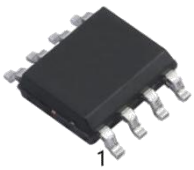
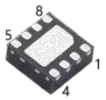
3.0V~5.5V,±15KV ESD-Protected, Fail-safe, Hot-Swap,RS-485/RS-422 Transceivers

Features

- 3.0~5.5V Operation
- Extended ESD Protection for RS-485/RS-422 I/O Pins ±15kV Human Body Model
- True Fail-Safe Receiver While Maintaining EIA/TIA-485 Compatibility
- Hot-Swap Input Structures on DE and $\overline{RE}$
- Enhanced Slew-Rate Limiting Facilitates Error- Free Data Transmission
- Low-Current Shutdown Mode
- Allow Up to 256 Transceivers on the Bus
- Available in Industry-Standard SOP-8 and DFN-8 Packages



SOP-8



DFN-8 3*3

Ordering Information

DEVICE	Package Type	MARKING	Packing	Packing Qty
MAX13485EIM/TR	SOP-8	X13485	REEL	2500pcs/reel
MAX13485EIDQ3/TR	DFN-8 3*3	X13485	REEL	5000pcs/reel

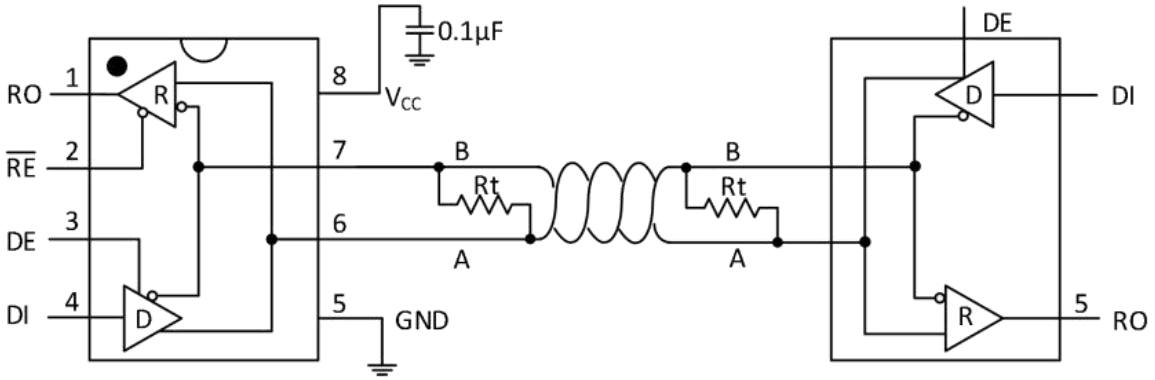
General Description

The MAX13485 3.0~5.5V,+15kV ESD-protected, RS-485/RS-422 transceiver features one driver and one receiver.The device includes fail-safe circuitry, guaranteeing a logic-high receiver output when receiver inputs are open or shorted. The receiver outputs a logic-high if all transmitters on a terminated bus are disabled (high impedance). The MAX13485 includes a hot-swap capability to eliminate false transitions on the bus during power-up or hot insertion.The MAX13485 features reduced slew-rate drivers that minimize EMI and reduce reflections caused by improperly terminated cables, allowing error-free data transmission up to 1Mbps.The MAX13485 is ideal for half-duplex communications and it draws 0.5mA of supply current when unloaded or when fully loaded with the drivers disabled. The MAX13485 has a 1/8-unit load receiver input impedance, allowing up to 256 transceivers on the bus.The MAX13485 is available in SOP-8 and DFN-8 packages.

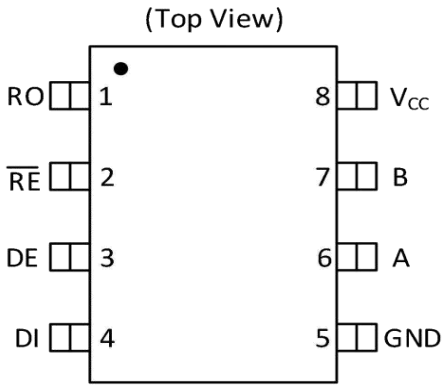
Applications

- Utility Meters
- Lighting Systems
- Industrial Control
- Telecom
- Security System
- Instrumentation
- Profibus

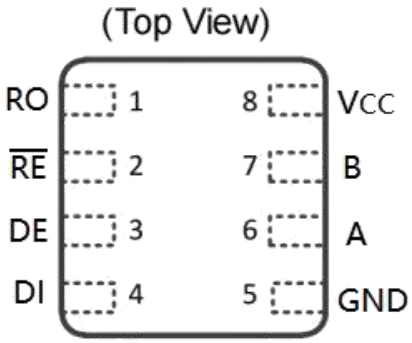
Typical Half-Duples Operating Circuit



Pin Configuration And Functions



SOP-8



DFN-8 3*3

Pin		Description
Name	No.	
RO	1	Receiver Output. When $\overline{RE}$ is low and if (A-B)≧-50mV, RO is high; if (A-B)≤-200mV, RO is low.
$\overline{RE}$	2	Receiver Output Enable.Drive $\overline{RE}$ low to enable the RO;Drive $\overline{RE}$ high to let the RO in high-impedance;Drive $\overline{RE}$ high and DE low to enter low-power shutdown mode. $\overline{RE}$ is a Hot-swap input(see the Hot-Swap Capability section for details).
DE	3	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.DE is a hot-swap input(see the Hot-Swap Capability section for details).
DI	4	Driver Input. With DE high, a low on DI forces noninverting output low and inverting output high. Similarly, a high on DI forces noninverting output high and inverting output low.
GND	5	Ground
A	6	Noninverting Receiver Input and Noninverting Driver Output
B	7	Inverting Receiver Input and Inverting Driver Output
V_{CC}	8	Positive Supply Vcc =3.0~5.5V.Bypass Vcc to GND with a 0.1μF capacitor.

