배전 설비의 무선 통신을 이용한 배전 설비의 신뢰성 향상 기술 동향

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Trend for Managing Electrical Distribution Equipments Using a Wireless Sensors

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Abstract : This paper introduce methods and analysis of a simple wireless sensor concept for detecting and locating faults as well as for load monitoring are presented. The concept is based on distributed wireless sensors that are attached to the incoming and outgoing power lines of secondary substations. A sensor measures only phase current characteristics of the wire it is attached to, is not synchronized to other sensors and does not need configuration of triggering levels. The main novelty of the concept is in detecting and locating faults by combining power distribution network characteristics on system level with low power sampling methods for individual sensors. This concept enables the sensor design to be simple, energy efficient and thus applicable in new installations and for retrofit purposes in both overhead and underground electrical distribution systems.

Key Words : **Power distribution, Power system, Communications, power Pystem monitoring, Wireless transducers**

1. Introduction

Efficient fault management and load monitoring of electrical distribution networks are expected in the digital society of today. A method for accessing the needed process data from the distribution network is to install sensors at different locations, e.g. at incoming and outgoing power lines of secondary substations, and collect data from the distributed sensors to some data concentrator for further processing and analysis. Installing the sensors requires a substantial cabling effort and wireless sensors are therefore seen as a promising alternative.

Fernandes studied in [1, 2] the basic principles of using wireless sensors to monitor operating parameters of power systems. These prior art systems had all in common that they proposed different means on how to use wireless sensors to monitor load, detect and locate short circuits and single phase to earth faults. By measuring the temperature of power conductors, cable joints and terminations as well as the load current, the loading state of a distribution network can be monitored. To estimate future load behavior, the network operator needs information about the periodic load variation. In line with the standard EN 50160 [3] this may be presented in the form of 10-minute average values. Also peak values during a period may be of interest.

Some prior art wireless sensor solutions have solved these issues by using specific hardware design, by constantly measuring and reporting phase current and voltage [2], or by synchronizing sensors using the Global Positioning System, GPS [4].

In this paper, we introduce methods and analysis of a simple wireless sensor concept for detecting and locating faults as well as for load monitoring are presented. The concept is based on distributed wireless sensors that are attached to the incoming and outgoing power lines of secondary substations. A sensor measures only phase current characteristics of the wire it is attached to, is not synchronized to other sensors and does not need configuration of triggering levels. The main novelty of the concept is in detecting and locating faults by combining power distribution network characteristics on system level with low power sampling methods for individual sensors. Different sampling methods are assessed in the concept framework and test results with a prototype implementation are discussed.

2. Experimentals

A sensor measures the phase current characteristic only, thus a fault can be determined based on only changes in the phase current amplitude and phase shift. This implies that to detect a fault, a sensor must frequently sample the current and compare its characteristics to pre-set trigger levels. Sampling draws energy, and configuring trigger levels for different network topologies, is a very demanding task. Another method that does not require frequent sampling or complex configuration is introduced. A sensor stores the measured current characteristics in a FIFO buffer of length N. Let T be denoted the period of the fundamental power frequency, t a specific fundamental power frequency period in the time domain, and i(t) the current amplitude for t. If the current is sampled with a steady cycle of T, a buffer will contain amplitude samples i(t) ... i(t-(N-1)T). A fault is not recognized until the sensor measures a current signal of zero (or close to zero). This happens when the protective relays in the primary substation trip and cause the circuit breaker of the faulty line to open. When a sensor measures this loss of load current, it assumes that a fault has occurred. If the buffer size has correctly been chosen, the buffer will contain measurements of the current before the fault and after the fault transient has occurred (denoted current during the fault).

3. Results and Discussion

Fig. 1 shows the average current consumption of a sensor during tests of different tasks and different periods between the tasks. The Fourier algorithm that utilized only 6 samples consumed, despite the low number of samples, significantly more current than the simpler peak sampling methods. With the peak sampling methods, the sleep current dominated the current consumption when the period between measurements was longer than 60 ms. With the Fourier algorithm, the average current consumption was still 30μA with a period of 100 ms (the longest feasible period between measurements as discussed above). Considering the fact that 6 samples is a minimum realistic number of samples with the Fourier algorithm, a microcontroller with lower operating current dissipation should be used in the implementation of the algorithm. This feature becomes especially important when considering that 16 samples or more are needed to effectively remove harmonics and imaging frequencies of a signal that first has passed a low order analogue filter.

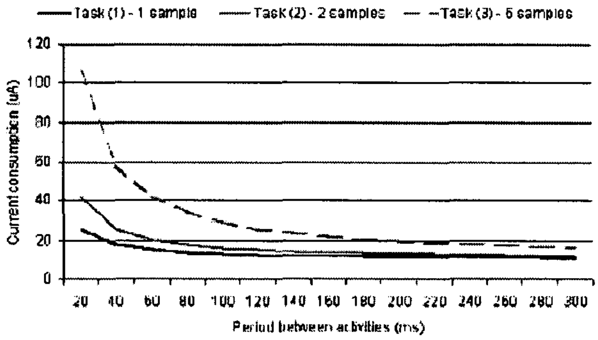

Fig. 1. Average current consumption of a prototype sensor with different sampling behavior and measurement periods.

4. Conclusion

A wireless sensor concept for load monitoring and fault management of electrical distribution networks has been presented. The concept is based on distributed wireless sensors that are attached to incoming and outgoing power lines of secondary substations. A sensor measures only phase current characteristics of the wire it is attached to, is not synchronized to other sensors and does not need configuration of triggering levels. However, current measurements made by these sensors are shown to be useful in fault management. This is achieved by analyzing the trend of the difference in measurements made before and during a fault.

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