Example of a Full-duplex Implementation

Melissa Duarte

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1 Introduction

Current deployed wireless communication systems employ devices which use either a time-division or frequency-division approach for wireless transmission and reception of signals. This requires dividing the temporal and/or spectral resources into orthogonal resources and results in an orthogonalization of the transmissions and receptions performed by a wireless device. Consequently, all currently deployed wireless devices operate in half-duplex fashion, where same frequency simultaneous transmission and reception of signals is not possible. The key challenge in achieving full-duplex wireless communications, where a device can transmit and receive signals over-the-air at the same time and in the same frequency band, is the large power differential between the self-interference created by a devices own wireless transmissions and the received signal of interest coming from a distant transmitting antenna. This large power differential is due to the fact that the self-interference signal has to travel much shorter distances than the signal of interest. The large self-interference spans most of the dynamic range of the Analog to Digital Converter (ADC) in the received signal processing path, which in turn dramatically increases the quantization noise for the signal-of-interest. Thus to achieve full-duplex it is essential to suppress the self-interference before the analog received signal is sampled by the ADC.

Current wireless network designs have assumed that the power differential between the self-interference and the signal of interest is such that it is impossible to cancel the self-interference enough in order to make full-duplex wireless communications feasible. However, recent work in self-interference cancellation and full-duplex implementation [1–4] has demonstrated that it is possible to implement self-interference cancellation mechanisms that can sufficiently attenuate the self-interference such that the resulting full-duplex wireless system can achieve higher rates than a half-duplex system.

In this document we describe an example of a full-duplex implementation. Our example is based on the code that was used to generate the results in [1]. We provide the code and explanations that will help the user get a full-duplex setup running. If a user is interested in reproducing this example in the lab we recommend to carefully follow the instructions below. There is a risk of permanently damaging the radios if the radios are connected in the wrong way. The user should use the code and explanation provided below in this document at his/her own risk.

2 Description of the experiment setup.

Place two WARP nodes and six antennas as shown in Figure 1. The distances do not have to exactly match those shown in Figure 1 but we recommend that they are within ±2 cm. The antennas that will be connected to Node 1 are labeled as A, B, and C. The antennas that will be connected to Node 2 are labeled as D, E, and F.

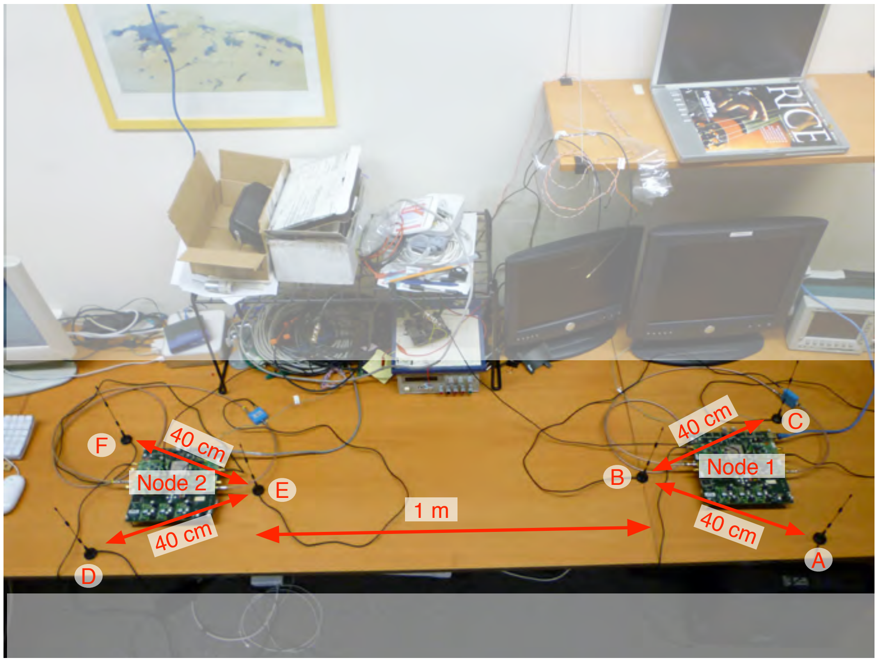

Figure 1: Figure showing the distance between nodes and the distance between antennas that must be set for running the example.

