

POLYPHASE SYNTHESIS FILTER BANK UP-CONVERTS UNEQUAL CHANNEL BANDWIDTHS WITH ARBITRARY CENTER FREQUENCIES DESIGN II

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30 November – 3 December 2010



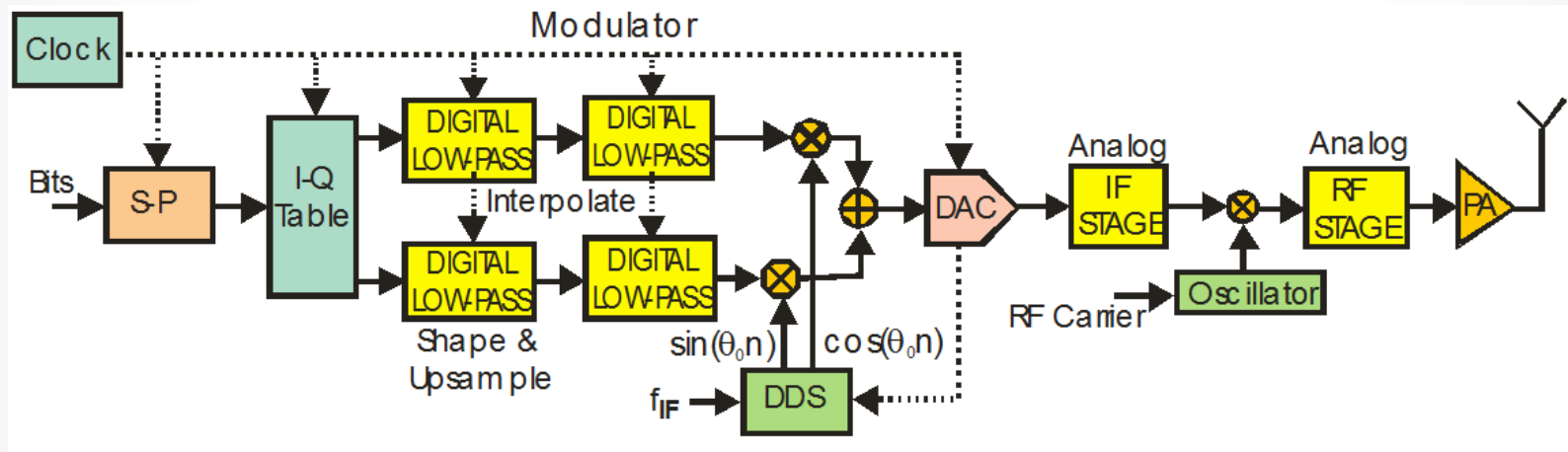
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College of Engineering

SDR'10

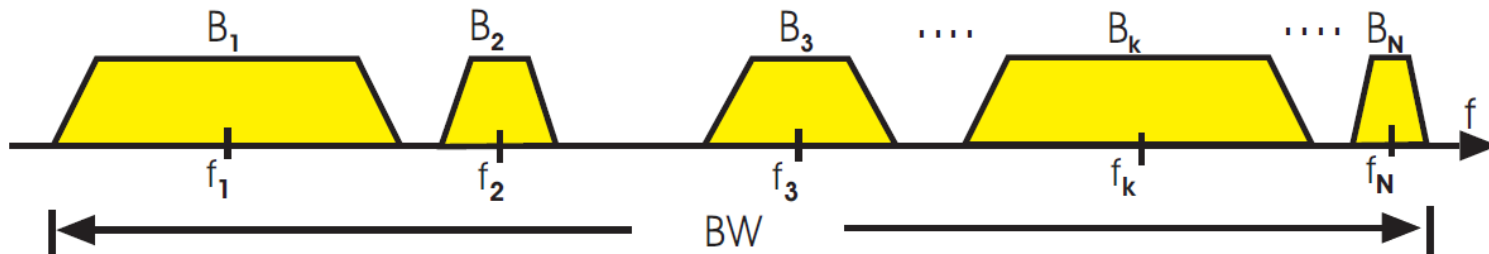
Wireless Innovation Conference
and Product Exposition

A Typical Digital Transmitter



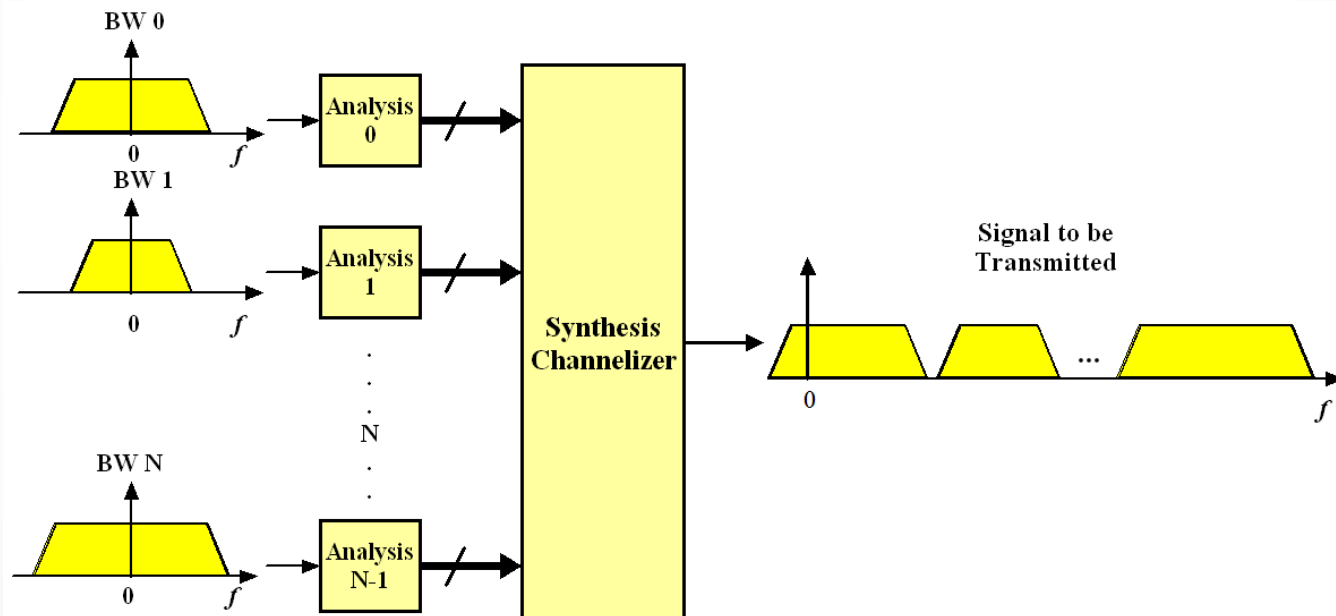
The more signals we have to simultaneously up-convert, the more sampled data sections we need to implement!

