1. Feature

- ESD Protection for RS-485 I/O Pins
  - ±15kV—Human Body Model
  - ±8kV—IEC 1000-4-2, Contact Discharge
  - ±15kV—IEC 1000-4-2, Air-Gap Discharge
- Operate from a Single +3.3V Supply—No Charge Pump Required
- Interoperable with +5V Logic
- Guaranteed 12Mbps Data Rate (GM3490E/GM3491E)
- Slew-Rate Limited for Error less Data Transmission (GM3488E)
- -7V to +12V Common-Mode Input Voltage Range
- Current-Limiting and Thermal Shutdown for Driver Overload Protection

2. APPLICATIONS

- Telecommunications
- Industrial-Control Local Area Networks
- Transceivers for EMI-Sensitive Applications
- Integrated Services Digital Networks
- Packet Switching

3. General Description

Devices in the GM3485E family (GM3488E/ GM3490E/ GM3491E) are ±15kV ESD-protected, +3.3V, low-power transceivers for RS-422 communications. Each device contains one driver and one receiver.
The GM3488E feature slew-rate-limited drivers that minimize EMI and reduce reflections caused by improperly terminated cables, allowing error-free data transmission at data rates up to 1Mbps. The GM3490E, and GM3491E transmit at up to 12Mbps.

All devices feature enhanced electrostatic discharge (ESD) protection. All transmitter outputs and receiver inputs are protected to ±15kV using IEC 1000-4-2 Air-Gap Discharge, ±8kV using IEC 1000-4-2 Contact Discharge, and ±15kV 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 circuit. The GM3488E, GM3490E, and GM3491E feature full duplex communication.

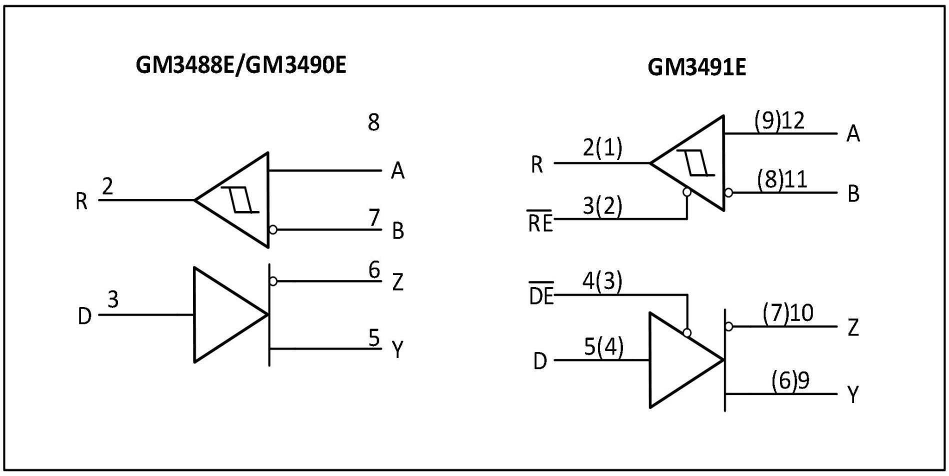

Figure 1 Simplified Schematic

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4. Specifications

4.1 ABSOLUTE GMIMUM RATINGS

Parameter	Description	MIN	MAX	UNIT
V_{CC}	Supply Voltage		+7	V
$\overline{RE}$, DE	Control Input Voltage	-0.3	+7	V
DI	Driver Input Voltage	-0.3	+7	V
A, B,Y,Z	Driver Output Voltage	-7.5	+12.5V	V
A, B	Receiver Input Voltage	-7.5	+12.5V	V
RO	Receiver Output Voltage	0.3	V_{CC}+0.3V	
	Storage Temperature Range	-65	150	°C

4.2 DC ELECTRICAL CHARACTERISTICS

(V_{CC} = +3.3V ±0.3V, T_A = T_{MIN} to T_{GM}, unless otherwise noted. Typical values are at T_A = +25°C.)

PARAMETER	SYMBOL	CONDITIONS		MIN	TYP	MAX	UNIT
Differential Driver Output	V_{OD}	R_L = 100Ω (RS-422), Figure 4		2.0			V
		R_L = 54Ω (RS-485), Figure 4		1.5			
		R_L = 60Ω (RS-485), V_{CC} = 3.3V, Figure 5		1.5			
Change in Magnitude of Driver Differential Output Voltage for Complementary Output States(Note 1)	△V_{OD}	R = 54Ω or 100Ω, Figure 4				0.2	V
Driver Common-Mode Output Voltage	V_{OC}	R = 54Ω or 100Ω, Figure 4				3	V
Change in Magnitude of Driver Common-Mode Output Voltage for Complementary Output States	△V_{OC}	R = 54Ω or 100Ω, Figure 4				0.2	V
Input High Voltage	V_{IH}	DE, DI, $\overline{RE}$		2.0			V
Input Low Voltage	V_{IL}	DE, DI, $\overline{RE}$				0.8	V
Input Current	I_{IN1}	DE, DI, $\overline{RE}$ V_{CC} floating				±2	μA
Input Current (A, B)	I_{IN2}	DE = 0V; V_{CC} = 0V or 3.6V	V_{IN} = 12V			1.0	mA
			V_{IN} = -7V			-0.8	
Output Leakage (Y, Z)	I_O	DE = 0V, $\overline{RE}$ = 0V, V_{CC}= 0V or 3.6V, GM3491E	V_{OUT} = 12V			100	μA
			V_{OUT} = -7V			-100	
Output Leakage (Y, Z) in Shutdown Mode	I_O	DE = 0V, $\overline{RE}$ = 3.6V, V_{CC}= 0V or 3.6V, GM3491E	V_{OUT} = 12V			100	μA
			V_{OUT} = -7V			-100	
Receiver Differential Threshold Voltage	V_{TH}	-7V≤V_{CM} ≤12V		-0.2		0.2	V
Receiver Input Hysteresis	△V_{TH}	V_{CM} = 0V			50		mV
Receiver Output High Voltage	V_{OH}	I_O = -4mA, V_{ID} = 200mV,Figure 6		V_{CC}-0.4			V

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DC ELECTRICAL CHARACTERISTICS(continued)

(V_{CC} = +3.3V ±0.3V, T_A = T_{MIN} to T_{GM}, unless otherwise noted. Typical values are at T_A = +25°C.)

PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	UNIT
Receiver Output Low Voltage	V_{OL}	I_O = 4mA, V_{ID} = -200mV, Figure 6			0.4	V
Three-State (high impedance) Output Current at Receiver	I_{OZR}	V_{CC} = 3.6V, 0V ≤ V_{OUT} ≤ V_{CC}			±1	μA
Receiver Input Resistance	R_{IN}	-7V ≤ V_{CM} ≤ 12V	96			kΩ
Supply Voltage Range	V_{CC}		3.0		3.6	V
Supply Current	I_{CC}	No load, DI = 0 or V_{CC}; DE = V_{CC}, $\overline{RE}$ = 0 or V_{CC}		0.5	1.0	mA
		No load, DI = 0 or V_{CC}; DE = 0V, $\overline{RE}$ = 0		0.45	0.9	mA
Supply Current in Shutdown Mode	I_{SHDN}	DE = 0, $\overline{RE}$ = V_{CC}, DI = V_{CC} or 0		1.3	2	μA
Driver Short-Circuit Current	I_{OSD}	V_{OUT} = -7V			-250	mA
		V_{OUT} = 12V			250	mA
Receiver Short-Circuit Output Current	I_{OSR}	0V ≤ V_O ≤ V_{CC}	±8		±60	mA
ESD Protection for Y, Z, A, B		IEC 1000-4-2 Air Discharge		±15		KV
		IEC 1000-4-2 Contact Discharge (GM3491E)		±8		KV
		IEC 1000-4-2 Contact Discharge (GM3490E, GM3488E)		±8		KV
		Human Body Model		±15		KV

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4.3 Switching Characteristics—GM3490E/GM3491E

(V_{CC} = +3.3V, T_A = +25° C.)

PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	UNITS
Maximum Data Rate			12	15		Mbps
Driver Differential Output Delay	t_{DD}	R_L = 60Ω, Figure 7	1	22	35	ns
Driver Differential Output Transition Time	t_{DD}	R_L = 60Ω, Figure 7	3	11	25	ns
Driver Propagation Delay, Low-to-High Level	t_{PLH}	R_L = 27Ω, Figure 8	7	23	35	ns
Driver Propagation Delay, High-to-Low Level	t_{PHL}	R_L = 27Ω, Figure 8	7	23	35	ns
$\vert t_{PLH} - t_{PHL}\vert$ Driver Propagation Delay Skew (Note 2)	t_{PDS}	R_L = 27Ω, Figure 8		-1.4	±8	ns
DRIVER-OUTPUT ENABLE/DISABLE TIMES (GM3491E only)						
Driver-Output Enable Time to Low Level	t_{PZL}	R_L = 110Ω, Figure 10		42	90	ns
Driver-Output Enable Time to High Level	t_{PZH}	R_L = 110Ω, Figure 9		42	90	ns
Driver-Output Disable Time from High Level	t_{PHZ}	R_L = 110Ω, Figure 9		35	80	ns
Driver-Output Disable Time from Low Level	t_{PLZ}	R_L = 110Ω, Figure 10		35	80	ns
Driver-Output Enable Time from Shutdown to Low Level	t_{PSL}	R_L = 110Ω, Figure 10		650	900	ns
Driver-Output Enable Time from Shutdown to High Level	t_{PSH}	R_L = 110Ω, Figure 9		650	900	ns

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4.4 SWITCHING CHARACTERISTICS—GM3488E

(V_{CC} = +3.3V, T_A = +25° C.)

PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	UNITS
Maximum Data Rate				1000		Kbps
Driver Differential Output Delay	t_{DD}	R_L = 60Ω, Figure 7	200	300	500	ns
Driver Differential Output Transition Time	t_{DD}	R_L = 60Ω, Figure 7	150	240	400	ns
Driver Propagation Delay, Low-to-High Level	t_{PLH}	R_L = 27Ω, Figure 8	200	300	500	ns
Driver Propagation Delay, High-to-Low Level	t_{PHL}	R_L = 27Ω, Figure 8	200	300	500	ns
$\|t_{PLH} - t_{PHL}\|$ Driver Propagation Delay Skew (Note 2)	t_{PDS}	R_L = 27Ω, Figure 8		±50		ns
Driver-Output Enable Time to Low Level	t_{PZL}	R_L = 110Ω, Figure 10		300	500	ns
Driver-Output Enable Time to High Level	t_{PZH}	R_L = 110Ω, Figure 9		150	400	ns
Driver-Output Disable Time from High Level	t_{PHZ}	R_L = 110Ω, Figure 9		50	80	ns
Driver-Output Disable Time from Low Level	t_{PLZ}	R_L = 110Ω, Figure 10		50	80	ns
Driver-Output Enable Time from Shutdown to Low Level	t_{PSL}	R_L = 110Ω, Figure 10		1.9	2.7	µs
Driver-Output Enable Time from Shutdown to High Level	t_{PSH}	R_L = 110Ω, Figure 9		2.2	3.0	µs

4.5 NOTES FOR ELECTRICAL/SWITCHING CHARACTERISTICS

Note 1: ΔV_{OD} and ΔV_{OC} are the changes in V_{OD} and V_{OC}, respectively, when the DI input changes state.
Note 2: Measured on $|t_{PLH}(Y) - t_{PHL}(Y)|$ and $|t_{PLH}(Z) - t_{PHL}(Z)|$.
Note 3: The transceivers are put into shutdown by bringing high RE 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.

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4.6 Pin Description

PIN		NAME	FUNCTION
GM3488E GM3490E	GM3491E		
SOP8	SOP14		
2	2	RO	Receiver Output: If A > B by 200mV, RO will be high; If A < B by 200mV, RO will be low.
—	3	$\overline{RE}$	Receiver Output Enable. RO is enabled when $\overline{RE}$ is low; RO is high impedance when RE is high.
—	4	DE	Driver Output Enable. The driver outputs, Y and Z, are enabled by bringing DE high. They are high impedance when DE is low. If the driver outputs are enabled, the parts function as line drivers. While they are high impedance, they function as line receivers if $\overline{RE}$ is low.
3	5	DI	Driver Input. A low on DI forces output Y low and output Z high. Similarly, a high on DI forces output Y high and output Z low.
4	6, 7	GND	Ground
5	9	Y	Non-inverting Driver Output
6	10	Z	Inverting Driver Output
—	—	A	Non-inverting Receiver Input and Non-inverting Driver Output
8	12	A	Non-inverting Receiver Input
—	—	B	Inverting Receiver Input and Inverting Driver Output
7	11	B	Inverting Receiver Input
1	14	V_{CC}	Positive Supply: 3.0V ≤ V_{CC} ≤ 5.5V. Do not operate device with V_{CC} > 5.5V
—	1, 8, 13	N.C.	No Connect—not internally connected

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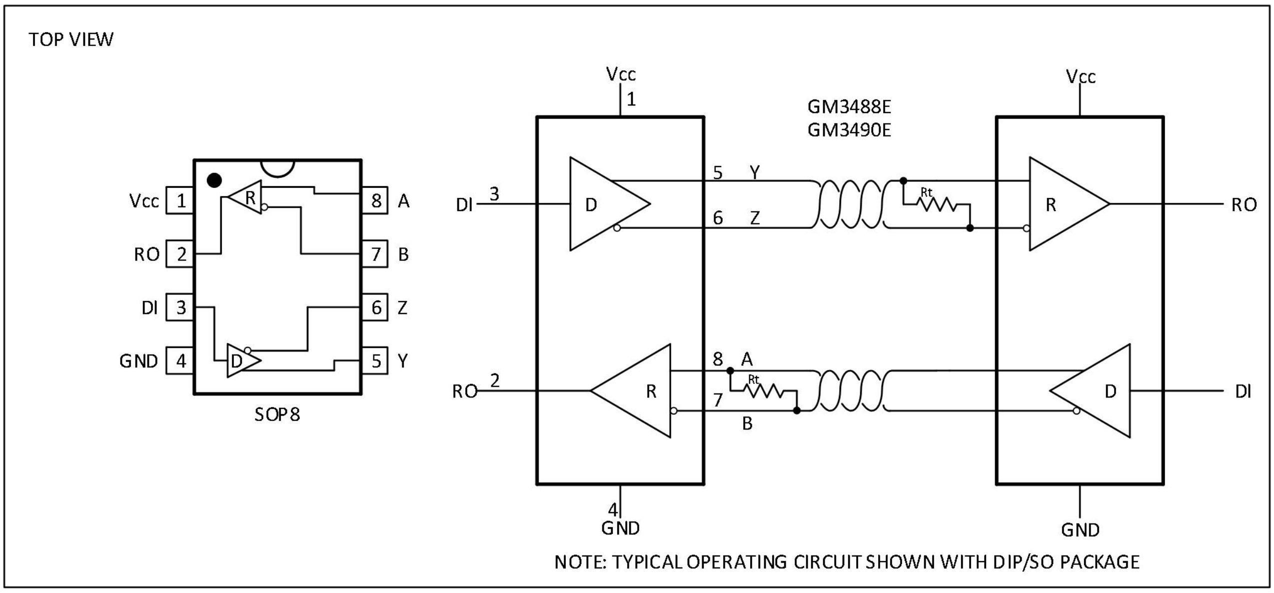

