

# Asymmetrical Interrupting Current Rating of Medium-Voltage Circuit Breakers

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The 1999 revision of ANSI Standards C37.04 and C37.09 changed several definitions relating to the rating structure of medium-voltage circuit breakers. The earlier revision of the circuit breaker standards utilized the “S factor” as a multiplying factor that defined the total current a breaker was rated to interrupt at contact part. The newest revision of C37.04 replaced the *S factor* with the % *dc* as the method of evaluating the asymmetrical current offset. The % *dc* is utilized to calculate the total interrupting current.

The asymmetrical current is an important component of the total fault current. It is critical that not only the symmetrical interrupting current but also the circuit breaker total interrupting rating be greater than the system worst-case available fault condition. In the past, we have been able to pay very little attention to the possibility of a system *x/r* ratio higher than the nominal value of 17 and the resulting total current. Today, with more generation being installed, the momentary rating and the total current capability play a greater role in the sizing of equipment because local generation increases system *x/r* ratio.

The maximum fault current occurs during the first loop of sinusoidal current after the instant of fault initiation. An asymmetrical offset containing a dc component of as much as 160 percent of the symmetrical current can be impressed on top of the symmetrical ac current in one or two of the three phase-currents. This dc component quickly decays and the fault current is greatly reduced in magnitude by the time the contacts part on the circuit breaker (see figure on structure of an asymmetrical current wave). The speed at which this dc component decays is a function of the system *x/r* ratio. A high *x/r* ratio means a greater system inductance will dominate the fault current and slow the attenuation of the dc offset.

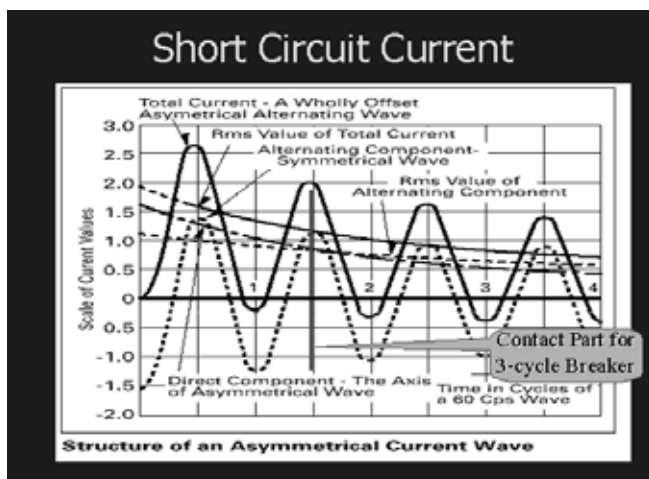


Figure 1

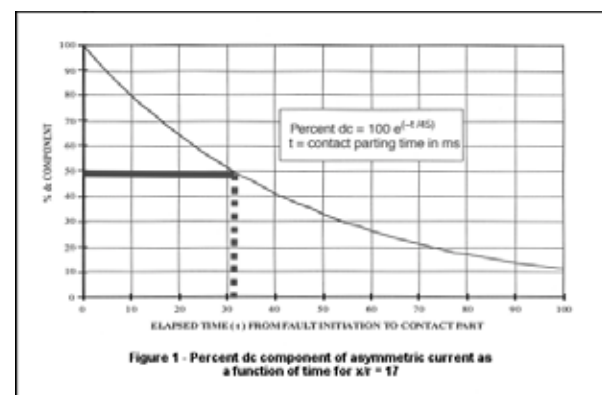


Figure 2

The %*dc* that circuit breakers are certified to interrupt is based on the contact part time and a standard *x/r* decrement curve (refer to Figure 1). The combination of the contact part time and the nominal *x/r* value results in the maximum value for % *dc* that the circuit breaker must interrupt. The nominal *x/r* of 17 coincides well with the typical 60 Hz industrial substation and utilities distribution systems.

The % dc is then used to compute the total interrupting current of the circuit breaker at the moment of contact part. The following equation shows how this total current is computed.

$$i_{\text{total}} = i_{\text{symmetrical}} \sqrt{1 + 2 (\%dc/100)^2}$$

Utilizing the chart and this formula we can compute the total current. An illustration will help clarify the calculation. To find the asymmetrical interrupting capability of a 36 kA, three-cycle rated breaker with a published opening time of 25 ms, a contact part time of 33 ms is used. The contact part time includes ½ cycle of minimum relaying time added to the opening time of the breaker. Using the 33 ms contact part time of our sample, we find the breaker is capable of interrupting the 36 kA symmetrical current with a 50 percent dc component riding on top of the symmetrical current. When these values are plugged into the formula above, the total rms current is 44 kA.

Since this breaker is certified as a three-cycle breaker, it is certified to interrupt a total current of 44 kA for any time duration from three cycles to two seconds. Note that if a five-cycle breaker is certified, the contact part time is 50 ms. The total interrupting current rating would be 40 kA, whether it clears in five cycles or two seconds.

Where does this all become significant? With more and more generation being installed we find that the system x/r ratio plays a much more significant part in applying equipment properly. In many generator bus cases the equipment may have to be oversized to handle the higher level of total current or the tripping of the breaker may have to be delayed a few cycles to allow the dc to decay to an acceptable level.



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