±15-kV ESD Protected, 10-Mbps, Full Fail-safe, RS-485 Transceiver

Features

- High Data Rates: 10 Mbps at a 5-V Supply
- 30/50-ns (Max) Tx/Rx Propagation Delays
- Full Fail-safe (Open, Short, Terminated) Receivers
- Up to 256 Nodes on a Bus (1/8 Unit Load)
- Wide Supply Voltage: 3 V to 5.5 V
- Low Quiescent Supply Current: 1.3 mA
- Bus-Pin Protection:
  - ±15-kV HBM Protection
  - ±15-kV IEC-ESD
- Pb-Free

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 TPT75176C is the enhanced RS485 which exceeds the standard TIA/EIA-485-A. The TPT75176C is a single transceiver for balanced communication with a ±15-kV IEC-ESD protection and a 3-V~5.5-V power. It also features a larger output voltage and higher data rate (up to 10 Mbps) required by high-speed PROFIBUS applications. The TPT75176C is offered in industrial and extended industrial (−40°C to +125°C) temperature ranges.

This transceiver requires a 3-V~5.5-V tolerance supply and delivers at least a 2.1-V differential output voltage on 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 TPT75176C is available in the SOP8, MSOP8, and DFN3×3-8 packages, and is characterized from −40°C to 125°C.

Typical Application Circuit

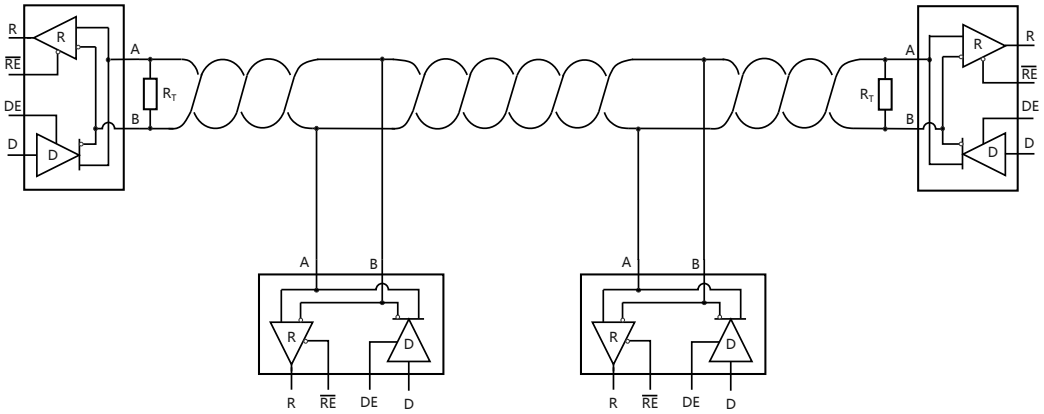


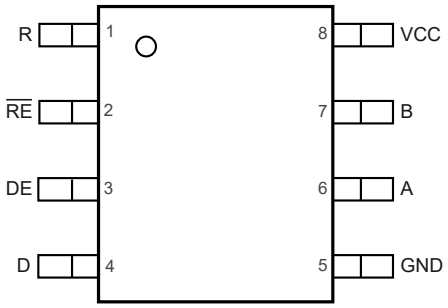
Table of Contents

Revision History

Date	Revision	Notes
2023-10-20	Rev.Pre.0	Initial version
2024-08-26	Rev.A.0	Released version

Pin Configuration and Functions

TPT75176C
SOP8/MSOP8
Top View



TPT75176C
DFN3×3-8
Top View

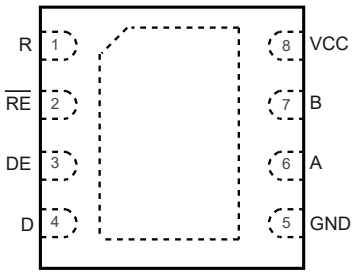


Table 1. Pin Functions: TPT75176C

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 (1)

Parameter	Min	Max	Unit
Supply Voltage: V_{DD} to GND	−0.3	+7	V
Input Voltages D, DE, $\overline{RE}$	–0.3	(V_{CC}) + 0.3	V
Input/Output Voltages A, B	−25	+25	V
A, B (Transient Pulse Through 100 Ω) (2)	−100	+100	V
Output Voltage, R	–0.3	(V_{CC}) + 0.3	V
Short Circuit Duration A, B		Continuous	
ESD Rating	See Specification Table		

(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.
(2) Test according to TIA/EIA-485-A, Section 4.2.6 (±100 V for 15 μs at a 1% duty cycle).

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	±15	kV
HBM	Human Body Model ESD (1)	ANSI/ESDA/JEDEC JS-001, Bus Pin: A, B	±15	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.
(3) Test at the temperature of 25℃.

