

Removing Harmonic Noise from Geophysical Surface Nuclear Magnetic Resonance Measurements

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What is Nuclear Magnetic Resonance?

- Geophysical method adapted from common chemistry technique.
- Nothing to do with nuclear fuels or fission.
- Detects groundwater.



Introduction

Methods

Results

Conclusions

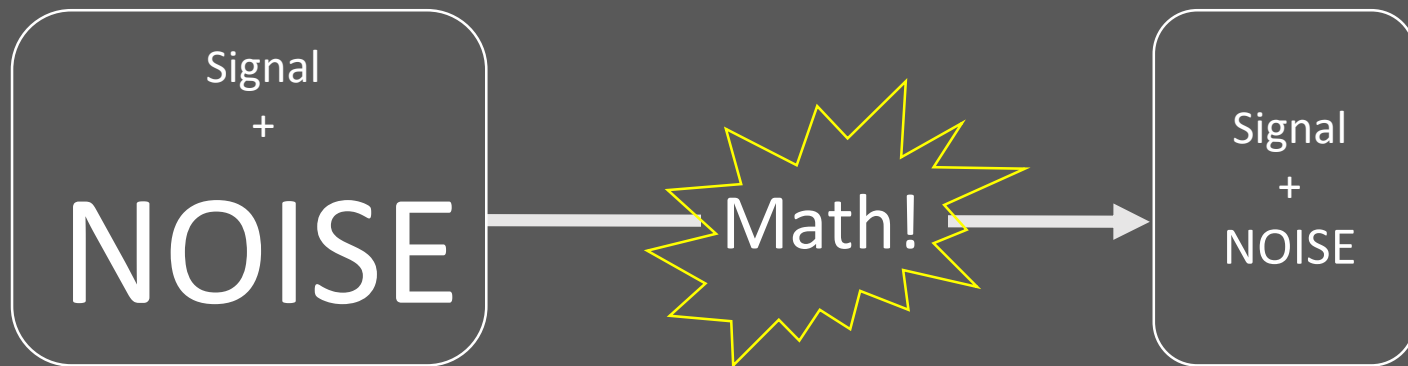
Why do we care?

- NMR produces point soundings (water content as a function of depth) from a surface measurement. [5]
- Useful for hydrologic studies, and can replace expensive wells.
- Not widely used because electromagnetic noise (generators, powerlines, etc) hinders the measurement. [1,7]



Signal processing basics

- Signal: what we're trying to measure; the groundwater response
- Noise: everything else we measured; lightning, electric fences, powerlines,
- Processing problem:



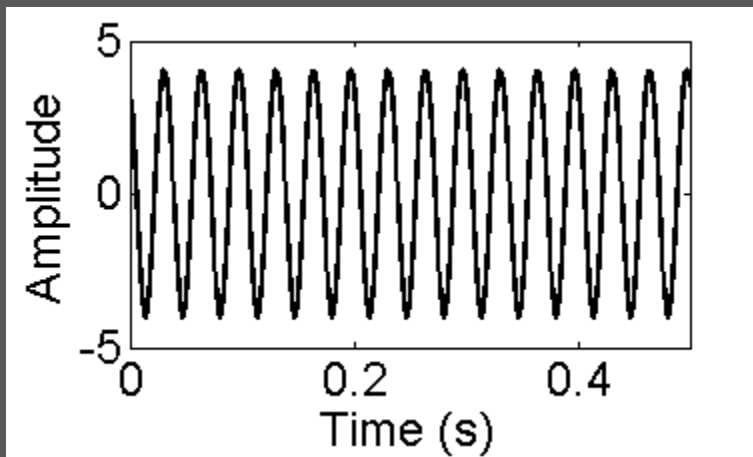
Removing powerline noise

- Most published approaches use knowledge about the noise to subtract it. [2,3,4]
- My approach uses knowledge about the signal to separate the noise.
- Focuses on powerline harmonics, one of the most common noise sources.

