# The Mathematical Model of Heart Sounds

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# Problems

- A small number of mathematical models of heart sounds and their static frequency-time parameters
- Use for modeling data limited to a frequency range above 28 Hz
- A unique set of harmonics in each systolic phonocardiogram cycle in reality
- Unique parameters of the time-frequency and phase-time characteristics of each systolic phonocardiogram cycle in reality
- Recognition systems are sensitive to variable parameters of phonocardiograms

# Description of the mathematical model

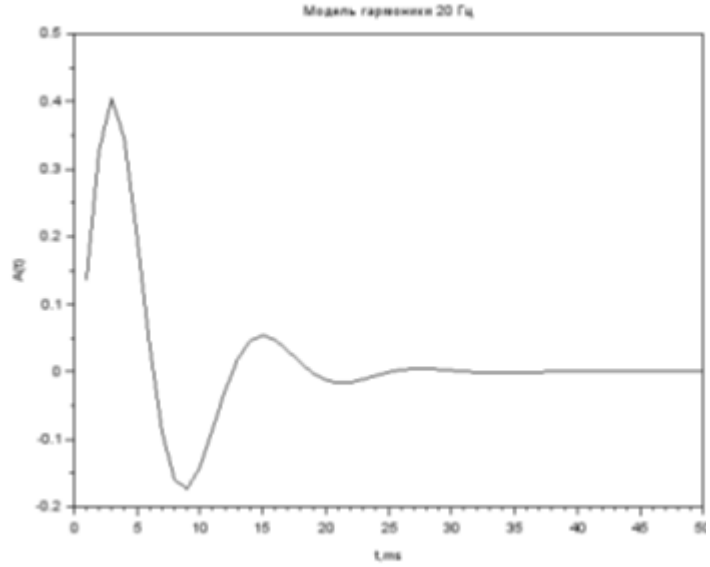
$$x(k) = \sum_{n=1}^{N} \sum_{k \to \infty} \delta_{A,k} A_k sin\left(\delta_{\omega 1,n} \omega_{n,k} + \delta_{\varphi 1,n} \varphi_{n,k}\right) + \delta_{B,k} A_k cos\left(\delta_{\omega 2,n} \omega_{n,k} + \delta_{\varphi 2,n} \varphi_{n,k}\right)$$

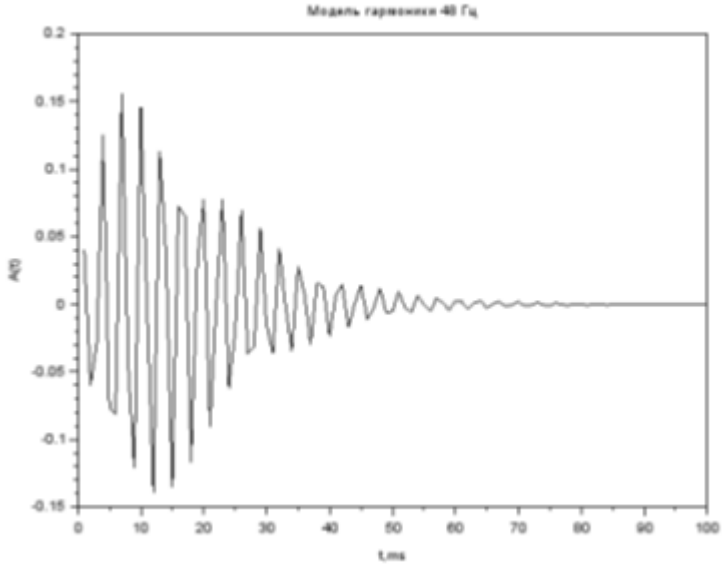
$$x(t) = sin(\delta_1 \omega t + \delta_2 \varphi) exp(\delta_3 - t \cdot \delta_4)$$

