

Bodo's Power Systems®

Making Wind

Wind turbines are being designed to cover an increasingly larger power range

Wind turbines featuring power electronics are becoming increasingly popular all over the world. Semikron provides application-specific solutions combining power electronics with customer support.

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Wind power generation is being steadily employed all over the world, particularly in Asia and the USA, with offshore applications playing an increasingly important role. What good are the perfect location and high wind speeds, however, if the power generation system does not feature properly matched components. SKiiP Intelligent Power Modules are optimised for use in wind power units. What's more, Semikron's broad expertise in this field guarantees customers extensive design support. An integrated approach and flexibility in thinking – these unique capabilities are what enables this global player to meet the ever increasing demands that the move towards full-size power conversion systems in wind power applications results in for components and applications: higher currents, parallel operation and more effective cooling.

Around 80 percent of the wind power units featuring electronic control systems installed worldwide now use a doubly-fed asynchronous machine which is fed by an inverter via the rotor current. The major advantage of this machine is that it only has to be designed for around 20 percent of the rated output of the WPU, since 80 percent of the power is generated in the stator winding, which is directly connected to the grid. One shortcoming here, however, is the high-maintenance slip ring contacts and the indirect control (system). In the event of grid disturbances, very high rotor current are needed to keep the grid stable in such difficult situations.

Technological progress is one of the main reasons why regenerative energy is not only used in addition to conventional energy generation means, but is in fact increasingly replacing it. Especially in countries where energy demand is high, recent years have seen the launch of wind farms that are as large as 35 km². In order to guarantee grid stability, the requirements with regard to reactive power supply and grid stability in the case of grid voltage dips have become increasingly tight. For this reason, when new WPU's are being installed, synchronous or asynchronous generators with full-size converters are increasingly being used, because they support the grid in the event of power outage. The inverter is directly controllable, provides optimum synchronisation to grid frequency of 50 or 60 Hz, and can both compensate harmonic reactive power and produce reactive power compensation. In addition, synchronous generators can feature a large number of many poles (>50), making gears in the drive part, which was one of the most common causes of malfunction in the past, superfluous.

In inverters used in all kinds of systems, a rated voltage of 690 V is commonly used for reasons of economy, as well as to achieve optimum efficiency. A common type of power converter comprises IGBTs with a blocking voltage of 1700 V; a transformer is used for power adjustment to the 20 kV grid. Far more costly 3.3-kV modules are barely used because here, too, the system requires transformers, making the overall solution too expensive.

More power, more power electronics

Wind turbines are being designed to cover an increasingly larger power range, although the location is the all-important factor for the output. In onshore wind turbines 3 MW turbines have proven to be most economic, while offshore wind farms with an output of 5 MWs and above are the better solution. If both types of wind power unit – doubly-fed asynchronous machine and synchronous/asynchronous generator with a full-size converter – are to be able to provide the same output, the power of the full-size converter has to be five times higher. This in turn means that five times the power electronics is needed. As, however, the low output frequencies of doubly-fed asynchronous machines have to be taken into account, this is normally reduced to an increase by a factor of 3 – 3.5.



Figure 1: Different climatic requirements exist, depending on the intended location of the WPU. For instance, the extreme climate conditions in China and Mongolia are somewhat conflicting as regards temperature and relative humidity, which is why the power electronics system used here has to be adapted to meet these very requirements.

Power electronics is not only becoming increasingly popular, however. In fact, the requirements they have to meet are changing constantly, too. Owing to the fact that in doubly-fed asynchronous machines the semiconductor heats up differently at low temperatures, the protective mechanism has to be adapted to be able to deal with this. Extreme climatic conditions are a further cause of new and changing demands that components have to meet. Off-shore wind turbines are subjected to high humidity levels, while wind power units in Texas, for instance, are exposed to elevated temperatures. Consequently, the cooling systems used have to be designed differently. It is therefore important that the development of cooling solutions for individual applications be based on an extensive pool of experience.

The right know-how to combat common problems

The efficiency of an inverter lies at between 98 and 99 percent. A 6 MW full-size converter will therefore display losses of around 100 kW. The heat produced in these compact systems proves to be a major problem for the electronic components in terms of cooling. If the coolant is too cold, this will cause condensation to form with the coolant condensing on the heatsink. This must be taken into account, especially in regions with high humidity levels.

A further challenge is the overvoltage that occurs during commutation of the huge currents. As modules designed for currents of 500A and above have a relatively large spatial expansion, their stray inductances are not negligible. To combat these two problems not only is an intelligent, well thought through cooling concept needed, but also

an optimum DC link design. Expertise, experience and optimised application-specific modules which help fully exploit the power of the wind are needed to ensure that minimum effort is called for to meet the requirements of operators of WPUs.

