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Siemens medium-voltage, gas-insulated switchgear bus differential protection

Bus differential protection is often specified in air-insulated medium-voltage switchgear, where there is a risk of a short-circuit fault or an arcing fault inside the equipment. These faults are typically caused by entrance of vermin (such as mice or rats), by humid or dirty environments, by condensation on insulation surfaces, or due to lack of maintenance.

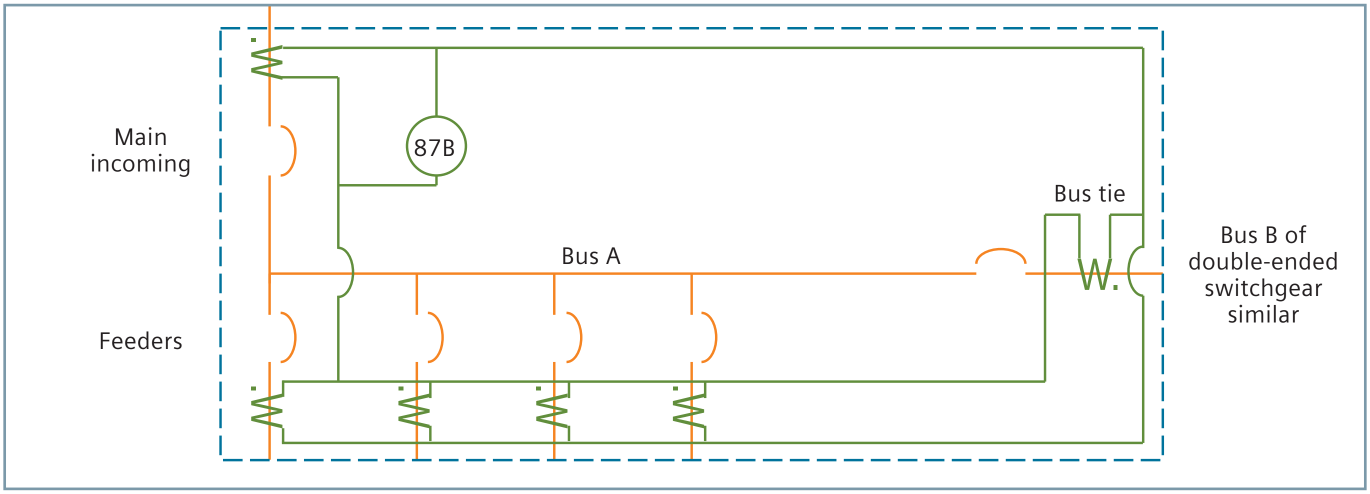
If a short-circuit or arcing fault occurs inside the equipment (and inside the zone of protection), bus differential protection will open all circuit breakers connected to the bus. The bus differential protection operates independently of the conventional overcurrent protection, which incorporates progressively longer time delays from feeder circuit breaker to tie circuit breaker to main incoming circuit breaker, so as to provide selectivity for downstream faults.

The basic concept of bus differential protection is shown in Figure 1 (one phase shown, other two phases identical).

In this scheme, the zone of protection is the area inside the current transformer locations, and includes the main bus (bus A in this example) and each of the connected circuit breakers. The differential relay will respond for any fault inside the zone, but ignore any fault outside the zone. Any fault outside the zone is a through-fault, for which the conventional overcurrent relays should provide selective protection.

In the Siemens type 8DA (type 8DB double bus is functionally similar), the zone of protection of the bus differential scheme encompasses the portions of the switchgear that are gas-insulated and are of isolated-phase construction, with the enclosing metal structure separating each phase from the other phases.

Figure 1: Basic bus differential protection



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The problems that occur with conventional air-insulated switchgear that could result in short-circuits or arcing faults inside the switchgear are therefore largely impossible with the Siemens gas-insulated switchgear. Since the equipment is gas insulated, vermin cannot enter. Humid or dirty environments are not of concern as the enclosure excludes external contaminants. Condensation is not an issue as the gas purity assures nearly zero water content. The gas-insulated portion of the equipment is almost maintenance-free. Therefore, the issues that make bus differential protection desirable in air-insulated medium voltage switchgear are not problematic for gas-insulated switchgear.

The basic structure of the type 8DA single-bus gas-insulated switchgear is shown in Figure 2.

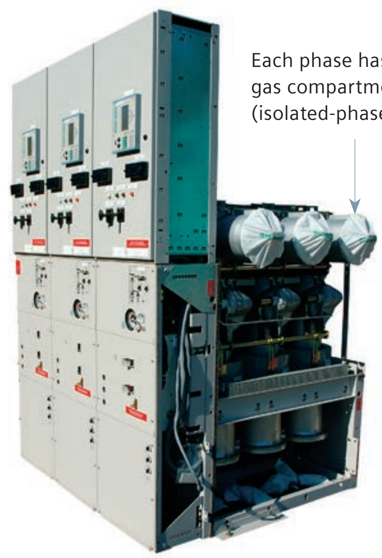

Figure 2: Basic structure

Table 1 highlights the most common causes of failures in air-insulated switchgear, as reported in the IEEE "Gold Book", IEEE Std 493-2007, "IEEE Recommended Practice for the Design of Reliable Industrial and Commercial Power Systems". As shown in the last column, with gas-insulated switchgear, over 50 percent of the causes for failures experienced in air-insulated switchgear are not relevant to gas-insulated switchgear.

The construction of the Siemens type 8DA and type 8DB gas-insulated switchgear makes the likelihood of a short-circuit fault or an arcing fault inside the switchgear extremely low, far, far lower than in air-insulated switchgear. For this reason, use of bus differential protection with gas-insulated switchgear is considered unnecessary.

Table 1: Overview of failure causes

Causes of failures in air-insulated switchgear	Share of air-insulated switchgear failures	Failure causes not relevant to gas-insulated switchgear
Thermocycling	7%	
Mechanical structure failure	3%	
Mechanical damage from foreign source	7%	☑
Shorting by snakes, birds, rodents, etc.	3%	☑
Malfunction of protective device	10%	
Above normal ambient	3%	
Exposure to chemicals or solvents	3%	☑
Exposure to moisture	30%	☑
Exposure to dust or other contaminants	10%	☑
Exposure to non-electrical fire	7%	
Normal deterioration from age	10%	
Severe weather condition	3%	
Others	4%	

Source: IEEE 493 Gold Book, Annex E, table XVIII, page 479.

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