Desired Transmitting Spectrum

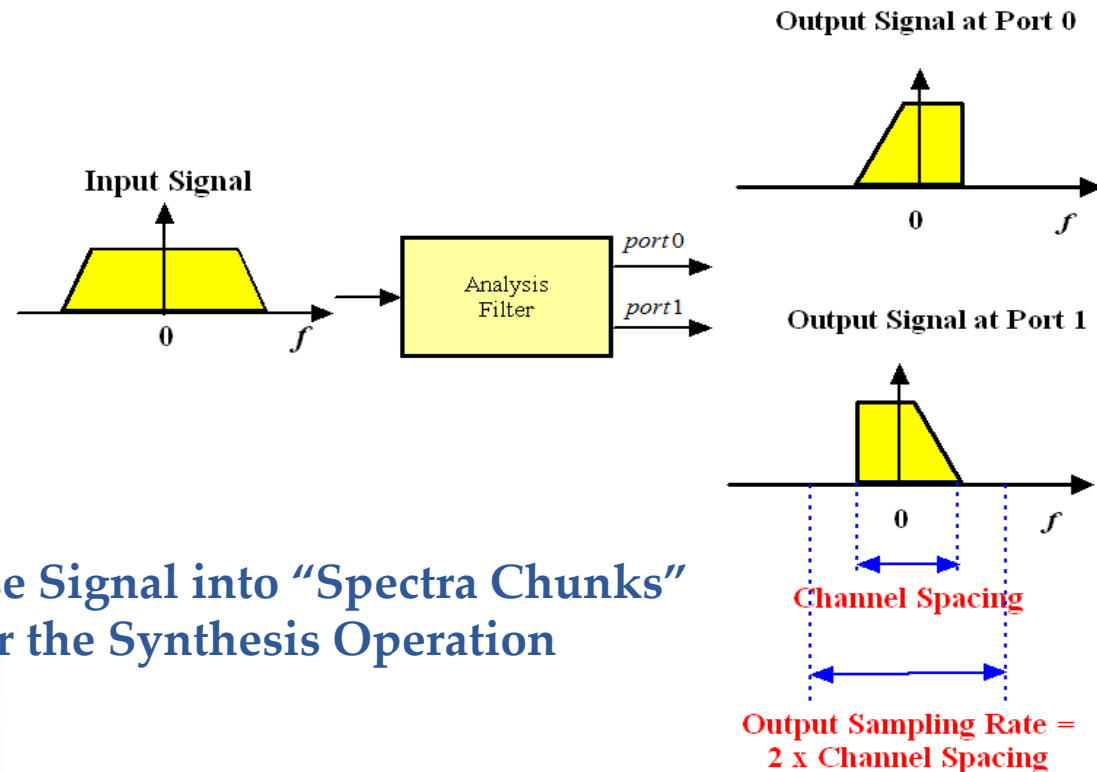


- ❖ Randomly Located Center Frequencies
- ❖ Arbitrary Bandwidths
- ❖ Variable Modulation Formats

A Simple Model for Channelizer Modulator

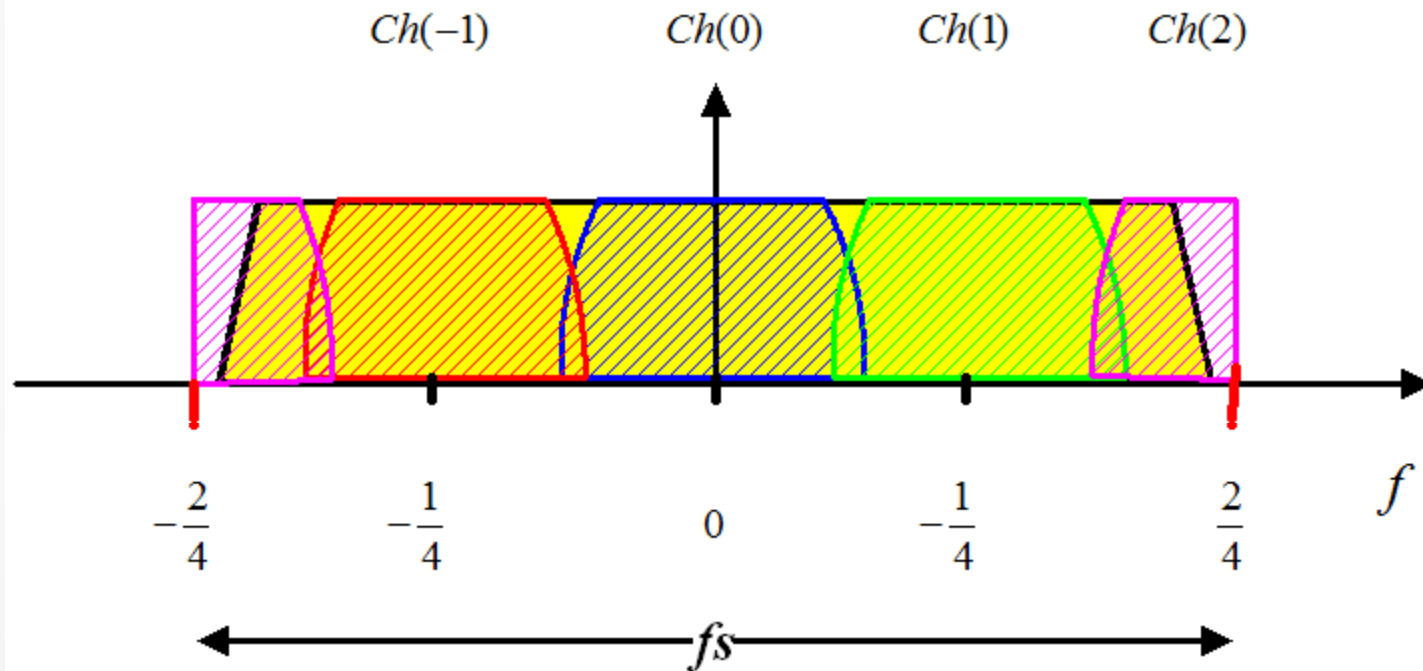


The Role of Analysis Filter



- ❖ Decompose Signal into “Spectra Chunks”
- ❖ Prepare for the Synthesis Operation

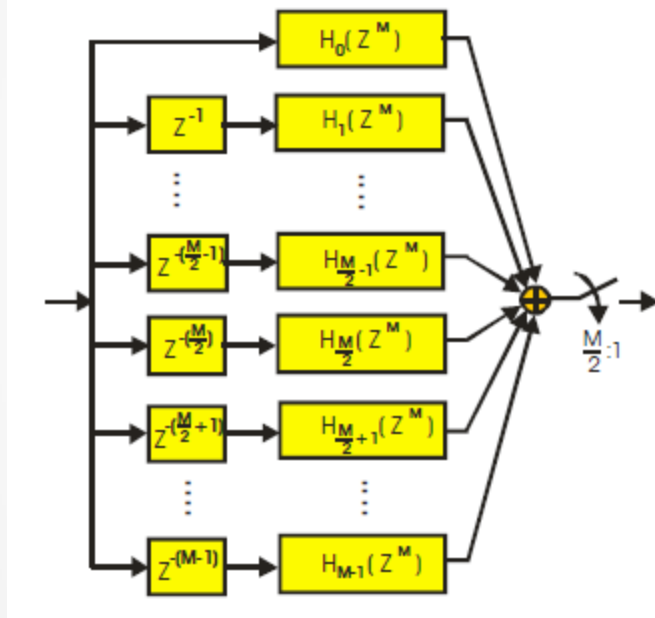
Analysis Filter Design



Use SQRT Nyquist Filter as Prototype Filter !

