Plosive voice /ga/ /ka/ sound waveform generation by pseudo blast impulse, noise source, and two tubes model

This is an experiment to generate plosive voice /ga/ /ka/ sound by pseudo blast impulse waveform, noise source instead of turbulent sound, and two tubes model.
In this method, the sound will be generated from resonance effected mixed sound of pseudo blast impulse and noise, and following vowel sound portion controlling glottal sound source.

Generation of pseudo blast impulse waveform
It is said that waveform generated by blast phenomenon has a characteristic of 1/f frequency response .
If it uses 1/f frequency response as it is, resonance effect is difficult to be appear, since the amplitude becomes too small even in low frequency component. For that reason, generation uses frequency response from DC to a certain frequency is flat and after that closes to 1/f.
Following figures is the waveform of generated pseudo blast impulse waveform by Hilbert transform and minimum phase condition. It sounds (blast_impulse_40.wav in the generated_wavform folder).
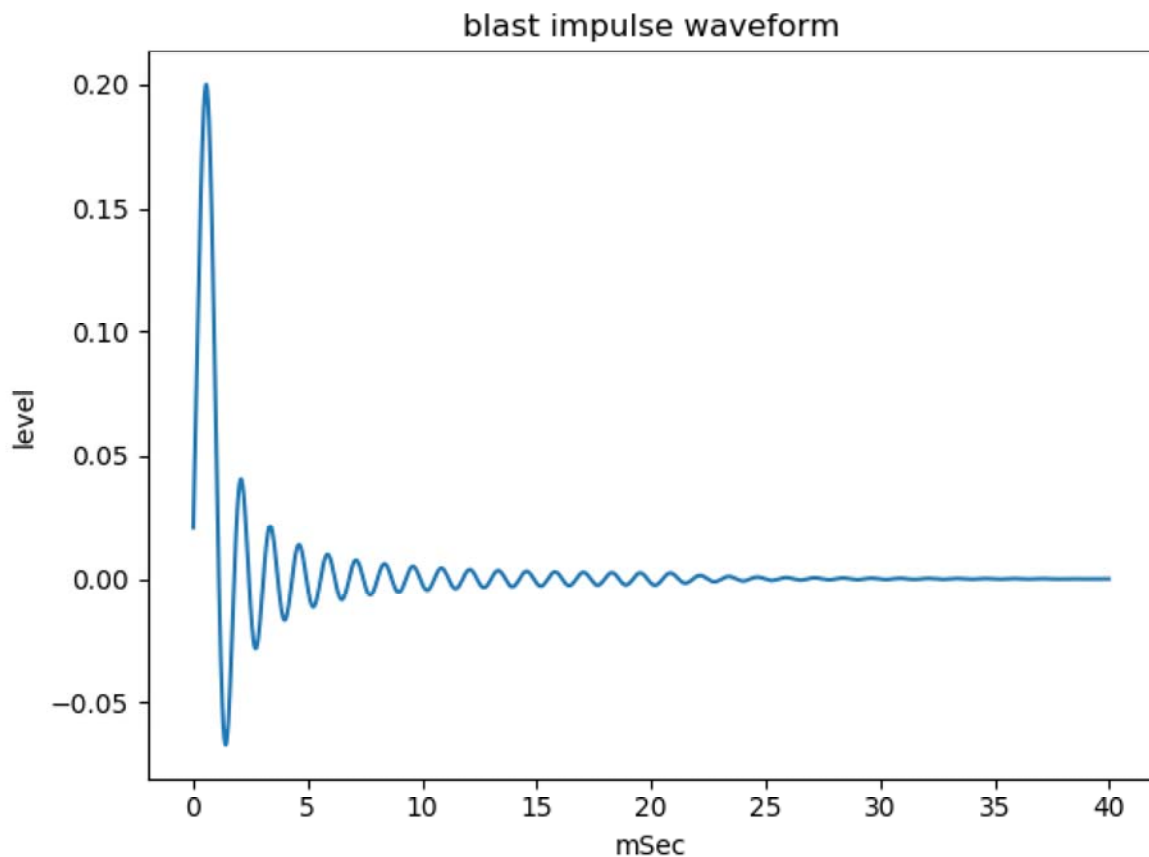

Next figure shows frequency response.

