

Popular Science Summary

As society moves towards renewable energy sources such as solar power, battery storage systems, and electric vehicle charging, the number of power-electronic devices connected to the electrical grid continues to increase. While these technologies are essential for the energy transition, they can also introduce electrical disturbances that reduce power quality. To address this issue, electrical filters containing inductors are commonly used.

Most inductors used today contain a magnetic core made of iron or similar materials. These cores help create strong magnetic fields but also introduce disadvantages such as energy losses, increased weight, higher costs, and the risk of magnetic saturation. Air-core inductors address these limitations by eliminating the magnetic core, thereby reducing core-related losses and weight, although they typically require larger physical dimensions. This thesis explores whether this alternative inductor technology could be a practical solution for power-quality filter applications.

The work was carried out in collaboration with Comsys AB and focused on industrial power-quality filter applications. Different air-core inductor designs were studied through calculations, computer simulations, and laboratory experiments. Prototype inductors were manufactured using 3D printing and tested under realistic operating conditions.

The results showed that toroidal (ring-shaped) inductors performed significantly better than traditional solenoid-shaped designs because their magnetic fields remain largely confined within the structure. This reduces unwanted electromagnetic interference while maintaining the benefits of air-core technology. The study also identified design features that improve cooling and simplify manufacturing.

Although air-core inductors generally require more physical space than conventional magnetic-core inductors, they provide highly predictable and linear performance while eliminating saturation effects and core-related losses. The findings demonstrate that air-core toroidal inductors have strong potential for future high-power and high-frequency electrical systems, where efficiency, reliability, and power quality are becoming increasingly important.