January 13, 2017

There is often a question about what type circuit breaker is required when the incoming source of a switchgear line-up is a generator. Does the presence of the generator mandate use of a generator circuit breaker (GCB) or will a general purpose circuit breaker handle the requirements? The short answer is maybe. Having a generator in the circuit does not automatically mean a generator circuit breaker is required, but determining which type of circuit breaker is appropriate is absolutely necessary.

This discussion will be limited to medium-voltage distribution equipment, defined by IEEE C37.20.2, where the circuit breaker in question is connected directly to a generator and is supplying other circuit breakers and loads from the switchgear main bus.

Figure 1 shows a typical Main-Tie-Main with Feeder breakers. Both Main breakers are connected to a generator with an X/R ratio of 45. If the calculated available fault current is 48kA, does the Main breaker have to be a 50kA generator circuit breaker?

To solve this we need to know the percent of dc current the breaker will see at contact part. Let’s start by assuming we need a 3-cycle breaker for protection coordination. The following equations are used to calculate the current at contact part.

\[ \tau = \frac{X/R}{2\pi f} \]  
Determines the time constant for the dc decay.

\[ \%dc = 100 e^{(-t/\tau)} \]  
Determines the \%dc at contact part, based on the breaker interrupting time \( t \).

\[ I_{asym} = I_{sym} \sqrt{1 + 2 \left( \frac{\%dc}{100} \right)^2} \]  
This equation provides the current at contact part.

In the 48kA example, the asymmetrical current is calculated to be about 70kA and the peak is 131kA. A 50kA GCB is capable of 74kA rms asym and a peak of 137kA. This is more than adequate.

Would a 50kA general purpose breaker do the job? The 50kA general purpose breaker has a 60kA rms asym current capability and an 130kA peak. This breaker is not designed to interrupt the generator short-circuit current of 70kA rms asym.

A 63kA general purpose breaker, with ratings of 76kA rms asym capability and 163kA peak, can handle the generator short-circuit current easily, so selecting a general purpose circuit breaker one rating higher is a good application. The generator circuit breaker is not necessarily required. However, additional investigation may be required as applying generator breakers in C37.20.2 Metal-Clad Switchgear may cause conflicts with ratings and protection coordination. This subject is covered in the 2015 edition of C37.20.2.
WHEN DO YOU REALLY NEED A GENERATOR CIRCUIT BREAKER?

Using the following guidelines can help start the evaluation:

1. General purpose breakers may be applied at higher dc time constants when the short-circuit requirement is less than 80% of the breaker rating.
2. An X/R ratio greater than 45 is a strong indication that a generator breaker, tested to IEEE 62271-37-013, is required.
3. When the X/R is 80 or greater, there is a possibility of delayed current zeros.

A delayed current zero occurs when the dc offset is decaying slower than the ac component and the current in that phase is not crossing the zero axis, as shown in figure 2. Since a zero crossing is required to interrupt, this creates a new set of concerns for the user.

The simplest solution for delayed current zeros is to delay tripping the circuit breaker until the zero crossings resume. Care must be exercised to assure the delay does not cause components such as cable lugs to exceed their thermal design limit and that the circuit breaker selected is capable of interrupting after a long period of short-circuit current.

4. Generator circuit breakers qualified to IEEE 62271-37-013 are not required to have the 2-second short-time rating found in C37.09 general purpose breakers and C37.20.2 switchgear.
5. Generator circuit breakers are not required to open immediately after short-time current events.
6. C37.20.2 switchgear may not be adequately braced for the peak current of the generator. The GCB uses a peak multiplier of 2.74 where the switchgear uses 2.6.

In addition to 62271-37-013 and C37.20.2, IEEE C37.010 provides excellent information on circuit breaker application.

Michael Wactor, P.E.
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Figure 2

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