | V _{CM} = -7V | | -0.075 | |
| Input Differential Threshold | V _{TH} | | -200 | | -50 | mV |
| Input Hysteresis | ΔV _{TH} | | | 30 | | mV |
| RS-232 TRANSMITTER OUTPUTS (T1OUT, T2OUT) | | | | | | |
| Output Voltage Swing | | Both transmitter outputs loaded with 3kΩ to GND | ±5 | ±5.4 | | V |
| Output Resistance | | V _{CC} = V ₊ = V ₋ = 0V, V _{T1OUT} = V _{T2OUT} = +2V | 300 | 10M | | Ω |
| Output Short-Circuit Current | | T _{OUT} = GND | | ±30 | ±60 | mA |
| Output Leakage Current | | V _{OUT} = ±12V TE232 = GND or $\overline{\text{SHDN}}$ = GND | MAX3160/ MAX3161 | | ±125 | μA |
| | | | MAX3162 | | ±25 | |
| RS-485/422 TRANSMITTER OUTPUTS (Y, Z) | | | | | | |
| Differential Output Voltage | V _{OD} | Figure 1 | R = 27Ω (RS-485) | 1.5 | | V |
| | | | R = 50Ω (RS-422) | 2 | | |
| Change in Magnitude of Differential Output Voltage for Complementary Output States | ΔV _{OD} | R = 27Ω or 50Ω, Figure 1 | -0.2 | | 0.2 | V |
| Common Mode Output Voltage | V _{OC} | R = 27Ω or 50Ω, Figure 1 | | | 3 | V |
| Change in Magnitude of Common Mode Output Voltage for Complementary Output States | ΔV _{OC} | R = 27Ω or 50Ω, Figure 1 | | | 0.2 | V |

Electrical Characteristics (continued)

($V_{CC} = +3V$ to $+5.5V$, $C1-C4 = 0.1\mu F$ when tested at $+3.3V \pm 10\%$; $C1 = 0.047\mu F$ and $C2, C3, C4 = 0.33\mu F$ when tested at $+5V \pm 10\%$; $T_A = T_{MIN}$ to T_{MAX} , unless otherwise noted. Typical values are at $T_A = +25^\circ C$.)

| PARAMETER | SYMBOL | CONDITIONS | MIN | TYP | MAX | UNITS |
|---|----------------------------|---|--|------|-----------|-----------|
| Output Short-Circuit Current | I_{SC} | V_Y or $V_Z = +12V$ to $-7V$ | | | ± 250 | mA |
| Output Leakage Current | I_O | V_Y or $V_Z = +12V$, DE485 = GND or $\overline{SHDN} =$ GND | MAX3160/ MAX3161 | | ± 125 | μA |
| | | | MAX3162 | | ± 25 | |
| RS-232 TIMING CHARACTERISTICS (FAST = GND, 250kbps, ONE TRANSMITTER SWITCHING) | | | | | | |
| Maximum Data Rate | | $R_L = 3k\Omega$, $C_L = 1000pF$ | 250 | | | kbps |
| Receiver Propagation Delay | | R_{IN} to R_{OUT} , $C_L = 150pF$ | | 0.15 | | μs |
| Receiver Output Enable Time | | | | 200 | | ns |
| Receiver Output Disable Time | | | | 200 | | ns |
| Transmitter Skew | | $ t_{PHL} - t_{PLH} $ | | 100 | | ns |
| Receiver Skew | | $ t_{PLH} - t_{PHL} $ | | 50 | | ns |
| Transition-Region Slew Rate | | $V_{CC} = +3.3V$, $T_A = +25^\circ C$, $R_L = 3k\Omega$ to $7k\Omega$, measured from $+3.0V$ or $-3.0V$ to $+3.0V$ | $C_L = 150pF$ to $1000pF$ | 6 | 30 | $V/\mu s$ |
| | | | $C_L = 150pF$ to $2500pF$ | 4 | 30 | |
| RS-232 TIMING CHARACTERISTICS (FAST = V_{CC}, 1Mbps, ONE TRANSMITTER SWITCHING) | | | | | | |
| Maximum Data Rate | | $V_{CC} = +3V$ to $+4.5V$, $R_L = 3k\Omega$, $C_L = 250pF$ | 1 | | | Mbps |
| | | | $V_{CC} = +4.5V$ to $+5.5V$, $R_L = 3k\Omega$, $C_L = 1000pF$ | 1 | | |
| Receiver Propagation Delay | | R_{IN} to R_{OUT} , $C_L = 150pF$ | | 0.15 | | μs |
| Receiver Output Enable Time | | | | 200 | | ns |
| Receiver Output Disable Time | | | | 200 | | ns |
| Transmitter Skew | | $ t_{PHL} - t_{PLH} $ | | 25 | | ns |
| Receiver Skew | | $ t_{PLH} - t_{PHL} $ | | 50 | | ns |
| Transition-Region Slew Rate | | $V_{CC} = +3.3V$, $T_A = +25^\circ C$, $R_L = 3k\Omega$ to $7k\Omega$, $C_L = 150pF$ to $1000pF$, measured from $+3.0V$ or $-3.0V$ to $+3.0V$ | 24 | | 150 | $V/\mu s$ |
| RS-485/422 TIMING CHARACTERISTICS (FAST = GND) 250kbps | | | | | | |
| Driver Propagation Delay | t_{DPHL} , t_{DPLH} | $R_{DIFF} = 54\Omega$, $C_L = 50pF$, Figures 3, 5 | 200 | 400 | 800 | ns |
| Driver Rise and Fall Time | t_{DPHL} , t_{DPLH} | $R_{DIFF} = 54\Omega$, $C_L = 50pF$, Figures 3, 5 | 200 | 400 | 800 | ns |
| Driver Propagation Delay Skew | t_{DSKEW} | $R_{DIFF} = 54\Omega$, $C_L = 50pF$, Figure 3, 5 | | | 200 | ns |
| Driver Output Enable Time | t_{DZH} , t_{RZL} | $R_{DIFF} = 54\Omega$, $C_L = 50pF$, Figures 4, 6 | | 400 | 800 | ns |
| Driver Output Disable Time | t_{DLZ} , t_{DHZ} | $R_{DIFF} = 54\Omega$, $C_L = 50pF$, Figure 4, 6 | | 200 | 400 | ns |
| Receiver Propagation Delay | t_{RPLH} , t_{RPHL} | $C_L = 15pF$, Figures 7, 9 | 25 | 80 | 150 | ns |
| Receiver Propagation Delay Skew | t_{RSKEW} | $C_L = 50pF$, Figures 7, 9 | | | 10 | ns |

Electrical Characteristics (continued)

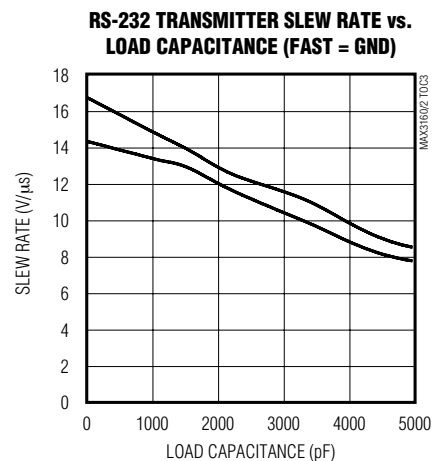
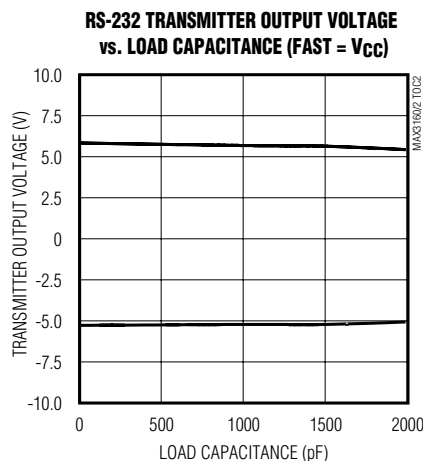
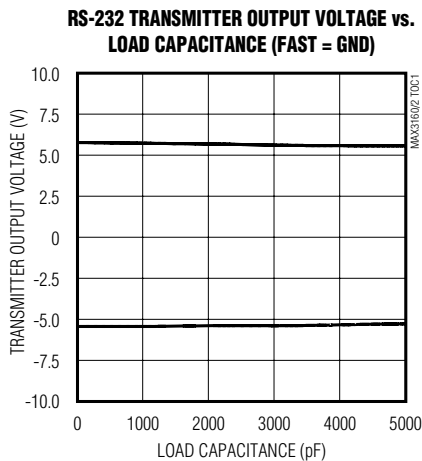
(V_{CC} = +3V to +5.5V, C1–C4 = 0.1μF when tested at +3.3V ±10%; C1 = 0.047μF and C2, C3, C4 = 0.33μF when tested at +5V ±10%; T_A = T_{MIN} to T_{MAX}, unless otherwise noted. Typical values are at T_A = +25°C.)

| PARAMETER | SYMBOL | CONDITIONS | MIN | TYP | MAX | UNITS |
|---|---------------------------------------|--|-----|-----|-----|-------|
| Receiver Output Enable Time | t _{RZL} , t _{RZH} | C _L = 50pF, Figures 2, 8 | | 100 | | ns |
| Receiver Output Disable Time | t _{RLZ} , t _{RHZ} | C _L = 50pF, Figures 2, 8 | | 100 | | ns |
| RS-485/RS-422 TIMING CHARACTERISTICS (FAST = V_{CC}, 10Mbps) | | | | | | |
| Driver Propagation Delay | t _{DPHL} , t _{DPLH} | R _{DIFF} = 54Ω, C _L = 50pF, Figures 3, 5 | | 60 | 120 | ns |
| Driver Rise And Fall Times | t _{DR} , t _{DF} | R _{DIFF} = 54Ω, C _L = 50pF, Figures 3, 5 | | 10 | 25 | ns |
| Driver Propagation Delay Skew | t _{DSKEW} | R _{DIFF} = 54Ω, C _L = 50pF, Figures 3, 5 | | | 10 | ns |
| Driver Output Enable Time | t _{DZL} | R _{DIFF} = 54Ω, C _L = 50pF, Figures 4, 6 | | 400 | 800 | ns |
| Driver Output Disable Time | t _{DLZ} , t _{DHZ} | R _{DIFF} = 54Ω, C _L = 50pF, Figures 4, 6 | | 200 | 400 | ns |
| Receiver Propagation Delay | t _{RPLH} , t _{RPHL} | C _L = 15pF, Figures 7, 9 | | 80 | 150 | ns |
| Receiver Propagation Delay Skew | t _{RSKEW} | C _L = 50pF, Figures 7, 9 | | | 10 | ns |
| Receiver Output Enable Time | t _{RZL} , t _{RZH} | C _L = 50pF, Figures 2, 8 | | 100 | | ns |
| Receiver Output Disable Time | t _{RLZ} , t _{RHZ} | C _L = 15pF, Figures 2, 8 | | 100 | | ns |

Note 2: Applies to A, B for MAX3162 and MAX3160/MAX3161 with HDPLX = GND, or Y, Z for MAX3160/MAX3161 with HDPLX = V_{CC}.

