ECE 3640 - Discrete-Time Signals and Systems
Convolution

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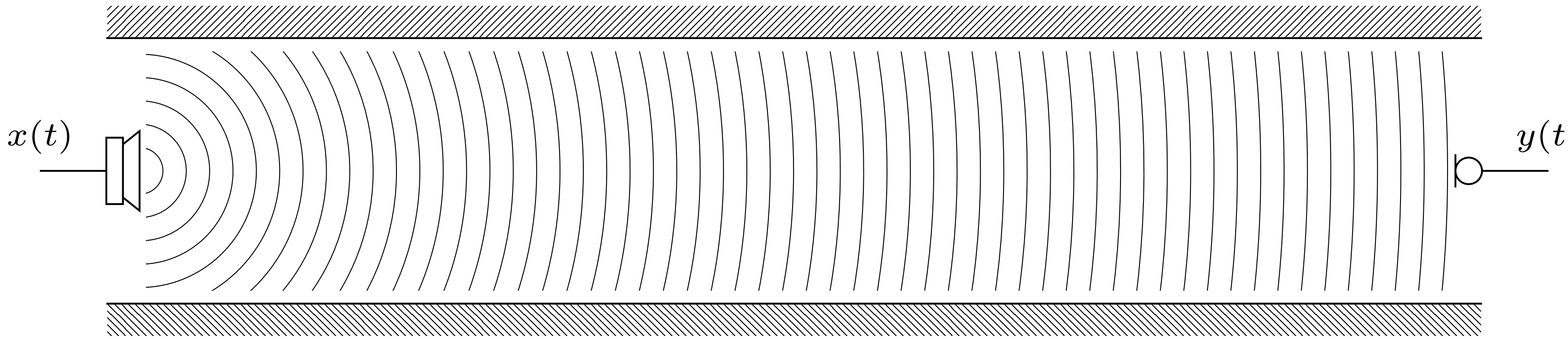
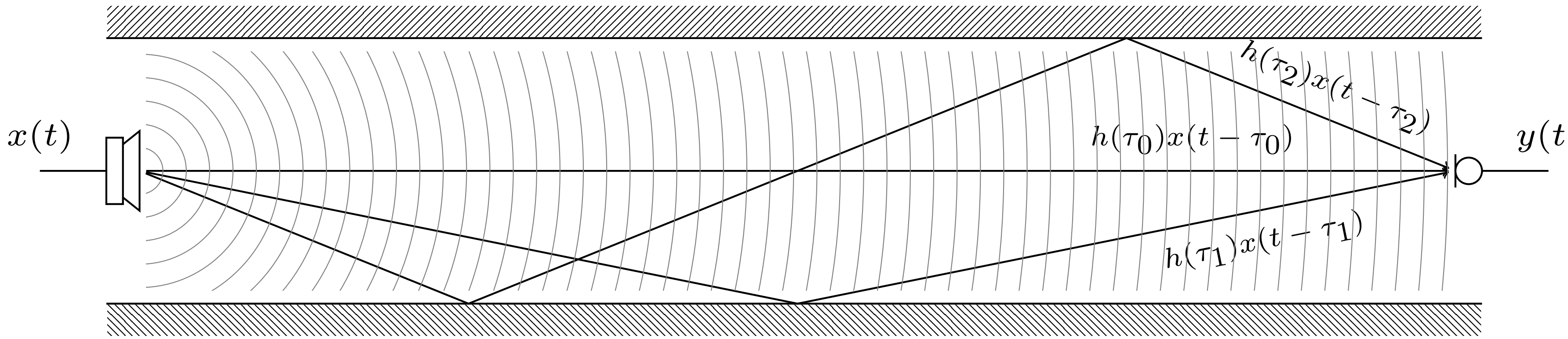
emitter + sensor in a hallway



