

**General Description**

The GM3485E is +/- 15kV electrostatic discharge (ESD) protected, high-speed transceiver for RS-485 communication that contain one driver and one receiver. The device features fail-safe circuitry, which guarantees a logic-high receiver output when the receiver inputs are open or shorted. This means that the receiver output will be logic-high even if all transmitters on a terminated bus are disabled. The GM3485E driver slew rate is not limited, making transmit speeds up to 10Mbps possible. All transmitter outputs and receiver inputs are protected to +/- 15kV using the Human Body Model. The transceiver typically draws 500 micron ampere of supply current when unloaded, or when fully loaded with the driver disabled. This device has a 1-unit-load receiver input impedance that allows up to 32 transceivers on the bus. The GM3485E is intended for half-duplex communications.

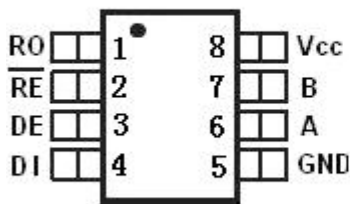
**I/O ESD protection**

Human Body Model: ±15kV

IEC 61000-4-2:

Contact discharge: ±12kV

Air discharge: ±15kV



GM3485E Pin figure

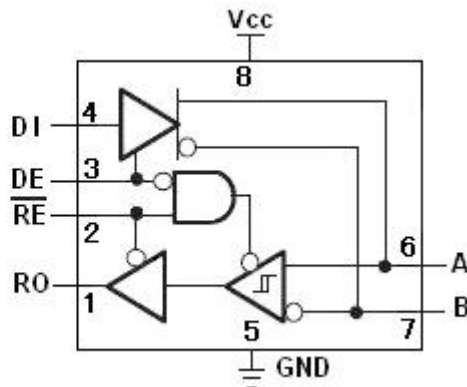
**Features**

- True Fail-Safe Receiver While Maintaining EIA/TIA-485 Compatibility
- Low Quiescent Supply Current: 500uA
- Allow Up to 32 Transceivers on the Bus
- 1nA Low-Current Shutdown Mode

**Applications**

- RS-485 Communications
- Level Translators
- Motor Controller
- Industrial Control Local Area Networks
- Energy Meter Networks
- Power Inverters
- Building Automation Networks
- Telecommunications Equipment

**PIN Configuration**



**Ordering Information**

PART	Duplex	Data Rate	Supply Voltage	Low- Power Shutdown	Rx/Tx on Bus	IEC 61000-4-2 Air discharge	TEMP RANGE	PIN PACKAGE
GM3485E	Half	10Mbps	3.3V	YES	32	±15kV	-40°C~+85°C	8 SOP

**Pin Description**

PIN	NAME	FUNCTION
1	RO	Receiver Output. When RE is low and if $A - B \geq -50\text{mV}$ , RO will be high; if $A - B \leq -200\text{mV}$ , RO will be low.
2	$\overline{RE}$	Receiver Output Enable. Drive $\overline{RE}$ low to enable RO; RO is high impedance when $\overline{RE}$ is high. Drive $\overline{RE}$ high and DE low to enter low-power shutdown mode.
3	DE	Driver Output Enable. Drive DE high to enable driver outputs. These outputs are high impedance when DE is low. Drive $\overline{RE}$ high and DE low to enter low-power shutdown mode.
4	DI	Driver Input. With DE high, a low on DI forces non-inverting output low and inverting output high. Similarly, a high on DI forces non-inverting output high and inverting output low.
5	GND	Ground
6	A	Non-inverting Receiver Input and Non-inverting Driver Output.
7	B	Inverting Receiver Input and Inverting Driver Output.
8	VCC	Positive Supply $3.0\text{V} \leq \text{VCC} \leq 3.6\text{V}$ .

**ABSOLUTE MAXIMUM RATINGS**

PARAMETER	SYMBOL	NUM	UNITS
Supply Voltage (VCC)	V <sub>CC</sub>	+6.0	V
Control Input Voltage ( $\overline{RE}$ , DE)	$\overline{RE}$ , DE	-0.3 to V <sub>CC</sub> +0.3	V
Driver Input Voltage (DI)	DI	-0.3 to V <sub>CC</sub> +0.3	V
Driver Output Voltage (A, B)	A, B	±13	V
Receiver Input Voltage (A, B)	A, B	±13	V
Receiver Output Voltage (RO)	RO	-0.3~V <sub>CC</sub> +0.3	V
Continuous Power Dissipation	SOP8	471	mW
Operating Temperature Ranges		-40~+85	°C
Storage Temperature Range		-65~+150	°C
Lead Temperature (soldering, 10s)		300	°C

**DC ELECTRICAL CHARACTERISTICS**

(VCC = +3.3V ± 5%, TA = T<sub>MIN</sub> to T<sub>MAX</sub>, unless otherwise noted. Typical values are at VCC = +3.3V and TA = +25°C.) (Note 1)

PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	UNITS
<b>DRIVER</b>						
Differential Driver Output (No Load)	V <sub>OD1</sub>	Figure 1	2.0			V
Differential Driver Output	V <sub>OD2</sub>	Figure 1, R = 27Ω	1.5			V
Change-in-Magnitude of Differential Output Voltage (Note 2)	ΔV <sub>OD</sub>	Figure 1, R = 27Ω			0.2	V
Driver Common-Mode Output Voltage	V <sub>OC</sub>	Figure 1, R = 27Ω	1		3	V

