Industrial Fiber Optic Products for Wind Turbine and Wind Farm Applications

White Paper

Introduction

Global warming and climate changes from CO_2 emissions of traditional energy sources, such as those powered by fossil fuels, have created huge markets for alternative power generation. Wind turbine energy has become a popular alternative to meet the fast growing energy demand. Unlike fossil fuels, which are a limited and diminishing resource, wind energy is limitless and readily available.

Conversion of wind energy into utility grade AC power requires power electronics, such as rectifiers and inverters. In a high power generation system, galvanic insulation becomes very important to ensure the quality and reliability of the power generation. Fiber optic components offer protection by providing insulation from high-voltage glitches and unwanted signals into power electronic devices.

Avago Technologies offers highly reliable industrial fiber optic components for data-acquisition/control and isolation in the power generation market. Featuring outstanding performance in high insulation voltage and high immunity to EMI, these products are able to be installed and operate in close proximity to power-carrying conduits which emit disruptive electrical interference. As the demand for renewable energy grows globally, wind turbine designs are becoming larger and larger. Avago's industrial fiber products offer a wide range of data-rate and link lengths for many applications in this power generation market.

Key applications for industrial fiber optic components in wind turbine system include:

- Power electronic gate driver for rectifiers and inverters
- Control and communication boards
- Turbine control units
- Condition monitoring systems
- Wind farm networking

Wind Turbine Power Generation

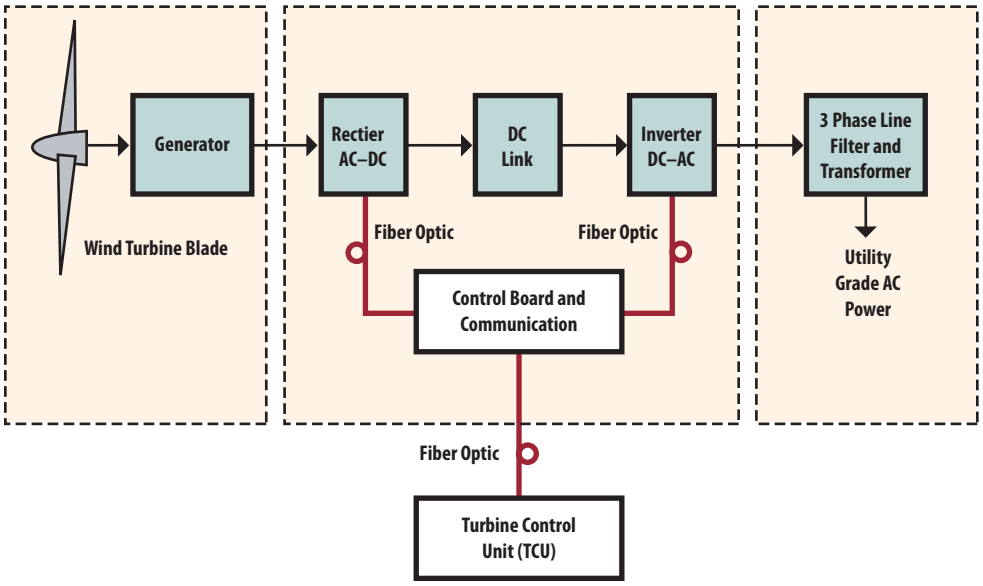

Figure 1. Wind Turbine Power Generation Block Diagram

Wind turbine power is used to convert kinetic energy into electrical energy through use of a generator. As wind conditions vary, the electrical energy created from the generator needs to be converted for usability. A rectifier, inverter, transformer and filter are needed within the wind turbine, in order for utility-grade AC power to be transmitted over long distances (Figure 1).

A transformer is usually installed at the bottom of the tower to provide voltage conversion from the low voltage generated by the wind turbine, to medium/high voltage for transmission.