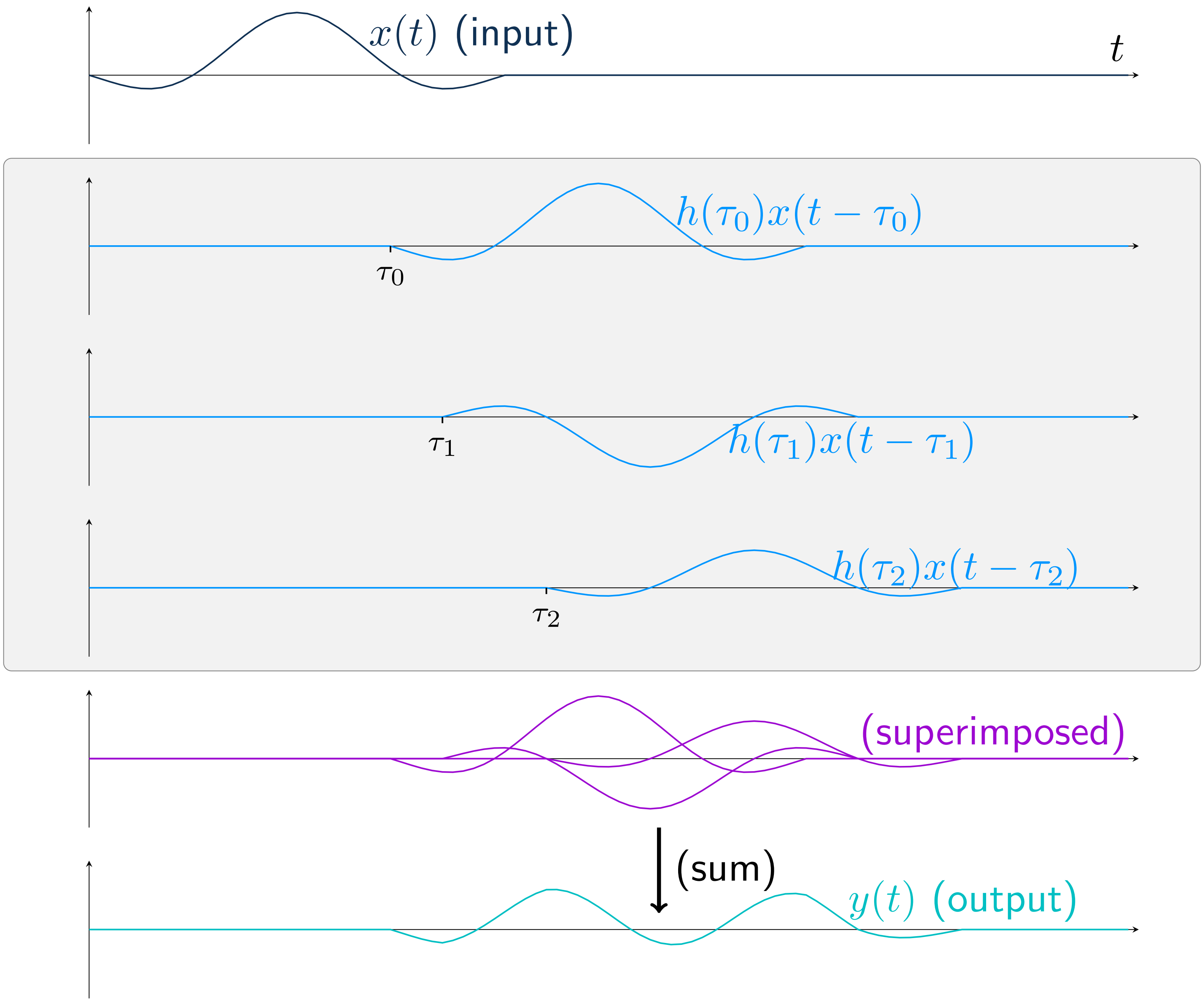
sound paths



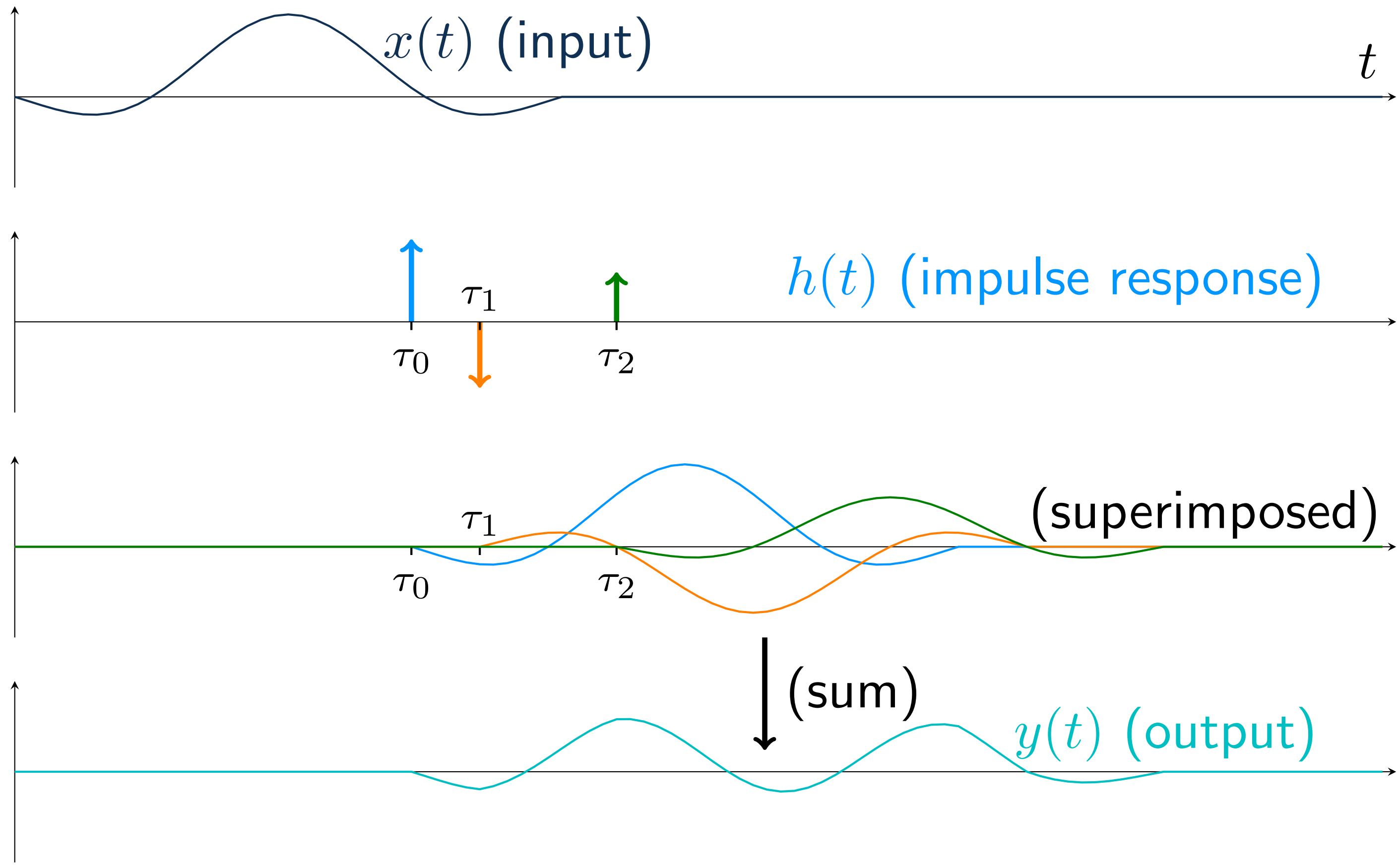
finite number of discrete paths

$$y(t) = h(\tau_0)x(t-\tau_0) + h(\tau_1)x(t-\tau_1) + h(\tau_2)x(t-\tau_2)$$

delayed and scaled replicas of input signal



impulse response

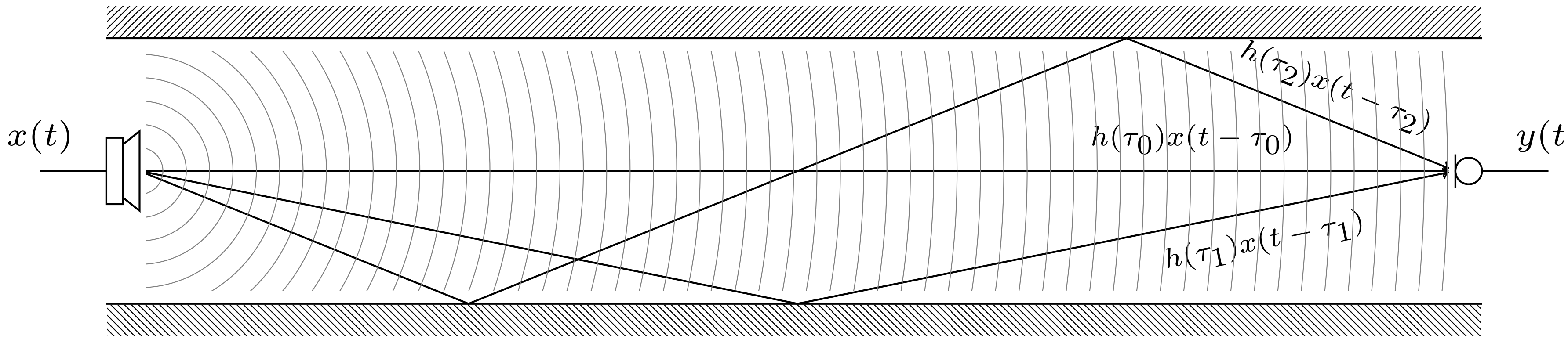


$$h(t) = 1.0 \cdot \delta(t - \tau_0) - 0.8 \cdot \delta(t - \tau_1) + 0.6 \cdot \delta(t - \tau_2)$$

$$y(t) = h(t) * x(t)$$

