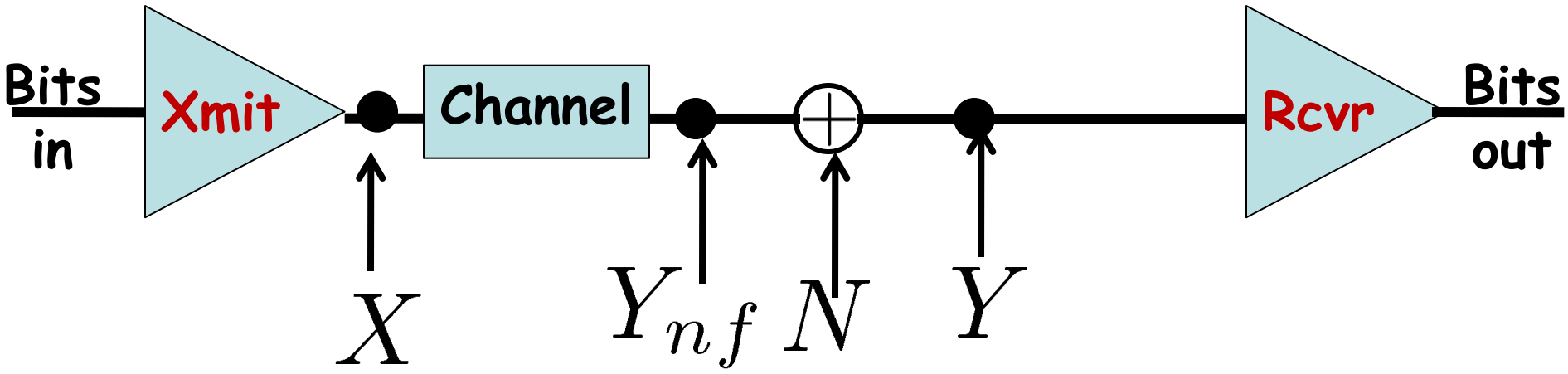
6.02 Lecture 5 – ISI and Noise

- Inter-Symbol Interference + Noise
  - Eye diagrams help us understand:
    - BER versus Samples per bit (1/(bit rate))
- Calculating BER from Eye Diagram
  - By picture in lecture, details in recitation
- Noise and Deconvolution
  - Massaging the Unit Sample response.

Block Diagram of the Channel



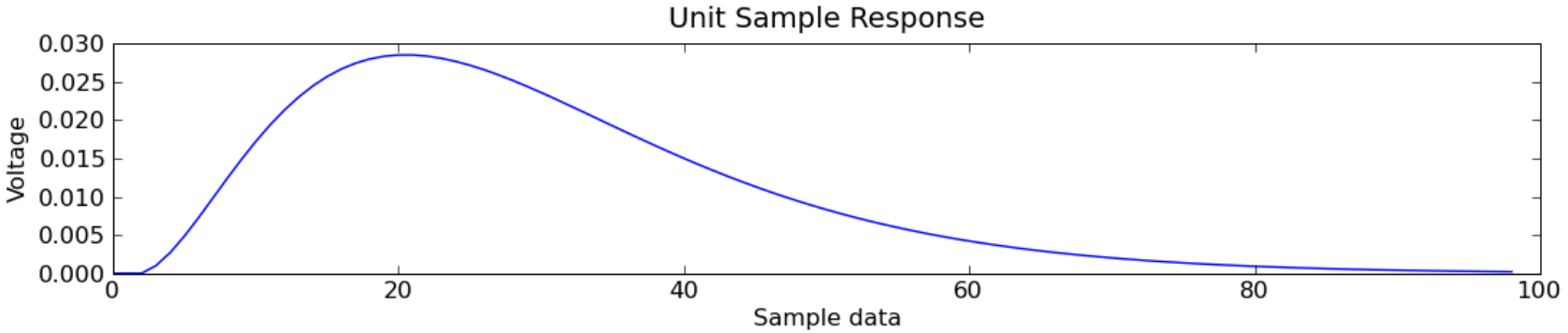
X : transmitted samples

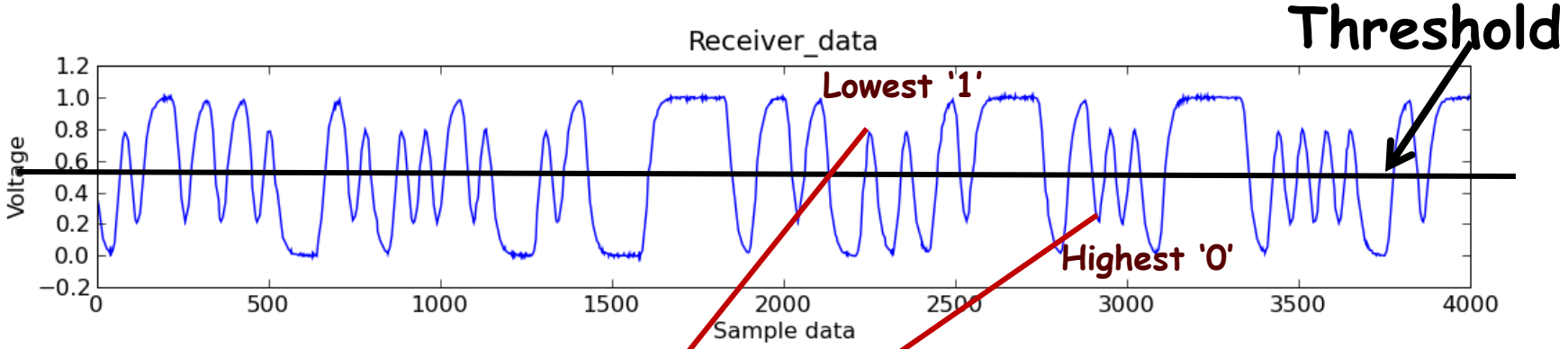
Y_{nf} : received noise-free samples

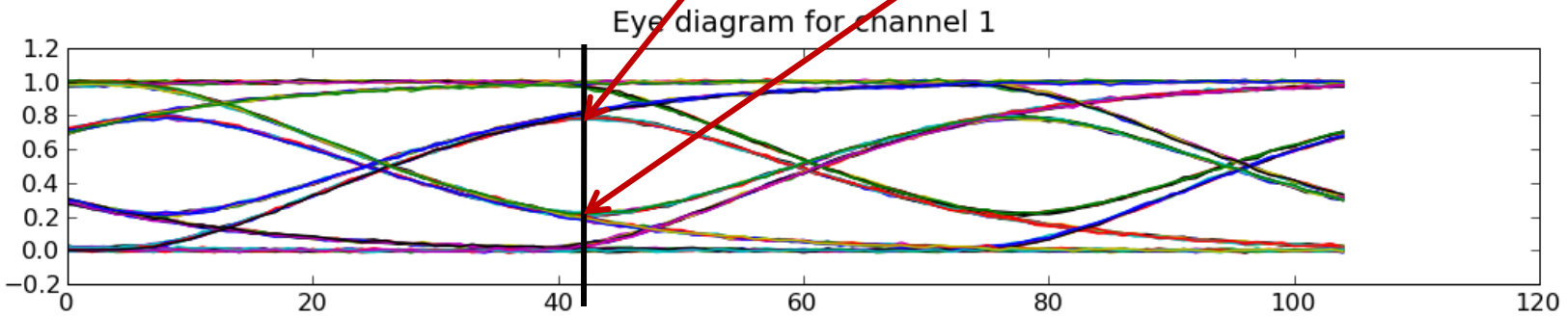
N : noise samples

Y : received samples with added noise

Unit Sample Response and Eye Diagrams (35 Samples per bit)

