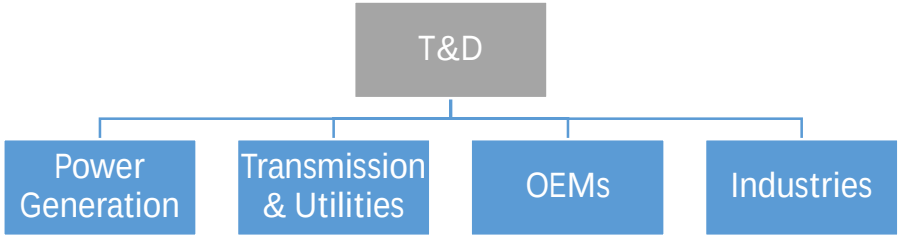
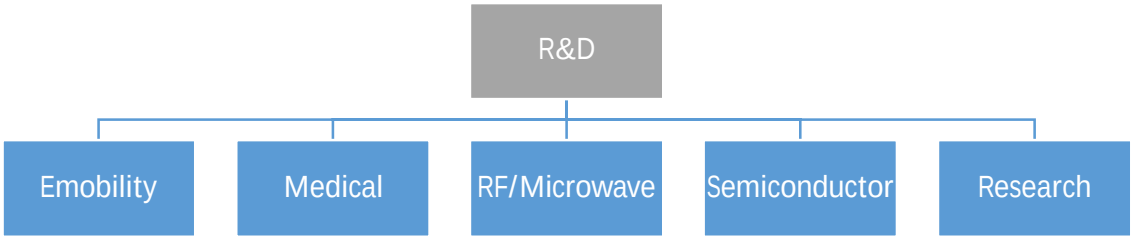
RUGGED MONITORING

MONITORING SIMPLIFIED

SOLUTION OVERVIEW

RM Business





- Condition Monitoring of High Value Assets
  - Begin with Temperature Monitoring
  - Vision: Condition Monitoring & Asset Performance Management
- Growth Drivers
  - Condition based / Preventive maintenance
  - Aging infrastructure and drive for automation

- Focus of Harsh Environment Conditions
  - Emobility: High Voltage, Magnetic and Chemical
  - Medical: High Magnetic and RF/Microwave
  - RF/Microwave applications
- Growth Drivers
  - Exponential Growth in high voltage Electric Vehicle
  - Growth in advance medical applications
  - RF/Microwave applications replacing traditional methods

Assets Monitored

Enterprise Asset Condition Monitoring System

Multi Asset Monitoring On Premise or hosted in Cloud

- Transformer Monitoring system
- GIS Monitoring system
- Breaker Monitoring system
- Cable Monitoring system
- AIS Monitoring system
- Switchgear Monitoring system
- Overhead line Monitoring system
- Battery Monitoring system
- Substation Monitoring system
- Motor Monitoring system

RM Enterprise

- Power Transformer
- Dry Type Transformer
- GIS EHV/HV
- GIS MV
- Breaker HV
- AIS
- Cable MV
- Cable EHV/HV
- Switchgear MV
- Breaker MV
- Overhead Lines
- Surge Arrester
- Current Transformer (CT)
- Voltage Transformer (VT)
- Batteries
- Substation Level (Thermal Camera's/Video)
- Motors
- Variable Frequency Drives

RM EYE Architecture

UI / UX

RM Enterprise

On premise
Cloud: AWS, Azure , Google Cloud

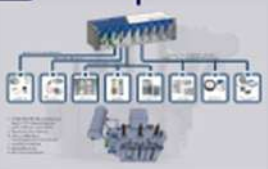
- RM Enterprise Data Layer
- RM Enterprise Analytics

- RM Enterprise User Interface
- RM Enterprise Custom Dashboards
- RM Enterprise Reporting
- RM Enterprise Email/SMS Notifications

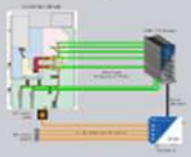
Data Collection

IEC 61850 | IEC 60870-104 | OPC-DA | - FTP/SFTP - XML, JSON - CSV, COMTRADE | Modbus | DNP3.0 | ODBC | https

Asset Data



Transformer Monitoring System



Switchgear Monitoring System

Power Cable Monitoring System

- Offline Test Results
- Inspection Records
- Name Plate

- Historian
- CMMS
- SCADA/ DCS

RM EYE Integration Bus

Offline Test Result

Inspection Records

Nameplate

Historian

CMMS

SCADA/DCS

IEC 61850

OPC-DA

Modus

DNP 3.0

IEC 60870-104

FTP / SFTP
- XML, JSON
- CSV, CDM TRADE

ODBC

Spreadsheets

Online Monitoring Systems

Presentation Layer

Analytics APIs

Reporting APIs

Data Access Services

Database

RM EYE Service Offering

Offline Testing

- DGA Labs
- Service Shops
- OEM service organization

Online + Offline Monitoring

1 Module

Multiple Module

1 Asset

Million Assets

1 Company

Multiple Company

On Premises

Cloud

SaaS

IoT Sensors

Fiber Optic

HF PD

UHF PD

PD Acoustic

Bushing

DGA

Others

Fiber Optic Sensors

- TSENS
- LSENS-R
- LSENS-T
- LSENS-U

HF PD Sensors

- HSENS-H
- HSENS-T
- HSENS-CC

UHF PD Sensors

- USENS-T
- USENS-D
- USENS-BT
- USENS-B
- USENS-W
- USENS-G
- USENS-C

PD Acoustic Sensors

- ASENS

Bushing Sensors

- BSENS

DGA Sensors

- H2SENS
- GSENS

Other Sensors

- Clamp on CT
- RTDs
- PT / VT

Fiber Optic Temperature Sensors

	Product	Description	Assets Monitored
	**TSENS**	Precisely designed sensor for direct measurement of temperature in Transformers	
	**LSENS-R**	Rugged fiber optic temperature sensor with a diameter of 1.7 mm for monitoring in AIS and Breakers	
	**LSENS-T**	A multiuse fiber optic temperature sensor that has a response time of 0.2s and tip diameter of 1.1mm for monitoring in Transformers, GIS, AIS, Rotating Machines, and Breakers	
	**LSENS-U**	Fiber optic temperature sensor specially designed for harsh and dynamic operating conditions with probe sensitive area of 1.6 mm for monitoring in Transformers, Cables, GIS, AIS, Rotating Machines, and Breakers	

HF PD Sensors

	Product	Description	Assets Monitored
	**HSENS-H**	HSENS-H is a High-Frequency Current Transformer sensor with a frequency response in the range of 100kHz-25 MHz for monitoring in Transformers, Cables, GIS, AIS, Rotating Machines, and Breakers	
	**HSENS-T**	Transient Earth Voltage Sensor that can be used to detect external partial discharges with frequency response in the range of 1 MHz-100 MHz for monitoring in Transformers, Cables, GIS, Rotating Machines, and Breakers	
	**HSENS-CC**	Compact Size, Highly Sensitive, Capacitive Coupler for PD Testing and Monitoring with capacitance of 1nF, 1.2nF, 1.5nF, 2nF, 500pF, 80pF for monitoring in Transformers, GIS, AIS, Rotating Machines, and Breakers	

UHF PD Sensors

	Product	Description	Assets Monitored
	**USENS-T**	UHF PD Sensors for Transformers with frequency response in the range of 200 - 3000 MHz	
	**USENS-D**	Wideband, Highly Sensitive, UHF PD Sensors for Transformer Drain Valves with frequency response in the range of 200 - 3000 MHz and with sensitivity up to -90 dBm	
	**USENS-BT**	Bushing PD sensor with wider frequency response in the range of 30MHz - 1500MHz and sensitivity up to -70 dBm	
	**USENS-B**	UHF PD Sensors for GIS barrier openings with frequency response in the range of 200 - 3000 MHz and with sensitivity up to -70 dBm	

UHF PD Sensors

	Product	Description	Assets Monitored
	**USENS-W**	Wideband, Highly Sensitive, UHF PD Sensors for GIS with Frequency response in the range of 200 - 3000 MH and with sensitivity up to -90 dBm	
	**USENS-G**	Partial Discharge Sensor for measuring ultra-high frequency signals emitted bypartial discharge activity inside GIS with frequency response in the range of 200 - 3000 MHz	
	**USENS-C**	Ultra-High Frequency PD sensors for Cables and Switchgear with frequency response in the range of 30MHz - 1GHz and sensitivity up to -70dBm	

PD Acoustic & Bushing Sensors

	Product	Description	Assets Monitored
	**ASENS**	Highly Accurate Acoustic sensor for partial discharge localization with different resonant frequencies of 40 kHz, 80 kHz, and 150 kHz for monitoring in Oil Filled Reactors, Transformers and GIS	

	Product	Description	Assets Monitored
	**BSENS**	Bushing Sensors for Tan δ and Capacitance monitoring are based on measuring Leakage Current in the range of 1mA to 200mA which also additionally provides HF signals between 100 kHz – 25 MHz for PD monitoring	

DGA Sensors

	Product	Description	Assets Monitored
	**H2SENS**	Hydrogen sensors for transformer dissolved gas monitoring using our proven DGA platform	
	**GSENS**	Provides highly accurate information about the abnormalities in the oil and to ensure the best health condition in transformers	

