

TechTopics No. 01

While current chopping is not a significant problem with Siemens vacuum interrupters, there are certain switching situations where special consideration should be given because of the possibility of multiple reignitions. Even though they are rare, if multiple reignitions do occur, excess voltages are possible on downstream (primarily inductive) equipment. Multiple reignitions can occur on almost any type of interrupting technology, including air magnetic, oil, air blast, vacuum and SF₆.

Multiple reignitions can occur if the following sequence of events occur together:

1. A motor is switched OFF during starting, or while stalled (locked rotor current flowing)
2. The interrupter contacts part just before (less than 1 ms) a natural current zero
3. The breaker interrupts at the natural current zero, but before the contact gap is large enough to withstand the recovery voltage following interruption
4. The circuit has a certain combination of load-side and source-side capacitances and inductances that results in a high-frequency transient recovery voltage (TRV) across the interrupter contacts. If the "right" circuit parameters exist, the rate-of-rise of the TRV can exceed the rate-of-rise of dielectric strength in the contact gap. If this occurs, the arc will reignite.
5. The reignition produces a high-frequency transient current, as the source-side and load-side voltages are brought back together. If the magnitude of the high-frequency component is large enough, a current zero will be produced that does not coincide with a natural current zero.
6. The vacuum circuit breaker can interrupt the current at a high-frequency current zero.

This process, once begun, repeats until the contact gap becomes sufficiently large that the dielectric strength of the gap exceeds the voltage imposed across the gap. At this point, further reignitions will not occur.

If multiple reignitions do occur, the downstream voltage can escalate and damage the protected equipment. Figure 3 of the paper entitled "Surge Limiters for Vacuum Circuit Breakers" by S. H. Telander, et. al., shows the escalation of voltage that accompanies multiple reignition, and Figure 4 of this paper depicts the zone of conditions where multiple reignition might occur. As discussed in the paper, the region of concern involves rotating machines, because of their large inductance and relatively weak insulation structure.

Surge limiter application recommendations for metal-clad switchgear up to 15 kV

Surge limiter data	Rated voltage	kV	3.6	6	7.5	11	15
	MCOV of ZnO element	kV	2.9	3.6	5.4	9.0	11.0
	Series gap sparkover voltage 1.2 μ s x 50 μ s wave	kV	8	10	15	25	31
	0.5 kA switching surge discharge voltage 8 μ s x 20 μ s wave	kV	8	10	15	25	31
	1.5 kA switching surge discharge voltage 8 μ s x 20 μ s wave	kV	8.3	12.4	16.5	28.9	33.0
System applications	Solidly grounded wye system applications	kV	2.4 4.16	6.9 7.2	8.32	12.0 12.47 13.2 13.8	---
	Delta system applications	kV	2.4	4.16 4.8	4.8 6.9	6.9 7.2 8.32	12.0 12.47 13.2 13.8
	Low resistance or high resistance grounded wye system applications	kV	2.4	4.16 4.8	4.8 6.9	6.9 7.2 8.32	12.0 12.47 13.2 13.8
Surge limiter part 18-665-161-xxx			-001	-002	-003	-004	-005

Fig. 1: Surge limiter selection according to system type

To protect against the overvoltages caused by multiple reignitions, we recommend that surge limiters be applied on those circuits with conditions that fall within the zone. Essentially, this means that surge limiters should be applied for all applications in which a circuit breaker is used to supply a motor that has a locked rotor current of 600 amperes (A) or less. This recommendation applies to full-voltage starting applications. It also applies to reduced-voltage starting applications, as the circuit breaker can interrupt the locked rotor current if the driven load jams or stalls.

Surge limiters should also be applied when any load has less than full insulation integrity, such as open dry-type transformers, which frequently have less than full BIL capability.

Zinc oxide surge arresters, with their higher energy absorption capability, can also be used. They are more expensive and, if they are not needed to protect against lightning or switching surges, are not necessary.

In capsule form, our recommendations are as follows:

1. For transformers of full BIL rating, no additional protection is needed.
2. For transformers of reduced BIL rating, add some form of protection (either surge limiters at the switchgear, surge capacitors at the transformer, or surge arresters at the transformer).
3. For motors with locked rotor current under 600 A, add some form of protection (either surge limiters at the switchgear, surge capacitors at the motor or surge arresters at the motor).

4. For motors with locked rotor current over 600 A, no additional protection is needed.

Selection of surge limiters for use in equipment up to 15 kV can be made using the application chart in Figure 1.

If applied in accordance with these recommendations, Siemens vacuum interrupters will impose dielectric stress on load equipment that are not significantly different from the stresses associated with traditional air magnetic or oil circuit breakers.

For more information, please contact your local Siemens representative.