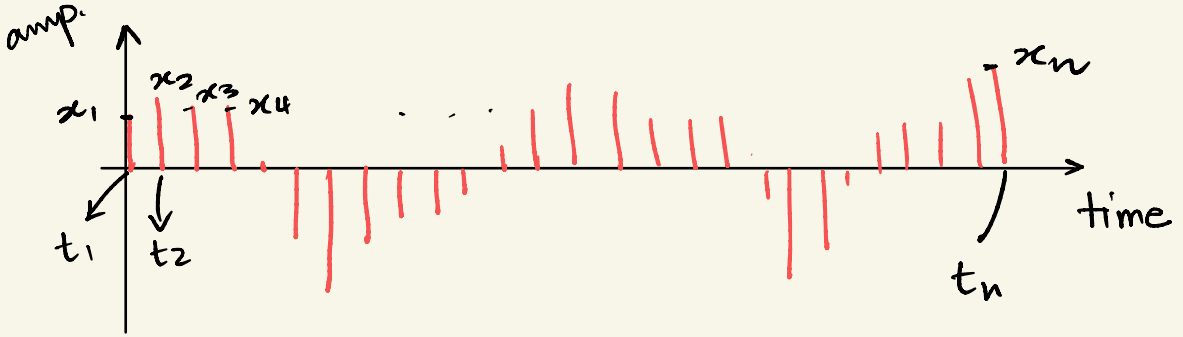
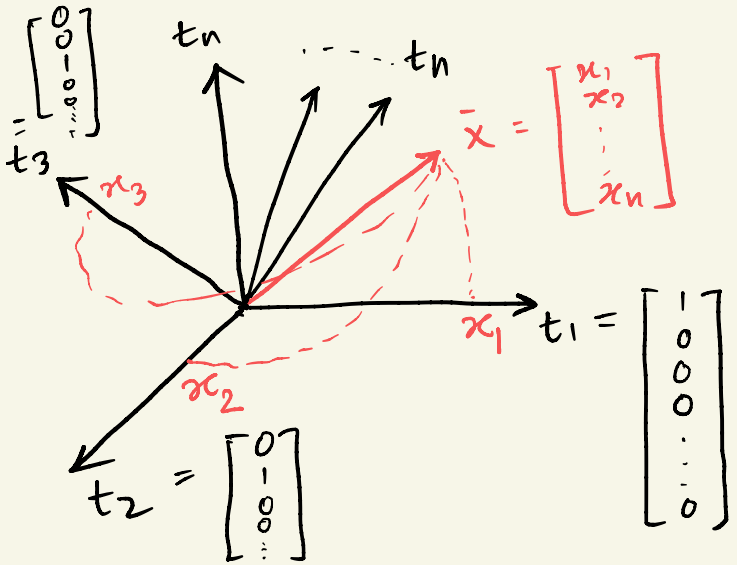
Internet

concepts, foundations

- [ ] FFT → Bandwidth → Spectrum
- [ ] Spectrum sharing → Carrier freq. → Modulation
  - amp.
  - freq.
- [ ] Baseband
- [ ] Bit rate → BER
  - noise
  - interference
  - Received power
  - → SINR
- [ ] Shannon Capacity
- [ ] PER → Throughput → Goodput
- [ ] Inter packet time Vs. throughput
- [ ] End to end latency → Processing + Q + T.T + P.D

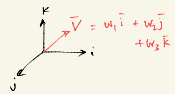


$$\bar{x} = [x_1 \quad x_2 \quad \cdots \quad x_n]^T = \boxed{x_1 | x_2 | x_3 | \cdots | x_n}$$



$$\bar{x} = \begin{bmatrix} x_1 \\ x_2 \\ \vdots \\ x_n \end{bmatrix} = \begin{bmatrix} | \\ t_1 \\ | \end{bmatrix} x_1 + \begin{bmatrix} | \\ t_2 \\ | \end{bmatrix} x_2 \cdots \begin{bmatrix} | \\ t_n \\ | \end{bmatrix} x_n$$

