Lab 1: Introduction to SDRs

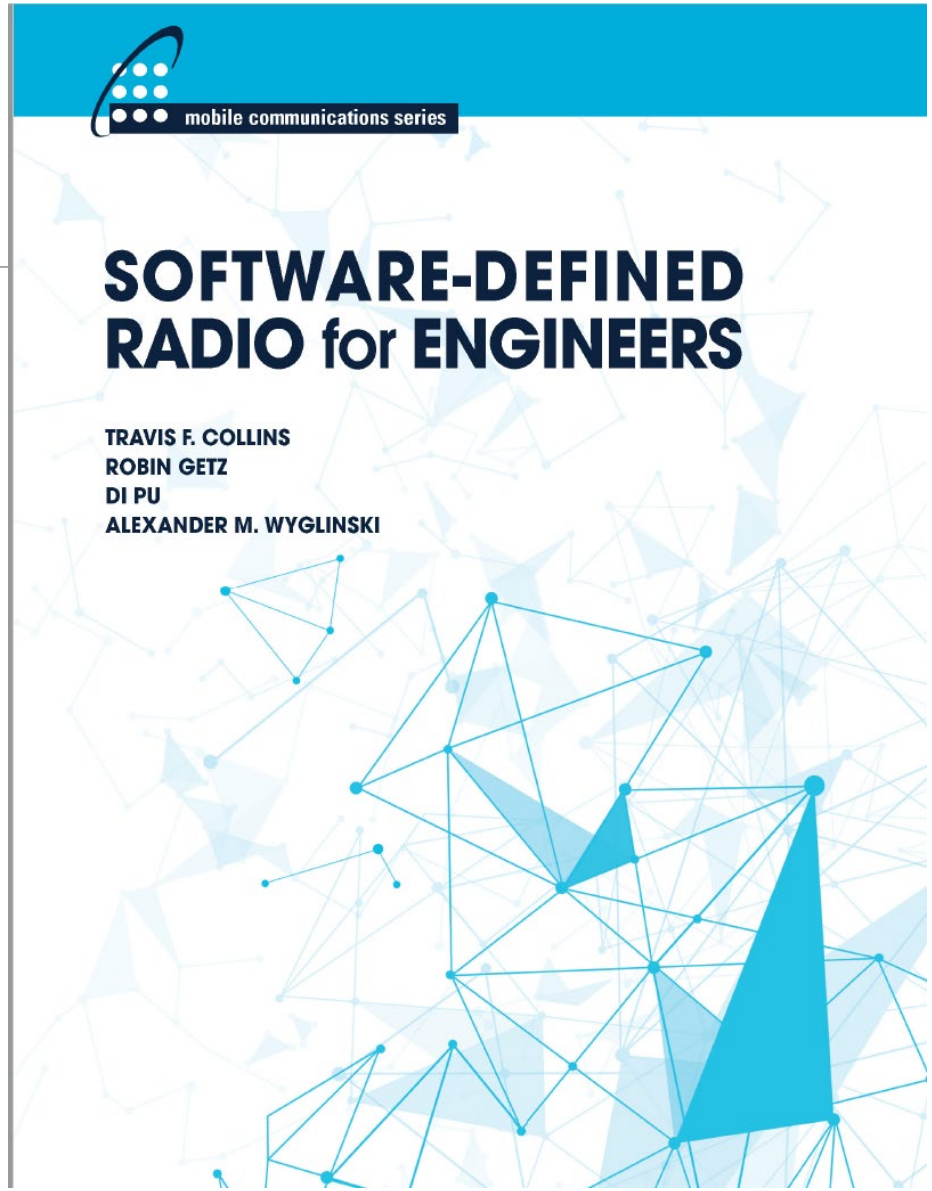
PROF. SUNDEEP RANGAN

Learning Objectives

- ❑ Describe a SDR vs. a traditional custom hardware device
- ❑ Describe the roles of the SDR and host in TX and RX processing
- ❑ Compare real-time and non-real time processing
- ❑ Set up the ADALM-Pluto for non real-time processing in MATLAB
- ❑ Set up different configurations (loopback, non-loopbacks, one or two hosts)
- ❑ Transmit samples in a continuous loop
- ❑ Capture and visualize a frame of samples

Excellent Reference

- Free instruction book on SDRs
  - Analog website
- MATLAB exercises
- Based on ADALM-Pluto
- But a little theoretical



