



Powell Technical Brief #47

X/R Ratio

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What is X/R ("X over R") ratio, and why is it important? First, X/R ratio is simply the ratio of the system reactance to the system resistance, looking back to the power source from any point in a power circuit, assuming that a short circuit is applied to the system at that point. It is another way of stating the power factor of the source system. Mathematically, if Power Factor = $\cos \theta$, then $X/R = \tan \theta$. Note that this is the power factor of the system up to that point. It has absolutely no relationship to the power factor of any load on the system. Since generators, transformers and transmission lines are generally quite highly inductive, the X/R ratio is generally significantly above unity in any utility or industrial power system.

Why is the X/R ratio important? Its importance is that it affects the level of short circuit current a circuit breaker is required to interrupt. When a short circuit occurs, the rms value of the symmetrical fault current is determined by the system source voltage and the total system impedance to the point of fault. However, almost all faults involve significant asymmetry in at least one phase. This asymmetry is treated in analysis as a dc component, which must be combined with the ac symmetrical component to give a new current value, the rms asymmetrical value. It is the value of the rms asymmetrical current at the moment of contact part which a circuit breaker must interrupt. See PTB 22 for further information.

This dc component of a fault current decays rather rapidly, reaching an insignificant value in a matter of 3 to 5 cycles of the power frequency. However, this rate of decay is determined by the X/R ratio of the circuit at the point of fault. The higher the X/R ratio, the more slowly the dc component decays.

Circuit breakers are tested using power sources with an X/R ratio prescribed by industry standards. For power circuit breakers, both low and high voltage, the ANSI standards require this X/R ratio to be 6.6 or higher, corresponding to a power factor of 15% or less. For a given level of symmetrical fault current and a given circuit breaker contact part time, this X/R ratio establishes the value of asymmetrical fault current the breaker is required to interrupt. A higher X/R ratio, with its slower decay rate, will result in a higher asymmetrical fault current at contact part time. If the X/R ratio is too high, the asymmetrical fault current may exceed the breaker's interrupting capability.

Since the X/R ratio of a system is inherent in its design and cannot be changed easily, what can be done about a high X/R? The approach is taken by the ANSI standards is to establish multiplying factors for the symmetrical fault current. These factors vary with the system X/R ratio and the speed of the circuit breaker. For high voltage circuit breakers (over 1000 V), information about the values and use of these factors is found in §5 of ANSI/IEEE C37.010-1979. For low voltage power circuit breakers, this information is found in §10 of ANSI/IEEE C37.13-1990.



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