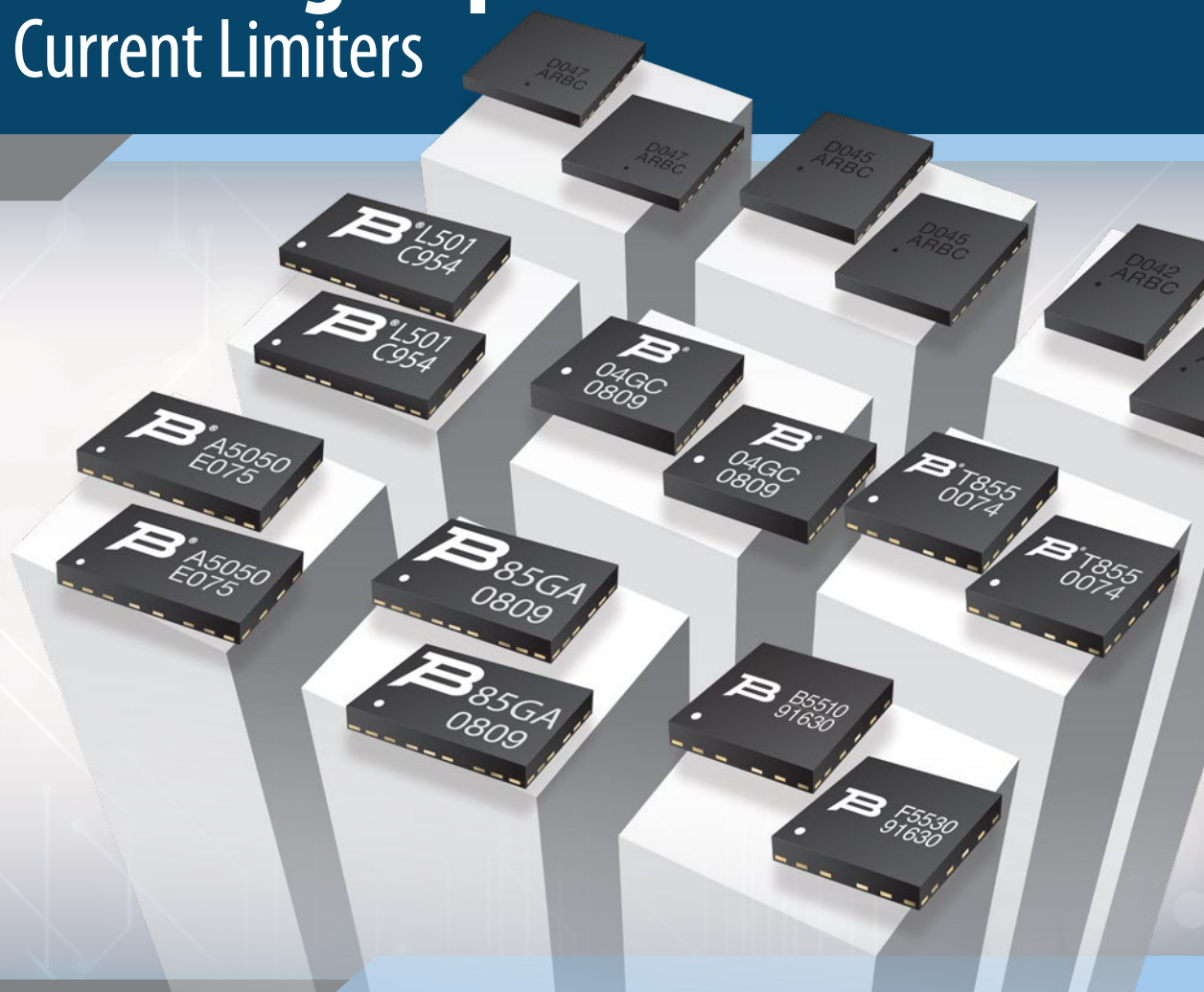


TCS™ & TBU® High-Speed Protectors

Electronic Current Limiters



BOURNS®

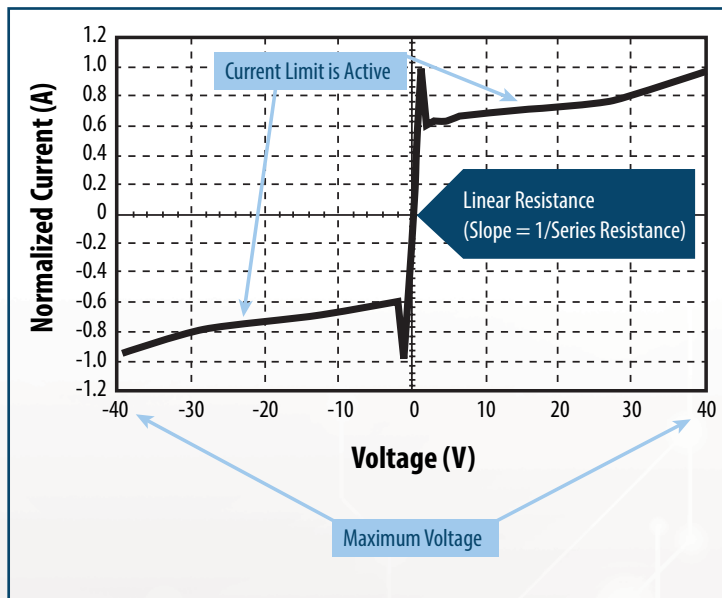
Bourns® TCS™ HSP Product Overview

Basic TCS™ HSP Device Operation

The Bourns® TCS™ DL Series High-Speed Protector (HSP) products contain dual, well-matched, low resistance, bidirectional, very high-speed Transient Current Suppressors. By limiting the maximum current to a safe level, a Bourns® TCS™ DL device offers superior protection for very high data rate differential lines against faults caused by momentary short circuits, induction and lightning surges.

A TCS™ device is designed to trigger at a specified current level and provide a moderate amount of foldback. The following graph shows the normalized response of the device.

TCS™ Device - VI Curve



Choosing between a TCS™ or TBU® HSP

Condition	TCS-DL	TBU® HSP
High Voltage Rating Required (> 40 V)	N	Y
Strong Foldback Required	N	Y
Short Duration Transient	Y	Y
Continuous or Repetitive AC Fault Condition	N	Y
Very Low Series Resistance Required (< 3 Ω)	Y	N
Oversvoltage Protection Device Alone Provides Inadequate Protection	Y	Y
Very Well-matched Channel to Channel Resistance Required	Y	N
Extremely Fast Response Time Required (from Normal Operation to Protected State)	Y	N*
Extremely Fast Reset Time Required	Y	N*

* Except Model P40-G240-WH.

