University of California
Berkeley

College of Engineering
Department of Electrical Engineering
and Computer Sciences

Professors : N.Morgan / B.Gold

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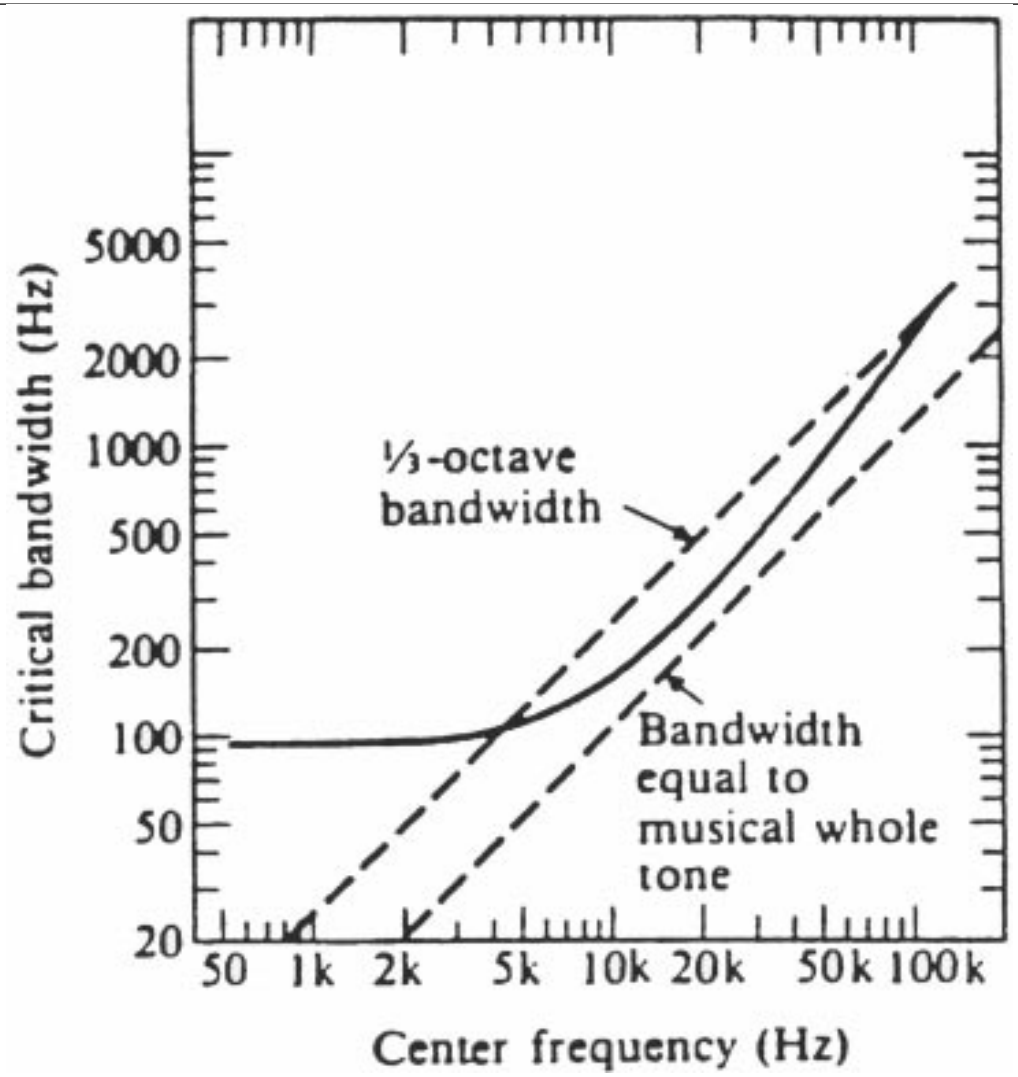
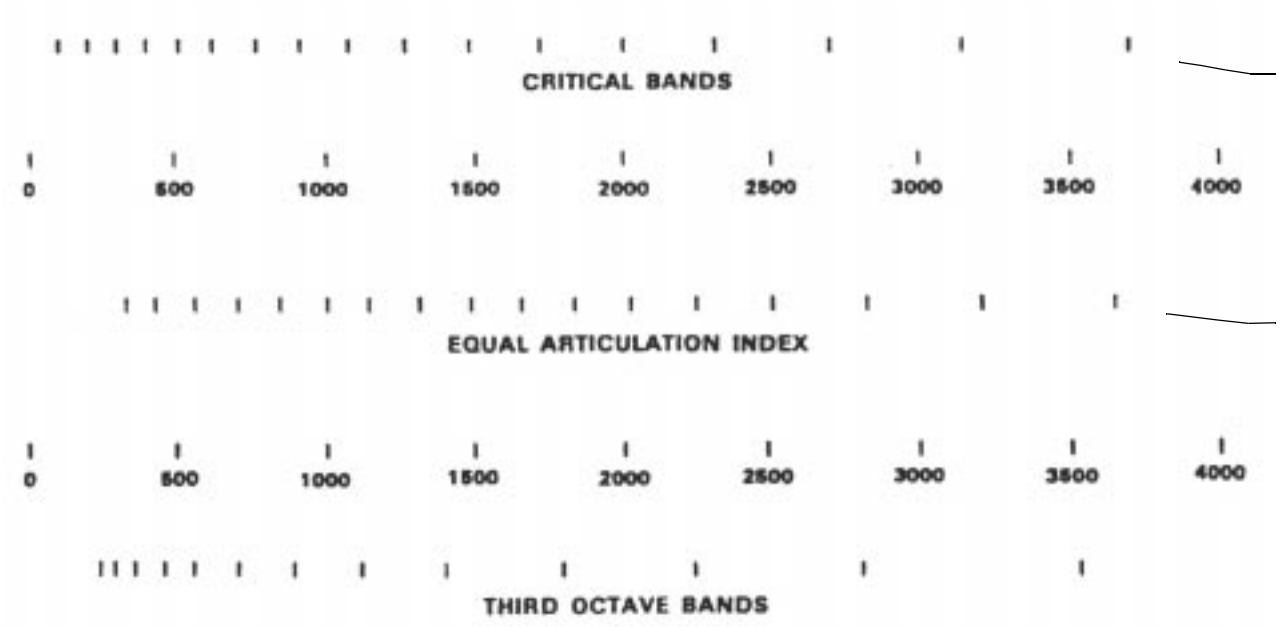
# The Auditory System as a Filter Bank

