

# 6T1: Harmonic Model

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# Harmonic model

$$y_h[n] = \sum_{r=1}^R A_r[n] \cos(2\pi r f_0[n] n)$$

$R$ : number of harmonic components

$A_r[n]$ : instantaneous amplitude

$f_0[n]$ : fundamental frequency (Hz)

# Spectral view

$$Yh_l[k] = \sum_{r=1}^{R_l} A_{(r,l)} W[k - r \hat{f}_{(0,l)}]$$

$W$  : spectrum of analysis window

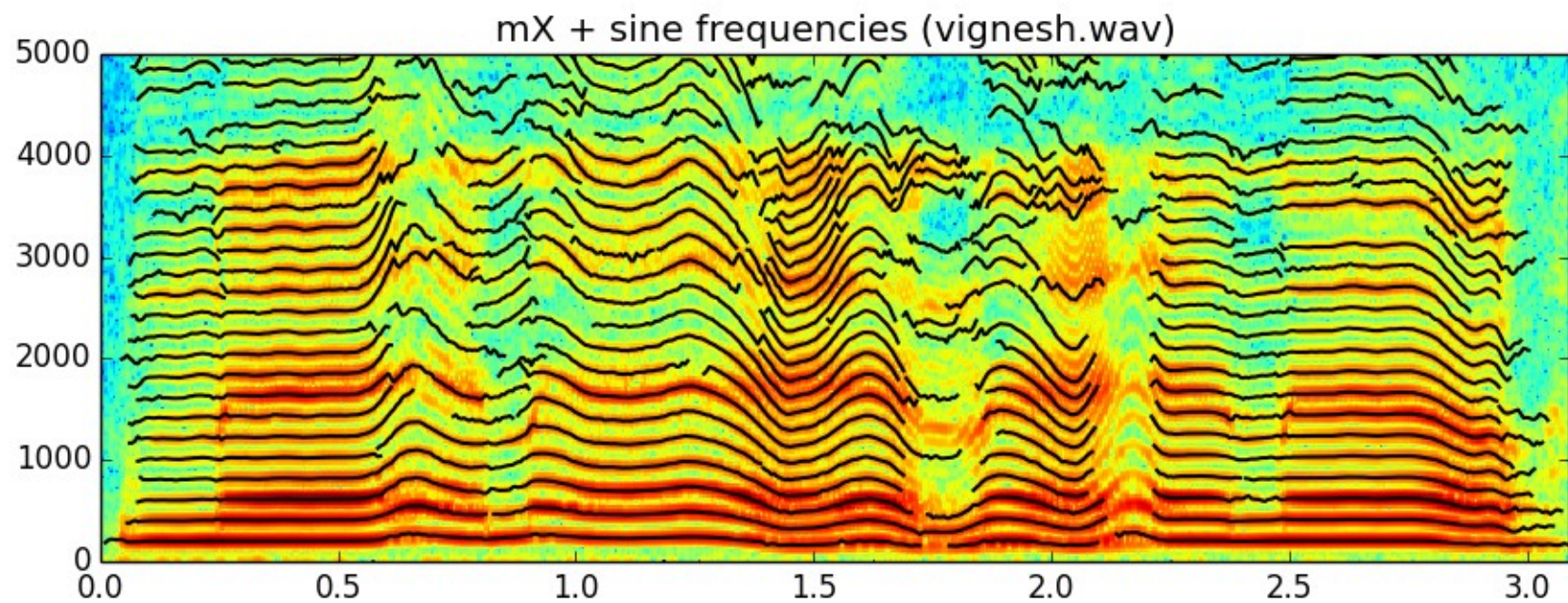
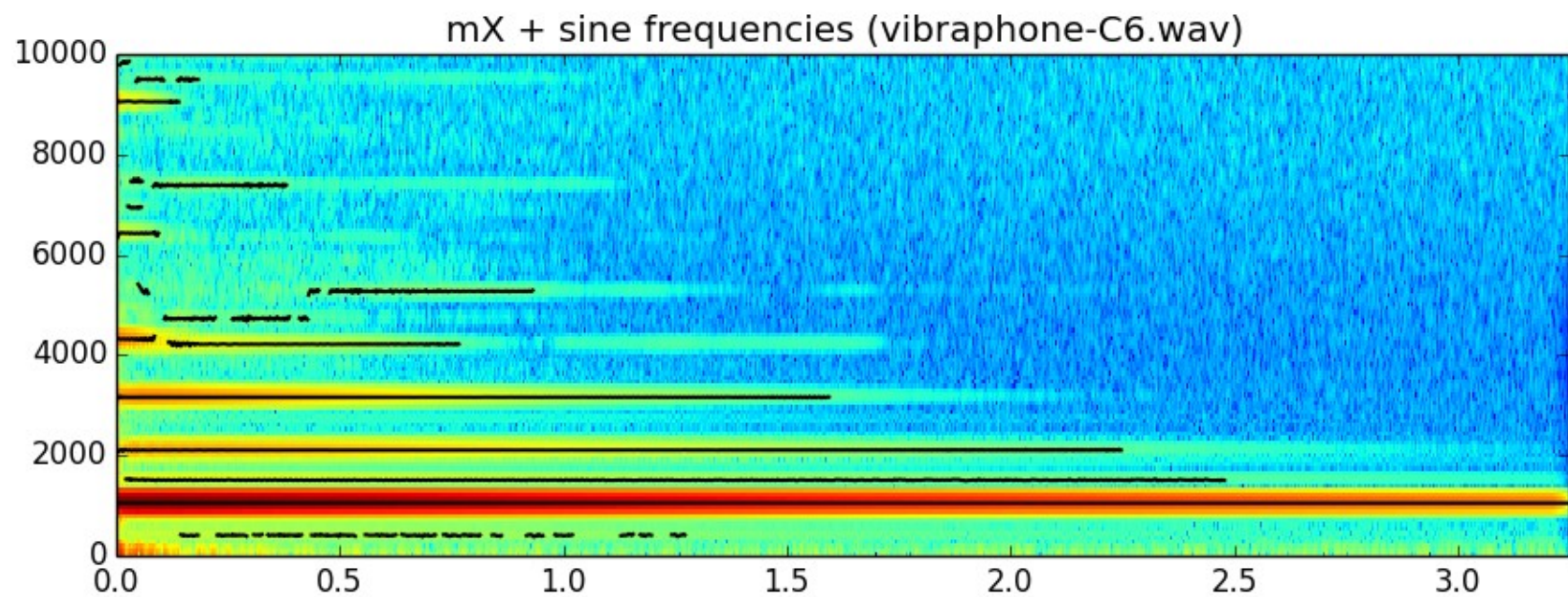
$R$  : number of harmonics