Key Features:

- 50 ns response time
- Low let-through energy
- Low series resistance
- Well-matched channel to channel resistance
- Low insertion loss
- Three trigger current levels available

Key Benefits:

- Creates ideal diode response to maximize protection
 - New approach: TVS diode and a TCS™ HSP working with the internal ESD protection of the protected circuit
- Supports applications up to a frequency of 6 GHz
- Up to 90 % reduction in stress compared to stand-alone Oversvoltage Protection (OVP)
- Negligible impact on differential signal balance
- Improves product reliability compared to stand-alone OVP
- Can reduce product repair costs

TCS™ HSP Device-based Solution Selection

Step 1: Current characterization:

Determine the maximum signal current and the maximum operating temperature of the application (e.g., 100 mA and 65 °C).

Step 2: Oversvoltage selection:

Determine the trip current derating factor using the data sheet graph and divide the maximum operating current by this number (e.g., 100 mA/0.75 = 133 mA).

Step 3: TCS™ HSP device selection:

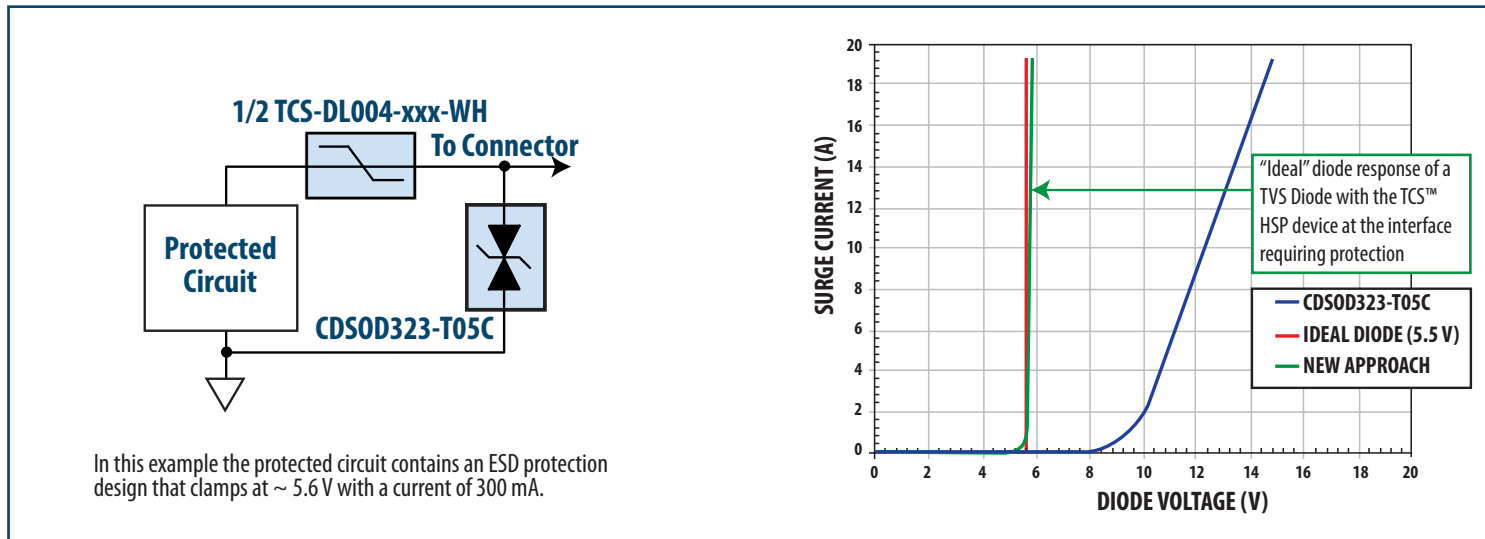
Pick a TCS™ device with a minimum trip current at 25 °C that is above the number calculated in step 2 (e.g., The Model TCS-DL004-250-WH has a minimum trip current of 250 mA, making it the lowest trip current device that will work in the example).

Step 4: Tertiary protection:

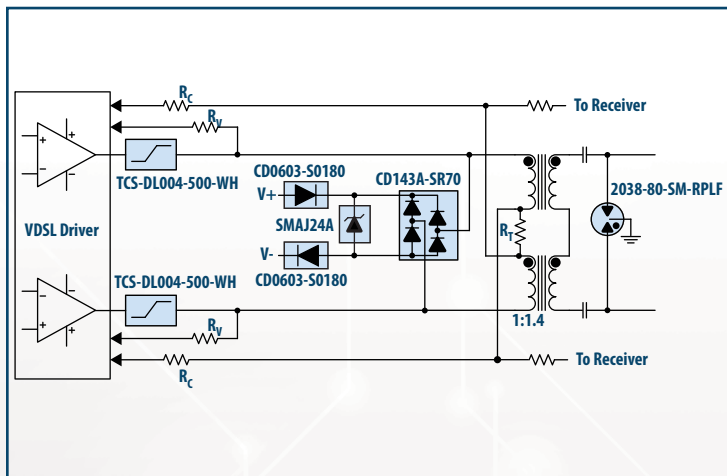
Determine whether the selected device's series resistance will adversely affect circuit performance. If a lower resistance device is required, then a device with a higher trip current should be selected.

