SPECIFICATION

EDS – Expert Diagnostic Systems

Overall Power Substation Condition Monitoring

DOCUMENT N. SIE10168, Rev. 7, May 2016

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1 GENERAL

The power industries, utilities and grid owners are facing several challenging. They are expected to maintain the same level of performances, in spite of their maintenance expenditure budgets have been cut, they have been asked to increase the lifecycle of their assets, to reduce the failure and fault risks.

The up-to-dated players are moving from a "routine based maintenance approach" to an "online conditioning based one" in order to optimize the efficiency of their networks and substations. Managers and operators need access at reliable data to know whether assets have to be repaired or replaced.

On line condition monitoring allows managers and operators to take well-founded decisions, optimize performance, extend lifecycle and reliability of the products, reduce expenditure for maintenance costs, prevent sudden failures, reduce failure risks, differ asset replacement costs, minimize the downtime of assets due to unforeseen structural issues and record detailed incident feedback for safety and risk management report.

The ISA EDS (Expert Diagnostic System) is an "Overall Power Substation Condition Monitoring" that integrates all the real time conditions from all relevant substation assets in a single system, and that allows managers and operators to prevent any type failure in operating condition.

EDS can include in one solution several assets that allows the appropriate scope of monitoring, according to the customised needs of each distribution, transmission or generation application: Circuit Breakers (like AIS and GIS), Current Transformers, Voltage Transformers, Power Transformers (Bushing, Load Tap Changers, Tanks, Cooling system, DGA, etc.), Surge Arresters, Batteries and other auxiliary assets, etc. Partial Discharge monitoring could be a complementary demand of each customer and it could be integrated in the proposal.

The following image exhibits the possible EDS applications:

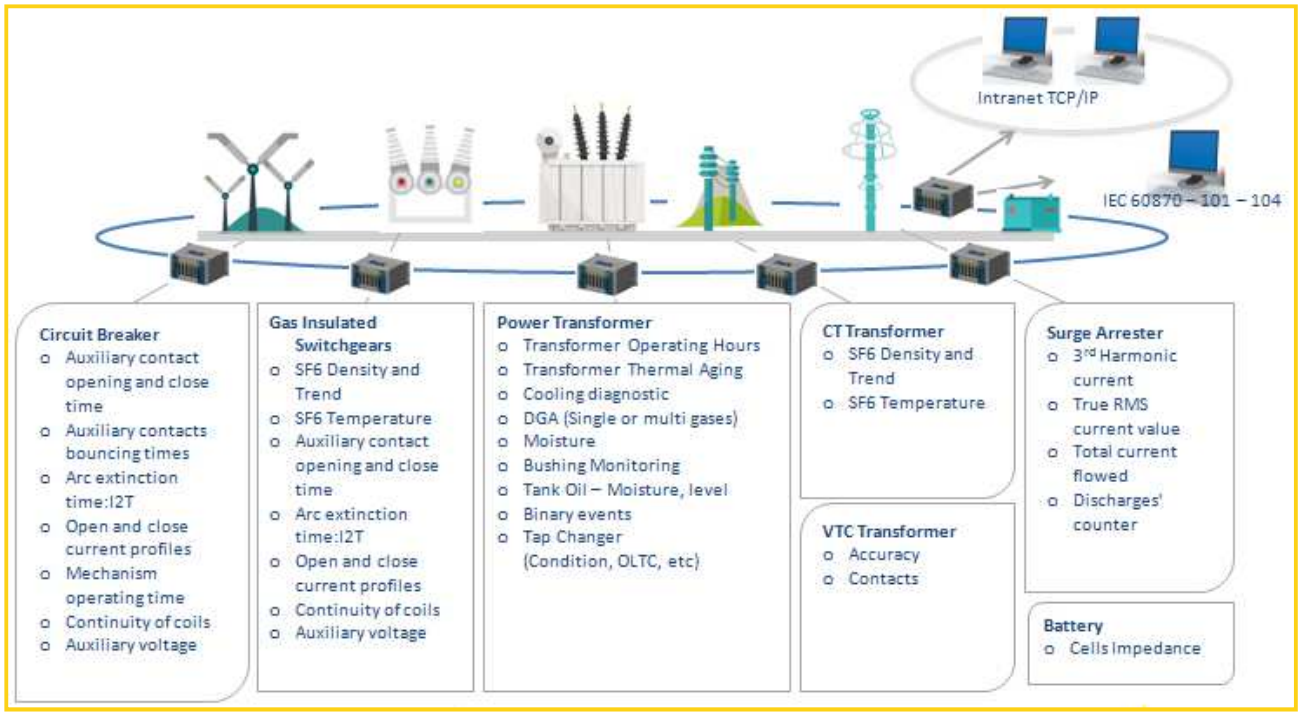

Figure 1 - Possible EDS applications

The following table lists the assets monitored by EDS:

Item	Asset to monitor	Code	Description
1	Circuit Breakers (AIS)		Circuit Breaker Breakers where it is necessary to monitor: opening and closing operations, analog loads, I2T, number of operations, time, SF6 gas density, trend and temperature
2	GIS – Gas Insulated Switchgears		GIS – all type of devices, gas insulated, where it is necessary monitoring Gas density, trend and temperature
3	Current Transformers		Current Transformer Monitoring where it is necessary to monitor analog loads, time, SF6 gas density and trend, capacitance
4	Voltage Transformers		Voltage Transformer Monitoring where it is necessary to monitor analog loads (voltages), comparison between different TVC in order to identify sudden deviations
5	Surge Arresters		Surge arresters where it is necessary to monitor the amount of current flow through the system and predict the residual operating life
6	Power Transformer		Power transformer where it is necessary to monitor all temperatures, predicting the thermal aging, verify the temperatures in windings, the status of cooling system, current in bushing, current load ratio, overload capacity, tap changer contact and temperature, moisture in tap changer, moisture in oil tank, the quantity of hydrogen gas dissolved or all the other gases, capacitance of bushings, partial discharges
7	MV Switchgears		MV Switchgears where it is necessary to monitor: open and close time delay, analog loads, I2T, number of operations, SF6 gas density, trend and temperature
8	Battery		Substation Set of Batteries in the cubicle (to be developed)

Table 1 - assets monitored by EDS

The configuration of the system is made with the right combination of single units, according with the customer requests. The following table lists possible configuration systems:

Item	Type	Code	Description
1	Central Unit		Central unit receives all the information from remote units and it provides computing calculation and is equipped with an optical communication interface. Central unit includes a web-server for the communication purpose or/and a communication interface IEC 60870-5-104
2	Remote Unit		Remote units are located close to the Devises Under tests and connected with a/more control unit(s), through optical cables. In case of a stand-alone system, remote unit could be configured also as central unit and equipped with the communication interface. Remote unit includes a web-server for the communication purpose
3	Slave Unit		Slave unit could be connected to remote unit for further connected modules
4	Sensors		Each unit is equipped with the appropriate sensors to perform the single measures and linked with the unit with the right set of cables.
5	Software		It is the proprietary software, that allows the display of the results, embedded in the units

Table 2 - Possible configuration systems

Communication between the units in field is normally split in two fiber optical loops. The following table lists the two fiber optical loops:

Item	Type	Code	Description
1	HV Loop		Units on the HV side of substation are connected each other through bi-directional fiber optical ring. Number of Fiber Optical Rings is configurable according with the layout of the substation and lengths between the devises
2	MV Loop		Units on the MV side of substation are connected to each other through bi-directional fiber optical ring

Table 3 - Fiber optical loops

Data collected by each unit could be handled following the architecture and layout of the substations and needs of the single customer. The following table lists the architecture and layout of the substations:

Item	Type	Code	Description
1	Intranet/Internet		Communication through TCP/IP (Ethernet) and web HMI interface
2	Protocols		Communication to customer data center through IEC 60870 – 5 – 101or 104
3	Protocol		Communication IEC61850 (to be developed in the future)

Table 4 - Architecture and layout of the substation

Each remote unit could be installed in a dedicated cabinet, according with the customer specifications and substation layout.

Item	Type	Type of Installation	Dimension
1	Central Unit	Internal	3U x 14” or 19” rack module IP 20
		External	400x500x350 mm Galvanized steel cabinet for external application IP 54 Option: stainless steel cabinet solution IP 54
2	Remote Unit	Internal	3U x 14” or 19” rack module IP 20
		External	400x500x350 mm Galvanized steel cabinet for external application IP 54 Option: stainless steel cabinet solution IP 54

Table 5 – Types of installation

2 STANDARD OPERATING CONDITIONS

Units and modules are designed for the below operating range conditions:

Item	Type	Description
1	Unit mounted outdoor	Units/Modules are designed to work outdoor • Extended temperature ranges from -40 °C to +85 °C • Operating relative humidity: 5÷95%
2	Unit mounted indoor	Units/modules adopt industrial type components • Temperature range: –20 °C to +85°C • Operating relative humidity: 5÷95%

Table 6 - Operating range conditions

ATTENTION: Units can operate at a maximum altitude 2.000 m above sea level

The following table lists the reference temperature, IP and humidity for the sensors used to collect the measures of the system:

Module	Sensor position	Temperature	IP	RH
Circuit Breaker	CB control box	-25°C to 65 °C	54	10÷90%
I2T	In the cubicle	-10°C to +50 °C	20	10÷90%
GIS SF6 TA	Outdoors	-25°C to +65 °C	54	10÷90%
Surge Arrester	Outdoor	-25 °C to+ 65 °C	54	10÷90%
Power Transformer	Outdoor and in the cubicle	-25°C to +65 °C	20	10÷90%
Cables	In the cubicle	-10°C to +50 °C	20	10÷90%
Central Unit	Substation, control room	-0°C to +50 °C	20	20÷80%

Table 7 - Sensors standards

3 APPLICABLE STANDARDS

The test set conforms to the EEC directives regarding Electromagnetic Compatibility and Low Voltage instruments.

