Engineering Tripos Part IIA Extension Activity (ExA): Wireless Communication with Software-Defined Radio (SDR)

Open to all engineering students, but particularly recommended for those in Electrical and Electronic Engineering, Information and Computer Engineering, or Electrical and Information Sciences.

Introduction to OFDM and SDR for Wireless Communication

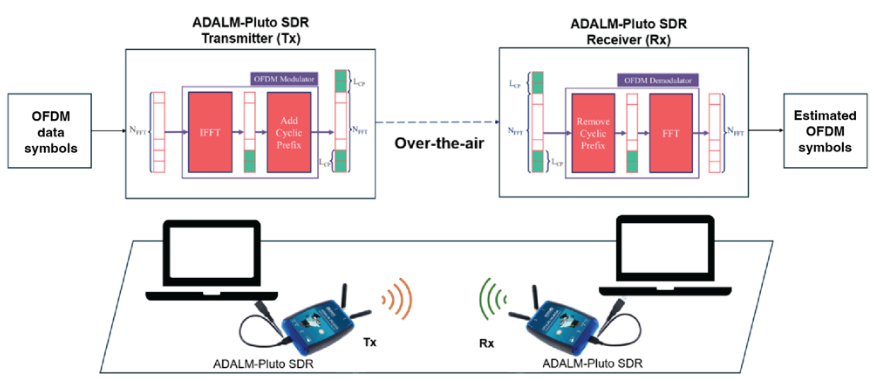
In this ExA, you will explore how digital information can be transmitted through a wireless channel using Orthogonal Frequency Division Multiplexing (OFDM). OFDM is used in many modern communication systems, including Wi-Fi, 4G, 5G, and digital broadcasting, because it allows data to be transmitted efficiently over many closely spaced frequency components.

The activity begins with signal processing concepts you have already met, especially sampling and the Fast Fourier Transform (FFT). Using Python, you will build a simple OFDM transmitter and receiver step by step: bits are represented by simple numerical symbols, the symbols are placed onto frequency positions called subcarriers, an inverse FFT combines the subcarriers into one time-domain waveform, and at the receiver an FFT separates them again so that the original bits can be recovered.

You will then use two ADALM-Pluto SDR radios to transmit and receive signals in a real wireless environment, observing effects such as noise, timing error, multipath propagation, gain settings, and frequency differences. The SDR code will be provided; your task is to run the link, explore how it behaves, and interpret what you measure. The aim is to develop a practical understanding of how OFDM works and why it is useful in wireless communication, connecting FFT-based signal processing with real over-the-air transmission.

Objectives: By completing this activity, you will

- use the FFT to analyse signals in the frequency domain
- explain how digital bits can be represented using simple modulation symbols such as BPSK or QPSK
- build a basic OFDM transmitter and receiver using the IFFT and FFT
- investigate how noise, multipath, timing errors, and frequency offset affect received signals
- explain the purpose of a cyclic prefix in reducing the effect of delayed signal paths
- use ADALM-Pluto SDR to transmit, receive, and observe simple wireless signals
- compare simulation results with real SDR measurements
- interpret time-domain plots, spectra, constellation diagrams, and bit-error results
- present your implementation, results, observations, and conclusions clearly



Assessment: Assessment is based on a 10–15 minute final presentation of your implementation, plots, results, and conclusions, including a demonstration or discussion of the SDR link and a comparison between simulation and real measurements. Total expected time is approximately 16 hours. Satisfactory completion of the core simulation and SDR tasks will lead to full standard credit.