Rectifier and Inverter

The rectifier and inverter are key components in the wind turbine system. The rectifier converts noisy AC power to DC power, while the inverter converts DC power to clean and reliable AC power. The switching of these devices is usually controlled by a DSP embedded controller via a fiber optic link, to provide efficient and reliable switching control with high galvanic isolation capability.

There are numerous rectifier and inverter control switches available:

- Insulated Gate Bipolar Transistor (IGBT)
- Gate Turn Off Thyristor (GTO)
- Integrated Gate Commutated Thyristor (IGCT)
- Symmetrical Gate Commutated Thyristor (SGCT)
- Emitter Turn Off Thyristor (ETO)

Fiber optic components are commonly used to control a high voltage and current switching device, with reliable control and feedback signals (Figures 2 and 3).

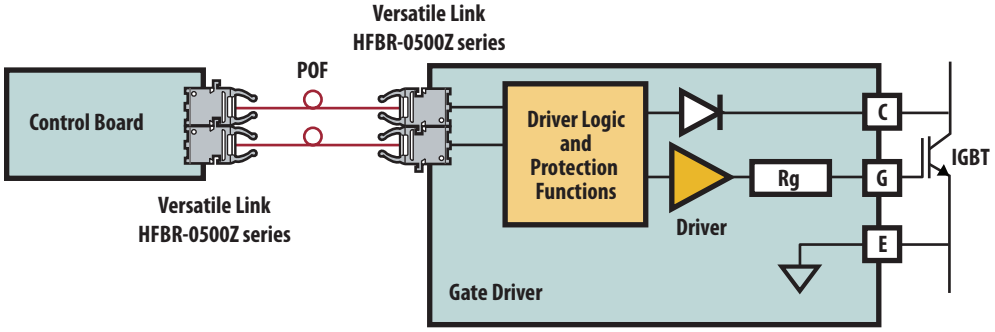

Figure 2. IGBT's Gate Driver Block Diagram

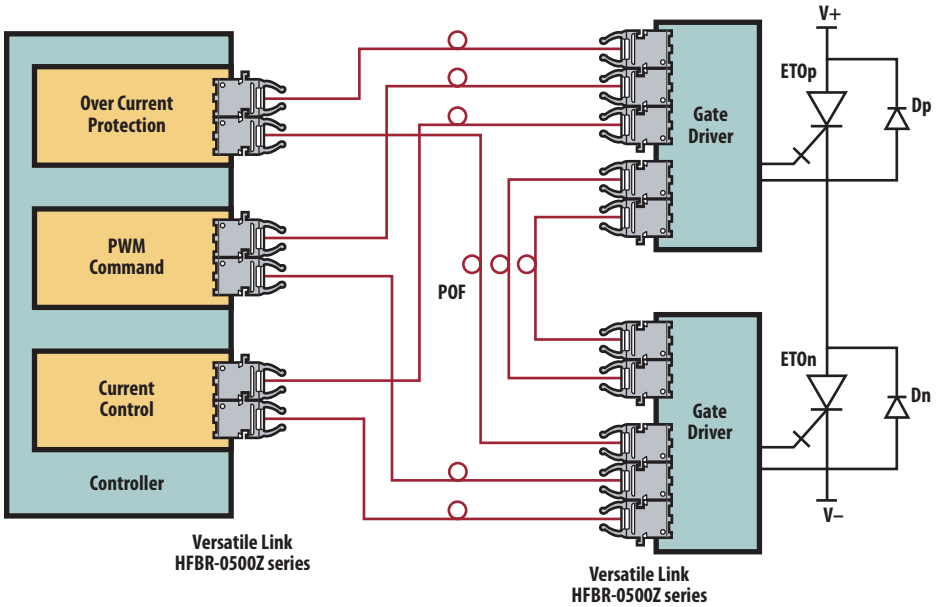

Figure 3. ETO's Two-Level Voltage Source Converter Phase Leg Block Diagram

Common Avago Fiber Optic Components Part Numbers

Part Numbers	Description	Data Rate	Distance[1]	
			POF (1mm)	HCS® (200µm)
HFBR-1521Z	650 nm, Transmitter	DC – 5 MBd	20 m	
HFBR-2521Z	650 nm, Receiver			
HFBR-1522Z	650 nm, Transmitter	DC – 1 MBd	45 m	
HFBR-2522Z	650 nm, Receiver			
HFBR-1528Z	650 nm, Transmitter	DC – 10 MBd	40 m	300 m
HFBR-2528Z	650 nm, Receiver			

