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
Logic Interface Voltage V_L	$V_L \leq V_{CC}$
Voltage at TTL Input Pins	-0.3V to +6.0V
Receiver Input Voltage (from Ground)	±18V
Driver Output Voltage (from Ground)	±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 32-pin 5x5 QFN (derate 26.0mW/°C above +70°C)	1400mW

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.

ESD PROTECTION

		MIN.	TYP.	MAX.	UNITS	
	TX Output & RX Input Pins		±15		kV	IEC 61000-4-2 Airgap
			± 8		kV	IEC 61000-4-2 Contact
			±15		kV	Human Body Model (HBM)
	All Other Pins		± 3		kV	Human Body Model (HBM)

ELECTRICAL CHARACTERISTICS

UNLESS OTHERWISE NOTED:
V_{CC} = +3.0V to +5.5V, C1-C4 = 0.1µF; $T_A = T_{MIN}$ to T_{MAX}. Typical values are at $V_L = V_{CC}$ = 3.3V, T_A = +25°C.

SYMBOL	PARAMETERS	MIN.	TYP.	MAX.	UNITS	CONDITIONS
DC CHARACTERISTICS						
I_{CC}	Supply Current (RS-232)		1	2.5	mA	No load, Idle inputs, RS-485/$\overline{\text{RS-232}}$ = 0V
I_{CC}	Supply Current (RS-485/422)		1.8	4.5	mA	No load, Idle inputs, RS-485/$\overline{\text{RS-232}}$ = V_{CC}
I_{CC}	Vcc Shutdown Current		0.01	1	µA	$\overline{\text{SHDN}}$ = 0V, Receiver inputs open or grounded
TRANSMITTER and LOGIC INPUTS (PINS 10 - 15, 20 - 22)						
V_{IL}	Logic Input Voltage Low			$\frac{V_L}{3}$	V	
V_{IH}	Logic Input Voltage High	$\frac{2V_L}{3}$			V	
I_{INL}	Logic Input Leakage Current		±0.01	±1	µA	
I_{INPD}	Logic Input Pulldown Current		10	50	µA	$\overline{\text{RE}}$, TERM, & FD_TX_TERM $V_{IN} = V_L$
V_{HYS}	Logic Input Hysteresis		200		mV	
RS-232 and RS-485/422 RECEIVER OUTPUTS (PINS 6 & 7)						
V_{OL}	Receiver Output Voltage Low			0.4	V	I_{OUT} = 1.5mA
V_{OH}	Receiver Output Voltage High	V_L-0.6			V	I_{OUT} = -1.5mA
I_{OSS}	Receiver Output Short Circuit Current		±20	±85	mA	$0 \le V_O \le V_L$
I_{OZ}	Receiver Output Leakage Current		±0.05	±1	µA	$0 \le V_O \le V_L$, Receivers disabled

ELECTRICAL CHARACTERISTICS (Continued)

UNLESS OTHERWISE NOTED:
V_{CC} = +3.0V to +5.5V, C1-C4 = 0.1µF; $T_A = T_{MIN}$ to T_{MAX}. Typical values are at V_{CC} = 3.3V, T_A = +25°C.

SYMBOL	PARAMETERS	MIN.	TYP.	MAX.	UNITS	CONDITIONS
RS-232 SINGLE-ENDED RECEIVER INPUTS (PINS 18 & 19)						
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	kΩ	-15V ≤ V_{IN} ≤ +15V
RS-232 SINGLE-ENDED TRANSMITTER OUTPUTS (PINS 3 & 4)						
V_{OUT}	Output Voltage Swing	±5.0	±5.5		V	Outputs loaded with 3kΩ to Gnd
R_{OFF}	Output Power Off Impedance	300	10M		Ω	V_{CC} = 0V, V_{OUT} = ±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} = ±9V, V_{CC} = 0V or 5.5V

ELECTRICAL CHARACTERISTICS (Continued)

UNLESS OTHERWISE NOTED:
V_{CC} = +3.0V to +5.5V, C1-C4 = 0.1µF; $T_A = T_{MIN}$ to T_{MAX}. Typical values are at V_{CC} = 3.3V, T_A = +25°C.

SYMBOL	PARAMETERS	MIN.	TYP.	MAX.	UNITS	CONDITIONS
RS-485/422 DIFFERENTIAL RECEIVER INPUTS (A,B)						
R_{IN}	Receiver Input Resistance	96			kΩ	Termination disabled, -7V ≤ V_{CM} ≤ +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 ≤ V_{CM} ≤ +12V
ΔV_{TH}	Receiver Input Hysteresis		25		mV	
R_{TERM}	Termination Resistance	100	120	155	Ω	Termination enabled, Figure 4 -7V ≤ V_{CM} ≤ +12V
R_{TERM}	Termination Resistance	100	120	140	Ω	Termination enabled, Figure 4 V_{CM} = 0V
RS-485/422 DIFFERENTIAL DRIVER OUTPUTS (Y, Z)						
V_{OD}	Differential Driver Output	1.5		V_{CC}	V	R_L = 54Ω (RS-485), Figure 5
		1.5		V_{CC}	V	-7V ≤ V_{CM} ≤ +12V, Figure 6
		2		V_{CC}	V	R_L = 100Ω (RS-422), Figure 5
$\lvert\Delta V_{OD}\rvert$	Change In Magnitude of Differential Output Voltage			0.2	V	R_L = 54Ω or 100Ω, Figure 5
V_{CM}	Driver Common Mode Output Voltage			3	V	R_L = 54Ω or 100Ω, Figure 5
$\lvert\Delta V_{CM}\rvert$	Change In Magnitude of Common Mode Output Voltage			0.2	V	R_L = 54Ω or 100Ω, Figure 5
I_{OSD}	Driver Output Short Circuit Current			±250	mA	-7V ≤ V_Y or V_Z ≤ +12V, Figure 7
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 5.5V

TIMING CHARACTERISTICS

UNLESS OTHERWISE NOTED:
V_{CC} = +3.0V to +5.5V, C1-C4 = 0.1µF; $T_A = T_{MIN}$ to T_{MAX}. Typical values are at V_{CC} = 3.3V, T_A = +25°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 = 3kΩ, C_L = 1000pF
t_{RHL}, t_{RLH}	Receiver Propagation Delay		100		ns	C_L = 150pF, Figure 8
$\lvert t_{RHL}-t_{RLH}\rvert$	Receiver Propagation Delay Skew			100	ns	
t_{DHL}, t_{DLH}	Driver Propagation Delay		1400		ns	R_L = 3kΩ, C_L = 2500pF, Figure 9
$\lvert t_{DHL}-t_{DLH}\rvert$	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 = 3kΩ to 7kΩ, C_L = 150pF to 2500pF, T_A = 25°C, Figure 9
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 = 3kΩ to 7kΩ, C_L = 150pF to 2500pF, Figure 9
RS-232, DATA RATE = 1Mbps ($\overline{SLEW}$ = V_{CC}), ONE TRANSMITTER SWITCHING						
	Maximum Data Rate	1			Mbps	R_L = 3kΩ, C_L = 250pF
t_{RHL}, t_{RLH}	Receiver Propagation Delay		100		ns	C_L = 150pF, Figure 8
$\lvert t_{RHL}-t_{RLH}\rvert$	Receiver Propagation Delay Skew			100	ns	
t_{DHL}, t_{DLH}	Driver Propagation Delay		300		ns	R_L = 3kΩ, C_L = 1000pF, Figure 9
$\lvert t_{DHL}-t_{DLH}\rvert$	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 = 3kΩ to 7kΩ, C_L = 150pF to 1000pF, Figure 9
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 = 3kΩ to 7kΩ, C_L = 150pF to 1000pF, T_A = 25°C, Figure 9