Recommended Operating Conditions

Parameter		Min	Typ	Max	Unit
Supply Voltage		3		5.5	V
Temperature Range		−40		+125	°C
Bus Pin Common-Mode Voltage Range		−7		+12	V
IO, output current	Driver	−60		60	mA
	Receiver	−8		8	mA
Maximum Junction Temperature (Plastic Package)				+150	°C
Maximum Storage Temperature Range		−65		+150	°C

Thermal Information

Package Type	θ_{JA}	θ_{JC}	Unit
SOP8	120	64	°C/W
MSOP8	150	49	°C/W
DFN3×3-8	65	45	°C/W

Electrical Characteristics

All test conditions: V_{CC} = 5 V, T_A = −45℃ to +125°C, unless otherwise noted.

Symbol	Parameter	Conditions		Min	Typ	Max	Units
$\|V_{OD}\|$	Driver Differential-Output Voltage Magnitude	R_L = 60 Ω with V_A or V_B from −7 to +12 V, V_{CC} = 4.5 V~5.5 V	See Figure 1B	2.1	3.3		V
		R_L = 60 Ω with V_A or V_B from −7 to +12 V, V_{CC} = 3.0 V~3.6 V		1.5	2.0		
		R_L = 54 Ω, V_{CC} = 5 V	See Figure 1A	2.3	3.1		V
		R_L = 54 Ω, V_{CC} = 3 V		1.5	2		
		R_L = 100 Ω, V_{CC} = 5 V		2.3	3.6		
		R_L = 100 Ω, V_{CC} = 3 V		1.5	2.3		
$\triangle\|V_{OD}\|$	Change in Magnitude of Driver Differential-Output Voltage	R_L = 54 Ω, C_L = 50 pF, V_{CC} = 5 V	See Figure 1A	−50	16	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
$\triangle V_{OC}$	Change in Differential Driver Common-Mode Output Voltage (1)				10		mV
$V_{OC(PP)}$	Peak-to-Peak Driver Common-Mode Output Voltage (1)				500		
C_{OD}	Differential Output Capacitance (1)				8		pF
V_{IT+}	Positive-Going Receiver Differential-Input Voltage Threshold	V_A or V_B from −7 to +12 V			−100	−10	mV
V_{IT-}	Negative-Going Receiver Differential-Input Voltage Threshold	V_A or V_B from −7 to +12 V		−200	−160		mV
V_{HYS}	Receiver Differential-Input Voltage Threshold Hysteresis (V_{IT+} – V_{IT-}) [1]				60		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, V_{CC} = 4.5 V to 5.5 V		4	4.3		V
		I_{OH}= −8 mA, V_{CC} = 3.0 V to 3.6 V		2.45	2.8		V

Symbol	Parameter	Conditions		Min	Typ	Max	Units
V_{OL}	Receiver Low-Level Output Voltage	I_{OL}= 8 mA, V_{CC} = 4.5 V to 5.5 V			0.16	0.4	V
		I_{OL}= 8 mA, V_{CC} = 3.0 V to 3.6 V			0.23	0.5	V
I_I	Driver Enable	DE		−5		30	μA
I_I	Driver Input, Receiver Enable Input Current	D, $\overline{RE}$		−5		5	μA
I_{OZ}	Receiver High-Z Output Current	V_O = 0 V or V_{CC}, $\overline{RE}$ at V_{CC}		−1		1	μA
$\|I_{OS}\|$	Driver Short-circuit Output Current	$\|I_{OS}\|$ with V_A or V_B from −7 to +12 V		−250	200	250	mA
		Bus Pin A,B Short Current			130	180	mA
I_{OS}	Receiver output short to ground current	$\overline{EN}$ = 0, DE = VCC			100	150	mA
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
I_{IN}	Bus Input Current (Driver Disabled)	V_{CC} = 4.5 to 5.5 V or V_{CC} = 0 V, DE at 0 V	VI = 12 V			120	uA
			VI = −7 V	−110			
I_{CC}	Supply Current (Quiescent)	Driver and Receiver Enabled	DE = V_{CC}, $\overline{RE}$ = GND, No LOAD		0.9	1.5	mA
		Driver Enabled, Receiver Disabled	DE = V_{CC}, $\overline{RE}$ = V_{CC}, No LOAD		0.9	1.5	
		Driver Disabled, Receiver Enabled	DE = GND, $\overline{RE}$ = GND, No LOAD		0.7	1.3	
		Driver and Receiver Disabled	DE = GND, $\overline{RE}$ = V_{CC}, D = V_{cc} No LOAD		0.7	1.3	

(1) The parameter is provided by the lab bench test and design simulation, NOT test in production.

