STC485E ±15kV ESD-Protected,Slew-Rate-Limited, Fail-Safe,True RS-485 Transceivers

General Description

The STC485E is ±15kV electrostatic discharge (ESD)-protected, high-speed transceivers for RS-485 communication that contains one driver and one receiver. These devices feature fail-safe circuitry, which guarantees a logic-high receiver output when the receiver inputs are open, shorted or idle. This means that the receiver output will be a logic high if all transmitters on a terminated bus are disabled (high impedance). The STC485E features reduced slew-rate driver that minimizes EMI and reduces reflections caused by improperly terminated cables, allowing error-free data transmission up to 500kbps. All devices feature enhanced ESD protection. All transmitter outputs and receiver inputs are protected to ±15kV using the Human Body Model.

These transceivers typically draw 400µA of supply current when unloaded, or when fully loaded with the drivers disabled.

All devices have a 1/8-unit-load receiver input impedance that allows up to 256 transceivers on the bus. The STC485E is intended for half -duplex communications.

Applications

RS-485 Transceivers
Level Translators
Transceivers for EMI-Sensitive Applications
Industrial-Control Local Area Networks

Features

ESD Protection for RS-485 I/O Pins
  ±15kV—Human Body Model
  ±15kV—IEC 1000-4-2, Air-Gap Discharge
True Fail-Safe Receiver While Maintaining EIA/TIA-485 Compatibility
Enhanced Slew-Rate Limiting Facilitates Error-Free Data Transmission
2nA 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
STC485EESA	-40°C to +85°C	8 SO
STC485EEPA	-40°C to +85°C	8 Plastic DIP

Selector Guide

PART NUMBER	GUARANTEED DATA RATE (Mbps)	Low- Power Shutdown	SLEW-RATE LIMITED	DRIVER/ RECEIVER ENABLE	SHUTDOWN CURRENT (nA)	Transceivers On Bus	±15kV ESD PROTECTION	PIN COUNT
STC485E	0.5	Yes	Yes	Yes	2	256	Yes	8

Absolute Maximum Ratings

Supply Voltage (VCC) 7V
Control Input Voltage (/RE, DE) .....-0.3V to (VCC + 0.3V)
Driver Input Voltage (DI) .....-0.3V to (VCC + 0.3V)
Driver Output Voltage (A, B) .....-7.5V to 12.5V
Receiver Input Voltage (A, B) .....-7.5V to 12.5V
Receiver Output Voltage (RO) .....-0.3V to (VCC + 0.3V)
Continuous Power Dissipation (TA = +70°C)
8-Pin Plastic DIP (derate 9.09mW/°C above +70°C.....727mW
8-Pin SO (derate 5.88mW/°C above +70°.....471mW
Operating Temperature Ranges
STC485EE_ _ .....-40°C to +85°C
Storage Temperature Range.....-65°C to +160°C
Lead Temperature (soldering, 10sec) .....+300°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 = +5V ±5%, TA = TMIN to TMAX, unless otherwise noted. Typical values are at VCC = +5V and TA = +25°C.) (Note 1)

PARAMETER	SYMBOL	CONDITIONS		MIN	TYP	MAX	UNITS
DRIVER							
Differential Driver Output (No Load)	VOD1	Figure 2				5	V
Differential Driver Output	VOD2	R= 50O, Figure 2		1.5			V
Change in Magnitude of Driver Differential Output Voltage (Note 2)	? VOD	R= 50O?Figure 2				0.2	V
Driver Common-Mode Output Voltage	VOC	R= 50O, Figure 2				3	V
Change in Magnitude of Common -Mode Output Voltage (Note 2)	? VOC	R= 50O, Figure 2				0.2	V
Input High Voltage	VIH	DE, DI, /RE		2.0			V
Input Low Voltage	VIL	DE, DI, /RE				0.8	V
DI Input Hysteresis	VHYS	UM3085E		100			mV
Input Current (A, B)	IIN2	DE = 0V, VCC = 0V or 5V	VIN = 12V			1.0	mA
			VIN = -7V			-0.8	
Driver Short-Circuit Output Current (Note 3)	IOSD	VOUT = -7V			-250		mA
		VOUT = 12V			250		
RECEIVER							
Receiver Differential Threshold Voltage	VTH	-7V=VCM=12V		-0.2		-0.05	V
Receiver Input Hysteresis	? VTH	VCM = 0V			25		mV
Receiver Output High Voltage	VOH	IOUT = -1.5mA, VID = 200mV		VCC –1.5			V
Receiver Output Low Voltage	VOL	IOUT = 2.5mA, VID = 200mV				0.4	V
Three-State (High Impedance) Output Current at Receiver	IOZR	VCC = 5V, 0V=VOUT\=VCC				±1	µA
Receiver Input Resistance	RIN	-7V=VCM=12V		96			kO?
Receiver Short-Circuit Output Current	IOSR	0V=VRO=VCC		±8		±60	mA
SUPPLY CURRENT							
Supply Current	ICC	No load, DI = 0V or VCC	DE = VCC, /RE = 0V or VCC	0.3			mA
			DE = 0V, /RE = 0V	0.25			
Supply Current in Shutdown Mode	ISHDN	DE = 0V, /RE = VCC, DI = VCC or 0V		0.002		10	µA
ESD Protection for A, B		Human Body Model			±15		kV
		IEC 1000-4-2 Air Discharge			±15		

