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Residual Self-Interference Cancellation and Data Detection in Full-Duplex Communication Systems

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***Abstract*—Residual self-interference cancellation is an important practical requirement for realizing the full potential of full-duplex (FD) communication. Traditionally, the residual self-interference is cancelled via digital processing at the baseband, which requires accurate knowledge of channel estimates of the desired and self-interference channels. In this work, we consider point-to-point FD communication and propose a superimposed signaling technique to cancel the residual self-interference and detect the data without estimating the unknown channels. We show that when the channel estimates are not available, data detection in FD communication results in ambiguity if the modulation constellation is symmetric around the origin. We demonstrate that this ambiguity can be resolved by superimposed signalling, i.e., by shifting the modulation constellation away from the origin, to create an asymmetric modulation constellation. We compare the performance of the proposed detection method to that of the conventional channel estimation-based detection method, where the unknown channels are first estimated and then the data signal is detected. Simulations show that for the same average energy over a transmission block, the bit error rate performance of the proposed detection method is better than that of the conventional method. The proposed method does not require any channel estimates and is bandwidth efficient.**

***Index Terms*—Full-duplex communication, symbol detection, self-interference cancellation, superimposed signaling.**

I. Introduction

For many years simultaneous signal transmission and reception in the same frequency band, known as full-duplex (FD) communication, was considered to be impractical due to the large self-interference signal [1]. More recently, with advanced multi-stage self-interference cancellation techniques, FD communication is becoming a reality and it is expected to be used by the next generation of wireless communication systems [2], [3].

In FD communication systems, self-interference cancellation is performed in two stages. In the first stage, which is known as *passive cancellation*, the radio frequency (RF) antennas are well-isolated to minimize the amount of interference [4]. In the second stage, which is known as *active cancellation*, the residual interference signal from the previous stage is cancelled either at RF or at digital baseband [5]–[8]. Due to channel estimation errors, the RF canceller cannot completely remove the interference. Hence, the residual interference after the RF canceller is still higher than the receiver noise floor and needs to be cancelled via digital processing at baseband [4], [5], [9]. However, effective self-interference cancellation at baseband requires accurate knowledge of the digital channels, which are the channels observed by the receiver at baseband after the passive and RF cancellation stages [10]. Consequently, for reliable FD communication first the digital channels are estimated and then the received signal is processed for data detection [5], [6], [11]. However, the digital channel estimation is not bandwidth efficient because it requires pilot transmission.

In this paper, we focus on the received signal after the passive and RF cancellation stages in a point-to-point FD communication system. Different from existing works, we propose a data detection technique based on superimposed signaling which does not require any channel estimates. We show that superimposed signaling can overcome the ambiguity inherent in the data detection problem when channel estimates are not used. The main contributions of this work are:

- We formulate a maximum a posterior (MAP) detector, based on the posterior probability distribution (PDF) function of the data, to detect the data symbols in FD communication without any requirement of channel estimation.
- We show that if the modulation constellation is symmetric around the origin, the data detection in FD communication results in ambiguity when the channel estimates are not available. We demonstrate that one simple method to resolve this detection ambiguity is to use superimposed signalling, i.e., to shift the modulation constellation away from the origin and create an asymmetric modulation constellation.
- We compare the bit error rate performance of the proposed detection method to that of the conventional channel estimation-based detection method, where the unknown channels are first estimated and then the data signal is detected, under the constraint of same average energy over a transmission block. The results show

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