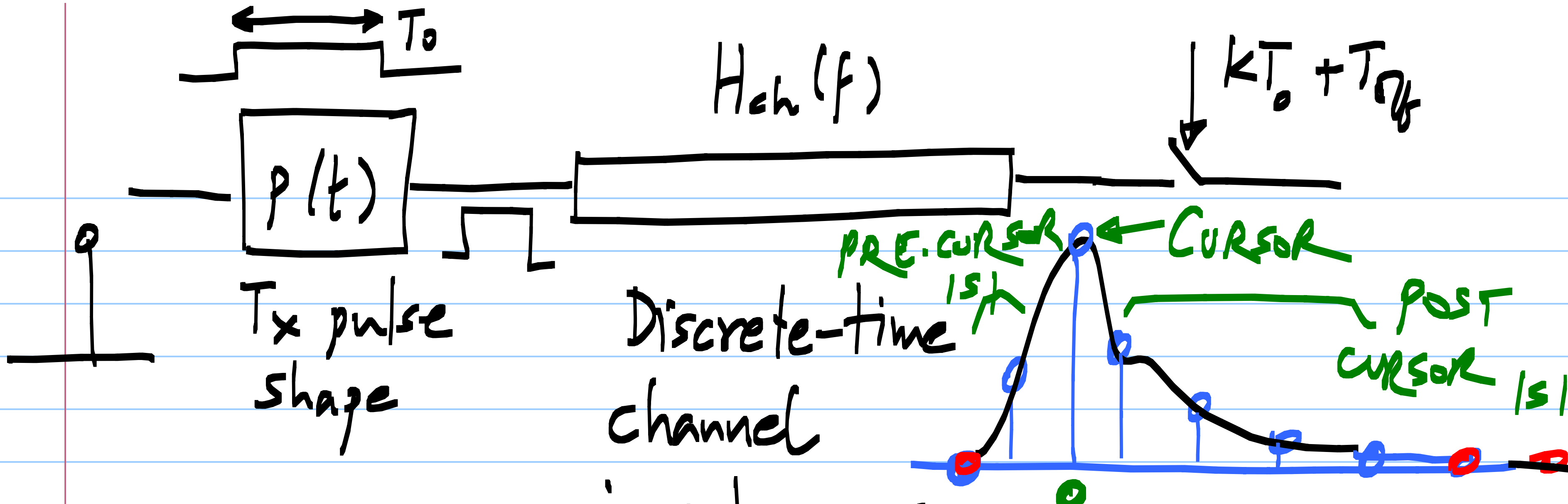


Tx pulse shape

Discrete-time channel impulse response

FIR response of the channel

$H_{ch}(z)$

$h_{ch}[n]$

ISI

$$y[n] = \overbrace{\sum_{k} h[k]\, x[n-k]}^{\text{ISI}}$$

$$= \underbrace{h[0] \cdot x[n]}_{\text{CURSOR DESIRED}} + \overbrace{\sum_{k>0} h[k]\, \underbrace{x[n-k]}_{\text{INPUTS BEFORE}}}^{\text{POST CURSOR}}$$

PAST BITS

$$+ \underbrace{\sum_{k<0} h[k]\, \underbrace{x[n-k]}_{\text{FUTURE BITS}}}_{\text{PRE CURSOR}}$$

$x[n] = 1$

$x[n-k] = -\mathrm{sgn}(h[k])$

$k \neq 0$

worst case (min. $y[n]$)

$$= h[0] - \underbrace{\sum_{k\neq 0} \left| h[k] \right|}_{\text{worst case ISI contribution}}$$

