GISNOVA

Global GIS Monitoring System

ALTANOVA GROUP

Advanced testing and monitoring solutions

TECHIMP isa IntelliSAW

Why performing condition assessment on high voltage Gas Insulated Switchgear?

Utilities are moving from time-based maintenance to condition-based maintenance to reduce the costs of maintenance of switchgears. Consequently, the need for non-intrusive methods is increasing.
According to the *CIGRE/CIRED Joint Working Group A3.32*, the goal of Non-Intrusive Condition Assessment Methods (NICAM) is to reduce the overall costs of asset management. Several techniques can be used to assess these benefits and from different perspectives:

1. Investment on NICAM
2. Cost of failure/outage with and without condition assessment
3. Cost of maintenance with and without condition assessment

Gas Insulated Switchgears have achieved a very high degree of reliability and availability, however, failures cannot be completely ruled out.
In addition to manufacturing problems, defects may be induced during transportation, installation or aging process.
Such defects must be identified as early as possible in order to avoid disruptions.

GIS faults may be the result of:

- Errors in production
- Shipping damage
- Assembly errors
- Moisture ingress
- Gas SF_6 leaks
- Malfunctions of the circuit breaker
- Battery malfunction
- Motor malfunction

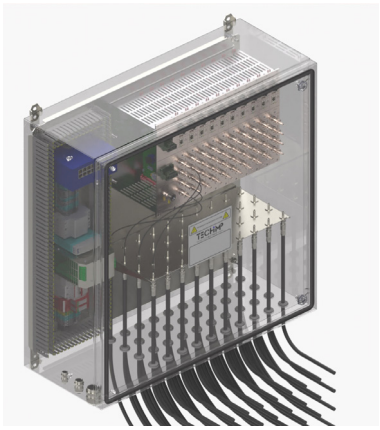
Typical defects that generate harmful PD:

- Moving particles
- Electrode protrusions/scratches
- Fixed particles on insulating surfaces
- Floating (or loose) electrodes
- Voids in solid insulation.

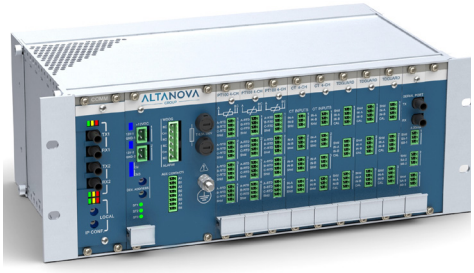
GISNOVA
A modular system for all types of Gas Insulated Switchgear

TECHIMP - ALTANOVA technology allows asset managers to adopt a monitoring strategy that guarantees maximum reliability of GIS. GISNOVA is a complete monitoring system based on the monitoring and analysis of partial discharges, SF_6 gas, and circuit breakers, avoiding most of the GIS failures that could be caused by lack of maintenance, aging, and electrical or overload failure.

GISNOVA HUB



PD Hub MKII GIS
Acquisition Unit



EDS Acquisition Unit

- Partial Discharge Monitoring
- Circuit Breaker Monitoring
- SF_6 Gas Monitoring

