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

Features

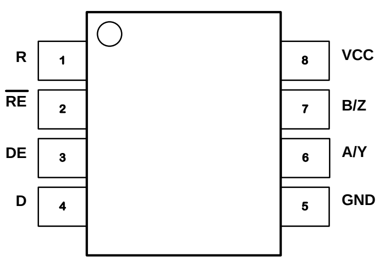
- **High Data Rates: 10Mbps At 5V Supply**
  : 6Mbps At 3.3V Supply
- **13/14ns (Max) Tx/Rx Propagation Delays; 10ns (Typ) Skew**
- **Full Fail-safe (Open, Short, Terminated) Receivers**
- **Up to 32 Nodes on a Bus (1 unit load)**
- **Wide Supply Voltage 3V to 5.5V**
- **Low Quiescent Supply Current: 2.2 mA**
- **Bus-Pin Protection:**
  – ±15 kV HBM protection
- **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

Pin Configuration (Top View)

TP75176E
8-Pin SOP/MSOP/DFN
-S, -V and -F Suffixes



Description

3PEAK's TP75176E is a ±15kV HBM ESD Protected, 3V~5.5V powered, single transceiver for balanced communication. It also features the larger output voltage and higher data rate - up to 10Mbps - required by high speed PROFIBUS applications, and is offered in Industrial and Extended Industrial (-40°C to +125°C) temperature ranges.

This transceiver requires a 3V~5.5V tolerance supply, and delivers at least a 2.1V differential output voltage on 5V supply condition. This translates into better noise immunity(data integrity), longer reach, or the ability to drive up to three 120Ω terminations in "star" or other non-standard bus topologies, at the exceptional 10Mbps data rate.

Receiver (Rx) inputs feature a "Full Fail-Safe" design, which ensures a logic high Rx output if Rx inputs are floating, shorted, or terminated but undriven. Rx outputs feature high drive levels (typically >25mA @ V_{OL} = 1V) to ease the design of optically isolated interfaces.

The TP75176E is available in an SOP-8 and MSOP-8 package, and is characterized from –40°C to 125°C.

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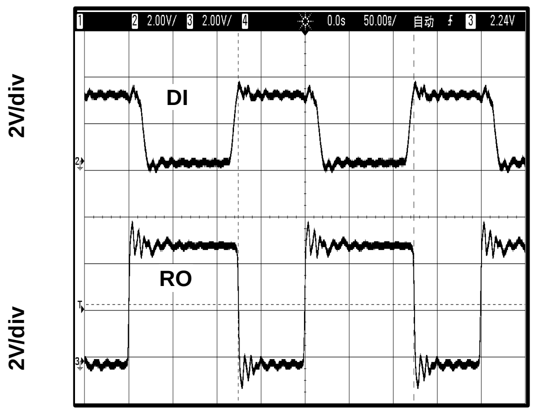
Loopback Test At 10Mbps/5V



Time (50ns/div)

Order Information

Model Name	Order Number	Package	Transport Media, Quantity	Marking Information
TP75176E	TP75176E-SR	8-Pin SOP	Tape and Reel, 4,000	75176E
TP75176E	TP75176E-VR	8-Pin MSOP	Tape and Reel, 3,000	75176E
TP75176E	TP75176E-FR	8-Pin DFN	Tape and Reel, 4,000	75176

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

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

Absolute Maximum Ratings

V_{DD} to GND..-0.3V to +7V

Input Voltages

DI, DE, RE……………………………………………………………………….…………………….....-0.3V to (VCC + 0.3V)

Input/Output Voltages

A/Y, B/Z, A, B, Y, Z……………………………………………………………………….………………. -9V to +14V

A/Y, B/Z, A, B, Y, Z (Transient Pulse Through 100Ω,

Note 1)……………………………………………………………………………………….…………..…. ±100V

R_O………………………………………………………………………………………….……………. -0.3V to (VCC +0.3V)

Short Circuit Duration

Y, Z…………………………………………………………….……………………….…………………….Continuous

ESD Rating…………………………..……………………..………………………..…………………..…….. See Specification Table

Recommended Operating Conditions Note 2

Supply Voltage……………………………………………………………………………..…………….3V~5.5V

Temperature Range……………………………………………………………………………….…….-40°C to +125°C

Bus Pin Common Mode Voltage Range ……………………………………………………….…….…. -5V to +7V

Thermal Resistance, Θ_{JA} (Typical)

8-Pin SOP Package ……………………………………………………………..…………………..……158°C/W

8-Pin MSOP Package ………………………………………………………….…………….…...…….210°C/W

Maximum Junction Temperature (Plastic Package) ……………………….………………….………….+150°C

Maximum Storage Temperature Range ………………………………………………………………….. -65°C to +150°C

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

Note 2: Do not operate at or near the maximum ratings listed for extended periods of time. Exposure to such conditions may adversely impact product reliability and result in failures not covered by warranty.

Electrical Characteristics

Test Conditions: V_{CC} = 5V, Ta = 25°C (unless otherwise noted)

PARAMETER		CONDITIONS		MIN	TYP	MAX	UNITS
$\|V_{OD}\|$	Driver differential-output voltage magnitude	R_L = 54 Ω V_{CC} = 5V	See Figure 1A	2.3	2.5		V
		R_L = 54 Ω with V_A or V_B from –7 to +12 V, V_{CC} = 5V (RS-485)		2.2	2.4		
		R_L = 54 Ω with V_A or V_B from –7 to +12 V, V_{CC} = 3V (RS-485)		1.2	1.5		
⊿$\|V_{OD}\|$	Change in magnitude of driver differential-output voltage	R_L = 54 Ω, C_L=50 pF, V_{CC} = 5V	See Figure 1A	-0.2	-0.002	0.2	V
$V_{OC(SS)}$	Steady-stage common-mode output voltage	Center of two 27 Ω load resistors	See Figure 1A		V_{CC}/2		V
⊿V_{OC}	Change in differential driver common-mode output voltage				0.05		V
$V_{OC(PP)}$	Peak-to-peak driver common-mode output voltage				0.5		
C_{OD}	Differential output capacitance				8		pF
V_{IT+}	Positive-going receiver differential-input voltage threshold	V_A or V_B from –5 to +7 V			-50	-10	mV
V_{IT-}	Negative-going receiver differential-input voltage threshold	V_A or V_B from –5 to +7 V		-200	-130		mV
V_{HYS}	Receiver differential-input voltage threshold hysteresis (V_{IT+} – V_{IT-})				75		mV
V_{IH}	Logic Input High Voltage	DI, DE, $\overline{RE}$		2			V
V_{IL}	Logic Input Low Voltage	DI, DE, $\overline{RE}$				0.4	V
V_{OH}	Receiver high-level output voltage	I_{OH}= -8 mA		4			V
V_{OL}	Receiver low-level output voltage	I_{OL}= 8 mA				0.4	V
I_I	Driver input, driver enable and receiver enable input current	DI, DE, $\overline{RE}$		-2	0.01	2	μA
I_{OZ}	Receiver high-impedance output current	V_O = 0 V or V_{CC}, /RE at V_{CC}		-2	0.005	2	μA
$\|I_{OS}\|$	Driver short-circuit output current	│IOS│ with V_A or V_B from –7 to +12 V			120	300	mA
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			1	mA
			VI= -7 V	-0.8			
I_{CC}	Supply current(quiescent)	Driver and receiver enabled	DE = V_{CC}, /RE = GND, No LOAD		2.2	2.5	mA
		Driver enabled, receiver disabled	DE = V_{CC}, /RE = V_{CC}, No LOAD		1.5	1.8	
		Driver disabled, receiver enabled	DE = GND, /RE = GND, No LOAD		0.5	0.6	
		Driver and receiver disabled	DE = GND, /RE = V_{CC}, D= V_{cc} No LOAD		0.0012	0.002	