Switching Characteristics

Symbol	Parameter	Conditions		Min	Typ	Max	Units
Driver							
f_{MAX}	Maximum Data Rate (1)	V_{OD} ≥ ±3 V, R_L = 54 Ω, C_L = 100 pF (Figure 4)			10		Mbps
		V_{OD} = ±1.5 V, R_L = 54 Ω, C_L = 100 pF (Figure 4)			6		Mbps
t_r, t_f	Driver Differential-Output Rise and Fall Times (1)	R_L = 54 Ω, C_L = 50 pF	See Figure 2		15		ns
t_{PHL}, t_{PLH}	Driver Propagation Delay				21	40	ns
$t_{SK(P)}$	Driver Pulse Skew, $\lvert t_{PHL} - t_{PLH} \rvert$ (1)				2	6	ns
t_{PHZ}, t_{PLZ}	Driver Disable Time		See Figure 3		30	50	ns
t_{PZH}, t_{PZL}	Driver Enable Time	Receiver Enabled			10	45	ns
	Driver Enable Time	Receiver Disabled			10	50	ns
Receiver							
t_r, t_f	Receiver output rise and fall times (1)	C_L = 15 pF	See Figure 5		5		ns
t_{PHL}, t_{PLH}	Receiver Propagation Delay Time				30	100	ns
$t_{SK(P)}$	Receiver Pulse Skew, $\lvert t_{PHL} - t_{PLH} \rvert$ (1)				10	50	ns
t_{PHZ}, t_{PLZ}	Receiver Disable Time				15	60	ns
t_{PZH}, t_{PZL}	Receiver Enable Time	Driver Enabled			10	30	ns
	Receiver Enable Time	Driver Disabled			10	40	ns

(1) The parameter is provided by the lab bench test and design simulation, NOT test in production.

Test Circuits and Waveforms

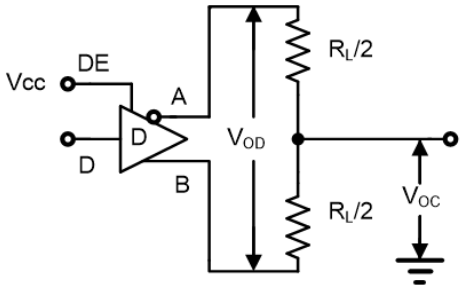


Figure 1A. VOD and VOC

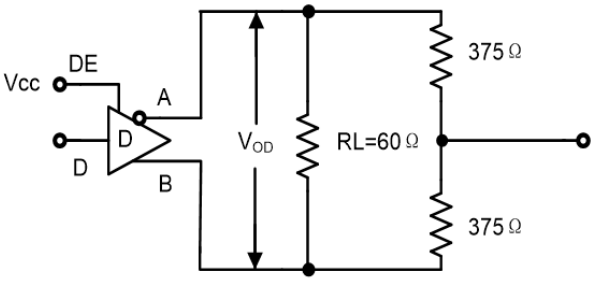


Figure 1B. VOD with Common Mode Load

Figure 1. DC Driver Test Circuits

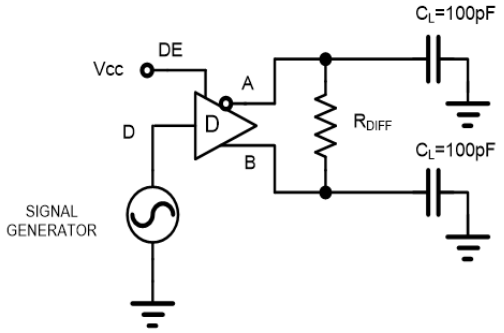


Figure 2A. Test Circuit

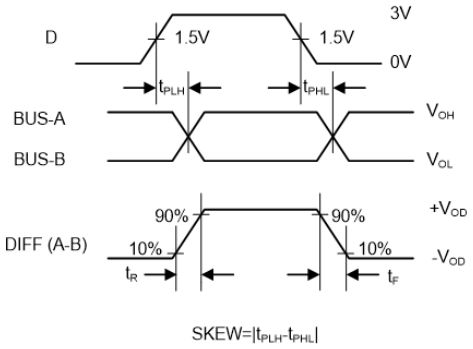
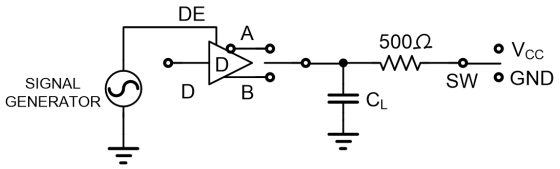


