Effective Condition Monitoring Solutions for Medium Voltage Assets

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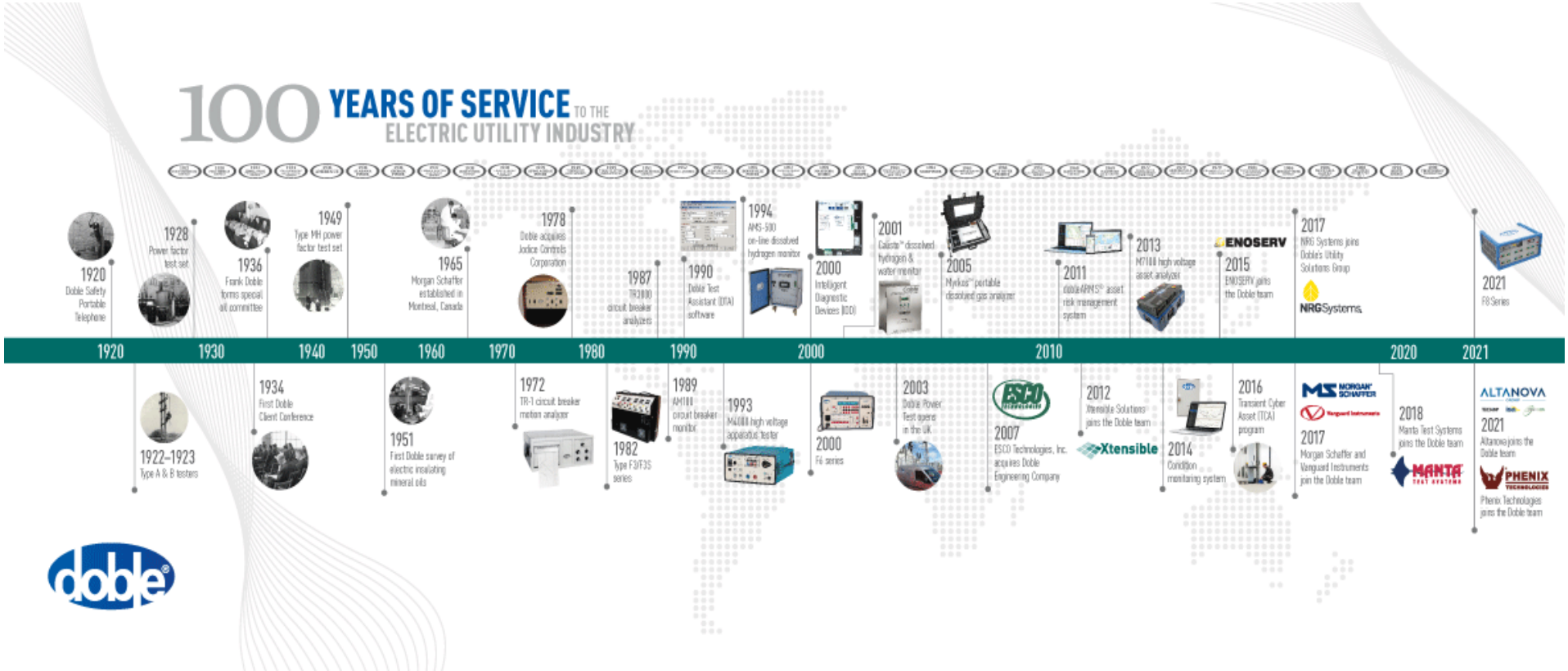
Doble History



Agenda

- Key CBM Technologies
- Substation / Plant Applications
  - Rotating Machines
  - Transformers
  - Cable Systems
  - Switchgear
- Sensors
- Acquisitions Units
- Communications
- Central Unit
- Software
- Case Studies

Substation / Plant Monitoring

DOBLE's permanent monitoring systems **cover ALL electrical** assets in MV and HV:

HV Cable	Generators
HV GIS	Power Transformer
MV Cable	Distr. Transformer
Motors incl. VSD	MV Switchgear

Substation / Plant Monitoring

DOBLE's offering for permanent monitoring by asset:

HV Cable

- Partial discharge
- Line currents LC
- Sheath currents SC
- Distr. Temp. Sensing
- Distr. Acoustic Sensing

HV GIS

- Partial discharge
- Circuit Breaker
- SF6

Generators

- Partial discharge
- Endwinding Vibration
- Flux
- Temperature

Power Transformer

- Partial discharge
- Bushing Monitoring
- Generic Parameter
- DGA

Substation / Plant Monitoring

DOBLE's offering for permanent monitoring by asset:

MV Cable

- Partial discharge
- Line currents LC
- Sheath currents SC

MV Switchgear AIS & GIS

- Partial discharge
- Temperature
- Humidity

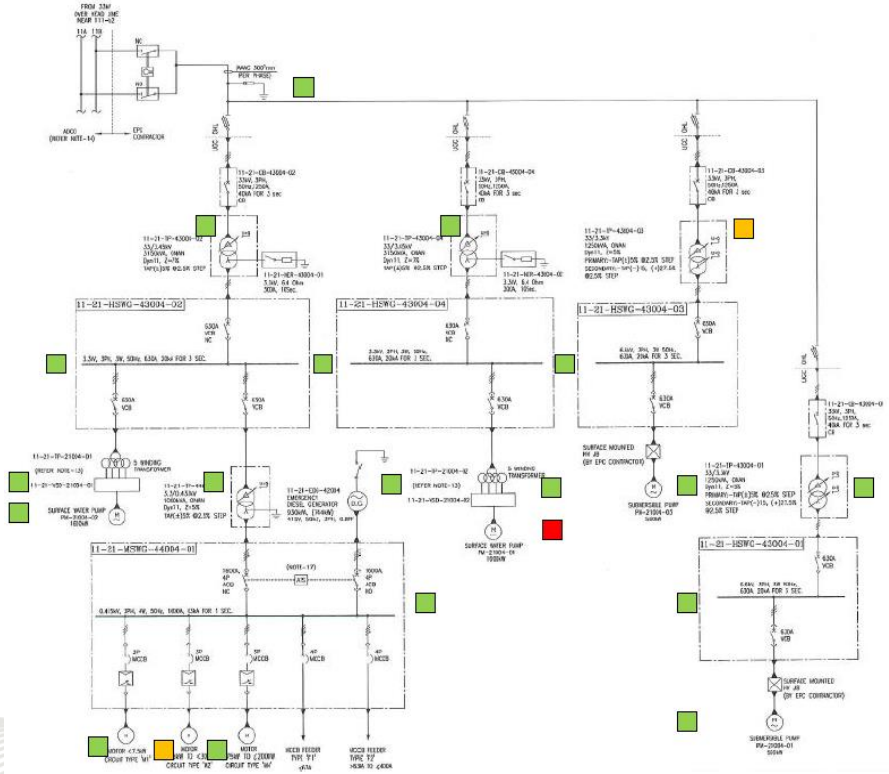
Motors incl. VSD

- Partial discharge

Distr. Transformer <72.5kV

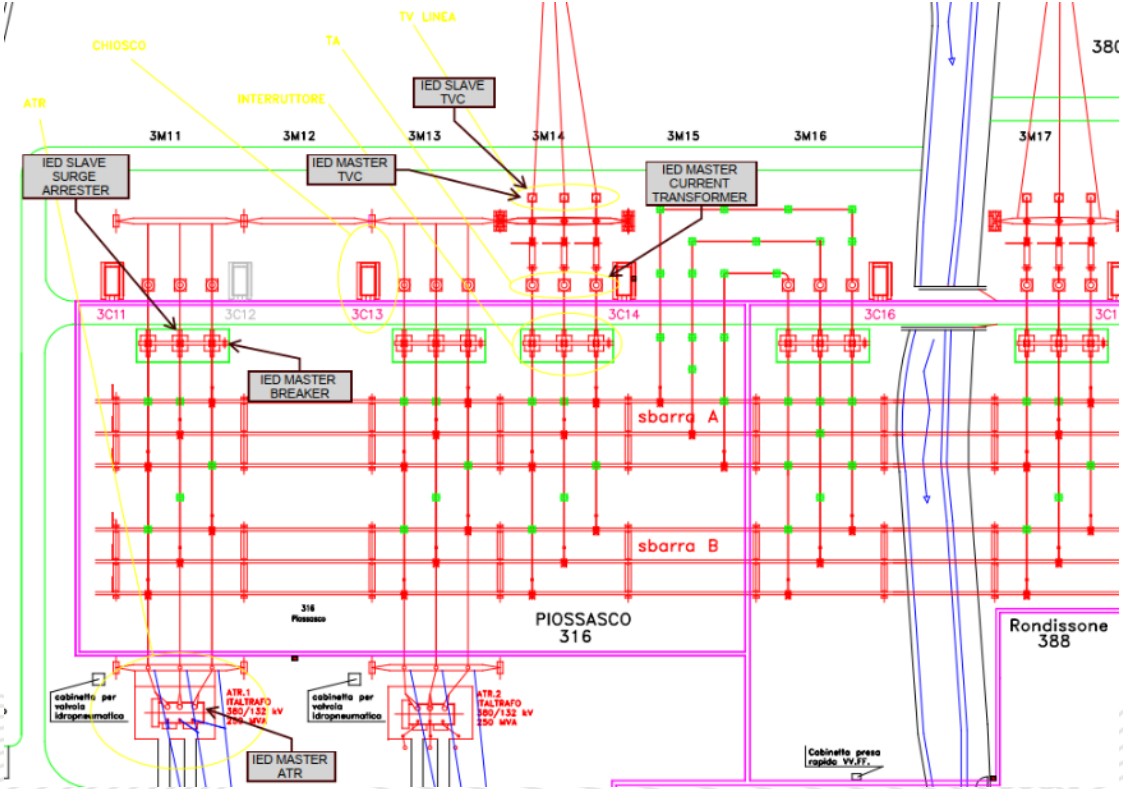
- Partial discharge
- Temperature

Plant Monitoring

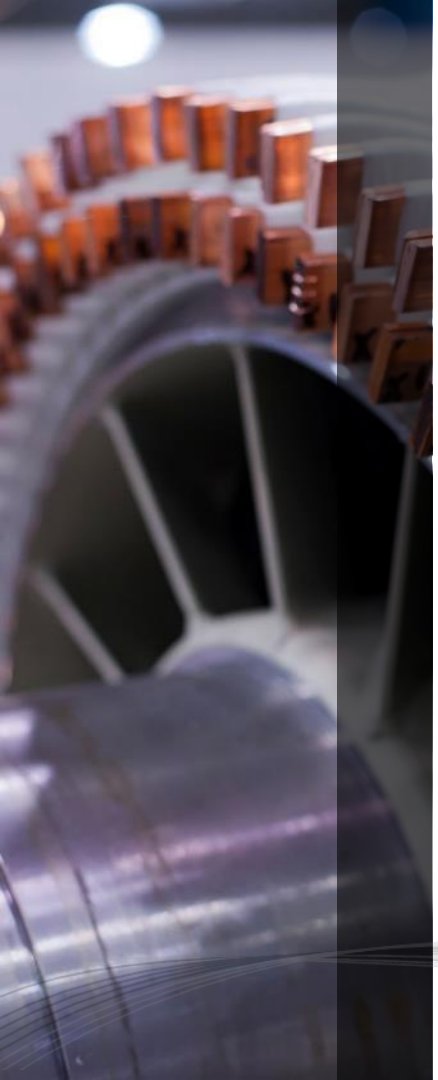


- Rotating Machines
- Transformers
- HV GIS
- Surge Arresters
- VTs/CTs
- Cables
- MV Switchgear