$$= 1.0 \cdot x(t - \tau_0) - 0.8 \cdot x(t - \tau_1) + 0.6 \cdot x(t - \tau_2)$$

sound paths



finite discrete paths

$$y(t) = h(\tau_0)x(t-\tau_0) + h(\tau_1)x(t-\tau_1) + h(\tau_2)x(t-\tau_2)$$

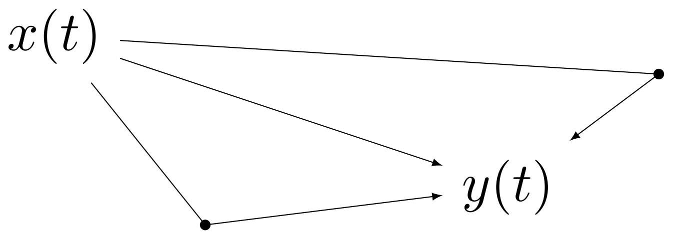
large number N of discrete paths

$$y(t) = \sum_{i=0}^{N} h(\tau_i)x(t-\tau_i)$$

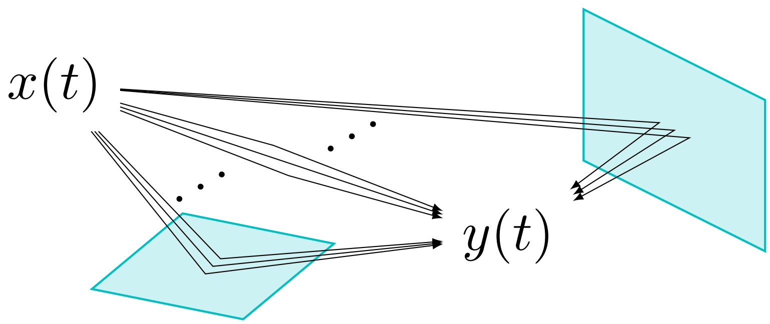
continuum of paths

$$y(t) = \lim_{N\to\infty} \sum_{i=0}^{N} h(\tau_i)x(t-\tau_i) = \int_0^{\infty} h(\tau)x(t-\tau)d\tau$$