$A$  : amplitude of harmonic

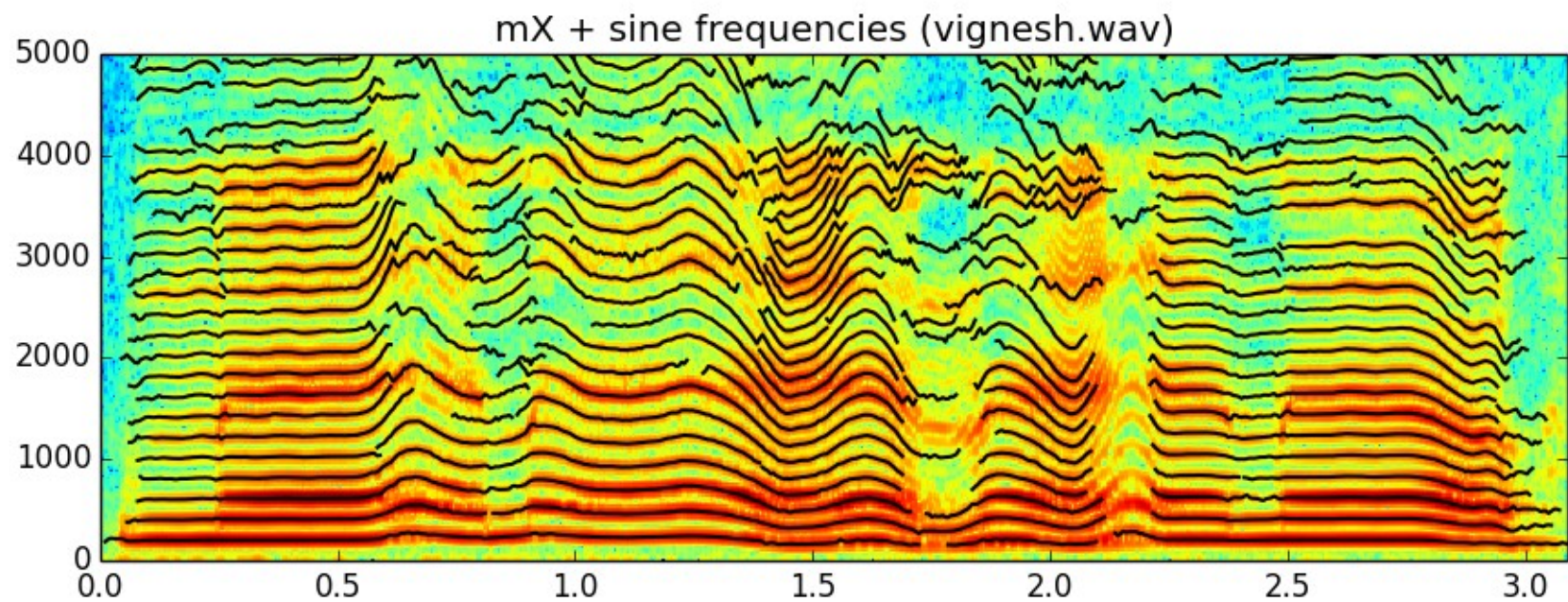
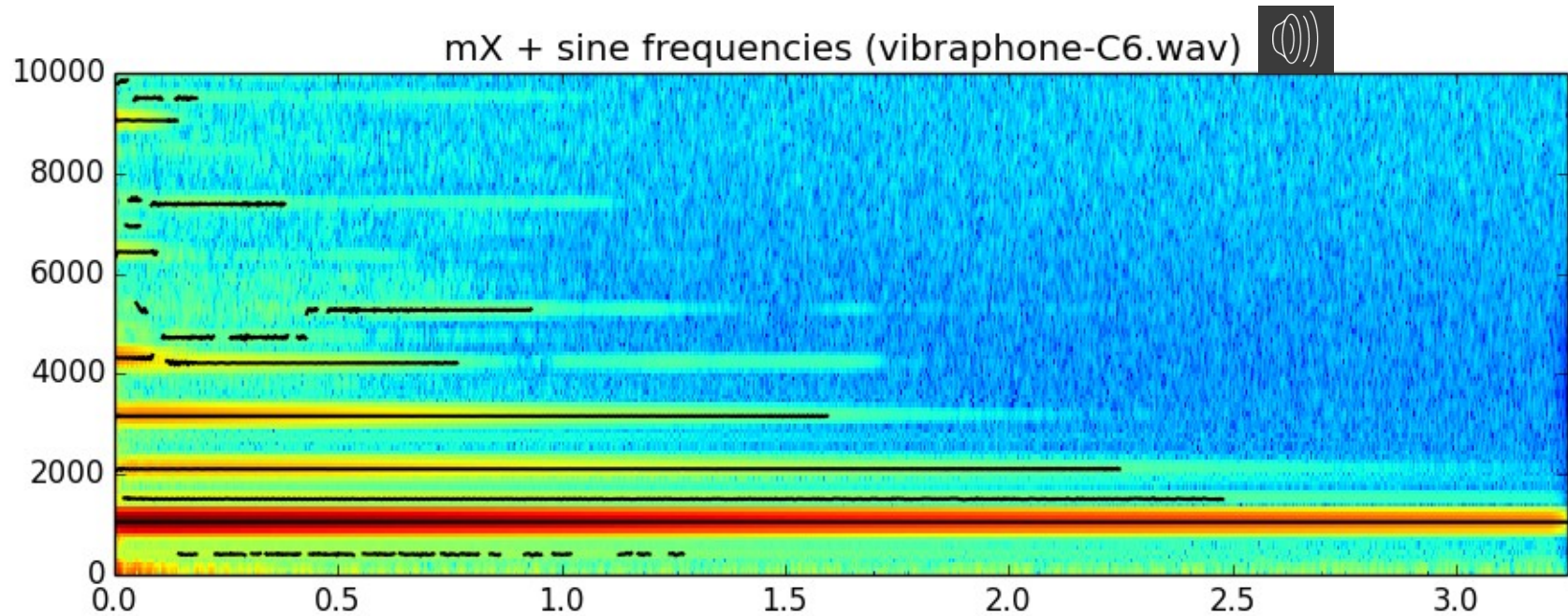
$\hat{f}_0$  : normalized fundamental frequency

$l$  : frame number

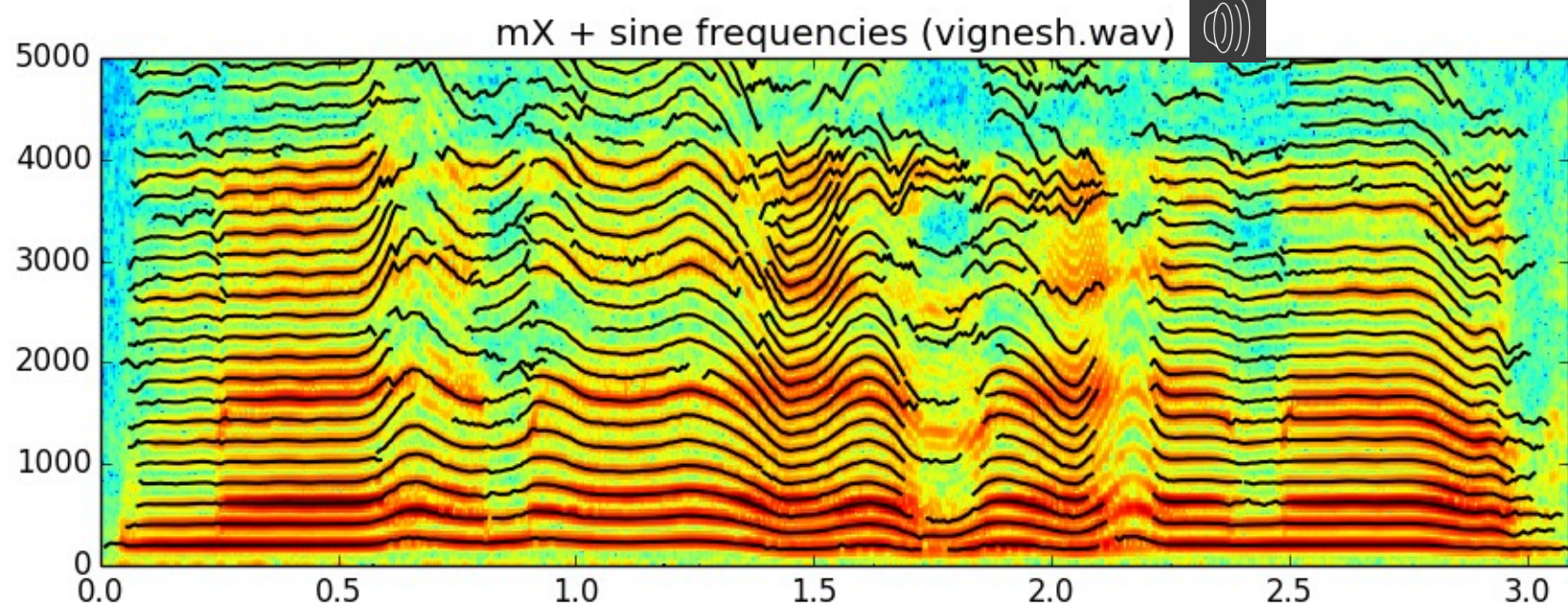
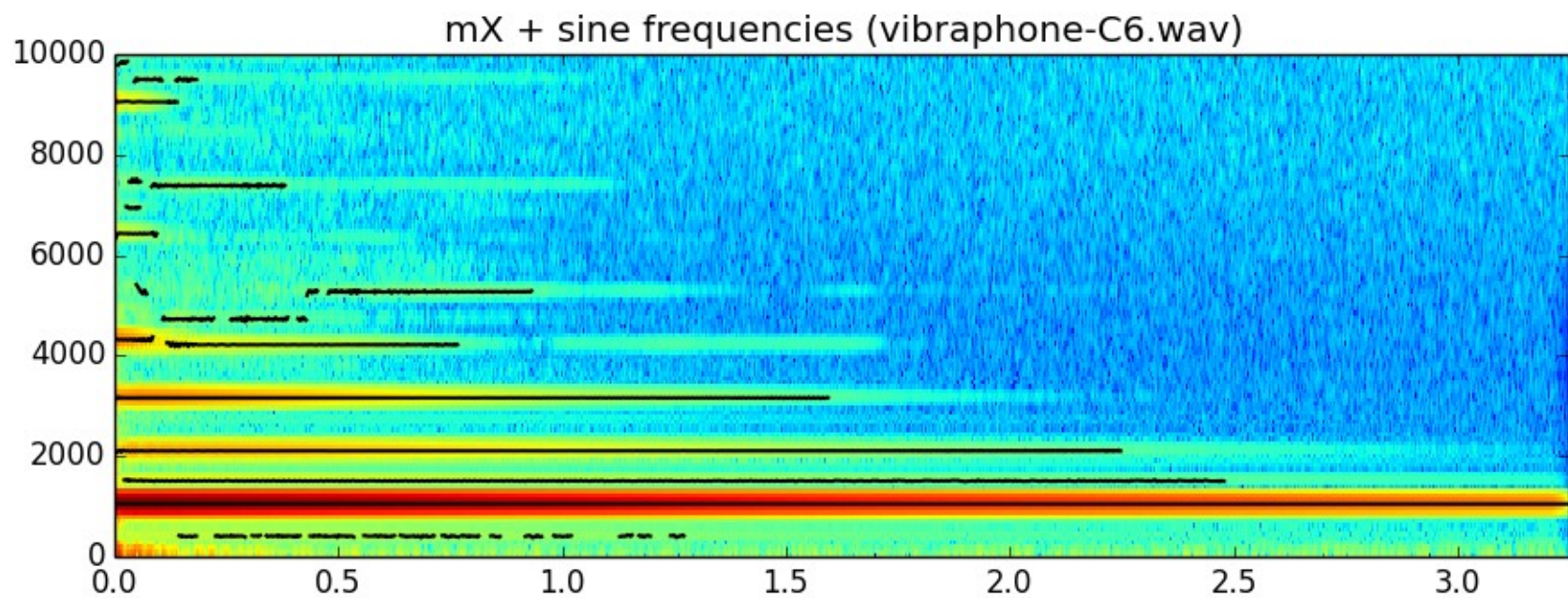
$r$  : harmonic number



