



# ECE 8863 CR Lab Logistics

## ■ Where

- Room 5148, 5<sup>th</sup> floor, Centergy One building, Tech Square

## ■ When

- During your scheduled time slots or by appointment with a TA

## ■ How

- Call BWN Lab **(404) 894-6616** from 5<sup>th</sup> floor lobby
- Go to Room 5158 (BWN Lab) to sign in
- Do your Lab work **(TAs are available in Room 5158)**
- Show deliverables to TAs
- Sign out



# In the Lab

## ■ CR Testbed Hardware

- USRP N210 x 5
- Wideband RF frontend
- Dell host laptops
- GB Ethernet switch

## ■ CR Testbed Software

- GNU Radio SDR platform
- Ubuntu OS
- Universal Hardware Driver (UHD)

## ■ Internet access: GTwpa

- No wired Internet access



# Meet the Software

## ■ GNU Radio

- Free software development toolkit (in Python and C++)
- Provide signal processing runtime and processing blocks to implement software radios
- Use readily available, low cost external RF hardware and commodity processors
- Graphical user interface: **gnuradio-companion** (used to be grc)

## ■ Universal Hardware Driver (UHD)

- UHD provides a host driver and API for USRPs



# USRP N210 Front View

Working state: verify these 3 green lights

GB Ethernet

A: transmitting

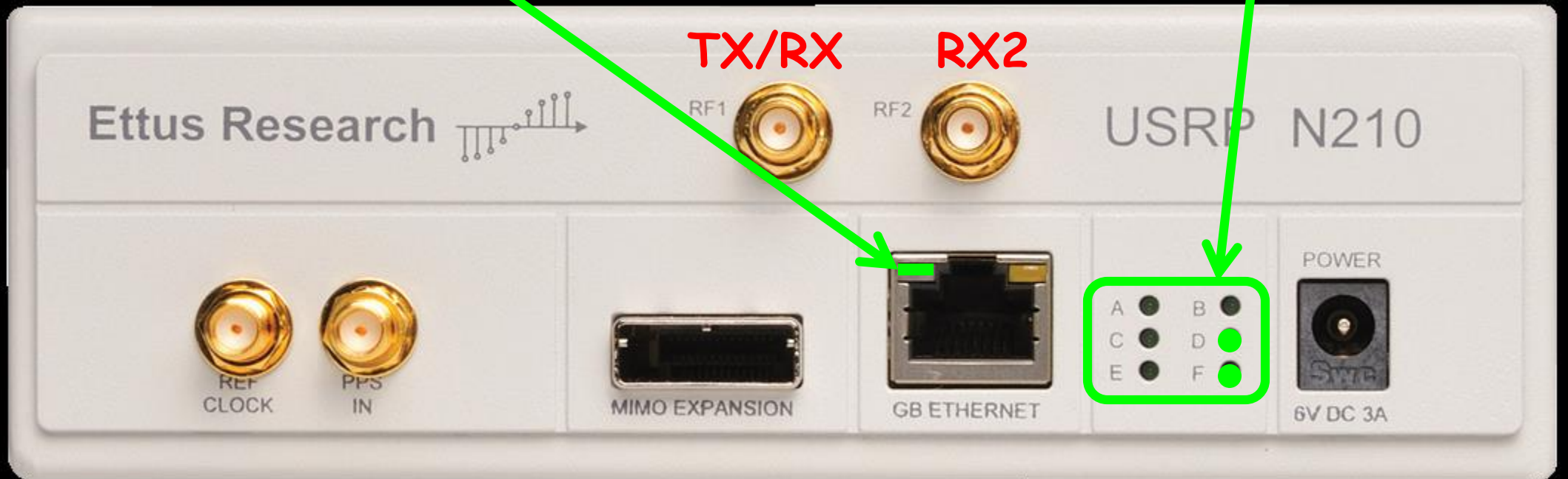
B: mimo cable link

C: receiving

D: firmware loaded

E: reference lock

F: CPLD loaded





# GNU Radio Companion

Generate  
flow graph

Execute  
flow graph

Kill  
flow graph

Options  
ID: dial\_tone  
Title: Dial Tone  
Author: Example  
Description: example flow graph  
Window Size: 1280, 1024  
Generate Options: WX GUI