frequency response
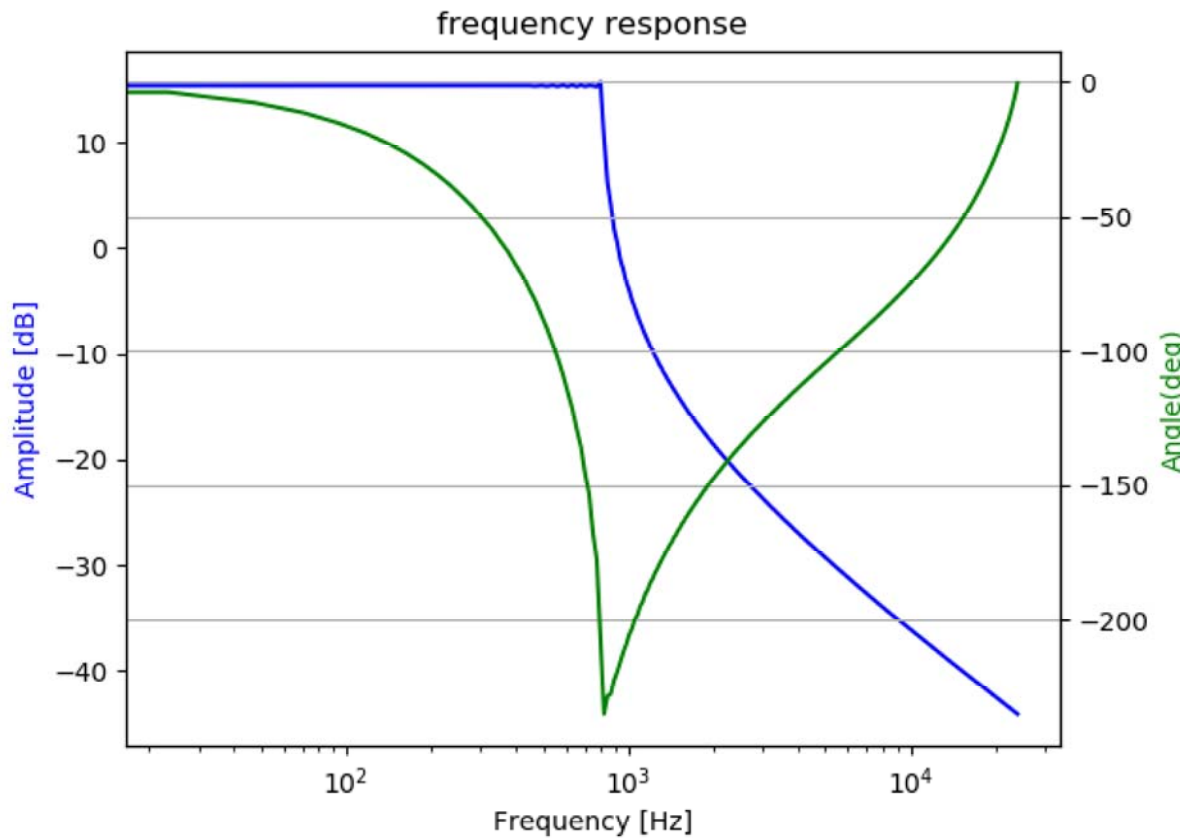
Generation of noise sound

Perlin noise method is used as noise source instead of turbulent sound. This is same as fricative voice /sa/ sound waveform generation described in Vocal-Tube-Noise-S-Model. The difference from fricative is that noise freuquency is low.
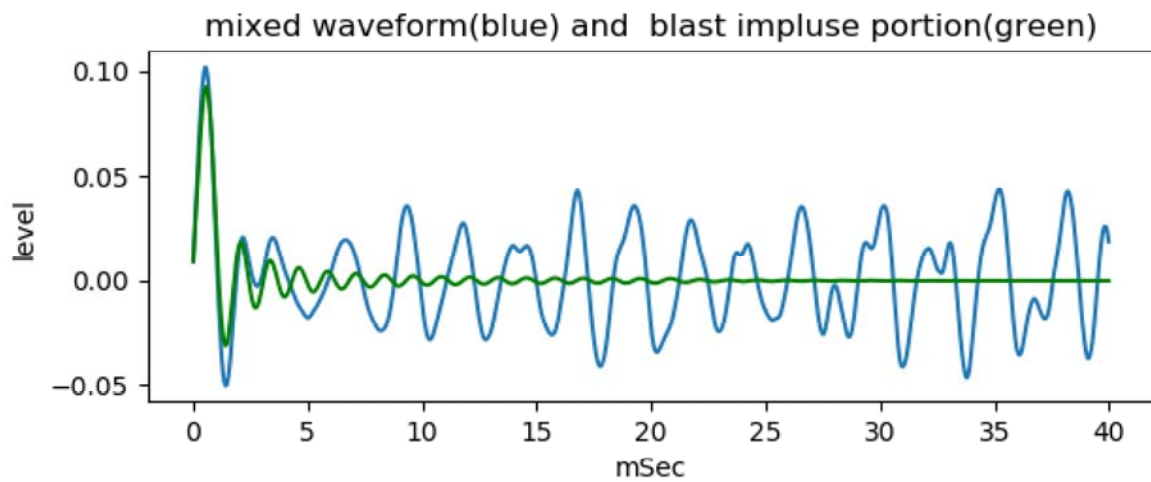
Following figure is the waveform of generated noise sound. It sounds (k_noise0.wav in the generated_wavform folder).