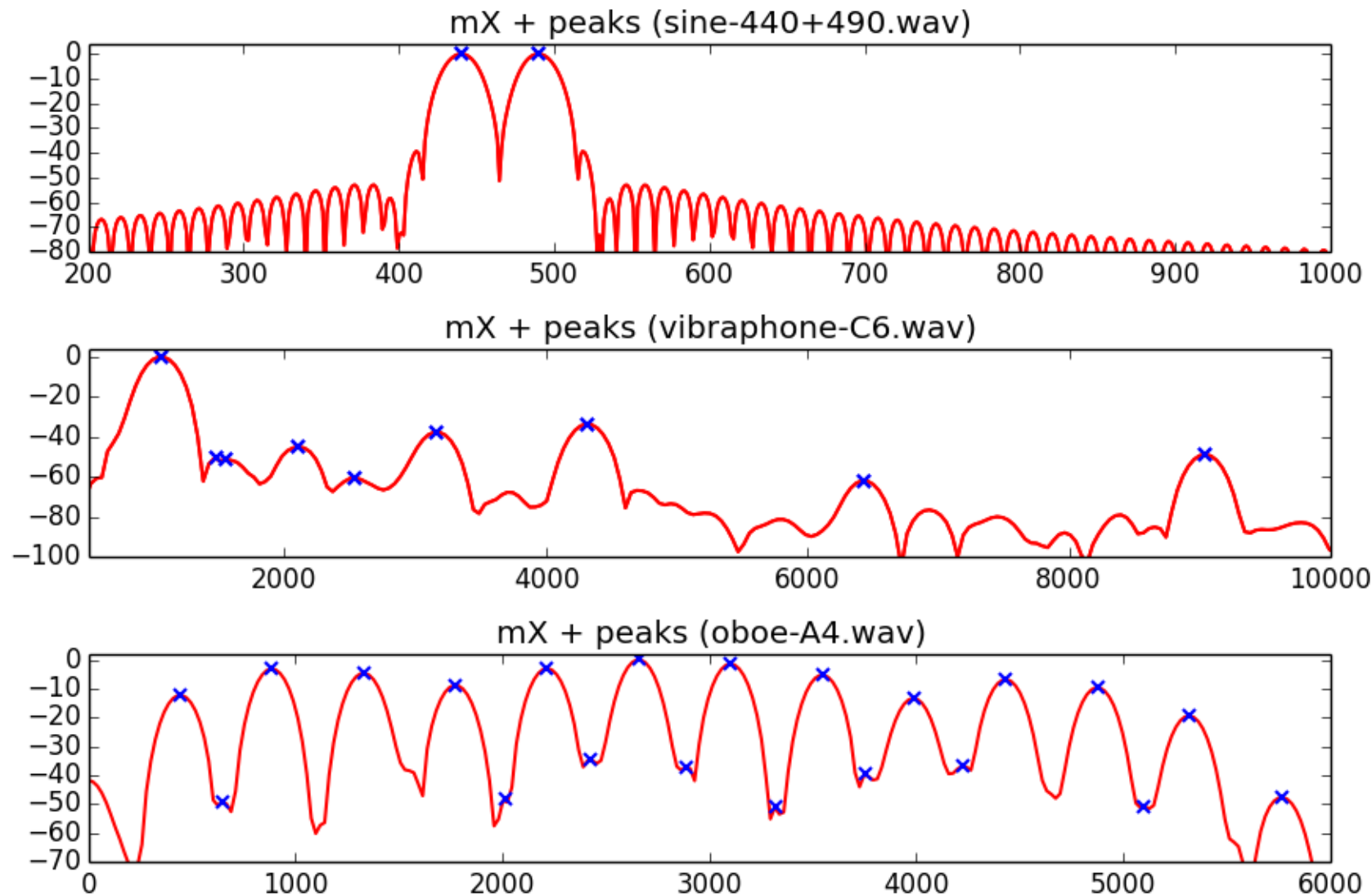






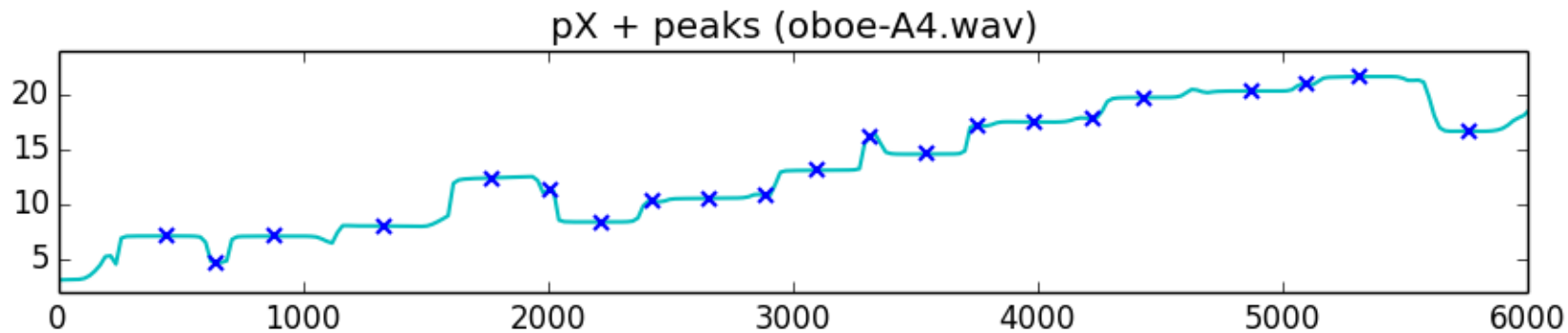
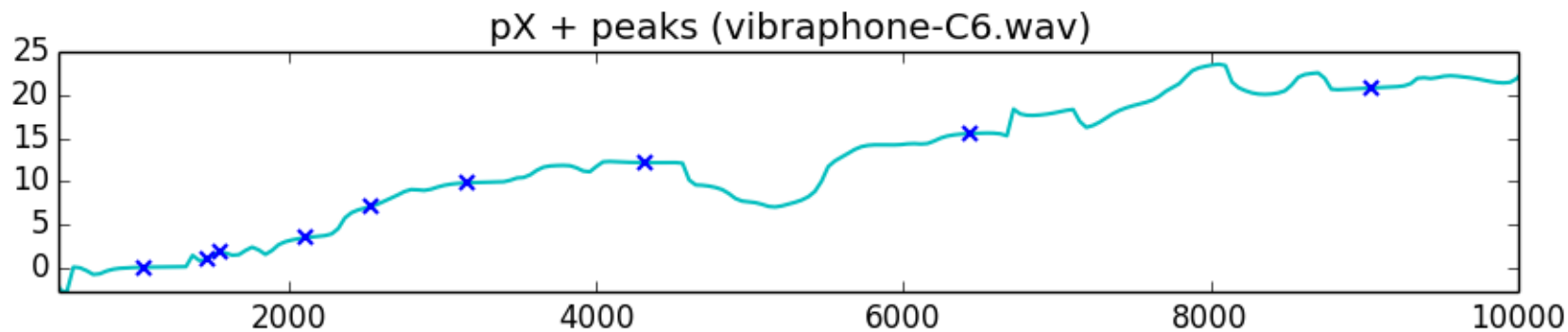