Bourns® TCS™ HSP Product Examples

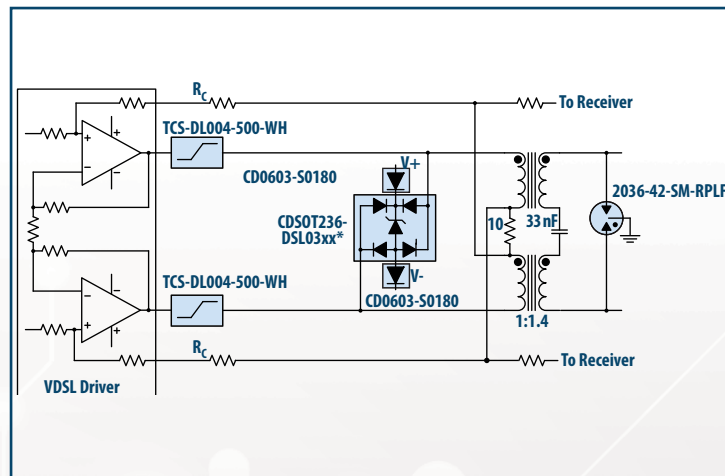
Create the Ideal Diode Response with a Bourns® TCS™ High-Speed Protector



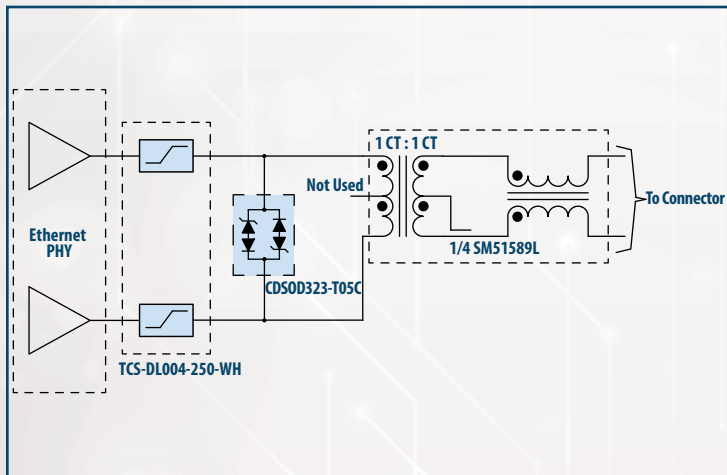
VDSL Class H Driver – Fully Resettable GR-1089 ISSUE 6 Solution for Port Types 1, 3 and 5



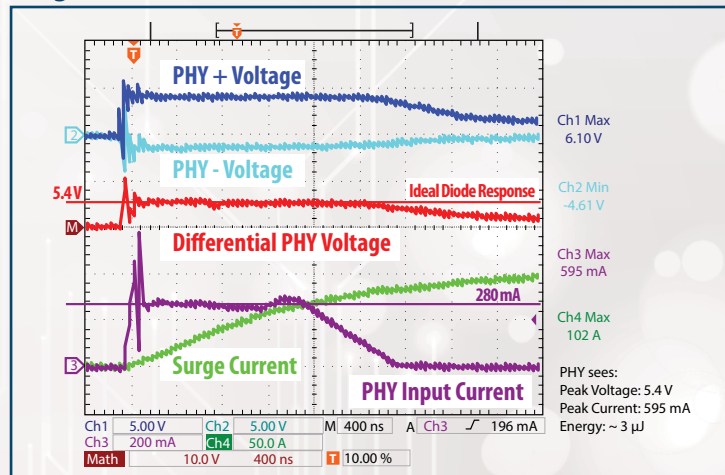
VDSL Class H Driver Protection for ITU-T K.21



Gigabit Ethernet Surge Protection – GR-1089 ISSUE 6 Port Type 4, ITU-T K.21 Basic



Test Results for Gigabit Ethernet Surge Protection Circuit



Bourns® TBU® HSP Product Overview

Basic TBU® HSP Device Operation

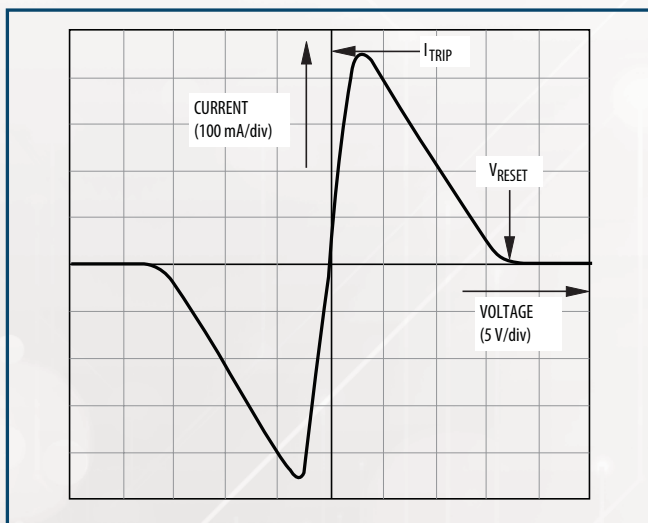
Bourns® TBU® High-Speed Protectors (HSPs) are circuit protection devices constructed using MOSFET semiconductor technology. When placed in series with a signal line, the TBU® HSP monitors the current flowing through the line. If the current exceeds a preset level, the TBU® HSP triggers, providing an effective barrier to high voltages and currents.

The TBU® HSP begins protecting in less than 1 μ s, once line current exceeds the TBU® device's trigger current I_{trigger} . When in the protected state, the TBU® HSP restricts line current to less than 1 mA typically, and blocks voltages up to the maximum voltage rating of the device.

At the end of a surge event, the TBU® HSP will begin the reset process when the voltage across the device drops below the V_{reset} level and will complete the reset process when the signal line returns to its normal operating range.

If the line has a normal DC bias above V_{reset} , the voltage across the TBU® HSP may not fall below V_{reset} after the surge. In such cases, special care needs to be taken to ensure that the TBU® HSP will reset. Bourns' application engineers can provide further assistance.

Example TBU® HSP VI Curve (TBU-CA050-300-WH)



Key Features:

- TBU® HSP is a series protection device
- Triggers at a specified current
- Can block voltages up to 850 V, enabling easy coordination
- Provides superior protection in less than 1 μ s
- Resets on voltage (V_{reset} Valve)
- Does not add capacitance to the signal line

Key Benefits:

- AEC-Q101 compliant* ("Q" part number suffix)
- High-speed performance
- Blocks voltages and currents
- Extremely low let-through energy
- Self-resetting (V_{reset} Valve)
- Very high bandwidth up to 3 GHz
- Small size in DFN package
- Model TBU-PL series offers voltage triggering
- Small PCB area
- Ultra-low profile

TBU® HSP Device-based Solution Selection

Step 1: Current characterization:

Determine the peak system operating current and maximum operating ambient temperature. Use the TBU® HSP data sheet's "trigger current versus temperature" derating curve to determine the TBU® HSP derating value.

Step 2: Overvoltage selection:

Select an overvoltage device that has the lowest available DC breakdown voltage greater than the normal system voltages and any expected AC power faults. The selected device must also be capable of handling the required lightning current.

Step 3: TBU® HSP device selection:

Choose a TBU® HSP device with a maximum impulse voltage (V_{imp}) greater than the maximum impulse breakover or clamping voltage of the selected overvoltage protector at the required peak surge current. The selected TBU® device must also have a minimum specified I_{trigger} (use derating value from step 1) above the maximum peak system operating current.

