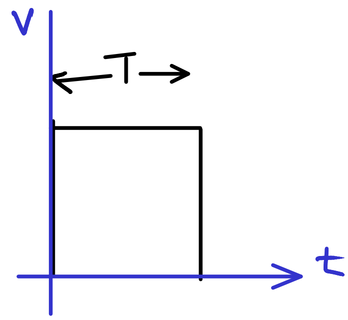
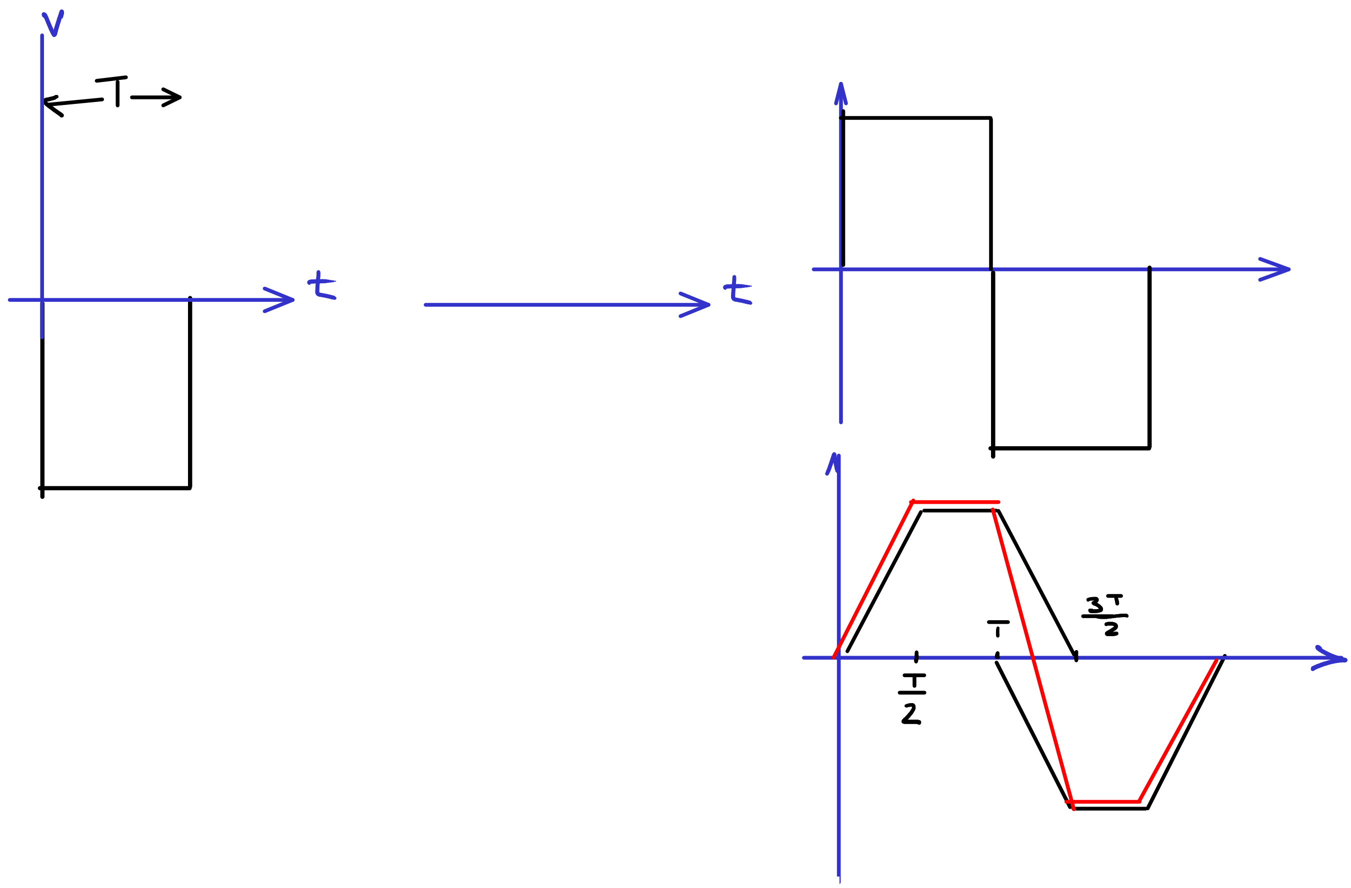
RS-232 and RS-422 Interface Circuits

