MARKET ANCILLARY SERVICE SPECIFICATION

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VERSION RELEASE HISTORY

Version	Effective Date	Summary of Changes
1.0	Sep 2001	Initial document issued at the commencement of the market ancillary services
1.5	27 Feb 2004	Revised to include the Tasmania region
2.0	5 May 2009	Revised to align with the revised Tasmania frequency operating standards
3.0	1 Jul 2010	Revised after consultation
4.0	30 Mar 2012	Revised after consultation
5.0	30 Jun 2017	Revised after consultation
6.0	1 Jun 2020	• Revised following consultation on relationship with the draft Primary Frequency Response rule change (ERC0274). • Minor drafting updates, corrections and clarifications.
7.0	1 Feb 2022	• Revised following consultation on measurement arrangements for aggregated ancillary service facilities. • Restructure to remove unnecessary duplication and improve readability.

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1. INTRODUCTION

1.1. Purpose and scope

This is the *market ancillary service specification* (**MASS**) made under clause 3.11.2(b) of the National Electricity Rules (**NER**). It includes the monitoring and recording standards referred to in clause 3.11.2(g).

The MASS has effect only for the purposes set out in the NER. The NER and the *National Electricity Law* prevail over the MASS to the extent of any inconsistency.

1.2. Definitions and interpretation

1.2.1. Glossary

Terms defined in the *National Electricity Law* or the NER have the same meanings in the MASS unless otherwise specified in this section 1.2.1. NER defined terms are intended to be identified in the MASS by italicising them, but failure to italicise a defined term does not affect its meaning.

The words, phrases and abbreviations in Table 1 have the meanings set out opposite them when used in the MASS.

Table 1 Definitions

Term	Definition
AGC	AEMO's automatic generation control system.
Aggregated Ancillary Service Facility	The *ancillary service generating units* or *ancillary service loads* aggregated by an FCAS Provider under clause 3.8.3 of the NER for the purpose of providing FCAS.
Aggregated Generation Amount	The aggregate Generation Amounts through one or more *connection points* of an Aggregated Ancillary Service Facility.
Aggregated Load Amount	The aggregate Load Amounts through one or more *connection points* of an Aggregated Ancillary Service Facility.
Ancillary Service Facility	An *ancillary service generating unit* or *ancillary service load* used to deliver FCAS, and includes an Aggregated Ancillary Service Facility unless the context otherwise requires.
Contingency Event Time	The time at which a *contingency event* occurred, which is determined as follows: (a) Where the initial *frequency* change that led to a Frequency Disturbance is clear, there was a single rapid and significant change in *frequency*, the Contingency Event Time is the starting point of that *frequency* change. (b) If there was a series of step changes in *frequency* or a slow ramp in *frequency*, the Contingency Event Time will be at the start of the greatest rate of change of *frequency*, as measured by AEMO. (c) If neither paragraph (a), nor (b), applies, AEMO will take into account the circumstances of the *contingency event* and select a time that, in AEMO's opinion, represents the start time of the *frequency* disturbance, against which the FCAS response to it can reasonably be measured.
Contingency FCAS	A term used to refer to *fast raise service*, *fast lower service*, *slow raise service*, *slow lower service*, *delayed raise service* and *delayed lower service* collectively.

Term	Definition
Control Response Delay or CRD	Applies to Regulation FCAS Providers: defines the maximum end-to-end time in seconds an Ancillary Service Facility takes to achieve at least 63.2%[1] of a step change in output following instructions via AGC.
Control Request Feedback	Applies to Regulation FCAS Providers: the latest AGC-issued control signal request (in MW) as known by an Ancillary Service Facility. This value excludes any change in output from frequency controller action, including PFR. For Setpoint Control Ancillary Service Facilities, this is simply an echo back of the AGC control signal request. For Raise/Lower Controlled Ancillary Service Facilities, this is the MW value of the stream of Raise/Lower Controls as accumulated internal to the Plant Controller or equivalent.
Controlled Quantity	A quantity of *generation* or *load* that is: (a) controlled by Raise Signals and Lower Signals; and (b) measured at the relevant *connection point*.
Delayed FCAS	*delayed raise services* and *delayed lower services*.
Fast FCAS	*fast raise services* and *fast lower services*.
FCAS	*market ancillary services*, commonly referred to as "frequency control ancillary services".
FCAS Provider	An *Ancillary Service Provider*. The term can be combined with 'Regulation', 'Delayed', 'Raise', 'Lower', 'Slow' or 'Contingency' or a combination of these to indicate an FCAS Provider providing a particular type of FCAS.
FCASVT	Frequency Control Ancillary Service Ancillary Service Verification Tool: An Excel spreadsheet used to verify the delivery of Contingency FCAS.
FOS	*frequency operating standard*.
Frequency Deadband	The range of Local Frequency through which a Variable Controller will not operate.
Frequency Deviation Setting	The setting allocated to an Ancillary Service Facility by AEMO within the range shown in 0 for the Mainland and Table 6 for the Tasmania *region*.
Frequency Disturbance	An occasion when System Frequency is outside the NOFB.
Frequency Disturbance Time or FDT[2]	The time[3] when Local Frequency is outside the NOFB following a Frequency Disturbance, as determined by AEMO.
Frequency Ramp Rate	0.125 Hz/s for the Mainland or 0.4 Hz/s for Tasmania.
Frequency Rate of Change Multiplier	See 0 for the Mainland, and Table 6 for Tasmania.
Frequency Recovery	The first change in Local Frequency to occur after a Frequency Disturbance from above 50.15 Hz to below 50.1 Hz, or below 49.85 Hz to above 49.9 Hz.
Frequency Setting	The level of *frequency* or a combined level of *frequency* and *frequency* rate of change determined by AEMO in accordance with section 6 for use by an Ancillary Service Facility's Switching Controller.
Generation Amount	The amount of *active power* flow through the *connection point* of an Ancillary Service Facility into the *transmission network* or *distribution network* to which it is *connected*, expressed as a positive value in MW. In respect of an Aggregated Ancillary Service Facility, a reference to the Generation Amount means the Aggregated Generation Amount.
Generation Event	As defined in the FOS.

[1] This value is specific to AGC.
[2] Referred to as occurring at t=0 in the equations used in the MASS.
[3] *Australian Eastern Standard Time*.

Term	Definition
Inertial Response	The change in Generation Amount or Load Amount due to the impact of an Ancillary Service Facility's *inertia*.
Initial Value	The Generation Amount or Load Amount immediately prior to a Contingency Event Time.
Load Amount	The amount of *active power* flow through the *connection point* of an Ancillary Service Facility from the *transmission network* or *distribution network* to which it is *connected*, expressed as a negative value in MW. In respect of an Aggregated Ancillary Service Facility, a reference to the Load Amount means the Aggregated Load Amount.
Load Event	As defined in the FOS.
Load Reference	An AGC term that refers to the target power output of an Ancillary Service Facility when System Frequency is at its nominal value (50 Hz). Other commonly used terminology to refer to this is 'speed-load reference' or 'basepoint'.
Local Frequency	The *frequency* measured by an FCAS Provider at the *connection point* of the FCAS Provider's Ancillary Service Facility or at each *connection point* in an Aggregated Ancillary Service Facility, in Hz.
Lower Control Limit	The lowest level to which a Controlled Quantity can be controlled in response to Lower Signals, subject to the *enablement* amount.
Lower Rate Limit	The highest rate at which a Controlled Quantity can be controlled in response to Lower Signals, subject to the *enablement* amount.
Lower Reference Frequency	The upper value in the 'containment band' for Load Events, as specified in Table A.3 of the FOS (Table A.6 for Tasmania).
Lower Response	The decrease in Generation Amount or increase in Load Amount as compared with its Initial Value.
Lower Signal	An AGC control signal sent by or on behalf of AEMO to request delivery of a Regulating Lower Response.
Mainland	All *regions* other than Tasmania.
MASS	This document, namely, the *market ancillary service specification.*
NER	National Electricity Rules.
NOFB	The *normal operating frequency band,* being the values specified in Column 2 of Table A.1 in the FOS.
OFTB	*operational frequency tolerance band*.
Online/Offline Status	Applies to Regulation FCAS Providers: a binary status flag indicating whether their Ancillary Service Facility is *connected* and ready to implement AGC-issued control requests.
PFR	*primary frequency response*.
Plant Controller	The system within an Ancillary Service Facility that controls the overall behaviour of the Ancillary Service Facility and is responsible for a variety of duties, including actioning AGC control requests and co-ordinating the behaviour of all *plant* within the Ancillary Service Facility.
Raise Control Limit	The highest level to which a Controlled Quantity can be controlled in response to Raise Signals, subject to the *enablement* amount.

