

INTRODUCTION TO EECs II

DIGITAL

COMMUNICATION

SYSTEMS

6.02 Fall 2010

Lecture #2

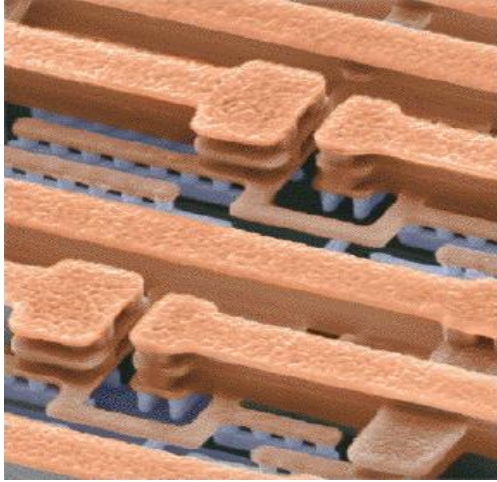
- Samples and Bits
- Real Wires
- Models
- Linearity and Superposition

6.02 Lecture 2 - Wires and Models

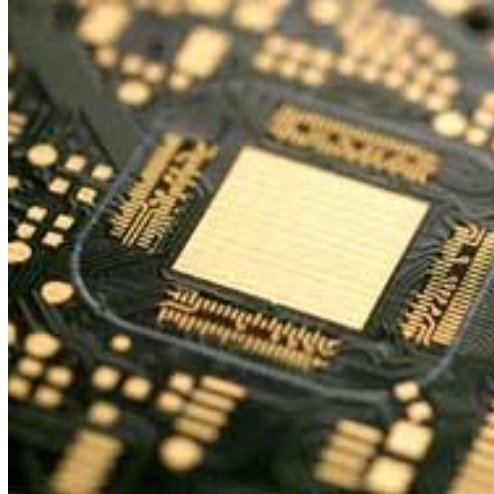
- Wires, Samples, and Bits
- Non-Ideal Transmission
 - Example wires and signal impact
 - Intersymbol Interference and Eye Diagrams
- Modeling Wires
 - Causality
 - Time-invariance
 - Linearity
- SUPERPOSITION
 - Demonstrating why it is so super

Types of Real “Wires”

IC Interconnect

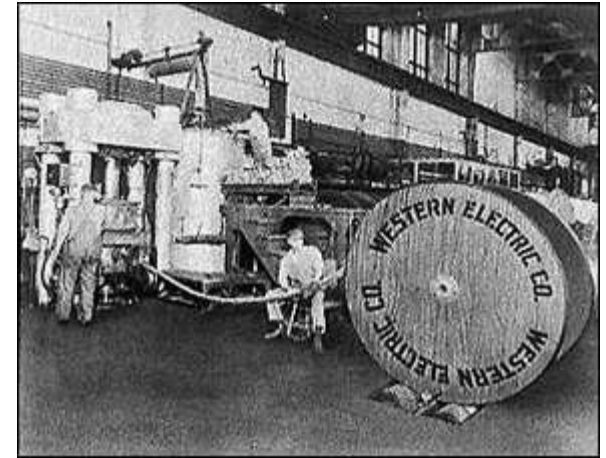


Printed Circuit Board



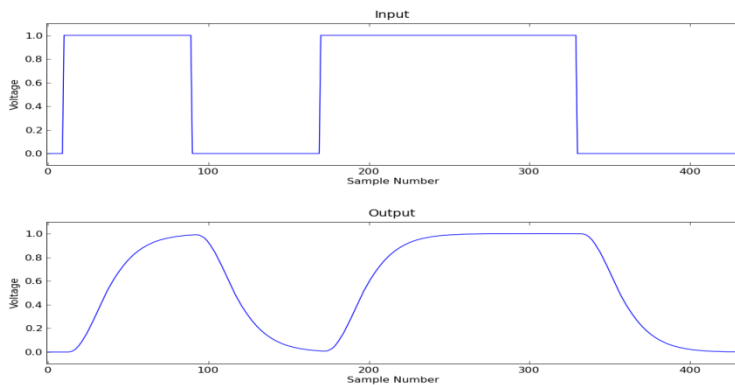
http://www.gpv-pcb.com/Files/Billeder/fabrikker/chemicalic/Chem_pcb_hdi.jpg

Transatlantic Cable

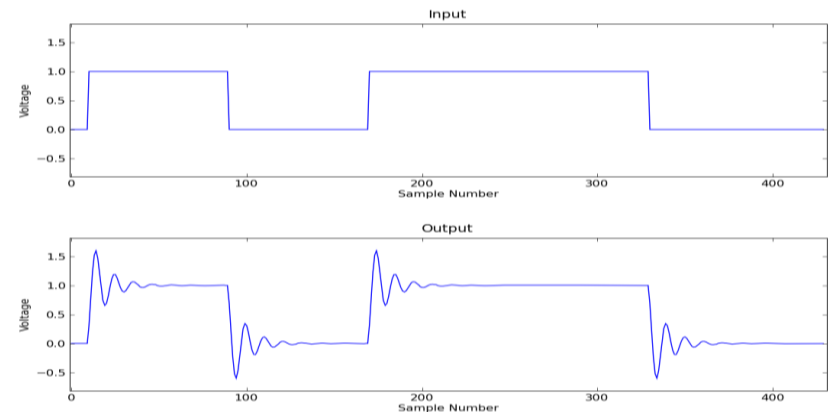


<http://www.satamerica.com/imagens/4a27897r1.jpg>

Slow Response

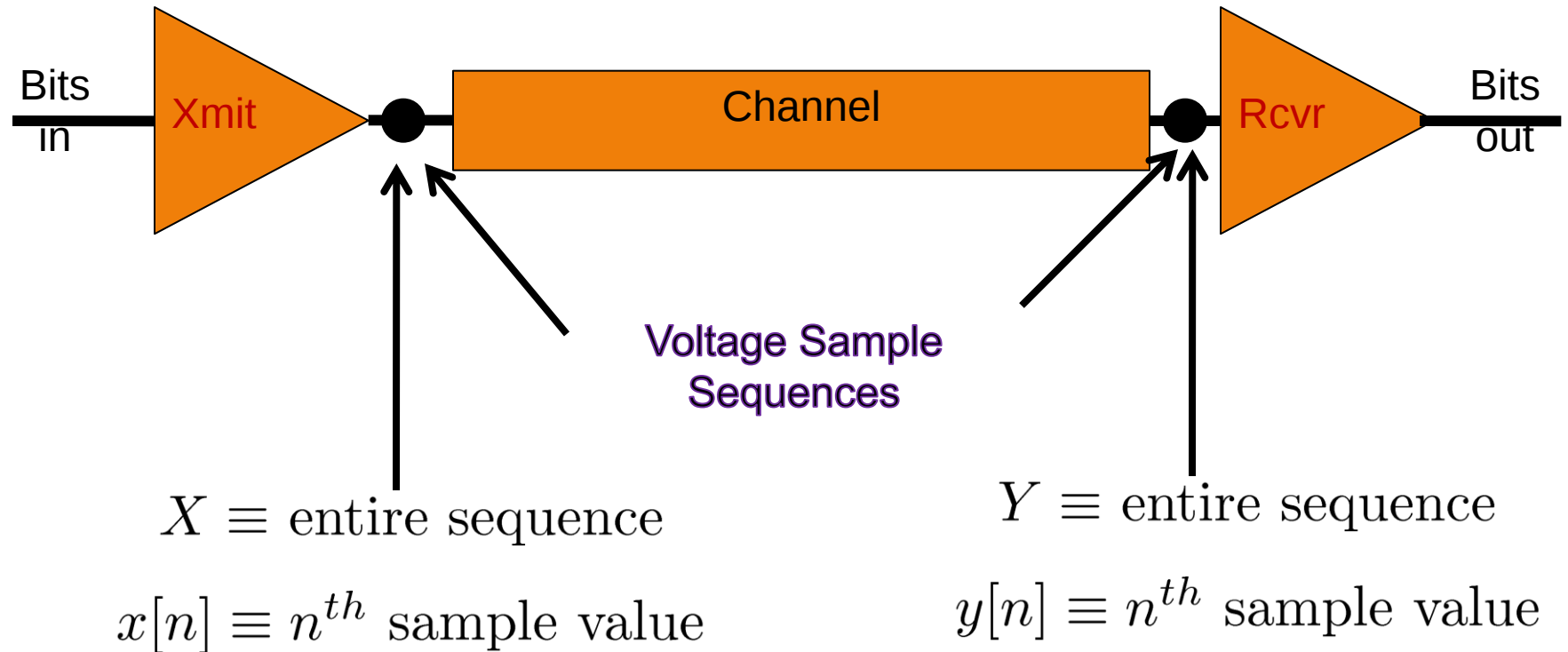


Ringing



May also have long delays (Receiver does NOT know)

Transmission Setup and Notation



Sample Rates:

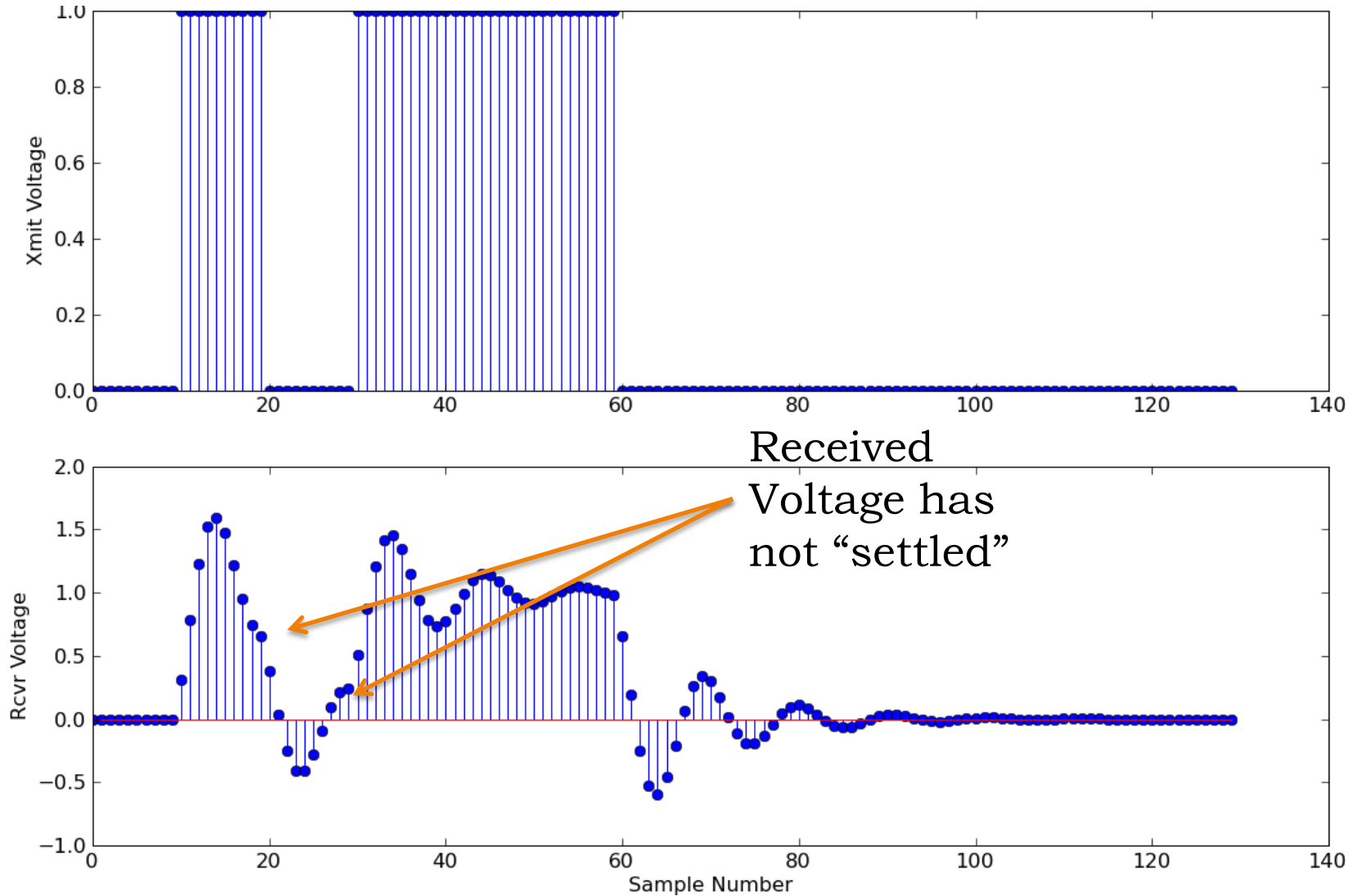
- 4 million Samples/Second (IR Transceiver)
- Up to gigaSamples/Second (Fastest)

Samples, Bit Period, Bit Rate

- Our Hardware
 - Updates transmitter output voltage every $\frac{1}{4}$ microsecond (4 million times a second).
 - Remeasures receiver voltage every $\frac{1}{4}$ microsecond (4 million times a second).
- Bit Period and Bit Rate
 - $BP = \text{Samples/bit} * \frac{1}{4} \text{ microsecond}$
 - $BR = \text{Bits transmitted per second}$
 - $BR = (4 \text{ million}) / (\text{Samples/bit})$
- Slower Bit Rate = Longer Bit Period
 - More time to propagate through channel

