Fully Automated MV Cable Monitoring and Measurement System for Multi-Sample Acquisition of Artificial Aging Parameters

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The Power quality of our networks is influenced by transients, short- and long-duration variations, voltage unbalance, waveform distortions, voltage fluctuations and power frequency variations. These impacts affect the aging rapidity of the electrical equipment and finally the entire electrical network. Cables and their equipment represent one of the major investments for power supply companies. In addition, cables and sleeves are a frequent source of damages and accordingly a source of network faults and supply discontinuities.

Since unexpected cable faults in MV cable networks appear more frequent, a lot of scientific research has been directed to determine the remaining cable life time (time to the first failure). In many cases PD and tan(δ) measurement and analyses are used for the prediction of failures, their localization and selective replacement of defective cable sections. Thus far, there are some aging systems developed for XLPE (cross-linked polyethylene) cables. In case of lead shielded cable types, these prediction systems do not deliver reliable prognostic data because the physical and chemical backgrounds are not comparable. Unlike to XLPE-cable analyses, where the PD-level is already a significant indicator for the cable status, PILC (paper insolated lead covered) cables need an additional criterion. Because of their physical characteristics, the PD-ratio on its own may not give a reliable impression of the actual aging status. Therefore, the determination of the tan(δ) has to be achieved by a sophisticated mathematical algorithm. The significance of the results depends on the quality of the measurement system and of the data interpretation.

As a result, a specially designed aging system for the accelerated aging of MV cables has been developed to point out the most relevant aging parameters and their limits. It consists of a measurement system, a control system and an integrated and combined soft- and hardware security system. As the whole system is designed to run twenty-four-seven for several years, the continuity and security of the aging process was focused especially. The cables' status and condition is analyzed by the measurement of the characteristic aging parameters.

To reduce hard- and software effort for the sequential tan(δ)- and PD-analyses of the cable samples, a 64-channel analog/digital switching matrix (CSU) was developed and realized. It enables the diagnostic kernel to be focused on a single cable and to measure all relevant parameters with the highest achievable accuracy.

The accelerated aging of the cable samples is accomplished by dielectric and thermal stress. Dielectric stress means up to four times nominal voltage, generated by a resonant system which works at mains frequency.

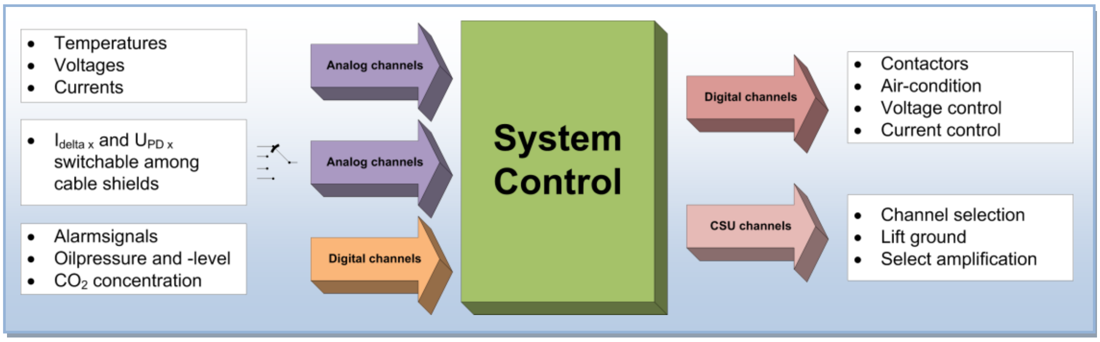

Fig. System control and influencing variables

Thermal stress is applied by a specially manufactured current transformer and rectifier, which feeds in about two times equivalent nominal current on high voltage level. The cables themselves are situated in an air-conditioned container.

The measurement and control system consists of a great number of integrated hardware units. Most of these single units are specially developed and constructed to build up an automatic and, in addition, remote-controllable accelerated aging system. The "System Control" realizes the control, acquisition and measurement of nearly 100 analog and digital in- and outputs (see fig.). All relevant parameters, like e.g. voltages, currents, temperatures, characteristic aging values and security information are acquired, evaluated and stored by this central control system.

Based on the described continuous and sample-wise monitoring of the significant aging parameters and their development during the aging process, an "aging" database will be built up. This database will be the fundament for the determination of the relevant electrical, physical and chemical parameters and for the further developments of cable diagnostic methods and mathematical aging models. On behalf of the created database, criteria for the development of a diagnostic system for field studies should be derived. One of the key values will be the aging factor - AF. It defines the aging rapidity, which is the rate between time to the failure under the test conditions and the characteristic cable life time for the same cable in real operation. Therefore, a condition-oriented maintenance strategy and asset management is made possible and the investment planning can be improved. Moreover, this is one way to increase the power quality and reliability in today's MV distribution networks.