Note 1: All currents into the device are positive; all currents out of the device are negative. All voltages are referred to device ground unless otherwise noted.
Note 2: VOD and VOC are the changes in VOD and VOC, respectively, when the DI input changes state.
Note 3: Maximum current level applies to peak current just prior to foldback-current limiting; minimum current level applies during current limiting.

Switching Characteristics

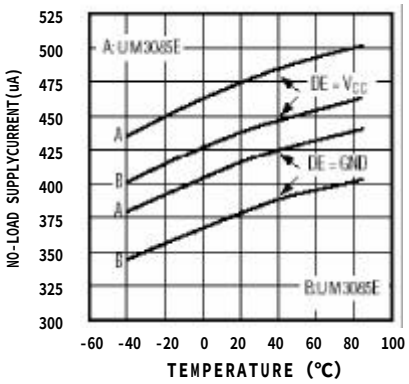
(VCC = +5V ±5%, TA = TMIN to TMAX, unless otherwise noted. Typical values are at VCC = +5V and TA = +25°C.) (Note 1)

PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	UNITS
Driver Input-to-Output	tDPLH	Figures 4 and 6, RDIFF = 54? , CL1 = CL2 = 100pF	250	720	1000	ns
	tDPHL		250	720	1000	
Driver Output Skew | tDPLH - tDPHL |	tDSKEW	Figures 4 and 6, RDIFF = 54? , CL1 = CL2 = 100pF		-3	±100	ns
Driver Rise or Fall Time	tDR, tDF	Figures 4 and 6, RDIFF = 54? , CL1 = CL2 = 100pF	200	530	750	ns
Maximum Data Rate	fMAX				500	kbps
Driver Enable to Output High	tDZH	Figures 5 and 7, CL = 100pF, S2 closed			2500	ns
Driver Enable to Output Low	tDZL	Figures 5 and 7, CL = 100pF, S1 closed			2500	ns
Driver Disable Time from Low	tDLZ	Figures 5 and 7, CL = 15pF, S1 closed			100	ns
Driver Disable Time from High	tDHZ	Figures 5 and 7, CL = 15pF, S2 closed			100	ns
Receiver Input to Output	tRPLH, tRPHL	Figures 11 and 13; | VID | =2.0V; rise and fall time of VID =?5ns		127	200	ns
| tRPLH - tRPHL | Differential Receiver Skew	tRSKD	Figures 8 and 10; | VID | =2.0V; rise and fall time of VID =?5ns	3	3	±30	ns
Receiver Enable to Output Low	tRZL	Figures 3 and 9, CL = 100pF, S1 closed		20	50	ns
Receiver Enable to Output High	tRZH	Figures 3 and 9, CL = 100pF, S2 closed		20	50	ns
Receiver Disable Time from Low	tRLZ	Figures 3 and 9, CL = 100pF, S1 closed		20	50	ns
Receiver Disable Time from High	tRHZ	Figures 3 and 9, CL = 100pF, S2 closed		20	50	ns
Time to Shutdown	tSHDN	(Note 4)	50	200	600	ns
Driver Enable from Shutdown-to-Output High	tDZH(SHDN)	Figures 5 and 7, CL = 15pF, S2 closed			4500	ns
Driver Enable from Shutdown-to-Output Low	tDZL(SHDN)	Figures 5 and 7, CL = 15pF, S1 closed			4500	ns
Receiver Enable from Shutdown-to-Output High	tRZH(SHDN)	Figures 3 and 9, CL = 100pF, S2 closed			3500	ns
Receiver Enable from Shutdown-to-Output Low	tRZL(SHDN)	Figures 3 and 9, CL = 100pF, S1 closed			3500	ns

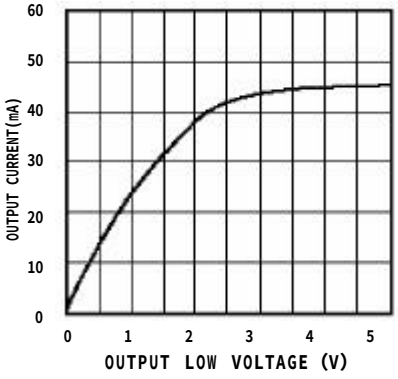
Typical Operating Characteristics

(V_{CC} = +5V, T_A = +25°C, unless otherwise noted.)

