Electric drives used in various industries, and especially in the area related to electromobility, are required to meet safety standards. For these reasons, each component of an electric drive should be continuously diagnosed during operation. An interesting issue that is gaining popularity is fault-tolerant control (FTC), which aims to provide on-line diagnostics of the system's operation and its elements, and if a fault is detected, appropriate action is taken to allow the system to continue operating. One of the key components used in electric drives are current sensors, which allow precise control of the electric motor torque using the appropriate feedback loops. Sensors using the Hall effect to measure current are popular due to the capabilities offered, as well as the quality-to-price ratio.

So far, current sensor diagnostics has been based on the use of simple mathematical models that simulated the current sensor's operation and its faulty state. However, the operating principle of this component is more complicated and the mathematical description of the physical phenomena that occur during the measurement itself requires the use of sophisticated mathematical apparatus.

Mathematical models of Hall effect current sensors that take these phenomena into account are used for purposes related to the design of new sensor structures. However, their role has so far ended there, and in the area of current sensor fault diagnosis such models have not previously been used. In this research project, it is planned to extend the existing mathematical models of current sensors to simulate their faults and then use the models developed in this way to generate training patterns for artificial neural networks aimed at detecting and classifying actual current sensor faults.

Within the scope of this project, mathematical models of current sensor faults such as gain error, offset, saturation will be developed, which will take place on the basis of a series of measurements that will be carried out on a test bench built as part of the project. Hall effect current sensors will be subjected to various types of damage (temperature effects, external electromagnetic field interference, change in supply voltage, mechanical damage, overcurrents) and the collected measurement data will be accurately described, catalogued and then made available as open resources. The research outcome of these activities will be to extend the current state of knowledge on the influence of environmental conditions on the performance of current sensors.

Advanced Hall effect-based current sensor models described in the available literature will be used for mathematical modelling of the damage. These models will be expanded to include the ability to simulate individual damages.The simulation studies will be carried out in the MATLAB/Simulink environment, so that the programme code and the models obtained as part of the studies can also be made available to the scientific community. Verification of the correctness of the new damage models thus obtained will take place by comparing the simulation results to experimental measurements using statistical methods.

In the final stage of the research, the newly developed damage models of current sensors will be used to generate training patterns for artificial neural networks, such as multilayer perceptron, LSTM, CNN, whose task will be the detection and classification of current sensor damage. The training process will therefore take place simulation-based using the developed sensor fault models, and verification of the performance of the detection and classification system will take place on a real test bench. Tests will also be carried out under the operating conditions of a permanent magnet synchronous motor drive with faulty current sensors.

The positive results of the research will contribute to an increased knowledge of the nature of current sensor faults, as well as the symptoms of these faults. An important aspect, is also to shorten the training process of neural networks, which usually require a significant amount of training data. The mathematical damage models developed as part of the project will allow the non-invasive generation of training patterns for neural network-based fault detectors and classifiers. This will contribute to a reduction in the costs associated with the training process of artificial neural networks for this type of application, as the simulation model will be able to replace real sensors that do not need to be physically damaged.