Figure 2B. Measurement Points

Figure 2. Driver Propagation Delay and Differential Transition Times



Parameter	Output	RE	DI	SW	CL (pF)
t_{PHZ}	A/B	X	1/0	GND	15
t_{PLZ}	A/B	X	0/1	V_{CC}	15
t_{PZH}	A/B	0	1/0	GND	100
t_{PZL}	A/B	0	0/1	V_{CC}	100
$t_{PZH\ (SHDN)}$	A/B	1	1/0	GND	100
$t_{PZL\ (SHDN)}$	A/B	1	0/1	V_{CC}	100

Figure 3A. Test Circuit

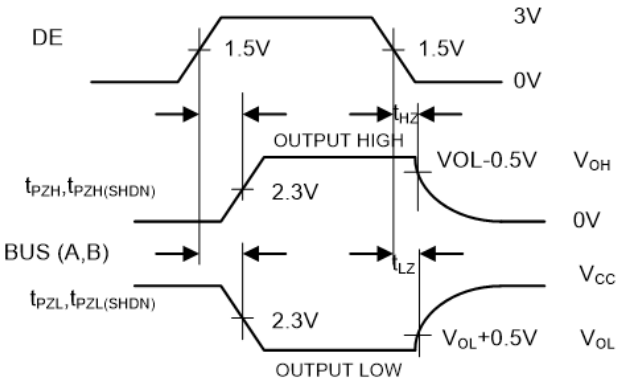


Figure 3B. Measurement Points

Figure 3. Driver Enable and Disable Times

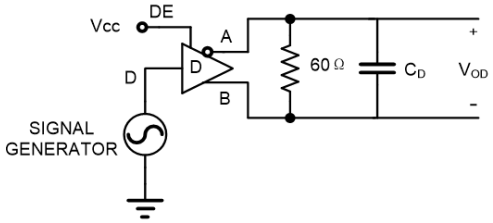


Figure 4A. Test Circuit

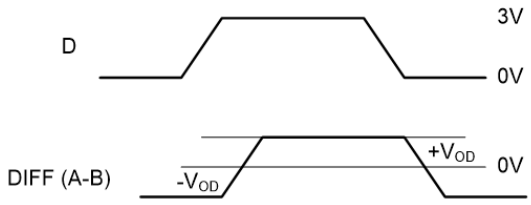


Figure 4B. Measurement Points

Figure 4. Driver Data rate

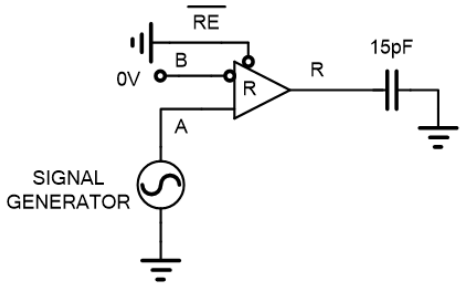


Figure 5A. Test Circuit

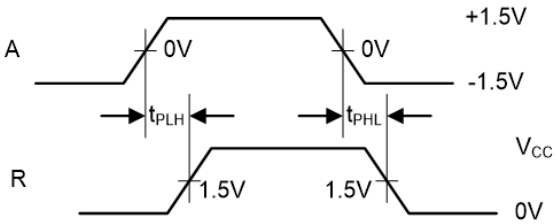
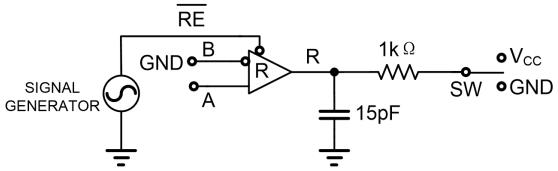


Figure 5B. Measurement Points

Figure 5. Receiver Propagation Delay and Data rate



Parameter	DE	A	SW
t_{PHZ}	1	+1.5 V	GND
t_{PLZ}	1	-1.5 V	V_{CC}
t_{PZH}	1	+1.5 V	GND
t_{PZL}	1	-1.5 V	V_{CC}
$t_{PZH\ (SHDN)}$	0	+1.5 V	GND
$t_{PZL\ (SHDN)}$	0	-1.5 V	V_{CC}

Figure 6A. Test Circuit

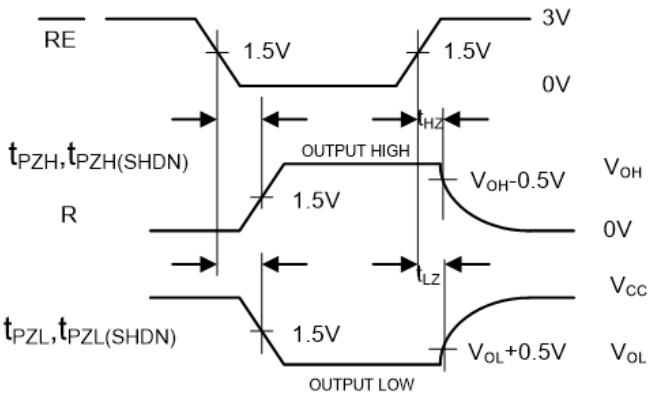


Figure 6B. Measurement Points

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
$V_{ID} = V_A - V_B$	**$\overline{RE}$**	**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 4000 feet, but the maximum system data rate decreases as the transmission length increases. Devices operating at 10 Mbps are limited to lengths less than 100 feet.

