Understanding signals

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previous lecture

- What is information and how we measure it
- Entropy
- Components of a communication system
- Signals: time and frequency domain
- Fourier coefficients: constructing a square wave
- Spectrum
- Aperiodic signals
- Energy and power signals

Today’s lecture

- Digital signal and PRBS
- Eye diagram
- Effect of filtering on data signals
- The impact of phase on a signal

Importance of knowing your Signals

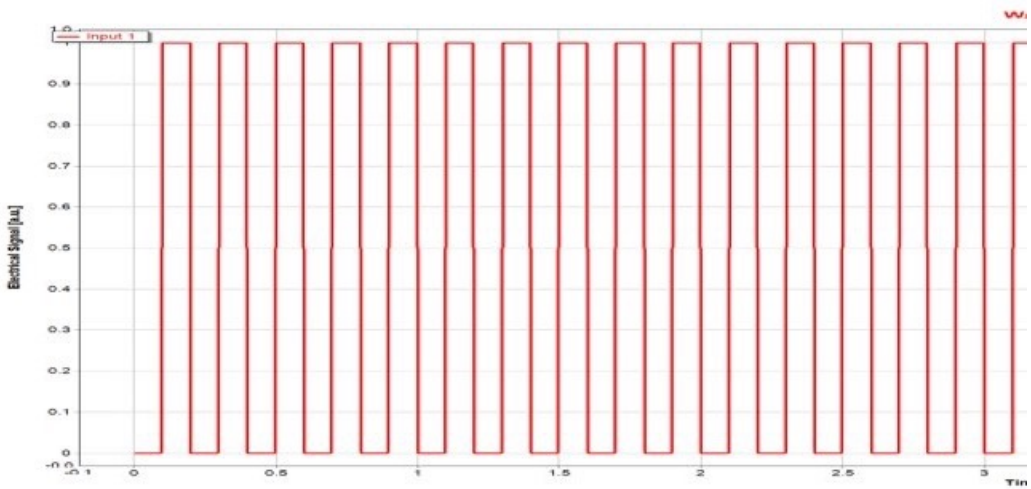
- A signal is a function that conveys information about a phenomenon.
- In telecommunications, it is usual a time varying voltage, current or EM wave
- Information is conveyed by changing some parameter of the signal e.g. amplitude, phase, frequency in time
- Knowledge or observation of the signal is useful to know if:
  - A particular signal can carry given information?
  - I can get rid of some of the frequencies and still recognise my information?
  - The quality of the signal good? If not, why?
  - My system is destroying the signal, causing a loss of information? How?

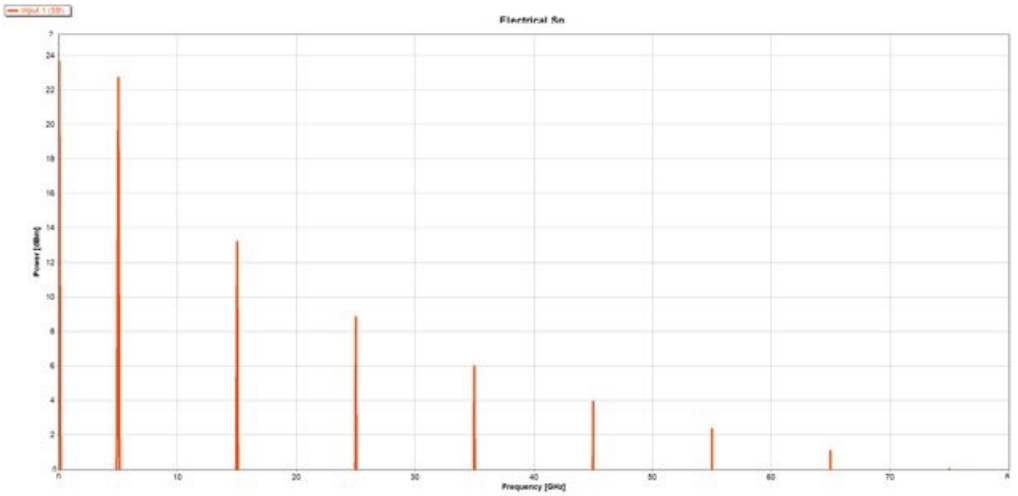
Importance of knowing your Signals

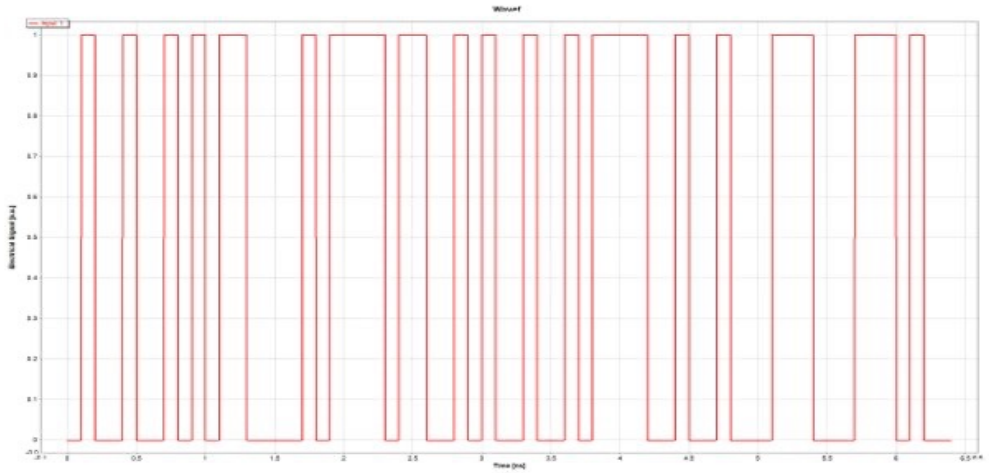
After today's lecture you will:

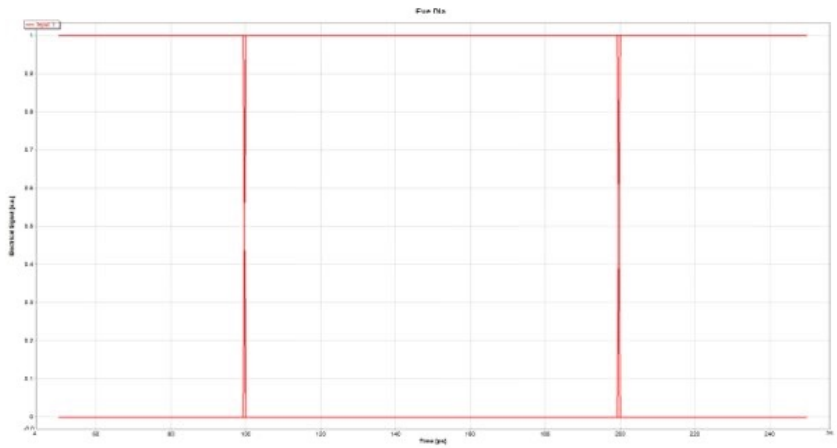
- Understand how time and frequency domain analysis can be used to troubleshoot telecommunication system,
- Recognise some of the symptoms or causes of distortions
- Understand why both amplitude and phase response of components is important