Term	Definition
Raise/Lower Control	An AGC term that refers to a method of AGC control where Load Reference controls are issued as relative MW values (e.g. an AGC request to set an Ancillary Service Facility's Load Reference to 100 MW would be sent as a value of +2 MW if the machine was currently at 98 MW). Raise/Lower Control is also sometimes referred to as 'pulse control'. See also Setpoint Control.
Raise Rate Limit	The highest rate at which a Controlled Quantity can be controlled in response to Raise Signals, subject to the *enablement* amount.
Raise Reference Frequency	The lower value in the 'containment band' for Generation and Load Events, as specified in Table A.3 of the FOS (Table A.6 for Tasmania).
Raise Response	The increase in Generation Amount or decrease in Load Amount as compared with its Initial Value.
Raise Signal	An AGC control signal sent by or on behalf of AEMO to request the delivery of a Regulating Raise Response.
Reference Trajectory	A linear trajectory between two consecutive *energy market dispatch* targets.
Regulating Lower Response	The decrease in Generation Amount or increase in Load Amount delivered in response to one or more Lower Signals.
Regulating Raise Response	The increase in Generation Amount or decrease in Load Amount delivered in response to one or more Raise Signals.
Remote/Local Status	Applies to Regulation FCAS Providers: a binary status flag. 'Remote' indicates the Ancillary Service Facility's Plant Controller, or equivalent for Aggregated Ancillary Service Facilities, is ready to receive AGC control signal requests.
SCADA	Supervisory control and data acquisition system.
Setpoint Change Deadband	A value set parameter assigned to each Ancillary Service Facility in AGC that indicates the minimum change in MW output AGC may request from that Ancillary Service Facility.
Setpoint Control	An AGC term that refers to a method of AGC control where Load Reference controls are issued as absolute MW values (e.g. an AGC request to set an Ancillary Service Facility's Load Reference to 100 MW would be sent as a value of 100 MW). See also Raise/Lower Control.
Slow FCAS	*Slow raise services* and *slow lower services*.
Standard Frequency Ramp	A linear change in Local Frequency from one level to another at the applicable Frequency Ramp Rate and then sustained, as per Appendix A.
Switching Controller	A *control system* that automatically delivers a specific amount of FCAS by either switching *generation* or *load* on or off (as applicable) or rapidly altering an Ancillary Service Facility's output when its Frequency Settings are detected.
System Frequency	The *frequency* of the *power system*, as measured by AEMO.
Time Average	For a Raise Response or Lower Response and a time interval, the average value of that Raise Response or Lower Response over that time interval, determined as the integral of the Raise Response or Lower Response over the time interval divided by the duration of the time interval.
Trigger Range	The *frequency* range for which an Ancillary Services Facility with one or more switching controllers must record and store data regarding its performance, commencing 0.2 Hz either side of 50 Hz for the Mainland, and 0.8 Hz for Tasmania.
Trigger Rate	0.05 Hz/s for the Mainland and 0.15 Hz/s for Tasmania.

Term	Definition
Variable Controller	A *control system* that is used by an Ancillary Service Facility to deliver FCAS upon the commencement of a Frequency Disturbance in proportion to the size of the *frequency* excursion.

1.2.2. Interpretation

The following principles of interpretation apply to the MASS unless otherwise expressly indicated:

(a) The MASS is subject to the principles of interpretation set out in Schedule 2 of the *National Electricity Law*.

(b) Units of measurement are in accordance with the International System of Units.

1.3. Related documents

Table 2 Title and Location of Related Documents

Title	Location
Application for Registration as a Customer in the NEM	https://aemo.com.au/energy-systems/electricity/national-electricity-market-nem/participate-in-the-market/registration/register-as-a-customer-in-the-nem
Application for Registration as a Generator in the NEM	https://aemo.com.au/energy-systems/electricity/national-electricity-market-nem/participate-in-the-market/registration/register-as-a-generator-in-the-nem
Application for Registration as a as a Demand Response Service Provider	https://aemo.com.au/energy-systems/electricity/national-electricity-market-nem/participate-in-the-market/registration/register-as-a-drsp
Dispatch Procedure SO_OP_3705	https://www.aemo.com.au/energy-systems/electricity/national-electricity-market-nem/system-operations/power-system-operation/power-system-operating-procedures
FCAS Verification Tool User Guide	http://www.aemo.com.au/Electricity/National-Electricity-Market-NEM/Security-and-reliability/Ancillary-services/Market-ancillary-services-specifications-and-FCAS-verification
Generator Exemption and Classification Guide	http://aemo.com.au/-/media/Files/Electricity/NEM/Participant_Information/New-Participants/Generator-Exemption-and-Classification-Guide.pdf
Generator Registration Guide	https://aemo.com.au/-/media/files/electricity/nem/participant_information/registration/generator/nem-generator-registration-guide.pdf?la=en
Guide to Ancillary Services in the National Electricity Market	http://www.aemo.com.au/Electricity/National-Electricity-Market-NEM/Security-and-reliability/Ancillary-services
MASS 4.0 FCAS Verification Tool_v2.08	http://www.aemo.com.au/Electricity/National-Electricity-Market-NEM/Security-and-reliability/Ancillary-services/Market-ancillary-services-specifications-and-FCAS-verification
Guide for Demand Response Service Providers – NEM – change or classify new Ancillary Service Load	https://aemo.com.au/-/media/files/electricity/nem/participant_information/registration/demand-response-service-provider/application-guide-nem-demand-response-service-provider-asl.pdf?la=en

Title	Location
Pre-Dispatch Procedure SO_OP_3704	http://www.aemo.com.au/Electricity/National-Electricity-Market-NEM/Security-and-reliability/Power-system-operation/Power-system-operating-procedures
Interim Primary Frequency Response Requirements	https://aemo.com.au/-/media/files/initiatives/primary-frequency-response/2020/interim-pfrr.pdf

2. MASS PRINCIPLES

2.1. Open access

When specifying the requirements for participation, the MASS is designed to permit open access to the FCAS *spot markets*.

2.2. No priority in delivery of different FCAS types

If an Ancillary Service Facility is *enabled* for Regulation FCAS and Contingency FCAS, it should be able to deliver both types of FCAS together in a co-ordinated manner. Section 10.3 provides guidance on how controls may be co-ordinated, including examples. Unless directed by AEMO to do otherwise[4], subject to clause 4.9.4 of the NER, an Ancillary Service Facility providing Regulation FCAS should follow AGC instructions at all times, noting that AGC instructions are subject to Local Frequency as outlined in section 10.3.

2.3. Contracting

Nothing prevents an FCAS Provider from procuring a third party to provide equipment or a monitoring or recording service to the FCAS Provider under contract, or perform any other action required or contemplated by the MASS on behalf of that FCAS Provider.

The FCAS Provider remains responsible for compliance with its NER obligations regardless of whether it provides *market ancillary services* itself or outsources part or all of their delivery.

2.4. Inertia

FCAS does not include the impact of *inertia*.[5]

2.5. Delivery of FCAS by Ancillary Service Facilities

An Ancillary Service Facility can be *enabled* to deliver any combination of FCAS it is capable of delivering and must deliver all types of FCAS for which it is *enabled*.

3. DESCRIPTION OF EACH TYPE OF FCAS

FCAS are essential to the management of *power system security*, facilitation of orderly trading in electricity, and ensuring that electricity supplies are of acceptable quality. They are, effectively, reserves procured through the FCAS *spot markets* operated by AEMO and the *central dispatch* process in accordance with clause 3.8.1 of the NER.

AEMO procures FCAS to manage System Frequency during normal operating conditions and following *contingency events*. FCAS usually takes the form of an increase or decrease in *active power* output or consumption by an Ancillary Service Facility to address the impact of

[4] Aside from reasons of safety or in a situation where a risk to unit stability exists.
[5] See also the definition of Frequency Disturbance Time.

supply/demand imbalances on System Frequency at any given point within a *dispatch interval*. Each type of FCAS is delivered to different specifications to address different needs.

Clause 3.11.2(a) of the NER specifies that there are eight different types of FCAS. Table 3 details these, provides their common names, differentiates between Contingency FCAS and Regulation FCAS, and provides a brief description of how they are usually provided.

Table 3 Description of each FCAS

Type	NER Term	Commonly Referred to as…	Group	Description	Key Purpose	Usually Facilitated by…
Contingency FCAS	*Fast raise service*	6-Second Raise FCAS	Fast FCAS	A rapid increase in *generation* or a decrease in *load* in response to decreases in Local Frequency.	To arrest a change in System Frequency following a *contingency event* that takes it outside the NOFB within the first 6 s of a Frequency Disturbance and then provide an orderly transition to a Slow FCAS.	• Governor or governor-like *control systems* • *Frequency* relay detecting a *frequency* deviation and starting a fast *generating unit* or *disconnecting load*. • Rapid change in charging or discharging from batteries.
	Fast lower service	6-Second Lower FCAS		A rapid decrease in *generation* or an increase in *load* in response to increases in Local Frequency.		• Governor or governor-like *control systems*. • *Frequency* relay detecting a *frequency* deviation and reducing a *generating unit's* output or increasing *load*.
	Slow raise service	60-Second Raise FCAS	Slow FCAS	An increase in *generation* or a decrease in *load* in response to decreases in Local Frequency.	To stabilise System Frequency following a *contingency event* within the first 60 s of a Frequency Disturbance, and then provide an orderly transition to a Delayed FCAS.	• Governor or governor-like control systems • *Frequency* relay detecting a frequency deviation and reducing *load*.
	Slow lower service	60-Second Lower FCAS		A decrease in *generation* or an increase *load* in response to increases in Local Frequency.		Governor systems on *generating units*.
	Delayed raise service	5-Minute Raise FCAS	Delayed FCAS	An increase in *generation* or a decrease in *load* in response to decreases in Local Frequency.	To return System Frequency to 50 Hz within the first 5 min of a Frequency Disturbance, and to sustain that response until *central dispatch* can re-schedule *generation* and *load* to balance the *power system*.	*Frequency* relay detecting a *frequency* deviation starting up *generating units* or reducing *load*.
	Delayed lower service	5-Minute Lower FCAS		A decrease in *generation* or an increase in *load* in response to increases in Local Frequency.		*Frequency* relay detecting a *frequency* deviation and reducing *generating unit* output or increasing *loads*.
Regulation FCAS	*Regulating raise service*	Raise Regulation FCAS	Regulation FCAS	Increasing *generation* or decreasing *load* relative to the Ancillary Service Facility's Reference Trajectory in response to Raise Signals to increase System Frequency.	To support control of System Frequency and time error in tandem with PFR in response to variations of demand and *generation* within a *dispatch interval*.	Setpoint controllers on *generating units*.
	Regulating lower service	Lower Regulation FCAS		Decreasing *generation* or increasing *load* relative to the Ancillary Service Facility's Reference Trajectory in response to Lower Signals to reduce System Frequency.		

