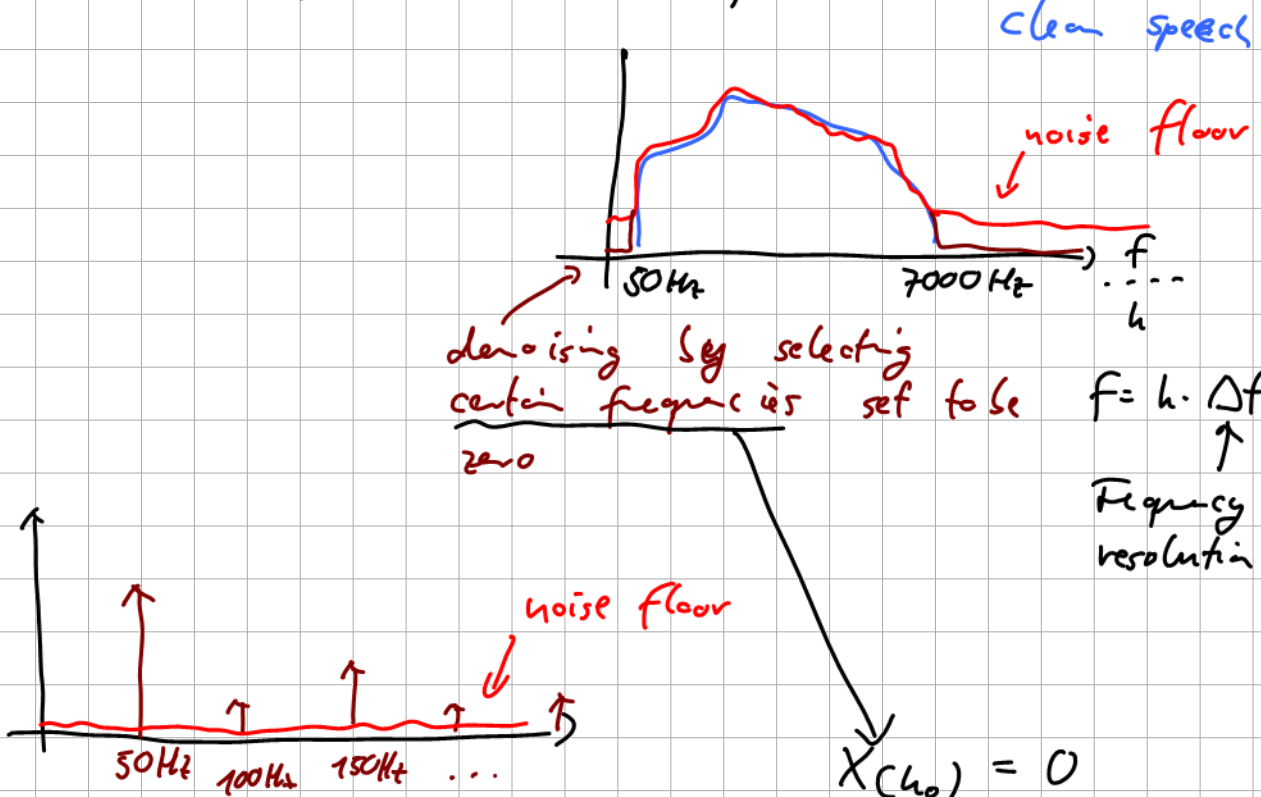
# Removing noise by transforms?

time domain signal ⟷ frequency domain

$x(n)$ ⟷ $X(k)$




$$X(k) = \sum_{n=0}^{N-1} x(n) \cdot e^{-j 2\pi \frac{nk}{K}}$$

zero padding is used if $K > N$

Block length

$N = 1000$ ⇒ $K = 1024 = 2^{10}$ ⇒ which results in faster evaluation (especially for small devices)

