B1

Sensor Noise Performance and Analogue System Design

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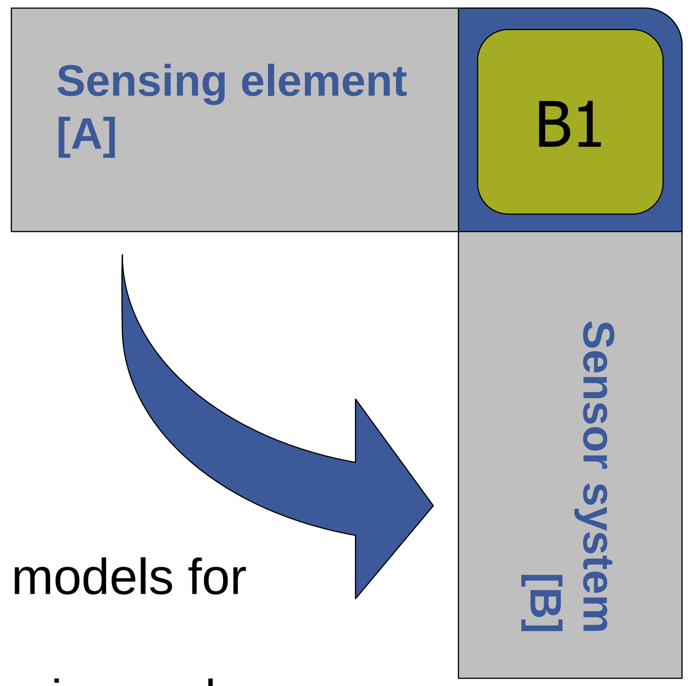
biomagnetic sensing SFB 1261

Motivation and Objectives

Motivation

The aim of this project is to provide application-specific sensor systems [for B projects] with the sensors [A] developed in the CRC on the basis of a comprehensive system analysis.



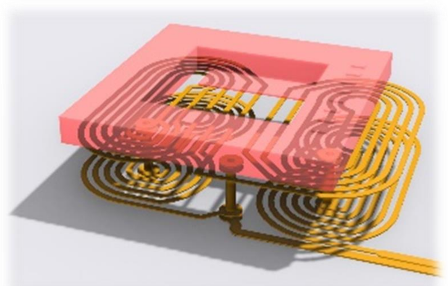
Objectives

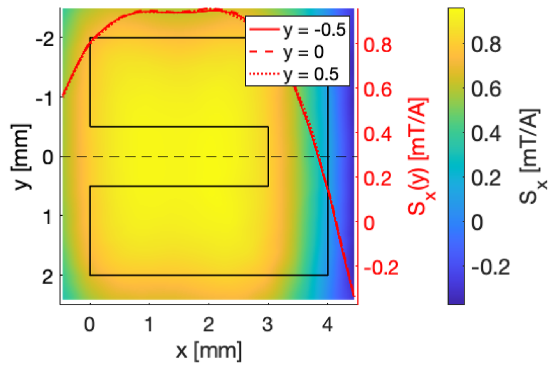
- Generating and analyzing in-depth noise models for ME sensors
- Implementation of analogue signal processing and sensor conditioning for various ME sensors with a focus on maximum signal to noise ratio (SNR) and minimum limit of detection (LOD)
- Investigation of ways for advanced sensor system integration using e.g. application specific integrated circuits (ASICs)
- Research into techniques with which LOD-optimized sensor systems can be operated in a magnetically unshielded environment.

