Interview on Power Electronics for Windmill Applications

with Dejan Schreiber, Senior Application Manager; Semikron

By Bodo Arlt, Editor BP

Bodo Arlt: What influence does the growing wind energy market have on the development of power semiconductors at Semikron?

Dejan Schreiber: We achieve our biggest growth rate in the renewable energy market. 31GW of the 72.6 GW of total wind power capacity installed since 1993 worldwide feature Semikron technology. In fact, we provided the first power semiconductor solutions for windmill applications at the beginning of the 90`s when we invested into the technologies and drive topologies of an Integrated Power Module specifically developed for use in wind generators owing to its high operational reliability, service life expectancy, efficiency and scalable design.

Our long track record enables us to develop state-of-the-art products and designs. This gives us a head start over our competitors.

Bodo Arlt: What are the challenges/alternatives in this market?

Dejan Schreiber: Up to now power electronics was used at the back-end of energy production. But power electronics is also to be used in front-end, for example in windmill applications, as well as for power distribution - in front-end and back-end solutions for power transmission lines. Power quality therefore has to be improved. Smart grid requirements for power distribution are becoming evermore stringent. Standards and approvals make the requirements even more complex. And all of these needs have to be met, despite the fact that pressure to increase development speed has been stepped up. The best way to meet this requirement is to develop products which can form a base platform and which can then be easily expanded to meet the demands of an ever-increasing power range. This is a huge challenge for the power electronics industry.

Bodo Arlt: Which solutions does Semikron offer to stay ahead in the wind market?

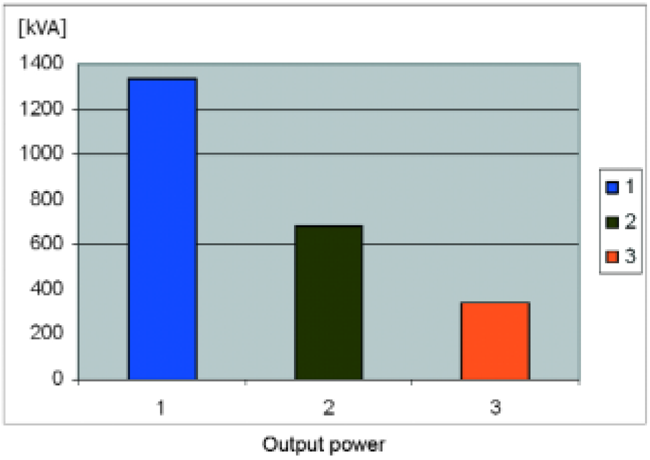
Dejan Schreiber: We offer SKiiP, an integrated power module that includes perfectly matched cooling, gate driver, current sensors and protective functions. We also have power assemblies and scalable solutions in the MW ranges. To stay ahead in the wind market, however, we have to develop solutions for even higher power requirements of more than 5 MW. Within 5 years this may be as high as 10 MW. As with all high-power generators, windmill generators have to be medium-voltage units.

Bodo Arlt: What semiconductor voltage do you recommend for variable-speed wind turbines?

Dejan Schreiber: 1700 V. Renewable energy applications undoubtedly need high-efficiency, proven semiconductors.

As seen in inverter operation when using different IGBT modules with the same module case but for different voltages, 1700V (low-voltage device), 3300V and 6500V devices, and simulate the available output power, it is obvious that medium-voltage IGBTs are not an economical solution (See Fig. 1). Output power limitation equals the total power losses. For the same power losses, 3.3kV 1200A medium-voltage modules can produce only half of the available power. Only a quarter of the available power is produced by 1.7kV 2400A and 6.5KV 600A modules.

Operation conditions are adjusted to the voltage levels; the switching frequency 3.6 kHz is equal in all cases. The reason for identical switching frequency in use is the filter size. At 3 to 4 kHz, the power of the sinusoidal filter is approximately 15% of the inverter power. In that way all inverters have similar filter sizes & costs. This means that for MV drives there is a need for different inverter circuit approaches.



1. 1,7kV; 2400A	2. 3,3kV;1200A	3. 6,5kV; 600A
Vdc = 1100V	Vdc = 1800V	Vdc= 3600V
Vac = 690V	Vac = 1130V	Vac= 2260V

Figure : Three-phase IGBT inverter output power with same module size and cooling conditions with Fsw= 3.6kHz

Bodo Arlt: What sets Semikron apart from other module suppliers?

