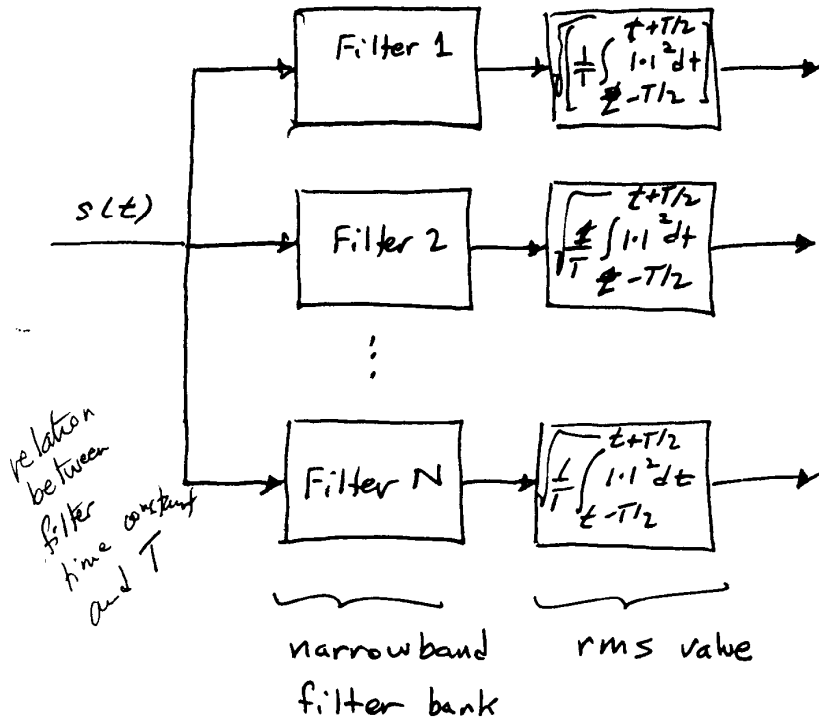


How to do spectral analysis of speech?
 How to display the results?

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Short-time Spectral Analysis



Schematic
 of
 Analog
 Spectrum
 Analyzer

(discuss digital approaches later)

Depending on bandwidth of filters, we obtain two different types of spectrogram displays

I. Wideband (short-time)

high time resolution - actually see excitation pulses

individual periods of time waveform are evident

insufficient frequency resolution to resolve fine spectral structure due to excitation

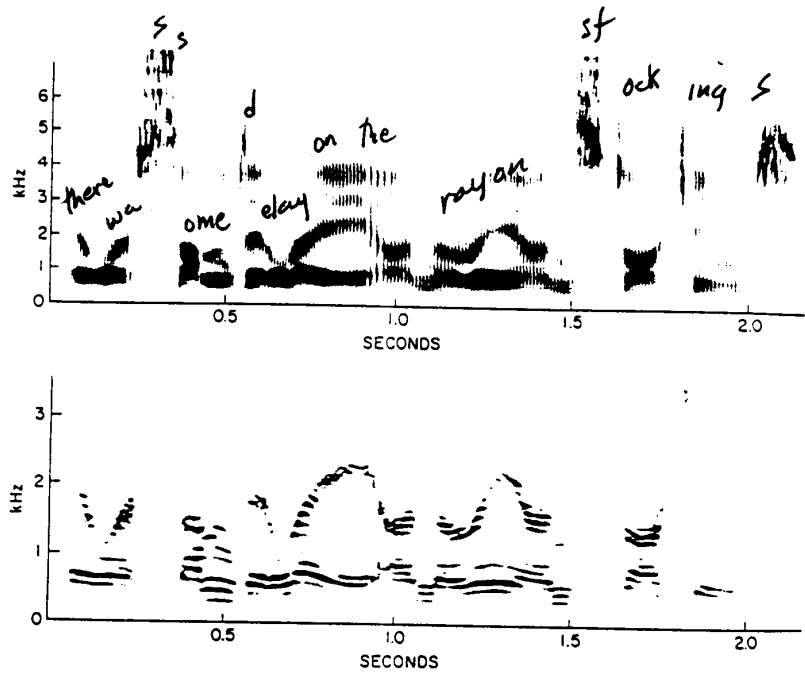


FIGURE 3-4. Speech spectrograms of the utterance "there was some delay on the rayon stockings"; (a) wideband spectrogram; (b) narrowband spectrogram.

II. Narrowband (long-time)

see all harmonics of excitation

temporal pulse repetition is not resolved

Example (Fig. 3-4)

~~time, frequency, amplitude~~
darker \Rightarrow larger magnitude

Information displayed:

- time
- frequency
- amplitude

darker \Rightarrow larger magnitude

Wideband spectrogram:

Filters had 300 Hz bandwidth \Rightarrow 0.003 sec. time constant

See resonance clear in voiced intervals

Pitch is resolved in time \sim 0.01 sec.