Other Sensors

	Product	Description	Assets Monitored
	**Clamp on CT**	Split-core current transformer for the measurement of AC currents from 1 to 200Amps	
	**RTDs**	Highly resistive oil / ambient temperature sensor with excellent accuracy over a wide temperature measurement range from -50°C to 250°C	
	**PT / VT**	Highly accurate voltage measurement with the most advanced potentiometer	

Monitors / Edge Devices

Fiber Optic Temperature

Condition Monitoring

PD for OEMs

Continuous PD

Portable PD

Bushing

Fiber Optic Temperature Monitors

- T301
- O201
- H201

Condition Monitoring Monitors

- T501
- T401
- T301
- O201 Fluro
- O201 GaAs

Partial Discharge Monitors for OEMs

- PD201
- PD211

Continuous Partial Discharge Monitors

- CPM601-C
- HPM601-C
- UPM601-C

Portable Partial Discharge Monitors

- CPM601-P
- HPM601-P
- UPM601-P

Bushing Monitors

- BM201

Fiber Optic Temperature Monitor / Edge Devices

	Product	Description	Assets Monitored
	**T301 (GaAs & Fluro)**	Rugged monitor, local display, with a range of communication options for monitoring in Transformers, Cables, GIS, AIS, Rotating Machines, and Breakers	
	**O201 (GaAs & Fluro)**	Rugged, Compact Design, Expandable to 256 Channels, Daisy chain up to 32 units (with Modbus, Canbus) for monitoring in Transformers, Cables, GIS, AIS, Rotating Machines, and Breakers	
	**H201**	Rugged, Compact Design, Expandable to 256 Channels, Daisy chain up to 32 units (with Modbus, Canbus) for monitoring in Transformers, Cables, GIS, AIS, Rotating Machines, and Breakers	

Partial Discharge for OEM Monitor / Edge Devices

	Product	Description	Assets Monitored
	**PD201**	**Available channels 4/8** High Frequency Partial Discharge Monitor with Frequency response in the range of 0.01– 100 MHz with 4 or 8 HF PD Channels for monitoring in Transformers, Cables, GIS, AIS, Rotating Machines, and Breakers	
	**PD211**	**Available channels 4/8** Ultra-High Frequency Partial Discharge Monitor with Frequency response in the range of 200 - 3000 MHz with 4 or 8 UHF PD Channels for monitoring in Transformers, Cables, GIS, AIS, Rotating Machines, and Breakers	

Continuous Partial Discharge Monitor / Edge Devices

Product	Description	Assets Monitored
CPM601-C	**Available channels 8/12** High Frequency and Ultra-High Frequency Continuous Partial Discharge Monitor with Frequency response in the range of 0.01 – 100 MHz and 200 MHz - 3000 MHz with 4/8 HF and 4 UHF PD Channels for monitoring in Transformers, Cables, GIS, AIS, Rotating Machines, and Breakers	
HPM601-C	**Available channels 8/12** High Frequency Partial Discharge Continuous Monitor with Frequency response in the range of 0.01 – 100 MHz with 4/8/12 HF PD Channels for monitoring in Transformers, Cables, GIS, AIS, Rotating Machines, and Breakers	
UPM601-C	**Available channels 8/12** Ultra-High Frequency Partial Discharge Continuous Monitor with Frequency response in the range of 200 - 3000 MHz with 4 UHF PD Channels for monitoring in Transformers, Cables, GIS, AIS, Rotating Machines, and Breakers	

Portable Partial Discharge Monitor / Edge Devices

Product	Description
CPM601-P	**Available channels 8** High Frequency and Ultra-High Frequency Portable Partial Discharge Monitor with Frequency response in the range of 0.01 – 100 MHz and 200 MHz - 3000 MHz with 4 HF and 4 UHF PD Channels for monitoring in Transformers, Cables, GIS, AIS, Rotating Machines, and Breakers
HPM601-P	**Available channels 4/8** High Frequency Partial Discharge Portable Monitor with Frequency response in the range of 0.01 – 100 MHz with 4 or 8 HF PD Channels for monitoring in Transformers, Cables, GIS, AIS, Rotating Machines, and Breakers
UPM601-P	**Available channels 4** Ultra-High Frequency Partial Discharge Portable Monitor with Frequency response in the range of 200 – 3000 MHz with 4 UHF PD Channels for monitoring in Transformers, Cables, GIS, AIS, Rotating Machines, and Breakers

Bushing Monitor / Edge Devices

	Product	Description
 	**BM201**	**Available channels 3/6** Operating under high voltage substation environments with greater reliability BM201 measures Power Factor/Tan _ and Capacitance from the bushing test tap adaptors for monitoring in Transformers, Cables, GIS, AIS, Rotating Machines, and Breakers

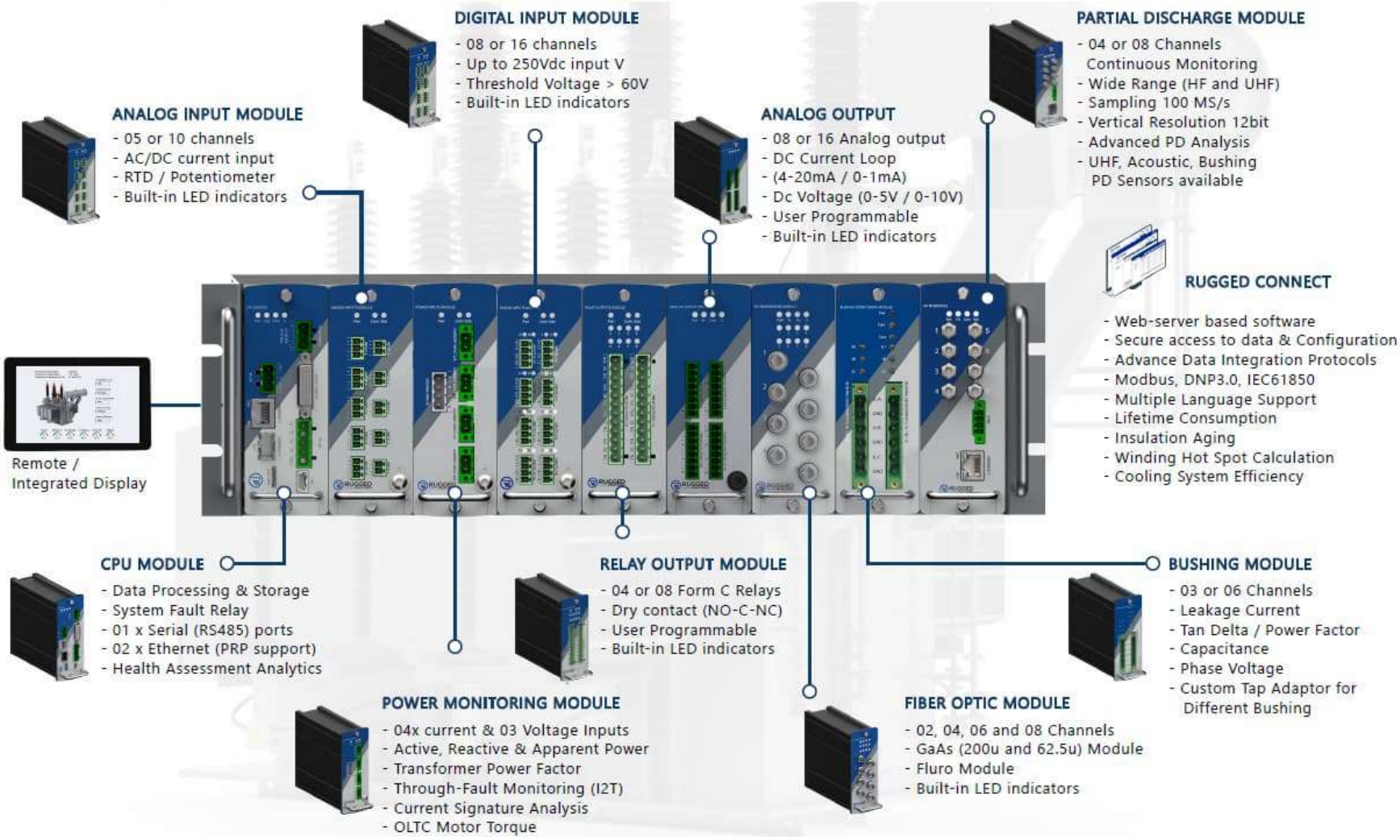
Continuous Monitoring Monitor / Edge Devices

	Product	Description
	**T301** **GaAs - 62.5µm**	**Available channels 2 to 24** 8 Configurable Analog / Digital Channels. 2 to 24 Fiber Optic Temperature channels for monitoring in Transformers, Cables, GIS, AIS, Rotating Machines, and Breakers
	**O201** **Fluro**	**Available channels 2 to 8** Rugged, Reliable and Accurate Fiber Optic Temperature Monitor compatible with fluorescence fiber optic sensors for monitoring in Transformers, Cables, GIS, AIS, Rotating Machines, and Breakers
	**O201** **GaAs - 62.5µm**	**Available channels 2 to 8** Rugged fiber optic temperature monitor for third-party sensors with GaAs 62.5 µm / 200 µm technologies for monitoring in Transformers, Cables, GIS, AIS, Rotating Machines, and Breakers