Figure 2. GM3488E/GM3490E Pin Configuration and Typical Operating Circuit

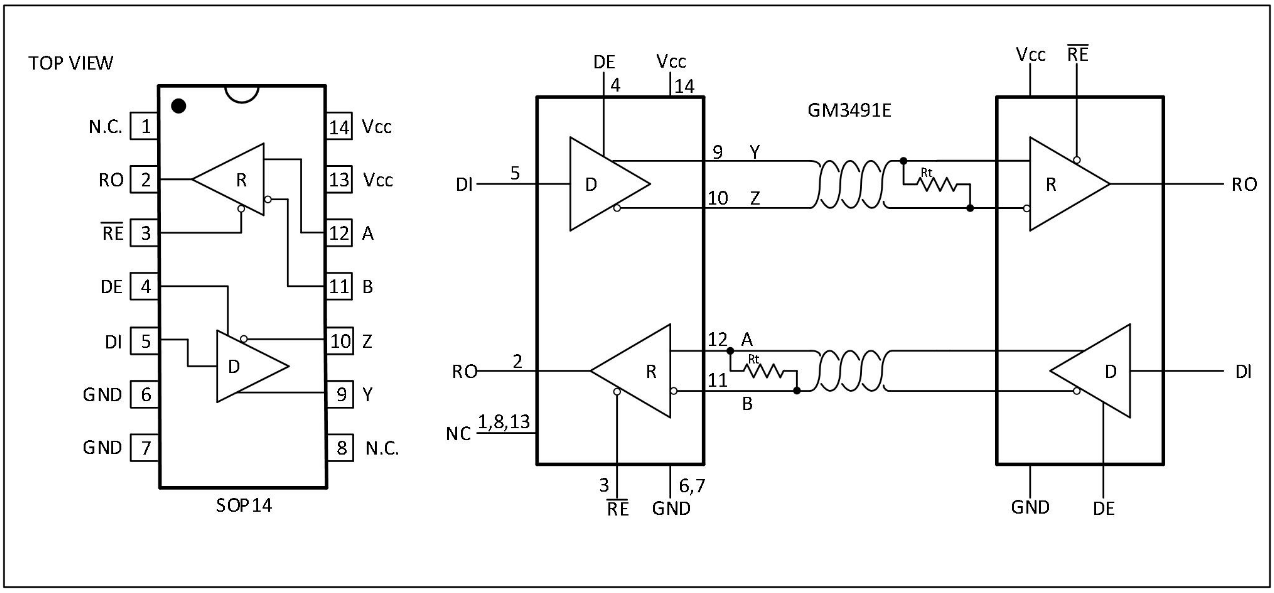

Figure 3. GM3491E Pin Configuration and Typical Operating Circuit

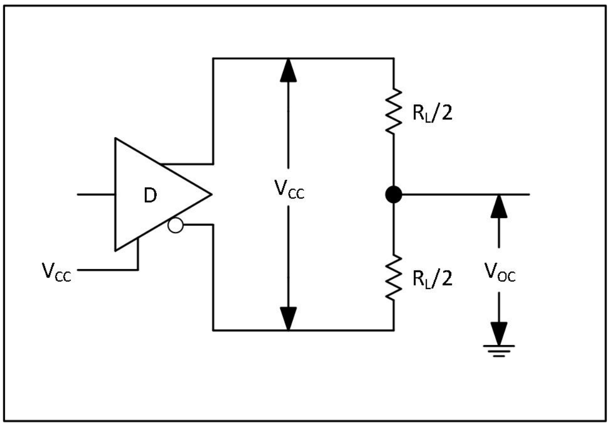

Figure 4. Driver V_{OD} and V_{OC}

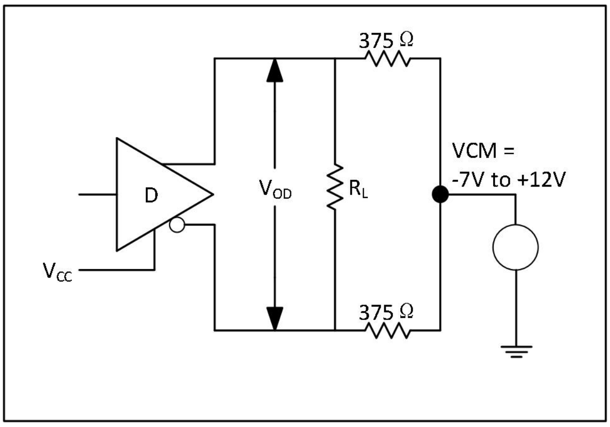

Figure 5. Driver V_{OD} with Varying Common-Mode Voltage

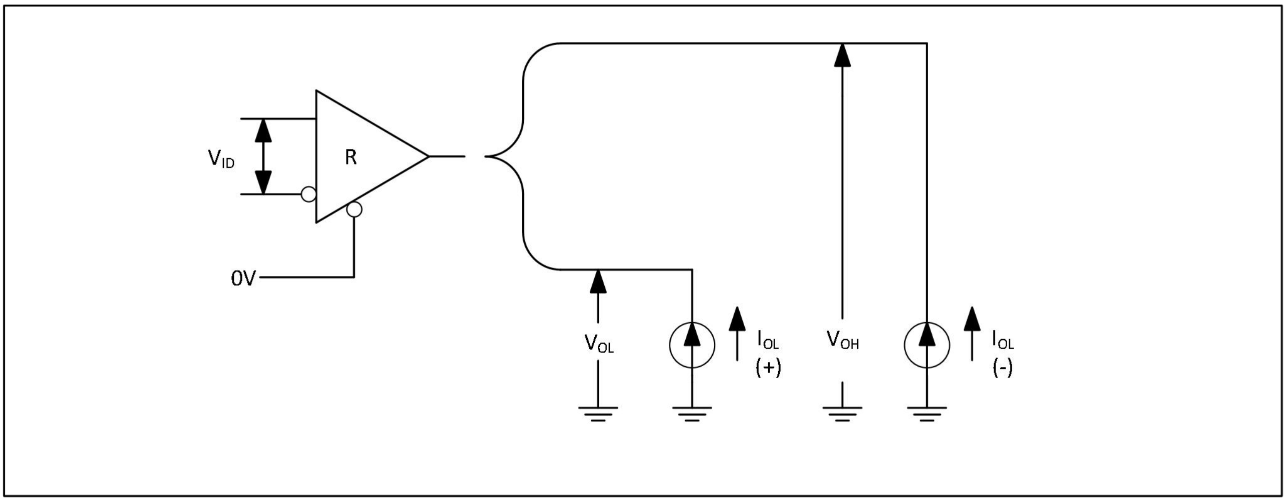

Figure 6. Receiver V_{OH} and V_{OL}

