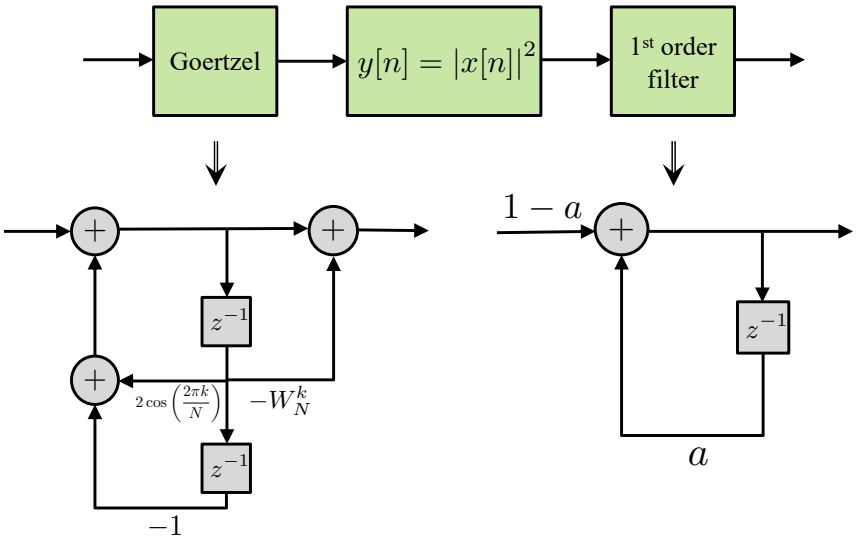
ECE 5415: Applied Digital Signal Processing and Communications
Cornell Tech, Fall 2020

Midterm Project
Due Date: Friday, Oct. 16, 2020

Decoder system

Consider the following system:

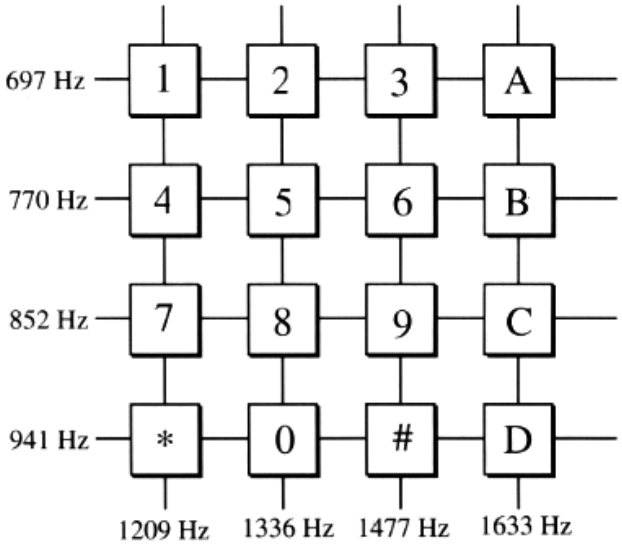


The first stage of the system is known as a second-order implementation of the Goertzel algorithm for the discrete Fourier transform ($W_N^k = e^{-\frac{2\pi k}{N}j}$). Explain and analyze the system response of the Goertzel system. Be sure to also explain what the latter stages of the system are doing.

DTMF tones

The Touchtone sounds that you hear when you dial a telephone number are made up of a combination of two simultaneous sinusoids, hence the name dual tone multifrequency (DTMF) signals. Each digit is guaranteed to be at least 40 ms in duration. The frequency of the tones are as shown in the following keypad diagram (DTMF signals A,B,C,D are not avaialble on most keypads):

Write and document a signal processing program that takes in sound samples and outputs the decoded telephone digits, e.g. digits = dtmfdecode(xsound). You should implement the above system assuming a sampling frequency $F_s = 8000Hz$, with $N = 205$ and calculate the values of k needed to implement your function. You should test your implementation on the example Touchtone sound files available on Canvas.



Robust decoder

To build a truly robust system, you should compare the energy of the fundamental frequencies of the DTMF tones with that of the second harmonics (DTMF tones should have little second harmonics present, as compared to speech and other sounds). For the second harmonic detection system, you should use $N = 210$ and choose the appropriate k's for the second harmonic frequencies.