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Technische Universität Kaiserslautern

ICSY Integrated Communication Systems

Multimedia Systems

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Outline

- Exercise 1.1: Digitization
- Exercise 1.2: Decibel
- Excursus: Error Detection and Correction

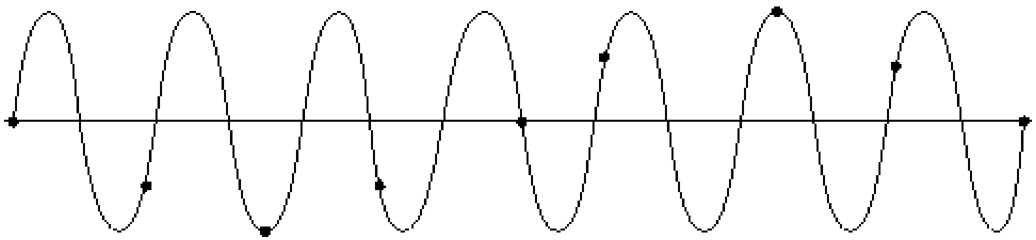
Exercise 1.1: Digitization

- An ISDN telephone has an integrated low-pass, which filters the incoming voice signal from the mouthpiece.
  a) What is the function of the integrated low-pass?
     - block frequencies above 4000 Hz
     - higher frequencies would be deformed during sampling process
  b) What is the sampling rate of the ISDN telephone system? Why?
     - ISDN sampling rate: 8000 Hz
     - The telephone system limited to signals with a maximum frequency of 4000 Hz. Regarding to the Nyquist-Shannon Sampling Theorem we can reconstruct a original signal of 4 kHz with a sampling rate of 8 kHz.

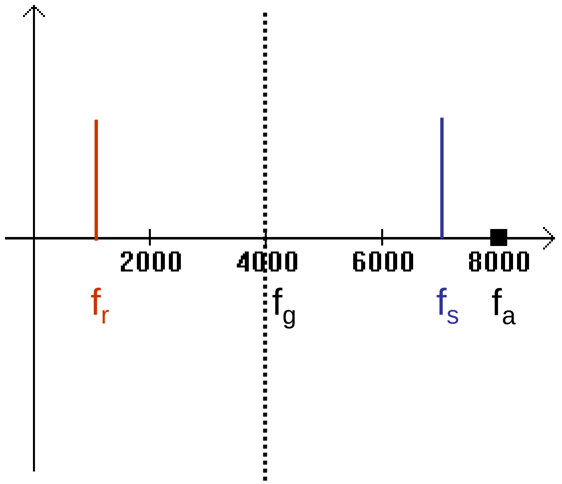
Exercise 1.1: Digitzation

c) Suppose the low-pass is removed. How would a dialog partner perceive a high sound with a frequency of f = 7000 Hz?

time domain



frequency domain



→ We receive a sound with a frequency of 1000 Hz.

Exercise 1.2: Decibel

- Calculating with decibel.
  a) Show the following:
    - doubling the power results in a approx. +3 dB

$$\Delta L = 10 * \log_{10}\left(\frac{2 * I_0}{I_0}\right) dB$$
$$= 10 * \log_{10}(2) dB$$
$$= 3{,}01 dB$$

    - a tenfold increase of power results in +10 dB

$$\Delta L = 10 * \log_{10}\left(\frac{10 * I_0}{I_0}\right) dB$$
$$= 10 * \log_{10}(10) dB$$
$$= 10 * 1 dB = 10 dB$$

Exercise 1.2: Decibel

b) How many decibel represents a thousandfold increase of power?

$$\Delta L = 10 * \left(\log_{10} \frac{1000 * I_0}{I_0} \right) dB$$
$$= 10 * \log_{10}(1000) dB$$
$$= 10 * 3 dB$$
$$= 30 dB$$

c) Speech has a typical power of 10µW, a violin of 1mW and a speaker of 100W. Calculate the ratio in dB.

$$L_{12} / dB = 10 * \log_{10} \left(\frac{1mW}{10\mu W} \right)$$
$$= 10 * \log_{10} \left(\frac{1 * 10^{-3} W}{10 * 10^{-6} W} \right)$$
$$= 10 * \log_{10}(10^2) = 10 * 2$$
$$= 20$$

$$L_{23} / dB = 10 * \log_{10} \left(\frac{100W}{1mW} \right)$$
$$= 10 * \log_{10} \left(\frac{1 * 10^2 W}{1 * 10^{-3} W} \right)$$
$$= 10 * \log_{10}(10^5) = 10 * 5$$
$$= 50$$

$$L_{13} = L_{12} + L_{23} = 20dB + 50dB = 70dB$$

Error Detection

- Goal: Detect the inversion of one ore more bits in a bit string.
- Solutions:
  - Parity bits
    - Add redundancy to a bit string
      01101011**1** ← even parity
      01101011**0** ← odd parity
  - Checksums
    - General form:

      $$pz = f(d_0, d_1, d_2, \ldots, d_n)$$

    - Simple example:

      $$pz = d_0 \oplus d_1 \oplus d_2 \oplus \ldots \oplus d_n$$

    - CRC (Cyclic Redundancy Check): based on polynomial long division

Error Correction

- Goal: Correct one or more inverted bits in a bit string.
- Solutions:
  - Retransmission
    - well suited for channels with low error rate
    - request and retransmission cause high delay
    - requires reverse channel
  - Channel coding (Forward Error Correction)
    - add redundancy to transmitted data
    - well suited for channels with high error rate
    - no reverse channel required
    - create high overhead

  → Combination of channel coding and retransmission
    - If an error cannot be corrected, a retransmission is requested.

Error Correction

- Problem: Error bursts
- Interleaving
  - done after encoding step
  - reorder bits of multiple bit strings to enable a correction of error bursts
  - Example

```
1011111   1010010   --interleave-->   1100111   0101110
        ↓ transmit                            ↓ transmit
1011100   1010010                     1100100   0101110
                                              ↓ reconstruct
                                      1010111   1000010
```

  - Use cases
    - Compact Disk (scratches)
    - Mobile Phone (impulse disturbance)
    - DSL
      - “Fastpath” mean deactivation of the interleaving functionality.

Questions?

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