3.1. Contingency FCAS

Contingency FCAS manages Frequency Recovery after an under-*frequency* or over-*frequency* event to arrest a fall or rise in System Frequency (as applicable), then stabilise and assist to restore System Frequency so that AEMO can meet the conditions specified in the FOS. This means that, while always *enabled* for delivery following a *contingency event*, Contingency FCAS are only required to be delivered if a *contingency event* occurs.

Contingency FCAS are provided by technologies that can detect a Local Frequency deviation and respond in a manner that corrects System Frequency following a *contingency event*.

Ancillary Service Facilities may cease to provide Contingency FCAS once Frequency Recovery has occurred. For example:

- If Local Frequency recovers above 49.9 Hz within 6 s from the FDT, the Ancillary Service Facility is not required to deliver any Slow Raise FCAS or Delayed Raise FCAS.
- If Local Frequency recovers below 50.1 Hz within 6 s from the FDT, the Ancillary Service Facility is not required to deliver any Slow Lower FCAS or Delayed Lower FCAS.
- If Local Frequency recovers above 49.9 Hz between 6 s and 60 s from the FDT, the Ancillary Service Facility is not required to deliver any Delayed Raise FCAS.
- If Local Frequency recovers below 50.1 Hz between 6 s and 60 s from the FDT, the Ancillary Service Facility is not required to deliver any Delayed Lower FCAS.

3.2. Regulation FCAS

Regulation FCAS are centrally controlled by AGC, which allows AEMO to monitor System Frequency, time error and Ancillary Service Facility output at all times. AGC sends control signals through SCADA (on a regular cycle such as every 4 s) to Ancillary Service Facilities *enabled* to deliver Regulation FCAS to alter the controlled MW output of *generating units* or electricity consumption of *loads* to assist with correcting the demand/supply imbalance. Adjustments to MW output are from an Ancillary Service Facility's Load Reference; the *enabled* Regulation Raise and Regulation Lower quantities form a band around the Ancillary Service Facility's Load Reference within which AGC may control it. An Ancillary Service Facility must be a *scheduled generating unit*, *scheduled load* or *semi-scheduled generating unit* to provide Regulation FCAS as it is required to have a centrally controlled MW output or consumption level visible to AGC.

Regulation FCAS are normally delivered during each *dispatch interval*.

3.2.1. Relationship with PFR

Regulation FCAS works in tandem with *primary frequency response* (**PFR**) to help control *frequency* and *power system* imbalance within and outside the NOFB[7], however, it is distinguished from PFR in two key ways:

1. Headroom, footroom and stored energy – Regulation FCAS is provided by the reserved headroom, footroom and stored energy, as specified in a *market ancillary service offer*. PFR is a response based on a *scheduled generating unit* or *semi-scheduled generating unit's* available capacity and energy at the time; there is no requirement to reserve capacity or energy.
2. AGC – Regulation FCAS need only be provided in response to an AGC control signal request from AEMO to do so, whereas PFR is an ongoing *power system security* requirement every

[7] Refer to guidance on co-ordination of PFR and Contingency FCAS controls with AGC controls in Section 10.3.

time a *Scheduled Generator* or *Semi-Scheduled Generator* receives a *dispatch instruction* to generate a volume greater than zero MW, as required by clause 4.4.2(c1) of the NER.

4. AGGREGATION OF ANCILLARY SERVICE FACILITIES

4.1. Requests for aggregation

4.1.1. Generally

FCAS Providers may apply to AEMO under clause 3.8.3 of the NER to aggregate their *ancillary service generating units* or *ancillary service loads* for the purposes of *central dispatch*. Where aggregation has been approved, *market ancillary service offers* must only be made in respect of the Aggregated Ancillary Service Facility.

4.1.2. Regulation FCAS

With Regulation FCAS, AEMO will approve aggregation if an FCAS Provider's AGC can support the aggregated *dispatch* of Regulation FCAS, namely it will respond to a single AGC signal from AEMO to deliver the requested Regulation FCAS.

The FCAS Provider must ensure that its Aggregated Ancillary Service Facility provides the requested Regulation FCAS in an accurate and timely manner.

4.2. Requests for reports on Aggregated Ancillary Service Facilities

4.2.1. Generally

A request from AEMO to an FCAS Provider for a report detailing how an Ancillary Service Facility responded to changes in System Frequency under clause 3.11.2(h) of the NER may also be made in respect of an Aggregated Ancillary Service Facility, in which case the FCAS Provider must detail in its report the response of each Ancillary Service Facility within the Aggregated Ancillary Service Facility.

An FCAS Provider must provide a report promptly but, in any event, no more than 20 *business days* after AEMO's request.

4.2.2. Contingency FCAS

Where the report requested concerns the delivery of Contingency FCAS, this may include the response as determined by the FCASVT, or the FCAS Provider may propose an alternative method of demonstrating the response of the relevant Ancillary Service Facility within the Aggregated Ancillary Service Facility. AEMO, in its absolute discretion, may accept an FCAS Provider's alternative method.

5. COMMON REQUIREMENTS

5.1. Market ancillary service offers

FCAS Providers must ensure their *market ancillary service offers* reflect the physical availability and capability of their Ancillary Service Facility to deliver the relevant FCAS, as required by clause 3.8.7A of the NER.

FCAS Providers must rebid in accordance with clause 3.8.22 to reflect changes to FCAS availability and capability.

5.2. Enablement

FCAS Providers must operate their equipment in accordance with clause 4.9.3A(c) of the NER to deliver FCAS in response to a *dispatch instruction* immediately following *enablement* by AEMO.

5.3. Measurement

5.3.1. Connection point

All measurements of Local Frequency, Generation Amount and Load Amount must be taken at or close to a relevant *connection point*.

If an FCAS Provider considers that an alternative measurement methodology can provide AEMO the required data more simply and accurately, the FCAS Provider must request AEMO's approval prior to using it. AEMO may approve any alternative measurement methodology on such conditions as AEMO considers appropriate.

5.3.2. Measurement requirements for all Ancillary Service Facilities

The equipment required to measure and record the delivery of FCAS, including both the source transducer and data recorder, must have the characteristics detailed in Table 4.

Table 4 Measurement requirements for FCAS

Requirement	Fast FCAS		Slow FCAS	Delayed FCAS	Regulation FCAS
Frequency of Local Frequency measurements	Aggregated Ancillary Service Facilities comprised of ≥25 Ancillary Service Facilities with **no** Inertial Response	≤200 ms	≤4 s	≤4 s	NR
	Aggregated Ancillary Service Facilities with Inertial Response and those comprised of <25 Ancillary Service Facilities with **no** Inertial Response	≤50 ms[8]	≤4 s	≤4 s	NR
	All other Ancillary Service Facilities	≤50 ms	≤4 s	≤4 s	NR
Frequency of Generation Amount and Load Amount measurements	Aggregated Ancillary Service Facilities comprised of ≥25 Ancillary Service Facilities with **no** Inertial Response	≤200 ms	≤4 s	≤4 s	≤4 s

[8] If another measurement at ≤50 ms is sufficient to determine the timing of the delivery of the Fast FCAS where a Switching Controller is used, the measurement may be at 4-s intervals. Information should be provided to AEMO's reasonable satisfaction to compare the Local Frequency and power flow data in a common time scale.

Requirement	Fast FCAS		Slow FCAS	Delayed FCAS	Regulation FCAS
	Aggregated Ancillary Service Facilities with Inertial Response and those comprised of <25 Ancillary Service Facilities with **no** Inertial Response.	≤50 ms[9]	≤4 s	≤4 s	≤4 s
	All other Ancillary Service Facilities	≤50 ms	≤4 s	≤4 s	≤4 s
Measurement Range of Power Flow Measurements	As appropriate to the Ancillary Service Facility with a margin of error of ≤2%, and resolution of ≤0.2%				
Settling Time	The time required for the measurement to remain within 99% of final value after a step change from pre-contingency conditions				
	Aggregated Ancillary Service Facilities comprised of ≥25 Ancillary Service Facilities with **no** Inertial Response	≤200 ms	≤4 s	≤4 s	NR
	Aggregated Ancillary Service Facilities with Inertial Response and those comprised of <25 Ancillary Service Facilities with no Inertial Response.	≤50 ms[10]	≤4 s	≤4 s	NR
	All other Ancillary Service Facilities	≤50 ms	≤4 s	≤4 s	NR
Local Frequency Measurement Range	At least the range specified in the OFTB, with:				NR
	Margin of error				
	≤0.01 Hz		≤to 0.02 Hz		
	Resolution				
	≤0.0025 Hz		≤0.01 Hz		
Frequency Disturbance Time	< 10 s				NR
Recording Period for Power & System Frequency Measurements	≥5 s before the FDT and ≥60 s after it		≥20 s before the FDT and 5 min after it	≥20 s before the FDT and 10 min after it	NR

[9] If another measurement at ≤50 ms is sufficient to determine the timing of the delivery of the Fast FCAS where a Switching Controller is used, the measurement may be at 4-s intervals. Information should be provided to AEMO's reasonable satisfaction to compare the Local Frequency and power flow data in a common time scale.

[10] If another measurement at ≤50 ms is sufficient to determine the timing of the delivery of the Fast FCAS where a Switching Controller is used, the measurement may be at 4-s intervals. Information should be provided to AEMO's reasonable satisfaction to compare the Local Frequency and power flow data in a common time scale.