Results of the Second Funding Period

PCB Coils for in situ characterization of ME Sensors

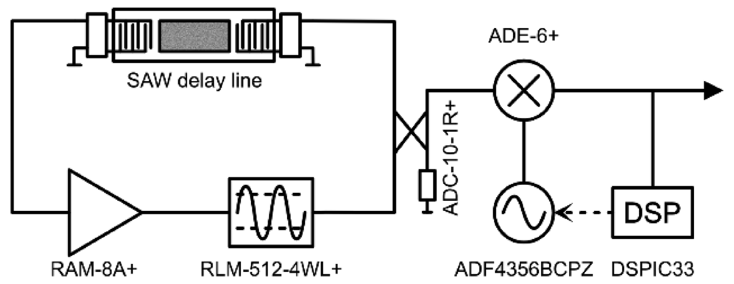
[B1-1] [B1-10] In situ calibration of ME sensor systems

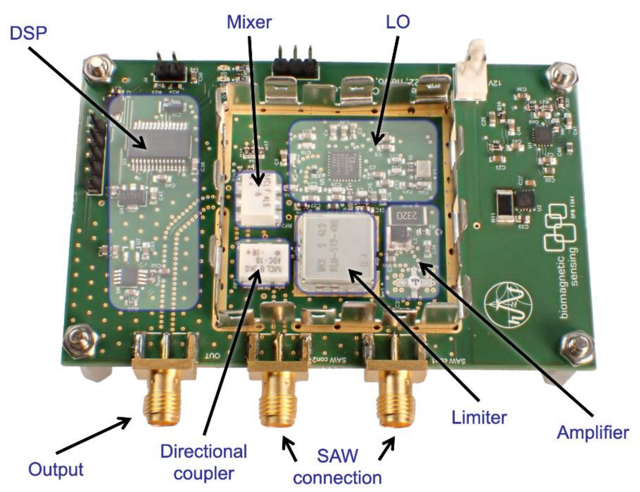




SAW sensor systems for use in arrays

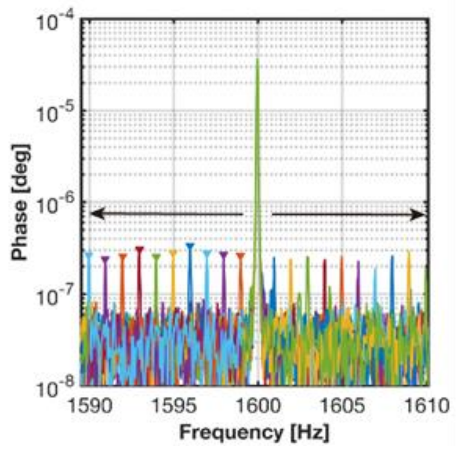
[B1-5] Compact LOD optimized electronics for evaluating SAW sensors

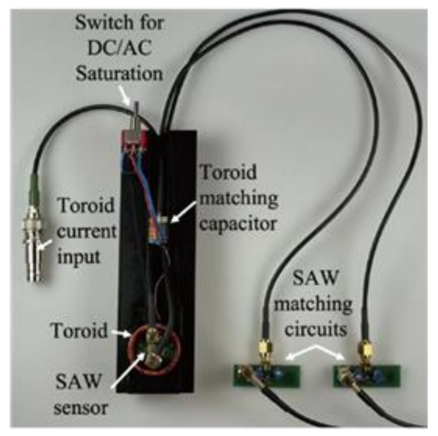




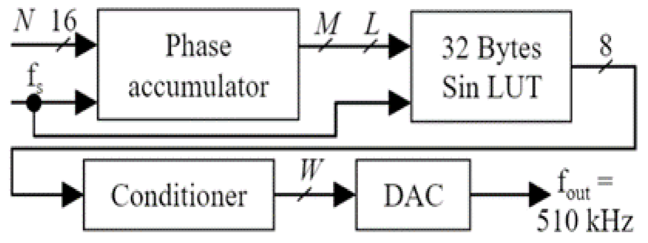
Chopping Flux Modulation: A Preliminary Study

[B1-3] Mag. flux modulation approach from low to intermediate frequency to avoid the flicker noise and artifacts but dealing with magnetic losses