Absolute Maximum Ratings

Parameter	Parameter	Rating	UNIT
V_{CC}	Supply Voltage	+6	V
$\overline{RE}$,DE	Control Input Voltage	-0.3 to +6	V
DI	Driver Input voltage	-0.3 to +6	V
A,B	Receiver Input Voltage	-8V to ±13	V
A,B	Driver Output Voltage	-8V to ±13	V
RO	Receiver Output Voltage	-0.3 to (VCC+0.3)	V
P	SOP(derate 5.9mW/°C above +70°C)	471	mW
T_{OP}	Operating Temperature Range	-40 to +85	°C
T_J	Junction Temperature	+150	°C
T_{STO}	Storage Temperature Range	-65 to +150	°C
T_L	Lead Temperature(soldering,10s)	260	°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

(V_{CC} = 5V ±5%, T_A = T_{MIN} to T_{MAX}.Typical values are at V_{CC}=+5V,T_A=25°C, unless otherwise noted.) (1)

Symbol	Parameter	Test Conditions		MIN	TYP	MAX	UNIT
Driver							
V_{CC}	Supply voltage			3.0		5.5	V
V_{OD1}	Differential Driver Output(No load)	No load				V_{CC}	V
V_{OD2}	Differential Driver Output	RL=100Ω(RS-422),Figure 1		3		V_{CC}	V
		RL=54Ω(RS-485),Figure 1		2		V_{CC}	V
ΔV_{OD}	Change in Magnitude of Differential Output Voltage(2)	RL=100Ω or RL=54Ω,Figure 1				0.2	V
V_{OC}	Driver Common- Mode Output Voltage	RL=100Ω or RL=54Ω,Figure 1			V_{CC}/2	3	V
ΔV_{OC}	Change in Magnitude of Common- Mode Voltage(2)	RL=100Ω or RL=54Ω,Figure 1				0.2	V
V_{IH1}	Input-High Voltage	DE,DI, $\overline{RE}$		2			V
V_{IL1}	Input-Low Voltage	DE,DI, $\overline{RE}$				0.8	V
V_{HYS}	Input Hysteresis	DE,DI, $\overline{RE}$			300		mV
I_{IN1}	Input Current	DE,DI, $\overline{RE}$,VCC floating				±2	μA
R_{PWUP}	Input Impedance on First Transition at Power-Up	V_{DE}, V_{RE} = V_{RE} = 2V		3.65		8.8	kΩ
R_{ft}	Input Impedance on First Transitionafter POR Delay	V_{DE} = V_{RE} = 2V		7		60	kΩ
I_{OSD}	Driver Short-Circuit Output Current	0≤V_{OUT}≤+12V(3)		40		250	mA
		-7V≤V_{OUT}≤VCC (3)		-250		-40	
I_{OSDF}	Driver Short-Circuit Foldback Output Current	(V_{CC}-1V)≤V_{OUT}≤+12V(3)		20			mA
		-7V≤V_{OUT}≤±1V(3)				-20	
T_{TS}	Thermal-Shutdown Threshold				175		°C
T_{TSH}	Thermal-Shutdown Hysteresis				15		°C
$I_{A,B}$	Input Current for A and B	DE=GND,	V_{IN}=+12V			100	μA
		V_{CC}=GND or V_{CC}	V_{IN}=-7V	-100			
Receiver							
V_{TH}	Receiver Differential Threshold Voltage	-7V≤V_{CM}≤12V		-200	-125	-50	mV
ΔV_{TH}	Receiver Input Hysteresis	V_A+V_B=0V			15		mV
V_{OH}	Receiver Output-High Voltage	I_O= -1mA		V_{CC}-0.6		V_{CC}	V
V_{OL}	Receiver Output-Low Voltage	I_O= 1mA				0.4	V
I_{OZR}	Three-State Output Current at Receiver	0V≤VO≤V_{CC}				≤1	μA
R_{IN}	Receiver Input Resistance	-7V≤V_{CM}≤12V		96			kΩ
I_{OSR}	Receiver Output Short-Circuit Current	0V≤V_{RO}≤V_{CC}				≤110	mV

Supply Current						
I_{CC}	Supply current	No load, $\overline{RE}$=GND DE=V_{CC}		0.5	0.7	mA
		No load, $\overline{RE}$=V_{CC}, DE=V_{CC}		0.5	0.7	
		No load, $\overline{RE}$=GND DE=GND		0.5	0.7	
I_{SHDN}	Supply Current in ShutdownMode	$\overline{RE}$=GND DE=GND		2.0	10	μA
ESD Protection						
E_{SD}	ESD Protection (A, B)	Human Body Mode		±15		kV
		Contact Discharge IEC 61000-4-2		±8		kV
		Air-Gap Discharge IEC 61000-4-2		±15		

Driver Switching Characteristics With Internal Srl(500Kbps)

(V_{CC}=+5V±5%,T_A=T_{MIN}~T_{MAX},Typical values are at V_{CC}=+5V and T_A = 25°C;unless otherwise noted.) (1)

Symbol	Parameter	Conditions	MIN	TYP	MAX	UNITS
t_{DPLH}	Driver Propagation Delay	R_L=54Ω,C_L=50pF, Figure 2 and Figure 3	200		1000	ns
t_{DPHL}			200		1000	
t_{DHKEW}	Driver Output Skew $\|t_{DPLH} - t_{DPHL}\|$	R_L=54Ω,C_L=50pF, Figure 2 and Figure 3			140	ns
t_R , t_F	Driver Differential Output Rise or Fall Time	R_L=54Ω,C_L=50pF, Figure 2 and Figure 3	100		500	ns
F_{MAX}	Maximum Data Rate		1000			kbps
t_{DZH}	Driver Enable to Output High	Figure 4			2500	ns
t_{DZL}	Driver Enable to Output Low	Figure 5			2500	ns
t_{DLZ}	Driver Disable Time from Low	Figure 5			100	ns
t_{DHZ}	Driver Disable Time from High	Figure 4			100	ns
$T_{DZH(SHDN)}$	Driver Enable from Shutdown to Output High	Figure 4			5500	ns
$t_{DZH(SHDN)}$	Driver Enable from Shutdown to Output Low	Figure 5			5500	ns
tS_{HDN}	Time to Shutdown		50	340	700	ns

Receiver Switching Characteristics With Internal Srl(500Kbps)

(V_{CC}=+5V±5%,T_A=T_{MIN}~T_{MAX},Typical values are at V_{CC}=+5V and T_A = 25°C;unless otherwise noted.) (1)

Symbol	Parameter	Conditions	MIN	TYP	MAX	UNITS
t_{RPLH}	Receiver Propagation Delay	C_L=15pF,Figure 6 and Figure 7			200	ns
t_{RPHL}					200	
t_{RSkEW}	Receiver Output Skew $\|t_{DPLH} - t_{DPHL}\|$	C_L=15pF,Figure 6 and Figure 7			30	ns
F_{MAX}	Maximum Data Rate		1000			kbps
t_{RZL}	Receiver Enable to Output Low	Figure 8			50	ns
t_{RZH}	Receiver Enable to OutputHigh	Figure 8			50	ns
t_{RLZ}	Receiver Disable Time from Low	Figure 8			50	ns
t_{RHZ}	Receiver Disable Time from High	Figure 8			50	ns
$t_{RZH(SHDN)}$	Receiver Enable from Shutdown to Output High	Figure 8			3500	ns
$t_{RZL(SHDN)}$	Receiver Enable from Shutdown to Output Low	Figure 8			3500	ns
t_{SHDN}	Time to Shutdown		50	340	700	ns

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.
2. ΔV_{OD} and ΔV_{OC} are the changes in V_{OD} and V_{OC}, respectively, when the DI input changes state.
3. The short-circuit output current applies to peak current just prior to foldback current limiting. The short-circuit foldback output current applies during current limiting to allow a recovery from bus contention.