Of the WPUs installed worldwide by the end of 2009, totalling an output of 122 GW, 57 GW feature solutions developed by Semikron. The wealth of experience in the wind power sector that the power electronics market leader has built up over the years does not, however, stop at the mere supply of IPM modules. In fact, Semikron is also actively involved in the design of new WPUs, where the company's experience and synergy effects are highly beneficial. Consultation in the area of system protection, for example overcurrent or overvoltage protection, are also part and parcel of the Semikron service portfolio. Semikron also manufactures inverter subsystems, which is why the developer of modules for WPU's boasts considerable expertise in the area of individual component dimensioning. This know-how is important for the manufacturers of inverters, as it helps them configure the DC link circuit properly, so as to ensure that this not only meets the application specifications, but also achieves a prolonged service life.

Improvements in design and packaging technology

Different locations mean different requirements and problems. This is something Semikron is very aware of and has factored in to the improvement of its IPMs. The SKiiP family is already in its 4th generation. Maximum reliability and prolonged service life in compact designs is top priority in wind turbines, especially because system maintenance is costly and complex, and results in financial loss due to loss of income during downtimes where no electrical energy is produced. Reliability throughout the WPU's minimum service life of 20 years is down to the SKiiP modules and their reliable high quality packaging technology. This is an important merit, especially given the increasing tendency towards offshore wind farms.



Figure 2: 88% of the total 1,471 MW of offshore wind power (as per 2008) is generated using SKiiP modules (Source: <http://www.renewableenergyworld.com>)

Thanks to the optimum chip distribution on the insulating substrate (DCB), the low-inductance module design and symmetric current distribution, the power density of SKiiP modules is around 20 times that of competitor products. All SKiiP modules come as a unit comprising heat sink, power electronics and gate drivers. Customers have two standard heat sinks to choose from, or may opt for a custom-developed heat sink solution.



Figure 3: SKiiP 4, maximum reliability and prolonged service life in compact designs

Growth and full-size converters are the key trends

Wind turbines featuring power electronics are becoming increasingly popular all over the world. China and the USA, for example, rely heavily on wind power to meet ever increasing energy demands. In countries with attractive energy subsidy schemes, a clear increase in the number of wind turbines can be seen.

Another clear trend is the move away from doubly-fed asynchronous machines towards full-size converters, as the latter allow more easily for operator requirements to be met and grid quality to be increased.

Semikron is fully aware of all of these challenges and requirements, boasting years of experience in the wind power sector. Power electronics market leader Semikron produces power electronic products for the wind power sector, designs and manufactures its own products, and offers development support to its customers. For 20 years, Semikron has contributed to all-important synergy effects resulting from its cooperation with leading wind turbine manufacturers. Semikron plays a key role in wind power generation and will continue to do so in the future.

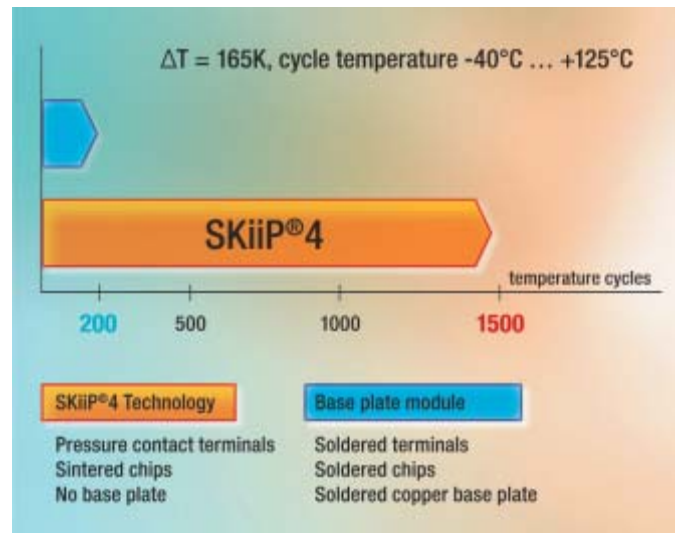


Figure 4: In comparison to standard leaded modules with base plate, SKiiP 4 IPM has a 7,5 times higher temperature cycling capability.

Both the increase in the number of wind turbines and the trend towards full-size converters has led to an increase in demand for power electronics. With its innovative products, Semikron considers itself well equipped to deal with the resulting new challenges, setting new standards in wind power technology.

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