



# INDUSTRIAL APPLICATIONS



**ADVANCED CIRCUIT PROTECTION DEVICES FOR OVERVOLTAGE TRANSIENT EVENTS**



Today's industrial applications are as diverse as ever. They include point of sale (PoS) systems that have card readers, modems and serial ports. They also include residential and commercial energy meters and smart meters; industrial displays; appliances; general control systems; instrumentation; photovoltaic systems; LED lighting and many more. Industrial system failures in the field due to improper circuit protection can be costly exercises in terms of time and money. In addition, system downtime can often result in damage to a company's image or quality reputation – both that of the user and the system provider. Any of these industrial applications are at risk to external threats that can include electrostatic discharges (ESD), electrical fast transients (EFT), surges, lightning or improper wiring.

Communications systems are at the heart of many industrial applications, such as the use of RS-485, CAN Bus, LIN Bus, USB2.0, ProfiNet or ProfiBus. To provide circuit protection, traditionally, a high capacitor was used to ensure overvoltage protection. However, due to the high speed requirements in today's communication ports, the capacitance per line must be significantly reduced. If not, transmission speed will be substantially negatively impacted. And, capacitance reduction must be done while still providing enough overvoltage protection against electrical threats. The capacitance of the protection device becomes a particular issue for data lines where higher baud rates are being designed. Here, what's required are circuit protection components where the load capacitance creates a first order filter to slow the rise and falling edge.

DATA TRANSMISSION RATES		
APPLICATION	DATA RATE Mbit/S	CAPACITANCE pF
LinBus	0.20	< 50
RS-232	0.20	
CanBus/Device Net	1.0	<30
T1	1.544	
E2	2.048	
I2C	2.4	
Ethernet	10	
FlexRay	10	
USB 1.1	12	< 20
E3	34.368	
RS-485	35	
T3	44.736	< 5
Fast Ethernet	100	
T5	400.352	< 3
USB 2.0	480	
E5	565.148	
IEEE-1394b	786.432	
GigabitE	1000	

Power supplies are also obviously critical to industrial systems and they can be easily susceptible to various electrical threats. But, power supplies are generally immune to ESD conditions. This is due to the use of passive components such as capacitors and inductors that are

inherently robust. Ferrite beads are commonly used in power supplies to add inductance that limits the impulse amplitudes under fast transients. While this traditional solution often provides adequate protection, it does use passive components that can strain other components. Thus, energy can then be diverted into the system power rail, causing electrical damage into other areas of the system. For this reason, overvoltage protection solutions with a fast response time that divert or shunt the energy to ground should be considered.

In addition, it is important that industrial application designers understand that their solutions are likely to be exposed to external ESD, EFT, surges, lightning or improper wiring during installation. This includes ESD levels per IEC 61000-4-2 and EFT levels per IEC 61000-6-4. Critical systems and integrated circuits (IC) will be exposed to such elements and designers should remember that devices may not be resettable and may be damaged beyond repair.

For surge protection per IEC 61000-4-5, it is critical for the design engineer to understand what installation classification is required for a system. They include:

- Class 0: Well-protected electrical environment, often within a special room.
- Class 1: Partly protected environment.
- Class 2: Electrical environment where the cables are well separated, even at short runs.
- Class 3: Electrical environment where cables run in parallel.
- Class 4: Electrical environment where the interconnections are running as outdoor cables along with power cables and cables used for both electronic and electric circuits.
- Class 5: Electrical environment for electronic equipment connected to telecommunication cables and overhead power lines in a non-densely populated area.

Once the classification is known, the level of protection required can be determined using the IEC 61000-4-5 test levels, as shown in table 1.

No matter the industrial application, ProTek Devices provides a comprehensive family of overvoltage and overcurrent protection devices. They are designed to seamlessly integrate within the various electronics design requirements for today's modern industrial electronics system. They are also designed for quality and cost-effectiveness. They also not only help meet all relevant standards, they provide real-world scenario circuit protection for mission critical industrial systems.

### IEC 61000-4-5 TEST LEVELS

CLASS	AC POWER SUPPLY COUPLING MODE (Note 1)		AC POWER SUPPLY COUPLING MODE (Note 2)		DC POWER SUPPLY COUPLING MODE (Note 3)		UNSYMMETRICAL COUPLING MODE (Note 4, d, f)		SYMMETRICAL COUPLING MODE (Note 4, d, f)		SHIELDED I/O COUPLING MODE (Note 5, f)	
	Line to Line kV	Line to Gnd kV	Line to Line kV	Line to Gnd kV	Line to Line kV	Line to Gnd kV	Line to Line kV	Line to Gnd kV	Line to Line kV	Line to Gnd kV	Line to Line kV	Line to Gnd kV
0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
1	N/A	0.5	N/A	N/A	N/A	N/A	N/A	0.5	N/A	0.5	N/A	N/A
2	0.5	1.0	N/A	N/A	N/A	N/A	0.5	1.0	N/A	1.0	N/A	0.5
3	1.0	2.0	1.0 <sup>e</sup>	2.0 <sup>b,e</sup>	1.0 <sup>e</sup>	2.0 <sup>b,e</sup>	1.0 <sup>c</sup>	2.0 <sup>b,c</sup>	N/A	2.0 <sup>b,c</sup>	N/A	2.0 <sup>c</sup>
4	2.0	4.0 <sup>b</sup>	2.0 <sup>e</sup>	4.0 <sup>b,e</sup>	2.0 <sup>e</sup>	4.0 <sup>b,e</sup>	2.0 <sup>c</sup>	4.0 <sup>b,c</sup>	N/A	2.0 <sup>b,c</sup>	N/A	4.0 <sup>c</sup>
5	a	a	2.0	4.0 <sup>b</sup>	2.0	4.0 <sup>b</sup>	2.0	4.0 <sup>b</sup>	N/A	4.0 <sup>b</sup>	N/A	4.0 <sup>c</sup>

**Notes**

1. AC power supply and AC I/O directly connected to the main network.
2. AC power supply and AC I/O NOT directly connected to the main network.
3. DC power supply and DC I/O.
4. Operated circuits/lines.
5. Communication lines.
  - a. Depends on the class of the local power supply system.
  - b. Normally tested with primary protection.
  - c. The test level may be lowered by one level if the cable length is shorter or equal to ten meters.
  - d. No test is advised at data connections intended for cables shorter than ten meters.
  - e. If protection is specified upstream from the EUT, the test level should correspond to the protection level when the protection is not in place.
  - f. High speed communications lines could be included under unsymmetrical, symmetrical, shielded IO and/or communications lines.