Requirement	Fast FCAS	Slow FCAS	Delayed FCAS	Regulation FCAS
Trigger for Recording Measurements	At least whenever Local Frequency changes ≥ Trigger Range.			NR

5.3.3. Additional requirements for Aggregated Ancillary Service Facilities

If an Aggregated Ancillary Service Facility is used for the delivery of FCAS, measurements must meet these **additional** requirements:

(a) The Generation Amount or Load Amount must be measured at, or close to, each relevant *connection point* and summed to calculate the Aggregated Generation Amount or Aggregated Load Amount. Where any part of an Aggregated Ancillary Service Facility shares a *connection point* with a variable *load* or *generating unit*, it is the gross *active power* flow to or from the relevant *plant* that forms the aggregated response by the Aggregated Ancillary Service Facility and must be measured directly.

(b) To correct for any discrepancy in the time measurement by Aggregated Ancillary Service Facility *meter* clocks, FCAS Providers must time-align the data logged by each *meter* to the actual time a Frequency Disturbance was detected.

5.4. Discounting Fast FCAS from Aggregated Ancillary Service Facilities in certain circumstances

If an FCAS Provider provides Fast FCAS using an Aggregated Ancillary Service Facility for which:

(a) the number of Ancillary Service Facilities aggregated by the FCAS Provider is ≥25 but <500; and

(b) the measurements of *power flow* and Local Frequency are captured with a sampling rate >50 ms but ≤200ms,

AEMO will apply a discount of 5% to the combined quantity of Fast FCAS measured at or close to the *connection points* of the Aggregated Ancillary Service Facility.

The discount is applied during the process of registering Ancillary Service Facilities when their Fast FCAS capability is assessed. The Aggregated Ancillary Service Facility must be able to deliver up to the maximum registered Fast FCAS capacity after factoring in the discount, as the quantity of Fast FCAS delivered in response to a Contingency Event must be at least 5% greater than the *enabled* quantity.

5.5. Data retention

Measurement and other data recordings must be digital and stored in a format that is reasonably acceptable to AEMO for analysis using commercial spreadsheet software.

Each FCAS Provider must retain recordings of data measurements for at least 12 months from the FDT and provide them to AEMO on request.

6. CONTINGENCY FCAS REQUIREMENTS

6.1. Frequency Deviation Settings provided by Switching Controllers

6.1.1. Default Frequency Deviation Setting

Until an Ancillary Service Facility that uses a Switching Controller to deliver Contingency FCAS is allocated one or more Frequency Deviation Settings under section 6.1.2, the FCAS Provider must

apply the default Frequency Deviation Setting shown in 0 if the Ancillary Service Facility is on the Mainland or Table 6 if the Ancillary Service Facility is in Tasmania.

Table 5 Frequency Settings for the Mainland

Level	Raise FCAS Frequency Deviation Setting (Hz)	Lower FCAS Frequency Deviation Setting (Hz)	Frequency Rate of Change Multiplier
Frequency Deviation Setting range	49.80 Hz to 49.60 Hz	50.20 Hz to 50.4 Hz	0.4
Default Frequency Deviation Setting	49.8 Hz	50.2 Hz	0.4

Table 6 Frequency Settings for Tasmania

Level	Raise FCAS Frequency Deviation Setting (Hz)	Lower FCAS Frequency Deviation Setting (Hz)	Frequency Rate of Change Multiplier
Frequency Deviation Setting range	49.50 Hz to 48.75 Hz	50.50 Hz to 51.25 Hz	0.875
Default Frequency Deviation Setting	49.125 Hz	50.875 Hz	0.875

6.1.2. Allocation of Frequency Settings

When allocating Frequency Settings to Ancillary Service Facilities for each Contingency FCAS, AEMO will take into account the following principles, as appropriate:

(a) Where an Ancillary Service Facility is used to deliver more than one type of Contingency FCAS, it will be allocated the same Frequency Settings for each.

(b) Ancillary Service Facilities with larger switched blocks of *generation* or *load* will be allocated Frequency Settings closer to the NOFB.

(c) Ancillary Service Facilities with higher availability will be allocated Frequency Settings closer to the NOFB.

(d) For Aggregated Ancillary Service Facilities, where possible, AEMO will negotiate with the FCAS Provider to allocate a series of Frequency Settings to minimise the potential for over-delivery of Contingency FCAS.

(e) AEMO will consider the physical characteristics of the Ancillary Service Facilities.

(f) A Frequency Setting:

  (i) for Fast FCAS may be a Frequency Deviation Setting or a combination of both the Frequency Deviation Setting and Frequency Rate of Change Multiplier shown in 0 for the Mainland and Table 6 for Tasmania; and

  (ii) for Slow FCAS or Delayed FCAS will be based on the allocated Frequency Deviation Setting alone.

(g) The criteria for a combined Switching Controller to initiate delivery of a *fast raise service* based on a combination of both Frequency Deviation Setting and Frequency Rate of Change Multiplier is to occur if both of the following conditions are satisfied:

  (i) Local Frequency < 49.85; and

  (ii) Local Frequency < FDS + (FRCM * LFRC).

  Where:

FDS is the allocated Frequency Deviation Setting

FRCM is taken from 0 for the Mainland and Table 6 for Tasmania

LFRC is the measured rate of change of Local Frequency.

(h) The criteria for a combined Switching Controller to initiate delivery of a *fast lower service* based on a combination of both Frequency Deviation Setting and Frequency Rate of Change Multiplier is to occur if both of the following conditions are satisfied:

(i) if Local Frequency > 50.15; and

(ii) Local Frequency > FDS – (FRCM * LFRC)

Where acronyms in the formula bear the same meanings as in paragraph (g).

(i) At AEMO's absolute discretion, a Frequency Deviation Setting outside the range specified in 0 for the Mainland and Table 6 for Tasmania may be allocated.

AEMO encourages FCAS Providers with Ancillary Service Facilities using Switched Controllers to configure them so that different Frequency Settings can be assigned to different parts of their Ancillary Service Facilities.

6.1.3. FCAS Provider request to change allocation

An FCAS Provider may request AEMO to change a Frequency Deviation Setting if there is a technical reason preventing an Ancillary Service Facility from delivering Contingency FCAS due to its Frequency Deviation Setting. AEMO may change the Frequency Deviation Setting in its absolute discretion subject to the principles in section 6.1.2.

6.1.4. AEMO request to change allocation

The only circumstances in which AEMO may request a change to a Frequency Deviation Setting are the following:

(a) the principles in section 6.1.2 have been amended;

(b) the classification of an Ancillary Service Facility that uses a Switching Controller to deliver a Contingency FCAS has changed;

(c) at least six months have elapsed since the last change of Frequency Deviation Settings and one or more Ancillary Service Facility has changed its maximum *response capability*; or

(d) a Frequency Disturbance that involved loss of *load* or *generation* has occurred and AEMO has determined that the relevant Frequency Deviation Setting was inadequate under those circumstances.

6.2. Control of Contingency FCAS

6.2.1. Notification of Control System Settings

Each FCAS Provider must inform AEMO of the details of each relevant *control system* as reasonably required by AEMO for the purposes of *central dispatch* or allocating the Frequency Settings.

6.2.2. Control System Requirements

(a) Whenever Contingency FCAS is *enabled*, the Ancillary Service Facility used to deliver the requested Contingency FCAS must have a *control system* to automatically initiate:

(i) a Raise Response when Local Frequency exceeds the Ancillary Service Facility's Frequency Deadband, which for a Variable Controller must not be less than the lower

limit of the NOFB and for a Switched Controller, must be equal to the Frequency Deviation Setting; and

(ii) a Lower Response when Local Frequency exceeds the Ancillary Service Facility's Frequency Deadband, which for a Variable Controller must not be greater than the upper limit of the NOFB and for a Switched Controller, must be equal to the Frequency Deviation Setting.

(b) The *control system* may be either a Variable Controller or a Switching Controller, or a discrete combination of both, and must operate so that the Raise Response or Lower Response is:

(i) for a Variable Controller, an amount commensurate with the difference between Local Frequency and Frequency Deadband where the Local Frequency is between the Frequency Deadband and the lower limit of the OFTB (for a Raise Response) or upper limit of the OFTB (for a Lower Response) in accordance with the Ancillary Service Facility's proportional response function[11];

(ii) for a Switching Controller, one or more step changes if Local Frequency falls below its Frequency Deviation Setting (for a Raise Response) or exceeds its Frequency Deviation Setting (for a Lower Response); or

(iii) for a discrete combination of both, responses in accordance with sub-paragraphs (a) and (b).

(c) Where a Switching Controller is used, it must be capable of adjusting its Frequency Deviation Setting to the Frequency Setting provided by AEMO with an error margin of <0.05 Hz for absolute Frequency Deviation Settings and <0.05 s for Frequency Rate of Change Multiplier.

6.3. Measurement when using a combination of Variable Controller and Switching Controller

In addition to the requirements specified in section 5.3, when proposing to use a combination of a Variable Controller and a Switching Controller, FCAS Providers must agree with AEMO on the process used to determine separate amounts of each Contingency FCAS that will be delivered through each type of controller.

6.4. Verification

The verification requirements that must be followed by FCAS Providers are provided in Table 7:

Table 7 Verification Requirements of Contingency FCAS

	Fast FCAS	Slow FCAS	Delayed FCAS
Assessment Period - From the Contingency Event Time to Frequency Recovery up to a maximum of:	60 s	300 s	600 s
Calculation Method	The amount of Contingency FCAS delivered must be compared with the amount of *enabled* Contingency FCAS as follows: (a) If the Ancillary Service Facility is a *scheduled generating unit*, *scheduled load* or *semi-scheduled generating unit*, determine the *generation* or electricity		

[11] Commonly known as a 'droop function' or 'droop curve'.

