±20-kV ESD Protected, 500-Kbps, RS-485 Transceiver

Features

- Exceeds Requirements of EIA-485 Standard
- Hot Plug Circuitry - Tx and Rx Outputs Remain Three-State during Power-up/Power-down
- Data Rates: 500 Kbps
- Full Fail-safe (Open, Short, Terminated) Receivers
- Up to 256 Nodes on a Bus (1/8 Unit Load)
- Wide Supply Voltage: 4.5 V to 5.5 V
- Bus-Pin Protection:
  - ±20-kV HBM Protection
  - ±15-kV IEC-ESD

Applications

- PROFIBUS® DP and FMS Networks
- SCSI “Fast 40” Drivers and Receivers
- Motor Controller/Position Encoder Systems
- Factory Automation
- Field Bus Networks
- Industrial/Process Control Networks

Description

The TPT485A is the enhanced RS485 which exceeds the standard TIA/EIA-485-A. The TPT485A is a single transceiver for balanced communication with a ±15-kV IEC-ESD protection and 4.5-V to 5.5-V power supply. It also features the larger output voltage and higher data rate (up to 500 Kbps) required by high-speed PROFIBUS applications.

Transmitters in this family deliver exceptional differential output voltages into the RS-485 required 54-Ω load. These 500-Kbps devices have very low bus currents, so they present a true “1/8 unit load” to the RS-485 bus. This allows up to 256 transceivers on the network without using repeaters.

This transceiver requires a 4.5-V to 5.5-V tolerance supply and delivers at least a 2.0-V differential output voltage on the 5-V supply condition. Receiver (Rx) inputs feature a “Full Fail-Safe” design, which ensures a logic-high Rx output if the Rx inputs are floating, shorted, or terminated but undriven. The Rx outputs feature high drive levels (typically > 25 mA @ V_{OL} = 1 V) to ease the design of optically isolated interfaces. The TPT485A is available in the SOP8 package, and is characterized from –40°C to 125°C.

Typical Application Circuit

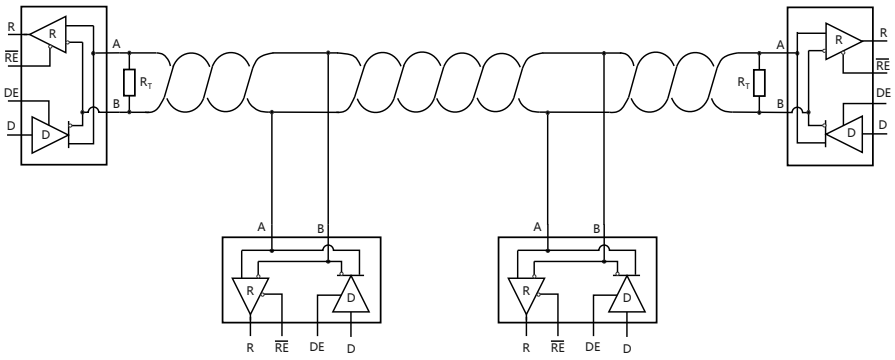


Table of Contents

Revision History

Date	Revision	Notes
2024-09-11	Rev.Pre0	Initial definition version
2025-04-01	Rev.A.0	Released version

Pin Configuration and Functions

TPT485A
SOP8
Top View

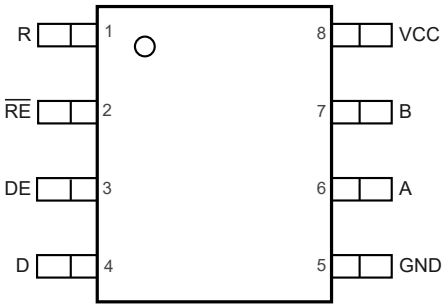


Table 1. Pin Functions: TPT485A

Pin No.	Name	I/O	Description
1	R	Digital output	Receiver Output.
2	$\overline{RE}$	Digital input	Receiver Output Enable.
3	DE	Digital input	Driver Output Enable.
4	D	Digital input	Driver Input.
5	GND	Ground	Ground.
6	A	Bus input/output	Noninverting Receiver Input A and Noninverting Driver Output A.
7	B	Bus input/output	Inverting Receiver Input B and Inverted Driver Output B.
8	V_{CC}	Power	Power Supply.

