Air Gap Monitoring System

improves availability, productivity and safety of your machines

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Hydropower – the renewable energy

Hydropower is one of man's earliest source of energy. It was used for centuries to drive flour mills, sawmills and hammer works. The first hydro power plants for producing electricity in Switzerland made their appearance around the year 1900. Today, hydropower constitutes the backbone of electrical power generation in Switzerland. It fulfils the requirements on sustainability as does scarcely any other source of energy. It is indigenous and renewable, and it produces no emissions which are harmful to the environment.

The term "Hydropower" designates the conversion of the kinetic energy of water into electrical energy. The prime source of hydropower energy is the sun. Through the radiation of heat to the earth it evaporates water, thereby maintaining a global water circulation system. The total mass of water on the earth is approx. 1.4 billion km^3, the by far greatest share of which (97.6%) is found in the oceans. The ice caps at the north and south poles contain about 1.9%, and the remaining 0.5% is on land.

Fig.1   Hydro Dam Edersee (D)

Hydropower makes up about 18% of the total energy production world-wide. This figure fluctuates substantially in the individual countries depending on geographical conditions. In Norway, for example, it constitutes 99%, in Brazil 90%, in Canada 60%, in France 12% and in Germany 4%. In Switzerland, at 60% hydropower is one of the principal mainstays of electrical power production. In Europe and in particular also in Switzerland the possibilities of exploitation of hydropower potential have already been largely exhausted. A certain potential still exists in the expansion and modernization of existing installations, as well as in the construction of small hydropower plants.

Fig. 2   The dam of « Iron gates » is with 2100 MW the most powerful hydro power plant of Europe and produce 12% of the Rumanian electricity power. The dam was built between 1965 and 1971.

Air Gap monitoring application

For economic reasons, the current trend among machinery users is to extend the life of their rotating machinery and increase plant availability and reliability. Instead of replacing 20 to 30 year old machinery, plant life extension programmes are being implemented to operate machinery up to and beyond its original lifespan. As machine uptime and reliability for power station operators is a top priority, the installation of an effective condition monitoring system is a very important issue.

Pump storage plants covering the peak power demand imposes severe thermal and mechanical stresses on the generator rotor and stator. Operating practice involves to run-up and run-down the machines two or more times per day which can lead to premature ageing and cycle-related stator winding deteriorations due to high temperature gradient in the material.

Problems with vibrations caused by rotor deformation or radial of the rotor deviations convinced many operators of large generators to install an effective method to measure the static and dynamic air gap.

Dynamic air gap monitoring is the process of measuring the distance from the rotor to the stator on a hydroelectric generator while it's running.

The Air Gap Sensor is a specially designed capacitive proximity probe that mounts on the inner bore of a hydroelectric generator stator. Multiple sensors provide in-service dynamic measurements of the distance between the rotor and the stator in both new and existing generators. Monitoring air gap is very important because the shape and location of the rotor and stator on a large hydro generator are affected by several factors like: centrifugal force, thermal and magnetic forces, mechanical expansion with load due to temperature increase, concrete growth, etc.

Understanding the rotor and stator shapes, positions and minimum air gap dimensions provides the operator with the information needed to remove a machine from service before serious damage from magnetically induced overheating or rotor-to-stator rub occurs.

Depending on the size of the generator (bore diameter and stator stack height) 4, 6 or 8 or more air gap sensors are installed around the stator wall. They are uniformly distributed on a top layer, bottom layer or both. A rule of the thumb define that when the stator bore diameter is less than six (6) meters, it is sufficient to install four (4 sensors) uniformly distributed around the stator on a top or bottom layer. For larger diameter, the amount of sensors shall be increase to obtain a sufficient accuracy.

