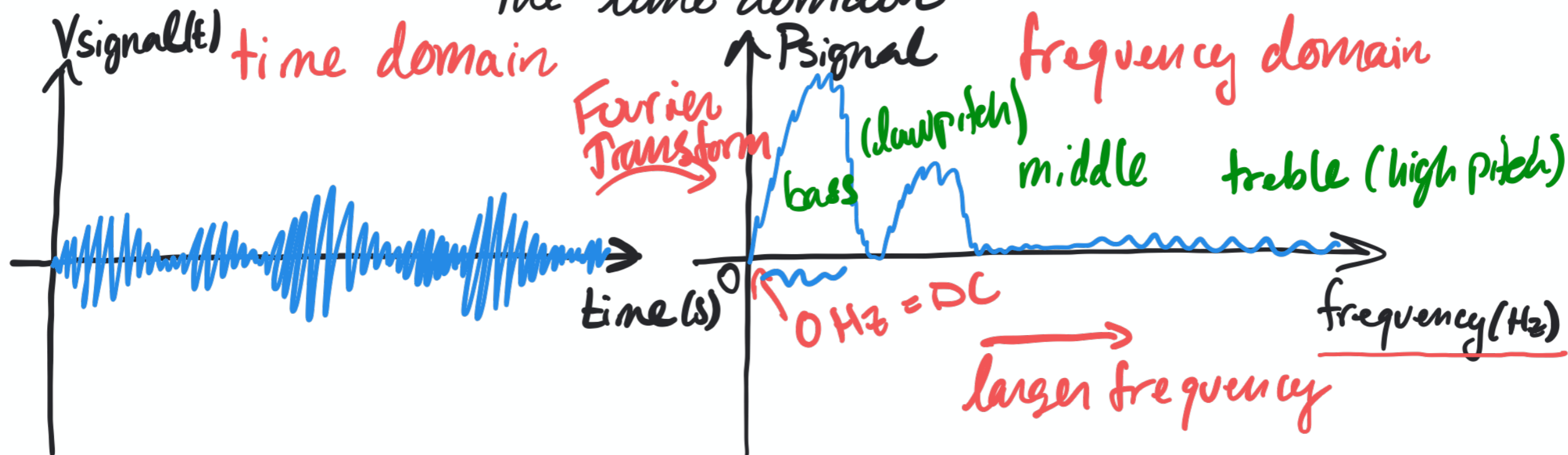


1) Frequency domain: another way to represent signals that gives us different information than in the time domain