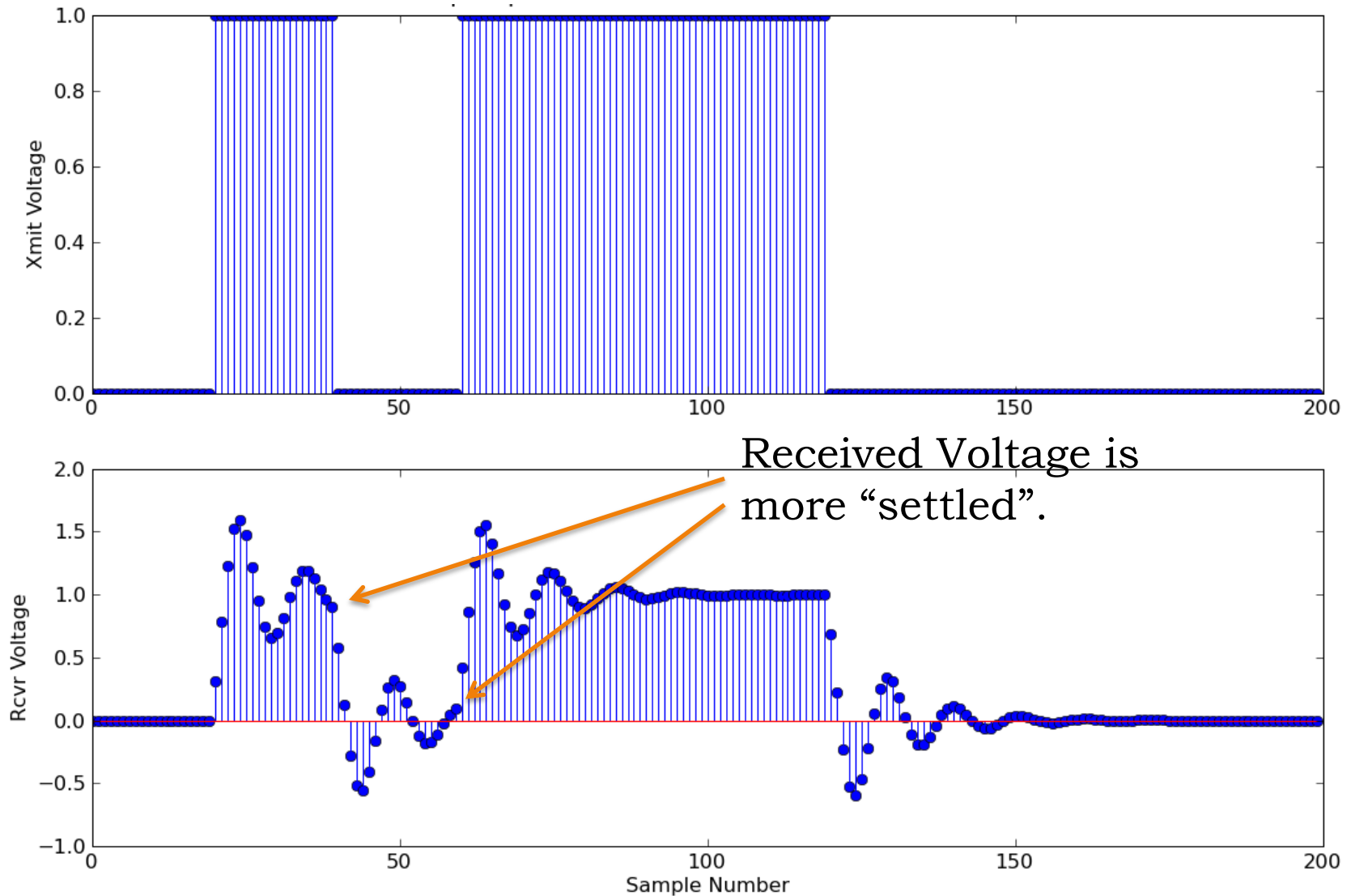
Sending 0101110, 2.5 microseconds/bit

10 samples/bit, 400,000 bits/sec



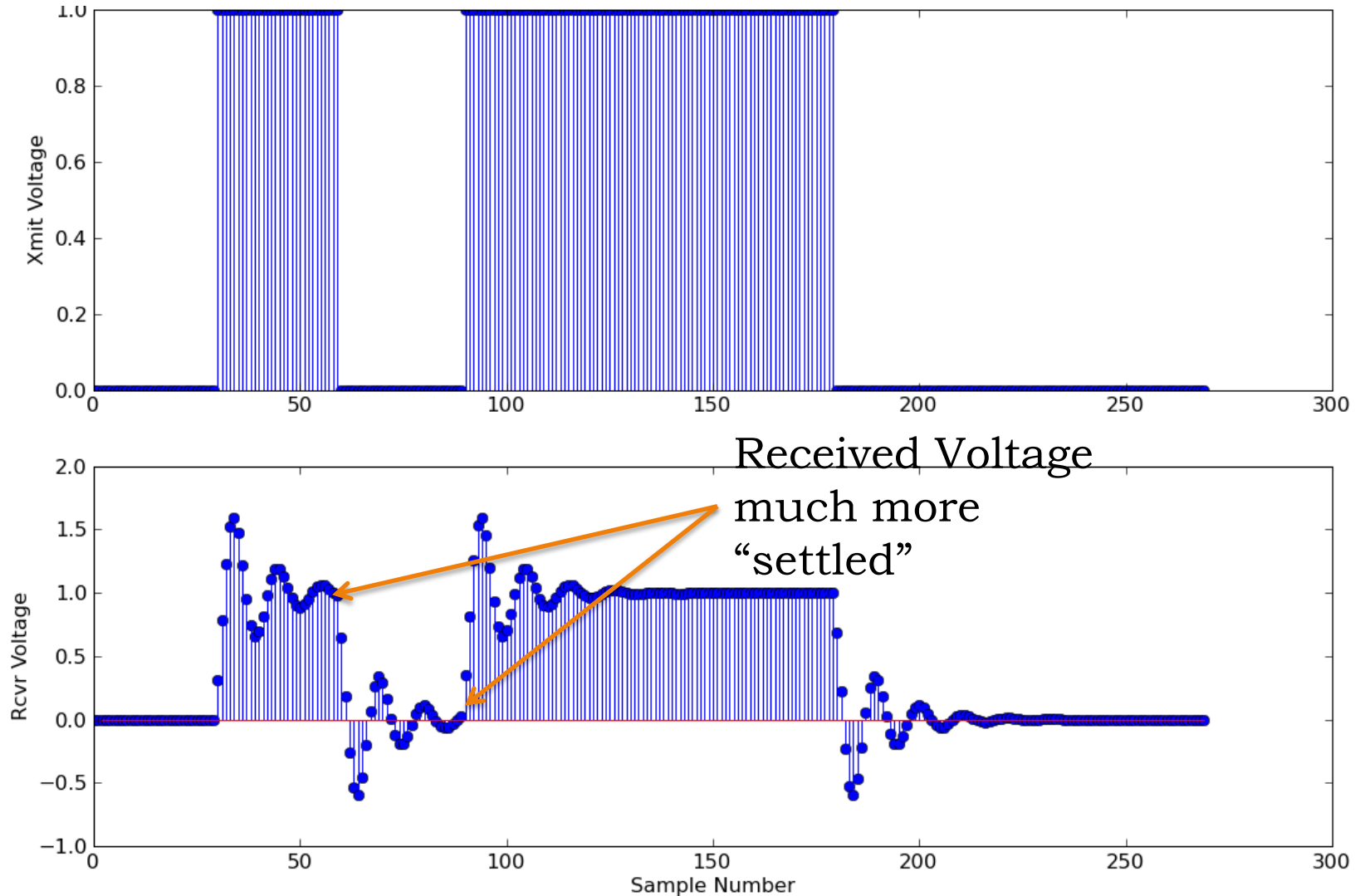
Sending 0101110, 5 microseconds/bit

20 samples/bit, 200,000 bits/sec

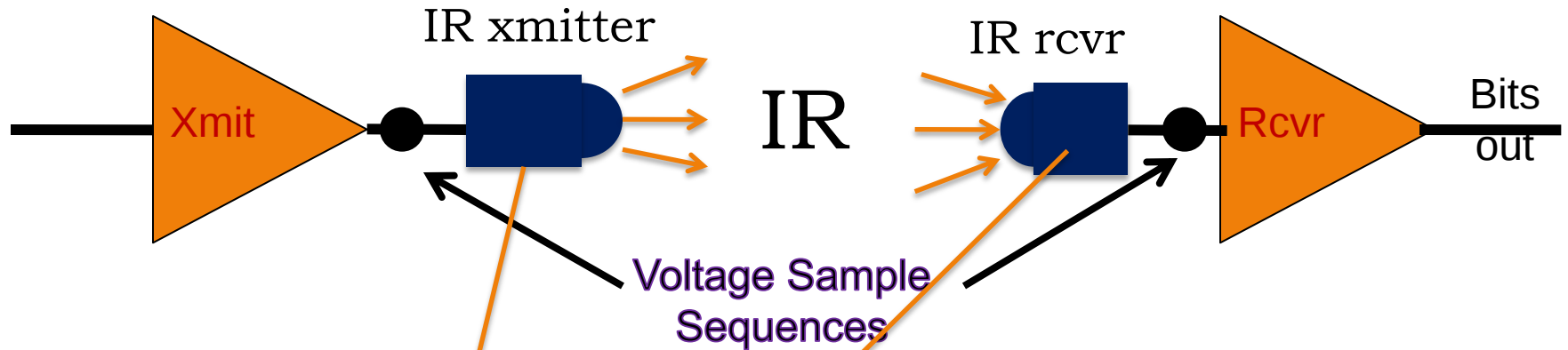


Sending 0101110, 7.5 microseconds/bit

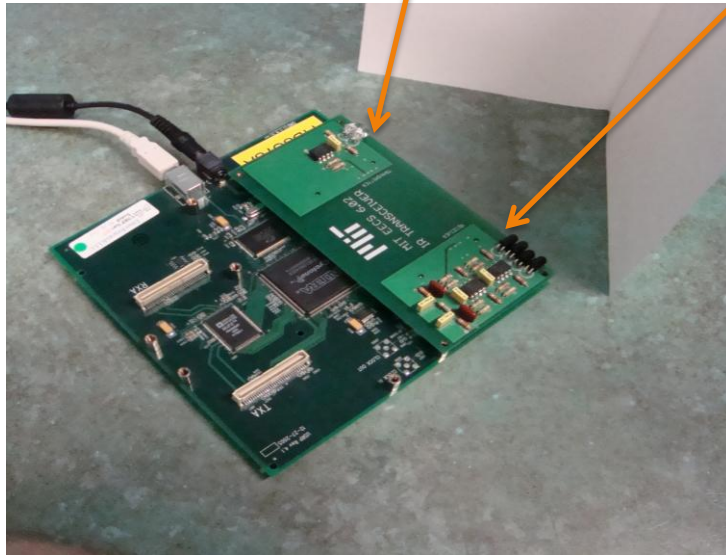
30 samples/bit, 133,333 bits/sec



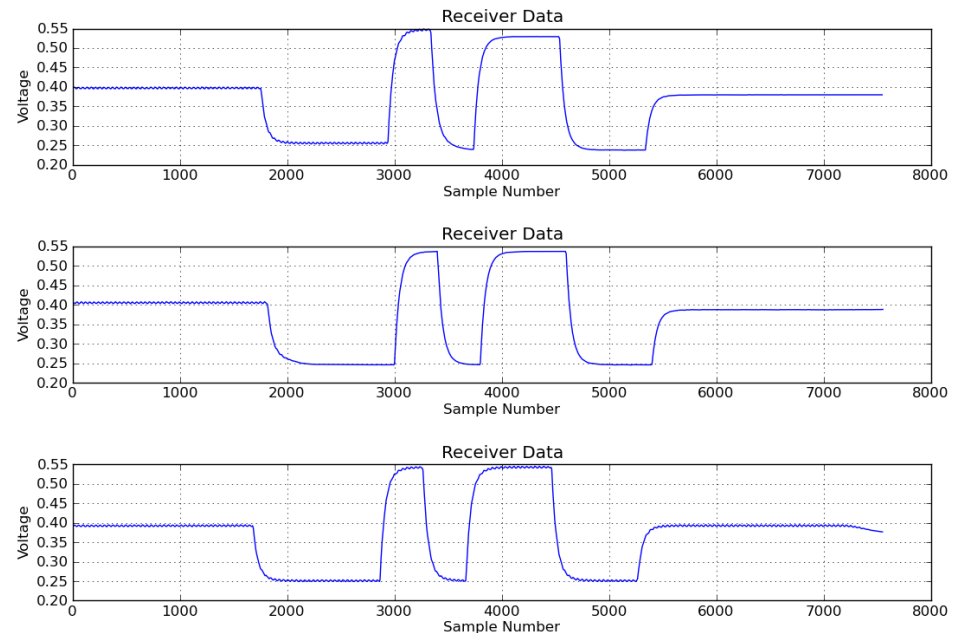
The 6.02 Infrared Transceiver



Loopback Setup

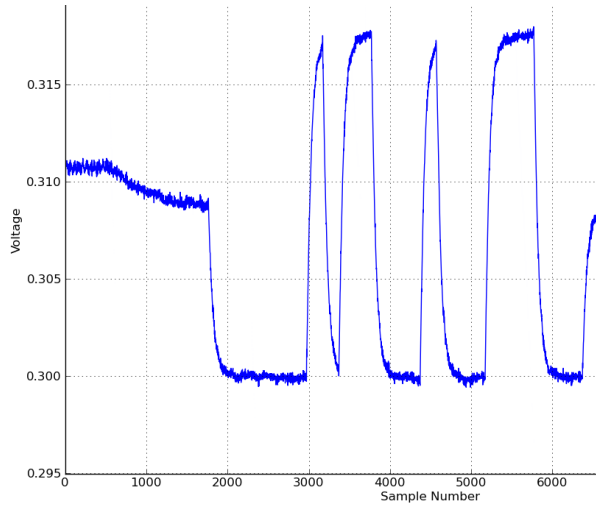


400 Samples/bit



The 6.02 IR Tranceiver - Bounce off ceiling

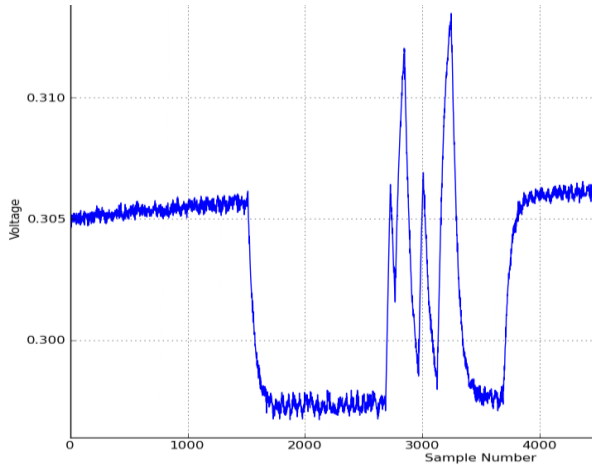
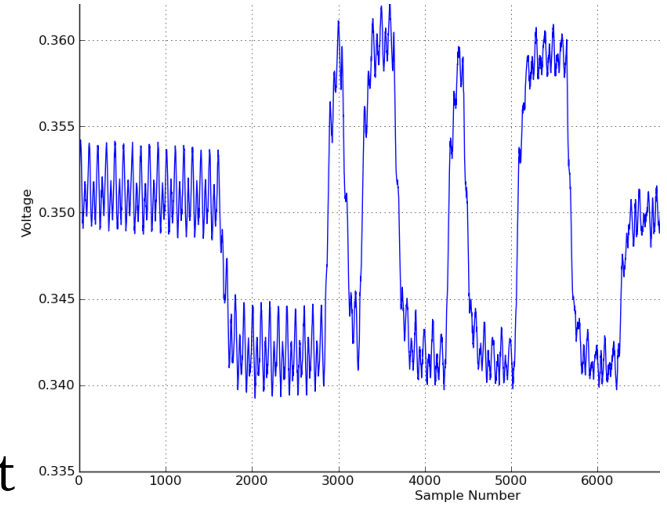
Dark Room



200 Samples/bit

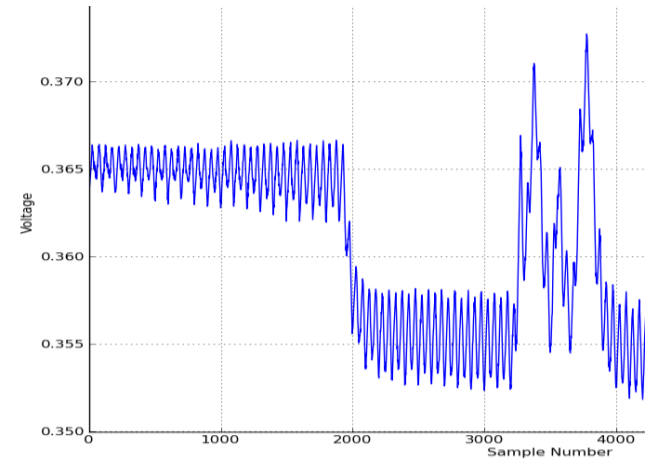
Bits sent = [10110001000111]

Lights On



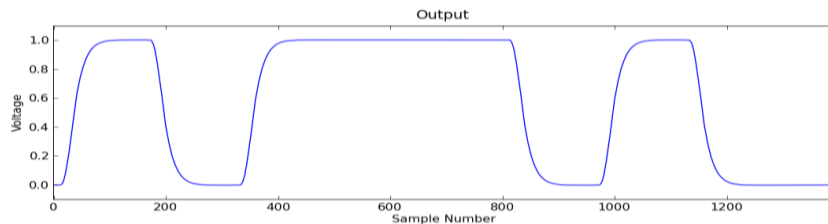
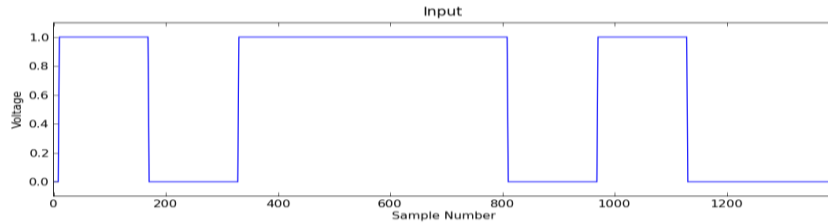
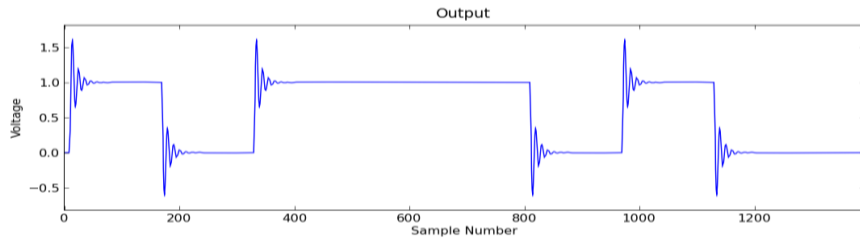
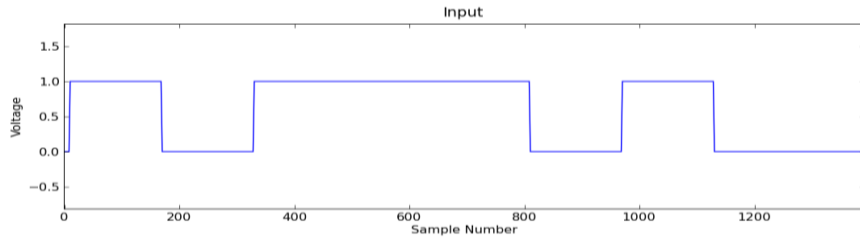
40 Samples/bit

Bits sent = [1011010111]

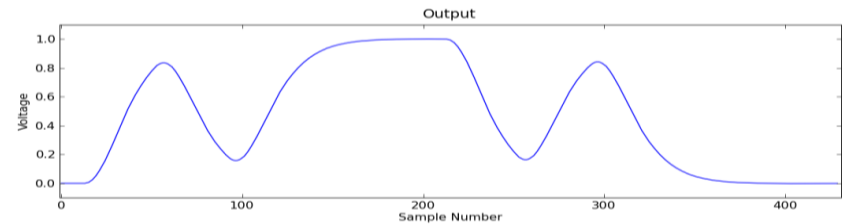
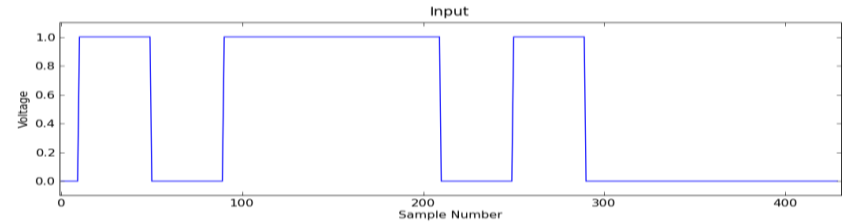
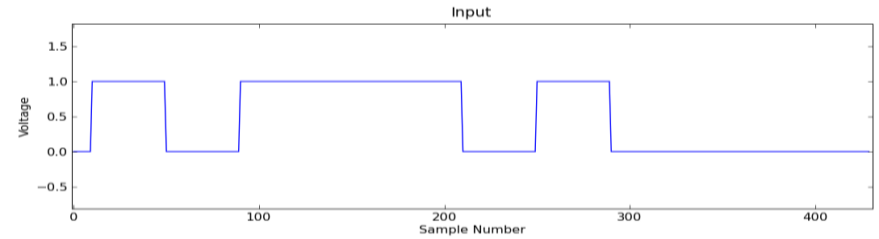


Intersymbol Interference

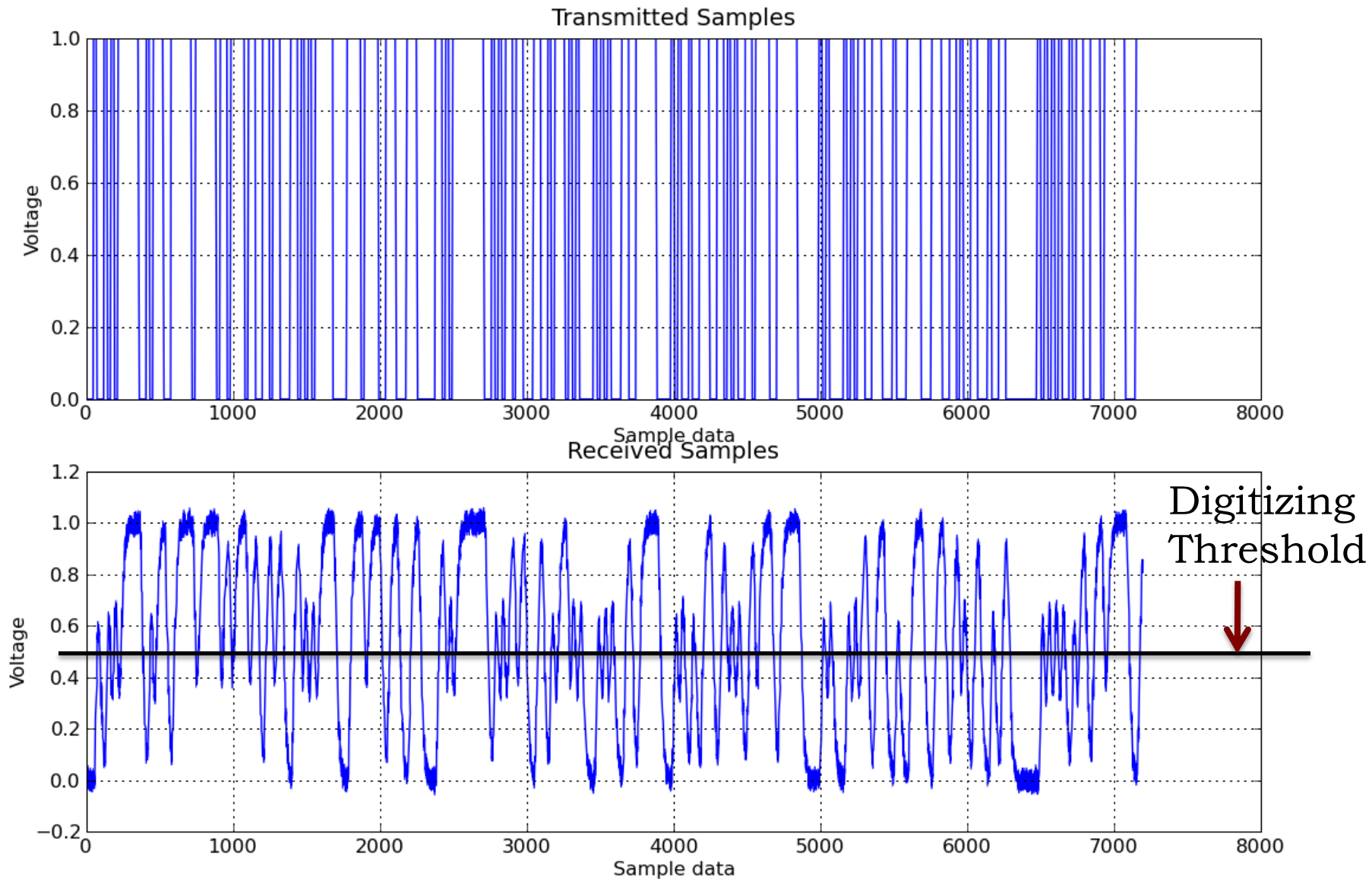
Long Bit Period (slow rate)



Short Bit Period (Fast Rate)

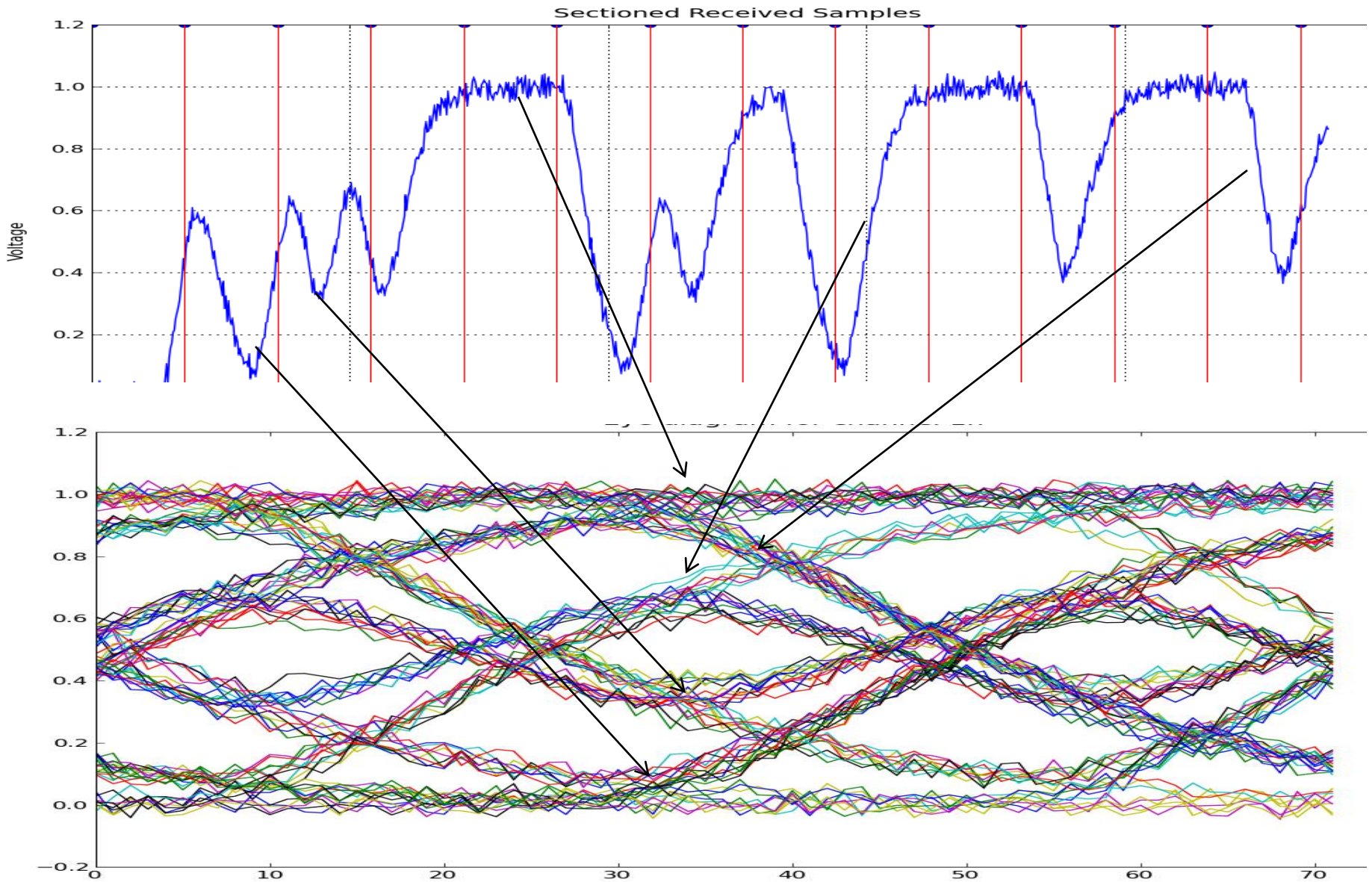


Received Data - Noisy Channel, 24 sample/bit



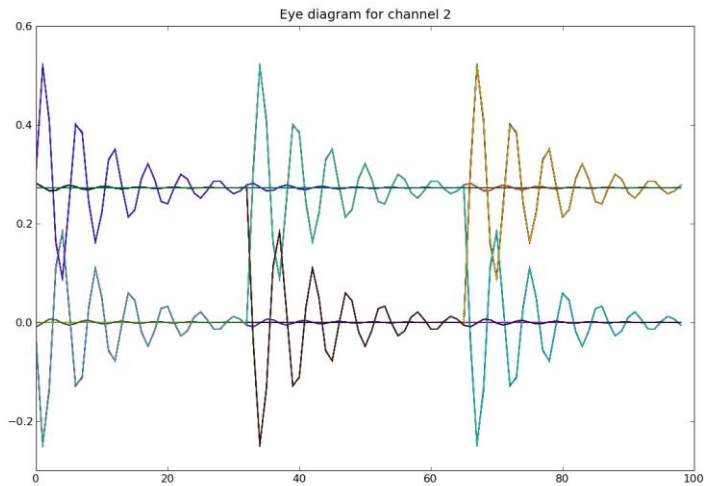
Any Bit Errors?

Eye Diagram-Overlay 3 Period Sections



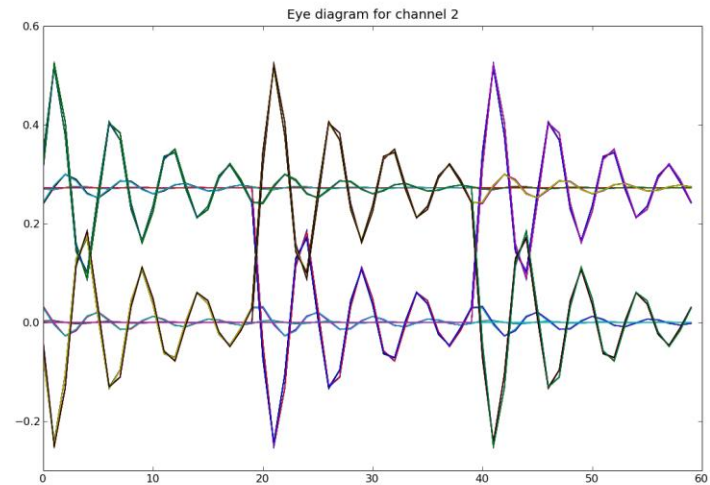
Eyes for Ringing versus Slow System

**Medium Bit
Period(33 samples)**

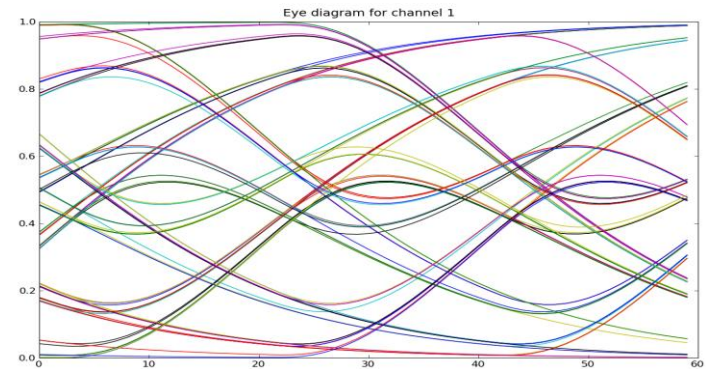
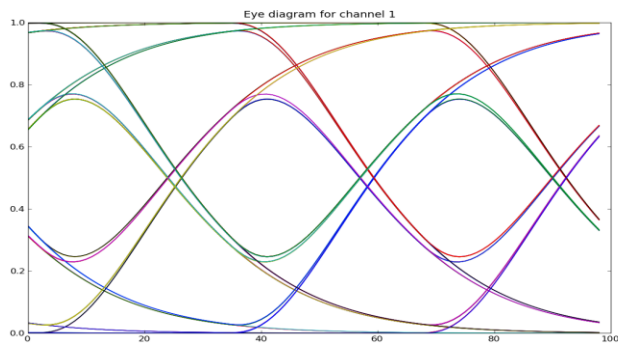


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Short Bit Period(20 samples)