SDRs vs. Custom Hardware

- Traditional custom communication hardware device
  - Ex: iPhone, Android, base stations (mostly)
  - Custom integrated circuits
  - Highly optimized
  - Power efficient, small form factor, high performance
  - Limited programmability of communications functions
- Software defined radio
  - Implemented in programmable components (FPGA, ARM, Host PC)
  - Limited functionality / processing speed
  - Large form factor
  - Not (typically) for commercial use
  - Easy to change / program
  - Excellent for learning, simple

ADALM-Pluto

- Simple, low-cost SDR
- Lightweight
- Can run on USB power
- Sufficiently capable for basic experiments
- WiFi and cellular emulation
- NYU students will be provided one Pluto each
  - Work in pairs for most labs

ADALM-Pluto Capabilities

Features and Benefits | Product Details

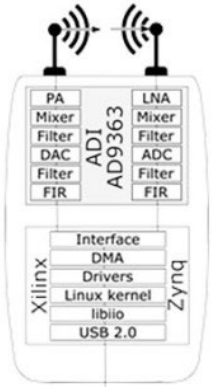
- Portable self-contained RF learning module
- Cost-effective experimentation platform
- Based on Analog Devices AD9363--Highly Integrated RF Agile Transceiver and Xilinx® Zynq Z-7010 FPGA
- RF coverage from 325 MHz to 3.8 GHz
- Up to 20 MHz of instantaneous bandwidth
- Flexible rate, 12-bit ADC and DAC
- One transmitter and one receiver, half or full duplex
- MATLAB®, Simulink® support
- GNU Radio sink and source blocks
- libiio, a C, C++, C#, and Python API
- USB 2.0 Powered Interface with Micro-USB 2.0 connector
- High quality plastic enclosure

❑From Analog devices webpage

Getting Started

- ❑ Purchase Pluto device
  - NYU students enrolled in class will get one device each to borrow for class
- ❑ Install drivers on PC (Windows, Linux, or IOS)
- ❑ Install MATLAB
- ❑ All instructions available at [MATLAB ADALM-Pluto webpage]

Inside the Pluto



MATLAB®

- Pluto
  - RF up-conversion & down-conversion
  - Filtering
  - ADCs and DACs
  - Interfaces with host via complex baseband samples
- Host
  - Performs all baseband processing
  - This class we use MATLAB

