BOURNS®

Optimized Surge Protection for Exposed DC Power Supplies

APPLICATION NOTE

Introduction

Remote Radio Units (RRUs) and small cell radios are common pieces of outdoor communication equipment, which are often deployed on towers, poles, and rooftops. These devices typically use a -48 V DC power supply via extended copper wiring. Unfortunately, exposed DC power supplies are particularly vulnerable to lightning-induced (both direct and indirect) overvoltage and other harmful transient surges. In particular, these surges pose a significant threat to their integrated sensitive electronics, making implementing robust overvoltage protection an essential requirement to prevent damage and minimize expensive disruptions.

This application note provides an optimized surge protection solution for exposed DC power supplies. The paper addresses the critical vulnerability of these systems to lightning-induced surges, which can lead to costly downtime and damage to sensitive electronics. It also presents practical insights into meeting stringent industry standards, such as IEC 61643-11, which now includes the more demanding 10/350 µs waveform testing. Moreover, it offers a detailed, multilayered protection scheme using stacked Gas Discharge Tubes (GDTs), inductors, and Power Transient Voltage Suppressor (PTVS) diodes, along with a helpful evaluation board for testing and customization. This information allows engineers to design robust protection circuits, select appropriate components, and ultimately enhance the resilience of their DC power supply systems in certain harsh outdoor environments.

Safety Standards Requirements

Communication system providers are required to adhere to various national and international standards (see Table 1). These standards define what level of protection or testing is needed to help safeguard equipment against transient events, including lightning. While external Surge Protective Devices (SPDs) are commonly employed, additional integrated protection is also highly recommended.

The most prevalent surge requirement for DC power supply inputs is the 8/20 µs waveform, that typically supports peak currents of 10 kA to 20 kA. Increasingly, communication equipment manufacturers are incorporating a 10/350 µs surge waveform requirement, with peak currents of 1 kA to 4 kA. The IEC 61643-11 standard introduced the 10/350 µs waveform to test SPDs, recognizing it as a more accurate representation of direct lightning strike surges. Consequently, some communication equipment manufacturers are now adopting the 10/350 µs waveform test for their equipment's DC power supply inputs.

Table 1. | Related DC Power Supply Standards

Document	Title	Notes
GR-1089-CORE	Electromagnetic Compatibility (EMC) and Electrical Safety - Generic Criteria for Network Telecommunications Equipment	Issue 7, December 2017, Port Type 8a
IEC 61000-4-5	Electromagnetic compatibility (EMC) - Testing and measurement techniques - Surge immunity test	Edition 3.0
IEC 62368-1	Audio/Video, information and communication technology equipment – Part 1: Safety requirements	IEC 60950 was replaced with IEC 62368-1
ETSI 300-132-2	Environmental Engineering (EE); Power supply interface at the input to telecommunications and datacom (ICT) equipment; Part 2: Operated by -48 V Direct Current (DC)	
UL 1449	Standard for Safety for Surge Protective Devices (SPDs): This standard focuses on the safety and performance requirements for devices that protect electrical systems from surge voltages.	5th Edition

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A Coordinated Multilayered Protection Scheme

Figure 1 depicts a robust protection circuit Bourns engineers have specifically tailored for exposed DC power supply applications. This design utilizes a stacked GDT, a series inductor, and a PTVS diode, or a functionally equivalent clamping device. Component selection is based on the ability to withstand a specified range of 8/20 µs and 10/350 µs surge waveforms.

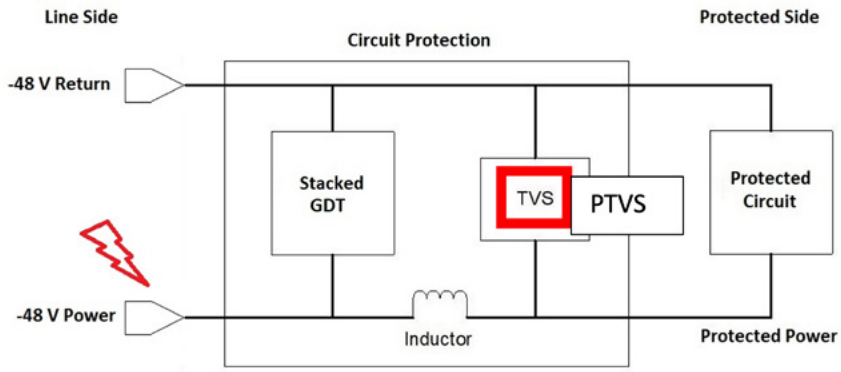

Figure 1. | *Protection Scheme Circuit Diagram*

This approach uses a stacked GDT, which is a single component comprising multiple GDTs connected in series, as symbolized in Figure 2. The configuration of capacitors C1 through C4 ensures the impulse sparkover voltage of the stack remains only slightly higher than that of a single GDT, a principle detailed in Recommendation ITU-T K.99. The inductor, an air-core type with low permeability, is designed to handle high surge currents without saturation. During a significant surge, this inductor acts as a coordinating element between the secondary overvoltage protection (e.g., PTVS diode) and the stacked GDT.