Air gap sensor
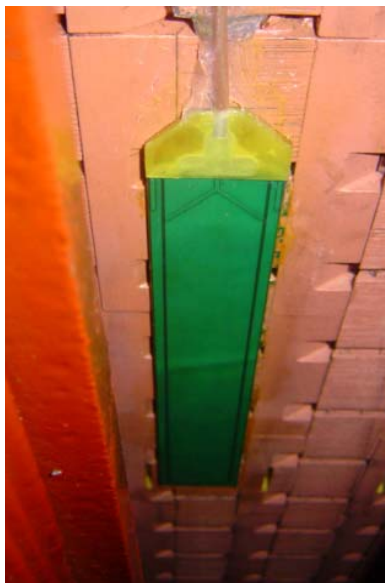
Fig. 3   Air Gap AGT 550 Sensor

**Fig. 4**   AGS-525   sensor and conditioner for air gap 5 to 25 mm

A modern Technology Compact

Module

The system offers a novel and efficient solution for the vibration and air gap protection for monitoring of the electrical machines. Thanks to the field proven PMS-100 Top Message data acquisition unit used and proven in the industrial automation and robotics, this material offers all guarantee concerning the reliability, robustness and performances in the industrial environment. PMS-100 data acquisition and processing cards are mass products with a very large worldwide diffusion ensuring long term production and support.
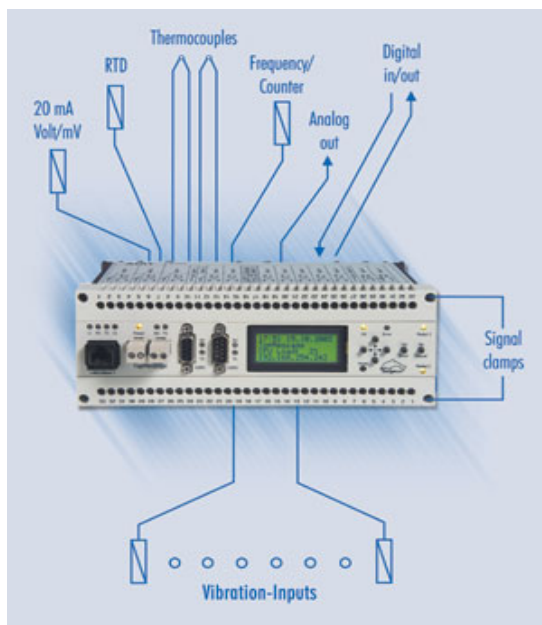
Fig. 5   PMS-100 Acquisition Module

The air gap signal acquisition, monitoring and analysis is performed by a modern technology compact module. Up to eight (8) respectively sixteen (16) simultaneous channels per DIN rail mount unit is possible. In addition, the process variables like temperature, load, and pressures can be monitored same time for correlation purposes. In such case and depending on the channel number and monitoring requirements, a slave module can be added and interconnected via CAN-Bus. This stand alone and networkable unit performs a continuous monitoring of the air gap signals in all operating conditions of the generator.

The PMS-100 data acquisition unit is fully programmable via RS-232 or Ethernet link when connected to a PC running the Bus Manager software. In addition, the unit offers a MODBUS port for connection to Digital Control System of the machine.

Networking capability

The Ethernet link using TCP/IP protocol provided by the acquisition module permits the transmission of the data where needed locally, at your desktop, and within the user network. If you do not use the company's network, you can easily set up a data network with standard components parts and can then evaluate the data on several computers.

PMS-100 Top Message hardware, ProfiSignal and Vibrolab software provide the benefits of quality assurance, diagnosis capabilities required functions for efficient machine air gap monitoring.
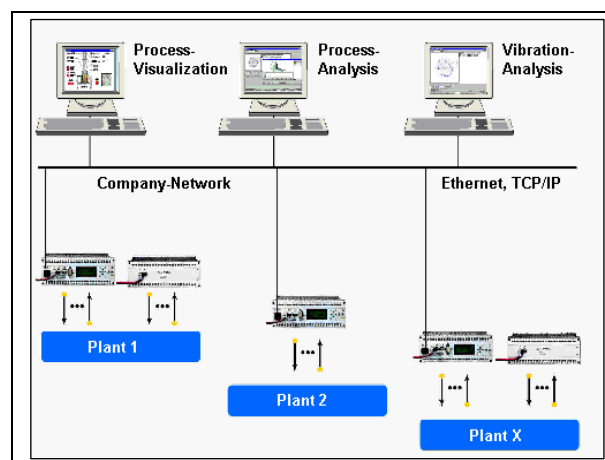
Fig. 6   Company network LAN

