HITACHI Inspire the Next





Condition monitoring for high-voltage switchgear

Modular Switchgear Monitoring

Hitachi Energy



Hitachi Energy is a pioneering technology leader

Our leading power and digital technologies, advanced automation systems and open digital platforms transform our customers' businesses and deliver significant operational and business value. We contribute pioneering solutions that make the world's power grids stronger, smarter and greener.

Our High-voltage products portfolio

We offer a wide range of high-voltage products up to 1200 kilovolts AC and 1100 kilovolts DC that help enhance the reliability, efficiency and quality of power in transmission and distribution grids, power plants and industries while minimizing environmental impact. The wide product range is complemented by a comprehensive service offering.

Need for a monitoring system Enabling a smarter and reliable grid

Failure of a high-voltage switchgear can have a massive impact on the power value chain. It can impact grid availability and reliability, as well as costs and resources.

Circuit breakers are a critical component in substations. To ensure their proper operation when needed, most breakers are regularly inspected, eventually requiring shutdown. Often this comes with significant effort for traveling and on-site activities with limited value addition. At site, a single "condition image" is typically recorded at the time of the visit. However, more than one site visit is needed in order to avoid biases on this "condition image" due to factors such as measurement conditions, tools and methods. With continuous monitoring application, these factors remain constant, varying conditions cancel out and long-term trends are revealed.

Ultimately, this allows to avoid unplanned outages and gives time to plan meaningful site visits ahead.

What affects the reliability of high-voltage switchgear?

Wear and ageing are top reasons for breaker's failure

RELIABILITY

- Age/ number of operations
- Type of enclosure
- Application mode
- Environmental conditions

IMPACT OF FAILURE

- Significant costs
- Safety hazards and adverse environmental impact
- Unplanned downtime

Where do breaker failures occur?

Final Report of the 2004 - 2007 international enquiry on reliability of high-voltage equipment, report 507 (2012)



With continuous monitoring there is no need to regularly inspect or open a breaker for exploratory inspection or maintenance. Information is streamlined throughout and work procedures become predictive rather than reactive. The overall result is lowered maintenance costs with a smarter and more reliable power grid.



Modular Switchgear Monitoring Scalable and versatile solution for all types of switchgear applications

Modular Switchgear Monitoring (MSM) is used to supervise, manage and analyze the performance of all type of high-voltage switchgear in new installations as well as retrofit solutions in existing high-voltage assets. The system operates independently of existing control and protection devices and can be installed in new substations or retrofitted in existing installations. By continuously monitoring critical parameters, MSM provides the base layer for a predictive maintenance strategy for the installation.

Based on the monitoring application, MSM is offered in 2 versions with additional options

- MSM-I is designed for SF₆ and gas monitoring allowing early detection and prevention of critical gas leakages in high-voltage switchgears, enabling to reduce gas emissions
- MSM-II enables circuit breaker monitoring in addition to gas monitoring, for improved operational reliability and performance of the circuit breakers
- MSM system is also available with options that enable humidity monitoring, internal arc localization, heater monitoring and disconnector and earthing switch monitoring
- MSM is designed to be compatible with the new EconiQ[™] solutions

MSM-I - Gas monitoring application

Highly stable SF₆ and gas density sensors are used to continuously monitor the integrity of the gas compartments and identify gas losses at an early stage. Advanced algorithms correct measured data for daily and seasonal variation and provide the leakage rate as well as the estimated time until counter measures are taken. Thus, gas losses which may become critical can be handled in a planned manner. In addition, the monitoring data provides a basis for SF₆ and gas balancing, and strategies to

reduce SF_6 emissions by leakage repair. Starting from one gas compartment, the system can be seamlessly scaled up to monitor several hundred gas compartments in large GIS installations.

- SF₆ and gas leakages make up 40–50% of "minor failure frequency" and up to 90% of GIS maintenance
- Early detection of SF₆ and gas leakages helps minimize emissions
- Have more time to prepare counter measures
- Get a detailed overview of banked gas in the equipment and simplify preparation of gas balance sheets
- · Reduce inspection work and maintenance cost



Web server view of SF_e monitoring application

MSM-II Gas monitoring and circuit breaker monitoring application

Non-invasive hall sensors and signals from auxiliary switches are used to monitor key parameters of the circuit breaker. Measured signals include phase current during operation, trip and close coil current, and motor current. Monitored parameters are categorized in mechanical performance, wear, as well as accessories. Measured curves are stored as comtrade files on the system, allowing further analysis. All features of MSM-I are included in this application as well.