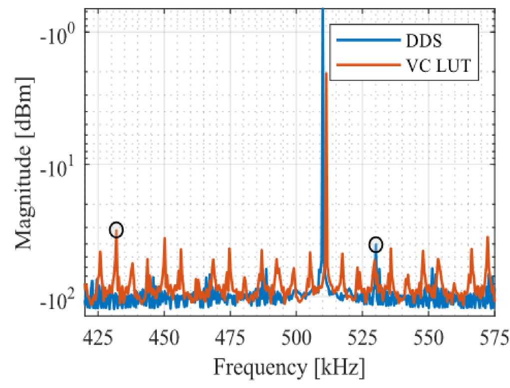




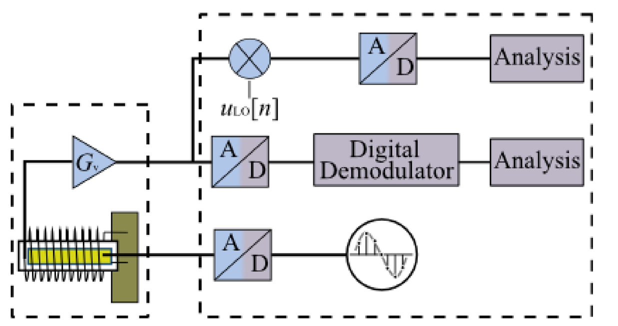
DDS Signal Generator Implemented in a FPGA

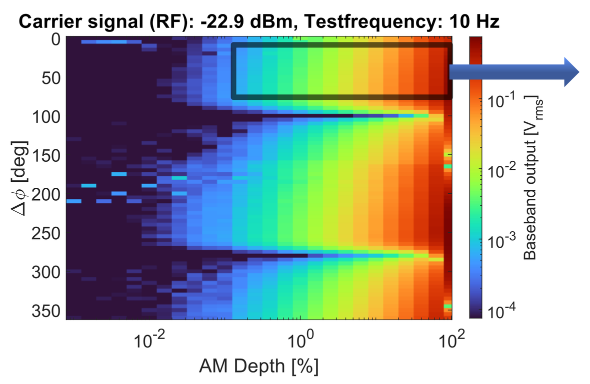


FPGA and ASIC alternative for high frequency resolution



In-depth analysis on demodulation techniques for converse effect ME sensors

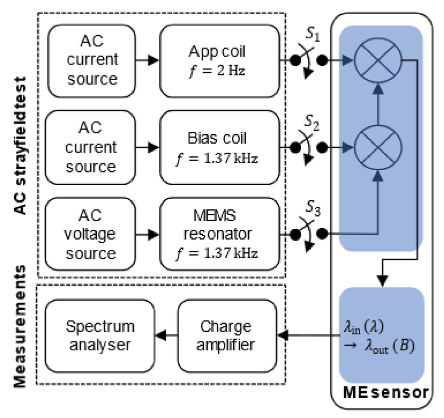


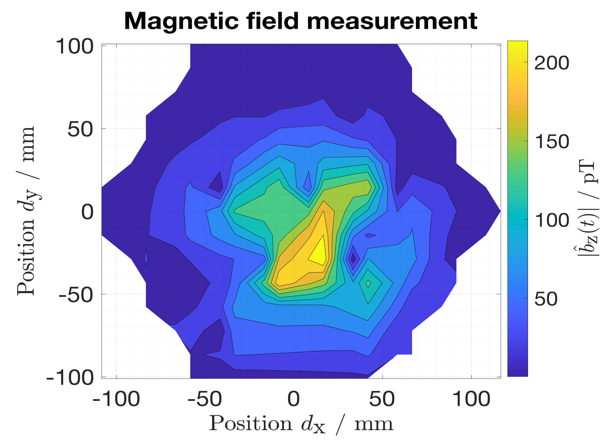


Challenge! Dynamic range of ME sensor approx. 98dB (LOD equivalent to a modulation index of 0.2%) [Z2]

Direct digitization would require an ADC with a dynamic range of approx. 120 dB and 140 MSPS