Noise waveform (narrow band)
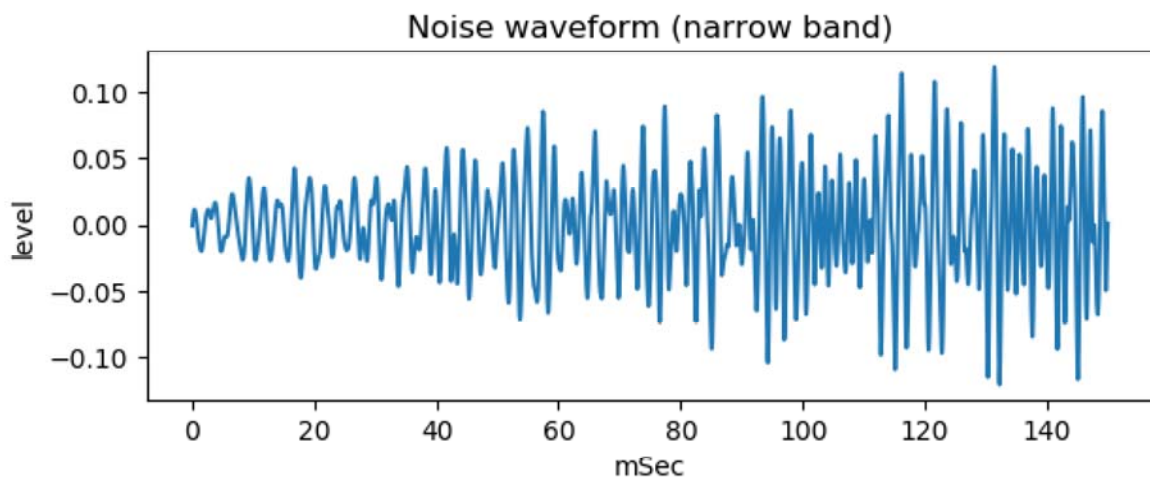
Mix the noise sound with pseudo blast impulse waveform

Assuming that a blast and subsequent breath will generate a turbulent sound, mix the noise sound with pseudo blast impulse waveform.

Following figure is the waveform of the mixed. It sounds (k_noise0_i40_s800_long.wav in the generated_wavform folder).

Apply resonance effect

By use two tubes model of which input source is the mixed waveform, it applies resonance effect to the mixed sound.