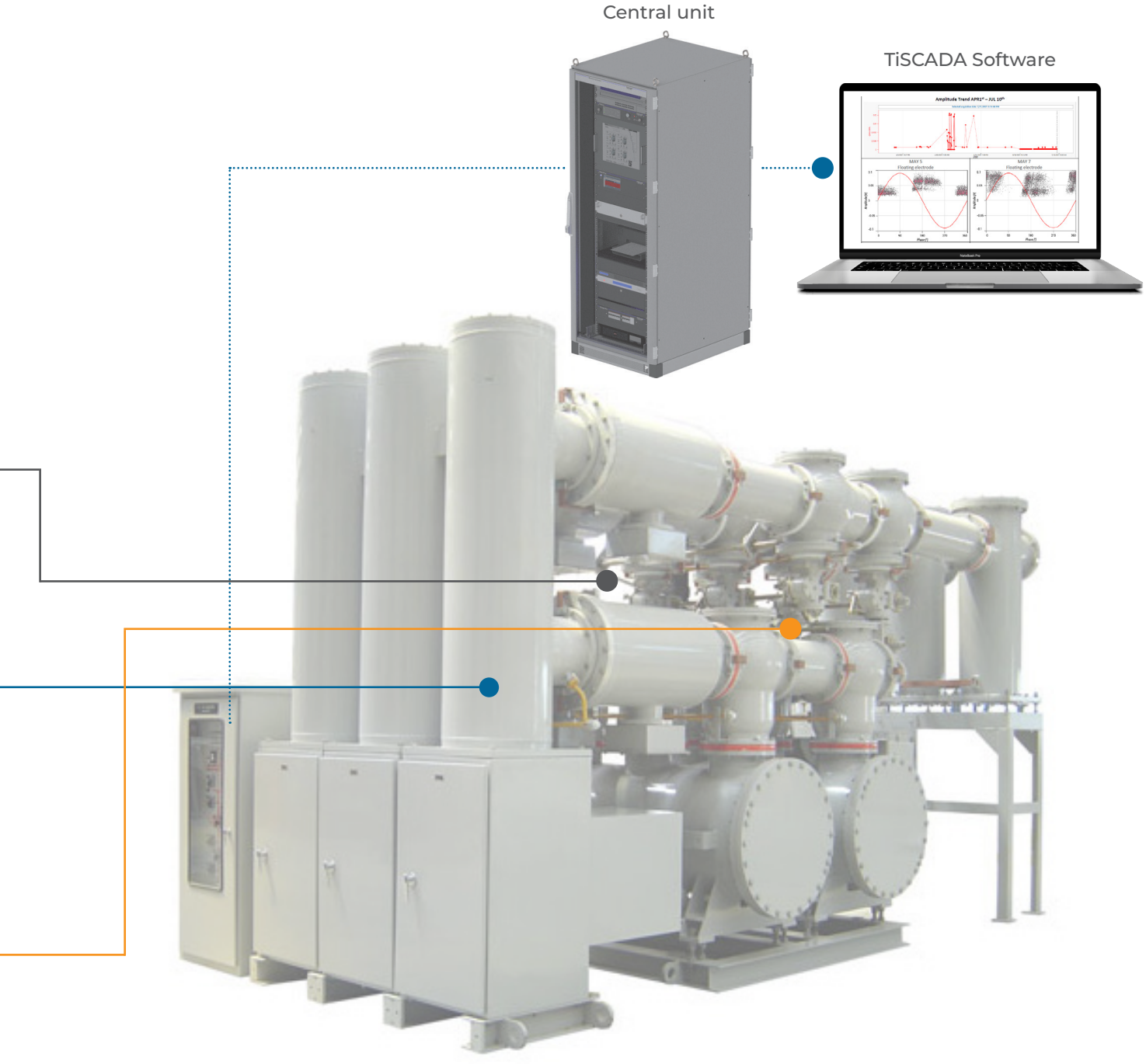
Main features of GISNOVA:

- Modular system adaptable to already installed and new GIS
- Non-intrusive technology
- Flexibility to use pre-existing sensors
- A large number of sensors are available, in order to adapt the monitoring system to a variety of GIS models
- End-to-end installation, commissioning, and data analysis provided by the TECHIMP – ALTANOVA Service Division
- Support from a team of experts, for the analysis of phenomena, and trends over time
- Maintenance decisions can be taken on the basis of the real equipment condition under test

System's main components

- **PD Hub MKII GIS acquisition unit** to detect partial discharge activity
- **EDS acquisition unit** to monitor the circuit breaker functionalities and SF_6 gas
- **A large variety of sensors:** PD sensors, SF_6 gas sensors, and circuit breaker sensors
- **A Central Unit** which includes: server unit, UPS unit, managed ethernet switch, watchdog unit, industrial monitor and server-rack (42U-19")
- **TiSCADA** software showing real time data, trends and current profiles

