

## 3.3V to 5V, RS-485 / RS-422 Transceiver with Auto-Direction Control

### Features

- 3-V to 5.5-V Supply voltage
- Auto Direction Enables Driver Automatically on Transmission
- Half-duplex Transceiver
- Data Rates:
  - COS13487E: 500kbps (Slew-Rate Limiting)
  - COS13488E: 12Mbps
- Low Power Consumption:
  - Quiescent Current During Operation:0.7mA
  - Standby Current <5uA
- -7V to 12V Bus Common Mode Input Range
- Open, Short, and Idle Fail-safe Functions
- Bus Glitch-Free Power-Up and Power-Down
- Over Temperature Protection
- 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
- 1/8-Unit Load, Allow Up to 256 Transceivers on the bus
- Small Packaging: SOP8/MSOP8/DFN8

### Applications

- Isolated RS-485 Interfaces
- Power Inverters
- Motor Control
- Industrial Automation
- Battery-Powered Applications

### General Description

The COS13487E and COS13488E are low power differential bus/line transceivers with fail-safe and hot-swap features designed for multi-point data transmission standard and RS485 applications. They operate from a single 3 to 5.5V supply and also meets the requirements of RS422.

The COS13487E/COS13488E family feature auto-directional control, where the driver input is used in conjunction with the driver-enable signal to drive the differential bus. This architecture makes the devices ideal for isolated RS-485 applications.

The COS13487E allow error-free transmission up to 500kbps. The COS13488E driving slew rate is not limited, allowing transmit speeds up to 12Mbps. The devices offer significant power saving without sacrificing ruggedness against overload or ESD damage. It is available in 8-lead plastic SOP8, MSOP8, and DFN3x3-8, and is specified for operation from -40°C to +125°C ambient temperature.

#### Rev1.4

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## 1. Pin Configuration and Functions

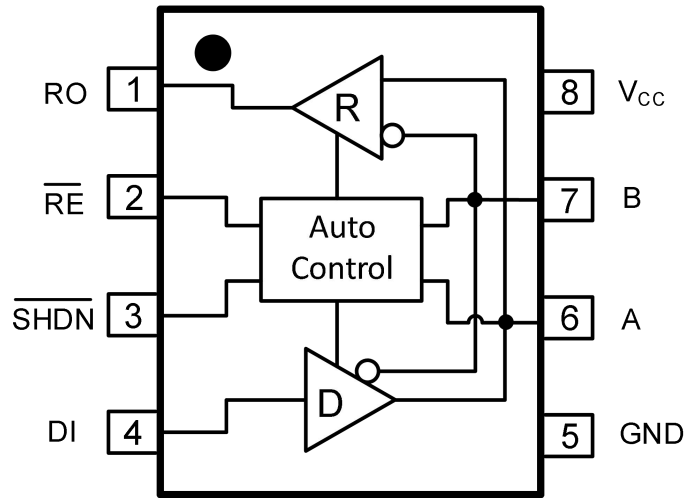


Figure 1 Pin Diagram

### Pin Description

Pin	Name	Description
1	RO	Receiver output. When the receiver output is enabled ( $\overline{RE}$ low), then if $A > B$ by 200mV, RO will be high. If $A < B$ by 200mV, then RO will be low.
2	$\overline{RE}$	Receiver output enable. A low enables the receiver output, RO. A high input to let the auto-direction circuit control the receiver. $\overline{RE}$ is a hot-swap input.
3	$\overline{SHDN}$	Shutdown. Drive $\overline{SHDN}$ low to put the device in shutdown mode. Drive $\overline{SHDN}$ high to let the device operate in normal operation.
4	DI	Driver input. Drive DI low to force non-inverting output low and inverting output high. Drive DI high to force non-inverting output high and inverting output low. DI is an input to the internal state machine that automatically enables and disables the driver.
5	GND	Ground
6	A	Non-inverting receiver input and non-inverting driver output
7	B	Inverting receiver input and inverting driver output
8	V <sub>CC</sub>	Power Supply, 3-V to 5.5-V. Bypass V <sub>CC</sub> to GND with a 0.1μF capacitor.

