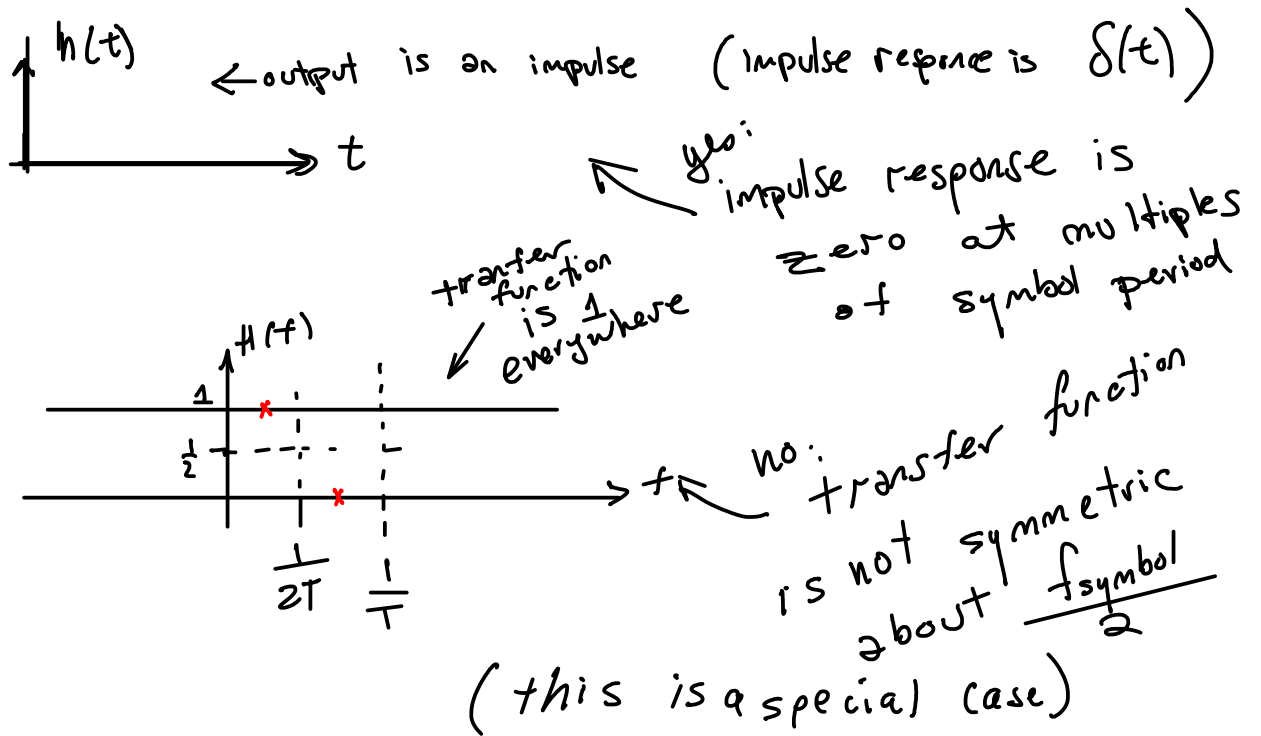


# Lecture 5

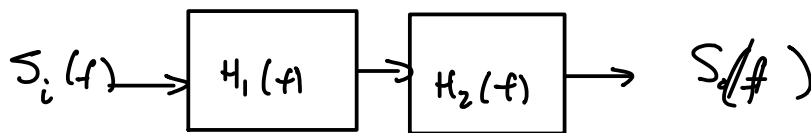
**Exercise 1:** What is the impulse response of a channel with infinite bandwidth? The transfer function? Does this channel meet the Nyquist no-ISI conditions?



**Exercise 2:** What is the possible range of values of  $\alpha$ ?

$$0 \leq \alpha \leq 1$$

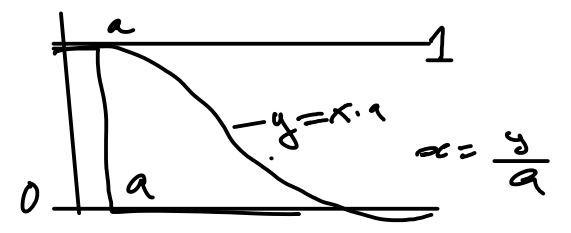
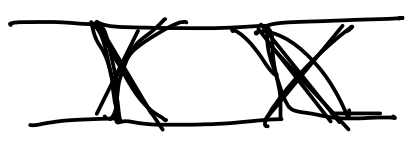
(0%) (100%)



$$S_o(f) = S_i(f) \cdot H_1(f) H_2(f)$$

**Exercise 3:** Could equalization be done at the receiver only? — yes, if the channel is not zero.  
 At the transmitter only? Why or why not?