Substation Monitoring



- Gas Insulated CB
- Air Insulated CB
- HV GIS
- Transformers
- Surge Arresters
- VTs
- CTs
- Cables
- MV Switchgear



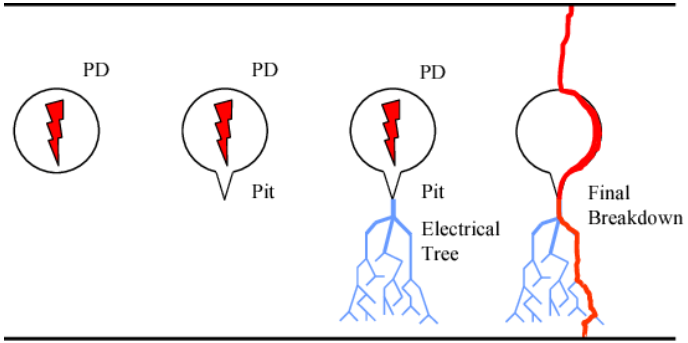
Global monitoring systems for Rotating Machines
(Generators – Motors – VSD)

- Partial Discharge Monitoring
- Vibration
- Flux
- Shaft voltage
- Temperature
- Machine Current Signature Analysis

RM Diagnostics - Partial discharge intro

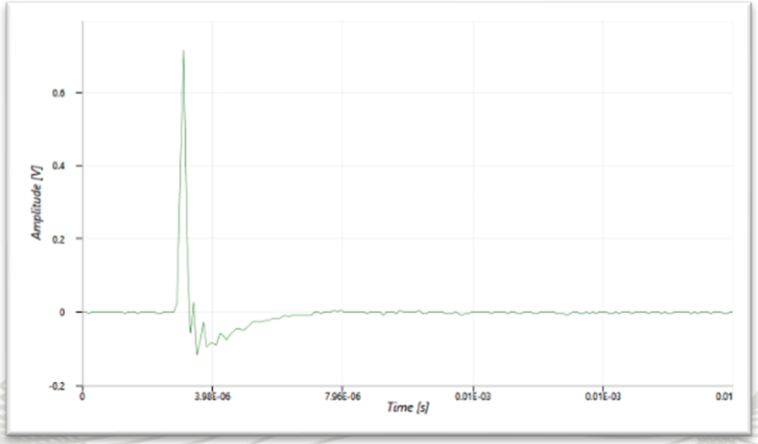
IEC: "Localized electrical discharge that only partially bridges the insulation between conductors and which can or can not occur adjacent to a conductor"

IEEE: "Localized electrical discharge that only partially bridges the insulation between conductors"



IEC: "Current or Voltage pulse that results from a Partial Discharge occurring within the object under test. The pulse is measured using suitable detector circuits, which can be introduced into the test circuit for the purpose of the test."

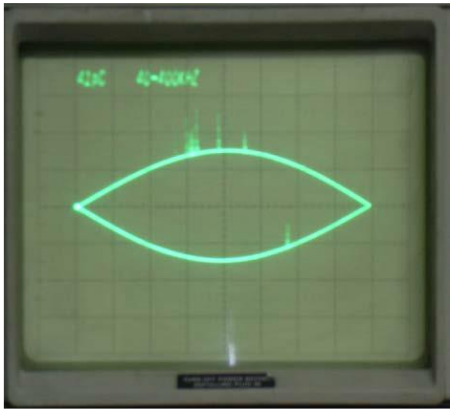
IEEE: "An high frequency current or voltage pulse that results from a partial discharge. In a shielded power cable the pulse propagates away from the PD source in both directions along the cable."



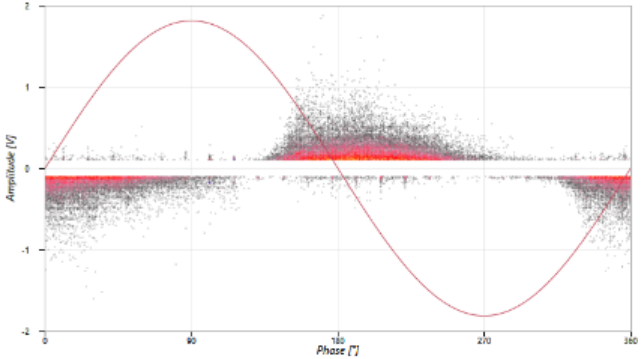
PD and Rotating Machines

Phase Resolved Partial Discharge Pattern:

Each PD phenomenon generates thousands of PD pulse each second. The common way to visualize them is to plot the pulses' amplitude correlated with the applied voltage.

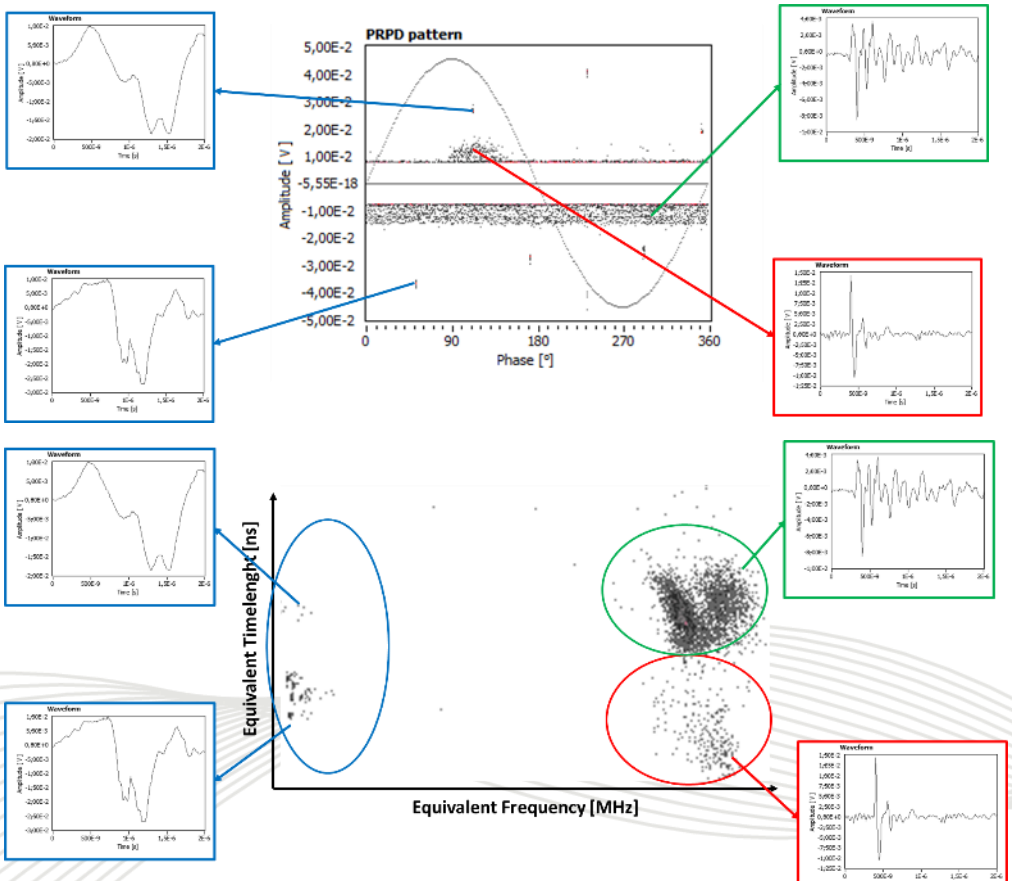


The correlation is based on the PD physics, the electrical stress due to the applied voltage activates PD.



PRPD pattern recognition is the key for PD diagnostics outside of laboratories.

TF-map Technology



Differences in pulse shape

➔ Different Eq. Freq.

➔ Different Eq. Timelength

PD and rotating machines

International standards:

IEC 60034-27-2: On-line partial discharge measurements on the stator winding insulation of rotating electrical machines

IEEE 1434: Guide for the Measurement of Partial Discharges in AC Electric Machinery

CIGRE 258: Application of on-line partial discharge tests to rotating machines

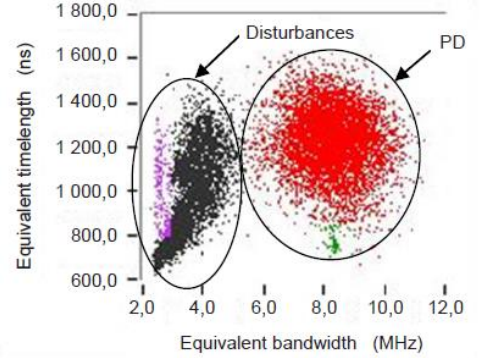
TF-map technology & standards

IEC 60034-27-2:

On-line partial discharge measurements on the stator winding insulation of rotating electrical machines

<< Time and frequency domain separation can be developed through a pulse shape analysis to produce the so-called "TF" map that plots the equivalent time length of the pulses versus their equivalent frequency content >>

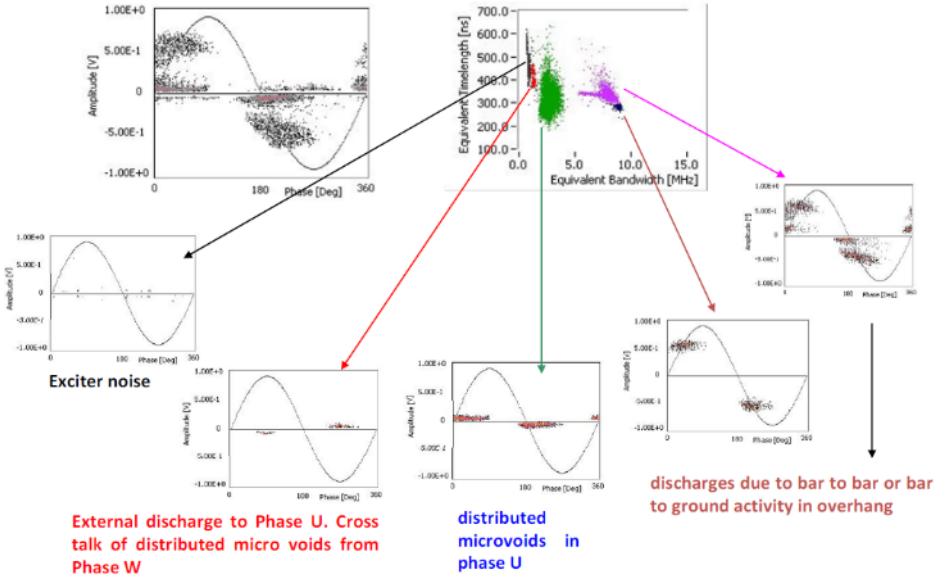
<< disturbances will often appear as a cluster of pulses that is in a position, which is distinctly different from stator winding PD, and can thus be identified and suppressed from the PD pattern >>



TF-map technology & standards

IEEE 1434: *Guide for the measurement of Partial Discharge in AC Electric Machinery*

<< The data are displayed in terms of pulse width and bandwidth for the purpose of separating different PD sources from the insulation system and discriminate from external noise sources >>