**Driver Truth Table**

Inputs			Outputs		Function
$\overline{\text{SHDN}}$	DI	A-B > $V_{DT}$	A	B	
H	L	X	L	H	Turn driver ON
H	H	True	Z	Z	Turn driver OFF
H	H	False	Z	Z	If driver was OFF, keep it OFF
H	H	False	H	L	If driver was ON, keep it ON
L	X	X	Z	Z	Shutdown

**Receiver Truth Table**

Inputs					Outputs
$\overline{\text{SHDN}}$	$\overline{\text{RE}}$	A-B	Driver State	Receiver State	R0
H	L	$\geq +0.2V$	X	ON	H
H	L	$\leq -0.2V$	X	ON	L
H	H	X	ON	OFF	Z
H	H	$\geq +0.2V$	OFF	ON	H
H	H	$\leq -0.2V$	OFF	ON	L
L	X	X	X	X	Z

Note: X = Don't care; Z = High impedance

## 2. Product Specification

### 2.1 Absolute Maximum Ratings <sup>(1)</sup>

Parameter	Min	Max	Unit
DC supply voltage, $V_{CC}$		+6	V
Control input voltages	-0.5	$V_{CC} + 0.5$	V
Driver input voltages	-0.5	$V_{CC} + 0.5$	V
Driver output voltage at A or B		$\pm 16$	V
Receiver input voltage		$\pm 16$	V
Receiver output voltage	-0.5	$V_{CC} + 0.5$	V
Operating junction temperature	-40	+135	$^{\circ}\text{C}$
Storage temperature	-55	+150	$^{\circ}\text{C}$

(1) Stresses exceeding the absolute maximum ratings may damage the device. The device may not function or be operable above the recommended operating conditions and stressing the parts to these levels is not recommended. In addition, extended exposure to stresses above the recommended operating conditions may affect device reliability. The absolute maximum ratings are stress ratings only.

## 2.2 Thermal Data

Parameter	Rating	Unit
Package Thermal Resistance, $R_{\theta JA}$ (Junction-to-ambient)	150 (SOP8) 206 (MSOP8) 57 (DFN8,3x3)	°C/W

## 2.3 ESD Rating

ESD Protection	Conditions	Rating	Unit
Bus terminals (A,B)	Air Gap Discharge IEC61000-4-2	± 15	kV
	Human Body Model	± 15	
All Other Pins	Human Body Model	± 2	

## 2.4 Recommended Operating Conditions

Parameter	Min.	Typ.	Max.	Unit
DC Supply voltage	3.0	5	5.5	V
Input voltage at any bus terminal	-7		12	V
Differential input voltage	-12		12	V
Differential load resistance	54	60		Ω
Data rate: (COS13487E)			500	kbps
Data rate: (COS13488E)			12	Mbps
Operating ambient temperature	-40		+85	°C
Operating junction temperature	-40		+125	°C

## 2.5 Electrical Characteristics

(Typical values are at  $T_A=25\text{ }^\circ\text{C}$ ,  $V_{CC}=5\text{V}$ , unless otherwise noted.)

Parameter	Symbol	Conditions	Min.	Typ.	Max.	Unit
<b>Driver Electrical Characteristics</b>						
Differential driver output (no load)	$V_{OD1}$	$I_O = 0$	2.0		$V_{CC}$	V
Differential driver output (with load)	$V_{OD2}$	$R_{DIFF} = 100\ \Omega$ (RS422) $R_{DIFF} = 54\ \Omega$ (RS485), (See Figure 2)	2.0 1.5			V
Change in magnitude of driver differential output voltage for complementary output states	$\Delta V_{OD}$	$R_{DIFF} = 54\ \Omega$ or $100\ \Omega$ , (See Figure 2)	-0.2	0	0.2	V
Driver common-mode output voltage	$V_{OC}$	$R_{DIFF} = 54\ \Omega$ or $100\ \Omega$ , (See Figure 2)		$V_{CC}/2$	3	V
Change in magnitude of driver common-mode output voltage for complementary output states	$\Delta V_{OC}$	$R_{DIFF} = 54\ \Omega$ or $100\ \Omega$ , (See Figure 2)			0.2	V
Driver disable threshold	$V_{DT}$		+0.6		+1.0	V
Driver short-circuit current	$I_{OS}$	$V_O = -7\text{V to }12\text{V}$ , (See Figure 2)	-250		250	mA
<b>Receiver Electrical Characteristics</b>						
Receiver differential threshold voltage	$V_{TH}$	$V_{CM} = -7\text{V to }12\text{V}$	-200	-125	-50	mV
Receiver input hysteresis	$\Delta V_{TH}$	$V_{CM} = 0\text{V}$		40		mV
Receiver input resistance	$R_{IN}$	$V_{CM} = -7\text{V to }12\text{V}$	96			k $\Omega$
Input current (A, B)	$I_{IN}$	( $V_{CC} = 0\text{V or }5\text{V}$ , $V_{DE} = 0\text{V}$ ) $V_{IN} = 12\text{V}$ $V_{IN} = -7\text{V}$			+200 -200	$\mu\text{A}$
Receiver output high voltage	$V_{OH}$	$I_O = -4\text{mA}$	$V_{CC}$ -0.4	$V_{CC}$ -0.2		V
Receiver output low voltage	$V_{OL}$	$I_O = 4\text{mA}$		0.2	0.4	V
Receiver output short-circuit current	$I_{OSR}$	$V_O = 0\text{V to }V_{CC}$			$\pm 60$	mA
Tristate output leakage current	$I_{OZR}$	$V_O = 0.4\text{ to }2.4\text{V}$	-1		1	$\mu\text{A}$

