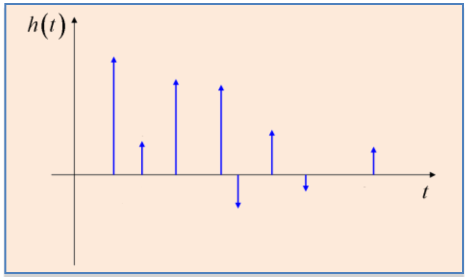
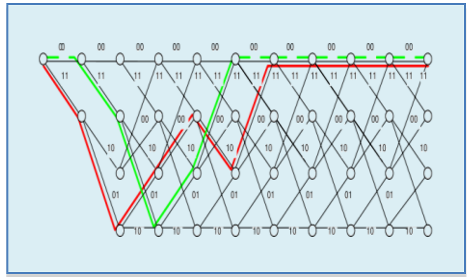
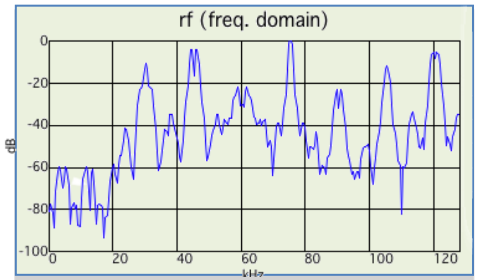
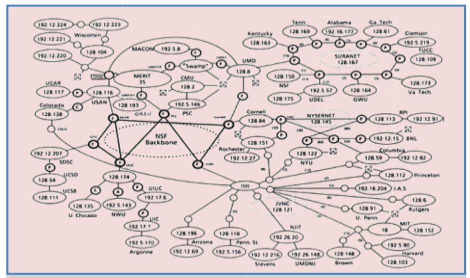




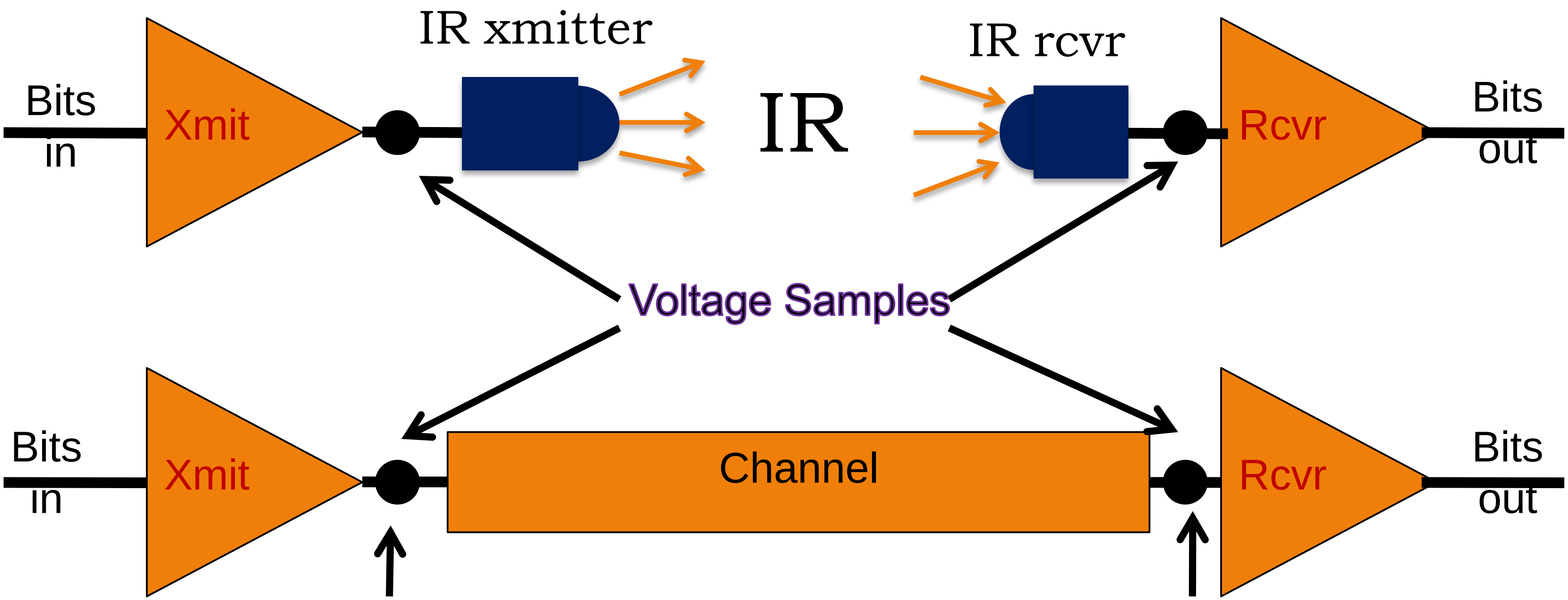
INTRODUCTION TO EECS II

DIGITAL COMMUNICATION SYSTEMS

6.02 Fall 2010
Lecture #3

- Good Channel → Eye's wide open
- LTI Channel ⇔ Convolution with Unit Sample Response
- Use USR to Deconvolve: Bad Channel → Good Channel
- Deconvolution and Noise

