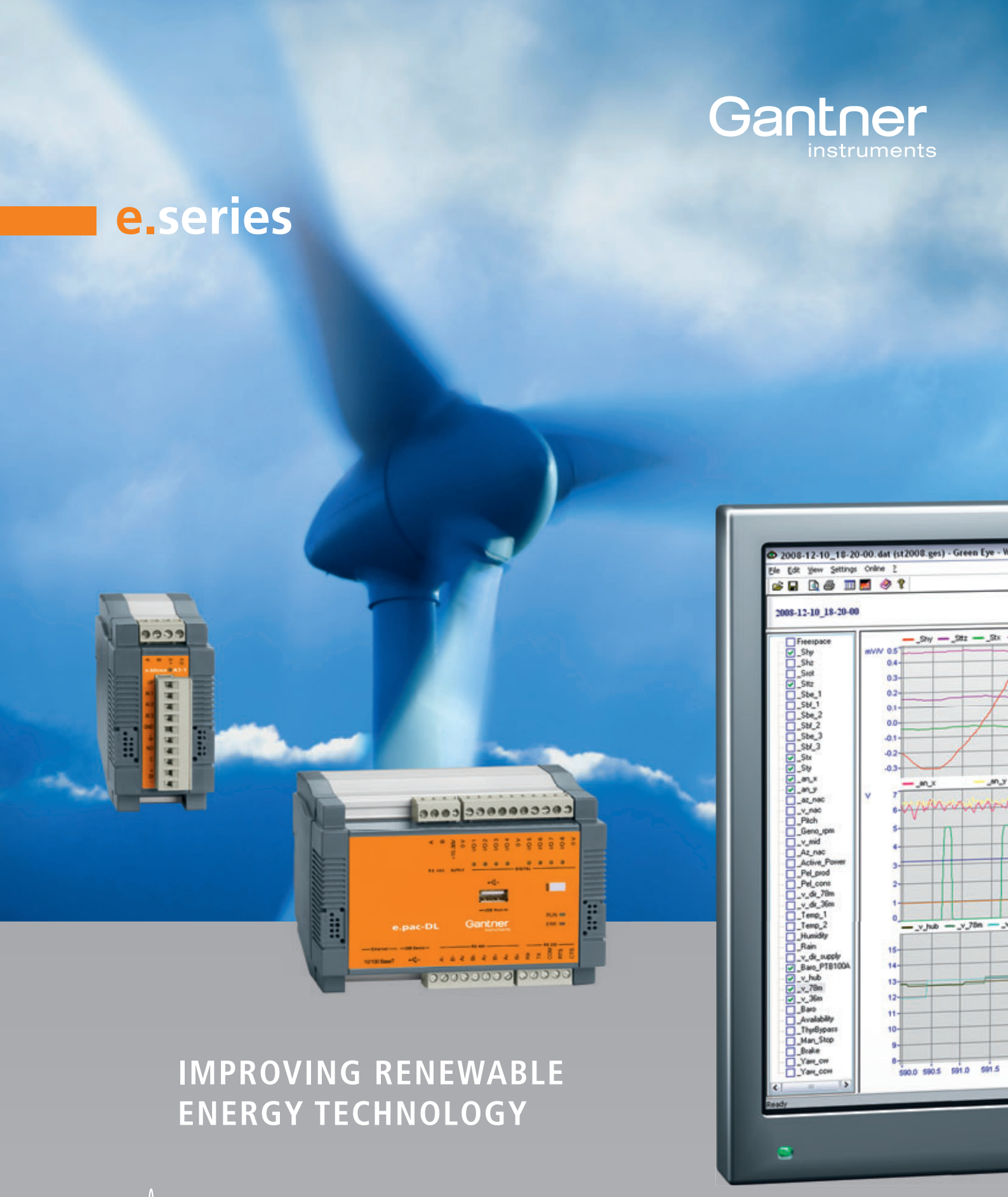
Gantner instruments

e.series



IMPROVING RENEWABLE ENERGY TECHNOLOGY

Intelligent Solutions for
Wind Turbine Performance Measurement

e.series

Wind Power is the fastest growing form of electric generation in the world. It is expected that by the year 2030, more than 20% of the world's electrical generation will be accomplished by wind. To support this growth, wind turbines are continuously increasing in size and complexity. With the new, larger (greater than 1 Megawatt) wind turbines being developed today, comes also the need for new, more sophisticated methods of understanding how efficient and effective the device is performing. The need to detect abnormal conditions (i.e. load parameters) before they affect the operation and health of a turbine is key in improving reliability, as well as ensuring ongoing operation. These abnormalities are best discovered during the prototype or start up period of a new wind farm, although long term monitoring of mechanical load conditions is also gaining in popularity – with measurements being made continuously over several months.

