Raycap

Phase GDT Technology

An innovative approach to Class I voltage-switching Surge Protective Devices

From the company that invented the revolutionary metal oxide varistor-based Strikesorb® technology comes a new innovative spark gap-based technology that will disrupt the surge protection market once again.

Raycap's new ProTec T1S Series of Surge Protective Devices (SPD) is based on Phase Gas Discharge Tube (PGDT) technology developed over several years. This premium voltage-switching technology enables the SPDs to be half the width of a standard 25kA Class I DIN Rail SPD without compromising performance. The innovative design is based on multi-cell, encapsulated spark gap technology that provides inherently greater safety by significantly reducing the follow-current conducted from the power supply each time the device is triggered into conduction by an overvoltage or surge event. By limiting the large follow-current typical of conventional gap technologies, the expected lifetime of the SPDs can be prolonged and nuisance tripping of upstream overcurrent protection devices minimized.

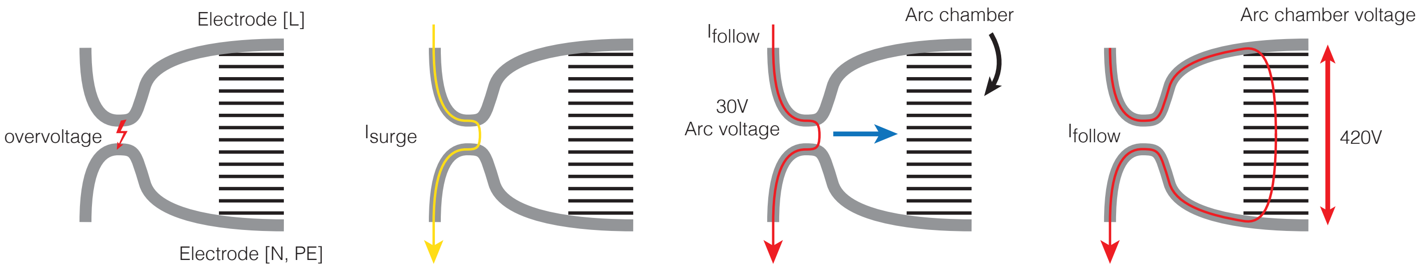
Voltage-switching SPDs

Voltage-switching SPDs are designed to trigger into a conductive state once an overvoltage (surge) exceeds the threshold needed to bridge an internal airgap. They achieve a high surge withstand in a compact package; however, they commonly suffer from poor voltage protection levels and have difficulty extinguishing follow-current. Several different technologies are typically used in the design of switching type SPDs, for example: air spark gaps, triggered spark gaps, multi-cell air spark gaps, and open-expulsion spark gaps, to name just a few. Of these different technologies, the triggered spark gap has probably gained the greatest market acceptance due to its ability to reduce the residual let-through voltage to levels comparable to that of voltage-limiting SPDs using a Metal Oxide Varistor (MOV).

This said, the encapsulated triggered spark gap still suffers from an inability to extinguish high follow-currents, particularly when the triggering surge is small and insufficient to propagate the arc into the device's extinguishing chamber quickly enough.

SPD's relying on voltage-switching technology can be made compact while at the same time having a high surge withstand capability, but these benefits usually come at the expense of poor follow-current control which may significantly limit the performance and safe operation of the SPD.

Follow-current control is the SPD's ability to switch itself out of conduction once the overvoltage condition has passed. The figures below illustrate how follow-current forms after the initiating surge and the means used to extinguish it.



An overvoltage (surge transient) causes air break down across the narrow gap and current begins to flow.

The surge current starts to flow accompanied by follow-current from the utility network.

Typically, the voltage needed to maintain the arc is about 30V. The shape of the electrodes affects the extinguishing of the follow-current. The arc (follow-current) is pushed in the direction of the extinguishing chamber. The function of the arc chamber is to raise the arc voltage above the system voltage (420V).

When the arc chamber voltage exceeds that of the system voltage, the follow-current is extinguished.

Figure 1: Operation of conventional voltage-switching technology.