discrete and continuous scattering



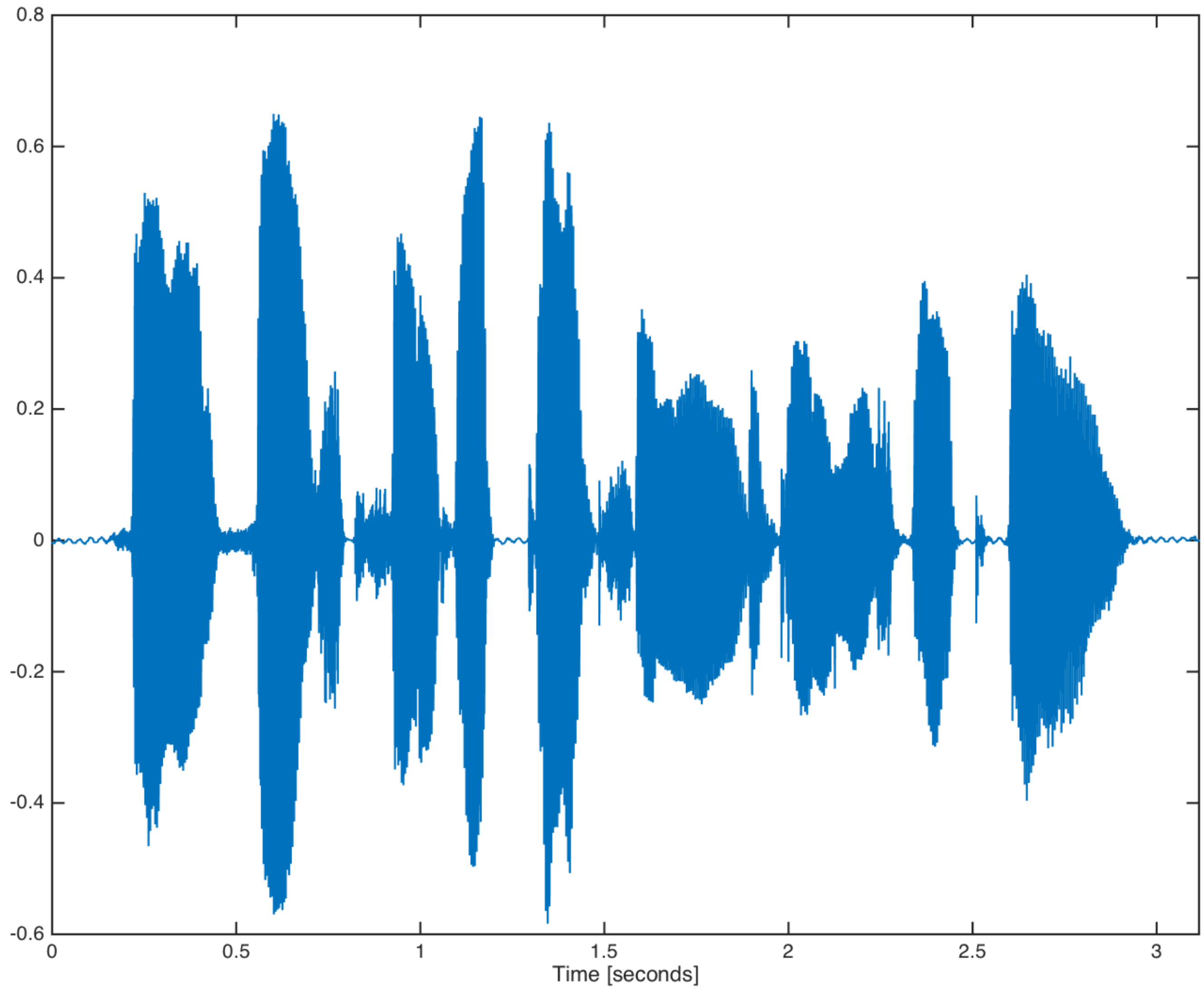
$$y(t) = \sum_{i=0}^{N} h(\tau_i)x(t - \tau_i)$$



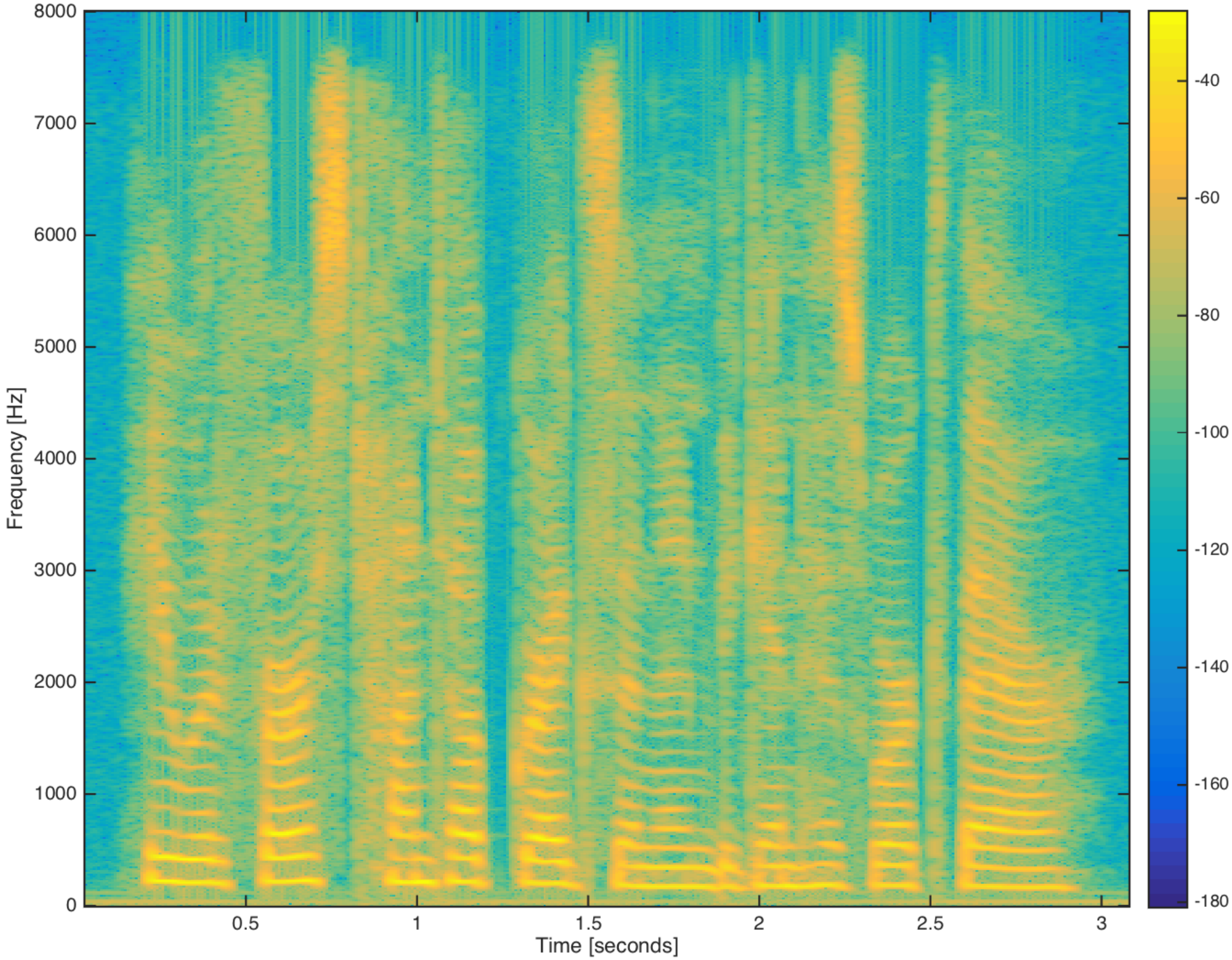
$$y(t) = \int_0^{\infty} h(\tau)x(t - \tau)d\tau$$

