SAN DIEGO STATE UNIVERSITY

A Receiver Structure that Performs Simultaneous Spectral Analysis and Time Series Channelization

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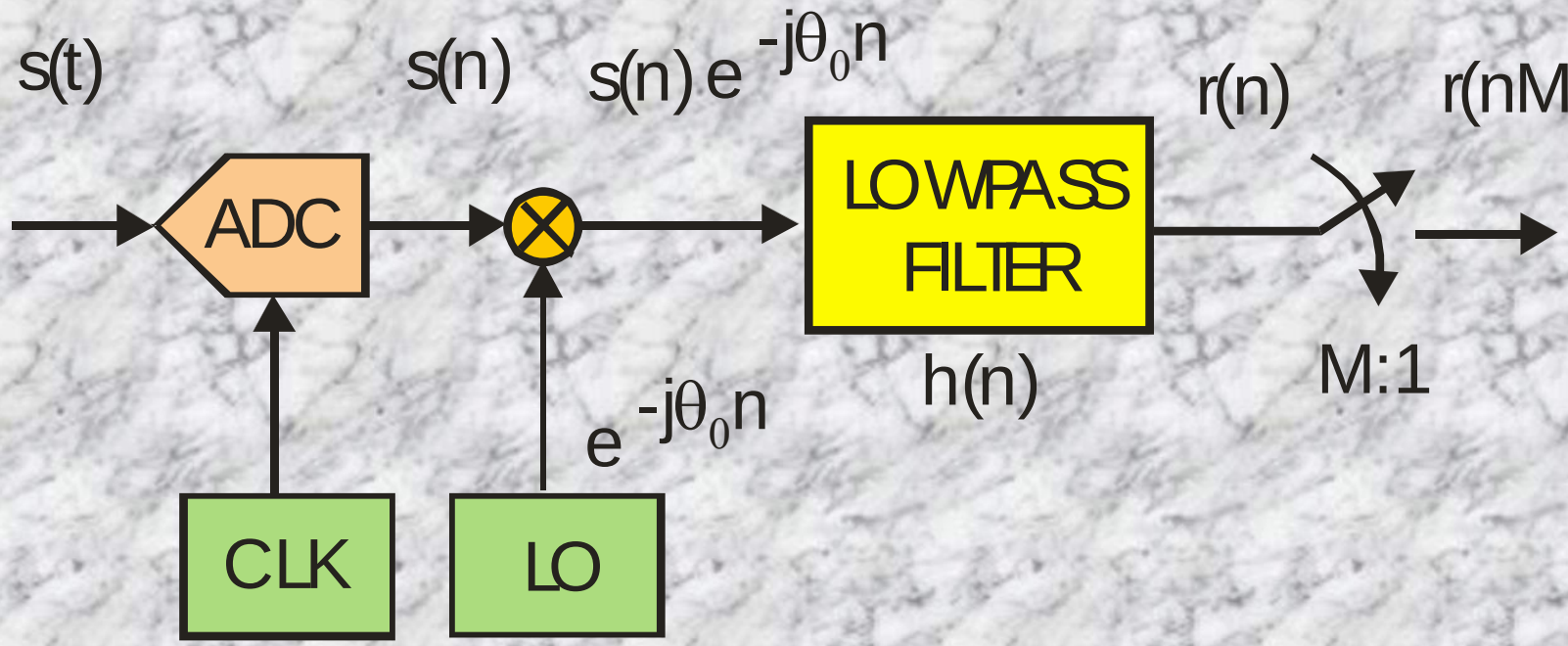
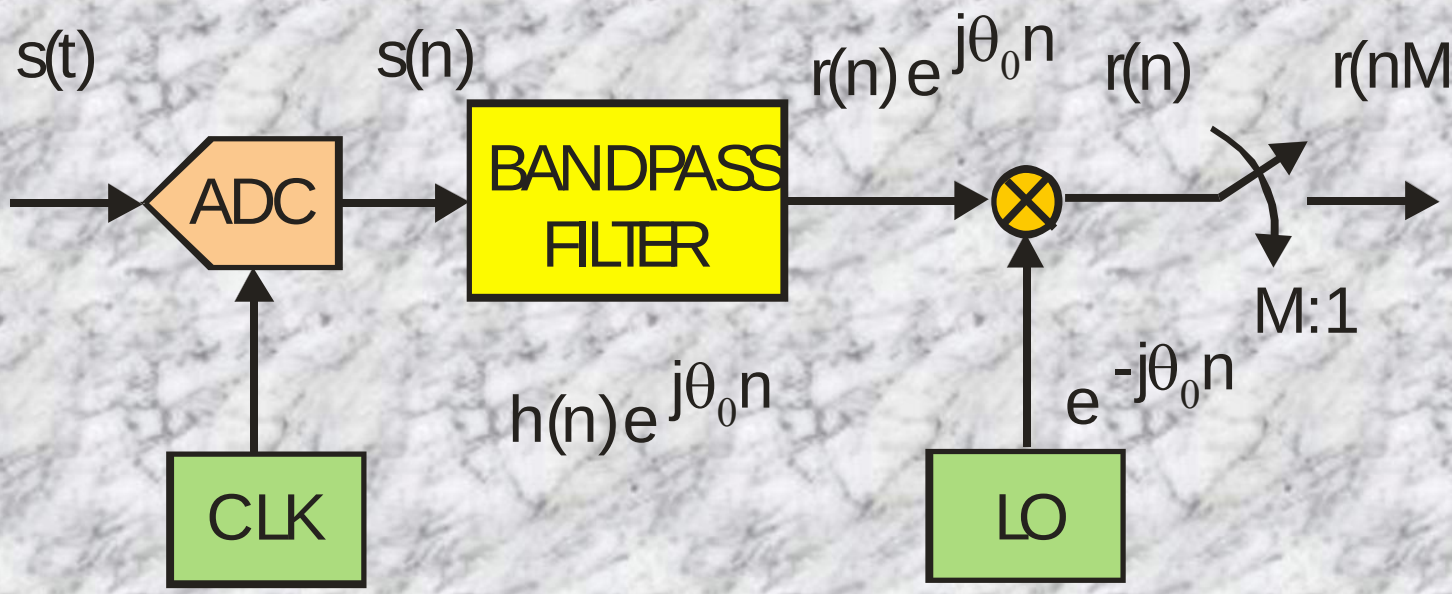
Standard Digital Down Converter

Heterodyne, Filter, Down-Sample



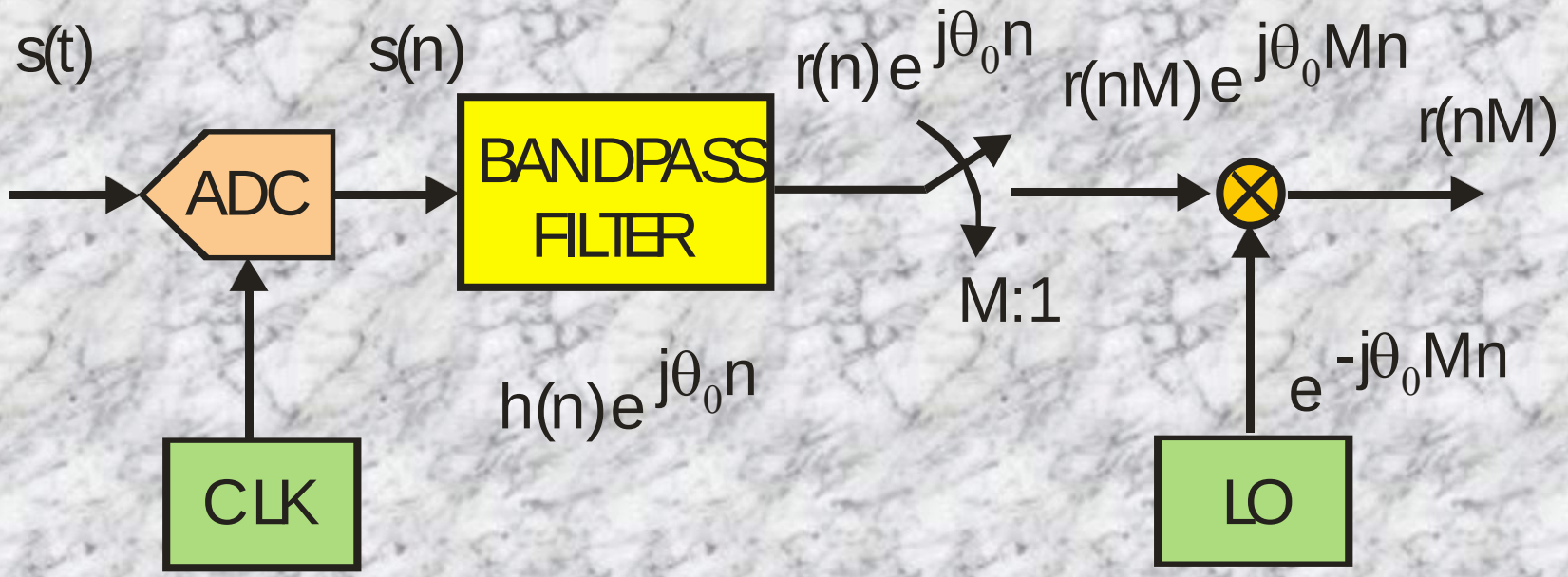
Equivalency Theorem: Interchange Filter and Heterodyne