Change-in-Magnitude of Common-Mode Voltage (Note 2)	$\Delta V_{OC}$	Figure 1, R = 27 $\Omega$			0.2	V	
Input High Voltage	$V_{IH1}$	DE, DI, $\overline{RE}$	2.0			V	
Input Low Voltage	$V_{IL1}$	DE, DI, $\overline{RE}$			0.8	V	
DI Input Hysteresis	$V_{HYS}$			100		mV	
Input Current (A and B)	$I_{IN1}$	DE = GND, VCC = GND or 3.3V	$V_{IN} = 12V$		500	$\mu A$	
			$V_{IN} = -7V$	-500			
Driver Short-Circuit Output Current (Note 3)	$I_{OSD}$		$-7V \cong V_{OUT} \cong VCC$	-250		mA	
			$0V \cong V_{OUT} \cong 12V$		250		
			$0V \cong V_{OUT} \cong VCC$	$\pm 25$			
<b>RECEIVER</b>							
Receiver Differential Threshold Voltage	$V_{TH}$	$-7V \cong V_{CM} \cong 12V$	-200	-110	-50	mV	
Receiver Input Hysteresis	$\Delta V_{TH}$			30		mV	
Receiver Output High Voltage	$V_{OH}$	$I_O = -4mA, V_{ID} = -50mV$	$V_{CC} - 0.4$			V	
Receiver Output Low Voltage	$V_{OL}$	$I_O = 4mA, V_{ID} = -200mV$			0.4	V	
Three-State Output Current at Receiver	$I_{OZR}$	$0.4V \cong V_O \cong 2.4V$			$\pm 1$	$\mu A$	
Receiver Input Resistance	$R_{IN}$	$-7V \cong V_{CM} \cong 12V$	12			k $\Omega$	
Receiver Output Short-Circuit Current	$I_{OSR}$	$0V \cong V_{RO} \cong VCC$	$\pm 7$		$\pm 95$	mA	
<b>SUPPLY CURRENT</b>							
Supply Current	$I_{CC}$	No load, $\overline{RE} =$ DI = GND or VCC	DE = VCC		500	900	$\mu A$
			DE = GND		400	600	$\mu A$
Supply Current in Shutdown Mode	$I_{SHDN}$	DE = GND, $V_{\overline{RE}} = VCC$			0.001	1	$\mu A$
ESD Protection for A, B		Human Body Model			$\pm 15$		kV

**SWITCHING CHARACTERISTICS**

(VCC = +3.3V  $\pm$  5%, TA = TMIN to TMAX, unless otherwise noted. Typical values are at VCC = +3.3V and TA = +25°C.)

PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	UNITS
Driver Input to Output	$t_{DPLH}$	Figure 3 and 5, RDIFF = 54 $\Omega$ , CL1 = CL2 = 100pF		20	40	ns
	$t_{DPHL}$			20	40	
Driver Output Skew   tDPLH - tDPHL	$t_{DSKEW}$	Figure 3 and 5, RDIFF = 54 $\Omega$ , CL1 = CL2 = 100pF		-3	$\pm 10$	ns
Driver Rise or Fall Time	$t_{DR}, t_{DF}$	Figure 3 and 5, RDIFF = 54 $\Omega$ , CL1 = CL2 = 100pF		12	25	ns

Maximum Data Rate	$f_{MAX}$		10			Mbps
Driver Enable to Output High	$t_{DZH}$	Figure 4 and 6, $C_L = 100\text{pF}$ , S2 closed			150	ns
Driver Enable to Output Low	$t_{DZL}$	Figure 4 and 6, $C_L = 100\text{pF}$ , S1 closed			150	ns
Driver Disable Time from Low	$t_{DLZ}$	Figure 4 and 6, $C_L = 15\text{pF}$ , S1 closed			100	ns
Driver Disable Time from High	$t_{DHZ}$	Figure 4 and 6, $C_L = 15\text{pF}$ , S2 closed			100	ns
Receiver Input to Output	$t_{RPLH}$ , $t_{RPHL}$	Figure 9, $ V_{ID}  \cong 2.0\text{V}$ rise and fall time of $V_{ID} \cong 15\text{ns}$		50		ns
$ t_{RPLH} - t_{RPHL} $ Differential Receiver Skew	$t_{RSKD}$	Figure 9, $ V_{ID}  \cong 2.0\text{V}$ rise and fall time of $V_{ID} \cong 15\text{ns}$		0	$\pm 10$	ns
Receiver Enable to Output Low	$t_{RZL}$	Figure 2, $C_L = 100\text{pF}$ , S1 closed		20	50	ns
Receiver Enable to Output High	$t_{RHZ}$	Figure 2, $C_L = 100\text{pF}$ , S2 closed		20	50	ns
Receiver Disable Time from Low	$t_{RLZ}$	Figure 2, $C_L = 100\text{pF}$ , S1 closed		20	50	ns
Receiver Disable Time from High	$t_{RHZ}$	Figure 2, $C_L = 100\text{pF}$ , S2 closed		20	50	ns
Time to Shutdown	$t_{SHDN}$	(Note 4)	50	200	600	ns
Driver Enable from Shutdown-to-Output High	$t_{DZH(SHDN)}$	Figure 4, $C_L = 15\text{pF}$ , S2 closed			250	ns
Driver Enable from Shutdown-to-Output Low	$t_{DZL(SHDN)}$	Figure 4, $C_L = 15\text{pF}$ , S1 closed			250	ns
Receiver Enable from Shutdown-to-Output High	$t_{RZH(SHDN)}$	Figure 2, $C_L = 100\text{pF}$ , S2 closed			3500	ns
Receiver Enable from Shutdown-to-Output Low	$t_{RZL(SHDN)}$	Figure 2, $C_L = 100\text{pF}$ , S1 closed			3500	ns

