How to attain wind-turbine efficiency

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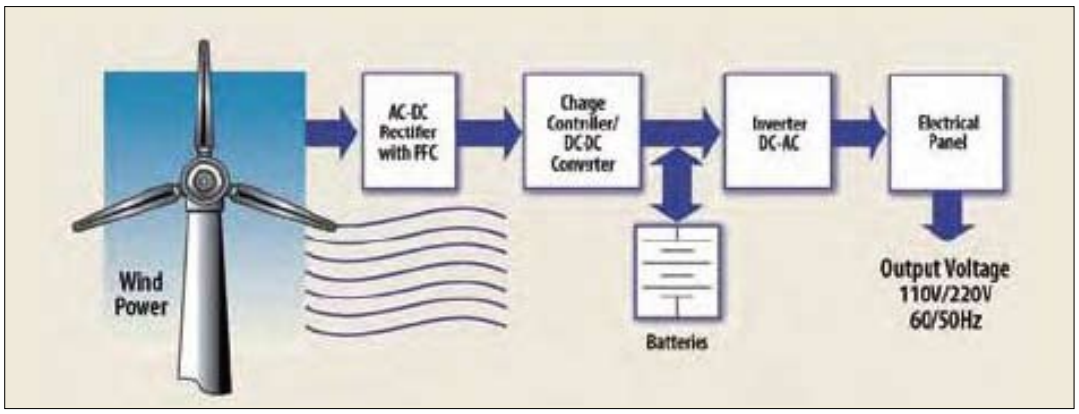

Figure 1: Shown is a simplified block diagram for small wind power generation system.

Isolation amplifiers (iso-amps), working in conjunction with shunt resistors, provide accurate current measurements in power converters even in the presence of high switching noise. When used with a resistive divider, they work as precision voltage sensors. The current and voltage information is required by the controller for calculation and effective control to achieve optimum conversion efficiency in typical small wind power systems. Featured with high common mode noise rejection, high isolation voltage, built-in safety insulation and very small footprint, miniature iso-amps provide a solution for small wind power turbines.

As one of the most promising alternative energy resources, wind power will continue to grow fast, despite the financial crisis and economy recession, at an annual rate of 22.4 per cent average for the next five years. Large wind power farms are expanding to offshore deep water regions, such as the 25MW Arklow Bank Wind Park in the Irish Sea, and the Cape Wind, America's first offshore wind farm, coming with 420MW capacity.

Despite the attention given to large multi-megawatt wind turbines, which are projected to continue growing both in size and number of installations, most of the opportunities for power inverter manufacturers are in the small wind turbine market (<100kW). Although the market for wind power inverters is small compared with the solar photovoltaic market, the small wind market is experiencing a number of significant developments, including the emergence of building integrated wind energy (e.g. the 1kW AVX 1000 and the 60kW Wind Cube) and the further development of Vertical Axis Wind Turbines (e.g. UGE 10KW VAWT).

Focus market

The U.S. market for small wind turbines grew 78 per cent in 2008 with an additional 17.3MW of new capacity. This compares to 53 per cent capacity growth worldwide with 38.7MW new installations in the same period. U.S. manufacturers accounted for 49 per cent of global small wind sales in 2008, maintaining their historically dominant position.

For the commercial segment of the U.S. small wind turbine market (21-100kW), the growth was due largely to increased private equity investment that allowed manufacturing volumes to increase. The residential segment (1-10kW), the largest segment of the market, was driven by both investment and cost down with volume up. The rising residential electricity price and increased public awareness of the technology also played apart behind the growth.

In Europe, there are more than 40 established manufacturers active in the small wind power industry. Mainly located in Germany and Spain, these manufacturers produce small wind generators with power ratings from sub-kW to a few hundred kilowatts.

A small wind system (**Figure 1**) usually includes a turbine, a generator, an ACDC rectifier, a charge controller and a rechargeable battery module, an inverter, wiring, and a tower supporting the whole system. The charge controller and battery module are often required to meet the needs of off-grid wind energy systems in difficult and remote locations.