The challenge with any measurement system is that the unpredictable behavior of wind makes the monitoring and analyzing of modern wind turbines difficult – unless you have a system designed to meet this challenge. Additionally, the remote and difficult to access locations of the wind farms makes 'local' serviceability difficult and impractical. The e.series system from Gantner Instruments has been engineered to address these requirements.

The Gantner system is designed to comply with IEC-61400-13 (Measuring Mechanical Loads on Wind Turbines), and specifically focuses on synchronized measurements and data collection of all key turbine performance and reliability measurements.

Key Load Measurement and Recording Parameters of Wind Turbines include:

- Strain measurements at the blade root for edge wise and flap wise bending moments
- Torque, bending and torsion measurements of the main shaft at varying speeds and yaw positions
- Nacelle position and azimuth angle measurements
- Bending and torsion measurements of the tower from all direction,
- Meteorological measurements, including air temperature, barometric pressure, humidity, wind speed, and wind direction
- Electrical parameters including voltage, current, status, etc.
- Specialized measurements (e.g. acceleration, vibration monitoring, etc.)

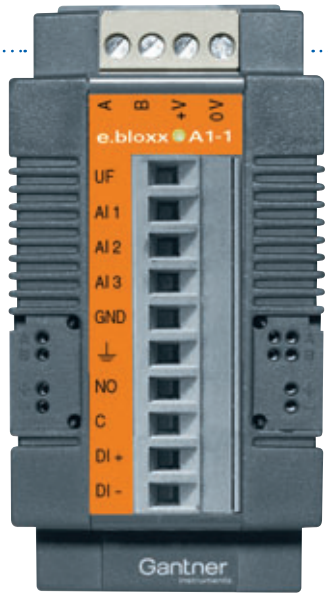
Measurement modules are installed at various locations throughout the wind turbine, and connected to the test controller via RS-485 communications – typically over fiber optics connections.

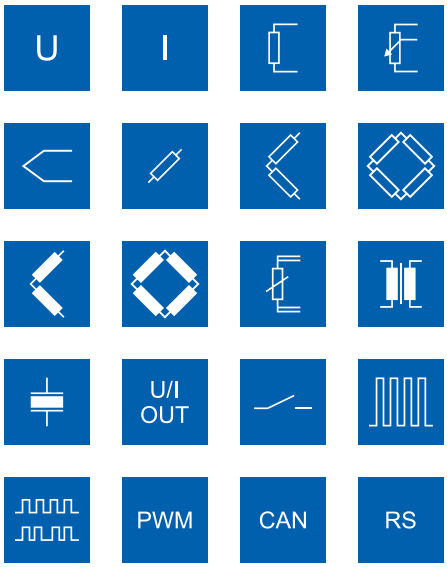
Typically, up to 100 synchronized measurements are required (at rates of up to 100 samples per second) to get an accurate overview of the operating condition of the wind turbine. All measurements are then analyzed to determine minimum and maximum values, along with the average and standard deviation values over the calculation period (usually every 10 minutes). Measured key values are then compared to internal 'good' reference points to determine if parameters are within satisfactory operating ranges. When any key value is found to be out of the normal operating range, an alarm is sent to a remote monitoring center or responsible individual via modem, e-mail or other appropriate connection means.

DISTRIBUTED MEASUREMENT AND SENSOR CONDITIONING

e.bloxx I/O and measurement modules handle the signal conditioning and precise measurement for all the process variables. Since e.bloxx is a distributed system, the modules can be placed next to the sensors for higher accuracy and system design flexibility. And since all e.bloxx measurements are synchronized, several distributed sensor points can be sampled simultaneously at rates of up to 1000 Hz (1 millisecond resolution). Several e.bloxx units can be connected to the e.pac (Controller and Data Logging Unit) via four RS-485 communication ports connected via fiber optic links.

e.bloxx modules provide full galvanic isolation on all inputs, communication ports, and power supply connections. Each unit housed in an industrial package, capable of handling the demanding environments (electro-magnetic interference, temperature, vibration, continuous operation) associated with the 'real-world' environments of wind turbines.



