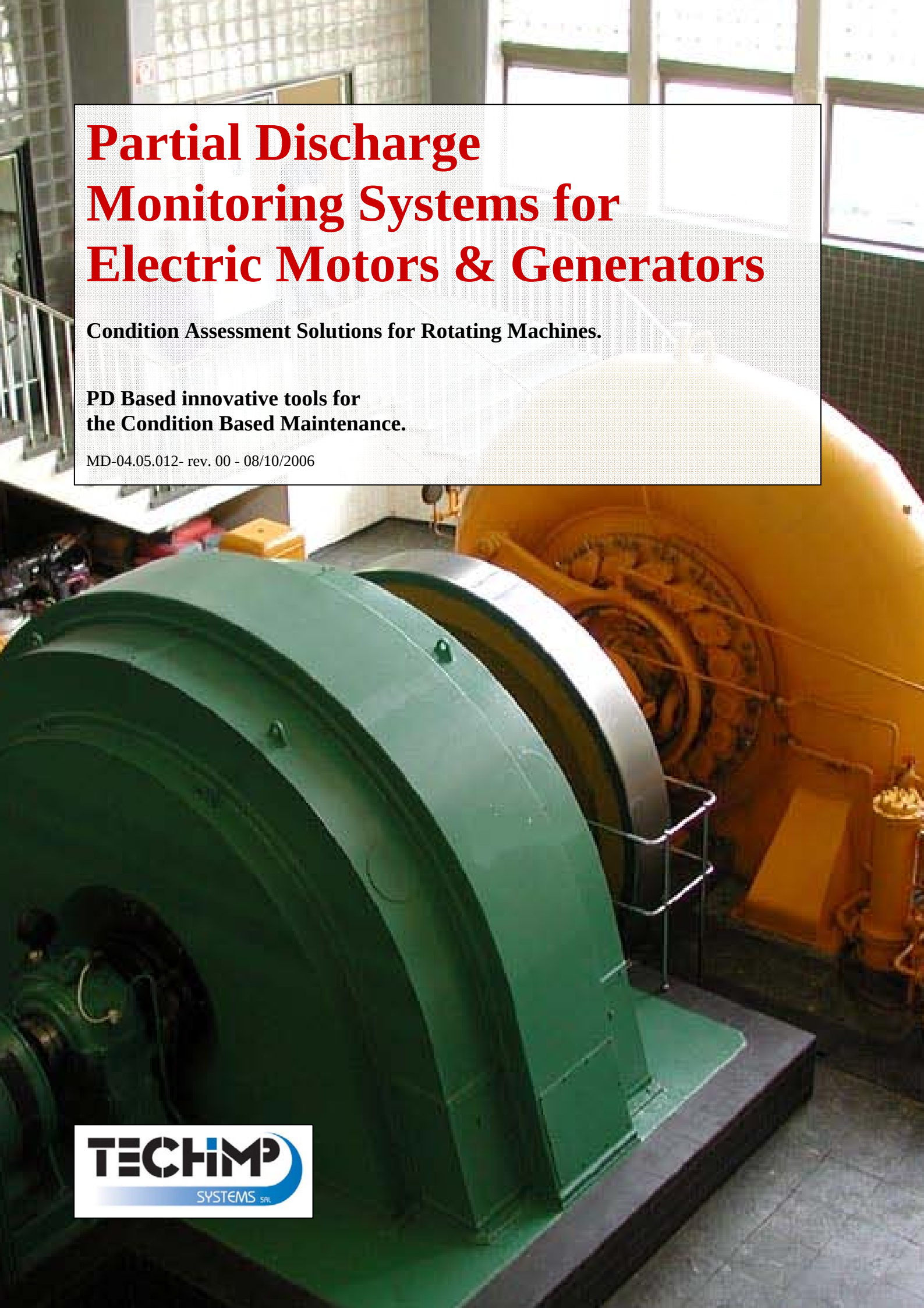

Partial Discharge Monitoring Systems for Electric Motors & Generators

Condition Assessment Solutions for Rotating Machines.

PD Based innovative tools for the Condition Based Maintenance.

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TECHIMP SYSTEMS SAL

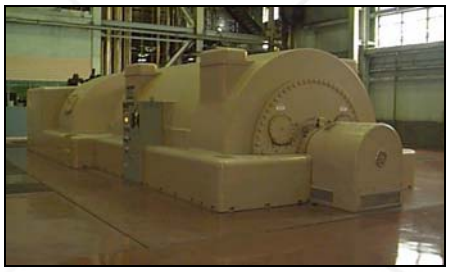
Condition assessment of electric motors & generators

PD assessment is an accepted practice to evaluate rotating machine conditions.

The presence of PD in **organic insulation** systems calls for immediate maintenance actions since the insulation can fail in a very short time.

For **inorganic insulation** systems, instead, PD can highlight degradation mechanisms (e.g., mechanical stresses, presence of contaminants etc.) and can be a cause of accelerated degradation. Therefore, only PD source identification can promote effective risk assessment practices, thus supporting maintenance actions and planning.