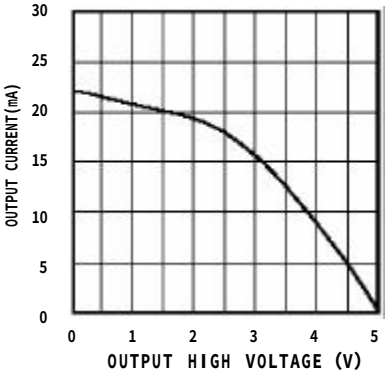
NO-LOAD SUPPLY CURRENT vs.TEMPERATURE



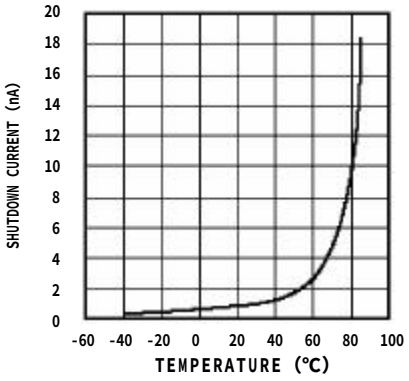
OUTPUT CURRENT vs.RECEIVER OUTPUT LOW VOLTAGE



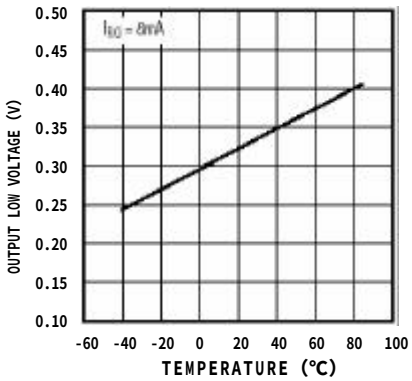
OUTPUT CURRENT vs.RECEIVER OUTPUT HIGH VOLTAGE



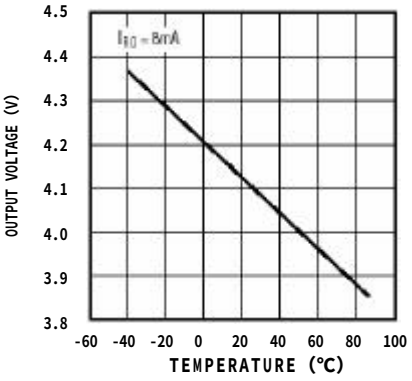
SHUTDOWN CURRENT vs.TEMPERATURE



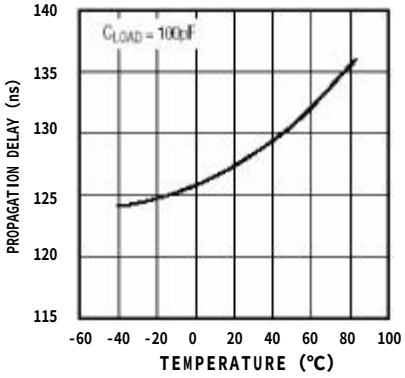
RECEIVER OUTPUT LOW VOLTAGE vs.TEMPERATURE



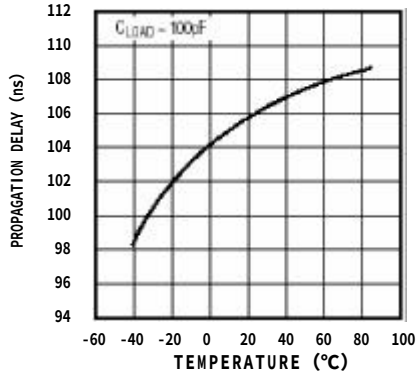
RECEIVER OUTPUT HIGH VOLTAGE vs.TEMPERATURE



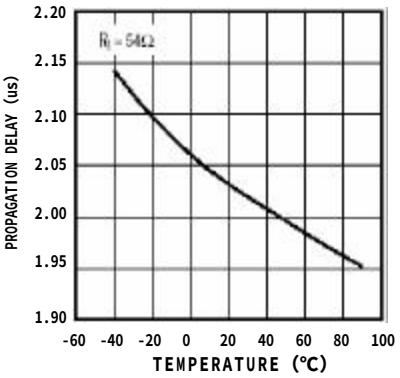
RECEIVER PROPAGATION DELAY (500kbps MODE) vs.TEMPERATURE



RECEIVER PROPAGATION DELAY (10Mbps MODE) vs.TEMPERATURE



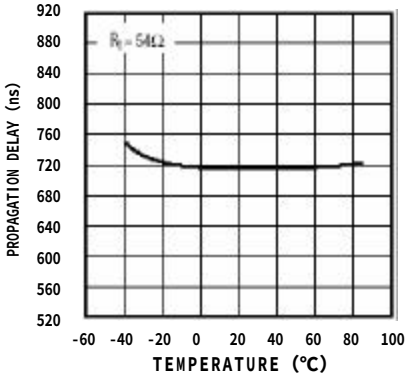
DRIVER PROPAGATION DELAY (115kbps MODE) vs.TEMPERATURE



