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The simulated effect of the lightning first short stroke current on a multi-layered cylindrical model of the human leg

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2015

http://hdl.handle.net/10539/22609

Lee, Yuan-chun Harry (2015) The simulated effect of the lightning first short stroke current on a multi-layered cylindrical model of the human leg, University of the Witwatersrand, Johannesburg, <http://hdl.handle.net/10539/22609>

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ABSTRACT

This research investigates the effects of the frequency components of the lightning First Short Stroke (FSS) on the current pathway through human tissues using frequency domain analysis. A Double Exponential Function (DEF) is developed to model the FSS with frequency components in the range 10 Hz $\sim$ 100 kHz. Human tissues are simulated using Finite Element Analysis (FEA) in COMSOL and comprises of two types of models: Single Layer Cylindrical Model (SLCM) and Multi-layered Cylindrical Model (MLCM). The SLCM models 54 human tissues independently and the MLCM models the human leg with five tissue layers: bone marrow, cortical bone, muscle, blood and fat.

Three aspects are analysed: current density, complex impedance and power dissipation. From the SLCM results, aqueous tissues have the lowest impedances and tissue heat dissipation is proportional to tissue impedance. Results from the MLCM show that 85% of the FSS current flows through muscle, 11% flows through blood, 3.5% through fat and the rest through cortical bone and bone marrow. From the results, frequency dependent equivalent circuit models consisting of resistors and capacitors connected in series are proposed.

The simulation results are correlated with three main clinical symptoms of lightning injuries: neurological, cardiovascular and external burns. The results of this work are applicable to the analysis of High Voltage (HV) injuries at power frequencies.