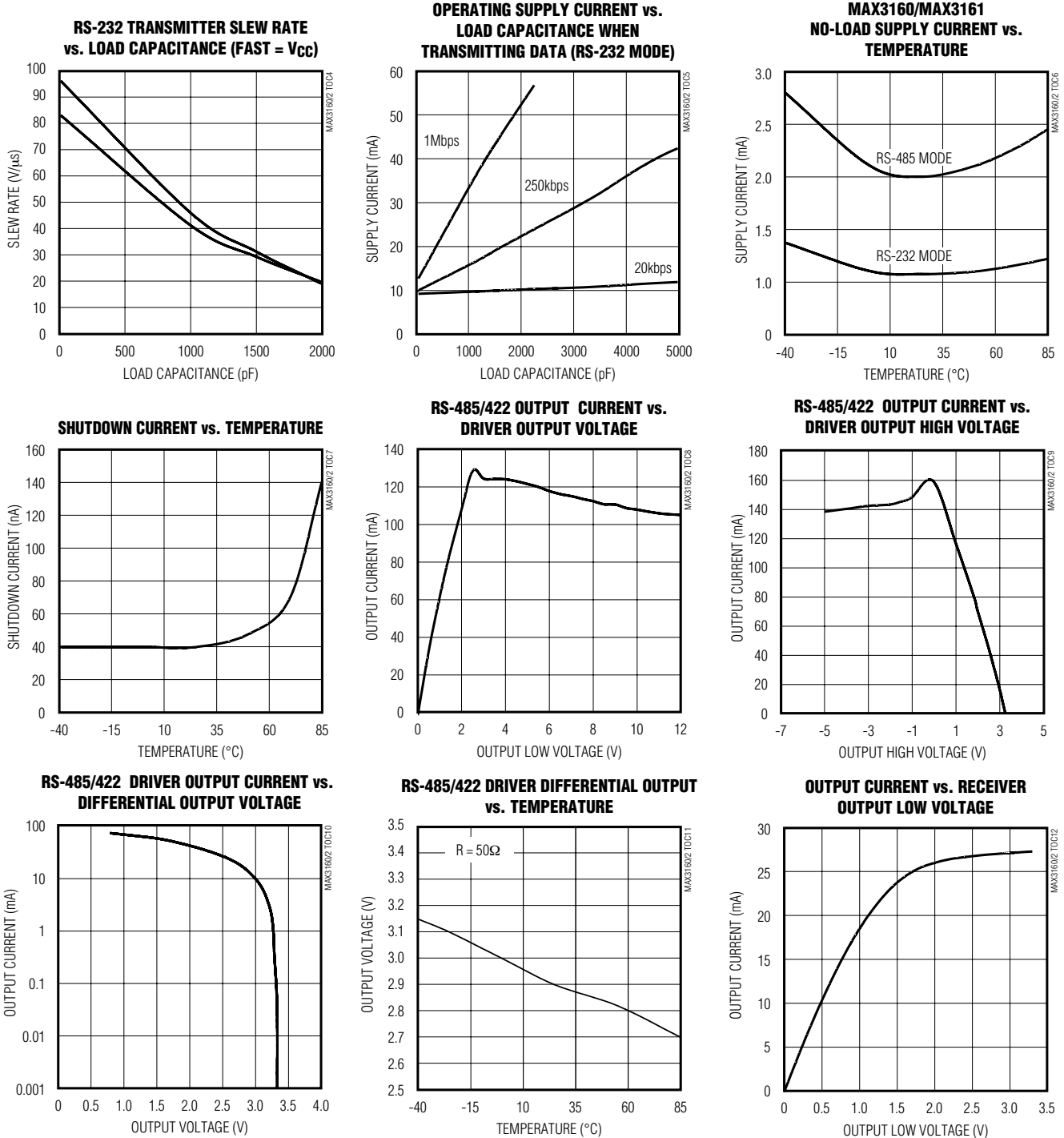
Typical Operating Characteristics

(V_{CC} = +3.3V, 250kbps data rate, 0.1μF capacitors, all RS-232 transmitters (RS-232 mode) loaded with 3kΩ to ground, T_A = +25°C,



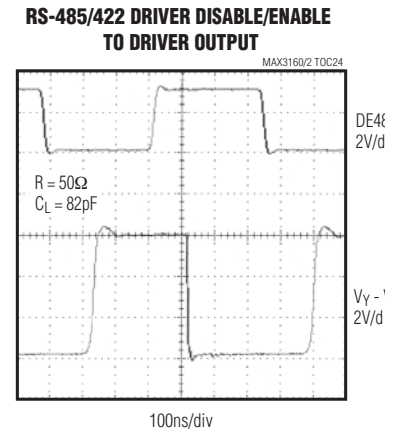
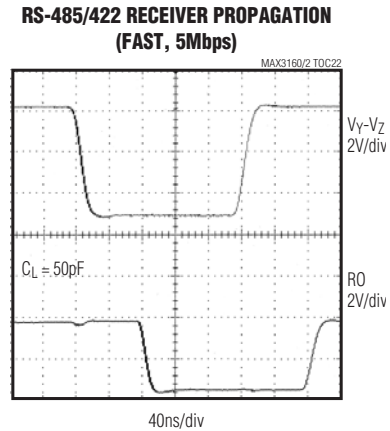
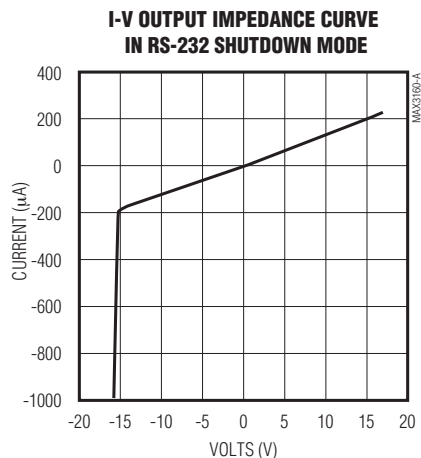
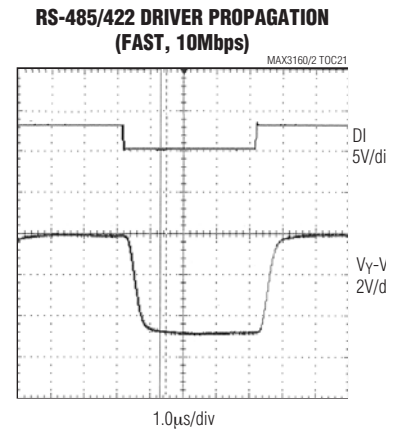
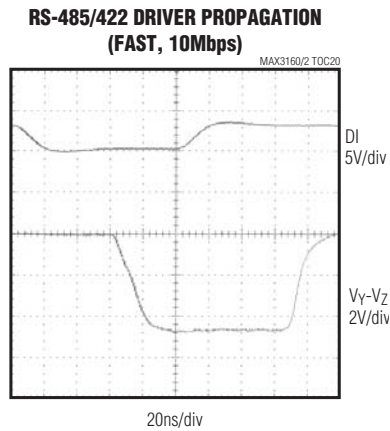
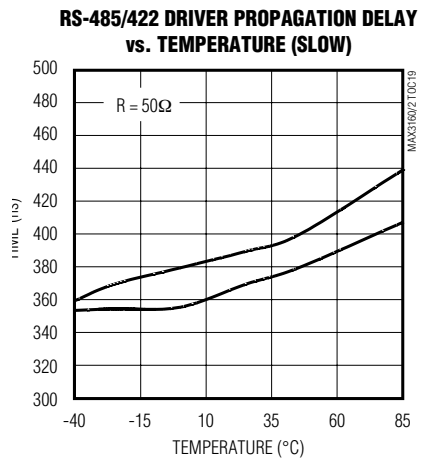
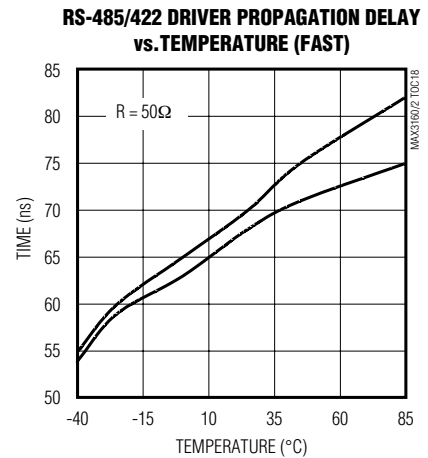
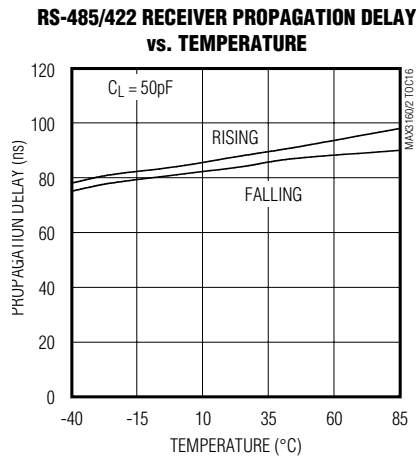
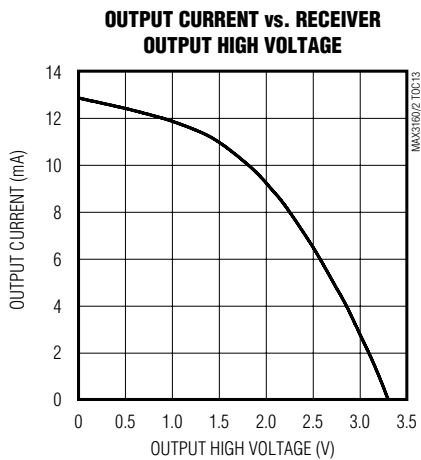
Typical Operating Characteristics (continued)

(V_{CC} = +3.3V, 250kbps data rate, 0.1 μ F capacitors, all RS-232 transmitters (RS-232 mode) loaded with 3k Ω to ground, T_A = +25 $^{\circ}$ C, unless otherwise noted.)