Binary Data signal

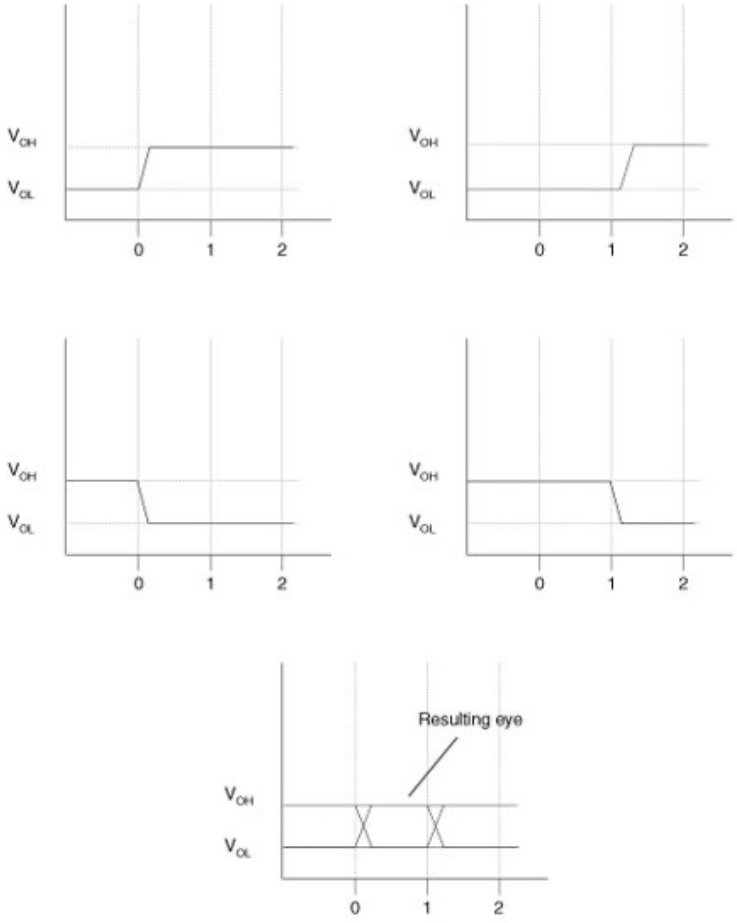


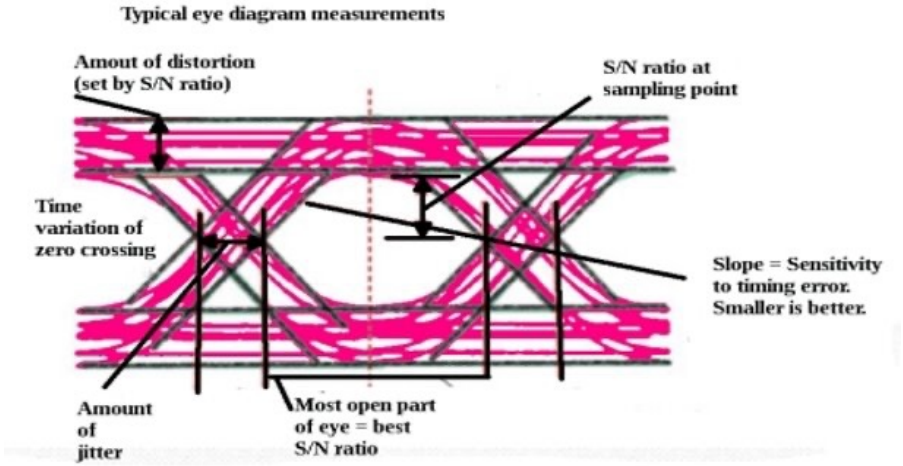


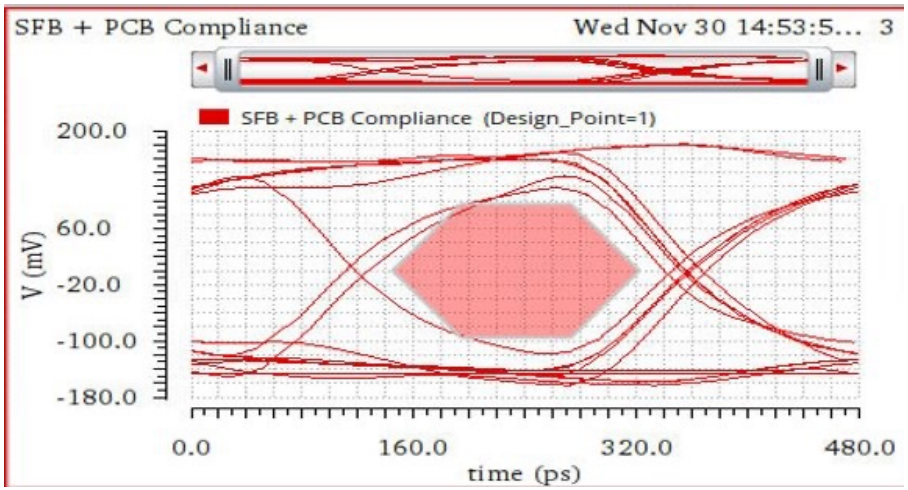




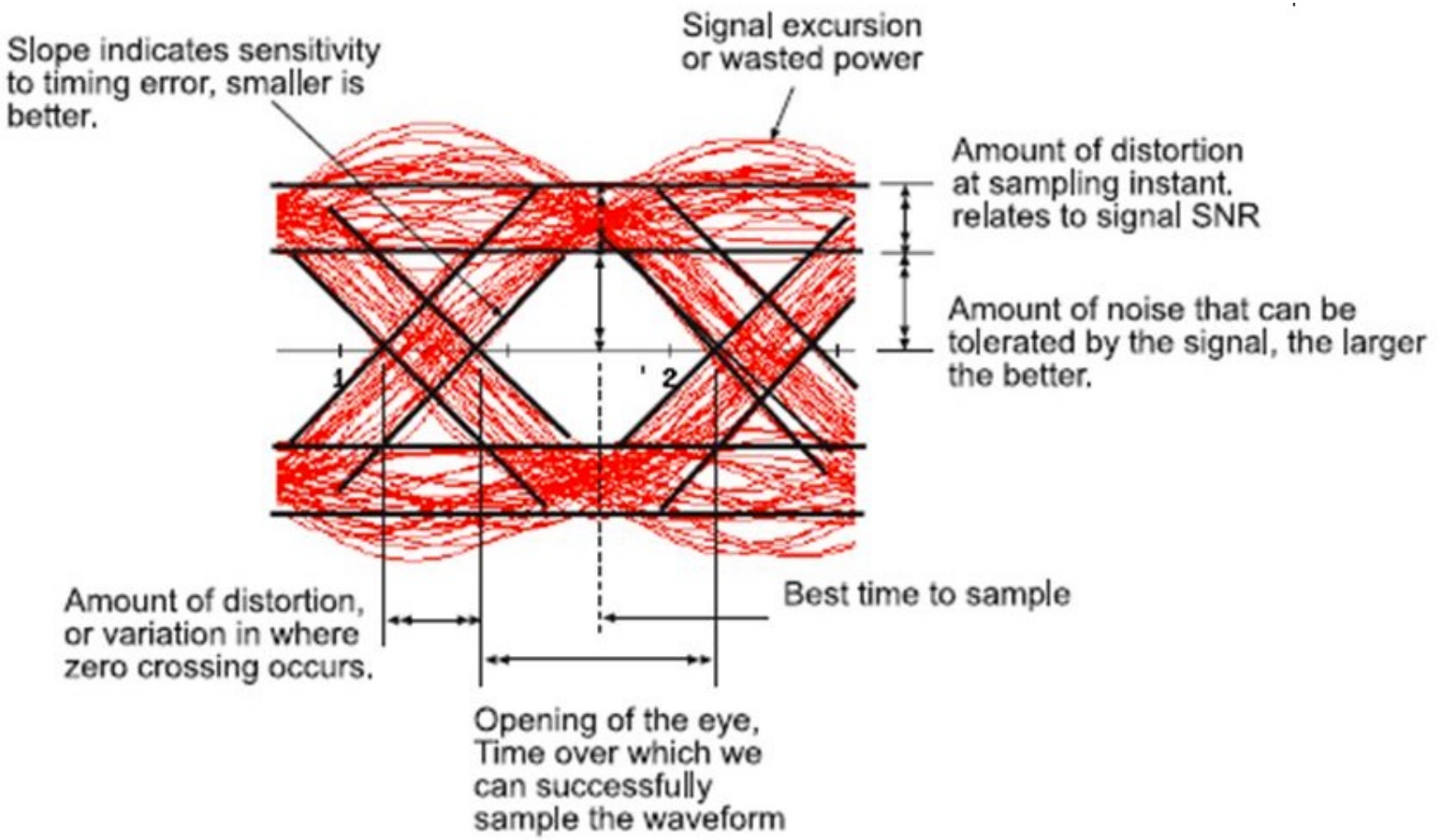
Eye diagram


V_{OH}
V_{OL}
0
1
2
Resulting eye

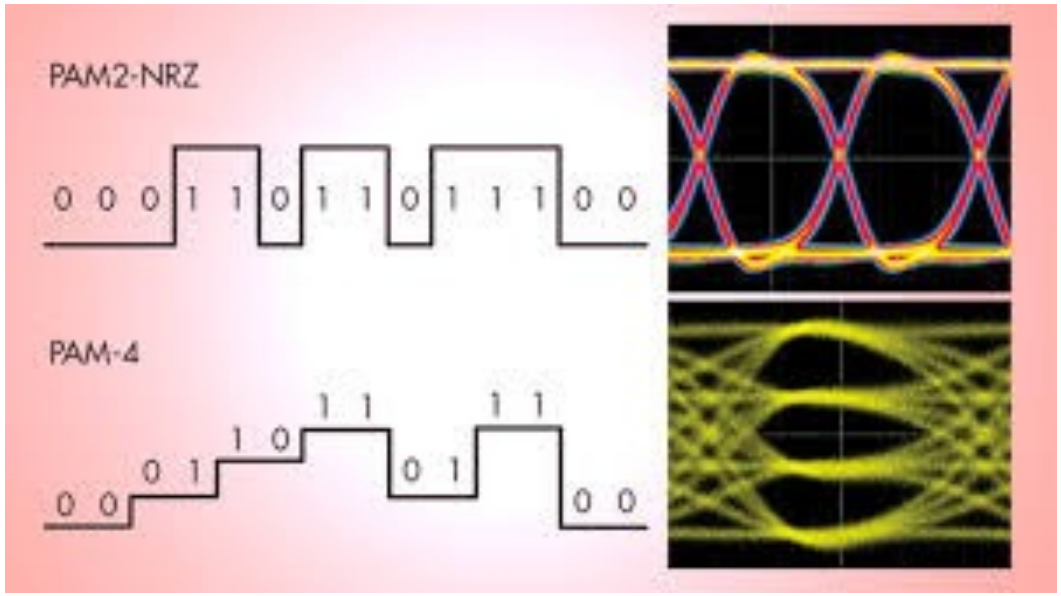

Typical eye diagram measurements
Amout of distortion (set by S/N ratio)
S/N ratio at sampling point
Time variation of zero crossing
Slope = Sensitivity to timing error. Smaller is better.
Amount of jitter
Most open part of eye = best S/N ratio


SFB + PCB Compliance
Wed Nov 30 14:53:5... 3
SFB + PCB Compliance (Design_Point=1)
200.0
60.0
-20.0
-100.0
-180.0
V (mV)
0.0
160.0
320.0
480.0
time (ps)