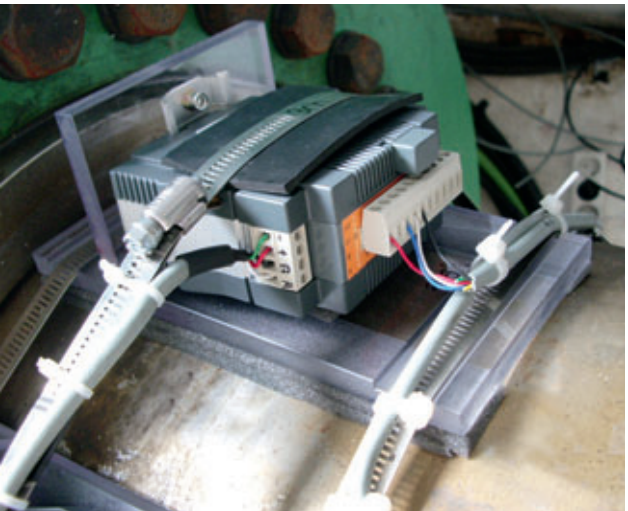


e.bloxx for measurement and acquisition of:

- meteorological quantities
- mechanical quantities
- electrical quantities
- positioning quantities
- thermal quantities

Key Features of the e.bloxx measurement modules include:

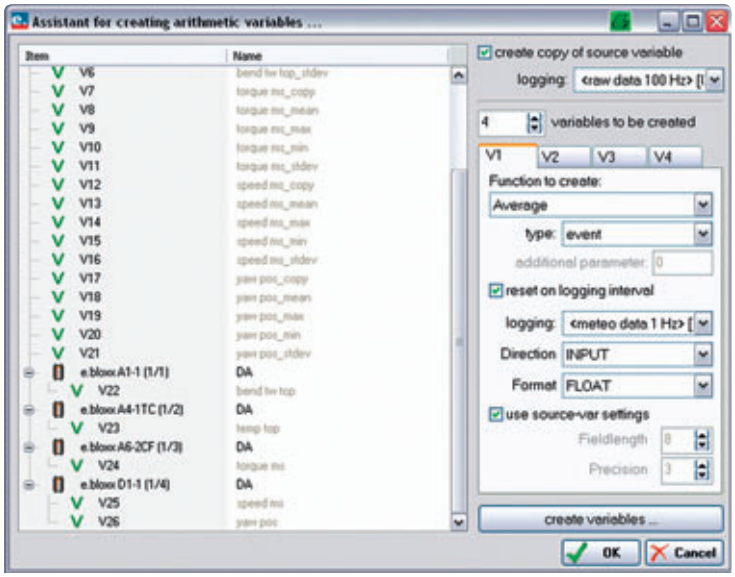
- Up to 24-bit A/D resolution
- High Accuracy
- Complete Signal Conditioning in every module: sensor interfacing, digital filtering, engineering unit conversions, linearization and programmable alarming
- Precision strain gauge measurement (DC or AC excitation)
- Flexible Digital Measurements: up/down counters, precision frequency measurement (Chronos method), PWM-signals, etc.
- Fieldbus interface modules for the integration of third party equipment (like meteorological logger) via Modbus, CAN, etc.
- Industrial Performance: Rugged, EMC proof, galvanic isolation
- Fiber optics communications between modules and controller to avoid equipment failures due to lightning strikes, etc.