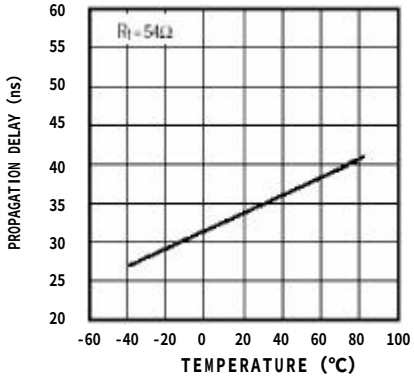
Typical Operating Characteristics(continued)

(VCC = +5V, TA = +25°C, unless otherwise noted.)

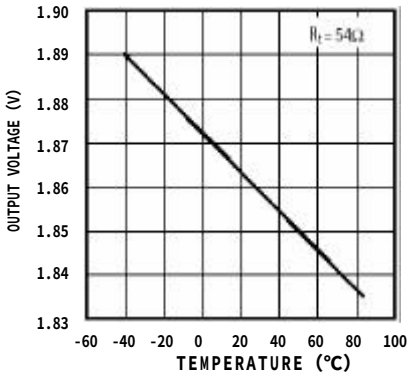
DRIVER PROPAGATION DELAY (500kbps MODE) vs. TEMPERATURE



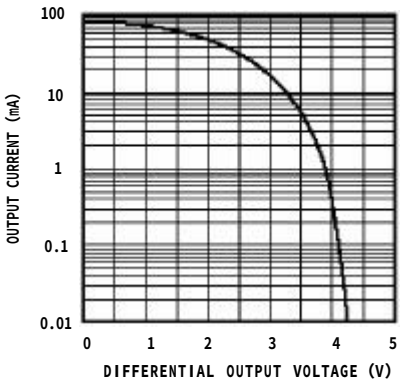
DRIVER PROPAGATION DELAY (10Mbps MODE) vs.TEMPERATURE



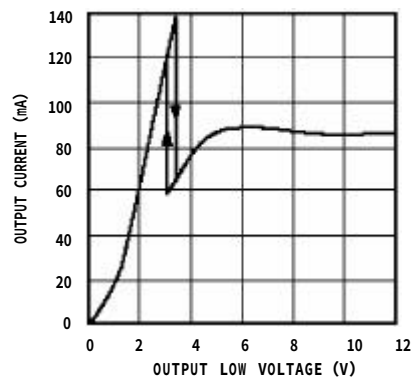
DRIVER DIFFERENTIAL OUTPUT VOLTAGE vs.TEMPERATURE



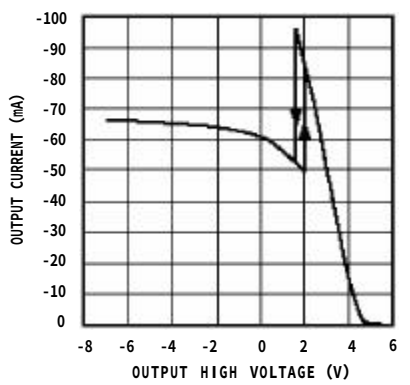
DRIVER OUTPUT CURRENT vs.DIFFERENTIAL OUTPUT VOLTAGE



OUTPUT CURRENT vs. DRIVER OUTPUT LOW VOLTAGE



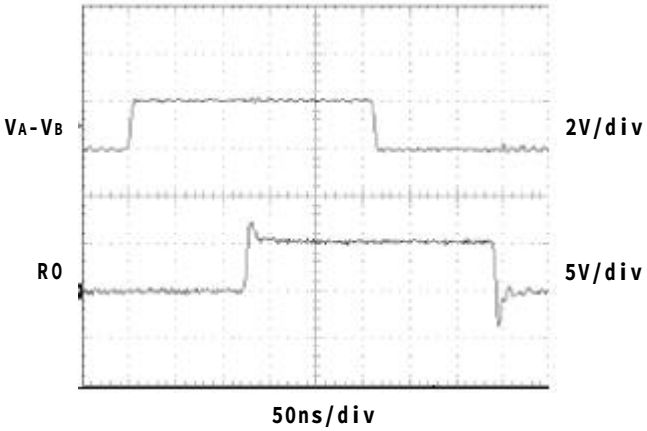
OUTPUT CURRENT vs. DRIVER OUTPUT HIGH VOLTAGE