TIMING CHARACTERISTICS (Continued)

UNLESS OTHERWISE NOTED:
V_{CC} = +3.0V to +5.5V, C1-C4 = 0.1µF; $T_A = T_{MIN}$ to T_{MAX}. Typical values are at V_{CC} = 3.3V, T_A = +25°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 = 54Ω, C_L = 50pF
t_{RPHL}, t_{RPLH}	Receiver Propagation Delay		50	150	ns	C_L = 15pF, Figure 10
$\lvert t_{RPHL}-t_{RPLH}\rvert$	Receiver Propagation Delay Skew			10	ns	
t_{DPHL}, t_{DPLH}	Driver Propagation Delay		500	1000	ns	R_L = 54Ω, C_L = 50pF, Figure 11
$\lvert t_{DPHL}-t_{DPLH}\rvert$	Driver Propagation Delay Skew			100	ns	
t_{DR}, t_{DF}	Driver Rise and Fall Time	300	650	1200	ns	
t_{RZH}, t_{RZL}	Receiver Output Enable Time			200	ns	C_L = 15pF, Figure 12
t_{RHZ}, t_{RLZ}	Receiver Output Disable Time			200	ns	
t_{DZH}, t_{DZL}	Driver Output Enable Time			1000	ns	R_L = 500Ω, C_L = 50pF, Figure 13
t_{DHZ}, t_{DLZ}	Driver Output Disable Time			200	ns	
RS-485/RS-422, DATA RATE = 20Mbps ($\overline{SLEW}$ = V_{CC}), ONE TRANSMITTER SWITCHING						
	Maximum Data Rate	20			Mbps	R_L = 54Ω, C_L = 50pF
t_{RPHL}, t_{RPLH}	Receiver Propagation Delay		50	150	ns	C_L = 15pF, Figure 10
$\lvert t_{RPHL}-t_{RPLH}\rvert$	Receiver Propagation Delay Skew			10	ns	
t_{DPHL}, t_{DPLH}	Driver Propagation Delay		30	100	ns	R_L = 54Ω, C_L = 50pF, Figure 11
$\lvert t_{DPHL}-t_{DPLH}\rvert$	Driver Propagation Delay Skew			10	ns	
t_{DR}, t_{DF}	Driver Rise and Fall Time		10	20	ns	
t_{RZH}, t_{RZL}	Receiver Output Enable Time			200	ns	C_L = 15pF, Figure 12
t_{RHZ}, t_{RLZ}	Receiver Output Disable Time			200	ns	
t_{DZH}, t_{DZL}	Driver Output Enable Time			200	ns	R_L = 500Ω, C_L = 50pF, Figure 13
t_{DHZ}, t_{DLZ}	Driver Output Disable Time			200	ns	

PIN DESCRIPTIONS

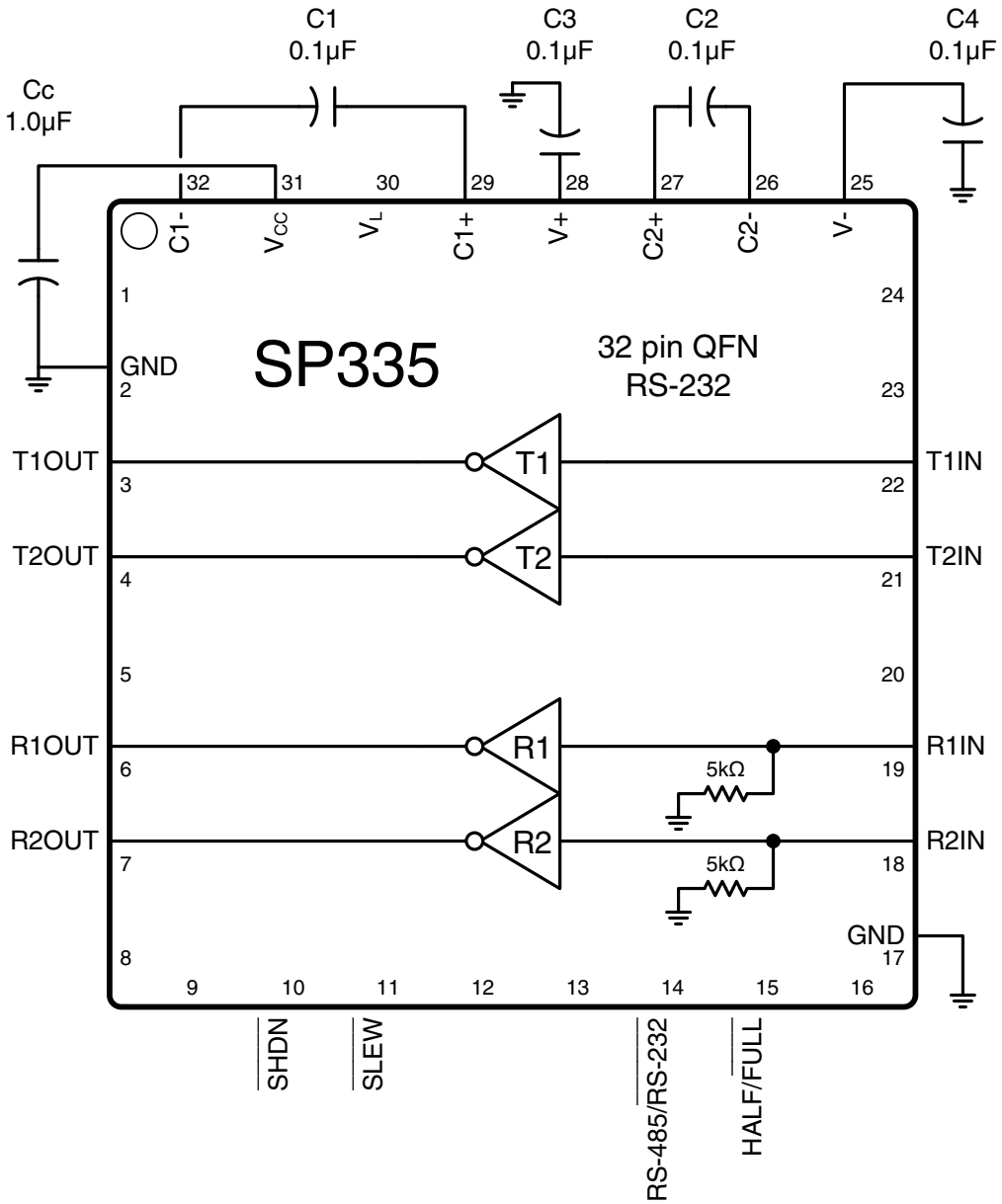
Pin	Name	RS-232	RS-485 Full Duplex	RS-485 Half Duplex
1				
2	GND	Ground		
3	T1OUT, B/Z	Transmitter 1 Output	Z Driver Neg Output	B/Z Neg Input/Output
4	T2OUT, A/Y	Transmitter 2 Output	Y Driver Pos Output	A/Y Pos Input/Output
5				
6	R1OUT	Receiver 1 Output	X	X
7	R2OUT, RO	Receiver 2 Output	Receiver TTL Output	Receiver TTL Output
8				
9				
10	$\overline{\text{SHDN}}$	Low power shutdown mode when low		
11	$\overline{\text{SLEW}}$	Data rate limited to 250kbps when low		
12	FD_TX_TERM	X	120Ω Y-Z termination enabled when both TERM and FD_TX_TERM are high	X
13	TERM	X	120Ω A-B termination enabled when high	
14	RS-485/$\overline{\text{RS-232}}$	0	1	1
15	HALF/$\overline{\text{FULL}}$	X	0	1
16				
17	GND	Ground		
18	R2IN, A	Receiver 2 Input	A Pos Receiver Input	X
19	R1IN, B	Receiver 1 Input	B Neg Receiver Input	X
20	$\overline{\text{RE}}$	X	Receiver enabled when low	
21	T2IN, DE	Transmitter 2 Input	Driver enabled when high	
22	T1IN, DI	Transmitter 1 Input	Driver TTL Input	
23				
24				
25	V-	Charge pump negative supply, 0.1µF from ground		
26	C2-	Charge pump cap 2 negative lead		
27	C2+	Charge pump cap 2 positive lead, 0.1µF		
28	V+	Charge pump positive supply, 0.1µF to ground		
29	C1+	Charge pump cap 1 positive lead, 0.1µF		
30	VL	Logic Supply for TTL Inputs and Outputs, V_L = +1.65V to +5.5V or tie to V_{CC}		
31	VCC	Main Supply, V_{CC} = +3.0V to +5.5V, bypass to ground with 1.0µF		
32	C1-	Charge pump cap 1 negative lead		

