

# Arbitrary waveform generator for simulation of energy harvesters

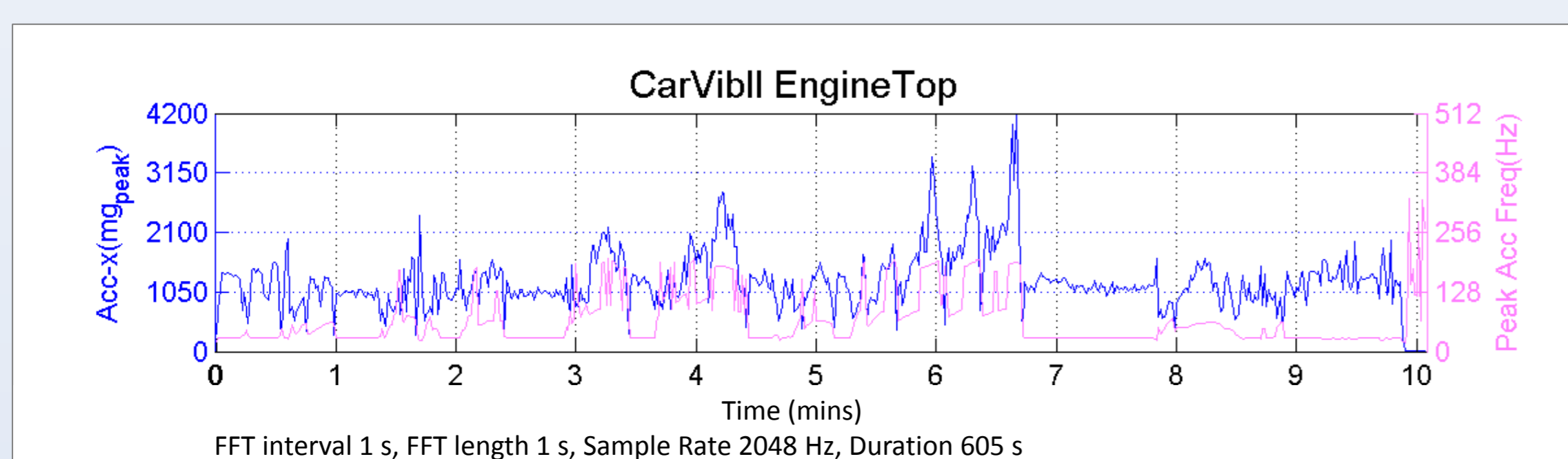
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## Goals

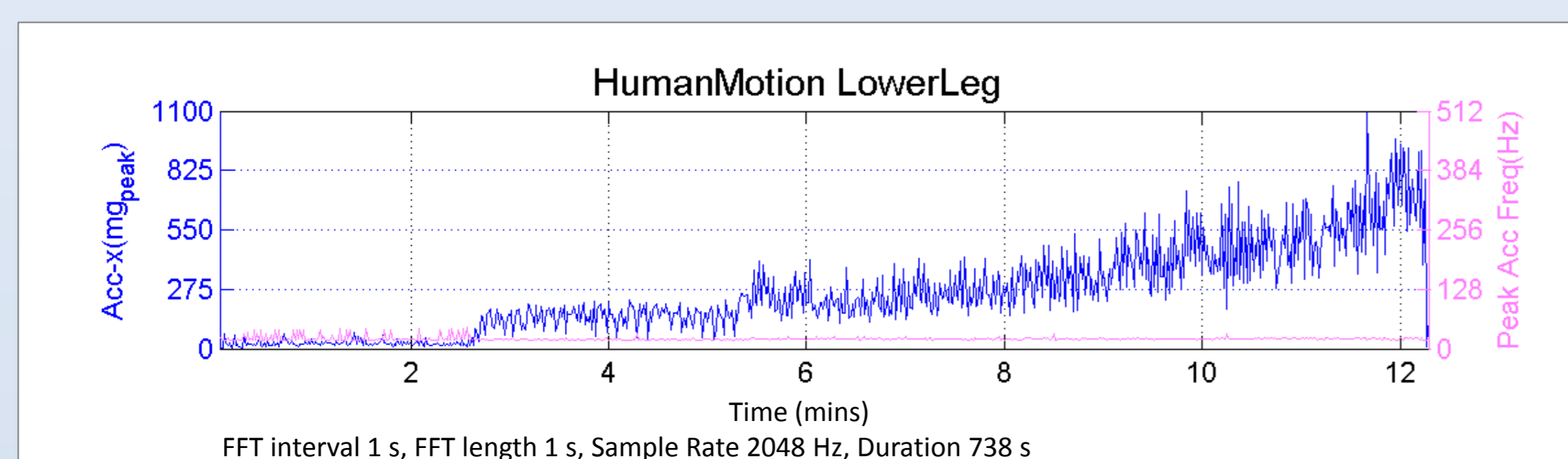
- Establishing traceability for low level complex signals (DC to 100 kHz)
- Providing measuring equipment for intercomparison on low level complex signals for voltage and power
- Simulation platform for EH devices