Filter, Heterodyne, Down-Sample

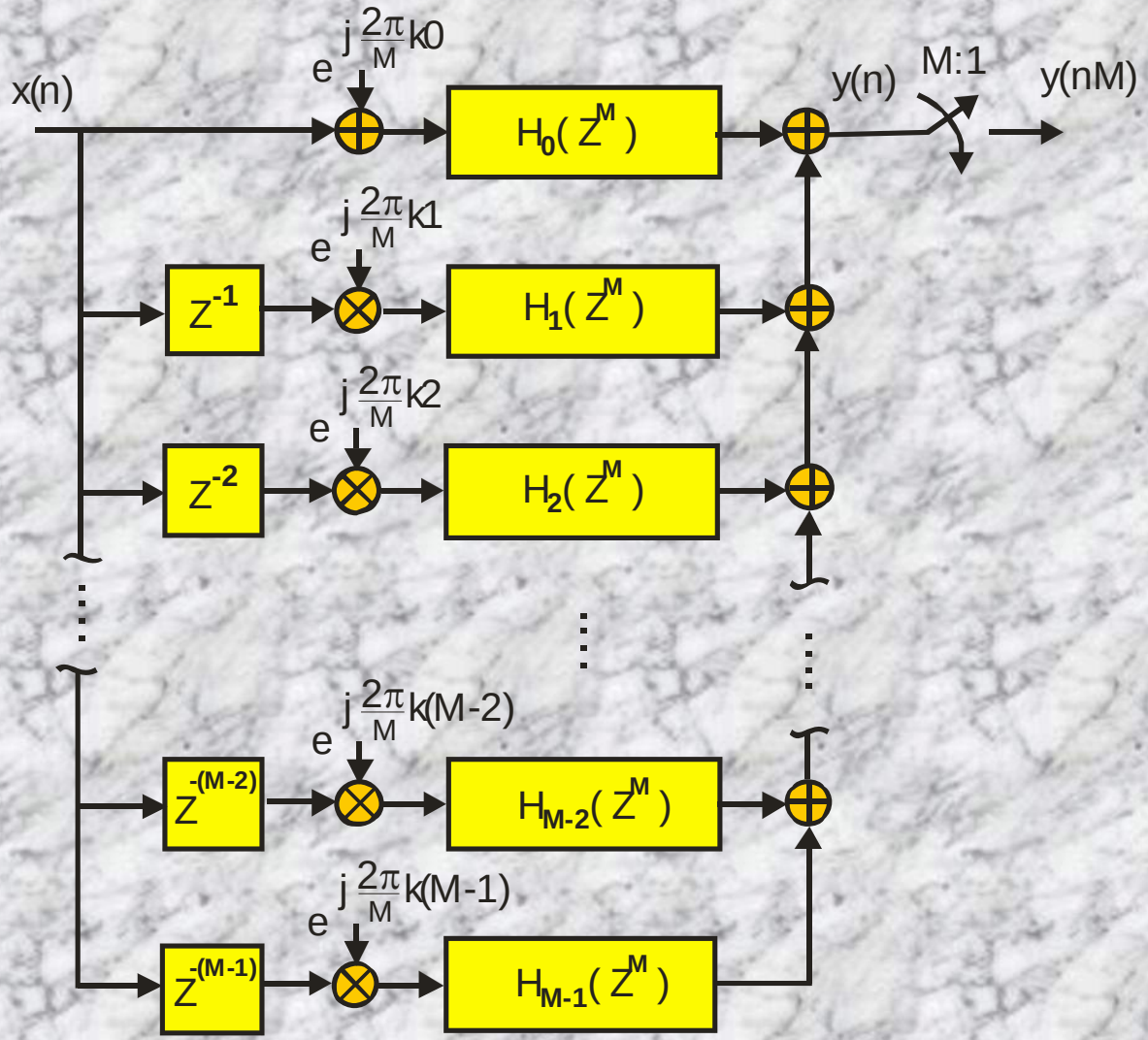


Interchange Down-Sample and Heterodyne

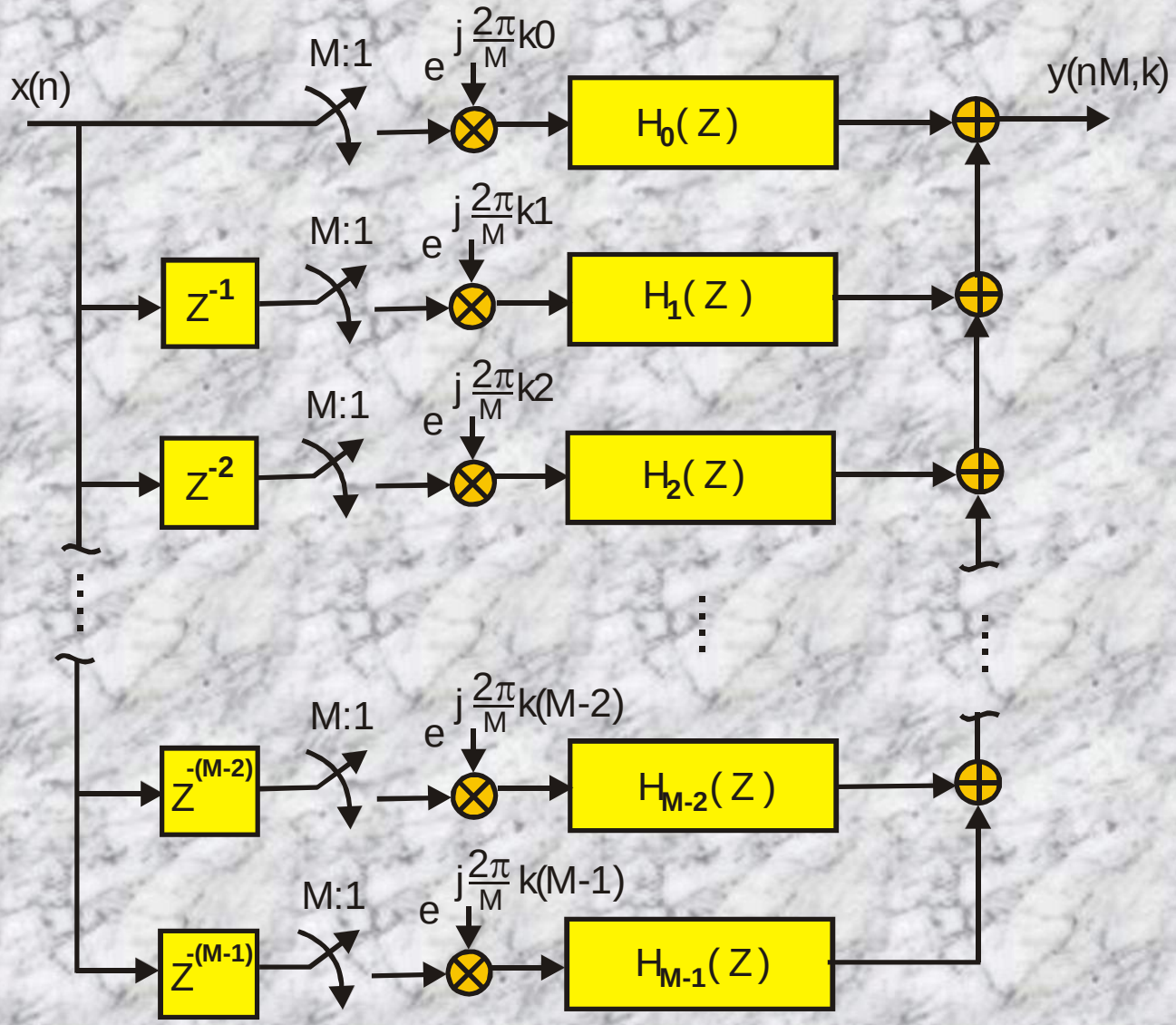
Filter, Down-Sample , Heterodyne



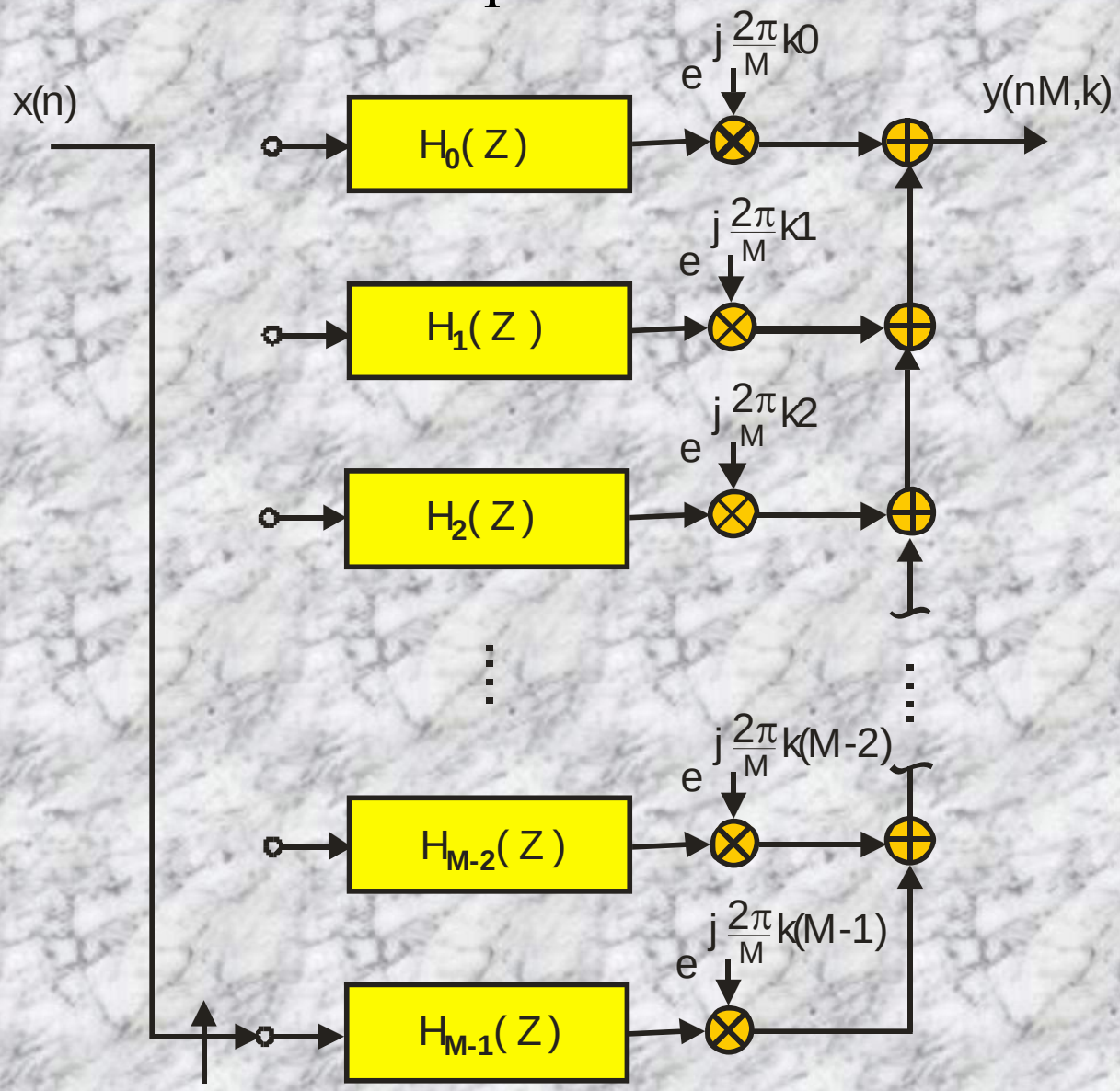
Polyphase M-Path Narrowband, Resampling Filter