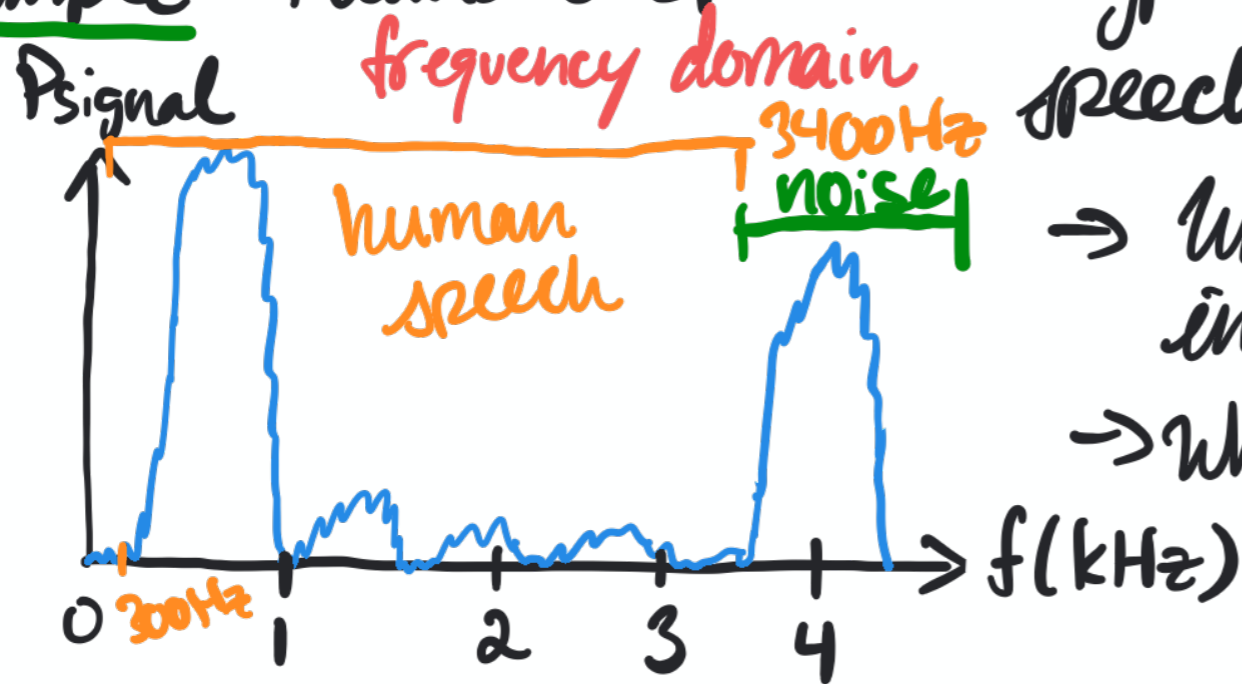
• Voltage amplitude vs. time

• Power in a signal in a certain frequency range

• For audio signals: Voltage signal amplitude: roughly equivalent to loudness
Voltage signal frequency: equivalent to pitch

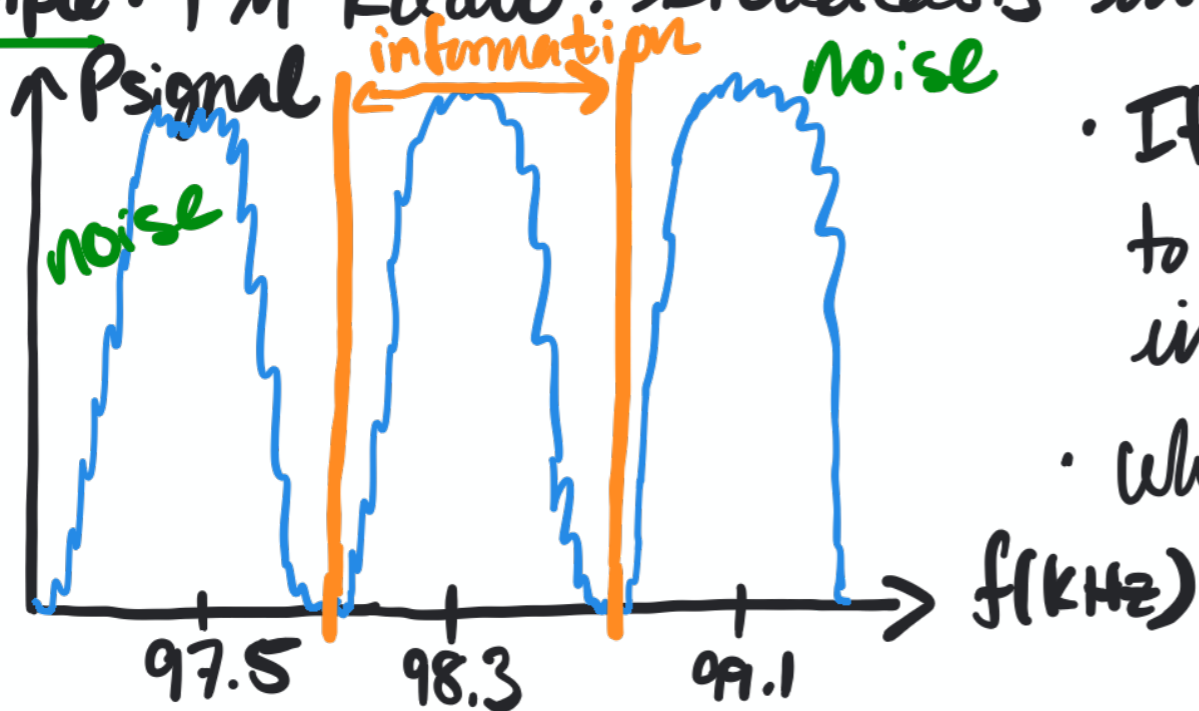
- It is often easier to identify and isolate information in a signal when we are in the frequency domain. 2

Example: Human Speech - typical frequency range for human speech is 300 Hz - 3400 Hz



- where is the information we're interested in in the plot to the left?
- where is the noise? 3400 Hz +