Analysis Filter Design

M/2-to-1 Polyphase Channelizer

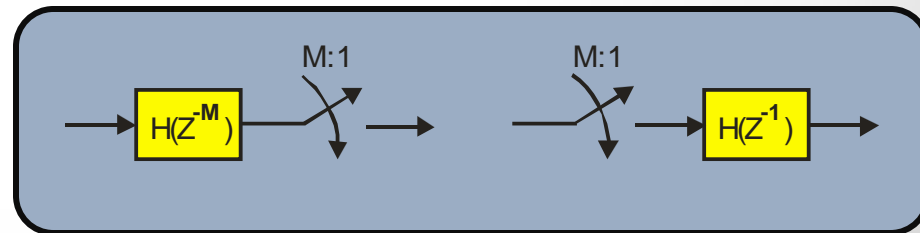
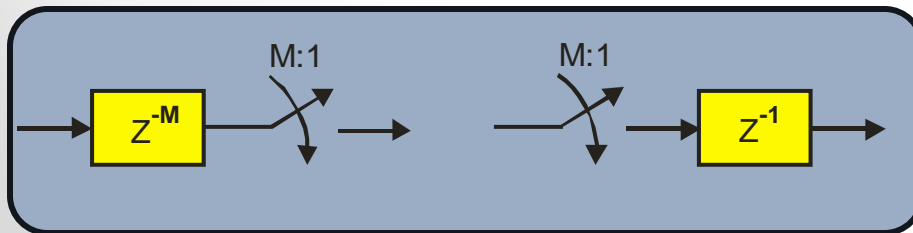
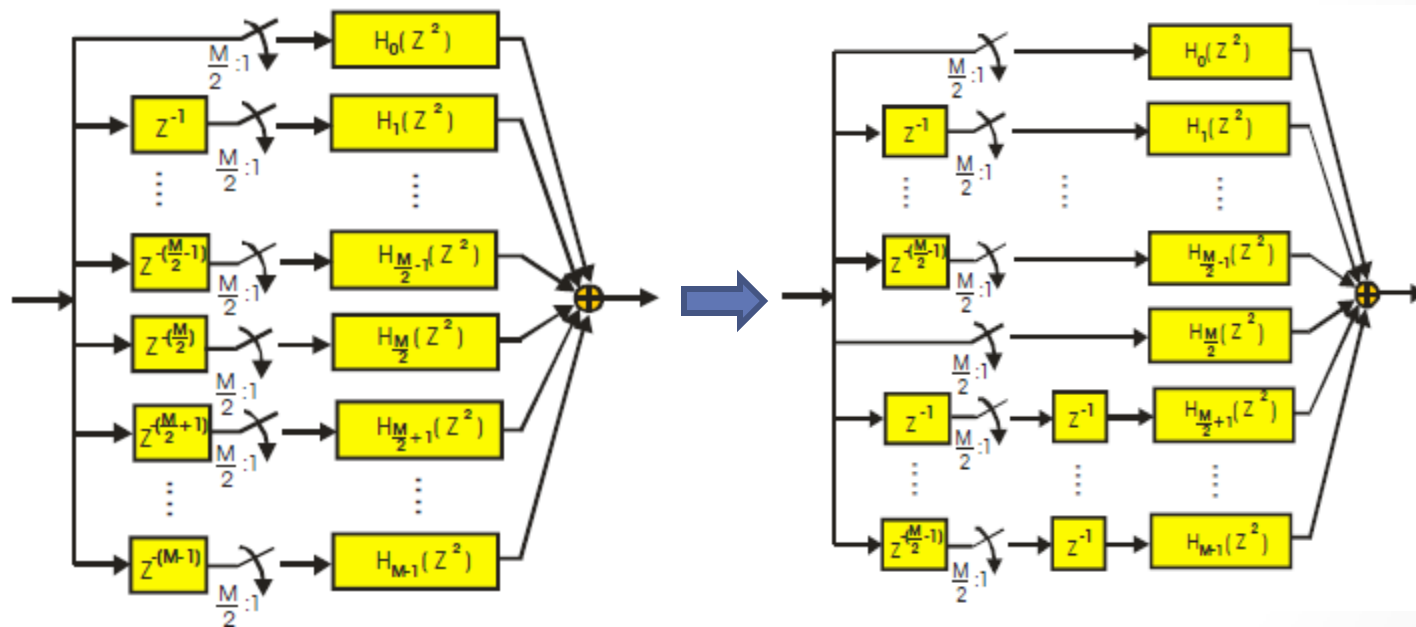


$$\begin{aligned}
 H(Z) &= \sum_{n=0}^{N-1} h(n)Z^{-n} = \sum_{r=0}^{M-1} \sum_{n=0}^{(N/M)-1} h(r+nM)Z^{-(r+nM)} \\
 &= \sum_{r=0}^{M-1} Z^{-r} \sum_{n=0}^{(N/M)-1} h(r+nM)Z^{-nM} = \sum_{r=0}^{M-1} Z^{-r} H_r(Z^M) \\
 \text{where } H_r(Z^M) &= \sum_{n=0}^{(N/M)-1} h(r+nM)Z^{-nM}
 \end{aligned}$$

M-path Partition Followed by M/2-to-1 Down Sampling

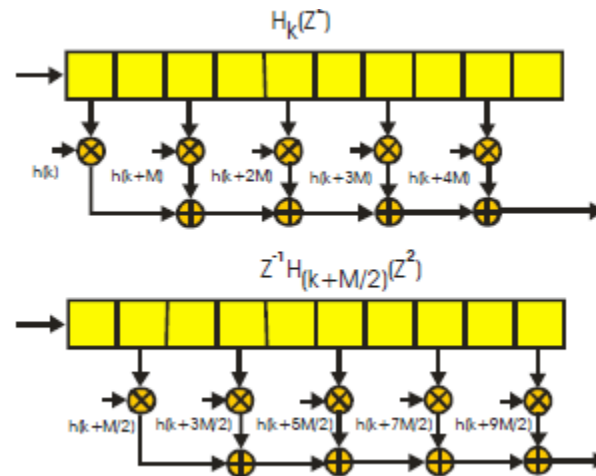
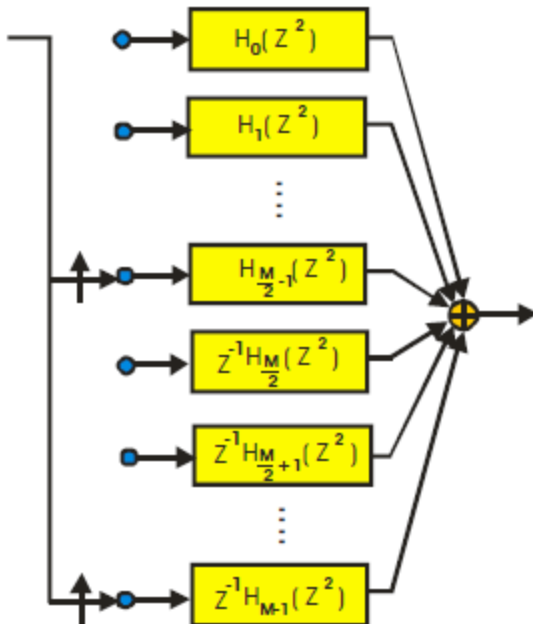
Analysis Filter Design

M/2-to-1 Polyphase Channelizer (cont'd)



Analysis Filter Design

M/2-to-1 Polyphase Channelizer (cont'd)



Path filters
without
extra delay

Path filters
with extra
delay

Deliver M/2 Inputs and Compute 1 Single Output!

