Sandboxed Environment Potential Experiments

Here's a list of experiments I've curated based on what I've been reading online on SDR's and the ARA manual. This is just a rough list of ideas randomly picked out, and this is not a final list please feel free to add to this or delete from this and we can decide on a final list at some point.

Experiment 1 - Transmitting, Receiving, and Visualizing Waveforms using UHD and GNURadio (ARA MANUAL)

Platform: Software Defined Radios.
Resources needed: 2 x USRP B210s
Short Description: Transmit and receive samples to a file using USRP Hardware Driver (UHD) and GNU Radio.
Detailed Description: The experiment makes use of UHD and Gnuradio to transmit signals from the base station, receive, visualize, and save the IQ samples to a file for analysis.

Experiment 2 - Modulation and Demodulation Techniques

Platform: Software Defined Radios.
Resources Needed: 2 x USRP B210s
Short Description: Explore different modulation and demodulation techniques using USRP and GNU Radio.
Detailed Description: This experiment involves setting up a basic communication link using modulation techniques like QPSK(Quaternary Phase Shift Keying), QAM(Quadrature Amplitude Modulation), or FM(Frequency Modulation). We will use GNU Radio to create a flowgraph that modulates a simple message at the transmitter (TX), and then demodulate it at the receiver (RX). The effectiveness of different modulation schemes in various conditions can be analyzed.

Experiment 3 - Signal Filtering and Noise Reduction

Platform: Software Defined Radios.
Resources Needed: 2 x USRP B210s
Short Description: Implement signal filtering and noise reduction techniques.
Detailed Description: We will learn about signal filtering and noise reduction techniques. Using GNU Radio, they will implement low-pass, high-pass, and band-pass filters to clean up a received signal. This experiment can also include adding artificial noise to the signal and using filters to improve signal clarity.

Experiment 4 - Spectrum Analysis

Platform: Software Defined Radios.
Resources Needed: 1 x USRP B210
Short Description: Analyze the radio frequency spectrum using USRP and spectrum analyzer software.
Detailed Description: In this lab, we will use the USRP as a spectrum analyzer to observe different frequency bands. They can scan for active frequencies, identify different signal types, and learn about spectrum allocation and usage.

Experiment 5 - Implementing a Simple OFDM Transmitter and Receiver

Platform: Software Defined Radios.
Resources Needed: 2 x USRP B210s
Short Description: Build and test an Orthogonal Frequency-Division Multiplexing (OFDM) transmitter and receiver.
Detailed Description: This experiment will introduce OFDM, a key technique in many modern communication systems. Using GNU Radio, we will build an OFDM transmitter and receiver. They can experiment with different parameters like the number of subcarriers, cyclic prefix length, and modulation types.

Experiment 6 - Frequency Hopping

Platform: Software Defined Radios.
Resources Needed: 2 x USRP B210s
Short Description: Implement a basic frequency hopping spread spectrum.
Detailed Description: We will use GNU Radio to implement a simple frequency hopping transmitter and receiver. This experiment will help them understand how frequency hopping can be used to avoid interference and improve communication security.

Experiment 7 - Data Encoding and Decoding

Platform: Software Defined Radios.
Resources Needed: 2 x USRP B210s
Short Description: Explore different data encoding and decoding techniques.
Detailed Description: This lab will focus on digital data encoding and decoding techniques, such as Manchester coding, NRZ, and NRZI. We will transmit encoded data using one USRP and receive and decode it using another, analyzing the efficiency and error rates of different methods.

Experiment 8 - Channel Simulation and Analysis

Platform: Software Defined Radios.
Resources Needed: 2 x USRP B210s
Short Description: Simulate different channel conditions and analyze their impact on signal quality.
Detailed Description: We will use GNU Radio to simulate various channel conditions like fading, multipath, and interference. They can then analyze how these conditions affect the signal quality and the performance of different modulation and error correction techniques.

Experiment 9 - Cognitive Radio Basics

Platform: Software Defined Radios.
Resources Needed: 2 x USRP B210s
Short Description: Introduction to cognitive radio concepts.
Detailed Description: This experiment introduces the basics of cognitive radio. Using a simple script, we can make one USRP dynamically change its operating frequency based on the spectrum availability, mimicking a basic cognitive radio system.

Experiment 10 - Implementing a Simple Packet Radio System

Platform: Software Defined Radios.
Resources Needed: 2 x USRP B210s
Short Description: Build a basic packet radio system.
Detailed Description: We will create a basic packet-based communication system using GNU Radio. They will learn about packet structure, synchronization, error detection, and handling. This experiment can be a lead into more complex topics like network protocols and error correction algorithms.

