Embedded Software Develpoment
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Basic tasks in signal processing, extraction of useful information

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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

original signal (signal+noise)
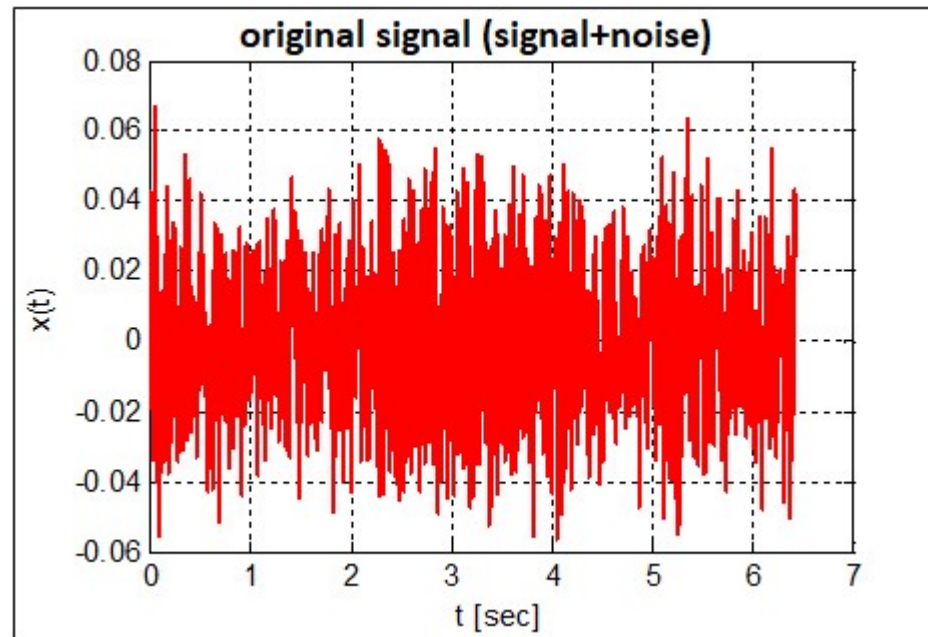
- Signal measured is totally buried in the noise, the noise level seems to be very high

- 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
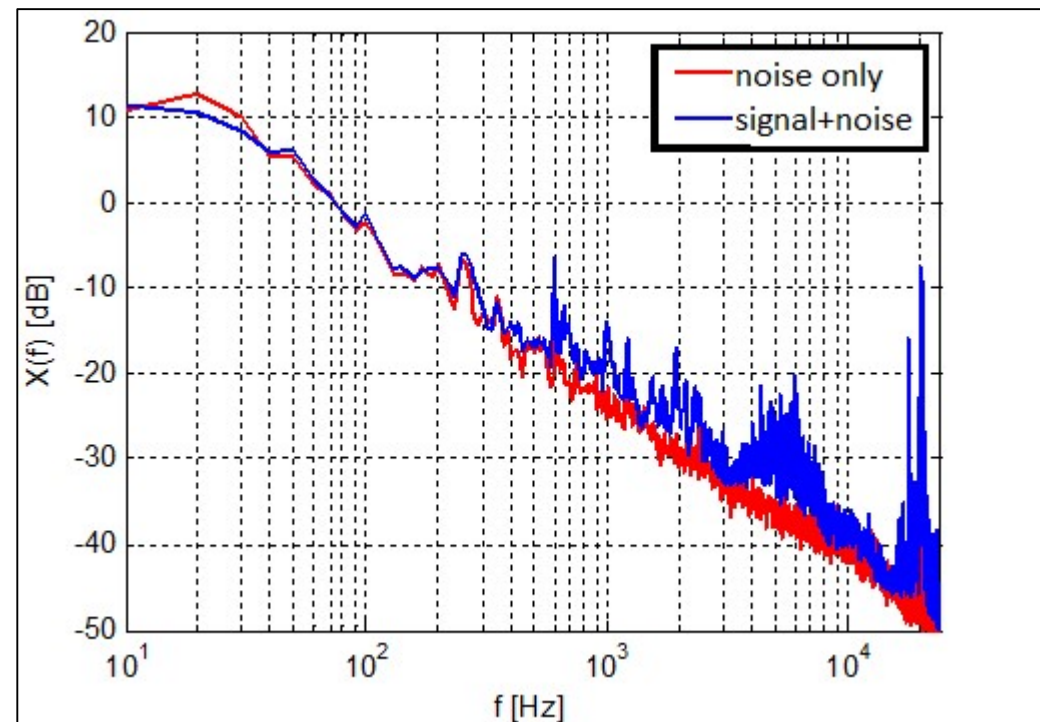
Spectrum calculation – digital filtering