Bits → Samples {X} → Channel → Samples {Y} → Bits

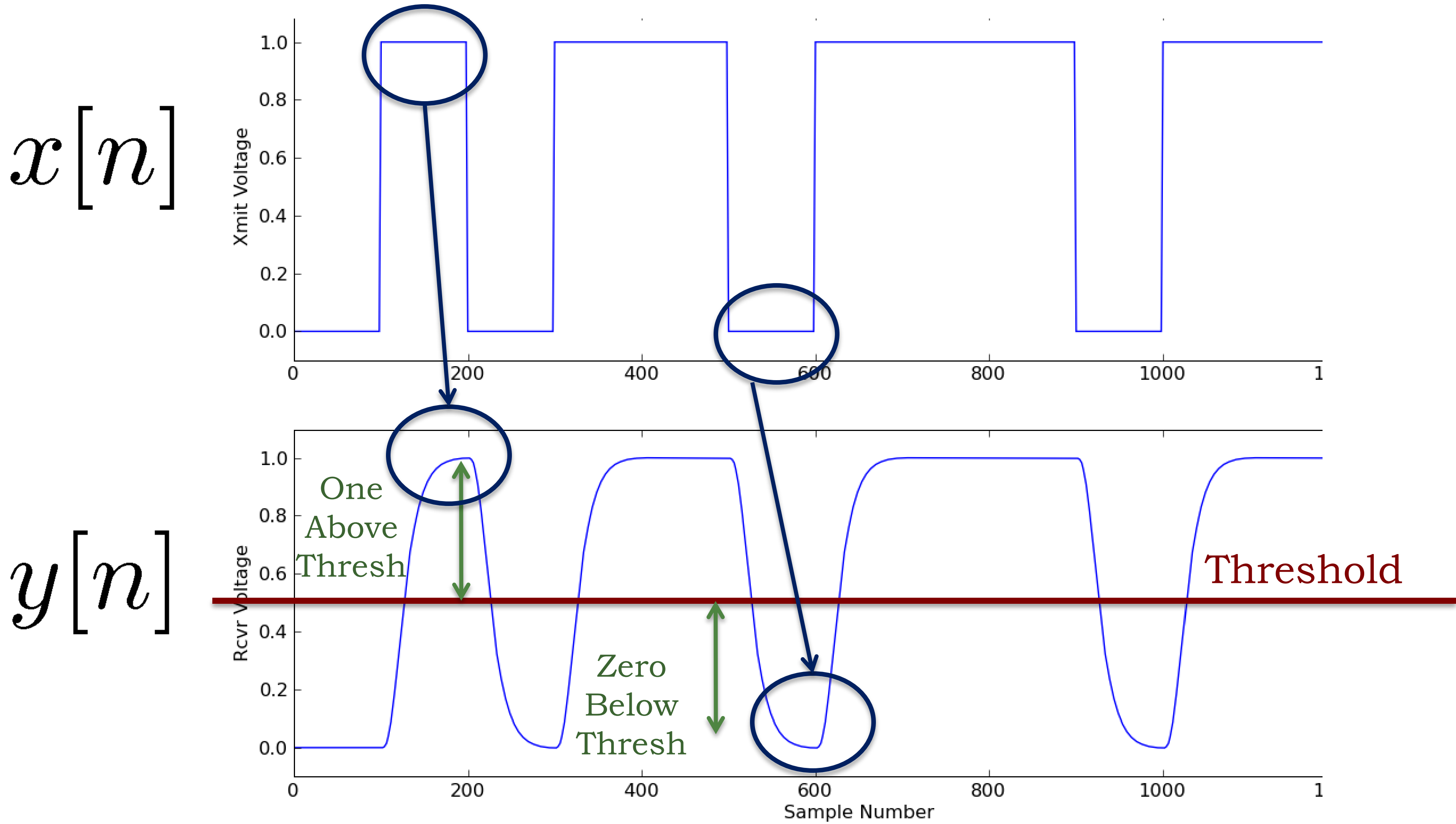


$$X \equiv \text{entire sequence}$$
$$x[n] \equiv n^{th} \text{ sample value}$$

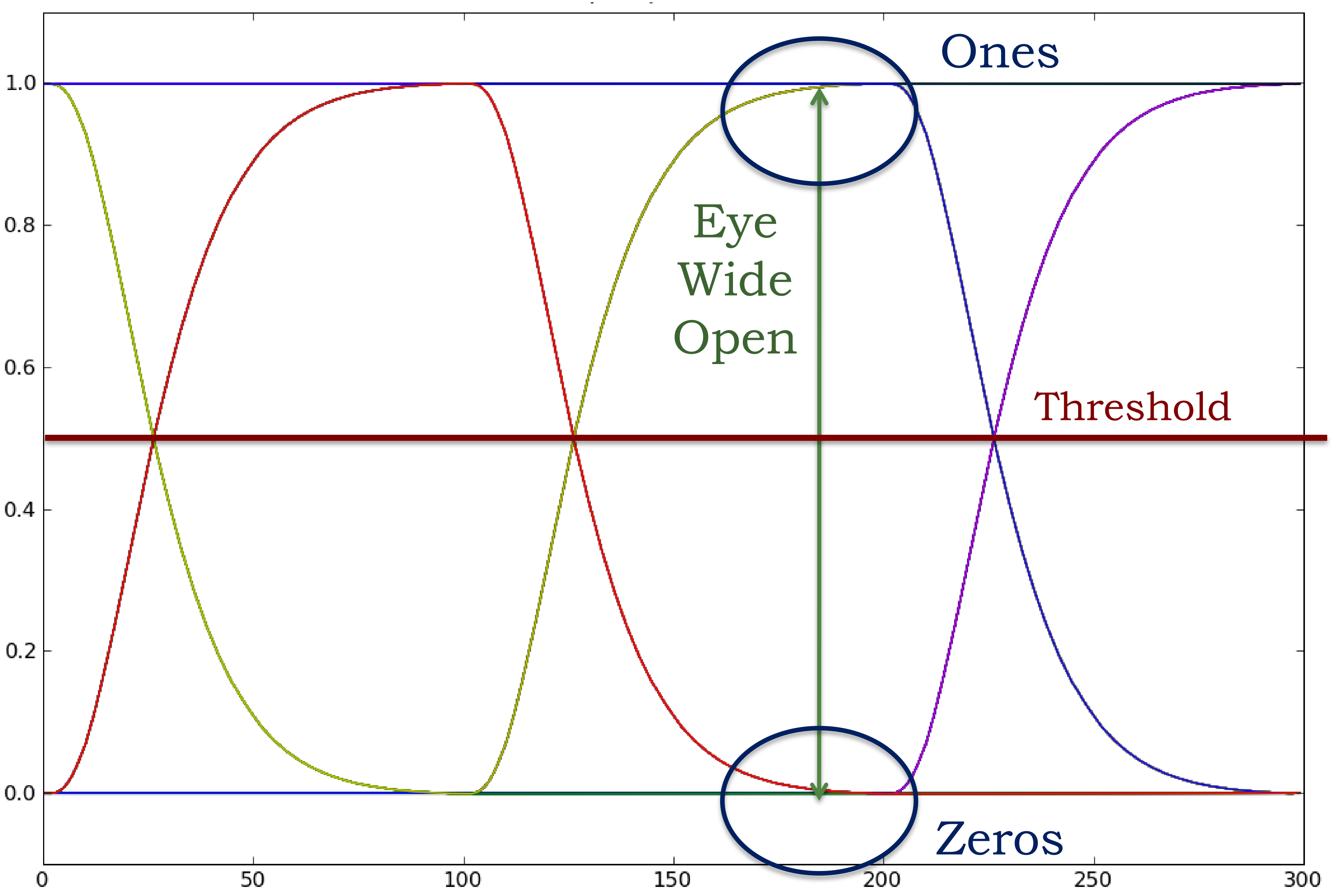
$$Y \equiv \text{entire sequence}$$
$$y[n] \equiv n^{th} \text{ sample value}$$

Sample Rates:
- 4 million Samples/Second (IR Transceiver)
- Up to gigaSamples/Second (Fastest)

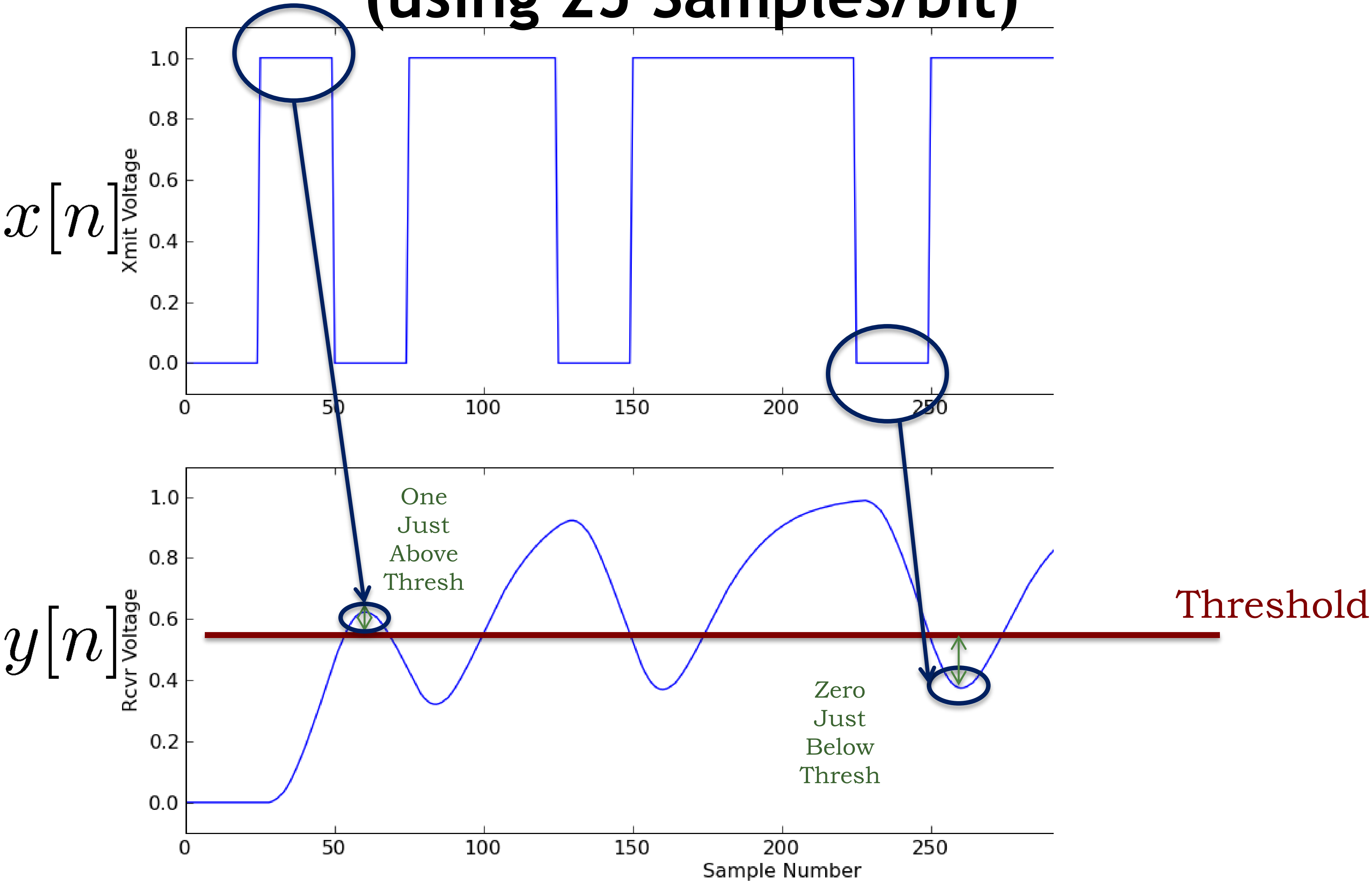
Excellent Channel Transmission (using 100 Samples/bit)



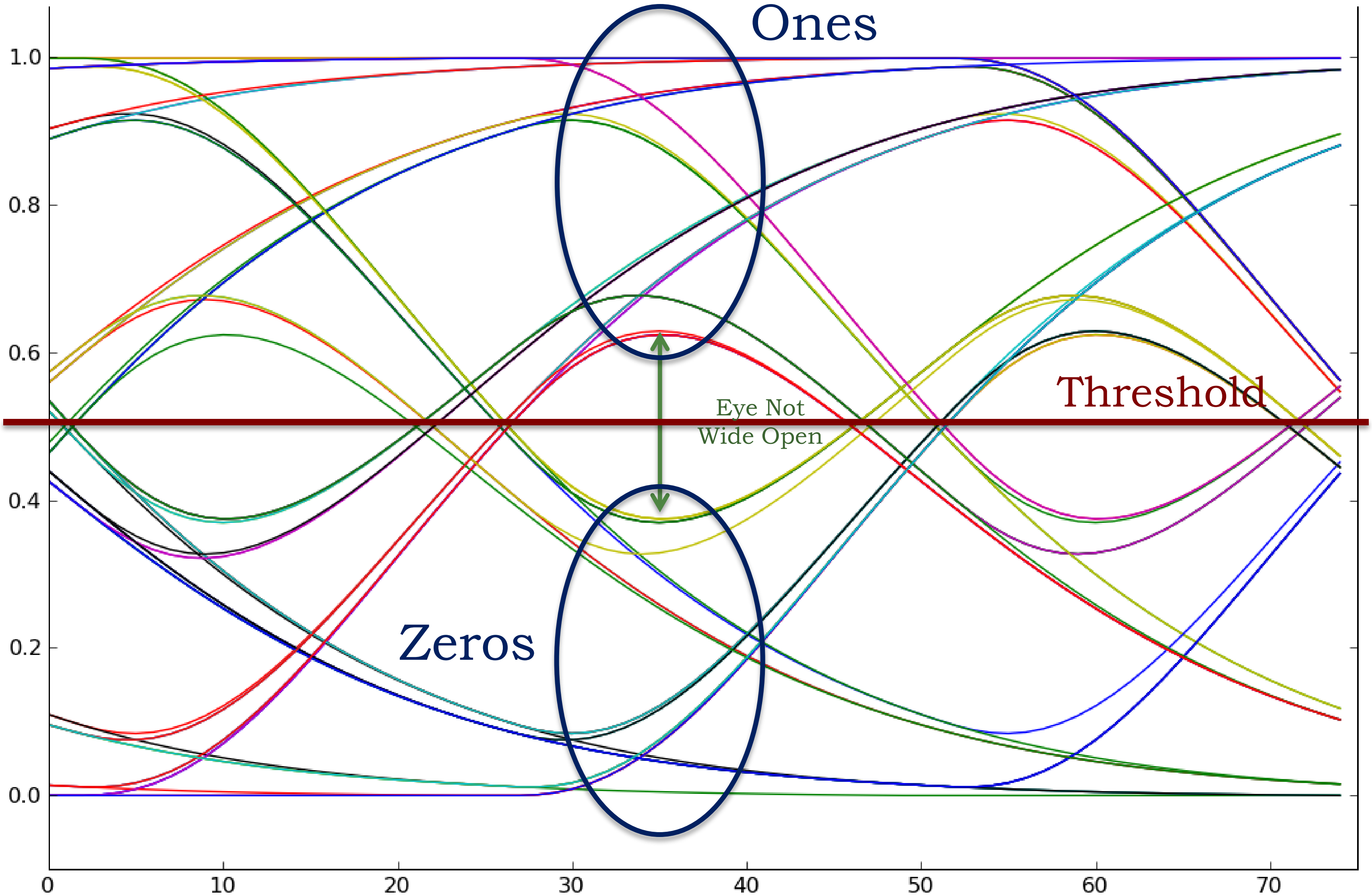
Excellent Channel Transmission Eye Diagram



