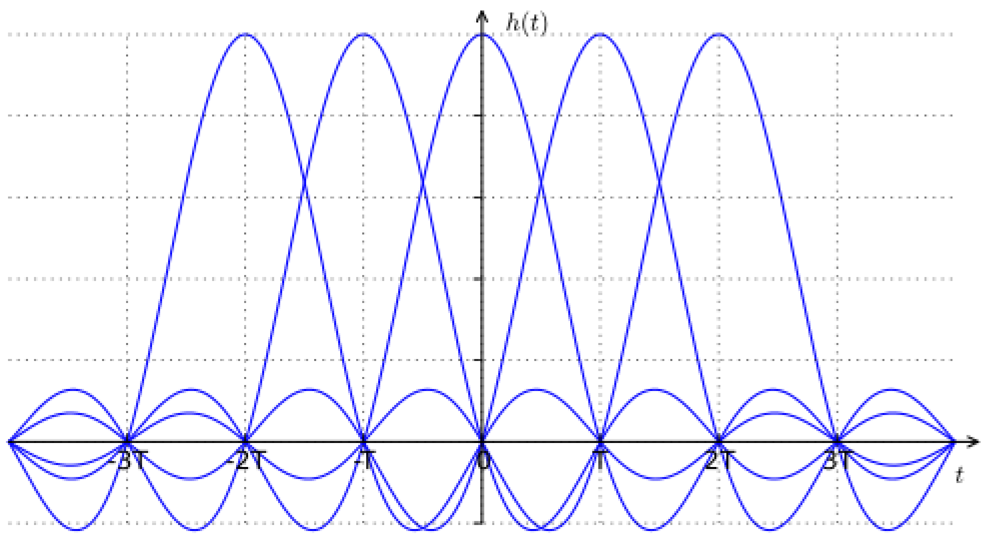
SYSC 4600 Digital Communications – READING TOPICS

Bandlimited Transmission
Intersymbol Interference
Transmission Rate
Spectral Efficiency
Equalization
MIMO

https://en.wikipedia.org/wiki/Nyquist_ISI_criterion
https://en.wikipedia.org/wiki/Intersymbol_interference
https://en.wikipedia.org/wiki/Raised-cosine_filter
https://en.wikipedia.org/wiki/Root-raised-cosine_filter
https://en.wikipedia.org/wiki/Equalization_(communications)
https://en.wikipedia.org/wiki/Zero_forcing_equalizer
https://en.wikipedia.org/wiki/Spectral_efficiency
https://en.wikipedia.org/wiki/MIMO



Consecutive raised-cosine impulses, demonstrating zero-ISI property

Effects on eye patterns [Wikipedia]

One way to study ISI in a PCM or data transmission system experimentally is to apply the received wave to the vertical deflection plates of an oscilloscope and to apply a sawtooth wave at the transmitted symbol rate R (R = 1/T) to the horizontal deflection plates. The resulting display is called an eye pattern because of its resemblance to the human eye for binary waves. The interior region of the eye pattern is called the eye opening. An eye pattern provides a great deal of information about the performance of the pertinent system.

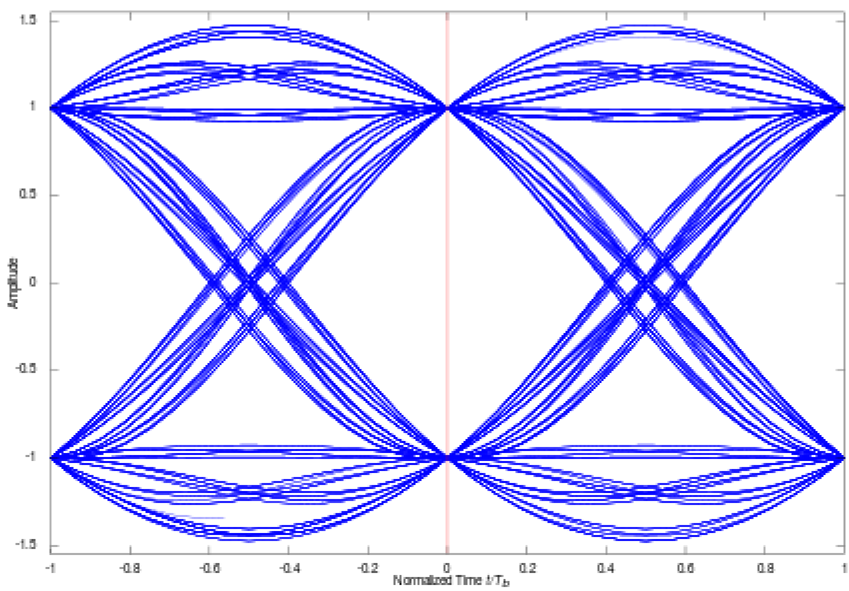
1. The width of the eye opening defines the time interval over which the received wave can be sampled without error from ISI. It is apparent that the preferred time for sampling is the instant of time at which the eye is open widest.