## Actual EH signals

- VW Van Engine



- Human Motion – Outside of lower leg near ankle

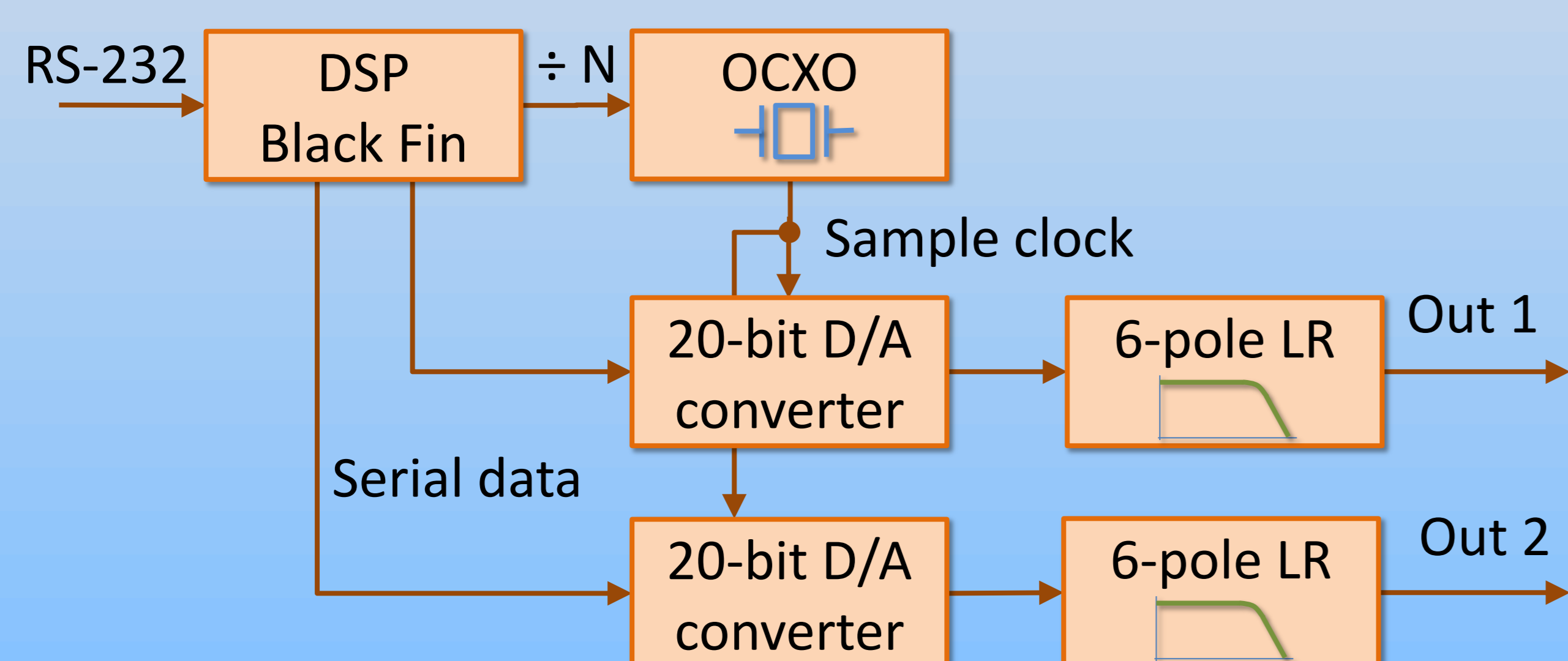


Acknowledge: "The EH Network Data Repository (<http://eh-network.org/data/>)"

