InvEx

Expert-Tool for Power Inverter Development

Kognitive Energiesysteme

J. Steffen, D. Stracke, A. Seibel, F. Schnabel

Contact: Jonas Steffen | Fraunhofer IEE | +49 151 7449-6128 | jonas.steffen@iee.fraunhofer.de

Background

The new development of medium power converters (5 -100 kW) takes about 2-3 years with experienced developers and requires a lot of expert knowledge. Furthermore, the shortage of skilled workers has been increasing for years.

The **InvEx | Expert-Tool for Power Inverter Development** aims to accelerate and automate the development by supporting artificial intelligence. The main objective of the tool is to shorten the development time for control, topology and layout despite the lack of experts.

Overview of the Expert-Tool

- Toolbox for automatic layout and design of power converters
- Several complex topics are covered
- Connection to databases
- Intuitive user interface

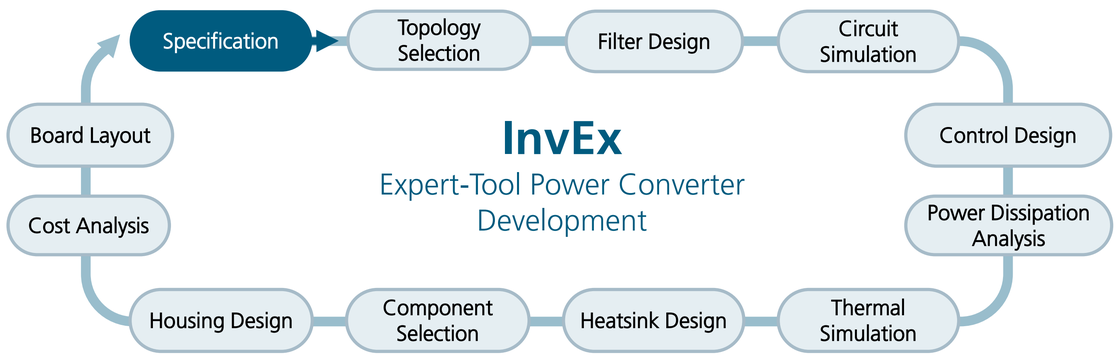

Figure 1: Schematic representation of the Expert-Tool. Main aspects of the converter development process are illustrated. The design of hardware, software and control technology is considered as a comprehensive approach.

Proof of concept

- Automatic design of switching frequency and DC link voltage
- Modeling of a single-phase battery power converter and application of Expert-Tool sub instruments
  - Filter Design
  - Circuit Simulation
  - Power Dissipation Analysis
  - Thermal Simulation
- Application profile of output power and air temperature characteristics
- Evaluation of annual lifetime consumption (LC) and line inductance
- Two-step procedure (according to Dragicevic[1])
  - Transfer of the complex simulation into a substitute model
  - Determination of LC over the year and inductance value

1. Dragicevic, T.; Wheeler, P.; Blaabjerg, F. Artificial Intelligence Aided Automated Design for Reliability of Power Electronic Systems. IEEE Trans. Power Electron. 2019, 34, 7161–7171.

1st Stage | Model Transfer

- Battery converter simulation is very complex
  - Simulation time of 1 s requires approx. 40 min computing time
- 375 parameter combinations of switching frequency f_{sw} , DC link voltage U_{DC}, ambient temperature T_a and instantaneous output power P
- Training of a neural network
- Use of the MATLAB Deep Learning Toolbox

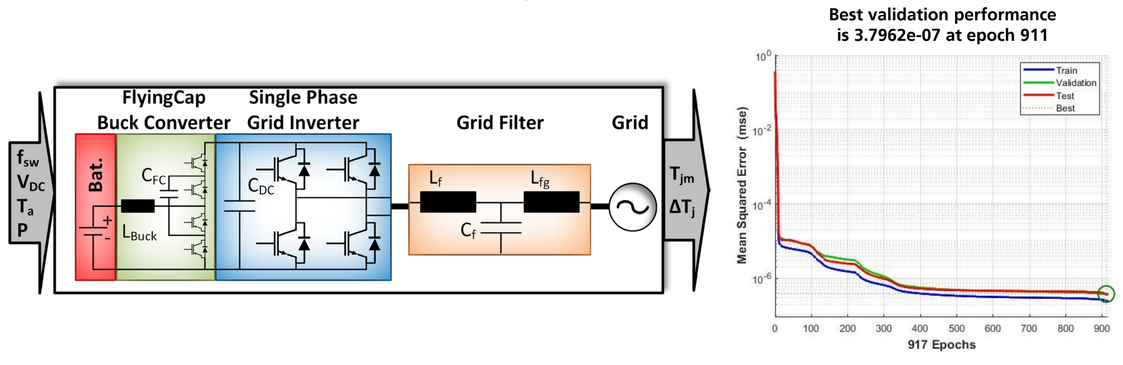

Figure 2: Single-phase battery power converter simulation model with input and output data, and the training results of the representation as a neural network.

2nd Stage | Automatic optimization of the battery power converter design

- Inclusion of curves of primary control demand and ambient temperature over one year
- Usage of the neural network of the battery power converter to calculate the annual trends
- Optimization for inductance and lifetime consumption
- Evaluation via a fitness function with different weights of the inductance

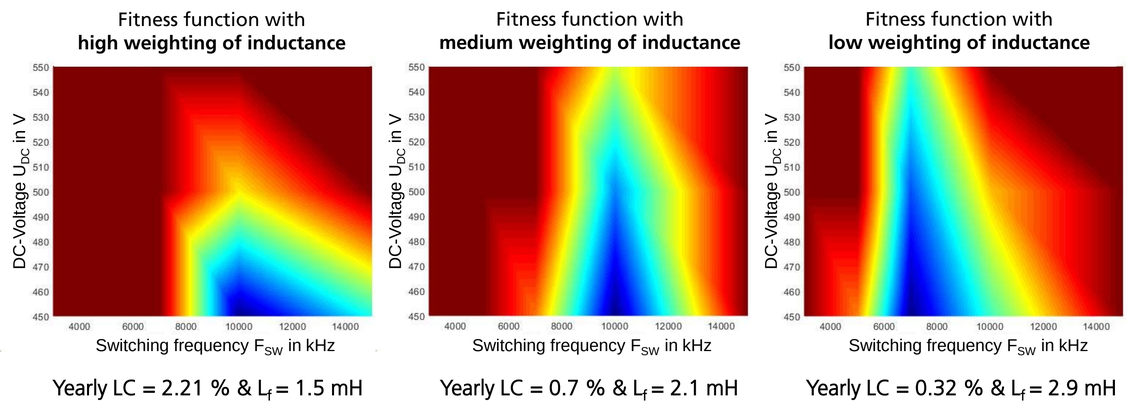

Figure 3: Evaluation of the annual trends on the representation of the fitness function with a weighting of lifetime consumption and inductance. The inductance was evaluated with different weightings.

Summary

- Outline specification of the Expert-Tool
- Proof of concept for selected features of the tool
- Use of neural network drastically reduces computation time
- Extension of the training of AI methods via automatic simulation and analysis scripts
- Further development and utilization of AI methods for additional points of the **InvEx | Expert-Tool for Power Inverter Development**

Supported by:

HESSEN Hessisches Ministerium für Wissenschaft und Kunst

SPOTLIGHTS

Fraunhofer IEE