↳ yes (same conditions) — we can scale the channel response to achieve any response if the channel response is non-zero

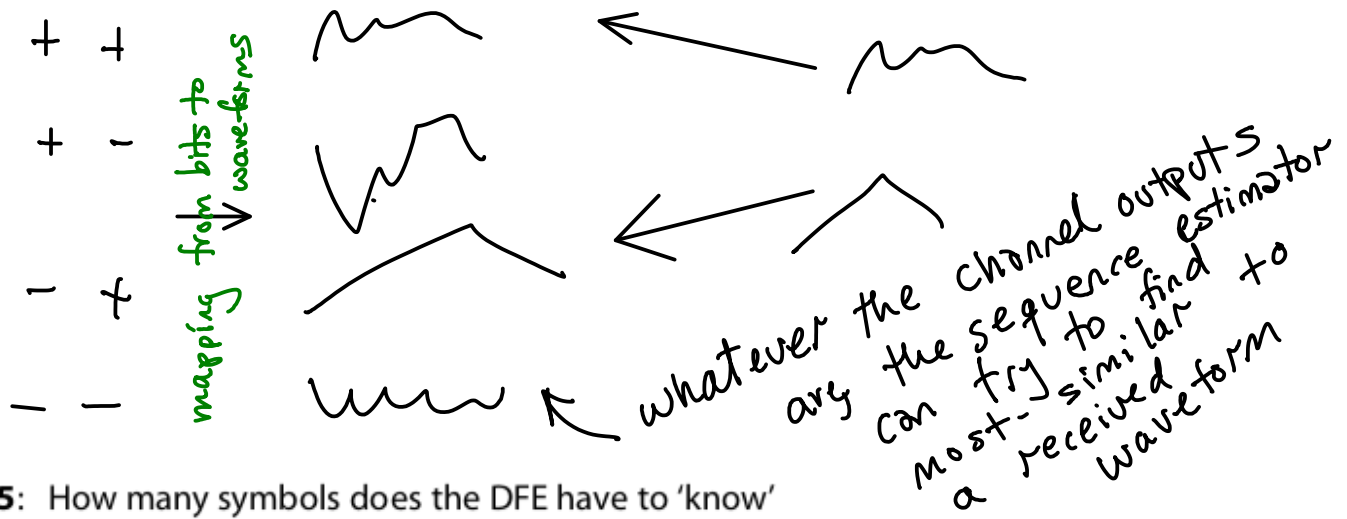


**Exercise 4:** Assuming the <sup>previous</sup> ~~initial~~ <sup>input</sup> output is zero, what waveform would result from transmitting +1, +1, +1, -1, +1, -1, 1?

assuming impulse response is  $1, \frac{1}{2}, 0, 0, \dots$

output = current input +  $\frac{1}{2}$  of previous input.

input	output	recovered input = current o/p - $\frac{1}{2}$ of previous <u>input</u>
0		
+1	$0 \cdot \frac{1}{2} + 1 \cdot 1 = 1$	1
+1	$1 \cdot \frac{1}{2} + 1 \cdot 1 = 1.5$	$1.5 - \frac{1}{2} \cdot 1 = 1$
+1	$1 \cdot \frac{1}{2} + 1 \cdot 1 = 1.5$	$1.5 - \frac{1}{2} \cdot 1 = 1$
-1	$1 \cdot \frac{1}{2} + 1 \cdot (-1) = -0.5$	$-0.5 - \frac{1}{2} \cdot 1 = -1$
+1	$-1 \cdot \frac{1}{2} + 1 \cdot 1 = +0.5$	$+0.5 - \frac{1}{2} \cdot (-1) = +1$



**Exercise 5:** How many symbols does the DFE have to 'know' before it can completely correct ISI on subsequent symbols?

as many as the duration of the impulse response of the channel.

**Exercise 6:** How many possible transmitted waveforms could be received if a sequence of 10 symbols is transmitted, each symbol being chosen from 4 possible symbols?

$$= 4 \times 4 \times 4 \times \dots \times 4$$
 (with 10 terms under a bracket)