MSM-II provides:

- Record of parameters regarding circuit breaker operations (timing, speed and travel curve) that identify any performance deterioration
- Coil Current Analysis informative feature to indicate health status of the operating mechanism and its operating condition

- Phase Current Monitoring informative feature to record current waveform during circuit breaker operation
- Fault Operation Counter informative feature to indicate the ageing of the circuit breaker
- Contact wear calculation computes contact erosion of circuit breaker and helps the user to plan the maintenance incase of excessive wear and tear of the interrupter
- Record motor/ pump runtime to identify wear and friction in the energy charging system of the operating mechanism
- Record of number of unforced motor/ pump starts symptom of leakages in hydraulic system of the operating mechanism
- Motor current curve and peak monitoring to identify damaged spring charging motor of the operating mechanism



Web server view of circuit breaker monitoring application

MSM – Options

Humidity Monitoring

High levels of humidity in SF₆ impact its dielectric withstand (the condensation of water on the surface of insulators will lead to significant reduction of dielectric strength and flashover) and on the formation of corrosive and toxic decomposition products. It is important to control humidity during initial manufacture, assemble, commissioning and over the lifetime of the equipment. Continuous humidity monitoring is provided as an option, applicable to both MSM-I and MSM-II

MSM provides:

- Humidity monitoring for each connected gas compartment
- · Alarms and warnings notification according to thresholds defined as per IEC 60480-2019, IEC 60376-2018 and GB/T 8905-2021
- Dew point visualization
- Up to 90 gas compartments connection per stack



Web interface view of ${\rm SF}_{\rm 6}$ humidity monitoring application

Heater Monitoring

Correct heater operation in drives, cubicles, etc. is crucial for reliable operation of circuit breakers. Monitoring of heaters is provided as an option, applicable to MSM-II.

MSM provides:

- Continuously operated heater monitoring
- Temperature-controlled heater monitoring



Disconnector and earthing switch monitoring

Disconnector and earthing switches are critical live components of HV switchgears. Disconnector monitoring is provided as an option, applicable to MSM-II.

MSM provides:

- Motor start counter monitoring
- Operation type/ positions monitoring
- Motor (RMS) current monitoring
- Motor runtime monitoring
- Alarms and warnings notification according to thresholds and misbehaviors during operations

DemoStation	-10	-14		You are here: DemoStation > Q0
A GO1	0	Gas Compartme	nt BD1_L1	
BD0 L3		SF ₆ pressure/density	Disconnector	
BD1_L2		Disconenctor1		
BD2_L2		Total starts L1	9	
BD3_L1		Total starts L2	6	
BD3_L3		Operations Curves		
BD4_L2		Motor RMS current L1	3 A	Operation List
BD5_L1		State L1	s1	2021-08-13 / 09:01:17 😑
BD5_L3				2021-08-13 / 09:01:11
Heater1_L1				2021-08-13 / 08:51:47 😑

Internal Arc Localization

Detect an internal fault arc and localize the gas compartment where it occurs is important since the event has a possible impact on gas dielectric withstand.

MSM allows to reduce the effort to determine the fault location by gas pressure analysis, automatically identifying the gas compartment where an arc occurs.

Internal arc localization is provided as an option, applicable to both MSM-I and MSM-II

MSM provides:

- Warning/notification when internal arc occurs
- Information about the affected gas compartment
- Information logging for active GC, and alarm logging for passive GC





Web interface view of internal arc detected in an active compartment (with switching components)



Web interface view of internal arc detected in a passive compartment (e.g. CT, VT, GIB)

🔺 🔴 TestKit1	-94	W You are here: Event List				
- Q01 - Q02 - Q03 - Event List	00	* Event Status	Ф Туре	Location	Parameter	© Date
Service Service System Info		Event Status	Туре	Location	Parameter	Date
		Alarm	Gas Compartment	TestKit1_Q01_B02	Arc Detected	2022-06-23 / 12:22:01
A C Equipment		Alarm	Gas Compartment	TestKit1_Q01_B05	Arc Detected	2022-06-23 / 12:22:01
A CCM1		Alarm	Ga Compartment	TestKit1_Q01_B04	Arc Detected	2022-06-23 / 12:22:01
Configuration		Alarm	Gas Compartment	TestKit1_Q01_B03	Arc Detected	2022-06-23 / 12:22:01
L System Log		 Information Showing 1 to 5 of 5 entries 	Gas Compartment	TestKit1_Q01_B01	Arc Detected	2022-06-23 / 12:22:00

Event list provided by web interface showing detected internal arcs

Travel Curve Monitoring with measured travel curve

Mechanical performance of switchgear depends on the travel characteristic of the closing and open operations

MSM-II can simulate travel curve but if accurate travel curve measure is needed, the travel curve monitoring option can be installed.