Modular and user's friendly software

Fully compatible German/English software modules operating on PC under WINDOWS XP PRO are available for:
- Process graphics, operating and monitoring
- Acquisition, monitoring, trending and analysis
- Vibration analysis of raw signals and display as time record, frequency spectra, waterfall graph, polar graph, orbit graph, short trend, etc.
- Visualisation of all poles over one revolution.
- Historical and events driven trend of data
- Acquisition and Monitoring System is delivered fully configured in accordance with the system requirements.

PROFISIGNAL Process Visualization module allows the user to create diagrams for the operation and monitoring of a HMI Human Man Machine Interface adapted for the application. It enables the realization of any number of applications by using just one software package.

Hereafter, a simple mimic of the machine, digital displays, alarm and trip lamps, bargraphs and selection buttons has been created using the tools of the ProfiSignal editor.
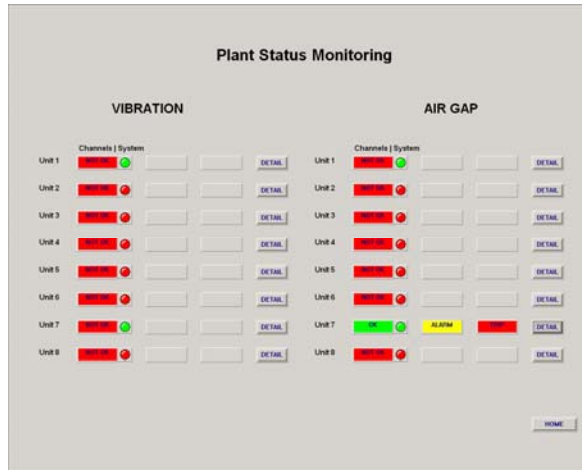
**Fig. 7**   Sample of HMI for a plant with 8 machines

One single display informs the operator about the vibration and air gap status of all machine in the plant. Alarm lights and selection buttons are available.

After selection of one machine by means of the *Detail* button it is possible to visualize the measured vibration or air gap data.
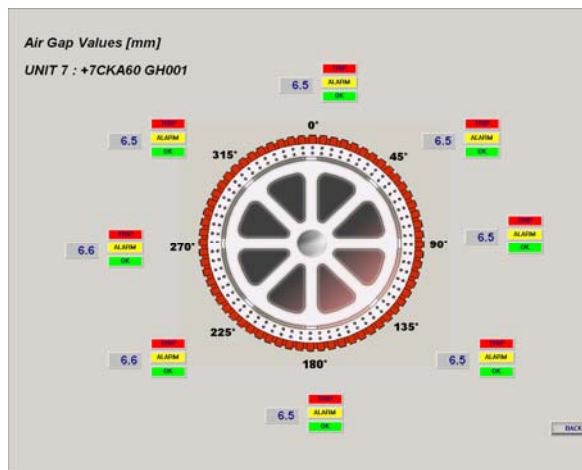

Fig. 8   Sample of air gap visualization software

Historical Trend graph is available for all measured data. For instance, trend over one month with a 5 second intervals is available. The buffer capacity can be as large as 512 Mbytes (64 Mio measured data)
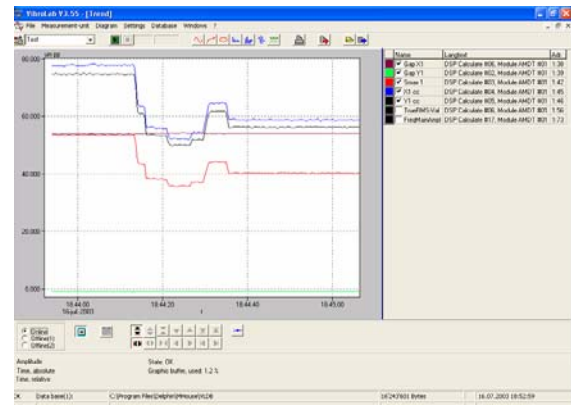

