Exercise 3.9 Binary Signalling

Open the system:

`Digital Comm\ch_03\binary_signalling.svu`

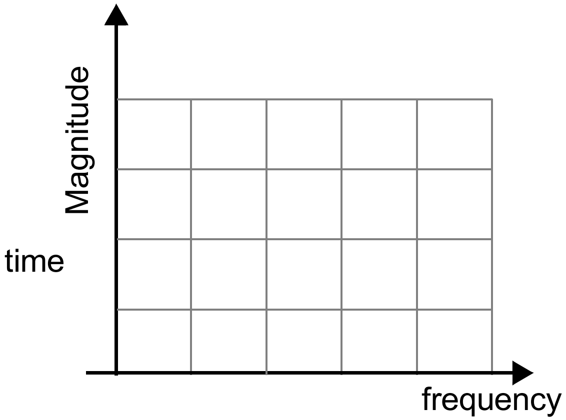
(a) The signalling pulse duration is 0.1 seconds, hence the data rate is 10 bits/second. Sampling rate is 100 Hz, hence one bit is represented by 10 samples. The data source is a text file of 1's and 0's, which has the initial sequence 0101011100100101000000....

(b) Run the simulation and compare the different signalling trains in the 

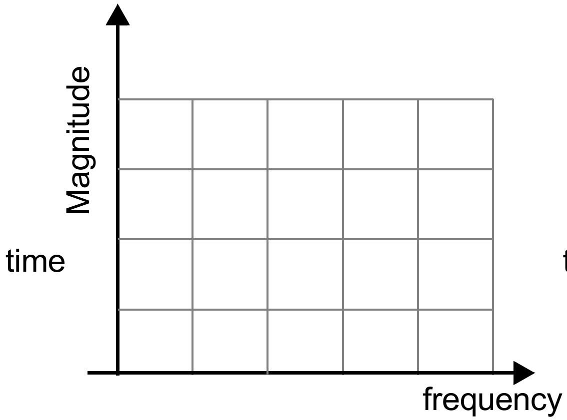
window.

(c) Increase the number of samples to 10000 and run the system again. In the 

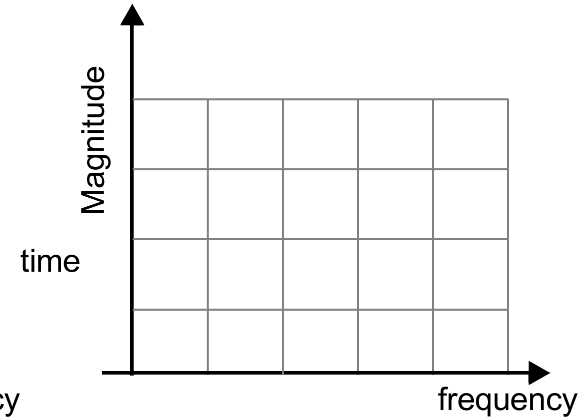
window view the magnitude frequency spectra that have been generated. Sketch the spectra below:



Unipolar RZ



Unipolar NRZ



Polar NRZ

Exercise 3.11 Sinc Pulse Shaping

Open the system:

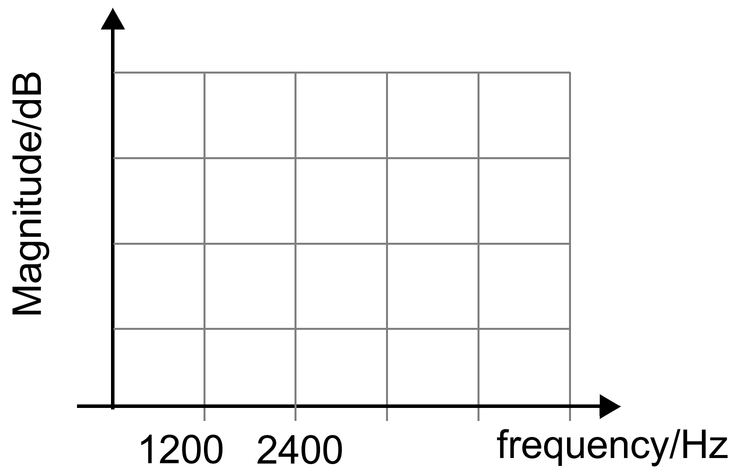
`Digital Comm\ch_03\sinc_pulse.svu`

The data impulses at the rate of 2400 bits/sec are shaped by a sinc pulse.

(a) Run the system and note in the **SystemView Analysis** window that there is NO intersymbol interference (ISI) occurring due to the zero crossings of sinc pulses occurring at the data sampling intervals.