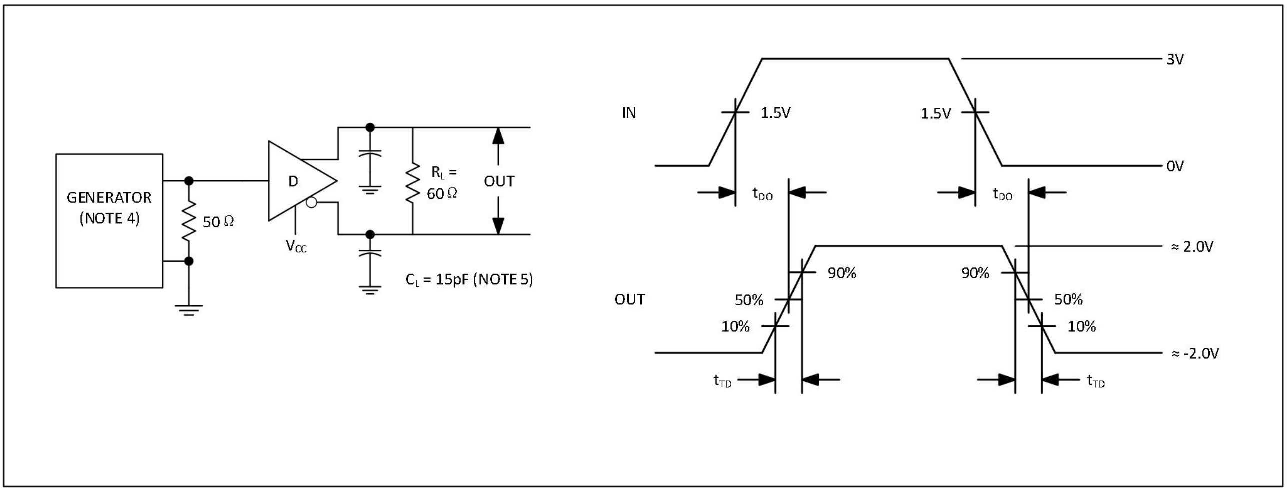

Figure 7. Driver Differential Output Delay and Transition Times

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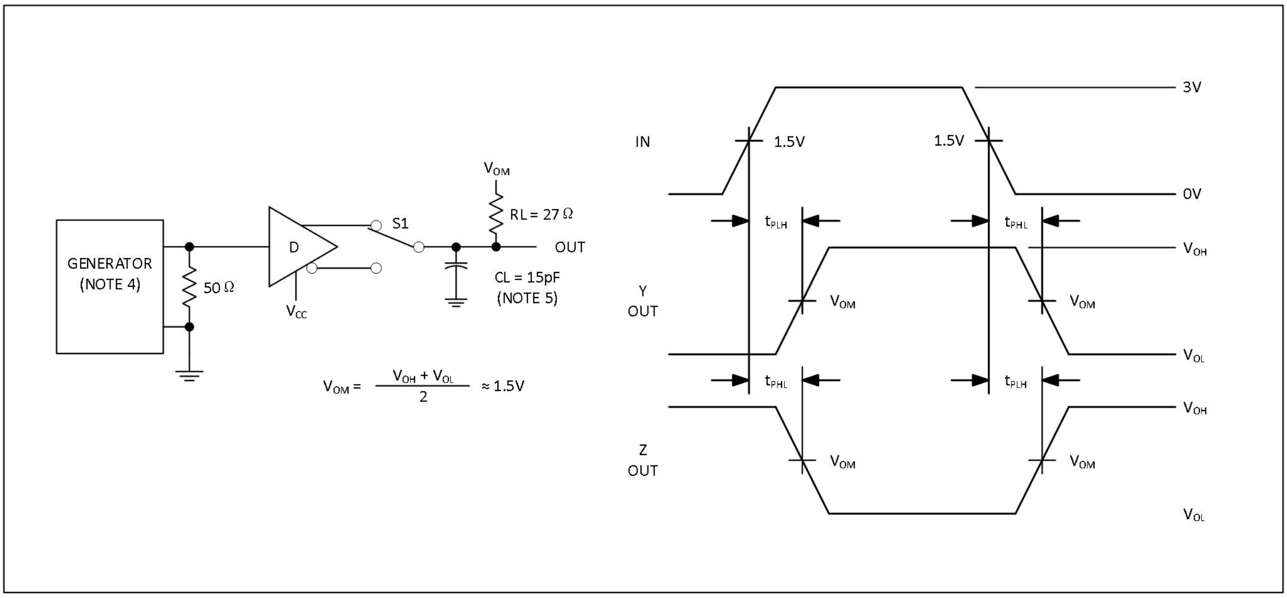

Figure 8. Driver Propagation Times

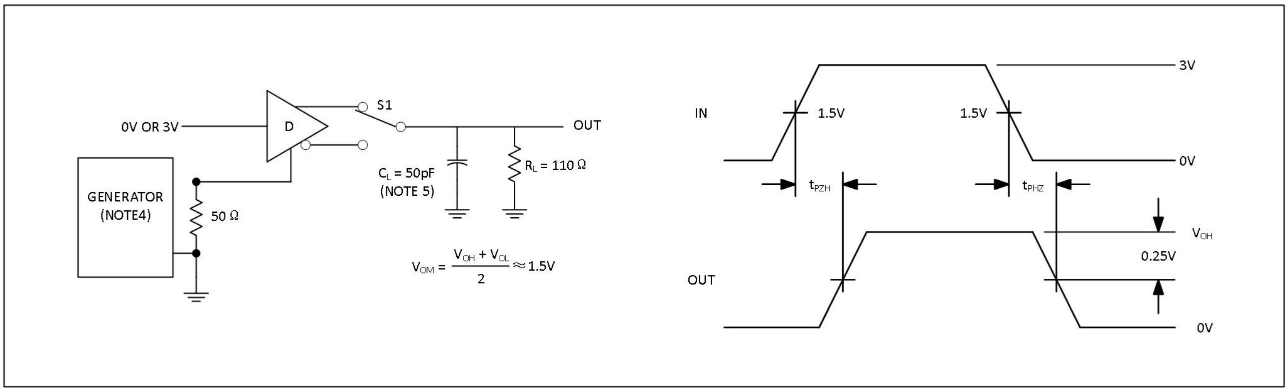

Figure 9. Driver Enable and Disable Times (t_{PZH}, t_{PSH}, t_{PHZ})

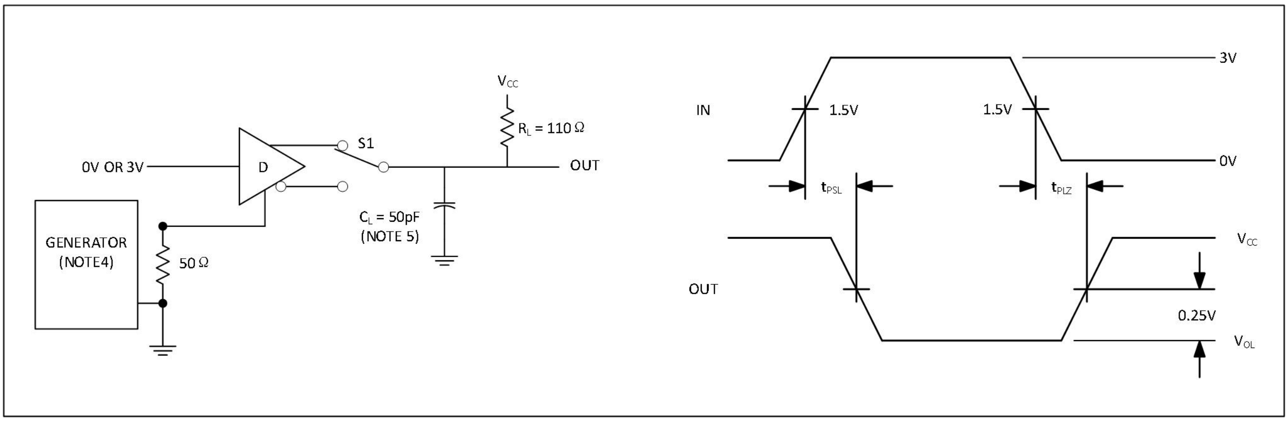

Figure 10. Driver Enable and Disable Times (t_{PZL}, t_{PSL}, t_{PLZ})

