DYNAMIC SYSTEM MONITORING (DSM)

PURPOSE AND SCOPE

This document describes the technical requirements for Dynamic System Monitoring (DSM) equipment pursuant to the Grid Code and the terms of the Bilateral Connection Agreement (BCA) between the User and the National Grid ESO (the Company).

PART 1 – PROCEDURAL

1 FUNCTIONAL AND PERFORMANCE REQUIREMENTS

1.1 General

This specification addresses the implementation of Dynamic System Monitoring (DSM). The specification provides the specification of the DSM's Data Acquisition Unit (DAU).

In this specification any clauses marked as "*Informative*" (texted italicized) is additional information. Compliance is not required with any "*Informative*" clauses which are intended to provide additional information or an indication of how the specification might be evolved in future.

Informative:

1. *This specification represents the requirements of the Electricity System Operator (ESO) and therefore, in general, does not specify form factor, markings, environmental, EMC emission standards, etc. These considerations are for the purchaser of the equipment.*

2. *It is the intention of this document that equipment supplied to this specification also be compatible with ENA Engineering Recommendation G99 Issue 1 Amendment 6 2020 section C.6. This is to allow for manufacturers to supply the same equipment types into the UK market irrespective of the point of connection.*

1.2 Time Keeping

All sampled and derived data shall be tagged (date and time) and stored against the DAU's internal clock synchronised to UTC, TAI or GPS time. The clock resolution must be 1 µs or better. The DAU's internal oscillator and clock shall be disciplined (synchronised) to GPS or other time standard of similar long-term stability.

The DAU's time should be accurate to less than 1 ms of the current UTC time after full synchronization has been achieved with GPS or equivalent time standard.

Timing accuracy in system holdover (loss of GPS or other timing standard) is currently unspecified.

It should be possible to specify a time zone within the unit.

Informative:

1. *If GNSS is used as a time source, then a multi-GNSS solution would be preferred.*

1.3 Bandwidth, Sampling Rates and Storage

1.3.1 The DSM shall be capable of sampling its analogue inputs at a minimum rate of 512 samples per cycle.

1.3.2 It must be possible to store all sampled data at 512 samples per cycle for the length of any event. The set of sampled (measured) and derived data and the max length of events is specified below. Sampling at 512 samples per cycle is referred to as fast scan mode.

1.3.3 It must be possible to store derived data at a lower storage rate of a minimum of twice the system fundamental (100 Hz in a 50 Hz system). This sampling rate is referred to as half-cycle or slow scan mode.

1.3.4 A pre-event capture (pre-trigger) of at least 200 ms (fast scan) and at least 5000 ms (slow scan) shall be possible in fast and slow scan respectively. Pre-event capture length shall be user specifiable.

1.3.5 A post-trigger capture of at least 2000 ms (fast scan) and at least 60 s (slow scan) shall be possible in fast and slow scan respectively. Post-event capture length shall be user specifiable.

1.3.6 The unit should be capable of storing at a minimum 28 days of data (captures and associated logs) in non-volatile memory. Automatic record and log rotation should be implemented on a first in first out basis.

Informative: To estimate the storage required the manufacturer can consider the maximum storage required for either a slow or fast scan event with all associated logs (whichever is larger) and multiple this record set size by 28.

Any other overheads that may be required should also be factored into the calculation.

1.4 Measured, Derived Quantities and Accuracy

1.4.1 The following quantities shall be measured or calculated (derived) in real time.

- Three phase voltage and three phase RMS voltage.
- Three phase current and three phase RMS voltage.
- Frequency, ideally derived from yellow phase voltage.
- Positive and negative phase sequences for voltage and current. (RMS magnitudes)
- Active and Reactive Power.
- Oscillatory conditions of active power below the synchronous frequency. It should be possible to detect oscillations of at least 15 Hz or less.

Informative: It is sufficient to implement detection of these oscillations within configurable frequency bands (filtering) but other suitable means of detection will also be considered.

1.4.2 Accuracy requirements for the DAU are as specified below. These requirements are applicable only to the measurement device.

Informative:

It is accepted that overall signal chain accuracy will be affected by the chosen instrument transformers and that in most cases the accuracy of the instrument transformers will dominate overall system accuracy.