<b>Logic</b>						
Logic Input high voltage	V <sub>IH</sub>	DI, $\overline{RE}$ , $\overline{SHDN}$	2.0			V
Logic Input low voltage	V <sub>IL</sub>	DI, $\overline{RE}$ , $\overline{SHDN}$			0.8	V
Logic Input current	I <sub>IN1</sub>	DI, $\overline{RE}$ , $\overline{SHDN}$			±5	μA
<b>Supply Current and Power Dissipation Characteristics</b>						
Supply current (quiescent)	I <sub>CC</sub>	$\overline{SHDN}=V_{CC}$ , $\overline{RE}=0$ , no Load		770	900	μA
Shutdown current	I <sub>SHDN</sub>	$\overline{SHDN}=0$		3	10	μA
Average power dissipation	P <sub>AVG</sub>	Unterminated; Data rate=500kbps, 50% duty cycle, R <sub>L</sub> = 150Ω, C <sub>L</sub> =50pF		75		mW
		RS-422; Data rate=500kbps, 50% duty cycle, R <sub>DIFF</sub> = 100Ω, C <sub>L</sub> =50pF		150		
		RS-485; Data rate=500kbps, 50% duty cycle, R <sub>DIFF</sub> = 54Ω, C <sub>L</sub> = 50pF		215		
Thermal shutdown junction temperature	T <sub>SD</sub>		150	170		°C
Thermal shutdown hysteresis	T <sub>HYS</sub>			30		°C

## 2.6 Switching Characteristics - COS13487E

(Typical values are at T<sub>A</sub>=25 °C, V<sub>CC</sub>=5V, unless otherwise noted.)

Parameter	Symbol	Conditions	Min.	Typ.	Max.	Unit
<b>Driver</b>						
Propagation delay input to output, low to high	t <sub>PLH</sub>	R <sub>L</sub> = 110Ω, C <sub>L</sub> = 50pF, (See Figure 3)		70	200	ns
Propagation delay input to output, high to low	t <sub>PHL</sub>			70	200	ns
Output to output skew,  t <sub>PHL</sub> – t <sub>PLH</sub>	t <sub>SK</sub>				15	ns
Differential output rise or fall time	t <sub>r</sub> , t <sub>f</sub>			100	250	400

Enable to output high	$t_{PZH}$	$C_L = 100\text{pF}$ , $S_2 = \text{Closed}$ (See Figure 4 and Figure 5)		120	200	ns
Enable to output low	$t_{PZL}$	$C_L = 100\text{pF}$ , $S_1 = \text{Closed}$ (See Figure 4 and Figure 5)		50	100	ns
Disable time from low	$t_{PLZ}$	$C_L = 15\text{pF}$ , $S_1 = \text{Closed}$ (See Figure 4 and Figure 5)		120	200	ns
Disable time from high	$t_{PHZ}$	$C_L = 15\text{pF}$ , $S_2 = \text{Closed}$ (See Figure 4 and Figure 5)		50	100	ns
Maximum data rate	$f_{MAX}$		500			kbps
<b>Receiver</b>						
Propagation delay input to output, low to high	$t_{PLH}$	$R_{DIFF} = 54\Omega$ , $C_{RL} = 100\text{pF}$ , (See Figure 6 )		25	50	ns
Propagation delay input to Output, high to low	$t_{PHL}$			25	50	ns
Output to output skew, $ t_{PHL} - t_{PLH} $	$t_{SK}$				5	ns
Enable to output high	$t_{PZH}$	$C_{RL} = 15\text{pF}$ , $S_1 = \text{Closed}$ (See Figure 7 and Figure 8)		50	70	ns
Enable to output low	$t_{PZL}$	$C_{RL} = 15\text{pF}$ , $S_2 = \text{Closed}$ (See Figure 7 and Figure 8)		10	50	ns
Disable time from low	$t_{PLZ}$	$C_{RL} = 15\text{pF}$ , $S_1 = \text{Closed}$ (See Figure 7 and Figure 8)		15	40	ns
Disable time from high	$t_{PHZ}$	$C_{RL} = 15\text{pF}$ , $S_2 = \text{Closed}$ (See Figure 7 and Figure 8)		20	50	ns
Maximum data rate	$f_{MAX}$		500			kbps

## 2.7 Switching Characteristics - COS13488E

(Typical values are at  $T_A=25\text{ }^\circ\text{C}$ ,  $V_{CC}=5\text{V}$ , unless otherwise noted.)