Variable  
ID: samp\_rate  
Value: 32000

Variable Slider  
ID: noise  
Label: Noise  
Default Value: 0.005  
Minimum: 0  
Maximum: 0.2  
Num Steps: 100  
Slider Type: Horizontal  
Grid Position: 1, 0, 1, 2

Variable Slider  
ID: ampl  
Label: Volume  
Default Value: 0.4  
Minimum: 0  
Maximum: 0.5  
Num Steps: 100  
Slider Type: Horizontal  
Grid Position: 0, 0, 1, 2

Signal Source  
Sample Rate: 32000  
Waveform: Cosine  
Frequency: 350  
Amplitude: 0.4  
Offset: 0

Signal Source  
Sample Rate: 32000  
Waveform: Cosine  
Frequency: 440  
Amplitude: 0.4  
Offset: 0

Noise Source  
Noise Type: Gaussian  
Amplitude: 0.005  
Seed: 42

Add

Audio Sink  
Sample Rate: 32KHz  
Device Name:  
OK to Block: Yes

Blocks

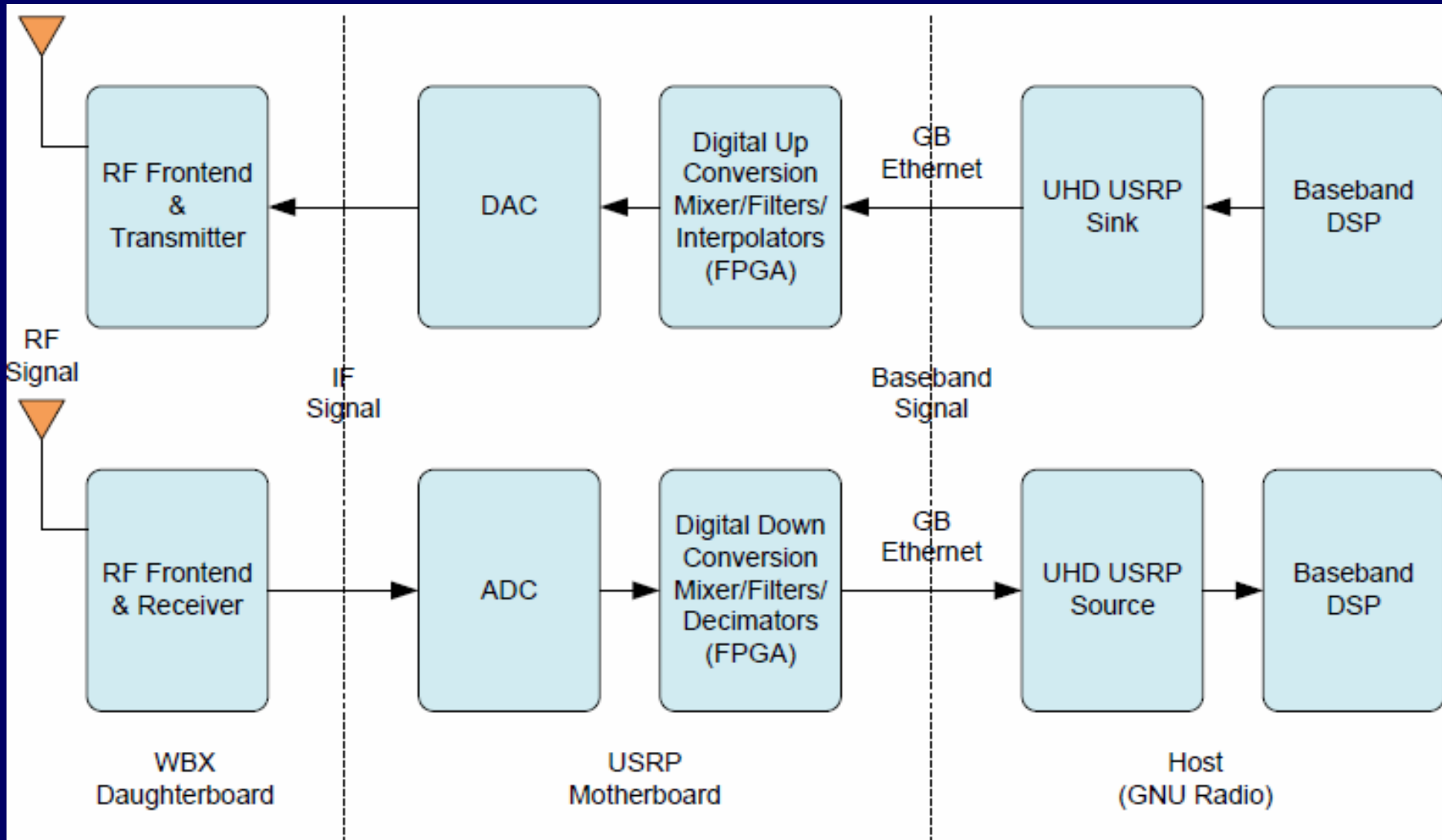
- [ Sources ]
- [ Sinks ]
  - Vector Sink
  - Null Sink
  - File Sink
  - UDP Sink
  - Audio Sink
  - Wav File Sink
  - Pad Sink
- [ Graphical Sinks ]
- [ Operators ]
- [ Type Conversions ]
- [ Stream Conversions ]
- [ Misc Conversions ]
- [ Synchronizers ]
- [ Level Controls ]
- [ Filters ]
- [ Modulators ]
- [ Error Correction ]
- [ Trellis ]
- [ USRP ]
- [ Variables ]
- [ Misc ]
  - [ UHD ]

