VPP DEMONSTRATIONS FCAS SPECIFICATION

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1.0	1 August 2019	First issue of the final specification for DER to provide Contingency FCAS
1.1	12 September 2019	Minor amendment to section 1

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1. INTRODUCTION

The specifications in this document relate to measurement facilities for distributed energy resources (DER) in virtual power plants (VPPs) to provide contingency frequency control ancillary services (FCAS).

1.1. Background

Traditionally, FCAS in the National Electricity Market (NEM) have been provided by utility-scale transmission connected plant that have high-speed data recorders in place as standard to confirm they are able to meet their registered Generator Performance Standard. These data recorders meet or exceed the telemetry requirements of the Market Ancillary Service Specification (MASS).

In recent years, the NEM has witnessed an unprecedented rise in the uptake of DER. These facilities, if properly orchestrated, are increasingly capable of providing frequency control services to the market.

AEMO is launching the Virtual Power Plant (VPP) Demonstrations to trial alternative metering and telemetry arrangements that would be manageable within VPP arrangements, but have sufficient capability to meet the need to verify fast FCAS delivery by aggregated DER. As provided for in Section 7.3 of the MASS, AEMO may allow an Ancillary Service Facility to participate in a trial to test the performance of new technologies.

1.2. Purpose of this document

This VPP Demonstration FCAS Specification applies to Market Participants who intend to apply to classify their loads as ancillary service loads, or who have so classified their loads, in the VPP Demonstration (VPP Participant). Further information on the VPP Demonstration, including how to apply for enrolment, are set out in the VPP Enrolment Guide[1].

This VPP Demonstration FCAS Specification provides:

- the monitoring and recording requirements which a VPP Participant must install and maintain, and the standards which apply to the equipment, to monitor and record the response of the *ancillary service load* to changes in the *frequency* of the *power system* under clauses 3.11.2(f) and (g) of the Rules;
- certain circumstances in which AEMO intends to request a report detailing how the relevant *facility* responded to a particular change or particular changes in the *frequency* of the *power system* in accordance with clause 3.11.2(h) of the Rules; and
- the standard test procedures that AEMO will use when requiring a VPP Participant to demonstrate the relevant *plant's* capability to provide the *market ancillary service* to the satisfication of AEMO under clause 3.11.2(i) of the Rules.

Nothing in this document should be taken to represent that these arrangements will continue after the VPP Demonstrations are complete, that any VPP will be permitted to participate in the VPP Demonstrations, or that any VPP will be able to participate in the FCAS markets after the VPP Demonstrations are completed.

Learnings from the VPP Demonstrations and the consultation in connection with MASS consultation will inform the ongoing arrangements for FCAS registration as those processes are completed. This may result in amendments to telemetry/metering equipment requirements for DER in VPPs.

[1] http://aemo.com.au/-/media/Files/Electricity/NEM/DER/2019/VPP-Demonstrations/VPP-Demonstrations-Enrolment-Guide

Parties installing telemetry and metering equipment on the basis of this specification do so at their own risk.

1.3. Definitions and interpretation

Terms defined in the MASS, the National Electricity Law or the National Electricity Rules (NER) have the same meaning in this VPP Demonstration FCAS Specification, unless otherwise specified in this section 1.3.

These requirements in the VPP Demonstration FCAS Specification support the following definitions for the purposes of the VPP Demonstrations:

Table 1 Definition of term

Term	Definition
Aggregated Loud Amount	means the amount of power flow through one or more *connection points* of an aggregated *ancillary service load*, measured in megawatts (MW).
Load Amount	means the amount of power flow through a *connection point* of an *ancillary services loa*d, measured in MW.
Lower Response	means: (a) the decrease in export of power from the *connection point* with respect to the corresponding Initial Value, measured in MW, with flow from the *connection point* being positive; and (b) the increase in import of power to the *connection point* with respect to the corresponding Initial Value, measured in MW, with flow towards the *connection point* being negative.
Raise Response	means: (a) the increase in export of power from the *connection point* with respect to the corresponding Initial Value, measured in MW, with flow from the *connection point* being positive; and (b) the decrease in import of power to the *connection point* with respect to the corresponding Initial Value, measured in MW, with flow towards the *connection point* being negative.

1.4. Interaction of this document with MASS

The VPP Demonstration FCAS Specification applies in accordance with the MASS, the National Electricity Rules (Rules) and the National Electricity Law.

The provisions in the MASS apply to the VPP Participant and the performance of ancillary services except as expressly provided in this VPP Demonstration Specification.

The National Electricity Rules and National Electricity Law prevail over the VPP Demonstration FCAS Specification to the extent of any inconsistency.

1.5. Contingency FCAS delivery

To determine if the VPP Demonstrations have been successful, AEMO will verify the performance of the VPP based on the aggregated response of the ancillary service loads to deliver contingency FCAS during a frequency disturbance.