Following figure is the waveform which is applied resonance effect. It sounds (k_noise0_i40_s800_resona_0_long.wav in the generated_wavform folder).
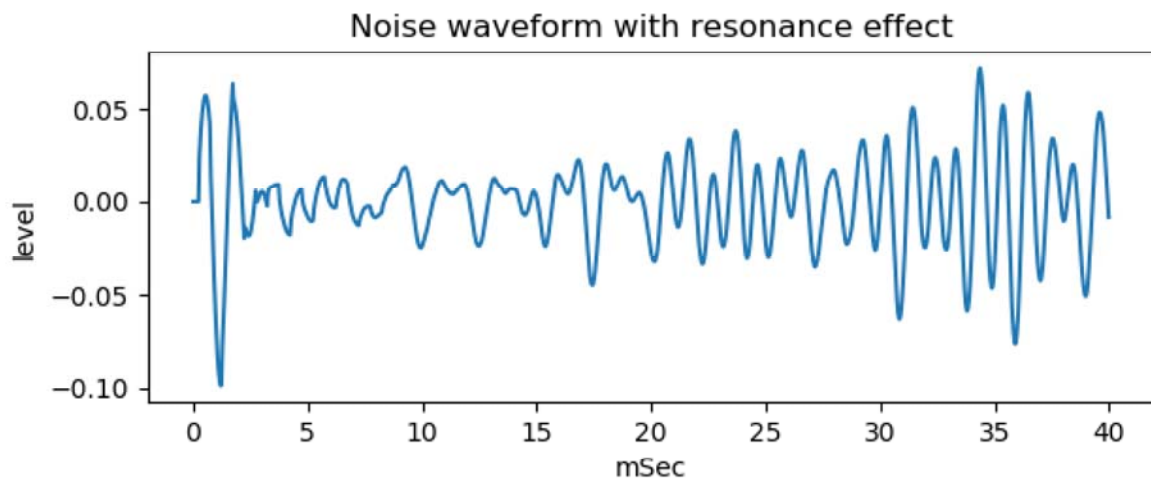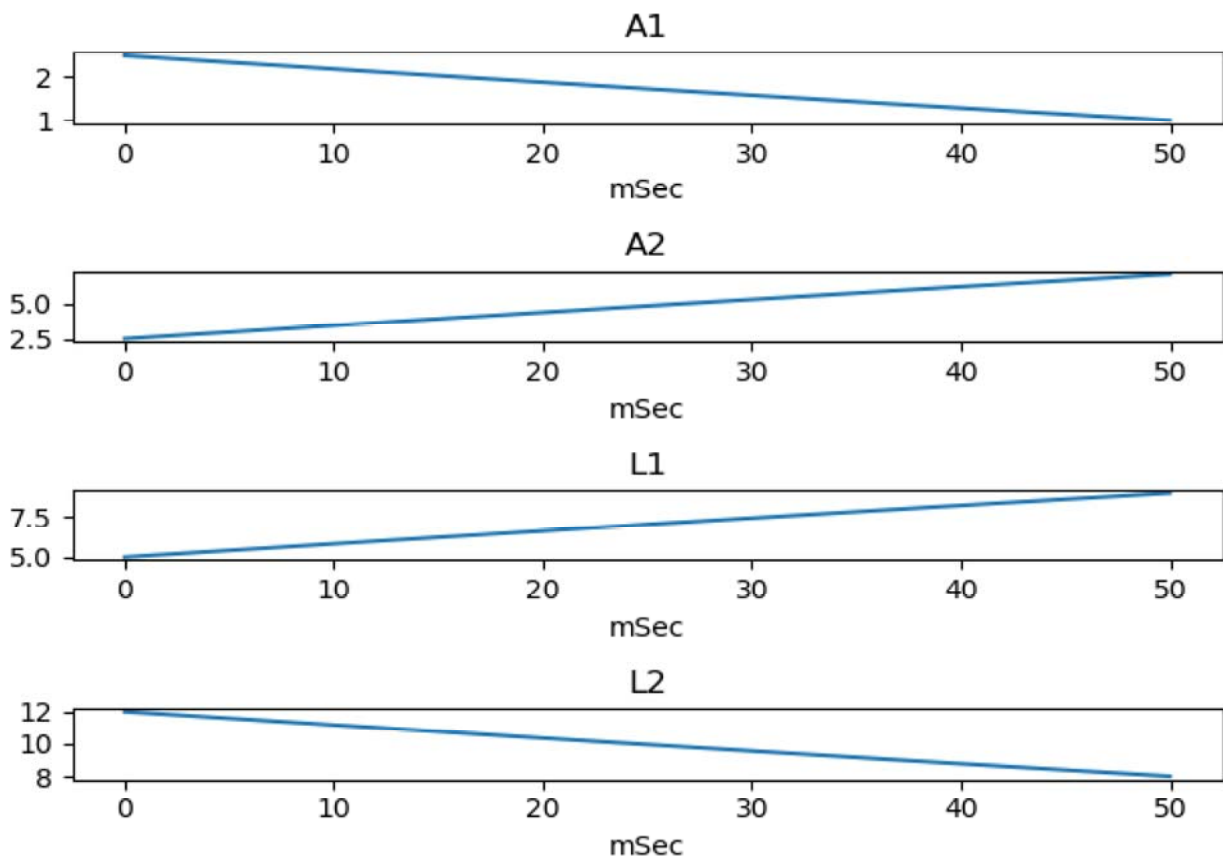