- physical processes convolve an input signal with a system impulse response
- convolution models physical processes

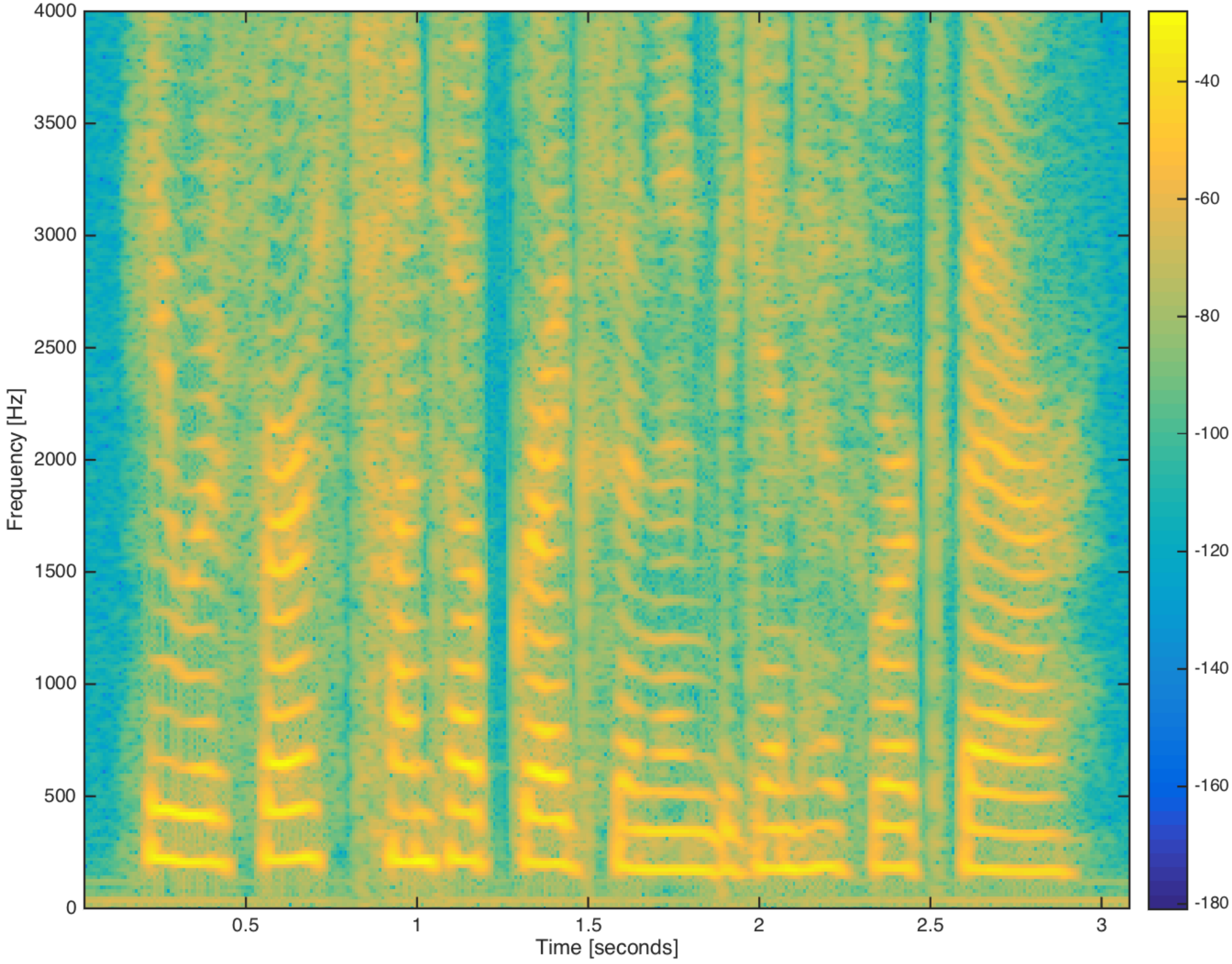
