±15-kV ESD Protected, 20-Mbps, Full Fail-Safe, RS-485 Transceivers

Features

- High Data Rates: up to 20 Mbps
- 30/50-ns Tx/Rx Propagation Delays (Max)
- 6-ns Skew (Max)
- Full Fail-Safe (Open, Short, and 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: 1.65 mA
- Bus-Pin Protection:
  - ±15-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

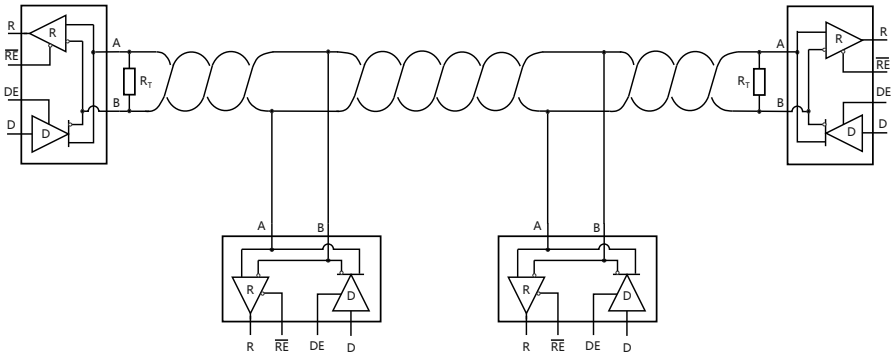
Description

The TPT75176F is a series of IEC61000 ESD protected, 3.0-V to 5.5-V powered transceivers that meet the RS-485 and RS-422 standards for balanced communication

Transmitters in this family deliver exceptional differential output voltages into the RS-485 required 54-Ω load. These 20-Mbps 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. Receiver (Rx) inputs feature a "Full Fail-Safe" design, which ensures a logic-high Rx output if Rx inputs are floating, shorted, or on a terminated but undriven bus.

The TPT75176F is available in the SOP8, MSOP8, and DFN3X3-8 packages, and is characterized from –40°C to 125°C.

Typical Application Circuit



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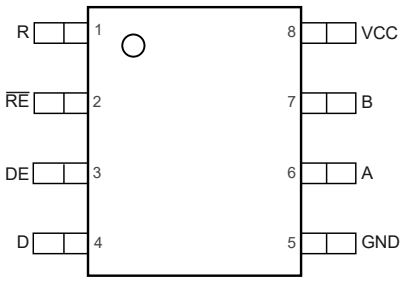
Revision History

Date	Revision	Notes
2025-06-04	Rev.A.0	Released version.

Pin Configuration and Functions

TPT75176F
SOP8/MSOP8
Top View



TPT75176F
DFN3X3-8
Top View

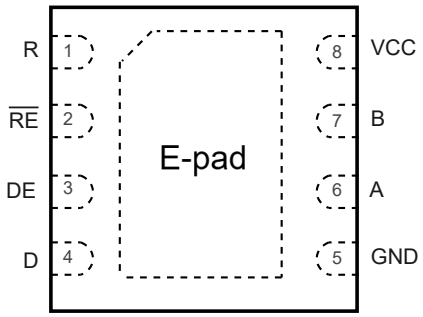


Table 1. Pin Functions: TPT75176F

Pin	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	Non-inverting receiver input A and non-inverting driver output A
7	B	Bus Input/ Output	Inverting receiver input B and inverted driver output B
8	V_{CC}	Power	Power supply
	E-pad		Thermal pad, connect to GND for optimal thermal performance

Functional Table

Table 2. Driver Pin Functions

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

(1) X = don't care.
(2) Z = high impedance.

Specifications

Absolute Maximum Ratings (1)

Parameter	Min	Max	Unit
V_{CC} to GND	−0.3	7	V
Input Voltages D, DE, $\overline{RE}$	−0.3	V_{CC} + 0.3	V
Input/Output Voltages A, B (2)	−15	15	V
A, B (Transient Pulse through 100 Ω (3))	−25	25	V
R	−0.3	V_{CC} + 0.3	V
Short Circuit Duration A, B		Continuous	

(1) Stresses beyond the Absolute Maximum Ratings may cause permanent damage to the device. These are stress ratings only, which do not imply functional operation of the device at these or any other conditions beyond those indicated under Recommended Operating Conditions.
(2) Support ±15 V in receiver mode, and −8 V to +13 V in driver mode.
(3) Tested according to TIA/EIA-485-A, Section 4.2.6 (±25 V for 15 μs at a 1% duty cycle).