Condition Monitoring Monitor / Edge Devices

	Product	Description	Assets Monitored
	**T501**	**Available channels 4/8** 8 Configurable Analog / Digital Channels. 2 to 24 Fiber Optic Temperature channels for monitoring in Transformers, Cables, GIS, AIS, Rotating Machines, and Breakers	
	**T401**	**Available channels 8** 8 Configurable Analog/ Digital input Channels for monitoring in Transformers, Cables, GIS, AIS, Rotating Machines, and Breakers	

R501 Condition Monitoring Monitor / Edge Devices



DIGITAL INPUT MODULE
- 08 or 16 channels
- Up to 250Vdc input V
- Threshold Voltage > 60V
- Built-in LED indicators

ANALOG INPUT MODULE
- 05 or 10 channels
- AC/DC current input
- RTD / Potentiometer
- Built-in LED indicators

ANALOG OUTPUT
- 08 or 16 Analog output
- DC Current Loop
- (4-20mA / 0-1mA)
- Dc Voltage (0-5V / 0-10V)
- User Programmable
- Built-in LED indicators

PARTIAL DISCHARGE MODULE
- 04 or 08 Channels Continuous Monitoring
- Wide Range (HF and UHF)
- Sampling 100 MS/s
- Vertical Resolution 12bit
- Advanced PD Analysis
- UHF, Acoustic, Bushing PD Sensors available

Remote / Integrated Display

RUGGED CONNECT
- Web-server based software
- Secure access to data & Configuration
- Advance Data Integration Protocols
- Modbus, DNP3.0, IEC61850
- Multiple Language Support
- Lifetime Consumption
- Insulation Aging
- Winding Hot Spot Calculation
- Cooling System Efficiency

CPU MODULE
- Data Processing & Storage
- System Fault Relay
- 01 x Serial (RS485) ports
- 02 x Ethernet (PRP support)
- Health Assessment Analytics

RELAY OUTPUT MODULE
- 04 or 08 Form C Relays
- Dry contact (NO-C-NC)
- User Programmable
- Built-in LED indicators

BUSHING MODULE
- 03 or 06 Channels
- Leakage Current
- Tan Delta / Power Factor
- Capacitance
- Phase Voltage
- Custom Tap Adaptor for Different Bushing

POWER MONITORING MODULE
- 04x current & 03 Voltage Inputs
- Active, Reactive & Apparent Power
- Transformer Power Factor
- Through-Fault Monitoring (I2T)
- Current Signature Analysis
- OLTC Motor Torque

FIBER OPTIC MODULE
- 02, 04, 06 and 08 Channels
- GaAs (200u and 62.5u) Module
- Fluro Module
- Built-in LED indicators

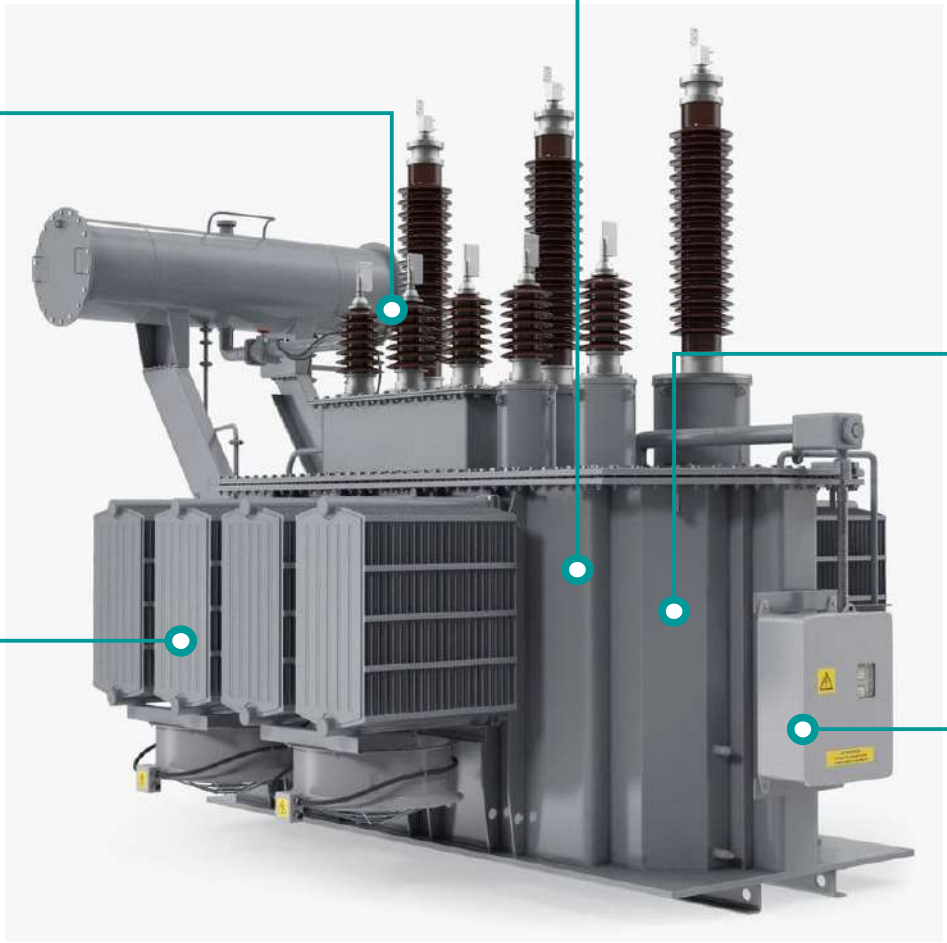
Transformer Condition Monitoring

HV/LV/MV Bushing

- Overheating
- Insulation Aging
- Bad Tap Contact
- Short Circuit in Capacitive Layers
- Moisture Ingress
- Partial Discharge

Cooling System

- Fan/Pump Failure
- Cooling Control Failure
- Pump / Fan Running in Reverse
- Radiator Blockages
- Reduced Efficiency
- Fan/Pump End of Life



Winding and Magnetic Circuit

- Winding / Core Overheating
- Excess Moisture in Insulation
- Generation of Bubbles
- PD in Winding Insulation
- Loose connection with Bushings
- Loss of Core Ground
- Unintentional Core Ground

Main Tank and Oil

- Excess Moisture in Oil
- Loose Connections
- PD in Oil Insulation
- Oil Level drops
- Sudden Rise in Tank Pressure
- Conservator Bladder Rupture

On Load Tap Changer (OLTC)

- OLTC End of Life
- OLTC Contact Coking
- OLTC Multiple Tap Movement
- OLTC Excess Arcing
- OLTC Motor Drive Issues
- OLTC Oil – Weak Insulation

Transformer Condition Monitoring – R501

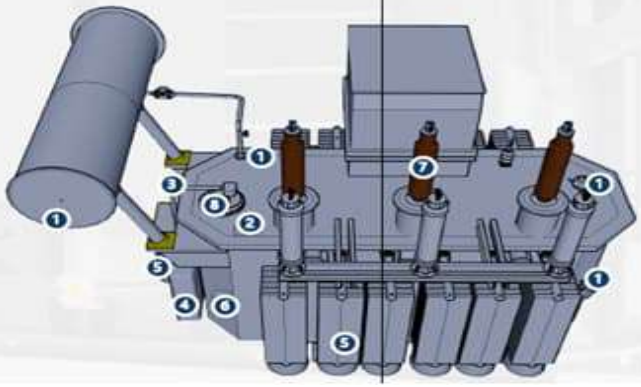
Hardwired (Analog/Digitals)

Fiber Optic Extensions

Hardwired (Analog/Digitals)

Serial (RS-485) or Ethernet (TCP/IP)
Modbus, DNP3.0, IEC60870-104, IEC61850

1. OTI,WTI, RTD, PRD, Breather, Buchholz Relay, LLG/OLI, Pressure Sensor etc.
2. Direct winding Hot Spot Monitor
3. Transformer Control Cubicle
4. OLTC and RTCC Panel
5. Cooling System and Control Cabinet
6. Dissolved Gas Analyzer
7. Bushing Monitoring
8. Partial Discharge Monitor