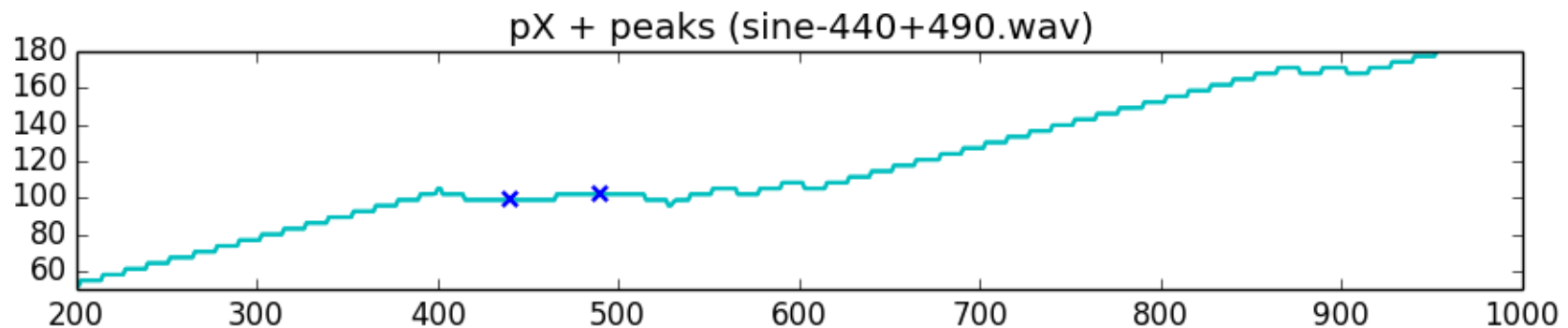


# Sinusoids-partials-harmonics

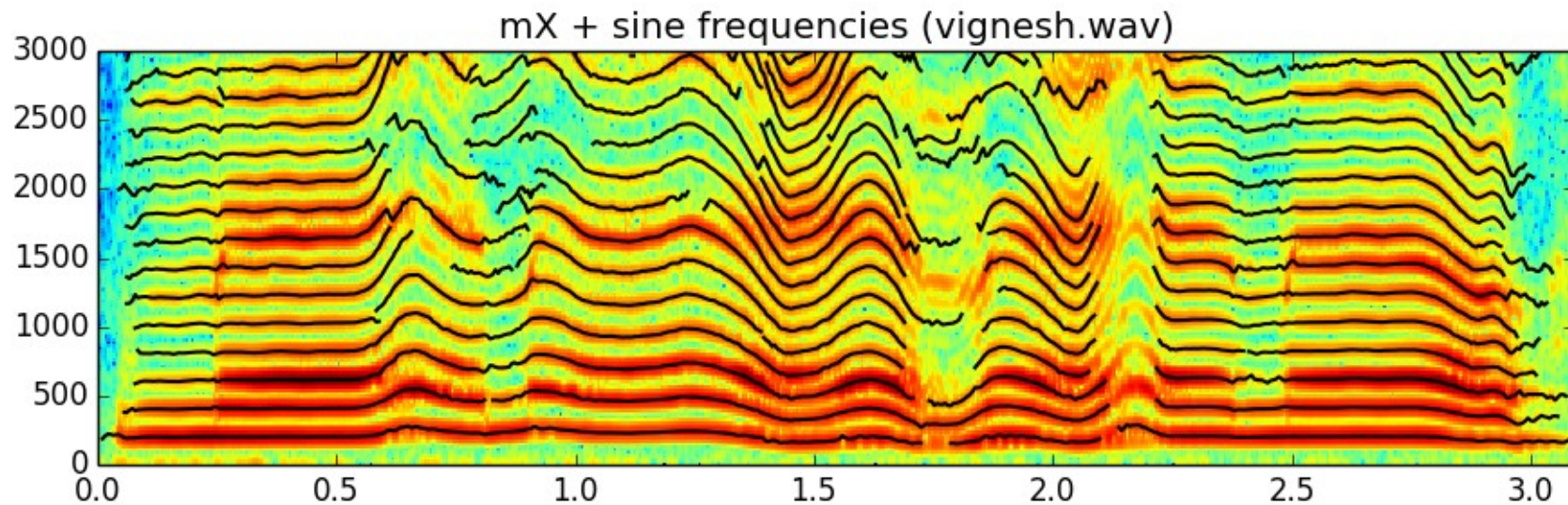
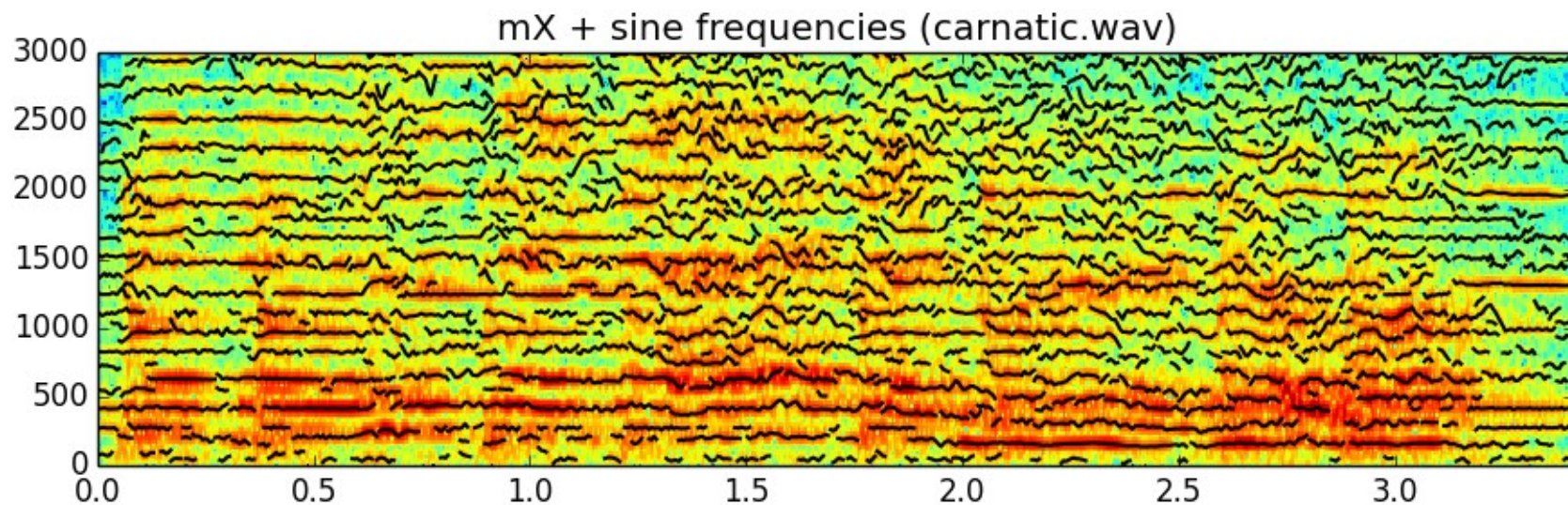




