TECHNICAL PAPERS
SS-WED-A

ADVANCED METHODS TO MODEL, EVALUATE, AND MEASURE ELECTROMAGNETIC INTERFERENCE AT LOW FREQUENCY IN TRANSPORTATION AND RENEWABLE ENERGY SYSTEMS

Chair: Waseem Wafik Elsayed, *Universiteit Twente Faculteit Elektrotechniek Wiskunde en Informatica, Zielona Góra, Lubuakie, Poland*
Co-Chair: Abduselam Hamid Beshir, *Politecnico di Milano, Milan, Italy*

11:00 **The Effect of Stray Capacitance to the Common Mode Current on Three-Phase System**
Muhammad S. Alamsyah[1], Francinei L. Vieira[1], Heyno Garbe[1], Sebastian Koj[2]
[1]Leibniz Universitat Hannover, Germany; [2]IAV GmbH, Germany
Abstract: The common-mode (CM) current phenomena is one of many problems in the EMC world due to the radiated magnetic field caused by it. A power transmission line with a delta-connection both generator and load normally do not have a connection to ground to establish a line for the return current. To determine the CM current, finding the stray capacitances to the ground is highly important because they are used as the return path for the CM current. In this paper, the investigation of predicting the CM current flowing through the stray capacitances will be done at a three-phase equivalent system of a wind turbine (WT). The wind turbine body is the place where the CM current flows, due to the stray capacitances between the power cables and the WT body around it. The CM current can be determined using the current magnitudes in a pointer-image method, which has a good agreement for CM current prediction and it might become a very useful tool applicable to measurements.

11:25 **Electromagnetic Fields on 3-Phase Induction Motor using Finite Element Analysis**
Douglas Nascimento[1,2], Robert Smolenski[1], Hermes Loschi[1,2,3], Flavia Grassi[4], Lu Wan[4], Abduselam H. Beshir[4]
[1]University of Zielona Góra, Poland; [2]University of Twente, Poland; [3]University of Nottingham, United Kingdom; [4]Politecnico di Milano, Italy
Abstract: Electromagnetic fields of a 3-phase induction motor, i.e., electric and magnetic fields and current density, are highly influenced by its geometry, conductor material (conductivity, magnetic permeability, electric permittivity, and nonlinearity), and boundary conditions applied (interface between conductors and dielectrics). Through Finite Element Analysis (FEA), the behavior of electromagnetic fields can be predicted. Thus, favoring the electromagnetic interference mitigation techniques of the 3-phase induction motor. Therefore, this paper presents numerical modeling with FEA, based on COMSOL, as an early pre-compliance tool to investigate the current density distribution and electric and magnetic fields. The validation of the modeling approach will be presented and discussed considering a 3-phase induction motor. Furthermore, CISPR 25 will be considered to evaluate the interactions between electric and magnetic fields, current density distribution, and skin effect on an increasing frequency.

11:50 **Micro-Grid Inrush Current Stability Analysis**
Alexander Matthee, Niek Moonen, Frank Leferink
University of Twente, The Netherlands
Abstract: Transient currents can severely impact the operation of weak or islanded grids. Inrush current electromagnetic compatibility challenges, due to their unpredictable and intermittent nature, are very difficult to identify. Using multi-point synchronised measurements, analysis is performed on an inverter. The supply powers various loads that are observed during cold start as well as under load switching conditions. Inrush event triggered failure probability is linked to non linear and average load levels.

12:15 **The Effect of Spread Spectrum Modulation for a Buck Converter Coupled with a Single Wired Communication Link**
A. Pena-Quintal, K. Niewiadomski, V. Muneeswaran, S. Greedy, M. Sumner, D.W.P. Thomas
University of Nottingham, United Kingdom
Abstract: This paper explores the effect of using a Spread Spectrum modulation technique with a Buck Converter on a communication cable coupled at the input voltage. The EMI created by the switching of the power converter generates damped oscillations on the data cable that can have great impact on the quality of the communication channel. Frequency domain analysis shows lower EMI levels in the power cable when compared to the standard deterministic modulation. However, there is no real improvement to the actual communications as there in an increase in the measured Bit Error Rate when evaluated experimentally.