Typical Operating Characteristics (continued)

(V_{CC} = +3.3V, 250kbps data rate, 0.1 μ F capacitors, all RS-232 transmitters (RS-232 mode) loaded with 3k Ω to ground, T_A = +25 $^{\circ}$ C, unless otherwise noted.)



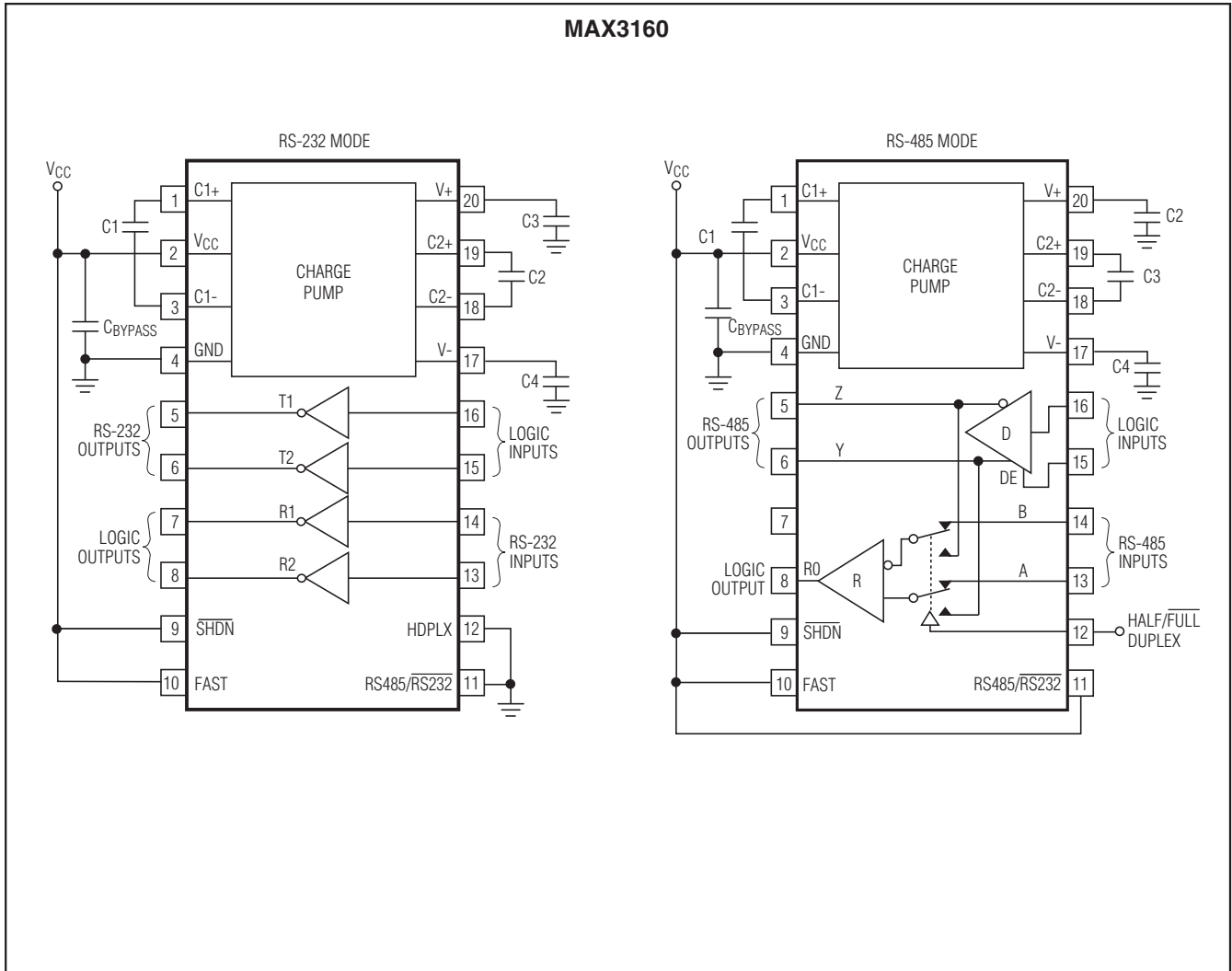
Pin Description

| PIN | | | NAME | FUNCTION |
|---------|---------|---------|----------------------------------|---|
| MAX3160 | MAX3161 | MAX3162 | | |
| 1 | 1 | 1 | C1+ | Positive Terminal of the Positive Flying Capacitor |
| 2 | 2 | 2 | VCC | Positive Supply Voltage |
| 3 | 3 | 3 | C1- | Negative Terminal of the Positive Flying Capacitor |
| 4 | 4 | 4 | GND | Ground |
| — | 5 | 5 | T1OUT | RS-232 Driver Output |
| 5 | — | — | Z(B)/T1OUT | Inverting RS-485/422 Driver Output in Full-Duplex Mode (and Inverting RS-485/422 Receiver Input in Half-Duplex Mode)/RS-232 Driver Output |
| — | — | 6 | Z | Inverting RS-485/422 Driver Output |
| — | 6 | — | Z(B) | Inverting RS-485/422 Driver Output in Full-Duplex Mode (and Inverting RS-485/422 Receiver Input in Half-Duplex Mode) |
| 6 | — | — | Y(A)/T2OUT | Noninverting RS-485/422 Driver Output in Full-Duplex Mode (and Noninverting RS-485/422 Receiver Input in Half-Duplex Mode)/RS-232 Driver Output |
| — | — | 7 | Y | Noninverting RS-485/422 Driver Output |
| — | 7 | — | Y(A) | Noninverting RS-485/422 Driver Output in Full-Duplex Mode (and Noninverting RS-485/422 Receiver Input in Half-Duplex Mode) |
| 7 | 9 | 9 | R1OUT | RS-232 Receiver Output |
| — | 8 | 8 | T2OUT | RS-232 Driver Output |
| 8 | 10 | — | RO/R2OUT | RS-485/422 Receiver Output/RS-232 Receiver Output |
| 9 | 11 | 13 | $\overline{\text{SHDN}}$ | Active-Low Shutdown-Control Input. Drive low to shut down transmitters and charge pump. |
| — | — | 10 | R2OUT | RS-232 Driver Output |
| 10 | 12 | 14 | FAST | Select slew rate limiting for both RS-232 and RS-485/422. Slew rate limits with a logic-level low. |
| — | — | 11 | RO | RS-485/422 Receiver Output |
| 11 | 13 | — | RS485/ $\overline{\text{RS232}}$ | Software-Programmable Pin Functionality. Operates as RS-485/422 with a logic-level high; operates as RS-232 with a logic-level low. |
| — | — | 12 | $\overline{\text{RE485}}$ | RS-485/422 Receiver Enable. Logic-level low enables RS-485/422 receivers. |
| 12 | 14 | — | HDPLX | Software-Programmable Pin Functionality. Operates in full-duplex mode when low; operates in half-duplex mode when high. |

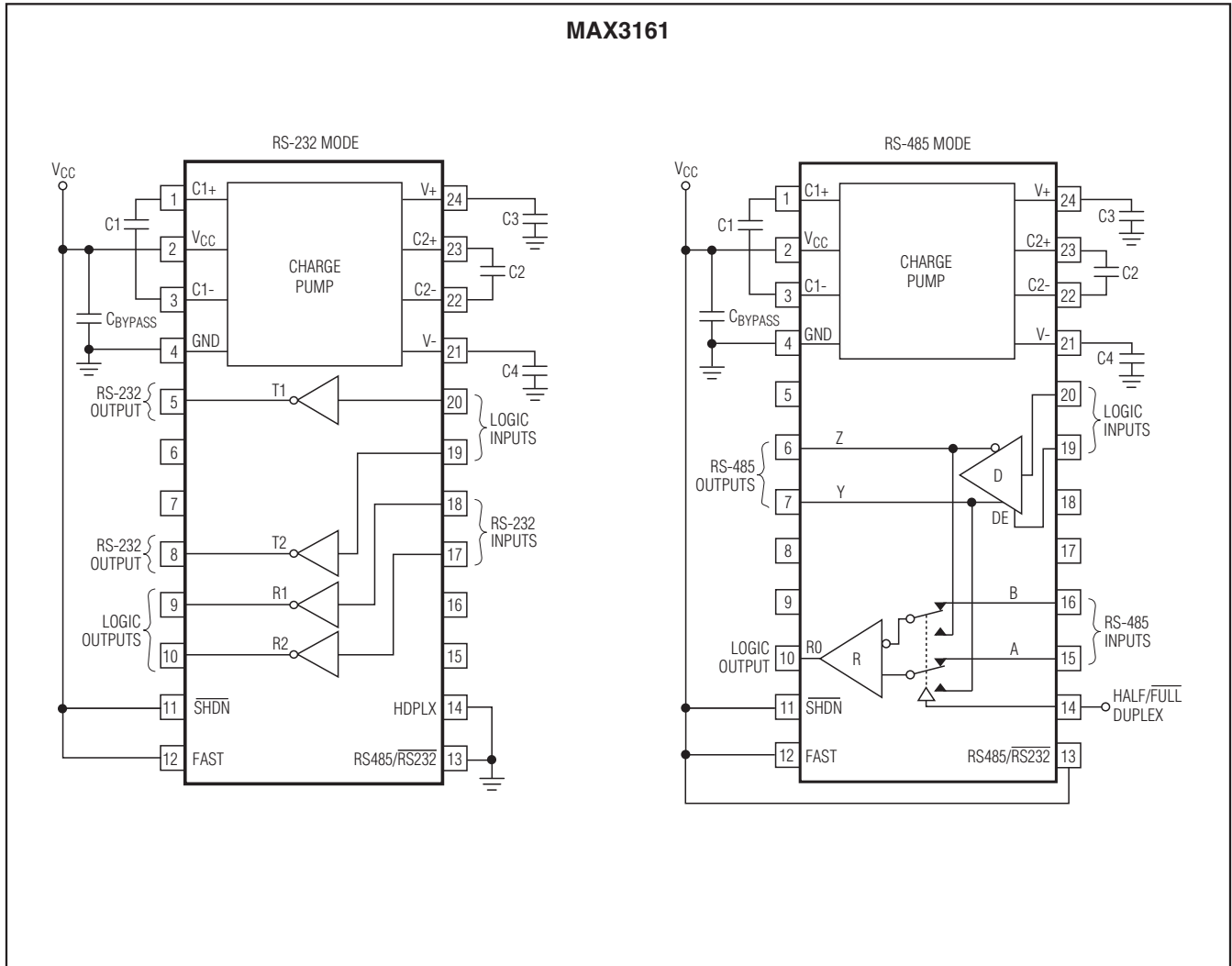
Pin Description (continued)