**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.

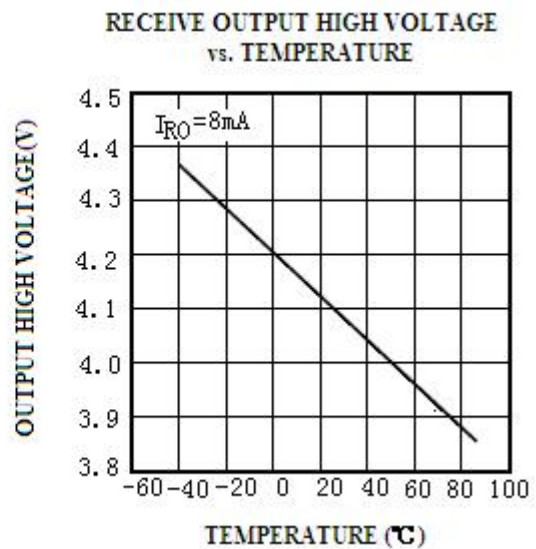
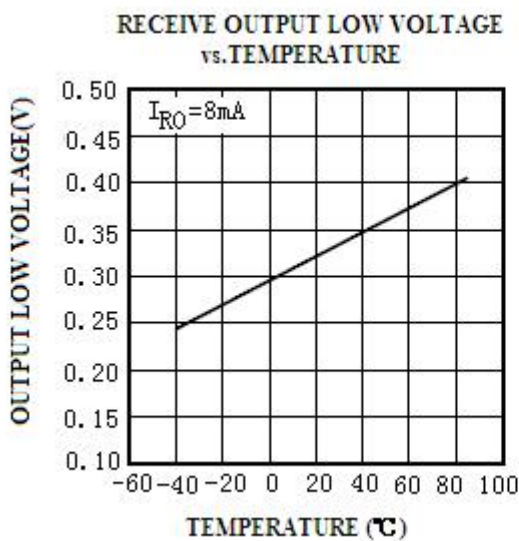
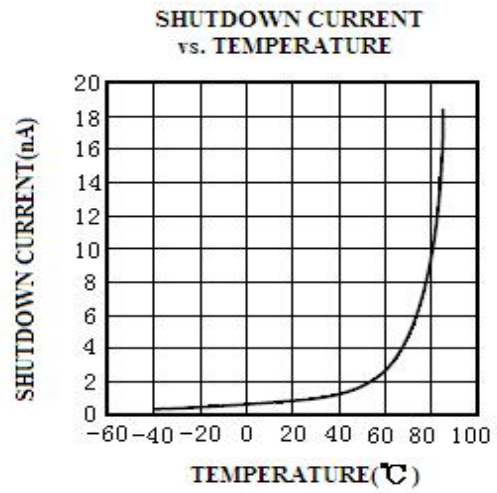
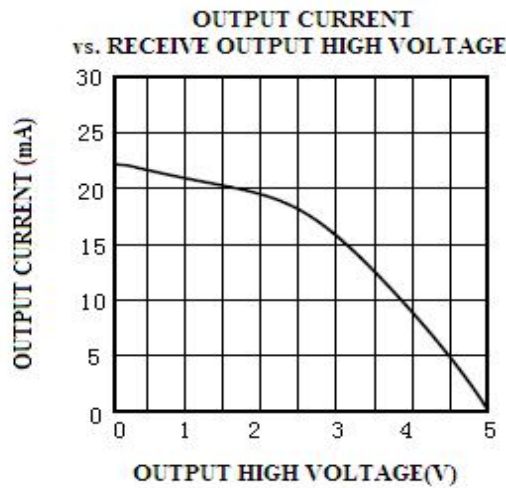
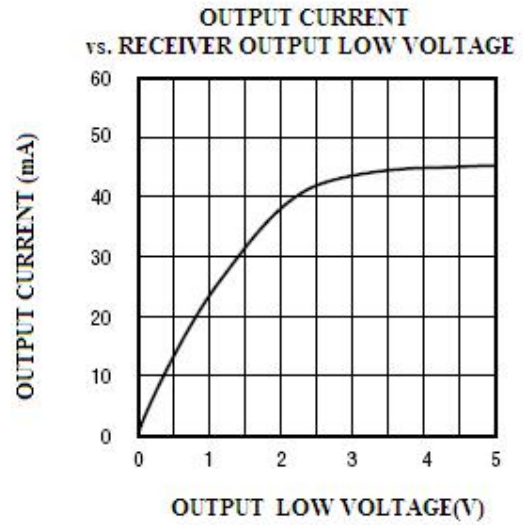
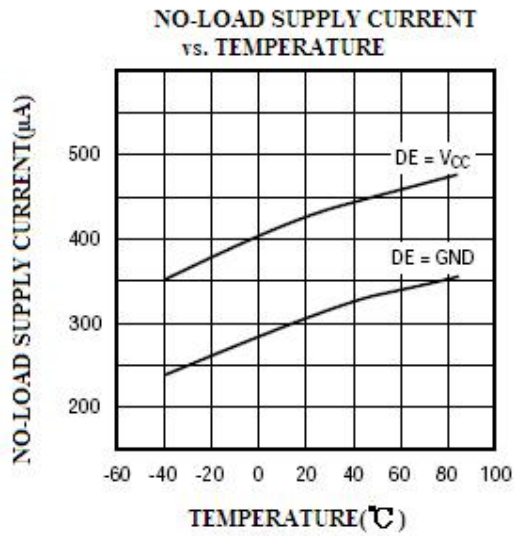
**Note 2:**  $\Delta V_{OD}$  and  $\Delta V_{OC}$  are the changes in  $V_{OD}$  and  $V_{OC}$ , respectively, when the DI input changes state.