The following table lists the standards related to the EMC Directive, 2014/30/EU:

Standard	Title	Requirement
EN 61326-1	Electrical equipment for measurement, control and laboratory use. EMC requirements. General requirements	
IEC EN 61000-3-2:	Electromagnetic compatibility (EMC) - Part 3-2: Limits - Limits for harmonic current emissions (equipment input current ≤ 16 A per phase)	Harmonic content of power supply Acceptable limits: basic
IEC 61000-3-3	Electromagnetic compatibility (EMC) - Part 3-3: Limits - Limitation of voltage changes, voltage fluctuations and flicker in public low-voltage supply systems, for equipment with rated current ≤16 A per phase and not subject to conditional connection	Limitation of voltage fluctuations and flicker Acceptable limits: basic
CISPR 16-1	Specification for radio disturbance and immunity measurement apparatus and methods	Acceptable limits for conducted emission: • 0.15÷0.5 MHz: 79 dB pk; 66 dB avg • 0.5÷5 MHz: 73 dB pk; 60 dB avg • 5÷30 MHz: 73 dB pk; 60 dB avg Acceptable limits for radiated emission: • 30÷230 MHz: 40 dB (30 m) • 230÷1000 MHz: 47 dB (30 m)
IEC EN 61000-4-2	Electromagnetic compatibility (EMC)- Part 4-2: Testing and measurement techniques - Electrostatic discharge immunity test	Immunity tests for ESD Test values: 8 kV in air; 4 kV in contact
IEC EN 61000-4-3	Electromagnetic compatibility (EMC)- Part 4-3: Testing and measurement techniques - Radiated, radio-frequency, electromagnetic field immunity test	Immunity tests for radio frequency interference Test values (f= 900 ± 5 MHz): field 10 V/m, modulated AM 80%; 1 kHz
IEC EN 61000-4-4	Electromagnetic compatibility (EMC) - Part 4-4: Testing and measurement techniques - Electrical fast transient/burst immunity test	Immunity tests for high speed transients (burst) Test values: 2 kV peak; 5/50 ns
IEC EN 61000-4-5	Electromagnetic compatibility (EMC) - Part 4-5: Testing and measurement techniques - Surge immunity test	Immunity tests for surge Test values: 1 kV peak differential mode; 2 kV peak common mode; 1.2/50 us
IEC EN 61000-4-6:	Electromagnetic compatibility (EMC) - Part 4-6: Testing and measurement techniques - Immunity to conducted disturbances, induced by radio-frequency fields	Immunity to low-voltage sinusoidal waveform Test values: 0.15-80 MHz, 3 Veff, 80% AM 1 kHz
IEC EN 61000-4-8:	Electromagnetic compatibility (EMC) - Part 4-8: Testing and measurement techniques - Power frequency magnetic field immunity test	Immunity tests for low frequency magnetic fields. Test values: 30 Arms/m
IEC EN 61000-4-11	Electromagnetic compatibility (EMC) - Part 4-11: Testing and measurement techniques - Voltage dips, short interruptions and voltage variations immunity tests	Immunity test for power supply drops. Test value: 20 ms with 100% dips.

Table 8 - Standards related to the EMC Directive

The following table lists the standards related to the LV Directive, 2014/35/EU:

Standard	Title	Requirement
IEC EN 61010-1	Safety requirements for electrical equipment for measurement, control, and laboratory use - Part 1: General requirements	For a pollution degree 2: dielectric rigidity 1.4 kV AC, 1 minute • Inputs/outputs protection: IP 2X, per IEC 60529 • Insulation resistance, at 500 V DC: > 10 MΩ • Ground resistance, at 200 mA DC: < 0.1 Ω • Operating temperature: (-10÷55) °C; storage: (-20÷70) °C • Operating relative humidity: 5÷95%, without condensing. Storage relative humidity: 0÷96%, without condensing • Altitude: less than 2,000 m
IEC 60068-2-6	Environmental testing - Part 2-6: Tests - Test Fc: Vibration (sinusoidal)	Vibration: 20 m/s^2 at 10÷150 Hz
IEC 60068-2-27	Environmental testing - Part 2-27: Tests - Test Ea and guidance: Shock	Shock: 1-5 g; 28 ms; half-sine

Table 9 - Standards related to the LV Directive

4 EDS CONDITION MONITORING SYSTEM CHARACTERISTICS

Several remote units compose EDS Condition Monitoring System; each one has dedicated electronic boards and sensors to perform the requested measurements. Each unit is also connected with the others through a bidirectional fiber optical loop. The HV loop is normally separated from the MV one.

A central unit integrates all the data from the other Condition Monitor Units through the optical loop. In many cases, one of the remote unit could be also be parameterized as central unit and it performs both functions of remote and central units. The configuration of the system could also be adapted using slave units, connected with remote units.

The Central Unit scope is the following:

- Data collation and computing

The Remote Units for monitoring are the following:

- Circuit Breaker AIS with or without SF6 monitor sensors
- Gas Insulated Switchgear - GIS
- Surge arrester
- Power Transformer
- CT
- VT
- MV Switchgears
- Battery check (to be developed)

There is also the EDS Condition Monitoring Software.

4.1 Central Unit

The central unit of the Conditioning Monitoring System is the unit dedicated at the acquisition of all the signals in a single diagnostic module, that includes power supply and Ethernet switch, optical fiber data collection to avoid interferences, input channels with parallel electronics to provide reliable data quality, data analysis with the generation of dedicated alarms, data access through web HMI or data access using IEC 60870-5-101 or 104 protocol and Modbus.

The central unit elaborates and store data from all sensors installed or provided by third party modules on substation.

It could be installed in the more appropriate existing cabinet in the station or in a dedicated cabinet.

In many cases, with very few condition monitor points (or assets), the central unit could be also configured integrated with the remote unit (normally dedicated for a single application).

The Central Unit is equipped with Computing card equipped with a microprocessor to process all computing processes, collecting all raw data from the remote units. The electronic card is also equipped to store the data, providing time synchronization and communication over protocol. Additionally, it is designed to provide a web user interface to communicate with the substation network.

The following table lists the typical measured period and the answer time for each remote unit:

Remote Unit	Typical measured period	Answer within
Circuit Breaker	10”	10”
I2T	10”	10”
Breaker SF6	From 10” to 24 h	10”
CT SF6	From 10” to 24 h	10”
VTC	1 day	10”
Surge Arrester	1 day	10”
Power Transformer	1 day	10”

Table 10 - Typical measured period and the answer time for each remote unit

The measure-polling period is programmable for each type of remote unit. The remote unit performs the measurements available within the times indicated. At confirmation of the measure successful message, the unit stores the measurement in the local memory; otherwise, it repeats the transmission of the measure.

4.2 Software of the central unit

The operating system of the central unit is supplied with several functionalities:

- Execution of the monitoring of the various remotes units
- Storage of the results in daily/weekly/yearly database that is downloaded through IP/TCP in a web server.
- Trend analysis of the SF6 density
- Possibility to modify the threshold parameters
- Possibility to remotely configure thresholds, zeroing measurements and so on
- Firmware Upgrade of the various peripheral units, through the optical fiber loop and a dedicated configuration tool
- Remote interrogation from another PCs via static TCP/IP
- Transmission of the measurements and the alarms to the customer control and maintenance center, through dedicated protocol

4.3 Characteristics of computing board in the central unit

The following table lists the characteristics of computing board in the central unit:

Feature	Characteristics
Data processing	Xilink Sprtan 6 FPGA Renesas RX62 µC, 32bit, 96 MHz clock Open RTOS real time operating system
Data Storage	2 parallel flash memory, 2 Gbit each 6 serial flash memory, 256 Mbit each 1 micro SD card slot
Memory	2 units, 512 SDRAM
RTC	Class 3ppm real time clock
Time synchronization	IRIG-B Protocol, 100PPS, FO-ST connector
Communication	Ethernet, FO-ST connectors, 1300nm, multimode
Web user interface	Over Ethernet, based on open RTOS, web-server, provided websites using Java script
Protocol	Over Ethernet, IEC 60870 – 5 – 101 and 104
Led	Provide status information

Table 11 - Characteristics of computing board in the central unit

4.4 General Characteristics of Central Unit

The following table lists the general Characteristics of Central Unit.

