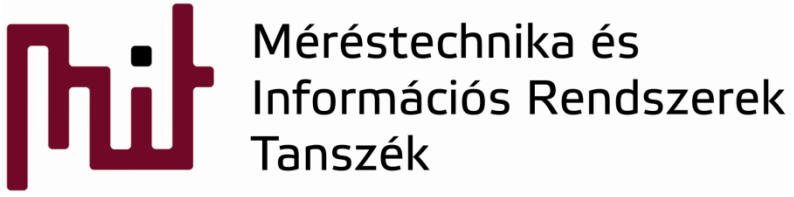
Embedded and Ambient Systems
2023. 11. 14.

Basic tasks in signal processing, extraction of useful information

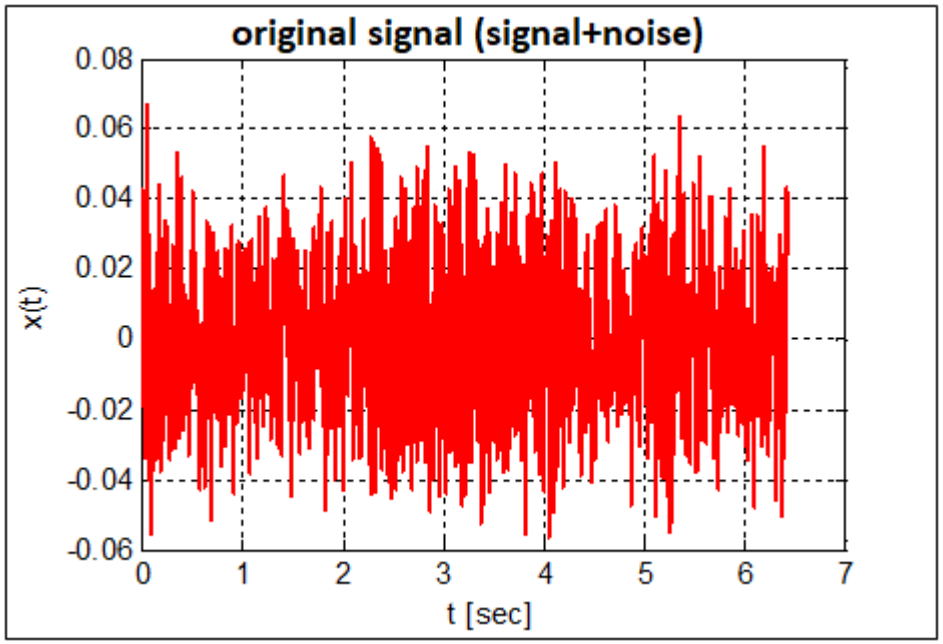


Basic tasks

- Filtering: extraction of useful information
  - Signal detection: signal distortion does not necessarily causes problem (e.g.: overshoot of a filter is not a problem when exceeding a threshold level is observed)
  - Parameter measurement: the signal parameter of interest must be preserved (e.g.: filter overshoot is not allowed when amplitude is to be measured
- Signal generation
- Measurement of signal properties
  - Average (DC component)
  - RMS (root mean square)
  - Frequency
  - Phase
- Determination of signal spectrum (Fourier transformation)
- Modulation/Demodulation