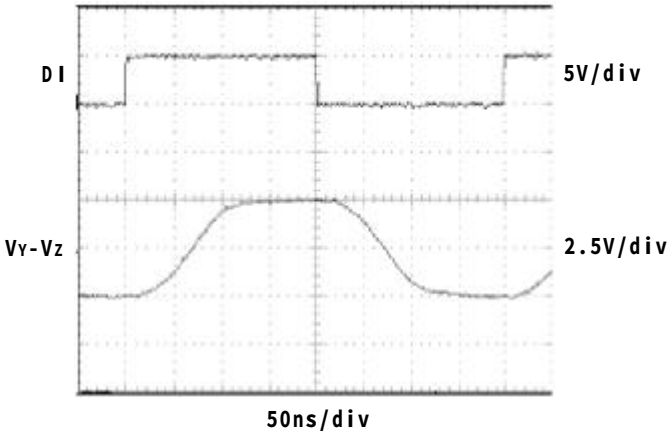
Typical Operating Characteristics(continued)

(VCC = +5V, TA = +25°C, unless otherwise noted.)

RECEIVER PROPAGATION DELAY



DRIVER PROPAGATION DELAY



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 A low and output B high. Similarly, a high on DI forces output A high and output B low.
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: VCC=5V±5%

Function Tables

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

X = Don't care; High-Z = High impedance

Table 2. Receiving

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

X = Don't care; High-Z = High impedance

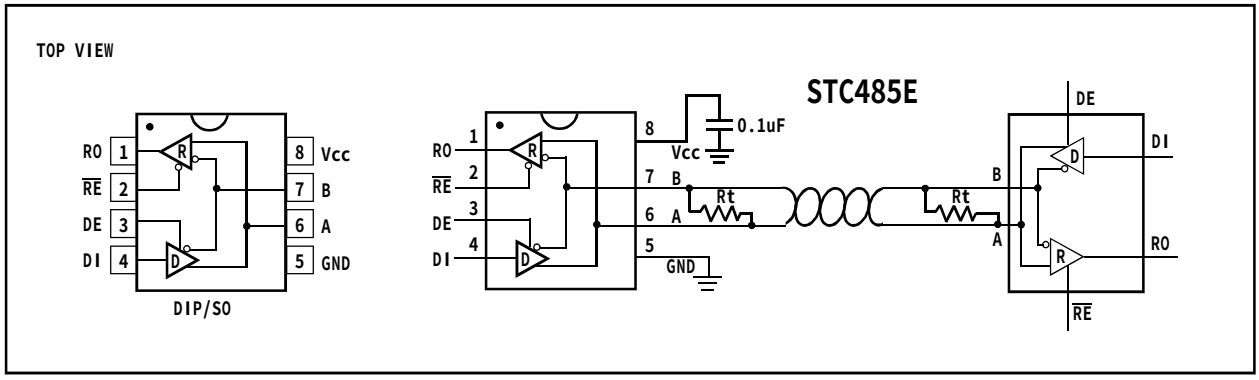


Figure 1. STC485E / Pin Configuration and Typical Operating Circuit

Detailed Description

The STC485E high-speed transceivers for RS-485 communication contain one driver and one receiver. These devices feature fail-safe circuitry, which 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 the *Fail-Safe* section). The STC485E feature reduced slew-rate drivers that minimize EMI and reduce reflections caused by improperly terminated cables, allowing error-free data transmission up to 500kbps (see the *Reduced EMI and Reflections* section).

All of these parts operate from a single +5V supply. Drivers are output short-circuit current limited. Thermal shutdown circuitry protects drivers against excessive power dissipation. When activated, the thermal shutdown circuitry places the driver outputs into a high impedance state.

Fail-Safe

The STC485E guarantees a logic-high 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 setting the receiver threshold between –50 mV 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 0V by the termination. With the receiver thresholds of the STC485E, , this results in a logic high with a 50mV minimum noise margin. Unlike previous fail-safe devices, the -50mV to -200mV threshold complies with the ±200 mV EIA/TIA-485 standard.

±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 STC485E have extra protection against static electricity. Union's engineers have developed state-of-the-art structures to protect these pins against ESD of ±15kV without damage.

The ESD-protected pins are tested with reference to the ground pin in a powered-down condition. They are tested to ±15kV using the Human Body Model.

ESD Test Conditions

ESD performance depends on a variety of conditions. Contact Union for a reliability report that documents test setup, test methodology, and test results.

Human Body Model

Figure 11a shows the Human Body Model and Figure 11b shows the current waveform it generates when discharged into a low impedance. This model consists of a 100pF capacitor charged to the ESD voltage of interest which is then discharged into the test device through a 1.5k? ?esistor.

Machine Model

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

Applications Information

256 Transceivers on the Bus

The standard RS-485 receiver input impedance is 12kO?(one-unit load), and the standard driver can drive up to 32 unit loads. The STC family of trans -ceivers have a 1/8-unit-load receiver input impe -dance (96kO), allowing up to 256 transceivers to be connected in parallel on one communication line. Any combination of these devices and/or other RS-485 transceivers with a total of 32 unit loads or less can be connected to the line.