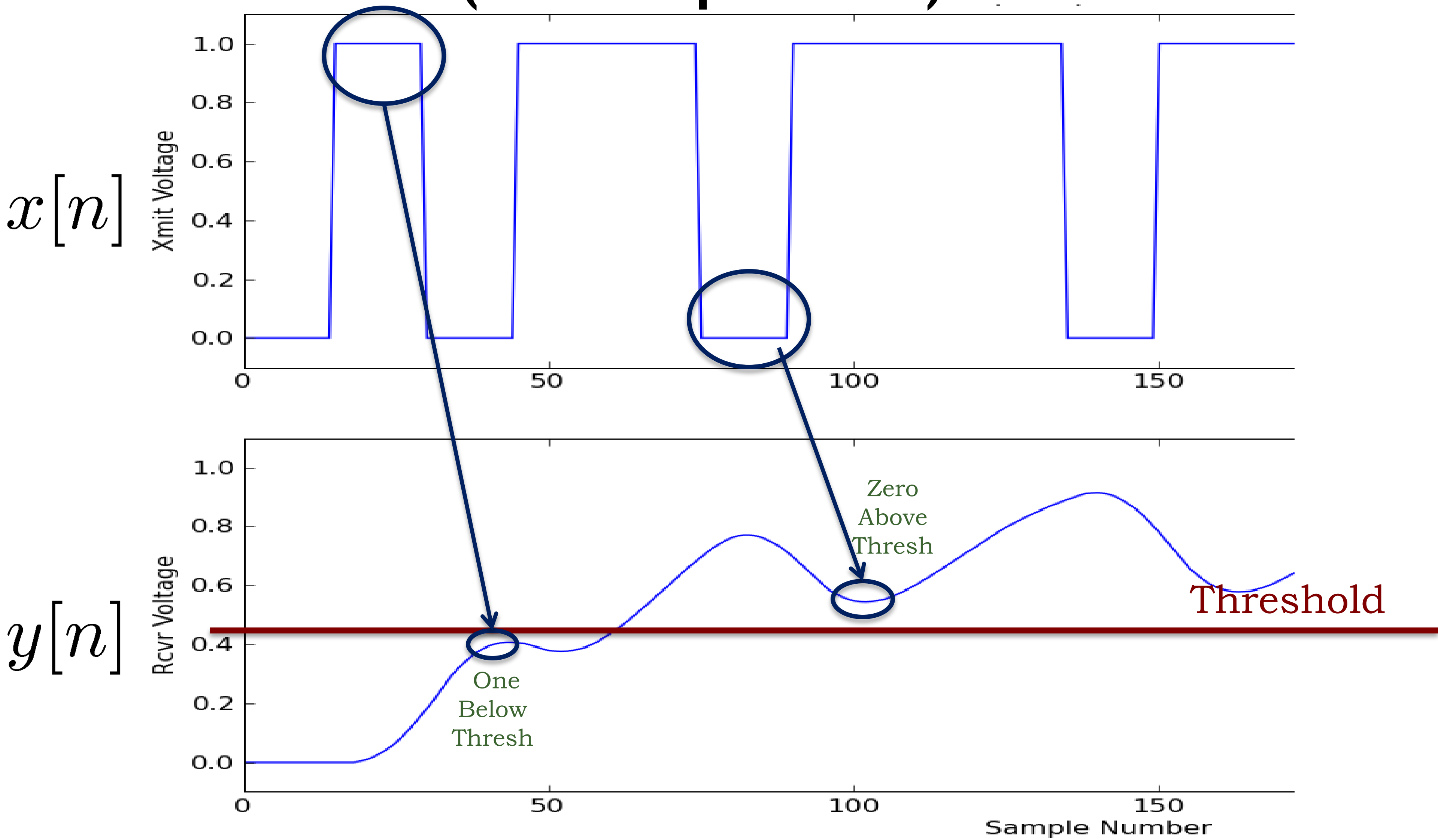
Okay Channel Transmission (using 25 Samples/bit)



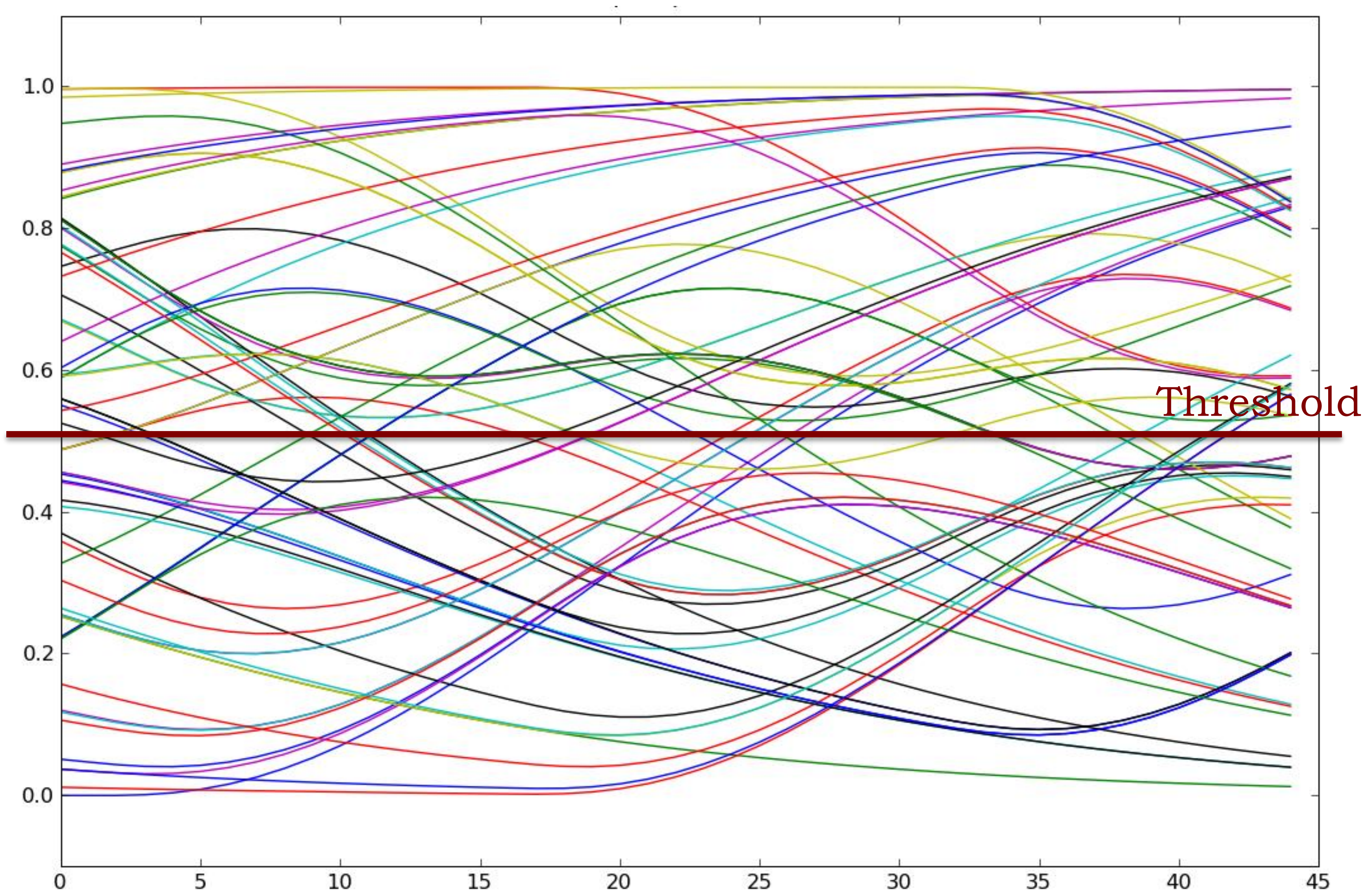
Okay Channel Transmission Eye Diagram



Unusable Channel Transmission (15 Samples/bit)



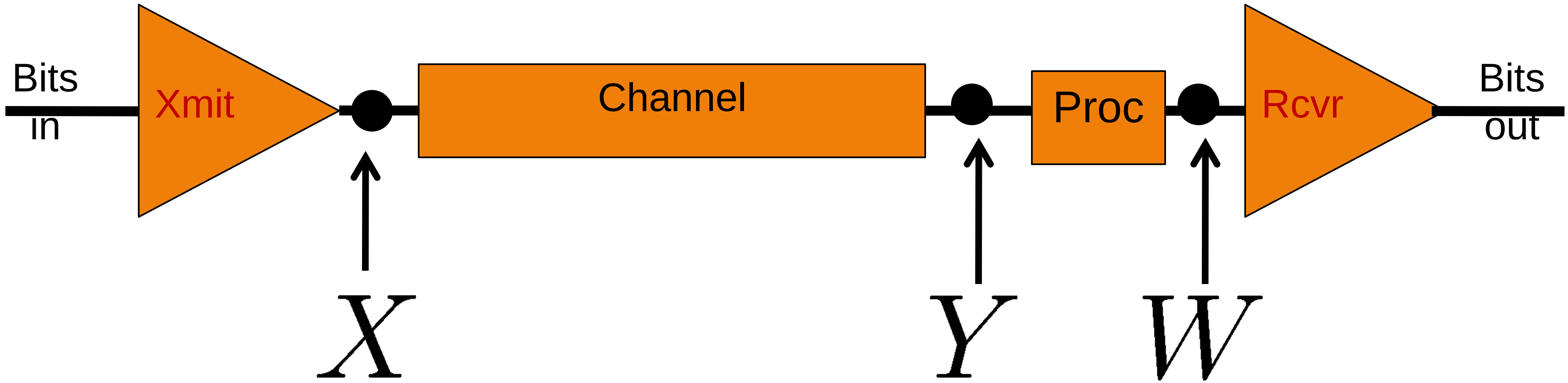
Unusable Channel Transmission Eye Diagram

