Lecture 6 - Digitized Speech

Exercise 1: Give some examples of legacy analog speech communications and very simple analog speech communication systems.

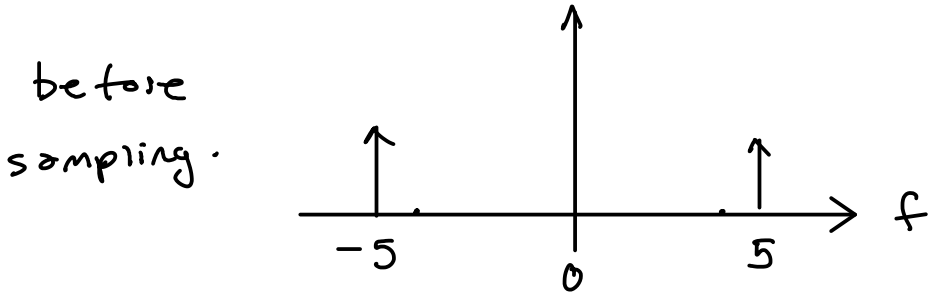
- AM & FM Broadcast
- aero & maritime mobile

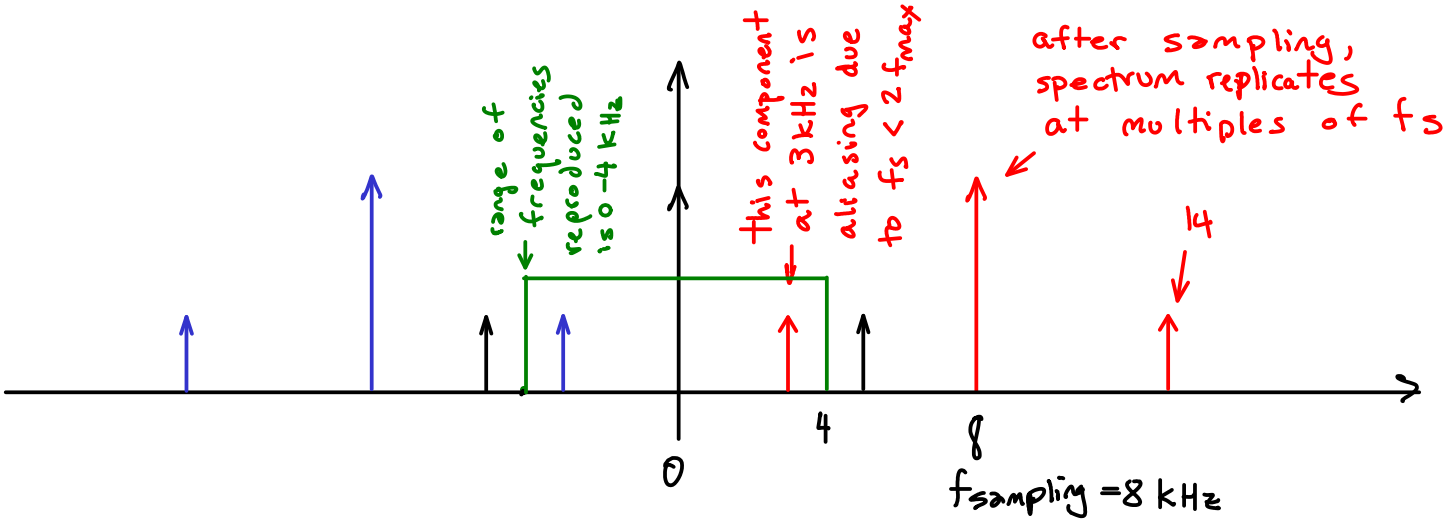
} legacy analog voice

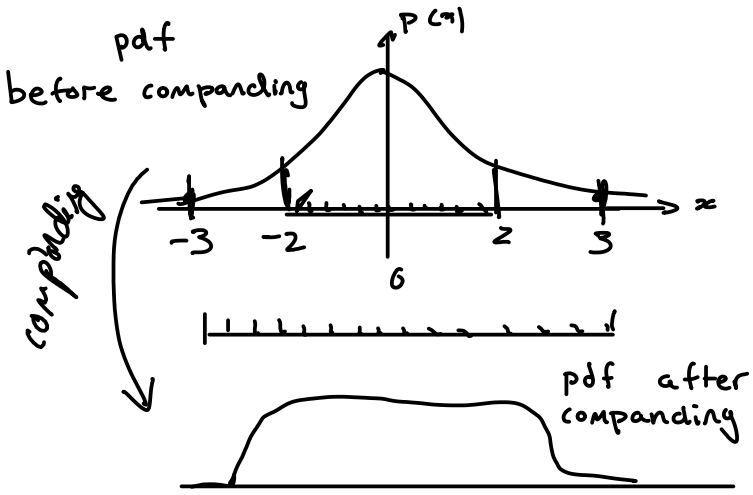
- intercoms
- baby monitor

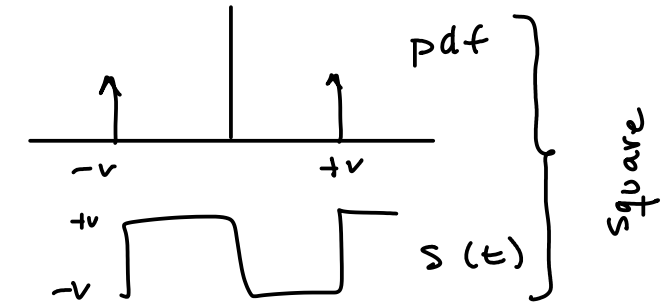
} very simple applications

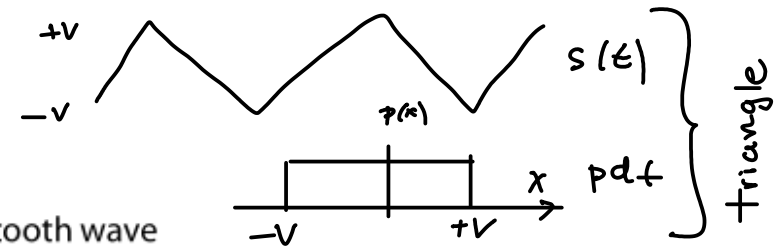
Exercise 2: A 5 kHz signal is sampled at 8 kHz. What are the positive and negative frequency components of the 5 kHz signal before sampling? What is the frequency of the aliased component falling into the 0-4 kHz range?







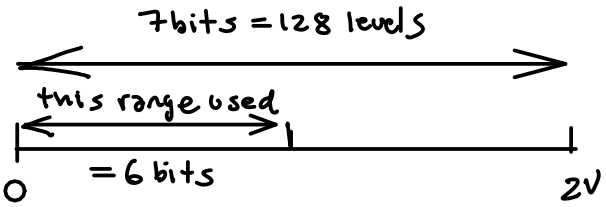


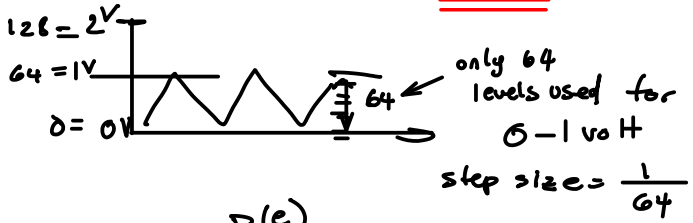


Exercise 3: What is the quantization SNR for a sawtooth wave varying from 0 to 1V if a 7 bit A/D converter is used with an input range of 0 to 2 V?

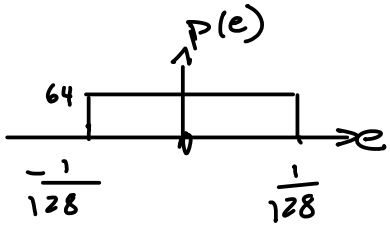
simple answer:

6b dB where b = 6 ∴ 6×6 = 36 dB





Longer answer: $\text{power} = \int_{-\infty}^{\infty} p(v) v^2 \, dv$ ← pdf of voltage v