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 TPT75176C may also be used at slower data rates over longer cables, but there are some limitations. The Rx is optimized for high-speed operation, so its output may glitch if the Rx input differential transition times are too slow. Keeping the transition times below 500 ns, which equates to the Tx driving a 1000 feet (305 m) CAT 5 cable, yields excellent performance over the full operating temperature range. For the below test waveform, the transmitter is driven at 10 Mps and/or with 100 feet (31 m) CAT 5 cable, and they are loaded with an RS-485 receiver in parallel with 54 Ω.

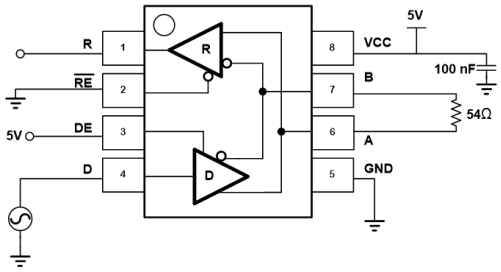


Figure 7. Loopback Test Circuit

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.

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 TPT75176C 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 $\overline{RE}$, 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 TPT75176C transceiver family possess on-chip ESD protection against ±15-kV HBM. The International Electrotechnical Commission (IEC) ESD test is far more severe than the HBM ESD test. The 50% higher charge

capacitance, CS, and the 78% lower discharge resistance, RD, of the IEC model produce significantly higher discharge currents than the HBM model.

As stated in the IEC 61000-4-2 standard, the 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