Specifications

Absolute Maximum Ratings

Parameter	Min	Max	Unit
Supply Voltage: V_{DD} to GND	−0.3	+7	V
Input Voltages: D, DE, RE	–0.3	(V_{CC}) + 0.3	V
Input/Output Voltages A, B	−25	+25	V
A, B (Transient Pulse Through 100 Ω) (1)	−25	+25	V
Output Voltage: R	–0.3	(V_{CC}) + 0.3	V
Receiver Output Current	−24	24	mA
Maximum Junction Temperature		150	°C
Storage Temperature Range	−65	150	°C

(1) Stresses beyond those listed under Absolute Maximum Ratings may cause permanent damage to the device. Exposure to any Absolute Maximum Rating condition for extended periods may affect device reliability and lifetime.

ESD, Electrostatic Discharge Protection

Symbol	Parameter	Condition	Value	Unit
IEC	IEC Contact Discharge	IEC-61000-4-2, Bus Pin: A, B	±15	kV
	IEC Air-Gap Discharge	IEC-61000-4-2, Bus Pin: A, B	±20	kV
HBM	Human Body Model ESD (1)	ANSI/ESDA/JEDEC JS-001, Bus Pin: A, B	±20	kV
		ANSI/ESDA/JEDEC JS-001, All Pin	±7	kV
CDM	Charged Device Model ESD (2)	ANSI/ESDA/JEDEC JS-002, All Pin	±1.5	kV
LU	Latch-up	LU, per JESD78, All Pin (3)	±500	mA

(1) JEDEC document JEP155 states that 500-V HBM allows safe manufacturing with a standard ESD control process.
(2) JEDEC document JEP157 states that 250-V CDM allows safe manufacturing with a standard ESD control process.

Recommended Operating Conditions

Parameter		Min	Typ	Max	Unit
V_{CC}	Supply Voltage	4.5		5.5	V
V_I	Input Voltage at any Bus Terminal	−15		15	V
V_{IH}	High-Level Input Voltage (driver, driver enable, and receiver enable inputs)	2		VCC	V
V_{IL}	Low-Level Input Voltage (driver, driver enable, and receiver enable inputs)	0		0.8	V
V_{ID}	Differential Input Common-Mode Voltage	−15		15	V
I_O	Output Current, Driver	−60		60	mA
I_O	Output Current, Receiver	−8		8	mA

Parameter		Min	Typ	Max	Unit
R_L	Differential Load Resistance	54			Ω
T_A	Operating Ambient Temperature	−40		+125	°C

Thermal Information

Package Type	θ_{JA}	θ_{JC}	Unit
SOP8	120	60	°C/W

Electrical Characteristics

All test conditions: V_{CC} = 4.5 V to 5.5 V, T_j = −40°C to +150°C, unless otherwise noted.

Symbol	Parameter	Conditions		Min	Typ	Max	Units
Driver							
$\|V_{OD}\|$	Driver Differential-Output Voltage Magnitude	R_L = 60 Ω with V_A or V_B from −7 to +12 V	See Figure 1B	1.6	2.6		V
		R_L = 54 Ω	See Figure 1B	1.6	2.5		V
		R_L = 100 Ω		2.4	3.2		V
$\Delta\|V_{OD}\|$	Change in Magnitude of Driver Differential-Output Voltage	R_L = 54 Ω, C_L = 50 pF	See Figure 1A	−50		50	mV
$V_{OC(SS)}$	Steady-Stage Common-Mode Output Voltage	Center of Two 27-Ω Load Resistors	See Figure 1A	1	V_{CC} / 2	3	V
ΔV_{OC}	Change in Differential Driver Common-Mode Output Voltage (1)			−65	50	65	mV
$V_{OC(PP)}$	Peak-to-Peak Driver Common-Mode Output Voltage (1)				600		
$\|I_{OS}\|$	Driver Short-circuit Output Current	|IOS| with A shorted to B			80	100	mA
Receiver							
V_{IT+}	Positive-Going Receiver Differential-Input Voltage Threshold	V_A or V_B from −7 to +12 V			-90	−50	mV
V_{IT-}	Negative-Going Receiver Differential-Input Voltage Threshold	V_A or V_B from −7 to +12 V		−200	-150		mV
V_{HYS}	Receiver Differential-Input Voltage Threshold Hysteresis ($V_{IT+} – V_{IT-}$) (1)				70		mV
V_{IH}	Logic Input High Voltage	D, DE, $\overline{RE}$		2			V
V_{IL}	Logic Input Low Voltage	D, DE, $\overline{RE}$				0.8	V
V_{OH}	Receiver High-Level Output Voltage	I_{OH} = −8 mA		4	V_{CC}-0.3		V
V_{OL}	Receiver Low-Level Output Voltage	I_{OL}= 8 mA				0.4	V
I_{IN}	DE = 0, V_{CC} = 0 or V_{CC} =5.5 V (A, B)	V_I = 12 V			30	140	μA
		V_I = −7 V		−100	−50		μA
R_A, R_B	Bus Input Impedance	V_A = −7 V, V_B = 12 V; or V_A = 12 V, V_B = −7 V		96			KΩ

