

# A Multipurpose Testbed for Full-Duplex Wireless Communications

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## Full-Duplex Radio

### Full-duplex radio:

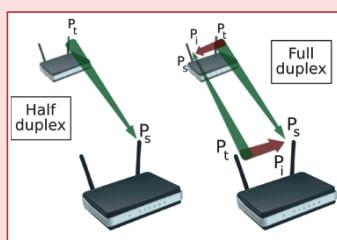
New paradigm, offers new wireless opportunities:

- 2x throughput
- 2x spectral efficiency
- More efficient MAC layer

### Challenges:

- Very strong **self-interference**
- Self-interference signal is known, but hard to replicate due to **transmitter imperfections**

Need for a versatile testbed to evaluate and improve self-interference cancellation methods



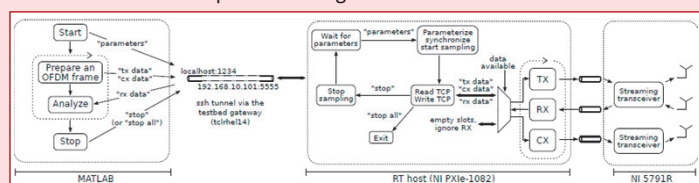
## LabVIEW – MATLAB Interface

### • LabVIEW (running on host):

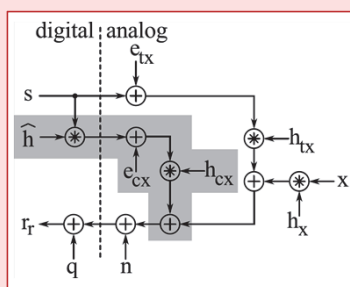
1. High speed processing through real-time host OS
2. Very high speed processing through access to built-in FPGA boards

### • MATLAB (running on network-connected PC):

1. Rapid prototyping through TCL codebase re-use
2. Interactive manipulation of signals



## Self-Interference Cancellation Method



### In principle:

- Self interference is **fully known**
- We can replicate negative signal and add it to cancel

### In practice:

- Only **digital** self interference is **fully known**
- **Analog** signal is affected by imperfections which cannot always be replicated

We can replicate negative signal and add it to cancel, but we are limited by **transmitter imperfections**

### Our testbed supports:

- **Wideband** cancellation of up to 100 MHz (i.e., multi-tap channels)
- **Non-linear** cancellation (i.e., cancellation of transmitter harmonics)
- **Any transmission scheme** can be implemented in software

## Testbed Hardware and Network Setup

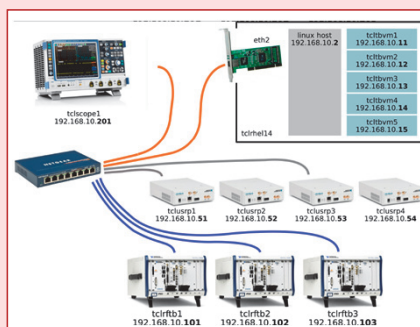
### Hardware

- 3x National Instruments **PXIe-1082**
  1. 1x **Host PC** (runs LabVIEW and real-time LabVIEW code)
  2. 3x **5791R RF transceivers** (contain FPGA for high speed DSP)
  3. Used for complex tasks (e.g. full-duplex OFDM transceiver)
- 4x National Instruments **USRP-2920**
  1. LabVIEW code runs on external PC connected over the network
  2. Used for simpler tasks (e.g., standard OFDM transceiver)
- 1x PC with 5 Windows 7 VMs with **LabVIEW**
- 1x Rohde & Schwarz **RTO1044** Oscilloscope

### Network

### • Testbed accessible from:

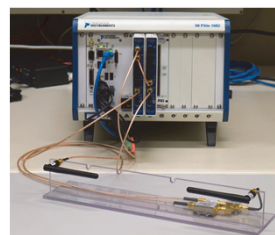
1. Within the lab through standard network
2. All over the world through SSH



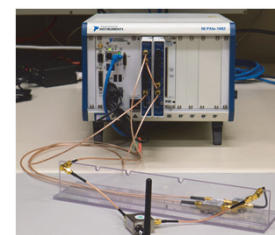
## Full-Duplex Node

### Full-Duplex SISO Node

1. 1x **PXIe-1082** with 2x **5791R** units (1 for Tx and Rx, 1 for CX)
2. Interchangeable antenna front-ends for evaluate passive suppression mechanisms



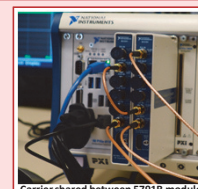
Front-end with two antennas spaced at 20 cm for Tx-Rx isolation



Front-end with circulator for Tx-Rx isolation

- Significant part of transmitter imperfections is **phase noise**

- Phase difference between Tx and Cx can be minimized by **sharing the carrier**

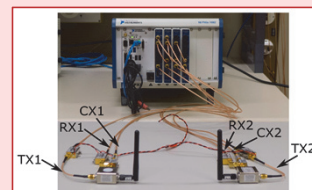


Carrier shared between 5791R modules

### Full-Duplex 2x2 MIMO Node

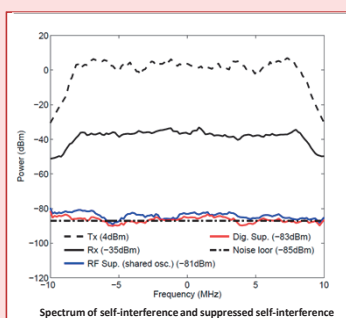
### • Setup:

1. 1x **PXIe-1082** with 4x 5791R units (2 for Tx and Rx, 2 for CX)
2. Cross-interference terms are handled in the **digital domain**



Carrier sharing between 5791R modules

## Self-Interference Cancellation Capability



- Self-interference can be reduced to the noise floor over **wide range of transmit powers and bandwidths**