max $y[n]$ $\quad +$

$h_{ch}[n] = h_0$

$h_{ch}[n] = \{\cdots h_{-1}, h_0, h_1, h_2 \cdots\}$

Noise : σ_n

+1 • h_0

−1 • $-h_0$

$h_0 + \sum_{k\neq 0} |h_k|$

$h_0 - \sum_{k\neq 0} |h_k|$

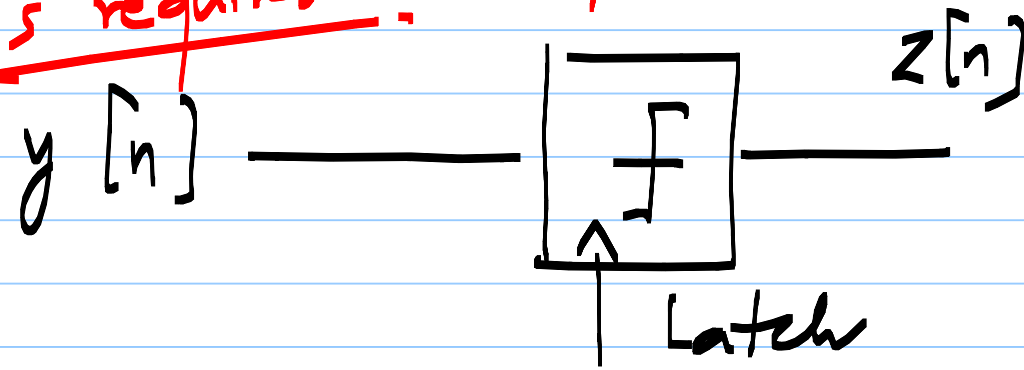
$-h_0 + \sum_{k\neq 0} |h_k|$

$-h_0 - \sum_{k\neq 0} |h_k|$

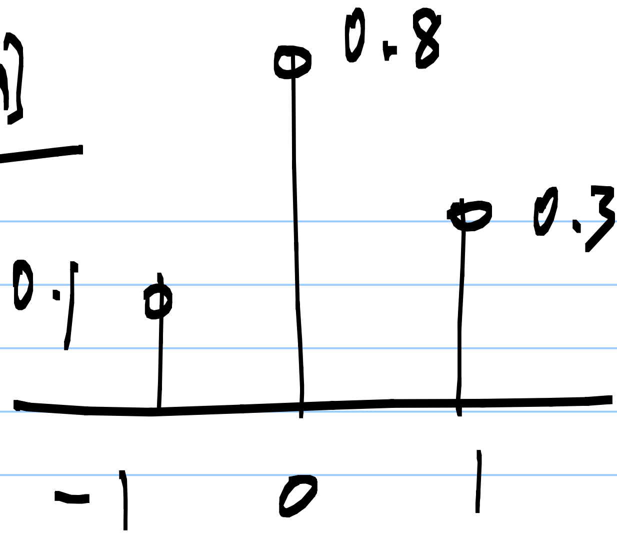
Opening determines worst case BER & whether any correction is required.

BER ??

BER = $Q\left(\frac{h_0}{\sigma_n}\right)$



$h[m]$



$h[n]$: length N, 2^{N-1} possibilities

$$\frac{1}{4}\left[Q\left(\frac{0.4}{\sigma_n}\right)+Q\left(\frac{0.6}{\sigma_n}\right)+Q\left(\frac{0.8}{\sigma_n}\right)+Q\left(\frac{1.2}{\sigma_n}\right)\right]$$