| PIN | | | NAME | FUNCTION |
|---------|---------|---------|--------------------|---|
| MAX3160 | MAX3161 | MAX3162 | | |
| 13 | — | — | A/R2IN | Noninverting RS-485/422 Receiver Input/RS-232 Receiver Input |
| 14 | — | — | B/R1IN | Inverting RS-485/422 Receiver Input/RS-232 Receiver Input |
| — | — | 15 | $\overline{RE232}$ | RS-232 Receiver Enable. Logic-level low enables RS-232 receivers. |
| — | 15 | 17 | A | Noninverting RS-485/422 Receiver Input |
| 15 | 19 | — | DE485/T2IN | RS-485/RS-422 Driver Enable/RS-232 Driver Input |
| — | — | 16 | TE232 | RS-232 Transmitter Output Enable |
| — | 16 | 18 | B | Inverting RS-485/422 Receiver Input |
| 16 | 20 | — | DI/T1IN | RS-485/RS-422 Driver Input/RS-232 Driver Input |
| — | 17 | 19 | R2IN | RS-232 Receiver Input |
| 17 | 21 | 25 | V- | Negative Charge-Pump Rail |
| — | 18 | 20 | R1IN | RS-232 Receiver Input |
| 18 | 22 | 26 | C2- | Negative Terminal of the Negative Flying Capacitor |
| 19 | 23 | 27 | C2+ | Positive Terminal of the Negative Flying Capacitor |
| 20 | 24 | 28 | V+ | Positive Charge-Pump Rail |
| — | — | 21 | T2IN | RS-232 Driver Input |
| — | — | 22 | DE485 | RS-485/RS-422 Driver Enable |
| — | — | 23 | DI | RS-485/RS-422 Driver Input |
| — | — | 24 | T1IN | RS-232 Driver Input |

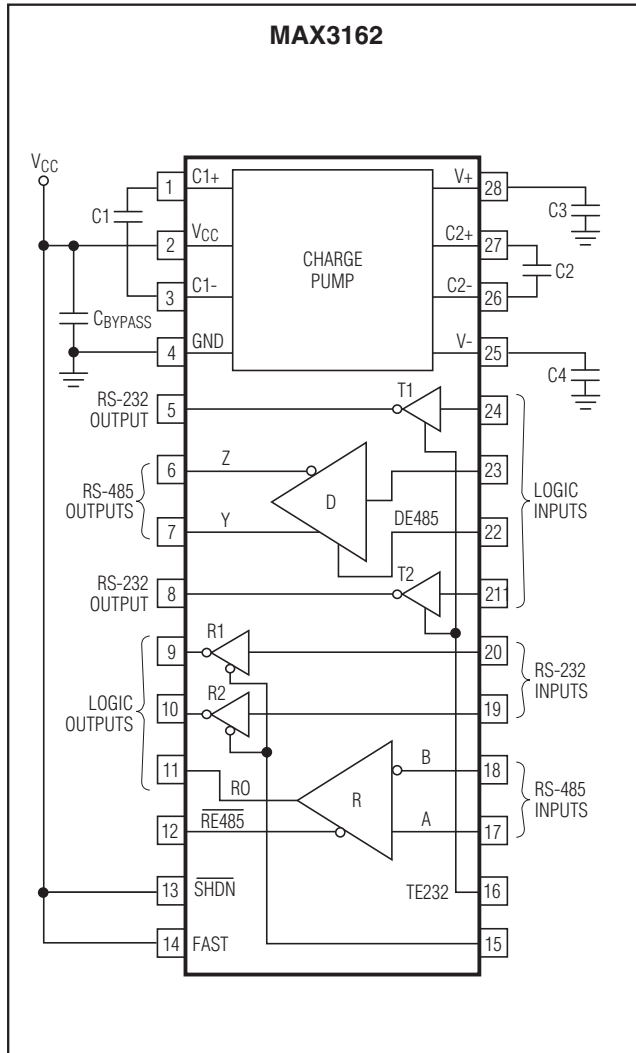
Functional Diagrams



Functional Diagrams (continued)



Functional Diagrams (continued)



Test Circuits

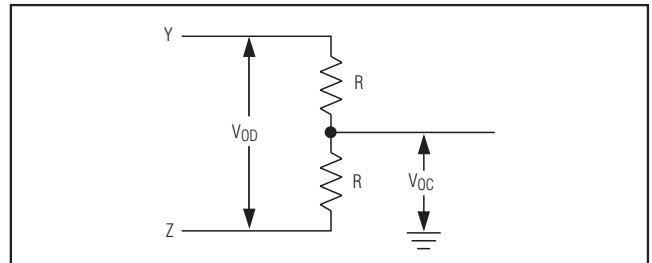


Figure 1. RS-485/422 Driver DC Test Load

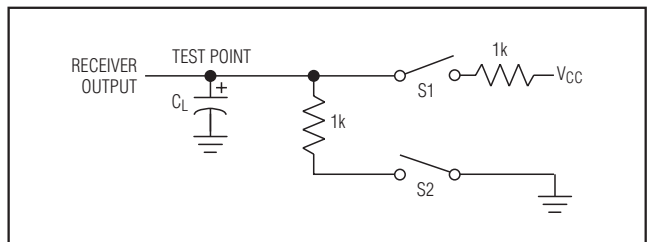


Figure 2. RS-485/422 Receiver Enable/Disable Timing Test Load

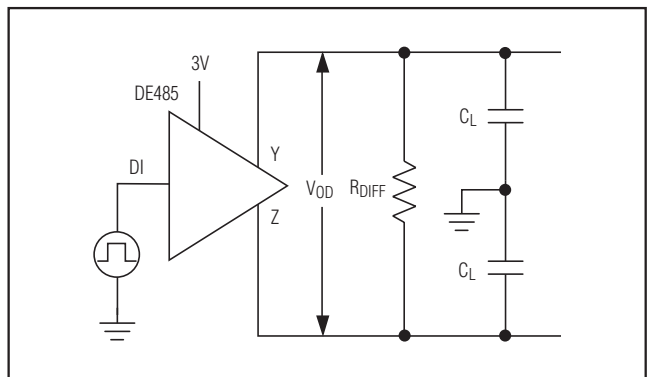


Figure 3. RS-485/422 Driver Timing Test Circuit

Test Circuits (continued)

