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I²t vs. I⁴t - What's the difference?

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Everyone knows that one of the purposes of a circuit breaker is to provide overload protection of conductors. Most people know that this relates to the thermal capacity of the conductors, i.e. the circuit breaker must trip before the conductors get hot enough to be damaged. Many people know that the term "I²t", or ampere-squared-seconds, is an expression of the energy, or heat, generated by electrical current.

IEEE standard 1015-1997, "IEEE Recommended Practice for Applying Low-Voltage Circuit Breakers Used in Industrial and Commercial Power Systems", paragraph 2.1.19 defines I²t as:

"An expression related to the energy available as a result of current flow, meaningful only for adiabatic conditions. With respect to circuit breakers, the expression refers to the I²t between the initiation of fault

current and the clearing of the circuit. ..."

The term "I²t" is most often seen in conjunction with electronic trip circuit breakers, in a lot of cases it's marked right on the front of the trip unit itself. Several trip functions found in modern digital electronic trip units determine tripping based on calculation of I²t. Generally offered are long time delay, short time delay, and ground fault delay.

The I⁴t function is of course based on a different calculation and provides different trip timing for a given current, but is simply an extension of I²t. The generally slower trip time might provide a benefit in getting a particular load online, but doesn't in itself usually provide an advantage. The I⁴t function does offer an advantage in another area.

Both the I²t and I⁴t functions are useful in the area of selective trip coordination.

The log-log plot of an I²t delay function more closely matches the sloping curve shape of a thermal-magnetic circuit breaker or a fuse. It therefore provides a better "fit" in many instances. The overlap of the trip curves may be eliminated and selective trip coordination achieved in that region.

However, as the ampacity of two overcurrent devices grows closer, the chances of an overlap grow greater. The graph in Figure 1 shows just such an overlap between a fuse and a downstream circuit breaker with an I²t long time delay. In Figure 2 the advantage of the I⁴t long time delay is clear, even with all other settings remaining the same, the miss-coordination is eliminated.

Four of the WL trip units offer both I²t and I⁴t long time delay functions to allow the user greater flexibility in selective trip coordination.

Figure 1 - I^2t Long Time Delay

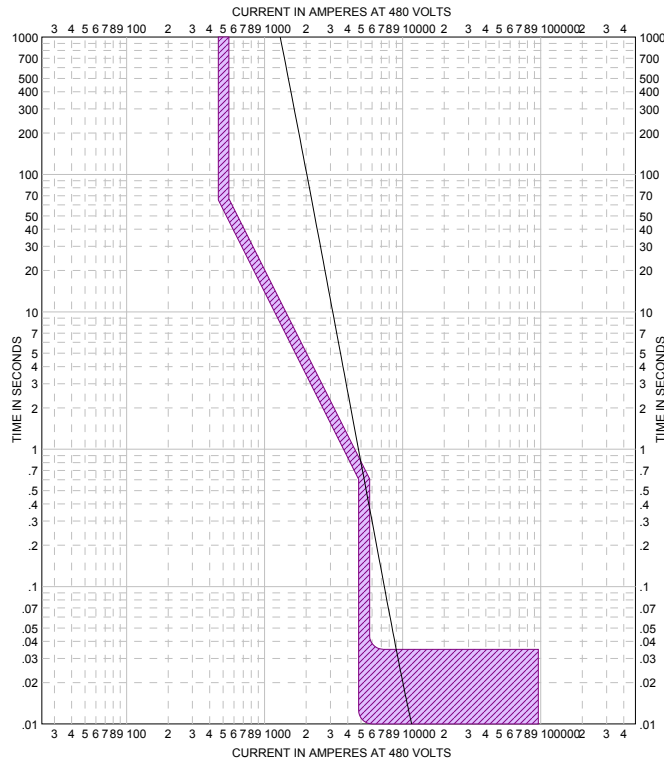


Figure 2 - I^4t Long Time Delay