The 9361 Integrated Circuit

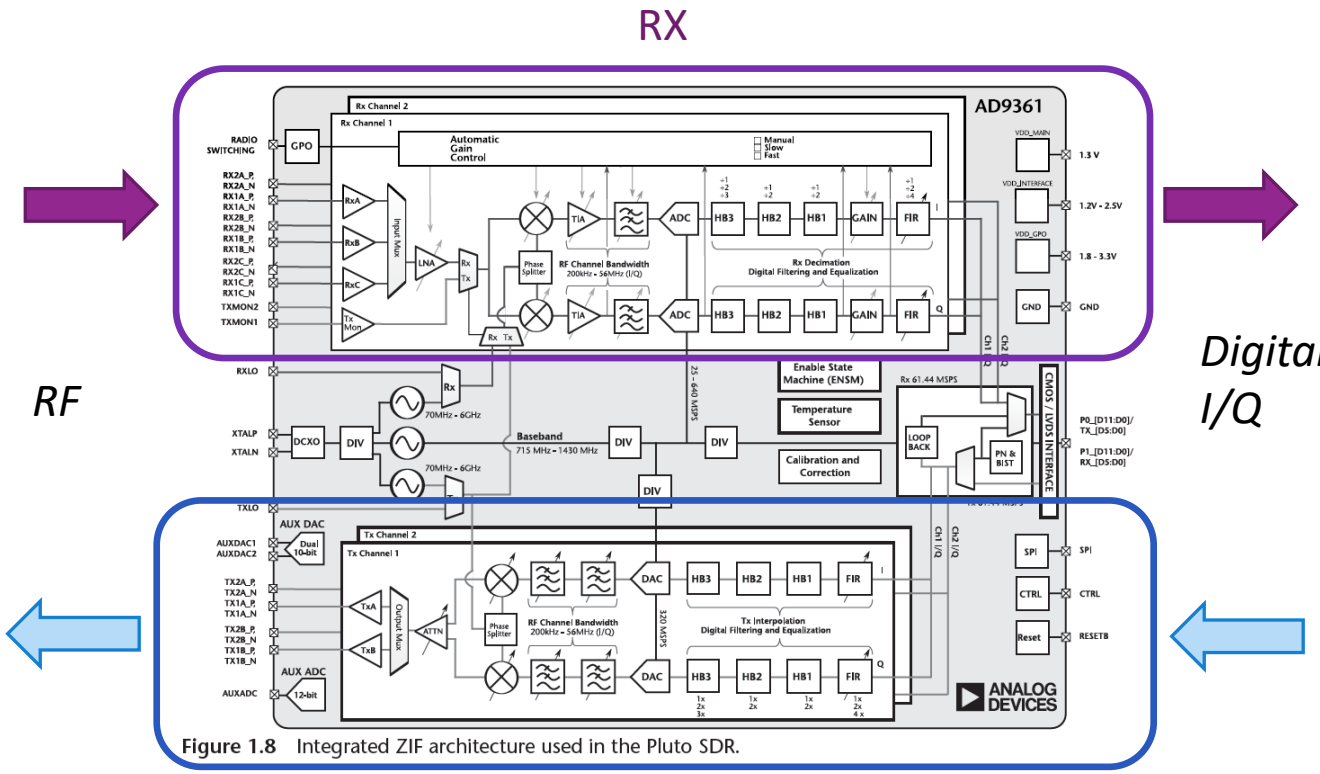


Figure 1.8 Integrated ZIF architecture used in the Pluto SDR.

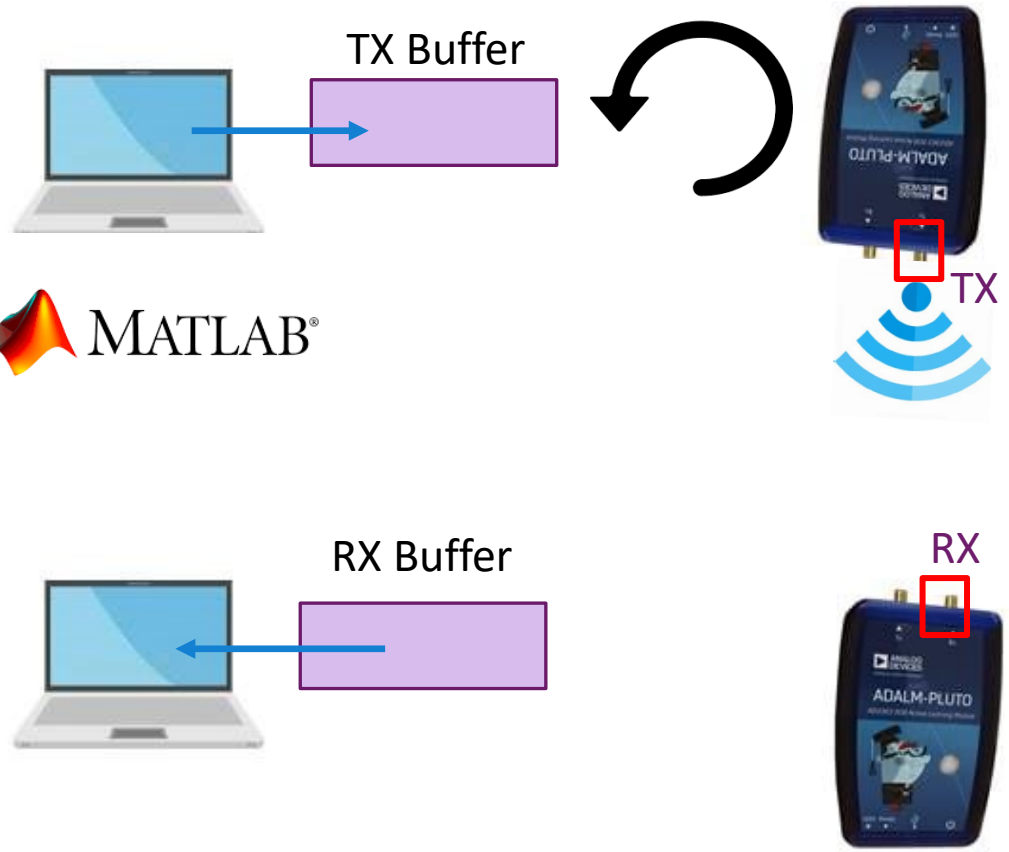
- Analog Devices AD9361 Wideband TXCR
  - Single integrated circuit
- Receiver (RX):
  - Low noise amplifier (LNA)
  - Then tunable mixer, ADC, Filters
- Transmitter (TX):
  - Filters, DAC, tunable mixer
  - Power amplifier (PA)