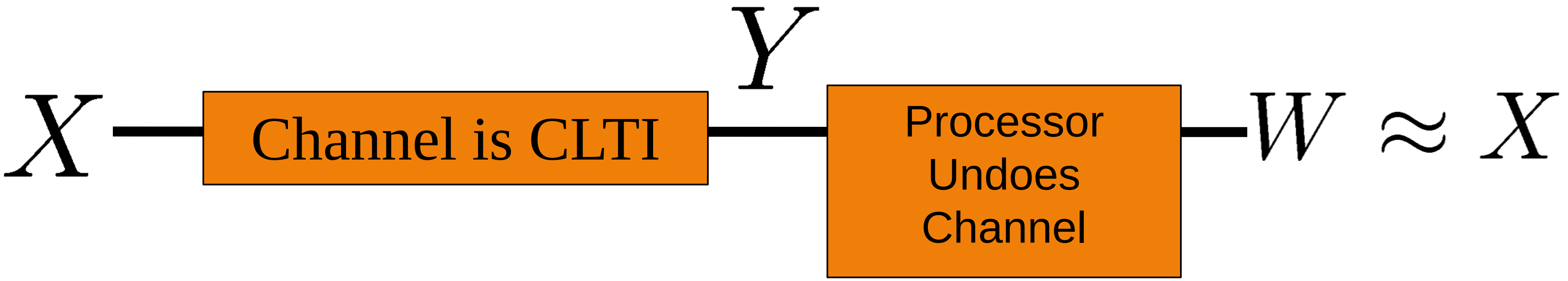


What does an Eye Diagram Tell You?

- How many samples to use per bit
  - More samples/bit:
    - More open eye → Easier detection
    - Fewer bits/second → Slower bit rate
- Where to put the 1-0 threshold
  - The threshold should evenly divide the upper and lower parts of the eye.
- How to estimate errors
  - Next Week.

Faster Bit Rate with Post-Channel Processing?



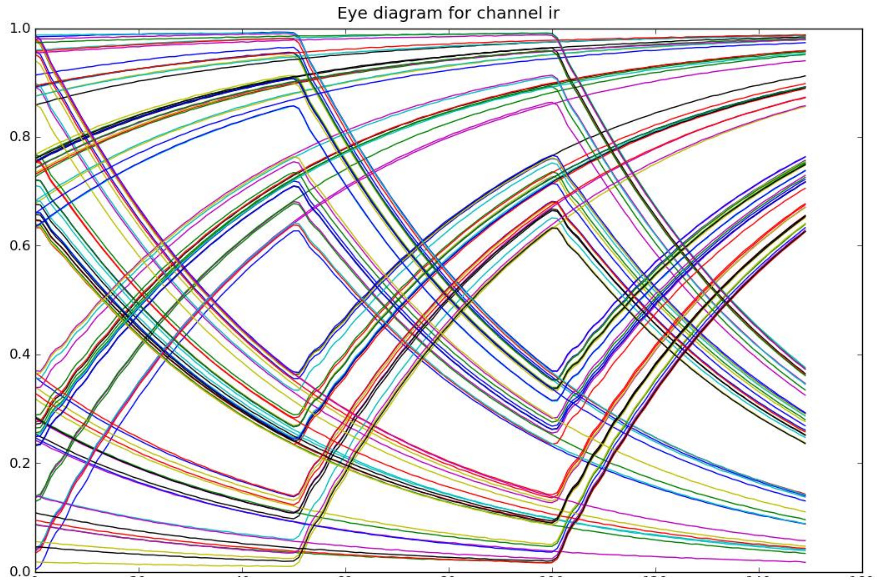


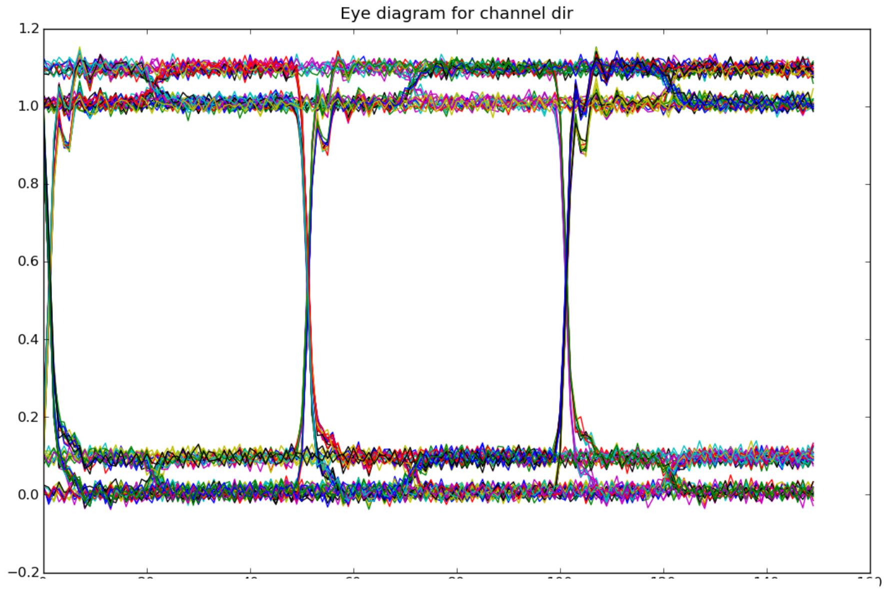
- Model Wire as Causal, Linear Time-Invariant (CLTI)
- Use Unit Sample Response to Undo Channel Effects