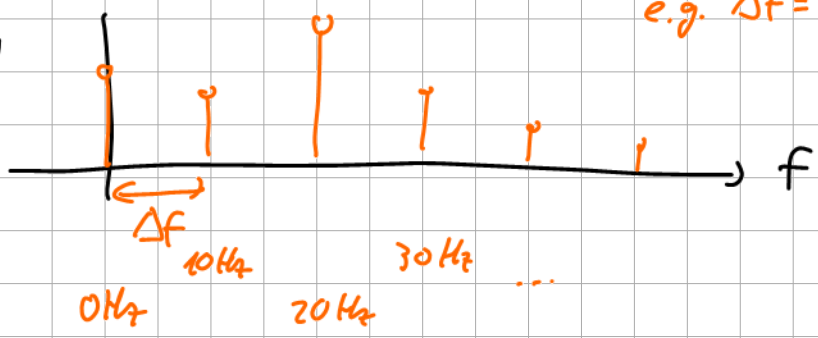
length of $x(n)$ — length of $X(k)$


zeros are padded concatenated

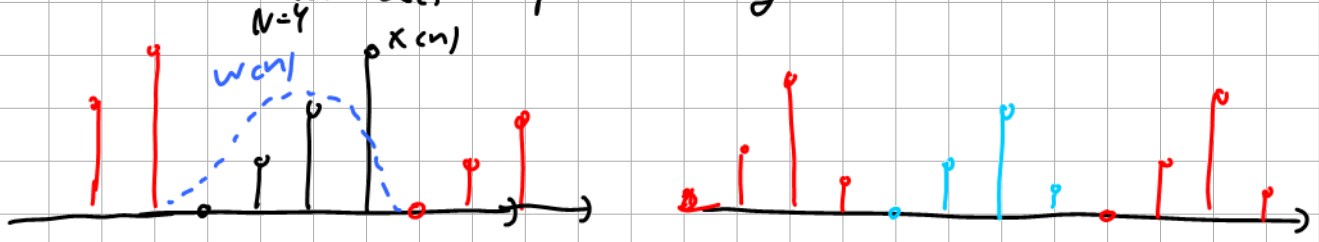
$$\Delta f = \frac{1}{K \cdot T} = \frac{F}{K}$$

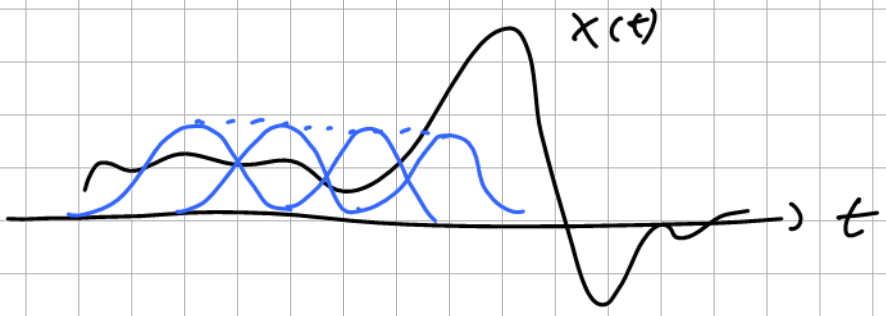
the greater $K$, the finer the frequency resolution