# Sinusoids-partials-harmonics

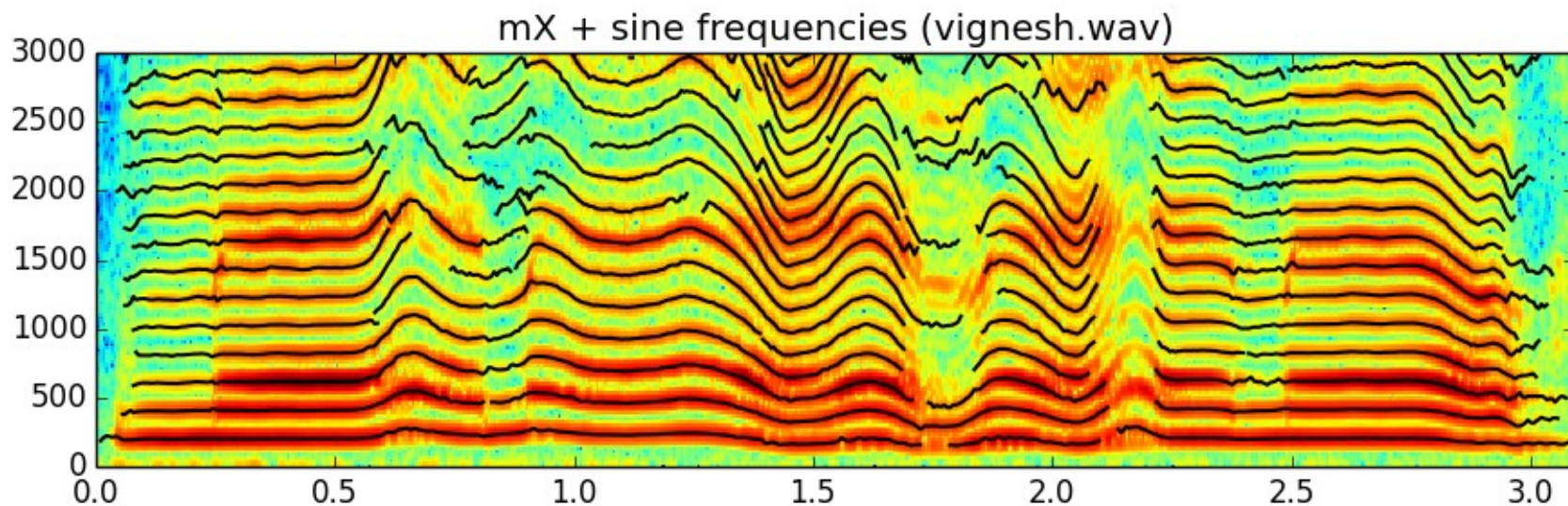
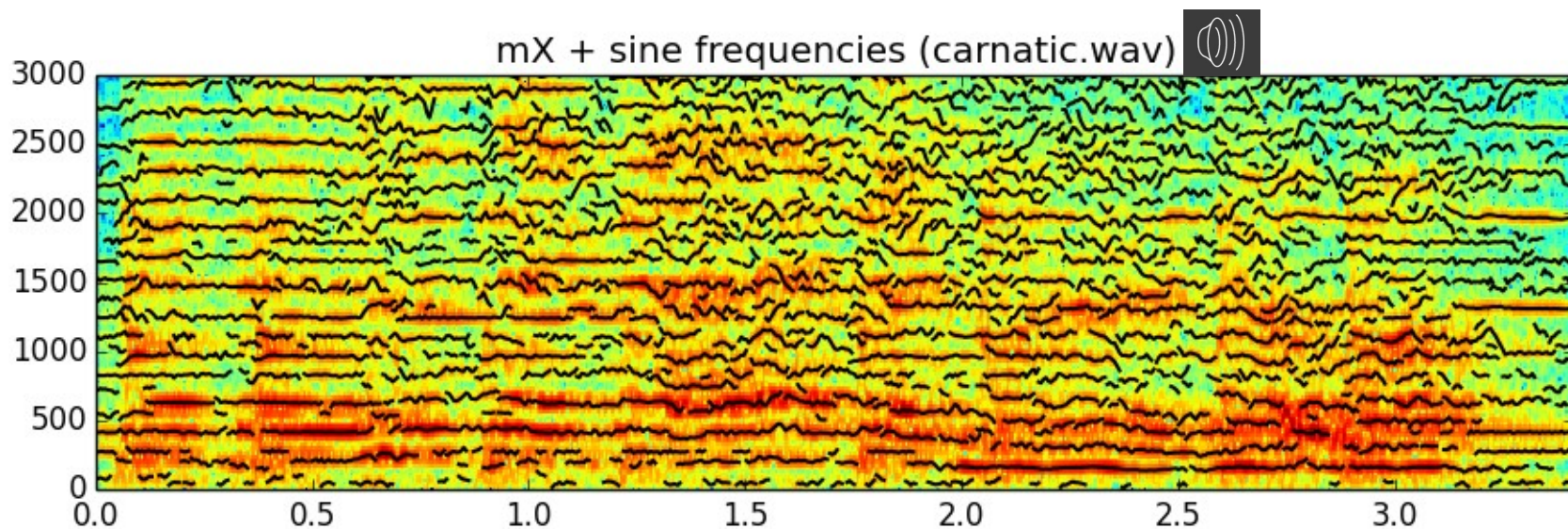


