

EE648 (CC761-M) DSP II

Session 19 (live: 3/23/99)

Outline:

- Perfect Reconstruction Filter Banks - Vaidyanathan, Chap. 5 P+M, 10.9.6
- Application: Subband coding of Speech and/or Image Signals
 - V. Text, Sect. 4.5.2

- For a review of digital upsampling and downsampling:
- See notes for Sessions 9, 11, 12 of EE538 DSP I at <http://shay.ecn.purdue.edu/ee538/>
- See Chap. 10 of P+M
 - Intro. material: Sects. 10.1-10.3
- See Chap. 4 of Vaidyanathan
 - Intro. material: Sect. 4.1

• Announcement:

Hmwk. 5 due date moved to Session 21

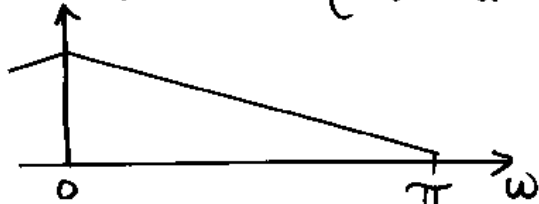
- Primary Application of PR Filter Banks Perfect Reconstruction
- Subband Coding of Speech and Image Signals
- basic idea: decompose signal into M partially overlapping bands/channels of same bandwidth
- decimate each subband output by a factor of M

- at this point, overall ~~data~~ bit rate is the same
 - the M decimated subband outputs would be interleaved in practice
- assign no. of bits/sample for each subband based on
 - energy in subband
 - psychoacoustic factors (speech)
 - psychovisual factors (images)

- crudely speaking: assign more bits/sample to subbands with more energy and less bits/sample to subbands with less energy
- ultimately reduce no. of bits needed to represent speech segment or image with negligible difference in perceptual quality

• Crude/Simplistic Example

$$X(\omega) = \text{DTFT} \{x[n] = x_a(nT_s)\}$$

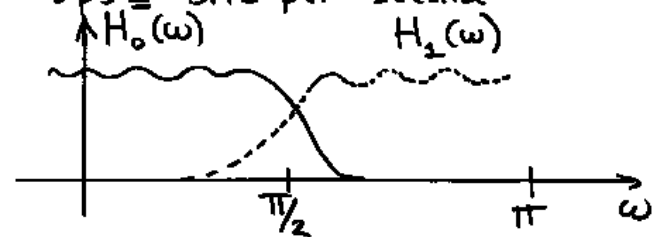


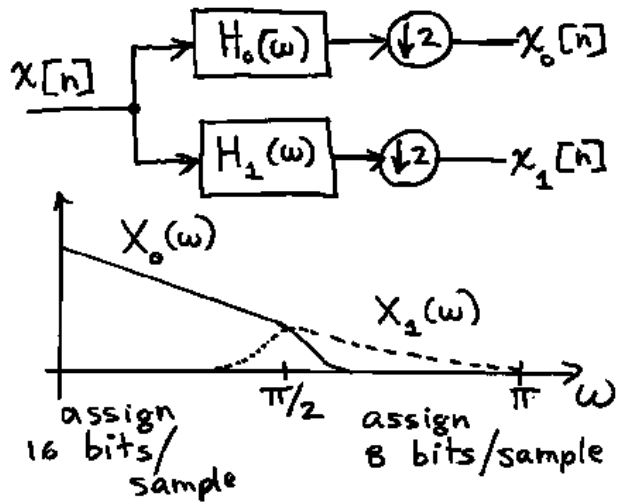
- assume $x[n]$ is sampled speech with $F_s = 10 \text{ KHz}$ and 16 bits/sample

- original bit rates:

$$10^4 \frac{\text{samples}}{\text{sec}} \times 16 \frac{\text{bits}}{\text{sample}} = 160 \text{ Kbps}$$

bps \triangleq bits per second





• compressed bit rates

$$5 \times 10^3 \frac{\text{samples}}{\text{sec}} \times 16 \frac{\text{bits}}{\text{sample}}$$

$$+ 5 \times 10^3 \frac{\text{samples}}{\text{sec}} \times 8 \frac{\text{bits}}{\text{sample}}$$

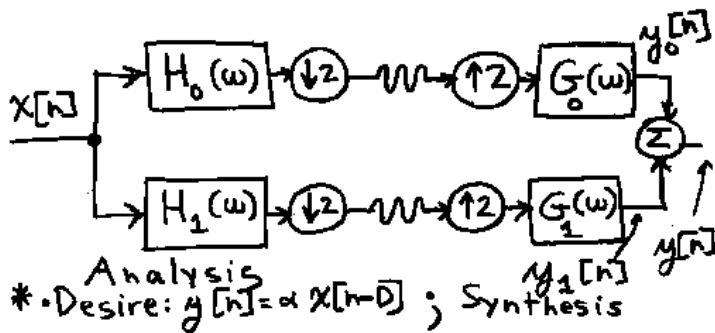
$$= 120 \text{ Kbps}$$

• compression ratio:

$$160 \text{ K} / 120 \text{ K} = \frac{4}{3}$$

• End of Example

- Consider Two-Channel Filter Bank \Rightarrow referred to as Quadrature Mirror Filter (QMF) Bank



• First review decimation:

$$x[n] \rightarrow \text{down arrow in circle } D \rightarrow y[n] = x[Dn]$$

• Relationship between $Y(w)$ and $X(w)$?

• Answer:

$$Y(w) = \frac{1}{D} \sum_{k=0}^{D-1} X\left(\frac{w - k2\pi}{D}\right)$$

• next: upsampling

$$x[n] \rightarrow (\uparrow L) \rightarrow y[n]$$

$$= \begin{cases} x\left(\frac{n}{L}\right), & n = \dots, -2L, \\ & -L, 0, L, \dots \\ 0, & \text{otherwise} \end{cases}$$

$$y[n] = \sum_{k=-\infty}^{\infty} x[k] \delta[n - kL]$$

$$Y(\omega) = X(L\omega)$$