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			

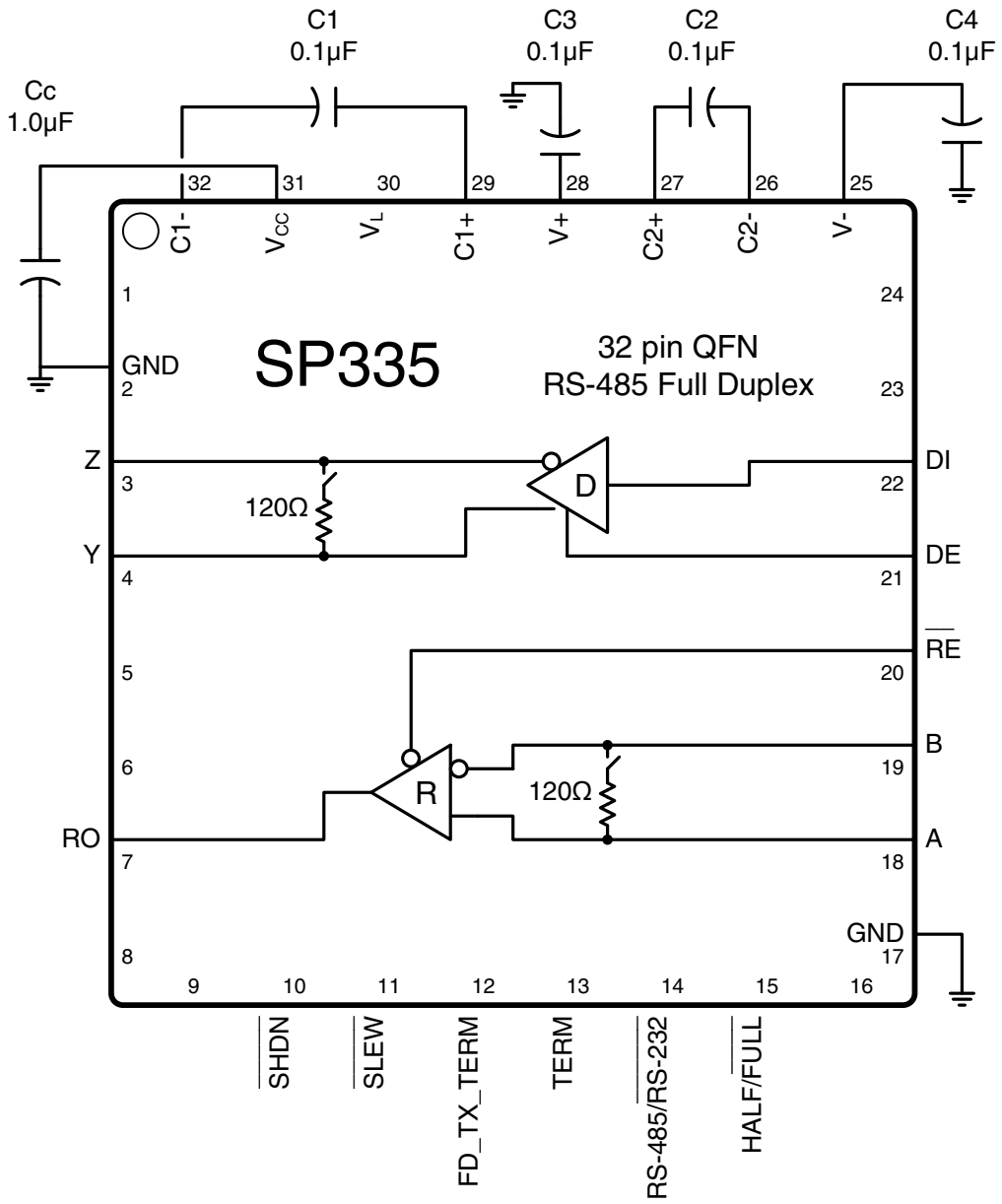
BLOCK DIAGRAMS

FIGURE 1. RS-232 MODE



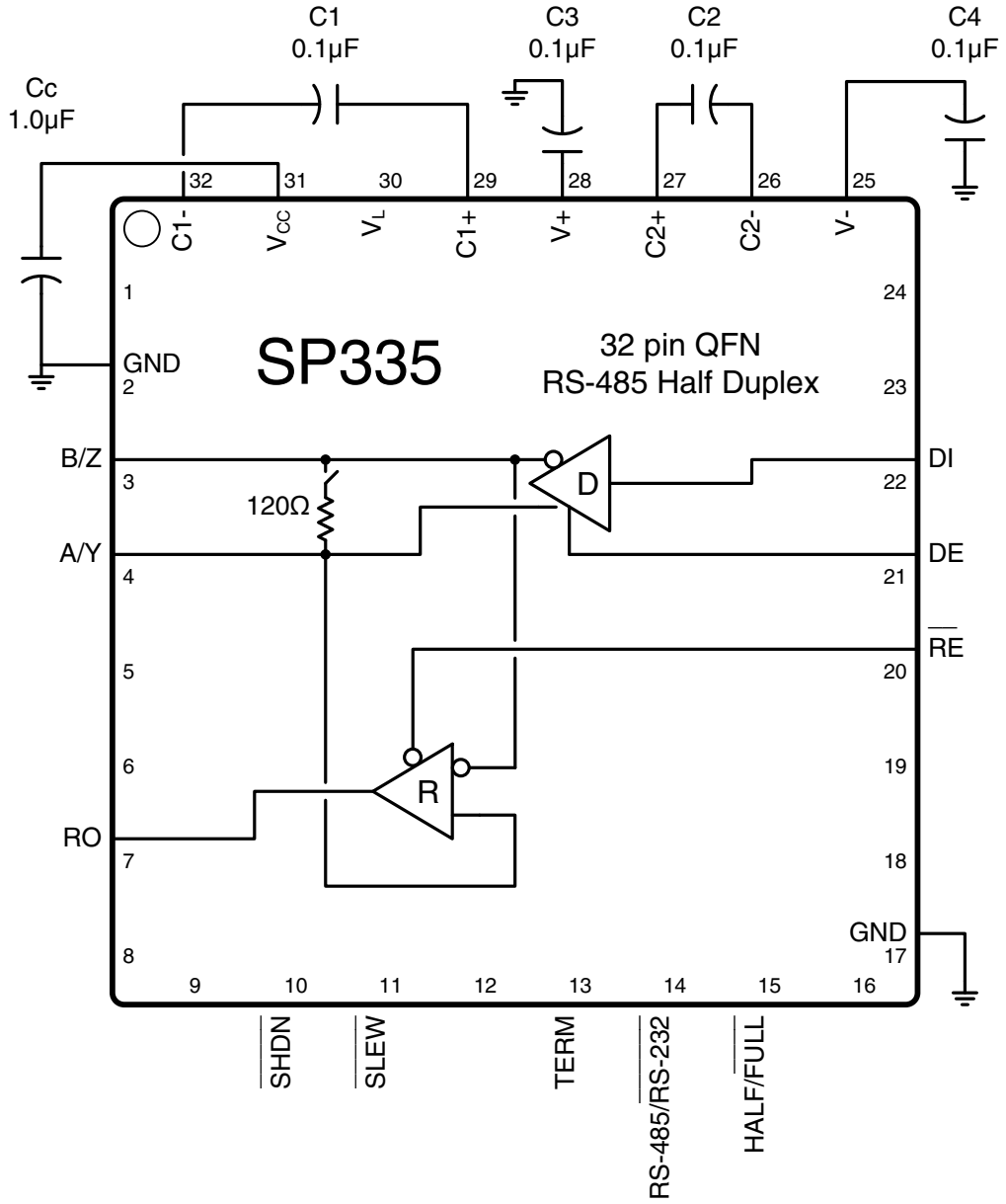
Pins 12, 13, and 20 have 300kΩ internal pull-downs (not shown).