Test Circuits And Waveforms

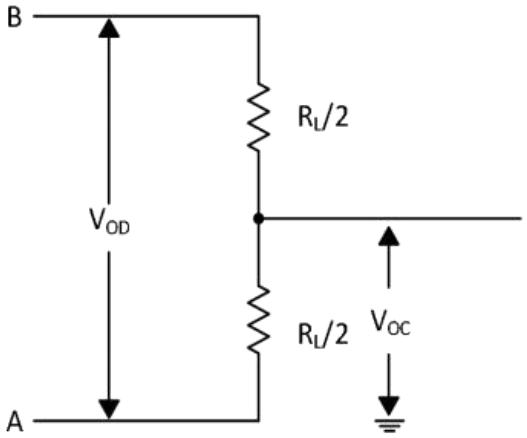


Figure 1. Driver DC Test Load

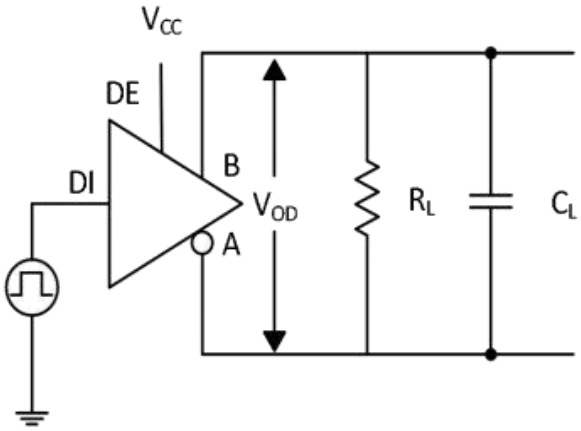


Figure 2.Driver timing test load

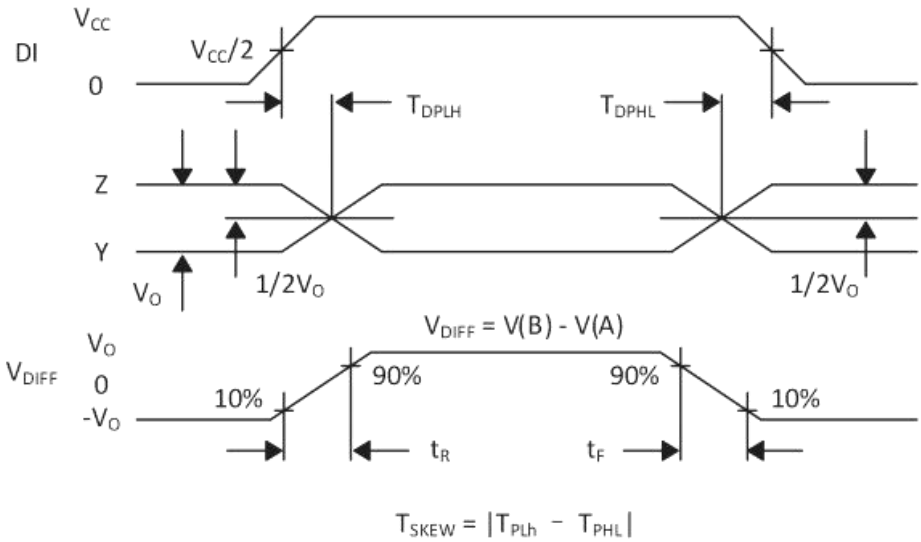


Figure 3.Driver Propagation Delays

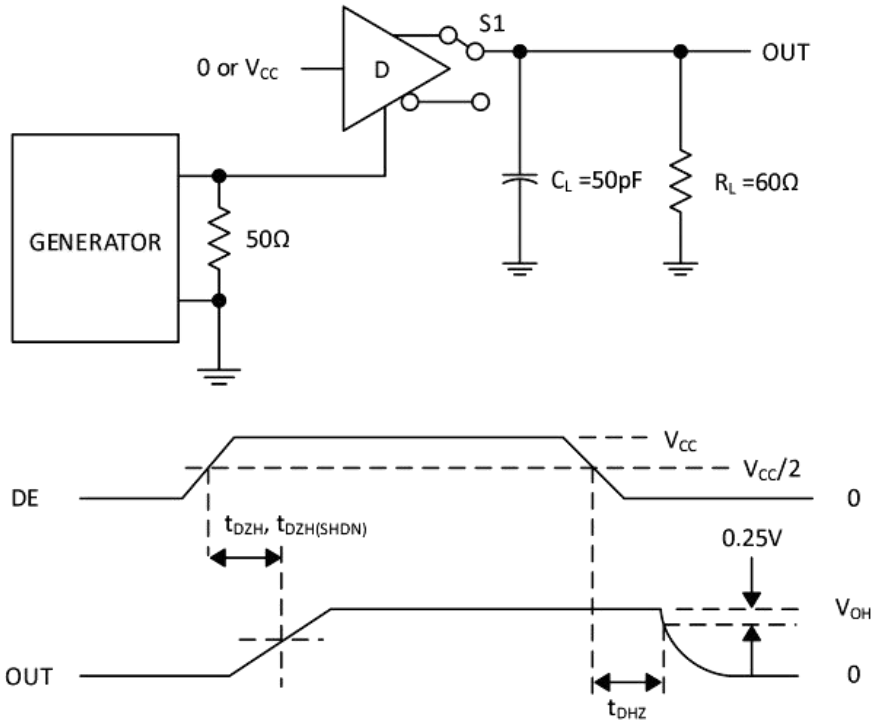


Figure 4. Driver Enable and Disable Times (t_{DHZ}, t_{DZH}, $t_{DZH(SHDN)}$)

