Magnetic Devices for a Beam Energy Recovery THz Free Electron Laser

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Abstract

This paper presents magnetic devices and numerical simulations on a THz Free Electron Laser (FEL) electron-beam recovery system. FELs have applications in a wide variety of fields due to their special properties of wide tunability, high power, and high brightness. The THz radiation lies above the frequency range of traditional electronics, but below the range of optical and infrared standard generators. This kind of source can be used for research in physics, astronomy, chemistry, biology, medicine, and materials science. The time-domain THz spectroscopy, with its temporal coherence and extremely wide spectral band, continues to expand its scope and range of applications. This work is a contribution for the development of a FEL open facility. This FEL is designed to produce continuous radiation from 0.38 to 1.2 THZ up to a power of 1 kW. The electron beam is produced by a 1.7 MV electrostatic accelerator and, using a beam recovery system, its current reaches 200 mA. The magnetic optical recovery system is formed mainly by dipoles, quadrupoles and an undulator.

The magnetic elements are intended to guide the electron beam and to reinject it in the accelerator (Figure 1). The quadrupole components are composed of four poles formed by rectangular hyperbolas alternating magnetic field with two poles to focus the beam and the other two to defocus it (Figure 2). The undulator is a mechanical structure composed of regular permanent magnets with alternating poles separated by a gap forming a sinusoidal magnetic field. In Figure 3 it is presented the sketch of a hybrid magnet undulator with iron poles exited by permanent magnet pieces.

The simulations of the magnetic elements were performed using COMSOL Multiphysics® software with the AC/DC Module. The numerical models are used to understand the behavior of the magnetic field in the different components (dipoles, quadrupoles and undulator) in order to improve the design of the system.
Special attention is given to the confrontation of the simulation results with the magnetic measurements and the design specifications. The next step is to include the electron beam interaction with the magnetic circuit using COMSOL.

Figures used in the abstract

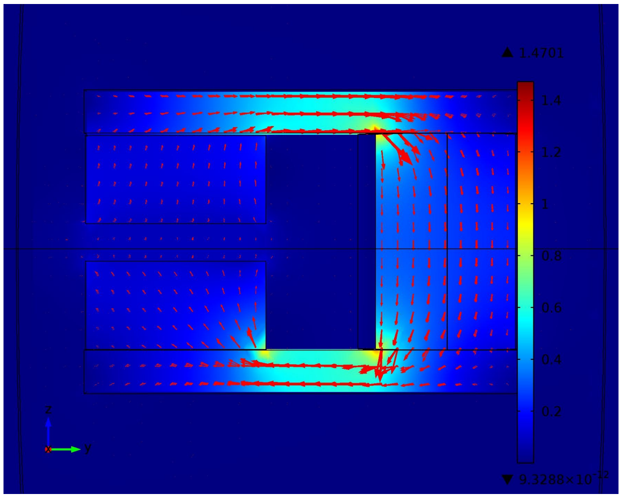

Figure 1: Magnetic Flux density in a dipole magnetic device.

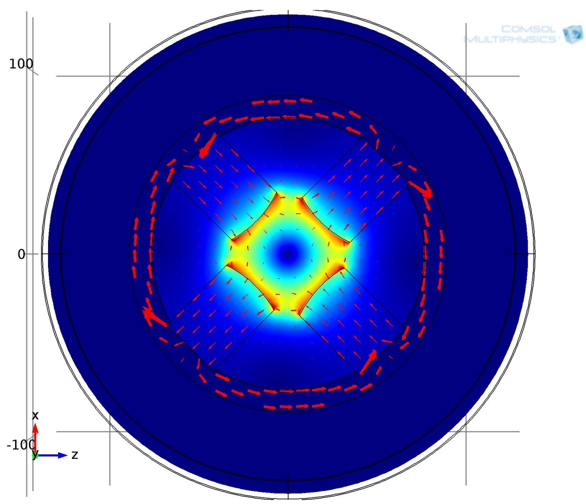

Figure 2: Magnetic Flux density in a quadrupole magnetic device.

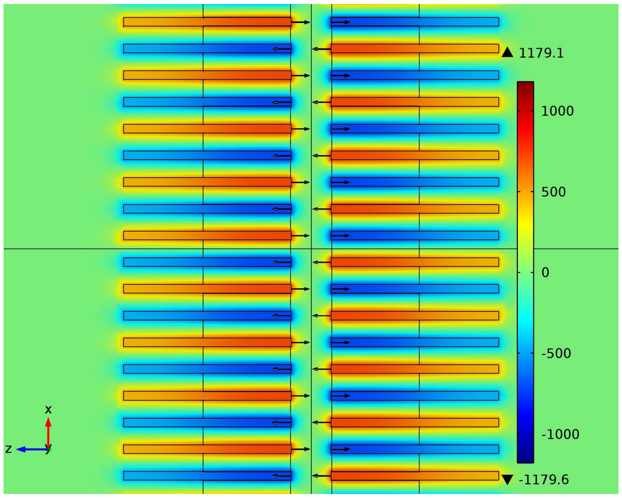

Figure 3: Magnetic Flux density in an undulator magnetic device.