Example: FM Radio: broadcasts in 88 kHz - 108 kHz range



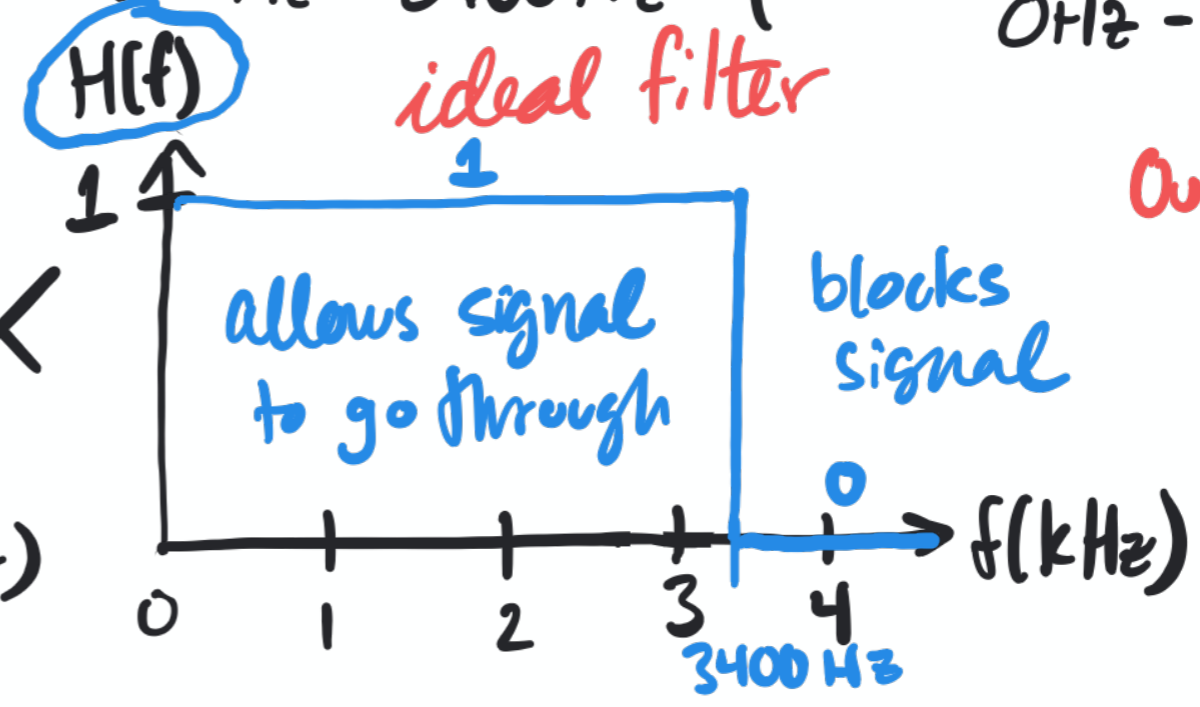
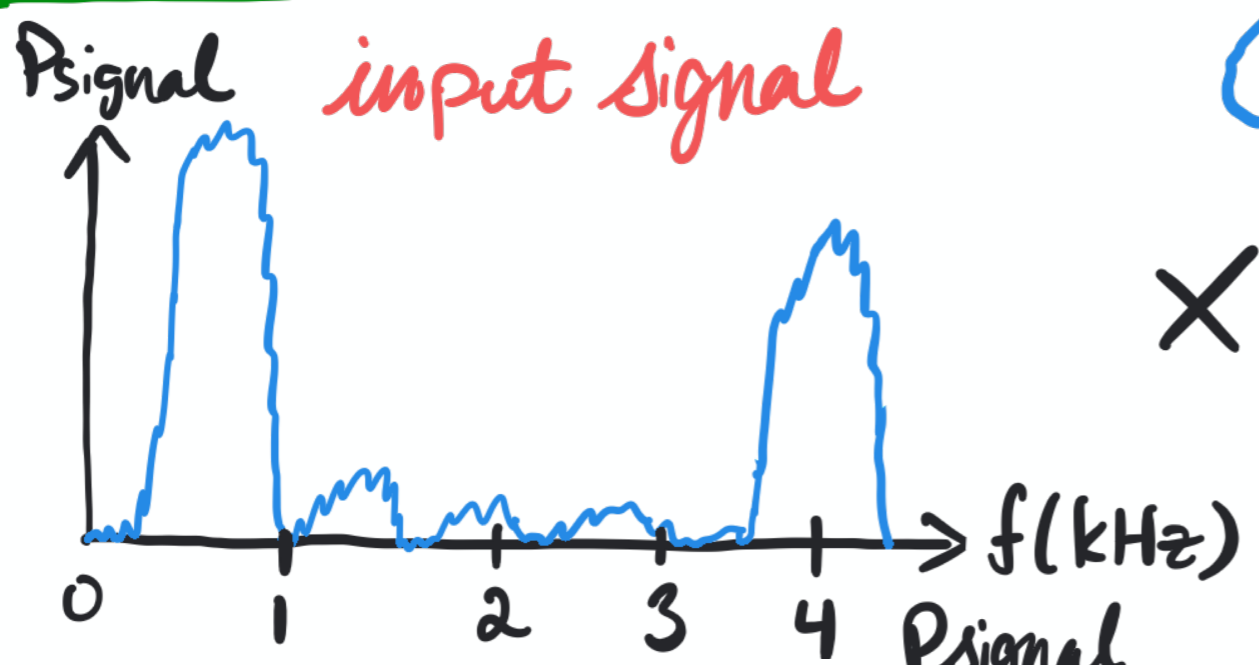
- If we're interested in listening to channel 98.3, where is our information?
- where is the noise?