Symbol	Parameter	Conditions		Min	Typ	Max	Units
I_{OZR}	Receiver High-Z Output Current	V_O = 0 V or V_{CC}, $\overline{RE}$ = V_{CC}		−1		1	μA
I_{OSR}	Receiver Output Short to Ground	$\overline{RE}$ = 0 V, DE = V_{CC}			78	95	mA
Logic							
I_I	Driver Enable	DE		-30		30	μA
	Driver Input, and Receiver Enable Input Current	D, $\overline{RE}$		-5		5	μA
Supply							
I_{CC}	Supply Current (Quiescent)	Driver and Receiver Enabled	DE = V_{CC}, $\overline{RE}$ = GND, No LOAD T_A = 25℃ (1)		550	600	μA
		Driver Enabled, Receiver Disabled	DE = V_{CC}, $\overline{RE}$ = V_{CC}, No LOAD		350	450	
		Driver Disabled, Receiver Enabled	DE = GND, $\overline{RE}$ = GND, No LOAD		350	500	
		Driver and Receiver Disabled	DE = GND, $\overline{RE}$ = V_{CC}, No LOAD		1	3	

(1) The data is based on bench tests and design simulations.

Switching Characteristics

All test conditions: V_{CC} = 4.5 V to 5.5 V, T_j = −40°C to +150°C, unless otherwise noted.

Symbol	Parameter	Conditions		Min	Typ	Max	Units
Driver							
f_{MAX}	Maximum Data Rate (1)	V_{OD} ≥ ±1.5 V, R_L = 54 Ω, C_L = 100 pF (Figure 4)			500		Kbps
t_r, t_f	Driver Differential-Output Rise and Fall Times (1)	R_L = 54 Ω, C_L = 50 pF	See Figure 2		300		ns
t_{PHL}, t_{PLH}	Driver Propagation Delay			220	330	450	
$t_{SK(P)}$	Driver Pulse Skew, $\lvert t_{PHL} - t_{PLH} \rvert$ (1)				10	30	
t_{PHZ}, t_{PLZ}	Driver Disable Time	Driver Disabled, DE = 0 V	See Figure 3		50	100	ns
t_{PZH}, t_{PZL}	Driver Enable Time	Receiver Enabled, DE = V_{CC}, $\overline{RE}$ = 0 V			200	600	ns
	Driver Enable Time	Receiver Disabled, DE = V_{CC}, $\overline{RE}$ = VCC			2800	4000	ns
Receiver							
t_r, t_f	Receiver output rise and fall times (1)	C_L = 15 pF	See Figure 5		30		ns
t_{PHL}, t_{PLH}	Receiver Propagation Delay Time				100	210	
$t_{SK(P)}$	Receiver Pulse Skew, $\lvert t_{PHL} - t_{PLH} \rvert$ (1)				20	50	
t_{PHZ}, t_{PLZ}	Receiver Disable Time	Receiver Disabled, $\overline{RE}$ = V_{CC}			30	80	ns
t_{PZH}, t_{PZL}	Receiver Enable Time	Driver Enabled, $\overline{RE}$ = 0 V, DE = V_{CC}			130	200	ns
	Receiver Enable Time	Driver Disabled, $\overline{RE}$ = 0 V, DE = 0 V			3000	4500	ns

(1) The data is based on bench tests and design simulations.

