University of California
Berkeley

College of Engineering
Department of Electrical Engineering
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EE225D Spring,1999

Cepstrum Analysis

Lecture 21

Deconvolution

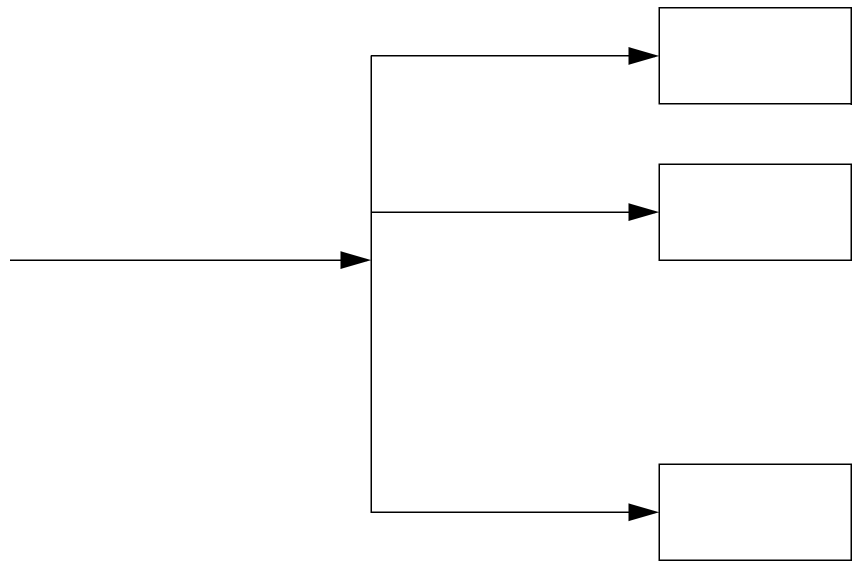
Separate *e(n)* from *h(n)*.

Methods :