b) Ideal Filters

- Step 1 is identifying where our information is, but how do we isolate that information from the noise?

Filters

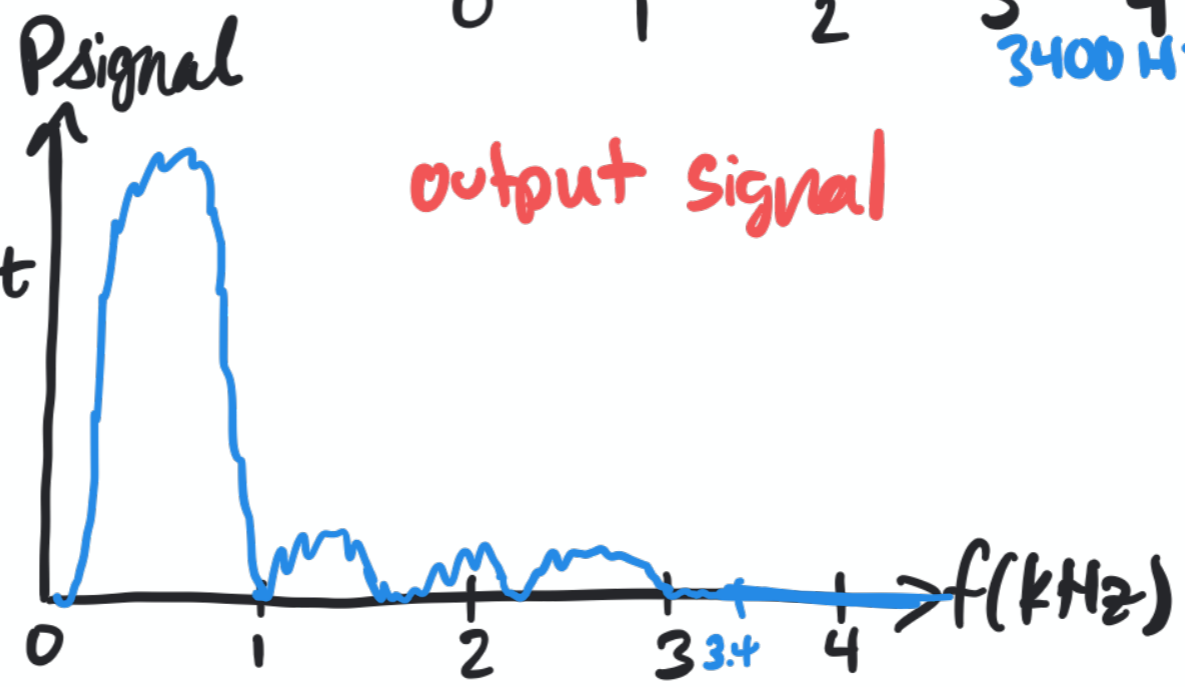
Example: human voice range $\sim 300\text{Hz} - 3400\text{Hz}$ (for simplicity say $0\text{Hz} - 3400\text{Hz}$)



