FIBER OPTICS
GENERATOR END-WINDING VIBRATION MONITORING SYSTEM

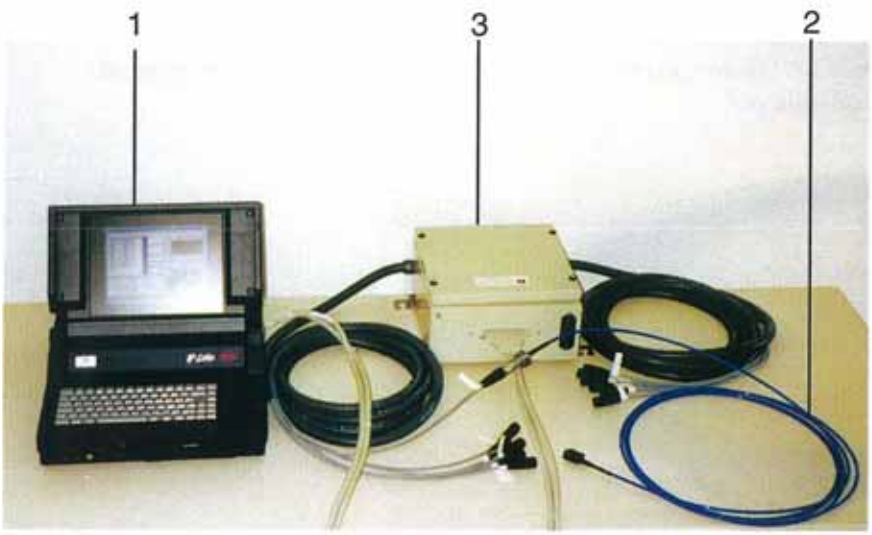
The economic performance of turbo generators and hydro generators can be considerably enhanced by on-line monitoring techniques.

Vibration signals as well as process data such as temperature, hydrogen pressure, hydrogen purity, flow rate, partial discharge, shaft voltage and field winding shorted-turns can be monitored and used for condition assessment of the entire generator. Because vibration, especially stator end-winding vibration are an important index showing the soundness of rotating electrical machines they can be used for the early detection of abnormalities and troubles.

A modern, reliable and efficient system of measuring, displaying, evaluating and storing of large amount of measurements has been designed to achieve this goal (see Figure 1). The system allows long term evaluations and statistics of the end-winding vibration behavior.

The operator gets a clear short overview and display of process data, machine condition as well as operation recommendations not long and difficult survey readings.

A Fiber Optic Vibration System is used to measure the vibration of high voltage generator stator end-windings where conventional hardwired transducers cannot be safely mounted. Because they do have an impact on end-winding vibration additional process data mentioned above can be integrated into the system. The extent of such additional data depends on the individual generator design.



1 PC for data processing and displaying

2 Fiber Optic Sensor and Fiber Optic Cable

3 Power Supply for the Fiber Optic Sensors

Figure 1: Fiber Optic System with 12 Fiber Optic Measuring Channels

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The generator end-windings of the stator experience forced mechanical vibrations during operation. The frequency of this vibration is two times the electrical synchronous frequency of the generator.
Therefore stator end-winding vibration occurs at 120 Hz for 60 Hz systems and 100 Hz for 50 Hz systems.
High vibration can lead to loosening of the entire end-winding support system, deterioration of supports, insulation wear, rupture of coil conductors or fatigue cracking of conductors which would require extensive out-of-service repairs.

The Fiber Optic Vibration System provides a data base which is helpful in anticipating generator end-winding vibration problems and predicting future maintenance needs, extending inspection and minimizing down time for maintenance.

The vibration sensor is shown in Fig. 2. The device is sensitive to vibration motion in one direction. Small size and the electrical isolation of the optical circuit allow the sensor to be mounted directly to the stator coil ends. The sensor head is located at the end of a three single strand multimode optical fiber glass cable. One fiber carries the light generated by the conditioning electronics for illumination. The sensor head returns two optical signals of variable intensity through the remaining fibers.
When the fiber optic accelerometer is subjected to vibration, the force proportional to the absolute acceleration encountered causes angular deflection of an elastic cantilever. The incoming beam is reflected at an angle proportional to the magnitude of acceleration. The conditioning electronics consists of optoelectronic detectors, amplifiers and filters. The resulting output is a calibrated analog acceleration signal which is interfaced with a computer. An appropriate passband filter attenuates the noise and resonance frequency of the cantilever.

1 Fiber Optic Sensor

2 Fiber Optic Cable

3 Signal Conditioner

Figure 2: Fiber Optic Sensor with Fiber Optic Cable and Signal Conditioner

A software system for Windows installed on a PC is used for data processing and display (see Figure 1). It provides outputs proportional to vibration acceleration and displacement. A digital signal processing performs a Fast Fourier Transform (FFT) and the data is presented in the form of a amplitude-frequency spectrum to the operator.

The system can be used as a independent stand-alone system or interfaced with a master computer.

The front panel of the data processing and display system is shown in Figure 3.

