

STC3485E**3.3V-Powered, $\pm 15\text{kV}$ ESD-Protected,
and Slew-Rate-Limited True RS-485 Transceivers****General Description**

The STC3485E is $\pm 15\text{ kV}$ ESD protected, slew-rate limited, ultra lower differential line transceivers which provide full RS485 compatibility while operating from single 3.3V supply. Each part contains one driver and one receiver, which is designed for data transmission with extended common mode range (-7V to 12V). The STC3485E features slew-rate limited driver that minimizes EMI and reduces reflections caused by improperly terminated cables, allowing error-free data transmission at data rate up to 500kbps.

All devices feature enhanced electrostatic discharge (ESD) protection. All transmitter outputs and receiver inputs are protected to $\pm 15\text{kV}$ using IEC 1000-4-2 Air-Gap Discharge and $\pm 15\text{kV}$ using the Human Body Model.

Drivers are short-circuit current limited and are protected against excessive power dissipation by thermal shutdown circuitry that places the driver outputs into a high-impedance state. The receiver input has a fail-safe feature that guarantees a logic-high output if both inputs are open, shorted or idle.

Both parts have power up/down glitch free driver outputs permit live insertion or removal of transceiver from/to data bus. The CMOS design offers significant power savings without sacrificing ruggedness against overload or ESD damage. Typical quiescent current is only 500 μA while operating and 1 μA in shutdown.

The STC3485E are fully specified over the commercial and extended industrial temperature range and are available in 8-pin and DIP packages.

Applications

Telecommunications
 Low-Power RS-485 Transceivers
 Integrated Services Digital Networks
 Transceivers for EMI-Sensitive Applications
 Packet Switching

Features

ESD Protection for RS-485 I/O Pins
 $\pm 15\text{kV}$ —Human Body Model
 $\pm 15\text{kV}$ —IEC 1000-4-2, Air-Gap Discharge
 Operate from a Single 3.3V supply
 Interoperable with +5V Logic
 Slew-Rate Limited for Errorless Data Transmission
 1 μA Low-Current Shutdown Mode
 -7V to +12V Common-Mode Input Voltage Range
 Allows up to 256 Transceivers on the Bus
 Thermal Shutdown
 Current-Limiting for Driver Overload Protection

Ordering Information

PART	TEMP. RANGE	PIN-PACKAGE
STC3485EESA	-40°C to +85°C	8 SO
STC3485EEPA	-40°C to +85°C	8 Plastic DIP

Selector Guide

PART NUMBER	GUARANTEED DATA RATE (Mbps)	SUPPLY VOLTAGE (V)	SLEW-RATE LIMITED	DRIVER/RECEIVER ENABLE	SHUTDOWN CURRENT (μ A)	± 15 kV ESD PROTECTION	PIN COUNT
STC3485E	0.5	3.0 to 3.6	Yes	Yes	1	Yes	8

Absolute Maximum Ratings

Supply Voltage (VCC)	5V	8-Pin Plastic DIP (derate 9.09mW/°C above +70°C)	727mW
Control Input Voltage (/RE, DE)	-0.3V to 5V	8-Pin SO (derate 5.88mW/°C above +70°C)	471mW
Driver Input Voltage (DI)	-0.3V to 5V	Operating Temperature Ranges	
Driver Output Voltage (A, B)	-7V to 12V	STC3485EE_ _	-40°C to +85°C
Receiver Input Voltage (A, B)	-7V to 12V	Storage Temperature Range	-65°C to +160°C
Receiver Output Voltage (RO)	-0.3V to (VCC + 0.3V)	Lead Temperature (soldering, 10sec)	+300°C
Continuous Power Dissipation (TA = +70°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 in the operational sections of the specifications is not implied. Exposure to absolute maximum rating conditions for extended periods may affect device reliability.

DC Electrical Characteristics

(VCC = 3.3V \pm 0.3V, TA = TMIN to TMAX, unless otherwise noted. Typical values are at TA = +25°C)

PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	UNITS
Differential Driver Output	V _{OD}	RL = 54O (RS-485), Figure 2	1.2			V
		RL = 60O (RS-485), Vcc = 3.3V, Figure3	1.2			
Change in Magnitude of Driver Differential Output Voltage for Complementary Output States (Note 1)	?V _{OD}	RL = 54O@r 100O, Figure 2			0.2	V
Driver Common-Mode Output Voltage	V _{OC}	RL = 54O@r 100O, Figure 2		2		V
Change in Magnitude of Common-Mode Output Voltage (Note 1)	?V _{OC}	RL = 54Oor 100O, Figure 2			0.2	V
Input High Voltage	V _{IH}	DE, DI, /RE	2.0			V
Input Low Voltage	V _{IL}	DE, DI, /RE			0.8	V
Logic Input Current	I _{IN1}	DE, DI, /RE			± 2	μ A
Input Current (A, B)	I _{IN2}	DE = 0V, Vcc = 0V or 3.6V	V _{IN} = 12V		1.0	mA
			V _{IN} = -7V		-0.8	
Receiver Differential Threshold Voltage	V _{TH}	-7V V _{CM} 12V	-0.2		-0.05	V
Receiver Input Hysteresis	?V _{TH}	V _{CM} = 0V		20		mV
Receiver Output High Voltage	V _{OH}	I _{OUT} = -1.5mA, V _{ID} = 200mV, Figure 4	Vcc - 0.4			V
Receiver Output Low Voltage	V _{OL}	I _{OUT} = 2.5mA, V _{ID} = 200mV, Figure 4			0.4	V
Three-State (High Impedance) Output Current at Receiver	I _{OZR}	Vcc = 3.6V, 0V V _{OUT} Vcc			± 1	μ A
Receiver Input Resistance	R _{IN}	-7V V _{CM} 12V	96			kO
Supply Voltage Range	V _{CC}		3.0		3.6	V
Supply Current	I _{CC}	No load, DI = 0V or Vcc	DE = Vcc, /RE = 0V or Vcc	0.6	1.2	mA
			DE = 0V, /RE = 0V	0.5	1.0	
Supply Current in Shutdown Mode	I _{SHDN}	DE = 0V, /RE = Vcc, DI = Vcc or 0V		1.0		μ A
Driver Short-Circuit Output Current	I _{OSD}	V _{OUT} = -7V			-250	mA
		V _{OUT} = 12V			250	
Receiver Short-Circuit Output Current	I _{OSR}	0V V _{RO} Vcc	± 8		± 60	mA
ESD Protection for A, B		Human Body Model		± 15		kV
		IEC 1000-4-2 Air Discharge		± 15		

