

Embedded and Ambient Systems

2022. 11. 22.

**Basic tasks in signal processing,
extraction of useful information**



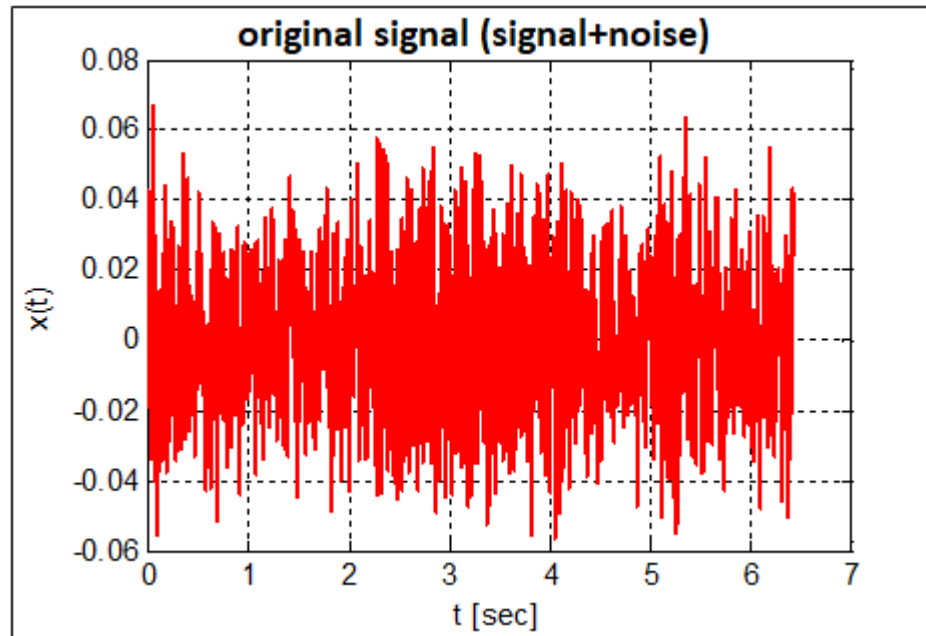
Méréstechnika és
Információs Rendszerek
Tanszék

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

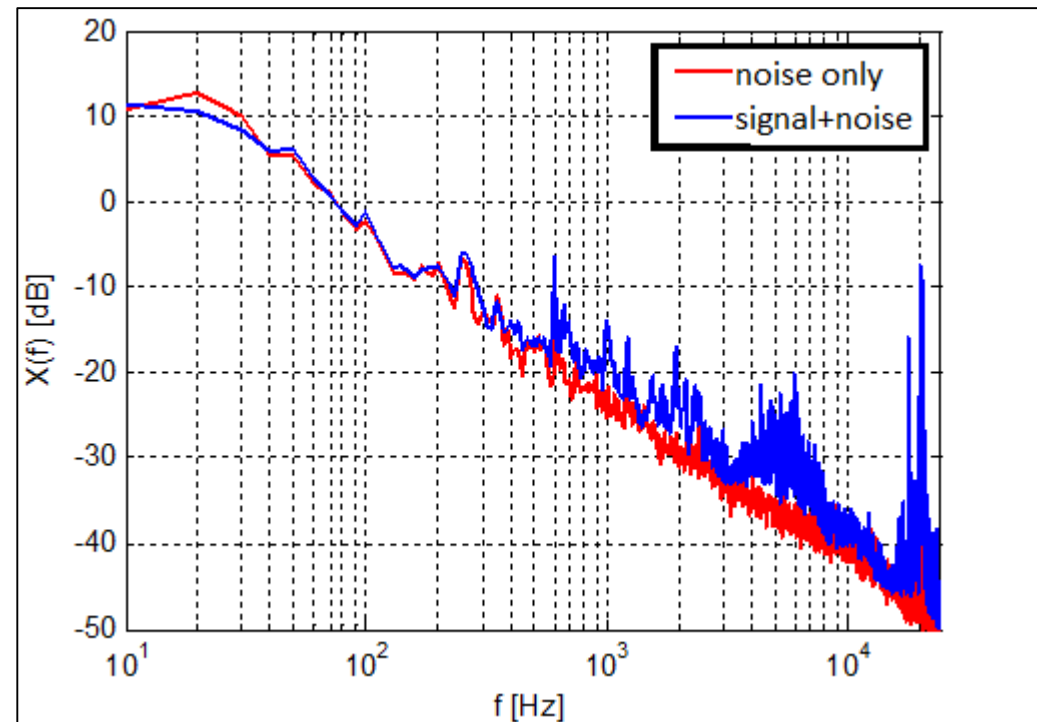
- Example: measurement of acoustic noise of DC motor



- 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?

