Numerical Assessment of Electric Field Distribution Around a Human Model Near High-Voltage Overhead Power Lines

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***Abstract*— This paper presents a numerical–experimental investigation of the influence of a human body on the spatial distribution of the power-frequency electric field in the vicinity of a 400 kV overhead transmission lines. The study focuses on the region directly below the phase conductor (L2), where the highest electric field intensities occur under the investigated operating conditions. Numerical simulations were performed using the CST Studio Suite to evaluate the perturbation of the ambient electric field caused by the presence of a simplified human body model. The numerical model was subsequently validated by in situ measurements carried out beneath an operating transmission line at the locality near Žilina (Varín, Slovakia). Electric field intensity and induced voltage measurements were performed to confirm the numerical predictions. The results obtained demonstrate that the conductive human body significantly modifies the local electric field distribution, producing pronounced field enhancement around the upper body and head regions. These findings contribute to a better understanding of electromagnetic field interactions between overhead power lines and exposed individuals and provide experimentally validated data suitable for safety-oriented assessment of pedestrian and cyclist exposure beneath high-voltage transmission systems.**

Keywords*— *electric field intensity, high-voltage transmission lines, human body model, numerical simulation, exposure.

I. Introduction

High-voltage overhead transmission lines constitute one of the principal sources of extremely low-frequency (ELF) electric fields (EF) in outdoor environments. Although the associated magnetic field has currently received considerable scientific attention [1-5], increasing interest has recently been devoted to the exposure to the ELF EF [6,7] especially under realistic environmental exposure conditions. Such situations occur whenever pedestrians, cyclists, maintenance personnel, or agricultural workers move beneath energized transmission lines, where the EF may induce surface charge accumulation, displacement currents, and perceptible electrostatic phenomena.

International exposure guidelines established by organizations such as ICNIRP in [8] define reference levels for external EFs to prevent established adverse health effects. Nevertheless, these recommendations primarily address whole-body exposure and do not explicitly consider local EF enhancement caused by the presence of conductive objects with complex geometries. In practical situations, the human body perturbs the surrounding electric field, leading to localized increases in field intensity that cannot be accurately estimated using analytical approaches alone. Consequently, numerical modelling has become an essential tool for evaluating realistic exposure scenarios.

The majority of previously published studies [9-12] focus on determining the ambient EF generated by overhead transmission lines or on estimating compliance with exposure limits [13-15]. Comparatively less attention has been devoted to analyzing how the presence of a human body modifies the local EF distribution immediately beneath transmission conductors and how accurately such numerical predictions correspond to measurements performed under real operating conditions. Experimental validation remains particularly important because the EF beneath transmission lines is influenced by conductor geometry, ground conditions, surrounding objects, atmospheric parameters, and measurement uncertainties.

The present work addresses this issue through a combined numerical and experimental investigation of the EF beneath a 400 kV overhead transmission line. The analysis is intentionally restricted to the region directly below the central phase conductor (L2), where the highest EF intensities were identified during preliminary investigations and subsequently confirmed by field measurements [16]. A simplified conductive human body model was incorporated into the computational domain to evaluate its influence on the surrounding electric field distribution. Numerical calculations were performed using the Finite Integration Technique implemented in CST Studio Suite, while experimental validation was carried out through in