Switching CHARACTERISTICS

PARAMETER		CONDITIONS		MIN	TYP	MAX	UNITS
DRIVER							
f_{MAX}	Maximum Data Rate	V_{OD} ≥ ±1.5V, R_L = 54Ω, C_L = 100pF (Figure 4)		10			Mbps
t_r, t_f	Driver differential-output rise and fall times	R_L = 54 Ω, C_L=50pF	See Figure 2		26		ns
t_{PHL}, t_{PLH}	Driver propagation delay				14		
$t_{SK(P)}$	Driver pulse skew, $\lvert t_{PHL} – t_{PLH} \rvert$				10		
t_{PHZ}, t_{PLZ}	Driver disable time		See Figure 3		50		ns
t_{PHZ}, t_{PLZ}	Driver enable time	Receiver enabled			10		ns
		Receiver disabled			125		
RECEIVER							
t_r, t_f	Receiver output rise and fall times	C_L=15 pF	See Figure 5		3.4		ns
t_{PHL}, t_{PLH}	Receiver propagation delay time				55		
$t_{SK(P)}$	Receiver pulse skew, $\lvert t_{PHL} – t_{PLH} \rvert$				10		
t_{PHZ}, t_{PLZ}	Receiver disable time				28		ns
t_{PZL}, t_{PZH}	Receiver enable time	Driver enabled	See Figure 6		11		ns
		Driver disabled	See Figure 6		15		
ESD							
RS-485 Pins (A, Y, B, Z, A/Y, B/Z)		Human Body Model, From Bus Pins to GND			±15		kV
All Other Pins		Human Body Model, per MIL-STD-883			±2		kV

Test Circuits and Waveforms

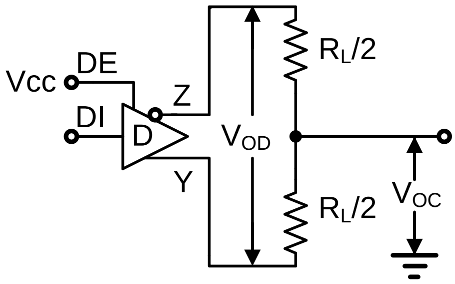


FIGURE 1A. VOD AND VOC

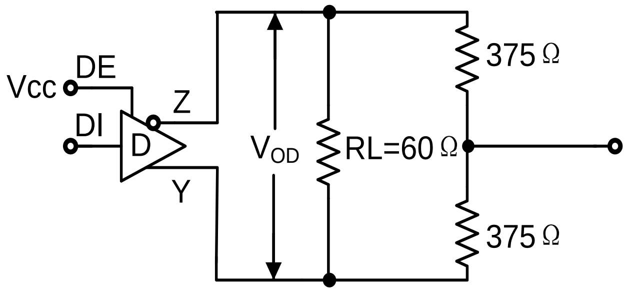


FIGURE 1B. VOD WITH COMMON MODE LOAD

FIGURE 1. DC DRIVER TEST CIRCUITS

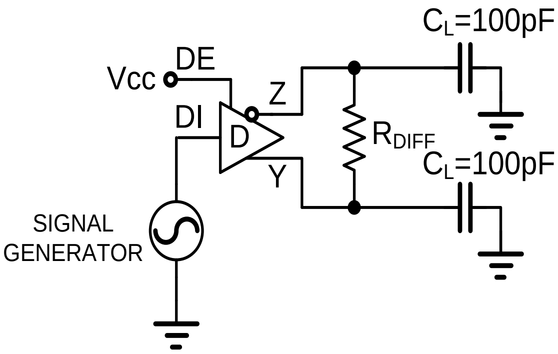


FIGURE 2A. TEST CIRCUIT

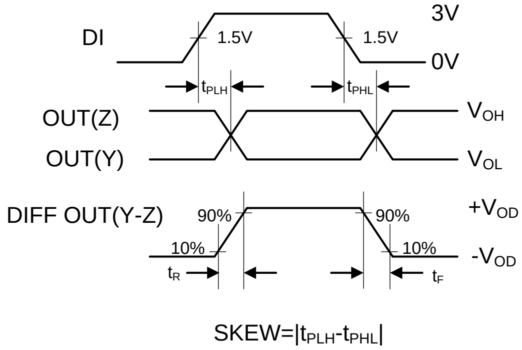
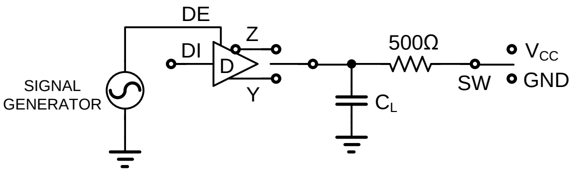


FIGURE 2B. MEASUREMENT POINTS

FIGURE 2. DRIVER PROPAGATION DELAY AND DIFFERENTIAL TRANSITION TIMES



PARAMETER	OUTPUT	RE	DI	SW	CL (pF)
tHZ	Y/Z	X	1/0	GND	15
tLZ	Y/Z	X	0/1	VCC	15
tZH	Y/Z	0	1/0	GND	100
tZL	Y/Z	0	0/1	VCC	100
tZH(SHDN)	Y/Z	1	1/0	GND	100
tZL(SHDN)	Y/Z	1	0/1	VCC	100

