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

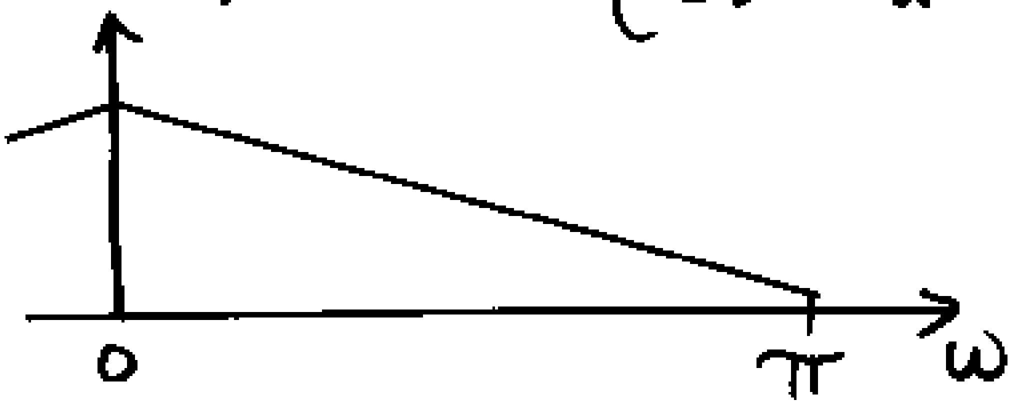
- Primary Application of $\underbrace{\text{PR}}_{\text{Perfect Reconstruction}}$ Filter Banks
- Subband Coding of Speech and Image Signals
- basic idea: decompose signal into M <u>partially</u> overlapping bands/channels of same bandwidth
- decimate each subband output by a factor of M

- 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 <u>perceptual</u> quality

