WIND TURBINE CONDITION MONITORING & ASSESSMENT
Some of the world's largest wind farms rely on IMI Sensors to keep their wind turbine operations at optimal performance by increasing reliability and reducing downtime. A broad range of industrial grade sensors from PCB® measure vibration, strain, torque and noise in new and existing wind turbines, providing measurements that are crucial to keep the operating health of these systems in tip-top shape.

**Sensor Placement Reference Key:**

- **Continuous Monitoring:** Measurements on gearboxes
- **Load & Torque:** Measurements on couplings & bolt tightness
- **Modal Analysis:** Measurements on turbine blades
LOW COST ICP® ACCELEROMETER
SERIES 607A
- Unique 360° swivel design
- Allows for easy cable orientation
- Integral or armored integral cable options available

LOW COST ICP® ACCELEROMETER
MODEL 602D01
- Easy installation in tight spaces
- 360° connector orientation
- Integral or armored integral cable options available
- M12 connector version available

LOW COST ICP® ACCELEROMETER
MODEL 603C01
- General purpose, hermetically sealed
- IMI’s most popular accelerometer
- Small footprint
- M12 connector version available

LOW FREQUENCY ICP® ACCELEROMETER
MODEL 626B01
- Ideal for slow rotating equipment
- Low noise floor
- High output sensitivity

EMBEDDABLE ACCELEROMETER
SERIES 660
- ICP®, charge, and low power versions available
- Easily designed into PC boards
- Variety of sensitivities

LOW COST ICP® ACCELEROMETER
MODEL 601A01
- Low noise
- Ceramic shear
- 100 mV/g
The RS Technologies product line from PCB Piezotronics serves the product assembly and fastener manufacturing communities with a complete line of rotary and stationary torque sensors, hand torque wrenches, measuring instruments and threaded fastener torque-tension testing systems. For more information on any of these products, please visit www.pcb.com/fasteningtechnology.

**WIND TURBINE ASSESSMENT**

**HAND TORQUE WRENCH**
**SERIES HT7000**
- Durable ergonomic construction
- Lightweight and high strength
- Excellent accuracy of measurements
- Compatible with most data collectors

RS Technologies, manufactures a complete line of lightweight, precision hand torque wrenches that are among the lightest in the industry and durable enough to be used in the toughest industrial environments.

Auditing the torque applied to tightened fasteners is an important part of assembly and maintenance of wind turbines. Monitoring the residual torque in assembled fasteners can be accomplished by using Series HT7000 Hand Torque Wrenches along with Model 920 Portable Digital Transducer Instrument.

**ROTARY TORQUE TRANSDUCER**
**SERIES PC9000**
- Industrial-rated for power and pulse tools
- Measure torque only or torque and angle
- 2 mV/V output with matched shunt calibration

Series PC9000 Rotary Torque Sensors are widely used in the fastener assembly market to verify the performance of hand and power torque tools. These strain gage-based transducers are fitted on the output drive of a power tool and measure the torque applied by the tool to the fastener on an actual assembly. When equipped with a Model 920 Portable Digital Transducer Instrument, this measurement provides important information about tool shut off and can assist in establishing specifications for proper assembly.

**PORTABLE DATA RECORDER**
**MODEL 962**
- Battery operated
- Cost-effective option
- Easy to operate
- Print both numeric and graphic data

Model 962 Portable Data Recorder Instrument can be used with other RS Technologies’ products such as the Stationary Torque Transducer, Rotary Torque Transducers, Hand Torque Wrenches and more. The instrument is powerful and accurate enough to be used as a primary standard for auditing most torque applications in manufacturing and quality departments. When connected to a Rotary Torque Transducer, the unit can be used to test the capability of power tools, verify the accuracy of hand tools, monitor the capability of a fastening process, or audit the quality of an assembled joint.
Microphones are used to measure the noise generated by wind turbines both internal and external to the structure. PCB's new model 378A07, with a 0.1 Hz (+/-3dB) capability, was designed specifically for assessing the low frequencies required of this application. The gearbox and the main bearing are typical noise sources that are analyzed to predict possible machine faults and monitor for preventative maintenance. This will reduce maintenance costs and minimize downtime. Resonance frequencies can be determined and corrective actions can be taken to counteract and extend the life cycle of the components. A grouping of free-field, model 378B02 or value oriented, model 130 series array microphones can be used to pinpointed noise sources to help engineers target problem areas. PCB® microphones use standard coaxial cables and low-cost, constant-current power supplies that are interchangeable with other ICP® compatible sensors. They can be used with IMI's 4-20 mA DIN rail transmitters.

