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Technology in Power Systems

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Abstract - IOT technology is considered an essential imperative for Smart Grids (SGs). However, IOT devices have inherently limited responsiveness that may not be sufficient for a time critical Smart Grid with strict demands on communication delay. In practice, it remains an outstanding problem to combine IOT technology with existing grids. To facilitate deployment of IOT-based grids in domestic environments, we propose IOT-grid, a programmable, small-scale grid that can be easily implemented with low-power hardware with limited processing capacity.

Keywords - ***Sensor, IOT, Smart Grid, Wi-FI.***

I. Introduction

ECONOMICALLY effective maintenance and monitoring of power systems to ensure high quality and reliability of electric power supplied to customers is becoming one of the most significant tasks of today's power industry. As with any preventive maintenance technology, the efforts spent on the status monitoring are justified by the reduction of the fault occurrence and elimination of consequent losses due to disruption of electric power, damage to equipment, and emergency equipment replacement costs. In the past few years, there have been several significant developments on monitoring technologies for distribution power cables. This review describes technical results relevant to mobile sensing of distributed systems, especially for maintenance tasks.

Hardly any successful robot applications have been reported for underground distribution cables. Numerous problems have to be solved for this kind of a robot, such as space confinement, size and weight restrictions, wireless design requirements, and adverse environmental conditions. Miniaturization has been one of the most difficult problems. With the continuing development of MEMS, microelectronics, and communication technologies, this problem is on the verge of being solved. Successful applications of microbots were demonstrated in other fields. Generally speaking, the mobile monitoring of power systems involves the following issues.

1) **Sensor fusion:** Monitoring the condition of cables requires incorporation of sophisticated property-monitoring sensors in addition to positioning, tactile, and other sensors aimed to support the autonomy of robot movement.

2) **Motion pattern:** Inspection robots used in power systems can be subdivided into external and internal ones. External robots travel over the outer surface of electrical components and may possess a high degree of autonomy whereas internal units use inner spaces of ducts and pipes and are often implemented as track-following devices with a predetermined route, and a limited set of operations. The level of autonomy depends on the task. For example, routine inspection and maintenance require a high degree of autonomy for economical reasons.

3) **Power supply:** Since the cable network is a global distributed system, it is very limiting for the inspecting robot to draw a power cord behind itself. Ideally, the power supply has to be wireless. It is desirable that the platform harvest energy from energized cables. Inductive coupling for a wireless power supply could be a desired method. It has been investigated for vehicles, batteries, microsystems, and numerous consumer applications. Although a low-frequency coupling is less efficient than a microwave mode, direct proximity to the power cable will make it a viable choice. Of course, the platform requires an independent backup power source as well.

Control strategy

It includes object tracking, collision avoidance, and prevention of electrical short circuits. The control system receives initiating commands from the operator for the global tasks, and small tasks are often preprogrammed. The most important requirements are the following.

a) The control should be robust because of complicated motion requirement and the irregular surface of the cable connections.

b) It should include an optimum algorithm used to locate the sensor array with respect to the inspected system, a path planning algorithm used to track the whole or part of the network with the shortest path, and control sequences adaptively switching sensor operation from a fast superficial inspection mode to a slow detailed inspection mode.

c) The robot requires considerable computational resources to be adaptive and flexible. This fact is highly problematic because of the limited size of the robot, especially for underground applications. Accordingly, this strongly argues for the use of communication and off board intelligence. This also involves allocation between local and remote signal processing.

II. Sensors and Signal Processing

The main sensing principles appropriate for monitoring of power cables include acoustics, dielectrometry, thermal imaging, eddy currents, and visual inspection. This section offers an overview of several projects dealing with relevant technological issues. A. Discrimination of Energized Cables As the power network continues to expand and becomes more interconnected, the task of maintaining an accurate topological representation of a power grid is often sacrificed. Consequently, maintenance personnel often need to determine the energization status of underground cables. A mobile monitoring system should be capable to do the same task. The predominant detection method practiced today is intrusive in nature, requiring the maintenance personnel either to puncture or remove the protective conducting sheath surrounding the cable in order to measure the emanating electric field. Fourier transform of acoustic signatures of underground power cables.

(a) Non energized cable.

(b) Energized and loaded cable.

This method compromises the integrity of cable insulation. Acoustic vibrations generated by columbic forces and current interactions are a preferred potential indicator of the cable's energization status because acoustic measurement is nondestructive. In an energized cable, whether or not it is carrying current, substantial second harmonic (120-Hz) acoustic surface waves are generated. A piezoelectric accelerometer responds to both surface acoustic waves and power frequency electric fields of an energized conductor. Analysis of the frequency spectrum and spatial distribution of acoustic waves on the sensor surface is required to discriminate between the two effects. Non-energized with strong ambient noise; and energized at low voltage, 10-A balanced load. The strong presence of the 120-Hz component is fairly easy to detect; however, the presence of other energized cables in the vicinity of the cable under test makes the discrimination task more difficult. Surface imaging is necessary for non-ambiguous classification. B. Evaluation of the Electrical Insulation Status Maintenance of aging power cables is a major cost item of the total maintenance of an electric network, which can be significantly reduced by a more accurate prediction of the remaining lifetime of cable insulation. Several methods are used to evaluate the aging status of electrical insulation, including eddy currents, acoustic sensing, and X-rays. The most useful and commonly used methods rely on measurement of electrical properties (dielectric conductivity and resistivity), measurement of partial discharge activity, and thermal analysis of insulation under stress.