Test Circuits and Waveforms

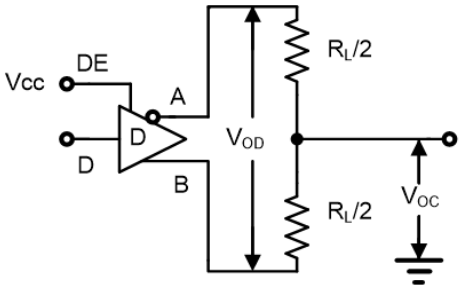


Figure 1A. VOD and VOC

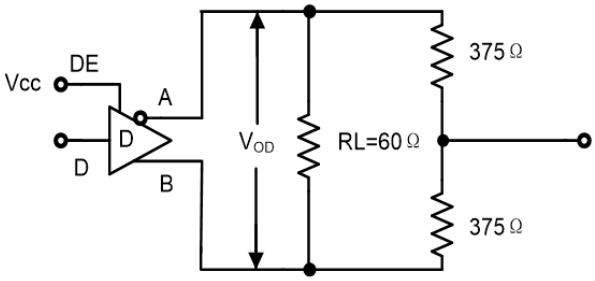


Figure 1B. VOD with Common Mode Load

Figure 1. DC Driver Test Circuits

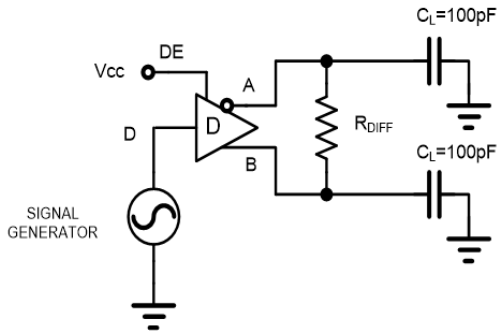


Figure 2A. Test Circuit

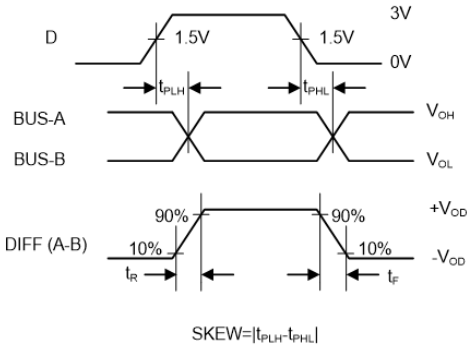
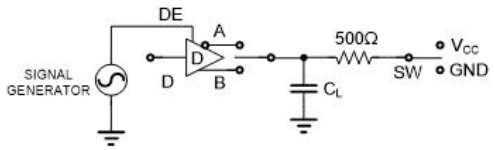


Figure 2B. Measurement Points

Figure 2. Driver Propagation Delay and Differential Transition Times



PARAMETER	OUTPUT	RE	DI	SW	CL (pF)
tPHZ	A/B	X	1/0	GND	15
tPLZ	A/B	X	0/1	VCC	15
tPZH	A/B	0	1/0	GND	100
tPZL	A/B	0	0/1	VCC	100
tPZH(SHDN)	A/B	1	1/0	GND	100
tPZL(SHDN)	A/B	1	0/1	VCC	100