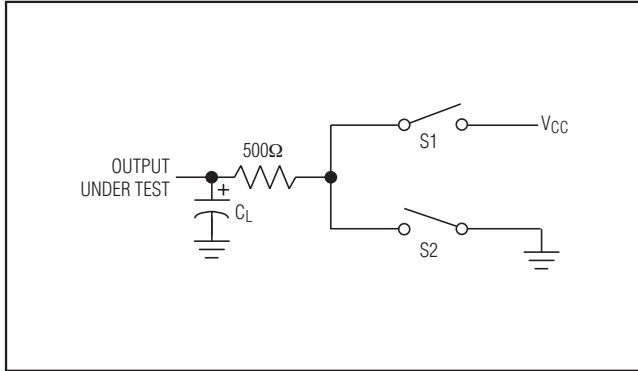


Figure 4. RS-485/422 Driver Enable/Disable Timing Test Load

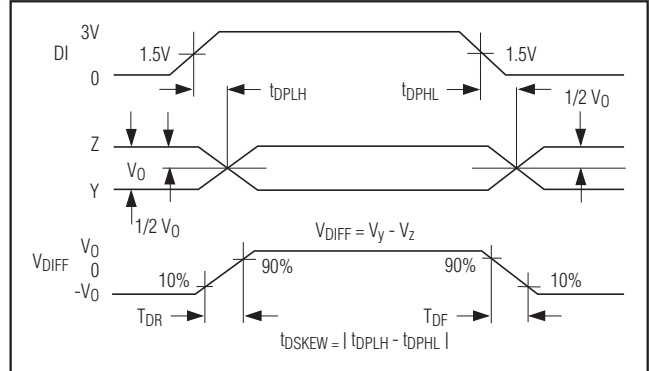


Figure 5. RS-485/422 Driver Propagation Delays

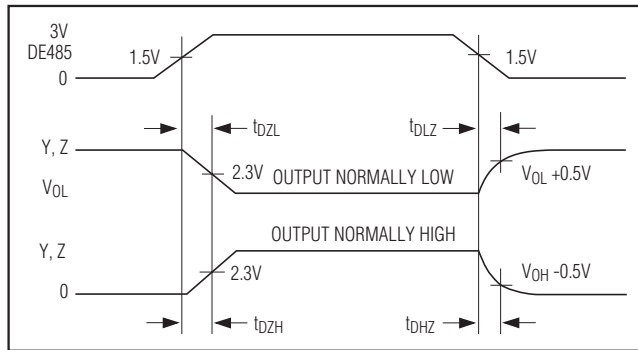


Figure 6. RS-485/422 Driver Enable and Disable Times

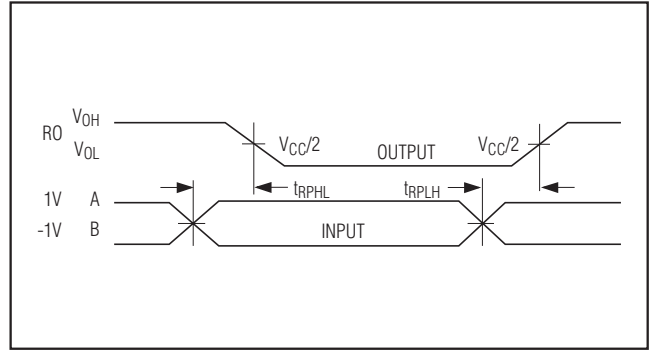


Figure 7. RS-485/422 Receiver Propagation Delays

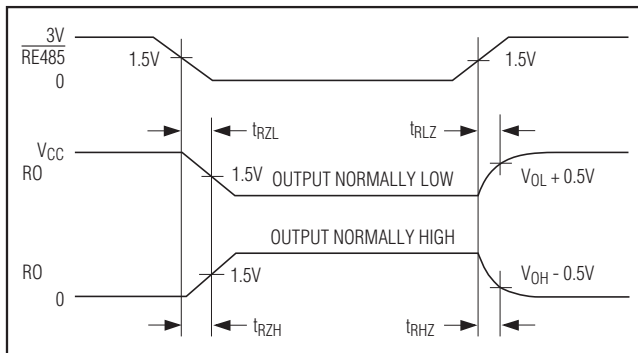


Figure 8. MAX3162 RS-485/422 Receiver Enable and Disable Times

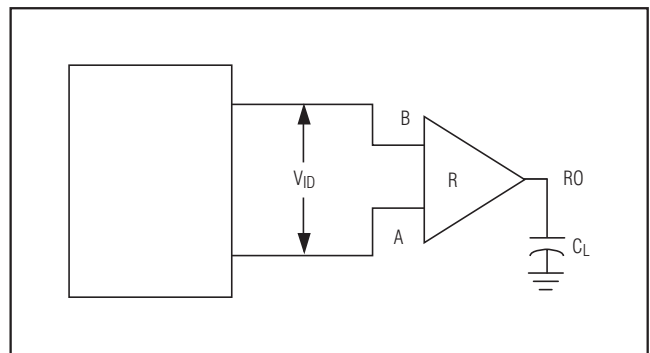


Figure 9. RS-485/422 Receiver Propagation Delays Test Circuit

Detailed Description

The MAX3160/MAX3161/MAX3162 3V/5V, multiprotocol transceivers can be pin configured in a number of RS-232 and RS-485/422 interface combinations. These circuit configurations are ideal for the design of RS-232 to RS-485 converters, multiprotocol buses, or any application that requires both RS-232 and RS-485 transceivers. The slew rate of these devices is on-the-fly pin programmable, allowing reduced EMI data rates, or up to 10Mbps RS-485 communications. Power consumption can be reduced to 1 μ A by using the shutdown function, but the RS-232 receivers remain active allowing other devices to query the interface controller. A flow-through pinout and the space-saving SSOP packages (available in the commercial and extended temperature ranges) facilitate board layout.

Device Selection

The MAX3160/MAX3161/MAX3162 contain RS-232 transceivers and an RS-485/422 transceiver. The primary difference between the devices is the multiplexing of the I/O pins.

The MAX3160 has common transmitter outputs and receiver inputs for its RS-232 and RS-485/422 transceivers, and common digital I/O pins. The MAX3160 is optimized for multiprotocol operation on a single interface bus and comes in a 20-pin SSOP.

The MAX3161 has separate transmitter outputs and receiver inputs for its RS-232 and RS-485/422 transceivers, and common digital I/O pins. The MAX3161 is optimized for multiplexing a single UART across two interface buses and comes in a 24-pin SSOP.

The MAX3162 has separate transmitter outputs and receiver inputs for its RS-232 and RS-485/422 transceivers, and separate digital I/O pins. The MAX3162 is optimized for protocol translation between two interface buses and comes in a 28-pin SSOP.

See Tables 1–12, *Functional Diagrams*, and the following descriptions for details on each device.

MAX3160

The MAX3160 is a 2TX/2RX RS-232 transceiver in RS-232 mode, capable of RS-232-compliant communication. Assertion of RS-485/RS232 converts the device to a single RS-485 transceiver by multiplexing the RS-232 I/O pins to an RS-485 driver and receiver pair. The logic inputs now control the driver input and the driver enable. One logic output carries the RS-485 receiver output, and the other is three-stated. The receiver input impedance is dependent on the device mode and is

1/4-unit load for RS-485 operation and 5k Ω for RS-232 operation.

MAX3161

The MAX3161 is a 2TX/2RX RS-232 transceiver in RS-232 mode or a single RS-485/422 transceiver in RS-485 mode. When in RS-485 mode, the unused RS-232 transmitter and receiver output pins are disabled. When in RS-232 mode, the RS-485 transmitter outputs are disabled and the RS-232 receiver inputs are 5k Ω to GND. The RS-485 receiver inputs are always 1/8-unit load. Logic lines are shared between the two protocols and are used for signal inputs and as an RS-485 driver enable.

MAX3162

The MAX3162 is a 2TX/2RX RS-232 transceiver and a single RS-485/422 transceiver simultaneously. All drivers, receivers, and transmitters can be enabled or disabled by pin configuration. All outputs are high-Z when not activated. RS-232 receiver inputs are 5k Ω when enabled, and RS-485 receiver inputs are 1/8-unit load.

FAST Mode operation

The FAST control pin is used to select the slew-rate limiting of the RS-232 transmitters and the RS-485/422 drivers. With FAST unasserted, the RS-232 transmitters and the RS-485/422 driver are slew-rate limited to reduce EMI. RS-232 data rates up to 1Mbps and RS-485/422 data rates up to 10Mbps are possible when FAST is asserted. FAST can be changed during operation without interrupting data communications.

Half-Duplex RS-485/422 Operation

Asserting HDPLX places the MAX3160/MAX3161 in half-duplex mode. The RS-485 receiver inputs are internally connected to the driver outputs. The RS-485 driver outputs can be disabled by pulling DE485 low. HDPLX has no effect on RS-232 operation.

Low-Power Shutdown

The MAX3160/MAX3161/MAX3162 have an active-low shutdown control input, $\overline{\text{SHDN}}$. When driven low, the charge pump and transmitters are shut down and supply current is reduced to 1 μ A. The RS-232 receiver outputs remain active if in RS-232 mode. The charge-pump capacitors must be recharged when coming out of shutdown before resuming operation in either RS-232 or RS-485/422 mode (Figure 10).

Dual Charge-Pump Voltage Converter

The MAX3160/MAX3161/MAX3162s' 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) for input voltages (V_{CC}) over the 3.0V to 5.5V range. The charge

pumps operate in a discontinuous mode: if the magnitude of either output voltage is less than 5.5V, the charge pumps are enabled; if the magnitude of both output voltages exceeds 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 (see *Functional Diagrams*).

RS-485/422 Transceivers

The MAX3160/MAX3161/MAX3162 RS-485/422 transceivers feature fail-safe circuitry that guarantees a logic-high receiver output when the receiver inputs are open or shorted, or when they are connected to a terminated transmission line with all drivers disabled (see *Fail-Safe*). The MAX3160/MAX3161/MAX3162 also feature pin-selectable reduced slew-rate drivers that minimize EMI and reduce reflections caused by improperly terminated cables, allowing error-free data transmission up to 250kbps (see *RS-485/422 Reduced EMI and Reflections*). The transmitters may operate at speeds up to 10Mbps with the slew-rate limiting disabled. Drivers are short-circuit current limited and thermally limited to protect them against excessive power dissipation. Half-duplex communication is enabled by driving HDPLX high.

Fail-Safe

The MAX3160/MAX3161/MAX3162 **guarantee** a logic-high RS-485 receiver output when the receiver inputs are shorted or open, or when they are connected to a terminated transmission line with all drivers disabled. This is done by having the receiver threshold between -50mV and -200mV. If the differential receiver input voltage (A-B) is greater than or equal to -50mV, RO is logic high. If A-B is less than or equal to -200mV, RO is logic low. In the case of a terminated bus with all transmitters disabled, the receiver's differential input voltage is pulled to GND by the termination. This results in a logic high with a 50mV minimum noise margin. Unlike other fail-safe devices, the -50mV to -200mV threshold complies with the \pm 200mV EIA/TIA-485 standard.

RS-232 Transceivers

The MAX3160/MAX3161/MAX3162 RS-232 transmitters are inverting-level translators that convert CMOS-logic levels to \pm 5.0V EIA/TIA-232-compliant levels. The transmitters are guaranteed at a 250kbps data rate in slew-rate limited mode (FAST = GND) with worst-case loads of 3k Ω in parallel with 1000pF. Data rates up to 1Mbps can be achieved by asserting FAST. When powered down or in shutdown, the MAX3160/MAX3161/MAX3162 outputs are high impedance and can be driven to \pm 12V. The transmitter inputs do not

have pullup resistors. Connect unused inputs to ground or VCC.

The receivers convert RS-232 signals to CMOS-logic output levels. All receivers have inverting outputs that remain active in shutdown. The MAX3160/MAX3161/MAX3162 permit their receiver inputs to be driven to Dia \pm 25V. Floating receiver input signals are pulled to ground through internal 5k Ω resistors, forcing the outputs to a logic high. The MAX3162 has transmitter and receiver enable pins that allow its outputs to be three-stated.