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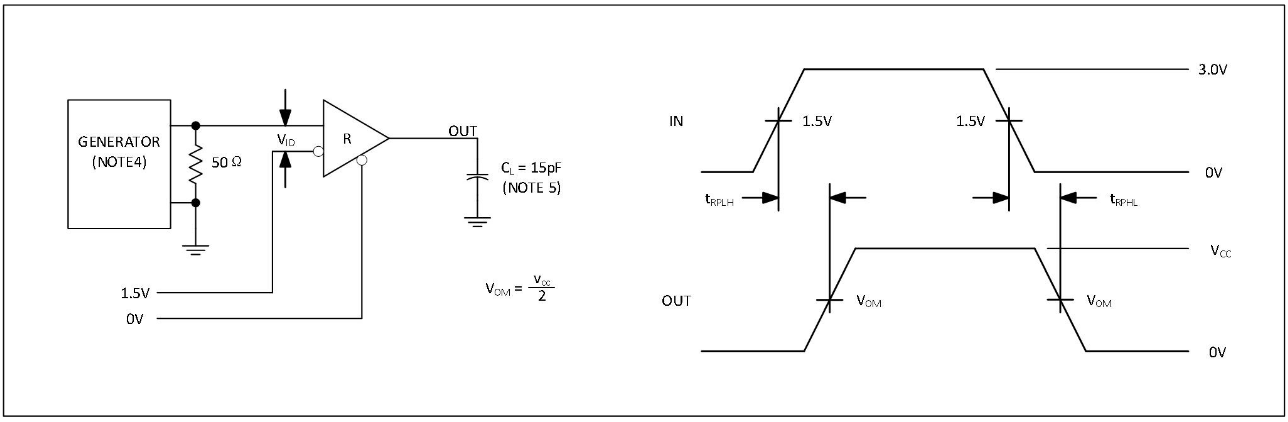

Figure 11. Receiver Propagation Delay

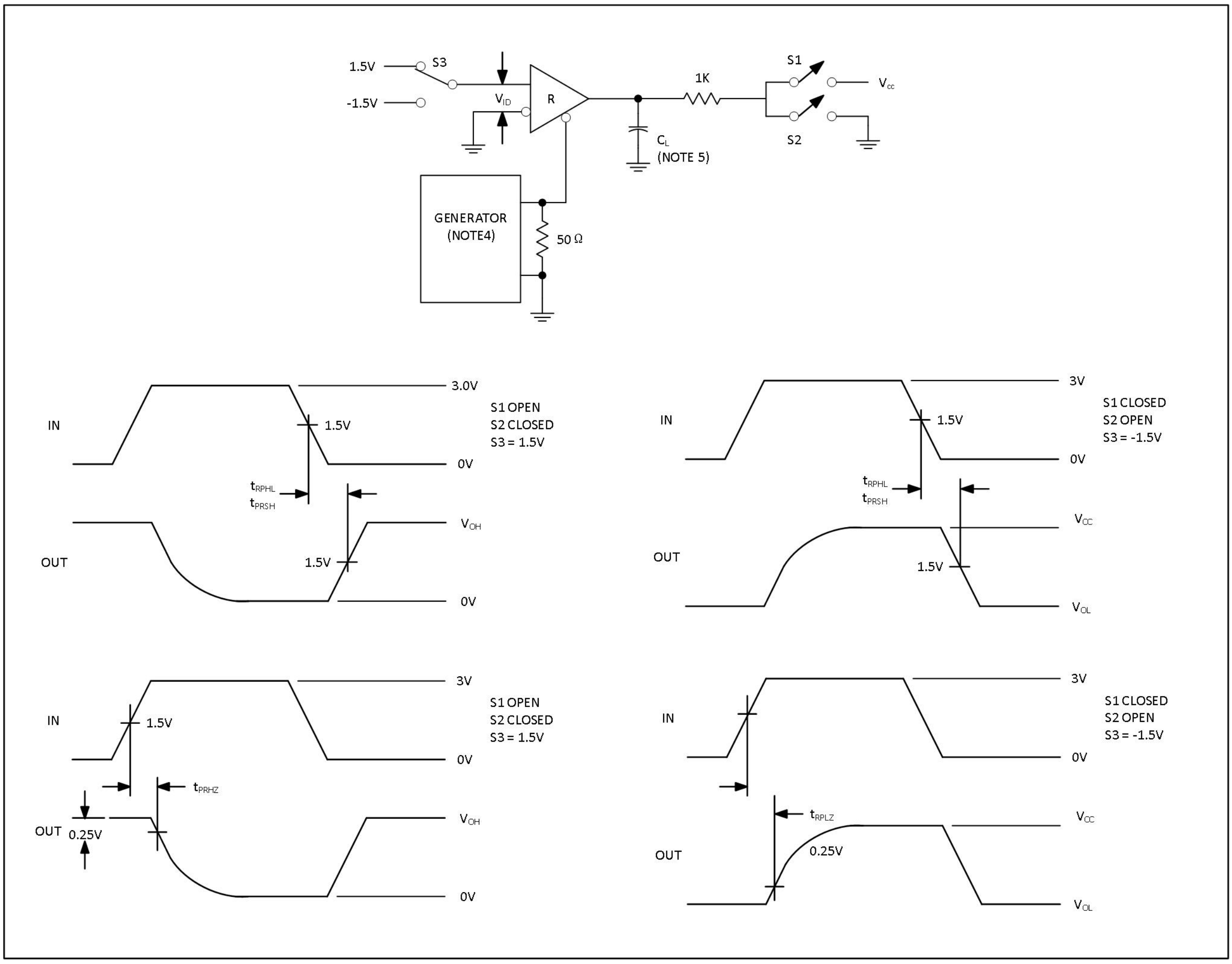

Figure 12. Receiver Enable and Disable Times

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

Note 5: C_L includes probe and stray capacitance.

5. Function Tables

5.1 Devices with Receiver/Driver Enable (GM3491E)

Table 1. Transmitting

INPUTS			OUTPUTS		MODE
$\overline{RE}$	DE	DI	B*	A*	
×	1	1	0	1	Normal
×	1	0	1	0	Normal
0	0	×	High-Z	High-Z	Normal
1	0	×	High-Z	High-Z	Shutdown

* B and A outputs are Z and Y, respectively, for full-duplex part (GM3491E).

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

Table 2. Receiving

INPUTS			OUTPUTS	MODE
$\overline{RE}$	DE	A,B	RO	
×	1	≧ +0.2V	1	Normal
×	1	≦ -0.2V	0	Normal
0	0	Inputs Open	1	Normal
1	0	×	High-Z	Shutdown

* DE is a "don't care" (x) for the full-duplex part (GM3491E).