Figure 3A. Test Circuit

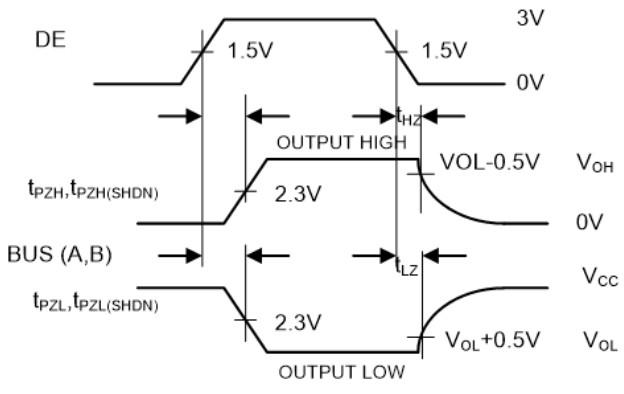


Figure 3B. Measurement Points

Figure 3. Driver Enable and Disable Times

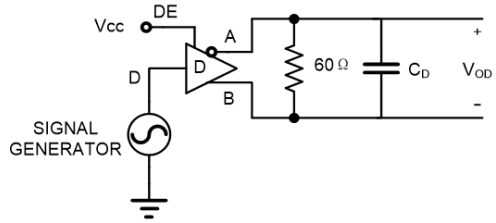


Figure 4A. Test Circuit

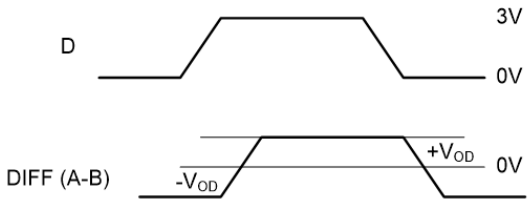


Figure 4B. Measurement Points

Figure 4. Driver Data Rate

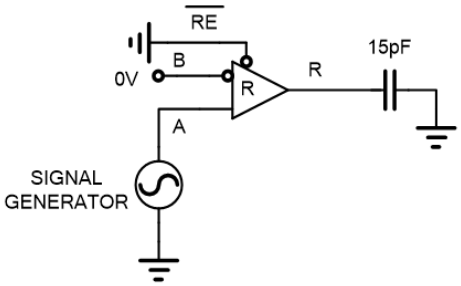


Figure 5A. Test Circuit

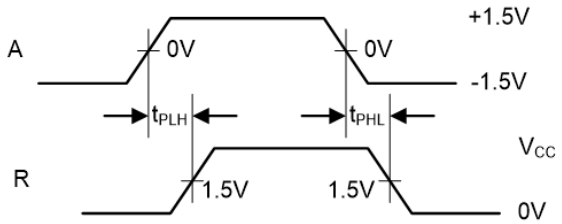
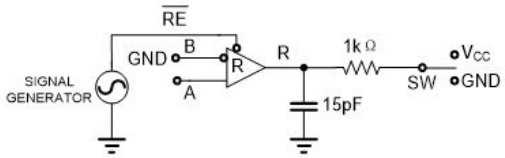


Figure 5B. Measurement Points

Figure 5. Receiver Propagation Delay and Data Rate



PARAMETER	DE	A	SW
tPHZ	1	+1.5V	GND
tPLZ	1	-1.5V	VCC
tPZH	1	+1.5V	GND
tPZL	1	-1.5V	VCC
tPZH(SHDN)	0	+1.5V	GND
tPZL(SHDN)	0	-1.5V	VCC

Figure 6A. Test Circuit

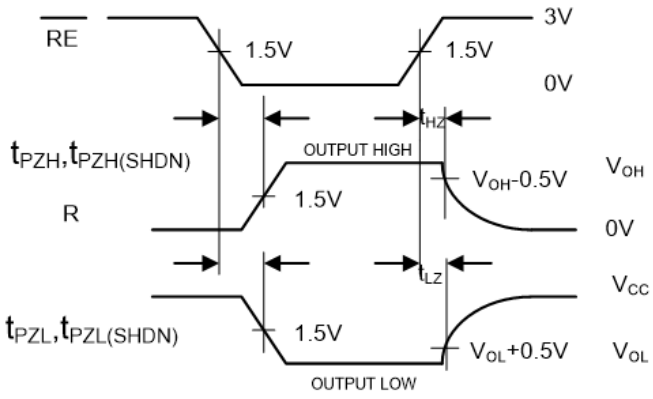


Figure 6B. Measurement Points

Figure 6. Receiver Enable and Disable Times

Functional Table

Table 2. Driver Pin Functions

Input	Enable	Outputs		Description
D	**DE**	**A**	**B**	
Normal Mode				
H	H	H	L	Actively drives bus High
L	H	L	H	Actively drives bus Low
X	L	Z	Z	Driver disabled
X	OPEN	Z	Z	Driver disabled by default
OPEN	H	H	L	Actively drives bus High

Table 3. Receiver Pin Functions

Differential Input	Enable	Output	Description
$V_{ID} = V_A - V_B$	**/RE**	**R**	
Normal Mode			
$V_{IT+} < V_{ID}$	L	H	Receive valid bus High
$V_{IT-} < V_{ID} < V_{IT+}$	L	?	Indeterminate bus state
$V_{ID} < V_{IT-}$	L	L	Receive valid bus Low
X	H	Z	Receiver disabled
X	OPEN	Z	Receiver disabled
Open, Short, Idle Bus	L	H	Indeterminate bus state

Detailed Description

Featured Description

High Data Rate

The RS-485/RS-422 is intended for network lengths up to 1200 meters (m), but the maximum system data rate decreases as the transmission length increases. TPT485A can operate at 500 Kbps and is limited to lengths less than 300 m.

