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Discussions

Interactive comment on "ArduiTaM: accurate and inexpensive NMR auto tune and match system" *by* Mazin Jouda et al.

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General remarks: This contribution offers a way of automated tuning and matching in NMR and MRI using an open-source hardware and software solution with a single board micro-controller. This maybe a good approach for from scratch new system design and refurbishing of older systems. With current commercial NMR probes we are not sure such a system can help to work around some of the commonly encountered problem, that is mechanical hysteresis and slip of the controller rods connecting the stepper motors to the capacitors. A software that "learns" this non ideal behavior of probes (which is also subject to aging) and can manipulate the actuators more efficiently than a human would be nice. In a production environment (i.e. with high throughput). The method for tuning and matching is not fundamentally "new" as it

relies on the well known rf-responses exploited by current commercial hardware. The speed of the process is apparently better, but it is not clear, if the same goal couldn't be achieved by an adaptive software implementation with existing hardware. Where the proposed solution may be highly beneficial are probes going beyond the current mechanical trimmer capacitor based system using varactors or digital capacitors, as the authors emphasize. NB: I have been looking at the paper mostly from a spectroscopy perspective. Some of my arguments may not apply in an imaging context.

Specific questions and comments: In the "homing routine" for driving the capacitors to their lowest values: How is the stop detected? Steppers do not usually sense that they are stuck and absolute positioning may not maintained when restarting the Arduino. Is there absolute angle sensing on the steppers? Is there a provision against excessive torque being applied? About the steppers: 20 steps per turn sounds like a low number. Could a gearbox be added achieve lower angles. But that could increase the mechanical instability. The first scan of the two capacitors appears to be quite coarse. Depending on the type of probe (high resolution liquids vs. static solids, for example you may to miss the actual minimum (multiply tuned probes may have several minima). How does the algorithm handle the sudden "jumps" when changing the capacitances (as experienced in manual tuning T&M, likely caused by release of torsional stress in long connection rods? This is a big problem, also for commercial systems and is (in my opinion) the reason for suboptimal T&M in existing systems. Could the hardware/software combo be extended to other tuning/matching modalities, like frequency pushing effects or spin noise? [J Mag Res 193 (2008) 153; J Biomol NMR 45 (2009) 241; ChemPhysChem 15 (2014) 3639] Considering the fact that the impedance of the pre-amplifier and the transmission line from the rf-coil to the pre-amp play a major role in high efficiency tuning, the scope of the approach, which apparently requires switching between the envelope detector and the proper detection preamplifier may be applicable to, for example, cryogenically cooled probes.

Conclusion: The paper offers new ideas to approach the practical problems of automatic tuning, but some additional discussion addressing the issues mentioned above would increase its impact. It is probably more of a technology demonstration than purely scientific innovation. In my opinion, the paper will be of largest benefit for researchers designing new probes in the field of imaging and solid state NMR. It may also be a starting point for designing future high resolution / high sensitivity NMR probe systems.

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