Informational Document from Harmonics Limited IDHL-12

Subject: Harmonic Blocking Filters and Short Circuit Protection

An experiment was performed to examine the effect having an HSS in the neutral of a system has on tripping of breakers during a phase-
neutral short circuit. The Harmonics Limited demonstration test bench, which is a fully functional 15 kVA three phase system was used for the experiment.

Each of the three phases of the test facility was loaded to 11 amps (~2 amps per breaker) and the short circuit was provided by a switch across one of the phases. The circuit was protected by a 15 amp circuit breaker. To our amazement the breaker tripping time was only 1.5 cycles with our unit in the line, and over 30 cycles without our unit in the line.

One of our competitors tested our unit to examine the operation of safety devices with and without our unit in the circuit. The unit tested was a 45 kVA SysteMax with a full-load rating of 125 amps, installed on , I presume, a 45 kVA standard impedance transformer. Such transformers usually have impedances in the 5-6% range. The short circuit current for a 6% impedance transformer is around 2,100 amps.

<u>Short circuit time of tripping</u>

At our competitor’s laboratory the transformer was protected with 125 amp quick-acting fuses and a phase-neutral short circuit was introduced. Tests were preformed with and without our unit installed in the neutral circuit. The transformer was unloaded at the time of the testing. The peak value of the current was 1440 amps without our unit installed and 1080 amps with our unit installed. Fault clearing times were 3 cycles without and 34 cycles with our unit.

We performed a smaller scale experiment with and without our unit installed.
I consulted with Alex McEchern, a power quality expert. Alex founded a company that manufacturers equipment to purposely introduce controlled short circuits, spikes, and other power quality faults into industrial facilities to test their protection. I received the following explanation. The tripping time of any breaker or fuse is quite dependent upon where in the voltage cycle the short circuit is initiated. If the short is initiated at the peak of the voltage wave, the instantaneous current is quite large and the breaker trips quite rapidly (magnetic element.) However, if the short is initiated at a zero crossing of the voltage wave, the voltage never builds up enough to provide a high trip current and the thermal response of the fuse or breaker is quite slow—many cycles. In either case the let-through energy is quite similar. This energy can be provided instantaneously, or over a short period of time.

It became apparent to me that both our experiment and that of our competitor were inconclusive since neither of us controlled the point on the voltage wave where the short circuit was introduced. Fuse tripping curves, attached, indicate that with a 1440 amp current a 100 amp fuse should operate in less than 0.01 seconds and with a 1080 amp current the same fuse should operate in less than 0.01 seconds. No difference is shown by the curves, and any difference in operation time is probably, as explained above, due to the location on the voltage wave where the short circuit was initiated.

UL has approved our units for the specified application. The following url leads to an IAEI News article that deals with all code issues surrounding our technology.

http://www.iaei.org/magazine/03_a/magazine_03_lowenstein.htm

I hope this discussion will help you in determining that our harmonic suppression systems pose no danger to a facility electrical distribution system if a phase-neutral short circuit should occur..

Sincerely,

Michael Z. Lowenstein President & CTO

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