WIRELESS SENSOR NETWORK BASED PD MONITORING OF UNDERGROUND CABLE SYSTEMS

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ABSTRACT

Maintenance of underline cable systems requires periodic measurement of many physical variables at numerous locations. This task can potentially be accomplished with wireless sensor networks. This paper describes the PD-sensing algorithms(Discrete Wavelet Transform) for the inspection of electrical power cables. The diagnostic sensor array includes thermal, visual, dielectric, and acoustic sensors for the measurement of cable status. Laboratory tests demonstrate the ability of integrated sensors to measure parameters of interest with the resolution required by the application. Field tests in the underground cable system demonstrate the ability of the designed platform to sense along the cable, and communicate with the host computer.

KEYWORDS

Underground Cable, PD, Wavelet, Wireless Sensor Network.

INTRODUCTION

Ensuring reliable and uninterrupted operation of transmission and distribution networks poses a key challenge in the area of monitoring and maintenance of power engineering systems. Indeed, monitoring the condition of high-voltage (HV) systems and cable networks is becoming increasingly important as customers demand cheaper electricity with greater security of supply. In turn, this translates to increased loading of HV cable circuits, whilst reducing overall maintenance and repair costs. Moreover, with unscheduled shutdown of equipment, additional costs are often incurred, which are subsequently found to be significantly above the cost of necessary repairs. A satisfactory online method of anticipating failure of key components is therefore required, so as to attain an economic lifetime extension of high-voltage equipment.

The development of wireless sensor networks(WSN) for monitoring and maintenance of underline cables is becoming more important among power utilities. The progress in this area is driven by the advancements in such enabling fields as ubiquitous computing, AI technologies, wireless communication, sensing, and power scavenging. The deployment of wireless sensor network systems can bring such advantages over traditional monitoring and maintenance methods as lower cost, higher measurement accuracy, and greater reliability of system operation. Due to the deregulation and the resulting increasing competition among utilities, the economic efficiency of daily operations is becoming increasingly important in power industry. One of the most costly tasks in the power industry is maintenance of power system infrastructure, namely, generating plants, transmission lines, substations, and distribution networks. A large portion of electric power distribution is accomplished through cable networks. A typical power utility maintains millions of miles of installed cables. Many urban cable installations, targeted in this project, are installed in tunnels, conduits, or pipes, which makes them accessible for WSN. Existing cable maintenance practices fall into one of the two categories: unplanned maintenance or planned maintenance. Unplanned maintenance is a response to a failure that may have caused a power outage. Planned maintenance is a scheduled inspection or replacement of power cables. Although planned maintenance ultimately delivers a more reliable continuous service, it is not an economical option for utilities. High reliability of an installed network requires conservative estimations of the remaining cable lifetime. Premature replacement of cables leads to economic losses, which could be avoided if the replacement decision were based on the specific site data rather than on generic estimates. Condition based maintenance is often viewed as a possible solution in the industry. Case studies showed that up to 2/3 of the cable systems scheduled for replacement could be kept in service with predictive diagnostics. A key component of condition based maintenance for cable systems is obtaining accurate information about the condition of each cable. Existing techniques for monitoring the aging of distribution networks require manual inspection of individual cables by maintenance staff or by outside consultants. The instrumentation used for such tasks varies from simple handheld devices to vans equipped with highly sensitive measurement devices. In all cases, the cable inspection is a costly process. A broad spectrum of sensing principles is used for the inspection tasks. Some of these sensing methods, especially acoustic detection, are greatly enhanced by the ability to take measurements along the cable, as opposed to relying on measuring parameters at the ends of the cables. The goal of this project is to develop an WSN platform that can inspect underground power distribution cables, thus providing utilities with accurate information regularly and at a lower cost.

OPERATIONAL ENVIRONMENT

The underground cable environment is not as geometrically simple as a pipe and requires a much more adaptable design for WSN. Fig. 1 shows an example of the cables and their surroundings in a 154kV underground installation at S district, Seoul, Korea.