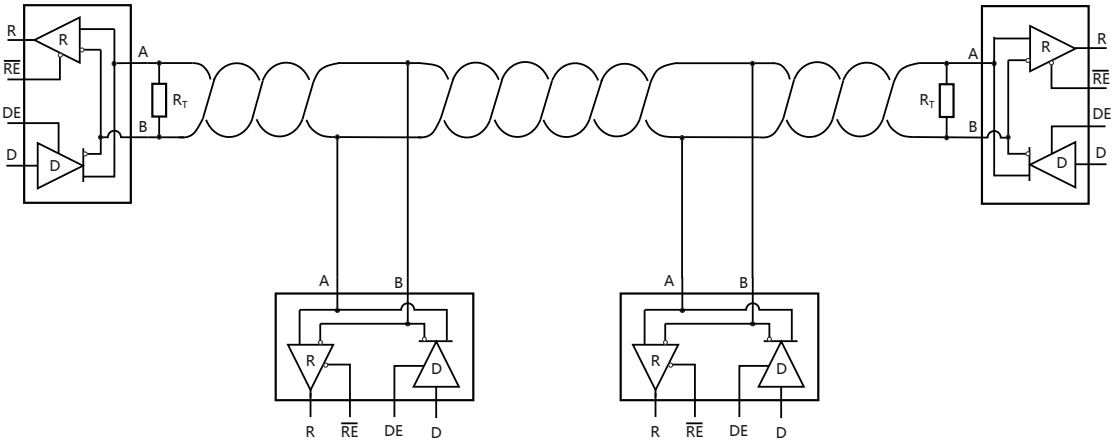
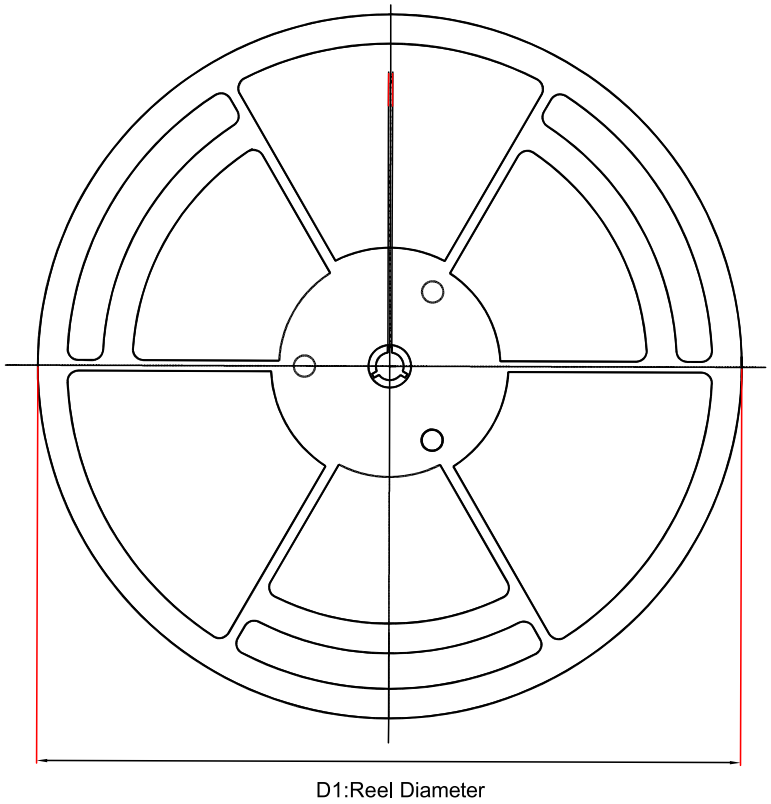
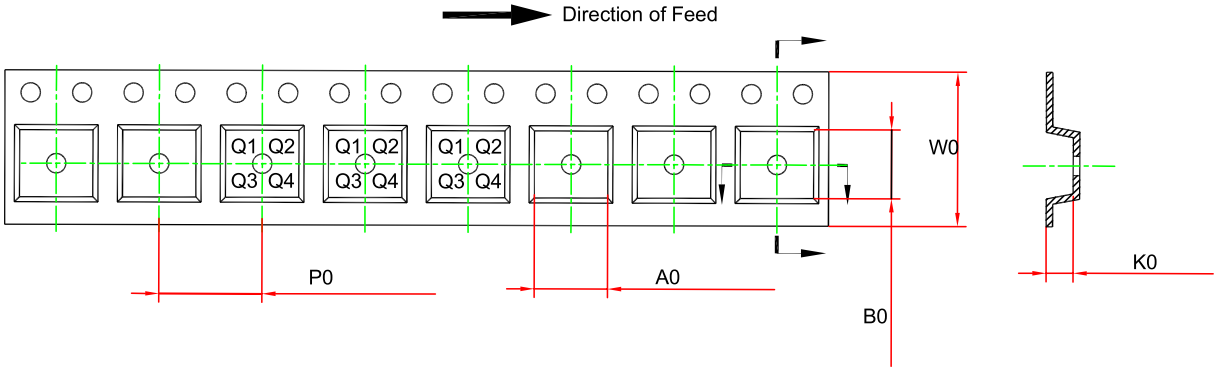