	Fast FCAS	Slow FCAS	Delayed FCAS
	consumption Reference Trajectory it would be expected to have followed if the Frequency Disturbance had not occurred[12]. (b) Use this Reference Trajectory to adjust the measured Generation Amount and Load Amount to obtain the response relative to this Reference Trajectory. (c) Remove the impact of any Inertial Response. (d) The difference between the value calculated following paragraph (c) and a measure of the output of the Ancillary Service Facility just prior to the Frequency Disturbance constitutes the Ancillary Service Facility's 'basic response'. Note that the 'basic response' includes all *frequency* response, regardless of whether it is inside or outside the NOFB. (e) Where a Variable Controller was used, the 'basic response' is compensated to take into account the difference between Local Frequency and the Standard Frequency Ramp. (f) Where a Switching Controller was used the 'basic response' is compensated to take into account the timing difference for Local Frequency to reach the Frequency Setting, compared to the Standard Frequency Ramp. (g) Where a discrete combination of Switching Controller and Variable Controller was used, the compensated 'basic response' is the sum of the compensated 'basic responses' of each.		
Where more than one Contingency FCAS Enabled	If a Slow FCAS was also *enabled*, the Ancillary Service Facility's response should exceed the required response, such that the Slow FCAS can be delivered.	If a Delayed FCAS was also *enabled*, the Ancillary Service Facility's response should exceed the required response such that the Delayed FCAS can be delivered.	
Specification of Market Ancillary Service Offers	The specifications in sections 7.1 and 7.2 are applied to calculate the Fast FCAS offered.	The specifications in sections 8.1 and 8.2 are applied to calculate the Slow FCAS offered.	The specifications in sections 9.1 and 9.2 are applied to calculate the Delayed FCAS offered
Delivery Requirements	The amount of Fast FCAS delivered in response to a change in Local Frequency must be at least equal to the *dispatched* quantity.	The amount of a Slow FCAS delivered in response to a change in Local Frequency must be at least equal to the *dispatched* quantity.	The amount of Delayed FCAS delivered in response to a change in Local Frequency must be at least equal to the *dispatched* quantity.

6.5. The FCAS Verification Tool

The FCASVT[13] is available to help calculate the quantity of any Contingency FCAS delivered by an Ancillary Service Facility. It contains detailed algorithms used by AEMO to verify whether Contingency FCAS has been delivered in accordance with the MASS.

If there is any inconsistency between the FCASVT and the MASS, the MASS will prevail to the extent of that inconsistency.

To avoid doubt, the FCASVT is not part of the MASS.

[12] Reference Trajectories take into account AGC control signals if required.

[13] Available at http://www.aemo.com.au/Electricity/National-Electricity-Market-NEM/Security-and-reliability/Ancillary-services/Market-ancillary-services-specifications-and-FCAS-verification.

7. FAST FCAS REQUIREMENTS

7.1. Specification of Fast Raise Service in Market Ancillary Service Offer

The amount of *fast raise service* in a *price band* and all cheaper *price bands* is the **lesser** of:

(a) twice the Time Average of the Raise Response starting at the Contingency Event Time and ending 6 s from the FDT, excluding any Inertial Response; and

(b) twice the Time Average of the Raise Response between 6 s and 60 s from the FDT, excluding any Inertial Response,

that the FCAS Provider making the *market ancillary service offer* expects would be delivered at the relevant *connection point* in response to a Standard Frequency Ramp from 50 Hz to the Raise Reference Frequency while this *price band* is *enabled*.

7.2. Specification of Fast Lower Service in Market Ancillary Service Offer

The amount of *fast lower service* in a *price band* and all cheaper *price bands* is the **lesser** of:

(a) twice the Time Average of the Lower Response starting at the Contingency Event Time and ending 6 s past the FDT, excluding any Inertial Response; and

(b) twice the Time Average of the Lower Response between 6 s and 60 s from the FDT, excluding any Inertial Response,

that the FCAS Provider making the *market ancillary service offer* expects would be delivered at the relevant *connection point* in response to a Standard Frequency Ramp from 50 Hz to the Lower Reference Frequency while this *price band* is *enabled*.

7.3. Dispatch

AEMO will issue *dispatch instructions* for the delivery of Fast FCAS to *enable* the required quantities based on the *market ancillary service offers* received.

During *enablement*, an Ancillary Service Facility must respond to Local Frequency without further instruction from AEMO.

8. SLOW FCAS REQUIREMENTS

8.1. Specification of Slow Raise Service in Market Ancillary Service Offer

The amount of *slow raise service* in a *price band* and all cheaper *price bands* is the **lesser** of:

(a) twice the Time Average of the Raise Response between 6 s and 60 s from the FDT, excluding any *fast raise service* provided; and

(b) twice the Time Average of the Raise Response between 60 s and 5 min from the FDT,

that the FCAS Provider making the *market ancillary service offer* expects would be delivered at the relevant *connection point* in response to a Standard Frequency Ramp from 50 Hz to the Raise Reference Frequency while this *price band* is *enabled*.

8.2. Specification of Slow Lower Service in Market Ancillary Service Offer

The amount of *slow lower service* in a *price band* and all cheaper *price bands* is the **lesser** of:

(a) twice the Time Average of the Lower Response between 6 s and 60 s from the FDT, excluding any *fast lower service* provided; and

(b) twice the Time Average of the Lower Response between 60 s and 5 min from the FDT,

that the FCAS Provider making the *market ancillary service* offer expects would be delivered at the relevant *connection point* in response to a Standard Frequency Ramp from 50 Hz to the Lower Reference Frequency while the *slow lower service* in this *price band* is *enabled*.

8.3. Dispatch

AEMO will issue *dispatch instructions* for the delivery of Slow FCAS to *enable* the required quantities based on the *market ancillary service offers* received.

During *enablement*, an Ancillary Service Facility must respond to Local Frequency without further instruction from AEMO.

9. DELAYED FCAS REQUIREMENTS

9.1. Amount of Delayed Raise Service in Market Ancillary Service Offer

The amount of *delayed raise service* in a *price band* and all cheaper *price bands* is the **lesser** of:

(a) twice the Time Average of the Raise Response between 1 min and 5 min from the FDT and *slow raise service* provided; and

(b) the Time Average of the Raise Response between 5 min and 10 min from the FDT,

that the FCAS Provider making the *market ancillary service offer* expects would be delivered at the relevant *connection point* in response to a Standard Frequency Ramp from 50 Hz to the Raise Reference Frequency while the *delayed raise service* in this *price band* is *enabled*.

9.2. Amount of Delayed Lower Service in Market Ancillary Service Offer

The amount of *delayed lower service* in a *price band* is the **lesser** of:

(a) twice the Time Average of the Lower Response between 1 min and 5 min from the FDT and *slow lower service* provided; and

(b) the Time Average of the Lower Response between 5 min and 10 min from the FDT,

that the FCAS Provider making the *market ancillary service* offer expects would be delivered at the relevant *connection point* in addition to the amounts in all cheaper *price bands* in response to a Standard Frequency Ramp from 50 Hz to the Lower Reference Frequency while the *delayed lower service* in this *price band* is *enabled*.

10. REGULATION FCAS

10.1. Specification of Regulating Raise Service in Market Ancillary Service Offer

Provided the amount bid is at least the greater of 1 MW or 1% (rounded to nearest whole MW) of the 'Max Cap' recorded for 'Raisereg' in the Ancillary Services worksheet in AEMO's NEM Registration and Exemption List,[14] the amount of *regulating raise service* specified in a *price band*

[14] Available at https://aemo.com.au/energy-systems/electricity/national-electricity-market-nem/participate-in-the-market/registration. FCAS Providers must comply with this requirement by 22 December 2023.

must be the amount of Regulating Raise Response that the FCAS Provider making the *market ancillary service offer* expects would be delivered at the relevant *connection point* progressively over a *dispatch interval* in addition to the amounts in all cheaper *price bands* in response to Raise Signals sent to request the maximum possible Regulating Raise Response while this *price band* is *enabled*.

10.2. Specification of Regulating Lower Service in Market Ancillary Service Offer

Provided the amount bid is at least the greater of 1 MW or 1% (rounded to nearest whole MW) of the 'Max Cap' recorded for 'Lowerreg' in the Ancillary Services worksheet in AEMO's NEM Registration and Exemption List,[15] the amount of *regulating lower service* specified in a *price band* must be the amount of Regulating Lower Response that the FCAS Provider making the *market ancillary service offer* expects would be delivered at the relevant *connection point* progressively over a *dispatch interval* in addition to the amounts in all cheaper *price bands* in response to Lower Signals sent to request the maximum possible Regulating Lower Response while this *price band* is *enabled*.

10.3. Compliance monitoring and action

AEMO needs assurance that an Ancillary Service Facility or Aggregated Ancillary Service Facility (as applicable) *enabled* to deliver Regulation FCAS will respond in an accurate, timely and co-ordinated manner.

AGC control requests apply to an Ancillary Service Facility's Load Reference point. If Local Frequency is not 50 Hz, any active Contingency FCAS or PFR controllers should adjust the Ancillary Service Facility output to take into account Local Frequency in accordance with the Ancillary Service Facility's droop function.

