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Analysis of Signal Processing for Gigabit Rate Wireline Communication

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Abstract-In this paper we mainly focus on achieving higher speed data which is about 1Gb/s over short copper loops using G.Fast technology. The use of TDD and higher bandwidth are two key features in G.Fast. Short twisted pair cable models are used to operate at relatively wider bandwidth. At higher frequencies, the problem of FEXT crosstalk becomes dominant. So to overcome these issues we are using different crosstalk cancellation techniques using various cables which provide different data rates at different frequencies and distances. Performance analysis of various crosstalk cancelation techniques has been done in this paper.
Keywords- G. Fast, VDSL, FTTH

I. INTRODUCTION

Continuous up-gradation has been done in the field of wireline communication to acquire better broadband data rates. Signal processing played a crucial role in enhancing the caliber of communication channels i.e twisted copper cable, coaxial cable, and optical fiber cable. For deployment purposes, we use a hybrid copper-fiber cable as per specific needs. It has been known that for longer distances optical fiber is preferred while for shorter distances which is about 100m copper cable is used. Copper cables have to potential to fetch data and power over a single cable.

Digital subscriber line (DSL) technology consigns digital data through telephone lines and provides affordable broadband services since the 1980s[1]. Certain classification has been proposed for DSL out of which we will be considering VDSL (very high rate digital subscriber line). It provides uneven speeds at upstream and downstream i.e 13 to 52 Mbits/s in downstream and 1.5 to 2.3 Mbits/s in upstream. Deployment of VDSL can be done by using coaxial cable and fiber optics cables. DMT modulation is the modulation technique used in VDSL technology. For this technique, the transmission frequency band disintegrates into a smaller sub-carrier to transform the frequency selective channel into frequency flat narrowband channels. Thus it helps in reducing the intersymbol interference.

Fiber-to-the-home (FTTH) is a technology which is basically deploying fiber to the home. This came into existence when the need for larger bit rates arise. But it shows certain economic constraints because of its high installation cost and huge difficulty in the rewiring of houses with fiber. Therefore, the main focus has been given to utilizing the existing telephone lines for the transmission of signals.

Another method is known as the vectoring method is standardized by ITU-T which is used in VDSL as it is a multiuser signal processing technique[2]. In 2002, vectored transmission is applied to DSL systems where signal processing techniques are used at the optical network unit site, thus taking advantage of user coordination to mitigate crosstalk. The major drawback of this technique was that it increases the data rate at the upstream and downstream transmission at the cost of synchronization of all users, channel matrix identification, and extra signal processing at the ONU [2].

Further studies were made to resolve the problems of the VDSL technology, research has been going on the latest G.Fast technology which is an ITU-T specified where G stands for G series recommendation(G.9701). It provides fiber-like data rates which are helpful in the higher bandwidth of telephone lines as compared to the previous standards i.e VDSL. It is a new copper access technology that provides (upstream and downstream) data rates of about 1 Gb/s over shorter distances up to 250 m. The field trials showed that crosstalk cancellation and bonding two pairs had push data rates of very high-speed DSL above 100 Mb/s on a single copper pair and above 200 Mb/s on two copper pairs. The operating frequency for the first generation G.Fast was 106 MHz while for the subsequent generations it uses 212 MHz[1].

But in this paper, the frequency spectrum which will be used for operation is 400 MHz. At this high frequency, the problem of electromagnetic coupling becomes dominant. Thus, to subdue this problem we will be applying certain crosstalk cancelation techniques for frequency and varying loop lengths. For this, we will be using cable models like CAT5 and CAD55. These are hybrid fiber–copper technology used in fourth generations broadband services.

II. METHODOLOGY

G.Fast made some radical changes in the outline choices made for the VDSL standard. It uses TDD(time division duplexing) and RPF(reverse power feeding) where as VDSL uses FDD(frequency division duplexing)[1].RPF helps in delivering power to the distribution point unit(DPU) which uses a DSL access multiplexer and optical network terminator which eventually links

DPU to the central office. Therefore we can say G.Fast has a resemblance to FTTdp(fiber to the distribution point) technology[2]. There are mainly two types of crosstalks, depending upon the position of disturber wrt suffered receiver namely FEXT(far end crosstalk and NEXT(near-end crosstalk). TDD helps in circumvent NEXT and provides unequal data rate speeds at upstream and downstream therefore for the simulation purpose, we will be concentrating on FEXT.