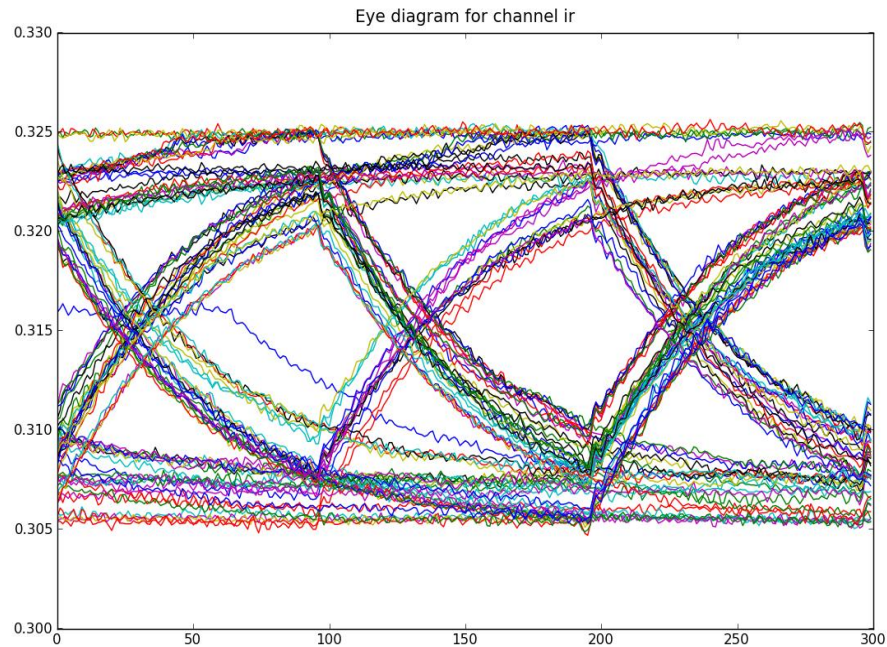


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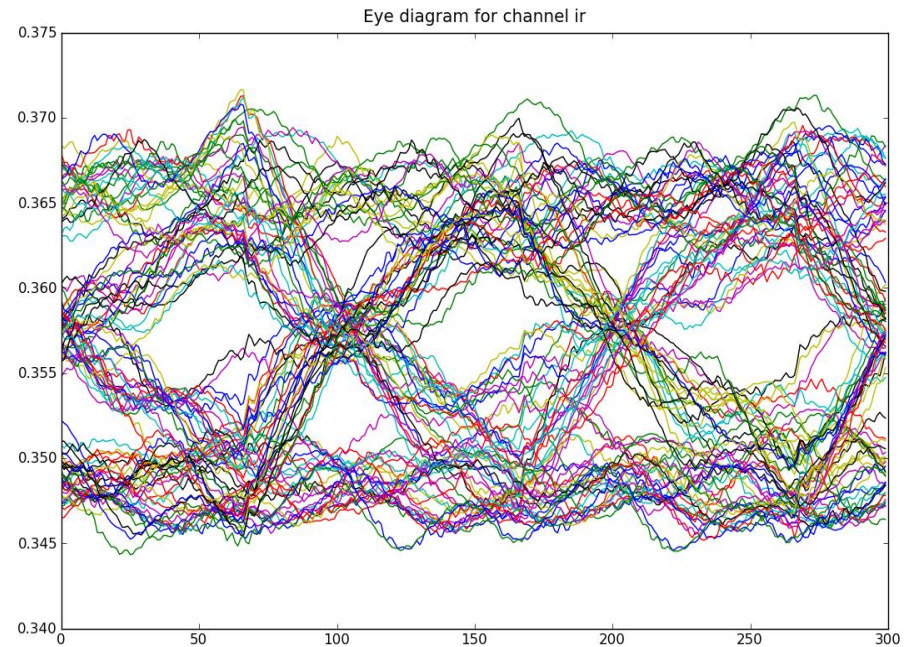


Eye Diagram for IR Detector

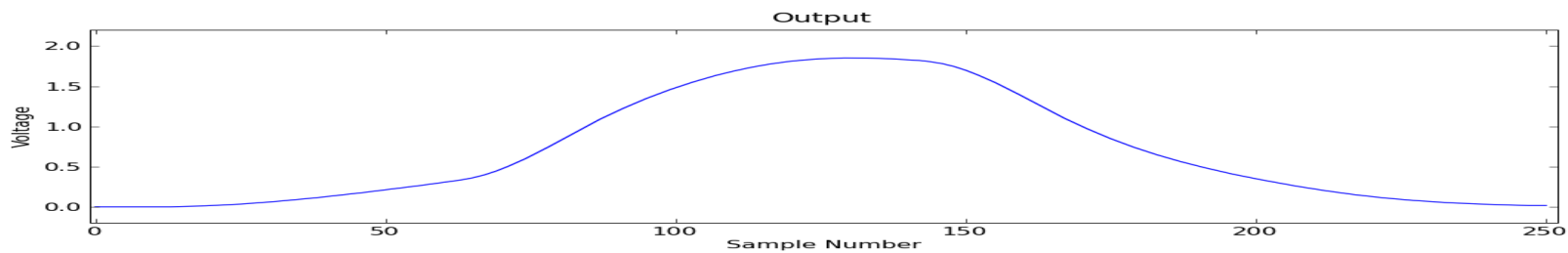
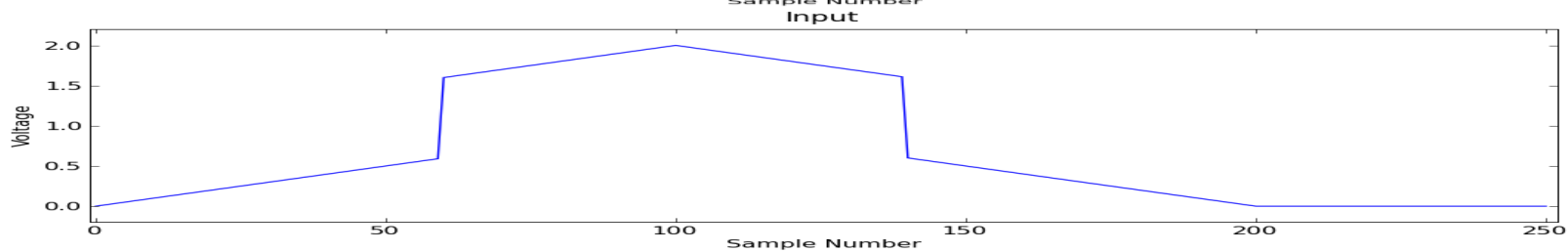
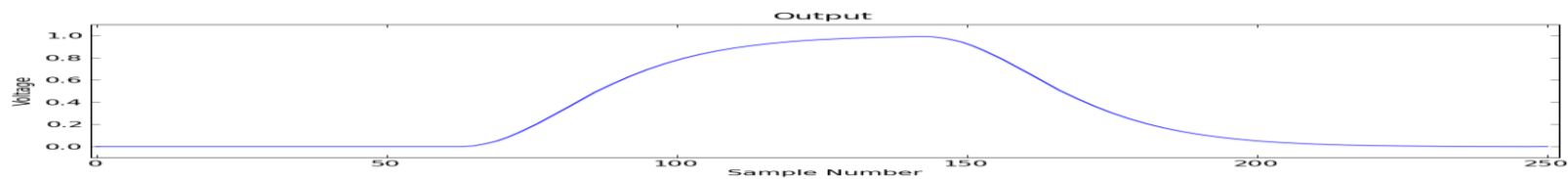
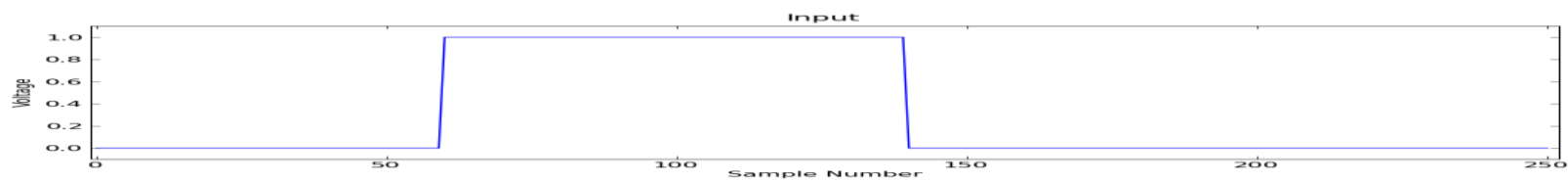
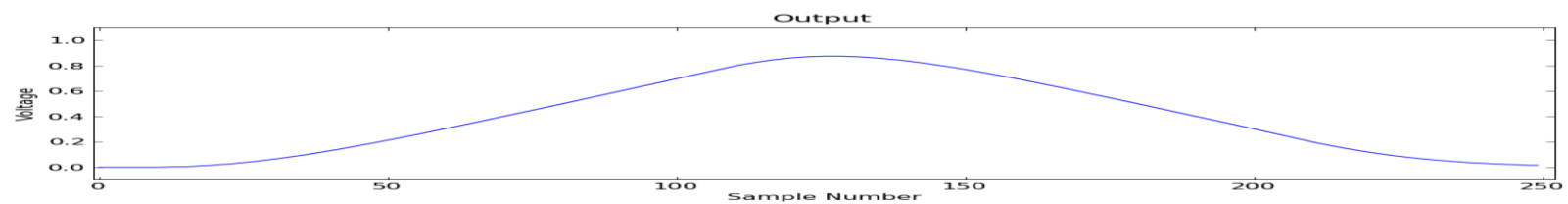
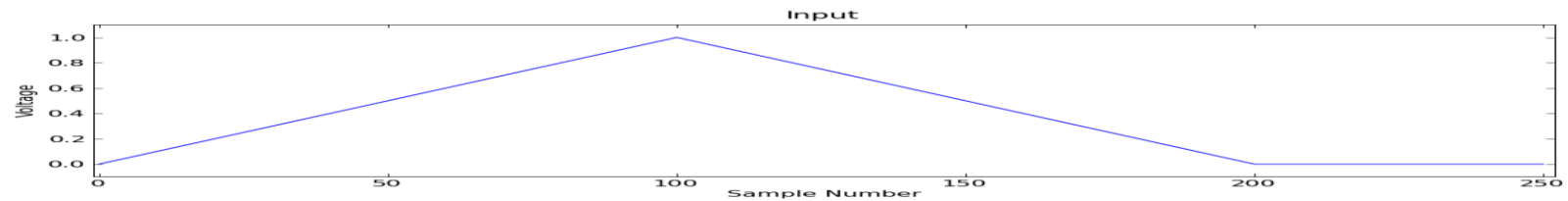
Eye Diagram 40 Samples per bit, dark room

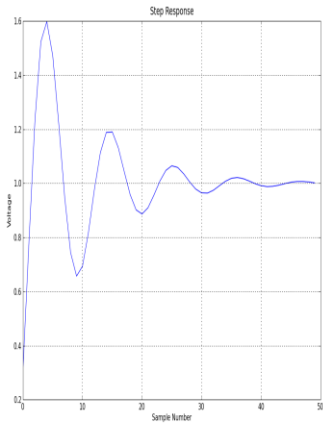


Eye Diagram 40 Samples per bit, lights on!

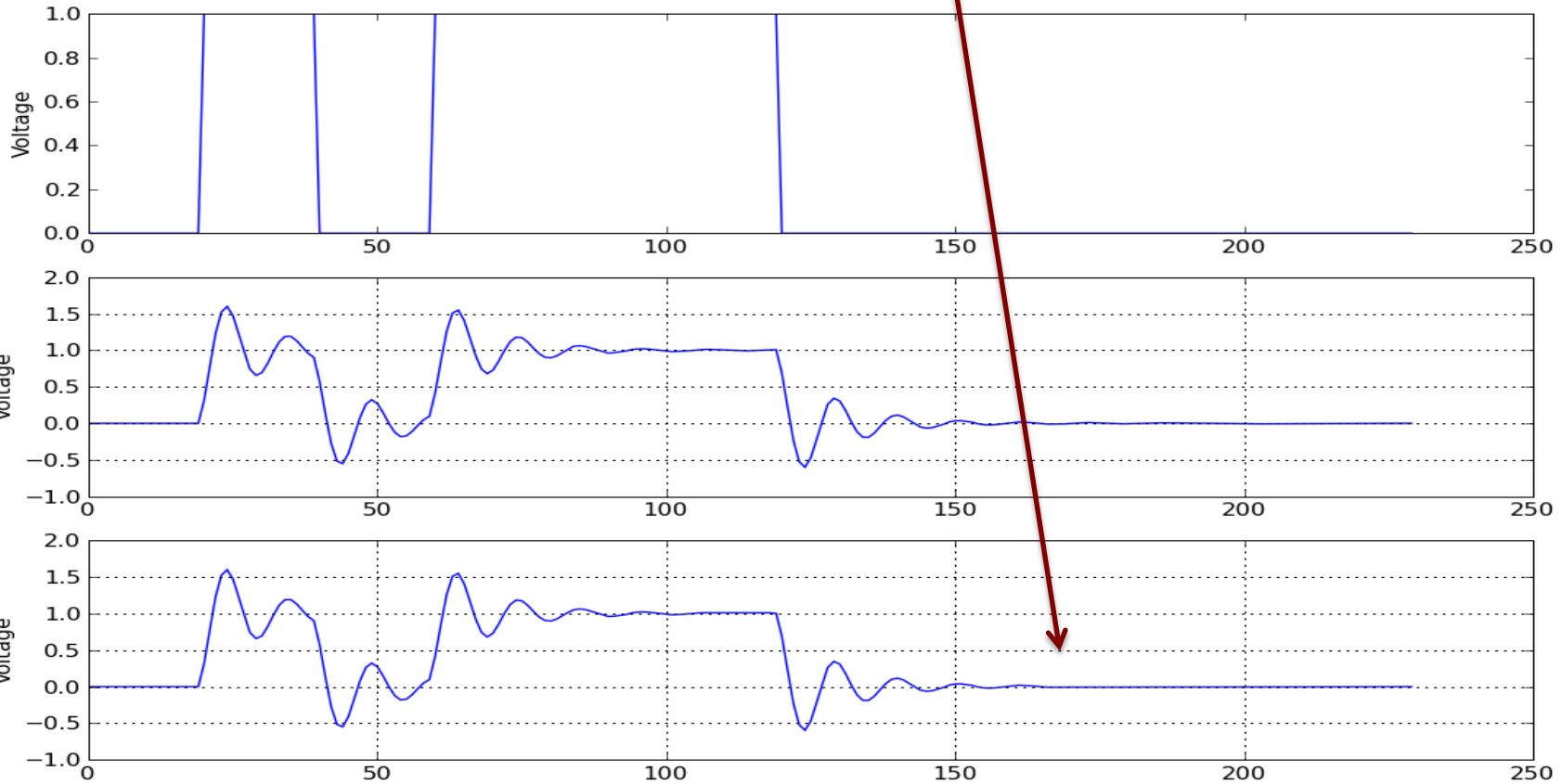


Superposition

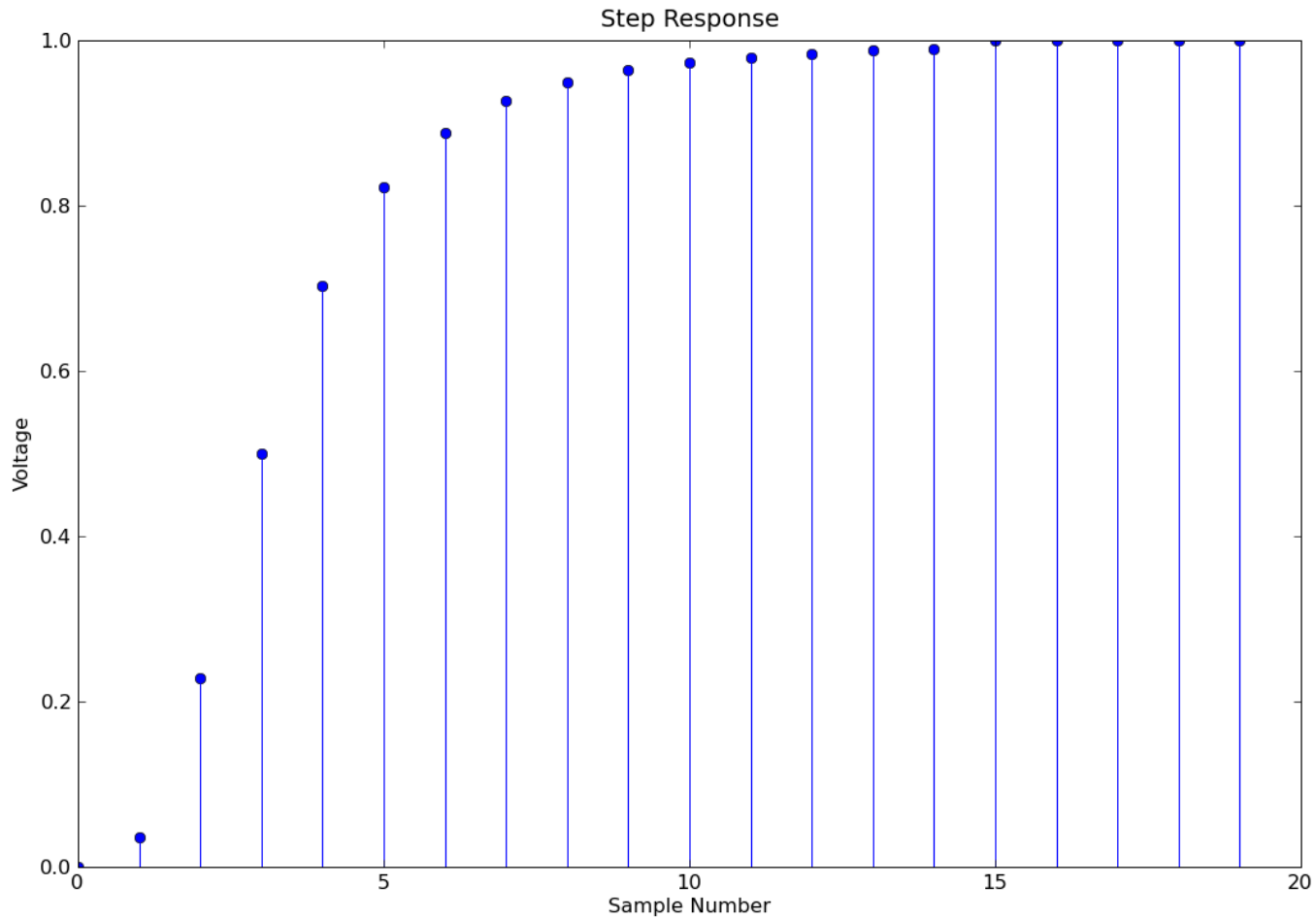




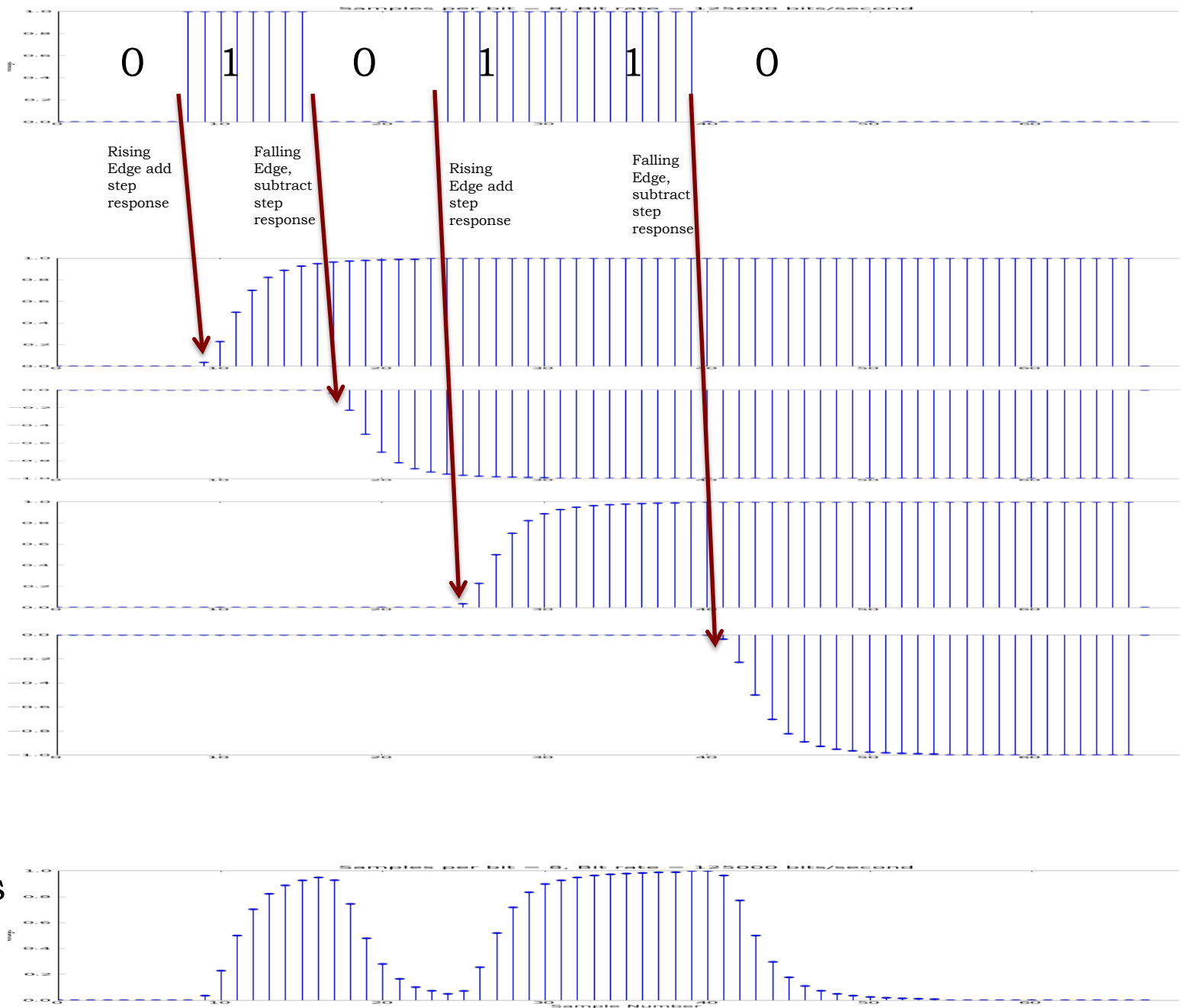
Step Response and
results from
superposition



