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MRS noise investigations with focus on optimizing the measurement setup in the field

Introduction

➢multi-channel MRS equipment allows for harmonic noise compensation (HNC) by using remote reference loops for simultaneous noise measurements (Walsh, 2008; Dalgaard et al., 2012; Müller-Petke and Costabel, 2012)

➢Usually, reference loops of similar sizes are preferred, which doubles the effort in the field

➢Investigations are conducted at different test sites (varying noise conditions) with focus on approaches to minimize effort in the field (Fig. 1)

➢Minimizing time and effort in the field enables increase of measurement progress for 2D, 3D, and monitoring experiments in the future

Figure 1: Small handy loops for MRS noise measurements (Standard equipment of MRS MIDI, Radic Research)

Decreasing reference loop size

➢Idea: decreasing reference loop size (and increasing number of turns) to minimize effort in the field

➢Loop layout at the test site Brädikow (near Nauen, East of Berlin, Germany), measurements with NUMIS Poly (Fig.2):
- MRS loop: 47m diameter, 2 turns
-1. Reference loop: 47m diameter, 2 turns
-2. Reference loop: 10m square, 21 turns
-3. Reference loop: 4m diameter, 56 turns

➢Loops work similarly well, except for the smallest pulse moments (Fig. 3)

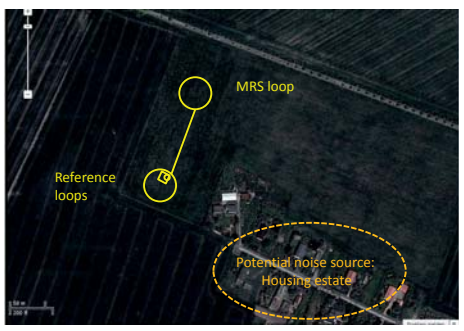


Figure 2: Loop layout for MRS measurements with reference loops of various sizes at the test site Brädikow.

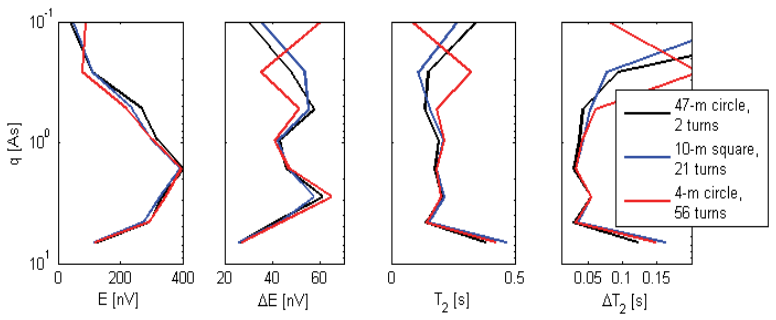


Figure 3: Results of MRS measurements in Brädikow after applying HNC using reference loops of various sizes.

Using x and y components of the EM field:

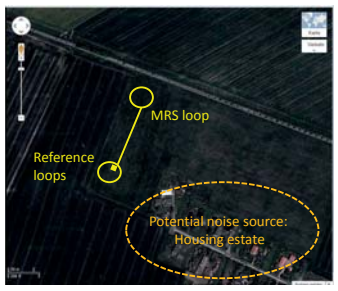
➢Idea: z component of EM field is linear combination of x and y components, thus usage of small handy loops for measuring x and y components could be sufficient

➢Comparison of two example testsites (near Nauen, East of Berlin, Germany):
1. Brädikow, noise consists mainly of 50-Hz multiples (from housing estate nearby, Fig. 4)
2. Barnewitz, noise consists mainly of 16.7-Hz multiples (from railroad in a distance of 3.5 km or rotary current of power line nearby, Fig. 4)

➢Same loop layout for both sites, measurements with NUMIS Poly:
-MRS loop: 47m diameter, 2 turns
-1. Reference loop: z-comp. 47m diameter, 2 turns
-2. and 3. reference loops: x,y-comp. 1m square, 140 turns

➢As expected, z component works better in the vicinity of the noise source, in the far field x and y components should be preferred (Fig. 5)

➢Using all EM field components leads generally to best results (Fig. 5)



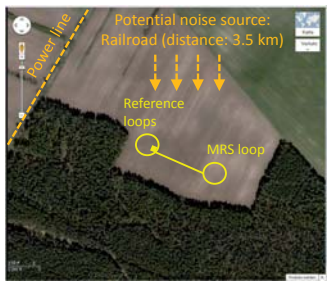


Figure 4: Loop layout for MRS measurements with reference loops for all EM components at the test sites Brädikow (top) and Barnewitz (bottom).