Receiver Switching Characteristics

(VCC = 3.3V, TA = +25°C)

PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	UNITS
Maximum Data Rate			0.5			Mbps
Driver Differential Output Delay	tDD	RL = 60Ω, Figure 5	600	900	1400	ns
Driver Differential Output Transition Time	tTD	RL = 60Ω, Figure 5	400	740	1200	ns
Driver Propagation Delay, Low-to-High Level	tPLH	RL = 27Ω, Figure 6	700	930	1500	ns
Driver Propagation Delay, High-to-Low Level	tPHL	RL = 27Ω, Figure 6	700	930	1500	ns
tPLH - tPHL Driver Propagation Delay Skew (Note 2)	tPDS	RL = 27Ω, Figure 6		± 50		ns
DRIVER-OUTPUT ENABLE/DISABLE TIMES						
Driver Output Enable Time to Low Level	tPZL	RL = 110Ω, Figure 8		900	1300	ns
Driver Output Enable Time to High Level	tPZH	RL = 110Ω, Figure 7		600	800	ns
Driver Output Disable Time from High Level	tPHZ	RL = 110Ω, Figure 7		50	80	ns
Driver Output Disable Time from Low Level	tPLZ	RL = 110Ω, Figure 8		50	80	ns
Driver Output Enable Time from Shutdown to Low Level	tPSL	RL = 110Ω, Figure 8		1.9	2.7	μs
Driver Output Enable Time from Shutdown to High Level	tPSH	RL = 110Ω, Figure 7		2.2	3.0	μs