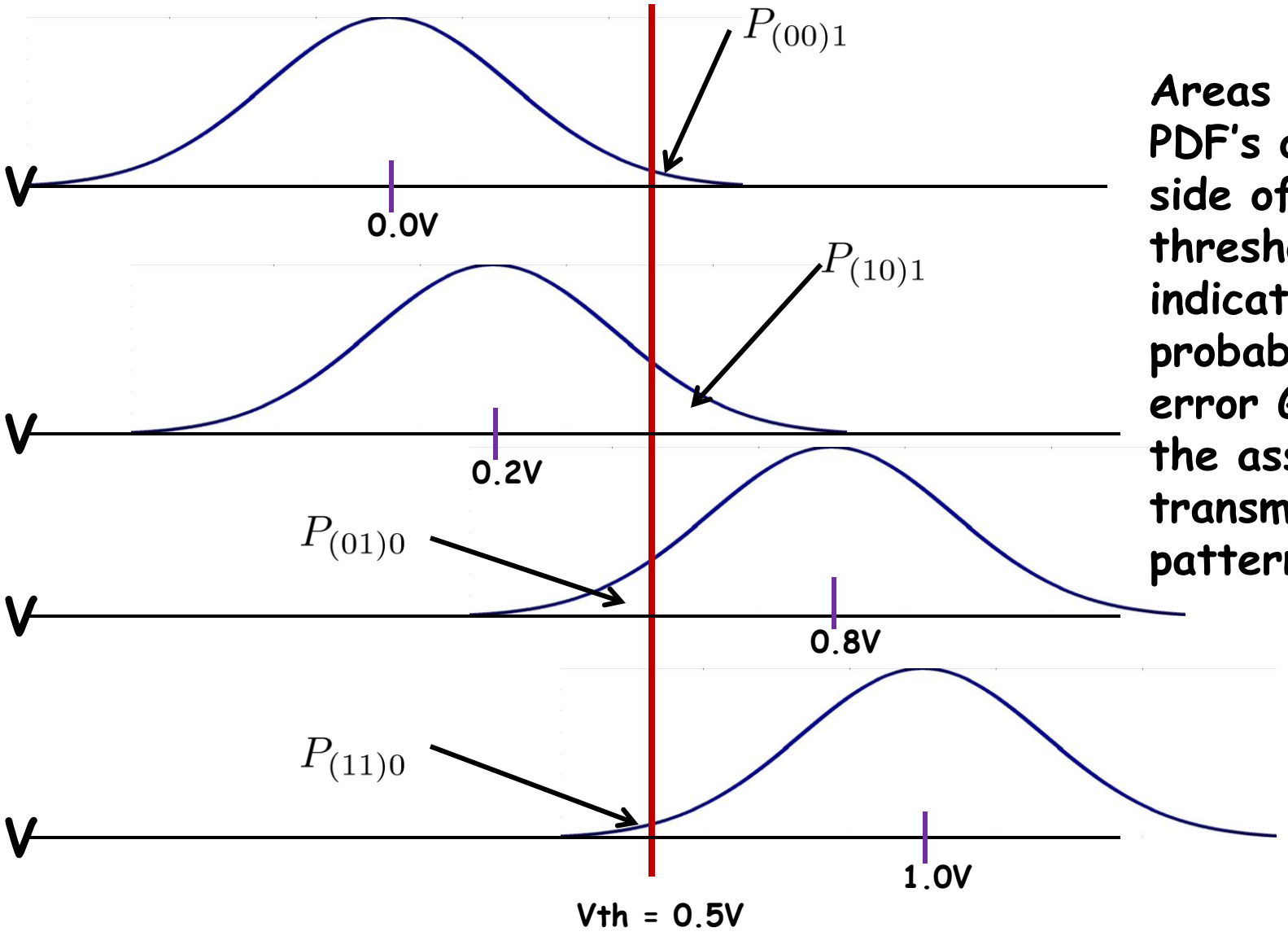






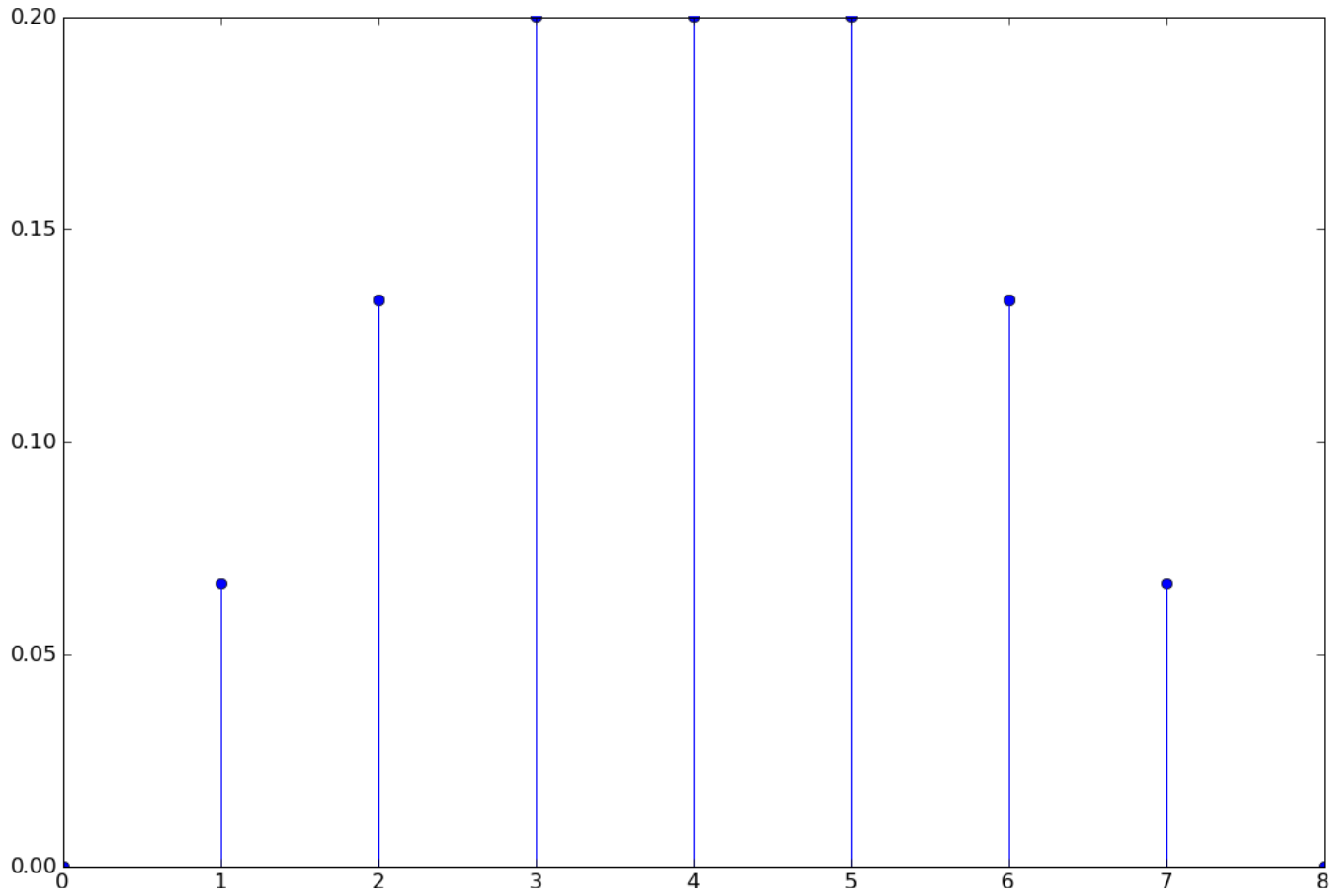
Bit detection Sample

Plots of PDF's of Noise + Detection V's

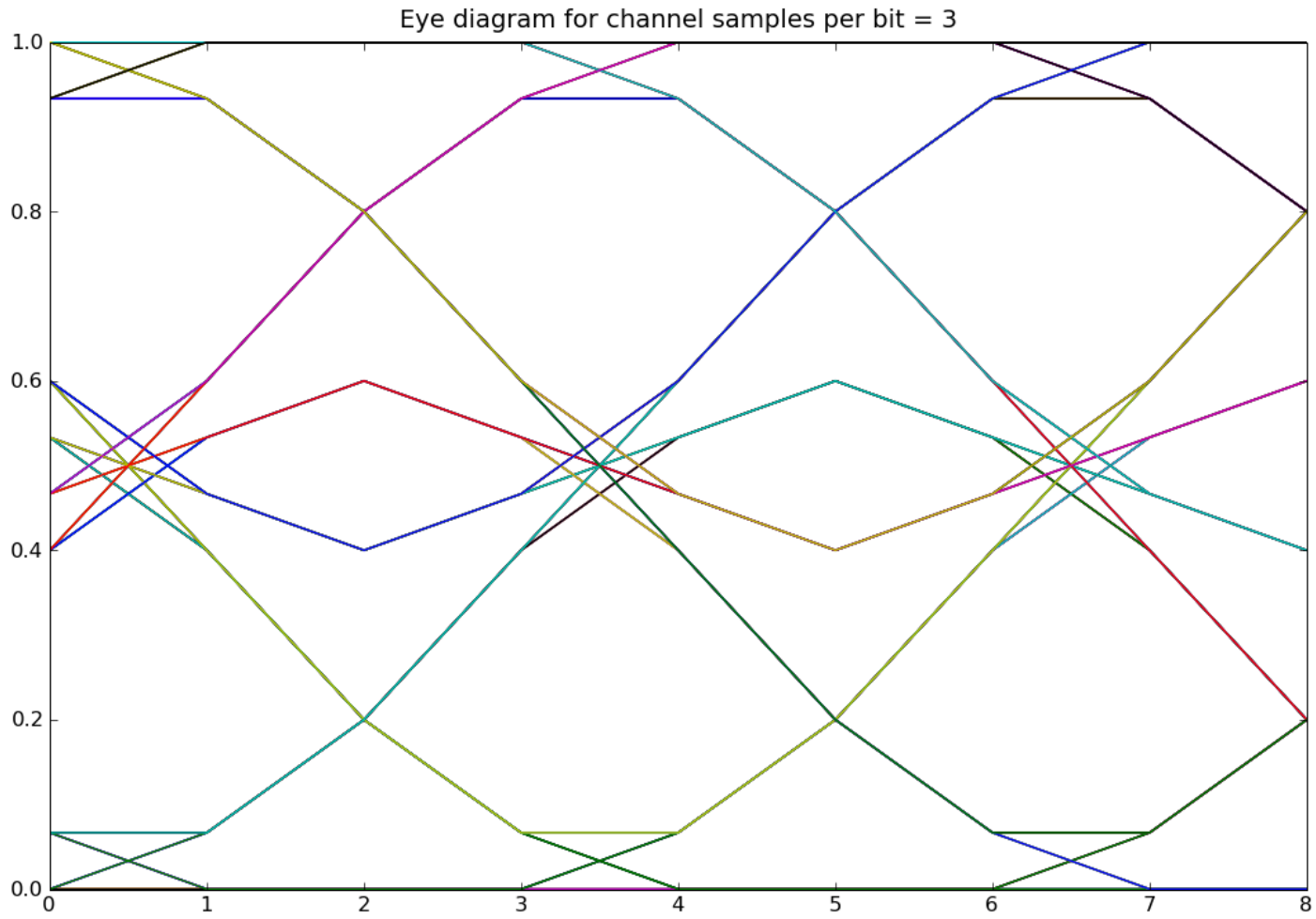


Areas under PDF's on wrong side of threshold indicate probability of error GIVEN the associated transmitted bit pattern

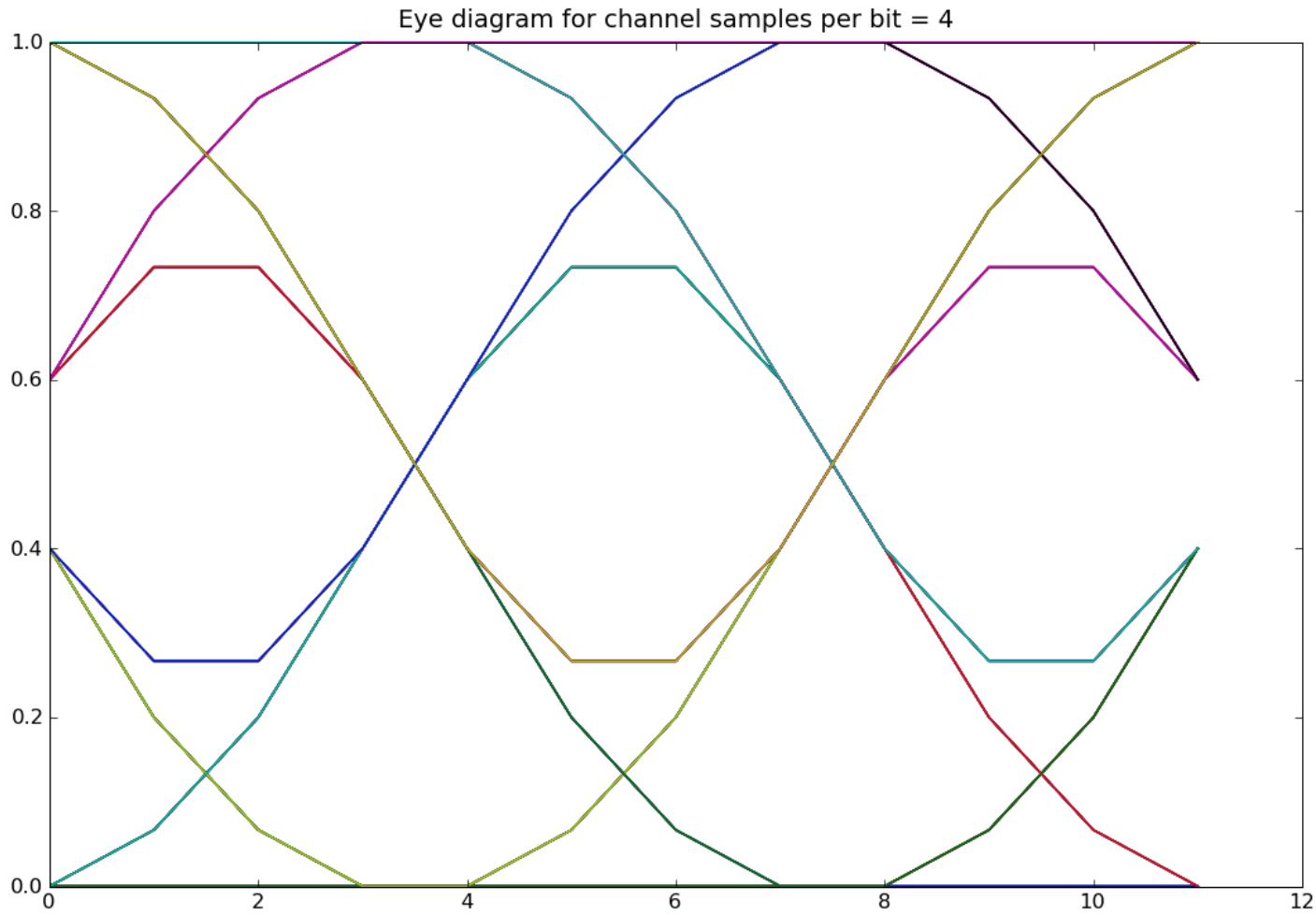
Unit Sample Response for a Simple Example



