Module 6

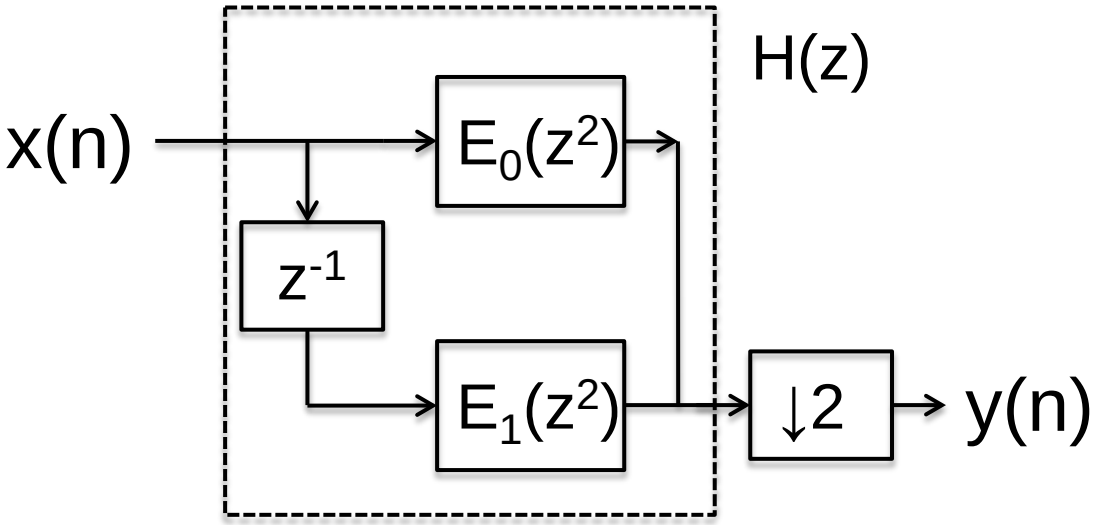
Upsampling and Downsampling, Part I

Overview

- Compressor and expander definitions
- The noble identities
- Polyphase representation
- Efficient structures for decimation and interpolation filters
- MATLAB example

Efficient Structures for Decimation and Interpolation Filters

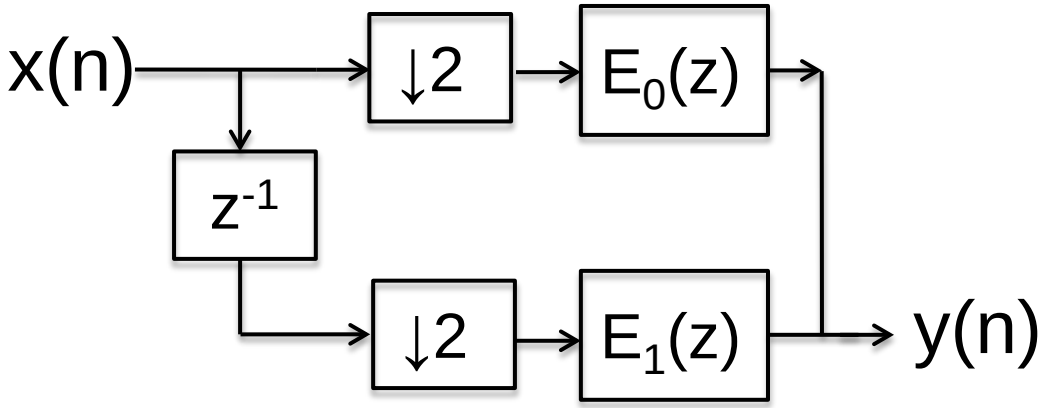
- Example decimation filter (M=2)



In this structure, the polyphase filters E_0 and E_1 are computed at the *input* sample rate.