MSM provides:

- Travel curve
- Opening time/ closing time
- Close velocity/ open velocity
- Total travel
- Alarms and warnings notifications according to thresholds and misbehaviors during operations









Features that support wide range of switchgear application

Features

- Scalable and versatile: applicable to all High Voltage switchgears, new installations and retrofits, OEM as well as third-party
- Focused on maintenance optimization:
 - Separated from control & protection
 - Gas monitoring including gas leakages, pressure forecasting features and ${\rm SF_6}$ humidity
 - Internal arc localization
 - Circuit-breaker monitoring
 - Disconnector monitoring
 - Accessories monitoring

• Easy system integration:

- DNP3 and IEC 61850 (TCP/ IP) communication
- Dry contacts for alarm and self supervision
- Remote connectivity enabling fleet supervision and expert services
- Easy system interaction:
 - Local Display: key information direct at bay
 - Web-Interface via embedded webserver



Benefits

Improved reliability with reduction in unplanned downtime saving losses



Optimized predictive and proactive maintenance by early warnings



Provides adequate time for maintenance planning with less chances of failure



Greater diagnostic capability in case of failure through the recorded data, reducing time to repair



Reduction of operational costs for inspection, maintenance and repair by at least 50%



Improved environmental/ regulatory compliance with reduced $SF_{_{\rm B}}$ leakages

Category	Parameter	MSM-I	MSM-II	Options
Dielectric	Gas pressure/ temperature	SF ₆ or Gas mixtures	SF_6 or Gas mixtures	-
	Gas leak rate	${\rm SF}_{\rm _6}$ or Gas mixtures	$\mathrm{SF}_{_{6}}$ or Gas mixtures	-
	SF ₆ moisture	-	-	For MSM-I/ -II
	Internal arc localization			For MSM-I/-II
Mechanical	Travel curve	-	Calc.	Measured for MSM-II
	Mechanism timing	-	•	-
	Contact Speed	-	•	-
Wear	Coil current analysis	-	•	-
	Operations counter	-	•	-
	Contact Wear	-	•	-
Accessories	Heater operation	-	-	For MSM-II
	Motor/ pump run-time	-	•	-
	Motor/ pump (unforced) starts	-	•	-
	Motor current (curve/ peak)	-	•	-
	DS / ES / DES * monitoring	-	-	For MSM-II
Interface	Webserver	•	•	-
	IEC61850/ DNP3 interface	•	•	-
	Device self-supervision	•	•	-

* DS = Disconnector Switch; ES = Earthing Switch; DES = Combined Disconnector and Earthing Switch



Key attributes

MSM system platform

The MSM system consists of a central control and communication module, as well as signal input modules for analog current (0-20 mA), voltage (+/- 5V), modbus and binary voltage signals. All modules comply with relevant standards for high-voltage substation electronic equipment, in particular the product is compliant to IEC 60255-26 and IEC 60255-27 for EMC and safety and is also compliant with more generic substation standard,IEC 61000-6-5.

Modules are mounted on a DIN-rail. The system can be fitted to single-pole and gang operated breakers

Modular Switchgear Monitoring (MSM) modules



CCM (Control and Communication Module)



AIM (Analog Input Module)



(Serial Interface Module)



BIM (Binary Input Module)



FAIM (Fast Analog Input Module)

Data visualization

Users can connect with the MSM system using a standard web browser. Through the embedded web interface, all monitored data are accessible. Starting from a substation view with a straightforward display of the overall condition, additional visualization layers provide more detailed information and, in case of an alarm, allow a first analysis of potential root causes. For more advanced analysis, data can be downloaded.

The web interface comes with additional features, such as alarm management, system logbook, user management and firmware updates. It is available in several languages. From the web interface, user could access the monitoring data for the latest 100 operations of circuit breaker, and the MSM system has a storage capacity for up to 10,000 operations of circuit breaker.

