Fraunhofer ISE

Press Release

Fraunhofer ISE Develops Highly Compact, High Frequency DC/DC Converter for Aviation

Gallium Nitride Transistors Enable Switching Frequencies in MHz Range

The efficiency of power electronic systems is not solely dependent on electrical efficiency but also on weight, for example, in mobile systems. When the weight of relevant components and devices in airplanes, for instance, is reduced, fuel savings can be achieved and correspondingly greenhouse gas emissions decreased. New materials and components based on gallium nitride (GaN) can help to reduce weight and increase the efficiency. With these new materials, power electronic switches can be operated at higher switching frequency, resulting in higher power density and lower material costs. Researchers at the Fraunhofer Institute for Solar Energy Systems ISE together with partners have investigated how these materials can be used to make power electronic systems in aviation applications more efficient.

In the project "GaN-resonat – Efficient, highly compact, high frequency power electronics with GaN transistors," the partners SUMIDA Components & Modules GmbH, Liebherr Elektronik GmbH and Fraunhofer ISE form a highly qualified consortium. The partners complement each other ideally in the fields of inductive components, aviation technology and power electronics. The concrete aim of the project was to develop a resonant DC/DC converter with GaN transistors, with switching frequencies significantly above 1 MHz and a nominal power of 3 kW. The converter was designed especially for applications in aviation, where compatibility between the economic and ecological challenges plays a major role.

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Compact Design with High Efficiency

In order to reach the project's ambitious target, the scientists and industry partners employed the most modern power transistors of gallium nitride (GaN) and innovative inductive components. Thus, typical switching frequencies for these applications of currently up to 350 kHz for resonant converters could be increased to 2.5 MHz. "With these higher frequencies, a large part of the weight due to the passive components and the volume of the 3 kW DC/DC converters could be appreciably reduced," says Cornelius Armbruster, developing engineer in the team "Efficient and High Frequency Power Electronics" at Fraunhofer ISE. By making the passive components smaller, less material (e. g. copper or ferrite) is required for manufacturing, which saves scarce resources. GaN transistors have a beneficial dynamic behavior which allows high efficiency in spite of a high frequency. "The developed converter has a power/weight ratio of 3.9 kW/kg and a total efficiency of over 90 % for a wide operating range. The converter reaches a comparatively high maximum efficiency of 94.5 % at half its nominal power and a switching frequency of 2 MHz," describes Armbruster. At such high frequencies, however special attention must be taken with the printed circuit board design, the measurement and control technology and the electromagnetic compatibility. In consideration of these aspects, an 8-layer printed circuit board (PCB) was produced for the demonstrator and, in particular, the control of the GaN transistors was developed and optimized.

Gallium Nitride – A Material with Perspective

For years, Fraunhofer ISE has been carrying out R&D on high-efficiency, high-frequency power electronics for renewable energy systems and on applications using the newest gallium nitride and silicon carbide components. In the "GaN-resonant" project, the Freiburg researchers and their project partners have developed a scenario for application in the aviation industry, designing the resonant voltage converter

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to meet the special requirements demanded by aviation electronics. The results gained from the project can be transferred to other fields of application in the future. One possible area of application is as power supply for server farms, or for communication electronics in general. The amount of energy consumed worldwide to supply the current communications infrastructure is immense, and all signs show that it will continue to rise. In this case, the new design of the extremely compact, high frequency DC/DC converter which saves material and reduces power losses shows clear advantages. It boasts not only a higher efficiency but also a lower cooling demand.

The "GaN-resonant" project was launched in 2013 and ran for a period of three years. It was funded with about 1.2 million euros by the German Federal Ministry for Education and Research (BMBF) within the Hightech Strategy of the federal government from the IKT2020 Research & Development Program for Projects on Power Electronics in Germany.

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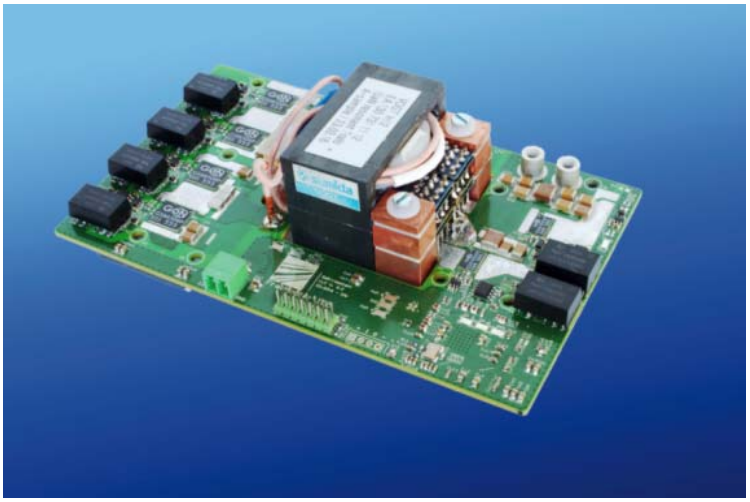
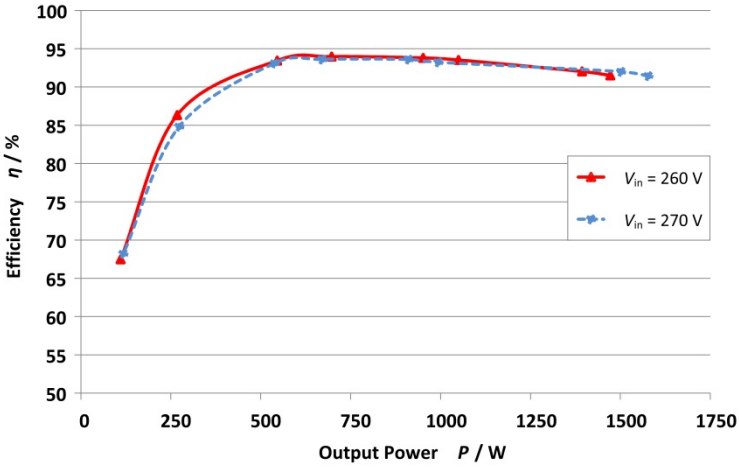


New materials enable high speed frequencies: Fraunhofer ISE develops resonant DC/DC converters with 2.5 MHz as demonstrator for aeronautical applications. ©Fraunhofer ISE



Efficiency measurements for different power outputs of the highly compact DC/DC converter developed at Fraunhofer ISE for aviation applications. (V_{out} = 28 VDC, f_{sw} = 1.8-2.5 MHz). The maximum efficiency is 94.5 %. ©Fraunhofer ISE

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