

Over Land, at sea and in the air



imc measurement solutions for onshore and offshore wind energy installations

From prototype testing to power grid analysis and monitoring



imc Solutions

- **Site assessment:** always know well ahead which way the wind blows
- **Certification:** prototype measurements and component testing
- **Load measurements:** testing safety, stability and durability
- **Robust and disturbance free,** durable and autarkic: imc measurement technology
- **Performance curve:** optimize the level of efficiency
- **Power grid integration:** electrical quantities and system parameters
- **Flexibility with imc CRONOSflex:** modular and decentralized measurement system
- **Enhancing your testing productivity** with imc STUDIO
- **Automatic data transfer** and condition monitoring: with imc LINK
- **System relevant control data read in directly:** using PROFIBUS, PROFINET and CAN

Your benefit - our goal:

- **Save time:** real-time calculation within the system while measurement is taking place
- PC-independent, robust, mobile and secure
- Network-capability and synchronization of all measurement systems
- Control all imc systems using one software
- Application-specific extensions
- Single source solutions - measurement, analysis, automatization, documentation and organization

- > Energy
- > Automotive
- > Transportation
- > Aerospace
- > Mechanical Engineering
- > Civil Engineering

Site Assessment: always know well ahead which way the wind blows

Wind energy installations need to operate reliably over many years in order to be productive and redeem costs. Along with the expert knowledge of developers and engineers, test measurements are crucial for disturbance-free operation of an installation in the long run. imc Meßsysteme GmbH offers solutions that perfectly meet these measurement demands. The performance spectrum of imc solutions ranges from performing measurements on individual components to load testing of the complete wind energy installation and grid quality analysis. Systems are based on more than 15 years experience in the wind energy sector.



Rotor blade tests

High concentrations of air-borne salt, cross-flowing wind gusts during storms and extremely high or low temperatures - clearly, rotor blades must be able to withstand demanding conditions over many years. The demands are especially high for offshore operations. Furthermore, as the amount of megawatts generated by installations increases, so too does the size of components such as rotor blades, towers and gondolas.

imc offers measurement solutions meeting the individual needs of customers for testing bending strength and vibration characteristics of rotor blades. Simulation processes and hardware in the loop are also gaining considerable importance for testing rotor behavior under certain environmental conditions or for examining load using a systematic and reproducible methodology.

On this basis it is possible to draw conclusions about the the whole operation lifespan and consequently carry out timely optimization.

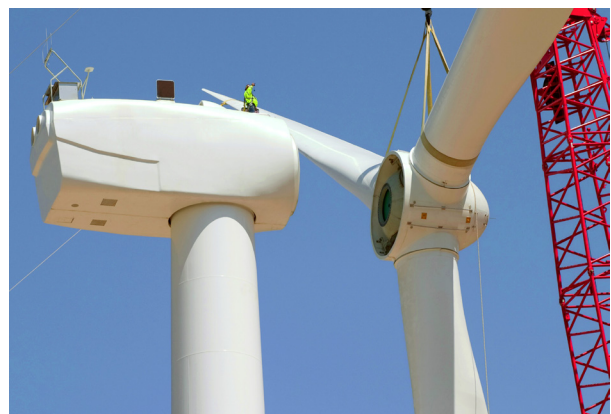
Rotor blade test stands - component tests

While extreme load tests (called "breaking tests") measure a rotor for its nominal load capacity, dynamic tests reveal fatigue characteristics. During rotation various loads are placed on the blades. The change of load places high demands on materials and construction. These load alteration tests are performed using hydraulic actuators with which the rotor blade can be stimulated or loaded for several axes of motion.

imc has far reaching experience and a comprehensive portfolio of integrated solutions for the control and regulation loops of these test installations as well as for performing tests and evaluating results.

Developing and testing the powertrain and gondola

Systematic tests of the entire energy transmission path from the wind turbine hub to the power grid must be performed by manufacturers in order to examine, improve and further develop the powertrain, gears and generator. Tests also need to be carried out on the converter and control concept. Along with these components, an installation also has auxiliary drives and devices such as those required for positioning and aligning the gondola, all of which require tests and trials.



Dynamometer test stands for systems such as these can perform at over 10 megawatts and fill an entire production hall. These test setups are used for performing accelerated life expectancy tests in which especially stressful operating situations are reproduced in concentrated, fast-motion cycles. Error events, sudden changes in load such

as a simulated power failure, load shedding and similar “stresses” can be applied to an installation over a period of weeks in order to simulate constant operation over a number of years.

For this real-life measurements and other measurement approaches can be performed using low voltage ride through (LVRT) test containers.