2. VPP DEMONSTRATIONS TELEMETRY REQUIREMENTS

The telemetry requirements set out below are issued by AEMO under Clause 3.11.2(f) of the National Electricity Rules (Rules) and apply for the purposes of the VPP Demonstrations only.

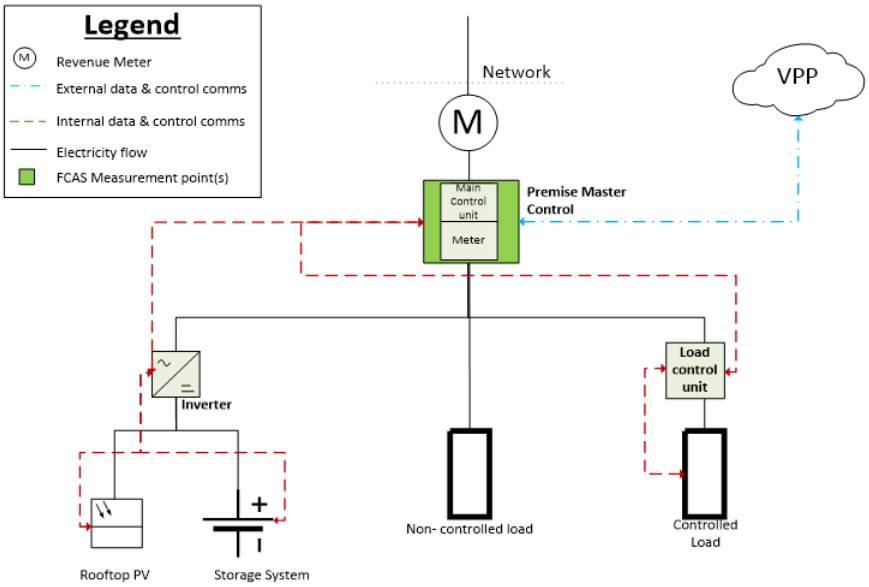
AEMO will apply the following minimum monitoring and recording requirements to parties that may participate in the VPP Demonstrations to deliver contingency FCAS from aggregated DER. Note that, depending on the proposed service, AEMO may require further conditions to be met.

2.1. Measurement points

FCAS response measurement points vary according to the configuration of the controllable devices behind the *connection point*. Some examples of the location of the FCAS response measurement points are provided as follows:

(a) If FCAS is being delivered from a battery energy storage system and controlled load via a main control unit, frequency and power must be measured at the main control unit as shown in Figure 1. The main control unit in Figure 1 is not required to be a separate physical device and could be integrated with the hybrid inverter shown below or the battery inverter as shown in Figure 2.

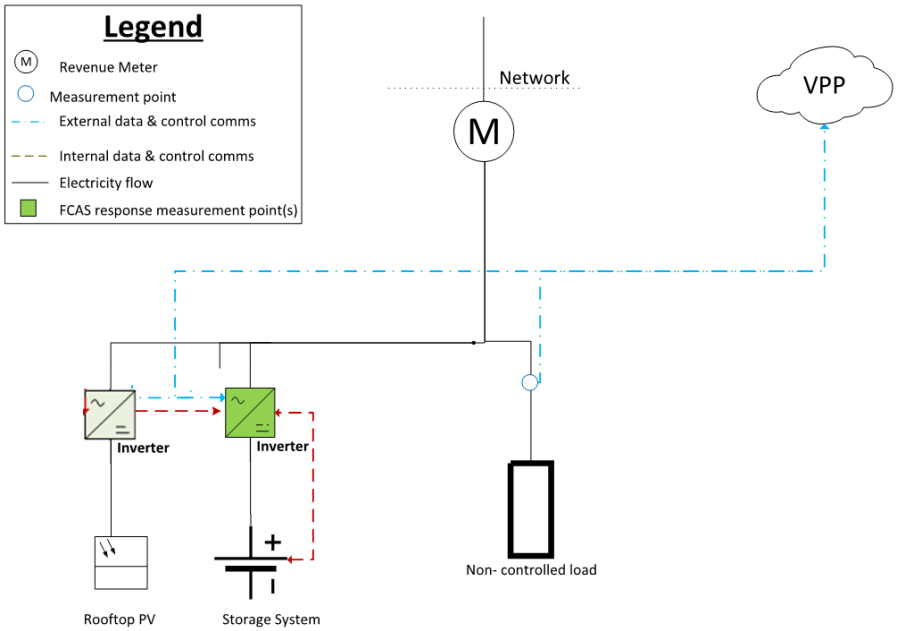
Figure 1 Main control unit FCAS measurement point



(b) If FCAS is being delivered from a battery energy storage system via a dedicated inverter, frequency and power must be measured at the battery inverter level and for the non-controlled load, as shown in Figure 2.