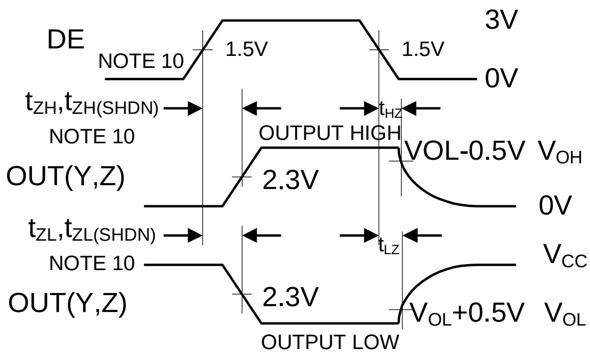


FIGURE 3A. TEST CIRCUIT

FIGURE 3B. MEASUREMENT POINTS

FIGURE 3. DRIVER ENABLE AND DISABLE TIMES

Test Circuits and Waveforms(continue)

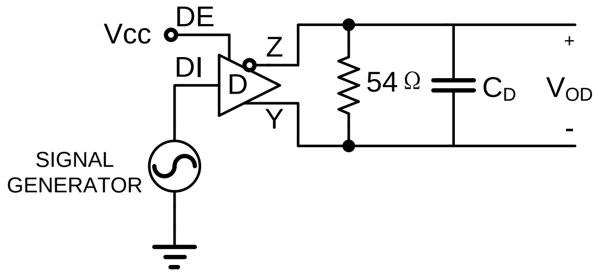


FIGURE 4A. TEST CIRCUIT

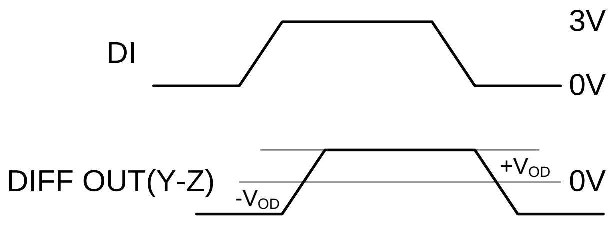


FIGURE 4B. MEASUREMENT POINTS

FIGURE 4. DRIVER DATA RATE

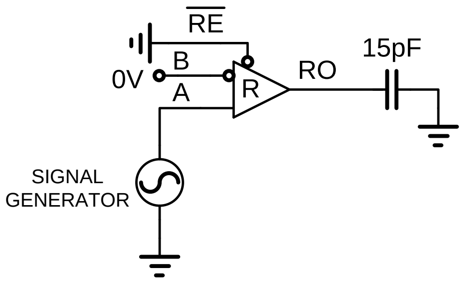


FIGURE 5A. TEST CIRCUIT

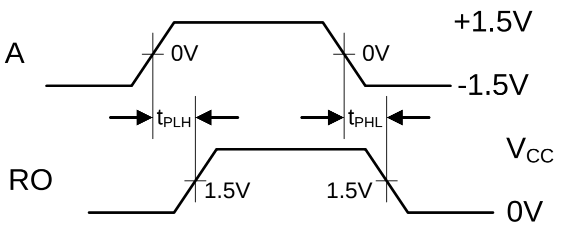
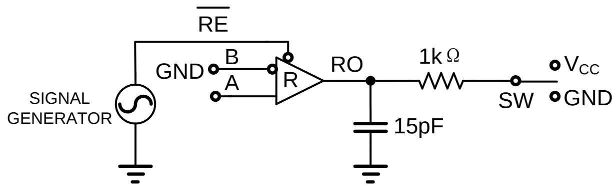


FIGURE 5B. MEASUREMENT POINTS

FIGURE 5. RECEIVER PROPAGATION DELAY AND DATA RATE



PARAMETER	DE	A	SW
tHZ	1	+1.5V	GND
tLZ	1	-1.5V	VCC
tZH	1	+1.5V	GND
tZL	1	-1.5V	VCC
tZH(SHDN)	0	+1.5V	GND
tZL(SHDN)	0	-1.5V	VCC

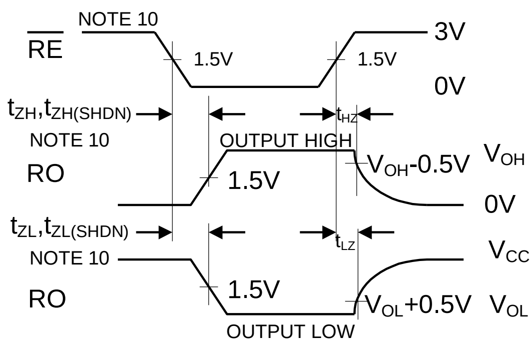


FIGURE 6A. TEST CIRCUIT

FIGURE 6B. MEASUREMENT POINTS

FIGURE 6. RECEIVER ENABLE AND DISABLE TIMES

Detailed Description

High Data Rate

RS-485/RS-422 are intended for network lengths up to 4000', but the maximum system data rate decreases as the transmission length increases. Devices operating at 10Mbps are limited to lengths less than 100'.

Twisted pair is the cable of choice for RS-485/RS-422 networks. 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.

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 120Ω) 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 TP75176E 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 500ns, which equates to the Tx driving a 1000' (305m) CAT 5 cable, yields excellent performance over the full operating temperature range. For below test waveform, the transmitter was driven at 10Mps and/or with 100' (31m) CAT 5 cable, the transmitters were loaded with an RS-485 receiver in parallel with 54Ω.