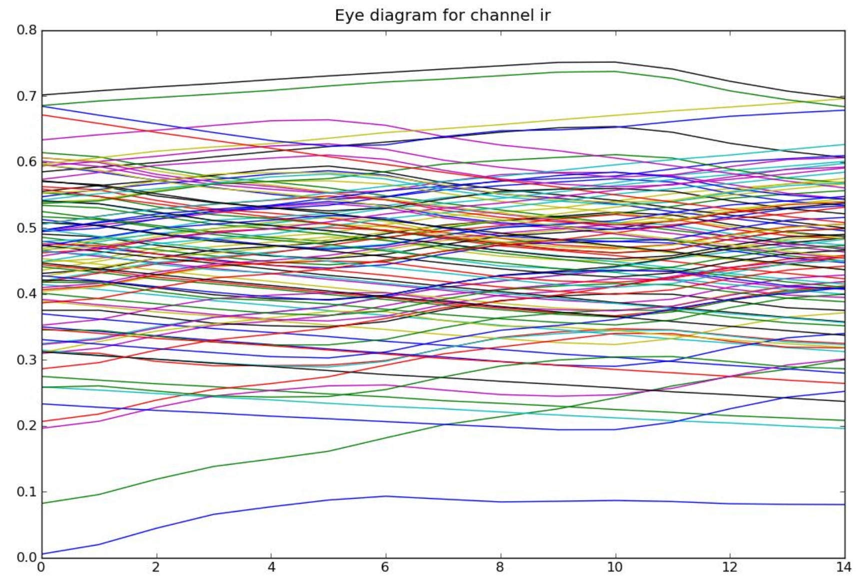
A Glimpse at IR Channel Results

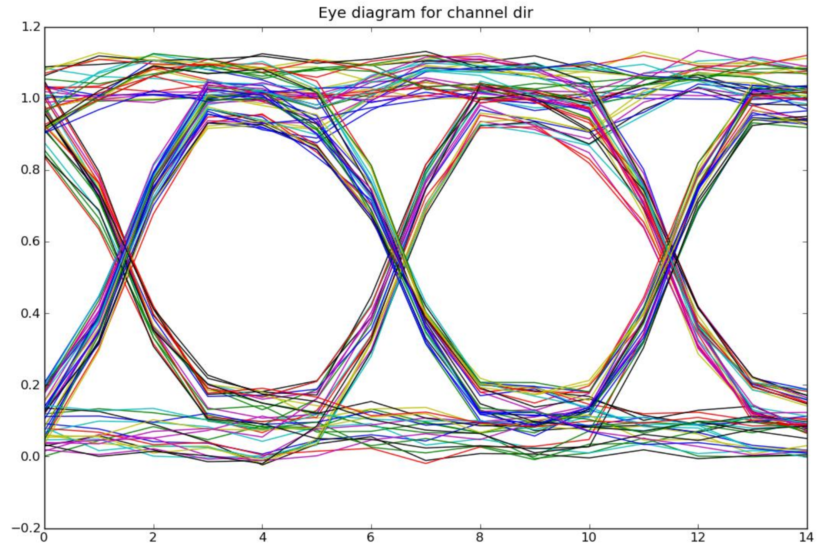
Eye Diagram No Deconvolution

Eye Diagram with Deconvolution







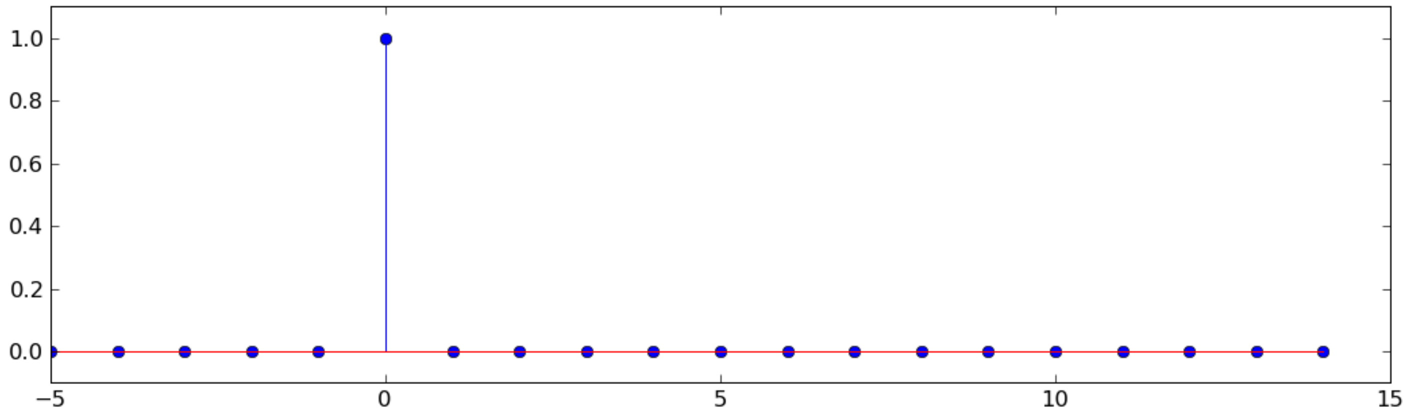


Causality, Time-Invariance and Linearity

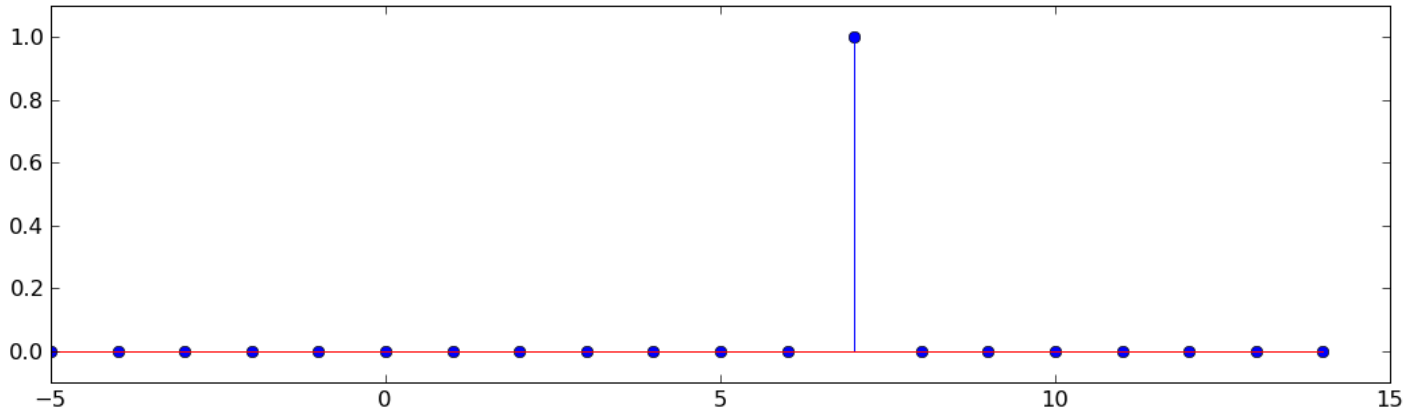
- Causality (out does not change before in)
  - If $x[n] = x[-\infty]$ for $n < N$
    - Then $y[n] = y[-\infty]$ for $n < N$.
- Time-Invariance (out shifts when in shifts)
  - If $in = x[n]$ → $out = y[n]$
    - Then $in = x[n-k]$ → $out = y[n-k]$
- Linearity
  - If $in = x_a[n]$ → $out = y_a[n]$, $in = x_b[n]$ → $out = y_b[n]$
    - Then $in = Ax_a[n] + Bx_b[n]$ → $out = Ay_a[n] + By_b[n]$

Unit Sample Reminder

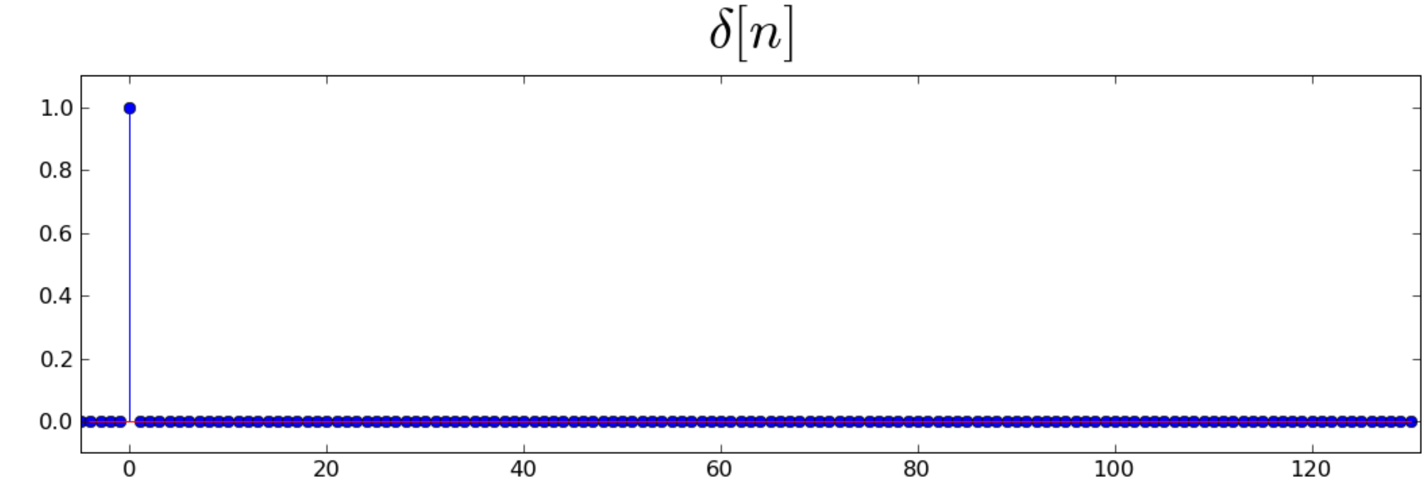
$\delta[n]$

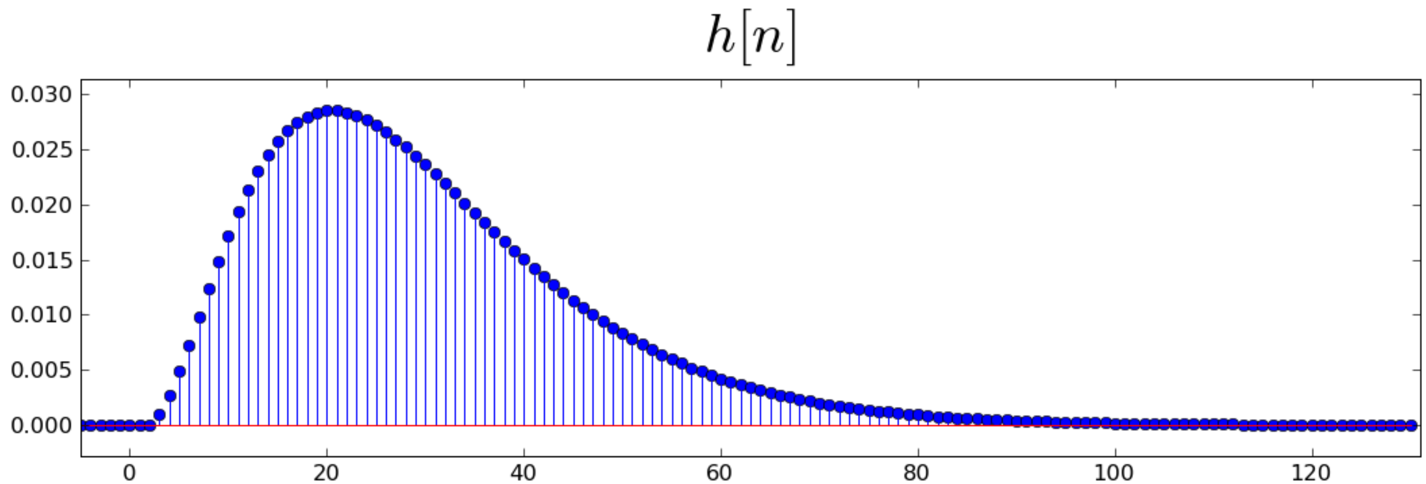


$\delta[n-7]$



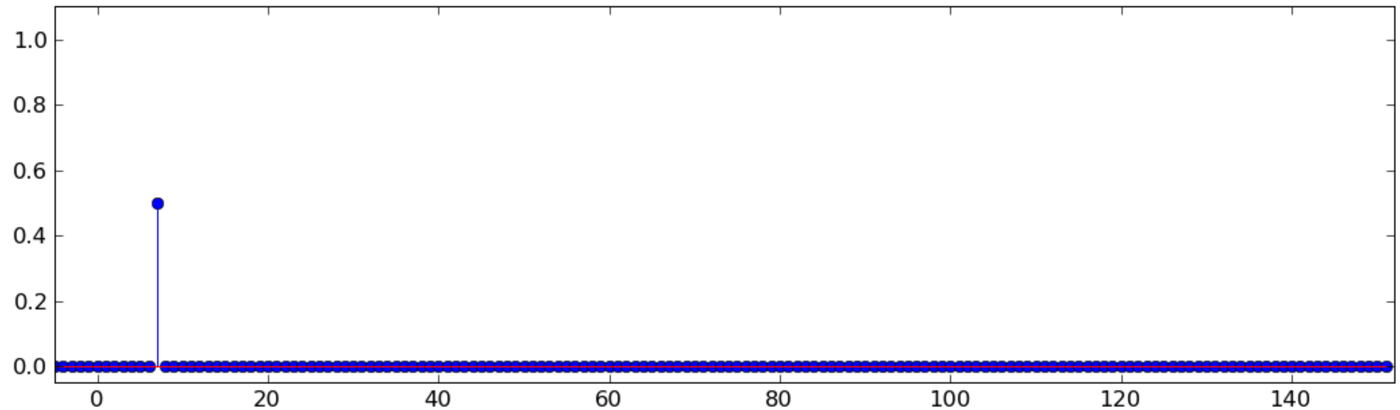
Unit Sample Response (slow wire)