$$\bar{x} = \begin{bmatrix} | & | & & | \\ t_1 & t_2 & \cdots & t_n \\ | & | & & | \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \\ \vdots \\ x_n \end{bmatrix}$$



$$\begin{bmatrix} x_1 \\ x_2 \\ \vdots \\ x_n \end{bmatrix} = \begin{bmatrix} 1 & 0 & 0 & \cdots & 0 \\ 0 & 1 & 0 & & 0 \\ 0 & 0 & 1 & & 0 \\ \vdots & \vdots & \vdots & & \vdots \\ & & & & 1 \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \\ x_3 \\ \vdots \\ x_n \end{bmatrix}$$

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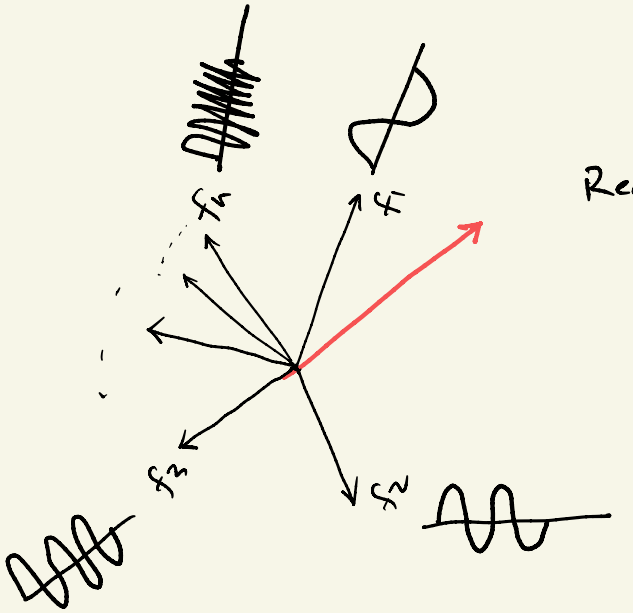
Time Domain Basis

Signal in time domain.



$$\text{Red vector} = \begin{bmatrix} \text{const} \\ 0 \\ 0 \\ 0 \\ \vdots \\ 0 \end{bmatrix}$$

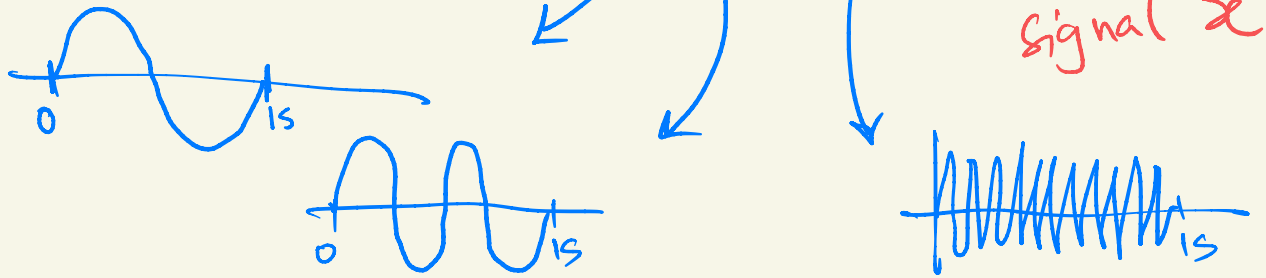
$$\begin{bmatrix} | & | & & | \\ t_1 & t_2 & \cdots & t_n \\ | & | & & | \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \\ \vdots \\ x_n \end{bmatrix} = \begin{bmatrix} | & | & & | \\ f_1 & f_2 & \cdots & f_n \\ | & | & & | \end{bmatrix} \begin{bmatrix} z_1 \\ z_2 \\ \vdots \\ z_n \end{bmatrix}$$