input speech signal: time domain



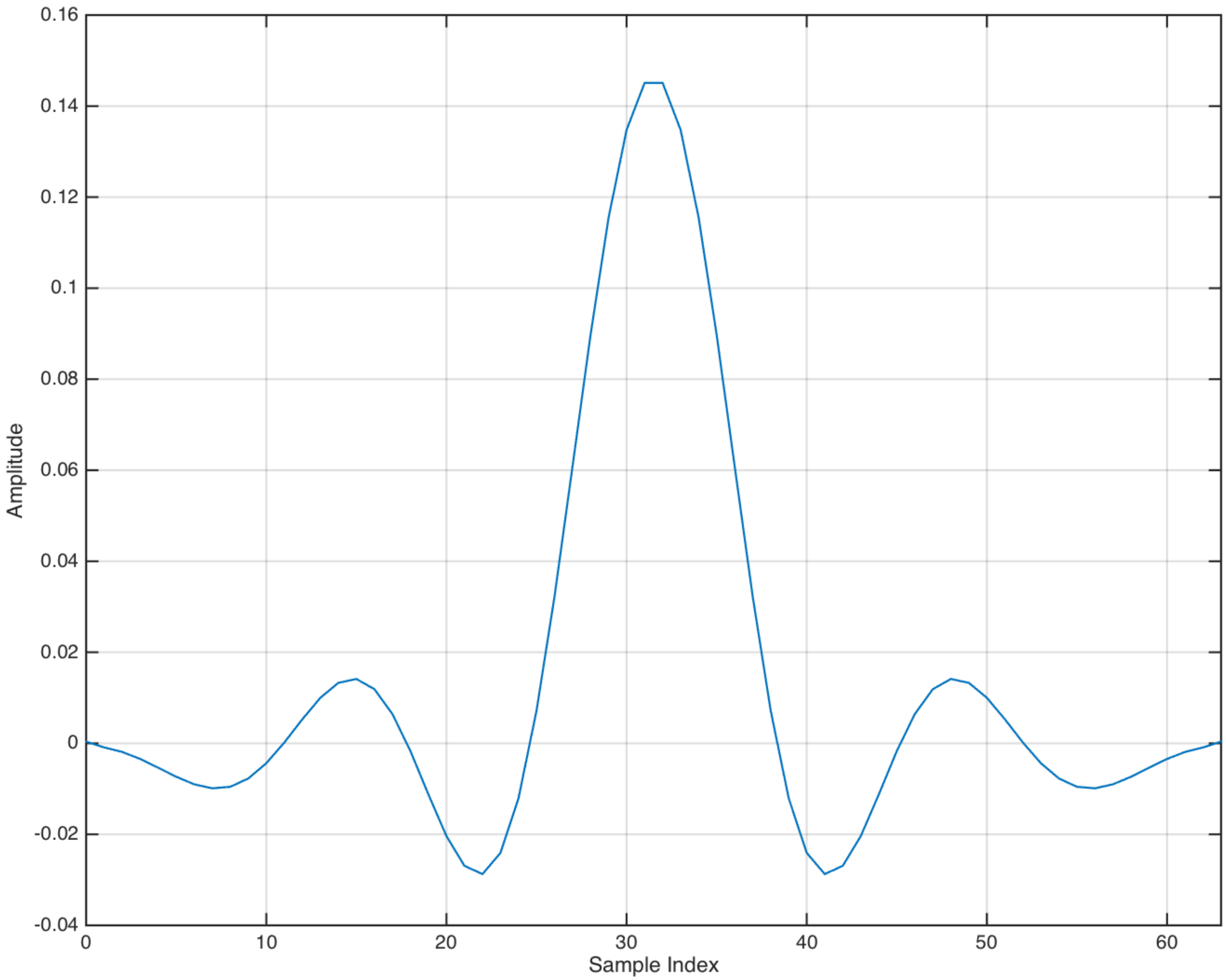
input speech signal: spectrogram