Figure 8. Typical RS485 Network

Tape and Reel Information



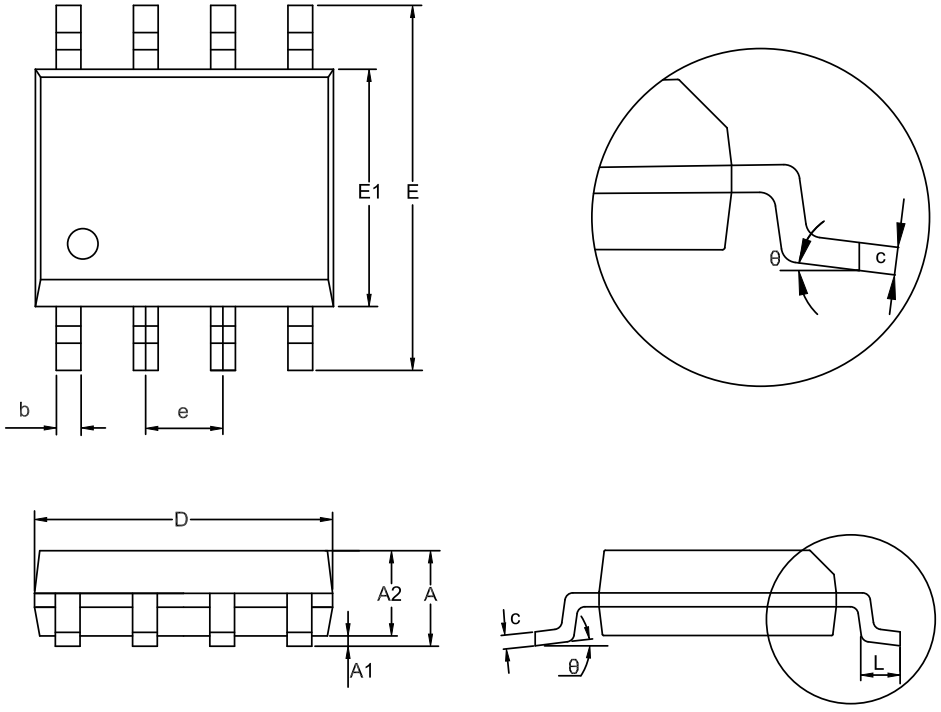


Order Number	Package	D1 (mm)	W1 (mm)	A0 (mm)	B0 (mm)	K0 (mm)	P0 (mm)	W0 (mm)	Pin1 Quadrant
TPT75176C-SO1R	SOP8	330.0	17.6	6.4	5.4	2.1	8.0	12.0	Q1
TPT75176C-VS1R	MSOP8	330.0	17.6	5.2	3.3	1.5	8.0	12.0	Q1
TPT75176C-DF6R	DFN3×3-8	330.0	17.6	3.4	3.4	1.1	8.0	12.0	Q1

Package Outline Dimensions

SOP8

Package Outline Dimensions SO1(SOP-8-A)



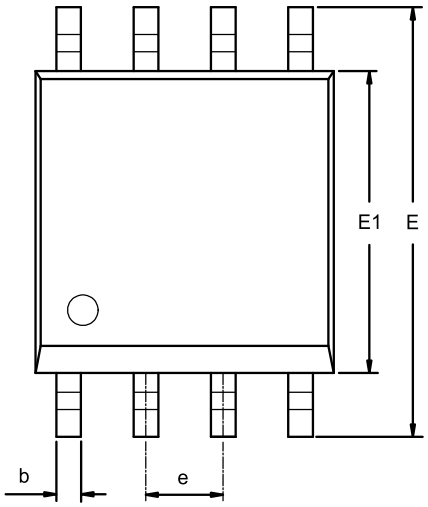
Symbol	Dimensions In Millimeters		Dimensions In Inches	
	MIN	MAX	MIN	MAX
A	1.350	1.750	0.053	0.069
A1	0.050	0.250	0.002	0.010
A2	1.250	1.550	0.049	0.061
b	0.330	0.510	0.013	0.020
c	0.170	0.250	0.007	0.010
D	4.700	5.100	0.185	0.201
E	5.800	6.200	0.228	0.244
E1	3.800	4.000	0.150	0.157
e	1.270 BSC		0.050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

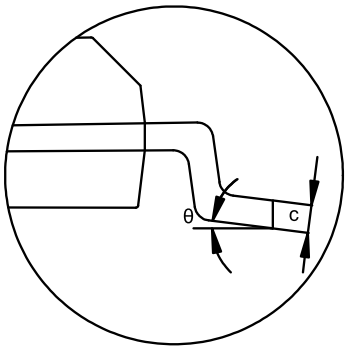
NOTES

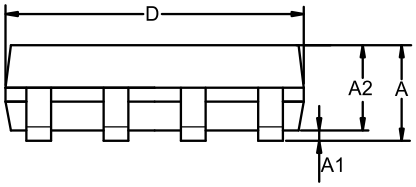
1. Do not include mold flash or protrusion.
2. This drawing is subject to change without notice.

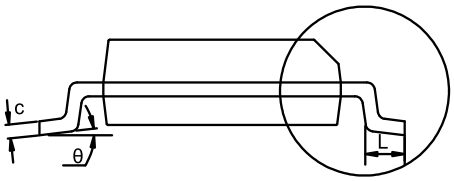
MSOP8

Package Outline Dimensions VS1(MSOP-8-A)