If the raise or lower FCAS response from the battery energy storage system varies with changes to the photovoltaic (PV) output or the non-controlled load during a frequency excursion, the net active power response behind the connection point must be provided to AEMO for the verification of the FCAS delivery.

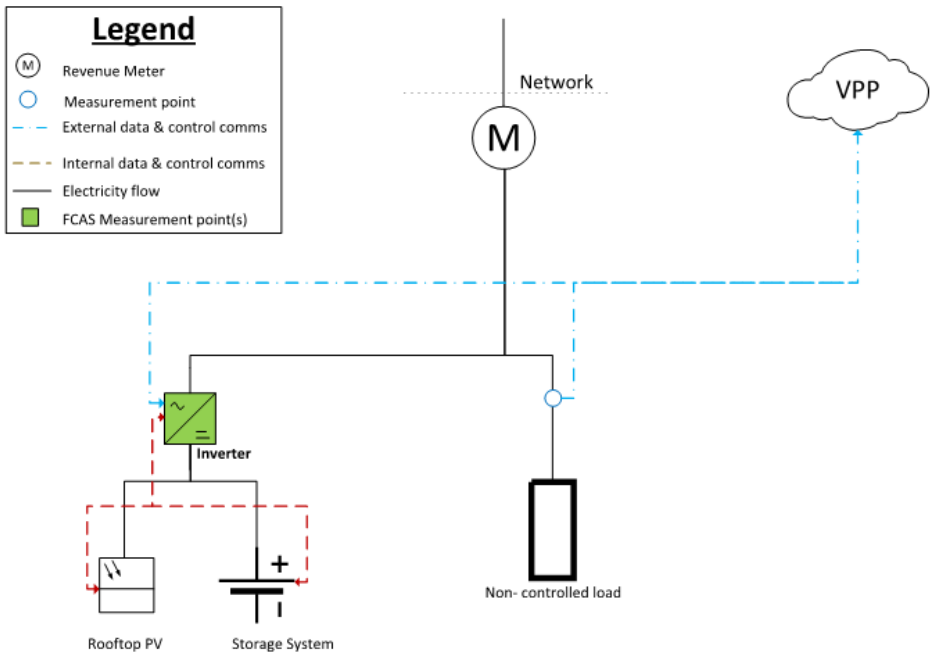
Figure 2 Dedicated battery inverter FCAS measurement point



(c) If FCAS is being delivered from a battery energy storage system via a hybrid inverter, frequency and power must be measured at the inverter level and for the non-controlled load, as shown in Figure 3.

If the raise or lower FCAS response from the battery energy storage system varies with changes to the PV output or the non-controlled load during a frequency excursion, the net active power response behind the connection point must be provided to AEMO for the verification of the FCAS delivery.

Figure 3 Hybrid inverter FCAS measurement point

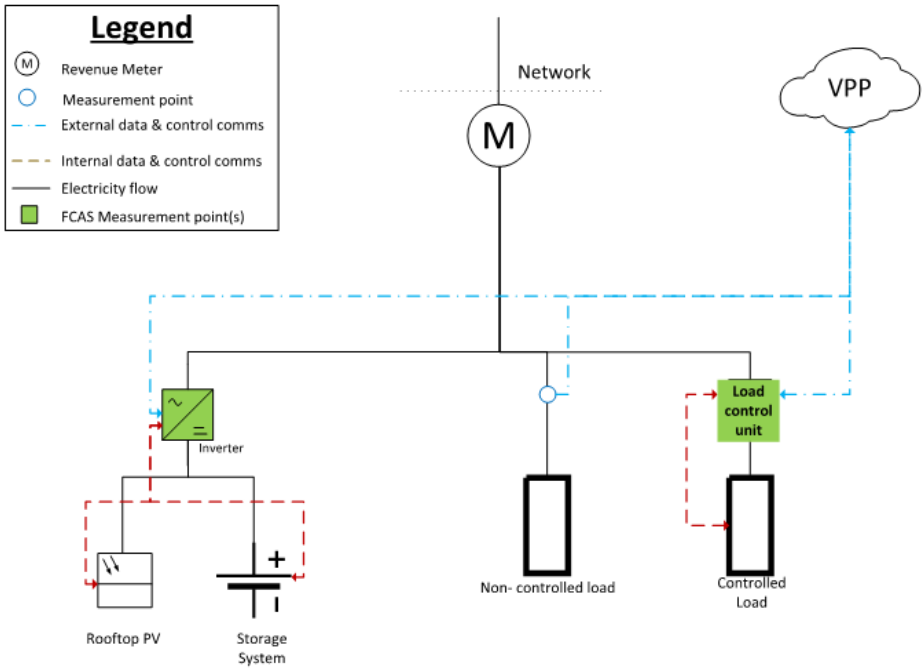


(d) If FCAS is being delivered from a battery energy storage system and from controlled loads separately, i.e. by different Dispatchable Unit IDs (DUIDs), there must be two FCAS response measurement points of frequency and power. In this example, the net load at the connection point (sampling on a time base less than or equal to 4 seconds) must also be measured for compliance purposes. One of the FCAS measurement points in this example could be from either the hybrid inverter as shown in Figure 4 or from a dedicted battery inverter as shown in Figure 2.

