Technical Brief

Power Quality Considerations for the Output of the M215 Microinverter

Overview

This document addresses two technical characteristics of power output quality in the Enphase M215 Microinverter System. Utilities are interested in Fault Current contribution and Total Distortion power output characteristics. Fault current is important because the total maximum fault current that a distributed energy resource (DER) can contribute determines how robust the over-current protection device (OCPD) on the downstream (grid) side of the DER needs to be. Total distortion, is also important, as it indicates how closely a device's output power signal adheres to an ideal sine wave.

Fault Current Contribution

Enphase has received inquiries as to the relationship of fault current contributed and kilo-Amperes Interrupting Capacity (kAIC) ratings.

With regard to the fault current contribution of Enphase Microinverters, the contribution from the microinverters is far less than the kAIC rating of any circuit breaker. Only circuit breakers, fuses, and some load-rated switches have AIC ratings. As a current source, a utility interactive inverter does not, by itself, require an AIC rating.

Some utility Electrical Services Requirements state that the Short-Circuit current and Over-Current protection is to be based on the type of service that is provided to the system (PCC). For instance, for residences, duplexes, and mobile homes supplied at 120/240 volts, one phase, three wire:

- 0-225A Service Ampacity the Short-Circuit Current rating (AIC) required is 10kA.
- 226-400A Service Ampacity, the Short-Circuit Current rating (AIC) required is 22kA.

Utilities are concerned with the kAIC rating of the main breaker for two reasons:

First, will it interrupt the current when a fault is present on the residential (load) side of the breaker?

Secondly, will it interrupt the current supplied by the Distributed Generator (DG) when the short is located on the grid side? Is it possible for the DG to deliver more current than the circuit breaker can interrupt?

When calculating the fault current contribution from Enphase Microinverters, one needs to add up the fault contribution from all microinverters. It is this sum that is compared to the AIC rating of the main breaker. So, for M215 Microinverters on a 240V single-phase connection, the correct fault contribution value is 1.05Arms for 3 cycles.

Let's say you have an installation with 120 microinverters and a main breaker rated at 10kAIC, then the fault current contribution from the microinverters is:

120 microinverters * 1.05Arms = 126Arms for three cycles

This number is only a small fraction of 10kAIC. So, the main breaker would be sized correctly to interrupt any fault current contributed by the DG. Likewise, the utility must insure that the fault current supplied from the utility be less than 10kA. This is determined by the utility and is based on several factors. Mainly the Full Load Amps of the transformer and the Transformer Impedance. This information should be available from the nameplate rating of the utility transformer. From this information one can determine the fault current available from the utility. This should be less than 10kAIC for the example above. For larger service ampacities, the rating may need to be higher.

In *Understanding Fault Characteristics of Inverter-Based Distributed Energy Resources*, a National Renewable Energy Laboratory study published in January 2010, Keller & Kroposki address fault current contributions of Distributed Energy Resources (DERs) and inverters in particular:

> "Inverters do not dynamically behave the same as synchronous or induction machines. Inverters do not have a rotating mass component; therefore, they do not develop inertia to carry fault current based on an electro-magnetic characteristic. Power electronic inverters have a much faster decaying envelope for fault currents because the devices lack predominately inductive characteristics that are associated with rotating machines. These characteristics dictate the time constants involved with the circuit. Inverters also can be controlled in a manner unlike rotating machines because they can be programmed to vary the length of time it takes them to respond to fault conditions. This will also impact the fault current characteristics of the inverter."

Summary

The UL 1741 standard requires us to perform a short circuit test and list the available fault current and duration. The discharge at the output of the inverter is through as short a length of wire as possible at an extremely low resistance. The discharge is not sustained, and as soon as any real world resistance from circuit conductors is included, the available fault current is dramatically reduced. PV modules and utility interactive inverters are both current limited devices. For a fault condition in any portion of the system, the fault current required to open overcurrent protection devices would necessarily always come from the utility, which remains the only source of a current of sufficient magnitude to do so.

Total Rated-Current Distortion and Total Demand-Current Distortion

Harmonic rated distortion and demand distortion are both measurements of how closely a device's output power signal adheres to an ideal sine wave.

- Distortion is measured at 40 different harmonics, fundamental (60Hz) to the 40th harmonic (50.4kHz)
- Across three power levels: 33%, 66%, and 100% of rated output capacity
- And three DC input voltages defined by the MPPT range: 33%, 66%, and 100% of rated input capacity
- Two measurements are recorded: Total Rated-Current Distortion (TRD) and Total Demand-Current Distortion (TDD)
- All measurements are made according to the procedures outlined under IEEE 1547.1, Clause 5.11
- The M215 meets the specifications as outlined in IEEE 1547, Clauses 4.3.3 and 5.1.6
- Typical value for TRD for the M215 is 2.0%
- Typical value for TDD for the M215 is 1.3%

Conclusion

Enphase Microinverters neither have nor need a kAIC rating, and their power outputs have a Total Distortion far lower than that required by IEEE 1547 or UL 1741. Sharing the above information with your local Authority having Jurisdiction and Utility, as appropriate, will minimize power quality related issues in your commercial Enphase Microinverter installation experience.