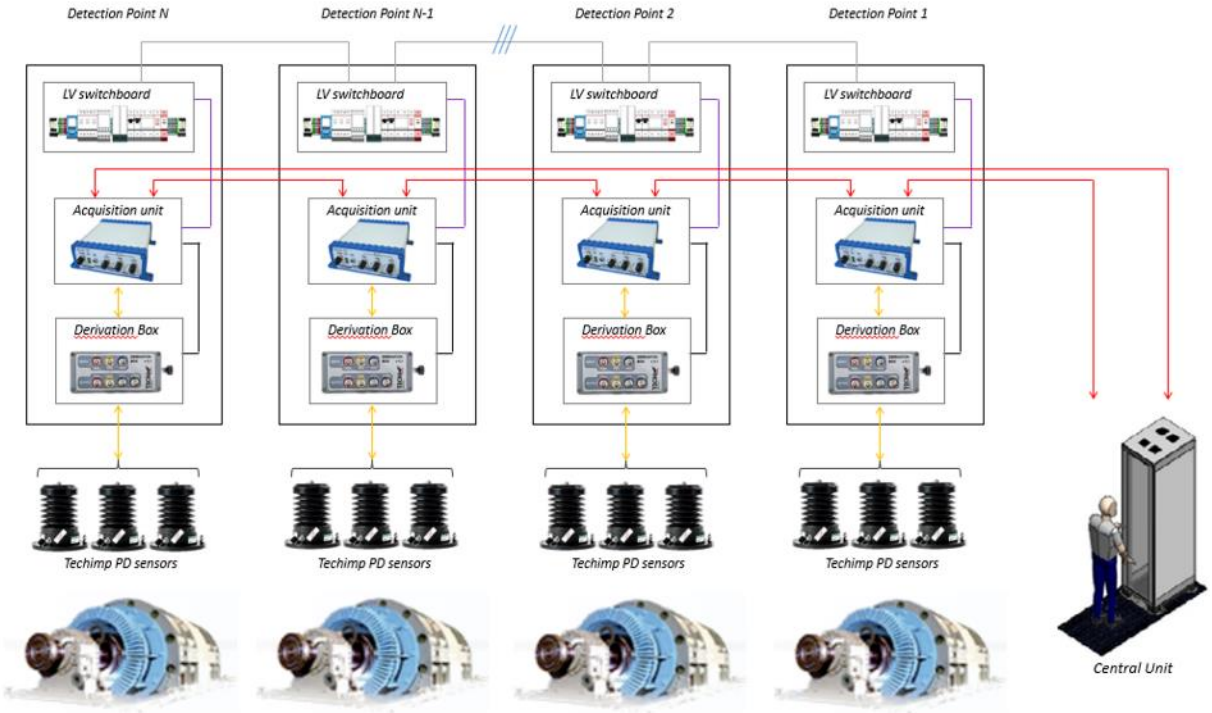


Global monitoring systems for RM

- Partial Discharge Monitoring
- Coupling capacitors from 7kV to 36kV
- HFCT
- 3 / 6 channel Acquisition Units PDHub
- Unsurpassed T/F-Map Technology
- Sensors and Acquisition units for EX-Zones

Global monitoring systems for RM

Failures: microvoids, embedded delamination, conductor side delamination, slot discharges, stress grading discharges, bar-to-bar / bar-to-ground



Global monitoring systems for RM

TiSCADA – Centralized Data

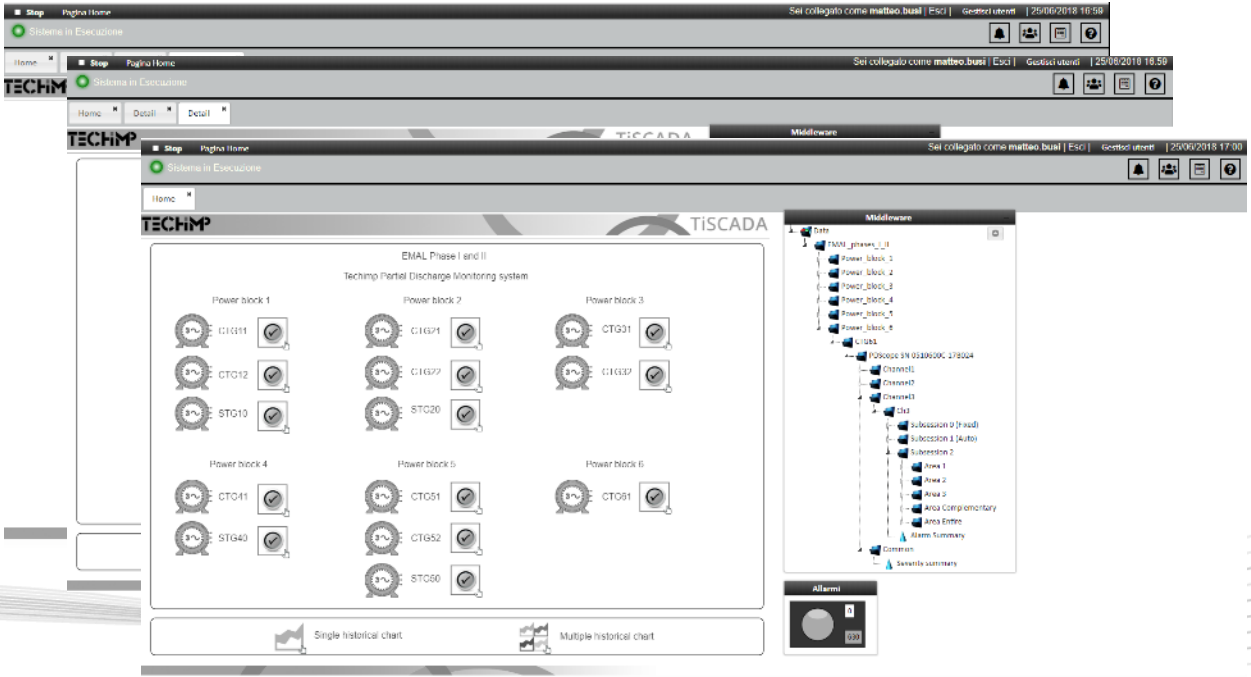
Status

Trending

Warning

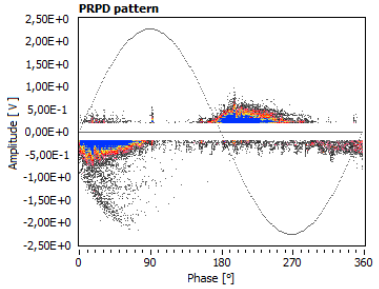
Analysis

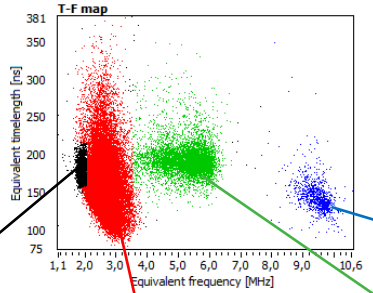
Export to Scada



Case study:

- Rotating Machine post processing



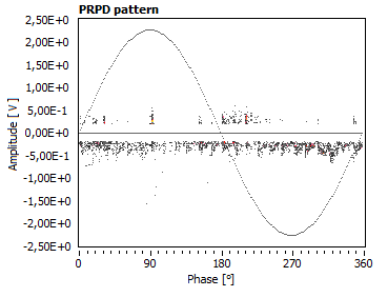


Asset: Synchronous Generator

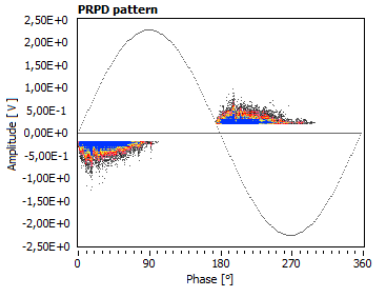
Rated Power: 20.1 MVA

Test Type: Online PD Maintenance Test

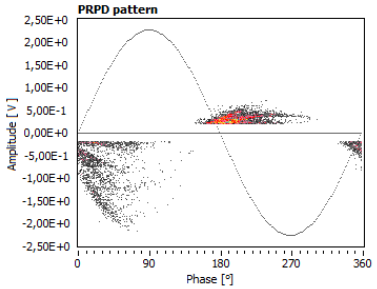
PD sensor: Coupling Capacitors



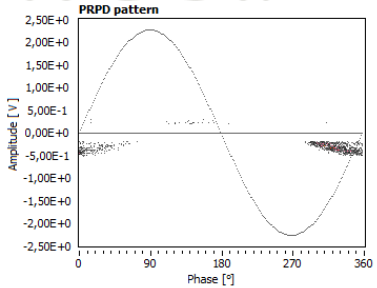
Background/Exciter Noise



Slot Discharges



Embedded Delaminations

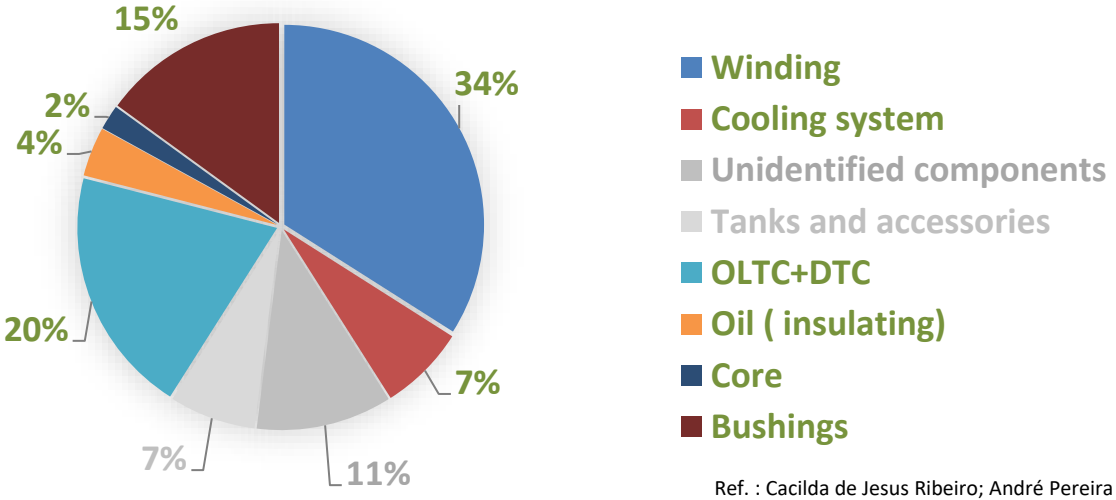


Crosstalk

Transformers failures

HV transformer faults in CELG (Brasil) 1979..2007

Windings and bushing failures represent about 50% of the overall failures, while tanks and cooling system add another 15% approximately. Winding failures are basically due to the lack of insulation inside the tank



Ref. : Cacilda de Jesus Ribeiro; André Pereira Marques and others. Faults and Defects in Power Transformers – A Case Study