### SELECTION GUIDE

APPLICATION	PREFERRED MULTI-LINE DEVICES	PREFERRED SINGLE-LINE DEVICES	ALTERNATE DEVICES
4-20mA Process Control	420E Series		
AC Power		15KPA, 30KPA, 5.0SMDJ, Kx, PHYTVSxxV3, SM15KPAxx/CAN, SM30KPAxx/CAN, SMAJ, SMBJ, SMCJ, SMDJ	P15KP, P30KP, SM3KW24A, SM5KW, SM10KWE, SM15KWE
Antenna		GBLCxx/C, GBLCxxI/CI, GBLCxxLC	
CAN Bus/DeviceNet	PESD1CAN, PESD2CAN	GBLC24C	ESOT24LCC-2
DC Power/Logic	PSOTxx/C, SMDAxx/C, SMDBxx/C	15KPA, 30KPA, 5.0SMDJ, PHYTVSxxV3, SM15KPAxx/CAN, GBLCxx/C, PSDxx/C, SM30KPAxx/CAN, SMAJ, SMBJ, SMCJ, SMDJ	P15KP, P30KP, SM3KW24A, SM5KW, SM10KWE, SM15KWE
I/O Link	DFN6-36, DFN8-36, PDFN3-32	PDFN2-32, SMBJ	GBLCxx/C, PSDxx/C, PSOTxx/C
LED Protection		5.0SMDJ, SMAJ, SMBJ, SMCJ & SMDJ Series	
LINBus	PESD1CAN, PESD2CAN	PESD1LIN	
LVDS	PAZC099, SRV05-4-A, SRV05-4LC		
Power Over Ethernet	PSR05, SR2.8, SR3.3	SMBJ58A	ESOT24LCC-2, PSOTxx/C Series
ProfiBus	SRV25-4, SRV3.3-4, SRV05-4	GBLC03/05C	PLR3304, SRV05-4M, SRV05-4LC
ProfiNet	PLR0524P, SRV25-4, SRV3.3-4	GBLC03CIHP, GBLC03/05CI	SLVU2.8-4, SRV05-4
RS-232	PSD05C, SMAJ5.0CA	PSOTxx/C	PSDxx/C
RS-422	PSLCxxC, PSM712, SMDB712	PSOTxx/C	422ELC
RS-485	PSLCxxC, PSM712, SMDB712	PSD12, SMBJ12CA	485ELC
Sensors	DFN6-36, PDFN3-32	PDFN2-32	PSOT36
USB 2.0	PLR0502, PLR0502-6, PLR0506	PLR0521, GBLC03/05CI	PLR0504F
VXI Bus	PSRDAxx-4/6		SMDAxxLC/LCC