III. PERFORMANCE ANALYSIS

The techniques used for crosstalk cancelation play a viable source in designing problems which ultimately projects that there is always some kind of trade-off between performance and complexing. Simulation has been done by using MATLAB software. The data rates are plotted against frequencies that range from 0 to 400 MHz. The bit loading is provided in form bit cap value equivalent to 12, which is a fixed value for G.Fast standard with QAM constellation of 4,096 tones or subcarriers and the number of users kept as 5 with a cable length of 100m. Thus, the performance of each canceler is being evaluated in terms of their rate reach plots with respect to the change in frequencies (when wire length is kept as a fixed value of 100m) and with respect to the change in wire length.

Fig.1 shows the rate reach plot with the varying frequency for CAT5 cable parameters and it can be observed that as frequency arises the data rates are getting lowered such that the crosstalk i.e, Far-end crosstalk (FEXT) decreases rapidly with the rise in frequency and at higher frequencies, it is minimized to a negligible level. Also, the crosstalk canceler methods used such as Approximate Zero Forcing (AZF) 1st-Order and linear ZF cancelers are achieving better data rates than FEXT one which proves the diagonal dominance property of the channel model. Also, the linear ZF canceler achieving data rates closer to the AWGN channel which is producing the best rate reach results. Due to this reason only, the AWGN channel is preferred for wired communication medium.

Similar improvement levels can be seen for CAD55 cable in fig.2 as shown for CAT5 cable. But here the data rates achieved for each case are comparatively lower as compared to that for CAT5 cable parameters. Thus, there are significant improvements for the CAD55 cable but not as good as the CAT5 one.

Now in fig.3, we can see the comparisons among the cancelers and channel model with the varying wire length from 50 to 400m of CAT5 cable. Thus, we can infer that with the increase in wire length, the data rates are reducing. Thus, longer the cable will reduce the data speeds. Here, again AWGN is bound to give a better performance than others and crosstalk is the minimum of the lot and linear ZF canceler achieve data rates closer to the preferred wired channel model i.e, AWGN channel model.

Similarly in fig.4 as well the performance achieved for CAD55 is similar to that of CAT5 cable. But with a reduced data rates for AWGN and Linear ZF canceler at the initial cable lengths of around 200 to 300m.

So, all in all, we can say that both the cable are showing significant performances for achieving higher data rates. But, CAT5 cable achieves better data rates as compared to CAD55 cable, in which AWGN being the dominant model and FEXT being the recessive of all.