# Lecture 20




- FIlters are rectangular
- Bandwidth ~100Hz up to 600Hz. log. afterwards

Figure 19.1 : Critical bands vs. center frequency. The solid line represents the critical bandwidth for each frequency, while the dashed lines are provided for comparison.

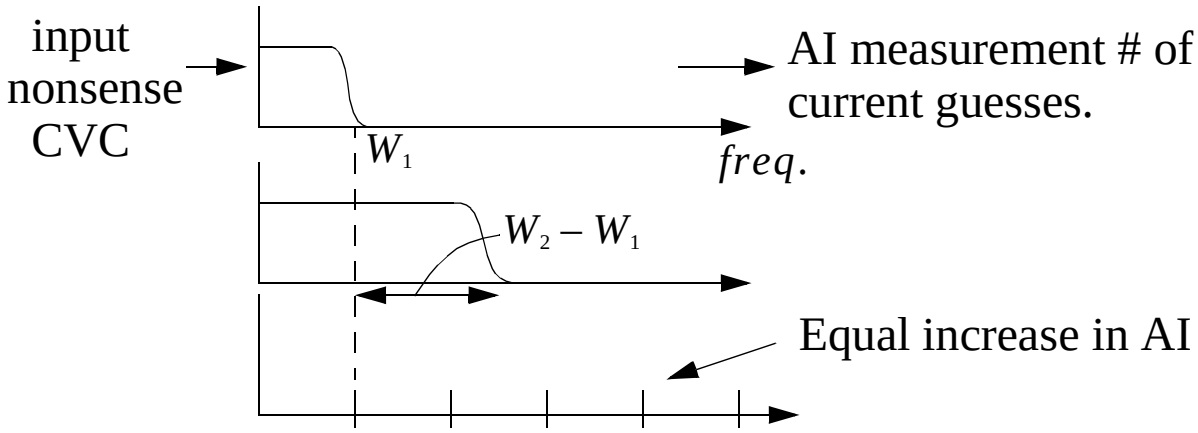



tones in noise

speech

In both cases, the entire auditory system is involved.

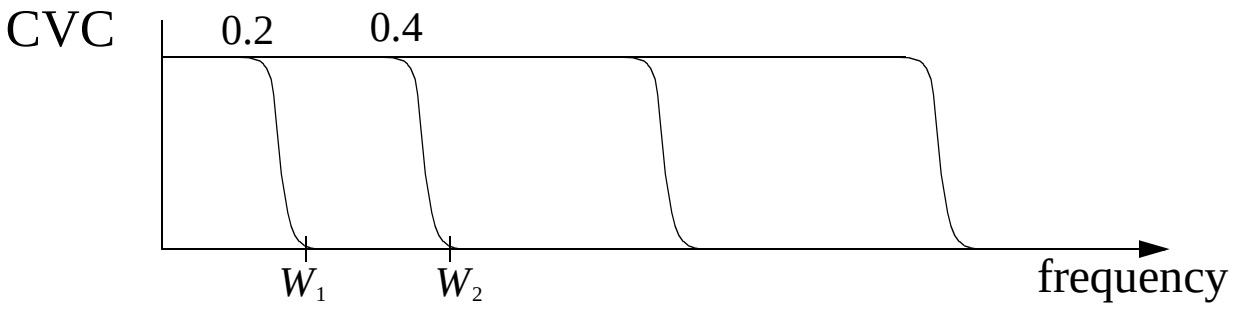
Figure 19.2 : Various concepts for defining filter bandwidth vs. center frequency.