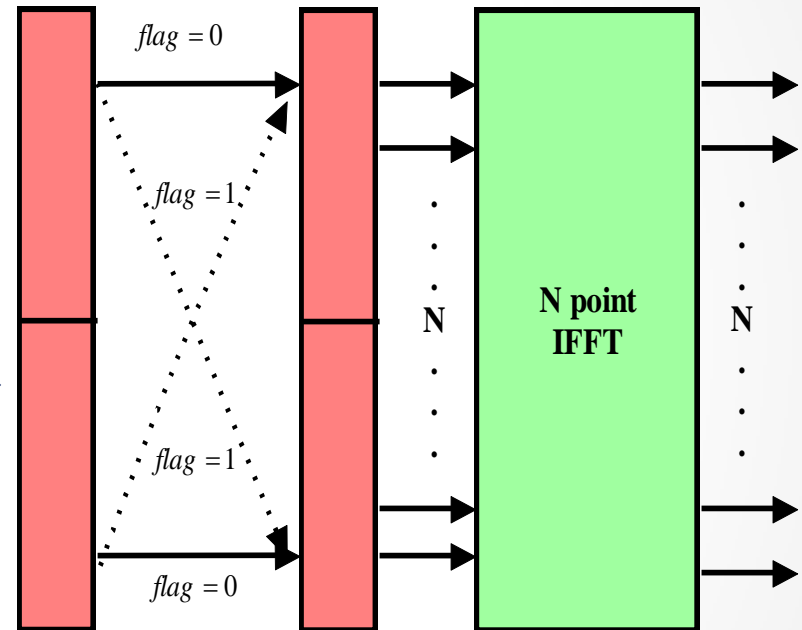
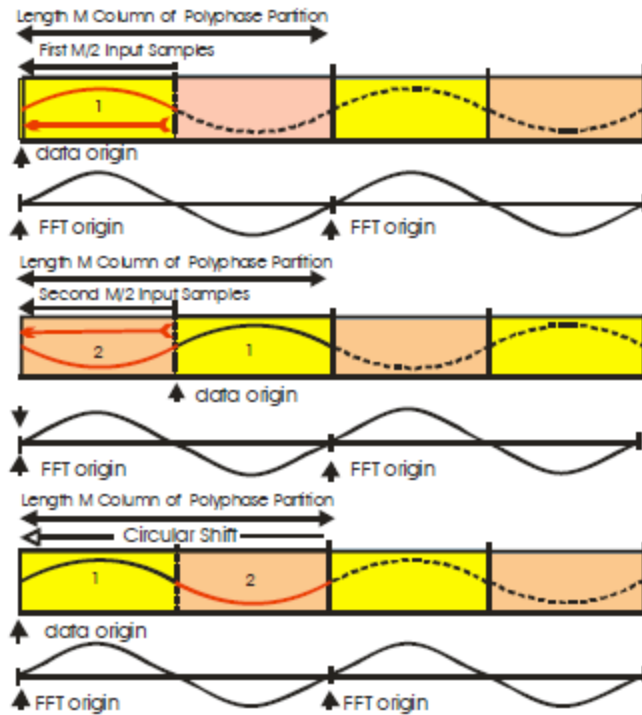
M-Path Low-Pass to Band-Pass Transformation

$$\begin{aligned} G(Z) &= \sum_{n=0}^{N-1} h(n) e^{j\frac{2\pi}{M}kn} Z^{-n} \\ &= \sum_{r=0}^{M-1} \sum_{n=0}^{\frac{N}{M}-1} h(r+nM) e^{j\frac{2\pi}{M}(r+nM)k} Z^{-(r+nM)} \\ &= \sum_{r=0}^{M-1} Z^{-r} e^{j\frac{2\pi}{M}rk} \sum_{n=0}^{\frac{N}{M}-1} h(r+nM) e^{j\frac{2\pi}{M}nM} Z^{-nM} \\ &= \sum_{r=0}^{M-1} Z^{-r} e^{j\frac{2\pi}{M}rk} \sum_{n=0}^{\frac{N}{M}-1} h(r+nM) Z^{-nM} \end{aligned}$$

It is an IFFT!

Analysis Filter Design

M/2-to-1 Polyphase Channelizer (cont'd)