Step Response For Another Example Channel



Xmit
Data

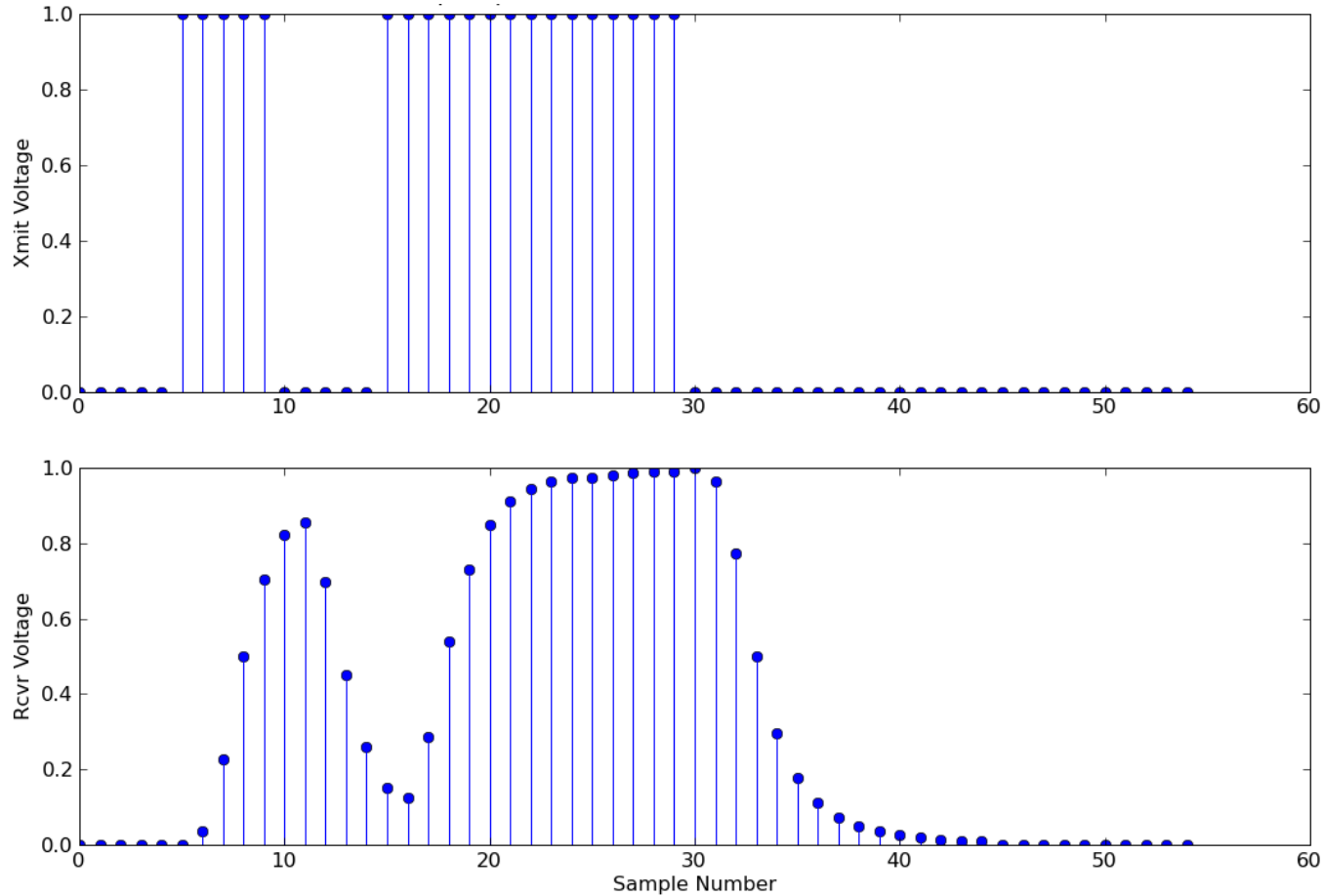


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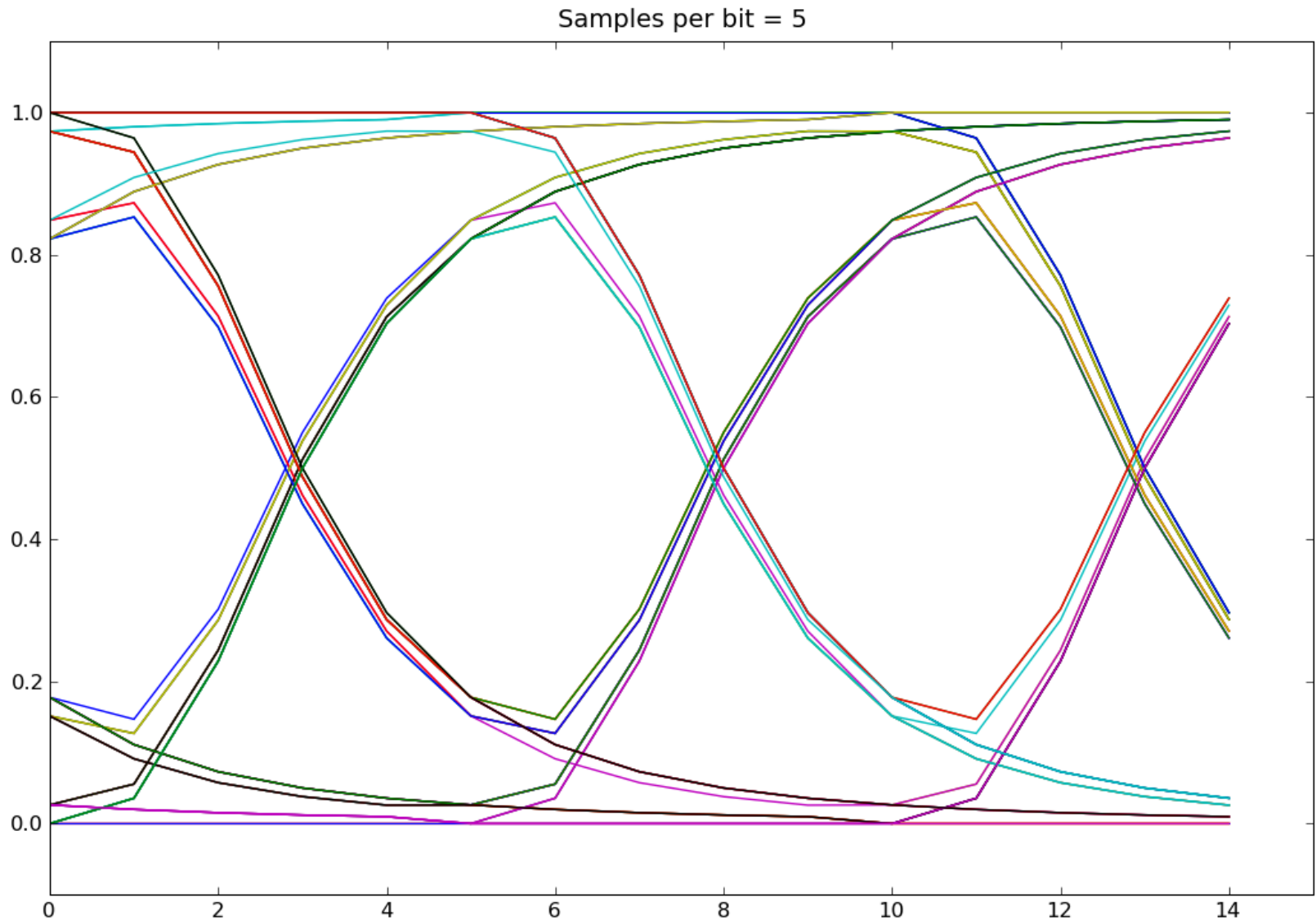
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Sending 0101110, 1.25 microseconds/bit

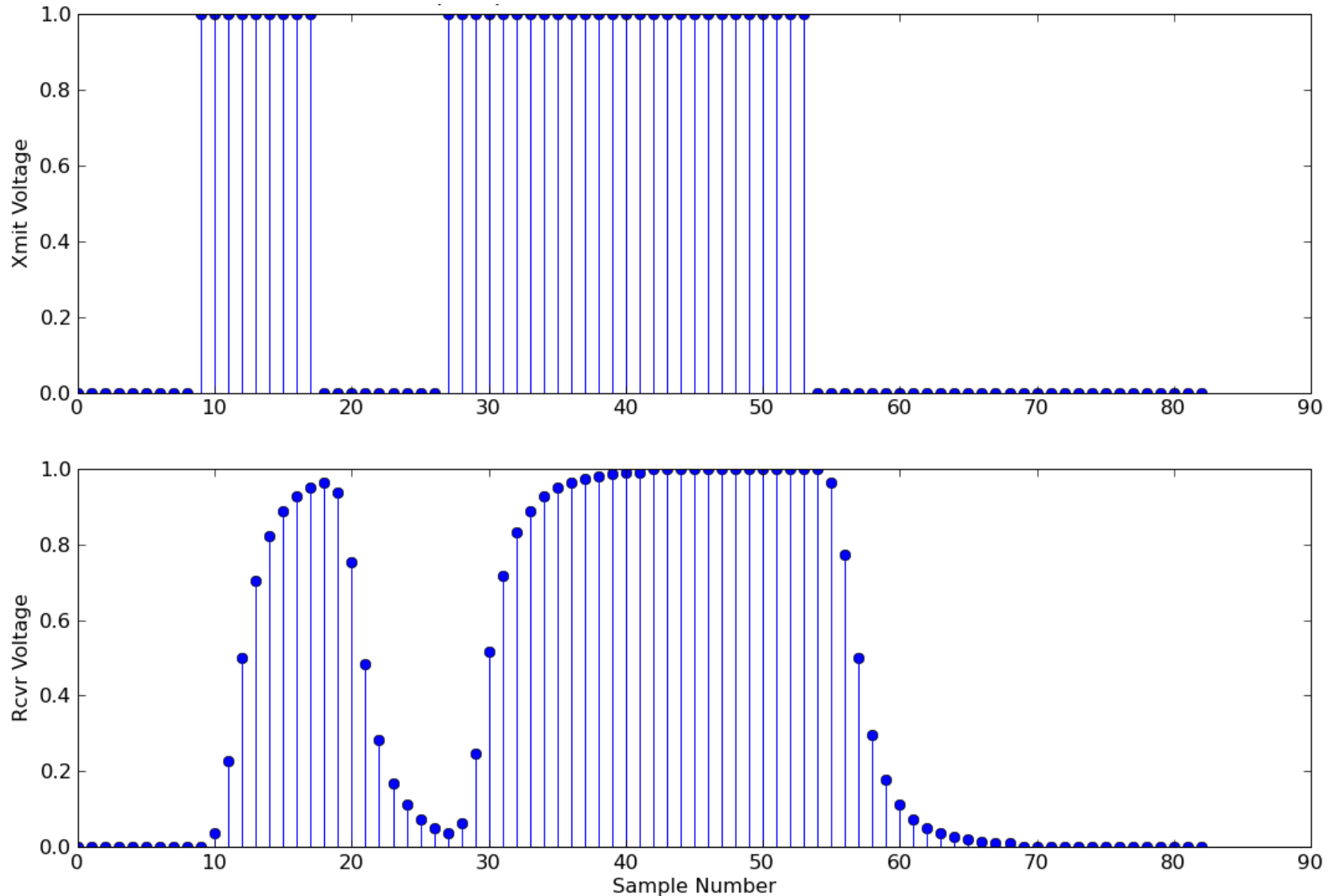
5 samples/bit, 800,000 bits/sec



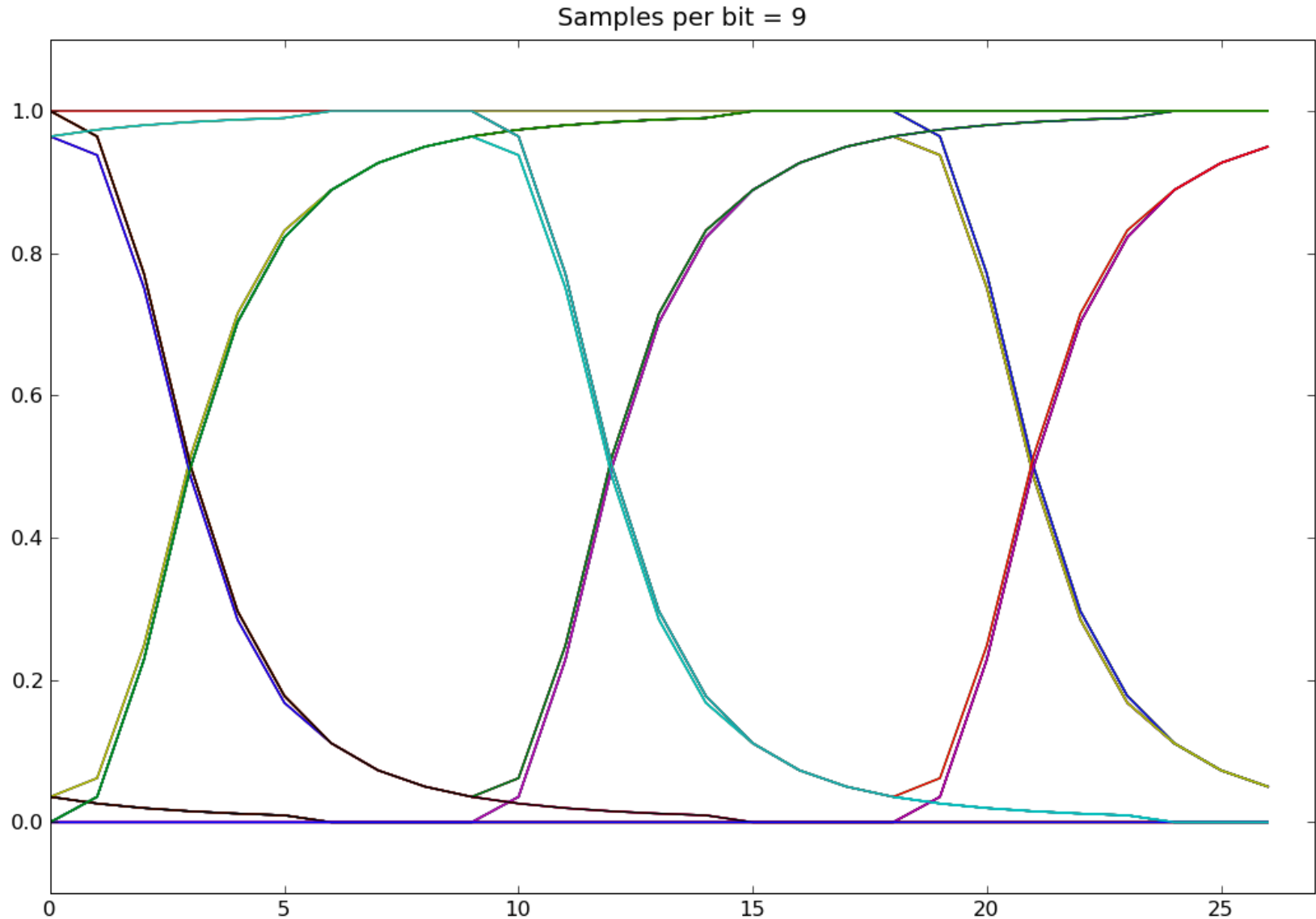
Eye Diagram for 1.25 microsecond bit period



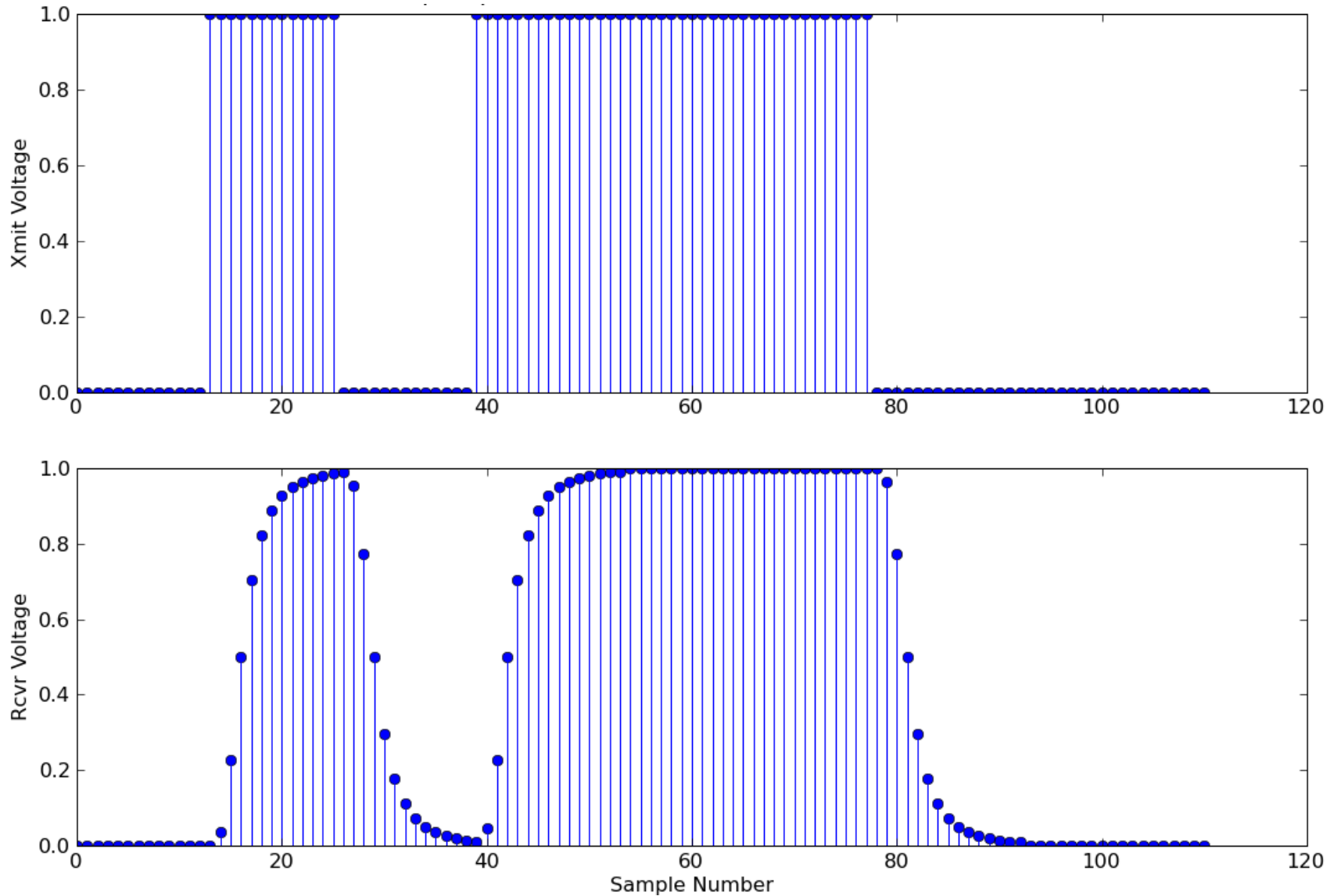
Sending 0101110, 2.25 microseconds/bit



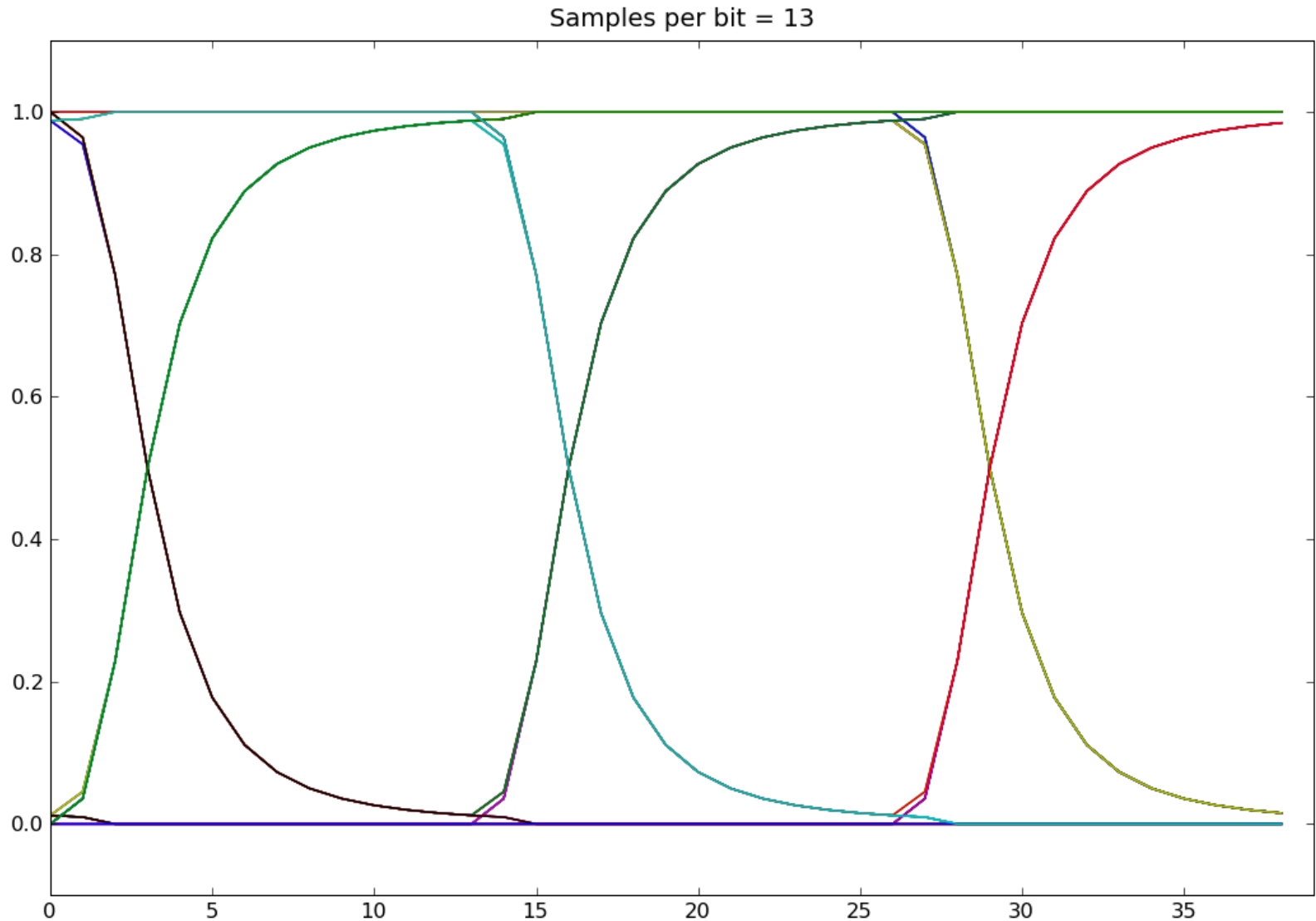
Eye Diagram for 2.25 microsecond bit period



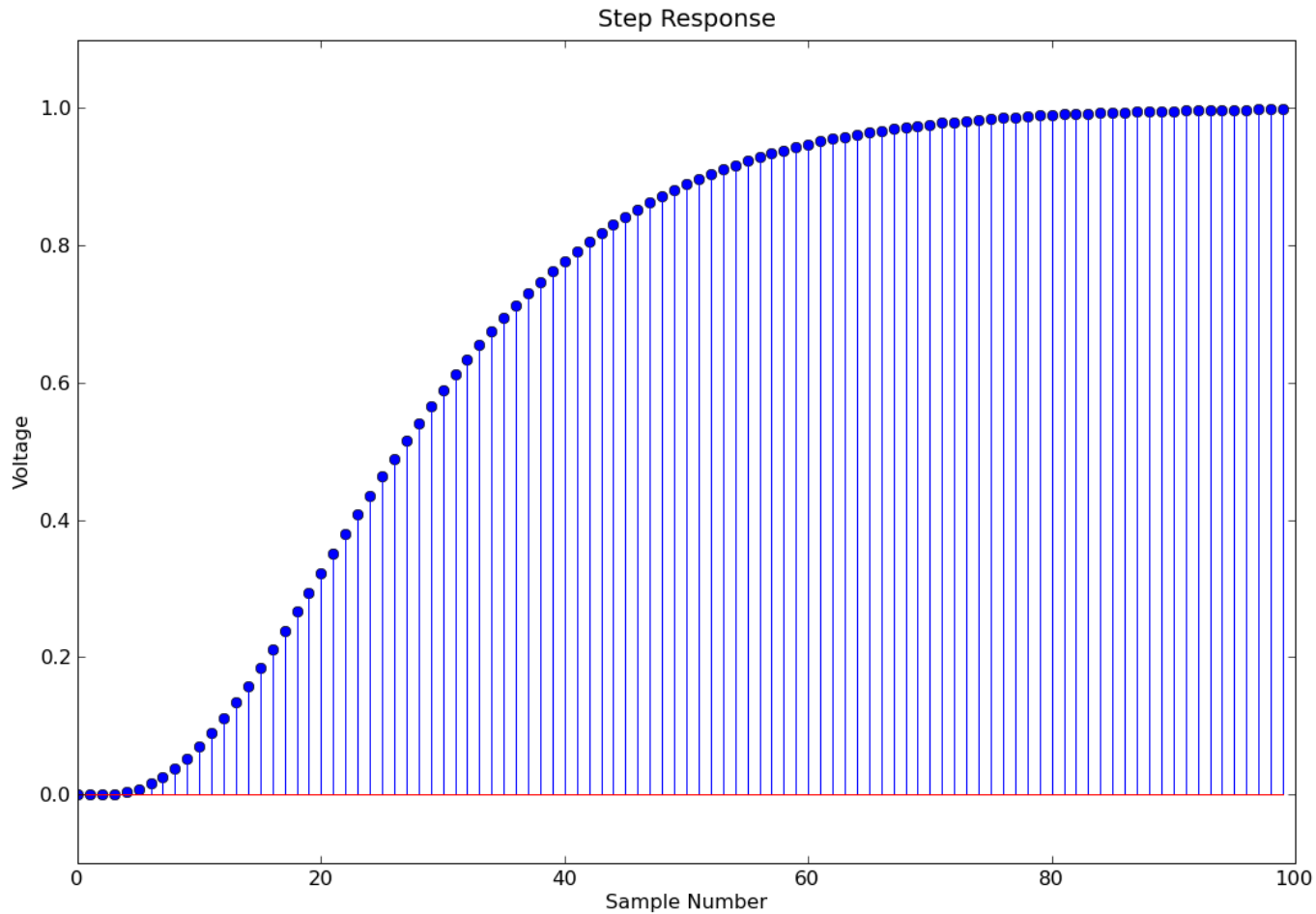
Sending 0101110, 3.25 microseconds/bit



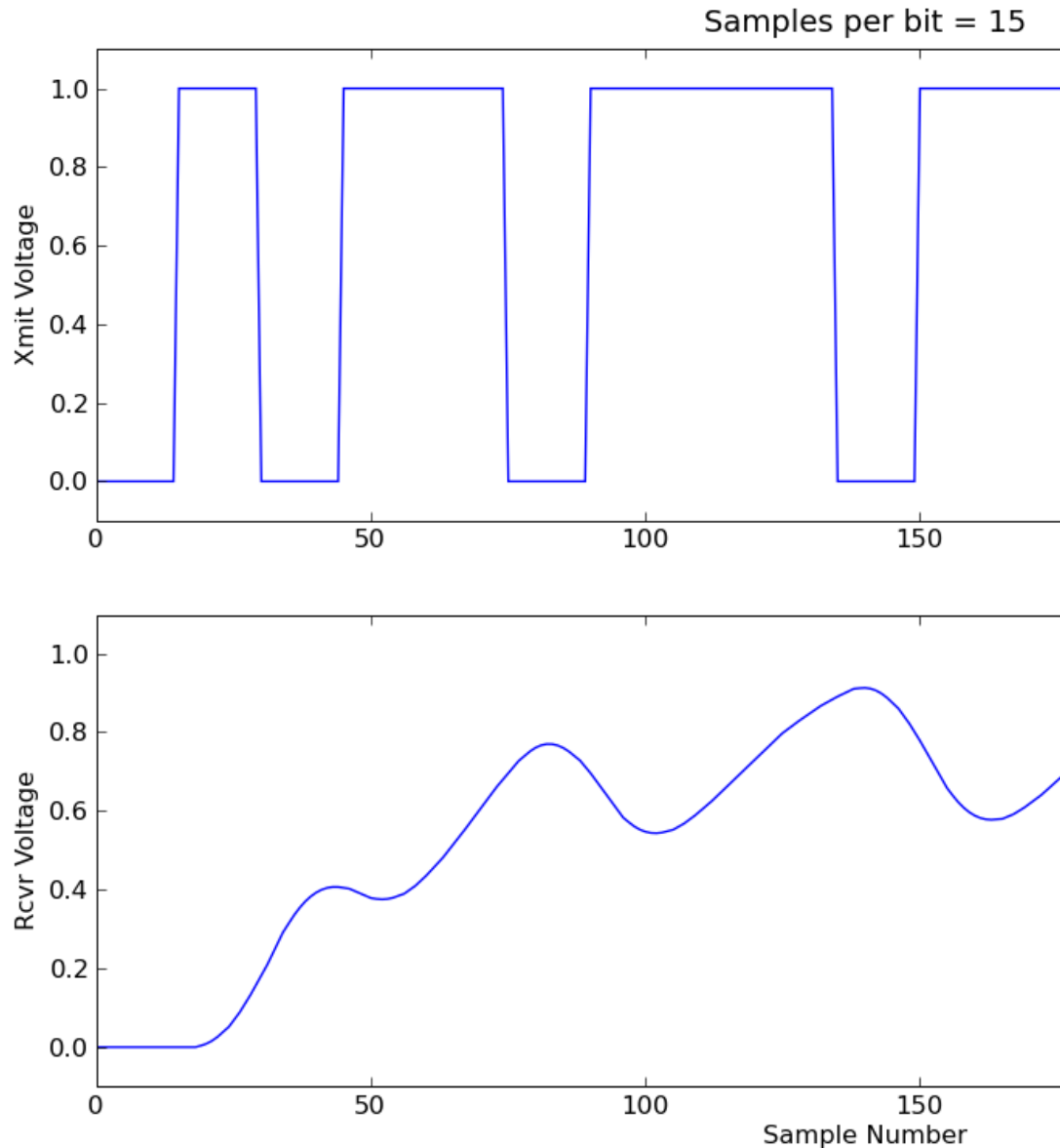
Eye Diagram for 3.25 microsecond bit period