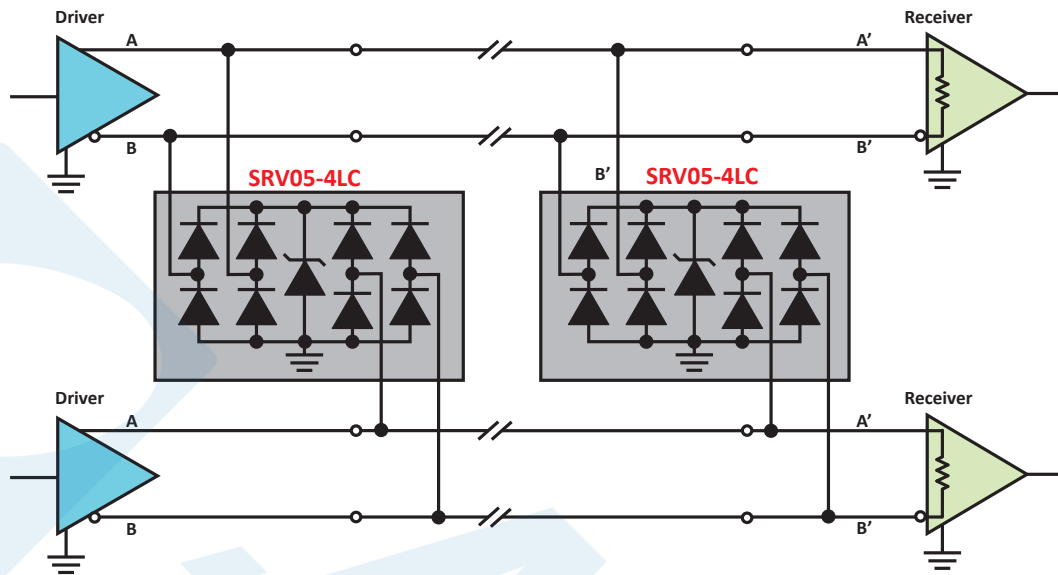


Figure 1. LVDS Protection Using Two SRV05-4LC Devices

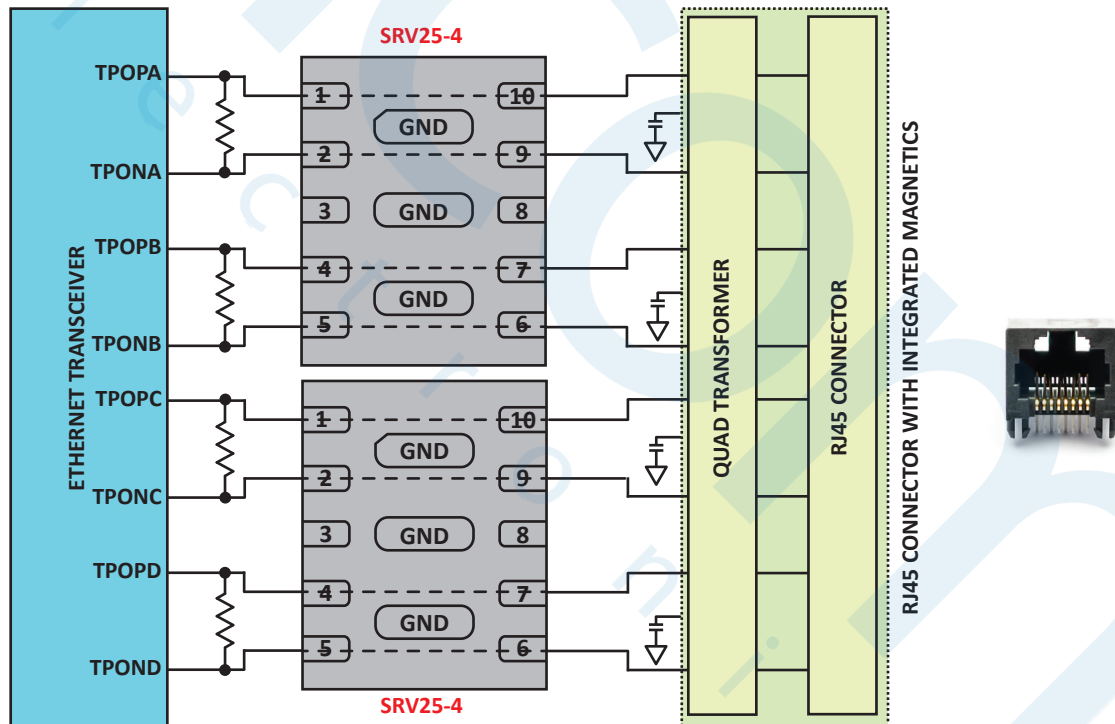


Figure 2. ProfiNet Interface Protection Using Two SRV25-4 Devices

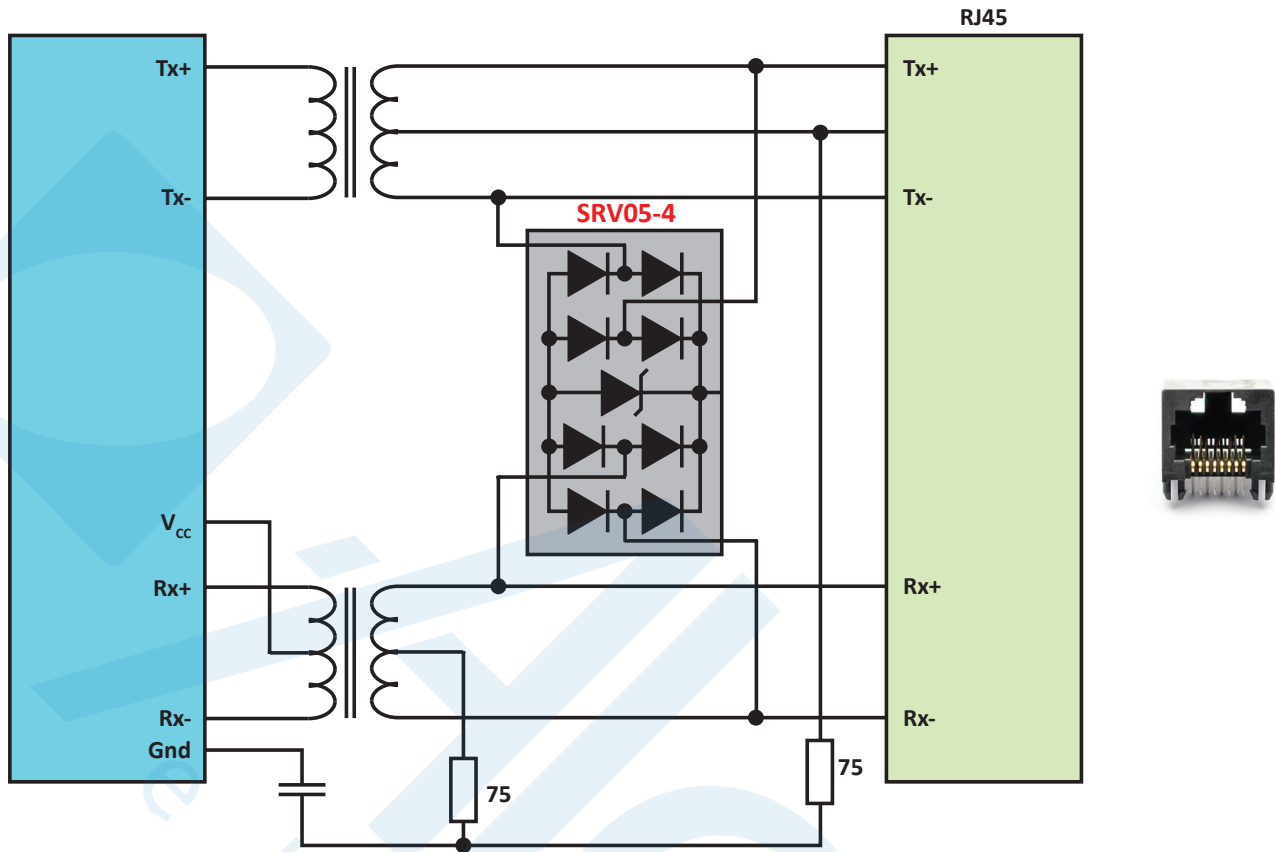