ESD, Electrostatic Discharge Protection

Symbol	Parameter	Condition	Minimum Level	Unit
HBM	Human Body Model ESD	ANSI/ESDA/JEDEC JS-001 (1), RS-485 bus pin (A, B)	±15	kV
		ANSI/ESDA/JEDEC JS-001, all other pins	±4	kV
CDM	Charged Device Model ESD	ANSI/ESDA/JEDEC JS-002 (2), all pins	±1.5	kV
IEC	IEC-61000-4-2 ESD	IEC-Contact ESD, RS-485 bus pin (A, B)	±15	kV

(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	Max	Unit
	Supply Voltage	3	5.5	V
T_A	Operating Temperature Range	−40	125	°C
	Bus Pin Common-Mode Voltage Range	−7	12	V
T_J	Maximum Junction Temperature (Plastic Package)		150	°C
T_{STG}	Maximum Storage Temperature Range	−65	150	°C

Thermal Information

Package Type	θ_{JA}	θ_{JB}	θ_{JC}	Unit
SOP8	112.2	90.6	45.8	°C/W
MSOP8	146.2	109.6	45.5	°C/W
DFN3x3-8	48.7	17.3	49.1	°C/W

Electrical Characteristics

All test conditions: V_{CC} = 5 V, T_A = −40°C to +125°C, unless otherwise noted.

Symbol	Parameter	Conditions		Min	Typ	Max	Unit
$\lvert V_{OD}\rvert$	Driver Differential-Output Voltage Magnitude	R_L = 60 Ω with V_A or V_B from –7 V to +12 V, V_{CC} = 4.5 V to 5.5 V	Figure 1B	2.1	2.8		V
		R_L = 60 Ω with V_A or V_B from –7 V to +12 V, V_{CC} = 3.0 V to 3.6 V		1.5	2		
		R_L = 54 Ω, V_{CC} = 5 V	Figure 1A	2.1	2.8		V
		R_L = 54 Ω, V_{CC} = 3 V		1.5	1.9		
		R_L = 100 Ω, V_{CC} = 5 V		2.1	3.5		
		R_L = 100 Ω, V_{CC} = 3 V		1.5	2.3		
$\Delta\lvert V_{OD}\rvert$	Change in Magnitude of Driver Differential-Output Voltage	R_L = 54 Ω, C_L = 50 pF, V_{CC} = 5 V	Figure 1A	−50	1	50	mV
$V_{OC(SS)}$	Steady-Stage Common-Mode Output Voltage	Center of two 27-Ω load resistors	Figure 1A	1	V_{CC} / 2	3	V
ΔV_{OC}	Change in Differential Driver Common-Mode Output Voltage (1)				50		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 V to +12 V			−90	−40	mV
V_{IT-}	Negative-Going Receiver Differential-Input Voltage Threshold	V_A or V_B from –7 V to +12 V		−220	−155		mV
V_{HYS}	Receiver Differential-Input Voltage Threshold Hysteresis ($V_{IT+} – V_{IT–}$)				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, V_{CC} = 4.5 V to 5.5 V		3	4.5		V
		I_{OH} = −8 mA, V_{CC} = 3.0 V to 3.6 V		2.45	2.65		V

Symbol	Parameter	Conditions		Min	Typ	Max	Unit
V_{OL}	Receiver Low-Level Output Voltage	I_{OL} = 8 mA, V_{CC} = 4.5 V to 5.5 V				0.4	V
		I_{OL} = 8 mA, V_{CC} = 3.0 V to 3.6 V				0.5	V
I_I	Driver Input, Driver Enable and Receiver Enable Input Current	D, DE, $\overline{RE}$		−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	$\|IOS\|$ with V_A or V_B from –7 V to +12 V		−250	120	250	mA
		Bus pin A, B short current				150	mA
I_{IN}	Bus Input Current (Driver Disabled)	V_{CC} = 4.5 V to 5.5 V or V_{CC} = 0 V, DE at 0 V	VI = 12 V			120	μA
			VI = −7 V	−110			
I_{CC}	Supply Current (Quiescent)	Driver and receiver enabled	DE = V_{CC}, $\overline{RE}$ = GND, no load		1.9	2.2	mA
		Driver enabled, receiver disabled	DE = V_{CC}, $\overline{RE}$ = V_{CC}, no load		1.8	2.2	
		Driver disabled, receiver enabled	DE = GND, $\overline{RE}$ = GND, no load		1.7	2	
		Driver and receiver disabled	DE = GND, $\overline{RE}$ = V_{CC}, D = V_{CC}, no load		1.65	2	

(1) Parameter is provided by lab bench tests and design simulation.