Experiment 11 - Basic RF Signal Propagation and Path Loss Measurement

Platform: Universal Software Radio Peripheral (USRP)
Resources Needed: Two USRP B210s
Short Description: Measure and analyze RF signal propagation and path loss in an indoor environment.
Detailed Description: This lab aims to give a practical understanding of RF signal propagation characteristics and path loss. Using two USRPs, we will transmit a signal from one USRP and measure its strength at various distances with the other. They can analyze how signal strength varies with distance and obstacles, and compare the results with theoretical path loss models.

Experiment 12 - Implementing a Basic Wireless Communication Link

Platform: Universal Software Radio Peripheral (USRP)
Resources Needed: Two USRP B210s
Short Description: Set up a basic wireless communication link to understand fundamental concepts.
Detailed Description: In this experiment, we will use two USRPs to set up a simple wireless communication link. They will transmit data from one USRP and receive it on the other, exploring basic concepts like carrier frequencies, modulation, and demodulation. This experiment will also introduce them to signal processing techniques required to recover the transmitted data at the receiver.

Experiment 13 - Basic Signal Generation and Analysis

Platform: Universal Software Radio Peripheral (USRP)
Resources Needed: 1 x USRP B210
Short Description: Generate basic RF signals and analyze their characteristics.
Detailed Description: We will use a USRP B210 to generate simple RF signals (such as sine waves at different frequencies). They will then analyze these signals using software tools to observe fundamental properties like amplitude, frequency, and phase. This experiment will familiarize students with basic RF concepts and the operation of the USRP. By varying parameters like frequency and amplitude, we will observe changes in the signal waveform and spectrum, using tools like GNU Radio or Python scripts for analysis. This lab will lay the foundation for understanding more complex modulation techniques.

Experiment 14 - Exploring Signal Reflection and Multipath

Platform: Universal Software Radio Peripheral (USRP)
Resources Needed: 2 x USRP B210s
Short Description: Investigate the effects of signal reflection and multipath in wireless communication.
Detailed Description: We will set up a scenario where RF signals transmitted by one USRP undergo reflection and multipath effects before being received by another USRP. Using signal processing techniques, they will analyze how these phenomena affect the signal quality. This experiment can include moving the USRPs or introducing obstacles to vary the multipath conditions.

Experiment 15 - Simulating a Simple Radar System

Platform: Universal Software Radio Peripheral (USRP)
Resources Needed: 1 x USRP B210
Short Description: Build a basic radar system to understand signal time-of-flight and reflection principles.
Detailed Description: Utilizing the USRP B210, we will create a simple radar system. They will transmit short pulses and measure the time it takes for these pulses to be reflected back from various objects. This experiment introduces basic radar concepts, including range measurement and target detection.

Experiment 16 - Implementing a Basic Positioning System

Platform: Universal Software Radio Peripheral (USRP)
Resources Needed: 3 x USRP B210s
Short Description: Develop a rudimentary positioning system using trilateration. **Detailed Description**: In

this lab, we will use multiple USRPs to simulate a basic positioning system. By measuring signal strength or time-of-arrival from different USRPs, they can calculate the position of a target. This experiment helps understand the principles behind technologies like GPS and indoor positioning systems.

Experiment 17 - RF Spectrum Scanning and Interference Analysis

Platform: Universal Software Radio Peripheral (USRP)
Resources Needed: 1 x USRP B210
Short Description: Perform RF spectrum scanning to identify sources of interference.
Detailed Description: We will use a USRP to scan a range of frequencies and identify various sources of RF interference. They will analyze the characteristics of these interferences, such as their frequency, bandwidth, and pattern. This experiment is crucial in understanding how to manage spectrum and troubleshoot interference issues in wireless networks.

Experiment 18 - Advanced Modulation Techniques Exploration

Platform: Universal Software Radio Peripheral (USRP)
Resources Needed: 2 x USRP B210s
Short Description: Dive deeper into advanced modulation techniques like 16-QAM or OFDM.
Detailed Description: Building on earlier modulation experiments, we will now explore more advanced modulation schemes. They will create, transmit, and receive complex signals using techniques like 16-QAM or OFDM, analyzing their efficiency and robustness under various channel conditions using GNU Radio and custom scripts.

Experiment 19 – OpenAirInterface 5G core network basic deployment using docker-Compose

Platform: OpenAirInterface (OAI)

Resources: : 4 CPU, 16Gib RAM, and a minimum of 1.5 Gib of free storage for docker image

Short Description: Help gain an understanding on how to deploy a basic core network using docker-compose.

Detailed Description: The user will deploy a network with the following Access and Mobility Management Function(AMF), session management function (SMF), user plane function (UPF), network repository function (NRF), unified data management function (UDM), user defined routing (UDR), authentication server function, (ASF), and mysql. In the process of establishing this network the user will be able to learn about network function container images, configuring host machines, configuring the OAI-5g core network functions, and deploying the 5g network.