Parameter	Symbol	Conditions	Min.	Typ.	Max.	Unit
<b>Driver</b>						
Propagation delay input to output, low to high	$t_{PLH}$	$R_L = 110\Omega$ , $C_L = 50\text{pF}$ (See Figure 3)			50	ns
Propagation delay input to output, high to low	$t_{PHL}$				50	ns
Output to output skew, $ t_{PHL} - t_{PLH} $	$t_{SK}$				5	ns
Differential output rise or fall time	$t_r, t_f$				15	ns

Enable to output high	$t_{PZH}$	$C_L = 100\text{pF}$ , $S_2 = \text{Closed}$ (See Figure 4 and Figure 5)			70	ns
Enable to output low	$t_{PZL}$	$C_L = 100\text{pF}$ , $S_1 = \text{Closed}$ (See Figure 4 and Figure 5)			70	ns
Disable time from low	$t_{PLZ}$	$C_L = 15\text{pF}$ , $S_1 = \text{Closed}$ (See Figure 4 and Figure 5)			50	ns
Disable time from high	$t_{PHZ}$	$C_L = 15\text{pF}$ , $S_2 = \text{Closed}$ (See Figure 4 and Figure 5)			50	ns
Maximum data rate	$f_{MAX}$				12	Mbps
<b>Receiver</b>						
Propagation delay input to output, low to high	$t_{PLH}$	$R_{DIFF} = 54\Omega$ , $C_{RL} = 100\text{pF}$ , (See Figure 6 )			75	ns
Propagation delay input to Output, high to low	$t_{PHL}$				75	ns
Output to output skew, $ t_{PHL} - t_{PLH} $	$t_{SK}$				5	ns
Enable to output high	$t_{PZH}$	$C_{RL} = 15\text{pF}$ , $S_1 = \text{Closed}$ (See Figure 7 and Figure 8)			50	ns
Enable to output low	$t_{PZL}$	$C_{RL} = 15\text{pF}$ , $S_2 = \text{Closed}$ (See Figure 7 and Figure 8)			50	ns
Disable time from low	$t_{PLZ}$	$C_{RL} = 15\text{pF}$ , $S_1 = \text{Closed}$ (See Figure 7 and Figure 8)			25	ns
Disable time from high	$t_{PHZ}$	$C_{RL} = 15\text{pF}$ , $S_2 = \text{Closed}$ (See Figure 7 and Figure 8)			25	ns
Maximum data rate	$f_{MAX}$				12	Mbps

### 3. Testing Circuits and Parameter Information

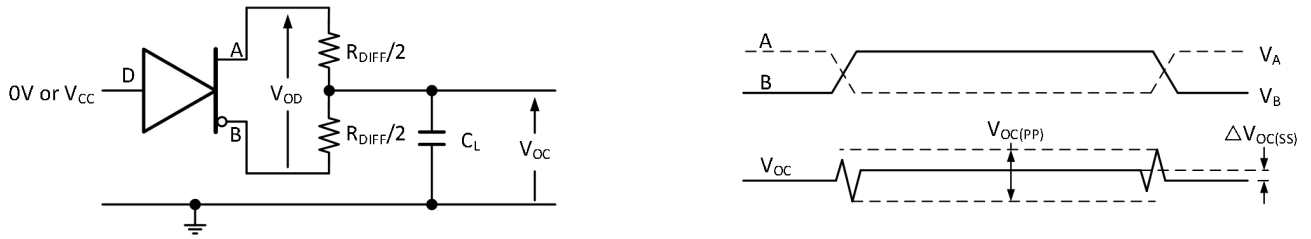


Figure 2. Measurement of Driver Differential and Common-Mode Output with RS-485 Load

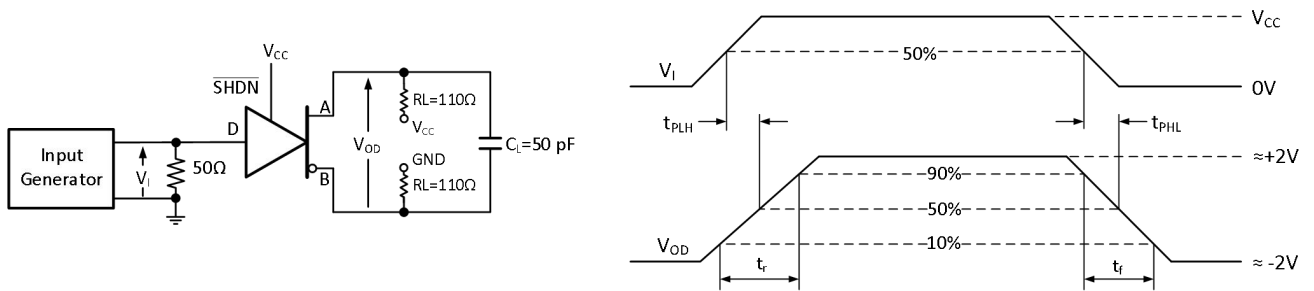


Figure 3. Measurement of Driver Differential Output Rise and Fall Times and Propagation Delays