A fully integrated monitoring system



Circuit Breaker Monitoring

Parameters monitored:

- Opening and closing times
- Open and close coil current profile
- Open and close coil current peak
- Fault current profiles
- Fault current peak
- Breaker velocity and position
- Motor and heater current (up to 3 phases)
- Battery voltage (main and backup)
- I2t sum - (dissipated energy)

The circuit breaker is a highly critical component for the power protection system, and breaker malfunction is one of the most common cause of failure.
Reliable conditions are required especially after a long period of inactivity, in which the mechanical system of the circuit breaker remains in a static state for long periods of time. These long periods of inactivity, in combination with thermal variations or ingress of contaminants, can lead to the degradation of the lubrication and control systems of the mechanism and can cause failure.
Normally, maintenance of the circuit breakers is performed at regular intervals but problems or failures between one maintenance and another cannot be ruled out.
Implementing on-line monitoring allows the operator to record parameters under real operating conditions. A waveform analysis of the main contacts, trip coils, transducers is provided, in order to evaluate and understand many of the vital operating parameters of the circuit breaker, such as the degradation of the breaker lubrication, the integrity of the trip coils, the problem in the operating mechanism, as well as, slow operating times.

EDS - Circuit Breaker and SF_6 Gas Acquisition Unit

CB SENSORS

AC current sensor

DC current sensor

EDS (Expert Diagnostic System) is the acquisition unit dedicated to the circuit breaker monitoring.
The installation of EDS is very simple and it is capable to generate and calculate automatic alarms. The drawer has a modular configuration, the electronic boards can be chosen according to the project needs, and the units have several dry contacts embedded.

Main parameters monitored by EDS:

- Breaker status
- Open and close time
- Pole discrepancy
- Fault current profile and I2t
- Profile of the current of the motor
- Peak of the full current or the motor current

Other measurements are available according to the configuration of the unit.

Alarms by dry contacts

- Open and close time alarm + pole discrepancy alarm, coil current alarm, breaker speed alarm, alarm on peak current of motor
- Alarm on peak current of feeder and maintenance threshold of I2t,
- Alarm on SF_6 density
- Details of each alarm can be provided through the embedded HMI.
- Alarms are also available via digital protocols (IEC104, etc.)

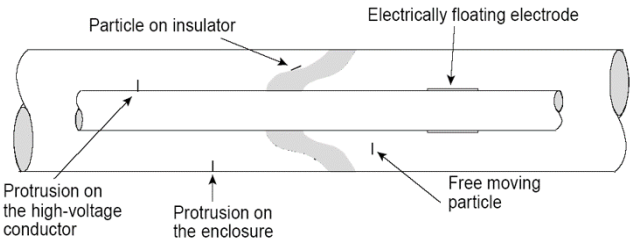
Partial Discharge Monitoring

- Continuous PD monitoring
- Automatic alarms based on PD trends and phenomena
- Automatic noise rejection based on patented T/F Map

The electrical field in the GIS is homogeneous and, thanks to the insulation properties of the SF_6 gas, no PD should be observed in the ideal case.
But, if a defect is found, an increasing electrical force will be observed around that imperfection, which, in some cases, may locally exceed the resistance of the SF_6 insulation material and, ultimately, may lead to partial discharges.