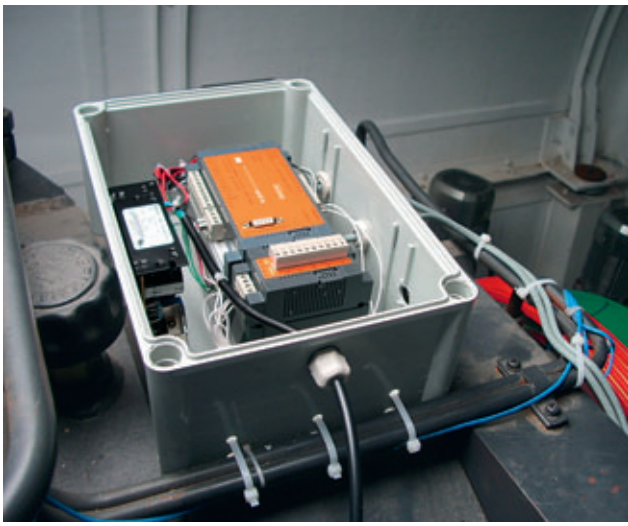
Measuring module e.bloxx A1-1 for strain gauge measurement mounted close to the blade load sensors

TEST CONTROLLER FOR INTELLIGENT ACQUISITION, CALCULATION, RECORDING AND TRANSMISSION OF DATA

The e.pac Test Controller is the heart of the e.series system. The e.pac DL handles all of the synchronized data acquisition with connected e.bloxx, all of the required statistical calculations (minimum, maximum, average, standard deviation, etc.) at selectable data rates, all data recording (utilizing internal and external data storage devices), and all communications to remote supervisory devices (via e-mail, FTP file transfers, VPN connections, etc.)



The configuration and set up of all e.bloxx inputs, alarm levels, scaling, arithmetic calculations, log rates, etc., are easily handled through menu-driven screens with intuitive pull down selections.



e.pac DL, mounted in a nacelle of a gearless 750-KW-turbine

Flexible Calculation and Recording of all associated performance data:

- Menu-driven 'wind wizard' for the automatic generation of statistical information.
- Complete library of arithmetic and logic functions for complex monitoring and control requirements.
- Definition of up to 4 internal simultaneous log files, each configurable with different logging intervals, logging criteria, and overall file size. For example:
  - File 1: Raw data, logging interval: 10 ms, file length: 1 hour
  - File 2: Meteorological Data, logging interval: 1 sec., file length: 1 hour
  - File 3: Statistical Data, logging interval: 10 min., file length: 24 hours
- Synchronized reset of calculated values based on time or event (e.g. reset statistical data each 10 min).
- Full flexibility to add variables (real or calculated) to any of the designated files

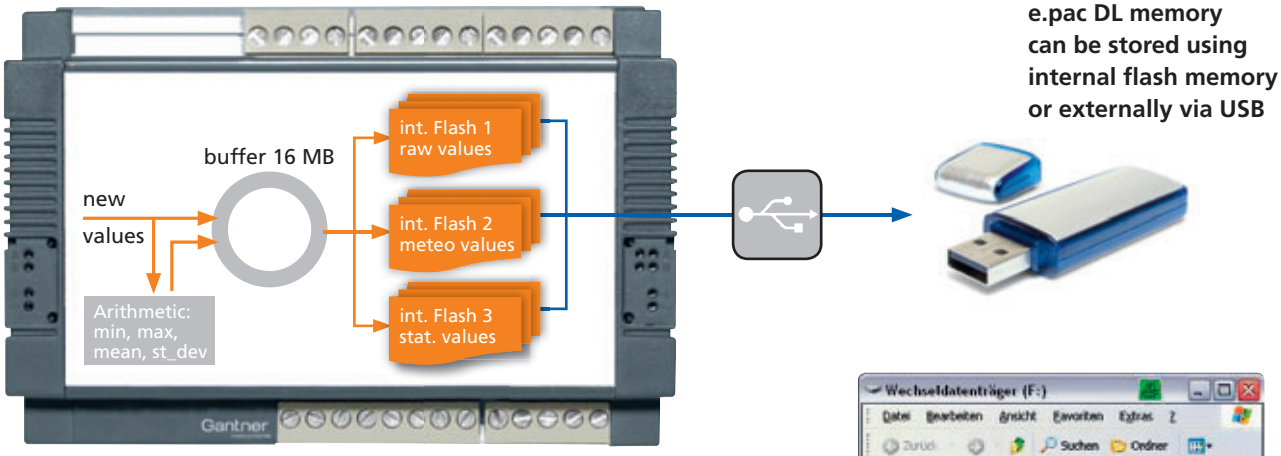
LOGGING OF DATA USING E.PAC DL

The ability to measure and store real and statistical data over long periods of time is an essential requirement in the evaluation of load characteristics on wind turbine components. The e.pac DL Test Controller offers many robust and redundant ways to accomplish this long term measurement.