Applications Information

Capacitor Selection

The capacitor type used for C1–C4 is not critical for proper operation; polarized or nonpolarized capacitors can be used. Ceramic chip capacitors with an X7R dielectric provide the best combination of performance, cost, and size. The charge pump requires 0.1 μ F capacitors for 3.3V operation. For other supply voltages, see Table 13 for required capacitor values. Do not use values smaller than those listed in Table 13. Increasing the capacitor values reduces ripple on the transmitter outputs and slightly reduces power consumption. C2, C3, and C4 can be changed without changing C1's value. **However, do not increase C1 without also increasing the values of C2, C3, C4, and CBYPASS to maintain the proper ratios to the other capacitors.**

When using the minimum required capacitor values, make sure the capacitance value does not degrade excessively with temperature or voltage. This is typical of Y5V and Z5U dielectric ceramic capacitors. If in doubt, use capacitors with a larger nominal value. The capacitor's equivalent series resistance (ESR), which usually rises at low temperatures, influences the amount of ripple on V+ and V-.

Power-Supply Decoupling

In applications that are sensitive to power-supply noise, decouple VCC to ground with a capacitor of the same value as reservoir capacitors C2, C3, and C4. Connect the bypass capacitor as close to the IC as possible.

RS-232 Transmitter Outputs when Exiting Shutdown

Figure 10 shows two transmitter outputs when exiting shutdown 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 transmitter is loaded with 3k Ω in parallel with 1000pF. The transmitter outputs display no ringing or undesirable transients as they come out of shutdown. Note that the transmitters are enabled only when V- exceeds approximately -3V.

Truth Tables

RS-232 Transmitters

Table 1. MAX3160

| INPUTS | | | OUTPUTS |
|--------------------------|------------------------------------|------------------------|---------------------------|
| $\overline{\text{SHDN}}$ | RS485 $\overline{\text{RS232}}$ | DI/T1IN, DE485/T2IN | Z(B)/T1OUT, Y(A)/T2OUT |
| 0 | X | X | 1/8 Unit Load |
| 1 | 0 | 0 | 1 |
| 1 | 0 | 1 | 0 |
| 1 | 1 | X | RS-485 Mode |

Table 2. MAX3161

| INPUTS | | | OUTPUTS |
|--------------------------|-------------------|------------------------|-----------------|
| $\overline{\text{SHDN}}$ | RS-485/ RS-232 | DI/T1IN, DE485/T2IN | T1OUT, T2OUT |
| 0 | X | X | High-Z |
| 1 | 0 | 0 | 1 |
| 1 | 0 | 1 | 0 |
| 1 | 1 | X | High-Z |

Table 3. MAX3162

| INPUTS | | | OUTPUTS |
|--------------------------|-------|-----------|-----------------|
| $\overline{\text{SHDN}}$ | TE232 | T1IN,T2IN | T1OUT, T2OUT |
| 0 | X | X | High-Z |
| X | 0 | X | High-Z |
| 1 | 1 | 0 | 1 |
| 1 | 1 | 1 | 0 |

High Data Rates

The MAX3160/MAX3161/MAX3162 maintain the RS-232 $\pm 5.0\text{V}$ required minimum transmitter output voltage even at high data rates. Figure 11 shows a transmitter loopback test circuit. Figure 12 shows a loopback test result at 250kbps, and Figure 13 shows the same test at 1000kbps. Figure 12 demonstrates a single slew-rate limited transmitter driven at 250kbps (FAST = GND) into an RS-232 load in parallel with 1000pF. Figure 13 shows a single transmitter driven at 1Mbps (FAST asserted), loaded with an RS-232 receiver in parallel with 1000pF. These transceivers maintain the RS-232 $\pm 5.0\text{V}$ minimum transmitter output voltage at data rates up to 1Mbps.

RS-232 Receivers

Table 4. MAX3160

| INPUTS | | | OUTPUTS |
|--------------------------|-------------------|-------------------|--|
| $\overline{\text{SHDN}}$ | RS-485/ RS-232 | B/R1IN, A/R2IN | R1OUT, RO/R2OUT |
| X | 0 | 0 | 1 |
| X | 0 | 1 | 0 |
| X | 0 | Inputs Open | 1 |
| X | 1 | X | R1OUT High-Z, RO/R2OUT in RS-485 mode |

Table 5. MAX3161

| INPUTS | | | OUTPUTS |
|--------------------------|-------------------|-------------|--|
| $\overline{\text{SHDN}}$ | RS-485/ RS-232 | R1IN, R2IN | R1OUT, RO/R2OUT |
| X | 0 | 0 | 1 |
| X | 0 | 1 | 0 |
| X | 0 | Inputs Open | 1 |
| X | 1 | X | R1OUT High-Z, RO/R2OUT in RS-485 mode |

Table 6. MAX3162

| INPUTS | | | OUTPUTS |
|--------------------------|---------------------------|-------------|-----------------|
| $\overline{\text{SHDN}}$ | $\overline{\text{RE232}}$ | R1IN, R2IN | R1OUT, R2OUT |
| X | 1 | X | High-Z |
| X | 0 | 0 | 1 |
| X | 0 | 1 | 0 |
| X | 0 | Inputs open | 1 |

256 Transceivers on the Bus

The standard RS-485 receiver input impedance is 12k Ω (one-unit load), and the standard driver can drive up to 32-unit loads. The MAX3160 has a 1/4-unit load receiver input impedance (48k Ω), allowing up to 128 transceivers to be connected in parallel on one communication line. The MAX3161/MAX3162 have a 1/8-unit load receiver input impedance (96k Ω), allowing up to 256 transceivers to be connected in parallel on

Truth Tables (continued)

RS-485/422 Drivers

Table 7. MAX3160

| INPUTS | | | | OUTPUTS | |
|--------|-------------|------------|---------|---------------|---------------|
| SHDN | RS485/RS232 | DE485/T2IN | DI/T1IN | Z(B)/T1OUT | Y(A)/T2OUT |
| 0 | 1 | X | X | 1/8 Unit Load | 1/8 Unit Load |
| 1 | 1 | 0 | X | 1/8 Unit Load | 1/8 Unit Load |
| 1 | 1 | 1 | 0 | 1 | 0 |
| 1 | 1 | 1 | 1 | 0 | 1 |
| X | 0 | X | X | RS-232 Mode | |

Table 8. MAX3161

| INPUTS | | | | OUTPUTS | |
|--------|-------------|------------|---------|---------------|---------------|
| SHDN | RS485/RS232 | DE485/T2IN | DI/T1IN | Z(B) | Y(A) |
| 0 | X | X | X | 1/8 Unit Load | 1/8 Unit Load |
| X | 0 | X | X | 1/8 Unit Load | 1/8 Unit Load |
| X | X | 0 | X | 1/8 Unit Load | 1/8 Unit Load |
| 1 | 1 | 1 | 0 | 1 | 0 |
| 1 | 1 | 1 | 1 | 0 | 1 |

Table 9. MAX3162

| INPUTS | | | OUTPUTS | |
|--------|-------|----|---------|--------|
| SHDN | DE485 | DI | Z | Y |
| 0 | X | X | High-Z | High-Z |
| X | 0 | X | High-Z | High-Z |
| 1 | 1 | 0 | 1 | 0 |
| 1 | 1 | 1 | 0 | 1 |

RS-485/422 Receivers

Table 10. MAX3160

| INPUTS | | | | | OUTPUT |
|-------------|------|-------|----------------------|----------------------|------------------------------|
| RS485/RS232 | SHDN | HDPLX | A - B* | Y - Z* | RO/R2OUT |
| 1 | 0 | X | X | X | High-Z Up to V _{CC} |
| 1 | 1 | 0 | $\geq -50\text{mV}$ | X | 1 |
| 1 | 1 | 0 | $\leq -200\text{mV}$ | X | 0 |
| 1 | 1 | 0 | Floating | X | 1 |
| 1 | 1 | 1 | X | $\geq -50\text{mV}$ | 1 |
| 1 | 1 | 1 | X | $\leq -200\text{mV}$ | 0 |
| 1 | 1 | 1 | X | Floating | 1 |
| 0 | X | X | X | X | RS-232 Mode |

*Y and Z correspond to pins Y(A)/T2OUT and Z(B)/T1OUT. A and B correspond to pins A/R2IN and B/R1IN.

Truth Tables (continued)

Table 11. MAX3161

| INPUTS | | | | | OUTPUT |
|-------------|------|-------|---------------|---------------|------------------------------|
| RS485/RS232 | SHDN | HDPLX | A - B | Y(A) - Z(B) | RO/R2OUT |
| 1 | 0 | X | X | X | High-Z up to V _{CC} |
| 1 | 1 | 0 | \geq -50mV | X | 1 |
| 1 | 1 | 0 | \leq -200mV | X | 0 |
| 1 | 1 | 0 | Floating | X | 1 |
| 1 | 1 | 1 | X | \geq -50mV | 1 |
| 1 | 1 | 1 | X | \leq -200mV | 0 |
| 1 | 1 | 1 | X | Floating | 1 |
| 0 | X | X | X | X | RS-232 Mode |

Table 12. MAX3162

| INPUTS | | | OUTPUT |
|--------|-------|---------------|--------|
| SHDN | RE485 | A - B | RO |
| 0 | X | X | High-Z |
| X | 1 | X | High-Z |
| 1 | 0 | \geq -50mV | 1 |
| 1 | 0 | \leq -200mV | 0 |
| 1 | 0 | Inputs Open | 1 |

one communication line. Any combination of these devices and/or other RS-485 transceivers with a total of 32-unit loads or fewer can be connected to the line.

The MAX3160/MAX3161/MAX3162 RS-485 driver outputs are 1/8-unit load when disabled. This impedance may be reduced if the D1 pin is toggled at a high frequency. With no power applied (V_{CC} = GND), the RS-485 transmitter output impedances typically go to 1/2-unit load on the MAX3161/MAX3162, and to one-unit load on the MAX3160.