To achieve this control co-ordination, Ancillary Service Facilities that are controlled by AGC must ensure that their Plant Controller is able to respond in an additive manner (i.e. a net sum) using their Contingency FCAS or PFR controllers and AGC controls. The total expected change in output is subject to *enabled* quantities of each FCAS and a applicable PFR obligations[16]. A high-level example is shown in Figure 1, which outlines the expected Ancillary Service Facility behaviour. Actual control design will vary by *plant* and technology and may be subject to other control actions, various limits and intermediate controllers.

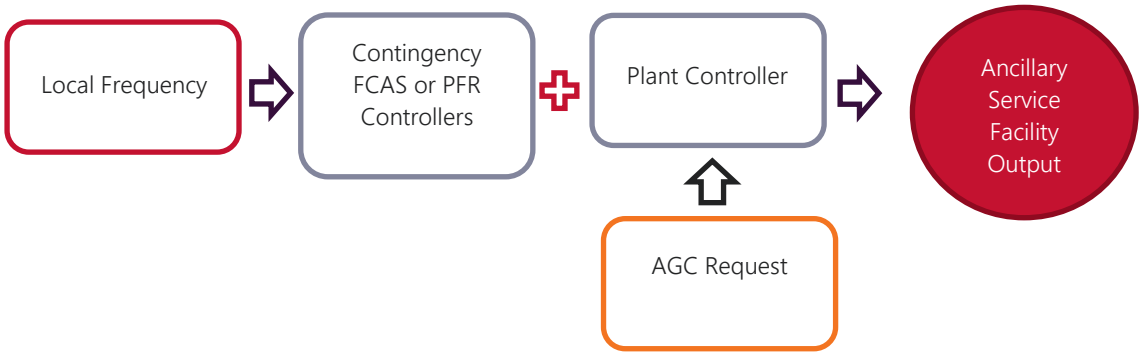
Hence, where relevant, Contingency FCAS or PFR controllers must detect Local Frequency and calculate an appropriate response. The Ancillary Service Facility's Plant Controller should take the sum of the response calculated by the Contingency FCAS or PFR controllers and response requested by the AGC control signal to determine the required output from the Ancillary Service Facility.

Because AGC must balance various objectives simultaneously (including frequency control, load following, time error correction and dispatch ramping), occasionally, the direction of the Contingency FCAS or PFR response calculated by the FCAS Provider could be the opposite to the AGC control signal. Example responses are provided in Appendix B.

[15] Available at https://aemo.com.au/energy-systems/electricity/national-electricity-market-nem/participate-in-the-market/registration. FCAS Providers must comply with this requirement by 22 December 2023.

[16] Only *Scheduled Generators* and *Semi-Scheduled Generators* have PFR obligations.

Figure 1 High level frequency-coordinated control design



AEMO will monitor the output of Ancillary Service Facilities and Aggregated Ancillary Service Facilities *enabled* to deliver Regulation FCAS in accordance with Appendix A of the Dispatch Procedure.

AEMO may invoke a fixed *constraint* equation until it is reasonably satisfied that the Ancillary Service Facility or Aggregated Ancillary Service Facility (as applicable) responds as contemplated by the MASS.

10.4. Control system

The Ancillary Service Facility must have a *control system* that can:

(a) transmit an agreed set of control parameters including Controlled Quantity, Control Request Feedback, Online/Offline Status, Remote/Local Status, Raise Control Limit, Lower Control Limit, Raise Rate Limit and, if different from the Raise Rate Limit, the Lower Rate Limit every 4 s to AEMO via SCADA and with no greater than 8 s latency, excluding external processing and communications delays[18];

(b) receive Raise Signals and Lower Signals;

(c) when *enabled* for Regulation FCAS, automatically deliver a Regulating Raise Response or a Regulating Lower Response corresponding to those Raise Signals or Lower Signals[19];

(d) ensure the Regulating Raise Response or Regulating Lower Response, where it exceeds the facility's Setpoint Change Deadband, is clearly discernible from any noise and oscillation in the telemetered output; and

(e) maintain at all times a Control Response Delay (CRD) no greater than 150 s[20]; and

(f) maintain at all times a Setpoint Change Deadband greater than or equal to half of the Ancillary Service Facility's minimum Regulation FCAS offer quantity as required by Sections 10.1 and 10.2[21].

An Aggregated Ancillary Service Facility's *control system* for *regulating raise service* or *regulating lower service* must only apply to the whole aggregated *generating unit* or *load*.

[18] FCAS Providers must comply with this requirement by 22 December 2023.
[19] AGC will control Ancillary Service Facility output within the ramping rates telemetered to AEMO by the Ancillary Service Facility.
[20] FCAS Providers must comply with this requirement by 22 December 2023
[21] FCAS Providers must comply with this requirement by 22 December 2023

10.5. Verification

For the purpose of verifying the maximum amount of *regulating raise service* or *regulating lower service* that can be delivered in response to a Raise Signal or a Lower Signal, the amount of service to be compared with the *enabled price bands* of the relevant *market ancillary service* offer must be determined using the recordings made under section 5.3.2 as follows:

(a) If AEMO or the FCAS Provider wishes to verify delivery of Regulation FCAS, AEMO must transmit no Raise Signals or Lower Signals to the relevant Ancillary Service Facility for at least 60 s and then immediately transmit Raise Signals or Lower Signals to the Ancillary Service Facility that would produce either a Regulating Raise Response or Regulating Lower Response equal to the lesser of the sum of the *enabled price bands*[22] of the relevant *market ancillary services offer* and the corresponding Raise Rate Limit or Lower Rate Limit for at least 5 min such that the Controlled Quantity remains at all times between the Raise Control Limit and the Lower Control Limit.

(b) The following procedure must be used:

  (i) fit a linear function of time (of the form P = P1 + R1 * t) to the power measurements made during the 60 s to which paragraph (a) refers;

  (ii) fit a linear function of time (of the form P = P2 + R2 * t) to the earliest power measurements made over the following 5 min that are all greater than (for Regulating Raise Response) or less than (for Regulating Lower Response) the function to which paragraph (b)(i) refers; and

  (iii) determine the Regulating Raise Response or Regulating Lower Response as the slope of the function to which paragraph (b)(ii) refers (in MW/min) multiplied by 5 min.

(c) The test must be discarded if the Ancillary Service Facility produces a Contingency FCAS response or significant PFR action during the test as this may invalidate the results.

10.6. Tests

FCAS Providers must notify AEMO of the date on which they intend to undertake tests to reasonably demonstrate that their Ancillary Service Facilities meet the MASS requirements applicable to Regulation FCAS:

(a) no less than every 4 years;

(b) within 8 weeks following a major overhaul of the facility or any change to *active power* controls; and

(c) within 8 weeks of a request from AEMO.

Tests should be undertaken within 8 weeks after the date of the FCAS Provider's notice to AEMO.

Test results must be provided to AEMO within 20 *business days* of completion of the relevant test. Any failure to provide test results to AEMO or to demonstrate that an Ancillary Service Facility complies with the MASS may result in AEMO constraining the Ancillary Service Facility's participation in the Regulation FCAS *market* as contemplated in the NER.

[22] For assessing Raise capability, only the enabled Raise price bands apply. For assessing Lower capability, only the enabled Lower price bands apply.

11. TRIALS OF NEW TECHNOLOGIES

11.1. AEMO's requirements

From time to time, a trial to demonstrate the capability of new technologies in the delivery of FCAS may be authorised. Where this occurs, AEMO may specify the capabilities, measurements, verification, duration and other requirements and conditions of the trial in its absolute discretion.

11.2. Report to AEMO

AEMO may specify the contents of a report and supporting data that trial participants must submit to AEMO upon the conclusion of a trial to enable AEMO to assess the efficacy of reviewing the MASS to address any issues that the trial has raised as to the performance of the new technologies in the delivery of FCAS or the operation of the *spot markets* for FCAS.

11.3. Transitional arrangements for VPP Demonstrations facilities

11.3.1. VPP Demonstrations and definitions

AEMO commenced a trial of the ability of virtual power plant (**VPP**) to deliver Contingency FCAS in June 2019 (**VPP Demonstrations**).

Participants enrolled in the VPP Demonstrations (**Trial Participants**) were permitted to deliver Fast FCAS in accordance with the VPP Demonstrations FCAS Specification[23] (**Trial Specification**), which included a power flow and *frequency* measurement time resolution of 1 s taken at the *connection point* of each *ancillary service load*.

For the period ending on 30 June 2023, (**VPP transition period**), the transitional requirements in section 11.3.2 will apply to Aggregated Ancillary Service Facilities that were classified by a Trial Participant and included in the VPP Demonstrations as at the date this section 11.3 comes into effect (**Trial Facilities**).

11.3.2. VPP transitional requirements

During the VPP transition period:

(a) Fast FCAS from a Trial Facility must be provided in accordance with the MASS, as varied by section 2.1 and clauses 2.2(a) and 2.2(b) of the Trial Specification;

(b) Trial Participants are not permitted to make changes to the device types or controller types in their Trial Facilities;

(c) where, in accordance with the Trial Specification, measurements of *power flow* and Local Frequency at a Trial Facility's *connection points* are captured with a sampling rate >200 ms, AEMO will apply a discount of 5% to the quantity of Fast FCAS measured at all those *connection points*;

(d) Ancillary Service Facilities that were not part of a Trial Facility immediately prior to the VPP transition period can only be added to a Trial Facility:

(i) to replace or add *ancillary service loads* so as to maintain (but not exceed) the total aggregate MW capacity of the Trial Facility to deliver Contingency FCAS immediately

[23] AEMO. VPP Demonstrations FCAS Specification. Available: https://aemo.com.au/initiatives/major-programs/nem-distributed-energy-resources-der-program/der-demonstrations/virtual-power-plant-vpp-demonstrations

before the VPP transition period, allowing for customer churn and for the discount applied under paragraph (c); and

(ii) in accordance with all applicable registration and classification requirements, including relevant fees.

