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Open-source electronics for magnetically-pulsed free-spin-precession OPMs

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Operating optically pumped magnetometers (OPMs) in unshielded environments is challenging. The sensors need a high dynamic range of at least several 100 nT to not be saturated by environmental noise (e.g. Mains noise), and a bandwidth of at least 1 kHz in order to avoid aliasing effects. Further, a multichannel system is often desired to allow for model-based spatial noise removal. We aim in developing open-source electronics to allow for low-cost multichannel OPM systems. A magnetically-pulsed free-spin-precession (FSP) magnetometer is well suited for unshielded operation. Compared to Mx-OPMs, FSP-OPMs operate without lock-in-amplifiers, avoiding phase-shift problems. While pulse-train-operated optically-pulsed systems are magnetically silent and show promising sensitivities in well-controlled environments, their sensitivity strongly degrades if the temporal magnetic field gradient is high with respect to the sample rate. This is found e.g. during the first instants of the relaxation in magnetorelaxometry of magnetic nanoparticles or in situations with high frequency noise contributions. In such cases, magnetic pulsing can be favorable.
Our OPM head consists of a microfabricated Cs cell with Indium-Tin-Oxide (ITO) heaters (Leibniz IPHT Jena), a 895 nm, 0.2 mW VCSEL Diode (L895VH1, Thorlabs), a lens, linear polarizing sheet, a quarter-wave plate, a photodiode, and a prepolarization coil. Our electronics is composed of a low-noise 3 mA constant-current driver with a 7-bit digital setpoint, pulsed coil drivers for driving the prepolarization coils, the ITO heater and the laser heater. Further it consists of a multi channel PT100 and PT1000 readout electronics for measuring the cell and laser temperature, a transimpedance amplifier with 300 kHz bandwidth, and ADC board with 24-Bit resolution and 1 MSPS.
The laser driver has a current noise of approx. 50 pA/rtHz, while the transimpedance amplifier has a noise floor of approx. 30 pA/rtHz.

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