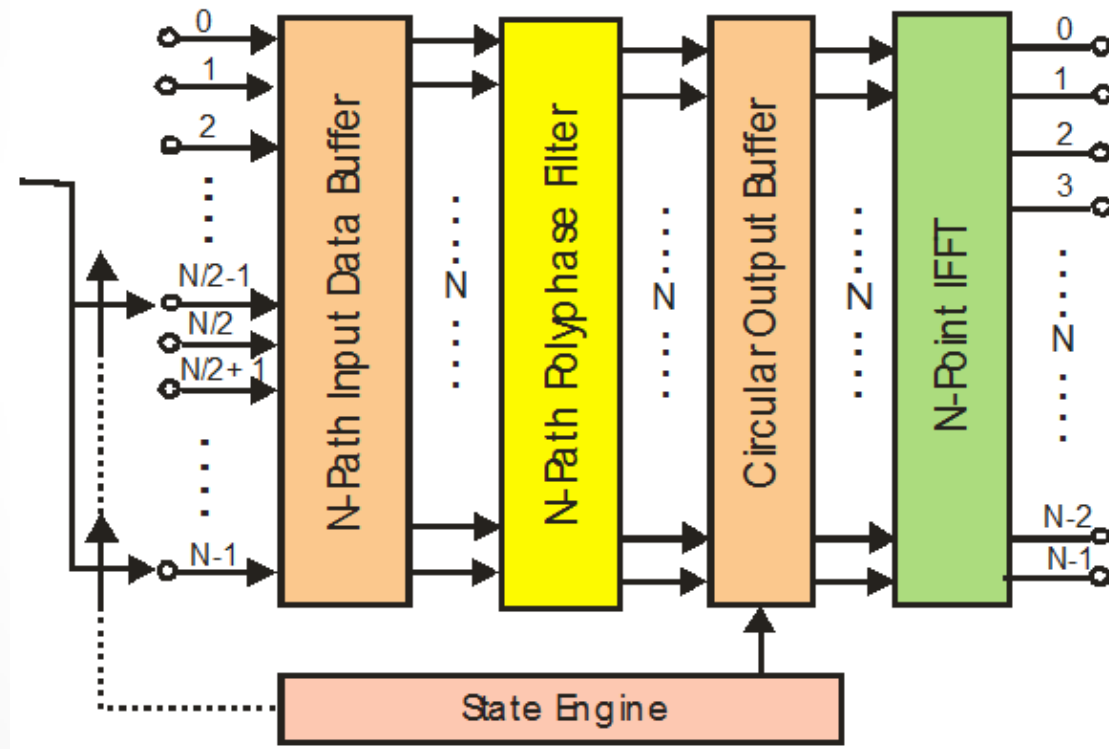


M-point Sinusoid Input to M/2 Path Polyphase Filter

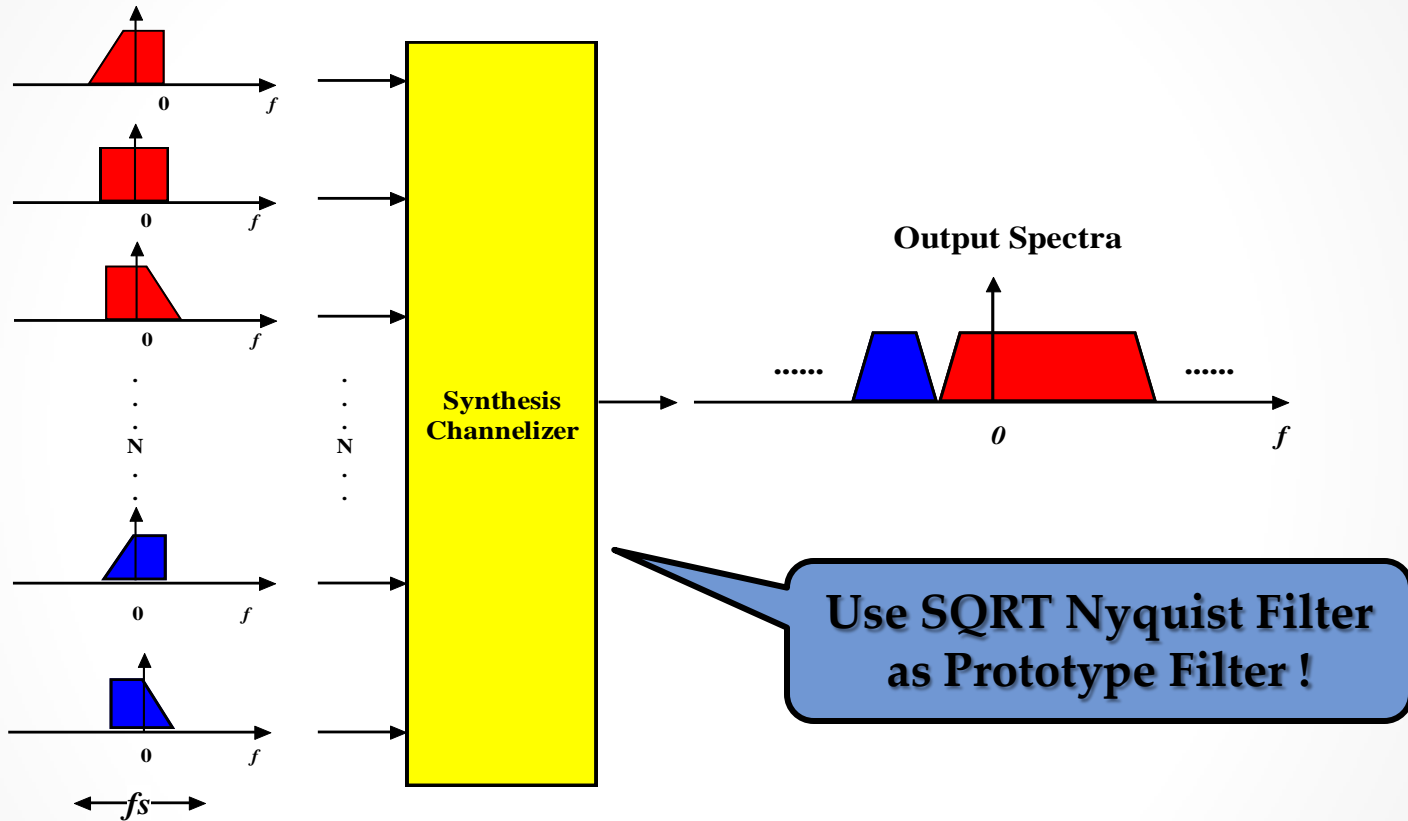


Circular Shift Buffer

Structure of Analysis Filter



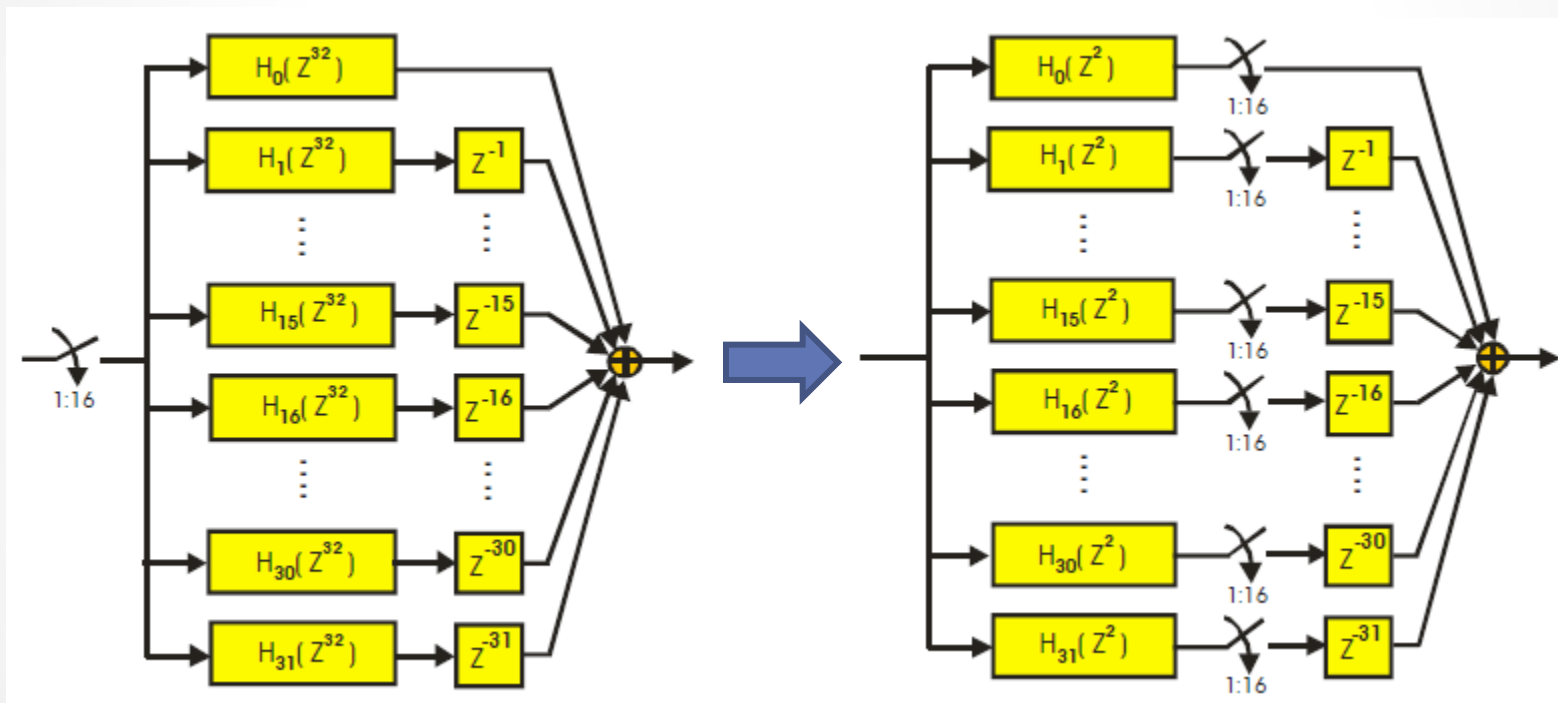
The Role of Synthesis Filter



- ❖ Recombine "Spectra Chunks" into Desired Transmitting Signals
- ❖ Up-Convert Each Signal onto Their Desired Center Frequencies

Synthesis Filter Design

1-to-M/2 Polyphase Channelizer (cont'd)