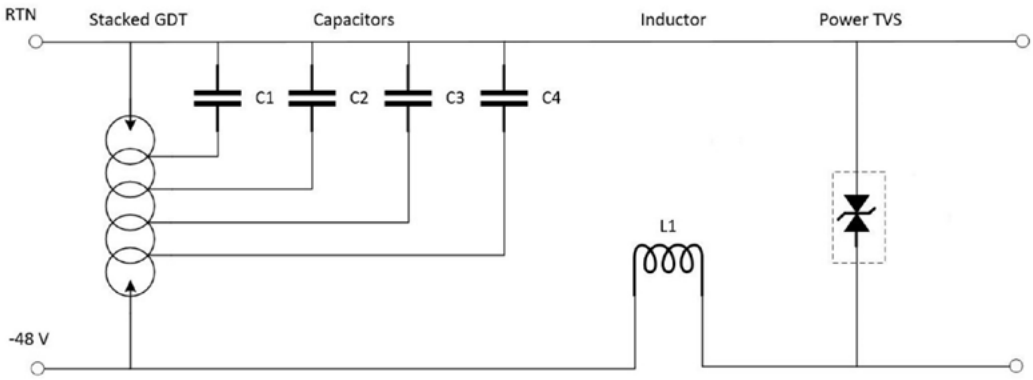

Figure 2. | *Protection Design Schematic*

The protection circuit shown in Figure 2 limits the voltage applied to the protected circuit. When a fast-rising surge occurs at the -48 V power supply input, the PTVS diode initially clamps the voltage. The rapid change in current through the inductor generates a voltage, raising the voltage across the stacked GDTs to their impulse sparkover level. Consequently, the stacked GDTs and the PTVS diode work together to limit the residual voltage and divert the surge current, protecting downstream circuitry.

The stacked GDT offers a significant advantage over a single GDT. After sparking over, a single GDT pulls the supply voltage down to its arc voltage. If the supply continues to provide current, the single GDT may fail to extinguish and remain in an arc or glow state, which can potentially cause damage. Conversely, when a stacked GDT sparks over, the voltage across the stack is the sum of the individual GDT arc voltages. This higher stacked voltage approaches or exceeds the supply voltage, facilitating the stacked GDT to completely extinguish once the surge has subsided.

Helpful Evaluation Board

Appropriate for this scenario and others, Bourns has created a compact evaluation board designed for testing various surge protection solutions. This board, shown in Figure 3, allows for the population of different component types and values, enabling customization for specific requirements.

Test points are integrated to facilitate easy connection of voltage and current probes for detailed evaluation. The board accommodates stacked GDTs with 800 V and 1400 V DC sparkover voltages, as well as a wide range of PTVS diodes with varying clamping voltages and surge current ratings. A sample Bill-of-Materials (BOM) is provided in Table 2.

