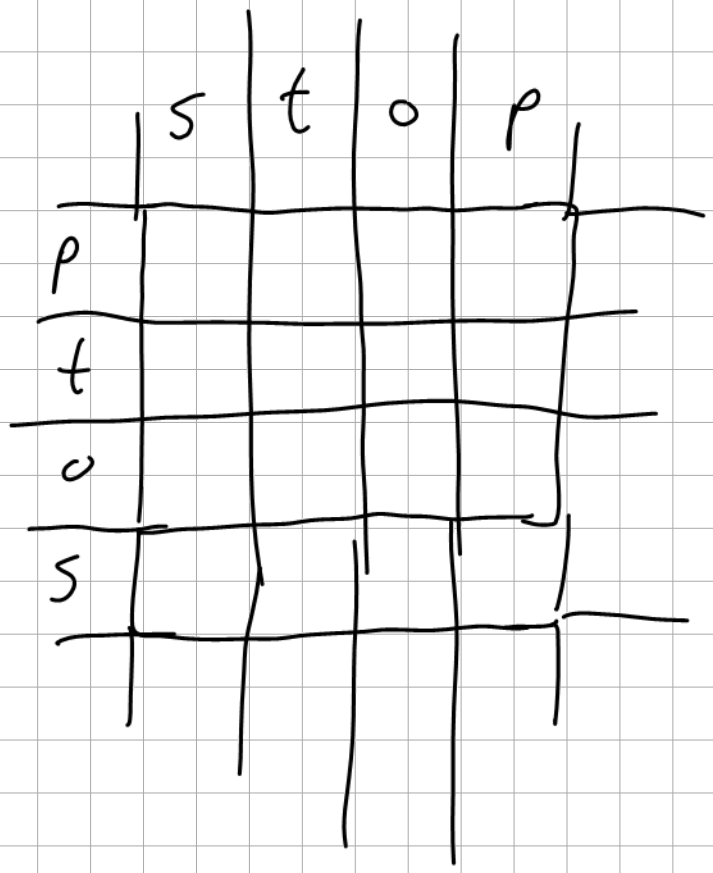
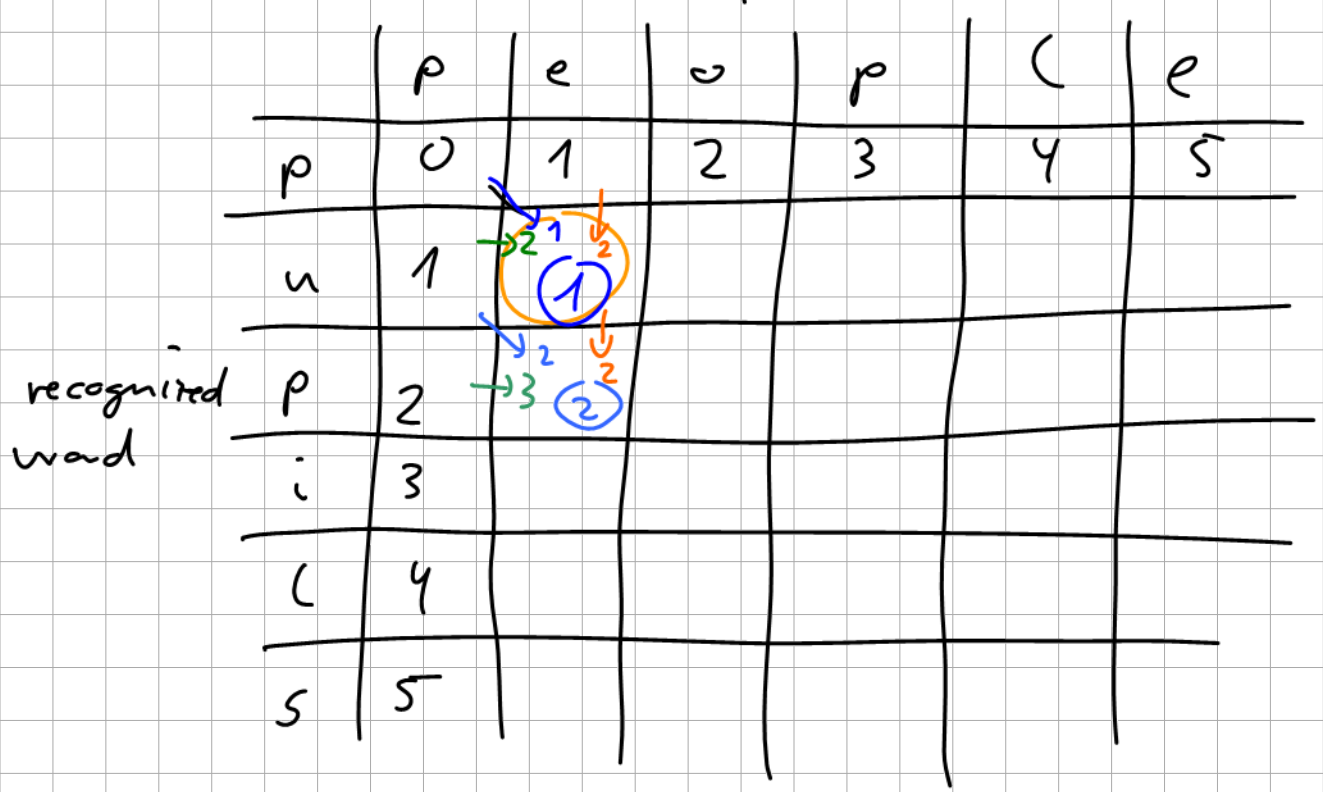


