White Paper

Use of Distribution Transformer Monitors for Voltage Based Fault Detection and Localization

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QinetiQ North America

LineWatch™
Powering Grid Awareness

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Introduction

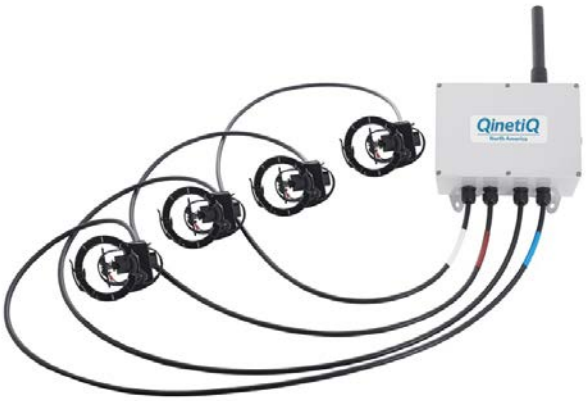

Figure 1: Three-Phase Four-wire LineWatch L

LineWatch L, a QinetiQ North America (QNA) product, is a Low Voltage sensor that monitors the secondary side of the distribution grid. These sensors provide a complete solution for the wireless monitoring of both pole-mount and pad-mount distribution transformers—no external current transformers or potential transformers are required. The built-in disturbance logging capabilities of these sensors have been employed by Hydro Quebec (HQ) in combination with a HQ developed fault detection and localization algorithm VDFL (Voltage Drop Fault Location - US 8,269,503) as the centerpiece of an innovative and inexpensive fault detection and localization system based on detecting voltage sags seen on the secondary side of distribution transformers. This white paper will briefly describe the business case for LineWatch™ L devices in combination with HQ's VDFL algorithm in the application of voltage based fault detection.

LineWatch L – Distribution Power Monitor

The LineWatch L system monitors single-phase, three-wire or three-phase, four wire transformers attached to the distribution grid. The LineWatch L system is shown above in Figure 1. In its normal monitoring mode, the system logs voltage, current, real and reactive power and energy, volt-hours and amp-hours once per minute. Voltage and current harmonics through the 13th harmonic are also computed and logged every minute.

For isolated installations, this data can be manually retrieved via a Wi-Fi connection to the sensor—data persists on the sensor for one month. However, the full utility of the sensor is realized when the sensor communicates via other communication protocols that allow it to be part of a distributed sensor network. Specifically, the sensors can communicate either via its internal Cisco mesh radio (an IEEE 802.15.4-type radio communicating on an IPv6 network, compatible with existing smart meter mesh radio infrastructure) or by using other communications platforms including cellular modems, WiMAX, gateways or any other device capable of being integrated to an Ethernet port. The sensor conveys instantaneous measurements using the industry-standard DNP3 format and makes fault data available via Secure FTP (either pushed to a remote SFTP server or downloadable by a device-hosted SFTP server).

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Fault Detection and Localization

The LineWatch L sensor is the key sensing mechanism used in Hydro Quebec's MILE[1] Intelligent Power Line Maintenance System, which has implemented the VDFL technique. The LineWatch L system collects the fault waveform data required by the MILE system's analytics and automatically delivers the fault logs via the communications platform to a central SFTP server. The LineWatch sensors are preferred by Hydro Quebec because the sensors are relatively low cost and very accurate, and they can be quickly installed on live distribution transformers without requiring access to customer property.

The LineWatch system looks for the voltage to sag below a user-definable threshold level. A fault can be triggered by a sag as short as one-half of an electrical cycle. When a fault is detected, the sensor captures 32 waveform cycles (4 before the fault and 28 after the fault) of voltage and current on all three phases at a 4096Hz sample rate. These voltage sag events, measured on the transformer secondary, are indicative of faults on the medium voltage distribution line that feeds the transformer. By processing waveform sag logs from several meters, the fault can be detected, and accurately located.

Figure 2: LineWatch-L sensor integrated with a three-phase pole-mounted distribution transformer installation.

The voltage triangulation used by the VDFL technique considerably reduces the patrol zone by pinpointing the faulty lateral tap. The arc voltage amplitude deduced by this technique combined with other information, as weather during the fault, are automatically processed by MILE's fault cause identification module to determine the origin of the problem. The accuracy, the reduced patrol zone and the cause of fault give a tremendous advantage to this fault location technique for locating non-permanent faults and, consequently, for avoiding outages.

The use of LineWatch L sensors as an integral part of an arc fault detection and location system is described in a recent conference publication by Hydro Quebec (see M. Tremblay, "Determining the location and cause of faults in power distribution system with an arc voltage evaluation method" http://www.ieee-pes.org/presentations/gm2014/PESGM2014P-002549.pdf).

[1] MILE - Maintenance Intelligente de Lignes Electriques

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Business Case

The benefits of the LineWatch L system can be understood by examining the demonstrated performance of the system as part of the MILE system in a pilot installation in Quebec. Four meters were installed on a feeder, which has an average of 180 outages annually. The use of sensors, as an integral part of the MILE fault location and diagnosis system, reduced the outage frequency by 51%; the SAIDI index by 61% and the number of outages of unknown cause by 92%. On this feeder alone, it is estimated that $1M of unnecessary investment was avoided by the use of MILE. Details of this experiment, was reported in the EPRI document number 1021999: "Fault-Location Application for Improving Distribution System Maintenance: Hydro-Quebec's Experiences"

Conclusions

QNA produces both Low Voltage and Medium Voltage sensor products that can be used as integral parts of either fault detection or power quality monitoring systems. This summary has focused on the fault and power quality aspects of these sensors, but the full specifications of these sensors are available online at https://www.qinetiq-na.com/linewatch/. QinetiQ North America welcomes the opportunity to discuss the capabilities of these sensors in more detail, or to discuss options for customizing these sensors or integrating them into novel applications.

Company Background

QinetiQ North America (www.qinetiq-na.com) is an engineering and technology development company. QNA maintains a staff of over 200 mechanical, electrical, thermal, chemical, nuclear, aerospace, software and materials engineers working in the areas of robotics, advanced materials, aerospace, homeland security, power systems, and transportation.

Hydro-Québec (www.hydroquebec.com) is a public utility that generates, transmits and distributes electricity. It is Canada's largest electricity producer and is among the world's largest hydropower producers. Its sole shareholder is the Québec government. Its research institute, IREQ, conducts R&D in energy efficiency, energy storage and other energy-related fields. Hydro-Québec invests $100 million in research annually.

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