The twisted pair is the cable of choice for the networks of the RS-485/RS-422. Twisted pair cables tend to pick up noise and other electromagnetically induced voltages as common-mode signals, which are effectively rejected by the differential receiver in this IC.

The proper termination is imperative to minimize reflections. In point-to-point, or point-to-multipoint (single driver on bus) networks, the main cable should be terminated in its characteristic impedance (typically 120 Ω) at the end farthest from the driver. In multi-receiver applications, stubs connecting receivers to the main cable should be kept as short as possible. Multipoint (multi-driver) systems require that the main cable be terminated in its characteristic impedance at both ends. Stubs connecting a transceiver to the main cable should be kept as short as possible.

The TPT485A may also be used at slower data rates over longer cables, but some limitations exist. Keeping the transition times below 500 ns, which equates to the Tx driving a 300 m CAT 5 cable, yields excellent performance over the full operating temperature range, and they are loaded with an RS-485 receiver in parallel with 54 Ω.

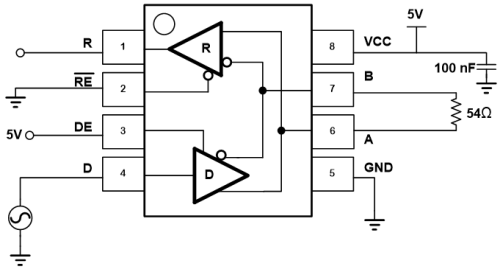


Figure 7. Loopback Test Circuit

Full Fail-Safe

All the receivers include a “full fail-safe” function that guarantees a high-level receiver output if the receiver inputs are unconnected (floating), shorted together, or connected to a terminated bus with all the transmitters disabled. Receivers easily meet the data rates supported by the corresponding driver, and all receiver outputs are three-stable via the active low RE input.

Hot Plug Function

When a piece of equipment powers up, there is a period where the processor or ASIC driving the control lines (DE, RE) of the RS-485 is unable to ensure that the Tx and Rx outputs of the RS-485 are kept disabled. If the equipment is connected to the bus, a driver activating prematurely during power-up may crash the bus. To avoid this scenario, the TPT485A incorporates a “Hot Plug” function. The circuitry monitoring V_{CC} ensures that, during power-up and power-down, the Tx and Rx outputs remain disabled, regardless of the state of DE and RE, if V_{CC} is less than ~2.5 V. This gives the processor/ASIC a chance to stabilize and drive the control lines of the RS-485 to the proper states.

Transient Protection

The bus terminals of the TPT485A transceiver family possess on-chip ESD protection against ±20-kV HBM. The International Electrotechnical Commission (IEC) ESD test is far more severe than the HBM ESD test. The IEC model, featuring a 50%

higher charge capacitance (C_S) and a 78% lower discharge resistance (R_D), produces significantly higher discharge currents than the HBM model. The TPT485A can support ±15-kV IEC 61000-4-2 contact ESD.

As stated in the IEC 61000-4-2 standard, contact discharge is the preferred transient protection test method. Although the IEC air-gap testing is less repeatable than the contact testing, air discharge protection levels are inferred from the contact discharge test results.

Application and Implementation

Note

Information in the following application sections is not part of the 3PEAK's component specification and 3PEAK does not warrant its accuracy or completeness. 3PEAK's customers are responsible for determining suitability of components for their purposes. Customers should validate and test their design implementation to confirm system functionality.

