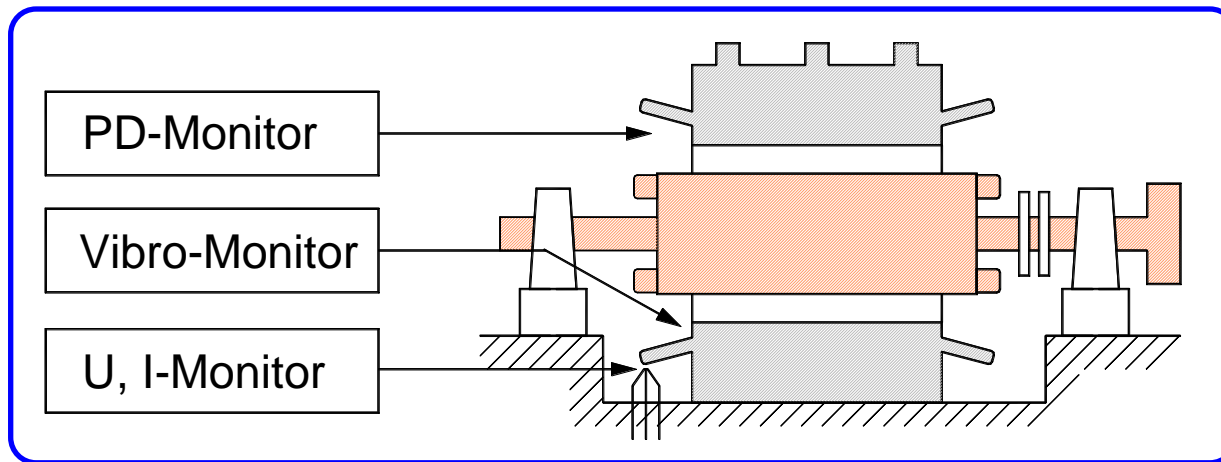




The Generators and Electric Motor Monitoring and Diagnostics Systems

MDR and PGU-DM

The «MDR» - Motor Diagnostics Relay – the Universal System for Insulation Monitoring in Electric Machines



The «MDR» system is for the insulation condition monitoring of the large electric machines – generators and electric motors.

In the «MDR» monitoring system 3 different methods of the diagnostics of the large electric machines are realized. They are:

- The measuring, analysis and distribution of the PDs in the winding insulation of the electric machine stator.
- The measurement and analysis of the stator core vibration.
- The measurement and analysis of the phase currents and voltages for the phase parameter imbalance monitoring.

Optionally the «MDR» monitoring system can be supplemented with the «external» subsystems of the end winding area vibration monitoring and the monitoring of the air gap of the electric machine.

The Measurement and Analysis of PDs in the Electric Machine Stator Winding - the Expert Report

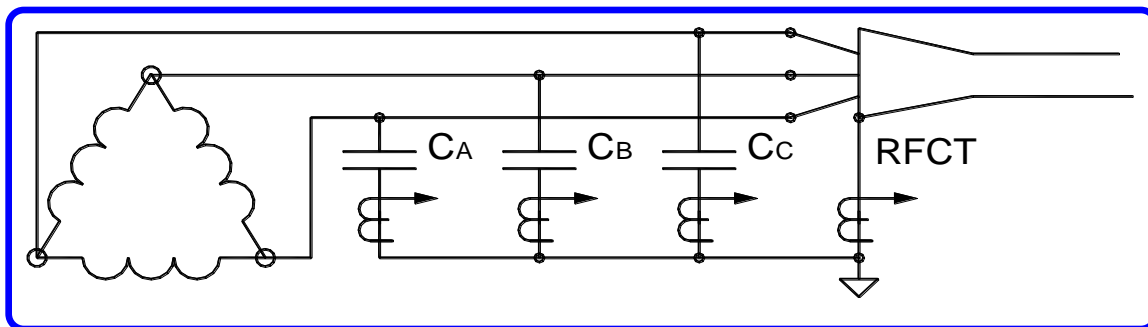
The most effective way of the stator insulation condition monitoring in high-voltage electric machines is the PD monitoring and PD distribution analysis in the winding.

Almost any type of defect in the stator winding insulation could be revealed by this method and at the early stages of its arising and development. Thus the technical staff will have enough time for taking measures against the generator or electric motor breakdown.