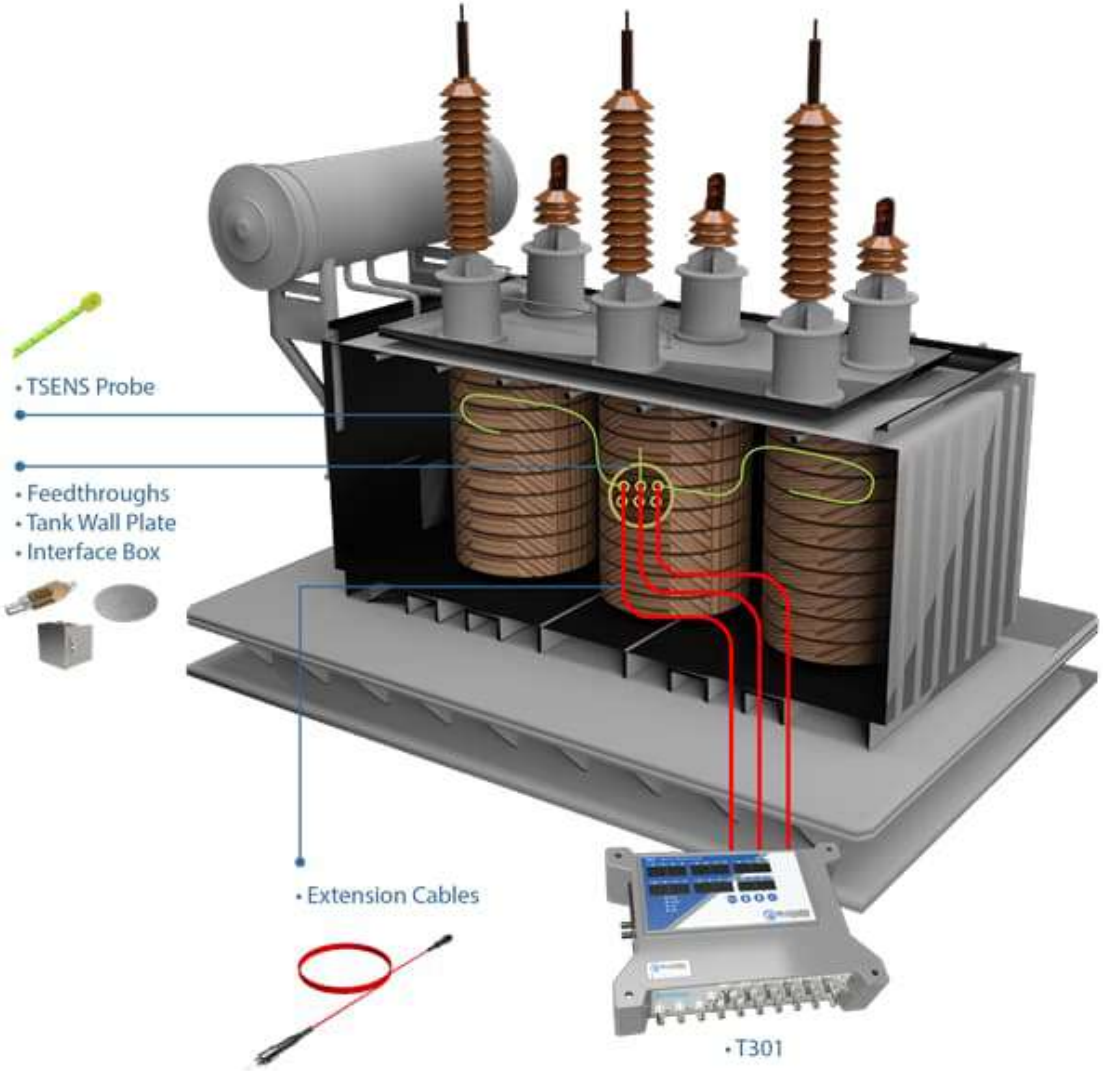
Certifications

- ATEX
- Lloyds
- CE / RoHs

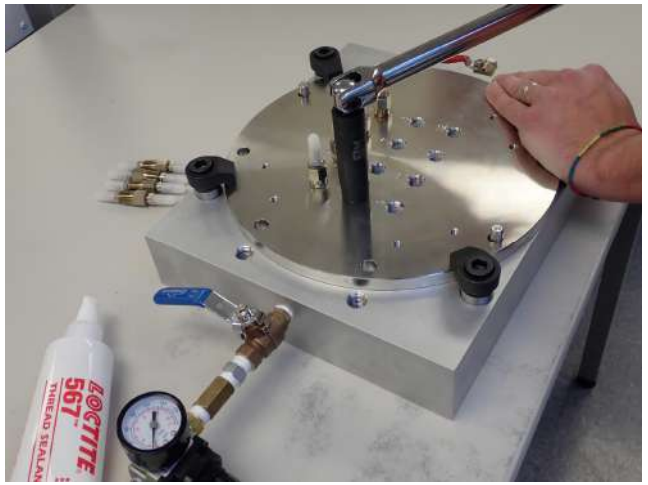
Variants

- Offshore / Marine
- Ethernet Redundancy: PRP
- Enterprise Monitoring Software

Transformer Condition Monitoring – FOTS



Fiber Optic Temperature Sensors installed on the Spacer



Transformer Tank Wall Plate & Feedthroughs

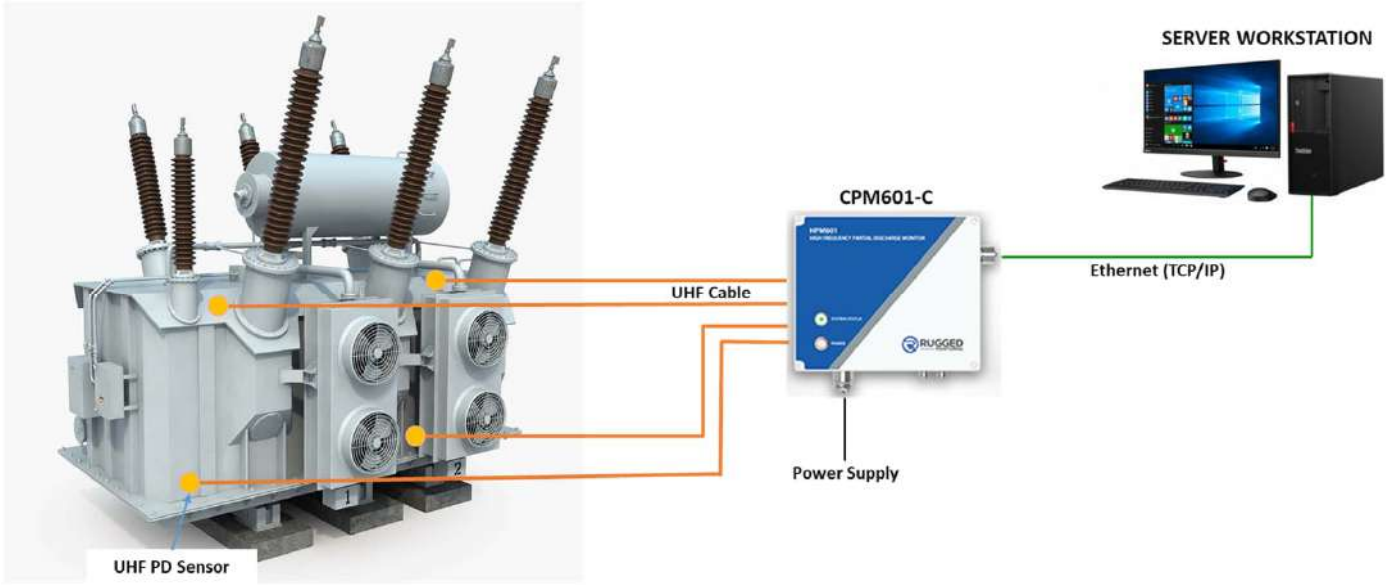
Transformer Bushing Monitoring System

1. Bushing Monitoring (BMT301)
    - System Voltage Range: to 1000kV (50 / 60Hz)
    - Standard 06 Bushing Solution (Extendable up to 12 bushings)
    - Leakage Current
    - Power Factor (Tan Delta)
    - Capacitance
2. Safer Bushing Adaptor Design
3. Support for Multiple bushing Monitoring Techniques
    - Sum of Current Method
    - Adjacent Phase Method
    - Comparison Method
    - VT Reference Method
4. Partial Discharge Monitoring
    - Solution available with Bushing Monitoring
    - PD Magnitude
    - PD Discharge Rate
    - Severity of Partial Discharge

Figure 11: Bushing Tap Adaptors

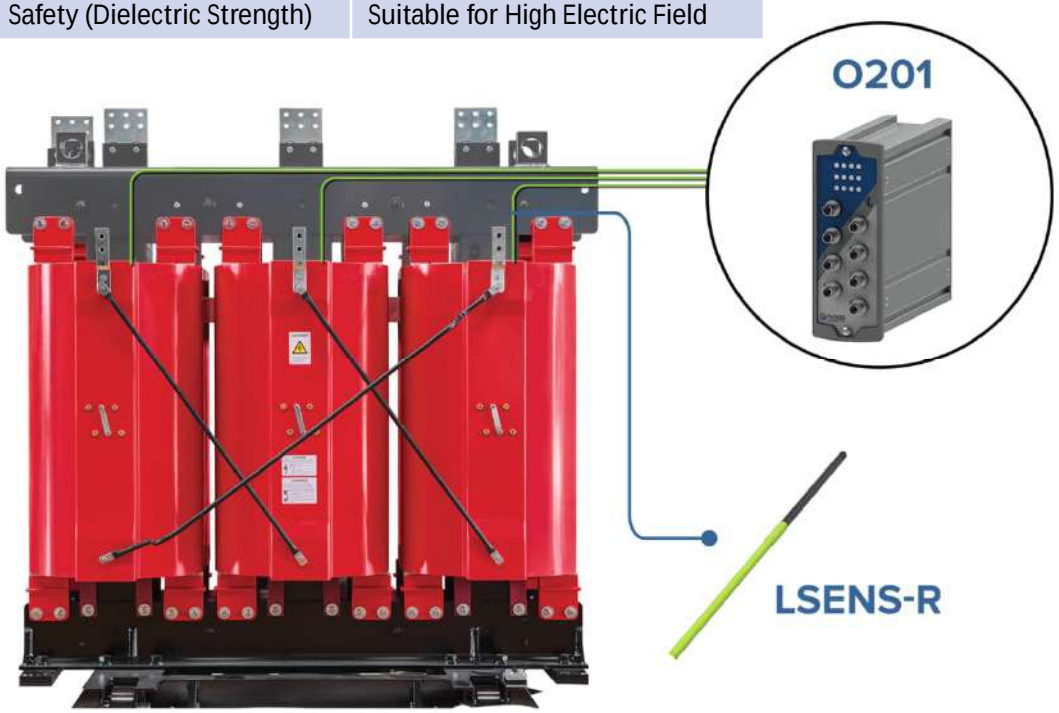
Transformer Partial Discharge Monitoring System