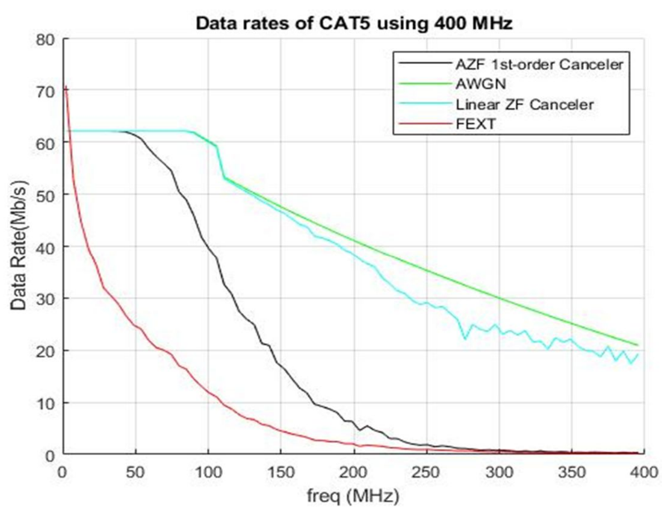


Fig 1. Data rate vs frequency plot of CAT5 using 400MHz

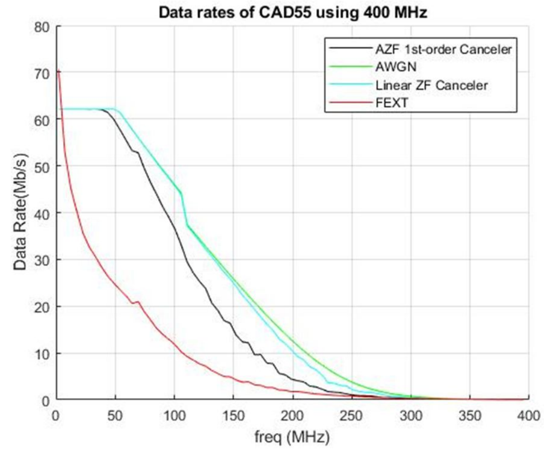


Fig 2. Data rate vs frequency plot of CAD55 using 400 MHz

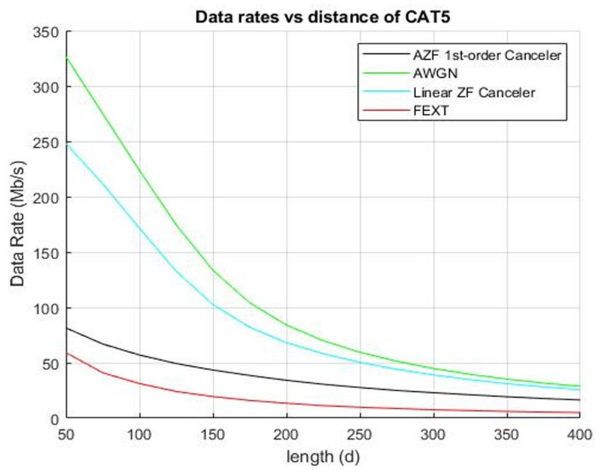


Fig 3. Data rate vs distance plot of CAT5 using 400 MHz

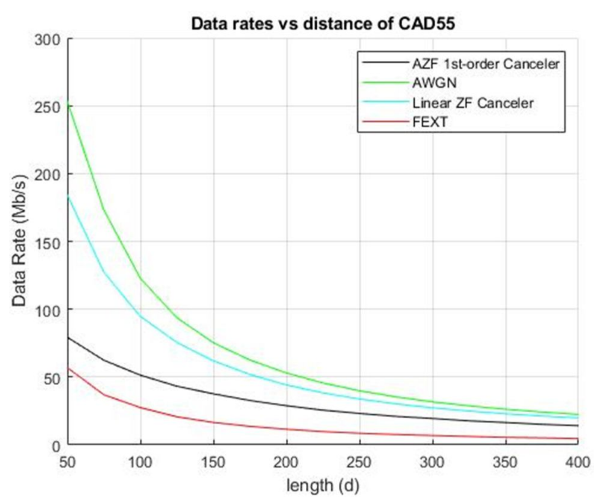


Fig 4. Data rate vs distance plot of CAD55 using 400 MHz

IV. CONCLUSION

In this article, we showed an outline of different types of DSL technologies used to transmit data over telephone lines. At higher frequencies, which is about 400 MHz the behaviour of the direct channel and crosstalk channel changes for various cables. We have shown data rates for CAT5 and CAD55 cables by using different cancelation techniques also how data rate deteriorates as distance increases. Depending upon different working scenarios, various complex non-linear crosstalk cancelation techniques can be used for further research.

REFERENCES

[1] Zafaruddin, Syed Mohammad, Itsik Bergel, and Amir Leshem. "Signal processing for gigabit-rate wireline communications: An overview of the state of the art and research challenges." IEEE Signal Processing Magazine 34.5 (2017): 141-164.

[2] Ginis, George, and John M. Cioffi. "Vectored transmission for digital subscriber line systems." IEEE Journal on selected areas in communications 20.5 (2002): 1085-1104.

[3] Timmers, Michael, et al. "G. fast: evolving the copper access network." IEEE Communications Magazine 51.8 (2013): 74-79.

[4] Yu, Wei, George Ginis, and John M. Cioffi. "An adaptive multiuser power control algorithm for VDSL." GLOBECOM'01. IEEE Global Telecommunications Conference (Cat. No. 01CH37270). Vol. 1. IEEE, 2001.

[5] Acatauassu, Diogo, et al. "Simple and causal twisted-pair channel models for G. fast systems." 2013 IEEE Global Communications Conference (GLOBECOM). IEEE, 2013.

[6] ITU-T, G. "9701 Fast Access to Subscriber Terminals (G. fast)—Physical Layer Specification." ITU-T recommendation, Series G: Transmission Systems and Media, Digital Systems and Networks (2014).

[7] Boets, Patrick, et al. "On the identification of cables for metallic access networks." IMTC 2001. Proceedings of the 18th IEEE Instrumentation and Measurement Technology Conference. Rediscovering Measurement in the Age of Informatics (Cat. No. 01CH 37188). Vol. 2. IEEE, 2001.