Receiver Switching Characteristics

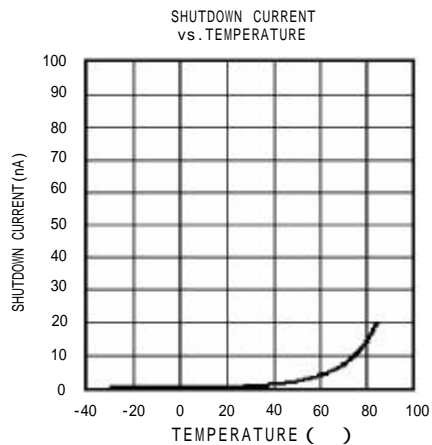
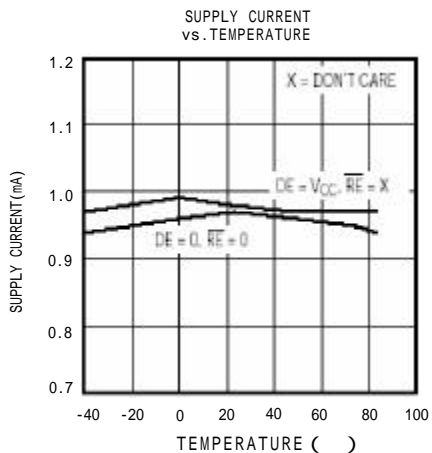
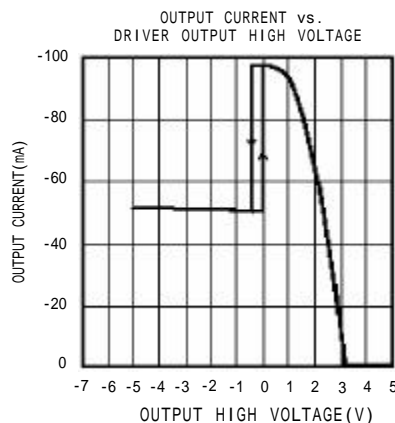
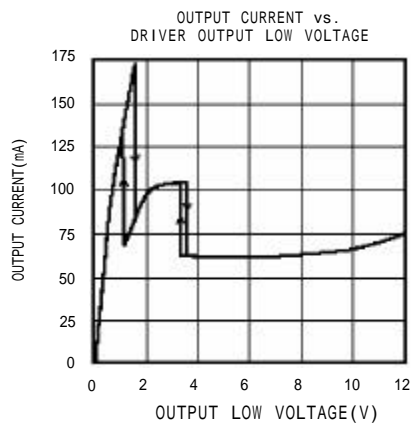
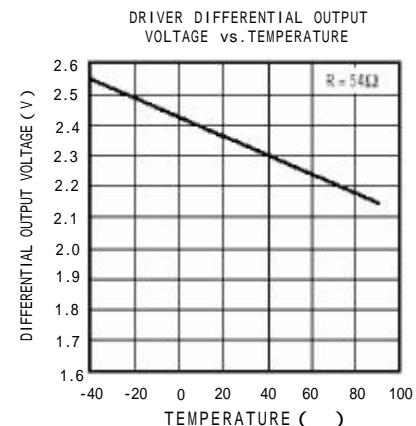
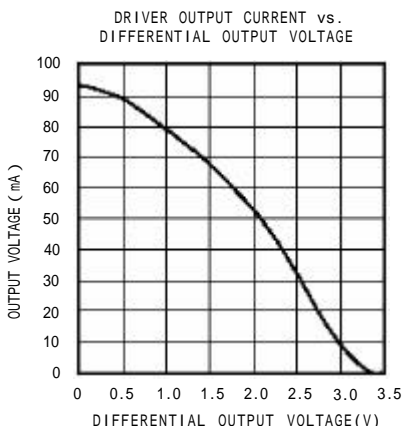
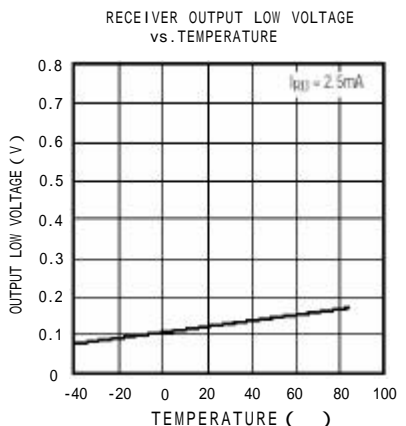
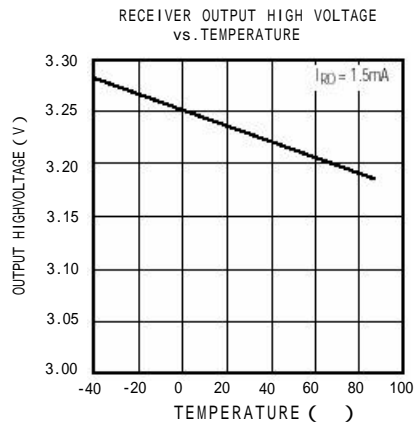
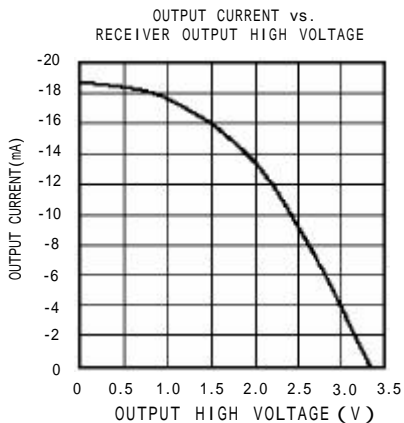
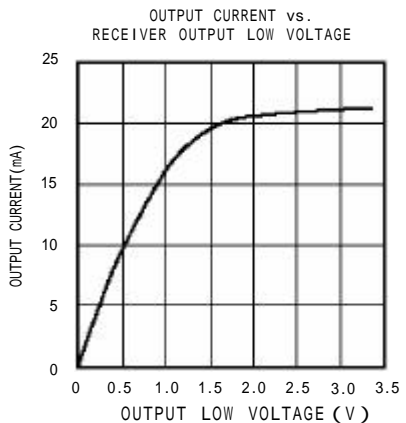
(VCC = +3.3V, TA = +25°C.)

PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	UNITS
Time to Shutdown	tSHDN	(Note 3)	80	190	300	ns
Receiver Propagation Delay, Low-to-High Level	tRPLH	VID = 0 to 3.0V, CL = 15pF, Figure 9	25	62	90	ns
		STC3485E	25	75	120	
Receiver Propagation Delay, High-to-Low Level	tRPHL	VID = 0 to 3.0V, CL = 15pF, Figure 9	25	62	90	ns
		STC3485E	25	75	120	
tPLH - tPHL Receiver Propagation-Delay Skew	tRPDS	VID = 0 to 3.0V, CL = 15pF, Figure 9		6	±10	ns
		STC3485E		12	±20	
Receiver-Output Enable Time to Low Level	tPRZL	CL = 15pF, Figure 10, STC3485E		25	50	ns
Receiver-Output Enable Time to High Level	tPRZH	CL = 15pF, Figure 10, STC3485E		25	50	ns
Receiver-Output Disable Time from High Level	tPRHZ	CL = 15pF, Figure 10, STC3485E		25	45	ns
Receiver-Output Disable Time from Low Level	tPRLZ	CL = 15pF, Figure 10, STC3485E		25	45	ns
Receiver-Output Enable Time from Shutdown to Low Level	tPRSL	CL = 15pF, Figure 12, STC3485E		720	1400	ns
Receiver-Output Enable Time from Shutdown to High Level	tPRSH	CL = 15pF, Figure 10, STC3485E		720	1400	ns

Note 1: ? VOD and ? VOC are the changes in VOD and VOC, respectively, when the DI input changes state.**Note 2:** Measured on |tPLH (Y) - tPHL (Y)| and |tPLH (Z) - tPHL (Z)|.**Note 3:** The transceivers are put into shutdown by bringing /RE high and DE low. If the inputs are in this state for less than 80ns, the parts are guaranteed not to enter shutdown. If the inputs are in this state for at least 300ns, the parts are guaranteed to have entered shutdown. See Low-Power Shutdown Mode section.

