HTS Resonators for Use as NMR Transmit Coils

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Introduction

Replacing normal metal NMR coils with thin-film high-temperature superconducting (HTS) coils in cryogenically cooled NMR probes can significantly improve the sensitivity and signal-to-noise ratio (SNR) due to the high quality (Q) factor of superconducting resonators [1,2]. NMR coils are typically used for both excitation and detection, but it is challenging to produce excitation pulses with a high-Q HTS coil that are short enough to excite the large chemical shift dispersion range of ^{13}C. In this project, the RF properties of a HTS NMR coil relevant to ^{13}C NMR excitation were investigated. The experiments were conducted on a double-sided, counter wound spiral carbon coil [3].

Experimental

Continuing our previous experiments on HTS coils we tried improving the excitation bandwidth and reducing the rise-up and ring-down time by adding a shorted stub as shown in Fig.1 to the circuit of over-coupled coil. We found that a stub length of 65 mm met the required transient response for ^{13}C NMR (S in Fig. 1). We varied the distance between the tee and the drive loop by inserting M-M and F-F adapters (D in Fig. 1). The number of adapters was adjusted to maximize the 3 dB transmission bandwidth.

Results and Discussion

By inserting the stub the transmission bandwidth was increased from 51 kHz to about 200 kHz, corresponding to a Q of 700. The pulse response of the modified system is shown in Fig. 2, and the rise and fall time are both significantly improved. τ was reduced to ~ 1.78 μs at 7 dBm. For the two cases of with and without stub corresponding to same current in the coil the 10 % to 90 % time for rise-up changed from 6.1 to 2.5 μs. Respectively, the ring-down time changed from 12.6 to 3.6 μs. As figure 3 shows, the stub insertion can also reduce the phase transients at the beginning and end of the pulse. Phase transient is caused by the deviation in the phase of the RF current during the ring up and ring down.

Acknowledgements

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References

[1] Ramaswamy, V., *et al.*, eMagRes, **2**, 215–228 (2013).
[2] Hill, H.D.W., *et al., IEEE Trans. Appiled Supercond.*, **7**, 3750–3755 (1997).
[3] Ramaswamy, V., *et al.*, J. Magn. Reson., **235**, 58–65 (2013).

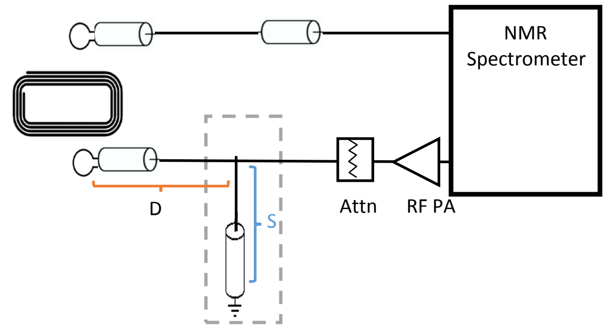

Fig. 1. Schematic of the experimental setup. Dotted region shows the shorted stub that was added later between the attenuator and the drive loop. RF PA refers to RF power amplifier.

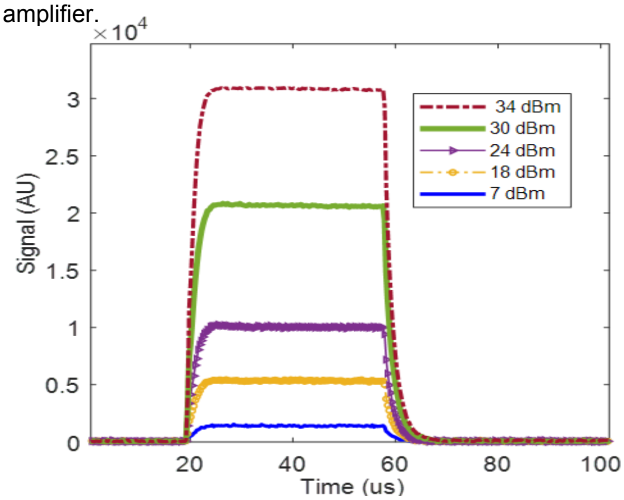

Fig. 2. Signal in the coil as a function of time for various powers when the coil is over-coupled and the stub is added.

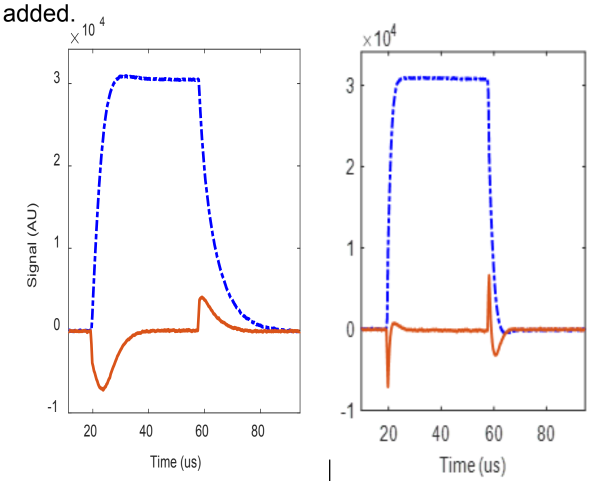

Fig 3. Comparison of the real (blue-dot dash line) and imaginary (red) components of the signal in the coil without stub (right) at 30 dBm and with the stub (left) at 34 dBm.