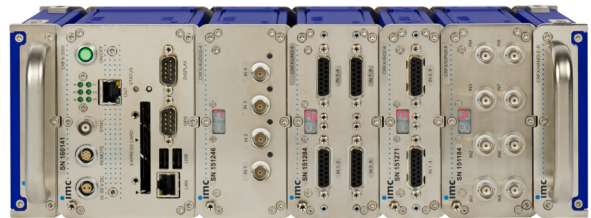


LVRT container, picture: © Windtest Grevenbroich GmbH

In complex tests that are almost impossible to repeat later, the “intelligence” of measurement technology plays an absolutely pivotal role. Firstly, because in this endurance test the task at hand is to continuously monitor a multitude of different measurement quantities - primarily to take into account completely the behavior of the most important components and to understand the operating processes as much as possible. Secondly, however, because the amount of data should not grow endlessly and as a result delay or complicate the process of performing fast and productive analysis.

Individually adapted sampling rates therefore play a decisive role - intelligent and complex triggers with which key events can be selected and captured in high resolution. Real-time calculation and the structured management of test procedures and measurement data also contribute significantly to efficiency.

With the imc CRONOS series of products and the imc STUDIO measurement software, engineers will find that they are able to comfortably manage even the most complex measurement tasks.



Modular measurement system: imc CRONOSflex

Intelligent and productive measurement systems for wind energy installations allow earlier release on the market, performance optimization, higher safety and a longer operating life, while reducing downtime and optimizing profitability.

Condition monitoring

Using measurement systems to continuously monitor wind energy installations is not only necessary in the development phase. They are also crucial for monitoring installations during regular operation. In-depth monitoring of the current condition, along with intelligent evaluation of changes in critical parameters, offers an opportunity to recognize wear and tear and potential downtime early on and to take timely action to prevent it.

imc offers a number of solutions that meet the specific requirements of condition monitoring. These solutions include autarkic measurement systems that are capable of performing complex signal processing without even needing a PC. Furthermore, important characteristic values can be extracted and transferred via modern communication networks to a central monitoring station. imc solutions offer security by making possible the comprehensive and continuous monitoring of an installation. The advantages are savings in expenses associated with travel to an installation and a reduction in the overall amount of work required.



imc C-SERIES: multi-functional measurement system

Noise measurement for wind energy installations

Developers and engineers testing wind energy installations often want to be able to perform complex measurements with a single device, and especially one that can also be used for measurements according to EC 61400-11 Ed. 3.

The evaluation of data for sound power measurement can be easily carried out using imc STUDIO and imc FAMOS. With the imc CRONOS family of measurement systems it is also possible to record non-acoustic data comfortably and efficiently, including:

- Wind speed and wind direction
- Air pressure, temperature and humidity
- The effective power of the installation
- A variety of additional control and evaluation data
- Extraneous noise, rain, etc.
- RPM of the installation and pitch angle

The uniform and simultaneous capture and storage of all data greatly simplifies data evaluation at a later stage. This allows in-depth analysis afterwards of any problems that have arisen under particular conditions. A significant plus is that all data is synchronized and available within the system in a uniform format. Final results can be easily compiled into multiple reports without having to further integrate the data.



Robust and disturbance free, durable and autarkic: imc measurement technology

Wind energy tests are performed under adverse environmental conditions such as severe cold, heat or vibration, and this demands a measurement device highly suited to these conditions. This applies especially to long-term testing and to field tests.



Furthermore, often considerable levels of electromagnetic disturbance and transient voltage peaks call for specially protected measurement technology capable of delivering precise results at all times. imc measurement systems have been designed to operate independently of a PC and with a high degree of reliability where other electrical instruments would often fail.

Thanks to the integration into one system all components necessary for signal conditioning, analog/digital (AD) conversion, real-time calculation and data storage, solutions developed by imc can be used in wind energy installations completely autarkically.

imc measurement solutions have also proved to be indispensable for the reliability of wind energy installations whenever environmental conditions are extreme. Strong and sudden temperature fluctuations or temperatures ranging from -40 °C to +85 °C are no problem for imc measurement systems.

Performance - optimize the level of efficiency

How much energy does a wind turbine deliver at a particular wind speed? Wind energy installations often operate with an optimized design for rotational speed control in order to achieve an ideal level of efficiency. This can be achieved through the best positioning of the angle of attack (pitch control).



Optimized operation

Extreme wind speeds can result in too much load being placed on mechanical components. In order to avoid damage, modern wind energy installations are constructed with storm control which ensures the safe operation of the installation at any wind speed. This requires precise testing during the optimization phase for the design of rotational speed control.

imc measurement systems, such as products in the imc CRONOS family, can be used autonomously for data acquisition. Due to their modular construction, an almost unlimited number of measurement channels are available. Data acquisition is usually at a sample rate of up to 200 Hz. Temporary processes, in particular stopping, frequently lead to extreme load peaks which can be examined more closely in shorter tasks using higher sampling rates in the kHz range.