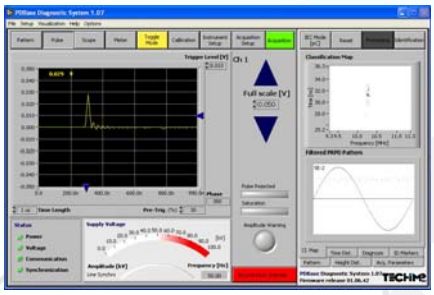
Diagnosis obtained from PD analysis, allows **Condition Based Maintenance** (CBM) practices to be established. CBM is far more effective than Time Based Maintenance (i.e., maintenance at fixed time intervals), since it avoids unnecessary and costly operations while minimizing the risk of catastrophic failures that can occur between two consecutive scheduled maintenances.



Overall, CBM techniques support asset manager decisions. The results are optimal resource allocation, time and money savings while preventing damages and unexpected outages.

After years of advanced research, laboratory and on-field tests, TechImp has developed powerful and effective tools which can help the asset manager to take important decisions and manage electrical apparatuses in a cost-saving way.

TechImp proposes two different approaches for the monitoring of rotating machines:
- **PD periodic monitoring**, suggested for non-critical loads (e.g., motors whose tasks are of secondary importance for industrial processes);
- **PD permanent monitoring**, recommended for generators and for those motors whose service continuity is fundamental for industrial processes).



PD Acquisition Program Interface

Main features

- Digital partial discharge monitoring
- PD pulse analysis
- Fuzzy logic tools and statistical processing for automatic identification
- Diagnostic database
- Trend of other parameters correlated to the PD activity for a global monitoring
- Fully stand-alone
- Remote controllable (Ethernet interface)

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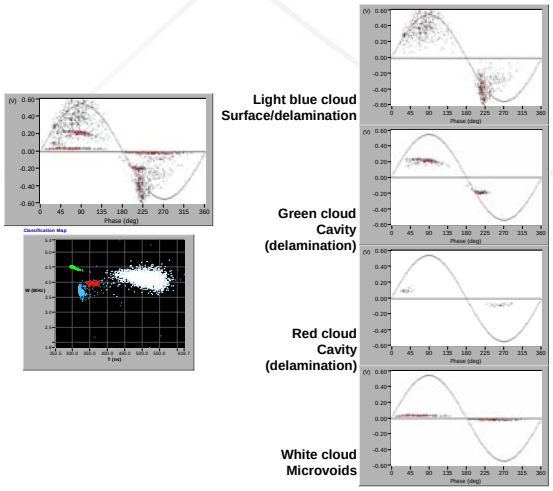
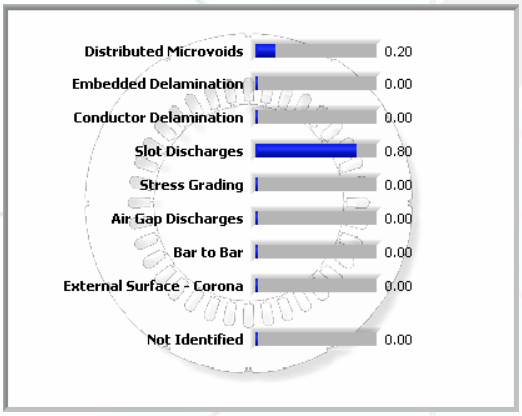
TechImp innovative technology

TechImp technology (patented) allows different PD phenomena to be classified on the basis of their pulse shape and split in different clusters, so that further analysis can be carried out on each dataset, separately. This enhances the likelihood of PD source **identification**, even in the absence of a skilled operator.

TechImp acquisition technology also provides efficient **noise rejection** in most cases without adding any suppression device. As a matter of fact, noise signals have been observed to be very different from PD signals; therefore, TechImp classification system can be successful in separating the contributions of PD from those generated by disturbances.
Specifically, each PD pulse waveform is acquired and the so-called equivalent time-length and bandwidth are evaluated and plotted on the TF map. Different types of discharges (e.g. PD and noise) shall group into different clusters in the TW map being characterized by different pulse shapes. Therefore, on the basis of the TF map, it is possible to achieve noise rejection and separation of PD phenomena. An example of this separation for a badly impregnated coil is shown in the picture below, in which PD due to different phenomena group into different clusters.



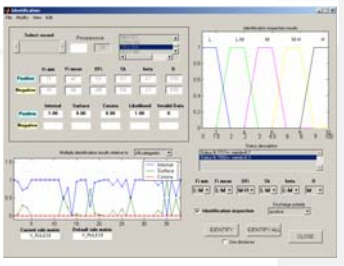
After the separation has been carried out, patterns associated with each phenomenon can be extracted and processed separately. The system software is also endowed with an automatic fuzzy logic based, defect identification tool dedicated to rotating machines.



Defect identification tool

Diagnostic database

Diagnostic data storage and retrieving is a fundamental support for TechImp instruments as well as service department. A database containing thousands of data relevant to partial discharge activities occurring in electrical system has been developed. The database approach is fundamental for both identification and risk assessment purpose. As a matter of fact, through data analysis and comparison PD phenomena can be successfully recognized and followed over time so as to recognize the need for a maintenance action. Thanks to the diagnostic database, identification algorithms can be customized for machines of each specific technology.