1. BMT601: Partial Discharge Monitoring via Bushing Adaptors/Sensors
   - Integrated with the Bushing Monitoring System
   - Cost Effective and Easy to Retrofit Solution
2. CPM601: Advance Partial Discharge Monitoring Using UHF Technology
   - Most accurate PD Monitoring with Fault Categorization and Localization flexibility
3. Key Features of PD Analysis:
   - Measures all attributes of Partial Discharge: Magnitude (Amplitude), and Discharge Rate
   - Flexibility for PD Severity Analysis



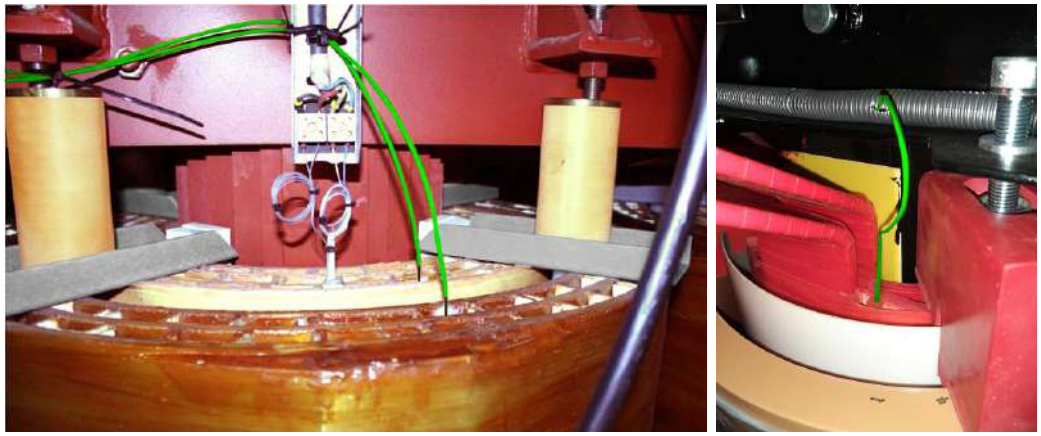
Dry Type Transformers – Winding Temperature Monitoring

FO Sensors/Monitors	Value/Comments
Accuracy	± 1°C
Temperature Range	-80°C to + 250°C
Sensor Size	0.5mm to 3mm
Response Time	200 ms
Safety (Dielectric Strength)	Suitable for High Electric Field



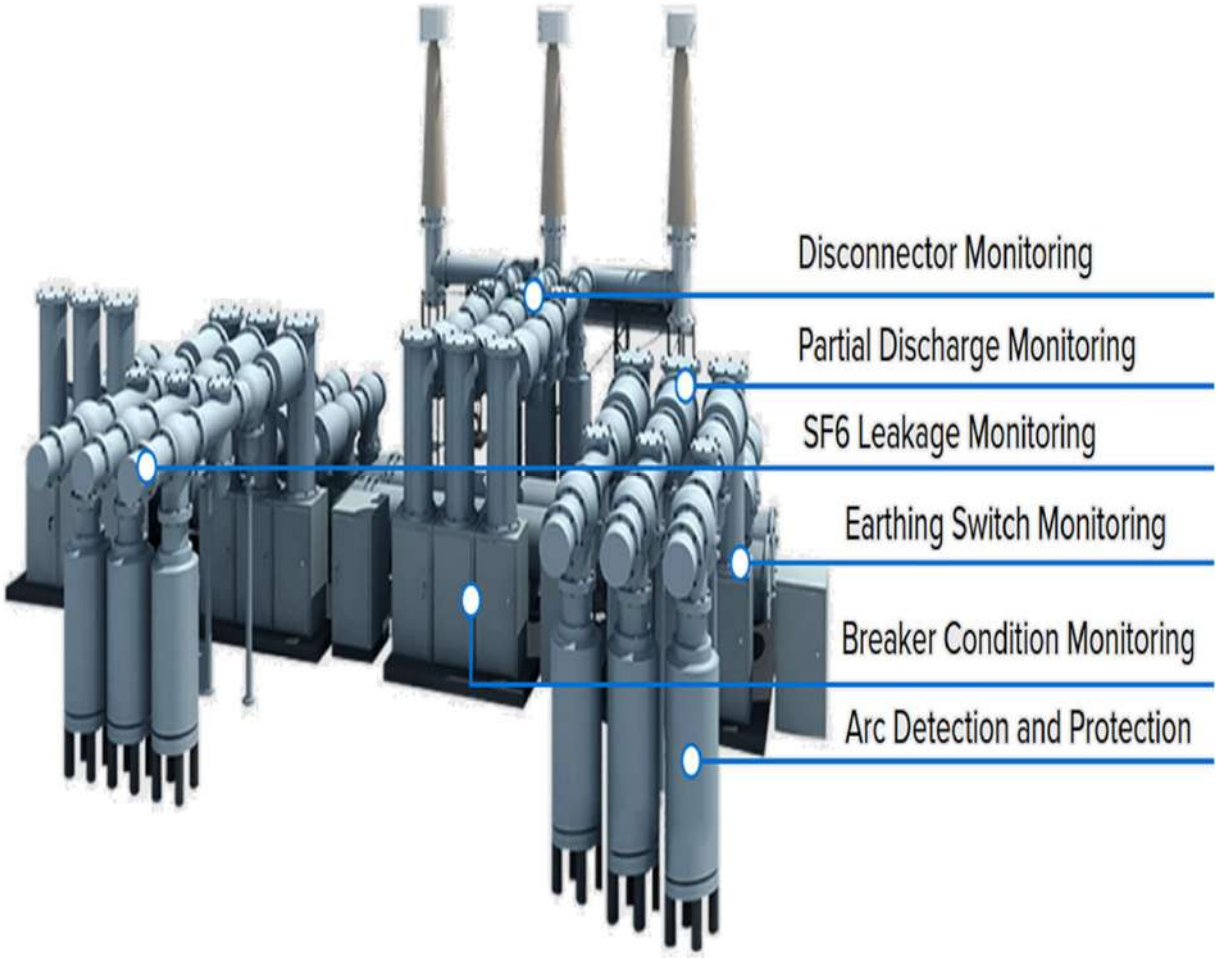
System Architecture: FO Sensors and Monitors

1. Most accurate hot spot measurement of all Windings and Core temperature
2. Maintenance Free; No Recalibration required
3. Portable PDM System for Partial Discharge Testing and Monitoring
   - IEC 60270 compliant PDM system
   - Suitable for connection with Capacitive Divider / Couplers
   - Advance Filtering and Noise Gating for accurate PD detection
4. Cost effective solution for PD testing in Transformer Factory
5. Most accurate solution for PD testing and monitoring on site.



Fiber Optic Sensors Installed into Dry Type Transformers

GIS Monitoring



Disconnector Monitoring
- Active Parts Temperatures
- Motors Condition
- Travel Curve and Speed during
- Opening and Closing
- Switches / Operating Drive Condition

Partial Discharge Monitoring
- PD Detection
- Fault Characterization
- PD Localization
- PD Severity Analysis
- PD Test and Measurement Services

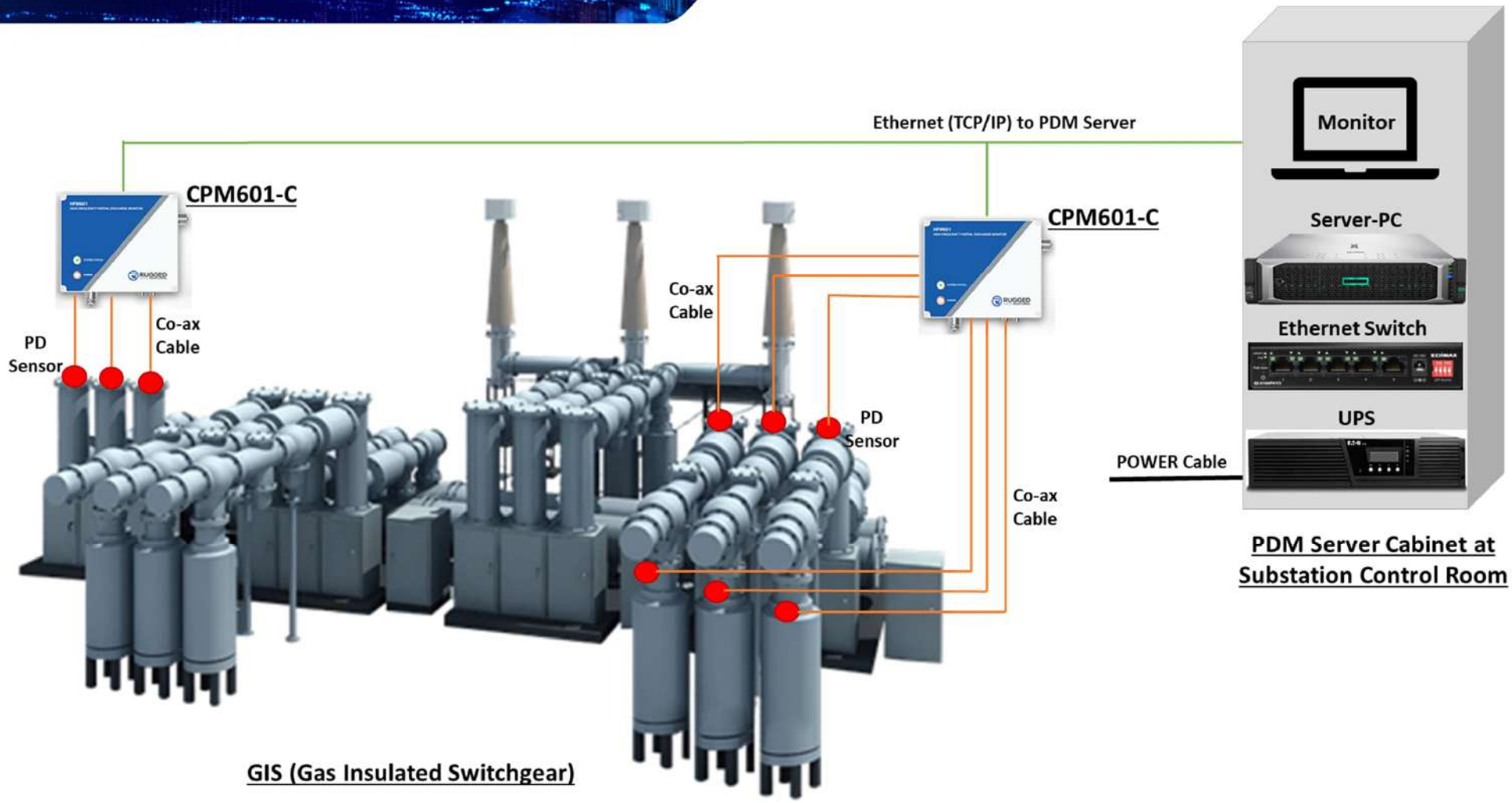
Earthing Switch Monitoring
- Switches / Operating Drive Condition
- Operating Mechanism
- Motor Condition
- Active Parts Temperatures