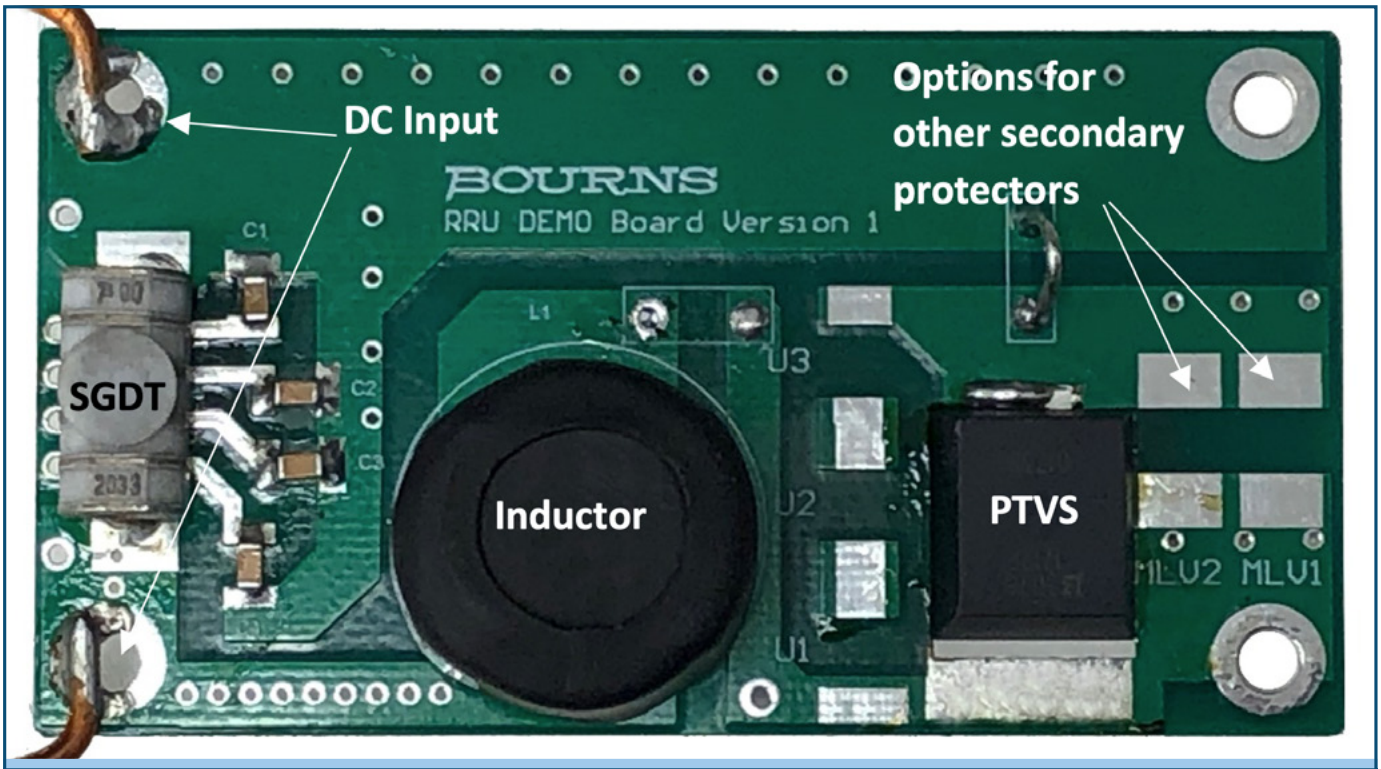

Figure 3. | *Bourns DC Power Supply Surge Protection Evaluation Board*

Table 2. | *DC Power Supply Protection Design Bill-of-Materials Example*

Quantity	Vendor	Part Number	Description
1	Bourns	2033-80-G5-LF	Stacked GDT, 800 V
2	AVX	1206GC101KAT1A	Capacitors, 100 pF, 2 kV
3	Bourns	Custom Inductor	4.7 - 10 µH air-core inductor
4	Bourns	PTVS6-076C-M	Power TVS Diode, 76 V

Additional protection solution options:

- Bourns® Model 2033-140-G5-LF, Stacked GDT, 1400 V
- Bourns® PTVS Diodes (wide range of voltage and current ratings)
- Bourns® Model 5.0SMDJ70A, 5,000 W TVS Diode, SMDJ, V_{wm} =70 V (wide range of voltage ratings)

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Summary

To provide the most effective protection for -48 V DC power inputs in exposed communication equipment, a resilient circuit protection scheme has been engineered. Leveraging Bourns' expertise in communication applications, and using its comprehensive range of discrete circuit protection components, this design effectively addresses elevated surge protection levels.

The coordinated and effective solution Bourns presents in this application note specifically meets the diverse protection requirements found in modern communication systems. To learn more about Bourns' advanced solutions in its reliable line of circuit protection and power conversion components, see the helpful links below.

References and Links

- ITU-T Recommendation K.99: http://www.itu.int/rec/T-REC-K.99/en
- IEC 61000-4-5: http://webstore.iec.ch/publication/61166
- GR-1089 CORE: http://telecom-info.telcordia.com/site-cgi/ido/docs.cgi?ID=SEARCH&DOCUMENT=GR-1089&
- Bourns® Power TVS Diodes: http://www.bourns.com/products/diodes/power-tvs-diodes
- Bourns® TVS Diodes: http://www.bourns.com/products/diodes/tvs-diodes
- Bourns® Stacked GDTs: https://www.bourns.com/products/circuit-protection/gas-discharge-tube-(gdt)-surge-arrestors/stacked
- Bourns® Series Inductors: available upon request
- Protection Evaluation Board – available upon request