Typical Application

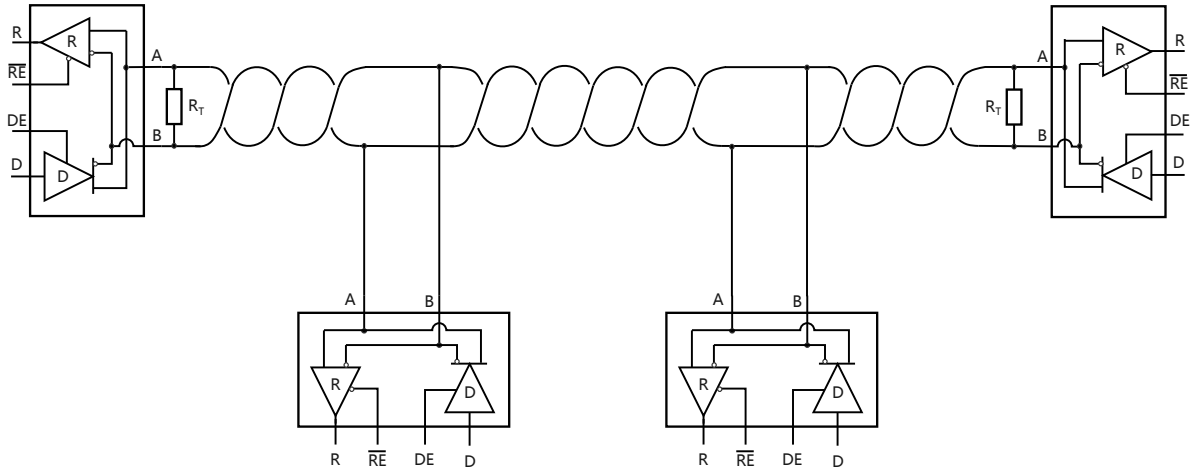
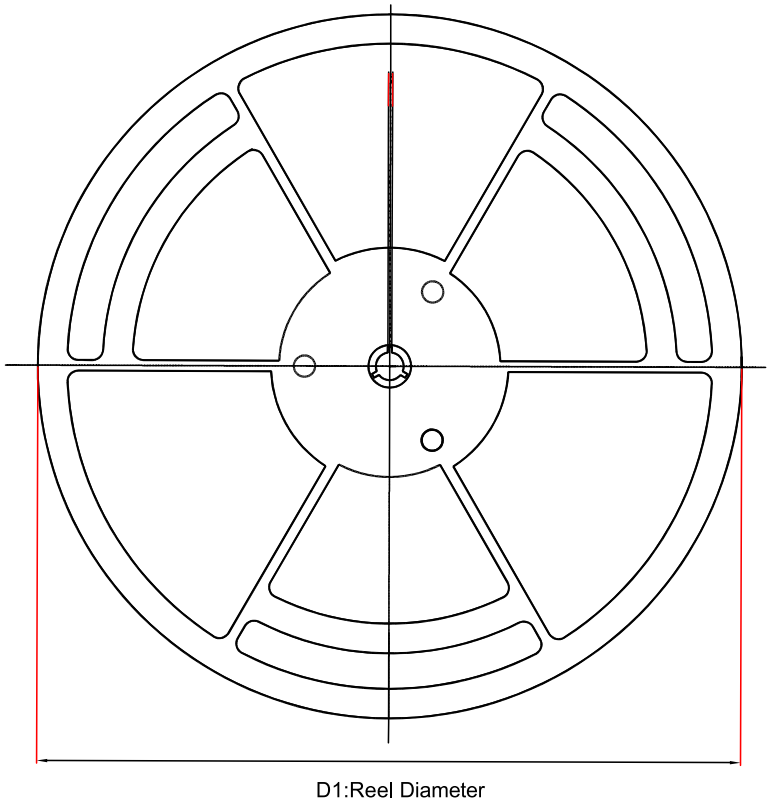
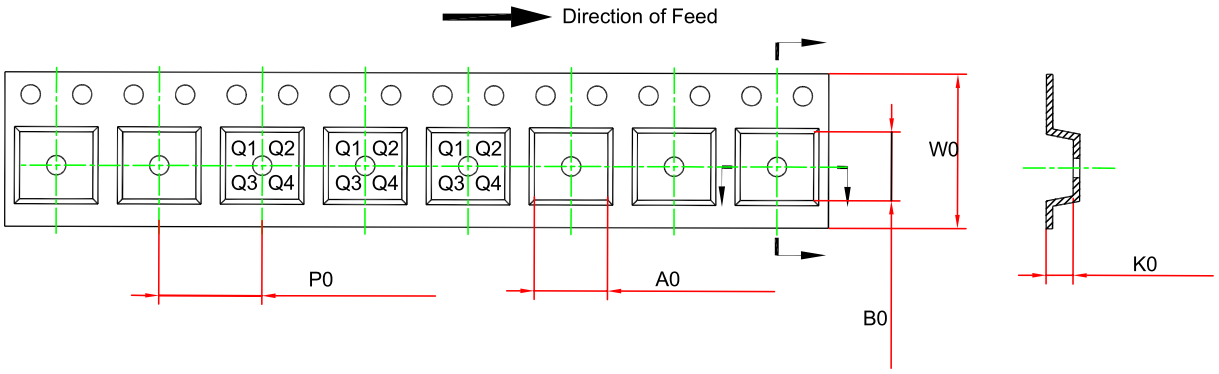