# Polyphonic-monophonic signals



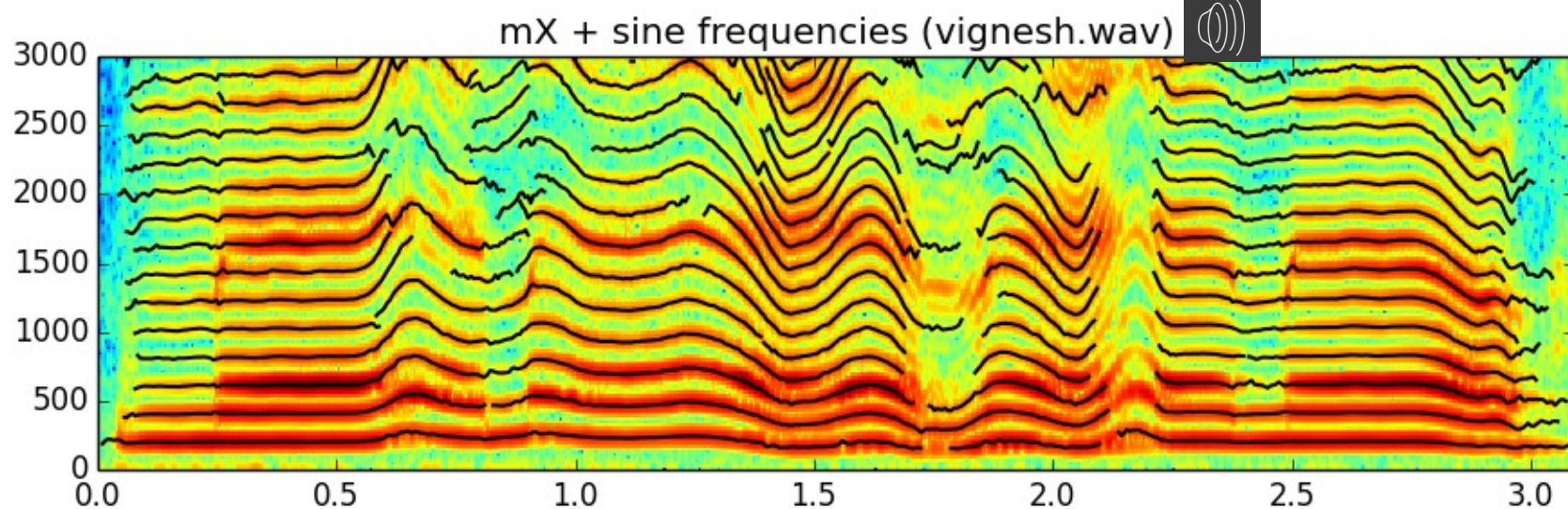
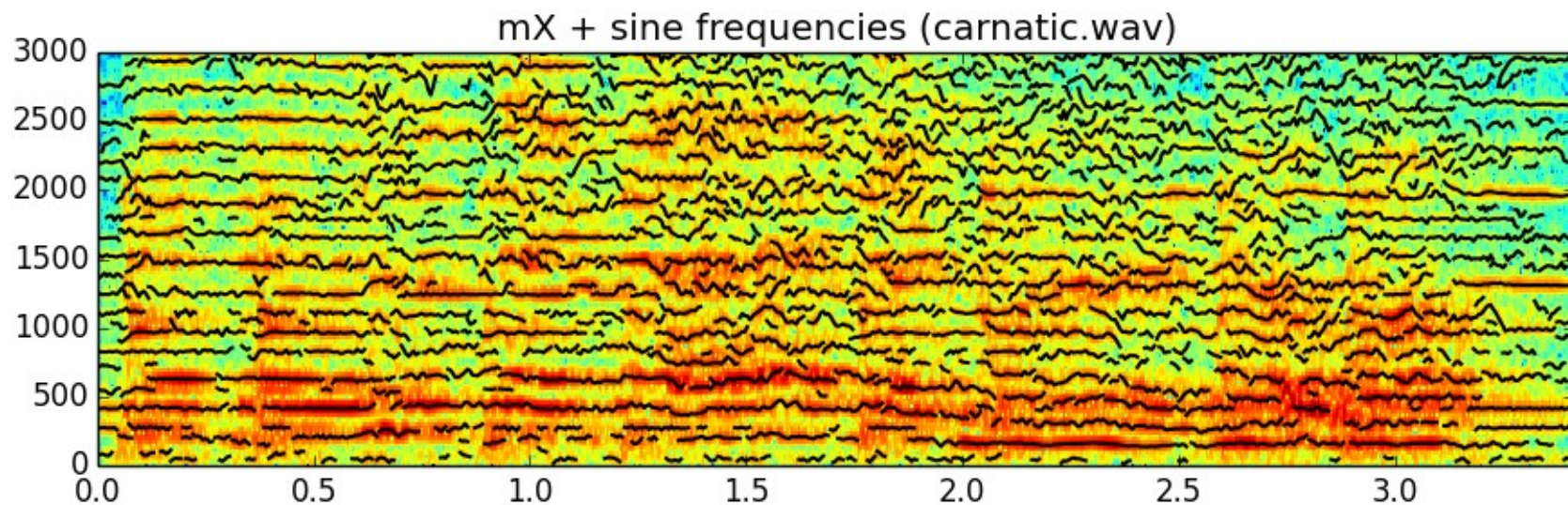


# Polyphonic-monophonic signals





# Polyphonic-monophonic signals



# Harmonic detection

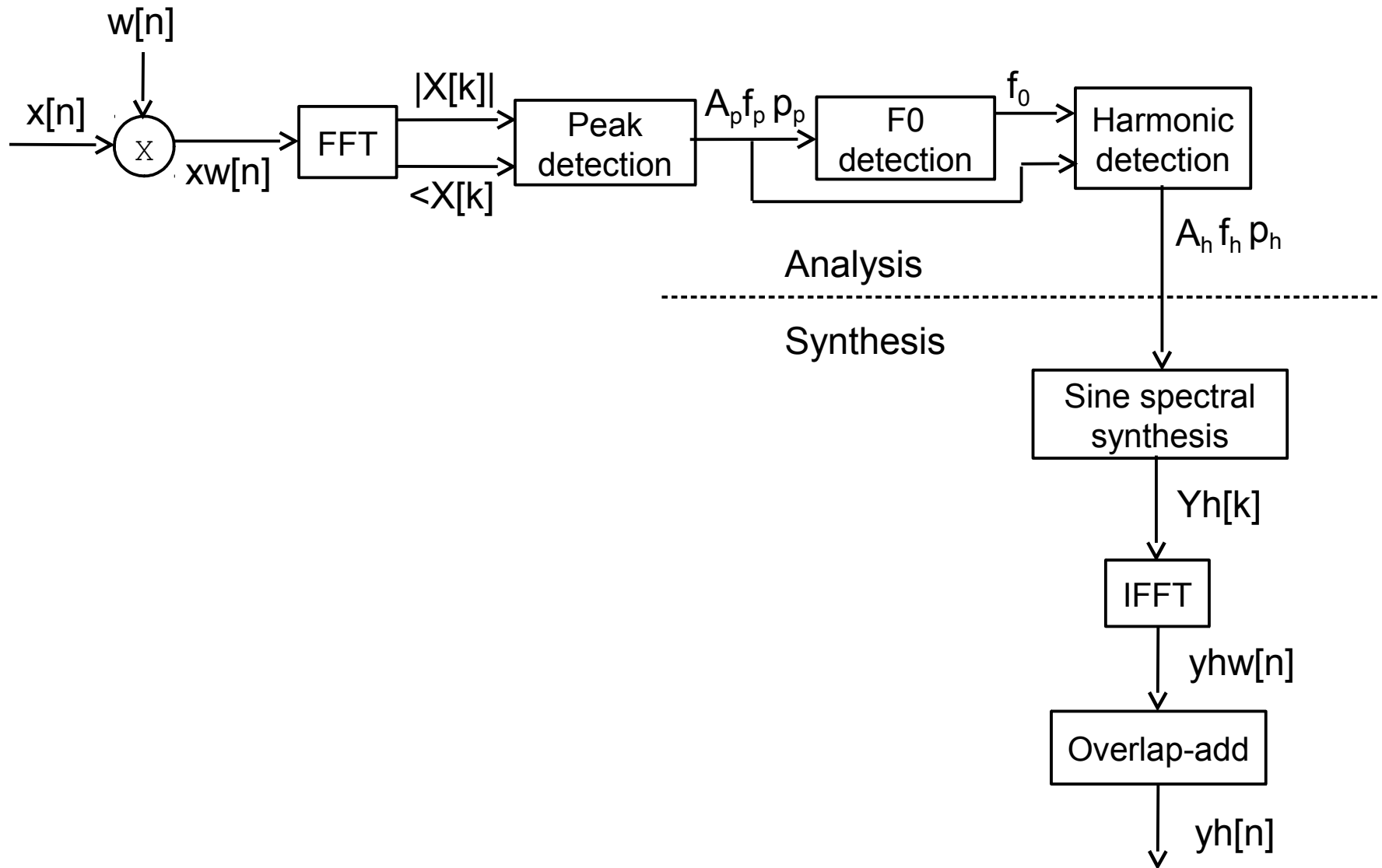
Harmonic  $\rightarrow$  stable spectral peak whose frequency is close to a **multiple** of the fundamental frequency.

Condition for a peak  $f_p$  to be a harmonic  $f_h$ :

$$f_p[l] = f_h[l] \quad \text{if} \quad (|f_p[l] - (h * f_0[l])| < \textit{threshold})$$

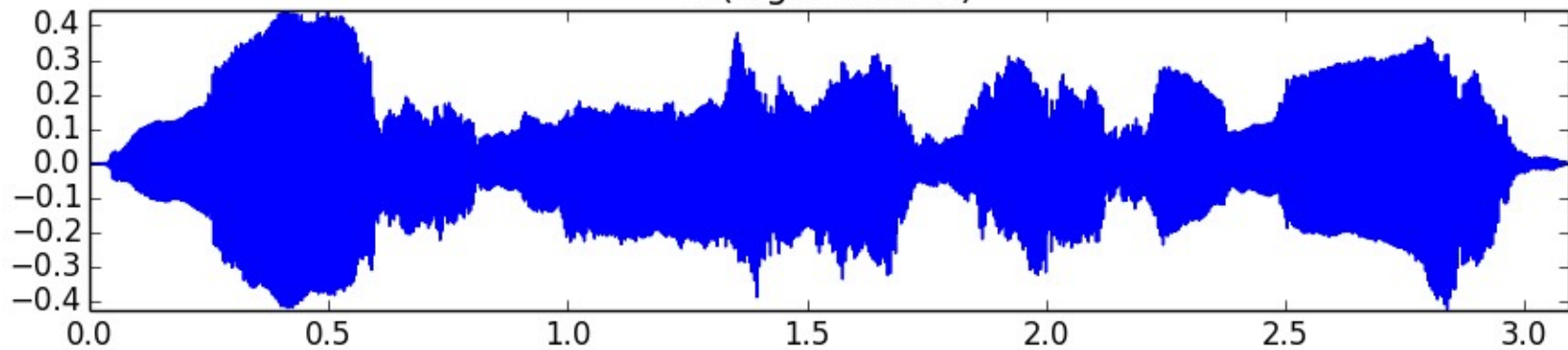
and exists  $f_h[l-2], f_h[l-3], \dots, f_h[l-L]$