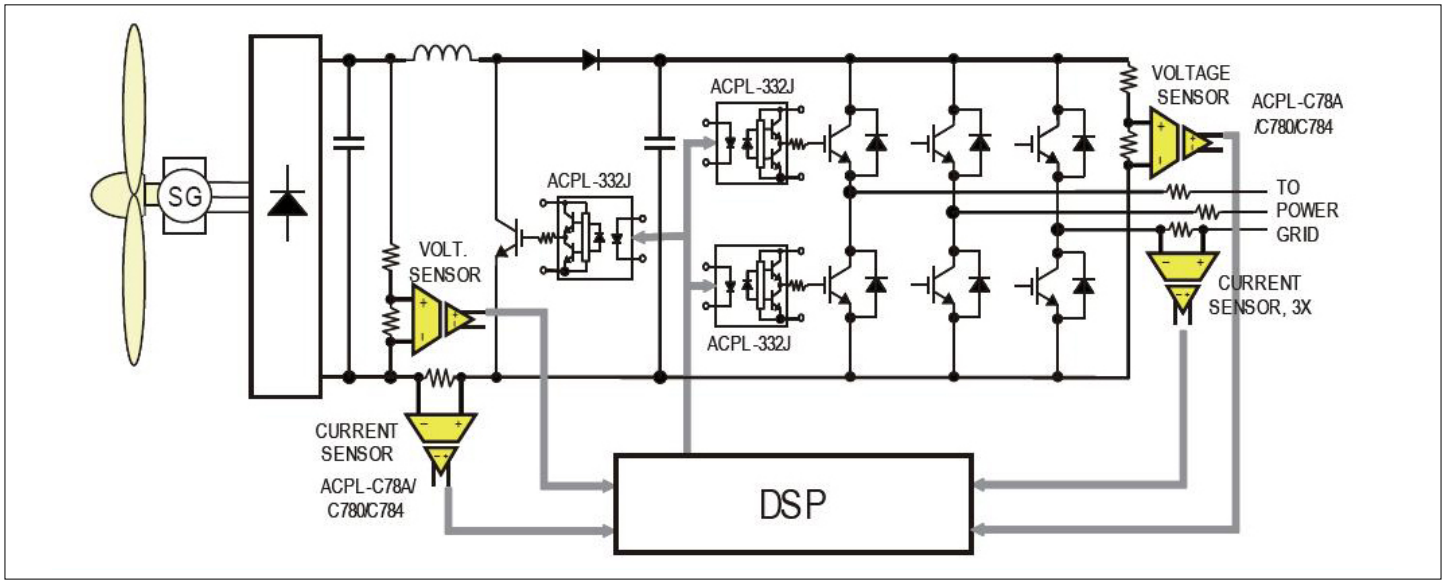

Figure 2: Shown is a block diagram of a small wind turbine using AC-DC-AC converter.

Speed control tech

Due to the variable wind speed characteristics, many wind solutions feature variable speed control technology to maximise energy capture from the wind and minimise turbine drive-train loads. Different variable speed control strategies have been proposed and discussed in the industry, with a common goal - optimum efficiency.

Besides the speed control section, the inverter plays a crucial role in enabling the power conversion process in a wind power system. In the case of wind turbines, variable-speed generation devices, an inverter is essential for the devices to connect to the grid and supply code-compliant power. Inverters can be either single (commercial) or three-phase (industrial) discrete components or modules and are controlled by a DSP to provide high-efficiency power conversion. High-performance inverter systems require precision timing control of power devices as well as safety isolation to prevent hazardous high voltage switching transients from damaging the controller and operator.

As an example, in a 30kW power conversion system, a simple AC-DC-AC converter and modular control strategy for grid-connected wind system was implemented.

Figure 2 shows a similar block diagram of the power converter. As the voltage and frequency of generator output vary along with the wind speed change, a DC/DC boosting chopper is used to maintain constant DC link voltage. The input DC current is regulated to follow the optimised, predetermined current reference for maximum power point operation of the turbine system. On connecting to the grid, PWM signals control the IGBTs through ACPL-332J gate drivers to supply currents into the utility line by regulating the DC link voltage of the inverter.

To achieve optimum system efficiency, the converter illustrated in Figure 2 and many others show that important current and voltage information must be fed back to the DSP for calculation and effective control. This information may include DC link current, generator phase currents, inverter output phase currents and DC link voltages. This need poses opportunities for current/voltage sensors with requirements of not only sufficient accuracy, response speed, but also high switching noise rejection and safety insulation at a competitive cost.