The 128 MB internal flash memory of the e.pac DL is capable of storing 32 million floating point values, or 64 million integer values. Extension of this memory is possible by using external storage devices connected to the e.pac DL's USB interface. When a device is connected to the USB interface, the e.pac will automatically transfer it's internal flash memory to the connected device. If the connection is lost for any reason, the e.pac will continue to store data to the internal flash memory, ensuring that no data is lost.

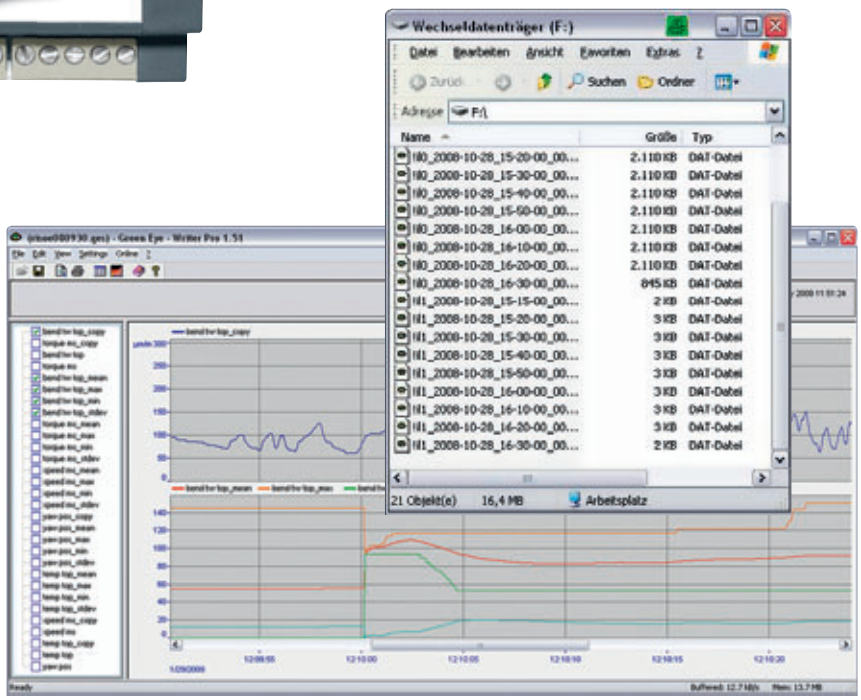
Amount of data storage

- e.pac DL Internal Flash Memory: 128 MByte = 32 million values
- e.pac DL ext. USB Flash Memory: (e.g. 1 GByte) = 250 million values
- Test Controller ext. USB HDD: (e.g. 100 GByte) = 25,000 million values
- e.pac DL connected to a PC: capacity unlimited



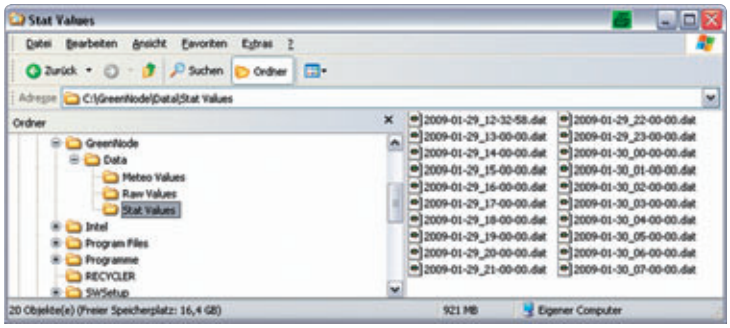
e.pac DL memory can be stored using internal flash memory or externally via USB

Data files are stored in binary in a pre-defined file format: File No. (YYYY,MM,DD) and Time (HH,MM,SS). By simply clicking on the file it will be opened with the included GreenEye Visualization Software. From this point, the files can be converted and saved for use by other software applications (e.g. Excel, FAMOS, MATLAB, DASYLAB, etc.)