2 Replacements

Additional blanks will be interpreted as Insertions in the case of Levenshtein distance for letters

But for Levenshtein distance for words additional blanks will be ignored.



↘ if $c_1 == c_2$: +0

else : +1 replacement

→ +1 deletion

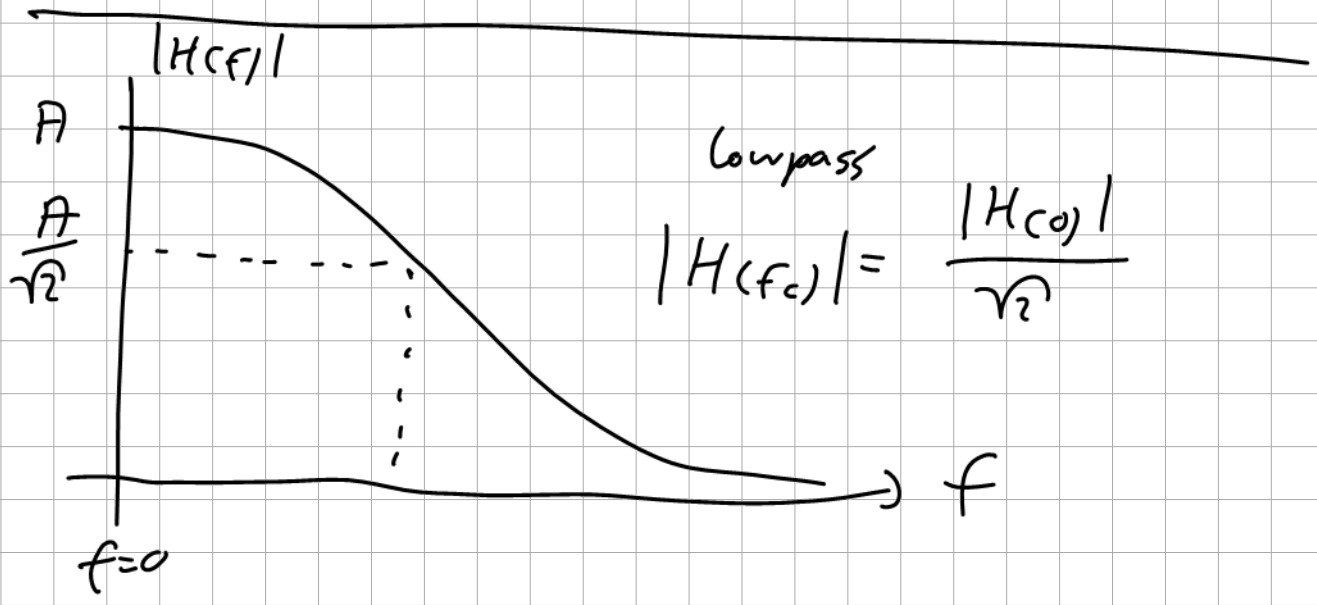
↓ +1 insertion

same implementation as Viterbi algorithm.