- 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
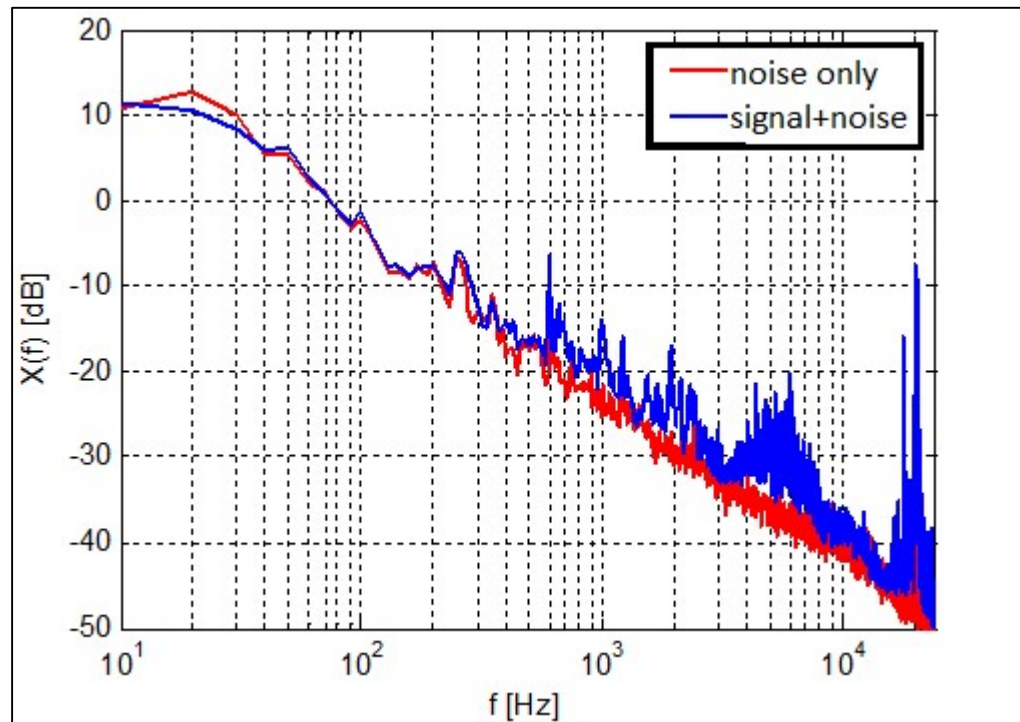
Filter design – digital filtering