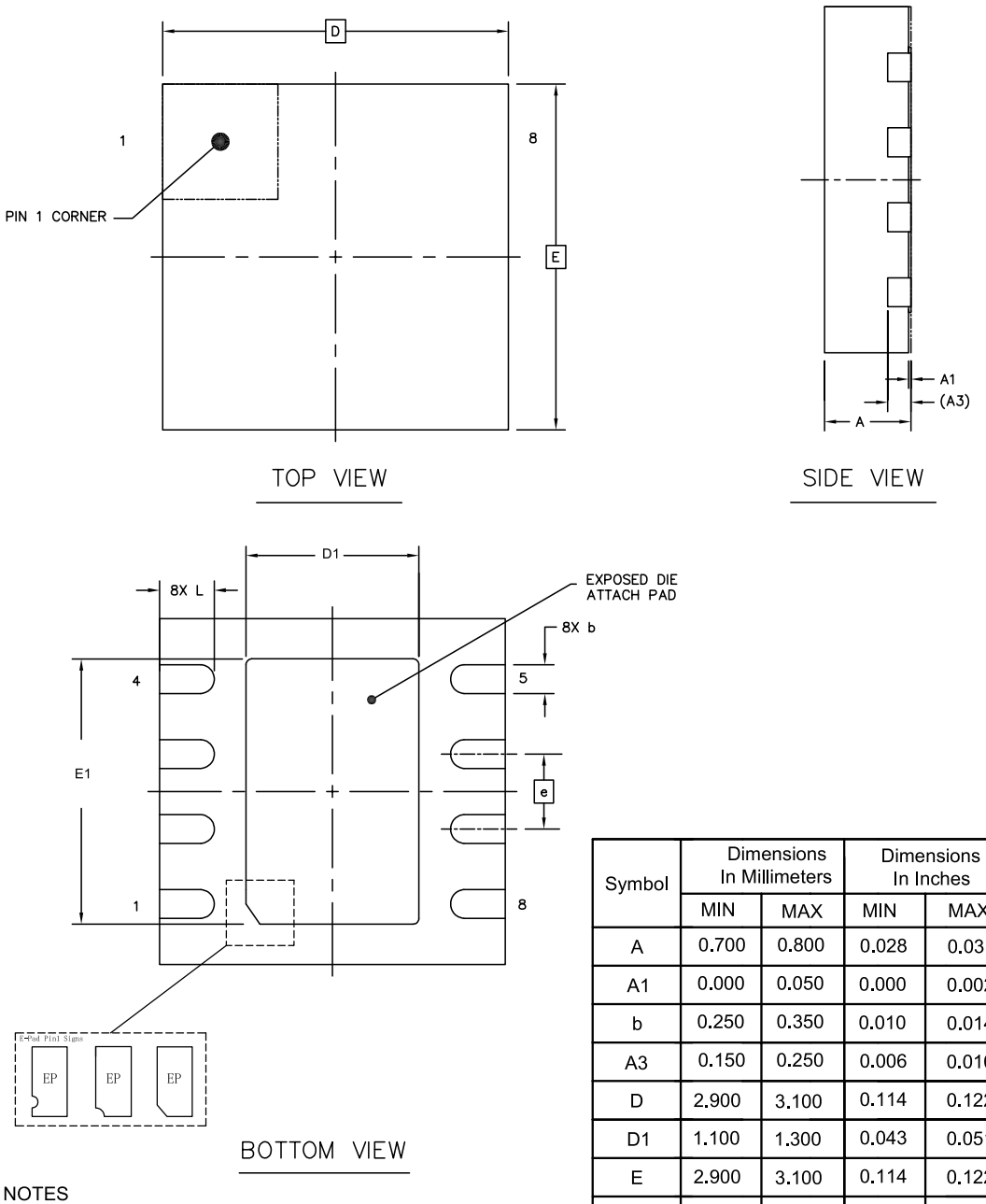
Symbol	Dimensions In Millimeters		Dimensions In Inches	
	MIN	MAX	MIN	MAX
A	0.800	1.100	0.031	0.043
A1	0.020	0.150	0.001	0.006
A2	0.750	0.950	0.030	0.037
b	0.250	0.380	0.010	0.015
c	0.090	0.230	0.004	0.009
D	2.900	3.100	0.114	0.122
E	4.700	5.100	0.185	0.201
E1	2.900	3.100	0.114	0.122
e	0.650 BSC		0.026 BSC	
L	0.400	0.800	0.016	0.031
θ	0	8°	0	8°

NOTES

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

DFN3×3-8

Package Outline Dimensions DF6(DFN3X3-8-B)



NOTES

1. Do not include mold flash or protrusion.
2. This drawing is subject to change without notice.
3. The many types of E-pad Pin1 signs may appear in the product.

Symbol	Dimensions In Millimeters		Dimensions In Inches	
	MIN	MAX	MIN	MAX
A	0.700	0.800	0.028	0.031
A1	0.000	0.050	0.000	0.002
b	0.250	0.350	0.010	0.014
A3	0.150	0.250	0.006	0.010
D	2.900	3.100	0.114	0.122
D1	1.100	1.300	0.043	0.051
E	2.900	3.100	0.114	0.122
E1	2.050	2.250	0.081	0.089
e	0.650 BSC		0.026 BSC	
L	0.350	0.450	0.014	0.018

Order Information

Order Number	Operating Temperature Range	Package	Marking Information	MSL	Transport Media, Quantity	Eco Plan
TPT75176C-SO1R	−40 to 125°C	SOP8	5176C	MSL1	Tape and Reel, 4,000	Green
TPT75176C-VS1R	−40 to 125°C	MSOP8	5176C	MSL1	Tape and Reel, 3,000	Green
TPT75176C-DF6R	−40 to 125°C	DFN3×3-8	5176C	MSL1	Tape and Reel, 4,000	Green

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

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