Lab #6: The Wireless Channel

Objective

The objective of this experiment is to observe the effect of the channel on the system performance using realistic signaling techniques. The students will be familiar with the following items:

- Performance evaluation in realistic multipath channel and comparison with direct cable connection.
- Multipath and fading channel and its effect on the system and signal design.
- Path loss, shadowing and multipath profile.
- LOS and NLOS.
- Doppler Shift and Spread.
- Wideband and narrowband channels.
- Reverberation Chamber.
- Effect of environment in the received waveforms.
- Radio Channel Impulse Response (CIR) estimation using sounding technique.

Procedure

PATH-LOSS EXPONENT

1. On MATLAB, initialize two objects for transmitter and receiver with the following parameters:
    - Tx:
        1. Gain: -10dB
        2. CenterFrequency: 2.35GHz, 2.4GHz, or 2.45GHz (*change to not interfere to other SDRs*)
        3. BasebandSampleRate: 1e6 Samples/s
        4. RadioID: (select the serial number using findPlutoRadio command)
    - Rx:
        1. CenterFrequency: 2.35GHz, 2.4GHz, or 2.45GHz (*match with Tx*)
        2. BasebandSampleRate: 1e6 Samples/s
        3. SamplesPerFrame: 30e3 Samples
        4. GainSource: ‘Manual’
        5. Gain: 20 (*you might need to change this value*)
        6. OutputDataType: 'double'
        7. RadioID: (select the serial number using findPlutoRadio command)

2. Build a proper baseband signal with no training data so that a tone signal is transmitted by the Tx object. Use transmitRepeat() function.

    how to configure the filter setup ? Rx() doesnt need filter setup

3. With LoS link, measure the received signal power, using any technique you learned before, at two different distances and record the values. Use Rx() to capture a signal and ensure that the captured signal is valid with no overflow.

    we can use pwelch, then the power is the peak value

4. Repeat (3) using same distances but with a non-LoS link between Tx and Rx.

5. Comment on the results obtained in (3) and (4). How do you compare the path gains in the two cases?

6. Repeat steps (3) to (5) at another operating frequency: 900MHz, 915MHz, or 930MHz. Make sure you do not interfere with close benches. How do you compare the pathloss variation at different operating frequencies and different distances?

FREQUENCY-SELECTIVITY

7. Use the same hardware setup in (1) but change the gain at Rx to ‘AGC Fast Attack’.

8. Build a frame with the following structure:

    - Preamble Symbols: two m-sequences, each of length 2e7-1 symbols.

- Data Symbols: 512 BPSK symbols.
- Filtering: RRC filter with 0.1 roll-off factor and 8 samples/symbol oversampling ratio. Enable match filtering.
- Guard samples: 2e2 samples at each end of the frame.

9. Send the generated frame using the Tx object at different *sample rates*, inclemently, as long as you have no overflow (e.g., 0.5Msps, 1Msps, 10Msps, 15Msps). Use the receive() function to capture the signal and plot the power spectral density for each transmission. (*You might need to repeat the measurements for one rate multiple times to get the right spectrum*.)

10. Using VSG and VSA, send and receive a modulated signal at higher *symbol rates* (e.g., 10MSps, 20MSps, 30MSps). Use the reverberation chamber for scattering to have more multipaths.
    - Set the VSG to send an arbitrary modulated signal using any linear modulation scheme but with an RRC filter having a roll-off factor 0.1.
    - At the VSA, set the measurement to vector mode and observe the averaged power spectrum of the received signal.
    - Increase the symbol rate gradually and comment on the power spectrum. Plot eye and constellation diagrams of the received signal.

TIME-SELECTIVITY

11. Connect two antennas to the reverberation chamber from one end, and to VSG and VSA from another end by coaxial cables. Setup the devices to send and receive a tone signal at 2.4GHz.

12. While observing the power spectrogram on VSA, turn on a fan inside the chamber to create Doppler spread. Comment on the obtained results.

13. Repeat (11) and (12) at a 900MHz operating frequency. Compare and comment on the results.

CHANNEL ESTIMATION

14. By following the same setup in (7) and (8), send and receive a frame with QPSK modulation. Use the receive() function to get the *non-equalized* symbols and preamble.
    - Using the preamble, estimate the channel and compensate for its effect to get the right constellation. What is the overall channel gain?
    - Build an ML detector to recover received symbols and compare them against transmitted ones.