- 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
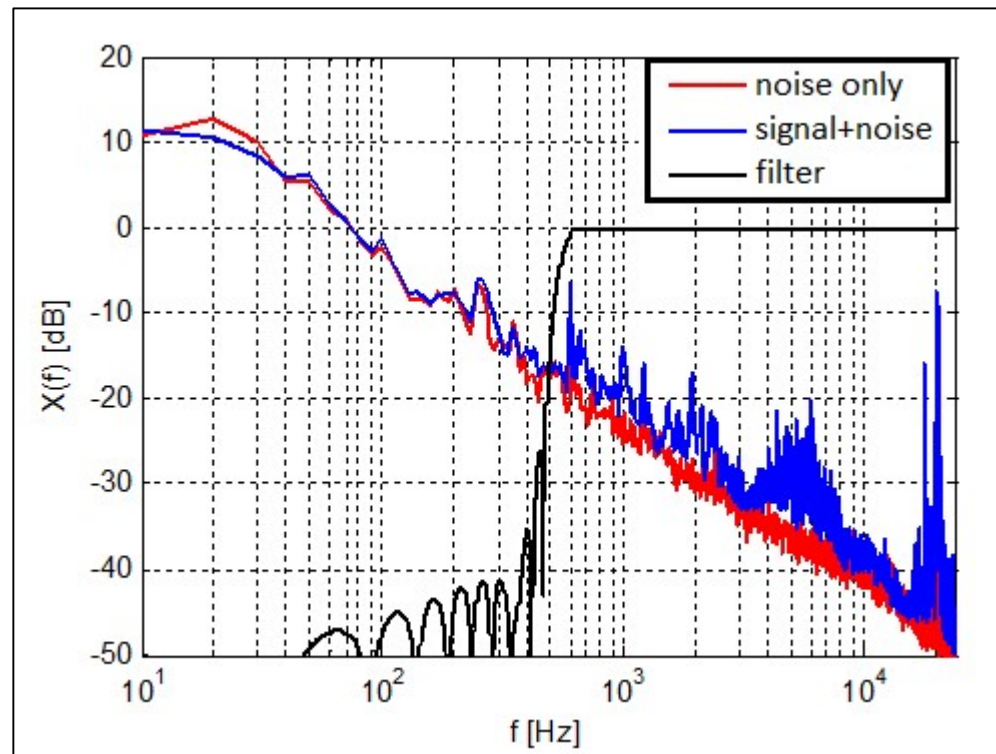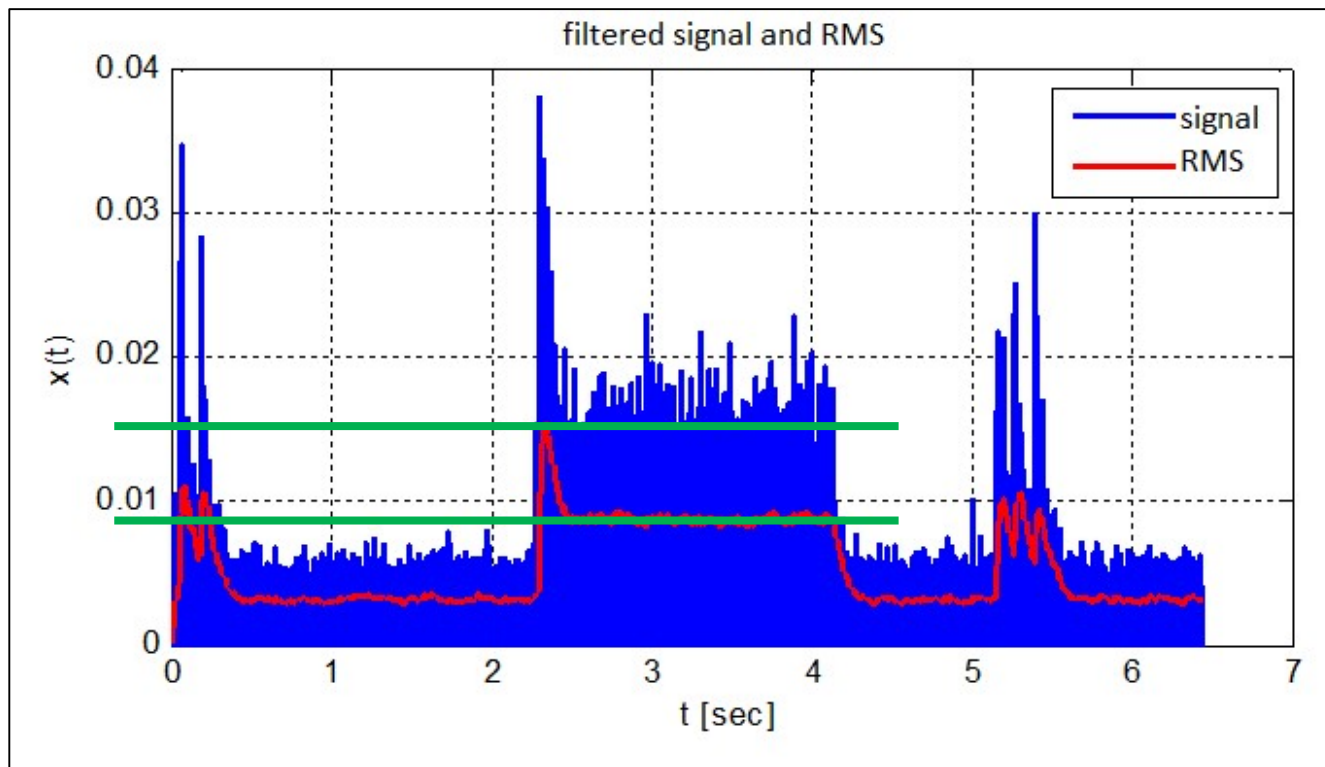
Digital filtering

