

GENERAL DESCRIPTION

The XR3160 is an advanced multiprotocol transceiver supporting RS-232, RS-485, and RS-422 serial standards. Full operation requires only four external charge pump capacitors.

The RS-485/RS-232 pin selects RS-485 mode when high and RS-232 mode when low. The HALF/FULL pin configures the RS-485 modes as either half or full duplex.

The high speed drivers operate up to 20Mbps in RS-485/422 modes, and up to 1Mbps in RS-232 mode. All drivers can be slew limited to 250kbps in any mode to minimize electromagnetic interference (EMI) by setting the dedicated SLEW pin low.

All transmitter outputs and receiver inputs feature robust electrostatic discharge (ESD) protection to $\pm 15\text{kV}$ IEC 61000-4-2 Airgap, $\pm 15\text{kV}$ Human Body Model (HBM) and $\pm 8\text{kV}$ IEC 61000-4-2 Contact. Each receiver output has full fail-safe protection to avoid system lockup, oscillation, or indeterminate states by defaulting to logic-high output level when the inputs are open, shorted, or terminated but undriven. No external biasing resistors are required.

The RS-232 receiver inputs include a $5\text{k}\Omega$ pull-down to ground when in RS-232 mode. The RS-485/422 receiver inputs are high impedance ($>96\text{k}\Omega$), allowing up to 256 devices on a single communication bus (1/8th unit load).

The XR3160 operates from a single power supply, 3V to 5.5V, with low idle current. The shutdown mode consumes less than $1\mu\text{A}$ in low power standby operation with RS-232 receivers enabled.

FEATURES

- **Pin Compatible Upgrade** for MAX3160 (20 SSOP)
- IEC Level 4 ESD Protection
 - $\pm 15\text{kV}$ IEC 61000-4-2 Air Gap Discharge
 - $\pm 8\text{kV}$ IEC 61000-4-2 Contact Discharge
 - $\pm 15\text{kV}$ Human Body Model (HBM)
- **20Mbps RS-485** and 1Mbps RS-232 Data Rates
- Pin-Selectable 250kbps Slew Limiting
- **Single Supply Operation from +3V to +5.5V**
- 2 Drivers, 2 Receivers RS-232/V.28
- 1 Driver, 1 Receiver RS-485/422
 - Full or Half Duplex Configuration
 - 1/8th Unit Load, up to 256 receivers on bus
- RS-485/422 Enhanced Receiver Fail-safe for open, shorted, or terminated but idle inputs
- **10nA Shutdown Supply Current** (typical)

TYPICAL APPLICATIONS

- Software Programmable Serial Ports (RS-232, RS-422, RS-485)
- Embedded and Industrial PCs (IPC)
- Process Control Equipment
- Point-Of-Sales Equipment
- Networking Equipment
- HVAC Controls Equipment
- Building Security and Automation

ORDERING INFORMATION⁽¹⁾

PART NUMBER	OPERATING TEMPERATURE RANGE	LEAD-FREE	PACKAGE	PACKAGING METHOD
XR3160EIU-F	-40°C to +85°C	Yes ⁽²⁾	20-pin SSOP	Tube
XR3160EIUTR-F				Tape and Reel
XR3160ECU-F	0°C to +70°C			Tube
XR3160ECUTR-F				Tape and Reel

NOTE:

1. Refer to www.exar.com/XR3160 for most up-to-date Ordering Information.
2. Visit www.exar.com for additional information on Environmental Rating.

ABSOLUTE MAXIMUM RATINGS

These are stress ratings only and functional operation of the device at these ratings or any other above those indicated in the operation sections to the specifications below is not implied. Exposure to absolute maximum rating conditions for extended periods of time may affect reliability and cause permanent damage to the device.

Supply Voltage V_{CC}	-0.3V to +6.0V
Voltage at TTL Input Pins	-0.3V to +6.0V
Receiver Input Voltage (from Ground)	$\pm 18V$
Driver Output Voltage (from Ground)	$\pm 18V$
Short Circuit Duration, TX out to Ground	Continuous
Storage Temperature Range	-65°C to +150°C
Lead Temperature (soldering, 10s)	+300°C
Power Dissipation 20-pin SSOP (derate 12.0mW/°C above +70°C)	662mW
ESD Ratings	
HBM - Human Body Model (Tx Output & Rx Input pins)	$\pm 15kV$
HBM - Human Body Model (all other pins)	$\pm 3kV$
IEC 61000-4-2 Airgap Discharge (Tx Output & Rx Input pins)	$\pm 15kV$
IEC 61000-4-2 Contact Discharge (Tx Output & Rx Input pins)	$\pm 8kV$

CAUTION:

ESD (ElectroStatic Discharge) sensitive device. Permanent damage may occur on unconnected devices subject to high energy electrostatic fields. Unused devices must be stored in conductive foam or shunts. Personnel should be properly grounded prior to handling this device. The protective foam should be discharged to the destination socket before devices are removed.

ELECTRICAL CHARACTERISTICS
UNLESS OTHERWISE NOTED:
 $V_{CC} = +3V$ to $+5.5V$, $C1-C4 = 0.1\mu F$; $T_A = T_{MIN}$ to T_{MAX} . Typical values are at $V_{CC} = 3.3V$, $T_A = +25^\circ C$.

SYMBOL	PARAMETERS	MIN.	TYP.	MAX.	UNITS	CONDITIONS
DC CHARACTERISTICS						
I_{CC}	Supply Current (RS-232)		1.2	2.5	mA	No load, Idle inputs, $\overline{RS-485/RS-232} = 0V$
I_{CC}	Supply Current (RS-485/422)		2.5	5.5	mA	No load, Idle inputs, $\overline{RS-485/RS-232} = V_{CC}$
I_{CC}	V_{CC} Shutdown Current		0.01	1	μA	$\overline{SHDN} = 0V$, Receiver inputs open or grounded
TRANSMITTER and LOGIC INPUT PINS (DI, T1IN, T2IN, DE, \overline{SHDN}, \overline{SLEW}, HALF/FULL, RS-485/RS-232)						
V_{IL}	Logic Input Voltage Low			0.8	V	
V_{IH}	Logic Input Voltage High	2.0			V	$V_{CC} = +3.3V$
V_{IH}	Logic Input Voltage High	2.4			V	$V_{CC} = +5.0V$
I_{INL}	Logic Input Leakage Current		± 0.01	± 1	μA	
V_{HYS}	Logic Input Hysteresis		0.2		V	
RS-232 and RS-485/422 RECEIVER OUTPUTS (R1OUT, R2OUT, RO)						
V_{OL}	Receiver Output Voltage Low			0.4	V	$I_{OUT} = 2.5mA$
V_{OH}	Receiver Output Voltage High	$V_{CC}-0.6$			V	$I_{OUT} = -1.5mA$
I_{OSS}	Receiver Output Short Circuit Current		± 20	± 85	mA	$0 \leq V_O \leq V_{CC}$
I_{OZ}	Receiver Output Leakage Current		± 0.05	± 1	μA	$0 \leq V_O \leq V_{CC}$. Receivers disabled

ELECTRICAL CHARACTERISTICS (Continued)

UNLESS OTHERWISE NOTED:

 $V_{CC} = +3V$ to $+5.5V$, $C1-C4 = 0.1\mu F$; $T_A = T_{MIN}$ to T_{MAX} . Typical values are at $V_{CC} = 3.3V$, $T_A = +25^\circ C$.