The magnitude of follow-current conducted through the SPD depends on several parameters:

- The available prospective current of the power source
- The surge voltage required to trigger the gap into conduction
- The phase angle of the voltage at which triggering occurs
- Ageing of the SPD (from exposure to multiple surges of high energy or excessive follow-current conduction)

Poor follow-current control within the SPD design may result in:

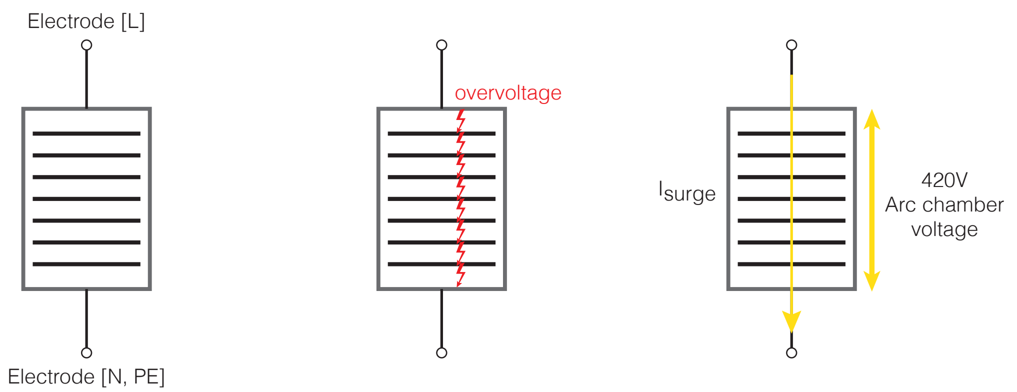
- Nuisance tripping of the backup fuse required to protect the SPD
- A reduced operation lifetime of the SPD
- Increases in the voltage protection level (greater residual voltage reaching the equipment being protected)

Depending on the SPD design, such follow-current can also result in catastrophic failure of the SPD.

Operating principles

Raycap's Phase GDT technology is a premium voltage-switching SPD for use in applications where such a specific technology is required. It has been developed to create an ideal Class I SPD – where a compact package is possible using voltage-switching technology, but without the drawbacks of a high residual voltage or poor follow-current control.

Phase GDT voltage-switching technology uses a breakthrough multi-cell, encapsulated GDT technology that is capable of controlling the follow-current conduction, as depicted in figure 2.



Phase GDT voltage-switching technology has a series connection of several gaps which are located inside the GDTs housing.

In the event of an overvoltage (transient, switching), an avalanche breakdown occurs between the opposing electrodes and Phase GDT starts to conduct.

The surge current starts to flow and the overall arc voltage between the end electrodes of the Phase GDT is sufficiently high, for example 420V, and prevents any follow-current conduction during the surge event.

After the surge event, there is no significant follow-current through the device.

Figure 2: Operation of Phase GDT voltage-switching technology.

As we have seen in Figure 1, in order for the follow-current to be extinguished, the voltage across the device needs to be above the peak of the system voltage. In Phase GDT voltage-switching technology this is achieved by developing this required voltage (approximately 420V) during the surge event, and therefore preventing any follow-current conduction during and after the event. This is different from conventional voltage switching technologies where the voltage is developed after the surge event and the SPD has already started to conduct high follow-current from the power source.

In addition to successfully addressing the inherent follow-current problems characteristic of voltage-switching SPDs, Phase GDT technology also achieves a low residual voltage, which is the result of its sophisticated internal triggering mechanism.

Phase GDT technology also eliminates any surge current flow towards the downstream equipment or Class II protection that might exist in the installation. This is because the remaining voltage during the surge event is comparable to the system network voltage, so no overcurrent condition is generated.

The above operating features allow the designer to ensure coordination, without regard to separation distance with the equipment, or any secondary Class II SPD that might exist downstream of the installation.

A benefit of Raycap's ProTec T1S Series featuring voltage-switching PGDT technology is that it provides a surge rating of Iimp 25kA 10/350 in a 1TE DIN footprint, which is half the size of the market competition. With no follow-current conduction issues to worry about, the Protec T1S Series products can be installed on networks with a prospective short circuit current at the point of installation up to the short circuit current rating of the Phase GDT, which is 50kArms.

