# ECE/CS 439
# Mini Project

## Acoustic FMCW RADAR

In this mini project, you would design an acoustic sensing system to determine the change in 2D location of a user's smartphone. The project would be evaluated based on a demo. To this end, you would replicate the techniques proposed in *CAT* [1] which is primarily based on Frequency Modulated Continuous Waveform (FMCW).

An ideal FMCW RADAR transmits a signal whose frequency changes linearly with time (between a maximum and minimum frequency). The reflected signal from the target would also change in frequency over time. An example of transmitted and reflected signals in shown in Figure 1. At any given point of time, the frequency difference between the transmitted and received signals is related to the target distance by the following relation.

$$delay = \frac{\Delta f}{slope\ of\ f\ over\ time}$$

Thus, by determining the frequency difference between the transmitted and reflected wave, an FMCW RADAR can track the target distance.

In this project, you would implement a slightly modified version of FMCW as presented in *CAT*. Consider a speaker continuously transmitting FMCW signals and a smartphone receiving them. While an ideal FMCW radar computes frequency difference between transmitted and received signal, *CAT* computes the frequency difference between signals received at the smartphone at two different time points. While an ideal FMCW radar can compute the distance of the target, CAT can use the computed frequency difference to compute the change in location.

You need to compute the change in location when the initial location is known. You are allowed to use a system of two smartphone/laptop speaker/receivers with known positions. A third smartphone's location is also known. The change in location of the third smartphone needs to be detected based on FMCW design. Perform all sound transmissions in the inaudible frequency range.

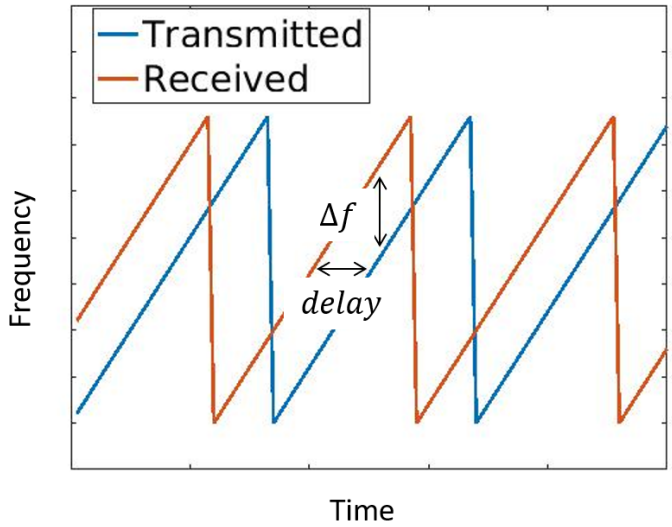


Figure 1: FMCW frequency sweep

## Echolocation

In this mini project, you would design an acoustic echo-location sensor. Consider a 1D array of sound speaker, receiver, and reflector at locations 0, 1, and 1.2 meters respectively on the x-axis. The receiver would receive direct line of sight signals from the speaker as well as the reflections from the reflector. The direct path and the reflected path are separated by 40cm. The channel impulse response (CIR) would have two peaks separated by 40cm. Your goal would be to design a system that measures the distance of the reflector from the receiver. The project would be evaluated based on a demo. The CIR peaks corresponding to direct and reflected path would move relative to each other if the reflector is moved. The echoes can be detected from the CIR. You need to design a training sequence at the transmitter to be able to detect the CIR.

## References

[1] Mao, W., He, J., and Qiu, L. Cat: high-precision acoustic motion tracking. In *MOBICOM* (2016), ACM.