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AUTOMATIC GENERATION OF EMBEDDED AIR COIL GEOMETRIES FOR CUBESAT MAGNETIC ATTITUDE CONTROL ACTUATORS

Abstract

When designing attitude control systems for CubeSats engineers are tasked with the challenge to place magnetic actuators in a volumetric efficient manner. Embedded air coils, i.e. coils inside printed circuit boards that often make up the side panels of CubeSats, are very efficient, when it comes to volumetric efficiency due to their easy integration with the cuboid shape of CubeSats. However, embedded air coils require large uninterrupted areas on those side panels. It is tedious work to lay the coil windings manually due their large number and the fact that they are distributed over multiple internal layers of the printed circuit board. This is especially so when the side panels require a larger number of mounting holes or cut-outs for sensors or mechanisms.

In the scope of the NanoFF mission of the Chair of Space Technology at Technische Universität Berlin we have developed an automated embedded air coil generator. The generator is build around the free and open source electrical design automation tool KiCAD and the Python application programming interface of its PCB layout component. This enables a workflow where the shape of the side panel that was designed in a mechanical computer aided design tool is exported to an intermediate file format and then imported into KiCAD. The generator then detects the outer contour of the side panel, the cut-outs, vias, and keep-out areas that define the printed circuit board. Based on a set of optimization target like the minimum magnetic dipole moment or maximum power consumption and a set of coil parameters like layer count available for the coil, minimum track separation, minimum and maximum track width, and supply voltage an optimized coil geometry that respects the available area on the side panel is found automatically. This geometry is then drawn on a selected set of layers on the printed circuit board where the windings on the different layers are connected by through vias that are also automatically placed.

We present the optimization and coil laying algorithms together with resulting coil geometries for the different side panels on the NanoFF mission. The optimized coils will be shown in pictures and we will do a comparison of the calculated coil properties in comparison to the measured properties on the actually manufactured boards. We will further show simulations and measurements of the resulting magnetic field.