Switching Characteristics

Symbol	Parameter	Conditions		Min	Typ	Max	Unit
Driver							
f_{MAX}	Maximum Data Rate (1)	V_{OD} ≥ ±1.5 V, R_L = 54 Ω, C_L = 100 pF	Figure 4			20	Mbps
t_r, t_f	Driver Differential-Output Rise and Fall Time (1)	R_L = 54 Ω, C_L= 50 pF	Figure 2		8		ns
t_{PHL}, t_{PLH}	Driver Propagation Delay				21	30	
$t_{SK(P)}$	Driver Pulse Skew, $\|T_{PHL} - T_{PLH}\|$				3	6	
t_{PHZ}, t_{PLZ}	Driver Disable Time		Figure 3		30	50	ns
t_{PZH}, t_{PZL}	Driver Enable Time	Receiver enabled			20	45	
	Driver Enable Time	Receiver disabled			30	50	ns
Receiver							
t_r, t_f	Receiver Output Rise and Fall Time (1)	C_L = 15 pF	Figure 5		14		ns
t_{PHL}, t_{PLH}	Receiver Propagation Delay Time				35	50	
$t_{SK(P)}$	Receiver Pulse Skew, $\|T_{PHL} - T_{PLH}\|$				10	15	
t_{PHZ}, t_{PLZ}	Receiver Disable Time				30	60	ns
t_{PZH}, t_{PZL}	Receiver Enable Time	Driver enabled			20	30	ns
	Receiver Enable Time	Driver disabled			25	40	ns

(1) Parameter is provided by lab bench tests and design simulation.