SYMBOL	PARAMETERS	MIN.	TYP.	MAX.	UNITS	CONDITIONS
RS-232 SINGLE-ENDED RECEIVER INPUTS (R1IN, R2IN)						
V_{IN}	Input Voltage Range	-15		+15	V	
V_{IL}	Input Threshold Low	0.6	1.2		V	$V_{CC} = +3.3V$
		0.8	1.5		V	$V_{CC} = +5.0V$
V_{IH}	Input Threshold High		1.5	2.0	V	$V_{CC} = +3.3V$
			1.8	2.4	V	$V_{CC} = +5.0V$
V_{HYS}	Input Hysteresis		0.5		V	
R_{IN}	Input Resistance	3	5	7	$k\Omega$	$V_{CC} = +3.0V$ to $5.5V$
RS-232 SINGLE-ENDED TRANSMITTER OUTPUTS (T1OUT, T2OUT)						
V_{OUT}	Output Voltage Swing	± 5.0	± 5.4		V	Outputs loaded with $3k\Omega$ to Gnd
R_{OFF}	Output Power Off Impedance	300	10M		Ω	$V_{CC} = 0V$, $V_{OUT} = \pm 2V$
I_{SC}	Output Short Circuit Current		± 30	± 60	mA	$V_{OUT} = 0V$
I_O	Output Leakage Current			± 125	μA	$\overline{SHDN} = 0V$, $V_{OUT} = \pm 9V$, $V_{CC} = 0V$ or $5.5V$

ELECTRICAL CHARACTERISTICS (Continued)
UNLESS OTHERWISE NOTED:
 $V_{CC} = +3V$ to $+5.5V$, $C1-C4 = 0.1\mu F$; $T_A = T_{MIN}$ to T_{MAX} . Typical values are at $V_{CC} = 3.3V$, $T_A = +25^\circ C$.

SYMBOL	PARAMETERS	MIN.	TYP.	MAX.	UNITS	CONDITIONS
RS-485/422 DIFFERENTIAL RECEIVER INPUTS (A,B)						
R_{IN}	Receiver Input Resistance	96			$k\Omega$	$-7V \leq V_{CM} \leq +12V$
I_{IN}	Receiver Input Current			125	μA	$V_{IN} = +12V$
				-100	μA	$V_{IN} = -7V$
V_{TH}	Receiver Differential Threshold Voltage	-200	-125	-50	mV	$-7V \leq V_{CM} \leq +12V$
ΔV_{TH}	Receiver Input Hysteresis		30		mV	
RS-485/422 DIFFERENTIAL DRIVER OUTPUTS (Y, Z)						
V_{OD}	Differential Driver Output	1.5		V_{CC}	V	$R_L = 54\Omega$ (RS-485), Figure 4
		1.5		V_{CC}	V	$-7V \leq V_{CM} \leq +12V$, Figure 5
		2		V_{CC}	V	$R_L = 100\Omega$ (RS-422), Figure 4
$ \Delta V_{OD} $	Change In Magnitude of Differential Output Voltage			0.2	V	$R_L = 54\Omega$ or 100Ω , Figure 4
V_{CM}	Driver Common Mode Output Voltage			3	V	$R_L = 54\Omega$ or 100Ω , Figure 4
$ \Delta V_{CM} $	Change In Magnitude of Common Mode Output Voltage			0.2	V	$R_L = 54\Omega$ or 100Ω , Figure 4
I_{OSD}	Driver Output Short Circuit Current			± 250	mA	$-7V \leq V_Y$ or $V_Z \leq +12V$, Figure 6
I_O	Driver Output Leakage Current			± 125	μA	$DE = 0V$ or $\overline{SHDN} = 0V$, V_Y or $V_Z = -7V$ or $+12V$, $V_{CC} = 0V$ or $5.25V$

TIMING CHARACTERISTICS

UNLESS OTHERWISE NOTED:

$V_{CC} = +3V$ to $+5.5V$, $C1-C4 = 0.1\mu F$; $T_A = T_{MIN}$ to T_{MAX} . Typical values are at $V_{CC} = 3.3V$, $T_A = +25^\circ C$

SYMBOL	PARAMETERS	MIN.	TYP.	MAX.	UNITS	CONDITIONS
ALL MODES						
t_{ENABLE}	Enable from Shutdown		1000		ns	
$t_{SHUTDOWN}$	Enable to Shutdown		1000		ns	
RS-232, DATA RATE = 250kbps ($\overline{SLEW} = 0V$), ONE TRANSMITTER SWITCHING						
	Maximum Data Rate	250			kbps	$R_L = 3k\Omega$, $C_L = 1000pF$
t_{RHL}, t_{RLH}	Receiver Propagation Delay		100		ns	$C_L = 150pF$, Figure 7
$ t_{RHL}-t_{RLH} $	Receiver Propagation Delay Skew			100	ns	
t_{DHL}, t_{DLH}	Driver Propagation Delay		1400		ns	$R_L = 3k\Omega$, $C_L = 2500pF$, Figure 8
$ t_{DHL}-t_{DLH} $	Driver Propagation Delay Skew			600	ns	
t_{SHL}, t_{SLH}	Transition Region Slew Rate from +3.0V to -3.0V or -3.0V to +3.0V	6		30	V/ μs	$V_{CC} = +3.3V$, $R_L = 3k\Omega$ to $7k\Omega$, $C_L = 150pF$ to $2500pF$, $T_A = 25^\circ C$, Figure 8
t_{SHL}, t_{SLH}	Transition Region Slew Rate from +3.0V to -3.0V or -3.0V to +3.0V	4		30	V/ μs	$V_{CC} = +3.3V$, $R_L = 3k\Omega$ to $7k\Omega$, $C_L = 150pF$ to $2500pF$, Figure 8
RS-232, DATA RATE = 1Mbps ($\overline{SLEW} = V_{CC}$), ONE TRANSMITTER SWITCHING						
	Maximum Data Rate	1			Mbps	$R_L = 3k\Omega$, $C_L = 250pF$
t_{RHL}, t_{RLH}	Receiver Propagation Delay		100		ns	$C_L = 150pF$, Figure 7
$ t_{RHL}-t_{RLH} $	Receiver Propagation Delay Skew			100	ns	
t_{DHL}, t_{DLH}	Driver Propagation Delay		300		ns	$R_L = 3k\Omega$, $C_L = 1000pF$, Figure 8
$ t_{DHL}-t_{DLH} $	Driver Propagation Delay Skew			150	ns	
t_{SHL}, t_{SLH}	Transition Region Slew Rate from +3.0V to -3.0V or -3.0V to +3.0V	13		150	V/ μs	$V_{CC} = +3.3V$, $R_L = 3k\Omega$ to $7k\Omega$, $C_L = 150pF$ to $1000pF$, Figure 8
t_{SHL}, t_{SLH}	Transition Region Slew Rate from +3.0V to -3.0V or -3.0V to +3.0V	24		150	V/ μs	$V_{CC} = +3.3V$, $R_L = 3k\Omega$ to $7k\Omega$, $C_L = 150pF$ to $1000pF$, $T_A = 25^\circ C$, Figure 8

TIMING CHARACTERISTICS (Continued)
UNLESS OTHERWISE NOTED:
 $V_{CC} = +3V$ to $+5.5V$, $C1-C4 = 0.1\mu F$; $T_A = T_{MIN}$ to T_{MAX} . Typical values are at $V_{CC} = 3.3V$, $T_A = +25^\circ C$.