- Crude/Simplistic Example

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

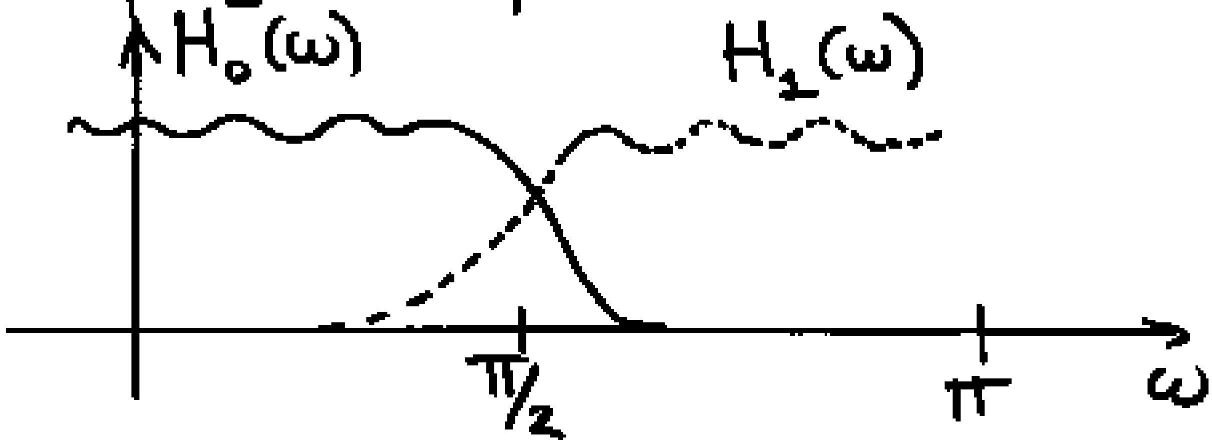


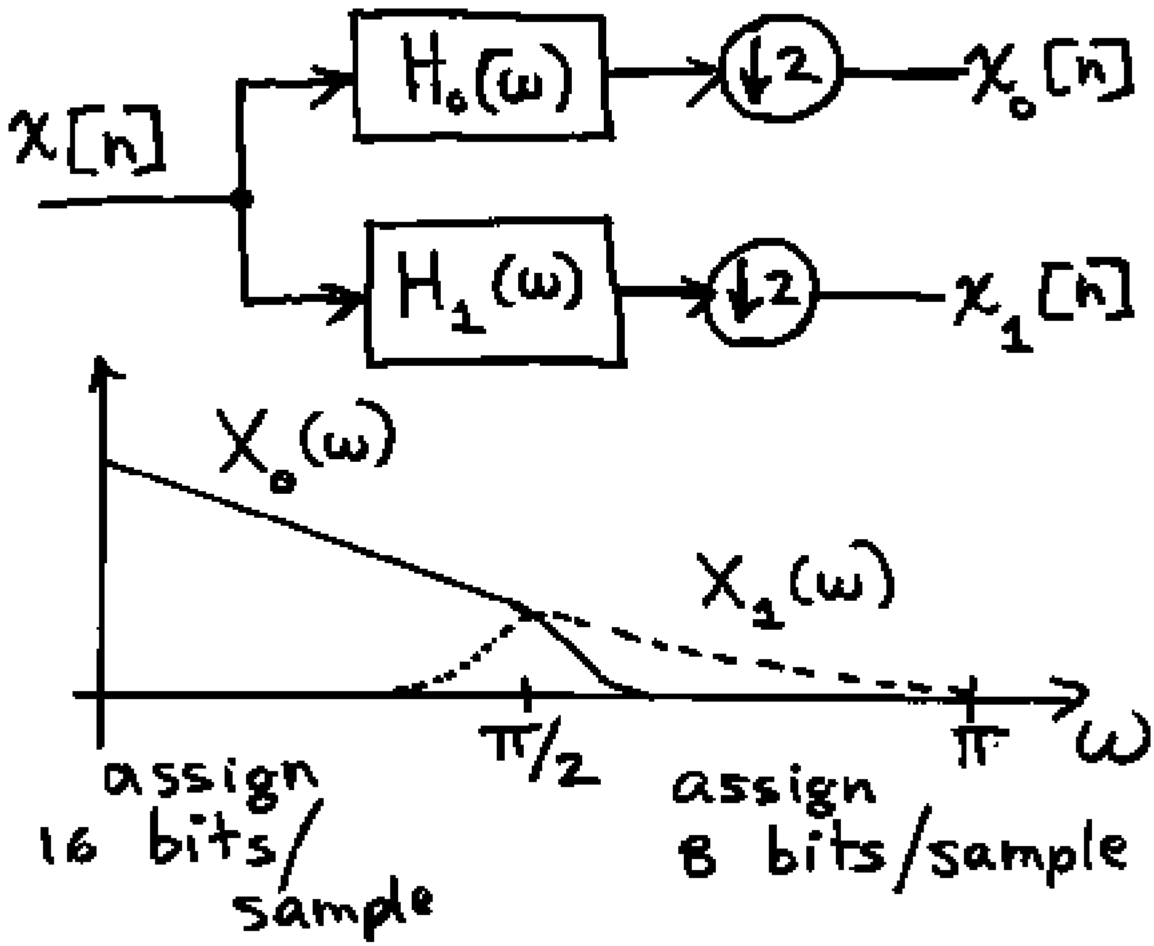
- assume $x[n]$ is sampled speech with $F_s = 10$ KHz and 16 bits/sample

- original bit rate:

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

bps $\triangleq$ bits per second




x[n]
H₀(ω)
↓2
x₀[n]
H₁(ω)
↓2
x₁[n]
X₀(ω)
X₁(ω)
π/2
π
ω
assign 16 bits/sample
assign 8 bits/sample

- compressed bit rate:

$$5\times10^3 \ \frac{\text{samples}}{\text{sec}} \times 16 \ \frac{\text{bits}}{\text{sample}}$$

$$+\ 5\times10^3 \ \frac{\text{samples}}{\text{sec}} \times 8 \ \frac{\text{bits}}{\text{sample}}$$

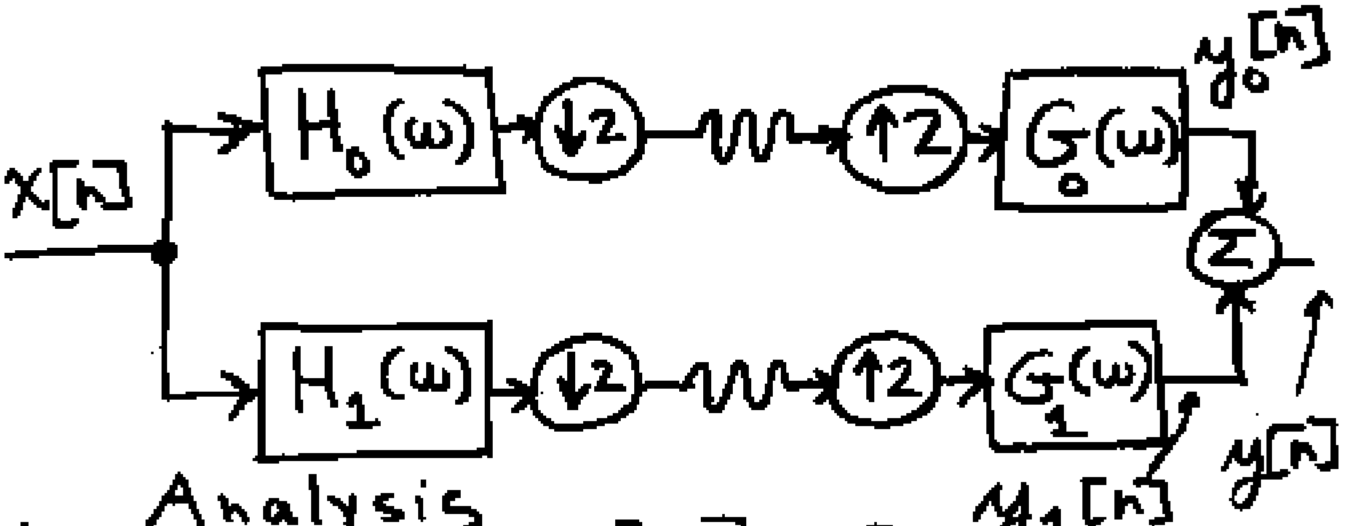
$$= 120 \text{ Kbps}$$

- compression ratio:

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

- End of Example

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



* • Desire: $y[n] = \alpha\, x[n-D]$; Synthesis

- First review decimation:

$$x[n] \longrightarrow \boxed{\downarrow D} \longrightarrow y[n] = x[Dn]$$

- Relationship between $Y(\omega)$ and $X(\omega)$?

- Answer:

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

- next: upsampling

$$x[n] \longrightarrow \uparrow L \longrightarrow y[n]$$

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

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

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