[8] Chen, Walter Y. DSL: simulation techniques and standards development for digital subscriber lines. Alpel Publishing, 1997.

[9] Van Den Brink, R., and B. Van Den Heuvel. "G. fast: Wideband modeling of twisted pair cables as two-ports." ITU-T SG15 Q4 Contrib. 11GS3-028 (2011).

[10] Musson, Joseph. "Maximum likelihood estimation of the primary parameters of twisted pair cables." ETSI TM6 981t08a0 (1998).

[11] Sector, ITU–Telecommunication Standardization. "G. fast: Improved model for shunt admittance in G. fast cable model _."

[12] Strobel, Rainer, Reinhard Stolle, and Wolfgang Utschick. "Wideband modeling of twisted-pair cables for MIMO applications." 2013 IEEE Global Communications Conference (GLOBECOM). IEEE, 2013.

[13] Chen, Jinghu, et al. "Reduced-complexity decoding of LDPC codes." IEEE transactions on communications 53.8 (2005): 1288-1299.

[14] Karipidis, Eleftherios, et al. "Crosstalk models for short VDSL2 lines from measured 30 MHz data." EURASIP Journal on Advances in Signal Processing 2006 (2006): 1-9.

[15] Sorbara, Massimo, et al. "Construction of a DSL-MIMO channel model for evaluation of FEXT cancellation systems in VDSL2." 2007 IEEE Sarnoff Symposium. IEEE, 2007.

[16] Maes, Jochen, Mamoun Guenach, and Michaël Peeters. "Statistical MIMO channel model for gain quantification of DSL crosstalk mitigation techniques." 2009 IEEE International Conference on Communications. IEEE, 2009.

[17] Xu, Wen, Christian Schroeder, and Peter Adam Hoeher. "A stochastic MIMO model for far-end crosstalk in VDSL cable binders." 2009 IEEE International Conference on Communications. IEEE, 2009.

[18] Karipidis, Eleftherios, et al. "Experimental evaluation of capacity statistics for short VDSL loops." IEEE Transactions on Communications 53.7 (2005): 1119-1122.

[19] Leshem, Amir, and Li Youming. "A low complexity linear precoding technique for next generation VDSL downstream transmission over copper." IEEE Transactions on Signal Processing 55.11 (2007): 5527-5534.

[20] Cendrillon, Raphael, et al. "A near-optimal linear crosstalk canceler for upstream VDSL." IEEE Transactions on Signal Processing 54.8 (2006): 3136-3146.

[21] Zafaruddin, S. M., Shankar Prakriya, and Surendra Prasad. "Iterative receiver based on SAGE algorithm for crosstalk cancellation in upstream vectored VDSL." International Scholarly Research Notices 2011 (2011).

[22] TM, ETSI STC. "Cable reference models for simulating metallic access networks." (1998).

[23] Humphrey, L., and T. Morsman. "G. fast: Release of BT cable measurements for use in simulations." 2013, Contribution ITU-T SG15/Q4a 2013-1-Q4-066 (2013).

[24] Telecom, British. "G. fast: Release of BT cable measurements for use in simulations." ITU-T SG15 Q 4 (2013): 5-9.

[25] Aligning, I. T., R. O. I. Maximizing, and Mobile Computing Handbook. "OTHER AUERBACH PUBLICATIONS." (2006).

[26] G. Series, "Transmission systems and media, digital systems and networks,"spitterless asymmetric digital subscriber line (adsl) transceivers,"itu-t g. 992.2," International Telecommunication Union, 1999.

