White Paper

LineWatch-M Fault Current Capabilities Overview

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QinetiQ
North America

LineWatch™ Powering Grid Awareness

LineWatch-M Fault Current Capabilities Overview

Introduction

QinetiQ North America's medium voltage distribution line sensor, LineWatch-M (pictured below as Figure 1) monitors voltage, current, and power flow during normal conditions. However, the sensor can also detect the presence of fault currents and produce a detailed log of the fault event containing waveform captures of the fault. This information can be used to diagnose and localize the fault. This note is meant to answer questions about the methodology applied in the sensor for detecting and recording faults.

Fault Current Sensing

The LineWatch-M sensor measures fault current using a Rogowski coil formed by the vias that traverse a thick printed circuit board (as shown in Figure 2). The PCB coil's performance is virtually identical from device to device, ensuring consistent current sensing performance. Since there is no iron, there is no saturation—high fault currents can be measured accurately. The Analog to Digital Converter sampling the current sensor is software configurable for sensing ranges consistent with either 10kA or 25kA class faults as defined by the IEEE 495:2007 standard.

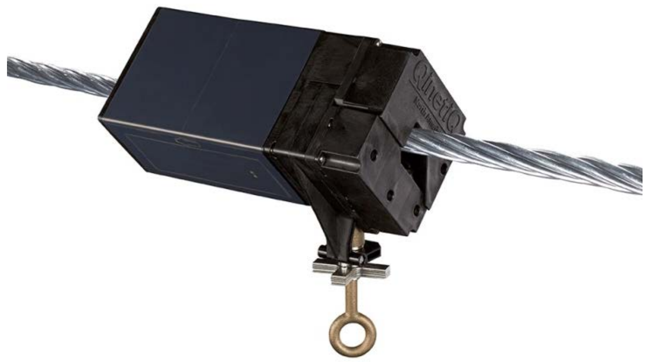

Figure 1: QNA LineWatch-M Medium Voltage Sensor directly monitors distribution feeders

Fault Current Signal Processing

The voltage across a Rogowski coil is proportional to the time rate of change of the current, rather than to the current. Internally, the sensor integrates the signal from the coil to get current. The signal samples the current at a 2048Hz rate. The integration algorithm provides a flat frequency response from 0.04Hz to 780Hz, allowing both short-term and long-term behaviors to be analyzed in waveform captures of the fault.

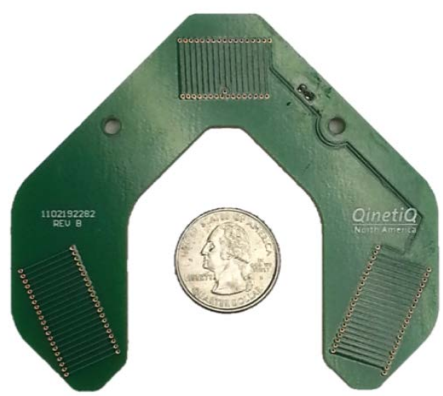

Figure 2: PCB Rogowski Coil allows accurate fault current measurement.

Waveform Capture

To determine when a fault has occurred, the sensor internally computes an RMS of the fault current measurement based on the measurements from the previous electrical cycle (*i.e.* the previous 34 samples). If the fault current RMS exceeds a configurable threshold level for a configurable duration, a current fault is declared. With an appropriate duration setting, the system will not spuriously trigger on inrush currents associated with feeder turn-on.

When a current fault is declared, the system logs Fault Current; Voltage; Current at the 2048Hz sampling rate. The sensor maintains a rolling buffer of these measurements so that the waveforms for 4 cycles prior to the declaration of the fault are measured, in addition to 8 cycles after the fault. The RMS magnitude of the eighth cycle of Fault Current data can be taken as the Fault Current Magnitude. [1]

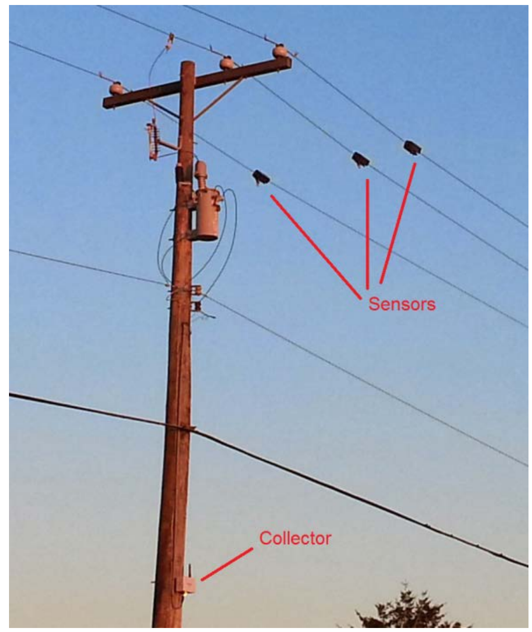

Figure 3: Sensors communicate to a Collector on a nearby pole.

