A pulsed vector optically pumped magnetometer operating in the SERF regime

Joonas Iivanainen[1], Kaleb Campbell[1,2], Bethany J. Little[1], Amir Borna[1], Tony R. Carter[1], Peter D.D. Schwindt[1]

1. *Sandia National Laboratories, 1515 Eubank SE, 87123 Albuquerque, USA*
2. *Department of Physics and Astronomy, University of New Mexico, 1919 Lomas Blvd NE, Albuquerque, USA*

We describe a vector optically pumped magnetometer operating in the SERF regime. By applying short pulses of 795 nm light using a high-power multimode laser diode (2.5 W), we generate spin polarization in a hot ^{87}Rb vapor. We monitor the free precession of the spin polarization by observing the Faraday rotation of a linearly polarized 780 nm probe beam (TA pro, Toptica Photonics AG) collinear to the pump beam [1]. One or multiple components of the magnetic field can be detected by rotating the spin polarization using magnetic field pulse sequences of different designs produced by an H-bridge circuit [2].

Fig. 1A shows a 5-ms pulse sequence used to detect B_y with pump/probe along z-axis. A 25 µs π/2-pulse along y-axis is used to rotate the initial spin polarization from z-axis to x-axis. A π-pulse also along the y-axis is used in the midway of the sequence to rotate the polarization around the y-axis to facilitate demodulation of the probe rotation signal with a bipolar waveform. The demodulated signal is linear with respect to small changes of B_y (Fig. 1B). Sensitivity of ~40 fT/rHz has been achieved (Fig. 1C). We are currently working to reduce the technical noise of the magnetometer.

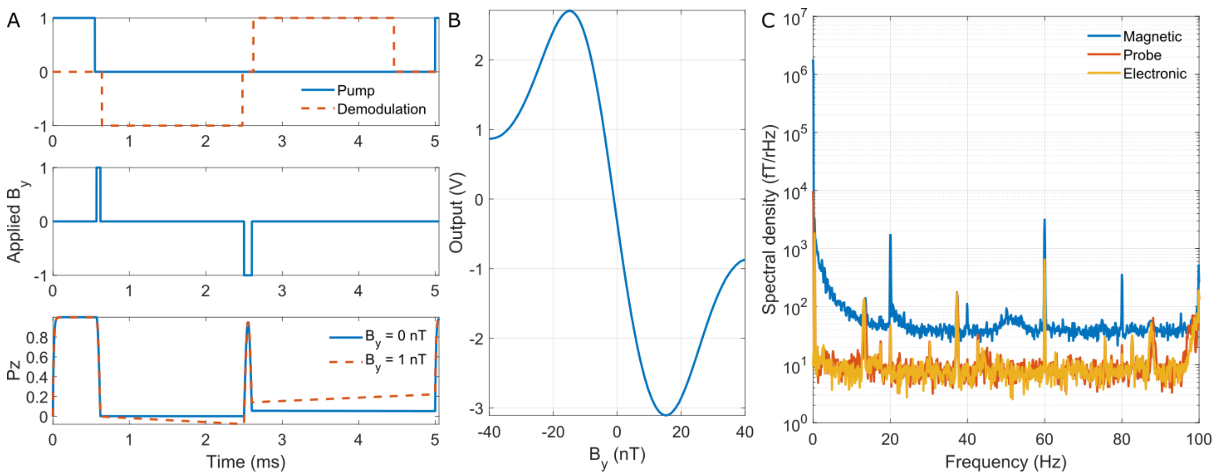

Fig. 1 A: Pulse sequence for measuring B_y. Top two panels illustrate the pump signal, demodulation waveform and the magnetic field pulses along the y-axis while the bottom panel shows the time-evolution of the spin polarization along pump/probe beams. **B:** Measured signal after demodulation as a function of B_y. **C:** Noise spectral density. Magnetic noise is shown as well as the estimated noise contributions from the probe beam and electronics.

References

[1] Colombo, A. P., Carter, T. R., Borna, A., Jau, Y. Y., Johnson, C. N., Dagel, A. L., & Schwindt, P. D. (2016). *Four-channel optically pumped atomic magnetometer for magnetoencephalography*. Optics Express, *24*(14), 15403-15416.

[2] Zhivun, E., Bulatowicz, M., Hryciuk, A., & Walker, T. (2019). *Dual-axis π-pulse magnetometer with suppressed spin-exchange relaxation*. Physical Review Applied, *11*(3), 034040.

Sandia National Laboratories is a multimission laboratory managed and operated by National Technology & Engineering Solutions of Sandia, LLC, a wholly owned subsidiary of Honeywell International Inc., for the U.S. Department of Energy's National Nuclear Security Administration under contract DE-NA0003525.