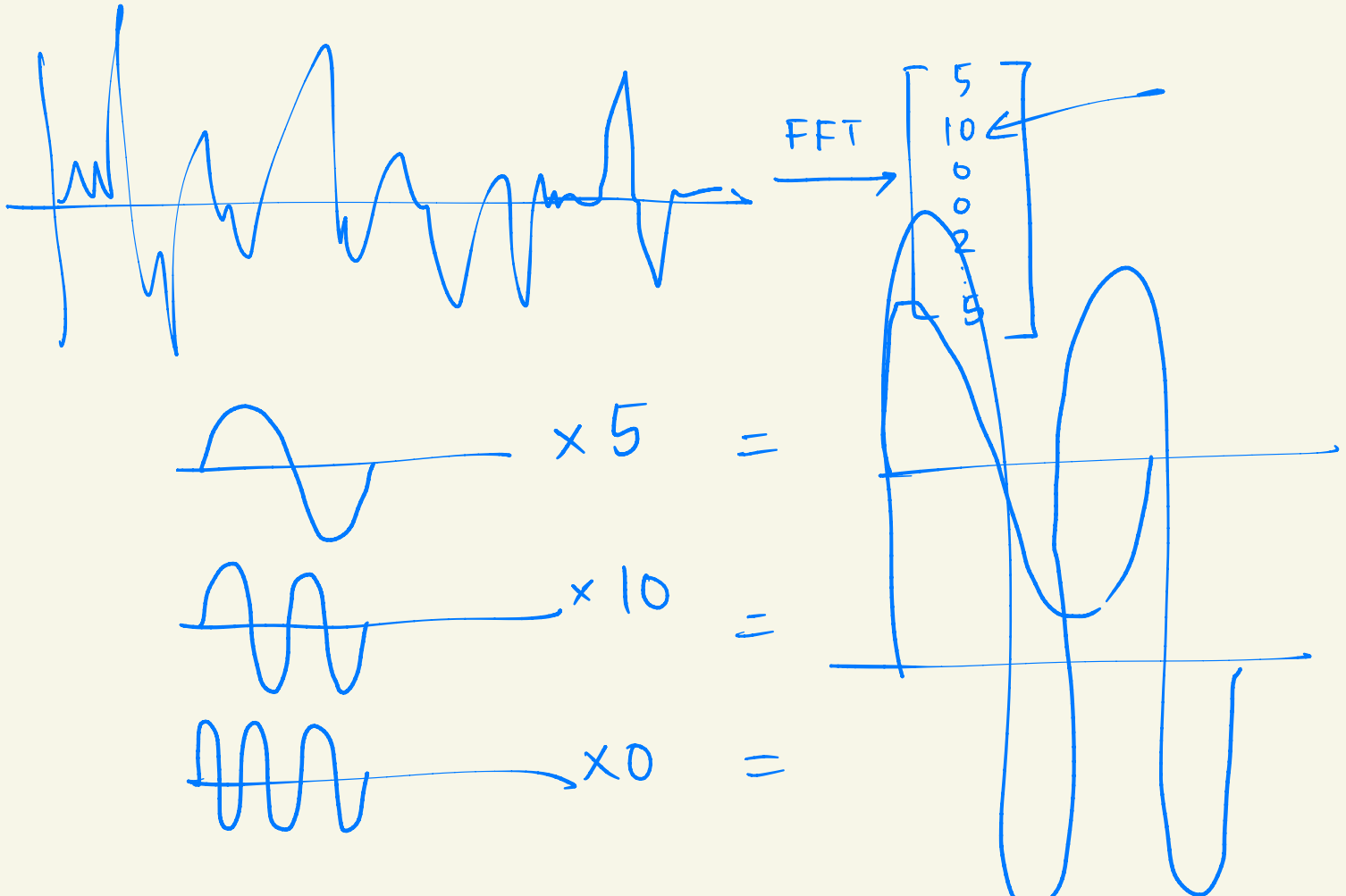
Time Domain Basis

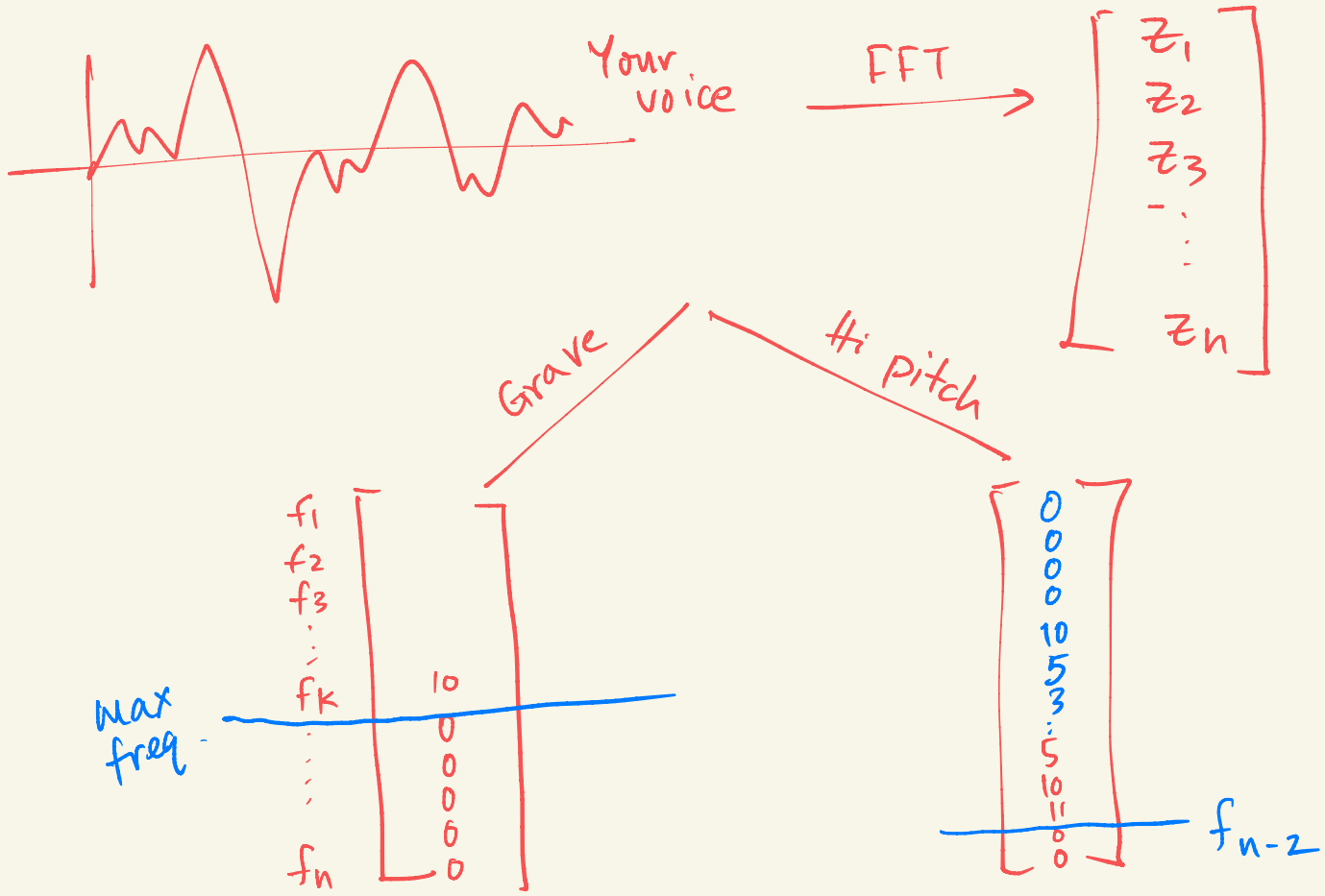
Signal in time domain

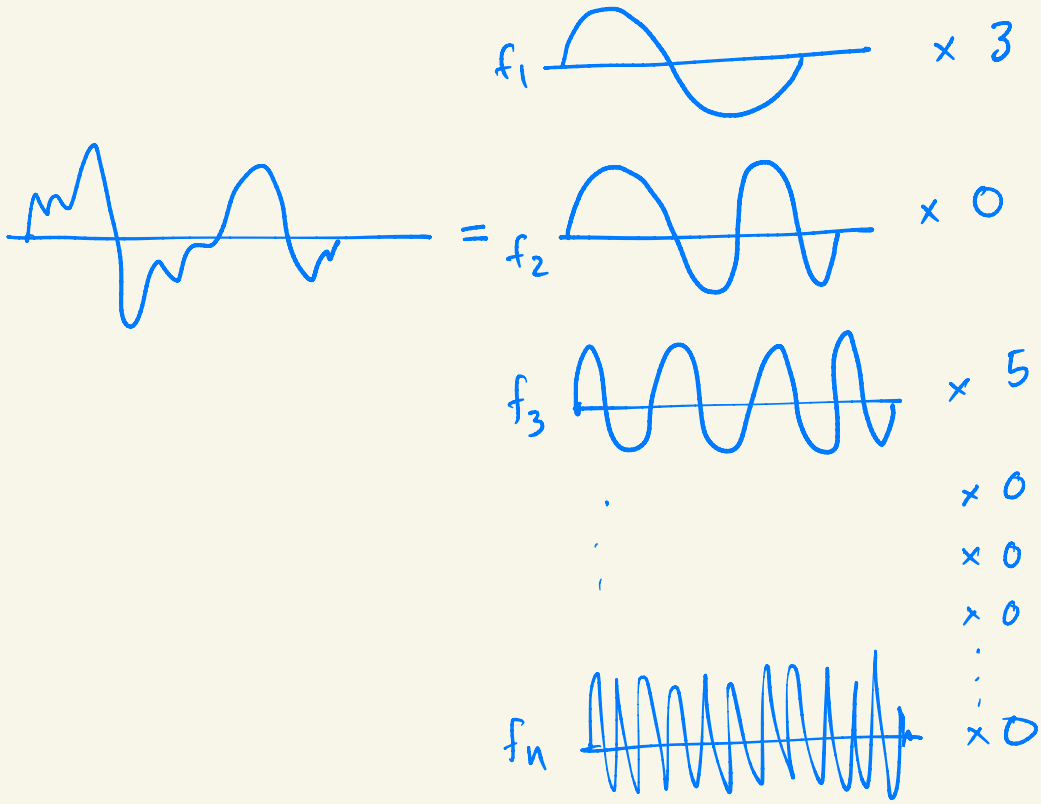