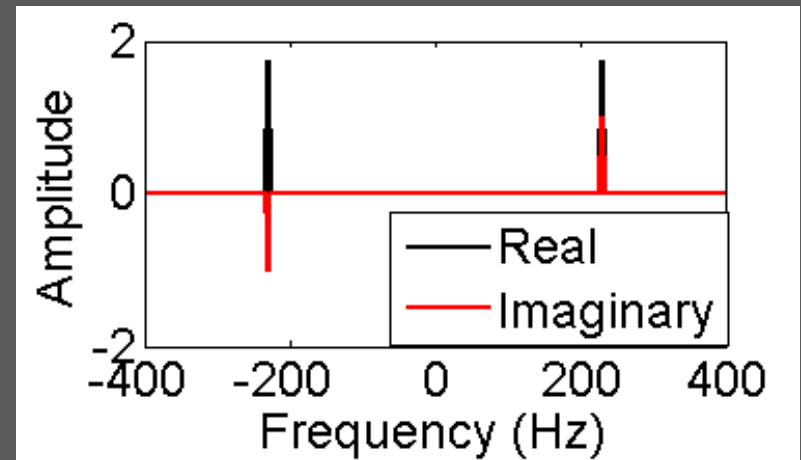


Powerline harmonics

Time domain



Frequency domain



Introduction

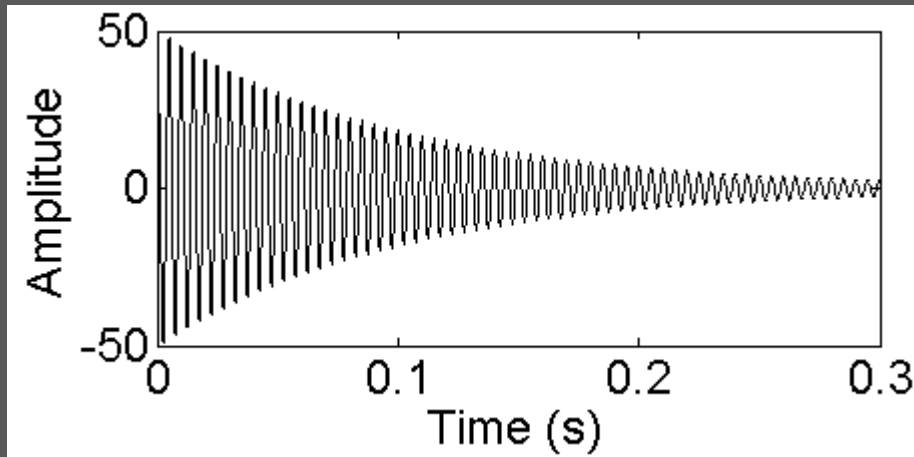
Methods

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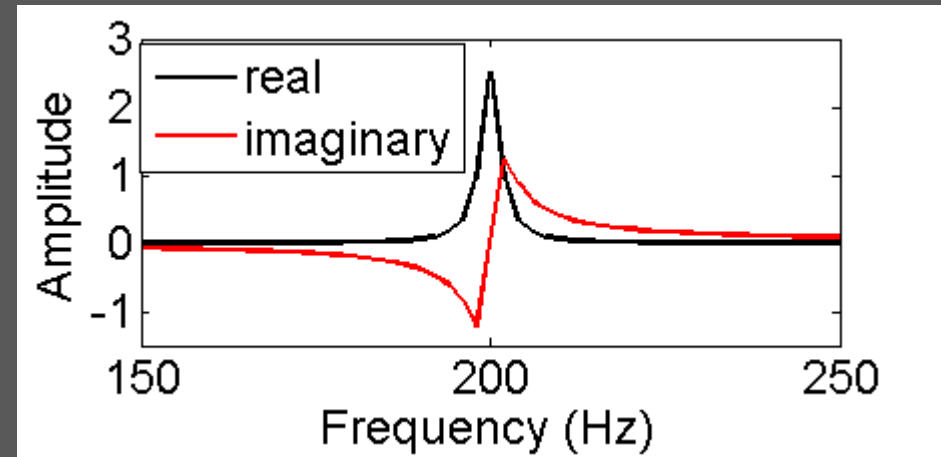
Conclusions

Conceptual NMR water signal

Time domain [5]

