Black Box for Electrical Machines
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*Black Box for Electrical Machines*

[www.koncarmonitoring.com](http://www.koncarmonitoring.com)
Introduction

In order to enable better asset management and to protect capital investments, a monitoring system called “Electrical Machines Black Box” (EMBB) has been developed. The name Black Box was chosen because of the similarity with an airplane black box, which helps investigators to uncover the causes of aircraft accidents. Therefore, the device was named Black Box in order to be recognizable to the users. In case of a fault, failure or operation under harmful working conditions, recorded information can be used to determine the causes.

Today, the power systems are equipped with various monitoring systems used for condition monitoring of the most important equipment. Different parameters are measured and presented to the users as current values, or used for numerous calculations and data base storage. For the data collected in this way an expert analysis is necessary in order to obtain the information useful to the end user. EMBB system uses a different approach in which only the most relevant information are displayed to the users.

"The measured parameters inside of the system allow conclusions to be drawn about the machine operations and its harmful conditions.”
EMBB at a glance

**DESCRIPTION**: SYSTEM FOR RECORDING HARMFUL OPERATING MACHINE CONDITIONS

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<th><strong>TARGET INDUSTRY</strong></th>
<th>energy production, industry applications</th>
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<td><strong>END APPLICATION</strong></td>
<td>hydro generators, turbo generators</td>
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<td><strong>DIRECT APPLICATION</strong></td>
<td>synchronous and induction machines</td>
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<td><strong>MARKET POTENTIAL</strong></td>
<td>large (unique concept)</td>
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**KEY VALUE PROPOSITION**

- protection against improper machine operation during the warranty period

**PRODUCTION BENEFITS**

- identification of operating procedures that are harmful for the machine
- provides key information (corrective measures) for machine life cycle extension and effective asset management

**TARGET SEGMENTS**

- rotating machine producers
- insurance companies
- system integrators and turn-key providers
- energy consultants

**PROBLEMS ADDRESSED**

- detection of all important working conditions that are not permissible or represent a potential danger to the life cycle of the machine
The purpose of the system

The detection of machine fault conditions is of great significance. With the appropriate machine monitoring and fault detection system early warning signs can be obtained for predictive maintenance, improved safety, and improved reliability of electrical machines. Faults can produce machine shutdown, economic and time losses, and even human casualties. Early, fast and accurate detection and diagnosis of faulty conditions is critical in preventing major damage.

The purpose of the EMBB system is dual:

1. **FOR PRODUCERS**

   After the occurrence of a malfunction or possible damage, EMBB system determines whether and to what extent the machine was operating under harmful working conditions. For electric machine manufacturers this is crucial, especially within the machine’s warranty period. In case of reclamation, with EMBB system it can be easily determined whether the machine was operating outside of the parameters determined by the contract. In such cases the manufacturer could refuse the request for the reclamation.

2. **FOR USERS**

   Another important purpose of EMBB system is to enable the users of electrical machines to get insight into all harmful and faulty conditions during the machine operation, recorded by the system. By reviewing all recorded data the user can conclude that some operating procedures are wrong or that certain parts of the system are failing during the operation. Based on those findings the users can make corrective measures which will greatly contribute to the reliability and availability of the entire system.
Harmful conditions detected by EMBB system

Asynchronous operation

Occurs if excitation current is terminated in the machine that is loaded and connected to the power grid. The rotating magnetic field changes direction, the machine shifts from generator to motor operation causing extremely high currents in the stator winding. The amplitudes of these currents may be similar to those in short circuit, which represent risks to a machine lifetime.

Incorrect synchronization

A condition that can occur during machine and power grid merger. The result is a failure to fulfil all the rules of synchronization.

Significant asymmetry

Implies difference between phase currents which are larger than those specified by machine characteristics or by the contract.

Two-phase operation

Represents a situation in which two phases of stator winding are loaded while the remaining third phase is unloaded. This condition represents significant asymmetry and significantly influences machine lifetime.