If the raise or lower FCAS response from the battery energy storage system varies with changes to the PV output or the non-controlled load during a frequency excursion, the net active power response behind the connection point must be provided to AEMO for the verification of the FCAS delivery.

Both frequency and power of the non-controlled load must also be measured.

Figure 4 Hybrid inverter and load control unit FCAS measurement points



(e) If FCAS is being delivered by a configuration of controllable devices which is not reflected in paragraphs (a) – (d) above, AEMO will consider the required measurement points for the configuration and devices in question to ensure an accurate measurement of FCAS delivery.

2.1.1. Non-controlled load measurement

The measurement of power for the non-controlled load will be used for compliance purposes to ensure that the FCAS response is not negated by the non-controlled load on purpose.

AEMO would agree to use the measurement of frequency at the inverter level only, if the measurement of power for the non-controlled load is on a common time scale as the measurement of frequency at the hybrid or battery inverter level.

The non-controlled load is not required to be directly measured if it can be calculated using measurement of net power behind the connection point, PV output, battery energy storage power and controlled load.

AEMO may require direct measurement of non-controlled load if a National Metering Identifier (NMI) is being registered under more than one DUID.

2.2. Monitoring and recording requirements

When recording a Raise Response of a *fast raise service*, or a Lower Response of a *fast lower service*, VPP Participants must satisfy the requirements of clause 3.6(a)(iii), (iv) and (vii) of the MASS, or one of the following alternative monitoring requirements:

(a) High speed data samples of active power flow and Local Frequency on a time base less than or equal to 100 milliseconds at every FCAS response measurement point shown under Section 2.1. Both the aggregated and individual response from every NMI enabled to deliver the *fast service* must be provided to AEMO on request following a contingency event.

(b) Measurements of Local Frequency and power flow must be captured on a time base less than or equal to 1 second at every FCAS response measurement point shown under Section 2.1, unless AEMO has specified as per Section 2.1.1 when one measurement of frequency would be acceptable for a *connection point*. Sufficient information should be provided to compare the Local Frequency and power flow data in a common time scale.

The provisions of 2.2.1 and 2.2.2 apply to measurement facilities for fast raise services and fast lower services only where the VPP Participant is measuring Local Frequency and power flow in accordance with paragraph (b) above.

The provisions of 2.2.3 apply to measurement facilities for fast raise services and fast lower services where a VPP Participant is measuring Local Frequency and power flow in accordance with paragraph (a) or (b) above.

2.2.1. Measurement facilities for fast raise services and fast lower services

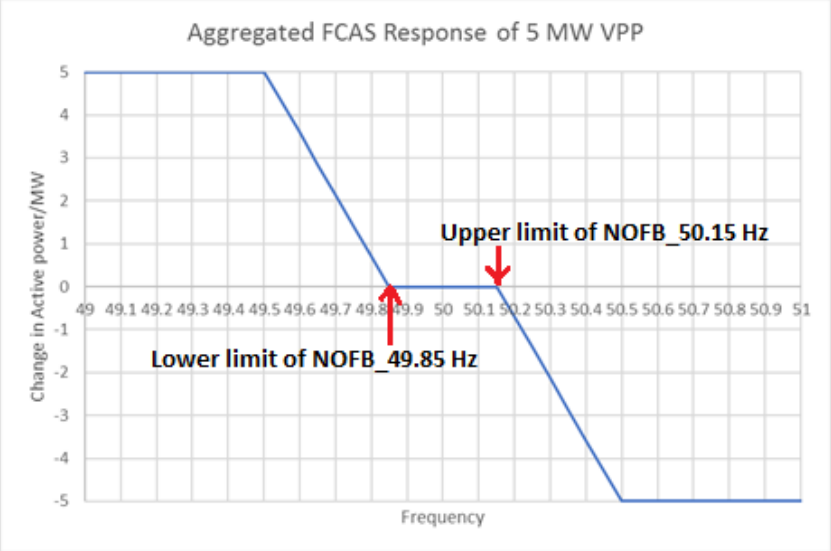
One high speed meter (sampling of frequency on a time base less than or equal to 50 milliseconds) is required per region. The purpose of this meter to determine the expected fast FCAS response using the assigned droop setting of the variable/proportional controllers or the frequency deviation setting of the switching controllers.

