HIGH-SPEED FALLING CONDUCTOR PROTECTION

TWO-PART INTERVIEW SERIES

Part 2: System Architecture, Testing, and Commissioning

A CONVERSATION WITH

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In Part 1 of this interview series, we discussed the protection elements of High-speed Falling Conductor Protection (HFCP) solutions. In this continued segment, learn from GE's experts Hasan Bayat and Yujie Yin as they explore HFCP system architecture and examine the testing and commissioning phases of an HFCP solution.

Hasan Bayat

Hasan is a Lead Customer Application Engineer with GE's Grid Solutions. He has more than ten years of academic and industrial work experience in power system studies and specializes in power system protection, automation, and control; microgrid control and protection; and hardware-in-the-loop testing.

Hasan received his PhD from the Electrical and Computer Engineering department at Western University in 2018. His thesis focused on grid integration of large-scale PV farms and battery energy storage systems. He has published several publications in IEEE transactions, international journals, and conferences from industrial and academic perspectives.

Yujie Yin

Yujie is a Senior Application Engineer with GE's Grid Solutions. He has more than 20 years of experience in power system protection and control applications, studies, analysis, and testing. He is also a senior member of IEEE, a CIGRE B5 WG member, and a licensed professional engineer in the province of Ontario.

Yujie's areas of expertise include microgrid protection and control, remedial action schemes, IEC61850 digital substations, phasor measurement, and synchrophasor applications. He has worked on many utility projects in North America and has authored/co-authored more than 15 technical papers published in IEEE journals and other major conferences.

Yujie received his PhD in Electrical Engineering from Mississippi State University in 2020. He also holds Bachelor of Computer Science and Master of Electrical Engineering degrees from Western University and a Bachelor of Electrical Engineering degree from Hefei University of Technology in China.

PART 2: SYSTEM ARCHITECTURE, TESTING, AND COMMISSIONING

What does the typical HFCP system architecture look like?

Yujie: GE's HFCP solution is a scalable system that provides reliable and fast detection of broken/falling conductors in the distribution or transmission system. The solution can connect to devices inside the substation as well as along the feeder.

The GE Power Gateway (GPG) provides real-time controller, HMI, and historian capabilities and can be integrated with any third-party devices using one of the supported protocols. The IEC 61850 GOOSE, IEC 61850-90-5, and the IEEE C37.118 protocols can be used to collect the synchrophasor measurements. The GPG can also be integrated to existing SCADA systems or substation HMIs through Modbus, DNP3, MQTT, IEC 60870-5-101, IEC 60870-5-104, or OPC.

What are the hardware requirements to run the HFCP algorithm?

Yujie: The HFCP solution is implemented on GE's real-time controller GPG and it is the only GE-specific hardware that is required.

Do we need a time sync at the GPG level?

Hasan: Yes, the HFCP solution requires time synchronization at the GPG level and all PMUs need to be synchronized as well. IRIG-B and the IEEE 1588 Precision Time Protocol is supported for the real-time controller while Network Time Protocol can be used for the HMI if required.

What typical latencies are allowed?

Yujie: A communication delay of 100ms is acceptable.

What different communication methods have been tested successfully?

Hasan: So far, only Ethernet has been tested. This will soon be extended to radio, LTE, and PLC.

What communication protocols are supported by HFCP?

Hasan: For breaker trip commands, IEC-61850 GOOSE. For voltage and current measurements, IEEE C37.118, IEC 61850-90-5, or IEC 61850 Analog GOOSE. For SCADA it's user preference.

How are the trips sent from GPG to PMUs/IEDs?

Yujie: While the GPG supports DNP3 and Modbus, the HFCP solution requires a high-speed protocol to trip the breaker in time. As a result, IEC 61850 GOOSE messaging needs to be used for trip commands.

What happens when a PMU is out of service and no synchrophasors are being received?

Yujie: The scheme will be in service but with reduced feeder coverage.

And what happens when a given trip IED/PMU is not available?

Hasan: I'd say that by default, a time delay is configured for the PMU at the substation. Should the downstream PMUs not clear the open phase condition within the coordinated time, the PMU at the substation can be configured to trip the feeder breaker.

How does hardware-in-the-loop (HIL) testing work?

Hasan: HIL testing is useful to determine and validate the performance of HFCP on the target feeder. It is offered as an optional, value-added service. HFCP can be commissioned without HIL testing.

How could you test this scheme using regular relay test sets?

Yujie: HFCP functionality can be tested using PMU emulation software to simulate predefined scenarios. Moreover, a test set that injects currents and voltages to a relay with PMU capability can be used for testing the HFCP.

Do you need an outage of the entire system to commission the HFCP?

Yujie: The commissioning procedure is similar to a relay installation; the feeder under commission of HFCP may need to be offline.

What test modes are supported?

Hasan: IEC 61850 test modes can be used. The typical steps for commissioning are:

1. Check time synchronization of the PMUs and the GPG.
2. Set up the communication for the PMUs.
3. Key integration for the HMI.
4. Integration of the historian.
5. Testing of IEC 61850 integration.

How would you describe the learning curve for HFCP?

Hasan: The core concepts are easy to understand! I'd say that the typical training duration is usually one day.

What is the typical cost of deploying an HFCP system?

Yujie: I'd say it's best to contact our sales team for a proposal and cost estimation, and of course, more information could be provided at that time.

AT A GLANCE

HFCP provides a scalable method that provides reliable and fast detection of broken falling conductors in the distribution or transmission system. The solution requires the GE Power Gateway (GPG) but can then connect to devices already inside the substation as well as along the feeder. And while the core concepts of an HFCP solution are straightforward, GE's team of experts is ready to support our customers every step of the way. Thank you, Hasan and Yujie, for all your expertise on the matter.

For more information about GE's HFCP solutions, contact our experts or visit our GridNode product page here.

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