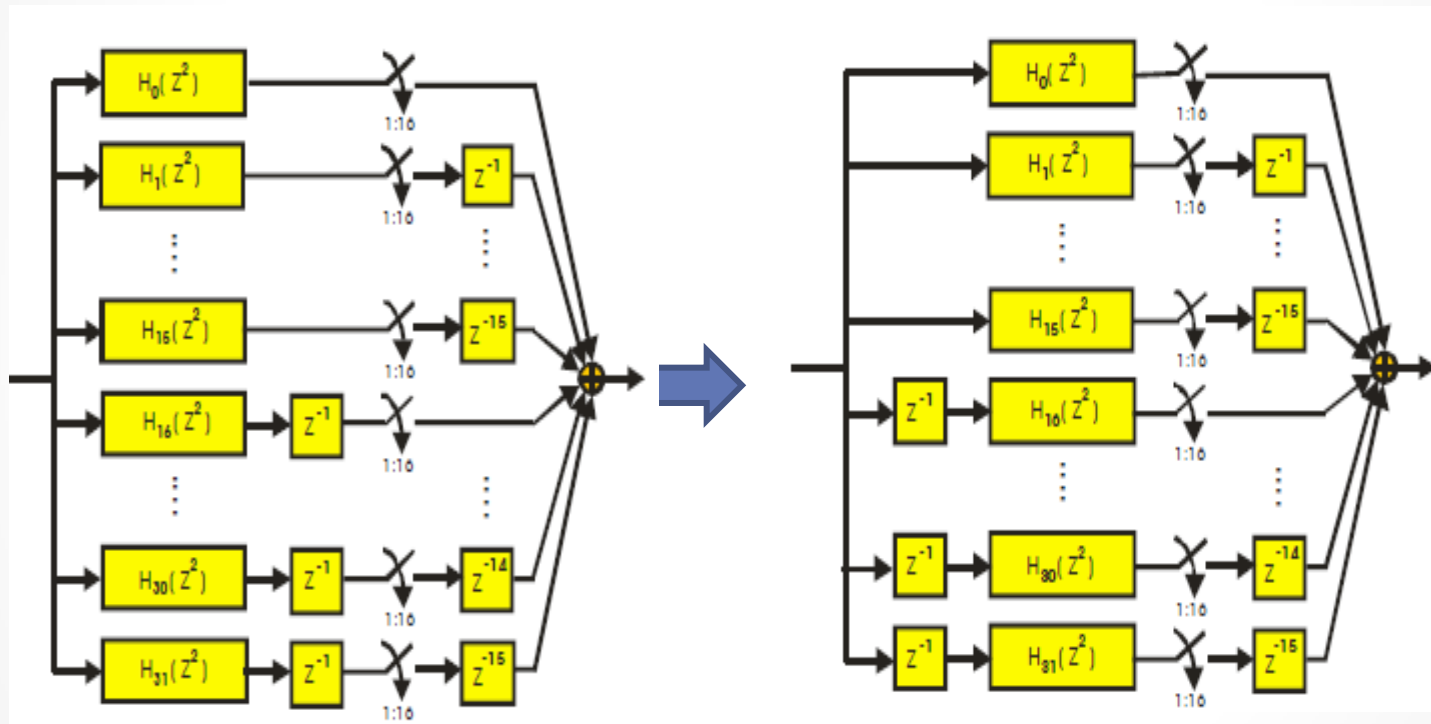


M-path Polyphase Filter

Apply Noble Identity

Synthesis Filter Design

1-to-M/2 Polyphase Channelizer (cont'd)

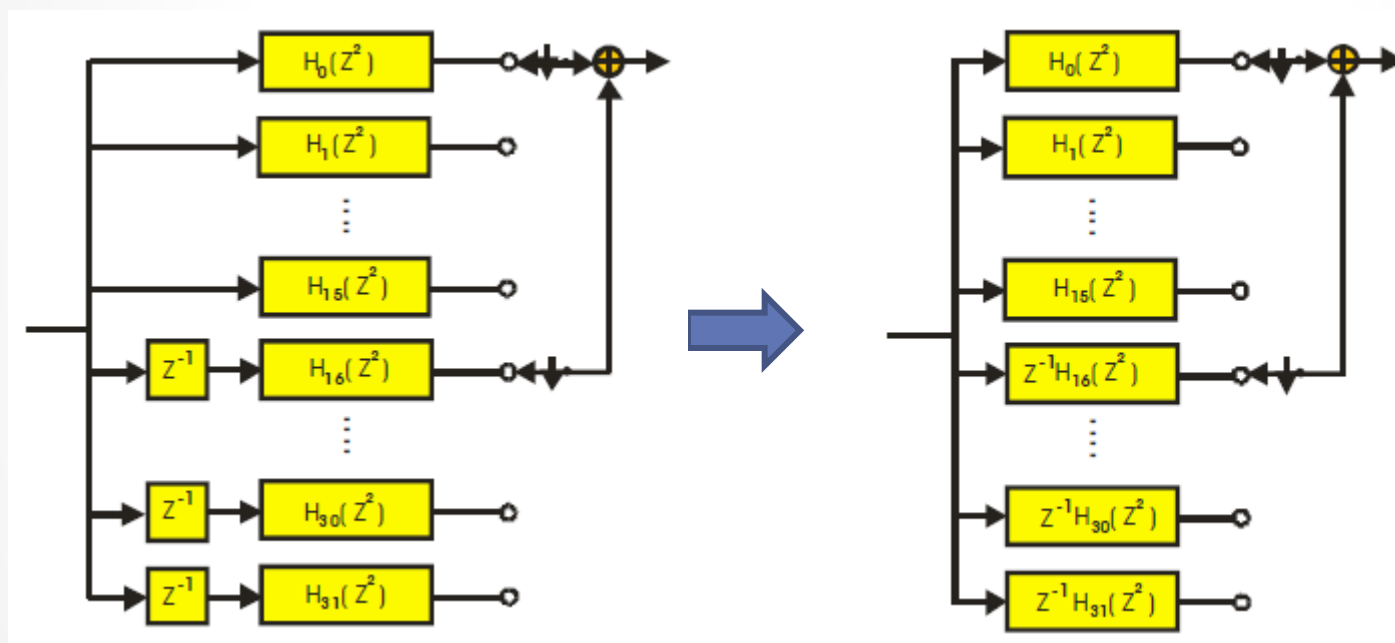


Apply Noble Identity to Delays

Interchange Unit Delays and Path Filters

Synthesis Filter Design

1-to-M/2 Polyphase Channelizer (cont'd)

