Renewable Energy and Power Quality Journal (RE&PQJ), ISSN 2172-038 X, No.9, 12th May 2011, Reference Paper: 623

European Association for the Development of Renewable Energies, Environment and Power Quality (EA4EPQ)	*International Conference on Renewable Energies and Power Quality* (ICREPQ'11)

High frequency Modelling of Cables in PWM Motor Drives by Using Polynomial Functions based Parameters

M. C. Di Piazza, *Member IEEE*, A. Ragusa, *Member IEEE*, G. Vitale, *Member IEEE*

Consiglio Nazionale delle Ricerche,
Istituto di Studi sui Sistemi Intelligenti per l'Automazione,
(ISSIA – CNR), sezione di Palermo, Palermo, Italy,
mariacarmela.dipiazza@ieee.org; ragusa@ieee.org; gianpaolo.vitale@ieee.org

Abstract- The high frequency behaviour of the cables in pulse width modulation (PWM) motor drives is of a crucial importance in the analysis of transient overvoltages and conducted electromagnetic interference (EMI) propagation, both common and differential mode. In order to give a tool for simulation of the above cited phenomena, a new method for high frequency cable modelling is proposed in this paper. The method is based on the measurement of the impedance frequency responses of the cables in short and open circuit conditions. The lumped parameters cable behaviour is described by polynomial functions in frequency domain. For a given frequency a simple equivalent circuit representation of the cable is obtained. The proposed model is easily implemented in Matlab/Simulink and it is validated comparing the computed frequency impedance responses of the cable, loaded by either a resistive load or an induction motor, to the corresponding measured ones. Moreover, the prediction, by the model, of the overvoltage at the motor terminals in a long-cable PWM drive is performed. The proposed model are also compared with some commonly used high frequency cable models presented in technical literature.

Keywords
High frequency modelling, Parameters identification, Induction motor drives

1. Introduction
The high speed commutation in modern pulse width modulation (PWM) motor drives is responsible for very rapid voltages and currents transitions that lead to several serious problems ranging from conducted and radiated electromagnetic interference (EMI) to overvoltages, up to two or three times the DC link voltage, at the motor terminals when long cable configurations are used.
The overvoltage, determined by reflection phenomena, is tied to the impedance mismatch between the cable and the load represented by the motor. Its magnitude is dependent both on the cable length and characteristics and on the rise time of power devices pulses. In particular, the switching of power devices is a step solicitation that can excite a travelling wave from the inverter to the motor. Furthermore, the reflected wave, associated to the traveling wave, gives a contribution to the common mode (CM) EMI affecting the reliability of the motors since they produce shaft voltages and possible bearing currents [1]. For all these reasons the development of accurate high frequency cable simulation models is crucial for an appropriate analysis of overvoltages and EMI in power drive systems. Several contributions based on lumped parameters schematization of the cables have been presented in technical literature [2]-[6]. A model based on mathematical formulas describing the transient voltage and current in the cable in the frequency domain is given in [7]. It permits to analyze the overvoltage at any point of the cable without the need to give a circuit representation of the drive components, anyway it requires a detailed and noteworthy analytical formulation of the propagation phenomena.
The cable representation by several lumped parameters equivalent sections has been successfully proposed [2]-[4]. In such methods the model parameters identification is based on the impedance measurement. The appropriate choice of the sections' number is the key issue in this case since a tradeoff solution is needed to conjugate accuracy and fast simulation times.
In [2] the multiple lumped parameters segments approach is used to develop a high frequency model of the cable in a PWM drive, where a lossy representation of the line is proposed. In this paper the frequency dependency of the cable parameters is accounted for by measuring the impedance frequency responses at only two frequencies, i.e., the lowest and the highest of the considered test range.
In [3] a ladder-type network is proposed in order to model the cables including the frequency dependence of their parameters and the variations due to the skin effect and proximity. This model, indicated as "n-branch" gives accurate results to represent the behavior of the cable longitudinal parameters but it needs an appropriate modification of the original structure to model the transversal ones.
In this paper the proposed method utilizes experimental measurements in order to achieve short and open circuit impedance of the cable. For a fixed frequency value, in