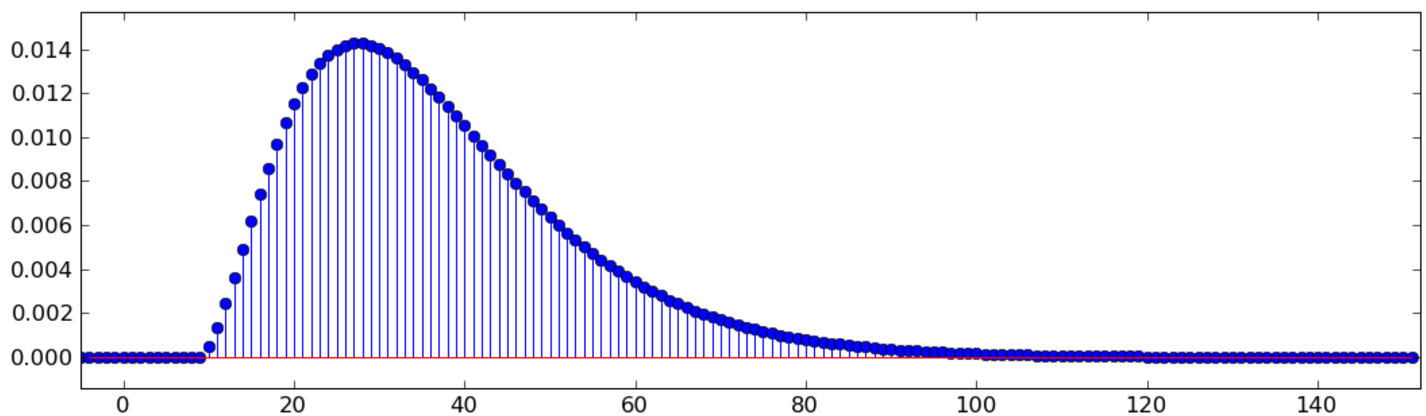


Shifted and Scaled Unit Sample Response

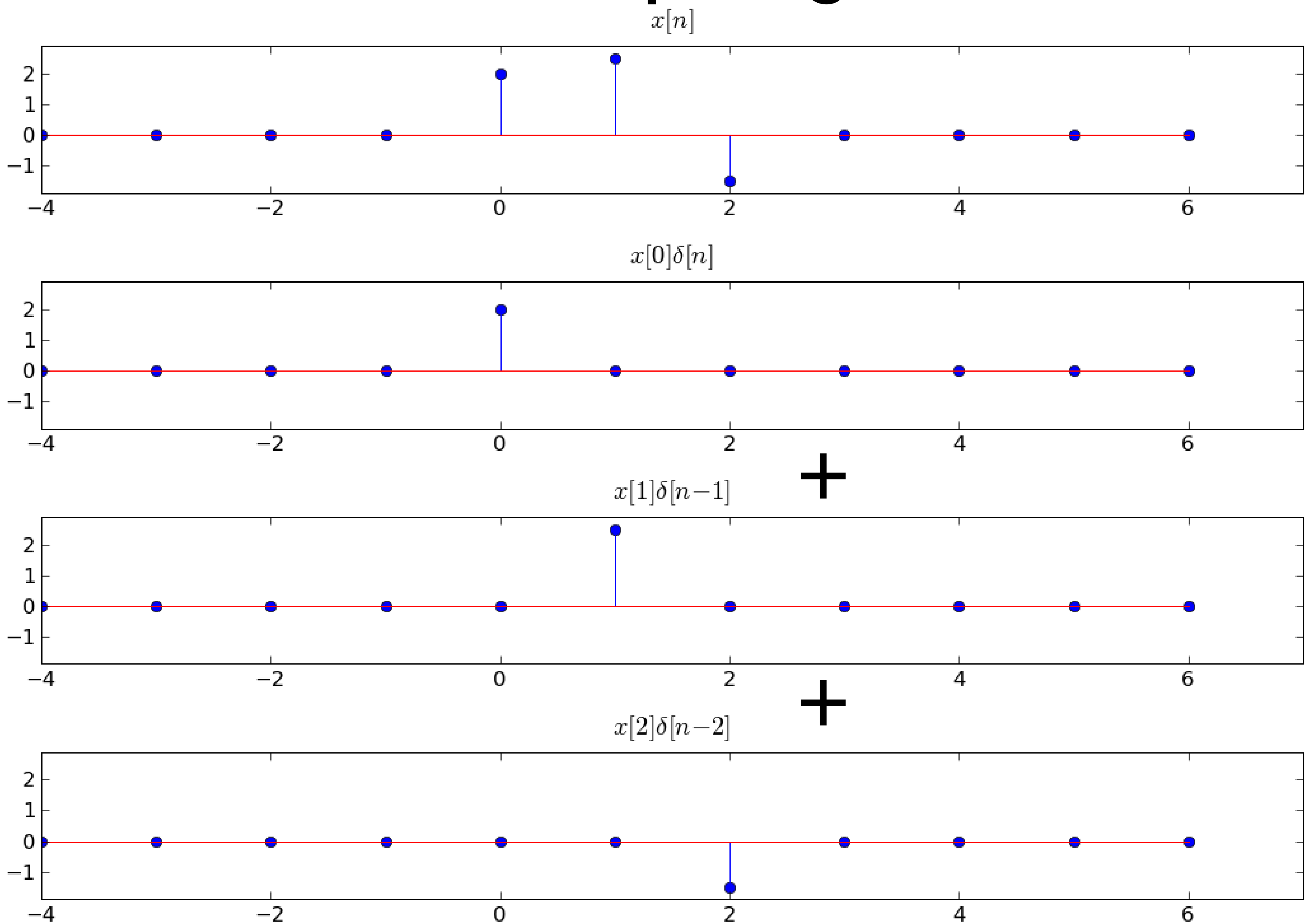
$0.5\delta[n-7]$



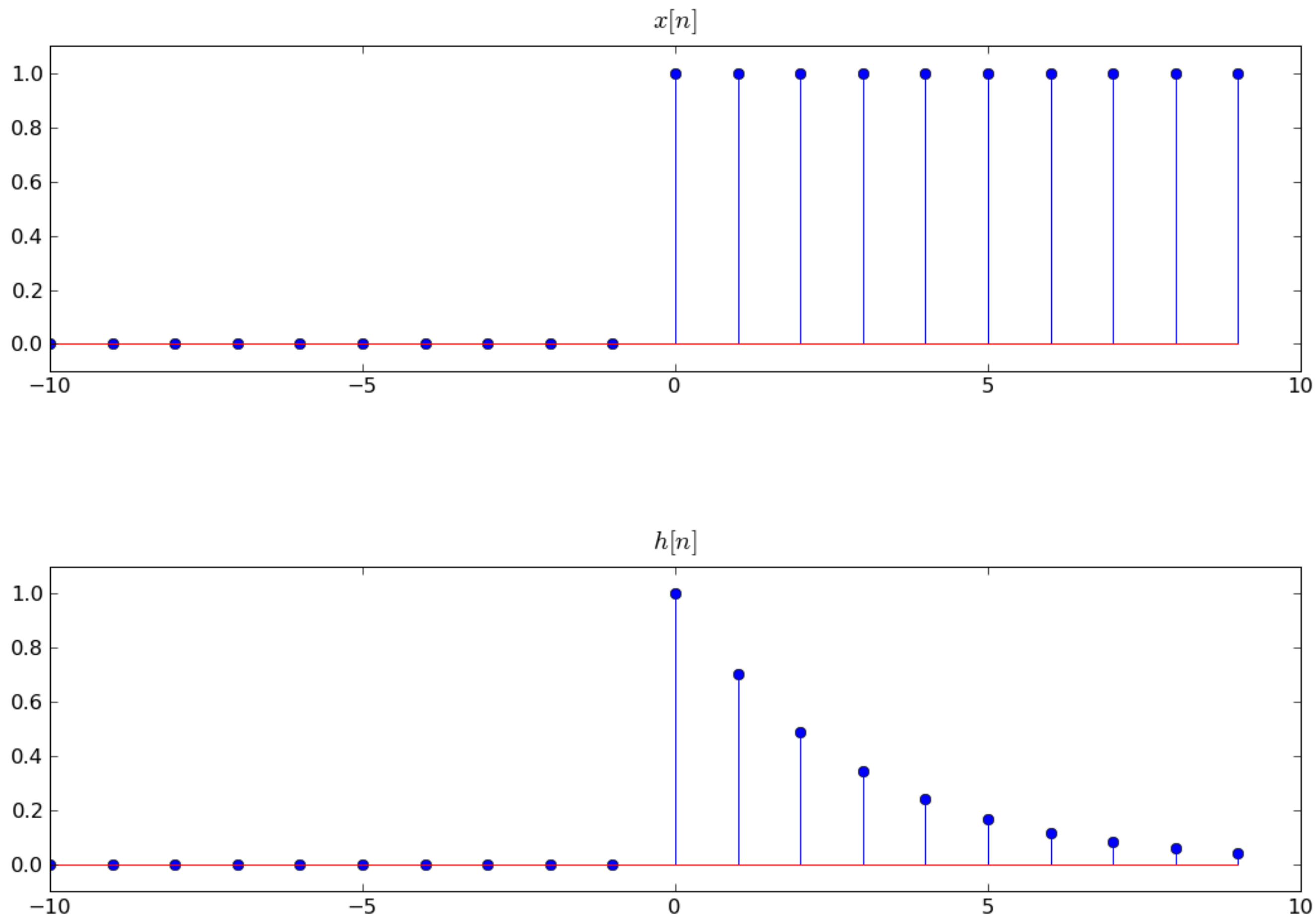