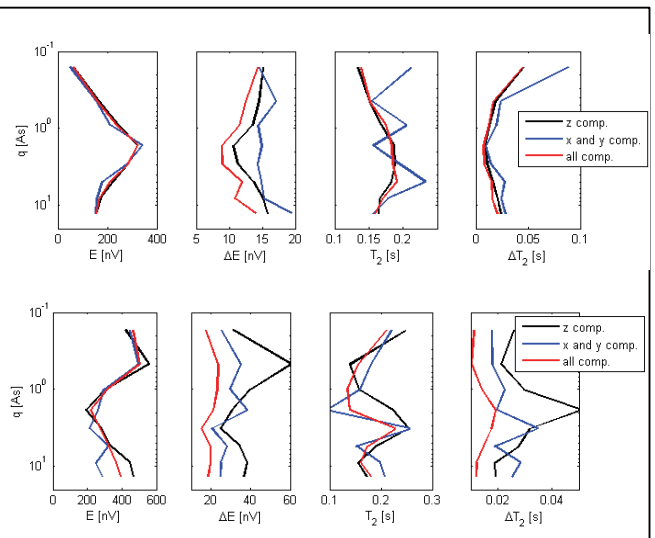


Figure 5: Results of MRS measurements in Brädikow (top) and Barnewitz (bottom) after applying HNC using reference loops of different orientation.

Accounting for more than one noise source

➢Experiment: simultaneous noise measurements using three Channels (only z component), each reference loop towards a potential noise source, measurements with MRS MIDI

➢Loop layout:

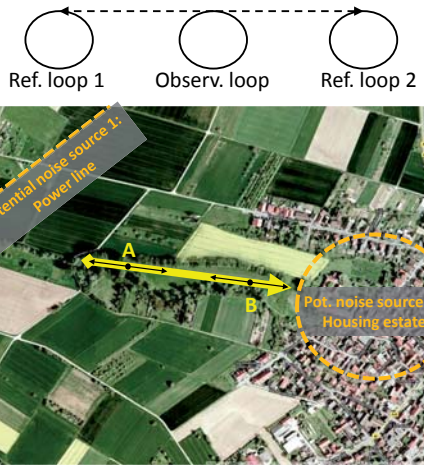


Figure 6: Noise measurements at the test site Weilbach near Mainz, Germany.

➢Movement of reference loops towards noise sources (Fig. 6)

➢ Comparison of remaining magnitudes for certain frequency bands after applying HNC (Fig. 7)

➢Consideration of two observation points and increasing distance of reference loops

➢With increasing distance of ref. loop(s) the coherence gets lost more and more, i.e. the resulting noise level increases

➢Noise source 1 (power line) has major effect, however, HNC using both reference channels leads to best results

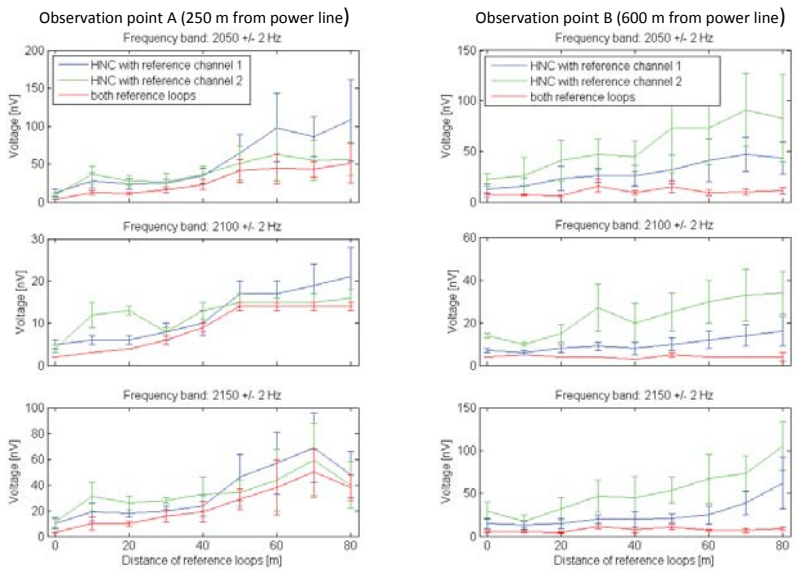


Figure 7: Results of applying HNC to pure noise measurements, y-axes show magnitudes of certain frequency bands near Larmor frequency, x-axes show distance of reference loops from observation points A (left) and B (right).

Conclusions

➢Reference loops of smaller sizes than MRS measurement loop can lead to similar results like using same size, if number of turns is adequately increased

➢Measuring x and y components of the EM noise leads to better results than z component, if the noise source is far away (far field conditions)

➢Using all three components of EM field leads to best results, no matter if noise source is close by or far away

➢When the measurement location exhibits more than noise source, each source should be accounted for with correponding reference loop

➢Time and effort in the field can be minimized by using small reference loops

References

➢Walsh, D. O. (2008): Multi-channel surface NMR instrumentation and software for 1D/2D groundwater investigations. Journal of Applied Geophysics, 66, 140-150.

➢Dalgaard, E., Auken, E. and Larsen, J. (2012). Noise cancelling of multichannel magnetic resonance sounding signals. Geophysical Journal International. In print.

➢Müller-Petke, M. and Costabel, S.(2012). A comparison of harmonic noise cancellation concepts. Proceeding of the 5th international meeting on Magnetic Resonance.