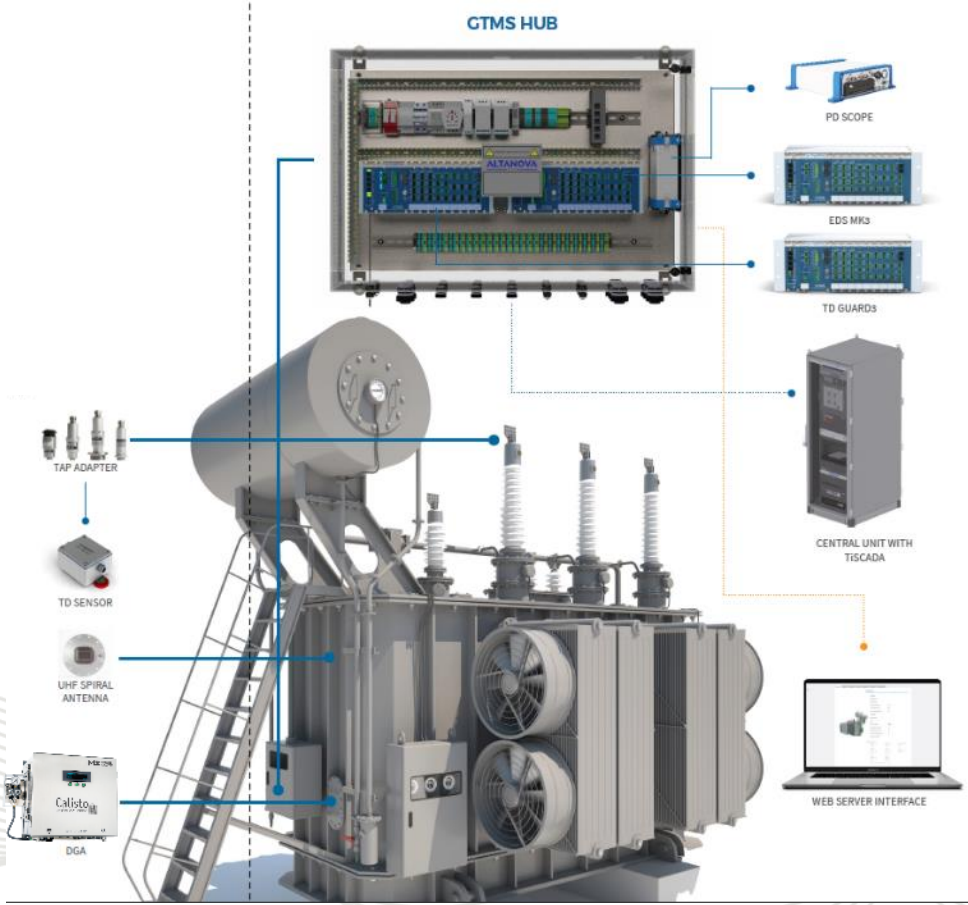
80% coverage

The most part of the components that generate failures are monitored by TrafoNOVA system

Monitoring of Transformer

Global monitoring systems for Power Transformer

- Generic Parameters
- Partial Discharge Monitoring
- Tan-δ Bushing Monitoring
- Dissolved Gas Analysis



Monitoring of Transformer

PD & TD Monitoring

Partial Discharge

- Tap adaptors
- UHF sensors (window or drain-valve)
- 3 / 6 channel Acquisition Units PDHub
- Unsurpassed T/F-Map Technology

Bushing Monitoring

- Capacitance
- Tan-δ
- Δtan-δ

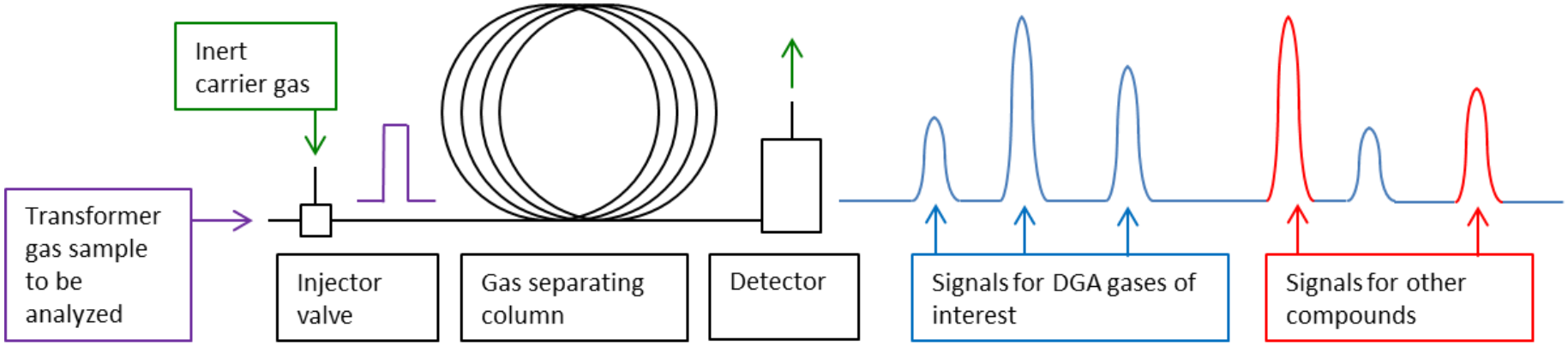
Monitoring of Transformer

DGA for Transformer Monitoring

Calisto Family - Up to 9 gases

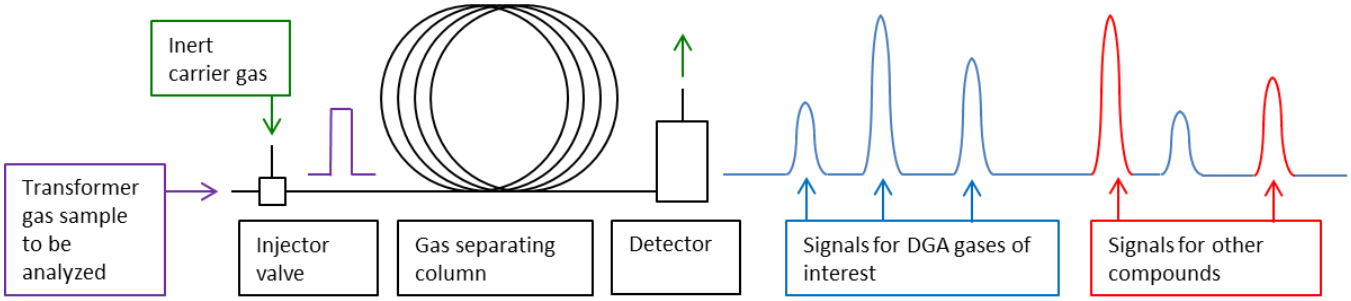
- Hydrogen (H2)
- Carbon monoxide (CO)
- Methane (CH4)
- Acetylene (C2H2)
- Ethylene (C2H4)
- Ethane (C2H6)
- Carbon Dioxide (CO2)
- Oxygen (O2)
- Nitrogen (N2)

Gas Chromatography



- The small sample of mixed gas is propelled through a gas separating column by a carrier gas (helium)
- Each separated gas species reaches the detector at a different time
- A calibration gas run is used to identify and quantify each component gas

Gas Chromatography



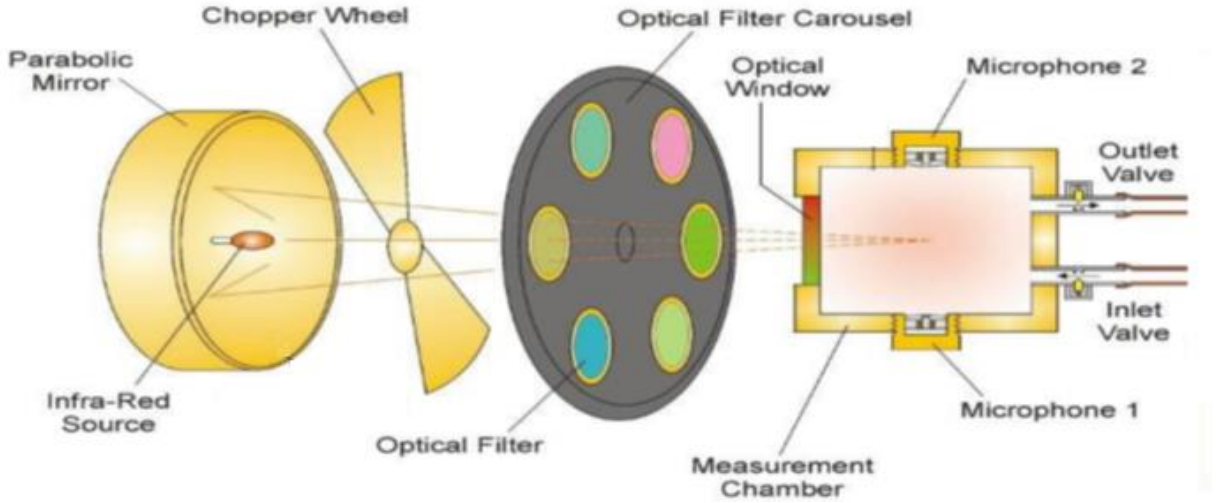
PROS

- Most sensitive
- Most accurate (like DGA lab) due to automatic calibration
- Readings not affected by interference gases

CONS

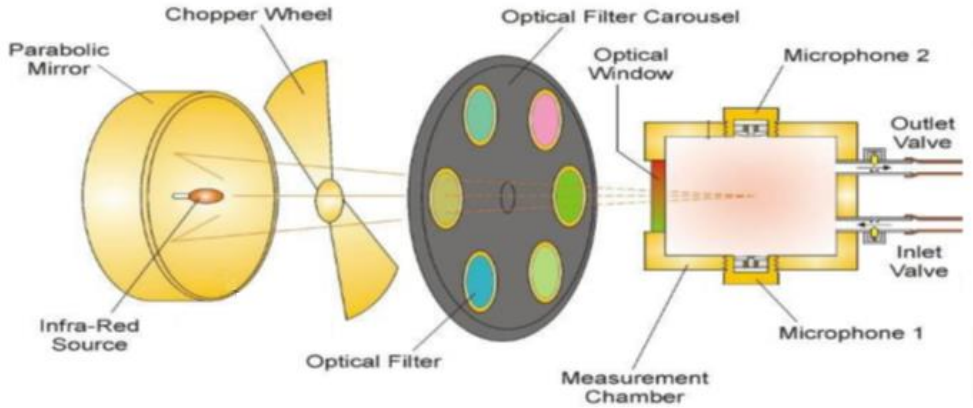
- Time and cost to replace consumables (carrier gas and calibration gas cylinders)
- Some models need major overhaul after 4-5 years

Photo-Acoustic IR Spectroscopy



- IR filters used to primarily excite one gas at a time
- IR light is chopped at an audio frequency
- Pulsed IR light → pulsed absorption → pulsed gas heating → pulsed expansion → sound waves → microphone signals
- Gas cell can be shaped to have an acoustic resonance at the chopping frequency (to boost microphone signal)

Photo-Acoustic IR Spectroscopy



CONS

- Some models accuracy can be compromised when interfering gases are present
- Some models loose accuracy over time (drift)
- Some models need major service after about 3-4 years

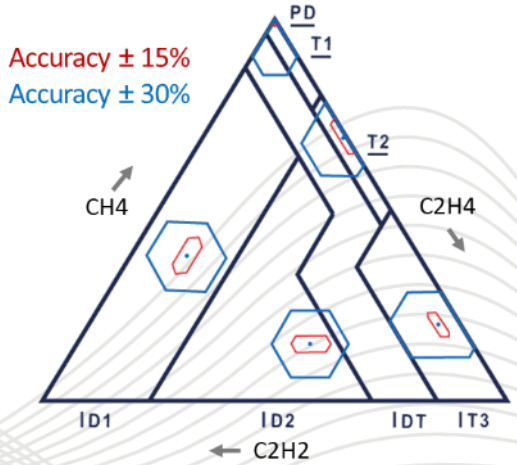
PROS

- Most sensitive IR method for a given absorption length
- NEW! One model has autocalibration using water vapor