## Available solutions

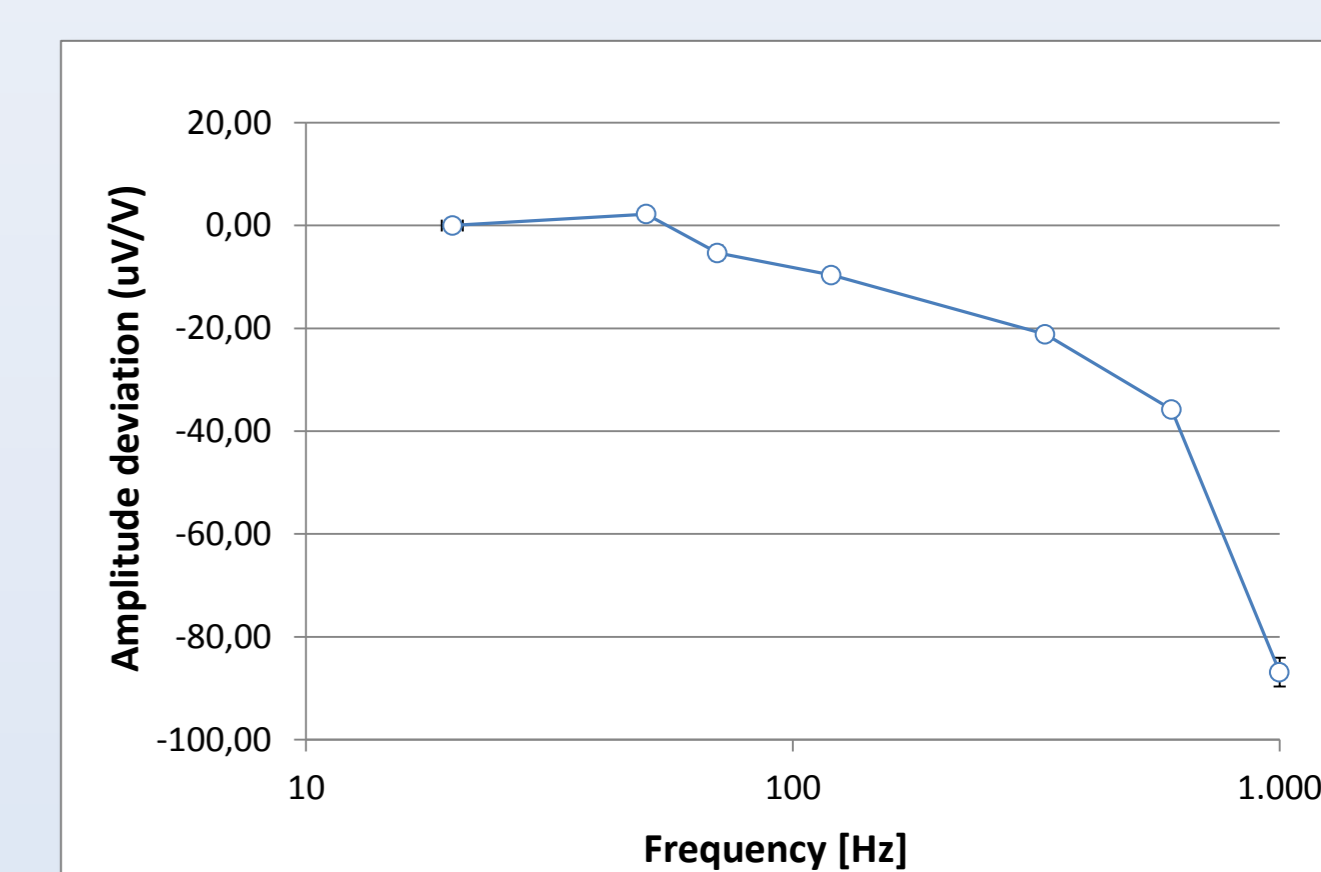
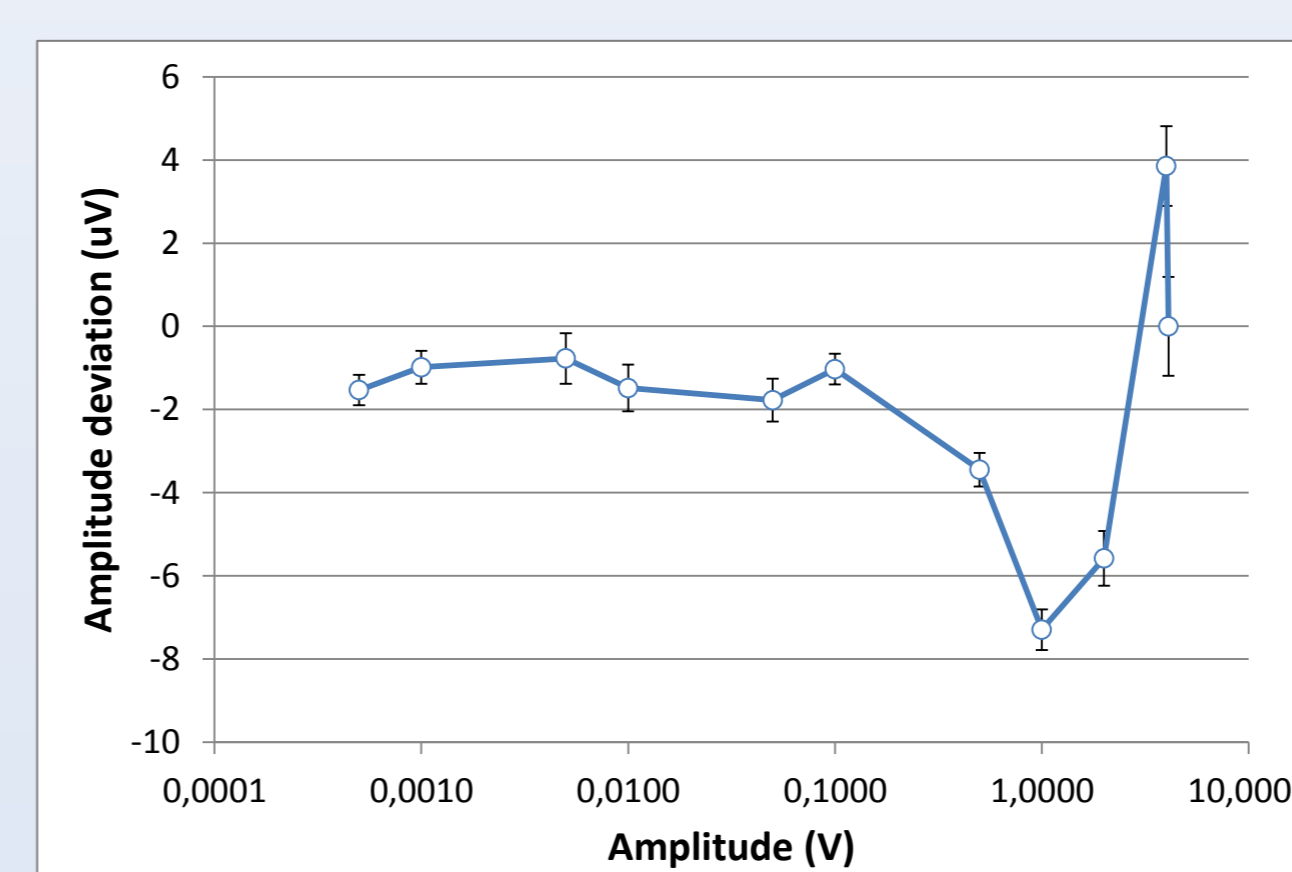
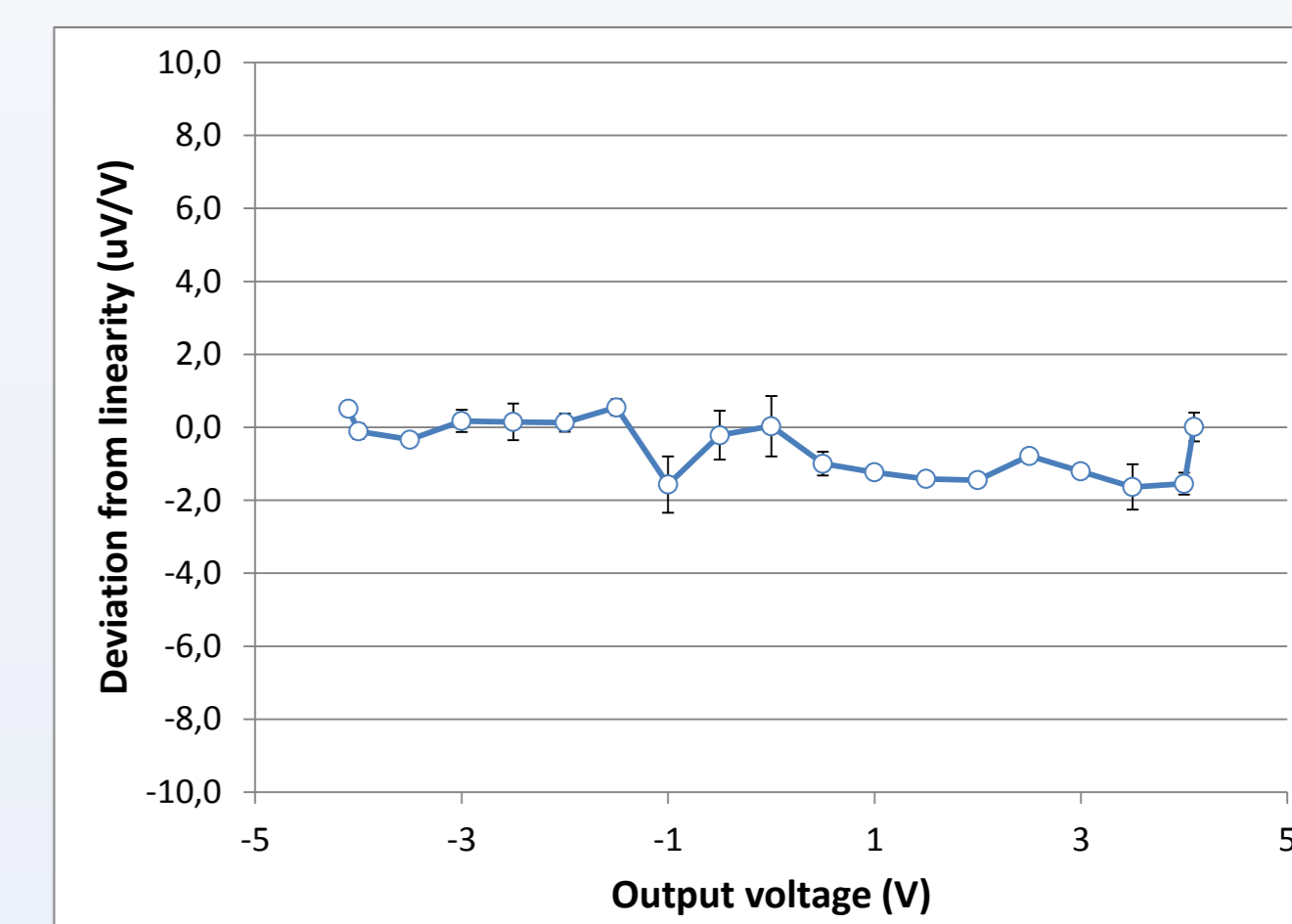