The measurement systems are adapted to the wind power station's particular performance requirements and structural conditions.

imc systems are especially good at achieving large-scale, distributed system configurations. As component building blocks within systems, the individual devices are equipped with standard Ethernet terminals, universal, wide input voltage range (10 ... 50V DC) power adapters, and precise synchronization mechanisms and can be re-arranged within the system as desired.

In this the measurement systems are perfectly adapted to match the specific measurement task and design of the wind energy installation. Along with mechanical loads, all quantities can be captured that describe the wind energy installation. These include electrical performance, status of the installation, RPM, pitch angle of the rotor blades and the gondola position.

Together with the recorded meteorological conditions, these measurement results are compared with each other and comprehensively documented using the signal analysis software imc FAMOS. Wind speed and direction, the strength of turbulence or atmospheric density are measured in a free stream wind measurement mast. As a rule, measurement and evaluation take place according to the international guidelines IEC 61400-13 and IEC 61400-12.

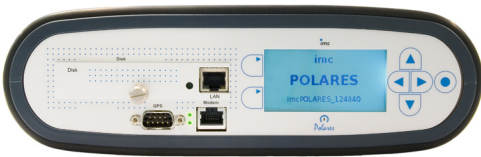
Power grid integration - measuring electrical quantities

A high degree of reliability and high power supply quality are imperatives. In order to evaluate interaction within a power distribution grid and to draw conclusions about grid quality it is necessary to continuously monitor and analyze a medium and low voltage power supply grid.



imc POLARES from imc Meßsysteme GmbH is a mobile device that analyzes the power grid and unites four functions:

- Performance measurement and analysis
- Event analyzer
- Analyzer for power grid quality according to EN 50160; IEC 61 400-7, -15-21,- 30
- Disturbance recorder for current, voltage and binary signals



imc POLARES: analyzer for power grid quality

More flexibility and effectiveness with imc STUDIO and imc CRONOSflex

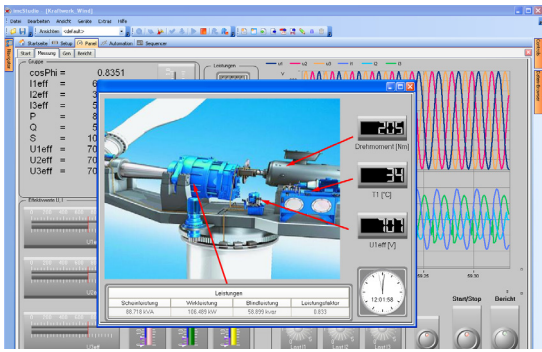
When it comes to achieving measurement results in the most effective way possible, the interaction between hardware and software components plays a central role. imc STUDIO measurement software offers the user a clear overview of the measurement task and comfortable handling. The various channels can be arranged, filtered and displayed within the software according to task, name, and measurement point. This makes it easier to perform measurements with a large number of channels.



Of particular importance is the visualization of measurement data. All data can be viewed and evaluated online on multiple PCs.

With imc CurveWindow, users have a tool at their fingertips that allows them to display data in 2D and 3D while the measurement is taking place. Real-time measurement cursors, markers and text in the CurveWindow mean that data can be examined the moment it is captured. Comments in the form of text and audio can be assigned during a measurement using a tagging function.





imc STUDIO Panel

The imc STUDIO Panel: customized user interface - simple to set up and saves time

Along with the Curve Window, an integrated panel within imc STUDIO forms the key display component of an imc measurement system. Customers can easily create operating and display panels to perfectly suit their own needs, without any need whatsoever to perform complex programming tasks. It's simply a matter of drag & drop. A function designed especially for wind energy and electrical applications makes configuration even simpler - each measurement system is ready to start within a few minutes.

How much energy does a wind turbine produce at what wind velocity? Wind power stations are often operated according to designs for optimized control of rotation speed in order to obtain ideal efficiency. This can be achieved by adjusting the blades' angle of attack (pitch control).



Saving time with automation

Furthermore, imc STUDIO makes it simple to perform test sequences automatically. An integrated sequencer allows the individual measurement and evaluation steps to be combined into one test sequence. Procedures such as loading the configuration, starting measurement, evaluating data and creating a report are simple to define as it is to create multiple page user guidelines. This renders repetitive manual tasks obsolete and shortens the path to finding a solution to any problem.