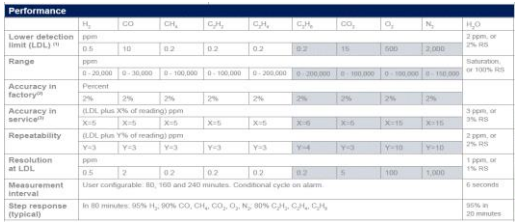
Accuracy

- According to ISO 5725-1, accuracy describe the closeness of measurement to true value.
- And precision (repeatability) is the closeness of group of

- When area of true measurement exceeds the boundaries of fault zones (poor accuracy)? fault severity is unclear



DGA Monitor accuracy - system vs detector

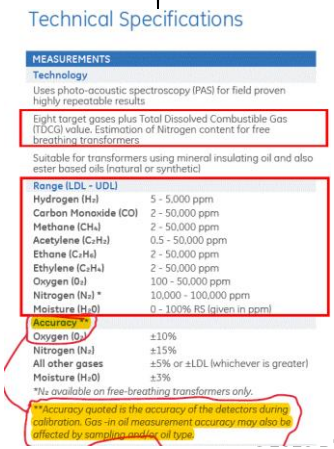


Performance										
	H_2	CO	CH_4	C_2H_2	C_2H_4	C_2H_6	CO_2	O_2	N_2	H_2O
Lower detection limit (LDL) [1]	ppm									2 ppm, or 2% RS
	0.5	10	0.2	0.2	0.2	0.2	15	500	2,000	
Range	ppm									Saturation, or 100% RS
	0 - 20,000	0 - 30,000	0 - 100,000	0 - 100,000	0 - 200,000	0 - 200,000	0 - 150,000	0 - 100,000	0 - 150,000	
Accuracy in factory[2]	Percent									
	2%	2%	2%	2%	2%	2%	2%	2%	2%	
Accuracy in service[2]	(LDL plus X% of reading) ppm									3 ppm, or 3% RS
	X=5	X=5	X=5	X=5	X=5	X=5	X=5	X=15	X=15	
Repeatability	(LDL plus Y% of reading) ppm									2 ppm, or 2% RS
	Y=3	Y=3	Y=3	Y=3	Y=3	Y=4	Y=3	Y=10	Y=10	
Resolution at LDL	ppm									1 ppm, or 1% RS
	0.5	2	0.2	0.2	0.2	0.2	5	100	1,000	
Measurement interval	User configurable: 80, 160 and 240 minutes. Conditional cycle on alarm									6 seconds
Step response (typical)	In 80 minutes: 95% H_2; 90% CO, CH_4, CO_2, O_2, N_2; 80% C_2H_2, C_2H_4, C_2H_6									95% in 20 minutes

System Accuracy

extraction separation detection

Measuring Quantity	Accuracy of gas extraction	Accuracy of the gas measurement
Hydrogen H_2	≤ ± 8 % ± 4 ppm	≤ ± 10 % ± 20 ppm
Carbon Monoxide CO	≤ ± 8 % ± 30 ppm	≤ ± 10 % ± 5 ppm
Carbon Dioxide CO_2	≤ ± 8 % ± 30 ppm	≤ ± 10 % ± 5 ppm
Methane CH_4	≤ ± 8 % ± 4 ppm	≤ ± 10 % ± 5 ppm
Acetylene C_2H_2	≤ ± 8 % ± 4 ppm	≤ ± 10 % ± 5 ppm
Ethylene C_2H_4	≤ ± 8 % ± 4 ppm	≤ ± 10 % ± 5 ppm
Ethane C_2H_6	≤ ± 8 % ± 4 ppm	≤ ± 10 % ± 5 ppm
Propane C_3H_8	≤ ± 8 % ± 4 ppm	≤ ± 15 % ± 20 ppm
Oxygen O_2	≤ ± 8 % ± 500 ppm	≤ ± 10 % ± 500 ppm
Nitrogen N_2	≤ ± 8 % ± 1500 ppm	≤ ± 10 % ± 1500 ppm



Technical Specifications

MEASUREMENTS

Technology

Uses photo-acoustic spectroscopy (PAS) for field proven highly repeatable results

Eight target gases plus Total Dissolved Combustible Gas (TDCG) value. Estimation of Nitrogen content for free breathing transformers

Suitable for transformers using mineral insulating oil and also ester based oils (natural or synthetic)

Range (LDL - UDL)	
Hydrogen (H_2)	5 - 5,000 ppm
Carbon Monoxide (CO)	2 - 50,000 ppm
Methane (CH_4)	2 - 50,000 ppm
Acetylene (C_2H_2)	0.5 - 50,000 ppm
Ethane (C_2H_6)	2 - 50,000 ppm
Ethylene (C_2H_4)	2 - 50,000 ppm
Oxygen (O_2)	100 - 50,000 ppm
Nitrogen (N_2) *	10,000 - 100,000 ppm
Moisture (H_2O)	0 - 100% RS (given in ppm)

Accuracy **	
Oxygen (O_2)	±10%
Nitrogen (N_2)	±15%
All other gases	±5% or ±LDL (whichever is greater)
Moisture (H_2O)	±3%

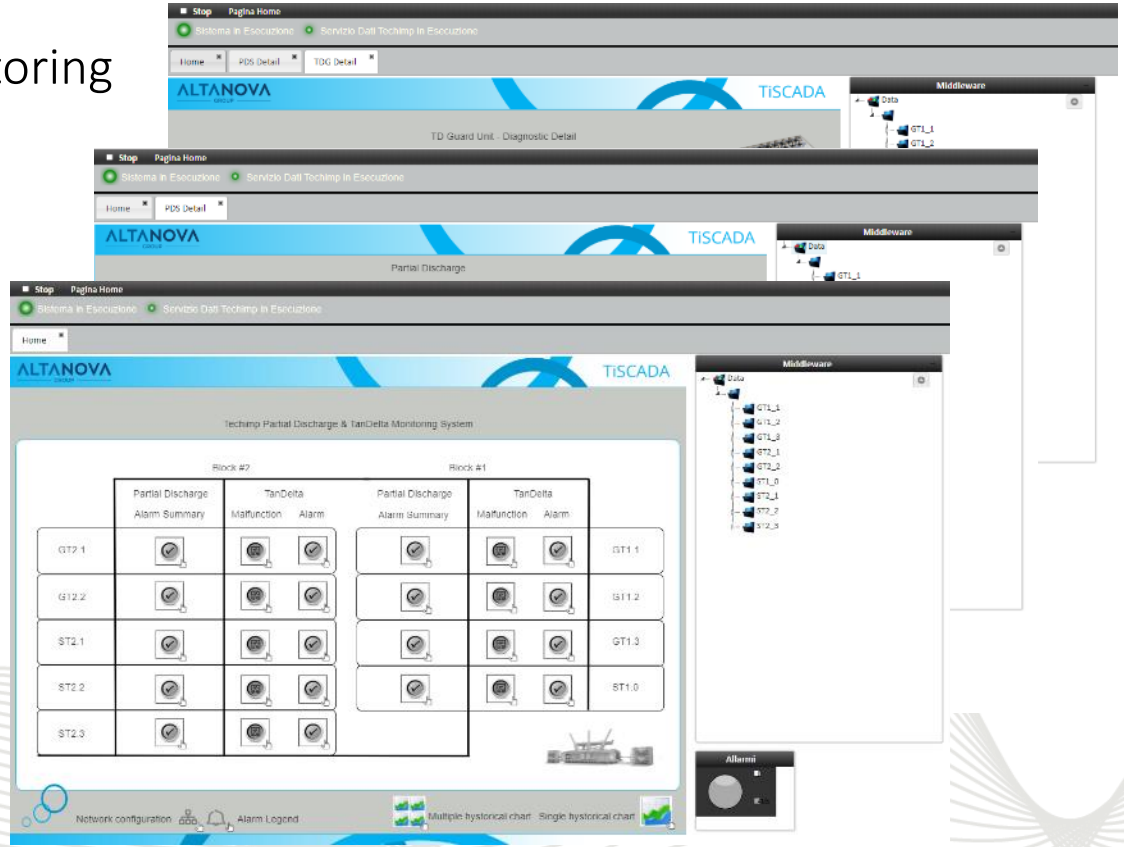
*N_2 available on free-breathing transformers only.

**Accuracy quoted is the accuracy of the detectors during calibration. Gas-in-oil measurement accuracy may also be affected by sampling and/or oil type.

Monitoring of Transformer

TiSCADA for Transformer Monitoring

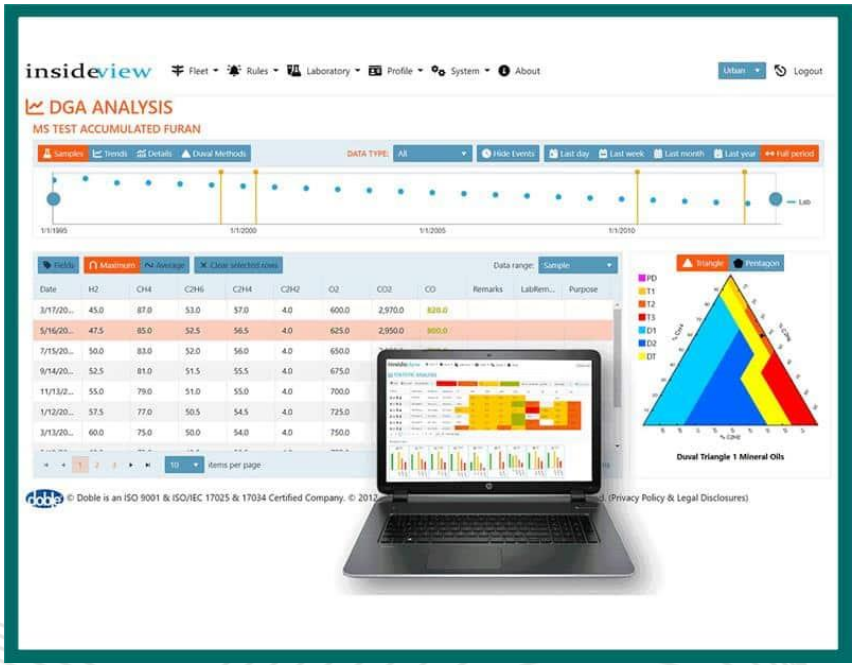
- Status
- Trending
- Warning
- Analysis
- Export to Scada



Transformer Fleet Management

InsideView for centralized fleet oil management

- Streamlined workflow between laboratories, experts, field personnel, and asset managers
- Compliance with IEEE C57.104-2019 for DGA data interpretation
- Native integration with Doble Laboratories
- Native integration with Calisto™ DGA condition monitors
- On-premise or cloud-based solutions leveraging state-of-the-art security delivered in Microsoft Azure Cloud data centers
- Data integration options with 3rd-party applications such as Maximo®, Cascade, etc.