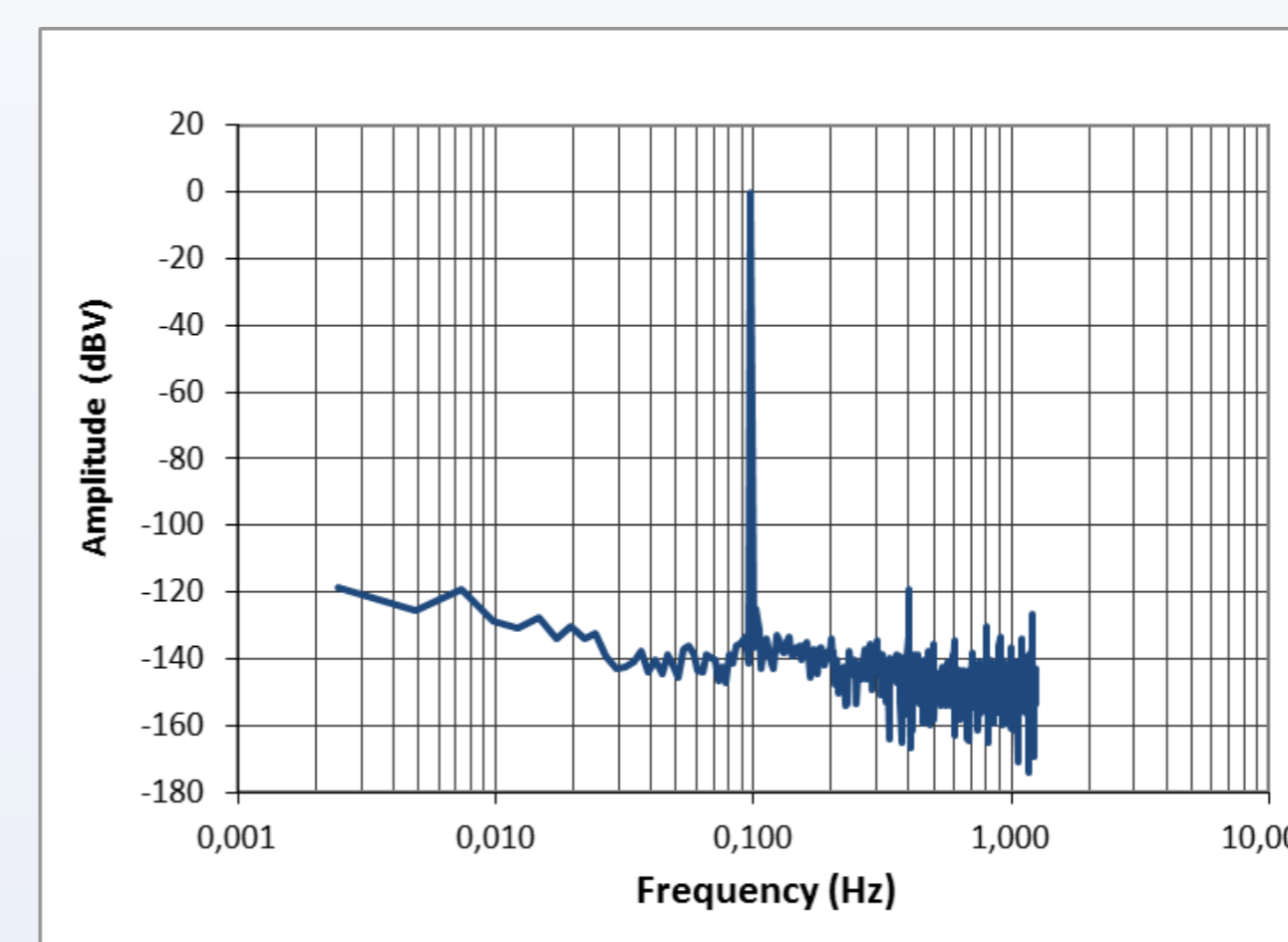
- Arbitrary waveform generators:  
SNR = 80 dB, THD = 0.04 %, 1 % amplitude accuracy, 50 ppm short term stability
- Sound cards:  
SNR > 110 dB, THD < 0.005 %, 5 % amplitude accuracy, 500 ppm short term stability