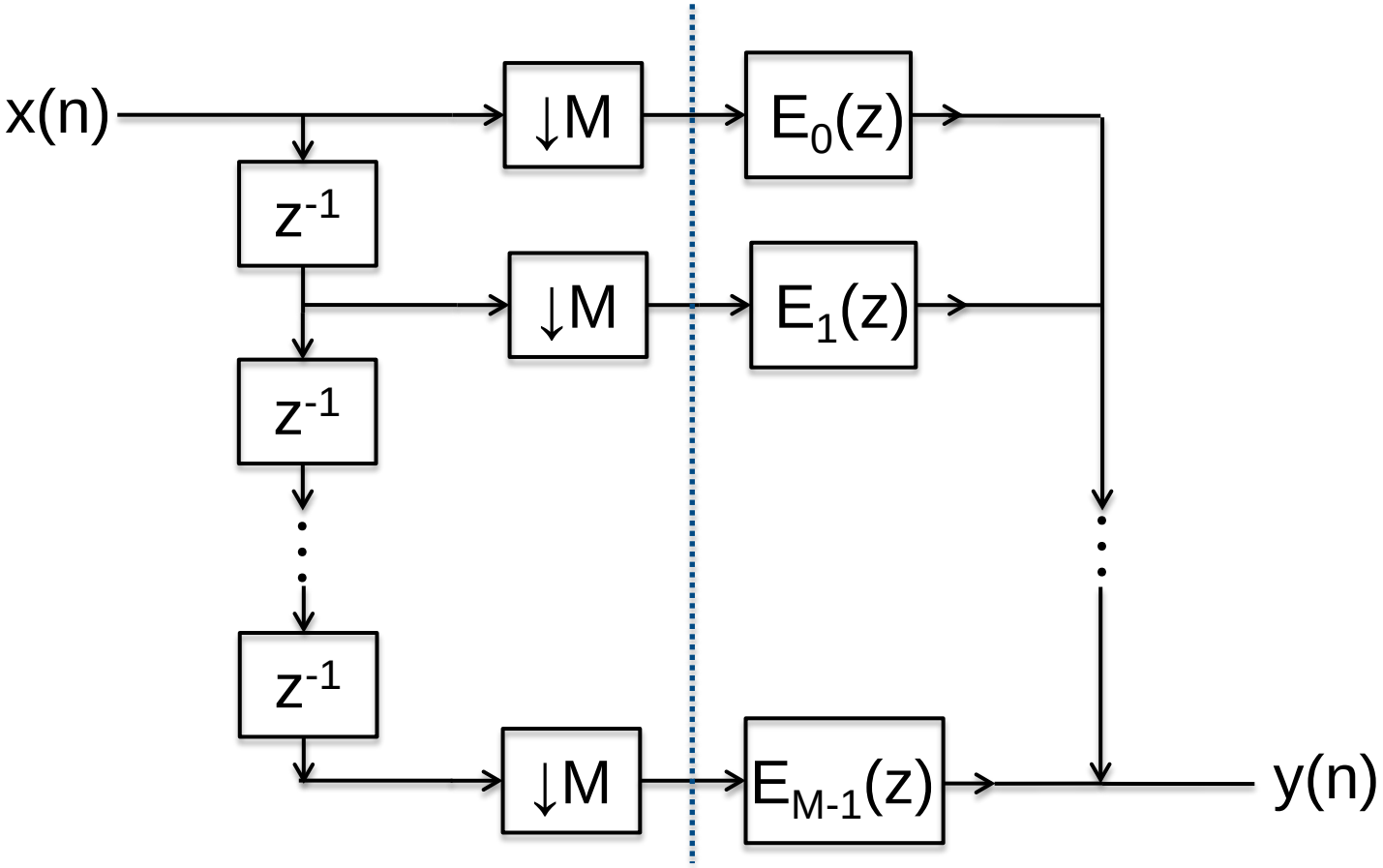
Efficient Structures for Decimation and Interpolation Filters