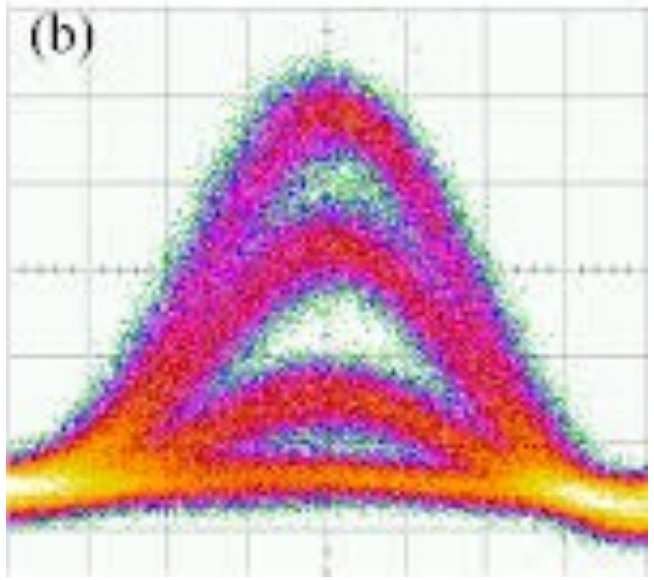
Eye diagram distortion



Multilevel eye diagrams

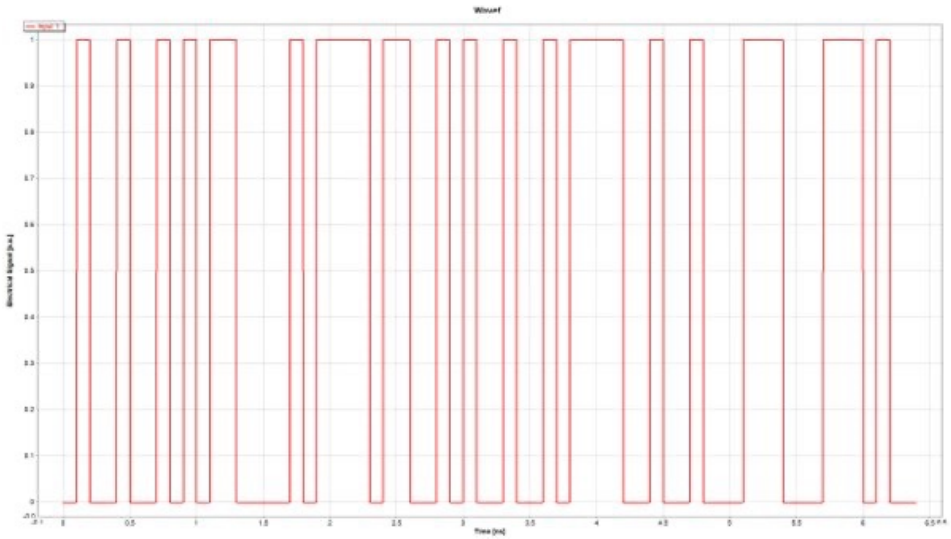


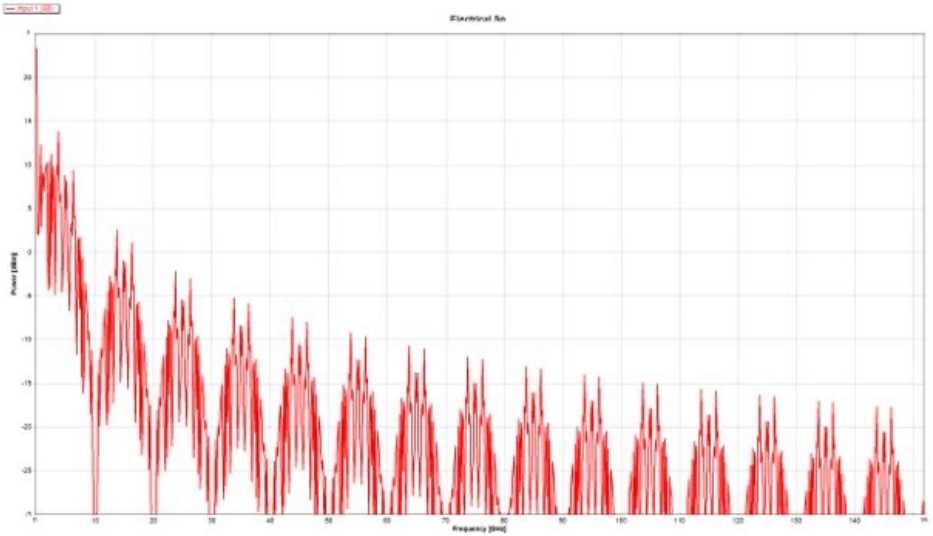
Non-return to zero

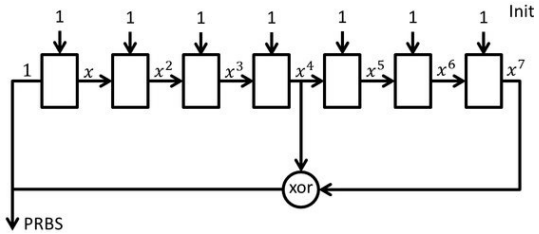


Return to zero

Pseudo-Random Bit Sequence (PRBS)