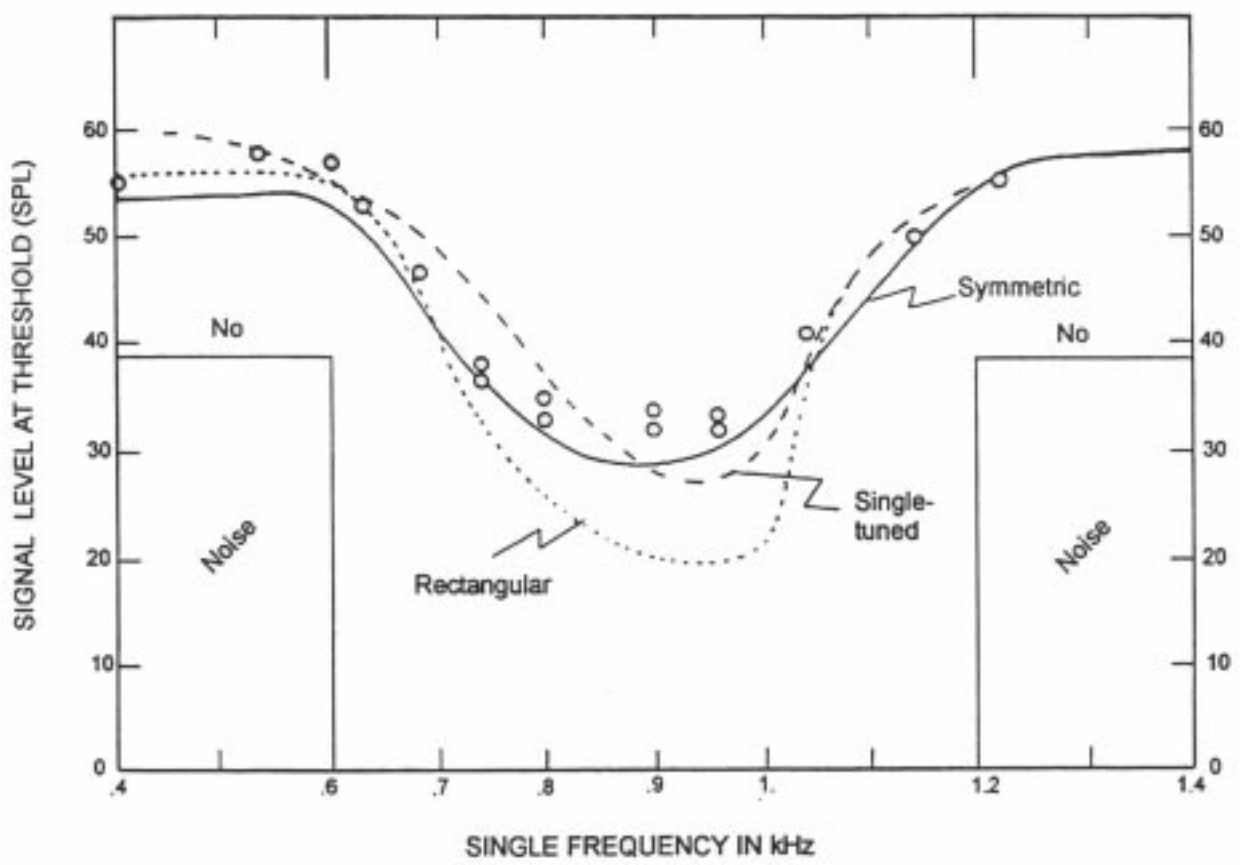



$$AI(s) = \frac{\log_{10}(1-s)}{\log_{10}(1-S_{max})}$$

$s$ = prob. of correct ident. of CVC.

$S_{max}$ = best prob. ( $\approx 0.985$ )






$$H(f) = \frac{1}{\left[\left(\frac{\Delta f}{\alpha}\right)^2 + 1\right]^2}$$

- To try to assign a shape to the auditory filter

- Experiment
  - Fixed noise bands for a given frequency range
  - Measure target tone from 0.4-1.4 of the nominal frequency.
  - Measure signal level at threshold of hearing
  - Results are the little circles.