SYMBOL	PARAMETERS	MIN.	TYP.	MAX.	UNITS	CONDITIONS
RS-485/RS-422, DATA RATE = 250kbps ($\overline{SLEW} = 0V$), ONE TRANSMITTER SWITCHING						
	Maximum Data Rate	250			kbps	$R_L = 54\Omega$, $C_L = 50pF$
t_{RPHL} , t_{RPLH}	Receiver Propagation Delay		50	150	ns	$C_L = 15pF$, Figure 9
$ t_{RPHL} - t_{RPLH} $	Receiver Propagation Delay Skew			10	ns	
t_{DPHL} , t_{DPLH}	Driver Propagation Delay		500	1000	ns	$R_L = 54\Omega$, $C_L = 50pF$, Figure 10
$ t_{DPHL} - t_{DPLH} $	Driver Propagation Delay Skew			100	ns	
t_{DR} , t_{DF}	Driver Rise and Fall Time	300	650	1200	ns	
RS-485/RS-422, DATA RATE = 20Mbps ($\overline{SLEW} = V_{CC}$), ONE TRANSMITTER SWITCHING						
	Maximum Data Rate	20			Mbps	$R_L = 54\Omega$, $C_L = 50pF$
t_{RPHL} , t_{RPLH}	Receiver Propagation Delay		50	150	ns	$C_L = 15pF$, Figure 9
$ t_{RPHL} - t_{RPLH} $	Receiver Propagation Delay Skew			10	ns	
t_{DPHL} , t_{DPLH}	Driver Propagation Delay		30	100	ns	$R_L = 54\Omega$, $C_L = 50pF$, Figure 10
$ t_{DPHL} - t_{DPLH} $	Driver Propagation Delay Skew			10	ns	
t_{DR} , t_{DF}	Driver Rise and Fall Time		10	20	ns	
RS-485/RS-422, DATA RATE = 20Mbps ($\overline{SLEW} = V_{CC}$), ONE TRANSMITTER SWITCHING						
t_{DZH} , t_{DZL}	Driver Output Enable Time			200	ns	$R_L = 500\Omega$, $C_L = 50pF$, Figure 11
t_{DHZ} , t_{DLZ}	Driver Output Disable Time			200	ns	

PIN DESCRIPTIONS

Pin	Name	RS-232	RS-485 Full Duplex	RS-485 Half Duplex
1	C1+	Charge pump cap 1 positive lead, 0.1 μ F		
2	VCC	Main Supply, V_{CC} = +3.0V to +5.5V, bypass to ground with 1.0 μ F		
3	C1-	Charge pump cap 1 negative lead		
4	GND	Ground		
5	T1OUT, B/Z	Transmitter 1 Output	Z Driver Neg Output	B/Z Neg Input/Output
6	T2OUT, A/Y	Transmitter 2 Output	Y Driver Pos Output	A/Y Pos Input/Output
7	R1OUT	Receiver 1 Output	X	X
8	R2OUT, RO	Receiver 2 Output	Receiver TTL Output	Receiver TTL Output
9	$\overline{\text{SHDN}}$	Low power shutdown mode when low		
10	$\overline{\text{SLEW}}$	Data rate limited to 250kbps when low		
11	$\overline{\text{RS-485/RS-232}}$	0	1	1
12	$\overline{\text{HALF/FULL}}$	X	0	1
13	R2IN, A	Receiver 2 Input	A Pos Receiver Input	X
14	R1IN, B	Receiver 1 Input	B Neg Receiver Input	X
15	T2IN, DE	Transmitter 2 Input	Driver enabled when high	
16	T1IN, DI	Transmitter 1 Input	Driver TTL Input	
17	V-	Charge pump negative supply, 0.1 μ F from ground		
18	C2-	Charge pump cap 2 negative lead		
19	C2+	Charge pump cap 2 positive lead, 0.1 μ F		
20	V+	Charge pump positive supply, 0.1 μ F to ground		

SUGGESTED DB9 CONNECTOR PINOUT

DB9 Pin	RS-232	RS-485 Full Duplex	RS-485 Half Duplex
1			
2	RXD	RX+	
3	TXD	TX-	Data-
4			
5	Ground		
6			
7	RTS	TX+	Data+
8	CTS	RX-	
9			