Step 4: Tertiary protection:

In many applications, the protected circuit can source and sink sufficient current to trigger the TBU® HSP. When this is not the case, a small avalanche diode to ground or small signal diodes clamping to the power supply and ground may be placed after the TBU® device. This will ensure that the TBU® HSP triggers and properly protects the circuit.

Bourns® TBU® HSP Product Examples

VOICE Protection Solution Selection Guide

Industry Standard	Surge & AC Withstand	Bourns® TBU® Device Selection			
		TBU® Device Part Number	Qty.	OVP Device Part Number	Qty.
Telcordia GR-1089-CORE Intra-building Port Type 4	1500 V, 100 A, 2/10 μ s 120 V _{rms} , 25 A, 900 s	TBU-PL050-200-WH	1	MOV-07D201K	2
Telcordia GR-1089-CORE Intra-building Port Type 4a	1000 V, 100 A, 10/1000 μ s 120 V _{rms} , 25 A, 900 s	TBU-PL060-200-WH	1	MOV-10D201K	2
Non-GR-1089-CORE Intra-building Specifications	5000 V, 500 A, 2/10 μ s 230 V _{rms} , 25 A, 900 s	TBU-PL085-200-WH	1	MOV-10D361K	2
	1500 V, 100 A, 2/10 μ s 275 V _{rms} , 25 A, 900 s	TBU-PL085-200-WH	1	MOV-10D431K	2
ITU-T Basic K.20, K.21, K.45	4000 V, 40 Ω , 10/700 μ s 230 V _{rms} 10 Ω - 1000 Ω , 900 s	TBU-PL075-200-WH	1	MOV-10D361K	2
	600 V _{rms} 600 Ω , 0.2 s	TBU-PL060-200-WH	1	TISP4400M3BJ	2
ITU-T Enhanced K.20, K.21, K.45	6000 V, 40 Ω , 10/700 μ s 240 V _{rms} 10 Ω - 1000 Ω , 900 s	TBU-PL085-200-WH	1	MOV-10D391K	2
	600 V _{rms} 600 Ω , 0.2 s 600 V _{rms} 600 Ω , 1 s* 1500 V _{rms} , 200 Ω , 2 s*	TBU-PL060-200-WH	1	TISP4500H3BJ	2
	6000 V, 40 Ω , 10/700 μ s 240 V _{rms} 10 Ω - 1000 Ω , 900 s	TBU-PL060-200-WH	1	TISP4500H3BJ	2
	600 V _{rms} 600 Ω , 1 s 1500 V _{rms} , 200 Ω , 2 s				

* Gas Discharge Tube (GDT) special test protector with DC breakdown (DCBD) of less than 330 V.

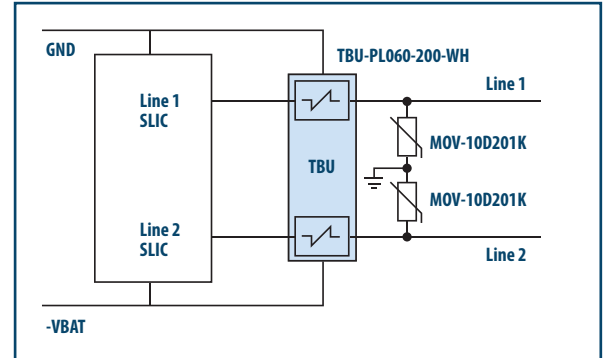
Notes:

- 1) The MOV maximum continuous rms voltage rating should not be exceeded. The exception is where the data sheet highlights withstand capability such as the 600 V_{rms}, 1 A for 0.2 s, for example.
- 2) If EN55024 EMC compliance is required, the TBU® device may require capacitors to be fitted between the Tip and Ring connections and ground (i.e., in parallel with the MOV device). The capacitance value can be chosen to meet levels as follows:
 - 10 nF for EN55024 Level 1
 - 20 nF for EN55024 Level 2
 - 47 nF for EN55024 Level 3

Selection of capacitor voltage rating depends upon TBU® HSP part number selection. Recommendations include:

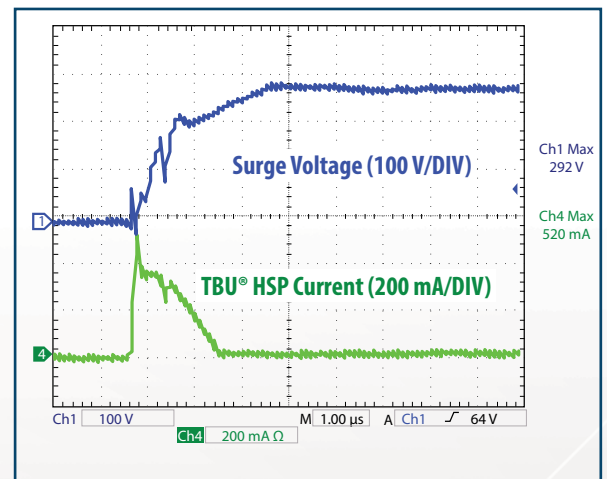
- TBU-PL050 & TBU-PL060 Series: 120 VAC, 500 V Peak Surge Rated
- TBU-PL075 & TBU-PL085 Series: 240 VAC, 750 V Peak Surge Rated

VOICE SOLUTION EXAMPLE

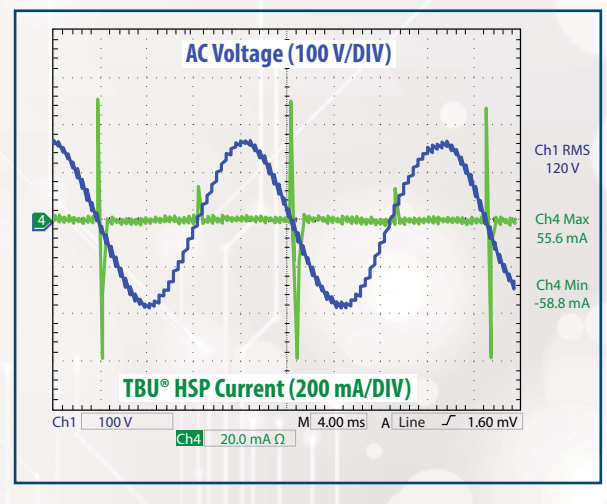


Review VOICE Protection Solution Selection Guide to select TBU® HSP and overvoltage part numbers to meet protection industry standard.

