Power Cable Temperature Reconstruction From Electromagnetic Reflectometry Data

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Project description

Connecting new customers to the electric power grid is only possible if the resulting current in power cables does not exceed a predefined limit. This limit is determined by the highest temperature a cable can sustain. Above this temperature, the isolation inside the cable may become ineffective, which may lead to a short circuit. The usual thermometers are not very practical for monitoring the temperature distribution over long underground power cables. One possible alternative is an indirect measurement technique that deduces the cable temperature distribution from the electromagnetic reflectometry data.

Reflectometry is a method used for measuring the properties of a transmission line by sending an electromagnetic pulse along the line and analyzing the reflected signal. The pulse is partially reflected by the inhomogeneities of the transmission line, namely, by the variations of its impedance. Theoretically, the electromagnetic constitutive parameters of the cable that determine its impedance, such as the dielectric permittivity of the insulation material, depend on the temperature. Thus, if one can recover the impedance variations along a power cable, then it should be possible to deduce the cable temperature profile as well.

In this project the student will study both the *forward* model of the pulse propagation along a cable with the temperature-dependent impedance, as well as the *inverse* problem of recovering the impedance and temperature distributions from the reflected data.

This project will be carried out in close cooperation with our industrial partner Alliander N.V. The company will provide a supervisor and financial support.

Recommended literature

Transmission lines and reflectometry

Wikipedia: https://en.wikipedia.org/wiki/Transmission_line

Wikipedia: https://en.wikipedia.org/wiki/Time-domain_reflectometer

S.Y. Liao, *Engineering Applications of Electromagnetic Theory*, West Pub. Co. 1988

L.C. Shen and J.A. Kong, *Applied Electromagnetism*, PWS Publishers, 1987

Steennis, F., Wagenaars, P., van der Wielen, P., Wouters, P., Li, Y., Broersma, T., Harmsen, D. and Bleeker, P., Guarding MV cables on-line: With traveling wave based temperature monitoring, fault location, PD location and PD related remaining life aspects. *IEEE Transactions on Dielectrics and Electrical Insulation*, 23(3), pp.1562-1569, 2016.

Li, Y., Wouters, P.A., Wagenaars, P., van der Wielen, P.C. and Steennis, E.F., Temperature dependent signal propagation velocity: Possible indicator for MV cable dynamic rating. *IEEE Transactions on Dielectrics and Electrical Insulation*, 22(2), pp.665-672, 2015.

Inverse problems

Wikipedia: https://en.wikipedia.org/wiki/Inverse_problem

C.R. Vogel, *Computational Methods for Inverse Problems*, SIAM 2002.

M. Norgren and T. Takenaka, Full Newton method for inverse transmission line problems, utilising explicit second order derivatives, *Inverse Problems in Science and Engineering*, Vol. 15, No. 8, December 2007, 827-853