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Author(s): Shafiq, Muhammad; Kauhaniemi, Kimmo

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Proactive Condition Monitoring for Power Grid

Muhammad Shafiq, Kimmo Kauhaniemi
School of Technology and Innovations, University of Vaasa, Finland
Muhammad.Shafiq@uwasa.fi, Kimmo.Kauhaniemi@uwasa.fi

TOPIC

Increased dependability and the demand of electric power have compelled the electrical utilities to focus on the modernization of power distribution systems. One of the major deriving forces to modernize is the demand for improved reliability, efficiency, and safety of power grid. This asks for optimization of capital assets while minimizing the operation and maintenance costs of the network. Currently, implementation of smart grid technologies is the key focus of EU in power system arena. Complying with the road map of the European Strategic Energy Technology Plan SET 2020 and SET 2050, broad ranging smart grid transformation is bringing both opportunities and challenges [1]. Because of smart grid based technological advancements, physical and operational character of the network is changing. One of the major targets of the energy roadmaps is the advancements in the methodologies for monitoring and diagnostics of the network components in order to extend the in-service lifetime of the power networks. The additional operational challenges requires significant upgradation of the condition monitoring solutions for critical components of the network that is the aim of this research work.

DESCRIPTION

A power network is composed of a number of electrical components (as shown in Fig. 1) such as underground cables, overhead covered conductor, and bare conductor overhead lines. Switchgears, transformers, and connecting and protection devices are the necessary electrical components. The networks are always exposed to predictable and non-predictable failures. During a survey of Stockholm, out of 1392 total failures, 174 were due to power transformers, cables (including joint and terminations) caused 435 failures, overhead lines, and bus bars were responsible for 36 failures [2] while rest of failures were due to other faults such as disconnectors, circuit breakers, and rectifiers etc. Insulation damage is one of the major causes of failure in the components. Slowly developing insulation faults are predictive failures that can be forecasted and hence be avoided by performing suitable preventive actions. The focus of this research is the proactive condition assessment of the medium voltage (MV) cables.

Fig. 1. Critical components of power network

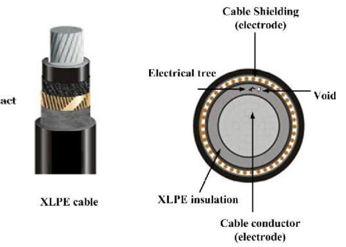


Fig. 2. Underground cable with crack in the insulation

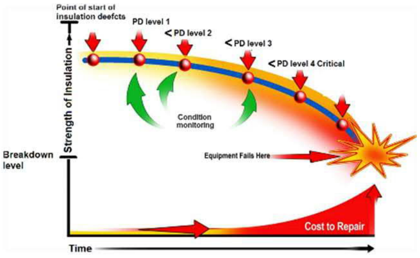


Fig. 2. General behavior of partial discharge

Depending upon the dielectric properties and thickness of the insulation material, the insulation of the electrical components has a certain electrical breakdown strength (kV/mm). The insulation defects such as cavities, cracks, air bubbles and treeing (see Fig. 2) in the dielectric insulation cause degradation to the cable insulation and grow with time due to TEAM stresses (thermal, electrical, ambient and mechanical stresses). At a certain time, insulation strength becomes so weak that it suffers localized breakdown and causes partial discharges (PD). Once the process is triggered, the insulating material start to deteriorate progressively and eventually leads to an electrical breakdown as shown in Fig. 3. PD is a clear indication of incoming insulation fault and suitable monitoring system can be developed for taking required maintenance actions before the failure happens.

The distribution grid infrastructure is getting bigger. As the DG predominantly is embedded in the distribution grid therefore a large scale cabling of the distribution grids is in progress. This transition is making the layout of the distribution cable network more meshed and interconnected. There is a significant increase in the number of cable sections, connection points such as joints, terminations, and transformer tapping. Such increased number of components pose a challenge for effective monitoring.

An efficient condition monitoring system consists of a suitable monitoring and diagnostic system as shown in Fig. 4. Monitoring system includes the design of sensors in order to capture the PD signals emitted from the occurred dielectric defects while diagnostic system refers to the sensor installation schemes and techniques of detection, location, and quantification of the faults. There are certain features of the PD signals, which can be identified and configured to assess the insulation condition of the affected components. A comprehensive condition assessment system with automation functionalities (shown in Fig. 5) requires the information of the type and characteristics of the employed sensors, the type of the components, and the techniques of diagnostics.

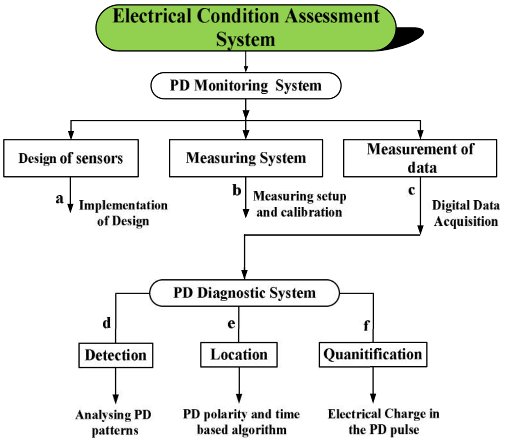
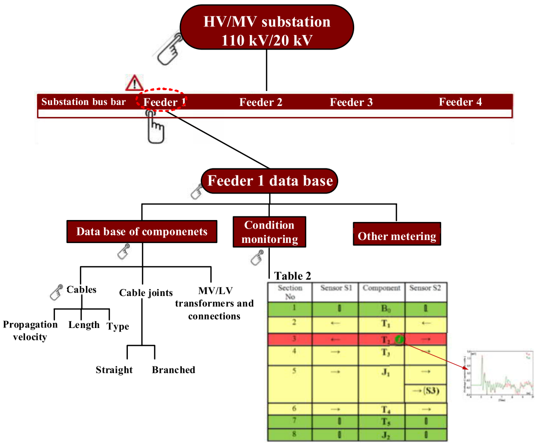


Fig. 4. Layout of an electrical condition monitoring system



Section No	Sensor S1	Component	Sensor S2
1	0	B_0	0
2	←	T_1	←
3	←	T_2	→
4	→	T_3	→
5	→	J_1	→ →(S3)
6	→	T_4	→
7	0	T_5	0
8	0	J_2	0

Fig. 5. Online condition monitoring system for MV cables

CONCLUSIONS

The outcome of the research serves to develop low cost, non-intrusive, and integrated monitoring solution with automation functionality for power grid. Continuous real time monitoring eliminates the probability of missing the threat, which can easily be missed during periodic monitoring. Optimized data processing will increase the processing speed and reduction in data volume for storage and management. In addition to reduced failures, a major outcome of this research aims at maximizing the in-service life of the components, which serves not only to increase the return on the investment but also to delay the heavy investments in replacing the components.

REFERENCES

[1] Catterson, V. M., et al. "The impact of smart grid technology on dielectrics and electrical insulation." IEEE Transactions on Dielectrics and Electrical Insulation, 2015.

[2] L. Bertling et al. "Survey of causes of failures based on statistics and practice for improvements of preventive maintenance plans" in14th Power Systems Computation Conference, 2002.

[3] M. Shafiq et al. "Online Condition Monitoring of MV Cable Feeders using Rogowski Coil Sensors for PD Measurements", Electric Power Systems Research, 2019.

[4] S. Bahadoorsingh et al. "A Framework Linking Knowledge of Insulation Aging to Asset Management," in IEEE Electrical Insulation Magazine, vol. 24, no. 3, pp. 38-46, May-June 2008.