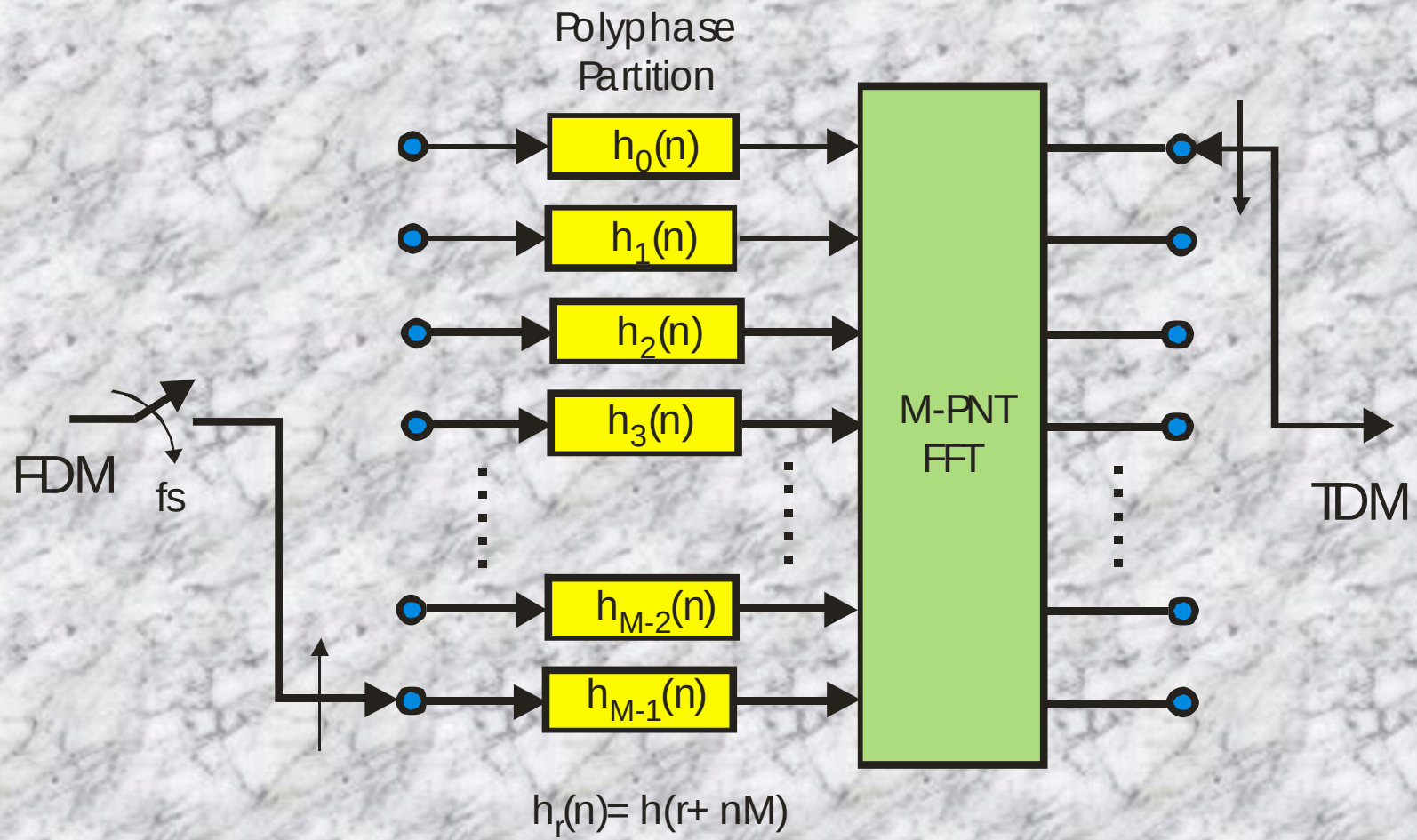
Interchange Resampling and Filtering



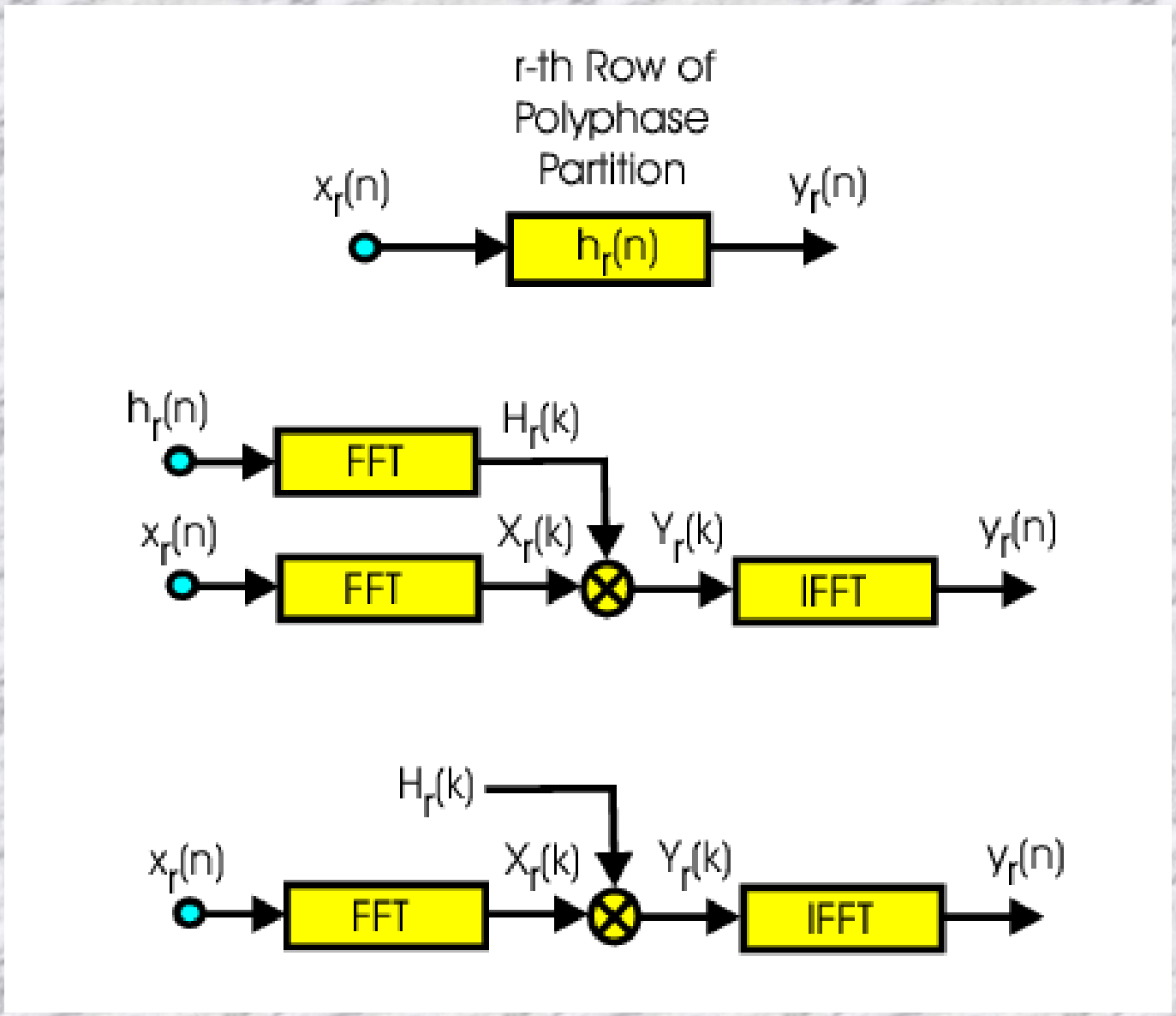
Replace Input Delays and Resampler with Input Commutator



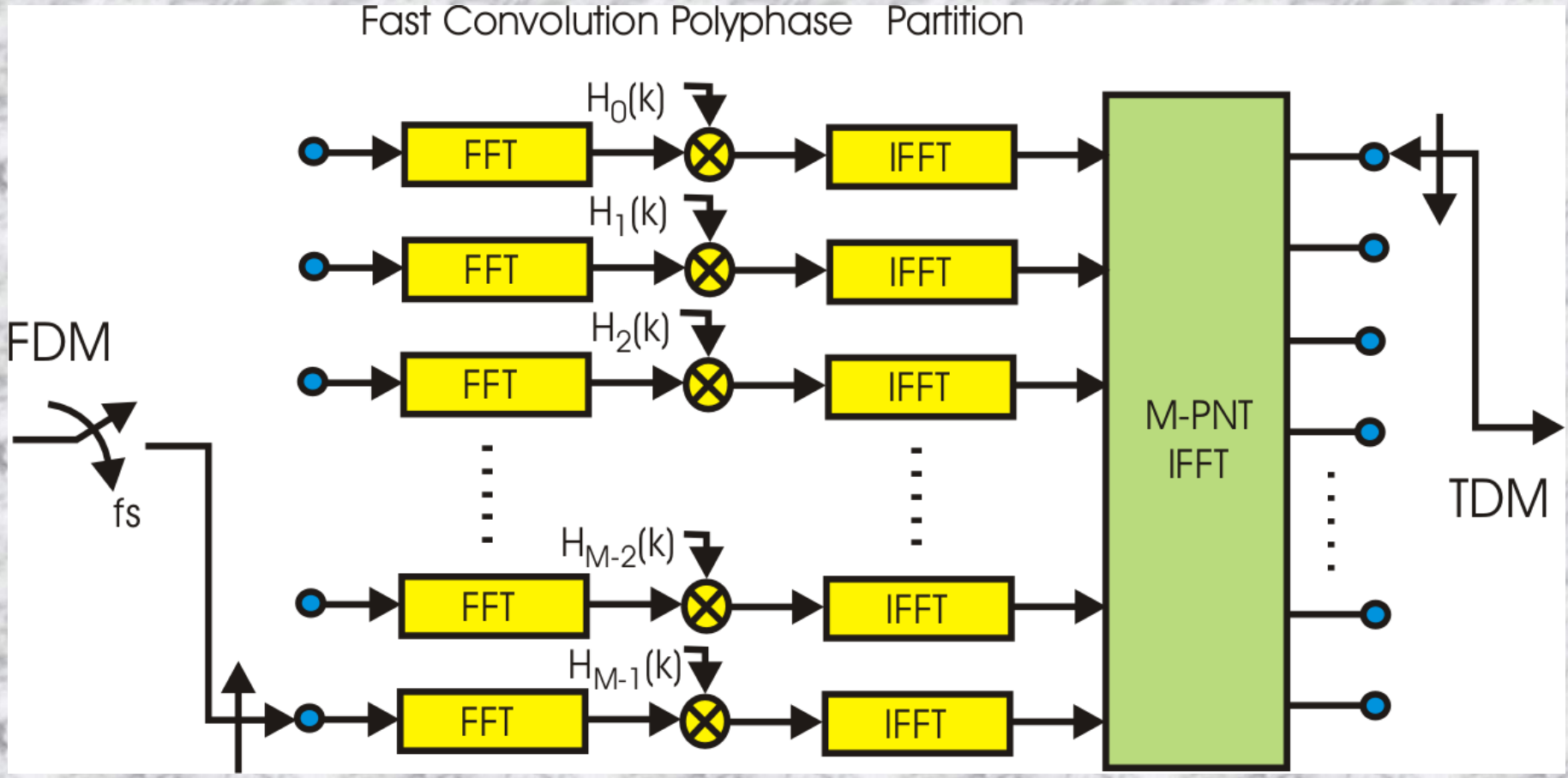
M-Channel Channelizer
Resampled M-Path Narrowband Filter with Rotators Replaced by M-Point IFFT