2. The sensitivity of the system to timing error is determined by the rate of closure of the eye as the sampling time is varied.
3. The height of the eye opening, at a specified sampling time, defines the margin over noise.

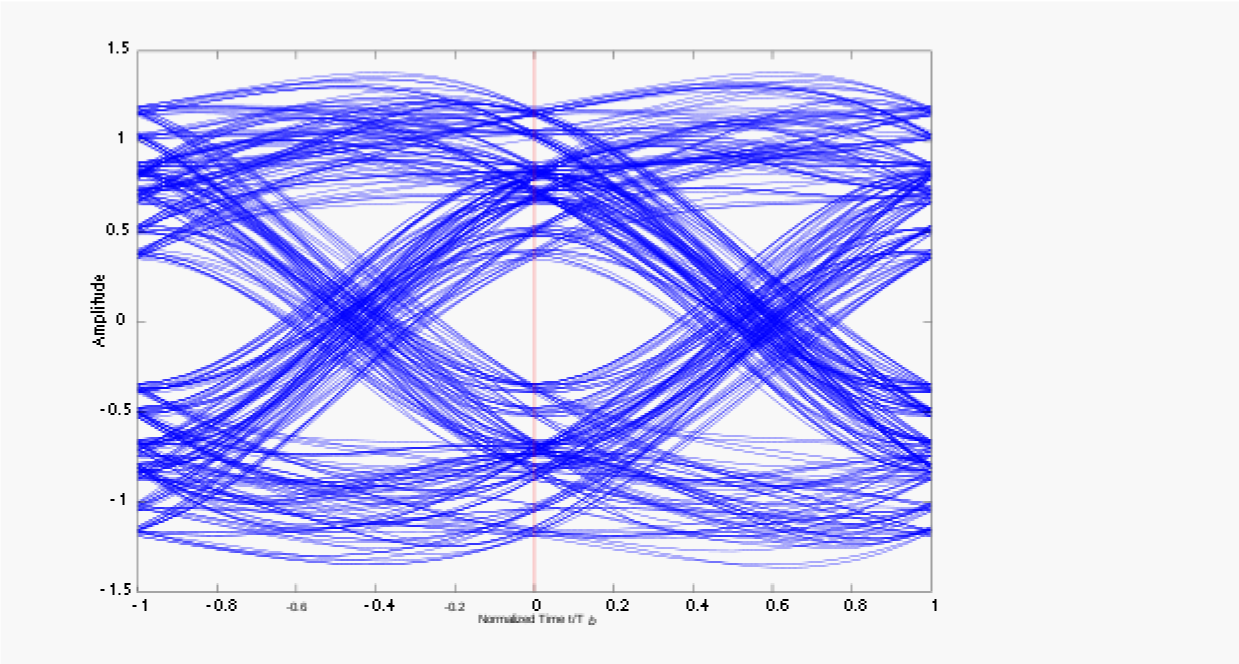
An eye pattern, which overlays many samples of a signal, can give a graphical representation of the signal characteristics. The first image below is the eye pattern for a binary phase-shift keying (PSK) system in which a one is represented by an amplitude of -1 and a zero by an amplitude of +1. The current sampling time is at the center of the image and the previous and next sampling times are at the edges of the image. The various transitions from one sampling time to another (such as one-to-zero, one-to-one and so forth) can clearly be seen on the diagram.