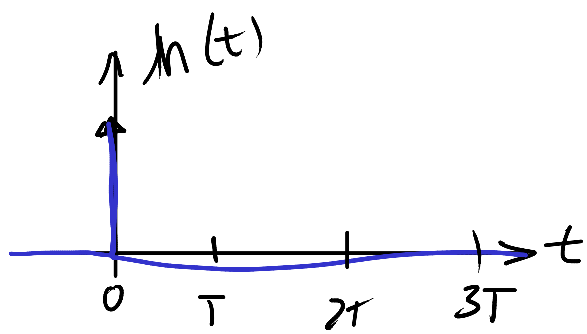
Exercise 1: Draw a square pulse of duration T. Draw the pulse after it has passed through a linear low-pass channel that results in rise and fall times of $T/2$. Draw the output for an input pulse of the opposite polarity. Use the principle of superposition to draw the output of the channel for a positive input pulse followed by a negative input pulse.



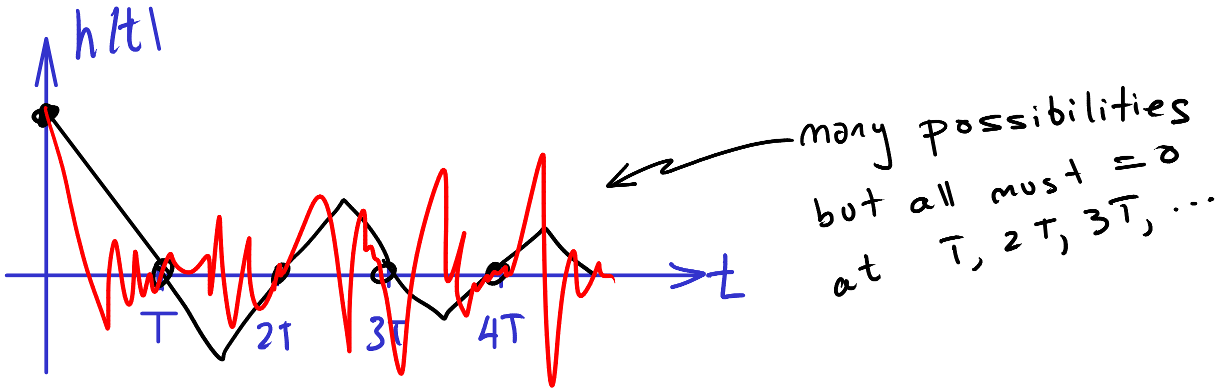


Exercise 2: What is the impulse response of a channel that does not alter its input? Does this impulse response meet the Nyquist condition? Will it result in ISI?