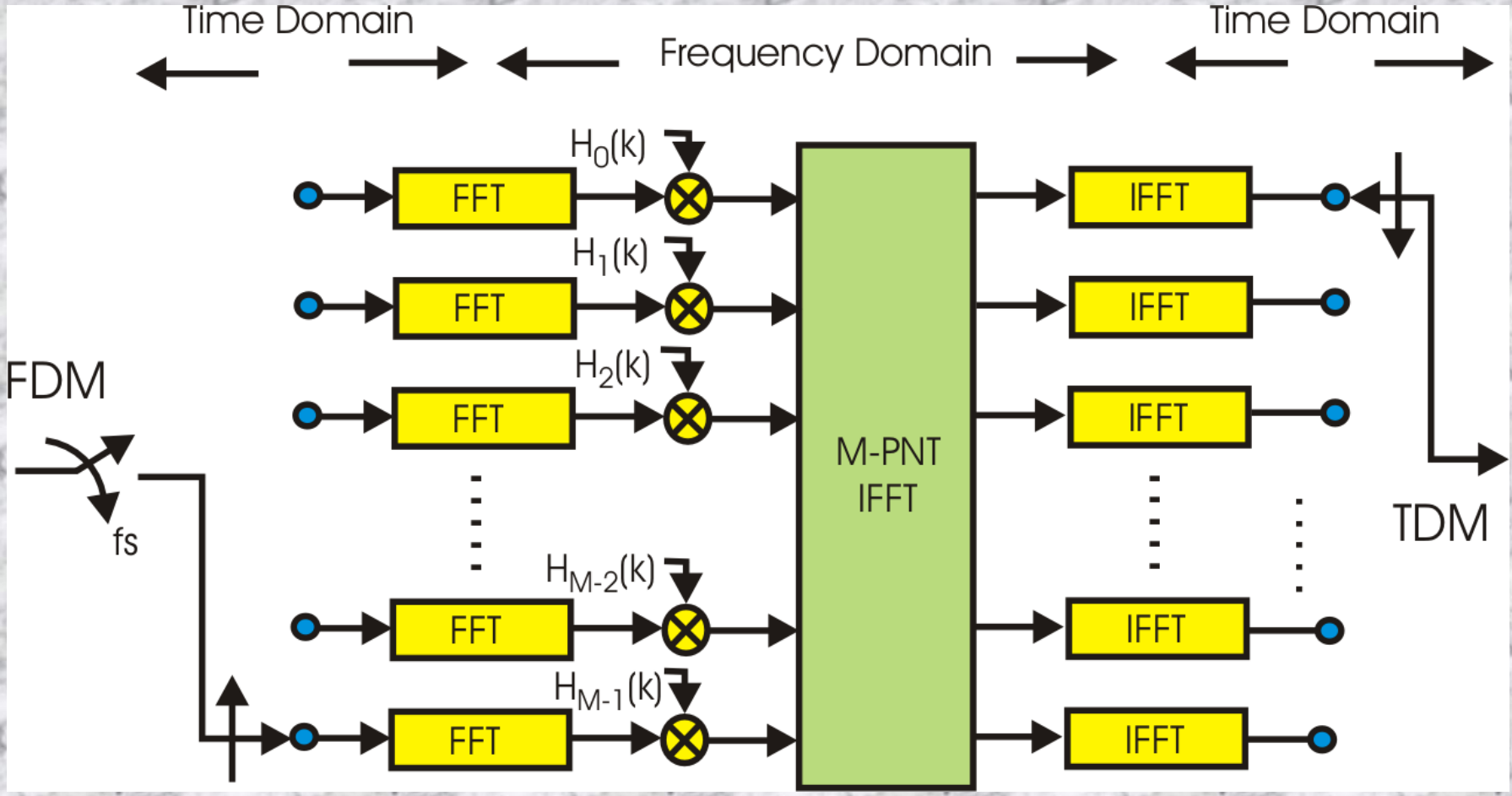
Polyphase Arm Convolution Replace by Fast Convolution
Fast Convolution Implemented by Spectral Product



M-Channel Polyphase Filter Bank with Path Filters Implemented by Fast Convolution, i.e. Spectral Products



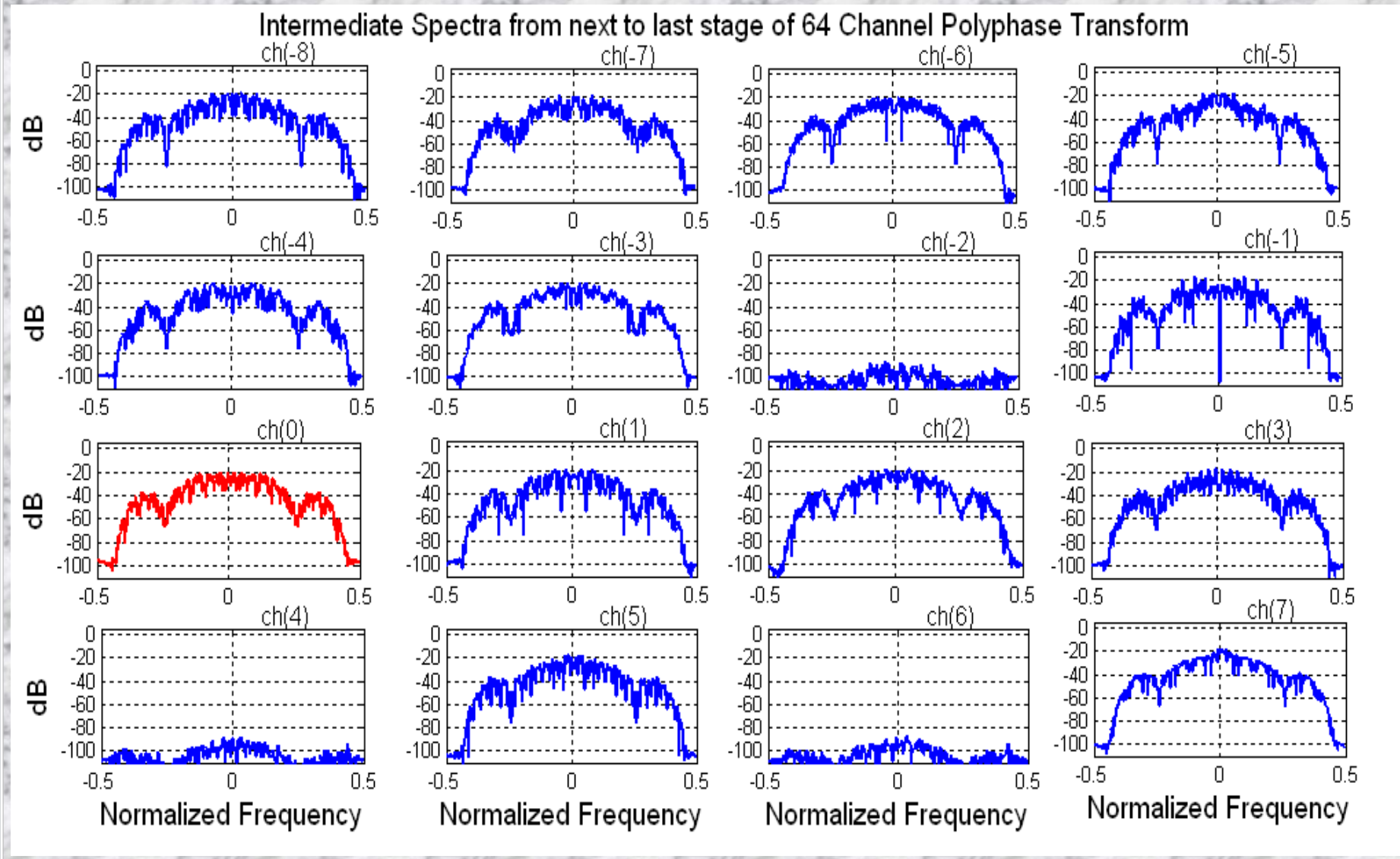
Fast Convolution M-Channel Polyphase Filter Bank
Reversed Order of Row and Column Transforms



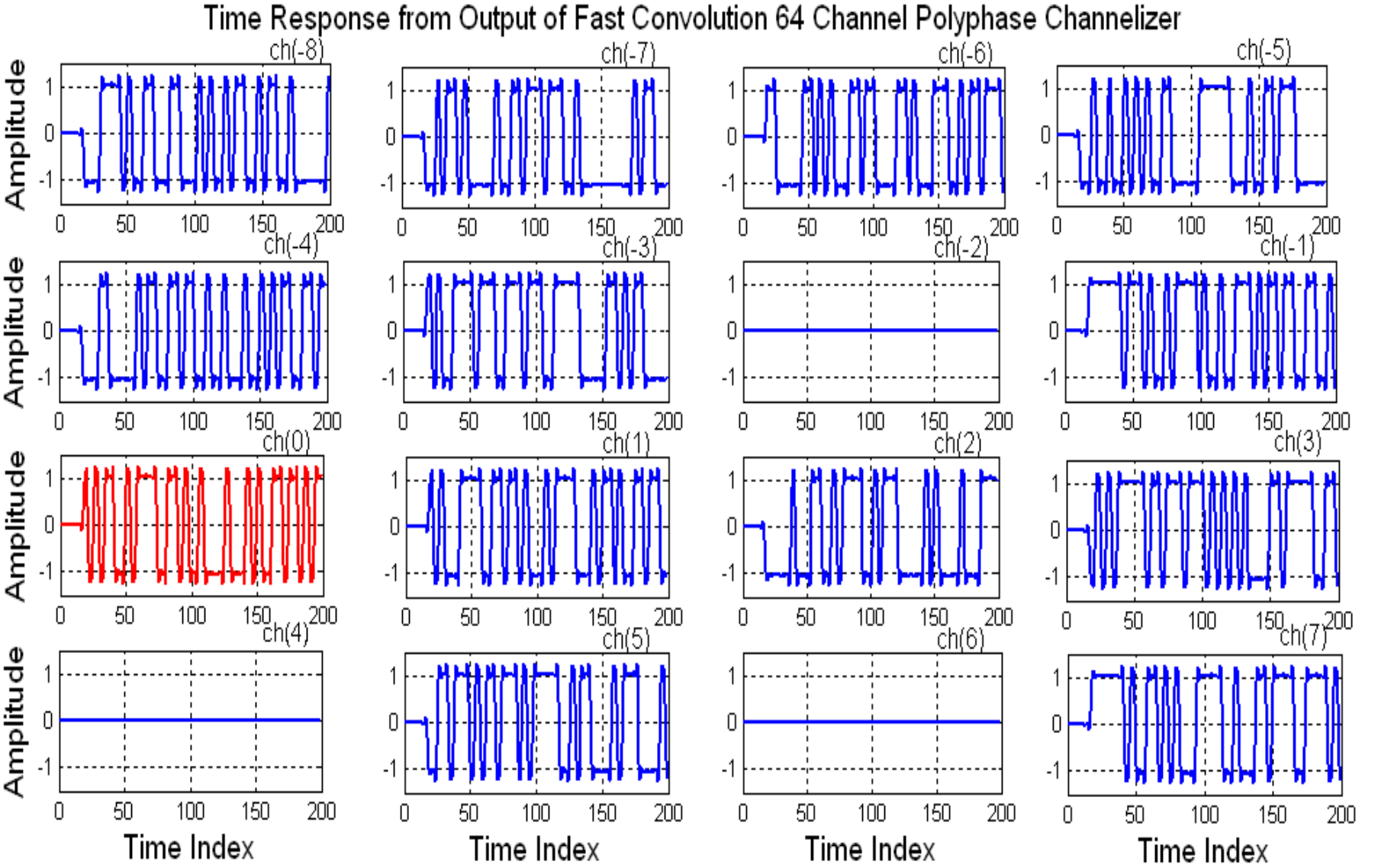
Too View Power Spectra of Each Channel we must Apply Window to Minimize Artifacts due to Block Processing Boundaries.