At Node 1 connect Antenna A to Radio 1 and Antenna C to Radio 4. The antennas and radios 1 and 4 are shown in Figure 2.

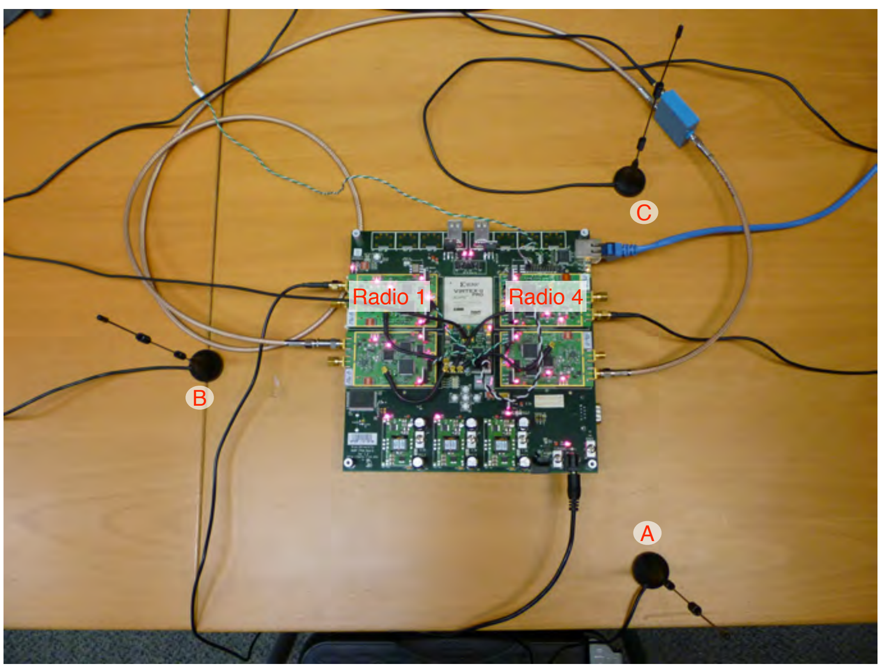

Figure 2: Antennas A and C at node 1 are connected to radios 1 and 4 at node 1 respectively.

At Node 1 connect a 30dB attenuator to the output of Radio 2. Connect a 50 Ohm coax cable to the 30dB attenuator. See Figure 3.WARNING: An attenuator of at least 30 dB must be connected to the output of Radio2. Using lower attenuation will most likely result in damage to the radios since the cable connected to Radio 2 will be connected to Radio 3 trough an RF adder. The attenuator of at least 30 dB is needed to cancel the effect of the power amplifier of Radio 2 so that the signal is reduced and the input to Radio 3 is within power levels that will not damage the radio. Input power levels larger than -15 dBm will most probably damage the radio