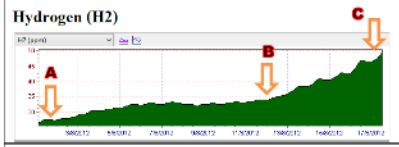
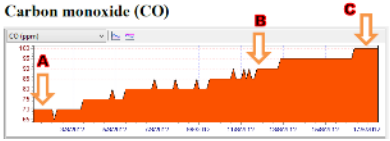
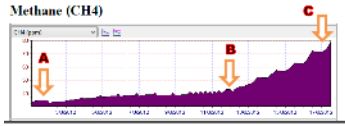
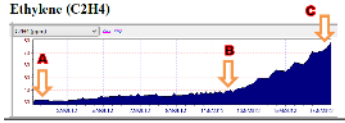
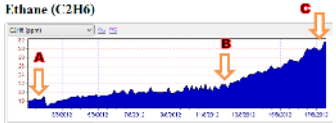


Case Study: Steel Industry S.E. Asia

Main Tank Transformer Capacity 96 MVA, 22/1.1kv

Manufacturers: TAMINI

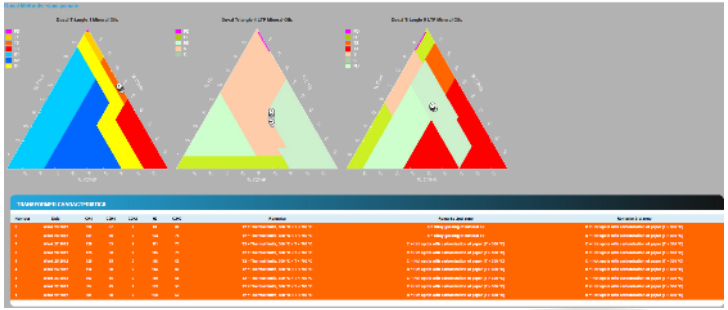
The DATA Bank It takes 12 days develop from A to B and 6 days form B to C

Hydrogen (H2) 	A to B	0.70 ppm/day
	B to C	2.25 ppm/day
Carbon monoxide (CO) 	A to B	1.66 ppm/day
	B to C	1.66 ppm/day
Methane (CH4) 	A to B	1.0 ppm/day
	B to C	6.16 ppm/day
Ethylene (C2H4) 	A to B	1.0 ppm/day
	B to C	6.83 ppm/day
Ethane (C2H6) 	A to B	0.3 ppm/day
	B to C	1.8 ppm/day

Case Study: Steel Industry S.E. Asia

DGA ANALYSIS

Date	Duval triangle	Rogers gas ratios	IEC 60599 gas ratios
Week 29 2012	T2 – Thermal faults, 300 °C < T < 700 °C	Thermal fault temp. range less than 700 °C	Thermal fault 300 °C < T < 700 °C
Week 26 2012	T2 – Thermal faults, 300 °C < T < 700 °C	Thermal fault temp. range less than 700 °C	Thermal fault 300 °C < T < 700 °C
Week 27 2012	T2 – Thermal faults, 300 °C < T < 700 °C	Thermal fault temp. range less than 700 °C	Thermal fault 300 °C < T < 700 °C
Week 26 2012	T2 – Thermal faults, 300 °C < T < 700 °C	Thermal fault temp. range less than 700 °C	Thermal fault 300 °C < T < 700 °C
Week 25 2012	T2 – Thermal faults, 300 °C < T < 700 °C	Thermal fault temp. range less than 700 °C	Thermal fault 300 °C < T < 700 °C
Week 24 2012	T2 – Thermal faults, 300 °C < T < 700 °C	Thermal fault temp. range less than 700 °C	Thermal fault 300 °C < T < 700 °C
Week 23 2012	T2 – Thermal faults, 300 °C < T < 700 °C	Low temp thermal fault	Unknown fault: partial or mixture of faults – mainly thermal faults
Week 22 2012	T2 – Thermal faults, 300 °C < T < 700 °C	Low temp thermal fault	Unknown fault: partial or mixture of faults – mainly thermal faults
Week 22 2012	T2 – Thermal faults, 300 °C < T < 700 °C	Low temp thermal fault	Unknown fault: partial or mixture of faults – mainly thermal faults



Cable Maintenance Strategies

Acceptable Risk

- Run to Failure
- Preventive maintenance
- Predictive maintenance
- Reliability centered maintenance

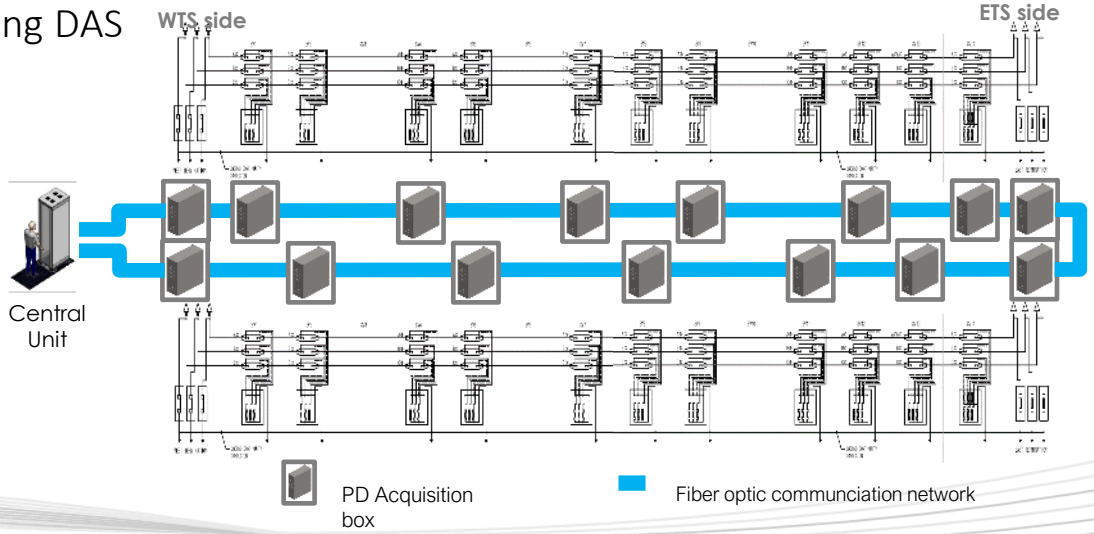
Data to manage

SURVEY	Visual Checks Thermography RFI surveys
INVESTIGATION	PD Screening PD test on specific assets
CONTINUOUS ASSESSMENT	Permanent monitoring MV cables Permanent monitoring HV cables

Monitoring of Cable

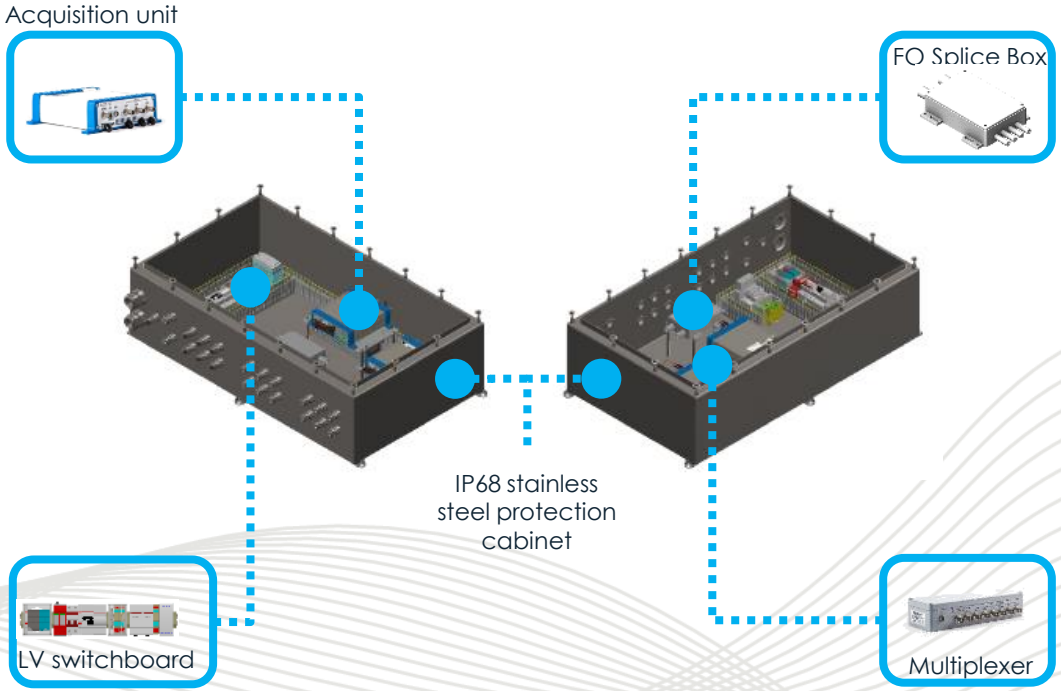
Global Monitoring Systems for Cables

- Partial Discharge Monitoring
- Sheath Current System SCS
- (HV) Distributed Temperature Sensing DTS incl. RTTR
- (HV) Distributed Acoustic Sensing DAS
- (HV) Fluid Pressure System FPS



Monitoring System for Cables

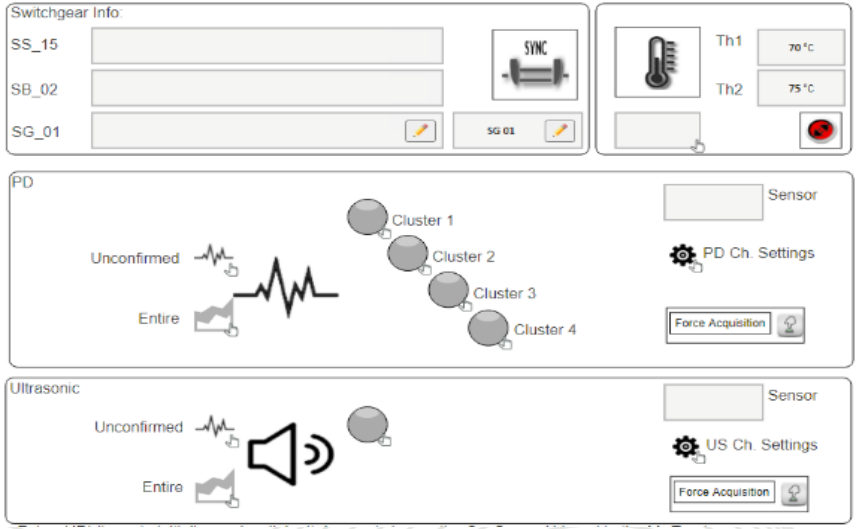
PDHub



MV cable online monitoring

State of the art MV cables monitoring includes

- Partial Discharge monitoring
- Ultrasonic monitoring
- Temperature monitoring



Case study:

Permanent online monitoring system installed on 20kV cables GIS terminations.