$0.5h[n-7]$



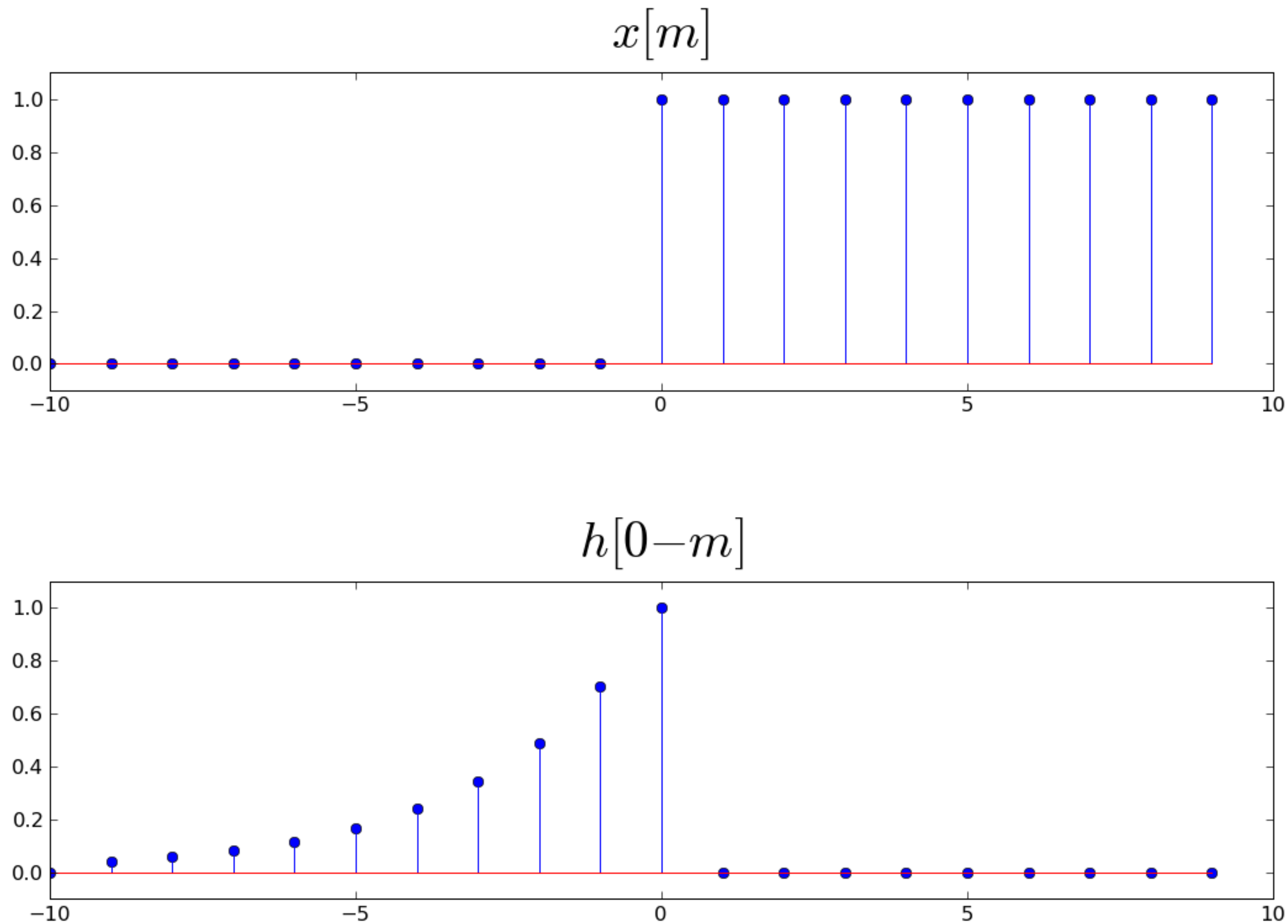
Decomposing X



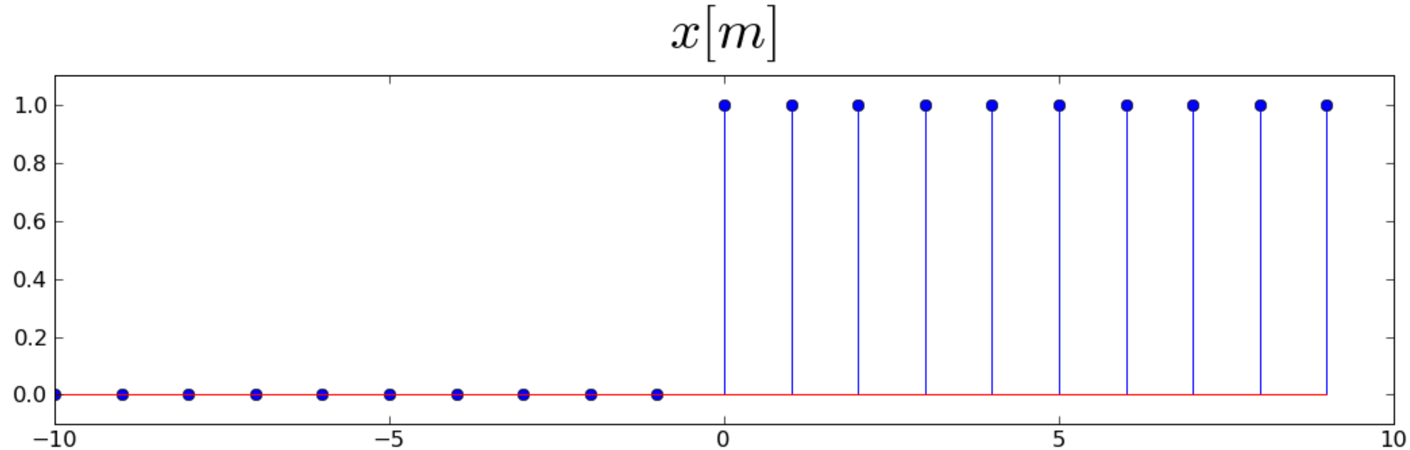
Example x[n] and h[n]

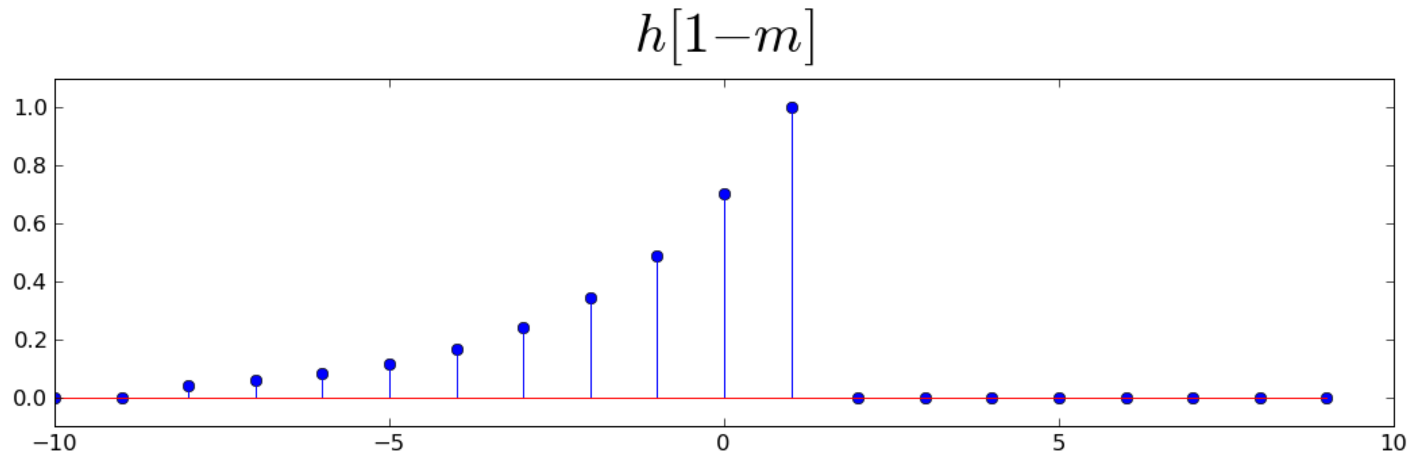


Evaluating y[0]