MICROPHONES & PREAMPLIFIER

- Type 1 compliant, modern prepolarized (0V) and externally polarized (200V) microphones
- High temperature (800 °C) 1472 °F microphones
- Water and dust resistant microphones for rough environments
- TEDS compliant and CE marked

Sound level meters and noise monitoring systems from Larson Davis are designed to streamline both your handheld and remote noise monitoring. The SoundAdvisor™ Model 831C, an IEC 61672-1:2013, ANSI S1.4-2014 Class 1 integrating sound level meter, offers capabilities customizable to your specific testing needs. Both systems below are also available for short or long term rentals. Learn more at www.larsondavis.com.

SOUNDADVISOR™ SOUND LEVEL METER
MODEL 831C

- Connect over cellular, WiFi, or wired networks
- Control meter and view data via web browser
- Easy setup and data download
- Measure < 6.5 dBa with low noise mic option

SOUNDADVISOR™ SOUND LEVEL METER
MODEL 831C

- From meter to modem, self-contained system for easy portability
- Simple remote deployment with solar power options
- Review data on demand and control meter remotely
- Receive real-time alerts on your mobile device
PCB's Model RHM240A02 single axis ICP® Strain Sensor is structured with a quartz sensing element and microelectronic circuitry in a low profile titanium housing, making this sensor ideal for high resolution measurements of dynamic strain on wind turbine blades. This unit is compatible with PCB's ICP® Sensor signal conditioners and is capable of driving long cables.

PCB® manufactures a wide range of high accuracy, strain gage load cells. The 1200 and 1400 series load cells are compact and are available in various capacities from 250 lbf and up. While the 1200 series is a general purpose load cell with a cycle life of 10 million plus reversing cycles, the 1400 series is a fatigue rated load cells with a life cycle of 100 million plus reversing cycles. The 1400 series load cell is available in both single and dual bridge configurations.

PCB's Series 5300 TORKDISC® in-line rotary torque sensor systems are designed for test applications requiring a robust rotary torque transducer where axial space is at a premium.
SINGLE CHANNEL TELEMETRY SYSTEMS

PCB’s single channel telemetry systems provide a simple, accurate method of conditioning and transmitting strain signals on rotating or moving machinery while operating in a completely contactless mode. Power is transferred inductively and the signal is RF-transferred between the moving and static component - no brushes or wires required. This method guarantees an absolute maintenance-free continuous operation and accurate transmission of measured data. Series 8180 performs a remote shunt calibration when the unit is powered up.

- Factory configurable for strain, thermocouple, voltage, or ICP®
- Easy to use, wear & maintenance free
- Extremely robust, dust & waterproof, yet compact and lightweight
- Contact-free signal transmission and power supply for continuous operation
- Remote shunt calibration Adjustable output

REceiving Unit
MODEL 8180-CUTO
- Extremely robust, dust and waterproof
- Remote shunt calibration
- Factory configurable for strain, thermocouple, voltage, or ICP®

Rotor Electronics
MODEL 8180-RE110A
- Compact size, lightweight
- Easy to use, wear and maintenance free
- Contact free signal transmission and power supply

Stator Head
MODEL 8180-SH2
- Compact size, lightweight
- Inductive power
- Distance to shaft 10 mm

Stator Head
MODEL 8180-SH4
- Compact size, lightweight
- Inductive power
- Distance to shaft 200 mm
Test engineers have used the principles of modal analysis, using PCB’s ICP® accelerometers, Modally Tuned® Impulse Hammers and ICP® quartz force sensors to determine the strength and structural integrity. Single-axis and triaxial MEMS DC accelerometers are placed on the tip of each blade. The photo on page 9 shows a wind turbine blade mounting in a dynamically controlled, hydraulic structural loading machine, along with the various sensors and cables mounted on the blade.