$$x(t) = k_0 e^{k_1 t} + k_2\left(1 - e^{k_3 t}\right)$$

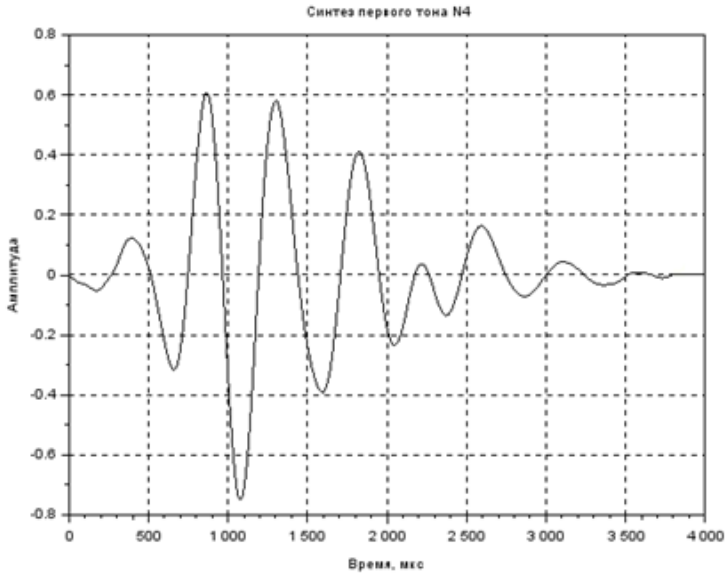
$$H(t) = harm(n, t) * expn(t)$$

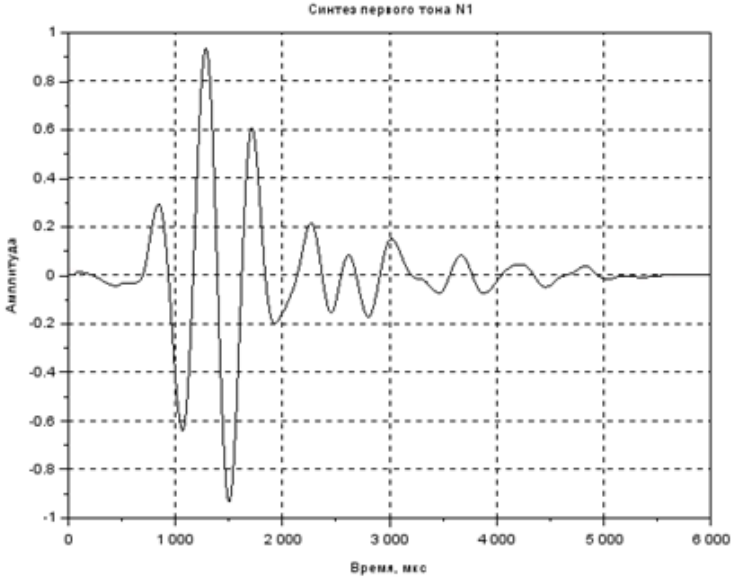
# Synthesis of individual harmonics



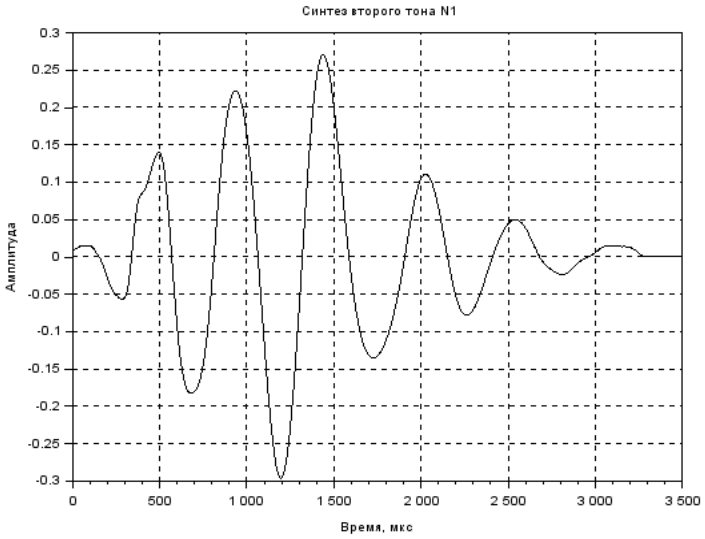



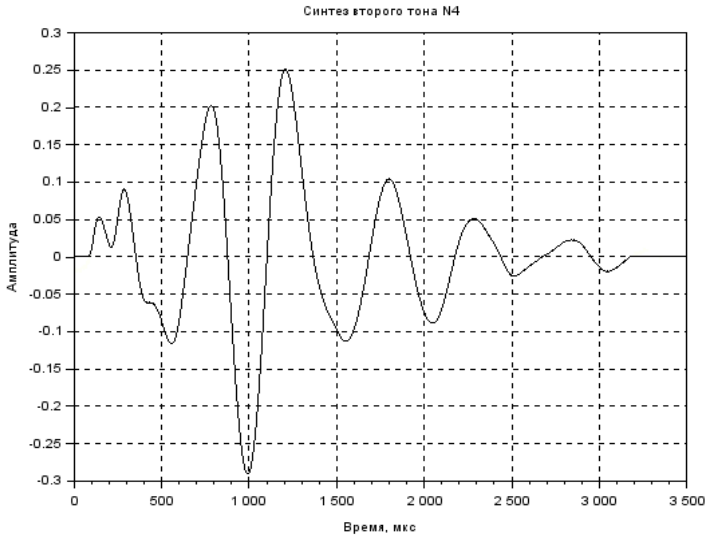
# Synthesis of signals of the first (systolic) tone S1



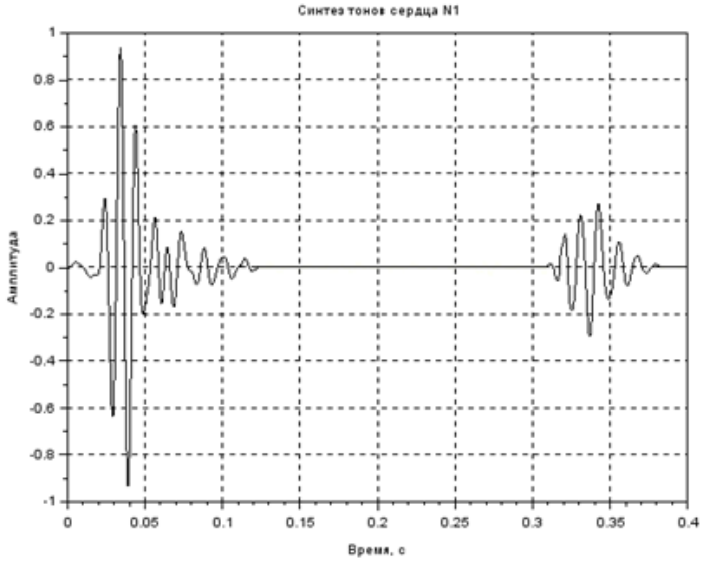



