Symmetrical and Asymmetrical Current

June 23, 2021

I was asked an interesting question the other day concerning symmetrical test current value for Medium Voltage (MV) circuit breaker testing. The question was; "Why is there a defined value of asymmetry at contact part for a symmetrical current test?"

Interesting because the IEEE definition of "symmetrical" is: *That portion of the total current that, when viewed as a waveform, has equal positive and negative values over time such as is exhibited by a pure single frequency sinusoidal waveform*. There is definitely no asymmetry in that definition.

Asymmetrical current is defined as *the combination of the symmetrical component and the direct current component of the current.*

The dc component in the asymmetrical current is controlled by the *X/R* ratio of the circuit and the contact parting time of the interrupter. The *X/R* ratio also plays a role in the rate of decay for the dc component. To get zero asymmetry you would need a circuit with no reactance; $X = 0$. This is going to be quite difficult to attain in a test lab with a generator or transformer source or any length of conductor with inductance, so a limit was set at <20% assymetry. The assumption being that less than 20% asymmetry is low enough to be thought of as essentially symmetrical.

The symmetrical current test found in IEEE C37.09 for MV circuit breakers is called T100s and it is used to prove the Standard Operating Duty for a circuit breaker. The test requires 100% of the rms symmetrical current rating and indicates that the asymmetry should be less than 20%. When the current interrupted is symmetrical (<20% asymmetry) the level of current measured in each of the three phases shall be totaled and averaged to determine the level of current which has been interrupted. No single phase of current shall be less than 85% of the required level and since the currents must sum to zero at any point in time, there is very little dc offset in the current values.

What is meant when referring to asymmetrical current can be a bit confusing because anything other than symmetrical is by definition asymmetrical and there are several specific asymmetrical currents of interest to switchgear and circuit breaker users.

For example, when testing a circuit breaker or switchgear for its ability to withstand the magnetic forces produced by the maximum short-circuit current, we test with Peak current. Peak current is an asymmetrical value that is the peak value, including the dc component, at the major peak of the maximum cycle as determined from the envelope of the current wave of the maximum offset phase. It is defined as 2.6 times the rated short-circuit current for the switchgear or circuit breaker.

The rated short-circuit current for the circuit breaker or switchgear is a symmetrical current. Where things become confusing is the current in between those two values. Mathmatically, the asymmetrical current for the switchgear is 1.55 times the rated symmetrical short-circuit current. The important current for a circuit breaker is not that value; the important value is total current, the value of asymmetrical current seen by the circuit breaker at the time of contact part. This value is determined by the *X/R* ratio and the timing of the circuit breaker; it is not simply 1.55 times the symmetrical rating.

If we look at the next circuit breaker performance test, the T100a test, it begins with a closed interrupter and a current that is the Peak Current for the circuit breaker. The operational timing is set such that at

Powell Industries, Inc.
7232 Airport Blvd.
Houston, TX • 77061

Tel: 713.944.6900 • Fax: 713.947.4453
powellind.com
info@powellind.com

Symmetrical and Asymmetrical Current

the point of contact part, the interrupter will see the total current, based on the circuit breaker time constant and contact part time. This asymmetrical total current is used to prove the symmetrical current rating of the interrupter. The circuit breaker must then close onto a circuit that produces the peak current value (to meet the close, latch, and carry related requirements for the circuit breaker) and open again at the total current level.

One of the contributing factors to all this confusion is related to the short-circuit study programs used to evaluate switchgear systems. If you are not using the latest versions, the program will ask for asymmetrical current ratings and you will not find that rating in the manufacturer's literature because it is no longer an ANSI or IEEE required rating.

Circuit breakers manufactured before the 1999 revision to IEEE C37.09 had a voltage range factor defined as k. This factor was used to determine the interrupting capability of a circuit breaker rated on an MVA basis at its specific operating voltage. The value calculated was the asymmetrical current rating for the circuit breaker. Short-circuit studies used this value to evaluate the suitability of a circuit breaker for the system.

After 1999, the value of k was set to equal 1 and circuit breakers were rated on a symmetrical current basis rather than an MVA basis. If you are using an older version of a short-circuit sudy program, you must calculate the value for asymmetrical current used for the circuit breaker. This is simple enough to do using the following formula for total current:

$$I_{total} = I_{sym}\sqrt{1+2\left(\frac{\%dc}{100}\right)^2}$$

The percentage of dc current is determined by the circuit breaker interrupting time and the circuit breaker time constant. Typical distribution circuit breakers have a time constant of 45ms and are tested at an X/R of 17. This means a 3-cycle circuit breaker must handle approximately 48% dc and a 5-cycle circuit breaker must handle approximately 33% dc.

So not every asymmetrical current is "*the*" asymmetrical current. It depends on which part of the equipment you are referring to and which performance requirement is being examined.

Michael Wactor, P.E.
Technical Director – R&D

Powell Industries, Inc.
7232 Airport Blvd.
Houston, TX • 77061

Powered by Safety®

Tel: 713.944.6900 • Fax: 713.947.4453
powellind.com
info@powellind.com