# NIC Project Holistic Circuit Condition Monitoring Specification

## 1 SCOPE

This Specification details SP Energy Networks (SPEN) requirements for network monitoring equipment for the 'Angle-DC' project being carried out in conjunction with Ofgem's Network Innovation Competition (NIC).

## 2 ISSUE RECORD

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## 3 ISSUE AUTHORITY – CHANGE BACK

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# 5 INTRODUCTION

This specification details the requirements for a Holistic Circuit Condition Monitoring (HCCM) system required for the SPEN 'Angle-DC' project trial to inform on the impact of AC to DC conversion on Medium Voltage (MV) 33kV AC circuits.

The HCCM System will be capable of real time monitoring of live circuits operating at 33kV AC and at or below ± 27 kV DC; consisting of both overhead line and cable sections. When monitoring 33 kV AC circuits, the HCCM system shall provide:

- The footprint of Partial Discharge (PD) phenomenon (ageing and early-fault trace);
- Transient Earth Fault (TEF) detection;
- Transient overvoltage detection;
- Power Quality Monitoring (PQM); and
- OHL and underground cable temperatures.

When monitoring ±27 kV circuits, , in addition to the above, the HCCM system should also be capable of DC converter 'ripple' monitoring; which may be a module including a DC converter (this can be Voltage Source Converter or Current Source Converter technology). Data from the above should be available remotely on real-time basis and may use graphical visualisation software for the representation of the above. The HCCM system should use appropriate algorithms for the specific circuit infrastructure upon which it operates.

Each of the capabilities above may be provided by equipment in a modular form. The holistic monitoring hardware could be made up outstation devices (situated along the circuit or housed at substations at either end of the circuit) and a local and remote server. The HCCM system should have the ability to allocate measurements to zones, one zone allocated to each length of cable.

# 6 FUNCTIONALITY AND MEASUREMENT REQUIREMENTS

## 6.1. Partial Discharge

The HCCM system shall be capable of detecting partial discharge currents using on-line, non-intrusive, inductive sensors These are to be deployed and operated on OHL and cable sections under 33 kV AC and ± 27 kV DC operation. PD detection equipment should contain adequate filtering to eliminate continuous sources of electromagnetic noise.

## 6.2. Transient Earth Fault (TEF) detection

The transient earth voltage probe should be capable of measuring PD in Gas Insulated Switchgear (GIS) operating at a nominal voltage of 33 kV and a DC voltage of ± 27 kV.

## 6.3. Transient Overvoltage Detection

The Transient overvoltage detector system should be capable of detecting and logging transient statistics including: the number of transient events, their magnitude, and duration

and stress factor. These will be used to help determine the severity and cause of transient over voltages.

## 6.4. Power Quality Monitoring

The HCCM system will record at 1-minute intervals the power factor of each phase of the measured feeders for periodic communication to the data server

### 6.4.1 Power Measurement

The HCCM system will record the 1- minute average for real, reactive and apparent power of each phase of the measured feeders for periodic communication to the data server.

### 6.4.2 Power Flow Sign Convention

The HCCM system will label current and power measurements that are being exported from the Anglesey network as negative figures and measurements.

### 6.4.3 Power Factor

The HCCM system will record the power factor at 1-minute intervals the power factor of each phase of the measured feeders for periodic communication to the data server.

### 6.4.4 Total Harmonic Distortion

It is preferred that the device will record Total Harmonic Distortion data at 1-minute intervals for periodic communication to the data server.

### 6.4.5 Harmonics

It is preferred that the device will record individual harmonics to minimum of 100th order to BS EN 61000-4-7, for voltage and current on the busbars at either end of the circuit.

### 6.4.6 Flicker

It is preferred that the device will record flicker data to BS EN 61000-4-15, for periodic communication to the data server.

### 6.4.7 Sampling Rate

The measurement sampling rate of the device must be stated. Preference will be given to devices with higher measurement sampling rates.

## 6.5. DC ripple monitoring

The HCCM system shall be capable of detecting DC partial discharge currents using on-line, non-intrusive, inductive sensors These are to be deployed and operated on OHL and cable sections under 33 kV AC and ± 27 kV DC operation. PD detection equipment should contain adequate filtering to eliminate continuous sources of electromagnetic noise.

## 6.6. Temperature Monitoring

The OHL and cables shall be temperature monitored in zones. These zones should be sympathetic to heat dissipation changes along the circuit length due to changes in: soil resistivity, wind sheltering conductor types and dimensions. No measurement zone should incorporate both OHL and buried cable sections.