According to Cigrè TF 15.11/33.03.02, depending on the source, the typical Partial Discharges are:

- Protrusion electrode
- Floating electrode
- Free moving particle
- Particle fixed to an insulation surface
- Voids

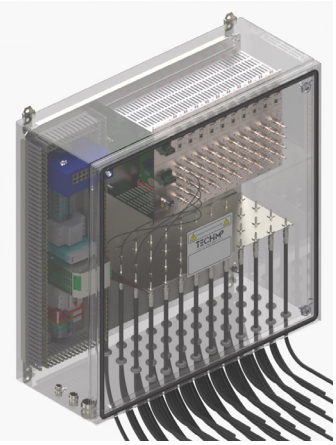


The Partial Discharge source can manifest itself under different types of energy: it could be light, acoustic waves, high frequency electromagnetic waves, but also chemical components, even sub-components and heat.
This process may lead to a degradation of the GIS insulation system and the aging of the mechanisms, and this can lead sooner or later to a failure. This energy can be measured using several approaches and techniques. Let's focus on the ultra-high frequency method, that, compared with the other methods, for example the acoustic or the optical method, has shown multiple benefits in terms of sensitivity and reliability.
The four main steps of the monitoring system chain with **ultra-high frequency method** are:

- **Detection**: dedicated UHF PD sensors and accessories
- **Acquisition**: wide band – multi channel acquisition unit
- **Processing**: noise separation and PD identification
- **Alarming and visualization**: customized HMI

PD Hub MKII GIS acquisition unit

PDHub MKII GIS is the core of the PD monitoring system.
It hosts the acquisition unit, able to collect the Partial Discharge signals coming from the internal or external UHF PD sensors.
One PD Hub MKII GIS can be connected to up to 40 UHF PD sensors via coaxial cables.
The device is able to sort different pulses with different shapes (T/F Map) hence improving the signal to noise ratio and collect mainly pulses related to PD activity.
The acquisition unit is composed by wide bandwidth electronic boards, with a sampling rate of 125MS/s and a resolution of 12bits and the proper frequency down conversion to match the UHF bandwidth.



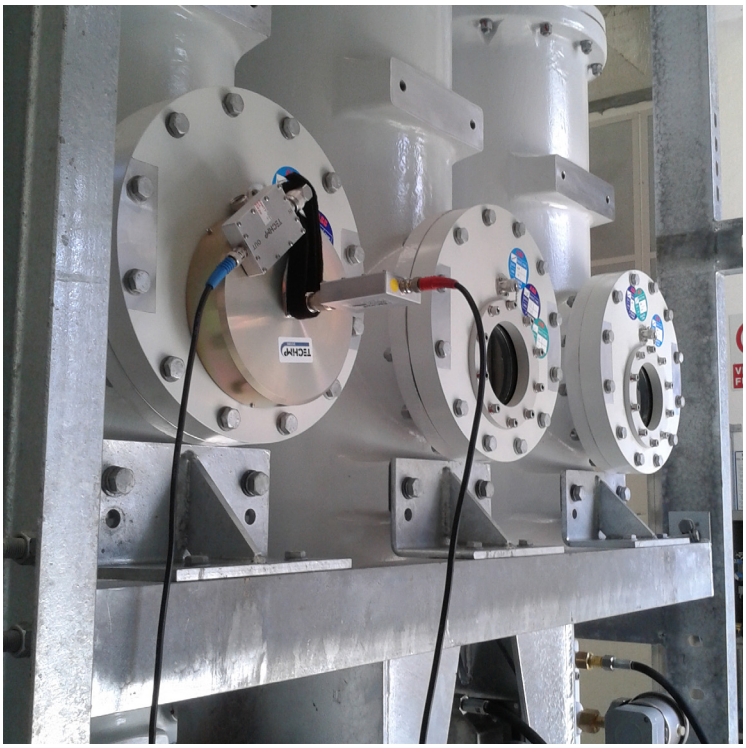
4-40 Channels Acquisition Box	240 Channels on 42U rack
Multi protocols OPC UA IEC 61850 dry contact ...	Continuous monitoring mode Simultaneous on trigger event
IP 66 Extended temperature range	5 Hz - 500Hz Sync

PD Hub MKII GIS for partial discharge acquisition

GISNOVA, PD Sensors

TECHIMP – ALTANOVA provides ONLINE PD monitoring on GIS, with one of the following measurement points available:

- **Pre-existing internal UHF sensor:** modern GIS are provided with internal UHF sensors. TECHIMP – ALTANOVA PD data acquisition system is fully compatible with all internal UHF sensor regardless of the OEM.
- **Unshielded epoxy spacers:** in the absence of internal sensors TECHIMP – ALTANOVA UHF Horn Antenna can be placed at at non-shielded GIS epoxy insulators.
- **Shielded epoxy spacers with small dielectric aperture:** many GIS breakers and GIL are provided with completely shielded spacers. In such cases PD detection is difficult. However, some of these are endowed with small dielectric apertures.
- **Unshielded epoxy spacers at cable terminations:** PD detection can be carried out through proper UHF sensors in correspondence of dielectric unshielded spacers at cable termination, achieving good sensitivity both in the cable termination and in the GIS connected to the cable.
- **Circular dielectric glass windows:** when circular glass windows are available, proper designed UHF sensors can be used fitting the circular aperture achieving good sensitivity.



Example of UHF sensor fitting the circular dielectric glass window

PD SENSORS

UHF Horn Antenna

HFCT sensor for cable connection

Internal UHF sensor

SF_6 Gas Monitoring

Parameters monitored:
- SF_6 instantaneous density
- SF_6 leakage with trend analysis and alarm prediction
- Dew point

In GIS installation, the SF_6 gas provides electrical insulation and, in the breakers, arc-quenching capability. These characteristics depend on the SF_6 gas density. SF_6 is also a greenhouse gas, over 20,000 times more harmful than CO2, so careful monitoring of SF_6 leakages become absolutely vital.
Electric utilities decide to permanently monitor the SF_6 gas level in all compartments of gas insulated switchgear mainly because of these reasons:
- To avoid unexpected failures
- To optimize their maintenance strategy
- For environmental reasons associated with greenhouse gas emission (for example UE directive n.517/2014)

Main features of the gas density monitoring system:
- It provides a permanent output signal that can be used for trending
- Threshold alarms: an alarm signal is started when the gas density decreases below a certain predefined limit. Two thresholds are normally used: first is a warning to signal low gas and the second is typically a control signal used to block switchgear service when the density reach the minimum density needed to ensure adequate equipment operation