BLOCK DIAGRAMS

FIGURE 1. RS-232 MODE

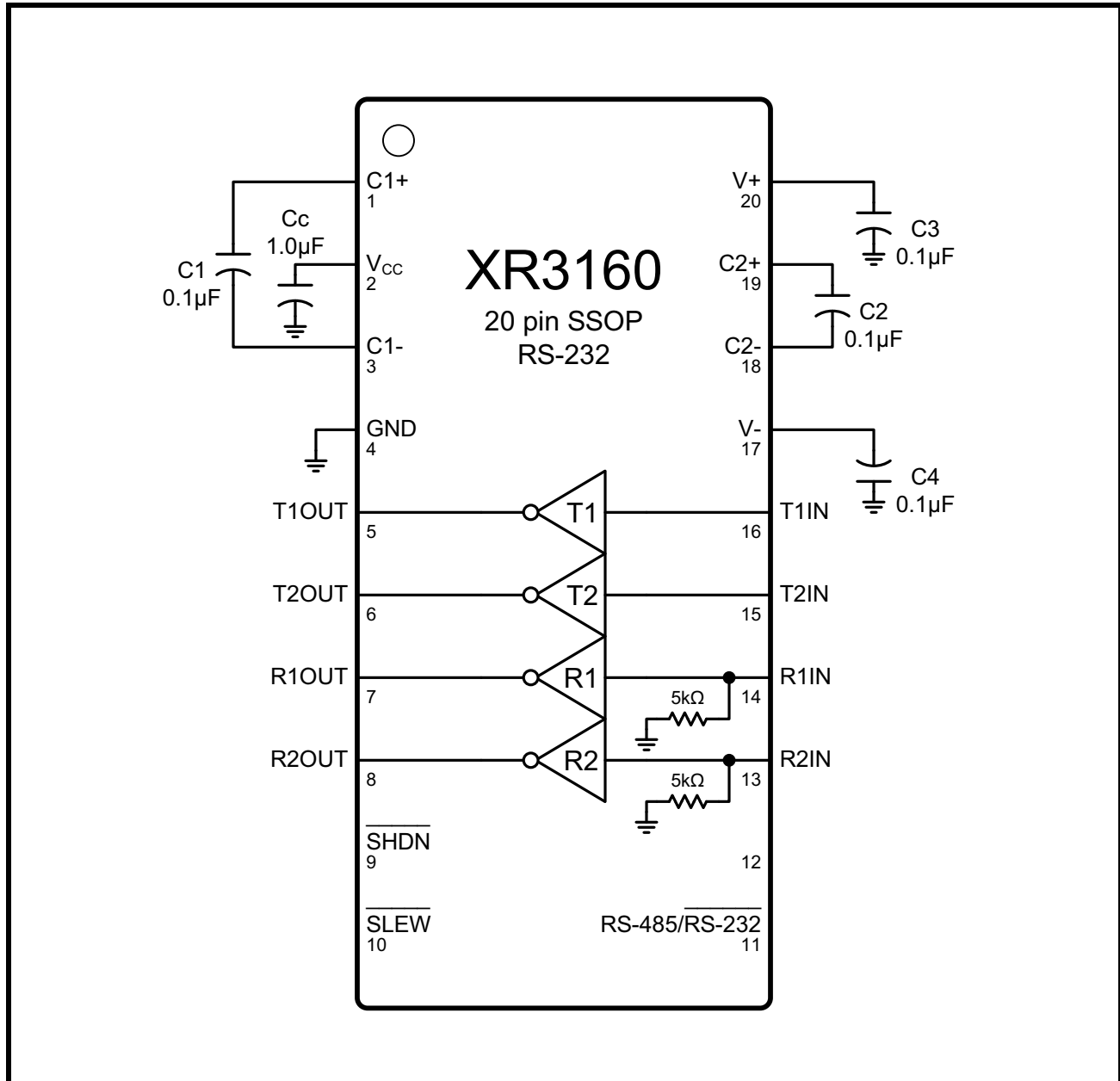


FIGURE 2. RS-485/422 FULL DUPLEX MODE

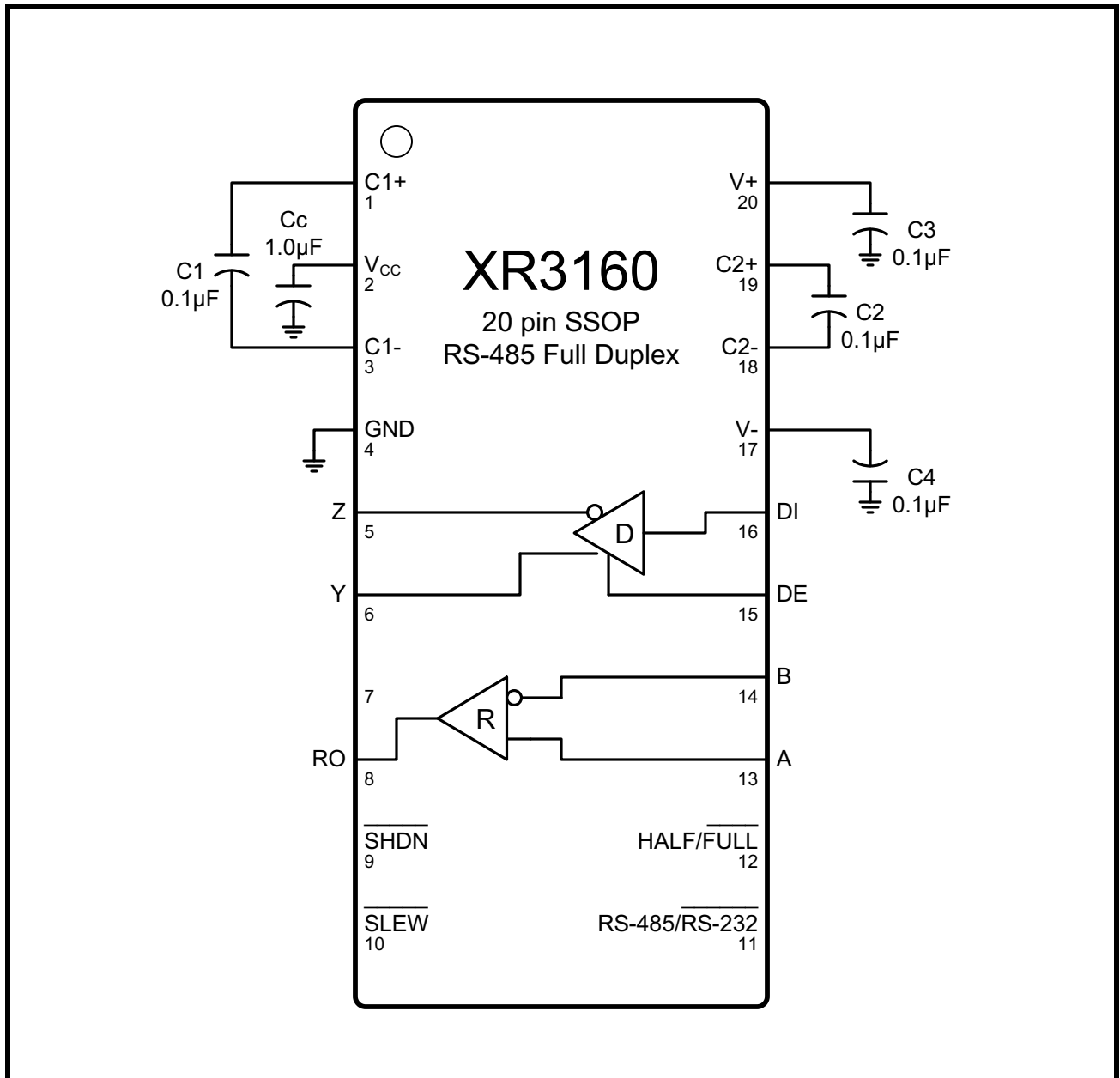
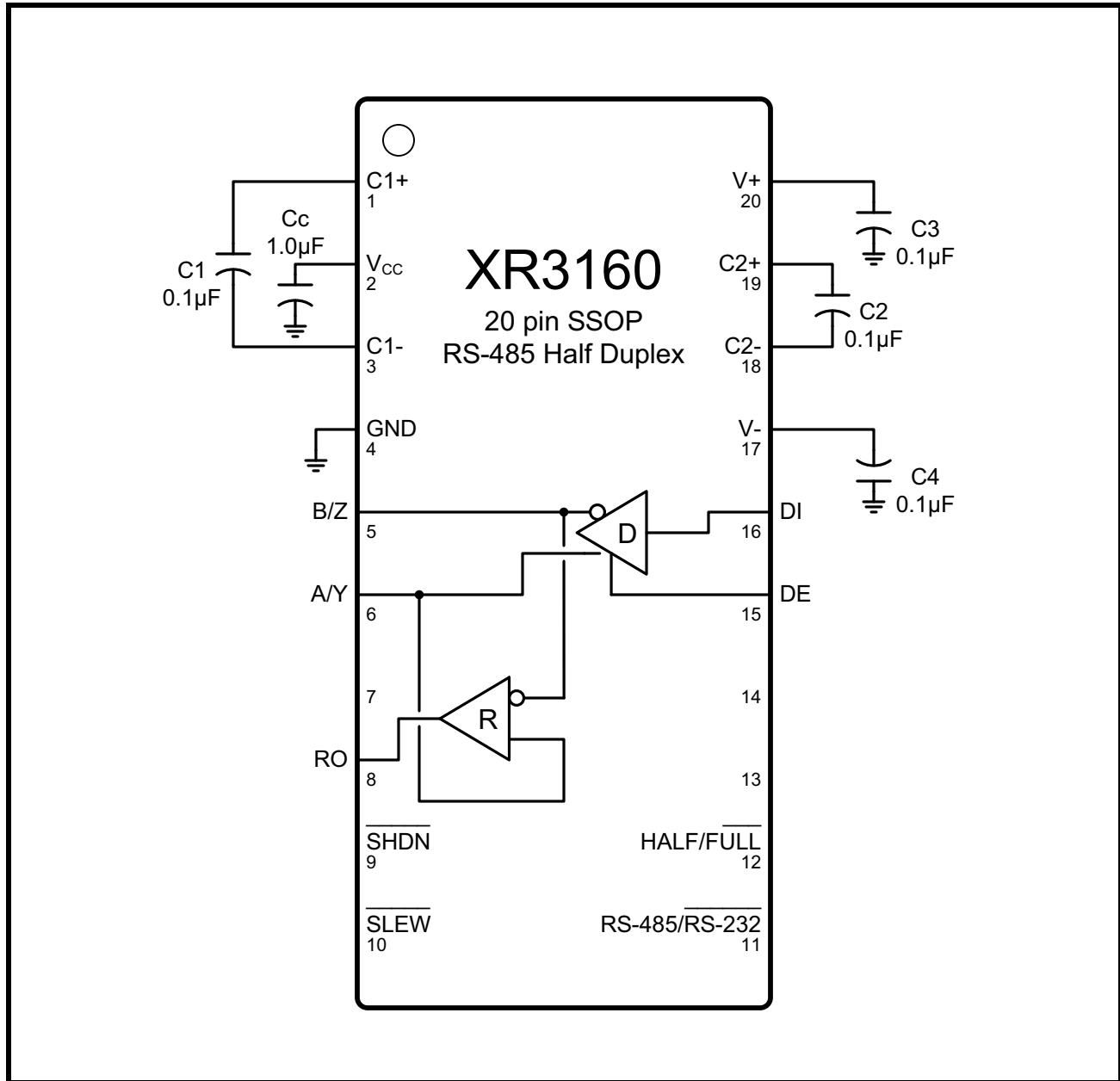


