11.10 Filter Banks
What Are Filter Banks?

Often need to slice up a “wideband” signal into various “subbands”

Figure 12.25 Division of the frequency range into bands in subband processing: (a) odd number (shown for $M = 3$); (b) even number (shown for $M = 4$).

Figure from Porat’s Book
Filter Banks Application: Cell Phone Basestation

FDMA = Frequency-Division Multiple Access
Each user (or set of users) is assigned a different band
Filter Banks & Subband Processing

Sometimes we want to:

• Split a signal into subbands using an “analysis” filter bank
• Process each subband
• Then… re-assemble subbands using a “synthesis” filter bank

Usual Design Goal: Design so that if the subband processing does nothing (i.e., imagine that \( v_i[n] = u_i[n] \)) we get:

\[
y[n] = c x[n - l]
\]

“Perfect Reconstruction (PR) Property”
Example: Subband Data Compression

Design Goal
Reduce Data Rate While Ensuring $x_r[n] \approx x[n]$
Decimated Filter Banks

Each output channel of a filter bank spans only a fraction of the input BW:

Whole digital BW = $2\pi$  
Each of $M$ subbands has BW = $2\pi/M$  
⇒ Can Decimate Each Channel by $M$

Recall Cell Phone Basestation Example:

![Diagram showing filter bank and decimation process]
Decimated Filter Banks (cont.)

Necessary: Decimation Factor $K \leq M$ ($M = \# \text{ Channels}$)

If $K = M$, called a “Maximally Decimated Filter Bank”

Maximally Decimated FB’s are the most computationally efficient

… but the filters must meet strict requirements.

$\Rightarrow$ sometimes better to use $K < M$