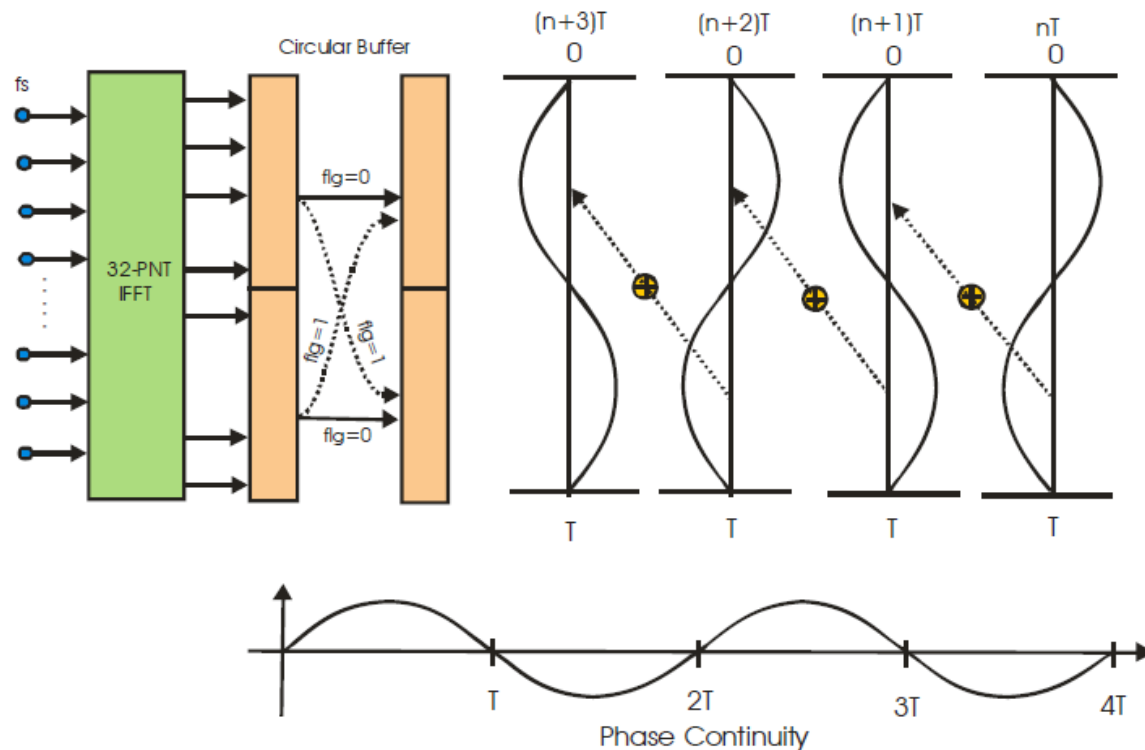


Insert Commutator

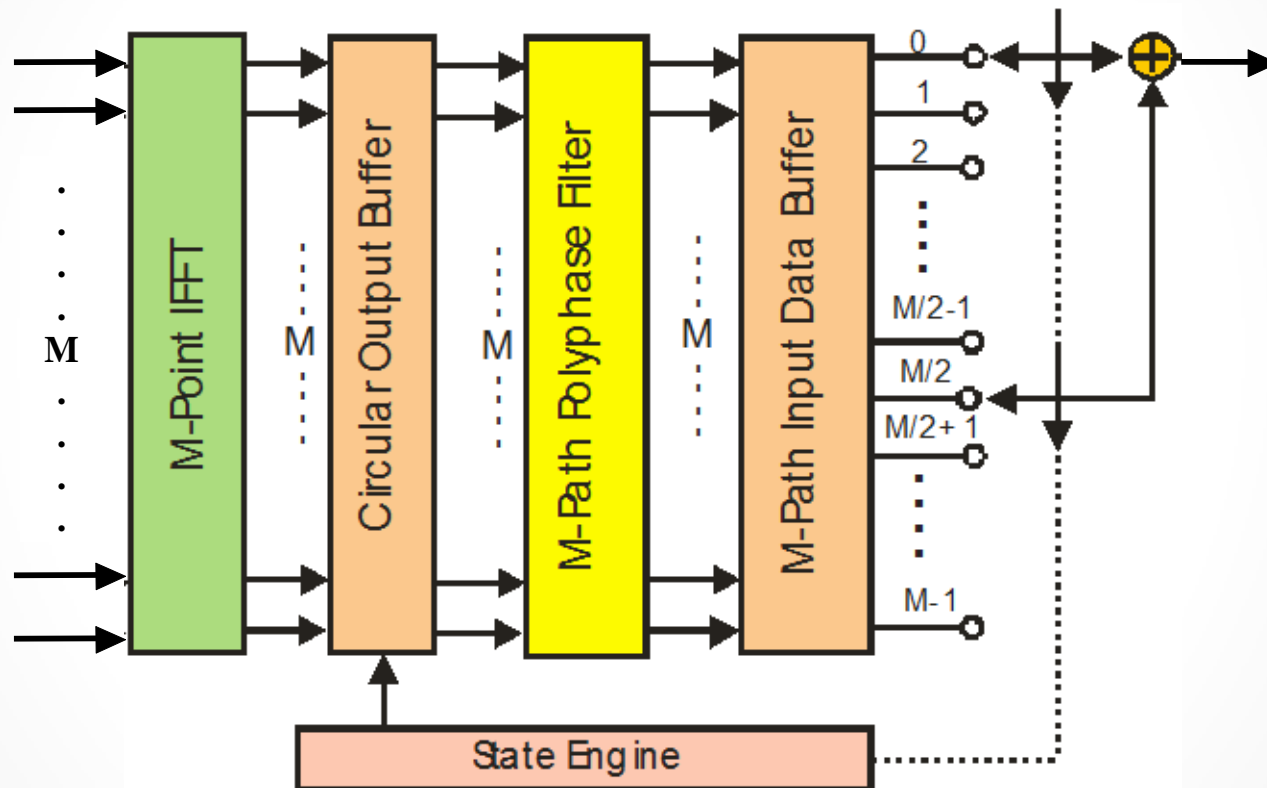
Merge Delays into Path Filters

Synthesis Filter Design

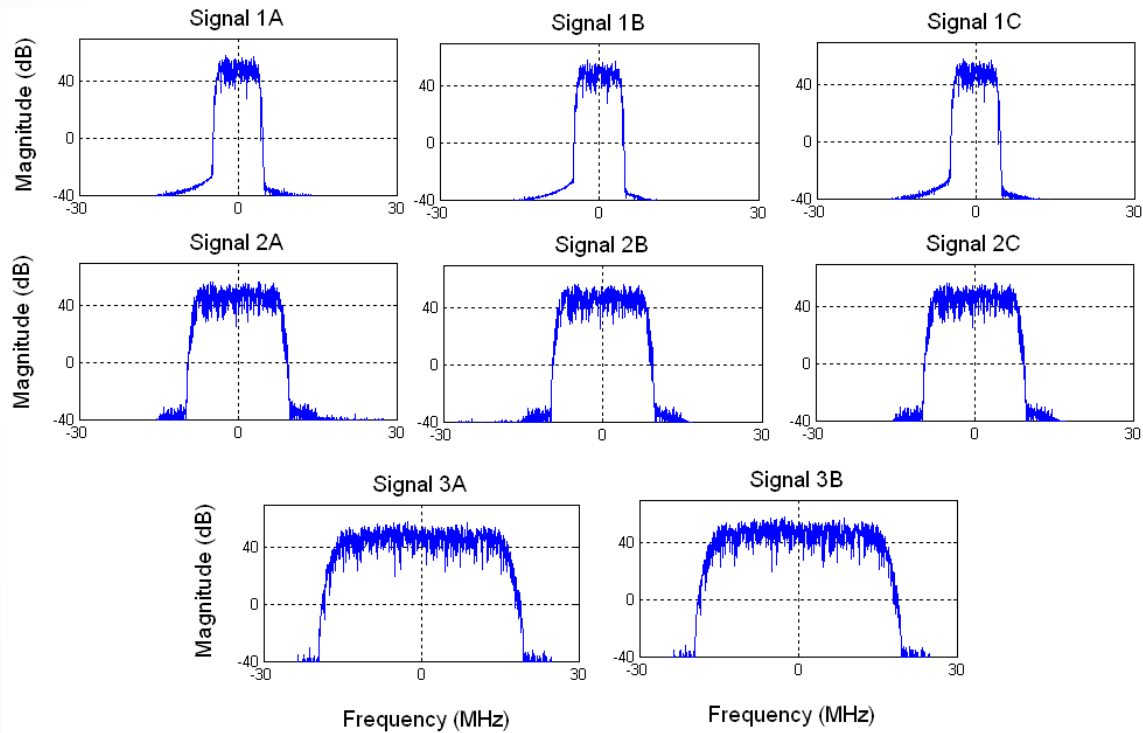
1-to-M/2 Polyphase Channelizer (cont'd)