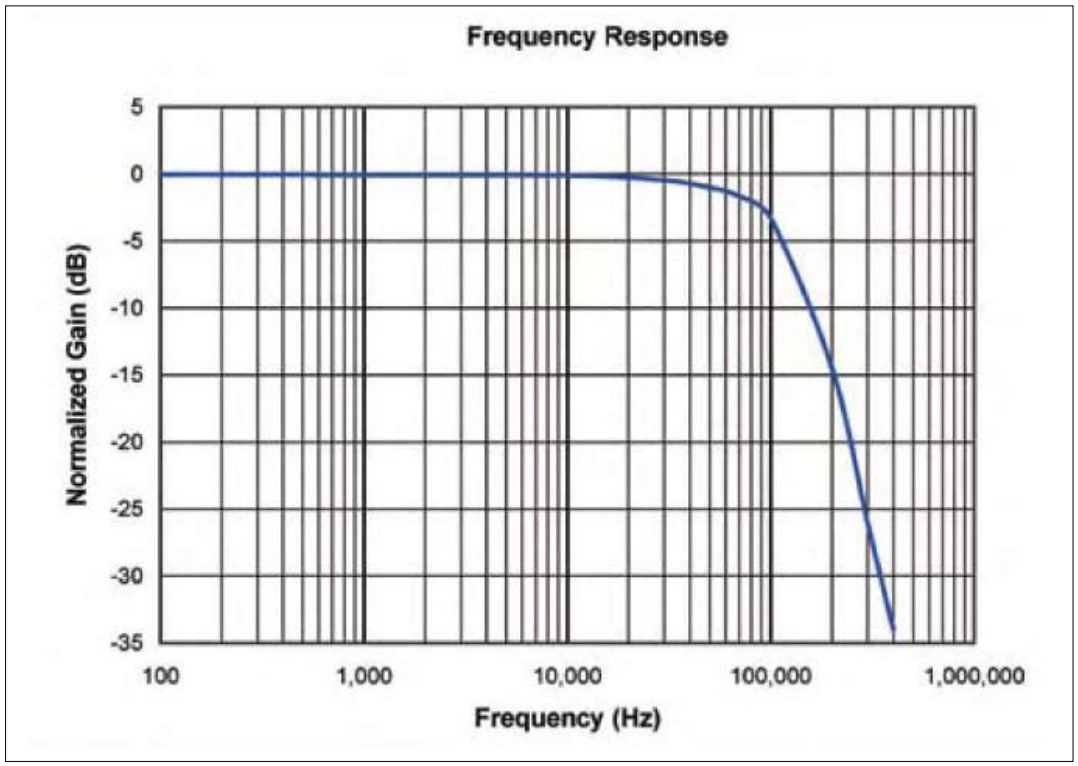

Figure 3: Shown is the gain-frequency response of the ACPL-C78X.

Iso-amp measures current and voltage

With advantages of better linearity, low cost and design flexibility, shunt current sensing is a classical method for current measurement despite the drawback of power loss on the shunt. From developments of better thermal performance and lower resistance in shunt technology, power loss can be minimised by reducing shunt signal level.

Specifically designed to meet the stringent requirements in power conversion systems, the ACPL-78A/C780/C784 miniature iso-amps accept signal of +/- 200mV, which is ideal for direct connection to shunt based current sensing applications. By choosing an appropriate shunt resistance, any range of current can be monitored, from less than 1A to more than 100A.

Figure 4: Shown is an SSO-8 package (left), 30 per cent smaller footprint vs. DIP-8 package.

The ACPL-C78X family uses advanced sigma-delta ADC technology and fully differential implementation to realise 1 per cent gain accuracy (ACPL-C78A), 0.004 per cent extremely low non-linearity and DC to 100kHz wide bandwidth (**Figure 3**). Available in a stretched small outline-8 (SSO-8) package with 8mm clearance and creepage (**Figure 4**), the ACPLC78X offers robust galvanic isolation with safety approvals of 1,140V working voltage per IEC/EN/DIN EN 60747-5-2, 5kVrms/1min. double protection per UL 1577, and 15kV/µs common-mode rejection.

Conclusion

Although the market forces driving the wind energy industry vary from region to region, from feed-in tariffs successfully implemented in Europe, to a combination of regulations, subsidies and tax incentives employed in North America and Asia, this industry is set to grow quickly. Despite the eye-catching multi-megawatt wind machines going offshore into deepwater regions, most of the opportunities for power inverters are in the small wind turbine market.

The ACPL-C78X miniature iso-amps provide accurate current and voltage measurements that are required in typical small wind power designs to achieve optimum efficiency. The high switching noise rejection and high insulation voltage capabilities ensure smooth inverter operation and safety of the controller and operator.