FIGURE 3. RS-485 HALF DUPLEX MODE



TEST CIRCUITS

FIGURE 4. RS-485/422 DIFFERENTIAL DRIVER OUTPUT VOLTAGE

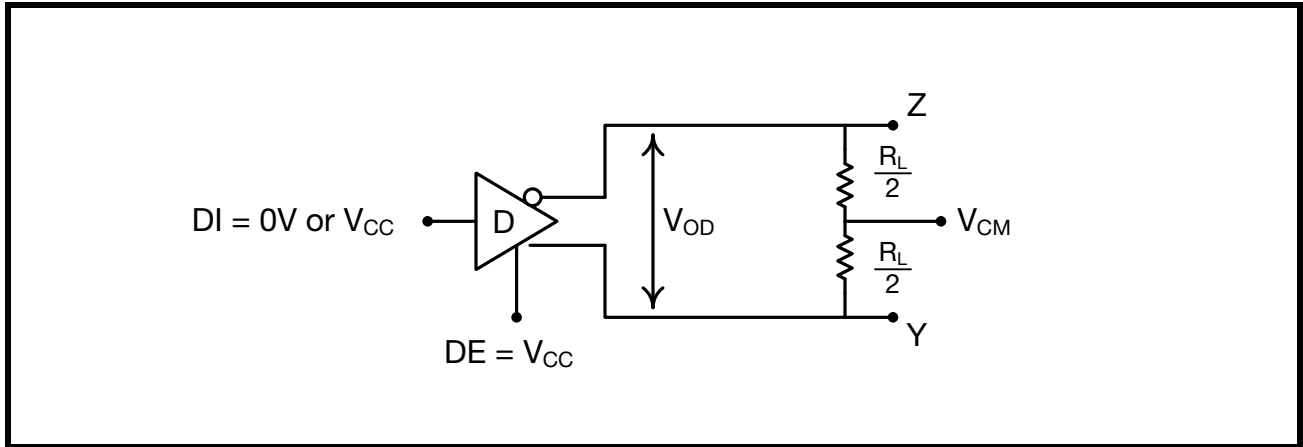


FIGURE 5. RS-485/422 DIFFERENTIAL DRIVER OUTPUT VOLTAGE OVER COMMON MODE

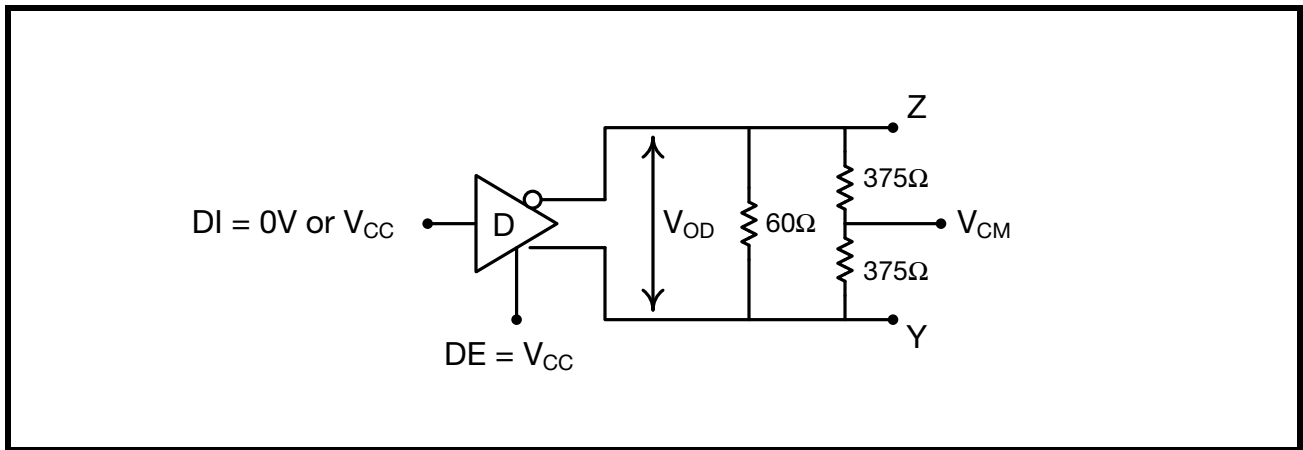


FIGURE 6. RS-485/422 DRIVER OUTPUT SHORT CIRCUIT CURRENT