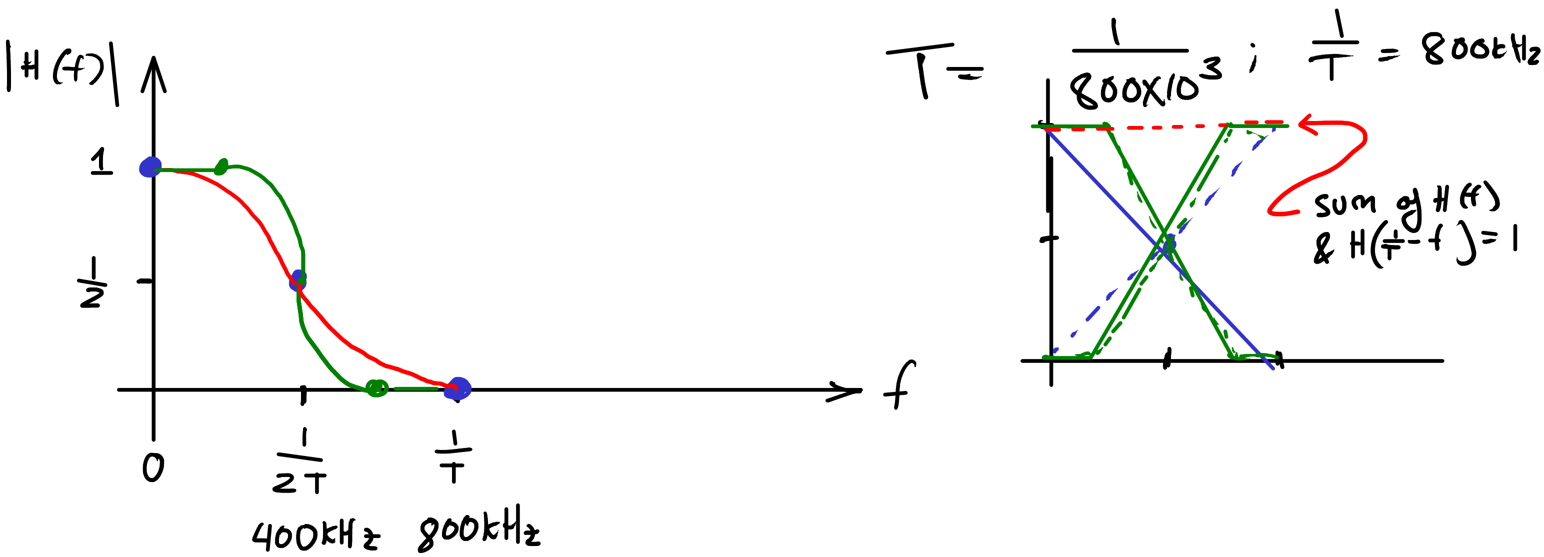
- an impulse
- yes
- no.



Exercise 3: Draw the impulse response of a channel that meets the Nyquist condition but is composed of straight lines.



Exercise 4: 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.



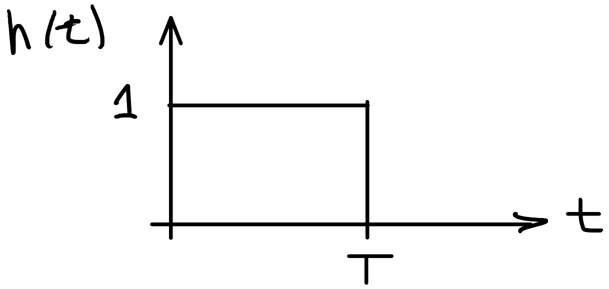
Exercise 5: Draw the impulse response of a filter than converts input impulses to pulses of duration T? What is the shape of the frequency response of this filter? *Hint: the Fourier transform of a pulse of duration T is $\frac{\sin(\pi f T)}{\pi f}$*. What is the "bandwidth" of this filter – when is it first zero? How does this compare to the "bandwidth" of the raised-cosine filter above?