The noise margin - the amount of noise required to cause the receiver to get an error - is given by the distance between the signal and the zero amplitude point at the sampling time; in other words, the further from zero at the sampling time the signal is the better. For the signal to be correctly interpreted, it must be sampled somewhere between the two points where the zero-to-one and one-to-zero transitions cross. Again, the further apart these points are the better, as this means the signal will be less sensitive to errors in the timing of the samples at the receiver.

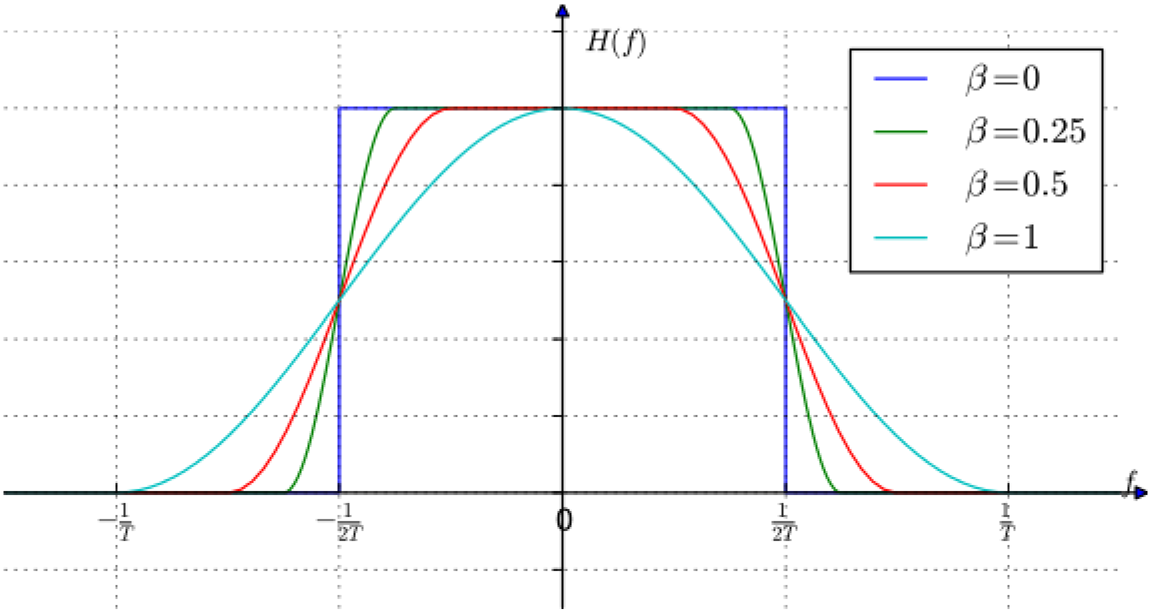
The effects of ISI are shown in the second image which is an eye pattern of the same system when operating over a multipath channel. The effects of receiving delayed and distorted versions of the signal can be seen in the loss of definition of the signal transitions. It also reduces both the noise margin and the window in which the signal can be sampled, which shows that the performance of the system will be worse (i.e. it will have a greater bit error ratio).