Digital filtering

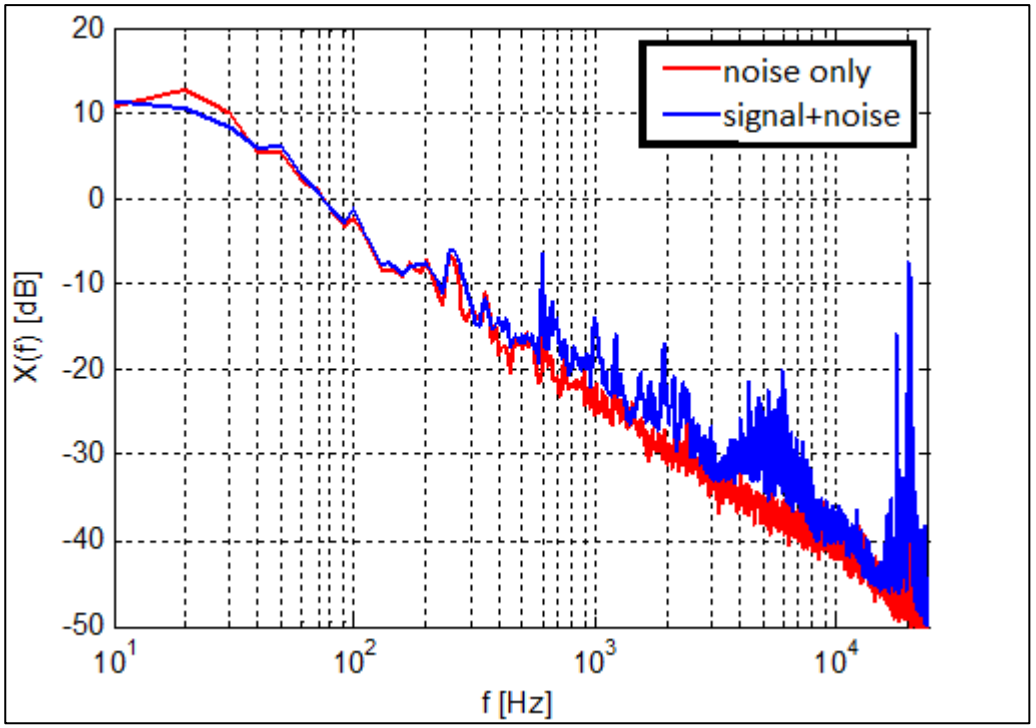
- Example: measurement of acoustic noise of DC motor



- Signal measured is totally buried in the noise, the noise level seems to be very high
- How the useful signal can be distinguished from noise?

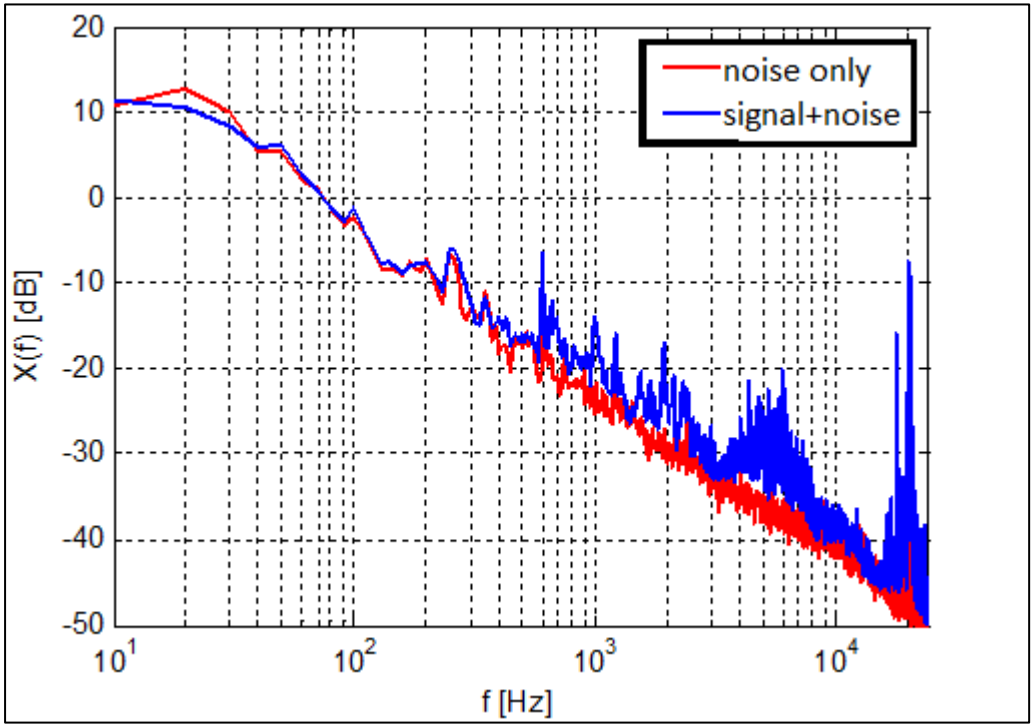
Spectrum calculation – digital filtering