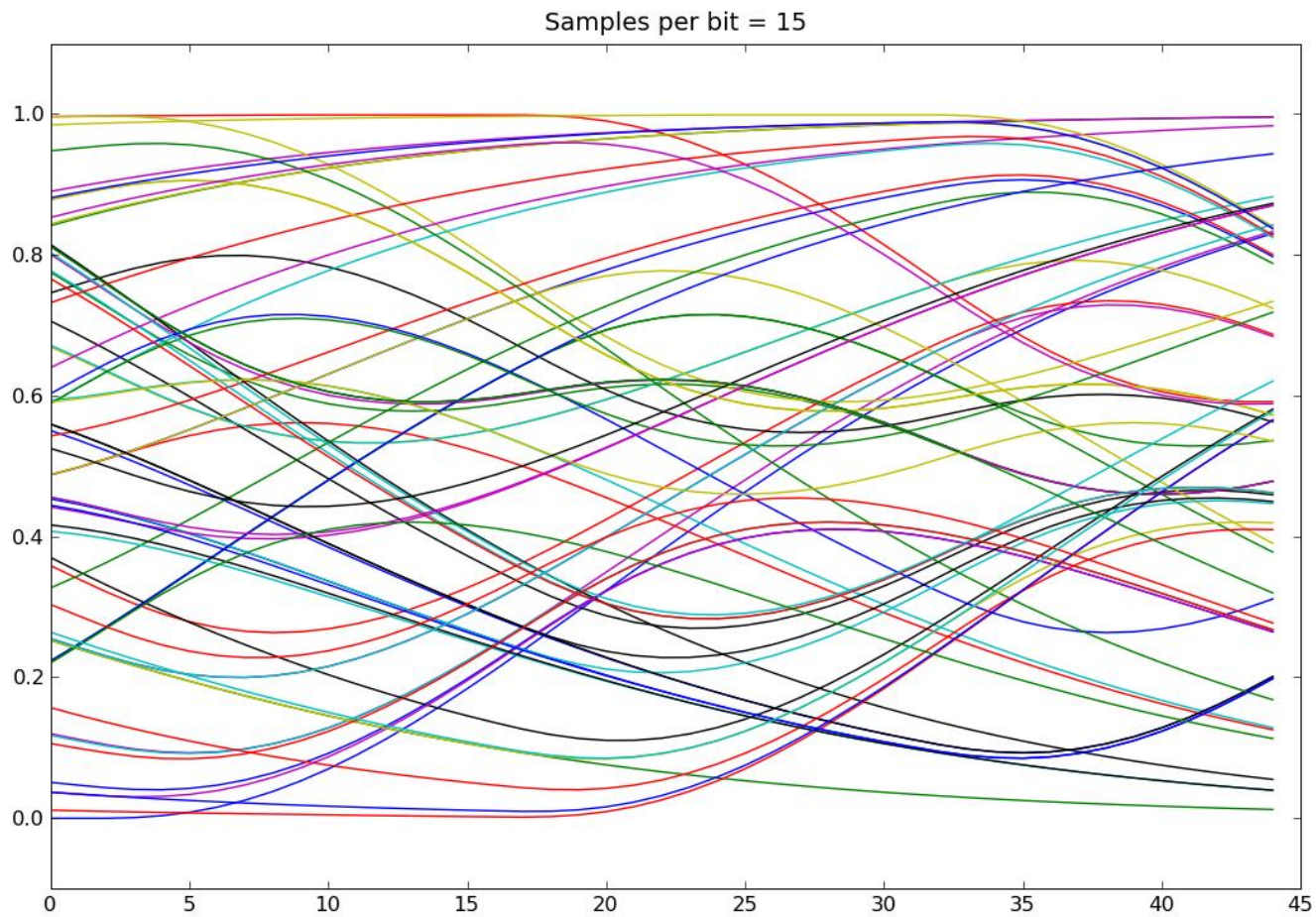
Step Response for Slow Channel



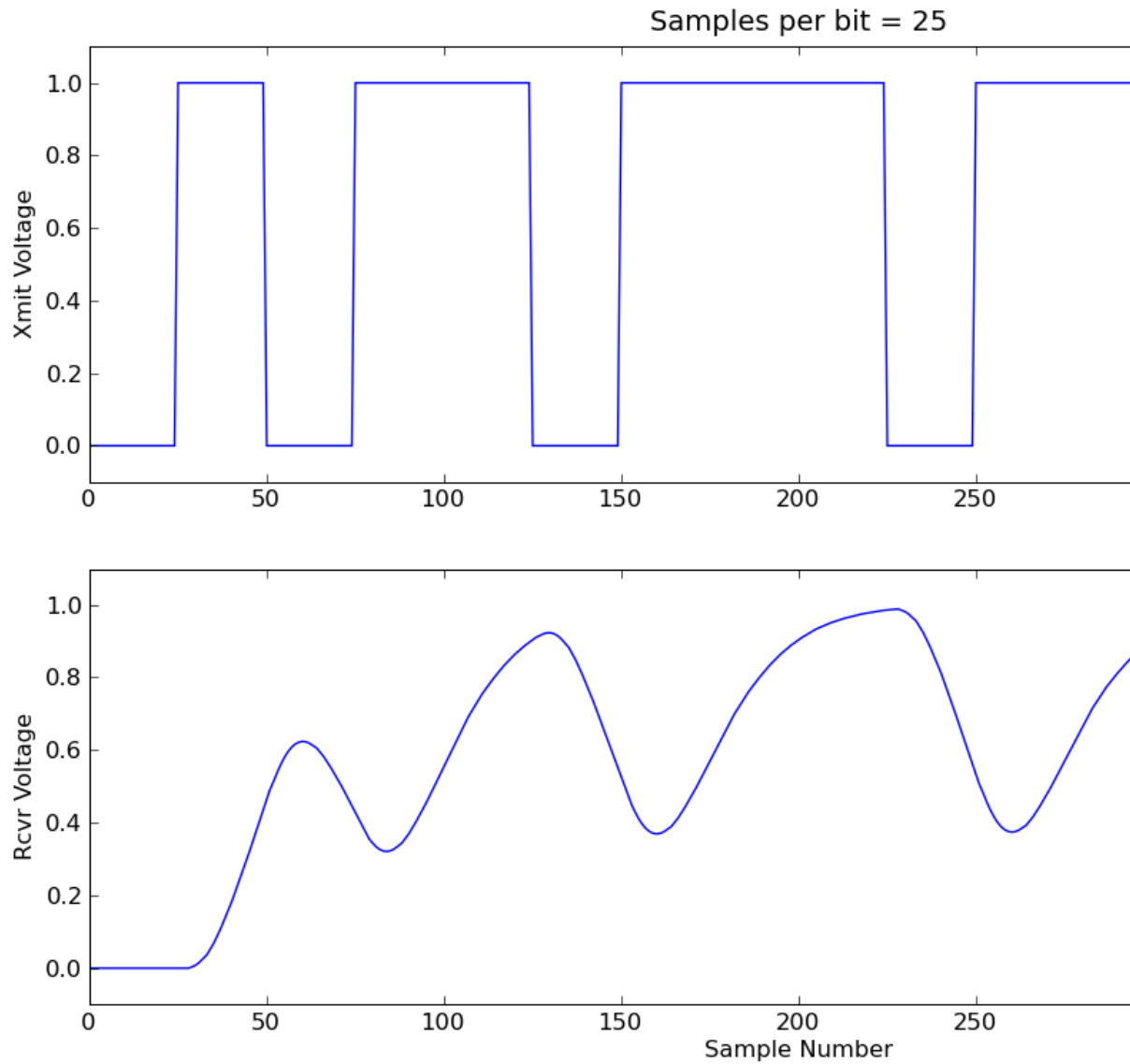
Slow Channel Response



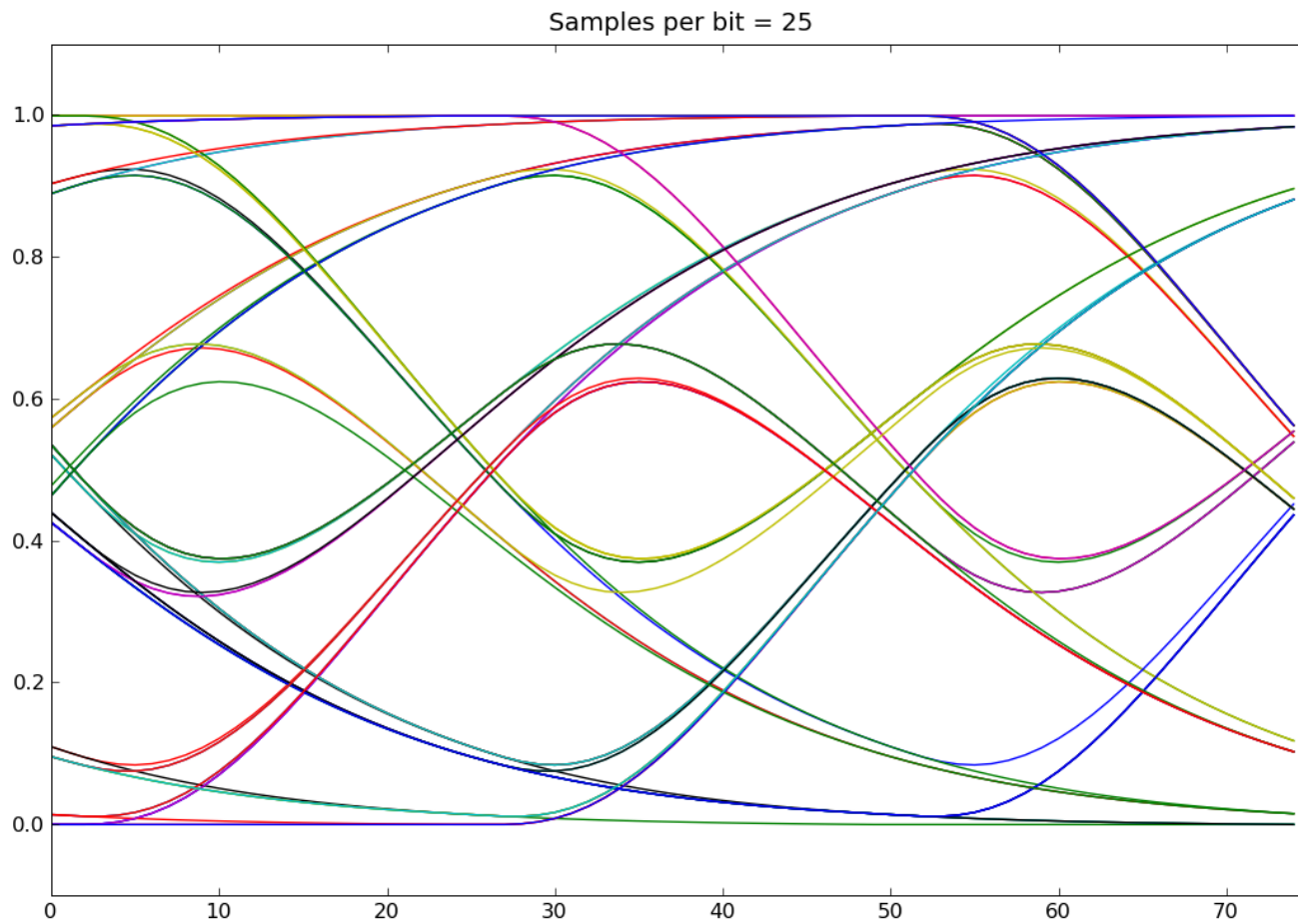
Slow Channel Eye Diagram



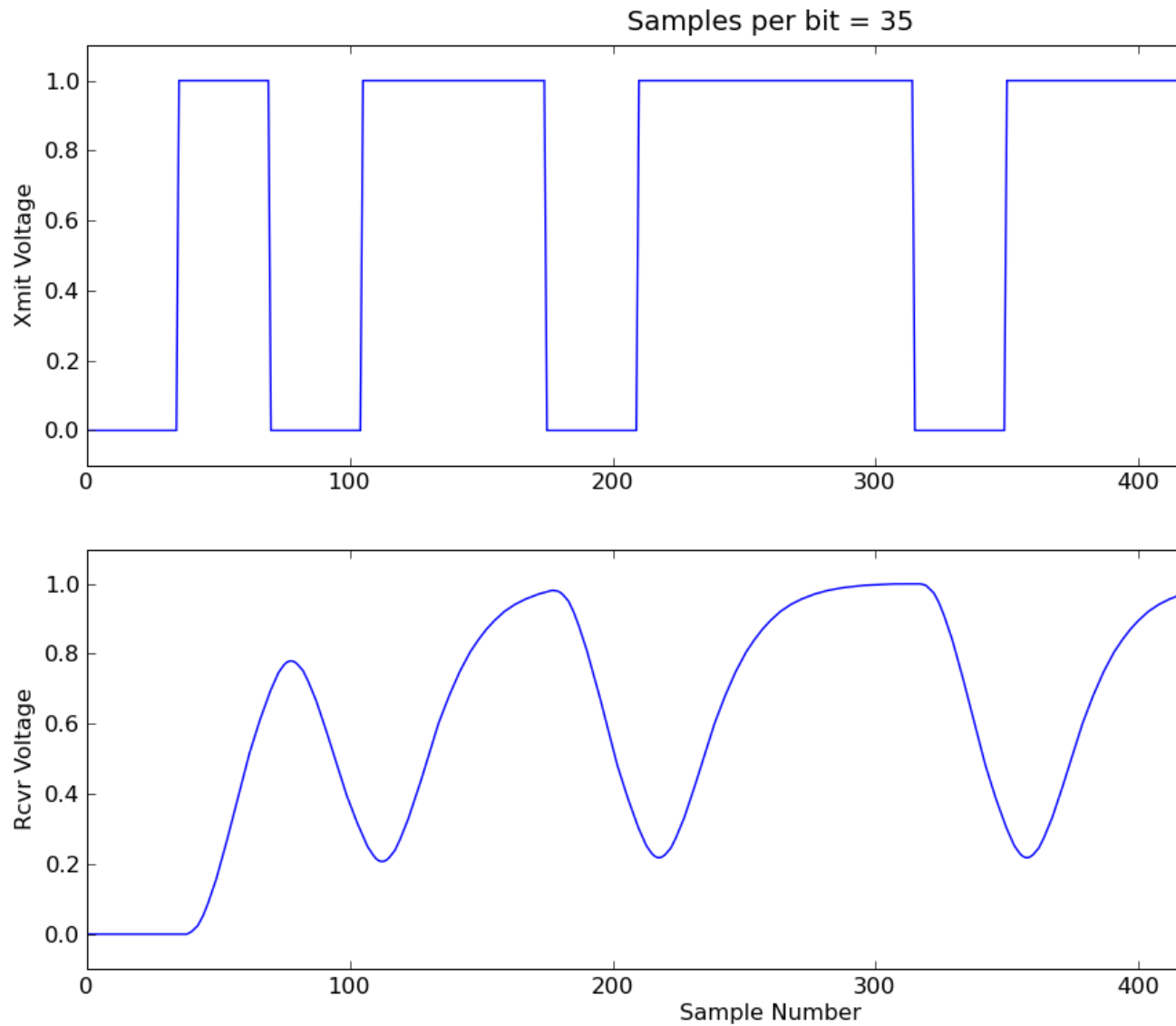
Slow Channel Response



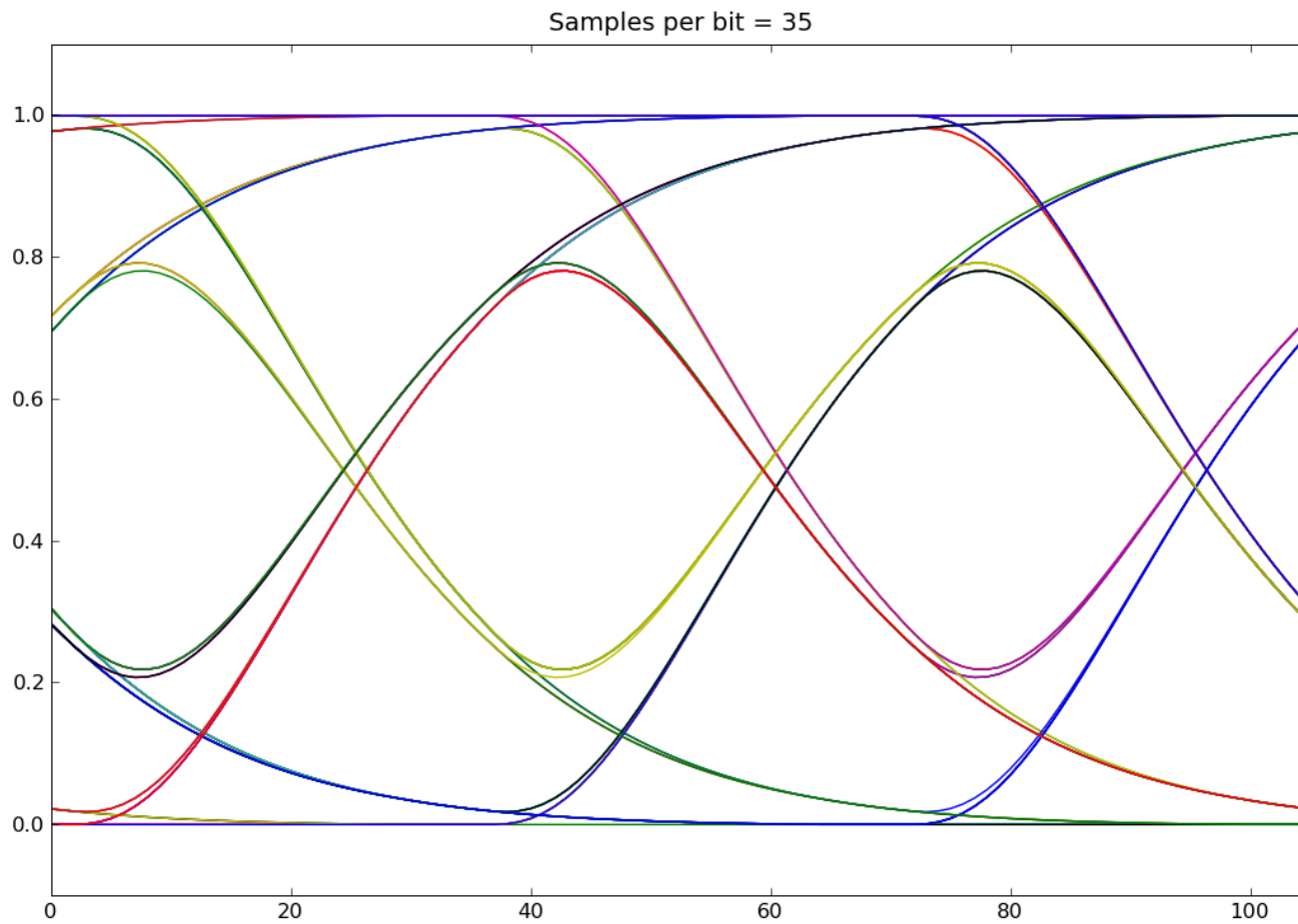
Slow Channel Eye Diagram



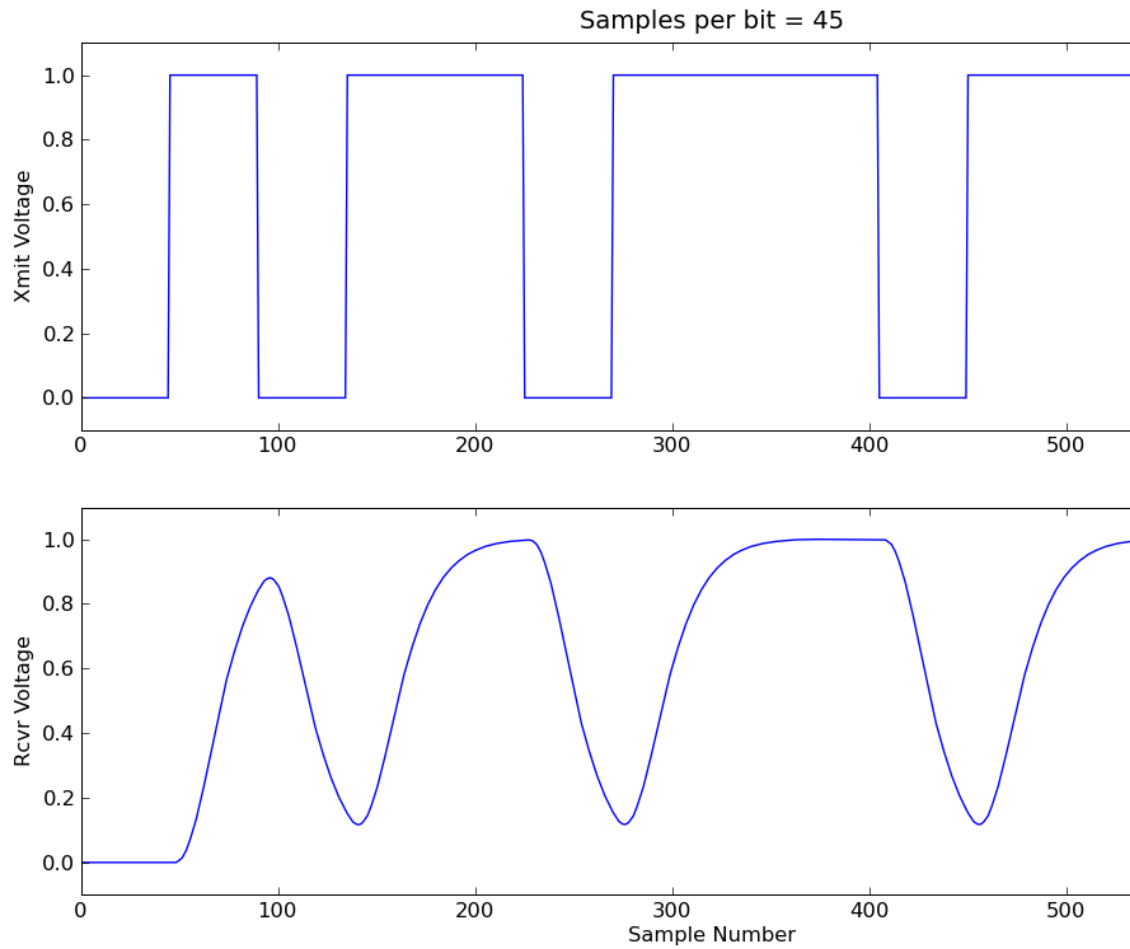
Slow Channel Response



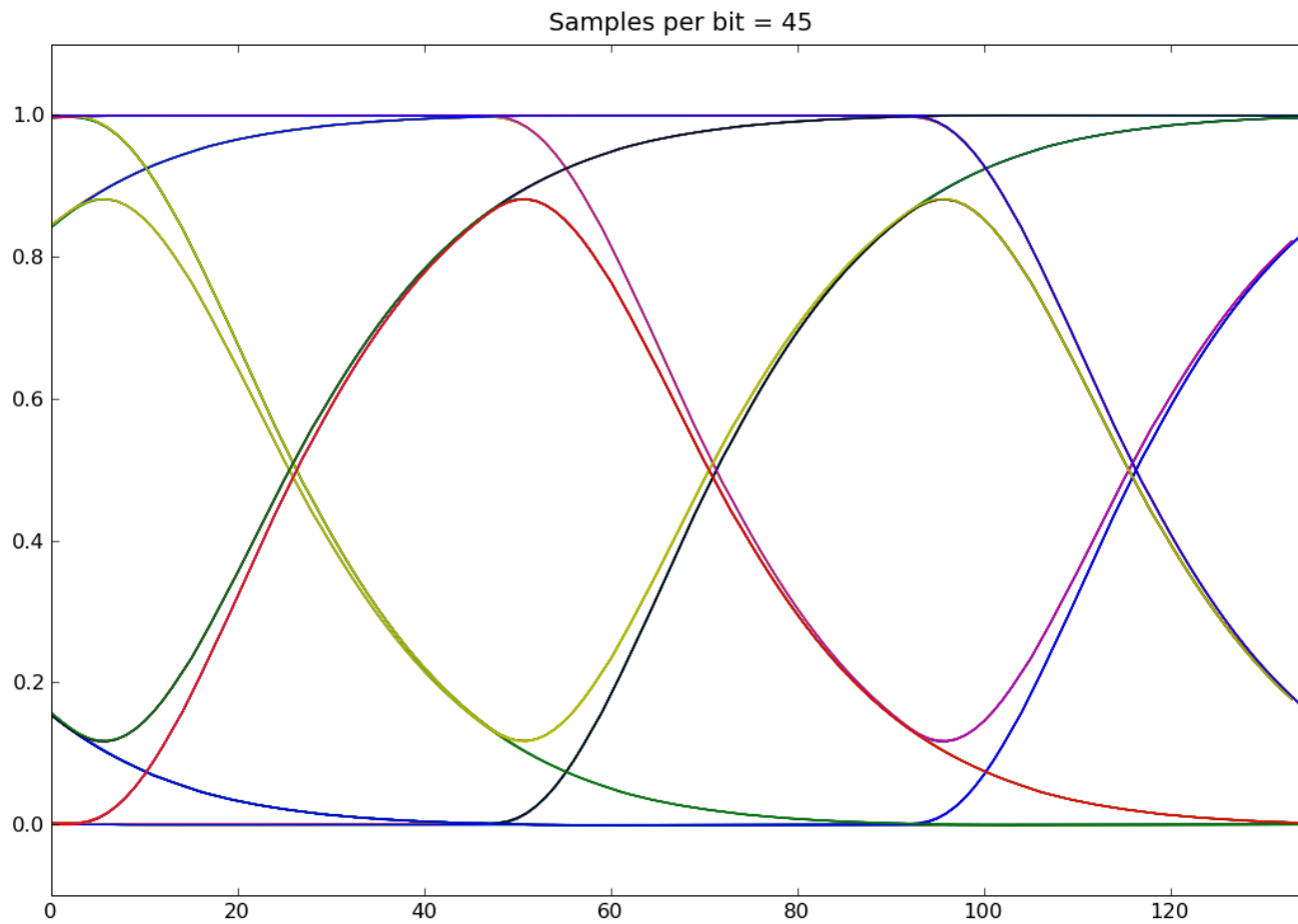
Slow Channel Eye Diagram