- By using the noble identity, an equivalent structure can be found

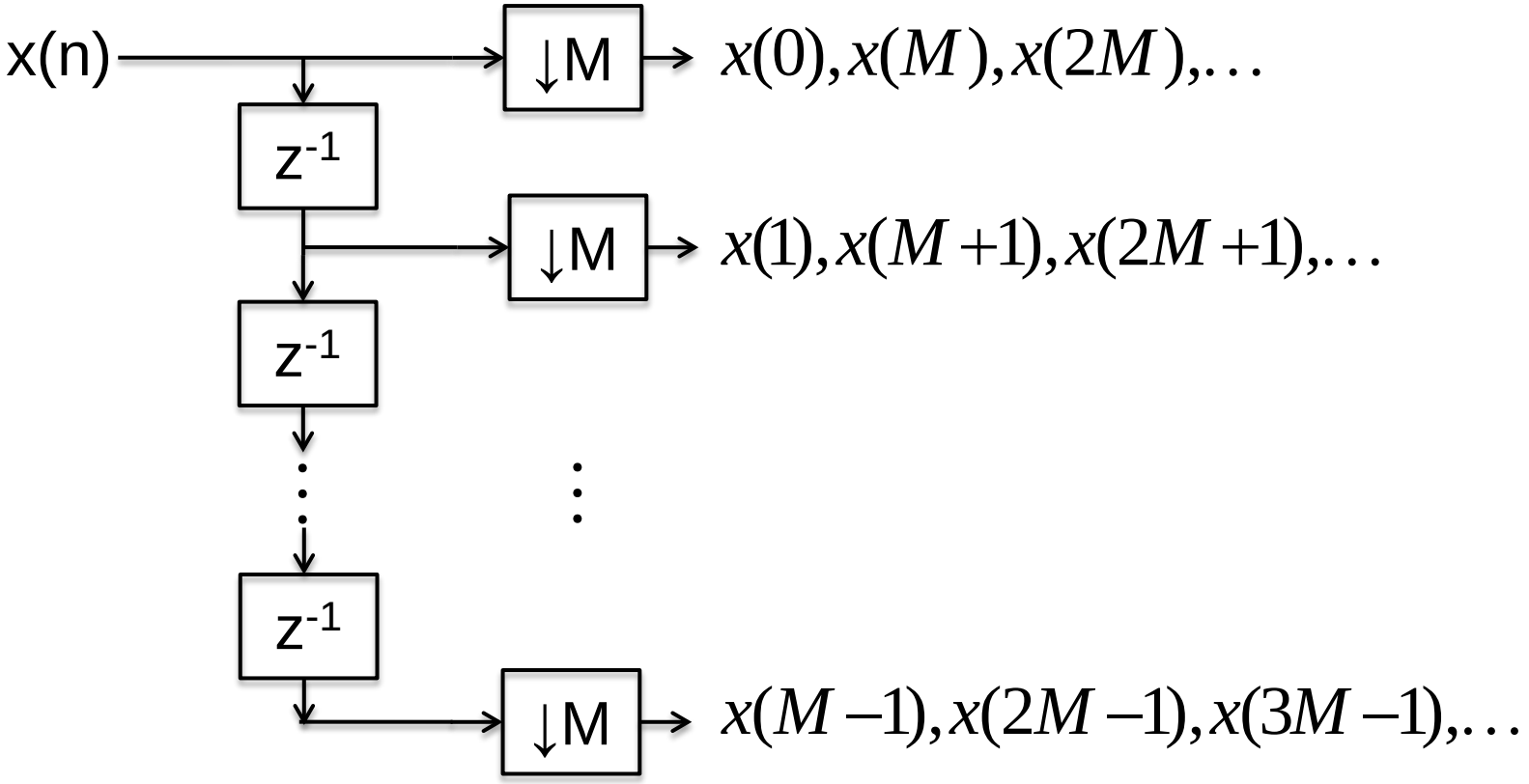


In this structure, the polyphase filters E_0 and E_1 are computed at the *output* sample rate (*i.e.* 2x reduction in computational load).