$x(n) \circ\!\!-\!\!\bullet\; X(k)$



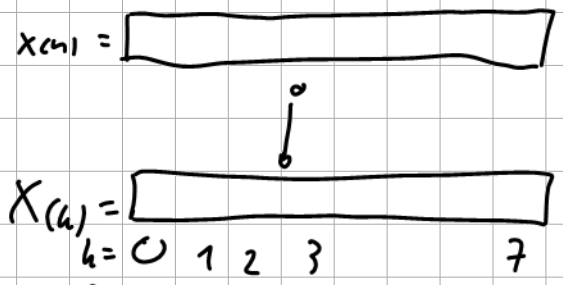

DFT assumes periodicity in the domain



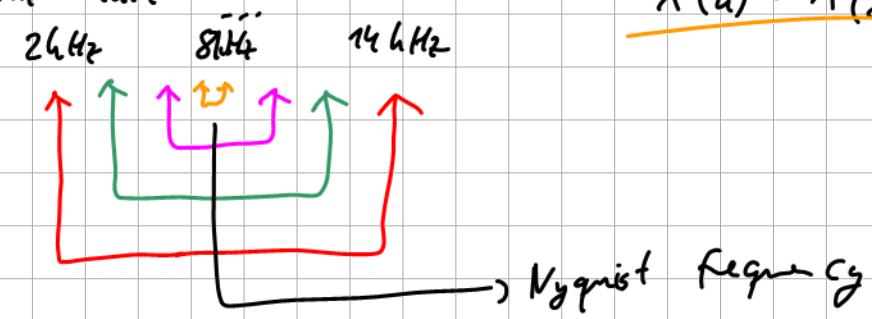




Symmetry $X(k) = X^*(K-k)$

$r = 16\,kHz$
$N = K = 8$
$\Delta f = \frac{r}{K} = 2\,kHz$




$X(k) = X^*(8-k)$

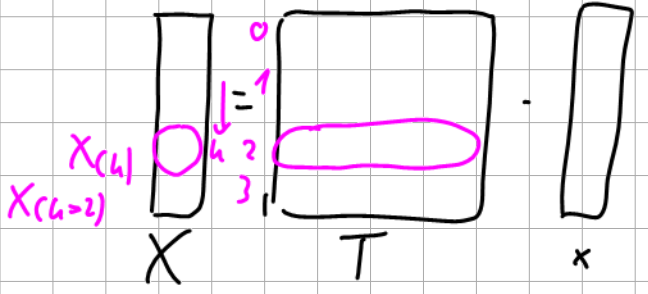



$X(1) = X^*(7)$
$X(2) = X^*(6)$
$X(3) = X^*(5)$
$X(4) = X^*(4)$ ⇒ real valued

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

$T(k,n)$

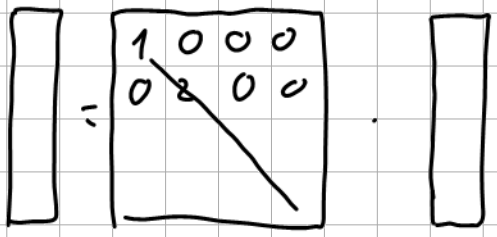
summation: full matrix

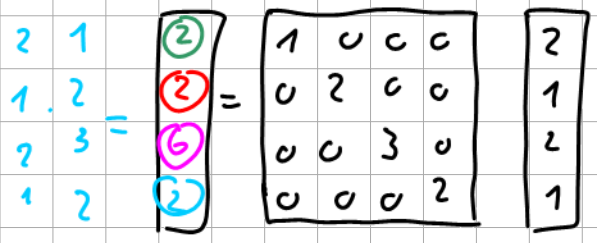



$x(n) = 2\ 1\ 2\ 1$

$w(n) = 1\ 2\ 3\ 2$

$x_w(n) = w(n) \cdot x(n)$




$1 \cdot 2 + 0 \cdot 1 + 0 \cdot 2 + 0 \cdot 1 = 2$

$0 \cdot 2 + 2 \cdot 1 + 0\,2 + 0 \cdot 1 = 2$

$0 \cdot 2 + 0 \cdot 1 + 3 \cdot 2 + 0 \cdot 1 = 6$

$0 \cdot 2 + 0 \cdot 1 + 0 \cdot 2 + 2 \cdot 1 = 2$

$$x_w = T_w \cdot x$$

$$X = T_{DFT} \cdot x_w$$

$$= T_{DFT} \cdot T_w \cdot x$$

$$= T \cdot x$$

$$\downarrow$$

$$T_{DFT} \cdot T_w \quad \hat{=} \quad \text{np.matmul}(T_{DFT}, T_w)$$