TOP 10 QUESTION
from the Tech Talk

TECHTALK

Protection System Design for Practical Microgrids

In our Tech Talk, **Protection System Design for Practical Microgrids**, learn how the drive for cleaner, more localized energy has brought microgrids into the mix for utilities and power producers seeking more secure, sustainable power supplies. But while there are similarities between conventional and microgrid-based protection schemes, it's not a one-size-fits all approach.

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GE VERNOVA

Protection System Design for Practical Microgrids

QUESTION	ANSWER
What are the fundamental design differences between traditional grids and microgrids?	In traditional electric power grids, the power flow is unidirectional from the utility to the customer. Power generation in traditional grids is done in large, centralized power plants. Furthermore, they make use of fossil fuels like coal, oil, and natural gas, and the generated power is transferred over a long distance using transmission and distribution lines. Microgrids, on the other hand, are distributed and smaller in size. The power flow is bidirectional and the use of renewable energy sources like solar PV, wind, and small hydro are commonly promoted. Microgrids are also located onsite, closer to the loads, and can supply their surplus generation to the utility if there is a purchase agreement in place.
How does the protection philosophy for microgrids differ from that of centralized traditional grids?	There are some differences between microgrid protection and utility protection requirements. Some of these differences include protection speed requirements, short-circuit current directionality, ground short-circuit protection, and other protection requirements such as point of interconnection (POI) protection, and anti-islanding protection. Also, inverter-based distributed energy resources (DERs) act like voltage-controlled, positive-sequence current sources and have little or no zero- or negative-sequence current quantities. Therefore, microgrid protection design is focused on these differences in addition to other protection requirements.
What are the criteria to consider in the design of protection systems for a microgrid?	Some criteria that should be considered in the design of microgrid protection systems include the utility interconnection requirements, network topology, system operating modes and possible operating scenarios, the type of DER technology and size, the configuration of the interconnecting transformer, system grounding, and the available communication infrastructure.
What are the solutions to sympathetic tripping in microgrids?	Sympathetic or false tripping occurs when the protection relay on an adjacent feeder operates for a fault on another feeder due to the change in the flow of fault currents. This false tripping can be avoided by updating the relay pick-up settings when the microgrid operating mode changes by using directional overcurrent functions. Another option is to enhance protection coordination by increasing the fault clearing time to allow the faulted feeder to be disconnected before the operation of the protection relay on the healthy feeder.
What are the solutions to protection blinding in microgrids?	Protection blinding occurs when current-based protection functions or relays are unable to detect faults within their protection zone because the fault current seen is less than their configured pick-up settings. One way of mitigating this is by updating the settings automatically (or changing the protection group setting), based on the mode of operation. For example, a protection group with a low pick-up current can be used when an inverter-based microgrid is operating in islanded mode.

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QUESTION	ANSWER
What are the protection requirements at the POI?	Protection requirements at the POI vary and depend on the interconnecting utility. Some utilities mandate that utility-grade interconnection relays, circuit breakers, and instrument transformers must be used. Additionally, in some cases, the utility will define the settings of the interconnection protection function like the pick-up settings and protection operate speed (trip time). Another common POI protection requirement is a loss-of-utility protection scheme for single-phase-to-ground faults on the utility side of the interconnection transformer, especially when the breaker on the utility feeder is tripped while the microgrid breaker remains closed. Typical protection schemes include the use of a 59G zero sequence over-voltage relay connected to a broken-delta voltage transformer or by using a direct transfer trip (DTT) trip from the utility protection relay to the microgrid POI protection relay.
What protection can be implemented in a grid-connected microgrid that is importing and exporting excess power?	When exporting excess power to the utility, the microgrid will need to satisfy the utility's technical interconnection requirements and POI protection requirements. In addition to this, the microgrid operator should comply to relevant local grid codes and international standards (e.g., IEEE 1547 Std.). Typically, reverse power (32), directional (67), undervoltage (27), overvoltage (59), and over/under/rate-of-change frequency (81O/U/R) protection functions are used.
Upon the detection of an islanding condition, should the islanded portion of the electrical system have its generation shut down before reconnection?	It depends. If the microgrid successfully transitioned to the islanded mode, it is not necessary to shut down the generation in the islanded portion before reconnection. This is because a load shedding controller would have shed the loads equivalent to the lost power imported from the utility. The microgrid protection should have a resynchronization check function (25) to ensure that the voltage, frequency and phase angle of the islanded portion are closely matching that of the utility before reconnection.
What is the short circuit contribution of wind farms? Is it significant?	This depends on the type of wind turbine generators (WTGs). Type I WTGs are squirrel cage induction generators (SCIGs) and have a short circuit current (SCC) typically more than six times the nominal current rating (IN). Type II WTGs are wound rotor type and have 4-5 x IN SCCs, Type III are doubly-fed induction generators (DFIGs) and have 2-3 x IN SCCs, and Type IV WTGs are full converter WTG and have 1.1-1.2 x IN SCCs.
How is short-circuit protection in inverter-based microgrids that have short circuit currents close to load current handled?	Sensitive protection in microgrids integrated with inverter-based DERs can be implemented by updating overcurrent protection settings with low pick-up currents, using definite-time overcurrent protection function instead of inverse-time characteristics overcurrent protection, or by using voltage-restrained overcurrent (51V-R)/voltage-controlled overcurrent (51V-C) protection functions.

QUESTION	ANSWER
Can adaptive protection be applied in microgrids?	Yes. Adaptive protection can be implemented in microgrids by updating the protection setting group, protection setting values (i.e., pick-up or time delay settings), protection functions, and protection logic as the microgrid topology or operating conditions changes.
How can protection coordination be enhanced in microgrids integrated with inverter-based DERs?	One way of enhancing protection coordination in microgrids with inverter-based DERs is by using peer-to-peer communications like the IEC 61850 Generic Object-Oriented Substation Event (GOOSE) messages among the protection intelligent electronic devices (IEDs). For example, each protective IED will communicate with its neighboring device during a fault to inform other devices of the direction of the fault. The other devices may use this information to either activate a blocking scheme or a permissive trip scheme in order to quickly isolate the fault. Also, the protection scheme can be automatically updated to adjust the overcurrent operating time of an upstream relay by adding some time delay when it receives a signal from its downstream relay. This allows several overcurrent devices to be coordinated with an adaptive coordination time interval.
What are the relevant industry standards related to microgrid protection?	Some standards and guides applicable to microgrid protection include: • IEEE 1547-2018 Standard: IEEE Standard for Interconnection and interoperability of Distributed Energy Resources with Associated Electric Power Systems Interfaces • IEEE 2030.12: Draft Guide for the Design of Microgrid Protection Systems • IEEE C37.106-2022: IEEE Guide for Abnormal Frequency Protection for Generating Plants • IEC TS 62898-3-1:2020 Microgrids – Part 3-1: Technical Requirements – Protection and Dynamic Control • UL 1741 Supplement SA and SB: Inverters, Converters, Controllers, and Interconnection System Equipment for Use with Distributed Energy Resources • NFPA 70 (NEC)-2020: National Electrical Code for the Installation of Safe Electrical Systems

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