- Examination of the signal in the frequency domain
- Determine the characteristics of the signal and noise
  - It is worth to perform two measurements (if possible, one noise-only and another with noisy signal) or one measurement but only-noise frequency parts should be examined separately (by filtering it out from the whole signal spectrum)
- Signal should not be distorted: overshoot and amplitude are important parameters



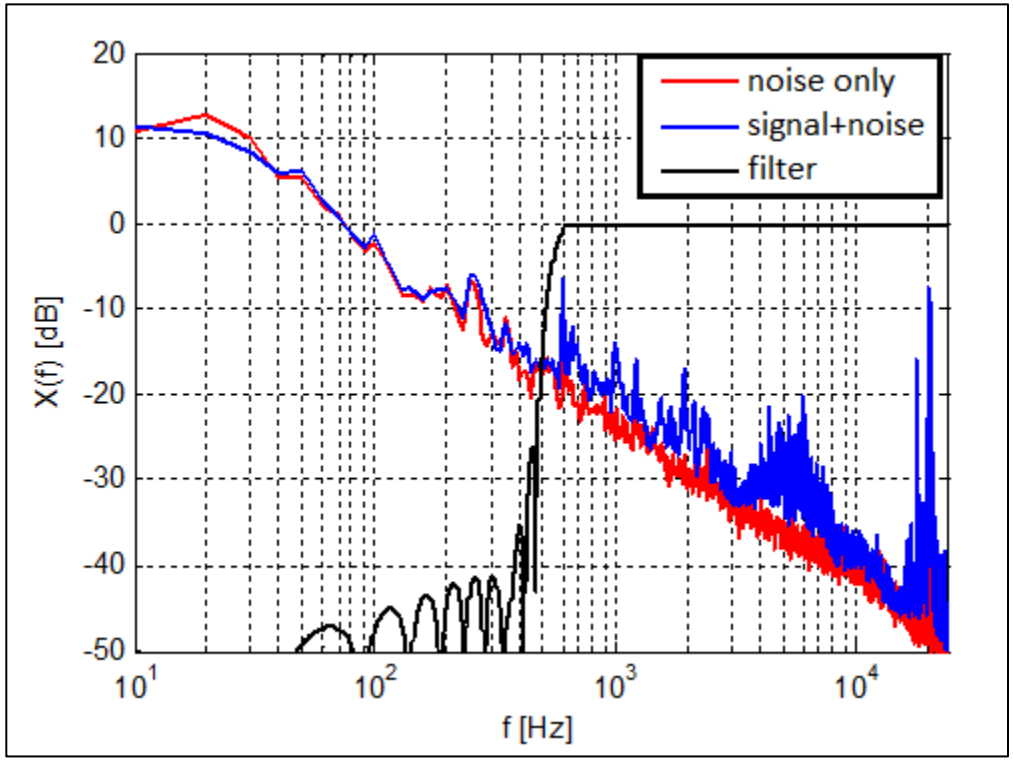
Spectrum calculation – digital filtering

- It has to be determined which part of the spectrum should be removed to reduce noise
- Noise is dominant when frequency is below approximately 600 Hz
- Above 600 Hz signal is significantly larger than noise
- Under 600 Hz due to the noise level it is not known whether signal component is present or not