1000 V, 100 A, 10/1000 μ s Surge Test Results

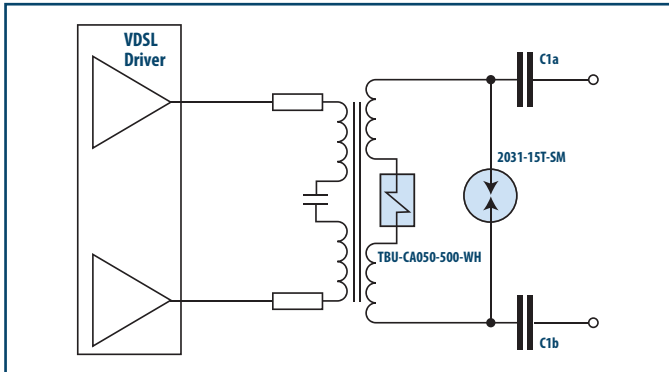


120 V_{rms}, 25 A Power Fault Test Results

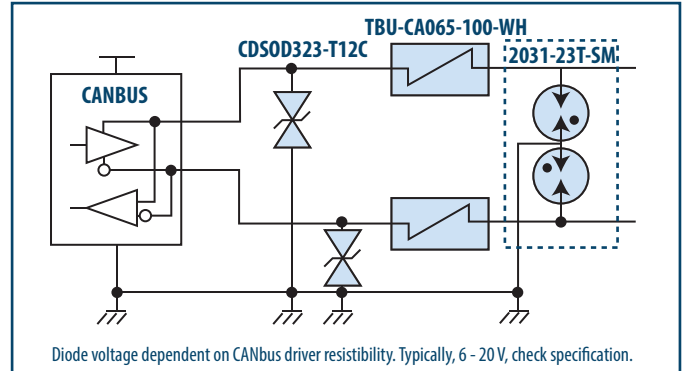


Bourns® TBU® HSP Product Examples

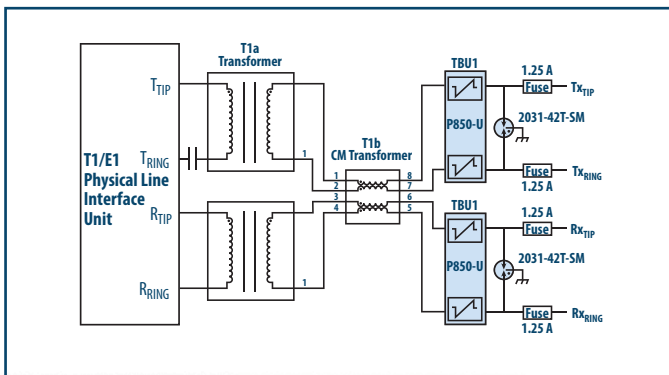
VDSL



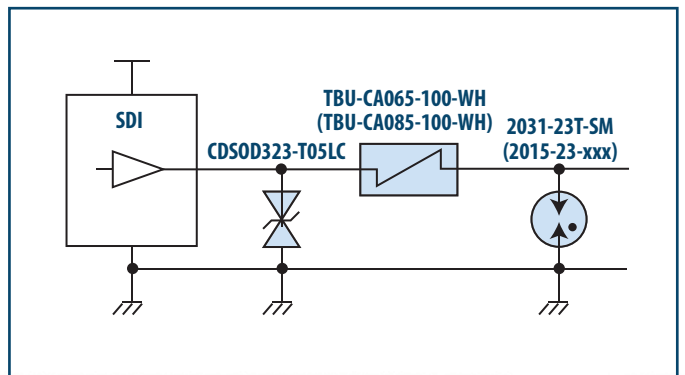
CANBUS



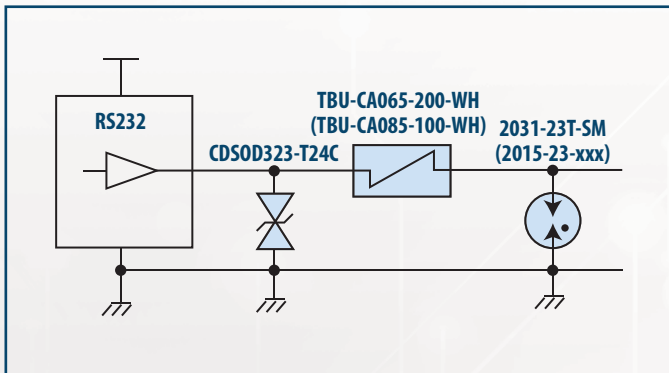
T1/E1 Interface



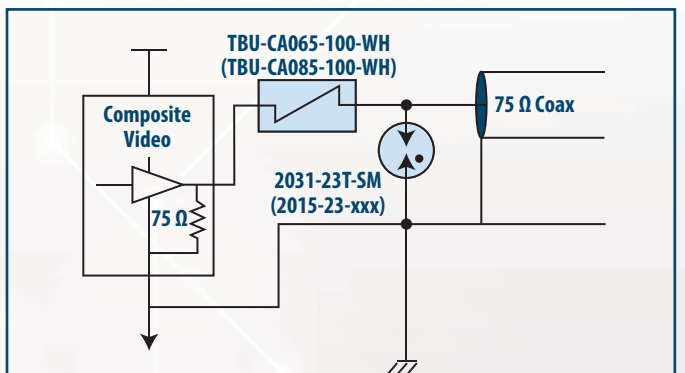
Video Surveillance



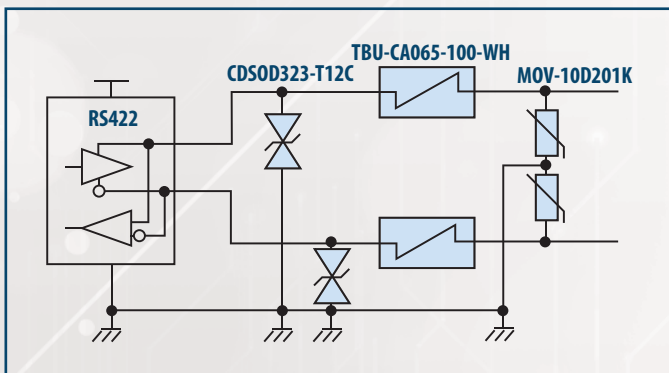
RS232 Interface



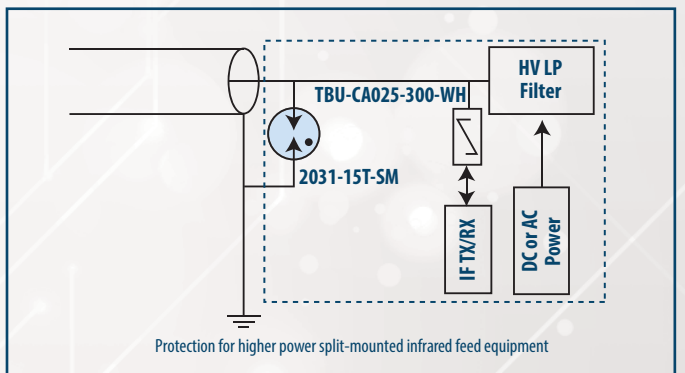
