

Theoretical Transmission-Line Study of Symmetrical Indoor Triple-Pole Cables for Single-Phase HF Signalling

Ioannis C. Papaleonidopoulos, Constantinos G. Karagiannopoulos, Nickolas J. Theodorou, and Christos N. Capsalis

Abstract— Theoretical study of symmetrical single-phase indoor triceps is performed with respect to High Frequency transmission-line modelling, aimed at potential communication applications over the Low Voltage in-house grid. The analysis is based on the fundamental Transverse-Electro-Magnetic wave propagation concept, commencing from the three-conductor transmission-line model. In the three-wire cable, any transmission circuit consisting of two conductors – out of all three – is by virtue of symmetry reduced to a two-conductor formulation. The distributed parameters of the resulting model are moreover extracted via proper observation of cable's field structure, whereupon complete conformance with the uniform isolated two-conductor line is obtained. Propagation of High Frequency signalling transmitted between phase and neutral may thence in practice be treated and formulated independently, as if no ground wire existed. Verification of the Transverse Electro-Magnetic mode assumption is in addition demonstrated, and hints on the applicability of the work presented are suggested.

Index Terms – High Frequency, Multiconductor Transmission Lines, Power Cables, Power-Line Communications, Transmission-Line Modelling.

I. INTRODUCTION

Implementation of modern Local Area Networking (LAN) applications over the Low-Voltage (LV) indoor grids is the primary terminus of current efforts in relation to in-house Power-Line Communications (PLC). Impending utilisation of the High Frequency (HF) band seems highly promising. The applicable ETSI standard [1] specifies hereupon occupation of the 1.6-9.4MHz frequency zone over the access network, whereas the 11-30MHz band is reserved for in-house systems. Analytical HF modelling of the power electric network is of prime significance in order to implement efficient PLC

applications. Mostly single-phase networks are found in both domestic and premises installations, and PLC channels appear intensively fading. Modelling of indoor LV cabling as transfer medium in the HF band is thus essential in order to develop reliable channel-analysing tools and simulating methods that would sufficiently estimate and possibly optimise the capacity of potential PLC links.

The cable type considered, cross section of which is depicted in Fig. 1, is widely used in Europe for in-house electrical plants. Such a configuration comprises the phase conductor, the neutral, and the ground one, all of equal radii. Each conductor lies inside a dielectric jacket, and an additional insulating sheath encloses all three wires. Flexible cables are assembled of litz wires, wherein the metallic conducting strands are self-twisted too as a whole; for permanent though installations, one-ply conductors are used, and the wires lie inside the cable in parallel – not twisted. Several cable types per VDE that are widely used in Europe for permanent installations in buildings fall into the structure studied herein – e.g. NYM and NYV.

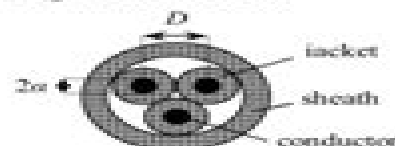


Fig. 1. Cable's cross-section.

Consistent investigation that has up to now been carried out involving mainly experimental and numerical surveys [2]–[9] reveals good compliance with the uniform two-conductor transmission-line (TL) model, which is yet adopted throughout [10]–[13]. The work presented in [7] involves in particular thorough exploration of the cable assembly in question, and transfer-function measurements over numerous sample cables confirm remarkable precision of the model evaluated therein. No deviation above 20% had in fact been observed on linear attenuation scale between measured curves and the corresponding theoretical ones, which, stemming from an experimental process, infers rather absolute compliance.

However, no theoretical HF characterisation has yet been provided, that would justify adoption of the two-conductor model. The latter is the scope of this paper. The rationale to be

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