

3.0V to 5.5V RS485/RS422 Transceivers with $\pm 20\text{kV}$ ESD Protection

1. Features

- **High-Performance and Compliant with RS-485 EIA/TIA-485 Standard**
 - Low EMI 500kbps Data Rate (CS48505Ax) and up to 20Mbps (CS48520Ax) High-Speed Data Rate
 - 1/8 Unit Load Enables up to 256 Nodes on the Same Bus
- **Integrated Protection for Robust Communication**
 - -7V to +12V Common-Mode Voltage Range
 - $\pm 20\text{kV}$ Human Body Model ESD Protection and $\pm 6\text{kV}$ Contact Discharge IEC 61000-4-2 ESD Protection on A/B pins
 - Short-Circuit Protection
 - Thermal Shutdown
 - True Fail-Safe Guarantees Known Receiver Output State
 - Glitch-free during Power on/Power off
- **Output Level is Compatible with Profibus Standard**
 - $|V_{OD}| > 2.1\text{V}$ @ 5V Supply Voltage
- **Low Power**
 - Low Supply Current (0.9mA, typ.)
 - Shutdown Current $< 5\mu\text{A}$
- **3V to 5.5V Supply Voltage Range**
- **Wide Operating Temperature Range: -40°C to 125°C**
- **8 pin SOIC, 8 pin MSOP and 8 pin DFN Packages**

The CS485xxA family of devices contain one driver(T_x) and one receiver(R_x), operates over the +3V to +5.5V supply range, making these devices convenient for designers to use one part with either +3.3V or +5V supply systems. The CS48520Ax devices can transmit and receive at data rate up to 20Mbps, while the CS48505Ax devices are specified for data rate up to 500kbps. These devices also include fail-safe circuitry, guaranteeing a logic-high receiver output when the receiver inputs are shorted or open.

All devices are specified over the -40°C to $+125^\circ\text{C}$ wide operating temperature range and are available in small 8-pin MSOP, 8-pin DFN packages for space constrained applications and 8-pin SOIC for drop-in compatibility design.

Device Information

Part number	Package	Package size (NOM)
CS48505AS CS48520AS	SOIC8	3.9mm*4.9mm
CS48505AM CS48520AM	MSOP8	3mm*3mm
CS48505AD CS48520AD	DFN8	3mm*3mm

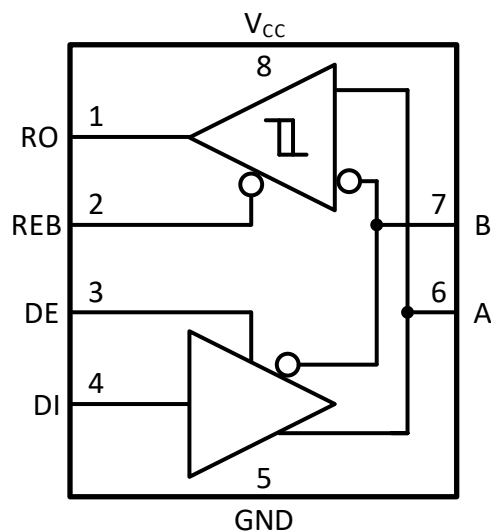
2. Applications

- Factory Automation & Control
- Grid Infrastructure
- Home and Building Automation
- Video Surveillance
- Smart Meters
- Process Control
- Telecommunication Equipment

3. General Description

The CS485xxA family of devices are low-power half-duplex transceivers for RS-485/RS-422 communications in harsh environments. All devices feature $\pm 20\text{kV}$ electro-static discharge (ESD) protection for the bus pins (A and B), eliminating the need for additional system level protection components.

Simplified Block Diagram



4. Ordering Information

Table 4-1. Ordering Information

Part #	Full/Half-Duplex	Data Rate(Mbps)	Number of Nodes on Bus	Package
CS48505AS	Half-Duplex	0.5	256	SOIC8(S)
CS48520AS	Half-Duplex	20	256	SOIC8(S)
CS48505AM	Half-Duplex	0.5	256	MSOP8(M)
CS48520AM	Half-Duplex	20	256	MSOP8(M)
CS48505AD	Half-Duplex	0.5	256	DFN8(D)
CS48520AD	Half-Duplex	20	256	DFN8(D)

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5. Revision History

Revision Number	Description	Page Changed	Revision Date
Version 1.00	N/A	N/A	2022-08-17

6. Pin Configuration and Descriptions

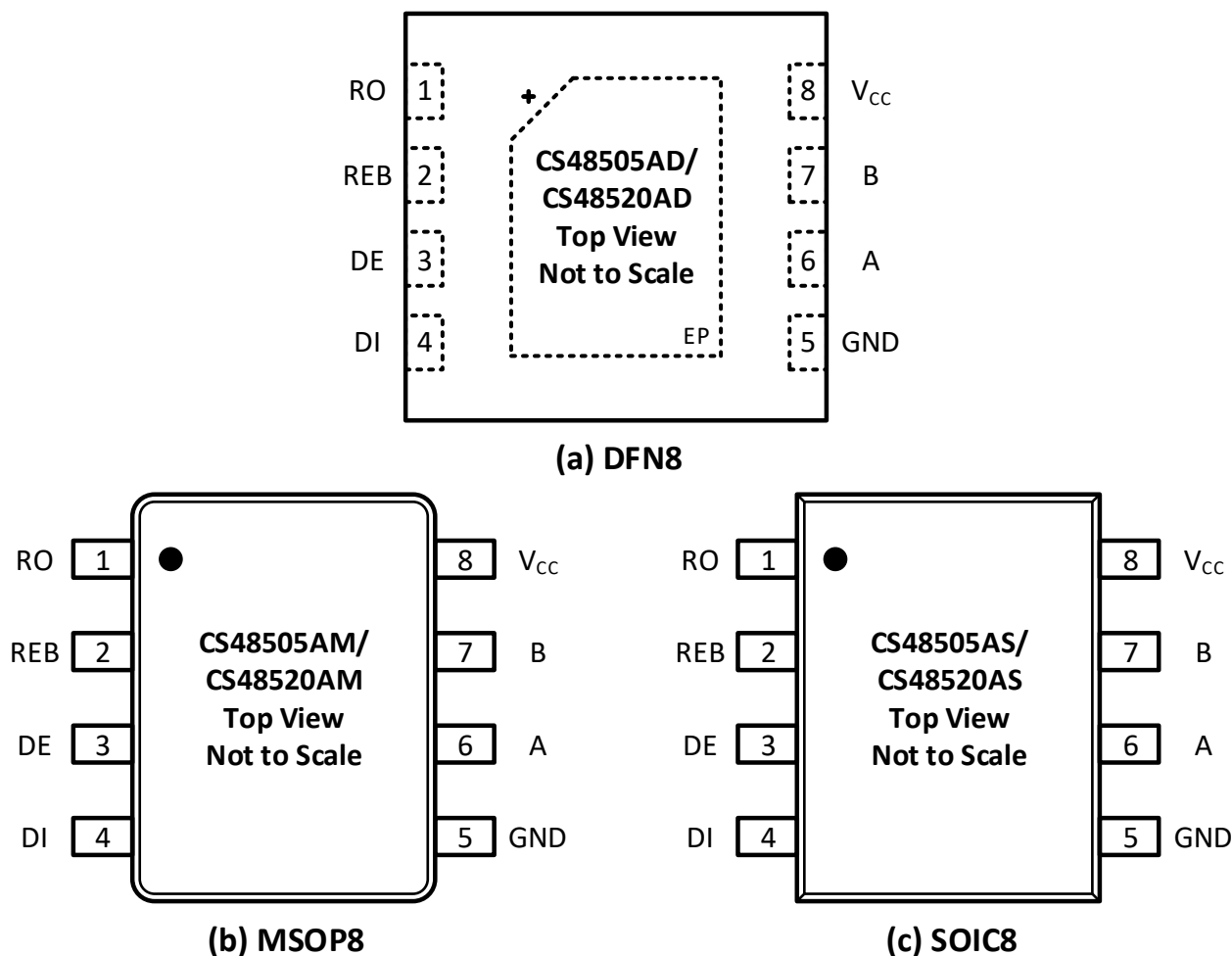


Figure 6-1. CS485xxA pin configuration

Table 6-1 CS485xxA pin description

Pin Name	Pin Number	Description
RO	1	Receiver data output. With REB low, RO is high when $(V_A - V_B) > V_{TH+}$ and is low when $(V_A - V_B) < V_{TH-}$. RO is high impedance when REB is high.
REB	2	Receiver output enable. Drive REB low or connect to GND to enable receiver. Drive REB high or leave open to disable the receiver and put RO in high impedance. Drive REB high and DE low to force the IC into low-power shutdown mode.
DE	3	Driver output enable. Drive DE high to enable the driver. Drive DE low or leave open to disable the driver. Drive REB high and DE low to force the IC into low-power shutdown mode.
DI	4	Driver data input. With DE high, a logic low on DI forces the noninverting output (A) low and the inverting output (B) high; a logic high on DI forces the noninverting output high and the inverting output low.
GND	5	Ground.
A	6	Noninverting RS-485/RS-422 driver output/receiver input.
B	7	Inverting RS-485/RS-422 driver output/receiver input.
V _{CC}	8	Power supply input. Bypass V _{CC} to GND with at least 0.1μF capacitor as close to the device as possible.
EP	---	Exposed Pad (DFN8 package Only). Connect EP to GND.

