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Tabletop setup for the characterization of magnetic nanoparticles with magnetorelaxometry and magnetoresistive sensors

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Magnetic nanoparticles (MNP) offer promising biomedical applications like magnetic hyperthermia and magnetic drug targeting. During production, treatment and post-treatment, the monitoring and characterization of MNP is crucial for a safe and efficient use of MNP. There are several techniques available for this purpose. One of them is magnetorelaxometry, where the magnetization dynamics of MNP after a short dc magnetization pulse is measured using highly sensitive magnetometers. Current setups are very costly and require specialized magnetometers. Here we developed a low-cost, tabletop setup using magnetoresistive sensors (AMRs). While exhibiting higher noise than superconducting magnetometers or optically pumped magnetometers, they allow for small target-to-sensor-distances, achieving similar performances at short distances of a few mm.
Our setup (see Figure 1) is composed of a sensor head and an electronics module. The sensor head consists of two magnetoresistive sensors (AMR2501, Multidimension Technology) and an excitation coil for magnetizing the MNP. The electronics module integrates low-noise supplies for the AMRs, a set-reset circuit to re-operate the AMRs a few microseconds after switching-off the excitation pulse of the MNP. Low noise, high gain and high bandwidth amplifiers were developed to amplify the bridge resistor voltage output of the AMRs. The output of each individual AMR is digitized by an ADC on the STM32 microcontroller, forming a software gradiometer for environmental noise suppression. The excitation circuit generates current pulses of up to 3 A, corresponding to excitation pulses of up to 5 mT at 3 mm distance. The 50 kSPS data is sent to a PC over galvanically isolated USB to avoid injection of 50 Hz and high frequency noise from the PC. The whole setup is battery powered to reach a white noise floor of ~50 pT/rtHz in unshielded environments.
With our setup we were able to characterize magnetic nanoparticles with relaxation times in the range of ~1 ms to ~1 s. The iron detection limit is currently being investigated.
We believe our compact, low-cost sensor will facilitate the use of magnetorelaxometry during MNP production and treatment.

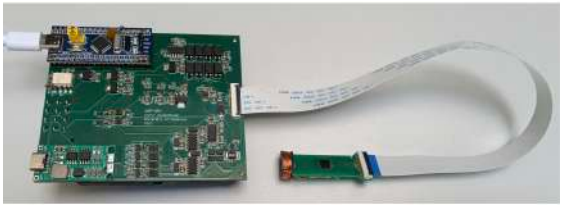

Figure 1: The standalone, compact electronics module (left) and the sensor head (right), which is composed of two magnetoresistive sensors and the excitation coil.

Type:

Poster