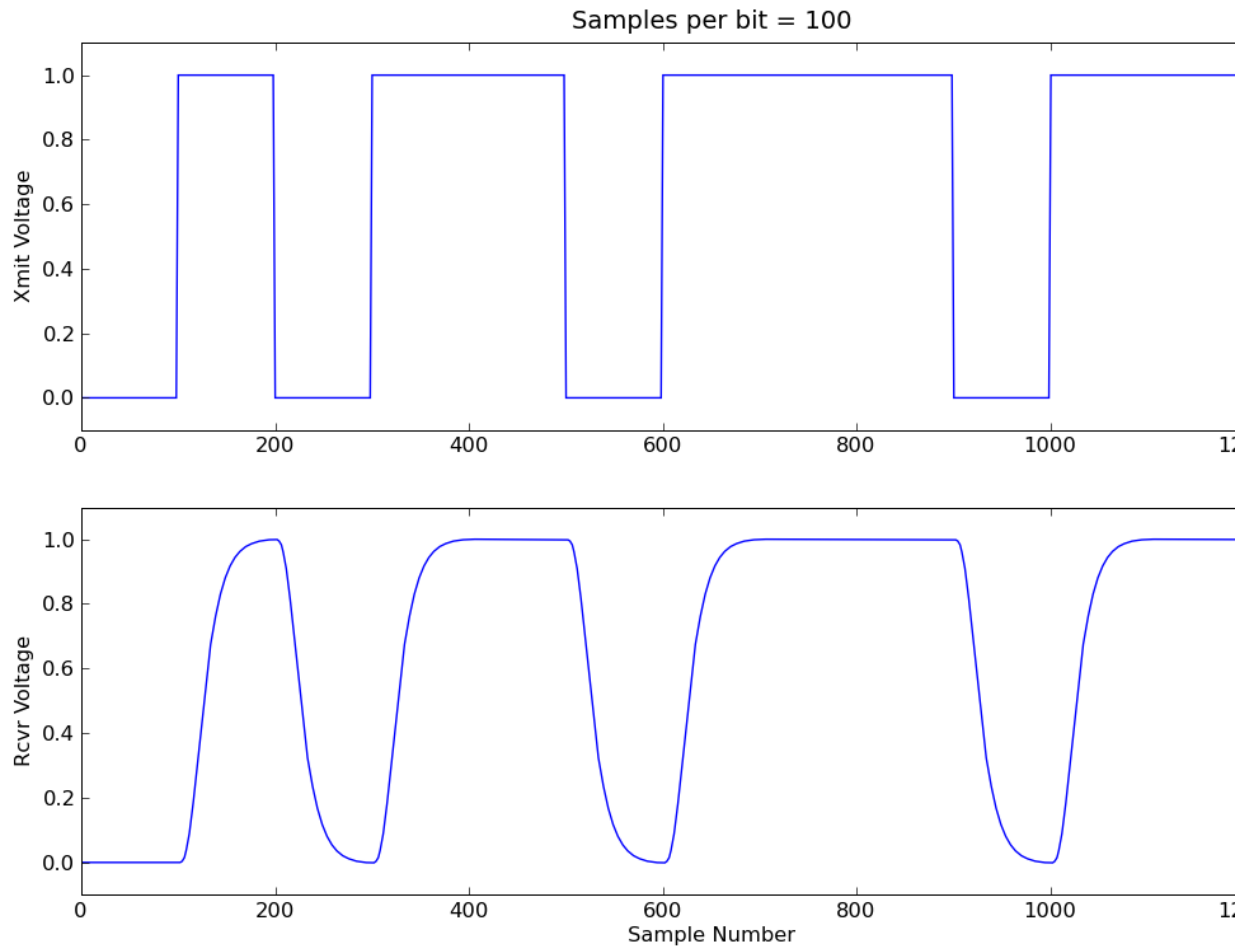
Slow Channel Response



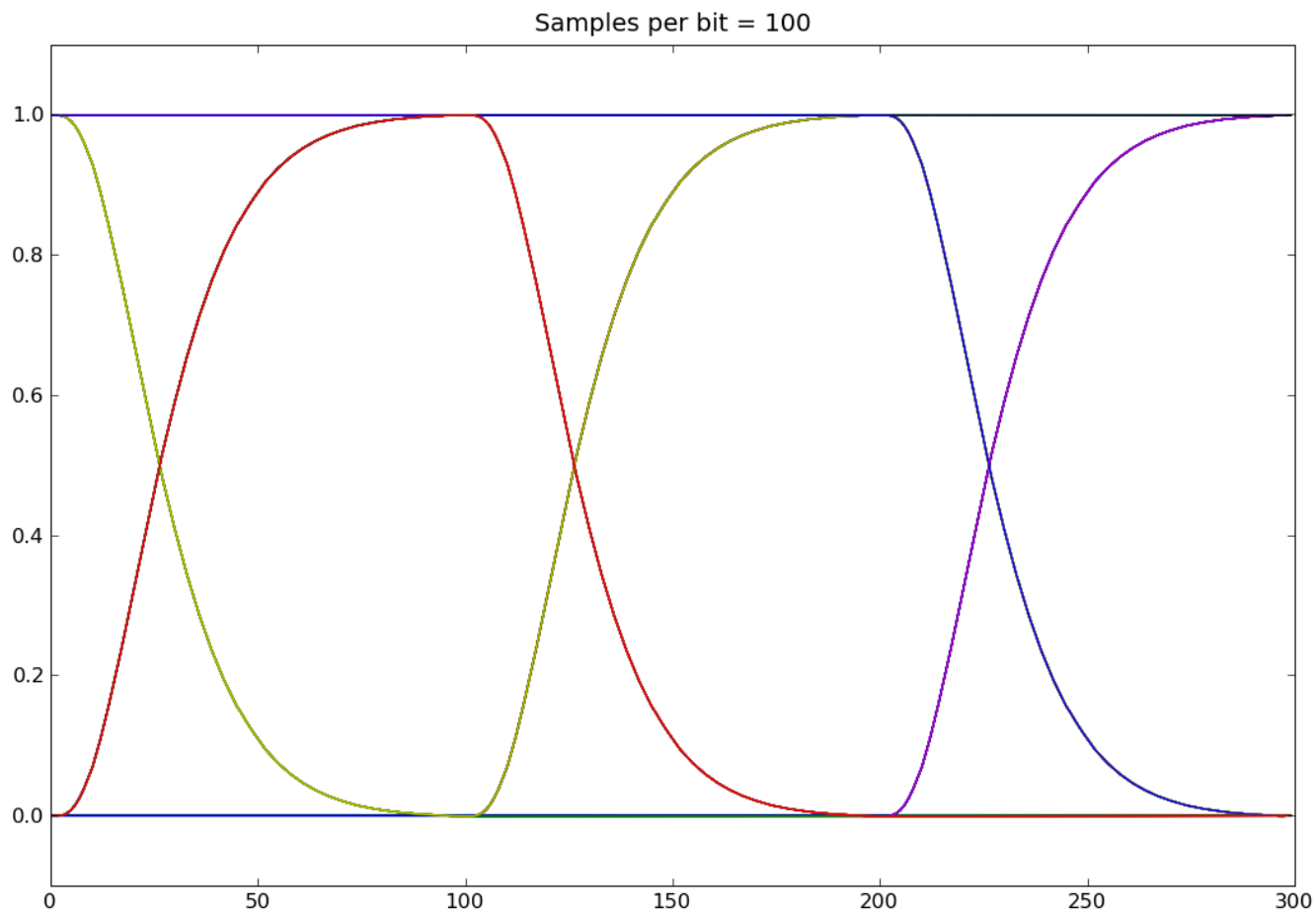
Slow Channel Eye Diagram



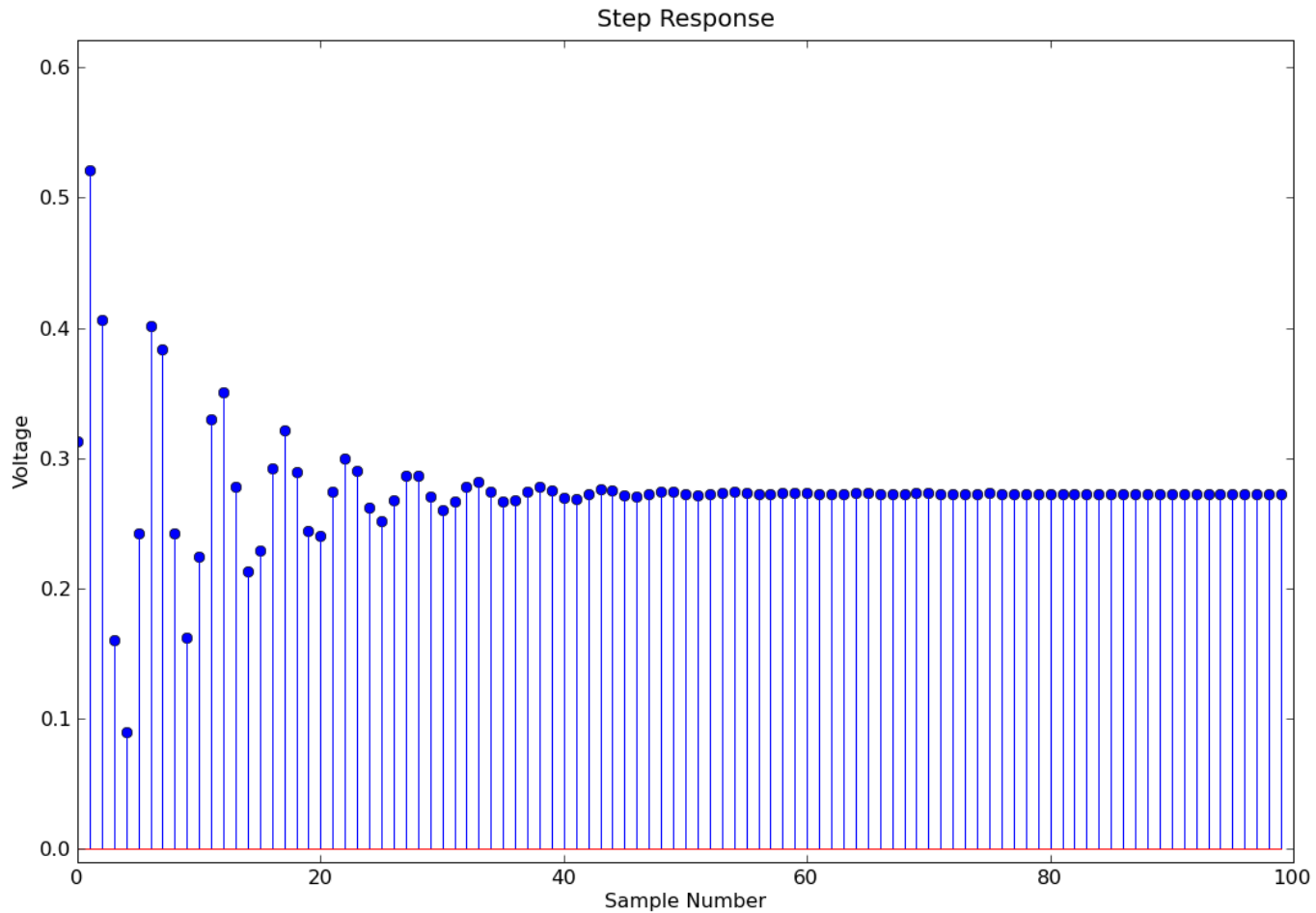
Slow Channel Response



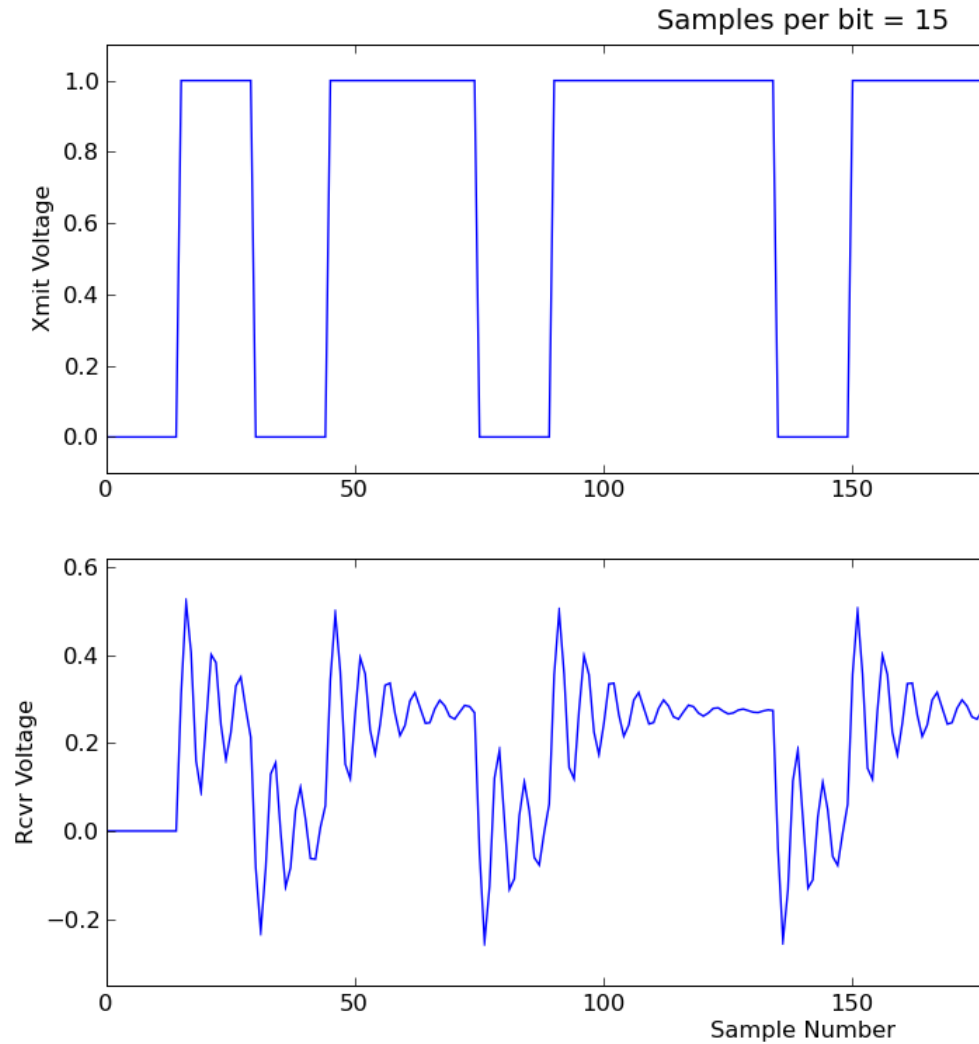
Slow Channel Eye Diagram



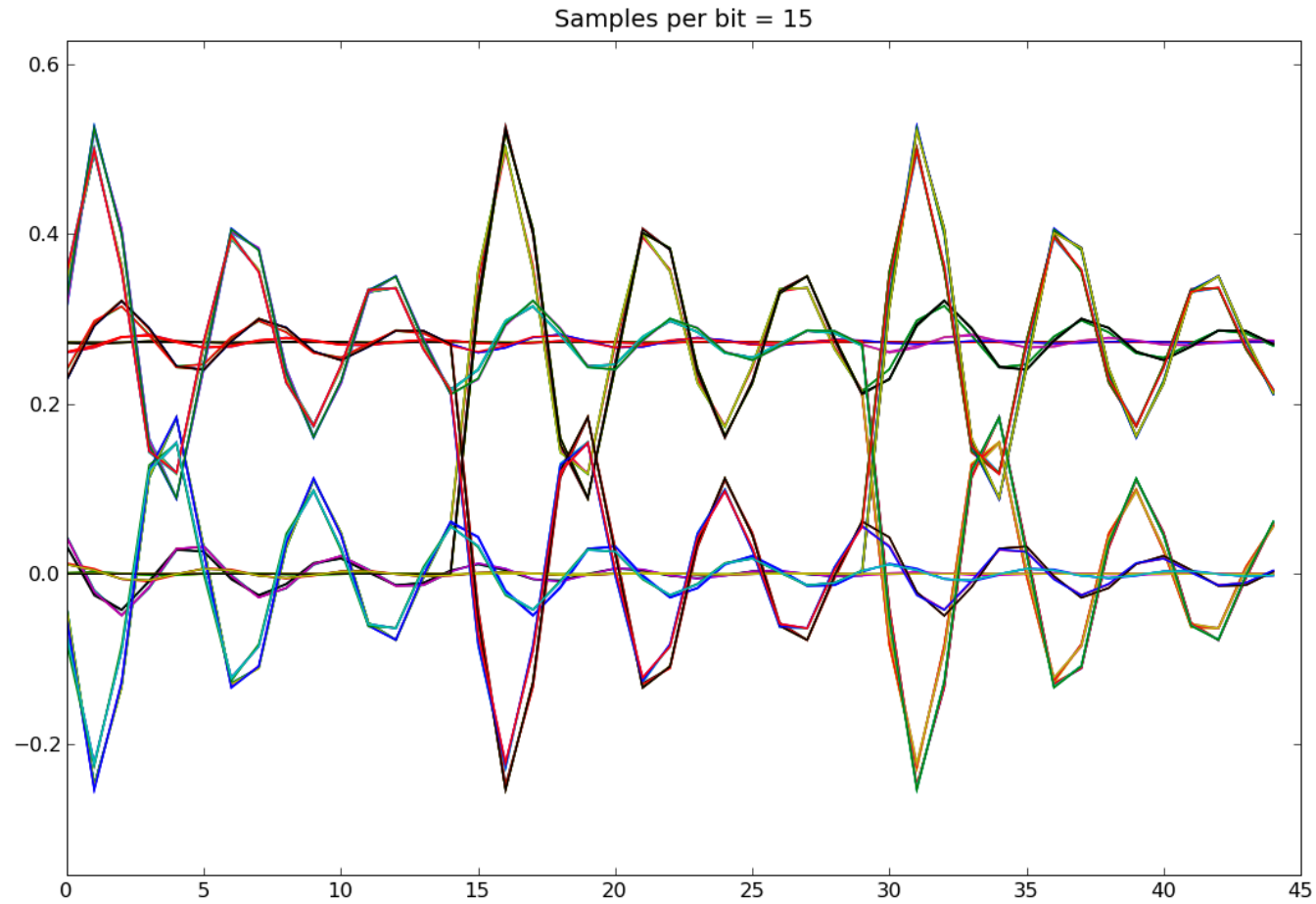
Step Response for Ringing Channel



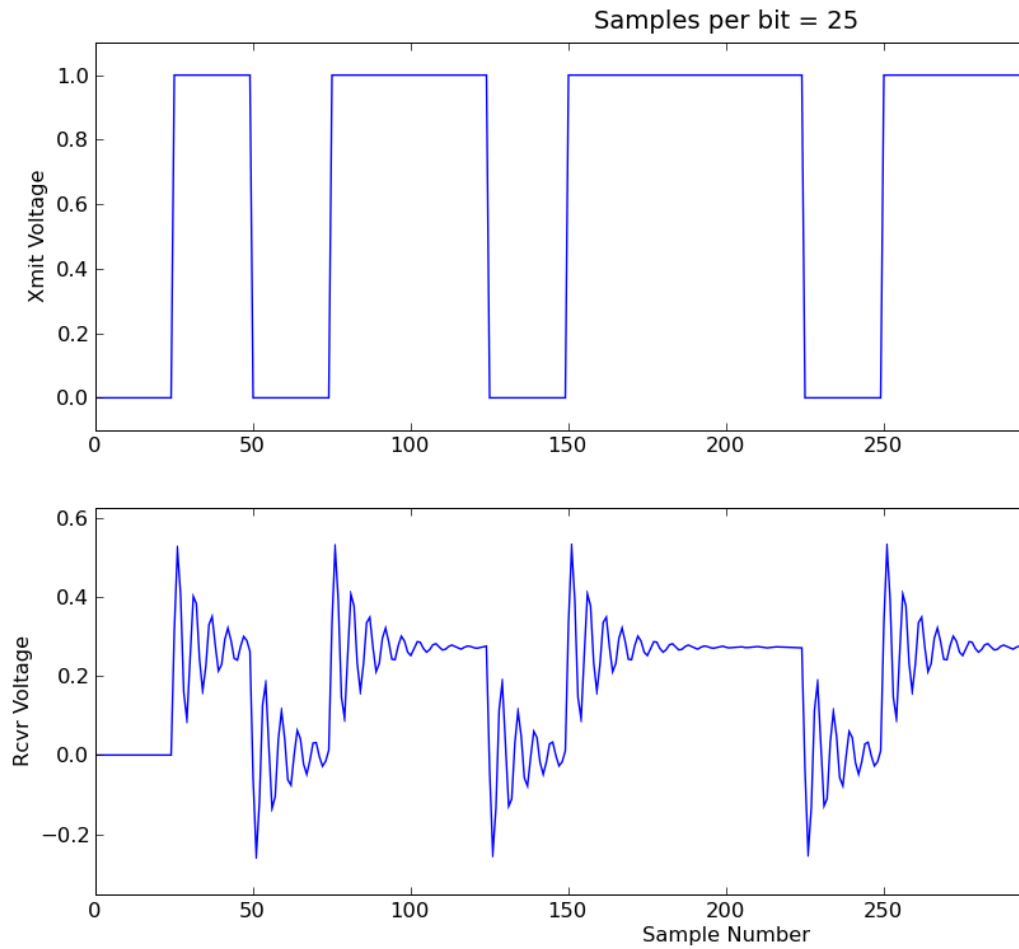
Ringing Channel Response



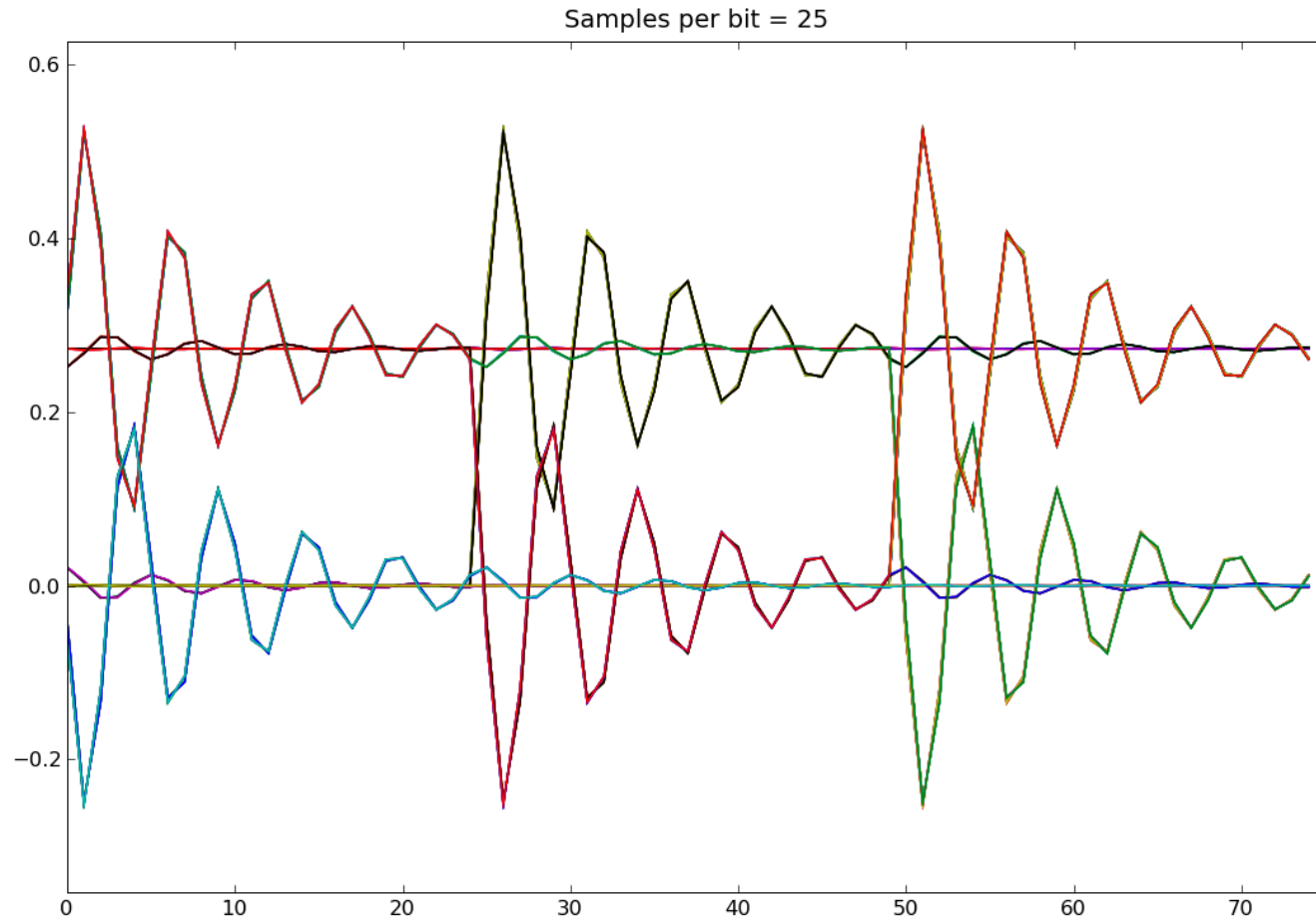