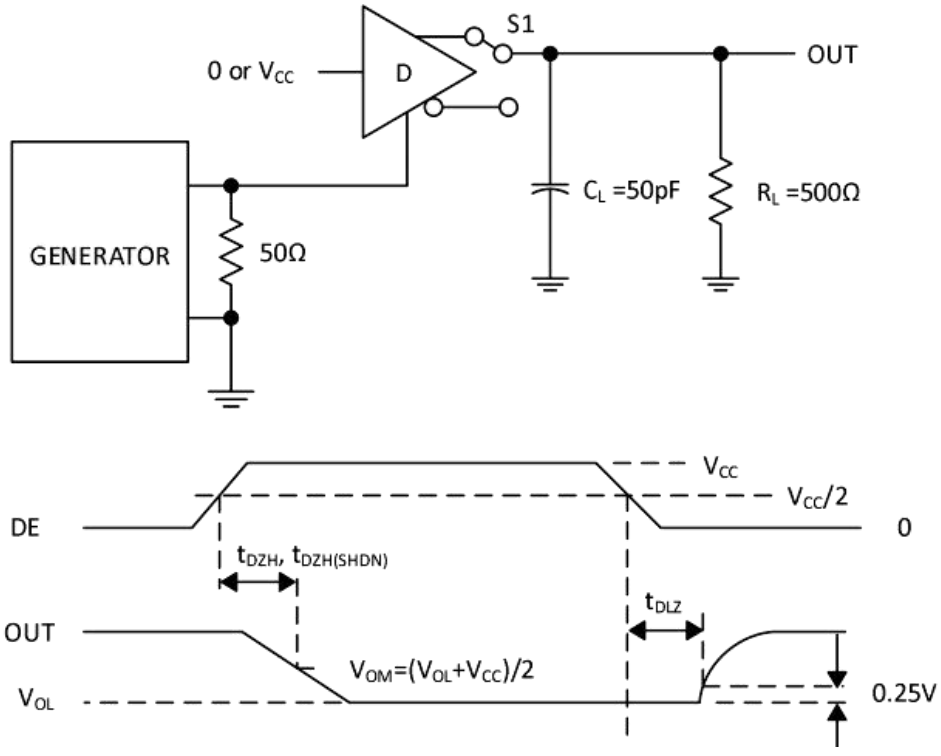


Figure 5. Driver Enable and Disable Times (t_{DZL}, t_{DLZ}, $t_{DLZ(SHDN)}$)

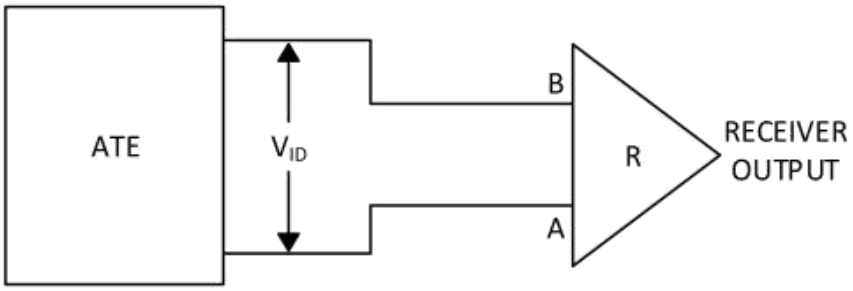


Figure 6. Receiver Propagation Delay Test Circuit

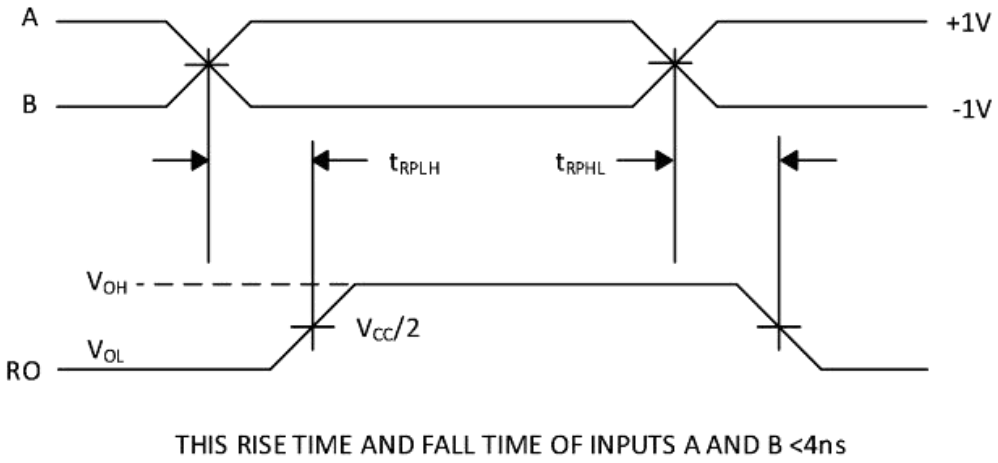
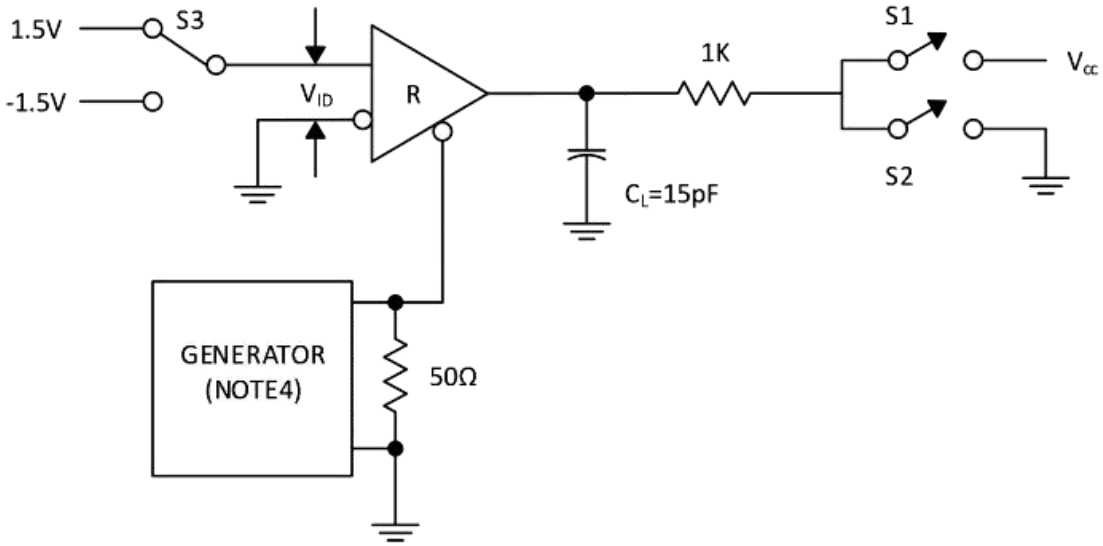