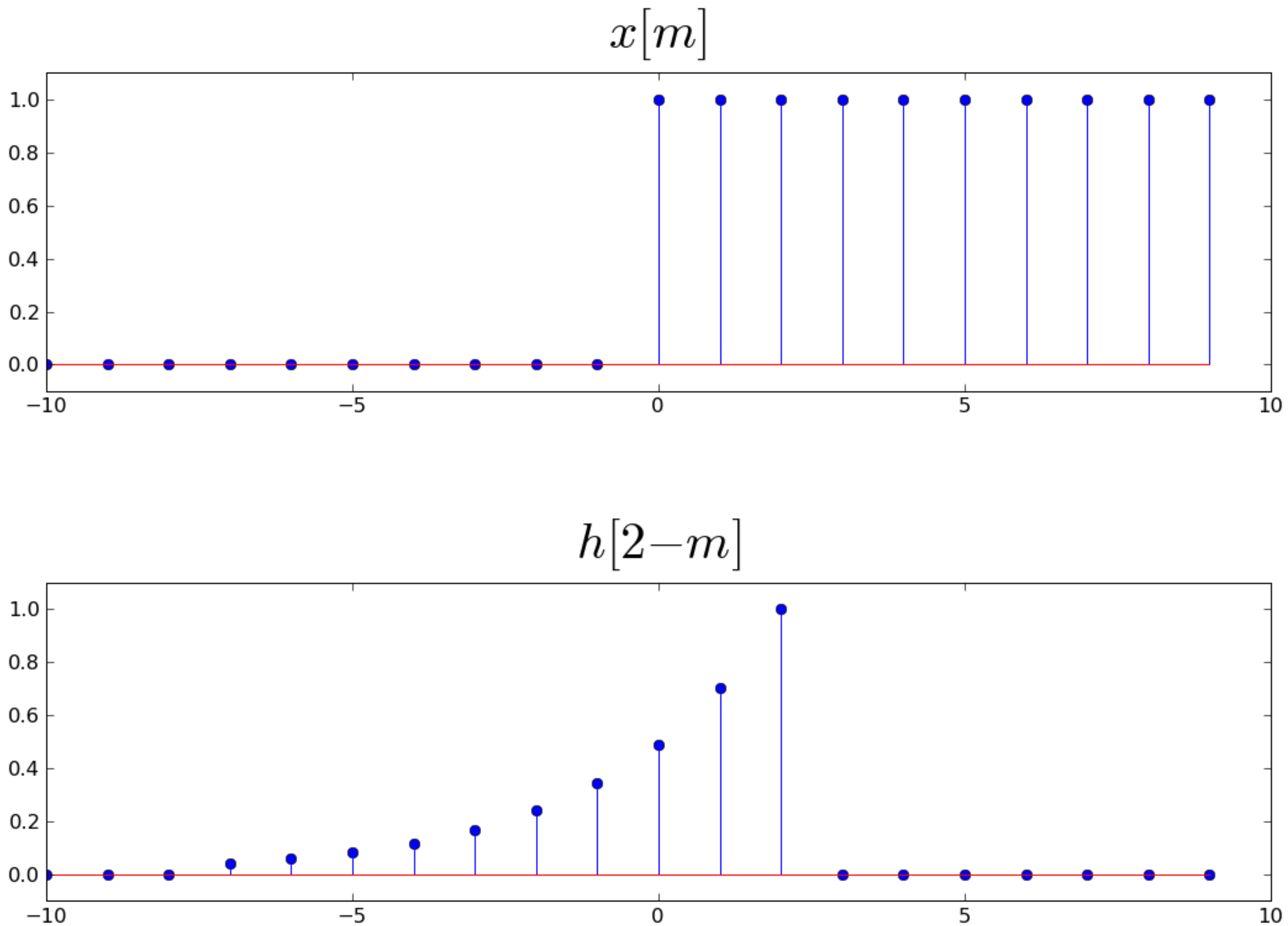


Evaluating y[1]

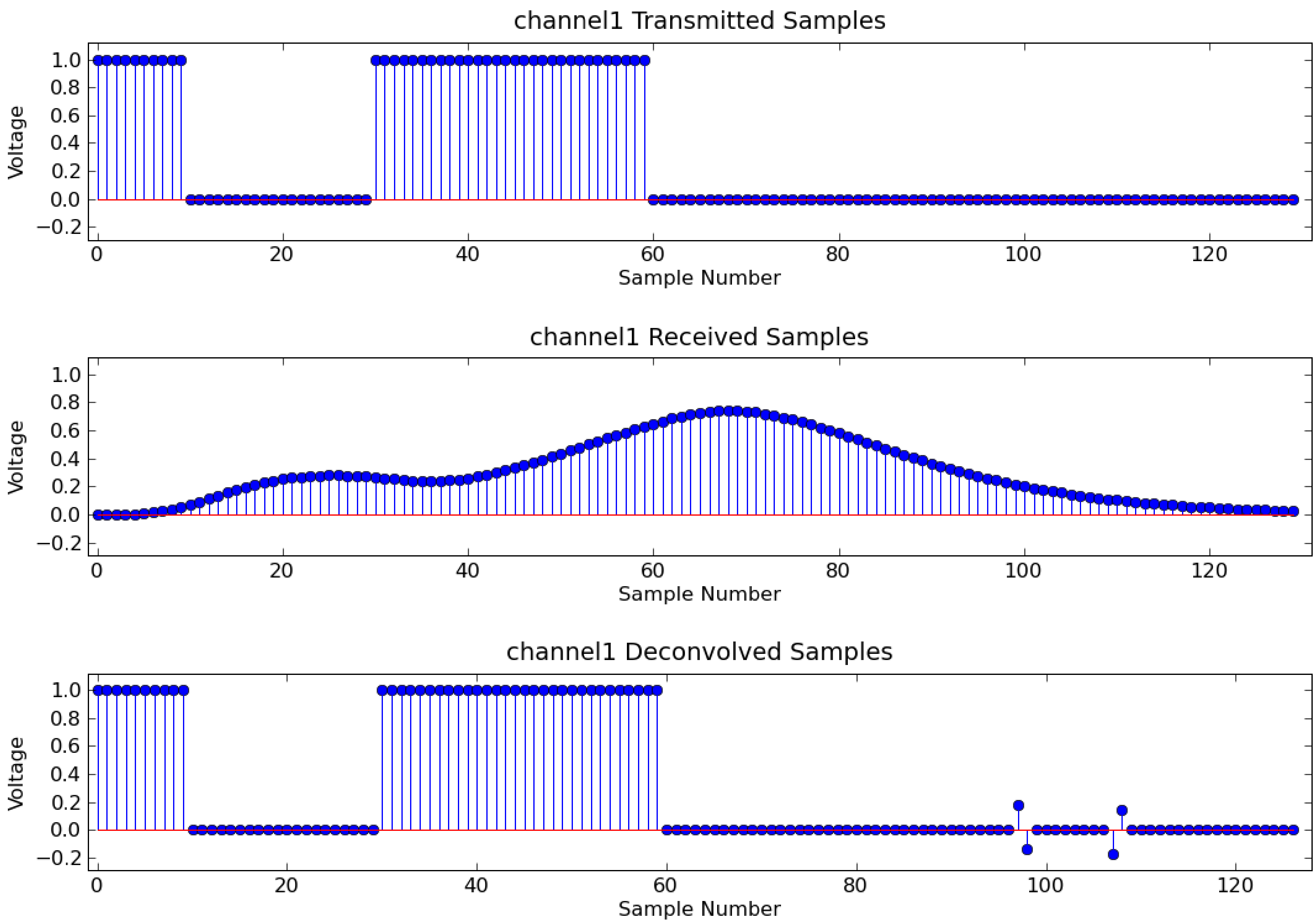




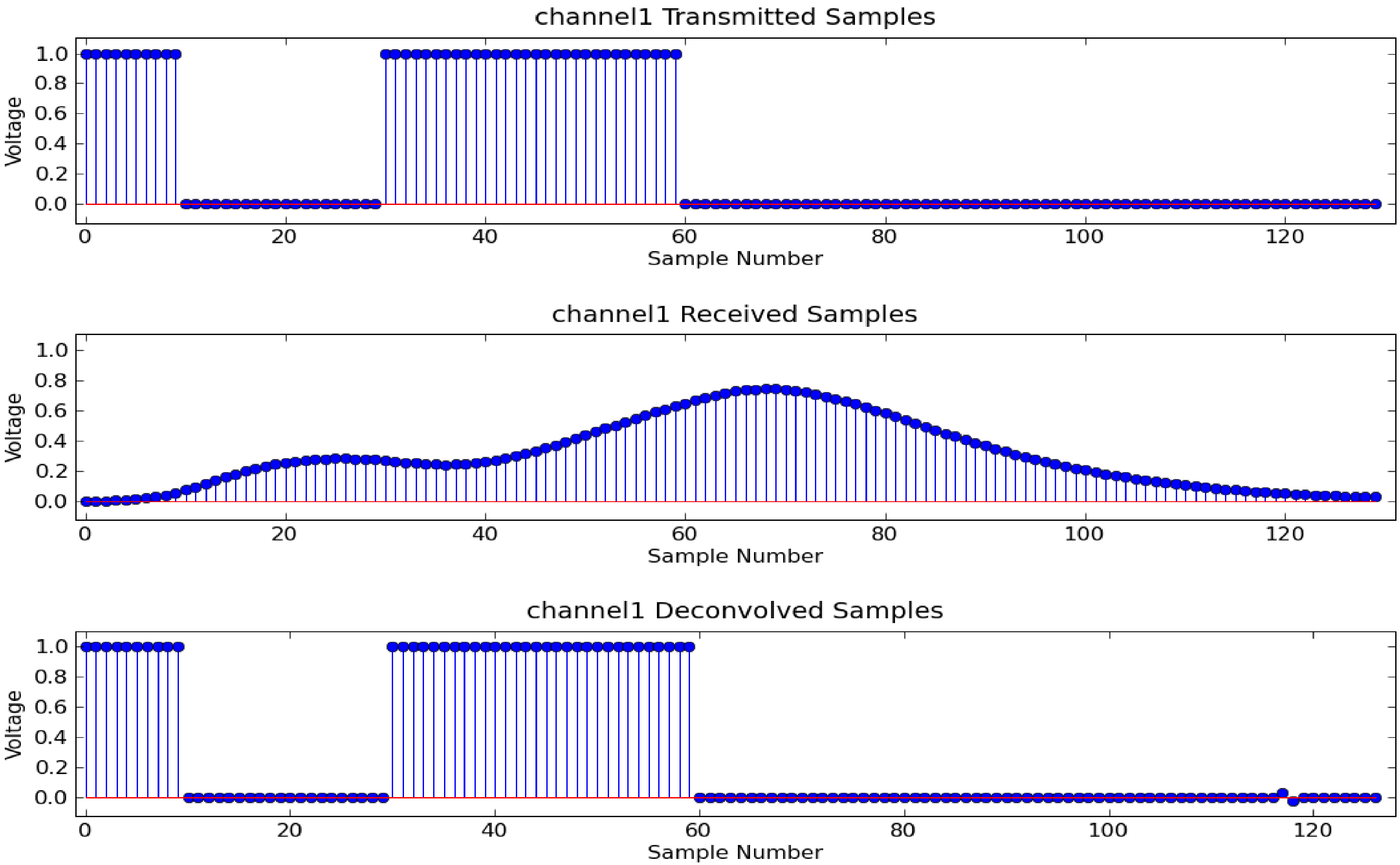
Evaluating y[2]



Noise Free Deconvolution (h[n] = 0, K >= 100)



Noise-Free Deconvolution (h[n] = 0, K >= 120)



NOISE CAN DESTROY DECONVOLUTION!
(Next Week!!!)

How bad is noise for deconvolution?