7. Specification

7.1. Absolute Maximum Ratings¹

Parameters		Minimum value	Maximum value	Unit
V_{CC}^2	Power supply voltage	-0.5	7.0	V
A, B ²	Voltage on the bus	-8	13	V
DE, DI, REB	Logic control voltage	-0.3	$V_{CC} + 0.3^3$	V
RO	Logic voltage at RO	-0.3	$V_{CC} + 0.3^3$	V
T_J	Junction temperature		150	°C
T_{STG}	Storage temperature range	-65	150	°C

Notes:

- The stresses listed under “Absolute Maximum Ratings” are stress ratings only, not for functional operation condition. Exposure to absolute maximum rating conditions for extended periods may cause permanent damage to the device.
- All voltage values are with respect to the ground terminal (GND) and are peak voltage values.
- Maximum voltage must not be exceed 7V.

7.2. ESD Ratings

Parameters		Value	Unit
V_{ESD} Electrostatic discharge	Human body model (HBM), per ANSI/ESDA/JEDEC JS-001, bus pins (A, B) to GND ¹	±20	kV
	Human body model (HBM), per ANSI/ESDA/JEDEC JS-001, all other pins ¹	±8	
	Charged device model (CDM), per JEDEC specification JESD22-C101, all pins ²	±2	
	Contact Discharge, per IEC 61000-4-2, bus pins (A, B) to GND	±6	
	Contact Discharge, per IEC 61000-4-2, all other pins to GND	TBD	

Notes:

- Per JEDEC document JEP155, 500V HBM allows safe manufacturing of standard ESD control process.
- Per JEDEC document JEP157, 250V CDM allows safe manufacturing of standard ESD control process.

7.3. Recommended Operating Conditions

Parameters		Minimum value	Typical value	Maximum value	Unit
V_{CC}	Power supply	3.0	5.0	5.5	V
V_{IN}	Input voltage at any bus terminal	-7		12	V
V_{IL}	Low-level input voltage	0		0.8	V
V_{IH}	High-level input voltage	2.0		V_{CC}	V
R_L	Differential load resistance	54			Ohm
$1/t_{UI}$	Signaling rate: CS48505Ax			500	kbits
$1/t_{UI}$	Signaling rate: CS48520Ax			20	Mbps
T_A	Operating ambient temperature	-40		125	°C
T_J	Junction temperature	-40		150	°C

7.4. Thermal Information

THERMAL METRIC		SOIC8	MSOP8	DFN8	Unit
$R_{\theta JA}$	Junction-to-ambient thermal resistance	120	160	45	°C/W

7.5. Electrical Characteristics

All typical specs are at $V_{CC} = 5V$, $T_A = 25^\circ C$, Min/Max specs are over recommended operating conditions unless otherwise specified.

Parameters		Test conditions		Minimum value	Typical value	Maximum value	Unit
Driver							
V _{OD}	Differential output voltage	R _L =60 Ω, -7 V ≤ V _{test} ≤ 12 V (see Figure 8-1) ⁽¹⁾		1.5	3.6		V
		R _L =60 Ω, -7 V ≤ V _{test} ≤ 12 V , 4.5 V ≤ V _{CC} ≤ 5.5 V (see Figure 8-1)		2.1	3.6		
		R _L = 100 Ω, C _L = 50pF (see Figure 8-2)		2	4.2		V
		R _L = 54 Ωm C _L = 50pF (see Figure 8-2)		1.5	3.6		V
Δ V _{OD}	Change in differential output voltage	R _L = 54 Ω or 100Ω, C _L = 50pF, (see Figure 8-2)		-50		50	mV
V _{OC}	Common-mode output voltage			1	V _{CC} /2	3.3	V
ΔV _{OC(SS)}	Change in steady-state common-mode output voltage			-50		50	mV
ΔV _{OC(pp)}	Change in steady-state common-mode output voltage, peak to peak			450			
I _{OS}	Short-circuit output current	DE = V _{CC} , -7 V ≤ V _O ≤ 12 V			100	150	mA
Receiver							
I _I	Bus input current	DE = 0 V, V _{CC} = 0 V or 5 V	V _I = 12V		75	125	μA
			V _I = -7V	-100	-40		μA
R _I	Receiver Input Resistance	V _A = -7V, V _B = 12V or V _A = 12V, V _B = -7V		96			kΩ
V _{TH+}	Receiver differential threshold voltage rising	Over common-mode range			-110	-50	mV
V _{TH-}	Receiver differential threshold voltage falling			-200	-140		mV
V _{HYS}	Receiver input hysteresis				30		mV
V _{OH}	Output high voltage	I _{OH} = -4mA		V _{CC} - 0.5	V _{CC} - 0.3		V
V _{OL}	Output low voltage	I _{OH} = 4mA			0.2	0.4	V
I _{OZR}	Output high-impedance current	V _O = 0 V or V _{CC} , REB = V _{CC}		-1		1	μA
I _{OSR}	Receiver output short current	REB = DE = 0V, see Figure 8-3				95	mA
Input Logic							
I _{IN}	Logic Input current	3 V ≤ V _{CC} ≤ 5.5 V, 0 V ≤ V _{IN} ≤ V _{CC}		-5		5	μA
Device							
I _{CC}	Supply current (quiescent)	Driver and receiver enabled REB=0V, DE = V _{CC} , No load			900	1400	μA
		Driver enabled, receiver Disabled REB=V _{CC} , DE = V _{CC} , No load			550	900	μA
		Driver disabled, receiver enabled REB=0V, DE = 0V, No load			500	800	μA
		Driver and receiver disabled REB=V _{CC} , DE = 0V, D=open, No load				5	μA
T _{SD}	Thermal shutdown temperature				170		°C
T _{SDHYS}	T _{SD} hysteresis				20		
Note:							
1. Under any condition, ensure that V _{TH+} is at least V _{HYS} higher than V _{TH-} .							

7.6. CS48505Ax Switching Characteristics

All typical specs are at $V_{CC} = 5V$, $T_A = 25^\circ C$, Min/Max specs are over recommended operating conditions unless otherwise specified.

Parameter	Test Conditions	Minimum value	Typical value	Maximum value	Unit
Driver					
t _r , t _f	Driver differential output rise/fall time	R _L = 54 Ω, C _L = 50 pF, see Figure 8-5	150	500	ns
t _{PHL} , t _{PLH}	Propagation delay		100	250	ns
t _{SK(P)}	Pulse skew t _{PHL} – t _{PLH}			10	ns
t _{PHZ} , t _{PLZ}	Disable time	See Figure 8-7, Figure 8-6	10	30	ns
t _{PZH} , t _{PZL}	Enable time	REB = 0V, See Figure 8-7, Figure 8-6	300	800	ns
		REB = V _{CC} , See Figure 8-7, Figure 8-6	6	12	us
Receiver					
t _r , t _f	Output rise/fall time	C _L = 15 pF, see Figure 8-8	10	20	ns
t _{PHL} , t _{PLH}	Propagation delay		50	100	ns
t _{SK(P)}	Pulse skew t _{PHL} – t _{PLH}			7	ns
t _{PHZ} , t _{PLZ}	Disable time	see Figure 8-9	30	60	ns
t _{PZH(1)} , t _{PZL(1)} ,	Enable time	DE = V _{CC} , see Figure 8-9 , Figure 8-9	50	100	ns
t _{PZH(2)} , t _{PZL(2)} ,		DE = 0 V, see, Figure 8-9 , Figure 8-9	6	12	μs
Note:					
1. C _L includes external circuit (fixture and instrumentation etc.) capacitance.					

