

# Renewable Energy Applications: Reliability and Safety with Fiber Optic and Optocoupler Isolation Technology

## Introduction

Climate change, rising carbon dioxide levels, environmental pollution and volatile fossil fuel prices have driven electric power generation producers, governments, and individual consumers to adopt alternative energy generation methods such as solar and wind. Governmental renewable energy support has been incorporated into strategic energy plans worldwide. During 2009 at least 73 countries had energy policy targets and more than 64 countries had policies to promote renewable power generation. Renewable energy is no longer an area dominated by research, but rather a large commercial market with high adoption and installation growth rates.

Renewable energy growth in 2008 was substantial and 2009 activity points toward continued progress. The United States ended 2008 with 25 GW of wind power, eclipsing Germany's 24 GW capacity. China's total wind power doubled for the fifth year in a row, ending the year above 12 GW, exceeding China's 2010 development target of 10 GW two years ahead of plan. More than 80 countries around the world now have commercial wind power installations.

With most 2008 offshore wind generation capacity in Europe, capacity reached nearly 1.5 GW. The United Kingdom became the offshore wind power leader in 2008 but other countries, such as the United States, have plans for new offshore facilities.

Grid-connected solar photovoltaic plants are the fastest growing power generation technology, with a 70-percent increase in existing capacity to 13 GW in 2008. This was a six fold increase in global capacity since 2004. Including off-grid applications, total 2008 photovoltaic generation increased to over 16 GW. In 2008, utility-scale solar PV power plants—plants over 200 kW—were estimated to have grown by 80%, to 1,800, since 2007. The added plants totaled over 3 GW, a tripling of existing 2007 capacity.

Utility photovoltaic plant additions were a major 2008 focus in Spain but facilities also went into the Czech Republic, France, Germany, Italy, Korea, and Portugal. New solar photovoltaic plants are planned and under development throughout Europe as well as China, India, Japan, and the United States.

Given the high growth rates and importance of renewable energy, Avago focused its fiber optic and isolation product portfolios and product development efforts toward renewable energy applications. Digital optocouplers, gate drivers, isolation amplifiers and solid state relays provide safety isolation and insulation along with their basic function. Fiber optic components, besides providing isolation, provide EMI resistant, long distance communication channels in wind turbine farms and panel-to-panel communications in solar photovoltaic systems. These control and communication channels are critical for safety and optimal power efficiency in distributed solar systems and especially for offshore wind farm installations.

## Avago Renewable Energy Solutions

Avago Technologies offers fiber optic transmitters, receivers and transceivers, as well as IGBT and Power MOSFET gate drivers and optocoupler isolation products for wind turbine, wind farm and solar electric power generation.

Avago fiber optic components, isolated gate drivers, isolation amplifiers and digital optocouplers are deployed in wind turbines, wind farms and solar photovoltaic energy farms today.

Applications include:

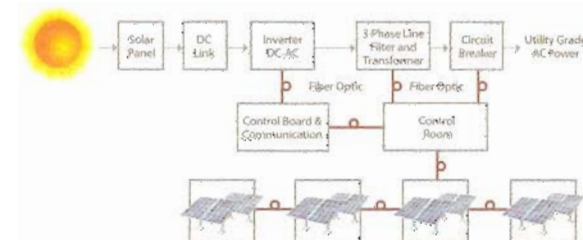
- Power rectifiers and inverter power assemblies
- Control and communication boards
- Turbine control unit condition monitoring systems
- Wind farm networks
- Sun tracking control
- Communications boards
- Solar farm substation automation and protection relays
- Single- and three-phase inverters
- Battery chargers
- Motor control
- DC-to-DC converters,
- System control and monitoring

## Solar Energy: Fiber Optic Solutions

Avago fiber optic transceivers provide control and communication links within a solar energy system and within the solar farm. Resistant to EMI and able to withstand rugged environments, Avago transceivers support POF, HCS and Multimode fiber. Plastic cable supports transmission up to 50 m. For longer distances 200  $\mu$ m HCS and 62.5/125  $\mu$ m fiber will support up to 2,700 m links. Maximum transmission distances, depending on data rates, are up to 80 km.

Data rates from 1/5/10/20/160 MBd are available with many different connector styles: LC, SC, SFP and MT-RJ.

Figure 1. Fiber data links in solar energy farm



## Wind Turbine Networking, Control and Communications: Fiber Optic Solutions

In wind turbine applications access for maintenance and repair is more limited than in land-based solar farms. This is especially true for off shore wind generation installations. In addition, large mechanical loads and changing local weather conditions must be monitored in near real time for optimal power generation, safety and control. Long term reliability and quality are very important component selection factors.

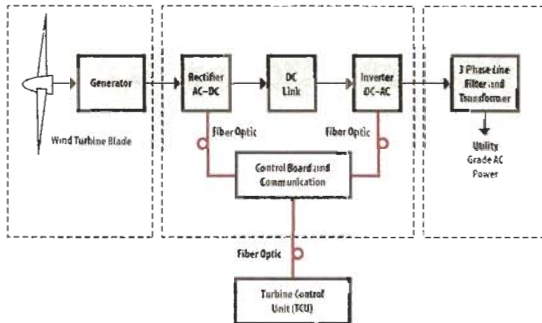
Inside the turbine nacelle, short range fiber optic connections connect power generation subsystems and the turbine pitch controller to the main system controller. Avago offers a broad portfolio of fiber-optics transmitter and receiver like the HFBR-0500Z family which are used in Wind-Turbines since many

years. For Wind-Turbines >2 MW the main choice inside the turbine is fiber optics because of EMI, lightning and galvanic isolation. Longer range fiber links connect to tower base and the wind farm network.