- Channel Vocoder
- Linear Prediction
- Cepstral Analysis

Channel Vocoder

$e(n) * h(n)$



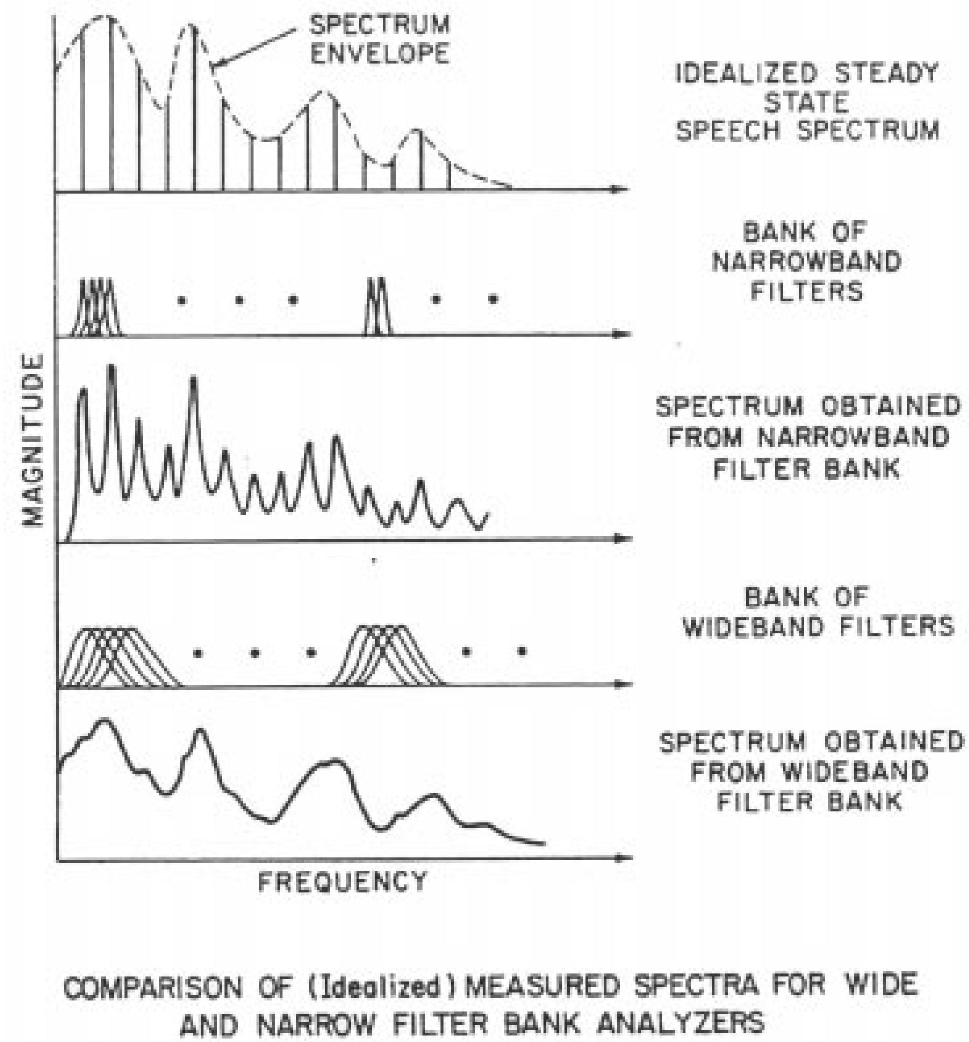


Figure 19.10 : Narrowband and wideband spectral analysis for an idealized speech sound.

LPC

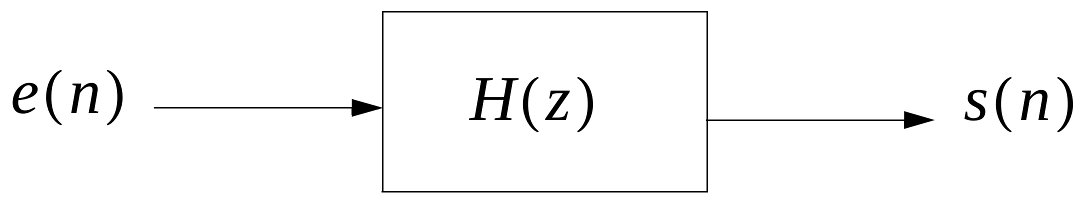
$$\hat{s}(n) = \sum_{k=1}^{p} a_k s(n-k)$$

$$e(n) = s(n) - \hat{s}(n)$$

$$s(n) = a_1 s(n-1) + a_2 s(n-2) + \ldots + a_p s(n-p) + e(n)$$

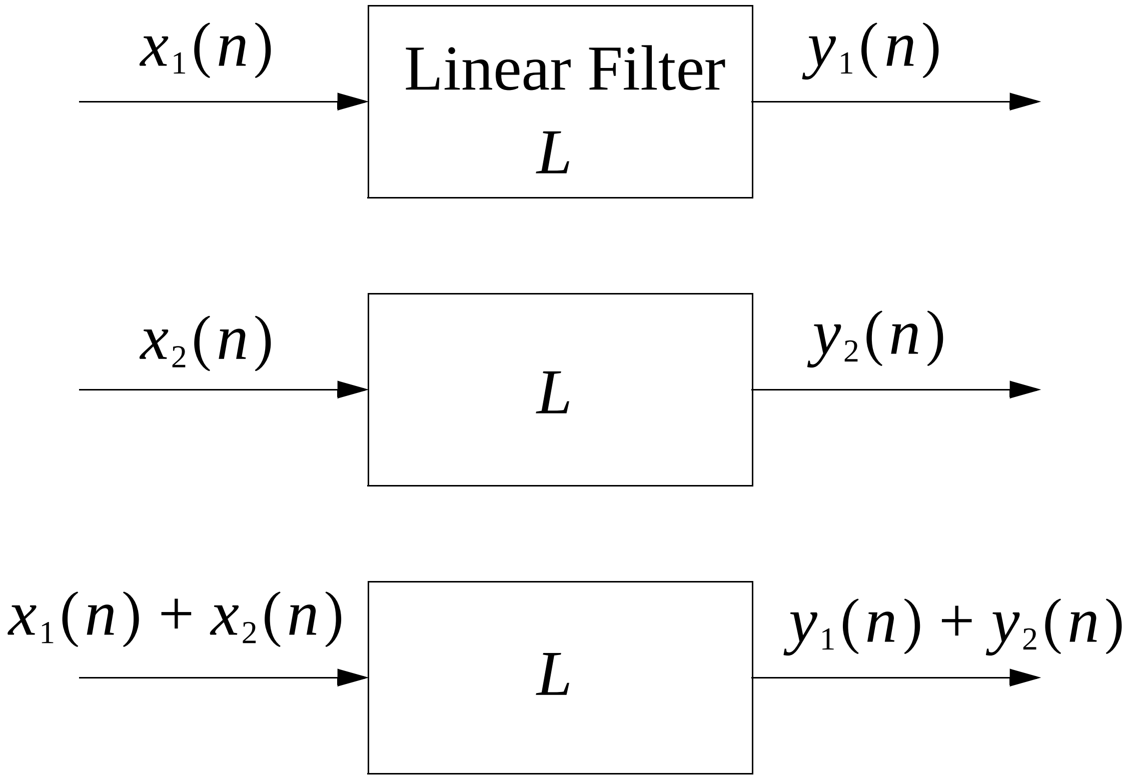
$$S(z) = \frac{E(z)}{1 - \sum^{p} a_k z^{-k}}$$