$$\mathrm{sinc}(x) = \frac{\sin(\pi x)}{\pi x}$$

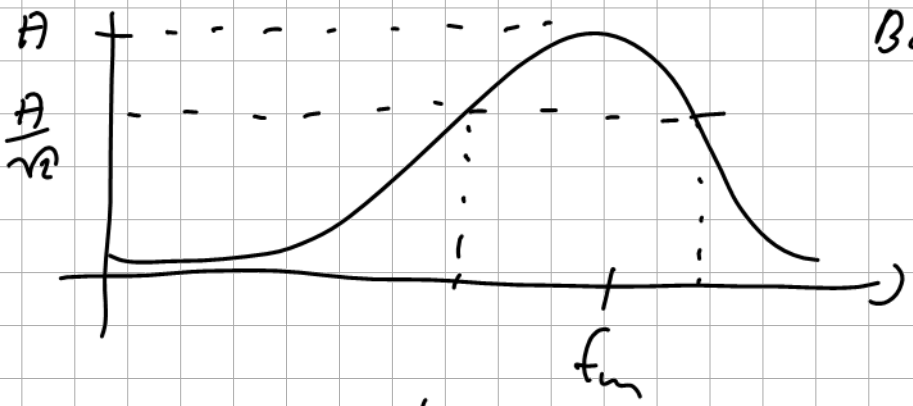
$$\lim_{x \to 0} \mathrm{sinc}(x) = 1$$

$$\mathrm{sinc}(x) = \begin{cases} 1 & \text{for } x = 0 \\ \frac{\sin(\pi x)}{\pi x} & \text{else} \end{cases}$$