$$\text{PRBS } L = 2^7 - 1$$

Example

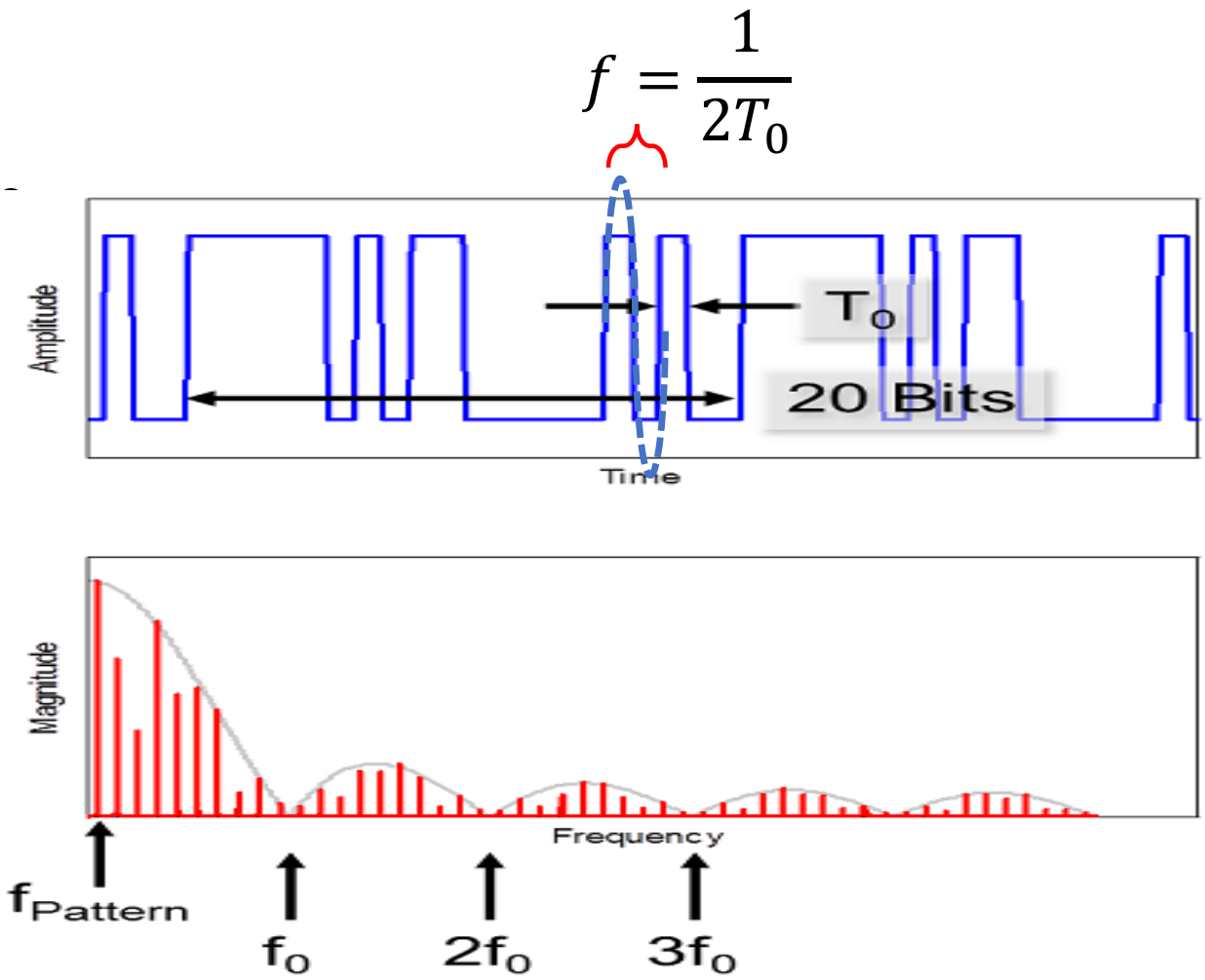
PRBS with length of 20 bit i.e.:

the pattern repeats every 20 bit

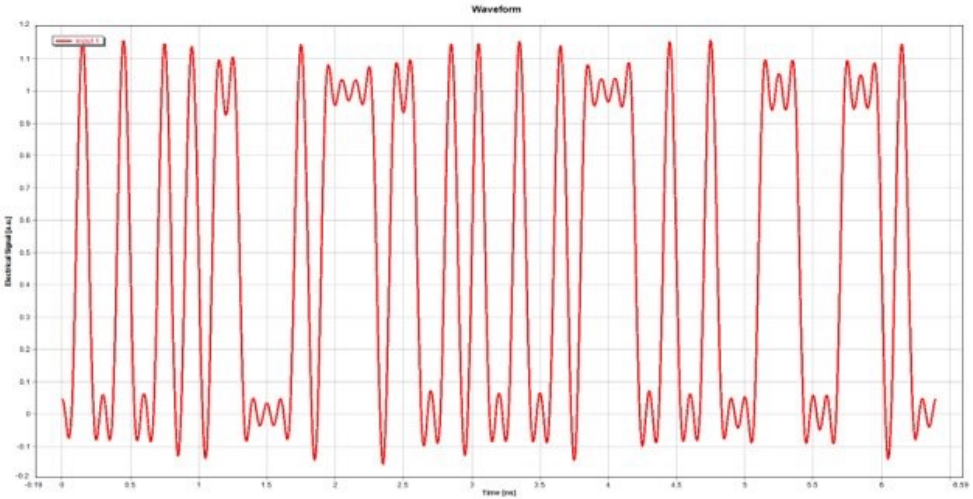
Bit duration T_0= 100 ps

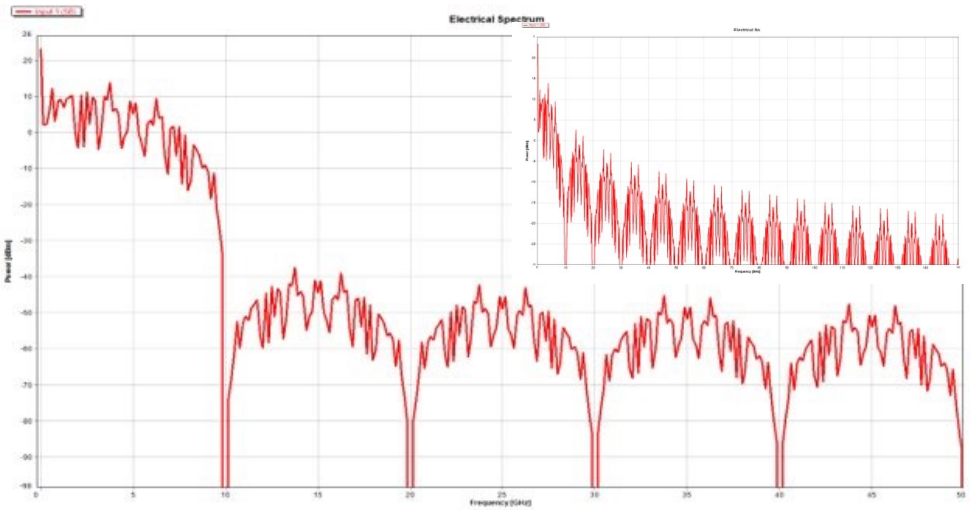
Bit rate $f_0 = \frac{1}{T_0} = 10\ \mathrm{Gb/s}$

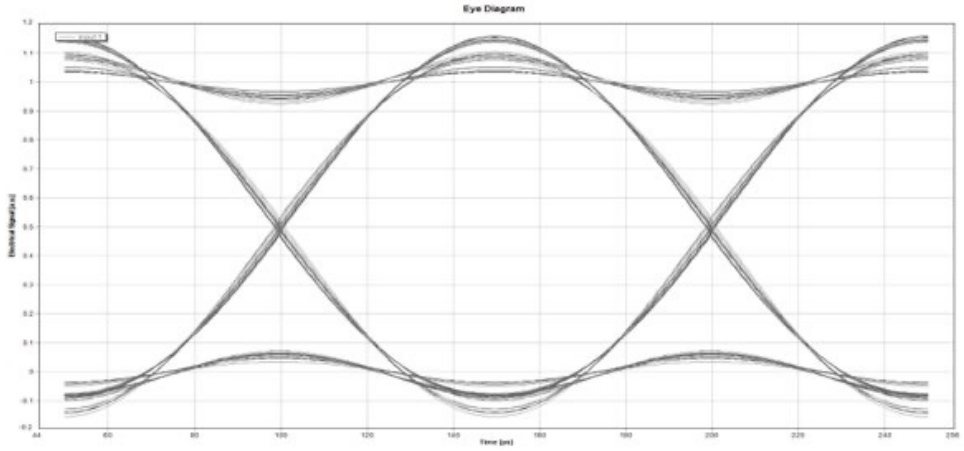
$f_{pattern} = \frac{1}{20 \cdot T_0} = 500\ MHz$