Available  
DSP blocks

USRP N210  
interface  
blocks are  
here!!!



# CR Testbed Block Diagram





# Universal Software Radio Peripheral (USRP)

## ■ Latest Version of USRP N210 Motherboard

- 2 channels or 1 I-Q pair for both input and output
- Dual 100 MHz 14-bit ADCs
- Dual 400 MHz 16-bit DACs
- 50/25 MHz instantaneous RF bandwidth (8/16-bit mode)
- Processing/**Streaming** signals up to 100MHz/**50MHz** wide
- Xilinx **Spartan 3A-DSP3400** FPGA (with 32-bit RISC processor)
- 1 MB of high-speed SRAM
- Configuration and firmware stored in **onboard Flash**
- External ref clock: 5/10 MHz and 1 PPS (pulse per second) input
- Gigabit Ethernet interface
- MIMO expansion capability

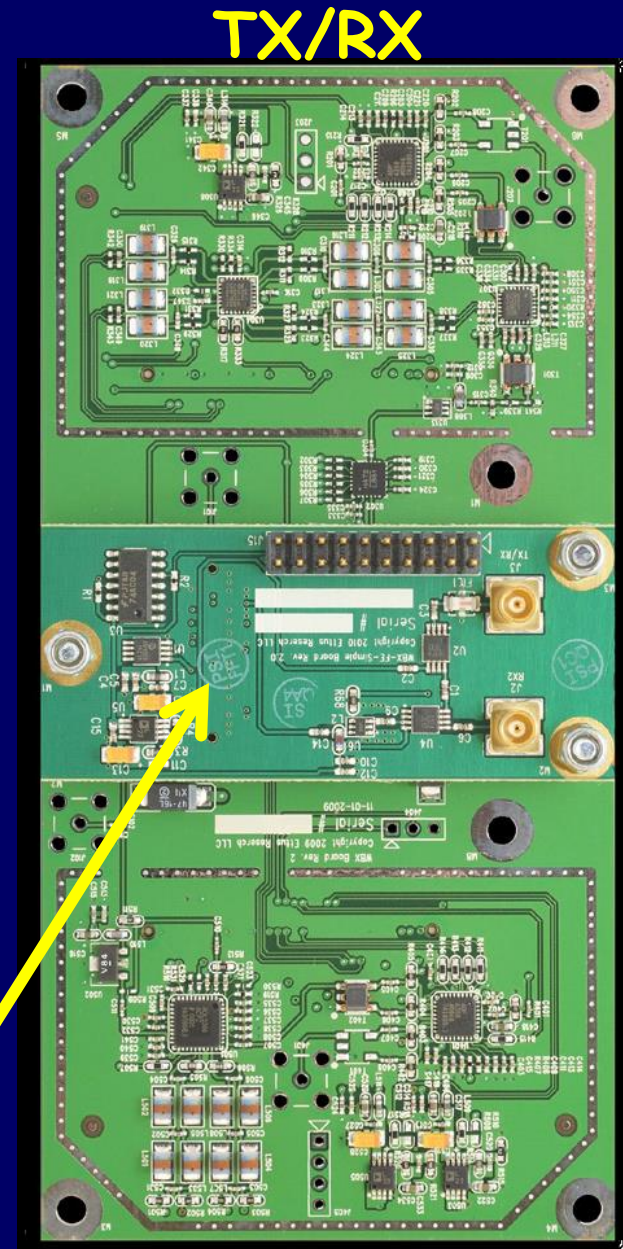


# WBX Transceiver Daughterboard

## ■ 50MHz-2.2GHz Full-duplex Transceiver

- Transmit antenna: **TX/RX**
- Receive antenna: **TX/RX** or **RX2**
  - When using WBX in full-duplex mode, the receive antenna will always be set to RX2
- Transmit gain range: **0-25 dB**
- Receive gain range: **0-31.5 dB**
- Bandwidth: **RX: 40 MHz** and **TX: 40 MHz**
- Cover white spaces, broadcast TV and FM radio, public safety radio, land mobile, WSNs, cell phones, and 6 amateur radio bands

LNA/filter board







# Antennas: VERT400 and VERT900

## ■ VERT400 (COMET SMA703)

- 144 MHz, 430 MHz, 1200 MHz Tri-band
- 118-160, 250-290, 360-390, 420-470, 820-960 MHz bands