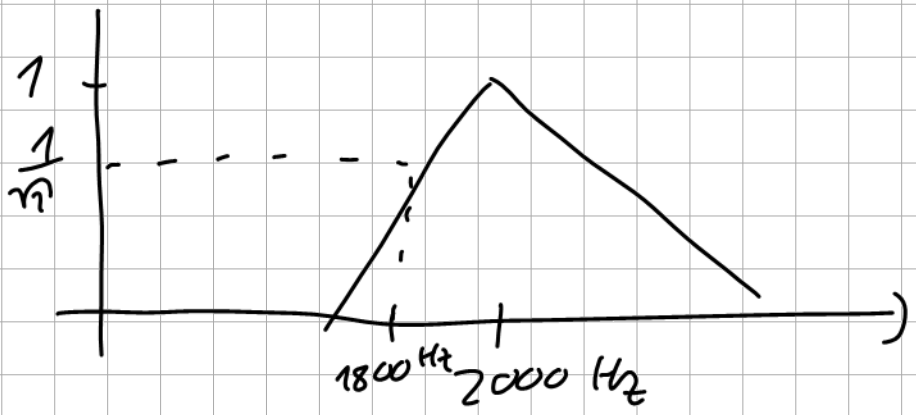
lowpass

$$|H(f_c)| = \frac{|H(0)|}{\sqrt{2}}$$

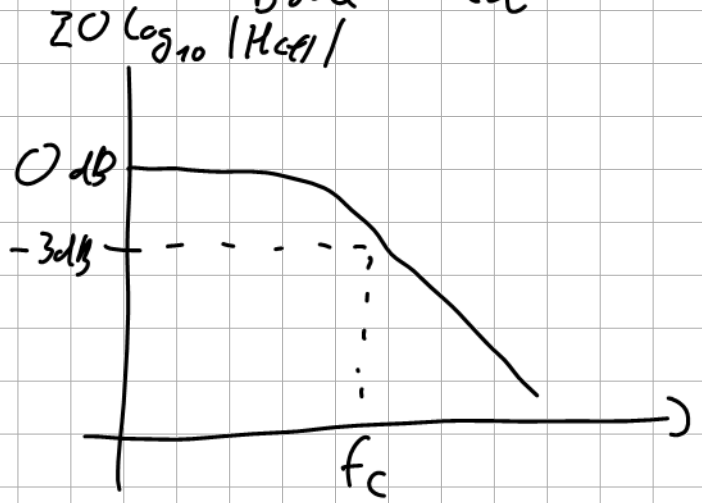


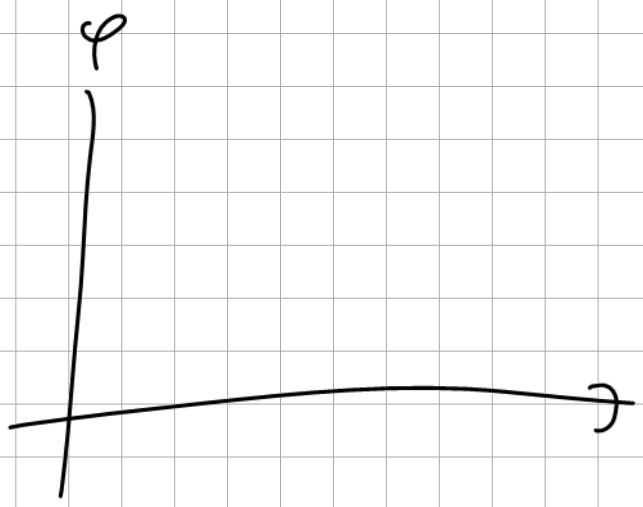
Bandpass

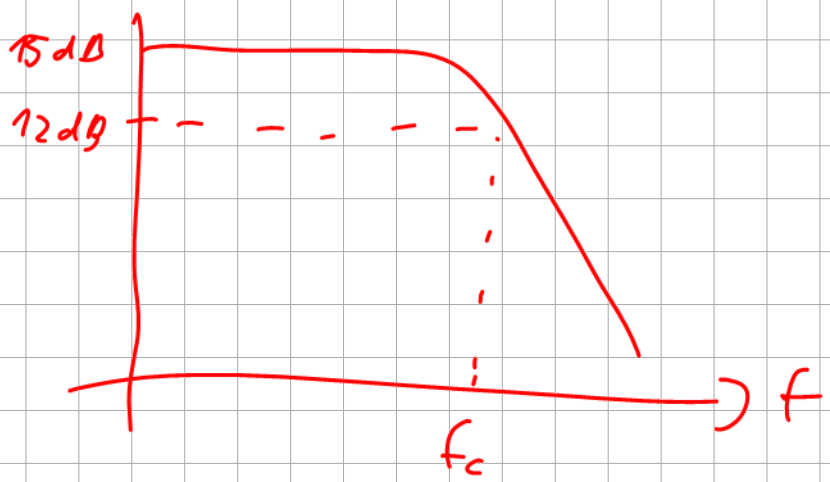
$$|H(f_c)| = \frac{|H_{max}|}{\sqrt{2}}$$



Bode Plot







$$20 \log_{10} \frac{1}{\sqrt{2}} \approx -3.01 \text{ dB}$$

C2]6 T3

$$\varphi(x,y) = \frac{\sum (x - m_x) \cdot (y - m_y)}{\sqrt{\sum_n (x - m_x)^2 \sum_n (y - m_y)^2}}$$

$$\varphi(x, a \cdot y) = \frac{\sum (x - m_x) \cdot (ay - a m_y)}{\sqrt{\sum_n (x - m_x)^2 \sum_n (ay - a m_y)^2}}$$

$$= \frac{\sum (x - m_x) \cdot a (y - m_y)}{\sqrt{\sum_n (x - m_x)^2 \sum_n a^2 (y - m_y)^2}}$$

$$= \frac{a \cdot \sum (x - m_x)(y - m_y)}{\sqrt{a^2} \cdot \sqrt{\sum_n (x - m_x)^2 \cdot \sum_n (y - m_y)^2}}$$