No grounding lead available

→ HFCT on cable monitoring

→ Acoustic airborne monitoring

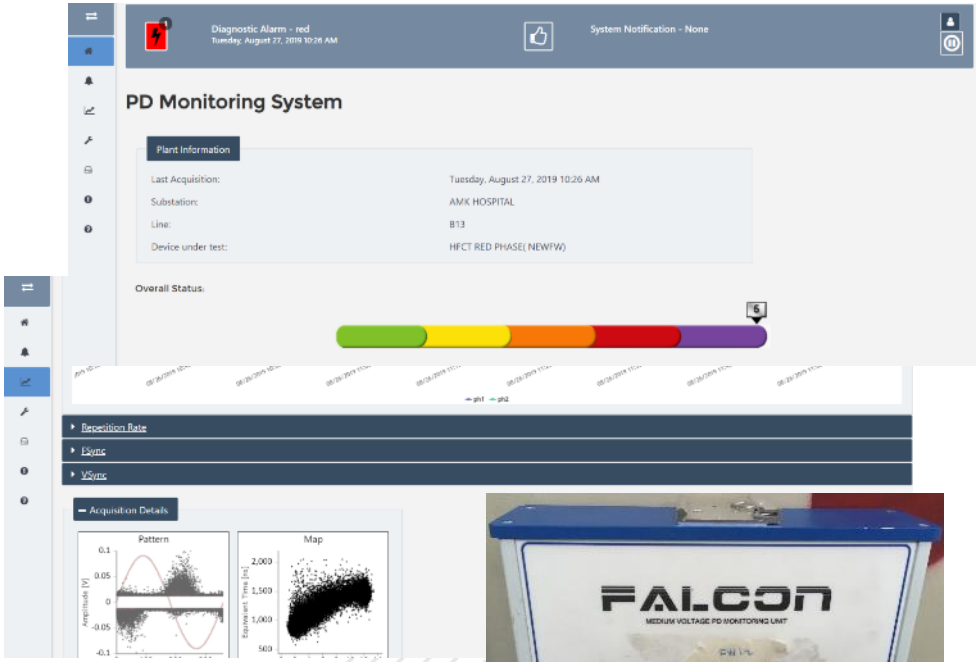
Case study:

HFCT on the MV cable.

PD activity was observed in one of the cables connected to the Switch side.

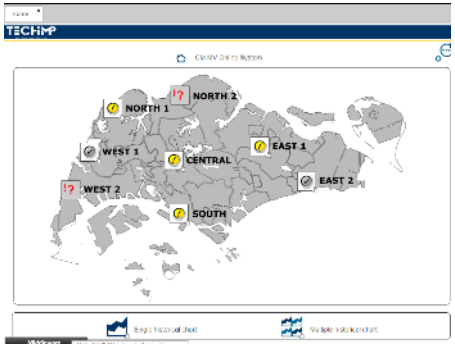
Asset owner policy is «zero PD»

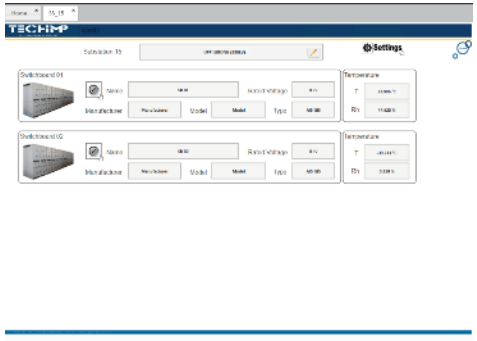
→ Out of service, offline test, PD localization, visual inspection and maintenance program.

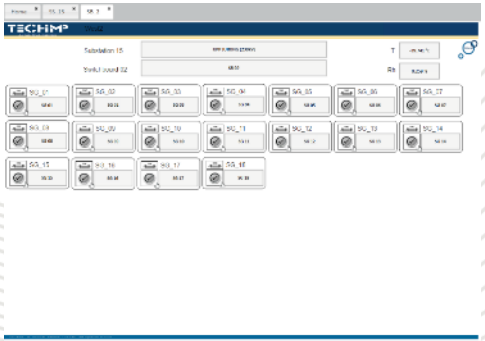


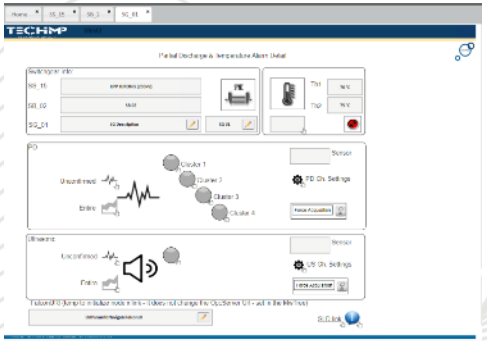
Case study Falcon & TiSCADA - Distribution

- Distribution Utility
- MV cables and panels montioring
- 1000+ detection point
- HFCT, TEV, US Airborn & T°
- Falcon MKII









- 1 platform from the whole distribution network
- High cooperation with customer
- New algorithm for PD on MV asssets
- Very competitive technology

Monitoring of MV Switchgear

Global Monitoring Systems for MV Switchgear

- Partial Discharge Monitoring
  - 1 – 40 channel DAUs
  - HFCT, TEV, TEM US & FMC sensors
- Circuit Breaker Monitoring
  - Parameters similar to HV CBM
- Temperature
  - Passive SAW Technology
  - PT1000
- Humidity

Asset Failure Mode: Insulation Breakdown

Failure Modes

- Aging insulation due to thermal, electrical, and ambient conditions
- Partial Discharge:
- Small electrical arcs at voids (air pockets) within or on insulation surface
- A symptom of failing insulators
- A flashover can occur once a tracking pathway between phases (or ground) is completed

IEEE Gold Book (Table 36) indicates cables, switchgear, and transformers suffer the greatest losses from insulation failure.

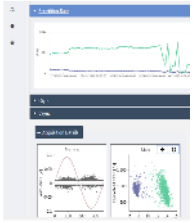
Traditional Monitoring

- Periodic: offline and ‘online’
- Expensive: 3rd party test or hardware
- Requires an engineer to conduct test and interpret data
- Needs proprietary databases to compare like machines for analysis

Falcon Continuous Monitoring

- Highest Safety
  - Permanent install with HFCT or TEV PD Sensors, no disconnection, inactivity or interruption needed
- Simple installation and commissioning
  - No configuration needed
  - No expert needed
- Automatic data elaboration
  - No skilled operator in PD is needed
  - Early warnings in case of harmful PD phenomena

Data input



Concise Output

Monitoring of MV Switchgear

Partial Discharge Monitoring

Sensors

- HFCT – High Frequency Current Transformer
- TEV – Transient Earth Voltage
- TEM – Transversal Electromagnetic Waves
- US - Acoustic

Continuous online PD monitoring for MV asset

FALCON system kit

PARTIAL DISCHARGE
HFCT sensor placed around the grounded shield of the cable

SYNCHRONIZATION
Line frequency synchronization

WEB APPLICATION
Measurements and alarms available through the web application

EASY INSTALLATION
FALCON is a Plug & Play device that can be installed with a few simple operations. It configures itself automatically, and once powered, it is immediately operational.

Continuous online PD monitoring for MV cables

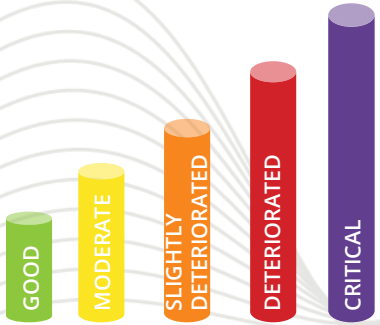
Operating principle of FALCON system

MEASURE
Automatic detection of partial discharges through sensors located on a cable termination

STORAGE
Historical archive of measures up to two years

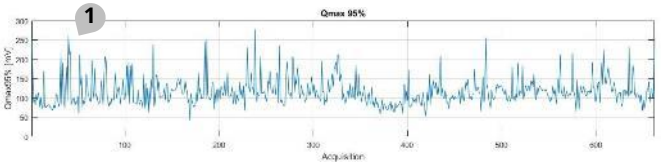
ANALISYS
Automatic recognition of critical issues in evolution

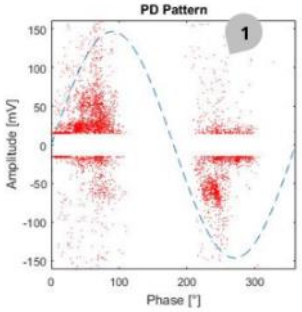
ALARMS
Maintenance work only where necessary and in advance of the failure event

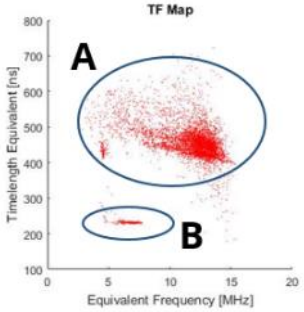


PARTIAL DISCHARGES
Each defect of a termination or joint produces signals whose variation in amplitude, if properly measured, allows to predict the failure weeks in advance.

Case Study







Details of the different phenomena acquired with TF map technology

A) Surface discharge
B) Corona discharge

PD acquisition unit

RFCT around ground lead

Surface tracking

1 month later

Monitoring of MV Switchgear

Partial Discharge Monitoring

Acquisition units

- FALCON – single (1-) channel
- FALCON MKII – multi channel up to
- 20 UWB and
- 20 US

Case Study: MV monitoring (Singapore)

Scope:

128 Substations, estimated 4,238 number of 22kV Panels. Air Insulated Switchgear (AIS) or Gas Insulated Switchgear (GIS)

To supply, install and commission an online Condition Monitoring and Diagnostic (CMD) system that monitors 3 main parameters on all AIS/GIS Panels, namely:

- Partial Discharge
- Ultrasonic
- Temperature

AIS Switchboard

GIS Switchboard

Case Study: MV monitoring (Singapore)

- HFCT Sensor
- Airborne Ultrasonic Sensor

➔ Installed below GIS Panel

GIS Panel

- Contact Temperature Sensor

➔ Installed above GIS Panel

Case Study: MV monitoring (Singapore)

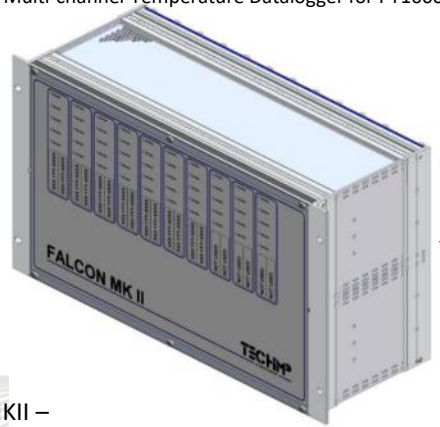
- **TEV Sensor**
- **Contact Temperature Sensor**
- **Contact Ultrasonic Sensor**

➔ **Installed below AIS Panel in cable floor**

AIS Panel

Case Study: MV monitoring (Singapore)

MCTLog 100 – Multi-channel Temperature Datalogger for PT1000 sensor

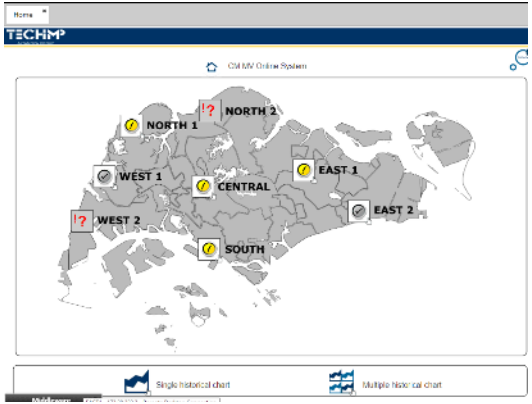


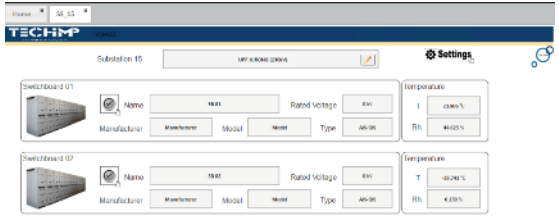
Falcon MKII –
for 2 UWB PD sensor inputs + 2 Ultrasonic sensor inputs

