Cable Thermal Rating Analysis based on Time-Series Load Flow in Distribution Networks

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ABSTRACT

Electric power distribution utilities perform cable thermal capacity simulations in design and planning processes to ensure safety and reliability of their underground systems. In this paper, the proposed simulation platform facilitates creation and maintenance of the network model, massive load profile data accessibility, model modification flexibility, as well as results accuracy arisen from detailed-model section-by-section analysis. The platform offers a wide coverage of various cable construction layers, configurations, and thermal installations for the steady-state and time-series cable thermal rating analysis.

KEYWORDS

Cable thermal analysis, cable ampacity, time-series simulation, load flow, duct bank, CYME software, CYMCAP software.

INTRODUCTION

Electric power utilities require to perform thermal capacity analysis for underground cables in distribution systems to determine an appropriate size of the cables, and study thermal violations in design and planning phases to ensure safety, reliability, and cost-effectiveness of their underground systems [1-2].

Most cable thermal capacity computer programs are built as standalone applications. This often results in time-consuming model creation and maintenance, as well as massive input data collection requirements. Furthermore, inconsistencies may arise in cable construction data when using different formats or datasheets. These programs may be also limited to specific applications and suffer from slow simulations specially for multi-year time-series simulation of large networks.

This paper proposes integrating cable thermal capacity analysis into power flow simulation tool to offer several benefits that can considerably improve the planning process for distribution networks. The proposed unified simulation platform facilitates network detailed-model creation, network modifications, scenarios investigation, and maintenance. The effect of any network modifications, such as adding or removing cables, switching devices, load transfers, etc., can be immediately seen on the thermal analysis results without requiring a change in the input data that is required in a typical standalone software. Additionally, the platform provides access to massive load profiles data and accurate current results obtained from power flow simulation on every section of the network, providing a more comprehensive analysis of the system.

The proposed platform integrates CYMCAP power cable ampacity software (CYMCAP Software) calculation engine [3], into CYME power system analysis software (CYME Software) [4]. In the widely used CYMCAP software thermal analysis, the heat transfer model is based on the formulas in the IEC Standards 60287 and 60853. The IEC models represent the cable and its soundings by thermal ladder network, where each cable construction layer and the installation are modeled by a thermal resistance and a thermal capacitance [5-7]. In the steady-state thermal analysis, the network is modelled with resistances and heat sources only. Depending on the number of layers in a cable construction, the thermal network for time dependent analysis may comprise several loops.

The thermal analysis integration into CYME software benefits from all CYME software capabilities as a unified platform for distribution planning. As shown in Fig. 1, the access to CYME Dynamic Data Pull module (DDP module) plug-in facilitates fetching historical and forecasted network profile data from external sources and databases to update the network model. In addition, the CYME Advanced Project Manager module (APM module) is leveraged to apply network modifications for network upgrades or define different project scenarios as mitigations to resolve an abnormal condition. Once the network and loading data are ready, the steady-state or time-series load flow can be executed and the resulting cable current profiles with one-hour or selected resolution for each section of the detail-modeled network will be exported as the inputs to the CYME Cable Thermal Rating module (CTR module) engine. This results in higher accuracy in representation

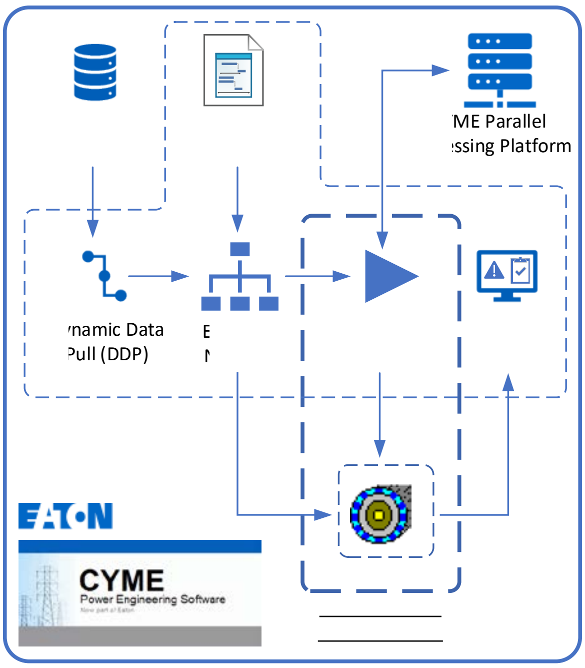

Fig. 1. High-level workflow of the platform for cable thermal capacity based on time-series load flow