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Significance of the Nyquist frequency:

Say we have ~~no~~ "voc voice noise", whose energy content, or bandwidth is 1.5 kHz → 5 kHz.

Say we sample this acoustic signal at 2000 Hz

$f_s = 2000\ Hz \Rightarrow f_{N/2} = \text{Nyquist freq} = 1000\ Hz.$

⇒ Our frequency decomposition does not contain frequencies high enough to represent the signal!!

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⇒ We choose the sampling frequency such that the Nyquist frequency exceeds the maximum anticipated frequency in the signal.

For our example, we would choose $f_s > 10$ kHz.

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We have x_n. We also have the frequency decomposition

$$\tilde{x}(t) = \frac{1}{N}|\hat{X}_0| + \sum_{k=1}^{\frac{N}{2}-1} \frac{2}{N}|\hat{X}_k| \cos(2\pi f_k t + \phi_k) + \frac{1}{N}|\hat{X}_{\frac{N}{2}}| \cos(2\pi f_{\frac{N}{2}} t + \phi_{N/2})$$

What we want is

$$X_{rms} = \sqrt{\frac{1}{T}\int_0^T x^2(t)\,dt} \approx \sqrt{\frac{1}{N}\sum_{n=0}^{N-1} x_n^2}$$

University of Idaho We can use Parseval's theorem to calculate X_{rms} given the FFT coefficients $\hat{X}_k$!!

$$\frac{1}{N}\sum_{n=0}^{N-1} x_n^2 = \left\{ \frac{1}{2}\sum_{k=1}^{\frac{N}{2}-1} \left| \frac{2}{N}\hat{X}_k \right|^2 \right\} + \frac{1}{2}\left| \frac{\sqrt{2}}{N}\hat{X}_{\frac{N}{2}} \right|^2$$