## Proposed AW Generator



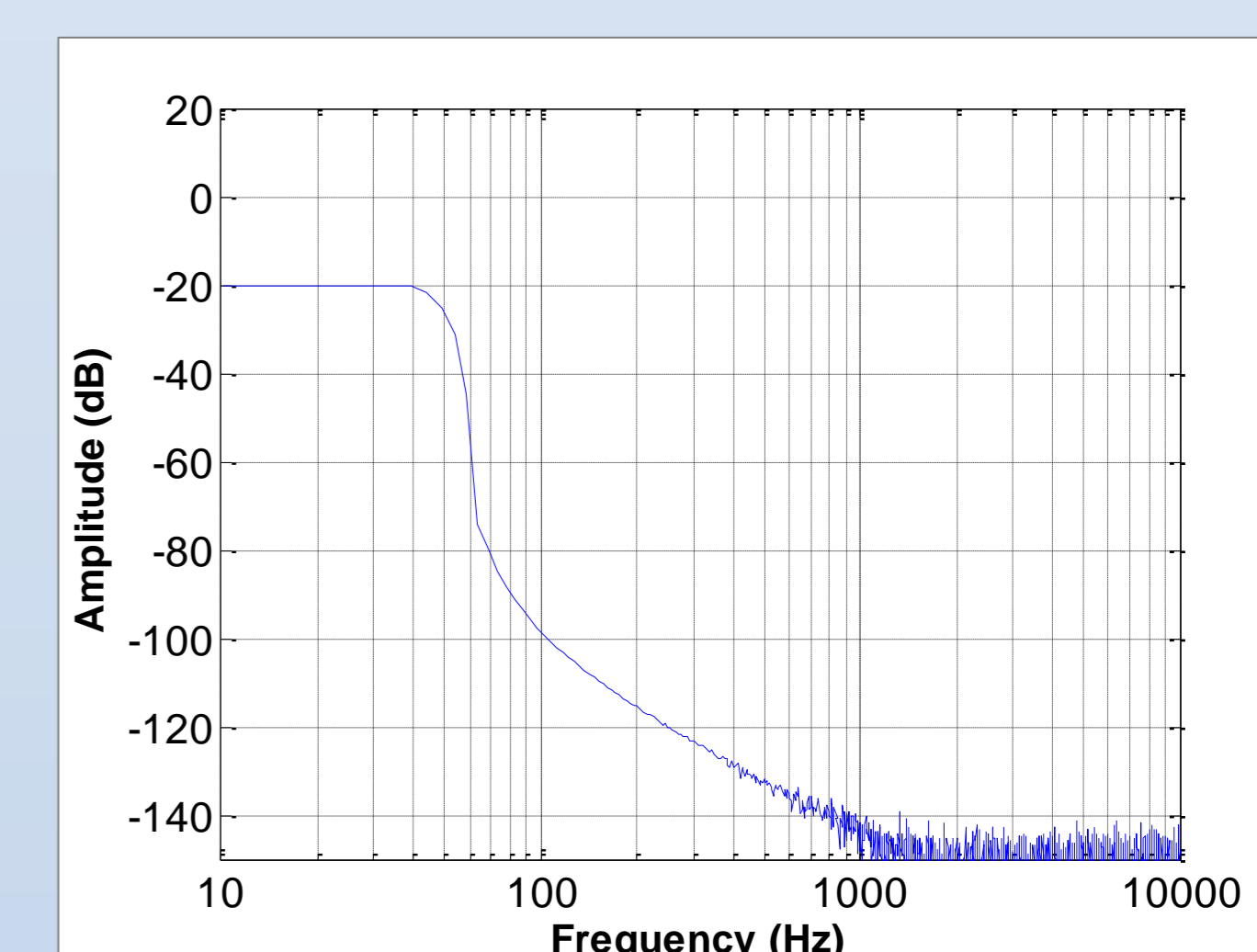
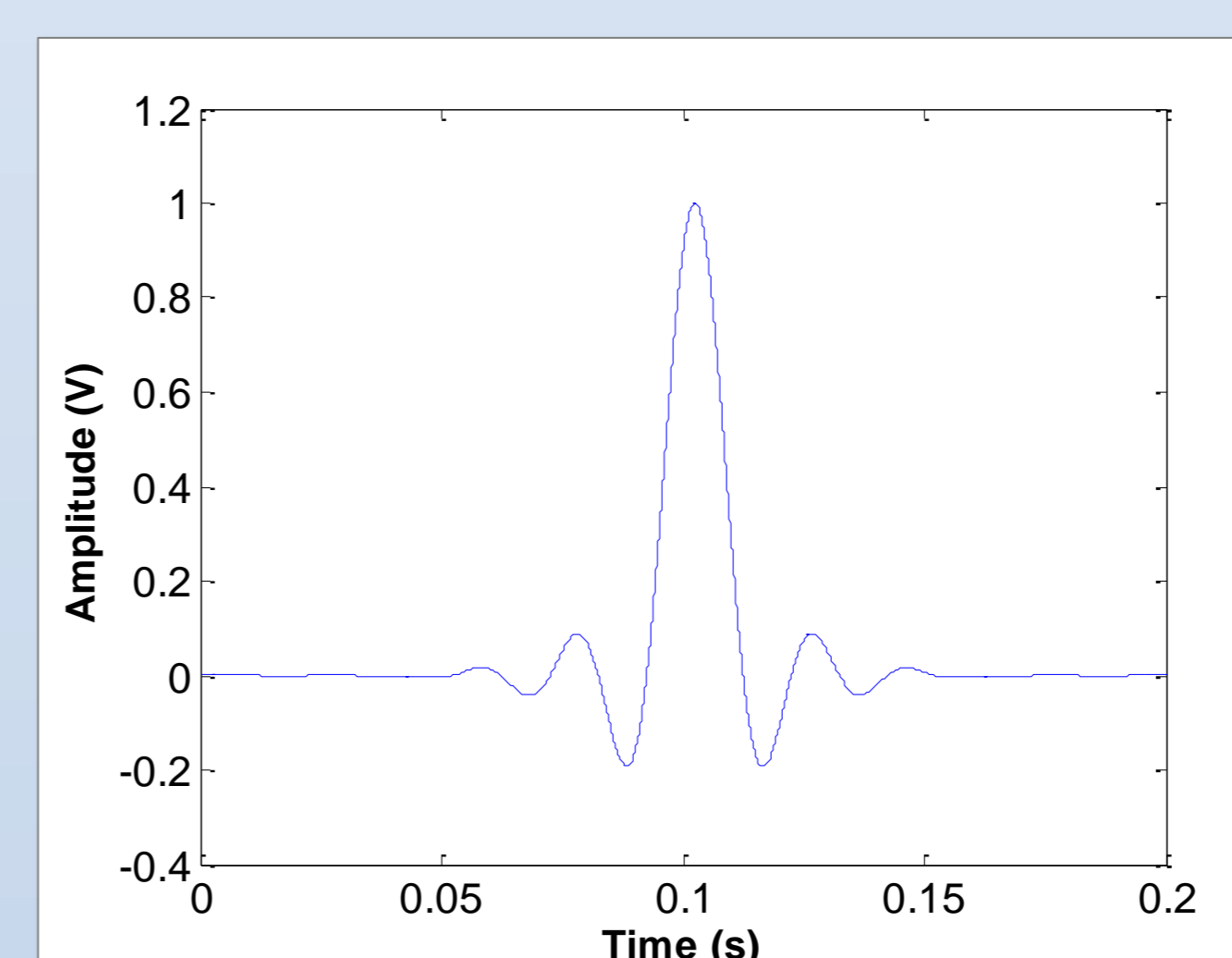
- 20-bit DAC
- 1 MHz sampling frequency
- 2 ppm short term stability
- 0.7 ppm linearity
- low phase noise