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

5.2 Devices without Receiver/Driver Enable(GM3488E/GM3490E)

Table 3. Transmitting

INPUT	OUTPUTS	
DI	Z	Y
1	0	1
0	1	0

Table 4. Receiving

INPUT	OUTPUT
A,B	RO
≧ +0.2V	1
≦ -0.2V	0
Inputs Open	1

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6. Applications Information

TheGM3488E/GM3490E/GM3491E are low-power transceivers for RS-485 and RS-422 communications. The GM3488E can transmit and receive at data rates up to 1Mbps, and the GM3490E/GM3491E at up to 12Mbps. The GM3488E/GM3490E/GM3491E are full-duplex transceivers, Driver Enable (DE) and Receiver Enable (RE) pins are included on the GM3491E. When disabled, the driver and receiver outputs are high impedance.

7. Reduced EMI and Reflections(GM3488E)

The GM3488E are slew-rate limited, minimizing EMI and reducing reflections caused by improperly terminated cables. Figure 13 shows the driver output waveform of a GM3490E/GM3491E transmitting a 125kHz signal, as well as the Fourier analysis of that waveform. High-frequency harmonics with large amplitudes are evident. Figure 14 shows the same information, but for the slew-rate-limited GM3488E transmitting the same signal. The high-frequency harmonics have much lower amplitudes, and the potential for EMI is significantly reduced.

8. Low-Power Shutdown Mode(GM3491E)

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 1.3uA of supply current.For these devices, the t_{PSH} and t_{PSL} enable times assume the part was in the low-power shutdown mode; the t_{PZH} and t_{PZL} enable times assume the receiver or driver was disabled, but the part was not shut down.

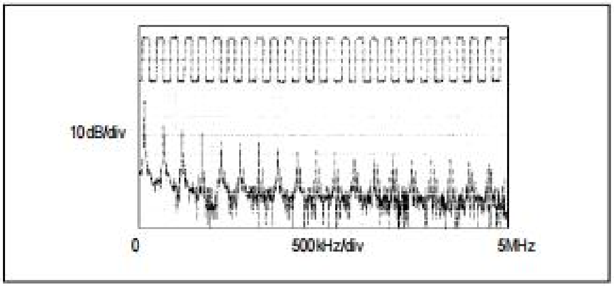

Figure 13. Driver Output Waveform and FFT Plot of GM3490E/GM3491E Transmitting a 125kHz Signal

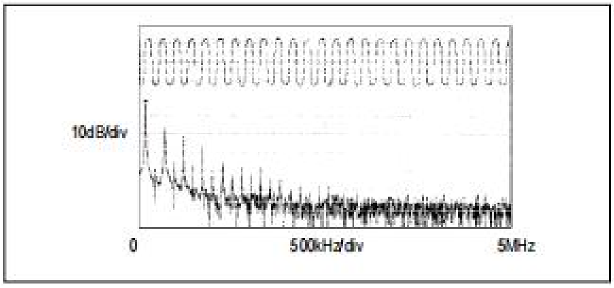

Figure 14. Driver Output Waveform and FFT Plot of GM3488E Transmitting a 125kHz Signal

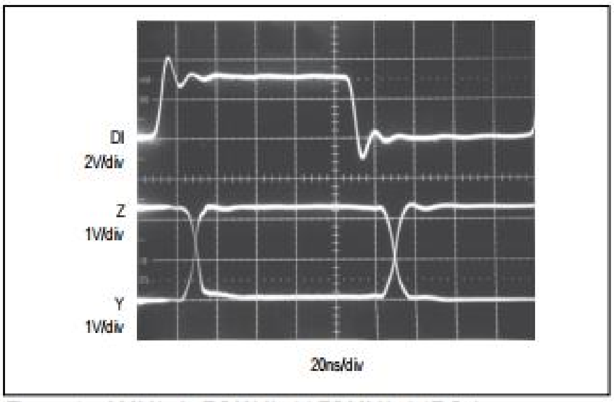

Figure 15. GM3490E/GM3491E Driver Propagation Delay

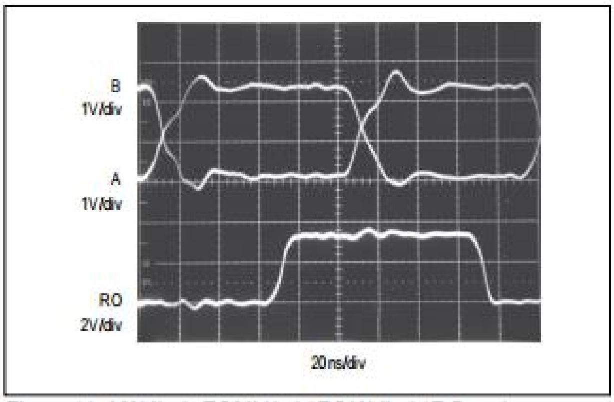

Figure 16. GM3490E/GM3491E Receiver Propagation Delay Driven by External RS-485 Device

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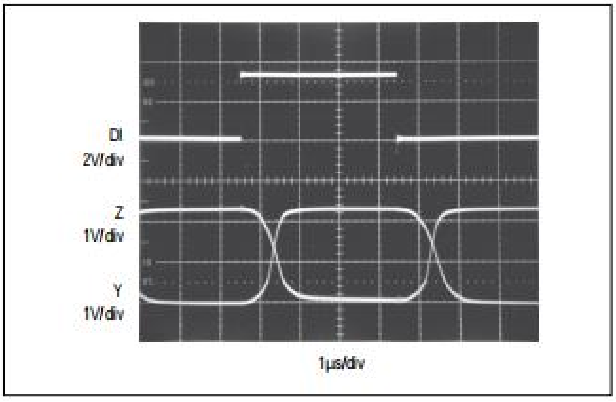

Figure 17. GM3488E Driver Propagation Delay

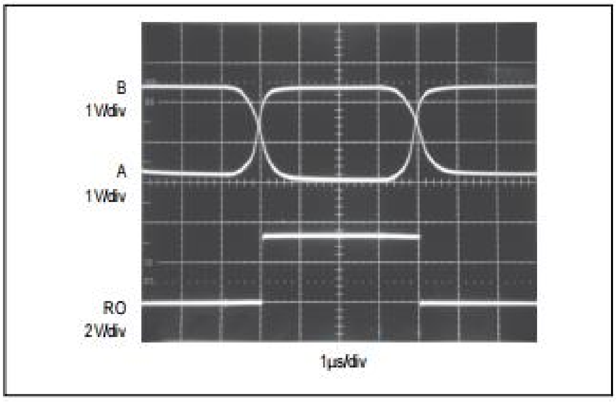

Figure 18. GM3488E Receiver Propagation Delay

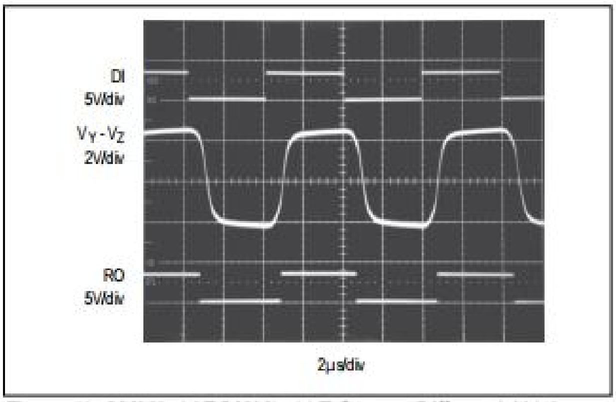

Figure 19. GM3488E System Differential Voltage at 125kHz Driving 4000 Feet of Cable

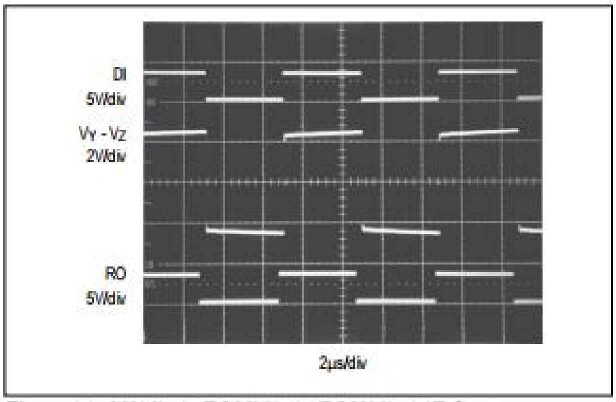

Figure 20. GM3490E/GM3491E System Differential Voltage at 125kHz Driving 4000 Feet of Cable

9. Driver Output Protection

Excessive output current and power dissipation caused by faults or by bus contention are prevented by two mechanisms. A fold-back current limit on the output stage provides immediate protection against short circuits over the whole common-mode voltage range. In addition, a thermal shutdown circuit forces the driver outputs into a high-impedance state if the die temperature rises excessively.