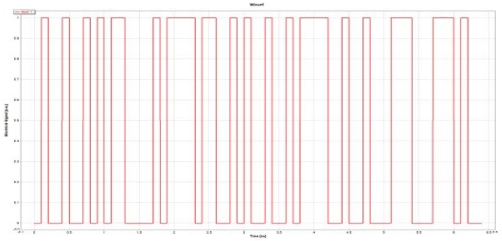


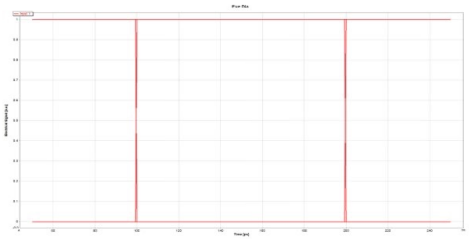
10 GHz filter (rectangular)



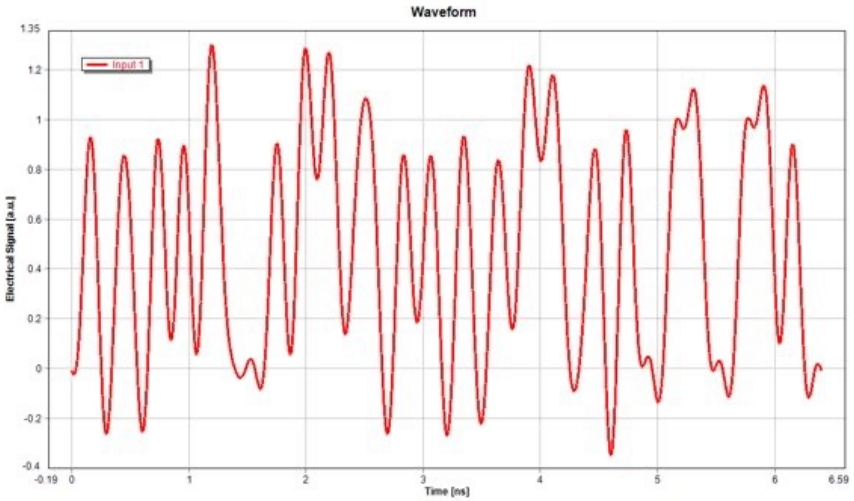


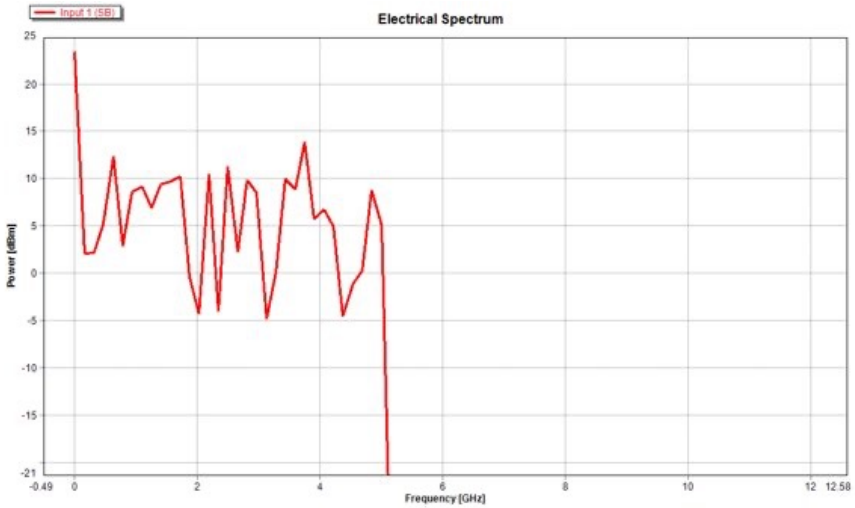


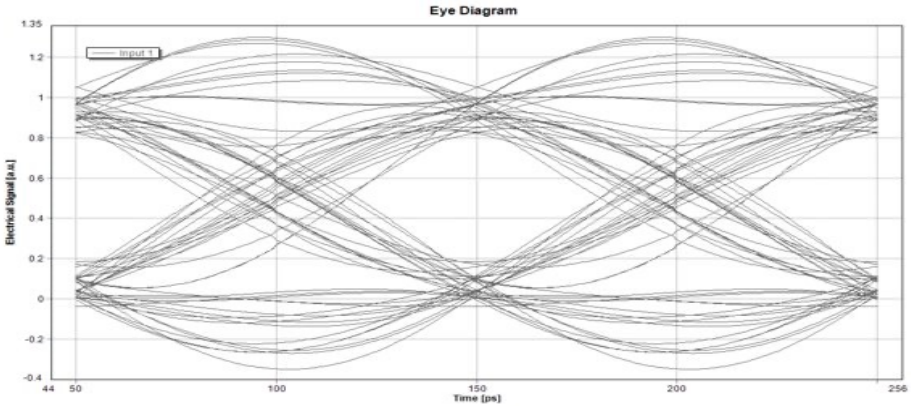




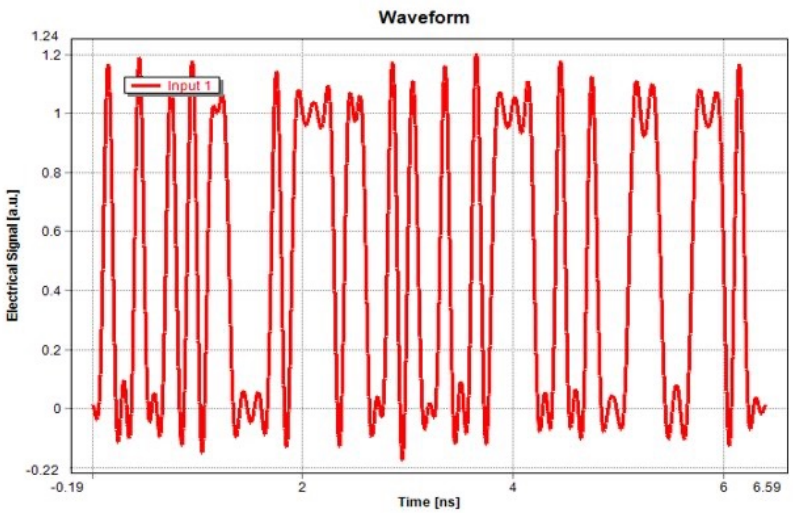
5 GHz filter (rectangular)