Output = $H \cdot \text{input}$



$V_{out}(f) = H(f) \cdot V_{in}(f)$

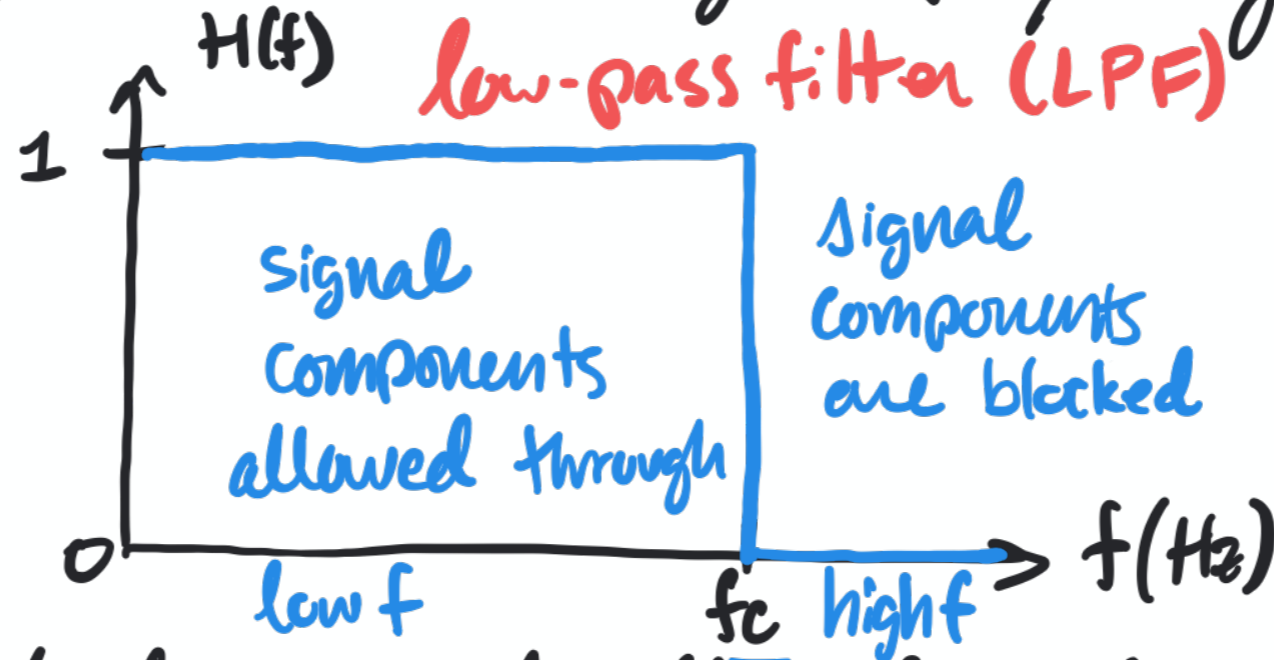


- This is an example of a low-pass filter. A low-pass filter allows signal components below a cutoff frequency to pass through, but blocks higher frequency components

