AEMO
AUSTRALIAN ENERGY MARKET OPERATOR

Attachment 1: New South Wales Phasor Measurement Unit Specification

November 2022

VERSION CONTROL

Version	Release date	Changes
0.8	8/11/2022	Minor wording changes to be in line with other NEM regions
0.7	08/06/2022	Incorporated Feedback from TransGrid
0.6	13/12/2021	Added details on replacement of Qualitrol devices and extra sites
0.5	04/10/2021	In section 3, clarify the relevant side (HV or LV) of transformers for current (and voltage) measurements
0.4	16/07/2021	Updated to align with the master NEM document
0.3	02/07/2021	Populate data in Table 2.
0.2	12/11/2020	Clarify the use of metering CTs and Protection CTs for obtaining current measurements. The term PSU meaning Power Supply Unit is added to the Glossary.
0.1	14/10/2020	Initial draft

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Functional requirements

1. PMU data measurement requirements

1.1. Measurement quantities

A Phasor Measurement Unit (PMU) must measure the quantities specified in section 3. Each quantity must be provided as 3 x single phase rms phasors as defined in IEEE standard c37.118. Voltages must be provided in volts as phase-to-ground measurements. Currents must be provided in amps. All phasors must be provided in polar format.

Frequency and rate-of-change-of frequency must also be provided in accordance with IEEE standard c37.118. Calculation of these Frequency and Rate-of-change of frequency quantities must be automatically performed by the PMU.

For each substation, 2 independent voltage measurements should be located so as to provide redundancy and coverage in the event of bus reconfiguration. Bus voltage measurements are preferred, however if 3 phase VTs are unavailable line measurements are also acceptable.

All quantities must have a 50Hz sample rate.

It is preferred to obtain current measurements from metering current transformers (CTs) to maximise overall accuracy of measurements. If the requested current measurements are not readily available from metering CT cores or would require excessive cost and complexity then, subject to a demonstration that confirms this meets requirements and with AEMO's written agreement, current measurements may be obtained from protection CT cores.

1.2. Accuracy range

All *new* PMU devices should be configured with protection (P) class accuracy and must meet the accuracy requirements set out in the IEEE standards C37.118.1-2011 and C37.118.1a-2014. For reference the standard specifies the following steady-state accuracies:

- Voltage: ±1% TVE[1]
- Current: ±1% TVE
- Angle: ±1% TVE
- Frequency accuracy: ±0.005 Hz
- Frequency range: 45-55Hz

Note: This is accuracy of the monitor, not the entire installation.

Legacy PMUs already installed in the network must meet the accuracy requirements in IEEE standards C37.118-2005 as a minimum. If firmware becomes available that supports C37.118.1a-2014 then devices should be upgraded with this new firmware.

1.3. Time measurement

The PMU's internal clock must be synchronised with a GPS sourced IRIG-B with an accuracy of at least ±500 nanoseconds.

[1] Total Vector Error - refer to IEEE Std C37.118.1-2011.

2. System requirements

2.1. Monitor hardware

At each location, a PMU capable of meeting the accuracy and synchronisation requirements as outlined in section 1 must be installed. As the devices must be located in electrical substations, they must be capable of operating in a wide range of environmental conditions and meet TNSP substation equipment standards.

2.2. Existing Qualitrol (HSM) Devices

As part of this request, all existing Qualitrol HSM devices are to be decommissioned in coordination with AEMO and replaced with PMUs as the Qualitrol devices have reached their end-of-life.

Where a PMU is to be installed to replace a Qualitrol device, the CTs, VTs, cabling and other infrastructure facilitating the HSM may be reused for the PMU. An outage of high-speed data is acceptable to facilitate cutting over from the HSM to the PMU, provided it is no longer than 14 days.

Following installation of all PMUs, the OPDMS / participant batcher system shall be decommissioned.

2.3. Monitor software

2.4. Data transfer requirements

Data transfer from each PMU to the TransGrid/AEMO interface shall be in accordance with AEMO's Power System Data Communication Standard[2] section 5: Interfacing (a) only.