Unvoiced areas are noise-like

Narrowband spectrogram:

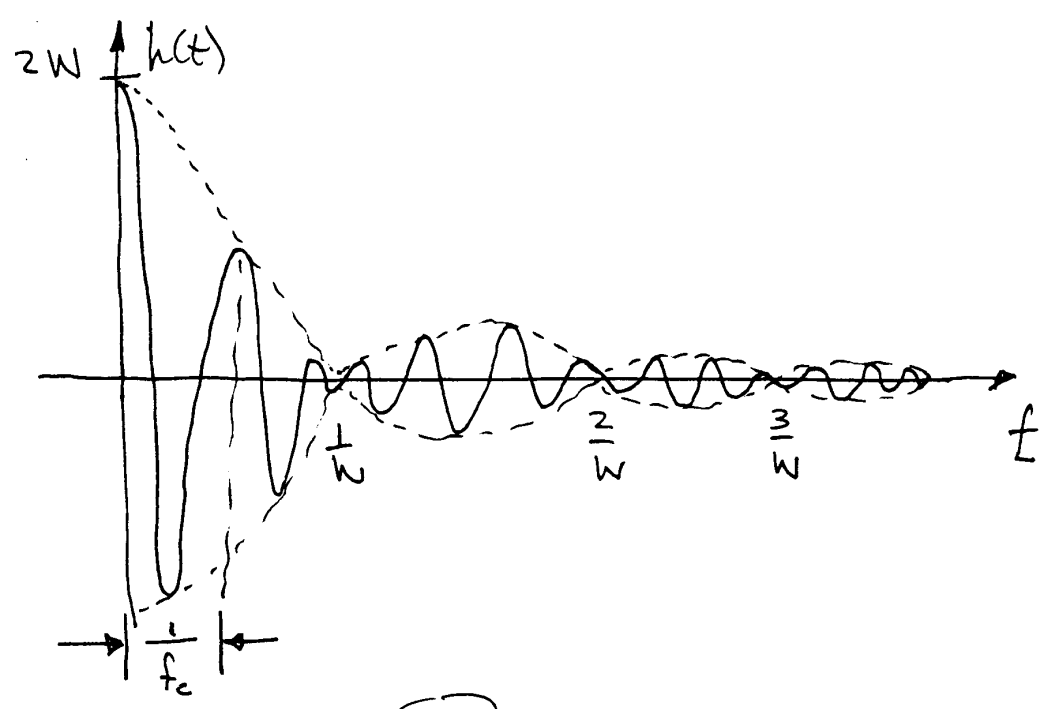
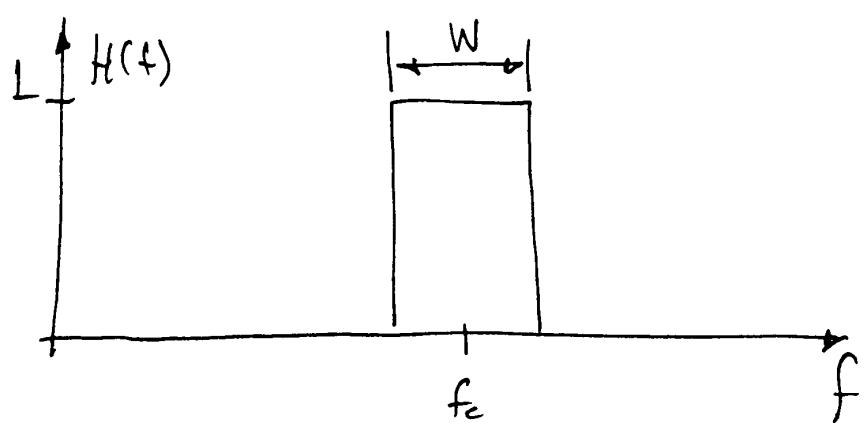
Filters had 45 Hz bandwidth \Rightarrow 0.022 sec. time constant

resolve harmonics (about 100 Hz apart)
but not temporal pulse repetition.

Details on Filter Response

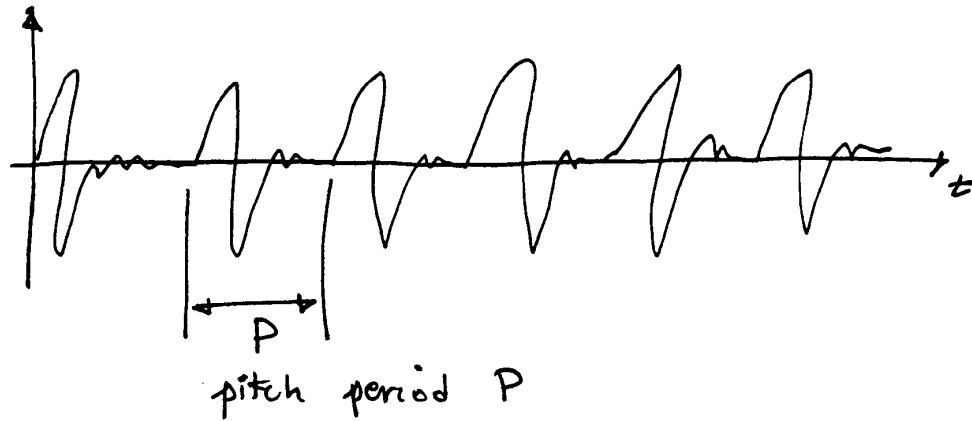
$$H(f) = \text{rect}\left(\frac{f - f_c}{W}\right) + \text{rect}\left(\frac{f + f_c}{W}\right)$$

$$h(t) = 2W \text{sinc}(Wt) \cos(2\pi f_c t)$$



Integration time T for determining RMS value should be about $\frac{1}{W}$.

Consider response to a narrowband pulse train



Examine relations between P & T & $\frac{1}{W}$ and implications for response.