Typical Operating Characteristics

(VCC = 3.3V, TA = +25°C, unless otherwise noted.)



Pin Description

PIN	NAME	FUNCTION
1	RO	Receiver Output. If $A > B$ by -50mV , RO will be high; if $A < B$ by 200mV , RO will be low.
2	/RE	Receiver Output Enable. RO is enabled when RE is low; RO is high impedance when RE is high. If RE is high and DE is low, the device will enter a low-power shutdown mode.
3	DE	Driver Output Enable. The driver outputs are enabled by bringing DE high. They are high impedance when DE is low. If /RE is high and DE is low, the device will enter a low-power shutdown mode. If the driver outputs are enabled, the parts function as line drivers. While they are high impedance, they function as line receivers if /RE is low.
4	DI	Driver Input. A low on DI forces output B high and output A low. Similarly, a high on DI forces output B low and output A high.
5	GND	Ground
6	A	Noninverting Receiver Input and Noninverting Driver Output
7	B	Inverting Receiver Input and Inverting Driver Output
8	VCC	Positive Supply: 3.0V V_{CC} 3.6V

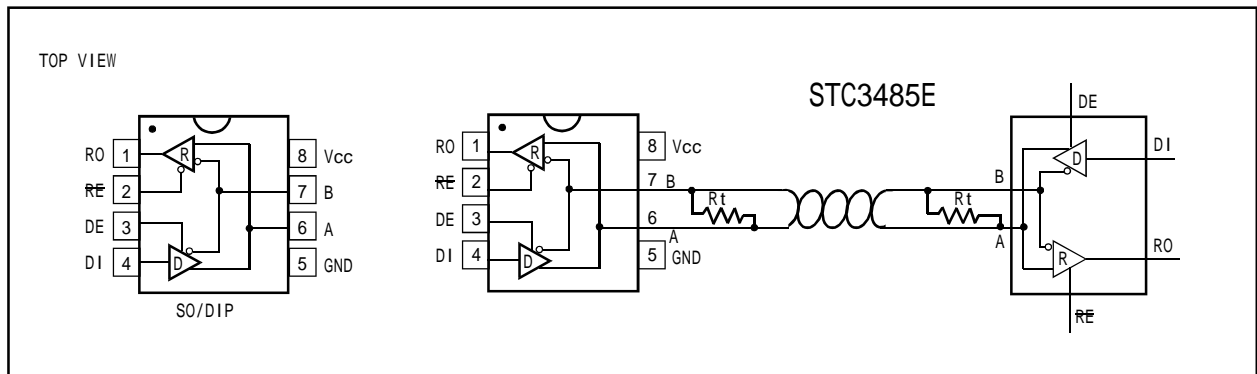


Figure 1. STC3485E Pin Configuration and Typical Operating Circuit

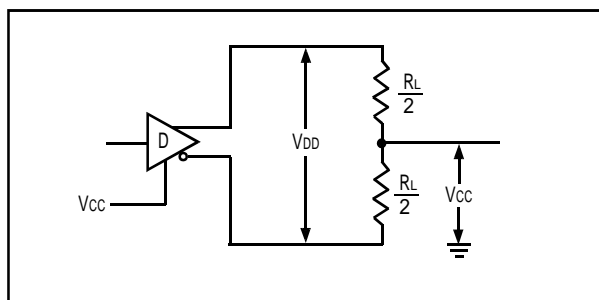


Figure 2. Driver VOD and VOC

