ECE 4880: RF Systems

Fall 2016

Lab 6: Free Lab Proposal

1 Learning Objectives

The students will learn to:

1) Understand the constraints of the hardware to propose a doable RF system.
2) Use Simulink to describe a full signal chain.
3) Devise test strategy to examine nonideal characteristics.

2 Sample Projects

The students have the freedom to propose any project on RF systems, but the system complexity and the hardware components need to be realistic. Also, the entire signal chain needs to be considered, from antenna to the method of display or listening. The most comfortable range for the components you have used in previous labs is from 600MHz to 2GHz. This covers the popular 900MHz ISM bands, but leaves out the 2.4GHz ISM bands (Bluetooth, Wi-Fi, Zigbee, etc.) and FM radio (88MHz – 108MHz). The largest RF power from the components is limited to about 30dBm. Below is a list of "possible projects" just for illustration purposes.

2.1 Listen-before-talk (LBT) or toy spectrum analyzer

LBT and the spectrum analyzer are sweeping LO to determine the power spectrum around LO. The goal for LBT can be maximizing the sweeping rate, whereas the toy spectrum analyzer can be the best bandwidth resolution within the bands. Surely the antenna gain needs to be considered for LBT, while the spectrum analyzer can just be a RF port input.

2.2 RF range finder or motion detector

Although RF range finder and motion detector have the ultrasound and optical counterparts, it is possible we can implement these functions as a "radar-like" system. It is not a full radar, as "radar" stands for "Radio Detection and Ranging", but we do not have the detection part. The range finder can be based on the received signal strength (RSS), which is a function of the range but is interfered by the multi-paths and ghost images. Depending on the carrier frequency you choose, there can be additional interference signal that can confuse range determination. The motion detector can be based on either RSS or phase variations. Phase is much more sensitive to multi-path and hard to be kept stable in indoor ambient, although it can be so sensitive that bees or mosquitos can be detected in an otherwise motion-less room (some room has wall or floor vibration, which can give unstable phase). If RSS is used, then AM noise is more important than the phase noise, and vice versa. Sputnik, the first satellite, built a similar beacon signal, so that its location by trilateration can be detected on the ground. When the transmitter and receiver are not at the same location for the radar system, it is called the "multistatic" (i.e., many positions) setup. If the radar TX/RX is co-located, it is called "monostatic". The interference along the the TX/RX path is also used for atmospheric studies for Sputnik.

2.3 Jammers for FM or 900MHz wireless units

There are two ways to implement a jammer, a sweeping frequency (for fixed frequency receivers like the FM radio) or by desensitization (for a broadband jamming or systems with LBT and channel hopping). The linearity of the LNA is most important for the latter case. A rule of thumb: inexpensive systems such as Bluetooth has LNA with high nonlinearity while smart phones has the state-of-the-art LNA to counter jamming. You can experiment both types of jamming and study the power and range difference.

2.4 Wireless data link

If you have taken ECE 4670 (Digital Communication) or 4760 (Microcontrollers), then you may have access to the digital baseband from a computer or a microcontroller board. You can replace the sound card interface in ECE 4670 or the data converter in 4760 with a point-to-point wireless link, i.e., not multiple access.

2.5 Commercial transceivers

We have many commercial transceivers around us, Bluetooth, Wi-Fi and Zigbee. I have a RFID reader/tag system that you can borrow. However, these systems are often entirely packaged with pre-determined multiple-access protocol that is hard for you to devise a meaningful project for this class.

2.6 Inappropriate projects

I will give two examples that are either too complex or too difficult. Remember that you have just 2 – 3 weeks to finish what you propose. For example, you may propose to implement a multiple-access protocol (IEEE 802), which is not difficult but too complex. This will be more appropriate if you have a built-in library from a software-defined radio (SDR). You may propose to do a replay attack for the garage door opener, which is too difficult for the digital recording and synthesis parts.

3. Proposal Guidelines

Submit the following items for your project proposal:

- Title (limited to one line)
- Members and netid
- Proposed system goals
- System diagram (partial Simulink setup if feasible)
- Implementation and testing plans

The proposal is due on 11/18 at 5pm, and you will get a feedback before 11/20. For proposal submission, please name your lab reports as: netid_netid_ECE4880_Lab for two students in a lab group. Submit your file in Word or pdf to kan@ece.cornell.edu. The report should be by each group. Submit your Simulink as a separate file.