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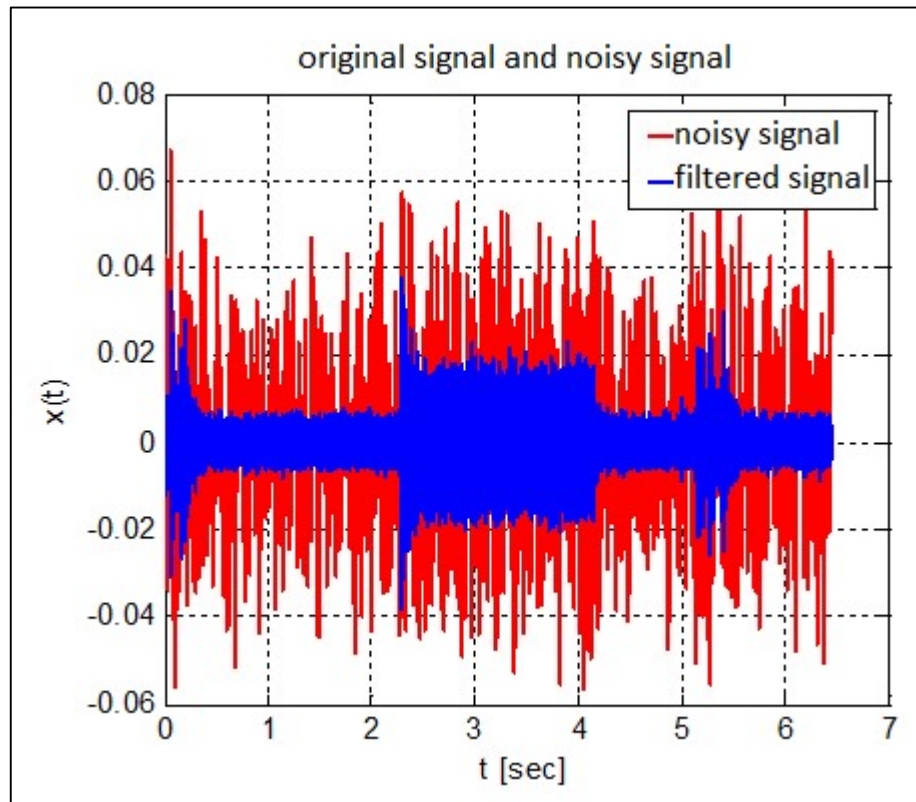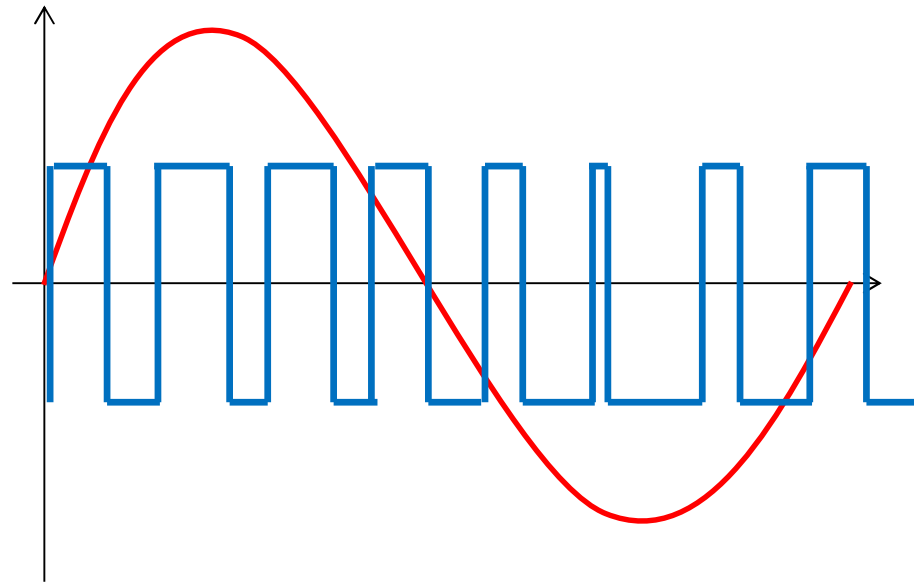
Measurement of signal parameters

- 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

Mutual influence on each other