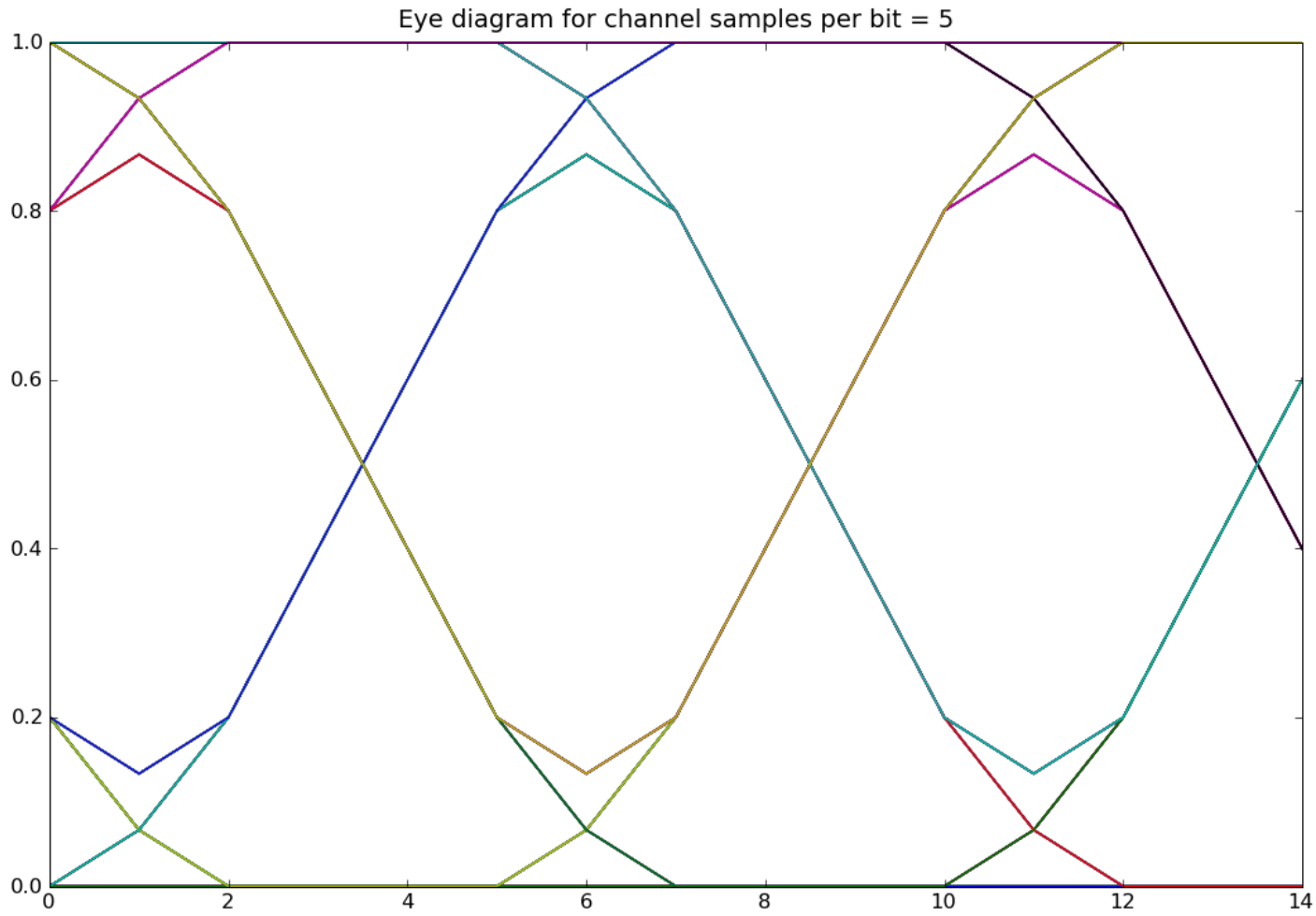
Eye Diagram for 3 samples per bit



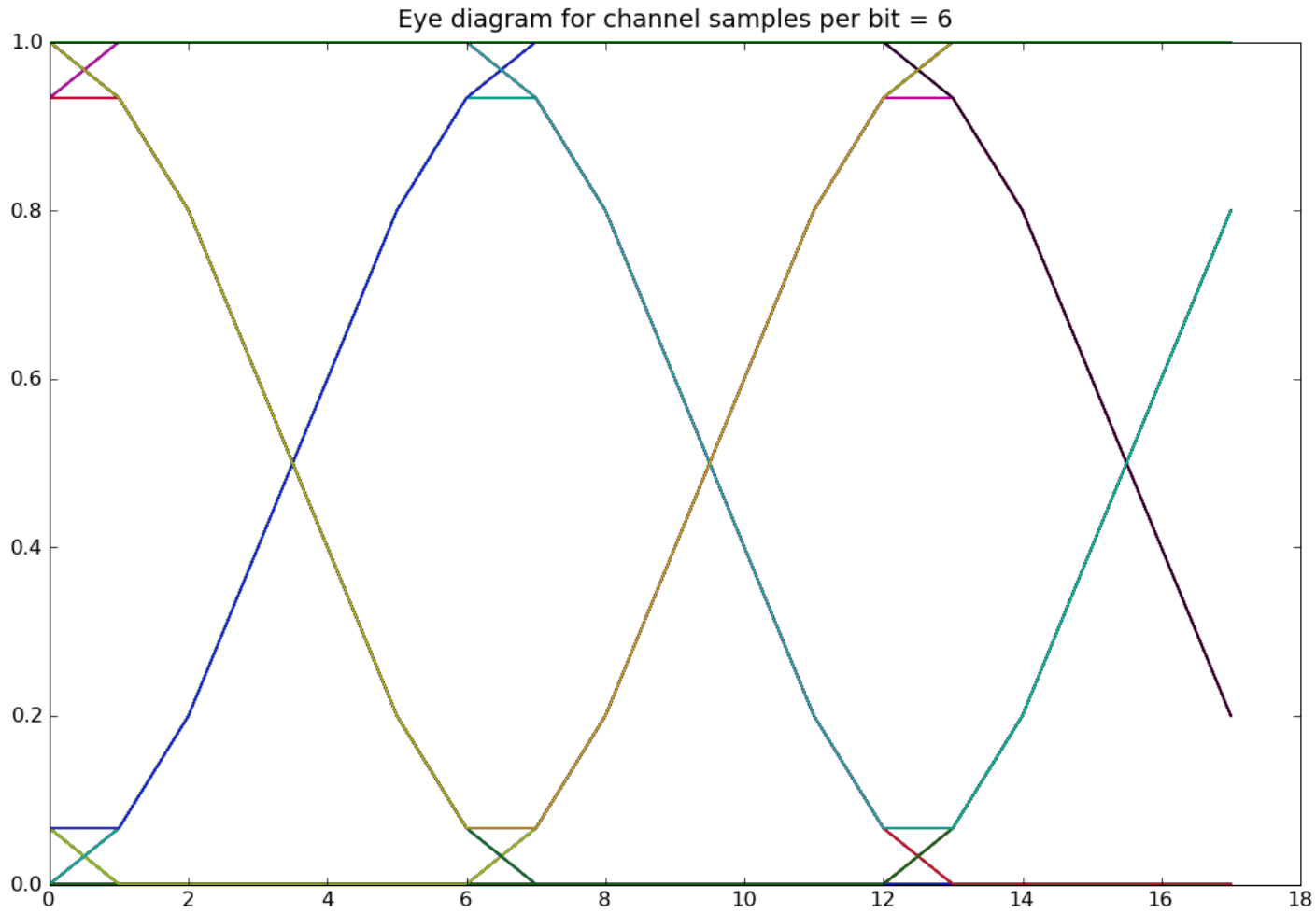
Eye Diagram for 4 Samples per bit



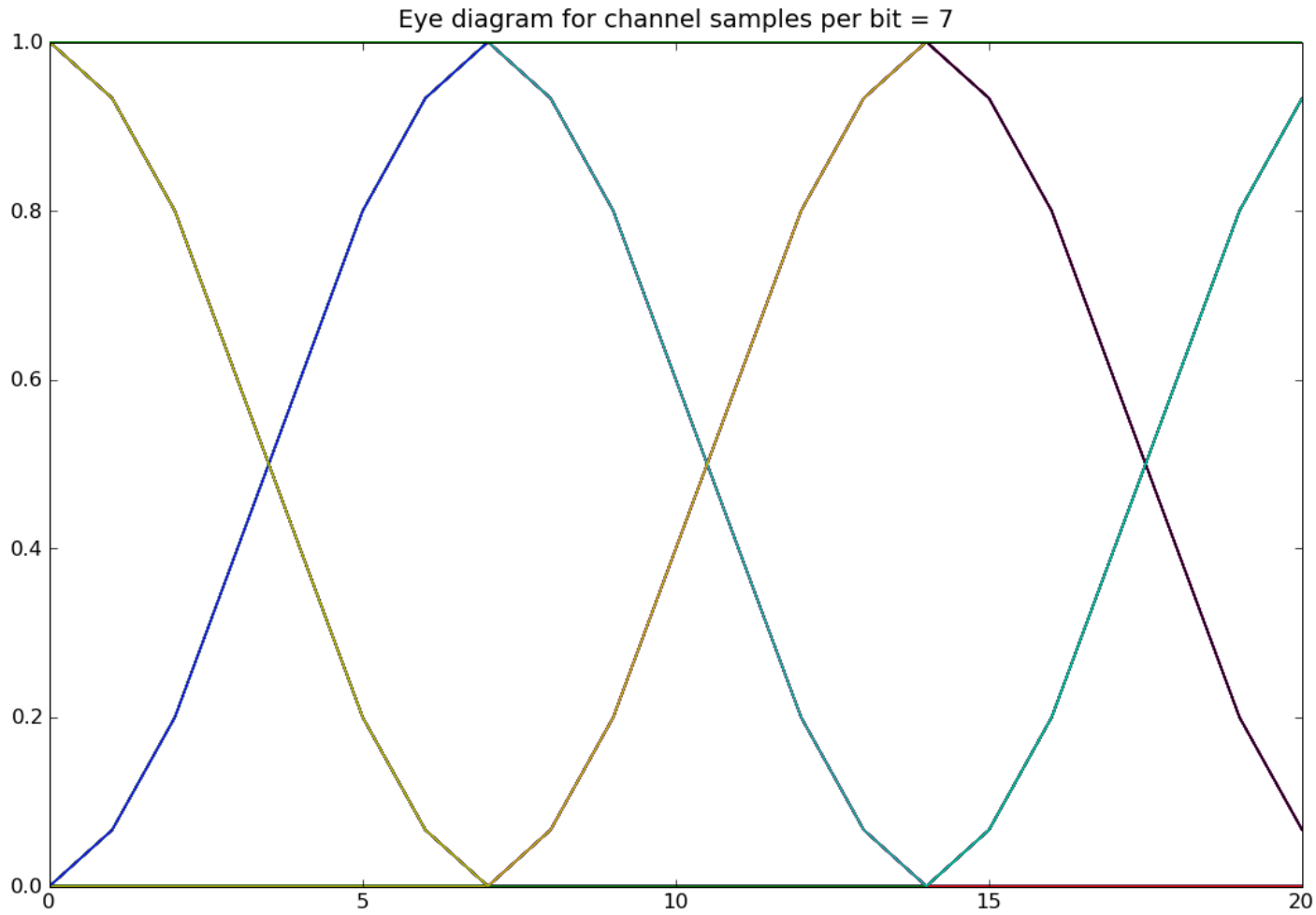
Eye Diagram for 5 Samples per bit