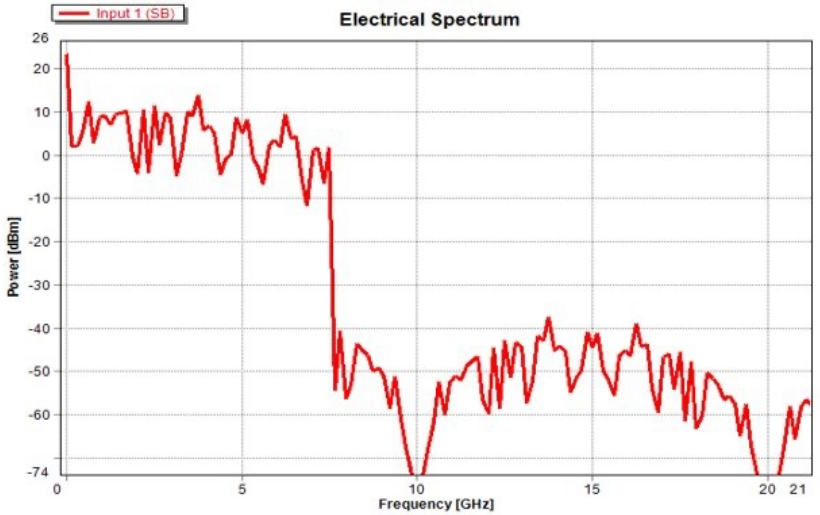


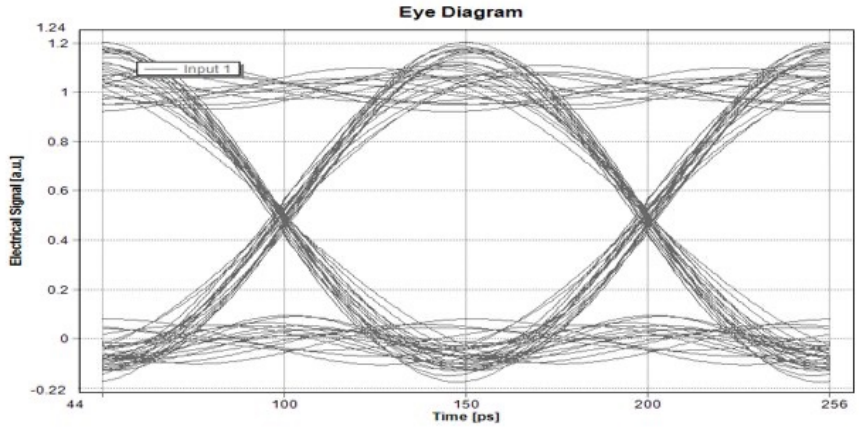




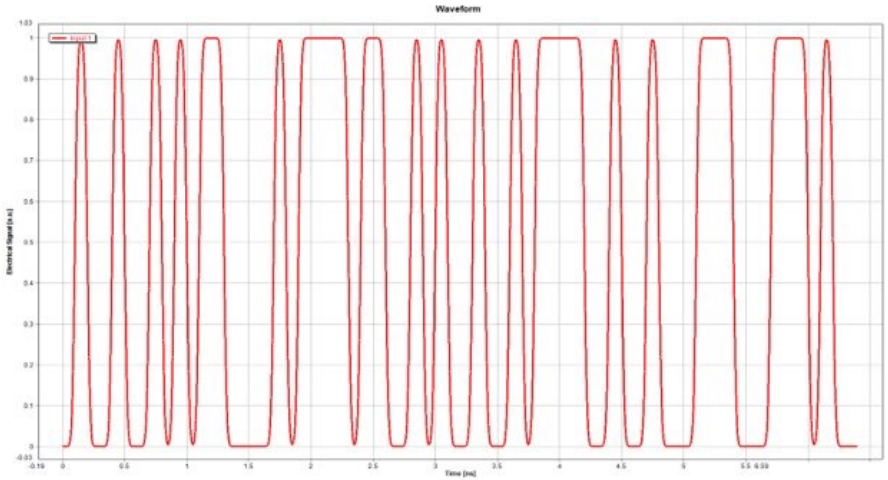
7.5 GHz filter (rectangular)

