Development of a Power and Communication Bus
Using HIL and Computational Intelligence Techniques

Doctoral thesis - Summary

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The main objective of this dissertation is to develop a power and communication bus using Hardware-in-the-Loop (HIL) and computational intelligence techniques. As a result of the research and development work carried out by the author, a Device Lightweight Network (DLN) bus has been proposed, which allows the transmission of data and power using two wires. The developed solution is dedicated mainly to the automotive industry, making it possible to supply power to selected executive and sensory systems of a vehicle while ensuring their communication with the embedded control systems. The dissertation addresses many issues in the field of mechanical engineering, including the construction and operation of modern automotive vehicles. The author focused his attention on various aspects concerning the design of conventional vehicle and battery electric vehicle, including the issue of CO_2 emission reduction. As a result of the literature survey and the analyses conducted, the author justified the need to innovate the cable harness by designing and developing a wholly new power and communication bus. The author has presented analyses confirming that the use of the proposed DLN bus can allow, among other things, a reduction in the weight of a motor vehicle and thus a reduction in CO_2 emissions, both by reducing the materials used in production and the energy consumption during operation. The development of a new power and communication bus was initially an engineering problem. However, the classical approach to DLN bus prototyping failed to develop a method for auto-addressing the modules operating in the network. For this reason, the main research objective of the dissertation was to elaborate a new prototyping method based on the HIL technique supported by computational intelligence algorithms to search for the optimal structure of communication modules, as well as the optimal characteristics of the hardware and software parts of these modules. As it is mentioned above, the desired properties of communication modules, which have a strong influence on the performance of the bus, cannot be found using a classical engineering approach due to the large number of possible combinations of configuration of the hardware and software parts of the whole system. Therefore, an HIL-based optimization method for bus prototyping is proposed, in which the optimization task is formulated

as a multi-criteria optimization problem. Several criterion functions are proposed, corresponding to the automotive objectives and requirements. Different soft computing optimization algorithms, such as a single-objective/multi-objectives evolutionary algorithm and a particle swarm optimization algorithm, are applied to searching for the optimal solution. The verification study was carried out in order to show the merits and limitations of the proposed approach. Attention was also paid to the problem of the selection of the behavioural parameters of the heuristic algorithms. The overall results proved the high practical potential of the DLN, which was developed using the proposed optimization method.

The dissertation resulted in the development of an innovative power and communication bus, which has a high practical and implementation potential from the perspective of DRÄXLMAIER's business. In addition, the author has developed an original method for the prototyping of mechatronic automotive systems based on the HIL technique supported by algorithms of computational intelligence, which has been implemented in the DRÄXLMAIER business and can now be successfully used for the development of new products of the company.