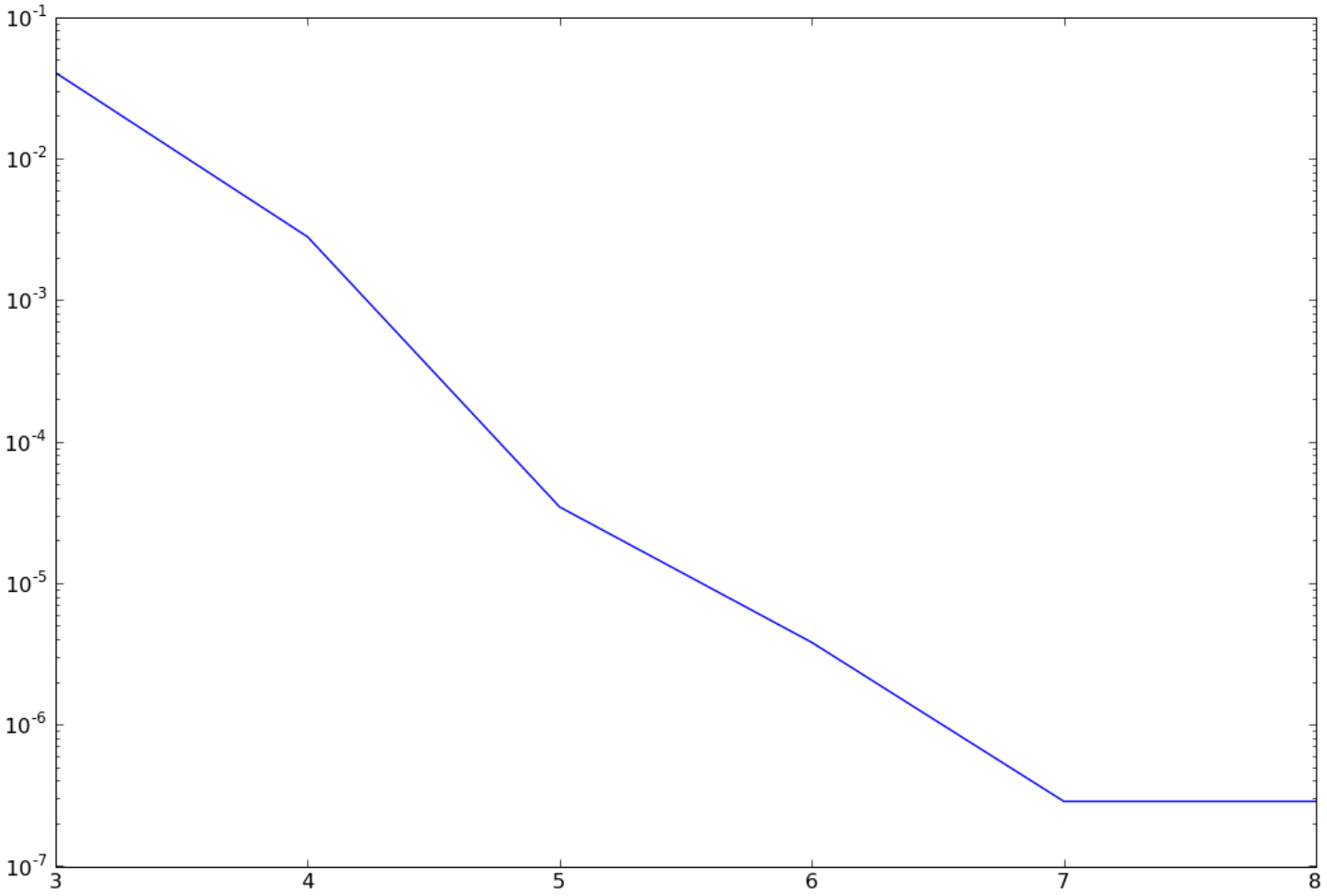
Eye Diagram for 6 Samples per bit



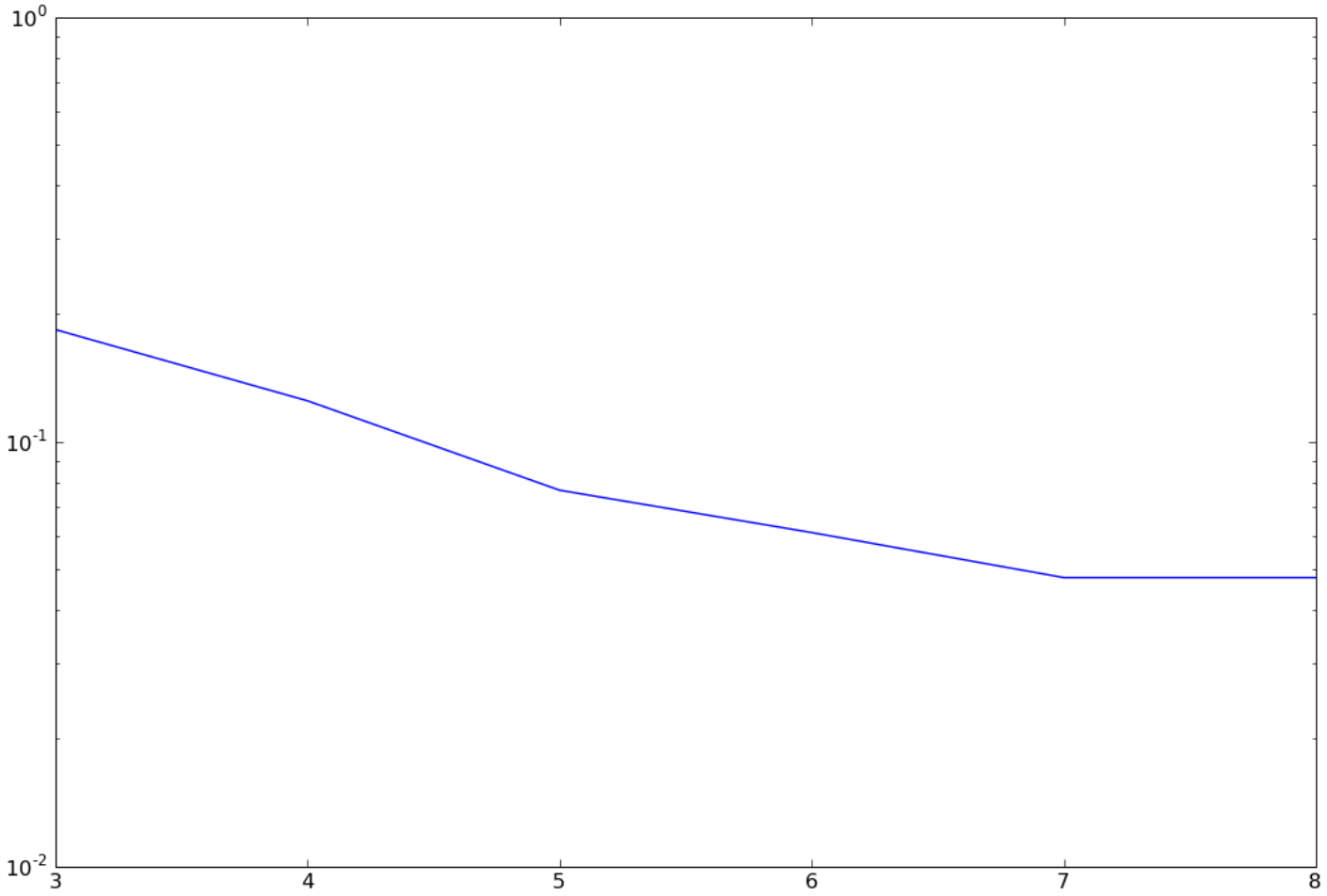
Eye Diagram For 7 Samples per bit



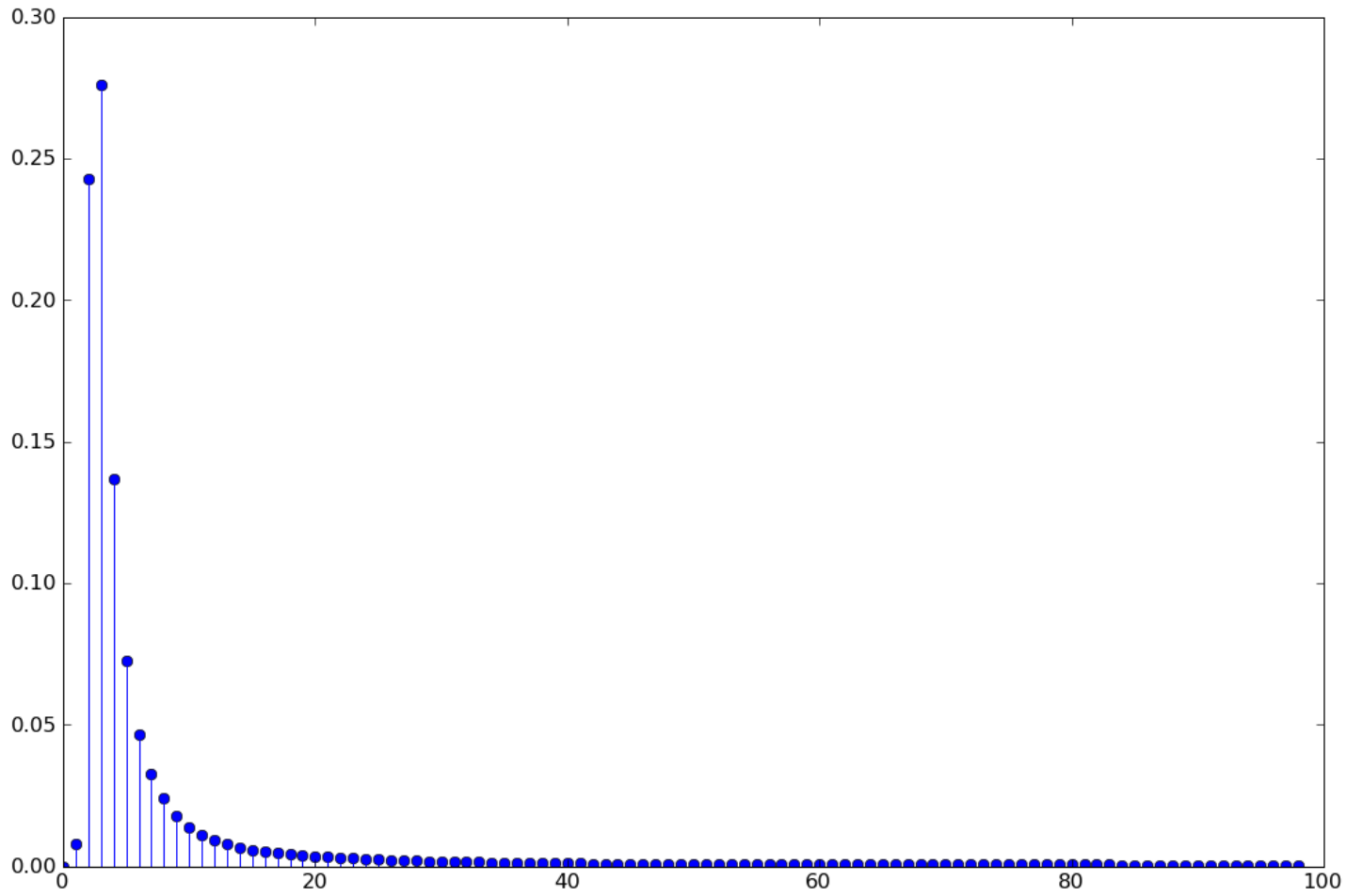
BER Versus Samples per Bit (std = 0.1)