Notes:
1. Optical link distance varies with operating data rate. Lower data rate allows longer optical link distance.
   HCS is a registered trademark of OFS

Condition Monitoring System

Most modern wind turbines have intelligent features to monitor and control the system to accommodate varying wind conditions. For example, atmospheric sensors detect wind speed and direction. Other sensors monitor the condition and strength of the turbine's parts to avoid run-to-failure.

Wind turbines need to withstand extreme weather conditions, such as storms and lightning. In these types of conditions, it is important to ensure that the turbine's monitoring system is designed to provide high voltage and current isolation. Fiber optics becomes a preferred choice of medium as it offers much higher voltage and current isolation properties compared to optocouplers and other similar components.

In the nacelle of the wind turbine (Figure 4), short link distances using fiber optics can utilize POF (plastic optical fiber) and Avago's HFBR-0500Z products. Connectors with snap-in, latching and screw-in designs are various options designers can select from. Avago's versatile link sub-family allows field connector capabilities for POF and the associated connectors, allowing for field repairs, maintenance and installation.

Besides good isolation properties, these products provide excellent signal integrity as they are immune to electromagnetic interference (EMI). It becomes an excellent solution for monitoring system communications over long distances with reliable data transmission in high voltage/current applications.

For greater ESD and EMI protection, Avago's HFBR-0506AMZ series offers a metalized packaging that provides excellent shielding. The SMA-styled connector also works well in areas with vibration and mechanical shocks.

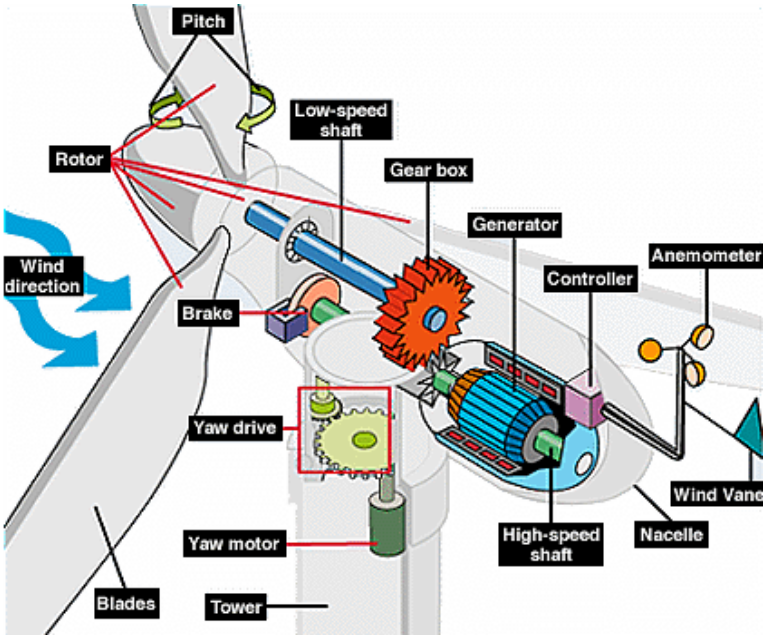

Figure 4. Elements within a Wind Turbine Nacelle Requiring Fiber Communications
Wind Turbine Development: Location of Manufacturing Activity, S. George and S. Matt, "Renewable Energy Policy Project", September 2004

Wind Turbine and Wind Farm Networking

Data collected from the condition monitoring systems, with the use of short-link POF fiber links in individual wind turbines, are typically multiplexed into HCS (hard-clad silica) or multi-mode fiber cables. The longer link distances of HCS and multi-mode fiber may be needed if wind turbine towers are greater than 100meters in height. Fiber cables are both robust, offer greater resistance to harsh environmental elements and are lightweight. All of these are requirements for vertical cabling in wind turbine towers.