LOGGING OF DATA USING A CONNECTED PC

When the goal of the system design is to have a PC connected directly to the e.pac DL, the GreenNode Server Software is an ideal tool. With GreenNode, it is possible to transfer data from the e.pac DL directly to the PC in a selectable format (e.g. FAMOS) and store the files in a hierarchical directory tree structure. There are two ways to accomplish this transfer:



Storage of transferred data in a configurable directory structure and definable format (e.g. FAMOS (.dat) by date and time)

GreenNode Benefits:

- Transfer of data from the e.pac DL to a connected PC – stand alone or redundant
- Creation of user-defined directory structures
- User selectable file formats: (FAMOS, EXCEL, MATLAB, DASYLAB)
- Maintain e.pac DL file sizes, or merge multiple e.pac DL files into new, larger ones

Cut and Paste

In this method, data is read from the e.pac DL data buffer then transferred directly to the connected PC. With this method, should the PC fail for whatever reason the e.pac can send an alarm notifying local maintenance personnel that the transfer has stopped. The e.pac DL will continue to log internally as long as memory space is available.

Copy and Paste

In this method, data is stored both at the e.pac DL and at the connected PC. Should the connected PC fail, or be shut down for whatever reason, the e.pac DL will log and control independent of the connected PC device. Should the local memory (e.g. USB HDD) fail, the e.pac DL will issue an alarm and continue to store data as long as internal memory will allow.

SYNCHRONIZED ACQUISITION

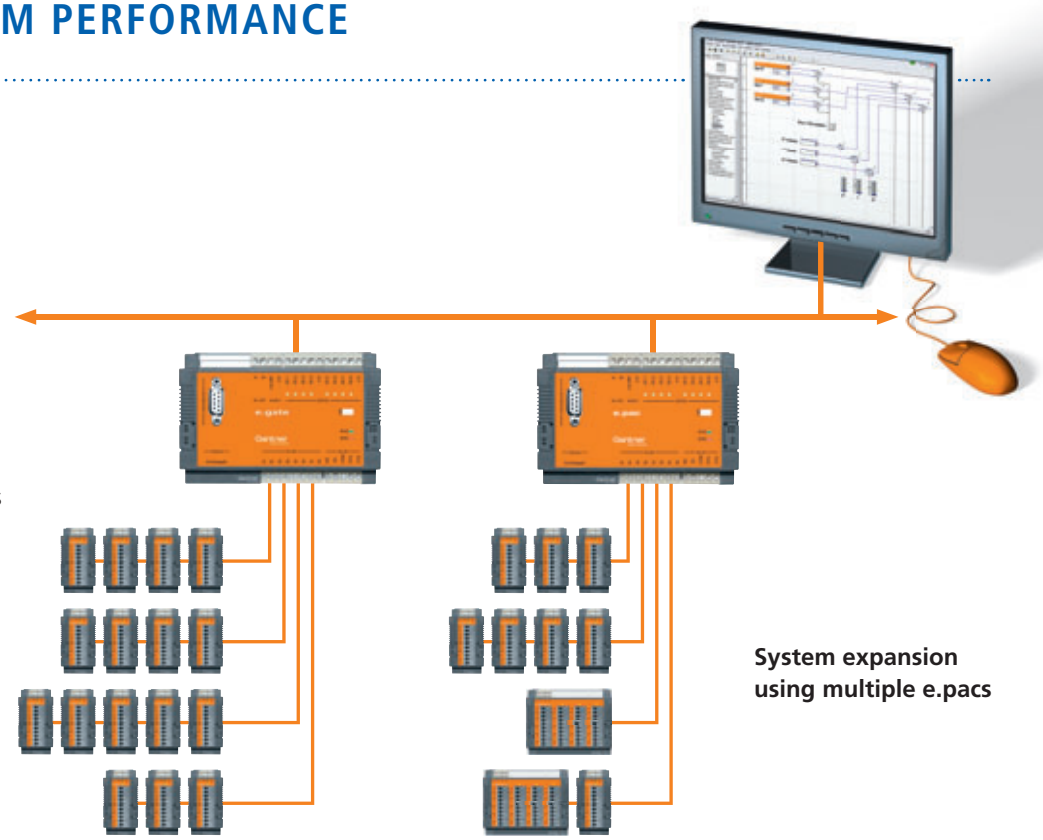
When multiple e.pac DL controllers are used in a single system, they may be wired together to ensure precise timing across all measurements. In addition, it is possible to synchronize multiple sites (e.g. multiple turbines in a single wind farm) by using an external clock (e.g. IRIG) to synchronize all e.pac DL controllers to one timing source.