FIGURE 2. RS-485 FULL DUPLEX MODE



Pins 12, 13, and 20 have 300kΩ internal pull-downs (not shown).
Termination control follows the truth table on page 20.
The full duplex driver termination is enabled only when both TERM and FD_TX_TERM are high.

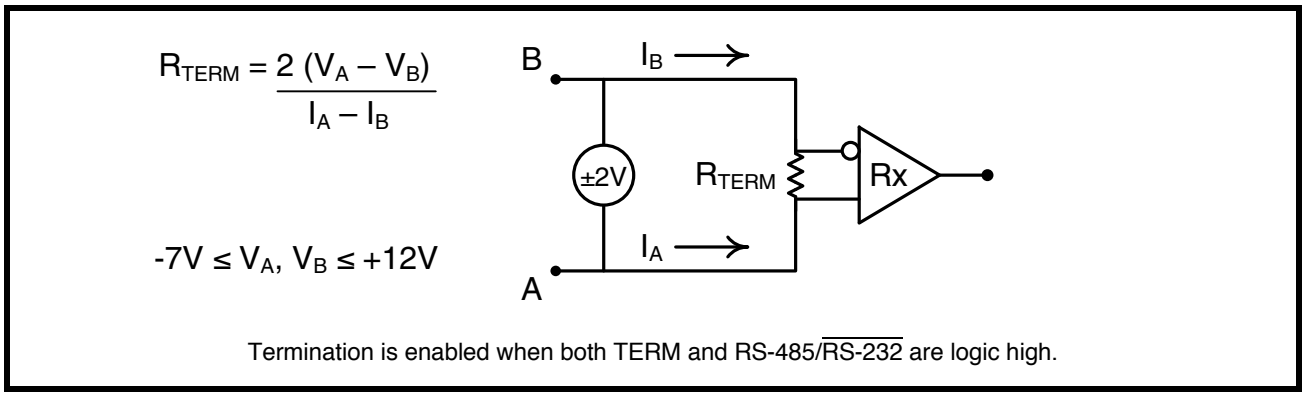
FIGURE 3. RS-485 HALF DUPLEX MODE



Pins 12, 13, and 20 have 300kΩ internal pull-downs (not shown).
Termination control follows the truth table on page 20.

TEST CIRCUITS

FIGURE 4. RS-485/422 RECEIVER TERMINATION RESISTANCE



Termination is enabled when both TERM and RS-485/$\overline{\text{RS-232}}$ are logic high.

