APPLICATION OF ARTIFICIAL INTELLIGENCE TO THE PROBLEM OF SELECTING THE APPROPRIATE DIAGNOSTIC FOR CABLE SYSTEMS

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ABSTRACT

Cable System Management requires an assessment of the health of the cables system. It is increasingly common for the assessment of aged cable systems to be made through the application of diagnostics measurements. There are a plethora of these techniques and embodiments; such that even an informed user has great difficulty making a rational choice on the most appropriate technique. To aid this decision making a Knowledge Based System has been developed that takes the knowledge of many diverse experts and delivers a robust framework by which rational, reproducible and transparent choices may be made. This paper discusses the development of the system and provides a number of illustrative case studies.

KEYWORDS

Diagnostic Techniques, Knowledge Based Systems, Expert Systems, Artificial Intelligence

INTRODUCTION

The proactive management of cable systems (accessories and cables) is of increasing interest to utilities the world over. One of the most useful tools available in this asset management process is a diagnostic approach to estimate the “health” of the system. There are a great many diagnostic techniques that are available for many of the specific cases that a utility may encounter. However the multitude of techniques presents its own challenge to a user; the most important of which is “how to select the most appropriate diagnostic for a particular set of circumstances”. The selection problem is complex because

- Not all utility systems are constructed in the same way or experience the same issues; thus prior history or peer recommendation are likely not to be useful
- The selection process requires multiple pieces of information that cannot be represented in a simple table or flow diagram.

To address these issues a Knowledge Based System (KBS) has been constructed, using Expert Systems and Fuzzy Logic, to assist utilities in selecting a short list of diagnostics that are suitable for their particular circumstances. The approach described in this paper solicits expert opinion from users, manufacturers and standardisation bodies. This knowledge is captured in databases that may then be interrogated by a user through the provision of some key information on the system to be diagnosed. The user provided input includes: the age of the cable system to be tested, the type of insulation system (PE, Paper, EPR, or hybrid combination) and likely remediation actions.

The output from the KBS is a short list of appropriate diagnostics to which the utility may apply engineering judgment to effect the final selection. The judgment process is assisted by the format of the output which provides the percentage of agreement between the contributing experts, thereby preserving the context of all the potential diagnostics. The expert recommendations are also presented with perspectives of total cost and total time required. Thus this paper will describe:

- Issues faced by diagnostic users.
- Limitations of classic approaches (flow diagrams, tables, etc).
- Available Artificial Intelligence tools including the Expert Systems & Fuzzy Logic used here.
- Challenges of acquiring expert opinion.
- Practical implementation of the methodology, including application to hybrid circuits (mixtures of EPR, Paper and PE based insulations).
- A case study where this approach was implemented successfully.

ISSUES FACED BY DIAGNOSTIC USERS

Table 1: Selection of Diagnostic Techniques proposed for MV Cable System Assessment

General Class	Implementation
Simple Withstand	DC Hipot
	VLF Hipot
Monitored Withstand	DC Hipot & Leakage
	VLF Hipot and Leakage
	VLF Hipot & Tan Delta
	VLF Hipot & Partial Discharge
Dielectric	Tan Delta
	Dielectric Spectroscopy (frequency or time domains)
	Recovery Voltage
	Leakage Current
Partial Discharge	Elevated Voltage (Offline)
	Operating Conditions (Online)
Combined	Partial Discharge and Dielectric Loss Estimation (Damped AC)

There is a wide range of cable system diagnostic testing techniques available for evaluating the condition of underground cable systems. For many of these techniques, there are also variations on the same basic technology. To determine the correct technique for a given application, an engineer should consider:

- Effectiveness – Does the technique do what is intended?
- Maturity – Has the technique been deployed long enough to assure its effectiveness? (Much of the benefit of diagnostic testing comes from a comparison with measurements on other circuits. Useful comparative data may be unavailable for immature or changing technologies/techniques).