Possible extension by modular setup

SCALABLE SYSTEM PERFORMANCE

A single e.pac DL is capable of logging 40 floating point variables, performing and logging 4 statistical calculations (e.g. minimum, maximum, average, and standard deviation) on these 40 measurements, all at a continuous data rate of 100 Hz.

When a system requires either a higher number of measurements at the same data rate, or a higher data rate (e.g. 1000 Hz) on a similar number of channels, then additional e.pac DL controllers should be added to 'distribute' the performance load.

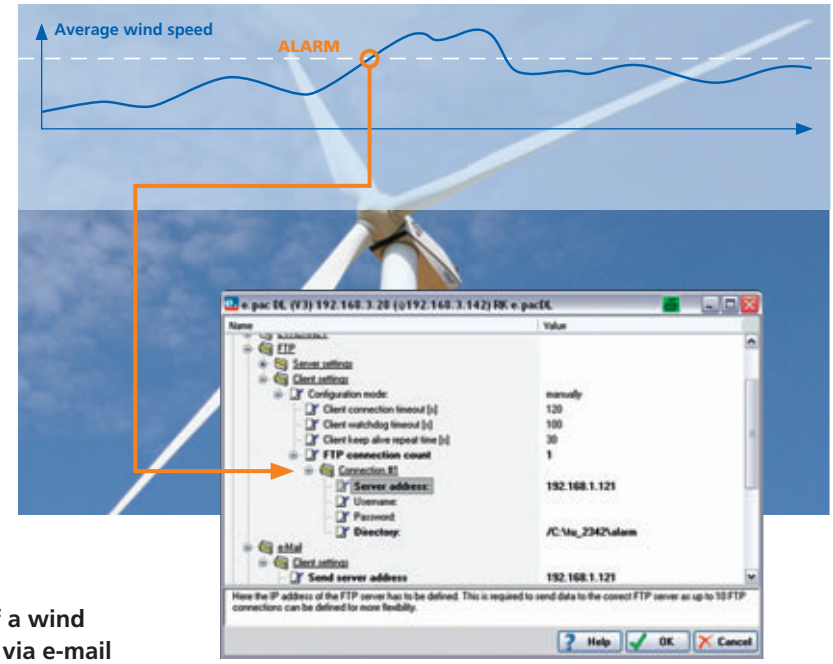


System expansion using multiple e.pacs

REMOTE MONITORING WITH COMPLETE CONTROL

Wind farms are typically installed in remote areas (in mountains or offshore), and are difficult to readily access. With e.pac DL it is possible to supervise and communicate with these locations via long distance. Each measurement can be monitored continuously, and if a critical situation occurs an e-mail or FTP message can immediately be sent to the appropriate maintenance personnel.

The e.pac DL also has the ability to reboot (should conditions dictate) without the need for on-site personnel. Additionally, when the GreenNode server software is utilized, it too can be configured to restart and automatically establish communications with the e.pac DL for total system reliability and piece of mind.



Sending information about the condition of a wind turbine via FTP (e.pac DL is an FTP-client) or via e-mail

