Attenuation-Based Cable Design for High-Quality Manufacturing

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ABSTRACT

The original design model for defining the attenuation of manufactured cables was derived and fitted to experimental data. The model relationship connects attenuation with some parameters of cable design and testing: copper wire, aluminum, and insulation thicknesses, cable impedance, test frequency, and lay length. Defined expression was used for Monte-Carlo simulation of the cable attenuation prediction. With developed MATLAB program, a special graphical user interface was created. After assigning the desired parameters, this interface generates a plot with distribution of the attenuation values and required attenuation limit, and outputs defined mean attenuation, its 98% error, and numbers of values that get in and out of the limiting value. Data of calculations were verified by experiments and reveal good concurrence with the actual data. The realized fitting and simulation procedure, together with developed programs and created interface can be used as compact tool for designing cables with optimal parameters.

KEYWORDS

Computer Simulation, Design Interface, Digital Cable, Manufacturing, MATLAB Consideration

1. INTRODUCTION

Wire cables have been used in an endless variety of applications. Their quality is critical requirement for wire communications. In digital communications, the multicore and symmetrical cables should meet the requirements of the international standards IEC 61156-1, 5, 6, 7 (2002-2012) that determine their transmission characteristics and testing methods for frequencies up to 1200 MHz. The design of each component of the cable includes the correct selection of the following mechanical parameters of cable: diameter of the copper conductor, diameter of the insulated wire pair, lay length, individual wire material indices, and some other parameters. These parameters should conform to standardized requirements of the operational characteristics of the cable, which tests during manufacturing, and it is in the first way: the impedance, attenuation, frequency, near-end crosstalk, and return loss.

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Design of the analog/digital cable parameters and cable technology were developed long ago and in detail, in terms of their strength and reliability, as described for example by US Navy Handbook (1976), Velinski (1988, 1989), Costello (1997, 2003). In contrast, relation between physical-mechanical parameters of the cable and the testing of electrical cable characteristics have been developed much later and improved relatively recently with appearance of the International Standards IEC 61156 1-7 (2002 - 2009). This time, some modeling and simulation studies appeared for assuring quality of communication cables, Tranter et all (2003), Hyland (2012), and steel cords, Turkseven and Ertek (2003), Gerdemeli, Kurt, and Anil (2013). Nevertheless, there are no studies regarding which relationship can join designed mechanical parameters and tested electrical performance, using for this the data gathered in technological process.

For this paper, we will assume that correctly designed and qualitative manufactured cables, with optimal wire and insulation diameters, lay length, aluminum thickness, impedance and frequency performance, should guarantee lower attenuation of the transmitted signal. These characteristics are not related to any unified theoretical relationship. Thus, the aid of the study is to find any empirical relation that describes the practical data and then use this relation for reliable cable design.

2. BACKGROUND AND FITTING THE DATA

The cable and test parameters that were assigned to search for an unifying relation are shown in Figure 1.

The attenuation was selected as the main parameter that should be kept and should be related with other design and test parameters. The general searching dependence reads:

\[ A = f\left(d_{cu}, d_{ins}, \delta_{Al}, I, F, p\right) \]  

where \( d_{cu} \) is the copper wire diameter, mm; \( d_{ins} \) diameter of the insulator, mm; \( \delta_{Al} \) is the aluminum thickness, μm; \( I \) – impedance value required in the cable testing, Ohm; \( F \) – the frequency assigned for the cable test, MHz; \( p \) – cable lay length, mm; \( A \) – attenuation, dB per 100 m of the cable.

The data that connects parameters in Equation (1) were assembled in production line of Teldor Cables and System Ltd. (Attachment 1) for cables designed from four individually foil-shielded twisted pairs with tinned copper drain conductor, and overall braid-shielded and jacketed.

Figure 1. Cable (a) and test (b) parameters selected to the relationship search
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