Performance analysis for transmission in phantom systems in corporate environments

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***Abstract*—The need for high bit rates in corporate systems environments is a crescent demand in the world. It has been researched in hybrid networks new technologies using cooper-based system. The G.fast uses short cables to reach aggregate rates up to 2 Gbps on band up to 212MHZ. In this paper we will analyze the aggregate rate and the symbols distortions in short CAT7 and CAT5e cables when phantom mode transmission is used. It will be seen the aggregate rate increases over 12 Gbps and the phantom mode does not affect the differential mode when vectoring is applied.**

Keywords—Phantom mode, aggregate rate, vectoring, EVM.

I. Introduction

The demand of high bit data rate is increasing on the last decade and the internet service provider need to improve the transmission quality. One solution is to reduce the cooper cable length at the last meters in hybrids access networks at high frequencies [1]. For instance, a solution is the new standard ITU called G.fast that can reach over than 1 Gbps [2]. Besides, other types of transmission mode can increase even more the bit rate and many of them are being analyzed. In [3] and [4] are presented the wire-shield and split-pair modes, respectively, as possible solutions due to the more number of channels with the same number of twisted pairs.

In [5] is presented the phantom mode, which is a new channel created by the difference between the common mode of two twisted pairs, each one already transmitting in differential mode. Thus, with only two pairs can be used three channels.

On phantom mode, a strong crosstalk interference is created by the phantom channel, which might not allow a proper communication [6]. This problem can be solved using vectoring, which can eliminate the most part of crosstalk interference in the system.

Among these three transmission modes, the phantom mode is less susceptible to external interference than split pair and wire shield. In [6] the phantom mode is mentioned as one of the alternatives to implement the 5th broadband generation.

In this paper we will focus our attention on the investigation of the efficiency of the systems with phantom mode transmission using vectoring in short cables, which are typical scenarios of corporate systems.

II. Simulation Scenario

To verify the systems were used the software CST (Computer Simulation Technology), a reliable tool for cable simulations, capable of simulate a cable with different lengths, twist rates and cable thickness, having as result the transfer functions and the crosstalk interference between the modes. The frequency range used in the simulation were 0 up to 200 MHz.

A representation of the simulated setup for PM (Phantom Mode) and DM (Differential Mode) transmitting simultaneously is shown in Figure 1. The phantom signal is inserted using a balun connected in the center tap of 2 other baluns transmitting the differential modes [5]. Note that using a cable of 4 pairs, it will have 4 differential modes and 2 phantom channels, resulting in 6 channels.

Fig. 1. Setup with the differential and phantom modes.

$$H = \begin{pmatrix} S_{11} & S_{12} & \cdots & S_{1N} \\ S_{21} & S_{22} & \cdots & S_{2N} \\ S_{31} & S_{32} & \ddots & \vdots \\ S_{41} & S_{42} & \cdots & S_{MN} \end{pmatrix} \quad (1)$$

Using the data from CST cable simulations is obtained the transmission matrix *H*, which contains in the main diagonal the transfer functions, represented by *Snn*, and the crosstalk in the other elements of the matrix, represented by *Smn*, as shown in Equation 1.

The vectoring technique used was zero-forcing [7] that is applied in the transmission matrix (1), generating a channel transmission without the presence of crosstalk interferences, called vectored matrix.

After that, it is calculated the data rate [7] and the EVM [8] of each channel with vectoring. Finally, we will have the aggregate data rate of the system and the average EVM of the differential channels and the phantom channels.

We used the 64 QAM constellation to calculate the EVM.

III. Results

In this section, it will be analyzed the behavior of the system using two cable types, CAT5e and CAT7 (higher quality cable) and also the performance using three different cable lengths. The goal is to verify whether or not the phantom mode affects the differential mode and how the phantom mode can improve the transmissions data rates in relation to a system using only differential transmission.

The first scenario uses a CAT5e cable of 30m. In Figure 2, the bitrate for each differential channel is about 2.10 Gbps using or not the phantom channels. Therefore, this bitrate is not affected for the phantom channels because the vectoring process is applied in all transmission modes.