Fourier Basis

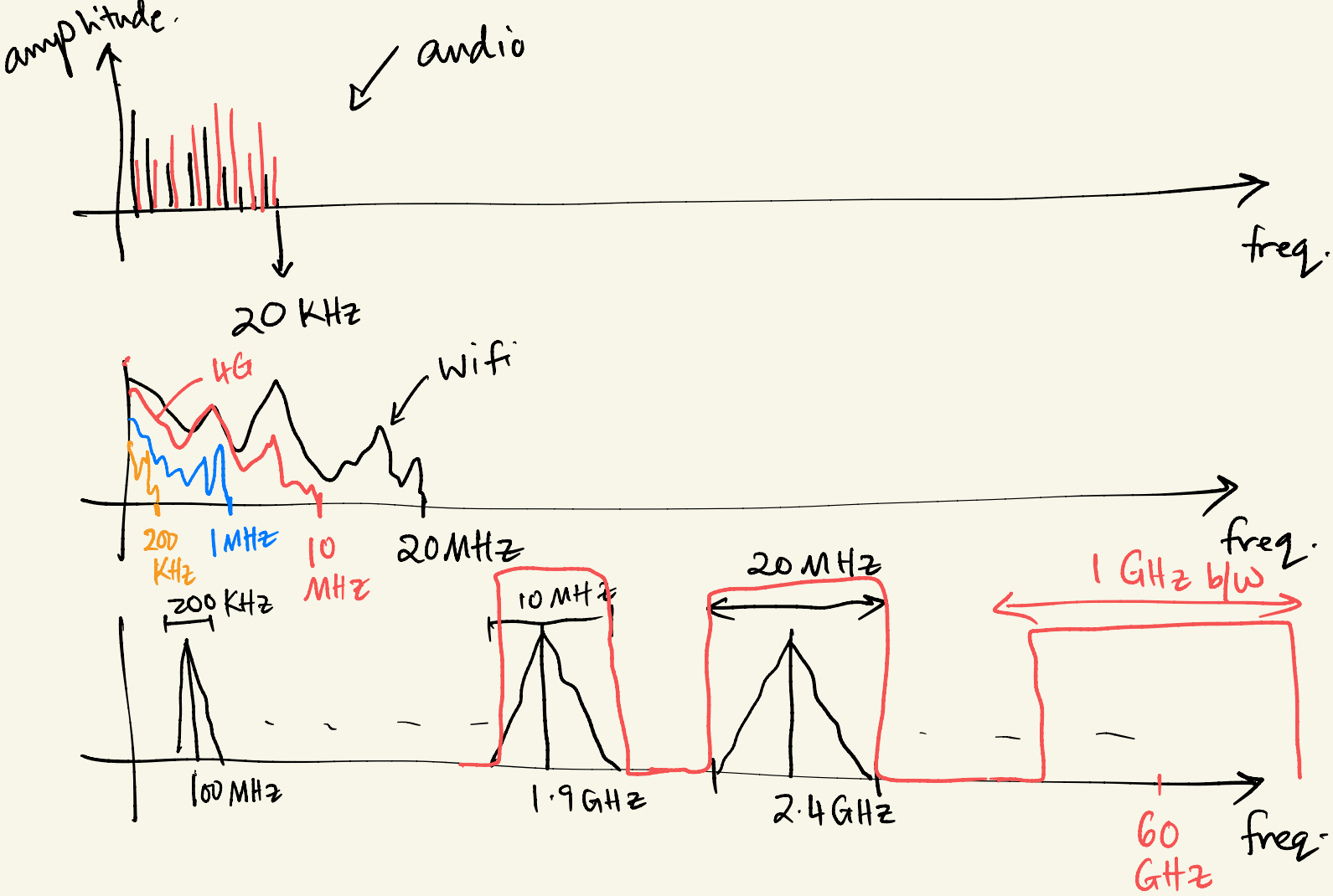
Fourier transform of the signal x.

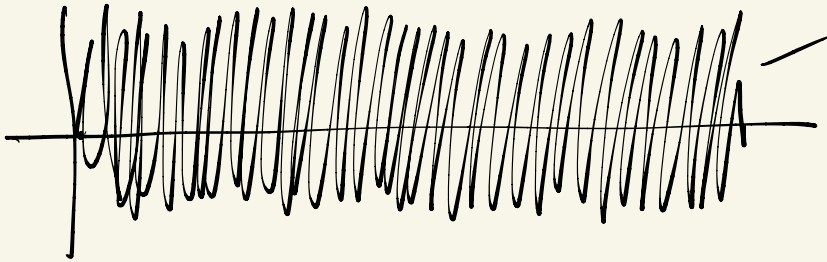



FFT
5
10
0
0
2
5
× 5
=
× 10
=
× 0
=


Your voice
FFT
z_1
z_2
z_3
z_n
Grave
Hi pitch
f_1
f_2
f_3
f_k
f_n
max freq
10
0
0
0
0
0
0
0
10
5
3
5
10
11
0
0
f_{n-2}


f_1
× 3
=
f_2
× 0
f_3
× 5
× 0
× 0
× 0
f_n
× 0


amplitude
audio
freq
20 KHz
4G
wifi
200 KHz
1 MHz
10 MHz
20 MHz
freq
200 KHz
100 MHz
10 MHz
1.9 GHz
20 MHz
2.4 GHz
1 GHz b/w
60 GHz
freq