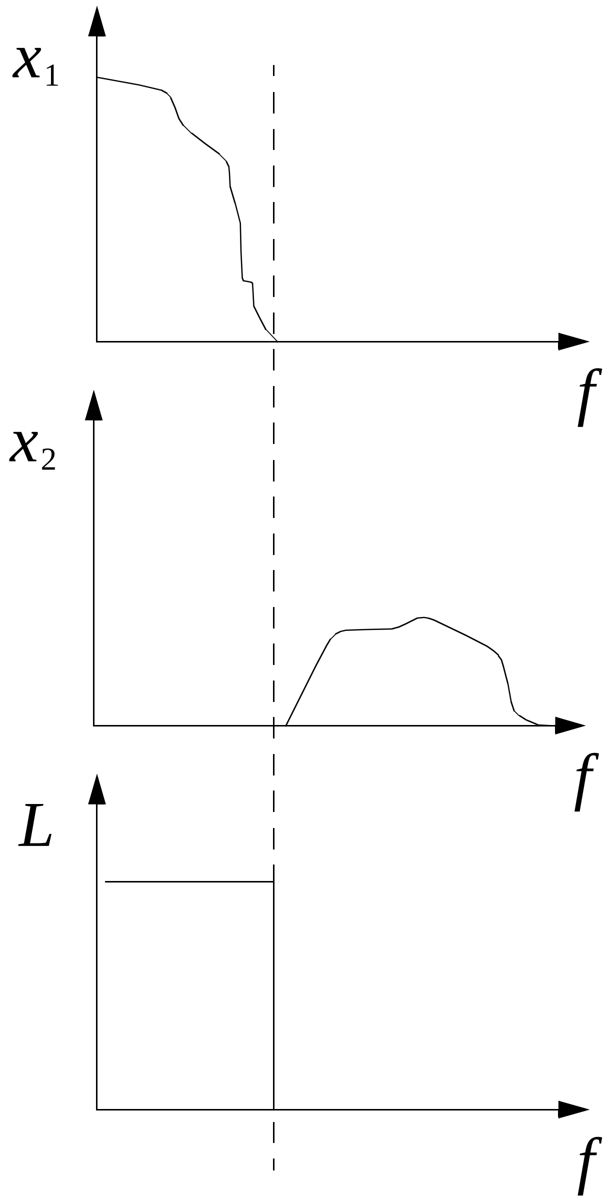
$$H(z) = \frac{1}{1 - \sum^{p} a_k z^{-k}}$$



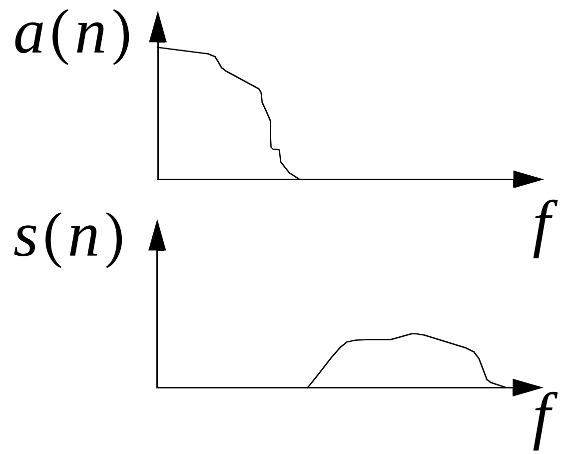
LPC Deconvolution :

- All pole model
- Model error signal


$x_1(n)$
Linear Filter
L
$y_1(n)$
$x_2(n)$
L
$y_2(n)$
$x_1(n) + x_2(n)$
L
$y_1(n) + y_2(n)$