Features

- Entire substation overview
- Easy navigation via tree-view
- Gas data: overall status, pressure, leaking rate, time to stage, actual value and history charts, humidity
- Drive and circuit-breaker monitoring data: overall status, counters and operation related data
- Disconnect and earthing switch monitoring data: overall status, operation counter ad related data
- Heater status
- Alarm and event log
- Data download per gas compartment, bay or substation
- System Log: System, warning, and alarm history are logged

testProject w b E01 O	Sensor status error: CCM11	You are here: TestPhote: ESI > 8201_L*	
TestProject Construction Co		Vis we here: TestPhysic > ESI > EBILis 11 meter 3 3 4 5 5 5 5 5 5 5 5 5 5 5 5 5	Tree view navigation with: • System/ Bay/ Gas compartment or CB level • Alarm list • User management • Services and system features





Example of data history visualization - SF6 leakage. Chart data can be downloaded for subsequent analysis

Download chart data (for gas compartment 'Station_E01_B200_L1')

System integration

To make full use of the MSM system, an integration in an Asset Management System is recommended. For this purpose, the system comes with IEC 61850 edition 1 and 2 and DNP 3.0 communication interfaces. In addition, for on-site integration in SCADA, the system has two dry binary outputs. These are triggered in case of a warning or alarm on the monitored asset and in case the internal watchdog, which supervises the MSM system itself, identifies an issue.

Embedded Webserver

Visualization interfaces



Switchgear

Technical specifications

Parameter		Specification
MSM system	Number of modules per MSM Stack (SF ₆ monitoring)	Up to 10
	Operating temperature LCD (clearly legible)	-20°C +60°C
	Protection class	IP 20
	Input voltage range of power supply	85277 V _{AC} 80370 V _{DC}
	Nominal supply voltage	24 VDC
	Isolation voltage	max. 2 kV _{AC}
	Operating temperature	- 40°C up to 70°C
	Device status indication	LED
Control and Communication	Dimensions W/ H/ D	79 × 99 × 113 mm
Module (CCM)	Nominal supply voltage	24 VDC
	Module power consumption	< 6 W
	Isolation voltage	max. 2 kV _{AC}
	Communication Ethernet interface	RJ45, 10/100 Mbit/s
	Communication protocols	IEC 61850 (MMS), DNP3.0, SNTP, SFTP, HTTP
	Supervision, Binary Output 1	Alarm/ Warning signal
	Supervision, Binary Output 2	Watchdog
Analog Input Module (AIM)	Dimensions W/ H/ D	56 × 99 × 113 mm
	Module power consumption	< 3 W
	Integrated power supply for sensors	12 V _{DC} , 200 mA
	Isolation voltage	max. 2 kV _{AC}
	Analog Inputs (configurable)	8 channels 020 mA
	Accuracy	± 1% full scale
Binary Input Module (BIM)	Dimensions W/ H/ D	56 × 99 × 113 mm
	Binary inputs (configurable)	6 channels 24 up to 250 $V_{_{\rm DC}}\!/$ 48 up to 230 $V_{_{\rm AC}}$
	Product safety	IEC 60255-27
	Electromagnetic compatibility	IEC 60255-26, Zone A
	Operating temperature	- 40°C up to +70°C
	Isolation voltage	max. 2 kV _{AC}
	Isolation resistance	100 MΩ
Serial Interface Module (SIM)	Dimensions W/ H/ D	34 × 99 × 113 mm
	Module power consumption	< 3 W
	Isolation voltage	2kV _{AG}
	Interface	EIA-485
	Bus protocol	Modbus
Fast Analog Input Module	Dimensions W/ H/ D	56 × 99 × 113 mm
(FAIM)	Analog inputs	4x ±5 V/ 0-20 mA
	Power outputs	24 V _{DC} , ±15 V _{DC} , ±5 V _{DC}
	Product safety	IEC 60255-27
	Electromagnetic compatibility	IEC 60255-26, Zone A
	Operating temperature	- 40°C up to + 70°C
	Isolation voltage	max. 2 kV
	Isolation resistance	100 MΩ

Successful installations across the globe

Over 350 projects in above 30 countries,

including new switchgears as well as field upgrades

Over 40000 gas compartments monitored with MSM

~1000 gas compartments, largest installation being monitored



MSM as a solution for GIS monitoring





MSM retrofit for circuit breaker monitoring on LTB

MSM installation allows to reduce maintenance cost, prevent critical failures and improve reliability in circuit breakers.



Our commitment

Quality assurance

We are committed to providing the best products and services. Our products comply with or exceed the latest international standards. In addition to type tests in independent laboratories, our certified design and manufacturing processes guarantee the highest quality. We are certified according to the latest relevant ISO quality standards.

Sustainability

Sustainability is about balancing economic success, environmental stewardship and social progress to benefit all our stakeholders. Sustainability considerations cover how we design and manufacture products, what we offer customers, how we engage suppliers, how we assess risks and opportunities, and how we behave in communities where we operate and towards one another, while striving to ensure the health, security and safety of our employees, contractors and others affected by our activities. We are certified according to the latest relevant ISO quality standards.



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