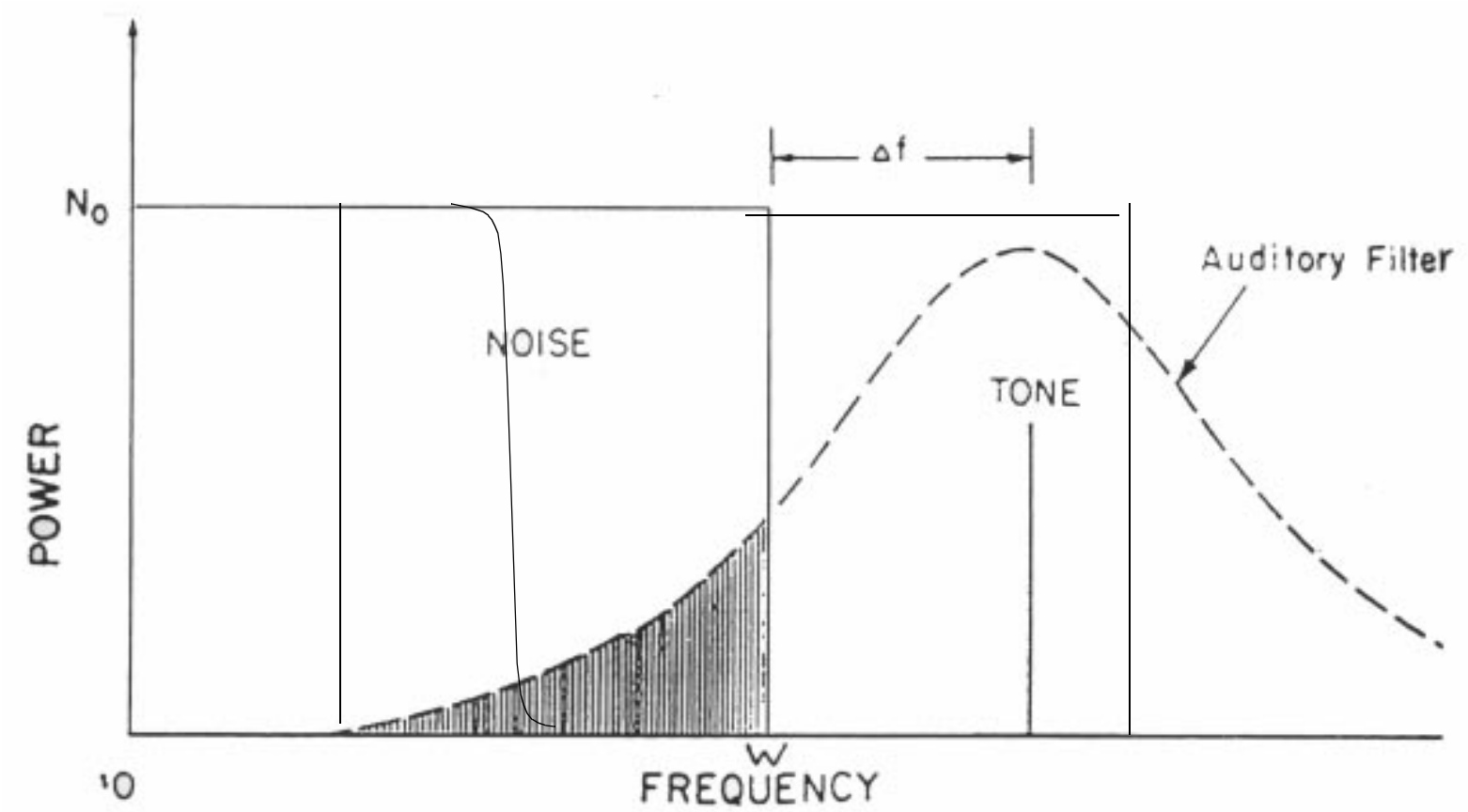


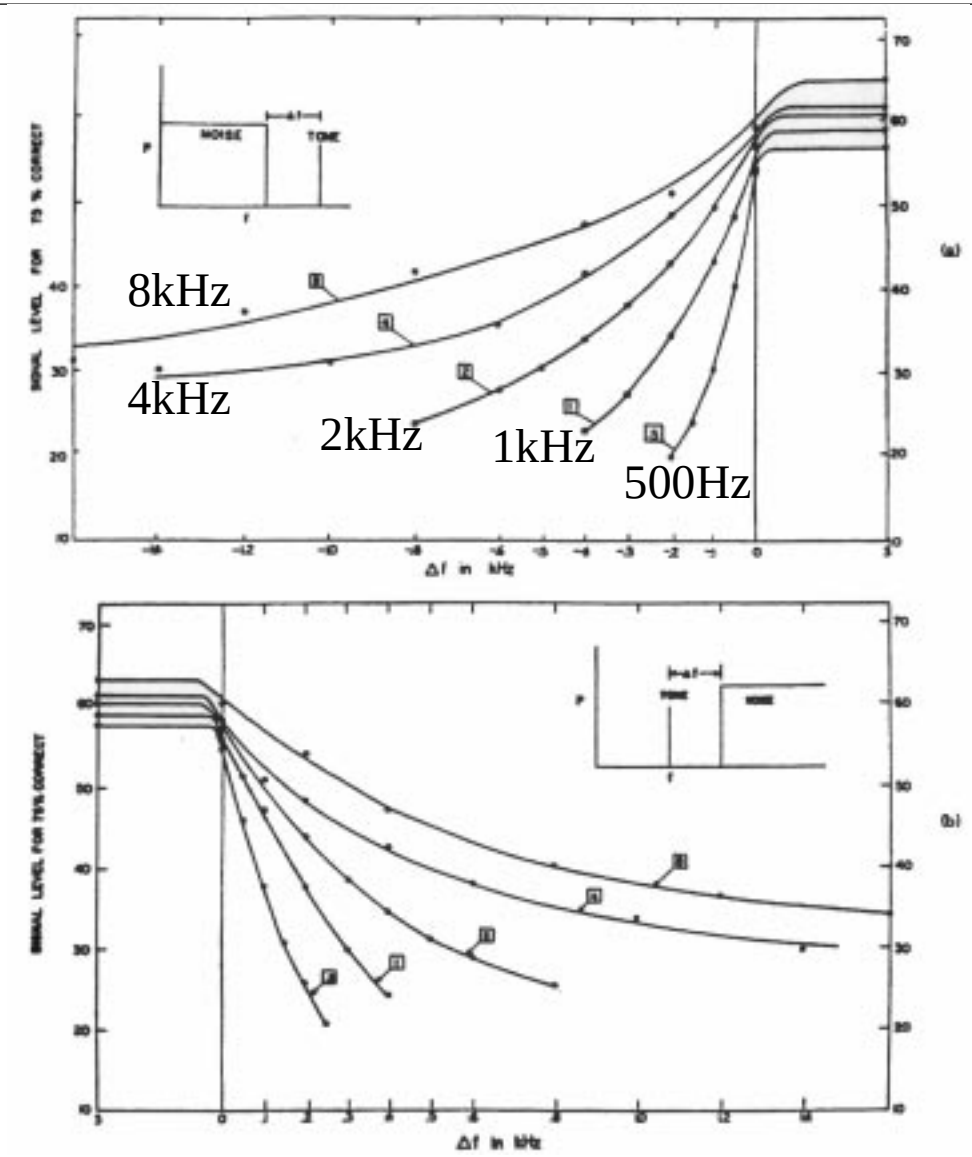

Figure 19.4 : Auditory filter shape computed by measuring threshold as a function of low pass filter noise bandwidth. $W$ is the cutoff frequency for the noise, and $\Delta f$ is the difference between the tone frequency and $W$.

*Noise power at threshold*

$$P = K\int_0^W N(f)|H(f)|^2 df$$

$N(f)$ is constant $= N_o$

$$|H(W)| = \frac{1}{KN_o}\frac{dP}{dW}$$




- Direct proof

Bandwidth of auditory filter increases with frequemcy.

