Magnetic materials are in extensive use for mitigation of Electromagnetic Interference (EMI) and for damping of overvoltages in electronics and electrical power devices. Their working conditions can be divided into two groups. In the first one, the system operates in the linear range, i.e. in the magnetic fields which are far from causing the magnetic material to saturate. These are the commonly used magnetic chokes in low-current devices (low-power electronics). The second group, being in the interest of the present project, are systems operating in the non-linear range. These are systems with high currents, e.g. Gas-Insulated Switchgear (GIS). The magnetic materials can be saturated there even at a single-turn arrangement.

For optimal and cost-effective design of electrical power products, there is a need to model magnetic rings working in specific devices (e.g. in GIS), which is typically performed on the basis of lumped element equivalent circuit (LEEC) approach using a software dedicated for the LEEC simulations (e.g. SPICE, EMTP-ATP). Properly developed models of the magnetic rings enable the selection of the material with the required characteristics (magnetic permeability, saturation value, and their dependence on frequency), and enables the selection of geometry and appropriate amount of material – which has an impact not only on the cost and performance of the ring itself, but also on the cost and reliability of the device in which the ring is used. Therefore, it is essential to investigate and develop new methods of creating appropriate models of the magnetic rings, together with techniques of obtaining necessary measurement data needed to build these models. The aim of this project is to take on this task.

The measurement data being necessary to build the models in question will be derived from two sources. The first one is a conventional impedance analyzer. The second source of data will be gathered from a dedicated measurement stand (developed within the project) allowing to obtain currents of several hundred Amperes in the frequency range from kHz to MHz.

The project will study of a wide range of magnetic rings (nanocrystalline, amorphous, ferrite, basing on rare earths, powder). Due to the challenging algorithmic part of the project, specifically in building of the models based on the oscillating high-current and voltage traces in time domain, the advanced optimization methods will be used, including those based on Machine Learning, being a subfield of modern Artificial Intelligence (AI) methods. The applicability of the resultant model will be verified in simulations of the damping phenomena of very fast transient overvoltages (VFTO) in high voltage GIS stations for different materials and ring arrangements.