Breaker Condition Monitoring
- Operating Mechanism
- Temperature Monitoring
- Trip/Close Coil Condition
- Active Parts Temperatures
- Contact Erosion

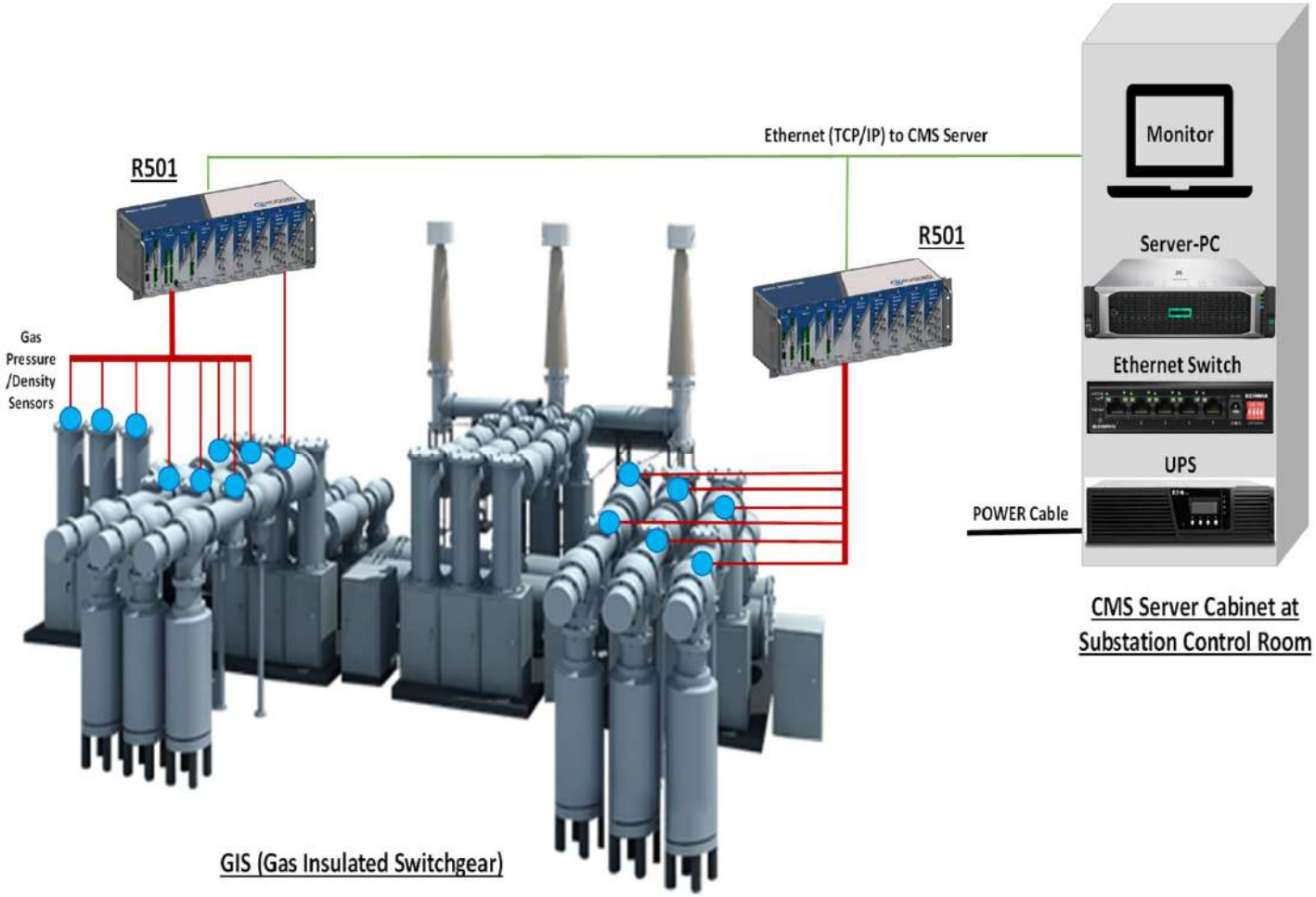
SF6 Leakage Monitoring
- SF6 Pressure / Density
- SF6 Leak Rate
- SF6 Time to Refill
- SF6 Time to Lockout
- Moisture / Dewpoint

Arc Detection and Protection
- Arc Detection
- Arc Localization
- HV Testing and Monitoring

GIS Partial Discharge Monitoring

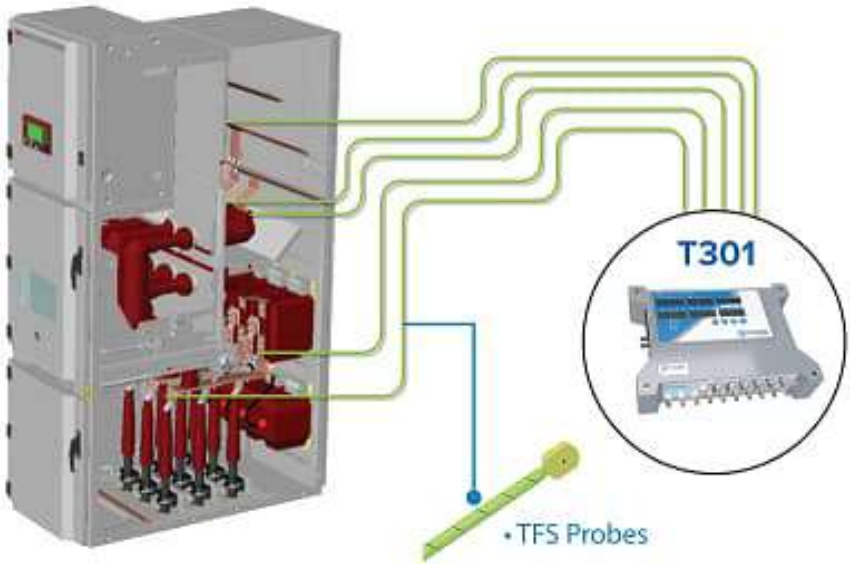


GIS SF6 Leakage Monitoring



- Gas Pressure / Density Sensors
  - Our solution is compatible with all Pressure, Density and Humidity sensors available in the Market
  - The sensors must have 4-20mA or Modbus (RS-485) output
- Data Acquisition System: R501 Monitor
  - Multichannel datalogger for various kinds of Analog and Digital signals
  - Expandable to 256 channels
  - Also capable to monitor Current, Voltage for GIS condition monitoring
  - Flexible to integrate Fiber Optic Temperature sensors for cable termination temperature monitoring
- SF6 Leakage Monitoring Software: Advance Analytics with
  - Predicting Time to Refill, Time to Lock out, Refill quantity
  - Advance notification tools for maintenance scheduling