Generation of following vowel sound

To generate vowel sound, it uses two tubes model that can vary cross section area and tube length every time step. They are varied from one cavity, one tube, to vowel /a/ state as following figures.

start tube shape

target tube shape (Mouth open toward /a/)
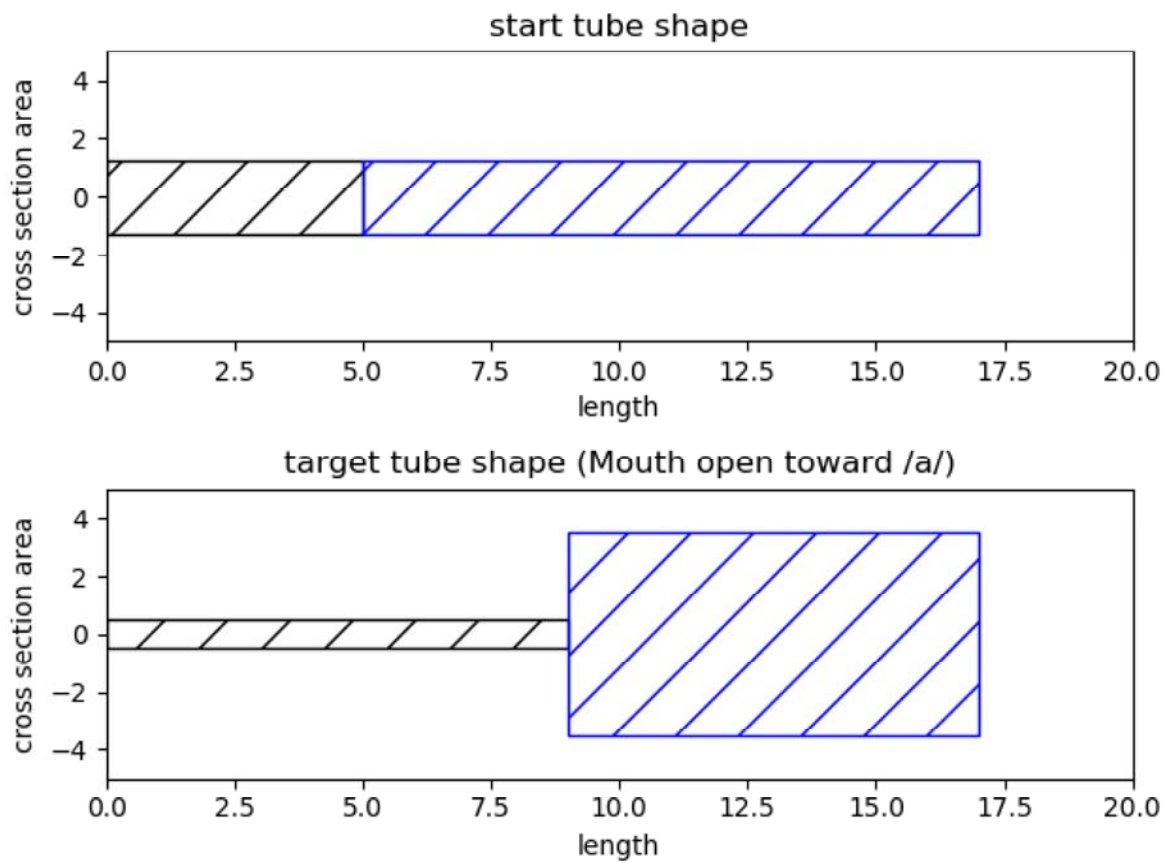
Following figure shows cross section area and tube length per time.


A1

A2

L1

L2

Reduction voiced feeling
The mixed waveform simply combined with following vowel sound becomes voiced sound like /ga/ or /da/.
Although the cause of the voiced sound is not clearly understood, to reduce voiced feeling in sound, two methods are adopted.

One is that glottal sound source control starts slowly (fade-in).
Following figure shows rising curve of glottal pulse appearance.