Characteristic of unit	Description
Supply voltage	110 V CC nominal; voltage range from 93,5 to 121 V CC
Absorption	50 W
Supply protection	In case of fault supply is protected by a fuse, 1 A
Communication	Ethernet port, with TCP/IP protocol, for the configuration of the monitoring system, and in general for the maintenance and querying of the system itself.
Inputs connection	By means of clamps
Output connection	By means of connector for optical fiber type ST multimodal 62.5/125 µm
Malfunction signaling	Fault on the internal supply; transmitted via optical fiber
Weight	About 2 kg
Dimensions Indoor installation	3U x 14” or 19” rack module IP 20 Panel size may vary to accommodate system selection
Dimensions Outdoor installation	400x500x350 mm Galvanized steel cabinet for external application IP 54 Cabinet could be supplied as option in stainless steel version Panel size may vary to accommodate system selection
Packaging Options	Instrument is delivered wired to its connection terminals; it does not include the wiring to the main contacts. A fuse incoming power connection is provided

Table 12 - General Characteristics of the Central Unit

The following image exhibits an example of standard Cabinet for outdoor application:

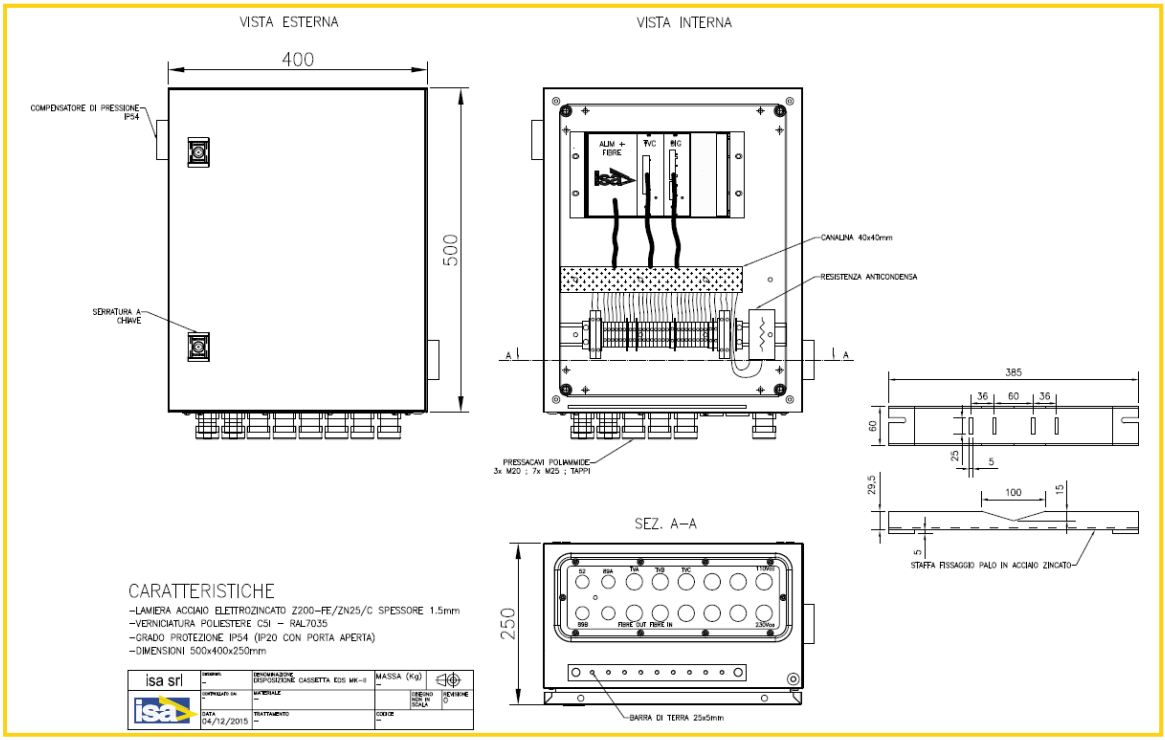

Figure 2– Example of standard Cabinet for outdoor application

5 CIRCUIT BREAKER UNIT AIS

This remote unit could be installed with non-invasive solution in an external cabinet and it includes the following functionalities:

- Monitoring of the auxiliary contacts
- SF6 gas – Gas monitoring: Density, trend and temperature (Option)
- Monitoring and computing I2T measurement.

The monitoring modules (called remote units) for the data acquisition are installed close to each sub-system monitored, installed in an appropriate cabinet. All the data are collected to a central unit that it is in charge also of the computation and communication of the results and alarms through a dedicated protocol to a data center/control room or through Ethernet to an Operator's PC.

The following image exhibits an example of CB Monitoring installation:

Figure 3 - Example of CB Monitoring installation

5.1 Monitoring of the auxiliary contacts

5.1.1 Circuits for monitoring of auxiliary contacts

The characteristics of the Circuits for monitoring of auxiliary contacts are the following:

- Number of inputs: 16
- Type of monitored inputs: wet
- Inputs voltage: from 93,5 to 121 V CC
- Threshold voltage: 77 V ±5 V
- Recognition criteria: an input is acknowledged as closed if it passes the threshold for a time longer than 200 µs
- Precision of the timing measure: ± 100 µs
- Input circuits are isolated; voltage withstand 500 V AC
- Absorbed current by the input circuits: 2 mA nominal
- Input impedance: greater than 20 kΩ
- In case of fault of one component of the measuring circuit, the minimum impedance of the input is 10 kΩ. The resulting current does not further damage the circuit.

5.1.2 Computation of circuit breaker timings

At installation, it is necessary to program the trigger inputs for the timing measures (trigger, total of seven) and the inputs matching the CB position and not matching the CB position(total of six).

When one of the trigger inputs becomes positive (for more than 200 µs), the unit records all the timings of the other 12 inputs (see the picture below).

The maximum duration of the measure is TMAX and it is programmable. If one input does not change within this time, the result is "not changed".

The measure of the timings ends if:

- TMAX is reached; or
- One of the trigger inputs opens (for more than 200 µs) and closes (for more than 200 µs) after a time TMIN (programmable), meaning that a new command has been raised
- Notice that if a command is present at the time of the trigger, the resulting delay is zero. The following image exhibits the measure of the timing until T_{max} is reached:

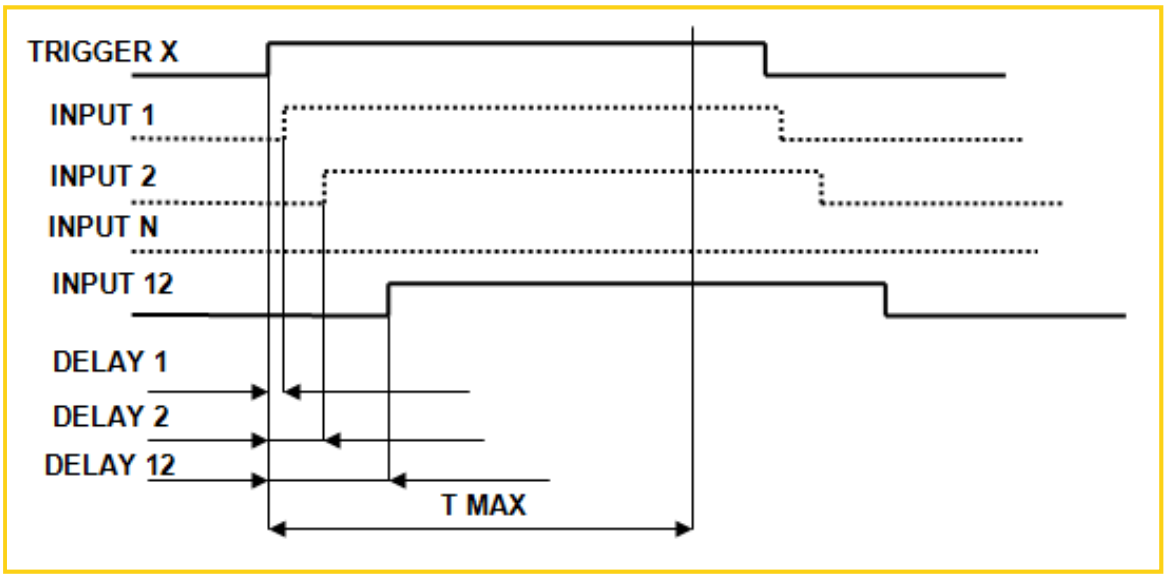

Figure 4 -Measure of the timing until T_{max} is reached

The following image exhibits the Second Trigger within T_{max}:

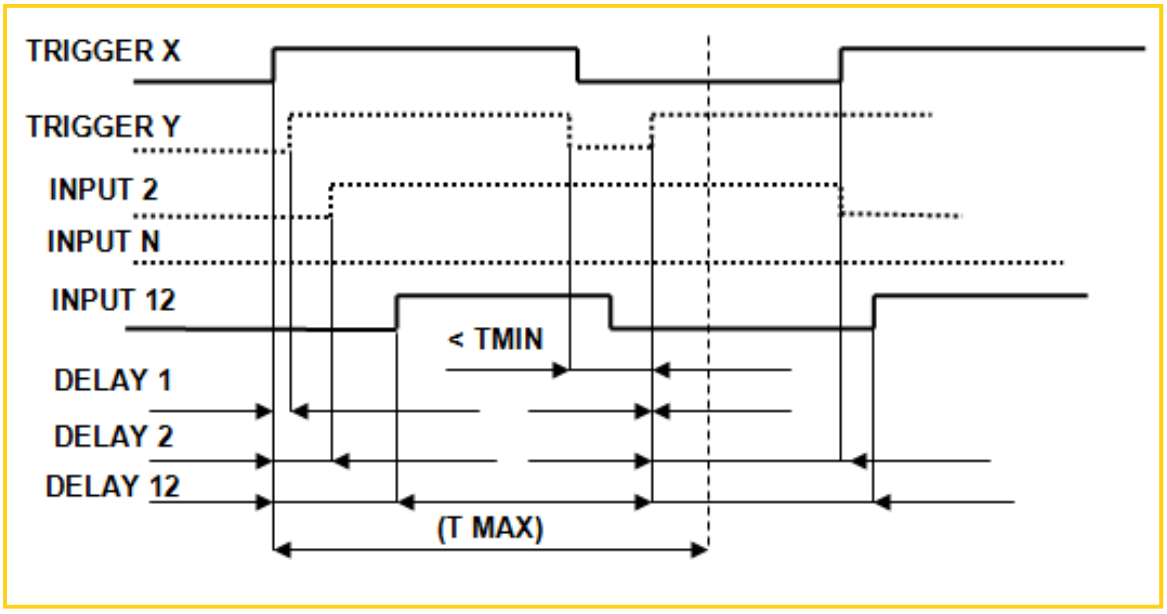

Figure 5 - Second Trigger within T_{max}

All measures, identified by the trigger channel and measured channel, are sent to the central unit for subsequent processing.