Test Circuits and Waveforms

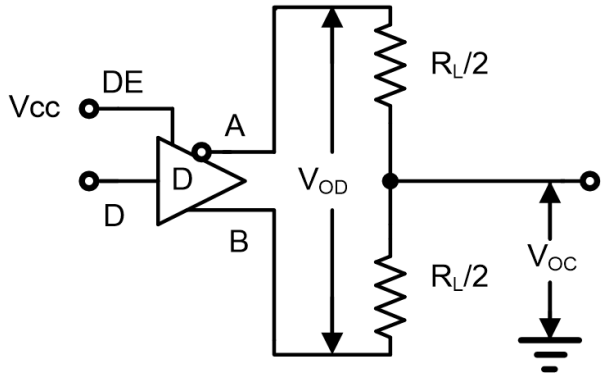


Figure 1A. V_{OD} and V_{OC}

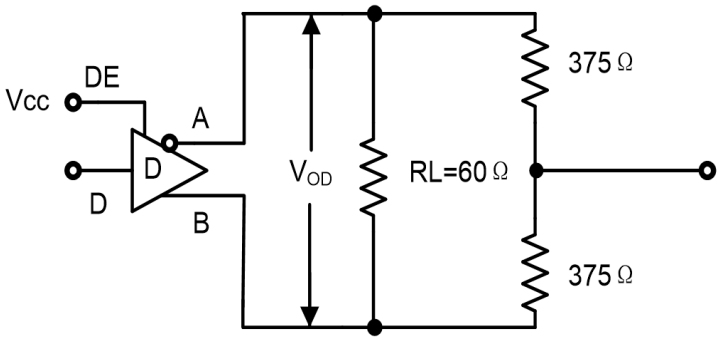


Figure 1B. V_{OD} with Common-Mode Load

Figure 1. DC Driver Test Circuits

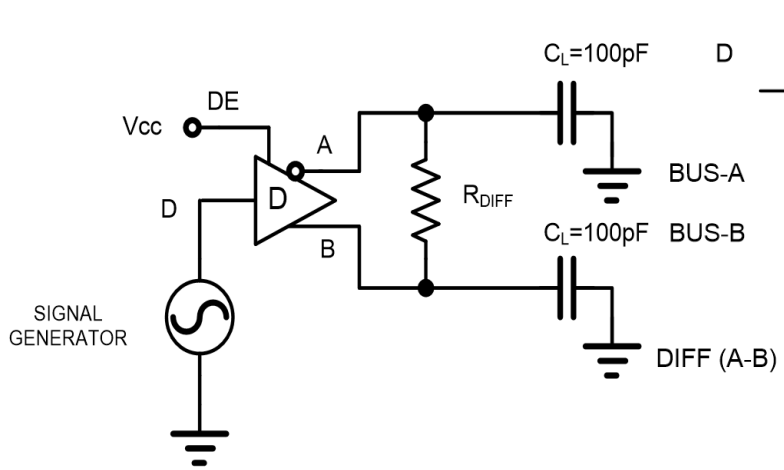


Figure 2A. Test Circuit

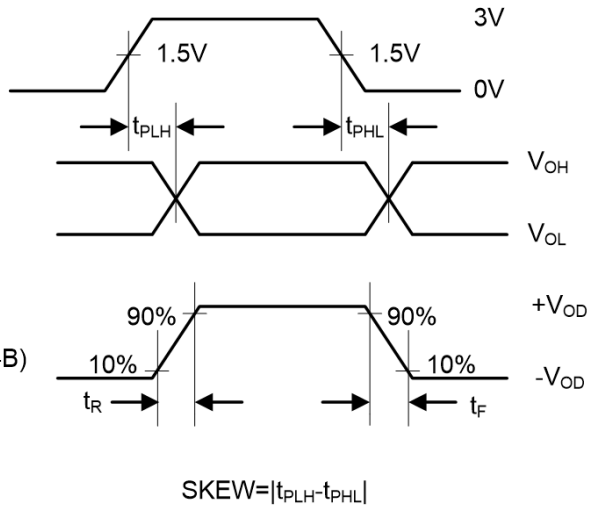
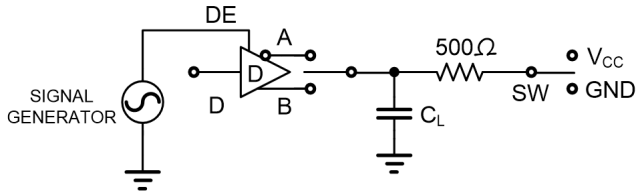


Figure 2B. Measurement Points

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	V_{CC}	15
tPZH	A/B	0	1/0	GND	100
tPZL	A/B	0	0/1	V_{CC}	100
tPZH(SHDN)	A/B	1	1/0	GND	100
tPZL(SHDN)	A/B	1	0/1	V_{CC}	100