Dejan Schreiber: We are application-oriented. We develop and produce power semiconductors which are easy to use in the given application. For example, many years ago huge IGBT single-switch modules had two terminals only (collector & emitter), and two versions, like in a mirror, one for the BOT and one for the TOP switch. We recognized the disadvantages of this type of solution from the very beginning. For a voltage source inverter, the power module has to be a half-bridge with separate DC and AC terminals. The SKiiP layout, which is more than 15 years old, has the DC terminal on one side and the AC terminal on the other side of the module with several terminals in parallel. This design is now being used by other suppliers too and has not been topped.

Furthermore, our experience in windmill applications allows us to integrate solutions where we can guarantee reliability and high efficiency. For example, modules without base plate with SKiiP® technology, which is based on thermal pressure contacts. The base plate is removed and a pressure system has been integrated to press the DCB onto the heat sink at several, uniformly spread points. This pressure contact technology ensures low thermal contact resistance, excellent durability against temperature cycling and increased power densities. Plus, if higher currents are required, several modules can easily be switched in parallel.

Bodo Arlt: How much is Semikron involved in the end customer's wind power applications?

Dejan Schreiber: From the initial specification to the design-in stage we work closely with our customers and provide them with local service and support.

Bodo Arlt: How do you see the future in IGBT gate driver technology for use in solar inverters and wind power applications?

Dejan Schreiber: In wind power applications more intelligent driver circuits where integration is the major driving force are called for.

As for solar inverters, Semikron is working closely with solar inverter manufacturers. The efficiency of a solar inverter is one of main selling arguments for the end market owing to the shorter pay-back period for higher current supply. Solar inverters operate at high switching frequencies to reduce the filter sizes. Silicon carbide diodes and MOSFETs are alternative solutions to standard silicon free-wheeling diodes and IGBT´s to reduce the switching losses. An inverter with SiC and IGBT´s has up to 30% lower switching losses. Very often customer-specific topologies are used in modules.

Dejan Schreiber

Dejan Schreiber received his Honours degree in electrical engineering from the University of Belgrade in 1970. Until 1988 he has been with the Technical Institute Nikola Tesla in Belgrade at the department of Power Electronics and Control. During the same time he was lecturer and visiting professor at universities in Belgrade and Novi Sad, Yugoslavia as well as in Harare, Zimbabwe.

In 1989 he joined SEMIKRON in Nuremberg, Germany, as Senior Application Manager. He specialises in power electronic converters for variable speed windmills and medium voltage drives designs for AC motor drives from, high speed micro turbine and variable speed gen-sets, innovative circuits for UPS applications, traction applications in trains, trolley-busses and trams, battery driven vehicles, automotive drives and fuel cell applications.

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Bodo Arlt: Do you expect monolithic inverters to be used in future wind power applications?

Dejan Schreiber: Definitely. Monolithic building blocks will allow for more flexibility.

Bodo Arlt: Can we expect to see more silicon carbide devices from Semikron for wind power solutions?

Dejan Schreiber: Not in the near future. Since high currents are required, the trade-off between the investment and the net metering makes it a non-viable proposition economically.

Bodo Arlt: Who of your competitors do you believe will fuel the race for leadership?

Dejan Schreiber: Again, looking at the total of 72.6 GW wind energy power capacity installed since 1993, 43% of this wind power capacity feature Semikron technology. Manufacturers of windmills need all-in-one power solutions that include matched cooling, gate driver, current sensors, as well as integrated protective functions. Here, we differ from the competition. Our customers value the ready-for-use SKiiP module, which provides excellent load and temperature cycling capability. This IGBT subsystem is suitable for power applications into the MW range, which is why it's one of the most powerful IPMs on the market.

At present, the dynamically growing wind energy market in Asia is also presenting new opportunities for us. By 2020 the Chinese government plans to cover 10% of their energy demands with renewable energies.

Bodo Arlt: Mr. Dejan Schreiber, thank you very much for your time. We look forward to a bright future for power modules in wind power and solar applications.

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