BOURNS®

How to Select the Right Signal and Data Surge Protective Device

APPLICATION NOTE

Introduction

Signal, data, and control lines are key elements in today's electronic systems that enable communication between sensors, controllers, and networked equipment. These low-voltage interfaces, however, are highly susceptible to transient overvoltage events originating from lightning, inductive switching, electrostatic discharge (ESD), or system-level disturbances.

An excessive surge applied to an unprotected communication line can cause data corruption, downtime, equipment degradation, or even complete system failure. A recommended safeguard is to employ signal and data line Surge Protective Devices (SPDs) designed to limit these overvoltage threats to safe levels, maintaining system reliability and protecting sensitive electronics.

This application note provides the key advantages of designing in signal and data line SPDs. It outlines the key parameters engineers should use to properly select the optimum SPD to protect signal, data, and control circuits.

Benefits of Signal and Data Line SPDs

Equipment Protection - SPDs reduce harmful transient voltages to prevent damage to communication interfaces, processors, and sensitive semiconductor components.

Signal Integrity - Appropriate SPD selection minimizes insertion loss and ensures communication protocols (analog or digital) maintain stability and accuracy.

Safety Assurance - By limiting transient energy, SPDs help reduce the risk of equipment overheating, insulation failure, and electrical fires—supporting safe, long-term system operation.

Key Selection Parameters for Signal/Data SPDs

Selecting the proper SPD requires careful evaluation of five essential parameters:

Voltage Compatibility

The SPD's Maximum Continuous Operating Voltage (MCOV / V_{RWM}) must exceed the normal operating voltage of the signal or data line.

Examples:

- TN-S: Separate PE and N conductors
- TN-C: Combined PE and N (PEN)
- TN-C-S: Combination of both—PEN upstream, separated downstream

SPD Bandwidth

The SPD must support the required frequency or data rate without inducing unacceptable attenuation or distortion.

Guidelines:

- Low-speed analog signals (4–20 mA) modest bandwidth acceptable
- Digital fieldbus systems moderate bandwidth needed
- High-speed data (Ethernet, RF, telecom) high-bandwidth, low-capacitance SPD required

Clamping Voltage (VPR)

The VPR defines the voltage at which the SPD begins to conduct heavily during a surge.

General rules:

- VPR < equipment's maximum allowable surge voltage
- Lower VPR provides better protection
- Must still ensure no false triggers under normal operation
- For data lines, excessive VPR may allow harmful spikes to pass upstream to the IC or transceiver

Line Current Capability

The SPD must support the maximum steady-state current that normally flows through the communication line.

Examples:

- Current loops (4–20 mA): require higher continuous-current support capabilities
- Sensor lines or digital logic: generally have very low continuous current
- Industrial I/O lines: may require a SPD that can support mA to tens of mA

Insufficient current capability can result in overheating or device degradation.

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Key Selection Parameters for Signal/Data SPDs (Continued)

Surge Rating (I_n and I_{max})
The appropriate surge rating depends on the installation environment and exposure:

Location	Typical Surge Exposure	Recommended SPD Rating
Indoor equipment	Low	Lower I_n/I_{max} acceptable
Industrial control cabinets	Moderate	Medium surge rating (e.g., 5–10 kA)
Outdoor sensors / long cables	High	High surge rating with GDT or hybrid SPD
Telecom/data	Variable	Match interface requirements

I_{max} defines the maximum single-shot surge current capacity.
I_n defines the nominal discharge current for repetitive surges.

SPD Technology
Advanced suppliers of signal line SPDs also provide other overvoltage protection technology products such as Gas Discharge Tubes (GDTs), Metal Oxide Varistors (MOVs), or Transient Voltage Suppressor (TVS) Diodes. Bourns also combines these technologies in a hybrid design. Since signal lines often require robust, fast, and low-capacitance solutions, new signal line SPDs that feature high surge robustness (via GDTs) with fast clamping (via TVS Diodes) offer a superior solution.

- GDTs provide very high surge current protection with extremely low capacitance, making them ideal for certain harsh environments and long signal lines.
- TVS Diodes react extremely fast and clamp to low voltages, making them best for protecting sensitive ICs and high-speed data lines.
- MOVs offer moderate surge protection at low cost but have higher capacitance, making them suitable mainly for low-frequency or control signals.
- Hybrid SPDs combine fast low-clamping protection with high-energy handling, delivering the most balanced and robust solution for demanding signal and data applications.

SPD Solution Examples

An excellent SPD series for data and signal line protection is the Bourns® 2510 Series. It offers the following features and benefits:

- High surge current capability
- UL listed data line protector per UL 497B standard
- Suitable for industrial control, long cable runs, and certain harsh environments
- Two-stage protection circuit limits the transients associated with Gas Discharge Tubes and Diodes
- Pluggable surge protection for DIN-Rail mounting

Recommended Process for SPD Selection

1. Identify the communication standard (e.g., RS-485, CAN, analog 4–20 mA, Ethernet)
2. Determine the operating voltage of the line
3. Check required data rate or bandwidth to avoid attenuation
4. Determine equipment clamping requirements based on IC ratings
5. Verify current-carrying needs of the signal line
6. Select appropriate I_n / I_{max} surge rating based on installation environment
7. Choose SPD technology (GDT, TVS, MOV, hybrid)

Conclusion

Selecting the proper SPD for signal and data line protection helps ensure long-term system stability, equipment longevity, and operational safety. By evaluating voltage compatibility, bandwidth, clamping voltage, line current, and surge rating, engineers are able to determine the most suitable SPD technology for their application.

Bourns has developed a comprehensive range of high-performance SPD signal protection solutions. Following this guideline helps designers meet stringent industrial, telecommunications, and communications protection requirements.