Figure 7. Receiver Propagation Delays



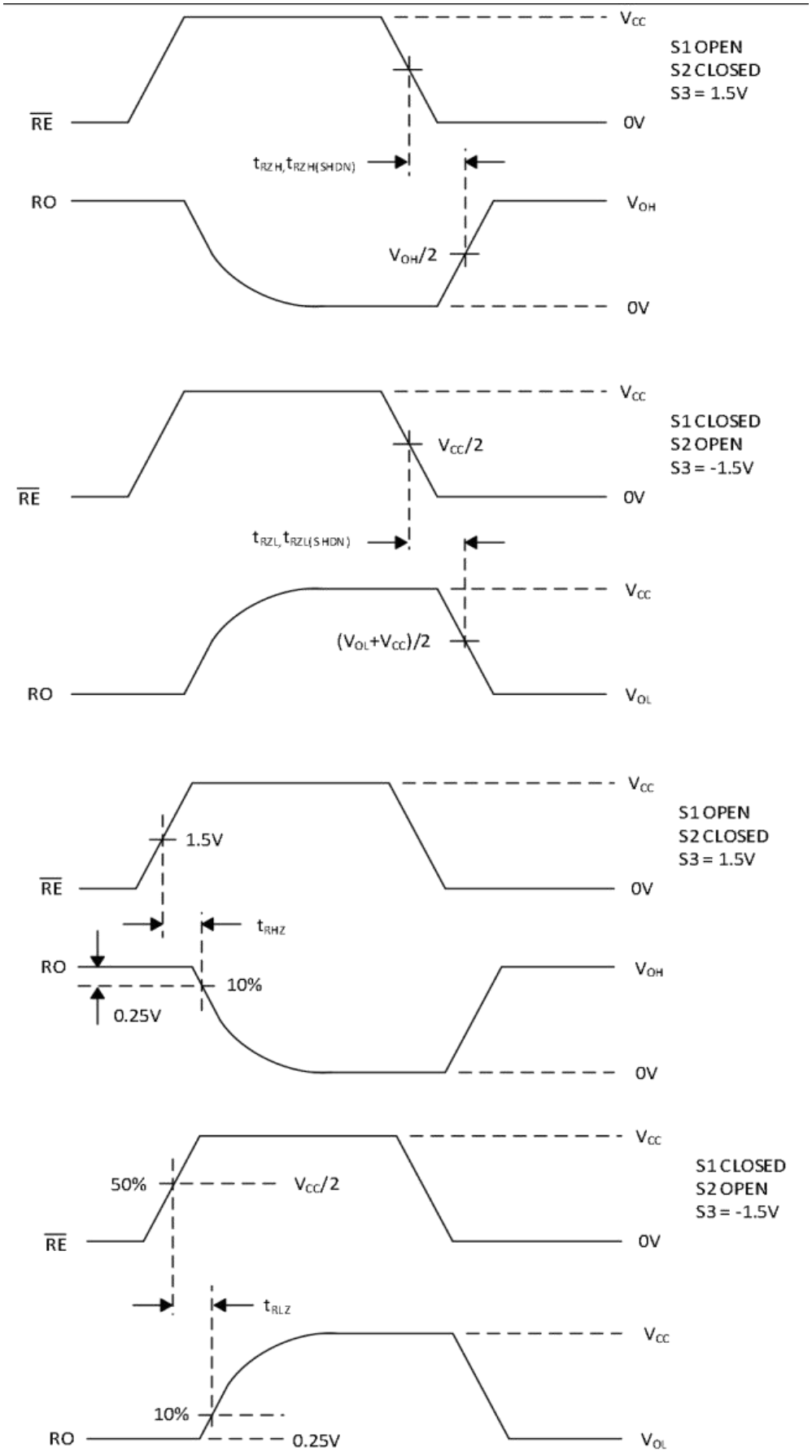
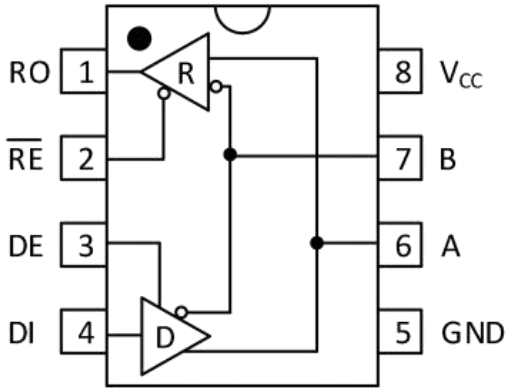


Figure 8. Receiver Enable and Disable Times

Function Tables



TRANSMITTING				
INPUTS			OUTPUTS	
DI	DE	$\overline{RE}$	A	B
1	1	X	1	0
0	1	X	0	1
X	0	0	Z	Z
X	0	1	Shutdown	

RECEIVING			
INPUTS			OUTPUTS
$\overline{RE}$	DE	A - B	RO
0	X	≥ -50mV	1
0	X	≤ -200mV	0
0	X	Open/Shorted	1
1	1	X	Z
1	0	X	Shutdown

Detailed Description

The MAX13485 high-speed transceiver for RS-485/RS-422 communication contains one driver and one receiver. This device features 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 MAX13485 also features a hot-swap capability allowing line insertion without erroneous data transfer (see the Hot-Swap Capability section). The MAX13485 features reduced slew-rate drivers that minimize EMI and reduce reflections caused by improperly terminated cables, allowing error-free data transmission up to 1Mbps. The MAX13485 is a half-duplex transceiver and operates from a single +3.0~5.5V 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 MAX13485 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 input threshold between -50mV 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 threshold of the MAX13485, 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.

Hot-Swap Capability

Hot-Swap Inputs

When circuit boards are inserted into a hot or powered backplane, differential disturbances to the data bus can lead to data errors. Upon initial circuit board insertion, the data communication processor undergoes its own power-up sequence. During this period, the processor's logic-output drivers are high impedance and are unable to drive the DE and RE inputs of these devices to a defined logic level. Leakage currents up to ±10μA from the high-impedance state of the processors logic drivers could cause standard CMOS enable inputs of a transceiver to drift to an incorrect logic level.Additionally, parasitic circuit board capacitance could cause coupling of V_{CC} or GND to the enable inputs. Without the hot-swap capability, these factors could improperly enable the transceiver's driver or receiver.When V_{CC} rises, an internal pulldown circuit holds DE low and RE high. After the initial power-up sequence, the pulldown circuit becomes transparent, resetting the hot-swap tolerable input.