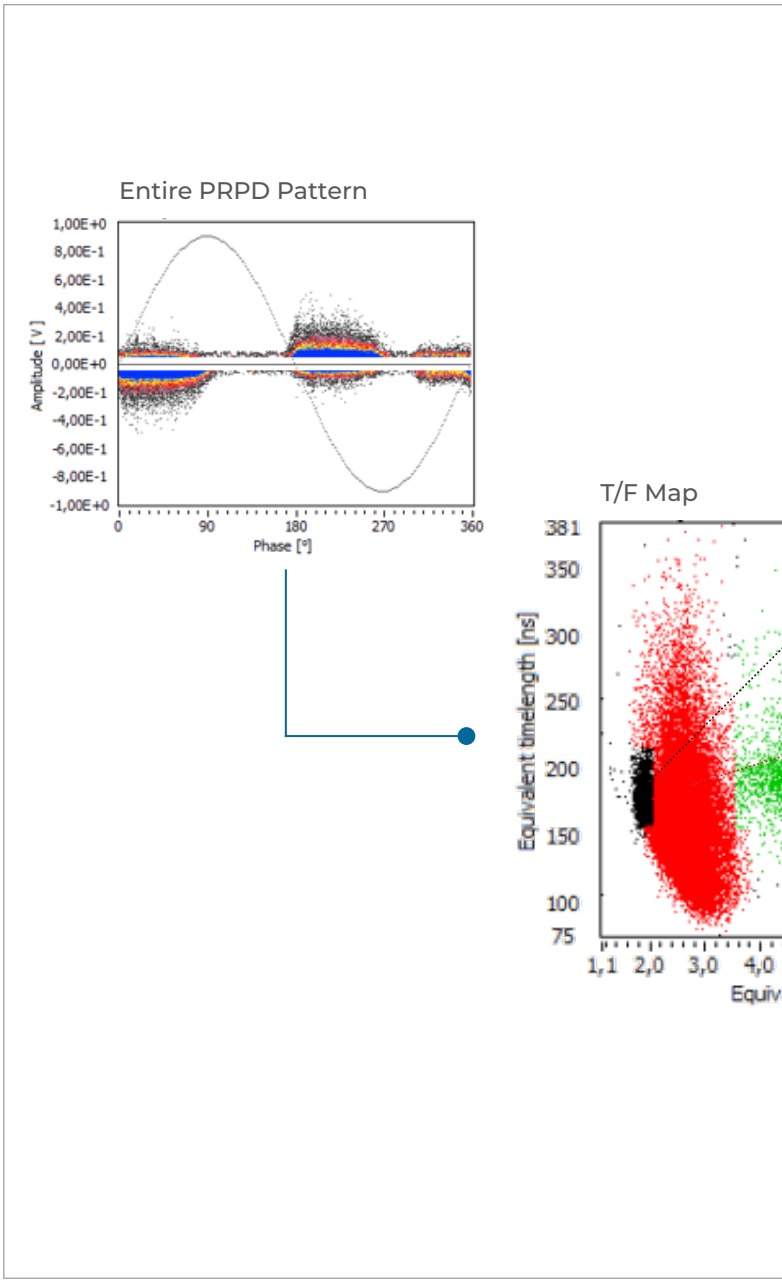
SF_6 density sensors are normally present in TECHIMP – ALTANOVA GIS monitoring system and are provided by a third party, e.g. Trafag, Wika and Vaisala, or others.
SF_6 Gas Hub is the core of the Gas monitoring system, able to collect the gas signals coming from the sensors.
A fiber optic or RJ45 Ethernet LAN will connect all the SF_6 Gas Hub to the Central Unit, where data can be collected, stored and processed. Up to 64 Gas sensors can be applied to each module.

PD Analysis

Noise and disturbances always affect an on-line measurement and they are generally different for each machine being tested/monitored.
Their amplitude and characteristics may vary depending on the location, the environmental conditions, the load conditions, and many other parameters. TECHIMP – ALTANOVA offers an innovative approach to identify the different phenomena, in order to obtain a correct diagnosis.
The diagnosis is carried out using the patented TECHIMP – ALTANOVA T/F Map technology, which consists in an efficient separation of the different discharge activities, including noise rejection.
This can be achieved through an analysis of the pulse shape, which avoids the identification to be affected by different phenomena overlapping, as well as noise superposition to real PD phenomena.
An example of TECHIMP – ALTANOVA T/F Map representation is reported in the figure here on the side, showing the so called SID approach: Separation – Identification – Diagnosis.
The example shows a PD separation: an internal PD phenomenon, overlapped by the noise in the complete acquisition, can be clearly separated through the acquisition of the pulse waveforms and the T/F Map tool.
In this graph it is clear that this phenomenon occupies a specific area of the map, different from the area where the noise is positioned. To further improve efficiency of a permanent PD Monitoring System the "T/F Map filter" tool has been implemented.

TiSCADA Software

TiSCADA software allows to display Partial Discharge activity, circuit breaker functions and SF_6 gas activity, all in one place.
The TiSCADA software gives the possibility to have a dashboard with multiple bays view. In this way, the operator can see the general status of the alarms related to PD activity, SF_6 gas, and/or the circuit breaker, in a single window.
An example of a dashboard is given in the figure on the side. On the right side, you can see a parameters' tree, where each parameter acquired can be displayed in a graph or in a table, and the customer can decide to select one or more parameters.
For a more detailed analysis, the view can be changed and focused on each individual parameter.