Comparative test results and lifetime expectancy

In Figure 3 and Table 1 we compare the follow-current conduction of a number of different voltage-switching technologies. From this it is clear that the follow-current of Phase GDT technology is significantly lower than that of conventional voltage-switching devices, and below the point where it can damage or age its internal components.

Follow-current and voltage on various voltage-switching technologies

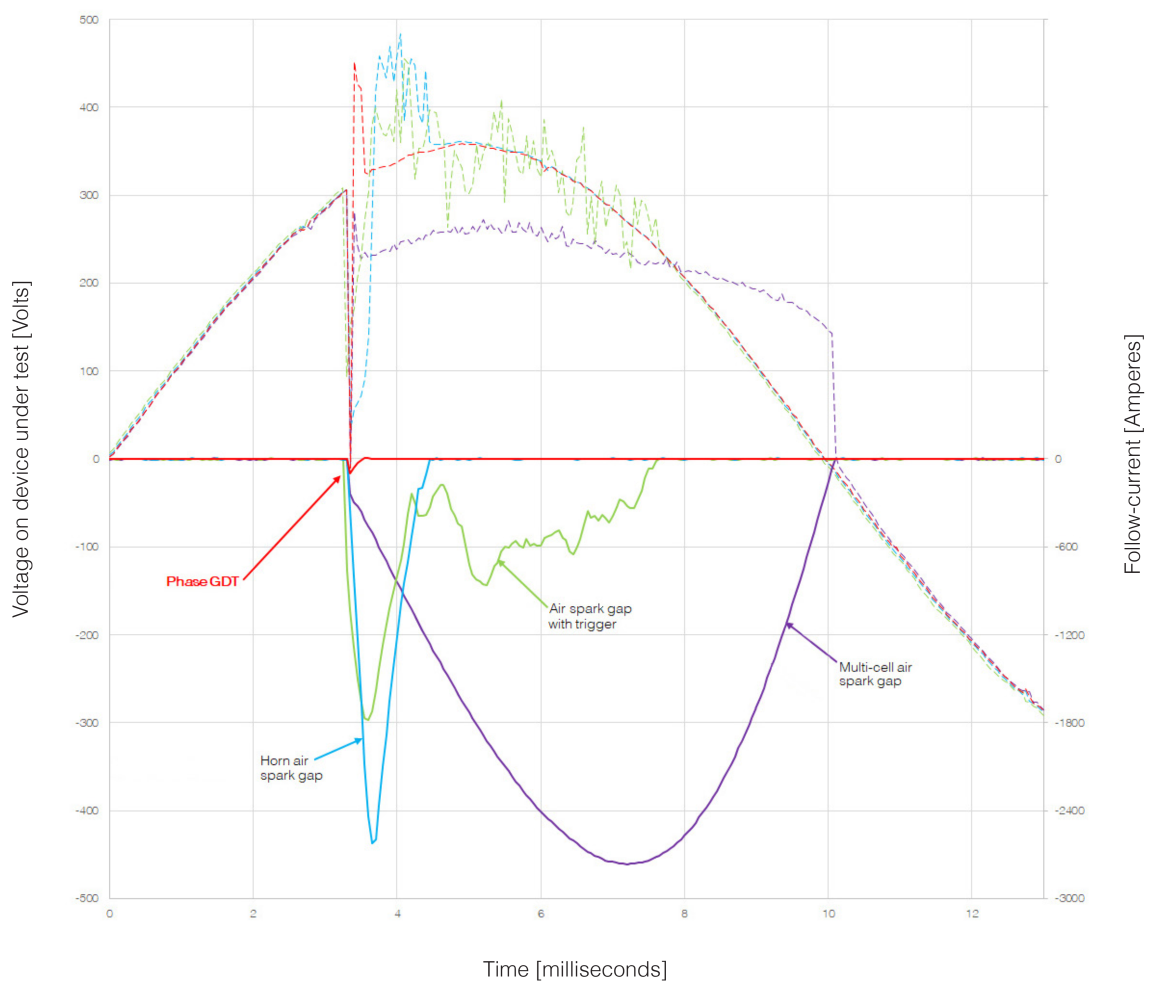


Figure 3: Follow-current conduction (solid lines) of various voltage-switching technologies following a triggering surge event. The corresponding voltage waveforms are shown as dotted lines.