2.2.1.1 Variable FCAS controller

To confirm the delivery of FCAS the following steps will be required:

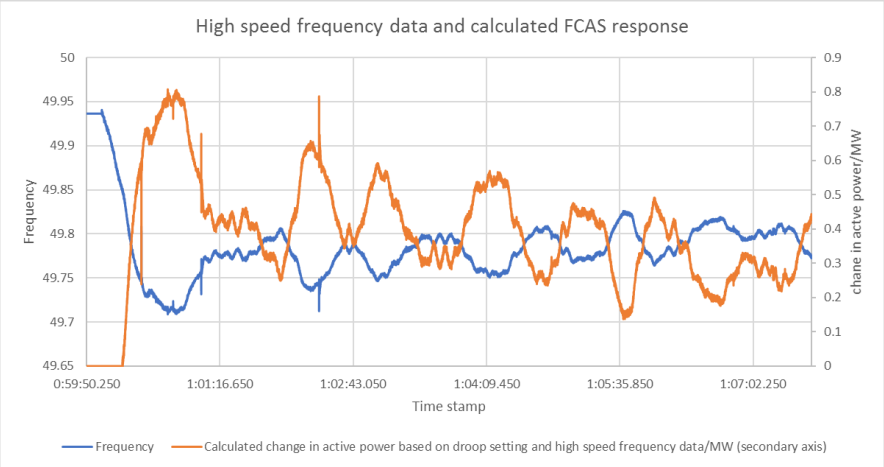
(c) Based on the droop setting of the controllable devices of the VPP, the expected response will be calculated using the high-speed data of frequency. The expected aggregated FCAS response of a 5 MW VPP with facilities delivering a variable/proportional FCAS response from the edge of the Normal Operating Frequency Band (NOFB) with a droop of 0.7% is shown in Figure 5:

Figure 5 Droop curve of 5 MW VPP



(d) If the frequency captured by the high-speed meter is as shown in Figure 6 and the VPP is enabled for 2 MW of the fast raise contingency services, the expected change in active power can be calculated using the high-speed frequency data captured.

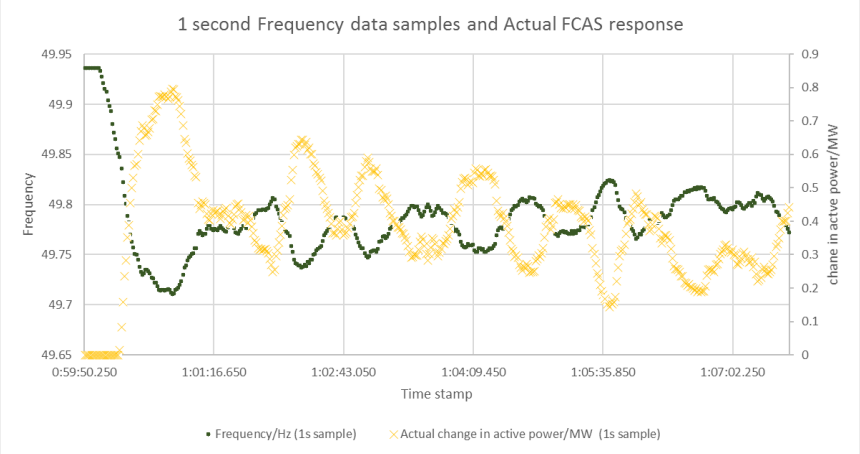
Figure 6 Calculated FCAS response based on high speed frequency data



(e) Measurement of power flow and frequency must be captured at every connection point and the sampling rate must be equal to or less than 1 second.

The actual response of the VPP following a frequency deviation is shown in Figure 7:

Figure 7 Actual FCAS response following frequency deviation

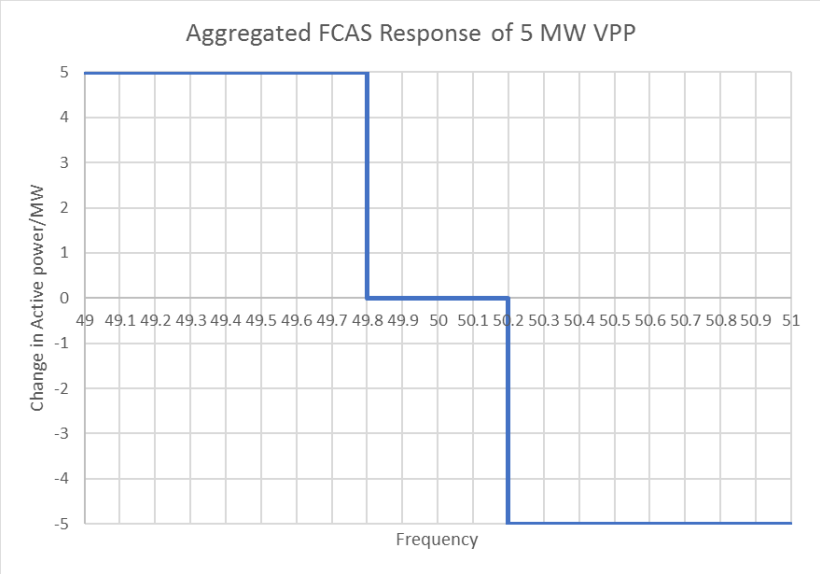


The actual change in active power measured at any time following the contingency event, must be equal to or more than the calculated FCAS response.