- Gain: 3.4dBi (1200MHz)
- 7-inch vertical antenna



## ■ VERT900

- 824-960 MHz, 1710-1990 MHz Quad-band Cellular/PCS and ISM band
- Gain: 3dBi Gain
- 9-inch vertical antenna





# Typical CR Lab Design Procedure

- Prepare system requirements and constraints (frequency of operation, ADC sampling rate, etc.)
- Build the communication chain for transmitter and receiver on parallel (one block at a time)
- Test the communication chain under simulation environment → understand the limitation of the design
- Add the UHD interfaces and test the design on the testbed
- Debug, troubleshoot and iterate



# UHD USRP Source/Sink Block

## ■ UHD: USRP Source

- Used in receiving path

Parameter	Value
ID	uhd_usrp_source_0
Output Type	Complex
Device Addr	addr=192.168.20.2
Ref Clock	Internal
Sync	don't sync
Clock Rate (Hz)	Default
Num Mboards	1
Mb0: Subdev Spec	
Num Channels	1
Samp Rate (Sps)	samp_rate
Ch0: Center Freq (Hz)	900e6
Ch0: Gain (dB)	0
Ch0: Antenna	RX2
Ch0: Bandwidth (Hz)	0

## ■ UHD: USRP Sink

- Used in transmitting path

Parameter	Value
ID	uhd_usrp_sink_0
Input Type	Complex
Device Addr	
Ref Clock	Internal
Sync	don't sync
Clock Rate (Hz)	Default
Num Mboards	1
Mb0: Subdev Spec	
Num Channels	1
Samp Rate (Sps)	samp_rate
Ch0: Center Freq (Hz)	900e6
Ch0: Gain (dB)	0
Ch0: Antenna	TX/RX
Ch0: Bandwidth (Hz)	0

WBX: fixed TX/RX BW  
BW must be set to 0