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Performance study of the vibrating wire technique to determine longitudinal magnetic field profile using measurements to high wire harmonic

A vibrating wire measurement system, deployed in 2023/24 for locating the magnetic center of quadrupoles at the Canadian Light Source, was used recently to study the magnetic flux density of a test quadrupole magnet. Vibrating wire scans up to the n=200 wire harmonic (˜10 kHz drive frequency) were measured in order to reconstruct the magnetic flux density across the length of the wire. The vibrating wire data agreed with a reference Hall probe scan on the order of 5%, with a flat scaling error caused largely by unsteady gain out of the optical switches used to observe wire vibrations. Software macros were developed to systematically process the many wire harmonics for field reconstruction, with exception handling for real-world noise. The stability of the n=10 wire harmonic was also studied with 340 repeated scans spanning multiple weeks, and limitations in the accuracy of the vibrating wire technique for field mapping are reviewed.

In this work, we briefly recap the theory of the vibrating wire technique for magnetic measurement, citing e.g. Temnykh, Wolf, Arpaia, and we describe a new vibrating wire setup at the Canadian Light Source. We measured the B field off-axis of a test quadrupole with both vibrating wire and Hall probe. We compare the reconstructed B field from n=200 vibrating wire harmonics against the reference Hall probe scan; moreover, we compare the Sine coefficients of a Discrete Sine Transform (DST) of the Hall probe scan against the individual vibrating wire harmonics. We present observed changes in the measured wire amplitude/phase profiles, distorted from the typical low-harmonic behaviour, beginning in our case at roughly the n=110 harmonic.

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