The important feature of the «MDR» and «PGU-DU» PD monitoring devices is the built-in PD-Expert diagnostic system. Thanks to that the final PD measurement data of stator winding includes not only the information on the PD level, but also the information on the defect types and development.

This is the main difference of the DIMRUS devices from the similar equipment of other firms in the market of diagnostic systems. Such additional information is very important for the technical staff.

The PD Measurement in Electric Machine Stator Winding with Coupling Capacitors



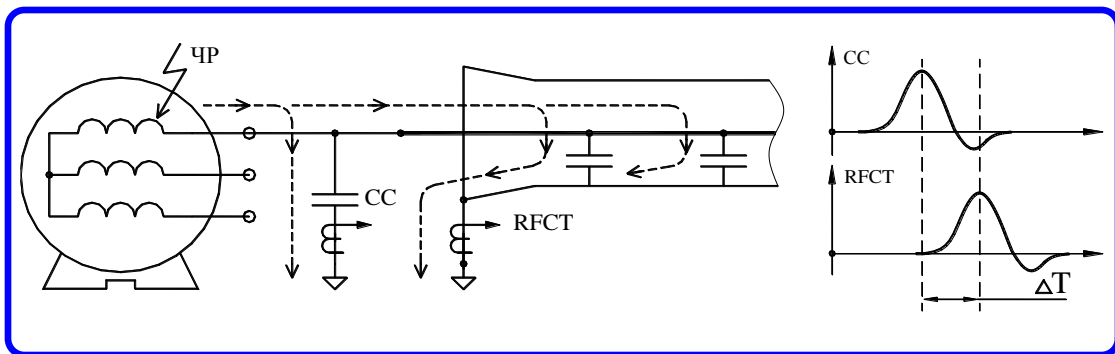
Coupling capacitor is the most widespread type of the sensor for PD measurement in electric machines.

The PD measuring scheme is the most cheap and simple, because PD arising in any point of the stator winding could be measured on the input terminals of the winding. So the capacitors are installed near the stator winding terminals and operate at the full phase rated voltage.

For most of the electric motors and generators with the power of less than 20 MW, it is enough to use 4 PD sensors: 3 coupling capacitors of CC type and 1 high-frequency current transformer of the RFCT type.

The noises, coming from the power supply, are rejected by the shift of the pulses coming from different channels accurate within nanoseconds. The algorithmic characteristics of the «MDR» system expand these abilities further on.

The External Noises Rejection by the «Time of Arrival»



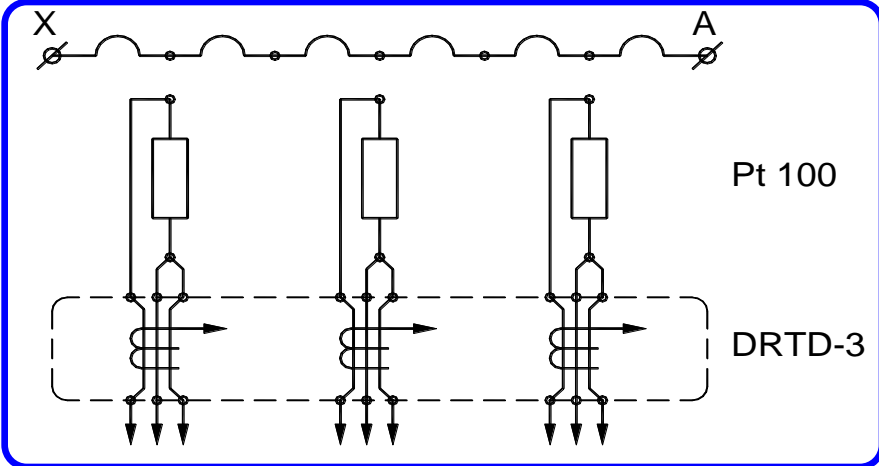
The figure illustrates the external noise rejection by the use of the RFCT sensor installed on the grounding shield of the cable.

If a PD pulse spreads from the stator winding, then it is measured by the CC coupling capacitor first. Then the pulse moves on and enters the cable. Through the inside of the cable (bus duct) the pulse passes to the cable shield and is measured by the RFCT sensor but with some delay.