Reduced EMI and Reflections

The STC485E is slew-rate limited, minimizing EMI and reducing reflections caused by improperly terminated cables. Figure 12 shows the same signal displayed for a STC485E, transmitting under the same conditions.

In general, a transmitter's rise time relates directly to the length of an unterminated stub, which can be driven with only minor waveform reflections. The following equation expresses this relationship conservatively:

Length = tRISE / (10 x 1.5ns/ft)

where tRISE is the transmitter's rise time.

A system can work well with longer unterminated stubs, even with severe reflections, if the waveform settles out before the UART samples them.

Low-Power Shutdown Mode

Low-power shutdown mode is initiated by bringing both /RE high and DE low. In shutdown, the devices typically draw only 2 nA of supply current.

/RE and DE may be driven simultaneously; the parts are guaranteed not to enter shutdown if /RE is high and DE is low for less than 50ns. If the inputs are in this state for at least 600ns, the parts are guaran -teed to enter shutdown.

Enable times tZH and tZL in the Switching Characteristics tables assume the part was not in a low-power shutdown state. Enable times tZH(SHDN) and tZL(SHDN) assume the parts were shut down. It takes drivers and receivers longer to become enabled from low-power shutdown mode (tZH(SHDN), tZH(SHDN)) than from driver/receiver -disable mode (tZH, tZL).

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

Line Length vs. Data Rate

The RS-485/RS-422 standard covers line lengths up to 4000 feet. For line lengths greater than 4000 feet, repeater is required.

Typical Applications

The STC485E transceivers are designed for bidirectional data communications on multipoint bus transmission lines. Figures 14 show 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.