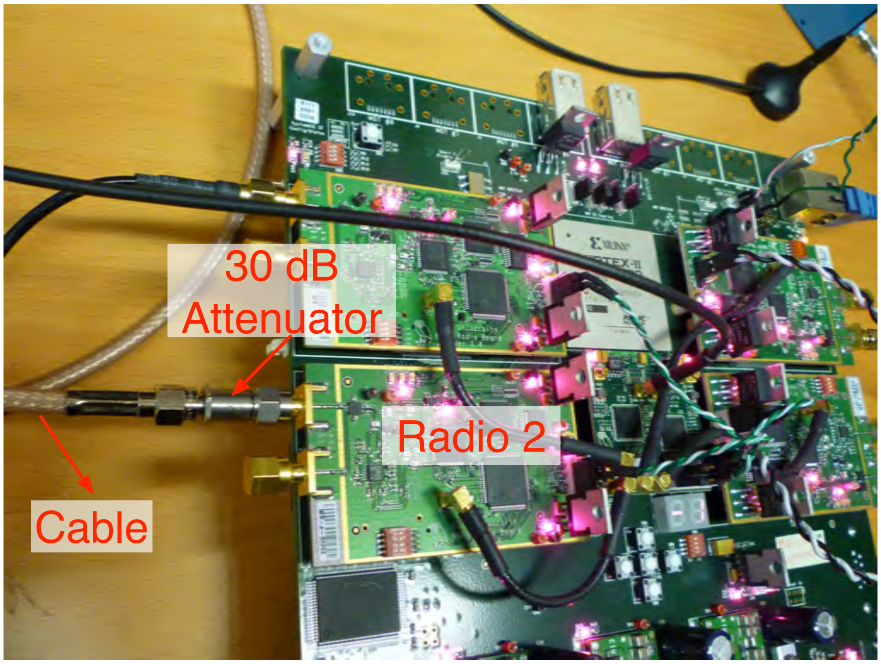

Figure 3: Connect Node 1 Radio 2 to a 30 dB attenuator and connect the attenuator to a cable.

Connect to an RF adder (for RF adder we used Pasternack power combiner PE2014) the cable that is connected to the 30 dB attenuator (which is connected to Radio 2). Connect Antenna B to the other input of the RF adder. Connect the output of the RF adder to Radio 3. See Figure 4.

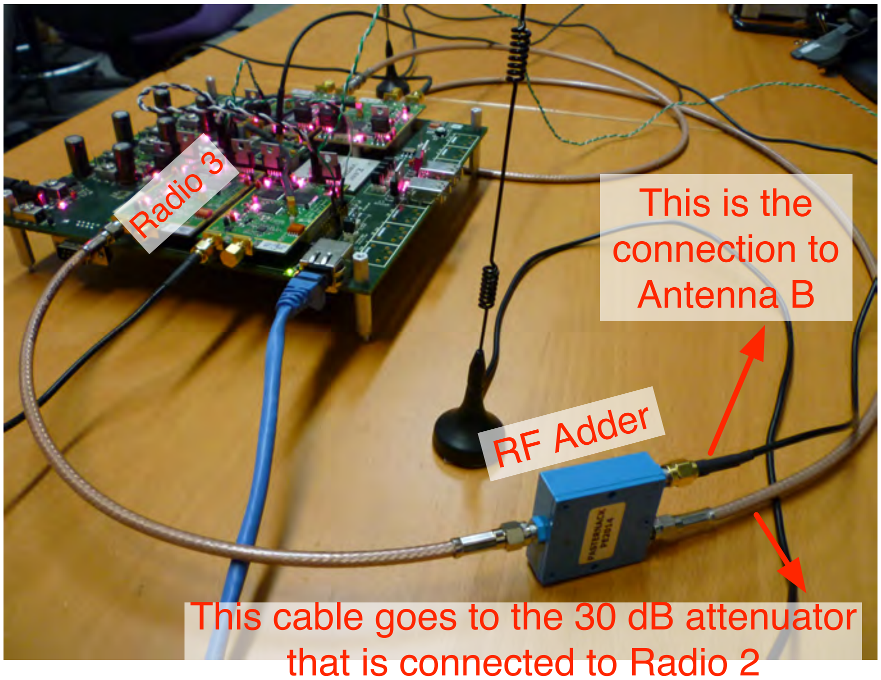

Figure 4: Connect Radio 3 to an RF adder. One input of the RF adder is connected to Antenna B. The other input of the RF adder is connected to the 30 dB attenuator that is connected to Radio 2.

References

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[3] J. I. Choi, M. Jain, K. Srinivasan, P. Levis, and S. Katti, "Achieving Single Channel, Full Duplex Wireless Communication," in Proc. Mobicom 2010.

[4] M. Jain, J. I. Choi, T. Kim, D. Bharadia, K. Srinivasan, S. Seth, P. Levis, S. Katti, and P. Sinha, "Practical, Real-time, Full Duplex Wireless," in Proc. Mobicom 2011.