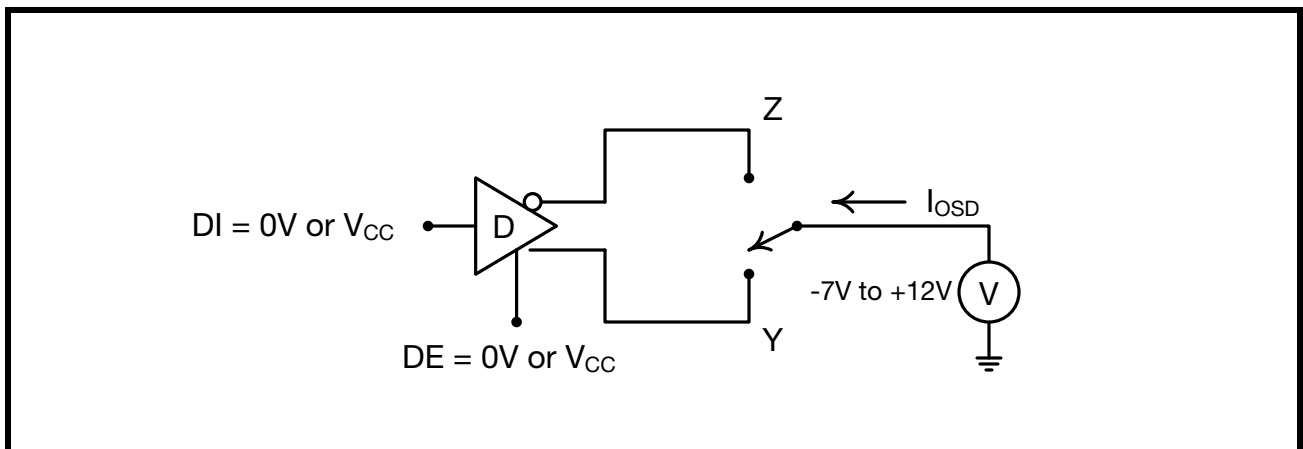


FIGURE 7. RS-232 RECEIVER PROPAGATION DELAY

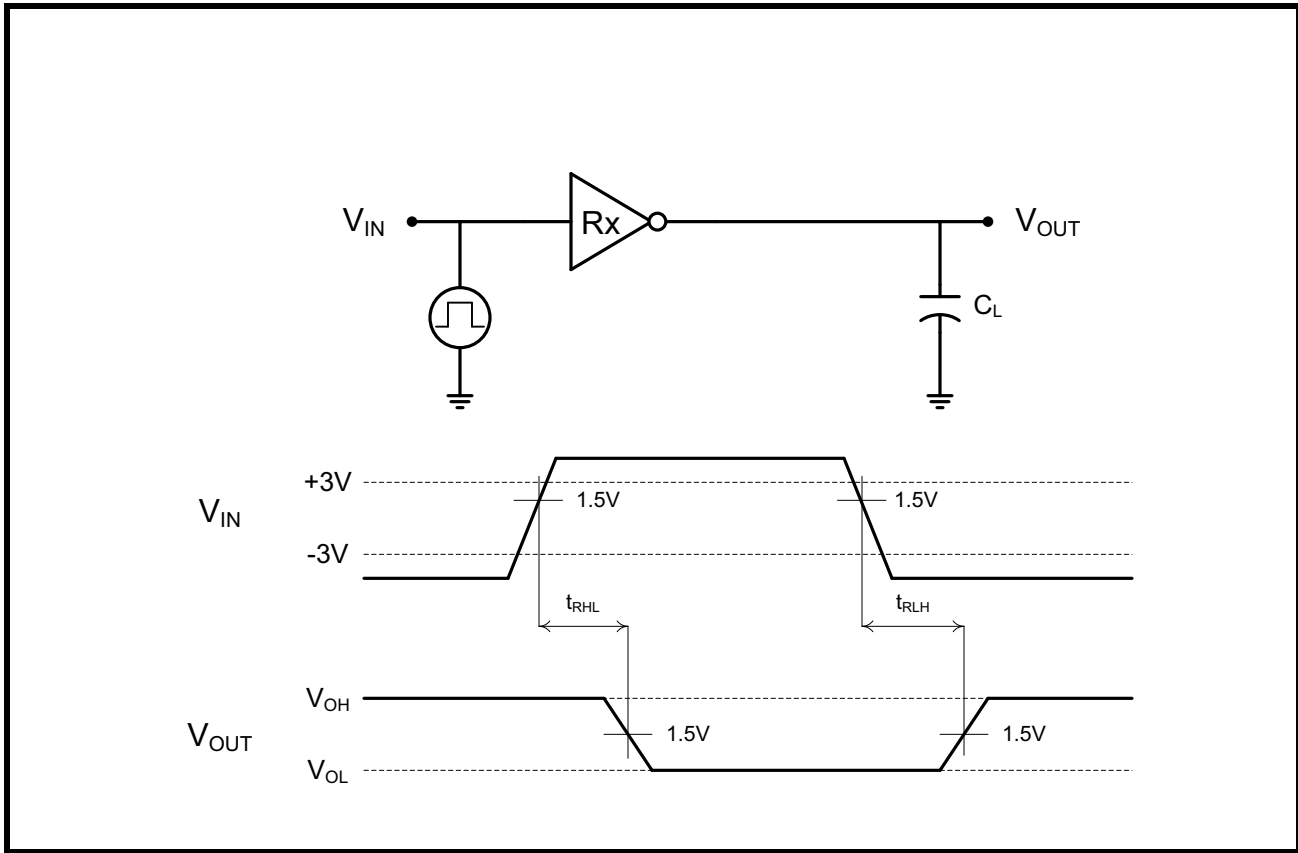


FIGURE 8. RS-232 DRIVER PROPAGATION DELAY

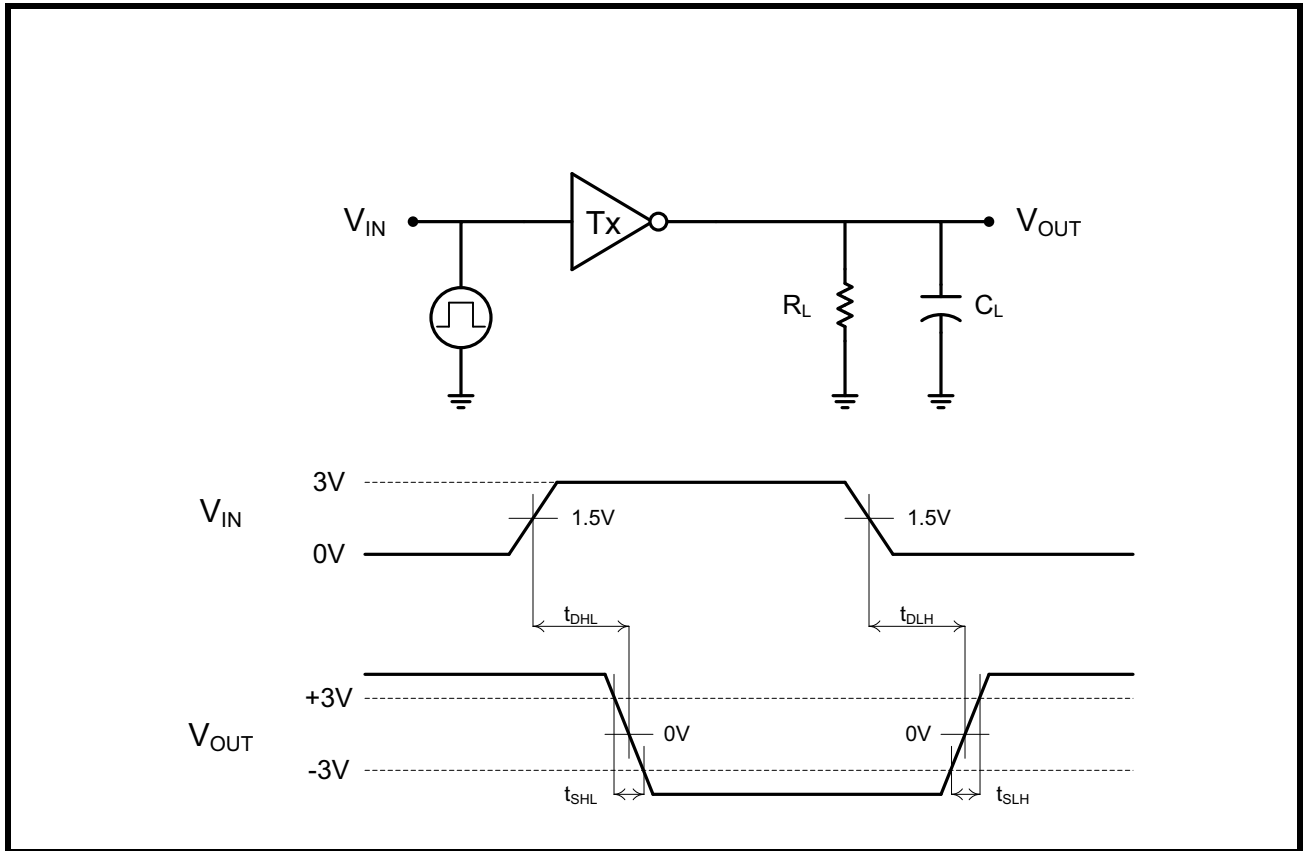


FIGURE 9. RS-485/422 RECEIVER PROPAGATION DELAY

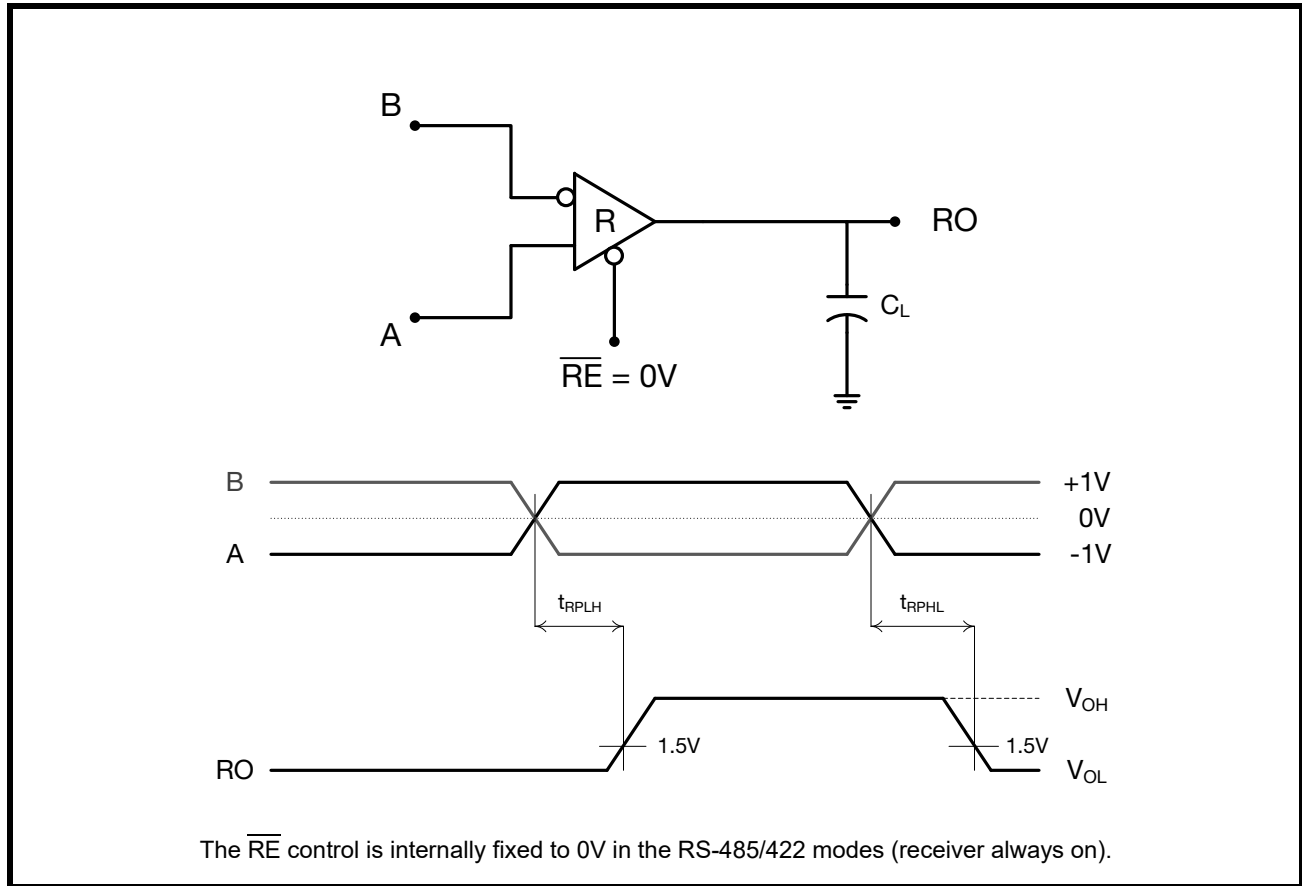


FIGURE 10. RS-485/422 DRIVER PROPAGATION DELAY AND RISE/FALL TIMES