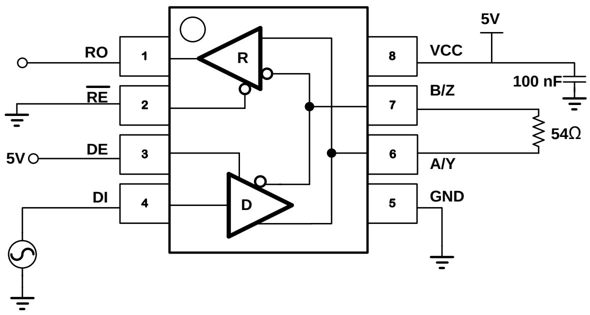


Figure 7. Loopback Test Circuit

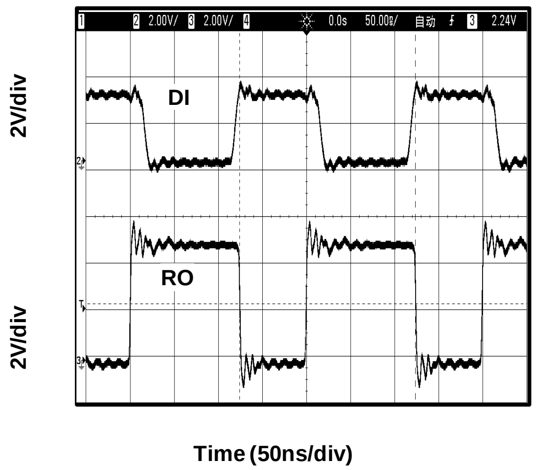


Figure 8. Loopback Test At 10Mbps/5V

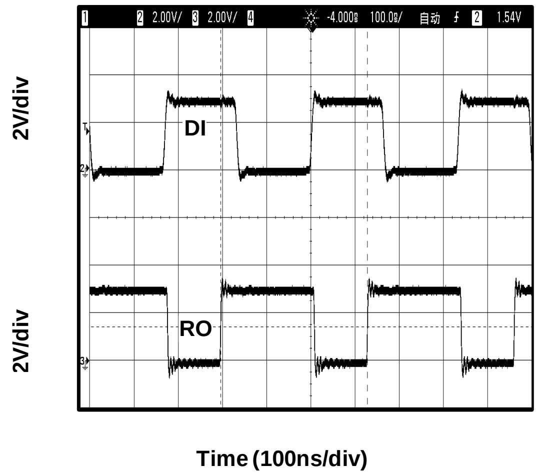


Figure 9. Loopback Test At 6Mbps/3V

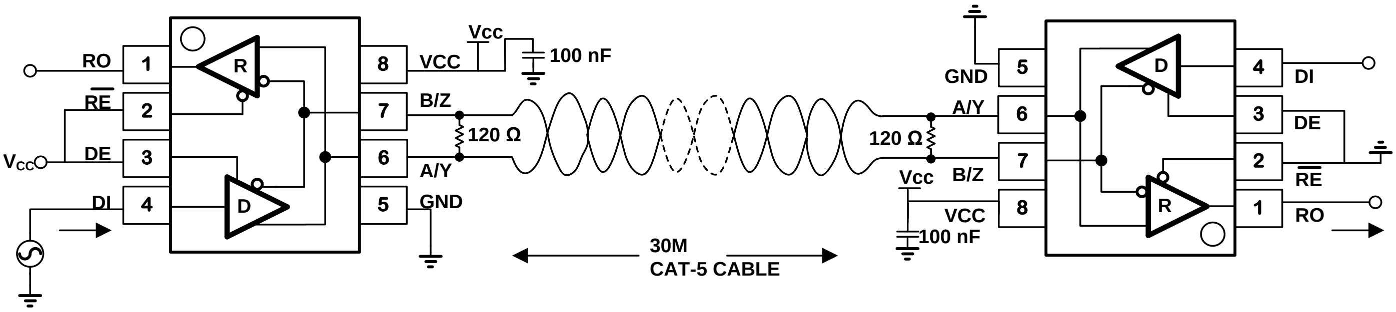


Figure 10. 10Mbps Data Rate With 30M CAT5 Cable Test Circuit

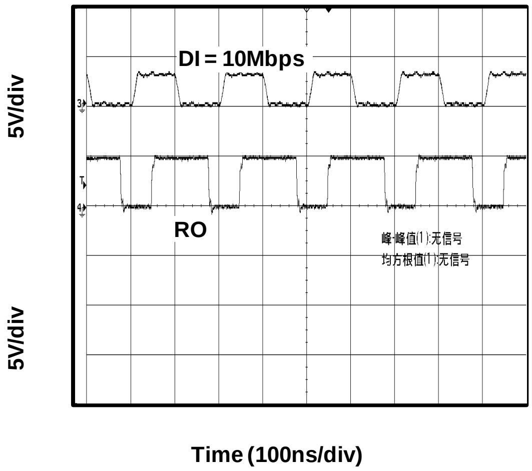


Figure 11. 5V Driver And Receiver Five Pulse Waveforms Driving 100 Feet (30 Meters)

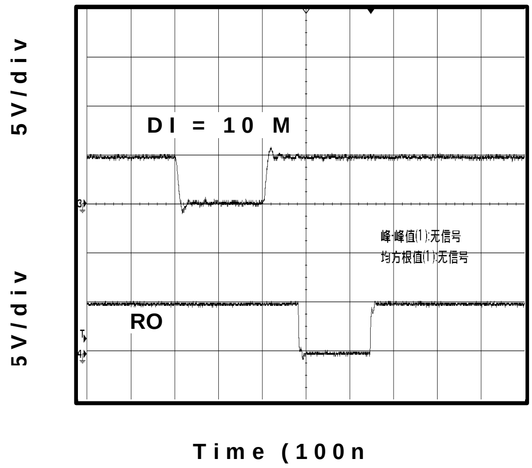


Figure 12. 5V Driver And Receiver Single Pulse Waveforms Driving 100 Feet (30 Meters)

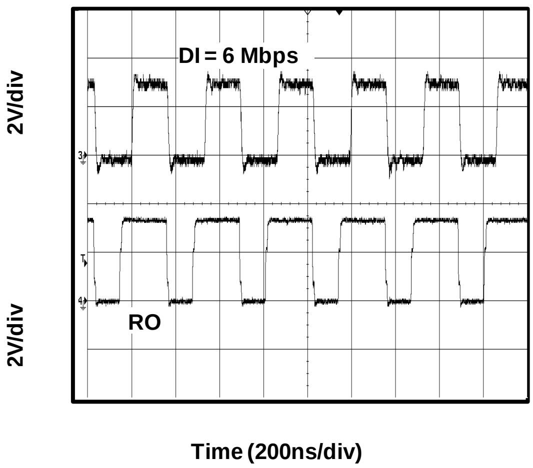


Figure 13. 3.3V Driver And Receiver Five Pulse Pulse Waveforms Driving 100 Feet (30 Meters)

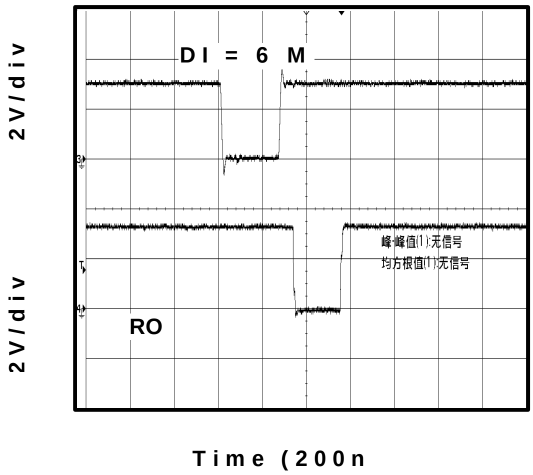


Figure 14. 3.3V Driver And Receiver Single Waveforms Driving 100 Feet (30 Meters)