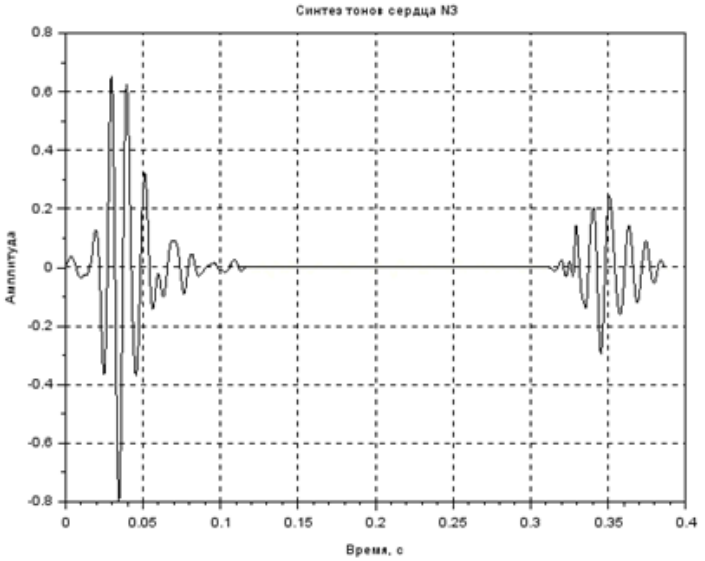
# Synthesis of signals of the second (diastolic) tone S2



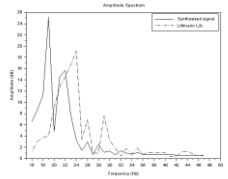



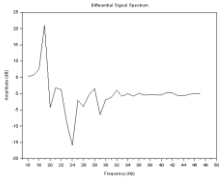
# Synthesis of a complex of heart tones



# Spectra of verified and synthesized signals





Thank you for attention