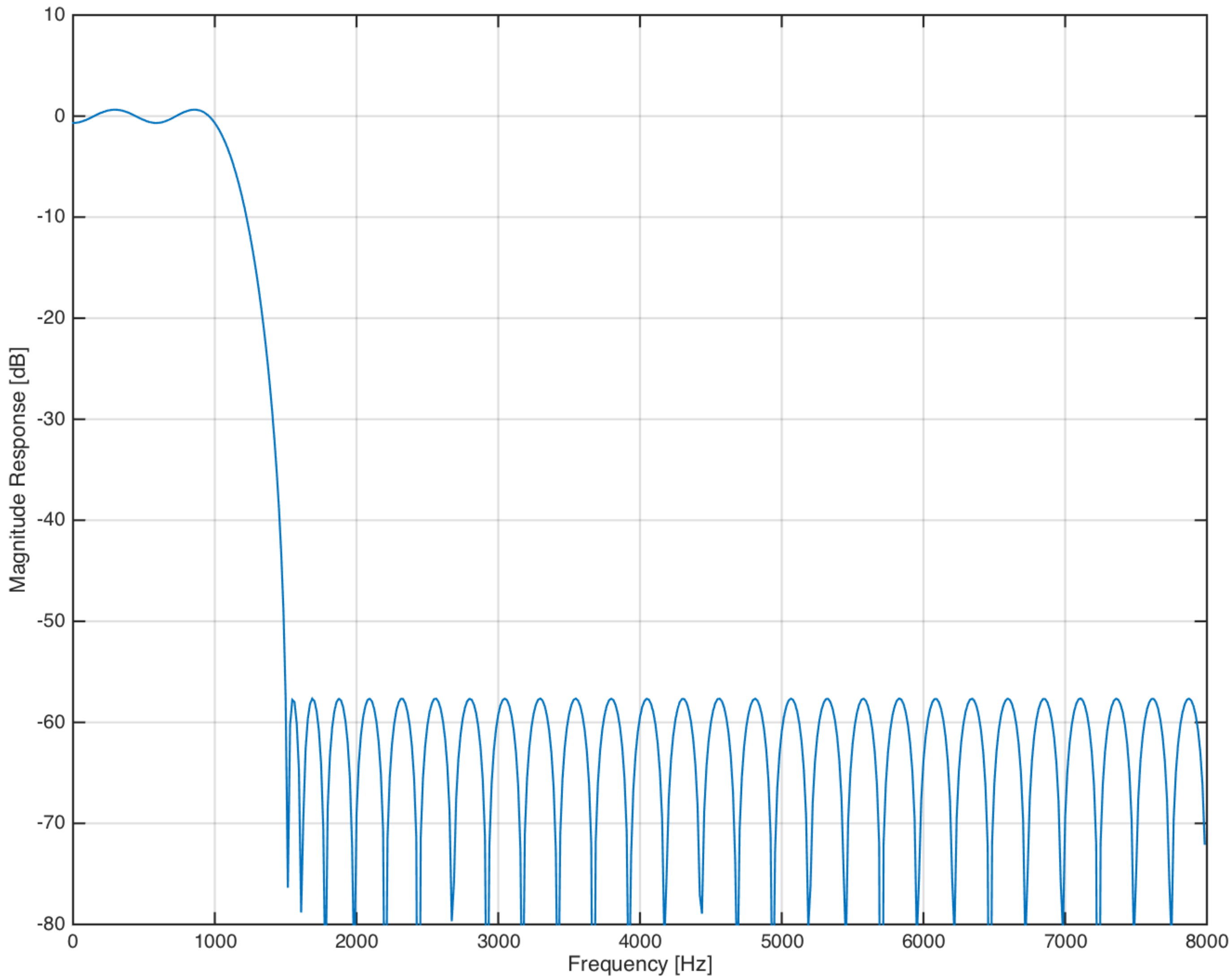
input speech signal: spectrogram



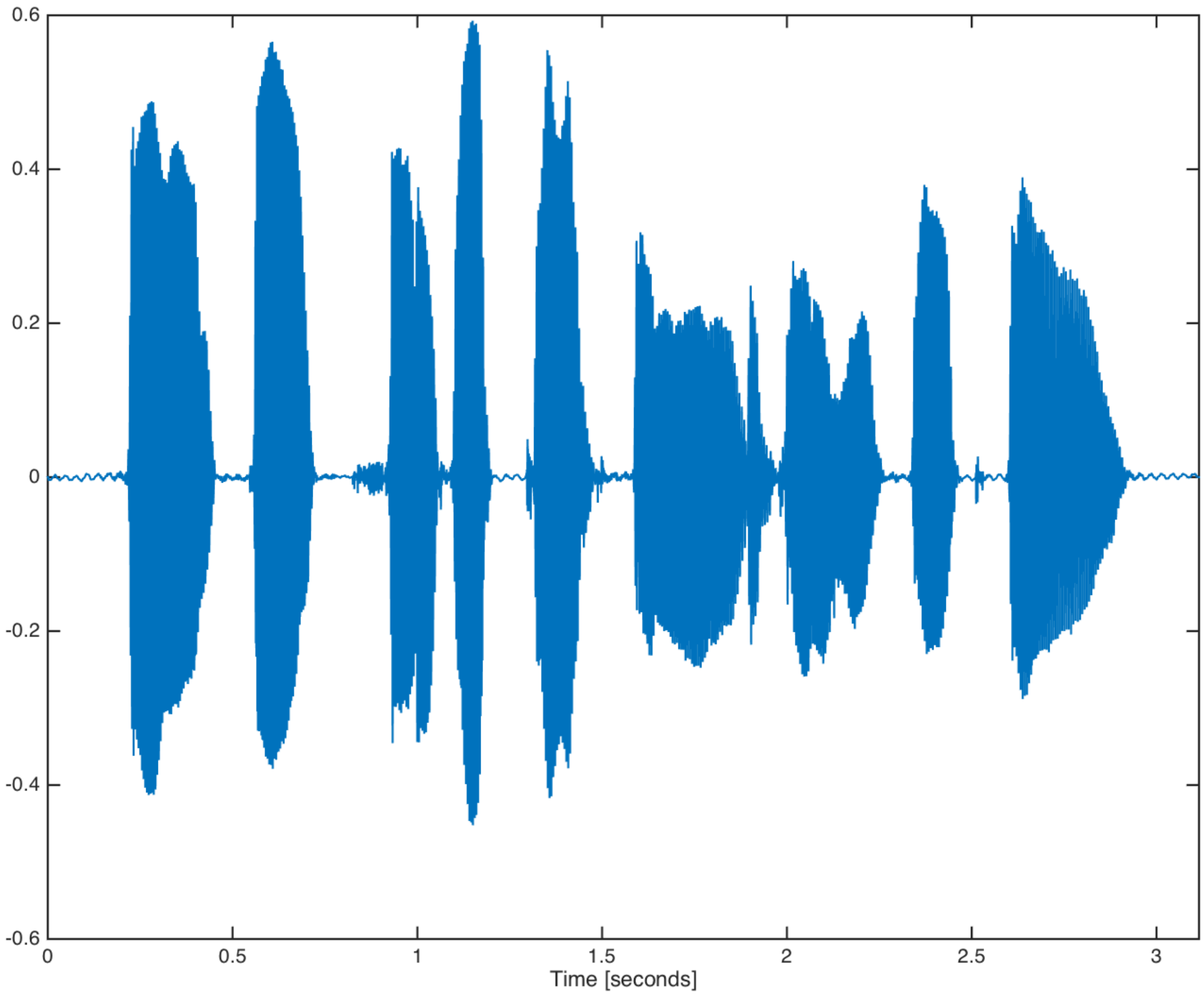
filter impulse response (low-pass filter)