(b) Increase the number of samples to 16384, run the system again, and in the **SystemView Analysis** window take the 20logFFT spectrum of the received sinc pulse shaped signal. Confirm that the required bandwidth is around 1200 Hz.

(c) Sketch the bandwidth required (compare with the values suggested in the textbook).



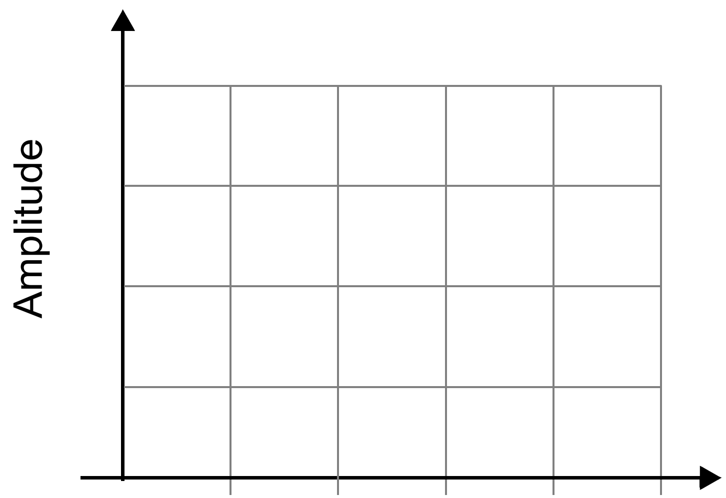
Sinc Pulse Bandwidth

Exercise 3.12 Generating an Eye Diagram

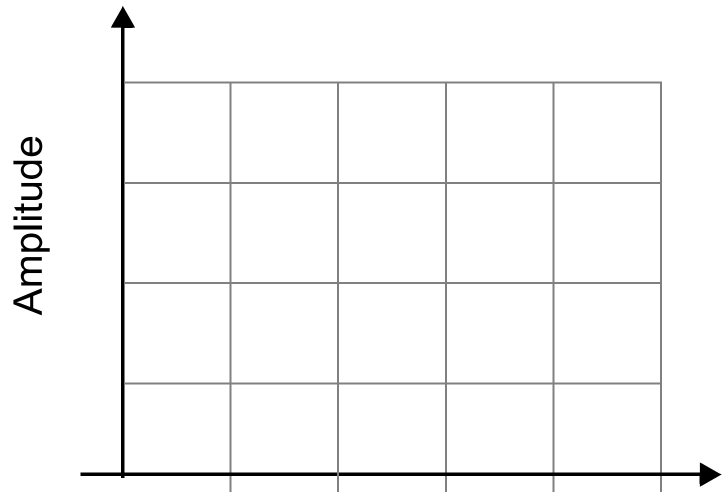
In this example we will generate the eye diagram for the signal in the previous example:

`Digital Comm\ch_03\sinc_pulse.svu`

(a) After running the system, in the analysis window choose Style then Time Slice... from the [icon]. Set the start time to an "appropriate value, and also set the time slice to the symbol rate. You should see only two significant crossing points which represent the sampling instants (Note you will also see the zero crossing point). Sketch the eye diagram for this signal below:



(b) Return to the design space and modify the data source to be a 4 level signal (you will require to open the "data stream" meta system) and then return to view the eye diagram in the analysis window. Sketch the eye diagram for this signal below:



(c) Add a low level of Gaussian noise to the shaped pulses and note the effect on the eye diagram.

(d) Remove the low level of noise, and pass the output through a simple phase distorting channel (perhaps design a simple IIR that essentially passes up to 4800 but distorts the phase), and again note the effect on the eye diagram.

Exercise 3.13 Raised Cosine Pulse Shaping

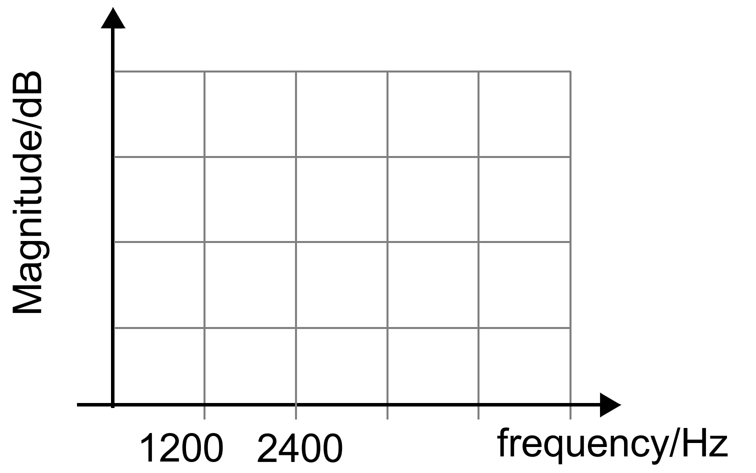
Open the system:

`Digital Comm\ch_03\raised_cosine_pulse.svu`

The data impulses at the rate of 2400 bits/sec are shaped by a raised cosine pulse. The raised cosine pulse has $\alpha = 1$ in this example.