Intelligent Transport System



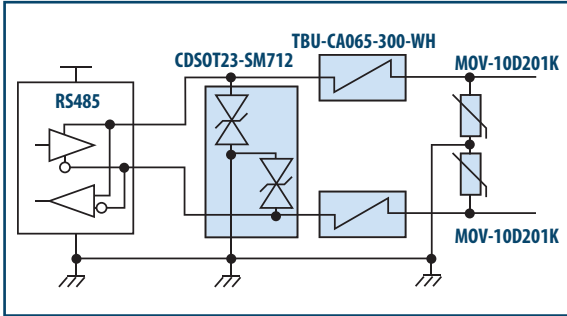
RS422 Interface



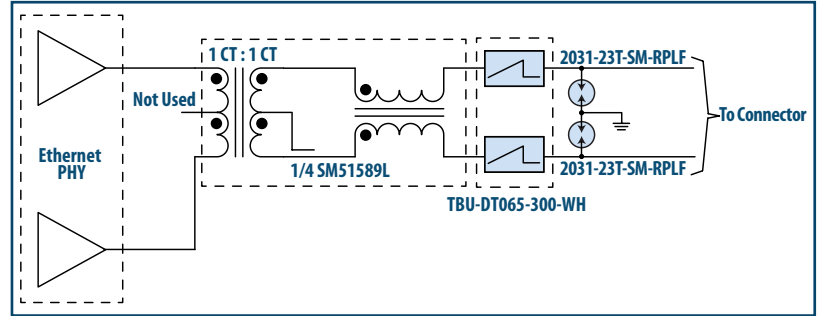
Microwave Link



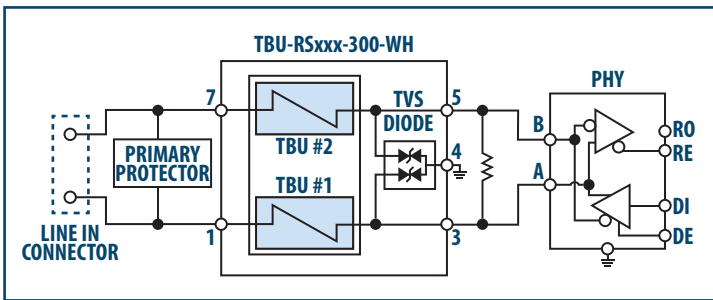
RS485 Interface



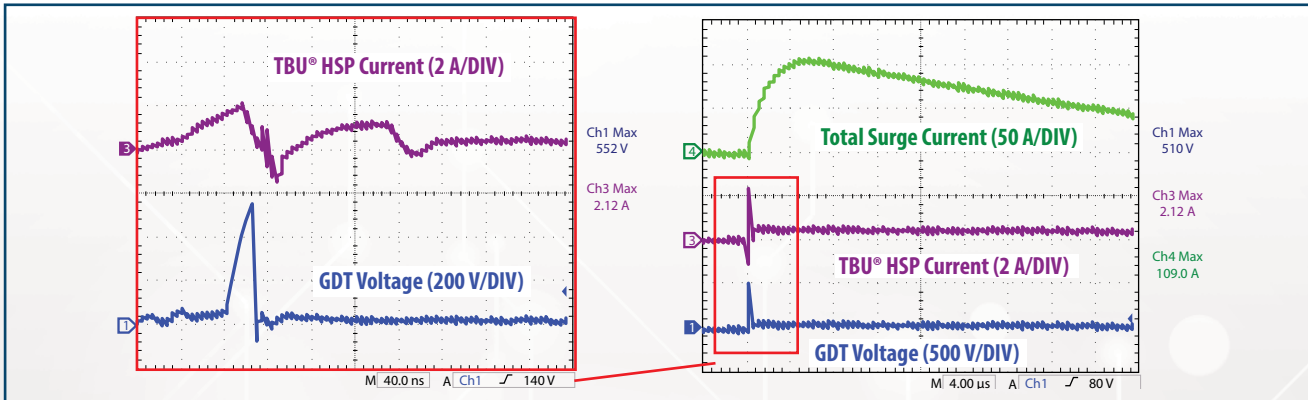
Ethernet Surge and Power Cross Protection – GR-1089 ISSUE 6, Port Type 4



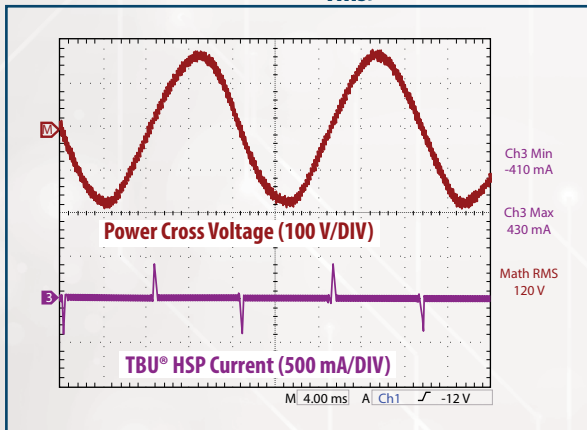
Device Description



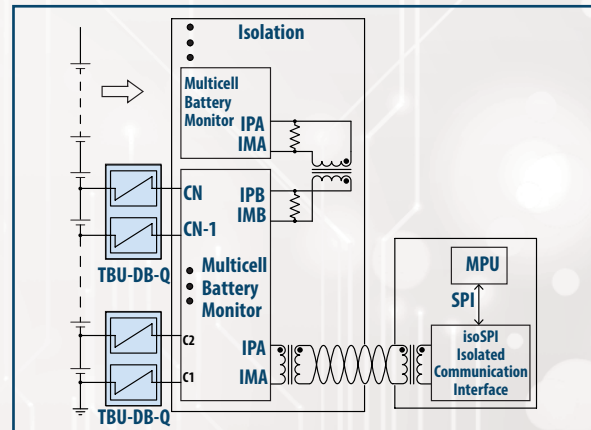
Ethernet Protection Circuit Test Results – Differential Surge Test: 800 V, 1.2/50 μ s Voltage, 8/20 μ s Current



