

TechTopics No. 37

Low current switching capabilities

www.usa.siemens.com/techttopics

It is amazing how long it takes old “problems” to die in the power engineering field. One of these old “problems” concerns the interrupting time of medium-voltage circuit breakers when switching low currents. The interrupting time of a vacuum interrupter does not increase as the value of the rms current gets small, but despite this, we continue to see specifications that dwell on this issue long after it became moot.

Early versions of the ANSI/IEEE standards for medium-voltage circuit breakers recognized that the air-magnetic interruption technology available had difficulty coping with low current levels during switching. As a result, the standards permitted the circuit breaker to have a longer interrupting time than its rated interrupting time for low-level currents. ANSI/IEEE C37.04-1979 discussed this in clause 5.7, as follows (extraneous information excluded):

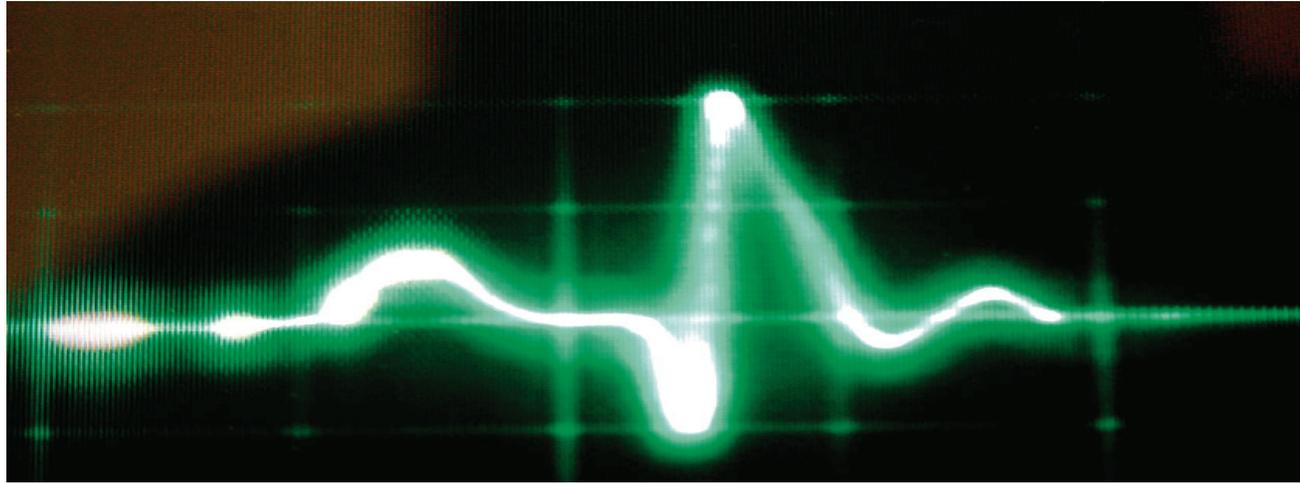
5.7 Rated interrupting time

The rated interrupting time of a circuit breaker is the maximum permissible interval between the energizing of the trip circuit at rated control voltage, and the interruption of the main circuit in all poles on an opening operation, when interrupting a current within the required interrupting capabilities, and equal to 25 percent or more of the required asymmetrical interrupting capability at rated maximum voltage.

At duties below 25 percent of the required asymmetrical interrupting capability at rated maximum voltage, the circuit shall be interrupted, but the time required for interruption may be greater than the rated interrupting time by as much as 50 percent for 5- and 8-cycle breakers, and one cycle for breakers of three cycles and less...

The interrupting time for a close-open operation at a specified duty shall not exceed the rated interrupting time by more than one cycle for 5- and 8- cycle breakers, and 1/2 cycle for breakers of three cycles and less...

These early standards reflected the physics associated with the air-magnetic interruption technology that was the “state of the art” at the time. In the air-magnetic circuit breaker, the arc is driven into the arc chute by a combination of two forces. The most significant is the electromagnetic force generated in blowout coils associated with the arc chute. This force is related to the magnitude of the current, so that the force is very high at high current levels. On the other hand, the electromagnetic force is near zero at low current levels. Accordingly, another technique is needed to cause the arc to move into the arc chute when the current to be interrupted is low. Air-magnetic circuit breakers incorporated a puffer system, using a stream of air created upon opening of the contacts to push the arc toward the arc chute. Of course, the force of the puffer was relatively low, and this resulted in a considerable lengthening of the interrupting time at very low currents.



The standards permitted interrupting time to increase for any operation below 25 percent of rated asymmetrical interrupting current. High interrupting capacity air-magnetic circuit breakers (5 kV, 350 MVA and 15 kV, 1,000 MVA) often required creative engineering to meet even the extended interrupting times allowed by the standards.

A number of consulting engineers and other sophisticated users were aware of this lengthened interrupting time. It may also be that some manufacturers experienced interruption failures attributed to difficulties with very low current switching. At any rate, detailed specification requirements began to appear, intended to assure that the products offered would be suitable for switching all currents, whether very high short-circuit currents or very low load currents. An example of such a specification clause was:

Breakers shall be capable of interrupting inductive loads having power factors in the range of 20 percent lagging to 80 percent lagging, with current values in the range of two percent to 100 percent of the breaker continuous current rating. These loads shall be interrupted without exceeding the rated interrupting time by more than 2.5 cycles for opening operations, and 3.5 cycles for close-open operations.

Subsequently, more definitive load switching requirements were added to the standards to alleviate these concerns. Today, for example, ANSI/IEEE C37.09-1999 requires tests at three percent to seven percent and 95 percent to 100 percent of rated continuous current.

With the advent of vacuum interruption technology, lengthening of interrupting times for low current switching ceased to be an issue. Vacuum circuit breakers do not have a longer interrupting time for small currents. For our circuit breakers, average arcing time is 8-9 ms across the entire range, from near-zero current to the maximum symmetrical current.

On fully-offset, asymmetrical interruptions at the full rating, the arcing time can go up to about 17 ms, but that is because current zeros can be as much as 15 ms apart on a fully-offset wave.

In summary:

- Interrupting time for a vacuum interrupter does not increase as the current is reduced.
- The standards require tests to confirm the low current switching capability of the circuit breaker.

It is no longer necessary for users to specify special requirements in this area. The required performance is now adequately addressed in the latest standards, and proven in the design tests required by ANSI/IEEE standards. We believe the time has come for this old “problem” to finally fade away.

The information provided in this document contains merely general descriptions or characteristics of performance which in case of actual use do not always apply as described or which may change as a result of further development of the products. An obligation to provide the respective characteristics shall only exist if expressly agreed in the terms of contract.

All product designations may be trademarks or product names of Siemens AG or supplier companies whose use by third parties for their own purposes could violate the rights of the owners.

Siemens Industry, Inc.
7000 Siemens Road
Wendell, NC 27591

Subject to change without prior notice.
Order No.: E50001-F710-A325-X-4A00
All rights reserved.
© 2012 Siemens Industry, Inc.

For more information, contact: +1 (800) 347-6659

www.usa.siemens.com/techttopics