for signal: $p(v) = \begin{cases} 1 & \text{for } 0<v<1 \\ 0 & \text{elsewhere} \end{cases}$

$$\text{power} = \frac{1}{1}\int_0^1 v^2 dv = \left[\frac{v^3}{3}\right]_0^1 = \frac{1}{3} \quad V^2$$

for noise: $p(v) = 64$ since area = 1

$$N = 64\int_{-\frac{1}{128}}^{\frac{1}{128}} v^2 dv = 64 \cdot \left[\frac{v^3}{3}\right]_{-\frac{1}{128}}^{\frac{1}{128}} = 64 \cdot \frac{1}{3}\left(\frac{1}{128}\right)^3 - \left(\frac{-1}{128}\right)^3 = \frac{2^6}{3} \cdot 2 \cdot \frac{1}{2^{7\cdot 3}} = \frac{1}{3} \cdot \frac{2^7}{2^{7\cdot 3}} = \frac{1}{3} \cdot \frac{1}{2^{7\cdot 2}}$$

if signal was distributed over ±½:

$$\text{power} = \frac{v^3}{3}\Big|_{-\frac{1}{2}}^{\frac{1}{2}} = \frac{1}{3} \cdot \frac{2}{8} = \frac{1}{3} \cdot \frac{1}{4}$$

and $\frac{S}{N} = \frac{2^{14}}{2^2} = 2^{12} = 36$ dB

$$\frac{S}{N} = 2^{14} = 42 \text{ dB}$$

NOTE: difference is due to including the DC power $(\frac{1}{2})^2$ in the signal power.

Exercise 4: If the sampling rate is 8 kHz and there are 8 bits per sample, that is the data rate in each direction? How many bytes per minute are transmitted for a two-way connection?

60 s · 2 dir · 8000 Bytes/s

= 1 M Byte/minute.