Waveform Data Transfer

The sensors operate by scavenging power from the monitored medium voltage line. Because a limited amount of power is available onboard a sensor, the sensors talk via short range radio to a nearby collector, as shown in Figure 3. Fault logs are captured in the sensors and then transferred to the collector for dissemination and transfer to remote machines. The collector is powered by 120V and has essentially no power limitations on its ability to communicate.

Fault current logs are stored on the collector associated with the sensor in the standard COMTRADE format [2] for ready consumption by third-party analysis tools. A number of COMTRADE plotting tools exist, or these files are readily processed using standard tools like Matlab to yield plots of fault data as shown in Figure 4. Fault-logs can be downloaded via an FTP server hosted by the collector. The file name of the fault record is a number indicating the timestamp (to the millisecond) at which the fault occurred.

The collector implements a DNP3 interface with Secure Authentication. The availability of new fault logs is advertised by this DNP3 interface. For each sensor monitored by the collector, there is an associated DNP3 data item containing a floating point number representing the date and time of the most recent fault. When a fault occurs, the value of the field changes, the collector sends an unsolicited report with the updated value to the collector's DNP3 master. It is then the responsibility of the DNP3 master to download the associated fault log.

Conclusions

This note clarifies when and how QNA's LineWatch-M sensor identifies and logs fault currents. Several configurable parameters specify the expected fault range and the conditions for triggering the detection of a fault current. These parameters can be changed either via the sensor's website or managed through QNA's Sensor Configuration Management System (SCMS).

References

[1] N. Kang, Advancements in transmission line fault location, PhD Dissertation, College of Engineering, University of Kentucky, 2010.
[2] "Common Format for Transient Data Exchange (COMTRADE) for Power Systems", IEEE Standard C37.111-1999.

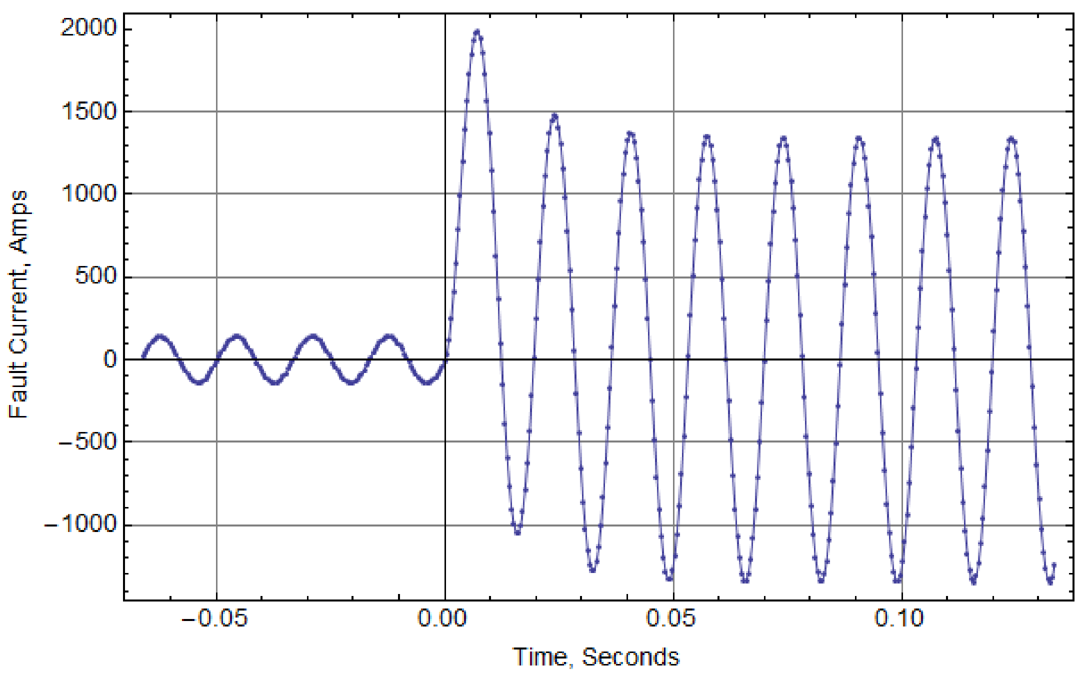

Figure 4: Notional current fault log: 4 cycles stored before the fault; 8 cycles after the fault; 2048Hz sampling rate.

Company Background

QinetiQ North America is an engineering and technology development company. QNA has achieved CMMI Level 3 certification and is certified to Aerospace Quality Management Standard AS9100. 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. The main QinetiQ North America campus in Waltham, MA contains 200,000 square feet of offices, laboratories, test facilities, and production areas.

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