If a noise pulse moves from the outside into the stator winding (from the right to the left in the picture) then it first passes RFCT sensor and after that the CC coupling capacitor. Thus the time shift definitely defines the place of the PD arising, and whether the pulse is a PD pulse or a noise.

The «MDR» and «PGU-DM» are specially calibrated for this method, and even the measurement cables length is taken into account. As a result the time gap between the pulse arrival is specified with the accuracy of 0.3 m.

The PD Measurement in Stator Winding with the Built-in Antennas



If the power of the electric machines and generators is 20 – 50 MW, then the stators are bigger. That's why the PD pulses decay in the winding stray capacitance.

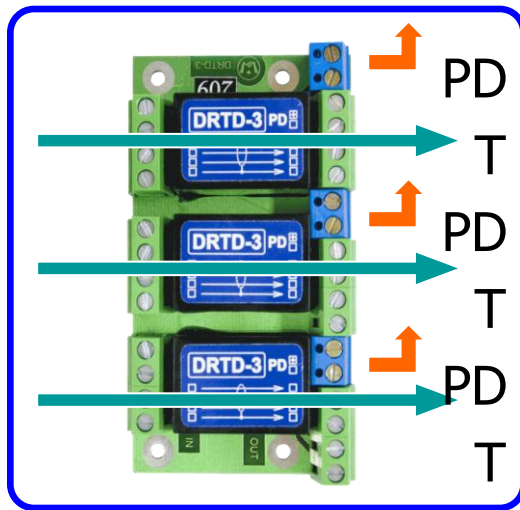
That is why the PD pulse arising deep inside the winding is impossible to measure on the terminals.

For large electric machines it is necessary to install some additional sensors inside the winding. The sensors will measure the pulses inside the winding, away from the input terminals.

If the monitoring system is planned for a new generator, then it is possible to install some electric field sensors - PD pulse antennas - in the winding slots during manufacturing. If the monitoring system is planned for some operating generator, the resistant sensors, which are already in the winding, can be used as antennas.

For operating equipment it is convenient to install «DRTD-3» sensors into the circuit of the stator winding temperature measurement, which could be done on-line.

The «DRTD-3» Sensors for PD Measurement in the Stator Insulation of the Large Electric Machines



The PD signals from the stator winding temperature measuring circuits are singled out with the high-frequency current transformers built into the «DRTD-3» sensors.

Thanks to such transformer connection, the «DRTD-3» sensors' installation into the circuit of the winding resistance sensors doesn't violate the stator temperature monitoring.

During the «MDR», or «PGU-DM», system installation, 3 or 9 temperature sensors, which are evenly distributed around the stator, are chosen. Such temperature sensors – PD antennas - distribution allows the most efficient stator insulation condition monitoring at the low costs.

In the same way the places for antennas' installation in the slots are chosen when new generators are manufactured. Such antennas usually present foil bands or the bands covered with foil, connected with coaxial cable.

The «DIMRUS» Primary Sensors and Calibration Equipment for PD Monitoring in Electric Machines

In all the systems of insulation condition monitoring in HV electric machines' stators the primary sensors produced by «DIMRUS» are used, except some types of mica coupling capacitors.

Usually the following equipment is used:

- The «CC» coupling capacitors with different rated voltage.
- The «RFCT» high-frequency current transformers, which have 7 modifications depending of the place of installation.
- The «DRTD-3» sensors for the connection to the resistance sensors in the stator winding of generators.
- The slot electromagnetic antennas.