AIS Monitoring



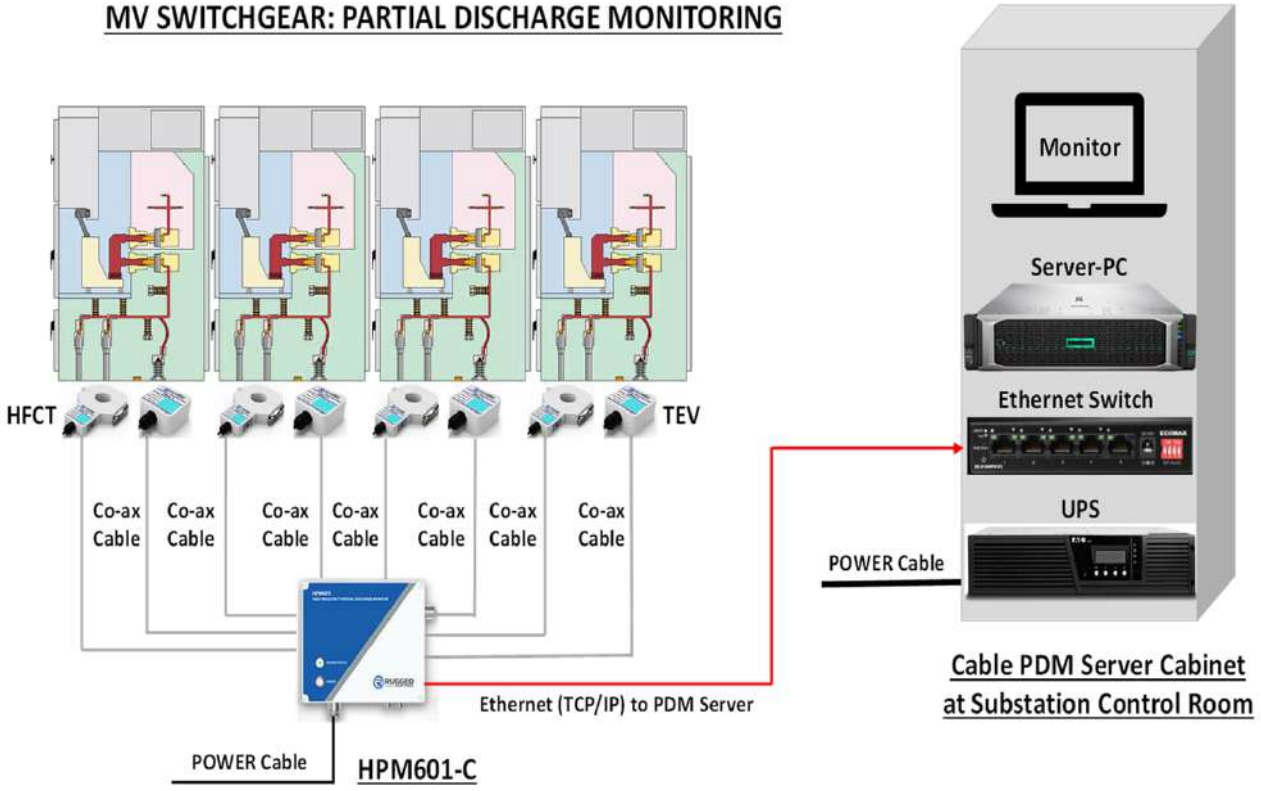
Why Fiber Optic Temperature Sensors in MVS

1. IEEE C37.20.3 Standard prohibits use of traditional sensors
   - Switchgear rated with a maximum voltage of 15 kV must have an impulse voltage of 95 kV, relating to a distance (in air) of approximately 160 mm
   - This requirement eliminates the most common types of direct contact temperature-monitoring systems, such as thermocouples and RTDs

2. Thermal Monitoring
   - Thermal Profiling
   - Hot Spot Identification
   - Hot Spot Localization

3. Fiber Optic Temperature Sensors have proved to be the best Hot Spot Monitoring Solution for Switchgears
   - Fiber Optic Sensors are immune to high electric field
   - Smaller size allows theme to be installed at difficult places on busbar
   - Higher Accuracy and Repeatability
   - Wider Temperature Measurement Range

AIS PD Monitoring

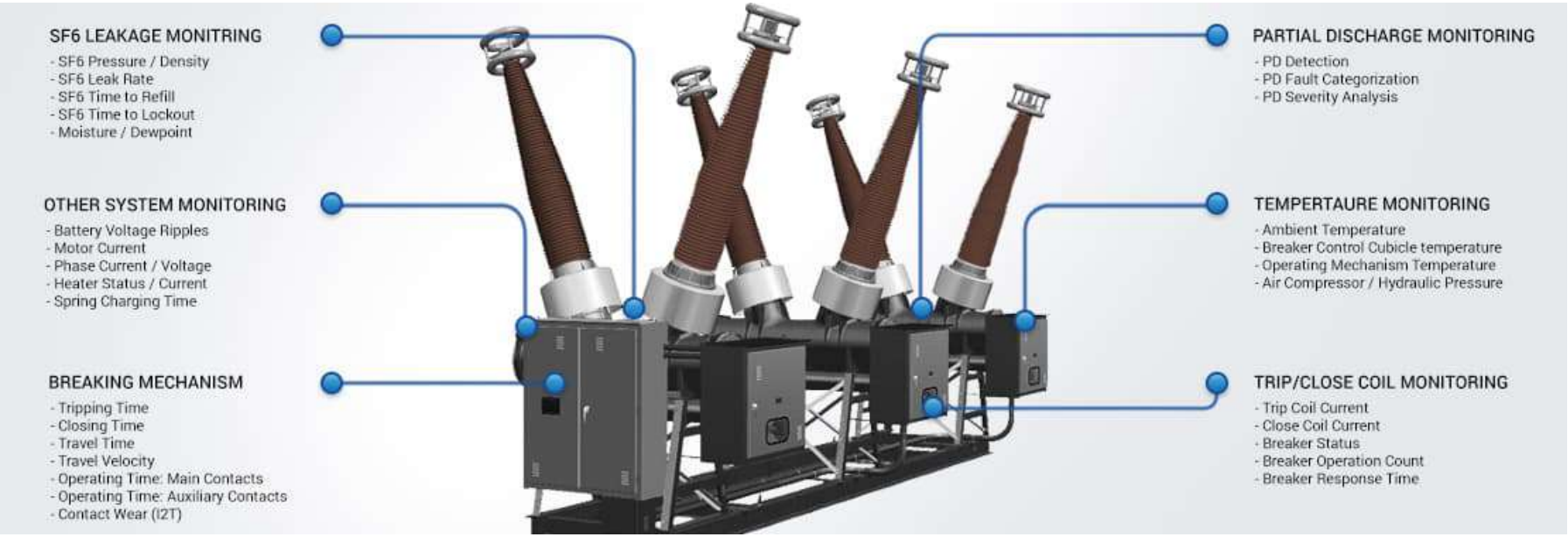


Permanent and Portable PDM System

- HFTC based sensors for Cable Terminations at Switchgear
- TEV based sensor for Surface discharge inside MV Switchgear Panels
- Customized solutions available as per customer requirements
- PD Monitoring
  - PD Detection
  - PD Localization
  - PD Severity Analysis
  - PD Test & Measurement Service
- Key Features
  - Highly accurate Monitoring of PD activity
  - Cost Effective solution of MV Switchgear Panels
  - Support for multiple technologies (HF, Capacitive Couplers, UHF etc.)
  - PD Expert Reporting Service

Breaker Condition Monitoring

- Continuous Online Monitoring of Circuit Breakers
  - IPOB (Independent Pole Operating Breaker) and GOB (Ganged Operated Breaker)
  - Live and Dead Tank Breakers (DTB)
  - EHV (Extra High Voltage), HV (High Voltage), MV (Medium Voltage) Circuit Breakers



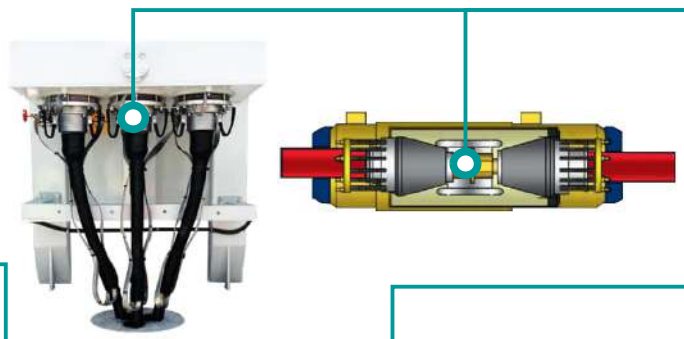
Power Cable: Failure Mode Analysis

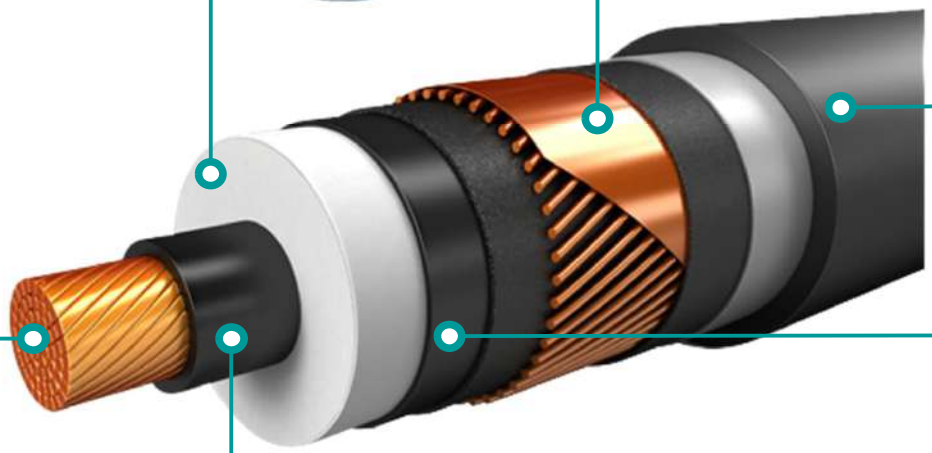
Terminations / Joints

- Overheating
- Discolored / Burnt Conductor
- Discolored / Burnt Insulator
- Bad Connector Crimps
- Cross Threading of the Elbow Probe
- Broken Stud in Bushing Well