Temperature sensor probes and data cabling should be protected using non-metallic flexible ducting. Temperature sensors used should be in accordance with IEC 60751.

Available cable and OHL temperature monitoring per zone should record the average, maximum and minimum temperatures.

*Table 1. Temperature sensor specification.*

| Measurement Parameter | Accuracy | Precision | Range | Sampling Rate |
|---|---|---|---|---|
| Cable sheath temperature | ±1 °C | 1 °C | -10 to 80°C | 1-minute average. |

## 7 SYSTEM ALARMS

The HCCM should be able to provide early warnings of deteriorating circuit condition and provide real time early warnings of faults and provide information to help direct preventative maintenance on monitored circuits; locating ‘incipient’ insulation defects ahead of failure. The alarm trigger points should be should consist of configurable thresholds within each monitoring zone and should provide early warning indicators of insulation deterioration using results from:

- The footprint of Partial Discharge (PD) phenomenon (ageing and early-fault trace);
- Transient Earth Fault (TEF) detection;
- Transient overvoltage detection;
- DC converter ‘ripple’ monitoring; and.
- Cable temperature including hotspots.

In addition to circuit fault alarms, preference shall be given to HCCM systems featuring hardware fault alarms.

## 8 PRE-INSATLLATION TESTING

The supplier shall test the equipment prior to delivery and a record of the testing/calibration results is to be included.

## 9 EQUIPMENT LOCATIONS

The HCCMS system may be double or single ended for each monitored circuit and can be installed in a modular form with module(s) and ancillary equipment located at several locations along the circuit. Installed equipment must be of a robust design suitable for the particular environment. It must be able to operate normally under vibration or shock conditions which would normally be encountered in service.

The envisaged siting scenarios are listed below:-

- Wall mounted in own enclosure as required
- Wood pole mounted in a suitable weatherproof IP68 enclosure
- Within an existing relay cabinet
- Within the existing switchgear auxiliary wiring/relay compartments

In many circumstances space for locating the device is limited. Preference will be given to smaller devices which ease installation. The space dimensions required for the device must be stated.

The monitoring device and any auxiliary communications equipment should be accommodated in a single housing where necessary. The housing will be constructed of suitable materials for the above installation scenarios and have a minimum of an IP54 rating.

Metallic enclosures will need an earthing facility.

When equipment is to be permanently attached to wood poles, M12 or M16 coach screws are to be used.

## 10 MAINTENANCE AND WARRANTY

The HCCM system shall have a working life of no less than 40 years. Parts of the holistic monitoring scheme can be replaced or refurbishment during the life of the system. Preference will be given to HCCM systems which have greater forward compatibility with replacement parts.

Any maintenance requirements of the monitoring equipment shall be specified by the supplier with details and frequencies. Preference will be given to devices requiring no maintenance and comprehensive long-term service contracts.

Details of the warranty offered for the HCCM system/component modules and ancillary devices must be stated. Preference will be given to products with warranties covering the 3 years of required monitoring during the project trial.

## 11 TRAINING, TECHNICAL SUPPORT AND PRODUCT DEVELOPMENT

Preference will be given to HCCM solutions that come with high support levels (documentation, support website, troubleshooting documents, user training, hotline etc.).

# 12 DATA RECORDING AND COMMUNICATION

All recorded data will be stored within the HCCM system for a minimum period of 90 days as standard. The device shall have capability for additional memory to extend this period to 3 years. Loss of power to the HCCM system shall not be detrimental to the stored data.

The device will be capable of communicating data from all monitoring zones to the HCCM system storage medium.

The recorded data will be time-stamped using the device real time clock. The device real time clock will be able to be synchronised remotely.

An industry standard data connection port will be available on the device for local data access and device configuration using a standard laptop PC. Software tools for configuration and data access will be included (10 licences minimum).

The HCCM system will be capable of downloading the stored data to a laptop PC for transfer to the data hub server. The output of the holistic monitor scheme shall be available for both local and remote monitoring and analysis.

The HCCM system will send processed data (as configured by the user) to a remote 3rd party data hub server in DNP3/BS 60870-5-3 format on a periodic basis (i.e. daily or more frequent as configured by the user) and have the capability of transmitting data upon a remote call request.

## 12.1. SCADA Systems

The HCCM system should be capable if interfacing with the network operators SCADA, database, enabling remote access of real-time monitoring and collected data. The HCCM system should be capable of interfacing with existing SCADA Remote Terminal Units (RTUs); including digital I/O at 48 V and analogue inputs at 0-10 mA DC and SCADA systems using industry standard SCADA protocols IEC 61850.