7.7. CS48520Ax Switching Characteristics

All typical specs are at $V_{CC} = 5V$, $T_A = 25^\circ C$, Min/Max specs are over recommended operating conditions unless otherwise specified.

Parameter	Test Conditions	Minimum value	Typical value	Maximum value	Unit
Driver					
t _r , t _f	Driver differential output rise/fall time	R _L = 54 Ω, C _L = 50 pF, see Figure 8-5	5	12	ns
t _{PHL} , t _{PLH}	Propagation delay		12	25	ns
t _{SK(P)}	Pulse skew t _{PHL} – t _{PLH}			3.5	ns
t _{PHZ} , t _{PLZ}	Disable time	See Figure 8-7, Figure 8-6	10	30	ns
t _{PZH} , t _{PZL}	Enable time	REB = 0V, See Figure 8-7, Figure 8-6	300	800	ns
		REB = V _{CC} , See Figure 8-7, Figure 8-6	6	12	us
Receiver					
t _r , t _f	Output rise/fall time	C _L = 15 pF, see Figure 8-8	4	8	ns
t _{PHL} , t _{PLH}	Propagation delay		40	80	ns
t _{SK(P)}	Pulse skew t _{PHL} – t _{PLH}			12	ns
t _{PHZ} , t _{PLZ}	Disable time	see Figure 8-9	7	20	ns
t _{PZH(1)} , t _{PZL(1)} ,	Enable time	DE = V _{CC} , see Figure 8-9 , Figure 8-9	30	70	ns
t _{PZH(2)} , t _{PZL(2)} ,		DE = 0 V, see, Figure 8-9 , Figure 8-9	6	12	μs
Note:					
1. C _L includes external circuit (fixture and instrumentation etc.) capacitance.					

7.8. Typical Characteristics

All typical specs are at $V_{CC} = 5V$, $T_A = 25^\circ C$, Min/Max specs are over recommended operating conditions unless otherwise specified.