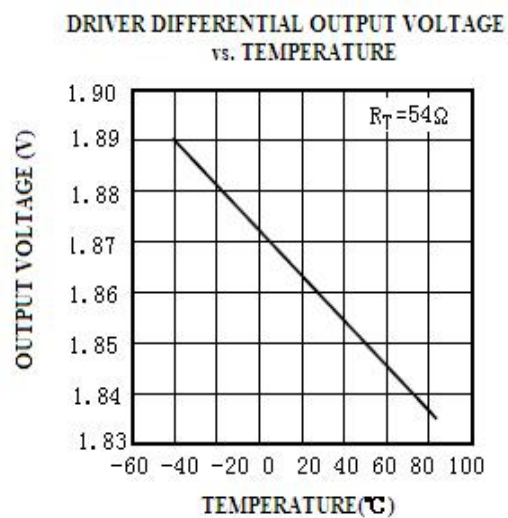
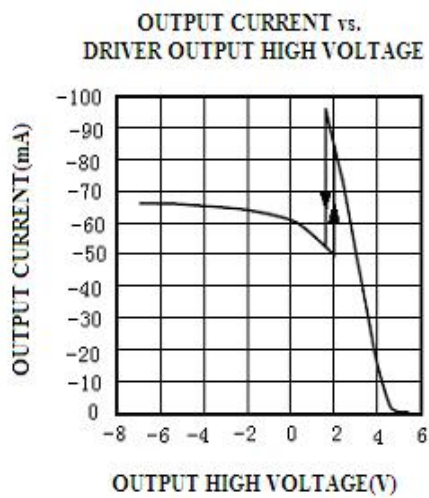
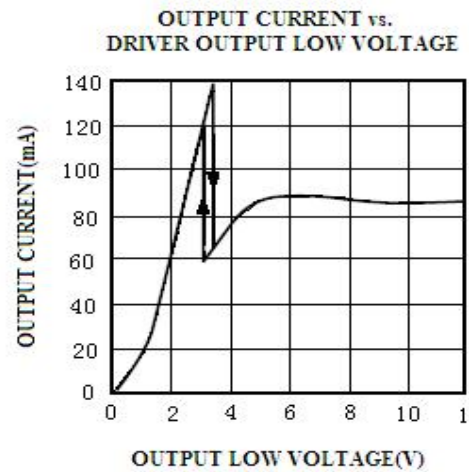
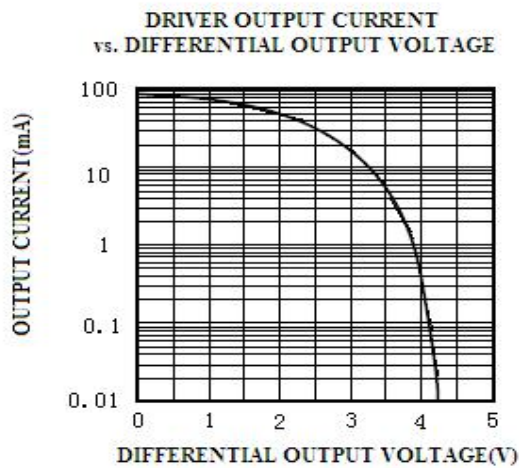
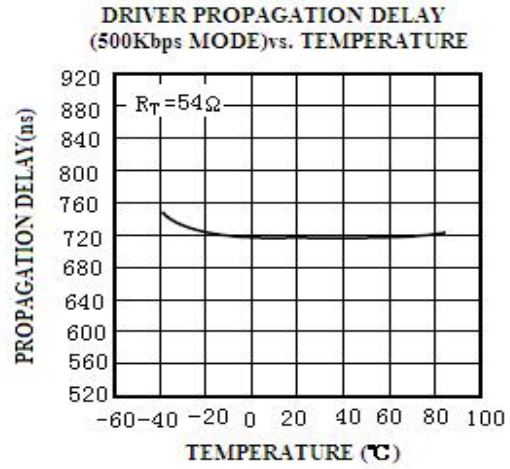
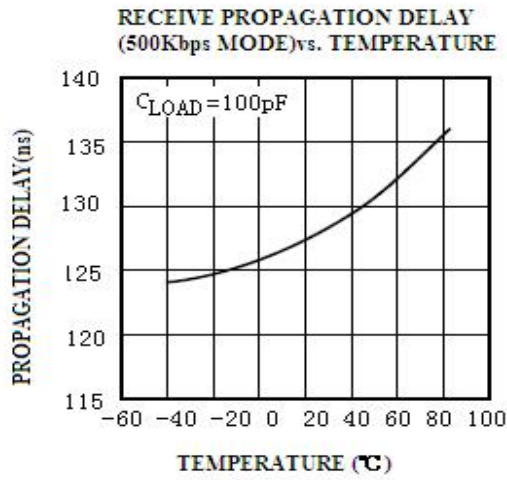
**Note 3:** Maximum current level applies to peak current just prior to fold-back current limiting; minimum current level applies during current limiting.