2.2.1.2 Switching FCAS controller

The expected aggregated FCAS response of a 5 MW VPP delivering FCAS from controllable loads only, using switching controllers with a raise service frequency deviation setting of 49.8 Hz and a lower service frequency deviation setting of 50.2 Hz is shown in Figure 8.

Figure 8 Expected Aggregated FCAS response based on frequency deviation



The same process used to verify the FCAS delivery from the proportional controllers, can be followed to confirm the compliance of the VPP with switching controllers, i.e, the actual power flow captured at a sampling rate of 1 second will be compared to the calculated FCAS response of the VPP based on the raise/lower frequency deviation settings and the enablement FCAS amount.

2.2.2. Calculated FCAS response adjustment

As per the calculated FCAS response required under Section 2.2.1, if the absolute value of the net power flow at the FCAS measurement point before the frequency disturbance was more than the

error of the measurement of the power flow, as specified under Section 2.2.3, the calculation of the FCAS response using high speed frequency data would need to take this into account.

2.2.3. Metering accuracy and sampling rate

The following measurement requirements are required to align with the metering accuracy and sampling rate specified in the MASS.

(a) The error and the resolution of the measurement of the power flow and Local Frequency must comply with Clause 3.6a (v) and (vi) of the MASS for *fast raise services* and *fast lower services* , Clause 4.6a (iv) and (v) for *slow raise services* and *slow lower services* and Clause 5.6a (iv) and (v) for *delayed raise services* and *delayed lower services*, unless otherwise agreed by AEMO if the participant can demonstrate that measurements with the proposed error and resolution can be used to accurately determine the delivery of FCAS.

(b) The aggregated and individual response of the DER units enabled to provide the *slow raise services, slow lower services* and *delayed raise services and delayed lower services* (sampling on a time base less than or equal to 4 seconds) must be captured and meet all the measurement facilities characteristics under MASS Section 4.6 for Slow FCAS and Section 5.6 for Delayed FCAS, unless otherwise agreed by AEMO in accordance with paragraph (a) above.

2.2.4. Frequency disturbance time alignment

The clocks associated with the meters at relevant sites that form the VPP, may record slightly differing times. To correct for this, VPP participants must time-align the data logged by each meter to the actual time the Frequency Disturbance was detected, being the time the system frequency measurement first falls outside the NOFB.

An example of how the active power flow is aggregated is provided in Appendix A.

3. COMPLIANCE

The delivery of contingency FCAS from a variable/proportional controller must start no later than when the frequency has first exceeded the upper limit or lower limit of the NOFB, and for a switching controller, when the frequency first falls through its raise service frequency deviation setting or rises through its lower service frequency deviation setting.

Following a contingency event, AEMO may request participants provide the following information to verify the aggregated response of the VPP as per Clause 3.7, 4.7 and 5.7 of the MASS. In addition, AEMO may request participants provide the following additional information:

(a) Calculated FCAS response of the VPP and high-speed data samples of frequency on a common time scale

(b) Aggregated power flow of the VPP and frequency (extrapolated from the high speed data samples of frequency) on a common time scale

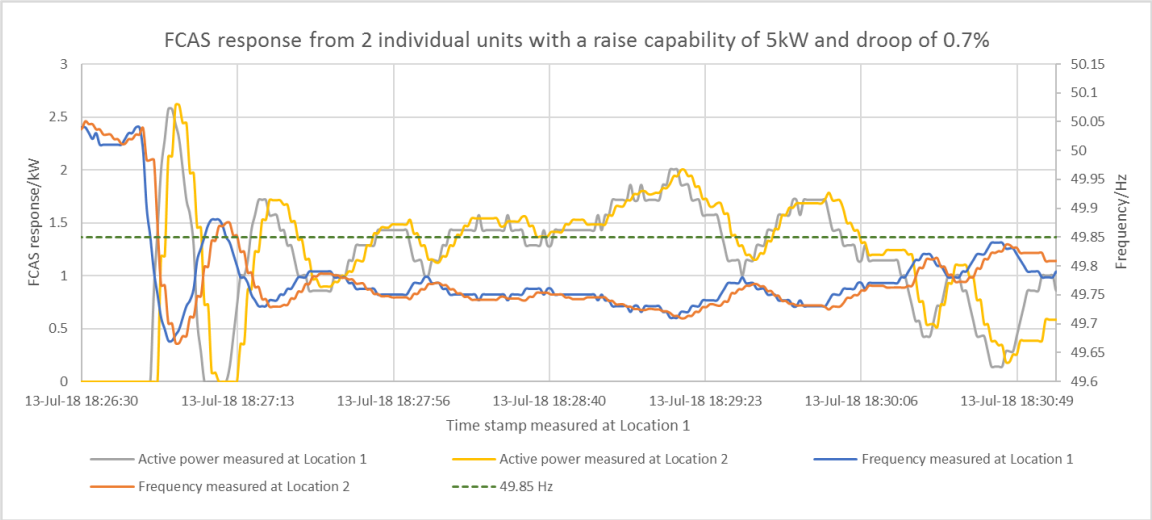
(c) Number of DER units enabled for FCAS in each dispatch interval