10. Propagation Delay

Figures 15 – 18 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, $|t_{PRLH} - t_{PRHL}|$, is under 10ns 20ns for the GM3488E). The driver skew times are 8ns for the GM3490E/GM3491E.

11. 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, see Figure 21 for an example of a line repeater. Figures 19 and 20 show the system differential voltage for parts driving 4000 feet of 26AWG twisted-pair wire at 125kHz into 120Ω loads. For faster data rate transmission, please consult the factory.

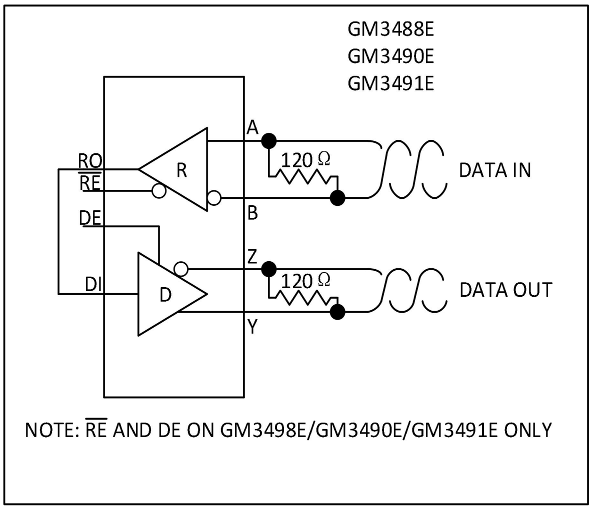

Figure 21. Line Repeater for GM3488E/GM3490E/GM3491E

12. ±15kV ESD Protection

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 GM3485E family of devices have extra protection against static electricity. 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.

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) ±8kV using the Contact-Discharge method specified in IEC 1000-4-2
3) ±15kV using IEC 1000-4-2's Air-Gap method.

13. ESD Test Conditions

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

14. Human Body Model

Figure 22a shows the Human Body Model and Figure 22b 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.

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15. 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 GM3485E family of devices helps 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 23a shows the IEC 1000-4-2 model, and Figure 23b 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. The contact-discharge method connects the probe to the device before the probe is energized.

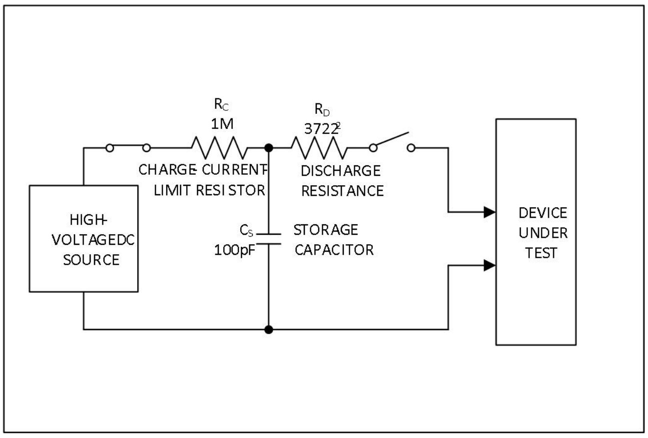

Figure 22a. Human Body ESD Test Model

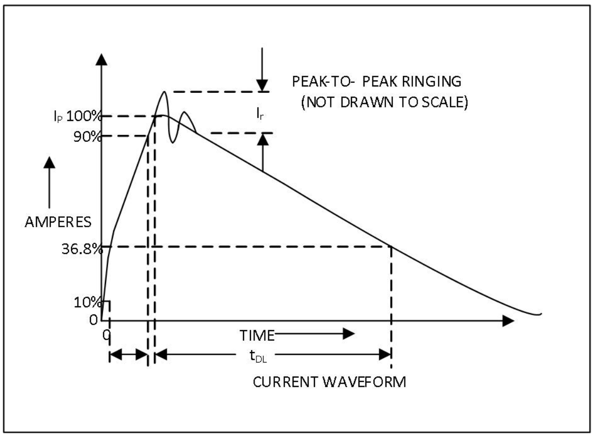

Figure 22b. Human Body Current Waveform

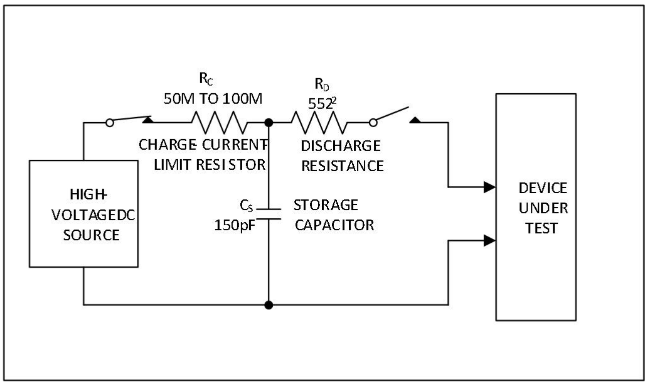

Figure 23a. IEC 1000-4-2 ESD Test Model

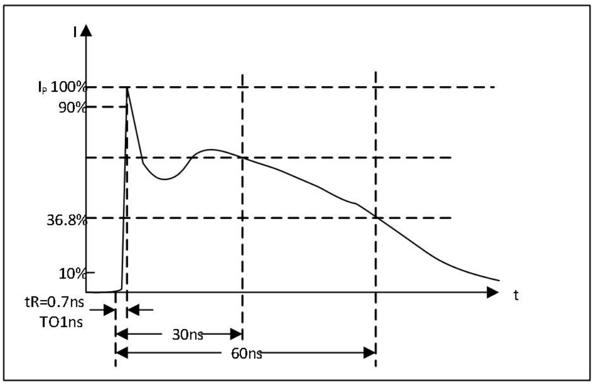

Figure 23b. IEC 1000-4-2 ESD Generator Current Waveform

16. 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.

17. Typical Applications

The GM3488E/GM3490E/GM3491E transceivers are designed for bidirectional data communications on multi point bus transmission lines. Figures 24 show typical net work applications circuits. These parts can also be used as line repeaters, with cable lengths longer than 4000 feet, as shown in Figure 21.

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 GM3488E is more tolerant of imperfect termination.