AC Power Cross Test 120 V_{rms}, 25 A

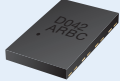




BMS Sense Line Interface



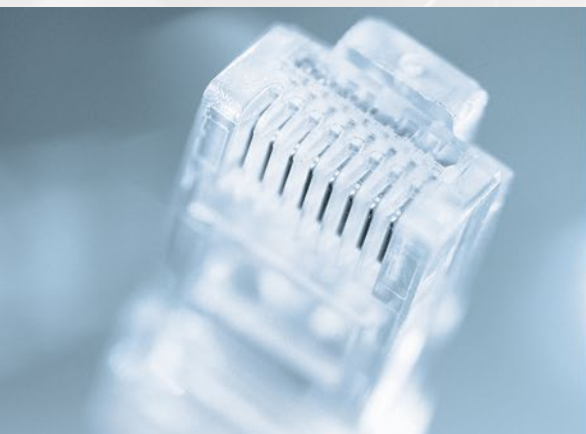
Dual Channel Bidirectional TCS™ HSP

TCS-DL Product Family

Part Number	Maximum Ratings	Operating Characteristics					Device Size (mm)	Form Factor
	V_{imp} (V)	$I_{trigger}$ (mA)			t_{limit} (ns)	R_{on} (Ω) Typ.		
		Min.	Typ.	Max.				
TCS-DL004-250-WH	40	250	375	500	50	2.3	4.00 x 2.50	
TCS-DL004-500-WH	40	500	750	1000	50	1.4	4.00 x 3.50	
TCS-DL004-750-WH	40	750	1100	1500	50	1.0	4.00 x 4.50	

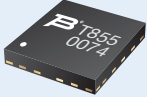
- V_{imp} — Maximum peak impulse voltage withstand with duration less than 10 ms.
- $I_{trigger}$ — Current required for the device to go from operating state to protected state.
- t_{limit} — Time for the device to go from normal operating state to current limiting state.
- R_{on} — Series resistance of the TCS™ device.

See data sheet for detailed specifications.



Unidirectional Dual TBU® HSP

TBU-DT Product Family

Part Number	Maximum Ratings		Operating Characteristics				Device Size (mm)	Form Factor
	V _{imp} (V)	V _{rms} (V)	I _{trigger} Min. (mA)	I _{trigger} Max. (mA)	t _{block} (μs)	R _{typ} (Ω)		
TBU-DT065-100-WH	650	300	100	200	1	8.5	5.00 x 5.00	
TBU-DT065-200-WH	650	300	200	400	1	5.6		
TBU-DT065-300-WH	650	300	300	600	1	4.6		
TBU-DT065-500-WH	650	300	500	1000	1	4.0		
TBU-DT085-100-WH	850	425	100	200	1	10.3		
TBU-DT085-200-WH	850	425	200	400	1	7.4		
TBU-DT085-300-WH	850	425	300	600	1	6.8		
TBU-DT085-500-WH	850	425	500	1000	1	5.8		

V_{imp} — Maximum peak impulse voltage withstand with duration less than 10 ms.

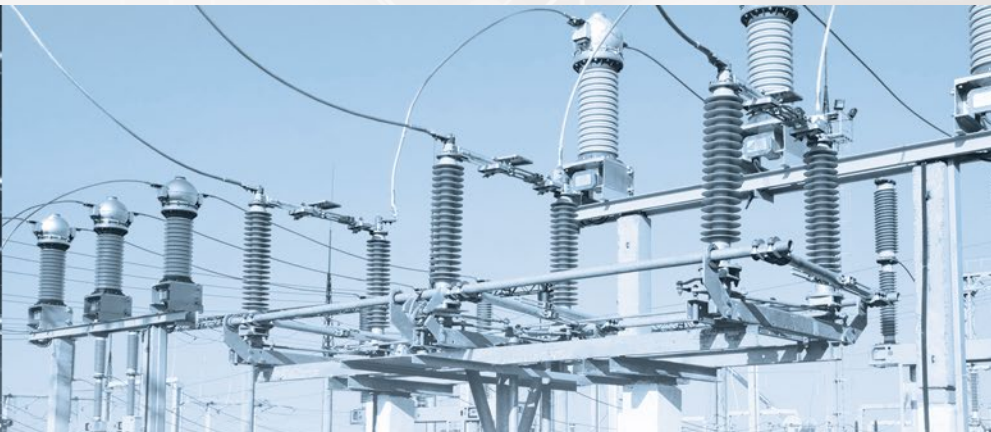
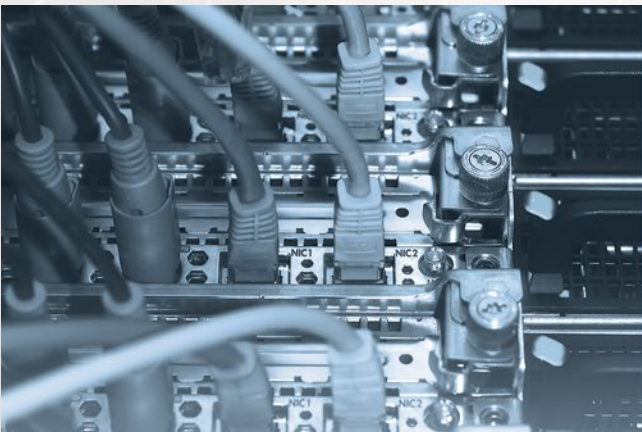
V_{rms} — Maximum continuous alternating current RMS voltage.

I_{trigger} — Minimum and maximum current required for the device to go from operating state to protected state.

t_{block} — Maximum time for the device to go from normal operating state to protected state.


R_{typ} — Typical series resistance of the TBU® device.

Consult factory for alternate specification values. See data sheet for detailed specifications.




