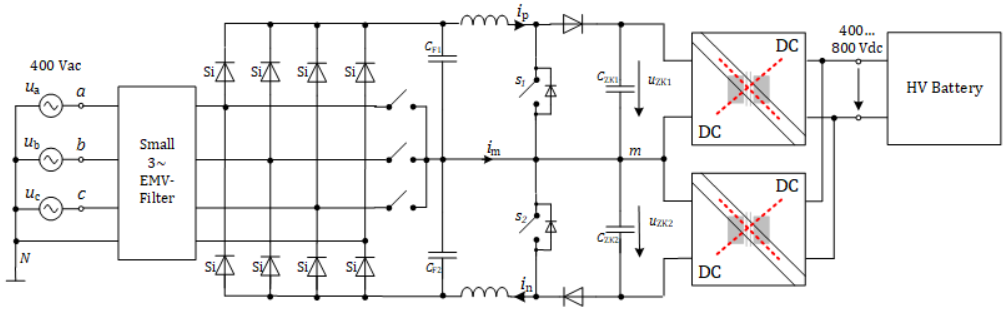
Smart charging for electric

Low-common-mode, three-phase PFC stage for on-board chargers

Invention

There is a growing trend for electric vehicles. Their drive batteries require charging at high power from the available AC power grid. Three-phase on-board chargers (OBCs) are used for this purpose at high power outputs of at least 11 KW.



Circuit diagram for a low-common-mode, three-phase on-board charger. The low-common-mode PFC stage (three-phase and single-phase) allows for the omission of transformers in the DC-DC stage.

The input stage of powerful OBCs is a three-phase, grid-friendly pulse rectifier (PFC: power factor correction). Conventional three-phase PFC circuits generate inherent common-mode inteference that needs to be reduced through electrical insulation from a power transformer in the downstream DC-DC stage and a bulky EMC filter. The problem is that both components bring with them extra weight, size and losses, resulting in higher operating costs. With this invention, both three-phase and single-phase AC (single-phase application: emergency charging or U.S. grids) can be converted into DC with low common-mode interference, i.e., with line frequency ratios only. This low common-mode interference makes it possible to omit the power transformer at the DC-DC stage and to reduce the EMC filter significantly. This circuit also requires just two high-frequency clocked power transistors as well as just two step-up reactors instead of the usual three (see figure). This not only results in appreciable cost savings but also reduces the weight of the circuit, which, in turn, increases the range of the vehicle.

Commercial Opportunities

All battery-based electric vehicles, whether all-electric or plug-in hybrid, could utilize this circuit in the future with a suitable control mechanism. All major car manufacturers and charging component suppliers are currently working on efficient charging concepts for electric vehicles in order to reduce charging time and costs (in material and electrical operating losses) and to increase range by, e.g., reducing weight. Industrial and IT applications also require high DC power outputs for server racks in data centers or in telecommunications infrastructures for cellular networks, where this circuit could also be used.

Current Status

An application has been submitted to the German Patent and Trademark Office, with subsequent applications in other countries possible in the priority year. The simulation results are proof of concept for the technology and a prototype is planned for completion by the end of 2021. On behalf of Paderborn University, we are offering interested companies the opportunity to license and continue to develop this technology.

An invention of Paderborn University.

Competitive Advantages

- Material cost savings
- Operating cost savings
- Weight reduction
- Overall installed size reduction
- Simple circuitry
- Single-phase operation possible
- Operation with international power grids

Technology Readiness Level

1 2 3 4 5 6 7 8 9

Experimental proof of concept

Industries

- Power electronics
- Electromobility
- AC-DC converters
- IT/industrial power supplies

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