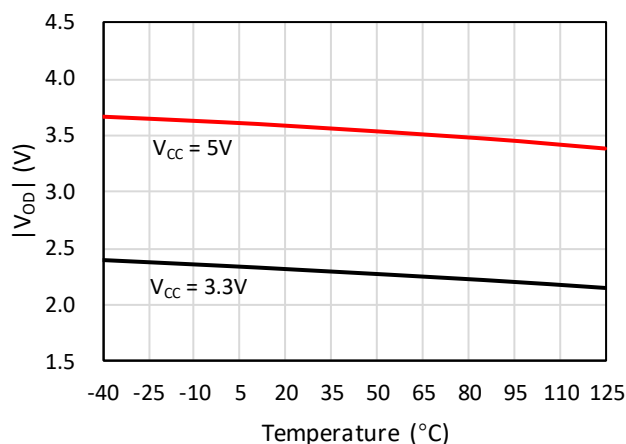


Figure 7-1 Driver Differential Output Voltage vs. Temperature, $R_L = 54\Omega$

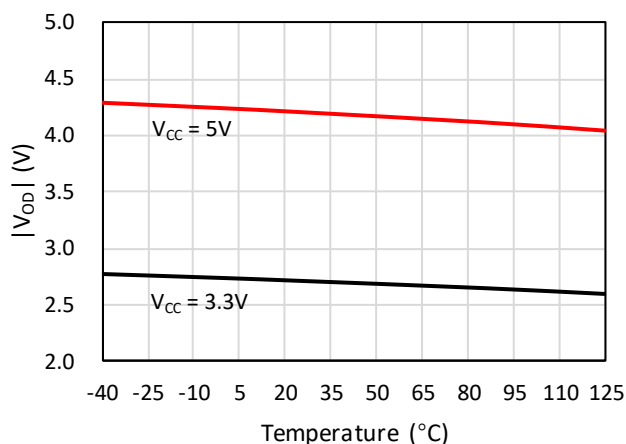


Figure 7-2 Driver Differential Output Voltage vs. Temperature, $R_L = 100\Omega$

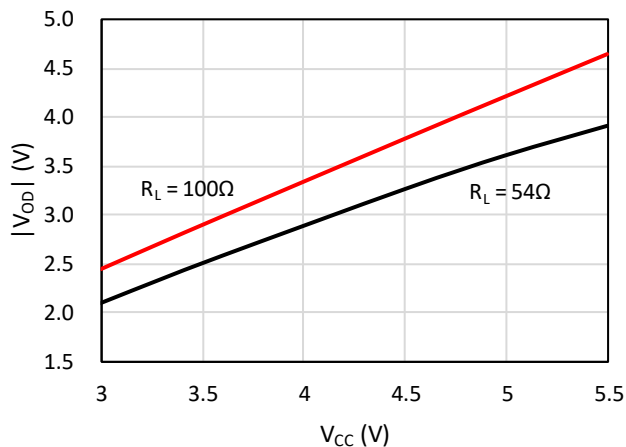


Figure 7-3 Driver Differential Output Voltage vs. Supply Voltage

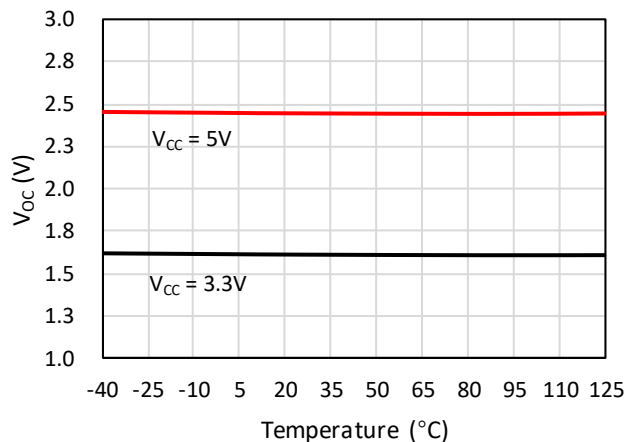


Figure 7-4 Driver Common-mode Output Voltage vs. Temperature

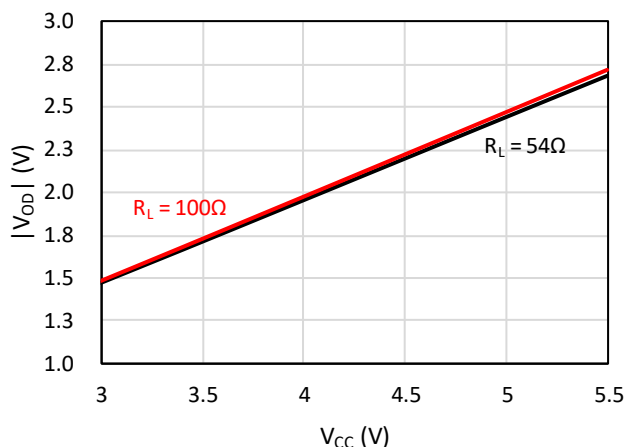


Figure 7-5 Driver Common-mode Output Voltage vs. Supply Voltage

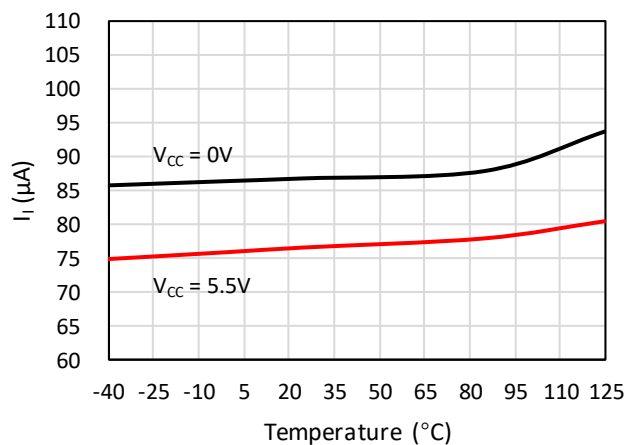
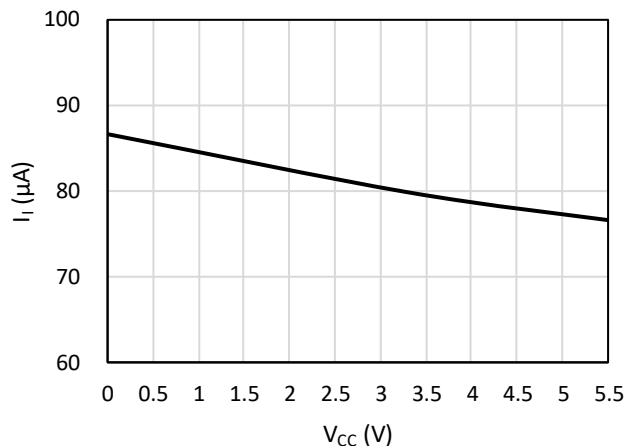
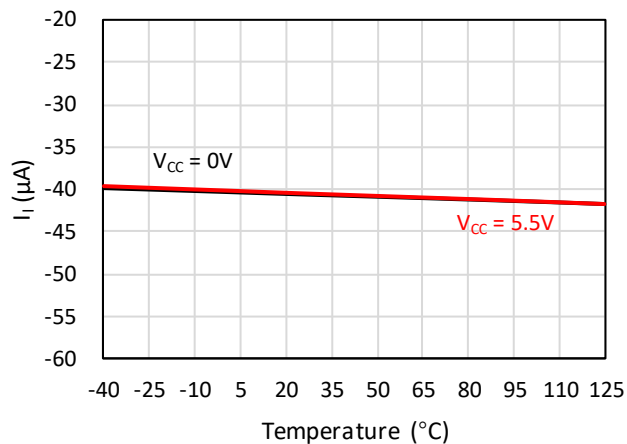
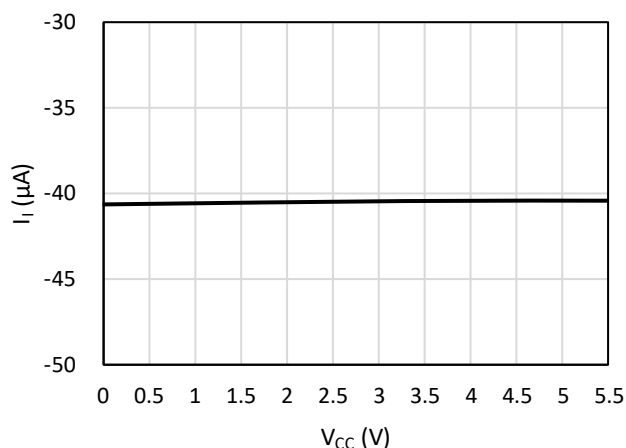
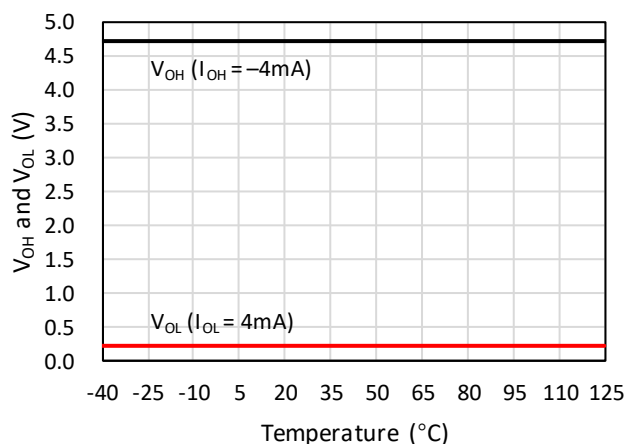
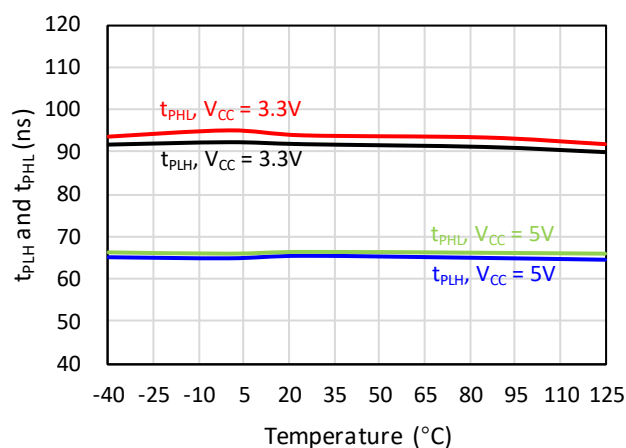
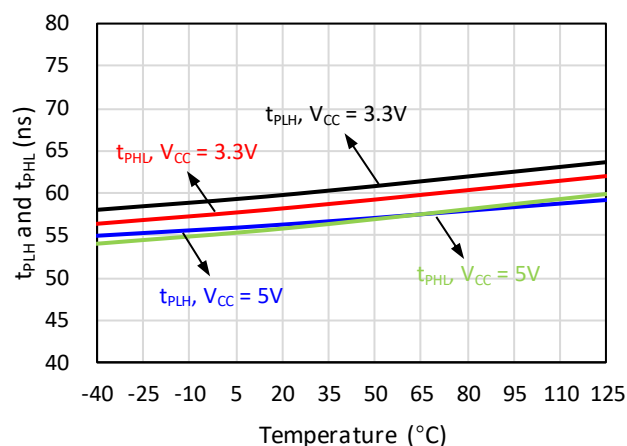
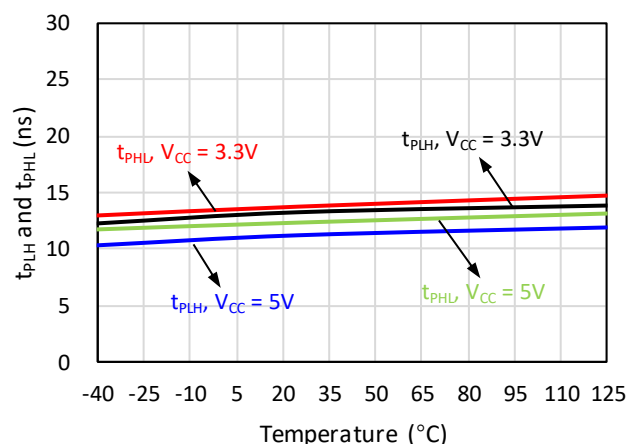
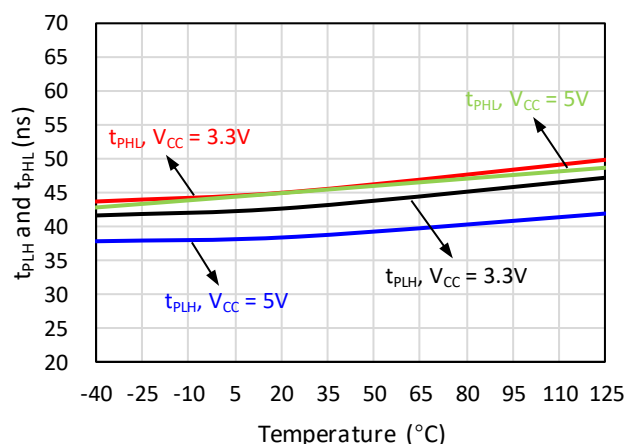
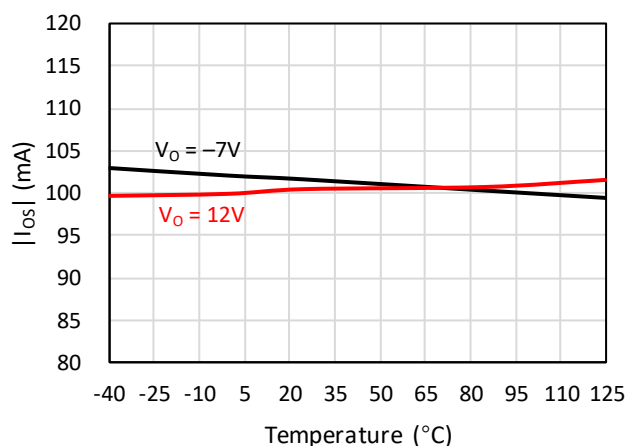
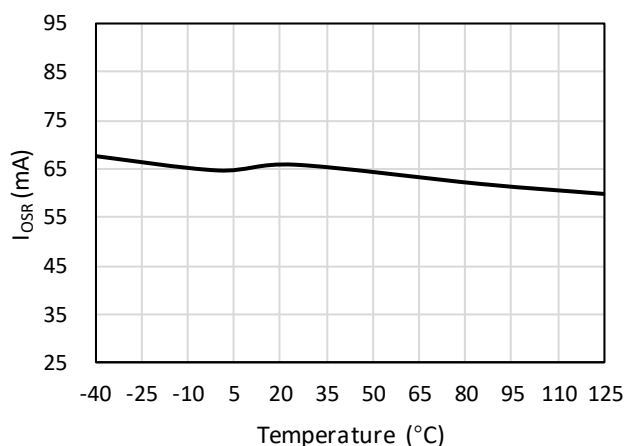
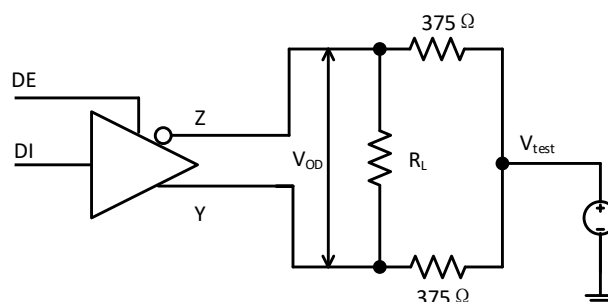