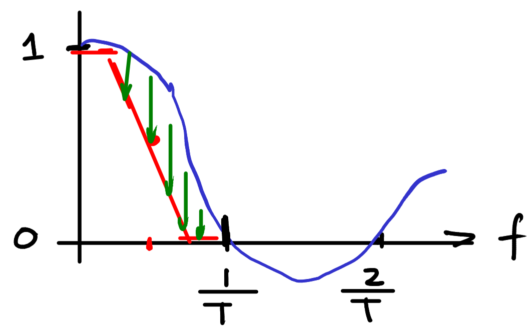
$\pi f T = \pi$

$f = \frac{1}{T}$

$\pi f T = 2\pi$

$f = \frac{2}{T}$





"first null bandwidth" $= \frac{1}{T}$

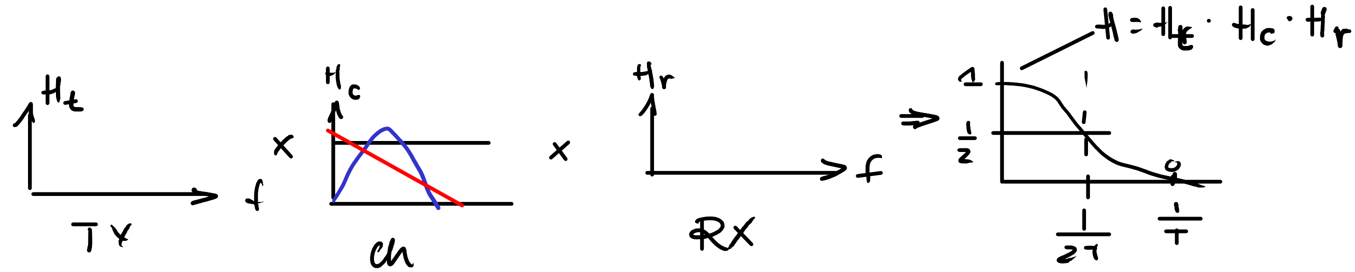
for RC filter $\frac{1}{2T} \leq$ "first null bandwidth" $\leq \frac{1}{T}$

Exercise 6: What is the possible range of values of α?

$0 \leq \alpha \leq 1$

Exercise 7: Could equalization be done at the receiver only? At the transmitter only? Why or why not? Which might be more practical?

YES } unless ch gain
YES } is zero.



if required $H(f) = g$ then $H_t = \dfrac{g}{H_r \cdot H_c}$

has solution unless $H_c = 0$

similarly for H_r

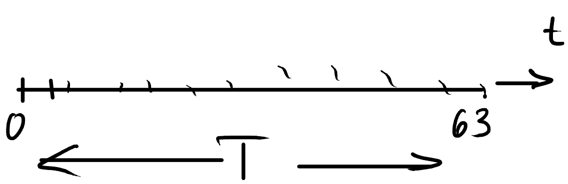
in general its easier at the receiver because it can measure the channel w/o needing feedback.

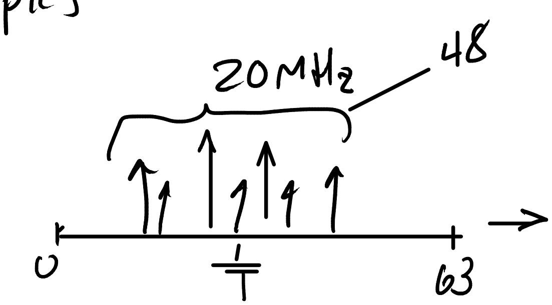
Exercise 8: The 802.11g WLAN standard uses OFDM with a sampling rate of 20 MHz, with $N = 64$ and guard interval of $0.8\mu s$. What is the total duration of each OFDM block, including the guard interval? How many guard samples are used?

$$T_{sym} = \frac{1}{20\times 10^6} \times 64 = 3.2\,\mu s.$$

w/ $0.8\mu s$ guard time, duration is $4.0\,\mu s$.

$$0.8\mu s \quad 20\times 10^6 = 16 \text{ samples}$$





Exercise 9: Can we use compression to transmit data faster than the Shannon capacity? Explain.

no. theorem applies to information rate, not data rate.

Exercise 10: What is the channel capacity of a 3 kHz channel with an SNR of 20dB?

$B = 3 \times 10^3$

$\frac{S}{N} = 20\,dB$

$= 10 \log\left(\frac{S}{N}\right)$

$\frac{S}{N} = 10^{\frac{20}{10}} = 100$

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

$$= 3 \times 10^3 \log_2(101) \approx 20\,kb/s$$

Exercise 11: What are some differences between the signalling rate limit imposed by the Nyquist no-ISI criteria and the Shannon Capacity Theorem?

	Nyquist Rate	Shannon Capacity
guarantees	no ISI	no errors
limits	symbol rate	information rate
based on channel's	impulse response	capacity