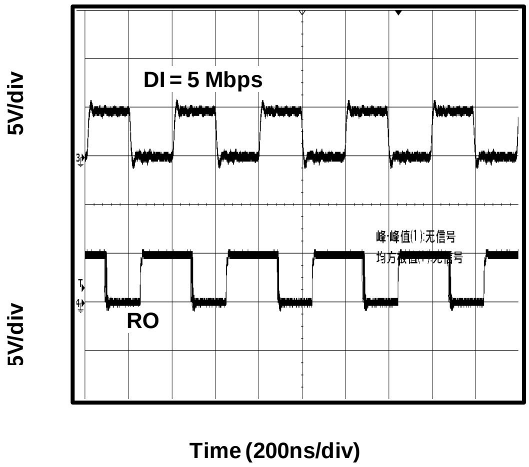


Figure 15. 5V Driver And Receiver Five Pulse Pulse Waveforms Driving 100 Feet (30 Meters)

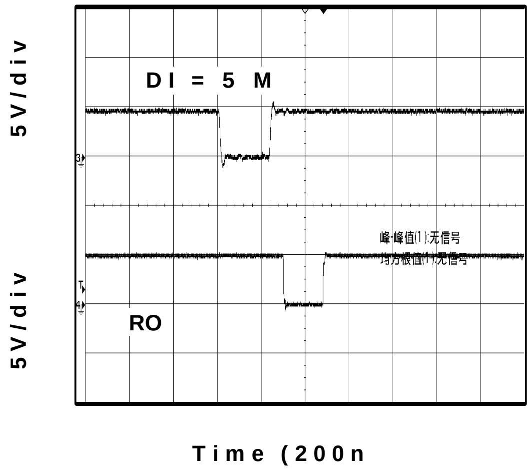


Figure 16. 5V Driver And Receiver Single Waveforms Driving 100 Feet (30 Meters)

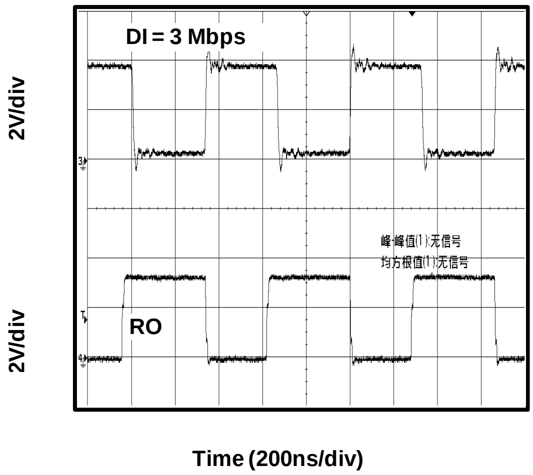


Figure 17. 3.3V Driver And Receiver Four Pulse Pulse Waveforms Driving 100 Feet (30 Meters)

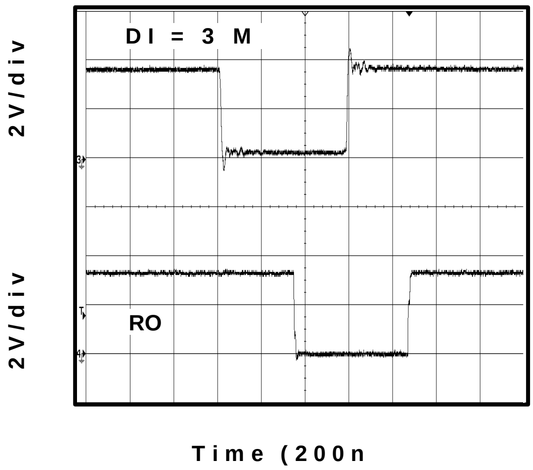


Figure 18. 5V Driver And Receiver Single Waveforms Driving 100 Feet (30 Meters)

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 of time where the processor or ASIC driving the RS-485 control lines (DE, 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 TP75176E devices incorporate a “Hot Plug” function. Circuitry monitoring VCC ensures that, during power-up and power-down, the Tx and Rx outputs remain disabled, regardless of the state of DE and RE, if VCC is less than ~2.5V. This gives the processor/ASIC a chance to stabilize and drive the RS-485 control lines to the proper states.

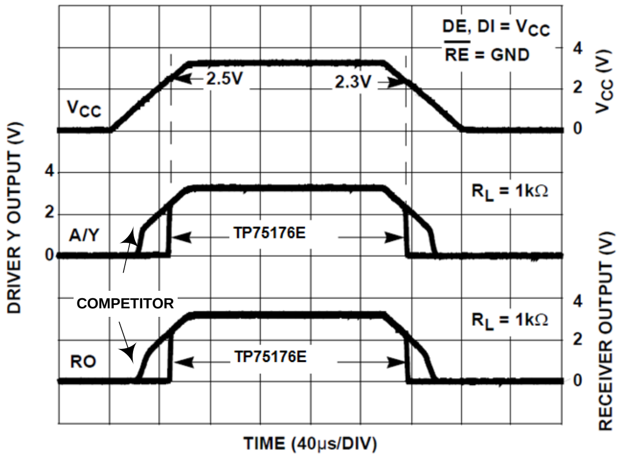


FIGURE 19. Hot Plug Performance (TP75176E) vs Competitor Without Hot Plug Circuitry

Transient Protection

The bus terminals of the TP75176E transceiver family possess on-chip ESD protection against ±15 kV HBM. The International Electrotechnical Commision (IEC) ESD test is far more severe than the HBM ESD test. The 50% higher charge capacitance, CS, and 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, 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.

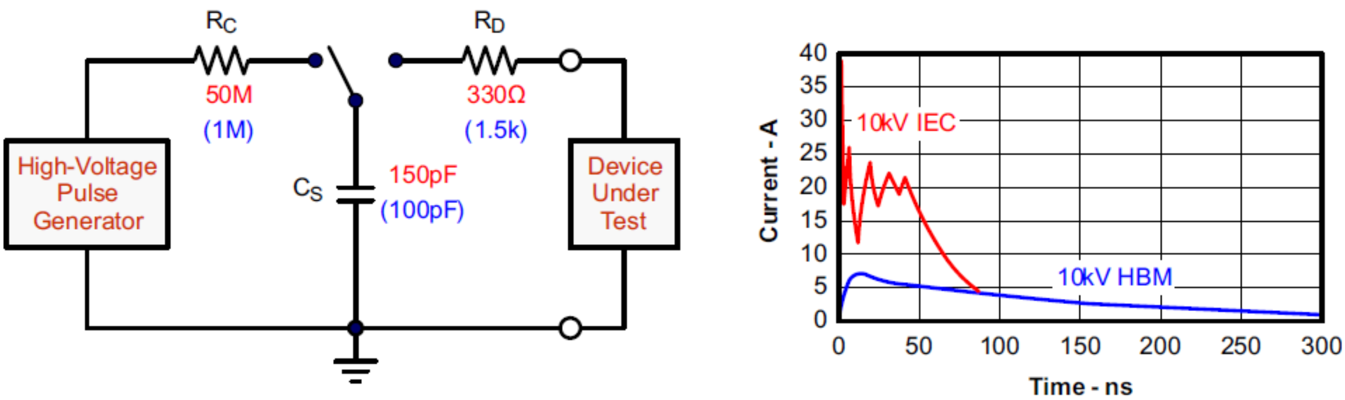


Figure 20. HBM and IEC-ESD Models and Currents in Comparison (HBM Values in Parenthesis)