Figure 3A. Test Circuit

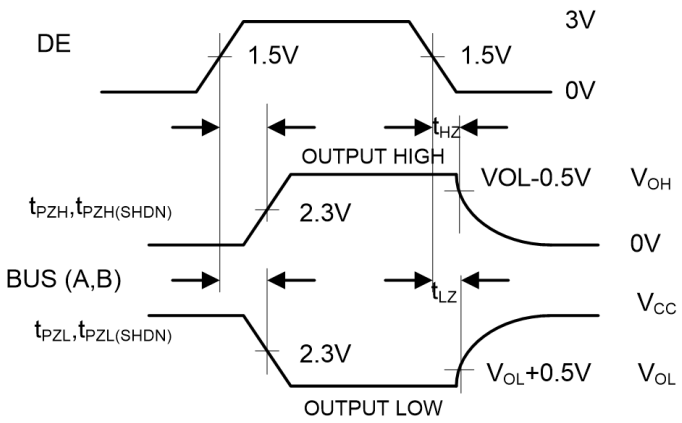


Figure 3B. Measurement Points

Figure 3. Driver Enable and Disable Times

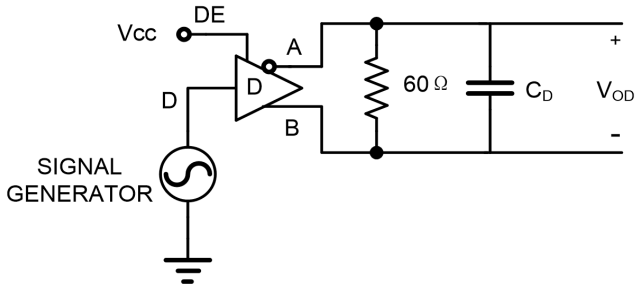


Figure 4A. Test Circuit

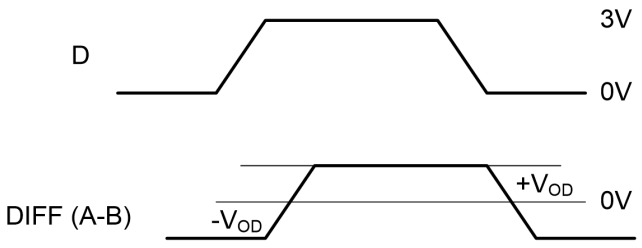


Figure 4B. Measurement Points

Figure 4. Driver Data Rate

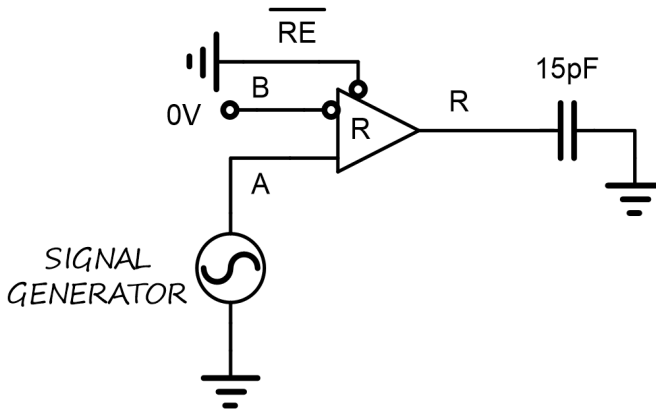


Figure 5A. Test Circuit

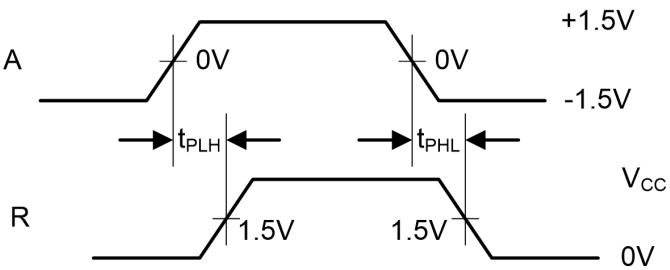
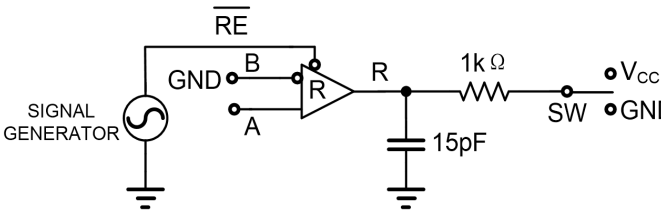


Figure 5B. Measurement Points

Figure 5. Receiver Propagation Delay and Data Rate



PARAMETER	DE	A	SW
tPHZ	1	+1.5 V	GND
tPLZ	1	-1.5 V	V_{CC}
tPZH	1	+1.5 V	GND
tPZL	1	-1.5 V	V_{CC}
tPZH(SHDN)	0	+1.5 V	GND
tPZL(SHDN)	0	-1.5 V	V_{CC}

Figure 6A. Test Circuit

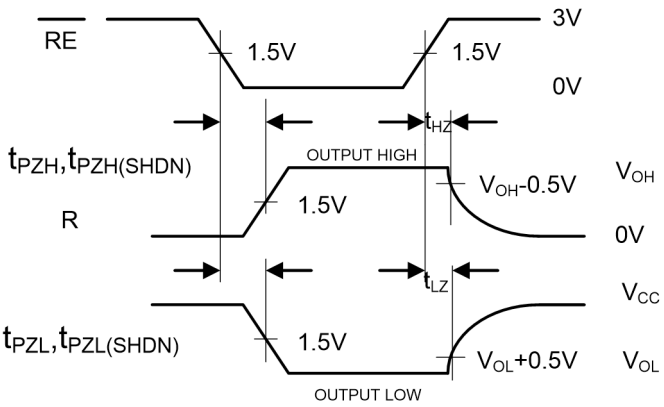


Figure 6B. Measurement Points

Figure 6. Receiver Enable and Disable Times

Detailed Description

Feature Description

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 $\overline{RE}$ input.