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

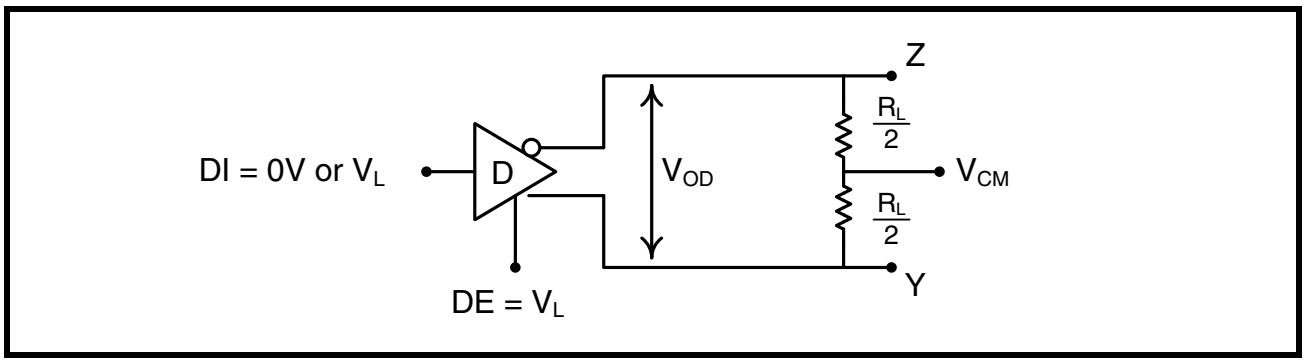


FIGURE 6. RS-485/422 DIFFERENTIAL DRIVER OUTPUT VOLTAGE OVER COMMON MODE

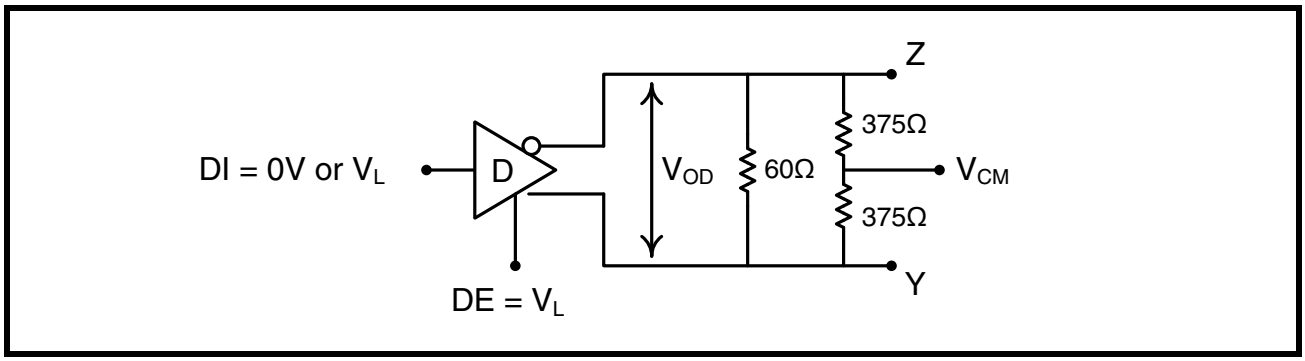


FIGURE 7. RS-485/422 DRIVER OUTPUT SHORT CIRCUIT CURRENT

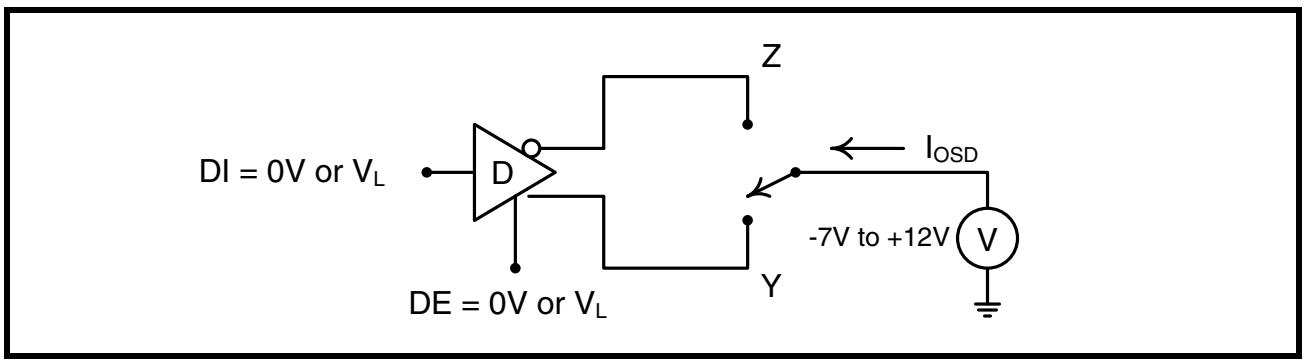


FIGURE 8. RS-232 RECEIVER PROPAGATION DELAY

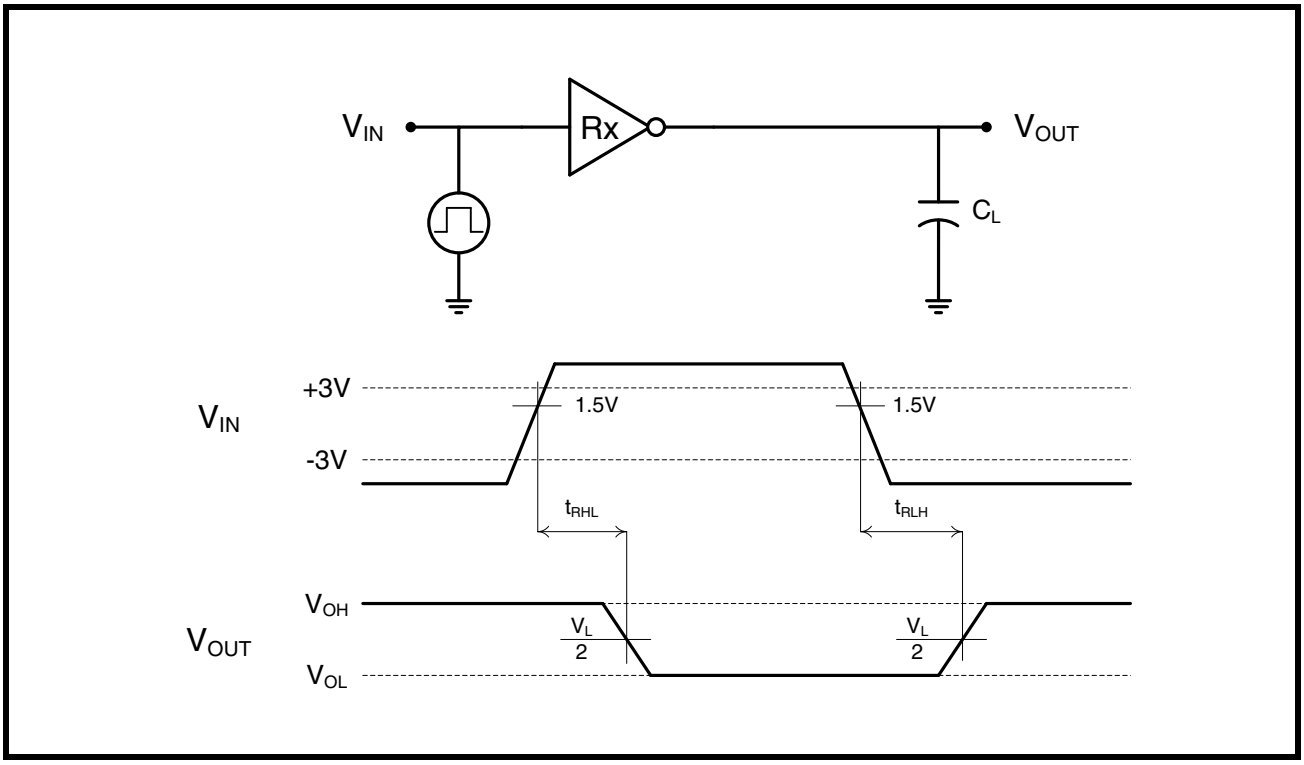


FIGURE 9. RS-232 DRIVER PROPAGATION DELAY