Glottal repeated Waveform fade-in (red), fade-in gain curve (green)
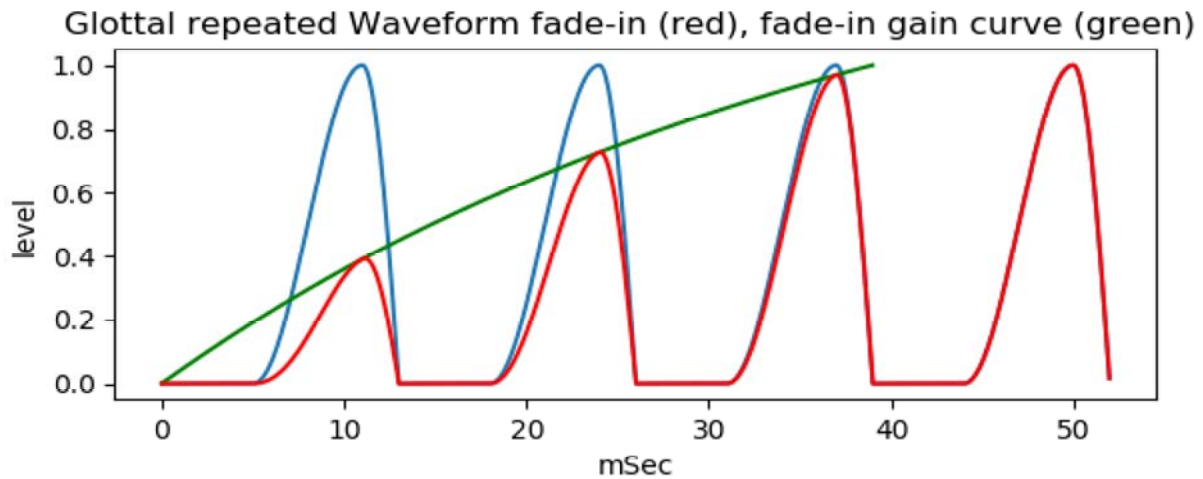
Another is that to use first portion removed. (That is a choice from what resonance position is used.)
In following figure, green waveform is vowel portion which is removed blue first one pitch duration,
which initial reflection is not yet seen. It sounds (yout_1a1_var_long.wav in the generated_wavform
folderwav file).

Waveform toward /A/ (using green portion: 1a1)
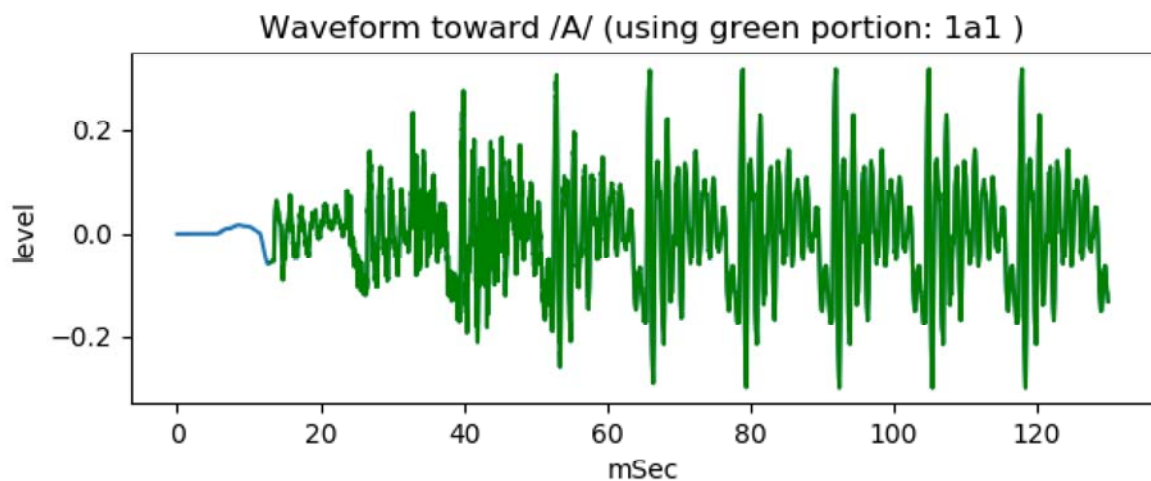
In next figure, green waveform is vowel portion which is removed blue first two pitches duration, that
includes reflection waveform. It sounds (yout_1a2_var_long.wav in the generated_wavform folderwav
file).