**Note 4:** The device is put into shutdown by bringing  $\overline{RE}$  high and DE low. If the enable inputs are in this state for less than 50ns, the device is guaranteed not to enter shutdown. If the enable inputs are in this state for at least 600ns, the device is guaranteed to have entered shutdown.

**Typical Operating Characteristics**

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





Function Tables

TRANSMITTING				
INPUTS			OUTPUTS	
$\overline{RE}$	DE	DI	B	A
X	1	1	0	1
X	1	0	1	0
0	0	X	High-Z	High-Z
1	0	X	Shutdown	
RECEIVING				
INPUTS			OUTPUTS	
$\overline{RE}$	DE	A - B	RO	
0	X	$\cong -0.2V$	1	
0	X	$\cong -0.2V$	0	
0	X	Open/shorted	1	
1	1	X	High-Z	
1	0	X	Shutdown	

X = Don't care  
 Shutdown mode, driver and receiver outputs high impedance

Test Circuits

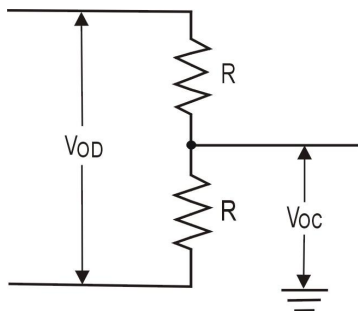


Figure1. Driver DC Test Load

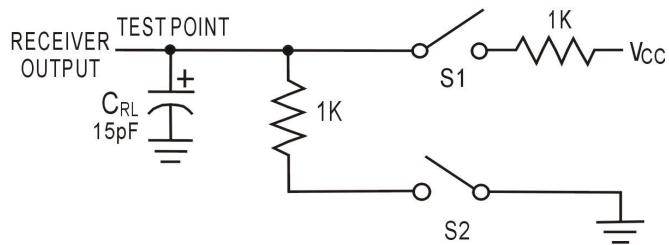


Figure 2. Receiver Enable/Disable Timing Test Load

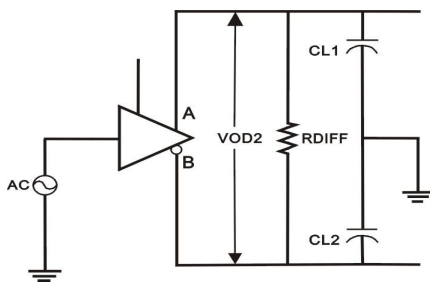


Figure3. Driver Timing Test Load

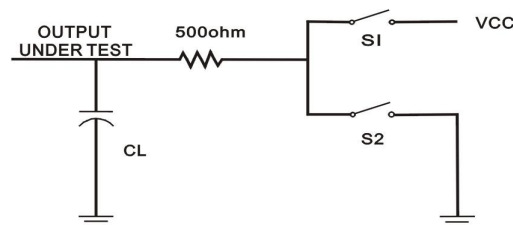


Figure 4. Driver Enable/Disable Timing Test Load

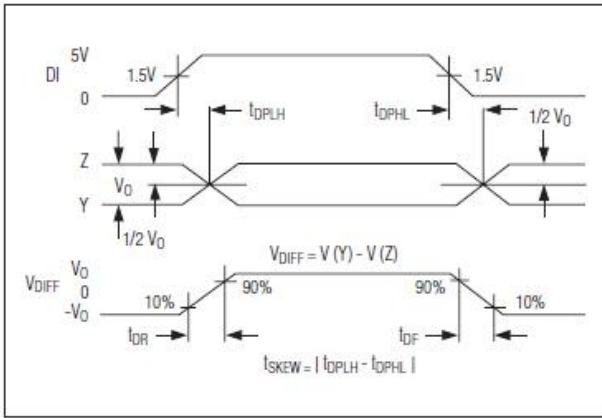


Figure 5. Driver Propagation Delays

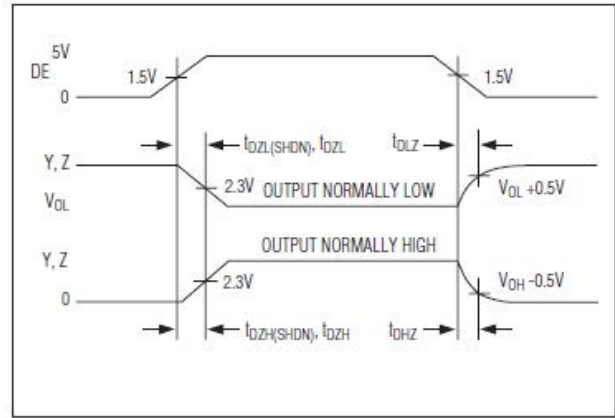


Figure 6. Driver Enable and Disable Times

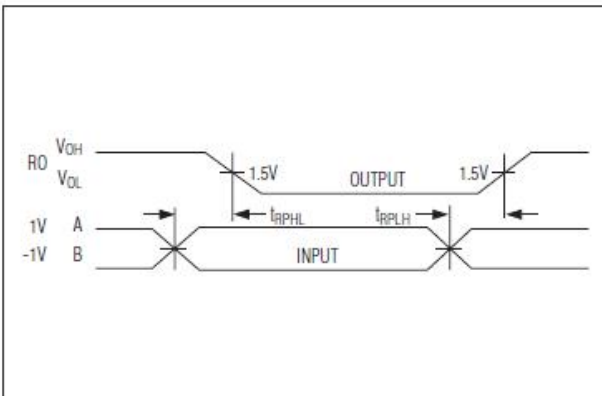