Figure 7-6 Bus Input Current vs. Temperature

Typical Characteristics (continued)

Figure 7-7 Bus Input Current vs. Supply Voltage, @ $V_I = 12V$

Figure 7-8 Bus Input Current vs. Temperature, @ $V_I = -7V$

Figure 7-9 Bus Input Current vs. Supply Voltage, @ $V_I = -7V$

Figure 7-10 Receiver Output @ Logic-low vs. Temperature

Figure 7-11 Driver Propagation Delay vs. Temperature (CS48505A)

Figure 7-12 Receiver Propagation Delay vs. Temperature (CS48505A)

Typical Characteristics (continued)

Figure 7-133 Driver Propagation Delay vs. Temperature (CS48520A)

Figure 7-14 Receiver Propagation Delay vs. Temperature (CS48520A)

Figure 7-15 Driver Output Short Current vs. Temperature

Figure 7-16 Receiver Output Short Current vs. Temperature
8. Parameter Measurement Information

Figure 8-1. Driver Differential Output Voltage With Common-Mode Load

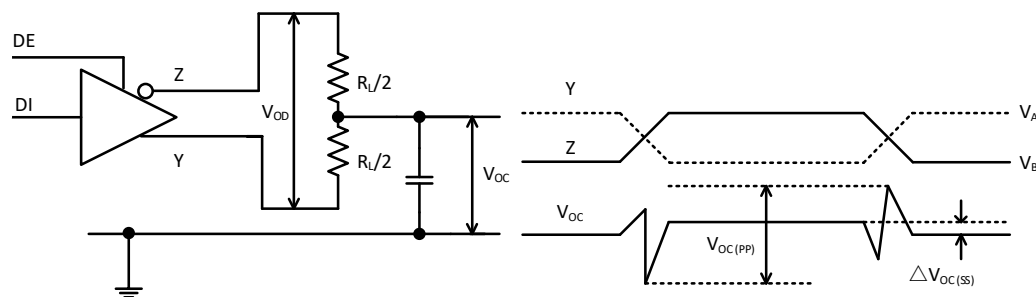


Figure 8-2. Driver Differential and Common-Mode Output With RS-485 Load

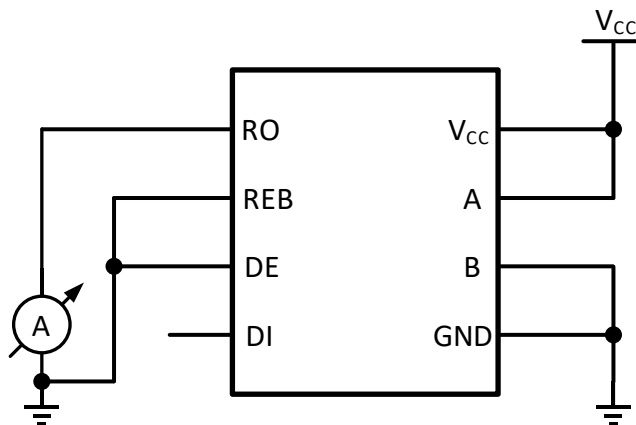


Figure 8-3. Receiver Output Short Current Measurement

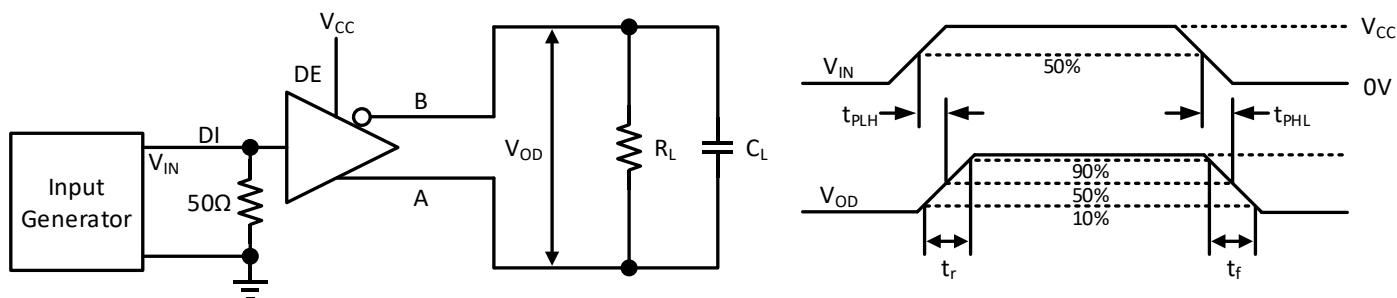


Figure 8-4. Driver Differential Output Rise and Fall Times and Propagation Delays

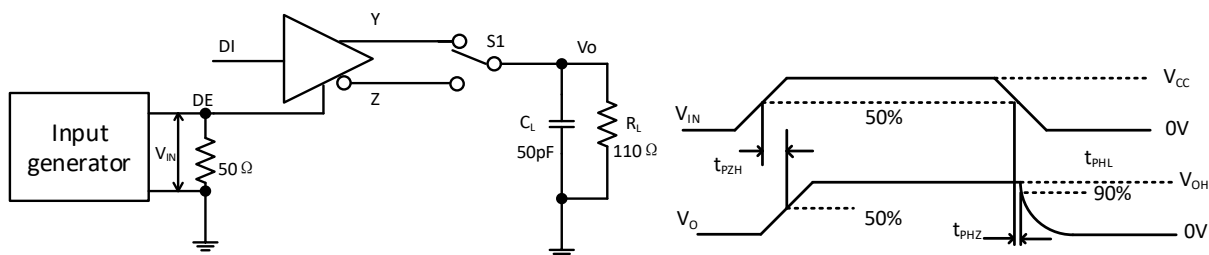


Figure 8-5. Driver Enable and Disable Times With Active High Output and Pull-Down Load

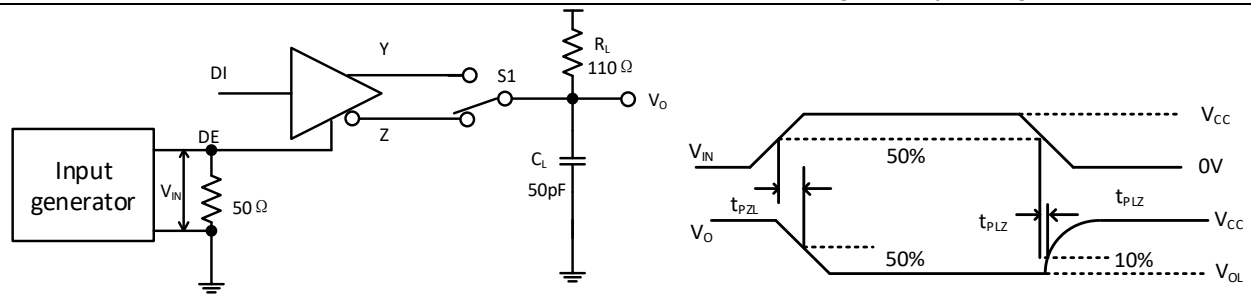


Figure 8-6. Driver Enable and Disable Times With Active Low Output and Pull-up Load