e.series THE INTELLIGENT SOLUTION

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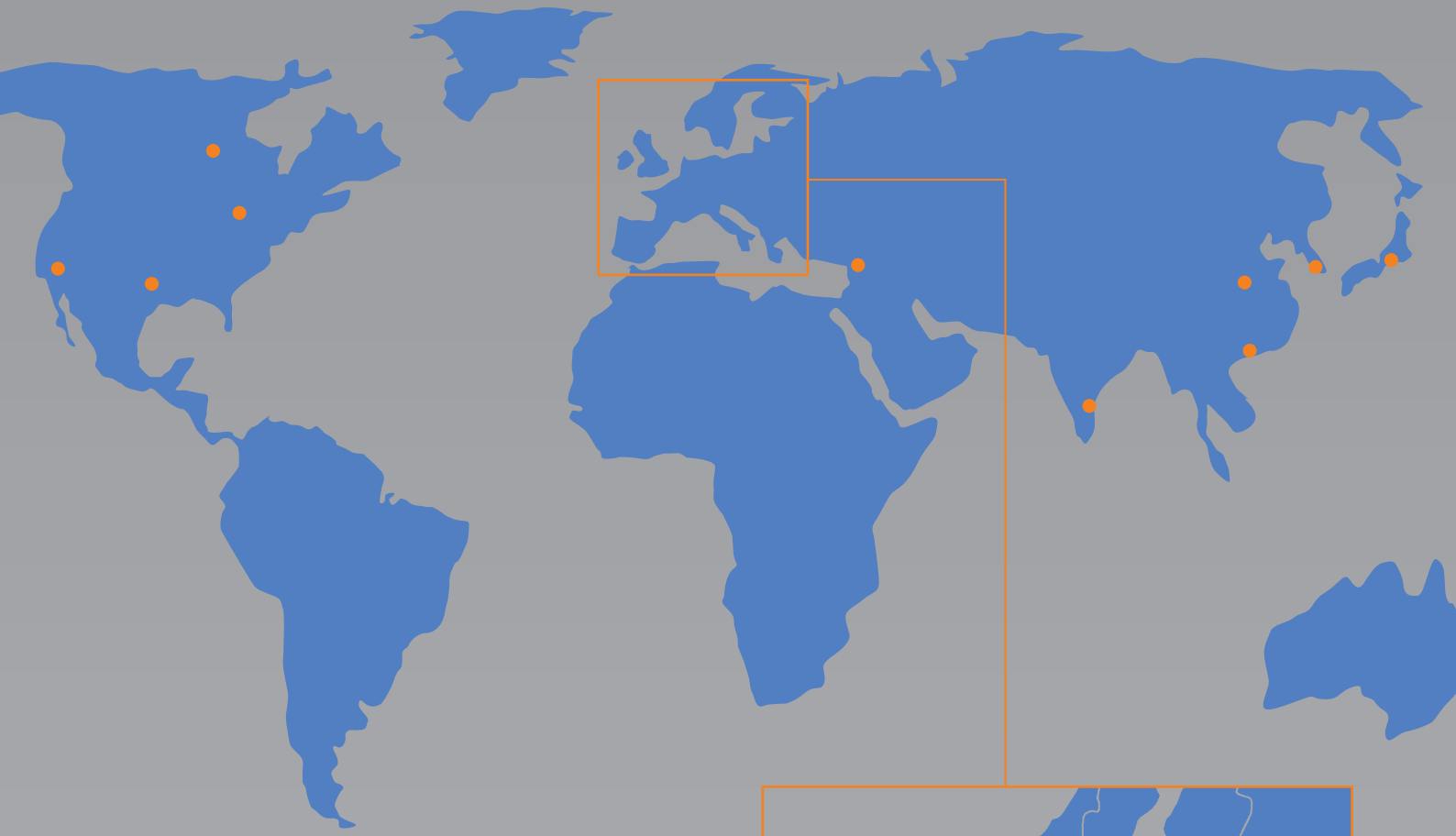
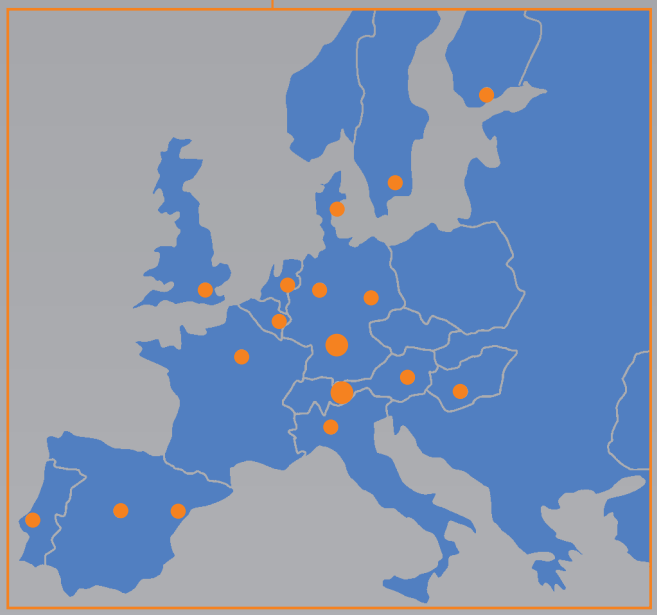
e.verywhere





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