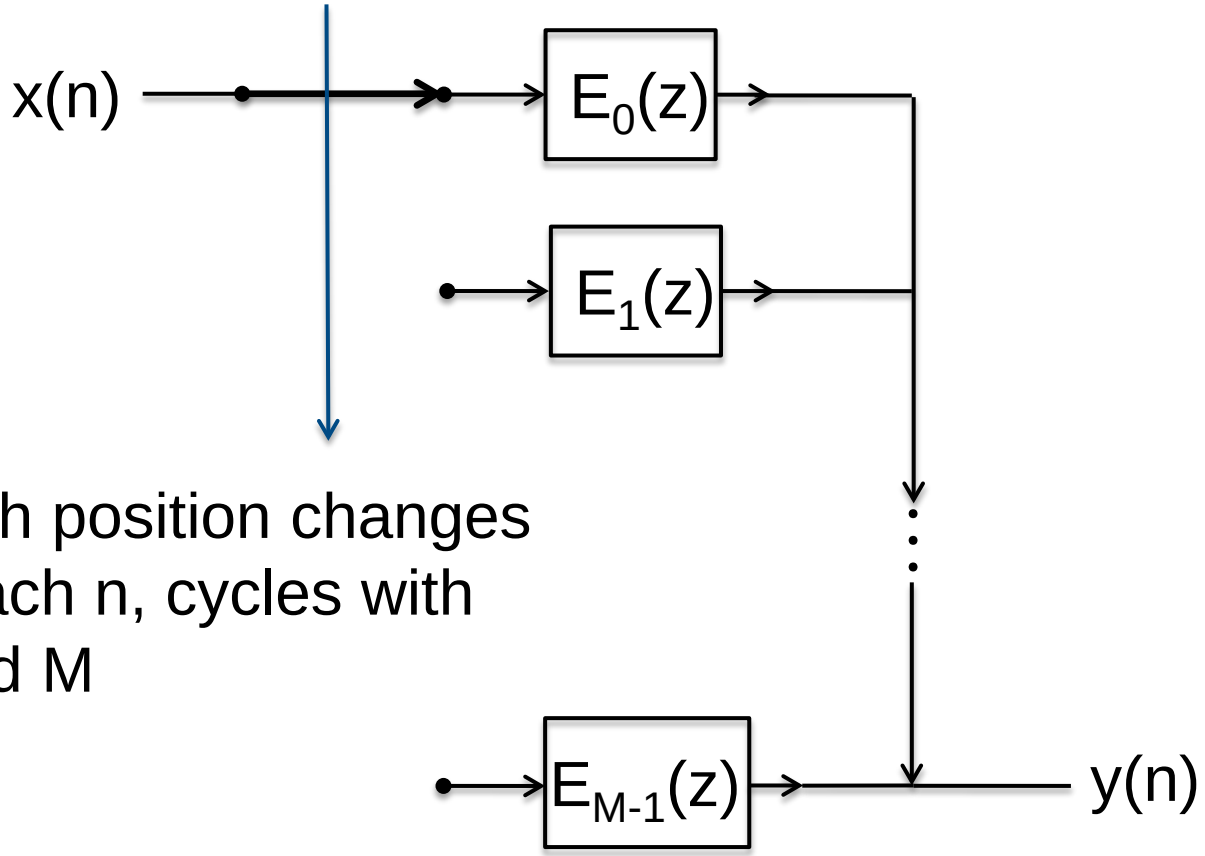
Polyphase M-fold Decimator



Switch Model

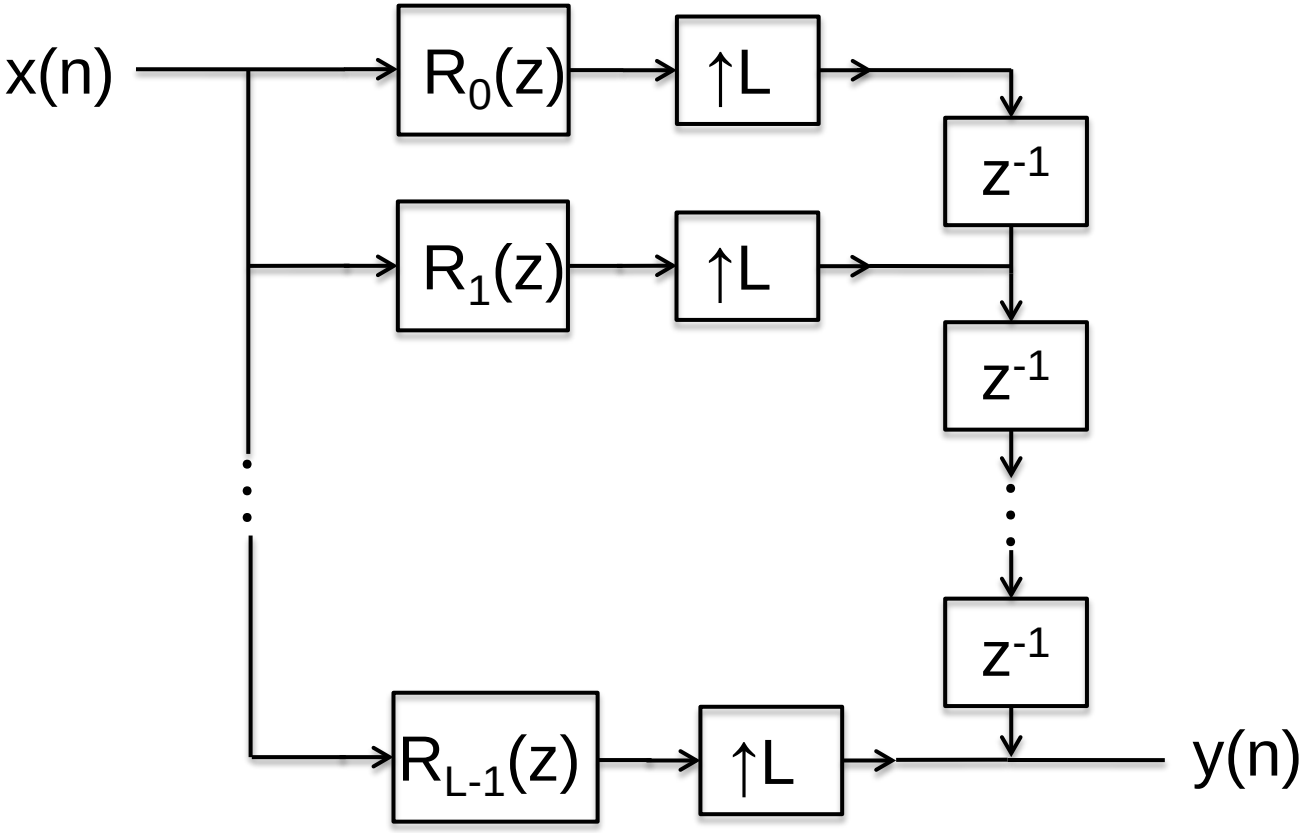