When polled for interrogation, the breaker unit transmits 12 measures. The central unit gets the following measures:

- Time between the open command and the contact not matching the CB position (one or three measures, depending on single-phase or three-phase open)
- Delay between the close contact and the contact matching the CB position(three measures)

- Trigger spread time (three-phase open command)
- Open pole discrepancy (none or one measure, depending on single-phase or three-phase open)
- Close pole discrepancy (none or one measure, depending on single-phase or three-phase open)

The following image exhibits the scheme related with those measures:

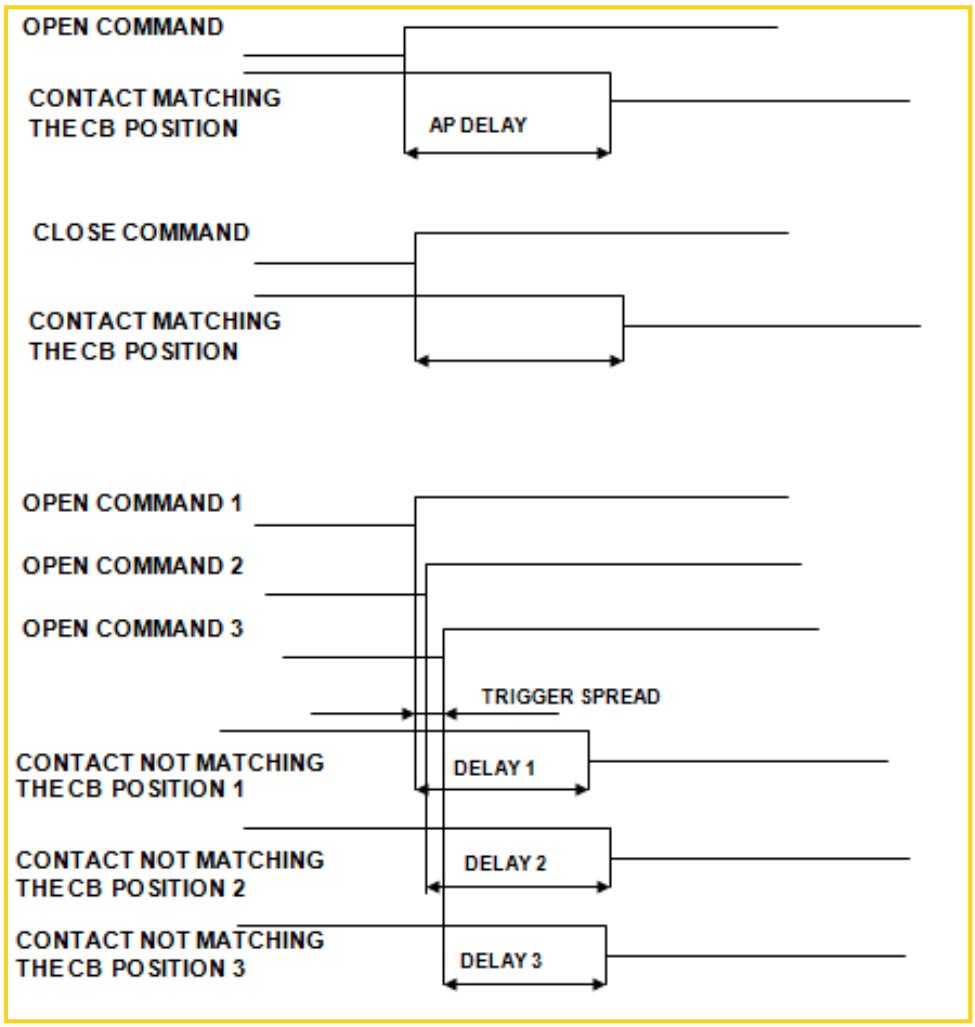

Figure 6 - Scheme related with the measures

Pole discrepancy = MAX ((DELAY1–DELAY2); (DELAY2-DELAY3); (DELAY3– DELAY1)).

The algorithm for the open pole discrepancy takes into account the possible discrepancy between the open commands on the various phases.

For each type of timing, there is a defined tolerance. The central unit checks the values against the tolerances and if surpassed, an alarm message is sent to the SAS/Scada system (total of 9 alarms).

5.1.3 General Characteristics of monitoring of auxiliary contacts

The following table lists the general Characteristics of monitoring of auxiliary contacts:

Characteristic of unit	Description
Supply voltage	110 V CC nominal; voltage range from 93,5 to 121 V CC
Absorption	10 W
Supply protection	In case of fault supply is protected by a fuse, 0,2 A
Inputs connection	Commands and breaker contacts: by means of clamps SF6 gas density: by means of clamps.
Output connection	By means of connector for optical fiber type ST multimodal 62.5/125 µm
Malfunction signaling	Fault on the SF6 transducers supply; transmitted via optical fiber Fault on the internal supply; transmitted via optical fiber.
Installation	Unit to be mounted inside the breaker control box
Weight	About 2 kg
Dimensions Indoor installation	3U x 14” or 19” rack module IP 20 Panel size may vary to accommodate system selection
Dimensions Outdoor installation	400x500x350 mm Galvanized steel cabinet for external application IP 54 Option: stainless steel cabinet solution IP 54 Panel size may vary to accommodate system selection
Packaging Options	Instrument is delivered wired to its connection terminals; it does not include the wiring to the main contacts. A fuse incoming power connection is provided

Table 13 - General Characteristics of the unit

5.2 SF6 Gas monitoring: Density, trend and temperature

In case of Circuit Breakers gas insulated, the Condition Monitor System has to be equipped with the gas leakage monitor functions, to control the density, trends and temperature.

The following images exhibit the SF6 sensor and two examples of SF6 sensor application:

Figure 7 - SF6 sensor

Figure 8 - Example of SF6 sensor application

Figure 9 - Example of SF6 sensor application

5.2.1 Circuit for monitor of SF6 gas density, trend and temperature

The characteristics of the circuit for monitor of SF6 are the following:

- Number of inputs: 3
- Type of transducers: density meters WIKA GD-10, or equivalent
- Range of densities to be measured: from 0 to 60 kg/m3, or from 30 to 60 kg/m^3
- Transducer output: DC current on the supply, useful to be measured by the monitoring circuit, with a fireproof cable respecting standard CEI 20-22, with maximum length 20 m
- Precision of the density measure: ±2% of the measure ±2% of the full range

5.2.2 Computations of SF6 gas: density, trends and temperature

The transducer current, that measures the gas density, is converted into a density measure; the value is transmitted via optical fiber.

The central unit collects all these raw data and supplies the trends of density and temperature.

When polled for interrogation, the breaker unit transmits the density measures. The computing unit in the line, having received the density for each phase, computes the density variation speed, as per the following algorithm:

- Rapid variation, fault: an average over a programmable number of measures is performed (for instance 10 measures, equivalent to 100 s) If the average of two averages varies of a value greater than the fault threshold (programmable), the event is immediately raised
- Slow variation. The derivative measure is performed once a day, overnight, when the temperature is more stable, at the programmed time; the time is synchronized by means of the clock input. The derivative is calculated on the average of a programmable number of values (for instance 100), as a difference of the readings over two or more days

In total, two alarms for each phase can be raised.

5.2.3 General Characteristics of monitoring of auxiliary contacts and SF6

The following table lists the general Characteristics of monitoring of auxiliary contacts and SF6:

Characteristic of unit	Description
Supply voltage	110 V CC nominal; voltage range from 93,5 to 121 V CC
Absorption	10 W
Supply protection	In case of fault supply is protected by a fuse, 0,2 A
Inputs connection	Commands and breaker contacts: by means of clamps SF6 gas density: by means of clamps
Output connection	By means of connector for optical fiber type ST multimodal 62,5/125 µm
Malfunction signaling	Fault on the SF6 transducers supply; transmitted via optical fiber Fault on the internal supply; transmitted via optical fiber
Installation	Unit to be mounted inside the breaker control box
Weight	About 2 kg
Dimensions Indoor installation	3U x 14” or 19” rack module IP 20 Panel size may vary to accommodate system selection
Dimensions Outdoor installation	400x500x350 mm Galvanized steel cabinet for external application IP 54 Option: stainless steel cabinet solution IP 54 Panel size may vary to accommodate system selection
Packaging Options	Instrument is delivered wired to its connection terminals; it does not include the wiring to the main contacts. A fuse incoming power connection is provided

Table 14 - General Characteristics of the unit SF6

5.3 Monitoring and computing of I2T

The value of I2T is a very good proxy of the arc extinction time and the integration of all the data in the years give an indication of the residual life cycle of the circuit breakers. The measure of the I2T is a remote unit stand-alone. For the right evaluation it is necessary collect the data also from the A/B bars. The functional requirements of this unit are described below.