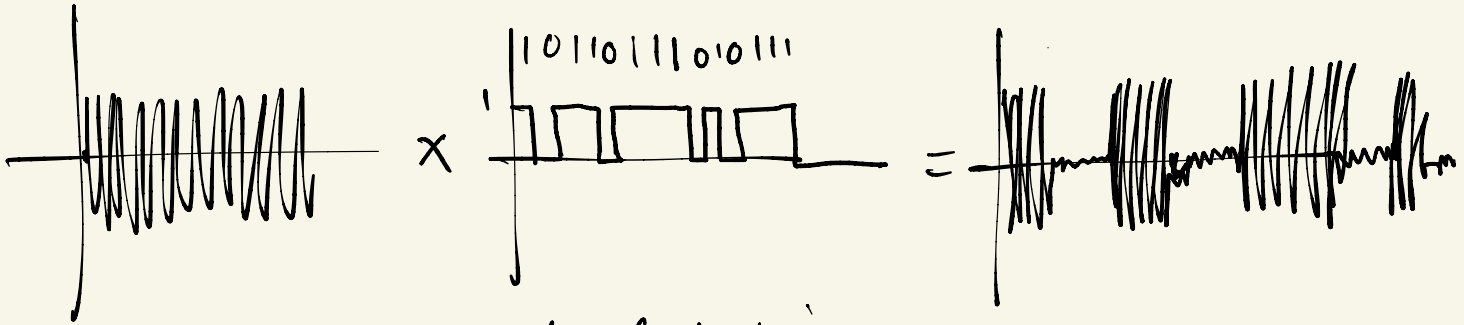


× Wifi's 20 MHz signal

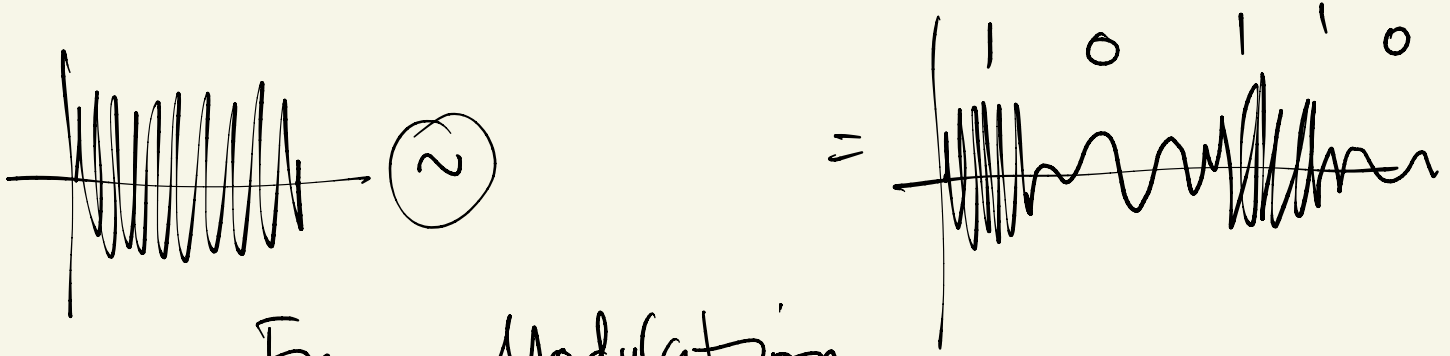
$$\cos(f_1) \times \cos(f_2) = \cos(f_1+f_2) \quad \cos(f_1-f_2)$$

$$\cos(2.4002\ \text{GHz}) \times \cos(2.4\ \text{GHz})$$

$$f_1 - f_2 = \underbrace{0.002\ \text{GHz}}_{\text{Baseband.}} = 20\ \text{MHz}$$



Amplitude Modulation



Freq. Modulation