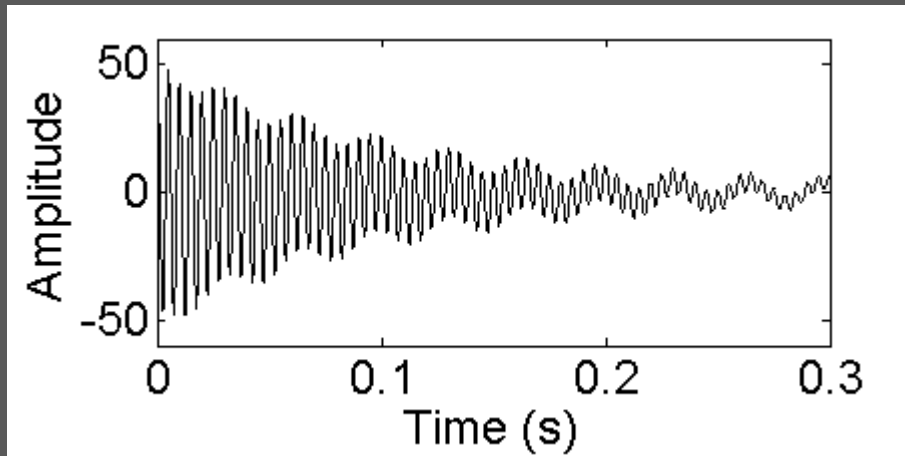


Frequency domain

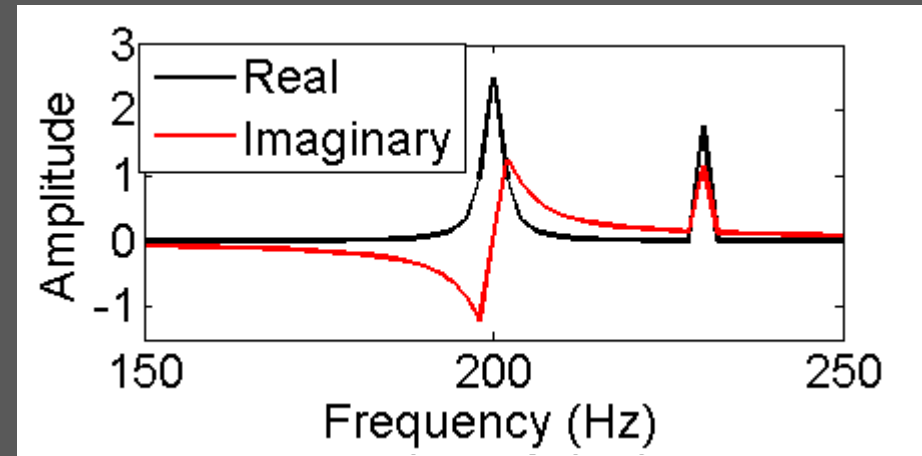


Removing powerline harmonics

Time domain



Frequency domain



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Symmetry based noise removal

- Transform NMR data into the frequency domain.
- Identify and remove corrupted portions of the spectrum.
- Reconstruct the corrupted portions with “mirror image” frequencies from the other side of the spectrum.
- In the absence of other noise, this procedure recovers an uncorrupted signal.



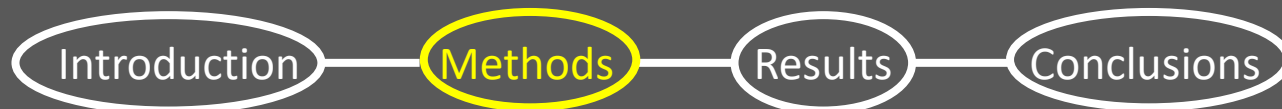
Symmetry based noise removal

Advantages:

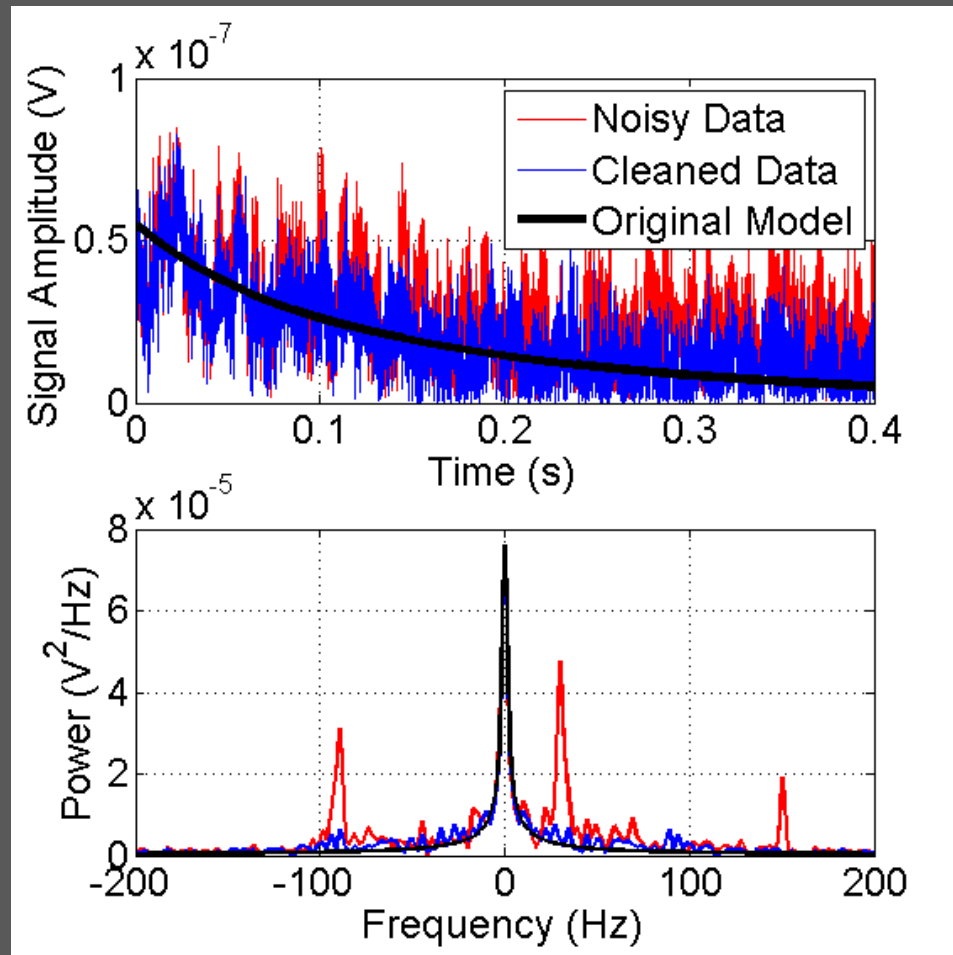
- Simpler than most published methods for removing powerline harmonics from NMR.
- Does not disrupt the dataset
- Requires no prior knowledge about the harmonics.