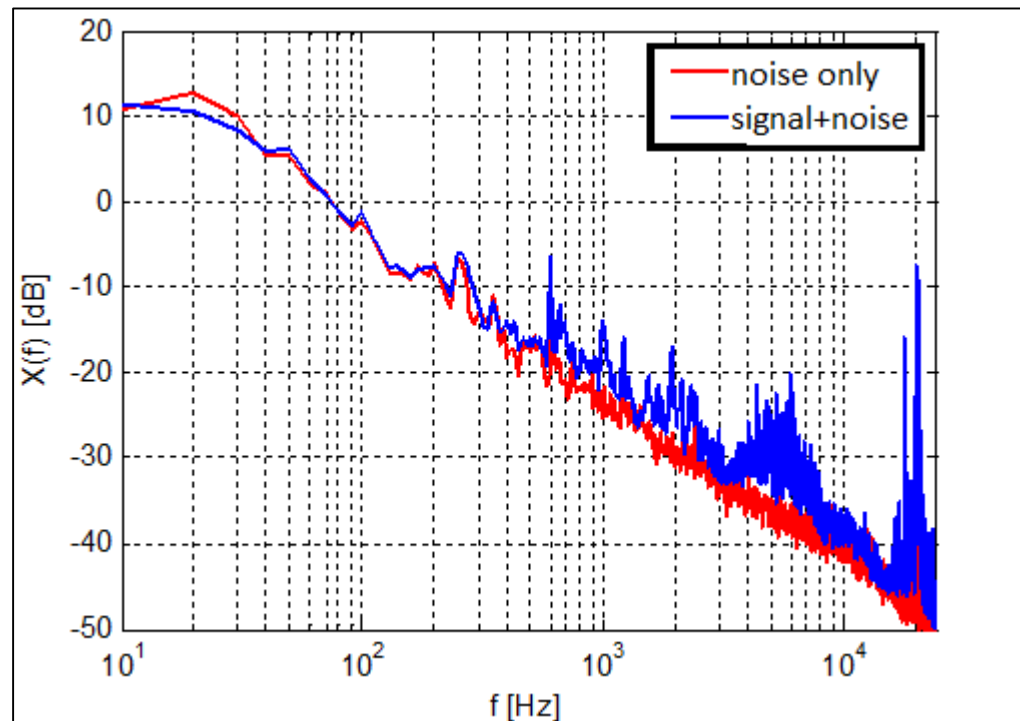
Spectrum calculation – digital filtering

- 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 with noisy and another with noiseless 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



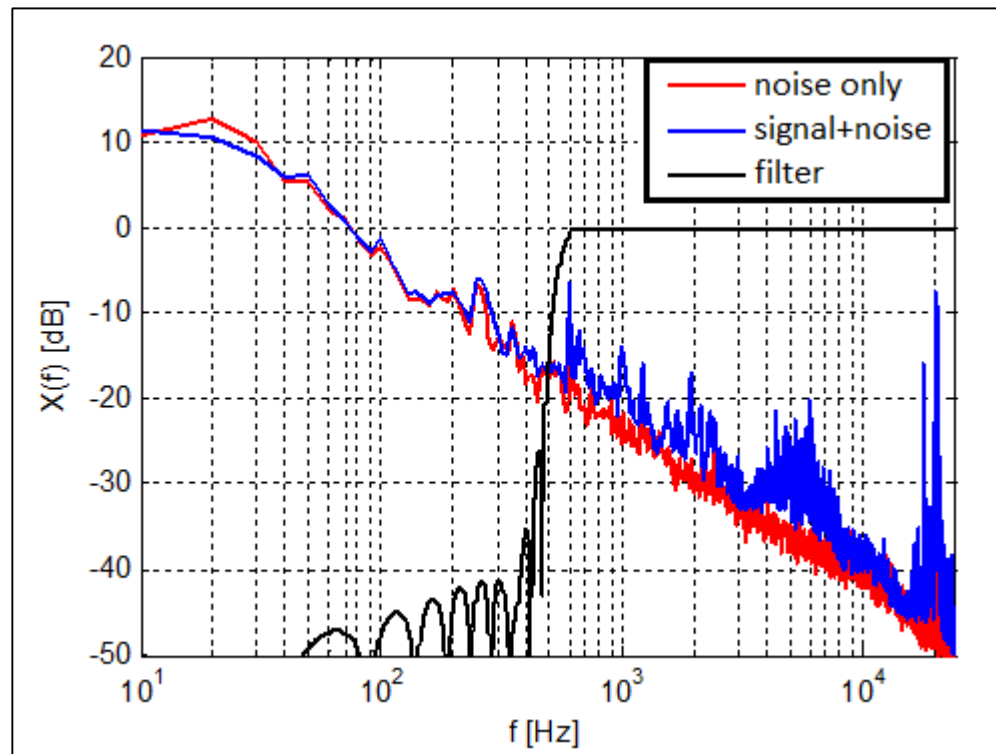
Spectrum calculation – digital filtering