4

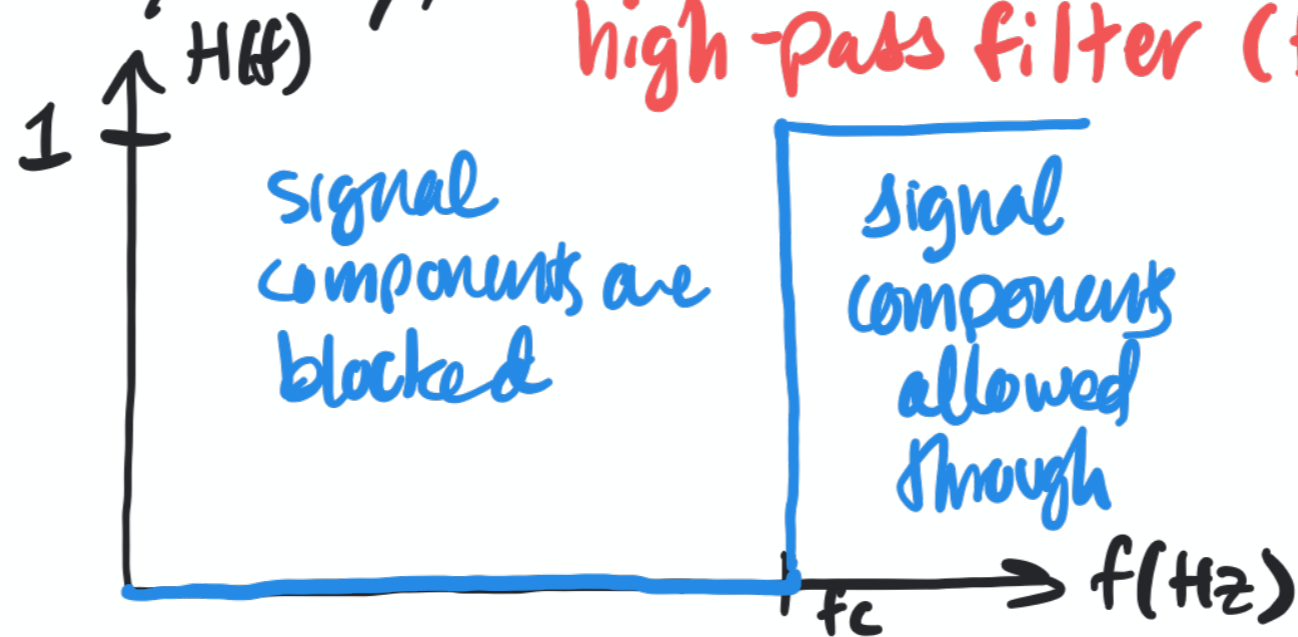
f_c or $\omega_c = 2\pi f_c$

1st order filter

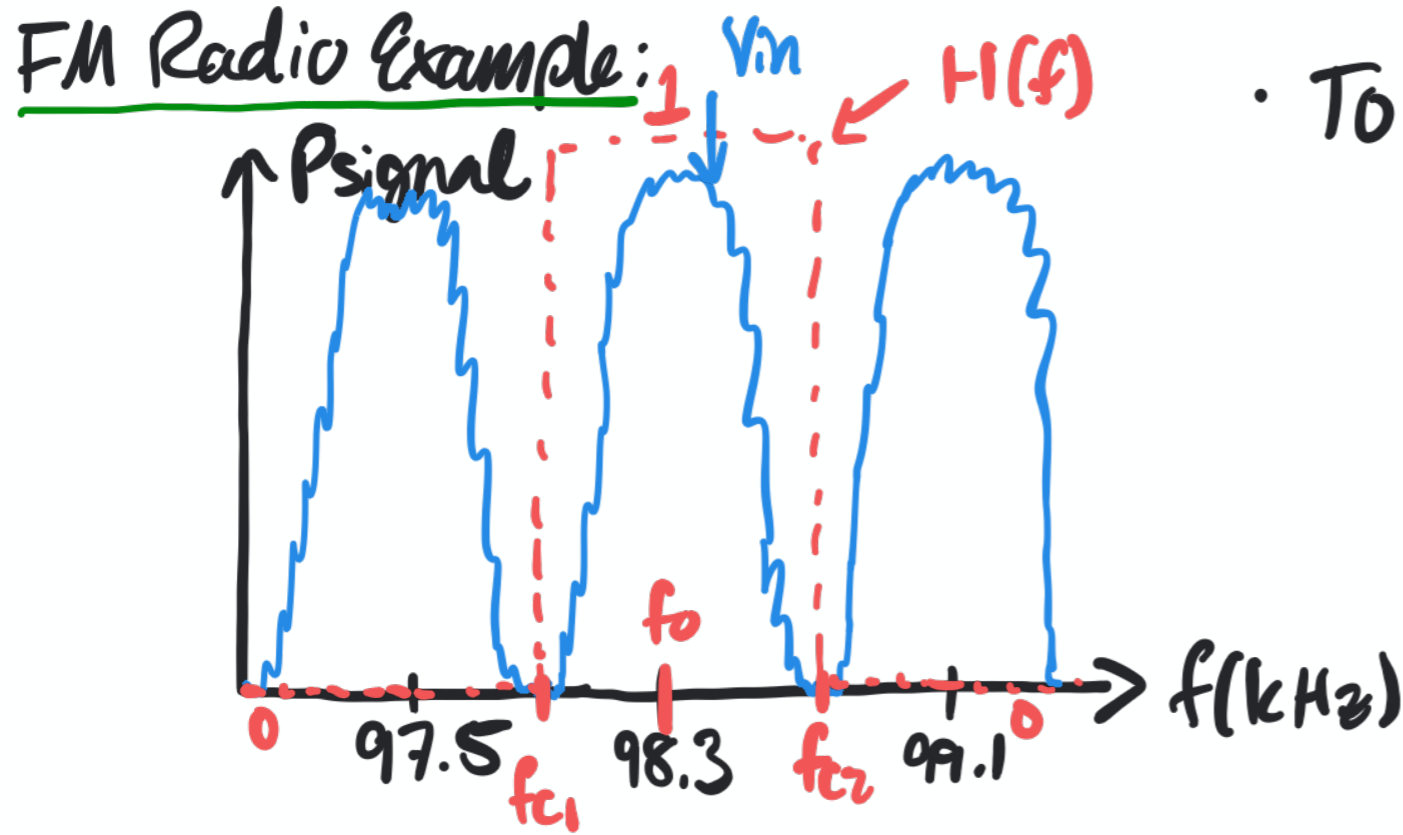


- If instead we had wanted all information at frequencies above a cutoff frequency, we would use a high-pass filter.