Disadvantages:

- Will not work in certain special cases.
- Will not work on extremely noisy data.



Modeling results



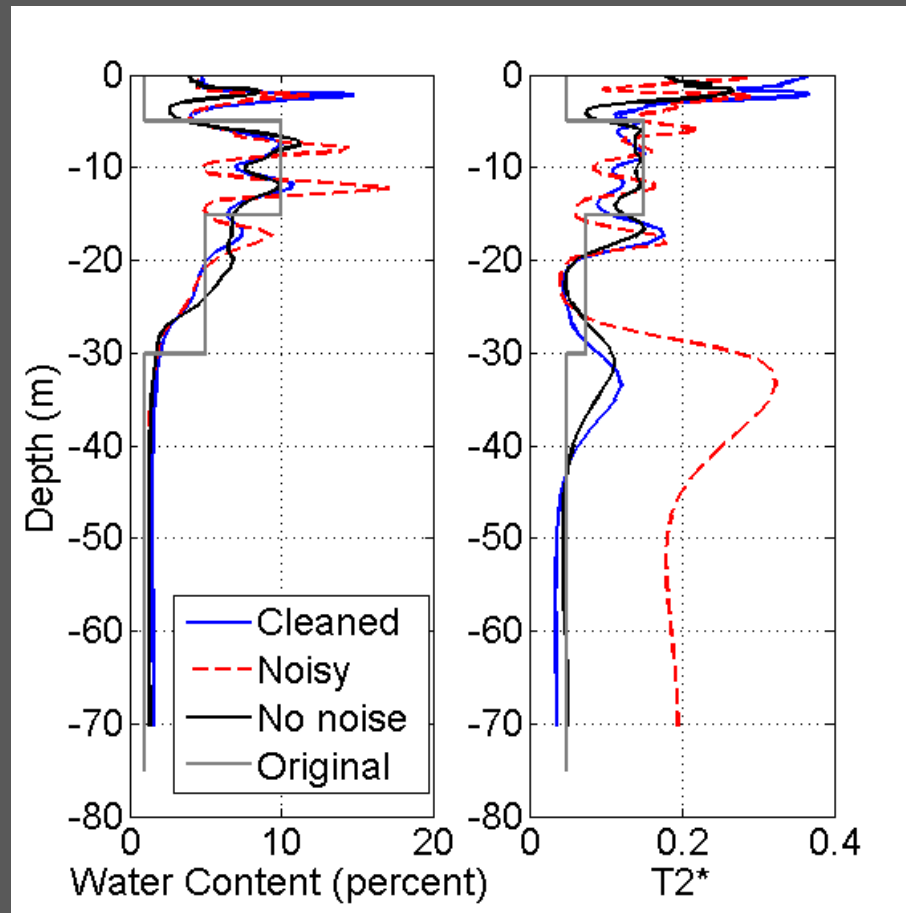
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Modeling results



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Conclusions

- Symmetry based processing removes the powerline harmonics without disrupting the signal.
- It is based on the mathematical theory describing NMR signals and exploits knowledge of the signal.
- When powerline harmonics are removed, the water content and $T2^*$ inversions are more accurate.



Acknowledgments

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Questions?



References

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