Voltage Switching Technology	Phase GDT	Horn air spark gap	Air spark gap with trigger	Multi-cell air spark gap
Follow-current peak amplitude	92 A	2600 A	1800 A	2700 A
Follow-current specific energy	39 A^2S	3080 A^2S	2297 A^2S	19602 A^2S

Table 1: Shows typical follow-current and specific energy levels associated with different voltage-switching technologies. The devices were connected to a power source of 255Vrms capable of delivering a short circuit current of 25kArms and triggered using a 2.5kA 8/20µs surge current applied at 60º phase angle.

Peak value and energy of the follow-current with phase angle				
Ø	Phase GDT		Horn air spark gap	
	Peak [A]	Specific Energy [A^2s]	Peak [A]	Speific Energy [A^2s]
0º	1	1	15	1
30º	29	3	1710	781
60º	92	39	2600	3080
90º	98	41	2590	2840
120º	67	23	2120	1350
150º	8	1	1320	456
180º	14	1	48	27
210º	18	2	1760	832
240º	56	19	2520	2910
270º	89	38	2470	2863
300º	77	29	2290	1730
330º	19	2	1341	516

Table 2: Shows typical follow-currents and specific energy values for different voltage-switching technologies at various phase angles. The SPDs were connected to a power source of 255Vrms capable of delivering a short circuit current of 25kArms and triggered using a 2.5kA 8/20µs impulse.

There can be a significant variation in the follow-current conduction between different voltage switching SPD technologies. A high follow-current can have a detrimental impact on the lifetime expectancy of an SPD and can create disturbances on the power network. Table 3 demonstrates the superiority of Phase GDT technology to withstand multiple low-level surge events when connected to a power supply with high prospective fault current. This improved lifetime performance is a result of the significantly lower follow-current created by Phase GDT voltage-switching technology each time the device is triggered into conduction.

	Phase GDT	Horn air spark gap	Air spark gap with trigger	Multi-cell air spark gap
Number of surges without failure	>> 20	0	< 20	2
Maximum follow-current	100 A	>5,000 A	>5,000 A	9,555 A
Maximum specific energy	44 A^2s	399,494 A^2s	59,104 A^2s	322,232 A^2s
Conclusion	No issues observed.	Exploded on first impulse, backup fuse also operated.	On the 11th impulse SPD's failure flag operated. At 20th impulse U_p reached > 4.4 kV.	Fuse operated on 3rd impulse.

Table 3: Shows the lifetime expectancy of SPDs using different voltage switching technologies. The SPDs were connected to a power source at 255Vrms with a prospective short circuit current of 25kArms and were triggered multiple times using a 2.5kA 8/20µs surge impulse, fired at 60º phase angle every 30s.

The above results also demonstrate that Phase GDT technology is not affected by the prospective short circuit current of the power source, the amplitude of the trigger impulse, nor the phase angle at which it is applied.

Phase GDT voltage-switching technology does not conduct follow-current even after exposure to high energy surge currents, as the following figure illustrates. In some cases, the ability of the SPD to limit the follow-current is significantly deteriorated after exposure to surge currents and this may lead to safety issues for the installation.