The on-chip implementation of IEC ESD protection significantly increases the robustness of equipment. Common discharge events occur because of human contact with connectors and cables. Designers may choose to implement protection against longer duration transients, typically referred to as surge transients. Figure 9 suggests two circuit designs providing protection against short and long duration surge transients, in addition to ESD and Electrical Fast Transients (EFT) transients. Table 1 lists the bill of materials for the external protection devices.

EFTs are generally caused by relay-contact bounce or the interruption of inductive loads. Surge transients often result from lightning strikes (direct strike or an indirect strike which induce voltages and currents), or the switching of power systems, including load changes and short circuits switching. These transients are often encountered in industrial environments, such as factory automation and power-grid systems. Figure 10 compares the pulse-power of the EFT and surge transients with the power caused by an IEC ESD transient. In the diagram on the left of Figure 10, the tiny blue blip in the bottom left corner represents the power of a 10-kV ESD transient, which already dwarfs against the significantly higher EFT power spike, and certainly dwarfs against the 500-V surge transient. This type of transient power is well representative of factory environments in industrial and process automation. The diagram on the fright of Figure 10 compares the enormous power of a 6-kV surge transient, most likely occurring in e-metering applications of power generating and power grid systems, with the aforementioned 500-V surge transient.

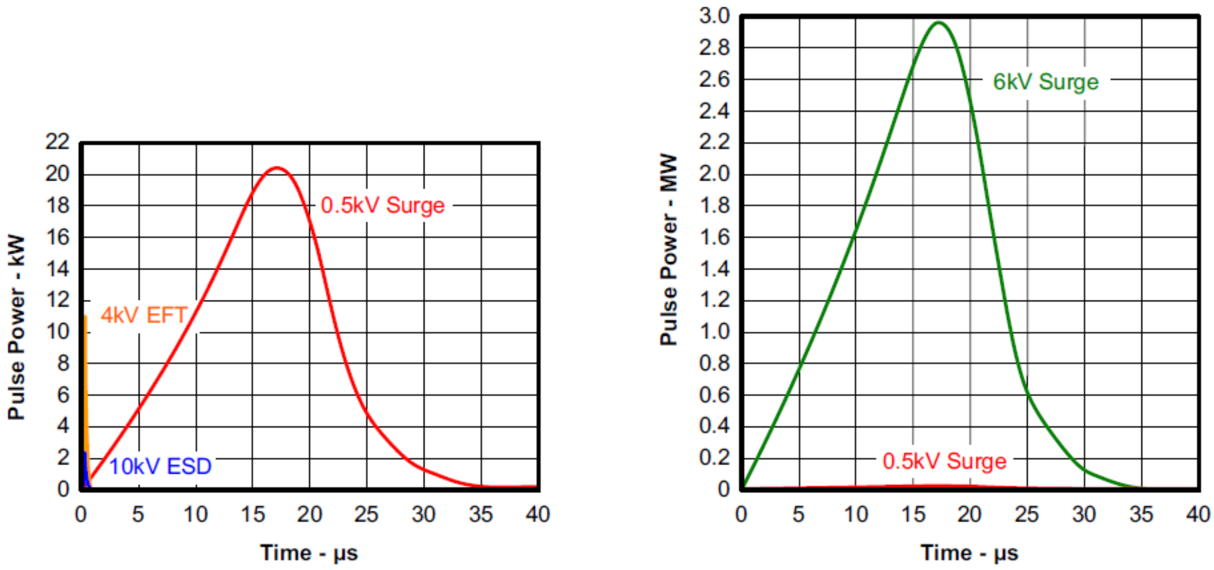


Figure 21. Power Comparison of ESD, EFT, and Surge Transients

In the case of surge transients, high-energy content is signified by long pulse duration and slow decaying pulse Power The electrical energy of a transient that is dumped into the internal protection cells of the transceiver is converted into thermal energy. This thermal energy heats the protection cells and literally destroys them, thus destroying the transceiver. Figure 11 shows the large differences in transient energies for single ESD, EFT, and surge transients as well as for an EFT pulse train, commonly applied during compliance testing.

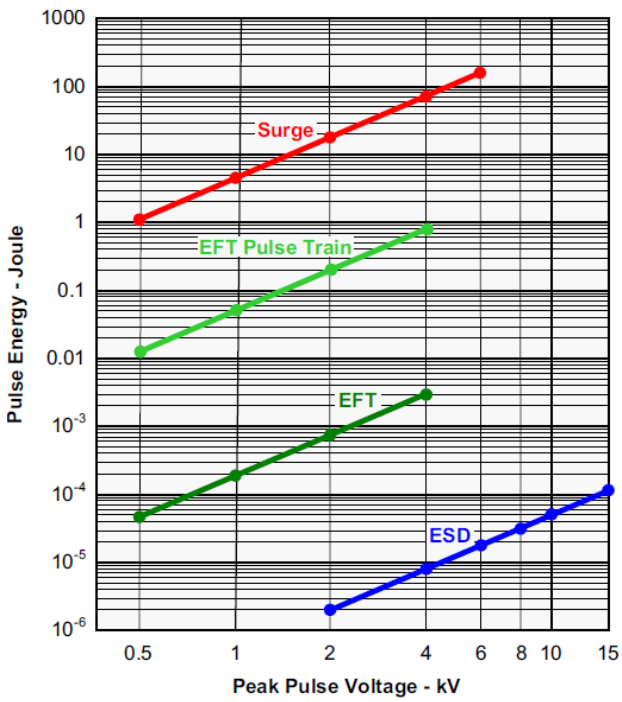


Figure 22. Comparison of Transient Energies

Table 1. Bill of Materials

Device	Function	Order Number	Manufacturer
485	5-V, 10Mbps RS-485 Transceiver	TP75176E	3PEAK
R1, R2	10-Ω, Pulse-Proof Thick-Film Resistor	CRCW0603010RJNEAHP	Vishay
TVS	Bidirectional 400-W Transient Suppressor	CDSOT23-SM712	Bourns
TBU1, TBU2	Bidirectional	TBU-CA-065-200-WH	Bourns
MOV1, MOV2	200mA Transient Blocking Unit 200-V, Metal-Oxide Varistor	MOV-10D201K	Bourns

