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ENERGY CABLE MODELING UNDER POWER ELECTRONIC CONVERTER CONSTRAINTS

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ABSTRACT

The rapid commutation of the modern power semi-conductor devices used in the static converters is the source of the conducted and radiated emissions. These devices produce high voltage variations (dv/dt) which excite leakage elements of the power circuit and induce high frequency parasitical currents. These currents used the energy cables to be propagated from the converter to the load and the power grid.

This paper proposes a high frequency modelling method of energy cable that takes into account phenomena that appear when the switching frequency increase as: skin and proximity effects and dielectric losses. The proposed method is applied to the three-wire unshielded cable and extended to the four-wire shielded cable. The obtained models are validated in both frequency and time domain in Adjustable Speed Drives system*.*

KEYWORDS

Power cables, skin effect, dielectric losses, modeling, transmission line circuits, frequency-domain analysis, time-domain analysis.

INTRODUCTION

In the power electronic converters, energy cables are the spreading paths of the conducted disturbances in the whole system. In order to use a circuit simulation tool as SPICE software to study the conducted emissions, it is necessary to use the high frequency models of each part of the system [1] [2].

Because most simulation software's doesn't have high frequency power cable models, one proposes in this study, a modelling method of shielded and unshielded cable. The proposed models are taking into account skin and proximity effects, dielectric losses in a distributed parameters model [3].

In the first section of this paper, the power cable model method is described and applied to model a 3-wire unshielded cable, and a 4-wire shielded. The second section presents the validation of the obtained models in both frequency and time domain.

UNSHIELDED 3-WIRE CABLE MODEL

The unshielded cable under study is composed of three conductors, the cross sectional area of each conductor is 2,5mm². Each conductor is coated with PVC and the unit is placed in a rubber sheath.

To model this cable, a distributed parameter circuit composed from cascaded basic cells is used whose the elementary cell is represented in Figure 1. However, a preliminary study has shown that 32 cells per meter length give a good compromise between simulation duration and model accuracy.

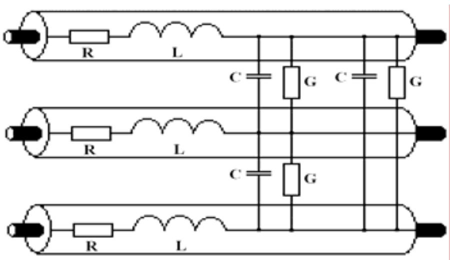

Figure 1: Unshielded 3-wire Cable model

The cable parameters per unit length (R, L, C and G) are obtained by three methods: analytic calculation, Finite-Element Method and measurement using impedance bridge (HP4294A).

To measure the cable parameters, two test configurations are necessary: the cable in short-circuit configuration to obtain R and L and in open circuit for C and G parameters as shown in Figure 2. All the cable parameters are measured with one-meter cable length.

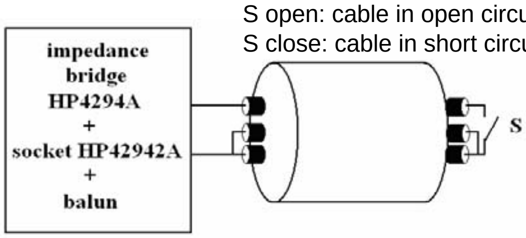

Figure 2: Cable parameters measurement

The previous study has shown that the simulation of the cable using the constant parameters measured at 500 kHz do not give satisfactory results. However, it is necessary to take into account the conductor resistance variation caused by the skin and proximity effects, and the conductance variation that which is due to the dielectric losses between wires. Measurements data have also shown that the wire inductance varies according to the frequency. On the other hand the capacitance between each pair of conductors is constant.

There are various methods making it possible to model the evolution of the cable parameters per unit length according to the frequency [4] [5]. In this study, to model the evolution of the conductor resistance and inductance when