Structure of Synthesis Filter

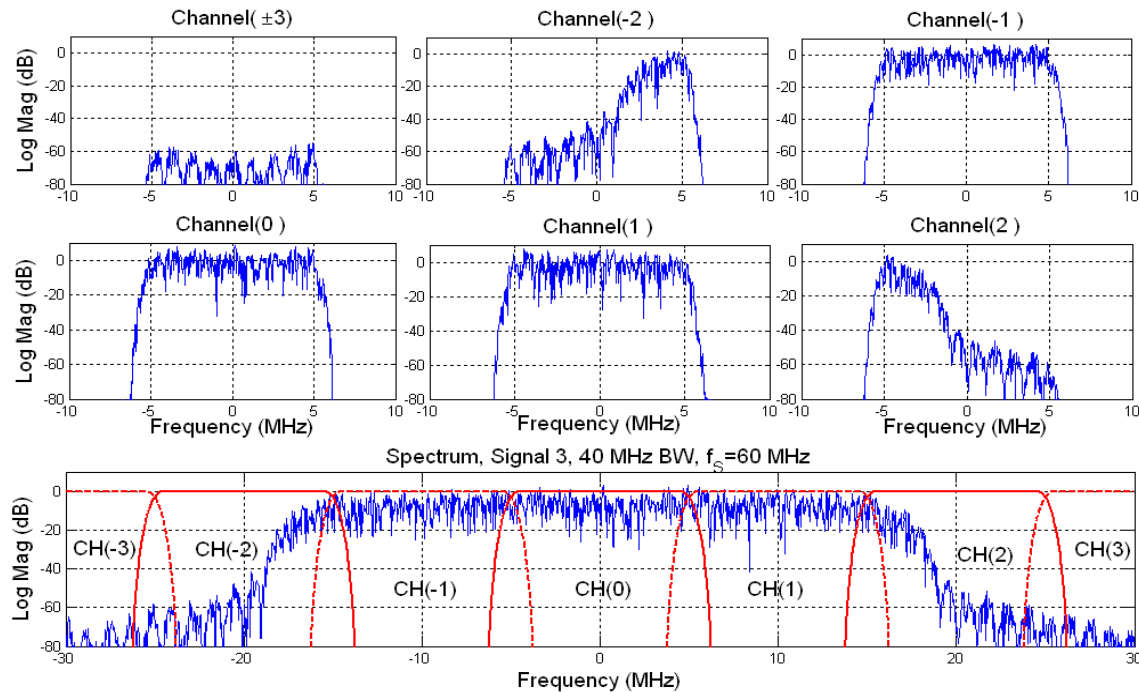


Simulation Demo



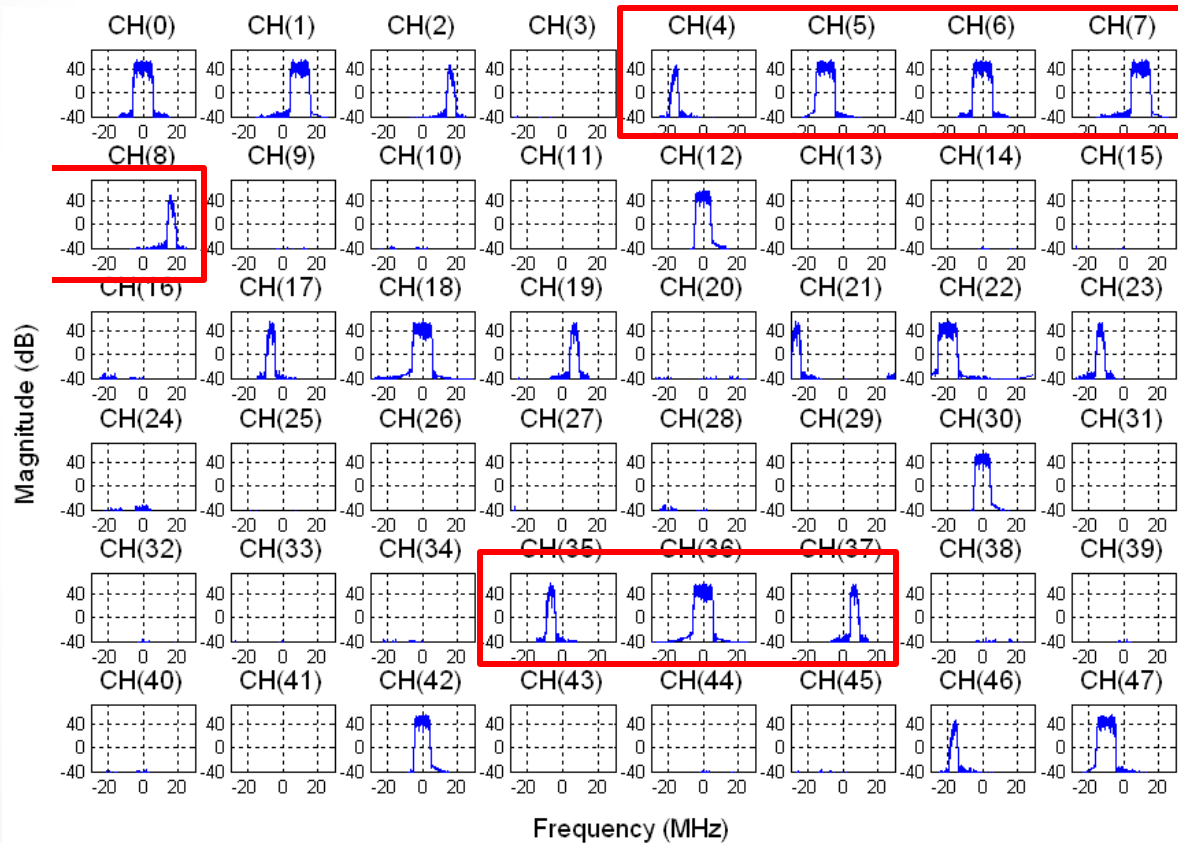
Signals to be Up-Converted

Analysis Channelizer Demonstration



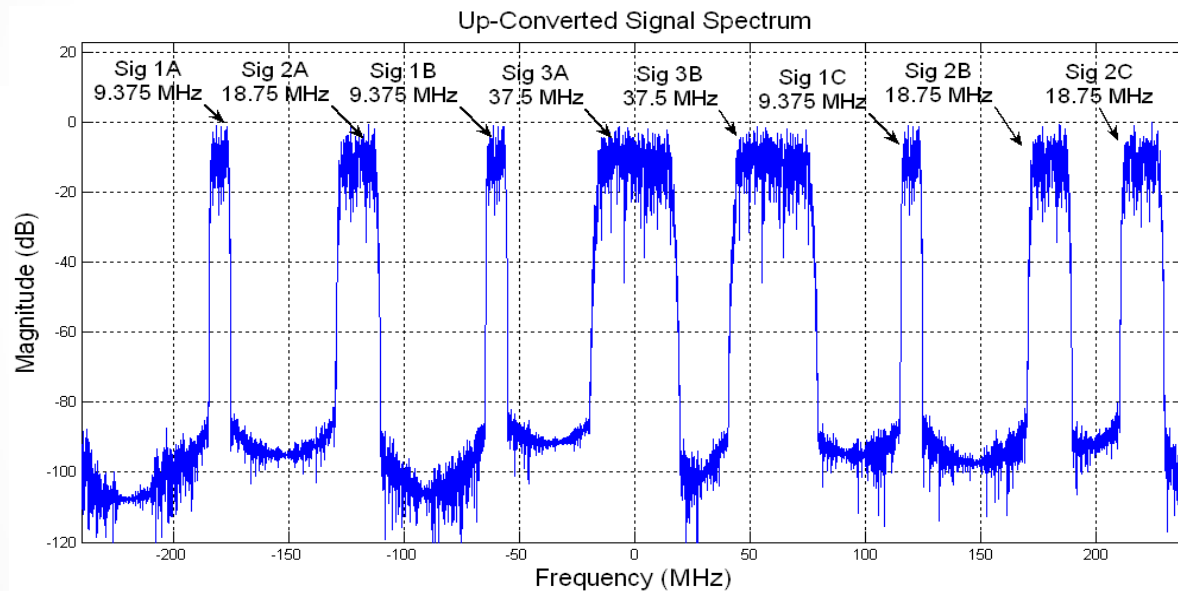
Spectral Fragments Formed by 6-Channel 6-to-2 Down Sample Analysis Channelizer Processing Wideband Signal 3.

Synthesis Channelizer Demonstration



2-to-M Up-Converter Channelizer Inputs

Synthesis Channelizer Demonstration



Up-Converter Synthesized Spectra with Unequal Bandwidths Fragmented and Defragmented Spectral Components.

Thanks for your patience 😊

We are now open for questions !