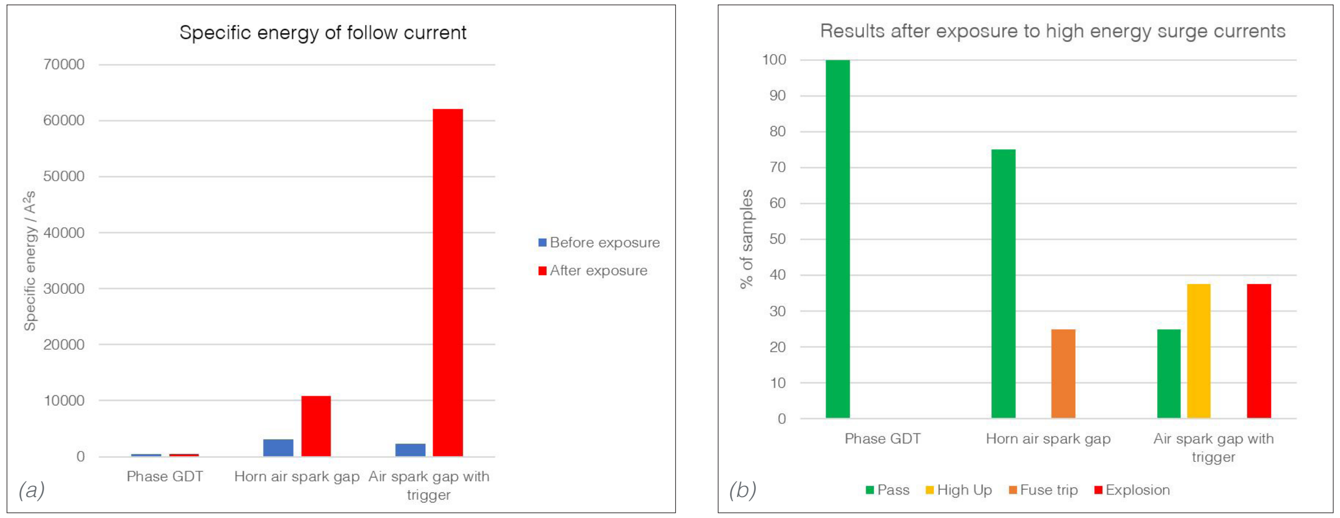


Figure 4: (a) Specific energy to follow-current conduction of various voltage-switching technologies before and after the exposure of SPDs to high energy surge currents. (b) Shows the effect of such exposure to the SPD performance when connected to a 25kA power source and subjected to 2.5kA surge current at 60o, 90o, 240o, and 270o of the voltage phase angle.

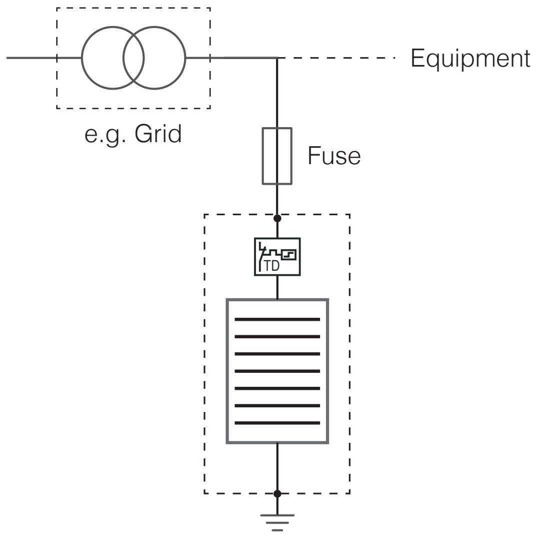
To summarize Phase GDT voltage-switching technology

- Significantly limits the follow-current conduction when connected to a power source (up to the declared SCCR) and triggered into conduction by both large and small impulses applied at any phase angle.
- Has the ability to suppress follow-current which does not decrease with exposure to high energy surges nor with multiple low-level surge events, even when connected to a power source with significant available fault current.

Safety performance

Raycap SPDs incorporating Phase GDT voltage-switching technology must be installed after a 315A overcurrent protective device to protect them in case of a short circuit end-of-life event. This level of protective device will also satisfactorily withstand 25kA 10/350µs lightning current impulses without operation or tripping.

SPDs incorporating Phase GDT technology are also internally protected with thermal disconnection. This ensures that the SPD will safely operate even during TOVs when triggered by an overvoltage or surge event. In such conditions there might be fault current drawn by the SPD due to the higher system voltage which may be below that required to cause operation of the upstream protective 315A fuse or breaker. In such event, the internal thermal disconnect will instead operate and ensure safe disconnection from the network.