5.3.1 Circuits for the measurement of the current

The characteristics of the circuits for the measurement of the current are the following:

- Number of inputs: 3
- Measure connections: toroidal transformers placed on the CT secondary sides
- Toroidal transformers characteristics:
    - Description: Resin coated toroidal transformer, to be screwed on a base, with output connector
    - Internal hole: 12 mm diameter
    - Transformer ratio: 1000//1
    - Primary current: 5 A; surge 150 A (30*IN) for 1 s, 2*IN to time indefinite
    - Global precision: transformer, converter, rms measure: ±5% of measure ±2% of range

5.3.2 Circuits for the monitoring of A/B Bars

The characteristics of the circuits for the monitoring of A/B Bars are the following:

- Number of inputs: 2
- Type of monitored inputs: wet
- Inputs voltage: from 93,5 to 121 V CC
- Threshold voltage: 77 V ±5 V
- Recognition criteria: an input is acknowledged as closed if it passes the threshold for a time longer than 200 µs
- Precision of the timing measure: ± 100 µs
- Input circuits are isolated; voltage withstand 500 V AC
- Absorbed current by the input circuits: 2 mA nominal
- Input impedance: greater than 20 kΩ
- In case of fault of one component of the measuring circuit, the minimum impedance of the input is 10 kΩ. The resulting current does not damage the circuit.

5.3.3 Computation of the I2T

The module receives the actual open command raised by the breaker unit, from the central unit, and such command orders the unit to start the measurement.

- The sampling frequency for each phase is 1 kHz.
- On the measured currents, the module will compute the following functions:
    - Verifies if the current is higher than the programmed threshold
    - Calculates I2T by integration of the current values of the last part of the phenomenon, corresponding to the arc extinction time Te programmed (average arc time). The following image exhibits the computation of the I2T performed by the instrument:

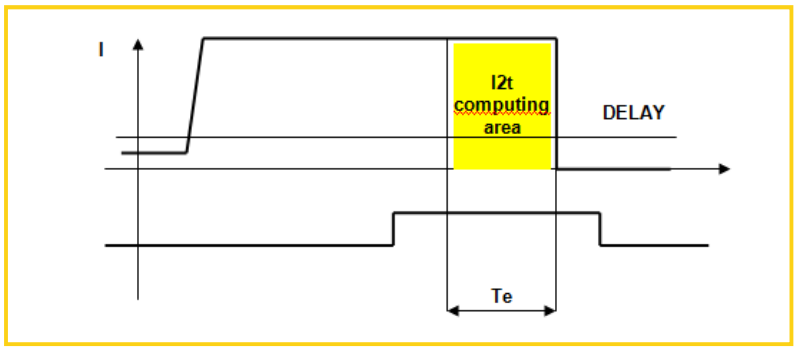

Figure 10 -Computation of the I2T performed by the instrument

- The I2Te computed value is transmitted to the central unit for further processing. The total error on the measure of I2Te is less than 10% for currents greater than 15 IN.
- The module detects and transfers the A/B bar selection, which will be used by the MRE system for the monitoring of the PT.

When polled for interrogation, the I2T unit transmits the I2T values for each phase measured for each interruption to the computing unit; therefore:

- It adds up, for each phase, the measured value to the previous ones, and stores the total
- Checks the total against the programmed threshold value, and transmits an alarm when the threshold is surpassed. Two thresholds are defined: pre-alarm, and alarm (total of six thresholds)

When the device is installed, the operator can program the actual I2Te value of the breaker since it has likely been in service for some time.

5.3.4 General Characteristics of monitoring I2T

The following table lists the general Characteristics of monitoring I2T:

Characteristic of unit	Description
Supply voltage	110 V CC nominal; voltage range from 93,5 to 121 V CC
Absorption	5 W
Supply protection	In case of fault supply is protected by a fuse, 0,1 A
Inputs connection	From the transformer: via connectors or clamps
Output connection	Via connector to the central unit
Malfunction signaling	Fault on the internal supply; transmitted via optical fiber
Installation	Unit to be mounted inside the line cubicle
Dimensions Indoor installation	3U x 14” or 19” rack module IP 20 Panel size may vary to accommodate system selection
Dimensions Outdoor installation	400x500x250 mm Galvanized steel cabinet for external application IP 54 Option: stainless steel cabinet solution IP 54 Panel size may vary to accommodate system selection
Weight	About 2 kg
Packaging Options	Instrument is delivered wired to its connection terminals; it does not include the wiring to the main contacts. A fuse incoming power connection is provided

Table 15 - General Characteristics of the unit for monitoring I2T

6 SURGE ARRESTER

6.1 Introduction to the monitoring

The module serves the purpose of verifying the discharger efficiency of the metal oxide surge arresters installed on the HV transport lines, according to IEC standards 60099-5 A1 ED. 1.0 Section 6: Diagnostic indicators of metal-oxide surge arresters in service (method B1).

The control is executed with the surge arrester in service, by analyzing through a current transformer the current discharged in the grounding connection. This current normally has values in the range between fractions of mA and a few mA, and is characterized by a deformation of the 3rd harmonic, whose value is an indication of the degradation of the surge arrester itself.

The instrument amplifies the current measured by the clamp, measures the real rms value of the total current, filters the 3rd harmonic component by means of a pass-band filter and measures the resulting rms value. This value is confronted with the maximum accepted value; when it gets higher than the threshold, an alarm is generated.

The measure environment is characterized by the presence of very high electrical and magnetic fields. In order to minimize their effect on the measurement, the transformer is shielded against magnetic fields; furthermore, the signal pre-amplification is done on the transformer itself. The cable that connects the transformer to the peripheral unit is therefore much less sensitive to the electrical field.

The monitoring modules (called remote units) for the data acquisition are installed close to each sub-system monitored, installed in an appropriate cabinet. All the data are collected to a central unit that it is in charge also of the computation and communication of the results and alarms through a dedicated protocol to a data center/control room or through Ethernet to an Operator's PC.

6.2 Measure of the currents

The characteristics of the measure of the currents are the following:

- Number of inputs: 3
- Connection: on the surge arrester grounding cable
- Characteristics of the measuring transformers:
  - Description: Resin coated toroidal transformer, with output connector
  - Transformer ratio: 1000//1
  - Ratio error from 0,1 mA to 10 mA: 5% ±0,05 µA
  - Internal hole diameter: 50 mm
  - Connection: with connector
  - Connection cable: shielded, 5 pins, maximum length 10 m
- Measure performed on the current measured by the clamp:
  - True rms value of the total current
  - 3rd harmonic rms value
  - Digital conversion of these voltages for the transmission on optical fiber
  - Range of the total current: 19,99 mA
  - Range of the 3rd harmonic: 1999 µA
  - 3rd harmonic filter response: < -60 dB at 50 Hz;0 dB at 150 Hz;< -20 dB at 250 Hz and greater frequencies
  - Errors:
    - Measure at 50 Hz, rms value: ±5% of the measure ±1% of the range.
    - Measure at 150 Hz, rms value: ±10% of the measure ±2% of the range
  - External field insensitivity. In presence of the following disturbances:
    - Electric field: < 10 kV/m
    - Uniform magnetic field:< 50 µT
    - Non-Uniform magnetic field, create by the circulation of a 20 A current in a conductor placed 50 mm away from the current transformer, the measure is maximum 2 mA rms at 50 Hz

6.3 Measure of the number of discharge

The characteristics of the measure of the number of discharge are the following:

- Number of inputs: 3
- Connection: on the surge arrester grounding cable
- The number of discharges will be increased if the current value is greater than the programmed threshold (500 A, 2.000 A, 5.000 A, > 5.000 A)
- Error on the measure of the current pulse amplitude:< 30%

6.4 Computation of the surge arrester units

Upon command issued by the central unit in the line cubicle, the measures of the fundamental current and those of 3rd harmonic are executed and transmitted to the central unit. Always upon command, the number of discharges is transferred, together with dates, hour and minute of the single events.

The central unit receives, by polling the surge arresters remote unit, for each phase:

- The value of the total current and of the 3rd harmonic current; then it checks the values against the programmed thresholds, and raises an alarm when the maximum-programmed threshold is surpassed. Two thresholds are defined: pre-alarm and alarm. The measure of the total current is stored together with that of 3rd harmonic, to complete the event information.
- The number of discharges, along with the timing of the various events

6.5 General Characteristics of surge arrester unit

The following table lists the general Characteristics of surge arrester unit:

Characteristic of unit	Description
Supply voltage	110 V CC nominal; voltage range from 93,5 to 121 V CC
Absorption	5 W
Supply protection	In case of fault supply is protected by a fuse, 0,1 A
Inputs connection	From the transformers and discharge sensors: via connectors or clamps
Output connection	By means of connector for optical fiber type ST multimodal 62.5/125 µm
Malfunction signaling	Fault on the internal supply; transmitted via optical fiber.
Dimensions Indoor installation	3U x 14” or 19” rack module IP 20 Panel size may vary to accommodate system selection
Dimensions Outdoor installation	400x500x350 mm Galvanized steel cabinet for external application IP 54 Option: stainless steel cabinet solution IP 54 Panel size may vary to accommodate system selection
Weight	About 2 kg + internal components
Packaging Options	Instrument is delivered wired to its connection terminals; it does not include the wiring to the main contacts. A fuse incoming power connection is provided

Table 16 - General Characteristics of the Surge Arrester Unit

The following image exhibits the Surge Arrester Remote Unit:

Figure 11 - Surge Arrester Remote Unit

7 POWER TRANSFORMER

7.1 Introduction

The EDS Condition Monitor System for Power Transformer is customized solutions that support the operation of maintenance of transformer.