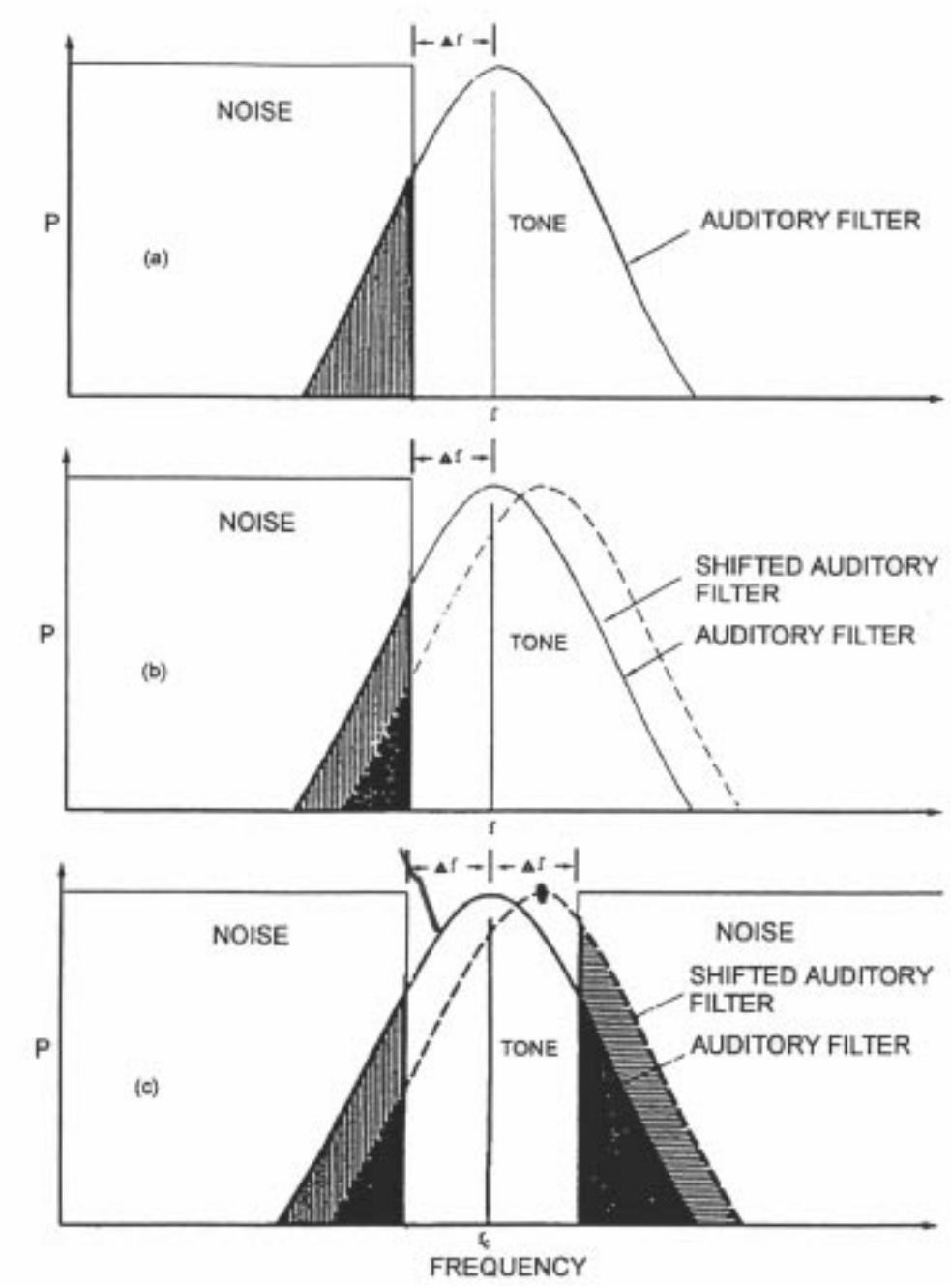
Best Math. representation

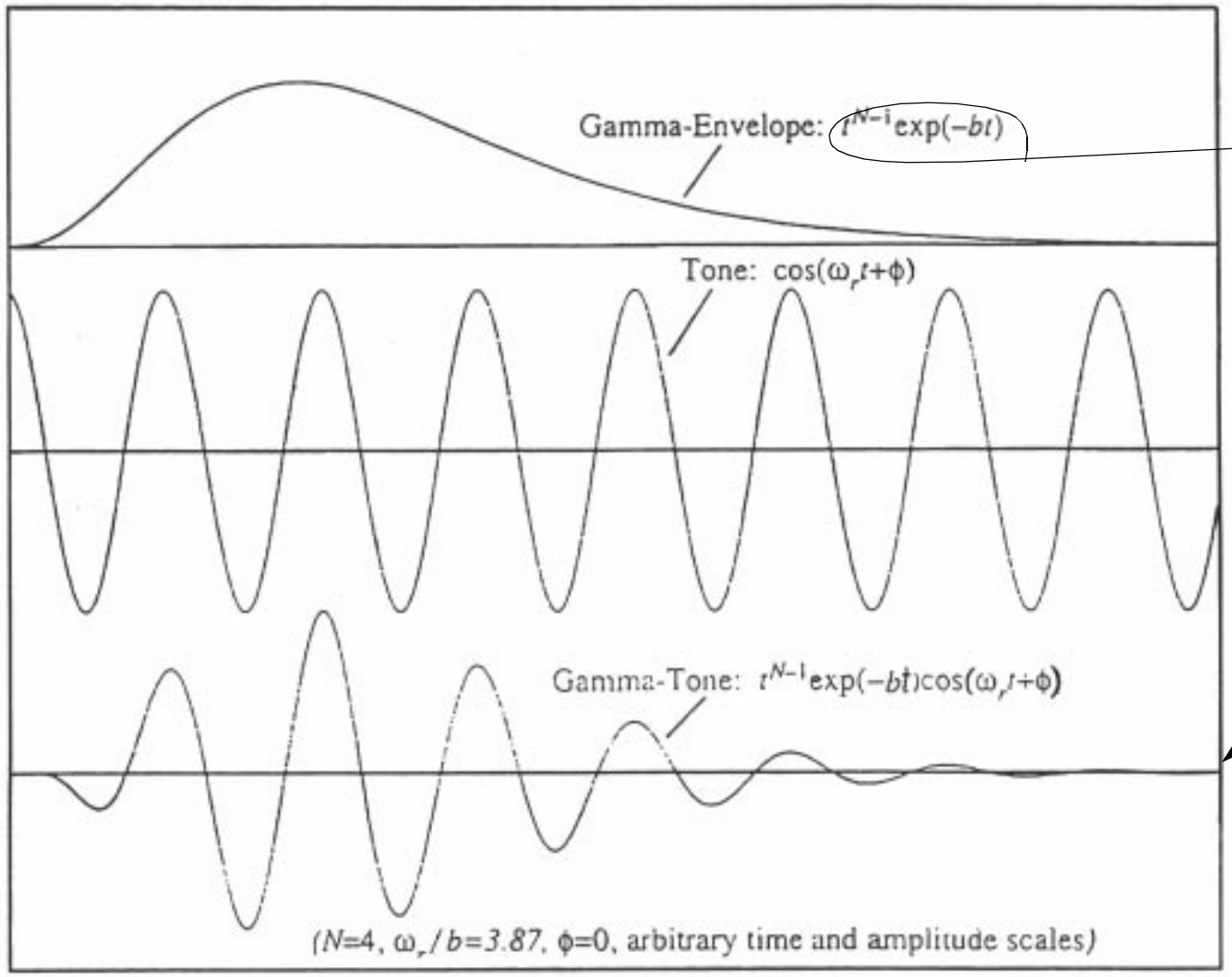
$$|H(f)|^2 = \frac{1}{\left[\left(\frac{\Delta f}{\alpha}\right)^2 + 1\right]^2}$$

$\alpha$ depends on center frequency.

Figure 19.5 : Low and high skirts of auditory filters computed by varying the bandwidth of both low pass and high pass noise.

Figure 19.6 : Bandpass notched noise to minimize effects of off-frequency listening. (a) shows the noise presented to a hypothetical auditory filter centered around the tone. (b) shows a hypothetical auditory filter that is shifted. (c) shows a noise spectrum at both low and high frequencies so that the shaded noise area is the same for both hypothetical filters.






math. representation

Impulse response

Parameters

b, N > envelope

$W_r$ center freq.