Figure 3. Profibus Protection Using SRV05-4

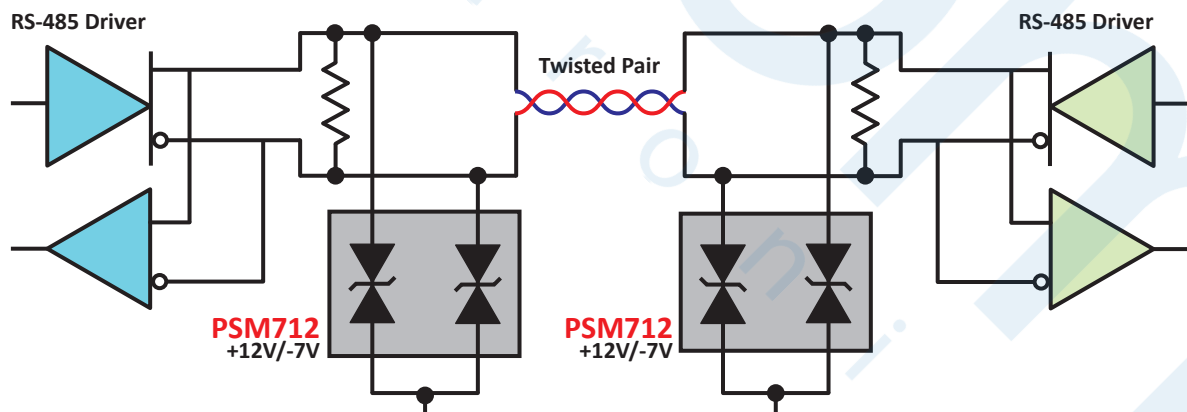


Figure 4. RS-485 Driver Application Using Two PSM712 Devices

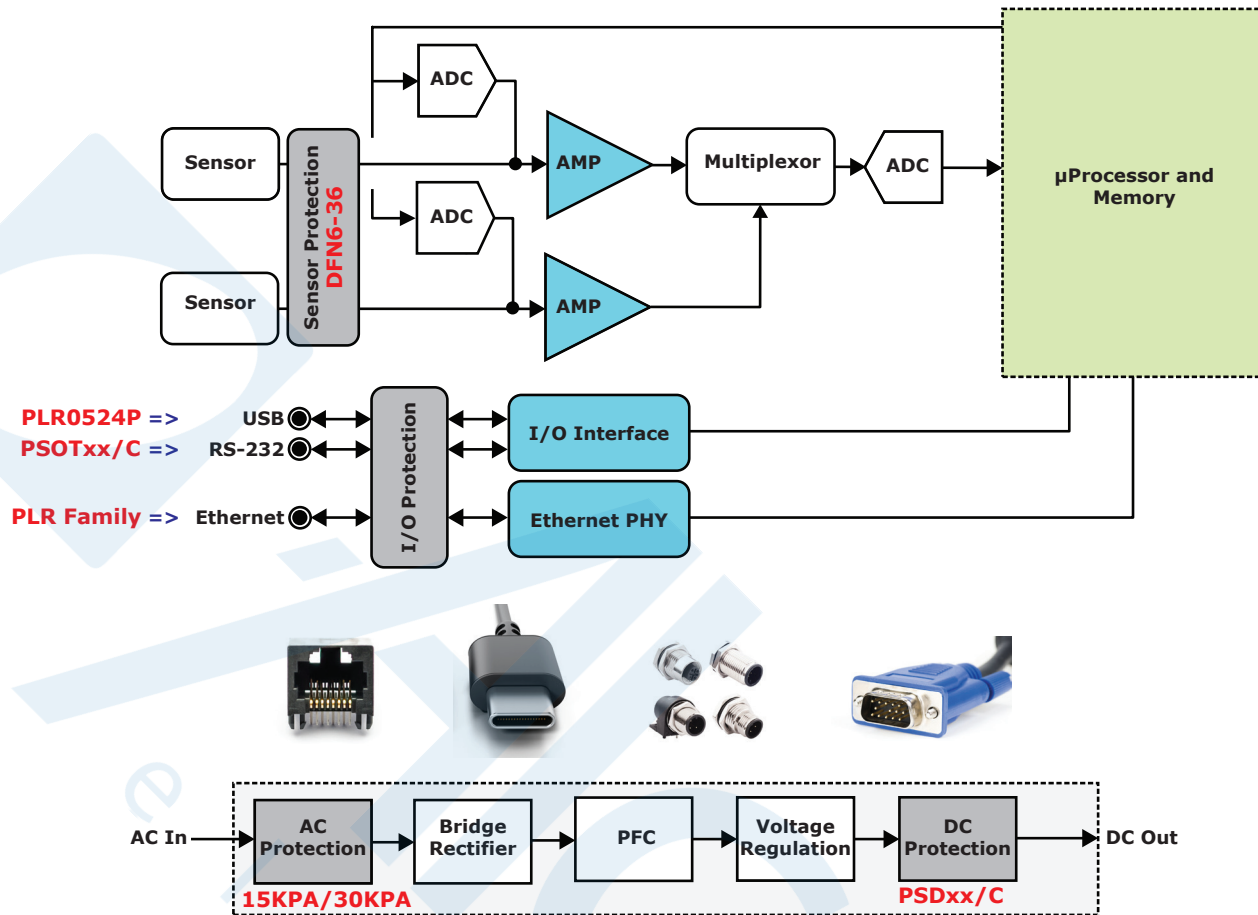


Figure 5. Sensor Block Diagram - Multiple Layers of Protection: Sensor, I/O, AC and DC.