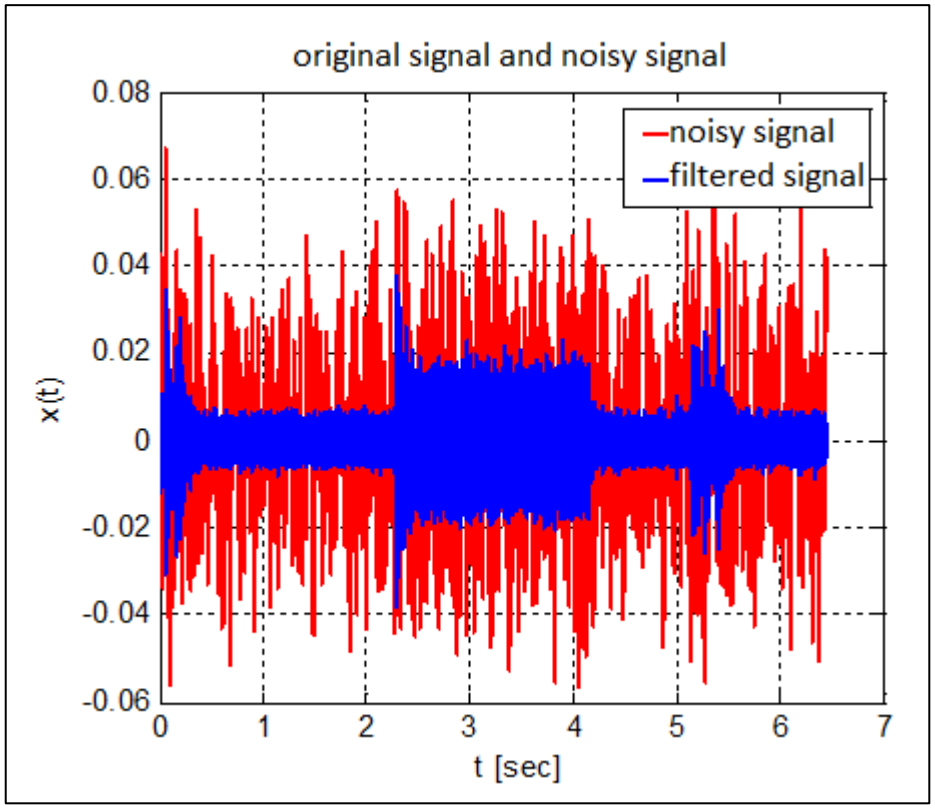
Filter design – digital filtering

- An appropriate filter needs to be designed that:
  - Preserves the spectral properties of the signal
  - Removes as much noise from the signal as possible
- Above 600 Hz the transfer characteristic should be preserved
- Under 600 Hz the cutting steepness of the filter and noise suppression should be large