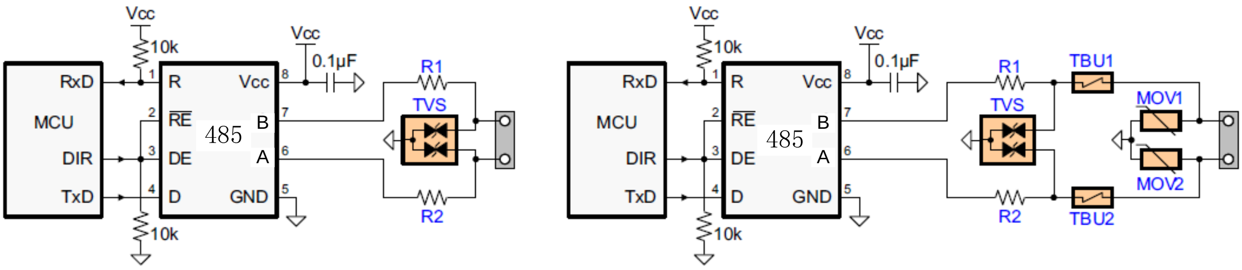


Figure 23. Transient Protections Against ESD, EFT, and Surge Transients

The left circuit shown in Figure 12 provides surge protection of ≥ 500-V transients, while the right protection circuits can withstand surge transients of 5 kV

Typical Performance Characteristics

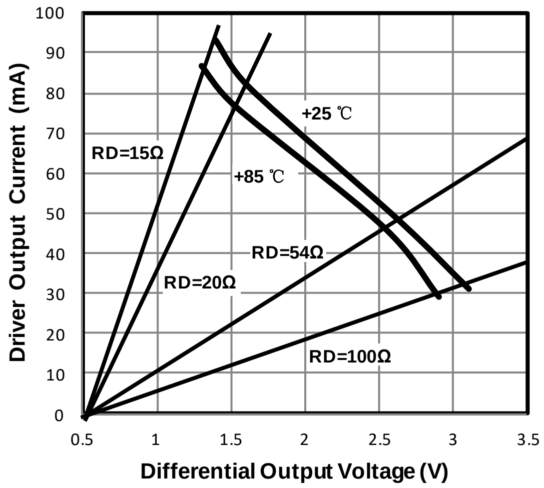


FIGURE 24. DRIVER OUTPUT CURRENT vs VOLTAGE DIFFERENTIAL OUTPUT VOLTAGE

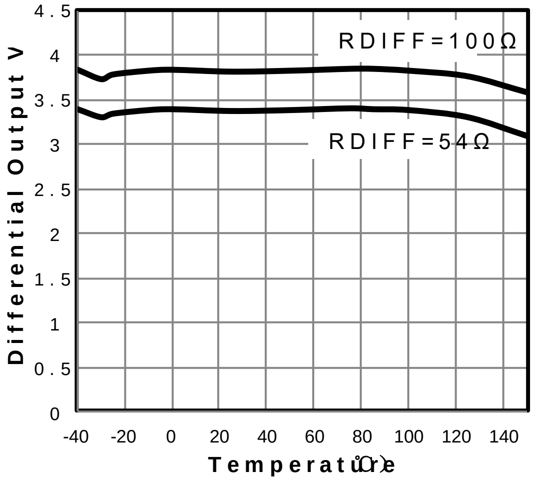
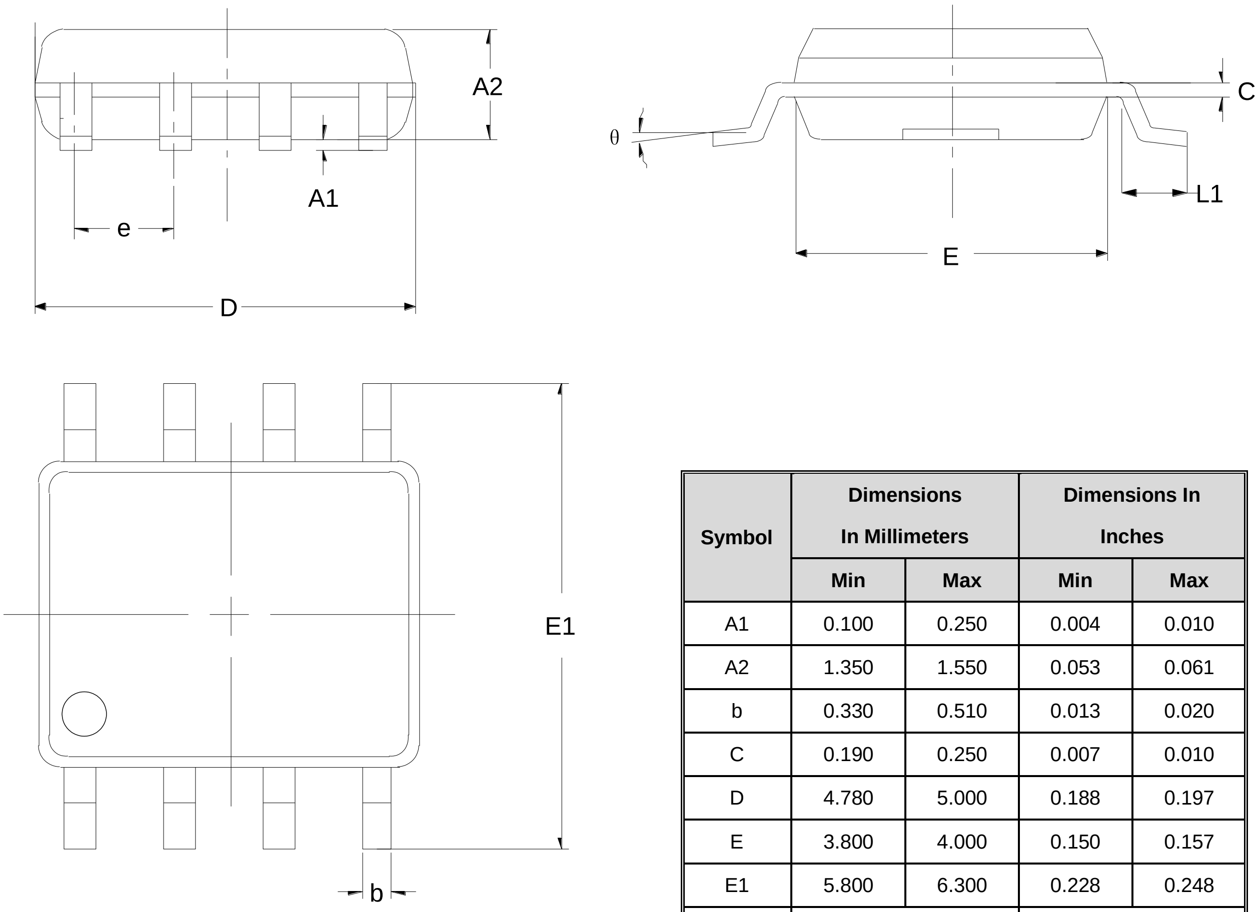