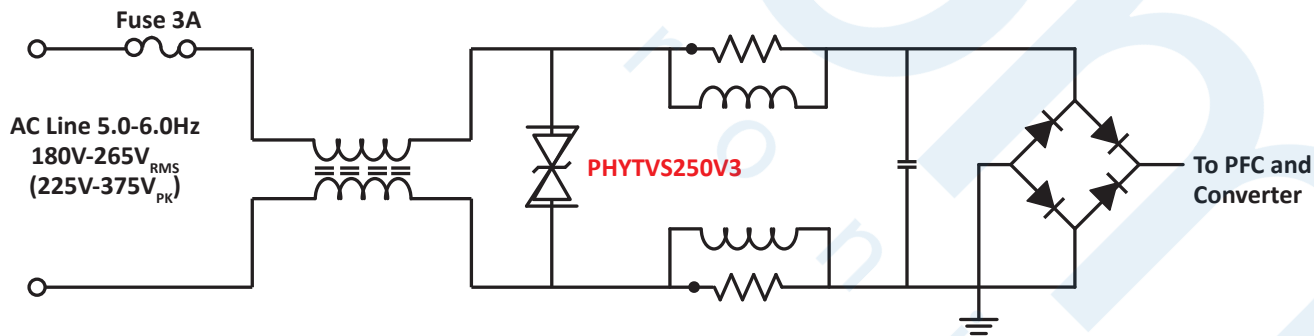


Figure 6. AC/DC Power Supply Protection Using PHYTVS250V3

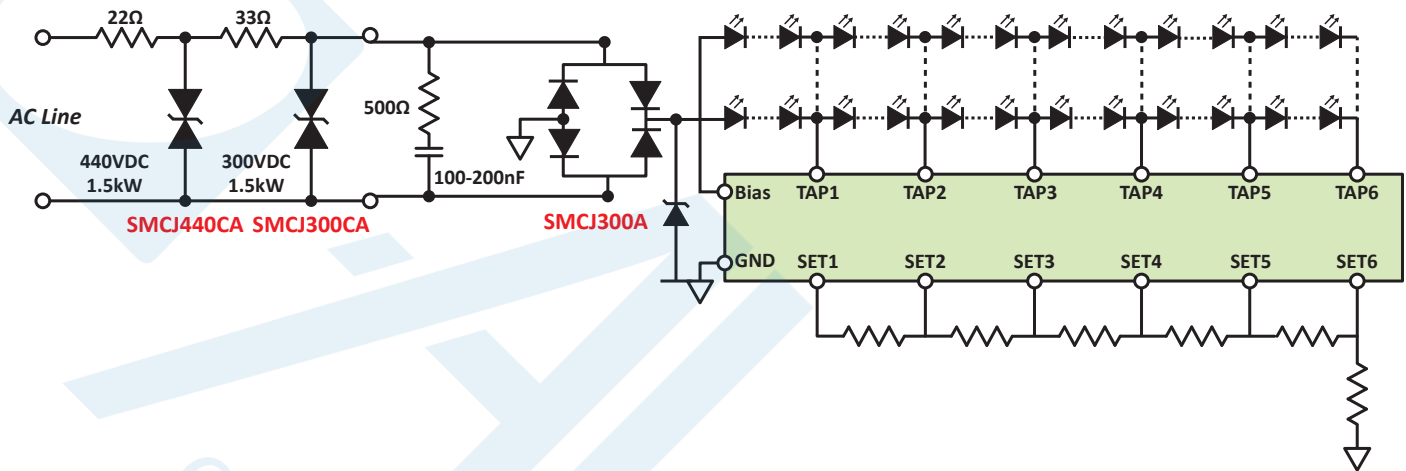


Figure 7. LED Luminaire Protection Using SMCJ300CA, SMCJ300A & SMCJ440CA

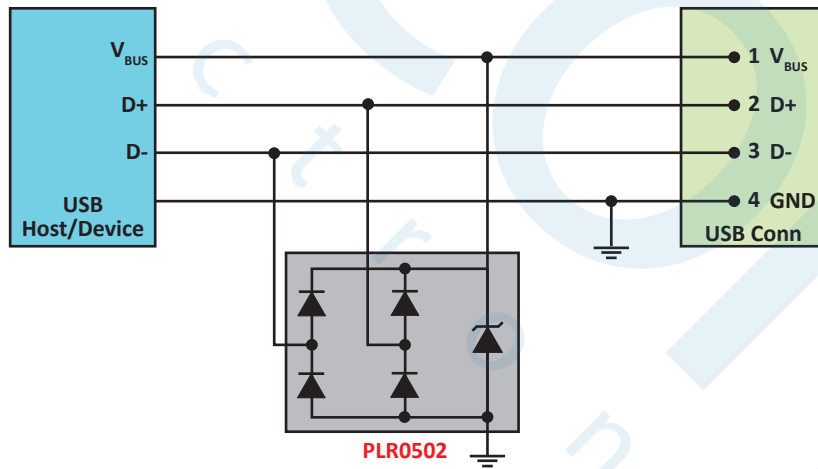


Figure 8. USB 2.0 Port ESD/EFT Protection Using PLR0502

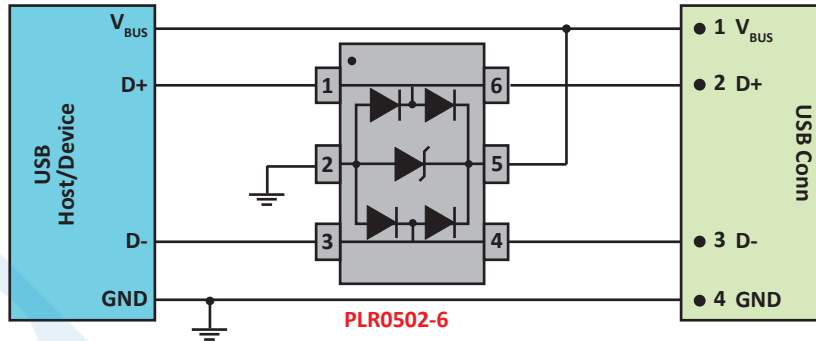


Figure 9. USB 2.0 Port ESD/EFT Protection Using PLR0502-6

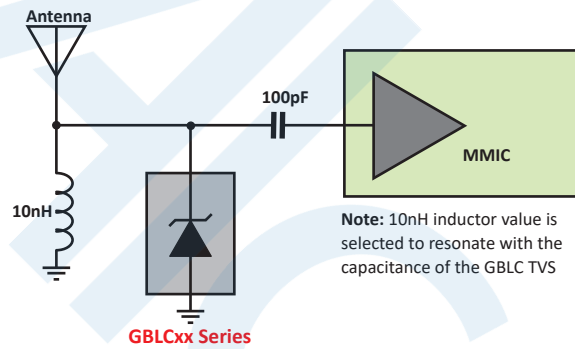


Figure 10. Antenna Protection Using GBLCxx Series

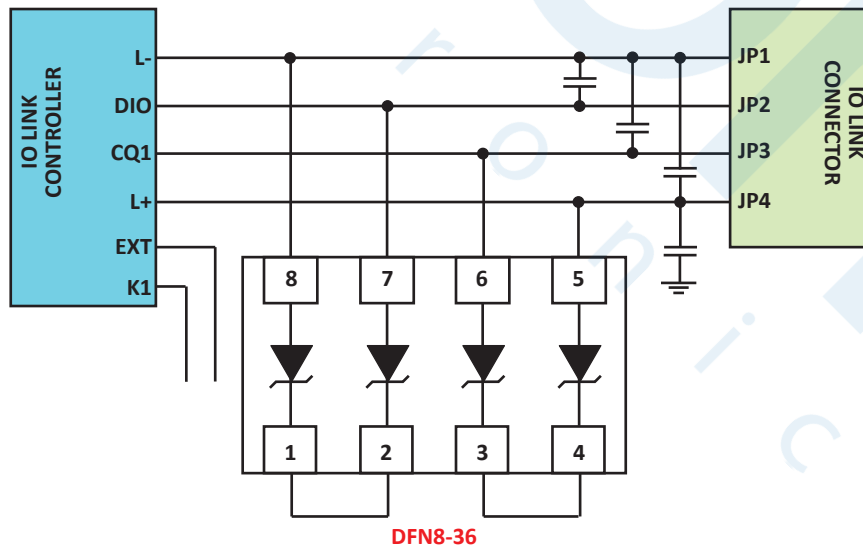


Figure 11. Industrial Automation IO Link Protection Using DFN8-36



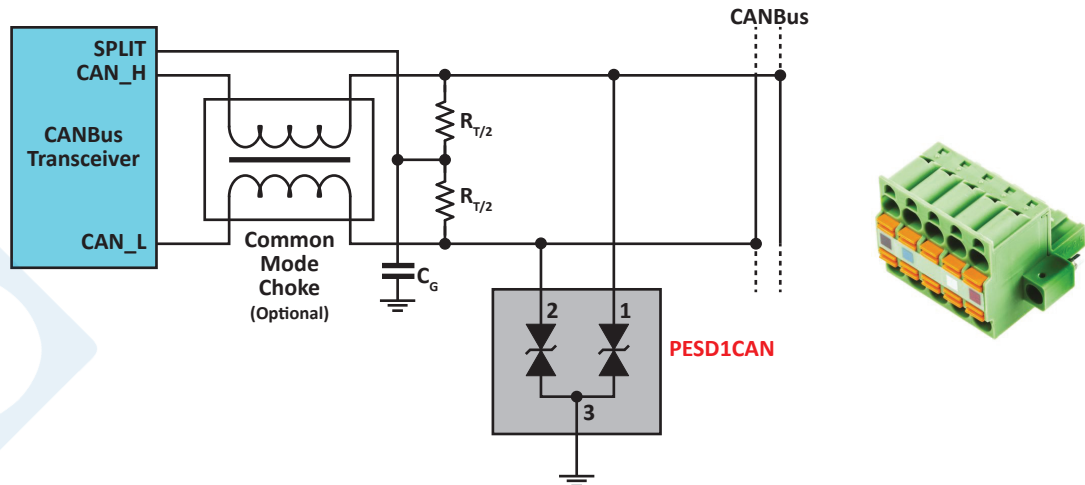


Figure 12. Industrial CANBus/DeviceNet Protection Using PESD1CAN