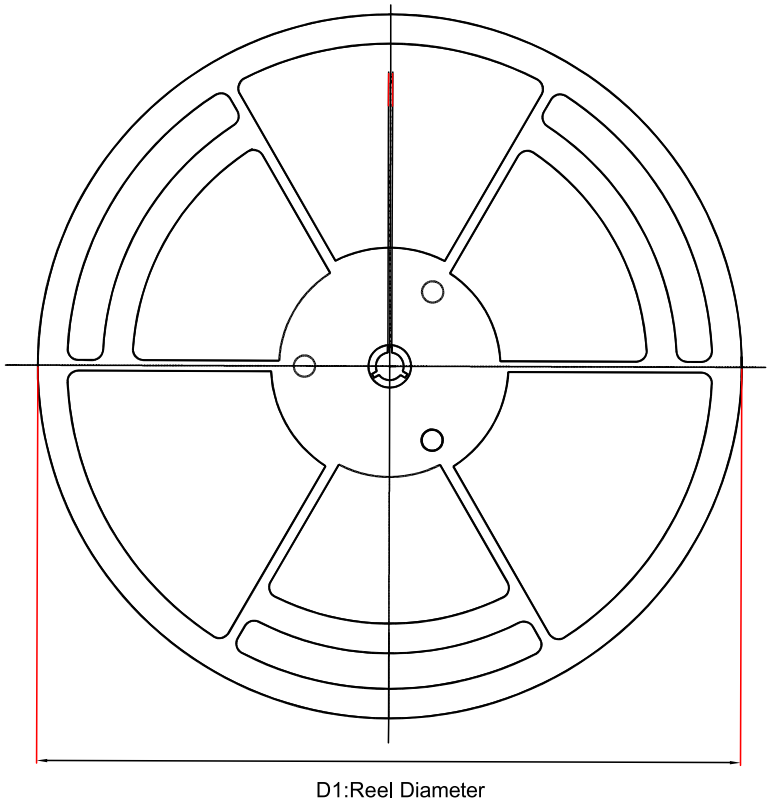
Hot Plug Function

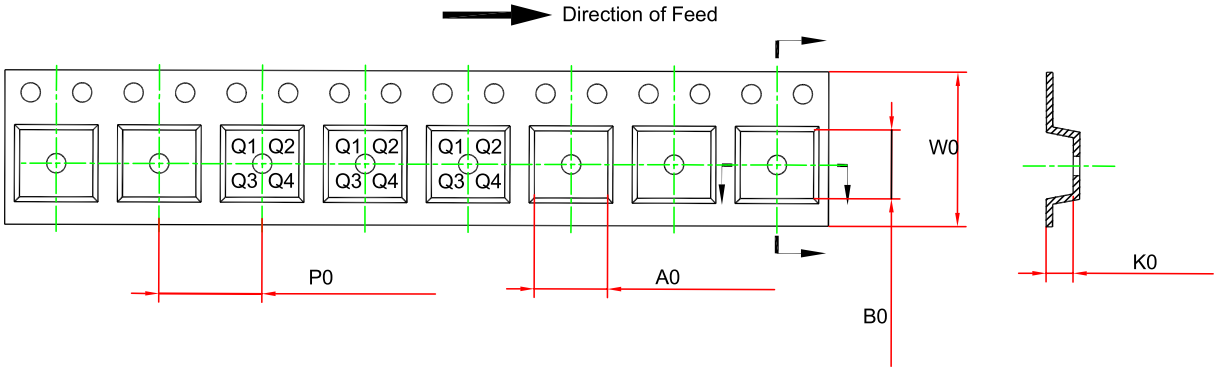
When a piece of equipment powers up, there is a period of time when the processor or ASIC driving the RS-485 control lines (DE, $\overline{RE}$) is unable to ensure that the RS-485 Tx and Rx outputs are kept disabled. If the equipment is connected to the bus, a driver activating prematurely during power-up may crash the bus. To avoid this scenario, the TPT75176F incorporates a "Hot Plug" function. 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 RS-485 control lines to the proper states.

Transient Protection

The bus terminals of the TPT75176F 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 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. As stated in the IEC 61000-4-2 standard, contact discharge is the preferred transient protection test method. Although IEC air-gap testing is less repeatable than contact testing, air discharge protection levels are inferred from the contact discharge test results.