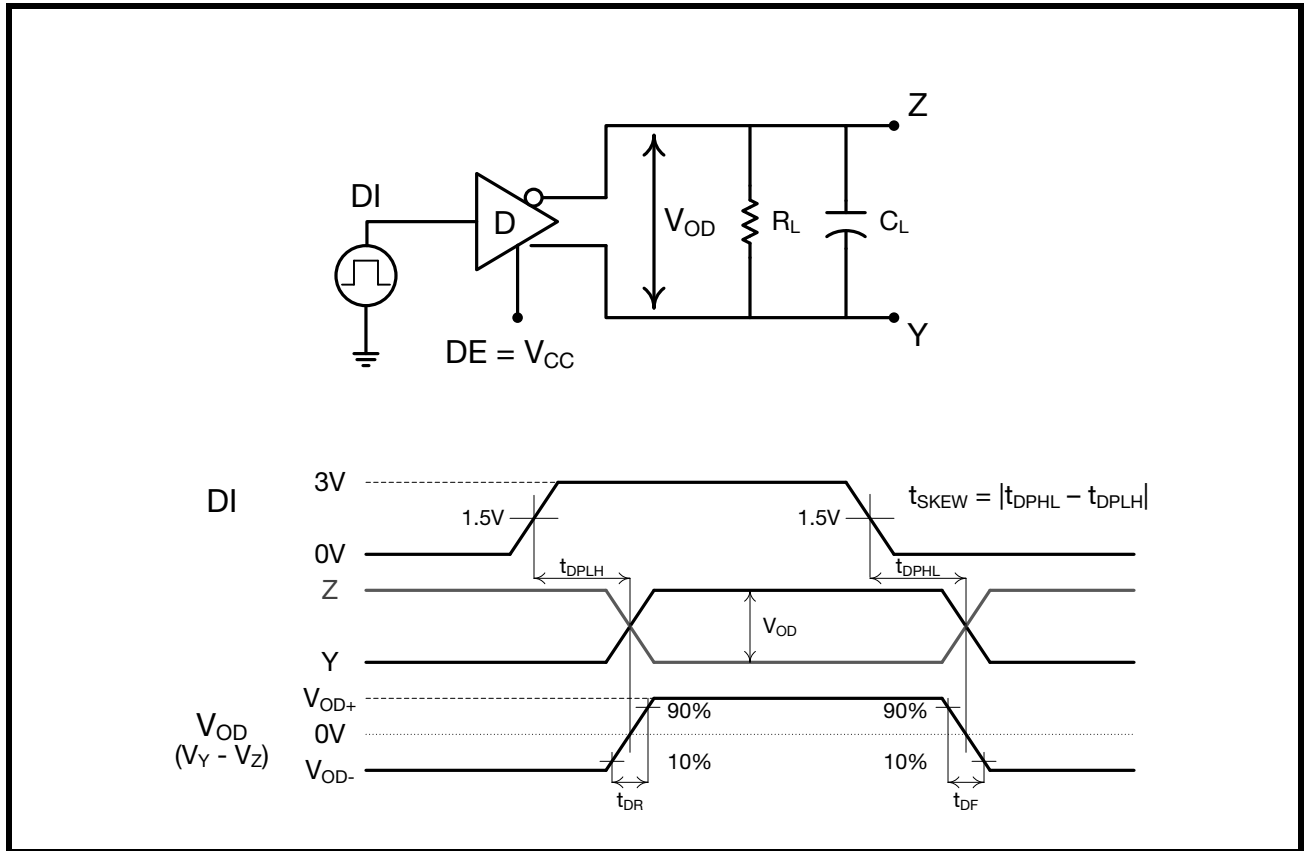
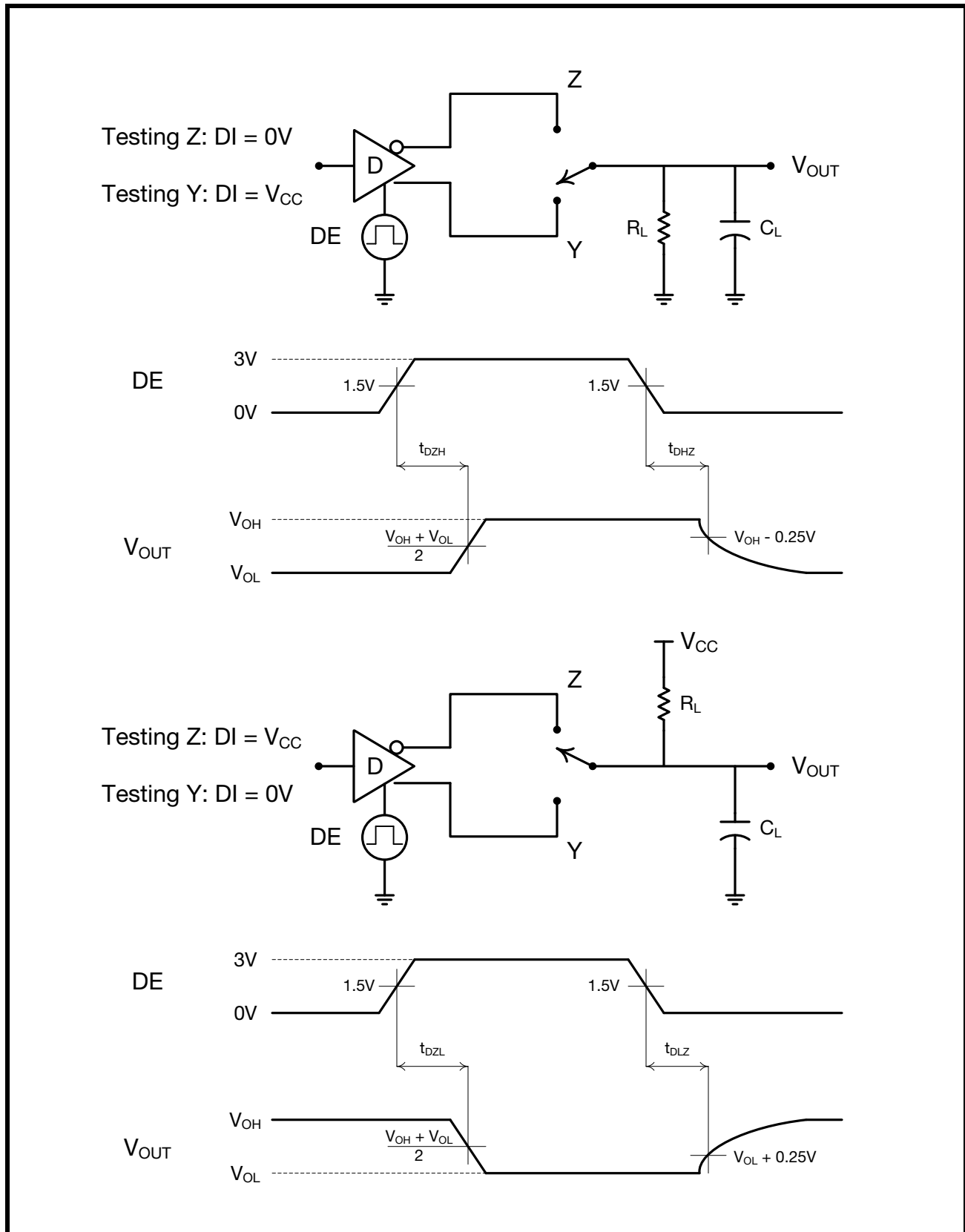


FIGURE 11. RS-485/422 DRIVER OUTPUT ENABLE/DISABLE TIMES



PRODUCT SUMMARY

The XR3160 is an advanced multiprotocol transceiver supporting RS-232, RS-485, and RS-422 serial standards. Full operation requires only four external charge pump capacitors.

