Compact Metamaterial based Coil-Element for Combined $^1$H/$^{23}$Na MRI at 7 Tesla

Jan Taro Svejda, Andreas Rennings, and Daniel Erni

General and Theoretical Electrical Engineering (ATE), Faculty of Engineering
University of Duisburg-Essen, D-47048 Duisburg, Germany

The Metamaterial Transmission Line

- Composite right-/left-handed (CRLH) transmission line
- Enabled design of dispersion characteristics
The Utilized Unit Cell

- Augmented microstrip line:
  - Series MIM capacitor
  - Shunt coaxial stub line
    - Inductive impedance below quarter wavelength
    - Capacitive impedance above quarter wavelength

Dispersion Characteristics

- EC: $\alpha$
- Sim.: $\alpha$
- EC: $\beta$
- Sim.: $\beta$

OP of $^1$H

OP of $^{23}$Na
Simulation Results

- FDTD Simulation with EMPIRE-XPU
- Congeneric current and field distributions

Prototype within Housing

dual-tuned matching network
open circuit termination
short-circuit termination
polycarbonate housing
**Setup of MRI Experiment**

- **23Na TX/RX switch**
- **1H channel**
- **Diplexer**
- **BTSL phantom**
- **CDRA element with housing**

**Results of MRI Experiment**

3D gradient echo, $T_1$=50ms, $T_2$=2ms, 4.7mm slice thickness, Average of 4 samples in case of 23Na
Conclusion

- Prototype of dual-resonant coil-element proposed
  - For combined $^1$H/$^{23}$Na MRI
  - Utilizing CRLH dispersion characteristics
- Similar field distributions at 79MHz and 298MHz
  - Good results with Hydrogen
  - Lower SNR in case of Sodium
    - Lower Concentration
    - Resistive losses in coil element
- Low coupling between elements
  - Reduction of losses in coil-element
  - Multichannel array arrangement

Thank you for your attention