We perform a Circular Convolution of the spectra with the spectral weights of a Short Cosine Window Such as the
Hann or Blackman-harris Window

Spectra from 16 Channels of 64-Path Polyphase Filter Bank



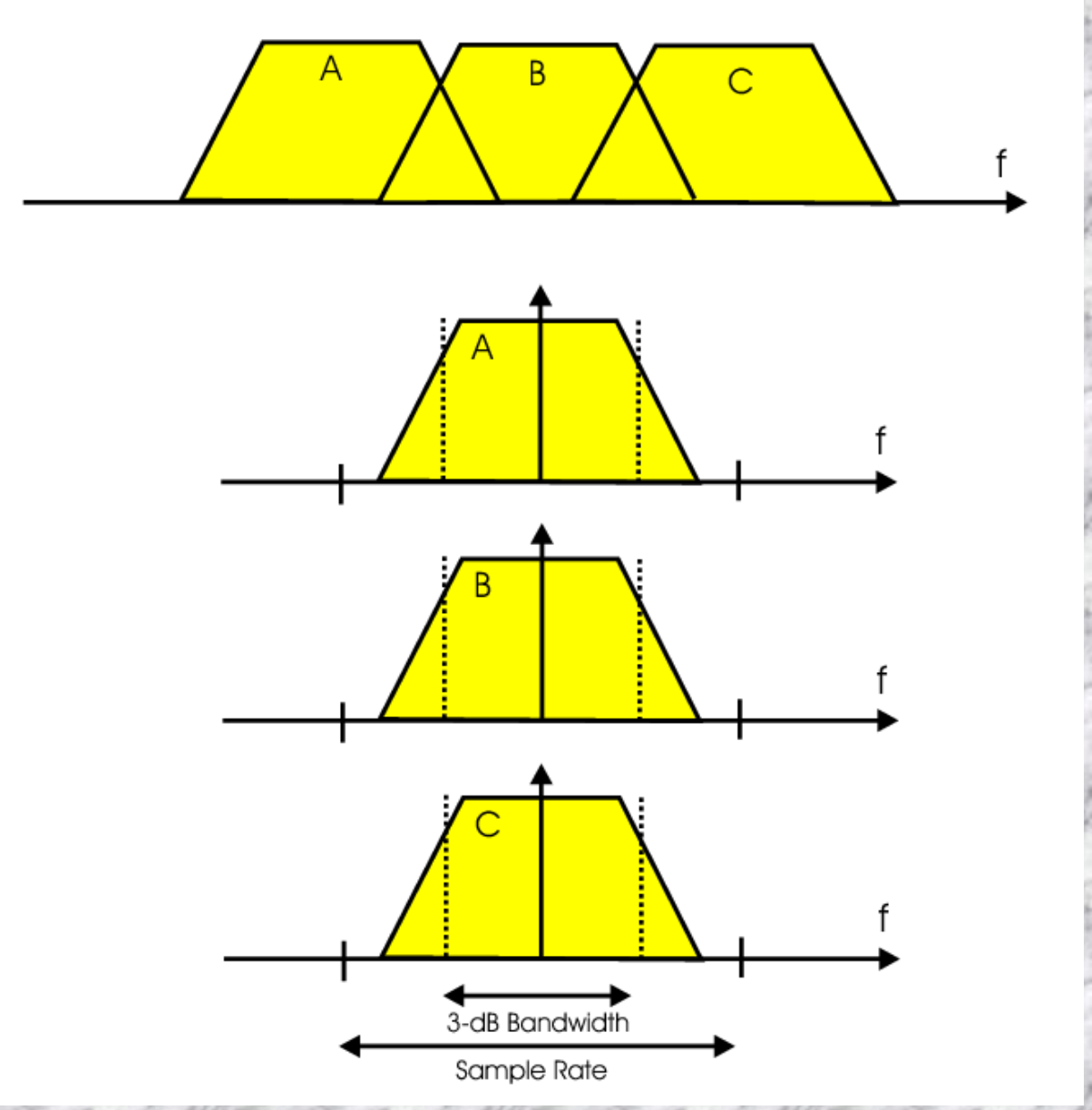
Time Series from 16 Channels of 64-Path Polyphase Filter Bank



Double Output Sample Rate of Time Series from Each Channel

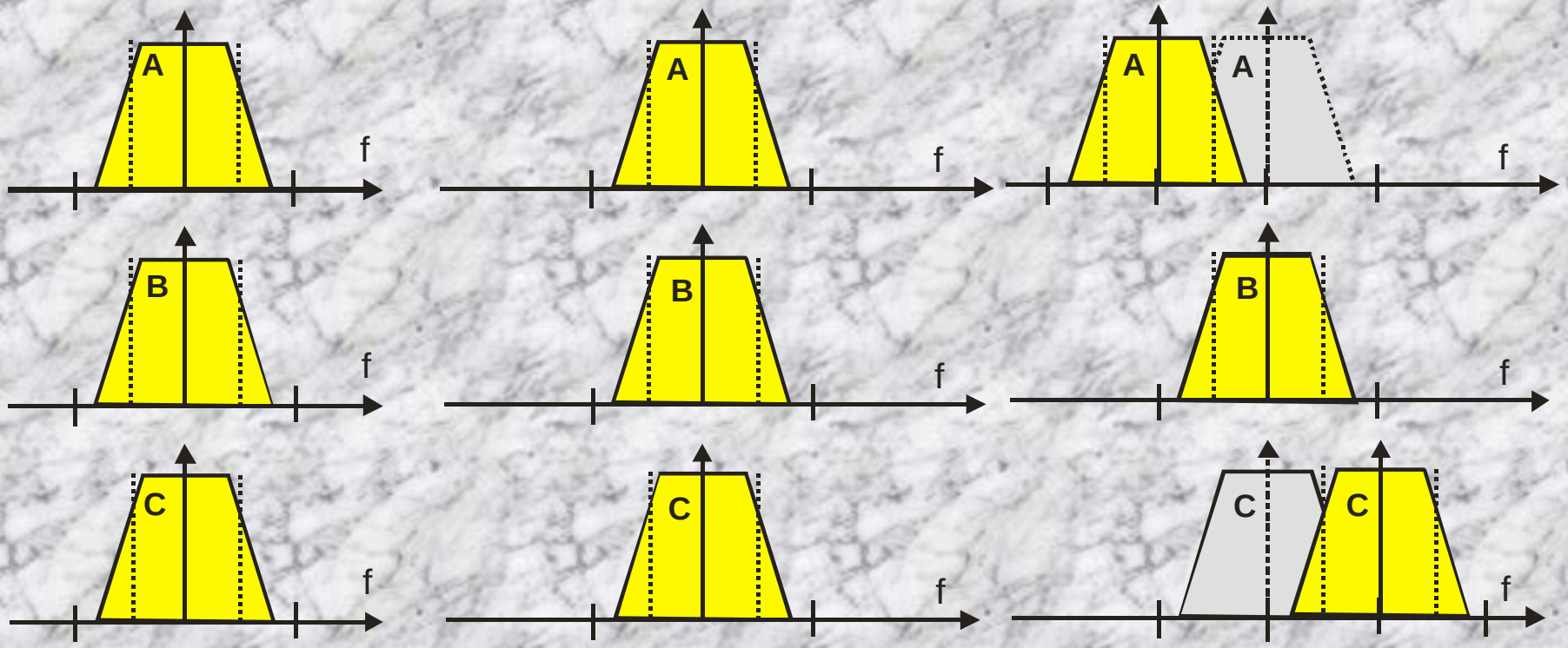
Rather Than Deliver M Input Samples to M-Path Filter to obtain Output Rate fs/M,
Deliver M/2 Input Samples to M-Path Filter to obtain Output rate fs/(M/2) or 2 fs/M