MEMS Magnetic Field Flux Generator

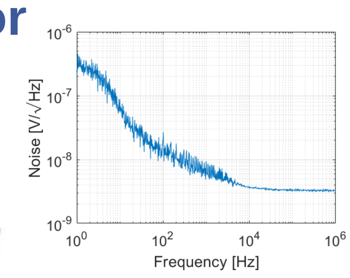


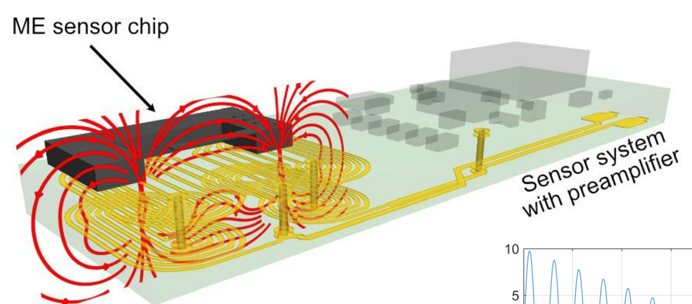


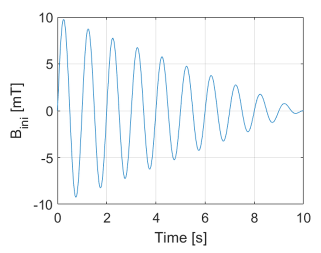
[B1-6] MEMS used on frequency conversion approach, further characterization for future application using SQUID (VMS-304, PTB-Berlin)

Work Plan for Third Funding Period

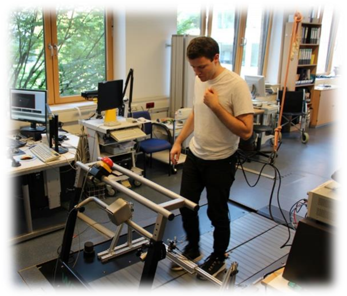
WP1: Experimental and theoretical analysis of sensor system noise performance

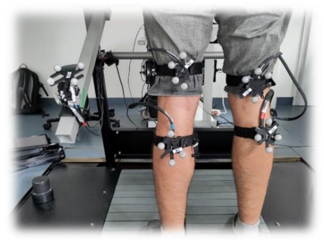




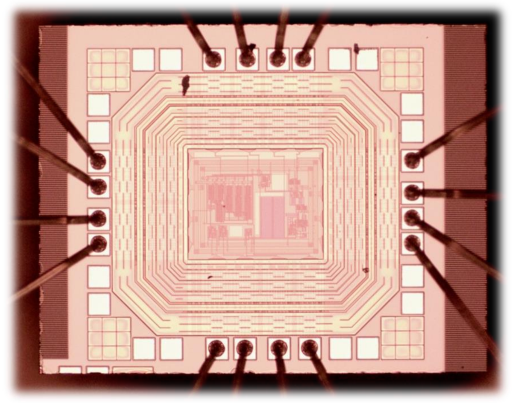


WP2: Research on concepts for sensor and sensor system conditioning

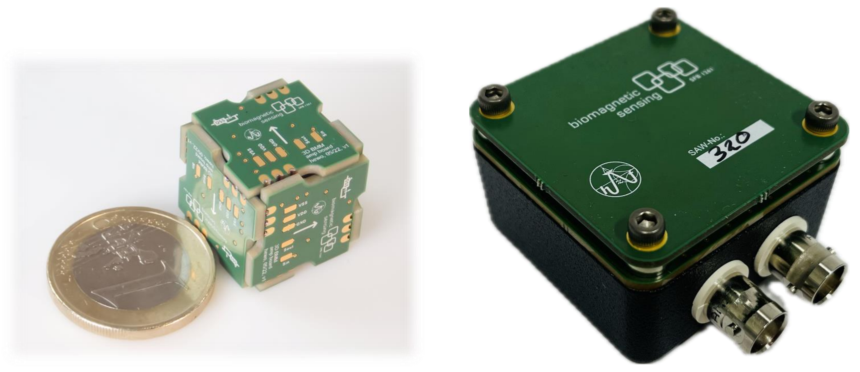




WP3: Enabling sensor systems to operate in unshielded environments



WP4: Advancing our research on analogue front ends for the realization of application specific sensor systems