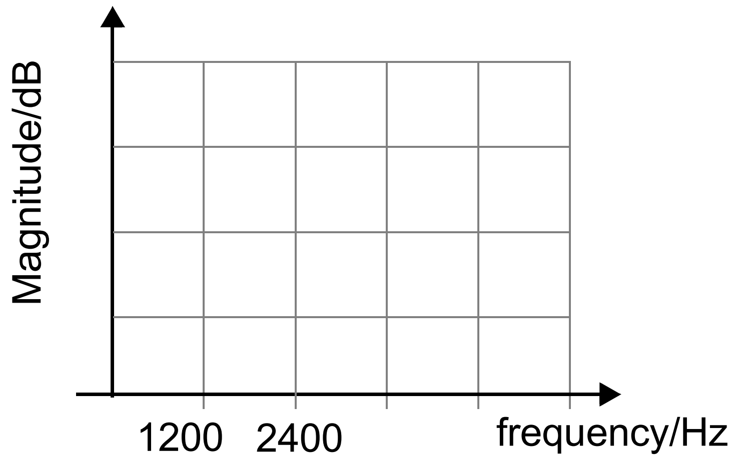
(a) Run the system and note in the SystemView Analysis window that there is NO intersymbol interference (ISI) occurring due to the zero crossings of raised cosine pulses occurring at the data sampling intervals.

(b) Increase the number of samples to 16384, run the system again, and in the SystemView Analysis window take the 20logFFT spectrum of the received raised cosine pulse shaped signal. Confirm that the required bandwidth is now 2400 Hz. Hence sketch the bandwidth required below.



Raised Cosine Bandwidth $\alpha = 1$

(c) Change the roll-off parameter, α, to 0.22 in the raised cosine filter dialog box (see LINEARSYS/FILTER-COMM), rerun the system. Note there is still zero ISI, but the excess bandwidth is reduced. Sketch the bandwidth required.



Raised Cosine Pulse Bandwidth $\alpha = 0.22$

(d) Generate the eye diagram for this system.

(e) Change the shaping filter to a root raised cosine. Note there is now some ISI.

Exercise 3.16 Raised Cosine, Root-raised cosine, and Sinc Filters

Intersymbol interference (ISI) can seriously degrade the performance of a digital communication system. Care must be taken when choosing a pulse shaping filter to insure that ISI is not introduced. The common technique for observing ISI is the so called 'eye diagram'. The eye diagram is obtained by taking the data waveform and folding it back on itself modulo the data rate. Figure 3.11 below shows such a diagram with no ISI. Note the sharp points in the centre where all of the traces converge. This is the sample time for best recovering the data. Figure 3.12 is a similar plot which indicates the presence of ISI.