# Harmonic model system

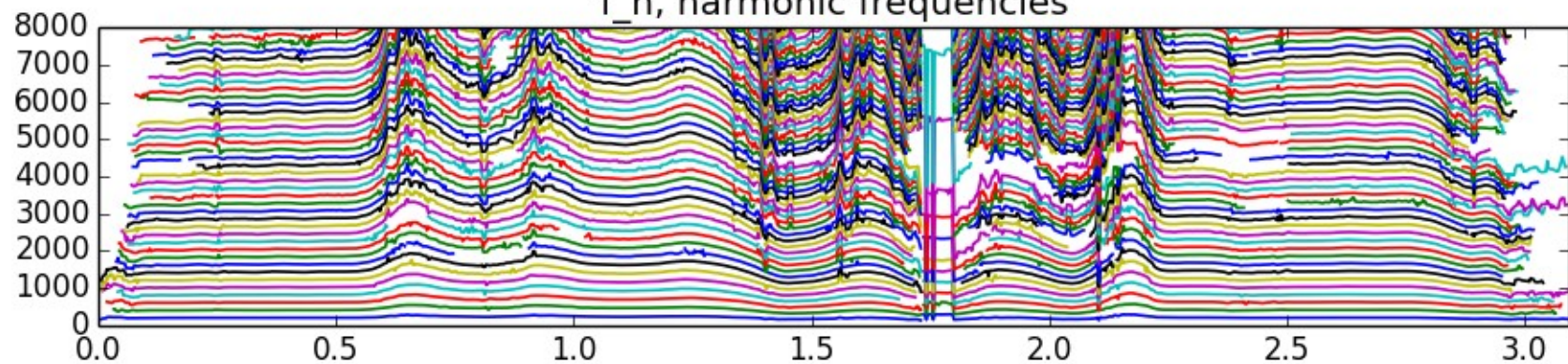




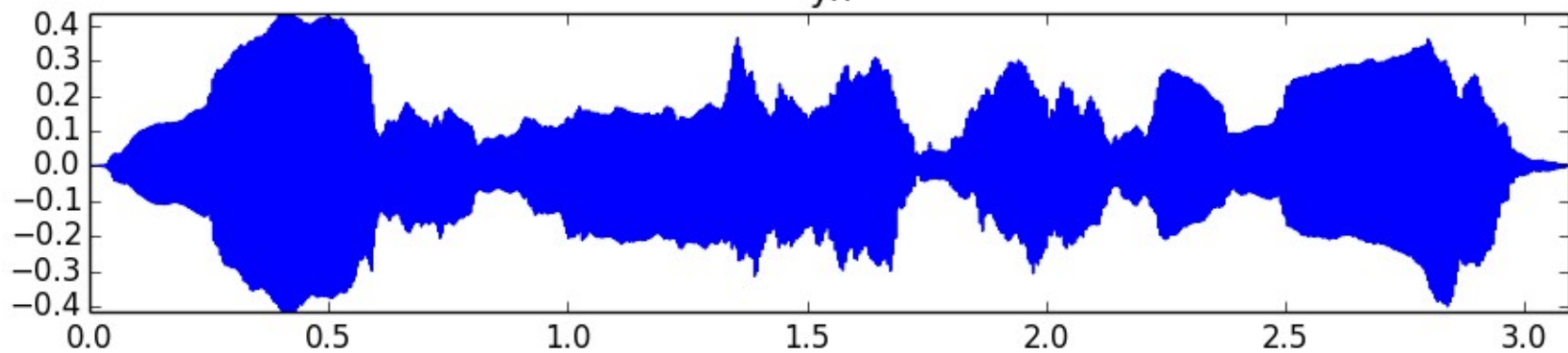
x (vignesh.wav)

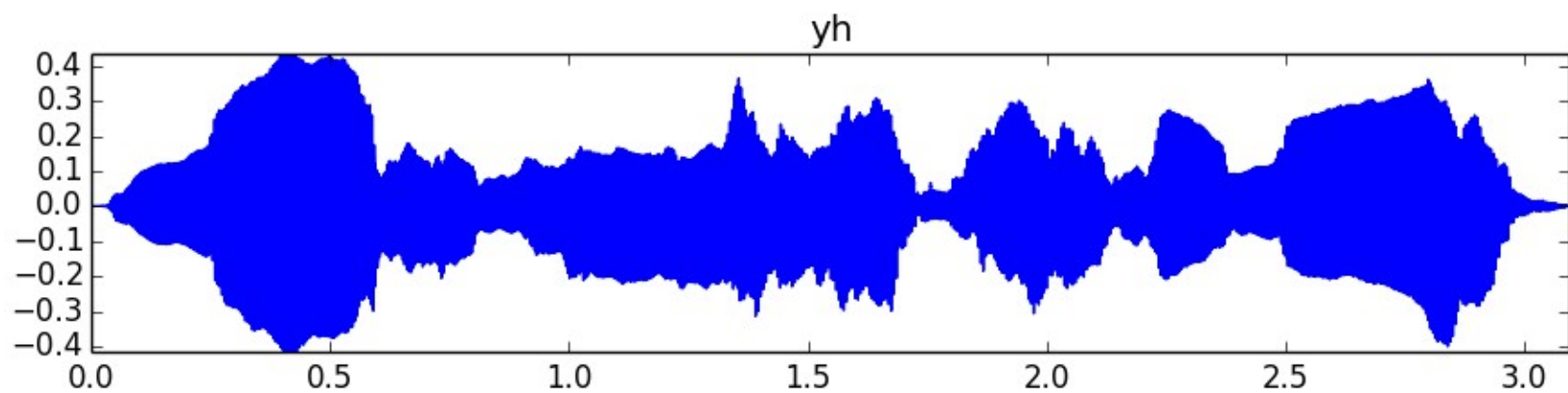
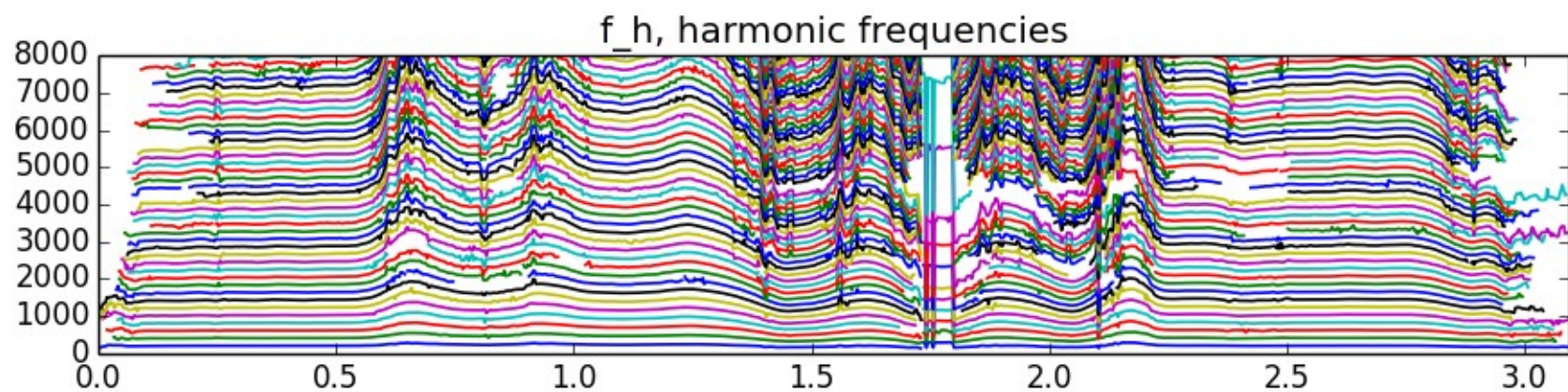
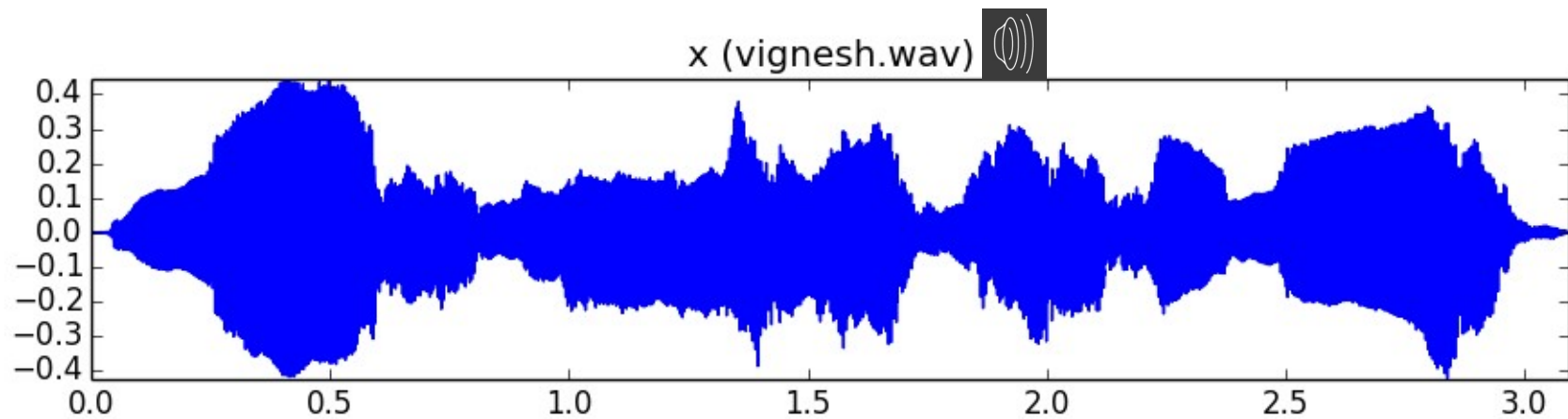