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The database shall be shared with customers and accessed via internet.

Diagnostic technique integration

Since PD may be affected by other factors of influence, such as temperature, humidity, vibrations, the monitoring system can also collect these kind of data from dedicated sensors.
All these data can be stored in the machine database and correlated with PD readings for an optimal condition assessment of the considered machine.

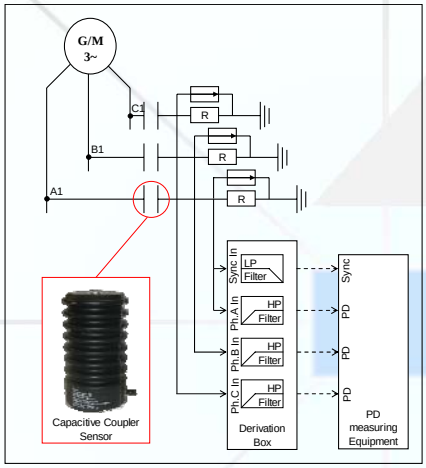
In case a continuous PD monitoring is carried out, the acquisitions of PD and other quantities can be mutually triggered, so that if the one of the parameter trend generates an alarm, the system immediately starts to acquire also the other (and vice-versa).

System lay-out and installation

The system can be easily installed and it is essentially made up of the following components:

- Sensors (one for each phase, in general permanently installed);
- Derivation box (permanently installed);
- PD monitoring system (to be connected at the measuring stage for *periodic* monitoring sessions or to be permanently installed for *continuous* monitoring).

A schematic layout of the monitoring system is shown in the picture below, where the connection points A1, B1, C1 represent the machine terminals.
Capacitive type sensors are normally used for rotating machines. These sensors, are 1000 pF high voltage dry-type (mica/epoxy) capacitors. These capacitors are permanently installed at the machine terminals (generally in the bus duct). The high frequency PD pulses originated in the machines are derived by capacitive couplers so that they can be measured.



System Layout

Downstream the capacitive sensor a suitable resistor is provided. The resistance forms together with the capacitance the measurement voltage divider. A surge arrester is also provided in parallel to the impedance to protect the whole system from over-voltages.
Downstream the voltage dividers, a derivation box with a set of 3 high-pass filters and 3 low-pass filters is installed.

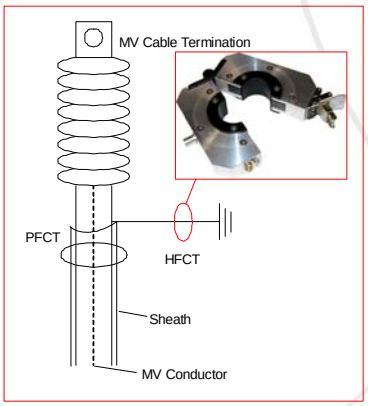
The 3 high-pass filters are aimed at PD measuring. The low-pass filters are used to derive power frequency reference signals (synchronisation with line-to-ground voltages).

Cable Derivation Box

If the installation of capacitive couplers is for any reason not possible, other sensors can be used. Among those, High Frequency Current Transformers (HFCT)

can be effectively employed. The HFCT has to be connected around one (or more) grounding connection(s) of the machines.
For synchronisation purposes, a Power Frequency Current Transformer (PFCT) or Rogowski coil may be used.

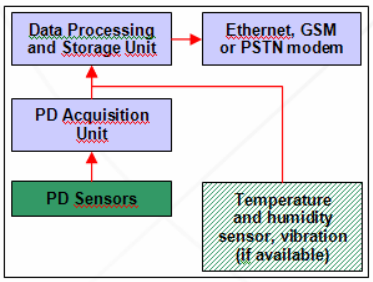
Even though this measurement configuration can provide useful diagnostic indications about the machine conditions, it has lower sensitivity with respect to the previous configuration.
In case the machine is supplied by means of insulated cables, a feasible solution is the use of HFCT installed around the earthing connection of the sheath of the cables relevant to each phase or around the power cables themselves.



Example of HFCT Installation

Permanent Monitoring and Periodic Assessment

For **Permanent Monitoring**, the PD acquisition unit is always connected to the derivation box (or directly to the sensors in case HFCT are used) and to other sensors (temperature, humidity, vibrations, etc.), if available.
PD signal cables are connected to the PD Monitoring device, which, in turn, must be linked to an Ethernet network for remote supervision and control.



Monitoring System

Interconnection with SCADA systems can be realized in several ways.
If an Ethernet network (and a static IP address) is available in the plant, the monitoring equipment can be directly connected to it. Otherwise, a dedicated phone line can be also used with a PSTN modem. When such communication facilities are both not available, a GSM or satellite modem (depending on the coverage of the area) can also be used.

For the **Periodic Assessment**, it is assumed that the PD measuring instrument is connected to the PD sensors from time to time (the same equipment can be used to check several machines).
The Derivation Box is provided with 4 sockets (one for each phase for the PD signal + the synchronisation signal) so that when the periodic measurement must be carried out, the PD acquisition unit can be easily and quickly connected to it, without need of putting the machine out of service.

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