Fig. 9   Sample of Historical Trend Graph

Event trend recording memory is available to store event triggered data storage. In case of an alarm, all measured data will be recorder with one (1) second interval for a period of 10 minutes before alarm and 10 minutes after. A sample of graph is shown hereafter.
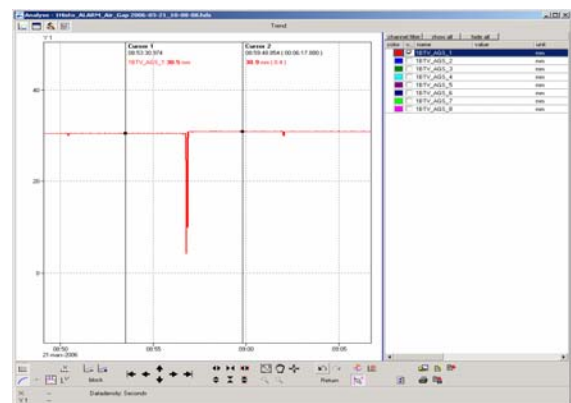
Fig. 10   Sample of Bus Manager information

Each measured parameters is associated with two alarm levels (alarm and trip) which depend on the operating mode of the machine (synchronous mode or transitory mode). When an alarm is exceeded on any measured channel, it is automatically recorded and displayed in the Alarm Master with date and time.
Alarm acknowledgement is possible by authorized personal only.
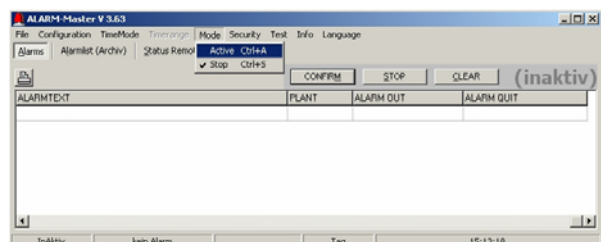
Fig. 11   Alarm Master

Installation of the air gap system

The flat design of the sensor and the usage of insulated material for the manufacturing of the sensor allow its installation in the air gap of any alternator or electrical motor. When mounted on the stator wall laminations, the probe is facing the rotor poles and detects the distance between the pole face and the surface of the air gap sensor. In fact, the air gap transmitter is factory calibrated to measure the true air

Fig. 12   Air gap Sensor on the stator wall

gap e.g. the distance from stator wall to the pole tip. After conditioning and linearization of the high frequency carrier frequency the air gap conditioner provides at its output a voltage or current exactly proportional to the measured air gap distance. The air gap conditioner has a flat frequency response up to 1 kHz which allows a proper transmission of the 100 HZ (120Hz) pole passing frequency.

The first step before an air gap sensor installation is the selection of the mounting locations. As a rule the sensors shall be mounted at a depth of 20 to 30 cm inside the air gap in order that the pole face covers the measuring face of the sensor.

The air gap sensor has an integral cable length of ten (10) meters terminated by a four pole connector. The sensor cable shall cross the end-windings as close as possible to the laminations. The cable length is normally sufficient to reach an AGC conditioner electronic installed on the outside wall of the generator. Whenever possible, the conditioner shall be accessible during the operation of the machine for ease of maintenance.

Electrical signals are transmitted by means of individual multi-core shielded cables to the centralized monitoring unit. In addition to the air gap sensors, a synchronization probe defining the physical reference of the pole provides a one per revolution trigger pulse used by the data acquisition system.