Waveform toward /A/ (using green portion: 1a2)
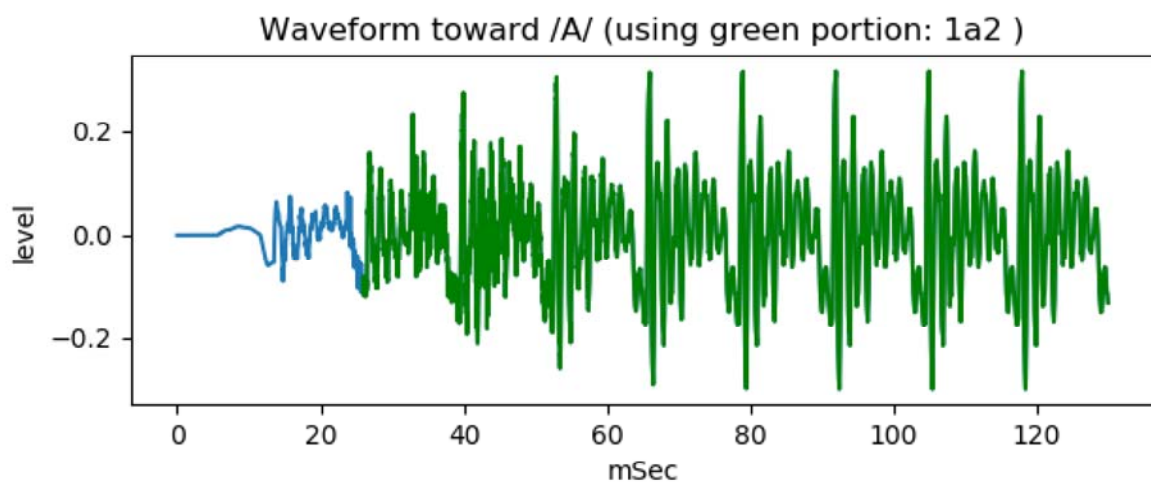
Combination waveforms

Finally, the mixed waveform of pseudo blast impulse and noise, which has resonance effect, is combined with following vowel portion, smoothing connection edge. Following figure is the waveform of combination with following vowel portion which is removed the first one pitch duration. This waveform (gka_1a1_noise0_i40_s800_resona_0.wav in the generated_wavform folder) sounds similar to voice /ga/ sound.
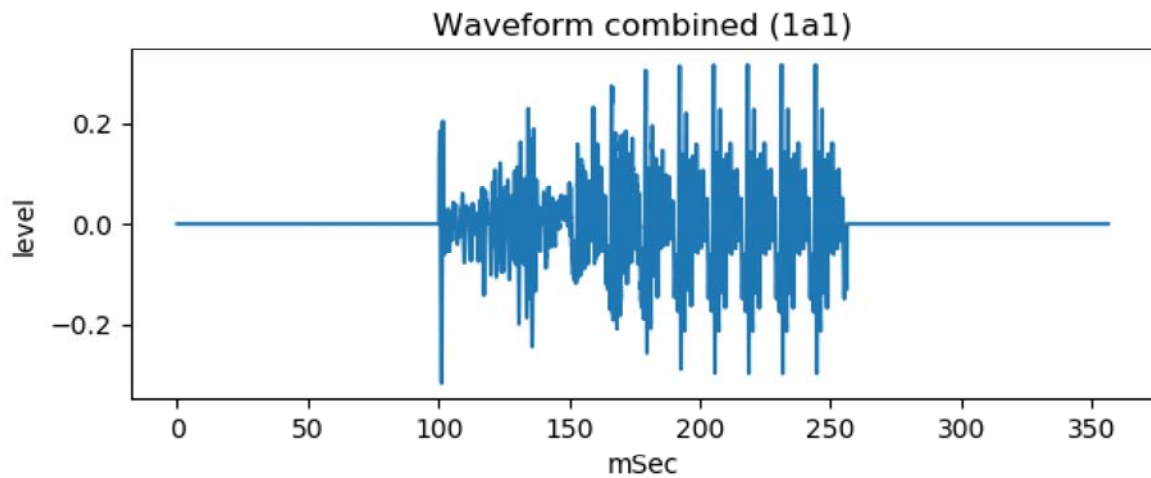
Next is the waveform of combination with following vowel portion which is removed the first two pitches duration. This waveform (gka_1a2_noise0_i40_s800_resona_0.wav in the generated_wavform folder) becomes small voiced feeling and is near to /ka/.