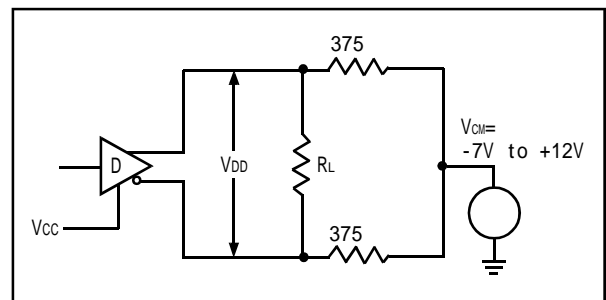


Figure 3. Driver VOD with Varying Common-Mode Voltage

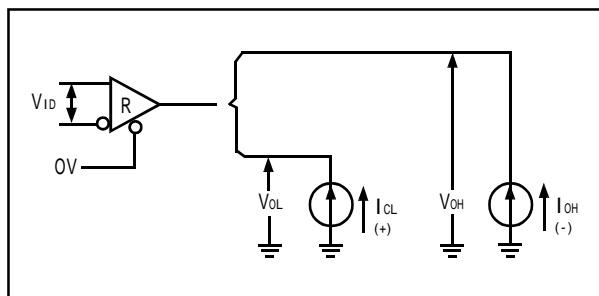


Figure 4. Receiver VOH and VOL

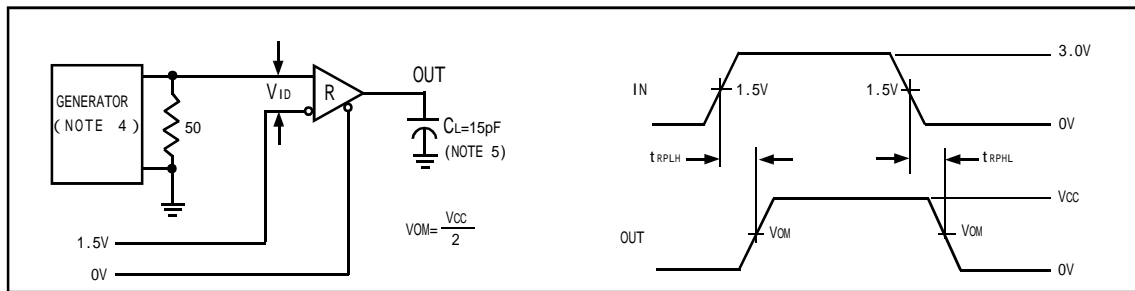


Figure 9. Receiver Propagation Delay

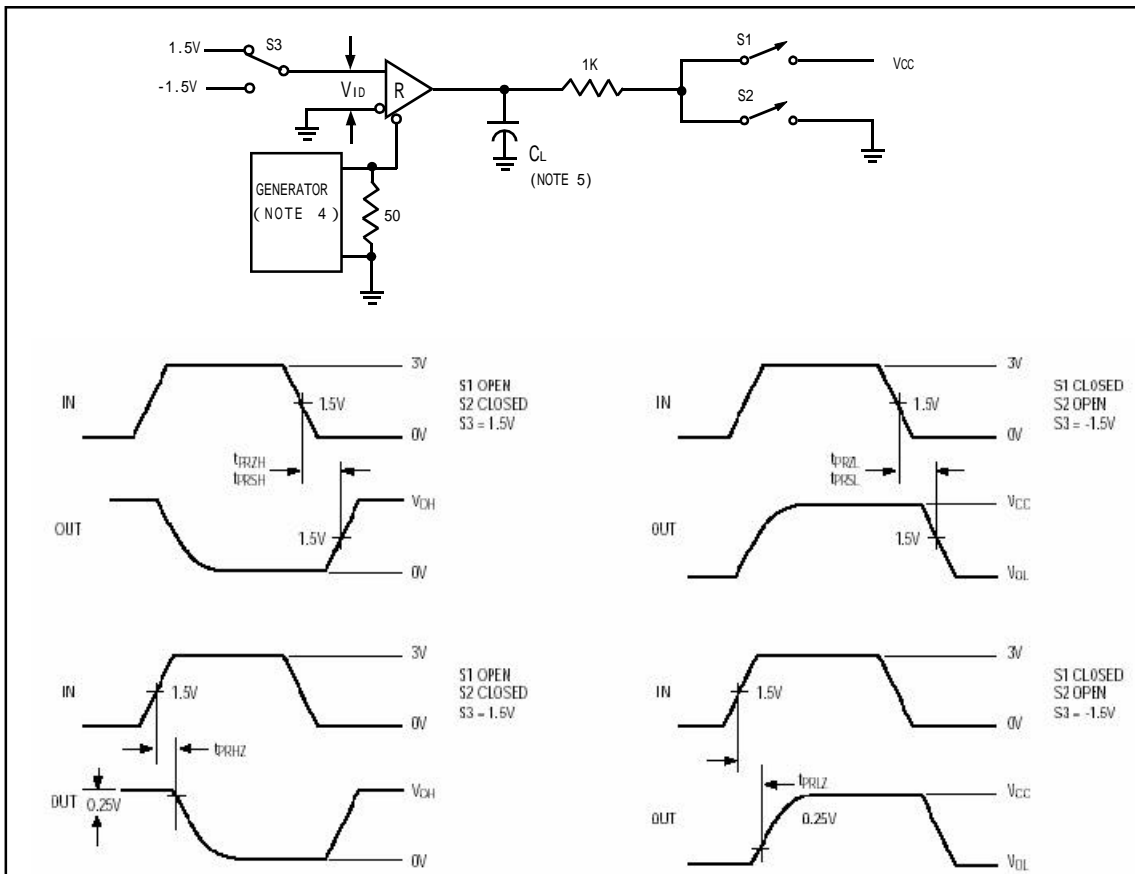


Figure 10. Receiver Enable and Disable Times

Note 4: The input pulse is supplied by a generator with the following characteristics: PRR = 250kHz, 50% duty cycle, $t_r=6.0ns$, $Z_O = 50\Omega$.

Note 5: CL includes probe and stray capacitance.

Function Tables

Devices with Receiver/Driver Enable

Table 1. Transmitting

INPUTS			OUTPUTS		MODE
/RE	DE	DI	B	A	
X	1	1	0	1	Normal
X	1	0	1	0	Normal
0	0	X	High-Z	High-Z	Normal
1	0	X	High-Z	High-Z	Shutdown

Table 2. Receiving

INPUTS			OUTPUTS	MODE
/RE	DE	A, B	RO	
0	X	$\neq 0.05V$	1	Normal
0	X	$\neq 0.2V$	0	Normal
0	X	Inputs Open	1	Normal
1	0	X	High-Z	Shutdown

Applications Information

The STC3485E is low-power transceivers for RS-485 communications. The STC3485E can transmit and receive at data rates up to 500kbps. The STC3485E is half-duplex. Driver Enable (DE) and Receiver Enable (/RE) pins are included on the STC3485E. When disabled, the driver and receiver outputs are high impedance.