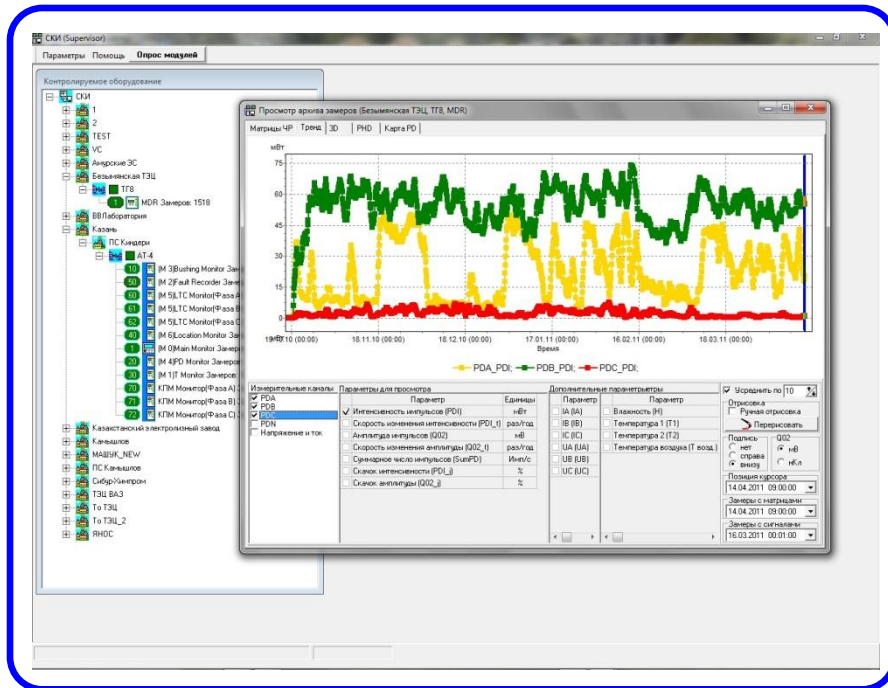
There are four types of calibration generators supplied for measurement circuit calibration.



The Software for the PD Monitoring and Analysis in the Stator Winding Insulation

The «MDR» system delivery set includes the specialized IHM software for electric machine condition monitoring on the PC.

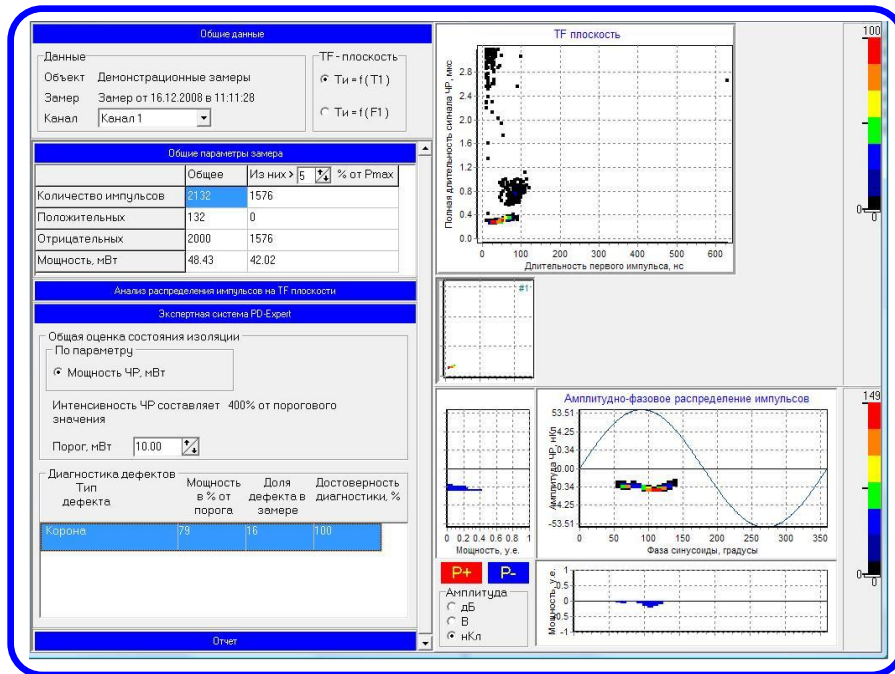
The IHM software allows to collect and store all the information about the generator (motor) condition, which has been received during monitoring.



The monitoring software allows:

- to archive the current information about the electric machine condition and to pass the necessary information into the process-control system.
- to process the source information for determining the trend of the electric machine condition.
- to use special diagnostic means for defect location and the danger level evaluation.