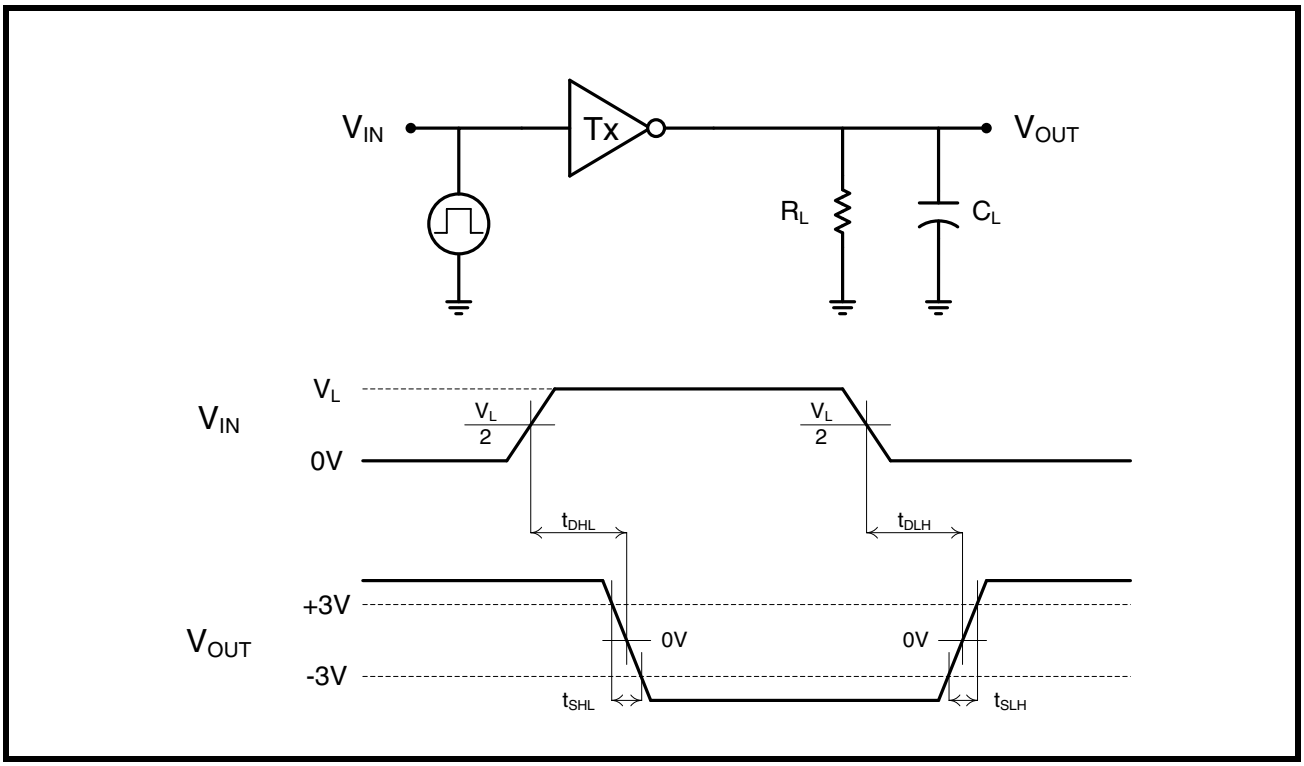


FIGURE 10. RS-485/422 RECEIVER PROPAGATION DELAY

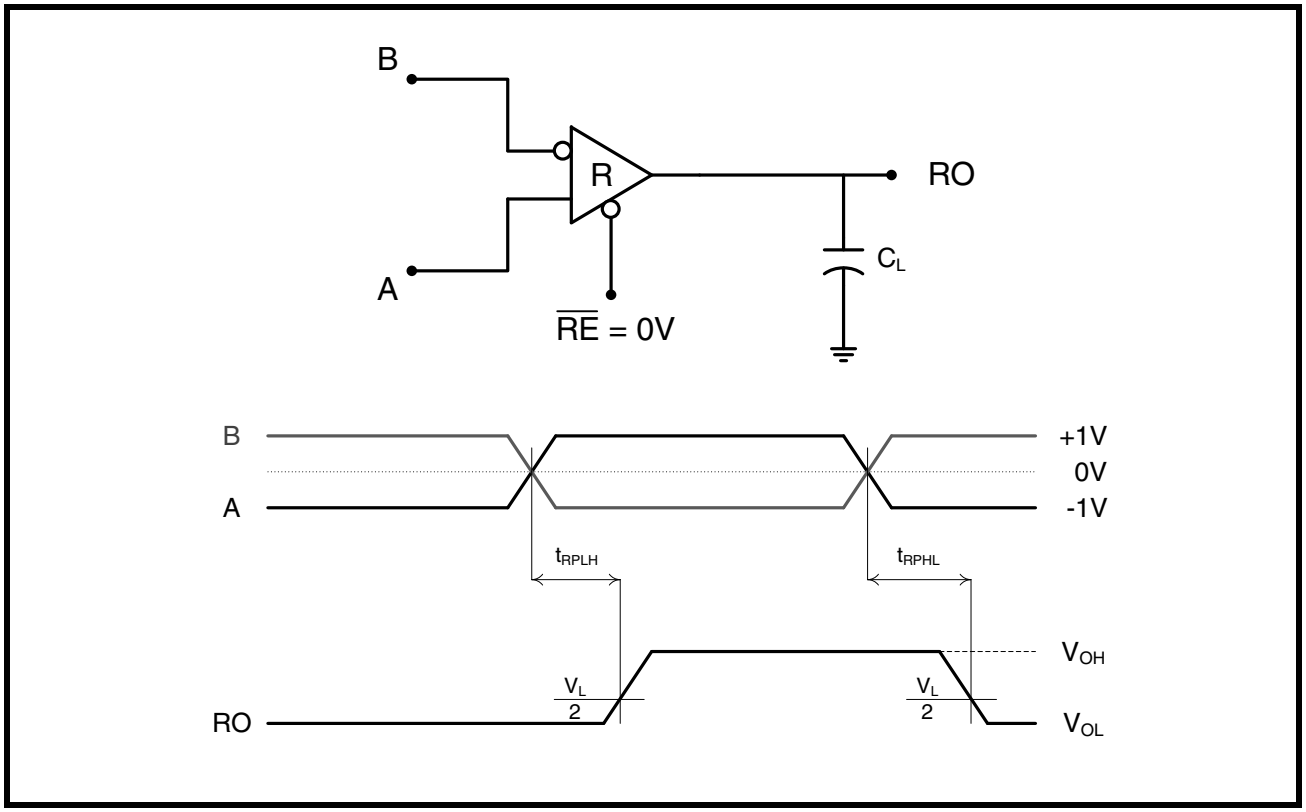


FIGURE 11. RS-485/422 DRIVER PROPAGATION DELAY AND RISE/FALL TIMES

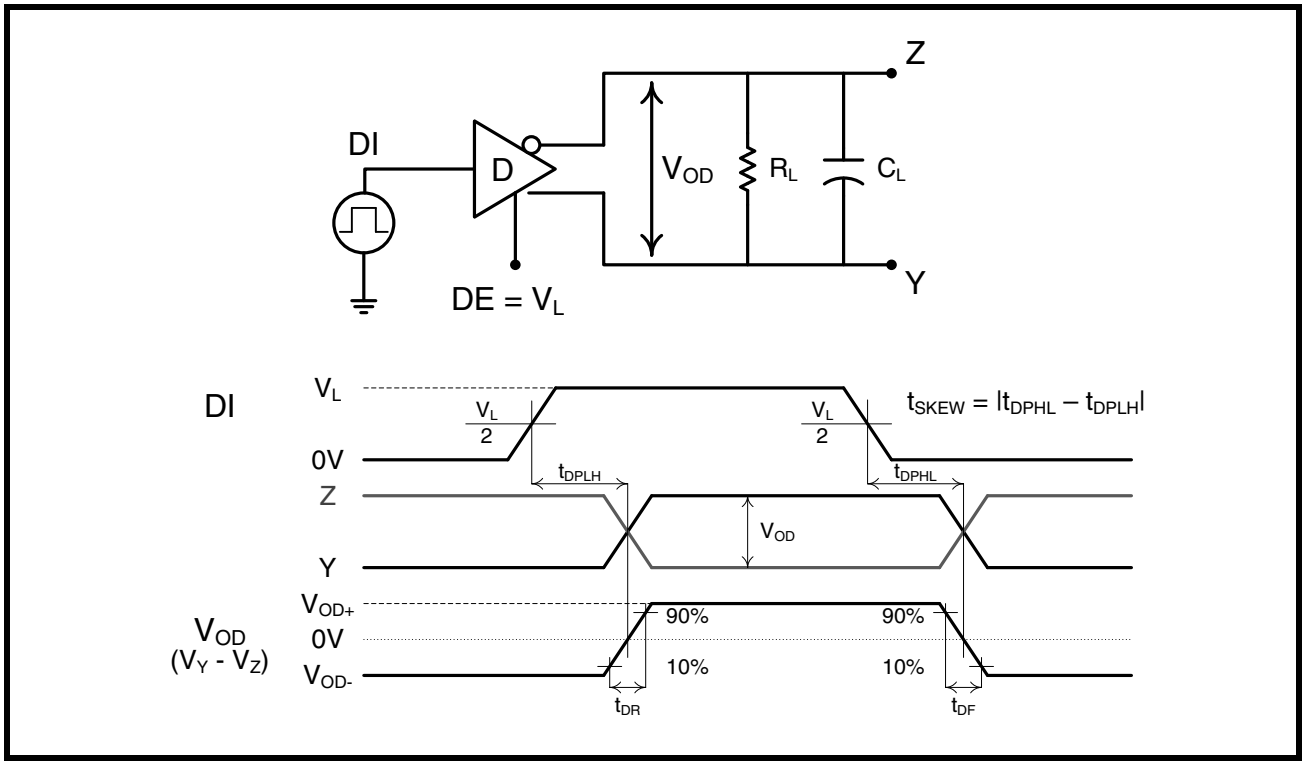


FIGURE 12. RS-485/422 RECEIVER OUTPUT ENABLE/DISABLE TIMES

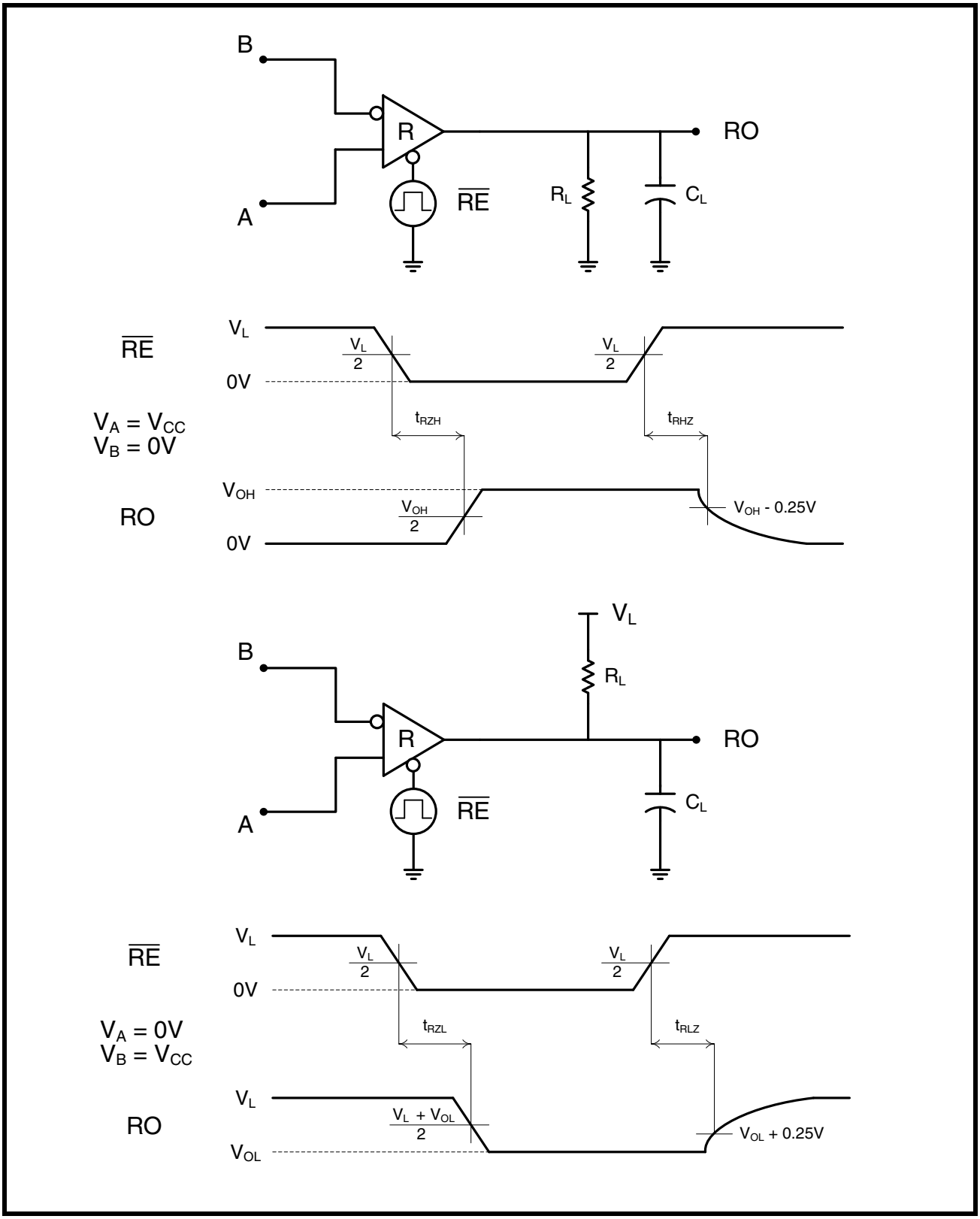
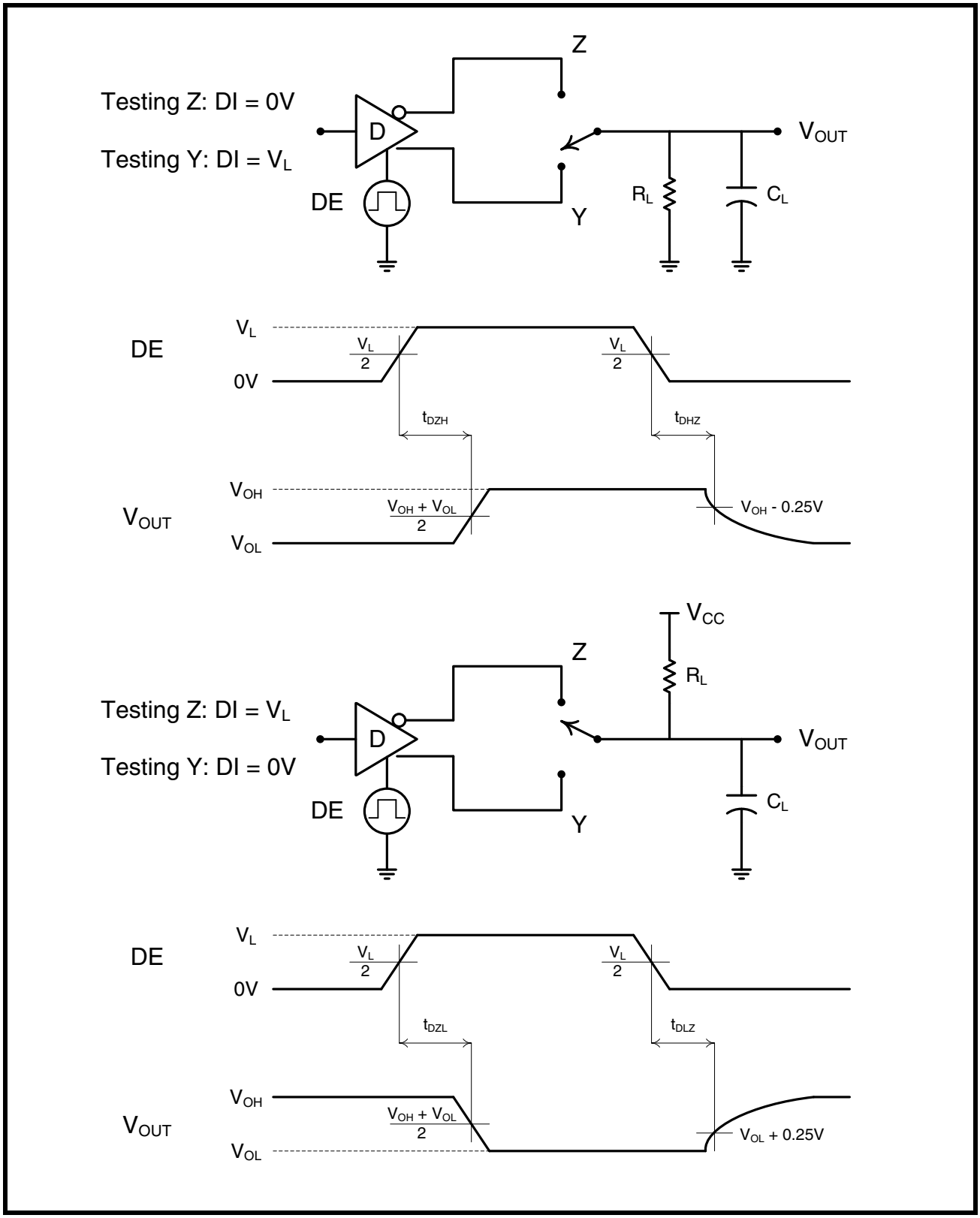


FIGURE 13. RS-485/422 DRIVER OUTPUT ENABLE/DISABLE TIMES



PRODUCT SUMMARY

The SP335 is an advanced multiprotocol transceiver supporting RS-232, RS-485, and RS-422 serial standards. Integrated cable termination and multiple configuration modes allow all three protocols to be used interchangeably over a single cable or connector with no additional switching components. Full operation requires only four external charge pump capacitors.