Driver Output Protection

Two mechanisms prevent excessive output current and power dissipation caused by faults or by bus contention. The first, a foldback current limit on the output stage, provides immediate protection against short circuits over the whole common-mode voltage range (see *Typical Operating Characteristics*). The second, a ther-

Table 13. Required Minimum Capacitance Values

| SUPPLY VOLTAGE (V) | C1 (μ F) | C2, C3, C4, CBYPASS (μ F) |
|--------------------|---------------|--------------------------------|
| +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 |

mal shutdown circuit, forces the driver outputs into a high-impedance state if the die temperature becomes excessive.

Protection Against Wiring Faults

EIA/TIA-485 standards require a common input voltage range of -7V to +12V to prevent damage to the device. The MAX3160/MAX3161/MAX3162 inputs are protected to RS-232 levels of \pm 25V for the receiver inputs and \pm 13.2V for the transmitter/driver outputs. This provides additional protection for the RS-485 transceivers against ground differential or faults due to miswiring.

RS-485/422 Reduced EMI and Reflections

The MAX3160/MAX3161/MAX3162 can be configured for slew-rate limiting by pulling FAST low. This minimizes EMI and reduces reflections caused by improperly terminated cables. Operation in slew-rate limited mode reduces the amplitudes of high-frequency harmonics.

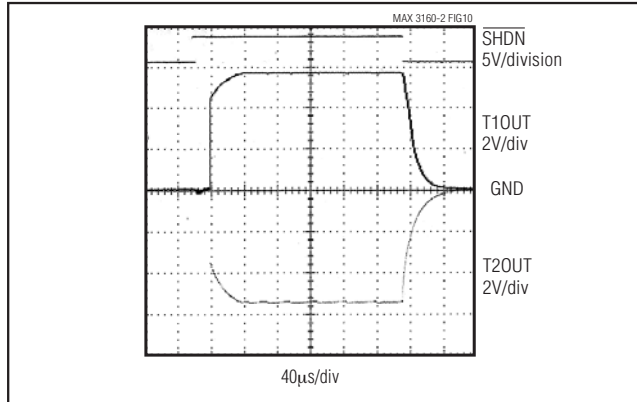


Figure 10. MAX3160 RS-232 Transmitter Outputs When Exiting Shutdown

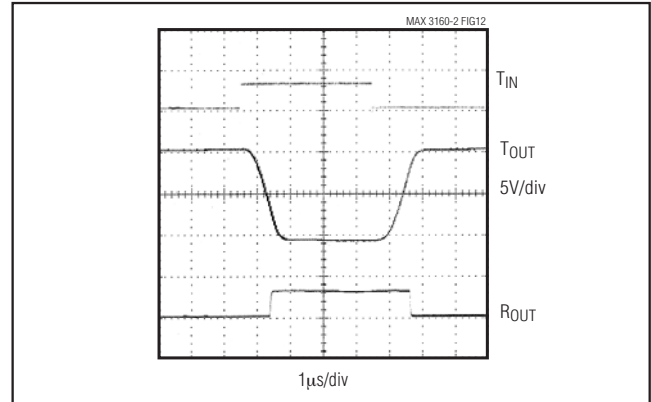


Figure 12. RS-232 Loopback Test Result at 250kbps, FAST = Low

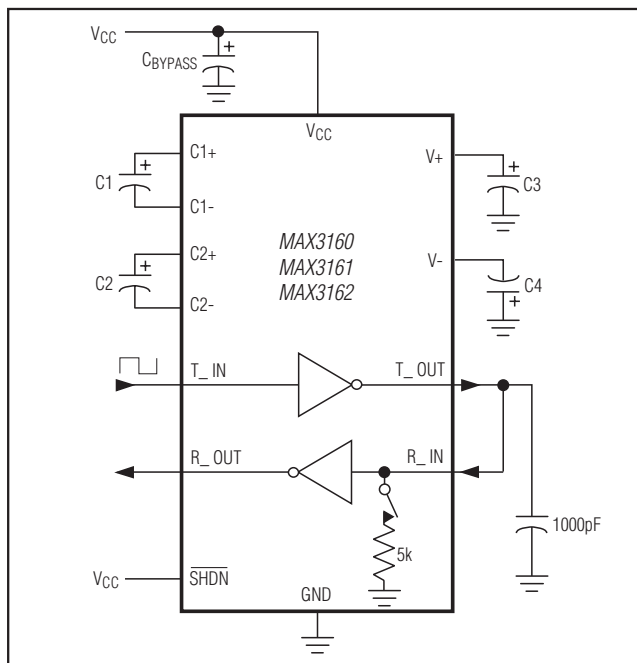


Figure 11. Loopback Test Circuit

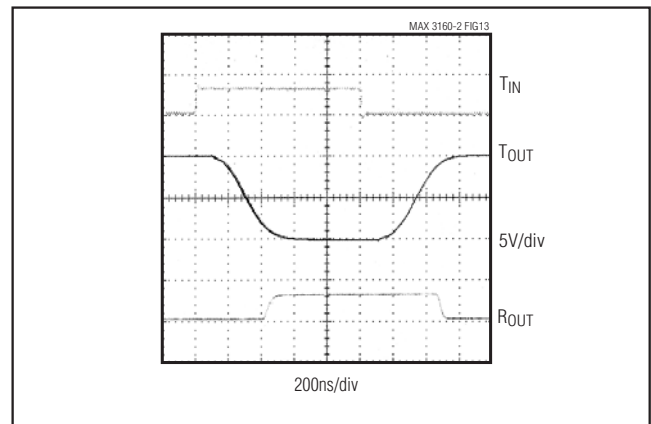


Figure 13. RS-232 Loopback Test Result at 1000kbps, FAST = High

RS-485/422 Line Length vs. Data Length

The RS-485/422 standard covers line lengths up to 4000 feet. For line lengths greater than 4000 feet, use the repeater application shown in Figure 14.

RS-232/RS-485 Protocol Translator

Figure 15 shows the MAX3162 configured as an RS-232/RS-485 protocol translator. The direction of transla-

tion is controlled through the RTS signal (R1IN). The single-ended RS-232 receiver input signal is translated to a differential RS-485 transmitter output. Similarly, a differential RS-485 receiver input signal is translated to a single-ended RS-232 transmitter output. RS-232 data received on R2IN is transmitted as an RS-485 signal on Z and Y. RS-485 signals received on A and B are transmitted as an RS-232 signal on T1OUT.

Multiprotocol Bus

The *Typical Operating Circuit* shows a standard application for the MAX3160. The MAX3160's output pins are multiplexed between RS-232 and RS-485 protocols by a microprocessor (μP). The μP also directs the shutdown functions, enable lines, and the duplex of the MAX3160. Data is transmitted to the MAX3100 UART

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MAX3160/MAX3161/MAX3162

+3.0V to+5.5V, 1μA, RS-232/
RS-485/422 Multiprotocol Transceivers

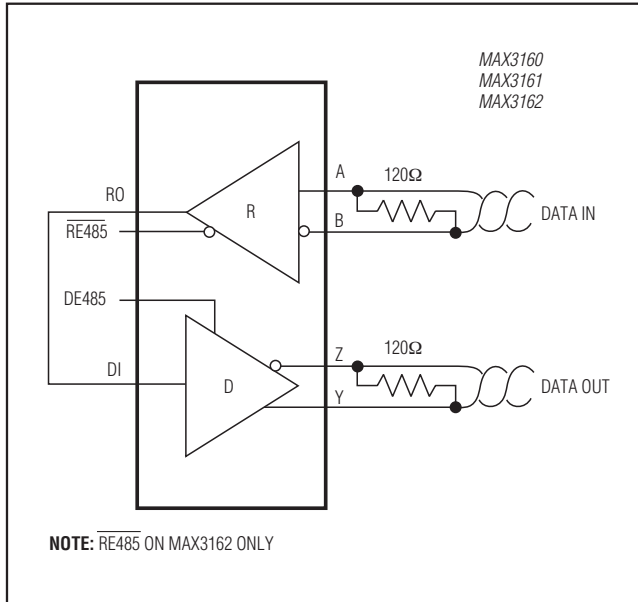


Figure 14. RS-485 Line Repeater

through an SPI™ port. The UART asynchronously transfers data through the MAX3160 to the pin-selected RS-232 or RS-485 protocol; see Table 14 for commonly used cable connections.

Multiprotocol Bus Multiplexer

The *Typical Application Circuit* shows the MAX3161 configured as a multiprotocol bus multiplexer. The MAX3161 separates the RS-232 and RS-485 lines, but shares the logic pins between modes. This application allows the μP to monitor a point-to-point RS-232 bus, and a multidrop RS-485 interface. The MAX3100 UART asynchronously transfers data through the MAX3161 to the pin-selected RS-232 or RS-485 protocol.