11.3.3. After the VPP transition period

All Trial Facilities that are not providing Contingency FCAS in accordance with the requirements of the MASS as if this section 11.3 did not apply (i.e, not as varied by the Trial Specification) by the end of the VPP transition period will be declassified by AEMO, effective on and from the day after the VPP transition period ends.

APPENDIX A. STANDARD FREQUENCY RAMP

Figure 2 Standard Frequency Ramp for the Mainland

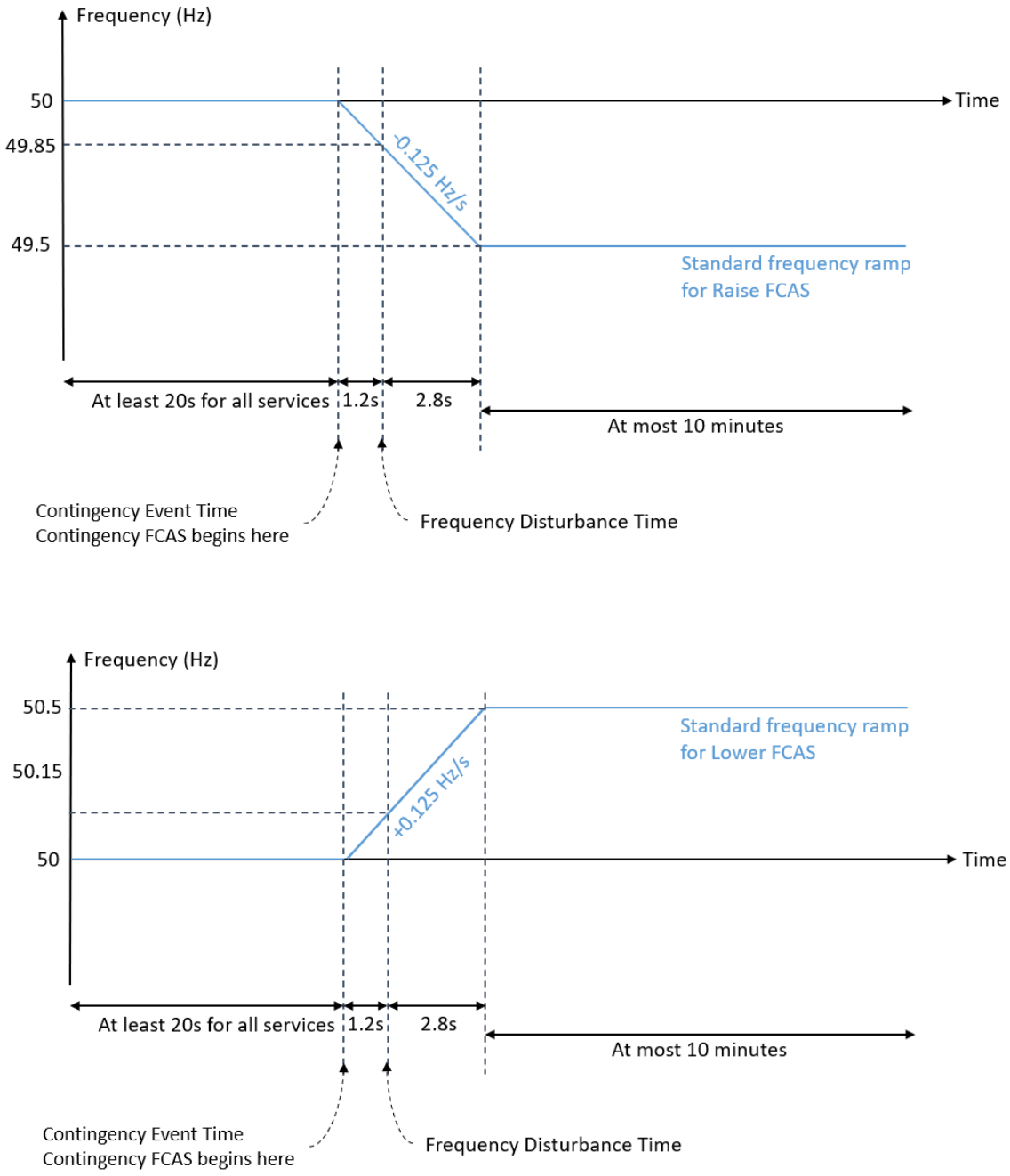
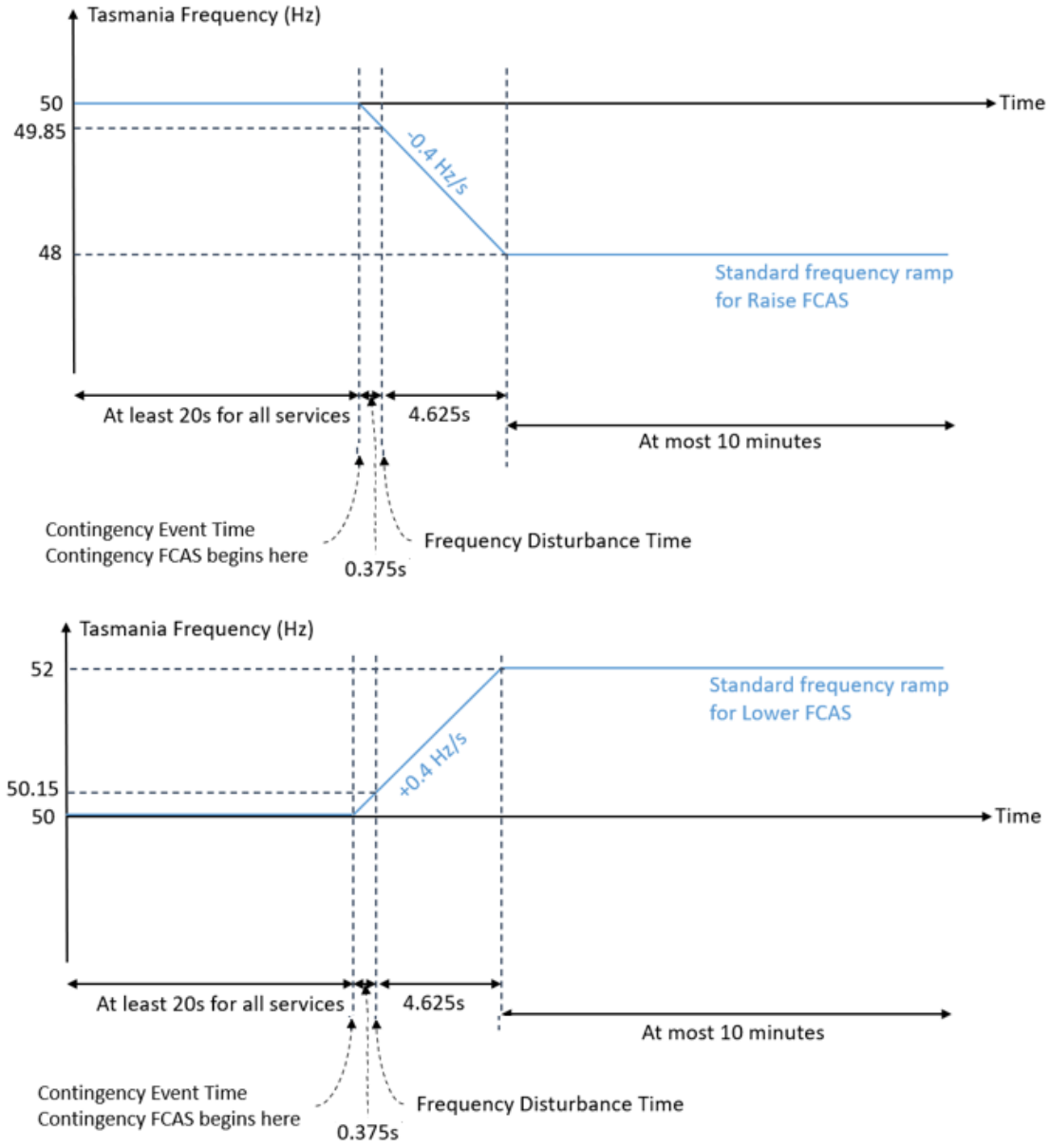


Figure 3 Standard Frequency Ramp for Tasmania



APPENDIX B. EXAMPLES OF FCAS MEASUREMENT AND DELIVERY

Measurement and delivery of Contingency FCAS

Figure 4 shows a visual representation of the measurements applied to verify that at least the minimum required Contingency FCAS has been delivered in each timeframe. It is not recommended that FCAS Providers use these measurements as the sole basis of FCAS control design.