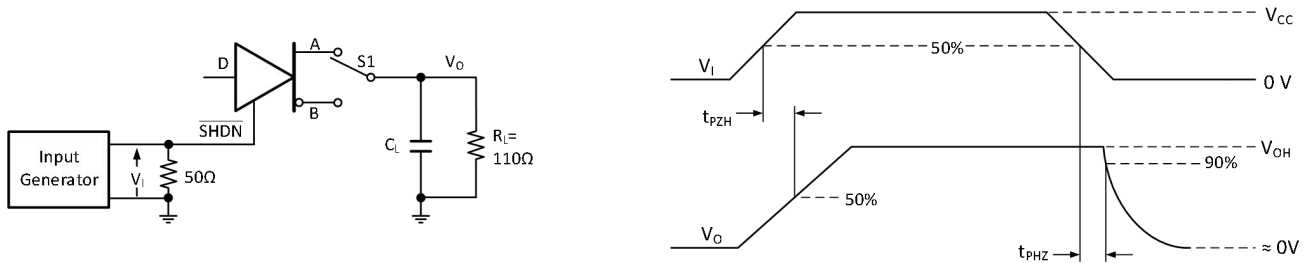


Figure 4. Measurement of Driver Enable and Disable Times with Active High Output and Pull-Down Load

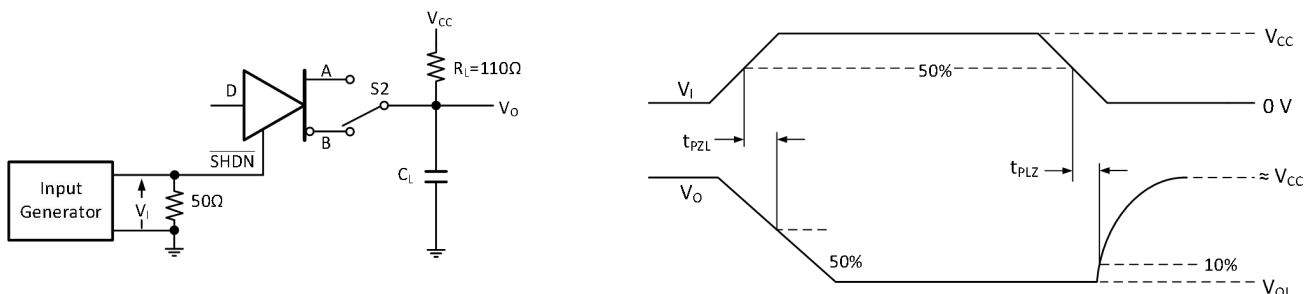


Figure 5. Measurement of Driver Enable and Disable Times with Active Low Output and Pull-up Load

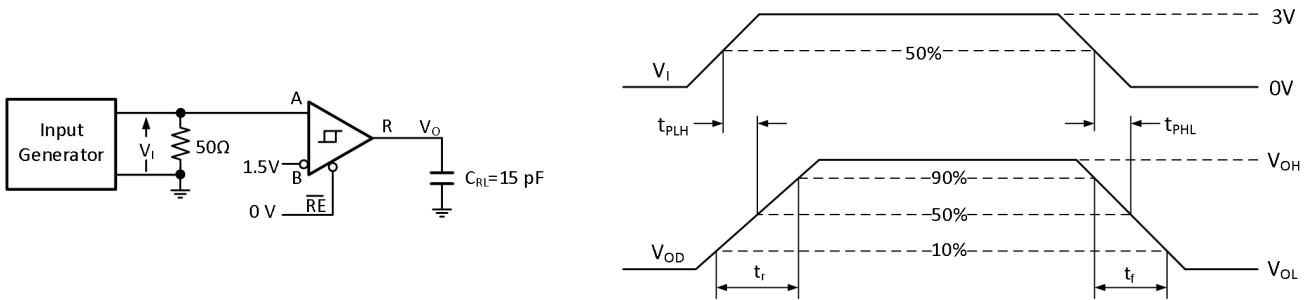


Figure 6. Measurement of Receiver Output Rise and Fall Times and Propagation Delays