## Preliminary results



## Proposed calibration signals

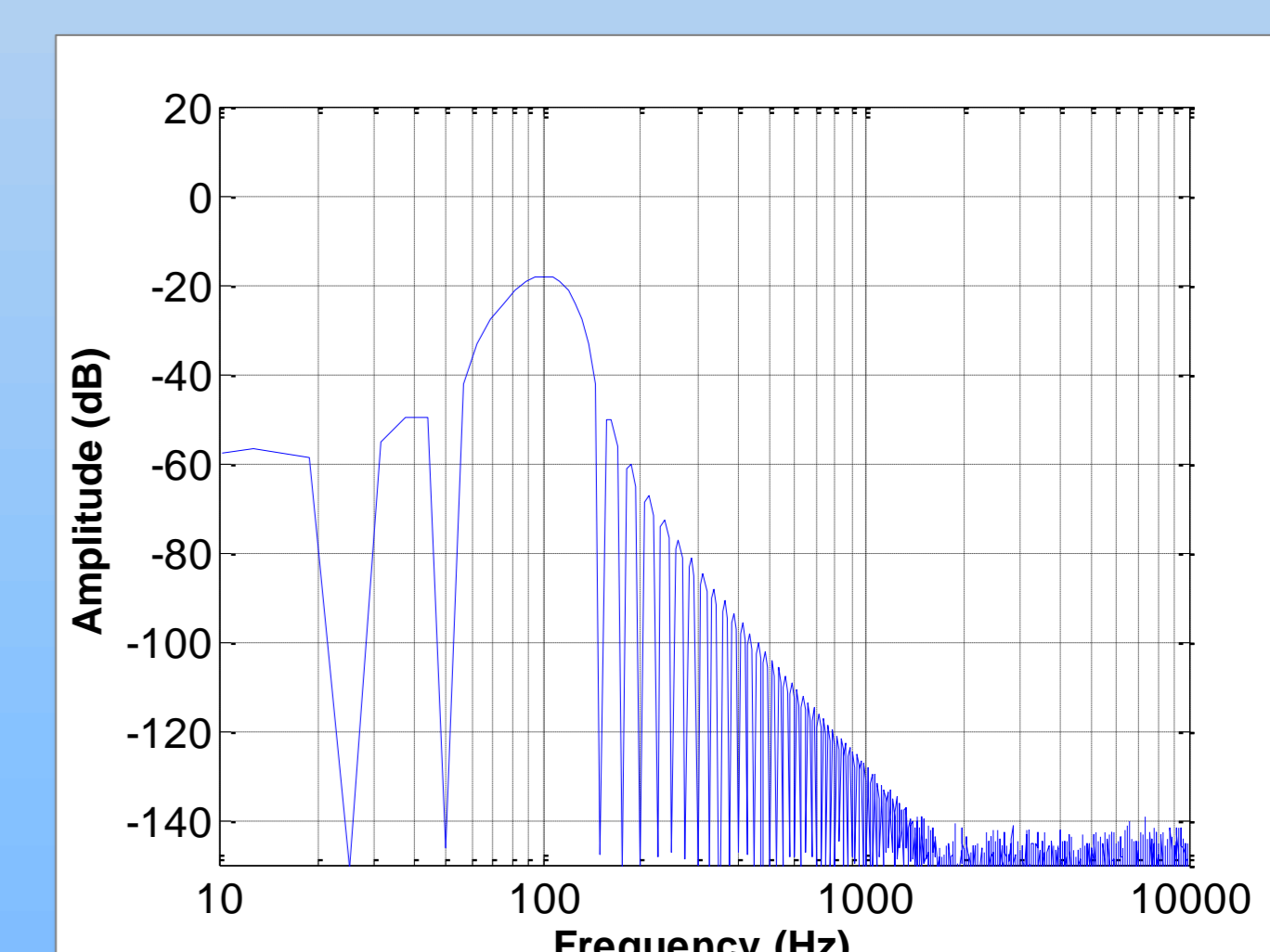
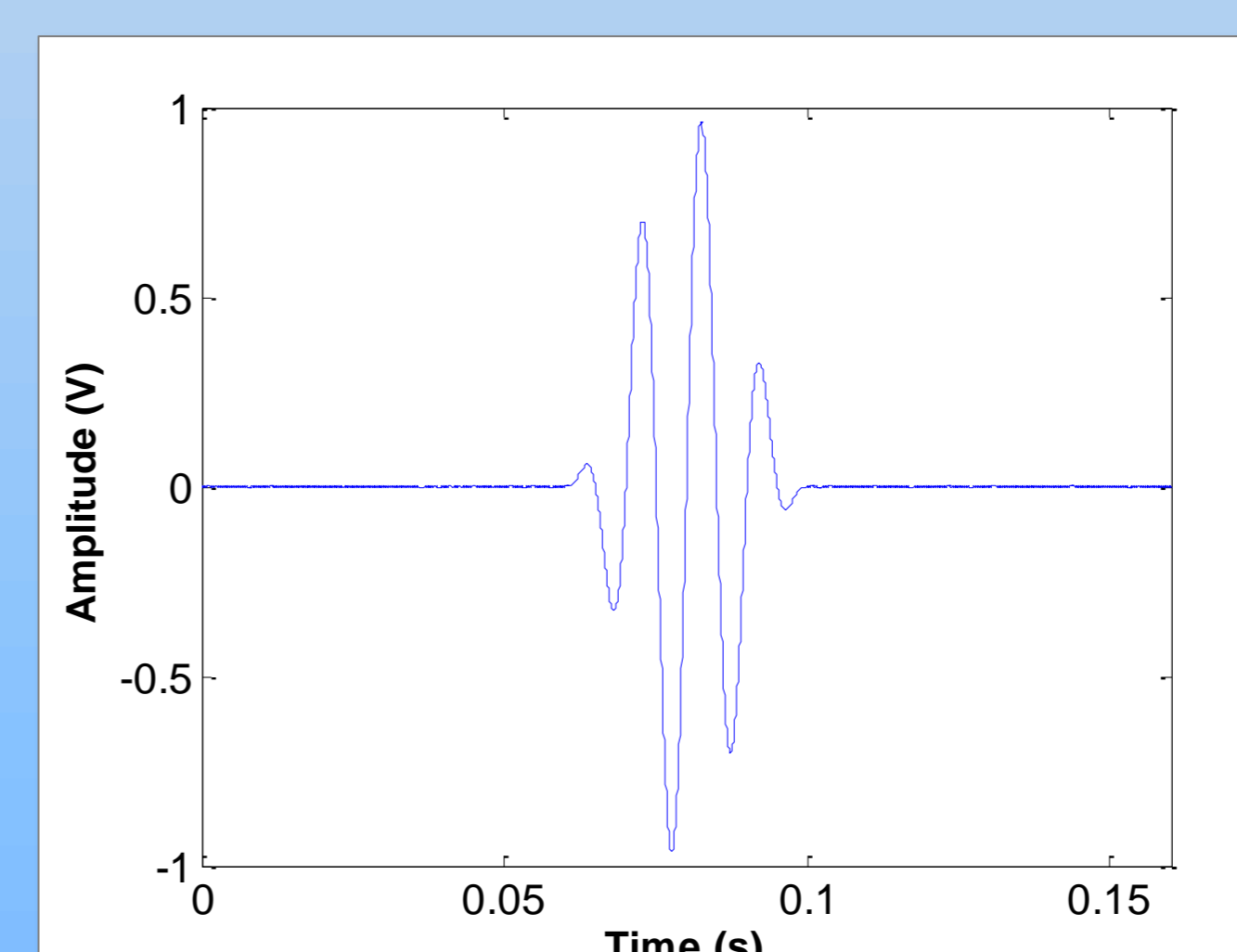
- Raised cosine:  $U(t) = \frac{\text{sinc}(\pi ft) \cdot \cos(\pi a ft)}{1 - (2a ft)^2}$



$f_s = 20 \text{ kHz}, f = 100 \text{ Hz}, \alpha = 0.2, \text{SNR} = 120 \text{ dB}, M = 4096$

- Cosine shaped burst:

$$U(t) = (0.5 - 0.5 \cos(2\pi ft)) \cdot \sin(2\pi N_B ft)$$



$f_s = 20 \text{ kHz}, f = 100 \text{ Hz}, N_B = 4, \text{SNR} = 120 \text{ dB}, M = 3200$

## Discussion

- How to achieve traceability for arbitrary waveform signals?
- What reference signals to use?
- What parameters to take into account?