Hot-Swap Input Circuitry

The enable inputs feature hot-swap capability. At the input there are two nMOS devices, M1 and M2 (Figure 9). When V_{CC} ramps from zero, an internal 7μs timer turns on M2 and sets the SR latch, which also turns on M1. Transistors M2, a 500μA current sink, and M1, a 100μA current sink, pull DE to GND through a 5kΩ resistor. M2 is designed to pull DE to the disabled state against an external parasitic capacitance up to 100pF that can drive DE high. After 7μs, the timer deactivates M2 while M1 remains on, holding DE low against three-state leak ages that can drive DE high. M1 remains on until an external source overcomes the required input current. At this time, the SR latch resets and M1 turns off. When M1 turns off, DE reverts to a standard, high-impedance CMOS input. Whenever V_{CC} drops below 1V, the hot swap input is reset.For RE there is a complementary circuit employing two pMOS devices pulling RE to V_{CC}.

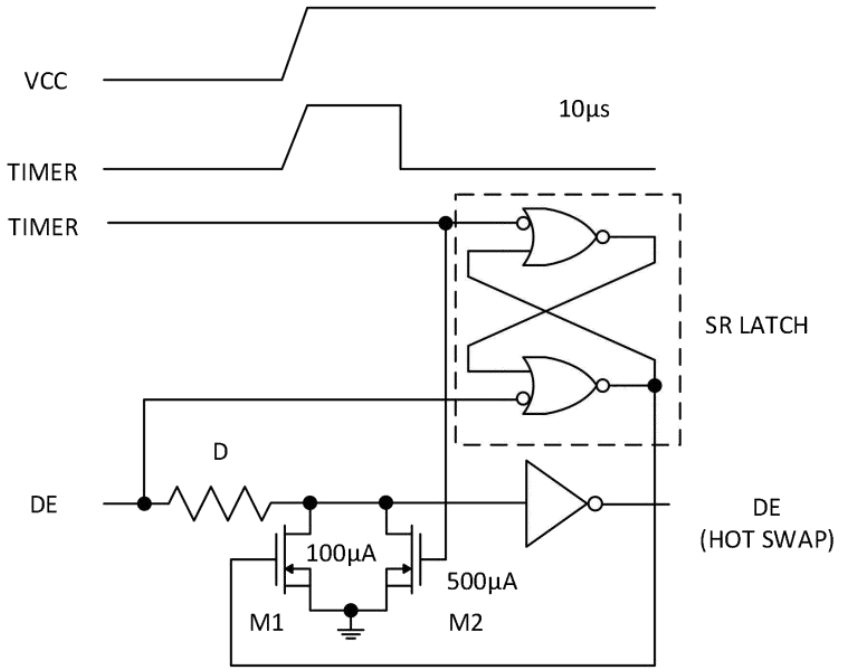


Figure 9. Simplified Structure of the Driver Enable Pin (DE)

±15kV ESD Protection

The driver output and receiver input of the MAX13485 have extra protection against static electricity.The ESD structures withstand high ESD in all states: normal operation, shutdown, and powered down. After an ESD event, the MAX13485 keeps working without latchup or damage.ESD protection can be tested in various ways. The transmitter

output and receiver input of the MAX13485 are characterized for protection to the following limits:

- ±15kV using the Human Body Model
- ±8kV using the Contact Discharge method specified in IEC 61000-4-2
- ±15kV using the Air-Gap Discharge method specified in IEC 61000-4-2

ESD Test Conditions

ESD performance depends on a variety of conditions.

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.