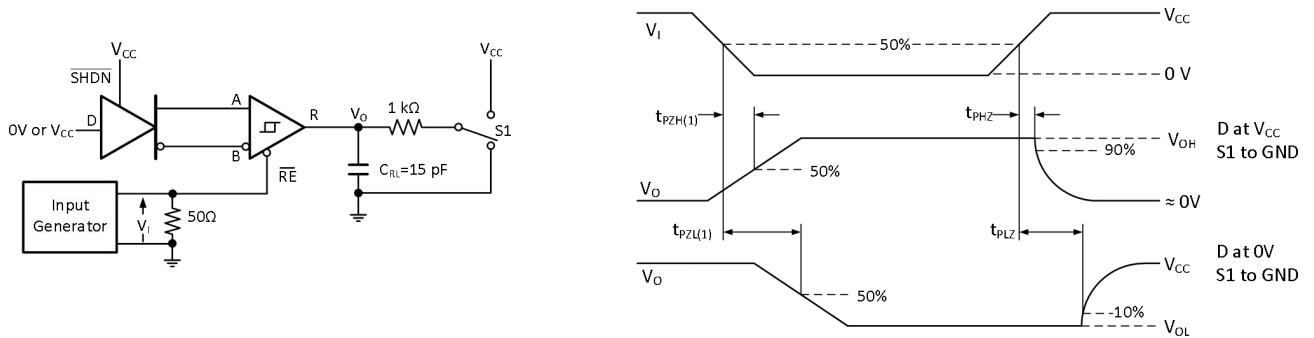


Figure 7. Measurement of Receiver Enable/Disable Times with Driver Enabled

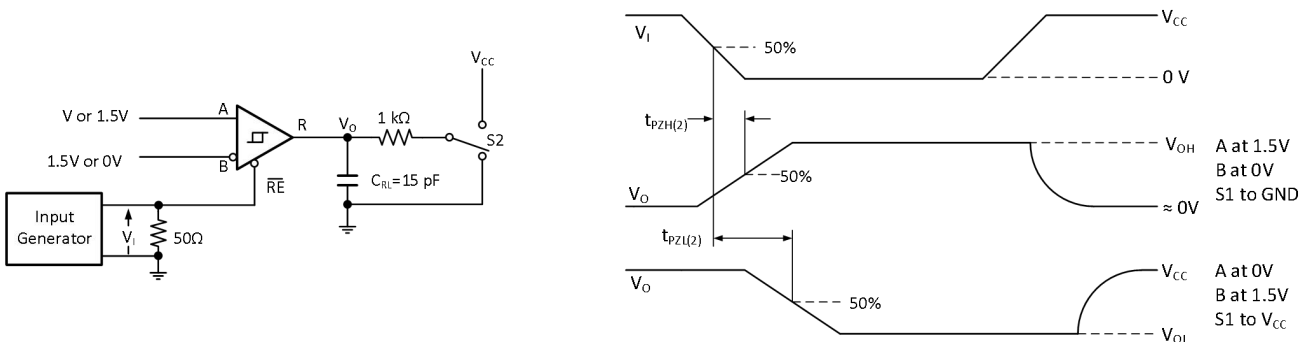


Figure 8. Measurement of Receiver Enable Times with Driver Disabled

### 4. Typical Application

The COS13487E/COS13488E devices are low-power half-duplex RS-485 transceiver suitable for data transmission at rates up to 12 Mbps over controlled-impedance transmission media (such as twisted-pair cabling). Figure 9 shown an isolated RS-485 Interface using the COS13487E /COS13488E. The transceiver is powered separately from the controlling circuitry. The Auto-direction feature of the COS13487E/COS13488E, replaces an external relay allowing faster switching speeds, no contact bounce, better reliability, and better electrical isolation. The COS13487E/COS13488E only require two opto-couplers to electrically isolate the transceiver.

