

EE 679 Speech Processing  
Computing Assignment 1: Signal synthesis based on source-filter model  
Due: August 26, 2023

Note: You can use Python (recommended), Octave or Matlab/Scilab. Make a single zipped folder for Moodle submission that includes a pdf report (with the solution for each question including method, important code fragments, plots and discussion) and sound files. Make neat and properly labeled plots. Alternately, if you use Jupyter notebook, you can submit your ipynb file together with the html version of your assignment (which should contain all the components of the report plus sounds).

1. Given the following specification for a single-formant resonator, obtain the transfer function of the filter  $H(z)$  from the relation between resonance frequency / bandwidth, and the pole angle / radius. Plot filter magnitude response (dB magnitude versus frequency) and impulse response.

F1 (formant) = 900 Hz  
B1 (bandwidth) = 200 Hz  
Fs (sampling freq) = 16 kHz

2. Excite the above resonator (“filter”) with a periodic source excitation of  $F_0 = 160$  Hz. You can approximate the source signal by a narrow-triangular pulse train. Compute the output of the source-filter system over the duration of 0.5 second using the difference equation implementation of the LTI system. Plot the time domain waveform over a few pitch periods so that you can observe waveform characteristics. Play out the 0.5 sec duration sound and comment on the sound quality.

3. Vary the parameters as indicated below; plot and comment on the differences in waveform and in sound quality for the different parameter combinations.

- (a)  $F_0 = 120$  Hz,  $F_1 = 300$  Hz,  $B_1 = 120$  Hz
- (b)  $F_0 = 120$  Hz,  $F_1 = 1100$  Hz,  $B_1 = 200$  Hz
- (c)  $F_0 = 180$  Hz,  $F_1 = 300$  Hz,  $B_1 = 120$  Hz

4. In place of the simple single-resonance signal, synthesize the following more realistic vowel sounds at two distinct pitches ( $F_0 = 120$  Hz,  $F_0 = 220$  Hz). Keep the bandwidths constant at 100 Hz for all formants. Duration of sound: 0.5 sec. Comment on the sound quality across the different sounds. Plot a few periods of any 2 examples.

**Vowel F1, F2, F3**

/a/ 730, 1090, 2440

/i/ 270, 2290, 3010

/u/ 300, 870, 2240

(Optional: Use glottal pulse shaping and lip radiation filtering. Add a small amount of aspiration noise and pitch jitter to enhance naturalness.)