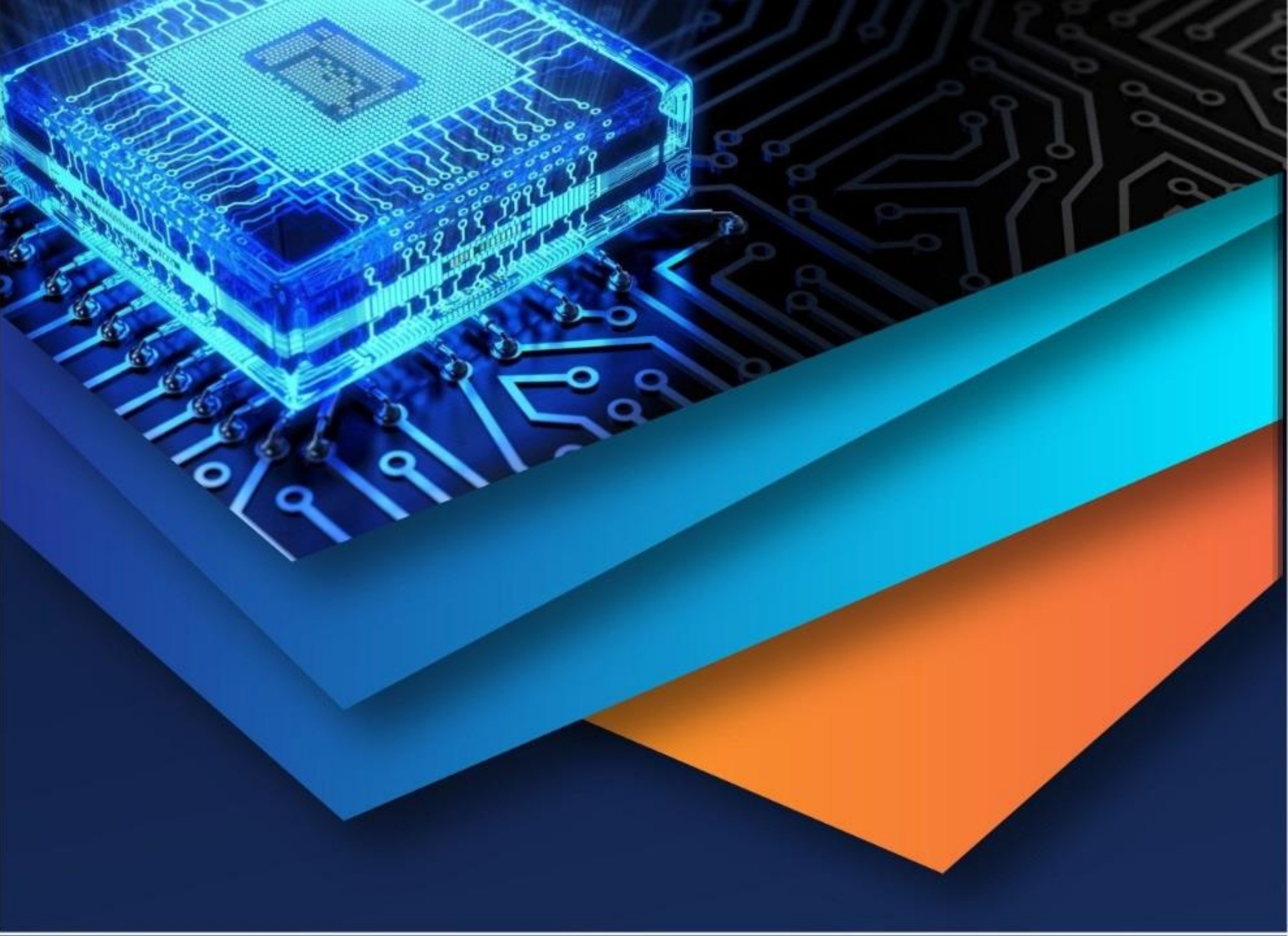
[27] G. ITU-T, "993.2 very high speed digital subscriber line transceivers 2(vdsl2)," Recommendation ITU-T G, vol. 993, 2006.

[28] Bostoen T, Boets P, Zekri M, Van Biesen L, Pollet T, Rabijns D. Estimation of the transfer function of a subscriber loop by means of a one-port scattering parameter measurement at the central office. IEEE Journal on Selected Areas in Communications. 2002 Aug 7;20(5):936-48.

[29] BT, "Parametric modeling of twisted pair cables for VDSL," ANSI contribution, T1E1.4/96-15, Jan 1996.

[30] Medeiros E, Lindqvist N, Monteiro M, Abrahim H, Lindqvist F, Dortschy B, Klautau A. DSM performance on practical DSL systems based on estimated crosstalk channel information. In2009 17th European Signal Processing Conference 2009 Aug 24 (pp. 2092-2096). IEEE.

[31] W. Y. Chen, DSL: Simulation Techniques and Standards Development for Digital Subscriber Lines. Indianapolis, IN, USA: Macmillan, 1998.



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