Sensor location

Sensor # 1 is normally located Upstream
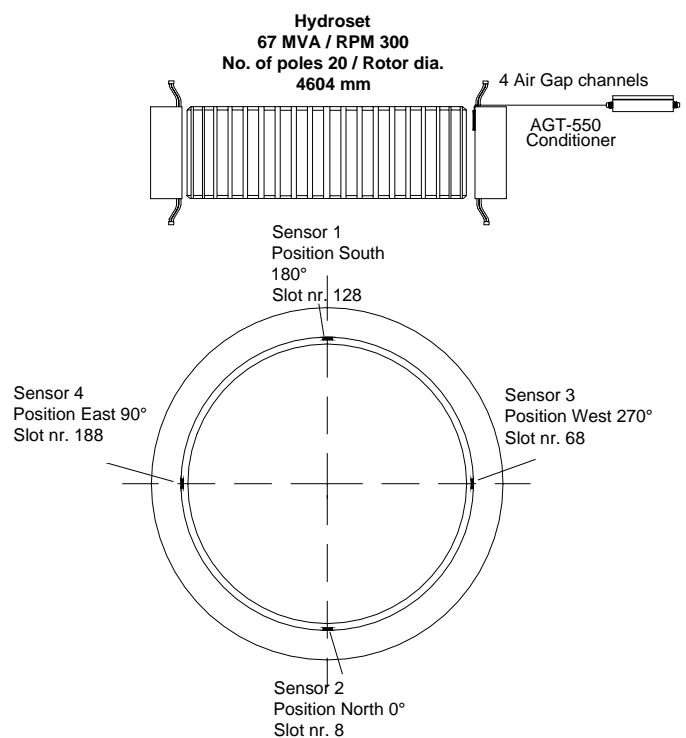
Fig. 13   Example of air gap sensor location

The size of the machine dictates a four air gap sensor arrangement 90° apart around the stator. They are mounted on a top layer because the bottom part of the stator is of the stator is secured on the sole plate and exhibits less movement than the stator top section.

Main features

AGT–525 transmitter

Linear Measuring range
AGC-525 M1   : 5 to 25 mm
Outputs
Voltage output   : +2 to +10V
Sensitivity to distance   : 0.4V / mm

Output current – Pole profile   : 4 to 20mA
Current sensitivity   :0.8mA / mm

Minimum Gap output   : +2 to +10V
Sensitivity   : 0.4 V / mm

AGT–550 M2 transmitter

Linear Measuring range
AGC-550 M2   : 20 to 50 mm
Outputs
Voltage output   : +2 to +10V
Sensitivity to distance   : 0.266 V/ mm

Output current – Pole profile   : 4 to 20mA
Current sensitivity   : 0.533 mA / mm

Minimum Gap output   : +2 to +10V
Sensitivity   : 0.266 V / mm

AGT–550 M2 transmitter

Linear Measuring range
AGC-550 M3   : 15 to 35 mm
**Outputs**
Voltage output   : +2 to +10V
Sensitivity to distance   : 0.4 V/ mm

Output current – Pole profile   : 4 to 20mA
Current sensitivity   : 0.8 mA / mm

Minimum Gap output   : +2 to +10V
Sensitivity   : 0.4 V / mm

Data Acquisition and Monitoring Unit

- Bandwidth DC to 10kHz
- Digital filters (LP, BP)
- Monitoring of the minimum air gap
- Triggered acquisition and analysis of air gap
- Broadband monitoring
- Relays output for alarming
- DIN Rail mount, detachable terminals
- 19" rack mount 3 U or 6 U height
- Multiple voltage power supply.
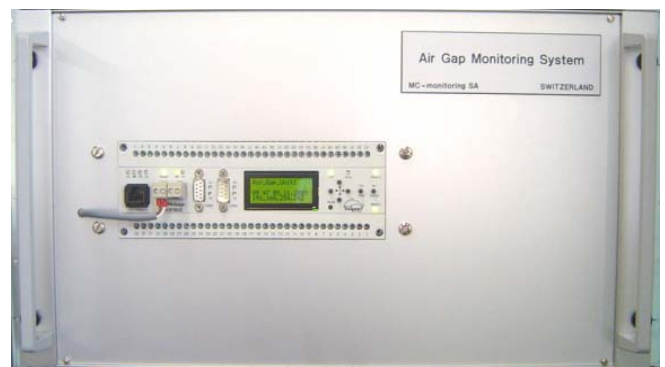
Fig 14   Example of Air Gap Monitoring 19" rack.

For detailed technical information please refer to individual data sheet of the products you can find on our web site www.mc-monitoring.com