Figure 4 Measurement timeframes for Raise Contingency FCAS for the Mainland and Tasmania

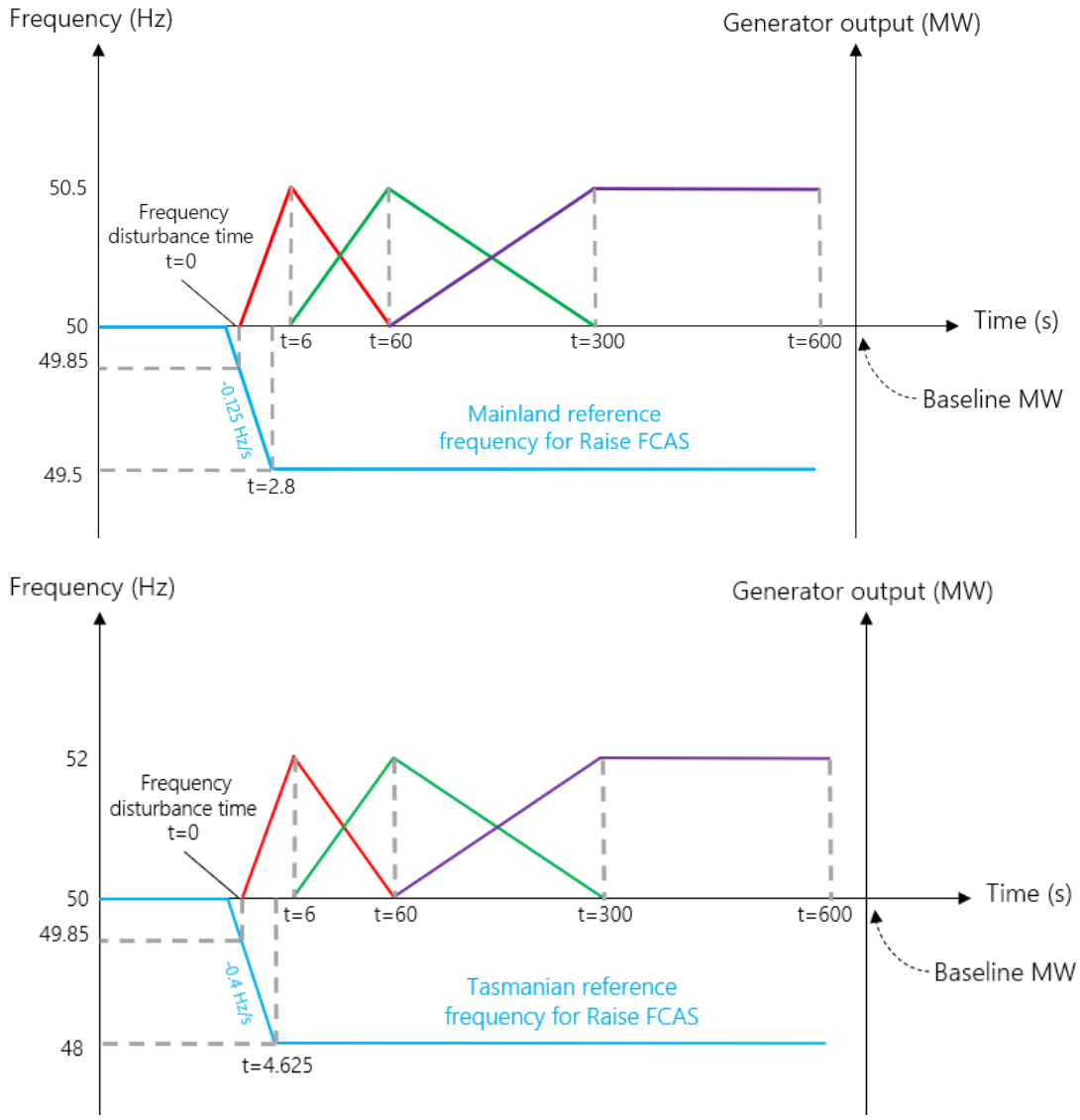
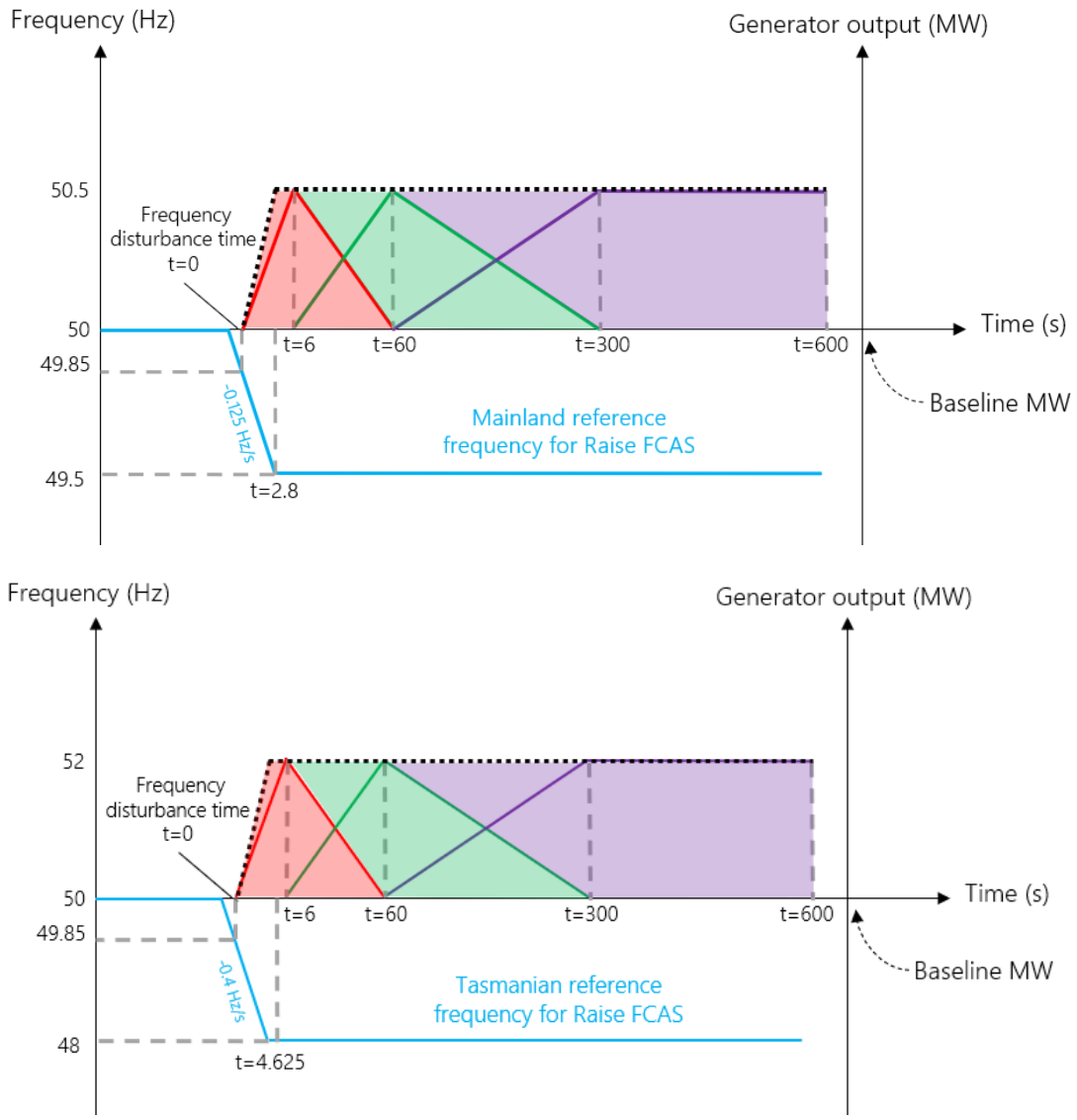


Figure 5 shows an example of how a simple Variable Controller that supplies a droop-based response to a Frequency Disturbance can deliver across the Contingency FCAS timeframes.

Figure 5 Combined measurement timeframes for Raise Contingency FCAS for Mainland and Tasmania



Examples of frequency co-ordinated response

Note that these examples are high level only and use a Setpoint Controlled Ancillary Service Facility. Raise/Lower Controlled Ancillary Service Facilities) are given Raise or Lower Controls that are relative to their current output, rather than a setpoint, but otherwise the desired behaviour is consistent. In all cases, the minimum expected Regulation FCAS response is subject to *enabled* quantities, ramp rates and PFR settings, where relevant.

Figure 6 Co-ordinated output for Ancillary Service Facility at 100 MW given Raise Regulation FCAS request of 2 MW while responding with 30 MW to a Frequency Disturbance

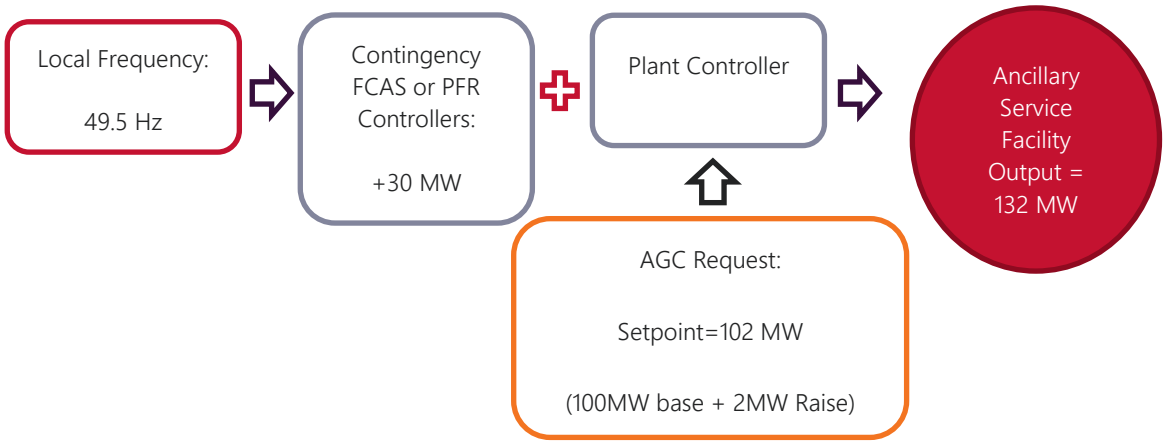


Figure 7 Co-ordinated output for Ancillary Service Facility at 100 MW given Lower Regulation FCAS request of 3 MW while responding with 30 MW to a Frequency Disturbance