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# Bandwidth Efficient Channel Estimation for Full Duplex Communication Systems

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***Abstract*—In this paper, the channel estimation problem in full duplex (FD) point-to-point wireless communication systems is investigated. Because of the existence of two interfering and communication channels, this problem is fundamentally different from the conventional channel estimation problems in half duplex (HD) communication systems. Here, we propose a blind channel estimator that simultaneously estimates the channel parameters of the FD system without requiring time division duplex. A major problem for blind estimators is the identifiability of the parameters. Therefore, thorough analysis is presented to determine the identifiable parameters in this estimation problem. It will be shown that a completely blind estimator utilizing a symmetric modulation set suffers from phase ambiguity. For this reason, only the channel magnitudes can be estimated blindly. It is further presented that if the modulation set is not centered around the origin then this phase ambiguity can be resolved.**

## I. Introduction

Wireless communication devices are traditionally designed for half duplex (HD) operation, where they can transmit and receive data on two different frequency bands. However this operation mode fundamentally limits the bandwidth efficiency of the communicating nodes. Therefore, a significant trend of research is now directed at wireless devices that are capable of transmission and reception in the same frequency band. These devices that are known as full duplex (FD) wireless devices, are more bandwidth efficient than their HD counterparts [1]–[3]. An important part of the research in this area is dedicated to the theoretical analysis of the performance of these devices. More specifically, the data rate improvements over the HD operation is analyzed in [4]–[6]. These studies reveal that a major flaw that severely affects the performance of FD devices, is self-interference caused by the shared channel for transmission and reception. To overcome this issue, a major research stream has emerged to deal with completely cancelling or partially removing the self-interference.

Active and passive cancellation techniques are proposed in the literature to address this issue. In passive cancellation transmitting and receiving antennas are well isolated to reduce the amount of interference. On the other hand, active cancellation techniques are proposed alongside passive cancellation to achieve better performance by further mitigating the self-interference. For efficient active self-interference cancellation the knowledge of the channel is essential. Therefore, accurate channel estimation is crucial to realizing the potential of FD devices. The problem of channel estimation in FD point-to-point systems is different from that of classical HD systems as in these systems there exist two channels, i.e, the self interference channel and the communication channel. These channels need to be simultaneously estimated at the receiver end. The self-interfering channel should be estimated for self-interference cancelation and the communication channel is required for data detection at the receiver.

The current approach for channel estimation is to keep the transmitting nodes silent while estimating the self interference channel. Subsequently, pilots are sent for the estimation of the channel parameters [7]–[10]. In [7], five pilots are sent to estimate the interfering channel parameters while the transmitting node is kept silent. As a result, in total, ten pilots are transmitted to estimate both the interfering and communication channels. Thus, such a channel estimation approach reduces bandwidth efficiency.

In this paper we present a blind channel estimator for FD wireless communication devices that does not require pilot training and enhances the bandwidth efficiency of the FD system. It is assumed that full knowledge of the distribution of transmitted symbols is available. With this assumption, it will be shown that the blind channel estimation problem for this system requires solving a non-convex Gaussian Mixture maximization that can be solved using the Expectation Maximization (EM) approach. Unlike existing work in the literature that focus on blind estimating of multiple channel parameters