Channelize and Baseband

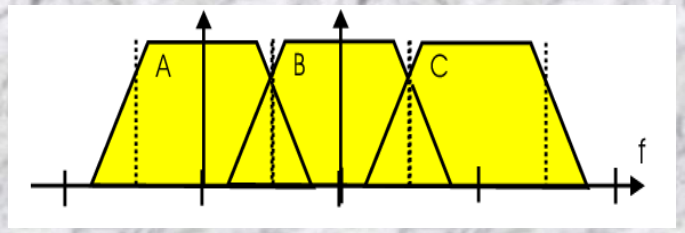


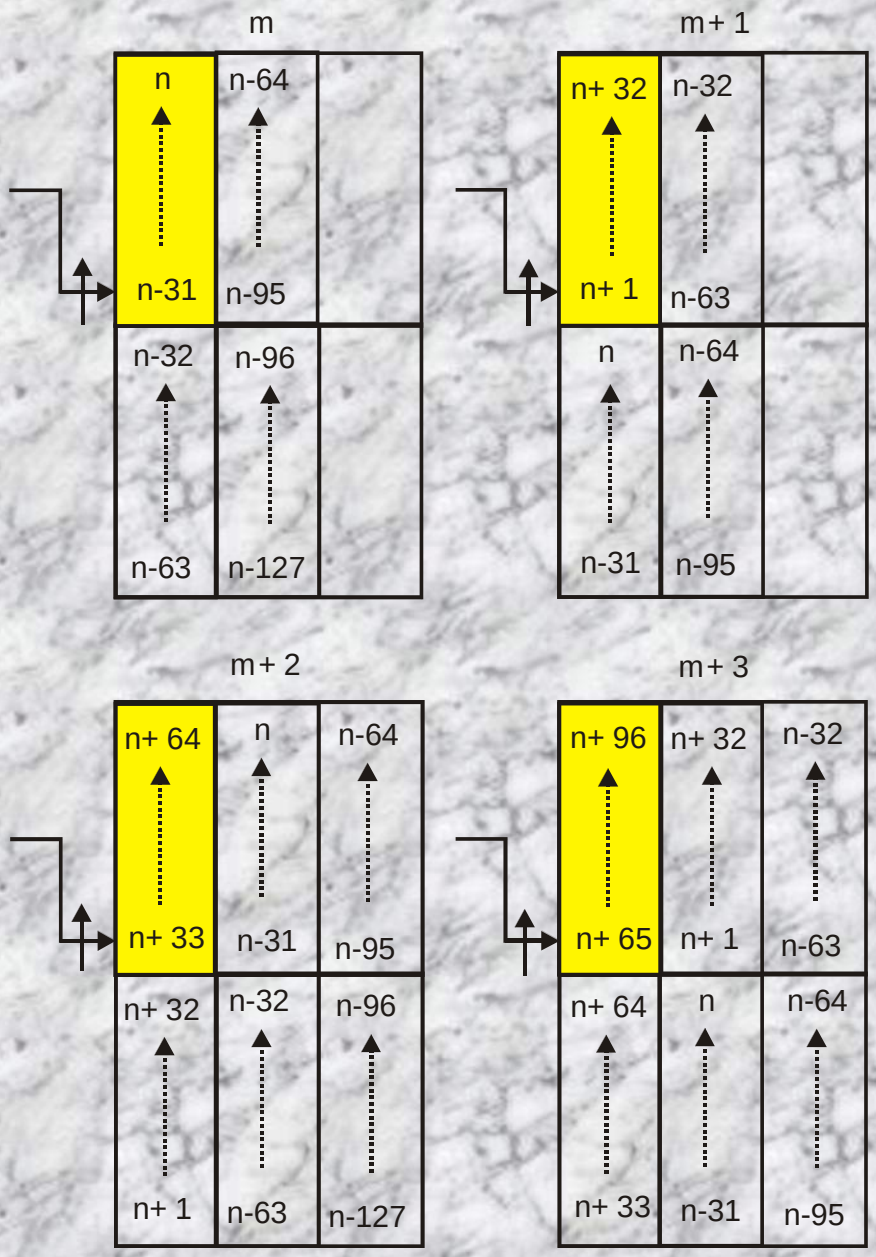
Raise Sample Rate

Translate Spectrum



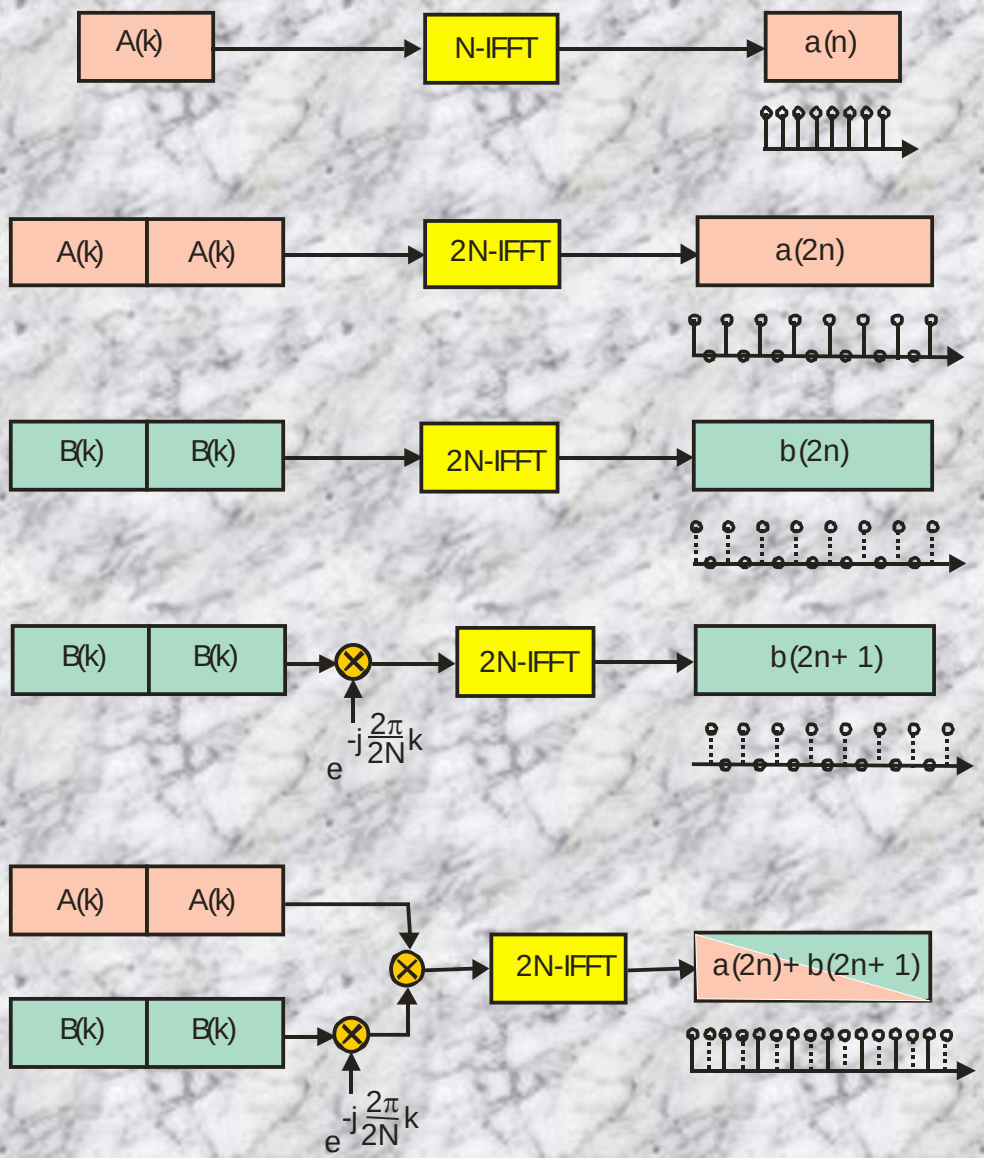
Merge by Summation

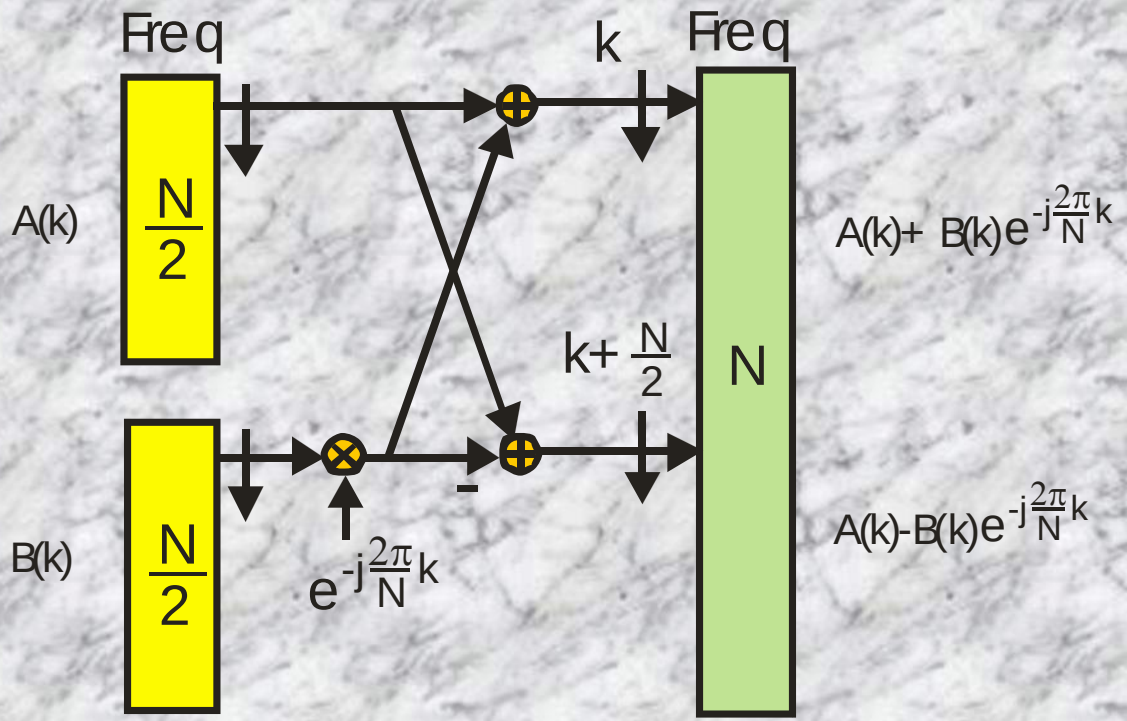



m
n
n-64
n-31
n-95
n-32
n-96
n-63
n-127
m+ 1
n+ 32
n-32
n+ 1
n-63
n
n-64
n-31
n-95
m+ 2
n+ 64
n
n-64
n+ 33
n-31
n-95
n+ 32
n-32
n-96
n+ 1
n-63
n-127
m+ 3
n+ 96
n+ 32
n-32
n+ 65
n+ 1
n-63
n+ 64
n
n-64
n+ 33
n-31
n-95