Figure 7. Receiver Propagation Delays

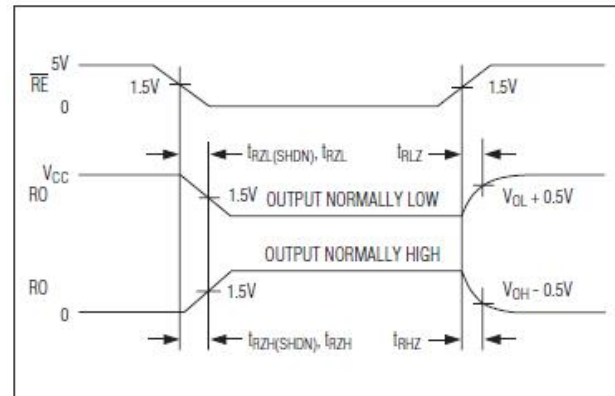


Figure 8. Receiver Enable and Disable Times

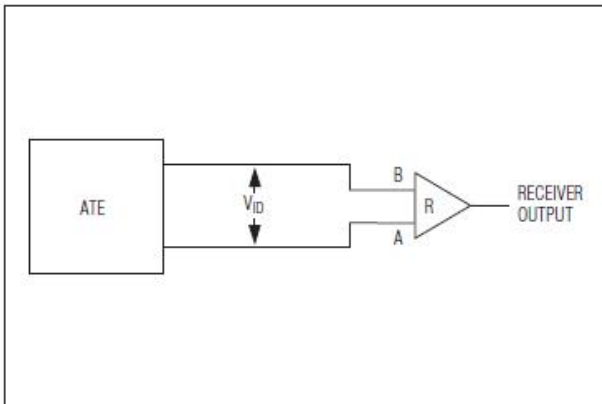


Figure 9. Receiver Propagation Delay Test Circuit

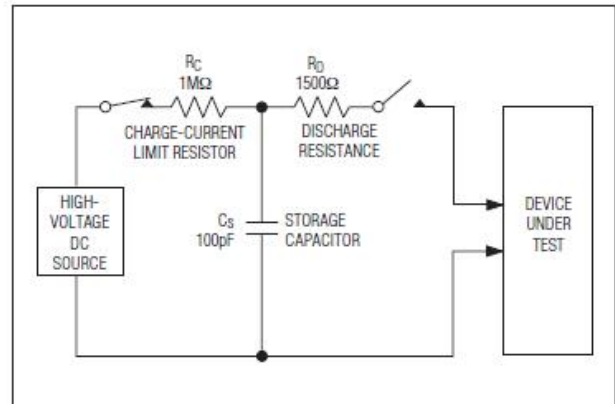


Figure 10a. Human Body ESD Test Model

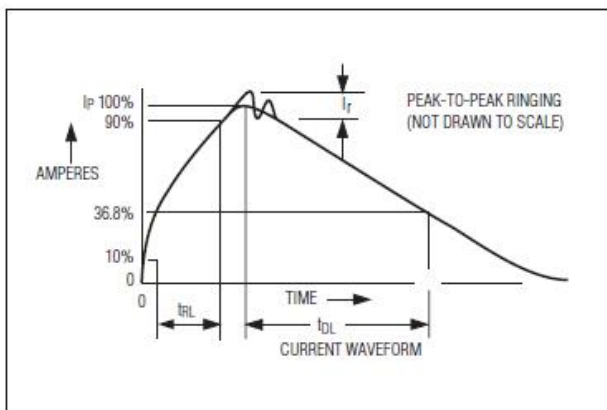


Figure 10b. Human Body Current Waveform

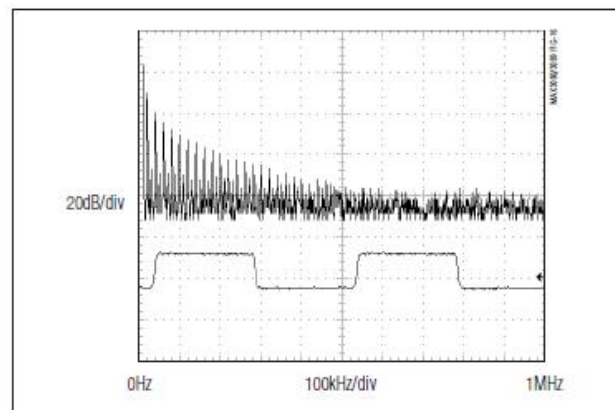


Figure 11. Driver Output Waveform and FFT Plot



### ***Detailed Description***

The GM3485E high - speed transceiver for RS-485 communication 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 or shorted, or when they are connected to a terminated transmission line with all drivers disabled (see the Fail-Safe section). The GM3485E driver slew rate is not limited, making transmit speeds up to 10Mbps possible. The GM3485E is a half-duplex transceiver. The voltage operates from a single +3.3V 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 GM3485E 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 -50mV and -200mV. If the input voltage of differential receiver (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 differential input voltage is pulled to 0V by the termination. With the receiver threshold of the GM3485E, 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 +/-200mV EIA/TIA-485 standard.