Reduced EMI and Reflections

The STC3485E is slew-rate limited, minimizing EMI and reducing reflections caused by improperly terminated cables. Figure 11 shows the output waveform of the slew-rate-limited STC3485E transmitting a 125kHz signal, as well as the Fourier analysis of that waveform. The high-frequency harmonics have much lower amplitudes, and the potential for EMI is significantly reduced.

Low-Power Shutdown Mode

A low-power shutdown mode is initiated by bringing both /RE high and DE low. The devices will not shut down unless both the driver and receiver are disabled (high impedance). In shutdown, the devices typically draw only 1 μ A of supply current. For these devices, the tPSH and tPSL enable times assume the part was in the low-power shutdown mode; the tPZH and tPZL enable times assume the receiver or driver was disabled, but the part was not shut down.

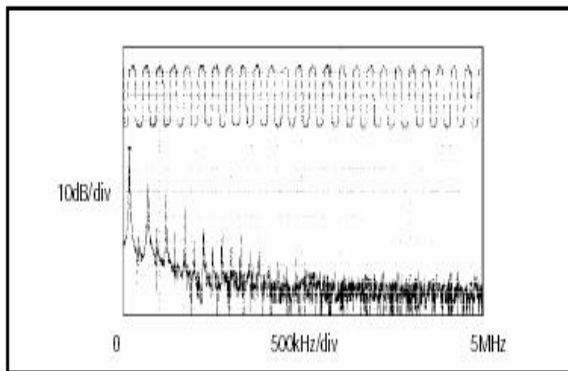


Figure 11. Driver Output Waveform and FFT Plot of STC3485E Transmitting a 125kHz Signal

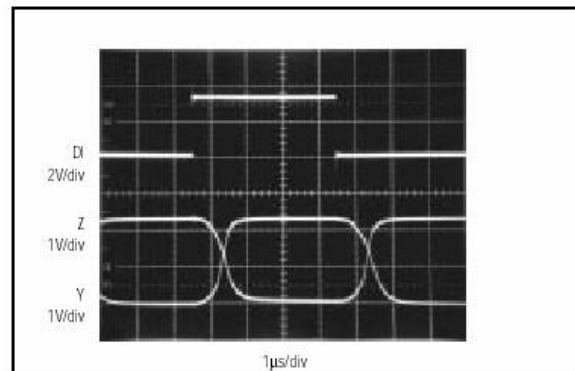


Figure 12. STC3485E Driver Propagation Delay

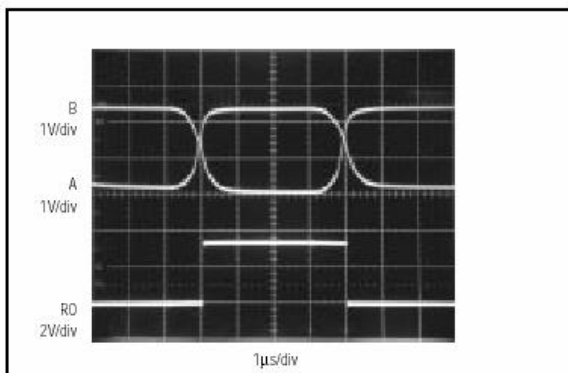


Figure 13. STC3485E Receiver Propagation Delay

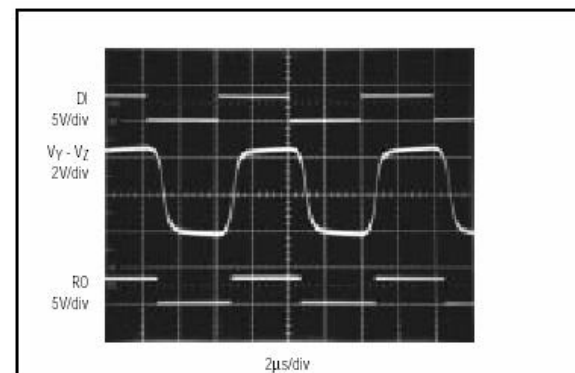


Figure 14. STC3485E System Differential Voltage at 125kHz Driving 4000 ft of Cable

Driver Output Protection

Excessive output current and power dissipation caused by faults or by bus contention are prevented by two mechanisms. 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). In addition, a thermal shutdown circuit forces the driver outputs into a high-impedance state if the die temperature rises excessively.

Propagation Delay

Figures 12 and 13 show the typical propagation delays. Skew time is simply the difference between the low-to-high and high-to-low propagation delay. Small driver/receiver skew times help maintain a symmetrical mark-space ratio (50% duty cycle).

The receiver skew time, $|t_{\text{PRLH}} - t_{\text{PRHL}}|$, is under 10ns (20ns for the STC3485E). The driver skew times are typically under 50ns for the STC3485E.

Line Length vs. Data Rate

The RS-485 standard covers line lengths up to 4000 feet. Figure 13 shows the system differential voltage for parts driving 4000 feet of 26AWG twisted-pair wire at 125kHz into 1200 loads.