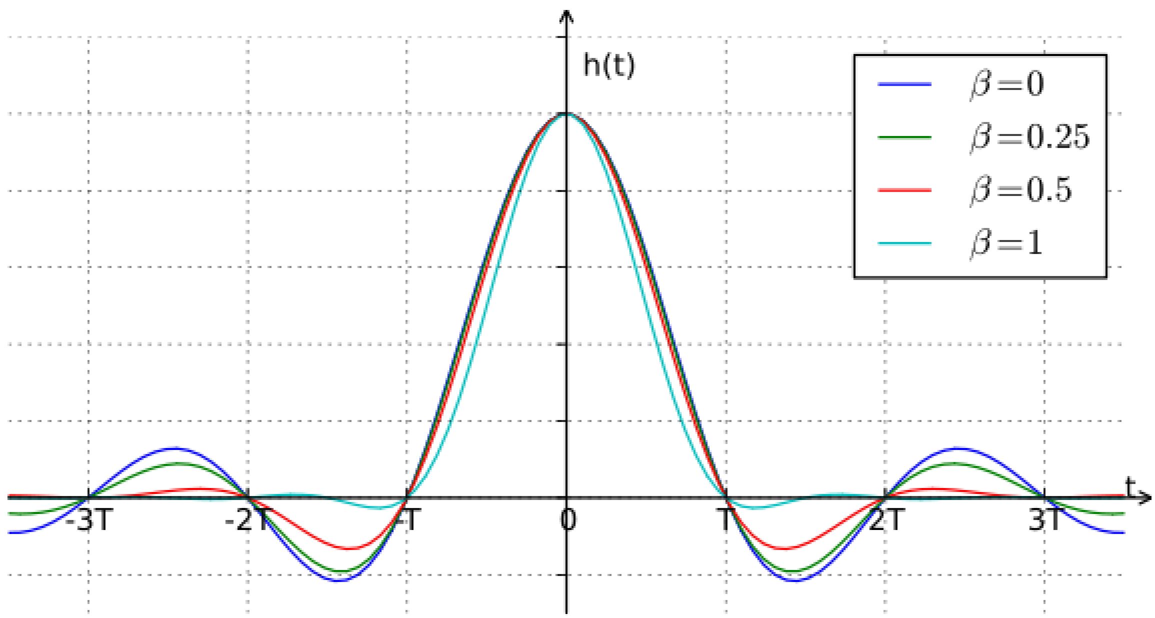
The eye diagram of a binary PSK system



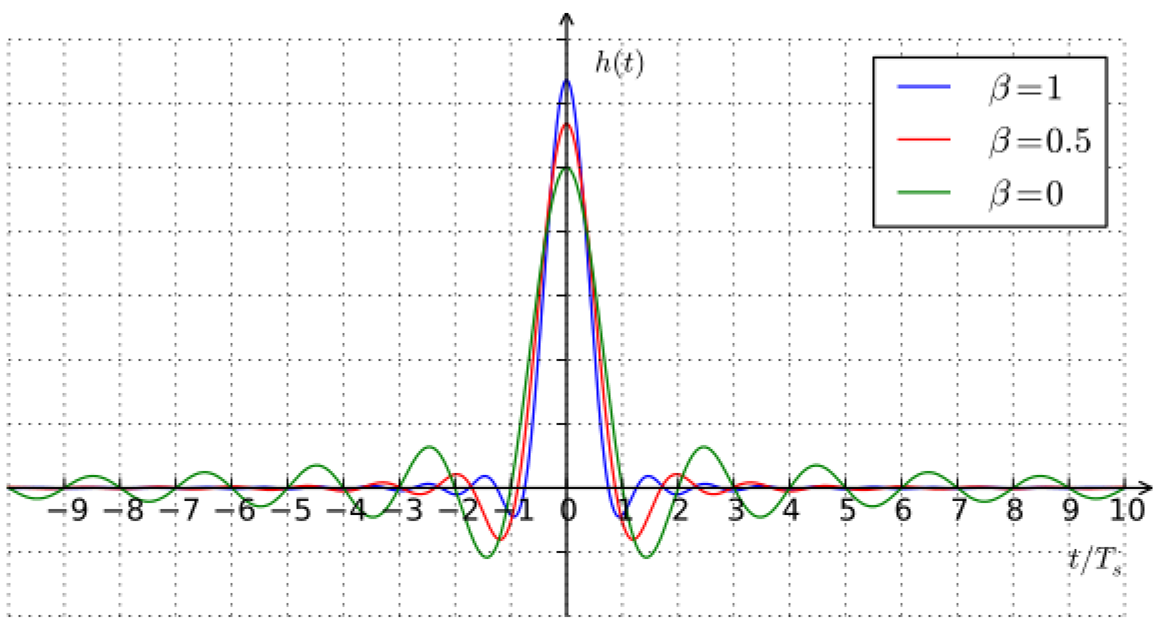
The eye diagram of the same system with multipath effects added



Frequency response of raised-cosine filter with various roll-off factors



Impulse response of raised-cosine filter with various roll-off factors



The impulse response of a root-raised cosine filter multiplied by $\sqrt{T_s}$, for three values of β: 1.0 (blue), 0.5 (red) and 0 (green).