Fringing Electric Field Dielectrometry: Interdigital dielectrometry is a subset of interdigital electrode sensor applications that relies on direct measurement of dielectric properties of insulating and semi-insulating materials from one side. The basic idea is to apply a spatially periodic electrical potential to the surface of the material under test. The combination of signals produced by the variation of the spatial period of interdigital electrodes, combined with the variation of electrical excitation frequency, potentially provides extensive information about the spatial profiles of the material under test. Since changes in the dielectric properties are usually induced by changes in various physical, chemical, or structural properties of materials, the dielectrometry measurements provide effective means for indirect nondestructive evaluation of vital parameters in industrial and scientific applications. While interdigital electrode structures have been used since the beginning of the century, the application of multiple penetration depth electric fields started in the 1960s. Later, independent dielectrometry studies with single and multiple penetration depths using interdigital electrodes have been continued. Generally speaking, the evaluation of material properties with fringing electric fields is a much less developed area than comparable techniques. This field holds tremendous potential due to the inherent accuracy of capacitance and conductance measurements and to imaging capabilities combined with noninvasive measurement principles and model-based signal analysis. For a homogeneous medium of semi-infinite extent, a periodic variation of electric potential along the surface in the direction produces an exponentially decaying pattern of electric fields penetrating into the medium in the direction. Note that each wavelength has an opposite conducting guard plane at the bottom of the substrate. For each wavelength, a follower op-amp drives the guard plane at the substrate bottom at the voltage , thus eliminating any current between the sensing and guard electrodes.

Generic fringing electric-field interdigital sensor. The terminal characteristics, namely, capacitance and conductance between the interdigitated electrodes, are functions of the substrate and ambient environment properties.

(a) A single-wavelength generic design.

(b) Half-wavelength cross-section with a superimposed equivalent circuit model.

Conceptual representation of forward and inverse problems in the framework of dielectrometry. Inherently more difficult. It does not necessarily have a unique or any solution, since it requires solving for unknown properties given a known subset of material and geometrical properties as well as the measured trans capacitance and trans conductance. Furthermore, even if a unique and exact mathematical solution exists for a given set of input values, it may have no resemblance to the true physical parameters because of the effects of measurement noise. Acoustic Sensing: Partial discharge (PD) measurement is an important diagnostic tool, especially for medium- and high voltage cables, where local intensity of electric stress can reach breakdown values. A broad range of PD measurement techniques includes acoustic, current, and voltage, electromagnetic, time- and frequency-domain reflectrometry, and optical sensing. Acoustic sensing is very successful for switchgear and transformers, because it is free from electrical interference, very easy to apply, has no need to power down, and does not require additional components, such as high-voltage capacitors. However, cable applications with acoustic sensing are much scarcer, while electrical PD measurement methods are more preferred. The main reason is that acoustical discharge signal is attenuated during propagation.

III. The IOT Smart Grid

IOT technology is considered an essential imperative for Smart Grids (SGs). However, IOT devices have inherently limited responsiveness that may not be sufficient for a time critical SG with strict demands on communication delay. In practice, it remains an outstanding problem to combine IOT technology with existing grids. To facilitate deployment of IOT-based grids in domestic environments, we propose IOT-grid, a programmable, small-scale, grid that can be easily implemented with low-power hardware with limited processing capacity. The proposed grid adopts relatively cheap DC-DC converters which not only provide high conversion efficiency but also accommodate existing small-scale DC power systems (e.g. solar panels). We then explore the communication aspects of IOT-grid, namely, control and monitoring functions. We observe that processing delays of IOT devices have large impact on IOT-grid, which cause a chain of control commands to take considerable longer time as the number of commands increases. To mitigate this problem, we propose a mechanism based on sending burst commands with scheduled responses. Our experimental results show that, in the presence of processing delays, this method can significantly reduce the overall response time.

To Make power systems more efficient and Information Technology enabled it is very important to incorporate smart concept in Grid Stations. A Smart Grid is simply a combination of electrical and infrastructure using IT service within existing electrical network.

IV. Sensor Technologies

We live in an age of relentless and accelerating change, driven by demographic, social, and economic evolution. Each day, there are more of us consuming the finite natural resources of the planet. Our impact on the planet is increasing through urbanization, energy utilization, waste production, and so on, and this impact is not without consequences. Levels of pollution are increasing in our environment, with corresponding effects on our health and well-being. From smog clouds in cities and pollution of our drinking water to simply being denied sufficient peace to sleep soundly at night, human activity has enormous impact on us and on our planet. Major changes in the way we work and live during the last century mean we are also living much more sedentary lifestyles. This has resulted in growing public health issues, such as obesity, arteriosclerosis, cancer, chronic liver disease, and other lifestyle diseases. Increased life expectancy places greater pressures on our healthcare systems as the world's population continues to grow older. Governments are being forced to cut programs such as home healthcare assistance to reduce burgeoning costs. The current model simply does not scale into the future.

Sensors play an integral role in numerous modern industrial applications, including food processing and everyday monitoring of activities such as electricity, transport, air quality, medical therapeutics, and many more. While sensors have been with us for more than a century, modern sensors with integrated information and communications technology (ICT) capabilities—*smart sensors*—have been around for little more than three decades. Remarkable progress has been made in computational capabilities, storage, energy management, and a variety of form factors, connectivity options, and software development environments. These advances have occurred in parallel to a significant evolution in sensing capabilities. We have witnessed the emergence of biosensors that are now found in a variety of consumer products, such as tests for pregnancy, cholesterol, allergies, and fertility. We can deploy different types of sensors in our electrical domain also to introduce smartness like ATmega32 with IOT Gecko.

V. Conclusion

In this paper I have briefly described technical results relevant to mobile sensing of distributed systems, especially for maintenance tasks. Replacing human workers for dangerous and highly specialized operations, such as live maintenance of high-voltage transmission lines, has been a long-standing effort in the power community

VI. References

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