Decentralized distributed measurements with imc CRONOSflex: flexible, synchronous and secure

A large number of individual measurement points can be spread throughout a wind energy installation. The distance between a measurement point situated in the tower and another in the rotor blade can easily exceed 100 meters. Using long measurement cables, however, has disadvantages due to the predominance of electromagnetism. They are susceptible to interspersions and the falsification of signals.

imc offers a solution to this problem through a decentralized and distributed measurement system consisting of local amplifier and storage components. The devices can be assembled quickly and flexibly according to individual requirements directly at measurement points throughout the entire wind energy installation. The shorter cables reduce the possibility of disturbance. Communication between various components takes place via disturbance-resistant digital busses such as CAN or via Ethernet.

The imc CRONOS*flex* measurement system provides an ideal platform for this. Its network-based modular system architecture means that all modules can be distributed and synchronized throughout the entire wind energy installation.



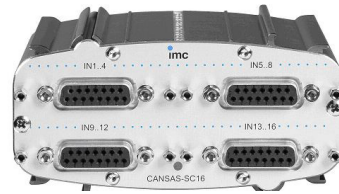
Flexible, expandable, fast: imc CRONOS*flex*

imc CRONOS*flex* offers the additional capability to process, link and analyze the measurement data in real time. This allows specific conditions and parameters of the installation to be calculated and displayed live while the measurement is taking place. Analysis therefore does not need to be carried out separately in a later step. It is synchronized, readily available and presented in visual form simultaneously with the primary measurement data, and it is always uniformly managed together with this data. The sources for these calculations can be analog channels or data fed in from the control system via CAN or PROFIBUS.

This ensures a complete overview of the current state of the wind energy installation and its individual components. Furthermore, because the results of an analysis are available continuously at all times, it is possible to intervene directly in the test whenever a need arises.



imc offers users a second series of products which have been especially designed for less dynamic measurements and for the acquisition of data in extreme temperatures - imc CANSAS.



Decentral, compact and robust: imc CANSAS

The imc CANSAS solution often takes the form of very small modules that can be perfectly integrated into the rotor blades and are capable of being used in ambient temperatures ranging from -40° C to +120° C directly on the cooler of a wind energy installation. CAN transmits the data from individual modules to a receiver connected to the rest of the measurement system. A specially patented process also makes synchronous measurement possible.

Reading in directly from bus systems such as PROFIBUS, PROFINET and CAN

With the recording of field bus data such as PROFIBUS or CAN - which are used to transfer information and commands within the control system - it becomes possible to capture analog data simultaneously with the process and control values. imc measurement systems extract the control and regulation signals from these busses together with the data from analog channels, such as channels for strain gauges, acceleration or temperature. The data transferred via PROFIBUS and CAN is read in synchronously with the other data and becomes available for further processing together with data from these other channels.

Furthermore, imc solutions operate with PROFINET technology based on TCP/IP. Proprietary Ethernet or RS 232 based busses can also be used, allowing all „private“ communication between participants in the control process to be heard or the systems of other manufacturers to be integrated into the process.

Automatic data transfer and condition monitoring with imc LINK

Once measurement data has been captured, the question often arises about how to access this locally stored information. Saving time and the expense of travel becomes an important factor when installations are located far away. imc LINK software transfers to users via the mobile telephone network or a DSL connection all measurement data that has been captured and stored in the device. It is also capable of transferring the calculated measurement results in a reduced data volume format.

Extended capabilities for status monitoring and configuring devices remotely offer the user comfortable options for control, as well as the flexibility to respond to specific events by changing the values for capturing data.

Measurement parameters can be monitored in real time directly through remote transmission. This allows the user to act quickly in order to prevent foreseeable problems. In case of emergency, the measurement system is capable of taking action independently or notifying users via SMS or email.



The ability of imc LINK to perform with multiple clients, support multiple devices at the same time and administer captured data and device configuration simultaneously makes it all the more effective as a tool.

Summary

For over 15 years imc has been successfully working with most of the leading manufacturers in the wind energy sector, as well as with suppliers and certification organizations in the sector. Many of imc's measurement tools and turnkey solutions have been developed in partnership with German and international companies - always with the goal of significantly increasing the productivity of our customers through test and measurement.

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imc Test & Measurement GmbH is a manufacturer and solution provider of productive test and measurement systems. imc implements metrological solutions for research, development, service and production. imc has particular expertise in the design and production of turnkey electric motor test benches. Precisely outfitted sensor and telemetry systems complement our customer applications.

Our customers from the fields of automotive engineering, mechanical engineering, railway, aerospace and energy use imc measurement devices, software solutions and test stands to validate prototypes, optimize products, monitor processes and gain insights from measurement data. As a solution

provider, imc offers their customers an attractive and comprehensive range of services. These include project consulting, contracted measurements, data evaluation, specialist deployment, customer-specific software development and system integration. imc consistently pursues its claim of providing services for “productive testing”.

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