Tape and Reel Information





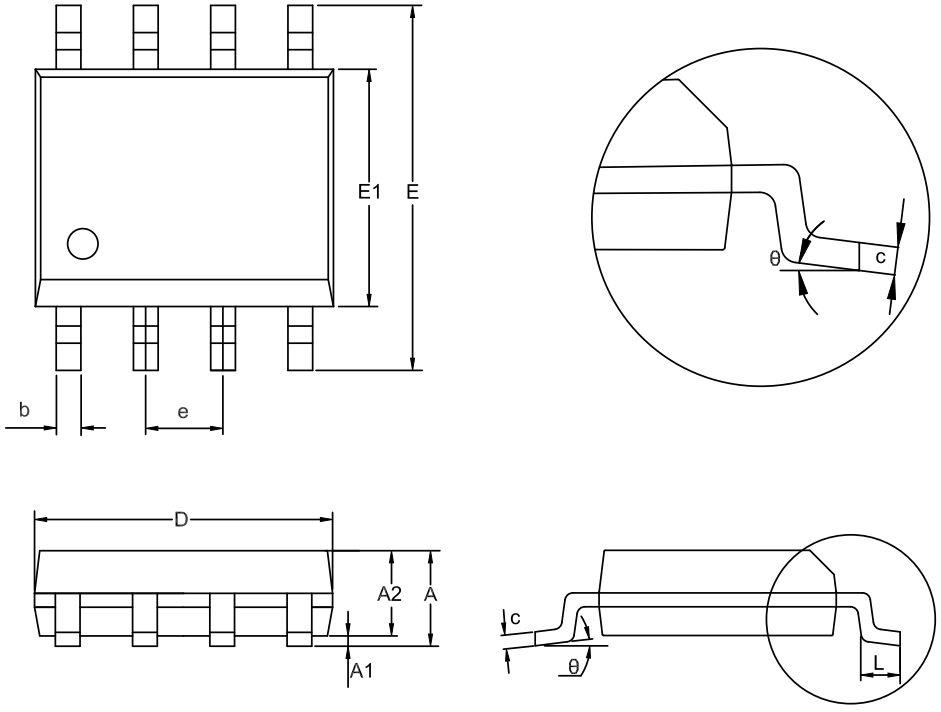
Order Number	Package	D1 (mm)	W1 (mm)	A0 (mm) (1)	B0 (mm) (1)	K0 (mm) (1)	P0 (mm)	W0 (mm)	Pin1 Quadrant
TPT75176F-SO1R	SOP8	330.0	17.6	6.5	5.4	2.0	8.0	12.0	Q1
TPT75176F-VS1R	MSOP8	330.0	17.6	5.3	3.4	1.3	8.0	12.0	Q1
TPT75176F-DF6R	DFN3X3-8	330.0	17.6	3.3	3.3	1.1	8.0	12.0	Q1

(1) The value is for reference only. Contact the 3PEAK factory for more information.

Package Outline Dimensions

SOP8

Package Outline Dimensions SO1(SOP-8-A)



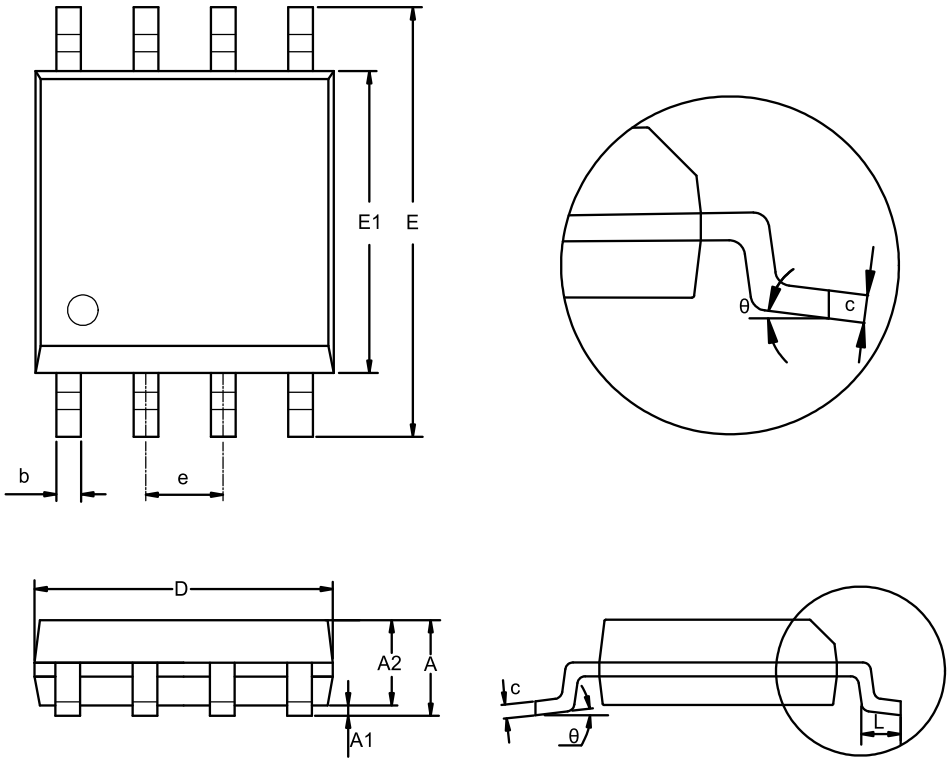
Symbol	Dimensions In Millimeters		Dimensions In Inches	
	MIN	MAX	MIN	MAX
A	1.350	1.750	0.053	0.069
A1	0.050	0.250	0.002	0.010
A2	1.250	1.550	0.049	0.061
b	0.330	0.510	0.013	0.020
c	0.170	0.250	0.007	0.010
D	4.700	5.100	0.185	0.201
E	5.800	6.200	0.228	0.244
E1	3.800	4.000	0.150	0.157
e	1.270 BSC		0.050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