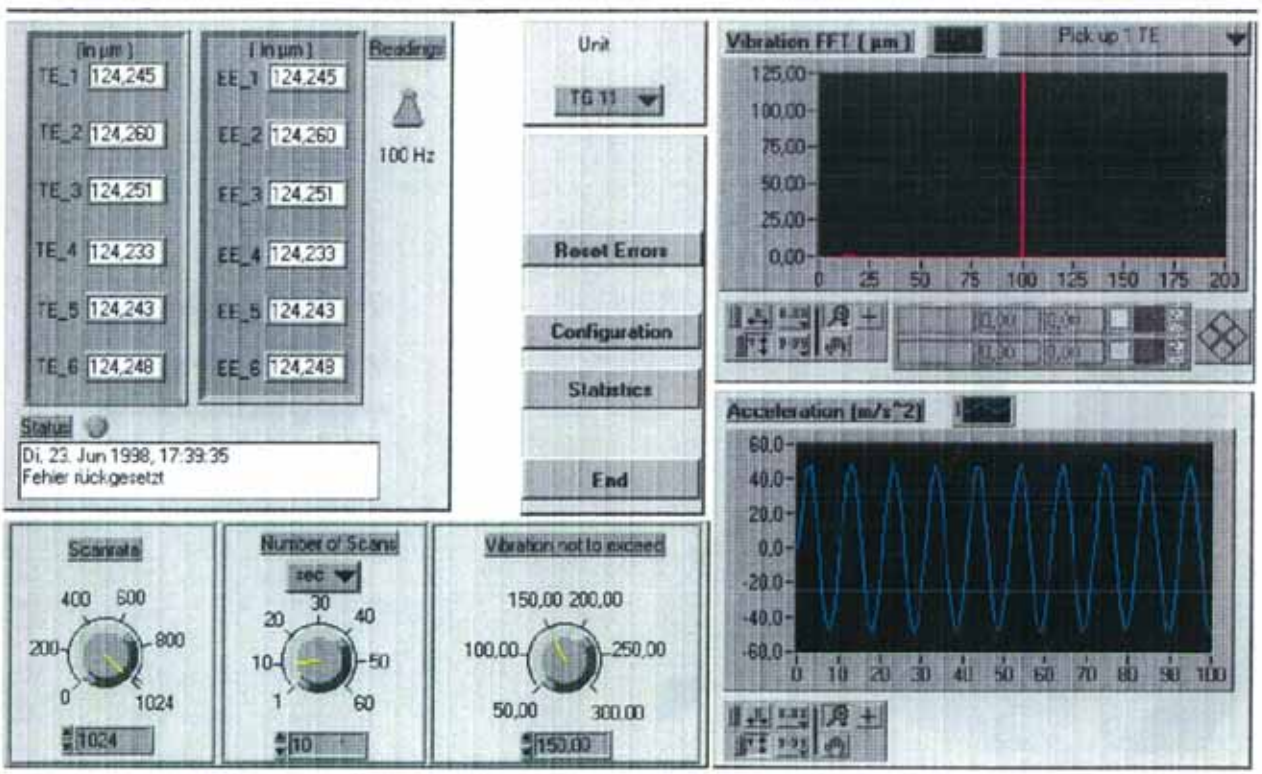

Figure 3: Front Panel of the Generator End-Winding Monitoring System

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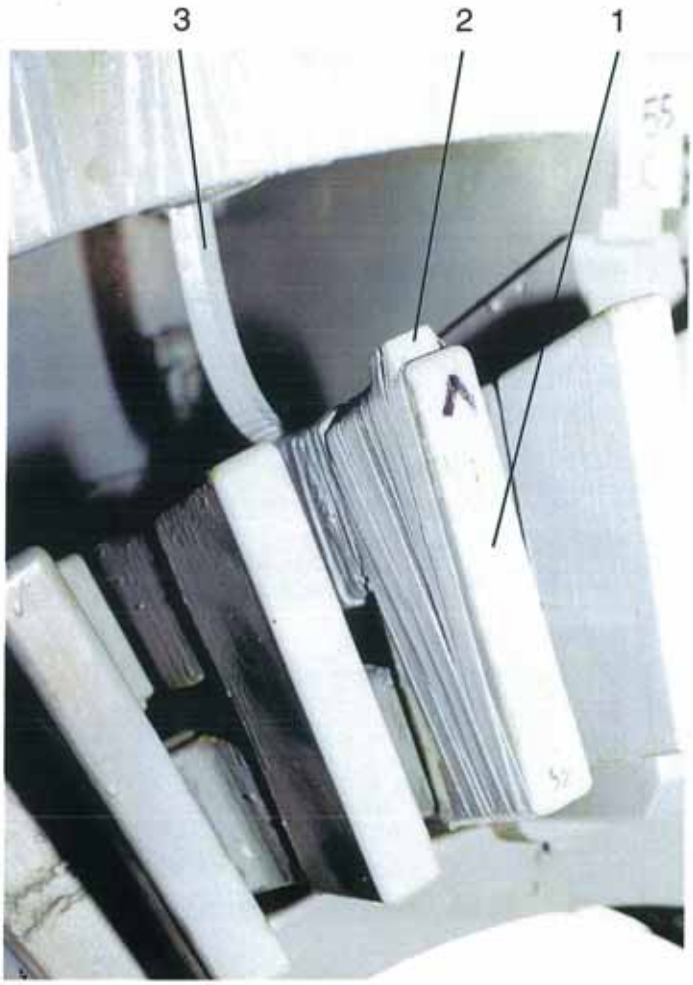
The Fiber Optic system can be installed in generators in service during an outage and be upgraded to a complete Generator Monitoring System.

Figure 4 shows a Fiber Optic Sensor installed on a high voltage stator end-winding.

Complete systems with 12 Fiber Optic channels, 6 on the turbine end and 6 on the exciter end have been installed in nuclear power plants for measuring, displaying, long time storing and evaluating the vibration behavior of generator stator end-windings.



1 High Voltage Stator End-Winding

2 Installed Fiber Optic Sensor

3 Routing of the Fiber Optic Cable

Figure 4: Installed Fiber Optic Sensor

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