$$y[n] = 0.8 \pm 0.3 \pm 0.1$$

0.4 to 1.2

$$\underbrace{\pm 1}\quad 1 \quad \underbrace{\pm 1}$$

4 possibilities

$$x[n] = +1$$

$$Q\left(\frac{\text{worst case } y[n]}{\sigma_n}\right)$$

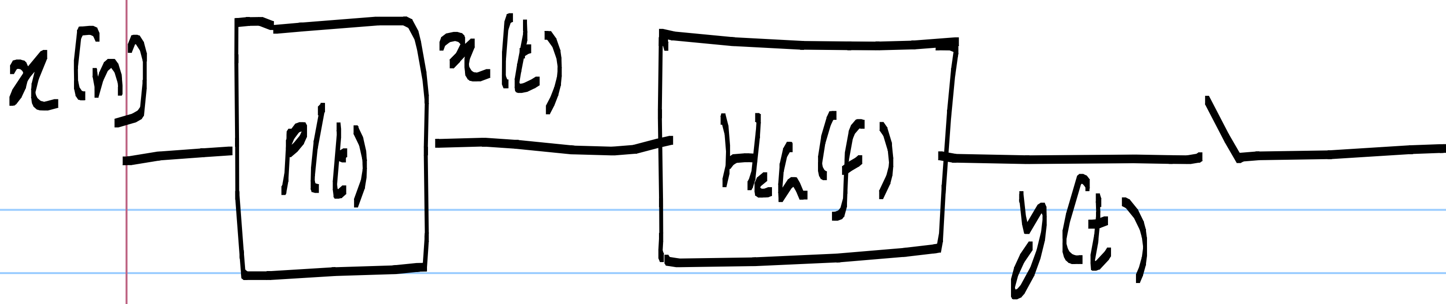
$h[n]$: length N

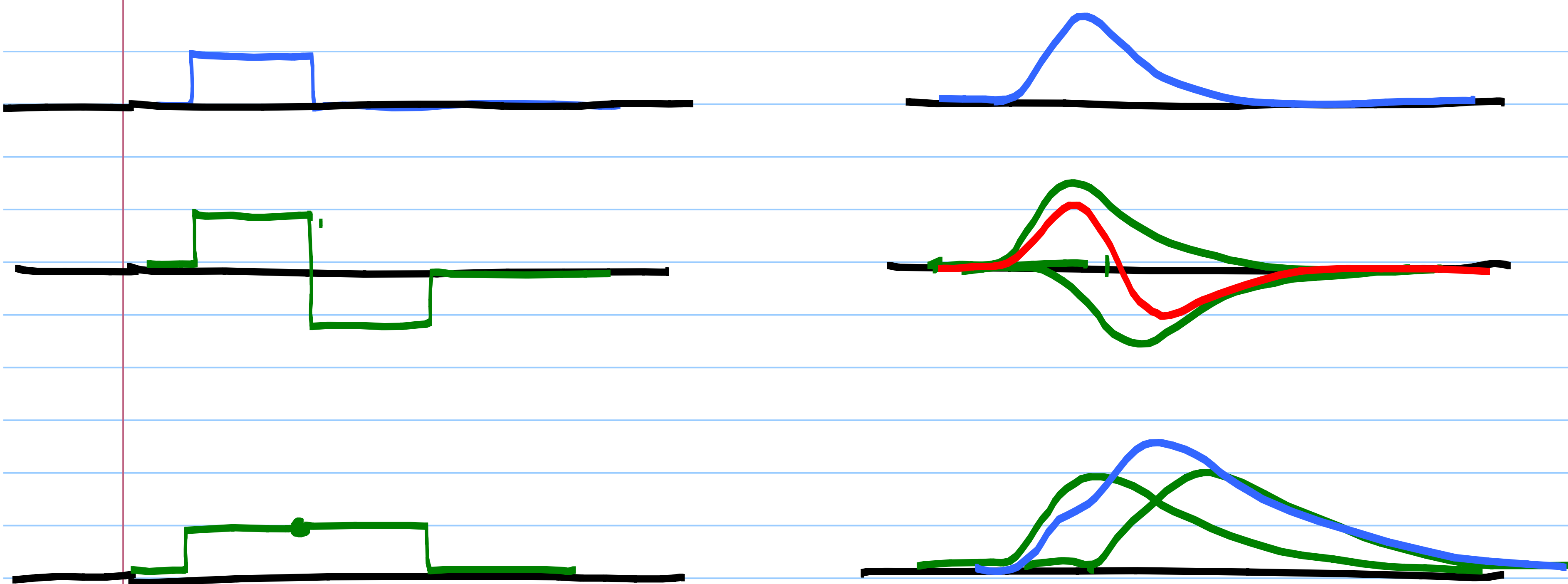
Number of possible $|s|$ combinations $= 2^{N-1}$

$$BER = \frac{1}{2^{N-1}} \underbrace{\sum_{k}}_{} Q\left(\frac{y_k}{\sigma_n}\right)$$

runs over 2^{N-1} $|s|$ bit combinations

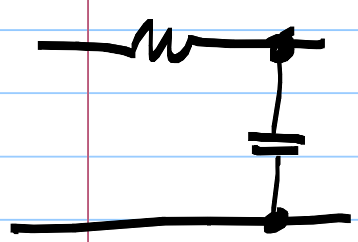
Crude approx. $BER = Q\left(\frac{y_{min}}{\sigma_n}\right)$