FIGURE 25. DRIVER DIFFERENTIAL OUTPUT vs TEMPERATURE

Package Outline Dimensions

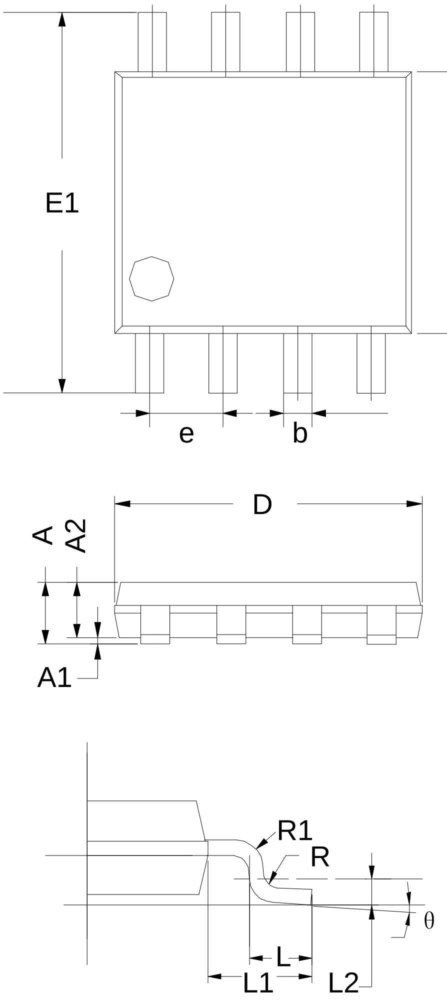
SOP-8 (SOIC-8)



Symbol	Dimensions In Millimeters		Dimensions In Inches	
	Min	Max	Min	Max
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	1.270 TYP		0.050 TYP	
L1	0.400	1.270	0.016	0.050
θ	0°	8°	0°	8°

Package Outline Dimensions

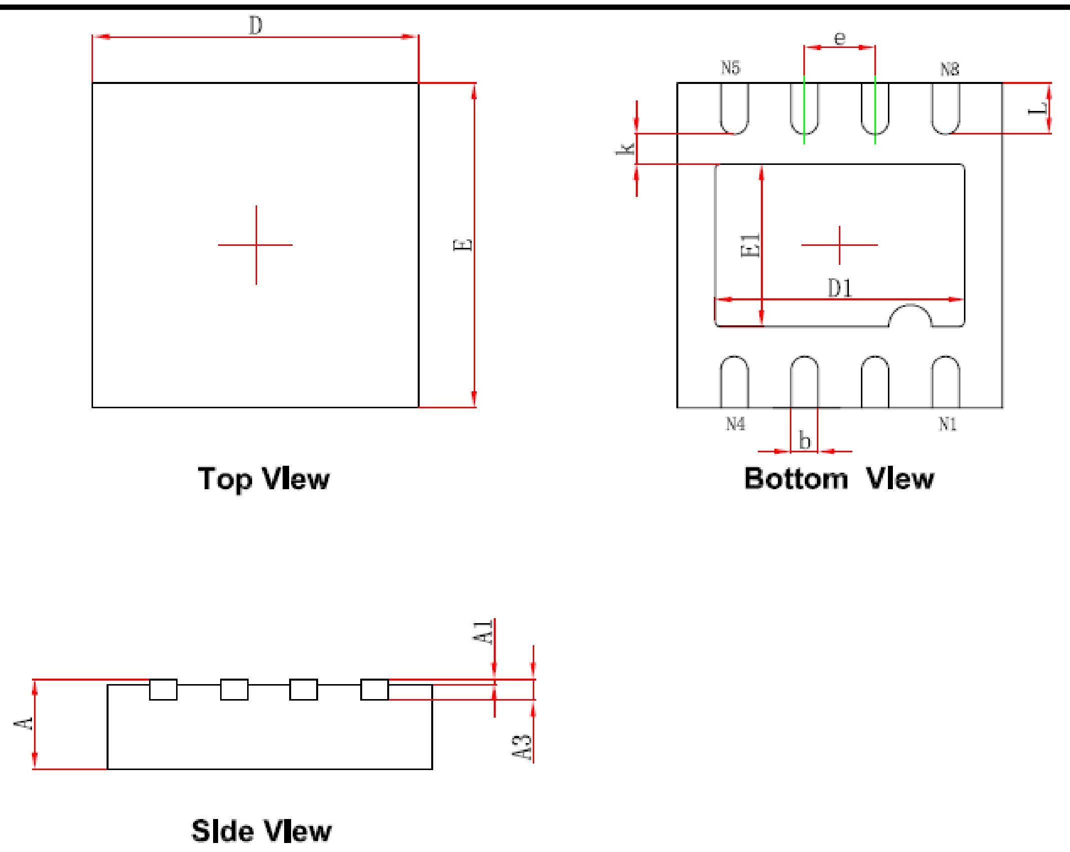
MSOP-8



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	
E	2.900	3.100	0.114	0.122
E1	4.700	5.100	0.185	0.201
L1	0.410	0.650	0.016	0.026
θ	0°	6°	0°	6°

Package Outline Dimensions

DFN-8



Symbol	Dimensions In Millimeters		Dimensions In Inches	
	Min.	Max.	Min.	Max.
A	0.700/0.800	0.800/0.900	0.028/0.031	0.031/0.035
A1	0.000	0.050	0.000	0.002
A3	0.203REF.		0.008REF.	
D	2.924	3.076	0.115	0.121
E	2.924	3.076	0.115	0.121
D1	2.200	2.400	0.087	0.094
E1	1.400	1.600	0.055	0.063
k	0.200MIN.		0.008MIN.	
b	0.200	0.300	0.008	0.012
e	0.650TYP.		0.026TYP.	
L	0.399	0.551	0.016	0.022

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