PD Analysis: representation of SID approach: Separation – Identification – Diagnc

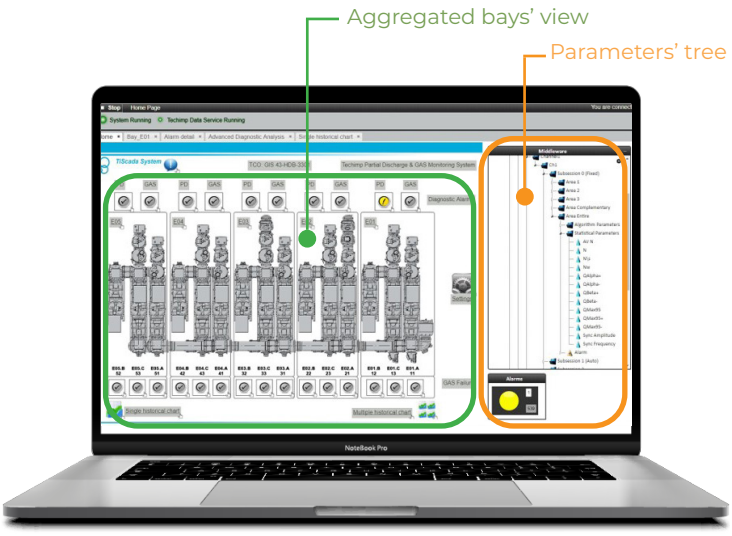
For each bay, the software can display:

- Alarm detail
- Sensor location
- Real-time values (e.g. SF_6 density, feeder current, breaker status, motor current, heater current, I2T...)

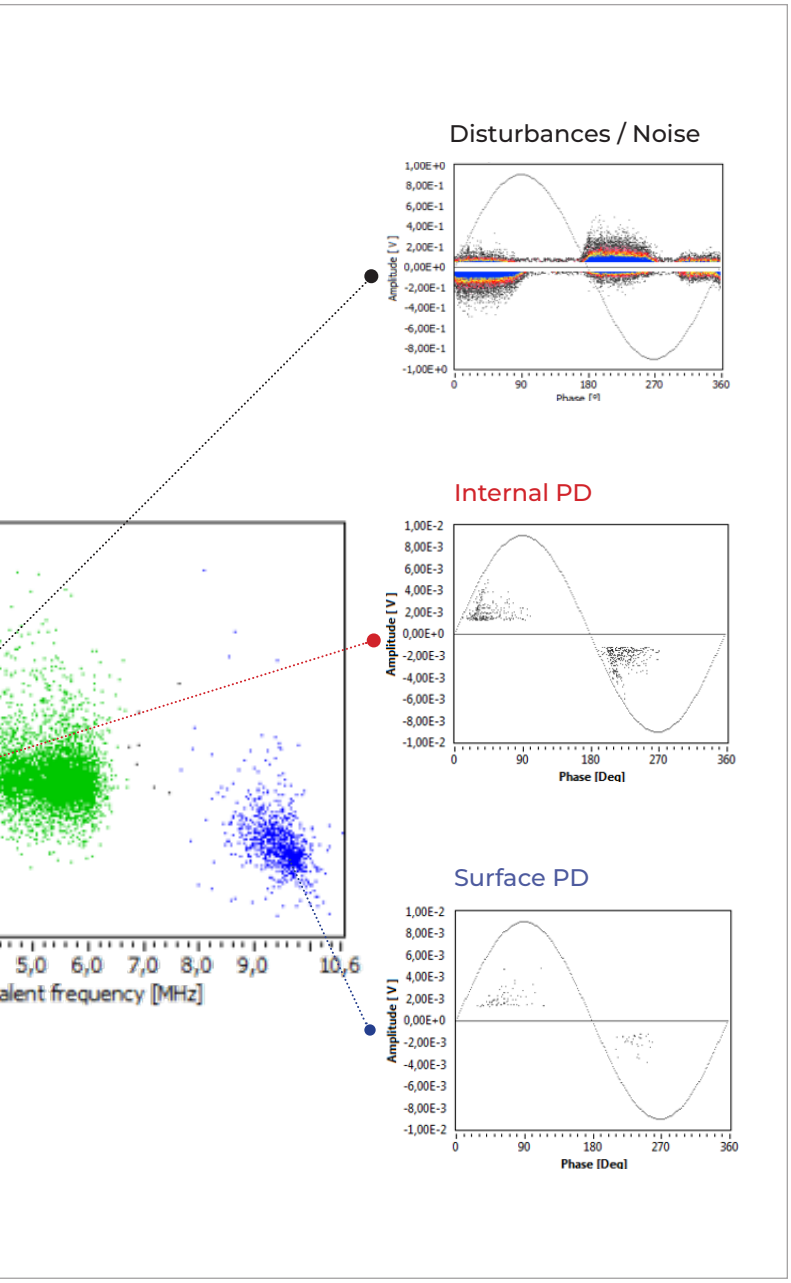
All parameters and thresholds can be set in a dedicated page and the waveform analysis can be seen with the comtrade view function, present in the system.