Switch Model



Switch position changes for each n, cycles with period M

Polyphase L-fold Interpolator



Polyphase L-fold Interpolator

- Type II polyphase representation

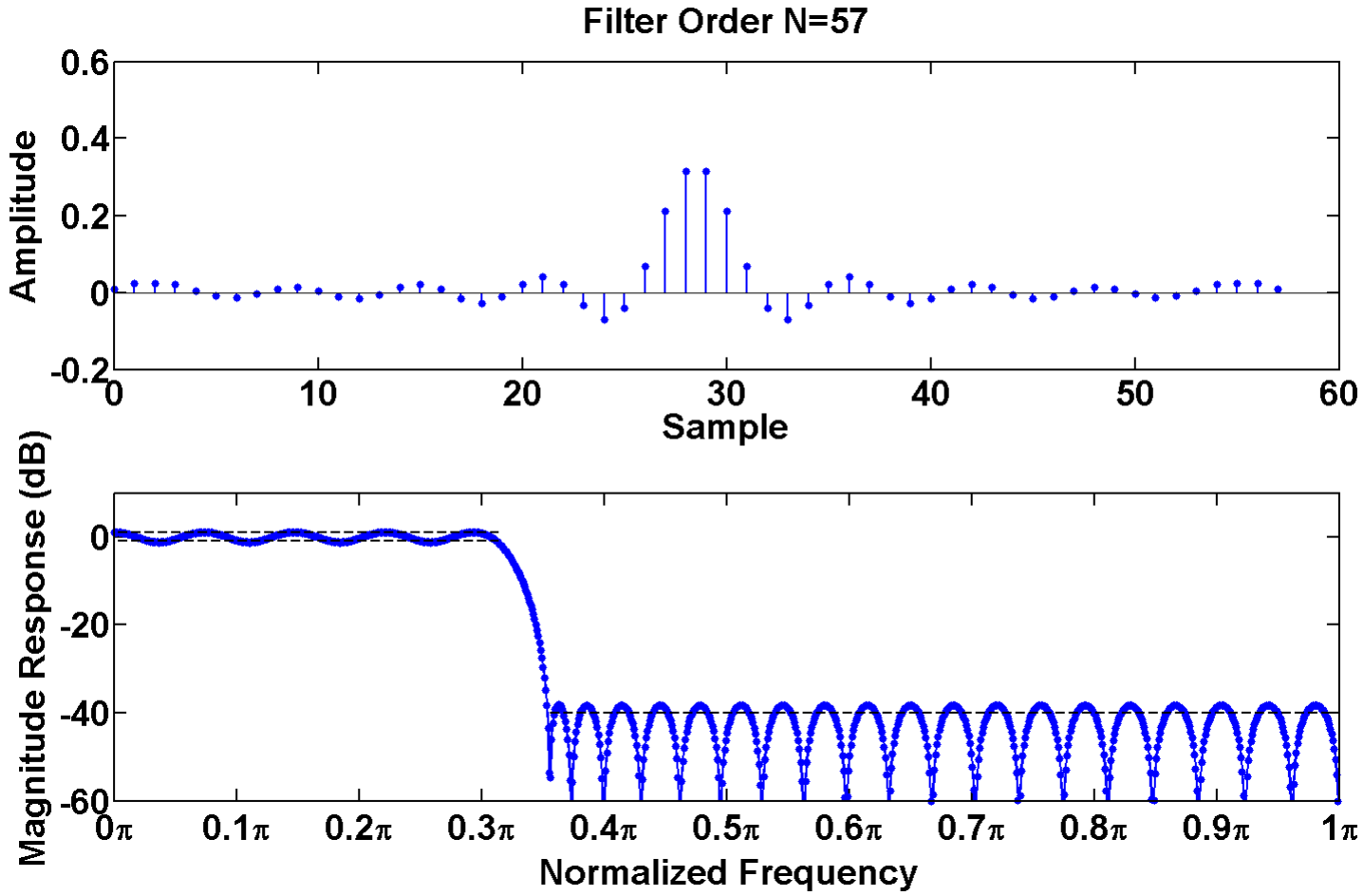
$$H(z) = \sum_{l=0}^{L-1} z^{-(L-1-l)} R_l(z^L)$$