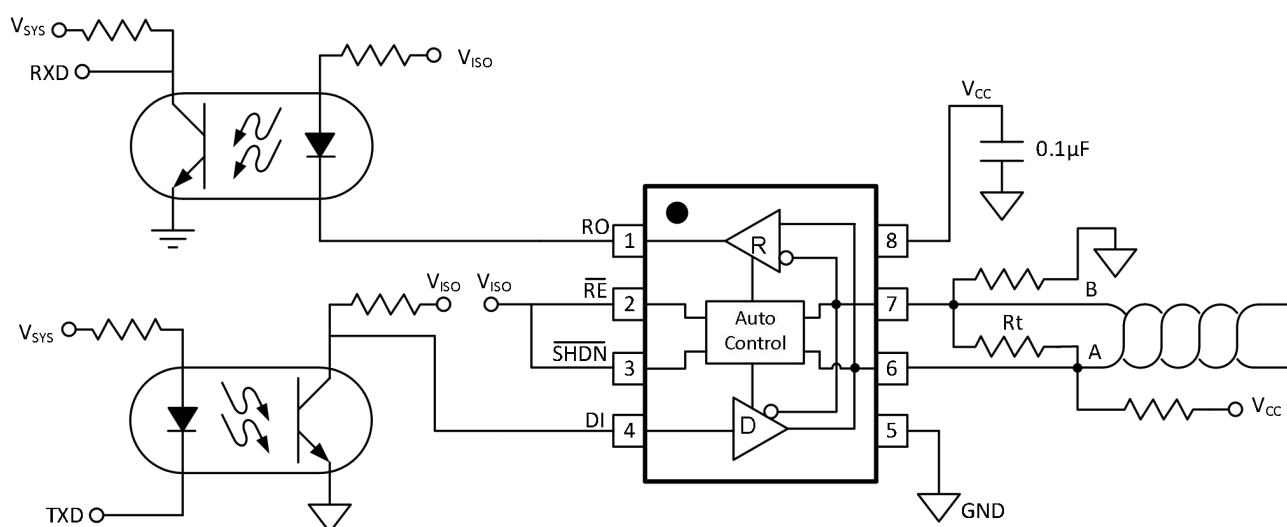


Figure 9. Isolated RS-485 Interface

Internal circuitry in the COS13487E/COS13488E, in conjunction with an external pullup resistor on A and pulldown resistor on B, act to automatically disable or enable the driver and receiver to keep the bus in the correct state. This Auto-direction circuitry consists of a state machine that determines whether this device is trying to drive the bus, or another node on the network is driving the bus. When DI is low, the device always drives the bus low. When DI is high, the device drives the bus for a short time, then disables the driver and allows the external pullup/pulldown resistors to hold the bus in the high state ( $A-B > 200\text{mV}$ ). During each low-to-high transition of DI, the driver stays enabled until  $(A-B) > VDT$ , and then disables the driver, letting the pullup/pulldown resistors hold the A and B lines in the correct state.

The pullup and pulldown resistors on the A and B lines are required for proper operation of the device although their exact value is not critical. They function to hold the bus in the high state ( $A-B > 200\text{mV}$ ) following a low-to-high transition. Sizing of these resistors is determined in the same way as when using any other RS-485 driver and depends on how the line is terminated and how many nodes are on the bus. The most important factor when sizing these resistors is to guarantee that the idle voltage on the bus ( $A-B$ ) is greater than  $200\text{mV}$  in order to remain compatible with standard RS-485 receiver thresholds.

When not transmitting data, the COS13487E/COS13488E require the DI input be driven high to remain in the idle state. A conventional RS-485 transceiver has DE and RE inputs that are used to enable and disable the driver and receiver. However, the COS13487E/COS13488E does not have a DE input, and instead uses an internal state machine to enable and disable the drivers. DI must be driven high in order to go to the idle state.

Up to 256 units of the COS1348x device can share a common RS-485 bus due to the low bus-input currents of the device. A typical application showing a multi-point transmission network is illustrated in Figure 9. Only one driver can transmit at a particular time, but multiple receivers may be enabled simultaneously. As with any transmission line, it is important that reflections are minimized. This can be achieved by terminating the extreme ends of the line using resistors equal to the characteristic impedance of the line. Stub lengths off the main line must also be kept as short as possible. A properly terminated transmission line appears purely resistive to the driver.

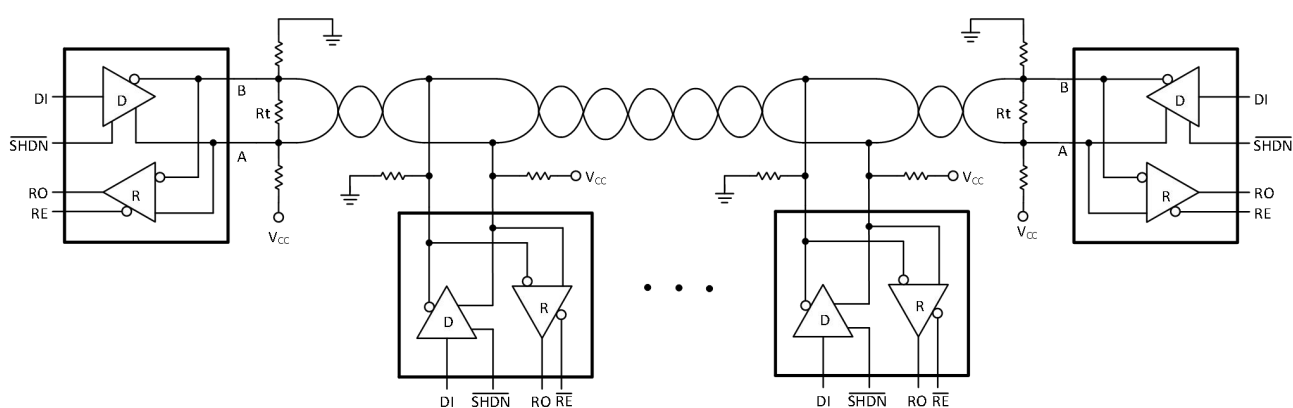
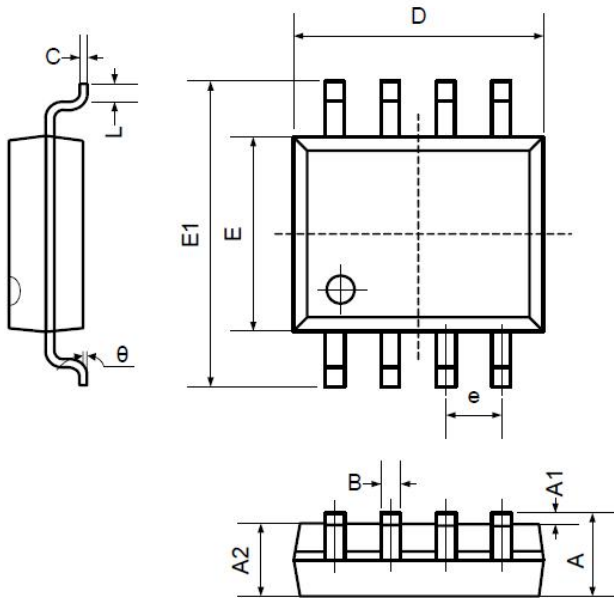