As part of the FCAS assessment process, AEMO retains the right to separate technologies into distinct DUIDs. The tests required as part of the FCAS assessment to confirm whether the VPP can respond to frequency excursions to meet the requirements of this specification have been described in Appendix B. The test plan has been divided in two sections, namely the frequency injection test (lab test) and the VPP-wide test.

APPENDIX A.

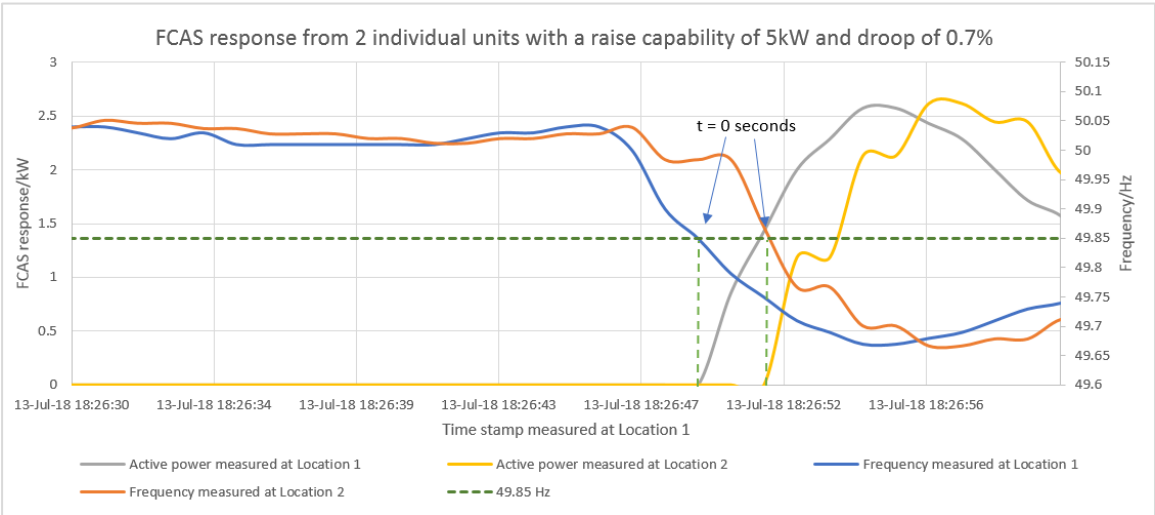
The timestamps recorded by every measurement point in the VPP may differ. However, the start of the FCAS response will be based on the frequency observed at every measurement point. Figure 9 below shows the proportional FCAS response from measurement points from 2 different locations. Although the timestamp and frequency do not align due to the devices not being GPS synced, the aggregated FCAS response can be determined by identifying when the frequency from each location exceeded the NOFB.

Figure 9 FCAS response from 2 FCAS response measurement points



When aggregating the response captured from all the measurement points of the VPP, the timestamp and the frequency data is to be extrapolated every 1 second from the high-speed meter data. Figure 10 shows the start of the FCAS response observed at different measurement points. The frequency disturbance time, t, is the same for both units when the local frequency goes below 49.85 Hz. The aggregated active power can be determined by adding the active power from t=0 seconds for all measurement points.

Figure 10 Frequency disturbance time for 2 FCAS response measurement points



APPENDIX B.