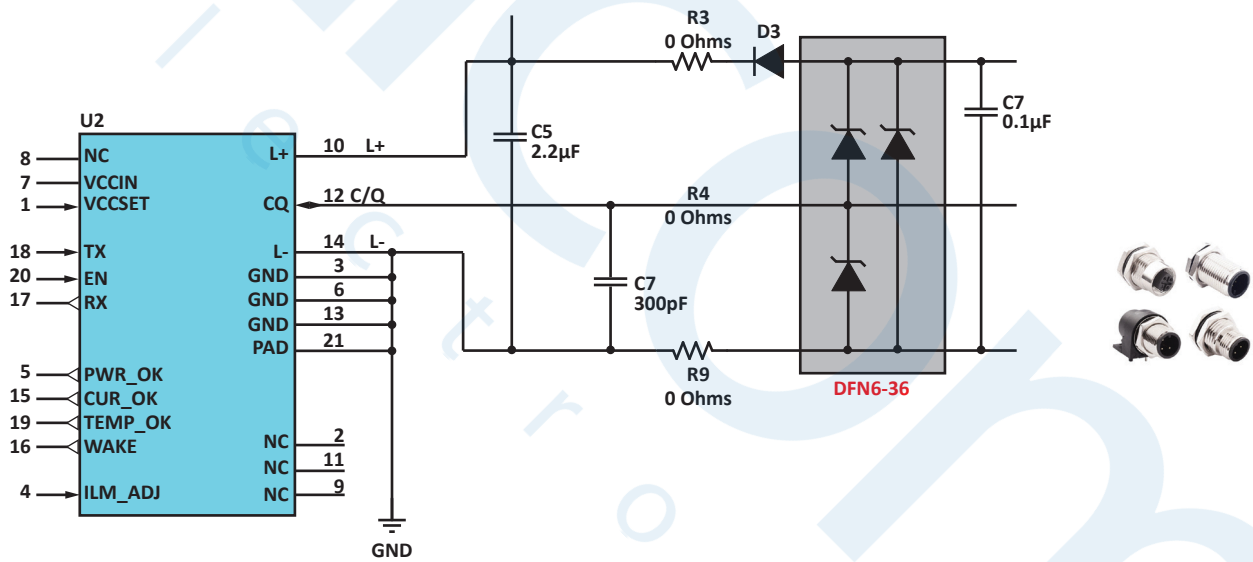


Figure 13. Industrial Automation IO Link Protection Using DFN6-36

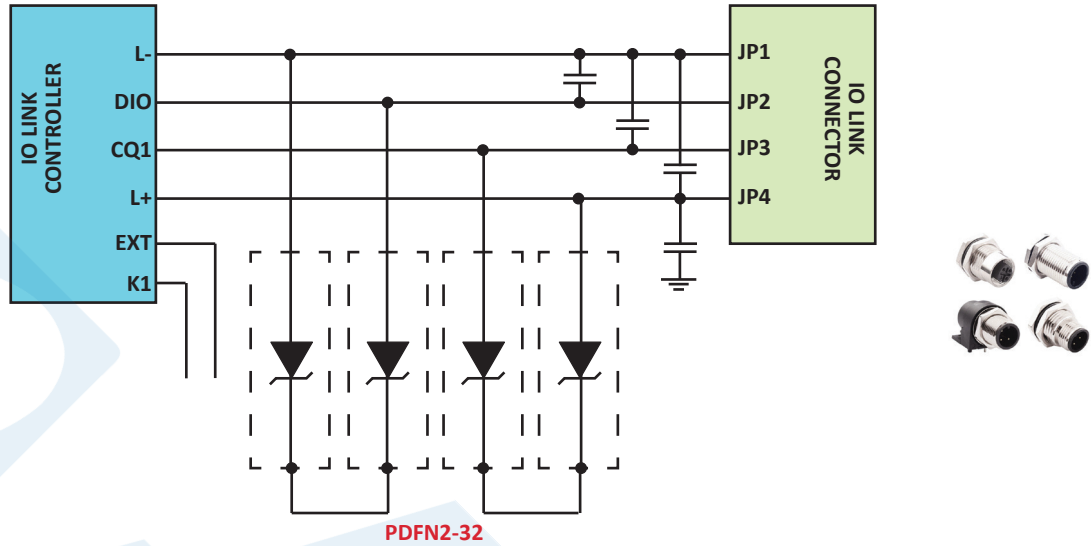


Figure 14. Industrial Sensor Protection Using PDFN2-32

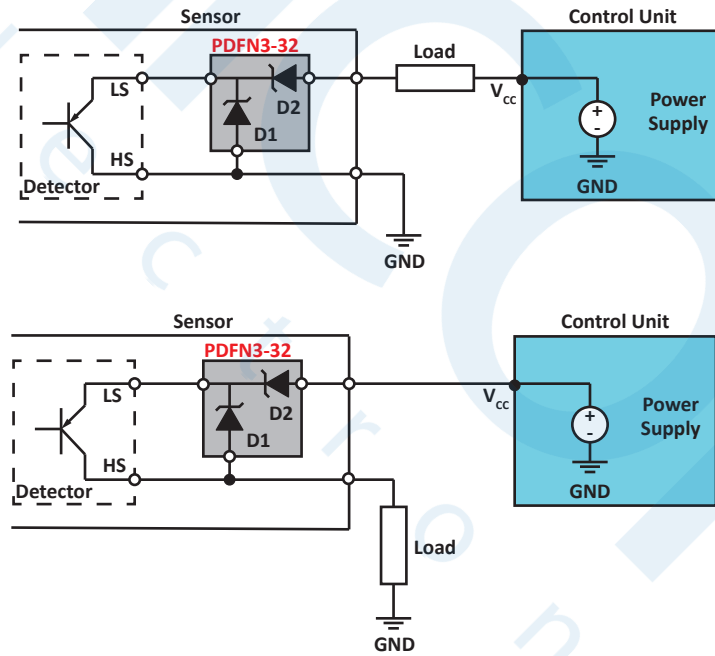


Figure 15. Industrial Sensor Protection Using PDFN3-32

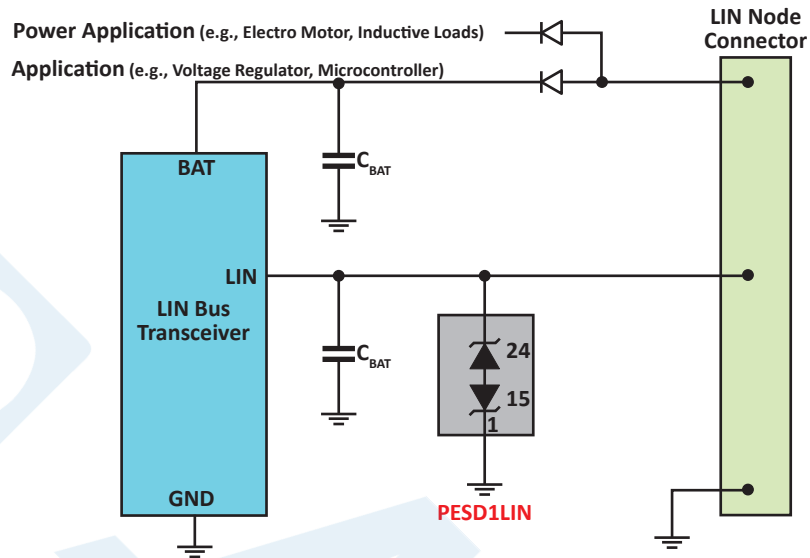


Figure 16. Industrial LinBus Protection Using PESD1LIN

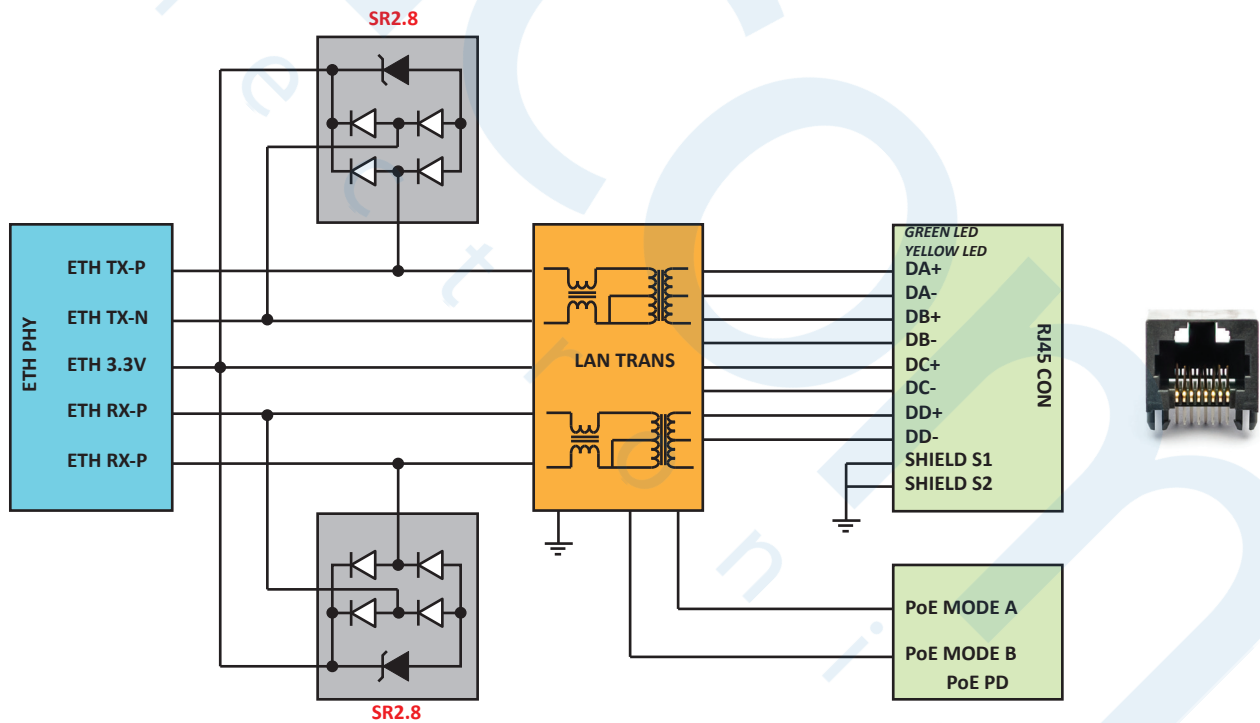


Figure 17. PoE (802.3at) Protection Using SR2.8

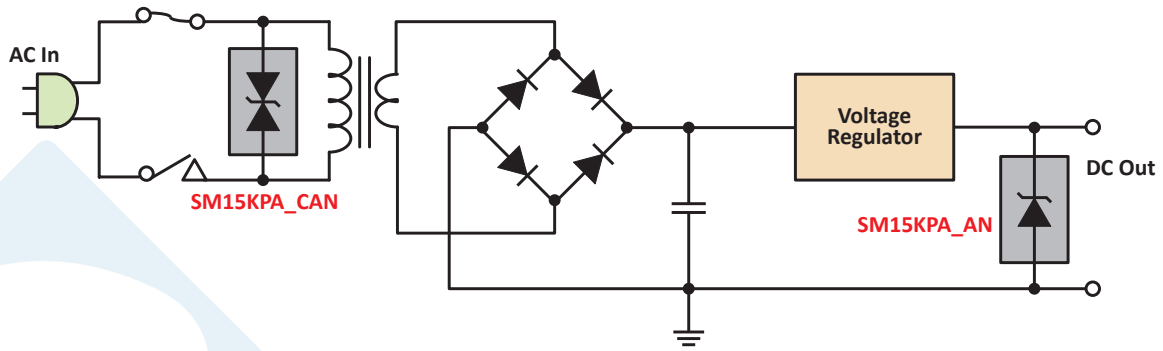


Figure 18. AC/DC Power Supply Protection Using SM15KPAxxAN/CAN

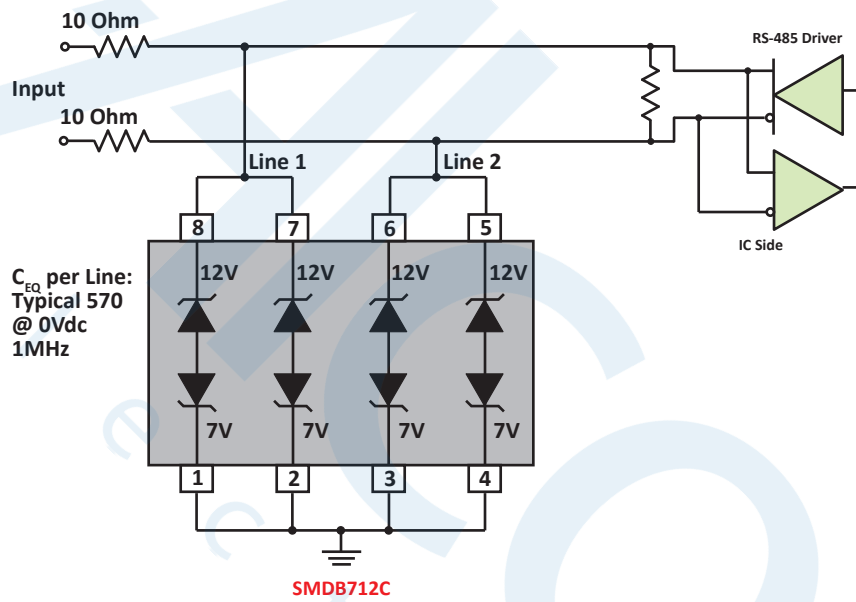


Figure 19. External RS-485 Protection Using SMBD712C