### ***ESD Protection***

As with GM3485E, ESD-protection structures are incorporated on all pins to protect against electrostatic discharges encountered during handling and assembly. The driver output and receiver input of the GM3485E has extra protection against static electricity. 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 Maxim for a reliability report that documents test setup, test methodology, and test results.

### ***Human Body Model***

Figure 10a shows the Human Body Model, and Figure 10b 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 1.5kΩ resistor.

### ***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 protection,

not just RS-485 inputs and outputs.

### **Applications Information**

#### **32 Transceivers on the Bus**

The standard RS-485 receiver input impedance is 12k $\Omega$  (one-unit load), and the standard driver can drive up to 32 unit loads. The GM3485E has a one-unit-load receiver input impedance (12k $\Omega$ ), allowing up to 256 transceivers to be connected in parallel on one communication line. Any combination of this device 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 GM3485E, driver slew rate is not limited, High-frequency harmonic components with large amplitudes are evident. transmitting under the same conditions. Figure 11 shows driver output waveform and its Fourier analysis of a 20kHz signal transmitted by a GM3485E. 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:

$$\text{Length} = t_{\text{RISE}} / (10 \times 1.5\text{ns/ft})$$

where  $t_{\text{RISE}}$  is the transmitter's rise time. For example, the GM3485E's rise time is typically 14ns, which results in excellent waveforms with a stub length up to 1 foot. 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**

When both the driver and receiver are disabled ( $\overline{\text{DE}}$  low and  $\overline{\text{RE}}$  high) the device is in shutdown mode. If the enable inputs are in this state for less than 60 ns, the device does not

enter shutdown mode. This guards against inadvertently entering shutdown mode during driver/receiver enabling. Only when the enable inputs are held in this state for 300 ns or more, the device is assured to be in shutdown mode. In this low-power shutdown mode, most internal circuitry is powered down except over temperature protection circuit, and the supply current is typically 40 micron ampere. When either the driver or the receiver is re-enabled, the internal circuitry becomes active. If only the driver is re-enabled ( $\overline{\text{DE}}$  changed to high) the driver outputs are driven according to the DI input after the enable times given by  $t_{\text{PZH}}(\text{SHDN})$  and  $t_{\text{PZL}}(\text{SHDN})$  in the driver switching characteristics. If the DI input is open when the driver is enabled, the driver outputs defaults to A high and B low, in accordance with the driver failsafe feature. If only the receiver is re-enabled ( $\overline{\text{RE}}$  changed to low) the receiver output is driven according to the state of the bus inputs (A and B) after the enable time given by  $t_{\text{PZH}}(\text{SHDN})$  and  $t_{\text{PZL}}(\text{SHDN})$  in the receiver switching characteristics. If there is no valid state on the bus the receiver responds as described in the failsafe operation section. If both the receiver and driver are re-enabled simultaneously, the receiver output is driven according to the state of the bus inputs (A and B) and the driver output is driven according to the DI input. Note that the state of the active driver affects the inputs to the receiver. Therefore, the receiver outputs are valid as soon as the driver outputs are valid.

**Driver Output Protection**

Two mechanisms prevent excessive output current and power dissipation caused by faults or by bus contention. The first, a fold back current limit on the output stage, provides immediate protection against short circuits over the whole common-mode voltage range. The second, a thermal shutdown circuit, forces the driver outputs into a high-impedance state if the die temperature becomes excessive.

110kHz into 120Ω loads.

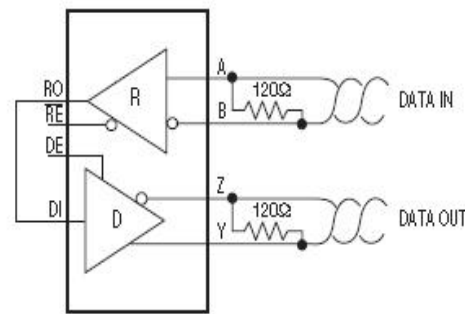


Figure 12. Line Repeater for GM3485E

**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, use the repeater application

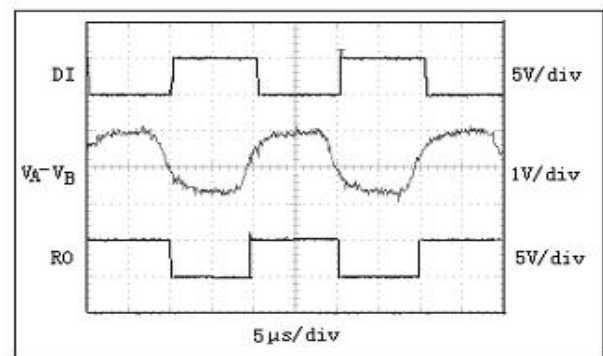


Figure 13. GM3485E System Differential Voltage at 50kHz Driving 4000ft of Cable

shows in Figure 12. Figure 13 shows the system differential voltage for the parts driving 4000 feet of 26AWG twistedpair wire at

**Applications**

The GM3485E transceiver is designed for bidirectional data communications on multipoint bus transmission lines. Figures 14 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 GM3485E is more tolerant of imperfect termination.