$$= \frac{a}{|a|} \cdot \varphi(x,y)$$

$$= \text{sign}(a) \cdot \varphi(x,y)$$

$$\left(\frac{a}{\sqrt{a^2}} \right)$$

$a = 3: \quad \frac{3}{\sqrt{9}} = 1$

$a = -3: \quad \frac{-3}{3} = -1$

C2 J7 T1

$$X(k) = X^*(K-k)$$

$$X(k) = \sum_{n=0}^{K-1} x(n) \cdot e^{-j2\pi \frac{n \cdot k}{K}}$$

$$X(K-k) = \sum_{n=0}^{K-1} x(n) \cdot e^{-j2\pi \frac{n \cdot (K-k)}{K}}$$

$$= \sum_{n=0}^{K-1} x(n) \cdot \underbrace{e^{-j2\pi \frac{nK}{K}}}_{e^{-j2\pi n} = 1} \cdot e^{+j2\pi \frac{nk}{K}}$$

$$1 \cdot e^{j2\pi \frac{nk}{K}}$$

$$= \sum_{n=0}^{K-1} x(n) \; e^{j2\pi \frac{nk}{K}}$$

$$X^*(K-k) = \left(\sum_{n=0}^{K-1} x(n) \; e^{j2\pi \frac{nk}{K}} \right)^*$$

$$= \sum_{n=0}^{K-1} \left(x(n) \; e^{j2\pi \frac{nk}{K}} \right)^*$$

↑ real valued

$$= \sum_{n=0}^{K-1} x(n) \; e^{-j2\pi \frac{nk}{K}}$$

q. e. d.

C2 J7 T2

$x(n) = \hat{x} \sin(2\pi f \cdot t)$ $\quad t = n \cdot T$

$= \frac{n}{r}$ ← sampling rate

$x(n) = 1 \cdot \sin(2\pi\ 440\,Hz \cdot \frac{n}{1000\,Hz})$

$x(0) = \sin(2\pi \cdot 0) = 0$

$x(1) = \sin(2\pi \frac{440}{1000}) = 0.368$

$x(2) = \sin(2\pi \frac{440}{1000} \cdot 2) = -0.685$

$$X(k) = \sum_{n=0}^{2} x(n) \cdot e^{-j2\pi \frac{n \cdot k}{3}}$$

$$X(0) = 0 \cdot \underbrace{e^{-j \cdot 0}}_{=1} + 0.368 \cdot \underbrace{e^{-j0}}_{=1} - 0.685 \underbrace{e^{-j0}}_{=1}$$

$= -0.317$

$$X(1) = \underbrace{0 \cdot e^{-j2\pi \frac{0 \cdot 1}{3}}}_{=0} + 0.368 \cdot e^{-j2\pi \frac{1 \cdot 1}{3}} - 0.685 \cdot e^{-j2\pi \frac{2 \cdot 1}{3}}$$

$= 0.368 \cdot (\cos(2\pi \frac{1}{3}) - j \sin(2\pi \frac{1}{3}))$

$- 0.685 \left(\cos(2\pi \frac{2}{3}) - j \sin(2\pi \frac{2}{3})\right)$

$= 0.159 \not{+ j \cdot 0.275} - j\,0.912$

$X(2) = X^*(1) = 0.159 \not{- j \cdot 0.275} + j\,0.912$

C2 J7 T3

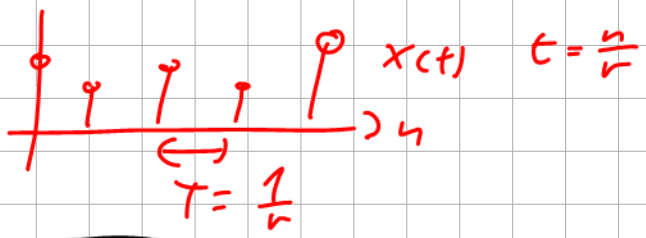
$r = 48\ kHz \qquad N = 1000 \qquad K = 1024$

$$\Delta f = \frac{1}{T \cdot K} = \frac{r}{K} = \frac{48000\ Hz}{1024} = 46.9\ Hz$$