Through TiSCADA software suite, the central server collects data from all acquisition units, connected by suitable Ethernet LAN (fiber optic or RJ 45) and/or mobile telecommunication technologies.

The system works with a central server, which processes and stores the data into a database. The information stored can be accessed locally or remotely and displayed through a web server on a graphical web interface.



TiSCADA Software



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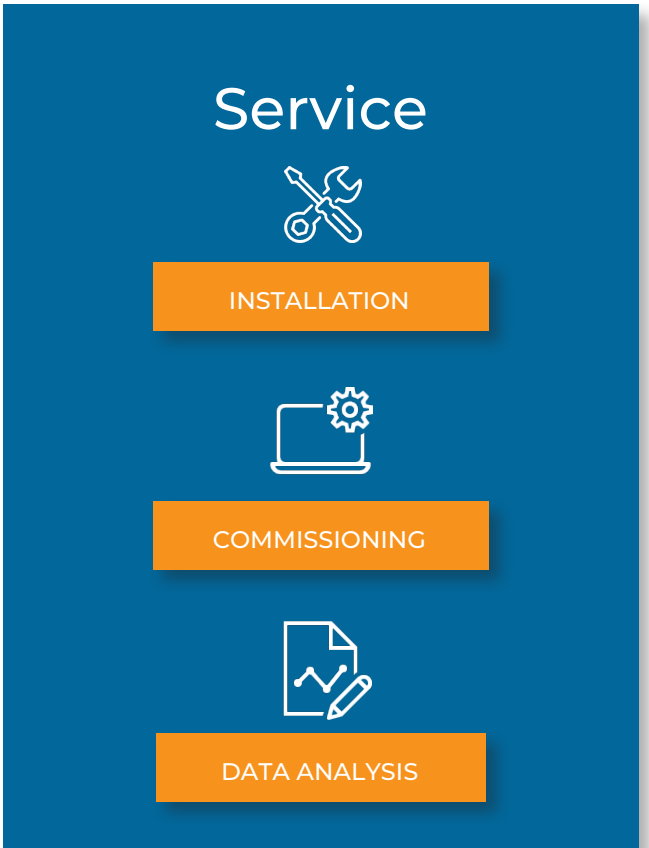
Service: installation, commissioning, & data analysis

TECHIMP – ALTANOVA Service Division is a team of experts dedicated to the installation, the commissioning of the monitoring systems, and if required, data analysis.

In order to perform a correct diagnosis and set reliable alarms, it is highly recommended to acquire sufficient data in the first operating period of the monitoring system, before optimizing the alarms thresholds.

Once sufficient data has been acquired, it will be possible to understand which areas of the T/F Map are linked to noise and disturbances and to ensure that they are ignored by alarms, and which are instead related to the probable partial discharge activity.

Through the remote monitoring, a higher data acquisition frequency can be set to build the trend of this phenomenon. The trend allows you to associate a level of harmfulness to the phenomenon detected in order to make a maintenance decision based on the real conditions of the equipment under test.



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