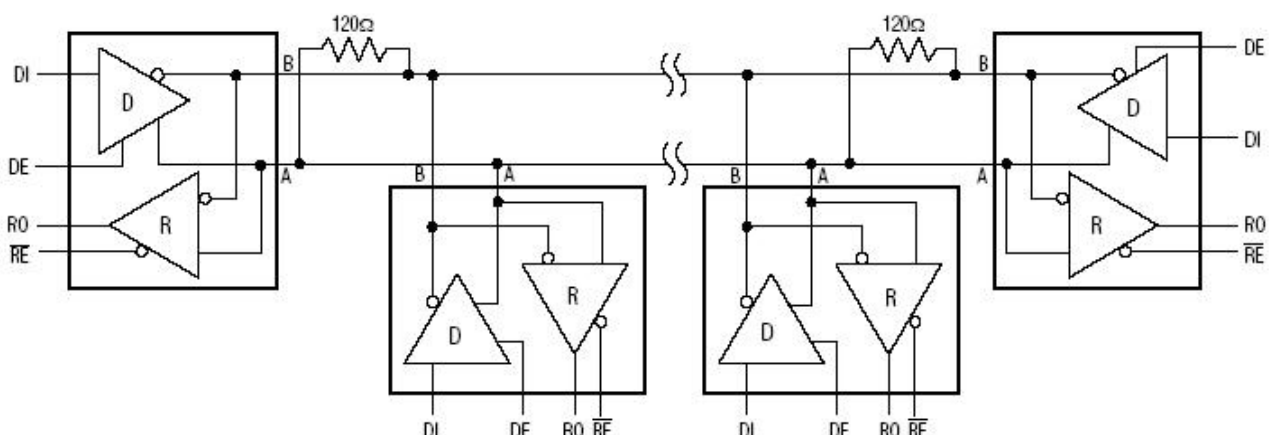
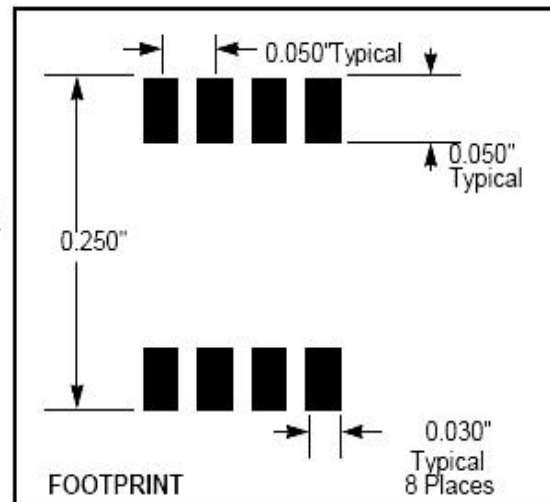
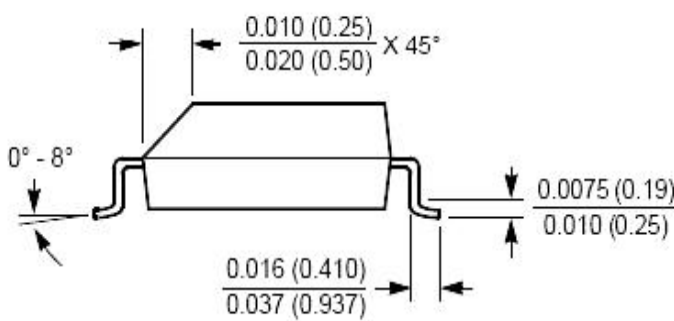
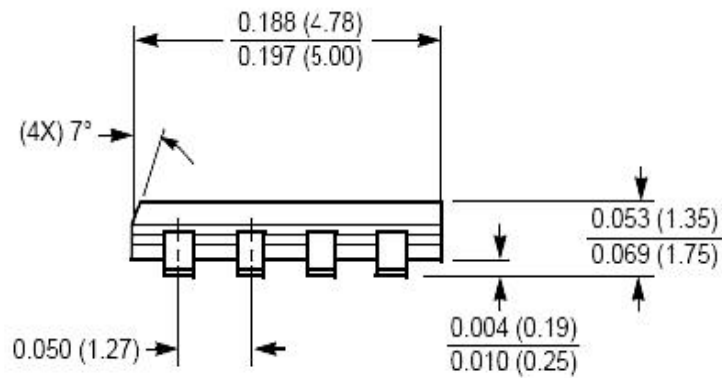
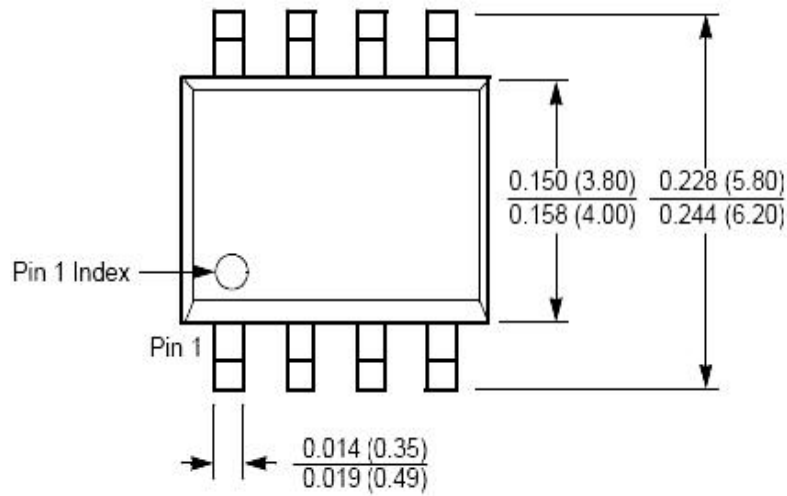


Figure 14. GM3485E Pin Configuration and Typical Half-Duplex Operating Circuit

Package Information

inches (millimeters) unless otherwise noted

SOP8



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