

A Review on Crosstalk in DSL Systems

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Abstract— Crosstalk is a serious problem in next-generation DSL systems such as VDSL. Several non-linear crosstalk cancelers and pre-compensators have been proposed to address this. Unfortunately they all suffer from high complexity, DFE error propagation and/or require modification of CPE. In this paper we propose the use of a simple non-linear adaptive filter for remove crosstalk canceler in upstream transmission. Adaptive filter for crosstalk cancel we use least mean square (LMS) technique and cancel crosstalk at near end in DSL line.

Key words: DSL, VDSL, LMS, NLMS

I. INTRODUCTION

One of the major impairments of DSL systems is the severe crosstalk among the telephone lines in the same or neighboring bundles. The crosstalk is classified into near-end crosstalk (NEXT) and far-end crosstalk (FEXT). In general, NEXT is much larger than FEXT because the interference source is closer to the receiver. Therefore, ADSL and VDSL use frequency division duplexing (FDD) to avoid NEXT from the same services. However, other types of services (such as HDSL, SDSL, T1, etc.), which use different duplexing schemes and overlap in frequency with ADSL and VDSL, may produce detrimental NEXT. Mitigating the effect of NEXT by cancelling it in a DSL receiver can dramatically increase the data rate, the line reach, or the system operational margin.

The optimum detector for interference cancellation can be theoretically achieved by maximizing the a posteriori probability of the primary signal (MAP rule), which is unfortunately too complex in practice. Some sub optimal multiuser detectors were proposed to mitigate or cancel the interference signal in the non-spreading system. These detectors decode each user's data using soft. Symbols and iterate the detection process until a certain criterion is reached (e.g., the maximum number of iterations). The convergence of this type of the algorithm is an open problem. The algorithm is still very complex when the signals have large constellation sizes.

This paper presents new practical methods to cancel or mitigate one (dominant) NEXT into an ADSL receiver. The principal idea is to estimate the crosstalk signal in certain frequency bands and subtract it in other frequency bands. A similar idea has been previously used to suppress very narrow band radio frequency interference (RFI) in VDSL systems. The crosstalk signal into an ADSL receiver has large excess bandwidth and its spectra in the main lobe and the excess band are strongly correlated, which gives the opportunity to cancel the crosstalk signal in some dependent frequency bands.

II. CROSSTALK ESTIMATION AND CANCELLATION

A. Geometrical Interpretation and Tone Selection:

A natural question arises on how to select the best frequency bands to estimate the crosstalk signal and to mitigate the

interference in the other bands. The answers for the two approaches above will be described separately in the following. The crosstalk signal uses baseband transmission; therefore the signal at a negative frequency is a conjugate of the counterpart at the positive frequency. For simplicity, this chapter describes the method in the single-sided positive frequency band.

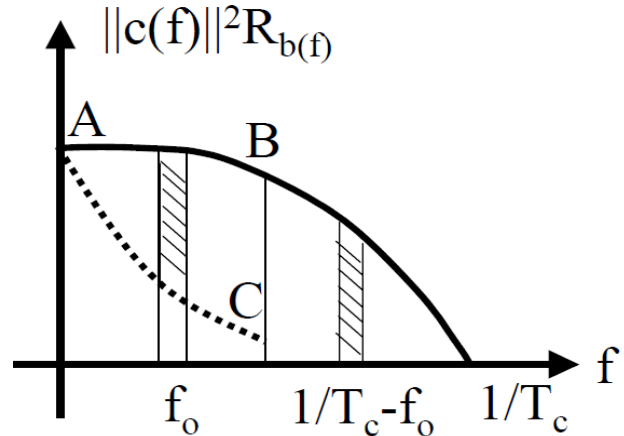


Fig. 1: Crosstalk Estimation and Cancellation

B. Crosstalk Cancellation:

The principal idea of crosstalk cancellation in this section is rest to estimate the crosstalk signal by observing the output of certain frequency bands and then to reconstruct the crosstalk signal in other bands to cancel, or minimize, the interference. If the crosstalk signal has an excess bandwidth, like HDSL and SDSL cross talkers, the cancellation is possible because the excess bandwidth provides more information about the crosstalk signal. In this section, the basic idea to cancel the crosstalk signal is described under the terminology of the above system model.

C. MMSE Estimation and Cancellation:

The right strategy, which will be justified later, is as follows:

- (1) Calculate SINRs in frequencies f_0 and $1/T_c - f_0$, where T_c is the crosstalk signal sampling period.
- (2) Estimate the crosstalk signal in the frequency bin that has a smaller SINR.
- (3) Cancel the interference in the other bin that has the larger SINR.

In Figure 3.2, the solid curve shows the power spectral density (PSD) of the crosstalk signal, with 100% excess bandwidth. The crosstalk signal is estimated in the excess band and then used to cancel the interference in the main lobe $(0, 1/2T_c)$. The dotted curve AC shows the residual crosstalk PSD as a result of the crosstalk subtraction. If the smaller one of the interference to noise ratios in frequencies f_0 and $1/T_c - f_0$ is denoted by g_s , then the SINR gain in frequency f_0 is approximately equal to g_s . Similarly, if the crosstalk signal is estimated in the main

lobe and used to cancel the interference in the excess band, the SINR gain in frequency $1/T_c - f_0$ is also approximately equal to g_s . These statements will be proved later in this subsection.

III. CONCLUSION

In this paper, a novel adaptive algorithm for the crosstalk cancellation using transmission line model was proposed. In our experiment, the proposed algorithm leads to a smaller MSE and faster convergence rate than the conventional LMS algorithm. Thus, this algorithm leads to a perceptually more accurate cancellation and faster convergence rate than the conventional algorithm. This algorithm would be suitable for general time-varying situation. Future work includes the reduction of other environmental noises which effect the signal during transmission.

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