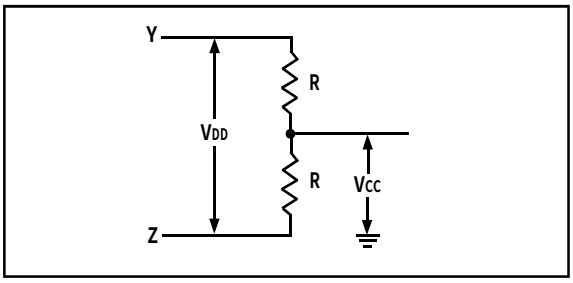


Figure 2. Driver DC Test Load

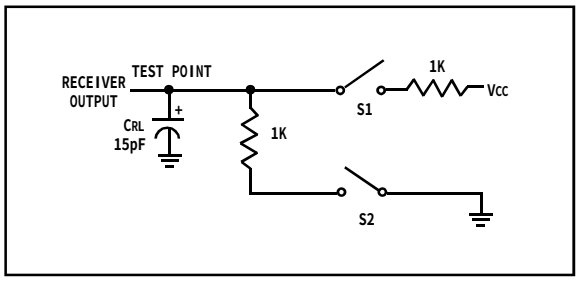


Figure 3. Receiver Enable/Disable Timing Test Load

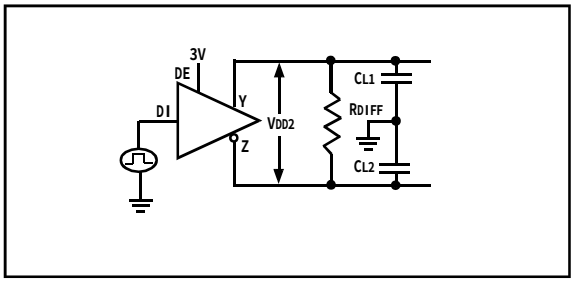


Figure 4. Driver Timing Test Circuit

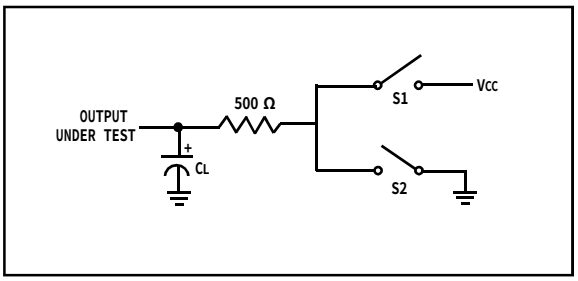


Figure 5. Driver Enable and Disable Timing Test Load

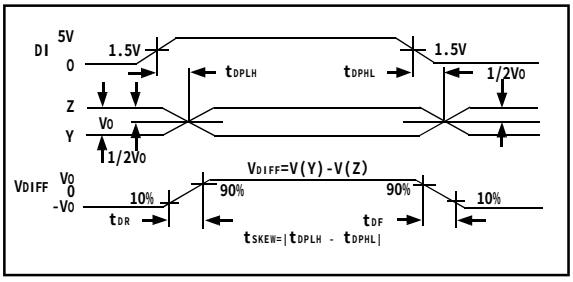


Figure 6. Driver Propagation Delays

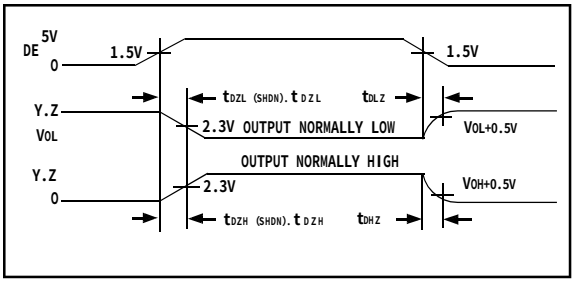


Figure 7. Driver Enable and Disable Times

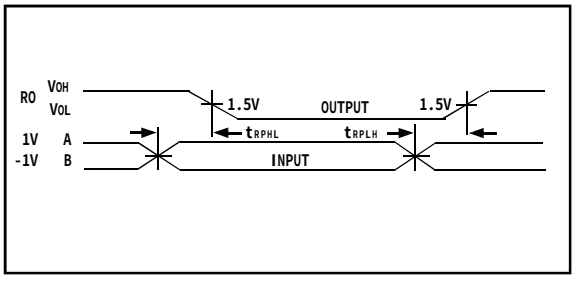


Figure 8. Receiver Propagation Delays

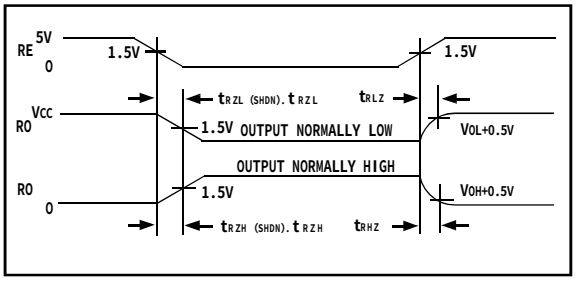


Figure 9. Receiver Enable and Disable Times

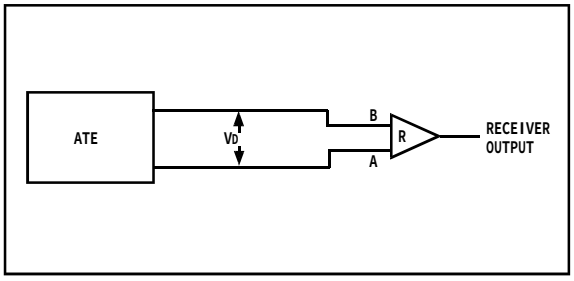


Figure 10. Receiver Propagation Delay Test Circuit

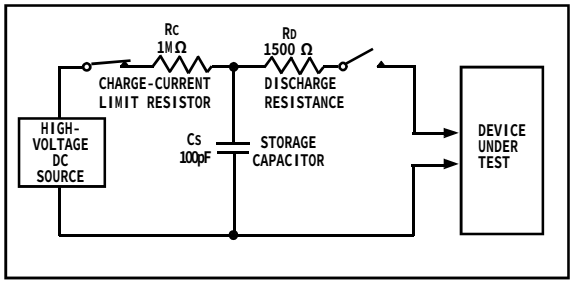


Figure 11a. Human Body ESD Test Model

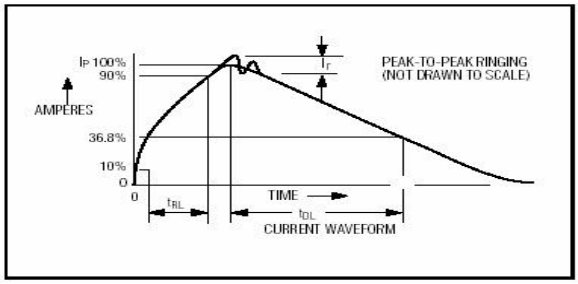


Figure 11b. Human Body Current Waveform

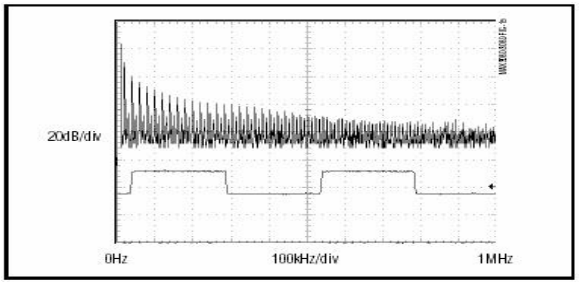


Figure 12. Driver Output Waveform and FFT Plot of STC485E, Transmitting a 20kHz Signal