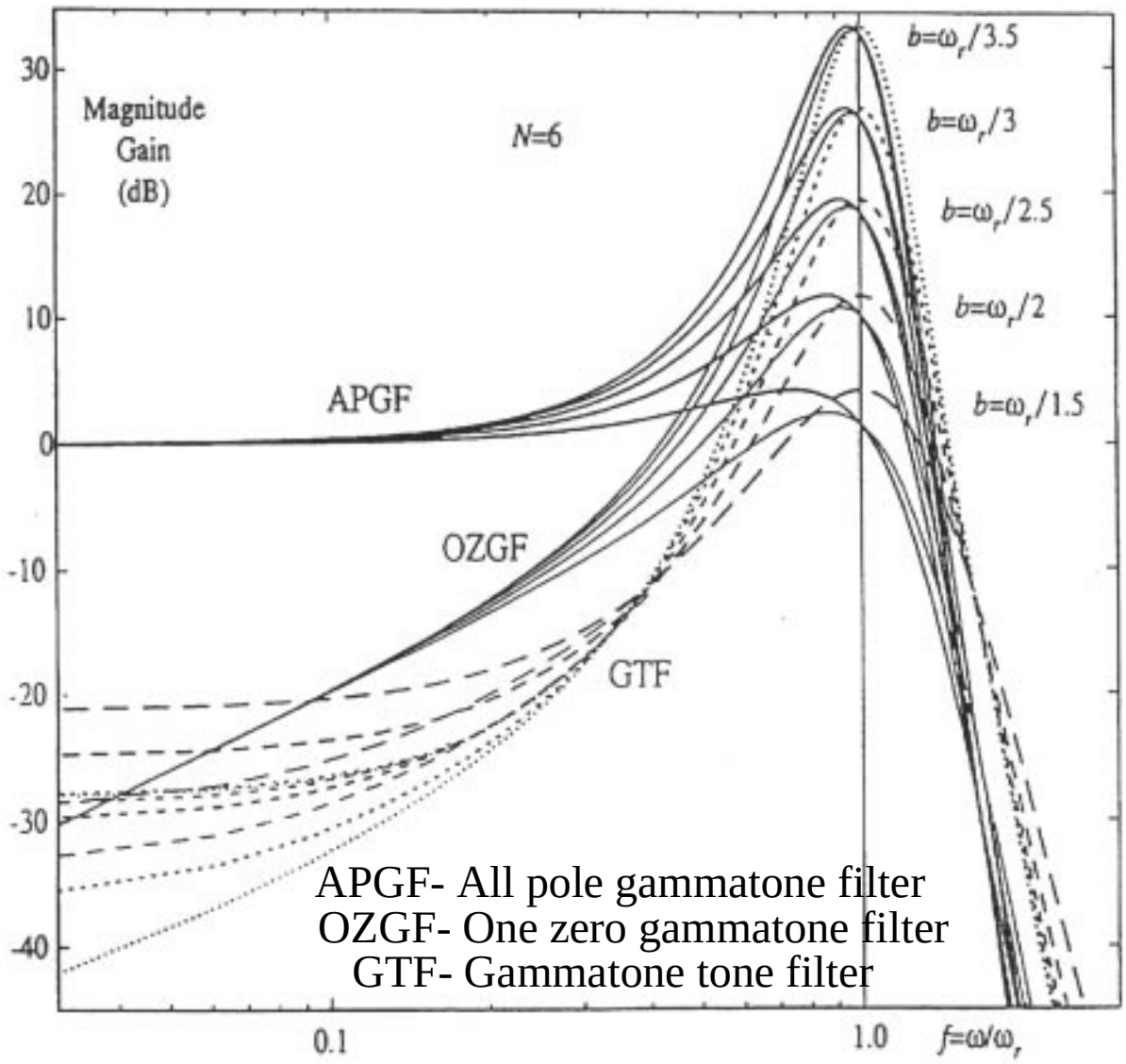



Figure 19.8 : Frequency responses of various forms of gammatone filter.