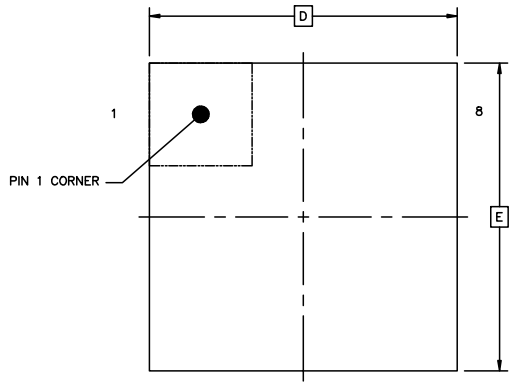
Symbol	Dimensions In Millimeters		Dimensions In Inches	
	MIN	MAX	MIN	MAX
A	0.800	1.100	0.031	0.043
A1	0.020	0.150	0.001	0.006
A2	0.750	0.950	0.030	0.037
b	0.250	0.380	0.010	0.015
c	0.090	0.230	0.004	0.009
D	2.900	3.100	0.114	0.122
E	4.700	5.100	0.185	0.201
E1	2.900	3.100	0.114	0.122
e	0.650 BSC		0.026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

NOTES

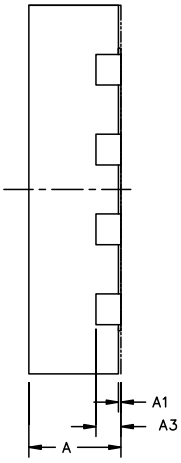
1. Do not include mold flash or protrusion.
2. This drawing is subject to change without notice.

DFN3X3-8

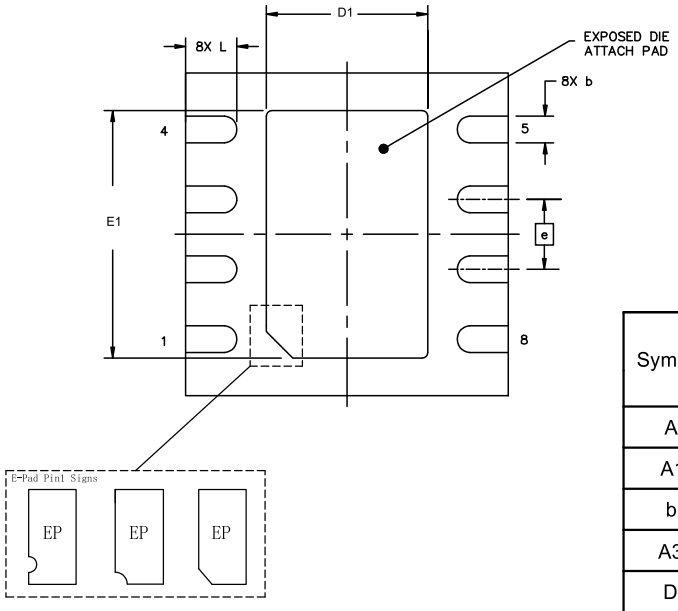
Package Outline Dimensions DF6(DFN3X3-8-A)



TOP VIEW



SIDE VIEW



BOTTOM VIEW

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	0.200	0.350	0.008	0.014
A3	0.150	0.250	0.006	0.010
D	2.900	3.100	0.114	0.122
D1	1.400	1.600	0.055	0.063
E	2.900	3.100	0.114	0.122
E1	2.200	2.400	0.087	0.094
e	0.650 BSC		0.026 BSC	
L	0.224	0.575	0.009	0.023

Order Information

Order Number	Operating Temperature Range	Package	Marking Information	MSL	Transport Media, Quantity	Eco Plan
TPT75176F-SO1R	−40 to 125°C	SOP8	T176H	1	Tape and Reel, 4000	Green
TPT75176F-VS1R	−40 to 125°C	MSOP8	176H	3	Tape and Reel, 3000	Green
TPT75176F-DF6R	−40 to 125°C	DFN3X3-8	176H	1	Tape and Reel, 4000	Green

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

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