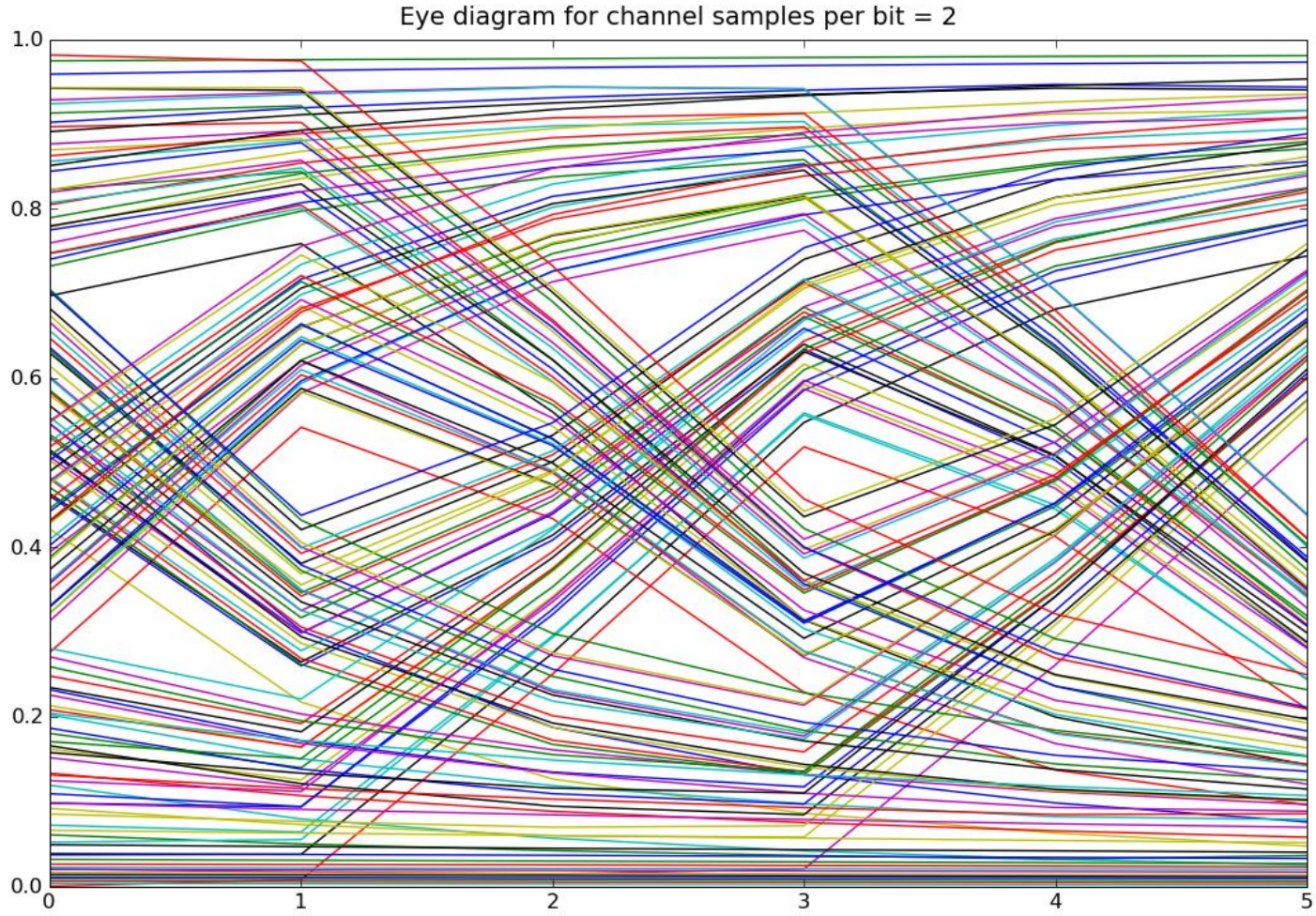
BER Versus Samples per Bit (std = 0.3)