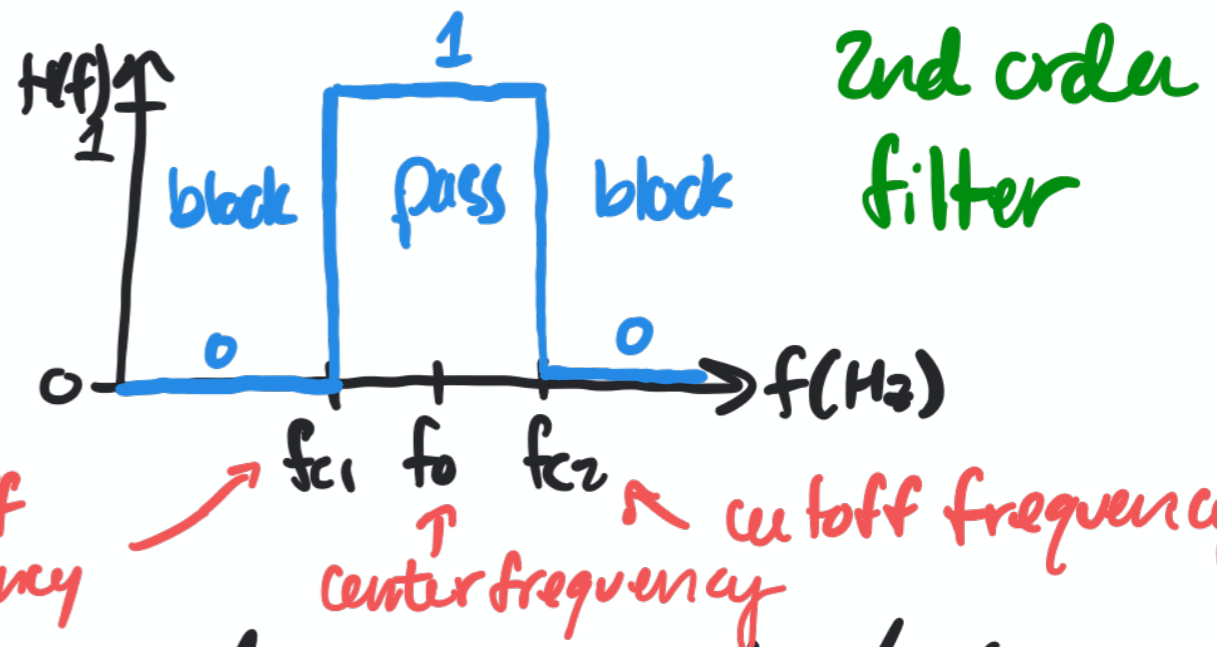
1st order filter



- What about isolating the components of a signal between two frequencies? 5

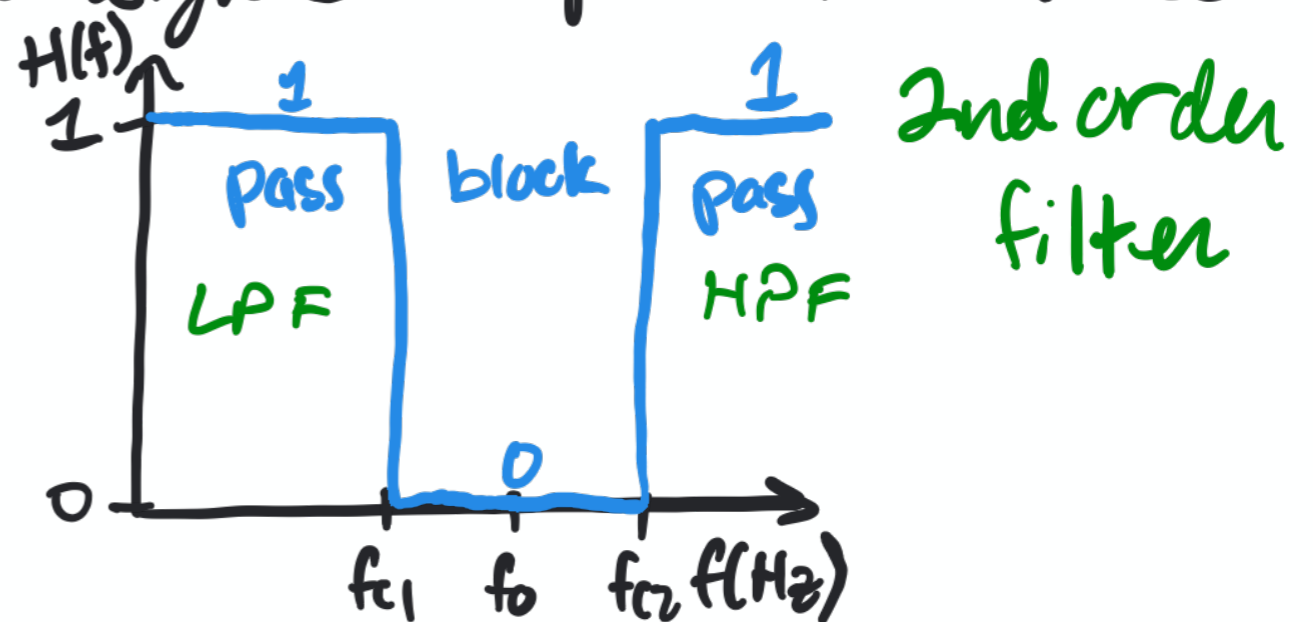


- To tune in to 98.3 kHz, we need a **bandpass filter (BPF)**.

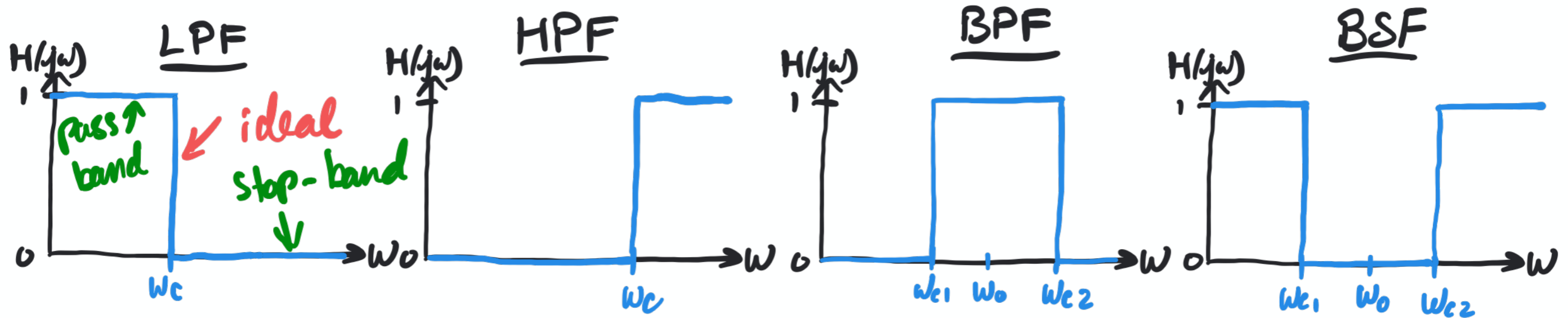


- What if we wanted to block all signal components between two frequencies?