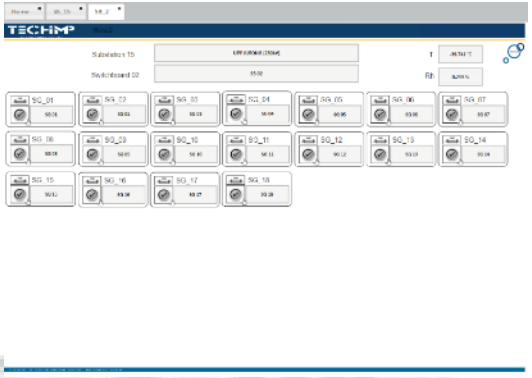
CMD Panel for switchboard located in S/S

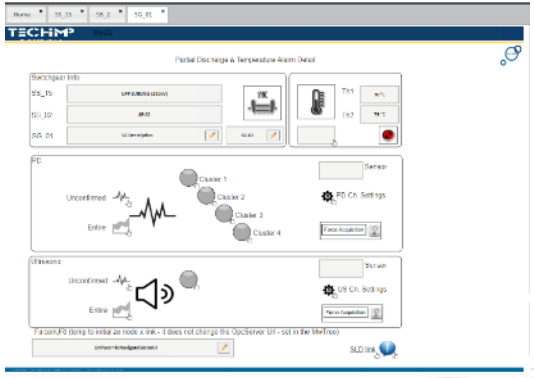
Short CMD Panel for Smaller switchboard

Case Study: MV monitoring (Singapore)









Monitoring of MV Switchgear

Temperature & Humidity

Sensors

- Passive SAW Technology
- Laser cut CMOS technology
- PT1000

Asset Failure Mode: Thermal Breakdown

Failure Modes

- Overload
- Corrosion
- Loose connections
- Improper mechanical racking

Traditional Monitoring

- Periodic, 1 or 2 times a year
- Requires a technician (sometimes 2)
- Dangerous & Expensive
- Cannot monitor main bus

Reader / CAM-5 Continuous Monitoring

- Highest Safety
  - Point of contact measurement
  - SAW sensor = RF signal (no battery)
- No Maintenance
  - Passive sensors
  - 20+ year life expectancy
- Easy Installation
  - Line of sight not required
  - Mounts under insulators
- Rugged Design
  - Tested for MV environments

Asset Failure Mode: Air Dielectric Breakdown

Failure Modes

- Humidity contamination and moisture on the insulation surface results in long term insulation damage and metallic corrosion, leading to:
  - Thermal breakdown
  - Insulation breakdown

Traditional Monitoring

- Visual inspection from the outside
- Heaters are often installed
  - Heaters fail and have no feedback
- "The power through the gear should be enough to keep it warm"

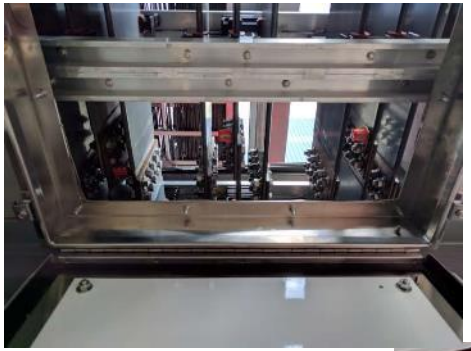
Reader / CAM-5 Continuous Monitoring

- Humidity & Ambient Temperature Sensing
- No Maintenance
  - No calibration required
  - <0.5% long term drift
- Easy Installation
  - Multiple bussing techniques
- Rugged Design
  - For installation in electrical assets in harsh environment

Installation Examples

Switchgear Cable / Breaker Arm

Bus Duct / Generator CB



Installation Examples

Oil Immersed Transformer

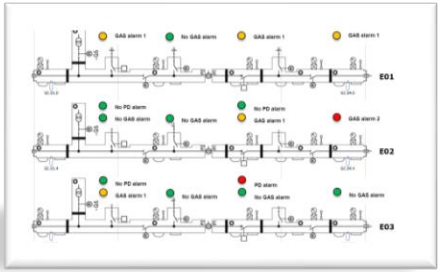
Dry-Type Transformers

TiSCADA Central Monitoring

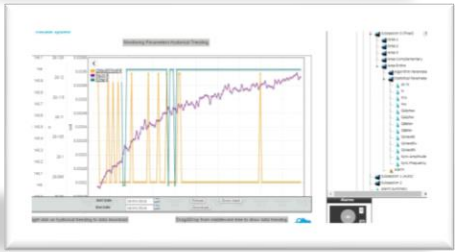
TiSCADA – Central Monitoring System

- Status
- Trending
- Warning
- Analysis
- Correlating
- Export to Scada

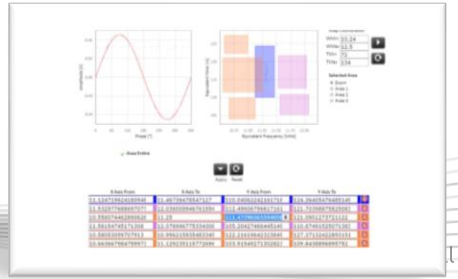
Dashboard



Asset view



Trendings

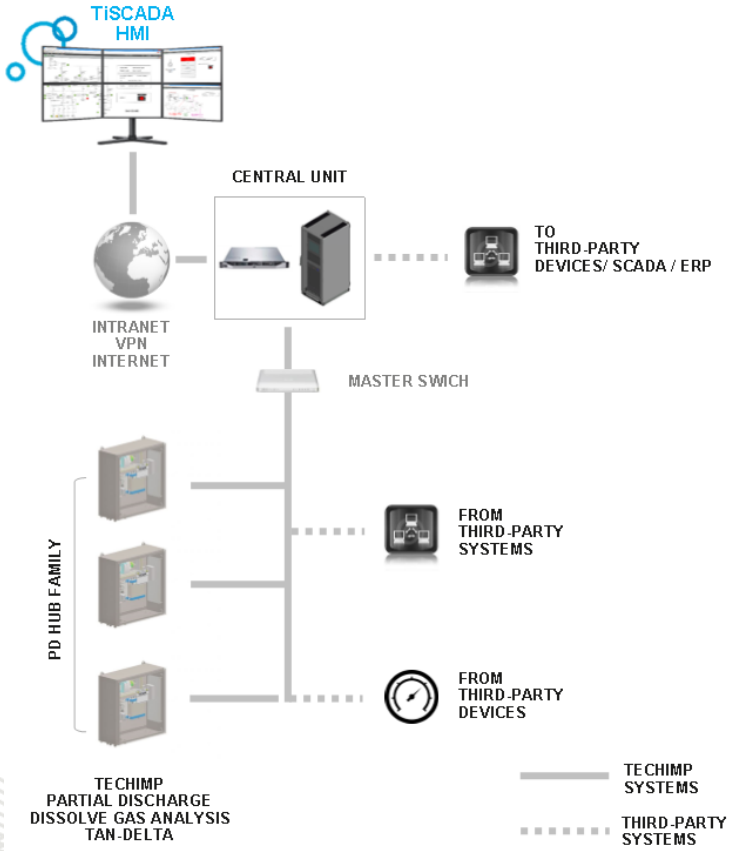


Data analysis

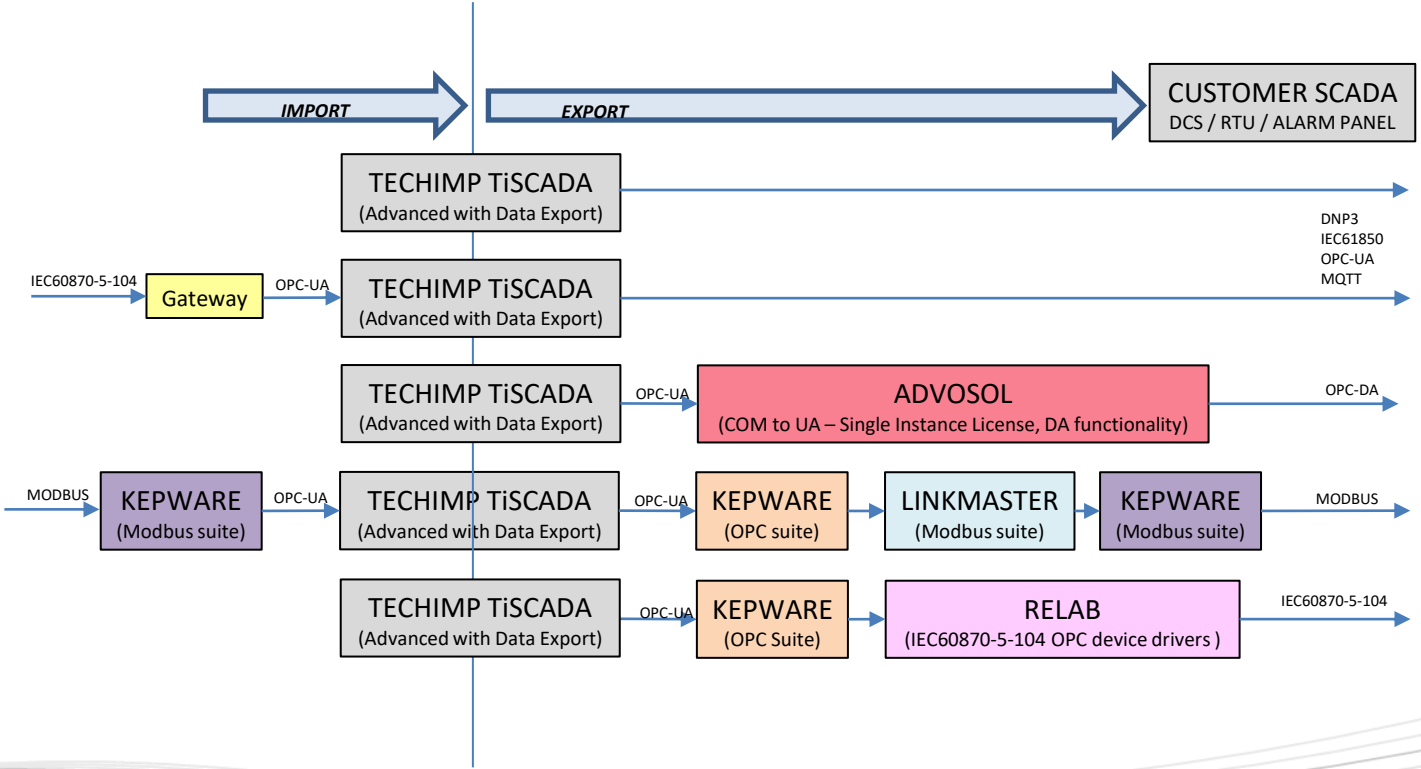
TiSCADA Central Monitoring

TiSCADA – Central Monitoring System

- Trending of condition parameters
- Expandable at any time in future
- Warning signal through e.g. SCADA system once threshold has been reached
- Additional services, e.g. data analysis



Substation/Plant Integration



Conclusions

Key winning differentiators for MV Asset Condition Monitoring:

- PD: Patented Technology (T/F map)
- DGA: best system accuracy in its class (extraction + separation + detection)
- DGA: Lab level accuracy Gas Chromatography
- DGA: Photo Acoustic IR Spectroscopy with autocalibration using water vapor
- Temperature/Humidity: service free SAW/CMOS system
- Condition assessment of ALL assets
- Complete Network Monitoring on one platform
- Global expert team
- Proven and reliable technology
- Highly professional project management
- Local presence (US / DE / IN / BR / SG / UAE / QT / PA)
- Operational excellence

Thank you!!

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