A new approach for estimation of the dynamic thermal rating model parameters based on the IEC standard

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ABSTRACT

Distributed Temperature Sensing, DTS, is a well-established technology that provides, in real time, temperature distribution all along the cable route. The technology is not fully exploited without real time thermal rating. In this paper, a new method based on the IEC standard to update the thermal model of cable installations in real time is introduced. The model has been tested on different types of installations. It is shown that one can use DTS readings, load variation and the IEC standards to calculate conductor temperature and optimize the usage of cable asset in steady state and transient situations.

KEYWORDS

distributed temperature sensing, real time thermal rating, dynamic feeder rating.

INTRODUCTION

In the majority of cable installations, maximum permissible conductor temperature is the parameter that limits current carrying capacity. This limiting temperature is determined by properties of the insulation material in direct contact with the conductor temperature conductor.

DTS systems provide, in real time, better understanding of how the conductor temperature responds to load variations. The current trend is to measure the temperature at a layer as close as possible to the cable conductor. To this end, fine steel tube with fiber optic sensor inside is included between concentric wires or set in direct contact with the jacket, duct or pipe depending on the type of cable and installation. In the case of existing installations, it is a common practice to install the fiber sensors in spare ducts close to the cables.

During the steady state operation, one can estimate the conductor temperature by using the load values, internal construction of the cable and the DTS readings for a given cable layer. The closer the fiber is to the cable conductor, the more accurate the estimate is. It is worth exploiting the full capacity of DTS systems once they are installed. The first step could involve using DTS systems to obtain conductor temperature. However, in practice the important question is how much more load can the cable system carry in the steady state, transient or emergency situations.

Parameters that affect the rating of a given installation are either constant or change with time. Geometry of the installation including depth and the relative position of the cables or cable construction are examples of constant parameters. For underground installations, soil thermal resistivity and ambient temperature are the most important parameters that depend on time. In the case of installations above ground, ambient temperature, solar radiation and wind velocity are important time varying parameters. Updating time varying parameters for cables in free air in real time can be very important because these installations usually have very low time constants.

External thermal resistance of a given cable is directly proportional to the soil thermal resistivity. It can contribute up to 70% of the conductor temperature rise above ambient [1]. Despite of its importance, its time variation or even steady state value are generally not known. Measurements at a given point along the cable route cannot provide a complete picture of its spatial variation. By the change in season and precipitation, soil thermal resistivity can change in time. Because the space/time variation of this important parameter is not known, normally a conservative approach is used and worst scenario is considered. The same conservative approach is used in the case of ambient temperature. Since the conductor resistance depends on temperature, knowing only the conductor current is not sufficient for obtaining accurate value of losses and the core temperature rise above ambient. However, if this is the only parameter that is measured, approximate calculations can still be performed with estimated soil ambient temperature as explained in [14]. The computed conductor temperature can be off by a few degrees in such case.

The brief discussion above should have clarified why one needs to use DTS systems together with the real time rating calculations. In a real time application, the time varying parameters of the thermal model are updated continuously in time. Using real time thermal model one does not need to use conservative approaches and the asset management is optimized. One can also make emergency or contingency plans more accurately taking into account the real operating point of the installation.

There are different approaches to update time varying parameters in real time. All these approaches use load variation and DTS readings. The criteria to use one approach over another could be the calculation time, accuracy, type of installation and, of course the cost. Ignoring the cost, the next section reviews the existing methods. The following section introduces a new method for estimating soil parameters. Next, the experimental setup and the results of the tests are presented. The last section contains the concluding remarks.

EXISTING APPROACHES

The objective in this section is to review published RTTR