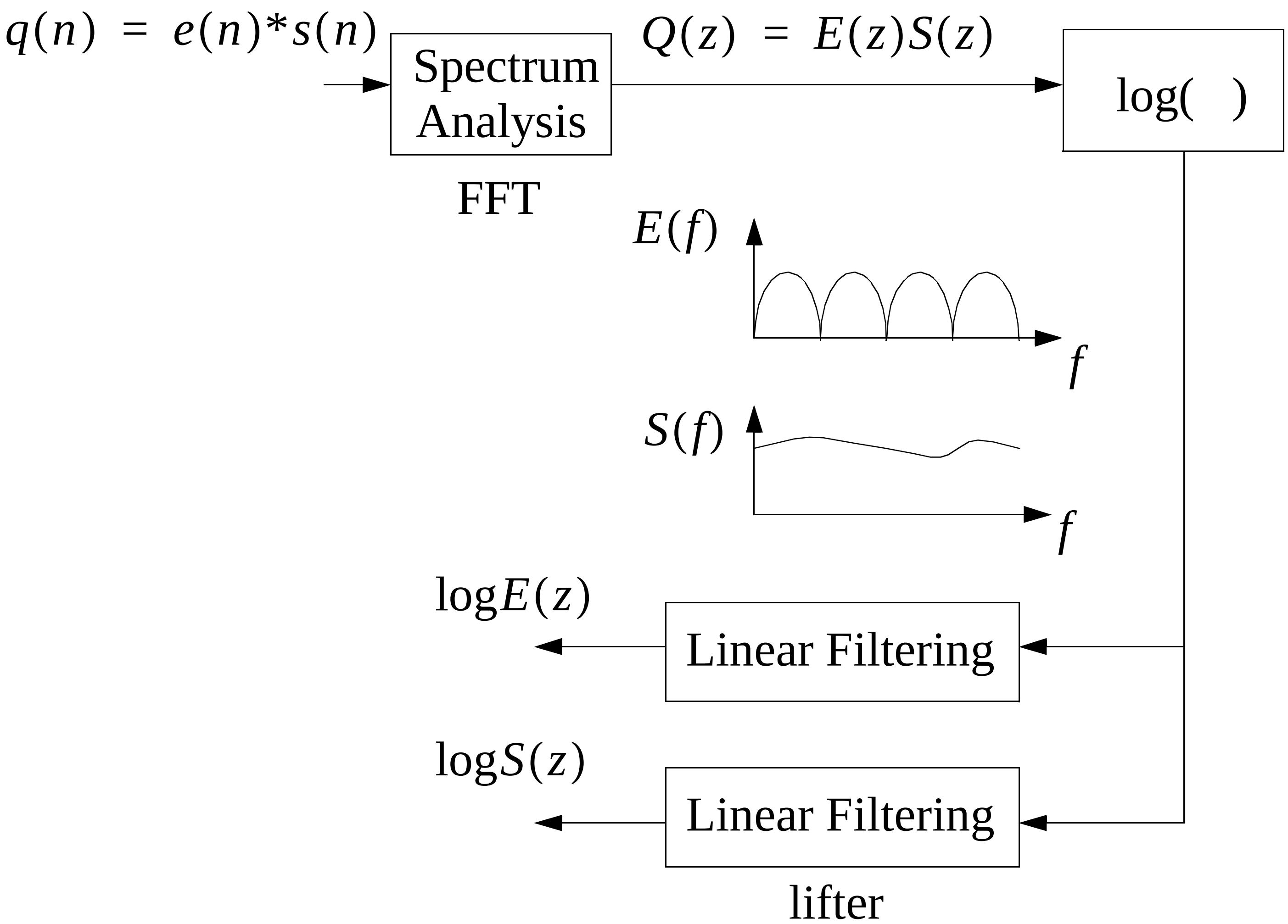

x_1
f
x_2
f
L
f

Consider the signal $q(n) = a(n)s(n)$



$$\log q(n) = \log a(n) + \log s(n)$$

Homomorphic Deconvolution



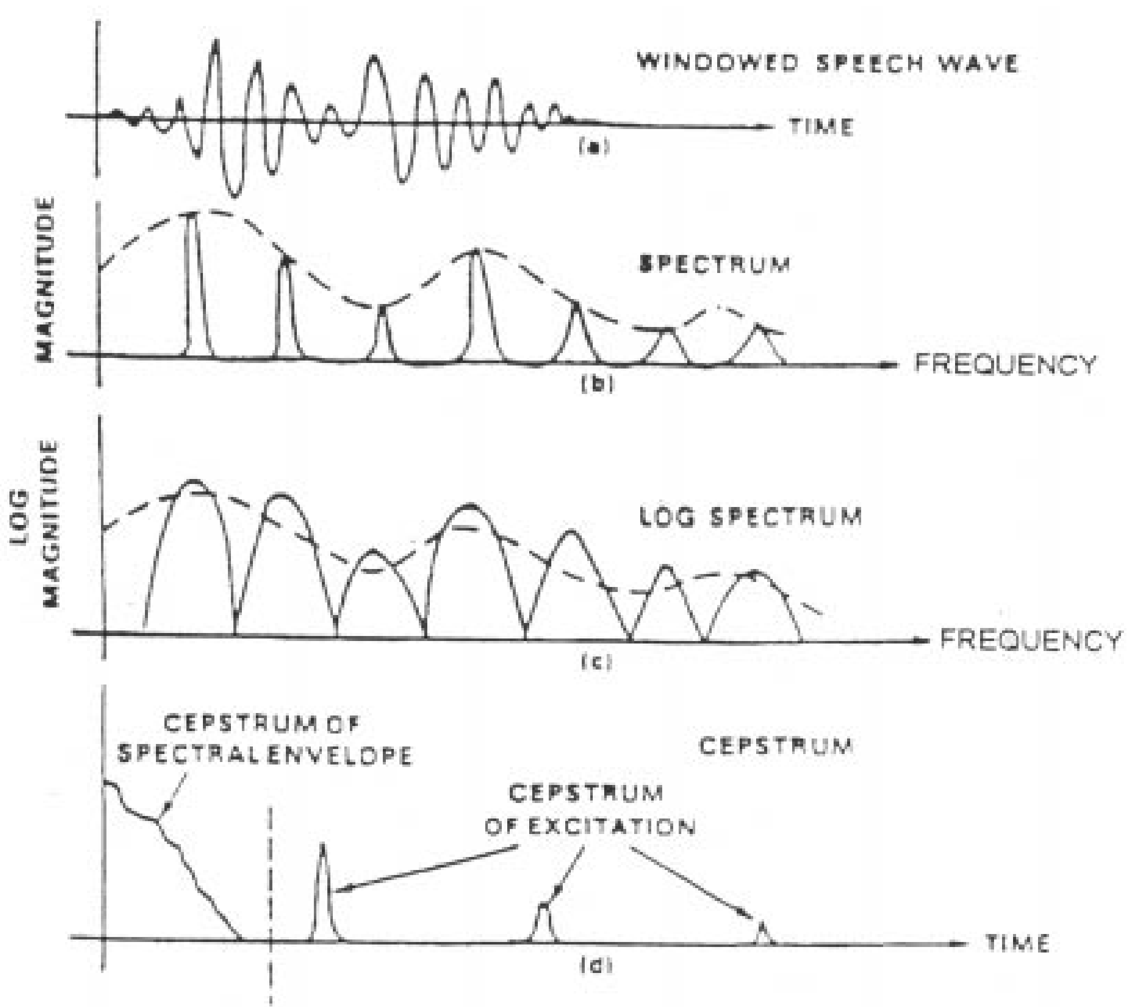


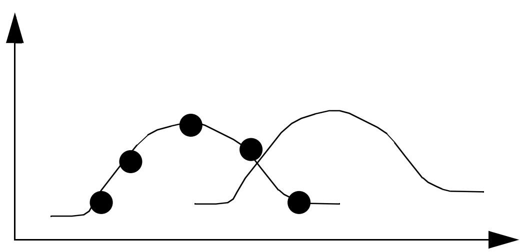
Figure 3.3 : Illustration of Source-Filter Separation by Cepstral Analysis.

•Cepstrum : DFT of the log of the |DFT| of a signal

•Complex Cepstrum : DFT of the log of the DFT of a signal

$$\hat{x}(n) \rightarrow \quad c(n)$$

if the signal is a min phase signal



Only magnitude are obtained

Min phase filter

$$c(n) = \frac{1}{N}\sum_{k=1}^{N-1} \log|X(\omega)|W^{-nk} \qquad 1$$

$$\hat{x}(n) = \left.\begin{array}{ll} 0 & n < 0 \\ c(n) & n = 0 \\ 2c(n) & n > 0 \end{array}\right) \qquad 2$$

$$\log\hat{X}(\omega) = \sum_{n=1}^{M-1} \hat{X}(n)W^{nk} \qquad 3$$