# CMPEN 462

# Mini-Project #1: Basic OFDM Transmitter

# Due: March 19, 2023 (11:59PM EST)

# (worth 10 pts total)

This project is designed to help you get a better understanding of some of the theory we have been covering in class by having you build a part of the OFDM transmit chain as would be used in a wireless communication device. We can then build on this for later projects and ultimately get to the point where you can explore security aspects of wireless systems at various layers of the protocol stack.

You will be building pieces of the OFDM transmitter (LTE in this case) we covered in class in SP8 – 10 (particularly slides 5-8 of SP10). The only piece you will not be constructing is the "DAC" (digital to analog converter). You will be using some simplifications to do the up-conversion (RF carrier) for generating the signal to be transmitted.

Project:

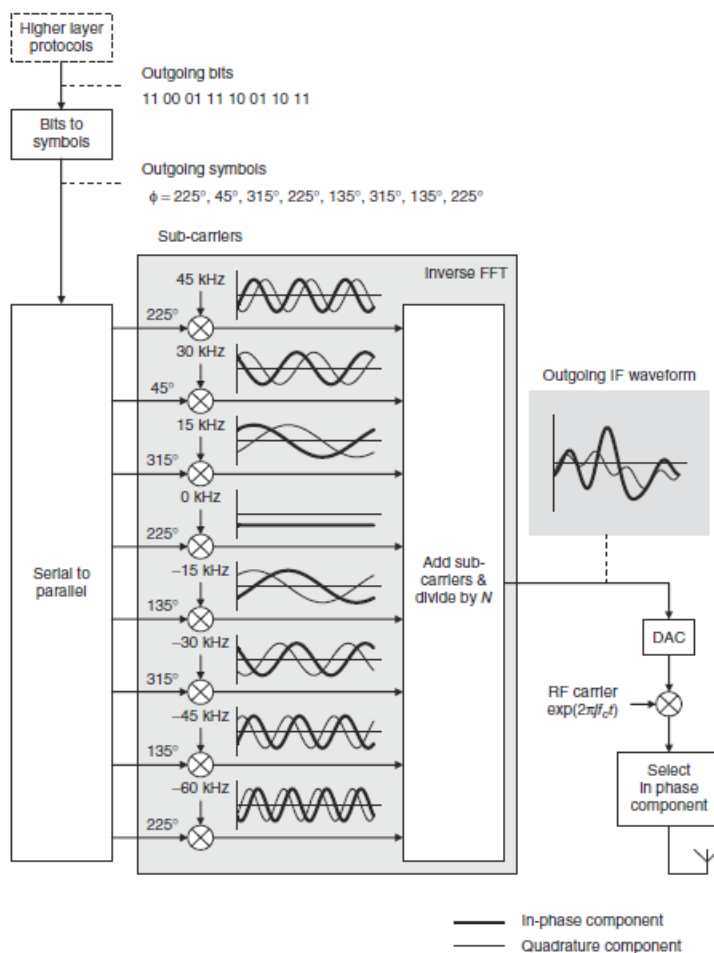Build the following OFDM processing chain components in Matlab:



**Figure 4.2**  Processing steps in an OFDM transmitter

Steps your code must perform:

1. Take the words "Wireless Communication Systems and Security" and concatenate it with your full name (without the spaces for both) and convert it to 8-bit ASCII. You will take this vector and repeat it as many times as required to create a source bit stream for the project (i.e., bits from higher layer protocols in the picture). **Your simulated bit stream must be such that you will be generating at least one subframe's worth of OFDM transmit symbols (i.e., 1 msec) for the 64QAM modulation scheme. All the other modulation schemes can use that same length regardless of how many output symbols they generate (hint: it will generate more than one subframe's worth for the other modulation schemes)**. So, if your name is Jane Marie Doe, your beginning phrase is: WirelessCommunicationSystemsandSecurityJaneMaireDoe and you will need to repeat this as many times as necessary to create a bit stream that is as long as you need to end up with 1msec worth of data that will be upconverted and 'transmitted'.

2. Perform the 'bits to symbols' mapping using [3GPP TS 36.211 Section 7.1.1 – 7.1.4] as your source for the definition of the following modulation schemes:
   a. BPSK
   b. QPSK
   c. 16QAM
   d. 64QAM

3. Perform the 'Serial to Parallel' conversion

4. There is no "Resource Element Mapping" for a single data stream (i.e. single user in slide 7) so you will not be implementing that feature for this project, but you will in the future.

5. Perform 2048-point IFFT to generate each OFDM symbol.

6. Perform "Cyclic Prefix Insertion" as shown on **slide 7** of SP10. Add a cyclic prefix equal to 5.2 usec onto the first OFDM symbol and 4.7 usec onto the remaining OFDM symbols in each slot of the subframe. Each [CP + OFDM symbol] pair creates a 'transmit OFDM symbol'.

7. Collect the transmit OFDM symbols in an output buffer.

8. **Generate a time-scaled plot of two transmit OFDM symbols (i.e., symbol plus CP) for each modulation scheme to include in your report write up.**

9. We are ignoring the "DAC" functional block. That is, assume you have a system that creates an analog signal at this point in the processing chain.

10. On paper, construct the up-conversion to an RF in the ISM band and illustrate the transmited signal. That is, draw the structure and write the equations with appropriate details to show the up-conversion and the signal that is sent out of the antenna.

*You will be assuming a sample rate of fs = 30.72MHz and sub-carrier bandwidth of 15kHz. The above implementation approach I am having you take (i.e., excluding the Resource Element mapper function), leads to an overall system bandwidth of 30.72MHz whereas an actual LTE system would have a maximum system bandwidth of 20MHz with a useable 18MHz bandwidth (the difference is in the details of how the Resource Element mapping is used to match a useable bandwidth of 18MHz).*

*FYI: The "Analogue Transmitter" on Slide 7 of SP10 is equal to everything from the output of the DAC to the input to the antenna shown on the diagram in slide 6.*

This isn't as complicated as it sounds and working through the concepts will help you understand what we covered in class.

I will be posting a grading rubric. You will be submitting your code and output buffer of OFDM symbols. We will demodulate what you have generated to assist in grading your project work. There will be points for your code design (meaning I don't want it to be sloppy and/or really inefficient).