$$R_l(z) = E_{L-1-l}(z) \quad 0 \le l \le L-1$$

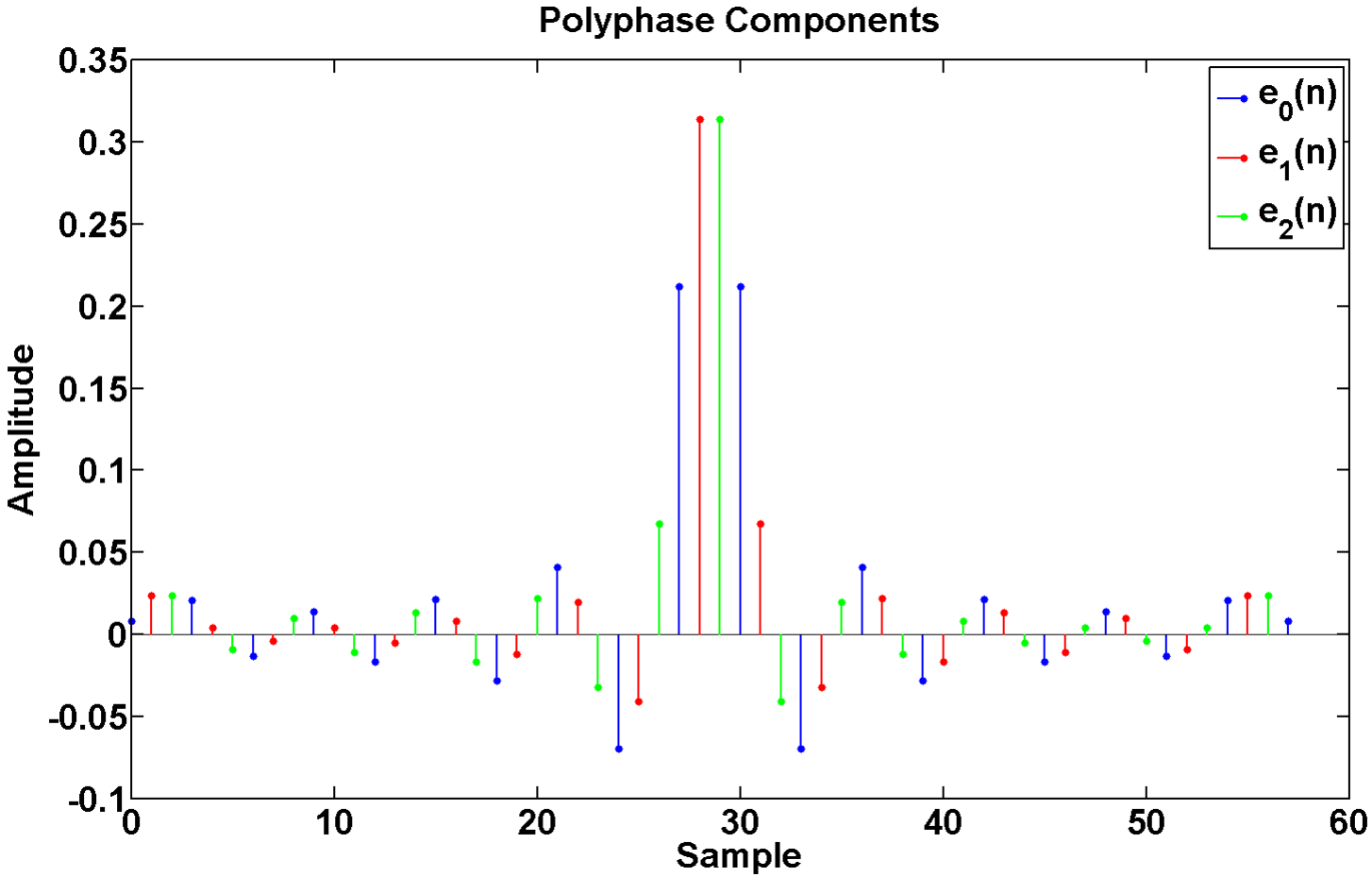
Numerical Example

- Design a lowpass decimation filter using the Parks-McClellan algorithm for M=3 and find the Type I polyphase components. The filter specifications are:
  - o $\omega_p = \pi/M - \Delta\omega$, $\omega_s = \pi/M + \Delta\omega$, $\Delta\omega = \pi/50$
  - o A_p = 1dB, A_s = 40dB

Numerical Example



Numerical Example



Numerical Example