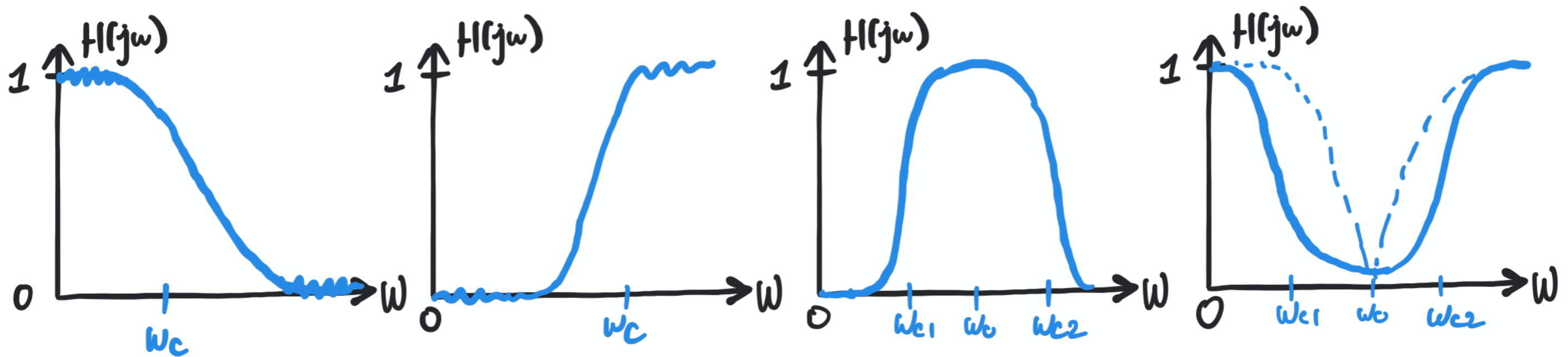
Band-stop filter *
 Band-reject filter *
 Notch filter



So far we have been considering only ideal filters 6



However, real filters do not have perfectly vertical transitions and do not have perfectly flat pass- and stop-bands.



Filters can be made with: **capacitors, resistors and inductors**