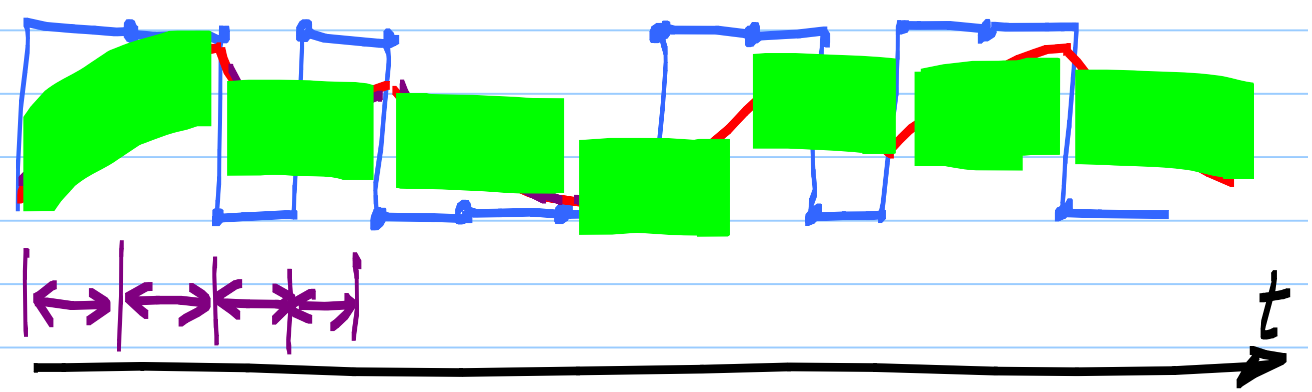

x[n]
p(t)
x(t)
$H_{ch}(f)$
y(t)

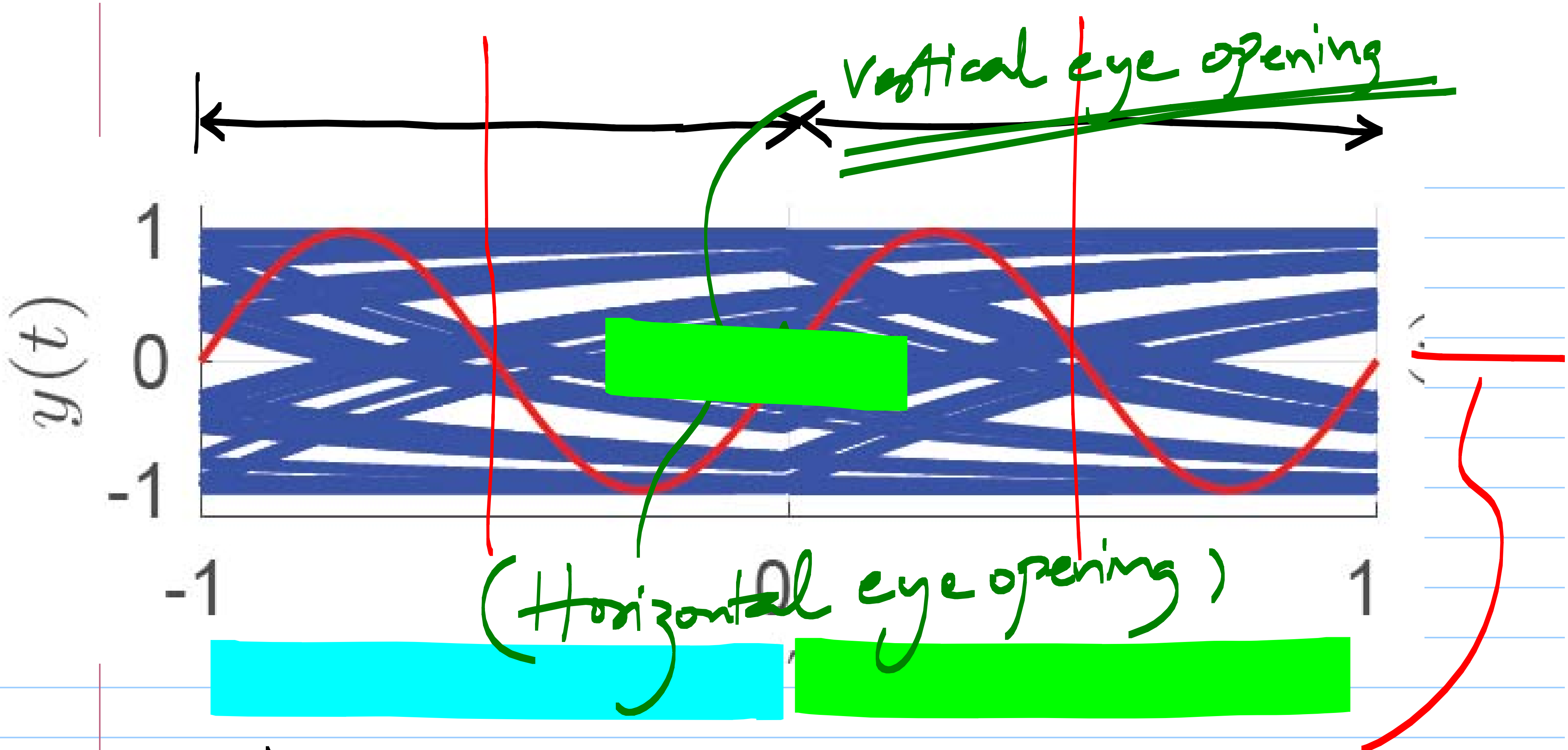


output waveform in each symbol interval is a result of multiple bits. waveforms depends on the bit pattern.

