Autonomous Tele-Information Network for Power Systems Switchgear Equipment e-Diagnostics

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1. Introduction

The purpose of the network is to integrate protection and control functions with e-testing of switchgear secondary voltage equipment and e-diagnosis of Circuits Breakers during normal operation.

Circuit Breakers (CB) are very important elements in the power system. They need to be reliable since their incorrect operation can cause major issues with power system protection and control. Due to large overloads that Circuit Breakers have to sustain when switching out shorted lines they are more susceptible to damage than other equipment and because of their cost they are expensive to replace. New methods of CB diagnosis have to be developed to increase the reliability of CB operation and to lower the power substation maintenance costs.

Keywords: circuit breaker diagnosis, IEC 61850, protection relay

2. Architecture of the system

The architecture of the system, with implementation shown in a greater detail in one power substation, is presented in Fig. 1. Within each substation all communication is according to IEC 61850 [1].

The controlling devices associated with each CB collect digitalized data from every possible electrical node of CB. The IEC 61850 wrapped data are then sent via SUBSTATION ETHERNET BUS to a CONCENTRATOR (CONC). The only processing of the data carried out at controlling devices is connected with protection functions implemented in it. It consists in determination of the Fourier spectrum of current and voltage signals and RMS values.

The main software processing of diagnostic data coming from CBs is localized at the CONCENTRATOR. It consists first of all of procedures for parameterization of the waveforms obtained at various nodes of CB. Various features of signals are extracted like transition time, pulse duration, spectrum content, contacts bouncing times etc. The second part of the software installed at the CONCENTRATOR is an Expert System that makes conclusions concerning the conditions of individual CB based on a system of rules collected in a database. These rules represent the knowledge about each CB and they have been formed as generalizations of long time testing of CB.

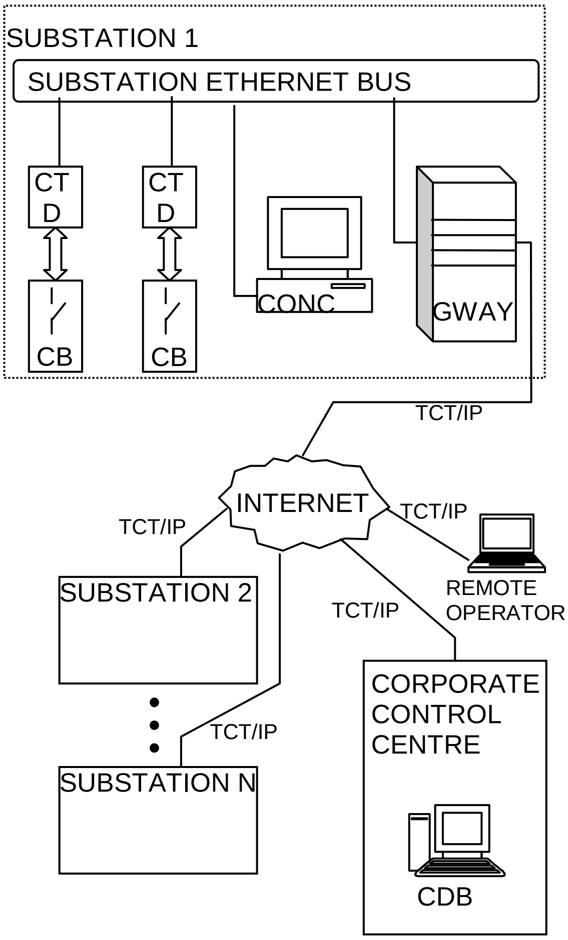

Fig. 1 e-Diagnostic Network System Architecture

The individual SUBSTATIONS are connected via GATEWAY (GWAY) to INTERNET. This enables the geographically dislocated classified operator (REMOTE OPERATOR) to access each SUBSTATION CONCENTRATOR or a CENTRAL DATABASE (CDB) and facilitates easy access to the historical data, making reports and their dissemination across the company.

3. New methods of CB monitoring

Normal procedures of CB servicing consist basically of counting the number of activations and then carrying out a detailed examination of the CB in off line mode. Recently methods have been developed to assess the condition of CB during normal operation by monitoring the electrical signals at every available CB node. These are switched currents and voltages, currents of activation coils and voltages at various auxiliary location contacts that measure the time it takes for the main contact to close or open. The behavior of electrical signals, however, cannot give precise information about the condition of CB contacts which are crucial to CB proper operation.

One of the new methods of CB monitoring is based on optical technology. It requires an optical fiber and special detector. The diagram of such a solution is presented in Fig. 2. The heat generated within contact area depends directly on the contact resistance. The infrared emission is detected and converted to temperature. For proper contact evaluation it is necessary to have an a priori determined heat distribution pattern during normal operation with healthy contact for comparison. The advantage of this method is that it can be used without any interference into inner construction of the CB.

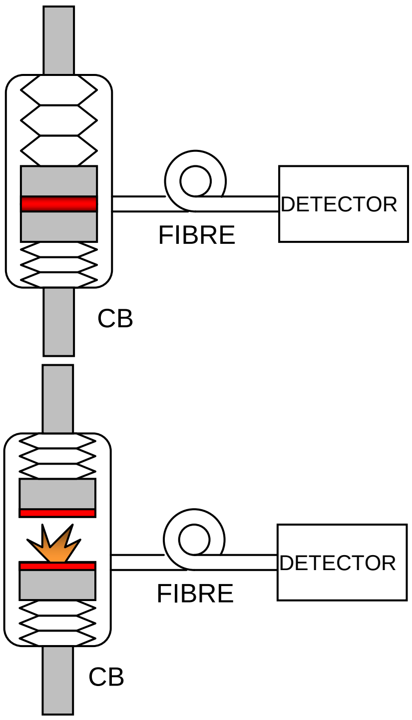

Fig. 2 Schematic of diagnostic circuit during CB closure and opening

The second of the CB diagnostic method uses spectral emission analysis and detection of special spectral lines during contact breaking. This solution demands from CB manufacturer a special construction of contact area. This construction is such that the contact is composed two layers made from different materials, one for the contact itself and one for the contact base. Such a construction greatly facilitates the detection of spectral emission changes and the moment of complete degradation of the contact area. The wear of the contact caused by subsequent closures and openings exposes its base layer so that emission lines that characterize the material in the base layer appear in the emission spectrum.

The spectral analysis has been carried out for arc and glow discharge for contacts made of pure materials like Ti, Ta, Ni, W Mo and for contacts made from sintering of different alloys [2,3].

4. Conclusion

The described method of contact diagnostic together with experimental research done on the subject [4] show that it is possible to apply optoelectronic elements for CB contact degradation detection during normal CB operation.

The optoelectronic methods together with detailed analysis of electrical signals at all nodes available in CB provide for comprehensive diagnostic of CB.

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