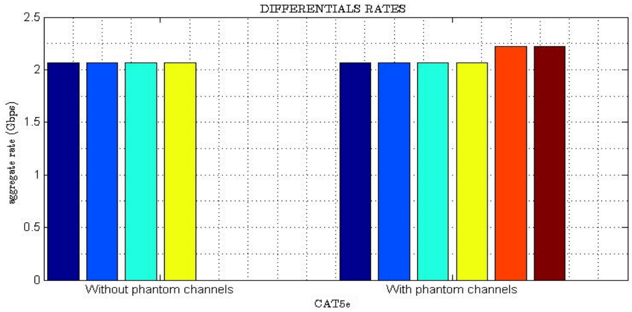

Fig. 2. Data rate per channel of a differential transmission and data rate per channel using phantom mode for a CAT5e of 30 meters with vectoring.

The second scenario uses the CAT5e and CAT7 cables, both with 30m. In Figure 3, it is possible to see the total aggregate data rate of the system with and without the two additional phantoms channels. The aggregate rate is almost 12 Gbps for CAT5e and 13 Gbps for CAT7. The bitrate only for the phantom channels were 4 Gbps and 4.4 Gbps for the CAT5e and CAT7, respectively.

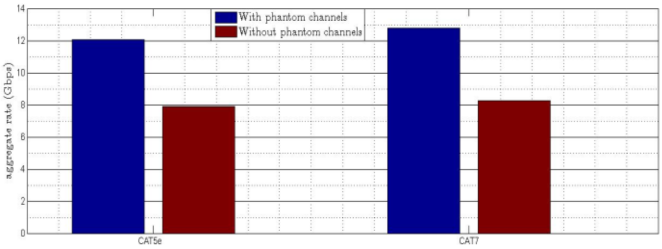

Fig. 3. Aggregate rate with and without phantom channels of both cable types with 30 meters.

The EVM analysis of the channels is shown in Table I, where can be seen the average EVM achieved in the second scenario. Knowing the EVM of each channel, it was calculated the average only of the 4 differential channels, and of the 2 phantom channels. It is possible to note the symbols suffer low distortion, far below the maximum of 8% for a 64 QAM constellation, according the 3GPP standard [9]. The average EVM of the PM is lower than the DM, indicating that the phantom channel has the lower distortion. This also represents a high quality communication system.

TABLE I. AVERAGE EVM (%)

cable types	DM (4 channels)	PM (2 channels)
CAT5e	0.0016	0.0012
CAT7	0.0014	0.0008

The third scenario uses CAT5e and CAT7 cables of 30m, 50m and 100m. Figure 4 shows the aggregate rate is higher on CAT7 than CAT5e for all cable lengths. It can be seen that the worst scenario was for a CAT5e of 100m, aggregate data rate about 8Gbps. However, the CAT5e still has an acceptable gain in bit rate and considering its lower cost, it can be more suitable to corporate environments. On the other hand, for a system that needs higher aggregate rates, independently of cost, can be more appropriate to use the CAT7. For instance, on the length of 30m, the difference in the bit rate between CAT5e and CAT7 was 0.7 Gbps (700 Mbps).

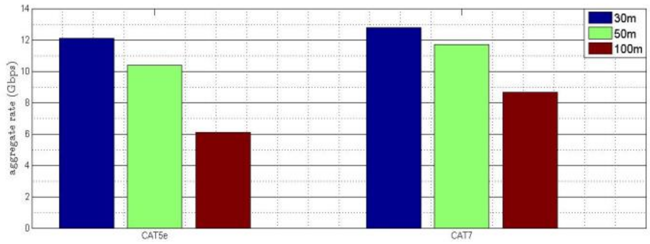

Fig. 4. Aggregate rate of two cable types transmitting PM and DM using vectoring.

IV. CONCLUSION

The phantom mode systems along with vectoring bring an additional potential in cooper-based systems, once with them it is possible to reach higher bit rates due to additional channels and crosstalk cancelation. It has been seen that phantom mode does not affect the differential mode and the shorter the cable length, better is the aggregate rate data rate. The EVM analysis shows also the phantom channels has a low bit distortion, even better than the differential channels. Therefore, this work shows that phantom mode can be used in corporate environments in high bit rate transmission.

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