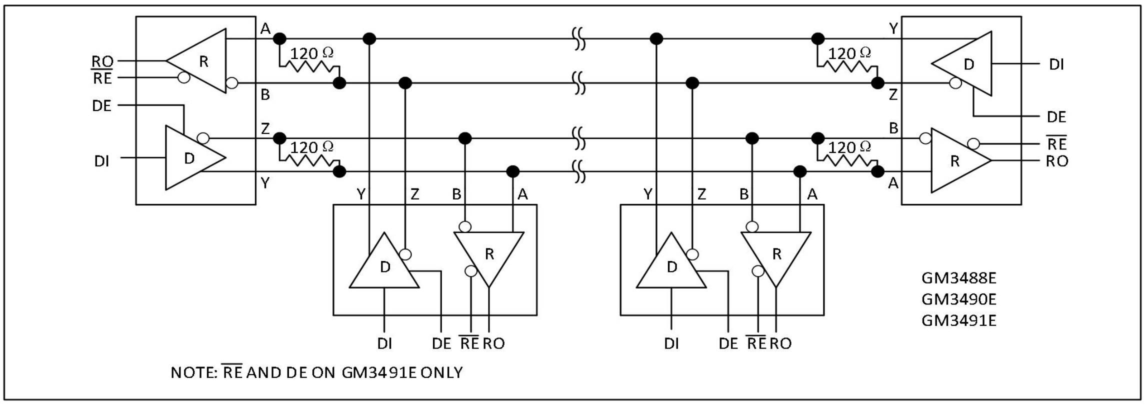

Figure 24. GM3488E/GM3490E/GM3491E Full-Duplex RS-485 Network

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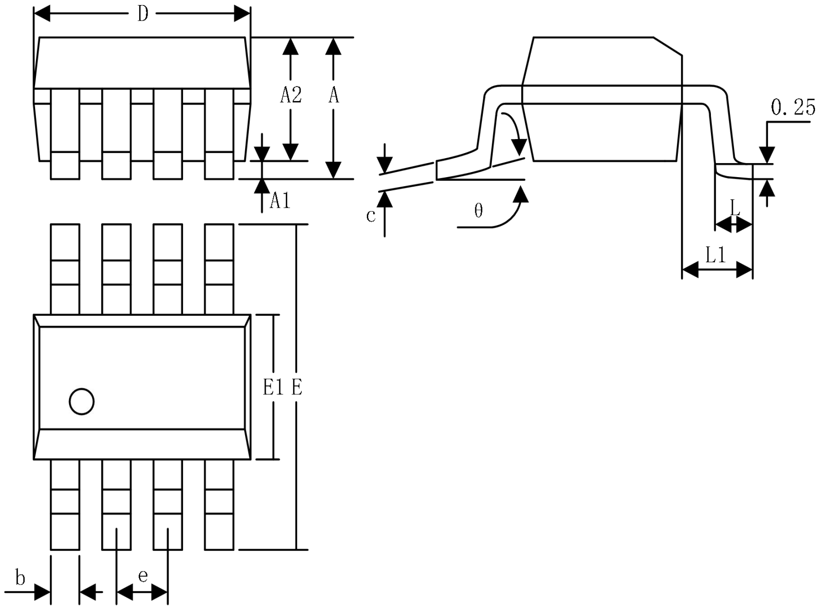
SOP-8L



SYMBOLS	MILLIMETER		
	MIN	NOM	MAX
A	1.5	-	1.7
A1	0.1	-	0.25
A2	1.3	1.4	1.5
b	0.33	0.4	0.47
C	0.2	-	0.25
D	4.7	4.9	5.1
E	5.9	6	6.1
E1	3.8	3.9	4
e	1.27(BSC)		
L	0.55	0.6	0.75
L1	1.05(BSC)		
θ	0°	4°	8°

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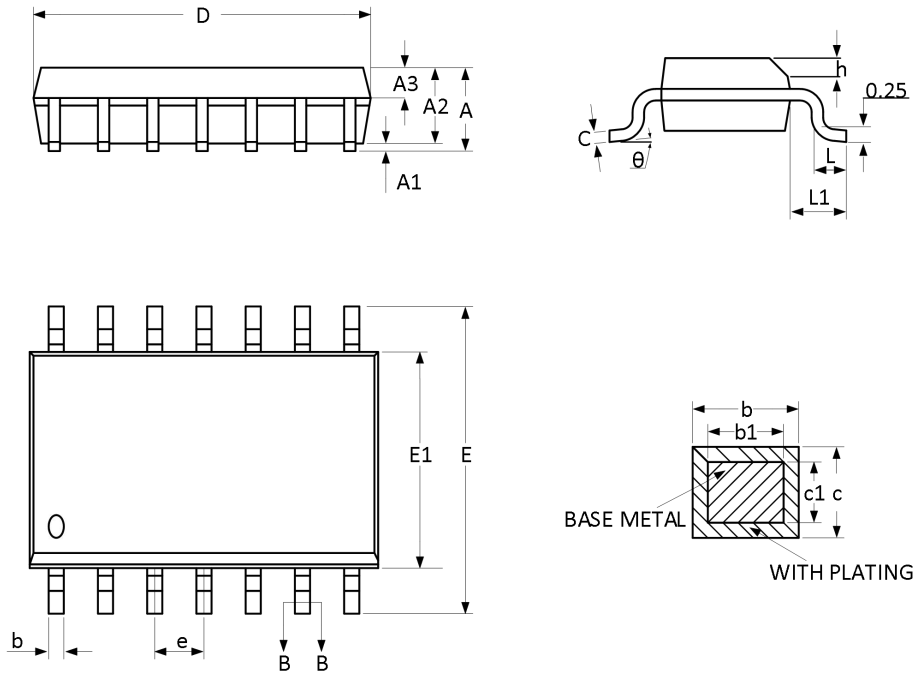
SOP-14



SYMBOLS	MILLIMETER		
	MIN	NOM	MAX
A	-	-	1.75
A1	0.05	-	0.225
A2	1.30	1.40	1.50
A3	0.60	0.65	0.70
b	0.39	-	0.47
b1	0.38	0.41	0.44
c	0.20	-	0.24
c1	0.19	0.20	0.21
D	8.55	8.65	8.75
E	5.80	6.00	6.20
E1	3.80	3.90	4.00
e	1.24BSC		
h	0.25	-	0.50
L	0.50	-	0.80
L1	1.05REF		
θ	0°	-	8°

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Order Information

Order number	Package	Marking information	Operation Temperature Range	MSL Grade	Ship, Quantity	Green
GM3488ESA	SOP8	GM3488E	-40 to 85°C	3	T&R, 2500	Rohs
GM3490ESA	SOP8	GM3490E	-40 to 85°C	3	T&R, 2500	Rohs
GM3491ESA	SOP14	GM3491E	-40 to 85°C	3	T&R, 2500	Rohs

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Version modification record

<table>
<tr><th>version</th><th>Modify the description</th><th>page</th><th>time</th><th>Modify personnel</th></tr>
<tr><td rowspan="4">1.1</td><td>1.Original:GM3490_GM3491_1.0 →
GM3490_GM3491_1.1</td><td></td><td rowspan="4">On June 21,2024</td><td rowspan="4">Fan</td></tr>
<tr><td>2.Input Current testing environment.Increase the VCC
Floating</td><td rowspan="3">2</td></tr>
<tr><td>3.Output Leakage (Y, Z)
V_{OUT} = 12V environment MAX=20uA → MAX=100uA.
V_{OUT} = -7V environment MAX=-20uA → MAX=-100uA.</td></tr>
<tr><td>4.Output Leakage (Y, Z) in Shutdown Mode,
testing environment $\overline{RE}$ =0V → $\overline{RE}$ =5V,
V_{OUT} = 12V environment. MAX=1uA → MAX=100uA.
V_{OUT} = -7V environment MAX=-1uA → MAX=-100uA.</td></tr>
</table>

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