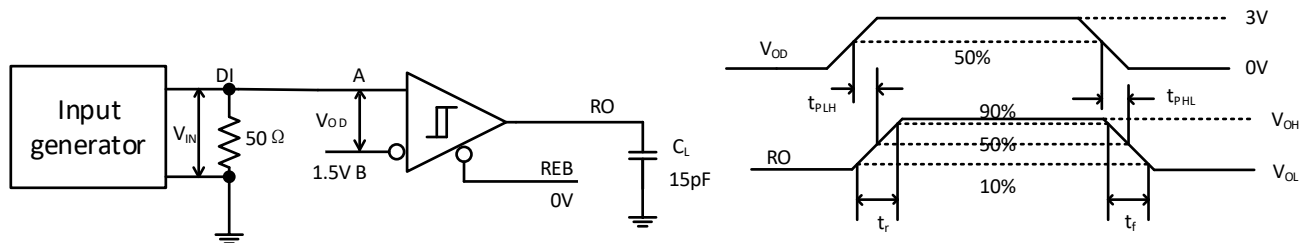


Figure 8-7. Receiver Output Rise and Fall Times and Propagation Delays

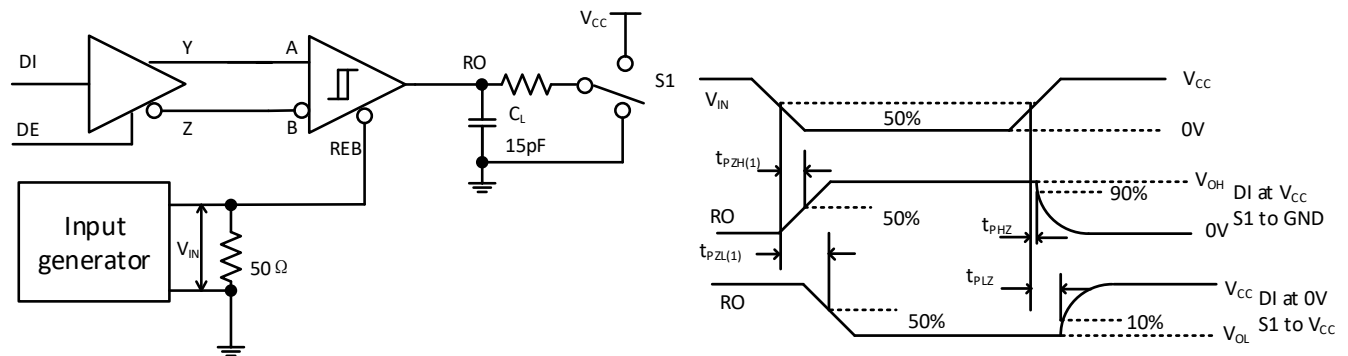


Figure 8-8. Receiver Enable/Disable Times With Driver Enabled

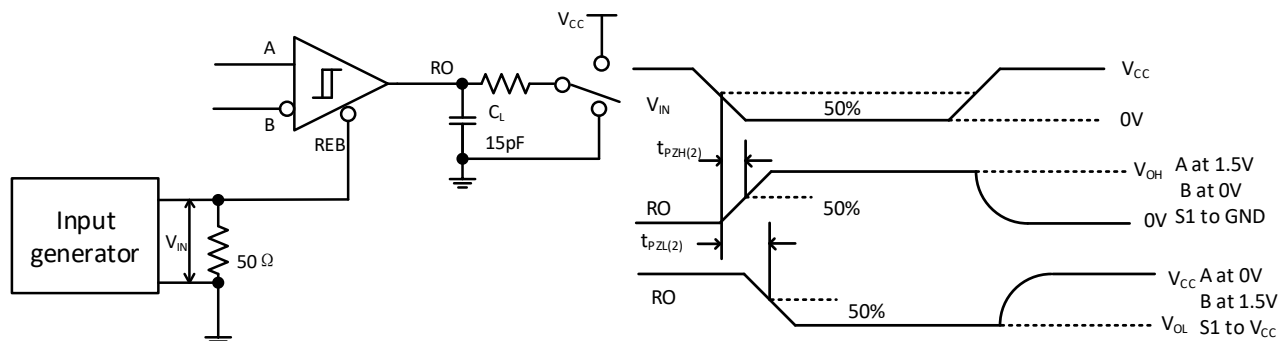


Figure 8-9. Receiver Enable Times With Driver Disabled

9. Detailed Description

9.1. Overview

The CS485xxA family of devices are optimized for RS-485/RS-422 applications per the EIA/TIA-485 standard. These devices contain one differential driver and one differential receiver. The receiver features a 1/8-unit load input impedance, allowing up to 256 transceivers on a single bus. Driver Enable (DE) and Receiver Enable (REB) pins are included on these half-duplex transceivers. When disabled, the driver and receiver outputs are high impedance. In addition, the CS48505Ax features reduced slew-rate driver that minimize EMI and reduce reflections caused by improperly terminated cables, thus allowing error-free data transmission up to 500kbps. The driver slew-rate of the CS48520Ax is not limited, allowing them to transmit up to 20Mbps data rate.

To reduce system complexity and the need for external protection, the driver outputs/receiver inputs of the CS48505A/CS48520A incorporate a high ESD protection circuit capable of protecting against up to $\pm 20\text{kV}$ of ESD Human Body Model (HBM) and $\pm 6\text{kV}$ Contact Discharge per IEC 61000-4-2. In addition, two mechanisms against excessive power dissipation caused by faults or bus contention. The first, over-current protection on the output stage, provides immediate protection against short circuits over the entire common-mode voltage range. The second, a thermal shutdown circuit, forces the driver outputs into a high-impedance state once the junction temperature of the devices exceed the thermal shutdown threshold T_{SD} (170°C , typ.). The shutdown condition is cleared when the junction temperature drops to 150°C .

9.2. Device Functional Modes

9.2.1. Driver

The CS485xxA driver accepts a single-ended, logic-level input (DI) and transfers it to a differential RS-485/RS-422 level output on the A and B driver outputs. Set the driver enable input (DE) low to disable the driver. A and B are high impedance when the driver is disabled. The DE pin has internal pull-down to GND. The DI pin has an internal pull-up resistor to V_{CC} , thus, when left open while the driver is enabled, the noninverting output A turns high and inverting output B turns low. See Table 9-1 for details.

Table 9-1. CS485xxA Driver Function Table

Input	Enable	Output		Function
DI	DE	A	B	
H	H	H	L	Drive bus high
L	H	L	H	Drive bus low
X	L	Z	Z	Driver disabled
X	OPEN	Z	Z	Driver disabled by default
OPEN	H	H	L	Drive bus high by default
Note: L = Low level; H = High level; Z = high impedance; X = Don't care.				

9.2.2. Fail-Safe Receiver

The CS485xxA receiver accepts a differential, RS-485/RS-422 level input on the A and B inputs and transfers it to a single-ended, logic-level output (RO). Drive the receiver enable input (REB) low to enable the receiver. Drive REB high to disable the receiver. RO is high impedance when REB is high. Also, REB pin has internal pull-up to V_{CC} .

The CS485xxA receiver includes a true fail-safe feature that ensures the receiver output (RO) is high when the receiver inputs are shorted or open, or when they are connected to a differentially terminated transmission line with all drivers disabled. If the differential receiver input voltage ($V_A - V_B$) is greater than or equal to V_{TH+} (-50mV , maximum), RO is logic high; if the input voltage ($V_A - V_B$) is less than the negative input threshold V_{TH-} (-200mV , minimum), the receiver output RO turns low. See Table 9-2 for more details.

Table 9-2. CS485xxA Receiver Function Table

Differential Input	Enable	Output	Function
$V_{ID} = V_A - V_B$	REB	RO	
$V_{TH+} < V_{ID}$	L	H	High-level bus state
$V_{TH-} < V_{ID} < V_{TH+}$	L	Indeterminate	Indeterminate bus state
$V_{ID} < V_{TH-}$	L	L	Low-level bus state
X	H	Z	Receiver disabled
X	OPEN	Z	Receiver disabled by default
Open-circuit bus	L	H	Fail-safe high output
Short-circuit bus	L	H	Fail-safe high output
Idle (terminated) bus	L	H	Fail-safe high output

Note:
L = Low level; H = High level; Z = high impedance.

10. Application Information

The CS485xxA family of half-duplex RS-485/RS-422 transceivers commonly used for asynchronous data transmissions, the driver and receiver enable pins allow for the configuration of different operating modes. An RS-485/RS-422 bus consists of multiple transceivers connecting in parallel to a bus cable. As seen in the following Figure 10-1 typical network application circuit, to minimize reflections, terminate the line at both ends with a termination resistor, R_T , whose value matches the characteristic impedance(Z_0) of the cable, and keep stub lengths off the main line as short as possible. This method, known as parallel termination, generally allows for higher data rates over longer cable length.

To ensure reliable operation at all data rates and supply voltages, each supply should be decoupled with at least 100nF ceramic capacitor located as close to the supply pins as possible.