- 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



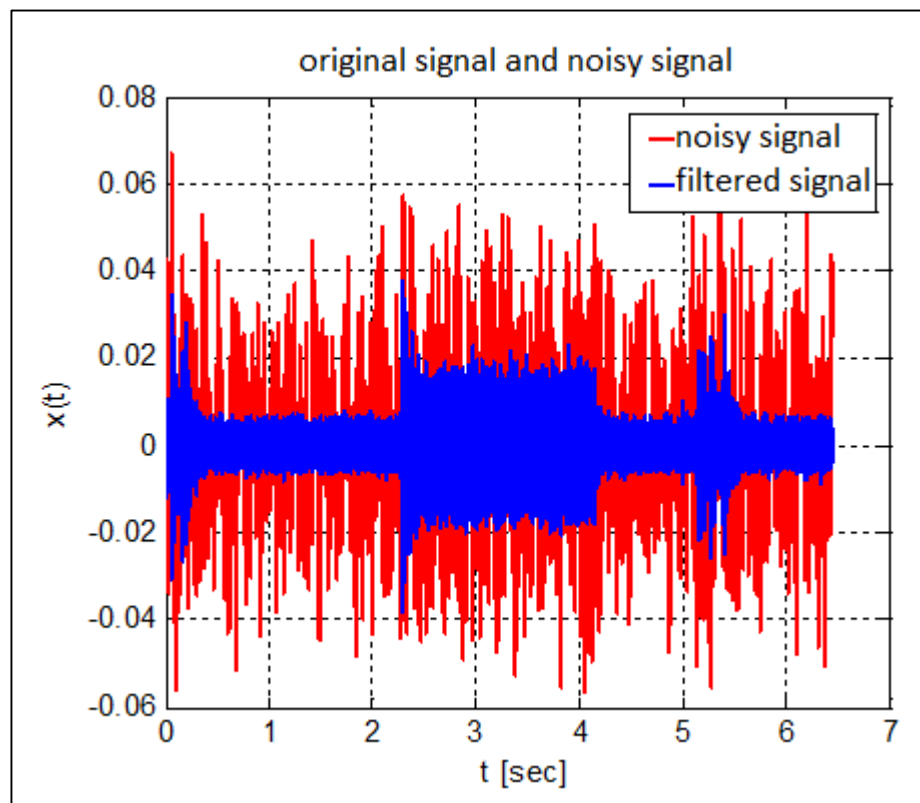
Filter design – digital filtering

- 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



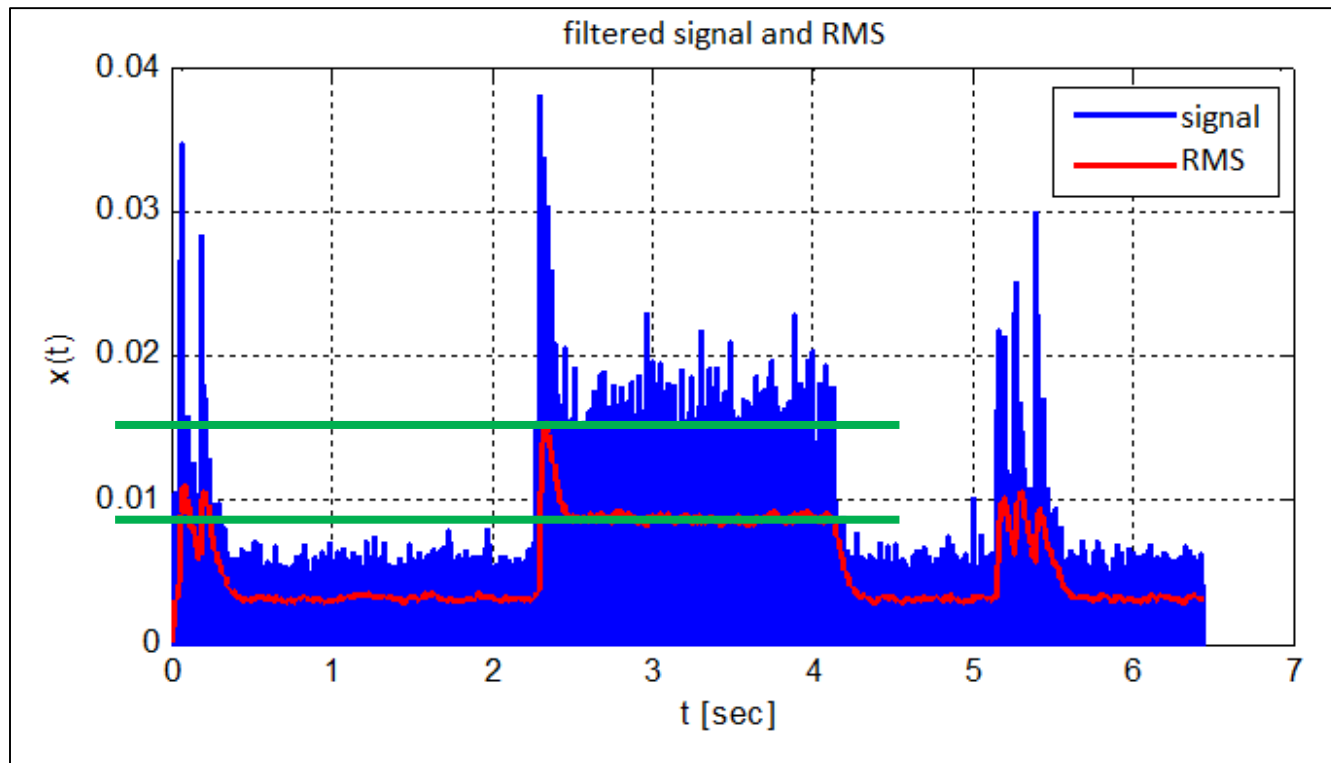
Digital filtering

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



Measurement of signal parameters