2.5. Performance & Reliability

Performance of a PMU and associated equipment including communications equipment to the TransGrid/AEMO interface must be in accordance with:

- PMU equipment failure – replace within 5 days
- PDC equipment failure – swap to hot standby in 24 hours, replace within 5 days

[2] https://www.aemo.com.au/-/media/Files/Electricity/NEM/Network_Connections/Transmission-and-Distribution/AEMO-Standard-for-Power-System-Data-Communications.pdf

- PMU network up time 99.5%
- PDC network up time 99.9%

2.6. Cyber Security

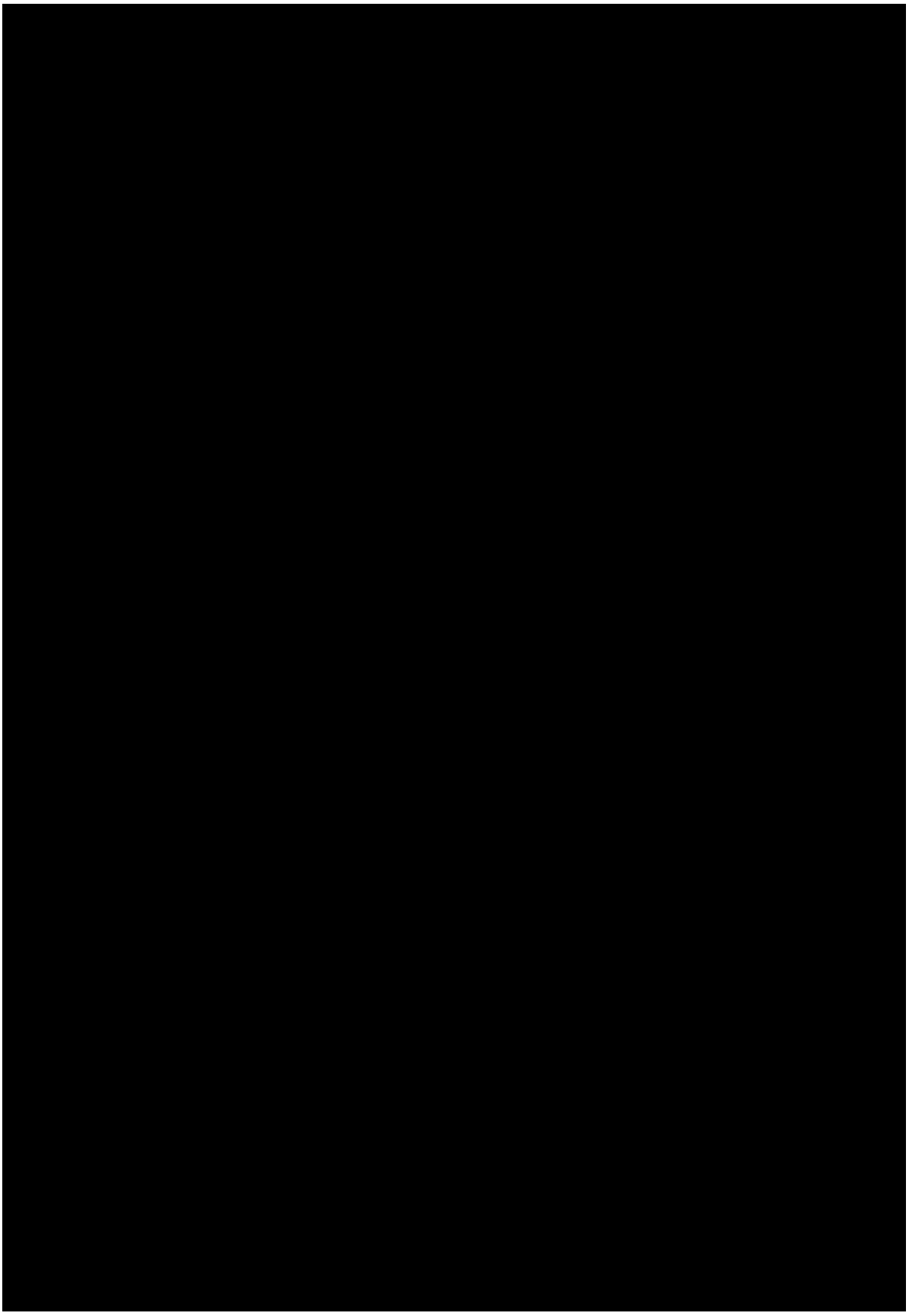
Security of a PMU and associated equipment including communications equipment to the TransGrid/AEMO interface must be in accordance with AEMO's Power System Data Communication Standard section 4: Security.

2.7. Maintenance requirements

Maintenance of a PMU and associated equipment including communications equipment to the TransGrid/AEMO interface including response to failures, outage co-ordination, data management and co-ordination, and testing to confirm compliance must be in accordance with section 2.5.

Configuration of phasor data concentrators and commissioning of data transfer will be performed in association with AEMO.

