A comparison of harmonic noise cancellation concepts

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Using multi-channel MRS equipment allows for cancelling harmonic noise from MRS data (Walsh, 2008). In addition to the MRS measurement loop, one or more reference loops are placed in an appropriate distance (remote reference) to measure the noise simultaneously. In the post-processing of the data, the electromagnetical (EM) transfer functions (TF) of the reference loop(s) to the measurement loop are calculated and used to predict the noise part in the MRS signal channel. Finally, the predicted noise trace is substracted from the measured signal, which leads to a significant cancellation of the harmonic noise.

The quality of the noise cancellation (NC) depends on several factors that we have investigated. We distinguish between practical parameter to be optimized in the field as presented in Costabel and Müller-Petke (2012) and theoretical aspects present in the following.

1. There are different approaches to calculate the TF. For instance Dalgaard et.al. (2012) investigated the differences in time domain using Wiener filtering compared to adaptive filter. We present a comparison of TFs in the time domain and frequency domain.

2. The stability of both the filter (i.e. the stability of the inverse problem) and the harmonic noise over the measurement time. We present two different approaches in the frequency domain. A global approach taking all available measurements into account and a local approach calculating the TF using only one measurement.

3. The complexity of harmonic noise. We distinguish between one source of noise with its higher harmonics and random distributed harmonics.

4. If the harmonic noise is significantly changing with time it is necessary to calculate the TF using the measurement that contains the signal instead of using the pure noise record.

We show how this influences the quality of NC, especially if the NMR frequency is close to a harmonic noise frequency.

In conclusion we show that the local frequency domain approach will be appropriate for most practical cases.

References

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