Design and Commissioning of Pulsed Wire Magnetic Measurement System for Insertion Device Characterization

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Abstract

Magnets are essential components in the construction of particle accelerators and are used to curve the trajectory of moving charged particles to contain them in a rings or to keep their size within limits. Magnets can also be used to generate light from an electron beam, and these magnets are called Insertion Devices (IDs).
To meet the demand of today's accelerators and users, magnets used in these applications need to comply with strict requirements on their field quality. Therefore, high accuracy magnetic measurement tools needed to made available.

The Pulsed Wire (PW) is a technique for performing magnetic measurements and works by creating vibrations within a wire that correspond to the magnetic field surrounding it. By analyzing these vibrations, we can determine the magnetic field and check its quality before using in an accelerator.

This work was aimed at designing, constructing and testing a pulsed wire system at MAX IV Laboratory which can be used to measure the magnetic fields of insertion devices where access is limited, as this method requires space only for a thin wire and has the potential to change the way IDs are currently constructed and enable designing closed structure IDs with small footprint, reducing their cost and complexity.

The design phase required the construction of a mathematical model that was used for calculating the wire oscillations resulting from the magnetic field and vice versa, a novel method was introduced to for the magnetic field recovery procedure.
An optical wire position sensing unit was designed to offers adjustable sensitivity and range.

The testing involved a full size ID that was previously characterized using traditional magnetic measurement methods and this was used to evaluate the accuracy of the new PW system. Many external factors that influence the measurement were identified and methods for their corrections were introduced. Finally, measurements of the test ID were obtained and compared against the reference data.

The experimental results revealed shortcomings of the mathematical model, as some unexpected behaviors were observed and could not be explained. An experimental method was found to reduce the effect of these anomalies and a more inclusive model is suggested and simulated to try and explain the experimental results.