The Automated «PD-Expert» System for the Defect Search in the Stator Winding Insulation



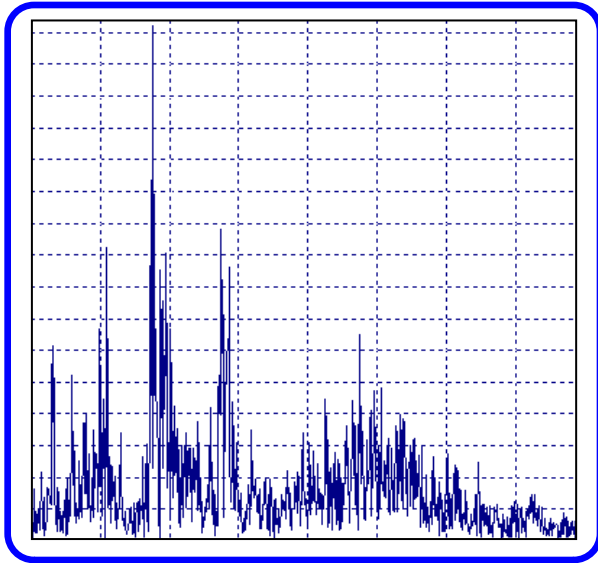
The unique feature of the «MDR» monitoring system is the automated expert diagnostics of the defect in the stator winding insulation of the generator (motor).

It is possible because of the inbuilt «PD-Expert» system. The system is adaptive, so its algorithms could be adjusted to the definite equipment type.

The «PD-Expert» system allows:

- to effectively reject the high-frequency noises of different types by algorithmic means;
- to identify the defect types using the defect images stored in the software memory;
- to separate PDs of several defect types, or the same defect types, but arising in different insulation zones.

The Stator Core Vibration - is the Important Parameter for the Generator Condition Evaluation



The condition of large generators is considerably influenced by the vibration of the core stack. The increased vibration accelerates the insulation damage during operation.

For monitoring of the stator active vibrations there are 2 vibration sensors in the «MDR» system. Usually they are installed at both the sides of the generator stator core.

If there are no defects, there should only be the harmonics with the double frequency of the power supply in the spectrum. The additional harmonics, that are always present in vibration signal, arise because of the mutual unfastening of the active elements and the stator in the electric machine body.

The high-frequency harmonics appear because of the higher mobility of the winding sections in slots and mutual unfastening of the end winding areas. The harmonic amplitudes depend to the machine operation regime.

The Problems in Generators that Can be Revealed by Vibration Measurement and Analysis of the Stator Core

The following defects can be revealed by the measurement and analysis of the stator core vibrations:

1. The «delamination» of the steel sheets at the end core stacks. The reason of the defect is the axial unfastening. The defect is diagnosed by correlation of the rotor current and the vibration level. The result of the defect development is the steel sheets destruction and insulation damage through attrition.

2. The winding sections unfastening in the slot and end parts of the stator winding. The reason is the unfastening and loosening of the pressing. The defect is revealed by the high-frequency harmonics presence in the vibration spectrum. The amplitude of the harmonics depends of the generator loading. The result of the defect development is the attrition of conductors in slots and the insulation breakdown.

3. The unfastening of the stator core in respect to the outer body of the electric machine. The defect is revealed by the presence in the vibration spectrum of the synchronous harmonics, multiple of 100 Hz in the frequency range of 1000 Hz. The result of the defect is the steel weakening and deterioration, attachment points and seals damage, the negative influence to the foundation.

The Realization of the «MDR-M» System for Electric Motor and Generator Insulation Monitoring



The most simple and cheap modification of the system for the stator winding insulation monitoring in electric motors and generators is produced by DIMRUS as «MDR-M».

The «MDR-M» fully coincide to the majority of the systems of stator winding insulation monitoring in electric machines, which are in the market.

The main and only purpose of the «MDR-M» system is the monitoring of the stator winding insulation condition. The «MDR-M» system favorably differs from the similar systems of other producers by the inbuilt «PD-Expert» system, which is absent in other products.

Thanks to the expert system, the «MDR-M» system not only reveals the high PD level in the stator winding insulation of electric motors, by also specifies the type of the defect. It allows to reveal and eliminate the problems in the stator winding insulation at the early stages of their development.

The Features of the «MDR-M» System Installation on the Monitored Electric Machines.



The «MDR-M» system is usually installed near the monitored electric motor, into the mounting case. The cable length from the PD sensors to the device should not exceed 50 meters.

The device itself can work in the wide temperature rang from 40 degrees below zero, so there are almost no restrictions for its installation.

The monitoring device has the memory for measurement storage, enough for two years of the operation. For data transmitting to the monitoring systems of higher level the standard USB, RS-485 and Ethernet interfaces are used.