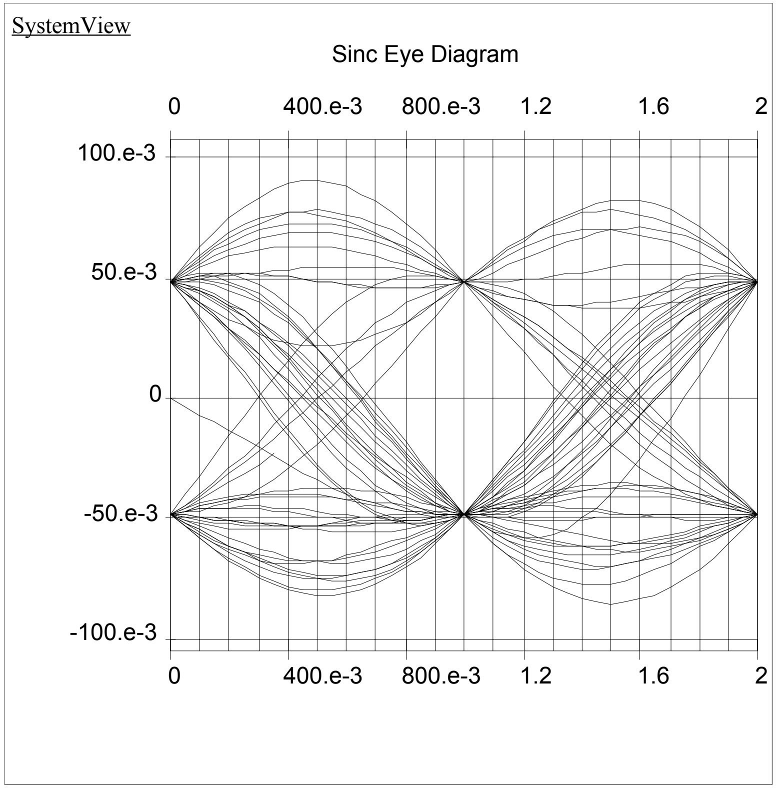


Figure 3.11: *No ISI eye diagram*

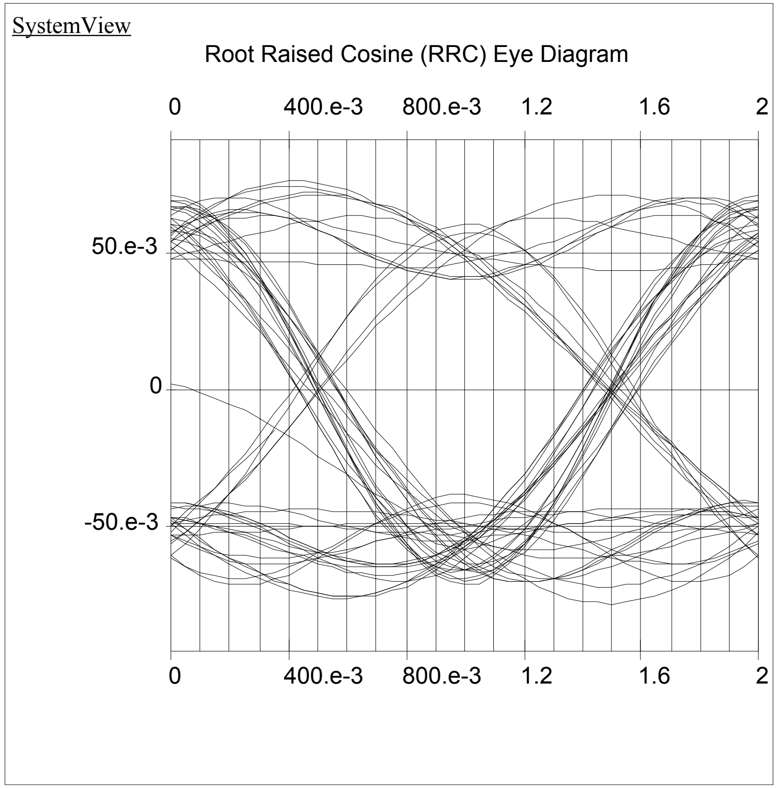


Figure 3.12: *ISI eye diagram*

So far the issue of pulse shaping has been limited to generating the signal. Nothing has been said regarding the optimum processing of this signal at the receiver end. We need a filter that is matched to the pulse shaping filter. In terms of noise only, the optimum receiver filter is identical to the filter used in the transmitter.

Now reconsider the ISI issue. The question is; 'What are the ISI properties of the waveform after recovery of the receiver with a matched filter, regardless of the ISI properties at the transmit side?'

Open the system:

`Digital Comm\ch_03\raised-cosine2.svu`

The sinc and raised cosine filter are described in the textbook. It was stated that the raised cosine filter exhibits no ISI and is easier to work with than the theoretically optimum sinc filter.

(a) Run the exercise file. Go to the analysis window where several eye diagrams are plotted. Observe the one labeled RC*RC (the * symbol indicates convolution). This is the eye diagram of the output of the raised cosine matched filter. Does this signal exhibit ISI?

(b) A common approach used in many systems is to use a root raised cosine (RRC) filter. A RRC filter is essentially half of a raised cosine filter with one half placed in the transmitter and the other half in the receiver. The matched filter properties are still preserved. What do you expect the ISI at the output of the RRC matched filter to be? Verify your answer by observing the plot labelled RRC*RRC.

(c) Theoretically the plot sinc*sinc should have no ISI but it does. Explain this result.

(d) It is instructive to fill in the table below with a yes or no.

Filter Type	**ISI at transmitter**	**ISI at receiver**
sinc		
raised cosine		
root raised cosine		