Model-based predictive control for use in RTTR temperature sensing systems of high voltage cables

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This study presents an adaptive method for the transient calculation of buried power cables in fiber optic distributed temperature sensing (DTS) systems with real time thermal rating (RTTR).

The accuracy of an RTTR system depends heavily on highly uncertain parameters: correct soil modeling with thermal resistance and thermal capacity of the soil, and accurate estimation of the ambient temperature. In order to eliminate these uncertainties, a model-based predictive control is used to determine and adapt the soil parameters and ambient temperature from the temperature measurement data.

The soil and the cables are modeled as multiple thermal layers with RC elements. The cable modeling remains basically compatible with the replacement model according to IEC 60287.

For the control of the nonlinear system two separate Kalman filters are used. Instead of splitting the thermal resistances to consider external heat sources, the heat source lossess are split and assigned to existing thermal nodes. This allows larger time constants and improves the calculation performance.

The modeling was extended with:

- consideration of cables buried directly in soil as well as in ducts and with backfill
- arbitrarily location of the DTS fiber inside or outside of the cable
- measurement time delay of a fiber optic cable for DTS inside a duct and buried in soil

The RTTR software was verified using existing DTS data over a longer time period. The change in the ambient temperature and the soil properties of the Kalman filters has also been analyzed.

Finally, prediction routines were implemented to iteratively calculate current, time or temperature.

Key words
Monitoring, Dynamic Current Rating, Real-Time-Thermal-Rating, Distributed-Temperature-Sensing, Integrated DTS/RTTR System

Topic (Category)

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