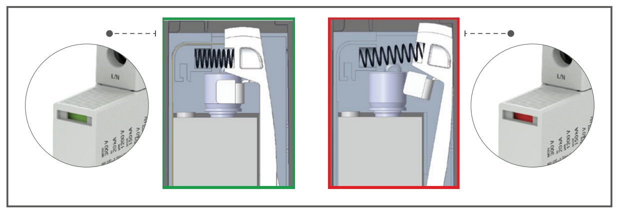


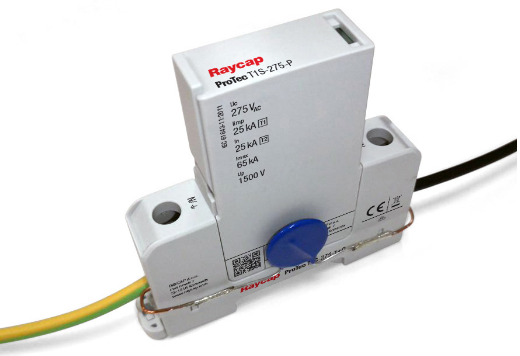
Figure 5: Phase GDT's internal thermal disconnection.

SPDs based on conventional voltage-switching technologies typically do not incorporate thermal disconnection to prevent the SPD from becoming a fire hazard (or fail catastrophically) during such conditions where the fault currents are below the level needed to operate the upstream protective devices.

Voltage protection level and coordination

The low residual voltage of Phase GDT technology makes it suitable for the protection of sensitive electronic equipment. The voltage waveform during a surge event consists of an initial peak below 1.5kV and then drops to a level slightly above that of the system voltage, at which point any follow-current conduction is extinguished.

Raycap's Class I ProTec T1S Series based on its voltage-switching Phase GDT technology not only provides efficient protection to installed equipment, but also ensures good coordination with any additional Class II SPD which may be installed as part of a distributed protection scheme. In an effort to verify the appropriate coordination with any Class II SPD and any internal protection circuit upstream of the equipment, we performed a coordination test between the Phase GDT and a standard 275V 20mm MOV disk. The energy sharing during an impulse current (following a 10/350μs waveform) between the Phase GDT and the MOV is presented in figure 6. The MOV did not overheat and remained fully functional after the test.



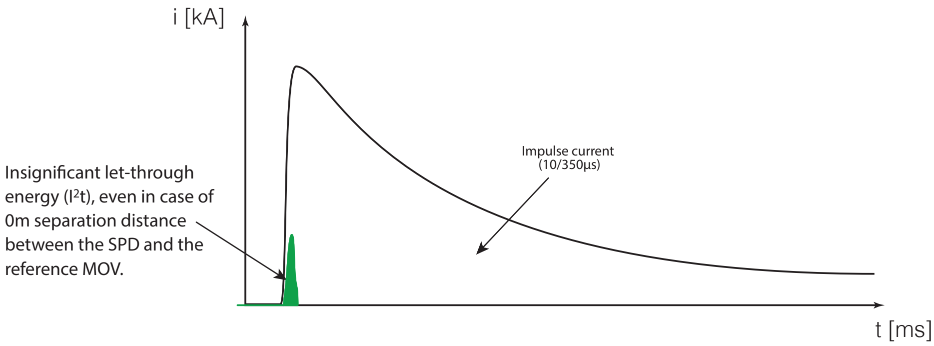


Figure 6: Coordination test between Raycap Class I Phase GDT voltage-switching technology and a 275V S20mm MOV.

Conclusions

Raycap's Phase GDT voltage-switching technology was developed to overcome three primary deficiencies encountered with other voltage switching devices: high follow-current conduction, poor voltage protection levels and large physical size.

Various attempts have been made by SPD manufacturers to overcome one or more of these problems, but Phase GDT technology is the first to resolve them all simultaneously, while being fully compliant with all aspects of the IEC 61643-11 SPD standard and integrating a number of novel end-of-life safety features.

The advantages of this technology in installations are as follows:

- Low residual voltage – suitable for the protection of sensitive electronic loads
- Low follow-current conduction once triggered - extended operation life and no nuisance tripping of upstream protective devices
- Safe operation – no venting of conductive ionized gases, encapsulated multi-cell gas discharge technology
- Safe end-of-life behavior – internal thermal disconnection
- Optimized design - implemented in half the footprint of other voltage-switching technologies
- High surge capacity – 25kA 10/350, Class I suitable for partial or direct lightning currents per IEC 62305.

Phase GDT technology provides a new and unique solution to SPD design – one suited to applications requiring a specific technology while also being exposed to lightning intensive environments where repetitive surge events can be expected, and where size, reliability and safe operation are of paramount importance.

Contact us today at info@raycap.com

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