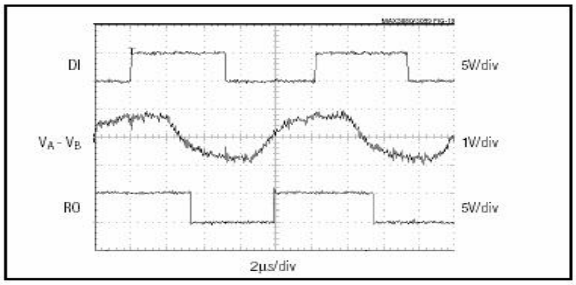


Figure 13. STC485E System Differential Voltage at 50kHz Driving 4000ft of Cable

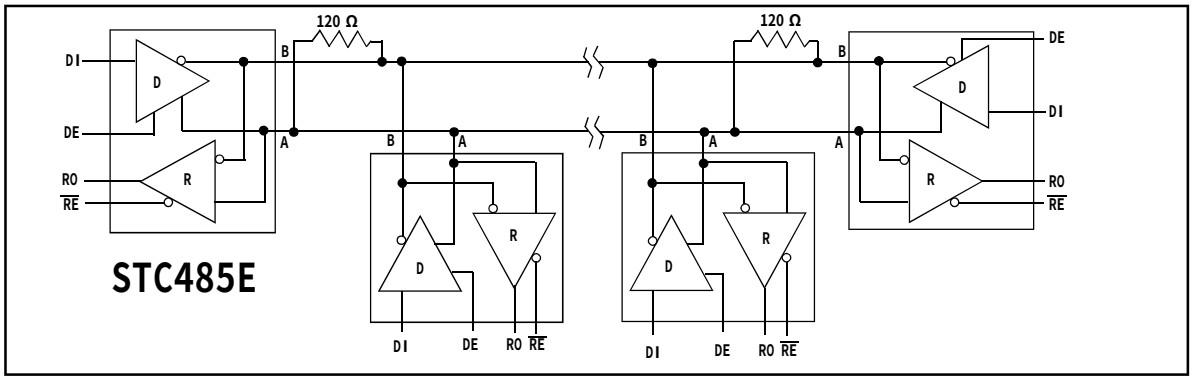
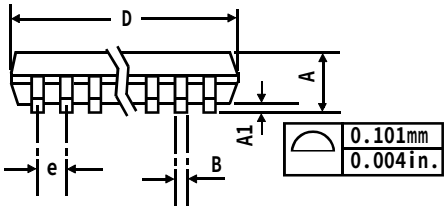
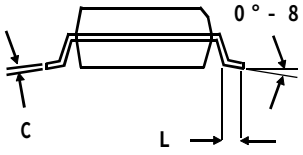


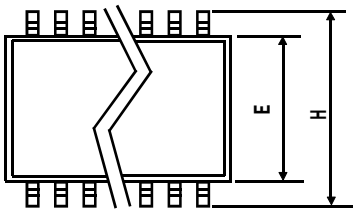
Figure 16. Typical Half-Duplex RS-485 Network

Package Information





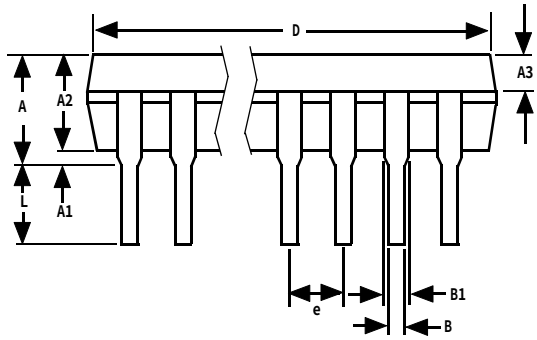
DIM	INCHES		MILLIMETERS	
	MIN	MAX	MIN	MAX
A	0.053	0.069	1.35	1.75
A1	0.004	0.010	0.10	0.25
B	0.014	0.019	0.35	0.49
C	0.007	0.010	0.19	0.25
E	0.150	0.157	3.80	4.00
e	0.050		1.27	
H	0.228	0.244	5.80	6.20
L	0.016	0.050	0.40	1.27

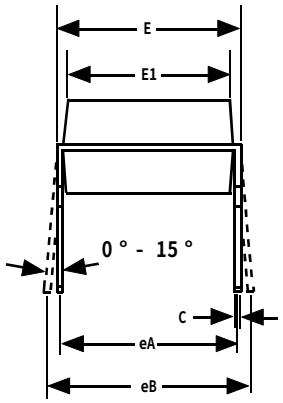


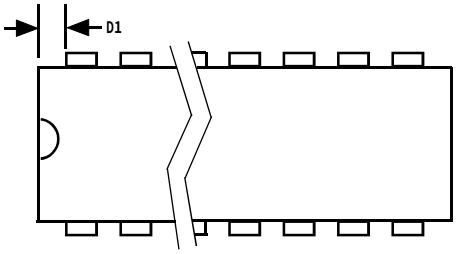
SO
SMALL OUTLINE
PACKAGE
(0.150in.)

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
(0.300in.)

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