# Modeling the Effect of a Water Tree Inside a Tape Shield and Concentric Neutral Cables

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## Abstract

A water tree is a phenomenon that forms in the insulation of underground cables and is one of the main reasons for cable failures [1]. A water tree grows from some imperfection in the insulation shield interface, which causes the electric field to increase. This increase causes the insulation to break down and form microfractures. These microfractures fill with moisture and increase the electric field, thus continuing dielectric breakdown of the insulation. It is difficult to understand or show the increase in the electric field. Therefore, COMSOL Multiphysics® software is used to model a water tree in two common types of cables, tape shield and concentric neutral. COMSOL allows for the effect on electric field intensity and electric potential due to the water tree to be better understood, as shown in Figures 1 and 2. COMSOL allows for the observation of the increase in the electric field at the tip of the water tree, which is what causes the continuing dielectric breakdown. Also, the lumped parameters of the water tree are well known to be represented as a parallel resistance and capacitance [2-5], but what are not well known are the values of this resistance and capacitance. Therefore, COMSOL is used to calculate the resistance and capacitance of a section of cable with a water tree as it grows across the insulation. These values can then be used to simulate the water tree on a cable and determine a detection method. This paper proposes to use COMSOL to show the effect of the water tree on the electric field and electric potential and determine the values of the lumped parameters of the water tree for two common types of cables, tape shield and concentric neutral.

# Reference

[1] V. Dubickas, "On-Line time domain reflectometry diagnostic of medium voltage XLPE power cables," Licentiate thesis, Royal Institute of Technology, Stockholm, Sweden, 2006.
[2] J. C. H. Mejia, "Characterization of Real Power Cable Defects by Diagnostic Measurements," Ph.D. dissertation, Dept. Elect. and Comp. Eng., Georgia Institute of Technology, Atlanta, GA, 2008.
[3] T. Ozaki, N. Ito, I. Sengoku, J. Kawai, S. Nakamura, "Changes of capacitance and dielectric dissipation factor of water-treed XLPE with voltage," Proceedings of 2001 International Symposium on Electrical Insulating Materials, 2001. (ISEIM 2001), pp.459,462, 2001.
[4] Y. Z. Arief, M. Shafanizam, Z. Adzis, M. Z. H. Makmud, "Degradation of polymeric power cable due to water treeing under AC and DC stress," 2012 IEEE International Conference on Power and Energy (PECon), pp.950,955, 2-5 Dec. 2012.
[5] S, Nakamura, J. Kawai, "Relative permittivity and conductivity of water-treed region in cross-linked polyethylene," Proceedings of the 2001 IEEE 7th International Conference on Solid Dielectrics, 2001. ICSD '01, pp.163,166, 2001.
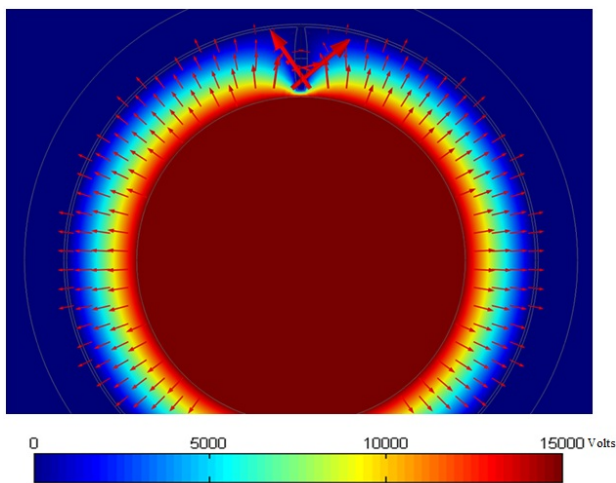
# Figures used in the abstract



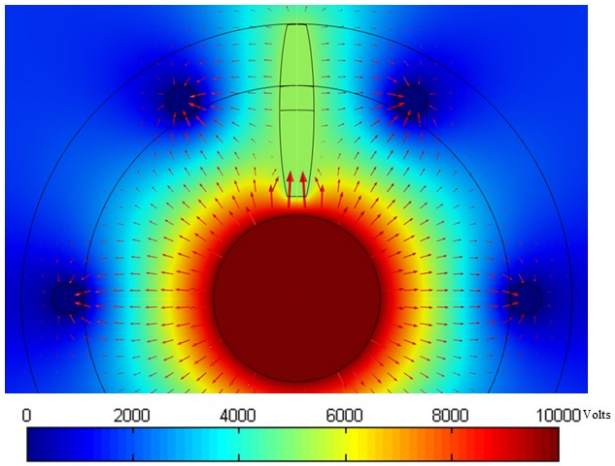**Figure 1**: Water tree 90% across insulation in tape shield cable.

**Figure 2**: Water tree 90% across insulation in concentric neutral cable.