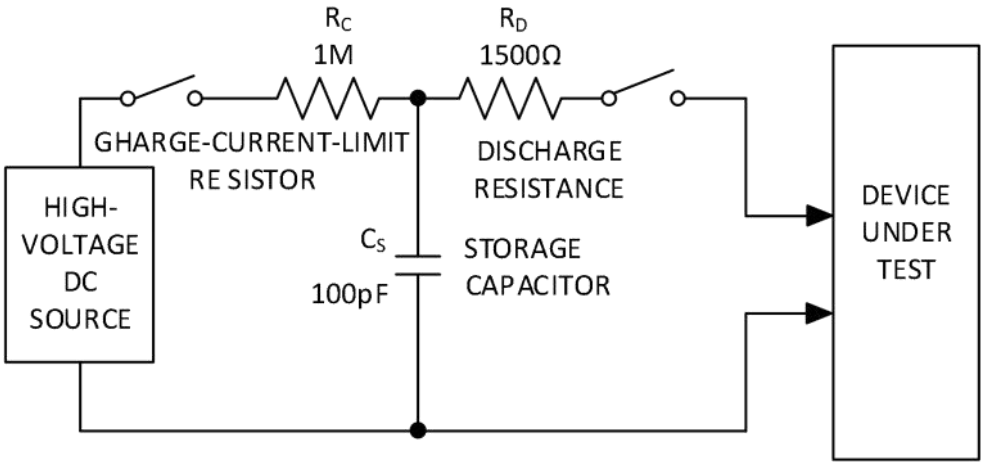


Figure 10a. Human Body ESD Test Model

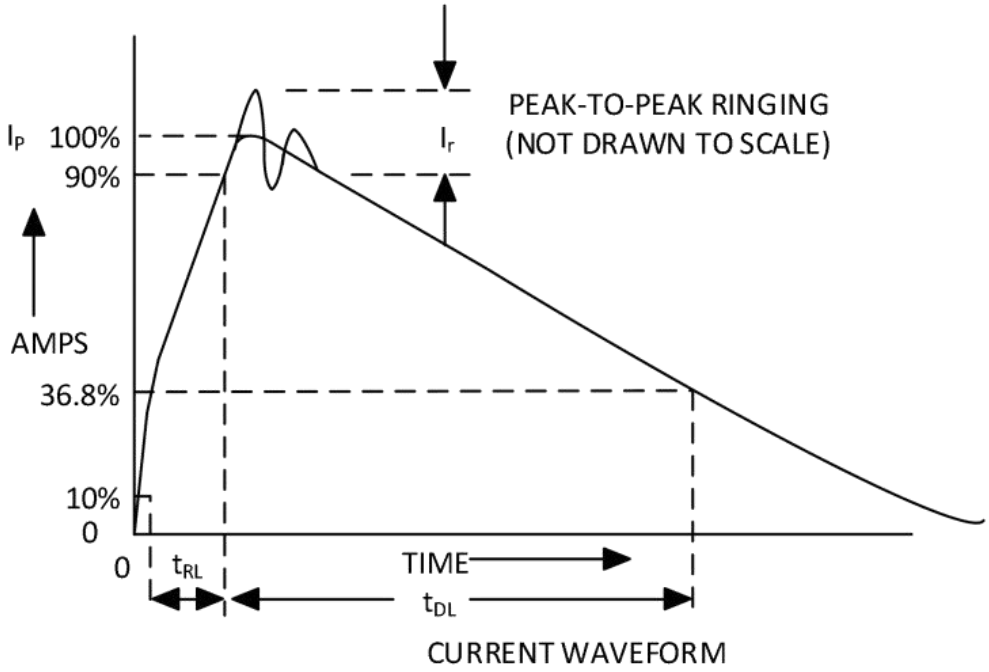


Figure 10b. Human Body Current Waveform

IEC 61000-4-2

The IEC 61000-4-2 standard covers ESD testing and performance of finished equipment. However, it does not specifically refer to integrated circuits. The MAX13485 helps you design equipment to meet IEC 61000-4-2, with out the need for additional ESD-protection components.The major difference between tests done using the Human Body Model and IEC 61000-4-2 is higher peak current in IEC 61000-4-2 because series resistance is lower in the IEC 61000-4-2 model. Hence, the ESD withstand voltage measured to IEC 61000-4-2 is generally lower than that measured using the Human Body Model. Figure 10c shows the IEC 61000-4-2 model, and Figure 10d shows the current waveform for IEC 61000-4-2 ESD Contact Discharge test.

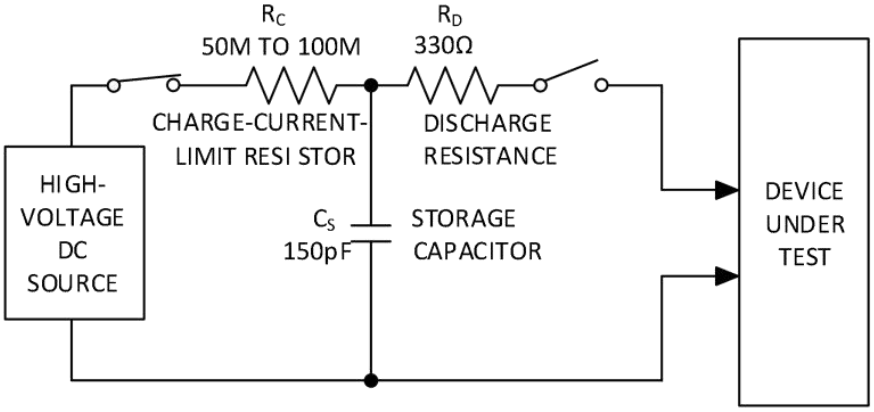


Figure 10c. IEC 61000-4-2 ESD Test Model

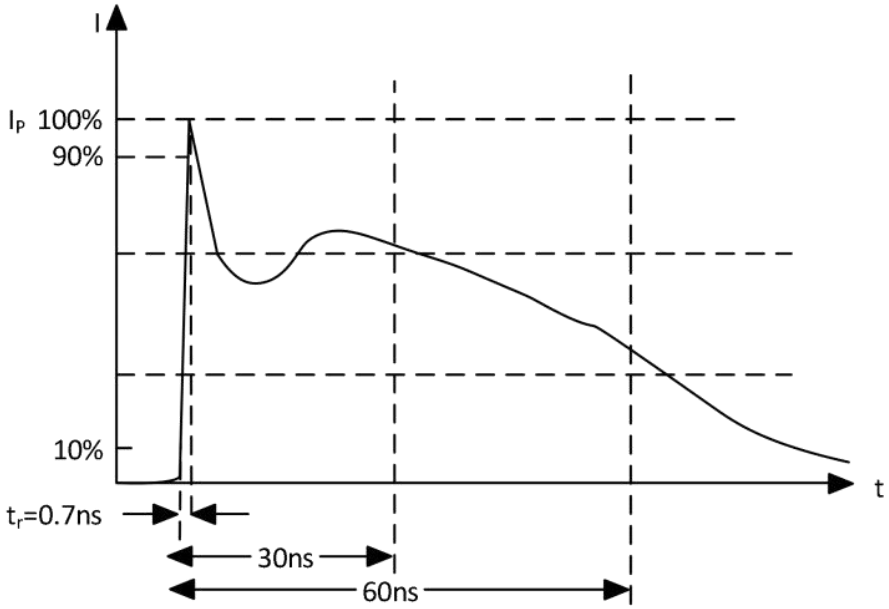


Figure 10d. IEC 61000-4-2 ESD Generator Current Waveform

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. Of course, all pins require this protection, not just RS-485 inputs and outputs.

Applications Information

The standard RS-485 receiver input impedance is 12kΩ (1-unit load), and the standard driver can drive up to 32-unit loads. The MAX13485 has a 1/8-unit load receiver input impedance (96kΩ), allowing up to 256 transceivers to be connected in parallel on one communication line. Any combination of the MAX13485, as well as other RS-485 transceivers with a total of 32-unit loads or fewer, can be connected to the line.

Reduced EMI and Reflections

The MAX13485 features reduced slew-rate drivers that minimize EMI and reduce reflections caused by improperly terminated cables, allowing error-free data transmission up to 1Mbps.

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 2.0μA of supply current.RE and DE can be driven simultaneously; the devices 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 700ns, the devices are guaranteed to enter shutdown.Enable times t_{ZH} and t_{ZL} (see the Switching Characteristics section) assume the devices were not in a low-power shutdown state. Enable times t_{ZH}(SHDN) and t_{ZL}(SHDN) assume the devices were in shutdown state. It takes drivers and receivers longer to become enabled from low-power shutdown mode (t_{ZH}(SHDN), t_{ZL}(SHDN)) than from driver/receiver-disable mode (t_{ZH}, t_{ZL}).

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 the Typical Operating Characteristics). The second, a thermal-shutdown circuit, forces the driver outputs into a high-impedance state if the die temperature exceeds +175°C (typ).

Line Length

The RS-485/RS-422 standard covers line lengths up to 4000ft. For line lengths greater than 4000ft, it may be necessary to implement a line repeater.

Typical Applications

The MAX13485 transceiver is designed for bidirectional data communications on multipoint bus transmission lines. Figure 11 shows a typical network applications circuit.To minimize reflections, terminate the line at both ends in its characteristic impedance, and keep stub lengths off the main line as short as possible. The slew-rate-limited MAX13485 is more tolerant of imperfect termination.