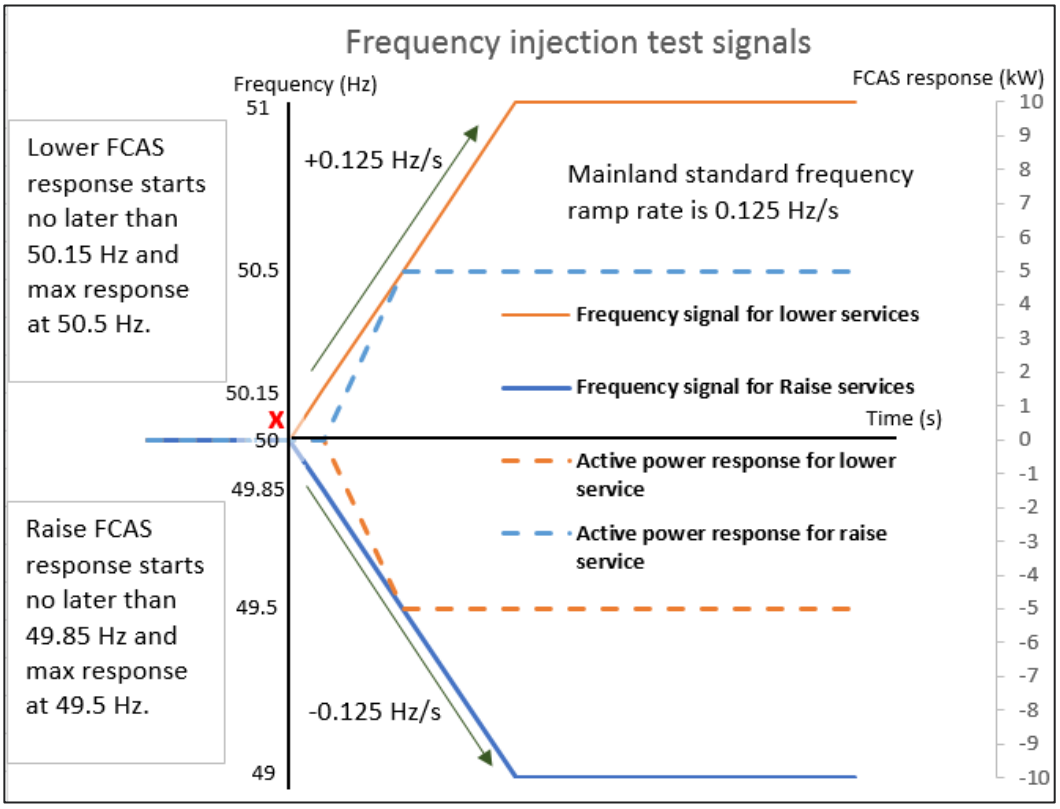
The test plan can be divided into 2 sections. A frequency injection test is required for every type of controllable devices to be used and a VPP wide test is conducted to demonstrate the capability of the VPP to respond to frequency deviations. Some of the requirements for the frequency injection test are from the BESS requirements for contingency FCAS registration document[2] published on the AEMO website.

Frequency injection test

The requirements for the frequency injection test are described below:

1. A single droop setting is to be chosen if the control system to provide FCAS is a proportional/variable controller. Unless agreed by AEMO, the delivery of active power must be configured to be in proportion to the local frequency.
2. All batteries, regardless of their capacity, may be allowed a minimum droop setting of 0.7%, unless an alternative droop limit is specified by AEMO.
3. The frequency signals to be injected and the expected change in active power from a battery (droop at 0.7%) with a 5 kW raise and 5 kW lower FCAS capability are shown in Figure 11 below:

Figure 11 Frequency injection signals and FCAS response



4. Point 'x' on the graph is where the frequency disturbance starts, and measurements of frequency and power flow must be made as follows (as per the MASS):
   (a) For the fast contingency services, the measurements must be made at intervals of 50 milliseconds or less for a period of at least 5 seconds before the frequency disturbance time and at least 60 seconds after the frequency disturbance time.

[2] At https://www.aemo.com.au/-/media/Files/Electricity/NEM/Security_and_Reliability/Ancillary_Services/Battery-Energy-Storage-System-requirements-for-contingency-FCAS-registration.pdf.

(b) For the slow contingency services, the measurements must be made at intervals of 4 seconds or less for a period of at least 20 seconds before the frequency disturbance time and 5 minutes after the frequency disturbance time.

(c) For the delayed contingency services, the measurements must be made at intervals of 4 seconds or less for a period of at least 20 seconds before the frequency disturbance time and 10 minutes after the frequency disturbance time.

(d) The error and the resolution of the measurement of the power flow and frequency must comply with Clause 3.6a (v) and (vi) of the MASS for Fast FCAS, Clause 4.6a (iv) and (v) for Slow FCAS and Clause 5.6a (iv) and (v) for Delayed FCAS.

VPP-wide test

The VPP-wide test is required to confirm the ancillary service capacity of the VPP by analysing the aggregated response of the ancillary service loads during frequency deviations.

There are two methods to complete the VPP-wide test, and the requirements are as follows:

1. A frequency injection test (similar frequency signal shown in Figure 11) can be conducted to observe the aggregated response of the VPP.
2. If a frequency injection test cannot be completed for the aggregated ancillary service loads, the participant will be required to carry out the following:
   (a) For variable/proportional FCAS controllers, decrease the frequency deadband to a narrower setting, e.g +/- 0.05 Hz, in order to capture the aggregated active power change of the VPP when responding to local frequency deviations. AEMO may request that this test is repeated if the frequency deviations during the initial test are minor.

   (b) For switching FCAS controllers, decrease the raise and lower service frequency deviation setting so that the FCAS response from the VPP can be observed while the frequency is within the NOFB.

   (c) Provide measurements of local frequency and aggregated power flow at intervals of 1 second or less for a period of at least 20 seconds before the frequency disturbance time and 10 minutes after.

   (d) The aggregated power flow of the VPP must be provided to AEMO, as specified under Appendix A.