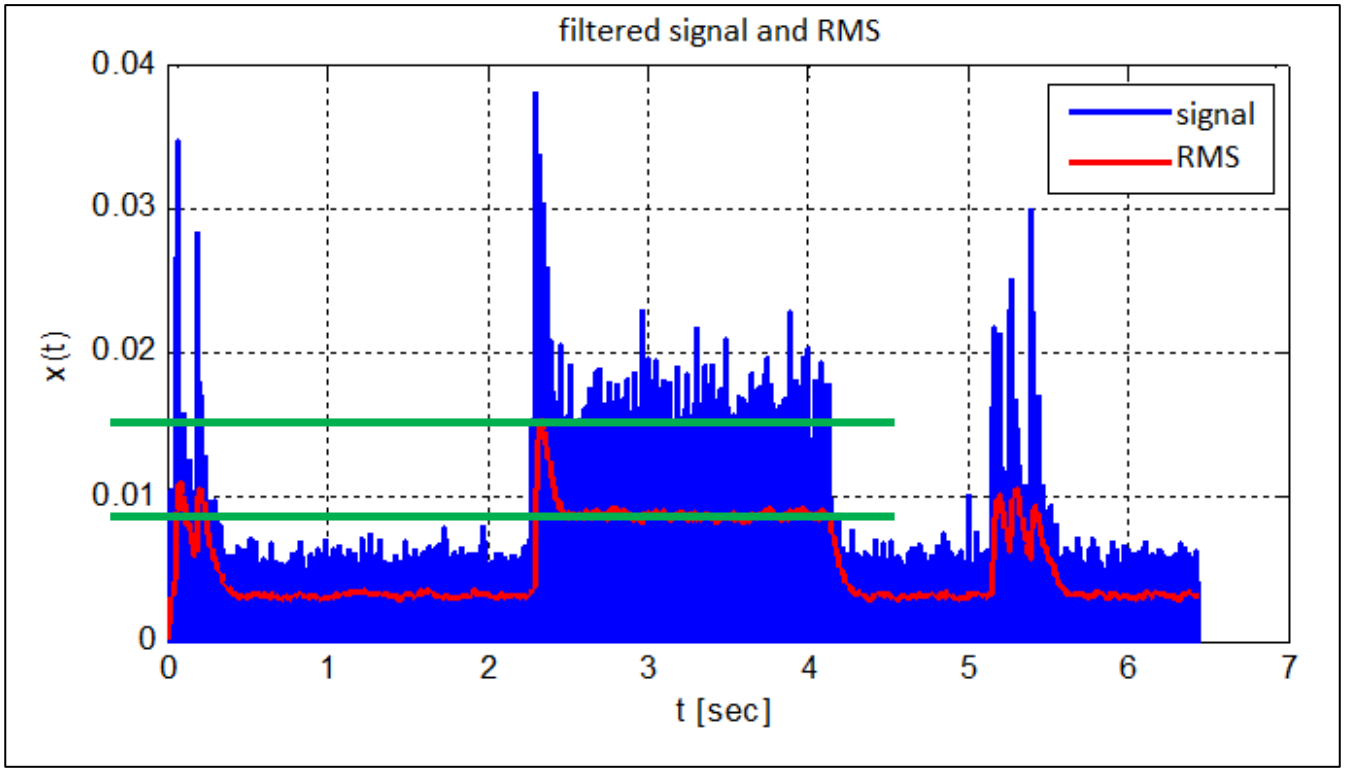
Digital filtering

- Filter design (pl. MATLAB, octave, python)
- Filtering
- Measurement of parameters of the filtered signal



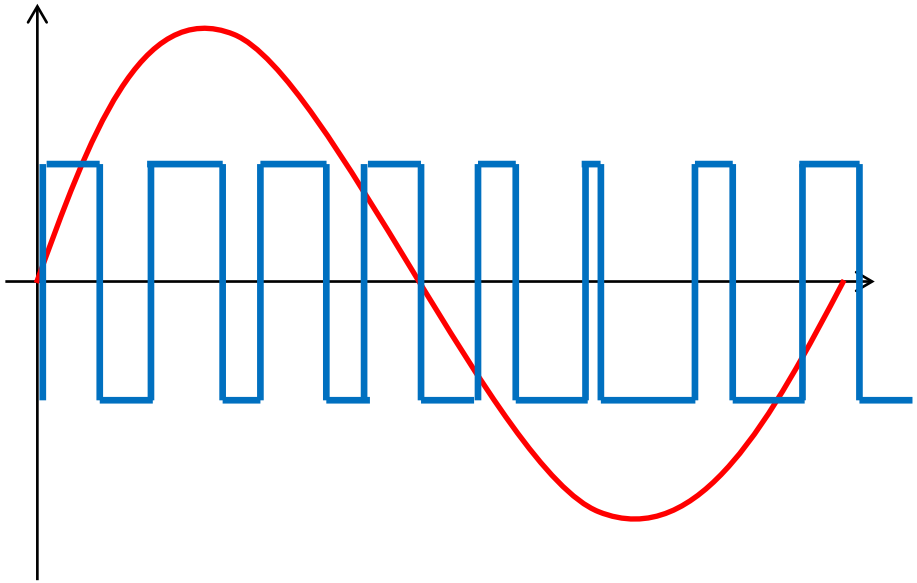
Measurement of signal parameters

- Parameters to be measured:
  - Instantaneous RMS value (in a certain window)
    - Maximal instantaneous RMS level
    - Stationary RMS level



Signal generation

- Typical waveforms:
  - Sinusoidal
  - Triangle
  - Sawtooth
  - Square
  - Trapezoid
  - Noise



- Sinusoidal signal:
  - General excitation for testing
  - Modulation
  - Motor control: sinusoidal phase current based on PWM (pulse width modulation)

Design of data processing systems

- Preliminary measurements
  - Signal analysis
    - Time-domain measurements and examination of time-domain signal properties
    - Examination of spectrum (filtering the signal to remove noise)
- Algorithm design
  - Searching for possible solution (scientific/technical literature, internet, etc.)
  - Choosing an algorithm that fits (i) for the resources of the embedded system intended to be used and (ii) expected quality features of the processing
- Offline testing of algorithm (e.g. MATLAB, python, octave)
- HW choice
  - Based on the expected features, e.g. accuracy, speed, etc.
    - More severe quality requirements -> more powerful processor (e.g. floating point calculations)
  - Computational capabilities
  - Memory needed
  - Price
- Algorithm implementation
  - Implementation of the SW environment is also time consuming: sampling, timing, etc…
- Testing