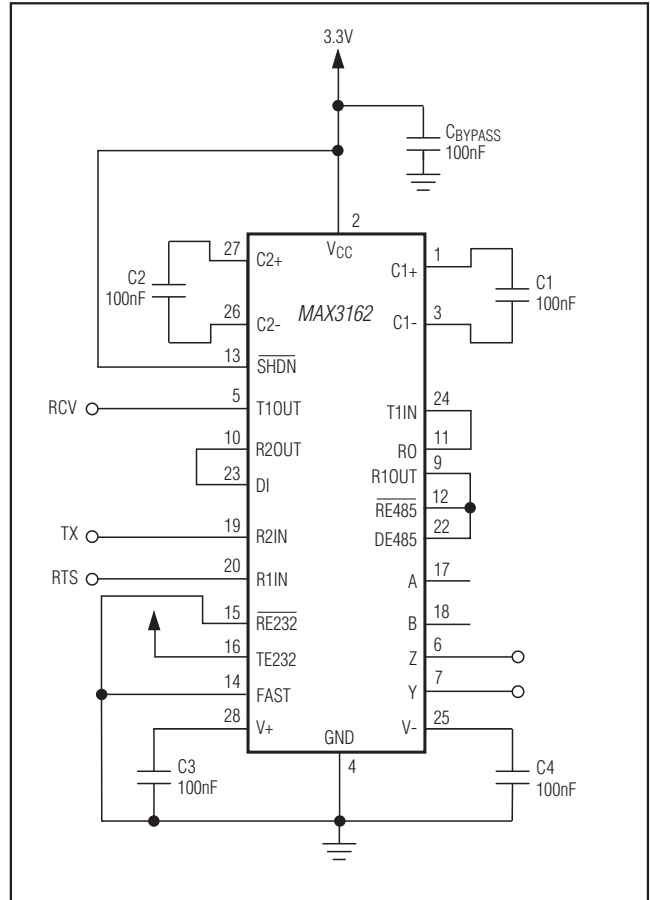
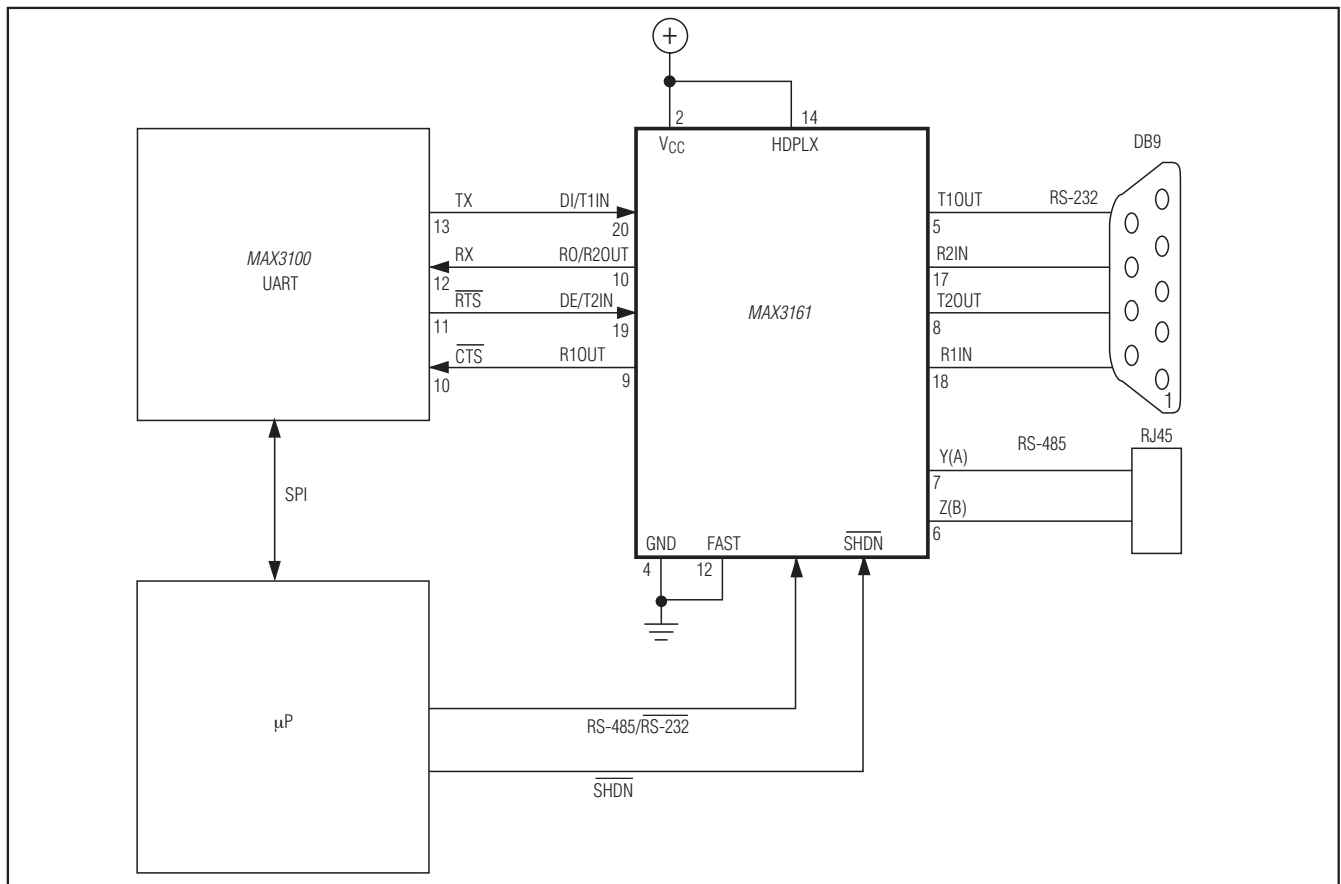


Figure 15. Protocol Translator

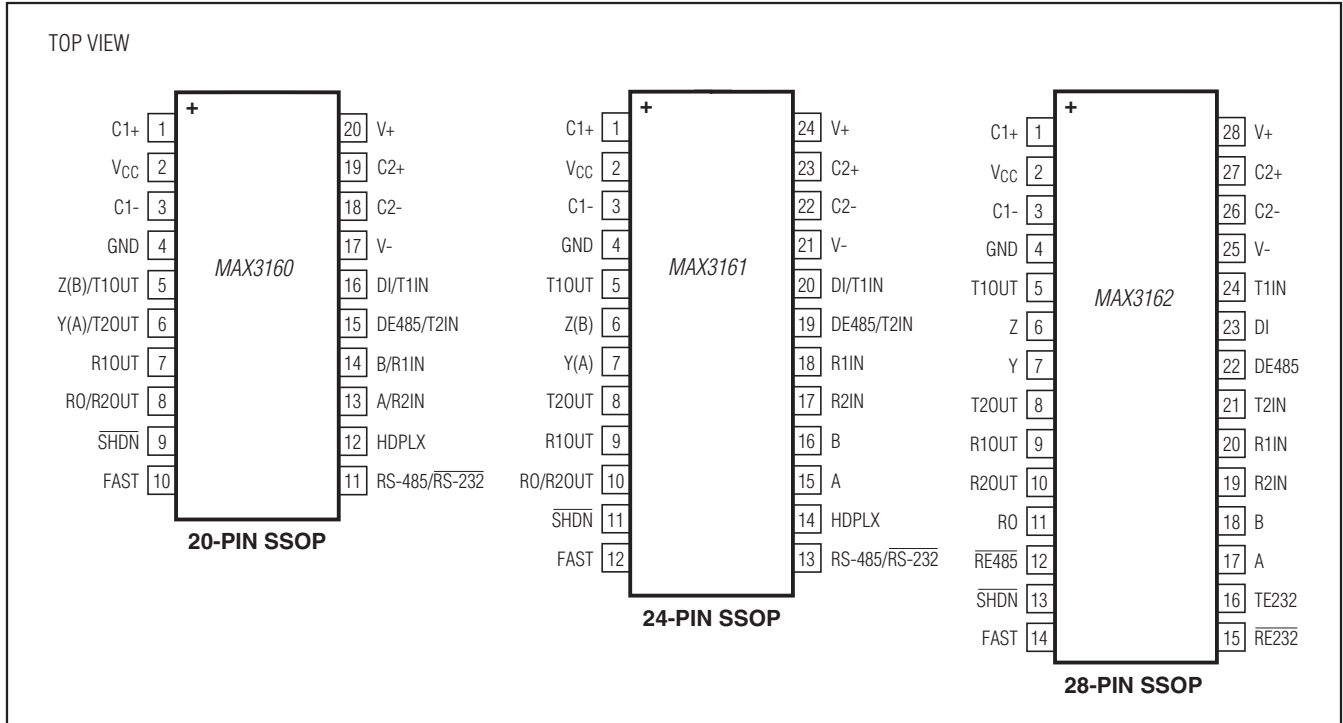
Table 14. Cable Connections Commonly Used for EIA/TIA-232 and V.24 Asynchronous Interfaces

| EIA/TIA-232 STANDARD | CONNECTOR PIN | MAX3160 MAX3161 MAX3162 | PIN NUMBER | | | FUNCTION (as seen by DTE) |
|----------------------|---------------|-------------------------------|------------|---------|---------|-------------------------------|
| | | | MAX3160 | MAX3161 | MAX3162 | |
| | | EQUIVALENT | | | | |
| DCD | 1 | | | | | Data Carrier Detect |
| RD | 2 | R2IN | 13 | 17 | 19 | Received Data |
| TD | 3 | T1OUT | 5 | 5 | 5 | Transmitted Data |
| DTR | 4 | | | | | Data Terminal Ready |
| SG | 5 | GND | 4 | 4 | 4 | Signal Ground |
| DSR | 6 | | | | | Data Set Ready |
| RTS | 7 | T2OUT | 6 | 8 | 8 | Request to Send (= DTE ready) |
| CTS | 8 | R1IN | 14 | 18 | 20 | Clear to Send (= DCE ready) |
| RI | 9 | | | | | Ring Indicator |

Typical Application Circuit



Pin Configurations



Selector Guide

| PART | DUAL-MODE | FLOW-THROUGH PIN-OUT | RS-485 INPUT UNIT LOADS |
|---------|-----------|----------------------|-------------------------|
| MAX3160 | No | Yes | 1/4 |
| MAX3161 | No | No | 1/8 |
| MAX3162 | Yes | Yes | 1/8 |

Chip Information

PROCESS: BiCMOS

Package Information

For the latest package outline information and land patterns (footprints), go to www.maximintegrated.com/packages. Note that a "+", "#", or "-" in the package code indicates RoHS status only. Package drawings may show a different suffix character, but the drawing pertains to the package regardless of RoHS status.

| PACKAGE TYPE | PACKAGE CODE | DOCUMENT NO. |
|--------------|--------------|-------------------------|
| 20 SSOP | A20+1 | 21-0056 |
| 24 SSOP | A24+3 | 21-0056 |
| 28 SSOP | A28+3 | 21-0056 |

Revision History

| REVISION NUMBER | REVISION DATE | DESCRIPTION | PAGES CHANGED |
|-----------------|---------------|---|---------------|
| 2 | 12/09 | Corrected the "Continuous Power Dissipation" specifications under the <i>Absolute Maximum Ratings</i> . | 2 |
| | | Changed pin labels in the <i>Functional Diagrams</i> . | 11 |
| | | Deleted "TRANSISTOR COUNT: 1580" and added "PROCESS: BiCMOS" to the <i>Chip Information</i> . | 22 |
| 3 | 5/15 | Updated the <i>General Description</i> and <i>Benefits and Features</i> sections | 1 |

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