Parameter	Measurement Range	Minimum Accuracy as a (±)% of applied input.	Resolution (±)% of nominal input	Notes
Phase sequence components (voltage)	0.8 – 1.5 $V_{n(peak)}$	0.1	0.01	Crest Factor ≤ 1.5 Measurement at 50 Hz.
Phase sequence components (current)	0 – 5 $I_{n(peak)}$	0.5 (over the range 0.1 – 5 $I_{n(peak)}$)	0.01	Crest Factor ≤ 3.0.
RMS voltage	0.8 – 1.5 $V_{n(RMS)}$	0.1	0.01	Crest Factor ≤ 1.5
RMS Current	0 – 5 $I_{n(RMS)}$	0.5 (over the range 0.1 – 5 $I_{n(RMS)}$)	0.01	Crest Factor ≤ 3.0
Active Power	0 – 5 $P_{n(RMS)}$	0.5 (over the range 0.1 – 5 $P_{n(RMS)}$)	0.01	For power factors between 0.5 and 1.0.
Reactive Power	0 – 5 $RP_{n(RMS)}$	0.5 (over the range 0.1 – 5 $RP_{n(RMS)}$)	0.01	For power factors between 0 and 0.984.
Frequency	45 – 55 Hz	0.005	0.001	0.8 to 1.5 V_n.

Table 1: Accuracy, Resolution and Measurement Range.

1.5 Triggering

1.5.1 Dynamic system event half-cycle triggering (slow scan) shall be:

Parameter	Level Trigger Over (+) Under (-)	Step	Phase step (º)	Rate of Change
Frequency	● (+/-)	● (+/-)* optional		● (+/-)
Voltage (waveform)	● (+) Based of absolute values of voltage.	● (+/-)	● (+/-)	● (+/-)
Voltage (RMS)	● (+/-)	● (+/-)	● (+/-)	● (+/-)
Current (waveform)	● (+) Based of absolute values of current.	● (+/-)* optional		
Current (RMS)	● (+/-)	● (+/-)* optional		

Parameter	Level Trigger Over (+) Under (-)	Step	Phase step (º)	Rate of Change
Positive sequence voltage (RMS)	● (+/-)			● (+/-)
Negative sequence voltage (RMS)	● (+)			
Active Power	● (+/-)			● (+/-)
Reactive Power	● (+)	● (+/-)		
Power Factor	● (+/-)			
Digital inputs	Rising edge/falling edge. (See section 4.2)			

*Triggering on frequency and current step changes are not mandatory requirements.

Table 2 Dynamic system event half-cycle (slow scan) triggering.

1.5.2 Dynamic system event waveform triggering shall be as be as detailed in the table below:

Parameter	Over (+)/ Under (-) Deviation (%)	Step (%)	Phase step (º)	Period	Number of oscillations in time window
Voltage waveform	● (+/-)	● (+/-)	●		
Current waveform	● (+/-)	● (+/-)	●		
Active Power oscillation	● (+)			●	●
Digital inputs	Rising edge/falling edge. (See section 4.2)				

Table 3 Dynamic system event waveform triggering.

1.5.3 The type and magnitude of triggering shall be independently selectable on all analogue input channels and on all calculated quantities.

1.5.4 Digital triggering shall be initialised by either the opening of a normally closed contact or the closing of a normally open contact. The required trigger mode shall be independently selectable on all channels. It shall be possible to deselect any channel so that it does not trigger the DAU. The Manufacturer shall specify the voltage tolerances for a logic '1' and a logic '0'.

2 OVERALL SYSTEM REQUIREMENTS

2.1 Instrument Transformers/Voltage and Current Transducers

Informative: The section is not part of the specification of the DAU itself. The following section provides indication of the minimum requirements for instrument transformers or similar voltage and current transducers. It is intended for system integrators to meet overall system performance and to allow integrators to provide quotes on a common footing.

2.1.1 Any variation in the required instrument transformers can be made in the connection agreement.

2.1.2 The three phase voltage analogue inputs shall be derived from a voltage transformer arrangement comprising three single phase voltage transformers connected in primary star with the centre point earthed. Other configurations can be considered on request.

2.1.3 The three phase current analogue inputs shall be derived from a current transformer arrangement comprising three single phase current transformers.

2.1.4 Should higher specification be required the instrument transformers, or similar transducer, will be specified in the connection agreement.

2.1.5 Unless otherwise specified in the connection agreement the voltage analogue inputs to the DAU can be derived from capacitive VTs and the current measurements from protection class CTs such as 5P10 or 5P20. If available dual class CTs should be used.

Informative: No frequency requirements are currently placed on the instrument transformers used.

3 DATA & USER REQUIREMENTS

Informative: This specification currently only provides the following limited requirements for remote and local data access. It would be an expectation that firmware and other software be reasonable made available to ensure the continued functioning and support of any installed unit. It is the responsibility of the owner of the DAU to maintain the unit and ensure that it is functional.

3.1 Communication Architecture

3.1.1 The DSM shall provide the ability to transfer captured data, logs, system diagnostic information, as may be required by the manufacturer, via:

(a) An ethernet LAN interface.

(b) A local interface other than the Ethernet interface specified above.

Both interfaces must be available.

Informative: The Ethernet interface is to be used for remote access and retrieval of records by the ESO, if required. The owner/purchaser of the DAU may have requirements/considerations beyond those specified within this TS. The above list of interfaces is the minimum set of interfaces which should be provided.