Bidirectional Dual TBU® HSP

TBU-DB-Q Product Family





Part Number	Maximum Ratings		Operating Characteristics				Device Size (mm)	Form Factor
	V _{imp} (V)	V _{dc} (V)	I _{trigger} Min. (mA)	I _{trigger} Max. (mA)	t _{block} (μs)	R _{typ} (Ω)		
TBU-DB055-100-WH-Q	550	450	100	200	1	13.5	6.50 x 5.50	

"Q" suffix for AEC-Q101 compliance

TBU-DF Product Family


Part Number	Maximum Ratings		Operating Characteristics				Device Size (mm)	Form Factor
	V _{imp} (V)	V _{rms} (V)	I _{trigger} Min. (mA)	I _{trigger} Max. (mA)	t _{block} (μs)	R _{typ} (Ω)		
TBU-DF055-050-WH	550	250	50	100	1	19	6.50 x 5.50	
TBU-DF055-100-WH	550	250	100	200	1	14		
TBU-DF055-200-WH	550	250	200	400	1	11.5		
TBU-DF055-300-WH	550	250	300	600	1	10		
TBU-DF055-500-WH	550	250	500	1000	1	9		
TBU-DF085-050-WH	850	425	50	100	1	30.5		
TBU-DF085-100-WH	850	425	100	200	1	20.5		
TBU-DF085-200-WH	850	425	200	400	1	17.5		
TBU-DF085-300-WH	850	425	300	600	1	20.5		
TBU-DF085-500-WH	850	425	500	1000	1	18.5		

P40, TBU-PL & P850 Product Families


Part Number	Maximum Ratings		Operating Characteristics				Device Size (mm)	Form Factor
	V _{imp} (V)	V _{rms} (V)	I _{trigger} Min. (mA)	I _{trigger} Max. (mA)	t _{block} (μs)	R _{typ} (Ω)		
P40-G240-WH	40	28	240	480	0.2	3.6	4.00 x 4.00	
TBU-PL050-100-WH	500	300	100	200	1	50	6.50 x 4.00	
TBU-PL050-200-WH	500	300	200	400	1	50		
TBU-PL060-100-WH	600	350	100	200	1	50		
TBU-PL060-200-WH	600	350	200	400	1	50		
TBU-PL075-100-WH	750	400	100	200	1	50		
TBU-PL075-200-WH	750	400	200	400	1	50		
TBU-PL085-100-WH	850	425	100	200	1	50		
TBU-PL085-200-WH	850	425	200	400	1	50		
P850-G120-WH	850	425	100	200	1	50	8.25 x 4.00	
P850-G200-WH	850	425	200	400	1	50	8.25 x 4.00	

Bidirectional Single TBU® HSP

TBU-CA Product Family

Part Number	Maximum Ratings		Operating Characteristics				Device Size (mm)	Form Factor
	V _{imp} (V)	V _{rms} (V)	I _{trigger} Min. (mA)	I _{trigger} Max. (mA)	t _{block} (μs)	R _{typ} (Ω)		
TBU-CA025-050-WH	250	100	50	100	1	13.3	6.50 x 4.00	
TBU-CA025-100-WH	250	100	100	200	1	7.1		
TBU-CA025-200-WH	250	100	200	400	1	4.2		
TBU-CA025-300-WH	250	100	300	600	1	3.2		
TBU-CA025-500-WH	250	100	500	1000	1	2.6		
TBU-CA040-050-WH	400	200	50	100	1	14.3		
TBU-CA040-100-WH	400	200	100	200	1	8.1		
TBU-CA040-200-WH	400	200	200	400	1	5.2		
TBU-CA040-300-WH	400	200	300	600	1	4.3		
TBU-CA040-500-WH	400	200	500	1000	1	3.6		
TBU-CA050-050-WH	500	250	50	100	1	15.7		
TBU-CA050-100-WH	500	250	100	200	1	9.5		
TBU-CA050-200-WH	500	250	200	400	1	6.6		
TBU-CA050-300-WH	500	250	300	600	1	5.6		
TBU-CA050-500-WH	500	250	500	1000	1	5.0		
TBU-CA065-050-WH	650	300	50	100	1	17.7		
TBU-CA065-100-WH	650	300	100	200	1	11.5		
TBU-CA065-200-WH	650	300	200	400	1	8.6		
TBU-CA065-300-WH	650	300	300	600	1	7.6		
TBU-CA065-500-WH	650	300	500	1000	1	7.0		
TBU-CA085-050-WH	850	425	50	100	1	21.4		
TBU-CA085-100-WH	850	425	100	200	1	15.2		
TBU-CA085-200-WH	850	425	200	400	1	12.3		
TBU-CA085-300-WH	850	425	300	600	1	11.3		
TBU-CA085-500-WH	850	425	500	1000	1	10.7		

TBU-RS Product Family

Part Number	Maximum Ratings		Operating Characteristics				Device Size (mm)	Form Factor
	V _{imp} (V)	V _{rms} (V)	I _{trigger} Min. (mA)	I _{trigger} Max. (mA)	t _{block} (μs)	R _{typ} (Ω)		
TBU-RS055-300-WH	550	250	300	600	1	10	8 x 5.5	
TBU-RS085-300-WH	850	425	300	600	1	21.5		

V_{imp} — Maximum peak impulse voltage withstand with duration less than 10 ms.

V_{rms} — Maximum continuous alternating current RMS voltage.

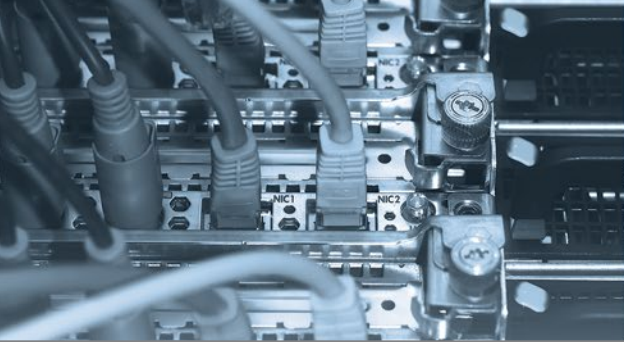
V_{dc} — Maximum peak DC voltage withstand with duration less than 1 hour.

I_{trigger} — Minimum and maximum current required for the device to go from operating state to protected state.

t_{block} — Maximum time for the device to go from normal operating state to protected state.

R_{typ} — Typical series resistance of the TBU® device.

Consult factory for alternate specification values. See data sheet for detailed specifications.



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