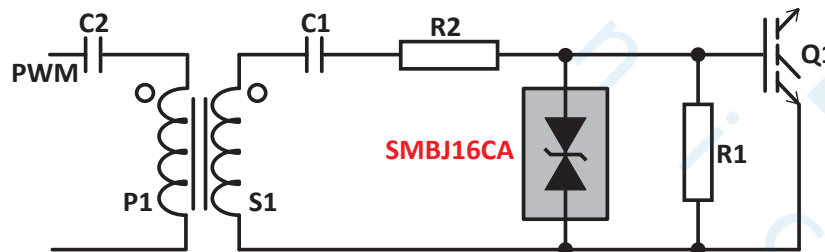


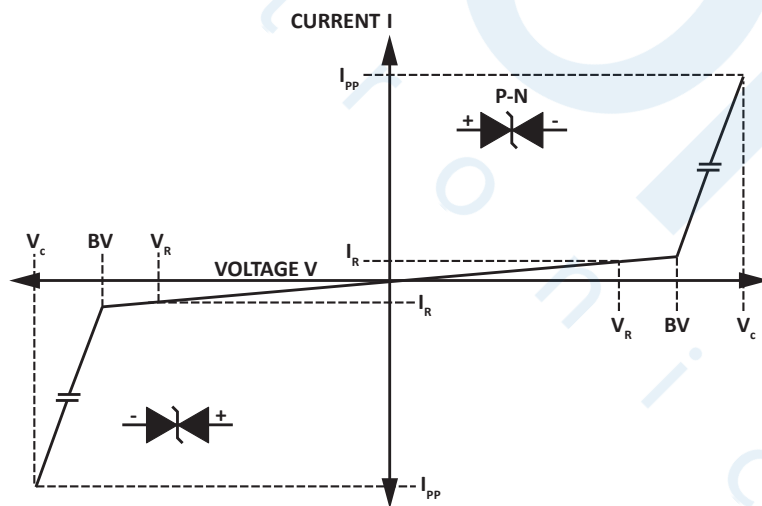
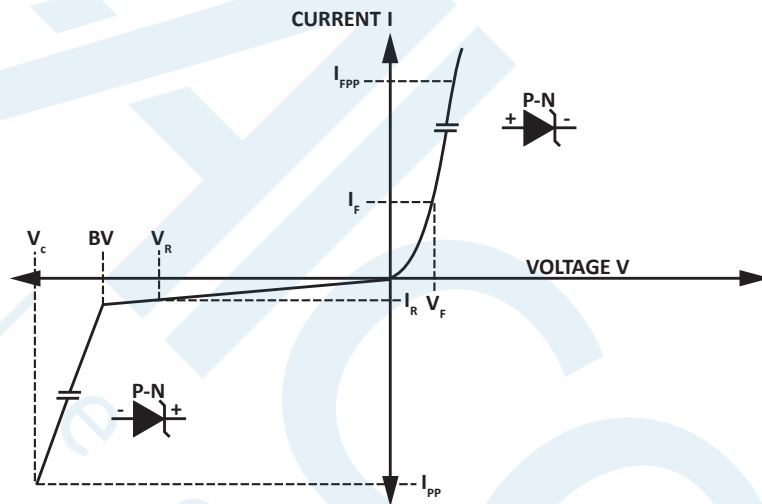
Figure 20. IGBT Gate Protection Using SMBJ16CA

## SELECTION PROCESS

TVS PARAMETERS	APPLICATION PARAMETERS
Stand-Off Voltage ( $V_R$ ) $\geq$	Operating Voltage ( $V_{OP}$ )
Pulse Current ( $I_p$ ) $\geq$	Transient Current ( $I_T$ )
Clamping Voltage ( $V_C$ ) $\leq$	Voltage Withstand Level ( $V_{WS}$ )
Input Capacitance of the Device $\leq$	Acceptable Line Loading for Functional Pass

**Graph Symbols/Parameters**  
 $B_V$  - Breakdown Voltage  
 $I_R$  - Leakage Current  
 $V_R$  - Reverse Stand-Off Voltage  
 $V_C$  - Clamping Voltage  
 $I_{PP}$  - Peak Pulse Current

