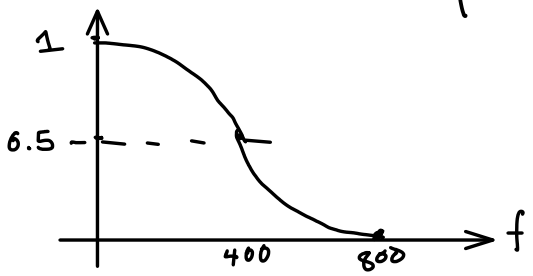
Lecture 5 - Data Transmission over Bandlimited Channels

Exercise 1: Draw the (real portion of) a raised-cosine transfer function that would allow transmission of impulses at a rate of 800 kHz with no interference between the impulses.

$f_{symbol} = 800\,kHz$

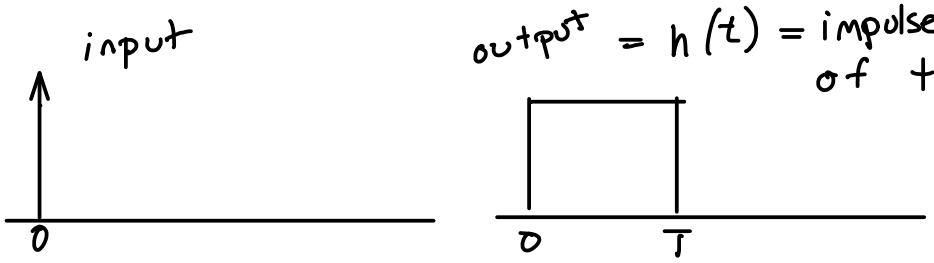
$\therefore$ need symmetry about $\frac{800}{2} = 400\,kHz$



$$|H(f)| = \frac{1}{2}\left(1 + \cos(kf)\right)$$

$kf = \pi$ at $f = 800\,kHz \Rightarrow k = \frac{\pi}{800 \times 10^3}$

Exercise 2: What is the impulse response of a filter than converts input impulses to pulses of duration T? What is the shape of the frequency response of this filter? *Hint: the Fourier transform of a pulse of duration T is* $\frac{\sin(\pi T)}{\pi T}$. What is the "bandwidth" of this filter (when is it first zero)? How does this compare to the "bandwidth" of the raised-cosine filter above?



$$H(f) = \mathcal{F}\{h(t)\} = \frac{\sin \pi f T}{\pi f T}$$

(Fourier Transform)

$\sin \pi f T = 0$ at $\pi f T = \frac{\pi}{2}$, $f = \frac{1}{2T}$ ("first-null" bandwidth)

this is same as above filters $-6dB$ bandwidth or $2\times$ the above filters total bandwidth

Exercise 3: What is the possible range of values of α?

$0 \leq \alpha \leq 1$

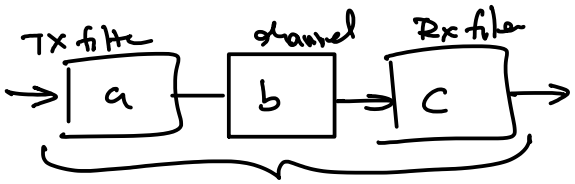
Exercise 4: Could equalization be done at the receiver only? At the transmitter only? Why or why not?

fixed Nyquist

$a \cdot b \cdot c = x$

none at tx → 1

$x = b \cdot c$



$a \cdot b \cdot c$ meets Nyquist

$= x$

if $a=1$ all equalization done at receiver:

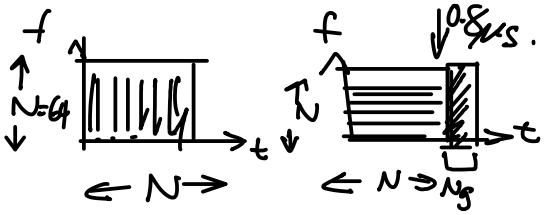
if $c=1$ (all at TX).

$a = \frac{x}{b}$

$c = \frac{x}{b}$ e.g. $\frac{0.5}{0.8} =$

Yes, both are possible as long as channel is nonzero.

Exercise 5: The 802.11g WLAN standard uses OFDM with a sampling rate of 20 MHz, with $N = 64$ and guard interval of $0.8\mu s$. What is the total duration of each OFDM block, including the guard interval? How many guard samples are used?



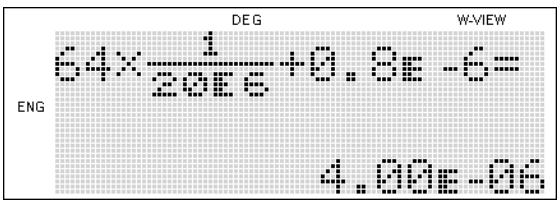
$= 64$

$f_{sample} = 20$ MHz

$N_{samples} = 64$

$duration = T_{sample} \cdot N + T_{guard} = 4\mu s.$

$T_{guard} = N \cdot T_{sample} = N \cdot \frac{1}{f_{sample}}$



$N = T_{guard} \cdot f_{sample}$

$= 0.8\mu s \cdot 20 \times 10^6 = 16$ samples.

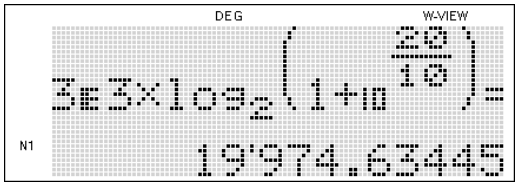
4V

Exercise 6: What is the channel capacity of a 3 kHz channel with an SNR of 20dB?

$$C = B \log_2\left(1 + \frac{S}{N}\right)$$

$$= 3\times10^3 \log_2\left(1 + 10^{\frac{20}{10}}\right)$$

$$= 3\times10^3 \log_2(101) \approx 20 \text{ kb/s}$$



Exercise 7: What are some differences between the signalling rate limit imposed by the Nyquist no-ISI criteria and the Shannon Capacity Theorem?

	Nyquist	Shannon
limits	symbol rate w/o ISI	information rate (not symbol or bit rate)
based on	-6dB Bandwidth	Bandwidth, $\frac{S}{N}$ ratio