Ringling Channel Eye Diagram



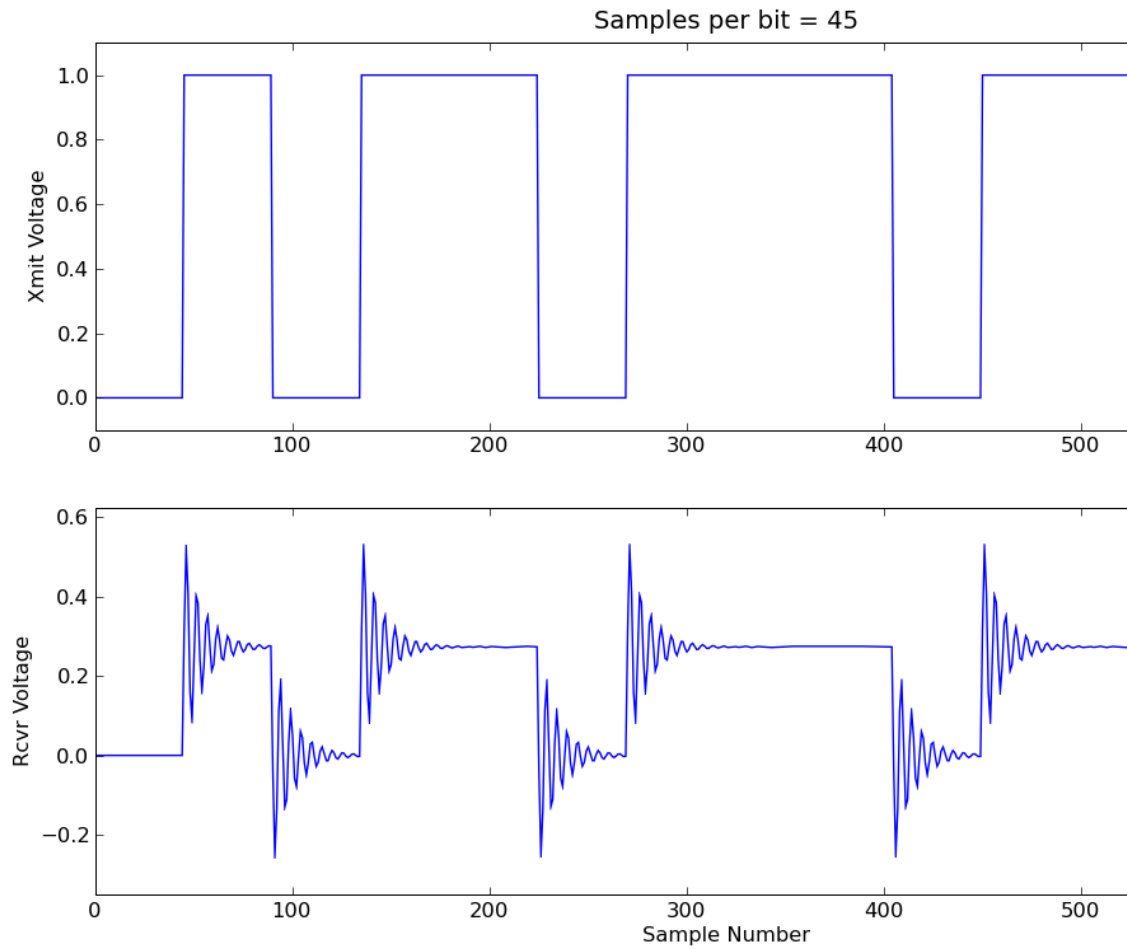
Ringing Channel Response



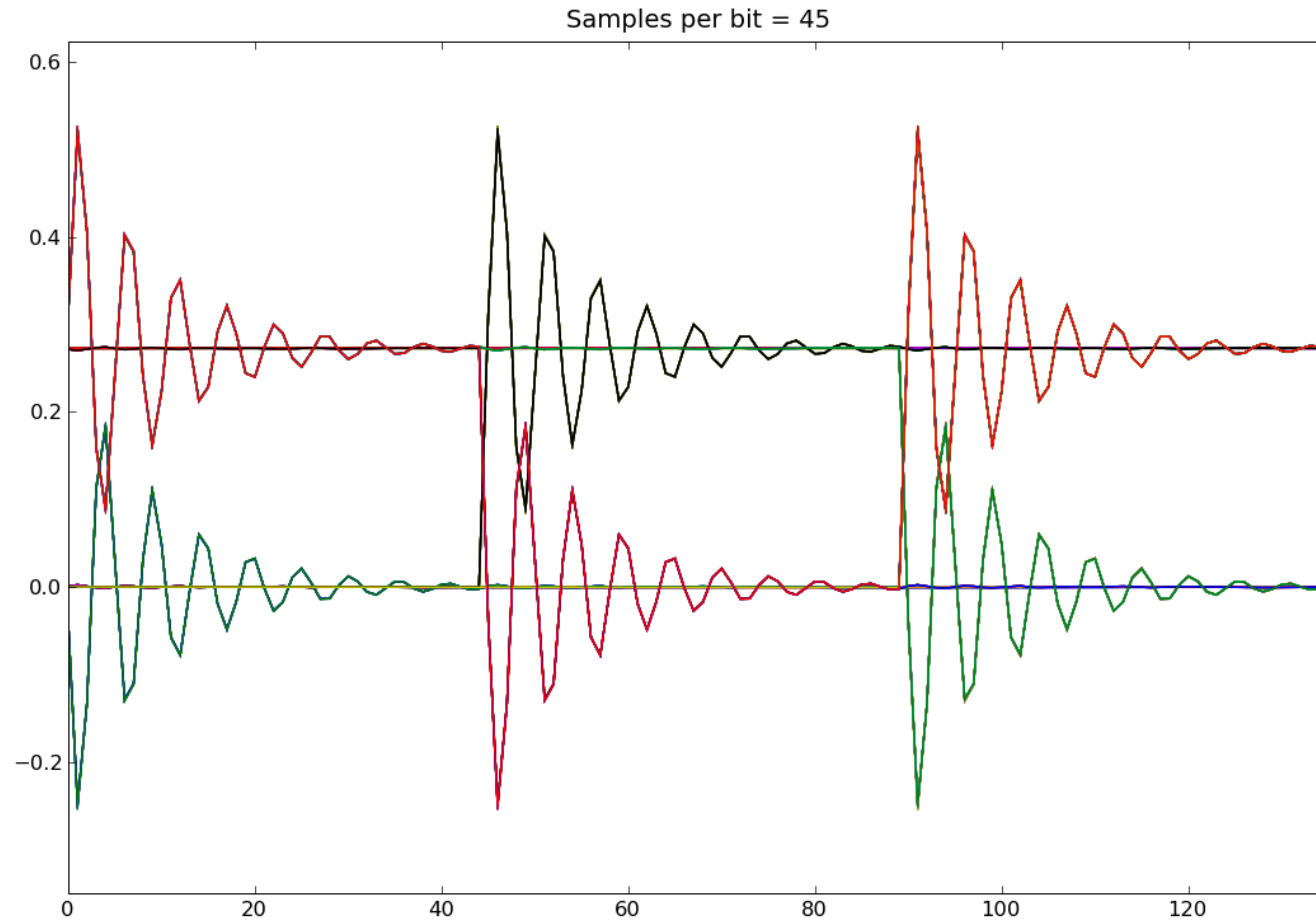
Ringling Channel Eye Diagram



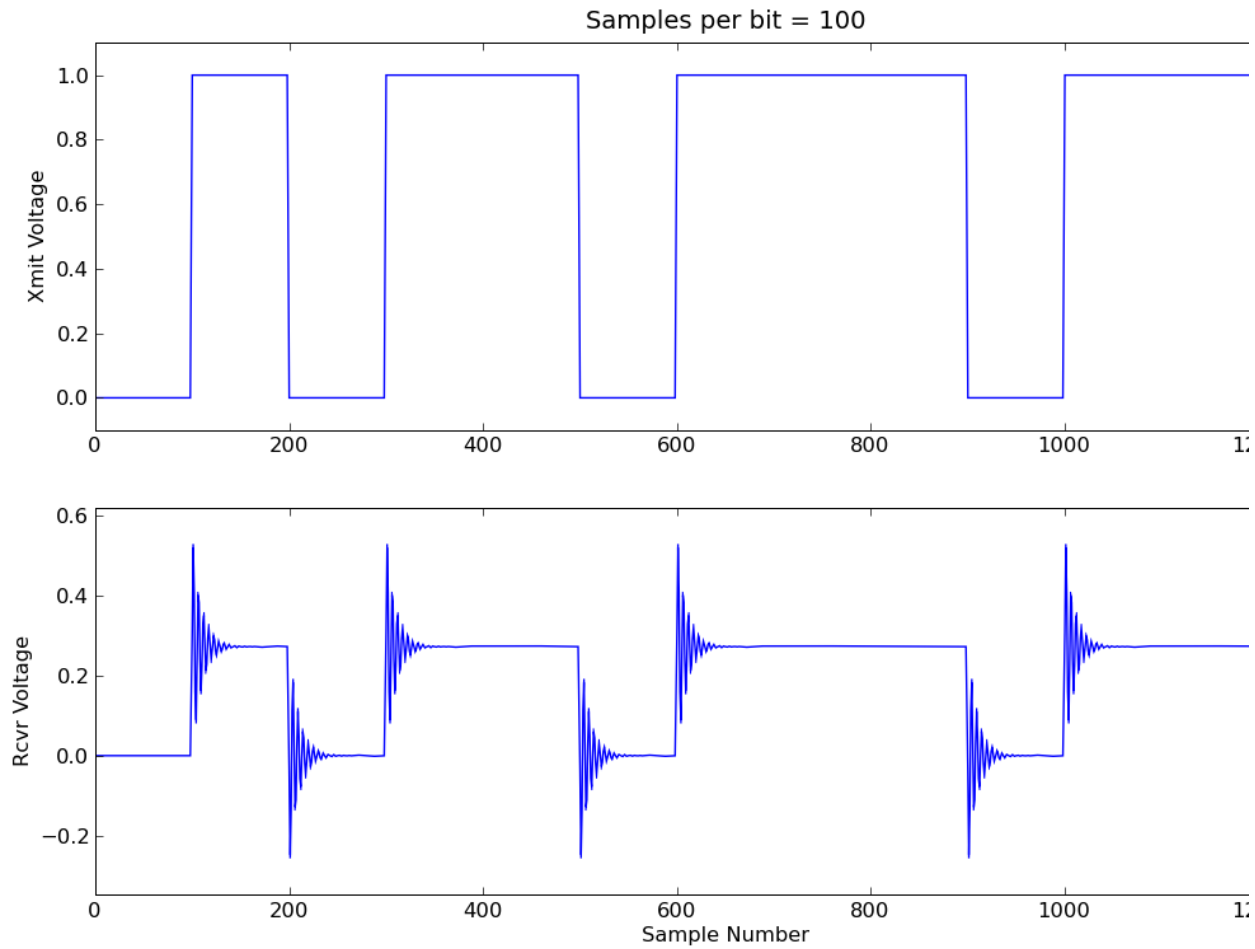
Ringing Channel Response



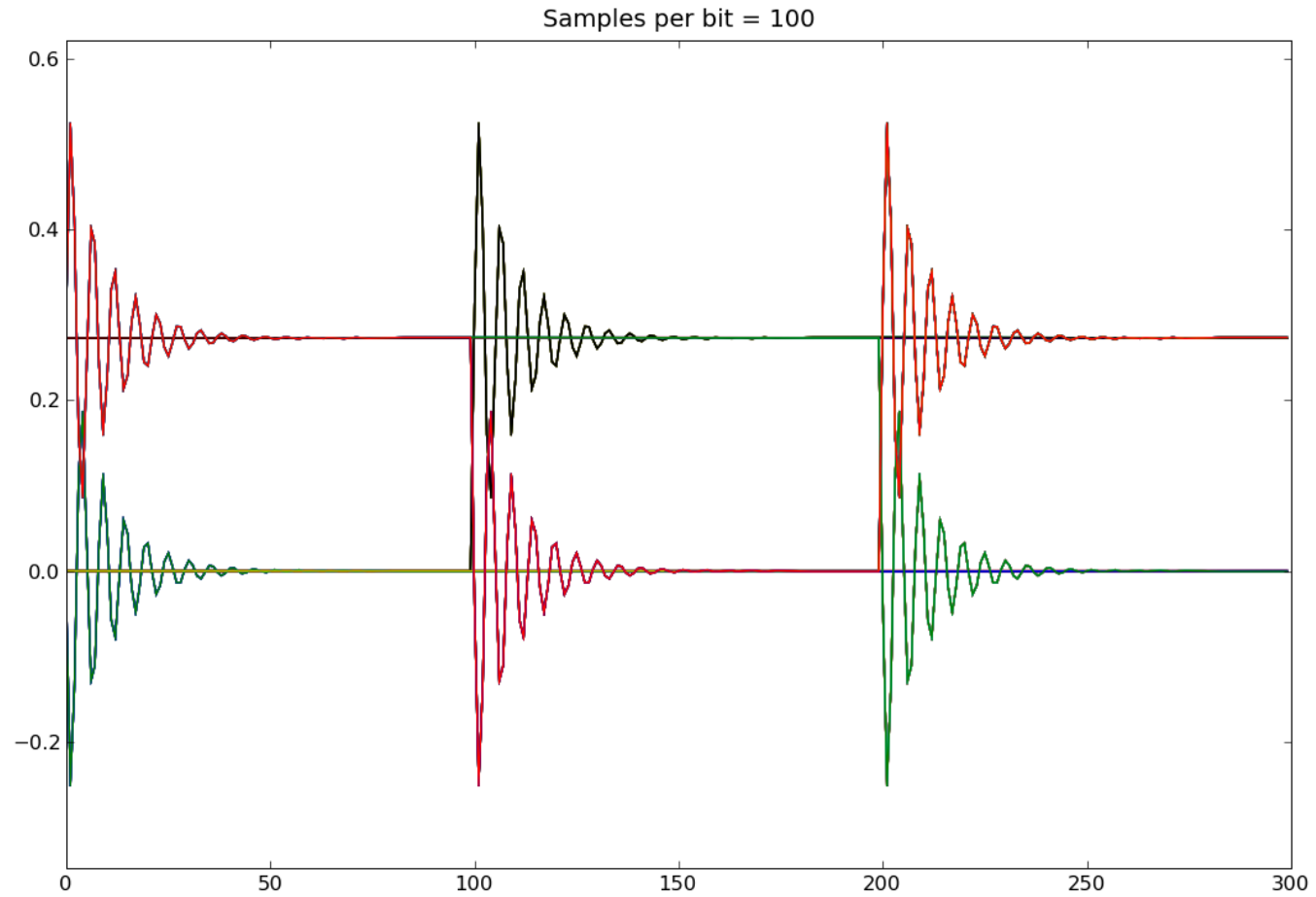
Ringling Channel Eye Diagram



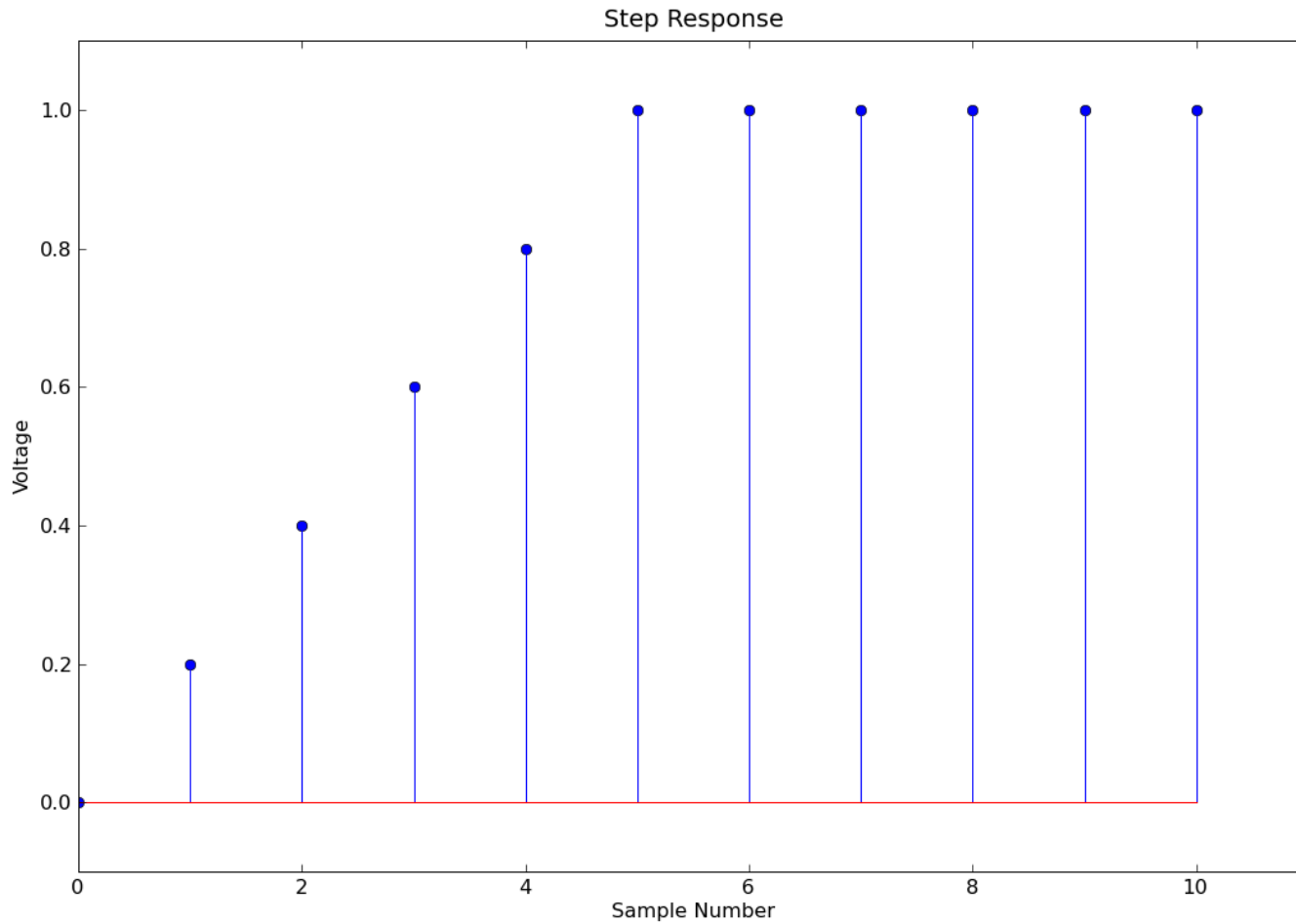
Ringing Channel Response



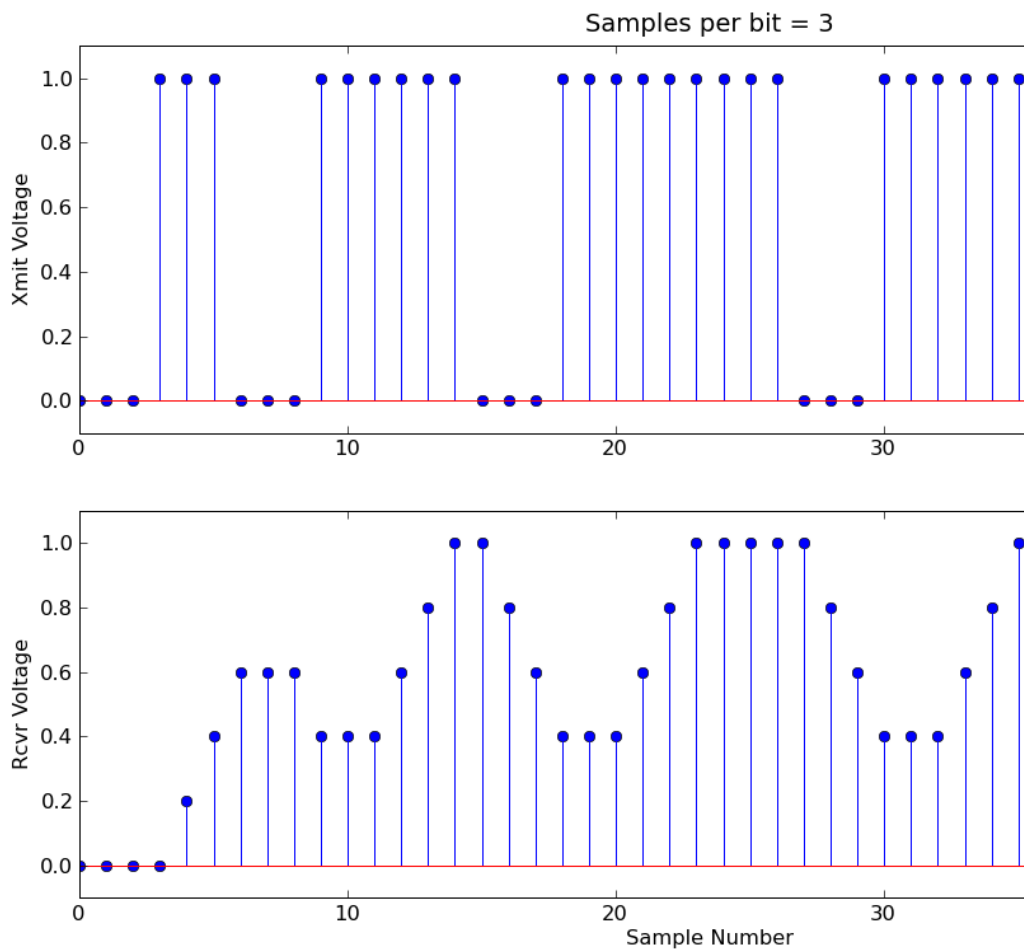
Ringling Channel Eye Diagram



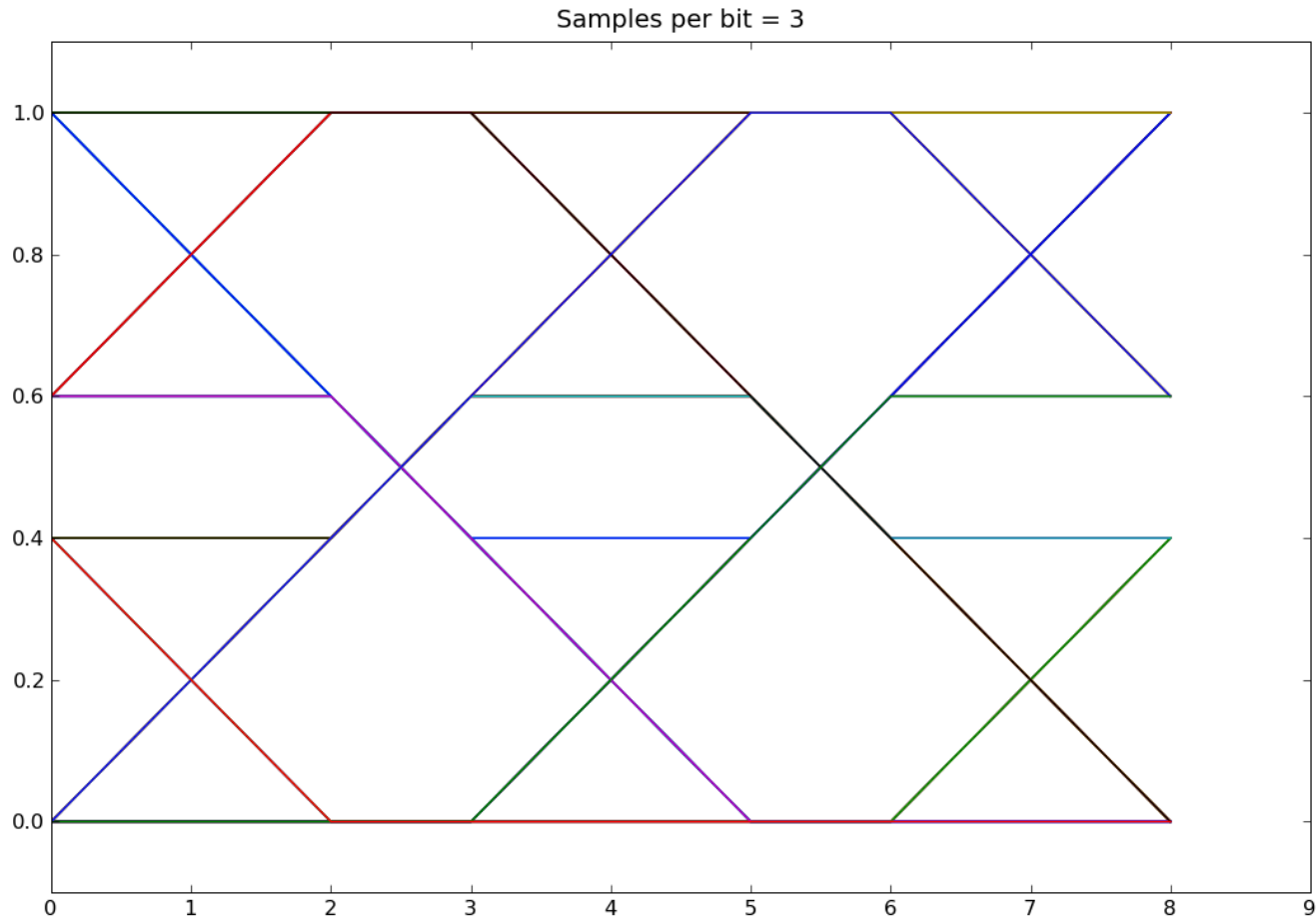