With the use of sensors, modeling and diagnostic functions, EDS PT helps to detect in advanced potential failure of all the main components of a power transformer, avoiding the risk of destructive shutdown.

It also provides tools to the operator to use the Power Transformer at the maximum load power, without accelerating the aging of the transformer itself.

The EDS PT functionalities in the Advance Option includes the condition monitoring of several sub-functions: Transformer operating status, temperature monitoring, cooling monitoring, DGA, Oil moisture, OLTC condition, and through dedicated options and systems provided by third partners: Bushing Monitoring and Partial Discharge.

The monitoring modules (called remote units) for the data acquisition are installed close to each sub-system monitored, installed in an appropriate cabinet. All the data are collected to a central unit that it is in charge also of the computation and communication of the results and alarms through a dedicated protocol to a data center/control room or through Ethernet to an Operator's PC.

The system provides numerical models for the main area of analysis of a Power Transformer:

- Thermal Model
- Cooling model
- Aging Model
- Tap changer model
- Moisture model
- DGA Model (*)
- Bushing model (*).

A PD model (*) could be also integrated as option.

Note (*) These models could be integrated in ISA EDS though numerical models. These systems are normally supplied by third partners, according with the customer's requests and specifications.

Generally speaking, the EDS PT monitoring system acquired several data through dedicated sensors and subsystems, which are the following:

- Load current on HV side
- Over currents and short circuit currents on HV side
- Top oil temperature
- Gas in oil content
- Relative moisture of oil (water %)
- Operating voltage on HV bushing
- Bushing Capacitance
- Ambient temperature
- Circuit state of each fan and pump
- OLTC position
- Active power consumption of OLTC motor drive

On the base of received condition measurements, it is possible to calculate and analyze for single transformer several behaviors:

- Apparent power (MVA)
- Load factor
- Number of over currents and short-circuit currents on HV side
- Statistics of over currents and short-circuit currents on HV side
- Actual losses
- Top oil temperature according with the thermal model
- Hot spot temperature in accordance with IEC 60076-7
- Ageing rate in accordance with IEC 60076-7
- Lifetime consumption in accordance with IEC 60076-7
- Gas in oil gradient
- Water content in oil [ppm]
- Moisture of insulation paper
- Bubbling temperature
- Bubbling safety margin
- Breakdown voltage of insulation oil
- Overload capacity
- Emergency overloading time when overloading
- Number of overloading voltage on HV bushing
- Last overload-voltage on HV bushing
- Change of capacitance on HV bushing
- Operating times of fans and pumps
- Cooling efficiency (Thermal resistance Rth)
- OLTC position (last and actual)
- Last OLTC operation
- Number of switching operations of OLTC
- Number of switching operations of pre-selector
- Number of switching operations of selector
- Sum of switching load current of OLTC
- Diverter switching current during switching operation
- Number of OLTC operation until service
- Power consumption of motor drive
- Time of inrush current
- Switching time
- Maximum power consumption of sector 1, 2 and 3
- Contact erosion (wear) of main contacts.

Also for the Condition Monitor of a Power Transformer, the system could be structured in one/more remote unit(s) and central unit. The following image exhibits the Power Transformer Central and/or Remote Unit:

Figure 12 - Power Transformer Central and/or Remote Unit

The conditioning monitor system for Power transformer has two main configurations, with different functionalities. The following table lists the characteristics of the two main configurations of the conditioning monitor system for Power transformer:

PT condition monitor	Functionalities
Basic option	Hotspot calculation (*) Aging rate (*) Loss of Life (*) Relative moisture in oil (**) Absolute moisture in oil (**) Dissolved gas in oil (DGA) (**) Content of moisture in cellulose Cooling state and efficiency
Advanced option	Hotspot calculation (*) Aging rate (*) Loss of Life (*) Relative moisture in oil Absolute moisture in oil Dissolved gas in oil (DGA) (**) Content of moisture in cellulose (**) Cooling state and efficiency Cooling efficiency TC position/counting TC motor drive power Statistical Overload capacity calculation Load current and apparent power on High Voltage side Operating voltage on the High Voltage side Oil and ambient temperature Circuit status on equipment such Buchholz relay, oil level indicator, pressurized valve, etc. Online capacities of High Voltage Bushing
(*) According with IEC 60076-7 (**) Systems provided by third partners, according with customer's specifications	

Table 17 - Two main configurations of the conditioning monitor system for Power transformer

7.2 Hardware configuration of PT condition monitoring

The two versions have different Hardware configurations, according with customer customization required.

7.2.1 Basic configuration

The following table lists the basic configuration elements:

Data	Input Type
Top oil Temperature	PT100
Ambient temperature	PT100
Current HV	±20mA
Single gas in oil	4 – 20mA
Relative moisture in oil	4 – 20mA
Cooling group 1 temp In/Out	PT100
Cooling group 1 temp In/Out	PT100
Cooling group 1 temp In/Out	PT100
Cooling group 1 temp In/Out	PT100
Cote Temperature	PT100
Gas max variation	Digital
Watchdog DGA	Digital

Table 18 - Basic configuration

7.2.2 Advanced configuration

The following table lists the advanced configuration elements:

Data	Input Type
Top and bottom oil Temperature	PT100
Ambient temperature	PT100
Housing Temperature	PT100
Current HV	±20 mA
Bushing capacities (*)	Modbus RS485
Bushing Tan Delta (*)	Modbus RS485
Bushing capacitive displacement current (*)	Modbus RS485
Multiple gas in oil	Modbus RS485
Relative moisture in oil	Modbus RS485
Fault contact of single gas sensor	Modbus RS485
TC position	Resistor read
TC Temperature	PT100
Current LV	±20 mA
TC electrical/mechanical operation	Digital
Voltage LV	±200 V
TC motor drive power	4 – 20mA
TC protective relay	Digital
Cooling group 1 temp In/Out	PT100
Cooling group 1 temp In/Out	PT100
Cooling group 1 temp In/Out	PT100
Cooling group 1 temp In/Out	PT100
TC tank min/max oil level	Digital
Transformer tank min/max oil level	Digital
Transformer pressure relief device	Digital
Transformer relay trip/alarm	Digital

Table 19 - Advanced configuration

Note (*): systems provided by partners, according with customer's specifications.

The unit is designed for an indoor installation or it can be installed outdoor cabinet existing or new one.

7.2.3 Thermal Monitoring

The Unit can be customized for condition monitoring the following features

- Bottom oil temperature
- Hot spot temperature, according with the IEC 60354
- Top oil temperature
- Outside temperature Sunlight temperature
- Outside temperature Ambient temperature

Several alarms cab customized:

- High Top Oil Temp
- high-high top Oil Temp
- High winding Hot Spot Temp
- High-high Winding Hot Spot Temp

7.2.4 Cooling Monitoring model

The Unit can be customized with the status of the cooler groups. Different colored symbols represent different rotating status (starting/stop). It is also displayed the number of operating hours and the thermal resistance:

- Operating times of fans and pumps
- Cooling efficiency (Thermal resistance Rth)

7.2.5 Ageing model

The calculation is based on the hot spot temperature in the hottest winding. The Ageing calculation is according to IEC 60076-7 for non-thermally upgraded paper. The expected service life will only be used for reference purpose. IEC specifies the expected service life to 150.000 hours, equal to 17,1 years.

7.2.6 Tap Changer Model

The Unit can be customized for monitoring the Tap changer. The features monitored are listed below:

- OLTC position (last and actual)
- Last OLTC operation
- Number of switching operations of TC
- Number of switching operations of pre-selector
- Number of switching operations of selector
- Sum of switching load current of TC
- Diverter switching current during switching operation
- Number of OLTC operation until service
- Power consumption of motor drive
- Time of inrush current
- Switching time
- Maximum power consumption of sector 1, 2 and 3
- Contact erosion (wear) of main contacts
- Contact erosion (wear) of auxiliary contacts

Several alarms can be settled according to the existing sub-system configuration.

7.2.7 DGA Dissolved Gas Analysis in PT and bushing

The EDS PT monitoring unit can be configured to collect data from DGA system.

The Basic Option has a dedicated input for 1 DGA measure (4-20 mA) for PT. Normally hydrogen is monitored.

The Advanced Option manages up to 8 DGA measures on PT through a RS485 connector and 2 Digital inputs for DGA in the Bushing. In this option the input is used also for the moisture measures.

The DGA System is supplied separately, if it is requested, following with the customer preferences, specifications or the systems already installed in the exiting Power Transformer. All the computation analyses will be integrated in the central unit and displayed in the web HMI interfaces.

References and alarms could be set and customized in the EDS PT unit before the installation, following the customer specification or the DGA manufacturer instructions.