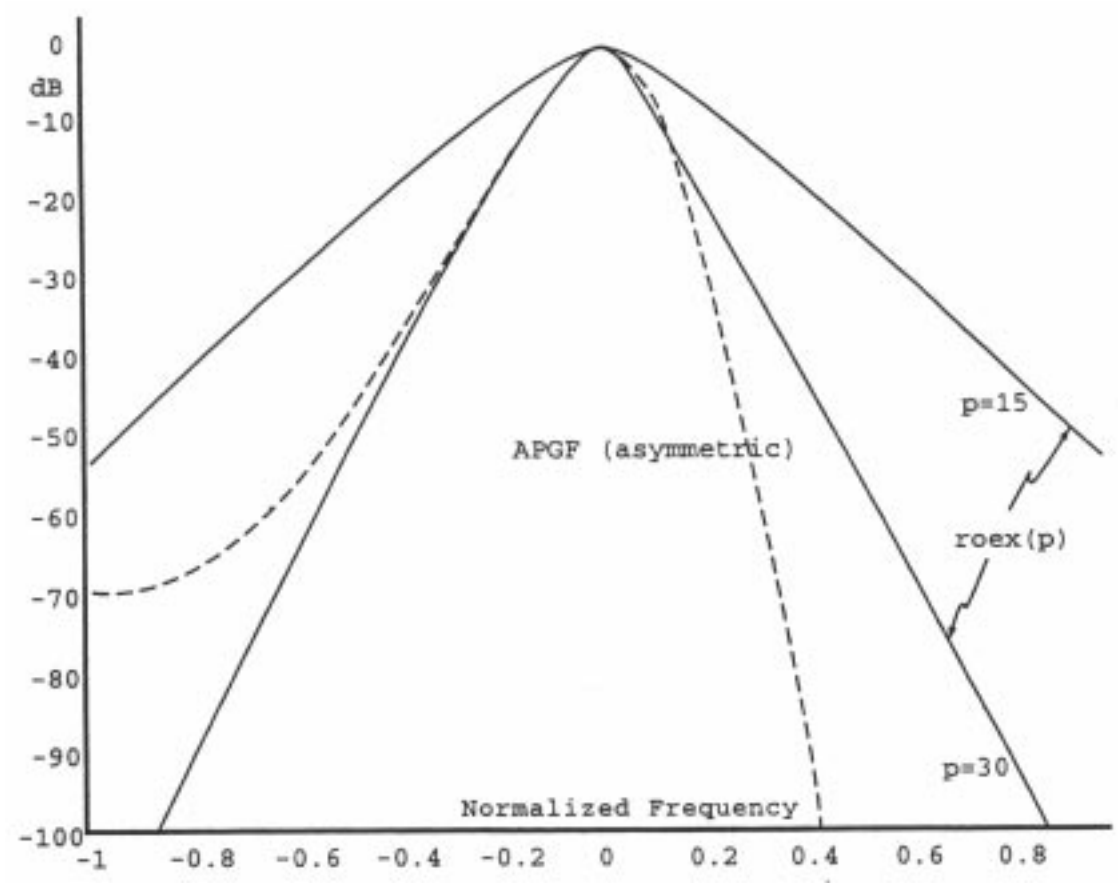



Figure 19.9 : Approximations to auditory filters: the APGF for N=16, and two roex filters, for p=30 and p=15.

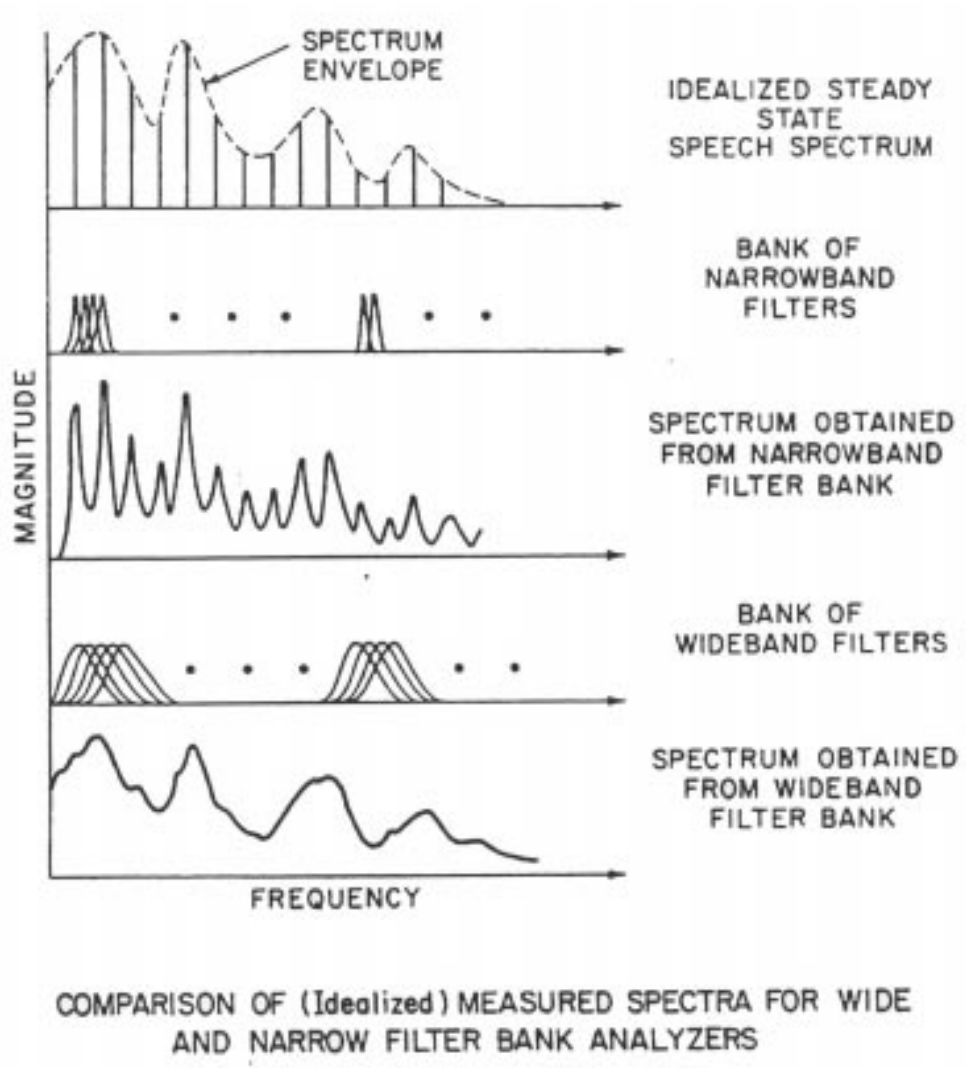



Figure 19.10 : Narrowband and wideband spectral analysis for an idealized speech sound.