WP5: Providing array-capable hardware

Workplan	2024		2025				2026				2027				2028	
	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2
WP1:																
WP2:																
WP3:																
WP4:																
WP5:																

(Main work done by: blue: Prof. Höft, red: Prof. Rieger, violet: both)

Collaborations

A1: Investigation and characterization of magnetic noise
A2: Low-noise amplifiers, determination of sensor noise performance
A4: MEMS cantilever samples ↔ fitted electronic circuits
A7: Readout electronics/noise model for EFC and inductive readout
A8: Noise models → more general multiscale numerical modeling
A9: Measurement to arrive at highly detective SAW sensors
A10: Investigation and characterization of magnetic noise
B2: Optimal interface between analogue and digital signal processing
B9: Amplifiers for wearable sensor systems and multidimensional sensors
B10: Sensor front ends for cardiologic applications
B11(N): Dedicated amplification boards and sensor calibration procedures
B12(N): Readout electronics developed in close interaction
B13(N): Analog excitation electronics for the MEMS magnetic probe
Z1: Reception of ME cantilever sensors for noise investigations
Z2: Transfer of research results for sensor system electronics

Participation in focus groups

F2: Modelling; F3: Comparison of Sensor Concepts; F4: Magnetoelectric Sensors; F5: Concepts based on ΔE effect

Funds Requested

2 Doctoral researchers, consumables: 60.5 k€

[B1-1] Wolframm, H., Hoffmann, J., Burgardt, R., Elzenheimer, E., Schmidt, G., & **Höft, M.** (2023). Current Directions in Biomedical Engineering. - **B1, B9, Z2**
[B1-2] Durdaut, P., & **Höft, M.** (2023). Sensors. - **B1**
[B1-3] Wang, H., Arbustini, J., Elzenheimer, E., Schell, V., **Höft, M.**, Quandt, E., ... & Bahr, A. (2022, October). 29th IEEE International Conference on Electronics, Circuits and Systems (ICECS). - **B1, A9, Z2**
[B1-4] Muñoz, J., Arbustini, J., Elzenheimer, E., **Höft, M.**, & Bahr, A. (2022, October). 2022 29th IEEE International Conference on Electronics, Circuits and Systems (ICECS). - **B1, Z2**
[B1-5] Wolframm, H., Schell, V., Quandt, E., **Höft, M.**, & Bahr, A. (2022, October). In Spintronics XV. - **B1, A9**
[B1-6] Arbustini, J., Muñoz, J., Wang, H., Elzenheimer, E., Hoffmann, J., Thormählen, L., **Höft, M.**, ... & Bahr, A. (2022, September). Current Directions in Biomedical Engineering. De Gruyter. - **B1, B9, A1, Z2**
[B1-7] Simmich, S., & **Rieger, R.** (2022, June). 2022 17th Conference on Ph. D Research in Microelectronics and Electronics (PRIME). - **A4**
[B1-8] Simmich, S., Bahr, A., & **Rieger, R.** (2021). Electronics. - **A4**
[B1-9] Simmich, S., Wiegand, P., & **Rieger, R.** (2023) IEEE Asia Pacific Conference on Circuits and Systems. (accepted paper). - **A4**
[B1-10] Wolframm, H., & **Höft, M.,** filed at the European Patent office at 20th Feb. 2023. - **B1**
[Z2] Elzenheimer, E.; Bald, C.; Engelhardt, E.; Hoffmann, J.; Hayes, P.; Arbustini, J.; Bahr, A.; Quandt, E.; **Höft, M**.; Schmidt, G: Sensors, (2022). - **B1, B2, B9, B10, A7, Z2**