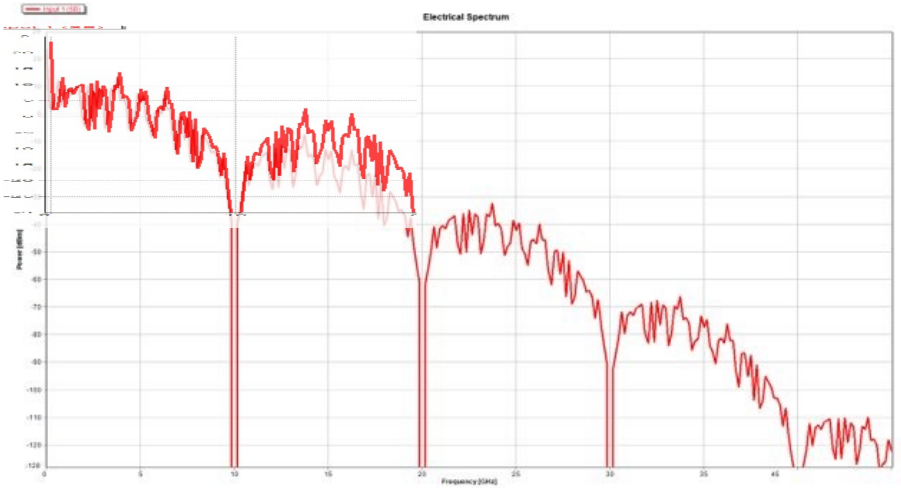


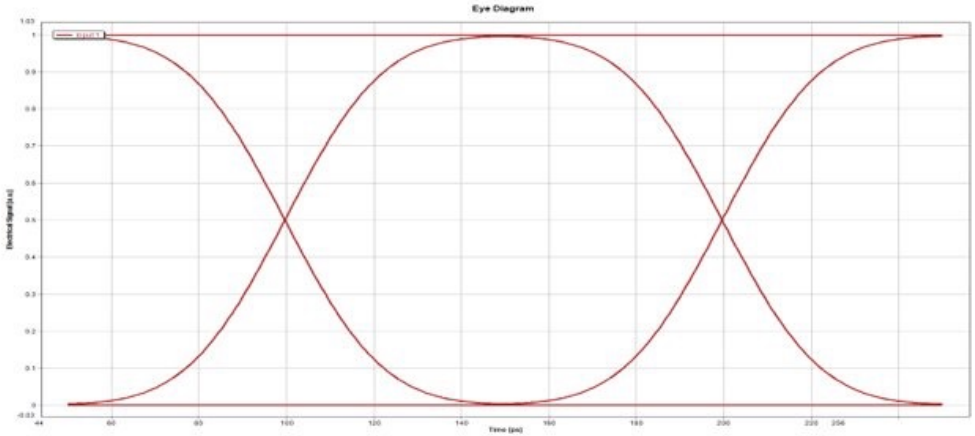




7.5 GHz filter (Gaussian)

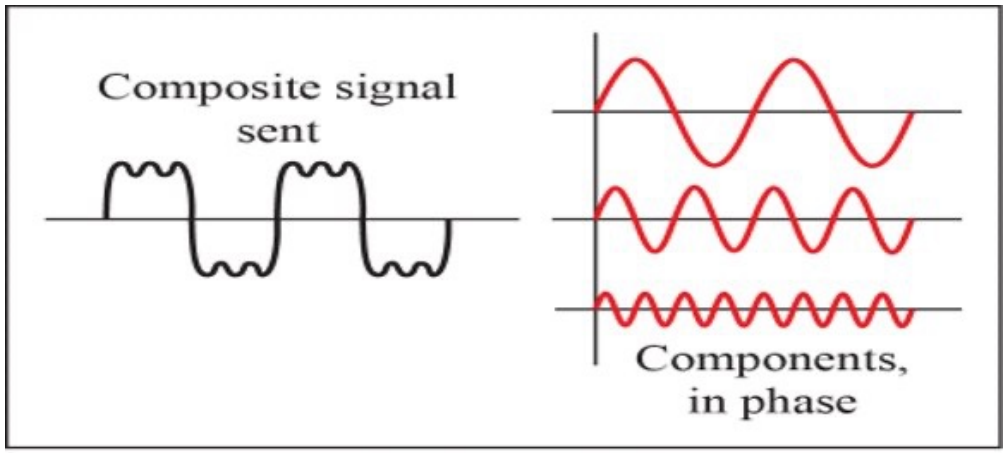




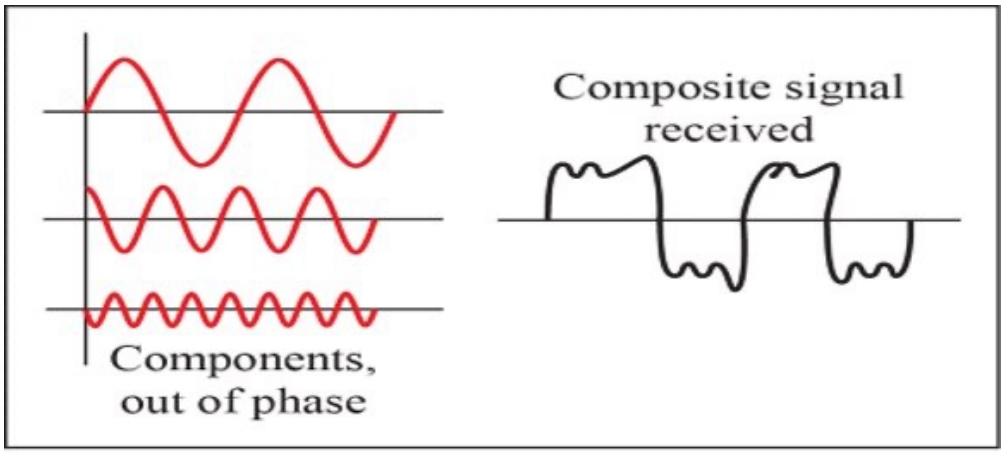


The Phase…

- The shape of a waveform is dependent on the frequency, power and phase of the individual frequency components
- A change in the relative phase of different components causes distortion



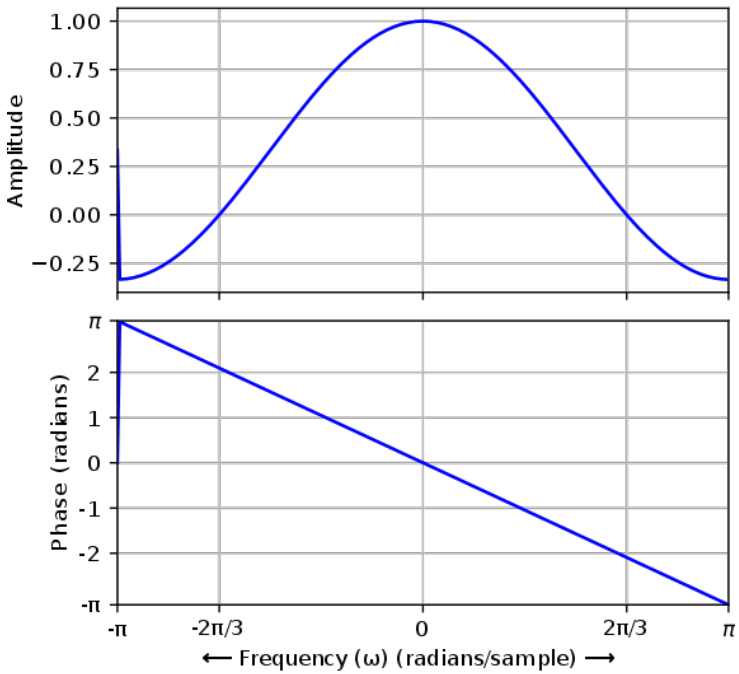
At the sender



At the receiver

Phase response

- Ideally, all system components would have a linear phase response i.e.: the phase would be a linear function of frequency
- Then all frequency components of the input signal are shifted in time (delayed) by the same constant amount, which is referred to as the group delay
- Group delay is the gradient of the phase response
- For linear phase response, there is no phase distortion due to the time delay of frequencies relative to one another



What have we learnt

- Digital signal and PRBS
- Eye diagram
- Effect of filtering on data signals
- The impact of phase on a signal