3.2 Data Formats and Client Software

3.2.1 It must be possible to export all captured data, logs and settings, this can be via client software, to either IEC 60255-24 COMTRADE, comma separated values (CSV) or plain text format. Character encoding is at the discretion of the manufacturer, but ASCII is preferred.

4 HARDWARE PLATFORMS

4.1 General

4.1.1 The DSM functionality may be integrated into a device that provides multiple other functions, for example quality of supply monitoring, provided that the requirements of the DSM are achieved as specified.

4.2 Single Point Status Inputs

4.2.1 Single point status inputs shall be provided for the indication of main plant status or the triggering of captures.

4.3 Single Point Status Outputs

4.3.1 The following Status Outputs shall be provided as a minimum.

a) Equipment healthy.

b) Out of service mode selected.

c) Optional: Loss of GPS/timing standard.

Informative:

1. *It is the expectation of the ESO that the end user will wire these contacts to their SCADA system. These outputs are provided because it is appreciated that users may not wish to have a direct computer network interface to the DSM for security reasons.*
2. *Ideally the single point output should be provided via normally open relay. It would also be expected that the DSM internal implement a hardware watchdog such that should the DSM's software fail that a hardware reset occur that would cycle the relay during the reboot process.*
3. *It would be suggested that it be possible to mute any particular alarm from operating the equipment health relay either permanently, or that the alarm remains muted until it is cleared. A simple option to mute all current standing alarms/events from operating the "equipment healthy" output until that alarm falls would be ideal.*

5 TEST REQUIREMENTS

5.1 General

5.1.1 The equipment shall be tested in accordance with the requirements of TS 3.24.15 (RES) – Environmental and Test Requirements for Electronic Equipment.

For the purposes of electrical environmental tests all equipment shall be classified as "substation equipment".

During and after all environmental tests, all equipment shall meet with the requirements of this specification. No additional derogation is given for influence quantities.

Performance requirements are inclusive of the effects of all external accessories e.g. current shunts and current transformers.

5.1.2 The manufacturer of the electrical equipment shall declare conformance with the essential requirements (safety objectives) of the European Union Low Voltage Directive 2006/95/EC. A CE mark shall be affixed to all equipment to confirm that the equipment has been manufactured in accordance with the applicable technical standards and essential requirements as defined in the Directive.

6 CALIBRATION AND TESTING

6.1.1 It is the DSM owner's responsibility to ensure that the DSM remains functioning and accurate. The ESO has the right to request demonstration of accuracy and functionality. Initial compliance will be demonstrated at commissioning.

6.1.2 Unless otherwise specified in the connection contract, it is expected that malfunctions that result in a loss of the DSM system should be rectified within one week.

7 OTHER REQUIREMENTS

7.1.1 The calibration period over which performance requirements are met shall be defined. The equipment and software shall be supportable for a period not less than 15 years.

8 FORMS AND RECORDS

Not applicable.

PART 2 – DEFINITIONS AND DOCUMENT HISTORY

9 DEFINITIONS

CT	Current Transformer
DAU	Data Acquisition Unit
DSM	Dynamic System Monitor
GPS	Global Positioning System
GNSS	Global Navigation Satellite System
I_n	Nominal input current
LAN	Local Area Network
NPS	Negative Phase Sequence
PPS	Positive Phase Sequence
QoS	Quality of Supply
TAI	International Atomic Time
V_n	Nominal input voltage
VT	Voltage Transformer
WAN	Wide Area Network
PMU	Phasor Measurement Unit
MTBF	Mean Time between Failure

10 AMENDMENTS RECORD

Issue	Date	Summary of Changes / Reasons	Author(s)	Approved By (Inc. Job Title)
1	October 2014	First Issue	Richard Poole	GCRP
2	February 2018	Alignment with EU codes	Thomas Charton	GCRP
3	December 2018	Updated data collection options as requested by the SO	Thomas Charton	GCRP
4	January 2021	Removed many hardware requirements. Tighten time specification. Aligned features with ENA G99 but excluded Power Quality Metering Parameters. Included minimum instrument transformer specifications.	Murray Yelland	

11 PROCEDURE REVIEW DATE

5 years from publication date.

PART 3 - GUIDANCE NOTES AND APPENDICES

12 REFERENCES

12.1 National/International Standards

IEEE C37.118-2005	Reporting synchronized phasor measurements in power systems.
IEC 61000-4-30	Electromagnetic Compatibility – Testing and Measurement Techniques – Power Quality Measurement Techniques
IEC 61850	Communication networks and systems in substations

12.2 National Grid ESO Documents

TS 3.24.15 (RES)	Environmental and test requirements for the hardware units
TS 2.19 (RES)	Ancillary Light Current Equipment