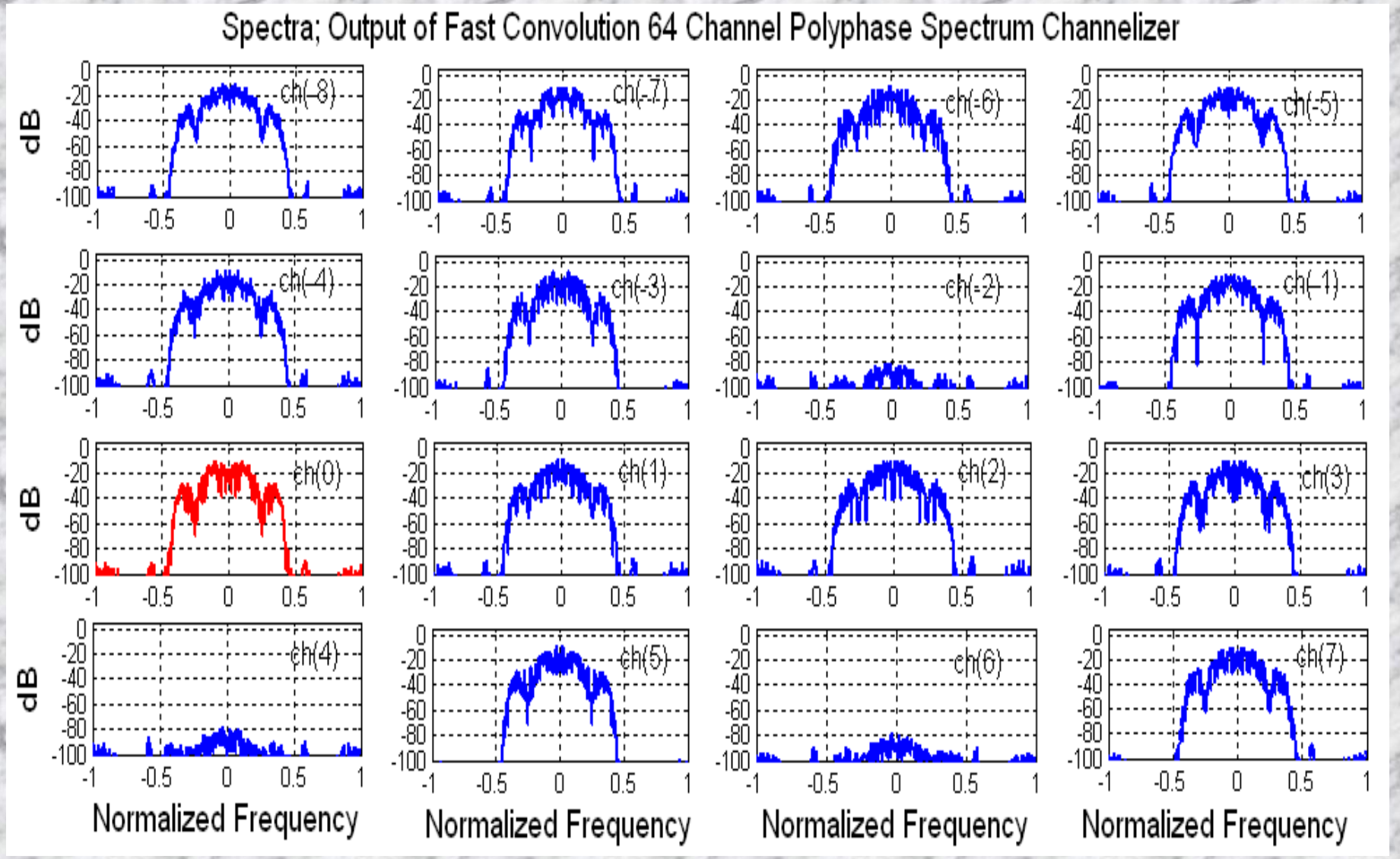
Operating the Polyphase Filter at Half Output Rate Causes the Signal Samples to see two Different Sets of Filter Weights,
A Time Varying Filter.
Fast Convolution Requires
A Time Invariant Filter.

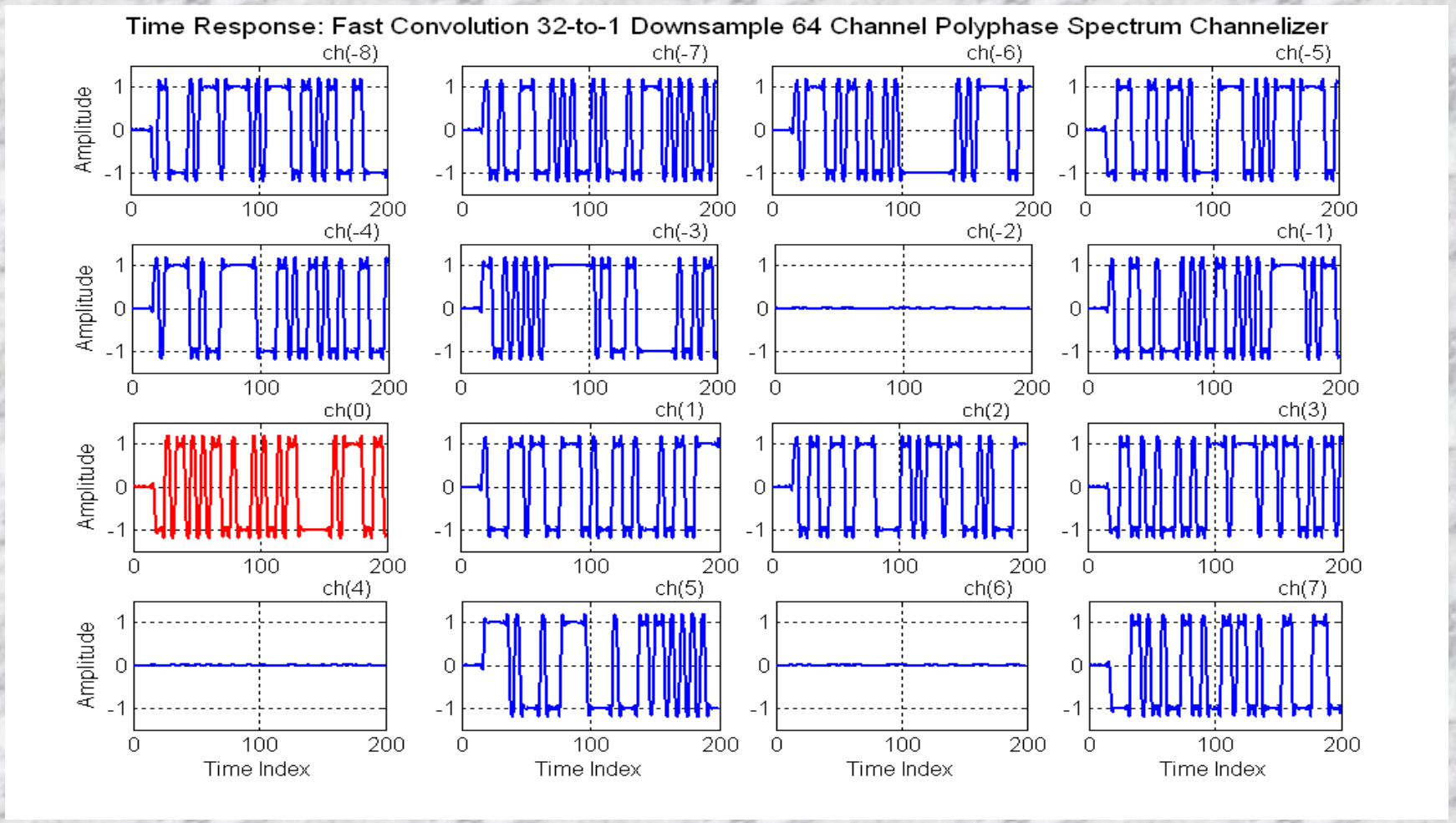
We developed a technique that determines the Filter output at two different half sample Rates, the Even Index Output Samples and the Odd Index Output samples and then Interleave The Two Responses.


A(k)
N-IFFT
a(n)
A(k)
A(k)
2N-IFFT
a(2n)
B(k)
B(k)
2N-IFFT
b(2n)
B(k)
B(k)
2N-IFFT
b(2n+ 1)
e
-j 2π/2N k
A(k)
A(k)
B(k)
B(k)
2N-IFFT
a(2n)+ b(2n+ 1)
e
-j 2π/2N k

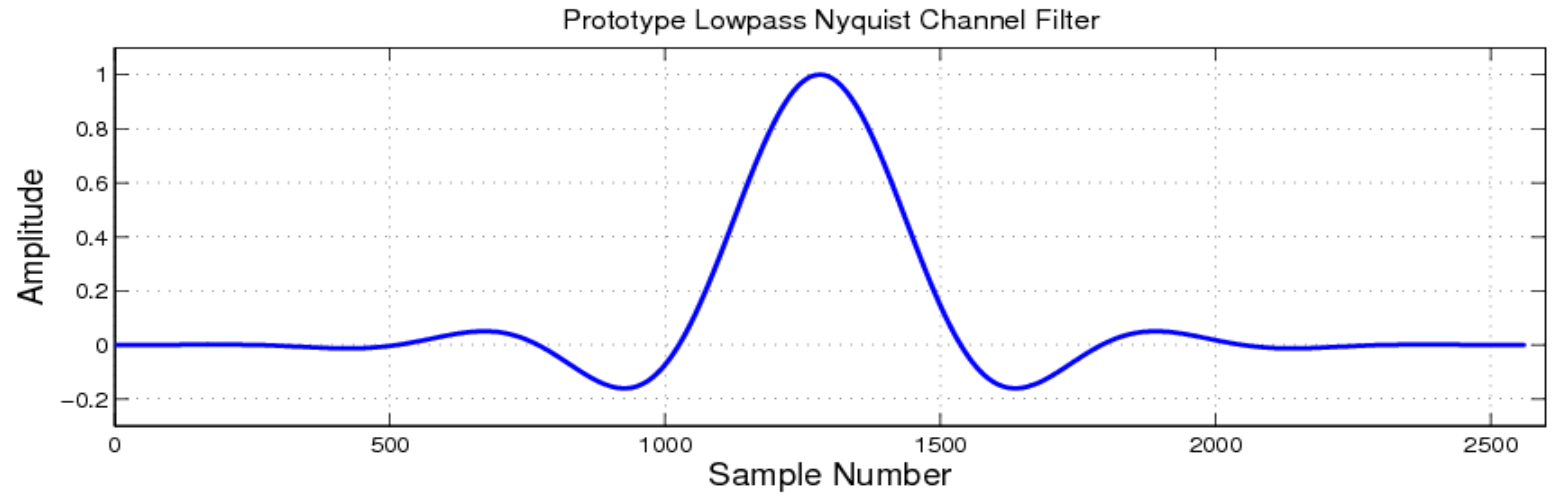

Freq
k
Freq
A(k)
N/2
A(k)+ B(k)e^-j2π/N k
k+ N/2
N
B(k)
N/2
-
e^-j2π/N k
A(k)-B(k)e^-j2π/N k