WIND TURBINE ASSESSMENT

MODAL SHAKERS & HAMMERS

The Modal Shop offers a complete line of electrodynamic modal and vibration shakers ideal for applications ranging from experimental modal analysis and general vibration testing to accelerometer calibration. Shakers are also available through the TMS Rental Program in addition to accelerometers, force sensors, hammers, microphones and sound level meters. As a global leader in sound and vibration, The Modal Shop designs and manufactures a comprehensive product range of dynamic calibration systems.

For structural excitation, Modally Tuned® ICP® impulse hammers and shakers are also available, allowing PCB® to be a complete, front-end instrumentation provider. If the excitation is coming from a shaker, The Modal Shop offers a full line of modal and vibration shakers. The Model 2060E, a lightweight electrodynamic modal exciter, is capable of providing up to 60 lbf (267 N) of peak force excitation in a small footprint weighing just 37 pounds (17 kg).

ICP® IMPACT HAMMER

MODEL 086D20

- Sensitivity: (±15%) 1 mV/lbf (0.23 mV/N)
- Measurement Range: ±5000 lbf pk (±22,240 N pk)
- Hammer Mass: 2.4 lb (1.1 kg)

VISIT WWW.THEMODALSHOP.COM FOR MORE INFORMATION

MODAL SHAKER

MODEL 2060E

- Through-hole armature provides simple setup with modal stingers
- Lightweight & portable – weighing just 37 lb (17 kg)
- Trunnion base provides flexibility when choosing best exciter location(s)
- 1.4” stroke supplies adequate input energy for almost any modal test application

VISIT WWW.THEMODALSHOP.COM FOR MORE INFORMATION
MEMS DC RESPONSE

Series 3711 (single-axis), 3713 (triaxial) and 3741 (single-axis) MEMS DC response accelerometers are designed to measure low frequency vibration and motion and are offered in full-scale ranges from ± 2 to ± 200 g to accommodate a variety of testing requirements. The units feature gas-damped, silicon MEMS sensing elements for uniform, repeatable performance and offer high frequency overload protection. Electrically, the units offer a single ended or differential output signal with power, signal and ground leads for each channel. Supply voltage regulation permits operation from + 6 to + 30 VDC and the low-noise, low-impedance output signal may be transmitted over long cable lengths without degradation.

SINGLE-AXIS MEMS DC ACCELEROMETER
SERIES 3711
- Hermetically sealed
- Robust titanium housing
- Single ended output

TRIAXIAL MEMS DC ACCELEROMETER
SERIES 3713
- Hermetically sealed
- Robust titanium housing
- Single ended output

TRIAXIAL MEMS DC ACCELEROMETER
SERIES 3741
- Low profile and low mass
- Anodized aluminum housing
- Differential output
PCB® pressure sensors have been specifically designed to provide high accuracy, excellent repeatability and unmatched long term stability. This is achieved by a unique thin-film process, which “atomically fuses” sensitive resistive material directly to the pressure sensing element. This process eliminates the traditional use of adhesives, as well as the need for a “fluid fill.” The pressure sensing element is mated to an integrated circuit, programmed to provide the required span, zero and output configuration. Then, to ensure reliability, the sensing cores are encapsulated by an all-welded, corrosion resistant, stainless steel diaphragm and housing.
Blade mounted pressure sensors can provide a signal to a blade pitch controller, which uses the signal to adjust the blade pitch to an acceptable level. PCB Piezotronics, Inc. pressure transducers, Series 1500, achieve the accuracy, repeatability and stability requirements of wind turbine measurement and control.

PRESSURE TRANSDUCERS & TRANSMITTERS
MODEL 2060E
- Available in gauge, absolute, and sealed gauge
- High precision final assembly
- Configure with a variety of electrical connectors and integral cables
MTS Sensors, a division of MTS Systems Corporation (NASDAQ: MTSC), vastly expanded its range of products and solutions after MTS acquired PCB Piezotronics, Inc. in July, 2016. PCB Piezotronics, Inc. is a wholly owned subsidiary of MTS Systems Corp.; IMI Sensors and Larson Davis are divisions of PCB Piezotronics, Inc.; Accumetrics, Inc. and The Modal Shop, Inc. are subsidiaries of PCB Piezotronics, Inc.