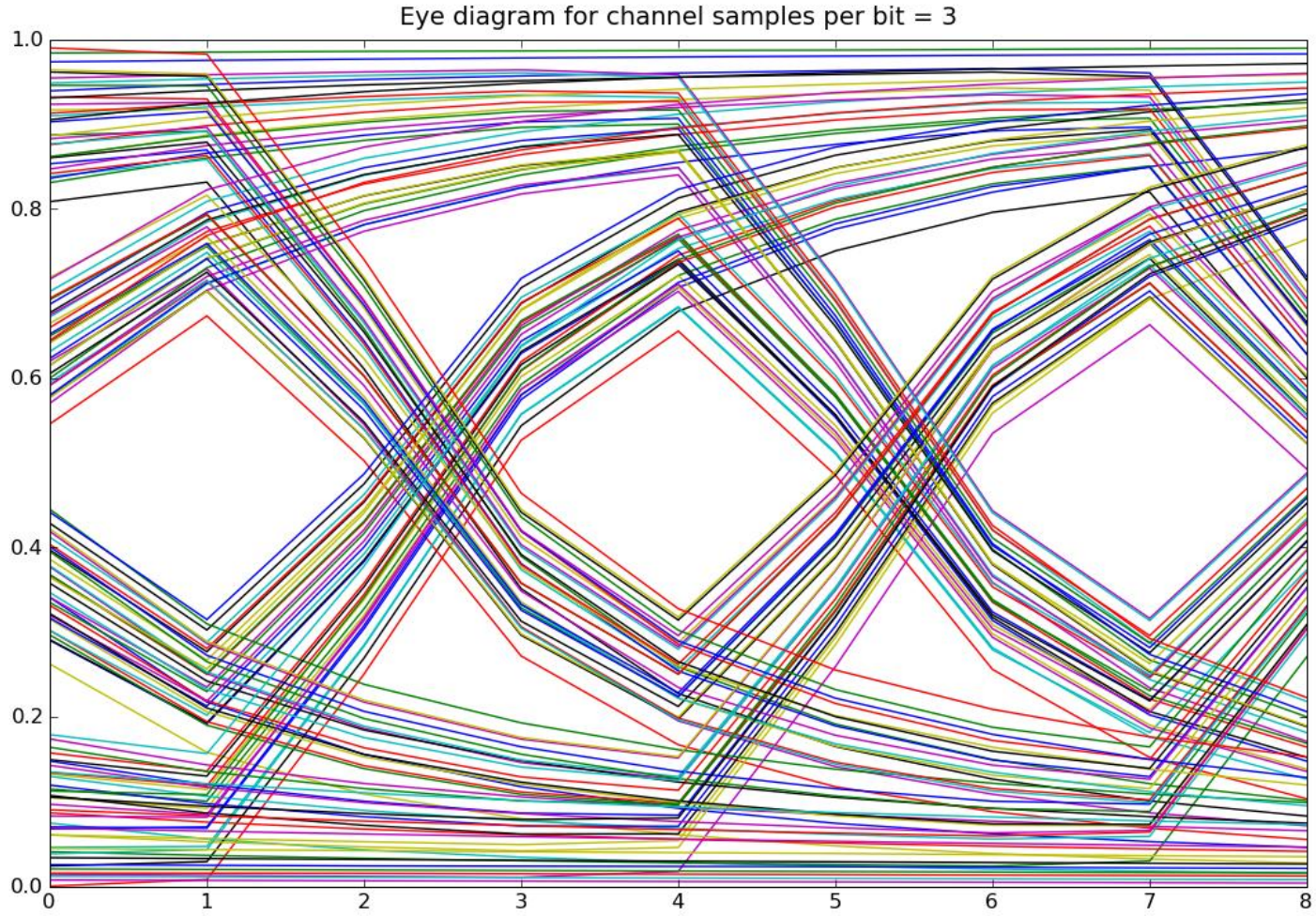
Unit Sample Response for a Real Example



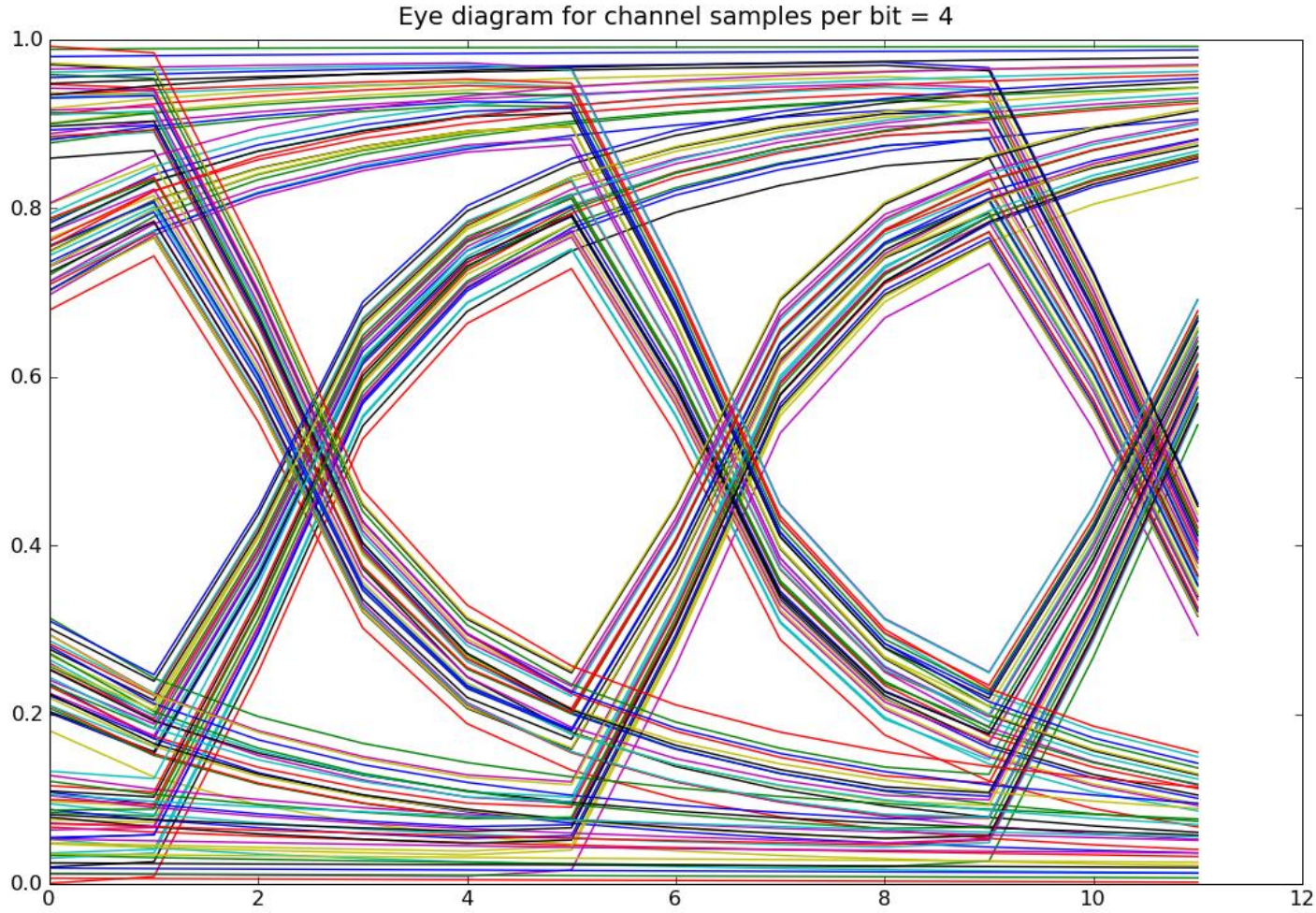
Eye Diagram for 2 samples per bit



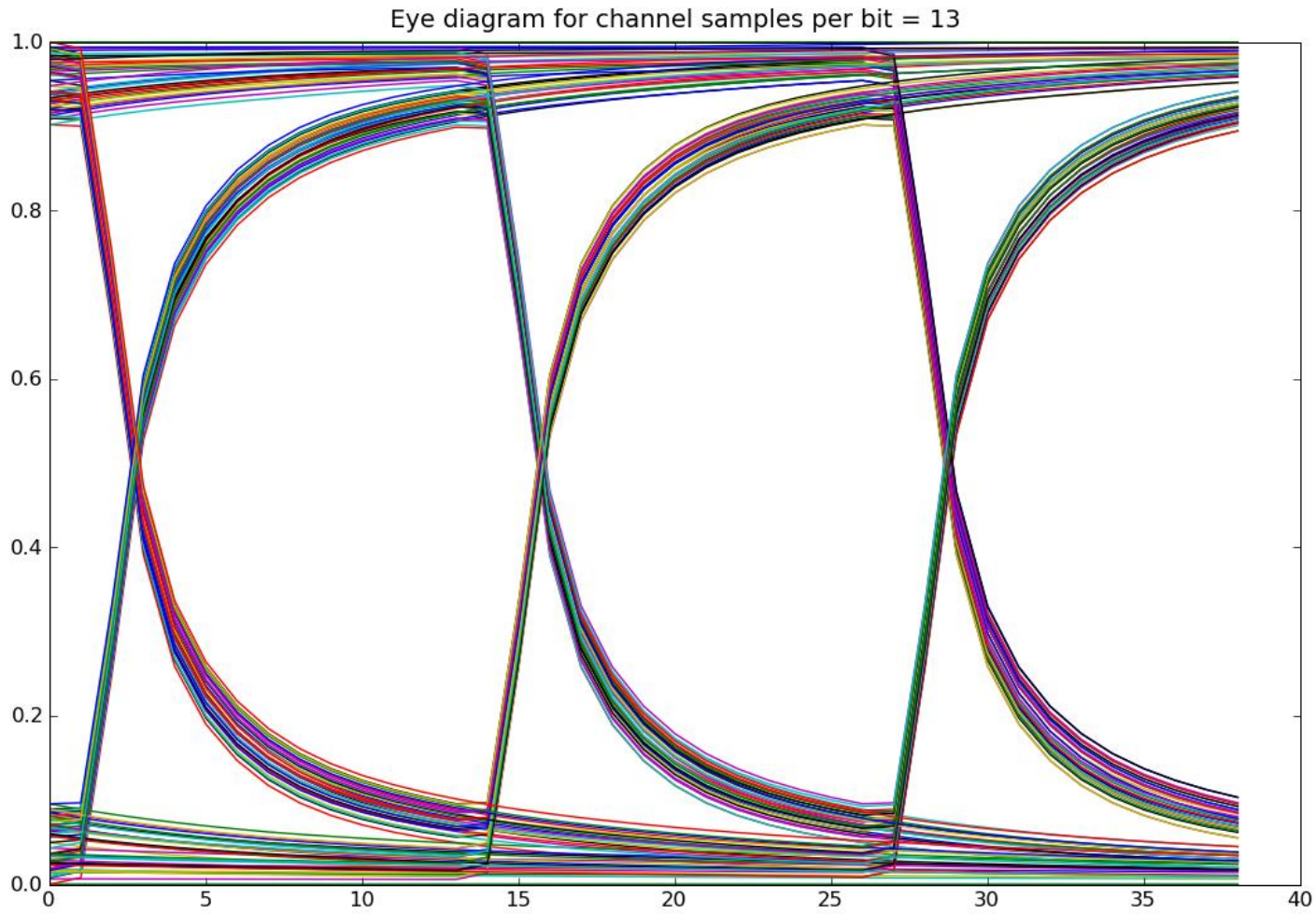
Eye Diagram for 3 Samples per bit



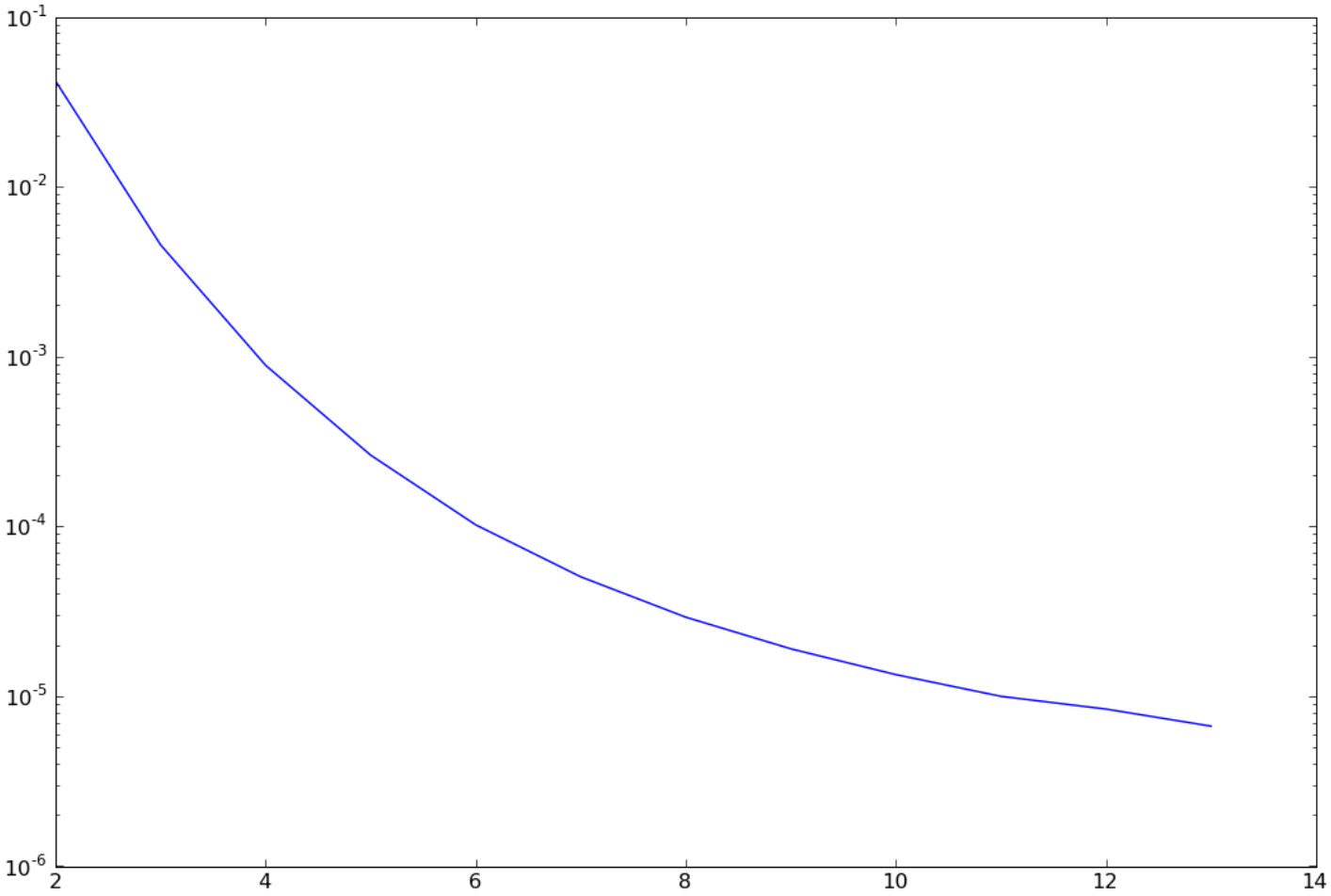