Figure 8. Typical RS485 Network

Tape and Reel Information



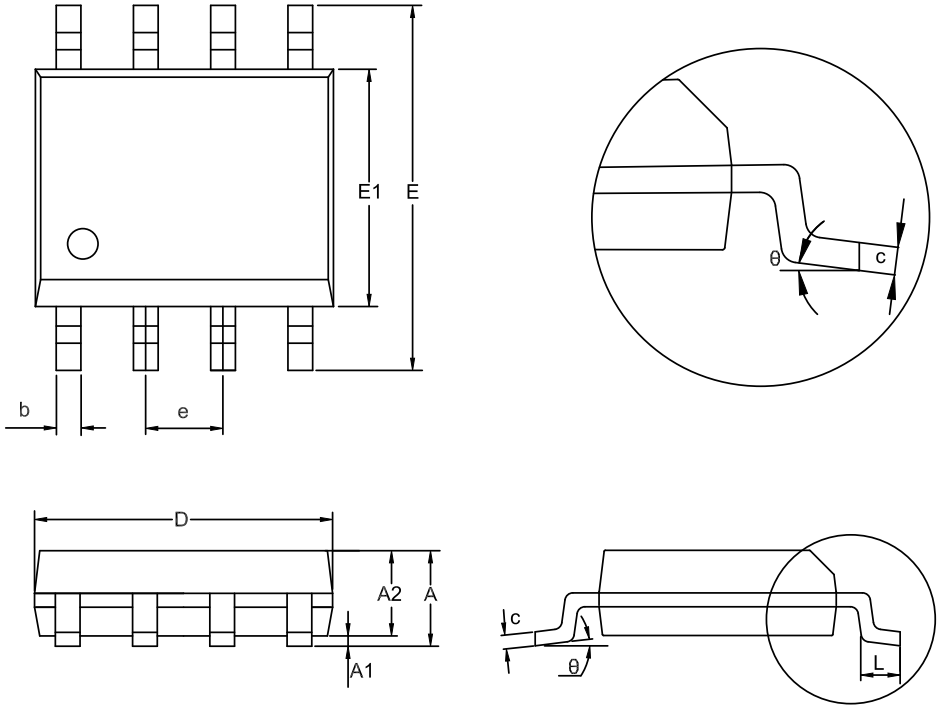


Order Number	Package	D1 (mm)	A0 (mm)	K0 (mm)	W0 (mm)	W1 (mm)	B0 (mm)	P0 (mm)	Pin1 Quadrant
TPT485A-SO1R	SOP8	330.0	6.5	2.0	12.0	17.6	5.4	8.0	Q1

Package Outline Dimensions

SOP8

Package Outline Dimensions SO1(SOP-8-A)



Symbol	Dimensions In Millimeters		Dimensions In Inches	
	MIN	MAX	MIN	MAX
A	1.350	1.750	0.053	0.069
A1	0.050	0.250	0.002	0.010
A2	1.250	1.550	0.049	0.061
b	0.330	0.510	0.013	0.020
c	0.170	0.250	0.007	0.010
D	4.700	5.100	0.185	0.201
E	5.800	6.200	0.228	0.244
E1	3.800	4.000	0.150	0.157
e	1.270 BSC		0.050 BSC	
L	0.400	1.000	0.016	0.039
θ	0	8°	0	8°

NOTES

1. Do not include mold flash or protrusion.
2. This drawing is subject to change without notice.

Order Information

Order Number	Operating Temperature Range	Package	Marking Information	MSL	Transport Media, Quantity	Eco Plan
TPT485A-SO1R	−40 to 125°C	SOP8	T485A	MSL1	Tape and Reel, 4,000	Green

Green: 3PEAK defines "Green" to mean RoHS compatible and free of halogen substances.

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