Overlapping all the waveforms gives us a visualization of intersymbol interference

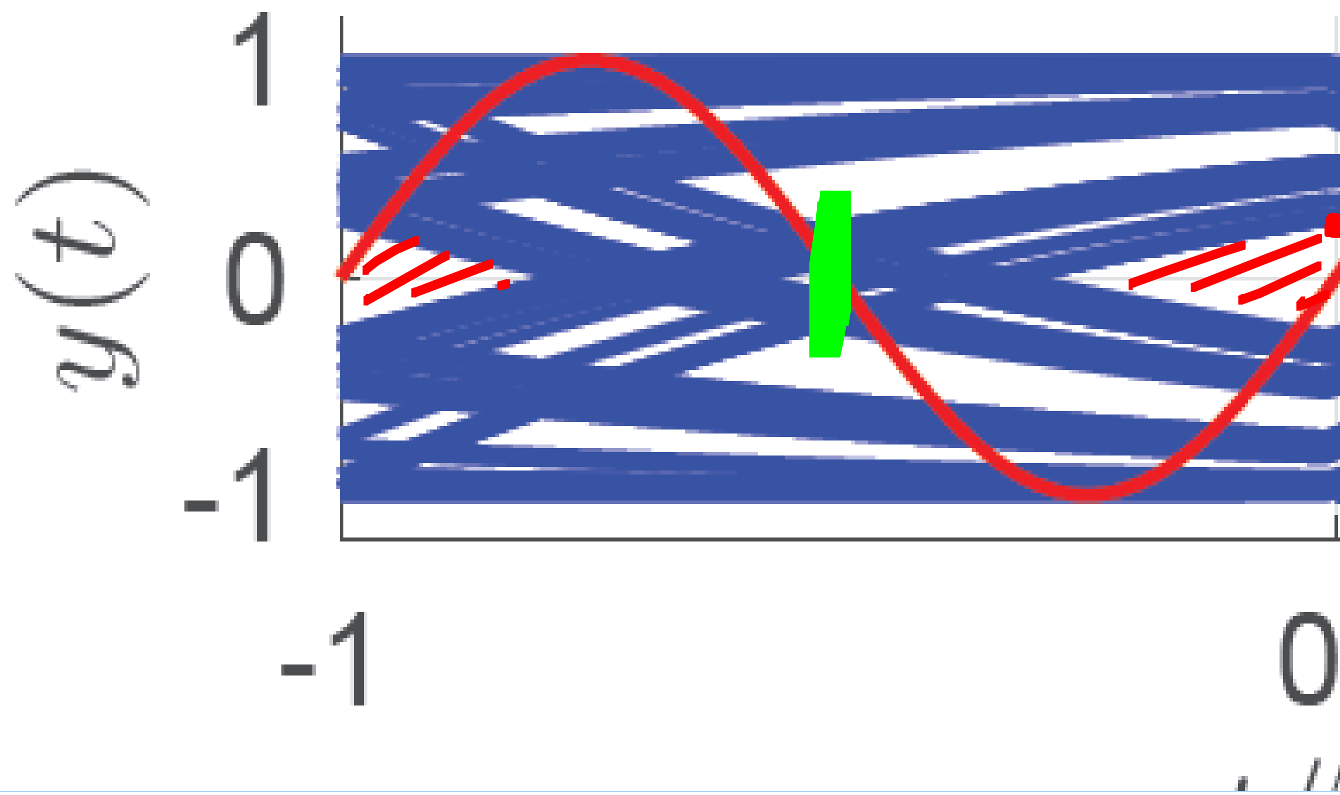






Symmetric about the x axis

Eye-diagram:
overlay of CT waveforms for all possible <u>bit patterns</u>



1
0
-1
$y(t)$
-1
0

Eye diagram of ideal rectangular data: