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**V. Lysiuk, student**

Chernihiv Polytechnic National University

**B. Pakhaliuk, PhD**

**O. Husev, PhD**

Chernihiv Polytechnic National University

Tallinn University of Technology, Tallinn, Estonia, [bohdan.pakhaliuk@gmail.com](mailto:bohdan.pakhaliuk@gmail.com)

**ANALYSIS OF FERROMAGNETIC SHIELDING PATTERNS IN WIRELESS POWER  
TRANSFER APPLICATIONS USING THE PYAEDT LIBRARY IN ANSYS**

The aim of this work was to create an automated system for numerical modeling and evaluation of the effectiveness of various configurations of ferrite shielding patterns in inductively coupled systems.

Ferromagnetic materials are widely used in wireless power transmission systems, transformers, and inductive components to form and focus a magnetic field. Optimization of the geometry of ferrite structures has a significant impact on the energy transfer efficiency, winding inductance, and the coupling coefficient between the primary and secondary windings. Given the complexity of setting up such processes, the classical approach of manually creating models and running simulations is extremely inefficient and impractical.

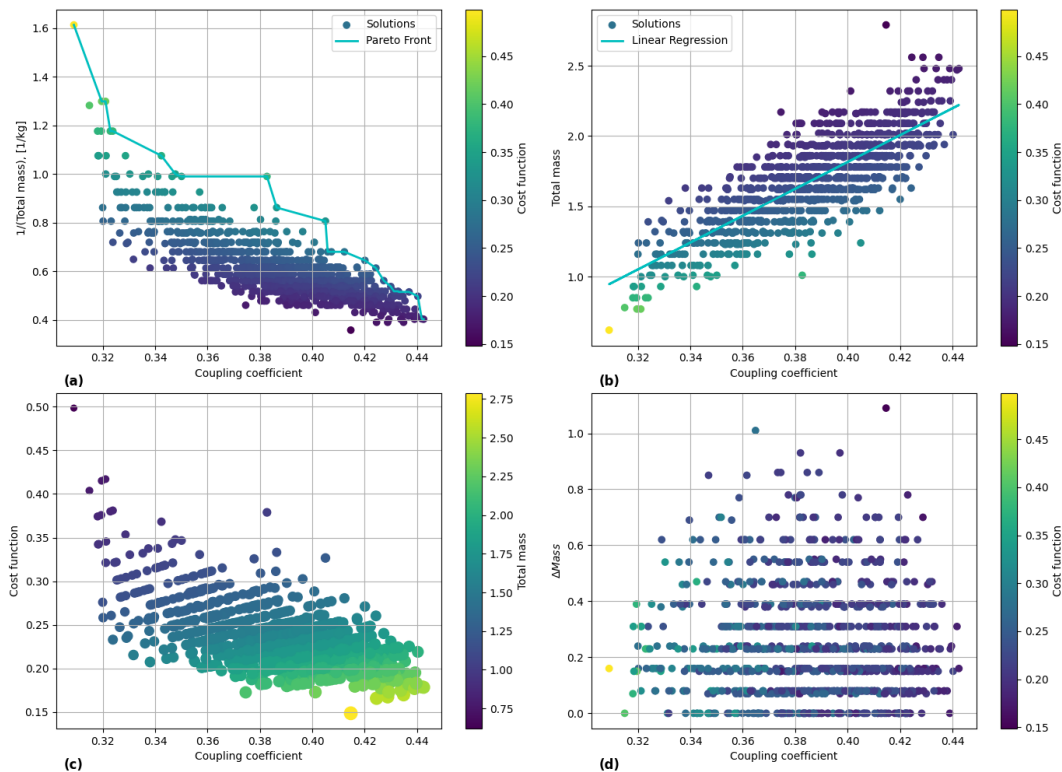


Fig. 1 – Simulation results: a) Coupling coefficient vs inverse of mass relation; b) correlation of total mass and coupling c) coupling coefficient vs cost function d) coupling coefficient vs mass asymmetry

In this paper, we propose an approach with full automation of modeling ferrite structures in the ANSYS Maxwell environment using the PyAEDT library and the Python programming language. Automation extends to creating a project, creating a model according to the parameters previously specified in the code, generating ferrite geometry from pattern files, running simulations, obtaining the results of the coupling coefficient, inductance of both coils, reading the results and building a consolidated data set in the form of a JSON file for further analysis.

### Methodology:

Two-dimensional binary matrices are used to build the transmitting (Tx) and receiving (Rx) structures, where 1 means the presence of a ferrite element, 0 means the absence. Thus, each cell in the matrix indicates the presence or absence of a ferrite block. The generation of such patterns is automated (the dimension of the matrix and the number of patterns are specified), and all patterns are symmetrical.

Each structure is modelled in ANSYS Maxwell 3D using the PyAEDT API. The run is performed taking into account the limitations of the Student version.

The resulting Json file has the following fields:

- `tx_pattern`, `rx_pattern` - ferrite configurations;
- `tx_ferrite_mass_kg`, `rx_ferrite_mass_kg` - ferrite mass;
- `L1_microhenry`, `L2_microhenry` - inductance values for the coils
- `coupling_coefficient` - coupling coefficient.

In Fig. 1.a the abscissa axis shows the value of the inductive coupling coefficient  $k$ , which characterizes the efficiency of magnetic interaction between the transmitter and receiver. On the ordinate axis is the value  $1/(\text{total mass})$ , i.e. the inverse of the total mass of ferrite elements, which is an indicator of the compactness and material consumption of the system. Since lower mass is desirable, higher values on the Y-axis are considered better. The color scale represents the cost function value (coupling coefficient/total mass); lighter points correspond to more desirable solutions. The Pareto front line illustrates the set of optimal solutions.

In Figure 1.b the direct relationship between the total mass of the system and the coupling factor for different solutions is shown. As the mass increases, there is a tendency for the  $k$  value to improve, as shown by the linear regression. This indicates that more massive ferrite configurations are able to concentrate the magnetic field more effectively and increase the mutual inductance.

In Figure 1.c the dependence of the cost function and the coupling factor is shown. Here, the cost function takes into account the efficiency and weight of the system, i.e. combines the desire to achieve a high  $k$  with minimal material use. Higher values on the y-axis indicate less desirable solutions. As can be seen, as the mass increases, the efficiency of the solution decreases. Light colors indicate configurations with higher total mass.

Figure 1.d investigates the effect of mass asymmetry between the transmitting and receiving sides (defined as  $|m_{tx}-m_{rx}|$ ) on the efficiency of inductive coupling. As shown, the level of asymmetry does not show a significant dependence on the coupling coefficient or cost function, indicating that it has a minor effect within the studied configurations. This can be useful in applied design, as it allows for a certain massive disequilibrium without a significant deterioration in system performance.

Top 5 solutions with highest cost function value are shown in Fig. 2.

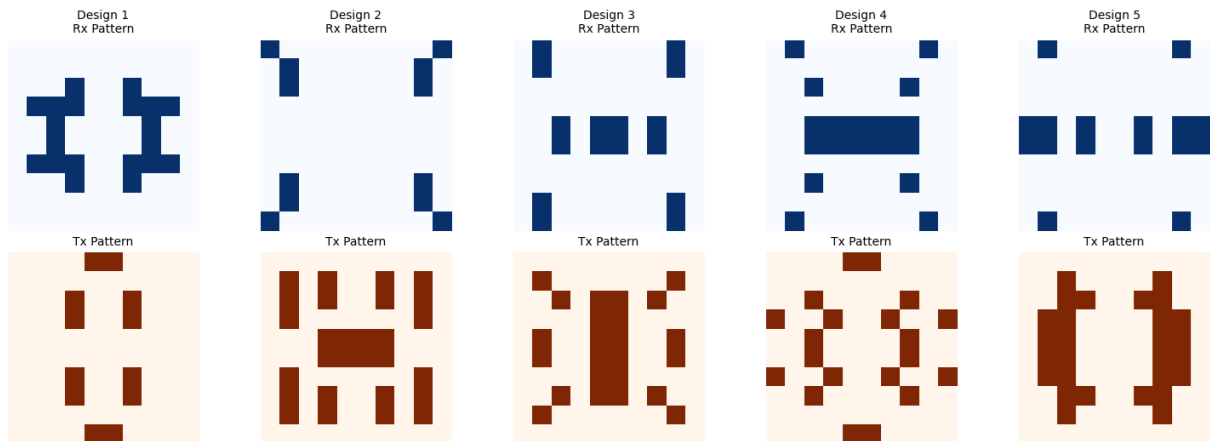


Fig. 2 – Top 5 patterns of transmitter and receiver shielding

The proposed approach significantly speeds up the process of exploring new ferrite topologies. Thanks to automation, hundreds of variants can be easily tested without manual involvement, which allows:

- Quickly test iterative structure improvements;
- Use optimization algorithms (genetic, etc.);
- Prepare the system for integration with a GUI interface, etc.

### Conclusions

Automated modeling of ferrite structures allows for large-scale and efficient investigation of parametric dependencies in inductive systems. The created tools based on PyAEDT and ANSYS Maxwell can be used both in research and in applied industrial design. Further work can focus on inline optimization and the application of machine learning methods for predictive analysis.

### References

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