In turbine monitoring and solar systems, Fast Ethernet transceivers with DMI and SC-RJ connectors, such as the Avago AFBR-5978Z, are popular as they operate at 650  $\mu$ m over POF and HCS cable and feature a -25°C to 85°C temperature range. A demonstration kit for the AFBR-5978Z (AFBR-0978Z) is available from any Avago sales offices or representative.

Our new multimode, small form factor (SFP) HFBR-57E5APZ Fast Ethernet transceiver with DMI requires only 611 mW and operates from 3.3 V.

Figure 2. Fiber optic communication links in wind turbines

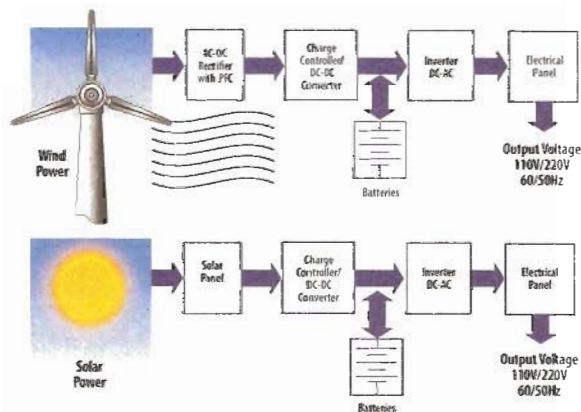


### Solar and Wind Power: Application Specific Optocouplers, Gate Drivers and Isolation Amplifiers

As the leading optocoupler supplier, Avago develops application specific isolated power MOSFET gate and IGBT drivers for power applications. Featuring high peak output current, high CMR, wide temperature range, low supply current, surface mount packages and integrated protection circuits they are ideal for motor control, inverter and battery charging circuits.

The ACNW3190 isolated gate driver has a 5 A peak drive current and under voltage lockout (UVLO) protection. Other devices have 0.4 A to 2.5 A peak drive current. For maximum reliability and design flexibility, Avago devices have protection features such as integrated VCE detection, UVLO, "soft" IGBT turn-off, isolated open-collector fault feedback and active Miller clamping for maximum design flexibility and circuit protection. A Miller clamp controls the Miller capacitance current during high dV/dt transitions and can eliminate the need for a negative supply voltage.

Figure 3. Isolation and insulation solutions in wind-solar power generation systems include inverters, charge controllers and communications.



With the Avago analog isolation amplifiers, current and voltage monitoring in motor control, inverter and battery applications is simple, safe and accurate. Phase currents and DC link voltages are easily measured while maintaining isolation. The amplifiers have working voltages of up to 1140 V for safety. Gain accuracy ranges from  $\pm 1\%$  to  $\pm 5\%$ .

The ACPL-796J 1-bit, second-order sigma-delta modulator converts an analog input signal into a high-speed data stream with galvanic isolation based on Avago's optical coupling technology. The ACPL-796J operates from a 5 V power supply with dynamic range of 80 dB with an appropriate digital filter. The differential inputs of  $\pm 200$  mV, full scale  $\pm 320$  mV, are ideal for direct connection to shunt resistors or other low-level signal sources in motor phase current measurement applications.

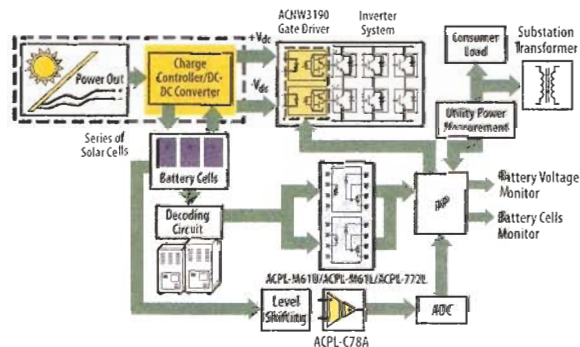
### Solar and Wind Power: Digital Optocouplers

Wind control systems must accommodate varying wind conditions and avoid run-to-failure by monitoring subsystems accurately. High voltage isolation, current isolation and immunity to EMI are critical for reliable and robust control systems. Solar and wind farms face harsh environmental conditions and operate over large physical areas susceptible to lightning and extreme temperatures. Avago digital optocouplers have the insulation and isolation specifications to make command and control systems safe and reliable. All our digital optocouplers are qualified to all international safety organization insulation and isolation specifications. Many devices have working voltages that exceed 1768 Vrms and isolation voltage up to 7500 Vrms are offered.

Operating at 10 Mb/s, multi-channel and bi-directional optocouplers (ACSL-6210/6310/64x0 in Dual/Triple/Quad channel) maximize design options and conserve PCB area. For extreme environments, the ACPL-M61U features -40°C to 125°C operation. The ACPL-M61L/061L/064L/W61L/K64L are ultra low power optocouplers suitable for energy efficient systems. Higher speed devices such as the ACPL-772L/072L operate at 25 Mb/s and from -40°C to 105°C.

Our photo MOSFETS, or solid state relays (SSRs), operate with voltages from 60 V to 600 V and with currents up to 2 A for energy storage management systems.

Figure 4. Isolated gate drive, digital optocoupler, level shifter and isolation amplifier applications.



### Summary

Innovative fiber optic and optical isolation solutions have been available from Avago for over three decades. As a major contributor to the work of international standards organizations, device reliability, quality and safety are always part of any Avago design. We offer the industry's best isolation technology, specifically designed and manufactured to meet the stringent requirements of applications in power generation systems.

Around the world our customers value what we do. We provide the components and technology to make their visions for the renewable energy market expand and prosper.

Contact us for your design needs at: [www.avagoresponsecenter.com/401](http://www.avagoresponsecenter.com/401)

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