ENHANCED FAILSAFE

The enhanced failsafe feature of the XR3160 guarantees a logic-high receiver output when the receiver inputs are open, shorted, or terminated but idle/undriven. The enhanced failsafe interprets 0V differential as a logic high with a minimum 50mV noise margin, while maintaining compliance with the EIA/TIA-485 standard of $\pm 200\text{mV}$. No external biasing resistors are required, further easing the usage of multiple protocols over a single connector.

$\pm 15\text{kV}$ ESD PROTECTION

ESD protection structures are incorporated on all pins to protect against electrostatic discharges encountered during handling and assembly. The bus pins (driver outputs and receiver inputs) have extra protection structures, which have been tested up to $\pm 15\text{kV}$ without damage. These structures withstand high ESD in all states: normal operation, in shutdown, and when powered off.

ESD protection is tested in various ways. MaxLinear uses the following methods to qualify the protection structures designed into XR3160:

- $\pm 8\text{kV}$ using IEC 61000-4-2 Contact Discharge
- $\pm 15\text{kV}$ using IEC 61000-4-2 Airgap Discharge
- $\pm 15\text{kV}$ using the Human Body Model (HBM)

The IEC 61000-4-2 standard is more rigorous than HBM, resulting in lower voltage levels compared with HBM for the same level of ESD protection. Because IEC 61000-4-2 specifies a lower series resistance, the peak current is higher than HBM. The XR3160 has passed both HBM and IEC 61000-4-2 testing without damage.

TRUTH TABLES

TABLE 1: RS-232 TX TRUTH TABLE

INPUTS			OUTPUTS
$\overline{\text{SHDN}}$	$\overline{\text{RS-485/RS-232}}$	DI/T1IN, DE/T2IN	Z(B)/T1OUT, Y(A)/T2OUT
0	X	X	1/8th unit load
1	0	0	1
1	0	1	0
1	1	X	RS-485 Mode

TABLE 2: RS-232 RX TRUTH TABLE

INPUTS			OUTPUTS
$\overline{\text{SHDN}}$	$\overline{\text{RS-485/RS-232}}$	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 3: RS-485/422 TX TRUTH TABLE

INPUTS				OUTPUTS	
$\overline{\text{SHDN}}$	$\overline{\text{RS-485/RS-232}}$	$\overline{\text{DE/T2IN}}$	$\overline{\text{DI/T1IN}}$	Z(B)/T1OUT	Y(A)/T2OUT
0	X	X	X	1/8th unit load	1/8th unit load
1	1	0	X	1/8th unit load	1/8th unit load
1	1	1	0	1	0
1	1	1	1	0	1
X	0	X	X	RS-232 Mode	

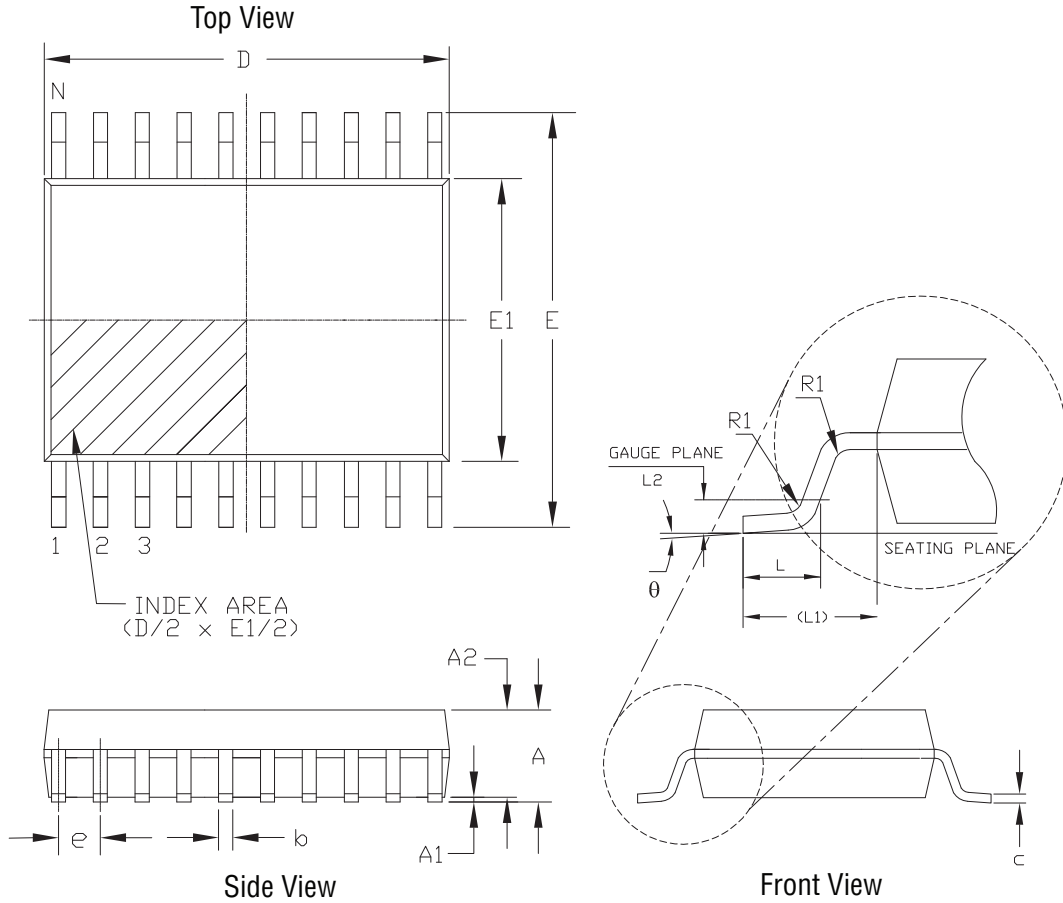
TABLE 4: RS-485/422 RX TRUTH TABLE

INPUTS					OUTPUT
$\overline{\text{RS-485/RS-232}}$	$\overline{\text{SHDN}}$	$\overline{\text{HALF/FULL}}$	(A-B)	(Y-Z)	RO/R2OUT
1	0	X	X	X	High-Z
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 6 and 5. A and B correspond to pins 13 and 14.

MECHANICAL DIMENSIONS

FIGURE 12. SSOP 20



SYMBOLS	PACKAGE OUTLINE SSOP 5.3mm BODY JEDEC MO-150 VARIATION AE					
	COMMON DIMENSIONS IN MM (Control Unit)			COMMON DIMENSIONS IN INCH (Reference Unit)		
	MIN	NOM	MAX	MIN	NOM	MAX
A	—	—	2.00	—	—	0.079
A1	0.05	—	—	0.002	—	—
A2	1.65	1.75	1.85	0.065	0.069	0.073
b	0.22	—	0.38	0.009	—	0.015
c	0.09	—	0.25	0.004	—	0.010
E	7.40	7.80	8.20	0.291	0.307	0.323
E1	5.00	5.30	5.60	0.197	0.209	0.220
e	0.65 BSC		0.026 BSC			
L	0.55	0.75	0.95	0.022	0.030	0.037
L1	1.25 REF		0.049 REF			
L2	0.25 BSC		0.010 BSC			
R1	0.09	—	—	0.004	—	—
θ	0°	4°	8°	0°	4°	8°
D	6.90	7.20	7.50	.272	0.283	0.295
N	20					

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Revision: A