Figure 10. Multi-point Transmission Networks

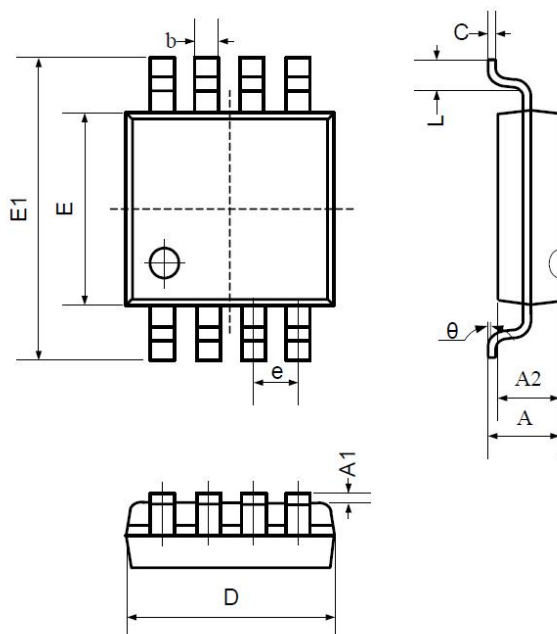
## 5. Package Information

### 5.1 SOP8 (Package Outline Dimensions)



Symbol	Dimensions In Millimeters		Dimensions In Inches	
	Min	Max	Min	Max
A	1.350	1.750	0.053	0.069
A1	0.100	0.250	0.004	0.010
A2	1.350	1.550	0.053	0.061
B	0.330	0.510	0.013	0.020
C	0.190	0.250	0.007	0.010
D	4.780	5.000	0.188	0.197
E	3.800	4.000	0.150	0.157
E1	5.800	6.300	0.228	0.248
e	1.270TYP		0.050TYP	
L	0.400	1.270	0.016	0.050
$\theta$	0°	8°	0°	8°

### 5.2 MSOP8 (Package Outline Dimensions)



Symbol	Dimensions In Millimeters		Dimensions In Inches	
	Min	Max	Min	Max
A	0.800	1.200	0.031	0.047
A1	0.000	0.200	0.000	0.008
A2	0.760	0.970	0.030	0.038
b	0.30 TYP		0.012 TYP	
c	0.15 TYP		0.006 TYP	
D	2.900	3.100	0.114	0.122
e	0.65 TYP		0.026 TYP	
E	2.900	3.100	0.114	0.122
E1	4.700	5.100	0.185	0.201
L	0.410	0.650	0.016	0.026
$\theta$	0°	6°	0°	6°

## 6. Ordering Information

<b>Model</b>	<b>Order Number</b>	<b>Package</b>	<b>Package Option</b>	<b>Marking Information</b>
COSMAX13487E	COSMAX13487EESA	SOP-8	Tape and Reel, 4000	COS13487EESA
	COSMAX13487EM	MSOP-8	Tape and Reel, 3000	COS13487E
	COSMAX13487EF	DFN3x3-8	Tape and Reel, 4000	COS13487E
COSMAX13488E	COSMAX13488EESA	SOP-8	Tape and Reel, 4000	COS13488EESA
	COSMAX13488EM	MSOP-8	Tape and Reel, 3000	COS13488E
	COSMAX13488EF	DFN3x3-8	Tape and Reel, 4000	COS13488E