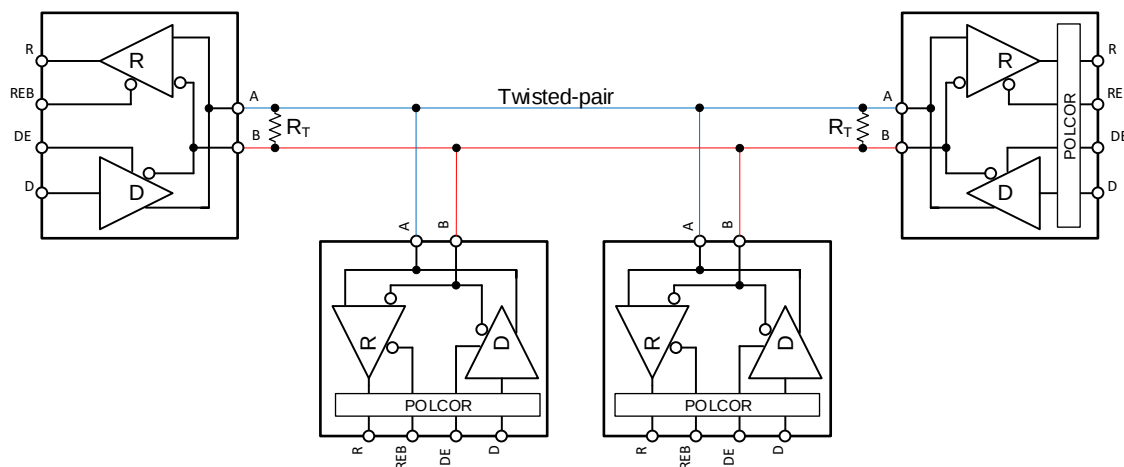
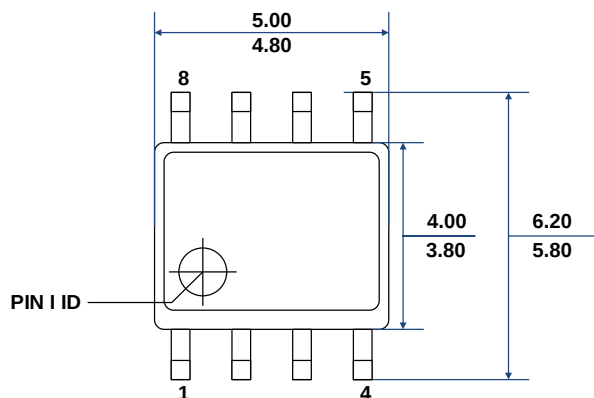


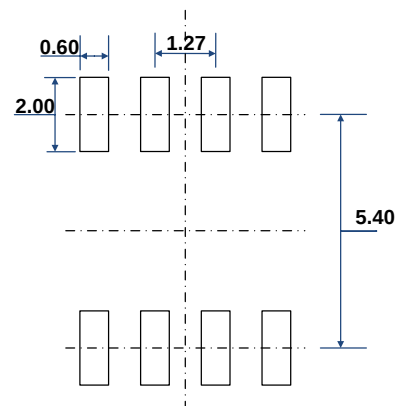
Figure 10-1. Typical RS-485 Network With CS485xxA Half-Duplex Transceivers

11. Package Information

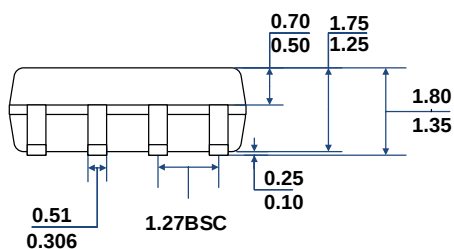
11.1. SOIC8 Package Outline



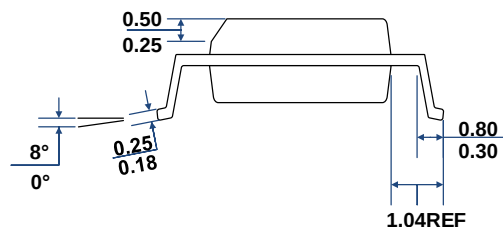
TOP VIEW



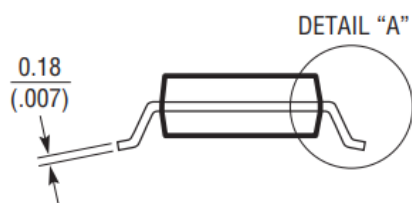
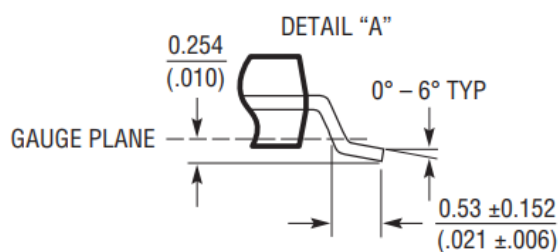
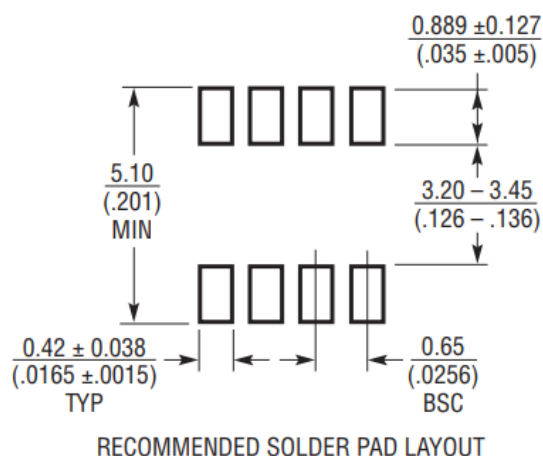
RECOMMENDED LAND PATTERN



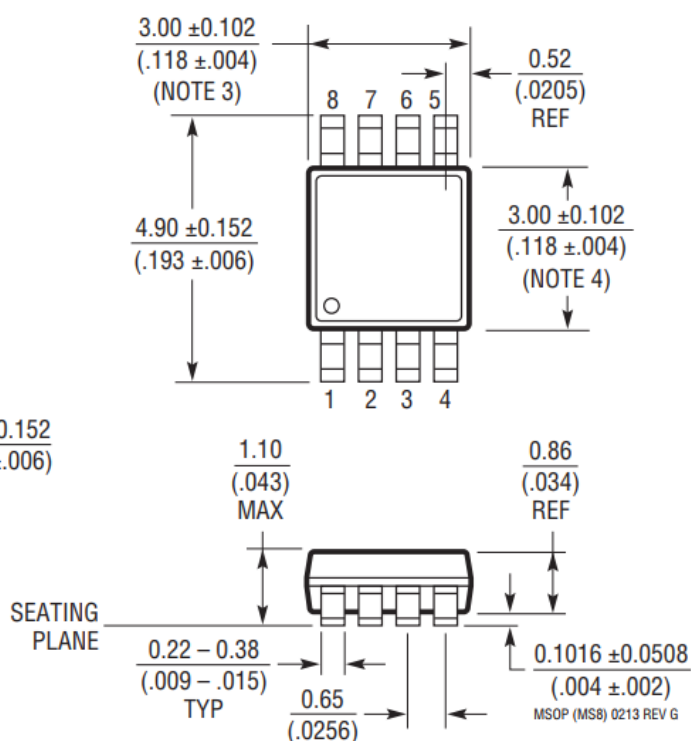
FRONT VIEW



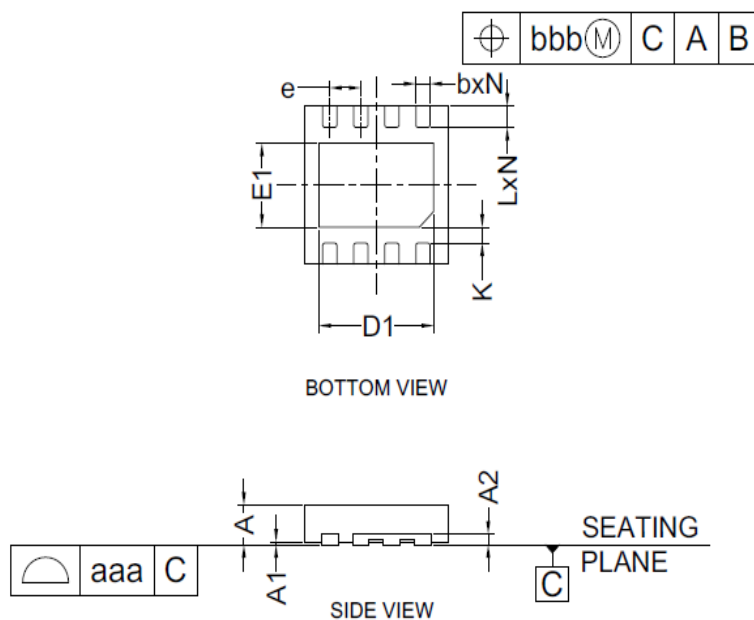
LEFT-SIDE VIEW

11.2. MSOP8 Package Outline


NOTE:



11.3. DFN8 Package Outline

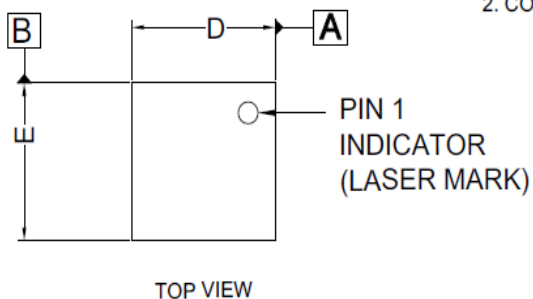


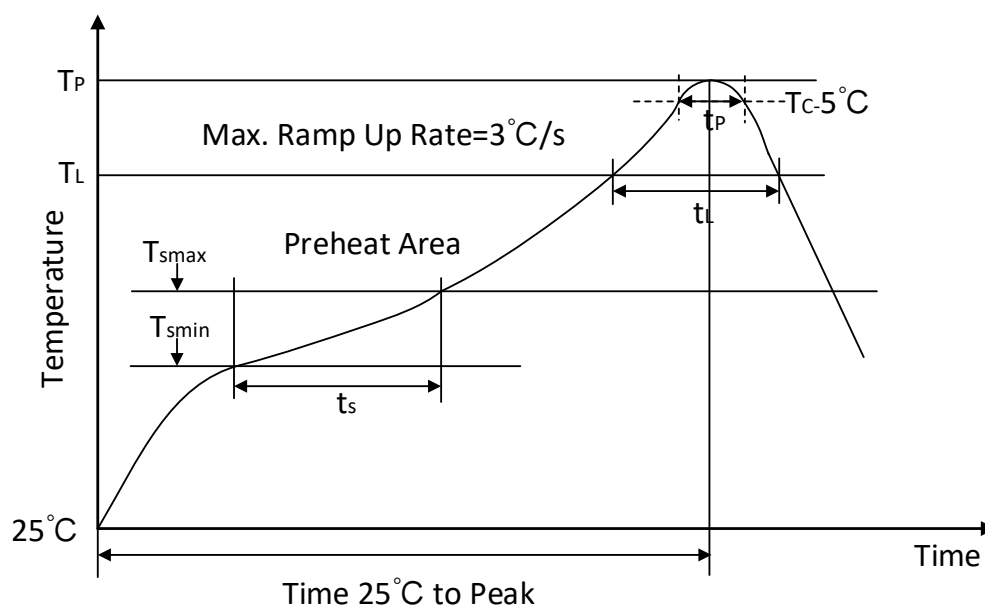
COMMON DIMENSIONS
(UNITS OF MEASURE=MILLIMETER)

SYMBOL	MIN	TYP	MAX
A	0.70	0.75	0.80
A1	0.00	0.02	0.05
A2	0.203		
b	0.30	0.35	0.40
D	2.90	3.00	3.10
D1	2.51	2.56	2.61
E	2.90	3.00	3.10
E1	1.55	1.60	1.65
e	0.65BSC		
L	0.35	0.40	0.45
N	8		
aaa	0.08		
bbb	0.10		

NOTES:

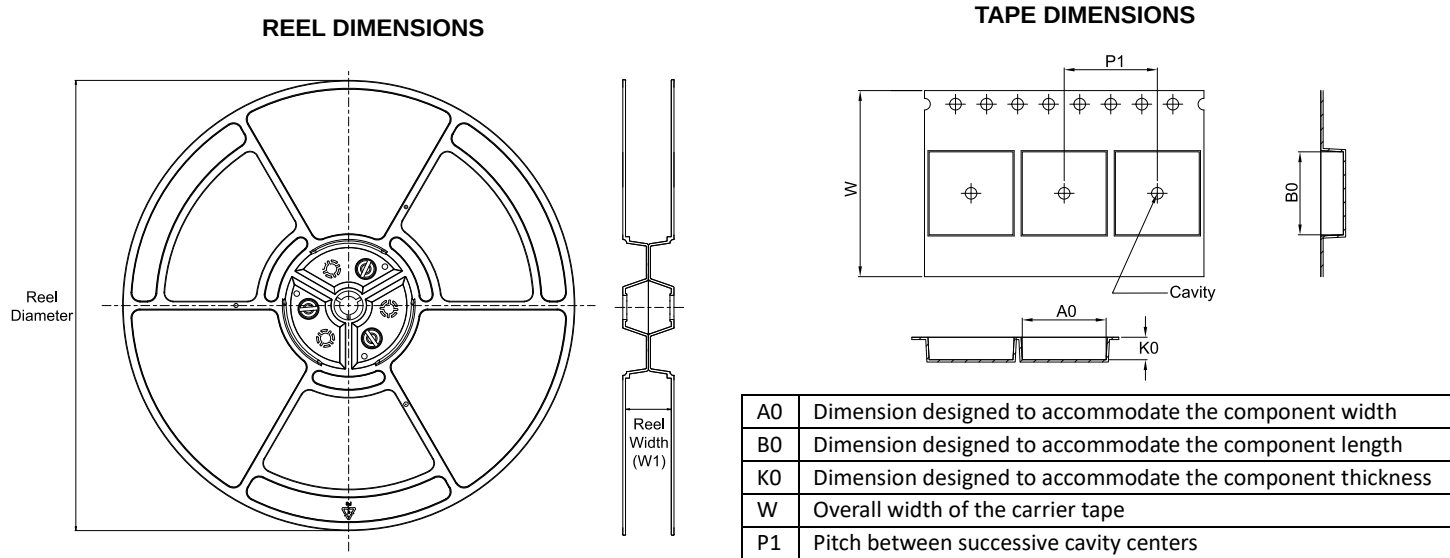
1. CONTROLLING DIMENSIONS ARE IN MILLIMETERS(ANGLES IN DEGREES).
2. COPLANARITY APPLIES TO THE EXPOSED PAD AS THE TERMINALS.



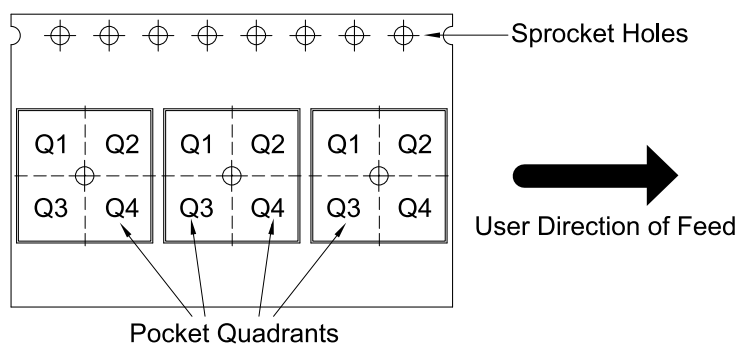
12. Soldering Temperature (reflow) Profile

Figure 12- 1 Soldering Temperature (reflow) Profile
Table12- 1 Soldering Temperature Parameter

Profile Feature	Pb-Free Assembly
Average ramp-up rate(217 °C to Peak)	3 °C/second max
Time of Preheat temp(from 150 °C to 200 °C)	60-120 second
Time to be maintained above 217 °C	60-150 second
Peak temperature	260 +5/-0 °C
Time within 5 °C of actual peak temp	30 second
Ramp-down rate	6 °C/second max.
Time from 25°C to peak temp	8 minutes max

13. Tape and Reel Information



QUADRANT ASSIGNMENTS FOR PIN 1 ORIENTATION IN TAPE



*All dimensions are nominal

Device	Package Type	Package Drawing	Pins	SPQ	Reel Diameter (mm)	Reel Width W1 (mm)	A0 (mm)	B0 (mm)	K0 (mm)	P1 (mm)	W (mm)	Pin1 Quadrant
CS48505AS	SOIC8	S	8	2500	330	12.4	6.5	5.4	2.1	8.0	12.0	Q1
CS48520AS	SOIC8	S	8	2500	330	12.4	6.5	5.4	2.1	8.0	12.0	Q1
CS48505AM	MSOP8	M	8	5000	330	12.6	6.55	5.4	1.9	8.0	12.0	Q1
CS48520AM	MSOP8	M	8	5000	330	12.6	6.55	5.4	1.9	8.0	12.0	Q1
CS48505AD	DFN8	D	8	3000	180	12.4	3.3	3.3	1.1	8.0	12.0	Q1
CS48520AD	DFN8	D	8	3000	180	12.4	3.3	3.3	1.1	8.0	12.0	Q1

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