The MDR-M device, as well as all the other monitoring systems of electric machines insulation, is universal, with the rated voltage of 85 – 260 V, the voltage type - AC/DC.

The «MDR» System for the Monitoring of the Stator Winding Insulation Condition of Large Generators by PDs



The complete version of the «MDR» device for the stator winding insulation monitoring is a finished module with the dimensions of 250 * 200 * 45 mm. The connection of all the sensors and links is done with the standard screw terminals.

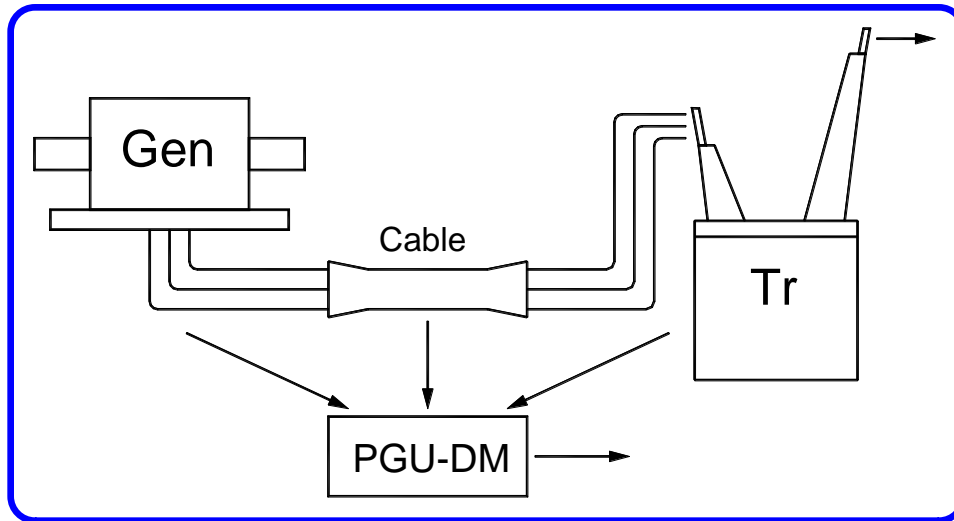
Usually the «MDR» system device is installed near the generator in the protecting enclosure with the outer dimensions 400 * 500 * 150 mm.

Alongside the PD measurement and analysis, done with the «PD-Expert» system, the following parameters could be measured with the MDR device:

- The temperature of the winding, the core and the air (hydrogen) inside the generator.
- The air (hydrogen) humidity inside the generator.
- The generator phase currents and the current in the winding neutral.

There are three relays inside the device, two of them control the alarm and warning signalization.

The «PGU-DM» is the Complex System for the Insulation Monitoring of the HV Equipment of the Power Block



The usual power block of a power station consists of the following standard set of HV equipment: a generator, a transformer, and some cable or conductor connecting them.

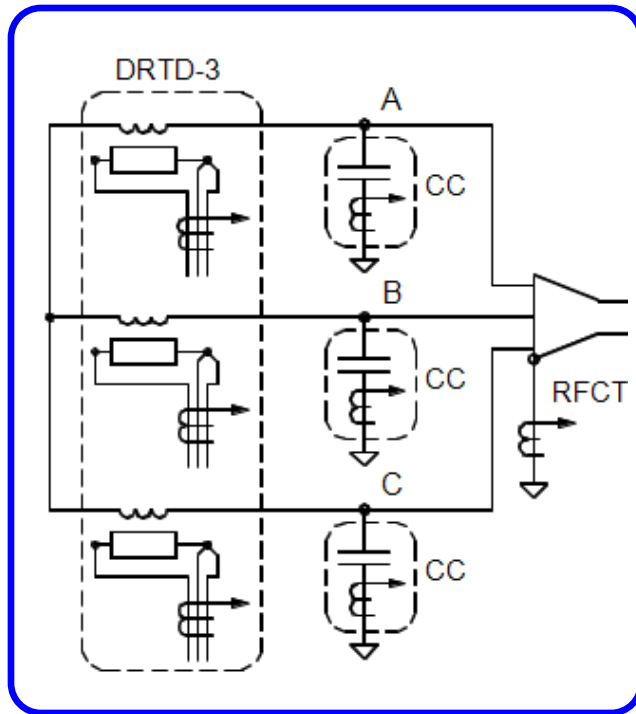
For the insulation condition monitoring of such set of equipment the single monitoring system «PGU-DM» (Power Generator Unit – Diagnostics Monitor) could be used.