### Avalanche Junction TVS VI Characteristics





## OVERVOLTAGE PART SPECIFICATIONS

PART NUMBER	STAND-OFF VOLTAGE	BREAKDOWN VOLTAGE	CLAMPING VOLTAGE	PEAK PULSE CURRENT 8/20 $\mu$ s	MAXIMUM LEAKAGE CURRENT	TYPICAL CAPACITANCE	NO. OF LINES	POWER 8/20 $\mu$ s	PACKAGE
	V <sub>WM</sub> VOLTS	V <sub>(BR)</sub> VOLTS	V <sub>C</sub> VOLTS	I <sub>PP</sub> AMPS	I <sub>D</sub> $\mu$ A	C pF		WATTS	
15KPAxxxx	17.0 - 280.0	-	-	-	5000 - 10	-	1	15000*	Axial
30KPAxxxx	30.0 - 360.0	-	-	-	5000 - 2	-	1	30000*	Axial
420E Series	12.0 - 60.0	-	22.0 - 95.0	200.0	5	6000 - 1000	1	-	Module
422ELC	$\pm$ 12.0	-	30.0	500.0	1	25	1	-	Module
485ELC	$\pm$ 7.0	-	20.0	500.0	10	25	1	-	Module
5.0SMDJ Series	6.0 - 440.0	6.67 - 492.0	-	-	2000 - 5	-	1	-	DO-214AB
DFN6-36	33.0	35.0	45.0	2.0	5	50	3	300	DFN-6
DFN8-36	33.0	35.0	45.0	2.0	5	50	3	300	DFN-8
ESOT24LCC-2	24.0	26.6	-	-	1	6	2	100	SOT-23
GBLC03CIHP	3.0	4.0	24.0	20.0	5	0.6	1	500	SOD-323
GBLCxx/C	3.0 - 24.0	-	7.0 - 43.0	1.0	5 - 1	3	1	350	SOD-323
GBLCxx/CI	3.0 - 24.0	-	7.0 - 43.0	1.0	5 - 1	0.6	1	250	SOD-323
GBLCxxLC	3.3 - 5.0	4.0 - 6.0	7.0 - 9.8	1.0	1 - 5	0.8 - 0.7	1	250	SOD-323
P15KPxxxx	17.0 - 280.0	-	-	-	5000 - 10	-	1	15000*	Axial
P30KPxxxx	30.0 - 260.0	-	-	-	5000 - 10	-	1	30000*	Axial
PAZC099	5.0	6.0	12.0	1.0	0.5	0.5	4	100	SOT-23-6
PDFN2-32	32.0	34.0	55.0	25.0	200nA	-	1	-	DFN2020-3
PDFN3-32	32.0	34.0	55.0	25.0	200nA	-	1	-	DFN-3
PESD1CAN	24.0	25.4	70.0	3.0	0.05	11	2	200	SOT-23
PESD1LIN	15.0, 24.0	17.2, 25.5	25.0, 40.0	1.0	0.001	14	1	200	SOD-323
PESD2CAN	24.0	25.4	60.0	4.0	0.05	11	2	230	SOT-23
PHYTVSxxxV3	125 - 277	200 - 410	130 - 250	250	10	80	1	250	DFN-2KW
PLR0502	5.0	6.0	20.0	10.0	1	0.6	2	200	SOT-543
PLR0502-6	5.0	6.0	17.0	3.0	1	0.7	2	50	SC-89
PLR0504F	5.0	6.0	25.0	5.0	3	1.9	4	200	SC70-6L
PLR0506	5.0	6.0	18.0	4.0	3	0.8	6	-	DFN-8
PLR0521	5.0	6.0	20.0	4.0	1	0.4	1	80	DFN-2
PLR0524P	5.0	6.0	9.0	6.0	0.5	0.7	4	-	DFN-10
PLR3304	3.3	3.3	10.0	10.0	1	4	4	400	DFN-10
PSDxx/C	3.3 - 36.0	-	6.5 - 60.0	1.0	125 - 1	500 - 35	1	500	SOD-323
PSLCxx/C	3.3 - 24.0	-	9.0 - 30.0	5.0	125 - 1	3	1	350	SOT-143
PSM712	7.0 - 12.0	-	11.0 - 19.0	1.0	20 - 1	75	1	600	SOT-23
PSOTxx/C	3.3 - 36.0	-	6.5 - 51.0	1.0	125 - 1	500 - 60	1	500	SOT-23
PSRDAxx-4	3.3 - 15.0	-	6.5 - 24.0	1.0	125 - 1	5	4	500	SO-8
SLVU2.8-4	2.8	3.0	21.0	30.0	1	3	2P	600	SO-8
SM15KPAxx/CAN	17.0 - 220.0	18.9 - 245.0	-	-	5000 - 10	-	1	15000*	Module
SM30KPAxx/CAN	30.0 - 75.0	33.3 - 83.3	-	-	5000 - 10	-	1	30000*	Module
SM3KW24A	24.0	26.7	43.0	69.8	3	-	1	3000*	DFN-2

1. \*10/1000 $\mu$ s waveshape.

2. For detail about each voltage level, please refer to the product datasheet.

## OVERVOLTAGE PART SPECIFICATIONS

PART NUMBER	STAND-OFF VOLTAGE $V_{WM}$ VOLTS	BREAKDOWN VOLTAGE $V_{(BR)}$ VOLTS	CLAMPING VOLTAGE $V_C$ VOLTS	PEAK PULSE CURRENT 8/20 $\mu$ s $I_{PP}$ AMPS	MAXIMUM LEAKAGE CURRENT $I_D$ $\mu$ A	TYPICAL CAPACITANCE C pF	NO. OF LINES	POWER 8/20 $\mu$ s WATTS	PACKAGE
SM5KW Series	10.0 - 36.0	11.1 - 40.2	-	-	15 - 8	-	1	5000*	DFN-2
SM10KWE Series	10.0 - 48.0	11.1 - 53.0	17.0 - 77.4	588 - 129	15 - 8	-	1	10000*	DFN-2-KW
SM15KWE Series	24.0 - 70.0	26.7 - 77.8	38.9 - 114.0	384 - 132	15 - 10	-	1	15000*	DFN-2-KW
SMAJ Series	5.0 - 440.0	6.40 - 492.0	-	-	800 - 5	-	1	400*	DO-214AC
SMBJ Series	5.0 - 440.0	6.40 - 492.0	-	-	800 - 5	-	1	600*	DO-214AA
SMCJ Series	5.0 - 440.0	6.40 - 492.0	-	-	1000 - 5	-	1	1500*	DO-214AB
SMDAxx/C Series	3.3 - 36.0	4.0 - 40.0	7.0 - 65.0	5.0	125 - 1	800 - 45	4	500	SO-8
SMDAxxLC/LCC	3.3 - 24.0	-	7.0 - 43.0	1.0	125 - 1	15	4	500	SO-8
SMDBxx/C Series	5.0 - 24.0	6.0 - 26.7	24.6 - 48.5	45.0 - 20	25 - 2	880 - 155	4	800	SO-8
SMDB712C	7.0, 12.0	8.5, 13.3	25.5, 32.9	40.0, 34.0	10, 2	284	4	1600	SO-8
SMDJ Series	5.0 - 440.0	6.40 - 492.0	-	-	5000 - 2	-	1	3000*	DO-214AB
SRV05-4	5.0	6.0	15.0	5.0	5	2.5	4	500	SOT-23-6
SRV05-4-A	5.0	6.0	17.5	5.0	1	3	4	250	SOT-23-6
SRV05-4LC	5.0	6.0	15.0	5.0	5	1.0	4	500	SOT-23-6
SRV05-4M	5.0	6.0	14.0	5.0	5	4.5	4	400	SOT-23-6
SRV25-4	2.5	3.0	7.4	10.0	0.5	1.7	4	800	DFN-10
SRV3.3-4	3.3	3.9	6.5	1.0	0.5	3.4	4	800	DFN-10

1. \*10/1000 $\mu$ s waveshape.

2. For detail about each voltage level, please refer to the product datasheet.