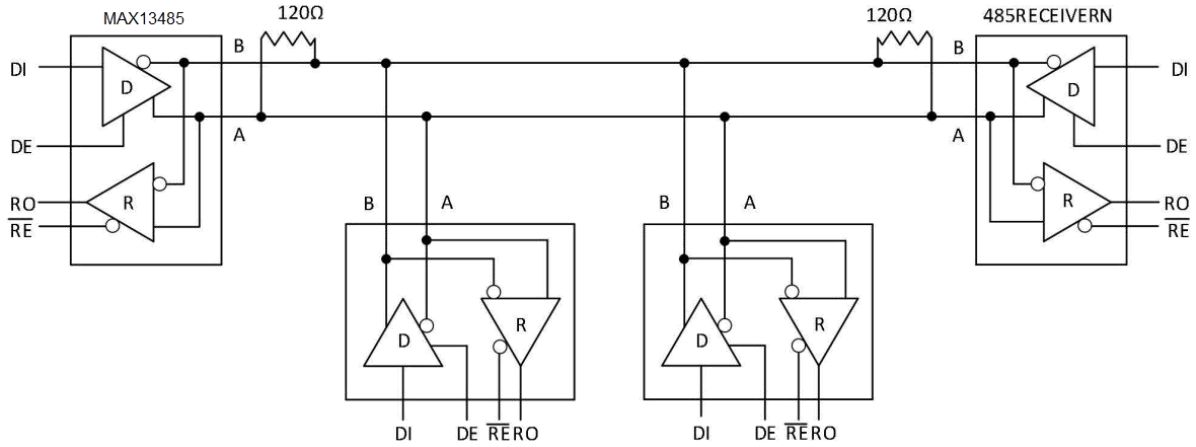
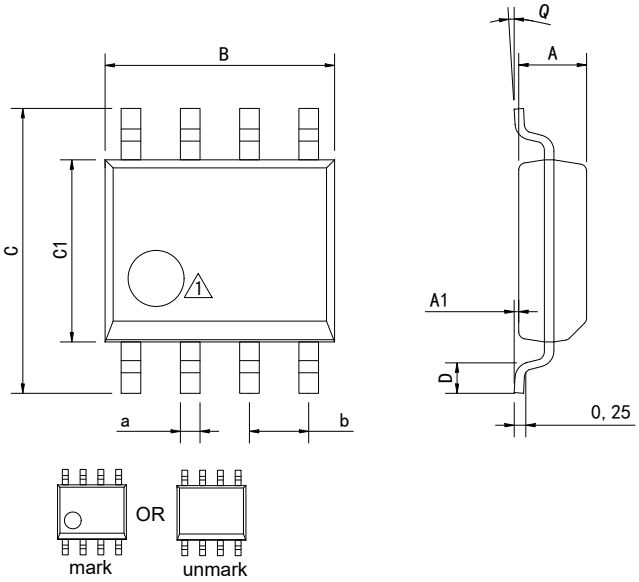


Figure 11. Typical Half-Duplex RS-485 Network

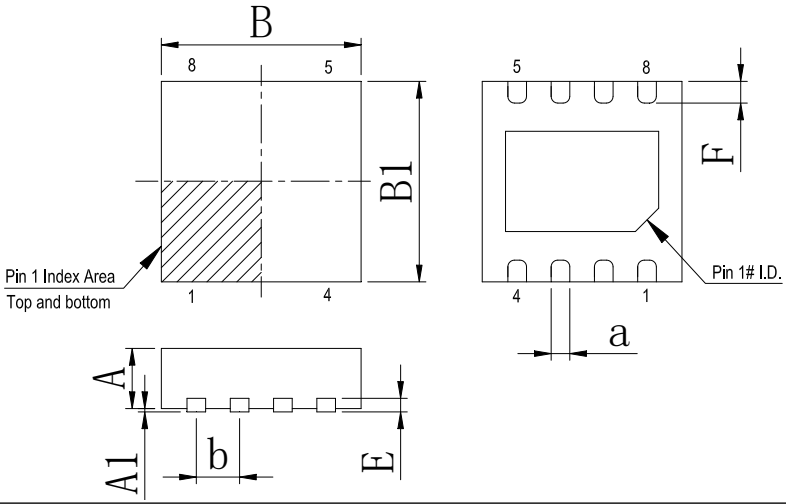
Physical Dimensions

SOP-8



Dimensions In Millimeters(SOP-8)									
Symbol:	A	A1	B	C	C1	D	Q	a	b
Min:	1.35	0.05	4.90	5.80	3.80	0.40	0°	0.35	1.27 BSC
Max:	1.55	0.20	5.10	6.20	4.00	0.80	8°	0.45	

DFN-8 3*3



Dimensions In Millimeters(DFN-8 3*3)								
Symbol:	**A**	**A1**	**B**	**B1**	**E**	**F**	**a**	**b**
Min:	0.85	0.00	2.90	2.90	0.20	0.30	0.20	0.65 BSC
Max:	0.95	0.05	3.10	3.10	0.25	0.50	0.34	

Revision History

REVISION NUMBER	DATE	REVISION	PAGE
V1.0	2020-12	New	1-21
V1.1	2025-8	Document Reformatting	1-21

IMPORTANT STATEMENT:

Huaguan Semiconductor reserves the right to change its products and services without notice. Before ordering, the customer shall obtain the latest relevant information and verify whether the information is up to date and complete. Huaguan Semiconductor does not assume any responsibility or obligation for the altered documents.

Customers are responsible for complying with safety standards and taking safety measures when using Huaguan Semiconductor products for system design and machine manufacturing. You will bear all the following responsibilities: Select the appropriate Huaguan Semiconductor products for your application; Design, validate and test your application; Ensure that your application meets the appropriate standards and any other safety,security or other requirements. To avoid the occurrence of potential risks that may lead to personal injury or property loss.

Huaguan Semiconductor products have not been approved for applications in life support, military, aerospace and other fields, and Huaguan Semiconductor will not bear the consequences caused by the application of products in these fields. All problems, responsibilities and losses arising from the user's use beyond the applicable area of the product shall be borne by the user and have nothing to do with Huaguan Semiconductor, and the user shall not claim any compensation liability against Huaguan Semiconductor by the terms of this Agreement.

The technical and reliability data (including data sheets), design resources (including reference designs), application or other design suggestions, network tools, safety information and other resources provided for the performance of semiconductor products produced by Huaguan Semiconductor are not guaranteed to be free from defects and no warranty, express or implied, is made. The use of testing and other quality control technologies is limited to the quality assurance scope of Huaguan Semiconductor. Not all parameters of each device need to be tested.

The documentation of Huaguan Semiconductor authorizes you to use these resources only for developing the application of the product described in this document. You have no right to use any other Huaguan Semiconductor intellectual property rights or any third party intellectual property rights. It is strictly forbidden to make other copies or displays of these resources. You should fully compensate Huaguan Semiconductor and its agents for any claims, damages, costs, losses and debts caused by the use of these resources. Huaguan Semiconductor accepts no liability for any loss or damage caused by infringement.