As references, the following three tables lists the common application ranges and alarm ranges.

DGA Options	Range [ppm]	Accuracy [ppm]	Repeatability [ppm]	Resolution [ppm]	Detection Limit DL [ppm]	Application Range [ppm]
H_2 (Hydrogen) or equivalent	20 - 10.000	±10 o ±5%	± 5 o ±3%	5	10	50 - 1.000

Table 20 - Dissolved Gas Analysis - 1 gas option

DGA Options	Range [ppm]	Accuracy [ppm]	Repeatability [ppm]	Resolution [ppm]	Detection Limit DL [ppm]	Application Range [ppm]
CO_2 (Carbon Dioxide)	DL - 5.000	DL +5% measured	DL +3% measured	1	1	5 - 1.000
CH_4 (Methane)	DL - 5.000	DL +5% measured	DL +3% measured	1	1	5 - 1.000
C_2H_4 (Ethylene)	DL - 5.000	DL +5% measured	DL +3% measured	1	1	5 - 1.000
C_2H_2 (Acetylene)	DL - 5.000	DL +5% measured	DL +3% measured	1	1	5 - 1.000
C_2H_6 (Ethane)	DL - 5.000	DL +5% measured	DL +3% measured	1	1	5 - 1.000
H_2 (Hydrogen)	DL - 5.000	DL +5% measured	DL +3% measured	1	1	N.A.
CO (Carbon Monoxide)	DL - 5.000	DL +5% measured	DL +3% measured	5	10	N.A.

Table 21 - Dissolved Gas Analysis – multi-gas options

DGA Options	Level 1 [ppm]	Level 2 [ppm]	Level 1 [ppm/1.000]	Level 2 [ppm/2.000]
H_2 (Hydrogen)	100	200	5	20
H_2 (Hydrogen) equivalent	200	500	5	20
CH_4 (Methane)	100	300	5	20
CO (Carbon Oxide)	500	3.000	25	100
CO_2 (Carbon Dioxide)	5.000	10.000	150	600
C_2H_4 (Ethylene)	50	100	3	10
C_2H_6 (Ethane)	100	300	5	20
C_2H_2 (Acetylene)	3	10	2	5

Table 22 - Alarm setting

7.2.8 Bushing Capacitance and Tan Delta measures

The Bushing Capacitance and tan delta measures are performed with a dedicated system that is not included in the standard unit. The system, it is required, is quoted separately, following with customer preferences, specifications or systems already installed in the exiting Power Transformer.

All the computation analyses will be integrated in the central unit and displayed in the web HMI interfaces.

7.2.9 Partial Discharge System

The Partial Discharge system is a dedicated system that is not included in the standard unit. This system, if it is required, is quoted separately, following with customer preferences, specifications or systems already installed in the exiting Power Transformer.

The PD system will be integrated in the Advanced option adding a dedicated HW.

8 VT VOLTAGE TRANSFORMER

8.1 Background

Purpose of this unit is to provide an accurate measure of the TVC secondary voltage, and to highlight anomalies in the functioning of the transformer itself by comparing the value at the secondary side of other TVC.

Each module includes the following:

- Digital inputs: 8 or 16
- Acquisition microprocessor electronic board
- Optical communication board, equipped with status led
- Power supplier unit
- Capability of local control and communication during commissioning
- 2 Rotary selectors for the setup of logic address (from 1 to 154)

The following image exhibits an example of VTC Condition Monitor System 8 digital input:

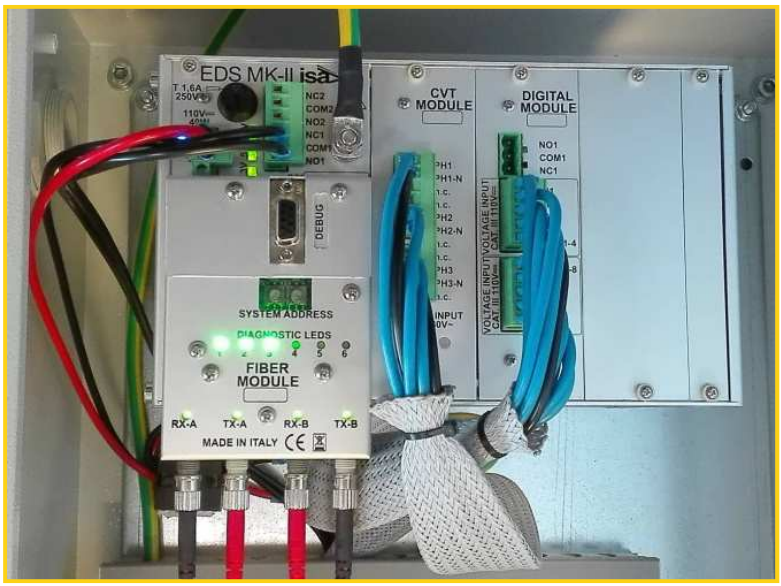

Figure 13 - Example of VTC Condition Monitor System 8 digital input

8.2 Circuits for binary inputs and the voltage measure

The characteristics of the Circuits for the voltage measure are the following:

- Number of digital inputs: 8 or 16, optical insulated
- Number of analog inputs:3 to be connected on TVC secondary side
- Connection: on the VTC secondary side, by means of isolation transformer
- Input Range intension: from 93,5 to 121 VDC. Max peak is 250 V DC
- Global precision: transformer, measure true rms and converter, from 65 V ±5 V
  - Temperature from 25 °C: ±0,1% of the measure ±0,02% of the range
  - Complete range of temperatures (from -25 °C to +60 °C): ±0,5% of the measure ±0,1% of the range
  - Differences between two units, whose temperature difference is lower than 10 °C: ±0,2% of the measure ±0,04% of the range
- Connectors on TVC side: compliant at CEI EN 60947-7-1 and 60947-7-2

8.3 Computations of the VT remote unit

Upon command issued by the central unit, the peripheral for each phase:

- Samples the voltage with rate 10 kHz for a period of 10 s
- Computes the true rms value of the measured voltage
- Transmits the measures to the computing unit

8.4 Algorithm for monitoring TV

The algorithm for the monitoring of the TV serves to the purpose of highlighting anomalies in the transformer, despite the line voltage variations and the unavoidable measure errors.

The algorithm works on the measures coming from at least three PT connected to the same phase.

If during the measure there is a switching on the line the measured values are discarded, and the measure is repeated 15 minutes after the line is restored back to normality.

The algorithm is the following:

- The three measures are recorded in a table
- The differences between the measures are computed, by taking as a reference the values of the various transformers
- The differences are added up together
- The differences with respect to the TV with lower total are considered, and checked against the maximum of the standard, which is double the sum of the maximum error of the TV adding the value of the measure.

8.5 General Characteristics of VT

The following table lists the general Characteristics of VT:

Characteristic of unit	Description
Supply voltage	From the secondary side of the VTC; voltage range from 40,0 to 110 V DC, tolerances -30%/+10%
Load	Max 30W
Fault	In case of fault of a component in the measuring circuit, the minimum impedance of the input becomes 1 kΩ (load on PT of 3,3 VA). The subsequent current does not further damage the circuit
Inputs connection	From the transformers by means of connectors of clamps.
Output connection	By means of connector for optical fiber type ST multimodal 62.5 / 125 micron
Malfunction signaling	Fault on the internal supply; transmitted via optical fiber.
Dimensions Indoor installation	3U x 14” or 19” rack module IP 20 Panel size may vary to accommodate system selection
Dimensions Outdoor installation	400x500x350 mm Galvanized steel cabinet for external application IP 54 Option: stainless steel cabinet can be supplied IP 54 Panel size may vary to accommodate system selection
Weight	About 2 kg + internal components
Packaging Options	Instrument is delivered wired to its connection terminals; it does not include the wiring to the main contacts. A fuse incoming power connection is provided

Table 23 - General Characteristics of the unit VT

9 CT, GAS INSULATED SF6

The unit includes three circuits for the measure of the SF6 gas density.

9.1 Circuit for monitor SF6 gas density, trend and temperature

The characteristics of the Circuit for monitor SF6 are the following:

- Number of inputs: 3
- Type of transducers: density meters WIKA GD-10, or equivalent
- Range of densities to be measured: from 0 to 60 kg/m^3, from 15 to 45 kg/m^3 or from 30 to 60 kg/m^3, depending on the installed transducer
- Transducer output: DC current on the supply, useful to be measured by the monitoring circuit, with a fireproof cable respecting standard CEI 20-22, with maximum length 20 m
- Precision of the density measure: ±2% of the measure ±2% of the full range.

9.2 Computations of SF6 gas: density, trends and temperature

See description of SF6: density, trends and temperature in CB monitoring paragraph.

10 MEDIUM VOLTAGE SWITCHGEAR CONDITION MONITORING

10.1 Introduction

MV Switchgears is one of the most reliable components within substation assets. Continuous Monitoring is allowing extending the lifetime of these assets and reducing the costs of routine maintenance, adopting a condition based approach. Condition monitoring will improve the efficiency of these systems anywhere there are severe environmental conditions.

The benefits of the unit are summarized as:

- Applicable to all substations
- Minimum impact on the existing substations (no modification of existing wirings)
- Easy installation
- Adapts to a variety of devices installed
- Applicable to all devices (Independently of the manufacturers)
- Maximum system reliability

This remote unit incorporates the condition monitoring options in a single rack unit, easy to install with the system in use. The signals for monitoring the coil current are collected from dedicated CTs without any interruption of installed set up.