K: $x(n)$

sampling

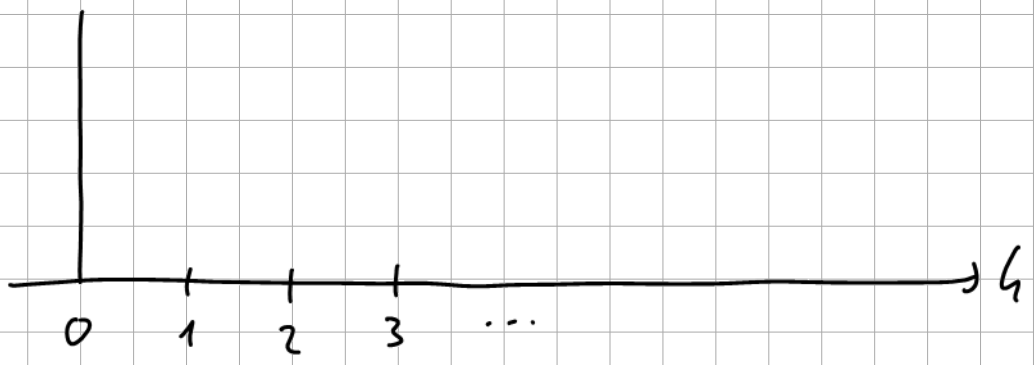
time domain



frequency domain

zero padding?

if $K > N$ → zero padding is used.



0 Δf 2Δf 3Δf ... f

$f = 50\ Hz$?

$k = 0 \mathrel{\hat{=}} k \cdot \Delta f = 0\ Hz$

$k = 1 \mathrel{\hat{=}} 1 \cdot \Delta f = 46.9\ Hz$

$$k = \frac{f}{\Delta f} = \frac{50\ Hz}{46.9\ Hz} = 1.07 \Rightarrow k = 1$$

$f = 75\ Hz$ $N = 1000$ $r = 48\ kHz$

$\Delta f = \frac{r}{K}$ ← reduce Δf by increasing K

$K = 10000 \Rightarrow \Delta f = \frac{48000\ Hz}{10000} = 4.8\ Hz$

$h = \frac{75\ Hz}{4.8\ Hz} = 15.6$ bad choice

$\Delta f = 7.5\ Hz \Rightarrow h = 10$

$K = \frac{48000\ Hz}{7.5\ Hz} = 6400$

$k = 8$

skip $\frac{K}{2} - 1$

$K = 1024 \Rightarrow$ how many skipped: 511

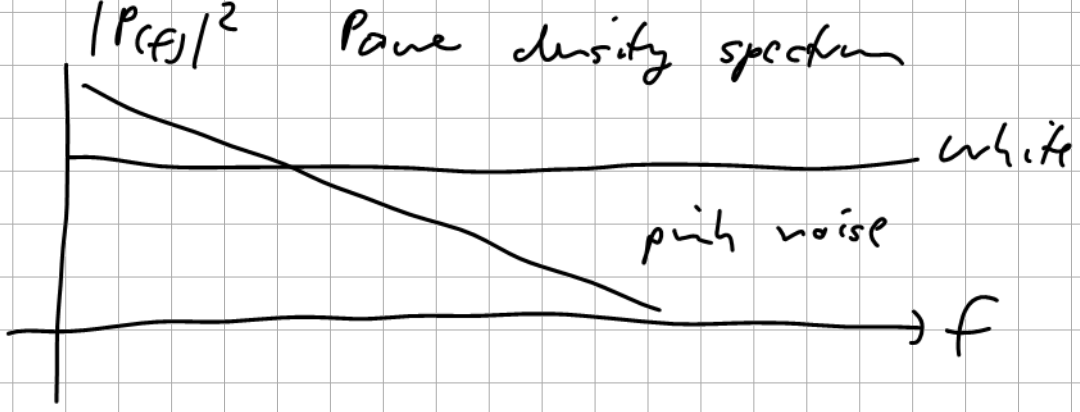
how many remains: 513

SNR Signal to noise ratio

„the higher the better"

60 dB SNR $\hat{=}$ no noise detectable

0 dB SNR $\hat{=}$ Noise and signal have same energy.



$$L = 20 \log_{10} a$$

$$a = 10^{\frac{L}{20}}$$

a = 10 **(L/20)

= np.pow(10 , L/20)

$y_{out} = a \cdot x_{in}$

a = 15

$L = 20 \log_{10} 15$ =23 dB