Industry standard connectors like the ST/ST-thread and SMA are all available from Avago. The HFBR-0400Z series operates over both HCS and multi-mode fiber, which offer greater bandwidth and link distance as compared to the POF solution. These parts are commonly used in wind turbine towers and over long distance wind farm networks.

Avago Technologies has developed a series of fiber optic transmitters, receivers and transceivers for wind turbine monitoring systems and networking applications. Avago offers parts from 650nm, 820nm or 1300nm, which have data rates up to 160MBd to meet customers' needs over various link distances.

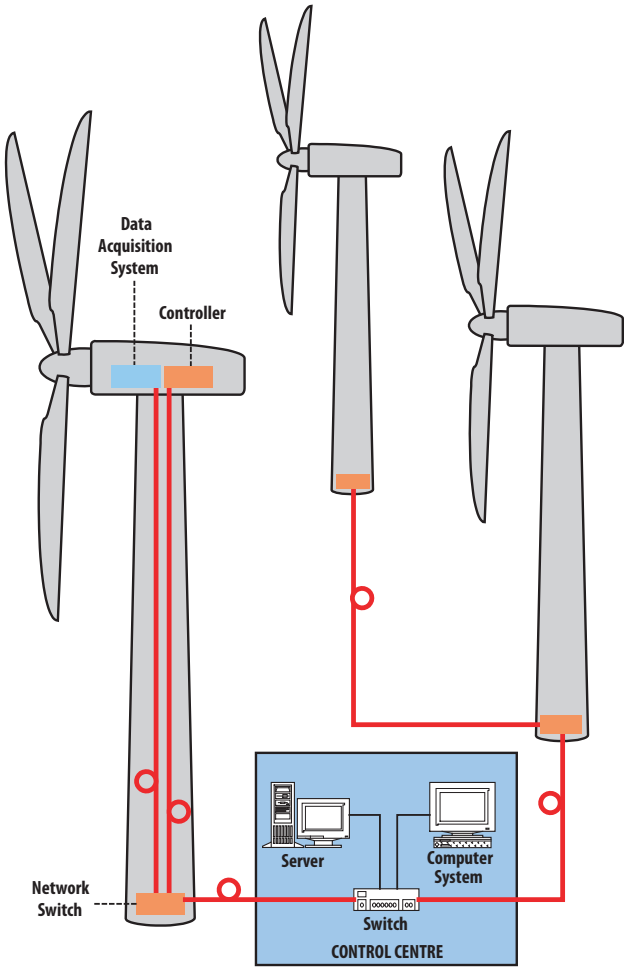

Figure 5. Wind Farming Configuration

Common Avago Fiber Optic Components Part Numbers

			Distance[1]		
Part Numbers	**Description**	**Data Rate**	**POF (1mm)**	**HCS® (200µm)**	**62.5um/125um**
HFBR-1527Z	650 nm, Transmitter	160 MBd	50 m	50 m	-
HFBR-2526Z	650 nm, Receiver	125 MBd	30 m	100 m	-
AFBR-5978Z	650 nm, Transceiver	125 MBd	50 m	100 m	-
HFBR-14X4Z	820 nm, Transmitter	160 MBd	-	-	500 m
HFBR-24X6Z	820 nm, Receiver				
HFBR-1312TZ	1300 nm, Transmitter	160 MBd	-	-	2 km
HFBR-2316TZ	1300 nm, Receiver				

Notes:
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For product information and a complete list of distributors, please go to our web site: **www.avagotech.com**

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