Insulation

- Water Treeing
- Void and Contaminants
- Protrusions from the Shields
- Cracking of embrittled insulation
- Aging / Overall Degradation





Metallic Shield / Neutral

- Damaged Shield
- Overheating

Jacket / Sheath

- Cracks on the Sheath

Conductors

- Very little can go wrong with a properly designed conductor
- Corrosion in some unusual cases
- Delamination on Conductor

Insulation Shield (Semicon)

- Small air pockets
- Loose bonding with Insulation
- Discolored Metal
- Protrusions on the semicon
- Burning / Arcing

Conductor Shield (Semicon)

- Overheating
- Protrusions on the semicon
- Burning / Arcing

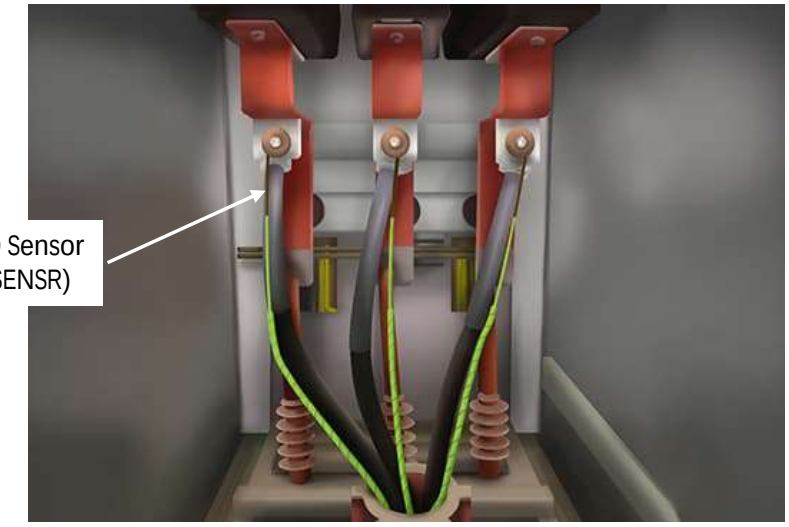
Power Cable: Termination / Junction Temperature Monitoring

Fiber Optic Based temperature Monitoring

1. Easy to install temperature Sensor for retrofit applications
2. Sensor installation suitable for all kinds of Cable (MV and HV) and Termination / Joint types
3. Highly dielectric Sensor – Do not need any isolation at high Voltage
4. Most accurate sensor for Cable Terminations – No Need for Compensation
5. Real time temperature monitoring to detect incipient faults

Fiber Optic Temperature Sensor

Temperature Monitor
O201



FO Temperature Sensors installed at Cable Termination

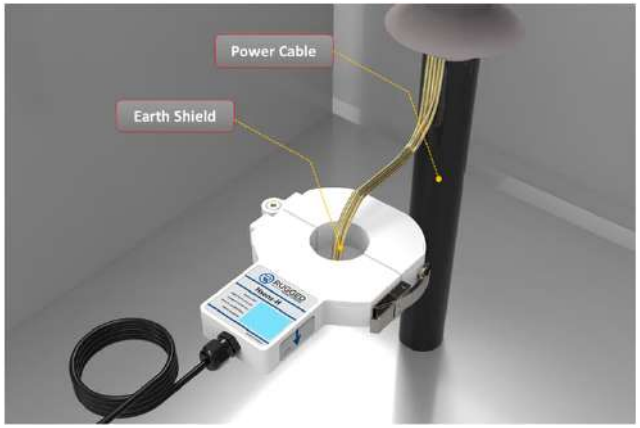
Power Cable: Partial Discharge Monitoring

High Frequency Partial Discharge Monitoring Systems

1. Portable System for periodic testing and measurement
2. Continuous Online Monitoring system for critical assets
3. Enterprise Software for multiple assets
4. Expert Reporting Service for customers

Cable PD Portable (HPM601)

Cable PD Continuous Online Monitor (HPM601)



Cable PD Sensors (HFCT)

Cable PD Sensors (TEV)

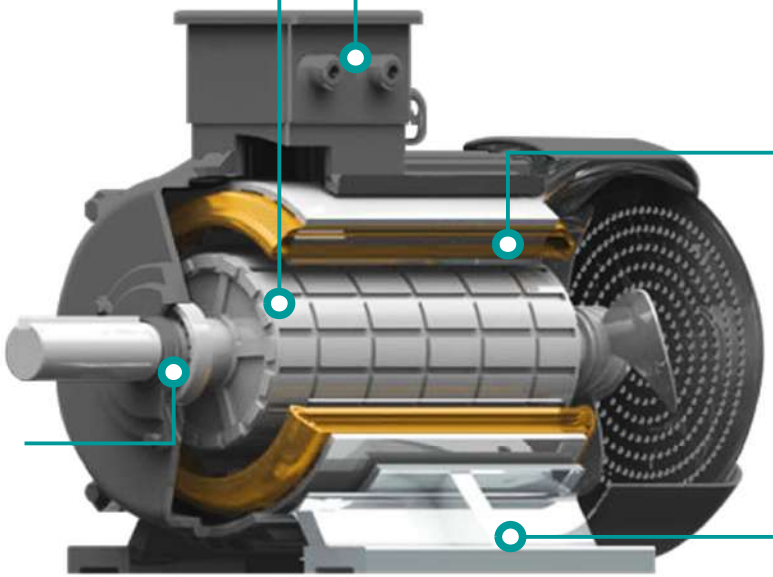
Rotating Machines Failure Modes

Rotor (Core and Windings)

- Inter Turn Fault / Short
- Ground Fault / Short
- Open turn and loss of excitation/trip
- H2 Cooling System Failure
- H2 Leak into air environment
- Rotor Surface Overheating
- Overheating Core (Core Melting)
- Insulation Erosion / Burning

Termination Box / Electrical Connections

- Connector Insulation Failure
- Connector: Mechanical Failure
- Bushing: Insulation Failure
- Bushing: Mechanical Failure



Stator (Core and Windings)

- Phase to Phase / Phase to Ground Fault
- Insulation abrasion, ground wall damage, ground fault
- Loss of phase or parallel
- Loosening of End Windings
- Insulation Erosion / Shorted Turns
- Damage to Grading Coating
- Broken Bars
- Excessive Moisture
- Scarf Joint Mechanically Opened

Shaft and Bearings

- Loss of Lubrication, Grease or Oil
- Mechanical Failure of Bearing
- Mechanical unbalance of Shaft
- Excessive Wear
- Electrically proved failure of Bearing Element
- Normal Aging of Bearing and Shaft

Frame / Enclosure

- Failure of Heat Exchanger Pipework
- Failure of Heat Exchanger Tubes
- Failure of Fans

Motor Condition Monitoring – R501

Hardwired (Analog/Digital)

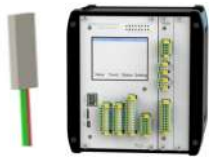
FO Cable

Serial (RS-485) of Ethernet (TCP/IP)
Modbus, DNP3.0, IEC60870-104, IEC61850

Other Sensors on the Motors

Fiber Optic Temp. Sensors

Vibration / EW-Vibration Monitor

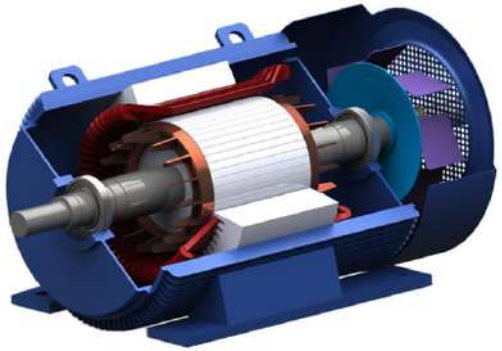


Airgap & Rotor Flux Monitor

Current Signature Analyzer

Partial Discharge Monitor

1. Alignment Sensors
2. Torque Sensors
3. Temperature Sensors
4. Viscosity Sensors
5. Noise Sensors
6. Motor Current and Voltage Sensors



Partial Discharge Monitoring

Permanent and Portable PDM System

1. Capacitive Coupler based sensors for Motor Terminal / junction Box
2. Customized solutions available as per customer requirements
3. PD Test and Measurement Service
4. Key Features
    - Highly accurate Monitoring of PD activity
    - Cost Effective solution of Motor and Generator PD Monitoring
    - Support for multiple technologies (HF, Capacitive Couplers, UHF etc.)
    - PD Expert Reporting Service

Capacitive Couplers

PD Test Kit for Motors / Generators

ESS / Battery Monitoring

Battery Monitoring and Management

1. A monitoring system will typically display the battery status, and record any changes to resistance, temperature or voltage
2. Battery Level Monitoring Module (Battery Sensor)
    - Measurements include Conductance, Voltage, Temperature, and Strap Resistance (intercell integrity) for each mono-block/cell /jar
    - Captures discharge voltage and temperature during load test or power outage
3. String Level Monitoring Module
    - Measurements include voltage, current, ripple current, and ambient temperature (2 pilot points)
    - Captures string level discharge current and voltage when batteries are under load
4. Fire Code Compliance at the Cabinet Level
    - Control Fire induced by Thermal Runway in Corrosive Environment