TECHNICAL PAPERS
TP-WED-1B

ANTENNAS AND ANALYSIS

(SPONSORED BY TC-2)

Chair: Thomas J. Fagan, *Aerospace Corporation, Vail, AZ, USA*

13:30 **Localized Time Rotation of the Electric Field Near the Boundary of the Reactive Near Field of a Dipolar Antenna**
James McLean, *TDK R&D Corp., USA*
Abstract: It is well known that in the reactive near electromagnetic field of a dipolar antenna such as a 1.4-m biconical antenna the electromagnetic field is predominantly electric in nature and that in some immunity measurements such as MIL- 461, RS 103, the DUT is located in this region. That the field is predominantly electric in nature is considered acceptable if the anticipated coupling mechanism into the DUT is electric. It is less widely noted that near the boundary of the reactive near field (the induction zone) and outside of the H-plane of the dipole, the near electric field vector undergoes time rotation. For the geometry of MIL-461 RS 103 with a DUT located 1 meter from a 1.4-m biconical dipole we show that in the vicinity of 100 MHz, in some portions of the uniform field area, the electric field appears to be pseudo-circularly polarized with two orthogonal equal-magnitude components in phase quadrature. A simple analytical model is used to confirm the electric field rotation for an isolated dipole. A numerical simulation is employed to compute the field of a more complex and practical 1.4-m biconical antenna and also to model the effects of ground. Preliminary experimental results confirm the simulation. Clearly, such a field would affect a DUT differently from the way a linearly-polarized electric field would and also very differently from the way a true circularly-polarized plane wave would.

13:55 **Assessment of the Antenna-Equivalence Approach to Common-Mode Input Impedance Modeling**
A. Hubrechsen, L.A. Bronckers, A. Roc'h
Eindhoven University of Technology, The Netherlands
Abstract: Analytical modeling of the common-mode input impedance of a motor along with its cable for various installation characteristics would allow designers to assess EMI levels and to evaluate in an early stage if adaptations are needed in their cable installation. Earlier work has shown that the input impedance over frequency of such a system is mostly dominated by the cable. A common assumption is that a cable can be approximated as a monopole antenna above a ground plane, which has an input impedance equivalent to that of a dipole with a correction factor. We compare the Hall´en and King & Middleton dipole models to a measurement setup which is designed to reproduce parastic effects from the installation, to assess the validity of the analytical model. We analyze these results for various distances between the cable and the groundplane. We show that large discrepancies occur due to paristics of the installation and the presence of the groundplane, but that for some applications such closed-form analytical models may suffice in assessing frequencies at which radiated emissions occur.

14:20 **Consistency Analysis of S-parameter Indirect Measurement for Improving Estimation Result**
Noboru Maeda[1], Kengo Fukunaga[1], Keishi Miwa[2], Soichiro Ota[2]
[1]*Soken, Inc., Japan;* [2]*Toyota Motor Corporation, Japan*
Abstract: A consistency analysis procedure for our previously proposed indirect measurement method for the S-parameters of a multiport reciprocal circuit (e.g. bundle of wires or PCB traces) is proposed. In the measurement method, half of the ports are connected with some known loads and the remaining ports are directly measured by changing the load values to estimate the whole S-matrix. Some linear relations in the transfer coefficient submatrices between the direct and indirect measured ports have been used in the method. Those relations are selected to analyze the consistencies of the method from the theoretical viewpoint. Then, the indirect measurement method is applied to an example target, fixtures to measure the characteristics of wireharness mounted in a vehicle, to evaluate the consistencies in the calculation process. Also, a method to obtain an improved estimation result using the consistency evaluation is provided. Index Terms—Circuit analysis, Measurement techniques, Estimation theory, Automotive electronics .

14:45 **Comparison of Extrapolation Methods for De-Embedding Truncated Measured Transfer Functions**
David Martinez, Fernando Albarracin-Vargas, Juan Galvis, Gideon N. Appiah, Felix Vega, Chaouki Kasmi, Nicolas Mora
Technology Innovation Institute, United Arab Emirates
Abstract: This paper presents a comparison of three extrapolation methods used to re-construct the missing parts of truncated transfer functions used to de-embed measured transient electromagnetic signals.