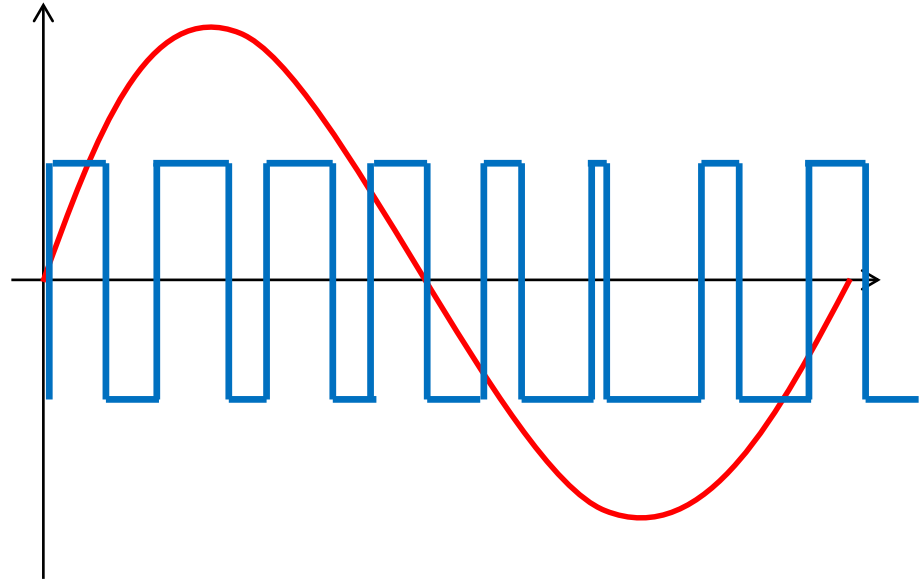
- Parameters to be measured:
 - Instantaneous RMS value (in a certain window)
 - Maximal instantaneous RMS level
 - Stationary RMS level



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

Mutual influence on each other



- 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