Figure 1 Proposed Communications link between TransGrid and AEMO



3. Measurement quantities

3.1. Locations of Qualitrol Devices to be Replaced

Table 1 High Priority HSMs to be Replaced by PMUs

Number	Location	Current measurements
1	[redacted]	[redacted]
2	[redacted]	[redacted]
3	[redacted]	[redacted]
4	[redacted]	[redacted]
4	[redacted]	[redacted]
5	[redacted]	[redacted]
6	[redacted]	[redacted]
7	[redacted]	[redacted]
8	[redacted]	[redacted]

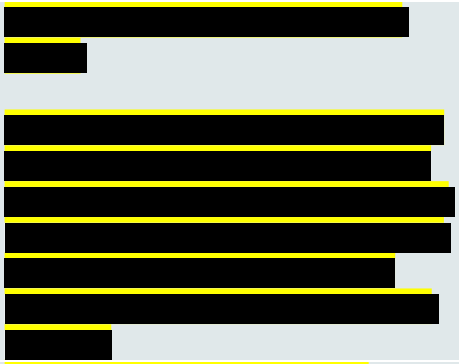
Number	Location	Current measurements
9	[redacted]	[redacted]
10	[redacted]	[redacted]
11	[redacted]	[redacted]
12	[redacted]	[redacted]
13	[redacted]	[redacted]
14	[redacted]	[redacted]
15	[redacted]	[redacted]
16	[redacted]	[redacted]
17	[redacted]	[redacted]

3.2. Locations of New PMUs to install (in priority order)

Table 2 Medium Priority New PMU installations

Number	Location	Voltage measurements	Current measurements
1	[redacted]	[redacted]	[redacted]
2	[redacted]	[redacted]	[redacted]
3	[redacted]	[redacted]	[redacted]
4	[redacted]	[redacted]	[redacted]

Number	Location	Voltage measurements	Current measurements
5			
6			
7			
8			

Number	Location	Voltage measurements	Current measurements
			
9			
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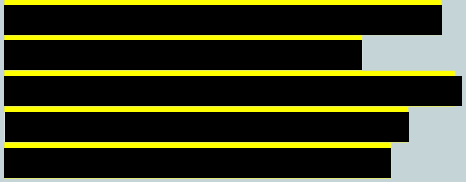
11			

Number	Location	Voltage measurements	Current measurements
12			
13			

Table 3 Low Priority New PMU installations

Number	Location	Voltage measurements	Current measurements
1			

Number	Location	Voltage measurements	Current measurements
2	[redacted]	[redacted]	[redacted]
3	[redacted]	[redacted]	[redacted]
4	[redacted]	[redacted]	[redacted]
5	[redacted]	[redacted]	[redacted]
6	[redacted]	[redacted]	[redacted]
7			[redacted]

Number	Location	Voltage measurements	Current measurements
	[redacted]	[redacted]	[redacted]
8	[redacted]	[redacted]	[redacted]
9	[redacted]	[redacted]	[redacted]
10	[redacted]	[redacted]	[redacted]

Number	Location	Voltage measurements	Current measurements
11	[redacted]	[redacted]	[redacted]

Number	Location	Voltage measurements	Current measurements
12	[redacted]	[redacted]	[redacted]

Glossary

Term	Definition
TransGrid/AEMO interface	A point where TransGrid's PDC system connects to AEMO's PDC system
IEEE c37.118	A standard covering many aspects relating to high-speed streaming devices including the calculation of synchrophasor, accuracy standards, communication protocols and message formats. Defines the raw binary message data structure emitted and consumed by PMUs and PDCs.
IRIG-B	A method of synchronising power system measurements with a global positioning satellite clock. Usually provided to the monitoring hardware via a co-axial cable.
PDC	Phasor Data Concentrator. A piece of software that communicates and coordinates a network of many PMUs, concentrates the data into a single stream and sends the data to a PDC located at another organisation.
PMU	Phasor Measurement Unit. A piece of hardware located at an electrical substation that converts an analog power system quantity to a digital signal, converts the waveform to a synchrophasor and then transmits the data at a typical rate of 50Hz over TCP/IP using the IEEE C37.118 protocol. Can also transmit analog non-phasor data and digital (boolean) data.
Power System Data Communication Standard	Means AEMO's Power System Data Communication Standard as amended, supplemented or replaced from time to time
PSU	Means Power Supply Unit
Synchrophasor	A representation of a current or voltage waveform using two numerical values. Consists of a magnitude that specifies the amplitude of the waveform, and an angle which specifies the phase shift of the waveform.
WAMS	Wide Area Monitoring System. A piece of software that analyses synchrophasor data in real-time to provide insights to power system operators. It also stores the raw synchrophasor data to a database for offline analysis.