Eye Diagram for 4 Samples per bit



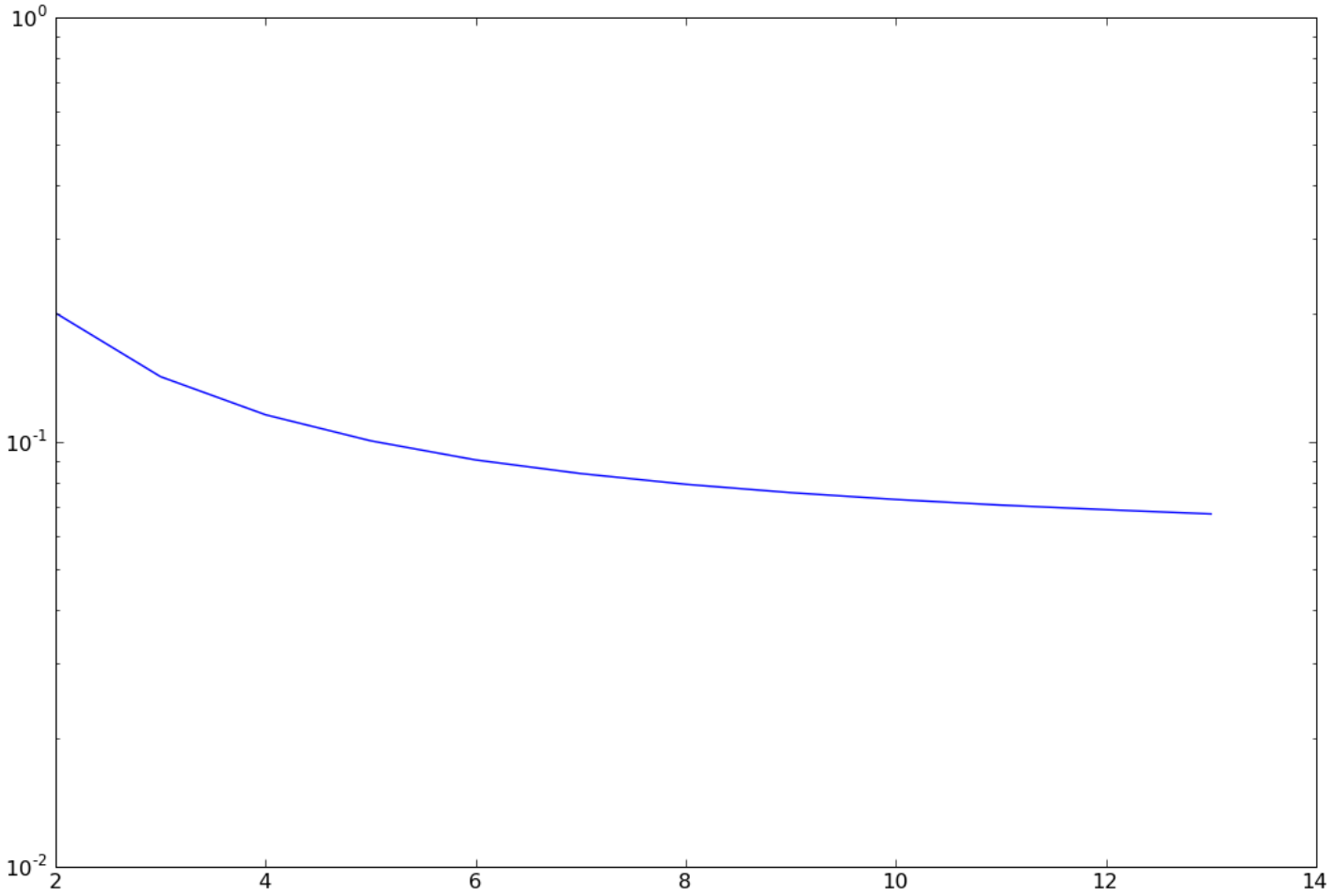
Eye Diagram for 13 Samples per bit



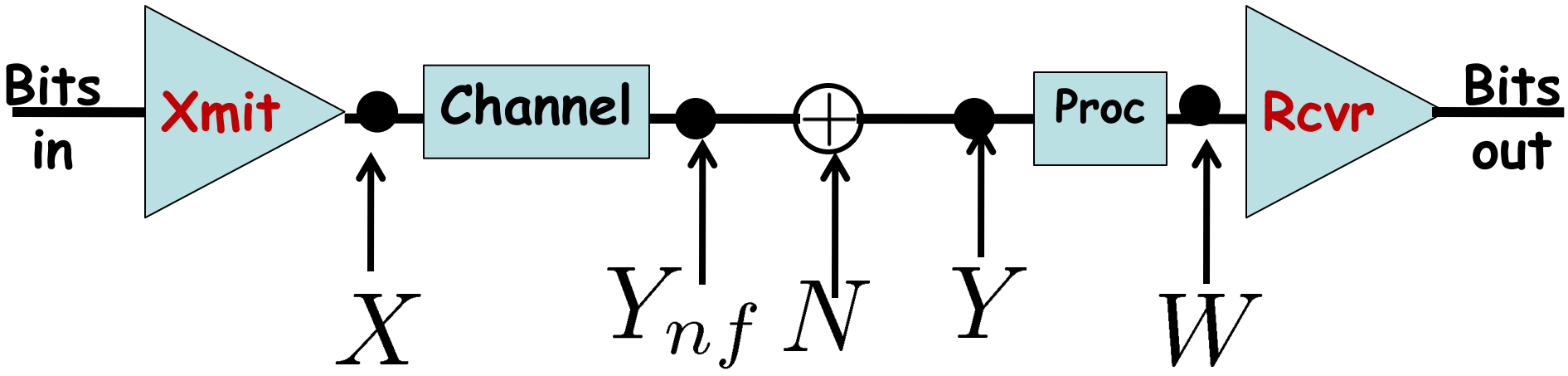
BER Versus Samples per Bit (std = 0.1)



BER Versus Samples per Bit (std = 0.3)