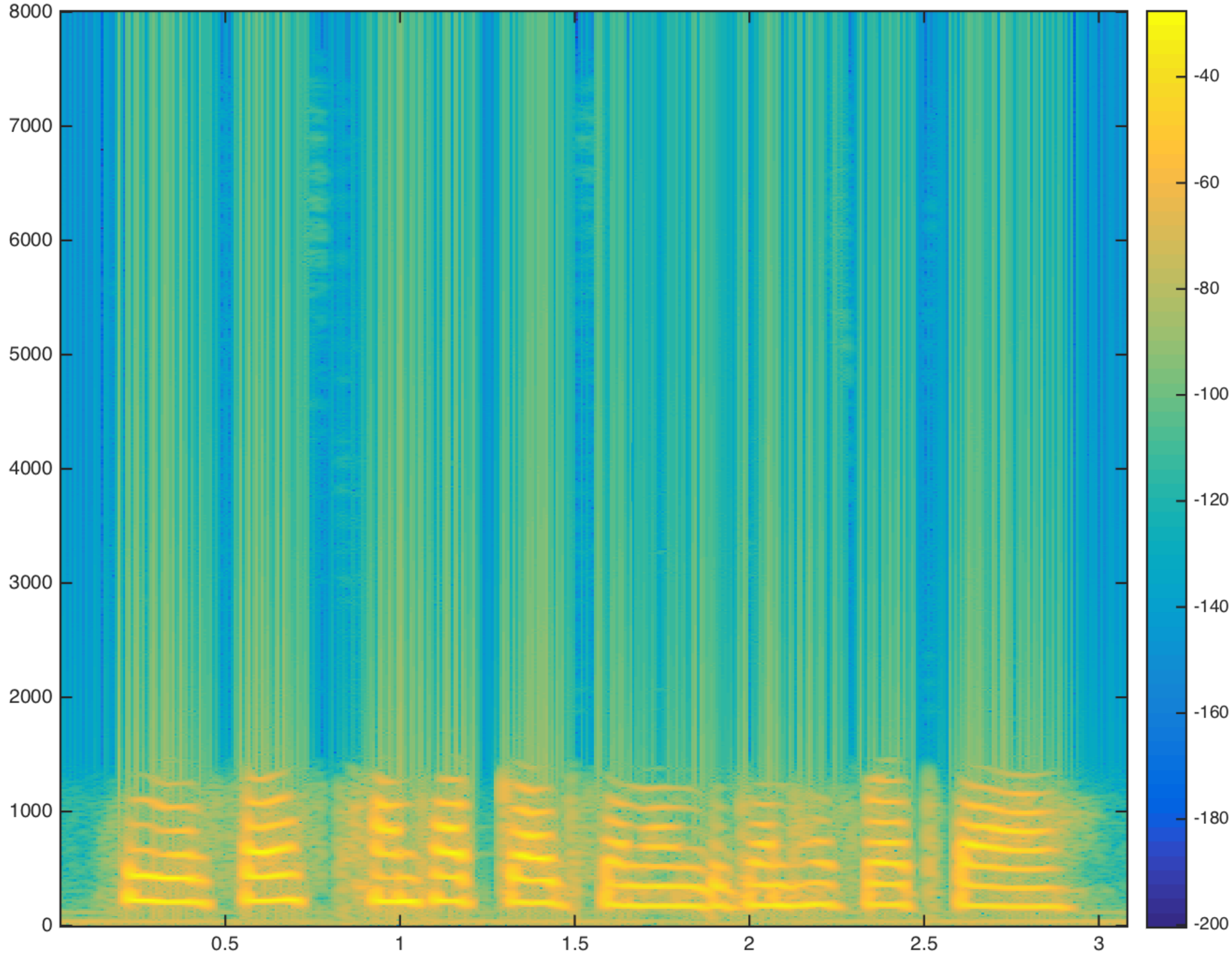
filter magnitude response (low-pass filter)



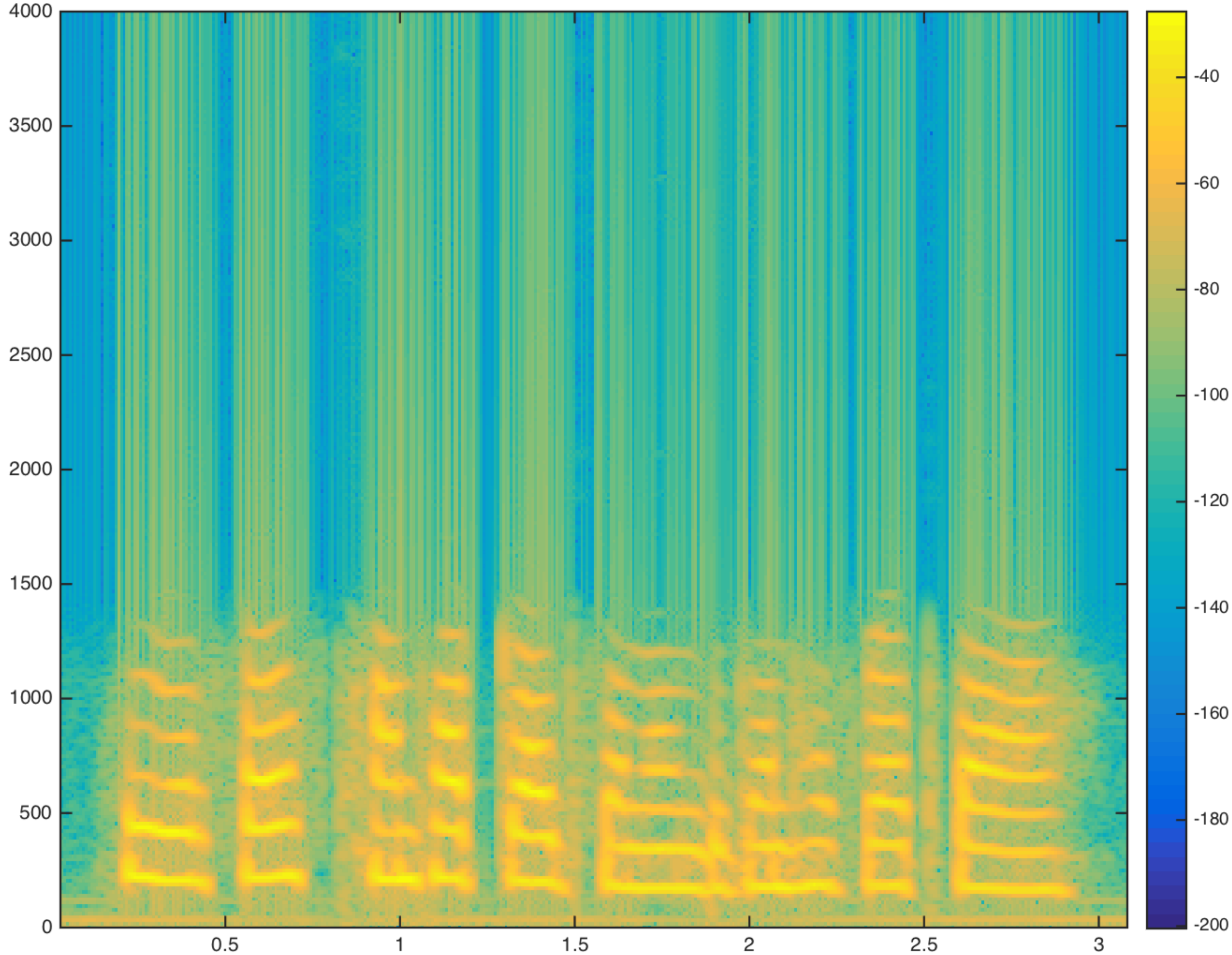
output speech signal: time domain



output speech signal: spectrogram



output speech signal: spectrogram



input & output comparison: time domain