Run-out

The machine speed exceeded the rated speed of rotation. This parameter is defined separately for each machine, depending on the type of turbine, regulation protection, and implementation project. Number of run-outs significantly affects machine lifetime.

Overloading

A machine condition where the stator current is above the rated or those agreed with contract.

Overheating

Overheating of stator/winding iron may be a result of overloading or operation during a machine fault. The boundaries are defined by the standards and for each machine in its implementation phase.

Extensive vibrations

The same as with overheating, the extensive vibrations may be a result of overloading or operation during a machine fault. This is also regulated with standards.
EMBB system concept and design

EMBB system is a combination of measurement sensors, programmable processing unit associated with measuring modules, application program that manages the process unit and wiring.

Processing unit is a fast and reliable industrial PLC, designed for harsh conditions and environments. It has all the necessary certificates and references for usage with electrical machines. Important advantage of the EMBB system is modularity. In combination with PLC there are various measurement modules, so the system can be easily adapted to customer requirements. Fast and reliable EtherCAT (Ethernet for control automation technology) communication, a real-time Ethernet technology from equipment manufacturer provides the EMBB system with outstanding performance, flexible topology and simple configuration.

Important part of the EMBB system and its processing unit is a memory card. It is a standard memory card type and data can be read by standard programs like Microsoft Word, Notepad, etc. The card can also be removed and the data can be read on any card reader. Additional security is provided using security labels that reveal removal of the memory card and using security lock on the EMBB system cabinet door.
Another important characteristic of the EMBB system is its simplicity. All the used sensors are easy to install. There is no need to interrupt machine in operation or to make any interventions on the equipment for sensor installation. Complete system for the new machines can be installed in the factory.

Application program

Before developing application program it was necessary to define parameters of the machine that need to be measured in order to obtain and calculate above mentioned harmful conditions. Some of the parameters EMBB measures and monitors are: voltage and stator currents, excitation current, vibrations, temperatures, rotation speed and number of machine start-ups.

It is important that all parts of the path: understanding of machines' physical nature – installation of appropriate measurement sensors – numerical calculations and fast on-line signal analysis – expert data interpretation, are designed and done carefully. This ensures quality and operational reliability of the product, which affects customers’ satisfaction.

"In contrast to conventional monitoring systems, EMBB records only harmful conditions. It is not necessary to record and store a lot of useless data. The users and manufacturers of electrical machines need to know how many harmful conditions occur over a certain period of machine operation time. After the expert data interpretation they can conclude what went wrong and what needs to be done in order to fix the encountered problems."
Key facts about EMBB and rotating machines

Today’s market is pushing machines to have more than one start per day. This is very dangerous for the machines that are made of different materials with different characteristics.

End users are sometimes not pleased to have EMBB installed. EMBB will record if they mishandle the machine or operate it against the agreed terms. Consequently, no fees can be charged against the equipment producer.

Standard machine warranty periods last two years. Without EMBB a customer can report any kind of error and ask for reimbursement due to the machine failure and lost revenue because of the production stoppage.

If producers deliver their machines with EMBB, not only do they record machine operations, but also get insights into critical ones.

With EMBB the cause of failure is familiar, which means that end users focus only on key faults that jeopardize the stability of their production.

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Conventional monitoring systems for rotating machines are based on the vibration measurement and are not designed to detect and identify the above mentioned harmful machine conditions. Their purpose is to record measuring data and to alarm the user when the measured value reaches pre-set value. Except for displaying the current values on user screens, measured values are permanently stored in a database for later complex analysis. Only after expert analysis of large amounts of data, conclusions can be brought about the machine state.

From previous collaboration with power plants and manufacturers of power equipment, one can conclude that there is a need for smaller and simpler systems. By using expert knowledge and specific measurements, the systems like EMBB provide specific information about the state of the machine directly to system users, without the need for detailed and expert analysis of the collected data.

Long-term data storage, system modularity, data protection, local and remote data access are some of the EMBB system characteristics and advantages that make it easy and safe to use.