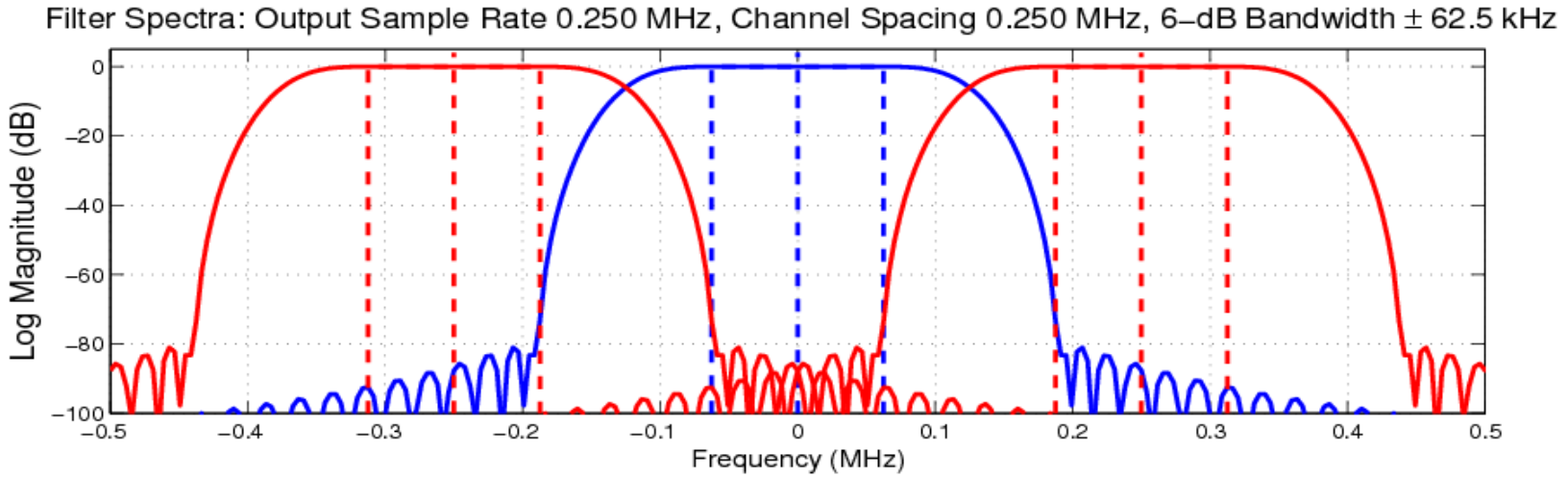
Double Sample Rate Spectra from 16 Channels of 64-Path Polyphase Filter Bank, (32-to-1 Down-Sampling)



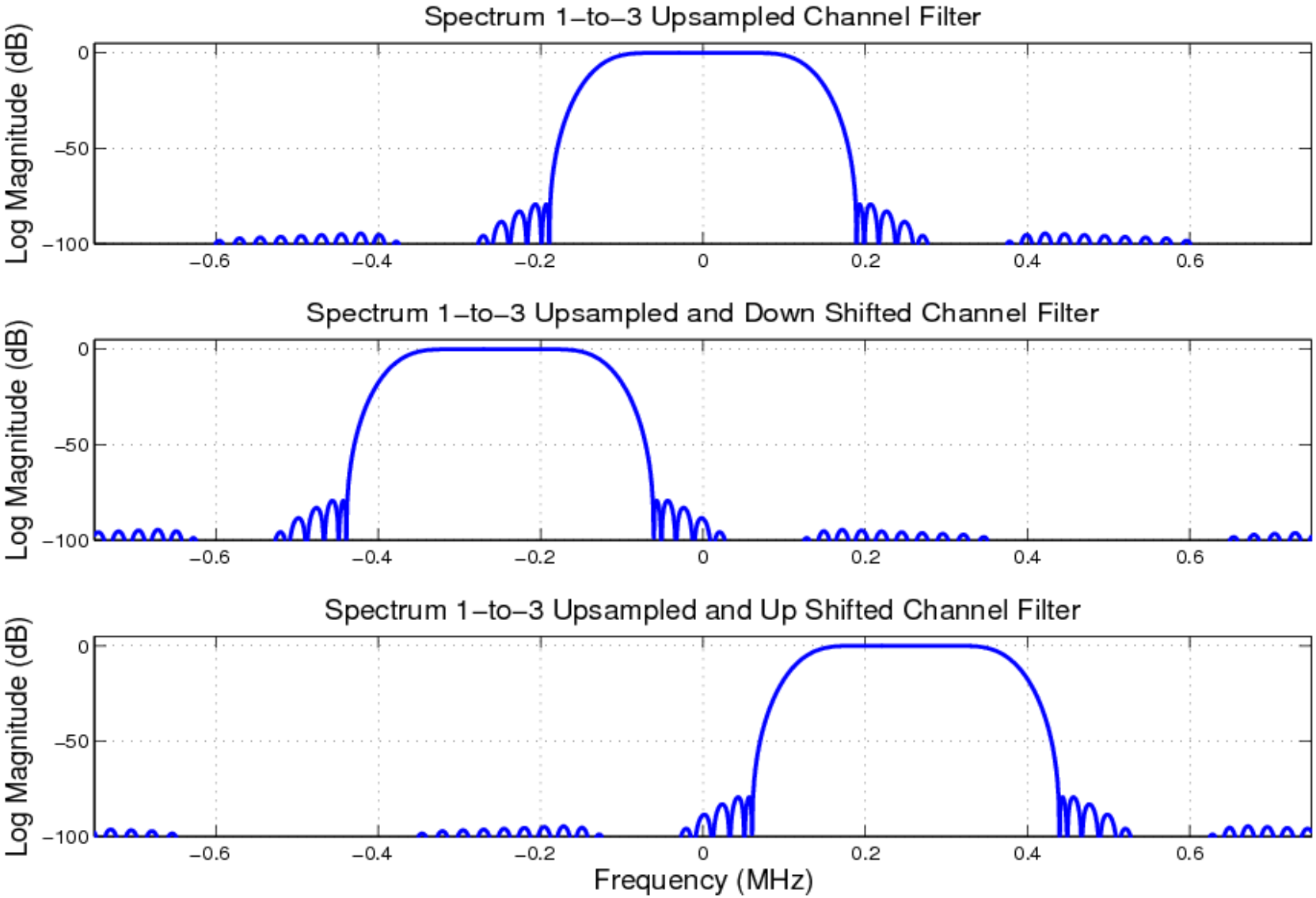

Time Response: Fast Convolution 32-to-1 Downsample 64 Channel Polyphase Spectrum Channelizer
ch(-8)
ch(-7)
ch(-6)
ch(-5)
ch(-4)
ch(-3)
ch(-2)
ch(-1)
ch(0)
ch(1)
ch(2)
ch(3)
ch(4)
ch(5)
ch(6)
ch(7)
Amplitude
Time Index
1
0
-1
0
100
200

Time and Frequency Response of Prototype Low Pass Filter in Channelizer

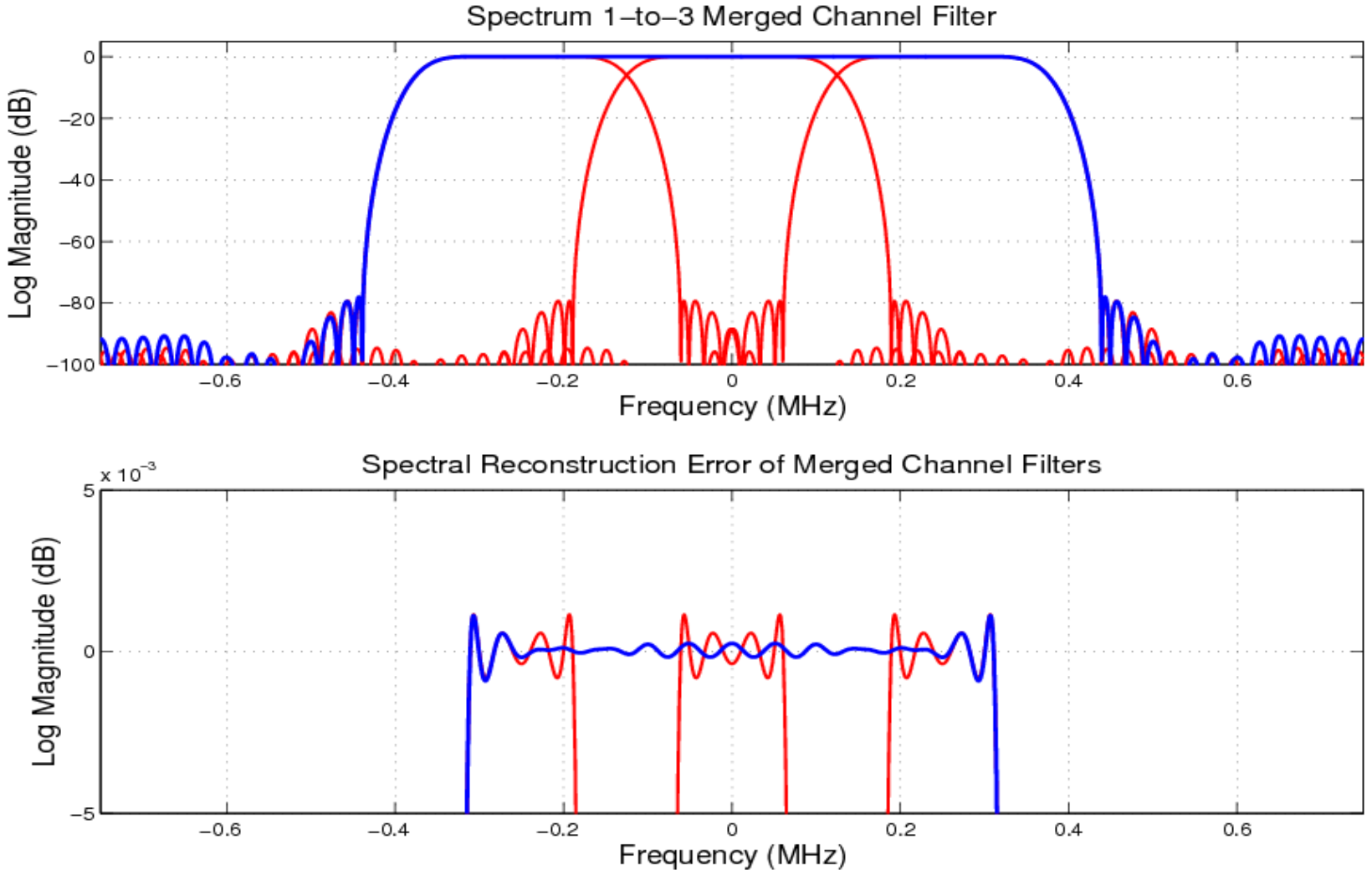




Spectra of three Adjacent Channel Filters: 1-to-3 Up Sampled and Frequency Offset



Sum of three Adjacent Offset Spectra with Zoom to Pass Band Reconstruction Error



We are Open For Questions