INTERNALLY SWITCHED CABLE TERMINATION

Enabling and disabling the RS-485/422 termination resistor is one of the largest challenges system designers face when sharing a single connector or pair of lines across multiple serial protocols. A termination resistor may be necessary for accurate RS-485/422 communication, but must be removed when the lines are used for RS-232. SP335 provides an elegant solution to this problem by integrating the termination resistor and switching control, and allowing it to be switched in and out of the circuit with a single pin. No external switching components are required. Termination on the receiver inputs will be enabled if both TERM and RS-485/$\overline{\text{RS-232}}$ are high.

ENHANCED FAILSAFE

The enhanced failsafe feature of the SP335 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 ±200mV. No external biasing resistors are required, further easing the usage of multiple protocols over a single connector.

±15kV 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 ±15kV without damage. These structures withstand high ESD in all states: normal operation, in shutdown, and when powered off.

ESD protection is be tested in various ways. Exar uses the following methods to qualify the protection structures designed into SP335:

±8kV using IEC 61000-4-2 Contact Discharge

±15kV using IEC 61000-4-2 Airgap Discharge

±15kV 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 SP335 has passed both HBM and IEC 61000-4-2 testing without damage.

VARIABLE LOGIC LEVEL VOLTAGE

The SP335 includes a V_L pin, which reduces the logic level thresholds to interface with processors operating at reduced supply voltages. This pin should be connected to the supply voltage of the processor, or can be connected to V_{CC} for typical logic levels.

TRUTH TABLES

TABLE 1: RS-232 TX TRUTH TABLE

INPUTS			OUTPUTS
$\overline{SHDN}$	RS-485/$\overline{RS\text{-}232}$	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
$\overline{SHDN}$	RS-485/$\overline{RS\text{-}232}$	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	
$\overline{SHDN}$	RS-485/$\overline{RS-232}$	DE/T2IN	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
RS-485/$\overline{RS-232}$	$\overline{SHDN}$	HALF/$\overline{FULL}$	$\overline{RE}$	(A-B)	(Y-Z)	RO/R2OUT
1	0	X	X	X	X	High-Z
1	1	0	0	≥ -50mV	X	1
1	1	0	0	≤ -200mV	X	0
1	1	0	0	Floating	X	1
1	1	1	0	X	≥ -50mV	1
1	1	1	0	X	≤ -200mV	0
1	1	1	0	X	Floating	1
1	1	X	1	X	X	High-Z
0	X	X	X	X	X	RS-232 Mode

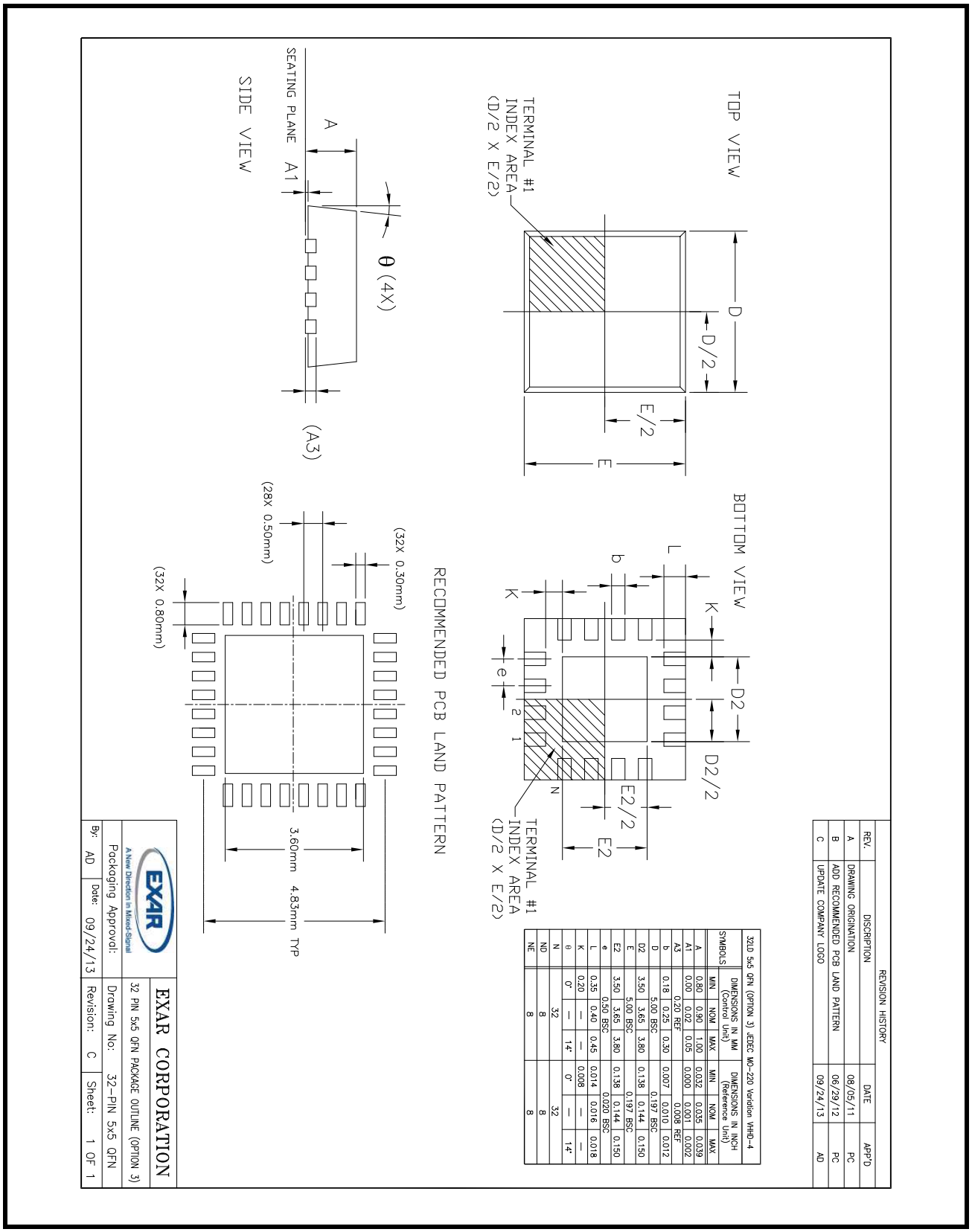
TABLE 5: RS-485/422 TERMINATION TRUTH TABLE

FD_TX_TERM	TERM	RS-485/$\overline{RS-232}$	HALF/$\overline{FULL}$	TX TERM	RX TERM
PIN 12	PIN 13	PIN 14	PIN 15	PINS 3-4	PINS 18-19
X	0	1	0	-	-
0	1	1	0	-	ON
1	1	1	0	ON	ON
X	0	1	1	-	-
X	1	1	1	ON	-
X	X	0	X	-	-

The DE and $\overline{RE}$ pins have no effect on the termination setting in any mode.

PACKAGE DRAWINGS

FIGURE 14. QFN 32



REVISION HISTORY

DATE	REVISION	DESCRIPTION
Sept 2013	1.0.0	Production Release

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Datasheet Sept 2013.

For technical support please email Exar's Serial Technical Support group at: serialtechsupport@exar.com.