f\_h, harmonic frequencies



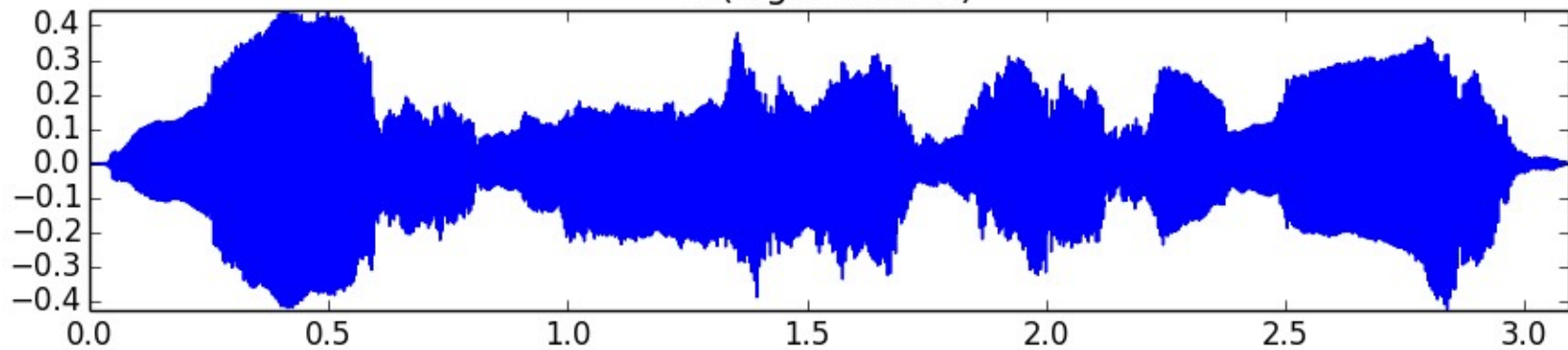
yh



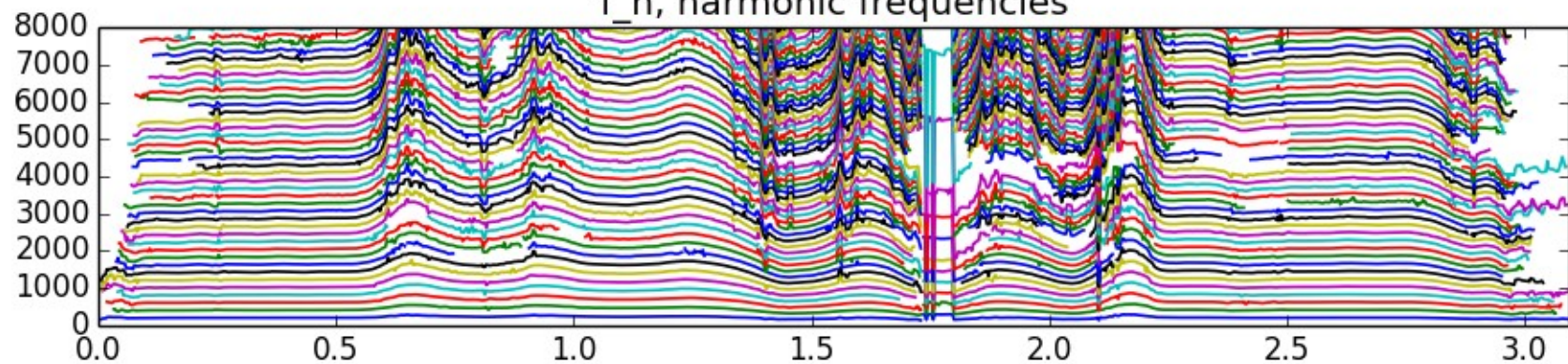




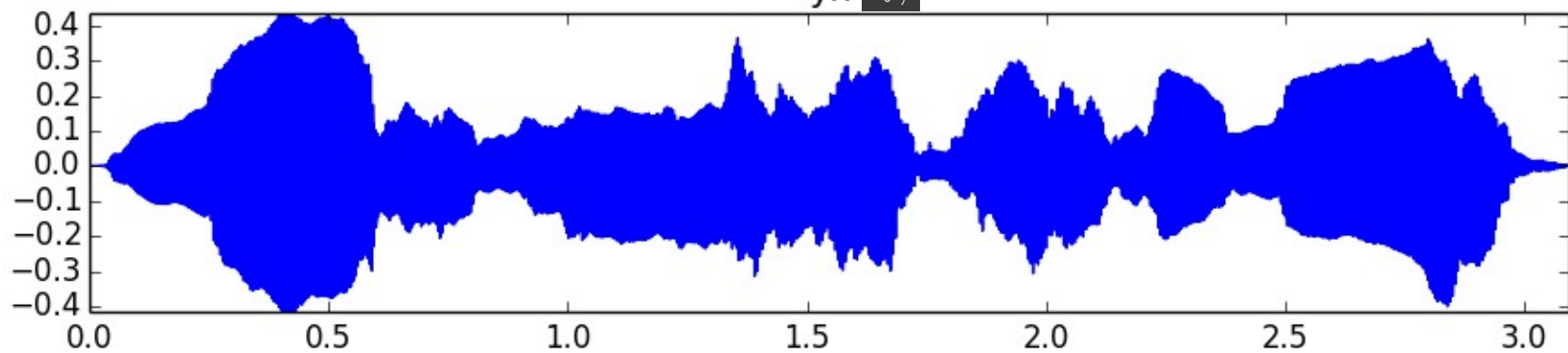
x (vignesh.wav)



f\_h, harmonic frequencies



yh





# References and credits

- More information in:
  - [https://en.wikipedia.org/wiki/Harmonic\\_series\\_\(music\)](https://en.wikipedia.org/wiki/Harmonic_series_(music))
  - <https://en.wikipedia.org/wiki/Harmonic>
- Sounds from:  
<http://www.freesound.org/people/xserra/packs/13038/>
- Slides and code released using the CC Attribution-Noncommercial-Share Alike license or the Affero GPL license and available from <https://github.com/MTG/sms-tools>

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