The «PGU-DM» monitoring system has been specially developed for these purposes.

The insulation monitoring of several pieces of equipment by one unit allows to solve two basic technical and financial problems:

- providing the complex diagnostics of the whole object.
- decreasing several times the cost of the monitoring system for power block equipment.

The Stator Winding Insulation Condition Monitoring with the «PGU-DM» system



The «PGU-DM» system is for the insulation monitoring of powerful large-scale generators, so there are seven PD sensors shown in the figure.

- Three coupling capacitors.
- Three electromagnetic antennas (or three temperature sensors) installed into the slots.
- The RFCT sensor on the grounding of the cable shield, or between the conductor shield and the generator body.

Such a set of sensors is usually enough for the PD measurement in generator stator winding.

Additionally the temperature and humidity are monitored inside the generator, which is very important for the PD measurements.

The «PGU-DM» system measures the PD level and calculates the PD intensity. The use of the «PD-Expert» system allows to reject noises, to reveal the type and development level of the defect in the generator stator winding insulation.

The Optional Diagnostic Functions which could be Realized in the «PGU-DM» System

Some optional diagnostic functions can be added to the basic set of functions of the «PGU-DM» system for monitoring of the HV insulation of the power block equipment.

1. By connecting additional cables to PGU-DM device:

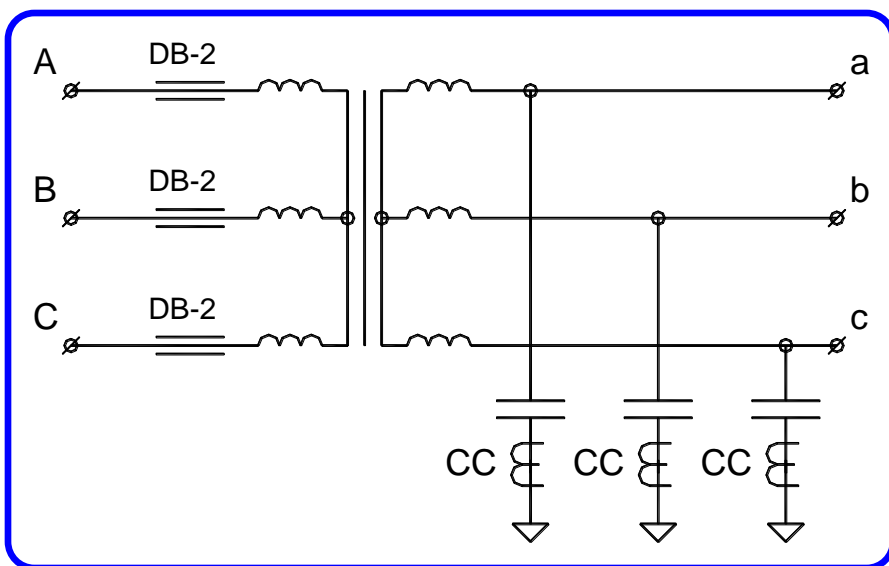
- The monitoring of the insulation condition of the generator rotor winding by measuring of the radial component of the magnetic field in the electric machine slot.
- The measuring of the gap between the rotor and the stator by the use of the two capacity sensors installed 90 degrees to each other.

2. By using the additional unit for the device:

- The monitoring of the stator winding ends by optical vibration sensors at the most critical points.
- The temperature monitoring of the hottest point of the block transformer winding by the optical temperature sensors installation inside the winding.

The use of the additional functions enlarges the diagnostic ability of the «PGU-DM» complex monitoring system.