Straight Rise Step Response



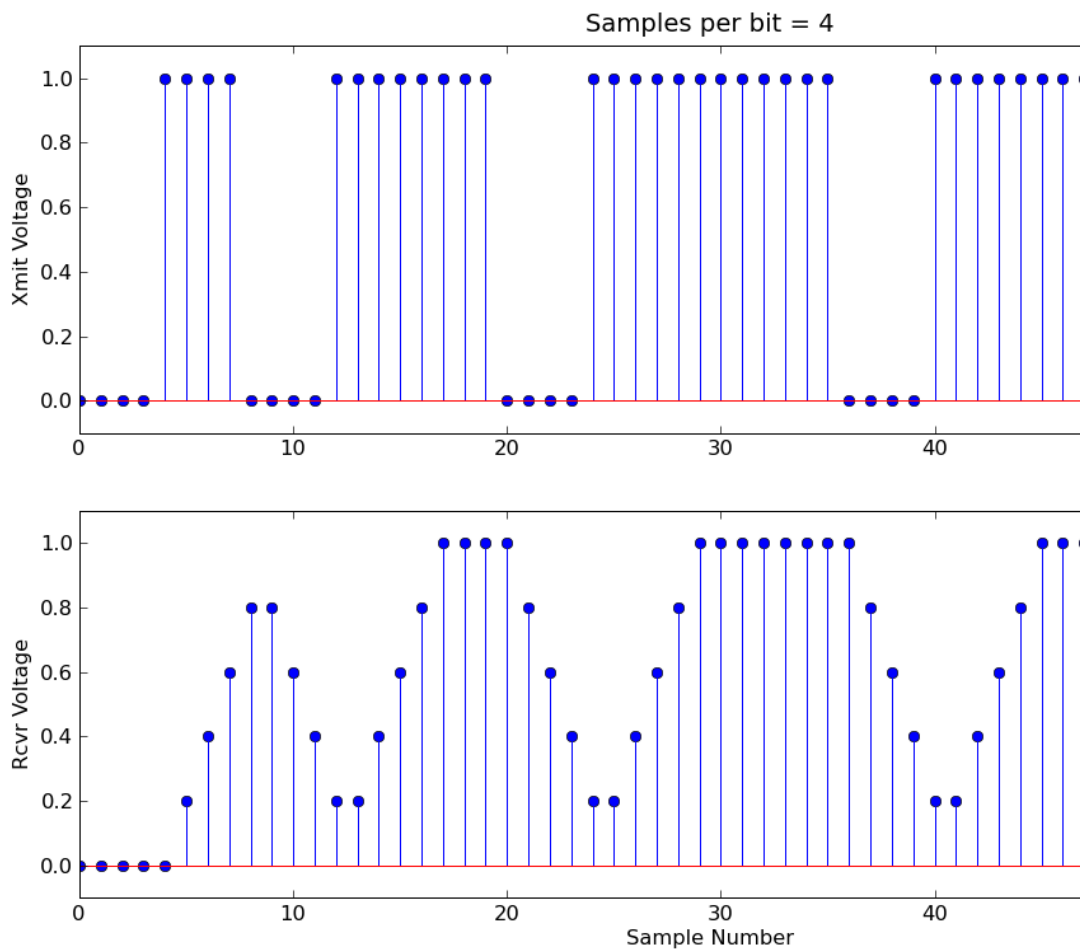
Straight Rise Response



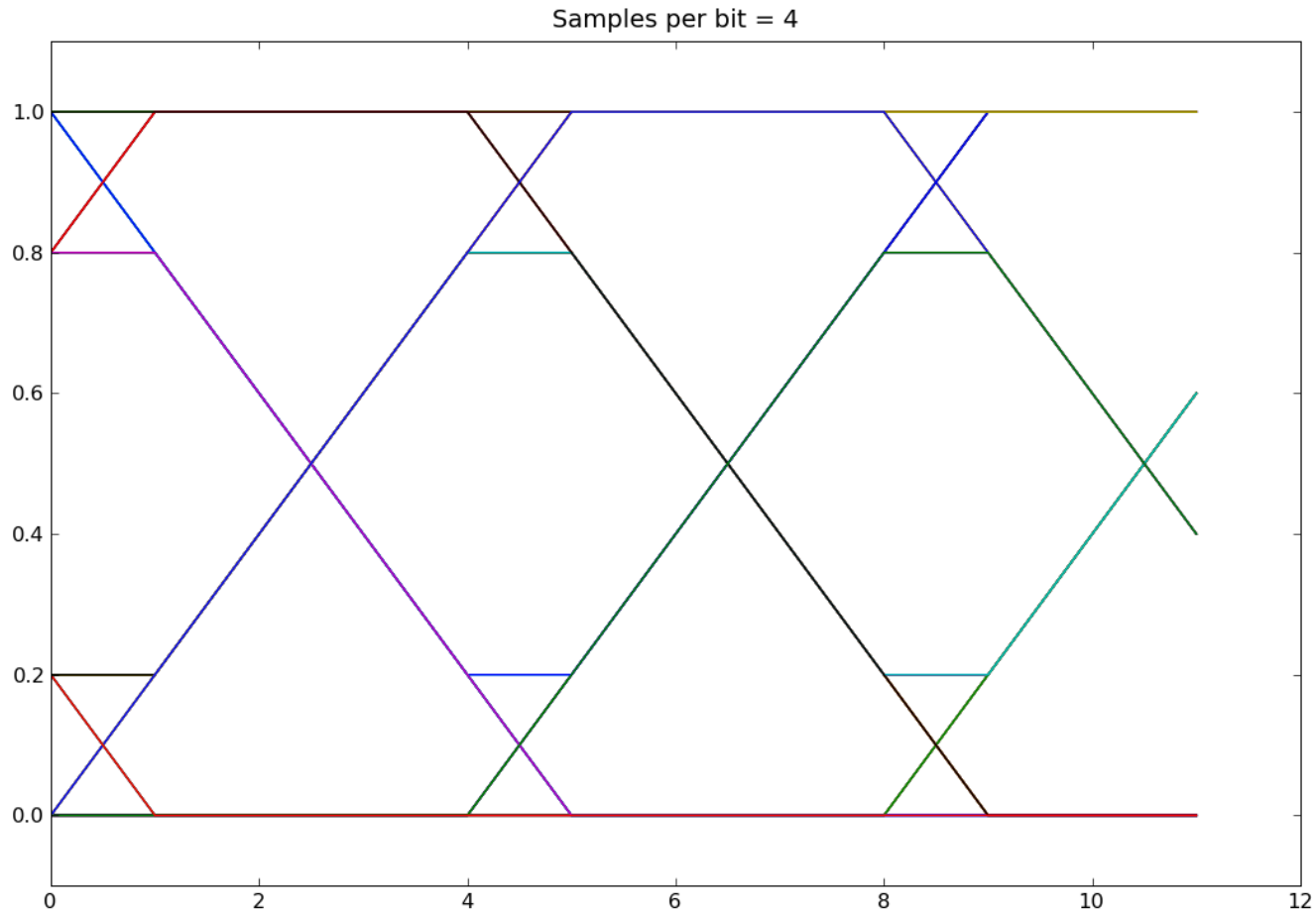
Striaght Rise Eye Diagram



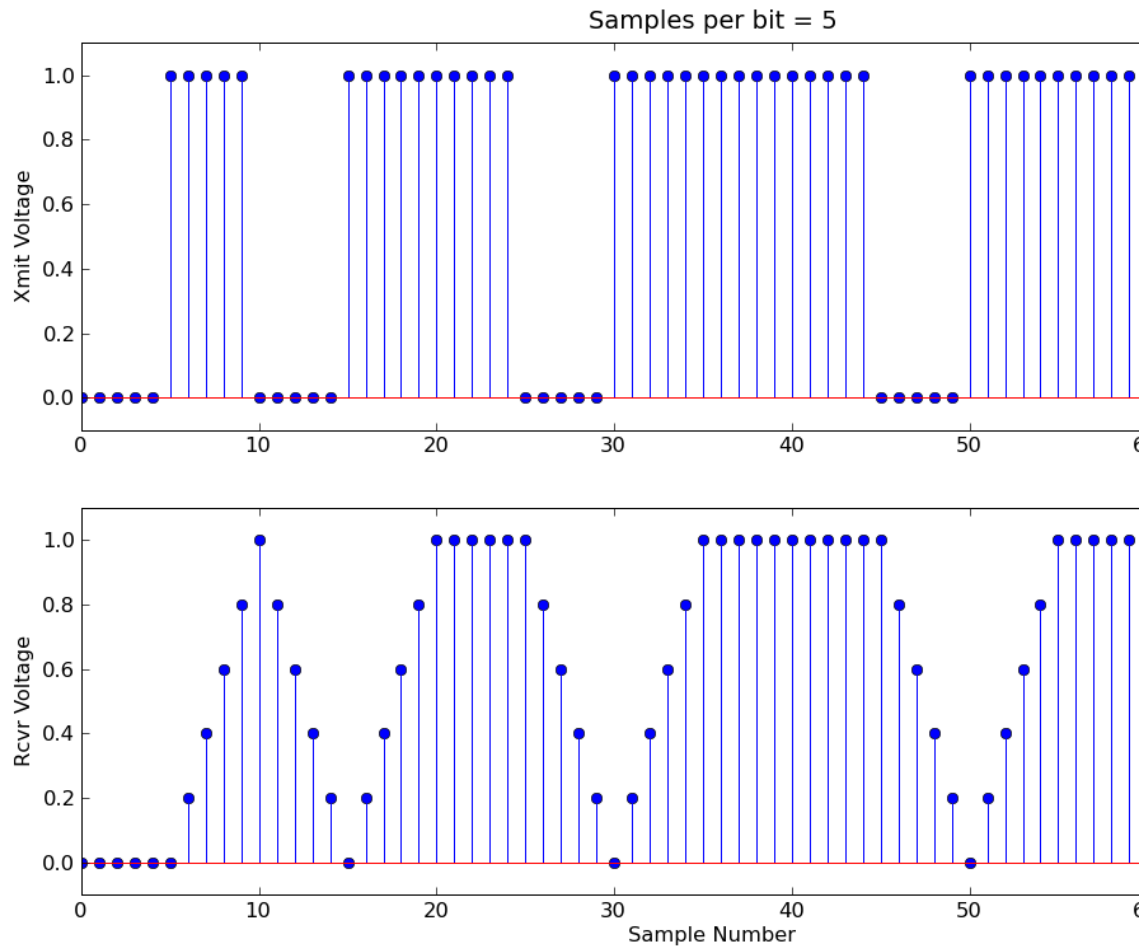
Straight Rise Response



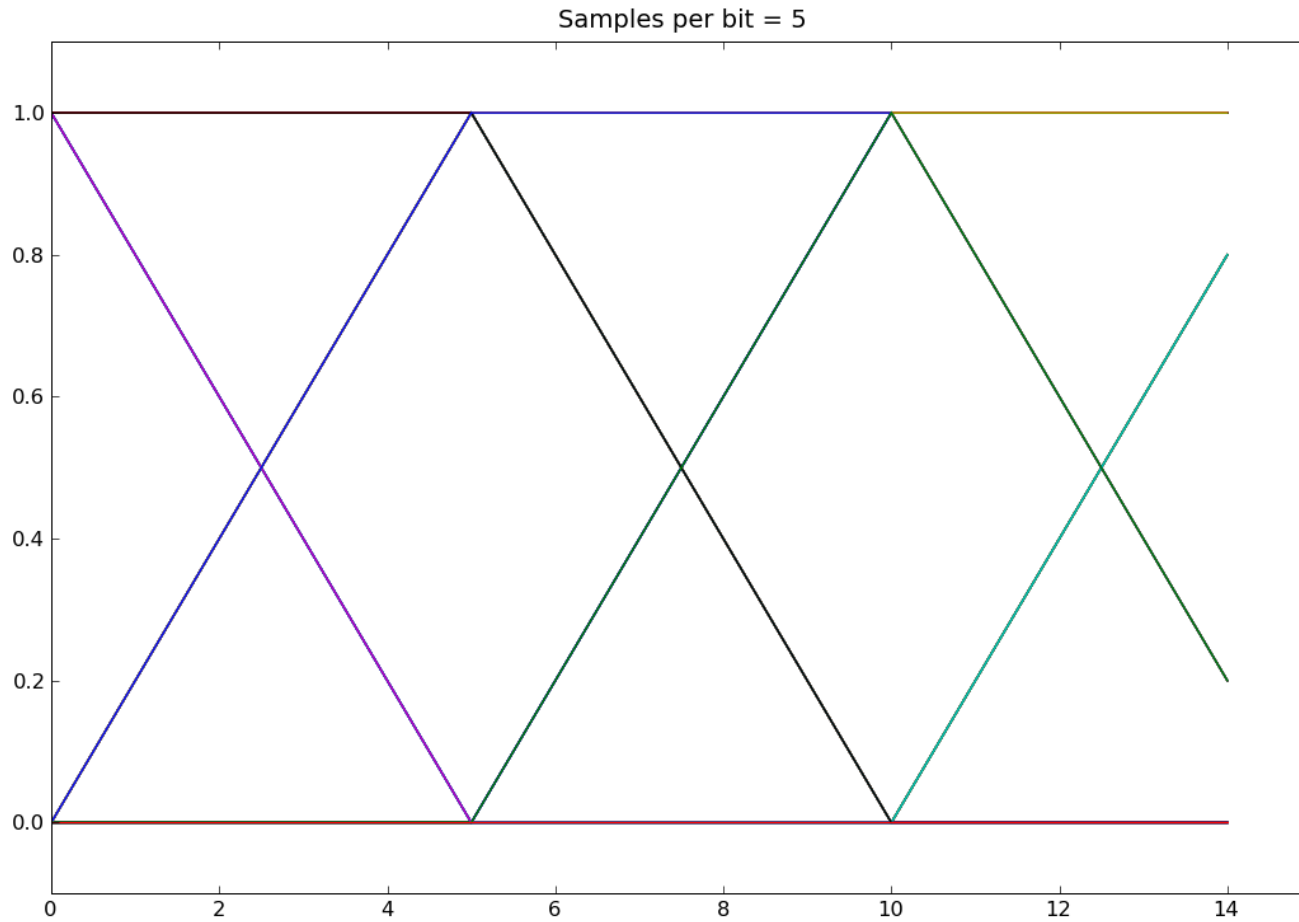
Striaght Rise Eye Diagram



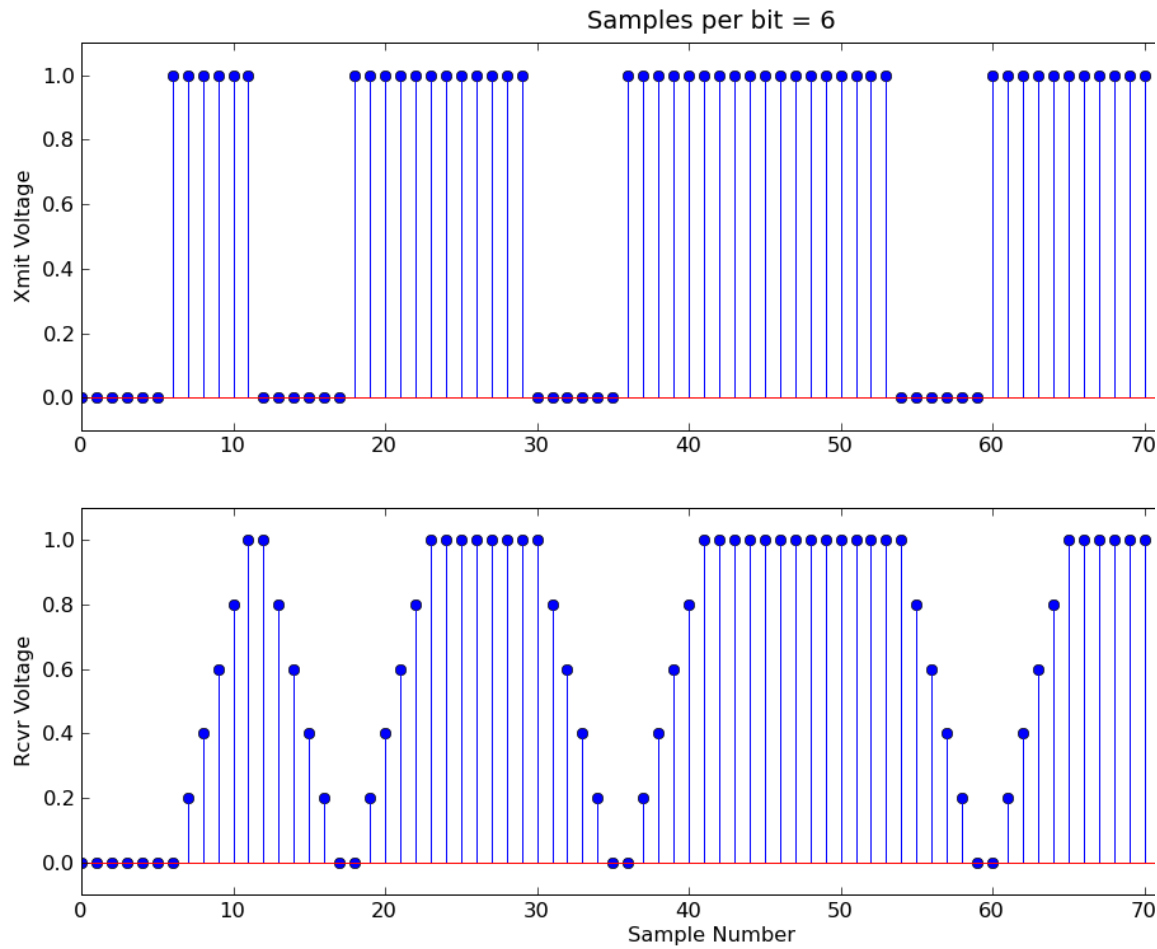
Straight Rise Response



Striaght Rise Eye Diagram



Straight Rise Response



Striaght Rise Eye Diagram