±15kV ESD Protection

As with all STC devices, ESD-protection structures are incorporated on all pins to protect against electrostatic discharges encountered during handling and assembly. The driver outputs and receiver inputs of the STC3485E family of devices have extra protection against static electricity. STC's engineers have developed state-of-the-art structures to protect these pins against ESD of 15kV without damage. The ESD structures withstand high.

ESD in all states: normal operation, shutdown, and powered down. After an ESD event, Union's E versions keep working without latchup or damage. ESD protection can be tested in various ways; the transmitter outputs and receiver inputs of this product family are characterized for protection to the following limits:

- 1) ±15kV using the Human Body Model
- 2) ±15kV using IEC 1000-4-2's Air-Gap method.

Human Body Model

Figure 15a shows the Human Body Model and Figure 15b shows the current waveform it generates when discharged into a low impedance. This model consists of 100pF capacitor charged to the ESD voltage of interest, which is then discharged into the test device through a 1.5kΩ resistor.

IEC 1000-4-2

The IEC 1000-4-2 standard covers ESD testing and performance of finished equipment; it does not specifically refer to integrated circuits. The STC3485E family devices help you design equipment that meets Level 4 (the highest level) of IEC 1000-4-2, without the need for additional ESD-protection components. The major difference between tests done using the Human Body Model and IEC 1000-4-2 is higher peak current in IEC 1000-4-2, because series resistance is lower in the IEC 1000-4-2 model. Hence, the ESD withstand voltage measured to IEC 1000-4-2 is generally lower than that measured using the Human Body Model. Figure 16a shows the IEC 1000-4-2 model, and Figure 16b shows the current waveform for the ±8kV IEC 1000-4-2, Level 4 ESD contact-discharge test. The air-gap test involves approaching the device with a charged probe.

Machine Model

The Machine Model for ESD tests all pins using a 200pF storage capacitor and zero discharge resistance. Its objective is to emulate the stress caused when I/O pins are contacted by handling equipment during test and assembly. Of course, all pins require this protection, not just RS-485 inputs and outputs.

Typical Applications

The STC3485E transceivers are designed for bidirectional data communications on multipoint bus transmission lines. Figures 1 shows typical network applications circuits.

To minimize reflections, the line should be terminated at both ends in its characteristic impedance, and stub lengths off the main line should be kept as short as possible. The slew-rate-limited STC3485E is more tolerant of imperfect termination.