The HCCM system shall provide a compatible option for an interface to the network operator's existing data logging system at a sample rate agreed with the network operator, the interface shall have the facility to transfer any measurement value available to the HCCM system to the data logging system, either upon change or at a sample rate to be agreed by network operator.

## 12.2. Based Risk Management (CBRM) Scheme

The Network Operator's Maintenance Management Scheme (MMS) directs and schedules asset maintenance or replacement cycles based on asset conditions as part of an asset management strategy. The HCCM shall be able to communicate information to the network operator's MMS to inform the direction and scheduling of preventative maintenance.

# 13 PERFORMANCE REQUIREMENTS

## 13.1. Measurements

The section specifies the HCCM scan rate, measurement resolution, range and accuracy requirements of the HCCM system including the spatial resolution capability to locate a particular partial discharge measurement.

*Table 2. Measurement resolution, range and accuracy.*

| Performance Criteria | Measurement | Value |
|---|---|---|
| Power cable ageing monitoring ‘ | Reach (km) | Up to 5 km |
| Partial discharge measurement resolution | Current (pC) | ≤ 50 pC |
| DC converter ripple resolution | Voltage (V) | < 3mV |
| Power Quality resolution | Current (A) | As per IEC 61000-4/30 |
| | Voltage (V) | |
| | Frequency (Hz) | |
| | Harmonics (n, A, V) | |
| | Power Factor | |
| Power Quality accuracy | Current (A) | 0 -1000 ± 2% |
| | Voltage (V) | 0 – 900 ± 0.5% |
| | Frequency (Hz) | 40 – 70 HZ & 320 - 560 ± 0.1 Hz |
| | Harmonics (n, A, V) | up to 50$^{th}$, 0 – 100% of fundamental to IEC 61000-.4-7 2002 |
| Fault location resolution | Spatial resolution (m) | 15 |

## 13.2. Real-time Clock

| Crystal | Temperature Compensated |
|---|---|

| | |
|---|---|
| Drift | <4ppm (~2s per week) |
| Synchronisation | by remote clock via comms |

### 13.3. Data Storage

Suppliers may supply proprietary software with proprietary file formats for the reading of stored data. Data must also be available in '.csv' format for use with 3rd party software applications.

| **Buffer Storage (day of data)** | **Requirement** |
|---|---|
| Expanded data storage capability (period of data) | 3 years |
| Storage Medium | Solid State Memory |

### 13.4.

## 13.5. Communications

| | |
|---|---|
| **Communication Compatibility** | SCADA |
| **Communication format** | DNP3 or IEC 61850 |

## 13.6. Status LEDs

| | |
|---|---|
| **Power OK** | green preferred |
| **System OK** | green preferred |
| **Comms operation** | amber preferred |
| **Attention** | red preferred |

## 13.7. Power Supply

The holistic monitoring hardware shall feature redundancy requirements such as a UPS which shall ensure system operation for a period of >24-hours regardless of chosen location

| | |
|---|---|
| **AC Supply** | 230/110VAC @ 50Hz nominal (from voltage input) |
| **Isolation** | 3.0kV$_{ac}$ |

## 13.8. Environment

| | |
|---|---|
| **Operating Temperature** | -20°C to 60°C |
| **Relative Humidity** | Up to 95% non-condensing |
| **IP Rating** | IP65 according to IEC 529 (EN 60529) |

## 13.9. EMC

| | |
|---|---|
| **General emissions standard** | BS EN 61000-6-3: 2007 |
| **Radiated Immunity** | BS EN61000-4-3 10V/m Criteria A |
| **Radiated Emissions** | BS EN55011 Class A |
| **Conducted Immunity** | BS EN6100-4-6 10V/m Criteria A |

| | |
|---|---|
| **Conducted Emissions** | BS EN55011 Class A |
| **EFT** | BS EN61000-4-4<br>Supply & Contact Input 2kV Criteria A<br>Voltage Inputs 2kV Criteria B |
| **ESD** | BS EN61000-4-2<br>Contact Discharge 4kV<br>Air Discharge 8kV |

## 13.10. Safety

Potential suppliers must comply with BS EN 61010 and with their statutory obligations under Construction (Design and Management) Regulations 2007. Manufacturers should provide method statements and risk assessments to the Network Operator. The Network Operator will use these documents to facilitate the assessment of safe installation procedures for energised and non-energised installations.