The Insulation Condition Monitoring of the Transformer with the «PGU-DM» System



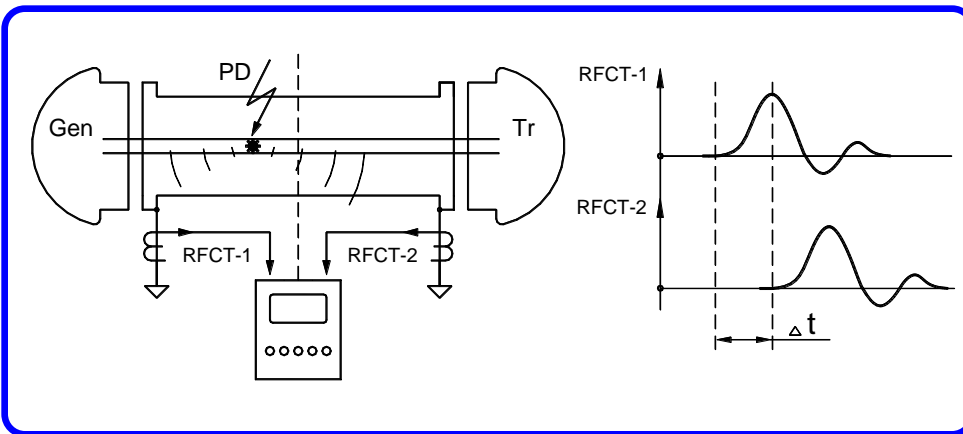
The PD measurement scheme in the transformer includes 6 sensors - 3 complex sensors at the HV bushings and 3 coupling capacitors at the LV (generator) side of the transformer.

The scheme of the LV winding connection (Y or Δ) does not influence the sensors location.

The additional sensors installed on the transformer are the phase load current sensors, transformer tank temperature sensors, ambient temperature and humidity sensors.

Optionally the PGU-DM system can monitor and diagnose the oil pumps condition of the transformer cooling system. By the spectrum analysis of the current, consumed by the oil pump engines, the «PGU-DM» software evaluates the bearing condition and the oil pump rotor.

The Insulation Condition Monitoring of the Power Block Conductor with the «PGU-DM» System



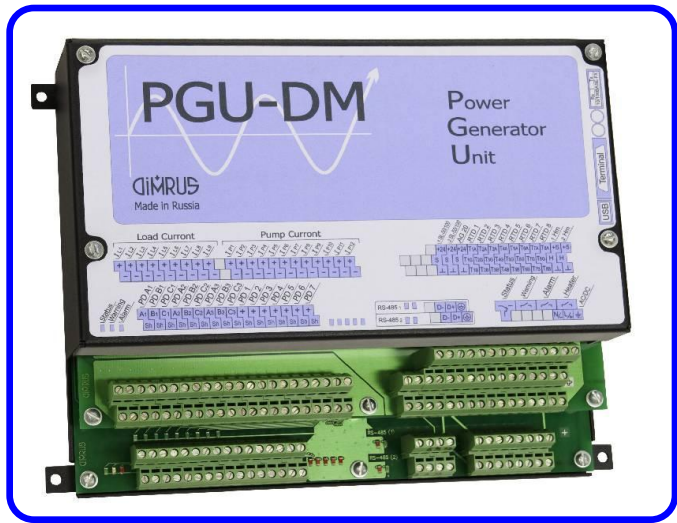
After the insulation monitoring system has been installed on the transformer and the generator, it is possible to monitor the conductor insulation condition without any additional sensors.

The advantage of the complex insulation monitoring systems is the possibility to use one and same sensors for PD insulation monitoring of several pieces of HV equipment.

By comparing the time of the pulse coming from PD sensors, coupling capacitors, installed at both sides of the conductor it is possible to locate the insulation defect place accurate within one meter.

This feature is implemented in the firmware of the «PGU-DM» device. It allows to locate of defective insulators, the conductors, which are installed to the busbar.

The Realization of the «PGU-DM» System for the Station Power Block Equipment Complex Diagnostics.



The insulation condition monitoring «PGU-DM» system is a device installed into the enclosure.

Usually the mounting case is installed so that the sensor cables from the generator and the transformer are of the same length.

The primary sensors are chosen for the definite insulation monitoring system, on the base of the generator and the transformer parameters.

The final information of the equipment condition is given by the three signal relays.

The full data of the HV insulation condition of the power equipment is transmitted to the SCADA system through RS-485 or Ethernet interfaces.



DIMRUS Ltd.

70 Kirova street, Perm

Phone: (342) 212-23-18

Phone/fax: (342) 212-84-74

www.dimrus.ru

dimrus@dimrus.ru