The data are collected, stored and analyzed in the measuring board of the unit. The system double-checks the measurements by parallel electronic inputs. A web HMI set up allows to access at the data and analysis with a dedicated browser. The system could also equip with the IEC 60870-5-104 protocol to communicate with a remote control center (i.e. Scada). The communication of the system is provided via bi directional fiber optic cables.

The Unit can also manage data of density, trend and temperatures provided by dedicated SF6 gas sensors, in case of SF6 gas insulated switchgears.

The unit could be configured as main unit or slave unit, to increase the number of digital inputs to connect and reducing the cost of the system.

The typical issues to solve in MV switchgear can be listed as below:

- Hardness in mechanical components of the kinematic chain due to lack of lubrication, non-used, lack of maintenance, operation at low rage of temperatures
- Accelerated aging, mechanical yield, deterioration of internal components
- Ageing/yield of the mechanical energy storage (springs)
- Damage of the end of stroke shock absorbers
- Wear of transmission mechanism
- Arch and main contacts wear
- Open / close coils damage

10.2 Logical Scheme of MV Switchgear conditioning monitor unit

Each unit can monitor up to 10 breakers accordingly with the scheme below:

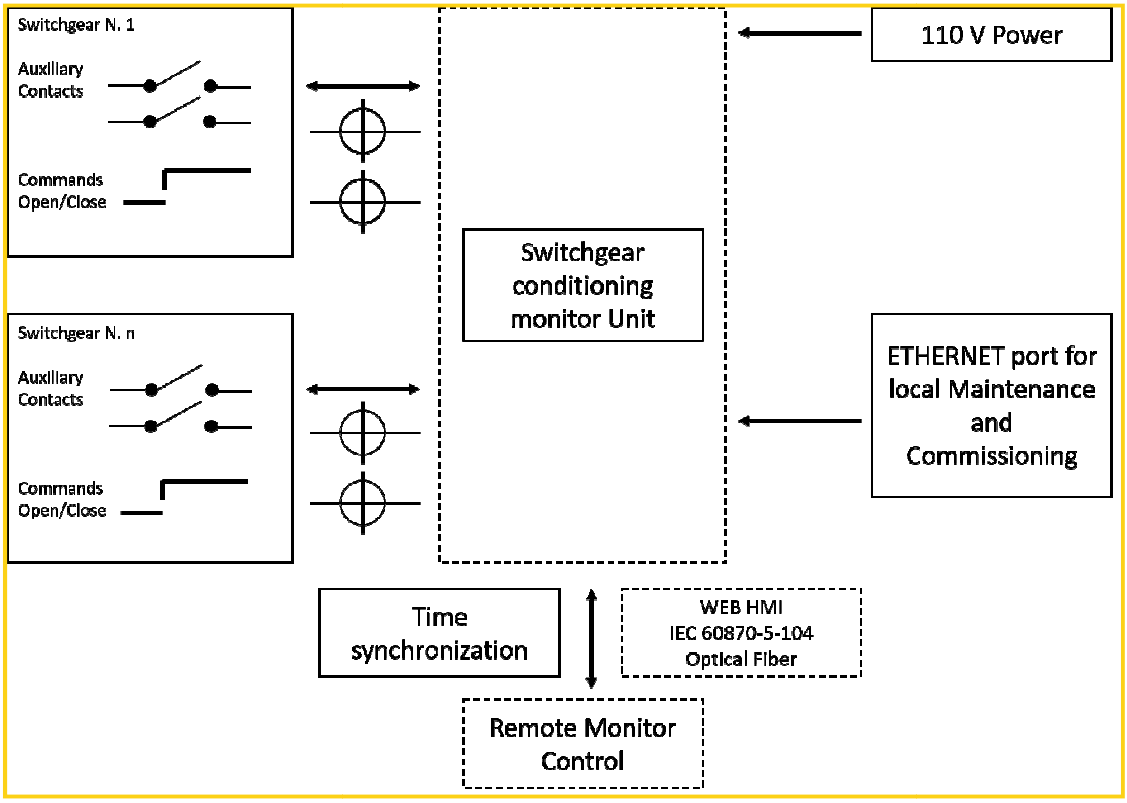

Figure 14 -Switchgear conditioning monitoring Logical Scheme

10.3 Main features of MV Switchgear conditioning monitor unit

The main features of MV Switchgear conditioning monitor unit are the following:

- Acquisition of all the signals in a single diagnostic module
- Compact size of the unit and peripherals
- All hardware concentrated in one enclosure, including power supply and Ethernet switch
- Optical fiber data connection to avoid interferences
- Input channels with parallel electronics to provide reliable data quality
- Data analysis with the generation of dedicated alarms
- Visualization of the acquired data on a web HMI
- Data access using IEC 60870-5-104 protocol
- Free parameterization by the end user administrators

10.4 Diagnostic functionalities of MV Switchgear conditioning monitor unit

The diagnostic functionalities of MV Switchgear conditioning monitor unit are the following:

- Operating times
- I2t during breaking operations
- Circuit breaker position
- Operation counter
- Fault currents summation
- Waveforms recording and processing
- Auxiliary Voltage monitoring
- Coil continuity check
- SF6 density monitoring

10.5 General Characteristics of of MV Switchgear conditioning monitor unit

The following table lists the general Characteristics of of MV Switchgear conditioning monitor unit:

Characteristic of unit	Description
Supply voltage	110 V DC tolerances -30%/+10%
Load	Max 30W
Fault	In case of fault of a component in the measuring circuit, the minimum impedance of the input becomes 1 kΩ (load on PT of 3,3 VA). The subsequent current does not further damage the circuit
Inputs connection	From the switchgears by means of connectors.
Output connection	By means of connector for optical fiber type ST multimodal 62.5/125 µm
Malfunction signaling	Fault on the internal supply; transmitted via optical fiber.
Dimensions Indoor installation	4U x 19" rack module IP 20 Panel size may vary to accommodate system selection
Dimensions Outdoor installation	Option: 400x500x350 mm Galvanized steel cabinet for external application IP 54 Panel size may vary to accommodate system selection
Weight	About 2 kg
Packaging Options	Instrument is delivered wired to its connection terminals; it does not include the wiring to the main contacts.

Table 24 - General Characteristics of MV Switchgear conditioning monitoring unit

The following image exhibits the front and back panel of the Switchgear conditioning monitoring unit:

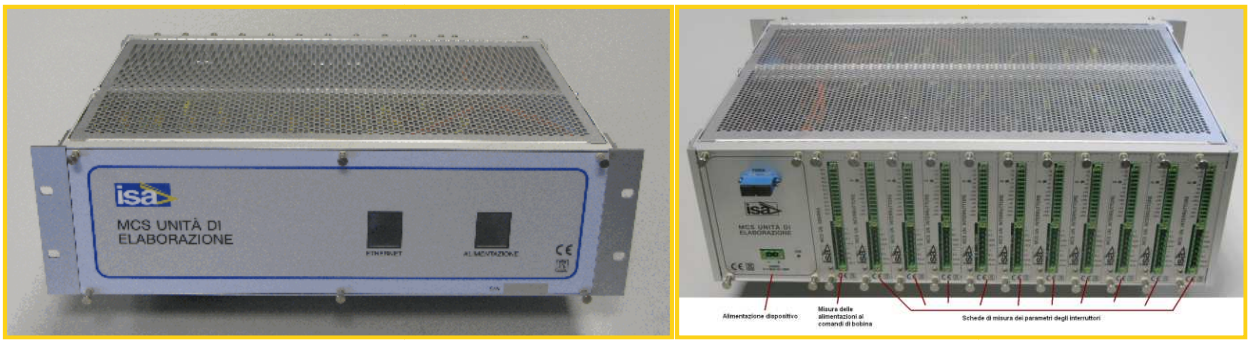

Figure 15 -Front and back panel

The following image exhibits an installation example of the Switchgear conditioning monitoring unit:

Figure 16 - Installation example

11 EDS SOFTWARE AND MONITORING

EDS software allows controlling the status of the apparatus under condition monitoring, according with the customer specifications and installation.

It is a web HMI application and it can activate with pinging the defined customer IP.

The software provides the user with information to optimize the operations and the planned maintenance activities of the assets under monitoring.

The Software provides also automatic report with the status information about the assets.

In case of values will exceed the limits the system generates alarms record which is also saved in the database. Optionally the alarm signals can be sent to the control room by standard protocols

The web based application will be customized based on the customer needs and requests.

As an option it can be possible to communicate with a SCADA by means od standard protocols such IEC 60870-5-104.

In the first page, all overall asset monitoring parameters are reported. The left menu allows to move from asset under monitoring to other.

All pages will be customized according with the specific needs of the customers.

The following images exhibit some examples of possible web Applications:

Figure 17 - examples of possible web Application

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REVISIONS

The following table lists the revisions of the document:

N.	Date	Description
1	May 2007	Preliminary Issue
2	July 2007	Complete revision of functionalities
3	July 2007	Definition of a monitoring system connected to the MRE system
4	November 2007	Revision of the document as a function of the MRE system
5	July 2015	Revision of the TVC
6	March 2016	Revision of the specifications and integration with PT
7	March 2016	Revision of the specifications

Table 25 - Revisions

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LIST OF FIGURES

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S P E C I F I C A T I O N

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