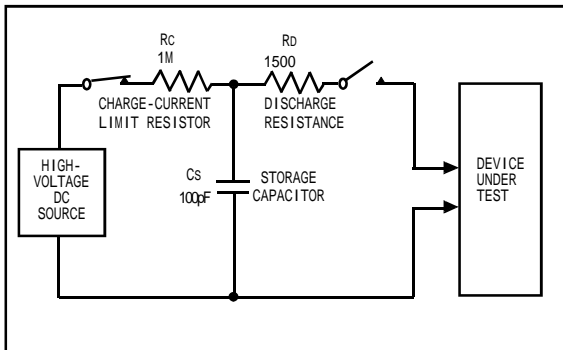


Figure 15a. Human Body ESD Test Model

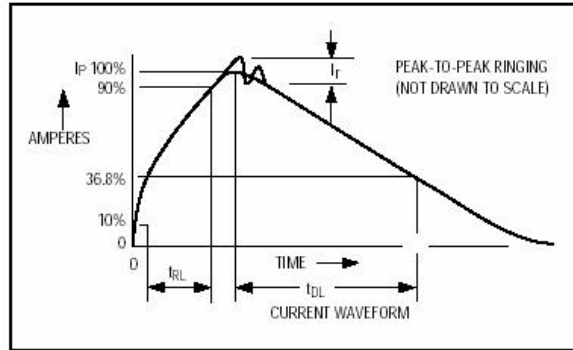


Figure 15b. Human Body Current Waveform

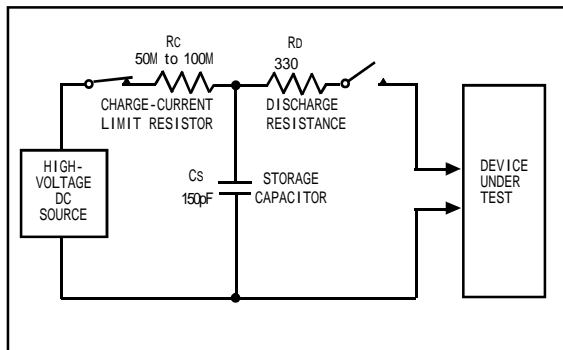


Figure 16a. IEC 1000-4-2 ESD Test Model

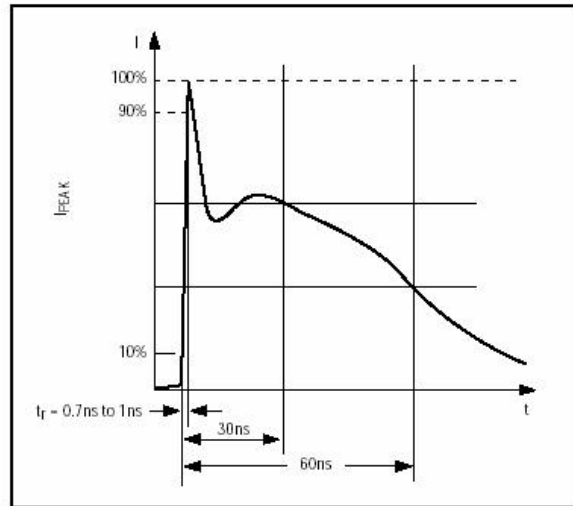
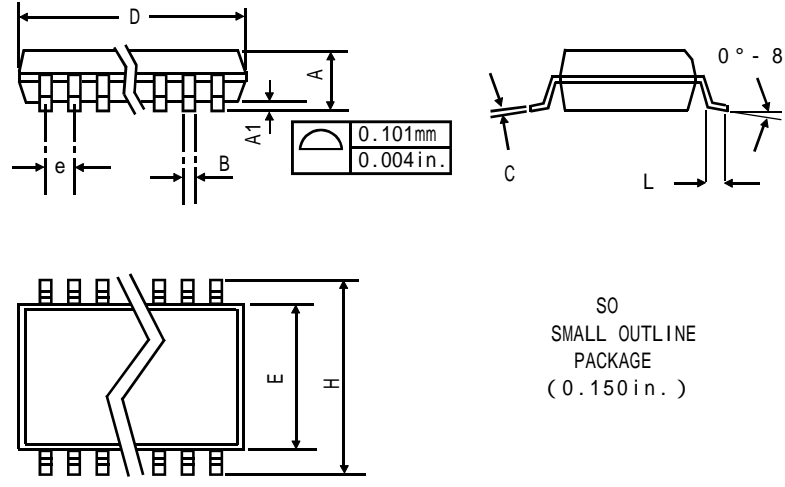


Figure 16b. IEC 1000-4-2 ESD Generator Current Waveform

Package Information

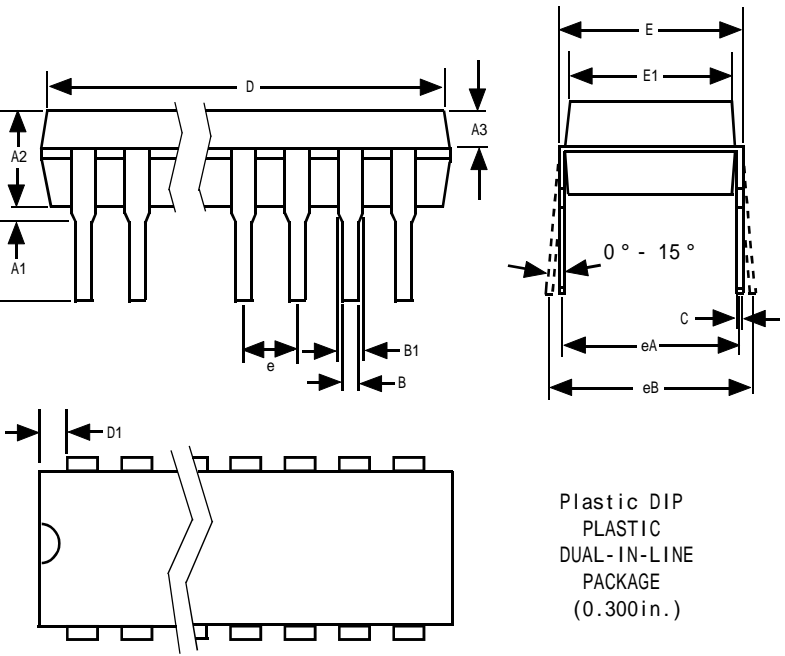


SO
SMALL OUTLINE
PACKAGE
(0.150 in.)

DIM	INCHES		MILLIMETERS	
	MIN	MAX	MIN	MAX
A	0.053	0.069	1.35	1.75
A1	0.004	0.010	0.10	0.25
B	0.014	0.019	0.35	0.49
C	0.007	0.010	0.19	0.25
E	0.150	0.157	3.80	4.00
e	0.050		1.27	
H	0.228	0.244	5.80	6.20
L	0.016	0.050	0.40	1.27

DIM	PINS	INCHES		MILLIMETERS	
		MIN	MAX	MIN	MAX
D	8	0.189	0.197	4.80	5.00
D	14	0.337	0.344	8.55	8.75
D	16	0.386	0.394	9.80	10.00

21-0041A



Plastic DIP
PLASTIC
DUAL-IN-LINE
PACKAGE
(0.300 in.)

DIM	INCHES		MILLIMETERS	
	MIN	MAX	MIN	MAX
A	-	0.200	-	5.08
A1	0.015	-	0.38	-
A2	0.125	0.175	3.18	4.45
A3	0.055	0.080	1.40	2.03
B	0.016	0.022	0.41	0.56
B1	0.045	0.065	1.14	1.65
C	0.008	0.012	0.20	0.30
D1	0.005	0.080	0.13	2.03
E	0.300	0.325	7.62	8.26
E1	0.240	0.310	6.10	7.87
e	0.100	-	2.54	-
eA	0.300	-	7.62	-
eB	-	0.400	-	10.16
L	0.115	0.150	2.92	3.81

DIM	PIN	INCHES		MILLIMETERS	
		MIN	MAX	MIN	MAX
D	8	0.348	0.390	8.84	9.91
D	14	0.735	0.765	18.67	19.43
D	16	0.745	0.765	18.92	19.43
D	18	0.885	0.915	22.48	23.24
D	20	1.015	1.045	25.78	26.54
D	24	1.14	1.265	28.96	32.13