o.g. 4 levels

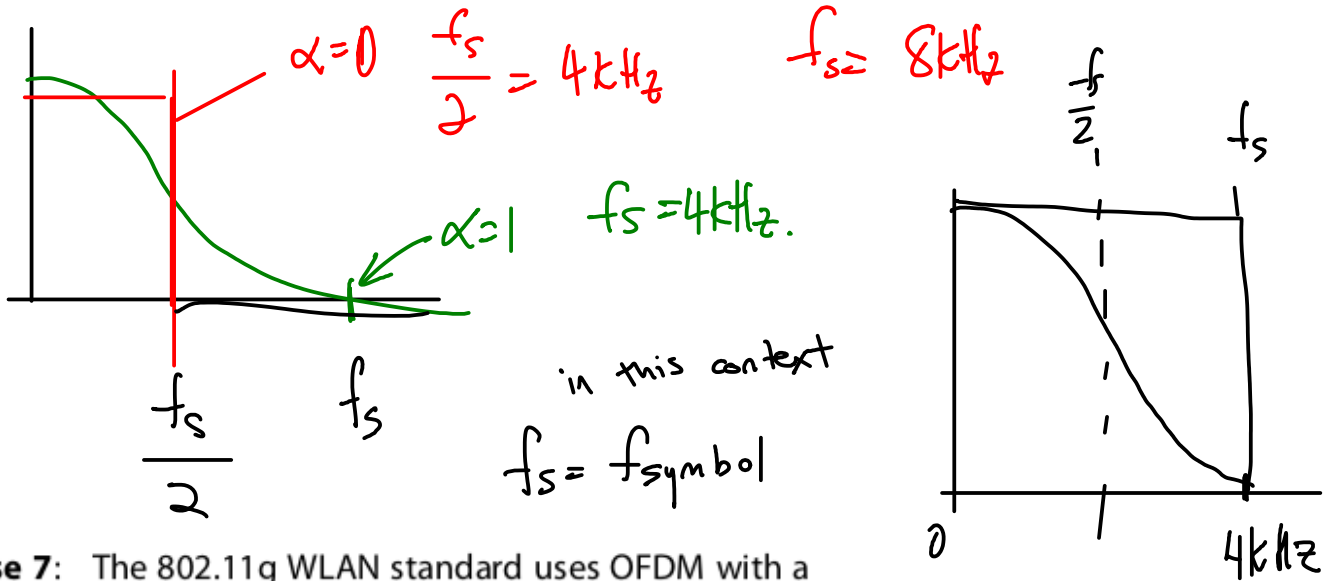
$$(4)^{10} = (2^2)^{10} = 2^{20} =$$

$$2^{10} = 1024$$

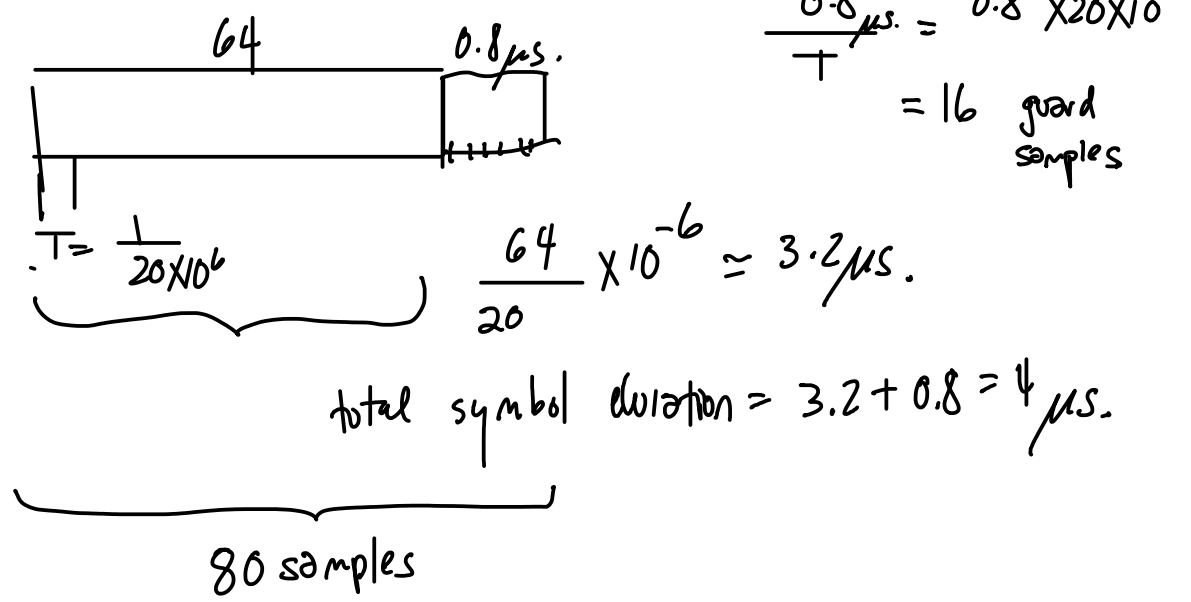
$$\frac{1024}{10} \approx 10^6$$

bandwidth = 4 kHz

What is maximum symbol rate?  $\alpha=0$   $2^? 4^?$   
 $\alpha=1$   $2^?$



**Exercise 7:** The 802.11g WLAN standard uses OFDM with a sampling rate of 20 MHz, with  $N = 64$  and guard interval of  $0.8 \mu\text{s}$ . What is the total duration of each OFDM block, including the guard interval? How many guard samples are used?



**Exercise 8:** What is the channel capacity of a 3 kHz channel with an SNR of 20dB?

$\log_2 128 = 7$   
 $\log_2 64 = 6$

$$C = B \log_2 \left( 1 + \frac{S}{N} \right) = 3 \times 10^3 \log_2 \left( 1 + 10^{\left(\frac{20}{10}\right)} \right)$$

$$\approx 3 \times 10^3 \cdot 6.5 \approx 20 \text{ kb/s}$$