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Cancellation of Partially-overlapped NEXT in DSL[1]

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유선 가입자 망에서 부분적으로 대역이 겹치는 NEXT 신호의 제거

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Abstract

We consider the NEXT cancellation problem when the transmit and receive signal spectrum are partially overlapped with each other in the frequency domain. In this case, the use of conventional NEXT cancellers may not be practical due to the computational complexity. When the overlapped bandwidth of the NEXT signal is less than the bandwidth of the transmit signal, the NEXT cancellation can be realized efficiently by processing in the baseband. The use of interpolation and decimation processing in the baseband makes it possible to realize the NEXT canceller with low computational complexity. The proposed scheme can provide NEXT cancellation performance comparable to the conventional one, while requiring the computational complexity less than one half the conventional one.

I. INTRODUCTION

Explosive demand for multimedia services requires higher data transmission speed, which can be achievable by increasing the spectral efficiency or signal bandwidth [1]. Although the spectral efficiency has been dramatically improved in the past three decades, it is unlikely that the demand for high speed transmission can be solved by simply increasing the spectral efficiency. As a result, it is also required to increase the symbol rate or the signal bandwidth. However, the increase of the symbol rate may not always be feasible in practice due to the limited available bandwidth and implementation complexity. For example, in digital subscriber loop (DSL) environment, different frequency bands are used for the transmitter (Tx) and receiver (Rx) for duplex operation. The increase of the symbol rate can be achieved without the increase of overall bandwidth by making the Tx and Rx spectrum overlapped with each other in the frequency domain [2]. In this case, it is indispensable to suppress the NEXT signal due to the use of non-insulating copper wires in a cable.

There have been extensive studies on the cancellation of echo signals [3-5]. This results can be also applied to NEXT cancellers. It is known that the inband data-driven NEXT canceller scheme provides reliable performance, while being robust to the timing and frequency offset [4]. Conventional inband data-driven canceller processes the NEXT signal at a Nyquist rate, which can be implemented using a polyphase structure [5]. When the overlapped bandwidth of the NEXT signal is smaller than the bandwidth of the Tx signal, the use of a conventional Nyquist rate inband data-driven canceller uses the sampling frequency much higher than the bandwidth of the overlapped NEXT signal, requiring large computational complexity.

In this paper, we propose a new scheme for cancellation of partially overlapped NEXT signal with reduced implementation complexity. When the bandwidth of the overlapped NEXT is small compared to that of the Tx signal, we can cancel the overlapped NEXT signal in the baseband. With the use of appropriate interpolation and decimation filters, the proposed scheme can process the operation at a lower rate, significantly reducing the computational complexity.

In Section II, the proposed scheme is applied to cancellation of partially overlapped NEXT signal due to the extension of the Tx and Rx signal spectrum in the DSL. The performance of the proposed scheme is analyzed and verified by computer simulation in Section III. Finally, concluding remarks are given in Section IV.

II. PROPOSED NEXT CANCELLATION SCHEME

Assume that the spectra of the Tx and Rx signal are partially overlapped for full-duplex operation as illustrated in Fig. 1, where f_{C_L} and f_{C_H} denote the carrier frequency of the low-band and high-band signal in the DSL, respectively, and $f_e = f_{C_L} + \frac{f_{b_L}}{f_{b_L} + f_{b_H}}\left(f_{C_H} - f_{C_L}\right)$. Here f_{b_L} and f_{b_H} are the symbol rate of the low-band and high-band signal, respectively. The bandwidth overlapping with the use of non-insulating copper wires in a cable results in an NEXT signal in the received signal. The shadowed region in Fig. 1 manifests the spectrum of the NEXT signal partially overlapped with the received signal in the frequency domain.

We assume that the Tx signal is pulse-shaped using a square-root raised cosine filter with roll-off factor α. Then, the spectrum of the NEXT signal is located in the frequency

$$f_{C_H} - \frac{f_{b_H}}{2}(1+\alpha) \le f \le f_{C_L} + \frac{f_{b_L}}{2}(1+\alpha). \qquad (1)$$

As a measure of the amount of the spectral overlapping, we define by the carrier spacing ratio

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