Block Diagram of Channel with Deconvolver



X : transmitted samples

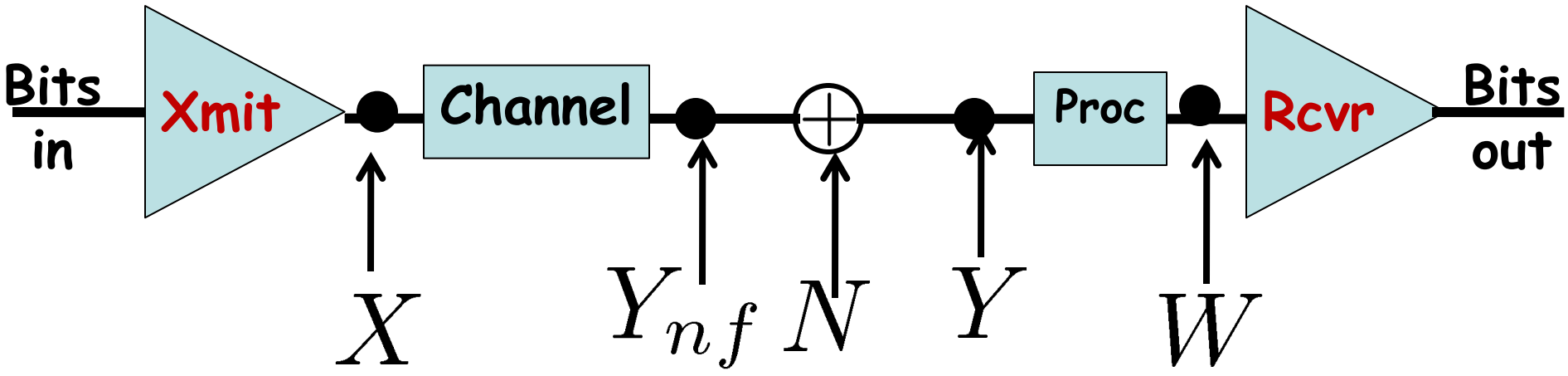
Y_{nf} : received noise-free samples

N : noise samples

Y : received samples with added noise

W : processed received samples

LTI Channel + Noise + Deconvolver

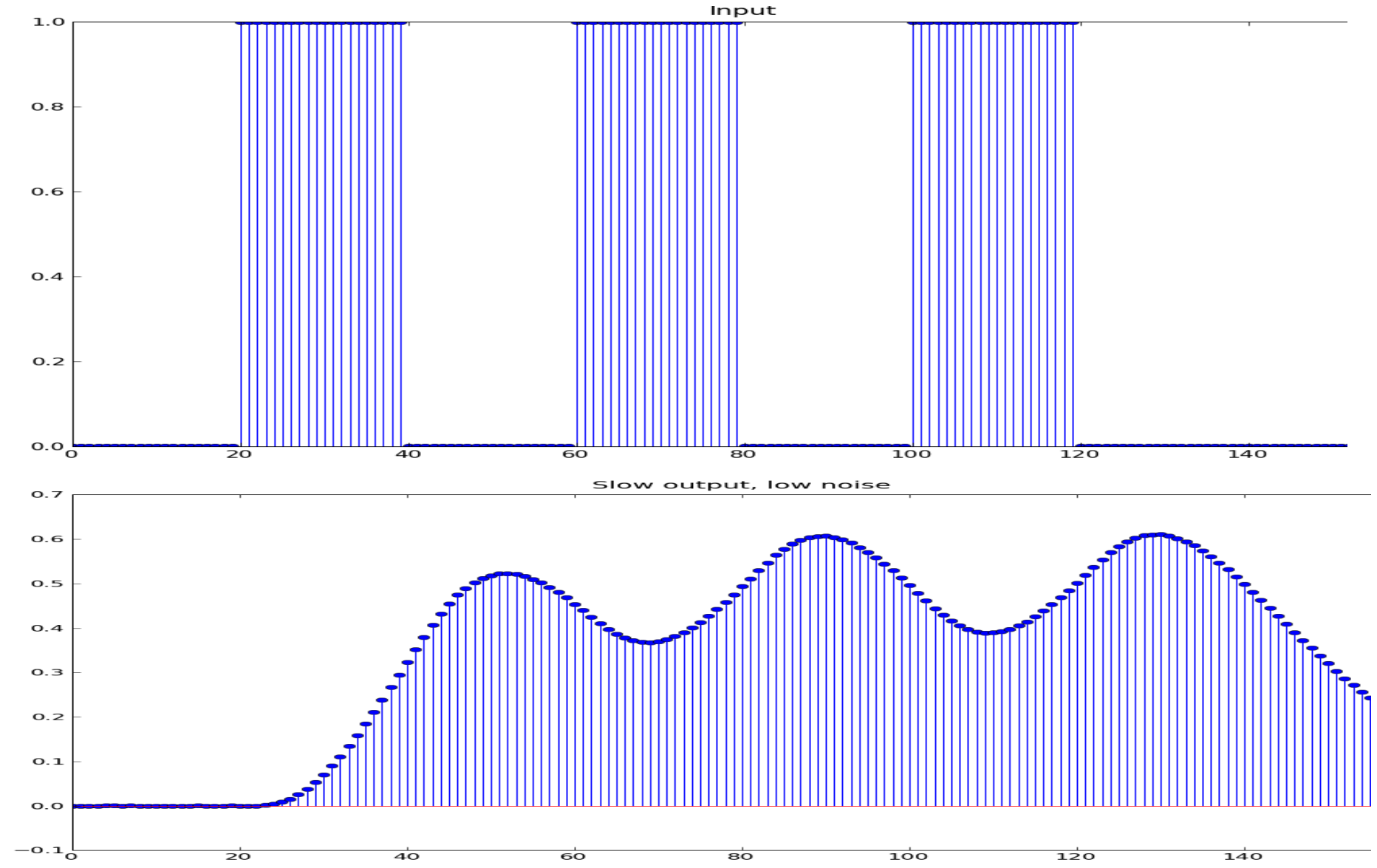


$$y_{nf}[n] = \sum_{m=0}^{m=n} h[m]x[n-m]$$

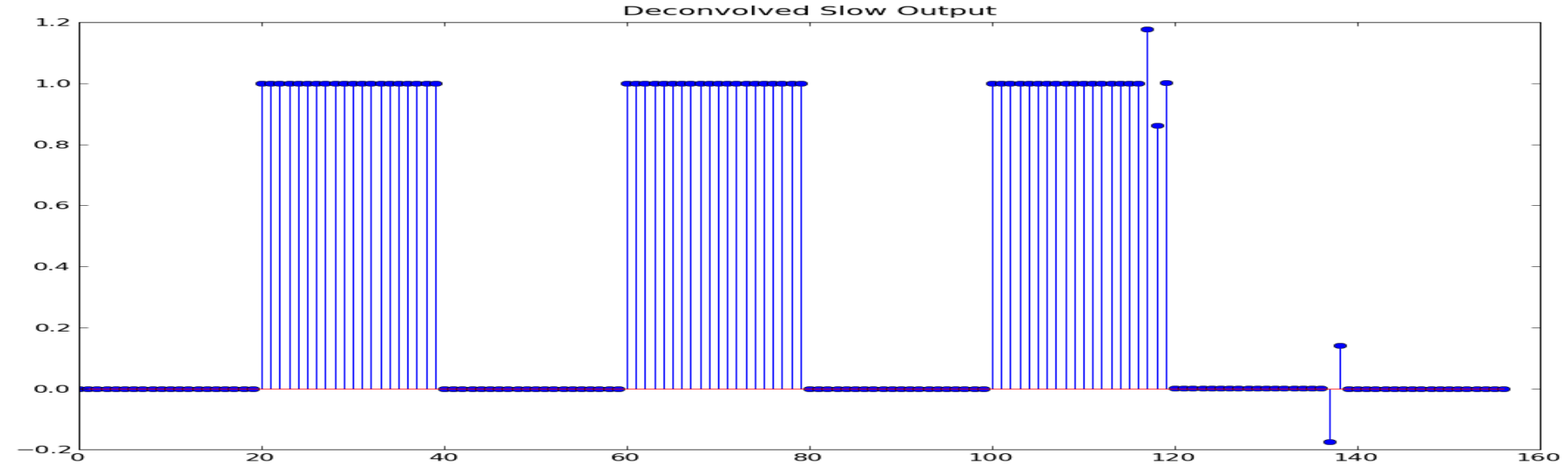
$$y[n] = y_{nf}[n] + noise[n]$$

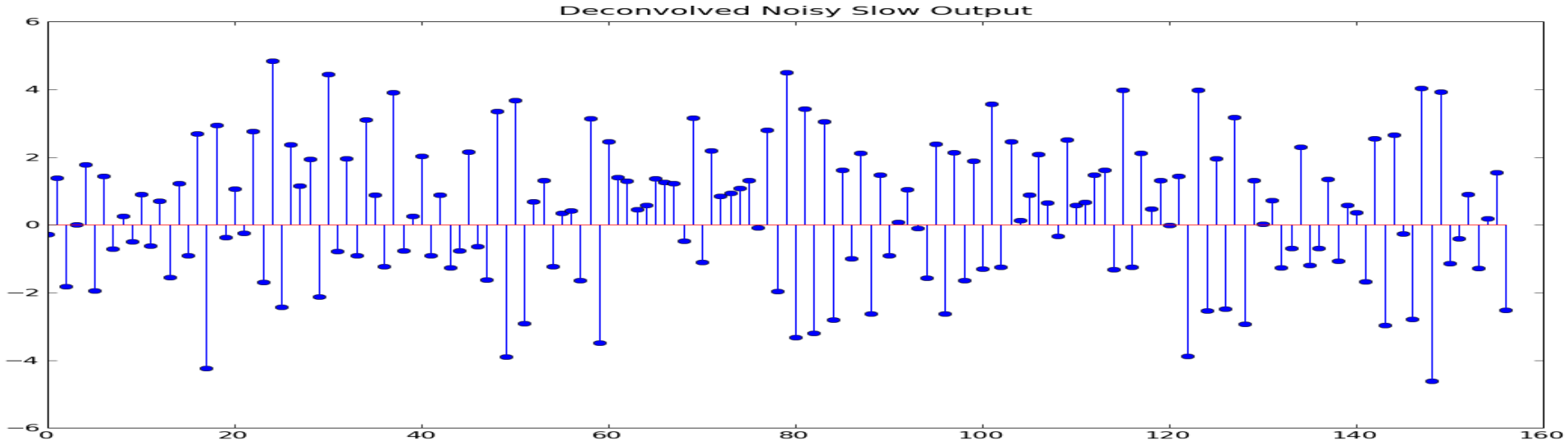
$$\sum_{m=0}^{m=n} h[m]w[n-m] = y[n]$$

Slow Wire and 20 Samples per bit



Deconvolution Great Unless There's Noise

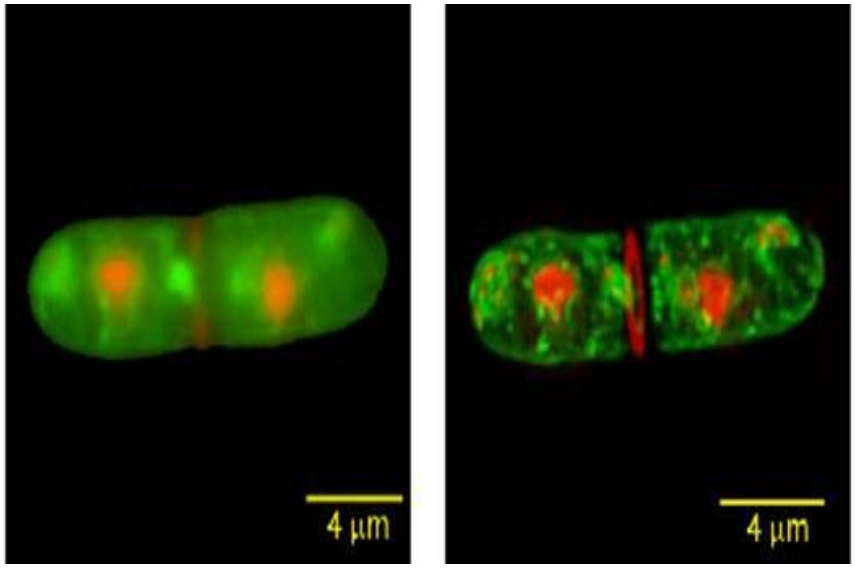




- Can we fix deconvolution when there's Noise?

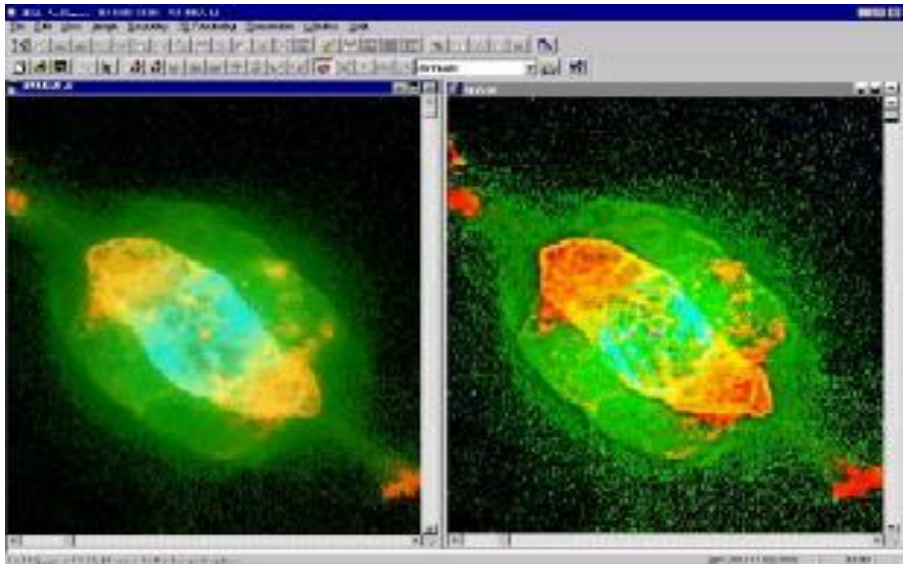
And why study deconvolution?

- High Speed channels use Decision Feedback Equalization (a form of deconvolution).
- Many applications in biology, aerospace, medical imaging, etc



http://www.mib.ac.uk/research/facilities/bionano/Copy%20of%20bionano%20Delta_clip_image002.jpg

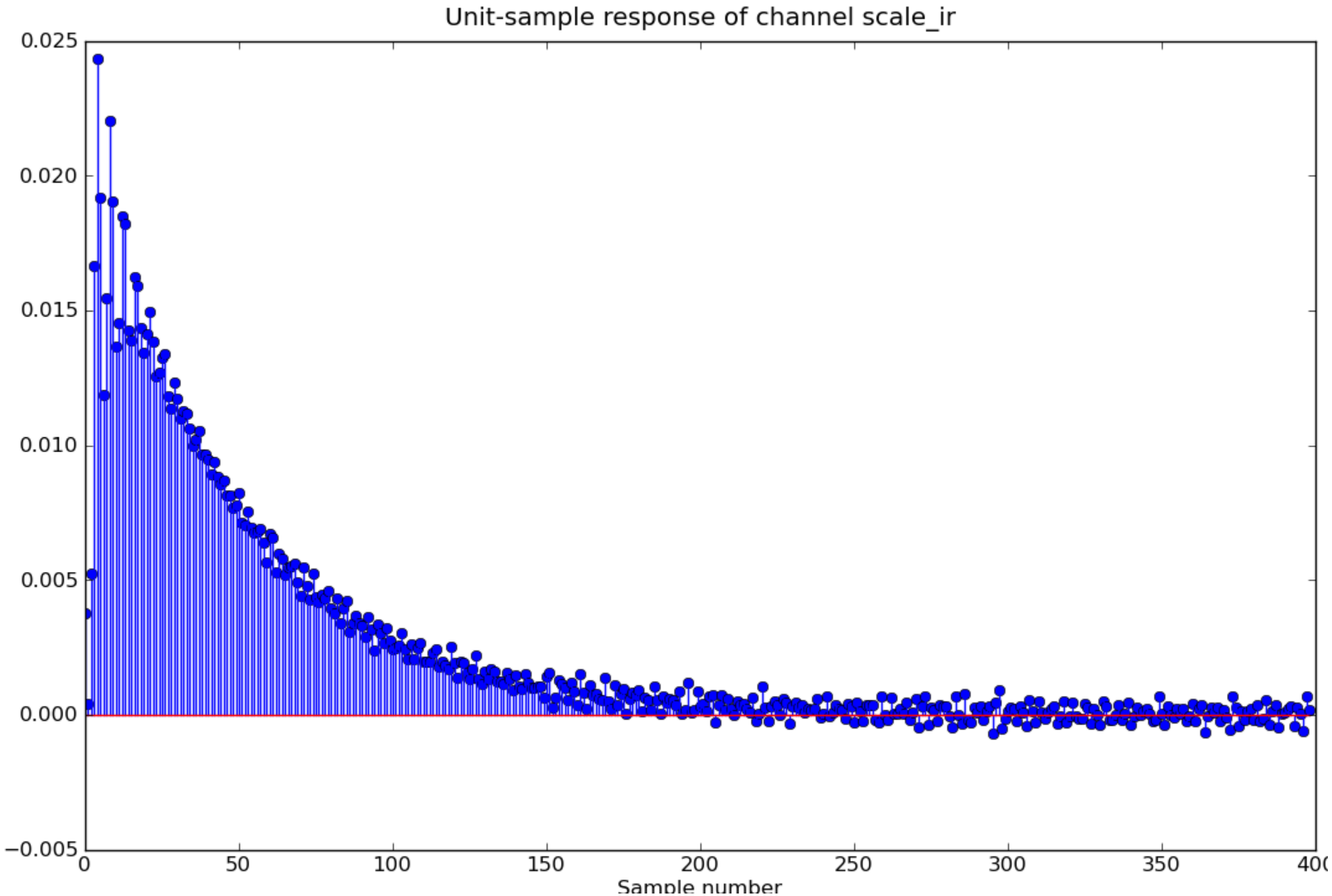
Deltavision 3D fluorescence microscopy of a diving *S. pombe* cell. Before deconvolution (Left) and after deconvolution (Right).



http://www.3d-doctor.com/hubblet.jpg

Deconvolution of an image from Hubble Space Telescope

We can "Fix" Deconvolution



"Fixed" Deconvolution on IR Channel