Non-Real Time Processing

- This class: non-real time experiments
  - Simple and channel is realistic
  - But one-way, limited duration

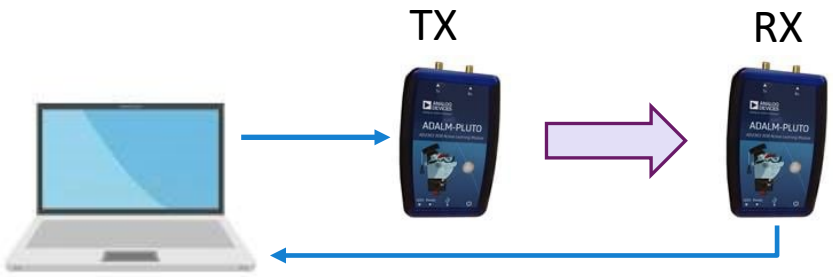
- Transmitter (TX)
  - Load circular buffer once
  - TX repeatedly sends same samples over and over again

- Receiver (RX)
  - Capture one frame of samples
  - Load IQ samples into computer
  - Process offline



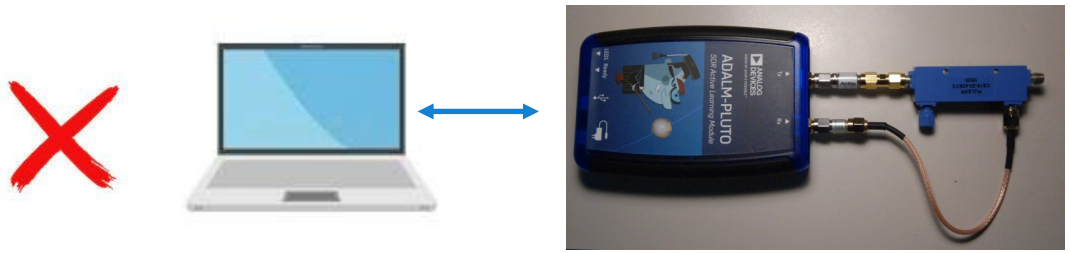
Configurations

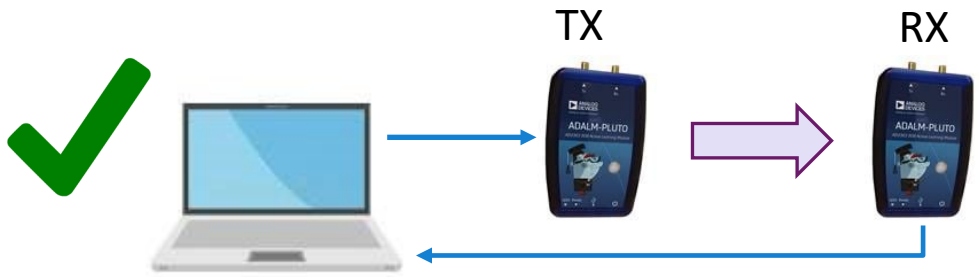
- Loopback
  - One Pluto, one host
  - Pluto performs TX and RX
  - Easy but fixed, uninteresting RF channels
  - Good for initial debugging
- One host, two Plutos
  - Requires only one host
  - Channel limited by cable length
- Two hosts, one Pluto each
  - Most flexibility in channels
  - But require two hosts



Lab Submissions

- Use two Pluto devices
  - Single or two hosts
- Work in pairs
  - At NYU, each student has one Pluto





Lab 1: Capturing and Receiving Samples

Setting Up and Capturing Samples with the ADALM-Pluto

The ADALM-Pluto is a simple, but powerful software defined radio (SDR) that is excellent for teaching basic concepts in digital communications and wireless. In this first lab, you will learn to:

- Initalize and configure the ADALM-Pluto device
- Connect one or more Pluto devices to the host computer for single device loopback and tw
- Transmit complex baseband samples in a repeated loop from a Pluto
- Receive a single frame of complex baseband sampes to perform offline processing
- Capture multiple frames and detect and visualize overflow

Submissions: Perform the lab in pairs so that you will have two Pluto devices. You can run in eith two hosts). Either way, fill in all sections labeled `TODO` . Print and submit the PDF. Do not submit th